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48th CMOS Congress

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2014-06-02

Plenary Day 1 / Plénière Jour 1

Room / Endroit (Langevin-Ouellet), Chair / Président (Michael Scarratt), Date (02/06/2014), Time / Heure (08:30 - 10:00)

P1.1 ID:7106 INVITED/INVITÉ 08:30

Coupled Environmental Prediction Within Canada: The CONCEPTS Initiative and the Year of Polar Prediction (2017-19)

Gregory Smith
Environment Canada
Contact: Gregory.Smith@ec.gc.ca

With increased refinement of numerical weather prediction systems, describing the interactions across the air-ice-ocean interface is becoming more important. This leads to a need for a new generation of fully-integrated environmental prediction systems composed of atmosphere, ice, ocean, and wave modeling and analysis systems. Such systems are in increasing demand as the utility of marine information products (e.g. for emergency response) becomes more widely recognized. This is particularly relevant in polar regions, as small-scale features of the sea ice cover (leads, ridges, melt ponds) can strongly modulate heat, moisture and momentum fluxes between the atmosphere and the ocean.

The World Weather Research Program has initiated a Polar Prediction Project (PPP) to promote cooperative international research enabling the development of improved weather and environmental prediction services for the polar regions on time scales from hourly to seasonal. A key activity of the PPP is the Year of Polar Prediction (YOPP) planned for 2017-19. The objective of YOPP is to enable a significant improvement in environmental prediction capabilities for the Polar Regions and beyond, by coordinating a period of intensive observing, modelling, verification, user-engagement and education activities.

Within Canada, this need for new and enhanced environmental products and services is being addressed through a government initiative called the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS), between Environmental Canada, Fisheries and Ocean Canada and National Defense. This presentation provides an overview of key challenges in polar prediction and how these are being addressed through the PPP/YOPP and related CONCEPTS activities. In particular, research into coupled atmosphere-ice-ocean forecasting will be presented, including the new Global Ice Ocean Prediction System now running in operations at the Canadian Meteorological Centre.

P1.2 ID:7284 INVITED/INVITÉ 09:15

Remote Sensing of the Arctic: Progress and Challenges

Alexander Trishchenko
Canada Centre for Remote Sensing

Contact: trichtch@ccrs.nrcan.gc.ca

Arctic is currently undergoing significant changes, as such it is important to have reliable information based on observations to better understand trends, to evaluate consequences and to complement and constrain models used for short-term and long-term prediction. The satellite remote sensing is important source of spatially complete data about the Arctic environment including atmosphere, ocean, cryosphere and land surface. The talk will provide an overview of various satellite systems employed for Arctic observations using passive and active, optical and microwave sensors. The challenges related to remote sensing of clouds, aerosols and cryospheric parameters in the Arctic environment will be discussed. Remote sensing in the Arctic is a challenge due to low sun geometry and long periods of nighttime conditions, frequent small thermal and visual contract between clouds and surface, as well as temperatures inversions. Retrievals from optical bands are complicated by bright reflection from snow and ice-covered surface. Recently released IPCC Fifth Assessment Report (AR5) highlighted some key uncertainties in the understanding of the Arctic climate system and the ability to project changes in response to anthropogenic influences. How well the satellite remote sensing is suited to narrow these uncertainties? Overview of upcoming satellite missions will provide some suggestions toward the answering this question for the Arctic. The concept and advantages of the satellite system on highly elliptical orbit (HEO) that permits continuous quasi-geostationary view of the entire Arctic domain will be also described.

General Atmospheric Science PART 1 / Sciences de l'atmosphère en général PARTIE 1

Room / Endroit (Langevin), Chair / Président (Martin Charron), Date (02/06/2014), Time / Heure (10:30 - 12:00)

1B1.1 ID:7324 **10:30**

Meteorological Service of Canada: Recent Accomplishments and Future Directions

David Grimes
Environment Canada
Contact: david.grimes@ec.gc.ca

The MSC is Canada’s National meteorological and hydrological service. No other organization, public or private, has the mandate, knowledge or resources to provide the weather forecasts and warnings and other related environmental services to Canadians that the MSC provides 24 hours a day / seven days a week. These services contribute to the Government’s mandate to protect the lives and property of its citizens from hazardous environmental conditions and have been identified as “Government Mission Critical”. The demand by Canadians for weather and environmental information is increasing, particularly in terms of the accuracy and timeliness of

forecasts of high-impact events on ever-increasing timescales from hours and days to seasons and decades. The Assistant Deputy Minister of the MSC David Grimes will provide an overview of recent advances in service delivery, recent investments in the MSC and future transformative directions planned to meet the needs of Canadians.

1B1.2 ID:7236 **10:45**

Potential Predictability of MJO in coupled and uncoupled models forecasts

Waqar Younas
(Presented by *David Tang,youmin*)
University of Northern British Columbia
Contact: vickyqau@gmail.com

In this study, the variability and actual and potential predictability of the Madden-Julian Oscillations (MJO) is evaluated, using state-of-the-art dynamical coupled and uncoupled models from the Canadian HFP2 (GCM3) and CHFP2 (CanCM3) ensemble. Emphasis is placed on the evaluation of actual prediction skill of the ensembles mean and the information-based potential predictability, and comparison of information-based potential predictability measure with usual signal to noise ratio measures. It is well established that most of current dynamical models are still lacking to correctly simulate the MJO variability due to model deficiencies and imperfect initial conditions. The MJO variability has been analyzed first in coupled and uncoupled models. The comparison of model's upper and lower level wind and precipitation patterns with observations revealed that models have suitable representation of the MJO variability. MJO signal was isolated using combined EOF analysis of upper and lower level winds and precipitation, using NCEP/NCAR reanalysis data from 1979-2001. Using first two PC time series, actual and potential prediction skill is estimated at daily time scale. It is found that coupled model (CanCM3) prediction skill is significantly better than uncoupled model (GCM3). The conclusion is not changed when MJO forecasts were divided into strong and weak MJO and into different phases. The similar interpretation can be given using potential prediction skill estimated by information theory based measure MI. In terms of potential skill, it is found that the mutual information (MI) is a reliable indicator of overall prediction skill. The comparison with conventional potential predictability measures of the signal-to-noise ratio, reveal that Mutual Information (MI) measures characterized more potential predictability when the ensemble spread varied over initial conditions. Further analysis showed that, the intra-seasonal SST prediction skill is significantly better than persistence skill in the tropics which can also explains the difference of actual and potential prediction skill between coupled and uncoupled models.

1B1.3 ID:7224 **11:15**

Error growth and optimum initialization of South Asian seasonal forecast using climatological relevant singular vectors

Siraj Ul Islam , *Youmin Tang*
University of Northern British Columbia, Prince George, BC, Canada
Contact: sislam@unbc.ca

Designing an efficient seasonal forecasting system is ensuring that the uncertainty in the forecast’s initial conditions is optimally sampled. In this study, using a recently developed

method of computing climatically relevant singular vectors, the error growth properties of initial perturbation over South Asian monsoon region are studied. Forecast simulations using CAM4 atmospheric climate model are investigated by examining the growth of perturbations with different lead times. It is found that reliable climatically relevant singular vectors can be estimated by running an ensemble of model forecasts for optimum initialization of monsoon forecast. The amplification of the perturbations occurs for more than 1 month with possibility of up to 6 months. Indian and equatorial Pacific Oceans are identified as regions of growing perturbations. The results show the growth rates of the singular vectors are very sensitive to the variable of perturbation, number of perturbations and the error norm. Further, it is demonstrated that the predictions with the climatically relevant singular vector have a more reliable ensemble spread, suggesting a potential merit for a probabilistic forecast This analysis potentially informs the design of reliable forecast system by identifying the sensitive regions where small uncertainties in the atmosphere can grow maximally.

1B1.4 ID:7252 11:30

An Establishment of an Objective Dynamical Framework for Forecast Model Evaluation of Extratropical Transitions

Alessio Spassiani [1], *John R. Gyakum* [1], *Ron McTaggart-Cowan* [2]
[1] McGill University
[2] Environment Canada
Contact: aspassiani@gmail.com

Extratropical Transition (ET) events describe the transformation of tropical cyclones as they move into the mid-latitudes and become more extratropical in nature. Although the threat of tropical cyclones is well realized, the same is not true for ET cyclone. These events are poorly forecasted and can affect the skill of forecasts downstream. Tropical cyclones that undergo ET can rapidly reintensify, producing intense rainfall, winds, and waves. This study will focus on the North Atlantic Ocean basin, where over a 30-year period (1970-1999) 45% of all tropical cyclones underwent ET. This is the largest percentage of any ocean basin. Bob Hart's Phase Space diagrams will be utilised to establish an objective dynamical framework for forecast evaluation of ET events. Four different reanalysis datasets will be used: NCEP Reanalysis 2 (R2), ERA Interim, the NCEP Climate Forecast System Reanalysis (CFSR), and the Japanese 55-year Reanalysis (JRA-55)

Biogeochemical Exchange Processes in Sea-Ice Areas: Measurements and Model Parameterisations / Processus d'échange

biogéochimique dans la glace de mer: mesures et paramétrisations des modèles

Room / Endroit (Courchesne), Chair / Président (Nadja Steiner & Jennifer Jackson), Date (02/06/2014), Time / Heure (10:30 - 12:00)

1B2.1 ID:7295 10:30

Inorganic carbon system dynamics in land-fast Arctic sea ice during the winter-spring transition

Kristina Brown [1], *Lisa Miller* [2], *Cj Mundy* [3], *Gauthier Carnat* [3], *Tim Papakyriakou* [3], *Michel Gosselin* [4], *Kyle Swystun* [3], *Roger Francois* [1], *Philippe Tortell* [1]
[1] University of British Columbia, Vancouver, Canada
[2] Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, Canada
[3] University of Manitoba, Winnipeg, Canada
[4] University of Quebec at Rimouski, Rimouski, Canada
Contact: kbrown@eos.ubc.ca

We conducted a six-week investigation of the sea ice inorganic carbon system during the winter-spring transition in the Canadian Arctic Archipelago. Significant changes in bulk sea ice and sackhole brine carbonate system parameters were associated with increasing temperatures and the build up of chlorophyll *a* concentrations in bottom ice. The warming sea ice column could be separated into three distinct geochemical zones where biotic and abiotic processes exerted different influences on inorganic carbon and pCO_2 distributions. In the bottom ice, biological carbon-uptake maintained undersaturated pCO_2 conditions during the time series, whereas pCO_2 was supersaturated throughout the remainder of the ice column. Low CO_2 permeability in the sea ice matrix and snow cover at the air-sea ice interface effectively impeded CO_2 efflux from the upper ice surface to the atmosphere, despite the strong pCO_2 gradient. Throughout the middle ice column, brine pCO_2 decreased significantly with time and was tightly controlled by sea ice temperature and in-situ melt dilution. However, once the influence of melt dilution was accounted for, both $CaCO_3$ dissolution and seawater mixing were found to contribute alkalinity and inorganic carbon to brines, with the $CaCO_3$ contribution driving brine pCO_2 to values lower than predicted from melt-water dilution alone. This field study reveals a dynamic carbon system within the rapidly warming sea ice, prior to snow melt. We suggest that the early spring period preconditions the ice column towards pCO_2 under saturation, contributing to a weak CO_2 sink as the melt period advances.

1B2.2 ID:7020 10:45

The role of sea ice DIC and TA boundary conditions on the cycling of carbon in a global blue-white-green ocean modeling system

Sébastien Moreau [1], *Martin Vancoppenolle* [2], *Laurent Bopp* [3], *Bruno Delille* [4], *Jean-Louis Tison* [5], *Hugues Goosse* [1]
[1] Université catholique de Louvain
[2] Université Pierre et Marie Curie, Paris, France
[3] Institut Pierre Simon Laplace, Gif-sur-Yvette, France

[4] Université de Liège, Liège, Belgique
[5] Université libre de Bruxelles, Bruxelles, Belgique
Contact: sebastien.moreau@hotmail.com

The direct role of sea ice in the carbon cycle of Polar Oceans is not represented in current Global Earth System Models. In many instances, how the model sea ice stores or transfers biogeochemical tracers is specified arbitrarily: the incorporation of tracers in sea ice is not considered and sea ice is assumed to prevent ocean-atmosphere gas exchanges. We focus on one of those aspects and investigate the role of sea ice and the role of CaCO3 precipitation on carbon cycling in the Polar Oceans. To accomplish this goal, we implemented the incorporation of tracers (here dissolved inorganic carbon, DIC and total alkalinity, TA) in sea ice in a state-of-the-art ocean-ice coupled model (NEMO) that includes an ocean biogeochemistry/food web model (PISCES). We ran a control (CTRL) simulation of NEMO in a 2° configuration (ORCA2) for 500 years and two 500 years experiments using different hypotheses on the incorporation of DIC and TA in sea ice. In the first experiment (PHYS), we considered the incorporation of DIC and TA in sea ice in the same proportion as sea ice salinity (i.e. ~6/34 of the DIC and TA oceanic concentrations). In the second experiment (IKAITE), we considered the incorporation of DIC in sea ice to 6/34 of its oceanic concentration and the incorporation of TA equal to 12/34 of its oceanic concentration. This latter experiment represents an upper limit of the impact of CaCO3 precipitation occurring in sea ice, leading to a sea ice TA/DIC ratio of ~2.

The PHYS experiment shows that the incorporation of tracers in sea ice significantly modifies CO2 fluxes in both the Arctic (by -1 10-3 Pg C yr-1) and the Southern (by -4 10-3 Pg C yr-1) Oceans. This incorporation also has the potential to modify the export of DIC to the deep layers of the Global Ocean. Compared to the sole incorporation of tracers in sea ice (PHYS), the IKAITE experiment shows that the precipitation of CaCO3 in sea ice also significantly modifies CO2 fluxes in both Polar Oceans (by 4 10-3 Pg C yr- 1 in the Arctic Ocean and by -5.5 10-3 Pg C yr-1 in the Southern Ocean) and, potentially, the export of DIC to the deep Global Ocean. Finally, the response of the model to the incorporation of tracers in sea ice is dominated by the role of ice growth regions in the Arctic Ocean and by the role of ice melt regions in the Southern Ocean. This study represents both a potential improvement to the representation of the biogeochemical cycle of carbon by Global Earth System Models and a contribution to a better understanding of the role of CaCO3 precipitation/dissolution in sea ice at a global scale.

1B2.3 ID:7091 11:00

Modeling Analysis With Tracer Experiment To Explore Source Regions Of Chukchi Borderland Water Mass

Eiji Watanabe
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Contact: ejnabe@jamstec.go.jp

The western Arctic hydrographic and biogeochemical structures were addressed using a pan-Arctic sea ice-ocean model. The seasonal experiment with lower-trophic marine ecosystem formulation from March to December 2010 demonstrated “eddy-induced biological pump” from the Chukchi shelf region to the southern Canada Basin. This system accounted for an early-winter peak of sinking flux of Particulate Organic Nitrogen (PON), which was captured by

JAMSTEC sediment trap measurements in the Northwind Abyssal Plain (Station NAP: 75°N, 162°W) of Chukchi Borderland. Besides, the multi-year time-series observation revealed that the summer fluxes of biogenic particles were clearly smaller in 2012 than those in 2011. The considerable suppression of sinking fluxes would attribute to the extension of oligotrophic Beaufort Gyre water toward the Station NAP. To examine the source areas of water mass around the Chukchi Borderland, a virtual passive tracer provided inside the Canada Basin and the shelf-break region, respectively. The modeled tracer distribution suggested that the Beaufort Gyre direction certainly switched from westward to southwestward (toward the East Siberian Sea) during the early period of 2012. The interannual variability of shelf-origin and/or basin water transport and its impact on marine ecosystem will also be discussed.

1B2.4 ID:7039 11:15

Developing a sea ice – ecosystem component within GOTM

Nadja Steiner [1], *Hakase Hayashida* [2], *Eric Mortenson* [2], *Adam Monahan* [2], *Carsten Abraham* [3]
[1] IOS - Fisheries and Oceans Canada
[2] School of Earth and Ocean Sciences, UVic, Canada
[3] Max Planck Institute, Hamburg, Germany
Contact: Nadja.Steiner@ec.gc.ca

The presentation will discuss progress in implementing sea ice and ecosystem model components into the 1-D General Ocean Turbulence model (GOTM) and Framework for Aquatic Biogeochemical Models (FABM) structure. This improved coupled system includes a multilayer thermodynamic ice model and sea-ice ecosystem components. A new parameterisation of light transmission through sea ice based on snow distribution functions improves the evolution of available Photosynthetic Active Radiation (PAR) within and below sea ice particularly during melting, allowing for a more realistic onset of sea-ice algae growth. The model system provides a tool for studies of carbon fluxes within sea-ice (a component of ArcticNet), aerosol sources from sea ice. i.e. DMS (within the Network on Climate and Aerosols) and pelagic primary production.We will present the model components and discuss early results from the Resolute area. This model development is a contribution to the SCOR WG on Biogeochemical Exchange Processes at Sea Ice Interfaces (BEPSII).

1B2.5 ID:7114 11:30

Effects of subgrid-scale snow thickness variability on sea ice

Carsten Abraham [1], *Nadja Steiner* [2], *Adam Monahan* [3], *Diane Lavoie* [4]
[1] Max Planck Institute for Meteorology
[2] Institute of Ocean Sciences, Fisheries and Oceans Canada
[3] SEOS, University of Victoria
[4] Institut Maurice-Lamontagne, Fisheries and Oceans Canada
Contact: monahana@uvic.ca

Previous studies of the onset of primary production within sea ice have found substantial biases in the timing of bloom onset. Biases of the light field within the sea ice were found to be the dominant factors in causing this ecosystem response bias. Snow thickness is an important control of the penetration of light into sea ice. Because the attenuation of light is a strongly nonlinear function of snow thickness, subgrid variations in snow thickness will influence the mean light

reaching the snow-ice interface. We will show that modelling this subgrid variability with snow thickness distributions results in more accurate representations of the light field within and below the sea ice. Accounting for snow thickness variability also changes the effective thermal diffusivity and influences sea ice growth and melt rates. Results from both a single column model and a regional model will be presented and will be compared to observations taken at Resolute. The potential of the new parameterization for modelling sea ice primary production will be discussed.

Collaboration in development, application and analysis of ocean forecasting models PART 1 / Collaboration dans le développement, application et analyse de modèles de prévision océanique PARTIE 1

Room / Endroit (Ouellet), Chair / Président (Youyu Lu, Frédéric Dupont, David Greenberg & Fraser Davidson), Date (02/06/2014), Time / Heure (10:30 - 12:00)

1B3.1 ID:7058 10:30

Suppressing Drift and Bias of a Global Ocean Model by Frequency Dependent Nudging to Observed Seasonal Climatology

Zhongjie He [1], *Keith R. Thompson* [2], *Harold Ritchie* [3], *Youyu Lu* [4], *Frederick Dupont* [3]
[1] Canadian Meteorological Centre
[2] Dalhousie University
[3] Environment Canada
[4] Fisheries and Oceans Canada
Contact: zhongjie_he@hotmial.com

Frequency dependent nudging is applied to a coarse resolution (nominal 1) global ocean model to suppress its drift and bias, and the impact of the nudging on the skill of the model is assessed. The nudging is applied to temperature and salinity in frequency bands centered on 0 and 1 cycles per year. As expected, the nudging reduces signicantly the biases in the long-term mean and annual cycle of temperature, salinity and sea level. By comparing the simulated (i) sea surface temperature to operational analyses based on observations, (ii) vertical proles of temperature and salinity to observations made by Argo floats, and (iii) sea level to altimeter observations, it is shown that skill of the model in simulating variability about the annual cycle is also improved. The potential benet of applying frequency dependent nudging to the ocean component of a coupled atmosphere-ocean model is discussed.

keywords: global ocean model, drift, bias correction, nudging, skill assessment

1B3.2 ID:7098 **10:45**

Water Masses in the Beaufort Sea in Mercator-Océan ORCA12 and BREA/CONCEPTS CREG12 high-resolution ocean-sea ice simulations

Matthieu Chevallier [1], *Gilles Garric* [2], *Romain Bourdallé-Badie* [2], *Greg Smith* [3], *Frédéric Dupont* [3], *François Roy* [3], *Simon Higginson* [4]
[1] Météo-France, CNRM-GAME
[2] Mercator-Océan
[3] Environment Canada
[4] Fisheries and Oceans Canada
Contact: matthieu.chevallier@meteo.fr

The representation of the water masses in the Beaufort sea (surface, summer/winter Pacific and Atlantic layers) is presented in several high-resolution hindcasts spanning the 2000s: the global ORCA12 from Mercator-Océan, and the regional CREG12 ocean-sea ice model. Simulations with lower-resolution ORCA025 are used for comparison. All hindcasts use NEMO ocean model. Increasing the resolution from 1/4° to 1/12° allows for a better maintenance of the Pacific water core in Mercator-Océan model. This picture is contrasted when moving to CREG12 driven by higher-resolution forcing CGRF. The regional model struggles to keep the vertical distribution of the water masses when state-of-the-art parametrizations are used. As this does not seem to be due to the atmospheric forcing, this questions the impact of essential model features as the sea ice model, the vertical mixing scheme, and Bering Strait inflow. Experiments with lagrangian tracers using ARIANE software have shown a potential impact of scaling the Bering Strait volume inflow, but new experiments with ORCA025 and ORCA12 at Mercator-Océan suggested also a need to adapt new parametrizations of vertical mixing in the Arctic ocean. Plans of new experiments with CREG025 aiming at improving regional ocean-sea ice simulations in the Arctic ocean will finally be presented.

1B3.3 ID:7025 **11:00**

High-resolution modelling of flow and meso-scale eddy variability around the Grand Banks of Newfoundland

Li Zhai [1], *Youyu Lu* [1], *Simon Higginson* [1], *Fraser Davidson* [2], *Fred Dupont* [3], *Francois Roy* [3], *Jerome Chanut* [4], *Greg Smith* [3]
[1] Bedford Institute of Oceanography
[2] Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada
[3] Environment Canada
[4] Mercator Ocean
Contact: Li.Zhai@dfo-mpo.gc.ca

Spatial variability of mean flow and meso-scale eddy variability in the region around the Grand Banks of Newfoundland (GBN) are quantified by analyzing surface drifter observations, along-track satellite altimeter observations and the solutions of two-high resolution ocean models. The models are based on NEMO (the Nucleus European Modelling of the Ocean). The CREG12 model covers the Arctic and North Atlantic Oceans with a horizontal resolution of about 8 km in the study area. The GBN36 model covers the study area with a horizontal resolution of about 2.5 km, and takes lateral boundary forcing from CREG12. Both models are forced with the Canadian

Meteorological Center's global reforecasts. Analyses are applied to model solutions during 2004-2006. Compared with estimates based on surface drifter observations, CREG12 overestimates the kinetic energy of the mean current (MKE) by 53%, whereas GBN36 obtains much closer agreement. GBN36 (CREG12) reproduces 70% (60%) of the eddy kinetic energy (EKE) observed from satellite altimetry. In terms of the spectra of sea surface height (SSH) anomalies, both GBN36 and CREG12 obtain a slope close to -5 on logarithmic spectral density scales at the high wave-number and frequency end.

1B3.4 ID:7055 **11:15**

Downscaling Ocean Conditions on the Scotian Shelf

Anna Katavouta , Keith Thompson
Department of Oceanography, Dalhousie University
Contact: a.katavouta@gmail.com

A straightforward method for assimilating information on large scale ocean conditions in order to recover small scale variability is tested using a realistic, regional high resolution model of the Scotian Shelf. The method is based on nudging in specific wavenumber bands and has been used successfully for atmospheric downscaling using limited area atmospheric models. The model of the Scotian Shelf is based on NEMO (Nucleus for European Modelling of the Ocean) modeling framework, and specifically the version used in MEOPAR (Marine Environmental Observation Prediction and Response Network). The Scotian Shelf model includes tides and radiative open boundary conditions, and has a horizontal grid spacing of order of 1/36 degree. The large scales conditions are obtained from the HYCOM+NCODA global 1/12 degree analysis product. Results of the downscaling are evaluated and discussed. The possibility of using this downscaling approach in the development of a rapidly relocatable, ocean forecast system is discussed.

1B3.5 ID:7154 **11:30**

Linking inter-annual variations of winter temperature and circulation to local wind variability in the Yellow Sea

Youyu Lu [1], *Hao Wei* [2], *Chengyi Yuan* [2], *Xiaofan Luo* [2]
[1] Bedford Institute of Oceanography
[2] Tianjin University of Science and Technology
Contact: Youyu.Lu@dfo-mpo.gc.ca

A 50-year simulation with a nested global and Northwestern Pacific model is analyzed to understand the inter-annual variations of water temperature and circulation in the Yellow Sea (YS). Changes in heat content integrated over the YS during cooling season are mostly balanced by changes in surface heat flux instead of the lateral heat flux due to the advection by the Yellow Sea Warm Current (YSWC). In most coastal areas less than 50 m deep, winter temperature decreases as the winter monsoon gets stronger. But in the deep trough in the central region, EOF analysis of winter temperature shows two distinct modes. The first mode shows a single pattern of variation over the central region which can be related to variations of surface heat flux in the region. The second mode shows a west-east dipole pattern that corresponds to variations of the YSWC pathway, which can be further related to variations in the curl of wind stress. Further,

variation of winter monsoon can be linked to variations of large-scale atmospheric circulation characterized by the Arctic Oscillation and the East Asia Trough.

Acoustics in Oceanography and Marine Sciences PART 1 / Acoustiques en océanographie et sciences marines PARTIE 1

Room / Endroit (Léonard-Blais), Chair / Président (len Zedel, Tetjana Ross & Yvan Simard), Date (02/06/2014), Time / Heure (10:30 - 12:00)

1B4.1 ID:7233 10:30

Assessing the effects and impacts of seismic exploration noises on marine life using acoustic propagation modelling. Are the whales going deaf ?

Martin Taillefer [1], *Dr. Diana Mccammon* [1], *Craig Hamm* [1], *Dr. Gary Brooke* [2], *Dr. Dave Thomson* [2], *Dr. Sean Pecknold* [3]
(Presented by *Len Zedel*)
[1] Maritime Way Scientific Ltd.
[2] Brooke Numerical Services
[3] Defence and Research Development, Canada - Atlantic
Contact:

Acoustic propagation modelling came of age in the midst of the Cold War where many of the “numerical models” were used to assist sonar systems to predict sound energy levels and propagation paths to locate and assess the posture of enemy submarines. Today, these propagation models have reached advanced levels of a very high degree of fidelity and accuracy, and used extensively to combat the threat of sound to marine life created through anthropogenic activities. The oil and gas exploration and production (E&P) industry is subject to stringent environmental regulations in regard to their activities underwater. In particular, prior to engaging in any activity that employs acoustic sources directly (e.g., air-gun survey, side-scan sonar surveys, acoustic telemetry and positioning systems) or that produces acoustic energy as a by-product (e.g., drilling, dredging, pile driving), the industry’s principals must complete an Environmental Assessment (EA). Among other things, the EA is required to contain documented evidence concerning the potential for E&P acoustic operations to adversely affect resident marine life (including mammals, fish, and invertebrates). A comprehensive, critical and objective analysis of the currently available numerical underwater acoustic propagation models and the required supporting data (marine physical databases, marine animal databases and environmental translation models) were assessed in 2013. The major accomplishments of this work was an in-depth evaluation of current acoustic model capabilities to meet E&P noise prediction requirements, specific recommendations for the models best suited to all the different types of E&P activities. The oil and gas industry must now use and are now fully dependent on acoustic modelling in order to assess the impacts of their activities on the marine life, their physiology,

their behaviors and health in particular, for marine mammals. The stakes are high for the oil and gas sector, and for the animals.

1B4.2 ID:7082 10:45

Ocean shipping noise: Measuring ship source levels of the present merchant fleet from an opportunistic acoustic observatory along the busiest seaway in eastern Canada

Yvan Simard [1], *Nathalie Roy* [2], *Cédric Gervaise* [3], *Samuel Giard* [4]
[1] Institut des Sciences de la Mer, UQAR & Institut Maurice-Lamontagne, Pêches et Océans Canada
[2] Institut Maurice-Lamontagne, Pêches et Océans Canada, Mont-Joli, QC, Canada
[3] GIPSA-Lab, Université de Grenoble, France
[4] Montréal, QC, Canada
Contact: yvan_Simard@uqar.qc.ca

World shipping is the main source of manmade noise in the ocean. Since decades, this human imprint on the planet is increasing with the world economic growth. Concerns about the effects of the ensuing rise of low-frequency underwater noise on aquatic ecosystems and marine life has brought the attention of the scientific community, the public and regulators worldwide. A critical step for a detailed assessment of this noise problem is the measurement of the spectral source levels (SSL) of the present merchant fleet, which is characterized by a large diversity of ships. This can be accomplished by operating an acoustic observatory along a seaway. The American National Standards Institute (ANSI) has proposed a standard protocol for measuring the SSL of a collaborating ship, but this protocol cannot be applied as is to opportunistic SSL assessment from a non-co-operating transiting ship. Here we present the results from such an observatory that has recently been operated for a complete annual cycle along a major seaway of North America: The St. Lawrence Seaway. A vertical array of three AURAL autonomous hydrophones has been moored on the inward traffic lane, in the 350-m deep x 25-km wide channel of the Lower St. Lawrence Estuary. The configuration has been optimized to comply with the ANSI standard protocol as much as possible. The simultaneous AIS data on ship position and characteristics were extracted from the Canadian Coast Guard traffic surveillance network. The developed single ship SSL assessment methodology includes ways to control for the various sources of errors and biases from opportunistic observations. Its application resulted in the building of a present merchant fleet SSL data bank containing several hundreds of diverse ships.

1B4.3 ID:7242 11:00

Modeling the ocean shipping noise of the St. Lawrence Seaway in order to study its impact on blue whale population.

Florian Aulanier [1], *Yvan Simard* [2], *Cédric Gervaise* [3]
[1] Institut des Sciences de la Mer, Université du Québec à Rimouski
[2] Maurice Lamontagne Institute, Fisheries and Oceans Canada
[3] GIPSA lab, Université de Grenoble
Contact: florian.aulanier@uqar.ca

The St. Lawrence Seaway is the busiest one in eastern Canada. Its proximity with known foraging habitats of the endangered blue whale has lead to initiate a study on the impact of ocean shipping noise radiated in the St Lawrence. The first part of the study deals with the choice of appropriate acoustic propagation simulation methods that permits to model accurately the third-

octave mean spectra produced by ships on a given period of time, all along the year and at all ranges from the sources. To this aim, 1-km2 resolution maps of mean shipping density, created from available AIS data, are used as spatial source distribution. The source spectra are then determined as a function of vessel sizes and speeds. Three typical frequency bands are considered regarding the propagation: 10 to 100 Hz, 100 to 1000 Hz and 1 to 16 kHz. The choice of the acoustic propagation model is then discussed regarding the frequency band, the ocean depth, and the range of propagation. The simulation results obtained with the methods of: the integrated wavenumber, the coupled normal modes method, the parabolic equation and the Gaussian-ray-tracing are compared with each other. As a validation, the simulated acoustic fields are also compared with those recorded during in-situ measurements at the vicinity of the St Lawrence shipping lane. Finally, the variability of the simulated radiated acoustic field is discussed regarding the environmental variability.

1B4.4 ID:7201 11:15

Measurements of near-bottom turbulence caused by shoaling internal waves in the St Lawrence Estuary

Clark Richards [1], *Dan Kelley* [2], *Daniel Bourgault* [3], *Peter Galbraith* [4], *Alex Hay* [2]
[1] Woods Hole Oceanographic Institution
[2] Dalhousie University, Halifax NS, Canada
[3] Institut des sciences de la mer de Rimouski, Rimouski, Canada
[4] Institut Maurice-Lamontagne, Mont-Joli, Canada
Contact: clark.richards@gmail.com

In Summer 2008, a field program was carried out in the St Lawrence Estuary with the goal of understanding the contribution of internal waves (IWs) to turbulence and mixing there. Sampling covered most of a spring-neap cycle, and involved ship-based surveys as well as a mooring array containing turbulence-resolving current meters. Remote sensing of IW surface signatures was carried out with shore-based time-lapse cameras. This presentation will focus on the energetics of near-bottom turbulence and its relation to shoaling IWs, leading to a parameterization for IW-induced turbulence based on estimates of the nonlinear energy flux.

1B4.5 ID:7218 11:30

Boundary Layer Velocity Structure in a Cold-Water Coral Area of Haddock Channel, Southwest Grand Banks

William Fowler , *Len Zedel*
Memorial University of Newfoundland
Contact: zedel@mun.ca

Bottom boundary layer currents in coral habitat in Haddock Channel were characterized using two 2-MHz acoustic Doppler profilers. The profilers were deployed on the seafloor, depth 700 m, looking upward, for 85 hours, beginning July 17th, 2007. The vertical profiling range was 4 m, with 1 m depth resolution. One instrument was placed in a coral (*Keratoisis grayi*) thicket (Coral Site), the second was deployed 100 m away in an area with similar sea floor characteristics, but from which corals had been removed by a research bottom trawl (Mud Site). Mean flow speeds at both sites were on the order of 10 cm/s. Speed profiles were fitted to the

logarithmic law of the wall to obtain bottom roughness (z_o) and friction velocity (u_*) estimates. Both sites appear to conform to the law of the wall for turbulent boundary layers. Friction velocities at flow speeds less than 5 cm/s, were consistently higher at the Coral Site. Mud Site u_* values were 30% to 80% of Coral Site estimates, indicating increased turbulence due to the presence of corals. Bed roughness values at the Coral Site (mean z_o = 0.51 +/- 0.28 cm), were generally higher at flow speeds below 5 cm/s, compared to the Mud Site (mean z_o = 0.27 +/- 0.40 cm). Backscatter levels increased faster with flow speed at the Mud Site for speeds between 2.5 and 7 cm/s. Above 7 cm/s, Coral Site backscatter intensity increased substantially, while Mud Site backscatter intensity declined. We conclude that higher u_* and z_o estimates at low flow speeds at the Coral Site were consistent with the hypothesis that enhancement of turbulence due to coral roughness elements is significant only at low speeds, enabling corals greater opportunities to extract organic material from the water column due to resuspension from the seafloor.

1B4.6 ID:7344 **11:45**

Acoustic observations of flow, turbulence and shear stress over orbital-scale ripples

Jenna Hare [1], *Alex E. Hay* [1], *Len Zedel* [2], *Richard Cheel* [1]
[1] Dalhousie University
[2] Memorial University
Contact: alex.hay@dal.ca

Bedforms and the near-bed flow are dynamically coupled via turbulence and bed roughness. However, the feedbacks between shear stress at the bed and bedform development under active sediment transport conditions are not well understood. In this presentation, the spatial and temporal structure of flow, turbulence, and stress over equilibrium orbital-scale sand ripples are investigated using experimental results obtained at turbulence-resolving scales with a wide-band coherent Doppler profiler (MFDop) and an oscillating tray apparatus. The oscillation period and horizontal excursion were 10 s and 0.5 m. The median grain size was 153 um. Ripple wavelength and amplitude were 25 and 2.2 cm. Velocity profiles ensemble-averaged over 20-ping pairs were acquired with 3 mm vertical resolution at 42 Hz. The MFDop measurements were used to investigate the co-evolution of the lee vortex, turbulent kinetic energy and Reynolds stress as a function of oscillation phase. Friction factors obtained based on stress estimates ranged from 0.1 to 0.2, which are comparable to values given in the literature. Preliminary results from a new set of experimental trials over evolving ripples will also be presented.

Wind and solar energy: the role of atmospheric science / Énergie éolienne et solaire: le rôle de la science atmosphérique

Room / Endroit (Parent), Chair / Président (Joël Bédard & Peter Taylor), Date (02/06/2014), Time / Heure (10:30 - 12:00)

1B5.1 ID:7162 **10:30**

MS-Micro-PBL: A new approach to complex terrain flow modelling

Wensong Weng [1], *Peter Taylor* [1], *Jim Salmon* [2]
[1] York University and Zephyr North
[2] Zephyr North and York University
Contact: pat@yorku.ca

For detailed wind farm design, most developers make some use of one of the commercial software packages, WindFarmer, Wind Farm, the AWS/openWind windmap or WindPRO. Part of each package involves a wind flow model for complex terrain which is used to take wind measurements from one or several towers as input in order to predict winds at potential turbine locations. Frequently the flow model used is either WAsP or MS-Micro. These models are based on flow perturbations caused by topography relative to a near-surface constant flux layer with, typically, a logarithmic velocity profile assuming neutral stratification. They are linearized in terms of the flow perturbations but perform well in terrain with moderate slopes, say of order 0.2. Roughness variations and wakes are treated in the same surface-layer context. As wind turbines get larger, and as the spatial extent of wind farms grow it is time to move to Planetary Boundary layer models, incorporating Coriolis effects and wind directions that turn with height, and to consider non-neutral stratification. MS-Micro-PBL includes these features. It is still a linear model but is more efficient than commercial CFD codes, and performs well in comparisons with measurements at wind farm sites.

1B5.2 ID:7115 **10:45**

The influence of coastline structure and atmospheric stability on wind conditions in the Baltic Sea

Martin Doerenkaemper [1], *Michael Optis* [2], *Adam Monahan* [2]
[1] ForWind Center for Wind Energy Research, University of Oldenburg
[2] SEOS, University of Victoria
Contact: monahana@uvic.ca

High-resolution simulations from the WRF mesoscale model are used with observations from an offshore meteorological tower and an offshore wind farm to examine land effects on the wind resource in the south Baltic Sea. Two main effects are investigated: the offshore advection of reduced wind speeds and the advection of warmer air over a colder sea, which induces offshore stable stratification. While both of these effects are well understood physically, a quantitative analysis of their importance has been lacking due in part to a lack of high-resolution simulations and availability of offshore observational data. We will demonstrate that the advection of reduced wind speeds can extend beyond 30km offshore and is strongly dependent on isolated onshore roughness features. In particular, reduced wind speed streaks are observed resulting from flow over high-roughness patches upwind of the coast. Their small cross-wind scale results in large changes in wind speed and power at the wind farm site with small changes in wind direction. We will further discuss five years of 10-min averaged data at the offshore FINO2

tower, which demonstrate a climatological diurnal cycle in the stratification. This cycle is most pronounced in the spring and summer seasons when the air to sea temperature difference is greatest. Furthermore, the strength of the induced stratification is shown to be strongly dependent on fetch. Increased wind shear at the tower is observed as a result of this induced stratification, which has implications for power output as well as potential shear damage at a wind farm site.

1B5.3 ID:7322 11:00

Bathymetry effects in the wind field estimation using RADARSAT-2 data in coastal area

Tahiana Ratsimbazafy [1], *Monique Bernier* [1], *Yves Gagnon* [2], *Mathieu Landry* [2]
[1] Institut National de la Recherche Scientifique - Centre Eau Terre Environnement
[2] Université de Moncton
Contact: tah.rats@ete.inrs.ca

Coastal areas are interesting for wind farm installations. They benefit more stable oceanic wind providing a more continuous electricity production. For ten years, Radar Synthetic Aperture (SAR) images are used in the estimation of wind potential on the surface of the ocean. Wind field can be extracted from SAR scenes. Numerical weather prediction (NWP) output model, scatterometry measurements, data from meteorological mast and buoys installed at sea have confirmed the effectiveness of SAR images to estimate the wind field at sea. This study focused on quantifying the bathymetry effects on the estimation of the wind fields in the coastal area. The study area is the region of North-Cape at the Prince-Edward Island , Canada. SAR images from the Canadian RADARSAT-2 satellite acquired in Standard Quad-polarization mode were used. Each of these scenes contains four polarimetric channels which can be used for wind field mapping at sea surface. The geophysical model CMOD5 was used to calculate the wind speeds. Data recorded at North-Cape meteorological mast were acquired from WEICan (Wind Energy Institute Of Canada) and Environment Canada. Information on the bathymetry of the local area was provided by the Canadian Hydrographic Service (CHS) of Fisheries and Oceans Canada. Local sea depth and wind speed calculated from SAR images were analyzed along linear profiles. The results showed that in areas where the depth is less than 20m, wind speeds were underestimated when the bathymetry varies abruptly in the first 10km off the coastline. Beyond this distance, and when the sea depth is greater than 20m, each of the wind speed calculated in the four polarimetric channels are similar.

1B5.4 ID:7056 11:15

Case study of Lidar in cold climate and complex terrain in Canada. Results of the 2012-2013 measurement campaign in Rivière-au-Renard (Québec) Canada

Cédric Arbez [1], *Mathieu Boquet* [2], *Raghavendra Krishna Murthy* [2]
[1] TechnoCentre Éolien
[2] Léosphère
Contact: carbez@eolien.qc.ca

The Lidar installs in cold climate is a new practice from the wind industry to assess the resource. To follow this tendency, this paper will focus on the technological validation of LIDAR in cold climate in completion with the current best practice. In order to validate this technology in North America, TCE performs a measurement campaign at R&D SNEEC site , located at Rivière-au-

Renard, Québec in Canada. This site is considered complex terrain and is qualified as cold climate according to the GL Technical note 69 . In completion of the test performed at Anse-a Valleau a WINDCUBE V2 Lidar has been installed to perform an additional measurement campaign near a met mast of 126 m height during 4 months near Rivière-au-Renard site. This met mast is equipped with more than 30 sensors especially ceilometer, standard differential probe, heated and unheated anemometers , wind vanes. The data acquisition is synchronized at 1Hz with the Lidar through Osisoft Pi archive system. Regarding this measurement campaign, TCE and Léosphère focuses on 4 analyses:determine the data availability of the Lidar;study the operational limitation that occurs during the operation due to cold climate; complex site calibration; global performance of Lidar in wind uncertainties. First, Leosphere and TCE will analyse data to ensure the functionality of remote sensing device in cold climate especially. The data availability of the Lidar has been calculated at each 10 min. to qualify themselves. In order to verify the operational performance of Lidar, we focus on the reason of low data availability period for the raw data compare to meteorological conditions. At the end, a cross comparison between the met mast wind speed and direction have been calculated to ensure the best performance of this technology in cold climate and complex terrain.

1B5.5 ID:7133 11:30

Recent Advances in Wind Turbine and Weather Radar Interactions

Jim M.c. Young
Environment Canada - MSC
Contact: jim.young@ec.gc.ca

Canada's weather radar network consists of 31 weather radars: 28 are owned and operated by Environment Canada; two are owned and operated by the Department of National Defence; and one is owned and operated by McGill University. Since 2006, Environment Canada's Meteorological Service of Canada has received and processed over 400 proposals from the wind energy industry to build turbines in proximity to weather radars. The contamination of the radar signal due to the wind turbine towers and blades has been previously documented. We present some recent analysis on the characterization of existing wind turbines with MSC radars (e.g. Val d'Irene and Gore). Some considerations for technical mitigation such as data interpolation, infill sensors, and signal processor enhancements will be described. Process mitigation options such as an "exceptional weather event protocol", curtailment, and setback distance recommendations will be presented. We will also describe a survey of the international efforts towards the management of wind turbine and weather radar interactions. Finally, we will propose some avenues (including technical, process and legislative) for a path forward towards co-existence.

1B5.6 ID:7116 11:45

Towards the mapping of global solar radiation over Tunisia using sunshine hour-based models and GIS techniques

Meher Chelbi , Yves Gagnon , Mathieu Landry
Université de Moncton, Edmundston (NB)
Contact: emc5202@umoncton.ca

Knowledge of solar energy potential and distribution over a territory is important for the

development of this renewable energy sector. Since global solar radiation measurements are limited in most countries, mathematical models using different climate parameters have been developed to estimate the solar radiation. In this study, a methodology is developed to estimate the solar radiation over a territory with limited ground solar radiation measurements; in addition, an application of the method is made to the country of Tunisia. As a first step in the methodology, four regression models based on the number of bright sunshine hours, including the Angstrom-Prescott model, are used to estimate the global solar radiation in the country of Tunisia. The Angstrom regression coefficients *a* and *b* are determined for each model and used to estimate the solar radiation over a period of time. Estimated values are then compared to ground measurements and the model showing the best results is retained. The next step in the methodology consists in interpolating the data of sunshine duration for every point of the study area where ground solar radiation measurements are available using two approaches for the Angstrom coefficients: the first approach consists in using generic *a* and *b* parameters for every point, while the second one consists in interpolating *a* and *b* as a function of the position over the area of interest. Further, for areas without ground measurements, a regression model is presented and assessed to extrapolate the monthly average sunshine duration as a function of latitude. Finally, a combination of the models for areas with ground solar radiation measurements and for areas without is used to generate annual and monthly global solar radiation maps on horizontal surfaces for the country of Tunisia.

General Atmospheric Science PART 2 / Sciences de l'atmosphère en général PARTIE 2

Room / Endroit (Langevin), Chair / Président (Martin Charron), Date (02/06/2014), Time / Heure (13:30 - 15:00)

1C1.1 ID:7011 13:30

Hydrometeorological Conditions Associated with the June 2013 Flood in Southern Alberta

Anthony Liu , Bob Kochtubajda , Curtis Mooney
Hydrometeorology and Arctic Lab, Environment Canada, Edmonton, Alberta
Contact: anthony.liu@ec.gc.ca

Excessive rainfall associated with an intense weather system triggered severe flooding over southern Alberta in June 2013, which became one of the costliest natural disasters in Canadian history, with four casualties and more than one hundred thousand people being forced to leave their homes. The current accumulated cost is estimated at several billion dollars. In this study, through detailed analyses of the hydrometeorological conditions associated with the event, we show that multiple factors combined to create the severe flooding. A slow-moving upper cut-off cold low blocked by a high pressure ridge, and a well-organized surface low kept southern

Alberta in continuous precipitation for up to two days, especially over the foothills and the lee slopes of the Rockies. Abundant moisture from the Gulf of Mexico transported into the region by a southeasterly low-level jet, and upper-level moisture associated with the cold low advected in from the Pacific Ocean enhanced the feeder- seeder process and provided sufficient moisture support for extremely high precipitation amounts. Also, low level easterly winds associated with the surface low produced strong terrain-induced vertical motion which enhanced precipitation in the lee slopes of the mountains and the foothill regions. Embedded convection between early evening to midnight on June 19th produced extreme rainfall rates near 50mm/hour at some locations. The system had a relatively high freezing level which resulted in rain rather than snow falling over still snow-covered high terrain regions. Melting associated with this rain-on-snow helped produce intense surface runoff which contributed to the downstream flooding. Upon reviewing NWP precipitation forecasts and associated hydrometeorological fields, it was found that although the total rainfall amount was underestimated in the weather model forecast guidance, the overall spatial and temporal evolution of the system was well captured by both deterministic models and ensembles.

1C1.2 ID:7229 **13:45**

Heavy snowfall over Coquihalla Summit – A case study

Rodger Wu
Environment Canada
Contact: rodger.wu@ec.gc.ca

Coquihalla Summit is located on a major high-elevation highway connecting the South Coast and the Interior of British Columbia (BC). Heavy snowfalls on the mountain pass lead to frequent car accidents and road closures in winter. On 16 March 2013, a Pacific frontal system moving across BC brought widespread snow to the southern parts of the province. Due to local effects of the complex terrain, heavy snowfall near Coquihalla Summit persisted for three days, resulting in total snow accumulation of 95 cm. The severe winter conditions from the heavy snowfall caused numerous car accidents on the Coquihalla Highway.

This case study focuses on the operational forecast challenge posed by the complicated impacts of the meso-scale terrain on the synoptic-scale flow pattern. Our analysis identified a unique synoptic-scale weather pattern conducive to the heavy snowfall. It was revealed that the post-frontal feature associated with the pattern played a major role in the event producing more than 80% total snow accumulation. A further detailed investigation indicated that three key weather ingredients (low level flow convergence, instability and snow density) made significant contribution to the heavy snow. The impacts of the local terrain on these weather ingredients were further analyzed by comparing the snow features between Coquihalla Summit and nearby Allison Pass (60 km apart). The findings from this case study would help meteorologists identify synoptic pattern and key ingredients for similar weather systems, with the expectation of more accurate snow amount forecast for the highway in the mountain pass.

1C1.3 ID:7305 **14:00**

Growing season comparison of ecosystem parameters from climate and remote sensing data sets

Aston Chipanshi [1], *Joe Piwowar* [2], *Jessica Vanstone* [3]
[1] Agriculture and Agri-Food Canada, Agri-Environment Services Branch
[2] Joe.Piwowar@uregina.ca
[3] Jessica.Vanstone@agr.gc.ca
Contact: Aston.Chipanshi@agr.gc.ca

An analysis of the growing season parameters describing crop development (phenology), the length of the growing season and plant biomass was conducted in two Canadian prairie catchments using the satellite imagery record and the gridded climate data sets from 1984 to 2011. The satellite imagery data consisted of a time series of the Normalized Difference Vegetation Index (NDVI) derived from the MODerate-resolution Imaging Spectroradiometer (MODIS). The gridded climate data sets were available at the 10km resolution and derived from Environment Canada's climate records using the Anusplin software. The gridded climate data sets were used to calculate the developmental phases of a representative cereal crop in the study area. The satellite imagery record referenced a pasture crop. The goal was to calculate trends and magnitudes of the developmental phases of plants under the present climate so that these can be used as a baseline for evaluating future ecosystem variables under a changed climate. Preliminary results show that both of the satellite record and climatological analysis confirmed that the growing season length has become longer by about one to two days and the onset of the start, peak and end of the growing season are occurring earlier than before. These trends are linked to the observed warming conditions that have been reported across western Canada under the present climate. The projection of climate variables to the 2050s using climate models suggests that western Canada will experience warmer and drier climatic conditions. It is therefore anticipated that, ecological parameters describing plant growth and development will change as well. These changes have implications on the productive capacity and food availability of agriculture systems. These implications are being evaluated using the CMIP5 scenario climate data sets.

1C1.4 ID:7175 14:15

Southern Ontario Ice Storm: Nightmare Before Christmas

Mark Schuster
Environment Canada
Contact: mark.schuster@ec.gc.ca

From Dec 20 till Dec 22, 2013 southern Ontario and the GTA (Greater Toronto Area) was impacted by a major ice storm, possibly the worst ice storm to hit the GTA in recent memory. Roughly 600 000 customers or an estimated 1.5 million people were without power at some point during the aftermath of the storm, many without power for upwards of a week. Close to 20 percent of Toronto's tree canopy may have been damaged by the effects of ice accretion. The Environment Canada forecast prediction system performed very well in the identification of this event both in the long range and short range prior to the event. The Freezing rain storm occurred in two phases or moisture surges across a quasi- stationary arctic frontal system with the second surge resulting in the greatest impact to people. This presentation will explore the messaging of the OSPC (Ontario Storm Prediction Centre) in conveying the significance of the upcoming ice storm, the meteorological forecast challenges and the visualization of the event through the NinJo workstation.

1C1.5 ID:7029 **14:30**

Rossby Wave Packets and Severe Weather in June 2012

Robert Ford , *Chris Sackiw*
Environment Canada
Contact: paul.ford@ec.gc.ca

The timing and locations of members of a series in June 2012 of severe weather events spanning North America and Europe are compared to time-longitude plots of the 300 hPa mean meridional wind in the mid-latitudes. A strong meridional wind couplet in the stationary summertime wavenumber 7 pattern emerged in the mid-Pacific Ocean in mid-June, crossed North America and reached Europe two weeks later. Each severe event occurred at the end of a prolonged period of strong, stationary southerly flow marked by the passage of the couplet. One interpretation of these observations is the propagation along the latitude zone of a Rossby wave packet at its group velocity. A possible wave generation mechanism is proposed.

1C1.6 ID:7303 **14:45**

Wind bias of an OTT Pluvio2 Accumulating Precipitation Gauge in a Single Alter Shield for the Measurement of Snowfall in a Cold and Windy Environment Craig Smith1, Aston Chipanshi2, Richard Warren2, Jessika L'Heureux2, Robert Tillie2, Mike Wroblewski3 and Andy Nadler4

Craig Smith [1], *Aston Chipanshi* [2], *Richard Warren* [2], *Jessika L'Heureux* [3], *Robert Tillie* [4], *Mike Wroblewski* [5], *Andy Nadler* [6]
[1] Environment Canada
[2] Agriculture and Agri-Food Canada, Science and Technology Branch
[3] Agriculture and Agri_Food Canada, Science and Technology Branch
[4] Agriculture and Agri-Food Canada, Sience and Technology Branch
[5] Manitotab Agriculture and Rural Iniatives
[6] Weather INnovations
Contact: Aston.Chipanshi@agr.gc.ca

Since November 2011, Agriculture and Agri-Food Canada, in collaboration with Environment Canada, have been running an inter-comparison between a single Alter shielded Pluvio2 and a Geonor in a Double Fence Inter-comparison Reference (DFIR) shield at Bratt's Lake, Saskatchewan. In addition, Alter Shield Pluvio2 measurements are compared with standard precipitation measurements at selected sites from Manitoba and Saskatchewan with Manitoba Agriculture and Rural Initiatives and Weather INnovations respectively. The inter-comparisons are intended to provide an informed understanding of why the standard measurements of precipitation under-estimate precipitation amounts especially in the winter months. The Alter shield Plubuio2 is becoming a popular instrument for measuring both solid and liquid precipitation; however its reliability particularly in windy and cold environments has not been widely established. Preliminary results show that snowfall measurements using the Single Alter shielded Pluvio2 results in a significant under catch due to wind as compared to the reference, similar to other single Alter shielded precipitation gauges at the site. A preliminary wind-speed vs gauge catch efficiency relationship has been developed and this relationship may be used to adjust other Pluvio2 snowfall measurements in similar environments.

1Environment Canada, Saskatoon 2 Agriculture and Agri-Food Canada, Science and Technology Branch 3Manitoba Agriculture and Rural Initiatives 4 Weather Innovations Inc.

Real-time ocean observing systems / Systèmes d'observation océanique en temps réel

Room / Endroit (Courchesne), Chair / Président (Denis Gilbert & Fraser Davidson), Date (02/06/2014), Time / Heure (13:30 - 15:00)

1C2.1 ID:7298 **13:30**

SWOT: A 2-D imaging altimetry mission for oceanography and hydrology

Guoqi Han
Fisheries and Oceans Canada
Contact: Guoqi.Han@dfo-mpo.gc.ca

In the past two decades nadir-looking satellite radar altimetry, providing nearly global measurements of ocean surface topography, has revolutionized physical oceanography. However, the noise level of a radar altimeter limits the along-track resolution to 50~100 km over the oceans. A new altimetry mission, Surface Water and Ocean Topography (SWOT), is being developed by the United States, France, and Canada. SWOT will use radar interferometry to make wide-swath measurements of the ocean surface topography and the elevation of land surface water. It is expected that SWOT will achieve an accuracy of 1 cm for 1 km by 1 km pixels over the ocean and of 10 cm for 50 m by 50 m pixels over land waters. Therefore the SWOT measurements will provide information on the mesoscale and submesoscale ocean variability that is critical to the climate change prediction and on the change of fresh-water resources affected by climate change. In this presentation I will give a brief introduction of the SWOT mission and its sampling characteristics, as well as the Canadian ocean science plan.

1C2.2 ID:7245 **13:45**

The Argo array of autonomous profiling floats

Denis Gilbert
Institut Maurice-Lamontagne, Pêches et Océans Canada
Contact: denis.gilbert@dfo-mpo.gc.ca

Argo is the largest in situ ocean climate monitoring system in the world. It is an array of over 3,500 freely-drifting floats that collects real-time data on ocean temperature and salinity, providing valuable information on changes to the Earth's climate and hydrological cycle. Argo data are publically available for free. The Argo array was deployed primarily for the purpose of ocean interior data assimilation in ocean models, in the context of GODAE (Global Ocean Data

Assimilation Experiment). With an average float lifetime of about five years, the Argo program has needed to develop methods for the detection of calibration drifts of pressure, temperature, and salinity. Detecting and properly correcting such calibration drifts remains an important technical challenge for the international Argo Data Management Team (ADMT).

1C2.3 ID:7263 14:00

The Ocean Tracking Network's use of Wave Gliders and Slocum Gliders to document animal movements and survival in response to ocean conditions

Frederick Whoriskey , Adam Comeau , Jon Pye , Richard Davis
Dalhousie University, OTN
Contact: fwhoriskey@dal.ca

The Ocean Tracking Network (OTN), a biological observing system of GOOS (Global Ocean Observing System), has established a global electronic telemetry network capable of tracking the movements and survival of aquatic animals. Tagged animals are detected by acoustic receivers deployed in lines across migration routes. To expedite data retrieval, and to provide information on environmental conditions that can be linked to animal movements and survival, OTN has recently worked with our receiver provider (VEMCO) and the Wave Glider manufacturer (Liquid Robotics) to enable the Wave Glider to remotely interrogate acoustic receivers and send the uploaded data back to shore via satellite. The Wave Glider also listens and reports in real time any tagged animals that it may encounter, as well as oceanographic and meteorological conditions. OTN's Slocum electric gliders are used for oceanographic profiling and are fitted with mobile acoustic receivers, providing additional acoustic listening stations. However, these data only become available with glider retrieval. The ability of both types of autonomous vehicles to serve as mobile receivers greatly expands the network's capabilities. OTN is meeting a global need for new biological observing capability, and makes its oceanographic observations freely available to the scientific community. Development of the autonomous vehicle capability is enabling better acoustic coverage, more timely retrieval of results, and reductions in operations and maintenance costs. Blue sharks, sturgeon, striped bass, Atlantic salmon and snow crabs have already been detected by these mobile platforms. OTN is funded primarily by the Canada Foundation for Innovation and Natural Sciences and Engineering Research Council of Canada.

1C2.4 ID:7293 14:30

Development strategy of automated real time oceanographic and meteorological observations from offshore industry ships and platforms

Fraser Davidson [1], *Doug Wallace* [2], *Chris Marshall* [3], *Bill Carter* [4], *Pierre Pellerin* [3]
[1] Fisheries and Oceans Canada
[2] Dalhousie University
[3] Environment Canada
[4] Memorial University Marine Institute
Contact: davidsonf@dfo-mpo.gc.ca

The DFO-EC-DND CONCEPTS activity and MEOPAR are working towards the development of a Canadian Capacity in operational marine environmental prediction. This includes eventually coupling the prediction of Oceanographic, Atmospheric, Ice and wave components together. A

key necessity to both monitor and to improve the prediction of these components is real time observation data that is relayed to prediction centers via the WMO Global Transmission System. The collection of data on industry supply vessels and on industry production platforms has many benefits. For the industry, this means the ability to verify forecast performance year in and year out at the location of their production platforms and along the transportation corridor between the platforms and the industry home base port. For oceanographic science, this provides a vector for collecting observations for monitoring and understanding climate change. For the Government of Canada environmental prediction systems, it means additional observations are available for validation and assimilation at economic important locations. More importantly the collection of data from oil industry platforms engages industry into contributing to and benefitting from oceanographic and meteorological prediction services. Herein we describe ongoing efforts to develop a validation platform and observing system to measure improvements in environmental prediction for an industry funded (ESRF) high resolution oceanographic prediction system for the Grand Banks and Orphan Basin

1C2.5 ID:7217 14:45

What have 20 months of CODAR surface currents told us about the Fraser River plume?

Mark Halverson , Rich Pawlowicz
University of British Columbia
Contact: mhalverson@eos.ubc.ca

The near-surface hydrography and circulation of the lower Strait of Georgia, near the outflow of the Fraser River, has been reasonably well characterized by numerous field studies over the past 40 years. The outflow from the estuary is tidally pulsed, and the location and intensity of estuarine mixing changes with river flow. Further from the river mouth, the buoyant plume, which can cover over 1500 square kilometers, is exposed to the tidal streams and wind forcing of the Strait of Georgia. The mean plume salinity varies in response to river discharge, tides, and fortnightly changes in estuarine mixing. Near-surface drifter trajectories, satellite observations, and aerial photography show that plume waters turn northward during weak or southeasterly winds, and southward during northwesterly winds.

Until recently, however, we lacked a detailed spatial view of the surface currents over a range of time scales. In August 2012, Ocean Networks Canada completed the installation of two CODAR high frequency radar surface current mapping systems in the lower Strait of Georgia. The radar produces hourly maps of the flow field over a domain which covers the region directly influenced by the Fraser River outflow. The result is a dataset with spatiotemporal qualities unprecedented in this region. These observations, in tandem with near-surface ship-of-opportunity hydrography and satellite imagery, reveal complex spatial flow patterns in the river plume, which, as we show, respond to wind, tide, and river forcing. The tidal flow is especially surprising because of how it differs from barotropic predictions.

Collaboration in development, application and analysis of ocean forecasting models PART 2 / Collaboration dans le développement, application et analyse de modèles de prévision océanique PARTIE 2

Room / Endroit (Ouellet), Chair / Président (Youyu Lu, Frédéric Dupont, David Greenberg & Fraser Davidson), Date (02/06/2014), Time / Heure (13:30 - 15:00)

1C3.1 ID:7171 13:30

Validation and analysis of ocean and sea-ice variability simulated by the high-resolution CONCEPTS regional model of the Arctic and North Atlantic oceans

Simon Higginson [1], *Frederic Dupont* [2], *Fraser Davidson* [3], *Youyu Lu* [1], *Greg Smith* [2], *Francois Roy* [2]
[1] Bedford Institute of Oceanography
[2] Environment Canada
[3] Northwest Atlantic Fisheries Centre
Contact: simon.higginson@yahoo.ca

High-resolution ocean and sea-ice forecast models for the Arctic and North Atlantic have been developed by the Canadian inter-departmental CONCEPTS program. The models are based on the Nucleus of European Modelling of the Ocean (NEMO). Several hindcast simulations have been completed for the period 2003-2009, with atmospheric forcing taken from the Canadian GDPS Reforecasts. In situ and satellite observations of the ocean and sea ice have been collected in order to develop a validation package that can be used to assess the performance of the model and the impact of model improvements. Observations include temperature, salinity and current measurements from long term moorings, temperature-salinity profiles from ship surveys and drifting profilers, ice draft measured by upward-looking sonar, ice motion from buoys, and satellite-derived estimates of ice concentration, thickness and motion. In this presentation we will show some of the key aspects of the model validation, including hydrography, sea-ice distribution and motion, and volume and freshwater transports between the Arctic and the North Atlantic. Results show that there is generally good agreement between the model and the observations, but several biases are identified and will be discussed.

1C3.2 ID:7041 13:45

CONCEPTS 1/12th ice-ocean Arctic-Atlantic model: improving the ice

Frederic Dupont [1], *Francois Roy* [1], *Jean-Francois Lemieux* [1], *Gregory Smith* [1], *Simon Higginson* [2], *Youyu Lu* [2], *Gilles Garric* [3], *Romain Bourdalle-Badie* [3]
[1] Environment Canada
[2] DFO
[3] Mercator-Ocean

Contact: frederic.dupont@ec.gc.ca

The Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) developed a high resolution ice-ocean model based on the NEMO model for the Arctic and North Atlantic regions for operational oceanography purposes. The present contribution focuses on the different additions made to the system for improving the ice representation, mainly related to the coupling with the Los Alamos CICE model, a more physically-based drag coefficient (ice-air and ice-water), ice mass embedding and some tests of the dynamic ice embedding.

1C3.3 ID:7155 14:00

High-resolution modelling of inter-annual variations of circulation and freshwater pathway in the Arctic Ocean

Youyu Lu [1], *Ji Lei* [2], *Simon Higginson* [2], *Frederic Dupont* [3], *Fraser Davidson* [2], *Gregory Smith* [3]
[1] Bedford Institute of Oceanography
[2] Fisheries and Oceans Canada
[3] Environment Canada
Contact: Youyu.Lu@dfo-mpo.gc.ca

In this study we analyze the hindcast simulation during 2003-2009 with a coupled ocean and sea-ice model covering the Arctic and North Atlantic Oceans. The model has a horizontal resolution of 3-8 km, and is forced with the atmospheric forcing obtained from a series of reforecasts from the Canadian Meteorological Centre's operational Global Deterministic Prediction System, at a horizontal resolution of 33 km. During the winters of 2004-2008, the modelled inter-annual changes of dynamic ocean topography (DOT) in the Canada and Eurasian Basins compare favourably with that obtained from remote sensing by the ICESat mission. Corresponding to changes in DOT, the model obtains changes in freshwater content, salinity, and circulation both at large-scale and near the coasts of Greenland. The relationship of these changes to atmospheric forcing is explored.

1C3.4 ID:7140 14:15

Influence of atmospheric forcing on the modelling of circulation in the North Atlantic and Arctic Oceans

Jean-Philippe Paquin [1], *Youyu Lu* [2], *Gilles Garric* [3], *Matthieu Chevallier* [4]
[1] Oceanography Department, Dalhousie University
[2] Bedfords Institute of Oceanography, Halifax
[3] Mercator-Ocean, Toulouse, France
[4] Meteo-France, Toulouse, France
Contact: jppaquin@sca.uqam.ca

Simulation results of the CREG025 model based on NEMO, covering the Arctic and North Atlantic Oceans with a nominal horizontal resolution of 1/4º in longitude/latitude are presented. We analyze the differences between two atmospheric forcing datasets, namely the European reanalysis ERA-Interim (Dee et al. 2011) available on a relatively coarse 1.5º horizontal resolution and the higher resolution (33km) Canadian Meteorological Center's Global Deterministic Prediction Systems Re-Forecast (CGRF; Smith et al. 2013). In particular, the

representation of intense mesoscale circulation features known as “Greenland Tip Jets”, associated with the strong interactions between Greenland's complex topography and large-scale atmospheric synoptic systems, will be presented. The influence of these different forcing datasets on the solutions of the CREG025 model will be presented and discussed.

1C3.5 ID:7214 **14:30**

A high-resolution baroclinic model of circulation off southwest of Nova Scotia

Fatemeh Chegini [1], *Youyu Lu* [2], *Hal Ritchie* [3], *Keith Thompson* [1]
[1] Department of Oceanography, Dalhousie University, Halifax NS
[2] Bedford Institute of Oceanography, DFO, Dartmouth NS
[3] Meteorological Research Division, EC, Dartmouth NS
Contact: harold.ritchie@ec.gc.ca

As part of a project to develop a coupled relocatable atmosphere-ocean prediction system within the “Marine Environmental Observation, Prediction and Response” (MEOPAR) Network of Centers of Excellence, a high resolution ocean model is developed to study upwelling off Cape Sable, southwest of Nova Scotia. Previous barotropic studies have shown that the region's low temperature, and high nutrients, during summer are driven by a combination of topographic upwelling and strong tidal mixing. However, the effect of stratification and wind forcing has not been taken into account in the models used to date.

In the present study a high resolution ocean model is used to investigate the baroclinic resposnse of the region to tidal and wind forcing. The three dimensional NEMO (Nucleus for European Modelling of the Ocean) circulation model is used with a horizontal resolution of 0.5 km. The effect of realistic meteorological forcing is considered and boundary conditions are derived from large-scale models covering the Scotian Shelf. The bathymetry is constructed from a multi-source bathymetry dataset, namely the Northwest Atlantic Bathymetry Data, in combination with ETOPO1 data. Details of the preparation of model inputs, including bathymetry, initial and boundary conditions and meteorological forcing are given. Furthermore, some preliminary results of the upwelling process off Cape Sable are presented. The implications of this study for the development of a rapid-response, relocatable models are discussed.

1C3.6 ID:7197 **14:45**

A Review of Particle Tracking, Theory and Applications

David Greenberg
DFO Bedford Institute of Oceanography
Contact: david.greenberg@dfo-mpo.gc.ca

Particle tracking has seen much development in recent years. In this paper we look at some of the subtleties of particle tracking within ocean model fields. Three specific applications will be explored. Non-cohesive sediments will be explored as dense particles. Oil related transport will be examined as chemically active particles. Individual based models (IBMs) will be described using biologically active particles that develop within model temperature and salinity fields and can add their own component of velocity to the model transport fields.

Acoustics in Oceanography and Marine Sciences PART 2 / Acoustiques en océanographie et sciences marines PARTIE 2

Room / Endroit (Léonard-Blais), Chair / Président (len Zedel, Tetjana Ross & Yvan Simard), Date (02/06/2014), Time / Heure (13:30 - 15:00)

1C4.1 ID:7198 **13:30**

Exploring the use of acoustics in monitoring harmful algal blooms in Alfacs Bay (a Mediterranean lagoon)

Tetjana Ross [1], *Mireia Lara Artigas* [2], *Oliver Ross* [3], *Norma Zoe Neszi* [2], *Elisa Berdalet* [2]
[1] Department of Oceanography, Dalhousie University
[2] Spanish National Research Council, Institute of Marine Sciences, Spain
[3] CNRS / Aix-Marseille University
Contact: tetjana@dal.ca

Harmful algal blooms (HABs) are a special concern in Alfacs Bay, which is an area of high ecological importance and an active aquaculture site in the North-West Mediterranean. Because HAB events are recurrent in the area, much effort has been invested in studying the population dynamics of the species causing them. Between 2007 and 2011, multidisciplinary data have been collected using a variety of physical, optical and direct-sampling methods. Of particular interest here is an AquaDopp (Nortek) profiler that has collected 2 MHz backscattering data over 4 bloom periods. We investigate the connection between variations in water column backscatter and the biomass of the total phytoplankton community, and in particular with the late spring-early summer high biomass bloom of the ichthyotoxic dinoflagellate Karlodinium spp. Are the phytoplankton and the HAB species the source of the scattering, or is it related to activity at another trophic level or other environmental variables? Can these scattering events be used to remotely sense HAB blooms? What are the limitations of the approach?

1C4.2 ID:7225 **13:45**

Differentiating Physical and Biological Structures in Acoustic Backscatter Using Spatial Patterns

Karen Fisher Favret
Univeristy of Montreal
Contact: kefavret@gmail.com

Spatial patterns in high frequency acoustic backscatter resulting from physical processes often have characteristics distinct from those resulting from biological processes. Applying a wavelet-based approach, developed for physics-based analysis of stochastic systems at Los Alamos National Laboratory, provides a straight-forward method to characterize the degree to which

patterns in acoustic backscatter records are organized as expected for a turbulent field (e.g. following -5/3 or -7/3 power laws), a diffusive field, or a field with other characteristic features. Applying a semi-discrete wavelet analysis, discrete in scale but continuous in data space, to every data point yields a localized characterization of regions in the record that follow physically or biologically consistent patterns, or convolutions of these patterns. Here, 120 kHz data from six survey cruises during the NW Atlantic GLOBEC field studies are re-analyzed using this approach. By comparing the spectral slope obtained for each point to the total power of the spectrum at that point, distinct patterns emerge for bubbles injected during wind events, backscatter in internal waves or fronts, and for biologically distinct regions free of major physical events. Interrogating thousands of kilometers of trackline using this approach gives us a new tool to distinguish sources of acoustic backscatter.

1C4.3 ID:7063 14:00

Automatic detection and classification of underwater walrus knocks

Marion Bandet [1], *Yvan Simard* [2]
[1] Institut des sciences de la mer de Rimouski
[2] Institut des sciences de la mer de Rimouski; Institut Maurice-Lamontagne, Pêches et Océans Canada
Contact: bandet.marion@gmail.com

From November 2011 to June 2012, passive acoustic monitoring systems have been deployed along the Hudson Strait to record marine mammal use of this overwintering habitat in eastern Canadian Subarctic. Preliminary inspections of the recordings indicated month-long presence of Atlantic walruses in the area during winter. Underwater acoustic signals of walruses in the wild are characterized by series of pulses of various spectral and cadence patterns. These pulses are organized into series of taps and knocks, punctuated at times with bell sounds. Distinctive sequences of underwater walrus songs have been reported and were detected in our recordings. To automatically detect and classify the series of walrus sounds, a three-stage algorithm is developed and tested. In a first step of detection of tap and knock events, a kurtosis-based detection scheme is applied to the amplitude values of the high-pass filtered signals using a low time resolution window. Comparisons with manual detections showed that this approach had a lower false alarm rate than other transient event detectors in time-amplitude or time- frequency domains. A second pass of the kurtosis-based detector with a finer time resolution provides accurate detection times. In the second stage of detection, trains of taps and knocks are identified based on the characteristics of their temporal structure. The knock echoes from multiple path propagation are extracted using a rhythm tracker-based algorithm to ignore them in feature vector computation. In the third stage of classification, the temporal and frequency features of the resulting tap or knock trains are used to hierarchically classify them by categories. The distinctive characteristics of these series of acoustic transients that are useful for automatic detections of walrus sounds are summarized. Walrus winter presence in the Hudson strait is examined in relation with the time-space seasonal extent of ice cover.

1C4.4 ID:7076 14:15

Blue whale multi-year time-series in the St. Lawrence system from passive acoustic monitoring

Nathalie Roy , *Yvan Simard* , *Samuel Giard*

Pêches et Océans Canada
Contact: nathalie.roy@dfo-mpo.gc.ca

The Estuary and Gulf of St. Lawrence is regularly frequented by Northwest Atlantic blue whales exploiting the local resources during their annual cycle of accumulating fat reserves. Opportunistic time-series of visual observations can track this seasonal frequentation pattern at some sites during daytime in the summer under favorable weather conditions. Detection and accurate identification ranges are then limited, the observation time windows are restrained to one season and short daylight and good visibility periods and rarely systematic, and the data continuity is deficient. Using a passive acoustic methodology (PAM) to detect and identify marine mammals from their specific vocalisations, these limitations of visual observations can be largely overcome. During the last decade, this approach was gradually implemented in the St. Lawrence system using autonomous hydrophones to obtain systematic time-series of blue whale frequentation of several habitats over the entire annual cycle. Automatic detection algorithms were developed to detect and classify the North Atlantic blue whale infrasonic A, B and audible D calls to build the frequentation time-series at the different PAM stations, located between the entrances of the Gulf of St. Lawrence up to the head of the Laurentian Channel in Lower Estuary and Saguenay—St. Lawrence Marine Park. Systematic spatial- temporal seasonal patterns emerge from this data set, including the confirmation of year-round frequentation. The same data set can be used for monitoring other species as well as characterizing the natural and anthropic noise budgets.

1C4.5 ID:7243 14:30

The Sound of Weather Heard under the Water: Can We Tell if it's Snowing?

Opeyemi Alonge [1], *Len Zedel* [2]
[1] Environmental Science, Faculty of Science Memorial University of Newfoundland, NL, A1B 3X7, Canada
[2] Physics and Physical Oceanography, Memorial University of Newfoundland, NL, A1B 3X7, Canada
Contact: ora341@mun.ca

The underwater environment is characterized by both natural and biological sound. Much of the naturally occurring underwater sound is caused by weather conditions and this kind of sound is found to originate from the surface of the water. Several research works have shown that the understanding of underwater sound of rain and wind can be used to measure both the rainfall rates and wind speed. How about snow sound? Does it generate any underwater noise at all? The limited publications on this question have found that snow has its own distinct sound when heard under the water. If this signal can be uniquely characterized, it will provide a tool for measuring snowfall rates in environments where direct measurement is difficult (for example by unattended buoys at sea). However, by understanding of the naturally generated underwater soundscape, we also provide insight on how noise can impact the marine environment. We explore sound of snow using a hydrophone installed in a pond. Recordings were made from December, 2012 until April, 2013. Data in this environment is collected both with and without ice cover. The sound levels are compared to observed wind, snow and rainfall rates.

1C4.6 ID:7345 14:45

On estimating turbulence dissipation rate in high-speed tidal channels using acoustic

Doppler profilers, and the apparent Doppler noise level

Alex Hay
Dalhousie University
Contact: alex.hay@dal.ca

The potential of high-speed flow in rivers and tidal channels as a source of hydroelectric power is attracting increased attention from government and industry both within Canada and around the world. The prospect offered by this approach is the much-reduced initial capital cost compared to a tidal barrage, and the incremental development of the resource through gradual addition of turbine array elements: i.e. the wind farm model. However, the turbulence intensity in the oncoming stream is a major unknown among turbine design engineers. Thus, quantitative knowledge of turbulence in situ is required. However, obtaining such measurements in > 2 m/s flow conditions, particularly the time series measurements needed to address the tails of the turbulent kinetic energy (TKE) probability distribution function, is a significant challenge. Remote acoustic Doppler profiling techniques represent a promising but option, but there are questions regarding the quantitative uncertainty of the velocity estimates on short time scales. Central to these questions is the Doppler noise level, and in particular its dependence on flow speed. Results are presented from two field experiments carried out in Grand Passage, Nova Scotia, in September 2012 and July 2013. Spectral techniques are used to determine the Doppler noise level prior to estimating 2nd-order turbulence quantities: i.e. TKE, root-mean-square velocity, and dissipation rate. Comparisons of these 2nd-order measures to independent estimates, and to established relationships to other independently measured quantities (i.e. the friction velocity) in turbulent boundary layers, yield good agreement indicating that the Doppler noise level has been correctly identified. The implications for its possible dependence on flow speed are discussed.

Climate Change and Extreme Events PART 1 / Le changement climatique et les événements extrêmes PARTIE 1

Room / Endroit (Parent), Chair / Président (Chad Shouquan Cheng), Date (02/06/2014), Time / Heure (13:30 - 15:00)

1C5.1 ID:7105 **13:30**

Observed trends in Canadian climate and influence of atmospheric circulation regimes

Lucie Vincent , Xuebin Zhang , Ross Brown , Eva Mekis , Ewa Milewska , Hui Wan
Environment Canada
Contact: Lucie.Vincent@ec.gc.ca

Climate data based on instrumental observations from the beginning of the 20th century for

temperature and other variables provide a comprehensive view of the climate variability and long-term changes in Canada. The data show that air temperature has increased in Canada and the observed warming is associated with widespread changes in other climate elements such as precipitation, snowfall, snow cover, river ice conditions and streamflow regimes. Since changes in the Canadian climate have major implications for the ecological systems, especially in the northern regions, it is important to continue to monitor and understand the past changes in different aspects of the Canadian climate. The main objectives of this presentation are two-fold: (1) provide an update of the climate trends in temperature, precipitation, snow cover and streamflow indices for Canada; (2) examine the influence of large-scale circulation regimes such as the North Atlantic Oscillation (NAO) and Pacific Decadal Oscillation (PDO) on observed trends.

1C5.2 ID:7012 13:45

An Assessment of Historical Hydro-Climatic Variability in Two Key Watersheds over the Southern Canadian Prairies

Barrie Bonsal
Environment Canada
Contact: barrie.bonsal@ec.gc.ca

Since human activities and ecosystem health are dependent on adequate, reliable water supplies, extreme hydro-climatic variability, including the occurrence of droughts and excessive moisture, pose a serious threat to society and the environment. The southern Canadian Prairies are a region with high natural hydro-climatic variability, however, recent dramatic shifts between extreme drought and extreme wet conditions have suggested that this variability may be increasing. Using the Oldman and Swift Current watersheds as case studies, this investigation assesses both the occurrence and potential atmospheric causes of hydro-climatic variability and extremes at various temporal and spatial scales during the instrumental period of record. Incorporation of the Standardized Precipitation Evapotranspiration Index (SPEI) reveals considerable decadal-scale variability in hydro-climate over both watersheds with no discernible long-term trends. However, the most recent decade has been associated with a greater frequency of shifts from extreme drought to excessive moisture conditions (and vice versa) than that observed during the previous 100 years. In addition, an assessment of the mid-tropospheric (500 hPa) circulation patterns associated with identified hydro-climatic extremes indicate that major drought episodes over both the Oldman and Swift current watersheds were associated with significantly higher frequencies of circulation types that included distinctive ridging patterns over the Prairie region, and lower incidences of zonal and mid-tropospheric troughing patterns. Excessive moisture conditions had opposite responses. Evidence also suggests that the sequencing of these atmospheric circulation patterns plays an important role in the initiation, persistence, and termination of droughts and excessive moisture in the study regions. Results from this analysis have increased knowledge regarding the occurrence and causes of extreme hydro-climatic variability in the southern Canadian Prairies, which may aid in the better understanding of the frequency and associated impacts of future events.

1C5.3 ID:7157 14:00

Multivariate multi-site stochastic modelling of weather variables using generalized linear

models

Zilefac Elvis Asong , Naveed Khaliq , Howard Wheater , Sun Chun , Badrul Masud
Global Institute for Water Security, University of Saskatchewan
Contact: aez849@mail.usask.ca

A multisite stochastic simulation approach for daily temperature and precipitation, based on a generalized linear model (GLM) framework, is developed using daily observations of precipitation and minimum and maximum temperatures from 120 sites located across the Canadian Prairie Provinces (i.e. Alberta, Saskatchewan and Manitoba). Temperature is modelled by a two-stage approach containing mean and variance components in a normal-heteroscedastic model. The mean and variance components are fitted separately, and temperature is simulated using the fitted models. In a similar manner, precipitation occurrence and conditional precipitation intensity are modelled separately. The relationship between precipitation and temperature is then accounted for by using transformations of temperature as covariates to predict precipitation. Large-scale climate covariates (2-m air temperature, 850-hpa relative humidity, 500-hpa specific humidity, sea level pressure, 850-hpa Uwind, 10-m Vwind) from the National Center for Environmental Prediction Reanalysis-I data and observed precipitation and temperature records are used to calibrate the models for the1971 to 2000 period. Model validation is based on both pre- and post- calibration period data. Preliminary results indicate that the developed framework is able to capture most spatiotemporal characteristics of precipitation and temperature such as inter-site correlation structure, systematic regional variations, as well as seasonality. The approach also performed satisfactorily in the simulation of different weather statistics, including seasonal averages and extremes. The framework will be further developed for multisite statistical downscaling to explore future climate variability in the Canadian Prairie Provinces.

Keywords: multivariate; multisite; stochastic modelling; GLMs; precipitation; temperature; extremes

1C5.4 ID:7061 14:15

Analyse multivariée des extrêmes du niveau du St-Laurent : Cas de la station Upper-Iroquois

Salah El Adlouni [1], *Iris Klein* [2], *Dorra Hammami* [2], *Hanane Hemi* [1], *Philippe Gachon* [3], *André St-Hilaire* [2]
[1] Université de Moncton
[2] INRS-ETE
[3] Environnement Canada
Contact: salah-eddine.el.adlouni@umoncton.ca

L'étude des extrêmes hydrologiques nécessite le développement d'outils d'analyse multivariée pour tenir compte des différentes interactions hydro-climatiques. Dans la présente étude, on propose une approche basée sur les copules trivariées pour la modélisation de la distribution des probabilités du niveau maximum saisonnier (Été-Automne) à la station Upper-Iroquois sur le St-Laurent et deux autres indices hydro-climatiques, il s'agit (1) des Degrés-Jours entre Avril et Novembre et (2) du débit minimum entre Avril et Juin à la station Sainte-Anne-de-Bellevue sur la rivière des Outaouais. Les indices choisis sont les plus corrélés avec la variable Niveau en

termes du coefficient de corrélation de Spearman. L'approche proposée montre qu'il est possible d'étudier l'évolution multivariée du niveau au fleuve en calculant des probabilités conjointes et d'en déduire les probabilités conditionnelles de certains événements extrêmes. Il est également possible de générer des scénarios sur l'évolution du niveau du fleuve pour des situations hydro-climatiques particulières. Nous présentons la méthodologie pour le choix des marginales et de la copule trivariée ainsi que des exemples de scénarios possibles sur l'évolution du risque associés aux événements extrêmes en fonction des indices sélectionnés.

1C5.5 ID:7206 14:45

Contribution of Cyclone Activity to Extreme Winter Warmings in Labrador

Joel Finnis
Memorial University of Newfoundland
Contact: jfinnis@mun.ca

Concerns regarding climate change and variability in Labrador have been significantly influenced by the extreme winter warming events of 2009/2010 and 2010/2011, during which the region experienced prolonged thaw conditions. A consequent lack of snow cover and reduced coastal sea ice rendered important snowmobile routes impassable, negatively impacting access to food, firewood, and neighbouring communities through much of rural Labrador. Previous research has emphasized that these events were largely a consequence of anomalous atmospheric circulation, with the negative phase of the North Atlantic Oscillation (NAO) accounting for much of the warming. This suggests warm winters are associated with atmospheric blocking over the North Atlantic and subsequent anomalies in extratropical cyclone activity in and around the northeastern Atlantic. The current study provides a more detailed treatment of relationships between Labrador warming events and circulation, using an extratropical cyclone climatology developed for the region. Variability in the frequency, character, and trajectory of systems influencing Labrador are examined. Results indicate warm winters are associated with reduced cyclone activity in regions expected to cool Labrador, rather than an increase in systems that would promote warming. The result is reduced cold advection from the north/northwest, while warm advection from the south/southeast remains relatively unchanged. These results provide context for the interpretation of 21st century climate projections, allowing large-scale shifts in the position of the climatological storm track to be interpreted as shifts in the probability of extreme warming events.

General Atmospheric Science PART 3 / Sciences de l'atmosphère en général PARTIE 3

Room / Endroit (Langevin), Chair / Président (Martin Charron), Date (02/06/2014), Time / Heure (15:30 - 17:00)

1D1.1 ID:7049 **15:30**

An update from the Canadian Meteorological Centre on changes to the operational production systems and offerings

Nicole Bois
Environment Canada
Contact: nicole.bois@ec.gc.ca

The Canadian Meteorological Centre (CMC) maintains a fully operational 24/7 production environment that includes data assimilation systems feeding data into various NWP weather and environment forecast models. Along with the requirements of maintaining a 24/7 operational environment, CMC also ensures it can implement a steady stream of systems' improvements. These improvements require careful coordination between EC's Atmospheric Research groups and CMC's various development groups before being installed into CMC operations.

A review will be made of the main implementation highlights of the past year, including:

- Update to the Global Ensemble Prediction System (GEPS 3.1.0) - Update to the Regional Ensemble Prediction System (REPS 2.0.1) - Updates to the SCRIBE now-cast (including radar data). - Experimental implementation of a new hydro-dynamical model for a portion of the Gulf of St-Lawrence - Experimental implementation of the new global ice-ocean prediction system (GIOPS.

Planned improvements for the coming year will also be presented, including in part:

- Implementing in parallel mode a new EnVar assimilation system for the GDPS, the GEPS and the RDPS with all the dependent sub-systems - Implementing in parallel mode a Canadian Precipitation Analysis (CaPA - RDPA) including radar data assimilation - Updates to the experimental ice prediction system (RIPS) - Updates to the Gulf of St-Lawrence coupled model - Implementing an experimental land and surface forecast and assimilation systems (CaLDAS); - Implementing in experimental mode a pan-Canadian HRDPS coupled with a CaLDAS assimilation system at 2.5 km. - Implementing in experimental mode an air quality model including forest fire emissions.

1D1.2 ID:7219 **15:45**

Reorganizing the numerical weather prediction suites at Environment Canada: An update

Martin Charron
Recherche en prévision numérique atmosphérique
Contact: Martin.Charron@ec.gc.ca

Environment Canada (EC) provides weather forecasting services for a large spectrum of space and time scales. In 2012, a five-year project with the objective of reorganizing the weather prediction suites at EC was presented at the CMOS Congress in Montréal. This reorganization aims at increasing efficiencies of technology transfer from research and development to operations, simplifying the overall picture of the forecasting suites, increasing their scalability on supercomputers, and providing improved deterministic and probabilistic forecasts, especially for

high-impact weather. Two years into the project, an update on the current status of this reorganization will be presented. Recent realizations as well as upcoming changes that are planned over the next three years will be discussed.

1D1.3 ID:7277 16:00

Recent forecast operations and outreach activities at the Canadian Hurricane Centre

Chris Fogarty
Canadian Hurricane Centre
Contact: chris.fogarty@ec.gc.ca

The way we do "business" is rapidly-evolving, so to remain relevant in today's changing world with new technology and media, we need to keep up with the pace - be that in the private weather sector or government sector. To deliver the best possible level of service to citizens and end-users of tropical cyclone forecast information requires building trusted relationships and partnerships.

This presentation will serve as a general overview of operational activities and developments at the Canadian Hurricane Center over the past few years. I will discuss various aspects of our forecast operations and service including work on new forecast products, evolution of outreach activities, a brief summary of how we apply numerical weather prediction, and key collaborations both domestic and international that are recognized as being important for enhancing the utility of tropical cyclone forecast information over various timescales.

1D1.4 ID:7204 16:15

Discovering Typical Canadian Cyclone Tracks

Ryan Lagerquist [1], *Yvonne Bilan-Wallace* [2], *Sara Hoffman* [2]
[1] Environment Canada, University of Alberta
[2] Environment Canada
Contact: lagerqui@ualberta.ca

For decades now, Canadian forecasters have had subjective knowledge of typical cyclone tracks through their domain – e.g., the Alberta Clipper, Nor'easter, etc. However, there are limits to this subjective knowledge, which motivated us to develop an objective climatology, showing typical cyclone tracks over Canadian territory. Although many cyclone climatologies have been done in the past, they are usually presented in density maps, which show "hot spots" for cyclones. The problem with these maps is that they contain no temporal information, which makes it difficult to tell how cyclones actually move through an area.

In order to develop our climatology, we have used a well-known cyclone-tracking algorithm, followed by a clustering algorithm specifically for the trajectories of moving objects. The input data for the cyclone-tracking algorithm consist of gridded fields from the NARR (North American Regional Reanalysis), whereas the output data consist of cyclone tracks determined from these fields. Each cyclone track is a series of points (low-pressure centers) at 3-hour intervals. Cyclone tracks are then divided into 3-month seasons, based on well-known seasonal differences in cyclone movement: winter (DJF), spring (MAM), summer (JJA), and fall (SON).

For each season, cyclone tracks are fed into an agglomerative hierarchical clustering (AHC) algorithm, which uses longest common subsequence (LCSS) as a similarity metric. In other words, the two most similar cyclone tracks are those with the longest common sequence of points (within a certain distance and in similar parts of the cyclone's life cycle). Eventually, the AHC algorithm reduces a large number (~1000) of cyclone tracks to a small number (~25) of representative tracks. These tracks are then smoothed, and a swath is drawn around each track to show the amount of variation. We have prepared results to publish in a marine-weather guide for the use of Arctic mariners.

1D1.5 ID:7274 16:30

Environment Canada and the TORONTO 2015 Pan Am / Parapan Am Games (TO2015).

John Macphee
MSC - Pan Am Games
Contact: john.macphee@ec.gc.ca

Environment Canada is required to support the safety and security of Canadians and participants during the Pan Am and Parapan Am Games 2015 Toronto (TO2015), by providing a 24/7, dedicated, venue specific weather warning service. To do so EC will extend the production of weather warnings to 20 venues or venue clusters using current EC criteria and standards for dissemination to Essential Federal Services, Emergency Management Ontario, and the TO2015 organization. A weather consultation service will be provided from the TO2015 Main Operations Centre at Corus Quay.

To inform this forecast and briefing system EC will provide enhanced environmental monitoring and high impact weather surveillance, and emergency support for the decision making by EFS, other public authorities, and the TO2015 organization as needed.

This talk will describe the status of these preparations for the TO2015 games.

1D1.6 ID:7283 16:45

Arctic Marine Users Manual

Terri Lang , John Cragg , Brian Proctor
ENVIRONMENT CANADA
Contact: terri.lang@ec.gc.ca

The Marine Users Manuals for Canada Project is a 2 year project which is designed to create a National Marine Publication for Canada. Funding has been provided by SARNIF (Search and Rescue New Initiatives Fund). As indicated by the name and source of funding, the Marine Manuals are aimed at small vessel users and should address 2 key priorities of SAR (Search and Rescue): protecting and supporting volunteers and public education. The project has been broken into 7 pieces: Basic Meteorology for Marine Users ("Met 101") and 6 local effects chapters for different regions of Canada: BC, the Prairies, Ontario, Quebec, the Atlantic, and the Arctic. The Manuals will be Internet-based, allowing for easy accessibility and future expansion of the information. The Canadian Arctic is currently experiencing some environmental change and there has been increased marine activity from both a commercial and pleasure boating

perspective. Safety concerns and an increased demand for arctic marine information are sure to increase in the coming years. This makes the publication on an Arctic Marine Manual especially important. There have been many challenges in the writing of the Arctic Manual. Unlike some of the other regions where older Marine publications helped build the base for the new regional guides, the Arctic manual essentially has had to be built from scratch. As well, the lack of weather observations over such a vast area is making for challenges in providing data for the manual. Models have been needed to produce wind roses over open water and fog climatology to fill in the missing weather information. With its short marine season and restricted number of marine users, local effects in the Arctic have also been difficult to document. The writers are relying heavily on experienced Arctic weather forecasts for their expertise and input. Additionally, the Canadian Ice Service has been providing important ice information. Partners, such as the Canadian Coast Guard, will be engaged to review the material before final publishing.

Planetary atmospheres, oceans and ice / Atmosphères, océans et glaces planétaires

Room / Endroit (Courchesne), Chair / Président (John Moores, Kimberly Strong, Tom McElroy, James Whiteway, Peter Taylor, Raymond Francis, Amy Shaw &), Date (02/06/2014), Time / Heure (15:30 - 17:00)

1D2.1 ID:7084 **15:30**

Summary of Canadian Planetary Mission Activities and Report from the Planetary Exploration and Consultation Committee

John Moores
York University
Contact: john.e.moores@gmail.com

An update will be provided to the Canadian Planetary Atmospheres, Oceans and Ice community about the activities of the Planetary Exploration and Consultation Committee, a CSA pannel on which CMOS is represented.

Additionally, highlights from progress on Planetary Missions with Canadian involvement will be presented, including a summary of Atmospheric investigations undertaken by the Mars Science Laboratory Rover at Gale Crater.

1D2.2 ID:7202 **15:45**

Temperature and pressure retrievals for an ACE-like mission to Mars.

Kevin Olsen [1], *Geoff Toon* [2], *Chris Boone* [3], *Kim Strong* [1]
[1] University of Toronto

[2] Jet Propulsion Laboratory
[3] University of Waterloo
Contact: olsen.kevin@gmail.com

The Mars Atmospheric Trace Molecule Occultation Spectrometer (MATMOS) was a joint Canadian Space Agency (CSA) and Jet Propulsion Laboratory (JPL) mission to send a high-resolution Fourier transform spectrometer to Mars to operate in solar occultation mode. We present work performed in support of this proposal. MATMOS would be very similar to the CSA's Atmospheric Chemistry Experiment (ACE) FTS which had a resolution of 0.02 cm $^{-1}$ and operates between 750–4400 cm $^{-1}$ in limb-scanning mode (solar occultation) using the sun as a light source. We present an algorithm to measure temperature and pressure from recorded spectra, accurate knowledge of which is vital to inferring volume mixing ratios of trace gases. This technique exploits the temperature dependence of absorption line depth in high-resolution vibration-rotation spectra. It has been applied to spectra recorded by the ACE-FTS and we will present a comparison of our temperature retrievals to those from ACE and the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC).

1D2.3 ID:7067 16:00

Observed UV radiation at Gale Crater, Mars and modeling UV radiation to approximate Martian atmospheric optical depth

Casey Moore, *John Moores*
York University
Contact: camoore@yorku.ca

The Mars Science Laboratory's Curiosity rover landed at Gale Crater (4.6° S, 222.6° W) in August 2012. Curiosity hosts a suite of scientific instrumentation designed to: detect and observe targets of interest, collect samples of soil, rock, and air for on-board analysis, and to monitor the local environment around the rover. We present the data obtained from the UV sensors located on the rover deck. The UV sensors capture the down welling flux of radiation in six different filters, namely: 315-370 nm (UVA), 280-320 nm (UVB), 220-280 nm (UVC), 200-370 nm (total dose), 230-290 nm (UVD), and 300-350 nm (UVE). Each UV sensor has approximately a 60° field of view centered on the rover's zenith. The UV sensors indirectly assess the distribution dust in the Martian atmosphere. The mean particle size of Martian dust (1.6 μm) implies the atmosphere predominately exhibits Mie scattering. If the direct solar beam is within the sensor's field of view, a more opaque atmosphere (more dust) will likely cause the sensors to register lower flux values. This is a by-product of some solar radiation being absorbed and some being scattered out of the sensor's field of view. If, however, the direct solar beam is not within the sensor's field of view, a more opaque atmosphere will likely cause the sensors to record higher flux values. The Martian atmospheric optical depth is approximated using the UV data from Curiosity along with a two-layer one-dimensional atmospheric modeling code that simulates UV irradiance on a cue-ball Mars.

1D2.4 ID:7085 16:15

Comparisons of surface and upper-level winds observed at Gale Crater, Mars

Raymond Francis [1], *John Moores* [2], *Sara Navarro López* [3], *Claire Newman* [4], *Kenneth Mcisaac* [1],

Gordon Osinski [1]
[1] Centre for Planetary Science and Exploration, University of Western Ontario
[2] York University
[3] Centro de Astrobiología (CAB-CSIC/INTA)
[4] Ashima Research
Contact: raymond.francis@cpsx.uwo.ca

The Mars Science Laboratory's Curiosity rover has been operating since August 2012 at Gale Crater, situated at 4.6° south latitude on Mars. Gale is a 150-km diameter impact crater, the rim of which forms a ring of hills which rise 2-4 km above the crater floor where the rover operates, and in the centre of which stands a mountain rising 5.5 km above the crater floor. Since the start of the surface mission, the mission science team has used the rover's instruments to study the surface environment at the landing site, including the dynamics of the atmosphere. These observations have included measurements of the wind by two techniques. First, the rover carries a wind sensor suite which collects periodic observations of wind speed and direction at the rover's position on the surface. Second, upper-level winds have been observed by cloud-tracking techniques, using sequences of images from the rover's navigation cameras. This work presents results from instances where both cloud-tracked upper-level winds and surface-measured winds are available, over the first 360 sols (Martian days) of the MSL surface mission. While certain patterns are visible in each dataset, together, they show that winds at the surface appear to be significantly independent of the winds at the cloud height. These differences are interpreted to show that the cloud-level winds represent a regional flow pattern, at heights above the elevation of the crater's rim and central mountain, while the surface winds are strongly influenced by this topography. Such an interpretation agrees with model predictions that show significant isolation of the crater interior from regional wind flows over the Martian year, and may have implications for dust and moisture transport to and from the interior of the crater.

1D2.5 ID:7083 16:30

Low Dust, Low Ice Conditions at Gale Crater, Mars as Observed during the first 360 Sols of Atmospheric Monitoring Movies from the Curiosity Rover

John Moores [1], *Mark Lemmon* [2], *Henrik Kahanpää* [3], *Scot Rafkin* [4], *Raymond Francis* [5], *Jorge Pla-Garcia* [6], *Justin Maki* [7], *Keri Bean* [7], *Robert Haberle* [8], *Claire Newman* [9], *Msl Science Team* [10]

[1] York University
[2] Texas A&M University
[3] Finnish Meteorological Institute
[4] Southwest Research Institute
[5] University of Western Ontario
[6] Centro de Astrobiología
[7] Jet Propulsion Laboratory/Caltech
[8] Ames Research Centre
[9] Ashima Research Corporation
[10] NASA
Contact: john.e.moores@gmail.com

We report on the first 360 sols, representing just over half a Martian year, of atmospheric monitoring movies acquired using the NavCam imager from the Mars Science Laboratory Rover Curiosity. Such movies reveal blowing dust, faint clouds and a single faint dust devil that are

difficult to discern in single images. The data set acquired was divided into three different classifications depending upon the orientation and intent of the observation. Up to sol 360, 73 Zenith Movies, 79 Supra-Horizon Movies and 91 Dust Devil Search Movies have been acquired.

The data set from MSL is compared to similar observations made by the Surface Stereo Imager onboard the Phoenix Lander and suggests a much drier environment at Gale Crater (4.6ºS) during this season than was observed in Green Valley (68.2ºN). Even with the proximity to significant topography, no orographic effects were observed in the dataset. Furthermore, examinations of dust devil frequency and line of sight optical depth suggest that most dust devils in Gale Crater are dustless, and that dust extinction is reduced below the crater rim compared to the bulk column optical depth. This suggests that the portion of Gale to the north of the rover may be a sink of dust in the current era. Reanalysis of Phoenix data in the light of the NavCam equatorial dataset suggests that cloud may have been more frequent in the earlier portion of the mission than was previously thought.

1D2.6 ID:7156 16:45

The javelin concept: a swarm of scientific microprobes to the clouds of jupiter in 2030.

Isaac De Souza [1], *John Moore* [1], *Kieran Carroll* [2], *Kartheephan Sathiyanathan* [1], *Barry Stoute* [1], *Jin Jun Shan* [1], *Regina Lee* [1], *Brenden Quine* [1]
[1] Centre for Research in Earth and Space Science, York University
[2] University of Toronto Institute for Aerospace Studies
Contact: souzaisaac14@gmail.com

Despite several space missions and extensive ground observation, the Jovian atmosphere, the largest atmospheric system in the solar system, remains largely unexplored. Only one mission, Galileo, has attempted a direct measurement but unfortunately obtained readings for what is considered an atypical part of the atmosphere. To further our knowledge of this dynamic system the Javelin Concept was designed to take advantage of current advances in nanosatellite technology and a collaborative mission architecture, as in the case of the Mars Science Laboratory which uses orbital assets to reduce requirements for its mission, specially communications requirements. Over the last 20 years, advances in miniaturization and electronics design have made practical a completely new class of small space vehicle in near earth orbits. Such micro, nano and cube satellites, some with masses of a kg or less, have lowered the cost of access to space [1] and have enabled many groups who were previously economically restrained from participating in larger missions to design their own satellites end to end in order to do small-scale science and test engineering advances on-orbit. Javelin address the feasibility of a low- cost probe delivery system to Jupiter taking advantage of ESA's expected JUICE orbiter mission as an in-situ asset. Javelin demonstrates that it is possible to deliver science instruments such as a NIR/VIS/UV spectrometer to obtain direct data from within Jupiter's atmosphere. Findings from these instruments could revolutionize our understanding of the nature of the clouds and of dynamic atmospheric processes too small to be observed from orbit or hidden beneath the upper cloud decks. Also it is possible achieve a 'first' in space exploration by obtaining an image from within the Jovian atmosphere.

References: [1] Selva, D. and Krejci, D. (2012) Acta Astronautica vol. 74 pp. 50-68.

Collaboration in development, application and analysis of ocean forecasting models PART 3 / Collaboration dans le développement, application et analyse de modèles de prévision océanique PARTIE 3

Room / Endroit (Ouellet), Chair / Président (Youyu Lu, Frédéric Dupont, David Greenberg & Fraser Davidson), Date (02/06/2014), Time / Heure (15:30 - 17:00)

1D3.1 ID:7294 **15:30**

Benchmarking performance of the CONCEPTS Global Ice Ocean Prediction System and CECOM regional ocean forecasts with in-situ observations in the North West Atlantic.

Jinshan Xu [1], *Fraser Davidson* [1], *Greg Smith* [2], *Youyu Lu* [1], *Yimin Liu* [1], *Simon Higginson* [1], *Gilles Garric* [3], *Fabrice Hernandez* [3]
[1] Fisheries and Oceans Canada
[2] Environment Canada
[3] Mercator-Ocean
Contact: davidsonf@dfo-mpo.gc.ca

When delivering ocean forecasts, it is important to quantify and inter-compare the performance of the forecast system with in-situ data and other existing forecast systems. Herein we present validation results over a 2 year period from the existing CECOM ocean forecasts and the recently implemented CONCEPTS Global Ice Ocean Prediction System. Model predictions are compared with in-situ and remotely sensed observations at the observed time and location. This is called class4 Metrics within the GODAE OceanView international collaboration under the UN International Oceanographic Commission. The CECOM two day ocean forecast system run at DFO–BIO for the last 10 years is currently used by Canadian Ice Service, the Oil Industry and Coast Guard. Over the last 5 years under the CONCEPTS MOU, EC, DFO and DND have developed and delivered to the EC's Canadian Meteorological Service a Global Ice Ocean Prediction System (GIOPS). A reference data base has been set up with in-situ profile data from three data bases, sea surface height from AVISO and sea surface temperature from the CMC SST analysis. Results of the inter-comparison demonstrate forecast performance limits for each of the two systems and gives insight into the abilities of each system. This work establishes validation protocols and routines by which all new prediction systems developed under CONCEPTS will be benchmarked prior to approval for operations. This includes anticipated delivery of CONCEPTS regional prediction systems over the next two years including, a pan Canadian 1/12th degree resolution ice ocean prediction system and limited area 1/36th degree resolution prediction systems.

1D3.2 ID:7312 **15:45**

Data Assimilation for CONCEPTS regional ocean prediction: Understanding and describing observed and modelled ocean statistical behaviour

Yimin Liu [1], *Greg Smith* [2]
[1] Fisheries and Oceans Canada
[2] Environment Canada
Contact: davidsonf@dfo-mpo.gc.ca

Under the CONCEPTS MOU, a Global Ice Ocean Prediction System has been delivered to the Canadian Meteorological Center this past year. The prediction system includes a data assimilation system developed by MERCATOR-OCEAN (SAM) and the NEMO ocean model. Current work within CONCEPTS is to develop a Pan Canadian Regional Ice Ocean Prediction System (RIOPS) on a configuration covering the Arctic and North Atlantic Ocean. A key step in developing RIOPS is the running of a 10 year hindcast for tuning the model but also for gaining understanding of the statistical behaviour of the model, the observations and the model-observation error. This development step benefits both climate modelling/prediction and the CONCEPTS developments for real time ocean prediction systems. Herein we present results of a short study on the statistical behaviour of: (1) two different resolutions of NEMO hindcasts, (2) the observations over the hindcast period, and (3) the respective model-observation errors. The study's geographical focus is in the North West Atlantic.

1D3.3 ID:7226 **16:00**

Rapid estimation of tidal open boundary conditions using incremental data assimilation with application to the Strait of Georgia

Vasily Korabel [1], *Keith Thompson* [1], *Jean-Philippe Paquin* [1], *Youyu Lu* [2], *Susan Allen* [3], *Nancy Soontiens* [3]
[1] Dalhousie University
[2] Fisheries and Oceans Canada, Bedford Institute of Oceanography
[3] University of British Columbia
Contact: v.korabel@gmail.com

A rapidly relocatable ocean prediction system is being developed as part of the Marine Environmental Observation, Prediction and Response (MEOPAR) Network of Centres of Excellence. A simple method is described for rapidly estimating the tidal open boundary conditions from tidal amplitudes and phases of interior observations of sea level and 3D currents. The method is illustrated using a high resolution (grid spacing of 500m), baroclinic ocean model based on the NEMO (Nucleus for European Modelling of the Ocean) code. An incremental form of data assimilation is used to estimate the open boundary conditions. The effectiveness of the approach is evaluated by withholding subsets of observations and checking how well the main diurnal and semi-diurnal amplitudes and phases can be estimated. The influence of stratification on the tidal heights and 3D currents, and the suitability of the scheme for a rapid response relocatable model, are discussed.

1D3.4 ID:7231 **16:15**

Software Collaboration Tools and the Salish Sea MEOPAR Project

Doug Latornell , *Susan Allen* , *Kate Le Souef* , *Nancy Soontiens*
Earth, Ocean & Atmospheric Sciences, University of British Columbia
Contact: dlatornell@eos.ubc.ca

The Salish Sea MEOPAR project is deploying the NEMO ocean model as a forecast model for the coastal region off the British Columbia mainland south coast. The domain includes the Strait of Georgia, Strait of Juan de Fuca, Johnstone Strait, and Puget Sound. The project uses a collection of software collaboration tools and web services. Those tools facilitate rapid sharing of documentation, results, tools and code among the geographically distributed team of researchers. They also enable instant publication to the web of aspects of the project's work that are deemed useful to the worldwide NEMO user community. The tools were chosen and configured to be as lightweight as possible so as to allow the research team to focus on model development rather than burden them with many new technologies to work with daily. Distributed version control is the foundation that ties the tools together. It is applied to not only code, but also documentation, model configurations, and analysis of model run results. A summary of the specific tools in use in the project, why they were chosen, and how they are coordinated through web services will be presented. The role that these collaboration tools played in implementing tidal forcing and evaluating tidal response in the Salish Sea NEMO model will be used as an example.

1D3.5 ID:7148 16:30

Discussion on strategy of collaboration in ocean modelling: Part 1. Global, basin and coastal scales

Youyu Lu [1], *Frederic Dupont* [2], *Francois Roy* [2], *Fraser Davidson* [3], *Gregory Smith* [2]
[1] Bedford Institute of Oceanography
[2] Environment Canada
[3] Fisheries and Oceans Canada
Contact: Youyu.Lu@dfo-mpo.gc.ca

This presentation starts with an overview of the application of the NEMO ocean model for developing modelling and forecasting capacity in Canada at global, basin, shelf and coastal scales. This is followed by suggestions and discussions on strategy and elements for collaboration and coordination. Specific topics include: 1) optimal design of model domain and grid; 2) sources of bathymetry data; 3) influence of initial conditions; 4) set up of lateral open boundary conditions; 5) surface forcing; 6) mixing parameterization; 7) improvement in model numerics; 8) relocatable model capability; 9) visualization tools; 10) particle tracking and tracer module; 11) validation and analysis; 12) coordinated experiments and inter-comparison; 13) strategy for code version control, sharing and transfer to operations; etc. The linkage between FVCOM and NEMO models, and the contribution of these models to the Canadian CONCEPTS, MEOPAR, VITALS and Wold Class Oil Tanker Safety projects, will also be discussed.

1D3.6 ID:7181 16:45

Discussion on strategy of collaboration in ocean modelling: Part 2. Shelf, coastal and nearshore scales

David Greenberg [1], *Michael Foreman* [2], *Susan Haigh* [3], *Charles Hannah* [2], *Yongsheng Wu* [1],

Youyu Lu [1]
[1] DFO Bedford Institute of Oceanography
[2] DFO Institute of ocean Sciences
[3] DFO St. Andrews Bilogical Station
Contact: david.greenberg@dfo-mpo.gc.ca

This presentation starts with an overview of the application of the finite-element model FVCOM for developing modelling and forecasting capacity in Canada at shelf, coastal and nearshore scales. This is followed by suggestions and discussions on strategy and elements for collaboration and coordination. Specific topics include: 1) optimal design of model domain and grid; 2) sources of bathymetry data; 3) influence of initial conditions; 4) set up of lateral open boundary conditions; 5) surface forcing; 6) mixing parameterization; 7) improvement in model numerics; 8) relocatable model capability; 9) visualization tools; 10) particle tracking and tracer module; 11) validation and analysis; 12) coordinated experiments and inter-comparison; 13) strategy for code version control, sharing and transfer to operations; etc. The linkage between FVCOM and NEMO models, and the contribution of these models to the Canadian CONCEPTS, MEOPAR, VITALS and Wold Class Oil Tanker Safety projects, will also be discussed.

Advances in Observations and Modeling of Land-Atmosphere Interactions / Avancements dans l'obsérvation et modélisation des intéractions terre-atmosphère

Room / Endroit (Léonard-Blais), Chair / Président (Daniel Nadeau, Marc Parlange & Alain Rousseau), Date (02/06/2014), Time / Heure (15:30 - 17:00)

1D4.1 ID:7340 INVITED/INVITÉ 15:30

Effects of urban trees on drag and turbulence in cities

Andreas Christen [1], *Scott Krayenhoff* [1], *Alberto Martilli* [2], *Timothy Oke* [1], *Jose-Luis Santiago* [2], *James Voogt* [3]
[1] University of British Columbia, Department of Geography / Atmospheric Science Program
[2] Department of Environment, CIEMAT, Spain
[3] Department of Geography, Western University, London, ON, N6A 5C2, Canada
Contact: andreas.christen@ubc.ca

Although urban areas cover a minimal fraction of Canada’s land surface (<0.05%), about 60% of the population lives in large urban areas. Hence, cities are of considerable interest when forecasting weather and air pollution for Canadians. The exchange processes at the city-atmosphere interface, and the specific climate of the urban canopy layer are represented in mesoscale models by urban canopy parameterizations (UCPs). UCPs are physically-based

models of the energetics and dynamics of roofs, walls, roads and their interactions with the urban atmosphere. However, Canadian cities are characterized not only by built materials but also by a substantial amount of vegetation. In many suburban neighborhoods tree cover is 10-30% and trees are often taller than buildings. The effects of urban trees on drag, wind and turbulence in cities are not accounted for in current UCPs. We present results from observations and numerical model experiments to identify and quantify the effect of tree foliage on drag, wind and turbulence in cities. We used an obstacle-resolving CFD approach simulating canopies of blocks (buildings) with varying distributions and densities of porous media (tree foliage). Specifically, sectional drag and mutual sheltering characteristics were analyzed and parameterized as a function of plan area densities of buildings (PAD) and leaf area densities (LAD) of vegetation in different vertical layers. Those parameterizations were implemented in a new one-dimensional, multi- layer UCP, which was compared to six years of field data from a 30m-tower in a residential area of Vancouver. A digital surface model inferred from airborne LIDAR was used to characterize LAD and PAD in different wind sectors. Although vegetation was not directly controllable, we used differences between leaves-on and leaves-off seasons to determine the incremental effect of increased LAD in summer (made possible as 77% of trees are deciduous). The leaves-off situation had a substantially lower roughness and the presence of trees affected turbulence and efficiency of turbulent exchange.

1D4.2 ID:7003 16:00

Frequent near-neutral atmospheric conditions over a boreal bog improve the estimation of daily evapotranspiration using basic weather observations.

Pierre-Erik Isabelle [1], *Daniel Nadeau* [2], *Alain Rousseau* [1]
[1] INRS-ETE
[2] Polytechnique Montréal
Contact: pierre-erik.isabelle@ete.inrs.ca

In the northern and vast La Grande River watershed (Quebec, Canada), wetlands represent 25% of the land cover and are thus a key component of the water budget, inducing significant water transfer by evapotranspiration for nearly half the year. These water exchanges greatly modulate inflows to the La Grande hydroelectric reservoirs and, therefore, have to be measured, estimated or modelled. The general objective of this study is to foresee the design of a future network of weather stations to monitor daily evapotranspiration rates using basic weather instruments, considering the operating costs in such a large and remote watershed. The main study site was a 60-ha bog (53.7°N, 78.2°W) located next to the Necopastic River, a tributary of the La Grande River. The analysis relied on data collected using a flux tower during a field campaign throughout summer 2012. The eddy covariance data revealed that the atmosphere was neutrally-stratified for more than 75% of the summer. This unusual feature greatly simplifies the Monin-Obukhov Similarity equations for wind speed, temperature and humidity profiles. Precisely, when assuming a wet surface, the equations can be solved with only air and surface temperature, air humidity and pressure, wind speed and average vegetation height. There is one adjustable parameter: kB^{-1}. The method leads to an excellent approximation of daily evapotranspiration fluxes, with a normalized mean error (NME) of 13%. As a comparison, the Priestley-Taylor formulation yields a NME of 11%, but the latter needs net radiation data, which is prohibitive in this context. The method has also been tested using data from two other Canadian wetlands: the Mer Bleue (Ontario, 45.4°N, 75.5°W) and Western Peatland (Alberta, 54.95°N, 112.5°W). While

those two peatlands are significantly less often neutrally-stratified (42% and 40% of the time, respectively), the method still yields interesting results considering its simplicity and low cost.

1D4.3 ID:7118 16:15

Evapotranspiration estimation based on hydrological land surface models with different model configurations

Moges Mamo [1], *Andrew Ireson* [2], *Bruce Davison* [3]
[1] GIWS, University of Saskatchewan, HAL, Environment Canada, 11 Innovation Blvd., Saskatoon, SK, Canad
[2] GIWS, University of Saskatchewan, 11 Innovation Blvd. Saskatoon, SK, Canada, S7N 3H5
[3] HAL, Environment Canada, 11 Innovation Blvd., Saskatoon, SK, Canada, S7N 3H5
Contact: moges.mamo@usask.ca

Global and regional climate is influenced by the heterogeneity of the land surface. The land surface is responsible for partitioning of net radiation into latent heat and sensible heat and precipitation into infiltration, evapotranspiration and streamflow. Evapotranspiration is a dominant component of the hydrological cycle and accurate modeling of evapotranspiration is believed to improve global climate models. In this work, the MESH modeling system developed at Environment Canada is applied to simulate hydrological processes in White Gull Creek, a highly instrumented basin located in the southern portion of the boreal plains ecozone. Four model configurations are applied, which include: 1) the Flat Canadian Land Surface Scheme (CLASS) configuration, where vertical land surface process are simulated using a priori parameter values and horizontal hydrological process are ignored; 2) the same flat CLASS configuration but with calibration of model parameters; 3) an enhanced hydrology configuration, with horizontal hydrological processes included, using a-prior parameters; and 4) an enhanced hydrology configuration with model parameter calibration. All configurations are modeled to fit simulated streamflow to observed streamflow. Streamflow result from flat CLASS with a priori parameter values is poor with Nash Sutcliffe Efficiency (NSE) of 0.095. Calibrated flat CLASS yield a better result with NSE of 0.31 still below satisfactory value. The same is true for the enhanced hydrology configuration with a priori parameter values with a NSE value of 0.11. The enhanced hydrology configuration with parameter calibration produced an acceptable result of NSE equal to 0.74. Evapotranspiration output from both flat CLASS and the enhanced configuration with a priori parameter values overestimate evapotranspiration while both calibrated flat CLASS and the enhanced hydrology model produced almost similar and improved results, especially in the western portion of the study area.

1D4.4 ID:7014 16:30

Morning Transition of Steep Slope Flows in a Narrow Alpine Valley

Daniel F. Nadeau [1], *Holly J. Oldroyd* [2], *Eric R. Pardyjak* [3], *Nicolas Sommer* [2], *Marc B. Parlange* [4]

(Presented by *Daniel Nadeau*)
[1] Department of Civil, Mining and Geological Engineering, Polytechnique Montreal
[2] School of Architecture, Civil and Environmental Engineering, EPFL
[3] Department of Mechanical Engineering, University of Utah
[4] Department of Civil Engineering, UBC
Contact: daniel.nadeau@polymtl.ca

Under clear-sky conditions and weak synoptic-scale forcing, thermally-driven flows predominate in mountainous terrain due to the uneven heating of the atmosphere inside the valley. During the day, upslope and upvalley flows are found, while at night winds travel downslope and downvalley. These diurnal mountain winds have been investigated quite extensively over the past decades given their importance in wind energy forecasting and pollution transport, thanks to numerous field experiments and numerical studies. Most of this past work has however been focused on flows over idealized terrain under quasi-steady conditions, and thus less so on transitional flows over realistic topography. This study aims to gain a deeper understanding of the morning transition period, or morning breakup of the nocturnal temperature inversion, guided by unique field observations taken over a steep alpine slope in Val Ferret, a narrow and meandering valley in the Swiss Alps. The slope (20° to 37°) was instrumented throughout summer 2010 with two turbulence flux towers, several temperature measurement stations, and two additional meteorological masts with the purpose of monitoring heat and momentum exchanges during the transition periods of slope flows. A tethered balloon was also deployed to collect mesoscale atmospheric profiles during a few intensive observation periods. The field data revealed a few striking features of the morning transition period, which usually lasted 2 to 3 hours after astronomical sunrise. Temperature measurements near the surface unveiled a local counter-gradient heat flux typically lasting 30 min long after direct solar radiation reached the measurement site. The change in wind direction from downslope to upslope begins several meters above the ground before reaching the surface where a very shallow nocturnal drainage flow (~ 1 m) was usually found. We believe these observations should help us develop better parameterizations for non-stationary, transitional slope flows over complex terrain.

Climate Change and Extreme Events PART 2 / Le changement climatique et les événements extrêmes PARTIE 2

Room / Endroit (Parent), Chair / Président (Chad Shouquan Cheng), Date (02/06/2014), Time / Heure (15:30 - 17:00)

1D5.1 ID:7173 **15:30**

Coastal Storms in Canada simulated by CMIP5 Climate Models

Christian Seiler
Pacific Climate Impacts Consortium
Contact: cseiler@uvic.ca

Extratropical cyclones can cause severe damages to infrastructure along Canada's coasts. Historic observations reveal a polar shift of storm tracks in Canada, leading to more durable, frequent and stronger winter cyclones in the lower Canadian arctic. A northward shift of storm tracks is also a robust feature projected by multiple climate models as a consequence of anthropogenic climate

change. However, models still have considerable biases, and uncertainties of future projections remain large. Furthermore, a detailed analysis for simulations from the most recent generation of climate models (CMIP5) is still missing for the Canadian case. To assess the impacts of climate change on coastal storminess, simulations from 29 CMIP5 models were evaluated for the historic (1980 to 2009) and future period (2010 to 2099), considering two emission scenarios (RCP4.5, RCP8.5). Historic simulations were compared against four different reanalysis products (ERA-Interim, NASA-MERRA, NCEP-CFSR, JRA-25). Extratropical cyclones were identified as the maxima of T42 vorticity of 6h wind speed at 850 hPa, and were tracked using the objective-feature algorithm TRACK. Cyclone frequency and intensity computed from reanalysis products were very similar despite large differences in horizontal resolutions, giving confidence in the use of these data for model evaluation purposes. Models reproduced accurate values for cyclone frequencies, but generally underestimated cyclone intensity along Canada's three coasts significantly. Models were clustered according to differences in biases and projections, and the physical mechanisms leading to these clusters were explored. Results are relevant for a discussion on climate change adaptation mechanisms for coastal storms in Canada.

1D5.2 ID:7205 **15:45**

Trend in frequency of extreme precipitation events over Ontario from ensembles of multiple GCMs and RCMs

Ziwang Deng [1], *Xin Qiu* [2], *Jinliang Liu* [3], *Neal Madras* [1], *Huaiping Zhu* [1]
[1] LAMPS, Department of Mathematics & Statistics, York University
[2] NOVUS Environmental, Ontario, M3J 1P3, Canada
[3] Ontario Ministry of the Environment, Ontario, M7A 1N3, Canada
Contact: ziwang.deng@gmail.com

Vulnerability of Ontario to climate change is demonstrated by the adverse impacts of recent severe weather events. Thus, to be well informed by improved understanding of both current and future change in extreme events over Ontario is becoming increasingly important as global climate continuing changes significantly. As a most important type of extreme weather events, the impacts of extreme precipitation events are significant. This study try to assess projected long term trends in frequency of occurrence of extreme precipitation events represented by indices R10mm(heavy precipitation days), R20mm(very heavy precipitation days),R95p(very wet days) and R99p(extreme wet days), over Ontario, based on ensembles of seven NARCCAP RCMs and twenty three CMIP3 GCMs. For comparison, R1mm (wet day) is also studied. To achieve this goal, first, all model data are linearly interpolated onto 540 Canadian Regional Climate Model (CRCM) grid points in Ontario; Next, biases in model daily precipitation amount are corrected with the local intensity scaling (LOCI) method to make the total wet days and total wet day precipitation from each of the models (GCMs and RCMs) are consistent with observation for the reference period (1970-1999); Then based on relationships between the bias-corrected seven paired GCM-RCM simulations for the common period (1968-2000 and 2046-2065), the 23 GCM simulations are downscaled to generate 161 (7X23) simulations; After that, with the assumption that the rate parameter of the Poisson process for the occurrence of extreme precipitation events may vary with time as climate changes, the Poisson regression model which expresses the log rate as a linear function of time is used to detect the trend in frequency in the RCMs, GCMs and the downscaled simulations; Finally, the trends and their uncertainty are estimated. The results show that there is significant upward trend in annual wet days (R1mm) in northern Ontario and

downward trend in the southern area. The trend is very weak in the central area. However, there are significant upward trends in annual R10mm, R20mm, R95p and R99p over major parts over Ontario, except for some small sub-regions in the northern Ontario. The upward trend is significant in summer and winter indices (e.g., R10mm and R95p) but weak in other seasons. There is no significant trend in all autumn indices over major parts of Ontario.

1D5.3 ID:7015 16:00

Evaluation of simulated precipitation regime from two recent Canadian RCMs over Maghreb (CORDEX-Africa runs): Links with NAO and storm activity

Mariem Jelassi [1], *Philippe Gachon* [1], *René Laprise* [2]
[1] ESCER Centre, University of Quebec at Montreal (UQAM), Montréal (Québec) Canada, H3C 3P8,
[2] Canadian Centre for Climate Modelling and Analysis, Climate Research Division, Environment Canada, M
Contact: mariem-jelassi@hotmail.fr

Abstract:

CORDEX-Africa simulations (driven by ERA-Interim) from the most recent two versions of Canadian Regional Climate Models, CRCM5 and CanRCM4 developed respectively by UQAM/ESCER and EC/CCCma, are evaluated over the Maghreb area (i.e. Morocco, Algeria and Tunisia). The focus is on the precipitation regime, using daily outputs, i.e. on the occurrence of rainfall, the wet/dry spells, and the highest precipitation intensity. The links between North Atlantic Oscillation (NAO) index, the storm activities over the Mediterranean area and the precipitation regime are also analyzed with various observed and reanalysis products over the recent 1998-2008 period. During the rainy season (mainly from fall to the end of winter), the comparison between observed and simulated values using the two RCMs reveals that CRCM5 reproduces quite well the frequency and the intensity of precipitations extremes as well as the occurrence of wet days, compared to the observations and reanalysis, while a general underestimation in the extreme precipitation is noted in the CanRCM4 simulation. Using gridded observed data and reanalysis products, the analysis of the links between NAO/storms and the precipitation regime across various Maghreb regions exhibits that over the Atlantic coast, the precipitation (occurrence, intensity, and wet spells) increases significantly with the storm frequency in winter, but this link weakens towards the Mediterranean coast. However, in fall, the link decreases but remains relatively significant over all Atlantic and Mediterranean coasts. The decrease in the NAO index is statistically linked with the increase in the precipitation occurrence and intensity during winter, but this link becomes weaker or non-statistically significant in fall. On-going work will examine if these links are or not reproduced by the two RCMs including the NAO/storm variability and the effects on the simulated precipitation regime.

KeyWords: Maghreb, Precipitation extremes, RCMs, CRCM5, CanRCM4, NAO, Storm, CORDEX.

1D5.4 ID:7239 16:15

High resolution scenarios of agroclimatic indices for Canada

Guilong Li , *Xuebin Zhang*
Climate Research Division, Environment Canada

Contact: Guilong.Li@ec.gc.ca

High resolution scenarios of agroclimatic indices are important indicators for future crop production. This study presents projection of 8 agroclimatic indices based on downscaled daily maximum temperature, minimum temperature, and precipitation simulations from 12 GCMs including ACCESS1-0, CanESM2m, CCSM4, CNRM-CM5, CSIRO-Mk3-6-0, GFDL-ESM2G, HadGEM2-CC, HadGEM2-ES, Inmcm4, MIROC5, MPI-ESM-LR, and MRI-CGCM3 at 10km resolution for Canada under two emission scenarios (RCP4.5 and RCP8.5). The downscaled are obtained by interpolating GCM outputs using various bias correction methods (Bias-Correction/Constructed Analogues, Bias-Correction/Climate Imprint,Bias-Correction/Spatial Disaggregation). The 8 agroclimatic indices are the starting and ending dates for growing season, crop heat unit, frost free day, killing frost free day, the last date of spring killing frost, the first date of fall killing frost, effective growing degree days, and extreme precipitation. The downscaled agroclimatic indices are compared with historical observations. Results indicate substantial changes in agroclimatic conditions in the future in both western and eastern Canada.

1D5.5 ID:7127 16:30

Analyse temporelle des occurrences de température extrême mesurée au Québec

Julie Drapeau
Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs
Contact: julie.drapeau@mddefp.gouv.qc.ca

À l’échelle mondiale, le climat du Québec est froid. En effet, on y retrouve trois types de climat selon la classification de Köppen-Geiger, basée sur les normales 1981-2010, soit un climat continental froid et humide au sud, un climat continental subpolaire entre les 51e et 58e degrés de latitude nord et un climat polaire de toundra plus au nord.

L’analyse des occurrences des températures les plus élevées et les plus faibles au cours des périodes d’enregistrements de stations climatiques peuplant ces différents types de climat dresse un portrait évolutif des extrêmes québécois de température. Par exemple, très peu des plus faibles températures minimales sont enregistrées dans les dernières décennies contrairement aux températures minimales les plus élevées. Ces constatations vont de pair avec l’augmentation variant de 1,5 à 2,1 °C de la température minimale annuelle qui a été observée entre 1961 et 2010.

1D5.6 ID:7030 16:45

Evidences during Historical Observed Period to Support Projection of Future Wind Regimes: An Application to Canada

Chad Shouquan Cheng
Meteorological Service of Canada, Environment Canada
Contact: shouquan.cheng@ec.gc.ca

In the field of climate change impact analysis, the literatures on projections of future wind regimes have exhibited bidirectional changes, varying among studies, locations, and models, which are reasonable over the global. However, we should attempt to find evidences in the

historical period to support these future projections. The current paper attempted to analyze historical wind gust observations for up to 57 years (1953–2009) over Canada for identifying the evidences with climate change. Two kinds of wind gust analyses were applied: the speed of daily wind gust events ≥50 km h-1 versus the climatological 1) daily temperature anomaly and 2) daily sea-level air pressure anomaly. In addition, the frequency of daily wind gust events ≥90 km h-1 versus both daily temperature and air pressure anomalies was analyzed. The results indicated that the gust wind speed significantly increased as the daily temperature anomaly increased and the daily air pressure anomaly decreased during the past five decades over Canada. About 50%–60% of the daily wind gust events ≥90 km h-1 occurred with positive daily temperature anomalies and negative daily air pressure anomalies over the historical period. In addition, the seasonality of these relationships was quantitatively assessed. A major conclusion from the study is that methods used in and results derived from this study might be applied for climate change impact analysis in supporting projections of future wind regimes. This talk will introduce the research project and outline the modeling exercise and verification process. The major findings on future wind gust projections over Canada from another study will be summarized in the presentation as well.

2014-06-03

Plenary Day 2 / Plénière Jour 2

Room / Endroit (Langevin-Ouellet), Chair / Président (Michael Scarratt), Date (03/06/2014), Time / Heure (08:30 - 10:00)

P2.1 ID:7276 INVITED/INVITÉ 08:30

Land processes and their climate interactions in the high-latitude regions

Laxmi Sushama
University of Quebec at Montreal
Contact: sushama.laxmi@uqam.ca

The increased recognition of the importance of land-climate interactions and feedbacks in modulating regional climate, including extreme temperature and precipitation events, and the interest in the climate-change impacts on regional water cycle, highlights the need for realistic representation of land-surface types and processes in climate models. For the Canadian high latitude and Arctic regions, this would imply representation of the multitude of surface types comprising of lakes, wetlands, rivers, glaciers, snow, permafrost etc. in climate models. Interactions and feedbacks between the atmosphere and these underlying surface types are important and determine the evolution of many simulated near-surface variables. A better understanding of these processes and their interactions at the regional level is essential to improve the quality of forecasting tools. Much progress has been achieved in the recent years in this direction and this talk will essentially discuss the impact of high latitude land surface types and processes on the regional climate and their evolution in future climate. In particular the

impact of snow cover, permafrost, peatlands, lakes, vegetation, glaciers, on the high-latitude climate will be discussed. The role of land-atmosphere coupling in modulating extreme events, particularly temperature and precipitation extremes, will also be discussed.

P2.2 ID:7341 INVITED/INVITÉ 09:15

The Northwest Atlantic Ocean is Changing: Are We Ready?

Douglas Wallace
CERC Chairholder, Dalhousie University
Contact: douglas.wallace@dal.ca

Canada's Atlantic waters stretch from Nares Strait in the north to the Gulf of Maine in the south, and encompass Baffin Bay, Davis Strait, the Labrador Sea, the Orphan Basin, Flemish Pass, the Grand Banks, the Newfoundland Basin, and the Scotian Slope. The region is subject to a broad range of globally significant processes including changes in sea-ice cover and sea-ice export, changes in freshwater input including glacial meltwater, climate-related variability in deep water formation, large and variable atmosphere-ocean heat exchange, both limbs of the overturning circulation, large and variable CO2 (and O2) uptake, major storage and transport of anthropogenic CO2 and associated ocean acidification. At the same time, the region is subject to rapidly changing economic uses of the ocean, including new developments related to offshore oil, shipping, tourism, aquaculture and fishing. The presentation will review key findings and questions associated with biogeochemical change in the Northwest Atlantic Ocean including changes in air-sea exchange of gases, changes in ecosystem productivity and ocean acidification of surface and deep waters. The need for a coordinated national observation and research strategy will be emphasised, and opportunities for Canada associated with a number of planned projects, the Galway Research Alliance and the EU's Horizon 2020 program will be presented.

General Atmospheric Science PART 4 / Sciences de l'atmosphère en général PARTIE 4

Room / Endroit (Langevin), Chair / Président (Martin Charron), Date (03/06/2014), Time / Heure (10:30 - 12:00)

2B1.1 ID:7210 10:30

Objective Identification of Lee Troughs Downstream of Rocky Mountains

Ryan Lagerquist [1], *John Wilson* [2]
[1] Environment Canada, University of Alberta
[2] University of Alberta
Contact: lagerqui@ualberta.ca

Lee troughs are important factors in many different types of weather phenomena: gap winds,

chinooks, severe thunderstorms, freezing rain, etc. To our knowledge, all papers on lee troughs involve either a case study or a small number of hand-analyzed cases, rather than long-term climatologies. The main reason for this seems to be that unlike other features, such as closed low-pressure systems, there has been no reliable method for objectively identifying lee troughs. This motivated us to develop our own objective ID method.

The input data for our method consist of gridded pressure and geopotential-height fields from the NARR (North American Regional Reanalysis). Currently, our analysis is only 2-D, which means that we are using only one of these fields at a time. Most often, we use either MSLP (pressure at mean sea level) or 850-mb heights. Once the input data have been chosen, our method includes six steps:

(1) Smooth the input (i.e., pressure or height) field, to remove small-scale disturbances. (2) Calculate curvature from smoothed field. (3) Find regions of maximum curvature in the smoothed field (since a trough is a local maximum in curvature). (4) Draw the main skeleton line (trough axis) through each region of maximum curvature. (5) Join nearby trough axes with similar angles. (6) Reject trough axes that do not satisfy criteria for a lee trough. Some examples of criteria: must have similar angle to mountains, must be within critical distance of mountains, must have consistent pressure/height gradient along feature, etc.

Our algorithm so far is specific to downstream of the Rocky Mountains. Since this is a parametric method, we also plan to use a genetic algorithm to narrow down an optimal set of parameters. We hope that researchers will be able to use this method in the future, for long-term climatologies of lee troughs.

2B1.2 ID:7280 10:45

GEN4 – A Fourth Generation Radiosonde Designed and Engineered For Operational Use

Herb Winston
Vaisala Inc
Contact: herb.winston@vaisala.com

Radiosonde data are crucial for many applications including numerical model data assimilation, weather forecasting, climatology and atmospheric research. Environment Canada performs approximately 23,000 radiosonde launches annually from thirty one upper-air sites across Canada. The Vaisala RS92 radiosonde and the corresponding MW31 ground stations is an integral part of EC's upper-air monitoring program. Vaisala's updated MW41 ground station was launched in the spring of 2012, which was followed with the recent release of a fourth generation RS41 radiosonde. Designed in close collaboration with multiple meteorological agencies and with the operational user in mind, the combined MW41/RS41 system provides many advantages to its predecessor. This includes, but is not limited to, Web-based networking, improved meteorological sensors, streamlined launch preparation, and integrated and lighter weight batteries that offer a greener environmental footprint. This paper will discuss the features of the combined MW41/RS41 system and compare it with the currently used RS92 radiosonde.

2B1.3 ID:7137 11:00

Canadian Network of Networks (NoN): A Collaborative Approach

Eleanor Blackburn , Rick Fleetwood , Mike Manore
(Presented by *Herb Karn,jeffrey*)
Environment Canada
Contact: eleanor.blackburn@ec.gc.ca

Canada's hydrometeorological observation needs can only be addressed through working in cooperation and partnership with other public and private observing network operators. The Meteorological Service of Canada's (MSC) "Modern Day Monitoring Strategy (2011)" identifies NoN among the strategies to help meet EC's evolving needs and to improve the overall quantity, quality, and accessibility of hydrometeorological data in Canada. NoN is a principles-based, multi-participant, collaborative approach to monitoring. It includes data policies and technical standards to encourage and facilitate timely and open exchange of data among many contributors – supported by a modern data management system.

This presentation describes the principles and benefits of a NoN; the MSC's proposed approach; the status of current projects including support to the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network; lessons learned and best practices.

2B1.4 ID:7275 11:15

Trends in stratospheric ozone derived from merged SAGE II and Odin-OSIRIS satellite observations

Adam Bourassa , Doug Degenstein , Chris Roth
Univ of Saskatchewan
Contact: adam.bourassa@usask.ca

Stratospheric ozone profile measurements from the Stratospheric Aerosol and Gas Experiment (SAGE) II satellite instrument (1984–2005) are combined with those from the Optical Spectrograph and InfraRed Imager System (OSIRIS) instrument on the Odin satellite (2001–Present) to quantify interannual variability and decadal trends in stratospheric ozone between 60°S and 60°N. These data are merged into a multi-instrument, long-term stratospheric ozone record (1984–present) by analyzing the measurements during the overlap period of 2002–2005 when both satellite instruments were operational. The variability in the deseasonalized time series is fit using multiple linear regression with predictor basis functions including the quasi-biennial oscillation, El Niño- Southern Oscillation index, solar activity proxy, and the pressure at the tropical tropopause, in addition to two linear trends (one before and one after 1997), from which the decadal trends in ozone are derived. From 1984–1997, there are statistically significant negative trends of 5–10% per decade throughout the stratosphere between approximately 30–50 km. From 1997–present, a statistically significant recovery of 3–8% per decade has taken place throughout most of the stratosphere with the notable exception between 40°S–40°N below approximately 22 km where the negative trend continues. The recovery is not significant in the tropical stratosphere between 25–35 km.

2B1.5 ID:7338 11:30

Remote Sensing of Cloud Properties and Nowcasting

Ismail Gultepe [1], *Robert Robin* [2], *Michael Pavolonis* [3], *James Gurka* [4], *Fasial Boudala* [1], *Randolph Ware* [5]
[1] EC, Toronto, Ontario, Canada
[2] 2NOAA/National Severe Storms Laboratory, Norman, OK, USA
[3] 3NOAA/NESDIS Madison, Wisconsin, US
[4] 4NOAA/NESDIS, Greenbelt, Maryland, US
[5] 5Randolph Ware, Radiometrics Corp., Boulder, CO, USA
Contact: ismail.gultepe@ec.gc.ca

The goals of this work are 1) to summarize the observations collected during two Arctic field projects called FRAM (Fog Remote Sensing and Modeling) and SAAWSO (Satellite Applications for Arctic Weather and SAR (Search And Rescue) Operations) projects that took place in the Arctic during winter of 2010-2011 and 2013-2014, respectively, and 2) to improve understanding of ice fog and light snow precipitation microphysics for operational applications. Both projects had unique ground-based instruments to measure extinction, visibility, ice particle spectra, aerosol spectra, light precipitation, turbulence, and solar radiation. In addition to surface in-situ observations, remote sensing instruments such as Lidar, Ceilometer, PMWR (Profiling Microwave Radiometer), and MRR (Microwave Rain Radar) were also used for data collection. In this presentation, the GOES satellite based products such as cloud top temperature, particles size, phase, cloud type, and wind vectors developed for nowcasting applications will be summarized and validated using in-situ observations, and associated challenges will be emphasized.

2B1.6 ID:7121 11:45

A probabilistic nowcasting approach to precipitation start/stop time using a recursive probability calculator.

Iain Russell , *Majid Fekri* , *Bryn Jones*
Pelmorex Inc.
Contact: irussell@pelmorex.com

Providing the start/stop time of precipitation at specific locations enables a wide range of consumers to benefit from the short term precipitation forecast. However, the accuracy of such forecast is limited by the predictability of small scale features in precipitation. The proposed solution at Pelmorex Media Inc. is to use an ensemble of forecasts to calculate a probability estimation based on consecutive runs of the Pelmorex radar nowcasting system. The system is based on McGill Algorithm for Precipitation Nowcasting Using Semi-Lagrangian Extrapolation (MAPLE) and produces short-term deterministic precipitation forecasts at 1 km resolution for the whole North America at every 10 minutes interval. The characteristic of the operational Pelmorex radar nowcasting system that distinguishes it from a normal NWP forecast is its high spatial and temporal resolution. The Recursive Probability Calculator (RPC) is an innovative method of merging forecasts from past runs to create statistical information about the current deterministic forecasts. For this study, more than 72 hours of nowcasting and radar data was recorded during 17, 18 and 19 April 2013 throughout several large scale rain storms that accompanied high wind gusts, scattered showers, and convective events. The deterministic nowcasting and probabilistic estimations were documented at 12 airport locations near major Canadian cities and then compared to METAR data. According to the experiments, the

probabilistic method can be tuned by setting proper thresholds for start/stop times based on a statistically significant amount of real events. In conclusion, the probabilistic approach increases the expected accuracy, reduces sensitivity to radar false echoes, and adds flexibility to the operational design.

The changing Arctic cryosphere: Drivers, feedbacks and biogeochemical impacts PART 1 / La cryosphère arctique en mutation: Facteurs déterminants, rétroactions et impacts biogéochimiques PARTIE 1

Room / Endroit (Courchesne), Chair / Président (Christine Michel & C.J. Mundy), Date (03/06/2014), Time / Heure (10:30 - 12:00)

2B2.1 ID:7050 10:30

Kinetic fractionation of stable hydrogen and oxygen isotopes upon early sea-ice formation

Alfonso Mucci [1], *Christine Michel* [2], *Andrea Niemi* [2], *Jean-François Hélie* [3]
[1] GEOTOP & Department of Earth and Planetary Sciences, McGill University, Montréal, QC, Canada
[2] Freshwater Institute, Fisheries and Oceans Canada, Winnipeg, MB, Canada
[3] GEOTOP et Sciences de la terre et de l'atmosphère, UQAM, Montréal, QC, Canada
Contact: alfonso.mucci@mcgill.ca

Under equilibrium conditions, heavier isotopes are typically enriched in the denser phase. Likewise, oxygen-18 is enriched in sea ice with respect to the parent seawater solution. Nevertheless, the isotopic fractionation is subject to kinetic effects related to the rate at which sea ice forms. In 2010 and 2011, we collected surface seawater and the co-existing, newly formed sea-ice (pancake ice and frazil ice) in Lancaster Sound near Resolute Bay in the Canadian Arctic Archipelago. The isotopic composition (δ2H and δ18O) and practical salinity (SP) of the surface seawater and sea ice were analyzed and results reveal a linear relationship between the difference in the isotopic composition (δ18Oice – δ18Osw and δ2Hice – δ2Hsw) and salinity (SP-SW – SP-ice; a proxy of the rate of sea-ice formation) of the sea ice and surface seawater. The slope of the relationships is positive and confirms a strong kinetic effect on the fractionation of stable hydrogen and oxygen isotopes during early sea-ice formation.

2B2.2 ID:7093 10:45

Effects of enhance of Greenland melt on the hydrography of Baffin Bay and the water exchanges between the Arctic and Atlantic Ocean.

Laura Castro De La Guardia , *Xianmin Hu* , *Paul Myers*

University of Alberta
Contact: castrode@ualberta.ca

The melting of Greenland's glaciers is predicted to increase as a result of temperature increases in the Northern Hemisphere. Here we examine the effects of increasing runoff from Greenland on the hydrography of Baffin Bay and on the total transport, heat and freshwater exchanges between the Arctic Ocean and Labrador Sea. Using a regional configuration of a coupled ocean/sea ice model (NEMO), we setup eight sensitivity experiments with enhanced runoff ranging from 158 to 1580 km^3/y and one control run with runoff <31.5km^3/y. The enhanced Greenland melt leads to a shallower mixed layer depth throughout the Bay, with largest changes along the eastern side during summer. Stratification becomes stronger in every season with the top 100 meters water column becoming fresher and colder in winter and fresher and warmer in summer, while the Baffin Bay Intermediate water (200-700m) become progressively warmer (0.75°C) with salinity remaining similar in all experiments. The velocity fields through Davis Strait also changed, with a significant reduction of the core velocities of Baffin Island current, and an increase in the northward transport of the West Greenland Current. Expansion of the surface layers results in an increase a result of the freshening and thermal expansion. This leads to an overall reduction in the transport of fresher and colder Arctic water through Nares Strait and Lancaster Sound, which is compensated with an increase in transport through Fram Strait. We conclude that the enhance Greenland melt will lead to significant hydrographic changes within Baffin Bay which can potentially affect the native fauna of the Bay. We highlight that through its impact on sea surface height, the increased Greenland runoff has the potential to reduce the Arctic water throughflow through the Canadian Arctic Archipelago but increase the export of freshwater through Fram Strait.

2B2.3 ID:7124 11:00

The nitrogen balance of sea ice in the Canadian Arctic Archipelago

Jean-Sébastien Côté [1], *Jean-Éric Tremblay* [1], *Jonathan Gagnon* [1], *Christine Michel* [2]
[1] Québec-Océan, Département de biologie, Université Laval, Québec, Qc
[2] Fisheries and Oceans Canada, Marine Productivity Laboratory, Winnipeg, Mb
Contact: jean-sebastien.cote.4@ulaval.ca

Nitrogen (N) supply exerts a major control on primary production in seasonally ice-covered waters of the Arctic Ocean. The biogeochemical N cycle is complex and involves diverse steps mediated by a variety of organisms ranging from microbes (bacteria and archea) and phytoplankton to microzooplankton and larger animals. Some of these steps lead to a net loss or gain of available N from the ecosystem while others recirculate N under different forms. These different N sources fuel either "new" (based on allochthonous N) or "recycled" (based on remineralized N) primary production. Overall, most of the current knowledge on N cycling comes from water column studies. Yet sea ice provides a unique habitat for abundant ice algae, microbes and small grazers. The contribution of sea ice to total annual production is highly variable, but can be substantial in some regions. With the rapid environmental changes now occurring in the Arctic, there is renewed interest in understanding how sea ice affects biogeochemistry and the cycling of key elements. While previous studies typically focused on one or two N cycling processes, this study aims to assess the overall N balance in bottom sea ice by quantifying the rates of and relationships between five crucial N cycling steps. In this study,

we collected bottom ice cores at 22 stations near Cornwallis Island during spring 2013, under the BIOTA (Biological Impacts of Trends in the Arctic) program. The ice samples were melted in filtered sea water and incubated with a suite of stable isotopic tracers to estimate N assimilation, regeneration, nitrification, denitrification and fixation. First results suggest a very dynamic situation with variable but high inorganic N concentrations and nitrification rates, distinct contributions of prokaryote and eukaryote to N assimilation and potentially significant N fixation. Based on these results, we present new perspectives on N cycling in sea ice and discuss their implications in a rapidly changing Arctic Ocean.

2B2.4 ID:7253 11:15

New sea-ice related sources of DMS(P) in the Arctic

Levasseur Maurice [1], *Galindo Virginie* [1], *Gourdal Margaux* [1], *Mundy Christopher J.* [2], *Gosselin Michel* [3], *Michel Christine* [4], *Babin Marcel* [1], *Tremblay Jean-Éric* [1], *Scarratt Michael* [5], *Lizotte Martine* [1], *Michaud Sonia* [5]
[1] Université Laval (Québec-Océan)
[2] University of Manitoba
[3] Université du Québec à Rimouski
[4] Pêches et Océans Canada
[5] Pêches et Océan Canada
Contact: maurice.levasseur@bio.ulaval.ca

The presence of sea ice in the Arctic makes it a spatially complex physical environment, hosting diversified biota and potential sources of the climate-active gas dimethylsulfide (DMS). For example, in spring, microfloral assemblages thrive at the bottom of the sea ice, in melt ponds, and in the water column under the ice (the so called ‘under-ice blooms’). Blooms of ice algae have consistently been associated with large concentrations of DMS and its algal precursor dimethylsulfoniopropionate (DMSP). The fate of these DMS(P) reservoirs in the water column and the rate of exchange of this ice-DMS with the atmosphere are still poorly documented. Likewise, the contribution of melt ponds and under-ice blooms to DMS(P) production and sea-air exchange is unknown. Here, during four successive years (2010 to 2013), we quantify the relative contribution of these different biotas to the production of springtime DMS in the High Canadian Arctic and discuss how these sources will change in the context of a rapid warming of the Arctic.

2B2.5 ID:7262 11:30

Production of mycosporine-like amino acids in sea ice covered Arctic waters

Ashley Elliot [1], *C.j. Mundy* [1], *Michel Gosselin* [2], *Michel Poulin* [3], *Karley Campbell* [1], *Feiyue Wang* [1]
(Presented by *Cj Mundy*)
[1] Center for Earth Observation Science, University of Manitoba, Winnipeg, MB
[2] Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, Rimouski, QC
[3] Canadian Museum of Nature, Ottawa, ON
Contact: cj.mundy@umanitoba.ca

To protect against damaging UV radiation, many marine phytoplankton are known to produce UV-absorbing mycosporing-like amino acids (MAAs), but little is known about their presence in

sea ice covered Arctic waters. Here we report the measurement of MAAs in ice algae, under-ice phytoplankton, water column phytoplankton, and ice melt algae communities in Allen Bay of the Canadian Arctic Archipelago during spring 2011. Five major UV-absorbing compounds were consistently identified in the samples taken after 31 May. Based on chromatographic retention times four of the compounds were suspected to be shinorine, palythine, porphyra-334, palythene, and an unknown UV-absorbing compound with an absorbance maximum of 363 nm. Interestingly, some MAAs were only observed in certain habitats. Furthermore, MAAs were only correlated with specific flagellate taxa, namely, prymnesiophytes and prasinophytes, inferring their production by these taxa. The presence of MAAs associated with particular taxa or communities may provide them a competitive advantage, and could be an important factor under a changing light environment in the Arctic system.

2B2.6 ID:7145 11:45

Can benthic biodiversity hotspots be created by presence of seabird colonies in the Arctic?

Marième Bouchard Marmen [1], *Philippe Archambault* [1], *Ellen Kenchington* [2]
[1] Université du Québec à Rimouski, Institut des sciences de la mer, Rimouski, Québec.
[2] Fisheries and Oceans Canada, Bedford Institute of Oceanography (BIO), Dartmouth, Nova Scotia.
Contact: marieve.bouchard.m@gmail.com

Seabirds play an important role as biological vectors, especially in the Arctic where food is seasonally restricted. Millions of seabirds inhabit cliffs that run Lancaster Sound each year during the breeding season. They return important quantities of organic matter (guano, feathers) locally in seasonal pulses, potentially creating hotspots of marine biological productivity in the area surrounding a colony. Benthic species are known to be good integrators (sessile, long-lived) of the environmental variation. The objective of this project is to characterize the impact of seabird colonies on benthic communities. With this important input of nutrients, we expect that primary and secondary production and deposition of organic matter on the sea floor will increase. These differences may affect the benthic biodiversity and abundance. Aboard CFAV Quest and CCGS Henry Larsen in 2012, photos of the seafloor have been taken in four control zones and in five bird-affected zones in Lancaster Sound. Seafloor photos taken along transects have been analyzed to characterize benthic communities. Results about potential impact of seabird colonies' presence on benthic communities will be discussed.

Coastal Oceanography and Inland Waters PART 1 / Océanographie côtière et eaux intérieures PARTIE 1

Room / Endroit (Ouellet), Chair / Président (Jinyu Sheng, Guoqi Han & Ram Yerubandi), Date (03/06/2014), Time / Heure (10:30 - 12:00)

2B3.1 ID:7134 **10:30**

Downwelling Canyons -- Strength of Downwelling and Is there Upwelling?

Jessica Spurgin , *Susan Allen*
Earth Ocean and Atmospheric Sciences, University of British Columbia
Contact: sallen@eos.ubc.ca

We use the Massachusetts Institute of Technology general circulation model to synthesize previous model and observational results of steady downwelling-favorable flow over submarine canyons. Canyon response can be separated into three or two groups depending on parameter of interest. Canyon flow patterns, including vertical velocity, are easily classified as cyclonic, weak or anti-cyclonic depending strongly on the Burger number with the strength of the response dependent on the Rossby number. However, time integral processes such as density or nitrate patterns are strongly dependent on incoming flow position (shelf or shelf-break to offshore) which in turn is dependent on vertical variations in stratification. Strength of the response is dependent on Burger number for density and Rossby number for nitrate. After we synthesize the dynamics, we will provide an answer to the question ``What makes downwelling canyons so biologically productive?"

2B3.2 ID:7270 **10:45**

A multi-nested circulation model for central Scotian Shelf: Model Validation

Shiliang Shan , *Jinyu Sheng* , *Kyoko Ohashi* , *Mathieu Dever*
Department of Oceanography, Dalhousie University
Contact: sshan@phys.ocean.dal.ca

The central Scotian Shelf is a region extending about 200 km seaward from the south coast of Nova Scotia passing the Emerald Basin to the shelf break. This region is dynamically and biologically complicated due to the effects of many oceanic processes including tides, the Nova Scotia Current, coastal upwelling, slope water intrusion and plankton blooms. This study presents a multi-nested circulation model developed recently over the central Scotian Shelf for a better understanding of the spatial and temporal variability of the main physical processes. The model has four submodels downscaling from the eastern Canadian Shelf to the central Scotian Shelf using a one-way nesting method. The model is forced by tides, wind, river discharges, and heat/freshwater fluxes. The model results are validated against various observations including results from a data-assimilative tidal model, temperature and salinity observations from the Atlantic Zone Monitoring Program, observations made by ADCPs, MicroCATs and gliders on the Halifax Line through the Ocean Tracking Network project and sea surface temperature from the Halifax Harbour Buoy and from remote sensing. The preliminary model results demonstrate that the model is able to capture the tides, Nova Scotia Current and seasonal variation of the hydrography over the central Scotian Shelf. The current-topography interaction and coastal upwelling simulated by the model are discussed.

2B3.3 ID:7172 **11:00**

The mean slope of sea level along the east coast of the US and Canada

Simon Higginson [1], *Keith Thompson* [2], *Philip Woodworth* [3], *Chris Hughes* [3]

[1] Bedford Institute of Oceanography
[2] Dalhousie University
[3] National Oceanography Centre, Liverpool, UK
Contact: simon.higginson@yahoo.ca

There have been numerous attempts to estimate the mean slope of sea level along the east coast of North America using both “oceanographic” and “geodetic” approaches. Oceanographers have been interested primarily in the relationship between the deep ocean circulation, including the Gulf Stream, and tilts of sea level. They have made extensive use of ocean circulation models to infer the slopes. Geodesists have been more concerned with obtaining accurate measurements of the sea level slope as a check on their estimates of the geoid. Both approaches have benefitted recently from the new generation of geoid models provided by the GRACE and GOCE satellite gravity missions. These geoid models, combined with tide gauge measurements of mean sea level, provide more direct measurements of the mean dynamic topography (MDT) along the coast. In this presentation we compare new estimates of the MDT along the east coast of North America using both oceanographic and geodetic approaches, and show how the two are converging to a remarkable degree. We will discuss the ocean dynamics behind the observed mean slope of coastal sea level, and the value of coastal tide gauges for validating both deep ocean and shelf circulation models.

2B3.4 ID:7257 11:15

A new way to look at river tides: Nonstationary tidal harmonic predictions in the St. Lawrence fluvial estuary

Pascal Matte [1], *Yves Secretan* [1], *Jean Morin* [2]
[1] INRS - Centre Eau Terre Environnement
[2] Environment Canada, Hydrology and Ecohydraulic Section
Contact: pascal.matte@ete.inrs.ca

Predicting tides in upstream reaches of rivers is a challenge, because tides are highly nonlinear and nonstationary, and accurate short-time predictions of river flow are hard to obtain. In the St. Lawrence fluvial estuary, tide forecasts are produced using a one-dimensional model (ONE-D), forced downstream with harmonic constituents and upstream with daily discharges using 30-day flow forecasts from Lake Ontario and Ottawa River. Although this operational forecast system serves its purpose of predicting water levels, information about tidal-fluvial processes that can be gained from it is limited, particularly the temporal changes in mean water level and tidal properties (i.e. constituent amplitudes and phases), which are function of river flow and ocean tidal range. In this paper, a harmonic model adapted to nonstationary tides, NS_TIDE [Matte P, Jay DA & Zaron ED (2013) Adaptation of classical tidal harmonic analysis to nonstationary tides, with application to river tides. J. Atmos. Oceanic Technol. 30(3):569-589], was applied to the St. Lawrence fluvial estuary, where the time-varying external forcing is directly built into the tidal basis functions. Model coefficients from 13 analysis stations were spatially interpolated to allow tide predictions at arbitrary locations as well as to provide insights into the spatiotemporal evolution of tides. Model hindcasts showed substantial improvements compared to classical harmonic analyses at upstream stations. The model was further validated by comparison with ONE-D predictions at a total of 32 stations. The slightly lower accuracy obtained with NS_TIDE is compensated by model simplicity, efficiency and capacity to represent stage and tidal

variations in a very compact way. The model also provides new understanding of tidal-fluvial processes in the St. Lawrence fluvial estuary. Possible extensions of the model include analysis of the effects of storm surges on tides.

2B3.5 ID:7288 11:30

Modelling North Atlantic Nor'easters with Modern Wave Forecast Models

Bash Toulany [1], *Will Perrie* [1], *Aron Roland* [2], *Mathieu Dutour-Sikiric* [3], *Changsheng Chen* [4], *Robert C. Beardsley* [5], *Jianhua Qi* [4], *Yongcun Hu* [1]
[1] Bedford Institute of Oceanography, Canada
[2] Technische Universität Darmstadt, Germany
[3] Rudjer Boskovic Inst., Croatia
[4] Univ. of Massachusetts-Dartmouth, USA
[5] Woods Hole Oceanographic Inst., Woods Hole, USA
Contact: perriew@dfo-mpo.gc.ca

Three state-of-the-art operational wave forecast model systems are systematically compared for three Northwest Atlantic storms. These models are: (1) a composite model system consisting of SWAN implemented within WAVEWATCHIII® (hereafter, WW3) on a nested mosaic system of structured grids, (2) an unstructured grid finite-volume version of SWAN wave model, denoted as 'SWAVE', and (3), a newly modified version of WW3, denoted as WWM (for 'wind wave model') which uses an unstructured grid finite element system. The wave models are compared for waves generated by three intense mid-latitude nor'easters: a spring storm in May 2005, Patriots Day storm in 2007 and the Boxing Day storm in 2010. These storms caused extensive flooding along the coasts of Massachusetts and Maine. Model system domains are selected to be large enough to capture all the wave energy generated by the storms, nesting (or zooming) down to fine-resolution nearshore regions around ~50m to simulate areas where inundation and coastal damage occurred, specifically at Situate, Massachusetts, during the storms. Source terms used in the inter-comparisons include simple WAMcycle 3 physics, and also more modern 'ST4' physics by Ardhuin et al. (2010, JPO). We systematically present wave model results. Results using SWAN, with modern ST4 source terms, nested within WW3 on a nested multi-grid mosaic, also using ST4 source terms, are shown to give the best results, in comparisons with available NDBC buoy data, and altimeter wave height data.

2B3.6 ID:7196 11:45

On the tides in fjords and bays of the South Coast of Newfoundland

Andry William Ratsimandresy , *Sebastien Donnet* , *Stephen Snook* , *Pierre Goulet*
Fisheries and Oceans Canada
Contact: andry.ratsimandresy@dfo-mpo.gc.ca

The tidal regimes within the fjords and bays of the south coast of Newfoundland are studied by means of in-situ measurements and circulation model. Acoustic Doppler Current Profilers (ADCP) were used to measure the currents and sea level at numerous locations within the region while Finite Volume Coastal Ocean Model (FVCOM) was run in barotropic mode to generate the co-range and co-tidal maps of the main tidal constituents for the domain of interest. Analysis of the sea level from both the observation and the model output shows that the model simulates

well the tidal variation in sea level within the bays. The analysis shows that the sea level variation is highly explained by tides while the total ocean currents have generally relatively small contribution from tidal currents. This is the case for vertically averaged currents as well as currents at different depths as shown by the analysis of the observation. Further analysis of the observation shows vertical and horizontal variability in the characteristics of the tidal currents. As the stratification within the bay changes between seasons, an attempt was made to find possible relation between the change in the tidal ellipses and the variation in the stratification within the water column. In addition, the spatial variability is also studied by computing correlations among stations at different depths. These results provide more insight in understanding the oceanographic conditions and their variability for the south coast of Newfoundland region and help develop an ocean circulation model to be used for aquaculture purposes.

General Climate Science / Sciences du climat en général

Room / Endroit (Léonard-Blais), Chair / Président (Michael Scarratt), Date (03/06/2014), Time / Heure (10:30 - 12:00)

2B4.1 ID:7323 **10:30**

The importance of Climate in the Arctic and what Canada stands to gain from international efforts such as the Global Framework for Climate Services

David Grimes
Environment Canada
Contact: david.grimes@ec.gc.ca

It is widely recognized that the Arctic is the “canary in the coalmine” when it comes to Climate Change. In spite of sparse Arctic monitoring coverage, it is obvious that conditions are visibly changing in our vast north as related to temperature extremes, permafrost and ice conditions and the occurrence of storms and even thunderstorms. It is also known that changes in the Arctic climate will have global effects, though this is not as yet well understood. A continued focus on climate monitoring and research in the Arctic is not only necessary for the development of services to inform socio- economic decision-making in this burgeoning region, but is necessary to improve climate services world-wide. The Assistant Deputy Minister of the MSC and President of the World Meteorological Organization David Grimes will speak to the climate challenge in the Arctic and how international efforts such as the Global Framework for Climate Services and the WMO Expert Panel on Polar Observations, Research and Services are bringing international resources and efforts to bear on these important matters.

2B4.2 ID:7169 **10:45**

Évolution de l'aire de distribution des climats mondiaux au Québec

Eric Larrivée
Ministère Développement durable, Environnement, Faune et Parcs
Contact: eric.larrivee@mddep.gouv.qc.ca

Dans le cadre du Plan d'action sur les changements climatiques, le Service de l'information sur le milieu atmosphérique (SIMAT) du Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs (MDDEFP) a entrepris le calcul des plus récentes normales et statistiques à ses stations d'observation du climat. Les nouvelles normales 1981-2010, appliquées dans les critères de définition des climats mondiaux de Köppen-Geigger, ont permis de mettre à jour les aires de distribution des climats mondiaux au Québec. Le suivi de l'évolution de ces aires de distribution permettra de témoigner de la progression des changements climatiques sur le territoire québécois. Les résultats suggèrent entre autres que la Côte-Nord serait une des premières régions sujette à basculer de type de climat, selon les changements climatiques anticipés.

2B4.3 ID:7149 11:00

Development of Predictive Water and Climate Services in Canada at the Monthly and Seasonal Scales: A Perspective from EC

Chantale Cote , Alain Pietroniro , Jamie Smith , Vincent Fortin , Pierre Pellerin , Bertrand Denis
Environnement Canada
Contact: chantale.cote@ec.gc.ca

There is a growing demand worldwide for useful, timely, reliable and readily accessible water availability and climate information at different timescales for managing water resources and climate risks in many sectors of our society. One of the Meteorological Service of Canada's (MSC) 10 Year Strategy projects aims to modernize and revamp its water and climate services as part of a transformative agenda to create a seamless impact-based weather, water and climate services over varying time scales, to support enhanced resilience to a changing climate.

In the North American context, the enhancement of the provision of integrated water and climate information across international borders requires that we build on existing collaborations and develop innovative new ways to develop, communicate and disseminate key information. An overview of the innovative efforts within the North American Climate Services Partnership (NACSP) initiative launched in 2012 will be presented.

The presentation will also focus on the development of services at monthly and seasonal scales by Environment Canada and its partners through newly established regional discussion forum pilots. Our initial plan to develop a single window to disseminate information on the components of the water cycle (precipitation, evaporation, water levels and flows) and climate information will also be presented.

2B4.4 ID:7016 11:30

Regionalization of precipitation using relevant atmospheric variables in Canada

Sarah Irwin , Roshan Srivastav , Slobodan Simonovic
Western University
Contact: sirwin9@uwo.ca

Regional frequency analysis is used to delineate regions of homogeneous hydrologic or meteorological characteristics such that data observed within the same region can be combined into one dataset. The purpose of this procedure is to create hydrologic or meteorological records of sufficient length from which design values such as flood quantiles and rainfall return periods can be estimated. Here a methodology for the regionalization of precipitation is presented for a Canadian setting. Canada has a vast landscape that is climatically diverse; therefore the relationships between atmospheric variables and precipitation vary significantly across the country. In this study homogeneous regions of precipitation are formed using location parameters and atmospheric variables that exhibit strong correlations with local precipitation; thus reserving precipitation as an independent dataset to validate regional homogeneity. The methodology has two steps: (i) identification of the atmospheric variables that influence local precipitation for different Canadian regions using correlation analysis; (ii) delineation of the homogeneous regions of precipitation using the k-means clustering algorithm, which groups climate stations with similar location and relevant atmospheric variables identified in step (i). An L-moment based regional heterogeneity test is employed to validate the homogeneity of the regions, and adjustments are made in order to improve homogeneity as necessary. The methodology is applied to a case study in Southern Ontario. The correlation analysis results indicate that mean sea level pressure (PMSL) and precipitation are strongly correlated in this region; therefore PMSL, latitude, longitude and elevation are used as input to the k-means clustering algorithm and the regional homogeneity is evaluated. The results are compared to the regionalization of precipitation using all atmospheric variables in order to prove the importance of the selection of relevant input parameters to the clustering algorithm.

2B4.5 ID:7054 11:45

On the integration of climate simulations in the dendrochronology project ARCHIVES.

Dominique Paquin [1], *Antoine Nicault* [2], *Luc Perrault* [3], *René Roy* [4], *Étienne Boucher* [5], *Yves Bégin* [6]
[1] Ouranos
[2] AMU – ECCOREV
[3] Hydro-Québec - IREQ
[4] Ouranos, Hydro-Québec - IREQ
[5] UQAM
[6] INRS-ETE
Contact: paquin.dominique@ouranos.ca

The ARCHIVES (Analyse Rétrospective des Conditions Hydroclimatiques à l'aide des Indicateurs de leur Variabilité à l'Échelle Séculaire) project was held from 2008 to 2013. The main objective of this multidisciplinary project was to study the hydrological and climatic variations of the last millennium in the boreal region of Quebec. Based on the use of several natural indicators such as tree rings (width, density and isotopic ratios of carbon and oxygen) and lake sediments, reconstructions of spatio-temporal variability of hydrological variables have been made.

In order to make an evaluation of different river flows, reconstructions for the Caniapiscau and Churchill Falls basins are compared to historical simulations performed with the Canadian Regional Climate Model version 4 (CRCM4) over a 40 years period, from 1960 to 2000, when streamflow observations are available. The CRCM4 simulations are driven by reanalyses and done over two regional domains (North American and Québec). Both the reconstructed and the simulated run-off from the Québec domain are comparable and show a good temporal correlation with the observations. The climate simulation done over the larger domain shows an under-estimation of the flows, as seen in others studies. .

Going further back in time, from 1850 when observed river flows are not available, the reconstructions are compared to global models simulations from CMIP3 (completed) and CMIP5 (on the way). With such simulations, we cannot expect any temporal correlation, but are looking at the general representation of the river flows such as mean and variability. The CMIP3 simulations with both natural and anthropogenic forcings show a good agreement with the reconstructions.

Remote sensing of coastal and arctic waters PART 1 / Télédétection des eaux côtières et arctiques PARTIE 1

Room / Endroit (Parent), Chair / Président (Cédric Jamet & Simon Bélanger), Date (03/06/2014), Time / Heure (10:30 - 12:00)

2B5.1 ID:7250 INVITED/INVITÉ 10:30

Monitoring & Understanding Changes in the Arctic: CSA Support for Earth Observation Applications & Solutions

Guy Aube , *Paul Briand* , *Yves Crevier*
Canadian Space Agency
Contact: guy.aube@asc-csa.gc.ca

Keywords: Northern region management, Arctic, coastal zones, Earth Observation, Canadian Space Agency

ABSTRACT Today, we see an ever-increasing number of demands on Arctic coastal zones, ocean and their resources. While traditional fishing and marine transportation continue to be of prime importance, they are now joined by other uses, such as oil and gas exploration, aquaculture, eco-tourism, search and rescue operations, etc. With over $20 billion in annual economic activity, Canada's coastal zones and their resources are significant contributors to the overall Canadian economy. Our need for tools to predict and monitor short and long-term environmental changes, especially in the Canadian Arctic, has never been greater. Improved, up-

to-date environmental data is needed to plan for environmentally and economically sound growth and to develop more sustainable practices and solutions to protect our waters and lands. Space-based Earth Observation (EO), including RADARSAT-2 and CryoSat-2, provides us with unique and essential information to understand how our northern environments work, allowing, for instance, reporting on biodiversity and wildlife, improving the understanding, modelling and prediction of weather, refining the techniques for the delivery of ecosystem services, predicting potential hazards on infrastructures, mapping of renewable energy potential, detecting new vector born diseases, measuring water quality and quantity, identifying shorelines and ecosystems at risk in preparation of emergencies, reporting on coastal glaciers and ice melting, measuring water quality and quantity, etc. Canada is among the world leaders in EO applications and utilizations. Since 2000, the Canadian Space Agency (CSA) EO Applications and Utilization Division has managed over 200 projects in partnership with Canadian OGDs, industry and universities. The presentation will be a review of CSA past & on-going EO initiatives and applications support to Canadian departments, industry and academia related to the monitoring and understanding of changes in the Arctic.

2B5.2 ID:7331 11:00

Phytoplankton phenology in a changing Arctic Ocean

Mathieu Ardyna [1], *Marcel Babin* [1], *Michel Gosselin* [2], *Emmanuel Devred* [1], *Jean-Éric Tremblay* [1]
[1] Takuvik Joint International Laboratory, Laval University (Canada) - CNRS (France)
[2] Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski
Contact: Mathieu.Ardyna@takuvik.ulaval.ca

Regions of the Arctic Ocean experiencing seasonal ice cover tend to have a single summertime phytoplankton bloom that occurs when light is sufficient to allow the phytoplankton to grow. With Global warming, the receding Arctic ice pack now allows more sunlight to penetrate into the ocean, which some studies suggest should allow summer blooms to spread and intensify. Other studies, however, conclude that increasing river runoff to the Arctic Ocean may enhance upper-ocean stratification and lower the effectiveness of wind-driven vertical mixing, thus decreasing the upward supply of nutrients and counteracting the positive influence of greater light availability on blooms. Using satellite-derived chlorophyll time series, we examined the Arctic phytoplankton phenology over the last 15 years. We observed that Arctic regions undergo potential changes in phytoplankton phenology, which coincide with delayed freeze-up and increasing exposure of the sea surface to winds. These shifts in phytoplankton phenology may have cascading effects and impacts on the Arctic marine ecosystem.

2B5.3 ID:7316 11:15

Remote sensing of the near shore ice complex in the Saint-Lawrence Estuary using fully polarimetric high resolution Radarsat-2 data.

Simon Tolszczuk-Leclerc , *Simon Bélanger* , *Éric Hudier* , *Pascal Bernatchez*
Université du Québec à Rimouski
Contact: tols0001@uqar.ca

A regional coupled sea-ice-ocean-atmosphere model of the Estuary and Gulf of St Lawrence (EGSL), along with climatic scenari of global warming, predict a major reduction of both sea ice

cover and near shore ice (namely icefoot) over the 2050-2070 horizon (Senneville et al, CMOS 2014). The icefoot plays two critical roles in the coastal geomorphology. First, it prohibits sedimentary transport along shore when is stable and well formed. Second, by incorporating and transporting sediments away, it acts as a potent erosion agent causing net loss of sediments of the shore zone to the benefit of deep basin. Third, heavy sea ice cover, stable landfast ice or icefoot completely reduced the negative impact of powerful winter storms, which can generate wind reaching 100km/h. Sea ice monitoring is routinely done for navigation since the 70's by the Canadian Ice Service. In contrast, icefoot, which is typically only a few meters wide across the shoreline not of interest from a navigation perspective, is often indistinguishable using the low-resolution data used (>250m). With the advent of a new generation of high resolution polarimetric SAR satellites, the extraction of ice structures as narrow as the strip of sea ice that forms the icefoot becomes feasible.

In this study we tested various polarimetric decomposition methods and classifiers on RADARSAT-2 Quad-polarization SAR images to map the icefoot at various sites along the shore of the EGSL. The Pottier & Lee method for polarimetric decomposition (i.e., entropy, anisotropy and alpha-angle parameter) and the Wishart statistical classifier provide the best results when compare to field observations. In addition, we examined the spatial variability of the icefoot in relation to the type of coast (i.e., beaches, marshes, rocky, etc.). We found that the type of coast significantly influence the setting and breaking of the icefoot for regions with similar climatic conditions. This study clearly demonstrates the potential of RADARSAT-2 for the monitoring the icefoot in coastal zone. The development of a semi-automated operational system for icefoot mapping, together with a forecasting system for waves, would be used to generate warnings of potentially damaging winter erosion events.

2B5.4 ID:7326 11:30

A simple algorithm to retrieve phytoplankton groups and CDOM in the Canadian Arctic: application to MODIS time series (2003-2013)

Emmanuel Devred [1], *Atsushi Matsuoka* [1], *Simon Bélanger* [2], *Pierre Coupel* [1], *Maxime Benoît-Gagné* [1], *Marcel Babin* [1]
[1] Takuvik, CNRS-Université Laval, Québec, Canada
[2] UQAR, Rimouski, Canada
Contact: emmanuel.devred@takuvik.ulaval.ca

Arctic phytoplankton exhibit peculiar properties which result from its adaptation to extreme (low) light and temperature forcing. For instance, for a given concentration of chlorophyll-a, phytoplankton absorption is lower in the Arctic Ocean than at intermediate latitudes due to packaging effects and pigment composition (e.g., high proportion of photoprotective pigments). Common tools to discriminate phytoplankton groups need to be adapted when applied to the Arctic Ocean. Here, we propose a new simple, yet robust, algorithm to retrieve the concentration of small and large phytoplankton cells based on absorption considerations. The algorithm accounts for the contamination of the marine signal by yellow substances, making it suitable for application in CDOM dominated waters such as the Canadian Arctic Shelf. The algorithm was applied to MODIS level-3 4-km resolution remote sensing reflectances between 2003 and 2013 over the Beaufort and Chukchi Seas. Analysis of time series of small and large phytoplankton shows a strong regionality in the trends, with, for instance, an increase of small phytoplankton in

the Chukchi Sea and a decrease of small phytoplankton in the Beaufort Sea over the period of observation.

2B5.5 ID:7282 11:45

Mapping shore and sea ice in the Estuary and Gulf of St Lawrence using archive Landsat imagery.

Remy Villeneuve , Simon Tolszczuk-Leclerc , Simon Belanger
Université du Québec à Rimouski
Contact: remyv@cgocable.ca

Sea ice is an important factor for shipping and transportation on the St. Lawrence Seaway and the Estuary and Golf of St. Lawrence (EGSL). Since 1969, the Canadian Ice Service (CIS, Environment Canada) provides ice cover maps aimed toward users of the EGSL ports and seaways. These maps are rendered using various sources of data and multiple methods. Sea ice extent is also an important factor in coastal erosion processes. Trends of sea ice extent are of paramount importance when examined in the context of global climate variability. These trends can be useful for planning remedial actions for the protection of critical coastal infrastructure, as well as a decision-making tool for those in a policy-making position for coastal land use and planning. Sea ice observations and processing from the CIS are not quite applicable for coastal ice climatological studies of the EGSL zones located away from maritime infrastructure and shipping lanes. However, the Landsat series of remote-sensing satellites enables a multispectral observation window back to 1972 without too much coverage bias. By adapting the multispectral classification and cloud layer identification algorithm from Zhe and Woodcock (2012), a completely undirected and automated mapping application is capable of identifying land with or without snow, lakes and rivers, open sea, or lake and sea ice, as well as cloudiness. This research project looked at the potential uses of Landsat 5 & 7 archived imagery from the USGS. The spatial extent of the sea ice climatology covers most of the EGSL from 1996 to 2012. The results clearly show sea ice cumulative annual patterns at relatively high spatial resolutions up to the coastal intertidal interface, as well as those of rivers and lakes of sufficient size.

General Atmospheric Science PART 5 / Sciences de l'atmosphère en général PARTIE 5

Room / Endroit (Langevin), Chair / Président (Martin Charron), Date (03/06/2014), Time / Heure (13:30 - 15:00)

2C1.1 ID:7138 13:30

Temperature and precipitation estimates in surface based analyses and reanalyses over the

Arctic

Maja Rapaic [1], *Marko Markovic* [1], *Ross Brown* [2], *Diane Chaumont* [1]
[1] Ouranos Inc
[2] Environment Canada
Contact: rapaic.maja@gmail.com

Characterization of Arctic climate variability and change typically relates on well-known temperature and precipitation gridded data-sets based on surface observations or reanalyses. However, all these "observational" data-sets rely on sparse observing networks and hence they can be significantly different one from another. In order to estimate these differences in climate representation of the Canadian Arctic, we analyse 8 widely used surface observations and 8 reanalyses. Comparison of spatial patterns among data-sets showed high correlation values for temperature but significantly lower for precipitation particularly in summer. The differences between area-averaged seasonal means in gridded data-sets are very small for temperature and more important for precipitation. Reanalyses generally tend to be warm and wet compared to observations particularly over the western Arctic. Systematic biases were found for several reanalyses. Differences among gridded data bases were found to be the largest in cold season with maximums over mountainous regions for temperature and over Canadian Archipelago for precipitation. For temperature, differences among reanalyses have similar patterns but higher magnitudes than those among observations. Due to the dominant regime of convective precipitation in summer, differences among reanalyses are largest over central northern Canada. In winter season, maximal differences occur over Canadian Archipelago due to known difficulties that reanalyses experience in representing low quantity precipitation in this region. The ensemble of gathered data-sets is used to construct consensus patterns of temperature and precipitation trends over the region. The consensus approach was found to be principally useful for analyzing precipitation trends since they differ significantly between data-sets. Due to important distinctions among evaluated "reference" data bases, we recommend using an ensemble of data-sets for trend and climate model evaluation over the Arctic region in order to account for uncertainty in observations.

2C1.2 ID:7240 13:45

The Meteorological Service of Canada's Nunavut Northern ATAD prototype

Brian Proctor
Meteorological Service of Canada
Contact: Brian.Proctor@ec.gc.ca

Environment Canada's Meteorological Service is developing a new ATAD prototype for the North which will undergo some preliminary testing this spring in Nunavut. If tests of the system prove its value, the prototype will be expanded to the Yukon and NWT. This system has a robust and objectively consistent design that will allow all users to access the system for local warnings, public forecasts, marine forecasts, and air quality forecasts (where they exist), as well as observations via a toll free phone number. The presentation will detail system design and structure as well as providing some preliminary statistics on which information is accessed and by whom.

2C1.3 ID:7230 **14:00**

Issues on vertical height transformation in numerical weather models

Marcelo Santos [1], *T. Hobiger* [2], *J. Boehm* [3], *J.-P. Boy* [4], *P. Gegout* [5], *J. Foster* [6], *R. Haas* [7], *F. Nievinski* [8], *A. Niel* [9], *M. Schindelegger* [10], *J. Wickert* [11]
[1] University of New Brunswick
[2] NICT
[3] TU Vienna
[4] GSFC
[5] CNES
[6] Hawaii
[7] Chalmers
[8] UNESP
[9] MIT
[10] ETH
[11] and T. van Dam (Luxemburg)
Contact: msantos@unb.ca

Geodesists make use of pressure, temperature or potential temperature, relative humidity or water vapor mixing ratio and wind speed and direction from numerical weather models (NWMs) for various purposes (e.g., modelling atmospheric loading, computing mapping functions, computing atmospheric angular momentum). There are a few main issues when dealing with NWMs in geodetic applications, such as transform from meteorological height system to a geodetic one, deal with grids irregularly spaced in the vertical, if not given on a regular (horizontal) grid then a transformation is necessary, latitude problem: geodetic vs. geocentric latitude, and what is the NWM topography and how does it relate to reality? In this presentation we discuss the issue related to the vertical (height) transformation, with a discussion on error sources related to the impact of the gravity model and the way how the mean gravity (g0) is calculated the impact of the vertical direction w.r.t. the ellipsoid instead of the vertical w.r.t. a sphere (as used for numerical weather models), the uncertainty of the geoid (undulation), and the use of a different value for the conventional gravity constant. This work is conducted within the framework of the International Association of Geodesy Joint Study Group 0.4 “Coordinate systems in numerical weather models”

2C1.4 ID:7221 **14:15**

Aspects of streamflow network design: the view from graph theory

Mark Halverson, *Sean Fleming*
Environment Canada
Contact: mhalverson@eos.ubc.ca

Graph theory is the mathematical framework for analyzing systems of pairwise relationships between nodes. The classic example is the analysis of social networks, which has revealed the well-known small-world phenomenon, whereby any two random people can be linked by an average of six steps. More recently, network theory has been applied to a wide range of disciplines, including finance, biology, climate, seismology, circuit design, and transportation.

Here we present the results of a study whereby complex network theory was applied to an array of streamflow gauges located in the Coast Range mountains of British Columbia and Yukon,

Canada. The goal of the analysis was to guide decisions concerning stream gauge network design, and to ensure that the full complexity of the regional hydrology is captured. Our analysis showed that the streamflow network is consistent with a small-world network, a network architecture common in nature which is known to be efficient and stable. Stability ensures that the network is robust to the loss of nodes.

Community structure was apparent in the streamflow network, and we exploited this to show that 90% of the stations analyzed fall within just three main groups. These communities were shown to be defined by their hydrographs, which were in turn determined primarily by basin elevation. The number of communities reflects the diversity of hydrologic regimes, and the number of stations per community sets the extent to which each is sampled. We then argued that the idealized sampling strategy should span the full range of hydrological regimes, while retaining some degree of redundancy. Finally, we identified a number of stations which warrant special attention because they characterize rare or undersampled hydrologic regimes.

2C1.5 ID:7234 **14:30**

Validation of CloudSat Products Using In-situ Observations

Hong Lin [1], *David Hudak* [2], *Peter Rodriguez* [2]
[1] Meteorological Service of Canada, Environment Canada
[2] Science and Technology Branch, Environment Canada
Contact: Hong.Lin@ec.gc.ca

CloudSat is satellite whose goal is to measure cloud properties from space with a nadir point 94 GHz radar. It provides information on the vertical structure of cloud systems and their microphysical properties for weather forecasting applications and climate research. In this study, we evaluated the performance of retrieval algorithms by comparing CloudSat products against in situ aircraft data collected over southern Ontario, Canada. The purpose of this study is to verify the applicability of CloudSat retrieval algorithms for the Canadian environment.

The validation was focused on the cold season mixed-phase cloud systems and lake effect winter storms. The CloudSat products were compared with aircraft measurement collected during Canadian CloudSat/CALIPSO Validation Project (C3VP). The main cloud parameters evaluated are: cloud ice water content (IWC), liquid water content (LWC), snow water content (SWC), cloud vertical structure and cloud phase. Cloud microphysical properties measured by in situ probes on aircraft were used to derive various cloud parameters for comparison. Because of the high spatial resolution, the aircraft measurements are able to characterize the variability of the cloud properties. In our evaluation, some of the maximum and minimum values of the cloud parameters were also used to study the uncertainties of the CloudSat products. Despite the limitations and uncertainties, analysis showed that there is general agreement between CloudSat retrievals and aircraft measurements. The analysis also revealed that the proper distinction of cloud phase would help to improve IWC, LWC retrieval quantitatively, especially for winter mixed phase cloud system.

2C1.6 ID:7334 **14:45**

Identifying winter weather conditions using geostationary satellite

Robert Rabin [1], *Ismail Gultepe* [2]
[1] NOAA/National Severe Storms Lab and Cooperative Institute for Meteorological Satellite Studies
[2] Environment Canada, Cloud Physics and Severe Weather Research Section, Toronto ON M3H5T4
Contact: Rabin@ssec.wisc.edu

The field programs conducted by Environment Canada near St Johns, NL and Goose Bay, NL in the winters of 2013 and 2014, respectively, were used in this work. The goals of these programs were to validate satellite-based nowcasting products, including snow amount, wind intensity, cloud cover etc., over northern latitudes with potential applications to Search And Rescue (SAR) operations. Ground based in-situ sensors and remote sensing platforms were used to measure microphysical properties of precipitation, clouds and fog, radiation, temperature, moisture and wind profiles. Infrared radiation observations from the geostationary GOES-east satellite provided estimates of cloud top temperature and height, phase (water, ice), hydrometer size, optical depth, and horizontal wind patterns at 15-minute intervals. In this work, a simple algorithm developed for identifying clouds capable of producing high snowfall rates and wind information from the satellite observations will be described. The cloud top properties obtained from the output of this technique will be validated using the measurements from the ground-based in-situ and remote sensing platforms over a variety of situations and measurement uncertainties will be emphasized.

The changing Arctic cryosphere: Drivers, feedbacks and biogeochemical impacts PART 2 / La cryosphère arctique en mutation: Facteurs déterminants, rétroactions et impacts biogéochimiques PARTIE 2

Room / Endroit (Courchesne), Chair / Président (Christine Michel & C.J. Mundy), Date (03/06/2014), Time / Heure (13:30 - 15:00)

2C2.1 ID:7314 **13:30**

The changing sea ice regime of Hudson Bay and Hudson Strait: implications for shipping to Churchill MB

David Fissel , *Mar Martínez De Saavedra Álvarez* , *Randy Kerr*
ASL Environmental Sciences Inc
Contact: dfissel@aslenv.com

On average, sea ice is present in Hudson Bay from late October through most of July. However, large reductions in sea ice extent have previously been reported for both the fall and early summer. A database of Canadian Ice Service (CIS) ice charts using high (4 km) spatial

resolution, for the years 1968 to 2013 inclusive, are used to analyse the long-term sea ice trends in relation to interannual variability for the period 1971-2013 along the shipping route from Churchill MB eastward through Hudson Strait to Baffin Bay. From mid-June to late July, the reductions in sea ice extent are comparable along the shipping route in Hudson Bay and Hudson Strait with reductions ranging from 5 to 11 percent per decade. In the latter part of July, Hudson Strait has larger reductions than for the shipping route portion of Hudson Bay. Large reductions in sea ice extent, ranging from 6 to 12 percent per decade, occur for mid-November to mid-December. The largest reductions occur in the latter half of November for Hudson Bay and in the first half of December for Hudson Strait. As the fall progresses, Hudson Bay exhibits an overall reduction in first year ice but this is offset by an increase in the concentration of the thinner new and young ice categories. Old ice, including multi-year ice, has been reported only very infrequently, with virtually no occurrences over the past 15 years. The impact of the changing ice conditions along the shipping corridor to Churchill will be evaluated by considering the changes in partial ice concentrations by ice types in relation to various ship ice ratings.

The role of changing regional air temperatures and winds, derived from four long-term weather stations along the shipping route, will be examined to estimate long-term changes in atmospheric effects on sea ice concentrations.

2C2.2 ID:7266 **13:45**

Study of sea ice dynamics in the Gulf of St. Lawrence using a nested-grid ocean-ice model

Jorge R. Urrego-Blanco , Jinyu Sheng
Department of Oceanography. Dalhousie University.
Contact: jorge.urrego.blanco@dal.ca

A nested-grid ocean-ice model for the eastern Canadian shelf is used to study sea ice conditions in the Gulf of St. Lawrence (GSL). The model is based on the Nucleus for the European Modelling of the Ocean (NEMO) with OPA 9.0 as the ocean component and the 2-category dynamic-thermodynamic model LIM2 as the ice component. The model is forced by atmospheric reanalysis fields produced by Large and Yeager (2004). The model results are used to examine the effect of oceanic and atmospheric forcing on the sea ice formation in the GSL, with a special emphasis on (1) the role of thermodynamics and dynamics on the sea ice formation and (2) the sensitivity of sea ice formation to the net heat fluxes between the ocean-ice system and atmosphere in the GSL. The analysis of model results suggests that the presence of sea ice over most parts of the Gulf is more affected by thermodynamics than ice dynamics. In regions directly affected by the Gaspé current over the western GSL the ice dynamics is also important. A sensitivity study indicates that uncertainties in the estimation of sensible heat fluxes can lead to significant errors in the simulated sea ice coverage in the region.

2C2.3 ID:7296 **14:00**

Matching the distribution, function and taxonomy of marine microbes

Connie Lovejoy
Université Laval
Contact: connie.lovejoy@bio.ulaval.ca

The importance of species diversity is only sometimes recognized among biological oceanographers. However, morphological species data such as the timing and makeup of the spring bloom has been implicitly used to infer biogeochemical processes such as the timing of maximum carbon and nitrogen utilization in the upper ocean. Environmental gene, transcriptome and ribosomal surveys can identify species and genes over regions, seasons and depths. Since the environment selects species best able to dominate under more or less narrow ranges of conditions; species composition itself is a promising tool that could be used to infer the biogeochemical processes and even the history and duration of physical processes over different regions and depths of the ocean.

2C2.4 ID:7183 14:15

Inter-annual variability in snow cover significantly affects nutritive quality of calanoid copepods at large scales.

Steven Duerksen [1], *Gregory Thiemann* [2], *Suzanne Budge* [1], *Michel Poulin* [3], *Christine Michel* [4]
[1] Dalhousie University
[2] York University
[3] Canadian Museum of Nature
[4] Fisheries and Oceans Canada
Contact: swd@dal.ca

Global temperatures are increasing due to rising CO2 levels and the Arctic is being disproportionately affected. Changes in ice, snow and water conditions are all occurring or anticipated, yet the impacts of these environmental changes on energy flow in marine food webs remain largely unknown. Our results suggest that inter-annual differences in snow cover indirectly control the nutritive quality of a keystone functional group, calanoid copepods, over a broad spatial scale. We analyzed the fatty acid and stable isotope compositions of primary producers and consumers near Resolute Bay, Nunavut in the springs of 2011-2013. Calanus fatty acid profiles differed significantly between years and inflows ($R2 = 0.29$, $AIC = 92.8$, $p < 0.001$). In years with deeper spring snow cover, copepods had significantly higher levels of nutritious polyunsaturated fatty acids (PUFA) compared to years with less snow ($p < 0.001$). PUFA levels in algae showed a similar trend, but were not significantly different between years ($p = 0.13$). However, as fatty acid profiles of copepods indicated that ice algae was their primary source of dietary lipid, it is likely that these same patterns exist for ice algae at a larger scale. Calanoid copepods in the Canadian Archipelago utilize an income breeding strategy and are reliant upon high quality PUFA from ice algae to successfully reproduce. Our results suggest that climate driven changes in the Arctic have the potentially to significantly affect the availability of these key resources, and therefore may alter the structure and function of marine food webs.

2C2.5 ID:7079 14:30

Rapid Photobleaching Of Dissolved UV-absorbing Compounds Produced By Arctic Sea Ice Algae

Huixiang Xie
Institut des sciences de la mer, Université du Québec à Rimouski
Contact: huixiang_xie@uqar.qc.ca

Bottom sections of landfast first-year sea ice in the Amundsen Gulf, Western Canadian Arctic were collected during the peak blooms of ice algae in 2005 and 2008. The ice samples were melted, 0.2-micrometer filtered, and analyzed for spectral absorbance. The absorption spectra exhibited pronounced shoulders in the ultraviolet (UV) region with peak wavelengths at ~315 and ~330 nm, implying the presence of ice algae-derived UV-absorbing compounds (UVACs) such as mycosporine-like amino acids (MAAs). Solar-simulated irradiation completely removed the absorption shoulders within 10-30 min. Wavelength-dependent irradiation indicated that the UVACs were readily photodegraded by the UV but resistant to the visible. It is posited that the high photodegradability of the UVACs resulted from sensitized photoreactions. Results from this study suggest that these UVACs can only provide partial protection of ice algae against solar UV radiation reaching the bottom ice.

Coastal Oceanography and Inland Waters PART 2 / Océanographie côtière et eaux intérieures PARTIE 2

Room / Endroit (Ouellet), Chair / Président (Jinyu Sheng, Guoqi Han & Ram Yerubandi), Date (03/06/2014), Time / Heure (13:30 - 15:00)

2C3.1 ID:7190 13:30

Submesoscale frontolysis event in the Saint-Lawrence estuary: observations vs mixed-Layer surface quasi-geostrophy predictions

Julien Robitaille , *Cédric Chavanne*
UQAR/ISMER
Contact: julien.robitaille@uqar.ca

High-resolution observations of an oceanic submesoscale frontolysis event in the Saint-Lawrence Estuary in Quebec, Canada, have recently been obtained with high-frequency radars and with an undulating underwater vehicle towed behind a ship, as well as shipborne acoustic doppler current profilers. We compare these unique high-resolution observations to the predictions of a new surface quasi geostrophic model that incorporates a surface mixed-layer. This model has already been proven to successfully reproduce the observed dynamics of a strain-driven frontogenesis event that occurred west of O'ahu, Hawaii. Here, we further test the model by applying it to a different and more complete set of observations. Model limitations are discussed.

2C3.2 ID:7292 13:45

Using numerical particle-tracking to study the movement of marine animals in eastern Canadian waters

Kyoko Ohashi , *Jinyu Sheng*

Department of Oceanography, Dalhousie University
Contact: kyokoohashi@gmail.com

A numerical particle-tracking scheme, in combination with time-varying, three-dimensional fields of numerically simulated hydrography and circulation, are used to study the movement of two marine animal species (the American eel and the Atlantic sturgeon) in the coastal waters of eastern Canada. In both examples, the hydrography and circulation are simulated using the Princeton Ocean Model, and observational information yielded by tagging of the two species (in a project known as the Ocean Tracking Network) are used as guidance in setting the experiment parameters. In the case of the American eel, the aim is to understand the effects of various observed and hypothesized behaviours (e.g. selective tidal stream transport, diel vertical migration, and a preference for higher salinity) during its spawning migration through the St. Lawrence Estuary and the Gulf of St. Lawrence on its way to the Sargasso Sea. In the case of the Atlantic sturgeon, the aim is to locate its overwintering sites in the Bay of Fundy. We also discuss features of the hydrography that may guide the Atlantic sturgeon in its annual migration into the Bay of Fundy, which is undertaken predominantly by individuals from the nearby Saint John River but is known to include some from as far away as Hudson River in the northeastern USA.

2C3.3 ID:7146 14:00

High-order numerical simulations of coastal shoaling of internal solitary waves of elevation

Christopher Subich [1], *William Xu* [2], *Marek Stastna* [2]
[1] Environment Canada
[2] University of Waterloo
Contact: Christopher.Subich@ec.gc.ca

Internal solitary waves of depression, commonly seen in deep water, have a wide variety of rich, breaking modes that can result in mixing of fluid near the thermocline. However, they are only dynamically permitted in regions where the thermocline is above the mid-depth, so their effect on the benthic boundary is limited. Their cousins, internal solitary waves of elevation, occur in regions where the thermocline is below the mid-depth, and their shoaling and subsequent breaking can potentially cause significant mixing in and near the boundary layer. Using a newly-developed pseudospectral model for the numerical simulation of the incompressible Navier Stokes equations capable of directly mapping bottom topography, the evolution of shoaling waves of elevation is characterized, including the onset of three-dimensional motion.

2C3.4 ID:7193 14:15

Simulating coastal circulation off East Newfoundland

Zhimin Ma [1], *Guoqi Han* [2], *Brad De Young* [1]
[1] Memorial University
[2] Fisheries and Oceans Canada
Contact: Guoqi.Han@dfo-mpo.gc.ca

A three dimensional coastal ocean model was established to examine circulation variability off East Newfoundland. Simulations were carried out from early spring to late summer in 2001.

Hourly spatially variable atmospheric fields from Canadian Meteorology Center were applied to force the model. Results were first extracted and compared with observed sea level, temperature and currents. Calculated sea level well captured both seasonal and weekly variations. The root-mean-square sea level difference between model and observation was 5.2 cm at St. John's. The model temperature and currents agree fairly with observations. Features such as coastal upwelling and stratification evolution will be examined and discussed.

2C3.5 ID:7010 **14:30**

Barotropic tidal circulation along the northern coast of British Columbia

Pramod Thupaki , *Mike Foreman* , *Charles Hannah* , *Di Wan*
Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney
Contact: thupakip@yahoo.com

A three-dimensional unstructured grid application of the Finite Volume Coastal Ocean Model (FVCOM) was used to simulate barotropic tidal dynamics for the northern coast of British Columbia in and around Hecate Strait and Douglas Channel. The numerical model was validated using tide gauge and current meter and will eventually be used to assist with the prevention, preparedness, and response to oil spills along the north coast of British Columbia.

2C3.6 ID:7008 **14:45**

Observed and Modelled Currents in the Discovery Islands, British Columbia

Di Wan [1], *Mike Foreman* [2]
[1] University of Victoria
[2] Institute of Ocean Sciences, Department of Fisheries and Oceans
Contact: diwan@uvic.ca

Long-term ADCP observations are analyzed for the region of Discovery Islands, British Columbia to show circulation patterns, and address issues directly related to the transmission of Infectious Hematopoietic Necrosis Virus (IHNV) in farmed Atlantic Salmon. An unstructured finite volume coastal ocean model had been developed for the region, but the resolution did not seem to be fine enough to capture the complex circulation patterns in many sub-regions. A higher resolution numerical model has been developed, and comparisons between these ADCP observation and the new model results will be presented to provide some validation of the model.

Detection and attribution of high latitude climate change / Détection et attribution du changement climatique à haute latitude

Room / Endroit (Léonard-Blais), Chair / Président (Nathan Gillett & Francis Zwiers), Date (03/06/2014), Time / Heure (13:30 - 15:00)

2C4.1 ID:7031 13:30

Attributing northern high-latitudes precipitation change in late 20th century to human influence

Hui Wan [1], *Xuebin Zhang* [1], *Francis Zwiers* [2], *Seung-Ki Min* [3]
[1] Climate Research Division, Environment Canada
[2] Pacific Climate Impacts Consortium, University of Victoria
[3] School of Environmental Science and Engineering, Pohang University of Science and Technology
Contact: hui.wan@ec.gc.ca

This study revisits influence of external forcing on northern high-latitudes precipitation. We compare annual and semi-annual precipitation from updated observations and those from CMIP5 simulations for 1966-2005 over northern high-latitude land north of 50N. We find that the multi-model simulated responses to the effects of anthropogenic forcing or of anthropogenic and natural forcing combined are consistent with observed changes. We also find that the influence of anthropogenic forcing may be separately detected from that of natural forcings. We examined the sensitivities of the detection results to the use of different detection methods (optimal fingerprinting and correlation-based), different ways of data filtering, and different model simulations for the estimation of model responses and natural variability, and found that the detection results are robust.

2C4.2 ID:7128 13:45

Have ozone changes had a detectable influence on surface temperature?

Nathan Gillett
CCCma, Environment Canada
Contact: nathan.gillett@ec.gc.ca

Climate model simulations from the CMIP5 archive of the response to historical variations in both tropospheric and stratospheric ozone show a pronounced surface temperature response over the high latitude Southern Ocean and Antarctica, consistent with previous simulations of the response to stratospheric ozone change. They also show a significant temperature response over the Northern Hemisphere, with pronounced warming over most of North America. This response is likely driven predominantly by tropospheric ozone changes. A detection and attribution analysis is applied to test whether such changes are identifiable in surface temperature observations over the past 60 years.

2C4.3 ID:7122 INVITED/INVITÉ 14:00

Human influence on Greenland temperature over the last 140 years.

Aurélien Ribes
CNRM-GAME, Météo France - CNRS
Contact: aurelien.ribes@meteo.fr

Several features make Greenland a highly interesting place to observe and study climate change.

Due to its Arctic location, Greenland is expected to experience a larger warming than the global average. But at the same time, internal variability over this region is particularly large, leading to a quite small signal to noise ratio regarding the detectability of human induced warming. Another interesting feature of Greenland is that temperatures on its coast have been continuously observed, and homogenised, from 1873 to present.

Here, we apply two standard detection methods to study human influence on Greenland temperatures, with some additional concern on how CMIP5 models are able to simulate decadal variability over this region. Our results suggest that human influence is detectable over the last 140 years. However, this conclusion is provided with two caveats. First, only about a third of the strong warming observed over the last three decades seems to be related to global warming. Second, most models fail to simulate a decadal variability as large as that suggested by observations. In particular, the early 20th century warming, particularly marked over Greenland, is not reproduced in historical ensembles. This makes the consistency between models and observations debatable.

2C4.4 ID:7136 **14:15**

Multi-Model Detection and Attribution of Arctic Temperature Change

Mohammad Reza Najafi [1], *Francis Zwiers* [1], *Nathan Gillett* [2]
[1] Pacific Climate Impacts Consortium, University of Victoria
[2] Canadian Centre for Climate Modelling and Analysis
Contact: rnajafi@uvic.ca

To date only the combined response to anthropogenic forcings has been detected in observed Arctic temperatures, even though modelling studies suggest that greenhouse gases and aerosols should have made distinctive contributions to Arctic temperature evolution. This study uses updated observations and the latest model simulations from the Coupled Model Intercomparison Project (CMIP5) to quantify the effects of individual combinations of external forcing agents on large-scale Arctic temperature variations. Our results show that large-scale changes in Arctic temperature observed over the past 100 years are largely due to the effects of anthropogenic forcing, with the effect of greenhouse gases being separately detectable from the combined effect of other anthropogenic forcing agents (including aerosols, land use change and other factors). Natural forcing agents (variations in solar and volcanic activity) do not appear to have had a detectable influence on Arctic temperatures over this period. The results are based on historical observations of surface air temperatures over land in the circumpolar region north of 60˚N for the period 1913-2012, six CMIP5 climate models that provided climate simulations using historical greenhouse gas changes only, historical natural forcings only, and historical variations in all forcings (greenhouse gases, other anthropogenic forcings, and natural forcings) combined, and 42 CMIP5 models that collectively provided 24800 years of pre-industrial control simulations. Consistent results were obtained with three different observational datasets that were assessed in the IPCC 5th Assessment Report, including CRUTEM4, GISS, and MLOST. Results were found to be robust to use of a smaller domain encompassing the circumpolar region north of 65˚N.

2C4.5 ID:7222 **14:30**

Attributing intensification of precipitation extremes to human influence on the climate

Xuebin Zhang [1], *Francis Zwiers* [2], *Hui Wan* [1]
[1] Climate Data and Analysis Section, Climate Research DIvision, Environment Canada
[2] Pacific Climate Impacts Consortium, University of Victoria
Contact: fwzwiers@uvic.ca

Observations indicate that extreme precipitation has intensified over the past several decades, with statistically significant trends occurring at substantially more stations globally than would be expected by random chance. This study evaluates whether human influence has played a role in this intensification, and provides estimates of the magnitude of the human contribution. We consider the annual maxima of daily (RX1day) and 5-day consecutive (RX5day) precipitation amounts over the Northern Hemisphere land area for 1951–2005 and compare observed changes with expected responses to external forcings as simulated by multiple coupled climate models participating in CMIP5. The effect of anthropogenic forcings can be detected in extreme precipitation observations, both individually and when simultaneously estimating anthropogenic and naturally forced changes. The effect of natural forcings is not detectable. The results imply that human influence has intensified annual maximum 1-day precipitation in sampled Northern Hemisphere locations by 3.3% [1.1% to 5.8%, >90% confidence interval] on average. This corresponds to an average intensification in RX1day of 5.2% [1.3%, 9.3%] per degree increase in observed global mean surface temperature consistent with the Clausius-Clapeyron relationship.

2C4.6 ID:7342 14:45

Estimating the Pattern of Human Climatic Influence in Sea Surface Temperatures

Adeline Bichet [1], *Paul J. Kushner* [1], *Lawrence Mudryk* [1], *Laurent Terray* [2], *John Fyfe* [3]
[1] University of Toronto
[2] CERFACS/CNRS, URA1875, Toulouse, France
[3] Canadian Centre for Climate Modelling and Analysis, Environment Canada, Victoria, Canada
Contact: abichet@atmosp.physics.utoronto.ca

In this work we seek to identify the pattern of sea surface temperature (SST) and sea-ice concentration response that has been forced by anthropogenic climate change using recently developed statistical methods. We use this estimated response pattern as a perturbation to force the atmosphere-land climate model CESM-CAM5 in a transient mode (ensemble covering 1980-2040), in order to interpret past climate change and to provide near-term decadal predictions. Our method is based on a very simplified version of the classic detection and attribution approach, whereby we extract from observed SSTs and sea-ice concentrations a time-independent spatial pattern, p(x,y) of the SST and sea-ice concentration response associated with anthropogenic forcing. This spatial pattern is then scaled by a temporal form, G(t), derived from the time evolution of the anthropogenic forcing to obtain a time varying pattern of anthropogenically forced SSTs, p(x,y,t). We first evaluate the robustness of our method, and find that the sensitivity of the anthropogenic SST response to the specific temporal form used is rather small, and that we can expect to account for 30-40% of the spatial variance of the forced signal from a single observation without additional information about the forcing. This fraction increases to 50-70% for global surface air temperature. Based on the spatial pattern p(x,y) extracted from observations, we find that the estimated anthropogenic impact on SSTs consists mostly of a warming of the mid-latitudinal coasts, Northern Indian Ocean and high northern latitudes, which

is in general agreement with previously published work. We then use the ensemble of simulations forced with our estimate of anthropogenically forced SSTs and sea-ice concentrations to investigate the impacts of these spatial patterns on land surface climate. We focus on the impacts on the hydrological cycle and atmospheric circulation, with a focus on seasonal snow cover responses and SSTs connection to high latitude climate.

Remote sensing of coastal and arctic waters PART 2 / Télédétection des eaux côtières et arctiques PARTIE 2

Room / Endroit (Parent), Chair / Président (Cédric Jamet & Simon Bélanger), Date (03/06/2014), Time / Heure (13:30 - 15:00)

2C5.1 ID:7290 INVITED/INVITÉ 13:30

All-Weather Remote Sensing of Ocean Surface Features with SAR: Waves, Winds, Sea surface Temperature Gradients, Oil and Surfactants

William Perrie [1], *Biao Zhang* [2], *Hui Shen* [3], *Haiyan Li* [4], *Tao Xie* [2]
(Presented by *Bash Toulany*)
[1] Bedford Institute of Oceanography
[2] Nanjing University of Information Science and Technology, China
[3] Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
[4] Graduate University, Chinese Academy of Sciences, China
Contact: perriew@dfo-mpo.gc.ca

The high resolution, flexible imaging properties of spaceborne SAR (synthetic aperture radar) systems, as well as their independence from sunlight and cloud conditions, make SAR imagery a crucial source of high-resolution high- accuracy information for various marine applications, e.g. ocean surface wind, wave, currents, oil spill monitoring, and sea ice monitoring, on global and regional scales. However, compared to other spaceborne remote sensing applications in marine areas, particularly in (pre-) operational services, e.g., sea surface temperature (SST) and ocean color by optical sensors, sea level and sea surface height (SSH) from radar altimeters (RAs), and sea surface wind from scatterometers and radiometers, there is still considerable room for improvement for SAR. Our focus is retrieval of marine winds, waves, sea surface temperature gradients,crude oil and surfactants, at high resolution, in all weather conditions, obtained from recently launched satellites capable of fully polarized SAR, particularly RADARSAT-2. We have derived algorithms and models to get winds, waves, crude oil from RADARSAT-2 SAR, and we have developed collaborations with SAR experts to develop methodology for surface currents from SAR, anticipating RADARSAT Constellation Mission (RCM), to be launched in 2018.

2C5.2 ID:7286 **14:00**

The impact of oceanic and climatic forcing on the inter-annual variability of pelagic phytoplankton in NOW polynya

Christian Marchese [1], *Camille Albouy* [1], *Dany Dumont* [2], *Jean-Éric Tremblay* [3], *Simon Bélanger* [1]

[1] UQAR
[2] ISMER
[3] U. Laval
Contact: christian.marchese@uqar.ca

Located between Greenland and Ellesmere Island (Canadian Arctic), the North Water (NOW), which begins to form in winter and dissolves in early-to-late summer, is one of the largest and most productive polynyas in the Northern Hemisphere. Recent sea ice and oceanic observations reveal that major changes are happening in the NOW. For instance the ice bridge that links Ellesmere Island to Greenland and forms when the region experiences optimal freezing conditions, tends to break up earlier and to form less often, leading to an important ice transport southward. Overall, changes in sea-ice as a result of climate change may have indirect effects on the primary production and trophic couplings of Arctic food webs. Using satellite ocean color imagery, phytoplankton phenology in the NOW was examined following a sub-regional approach (8 sub-regions were identified to approximate the distribution of the different water masses) from 1998 to 2012. The annual cycle of chlorophyll-a concentration averaged over 8-days period was fitted to a Gaussian model from which a baseline of phenological characteristics was extracted. Timing, amplitude and duration of the phytoplankton bloom among the eight defined sub-regions showed a strong inter-annual variability. Interestingly, the onset of the bloom tended to happen earlier in season in most sub-regions. For instance, consistent with previously reported results, the earliest bloom occurred around Carey Island in the eastern part of the polynya, while the latest bloom, as expected, occurred in the Kane Basin, where land-fast ice prevents light to penetrate the water column until July. Overall, these preliminary results neatly suggest the dominant role of a succession of oceanic and climatic forcing in controlling the timing and magnitude of blooms in the NOW. In particular, together with the wind (direction and speed) changes in sea-ice (extent and concentration) may have a strong impact, especially at specific locations. This presentation will outline the potential role that sea-ice and wind could play at local scale on the inter-annual variability of pelagic phytoplankton in NOW.

2C5.3 ID:7182 **14:15**

Inferring the upper ocean 3D circulation from surface observations

Cédric Chavanne [1], *Patrice Klein* [2]
[1] UQAR-ISMER, Rimouski, Canada
[2] IFREMER, Brest, France
Contact: cedric_chavanne@uqar.ca

Surface quasi-geostrophic (SQG) theory has been recently shown to describe the upper open ocean (0-500 m) dynamics better than the traditional interior quasi-geostrophic theory, both in numerical simulations and in observations. All these studies approximate the ocean as a single semi-infinite layer with homogeneous stratification, therefore either ignoring or simplifying too much the impact of the quasi-ubiquitous surface mixed-layer (SML). A new SQG model is

presented here, which explicitly incorporates a fully active SML. The model approximates the ocean as a two-layer system, composed of a finite surface layer with weak and homogeneous stratification, and a semi-infinite lower layer with stronger and homogeneous stratification. The interface between the two layers is allowed to move vertically, and the dynamics of the system are driven by buoyancy anomalies on both the ocean surface and the interface between the two layers. Buoyancy anomalies on the interface can be obtained from buoyancy anomalies on the ocean surface and the surface streamfunction, both of which can be measured from space. The model skill in reproducing the three-dimensional circulation in the upper ocean from surface data is checked against the output of a high-resolution primitive-equation numerical simulation.

2C5.4 ID:7339 14:30

Remote sensing of the harmful algae Alexandrium fundyense in the Bay of Fundy, Canada

Marie-Helene Forget [1], *Emmanuel Devred* [1], *Jennifer Martin* [2], *Shubha Sathyendranath* [3], *Venetia Stuart* [4], *Edward Horne* [2], *Trevor Platt* [4], *Peter Smith* [4]
[1] Université Laval
[2] DFO - St. Andrews Biological Station
[3] Plymouth Marine Laboratory
[4] DFO - Bedford Institute of Oceanography
Contact: marie-helene.forget@takuvik.ulaval.ca

Alexandrium fundyense, a toxic dinoflagellate blooming every summer in the Bay of Fundy, constitutes a health threat to humans through consumption of contaminated shellfish and fish. Physical, biological and optical variables were measured both in situ and in the laboratory in spring and summer of 2007 to 2013. The size classes and types of phytoplankton present in the Bay of Fundy at the time of sampling, determined by HPLC pigment data, showed a phytoplankton community dominated by microphytoplankton with a variation in the community structure (dinoflagellates and diatoms). The relationship between the occurrence of Alexandrium fundyense and diatoms was investigated from a decadal time-series of remotely sensed data and in situ taxonomic counts. We explore the potential of detecting Alexandrium fundyense indirectly, using some indicators of the marine ecosystem that are accessible to remote sensing such as the occurrence of diatoms, sea-surface temperature and wind. Moreover, the optical properties (absorption and fluorescence spectra) of 12 cultures of diatoms and dinoflagellates, including Alexandrium fundyense, grown under stable conditions were measured and results will be presented. An in situ fluorometer was designed according to the scientific evidence uncovered from the culture work and was used in the field.

2C5.5 ID:7247 14:45

Improvement of two MODIS-AQUA atmospheric correction algorithms using spectral relationships over optically-complex waters

Cédric Jamet , *Clémence Goyens*
Laboratoire d'Océanologie et de Géosciences
Contact: cedric.jamet@univ-littoral.fr

Atmospheric correction algorithms over coastal and turbid waters are still very challenging. Indeed, the classic black pixel assumption (i.e. the ocean is totally absorbant) is not valid in the

near-infrared (NIR) bands and new assumptions/hypothesis are necessary for taking into account the NIR marine reflectance. Numerous NIR schemes have been developed for the past decades. But their accuracies do not reach the requirements for ocean color studies in this kind of waters. An alternative is to use spectral relationships between marine reflectances at two different wavelengths, as proposed by Wang et al. (2012). New spectral relationships in the red and NIR and a validation exercise will be presented, leading to propose a new NIR scheme valid for very to extremely turbid waters. These new spectral relationships are implemented in the standard NASA MODIS and MUMM atmospheric correction algorithms. MODIS-AQUA images over the Strait of Georgia and the St-Lawrence river will be shown, with comparison with the standard NASA processing.

POSTER-General Atmospheric Science / AFFICHES- Sciences de l'atmosphère en général

Room / Endroit (Congrès A), Chair / Président (Michael Scarratt), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E1.1 ID:7248 **15:30**

Water saturation curve used on the ice crystal growth diagram

Médéric St- Pierre , *Julie Theriault*
Université du Québec à Montréal
Contact: theriault.julie@uqam.ca

It has been known for a long time that the shape of ice crystal depends on both the air temperature and the relative humidity of the environment. The atmospheric conditions in which they grow are summarized in two types of diagrams based on (1) the excess of vapour density with respect to ice and (2) the supersaturation with respect to ice both varying with air temperature. These two classification diagrams also include the water equilibrium vapour-density excess with respect to ice and the supersaturation with respect to ice at water equilibrium varying with air temperature. The goal of this study is to examine the definition of the saturation relative to water equilibrium curves represented on these diagrams. The temperature of the ice crystal is warmer than the environment due to growth by deposition. This suggests that water saturation can be computed either using the air temperature (thermal equilibrium) or the ice crystal temperature (not in thermal equilibrium with the environment). The results indicate that the definition of the water saturation curves is inconsistent between diagrams. For example, the difference in the excess of vapour density calculated at air temperature is up to 30 % more than the one calculated at the ice crystal temperature event if the temperature differences are very small (< 0.45 °C). Updated versions of the diagrams are finally proposed to clarify the definition of these water saturation curves.

2E1.2 ID:7103 **15:30**

Sensitivity of snowflake types on the production of winter precipitation types

Housseyni Sankare , *Julie M. Theriault*
Departemet de sciences de la Terre et de l'atmosphere de l'université du Québec à Montréal
Contact: sankare@sca.uqam.ca

Several types of precipitation can occur during winter storms when the temperature is near 0°C. Among these categories, wet snow, freezing rain and ice pellets are the most damaging. They are formed when a warmer layer (T> 0°C) is located above a sub-freezing layer (T<0°C) near the surface. The precise prediction of the type of precipitation is critical to understand how winter storms evolve and to evaluate the severity of such meteorological events. The goal of this study is to assess the impact of the type of snowflake aloft on the precipitation type reaching the surface. To address this, a one dimensional cloud model coupled with a bulk microphysics scheme is used. Two different snowflake types (dendrites and columns) have been added to the model, which initially only accounted for an average type of snow. First, the results will show how the terminal velocity of these types of snow varies with the liquid fraction. Second, the results will be compared with observations associated with a rain-snow transition along a mountainside. The characteristics of the rain-snow transition will be studied with respect to the type of snow produced. Third, systematic studies on the link between the vertical temperature profile characteristics, the thickness of the warm layer aloft, precipitation rates, initial snowflake types and the production of surface precipitation types will be conducted. Overall, this study contributes to a better understanding of winter precipitation type formation mechanisms, which can lead to catastrophic weather events.

2E1.3 ID:7246 **15:30**

Arctic buoy deployment in support of METAREAs

Jonathan Bau
Meteorological Service of Canada
Contact: kitty.wilkes@ec.gc.ca

The Meteorological Service of Canada’s commitment to providing quality marine forecasts and its participation in the METAREAs marine project requires data collection of several meteorological observations in the Arctic Ocean. As part of the METAREAs marine project, MSC is deploying an array of ice buoys over the Arctic Ocean over a span of three years with the help of the Department of National Defense. These buoys will collect data on air temperature, barometric pressure and sea ice movement. The team consists of the METAREA Marine Monitoring Coordinator, MSC meteorologists and several military personnel to pilot the aircraft and deploy the buoys. Weather conditions can change rapidly in the Arctic and so the latest weather data and weather forecast are critical for the successful deployment of the buoys. As one of the MSC Arctic meteorologists on the trip, I was responsible for preparing a forecast each morning for buoy deployment and flight planning purposes. This poster presentation will highlight my experiences during the trip. The deployment of 10 buoys in 2013 was successful and the data reported is readily available at the forecast offices for use in marine forecasting. MSC will deploy the remaining buoys later this year to complete the coverage of the Arctic

Ocean.

2E1.4 ID:7120 15:30

Operational Bias Correction of RWIS Pavement Temperature Forecasts

Iain Russell , Bryn Jones , Majid Fekri
Pelmorex Inc.
Contact: irussell@pelmorex.com

The forecasting of pavement temperatures for winter road maintenance operations is becoming increasingly important in the effort to increase operational efficiency through better use of equipment and freeze-point depressant chemicals during winter weather. Road Weather Information Systems (RWIS) facilitates this through use of road weather observations, including pavement and subsurface temperature sensing, coupled with weather forecasts and a heat balance model to predict pavement temperature over 24 to 48 hours. Currently, one heat balance model in vogue is METRo, developed by Environment Canada, which explicitly forecasts pavement temperatures and road conditions under the sole maintenance assumption that plowing occurs at 2 cm snow depth thresholds. As METRo can exhibit diurnal biases in its forecast pavement temperatures, an operational correction scheme was implemented to improve forecast accuracy on an hourly basis. The use of weighted and blended METRo model data to generate hourly bias corrections, based on the recent performance of respective model runs as verified by the actual in situ observations at RWIS sensor stations, is explored. By applying such corrections, using 45 days of antecedent performance metrics, the general forecast result was improved. Stations with unique exposures, such as those in recurring shadow for part of the day (rock cuts, mountainous or forested terrain), have such influences implicitly accounted for; an important advantage considering the high impact solar radiation has on pavement temperature. One challenge was that METRo also forecasts pavement conditions and these are dependent on the presence of moisture on the road and whether the concurrent pavement temperature is above, at, or below freezing. When bias corrections changed the sign of the forecast pavement temperature, and/or shifted it to the other side of the forecast dew point, the road condition forecast needed to be altered as well in order for all three to be logically consistent.

2E1.5 ID:7045 15:30

Long-term air humidity variability in the Arctic region from upper-air observations

Alina Agurenko , Anna Khokhlova
RIHMI-WDC
Contact: agualina@ya.ru

Under climate change, atmospheric water content also tends to change. This gives rise to changes in the amount of moisture transferred, clouds and precipitation, as well as in hydrological regime. This work analyzes seasonal climatic characteristics of water deposited in the Arctic atmosphere, by using 1972-2011 data from 55 upper-air stations located north of 60°N. Regions of maximum and minimum mean values and variability trends are determined. In the summer, water amount is shown to increase in nearly the whole of the latitudinal zone. The comparison with the similar characteristics of reanalysis obtained by the other authors shows a good

agreement. Time variation in mean annual water amount crossing 70°N, which is calculated from observation data, is presented and compared with model results. The work is supported by the joint EC ERA.Net RUS and Russian Fundamental Research Fund Project "Arctic Climate Processes Linked Through the Circulation of the Atmosphere" (ACPCA) (project 12-05-91656-ERA_a).

2E1.6 ID:7051 15:30

The Canadian Regional Ensemble Prediction System: Model improvements and products

Ronald Frenette , Jean Brassard , Martin Charron , Amin Erfani , Normand Gagnon
(Presented by *Guy Roy*)
Environnement Canada
Contact: ronald.frenette@ec.gc.ca

CMC's Regional Ensemble Prediction System (REPS 2.0.1) became operational on Dec 4th 2013. This version, with a horizontal resolution of 15km is composed of 20 perturbed members and one control member. Each member integrates at 00Z and 12Z a limited-area version of the Global Environmental Multi-scale model (GEM) to produce a 72-hour forecast. The REPS initial conditions are generated by using the 20 perturbed analyses of the global ensemble prediction system (GEPS). Boundary conditions, also provided by the GEPS, are updated every hour during the integration. The REPS uses a single model configuration with stochastic perturbations of physical tendencies. With this version, REPS ensemble products are now generated and supported operationally and 24/7 at CMC. REPS products are now also available on internal and external web sites and in the Ninjo WMS layer. A Ninjo EPS layer is planned to be available operationally in the 1.8 version in the autumn of 2014. New summer severe weather convective products will be added on the web and Ninjo WMS for the summer of 2014.

External products are available at
http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/submenus/reps_e.html

2E1.7 ID:7147 15:30

Monthly and seasonal precipitation monitoring in Canada using CaPA

Marc Beauchemin
Environment Canada
Contact: marc.beauchemin@ec.gc.ca

Monitoring of precipitation anomalies over months and seasons in real-time is critical for many sectors: water control, hydroelectricity production and agriculture, to name a few. In Canada, a few governmental bodies produce such information, but very little in real-time. Moreover, the spatial resolution and skill is generally low. Since 2012, the Meteorological Service of Canada (MSC) has tested monthly and seasonal precipitation monitoring maps using CaPA, MSC's operational precipitation analysis blending different types of data. In the USA, such precipitation monitoring over long time frames using a similar multi-data precipitation analysis is done since 2005 by the National Weather Service (http://water.weather.gov/precip/). This presentation explains the method used by MSC, the end product, user feedback and planned improvements.

2E1.8 ID:7139 **15:30**

Training Forecasters to Use Satellite Data in High Latitudes

Bryan Guarente , Wendy Schreiber-Abshire , Dr. Richard A. Jeffries , Dr. Gregory P. Byrd , Tsvetomir Ross-Lazarov
UCAR/The COMET Program
Contact: guarente@comet.ucar.edu

Forecasting for a massive country like Canada is daunting, especially with the sparseness of surface observations in the northern latitudes. Satellite information, especially water vapour imagery, can expand forecaster understanding of the atmospheric dynamics and kinematics. With this understanding, forecasters can build a personally-derived, complex, three- dimensional, mental model which can be used to evaluate and interpret numerical weather prediction data better. The COMET® Program, funded by the Meteorological Service of Canada, has built the "Satellite Palette" series for learners to experience building their own understanding of atmospheric processes through short, web-based, active-learning lessons. These include analyzing deformation zones, exploring atmospheric rivers and inferring three-dimensional structures from two- dimensional satellite imagery. Learners can track their progress through over 10 hours of training on the COMET Program's MetEd website to enhance their own palette of satellite forecasting tools. These and many other resources are freely available on the COMET Program's MetEd website (www.meted.ucar.edu).

2E1.9 ID:7002 **15:30**

Biogenic S versus Sea Salt Sulfate in Aerosols and Precipitation on the West Coast of Canada

Ann-Lise Norman , Fwziah Mohammad , Jamie Cameron
The University of Calgary
Contact: alnorman@ucalgary.ca

EPS (exopolymer surfactants), in association with bursting bubbles in the sea surface are suggested to be more important than atmospheric DMS (dimethylsulfide) in forming CCN (cloud condensation nucleii) in the marine atmosphere. If this were the case EPS could be anticipated to be found in association with conservative tracers of sea salt such as sodium in submicron aerosols while sulfate from DMS oxidation would be independent of them. Characteristics of the biogenic, anthropogenic and sea salt components of size-segregated aerosols, and comparisons to these same components in precipitation can provide insights into the role EPS versus DMS might play in the formation of precipitation. Marine biogenic sulfate in comparison to sea salt components in aerosols are examined in a study of precipitation collected along the Canadian Pacific northwest coast to evaluate the relative magnitude of each of these processes in aerosol dynamics.

POSTER-Climate Change and Extreme Events / AFFICHES- Le changement climatique et les événements extrêmes

Room / Endroit (Congrès A), Chair / Président (Lucie Vincent), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E2.1 ID:7004 15:30

Changes in the frequencies of record-breaking temperature events in China and its association with East Asian winter monsoon variability

Yaocun Zhang [1], *Xueyuan Kuang* [2]
[1] School of Atmospheric Sciences, Nanjing University
[2] School of Atmospheric Sciences, nanjing University
Contact: yczhang@nju.edu.cn

The daily maximum and minimum temperatures observed at the 1897 meteorological stations of China over the past 60 years (1951-2010) are analyzed in this study to examine the interdecadal variation of frequency for record-breaking event (RBE) of temperature in the context of global warming. The results indicate that the frequency of record-breaking high temperature in the first decade of the 21th century is the highest in the three decades from the 1980s to the 2000s, implying a distinct warming trend. Meanwhile, frequencies of record-breaking low temperature in the 1990s and the beginning of the 21th century are also significant. In particular, the RBEs of low temperature occurred over most of China in the 1990s but concentrated in northern China during the 2000s. To understand why the record-low temperatures in northern China are repeatedly broken in the 2000s, the related East Asian Winter Monsoon (EAWM) variability is investigated. The EOF analysis of surface air temperature reveals that the northern mode of the EAWM variability, which is highly associated with the Arctic Oscillation (AO) activities at both interdecadal and interannual timescales, has been intensifying since late 1990s. Corresponding to the intensification of the northern mode of the EAWM variability and the negative phase of AO in the 2000s, the Siberian High and East Asian trough intensify while the polar-front jet stream strengthens and the subtropical westerly jet stream abnormally shifts northward. As a result, anomalously strong cold air masses, originated from Siberia, intrude into East Asia, but are blocked by the enhanced northward subtropical westerly jet and cannot reach low latitudes area. Therefore the extremely strong cold air masses are amassed in mid-high latitudes of East Asia, resulting in RBEs of low temperature in this area.

2E2.2 ID:7074 15:30

Validation of fifth-generation of the Canadian Regional Climate Model (CRCM5) using precipitation data Stage IV analyzes over the eastern United States.

Mamadou Insa Diop
Université du Québec à Montréal (UQAM)

Contact: ediopinsa@gmail.com

We used the precipitation data Stage IV analyzes at high spatiotemporal resolution (4 km, 1 h) to assess the performance of the fifth-generation Canadian Regional Climate Model (CRCM5) on the eastern United States over a period of 11 years. The results show that the CRCM5 reproduces the main features of the spatial distribution of observed precipitation, but with events that, on average, are more intense and more widespread, especially in summer. During this season, the heavy nocturnal precipitations in the centre of the USA remain problematic for the model, and the peak intensity is shifted towards lower intensities. In the cold season, the contribution of the lower intensity precipitations is overestimated in the CRCM5. The model generally shows good skills in reproducing the average duration of rainfall events.

2E2.3 ID:7142 15:30

Hydrometeorological flood risk assessment of the Richelieu river (Quebec): A mid-term flood warning system appraisal

Christian Saad [1], *André St-Hilaire* [1], *Philippe Gachon* [2], *Salaheddine El Adlouni* [3]
[1] Centre Eau-Terre-Environnement, Institut National de la Recherche Scientifique, Québec, Canada
[2] Environment Canada and Centre ESCER, Université du Québec à Montréal, Montréal, Canada
[3] Département de Mathématiques et Statistique, Université de Moncton, Moncton, Canada
Contact: christian.saad@ete.inrs.ca

The 2011 Richelieu River (Québec, Canada) spring flood was unprecedented in terms of destruction of property and negative impacts on agricultural as well as fish habitat within its watershed. Due to the strong damaging effects of spring floods on both human and natural systems, the need for proper assessment of flood risks with a particular emphasis on the underlying key meteorological causes is pressing.

This study lays the foundation of what could become a 2-component flood risk assessment approach applied to the Richelieu River. A multivariate frequency analysis of flood and monthly to seasonal observed hydrometeorological indices was completed using copulas. Subsequently, scenarios developed using the results of the copula analyses were integrated as inputs to a semi-distributed hydrologic model, CEQUEAU, to quantify flood risks along the river. Synthetic time-series of ten scenarios were generated by applying a monthly delta on observed daily precipitations and temperatures for the 2007-2008 and 2010-2011 years in order to evaluate the flow response of seasonal meteorological target conditions. The results reveal that the CEQUEAU model constitutes an efficient tool to estimate observed spring floods of the Richelieu river between 1981 and 2011, including the 2011 record flood. The 2010-2011 scenario results show that events with 2-year recurrences of total precipitation cumulated between November and March and of 90th percentile precipitation in spring fallen over the Lake Champlain valley produce less severe spring floods (ranging from medium to minor floods) relative to the major flood of 2011. These two precipitation indices in combination with the number of frost/thaw cycles during winter partially explain the record flood of 2011. The 2007-2008 scenario results show important variations in simulated peak flows for similar conditions of cumulative total precipitation fallen between November and March and of 90th percentile of liquid precipitation in spring when daily precipitation events are generated with different temporal distributions.

2E2.4 ID:7297 **15:30**

Assessing the synchronism of time series trends across the regions and beyond

Vyacheslav Lyubchich [1], *Yulia Gel* [2], *Abdel El-Shaarawi* [3]
(Presented by *Viacheslav Lyubchich*)
[1] University of Waterloo
[2] University of Texas at Dallas, University of Waterloo
[3] The American University in Cairo, Egypt
Contact: vlyubchich@uwaterloo.ca

The regional climate may or may not follow the global trend, as well as climate trends in neighbour regions can differ substantially. Thus, the effect of climate change is more severe in some regions, and less noticeable in other areas, what affects the local climate change adaptation policies, the particular concern of authorities. To asses whether two or more time series follow the same common trend, we develop a new statistical test for synchronism of trends. The core idea of this new approach is based on employing the local regression goodness-of-fit test, which allows to detect possibly non-monotonic (non)linear trends in time series with autocorrelated noise. The robust autoregressive filter with automatic order selection based on Bayesian Information Criterion (BIC), the data-driven bootstrap approach and m-out-of-n selection algorithm enhance the finite-sample performance of the test statistic. We illustrate the proposed methodology by simulations and case studies on assessing joint dynamics of various climatic variables in space and time.

2E2.5 ID:7108 **15:30**

Renewal of Ontario Ministry of Transportation Intensity- Duration-Frequency (IDF) Curves, Phase III: Validation of the Interpolation Tool

Ric Soulis [1], *Daniel Princz* [2], *Hani Farghaly* [3], *Muhammad Naeem* [3]
[1] Civil and Environmental Engineering, University of Waterloo
[2] MSc candidate, Civil and Environmental Engineering, University of Waterloo
[3] Design and Contract Standards Office, Ontario Ministry of Transportation
Contact: rsoulis@uwaterloo.ca

This paper will describe the work-in-progress, primarily to validate the Intensity-Duration-Frequency Curve web interface previously developed for the Design and Contract Standards Office at the Ministry of Transportation Ontario (MTO). Results will be validated using data from nearby jurisdictions and by expanding the database to include data recorded at non-network weather stations within Ontario. Overall validation of the system will use the recently available results for selected US Great Lakes states. We expect a good match with some differences due to analysis methods. For example, the US studies use a three-parameter IDF equation while the MTO model uses a two-parameter version.

Validation of the procedural alternatives selected for the MTO analysis will be performed using the Ontario Phase I and Phase II results. The base case will be methods recommended in the MTO Drainage Management Technical Guidelines (1989) for station analysis and the MTO square grid technique for regionalization

A weighting technique developed in a previous phase of the project will be adapted to produce a quality control measure that can be used to manage entry of non-network data. Preliminary tests suggest that the technique may allow detection of time trends.

Finally, the project will produce an improved web interface that will allow the users to download their requested storm data, as well as specify specific storm parameters, and provide an onscreen graphic representing their hydrological footprint.

POSTER-Detection and attribution of high latitude climate change / AFFICHES-Détection et attribution du changement climatique à haute latitude

Room / Endroit (Congrès A), Chair / Président (Nathan Gillett & Francis Zwiers), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E3.1 ID:7038 **15:30**

Global and regional scale radiative perturbations of Asian aerosols from different emission sectors

Rashed Mahmood , *Knut Von Salzen*
Canadian Centre for Climate Modeling and Analysis, Environment Canada
Contact: rashed.mahmood@ec.gc.ca

Aerosol induced radiative forcing is a major source of uncertainty in estimates of anthropogenic influences on climate. In recent decades, Asian emissions of aerosols and their precursors have strongly increased due to high economic growth. This study utilizes the Canadian global atmospheric general circulation model (CanAM4.2/PAM) by incorporating latest sets of aerosol emission estimates to investigate aerosol induced regional to global scale radiative forcings. Emissions from six different sectors are used, namely domestic, transport, vegetation fires, agricultural, energy + industrial + waste burning, and gas flaring. Contributions of black carbon, organic aerosol, and sulphate to net aerosol radiative forcings are considered. Model results provide evidence for large impacts of Asian emissions on radiative forcings on global and regional scales. Simulated impacts are particularly large in the Arctic. Results of the study are used to estimate the efficiency of potential emission reduction measures for radiative forcings.

2E3.2 ID:7126 **15:30**

Why and how to deal with modelling uncertainty in D&A ?

Aurélien Ribes

CNRM-GAME, Météo France - CNRS
Contact: aurelien.ribes@meteo.fr

Commonly used methods in detection and attribution usually assume that climate models are able to properly simulate the (temporal, spatial or spatio-temporal) response patterns of the climate system to external forcings. However, a few recent results obtained in analysing global temperatures suggest that the discrepancies in the response patterns as simulated by different models may be sufficiently large to substantially deteriorate D&A results. This poses the question of taking into account modelling uncertainty in D&A studies.

This poster presents a tentative discussion on this issue. Based on a linear regression method, an Error In Variable (EIV) approach has been previously proposed by several authors. We here discuss how using such a framework and revisit the statistical inference under EIV. We focus in particular on the required estimation of the covariance matrix of modeling error, which is very challenging given the very limited number of climate models available worldwide.

2E3.3 ID:7177 15:30

Attribution of Snow Cover Extent Decline in High Latitudes to Anthropogenic Influence

Mohammad Reza Najafi [1], *Francis Zwiers* [1], *Nathan Gillett* [2], *Xuebin Zhang* [3]
[1] Pacific Climate Impacts Consortium, University of Victoria
[2] Canadian Centre for Climate Modelling and Analysis
[3] Climate Research Division, Environment Canada
Contact: rnajafi@uvic.ca

Observational records of snow cover extent in high latitudes show a declining trend during the past 50 year period. We investigate the causes of this trend using simulations from the Fifth Coupled Model Intercomparison Project (CMIP5) that use a suite of forcing scenarios including greenhouse gases, other anthropogenic forcing agents (dominantly aerosols) and natural forcing due to solar and volcanic activity combined. The NOAA Northern Hemisphere climate data record (CDR) for snow cover extent is considered as the observational data ranging from 1966 to 2012. Analysis is performed separately for December through February and March through May over North America and Eurasia. Detection and attribution analysis is performed based on the optimal fingerprinting and total least squares approach.

2E3.4 ID:7223 15:30

A robust bootstrapping algorithm for optimal fingerprinting

Qiuzi Han Wen [1], *Francis Zwiers* [2], *Xuebin Zhang* [1]
[1] Climate Data and Analysis Section, Climate Research DIvision, Environment Canada
[2] Pacific Climate Impacts Consortium, University of Victoria
Contact: fwzwiers@uvic.ca

The large majority of climate change detection and attribution studies use the so-called optimal fingerprinting method, which in essence, fits a combination of expected responses to external forcing (signals) to an observed sequence of changes in time and space using an “errors-in-variables” regression model. Key findings from such studies are based on statistical inferences concerning the fitted regression coefficients (referred to as scaling factors) and the remaining

residual variability, which is generated internally by the climate system. However, inference uncertainty has not yet been fully studied. Such uncertainty arises from uncertainty in the signal estimates, the internal variability estimates, the observations and the method that is used to estimate internal variability. We explore how the estimates of scaling factors, their confidence intervals, and the results of the residual consistency check are affected by various sources of uncertainty, including the use of different estimators of internal variability. Using CMIP5 surface air temperature data, a series of Monte Carlo experiments performed and subsequently analyzed with fixed-effect and mixed-effect ANOVA models. The results of these experiments demonstrate uncertainty in the estimate of internal variability has considerable impact on the robustness of optimal fingerprinting, in contrast with sampling uncertainties, which has only a modest impact. We propose a bootstrapped optimal fingerprinting (BOF) algorithm to account for inference uncertainty. The algorithm makes use of all available information to produce realistic and robust results for detection and attribution studies. We illustrate the use of this method via an application to observed surface temperature change.

POSTER-General Climate Science / AFFICHES- Sciences du climat en général

Room / Endroit (Congrès A), Chair / Président (Michael Scarratt), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E4.1 ID:7144 **15:30**

A comparative study of the UTLS water vapor in two monsoon regions

Ying Sun
McGill University
Contact: ying.sun3@mail.mcgill.ca

Abstract: Global water vapor distribution in the upper troposphere and lower stratosphere (UTLS) is examined by using satellite observations of water from ACE-FTS. Our examination is focused on the North American and East Asian monsoon regions, aiming at understanding the mechanisms governing water vapor transport into stratosphere. The Ibtracs datasets is used for a comparative study of the cyclone impact on the UTLS in the two regions. Besides the water vapor concentration, the corresponding change of troposphere structures and anomalous isotopic concentrations are also examined. Finally responses of water vapor to surface temperature variations are quantified and the resulting radiative impacts on climate are assessed based on radiative transfer simulations.

2E4.2 ID:7081 **15:30**

A Synoptic climatology of Gap Winds on the Coast of British Columbia

Talaat Bakri [1], *Peter Jackson* [2]

[1] MSc Candidate at the University of Northern British Columbia
[2] Professor of Atmosheric Science at the University of Northern British Columbia
Contact: bakri@unbc.ca

A synoptic climatology using mean sea level pressure and 500 hPa geopotential height composites is conducted for five gap winds that occur through the channels and passes dissecting British Columbia's coastal mountains. Seasonal (winter, summer) and directional (inflow: air moving from the coast inland; outflow: air moving from inland toward the coast) partitioning of gap winds results in four distinct gap winds that occur: summertime inflow, summertime outflow, wintertime inflow and wintertime outflow. Composite analyses using NCEP-NCAR reanalysis data and in-situ observations are used to examine each type of gap wind at all five locations. Wintertime gap winds produce distinctive patterns from the overall winter climatology, in which outflows occur when cold-air damming associated with an arctic surface high pressure area on the inland side of the coastal mountains is accompanied by the presence of an area of low surface pressure at the northwestern Pacific. Inflow composites in the winter indicate low pressure areas associated with midlatitude cyclones over the Gulf of Alaska. In this winter inflow situation, winds blow semi-parallel to isobars as a boundary-layer gradient wind, whereas the wind crosses isobars down the pressure gradient in the wintertime outflows. The composites of the summertime gap winds are similar to the overall summer climatology, therefore other approaches are applied to explain these winds. We analyse 104 summertime inflow event at three gap wind locations using surface analysis charts for 13 summer seasons. The analysis indicated the importance of fronts at the time of gap wind events, with fronts associated with almost half of the events at the three gap locations. Non-hierarchical clustering analysis is applied for the summertime inflow events. The clustering analysis gives a better explanation of the events than the composites through grouping events into different clusters allowing for better illustration of the variance among the composites and showing more obvious pressure gradient along the coast.

2E4.3 ID:7189 15:30

Frostquakes in Central Canada and Neighbouring Regions in the United States Identified through Social Media

Andrew Leung , *William Gough*
University of Toronto Scarborough
Contact: andrewc.leung@mail.utoronto.ca

Noises that resembled falling trees were first heard on the night of December 24, 2013. Through public reports on Twitter, mainstream media determined that those noises were generated by a rare phenomenon called cryoseism, or more commonly referred to as frostquake by the public. The event on December 24 became the first recorded report of frostquake in Canada. This work is the first study that analyzes frostquakes in Canada. Occurrences of frostquakes were explained by examining the climatological variables. These conditions include precipitation events above the freezing mark to saturate the soil with water follow by a quick freeze that causes water in the soil to freeze. Pressure builds up inside the soil until it cracks to relieve the pressure, causing the sound to be heard by humans and animals. Frostquakes are too localized for any effective monitoring system to be set up. However, using weather conditions, we successfully forecasted two upcoming frostquakes in January 2014 that were later cross-referenced with reports on

Twitter. Through social media such as Twitter and Facebook, six more episodes of frostquakes along with their locations were identified in January and February 2014. Results showed that in Canada, frostquake occurrences ranged from Sarnia in the west to Montreal in the east and from Niagara Falls in the south to North Bay in the north. In the United States, the reports came from states bordering the Great Lakes as well as New England. Illinois and Minnesota did not have any prior reported frostquakes until 2014. This study showed that rare phenomena such as frostquakes could be identified by gathering data through social media.

2E4.4 ID:7153 **15:30**

Assessing Water and Climate Services in Canada : Utilization of the Global Framework for Climate Services

Chantale Cote , Sharon Ribero , Grace Koshida , Jamie Smith
Environnement Canada
Contact: chantale.cote@ec.gc.ca

Assessing the state of Water and Climate Services in Canada is an essential step to understanding current capacity at the National level allowing for the identification of steps to build a more efficient and coordinated service delivery model. The Global Framework for Climate Services (GFCS) provides a framework that categorizes important services from observations and research to the dissemination of information through a user interface. In Canada, we tested the application of the GFCS framework as a basis of an assessment “tool”. Through a consultative process with stakeholders and service providers across the country, our preliminary results to date suggest this approach is helpful for identifying gaps in service and areas where services can be optimized by reducing duplication, can help create a common understanding of water and climate services that will form the basis of improved coordination (governance). Further, we have found that opportunities for improved sharing of climate information and products have been identified, such as sharing of data from observation networks currently not commonly shared with all providers. We are optimistic that the results will form the basis for developing actions to address weaknesses in the current service model if required.

POSTER-The changing Arctic cryosphere: Drivers, feedbacks and biogeochemical impacts / AFFICHES- La cryosphère arctique en mutation: Facteurs déterminants, rétroactions et impacts biogéochimiques

Room / Endroit (Congrès A), Chair / Président (Christine Michel & C.J. Mundy), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E5.1 ID:7117 15:30

Assessing the risk of aquatic invasive species in relation to climate change in the Canadian Arctic

Jesica Goldsmit [1], *Kimberly Howland* [2], *Philippe Archambault* [1]
[1] UQAR / ISMER
[2] Fisheries and Oceans Canada
Contact: jesigold@yahoo.com.ar

Changes in climate, hydrography, and ecology related to global warming are expected to be strongly expressed in the Arctic Ocean. The combination of global warming, resource exploitation and the resulting increase in Arctic shipping activity are expected to increase the risk of aquatic invasive species (AIS) introductions to Arctic waters in the near future. This project has two main objectives: i) to assess the relative risks for future AIS incursions across the Canadian Arctic using spatial probabilistic modelling of current and projected environmental and vector information, in relation to areas of biological importance and ecosystem services and ii) to predict species-specific potential spatial distributions and assess the probability of establishment for a subset of higher risk AIS under various climate changes scenarios using ecological niche modelling based on known environmental ranges for these species. The utilization of spatial probabilistic and species-specific niche models will help in understanding potential risks of future AIS incursions as a result of climate change and shipping at large spatial scales. This study aims to identify high risk geographic locations and species where the focus in future monitoring and research efforts in response to climate change should be placed. It will also provide a basis for understanding how range shifts of AIS and other species may impact the structure and functioning of marine ecosystems.

2E5.2 ID:7203 15:30

Changement de la composition pigmentaire des algues de glace dans le passage de Resolute, Nunavut

Joannie Charette [1], *Michel Gosselin* [2], *Marjolaine Blais* [2], *Michel Poulin* [3], *C.j. Mundy* [4]
[1] Départment de Biologie, Chimie et Géographie, Université du Québec à Rimouski, Rimouski, Québec
[2] Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, Rimouski, Québec
[3] Recherche et collection, Musée canadien de la nature, Ottawa, Ontario
[4] Centre for Earth Observation Science, University of Manitoba, Winnipeg, Manitoba
Contact: joannie.charette@uqar.ca

Les pigments sont des outils précieux qui nous informent sur plusieurs aspects des communautés algales, comme leur composition et leur état physiologique. Dans cette optique la composition pigmentaire des algues qui colonisent la couche inférieure de la glace de mer au printemps fut analysée et comparée avec les résultats taxonomiques. Les échantillons furent récoltés dans le passage de Resolute du 8 mai au 18 juin 2010 sous différents couverts de neige. Les échantillons furent par la suite analysés au HPLC (High Performance Liquid Chromatography) afin d'en obtenir la composition pigmentaire, puis en taxonomie. Les principaux piments retrouvés aux différentes stations sont la chlorophylle a (chl a), la fucoxanthine, la chl c1, la chl c2 et la chl c3. Ces pigments sont en grande partie associés aux diatomées, le principal groupe d'algues retrouvé en taxonomie, plus précisément, les diatomées pennales. D'autres pigments, qui sont plutôt associés à différentes classes de flagellées, sont présents, mais en abondance moindre, soit la

péridinine, la chl b, la diadinoxanthine et la β-carotène. Le rapport entre les pigments caroténoïdes photoprotecteurs et ceux photosynthétiques était généralement plus élevé sous une mince couverture de neige et augmentait au fil de la saison avec l'accroissement de l'éclairement à la base de la glace. Ces sites montraient également davantage de pigments de dégradation de la chl a. Ces résultats montrent une détérioration des conditions physiologiques des diatomées de glace associée à l'augmentation saisonnière de la lumière et à la fonte du couvert de neige à la fin du printemps.

2E5.3 ID:7328 **15:30**

Impact of a snow storm on coastal ice as observed by RADARSAT-2

David Didier [1], *S. Tolszczuk-Leclerc* [2], *S. Bélanger* [2], *D. Dumont* [3]
[1] UQAR, Laboratoire de dynamique et de gestion intégrée des zones côtières
[2] UQAR, Laboratoire d'Optique aquatique et de Télédétection
[3] UQAR, Institut des sciences de la mer
Contact: david_didier@uqar.ca

Synthetic aperture radar (SAR) data from RADARSAT-2 allows monitoring of sea ice in operational setting. To complete its mission, the Canadian Ice Service needs parameters such as ice-edge location, stage of development and ice concentration. Due to contrast variations driven by sea state and winds, such parameters can be difficult to define. In February 2014, two acquisitions where made before and after a snowstorm over a coastal site in Rimouski (Qc). The first image was acquired on February 13th, together with in situ validation using an ice canoe. The ice-edge location was surveyed using a GPS handheld device, and a GPS data logger was installed on an ice floe to acquire data on ice drifting dynamics. Sea ice concentrations were estimated for each type of ice present during the survey. The sea ice cover consisted mainly of first year grey-white ice and grey ice with some new ice. The estimates and classification of the sea ice were based on the methodology of the CIS described in the MANICE. During the evening of February 13th, wind speeds increased considerably, reaching 58 km/h generating important waves in the open waters of the estuary. This event effectively cleared the area of any form of ice that wasn't shielded by a land feature. This is clearly visible on the second image obtained three days later during a snow storm associated with northeaster winds. Image analysis using polarimetric decomposition theorems were used to assess the impact of consecutive snow storms on sea ice extent and concentrations. Accuracy was assessed using the ice canoe survey data, which proved to be a valuable tool that enabled us to reach previously inaccessible zones of the ice pack.

POSTER-Real-time ocean observing systems / AFFICHES- Systèmes d'observation océanique en temps réel

Room / Endroit (Congrès A), Chair / Président (Denis Gilbert & Fraser Davidson), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E6.1 ID:7273 **15:30**

Smart Oceans North: monitoring the Arctic through a mini-observatory network

Alice Olga Victoria Bui , Kim Juniper , Ryan Michael Flagg
(Presented by *Steven Mihaly*)
Ocean Networks Canada
Contact: aovbui@uvic.ca

In the current context of climate change and the pressures that global warming imposes on the environment, especially in the Arctic, continuous monitoring and collection of time series data are crucial to understanding and managing the Arctic Ocean. In late September 2012, Ocean Networks Canada installed a pilot, small-scale cabled observatory in Cambridge Bay, Nunavut. The observatory collects year-round seawater property, sea ice, meteorological data and imagery in near-real time that are available online. Following the successful demonstration of the Cambridge Bay mini-observatory, Ocean Networks Canada is developing a network of low-cost, community based, mini-observatories for coastal settlements as a first step toward “Smart Oceans North”, a wired ocean observatory program in the Canadian Arctic. This network of monitoring sites, from Sachs Harbour (Northern Territories) to Nain (Newfoundland and Labrador) will provide a baseline to study and track environmental changes in sensitive coastal regions and serve as a platform for school and community scientific outreach programs.

2E6.2 ID:7207 **15:30**

Analysis of Oceanographic Metadata from Seismic Surveys

Len Zedel [1], *Yanan Wang* [1], *Fraser Davidson* [2]
[1] Memorial University of Newfoundland
[2] Department of Fisheries and Oceans
Contact: zedel@mun.ca

Analysis of oceanographic metadata from seismic surveys provides a valuable opportunity to monitor the physical oceanographic environment and its variability. The Acoustic Doppler Current Profiler (ADCP) data this project reviews stems from one such seismic survey from the NE Grand Banks over a 5 week period.. The instrument is a 75 kHz ADCP, but configured as a 500kHz or 1 Mhz system. This configuration complicates the analysis but permits recovery of near surface water velocities by averaging available data. Data quality are evaluated by determining the degree to which water velocities are dependent on ship speed and direction; the seismic survey track is ideal for this analysis because of the many regular course changes and closely spaced tracks. Final data are sorted by space and time intervals and then corrected for tidal content. The long term goal of this project is to compare the data to Government of Canada CONCEPTS (Canadian Operational Network of Coupled Environmental PredictTion Systems) ocean prediction output with the hopes of potentially using ship based ADCP data from seismic surveys for assimilation purposes into CONCEPTS prediction systems.

2E6.3 ID:7279 **15:30**

Ocean Networks Canada's Cambridge Bay Observatory: Almost two years of continuous data

Steve Mihaly , S. Kim Juniper , Alice Olga Victoria Bui
(Presented by *Kim Juniper*)
Ocean Networks Canada, University of Victoria
Contact: kjuniper@uvic.ca

In the current context of climate change and the pressure that global warming imposes on the environment, especially in the Arctic, continuous monitoring and collection of time series data are crucial to understanding and managing the Arctic Ocean. In late September 2012, Ocean Networks Canada installed its first cabled observatory in Cambridge Bay, Nunavut. The observatory consists of an instrument platform on the seafloor at 6 m depth that hosts a Wetlabs Water Quality Monitor (WQM), a shallow water ice profiler, an underwater camera, a hydrophone and an acoustic fish tag receiver. The shore-based components consist of a seaward looking camera, two weather stations, a high-resolution barometer and an Automatic Identification System antenna for marine traffic monitoring. All data and imagery are freely available through the ONC website. For the WQM and ice draft data, both raw data and data processed for Quality Assurance/Quality Control (QA/QC) are available online.

Nearly two full cycles of ice formation have been observed, permitting analysis of the relationship between air temperature and the rate of ice formation, together with the influence of freezing and melting on seawater temperature and salinity. These processes will be summarized in a 1-dimensional model of interaction between the atmosphere, the sea ice and the underlying water column. We will also use data from underwater instruments to verify a recent hypothesis that phytoplankton blooms can occur under sea ice prior to breakup. In early April 2013, we observed an abrupt increase in chlorophyll fluorescence and dissolved oxygen at our 6 m depth instrument platform, suggesting that a phytoplankton bloom had added oxygen (and phytoplankton biomass) to the water column. Data from April 2014 will confirm or refute this observation.

POSTER-Remote sensing of coastal and arctic waters / AFFICHES- Télédétection des eaux côtières et arctiques

Room / Endroit (Congrès A), Chair / Président (Cédric Jamet & Simon Bélanger), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E7.1 ID:7251 **15:30**

CSA Supported Earth Observation Missions Affecting the Arctic

Guy Aube , Paul Briand , Yves Crevier

Canadian Space Agency
Contact: guy.aube@asc-csa.gc.ca

Keywords: Northern region management, Arctic, coastal zones, Earth Observation, Canadian Space Agency

ABSTRACT Since the mid-90's, the Canadian Space Agency (CSA) is supporting the development of space-based Earth Observation (EO) missions that provide unique and essential information to understand the Arctic environments. Past satellite missions (i.e. RADARSAT-1, ENVISAT/MERIS & ASAR), operational satellite missions (RADARSAT-2, CRYOSAT-2, SMOS) and future missions (RADARSAT Constellation, SENTINELs, SMAP, SWOT, Watersat) will continue to contribute to the reporting on: biodiversity and wildlife; improving the understanding, modelling and prediction of weather; refining the techniques for the delivery of ecosystem services; predicting potential hazards on infrastructures; mapping of renewable energy potential; detecting new vector born diseases; measuring water quality and quantity; identifying shorelines and ecosystems at risk in preparation of emergencies; reporting on coastal glaciers and ice melting; measuring water quality and quantity, etc. The poster will be a review of past, existing and planned CSA EO missions related to the Arctic regions management.

2E7.2 ID:7068 15:30

Étude de la performance des radars hautes-fréquences CODAR et WERA pour la mesure des courants marins en présence partielle de glace de mer

Emna Kamli , Cédric Chavanne , Dany Dumont
Institut des sciences de la mer, Rimouski
Contact: emna.kamli@gmail.com

Les radars hautes-fréquences (HF) mesurent les courants marins de surface avec une portée pouvant atteindre 200 kilomètres et une résolution de l'ordre du kilomètre. Ils permettent ainsi de mesurer la variabilité horizontale des courants. Deux radars de type CODAR de fréquences 12.5 et 13.5 MHz ont été installés en novembre 2012 à Pointe-au- Père et à Sainte-Flavie sur la rive sud de l'estuaire maritime du Saint-Laurent. D'autre part, deux radars de type WERA de fréquence 16.15-MHz ont été installés sur la rive nord à Pointe-aux-Outardes et à Pointe-à-Boisvert. Les mesures des courants pendant l'hiver 2013 ont été utilisées pour caractériser la performance des radars (en terme de couverture spatiale) en présence de glace de mer. Dans un premier temps, l'aire moyenne journalière de la zone où les courants sont mesurés par chaque radar a été comparée à des mesures de vagues et de vent prises par une bouée mouillée dans la zone couverte par les radars (bouée IML-4, Institut Maurice Lamontagne). La couverture des CODARs est corrélée avec la hauteur dominante des vagues ainsi qu'avec la vitesse du vent, alors que la couverture des WERAs est insensible à ces variables environnementales. Ces résultats permettent d'établir la couverture normale de chaque radar en absence de glace de mer. Dans un deuxième temps, la relation entre le ratio des couvertures journalières obtenues pendant l'hiver 2013 et des couvertures normales de chaque radar d'une part, et la concentration moyenne journalière de glace de mer prédite par le modèle CICE (Los Alamos sea ice model) d'autre part, a été établie. La vitesse du vent prédite par le modèle GEM (Global Environmental Multiscale) d'Environnement Canada a été utilisée pour estimer la couverture normale des CODARs pendant l'hiver 2013. Les relations empiriques établies entre la couverture des radars HF et les paramètres

environnementaux (vent, glace de mer) permettront de prédire la couverture que pourraient fournir des radars HF installés dans d'autres régions soumises à la présence saisonnière de glace de mer.

2E7.3 ID:7329 15:30

Sensitivity analysis of primary production from MODIS, SeaWiFS and ISCCP in arctic waters

Maxime Benoît-Gagné [1], *Emmanuel Devred* [1], *David Dessailly* [2], *Simon Bélanger* [3], *Marcel Babin* [1]
[1] Takuvik Joint International Laboratory (CNRS & ULaval), Département de Biologie and Québec-Océan
[2] Laboratoire d'Océanologie et de Géosciences, Université du Littoral-Côte d'Opale, Wimereux, France
[3] Université du Québec à Rimouski, Département de Biologie, Chimie et Géographie and BORÉAS
Contact: maxime.benoit-gagne@takuvik.ulaval.ca

Remote sensing of ocean-colour is a powerful tool to monitor changes of the marine ecosystem in a warming Arctic Ocean. One of the key parameters to infer the state of the marine ecosystem is the primary production. Long-term satellite observations of the Arctic Ocean are only possible when merging time series from multiple sensors. However, such merging can result in sensor-induced biases and artifacts when estimating trends. Here, we assess the consistency of primary production estimations using time series of atmospheric and ocean-colour parameters acquired by various satellite sensors. Primary production was modelled (Bélanger et al. 2013) using Level-3 remote sensing reflectances (Rrs) SeaWiFS (1998-2007) and MODIS-Aqua (2003-2013) and auxiliary data (i.e., sea-ice concentration, atmospheric optical properties). Atmospheric parameters, required to compute the irradiance at the sea surface, were derived from two datasets: the International Satellite Cloud Climatology Project (ISCCP, 1984-2009) and MODIS (2003-2013). The goal is to quantify the relative impact of some of the intermediate parameters, such as irradiance, chlorophyll-a concentration, cloud cover, in the discrepancies in primary production between the two ocean-colour sensors. The study site is located in the Beaufort Sea (70 to 71°N and -141 to -140°E), a polar region with seasonal ice coverage. The sensitivity analysis conducted over the 2003-2007 time period reveals important inter-sensor differences, both for the atmospheric and ocean-colour parameters emphasizing the need for advanced merging methods to mitigate sensor differences.

2E7.4 ID:7327 15:30

Remote Sensing of Suspended Particulate Matter in the Delta and Plume of the McKenzie River: Time Series Analysis of MODIS data

Emmanuel Devred [1], *David Doxaran* [2], *M. Babin* [1]
[1] Takuvik, CNRS-Université Laval
[2] LOV, Villefranche-sur-mer, France
Contact: emmanuel.devred@takuvik.ulaval.ca

The Mackenzie River has a strong impact on the hydrodynamic and carbon budget of the Beaufort Sea. The recent warming of the Arctic increases the thawing of the permafrost with a possible effect on sediment transport of the McKenzie River to the Arctic shelf and Basin. In this study, we have produced a time series of high temporal (daily) and spatial (1 km) resolution of

suspended particulate matter (SPM) over the Mackenzie River and plume (68 to 72.5o N and 122 to 142o W). The atmospheric correction procedure developed by NASA, and aiming at retrieving the radiative signal leaving the water, was modified to avoid flagging of the very turbid water of the Mackenzie delta and to increase the number of available pixels when processing the data from raw (top-of- atmosphere) to SPM values. Time series of SPM and sea-ice concentration were computed using MODIS and SSMIS for the period 2003-2013 respectively. Analysis of the time series reveals variations in SPM concentrations in the McKenzie delta and Plume.

2E7.5 ID:7346 15:30

Arctic-COLORS (Coastal Land Ocean Interactions in the Arctic) – a NASA field campaign scoping study to examine land-ocean interactions in the Arctic

Antonio Mannino [1], *Carlos Del Castillo* [2], *Marjorie Friedrichs* [3], *Peter Hernes* [4], *Patricia Matrai* [5], *Joseph Salisbury* [6], *Maria Tzortziou* [7], *Diane Lavoie* [8]
[1] NASA Goddard Space Flight Center
[2] Johns Hopkins University
[3] Virginia Institute of Marine Science
[4] University of California, Davis
[5] Bigelow Laboratory for Ocean Sciences
[6] University of New Hampshire
[7] University of Maryland
[8] Institut Maurice-Lamontagne, Pêches et océans Canada
Contact: antonio.mannino@nasa.gov

The overarching objective of our project is to design an integrative, interdisciplinary oceanographic field campaign to address high priority science questions related to land-ocean interactions in the Arctic, and assess the impacts of natural and anthropogenic changes on coastal ocean biology, biogeochemistry and biodiversity. A key component of the proposed field campaign will be the use of spatial-temporal information products derived from remotely-sensed data to extend observations to larger spatial and longer temporal scales, and the proposed integration of satellite and field observations with coupled physical-biogeochemical models for predicting impacts of future pressures on Arctic, coastal ocean, biological processes and biogeochemical cycles. Specific science objectives include: 1. Quantification of Arctic riverine fluxes of constituents with a significant impact on coastal biology, biodiversity, biogeochemistry (i.e. organic matter, nutrients, suspended sediment), and the processing rates of these constituents in coastal waters. 2. Evaluation of the impact of the thawing of Arctic permafrost within the river basins on coastal biology, biodiversity and biogeochemistry, including various rates of community production and the role these may play in regional economic well being. 3. Evaluation of the impact of changing Arctic land-fast ice and coastal sea ice dynamics on estuarine and coastal biology, biodiversity and biogeochemistry, including rates of community production. 4. Establishment of a baseline for comparison to future change, and utilizing models to assess the potential impacts of these future changes on coastal biology, biodiversity and biogeochemistry. Through organization of two dedicated workshops and presentations at NASA Ocean Biology and Biogeochemistry (OBB) science team meetings, the scoping study will engage the broader scientific community and invite participation of experts from a wide range of disciplines, to refine our research objectives and outline detailed research strategies needed to attain these objectives. The scoping study will also involve interagency and international collaborations. The deliverable will be a comprehensive report to NASA outlining the major

scientific questions, and developing the initial study design and implementation concept.

POSTER-Coastal Oceanography and Inland Waters / AFFICHES- Océanographie côtière et eaux intérieures

Room / Endroit (Congrès A), Chair / Président (Jinyu Sheng, Guoqi Han & Ram Yerubandi), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E8.1 ID:7212 **15:30**

Improving Marine Drift and Dispersion Forecasts in the Lower St. Lawrence Estuary

Marion Bandet [1], *Dany Dumont* [1], *Cédric Chavanne* [1], *Daniel Bourgault* [1], *Urs Neumeier* [1], *Bruno Tremblay* [2], *Denis Lefaivre* [3], *Simon Senneville* [1], *James Williams* [2], *Simon St-Onge Drouin* [1], *Anne-Claire Bihan-Poudec* [1]
[1] Institut des sciences de la mer de Rimouski
[2] Université McGill
[3] Institut Maurice-Lamontagne, Pêches et Océans Canada
Contact: bandet.marion@gmail.com

With over 200 000 km, Canada has the longest coastline, covering three oceans, two of which are at least seasonally ice-covered. Being able to respond to emergencies along Canadian coasts requires appropriate equipment, reliable and efficient communication systems, and trained personnel. It also requires accurate hindcasts and forecasts of winds and surface currents to estimate where a person or an oil patch will drift. This poster presents the first results of a new project aiming at deepening our understanding of surface marine drift and dispersion and at improving model forecast skills. The project is carried out in the Lower St. Lawrence Estuary, a particularly dynamic marine environment, seasonally ice-infested, where a suite of modelling and monitoring systems are maintained. This suite includes a 5- km resolution operational coupled ice-atmosphere-ocean numerical model, a 400-m resolution tidal ocean model, four high-frequency radars (HFR) measuring surface currents in real-time, and one automatic buoy providing real-time surface measurement during the summer. To validate HFR and model estimations of the surface drift in various conditions all year-round, drifting buoys were deployed both in summer (from small boats) and winter conditions (from ice canoes and icebreakers). Comparisons are presented and some recommendations provided for refining the next validation round and for improving models. This project is funded by the MEOPAR Network of Centres of Excellence and is carried in partnership with the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) and the Canadian Coast Guard.

2E8.2 ID:7317 **15:30**

Lake Melville variability in the past fifty years: impact of climate change and anthropogenic stress

Nonna Belalov , *Entcho Demirov*
Department of Physics and Physical Oceanography, Memorial University of Newfoundland
Contact: entcho@mun.ca

Lake Melville is part of a greater fjord-type estuary system, the Hamilton Inlet on the east coast of Labrador, Canada. As such, it serves as an outlet of freshwater into Labrador sea and consequently the Atlantic ocean. Although the region attracted much scientific attention following the hydroelectric development located at one of its tributaries, little is known about the ecosystem of Lake Melville.

Hydroelectric developments altered the river discharge into Lake Melville, thus changing the natural seasonal cycle and altering freshwater dynamics within the estuary. The environmental implications of these alterations to the regional oceanography as well as the climate are unknown, but their importance was revived following the proposal for further hydroelectric development in the region. Our research explores the the intricate relationship between seasonal river discharge, mixing within the estuary and the estuarine ecosystem. While the estuarine dynamics are affected by the anthropogenic factor that is altering river discharge, the naturally variable climate also contributes to the oceanography and ecosystem of Lake Melville.

In order to assess the relationship between the climatic variability and the ecosystem of Lake Melville, we first studied observational climate characteristics in Labrador and compared to those simulated by a high resolution atmospheric model model. Preliminary results show a strong agreement between the observational and model simulated data. The estuarine ecosystem and its feedback with the atmosphere are studied with the aid of a coupled physical-biological model.

2E8.3 ID:7075 15:30

Variations of the Nelson and Churchill River dynamics and environmental changes since the last 1700 years.

Quentin Duboc [1], *Guillaume St-Onge* [1], *Patrick Lajeunesse* [2]
[1] Institut des sciences de la mer de Rimouski (ISMER) and GEOTOP
[2] Département de géographie , Centre d'études nordiques and GEOTOP, Université Laval
Contact: quentin.duboc.29@gmail.com

Hudson Bay is a large shallow inland sea that receives about 30% of the total Canadian river runoff. With their mouths located in western Hudson Bay, the Nelson and Churchill Rivers drain more than two Canadian provinces, making their hydrology and sediment discharge highly sensitive to environmental changes in central Canada. These rivers were dammed in the 1970s. Therefore, by studying the sediments at their mouths, it should be possible to reconstruct variations in river dynamics in relation to climatic and anthropogenic changes through time.

During the summer of 2012, three sites located in western Hudson Bay were sampled using a 3-m long gravity-corer on board the CCGS Pierre-Radisson as part of the ArcticNet program: two near the mouth of the Nelson River and one at the mouth of the Churchill River. A fourth core was collected 200 km offshore from these rivers. According to 210Pb analyses in combination

with 14C data, the three cores collected near the coast have high sedimentation rates (between 0.3 and 1.0 cm/yr) and span the last 500 years. Several physical, magnetic and chemical properties of the recovered sediment were measured at high-resolution and reveal high-frequency variations. These variations are likely caused by hydrologic variations of the rivers that could highlight climatic oscillations (e.g., NAO, AO) and/or environmental changes during the last centuries. The fourth core, sampled at a more distal location, covers the last 1700 years, but did not record high-frequency variations as observed in the more coastal cores. However, some magnetic properties show gradual changes through this period, suggesting that the nature and/or the source of the sediment may have changed through time. Further work will focus on the more recent changes to distinguish the climatic from the anthropogenic factors controlling some of these variations.

2E8.4 ID:7174 15:30

High seasonal variability of pH and aragonite saturation state in the Strait of Georgia

Ben Moore-Maley [1], *Susan Allen* [1], *Debby Ianson* [2]
[1] University of British Columbia
[2] Institute of Ocean Sciences
Contact: bmoorema@eos.ubc.ca

A one-dimensional bio-physical model is used to investigate the range and variability of pH and aragonite saturation state in the southern Strait of Georgia, British Columbia. Dissolved inorganic carbon and total alkalinity are modeled as state variables in order to produce pH and aragonite saturation state as outputs. The southern Strait is distinct from neighbouring basins and the continental margins off of Vancouver Island and the United States with respect to pH and aragonite saturation state. Winter is characterized by a well-mixed water column with a pH range of (ca) 7.7 to 7.9. A strong vertical pH gradient appears at (ca) 10 m in spring due to surface productivity and persists until autumn, with near-surface values of (ca) 8.0 to 8.3. Winter surface aragonite undersaturation is a robust feature of the model, and the saturation horizon deepens to (ca) 20 m in early spring prior to the onset of the spring diatom bloom. Periods of summer surface aragonite undersaturation also occur during large Fraser River freshets. By contrast, seasonal cycles of pH and aragonite saturation state in adjacent basins are weak due to enhanced tidal mixing and weak stratification, although similar observations have been reported for Puget Sound, Washington. Over the continental shelf, upwelling and productivity interact to produce region-specific seasonal cycles, none of which are similar to the Strait. The 20 m depth of the aragonite saturation horizon in the Strait is much shallower than typically observed in Puget Sound or over the shelf. Surface aragonite undersaturation is not widely prevalent over the shelf, although isolated incidents have been reported.

2E8.5 ID:7066 15:30

Modelling study of circulation and particle movement in a submarine canyon: Sable Gully

Shiliang Shan [1], *Jinyu Sheng* [1], *Blair Greenan* [2]
[1] Department of Oceanography, Dalhousie University
[2] Ocean and Ecosystem Sciences Division, Bedford Institute of Oceanography
Contact: sshan@phys.ocean.dal.ca

The Sable Gully is a broad submarine canyon located on the edge of eastern Scotian Shelf. Being the home of many marine species, the Gully was designated as a marine protected area (MPA) in 2004. Better understanding of oceanic conditions over this MPA is needed for sustainable ecosystem management. In this study, a multi-nested ocean circulation model and a particle tracking model are used to examine the three-dimensional (3D) circulation and movement of particles carried passively by the flow over the Sable Gully. The circulation model is driven by tides, wind, and surface heat/freshwater fluxes. The model performance is assessed by comparing the model simulations with previous numerical tidal results and current meter observations made in the Gully. The simulated tidal circulation over the Gully is relatively strong on shallow banks and relatively weak on the continental slope. Below the depth of the Gully rim (~200 m), the tidal currents are constrained by the thalweg and amplified toward the Gully head. The simulated subtidal circulation in the Gully has a complex spatial structure and significant seasonal variability. The simulated time- dependent 3D flow fields are then used in a particle tracking model to study the particle movements forward and backward in time, downstream and upstream areas, and residence time of the Gully. Based on the movements of particles released at the depth of the Gully rim and tracked forward in time, the e-folding residence time is estimated to be about 7 and 13 days in February and August 2006, respectively. The Gully flanks are identified as high retention areas with the typical residence time of 10 and 20 days in February and August 2006, respectively. Tracking particles with and without tides reveals that tidal circulation reduces the value of residence time in the Gully, particularly along the Gully flanks.

2E8.6 ID:7348 15:30

A three-dimensional hydrodynamic model for aquaculture: a case study in the Bay of Fundy

Yongsheng Wu [1], *Jason Chaffey* [1], *Brent Law* [1], *David A. Greenberg* [1], *Adam Drozdowski* [1], *Fred Page* [2], *Susan Haigh* [2]
[1] Bedford Institute of Oceanography
[2] St. Andrews Biological Station
Contact: Yongsheng.Wu@dfo-mpo.gc.ca

Impacts of fish cages on the local current field and the erosion rate of the bottom sediment have been investigated with a three-dimensional hydrodynamic model. The model is evaluated against independent observational current data and reasonable agreement is obtained. Model results show that the presence of fish cages restricts water flow and damps the velocity in the surface layer occupied by the cages, but enhances the water velocity in the bottom layer beneath the cages. Sensitivity studies show that the change of the flow velocity beneath the cages is sensitive to variations of the drag coefficient and the depth of the fish cages. As for the drag coefficient, the bottom velocity increases with the drag coefficient before reaching the steady state value. For the cage depth, however, the tidal speed beneath the cages first increases with the cage depth and then significantly decreases with the further increasing depth. The maximum increase of velocity occurs when the cage depth is about half of the local water depth (H/H0 = 0.5, where H is the cage depth and the H0 is the water depth). The increase of the bottom velocity significantly improves the erosion rate of the bottom sediment. The model results also indicate that there exists an optimal drag coefficient and an optimal cage depth for a specific farm site. With the utilization of the optimal drag coefficient and depth, it is possible to speed up the sediment erosion beneath the cages and, thus, decrease the environmental problems caused by

accumulated fish farm wastes.

2E8.7 ID:7350 **15:30**

Evidence for cross-shelf exchange catalyzed by a coastal canyon

Jody Klymak [1], *Susan Allen* [2], *Richard Dewey* [1], *Stephanie Waterman* [2], *Richard Pawlowicz* [2]
[1] University of Victoria
[2] University of British Columbia
Contact: jklymak@uvic.ca

Intense hydrographic and oxygen observations on southern Vancouver Island Shelf during upwelling demonstrate that shelf water north of Barkley Canyon is displaced offshore and replaced by salty, high oxygen water upwelled from the canyon. The "old" shelf water was seen to be moved offshore by approximately 25 km (approximately a Rossby radius) in a well-defined tongue, though its final fate was not tracked. The canyon water flooded the southern shelf west of the "Tully Eddy" with high oxygen water. Exchange with the eddy was limited, likely due to strong geostrophic vorticity over the flat part of the shelf, and any exchange appeared to be linked to ageostrophic tidal motions over the banks.

POSTER-Collaboration in development, application and analysis of ocean forecasting models / AFFICHES- Collaboration dans le développement, application et analyse de modèles de prévision océanique - AFFICHES

Room / Endroit (Congrès A), Chair / Président (Youyu Lu, Frédéric Dupont, David Greenberg & Fraser Davidson), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E9.1 ID:7228 **15:30**

The assimilation of sea level and sea surface temperature into a 1/4 degree North Atlantic model using multivariate ensemble optimal interpolation: the importance of tailoring the ensemble

Vasily Korabel , *Keith Thompson*
Dalhousie University
Contact: v.korabel@gmail.com

The assimilation of three years of surface observations of sea level and sea surface temperature into an eddy permitting model of the North Atlantic is described. It is shown that the performance of the model is improved significantly if the ensemble of model states used to

estimate multivariate covariances is first “tailored” to better represent the forecast errors. More specifically it is shown that vertical filtering of the ensemble, conditioned on season, extends the positive effect of data assimilation on the subsurface fields to the seasonal thermocline and below.

2E9.2 ID:7178 15:30

Effects of different grid resolutions when simulating passive ocean tracers using NEMO and AGRIF

Clark Pennelly , *Paul Myers*
Department of Earth and Atmospheric Sciences, University of Alberta
Contact: pennelly@ualberta.ca

The Nucleus for European Modelling of the Ocean (NEMO) model supports the Adaptive Grid Refinement In Fortran (AGRIF) package, allowing for the introduction of a high resolution sub-domain into any ocean simulation. The addition of a high resolution sub-domain allows for better representation of small-scale features over selected areas of interest, due to a more refined grid resolution. Numerical simulations aim to produce an accurate representation of events, so finer resolution models are highly valued. However, computational cost increases dramatically as resolution increases, therefore the concept of a higher resolution sub-domain is interesting to numerical modelers. AGRIF allows for a combination of high resolution in an area of interest without having the dramatic increase in computational time for a full domain of similar resolution.

We simulated events in the Gulf of Mexico using a 1/4-degree resolution grid with and without an embedded 1/12-degree sub-domain created by AGRIF. We compared the simulations using both resolutions to understand advantages and disadvantages of the AGRIF package when used with NEMO. We specifically examined the effects of grid resolution on a simulated oil spill similar to that of the Deepwater Horizon event. While computational cost doubled when we included the AGRIF sub-domain, the resulting simulation was of higher quality than the simulation without.

2E9.3 ID:7352 15:30

The geometric ingredients of eddy-mean flow feedbacks

Stephanie Waterman [1], *Jonathan Lilly* [2]
[1] Dept. of Earth, Ocean and Atmopsheric Sciences, University of British Columbia
[2] NorthWest Research Associates
Contact: abstracts@CMOS.CA

Understanding eddy-mean flow feedbacks is a long-standing problem in geophysical fluid dynamics with modern relevance to the challenge of representing these effects in coarse resolution models in a manner that accurately represents their dependence on the underlying dynamics of the flow field. Progress may be made by exploiting the recognition that the velocity covariance matrix/eddy stress tensor that describes eddy fluxes, also encodes information regarding eddy size, shape and orientation (see Hoskins et al. 1983; Marshall et al. 2012, Waterman and Hoskins 2013). This provides a potentially fruitful means to link the structural

properties of the eddy field (i.e. eddy energy, anisotropy and orientation) to eddy–mean flow interactions (i.e. eddy fluxes and flux divergences of momentum, buoyancy and vorticity).

Here we outline a framework that describes eddy-mean flow feedbacks in terms of a geometric description of the eddy motion. We discuss generic insights into eddy-mean flow interactions that are offered by this description, and illustrate the insights the framework provides in idealised case studies. Preliminary results suggest that this is a promising approach for progressing our understanding of eddy-mean flow feedbacks: by identifying the important ingredients of the eddy motion that have a mean flow forcing effect; by providing a conceptual picture of the mechanisms of eddy-mean flow interactions; and by illustrating that failure to adequately resolve eddy shape properties, in particular the small length scales needed to resolve eddies with large anisotropy, can result in a critically reduced eddy effect at a model spatial resolution that nevertheless well resolves the eddy size.

POSTER-Acoustics in Oceanography and Marine Sciences / AFFICHES- Acoustiques en océanographie et sciences marines

Room / Endroit (Congrès A), Chair / Président (len Zedel, Tetjana Ross & Yvan Simard), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E10.1 ID:7220 **15:30**

Doppler noise in sonar velocity measurements: what you should be aware of and what you can to minimize the effect

Len Zedel
Memorial University of Newfoundland
Contact: zedel@mun.ca

Doppler sonar systems are the preferred choice for water velocity measurements in many applications ranging from long range profiling to point velocity measurement. However, as with all instrumentation, there are limits to where and how measurements can be made. For all of these systems, low signal levels will degrade data quality, and for profiling systems, signal level decay is typically what limits the operating range. But even when signal levels are adequately high, Doppler sonar systems are subject to so called Doppler noise which originates because of the nature of the acoustic beams that are used and the finite sample volumes. While present in all Doppler systems, the Doppler noise effect is most noticeable in high frequency coherent Doppler systems because of their high measurement precision and the limited data averaging that they require. We discuss some of the sampling considerations important to Doppler sonar systems including how many actual scatterers are required to establish a measurement and how the component velocities are defined. We show how the sample volume gives rise to Doppler noise

and present some examples of how data quality can be improved.

POSTER-Planetary atmospheres, oceans and ice / AFFICHES- Atmosphères, océans et glaces planétaires

Room / Endroit (Congrès A), Chair / Président (John Moores, Kimberly Strong, Tom McElroy, James Whiteway, Peter Taylor, Raymond Francis, Amy Shaw &), Date (03/06/2014), Time / Heure (15:30 - 19:00)

2E11.1 ID:7077 **15:30**

Improvements to a 1-D Single Column Model for simulating atmospheric conditions at the Phoenix Lander Site

Robert Fajber [1], *John Moores* [2], *Frank Daerden* [3], *Jim Whiteway* [2]
[1] University of Victoria
[2] York University
[3] Belgian Institute for Space Aeronomy
Contact: rfajber@gmail.com

Many of the key questions about the climate of Mars and potential for life on the planet are related to the presence and history of water on the planet. To better understand the current water cycle on Mars, the Phoenix Mars lander was sent in 2008 to investigate water in both the atmosphere and regolith. Using a Lidar system the lander made unprecedented observations of both water ice clouds and fog as well as the precipitation of ice. The presence of water ice clouds may be significant for explaining the presence of water in the atmospheric boundary layer, as well as explaining the current stability of the Martian climate. In order to simulate water ice clouds during periods when the Lidar system was not operational and to further investigate water in the Martian boundary layer, a 1-D single column model was developed. Recent improvements to the model include a radiative transfer scheme which allows for the clouds to be radiativley active, and a new soil scheme which allows for a more realistic parameterization of the Martian soil. These changes to the model allow for the simulation of ground fog at the surface and for the potential simulation of boundary layer clouds during the day. These simulations could be used to understand effects of boundary layer weather on the the water cycle (particularly the flux across the surface boundary), investigate the stability of water under different surface conditions, and test the validity of parameterizations of water ice clouds used in general circulation model. The model could also be ported to other locations with a minimum of effort.

Plenary Day 3 / Plénière Jour 3

Room / Endroit (Langevin-Ouellet), Chair / Président (Michael Scarratt), Date (04/06/2014), Time / Heure (08:30 - 10:00)

P3.1 ID:7347 INVITED/INVITÉ 08:30

Le climat et la biodiversité arctique

Dominique Berteaux
Université du Québec à Rimouski
Contact: dominique_berteaux@uqar.ca

Le changement rapide du climat a des effets importants sur la biodiversité arctique. Les deux dernières décennies ont apporté de nombreuses observations sur le sujet, comme le montre le Arctic Biodiverstiy Assessment (2013), un rapport majeur du Conseil de l'Arctique, présidé aujourd'hui par le Canada. De nombreuses questions restent cependant en suspens. Jusqu'à quel point peut-on prédire les effets écologiques futurs des changements climatiques? La biodiversité arctique y est-elle vraiment plus vulnérable que celle d'autres biomes? Devrait-on s'attendre, paradoxalement, à une augmentation de la biodiversité arctique? Nous ferons le point sur ces questions et tracerons quelques voies de réflexions pour l'avenir.

P3.2 ID:7343 INVITED/INVITÉ 09:15

Summary and Key Messages from Working Group I, Physical Science, of the IPCC 5th Assessment

Gregory Flato
Canadian Centre for Climate Modelling and Analysis, Environment Canada
Contact: greg.flato@ec.gc.ca

The IPCC Working Group I is concerned with the physical climate science that underpins our understanding of historical climate change, and contributes to our ability to make quantitative projections of future climate change. The 5th Assessment, published this year, provides a comprehensive update relative to the previous assessment published in 2007. This talk will provide a broad summary focussing on new evidence from observations, the evaluation of comprehensive global climate models, and the use of such models in making predictions and projections of future climate change. Mounting observational evidence illustrates ever more clearly the large-scale, consistent changes that are occurring in the climate system: in the atmosphere, the ocean, the land surface and the cryosphere. Increasingly coordinated and extensive climate model intercomparison efforts have allowed an unprecedented ability to evaluate the performance of global 'Earth System' models (physical models of the coupled climate system that include a range of biogeochemical processes and feedbacks). These models have improved in many, though not all, respects relative to the models available at the time of the 4th Assessment, and the models are able to simulate many large scale features of the climate and its variability. Although there is in general no way to translate quantitative measures of past performance into confident statements about future fidelity, the ability of physically-based models to reproduce many important aspects of the observed climate contribute to our

confidence in the application to climate change detection and attribution, and future climate projections. The presentation will conclude with some results from new climate model projections based on the recent ‘representative concentration pathways’ used as the specification of future climate forcing.

Air quality modeling, analysis and prediction PART 1 / Modélisation, analyse et prévision de la qualité de l'air PARTIE 1

Room / Endroit (Langevin), Chair / Président (Louis Garand), Date (04/06/2014), Time / Heure (10:30 - 12:00)

3B1.1 ID:7072 **10:30**

Data transfer and products for the national AQHI forecast program

Sylvain Menard , David Anselmo , Paul-André Beaulieu
Environnement Canada
Contact: Sylvain.Menard@ec.gc.ca

The national Air Quality Health Index (AQHI) is an information tool that communicates to the Canadian public the total health risk of a mixture of the air pollutants nitrogen dioxide (NO2), ground level ozone (O3), and fine particulate matter (PM2.5). As of May 2014, the AQHI forecast program is active in 82 communities across Canada serving a majority of the population.

In order to provide hourly observations and twice-daily forecasts of the AQHI to Canadian citizens and numerous other clients (e.g. media, regional partners, and health organizations), a comprehensive data transfer and data processing infrastructure has been established. This presentation will provide an overview of this system covering all of the essential, interdependent components.

Perhaps the most critical component of the system is the transfer of air quality observations from provincial and municipal observation networks to the Canadian Meteorological Centre (CMC). This data serves as the source for the calculation of the observed AQHI, as well as the basis for the public forecasts issued twice per day (morning and evening). Both observed and forecasted AQHI, as well as model guidance, are available to the public on Environment Canada’s public web site (http://weather.gc.ca). A data delivery server (Datamart) for the dissemination of AQHI products is also in place for clients and partners. Mobile device applications, build by third party developers, are available to Canadians who wish to access AQHI products while on the go. The primary forecast guidance is provided by the Canadian operational air quality forecast system (RAQDPS). The UMOS statistical post-processing system is applied to RAQDPS output to correct model bias and systematic errors. In addition, hourly surface objective analysis maps are produced for two of the three constituent pollutants of the AQHI (O3 and PM2.5). An internal

Environment Canada web site that integrates all of the above pieces of information into a single resource for operational forecasters will also be presented.

3B1.2 ID:7009 10:45

Northern New Brunswick AQHI Evaluation Study

Alan Wilson [1], *David Waugh* [1], *Steve Beauchamp* [1], *Lucy Chisholm* [1], *Pamela Lehr* [1], *Craig Stroud* [2], *Réjean Savoie* [3], *Mark Gibson* [4], *Dave Henderson* [5], *Mike Howe* [5], *Doug Steeves* [6], *Eric Blanchard* [7]
[1] Environment Canada - MSC Atl AQSU
[2] Environment Canada - S&T
[3] Community College of New Brunswick
[4] Dalhousie University
[5] Environment Canada - MSC AQHI
[6] Environment Canada - MSC ASPC
[7] NB Dept. of Env. and Labout
Contact: alan.wilson@ec.gc.ca

The Campbellton, New Brunswick AQHI measurement site was established in September 2012 in order to evaluate GEM-MACH AQHI forecasts in a rural area. This study is in support of the expansion of Environment Canada's air quality forecast program to providing regional forecasts of the AQHI and to evaluate the efficacy of model based AQHI forecasts. Campbellton was chosen because of its rural landscape settings with relatively low pollutant concentrations with some local anthropogenic sources. Monitoring was conducted with state-of-the-art high-temporal resolution instrumentation for the AQHI constituents (NO_2, O_3, and $PM_{2.5}$), NO, NO_x, and CO, as well as meteorological conditions at the monitoring site. Data available for the period of mid-September 2012 to 31 December 2013 were 97% complete (N ≈ 10000 hourly means). Pollutant concentrations were (read as median, first quartile, third quartile): NO 0.4, 0.0, 1.3 ppbv; NO_2, 2.0, 1.0, 3.8 ppbv; O_3 26.2, 17.3, 32.8 ppbv; $PM_{2.5}$ 3.7, 2.1, 6.4 μgm^{-3}. CO data was available from January – June 2013 and September 2013 to December 2013. CO median, 1st quartile, and 3rd quartile concentrations were 176, 160, 220 ppbv. The observed concentrations of AQHI constituent species are considered to be generally low ambient concentrations. However, the site is inhomogeneous with respect to local emission influences, including motor transport and local heating. The GEM-MACH air quality forecast model and observed AQHI values were within ± 1 of the observed AQHI 98% of the time. The operational GEM-MACH model does not consider forest fire smoke; PM smoke events on 15 June and 1 July 2013 were not seen in model data. Local hourly AQHI maximum values for these two events were 6. There was generally good agreement between modeled and observed constituent values for long-range transport (LRT) of anthropogenic emissions from the St. Lawrence and Ohio valleys. Data collection is scheduled to end June 2014.

3B1.3 ID:7101 11:00

Winter smog? The case of southern Ontario's unusual 'winter smog' event on January 10th, 2014

Trudy Kidd , *Sarah Wong*
Environment Canada

Contact: trudy.kidd@ec.gc.ca

Friday, January 10th, 2014 was a very unusual air quality day over southern Ontario and especially around the Greater Toronto Area. It had all of the right ingredients for a moderate Air Quality Health Index (AQHI) event with a stable airmass over the area due to a dominate high pressure system situated to the east over the Atlantic Ocean and calm to light southerly winds over southern Ontario. There was also widespread mist and fog patches across the region. The build-up of high NO2 from the morning commute combined with increasingly elevated PM2.5 concentrations resulted in high AQHI readings of 7 and 8 at some stations that day. However, was it actually winter smog or was the elevated PM2.5 readings the result of something else? A closer look will be taken at the composition of the PM2.5 as well as the weather pattern experienced that day.

3B1.4 ID:7141 11:15

Deriving relative humidity fields in the Lower Fraser Valley of British Columbia: national implications for assessment of visual air quality

Robert Nissen , Bruce Ainslie , Roxanne Vingarzan , Rita So
Meteorological Service of Canada
Contact: robert.nissen@ec.gc.ca

Fine particulates with diameters less than 2.5 micrometres (PM2.5) pose a significant risk to human health. Concentrations of PM2.5 are commonly measured at air quality monitoring stations; however the distribution may vary widely in space and time. As visibility reduction is strongly correlated with PM concentrations integrated along a linear pathway, visibility monitoring offers a passive remote sensing estimation of air quality. Environment Canada's Air Quality Science Unit, Pacific and Yukon Region, in collaboration with regional agencies have been working on the Lower Fraser Valley (LFV) Visibility Pilot, whose components include monitoring, modelling and the development of a visual air quality index. A major challenge in assessing trends in visual air quality arises from differentiating between changes in meteorology and changes in emissions. Given the LFV's location next to the Strait of Georgia and adjacent waterways, relative humidity remains an important meteorological variable during episodes of impaired air quality, as particulates undergo hygroscopic growth when relative humidity is high. This presentation outlines procedures used to construct reference relative humidity fields spanning the LFV during predominantly sunny weather patterns in the summer. Surface observing stations offer ground truth values of relative humidity. These are spatially supplemented by 3-dimensional fields generated by the Global Environmental Multiscale Limited Area Model (GEM LAM) which has been run at 2.5 km horizontal resolution since 2007. Resultant relative humidity fields for different summer months will be displayed and implications for LFV visual air quality discussed. National relevance and applicability of the analysis methods will also be presented in the context of the existing GEM LAM domains and future plans for a 2.5-km resolution grid spanning southern Canada.

3B1.5 ID:7304 11:30

Spectroscopic measurements of marine boundary layer composition and evolution in an urban shipping environment

Aldona Wiacek
Saint Mary's University
Contact: aldona.wiacek@gmail.com

The measurement capability of atmospheric trace gases relevant to air quality and greenhouse gases (GHGs) that contribute to climate change has been significantly expanded in Halifax, Nova Scotia and the Atlantic Canada region with the recent acquisition of a new open-path Fourier Transform InfraRed (OP-FTIR) remote sensing system. The OP-FTIR system is being commissioned for continuous deployment at Saint Mary's University in Halifax at the newly established Tropospheric Remote Sensing Laboratory (SMU-TRSL). Campaign-based deployments in locations farther afield will be possible as the system is fully mobile, and collaborations with the air quality modeling, analysis and prediction community are desired. The specific research objectives of the SMU-TRSL include:

1) Continuous high temporal resolution characterization of the evolution of a broad suite of Volatile Organic Compounds (VOCs) and other trace gases related to air quality and GHG emissions (e.g., O3, NOx, SO2, CO, CH4, CO2, N2O, NH3, CH2O);

2) Mobile characterization and monitoring of individual sources (e.g., ship plumes, stacks), line emission sources (e.g., roads) and diffuse sources (e.g., crop fields, fuel wood combustion) of air quality and greenhouse trace gases;

3) Correlation of VOC and other trace gas concentrations with the Canadian Air Quality Health Index (AQHI) as well as morbidity and mortality attributed to poor air quality;

4) Determination of the relative importance of local vs. transported air pollution as well as anthropogenic vs. biogenic air pollution as a function of season at ground level in Halifax;

5) Production of unique ground-truthing data to challenge satellite- and model-derived surface concentrations and emissions of air quality and greenhouse trace gases;

6) Expansion of the spectral data analysis technique to perform the retrieval of more trace gases with higher precision and accuracy by investigating radiative transfer theory, optimal spectral region combinations, interfering species relationships and retrieval theory.

Details of the SMU-TRSL will be presented, along with the technical details of the new OP-FTIR remote sensing system and its trace gas measurement capabilities.

3B1.6 ID:7299 **11:45**

OSIRIS and ALiSS Measurements for Air Quality Prediction

Doug Degenstein
University of Saskatchewan
Contact: doug.degenstein@usask.ca

For the past thirteen years the Canadian built OSIRIS instrument onboard the Swedish led Odin satellite has been collecting measurements of spectrally dispersed limb scattered sunlight and

using these to retrieve information on the composition of the Earth's atmosphere in the altitude range from 7 km to 60 km. In particular OSIRIS measurements have been used to retrieve vertical profiles of the ozone and nitrogen dioxide number density and vertical profiles of the stratospheric aerosol extinction. Also, over the past decade OSIRIS measurements have been extremely useful in identifying the impact of volcanic eruptions on not only the stratosphere but on the atmosphere near the surface of the earth. Recently Canada and Sweden have begun studying the concept of a follow-on mission to the highly successful Odin. This new mission, currently named the Atmospheric Limb Sounding Satellite (ALiSS), will involve modified versions of OSIRIS and the Odin-SMR as well as a new Canadian instrument designed to measure vertical profiles of UTLS water vapour. The modified OSIRIS has been named the Canadian Atmospheric Tomography System (CATS) and will make similar measurements to OSIRIS but with greater precision and higher spatial resolution, especially within the UTLS region. This presentation will: describe the Odin instrumentation; discuss recent work on the OSIRIS data records that indicate both the nitrogen dioxide and ozone measured from Odin can be used for air quality analysis; introduce the ALiSS instrumentation; and discuss the potential of the ALiSS measurements for air quality analysis and forecasting should these measurements be made available in near real time.

Oceanographic Services: Applications, Application Development and Dissemination Methodology / Les produits océaniques: Leur utilisation, leur développement et leur diffusion

Room / Endroit (Courchesne), Chair / Président (Fraser Davidson, Denis Lefaivre & Douglas Bancroft), Date (04/06/2014), Time / Heure (10:30 - 12:00)

3B2.1 ID:7160 **10:30**

DFO Services in Operational Oceanography. Case study: Gulf of St. Lawrence

Denis Lefaivre , *Alain D'Astous* , *Zhigang Xu*
Pêches et Océans Canada, Institut Maurice Lamontagne
Contact: denis.lefaivre@dfo-mpo.gc.ca

From 1997 to nowadays, Fisheries and Oceans Canada Services in Operational Oceanography for the community around the Gulf of St. Lawrence has evolved from specific to a restricted clientele into open access through web links. As regional ocean model NEMO becomes operational for all coastline of Canada, the ocean services will follow. Gulf of St. Lawrence as a showcase provides an outlook in the future for all regions of Canada. Services in Operational

Oceanography are provided along three branches: Operational forecast, Hindcast and Climate studies. In all three branches, ocean model are operated in close collaboration with Environment Canada, Meteorological Service of Canada for atmospheric model results. Operational forecasts of water level, surface currents and sea ice cover are oriented towards the navigation community including the recreational boating and in support to operations of the Canadian Coast Guard Search and Rescue, Environmental Response, and Icebreaking Services. The latest breakthrough in the delivery of services is the orientation of the Canadian Hydrographic Service to develop web services in tidal prediction, water level forecast and surface ocean currents. The forecasts are now available freely under a stable format to all users. Developers can tap in the web service and provide tailored outputs for specific clientele: Surface currents for Estimated Time of Arrival of ships to port; water level forecasts for pilots in ship transit and carriers for ship loading; and finally to the general public through a Web site: St. Lawrence Global Observatory: SLGO.ca . Annual Hindcasts of hourly three-dimensional fields of temperature, salinity, currents, water level are being used in ecosystem studies. It has been used for Beluga, lobsters and others. Climate studies provide hourly three-dimensional fields of temperature, salinity, currents, water level over climate periods.

3B2.2 ID:7070 10:45

An Overview of the Oceanographic Component of the World Class Tanker Safety Initiative

Charles Hannah [1], *Patrick Cummins* [1], *Fraser Davidson* [2], *Mike Foreman* [1], *Youyu Lu* [3], *Diane Masson* [1], *Pierre Pellerin* [4], *Greg Smith* [4], *Pramod Thupaki* [1], *Svein Vagle* [1]
[1] Fisheries and Ocean Canada, Sidney, BC
[2] Fisheries and Oceans Canada, St. John's, NL
[3] Fisheries and Oceans Canada, Dartmouth, NS
[4] Environment Canada, Montreal PQ
Contact: Charles.Hannah@dfo-mpo.gc.ca

The World Class Prevention, Preparedness and Response for Oil Spills from Ships Initiative is a major program of the Government of Canada to improve the overall regime under which oil tankers operate in Canada. Oceanography plays a small but vital role in this Initiative. This presentation will provide an overview of the oceanographic program for the North Coast of British Columbia. This includes the observing program and work with Environment Canada to provide a comprehensive environmental prediction system for the north coast of BC. This project can be viewed as a key element in the new DFO Oceanographic Services program.

3B2.3 ID:7321 11:00

The Ocean Data Integrator (ODI)

Martin Taillefer [1], *David Fissel* [2], *Douglas Bancroft* [1]
[1] Maritime Way Scientific Ltd.
[2] ASL Environmental Sciences Inc.
Contact:

Maritime Way Scientific Ltd. in collaboration with ASL Environmental Sciences Inc. have initiated the concept, design and development of the Ocean Data Integrator (ODI). The intent of the ODI is to access a broad range of oceanographic, acoustic & hydrographic datasets on a

single platform for near real time 2D and 3D analysis and forecasting of a wide variety of oceanographic parameters. Fisheries and Oceans Canada (DFO), Environment Canada (EC) and DND have jointly developed the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) with academic partners. CONCEPTS atmosphere-ocean-ice assimilation system and models aims to take advantage of major improvements in models and near real time global oceanographic data sets in order to provide better predictions for synoptic to inter-annual climate forecasts. Maritime Way and ASL are collaborating with, and building on, CONCEPTS to design and implement a system that ingests oceanographic model output data sets to generate value added products for public good and commercial use. This system would fuse in-situ and remotely sensed data with forecast model output, in order to create additional layers of derived geospatial information to support marine decision making and create Decision Aid Products (DAPs) tailored for an end-user. Such a system would integrate the results from decades of advances from university, DFO and EC researchers in coupled physical ocean modelling and improving marine observations. In 2014, Maritime Way and ASL will build the ODI prototype platform to enable the integration of critical data from numerous disconnected data bases (search once, find everything). This will be a modular and forward thinking framework to allow easy expansion to other environmental challenges. The ODI will allow for much simpler updates to Environmental Assessments (EAs) based on new research, and improved data, and the availability of easy and rapid recalculations of scenarios that underpin decisions.

3B2.4 ID:7186 11:15

A 65 year (1948-2012) hindcast of ice-ocean dynamics in the Gulf of St. Lawrence.

Joël Chassé [1], *Dave Brickman* [2], *Diane Lavoie* [3], *Peter Galbraith* [3], *Pierre Larouche* [3], *Nicolas Lambert* [3]
[1] DFO-Gulf
[2] DFO-Maritimes
[3] DFO-Québec
Contact: joel.chasse@dfo-mpo.gc.ca

Knowledge of past physical ocean states is important to better understand environmental issues like hypoxia, acidification and future ocean climate projections. It is also important for management activities like fish stock assessments and marine protected area delineation. Unfortunately, observational systems are often not sufficient to obtain detailed information on ocean state and its variability. Coupled ice-ocean models are good complementary tools to provide ocean state information for the time windows when observational data is scarce. We present the results of an ice-ocean modeling system used to hindcast oceanic conditions in the Gulf of St. Lawrence (GSL). The ocean model is driven with the NCEP atmospheric forcing (winds, heat fluxes), tides and river runoff and it is coupled to an ice model allowing for the modeling of winter processes. Simulations have been carried out for 1948 to 2012 and a climatology (1981-2010) has been calculated from which anomalies are derived. A comparison with ice observations shows that the model performs very well in simulating the inter-annual variability of ice properties. Good agreement of the simulated water temperature with sea surface temperature from remote sensing also indicated a good performance of the modeling system. A selection of physical variable (SST, stratification, estuarine circulation, etc) time series were derived from the modeling system and they are made available to other studies in the Gulf of St.

Lawrence.

3B2.5 ID:7111 11:30

Impact of Coupled Ice-Ocean Data Assimilation on the Coherence of Sea Surface Temperature and Ice Concentration Analyses

Zhongjie He [1], *Gregory C. Smith* [1], *Mark Buehner* [1], *Alain Caya* [1], *Matt Reszka* [1], *Gilles Garric* [2], *Charles-Emmanuel Testut* [2]
[1] Environment Canada
[2] Mercator-Océan
Contact: zhongjie_he@hotmial.com

A coupled ocean and sea ice data assimilation system is being developed to improve the CONCEPTS global and regional ice-ocean forecasting capacity for the Arctic. The assimilation system is constructed based on the SAM2 ocean assimilation system and a 3DVar sea ice analysis system. By coupling the ocean and ice assimilation systems, it is expected that the analysis and forecast of both the ice concentration and sea surface temperature (SST) near the ice edge could be improved. The impact of assimilating ice concentration on the SST and ice extent analysis and forecast skill will be investigated through a series experiments.

3B2.6 ID:7100 11:45

Evaluation of a new operational Gulf of St. Lawrence coupled environmental prediction system based on GEM and NEMO-CICE

Francois Roy [1], *Sarah Dyck* [2], *Greg Smith* [1], *Fred Dupont* [2], *Mark Pilon* [3], *Serge Desjardins* [3], *Jérôme Chanut* [4]
[1] Division de la Recherche en Météorologie, Environnement Canada, Dorval, Québec, Canada
[2] Service Météorologique Canadien, Environnement Canada, Dorval, Québec, Canada
[3] National Lab for Marine and Coastal Meteorology, Environment Canada, Halifax, NS, Canada
[4] Mercator-Océan, Toulouse, France
Contact: francois.roy@ec.gc.ca

The CMC's operational Gulf of St. Lawrence (GSL) coupled weather forecast system is planned to be updated with a new ocean-ice component (NEMO-CICE) and coupling methodology. The use of NEMO-CICE will facilitate future advances toward an increase in resolution and the introduction of new scientific developments. Indeed NEMO and CICE are supported by a large scientific community and are based on more efficient computing technologies than the current system. An ensemble of hindcasts over previous years demonstrate that recent developments in the NEMO-CICE model make it possible to meet the high quality standards of the ocean model by Saucier et al. (2009) used in the current operational system in terms of the tides, circulation and water mass properties. We present results from these hindcasts as well as from an experimental run for the winter of 2014 and compare them with the operational system. The experimental run includes a pseudo-analysis cycle producing daily initial ice-ocean conditions and their subsequent coupled atmosphere-ice-ocean 48 hr forecasts. We first examine extreme weather event cases, and then present results from a subjective evaluation as well as objective skill scores for SST analyses and for ice, surface air temperature and wind forecasts.

Regional climate modelling and climate projections PART 1 / Modélisation régionnale et prévision du climat PARTIE 1

Room / Endroit (Ouellet), Chair / Président (Laxmi Sushama, René Laprise, Ramon de Elia & Anne Frigon), Date (04/06/2014), Time / Heure (10:30 - 12:00)

3B3.1 ID:7069 10:30

Comparison of North-American CORDEX simulations with the Canadian Regional Climate Model at 0.11, 0.22 and 0.44 degree: Does the simulated climate get better with higher resolution?

Philippe Lucas-Picher , Rene Laprise , Katja Winger
Centre ESCER - Université du Québec à Montréal
Contact: plp@sca.uqam.ca

In the CORDEX project, climate modelling centres around the world are invited to perform regional climate model simulations over predefined domains. The horizontal resolution of the simulations are fixed to a relatively coarse resolution of 0.44 degree in order to perform large ensembles of simulations and allow centres with less computer power to participate to the project. However, centres with strong computing capabilities are invited to perform higher resolution simulations to investigate the added value of higher resolution simulations. In this presentation, we compare three simulations with the Canadian RCM at 0.11, 0.22 and 0.44 degree resolution driven with ERA-Interim for the period 1989-2011 over the North American CORDEX domain. Firstly, the analysis focuses on the validation of these simulations with available gridded observations. Then, we verify if two important climate processes over North America, the low-level jet and the North American monsoon, are well simulated at different resolutions. Finally, we investigate the ability of the simulations to reproduce the distribution of daily precipitation intensities.

3B3.2 ID:7053 10:45

Evaluation of daily precipitation statistics from CanRCM4 and CRCM5 simulations over North America CORDEX domain

Emilia Paula Diaconescu [1], *Philippe Gachon* [1], *René Laprise* [2], *John Scinocca* [1]
[1] Canadian Centre for Climate Modeling and Analysis (CCCma), Environment Canada
[2] Centre ESCER, Université du Québec à Montréal
Contact: Emilia.Diaconescu@ec.gc.ca

Daily precipitation statistics simulated by the last two versions of Canadian Regional Climate Models (RCMs), CRCM5 and CanRCM4 developed respectively by UQAM and CCCma, are evaluated over North America using three different observed datasets, i.e. the new version of 1-

Degree Daily precipitation of Global Precipitation Climatology Project (GPCP -1DD v.1.2), the ANUSPLIN developed by Agriculture and Agri-Food Canada/Natural Resources Canada and CPCUS. These runs correspond to Canadian contribution of the international CORDEX project. Both RCMs are driven by ERA-Interim reanalysis and use the same dynamics from the Environment Canada forecast model-GEM (Global Environmental and Multiscale model). The primarily difference between these two RCMs consists in using different physics packages. The evaluation is focused on the high order daily precipitation statistics (maximum length of wet and dry spells, number of heavy and very heavy precipitation events, and precipitation frequency distribution). The results show that the skill for the annual and seasonal rainfall totals is quite good for both models. However, the models present substantial differences in the number of very heavy precipitation events as well as in the longest simulated wet spells over the summer season.

3B3.3 ID:7208 11:00

Storm track variability and changes over Canada as simulated by different regional climate models

Philippe Gachon [1], *Rabah Aider* [2], *Guillaume Dueymes* [2], *Milka Radojevic* [2], *Rene Laprise* [2], *Laxmi Sushama* [2]
[1] Environnement Canada
[2] UQAM (ESCER)
Contact: philippe.gachon@ec.gc.ca

As major storms have the strong potential to deeply affect natural and human systems, there is a crucial need to better understand storm exposure in its spatial and temporal dimensions, including its plausible change. Furthermore, projected changes in weather storminess over Canada are expected to contribute to changes in weather extremes and hydro-meteorological hazards, through an interrelation of large-scale and regional-scale physical processes. Hence, the main objective of this study is to improve our understanding of the regional features of storm changes and the links between storm activities, including blocking events and weather extremes, for various regions across Canada. This study is part of the recent CNRCWP (Canadian Network for Regional Climate and Weather Processes) project, coordinated by UQAM/ESCER in collaboration with Environment Canada. This study examines both current and future regional-scale climate simulations from three different Canadian Regional Climate Models (CRCMs) versions. This includes the previous CRCM4.2.3 model (simulations available from Ouranos), and the last two recent CRCM versions, i.e. the CanRCM4 developed by CCCMA and the CRCM5 developed at UQAM/ESCER centre. The storm features simulated by RCMs are first compared against four different reanalysis datasets over the current baseline period (1961-2009), and then evaluated over future period (i.e. 2041-2070) with CRCM simulations driven by two different Canadian Global Climate Models (i.e. CGCM3 and CanESM2). The cyclone characteristics are analyzed in terms of mean occurrence (density), duration or persistence (lifetime and moving speed), redevelopment, extent and intensity. The links between these storm track characteristics and large-scale teleconnection indices, as well as blocking events, are analyzed over three key stormy regions, i.e. the Hudson Bay area, the Atlantic coasts and the Great Lakes area. The variability and changes in storm tracks and their effects on the variability and changes of cold/warm extremes and dry/wet spells are also briefly presented.

3B3.4 ID:7065 **11:15**

Exploring a 3-step Regional Climate Downscaling: the SST bias correction

Leticia Hernandez-Diaz , René Laprise , Oumarou Nikiema , Katja Winger
Centre ESCER, Dép. Sc. de la Terre et de l'atmosphère, UQAM
Contact: leticia@sca.uqam.ca

The use of Regional Climate Models (RCM) for the Dynamical Downscaling of climate projections over a selected domain is nowadays very common. This technique needs large-scale information from a Coupled Global Climate Model (CGCM) simulation to serve as boundary conditions (BC) to drive the RCM simulation. CGCM fields serve both as lateral BC in the atmosphere and lower BC over the ocean. It is well documented that biases in CGCM simulations have detrimental impacts in nested RCM simulations, a process referred to as "garbage in, garbage out" in the RCM community. While the quality of CGCMs has steadily been improved, force is to admit that BC from the state-of-the-art CGCMs are not yet as good as one would like. For example, strong sea surface temperature (SST) biases are still present in most of the CGCMs participating in the recent Coupled Model Inter-comparison Project – Phase 5 (CMIP5). In an attempt to improve BC used to drive RCM simulations, an empirical correction of SSTs biases from a CGCM simulation has been done in some recent studies. Here we present a 3-step approach in which the SST from a CGCM (MPI-ESM-LR) simulation are empirically corrected and used as ocean lower BC for an Atmosphere-only GCM (GEM-Global) simulation, which in turn will provide the BC to drive an RCM (CRCM5) simulation.

3B3.5 ID:7064 **11:30**

Energy cycle associated with Inter-member Variability in a large ensemble of simulations of the Canadian RCM (CRCM5)

Oumarou Nikiéma , René Laprise
(Presented by *Oumarou Nikiema*)
ESCER - UQAM
Contact: nikiema@sca.uqam.ca

In an ensemble of high-resolution Regional Climate Model (RCM) simulations where different members are initialised at different times, the individual members provide different, but equally acceptable, weather sequences. In others words, RCM simulations exibit a kind of uncertainty called Internal Variability (or Inter-member Variability – IV), defined as the inter-member spread between members of the ensemble of simulations. Our recent studies reveal that RCM's IV can be associated with energy conversions similar to those taking place in weather systems. By analogy with the classical work on global energetics of weather systems, a formulation of an energy cycle for IV has been developed that is applicable over limited-area domains. Prognostic equations for ensemble-mean kinetic energy and available enthalpy are decomposed into contributions due to ensemble-mean (EM) variables and those due to deviations from the ensemble mean (IV). Together these equations constitute an energy cycle for IV in ensemble simulations of a RCM. By using a 50-member ensemble of one-year simulations that differ only in their initial conditions (IC) and performed with the fifth-generation of the Canadian RCM (CRCM5) over an eastern North America domain, we evaluate the various energy reservoirs of IV and exchange terms between reservoirs. Results show a remarkably close parallel between the

energy conversions associated with IV in ensemble simulations of RCM and the energy conversions in weather systems.

High Resolution Atmospheric Modeling PART 1 / Modélisation atmosphérique à haute résolution PARTIE 1

Room / Endroit (Léonard-Blais), Chair / Président (Jason Milbrand & Stéphane Bélair), Date (04/06/2014), Time / Heure (10:30 - 12:00)

3B4.1 ID:7143 10:30

Impacts of high-resolution modeling on forecasts of ocean-surface winds in the Lancaster Sound region

Christopher Subich , Greg Smith , Vincent Fortin
Environment Canada
Contact: Christopher.Subich@ec.gc.ca

Sea ice dynamics have a significant impact on Arctic weather over the short and medium term, but current atmospheric forecast configurations are insufficient to fully capture topographically channeled winds that can potentially lead to localized polynya events in coastal areas, which in turn lead to significant heat fluxes that would otherwise remain un-modeled.

One area particularly susceptible to these topographically channeled winds is the region near Lancaster Sound, including northern Baffin Bay, where existing GEM (Global Environmental Multi-scale) configurations for global (~25km grid size) and regional (10km grid size) forecasting are insufficient to resolve the narrow, deep fjords of Baffin Island.

This work attempts to characterize the effect of high resolution modeling on the surface ocean winds, especially in coastal regions, with the eventual aim of better informing ice forecasting and coupled atmosphere/ice/ocean modeling. Comparisons of surface wind fields over the Winter 2011 and Summer 2012 period between high-resolution (2.5km), regional, and global reforecasts and available wind measurements will be shown, with focus on near-coastal measurement stations and SARWinds satellite imaging over open water.

3B4.2 ID:7151 10:45

Distribution spatiale de la température de l'air dans le Grand Montréal en fonction des caractéristiques de l'environnement physique et des conditions météorologiques.

Sylvain Labrecque [1], Frédéric Chagnon [1], Philippe Martin [1], Éric Marcotte [2], Abderahmane Merahi [3], Christian Saad [1]

[1] Environnement Canada
[2] École Polytechnique de Montréal
[3] Université du Québec à Montréal
Contact: Sylvain.Labrecque@ec.gc.ca

Les prévisions météorologiques estivales émises pour l'Aéroport International de Montréal-Trudeau (YUL) ne sont pas systématiquement représentatives des conditions observées au sein des divers secteurs de l'agglomération en raison de leurs différents environnements physiques. Par exemple, un réseau d'observations météorologiques (Wunderground) a révélé que, lors de la vague de chaleur de juillet 2010 à Montréal, des seuils de température servant au déclenchement d'un « plan chaleur » ou à l'émission d'avertissements de chaleur accablante ont été atteints dans certains quartiers sans toutefois l'être à la station de référence (YUL). L'objectif de ce projet est de développer un modèle numérique décrivant le biais thermique et d'humidité dans le tissu urbain de Montréal par rapport à la valeur prévue pour YUL par le Service Météorologique du Canada. Ce modèle permettra de prévoir la température et l'humidité dans divers quartiers avec comme prédicteur les conditions météorologiques prévues à YUL et les caractéristiques de l'environnement physique. Ainsi, le Service météorologique du Canada a établi une base de données à partir d'un réseau de 27 capteurs (21 sondes et 6 micro-stations) enregistrant la température et l'humidité de l'air entre juin et septembre 2013 afin de caractériser ces écarts et de développer le modèle d'inférence. Le choix des sites du réseau tient compte de l'ensemble des types de tissus urbains et d'environnements présents à Montréal. De plus, des données de surface ont servi à la cartographie du potentiel de réchauffement des divers secteurs de la ville et de ses alentours. La méthodologie employée ainsi que l'avancement du projet seront présentés lors de la conférence.

3B4.3 ID:7022 11:00

Slope winds during abnormally cold weather in Southern New Zealand: downscaling a reanalysis

John Wilson
University of Alberta
Contact: jaydee.uu@ualberta.ca

During July 1996 south-eastern New Zealand experienced a period of extreme cold, and the resulting pattern of tree damage indicated that cold air ponding had been an important factor. To confirm that hypothesis reanalysis fields (2.5 degree resolution) have been downscaled dynamically using the Weather Research and Forecasting (WRF) mesoscale model, across nested grids to an inner domain covering 17 km x 17 km with a resolution of 222 m. So long as vertical resolution is enhanced near ground relative to the default configuration, WRF resolves small scale drainage flows during strongly stable wintertime conditions over this modest topography (peak elevations above sea level roughly 400 m, and valley-crest amplitudes of order 100 m).

3B4.4 ID:7188 11:30

High Resolution Modeling Over Placentia Bay, Newfoundland

David Bryan , Benoit Pouliot , Shawn Allen
AMEC

Contact: david.bryan@amec.com

Placentia Bay in Newfoundland, Canada is a busy bay with a wide variety of users, from commercial vessels to pleasure crafts. In addition to the traffic, aspects of the bay navigation include narrow waterways in places, the presence of shoals and small-craft users. Therefore, accurate wind, wave and visibility observations and forecasts are important to ensure the safety of all users. Small crafts are especially vulnerable to winds and waves, though large crafts can be affected as well. If seas or winds are high enough, it can be impossible for crafts to dock safely. Successful navigation of such waters is facilitated by knowledge of current and forecast wind speed, wave height and visibility. The Marine Institute of Memorial University of Newfoundland created the Smart Bay project with funding from the Canadian government's Economic Action Plan and the provincial government of Newfoundland and Labrador. Smart Bay's mission is to foster sustainable development and to improve all users' experience in Placentia Bay through the availability of sophisticated forecasting services. For the Gateway project, Smart Bay has contracted with Amec to provide its latest enhancement to its forecasting services. Amec has adopted a number of sophisticated techniques in their implementation of the Weather Research & Forecasting (WRF) model. First, Amec created a high resolution model (2 km) of the bay and then performed a sensitivity analysis of WRF's seven planetary-boundary layer models over the bay. Amec then incorporated high resolution (10 km) sea surface temperature data into the model's input. Amec has also implemented four dimensional data assimilation in their model. Furthermore, this output from WRF is used to drive Amec's implementation of Wavewatch III. When considering mean absolute error and the Heidke skill score, the results from both Amec's WRF and Wavewatch III are typically better than that from publicly available models.

3B4.5 ID:7080 11:45

Évaluation subjective dans un contexte opérationnel d'une nouvelle version du Système régional de prévisions d'ensemble canadien en phase de développement.

Alexandre Parent [1], *Amin Erfani* [2], *André Giguère* [1], *Normand Gagnon* [2], *Ronald Frenette* [3]
[1] Environment Canada / CMC / Opérations
[2] Environment Canada / CMC / Développement
[3] Environment Canada / SMC / Lab-Québec
Contact: andre.giguere@ec.gc.ca

À la suite d'une évaluation objective non concluante, la division du Développement des Prévisions Nationales du Centre météorologique canadien (CMC) a demandé à la section des Analyses et Pronostics (AetP) de la division des Opérations des Prévisions Nationales du CMC d'évaluer de façon subjective des modifications apportées à la physique du nouveau Système Régional de Prévision d'Ensemble (SRPE version 2.0) alors en phase de développement.

Sur une période d'un mois, une évaluation de la performance du SRPE v2.0 pour les quantités de précipitations fut faite par sept météorologues opérationnels d'AetP. Un nouvel outil d'analyse fut développé afin de comptabiliser les observations et d'en générer des conclusions statistiques. L'exercice s'est fait sur 106 cas météorologiques différents avec des précipitations supérieurs à 5 mm, étalés sur 236 périodes de 24 heures. Deux produits des Systèmes Régionaux de Prévisions d'Ensembles furent utilisés en particulier pour l'évaluation, soit les seuils et les centiles.

Les résultats de l'exercice ont validé les modifications apportées en phase de développement au SRPE v2.0 qui améliorent les prévisions de précipitation sur le territoire nord-américain dans un rapport de 5 pour 1. De plus, les épisodes de prévisions extrêmes et irréalistes furent diminués de façon drastique sans pour autant affecter les propriétés dispersives du système de prévisions d'ensemble.

Marine Ice from Science to Operations PART 1 / Glace de mer : de la science à l'opérationnel PARTIE 1

Room / Endroit (Parent), Chair / Président (Thomas Carrières, David Barber, Hal Ritchie & Greg Smith), Date (04/06/2014), Time / Heure (10:30 - 12:00)

3B5.1 ID:7019 **10:30**

Sea ice thickness variability in the Canadian Arctic: from Science to Operations

Christian Haas
York University
Contact: haasc@yorku.ca

The high Canadian Arctic is the focus of national and international attention, however, little is known about ice conditions apart from ice concentration, type, and drift which are observable from satellites. Here we report about efforts and observations to better understand the temporal and regional variability and trends of sea ice thickness. We have performed airborne electromagnetic (EM) ice thickness surveys between Canada and the North Pole since 2004, and in the Beaufort Sea since 2009. These provide unique insights into the thinning of multiyear ice in these regions. For example, our results show significant thinning, with mean regional thicknesses of only 3.9 m in 2012, 0.9 m less than in 2004. However, the gathered information is also important for the assessment of environmental conditions and development of policies for safe and environmentally responsible offshore operations. Results also show that there are still significant amounts of hazardous multiyear ice and heavily deformed first-year ice of considerable thickness. For example, ice thickness in Viscount Melville Sound was more than 5 m on average over numerous 1 km long sections of the flight track. We also surveyed the thickness of several ice islands and the Ward Hunt Ice Shelf, and show that thicknesses of up to 60 m can be measured by means of our airborne, frequency-domain electromagnetic sounding method. Ice islands in Viscount Melville Sound and the Beaufort Sea had thicknesses well over 30 m. We will also report on efforts to extend our observational capabilities along the vast regions of the Northwest Passage, by means of ground-based surveys during snowmobile trips by hunters or the Canadian Rangers. Together with airborne surveys these provide the opportunity for a Canadian Arctic Sea Ice Observatory where routine observations can be obtained in support of seasonal ice prediction and ice navigation.

3B5.2 ID:7227 **10:45**

Thickness of sea ice in the Gulf of St. Lawrence

Urs Neumeier , Sylvain Joly
Institut des sciences de la mer de Rimouski
Contact: urs_neumeier@uqar.ca

The spatial distribution of sea ice can be determined relatively easily from satellite, ship and aircraft-based observations. In the Gulf of St-Lawrence (GSL), daily sea-ice charts are produced by the Canadian ice service, which describe ice concentration, stage of development (thickness estimates) and floe size. However these thickness estimates are not well suited for small-scale coastal erosion studies and numerical modelling. Only limited information is available about accurate ice thickness over the GSL. Since 2010, several ADCPs (AWAC-AST) were moored at different coastal sites in the GSL at 30 to 40-m depth. These instruments carry a vertical acoustic beam that works like an ice pinger, measuring the distance to the water-ice interface. Thus, hourly time-series of sea-ice thickness (17 minute bursts) were obtained over several winters. These one-point measurements inform also of lateral sea-ice variability, since sea-ice is very dynamic under the effect of wind and currents. Our results show a high variability in sea-ice cover over the winter season, which can be explained by relatively mild winters and dispersion by wind and currents. Moreover, sea-ice thickness is rarely constant during several hours, and the sea-ice bottom shows different kinds of roughness. Thickness varies from young ice of 10-20 cm to first-year ice of 30-100 cm, and there are sometimes thickenings up to 5-8 meters. These thickenings are observed in sites where wind and currents converge to deform ice and produce pressure ridging. Data show also small floes with free-water windows where waves can be still present. When sea-ice is discontinuous and wave energy sufficient, floes and ice cakes oscillate with the waves. These new results for the GSL will allow the further improvement of data recorded by the Canadian ice service, and the validation of numerical modelling output.

3B5.3 ID:7353 **11:00**

The METAREA Initiative: Latest Update

Marie-France Gauthier
n/a
Contact: abstracts@CMOS.CA

N/a

3B5.4 ID:7086 **11:15**

East-West Asymmetry in Coastal Temperatures of Hudson Bay as a Proxy for Sea Ice

Peter Mcgovern , William Gough
University of Toronto
Contact: p_mcgoo@hotmail.com

The seasonal asymmetry in coastal temperatures on Hudson Bay was explored and evaluated as a proxy to hindcast sea ice conditions prior to 1972. Various indices of air temperature difference

(ΔT) between Churchill, MB and Inukjuak, QC were tested for linear correlations with spatially averaged sea ice concentration (SIC) and ice-free season length (IFS). A multiple regression equation employing a 31-day average of peak ΔT and a 61-day average of temperature during freeze-up reproduced the IFS record with an average error of 8.1 days. This equation was employed to extend the IFS record by 28 years. The resulting 68-year time series revealed a significant increasing trend most pronounced from 1985 to 2011. Hindcast data helped eliminate low-frequency climate oscillations of periodicity <68 years as a source of this trend, lending further evidence to the growing consensus for the decline in sea ice being a result of anthropogenic climate forcing.

3B5.5 ID:7281 **11:30**

What do ice charts tell about wave-ice interactions?

Paul Nicot, *Dany Dumont*
UQAR-ISMER
Contact: paul_nicot@uqar.ca

The marginal ice zone (MIZ) is a very dynamic area where ocean waves and sea ice interact strongly. Sea ice scatters and dissipates the energy of the waves that can travel very long distances in the ice, while flexural stresses in the ice induced by waves break large floes into smaller ones. Recent theoretical and modelling efforts led to the development of coupled wave-ice interaction models that predict what should be the floe size distribution as a function of the incident wave spectrum. However, this prediction is not easy to confirm and validate due to the scarcity of reliable measurements of the floe size distribution. Ice charts produced by National Ice Services represent a long-term and systematic evaluation of ice properties in most Arctic and sub-arctic ice-covered seas given in the form of the internationally recognized egg code standard. The egg code contains information about the predominant floe size of each ice type. Here we use digital ice charts to characterize MIZs of the Greenland, Labrador and Beaufort Seas, analyse the sensitivity of various criteria and algorithms on the MIZ width assessment, and compare the results with wave conditions prevailing in the adjacent open water areas. Based on obtained results, we argue that floe size is a key state variable for sea ice dynamics, that ice charts present a great potential for better understanding and monitoring the MIZ, and that efforts must be done to improve the way we assess this more precisely and systematically.

3B5.6 ID:7092 **11:45**

Can polar bear's radio-collar-telemetry data help validate sea ice models?

Laura Castro De La Guardia [1], *Paul Myers* [1], *Andrew Derocher* [1], *Arjen Terwisscha Van Scheltinga* [2], *Nick Lunn* [3]
[1] University of Alberta
[2] University of Bristol
[3] Environement Canada
Contact: castrode@ualberta.ca

Validation of ice concentration during periods of rapid ice changes is limited by the accuracy and resolution of satellite imagery. To fill this gap we explore the use of polar bear (Ursus maritimus) telemetry data to validate an ice model and to study ice phenology in Hudson Bay.

Telemetry data was obtained from Argos-satellite radio collars deployed on female bears in western Hudson Bay. The dependence of polar bears on sea ice and the limitation of radio collars to transmit when the antenna is submerged, suggest the possible use of offshore-locations as presence of sea ice. Ice simulations were done with an unstructured finite element sea-ice model of the northern hemisphere over the period 1979-2010. The model and passive microwave data (PMW) climatology were first compared to Canadian Ice Service Digital Archive (CISDA). Secondly, model and PMW daily ice concentration was compared to telemetry data. Compared to CISDA, large differences were found for both model and PMW data in June, July, November and December. Compared to telemetry data, largest underestimations were found in July when PMW significantly underestimated the sea ice used by polar bears, however the model underestimation in July was minor. As PMW did not represented well the habitat used by polar bears in July we did not use PMW to study ice phenolgy, instead, we use the migration of polar bears. We confirm the high correlation between the migration and the ice concentration in western Hudson Bay: migration ashore was 1.2 days before the 50% ice concentration and migration offshore was 0.7 days after the 10% ice concentration. A hindcast of the ice-free period define from polar bear perspective showed that the period polar bears spent on land lengthened by 2 weeks between the decades of 1980 and 2000.

Air quality modeling, analysis and prediction PART 2 / Modélisation, analyse et prévision de la qualité de l'air PARTIE 2

Room / Endroit (Langevin), Chair / Président (Louis Garand), Date (04/06/2014), Time / Heure (13:30 - 15:00)

3C1.1 ID:7235 **13:30**

Mercury pollution in Canada: A modeling study

Ashu Dastoor , Andrei Ryzhkov , Dorothy Durnford
Environment Canada
Contact: ashu.dastoor@ec.gc.ca

Human activities have increased the amount of mercury (Hg) cycling in Earth’s land-atmosphere-ocean system by a factor of 3-5 from pre-industrial to present day. Atmospheric transport and deposition is the main pathway for the introduction of Hg in the global ecosystems. In aquatic systems, Hg converts into methylmercury, a neurotoxin, and bioaccumulates up the food chain causing risks to human health and the environment. We have developed a three dimensional Hg model-GRAHM (Global/Regional Atmospheric Heavy Metals Model) to investigate the pathways and cycling of mercury in Canada. GRAHM is an extension of Environment Canada's weather forecast model. Meteorological processes and Hg physico-chemical processes in the atmosphere are simulated in the model. Hg emissions include global

anthropogenic, natural and re-emission of previously deposited Hg from land and oceans. The model includes mercury emissions, transport, boundary layer mixing, gas and aqueous phase chemical reactions, scavenging by clouds, deposition and bi-directional surface exchange of mercury. It is important to model the fate of mercury deposited onto snowpacks to capture the impact of changing climate on mercury accumulation in the North. Deposited mercury may be reduced to volatile mercury in the snowpacks and re-emitted back to the atmosphere or be trapped and enter the aquatic bodies via meltwater depending on the surface characteristics and meteorological conditions. A dynamic scheme of air-ice-snowpack-melt water exchange of mercury is implemented in the model.

The model is applied to study mercury pathways, budgets, source-attribution, temporal trends and net accumulation of mercury in Canada including the Arctic. Relevance of mercury deposition to the snowpacks in the Arctic including Arctic Ocean is analyzed. It is found that over 95% of anthropogenic mercury deposition in Canada comes from foreign sources. Model and detailed analysis of mercury pathways, spatial distribution, source-attribution and temporal trends in Canada will be presented at the conference.

3C1.2 ID:7013 **13:45**

Measuring the Effects of Shipping on Air Quality in Arctic Communities

Amir Aliabadi , Ralf Staebler
Environment Canada
Contact: ralf.staebler@ec.gc.ca

The Arctic has experienced rapid climate change and increasing resource development in the recent years. There are environmental concerns that decreasing ice, increasing ship navigability, and potential resource development will disturb fragile ecosystems even faster in the decades to come. Environment Canada has been particularly interested in shipping activity in the Canadian Arctic and has provisioned surface air monitoring capacities to study its impact. NOx, SO2, O3, and PM2.5 concentrations in the atmosphere near the ground were measured both during a ship-based campaign on the CCGS Louis St-Laurent ice breaker (2012) and a land-based campaign in Cape Dorset and Resolute, Nunavut (2013) during the high shipping season. Arctic shipping activity in Canada has been studied in detail as well. The ship-based campaign results indicate that the influence of shipping emissions in the 'remote' Arctic increases NOx, SO2, and PM2.5 levels but decreases O3 levels due to titration processes. The land-based campaign results indicate that the influence of shipping emissions in the `high traffic' zones of the Arctic increases NOx, SO2, PM2.5, and O3 levels simultaneously, possibly due to enhanced photochemical processes. For the land-based campaign, an analysis is performed to apportion surface air pollution into local and marine (shipping) sources using air mass trajectories. It is estimated that O3 caused by ship emissions contributes more to concentrations measured in these communities than NOx, SO2 and PM2.5 when compared to local emissions. SO2 and PM2.5 contributions due to shipping are higher for Resolute than Cape Dorset, suggesting a more direct impact of shipping emissions at higher latitudes. These results will assist modeling capacities at Environment Canada.

3C1.3 ID:7104 **14:00**

Modelling the Canadian Arctic and Northern Air Quality Using GEM-MACH: (1) Overview of model development

Wanmin Gong , Stephen Beagley , Sophie Cousineau , Jack Chen , Mourad Sassi
Environment Canada
Contact: wanmin.gong@ec.gc.ca

The Arctic is recognized as one of the key areas of the globe, both in terms of its sensitivity to climate change, and by the increasing economic activity associated with the opening up of Arctic waters in a warming climate. Environment Canada is undertaking an initiative to develop an air quality modelling capacity for the Canadian North and Arctic region, in the context of assessing the impacts of the current and future air contaminant emissions from shipping and other sources on the northern environment and human health.

In this paper, we describe the current development of a GEM-MACH based air quality modelling platform for the Canadian Arctic, including model configuration and science module updates pertinent to the northern environment. Preliminary results on model sensitivity to chemical boundary conditions and removal processes will be discussed.

3C1.4 ID:7107 14:15

Modelling the Canadian Arctic and Northern Air Quality Using GEM-MACH: (2) Assessing the modelling system

Stephen Beagley , Wanmin Gong , Sophie Cousineau , Jack Chen , Mourad Sassi
Environment Canada
Contact: wanmin.gong@ec.gc.ca

A GEM-MACH based Arctic air quality modelling capability is being developed at Environment Canada to, in the short-term, assist with an assessment of the impact of the current and future air contaminant emissions from shipping and other sources on the Arctic environment and human health and, in the longer term, meet the needs for both scientific research and policy applications in understanding and addressing air quality and environmental issues in the Canadian North.

A number of model simulations have been conducted for the year 2010 using the new Arctic air quality modelling platform. Comprehensive evaluation of the model's simulation capability of O3, NOx, CO, and other species has been carried out against available observations from various surface monitoring networks, such as NAPS, AIRS, and WDCGG. In this paper, we present preliminary results from this model evaluation. As well, the role of long-range transport and, in particular, the impact of North American wild fire emissions on the Arctic regions during summer period will also be discussed.

3C1.5 ID:7249 14:45

Transport of constituents in the Global Environmental Multiscale (GEM) model

Jean De Grandpre , Monique Tanguay , Abdassamad Qaddouri , Saroja Polavarapu
Environment Canada
Contact: jean.degrandpre@ec.gc.ca

With the development of Chemical Data Assimilation systems and cloud resolving NWP models, mass conservation properties of Semi-Lagrangian (S-L) transport schemes need to be reassessed. For this reason the Meteorological Research Division in collaboration with the Air Quality and Climate Research Divisions have initiated a study on the transport of constituents and associated mass conservation issues in GEM at short, medium range and seasonal time scales. Explicit mass fixers have been implemented in the S-L dynamical core and have been evaluated with different configurations using both the Global Uniform and Yin-Yang grid systems. Different approaches have been evaluated for various constituents including stratospheric ozone and greenhouse gases such as methane, nitrous oxide and carbon dioxide. Results show that mass drifts associated with the transport of long lived constituents can be significant but generally reach a quasi-equilibrium over multi-year simulations. The study also highlight limitations associated with the use of such approaches and the need for the development of an inherently mass conserving S-L scheme for Air quality applications in GEM.

Trends and projections of climate change in the Canadian Aquatic Environment PART 1 / Tendances et projections du changement climatique dans l'environnement aquatique canadien PARTIE 1

Room / Endroit (Courchesne), Chair / Président (Guoqi Han, Joël Chassé & Nadja Steiner), Date (04/06/2014), Time / Heure (13:30 - 15:00)

3C2.1 ID:7238 **13:30**

DFO's Climate Adaptation Program: The Science behind the Basin-Level Risk Assessments

Paul Lyon
Fisheries and Oceans Canada
Contact: Paul.Lyon@dfo-mpo.gc.ca

The objective of the Aquatic Climate Change Adaptation Services Program (ACCASP) is to assess the risks that climate change poses to the delivery of the Department of Fisheries and Oceans' mandate across diverse aquatic ecosystems and assist mangers in making evidence-based decisions that enable adaptation. The Program was responsible for four large basin assessments: the Arctic, Pacific, Atlantic and Freshwater, which were completed in March 2013. In the fall and winter of 2013-14 detailed Technical Reports portraying the science inputs into the risk assessments were published. This presentation provides an overview of ACCASP to contextualize the series of papers being presented in this special CMOS session.

3C2.2 ID:7185 **13:45**

Regional simulation ensemble of the Gulf of St. Lawrence future ocean climate.

Joël Chassé [1], *Will Perrie* [2], *Zhenxia Long* [2], *Dave Brickman* [2], *Lanli Guo* [3], *Nicolas Lambert* [4]
[1] DFO-Gulf
[2] DFO-Maritimes
[3] Dallhousie University
[4] DFO-Quebec
Contact: joel.chasse@dfo-mpo.gc.ca

Global Climate Models (GCMs) have proven to be useful tools in understanding potential climate change at the scale of ocean basins but they lack the spatial resolution to give good estimates over the shelf, especially in semi-enclosed systems like the Gulf of St. Lawrence (GSL). Mid-latitude semi-enclosed seas typically respond to local forcing which is not represented very well in GCMs and climate downscaling techniques are necessary to better assess the potential change. We present the results of a regional ocean climate dynamical downscaling system for the Gulf of St. Lawrence. The system consists of the atmospheric Canadian Regional Climate Model (CRCM), a hydrology model and the NEMO ice-ocean coupled model. The presentation will focus on the analysis of six 130-year-long high-resolution simulations of ocean dynamics (1970-2100) under the A1B, RCP4.5 and RCP8.5 scenarios. The global simulations used as input in the downscaling system were obtained from the Canadian Centre for Climate Modelling and Analysis, the National Center for Atmospheric Research and the Max Planck Institute for Meteorology. A finding of the downscaling system is the significant spatial variability of the projected changes at the scale of the Gulf of St. Lawrence with the southern GSL warming up at a faster rate than the northern portion over the next 85 years. Due to increased river runoff and a re-distribution of its annual cycle, surface salinities will be decreasing in the Gulf except in summer. The decrease in salinities will be particularly marked in the St. Lawrence estuary in winter. The stratification (0-50m) will be increasing for the four seasons with maximum change in summer and minimum change in fall.

3C2.3 ID:7287 **14:00**

Impacts of Climate Change in the Gulf of St. Lawrence

Zhenxia Long [1], *Will Perrie* [1], *Joel Chasse* [2], *Dave Brickman* [1], *Lanli Guo* [3], *Adam Drozdowa* [1]
[1] Bedford Institute of Oceanography
[2] Maurice Lamontagne Institute
[3] Dalhousie University
Contact: perriew@dfo-mpo.gc.ca

The present study explores how water temperature and salinity might be modified under warming-induced conditions due to climate change. We performed simulations from 1970 to 2069 with a coupled ice-ocean model (CANOPA) implemented for the Gulf of St. Lawrence and Scotian shelf. The surface fields to drive CANOPA were provided by the Canadian Regional Climate Model (CRCM), driven by the third- generation Canadian global climate model (CGCM3) outputs following the A1B climate change scenario. The sea ice concentration and volume simulated by CANOPA are shown to have consistent patterns to those seen in observations. In addition, CANOPA simulates the sea surface temperature well, compared to

observations. While the model simulation shows the observed vertical structure of water temperature and salinity, it tends to underestimate the cold intermediate layer and overestimate the water salinity in the central Gulf. In terms of the possible future climate, the CANOPA simulations suggest the Gulf of St. Lawrence (GSL) will be largely ice free in January, with the ice volume in March steadily decreasing from about 80km3 in the 1980s to near zero in 2069. On average, the GSL water will become warmer and fresher over this study period. In January, maximum SST increases are located near the eastern Cabot Strait, with a qualitative amplitude of about 1.5-2.5oC, corresponding to reduced sea ice in that area, and there is no significant change along the western and northern GSL coasts. In July, there is also a maximum SST increase over the western GSL due to the maximum increases of surface air temperature in the region. In addition, the maximum decreases in surface salinity are near western coastal areas and Scotian Shelf, although the reductions in the eastern GSL are relatively weak. Finally, compared to the present climate, the cold intermediate layer (CIL) is significantly weaker in 2040- 2069 than in 1980-2009.

3C2.4 ID:7130 14:15

Projections of biogeochemical conditions in the Northwest Atlantic from 6 CMIP5 global climate models

Diane Lavoie , Nicolas Lambert
Institut Maurice-Lamontagne
Contact: diane.lavoie@dfo-mpo.gc.ca

In order to adapt to climate change, fisheries and oceans managers need to know the likely effects of climate change on fisheries and ecosystem functioning, starting with how biogeochemical conditions and primary production will be impacted. As a contribution to DFO`s Aquatic Climate Change Adaptation Services Program, we analyzed the Coupled Model Intercomparison Project Phase 5 simulations performed with 6 Earth System Models (ESM) in terms of nitrate concentration, primary production, chlorophyll a, dissolved oxygen, dissolved inorganic carbon, pH, and aragonite and calcite saturation horizon depths. A comparison of simulated and observed trends was made for the historical period (between 1960 and 2005) when possible for different variables to assess the skills of the different models. Multi-model ensemble mean projections were then calculated for the next 50 years with two different scenarios (RCP 4.5 and RCP 8.5). The ESMs present consistent future trends for dissolved inorganic carbon (increase), dissolved oxygen (decrease), pH (decrease), and variable trends for nitrate concentration, although negative in general, while for chlorophyll a and primary production, no firm conclusions could be drawn in the region under study due to large differences in the trends from one model to another.

3C2.5 ID:7301 14:30

Statistical projections of physical oceanographic variables over the Newfoundland and Labrador Shelf

Guoqi Han , Eugene Colbourne , Pierre Pepin , Ruohan Tang
Fisheries and Oceans Canada
Contact: Guoqi.Han@dfo-mpo.gc.ca

Present global climate models (GCM) are unable to resolve many oceanic processes, and, thus, are unable to provide reasonable projections for coastal and shelf physical oceanographic properties. On the other hand, studies have shown that physical oceanographic properties over the Newfoundland and Labrador Shelf are closely linked to air temperatures. Here we first explore statistical relationships between shelf oceanographic properties and air temperature based on historical observations. Oceanographic properties include the sea surface temperature at Station 27, the fall bottom temperature over the Newfoundland Shelf, the area of the cold intermediate layer on the Flemish Cap (47°N) section, and the winter sea ice extent off Newfoundland and Labrador. Using the statistical relationships we then project future states of the physical oceanographic variables under two representative concentration pathways (RCP): RCPs 4.5 and 8.5, based on the projected air temperatures from two global climate models (GCM): CanESM2 and GFDL-ESM2M. Projections are also produced under the A1B emission scenario based on the model air temperatures from a Canadian regional climate model (CRCM). In the next 50 years, the projected sea surface temperature increases off eastern Newfoundland (Station 27) range from 0.4 to 2.0°C. The bottom temperature increases over the Newfoundland and Labrador Shelf range from 0.4 to 2.1°C. The area of the cold intermediate layer (<0°C) decreases on the Flemish Cap (47°N) section are in the range of 2 to 10 km2 (8-38% of the 1981-2010 mean). The sea ice extent decreases off Labrador and Newfoundland range from 0.3 to 1.6×105 km2 (15-80%), and the decrease in the number of icebergs at 48°N off Newfoundland range from 245 (30%) to 1315 (almost no icebergs at this latitude).It is cautioned that the statistical relationships established are from historical data and may not hold for the future and that there are large uncertainties in the air temperatures projected by the climate models.

3C2.6 ID:7192 14:45

Indices of near-surface ocean properties for the Atlantic Zone and Hudson Bay complex used for long term trends and climate change projections

Peter Galbraith , *Pierre Larouche*
Institut Maurice Lamontagne, Fisheries and Oceans Canada
Contact: Peter.Galbraith@dfo-mpo.gc.ca

Indices of near-surface ocean properties such as sea-surface temperature and ice cover were elaborated for the Gulf of St. Lawrence and the Atlantic Zone, as well as for Hudson Bay and Hudson Strait. Based on air temperature proxies, they allow the estimation of long term trends extended prior to high-resolution remote sensing records, and can be used in support of climate change projections.

Air temperature appears to be a reliable proxy for SST when averaged over ice-free seasonal time scales from the Labrador Shelf to the Newfoundland Shelf, the Gulf of St. Lawrence, and the eastern portion of the Scotian Shelf. Winter-time air temperature is correlated with sea-ice volume in the Gulf of St. Lawrence and a threshold temperature explains all 3 nearly ice-free winters since 1969.

Seasonality trends in relation to air temperature show that onset of summer has occurred from 0.9 to 1.4 weeks earlier for each degree of air temperature anomaly over the past three decades, for all Atlantic Zone regions examined. Combined with fall variability, some regions could see summertime conditions (i.e. warmer than the spring and fall selected thresholds) extended by as

much as 2 weeks for each increase of seasonal-average air temperature of 1°C, if recent trends and relationships continue.

In the Hudson Bay complex, results show decreasing trends in the breakup date of the sea-ice to be correlated with summer air temperature Interannual variability of 5°C in the Hudson Bay average SST in August between extreme years is correlated with air temperature. Correlations with air temperature are used to estimate long term trends of ocean SST.

Regional climate modelling and climate projections PART 2 / Modélisation régionnale et prévision du climat PARTIE 2

Room / Endroit (Ouellet), Chair / Président (Laxmi Sushama, René Laprise, Ramon de Elia & Anne Frigon), Date (04/06/2014), Time / Heure (13:30 - 15:00)

3C3.1 ID:7109 **13:45**

On the implementation of dynamic glaciers in CRCM5

Katja Winger [1], *Laxmi Sushama* [1], *Shawn Marshall* [2]
[1] UQAM
[2] University of Calgary
Contact: Katja.Winger@ec.gc.ca

Glaciers are frozen fresh water reservoirs that respond to changes in temperature and snowfall. Concern is growing about the impact that changes in glaciers may have on water resources in regions such as western Canada that derive a lot of their summer streamflow from glacier melt. Given that RCM projections are an important tool and are increasingly being used in assessing projected changes to water resources, particularly due to their high resolution compared with GCMs, realistic representation of glaciers in RCMs is very important. Currently, glaciers are only represented in an extremely simplified way in CRCM5. This simple approach of representing glaciers as static glacier masks is appropriate for short-term integrations, where the response of glacier to changing atmospheric conditions might still be small due to glacier response times and therefore the feedback of changing glacier extent on large-scale atmospheric flow conditions might be negligible. Work is underway to implement a dynamic glacier scheme in CRCM5. This talk will discuss the dynamic glacier parameterization and some preliminary results obtained with the dynamic glacier parameterization in CRCM5.

3C3.2 ID:7195 **14:00**

Evaluation of rainfall and temperature extremes over North America in CanRCM4 and CRCM5

Kirien Whan , *Francis Zwiers*
The Pacific Climate Impacts Consortium
Contact: kwhan@uvic.ca

Regional climate models (RCMs) are used to downscale coarse global climate models to a higher resolution that generates more regionally relevant information. Extreme climate and weather events can have potentially large adverse impacts on human and natural systems. As such, improved understanding of a RCMs ability to simulate extreme events is a key research challenge. Here we assess the simulation of climate extremes over North America with two Canadian RCMs (CanRCM4 and CRCM5) using lateral boundary conditions derived from ERA Interim reanalysis. These RCMs share the same dynamical core and have different land-surface and physics schemes. This allows us to assess to what extent these schemes influence extremes.

The annual cycle and spatial patterns of the ETCCDI extreme temperature indices are well reproduced in both models, but the magnitude varies regionally. CanRCM4 has higher maximum temperature extremes, while CRCM5 has higher minimum temperature extremes. The annual cycle of rainfall extremes is more varied regionally. CRCM5 delivers too much extreme rain on the west coast, while CanRCM4 is too wet in the south-east.

As atmospheric rivers (ARs) are associated with extreme rainfall on the west- coast the rainfall response to these events in the RCMs is explored. AR days are defined from ERA Interim reanalysis and the rainfall footprint associated with these days is compared in the RCMs. CRCM5 has more intense winter precipitation that is often associated with AR days. In summer, CanRCM4 has more intense precipitation events that are not likely not associated with atmospheric river events. The RCMs simulation of total column water vapor and precipitation type is assessed. The percentage of winter rainfall associated with ARs was assessed in both models. In some areas, a higher percentage of winter rainfall in CanRCM4 comes from AR days, compared to CRCM5.

3C3.3 ID:7179 14:15

Impact of increased resolution on RCM-simulated extreme climate events over western Canada

Bárbara Tencer , *Charles Curry* , *Angus Johnston*
School of Earth and Ocean Sciences, University of Victoria
Contact: btencer@uvic.ca

Regional Climate Models (RCMs) have become standard tools for downscaling low-resolution global climate simulations into high-resolution fields useful for climate change impact and adaptation studies. With increasing computing power, RCMs can provide simulations at higher horizontal resolution, improving the representation of coastlines and complex topography. However, since modified parameterizations of atmospheric processes are often required at finer resolution, these RCM simulations may not necessarily lead to improvements in simulated climate. In order to assess the capacity of high-resolution RCMs to represent observed extreme climate events and the impact of increased resolution on simulated extremes this study employs two climate simulations of western Canada with the Canadian Regional Climate Model (CRCM4) at 15km and 45km resolution driven at the lateral boundaries by the ERA40 reanalysis

for the period 1973-1995. The simulations are validated against two observational gridded surface temperature and precipitation products: the monthly dataset from the University of Delaware and the ANUSPLIN daily dataset from the Pacific Climate Impacts Consortium. Overall, both simulations show cold biases for mean, minimum and maximum temperature when compared to observations, with greater biases for the higher resolution simulation of minimum temperature. Cold biases are consistently found for mean values and the tails of the distribution, showing a shift of the entire simulated distribution towards the left. Daily variability is well captured by the models for maximum temperature, but minimum temperature shows differences of up to 4°C in winter standard deviation in southern and coastal British Columbia. In terms of spatial variability, the annual mean temperature simulated at 15km resolution is closer to observed patterns, especially to the west of the Rocky Mountains. For precipitation, both simulations show wet biases compared to observations, except along the coast and west of the Rocky Mountains where the 45km simulation exhibits dry biases. When compared to each other, the higher resolution simulation features enhanced precipitation on the windward side of the Rockies and Coastal Mountains, thereby improving the simulation of precipitation over these regions.

3C3.4 ID:7073 14:30

Impact of dynamic vegetation on CRCM5 simulated climate over North America

Camille Garnaud , Laxmi Sushama
Centre ESCER, UQAM
Contact: camille@sca.uqam.ca

Regional climate change can strongly impact on local surface vegetation characteristics, which can in turn modulate the regional climate by modifying key surface characteristics. To capture these feedbacks a dynamic vegetation model, the Canadian Terrestrial Ecosystem Model (CTEM), has been implemented in the 5th generation of the Canadian Regional Climate Model (CRCM5). CTEM can grow vegetation from bare ground and includes processes of photosynthesis, autotrophic and heterotrophic respiration, phenology, turnover, mortality and allocation. Two recent-past experiments (1971–2010) of CRCM5 are compared – one with dynamic vegetation and the other with static vegetation – in order to assess the impact of dynamic vegetation on the regional climate over North America. Simulated vegetation attributes, temperature and precipitation are compared to those observed. CTEM improves the model (CRCM5) in some regions, although it introduces new biases in other regions such as western USA, due to large differences in the leaf area index (LAI), greatly affecting biosphere-atmosphere interactions with respect to energy and water fluxes. Although implementation of dynamic vegetation in CRCM5 does not improve the model in a clear manner with respect to the mean climate, it introduces biosphere-atmosphere interactive feedbacks and long-term memory in the model, which impact the simulation of energy fluxes variability and lead to improved climate extremes simulation. For example, the dynamic vegetation simulation shows a great improvement on how the model captures the number of hot days during the 1988 drought and its effect on the biosphere, as it is able to simulate the drought-stress effect on the plants.

3C3.5 ID:7125 14:45

Land-atmosphere coupling over North America in the Canadian Regional Climate Model

(CRCM5) simulations for current and future climates

Gulilat Tefera Diro , Laxmi Sushama
University of Quebec at Montreal
Contact: diro@sca.uqam.ca

The strength and characteristics of land-atmosphere (L-A) coupling over North America in current and future climates are assessed using the fifth generation of the Canadian Regional Climate Model (CRCM5). The L-A coupling is first assessed, in current climate, by analyzing the coupled (interactive soil moisture) and uncoupled (prescribed soil moisture) CRCM5 simulations driven by ERA-Interim reanalysis for the 1981-2010 period. Results indicate strong soil moisture-temperature coupling over the Great Plains, which is in line with previous studies. In addition coupling is also found to significantly modulate extreme temperature conditions such as the percentage of hot days, the frequency and maximum duration of hot spells for this region. The soil moisture-precipitation coupling in CRCM5, on the other hand, is weak compared to the soil-moisture temperature coupling. Coupling is noted mostly over the semi-arid regions of the western US for the case of persistent extreme precipitation events (defined as consecutive days with precipitation greater than the long term 90th percentile), probably due to its more transition zone like conditions, which is favorable for L-A coupling, in these circumstances. To study projected changes to L-A coupling in future climate, coupled and uncoupled CRCM5 simulations, driven by CMIP5 GCMs, were performed, for current (1981-2010) and future (2071-2100) climates. Coupling regions in the GCM-driven current climate CRCM5 simulations are similar to those obtained with ERA-Interim driven CRCM5 simulations discussed above. In future climate, soil-moisture-temperature coupling regions extend beyond the Great Plains, for instance to mid-west and the eastern part of the US, while the regions of soil-moisture-precipitation coupling have a more complex spatial structure.

High Resolution Atmospheric Modeling PART 2 / Modélisation atmosphérique à haute résolution PARTIE 2

Room / Endroit (Léonard-Blais), Chair / Président (Jason Milbrand & Stéphane Bélair), Date (04/06/2014), Time / Heure (13:30 - 15:00)

3C4.1 ID:7078 **13:30**

Towards Collaborative Developments Applied to Meteorology

Daniel Figueras-Nieto , Sandrine Edouard , François Fortin , Marc Klasa , Maryse Beauchemin , Luc Pelletier , Guylaine Hardy , Philip Mann , Neil Taylor , Gérard Croteau
Environment Canada
Contact: daniel.figueras@physics.org

The Canadian Meteorological Centre (CMC) delivers a large number of numerical weather prediction products to various weather offices and clients throughout Canada and abroad. In order to address the maintenance of post production efficiently, an innovative system , SPOOKI (Système de Production Orienté-Objet contenant une Kyrielle d'Informations – Object oriented production system containing a myriad of information) and its development methodology were developed several years ago. It is based on a modular approach where each plug-in component is specialized, reusable and autonomous, allowing for quick adaptation to the rapidly evolving world of operational weather prediction.

The system is now operational and is used to review in depth the whole approach to the operational post production of the CMC.

This user-friendly system also facilitates further innovative development of weather products for aviation, summer and winter high impact phenomena, etc... by the collaboration of partners throughout Canada. Recently using SPOOKI, snow line forecasts have been easily and rapidly developed in experimental mode, in partnership with the National Lab for Coastal & Mountain Meteorology in Vancouver, using work done for convective storm diagnostic fields, from the Hydrometeorology and Arctic National Lab in Edmonton, showing the benefit of the partners' collaboration via a common development platform.

This type of system can be used by the community at large and across several disciplines.

3C4.2 ID:7135 13:45

Object-oriented forecast and verification of a proposed severe thunderstorm intensity index

Anna-Belle Filion [1], *Frederic Fabry* [2], *High Impact Weather National Laboratory* [1]
[1] Environment Canada
[2] McGill University
Contact: anna-belle.filion@ec.gc.ca

Ongoing work will be presented in the development of a severe thunderstorm index that takes advantage of high-resolution numerical weather prediction systems in which researchers have noted realistic simulation of the 3D structure of severe thunderstorms. High-resolution models now enable us to post-process model data into a severe thunderstorm intensity (STI) index based on the commonly known structural features of severe thunderstorms and also using the ingredients (moisture and the wind shear) present in the atmosphere as seen by the model. This approach complements traditional instability indices and indices based on the wind shear still commonly used. It will be shown how the STI was created using the Canadian Meteorological Centre (CMC) 1-km High-Resolution Deterministic Prediction System (HRDPS) data. Based on the encouraging results, the STI is now being adapted and applied to CMC's HRDPS 2.5-km model. Since traditional verification methods, especially for rare events, are not suitable for high-resolution models, an object-oriented method was used to verify the STI index forecasts against severe weather observations. The tool used was the Method for Object-Based Diagnostic Evaluation (MODE) from the Model Evaluation Tools package (MET), which was developed by the Verification Group at the Research Applications Laboratory at the National Center for Atmospheric Research (NCAR). Verification results for the STI will be briefly presented and

discussed.

3C4.3 ID:7265 14:00

The new pan-Canadian High Resolution Deterministic Prediction System

Anna Glazer , *Jason Milbrandt* , *Stephane Belair*
Environment Canada (RPN)
Contact: jason.milbrandt@ec.gc.ca

For nearly 10 years, Environment Canada (EC) has been running an experimental, real-time, high-resolution (2.5-km horizontal grid spacing) forecast system using the GEM atmospheric model over various domains in Canada. This system is referred to as the High Resolution Deterministic Prediction System (HRDPS). More and more, the numerical guidance from this system has been used by operational forecasters. As a step towards implementing a national 2.5-km forecast system, the west domain has been recently declared formally operational.

In the summer of 2014, a new component of the HRDPS will be added. This component includes a large, pan-Canadian 2.5-km domain, with complete coverage of all provinces and much of the territories. Unlike the other smaller domains in the existing system, this new component has surface initial conditions provided by a fully-coupled 2.5-km land-surface data assimilation system. Development is currently underway to equip the pan-Canadian HRDPS with its own upper-air data assimilation system. At this point, the system will replace the multi-grid 2.5-km system and will become EC's primary source of short-range numerical guidance. An overview of the new system will be provided in this talk.

3C4.4 ID:7264 14:15

A new approach for parameterizing ice-phase cloud microphysics based on the prediction particle properties

Jason Milbrandt [1], *Hugh Morrison* [2]
[1] Environment Canada (RPN)
[2] National Center for Atmostpheric Research
Contact: jason.milbrandt@ec.gc.ca

The appropriate treatment of cloud and precipitation microphysics continues to be a source of uncertainty in NWP models. There is often great sensitivity of forecasts to the representation of the various types of ice particles that occur in the atmosphere (pristine ice, snow, rimed snow, graupel, hail, etc.). To address this, a new approach is proposed that differs substantially from the traditional approach of partitioning ice into different categories with pre-defined properties. In the new scheme, ice particle properties are predicted and evolve locally in time and space by prognosing four variables: number concentration, vapor deposition mass mixing ratio, rime mass mixing ratio, and rime volume mixing ratio. This allows the full range of ice particle types to be represented by a single ice category. The new approach thus eliminates the need for conversion rates and thresholds between different ice categories, which are poorly constrained and often unphysical, used by the standard approach.

The new scheme is tested with 3D simulations over a wide range of conditions including winter orographic precipitation and different types of convective storms. Results are compared to observations and simulations using other bulk microphysics schemes. Despite the simplicity of the new scheme, it produces a realistic simulation of meteorological phenomena at a reduced computational cost.

3C4.5 ID:7164 14:30

Numerical studies of hurricane boundary layer turbulence and its effect on hurricane intensity

Sopan Kurkute , *Yongsheng Chen*
York University
Contact: yochen@yorku.ca

The turbulence in the hurricane boundary layer (HBL) and its effect on the hurricane intensity were investigated in a large eddy simulation of an idealized hurricane using the Weather Research and Forecasting (WRF) model. Defining a filter scale of ~ O(1km) matching the resolution of the current hurricane forecast models, the flow in the HBL was spectrally decomposed into the filter scale and sub-filter scale motions. The sub-filter scale motions were then used to diagnose turbulence properties. The turbulent kinetic energy budget shows that the shear production is the dominant mechanism for generating turbulence, but it is also largely balanced by the advection within the HBL. The size of the maximum energetic eddies lies between 1 – 3 km which matches well with the estimated horizontal turbulence mixing length scale Lh ~ 3 km. The fact that the explicitly computed sub-filter turbulence stresses are one order larger than the parameterized turbulence stresses suggests that the some turbulence parameterization schemes in the WRF model underestimate the turbulence effects on resolved scale flows in the HBL. Hurricane intensities are sensitive to sub-filter scale turbulence represented by the turbulence parameterization schemes. The sensitivity was tested in real hurricane case simulations.

3C4.6 ID:7023 14:45

Surface wind variation over local terrain undulations: comparison of measurements with the Mixed Spectral Finite-Difference (MSFD) model

John Wilson
University of Alberta
Contact: jaydee.uu@ualberta.ca

In the context of gas tracer experiments testing methods for micrometeorological inverse dispersion calculations, mean wind speeds were measured at twelve locations sampling an area of about 30 m x 150 m over gently rolling pasture in central Alberta. Mean wind speeds were normalized relative to the value at a reference location, and these normalized mean speeds were binned (averaged) within sectors of mean wind direction centred on the cardinal directions. The normalized speeds, which varied away from the reference location by up to about +/-20%, have been compared with simulations using the Mixed Spectral Finite-Difference (MSFD) wind model with mixing length closure.

Marine Ice from Science to Operations PART 2 / Glace de mer : de la science à l'opérationnel PARTIE 2

Room / Endroit (Parent), Chair / Président (Thomas Carrières, David Barber, Hal Ritchie & Greg Smith), Date (04/06/2014), Time / Heure (13:30 - 15:00)

3C5.1 ID:7291 **13:30**

Assimilation of ice and water observations from synthetic aperture radar imagery to improve sea ice concentration estimates

Andrea Scott [1], *Lei Wang* [1], *Mark Buehner* [2], *Tom Carrieres* [3]
[1] Department of Systems Design Engineering, University of Waterloo
[2] Data Assimilation and Satellite Meteorology Research Section, Environment Canada
[3] Marine and Ice Services, Environment Canada
Contact: ka3scott@uwaterloo.ca

Synthetic aperture radar (SAR) sensors are able to return high resolution information regarding the sea ice state over a range of weather and illumination conditions. Ideally, sea ice data assimilation systems would assimilate information from SAR imagery to improve the representation of small scale details of the ice cover. However, automatic interpretation of these images is challenging. In this work a Bayesian method is used to calculate the probability that a given set of pixels in a SAR image is ice-covered or open water. These probabilities are then used to generate ice and water observations which are assimilated into a sea ice concentration background state, provided by the Regional Ice Prediction System (RIPS). The mapping between the ice concentration background state and the ice and water observations will be described, and preliminary results from the assimilation will be presented. It has been found that the assimilation leads to small improvements in the ice concentration when validation is carried out with image analysis charts. Future improvements to the method will be discussed.

3C5.2 ID:7244 **13:45**

Modeling of Sea Ice: A Study of Non-Linearity and Numerical Solvers

Jean-Pierre Auclair [1], *Harold Ritchie* [2], *Jean-François Lemieux* [3]
[1] Department of Oceanography, Dalhousie University, Halifax, NS
[2] Meteorological Research Division, Environment Canada, Dartmouth, NS
[3] Meteorological Research Division, Environment Canada, Dorval, Qc
Contact: jn402157@dal.ca

Accurate representation of small scale ice features such as openings in landfast ice and ice leads constitutes a challenge for current sea ice models. The strong velocity gradients present in high

resolution simulations of the ice slow the convergence of numerical solvers. This results in increased computational time, often preventing models from reaching properly refined solutions. Errors in the sea ice velocity field impact both ice cover and thickness. These can in turn propagate and significantly affect weather forecasts by modifying the exchanges of energy and moisture between the ocean and the atmosphere. In order to address this issue, new numerical solvers are being considered for the sea ice momentum equation. The study of both these solvers and the equation itself is providing insight regarding possible causes of the loss of efficiency in models at high resolutions. A comparison of one-dimensional model results using different solvers will be presented. Their efficiency and ability to cope with the complexity of the sea ice momentum equation will also be discussed.

3C5.3 ID:7096 14:00

An integrated marine Arctic prediction system for METAREAs

Hal Ritchie [1], *Natacha Bernier* [2], *Mark Buehner* [2], *Tom Carrieres* [3], *Serge Desjardins* [4], *Luc Fillion* [2], *Diane Johnston* [5], *Pierre Pellerin* [2], *Gregory Smith* [2], *Gilles Garric* [6]
(Presented by *C. Harold Ritchie*)
[1] Meteorological Research Division, EC, Dartmouth NS
[2] Meteorological Research Division, EC, Dorval QC
[3] Canadian Ice Service, EC, Ottawa ON
[4] Meteorological Service of Canada, EC, Dartmouth NS
[5] Meteorological Service of Canada, EC, Downsview ON
[6] Mercator-Océan, Toulouse, France
Contact: harold.ritchie@ec.gc.ca

In December 2007 Canada accepted official designation as the Issuing Service for meteorological Marine Safety Information (MSI) in the form of forecasts / warnings and ice bulletins for METAREAs XVII and XVIII as part of the Global Maritime Distress and Safety System (GMDSS). These areas are in the Arctic bordering on Canada. An important part of Environment Canada's involvement is the development of an integrated marine Arctic prediction system and satellite products in support of monitoring and warnings. The integrated marine Arctic prediction system will feed into a highly automated information dissemination system. In particular, our group is working on the development, validation and implementation of marine forecasts with lead times of 1 to 3 days using a regional high resolution coupled multi-component (atmosphere, land, snow, ice, ocean and wave) modelling and data assimilation system to predict near surface atmospheric conditions, sea ice (concentration, thickness, pressure, drift, ice edge), freezing spray, waves and ocean conditions (temperature and currents). The core of the system is an Arctic extension of the highly successful Gulf of St. Lawrence coupled modelling system, with the GEM (Global Environmental Multi-scale) model as the atmospheric component coupled to the NEMO (Nucleus for European Modelling of the Ocean) ocean model, the CICE ice model and the WAVEWATCHIII® wave model. An ice-ocean data assimilation system is being developed in collaboration with Mercator-Océan using their SAM2 system for ocean data assimilation together with the 3DVAR ice analysis system developed at Environment Canada. The METAREAs research and development is a cornerstone activity within the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS). This presentation will provide an overview of these activities, illustrate some results to date, discuss plans for future operational systems, and link with other complementary presentations at this meeting.

3C5.4 ID:7269 **14:15**

Assimilation of Advanced Very High Resolution Radiometer (AVHRR) observations in the Regional Ice Prediction System (RIPS) at Environment Canada.

Alain Caya , Mark Buehner , Tom Carrieres , Yi Luo , Lynn Pogson , Michael Ross
Environnement Canada
Contact: alain.caya@ec.gc.ca

RIPS is a three-dimensional variational data assimilation system developed at Environment Canada for producing 5-km resolution analyses of sea-ice concentration for the waters surrounding North America and Greenland. Currently, the sea ice analysis relies mostly on passive microwave observations and to a lesser extend on scatterometer observations (ASCAT). These observation types have large footprints of the order of 50 km. The passive microwave observations can effectively be used for sea ice analysis when the surface air temperature is below the freezing temperature of water. When melting occurs at the surface, passive microwave sea ice concentration retrieval algorithms are less reliable.

The Canadian Ice Service (CIS) image analysis and daily ice charts are also assimilated and provide information at the resolution of the analysis grid. However, these ice charts are only prepared for active marine areas and do not cover the whole analysis domain.

The AVHRR observations are assimilated to improve the sea ice concentration analysis during melting conditions and to better represent the sea ice features at the scale of the analysis grid. The initial approach is to use a simple ice / open water retrieval algorithm and assimilate these values as nominal ice concentrations. The impact of assimilating these data over a full year will be presented.

3C5.5 ID:7095 **14:30**

Environment Canada high resolution short-term sea-ice prediction system, RIPS

Frederic Dupont , Christiane Beaudoin , Mark Buehner , Tom Carrieres , Alain Caya , Jack Chen , Jean-Francois Lemieux , Francois Roy , Anna Shlyaeva , Gregory Smith
Environment Canada
Contact: frederic.dupont@ec.gc.ca

Environment Canada has implemented operationally an experimental stand-alone short-term regional ice prediction system (RIPS) based on the Los Alamos sea-ice model, CICE-4.0. This contribution focuses on the new updates to the system which should become operational by fall 2014. First, the domain is now covering the Pan-Arctic and North Atlantic Oceans. Second, fields for initialization were improved: the global ice-ocean prediction system (GIOPS) feeds in the mixed layer depth, the surface currents and temperature, and the ice thickness distribution at each point. The initial ice concentration still comes from an independent 3-D-var analysis which is also used to adjust the ice thickness distribution coming from GIOPS. The system was run for verification for the entire year 2011. The forecast skills were measured against independent products such as IMS, Radarsat, ULS and IceBridge. Buoy drift was used to tune the dynamics of the model, and some attempts were made to accommodate landfast ice in coastal and shallow

regions. A subjective evaluation was also carried by professional forecasters of the Canadian Ice Service. Finally, a web application allows to visualize the output.

3C5.6 ID:7097 14:45

Impact of improved surface boundary layer interactions on Arctic simulations and freshwater balance in NEMO-ORCA025

Francois Roy [1], *Greg Smith* [1], *Frédéric Dupont* [2], *Matthieu Chevallier* [3], *Jean-Francois Lemieux* [1], *Gilles Garric* [4]
[1] Division de la Recherche en Météorologie, Environnement Canada, Dorval, Canada
[2] Service Météorologique du Canada, Environnement Canada, Dorval, Canada
[3] Météo France, France
[4] Mercator-Océan, France
Contact: francois.roy@ec.gc.ca

An ensemble of NEMO-ORCA025 simulations of the first decade of 2000 is presented where we improve results in the Arctic by refining the representation of boundary layer interactions at the atmosphere-ice-ocean interface. Results are compared to various data sets (ICESAT, NSIDC, IABP, …) and we examine their sensitivity to different boundary layer parameters and to the use of two different ice models: LIM2 (single-category) and CICE4 (multi-category). First, more realistic ice volumes are obtained with CICE4 compared to LIM2. Additionally, more realistic ice drifts and ice thickness are obtained by applying more consistent atmosphere-ice and ice-ocean drag parameters. As a consequence, a commonly seen positive bias in the Beaufort Gyre ice thickness is reduced significantly. The sensitivity of freshwater (FW) balance is also presented. The simulated Beaufort Gyre FW content is more sensitive to the atmosphere-ice drag and its effect on Ekman convergence, and less to the ice-ocean drag. Conversely, the Arctic FW export at Fram Strait is more sensitive to the ice-ocean drag. Overall these parameters may have an important effect when studying FW balance with ocean models.

Science, Policy and Management of Northern Environments / Science, politique et gestion des environnements nordiques

Room / Endroit (Langevin), Chair / Président (Mar Martinez de Saavedra Alvarez), Date (04/06/2014), Time / Heure (15:30 - 17:00)

3D1.1 ID:7336 15:30

The Changing Cold Regions Network: Improving the Understanding and Prediction of Changing Land, Water, and Climate in the Mackenzie and Saskatchewan River Basins, Canada

Chris Debeer , *Howard Wheater*

University of Saskatchewan
Contact: chris.debeer@usask.ca

Within the cold interior of western and northern Canada, rapid and dramatic environmental changes are taking place, which is of serious concern for society and has a range of implications from local to regional and global scales. From a scientific standpoint there is an urgent need to understand the changes and develop improved diagnostic and predictive modelling tools to deal with the uncertainty faced in the future. The Changing Cold Regions Network (CCRN) is a research consortium of over 50 Canadian university and government scientists and international researchers aimed at addressing these issues within the geographic domain of the Mackenzie and Saskatchewan River Basins. CCRN's primary focus is to integrate existing and new experimental data with modelling and remote sensing products to understand, diagnose and predict changing land, water and climate, and their interactions and feedbacks. The Network is funded over five years (2013–18) through the Natural Sciences and Engineering Research Council of Canada. The research programme is divided into five major thematic areas: A, Observed Earth System Change in Cold Regions – Inventory and Statistical Evaluation; B, Improved Understanding and Diagnosis of Local-Scale Change; C, Upscaling for Improved Atmospheric Modelling and River Basin-Scale Prediction; D, Analysis and Prediction of Regional and Large-Scale Variability and Change; and E, User Community Outreach and Engagement. To support these activities, the Network utilizes a suite of 14 world-class water, ecosystem, cryosphere and climate (WECC) observatories across this region that provide exceptional opportunities to observe change, investigate processes and their dynamics, and develop and test environmental models.

This talk will describe the CCRN and discuss some of its recent areas of progress and scientific developments. Examples of the rapid and extreme environmental changes across the CCRN study domain will be shown drawing on a range of literature sources and highlighted by some local observations from the WECC sites and some new regional statistical analyses carried out by the Network. Recent and ongoing advancements in hydrological and cryospheric process understanding and model development have allowed better understanding of some elements of change, and provide insights into the sensitivity and coupled responses of these systems. Some case studies will be briefly presented that help to reveal the process dynamics at local scales and partly explain the resulting emergent responses observed at larger regional scales. Some future prospects for the Network and its themes will also be discussed.

3D1.2 ID:7335 15:45

Mobilizing Scientific Knowledge and Enhancing Environmental Decision Support in Northern and Western Canada: The Outreach and Engagement Programme of the Changing Cold Regions Network

Chris Debeer [1], *Graham Strickert* [1], *Howard Wheater* [1], *William Quinton* [2]
[1] University of Saskatchewan
[2] Wilfrid Laurier University
Contact: chris.debeer@usask.ca

Within the cold interior of western and northern Canada, rapid and dramatic environmental changes are taking place, which is of serious concern for society due to the impacts on water and

other natural resources, agriculture, infrastructure, and risk associated with extreme events. There is an urgent need to improve understanding of the past and potential future changes, and to develop better predictive tools for effective environmental management and decision making support in the face of an uncertain future. Translation of new scientific knowledge and tools into management practice is a major challenge, however, and there is a need for new strategies for knowledge mobilization and application that recognize the social dimensions involved. The Changing Cold Regions Network (CCRN) is a research consortium of Canadian university and government scientists and international researchers focused on understanding, diagnosing, and predicting changing land, water and climate, and their interactions and feedbacks within the geographic domain of the Mackenzie and Saskatchewan River Basins. One of the main thematic components of the Network is user community outreach and engagement, which seeks not only to convey scientific knowledge to relevant stakeholders and users, but to engage in a two-way dialogue and interaction that increases the usefulness and benefits of the research to the user community.

This talk will describe the framework strategy for CCRN's outreach and engagement programme, including the use of social science tools. Key activities and developments in this area during the first year of the Network will be highlighted. The connections with local/municipal, provincial/territorial, and federal governments, First Nations and other communities will be described. CCRN has particularly strong links with Environment Canada, and is involved in developing their capability for weather, climate, and large-scale hydrological modelling. Discussions on collaboration with the Canadian High Arctic Research Station of Aboriginal Affairs and Northern Development Canada are underway. CCRN has also partnered with provincial water agencies in Alberta and Saskatchewan, and is linked with the Government of Northwest Territories – Wilfrid Laurier University Partnership, which is a key mechanism in the north for the provision of scientific advice and water management and climate change decision support. At an international level, CCRN is connected to the World Climate Research Program's Global Energy and Water Exchanges, and Climate and Cryopshere Projects, while discussions with NASA's Arctic–Boreal Vulnerability Experiment are underway. The talk will conclude with a vision of the Network's future outreach prospects and its legacy beyond the end of the five year research programme.

3D1.3 ID:7060 16:00

Climate change and water at Stellat'en First Nation, British Columbia, Canada: Insights from western science and traditional knowledge

Stephen Dery [1], *Darlene Sanderson* [2], *Ian Picketts* [1], *Bryndel Fell* [1], *Sharolise Baker* [3], *Eddison Lee-Johnson* [3], *Monique Auger* [2]
[1] UNBC
[2] University of Victoria
[3] Stellat'en First Nation
Contact: sdery@unbc.ca

This presentation will report insights from both western science and traditional knowledge that were applied to identify and begin to address climate change and water issues at Stellat'en First Nation, British Columbia, Canada. Qualitative data from interviews and surveys of Stellat'en community members were compiled and compared with air temperature, precipitation and

hydrometric data from meteorological stations and proximal rivers. Community Elders noted changes to river water levels and shifts in fish populations. The quantitative data revealed a 2.3°C rise in air temperature, 5% increase in precipitation, and 10% decline in snowfall over a 40-year period. Results from these analyses were reported in two knowledge intersection workshops at Stellat'en First Nation, and information sharing took place to: facilitate discussion and awareness between traditional and western knowledge holders; gain insights on the community's views of climate change and water; and identify strategies for action. Recommendations formulated and implemented by Stellat'en First Nation include improved policies, and community and individual actions.

3D1.4 ID:7302 16:15

Too warm and too fresh? The changing sea ice regime of southeastern Hudson Bay: An interdisciplinary approach

Mar Martinez De Saavedra Alvarez [1], *Joel Heath* [2], *David Fissel* [1], *Randy Kerr* [1]
[1] ASL Environmental Sciences Inc.
[2] The Arctic Eider Society
Contact: mmartinez@aslenv.com

Since the late 1970s, the hydrological balance in southeastern Hudson Bay has been under increasing pressure from hydroelectric projects. Drastic changes in the sea ice conditions have been reported in this region during mid-winter, when large amounts of warm freshwater are discharged from hydro developments in response to consumer demand. The disruption of the natural winter hydrological cycle is being studied by the Arctic Eider Society combining Inuit and scientific knowledge. These interdisciplinary efforts aim to better understand the cumulative impact of these changes on the sea ice habitats, and seek to transform this knowledge into action that empowers communities and decision makers to find adaptive solutions that ensure the long-term sustainability of ecosystems and communities in the region. ASL Environmental Sciences has a long history of Arctic research dating back to 1977, and has recently developed software to convert the 4-km spatial resolution Canadian Ice Service (CIS) ice chart vectors into standardized raster and vector products; we have created an in-house database that provides synoptic views of sea ice changes by type and concentration in different regions of the Canadian Arctic. We will use this database to examine the long-term sea ice trends for the period 1971-2013 for a number of selected areas, in particular, the southeast region around Sanikiluaq, in the Belcher Islands. A larger region extending westward to Churchill will also be examined. Monthly average air temperatures from six weather stations will be included to determine atmospheric effects, as well as regional freshwater discharges from hydrological datasets. The work presented here is a contribution to the understanding of complex biophysical processes happening in southeastern Hudson Bay, in support of the ongoing interdisciplinary studies by the Arctic Eider Society

3D1.5 ID:7021 16:30

Establishment of a Cooperative Volunteer Snow Network in Atlantic Canada

Jim Abraham [1], *Mac Mcleod* [2], *Dean Reichheld* [2], *Rick Fleetwood* [3], *Vincent Fortin* [3]
[1] Environment Canada (ret.)/ScotiaWeather
[2] ScotiaWeather

[3] Environment Canada
Contact: abraham.jd@hotmail.com

Snowfall is a very important weather and climate element given the important impact of snow on transportation and public safety, as well as the contribution of snowfall for water resources management and flood forecasting. Snowfall is also an important consideration in the design and standards for construction of buildings.

Over the past 20 years, the quality of snowfall measurements in Canada has been negatively impacted by government fiscal restraint and related modernization efforts. Most of the Canadian Climate Reference Network comprises automatic sensors, which include weighing precipitation gauges and sonic sensors to measure snowfall and snow depth. The majority of manual snow observations that remain are taken at airports by staff fulfilling responsibilities related to the aviation program for NavCanada. Snow measurements at many of these exposed airport sites are challenging to make, and not the highest priority parameter for aviation operations.

Given the importance of an adequate snow measurement network to meet the weather and climate responsibilities of Environment Canada and the private sector, the authors established a partnership to facilitate recruitment of volunteers to conduct precipitation measurements over the Winter 2013-14. Since the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network has been successfully established in the USA, and has begun in Western Canada, it was decided to take advantage of this protocol for the Atlantic Snow Network.

This presentation will describe the collaborative approach to recruit over 120 volunteers within Atlantic Canada. We will present some cases to demonstrate the added value of the additional observations, and provide some preliminary assessment of the quality and reliability of the volunteers.

3D1.6 ID:7333 **16:45**

A Bayesian Perspective on Climate Denialism

David Huard
David Huard Solutions
Contact: david.huard@gmail.com

A vocal fraction of U.S. population is now dismissive of the consensus view on climate change in spite of scientific evidence bordering on certainty. This communication suggests that organized climate change denial propagates memes that hijack the inferential process of genuine skeptics. Once skeptics accept those memes as plausible, any piece of evidence about anthropogenic climate change is systematically interpreted such that it reinforces the belief that climatology is junk science and climate change a scam, their skepticism gradually turning into denialism. We propose a bayesian model for such an inferential hijacking mechanism, the key ingredient being a selective switch in the target of inference depending on whether or not evidence supports the anthropogenic global warming theory. Climate change is used here as an illustrating example, but the same ideas apply to a large class of beliefs. While the model proposed is only a crude and idealized representation of the cognitive processes involved in decision-making, it seems nonetheless useful in understanding a possible pathway leading from

skepticism to denialism and may suggest counter-measures.

Trends and projections of climate change in the Canadian Aquatic Environment PART 2 / Tendances et projections du changement climatique dans l'environnement aquatique canadien PARTIE 2

Room / Endroit (Courchesne), Chair / Président (Guoqi Han, Joël Chassé & Nadja Steiner), Date (04/06/2014), Time / Heure (15:30 - 17:00)

3D2.1 ID:7001 **15:30**

Regional ocean climate model projections for British Columbia

Michael Foreman , Wendy Callendar , Diane Masson , John Morrison , Isaac Fine
Institute of Ocean Sciences, DFO
Contact: mike.foreman@dfo-mpo.gc.ca

A regional, ocean-only, climate model has been developed and run for the British Columbia continental shelf using initial and forcing fields downscaled from the NARCCAP global and regional climate model archives. As the archived winds were shown to poorly capture upwelling winds over the baseline period of 1971-2000, a “pseudo global warming” strategy was adopted wherein future-minus-contemporary anomalies were added to the initial and forcing fields used in a recent hindcast simulation for the same region. The simulated future conditions include warmer and fresher waters, stronger winter winds, an intensification of some seasonal eddies, but little change to the summer winds and contemporary upwelling conditions. Possible implications for local ecosystems will be discussed.

3D2.2 ID:7040 **15:45**

Climate change trends and projections affecting the marine ecosystem in the Canadian Arctic

Nadja Steiner
IOS - Fisheries and Oceans Canada
Contact: Nadja.Steiner@ec.gc.ca

Within the Aquatic Climate Change Adaptation Services Program (ACCASP) a climate change assessment for the Arctic Basin has been prepared. A summary of part 1, trends and projections, will be presented here: Trends and projections of change in atmospheric, oceanic and sea-ice

variables affecting the aquatic ecosystem are amplified in the Arctic. Insufficient observational data limit our ability to discern longterm trends. Nonetheless significant increases in air temperature (0-3ºC in summer and 3-7ºC in winter over the next 50 years), a slight increase in precipitation and snow depth as well as an intensification in extreme events (hot spells, extreme precipitation) can be seen. An Arctic-wide decrease in the extent of multi-year ice has been observed, together with an increase in ice-free waters in summer (longer time periods and larger areas), localized strengthening in ocean stratification, and increased ocean acidification throughout the Canadian Arctic, leading to decreased saturation states of calcium carbonate (aragonite and calcite). The observed trends are projected to continue into the future. Projections suggest an increase in storm strength and size as well as a slight increase in wave heights with only small changes in windspeed. It can be anticipated that the longer open water period will allow wind and storms to have a greater impact on the coast, i.e. erosion. Projections for the next two decades do not differ much between RCP4.5 and 8.5 scenarios, but become more severe for RCP8.5 on longer timescales. The assessment points out the need for 1. higher resolution regional models to help identify the severity of local impacts and 2. improved monitoring.

3D2.3 ID:7042 16:00

Climate change trends, projections and impacts in the freshwater Great Lakes and Prairie regions

Sommer Abdel-Fattah , Susan.Doka@dfo-mpo.gc.ca Susan Doka , Haitham.Ghamry@dfo-mpo.gc.ca Haitham Ghamry
Department of Fisheries and Oceans Canada (DFO)
Contact: Sommer.Abdel-Fattah@dfo-mpo.gc.ca

Current management of freshwater resources does not consider environmental variability expected from climate change. Resource managers recognize the need to evaluate the impact of a shifting climate, the uncertainty about the impacts, and consider adaptation strategies.

This study aims to identify trends and projections for several variables (including air and surface temperatures, precipitation, ice freeze and break up, lake levels, wind and evaporation) as well as the impacts of the expected changes. There is a general recognition that not all climate variables will change in a linear fashion and that climate variables that are projected to change could interact in complex ways that are not fully understood. This study attempts to recognize the drivers of change in order to identify linkages and interactions between climatic variables and proposed impacts.

Past climate trends indicate that the average air temperature in Canada has increased 1.2˚C in the last 58 years (Environment Canada, 2006). However, the warming was not uniform across the country; for this reason we evaluate two freshwater regions including the Great Lakes and Prairies. Warming has been more significant in winter and spring and has contributed to changes in evaporation rates, less annual precipitation with less as snowfall and more as rainfall, and shorter periods of ice-cover; all of which affect freshwater ecosystems through hydrodynamic and thermodynamic processes. Furthermore, more Northern regions of the study areas are expected to experience an accelerated rate of change due to global warming.

Climate change is anticipated to alter freshwater ecosystems as a result of projected increases in

air and consequently, water temperatures, changes in ice and snow dynamics — particularly declines in ice and snow cover, thickness and duration, as well as changes in the timing, pattern, distribution and amount of precipitation. These changes will affect hydrologic cycles and therefore chemistry of the water. The changes in evaporation, precipitation patterns and ice dynamics are expected to increase the frequency of extreme events such as flooding and drought; this will physically alter habitat and the productivity of those habitats and have other detrimental impacts in the Great Lakes Basin.

3D2.4 ID:7035 16:15

Mean Relative Sea Level Trends in the Northwest Atlantic: Historical Estimates and Future Projections

Guoqi Han [1], *Zhimin Ma* [2], *John Loder* [1], *Huizhi Bao* [1], *Augustine Van Der Barren* [3]
[1] Fisheries and Oceans Canada
[2] Memorial University of Newfoundland
[3] Wolfville, NS
Contact: Guoqi.Han@dfo-mpo.gc.ca

Mean sea level is one of the most important indicators for climate variability and change. In the Northwest Atlantic, mean relative sea level (RSL) is mainly influenced by ocean temperature and salinity changes, large-scale oceanic circulation, mountain glacier and ice-sheet melt, and glacial isostatic adjustment (GIA). Here we use tide-gauge data to examine recent trends in mean RSL, and then combine the sea level output of global climate models and a global land ice melt model with modelled and measured GIA effects to provide sea level projections. The mean RSL trend based on tide-gauge data shows large regional variations, from 2-4 cm/decade in the south (above the global mean RSL rise rate) to -2 cm/decade along the Labrador coast and between the northern coast of the Gulf of St. Lawrence and the St. Lawrence Estuary. This spatial difference can, to a significant degree, be attributed to vertical land motion. When the vertical land motion measured by the Global Positioning System is used, the projected mean RSL rise between 1986-2005 and 2046-2065 ranges from 20 to 40 cm along the Canadian Atlantic coast and is smaller along the Labrador coast, the northern coast of the Gulf of St. Lawrence, and the St. Lawrence Estuary. There are considerable uncertainties in the magnitude of the sea level projections associated with the ocean dynamic effect, the ice-sheet melt component, and the spatial structure of the GIA effect (mainly the vertical land motion). On the decadal time scale, it is projected that mean RSL will continue to rise at 3-4 cm/decade along many parts of the Canadian Atlantic coast and to fall or rise, with smaller magnitude, along the northern coast of the Gulf of St. Lawrence, the St. Lawrence Estuary, and Labrador, with uncertainties as much as or greater than the estimates.

3D2.5 ID:7024 16:30

Estimating sea-level allowances for Canada using the fifth assessment report of the IPCC

Li Zhai [1], *Blair Greenan* [1], *John Hunter* [2], *Tom James* [3], *Guoqi Han* [4], *Phillip Macaulay* [1], *Richard Thomson* [5]
[1] Bedford Institute of Oceanography
[2] Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, Australia
[3] Pacific Division, Geological Survey of Canada, Natural Resources Canada
[4] Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada

[5] Institute of Ocean Sciences
Contact: Li.Zhai@dfo-mpo.gc.ca

Coastal regions are expected to face massive increases in damages from storm surge flooding over the course of the 21st century, if no adaptation action is taken. These increases are expected to be due to a combination of rising sea level along with population and economic growth in the coastal zone. The Canadian Extreme Water Level Adaptation Tool (CAN-EWLAT) project is funded under the DFO Aquatic Climate Change Adaptation Services Program (ACCASP) to develop and deliver a web-based planning tool for operational sectors of the department. Sea-level allowances at tide gauge sites in Atlantic, Pacific, Arctic and Hudson Bay regions, are here derived for the tool project, based on the method of Hunter (2012). The allowances are defined as the amount by which an asset needs to be raised in order to maintain the same frequency of inundation events as that site has experienced in the recent past. The allowances are determined by the latest projections of regional sea-level rise from the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), and by the statistics of present tides and storm surges (storm tides). The latter have been derived from tide-gauge data and assumed to be unchanged during the 21st century. This presentation will provide an overview of the allowance analysis for both IPCC Representative Concentration Pathways RCP4.5 and RCP8.5. The sea-level allowances for Atlantic Canada are larger than those for the Pacific coast and Arctic, due to the combined effect of a local steric sea level rise caused by the weakening of the Atlantic Meridional Overturning Circulation (AMOC) and land subsidence caused by glacial isostatic adjustment (GIA) along the Canadian Atlantic coast.

3D2.6 ID:7046 16:45

Modeling tidal water levels for all Canadian coastal and offshore waters

Catherine Robin [1], *Phillip Macaulay* [2], *Shannon Nudds* [2], *André Godin* [2], *Bodo De Lange Boom* [2], *Jason Bartlett* [2], *Louis Maltais* [2], *Terese Herron* [2], *Michael Craymer* [3], *Marc Véronneau* [3], *Kian Fadaie* [2], *Denis Hains* [3]
[1] Canadian Geodetic Survey, NRCan & Canadian Hydrographic Service, DFO
[2] Canadian Hydrographic Service, DFO
[3] Canadian Geodetic Survey, NRCan
Contact: crobin@nrcan.gc.ca

In 2010, the Canadian Hydrographic Service initiated the Continuous Vertical Datum for Canadian Waters (CVDCW) project, the aim of which is to connect tidal water level datums (high and low water levels, chart datum, etc.) to a national geodetic reference frame over all Canadian tidal waters. Currently, water level datums are tied to a geodetic reference frame at approximately 400 tide gauges which have been surveyed with GPS, whereas water levels vary significantly in space even a short distance away from tide stations. The CVDCW captures the relevant spatial variability between stations and offshore by integrating ocean models, gauge data (water level analyses and/or GPS observations), sea level trends, satellite altimetry, and a geoid model. The CVDCW is particularly useful in the Arctic where both geodetic control points and tide gauge data are limited.

The CVDCW will enable the use of Global Navigation Satellite System technologies (primarily GPS) for hydrographers and navigators, and be of interest to users interested in water and coastal

zone management including oceanographers, environmental scientists, surveyors and engineers. In particular, it will allow easier integration of hydrographic and terrestrial data, provide a baseline for storm surge modeling and climate change adaptation, and aid with practical issues such as sovereignty and the definition of the coastline. Once high and low water surfaces are complete, they will define a large portion of the vertical link between land and ocean, helping to delineate flooding thresholds and inter-tidal ecosystem zones and boundaries.

Here we present an overview of the methodology using a set of prototype model results, and will outline features of interest for studies in coastal stability, climate change adaptation, and sea level change. We would also like to explore opportunities for recruiting new ocean model data to incorporate into our surfaces.

Regional climate modelling and climate projections PART 3 / Modélisation régionnale et prévision du climat PARTIE 3

Room / Endroit (Ouellet), Chair / Président (Laxmi Sushama, René Laprise, Ramon de Elia & Anne Frigon), Date (04/06/2014), Time / Heure (15:30 - 17:00)

3D3.1 ID:7191 15:30

CRCM5 performance, boundary forcing errors and climate change projections for the Indian domain

Adelina Alexandru , Laxmi Sushama
Département des sciences de la Terre et de l'Atmosphère, UQÀM
Contact: adelina@sca.uqam.ca

The performance of the fifth generation of the Canadian Regional Climate Model (CRCM5) in reproducing the main climatic characteristics over India during the South West (SW)-, Post- and Pre-monsoon seasons will be presented in the first part of this study. For this purpose, CRCM5 driven by ERA-40/Era-Interim re-analysis is compared against independent observations and reanalysis data for the 1971–2000 period. Boundary forcing errors, i.e. errors in CRCM5 simulations due to errors in the driving Global Climate Model (GCM), are also assessed by comparing CRCM5 simulations driven by two independent GCMs, the Canadian Earth System Model version 2 (CanESM2) and Max Planck Institute for Meteorology's Earth System Model Low Resolution (MPI-ESM-LR), with the CRCM5 simulation driven by ERA-40/ERA-Interim for the 1971–2000 period. Projections of future climate change over India for two 30-year time slices, 2041–2070 and 2071–2100, will be presented in the second part, based on CRCM5 simulations driven by the GCMs, CanESM2 and MPI-ESM-LR; The two GCM-driven CRCM5 simulations span the 1951–2100 period and follow RCP4.5 scenario for the 2006–2100 period.

Results show that CRCM5 driven by ERA-40/ERA-Interim is able, in current climate, to capture well the spatial patterns of selected variables (temperature, precipitation, wind, sea level pressure, total runoff and soil moisture) over most part of India in comparison with available reanalysis and observations. However, some noticeable differences between the model and observational data were found during the SW monsoon season within the domain of integration. CRCM5 generates too much precipitation over the west coast and central India and not enough in north and northeast India and along the western part of the Western Ghats. The monsoon onset occurs earlier in CRCM5 simulations while the monsoon withdrawal occurs too late in CRCM5 simulations over in comparison with observations.

For the two future 30-year time slices (2041–2070 and 2071–2100) analyzed here, both CRCM5 climate projections imply a general warming over India in the 21st century, especially in the pre-monsoon and winter seasons. However, for precipitation and other related variables, such as the total soil moisture and total runoff, the two GCM-driven CRCM5 simulations give quite different climate change projections with reference to the 1971–2000 baseline. This is mostly due to the differences between the two GCM-driven simulations in representing the 1971–2000 baseline precipitation.

3D3.2 ID:7330 15:45

Multivariate multisite statistical downscaling using a probabilistic Gaussian copula regression model

Mohamed Ali Ben Alaya [1], *Fateh Chebana* [1], *Taha B.m.j. Ouarda* [2]
[1] INRS-ETE, 490 rue de la Couronne, Québec (QC), Canada G1K 9A9
[2] Institute Center for Water and Environment (iWATER), Masdar Institute of science and technology, P.O
Contact: mohammed_ali.ben_alaya@ete.inrs.ca

Atmosphere–ocean general circulation models (AOGCMs) are useful to simulate large-scale climate evolutions. However, AOGCM data resolution is too coarse for regional and local climate studies. Downscaling techniques have been developed to refine AOGCM data and provide information at more relevant scales. Among a wide range of statistical approaches, regression-based methods are commonly used for downscaling AOGCM data. When several variables are considered at multiple sites, regression models are employed to reproduce the observed climate characteristics at small scale, such as the temporal variability and the relationship between sites and variables. This study introduces a probabilistic Gaussian copula regression (PGCR) model for simultaneously downscaling multiple variables at several sites. The proposed PGCR model relies on a probabilistic framework to specify the marginal distribution for each downscaled variable at a given day through AOGCM predictors, and handles multivariate dependence between sites and variables using a Gaussian copula. The proposed model is applied for the downscaling of AOGCM data to daily precipitation and minimum and maximum temperatures in the southern part of Quebec, Canada. Reanalysis products are used in this study to assess the potential of the proposed method. Results of the study indicate the superiority of the proposed model over classical regression-based methods and a multivariate multisite statistical downscaling model.

Keywords: Downscaling, Gaussian copula, Probabilistic regression, Temperature, Precipitation, Multisite, Multivariable.

3D3.3 ID:7213 **16:00**

Lake-river-atmosphere interactions as simulated by the Canadian Regional Climate Model (CRCM5) over north-east Canada

Oleksandr Huziy , Laxmi Sushama , René Laprise
ESCER, UQAM
Contact: guziy.sasha@gmail.com

Lakes are important components of the climate system and can affect regional climate by modulating surface albedo, surface energy and moisture budgets, especially for the lake rich regions such as Canada. From the regional hydrology perspective, interactions between lakes and rivers are important as streamflow patterns can be significantly modified by lake storage, while lake levels can be modified by streamflows. In this study, using a suite of experiments performed with the fifth generation of the Canadian Regional Climate Model (CRCM5), we try to assess the interactions between lakes and rivers and their impact on the atmosphere, over north-east Canada; in these simulations lakes are represented by the Hostetler model, while the rivers are modelled using the modified WATROUTE scheme including interflow. Comparison of CRCM5 simulations with and without lakes suggests big differences in winter/summer precipitation and winter temperature. CRCM5 simulations performed with and without lake-river interactions suggest improved representation of streamflows when lake storage is taken into account. Introduction of interflow shows slight increase to streamflows during summer and fall seasons for majority of rivers, and some impacts on the land atmosphere interactions via modified soil moisture.

3D3.4 ID:7088 **16:15**

Probabilistic Characterization of Meteorological Droughts for the Saskatchewan River Basin

Mohammad Badrul Masud , M. Naveed Khaliq , Howard S. Wheater , Zilefac E. Asong
Global Institute for Water Security, School of Environment and Sustainability, U of S
Contact: mbm806@mail.usask.ca

Drought is one of the costliest and recurrent natural disasters in Canada and the southern parts of the Prairie Provinces (i.e. Alberta, Saskatchewan and Manitoba) are particularly susceptible to drought. Therefore, proper understanding of the spatiotemporal characteristics of historical droughts is important for different water and agricultural resources planning and management related activities in this drought-prone region. This investigation assesses the characteristics and occurrence probabilities of meteorological droughts using both univariate and multivariate approaches for the 1961 to 2003 period in the Saskatchewan River Basin (SRB), which is the major water resource in the region. Observed gridded (10 km×10 km) daily temperature and precipitation data are used to characterize drought events on the basis of Standardized Precipitation Index (SPI) and Standardized Precipitation Evapotranspiration Index (SPEI). Based on SPI and SPEI values of 3-, 6- and 12-month time scales, drought events are defined and frequency analyses of drought severity and duration characteristics are undertaken for recurrence intervals of 5, 10, 20 and 30 years in order to develop and spatially map drought risk indicators across the entire SRB. The results of the study suggest that at all three time scales, southern parts

of the SRB (i.e. Seven Persons Creek, Bigstick Lake, western part of the South Saskatchewan River, and a major portion of the Red Deer River watersheds) are more vulnerable to droughts compared to other parts of the basin. Moreover, no substantial differences are found in the spatial extent of drought-affected areas identified on the basis of SPI and SPEI, which suggests little effect of evapotranspiration in defining drought events over this period.

3D3.5 ID:7131 16:30

The role of temperature in drought projections over North America based on NARCCAP simulations

Dae Il Jeong [1], *Laxmi Sushama* [1], *M. Naveed Khaliq* [2]
[1] Centre ESCER, Université du Québec à Montréal
[2] School of Environment and Sustainability, University of Saskatchewan
Contact: jeong@sca.uqam.ca

This study presents future temperature and hence evapotranspiration increases on drought risk over North America, based on ten current (1970–1999) and corresponding ten future (2040–2069) Regional Climate Model (RCM) simulations from the North American Regional Climate Change Assessment Program. The ten pairs of simulations considered in this study are based on six RCMs and four driving Atmosphere Ocean Coupled Global Climate Models. The effects of temperature and evapotranspiration on drought risks are assessed by comparing characteristics of drought events identified on the basis of Standardized Precipitation Index (SPI) and Standardized Precipitation and Evapotranspration Index (SPEI). The former index uses only precipitation, while the latter uses the difference (DIF) between precipitation and potential evapotranspiration (PET) as input variables. As short- and long-term droughts impact various sectors differently, multi-scale (ranging from one- to 12-month) drought events are considered. The projected increase in mean temperature by more than 2°C in the future period compared to the current period for most parts of North America results in large increases in PET and decreases in DIF for the future period, especially for low latitude regions of North America. These changes result in large increases in future drought risks for most parts of the USA and southern Canada. Though similar results are obtained with SPI, the projected increases to the drought characteristics such as severity and duration and the spatial extent of regions susceptible to drought risks in future are considerably larger in the case of SPEI-based analysis. Both approaches suggest that long-term and extreme drought events are affected more from the future increases in temperature and PET than short-term and moderate drought events, particularly over the high drought risk regions of North America.

3D3.6 ID:7176 16:45

Ensemble regional climate modeling over Ontario

Yongsheng Chen [1], *Zhongqi Yu* [2], *Jinliang Liu* [3], *Gordon Huang* [4]
[1] York University
[2] Shanghai Meteorological Service
[3] Ontario Ministry of the Environment
[4] University of Regina
Contact: yochen@yorku.ca

Dynamic downscaling simulations using regional climate models (RCMs) have been adopted widely for regional climate studies. Uncertainties in dynamic downscaling simulations due to errors in the atmospheric state and models need to be understood first. The ensemble forecast technique considering these uncertainties was utilized to perform regional climate simulations over Ontario. Three sets of ensembles, the 7-member North American Regional Climate Change Assessment Program (NARCCAP) RCM simulations, the 5-member downscaling simulations using the Weather Research and Forecasting (WRF) model driven by five NARCCAP RCM model data, and a 14-member perturbed ensemble simulations using the WRF model with the stochastic kinetic energy backscatter scheme are conducted and analyzed to assess the performance of the ensemble approach in regional climate simulations. The ensemble mean temperature and precipitation were compared to reanalysis data and observations. The root mean square errors and the correlations were calculated. The results showed that the ensemble method improves the accuracy of simulations, for both temperature and precipitation.

Data assimilation systems and impact of observations PART 1 / Systèmes d'assimilation des données et l'impact des observations PARTIE 1

Room / Endroit (Léonard-Blais), Chair / Président (Louis Garand), Date (04/06/2014), Time / Heure (15:30 - 17:00)

3D4.1 ID:7043 **15:30**

Recent advances in the field of satellite data assimilation at the Canadian Meteorological Center

Louis Garand , Mark Buehner , Stephen Macpherson , Sylvain Heilliette , Alain Beaulne
Environnement Canada
Contact: louis.garand@ec.gc.ca

We present the current status of satellite data assimilation at the Canadian Meteorological Center (CMC). Satellite radiances account for about 85 % of all assimilated data. Environment Canada is moving from the current 4D-var data assimilation system to an ensemble-variational approach (En-var). A key aspect of En-Var is the use of a flow-dependent background error covariance matrix. Error correlations between temperature and humidity are considered for the first time. The analysis grid is reduced from 66 km to 50 km. In that context, tests were successfully conducted to improve the impact of radiances in forecasts. The number of assimilated channels from AIRS and IASI was doubled (~140 channels for each instrument). The radiance observation error was revised, as well as the bias correction procedure. Another important consideration is the density of observations. At the time of the conference, an evaluation of impact resulting from

reduced radiance thinning (from 150 km to ~100 km) should also be available. Several new sources of satellite data are under evaluation (Cris, ATMS, IASI from Metop-B). Overall, the volume of satellite observations assimilated is expected to increase by an order of magnitude in the next five years (from 3 M/day to ~30 M/day). Specific research projects currently in progress will be outlined, followed by detailed presentations in this session.

3D4.2 ID:7036 **15:45**

Radiance assimilation experiments using correlated inter-channel observation error statistics in Environment Canada global ensemble variational assimilation system.

Sylvain Heilliette , *Mark Buehner* , *Louis Garand*
Environnement Canada
Contact: sylvain.heilliette@ec.gc.ca

Model background and observation error statistics are key inputs of variational data assimilation systems used in Numerical Weather Prediction. For a long time, it was customarily assumed in operational context that the observation covariance error matrix is diagonal. The neglected errors correlations being, in principle, accounted for indirectly via for example data thinning or error inflation. In the case of vertical sounders radiances, the advent of hyperspectral infrared sounders such as AIRS (Atmospheric Infrared Sounder), IASI (Infrared Atmospheric Sounding Interferometer) and the recently launched CrIS (Cross-track Infrared Sounder) with their thousands of channels represented an important challenge for the data assimilation community. Recently, inter-channel observation error covariances matrices were estimated for these instruments by various authors (e.g. Garand et al. 2006, Bormann et al. 2010) using different methods which gave consistent results. The purpose of this work is first the estimation of radiance's observations error statistics including inter-channel correlations and then the study of the impact of their use in a near operational context in Environment Canada's Envar global assimilation system.

3D4.3 ID:7032 **16:00**

Information content of the high temporal coverage infrared hyperspectral data

Yi Huang [1], *Maziar Bani Shahabadi* [1], *Louis Garand* [2]
[1] McGill University
[2] Environment Canada
Contact: Yi.Huang@mcgill.ca

It is likely that high temporal coverage high-resolution infrared (HIR) spectral data will be made available for weather and climate applications. How such data provided by geostationary and highly elliptical orbit satellites, or by multiple coordinated low Earth orbit satellites, may impact the weather forecast is still an open question. We use atmospheric analysis data based synthetic hyperspectral data to assess the information content of the high temporal coverage HIR data in describing the atmospheric variability at regional scales and to assess their possible impact on weather forecast.

3D4.4 ID:7132 **16:15**

Assimilation Experiments with Ground-based GPS Observations in the Environment Canada Global and Regional Deterministic Prediction Systems

Stephen Macpherson , Stéphane Laroche , Josep Aparicio
Environment Canada, Science and Technology Branch
Contact: stephen.macpherson@ec.gc.ca

The NOAA GPS-IWV network consists of over 600 sites equipped with high-precision dual-frequency GPS receivers located mainly in the North America region. The primary ground-based GPS (GB-GPS) observation for meteorological applications is the Zenith Tropospheric Delay (ZTD), a measure of the delay in GPS satellite signal reception at the ground due to the retarding effect of atmospheric refractivity. The ZTD can be related to total air weight (surface pressure) and integrated water vapour (IWV) above the GPS antenna. Surface weather observations of pressure, temperature and relative humidity at the GPS-IWV network sites allow IWV to be retrieved from ZTD. Data from the network are available every 30 minutes with quality largely unaffected by clouds and precipitation. Results will be presented of recent data assimilation experiments involving addition of NOAA GPS-IWV network observations to Environment Canada's new global and regional ensemble-variational (EnVar) analysis systems (planned for mid-2014). The impact of GB-GPS data assimilation is evaluated through verifications of forecasts using radiosonde observations, GB-GPS IWV observations and rain gauge precipitation data.

3D4.5 ID:7018 16:30

Assimilation of Hyper-Spectral Infrared Radiances over Land and Sea-Ice Surfaces

Suryakanti Dutta , Louis Garand , Sylvain Heilliette , Stephen Macpherson
Environment Canada
Contact: SuryaKanti.Dutta@ec.gc.ca

The present study highlights the recent progress in the assimilation of AIRS and IASI radiances sensitive to land and sea-ice surfaces at the Canadian Meteorological Center. The assimilation work is carried out using the upcoming Global Ensemble Variational (EnVar) System and the corresponding forecasts are made using Global Environmental Multi-Scale Model (GEM). The EnVar system provides flow- dependent background errors which include covariances between surface temperature and atmospheric variables. About 140 channels are assimilated from both AIRS and IASI. The sensitivity of radiance monitoring statistics to quality control criteria are examined. The presentation is completed by impact studies based on 1-2 month assimilation cycles.

3D4.6 ID:7209 16:45

On the Strategic Importance of Far IR Data for Forecasting Cold Airmass Formation in the Polar Vortex

Jean-Pierre Blanchet [1], *Yacine Bouzid* [2]
[1] Université du Québec à Montréal
[2] Université du Québec à Montréal - UQAM
Contact: blanchet.jean-pierre@uqam.ca

During Polar night, the establishment of extremely cold airmasses normally takes place over periods of about 2 weeks, well in the range of medium range forecasting. Improving physical processes at that scale is essential for extending weather forecasts and climate simulations alike. Satellites on the A-Train constellation and a decade of measurements at PEARL, Eureka, NU, have given us the opportunities to assess the role of polar clouds and aerosols in controlling the atmospheric water budget and the radiation balance. During the cold season (November to April) and unlike most lower latitude clouds, radiation from extensive thin ice clouds (TIC) in the High Arctic are a very effective diabatic cooling agent thought the whole troposphere. Far IR radiation is controlled by the molecular water vapour rotation modes which collapse rapidly below temperatures around -40°C typical of the Polar and the upper troposphere regions, forming the so-called “dirty- window”. Most of the cooling process takes place in the far IR spectral range (15 to 50µm), just beyond the current operationally observed domain of current satellite instruments (< 15µm). To fill this critical observation gap, with INO we are developing a new multi spectral radiometer based on microbolometer technology covering most of the thermal and far IR ranges and suitable for monitoring radiation, cloud microphysics of TICs, light precipitation (diamond dust) and water balance in the low concentrations typical of cold airmasses. In this paper, we will review the current status of the Thin Ice Cloud in Far IR Experiment (TICFIRE), a microsatellite mission at CSA dedicated to improve our observation system of the cold Polar vortex and the upper troposphere.

The Labrador Sea as a vital element of the climate system PART 1 / La mer du Labrador comme élément vital du système climatique PARTIE 1

Room / Endroit (Parent), Chair / Président (Paul G. Myers), Date (04/06/2014), Time / Heure (15:30 - 17:00)

3D5.1 ID:7017 **15:30**

Role of resolved and parameterized eddies in the Labrador Sea balance of heat and buoyancy

Oleg Saenko [1], *Frederic Dupont* [2], *Duo Yang* [1], *Paul Myers* [3], *Gregory Smith* [4]
[1] Environment Canada, Canadian Centre for Climate Modelling and Analysis
[2] Environment Canada, Canadian Meteorological Centre
[3] University of Alberta
[4] Environment Canada, Meteorological Research Division
Contact: Oleg.Saenko@ec.gc.ca

Deep convection in the Labrador Sea is an important component of the global ocean ventilation. The associated loss of heat to the atmosphere in the interior of the sea is thought to be mostly

supplied by mesoscale eddies, generated either remotely or as a result of convection itself - processes that are not resolved by low-resolution ocean- climate models. We employ a high resolution (1/12 deg) ocean model forced with high resolution (33 km/3 hr) atmospheric fields to further elaborate on the role of mesoscale eddies in maintaining the balance of heat and buoyancy in the Labrador Sea. In general agreement with previous studies, it is found that eddies remove heat and buoyancy along the coast and supply it to the interior. In the localized region of deep convection, the convergence of heat by eddies significantly increases with the deepening of winter mixed layer. This is mostly offset by the heat divergence due to time-mean circulation. In the broad area to the north of the convective region, vertical eddy flux plays an important part in the heat and buoyancy budgets of the upper Labrador Sea, accounting about half of the heat loss to the atmosphere. A low-resolution (1 deg) model captures only the general structure of buoyancy transport by eddies along the boundary currents, and more along the coast of Labrador than off the west coast of Greenland.

3D5.2 ID:7059 15:45

Mixed layer processes in the Labrador Sea from a high resolution Atlantic and Pan-Arctic ocean-ice model configuration

Xianmin Hu , Paul Myers
University of Alberta
Contact: xianmin.hu@gmail.com

The Labrador Sea, off the east coast of Canada, is one of the few oceanic regions where the deep ocean exchanges gases such as oxygen and carbon dioxide (CO2) directly with the atmosphere. This gas exchange, driven by wintertime deep convection is the ocean's "deep breathing" and the Labrador Sea can be viewed as a lung in the Earth System. Localized deep convection releases large amounts of heat to the atmosphere and the resulting Labrador Sea Water contributes to the global ocean thermohaline circulation that redistributes heat from low latitudes to the poles. In this study, we utilize preliminary results from a coupled sea-ice and ocean high resolution (1/12th degree) model driven by high frequency (hourly) atmospheric forcing from Canadian Meteorological Center (CMC) global deterministic prediction system (GDPS). We will first present the general evolution of the simulated mixed layer in Labrador Sea and associated variations in the oceanic fields, i.e., density, potential temperature and salinity. Then we will focus on the processes associated with mixed layer restratification, analysing the ocean density changes (both the thermal and haline components) as well as the surface and lateral heat and freshwater exchanges.

3D5.3 ID:7129 16:00

The Role of Storms in the Deep Convection and Restratification of the Labrador Sea

Amber Holdsworth , Paul Myers
University of Alberta
Contact: amberholdsworth@gmail.com

The role of storms in the preconditioning, deep convection and restratification of the Labrador Sea is investigated using the NEMO (Nucleus for European Modelling of the Ocean) ocean model coupled with CICE (The Los Alamos sea ice model). Forced with interannual atmospheric

data derived from the Canadian Meteorological Centre's (CMC) global deterministic prediction system (GDPS) from 2002-2008, the model is eddy permitting with a 1/4 degree resolution. To determine the relative impact of storms on ocean stratification in this region, storms up to synoptic scales were filtered from the interannual wind and temperature fields using a moving average filter. The filter removed all perturbations lasting less than ~12 days. Comparisons between the two simulations of mixed layer depths, convective resistance, as well as air- sea fluxes reveal that storms play a significant role in the deep convection process.

3D5.4 ID:7199 16:15

Observations of watermass transformation and eddies from the Nordic Seas: parallels and contrasts with the Labrador Sea

Clark Richards , Fiamma Straneo
Woods Hole Oceanographic Institution
Contact: clark.richards@gmail.com

It is now accepted that deep convection in the Nordic Seas involves watermass transformation along the path of warm-water inflow from the Atlantic to the Arctic ocean (see e.g. Mauritzen 1996). The Lofoten Basin has been hypothesized to be an important site for this process, but the details of both water mass transformation and transport within the region of closed topographic contours remains unclear. Measurements of hydrography and currents from a mooring deployed in the centre of the Lofoten Basin between June 2010 and September 2012 reveal the seasonal cycle of water column properties, as well as features of the eddy field. These observations may shed light on watermass formation in the Labrador Sea, particularly with respect to: surface buoyancy loss, wintertime mixed layer evolution, observed eddy properties, and the control of bathymetry on boundary current stability and export of convection products. In the talk, this theme will be explored through comparing and contrasting the two systems, with the goal of increasing understanding of watermass transformation within the Subpolar North Atlantic as a whole.

3D5.5 ID:7167 16:30

Pathways and variability of melt from the Greenland Ice Sheet into the Atlantic Ocean over 1960 to 2000

Laura C. Gillard , Paul G. Myers
Department of Earth and Atmospheric Sciences, University of Alberta
Contact: gillard2@ualberta.ca

As melting and freshwater discharge from the Greenland Ice Sheet has been increasing with time, one question is where the low salinity melt water will go and thus how and where it will be taken up in the Atlantic Ocean. We will examine this question with using the output from a series of ocean general circulation models and ranging in resolution from 1/4 degrees to 1/12 degree. Freshwater pathways will be tracked using the Ariane Lagrangian flow package to look at probabilities of freshwater from given glaciers reaching given parts of the Atlantic Ocean. As well we will compare how the pathways have changed through the 4 decades of 1960 to 2000.We also hope to present results from the same models using a reverse trajectory analysis to examine the sources of the warm Irminger Water that reaches the fjords of Greenland and it’s

evolution over the entire timeseries

3D5.6 ID:7216 **16:45**

Freshwater exchange from the Labrador Current into the sub- polar North Atlantic

Paul Myers
Department of Earth and Atmospheric Sciences, University of Alberta
Contact: pmyers@ualberta.ca

The Labrador Current carries freshwater from the Arctic, Greenland and Canadian north south along the western margin of the sub-polar gyre. Given the proximity of the region of deep water formation in the Labrador Sea to this fresh boundary current, many have speculated on the role high- latitude freshwater may have on the formation of Labrador Sea Water and the meridional overturning circulation. However, other studies have suggested that there is little offshore exchange along the Labrador margin, with most freshwater being mixed offshore in the region of Flemish Cap and the Grand Banks. Therefore we here focus on the question of how does this freshwater leave the boundary current system and where is it taken up into the Atlantic Ocean. We examine these questions using data collected from DFO's AZMP program, as well as several eddy-permitting regional configurations of the NEMO coupled ocean/sea-ice numerical model ranging from 1/4 to 1/12 degree. As well as examining hydrographic properties and fluxes, we use the lagrangian float tool Ariane to examine the freshwater pathways and their variability. We find little offshore exchange from the Labrador Current north of the Grand Banks and most of the freshwater exchanged offshore only enters the interior of the Labrador Sea after circulating around the sub-polar gyre via the North Atlantic Current and the West Greenland Current

POSTER-Air quality modeling, analysis and prediction / AFFICHES- Modélisation, analyse et prévision de la qualité de l'air

Room / Endroit (Congrès A), Chair / Président (Louis Garand), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E1.1 ID:7184 **17:00**

Carbon Data Assimilation Using An Ensemble Kalman Filter

Nan Miao , *Yongsheng Chen*
York University
Contact: yochen@yorku.ca

As a first step to build an ensemble data assimilation and source inversion system for atmospheric carbon, we implemented column integrated carbon monoxide (CO) concentration

assimilation capability in an ensemble Kalman filter (EnKF) data assimilation system with Weather Research and Forecasting model coupled with chemistry (WRF-CHEM). In spite of its global coverage, the CO retrievals from the Measurements Of Pollution In The Troposphere (MOPITT) instrument onboard the Terra satellite are available only once per day. There has been limited use of these CO data for atmospheric chemistry forecast. Data assimilation provides an effective way to guide the model in time.

This WRF-CHEM/EnKF system has been tested for a real forest fire case in British Columbia in 2010. It has been seen that after assimilating MOPITT data, the root mean square errors between forecasts and observations are reduced. Verifications of the analyses and forecasts using other independent observations will be presented. An inverse modeling of CO sources using parameter estimation with the EnKF will be explored.

3E1.2 ID:7318 **17:00**

The unusual air quality, synoptic-scale and mesoscale meteorology conditions in southern Ontario during July 15, 2013

Frank Dempsey
Ontario Ministry of Environment
Contact: frank.dempsey@ontario.ca

A very unusual day for air quality in Ontario occurred July 15, 2103, when ground-level ozone concentrations increased above 80 ppb in the Greater Toronto and Hamilton Area (GTHA), while other regions of southwestern Ontario experienced significantly lower ozone concentrations. An ozone-enriched marine layer moved inland, following a distinct lake breeze front. From an air quality perspective, the most unusual aspect was high ozone concentrations in the regions close to the lakeshore while significantly lower concentrations were recorded elsewhere across the province, particularly locations in southwestern Ontario that normally experience increasing ozone concentrations before ozone increases at the GTHA air quality monitoring stations. From a synoptic meteorology perspective, the period was unusual with a high pressure ridge retrograding westward over eastern North America, after a low pressure trough moved westward from the eastern US to the southern Great Plains region. From a mesoscale meteorology perspective, nearly ideal conditions for lake breeze formation developed following a day of sunshine and weak winds that allowed ozone concentrations to increase in the Lake Ontario marine layer. Other interesting aspects of the meteorological pattern leading up to July 15 include a trough split and merging of the southern trough with the remnant of Tropical Storm Chantal near the Gulf coast.

3E1.3 ID:7259 **17:00**

The Trouble with High Resolution Models

Martin Gauthier
Rowan Williams Davies and Irwin Inc. (RWDI)
Contact: martin.gauthier@rwdi.com

Air quality modellers strive continuously toward the use of higher resolution grids, based on the underlying assumption that this will lead to improved accuracy (or at least precision) of model

results. Although this goal can be achieved in some cases, modellers must remain ever mindful of the limitations of the inputs to their models. In this presentation we review how GIS data are used to allocate geographically aggregated (e.g., Province-wide) emissions inventories to individual model grid cells. This is followed by a discussion of the relative importance of the appropriateness of both the spatial representation (the where), and the weighting factors or activity data (the what) used in the emission allocation process. We describe these issues using real-world examples from a 100 km by 108 km, 1.0 km grid resolution SMOKE and CMAQ modelling domain covering most of the Golden Horseshoe, being developed for the Region of Peel Department of Public Health. In addition to highlighting the kinds of challenges that can be expected, we also provide ideas and recommendations as to how modellers can address and rectify these issues in their models.

3E1.4 ID:7194 17:00

Forecasting the Influence of Climate Change on Extreme Ground-level Ozone Events in the Downtown Area of Toronto, Ontario

Kinson Leung , William Gough
University of Toronto: Department of Physical and Environmental Sciences
Contact: kinson.h.leung@gmail.com

Increasingly, it is becoming clear that climate change is affecting both the physical and social environments, often in ways unanticipated. The relationship between climate change and air pollution is becoming or will become one of the major concerns to many people living in Toronto, Ontario, Canada. Ground-level ozone (O3) is perhaps one of the most familiar pollutants in Ontario because it is associated with most smog alerts in the province. The goal of this study is to statistically downscale the Toronto ground-level-ozone-concentration data with the general circulation model (GCM) and use the model output to forecast the influences, the changes, and the probabilities of occurrence of future Extreme Ground-level Ozone Events that occurs in the Toronto Downtown area under different climate-change scenarios. The dowscaling method used in this research to generate climate-change scenarios was the Statistical DownScaling Model (SDSM) version 4.2.2. SDSM is a hybrid of regression-based and stochastic weather-generator downscaling methods. The result from this research has suggested that there will be approximately 30% of gradual increase of daily ozone-concentrations in the next eight decades. In addition, the result also forecasted that the probabilities of occurrence of Extreme Ground-level Ozone events with the O3 concentration ≥ 80 ppb (the current Ontario 1-hour Ambient Air Quality criterion for extreme ozone concentration) will gradually increase by 20% in the Toronto Downtown area by the year of 2100 under the different future scenarios in the third version of the Coupled Global Climate Model (CGCM3).

3E1.5 ID:7320 17:00

Development of Transportation Air Emissions in Canadian Cities

Xin Qiu , Nick Walters , Hamish Hains , Fuquan Yang
Novus Environmental Inc.
Contact: xqiu5685@rogers.com

Transportation emissions in an urban area can impact significantly on local and regional air

quality. A common approach is to apply road network spatial allocations with regional transportation total emissions through emission processing model, such as U.S. EPA's SMOKE to obtain gridded, hourly, speciated emissions. Therefore, an updated road network is curious to estimate transportation emissions in an urban area. CanVec is a digital cartographic reference product produced by Natural Resources Canada (NRCan). CanVec originates from the best available data sources covering Canadian territory and offers quality topographic information in vector format that complies with international geomatics standards, including the road network. Implementing CanVec road network data into Canadian urban emissions studies indicates that significant improvement in emission quantity and spatial allocations. In addition, local real traffic counts and customized mobile emission model can further improve the quality of transportation emissions. Modelling results and comparison will be discussed in the presentation.

3E1.6 ID:7256 **17:00**

Ozone assimilation and its impact on the Environment Canada UV index forecasts

Yves J. Rochon , Jean De Grandpre , Vitali Fioletov , Paul A. Vaillancourt
Environment Canada
Contact: jean.degrandpre@ec.gc.ca

The operational UV index forecasts being provided by Environment Canada (EC) rely on total column ozone maps empirically estimated from meteorological variables followed by scaling with ground-based total column ozone measurements from a few Brewer stations in Canada. In parallel, stratospheric ozone assimilation has been conducted in research mode at Environment Canada for over ten years. A new project has been undertaken to produce UV index forecasts using ozone analyses and resulting model ozone forecasts. The ozone model consists of the LINOZ linearized ozone chemistry scheme. The assimilated ozone data includes GOME2 and SBUV-2 data. The resulting total column ozone and UV index forecasts will be compared to ground-based and satellite measurements and to output of the EC and NOAA operational products.

POSTER-Regional climate modelling and climate projections / AFFICHES-Modélisation régionnale et prévision du climat

Room / Endroit (Congrès A), Chair / Président (Laxmi Sushama, René Laprise, Ramon de Elia & Anne Frigon), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E2.1 ID:7037 **17:00**

Limited-Area Energy Budget for the Canadian RCM

Marilys Clément , René Laprise , Oumarou Nikiema

Centre ESCER, Earth and Atmospheric Sciences, UQAM
Contact: clement.marilys@courrier.uqam.ca

The study of the atmospheric energetics provides fundamental information on the physical behaviour and maintenance of the general circulation. There are two forms of energy to be considered for the whole atmosphere: the available potential energy (APE) and the kinetic energy (KE). APE is generated by the horizontal temperature gradient caused by the differential heating by the Sun. APE is converted into KE by the weather systems (eddies) that transport heat from low to high latitudes, thus reducing the temperature gradient and associated APE, and KE is ultimately dissipated by friction. The cycle goes on infinitely as the horizontal temperature gradient is constantly replenished by differential heating by the Sun. To better represent the role of weather disturbances, global APE and KE can be resolved into components associated their zonal mean atmospheric state and departures thereof, giving as a result four different reservoirs of energy. To understand the physical processes and the underlying energy conversions responsible for the formation and development of individual weather systems, it is important to develop an atmospheric energetics approach suitable for limited regions. The advent of high-resolution atmospheric analyses and regional model simulations provides the means to do so. The goal of this study is to carry a limited-area energy cycle calculation. The formalism developed by Marquet (2003) and exploited by Nikiema and Laprise (2013) for inter-member variability budget will here be used to compute a limited-area energy budget from a simulation of the fifth-generation Canadian Regional Climate Model (CRCM5) driven by reanalyses. The four aforementioned energy reservoirs and conversions will be computed, and a fifth reservoir, arising from the fact that the mass is not constant in a limited-area domain, will also be computed. The first results of this energy cycle will be presented for the month of February 2005.

3E2.2 ID:7187 17:00

Frozen soil scheme for high latitude regions in land surface models

Arman Ganji , Laxmi Sushama
Université du Québec à Montréal, Département des Sciences de la Terre et de l'Atmosphère
Contact: arman22ga@gmail.com

Regional and global climate model simulated streamflows for high-latitude regions show systematic biases, particularly in the timing and magnitude of spring peak flows. Though these biases could be related to the snow water equivalent and spring temperature biases in the model, a big part is due to the unrealistic representation of frozen soil hydrological properties including hydraulic conductivity. This is demonstrated by comparing two simulations performed with the Canadian Land Surface Scheme, over North-east Canada; the two simulations differ in the frozen soil scheme formulation, particularly hydraulic conductivity and supercooled water. Analysis of the linkages between the soil/surface variables such as soil-moisture, infiltration, snow water equivalent (SWE) and runoff in these two simulations with different frozen soil scheme formulations and comparison of simulated streamflows to those observed show significant improvements in the simulation that explicitly models the effects of frozen soil on hydraulic conductivity.

POSTER-Marine Ice from Science to Operations / AFFICHES- Glace de mer : de la science à l'opérationnel

Room / Endroit (Congrès A), Chair / Président (Thomas Carrières, David Barber, Hal Ritchie & Greg Smith), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E3.1 ID:7285 17:00

Le canot à glace comme plate-forme de recherche en milieu côtier océanique

Robin Accot [1], *David Didier* [2], *Dany Dumont* [1], *Julien Robitaille* [1], *Simon Bélanger* [2]
[1] ISMER
[2] UQAR
Contact: robin.accot@uqar.ca

Le canot à glace fait partie du patrimoine culturel québécois, tant à titre moyen de transport et de subsistance dans le passé que comme sport de compétition aujourd'hui. Durant l'hiver 2013-2014, le canot à glace de l'Université du Québec à Rimouski a servi pour une autre activité cruciale : la recherche. L'avantage du canot repose sur sa haute manœuvrabilité dans des environnements glaciels très dynamiques et peu accessibles. Néanmoins, il présente aussi deux aspects limitant: l'exigence physique et la distance du lieu d'échantillonnage par rapport à la côte. Sa propulsion est assurée par trois ou cinq personnes et il est possible de transporter une charge utile légère. Deux sorties ont permis de témoigner de l'efficacité de cet outil à des fins scientifiques : la première dans le cadre d'un projet MEOPAR où une balise GPS a été installée sur un radeau de glace au large de Rimouski, afin de mesurer la dérive de la glace de mer; la seconde dans le cadre de la validation d'une image acquise avec le satellite RADARSAT-2 obtenue sur commande spécifiquement caractériser la glace côtière. Dans ce cas, les types de glace de mer et des limites banquise-eau et pied de glace/eau ont été identifiés et géoréférencés à l'aide de caméras numériques et un GPS. Dans le cas des balises, elles permettront de valider les modèles numériques de prévision de la dérive de la glace. Le recours à son utilisation dans le futur pourrait ainsi être une alternative lors de relevés sur des glaces instables en conditions hivernales.

3E3.2 ID:7267 17:00

An Operational Application of the Regional Ice Prediction System for MetArea Bulletins

Thomas Carrieres , *Lynn Pogson* , *Angela Cheng* , *Jack Chen* , *Hai Tran* , *Mark Buehner* , *Alain Caya* , *Jean-Francois Lemieux* , *Fred Dupont* , *Greg Smith* , *Paul Pestieau*
Environment Canada
Contact: tom.carrieres@ec.gc.ca

Environment Canada will soon be responsible for adding ice information to operational marine

bulletins for the new MetAreas XVII and XVIII. To assist Canadian Ice Service (CIS) operational ice forecasters prepare their component of the bulletins, an automated sea ice analysis and prediction system and a flexible MetArea bulletin display and GUI have been developed. Every 6 hours, the Regional Ice Prediction System (RIPS) provides analyses of ice concentration and forecasts of ice concentration, drift and pressure on a 5 km grid. Besides assimilating CIS manually prepared chart products, RIPS also assimilates fairly coarse resolution satellite data. To prepare for full operational support to the MetAreas, CIS ice forecasters have evaluated the automated system and GUI since July 2013. Based on their feedback, the GUI has been adjusted using the RIPS analysis uncertainty estimate. The RIPS 2.1 system will be briefly described along with the display and GUI system and an evaluation of its optimal utility as guidance for MetArea bulletins.

3E3.3 ID:7099 17:00

The METAREA initiative – a governmental focus on the Arctic

John Parker [1], *Marie-France Gauthier* [2], *Hal Ritchie* [3]
[1] Meteorological Service of Canada, EC, Dartmouth NS
[2] Meteorological Service of Canada, EC, Gatineau QC
[3] Meteorogical Research Division, EC, Dartmouth NS
Contact: harold.ritchie@ec.gc.ca

The Arctic Ocean is undergoing a significant physical transformation as a result of changing environmental conditions including earlier and longer opening of the various waterways such as the Canadian Northwest Passage, the occurrence of large fractures in the middle of the winter sea ice pack and formation of polynyas where previously there had been solid ice.

In recognition of the potential for significant increases in Arctic shipping and therefore an increase in the likelihood of shipping accidents that can put human lives and the integrity of the Arctic marine environment at risk, the International Marine Organization (IMO) has established five new meteorological areas (METAREAs) covering the Arctic Ocean and adjacent northern waters to provide the marine meteorological services required to meet the needs of mariners.

In summer 2010, Environment Canada's Meteorological Service received $26 million dollars over a five year period from Treasury Board to develop and implement "The METAREA Initiative".

This talk will describe the METAREA Initiative and the progress made so far including the summer 2014 final service expansion under the initiative.

POSTER-High latitude estuarine systems in a changing climate / AFFICHES- Estuaires de hautes latitudes dans un climat changeant

Room / Endroit (Congrès A), Chair / Président (Robie Macdonald, Clark Richards & Peter Galbraith), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E4.1 ID:7047 17:00

Pelagic respiration in the twilight zone of the Gulf of St.Lawrence: A meta-analysis and critical review

Yann Follin , Daniel Bourgault , Jean-Pierre Gagné , Karine Lemarchand , Gesche Winkler
Université du Québéc à Rimouski
Contact: yann.follin@yahoo.fr

It has recently been hypothesized that the consumption of dissolved oxygen by marine organisms living in the twilight zone may be the principal cause of oxygen depletion in the Gulf of St. Lawrence leading to hypoxic conditions in the Lower Estuary. This new view contradicts previous hypotheses, models and interpretations that attributed the principal cause of hypoxia to respiration of benthic organisms. However, this new "pelagic hypothesis" does not make unanimity among scientists and is the source of debates. For example, it has been argued that this new hypothesis is not supported by field measurements. We argue here, based on a meta-analysis and a critical review, that there are in fact no available robust measurements of pelagic respiration but only very few inferences that rely on uncertain coefficients (e.g. Electron Transport System (ETS) method) or questionable assumptions that are incompatible with the physics of the deep St. Lawrence (e.g. method based on stable isotope ratios of dissolved oxygen). Our review also highlights a number of misinterpretations found in the literature, especially regarding the re-interpretation of ETS-based measurements of pelagic respiration made in the '90s. When re-interpreted in the light of our analysis and using recently proposed conversion coefficients (to go from ETS to actual respiration), the historical ETS-based measurements are not inconsistent with the idea of a dominant pelagic sink of oxygen over benthic. This meta-analysis also synthesizes past information on organic matter fluxes that we re-interpret in the context of oxygen consumption. Finally, although generally considered less important than microbes, our analysis also examines the potential role of zooplankton in oxygen consumption, particularly in the context of recent discoveries that suggest that diel vertical migration may significantly contribute to oxygen consumption in the twilight zone.

3E4.2 ID:7168 17:00

Reconstruction of natural climatic and oceanographic variability with a high temporal resolution in the Estuary and Gulf of St-Lawrence over the last 8000 years.

Marie Casse [1], *Jean Carlos Montero Serrano* [1], *Guillaume St-Onge* [1], *Denis Gilbert* [2]
[1] ISER-UQAR
[2] Institut Maurice Lamontagne
Contact: marie.casse@uqar.ca

Variations in sedimentary dynamics observed in the Estuary and Gulf of St. Lawrence (EGSL) are closely linked with hydrological and climatic changes. One part of recent climatic and oceanographic changes observed in the EGSL has been associated to the influence of climatic oscillations such as the Arctic Oscillation and North Atlantic Oscillation. The main purpose of this research project is to rebuild natural climatic and oceanographic variability with a high

temporal resolution in EGSL over the last 8000 years. To reach this goal, we propose to use sediments' magnetic properties, clay mineralogy, trace metals and radiogenic isotopes of surface sediments and sediment cores with high sedimentation rates. The reconstruction of climatic and oceanographic variability is essential to improve the understanding of feedback mechanisms and impacts of future climate change in the EGSL. This research project will be centered around several scientific questions: (1) What is the long-term variability of sediment dynamics and deep water circulation in the EGSL over the last 8.000 years? (2) Has the natural oscillations of the ocean-atmosphere system represented an important forcing in the dynamic of terrigenous sediment flow and deep water circulation in the EGSL over the last 8.000 years? (3) Are the recent changes in the dynamics of deep water circulation in the EGSL (Gilbert et al, 2005) induced by a natural or an anthropogenic forcing? In order to answer to these questions, I will try to establish the potential relationship between changes in sedimentary dynamics, climate variability and oceanic circulation.

3E4.3 ID:7232 17:00

Spatio-temporal variability of DIC apparent quantum yields and photoproduction in the western Arctic Ocean

Abderrahmane Taalba [1], *Huixiang Xie* [2], *Simon Bélanger* [3]
[1] ISMER-UQAR
[2] ISMER/UQAR
[3] UQAR
Contact: ntaalba@gmail.com

It is now evidence that Chromophoric Dissolved Organic Matter (CDOM) photochemistry plays important roles in euphotic-water. CDOM driven by several physical and biological processes contributes significantly to ecological and biogeochemical cycles within the ocean-atmosphere system. However, quantitative studies of the effects of DOM phototransformation on the carbon fluxes in the Arctic Ocean are still scarce. For a long time photochemical processes have been assumed to be limited mainly by the low solar angles and extensive seasonal and year-round ice cover. In the context of ice-free scenario of the Arctic Ocean one could expect terrestrial dissolved organic carbon (DOC) inputs will increase due to the melting of the permafrost and to the increasing riverine discharges. In addition UVs radiations could deepen in the water column and lead to an enhancement of photochemistry process efficiency. Here using CDOM absorption spectra we report results from investigations on Dissolved Inorganic Carbon photoproduction processes in the Western Arctic region. The DIC photoproduction apparent quantum yields ($\Phi DIC(\lambda)$) were modeled for two contrasting systems (i.e. Chukchi Sea and Beaufort Sea) during summer 2009 and 2010 to investigate on the spatial and temporal variability of the DIC photoproduction processes efficiency.

3E4.4 ID:7211 17:00

Diagenetic recycling of manganese and iron along a spatial gradient in organic matter supply and bottom water oxygenation

Qiang Chen [1], *Alfonso Mucci* [1], *Bjorn Sundby* [2]
[1] GEOTOP and Dept. Earth and Planetary Sciences, McGill University, Montreal, QC, Canada
[2] GEOTOP and ISMER-UQAR, Rimouski, QC, Canada

Contact: alfonso.mucci@mcgill.ca

To explore how the recycling of sedimentary Mn and Fe is affected by the bottom-water oxygen concentrations ([O2]bw) and the accumulation rate of sedimentary organic matter (OM), we measured the vertical distributions of reactive Mn and Fe in the solid phase and pore-water Mn and Fe, as well as the concentrations, elemental ratios (Corg:Ntotal) and isotopic composition (δ13Corg) of the organic matter (OM) in six cores recovered along a transect in the Laurentian Trough, extending from the Lower Estuary and Gulf of St. Lawrence to the edge of the continental shelf. The [O2]bw and the quantity and source of OM (i.e., marine vs terrestrial) delivered to the sediment vary systematically along the Trough, a model site to test the sensitivity of the Mn and Fe diagenetic cycles to these environmental parameters. The maximum pore-water and integrated reactive Fe concentrations are observed at the landward station (Sta. 23) while the maximum pore-water and integrated reactive Mn concentrations are found in the western Gulf. The maximum pore-water Mn and Fe concentrations decrease seaward from the Gulf to the shelf break, with the exception of the Cabot Strait station where additional OM is delivered by lateral transport from the Magdalen Shelf. These observations are presumably a manifestation of the decreasing rates of OM sedimentation and remineralization. Hence, the intensity of Mn and Fe diagenetic cycling along the Trough may reflect the decreasing reactivity of the OM that is delivered to the seafloor, itself a function of the water depth, its residence time within the oxic sediment layer and the [O2]bw.

POSTER-Interactions between microbial diversity and oceanic processes over multiple scales / AFFICHES- Intérations entre la diversité microbienne et les processus océaniques sur multiples échelles

Room / Endroit (Congrès A), Chair / Président (Connie Lovejoy), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E5.1 ID:7315 **17:00**

RNA viral dynamics along the Antarctic peninsula

Jaclyn Mueller [1], *Alexander Culley* [2], *Grieg Steward* [1]
[1] University of Hawaii at Manoa
[2] Université Laval
Contact: alexander.culley@bcm.ulaval.ca

The majority of viruses in the ocean were assumed to be dsDNA containing bacteriophage until a

recent study suggested RNA viruses may contribute up to half of the total virioplankton. RNA viruses from the marine environment appear to predominantly infect a range of protists, including diatoms and dinoflagellates. These types of phytoplankton play a vital role in the Antarctic ecosystem by creating massive blooms each summer, thus providing an excellent location to investigate the dynamics of the RNA viral community. A metagenomic approach was used to investigate the RNA virus community diversity throughout the season, identify novel RNA viruses, and determine the relative abundance of RNA viruses to the total virus pool in Antarctic waters. We found that marine RNA viruses are abundant (up to 88%), persistent, and appear to predominantly infect eukaryotes; that the RNA virus community had a similar composition throughout the season, with a major dominance in +ssRNA viruses; and that RNA viruses identified represent a broad diversity of phylotypes highly divergent from known viruses.

3E5.2 ID:7332 17:00

Physical control of subsurface chlorophyll maximum in the Arctic Ocean

Mathieu Ardyna [1], *Marcel Babin* [1], *Peter Franks* [2], *Michel Gosselin* [3], *Jean-Éric Tremblay* [1]
[1] Takuvik Joint International Laboratory, Laval University (Canada) - CNRS (France), Québec, CANADA
[2] Scripps Institution of Oceanography, University of California at San Diego, La Jolla, USA
[3] Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, Rimouski, CANADA
Contact: Mathieu.Ardyna@takuvik.ulaval.ca

Subsurface chlorophyll maxima (SCM) are common features of phytoplankton aggregation at depth in marine ecosystems ranging from the tropics to the Arctic. However, the large-scale abiotic and biotic mechanisms behind their maintenance, depth and magnitude still need to be clarified. In this study, we examined a large database of ocean stations documented with physical (i.e. vertical structure and light attenuation of the water column), nutritive (i.e. nitrate, silicate and phosphate concentrations) and biological (i.e. vertical profiles of phytoplankton production and biomass, particulate organic carbon and nitrogen) variables in an extremely cold and stratified biome, the Arctic Ocean. The hypothesis that SCM dynamics are driven by light attenuation, as shown at tropical latitudes, appears not to be valid in the Arctic Ocean. On the contrary, strong vertical density gradients between the polar surface mixed layer and both the Atlantic (i.e. Eastern Arctic Ocean) and Pacific (i.e. Western Arctic Ocean) – nutrient-rich waters seem to constrain the maximal depth of SCM. This is particularly prevalent during the post-bloom period throughout the Arctic Ocean, when the surface mixed layer is shallow and surface nutrients are exhausted. Following SCM deepening, changes in phytoplankton physiology are also observed, such as decreased productivity and biomass and evidence of photo- acclimation at the SCM depth. To further assess this hypothesis, a 1D model (Fennel & Boss 2003) was used to perform a sensitivity analysis, exploring these mechanisms and the role of other environmental variables on SCM dynamics (i.e. temperature, grazing pressure…).

3E5.3 ID:7087 17:00

Thin layers of phytoplankton

Robin Accot [1], *Cédric Chavanne* [1], *Suzanne Roy* [1], *John Ryan* [2], *Gustavo Ferreyra* [1], *Daniel Bourgault* [1], *Dany Dumont* [1]
[1] Institut des sciences de la mer à Rimouski

[2] Monterey Bay Aquarium Research Institute
Contact: robin.accot@uqar.ca

Thin layers of phytoplankton can have an important chlorophyll concentration, modify acoustical and optical signals in the water column, as well as carbon dynamics. A comparison of phytoplankton's thin layers was made between two systems, the St. Lawrence marine estuary (SLME) in Québec, Canada, and the Monterey Bay (MB) in California, USA, to investigate how thin phytoplankton layers respond to different physical environments. In the SLME, density changes are dominated by salinity changes. Conductivity, temperature and depth (CTD) and fluorescence data were collected over a frontal area in the SLME in May 2013 using a ship-towed underwater undulating vehicle. In MB, on the other hand, density changes are dominated by temperature changes. Fluorescence, CTD, optical backscattering and nitrate data were taken in August and September 2013 with an autonomous underwater vehicle.The criteria used to detect the thin layers were 1) layer thickness less than 5 m, 2) phytoplankton concentration two times greater than the background and 3) temporal persistency. The observations show that the frequency of occurrence of thin layers and the average fluorescence ratio (peak / background) was higher in BM than in SLME . In MB, the depth of the thin layers was closely associated with the depth of the thermocline and nutricline, but not in SLME. Vertical movements of water masses due to frontal ageostrophic circulations may explain the presence of phytoplankton at 60 m depth in the SLME, well below the pycnocline depth of about 25 m.

POSTER-The Labrador Sea as a vital element of the climate system / AFFICHES- La mer du Labrador comme élément vital du système climatique

Room / Endroit (Congrès A), Chair / Président (Paul G. Myers), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E6.1 ID:7215 **17:00**

VITALS - Ventilation, Interactions and Transports Across the Labrador Sea

Paul Myers
Department of Earth and Atmospheric Sciences, University of Alberta
Contact: pmyers@ualberta.ca

The VITALS (Ventilation, Interactions and Transports Across the Labrador Sea) research network is a newly funded NSERC CCAR project. Our goal is to answer fundamental questions about how the deep ocean exchanges carbon dioxide, oxygen, and heat with the atmosphere through the Labrador Sea. Our working hypothesis is that deep convection in the Labrador Sea,

which allows for exchange of oxygen and natural and anthropogenic carbon to the deep ocean, is sensitive to the warming that is taking place at high latitudes. Validating and quantifying this sensitivity is central to our research network and also the broader community of climate change researchers and policy makers interested in characterizing, and possibly minimizing, the effects of global climate change. New observations, including biogeochemical, will include those collected from a SeaCycler moored in the interior of the Labrador Sea, additional moorings, gliders and floats as well as ship-board measurements and remote sensing). Combined with numerical modelling at a variety of scales and resolutions, we will determine what controls these exchanges and how they interact with varying climate, in order to resolve the role of deep convection regions in the Carbon Cyle and Earth System. VITALs is a pan-Canadian initiative involving scientists from 11 Canadian universities as well as multiple federal government laboratories (Fisheries and Oceans Canada, as well as Environment Canada), industrial and foreign partners. This presentation will outline the project and our plans with a goal of improving collaboration and coordination with other projects and initiatives.

3E6.2 ID:7071 17:00

Oceanographic observations along a section from the Labrador Sea to Lancaster Sound 2002-2013

Jane Eert [1], *Bill Williams* [1], *Eddy Carmack* [1], *Koji Shimada* [2], *Motoyo Itoh* [3]
[1] Department of Fisheries and Oceans Canada
[2] Tokyo University of Marine Science and Technology
[3] Japan Agency for Marine-Earth Science and Technology
Contact: jane.eert@gmail.com

Changes within the ice-cover, water column and ecosystems of Arctic Canada are inextricably linked to the global system in general and to the bordering subarctic Pacific and Atlantic in particular. Here we present temperature and salinity profile data collected from 2002-2013 along an annual early summer transect which starts in the Labrador Sea and passes through Davis Strait and Baffin Bay to Lancaster Sound. We will discuss the observed oceanic structures with regards to the downhill journey of low salinity Pacific-origin water though the Arctic and into the North Atlantic and the flow of Atlantic-origin water northward through Davis Strait. Inter- annual variability in watermass extent and inferred circulation as well as trends over the decade of observations will be discussed.

POSTER-Coastal ecoclines: a biogeochemical continuum between high latitude terrestrial and marine systems / AFFICHES- L'écocline côtière: un continuum biogéochimique entre

les systèmes continentaux et marins aux hautes latitudes

Room / Endroit (Congrès A), Chair / Président (Gwénaëlle Chaillou & Alexandra Rao), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E7.1 ID:7268 **17:00**

Seasonal and spatial variability of river's exports, Côte-Nord, QC, CANADA

Thomas Jaegler , *Simon Bélanger* , *Thomas Buffin-Bélanger*
UQAR
Contact: thomas.jaegler@gmail.com

River inputs of particulate and dissolved organic matter (POM and DOM) play a structural role for the coastal ecosystems. The supply of DOM and inorganic nutrients fuels both autotrophic and heterotrophic microorganisms. Simultaneously, colored dissolved organic matter (CDOM) and POM strongly attenuate solar radiation in the water column, reducing photosynthetically usable radiation. Here we study the seasonal variability in nutrients, bulk chemical composition and optical properties of CDOM in nine large river systems on the north shore of the estuary and gulf of St Lawrence (EGSL). These rivers account for up to 16% of the total freshwater discharged to the EGSL and four of them are regulated by large hydroelectric dams. The rivers regulated by dams showed a greater proportion of dissolved inorganic nitrogen (essentially nitrate) readily available for microorganisms. Unlike other boreal rivers, the export of silicate were similar between natural and dammed rivers. As expected, the regulation of the river flow, however, impeded large differences in the timing of the peak in nutrient and DOM exports to the coastal zone. For example, for the regulated rivers, small seasonal variations of the exports of dissolved organic carbon (DOC) were observed : ~33% in winter and ~25% in spring, compare to <10% and ~50% for natural systems. The optical properties of CDOM (absorption and fluorescence), suggested that DOM in all systems was primarily derived from terrestrial ecosystems. The spectral slope of the CDOM absorption spectra exhibit higher values in regulated rivers indicating that DOM was made up of smaller molecules. Based on the PARAFAC decomposition of exitation-emission matrices, DOM in natural systems tend to be more labile than in regulated ones.

3E7.2 ID:7289 **17:00**

Coastal aquifers: Where groundwater was connected to the sea.

Frédérike Lemay-Borduas [1], *Daniel Bourgault* [2], *Marie Larocque* [3], *Gwénaëlle Chaillou* [4]
(Presented by *Frédéike Lemay-Borduas*)
[1] Université du Québec à Rimouski
[2] Université du Québec à Rimouski-ISMER
[3] Université du Québec à Montréal
[4] Université du Québec à Rimouski
Contact: flemayb@gmail.com

Submarine groundwater discharge (SGD) is common in the coastal areas and occurs mainly in form of seepage through permeable sediments or continental shelves. These groundwater are a diffuse source of carbon, nutrients and contaminants to the coastal ocean and can directly influence the "health" of coastal ecosystems. SGD are still insufficiently documented to robustly quantify their contributions to global biogeochemical cycles, particularly in Nordic systems where the hydrology and the organic carbon dynamics rapidly change in response to recent climate warming. It is therefore important to quantify these discharges but also to understand where and how it occurs. We conducted a study to the Magdalen Islands to provide a qualitative and quantitative analysis of submarine groundwater discharges through sandy beaches. We used in situ 222-Radon measurements coupled with a stable isotope survey (∂2H, ∂18O and ∂13C) to locate discharge zone in the bay and estimate groundwater flux. Spatial distribution map of the data shows a contribution of groundwater for a distance of 200 m and to a depth of 2 m corresponding to the active area of the tides and waves breaking. First estimation of SGD flux using seepage chambers is 1000 ml per hour it was included mix of fresh water and recirculate water. Contribution of different water source will be considered by stable isotopic mass balance approach to understand how driving forces influences groundwater discharge. In contrast terrestrial environment, coastal aquifers are continuums of groundwater discharges are subject of hydrological driving forces but also oceanographic driving forces such as tides, winds and storm surges that can cause important variations of the sea-level and water properties.

3E7.3 ID:7261 **17:00**

Origin of dissolved organic matter through a northern sandy beach

Mathilde Couturier [1], *Gwénaëlle Chaillou* [1], *Christian Nozais* [2]
[1] UQAR-Chaire de recherche sur la géochimie des hydrogéosystèmes côtiers
[2] UQAR
Contact: couturier.math@gmail.com

Sandy beaches are now recognized as key environment at the land-sea interface. Recent studies showed that beaches are biogeochemical reactors responsible for significant mineralization of organic matter. These biogeochemical reactors are mainly fed by tidally marine inputs which provide marine organic matter, nutrients and oxygen. However, hydrological conditions and groundwater discharge can also act on biogeochemical reactors. In northern regions the hydrology and organic carbon dynamics are changing in response to global changes, altering terrestrial and marine exchanges. In order to explore the connectivity between terrestrial and marine organic matter input, we realized a biogeochemical survey in surface seawater, fresh ground water and pre-discharge beach groundwater in a northern sandy beach. We used optical properties of colored dissolved organic matter (CDOM) to trace and characterize transformation of DOM through the pre-discharge beach groundwater to coastal ocean. Fluorescence and absorption index show that terrestrial organic matters likely play a significant role to the biogeochemical reactor of sandy beach. These results highlight the biogeochemical connectivity across the terrestrial-marine continuum and potential importance of terrestrial organic matter in coastal ecology.

POSTER-Ocean, lake and river renewable energy extraction: the role of atmospheric and ocean sciences / AFFICHES- L'énergie renouvellable des océans, lacs et rivières: le rôle des sciences atmosphériques et océaniques - AFFICHES

Room / Endroit (Congrès A), Chair / Président (Joël Bédard & Peter Taylor), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E8.1 ID:7166 **17:00**

Ray models of sound propagation in the atmosphere and applications for wind turbine noise issues.

Peter Taylor [1], *Sumita Biswas* [2], *Jim Salmon* [3]
[1] York University and Zephyr North
[2] York University
[3] Zephyr North and York University
Contact: pat@yorku.ca

In some parts of Canada the aerodynamic noise created by wind turbine blades can be a significant issue in securing approvals for wind farm projects. The models used in the approvals process in Ontario (see Noise Guidelines for Wind Farms, 2008, PIBS 4709e) are based on ISO 9613-2 (Acoustics - Attenuation of sound during propagation outdoors - General method of calculation) under a specified set of conditions. Sound propagation can depend on wind and temperature profiles and reflection from the ground surface can be an important factor adding to the sound pressure levels at a receptor.

Most models assume the surface to be flat and uniform, but wind farms are often planned in more complex terrain and we are seeking to investigate these impacts. The ray model that we have developed allows for sloping terrain and variable surface characteristics as well as vertical variation in wind and temperature. Initial results are for a stationary point source (as assumed in the regulatory models) but the model has the potential to be extended to more realistic wind turbine noise source definitions.

3E8.2 ID:7057 **17:00**

Met mast configuration guidelines in Cold Climate for wind energy purpose

Cédric Arbez , *Antoine Amossé*
TechnoCentre Éolien
Contact: carbez@eolien.qc.ca

TechnoCentre Éolien (TCE) is.a not-profit organisation specialized in research in cold climate for wind energy. TCE is the owner of a wind farm including four met mast installed in cold climate (. including two of 126 m height) installed at 330 m with more than 40 mm of ice accumulation. This presentation will introduce additional recommendations to met mast configuration consistent to IEA Task 19 following a practical point of view. Many considerations need to be taking in account to optimize the sensor acquisition for met masts in cold climate due to: ice throw, icing accumulation, extreme cold temperature, and maintenance challenges in cold climate. Subsequent to these complications, TCE will develop over 3 subjects: maintenance challenge for sensors in cold climate, sensors behavior during icing events, instrumental icing detection. First, the configuration of booms is a big challenge to minimize the ice throw over sensors and maximize the undistributed wind sector acquisition. So, TCE will elaborate an optimize booms pattern to limit the corrective maintenance due to ice throw over sensors during winter in the goal to increase the data availability. Futhermore, recommendation about the design of sensors adapted to cold climate will be demonstrated to reduce the maintenance cost. Second, to ensure a high performance of heat anemometer during icing, an adequate power supply needs to be furnished to sensors in the tower. Many times, voltage losses between the power transformation and the sensors represent a lack of heat performance during the data acquisition. TCE will demonstrate different possibilities of electrical design to guarantee a maximum delivery of energy for heat sensors. Basically, TCE investigates the efficiency of instrumental icing detection method. Many meteorological characteristics are verified to know which are the most accurate between the field observations and the data acquisition and the limit of them.

3E8.3 ID:7237 17:00

Investigation sur les Méthodes d'Évaluation de la Rugosité dans le Domaine de l'Énergie Éolienne

Hussein Ibrahim [1], *Cédric Arbez* [1], *Cédric Daumas* [2]
[1] TechnoCentre éolien
[2] Université de Provence - Aix-Marseille I
Contact: hibrahim@eolien.qc.ca

Au cours de l'étape initiale d'un projet éolien, les trois composantes principales liées à l'évaluation et à la prédiction des ressources énergétiques sont examinées, à savoir : les données de vent (1), les données de rugosité (2) et les modèles d'extrapolation (3). Dans la couche limite de surface, le vent varie avec la rugosité du terrain et avec l'altitude. En effet, la rugosité du terrain (obstacles naturels ou artificiels) freine le vent de façon plus ou moins marquée. C'est ainsi que, les montagnes, les collines, les forêts, les herbes, les buissons et les constructions freinent considérablement le vent au sol. En revanche, les terrains sablonneux, les savanes sèches ou même les terrains enneigés influencent très peu les vitesses du vent. Comme conséquence, la vitesse du vent augmente avec l'altitude. Pour retrouver la vitesse du vent à un niveau différent du point de mesure, on procède souvent à une extrapolation verticale des données du vent. La majorité des travaux, sur la variation du vent avec la rugosité et avec l'altitude dans la couche limite de surface, est basée sur la théorie de similitude de Monin-Obukhov (1954). La variation du module du vent avec la hauteur se produit essentiellement dans la couche de surface (dans laquelle on considère les flux comme conservatifs) où elle suit une loi de logarithmique. Cependant, la variabilité spatiale et temporelle (en fonction des saisons par exemple) de la rugosité est rarement pris en compte, ce qui pourrait avoir un impact important sur la production

des parcs éoliens et leur rendement. Dans le cadre de ce travail, les différentes méthodes permettant d'évaluer la rugosité et sa variabilité en fonction du temps (saison) et de l'espace seront présentées, comparées et analysées afin d'en conclure avec de recommandations utiles pour l'industrie éolienne.

POSTER-Atmosphere, Ocean, and Climate Dynamics / AFFICHES- Dynamique de l'atmosphère, l'océan et le climat

Room / Endroit (Congrès A), Chair / Président (Adam Monahan, Ron McTaggart-Cowan, Marek Stastna & Mike Waite), Date (04/06/2014), Time / Heure (17:00 - 19:00)

3E9.1 ID:7260 **17:00**

The Influence of El Niño-Southern Oscillation on Tropical Cyclone Activity in the Eastern North Pacific Basin

Jerry Jien , *William Gough*
University of Toronto Scarborough
Contact: jjien@hotmail.com

The inter-annual variability of tropical cyclone activity due to El Niño-Southern Oscillation (ENSO) phenomenon has remained undetermined at the main development region of the eastern North Pacific basin. Here we classify years of El Niño, La Niña and neutral conditions using the Multivariate ENSO Index. Between 1971 and 2012, the seasonal storm measurements of the net tropical cyclone activity index and power dissipation index are used to summarize the overall seasonal TC activity and TC intensity and are both found to be statistically different between the two opposite ENSO phases at the basin's main development region. However, when the area is longitudinally divided, only the western portion of the development region experienced a significant difference ($p<0.05$). Specifically, El Niño years are characterized by more frequent, more intense events than during La Niña conditions for this sub-region. Bivariate correlation analyses of the relationship of MEI and both TC indices demonstrate strengths of correlation between ENSO and TC activity and TC intensity are statistically significant ($p<0.01$) only in the western region. The relevancy of annual ENSO conditions can improve the short-term forecast of the local TC activity and TC intensity on a seasonal basis for public awareness and disaster preparation.

3E9.2 ID:7044 **17:00**

A New Diagnostic Turbulence Parameterization Scheme for Representing Diurnal Variations of the Boundary Layer Wind Speed PDF in CANAM4 SCM

Yanping He [1], *Norman Mcfarlane* [2], *Adam Monahan* [3]
[1] University of Victoria
[2] CCCma
[3] Univeristy of Victoria
Contact: yhe@uvic.ca

A new diagnostic turbulence parameterization scheme is developed to improve atmospheric boundary layer wind, temperature, humidity simulations used in climate models. The scheme is compared with observations and the default scheme in the CCCma fourth generation atmospheric general circulation model (CANAM4) using single-column modeling cases studies and using both operational and high vertical resolution in the boundary layer. Diurnal variations of near surface wind speed PDF was much better simulated using the new scheme and higher vertical resolution in both nocturnal stable PBLs and convective PBLs over land.

3E9.3 ID:7052 17:00

Forecast Skill of the Pacific/North American pattern, North Atlantic Oscillation, and variabilities of different time scales, using global atmosphere-ocean coupled models

Nicholas Soulard [1], *Hai Lin* [2]
[1] McGill University
[2] Environment Canada
Contact: nicholas.soulard@mail.mcgill.ca

A skillful prediction of the Pacific/North American pattern (PNA), and the North Atlantic Oscillation (NAO) contributes greatly to the overall seasonal forecast in the extratropical Northern Hemisphere. The predictability of these flow patterns is examined on a seasonal time scale using 32 years of historical data from the Canadian Seasonal to Interannual Prediction System (CanSIPS), which consists of two global atmosphere-ocean coupled models. Using the PNA and NAO indices from the multi-model average, the forecast skill of each pattern's time series was calculated for the winter season (December-February). The NAO showed high correlation skill out to the one-month lead forecast, while the PNA showed skill out to the 8-month lead forecast. The relationship between the PNA and El-Nino is well documented and accounts for the high skill observed for the PNA. The skill of the 1-month lead NAO forecast can be attributed in part to tropical sea surface temperature anomalies, and to land surface temperature anomalies (or snow depth anomalies) over Asia. The models' skill for variabilities of different time scales is also examined. Looking at two time scales in particular (2-10, and 10-90 days) we see that there is significant skill for the surface air temperature forecasts over the central and eastern United States at the synoptic time scale, as well as over the north central Pacific at both time scales.

3E9.4 ID:7112 17:00

The role of meltwater fluxes in the evolution of Atlantic Ocean's deep circulation since the Last Glacial Maximum

Juliana Marson [1], *Ilana Wainer* [1], *Mauricio Mata* [2], *Lawrence Mysak* [3]
[1] University of Sao Paulo
[2] Federal University of Rio Grande
[3] McGill University

Contact: jumarson@gmail.com

Since 21,000 years ago, the oceans have received large amounts of freshwater in pulses coming from the melting of continental ice sheets. These pulses are known to perturb the Atlantic Meridional Overturning Circulation (AMOC) when they enter the upper ocean near deep water formation locations. The present work aims to show the impacts of meltwater fluxes on the Atlantic Ocean's water mass distribution and deep circulation through the analysis of the first CGCM transient simulation of the last 21,000 years. The simulation spans from the Last Glacial Maximum to Present Day using a state- of-art CGCM, the National Center for Atmospheric Research Community Climate System Model version 3 (NCAR CCSM3). Results show that the freshwater discharges were crucial establishing the present Atlantic Ocean's thermohaline structure, marking the transition between a shallower and a deeper AMOC.

2014-06-05

Plenary Day 4 / Plénière Jour 4

Room / Endroit (Langevin-Ouellet), Chair / Président (Michael Scarratt), Date (05/06/2014), Time / Heure (09:00 - 10:30)

P4.1 ID:7351 INVITED/INVITÉ 09:00

Inuit experiences of climate change and the development of community-based environmental monitoring

Vincent L'Hérault [1], *Curtis Kunnuaq Konek* [2], *Shirley Tagalik* [2]
[1] ARCTIConnexion, Rimouski, QC
[2] Arviat Wellness Center, Arviat, NU
Contact: Vincent.LHerault@uqar.ca

Scientists have been successful at gathering recent and paleo data to document the modern rise in global temperature and changes in planetary climates. Understanding the impact of these changes on the environment and on human beings is challenging and requires fine-scale investigation. The knowledge held by local users of the environment (hunters, fishers, farmers) can be utilized as a complementary source of information to better understand environmental changes at local and regional scales. In Arviat, Nunavut, Inuit possess a lifetime of tremendously valuable information on the environment. Patterns in the wind, snow formation, rainfall, sea ice thickness and sun heat have been scrutinized by local observers over several decades and many linkages have been drawn between these observations and changes in the biology (plants, animals and humans). To gain more information on the observed and potential impacts of climate change on the biology of the region, we examined observations from Inuit (Inuit Qaujimajatuqangit) and scientific assessments gathered since 2000. Our main objective was to determine what is known and what needs to be known in order to improve the community's ability to adapt to climate change. We observed that the most accurate understanding of the impact of climate change on

the environment in the region of Arviat came from Inuit observations over the last seven decades. These observations covered a very large spectrum of topics, from the shift in dominant winds and its impact on hunter's orientation on the land to the increase in the dryness of the tundra and its impact on plant growth and animals' health. Interestingly, the few scientific documents found have unanimously identified the need to gather more data at fine-scale and to combine knowledge from both Inuit and scientists. To address these needs, we have created a community-based monitoring procedure to routinely document weather and environmental parameters, living species and human health. We wish to create a partnership with scientists and are seeking help in the gathering and the analysing of data as well as in the mentoring of local students. We encourage any interested person to contact us.

P4.2 ID:7349 **INVITED/INVITÉ 09:45**

Dancing with the waves

Dany Dumont
Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski
Contact: dany_dumont@uqar.ca

In our globalized world that races for resources, economic opportunities seem to appear where sea ice disappears: seasonally ice-covered seas at the periphery of the Arctic Ocean become natural prospects for resource exploitation or navigation. Knowing that the cryosphere in general and sea ice in particular exert a fundamental control on our physical, biological and social environment, it remains crucial to understand its behaviour. But because sea ice is a natural integrator of many environmental processes, it is very challenging to model. Discrepancies between models and observations suggest that we miss important physical processes. In this lecture, I will talk about my exciting journey en route towards a better understanding of the role surface gravity waves play in sea ice dynamics and, hopefully, towards better model accuracy. Wave-ice interactions that shape the so-called marginal ice zones have long been studied, both theoretically and observationally, but research is now reinvigorating as these processes are included into coupled operational models. Let's look at what happens when sea ice dances with waves!

Atmosphere, Ocean, and Climate Dynamics / Dynamique de l'atmosphère, l'océan et le climat

Room / Endroit (Langevin), Chair / Président (Adam Monahan, Ron McTaggart-Cowan, Marek Stastna & Mike Waite), Date (05/06/2014), Time / Heure (11:00 - 12:30)

4B1.1 ID:7311 **11:00**

A reanalysis of extreme cyclone growth processes in the North Atlantic Basin: Tropical, extratropical, and otherwise

John Gyakum [1], *Shawn Milrad* [2]
[1] McGill University
[2] Embry-Riddle Aeronautical University
Contact: john.gyakum@mcgill.ca

The purpose of this research is to analyze historically extreme cyclogenesis cases in the context of synthesizing crucial dynamic and thermodynamic processes occurring on planetary-, synoptic-, and mesoscales. Our analysis includes diagnoses from both the classical Sutcliffe quasi-geostrophic, and the potential vorticity perspectives. The particular foundational analysis is that of an historical analysis of moist baroclinic growth rates, and their relationships to extreme cases of North Atlantic dynamic tropopause jets, and to extreme cases of explosive cyclogenesis. In turn, we employ similar analyses to both historically extreme named tropical cyclones, and to the most explosive of cyclogenesis cases occurring in the extratropical North Atlantic basin. Our analysis of extratropical cyclones' dynamic and thermodynamic structures throughout their full life cycles reveals similarities to several named tropical cyclones. Our results suggest that dynamic and thermodynamic similarities, among our investigated set of cyclones, are sufficiently strong to warrant the development of a unified dynamical classifier for cyclogenesis, regardless of whether they appear in the extratropical or tropical latitudes.

4B1.2 ID:7319 11:15

Stochastic Parameterizations of Cloud Microphysical Processes: Addressing the Closure Problem in Bulk Rate Equations

David Collins , *Boualem Khouider*
University of Victoria
Contact: davidc@uvic.ca

Regional climate models use parameterizations of cloud microphysical processes to model (i) the amount of solar and terrestrial radiation reflected by cloud droplets and (ii) the time until the onset of precipitation. The spectrum of cloud droplet radii can span five orders of magnitude: from less than 1 micron to several millimetres. After initial formation, droplets increase in size by collision and coalescence before precipitating under the force of gravity. The evolution of the droplet spectrum by the collision and coalescence processes can be modelled by the evolution of bulk rate equations. The bulk rate equations are the zeroth (number concentration) and first (liquid water content) moments of the kinetic collection equation. Separating the droplet spectrum into cloud droplets and rain droplets via a separation mass gives a set of four coupled ODEs. Solving this set of equations is hindered by a closure problem.

Current bulk rate parameterizations overcome this closure problem with assumed distributions for the cloud and rain portions of the spectrum. The accuracy of commonly used distributions has recently been called into question. As an alternative to the use of a priori assumptions to eliminate the closure problem, we manage the closure problem by parameterizing physically relevant relations (covariances). The covariances arise from considering the number concentrations as the sum of a mean and a variance. They remain after taking the mean of the stochastic bulk rate equations. Using the same kernels identified by Seifert and Beheng in their

2001 paper and selecting appropriate values for covariances, we reproduce their bulk rate parameterizations. Our preliminary results encourage generalizations of this technique to employ other kernels, to utilize a full suite of covariance parameters, and to include multiphase processes.

4B1.3 ID:7158 11:30

Internal waves and boundary layer instabilities

Nancy Soontiens [1], *Marek Stastna* [2], *Michael Waite* [2]
[1] University of British Columbia
[2] University of Waterloo
Contact: nancy.soontiens@gmail.com

In this investigation, internal waves are generated as a constant background current advects a stratified fluid over topography. The velocities induced during the generation of the internal waves interact with the viscous bottom boundary layer resulting in boundary layer instabilities. These instabilities may have implications for sediment transport. This study examines the generation of such instabilities over elevation and depression topography under conditions where large trapped waves would be expected in a steady, inviscid framework. Using a spectral numerical model of the Navier-Stokes equations, three-dimensional effects are investigated under changes in viscosity. Pycnocline stratifications are considered and results are presented at both lab scales of 1-m depth and field scales of 10-m depth.

4B1.4 ID:7090 11:45

Analyzing the Linear Stability of Stratified Parallel Shear Flows

Tim Rees , *Adam Monahan*
University of Victoria
Contact: trees@uvic.ca

The stability analysis of stratified parallel shear flows is fundamental to investigations of the onset of turbulence in atmospheric and oceanic data sets. The stability analysis is performed by considering the behaviour of small-amplitude waves, which is governed by the Taylor-Goldstein (TG) equation. In this talk I will present a numerical method for the TG equation, and illustrate its use on a selection of idealized problems. New results on the stability characteristics of long waves in a classic shear profile will be discussed, and the effects of perturbing symmetric flow profiles will also be demonstrated. Finally, stability calculations for flows from observational data sets will be presented.

4B1.5 ID:7150 12:00

Propagating Sea Level Signals at Different Frequency Bands in the Kuroshio Extension Region

Hongyang Lin , *Keith Thompson*
Dalhousie University
Contact: hylin7311@gmail.com

The Kuroshio Extension is one of the most energetic regions of the global ocean. Hilbert empirical orthogonal function analysis is used in the present study to provide a frequency dependent description of observed sea level variability in this region, for the period 1993 to 2012 inclusive. The dominant high frequency (140 and 350d) mode describes signals that propagate westward with the largest amplitudes in the vicinity of the Shatsky Rise and Emperor Seamounts. We argue that this mode is driven by jet-bathymetry interactions. The dominant low frequency mode (longer than 350d) is explained in terms of wind-forced, jet-trapped Rossby waves that propagate along the mean Kuroshio Extension jet. In the meander region, sea level changes north of the jet anticipate changes south of the jet by about 3 years. Based on correlations of observed sea level with the Pacific Decadal Oscillation, and western boundary transport variability estimated from the GLORYS reanalysis, this anticipation is explained in terms of differences in the time taken for (i) Rossby waves to travel from eastern North Pacific to the meander region, and (ii) the much faster barotropic response of western boundary transport, and sea level north of the jet, to large scale forcing by the wind stress curl.

4B1.6 ID:7034 12:15

Subseasonal Variability of North American Wintertime Surface Air Temperature

Hai Lin
RPN-A, Environment Canada
Contact: hai.lin@ec.gc.ca

Using observational pentad data of the most recent 34 Northern Hemisphere extended winters, subseasonal variability of surface air temperature (SAT) over North America is analyzed. The four leading modes of subseasonal SAT variability, that are identified with an empirical orthogonal function (EOF) analysis, account for about 60% of the total variance. The first (EOF1) and second (EOF2) modes are independent of other modes, and thus are likely controlled by distinct processes. The third (EOF3) and forth (EOF4) modes, however, tend to have a phase shift to each other in space and time, indicating that they are related to a common process and represent a propagating pattern over North America.

Lagged regression analysis is conducted to identify the precursors of large-scale atmospheric circulation for each mode a few pentads in advance, and to understand the processes that influence the subseasonal SAT variability and the predictability signal sources. EOF1 is found to be closely related to the Pacific - North American (PNA) circulation pattern and is preceded by the East Asian cold surge. The cold surge leads to low-level convergence and enhanced convection in the tropical central Pacific which in turn induces the PNA. EOF2 tends to oscillate at a period of about 70 days, and is influenced by the low frequency component of the Madden-Julian Oscillation (MJO). On the other hand, EOF3 and EOF4 are connected to the high-frequency part of the MJO which has a period range of 30-50 days. These findings would help understanding the mechanisms of subseasonal surface air temperature variability in North America and improving weather predictions on a subseasonal time scale.

General Interdisciplinary Science / Sciences interdisciplinaires en général

Room / Endroit (Courchesne), Chair / Président (Michael Scarratt), Date (05/06/2014), Time / Heure (11:00 - 12:30)

Storm Surges and Extreme Sea Levels under Climate Change / Les ondes de tempêtes, les niveaux extrêmes de la mer sous les changements climatiques

Room / Endroit (Ouellet), Chair / Président (Zhigang Xu & Denis Lefaivre), Date (05/06/2014), Time / Heure (11:00 - 12:30)

4B3.1 ID:7110 **11:00**

Operational Forecast of Storm Surges in the St. Lawrence River

Denis Lefaivre , *Alain D'Astous* , *Zhigang Xu*
Pêches et Océans Canada, Institut Maurice-Lamontagne
Contact: denis.lefaivre@dfo-mpo.gc.ca

Water level in the St. Lawrence River is forecasted hourly for navigation purposes between Montreal and Ile-aux-Coudres. A One-Dimensional model is used with flow conditions at the upstream boundary and tidal prediction at the downstream one. Storm surges are added at the downstream boundary using a regression relationship between the recorded storm surges at Quebec City and the along channel wind recorded in the St. Lawrence Estuary. While providing good results on average, the standard deviation is large. Moreover, the storm surge amplitude is unduly damped as it progresses upriver when compared to observations. Several corrective actions are considered. Global storm surge modelling results is the most promising one.

4B3.2 ID:7006 **11:15**

Current State and Future Developments of the Storm Surge Program in Atlantic Canada.

Devon Telford
EC/ MSC / Atlantic
Contact: devon.telford@ec.gc.ca

MSC Atlantic Region is currently using a storm surge model, Dalcoast1, that was developed by Dalhousie University, as their numerical guidance. Though Dalcoast1 has served the region well

over the past decade, improvements in storm surge modeling made by the Science and Technology Branch have indicated that a better model, Dalcoast 5, maybe a candidate to replace the Dalcoast 1. Both the Dalcoast 5 and Dalcoast 1 storm surge models where validated against tide gauge observations over this past spring and summer. It was found that the Dalcoast 5 coefficient of determination was an improvement over Dalcoast 1. Further details of this validation will be presented at the conference.

4B3.3 ID:7007 11:30

The Current State and Future Developments for the inclusion of Wave Set-up in Coastal flooding forecasting in Newfoundland and Labrador.

Devon Telford
EC/ MSC / Atlantic
Contact: devon.telford@ec.gc.ca

During 1978, AES in the Atlantic Region assumed the responsibility for alerting the public whenever coastal sea levels appeared likely to be significantly higher (0.6m) than normal, and this practice has continued for areas without flood stage information. However, numerous cases of coastal flooding have occurred that, if the forecaster had relied solely on storm surge models, would have been missed. The inclusion of waves and the impact of wave setup in conjunction with the storm surge model has lead to an improvement in the forecasting of coastal flooding. This presentation will outline the guidance currently used by operational forecasters for the forecasting of coastal flooding and also outline current and future work in the field by the Marine and Coastal lab for Meteorology.

4B3.4 ID:7089 11:45

Superfast and Lease Square Fitting Simulations of Storm Surges ---Establishing a Database of Storm Surges of the Past and of the Future for three Coasts of Canada

Zhigang Xu
IML, DFO-MPO
Contact: Zhigang.Xu@dfo-mpo.gc.ca

This presentation will show how the All-Source Green's Functions (ASGF) can be used together with the Singular Value Decomposition (SVD) and the Fast Fourier Transform (FFT/IFFT) to extremely fast simulate storm surges and to best minimize the misfits between the simulations and the observations. It only takes 1 second to achieve a 10-year simulation of hourly time series, with SVD-compressed global atmospheric forcing as the inputs. With such a superfast speed, it is very feasible to establish a database of the storm surge time series of the past and of the future at hundreds or even thousands points of interest along the three coasts of Canada, by converting atmospheric forcings provided by realistic re-analysis atmospheric models and various climate models. The surge-weighted least square fitting simulations can explain up to 90% of the variances of the observed surges. Furthermore, it will be demonstrated that once trained by the observation the surge model can predict well for the period where the observations are reserved from the data assimilation. The good prediction skill makes meaningful to have future storm surge time series driven by an ensemble of climate model solutions.

4B3.5 ID:7258 12:00

Mapping Present Day Extreme Sea Levels Over The Coastal Waters Of Northwestern Pacific

Heng Zhang , *Jinyu Sheng*
Oceanography Dept., Dalhousie University
Contact: zhheng81@gmail.com

This study estimates the spatial distribution of the return level of extreme storm surges and total sea levels over the coastal waters of northwestern Pacific (CWNP) based on two- dimensional (2D) circulation model results for the period 1979-2010. The 2D circulation model is driven by atmospheric and tidal forcing. The atmospheric forcing is the combination of a parameterized vortex and large-scale Climate Forecast System Reanalysis (CFSR fields) at 6-hour intervals. The parameterized vortex is inserted into the CFSR fields to better resolve the atmospheric profiles associated with typhoons. The performance of the 2D circulation model is assessed by using observations over the CWNP. Results show that the 2D circulation model can reasonably reproduce tides and storm surges over the CWNP. The simulated surge-induced sea levels are used to estimate the 50-year extreme sea levels associated with storm surges over the CWNP by using an extremal analysis technique. The regions experiencing significant impacts from the 50-year surge-induced sea levels are then mapped. The simulated surge-induced and tidal sea levels are used to estimate the 50-year extreme total sea levels using the Monte Carlo method. Results show that the highly risky regions to be threatened by the 50-year extreme total sea levels are similar to those of the 50-year extreme surge-induced sea levels, but with much higher extreme values.

4B3.6 ID:7102 INVITED/INVITÉ 12:15

Projecting the Probability of Coastal Flooding Over the Next Century Taking Into Account Uncertainty in Sea Level Rise and Storminess

Keith Thompson
Dalhousie University
Contact: keith.thompson@dal.ca

The probability of coastal flooding is increasing with time due a global rise of observed mean sea level. The rate of rise is expected to accelerate over next century but the projections span a wide range of possible rates due to uncertainty in future emission scenarios and errors in the models used to make the projections. This raises the question of how to allow for uncertainty in sea level rise when, for example, developing policy and also tackling more practical problems related to the design of coastal infrastructure. A Bayesian approach is developed to project the probability of coastal sea level exceeding a site specific critical level, taking into account uncertainty in sea level rise and storminess. The approach is based on the decomposition of an annual maximum into an annual mean and a deviation with this mean. The probabilistic description of the annual maxima assumes sea level rise controls the evolution of the annual means and oceanographic phenomena (e.g., tides and storm surges) control the deviations. The effect of uncertainty of sea level rise and storminess on (i) the probability of sea level exceeding a specified level, and (ii) the expected number of exceedances between the present day and some future year is discussed and illustrated using long, representative time series of observed hourly values.

Data assimilation systems and impact of observations PART 2 / Systèmes d'assimilation des données et l'impact des observations PARTIE 2

Room / Endroit (Léonard-Blais), Chair / Président (Louis Garand), Date (05/06/2014), Time / Heure (11:00 - 12:30)

4B4.1 ID:7300 **11:00**

Towards the Assimilation of Near-Surface Winds: Development of a Geo-Statistical Observation Operator

Joël Bédard [1], *Stéphane Laroche* [2], *Pierre Gauthier* [1]
[1] Department of Earth and Atmospheric Sciences, UQAM, Canada
[2] Data Assimilation and Satellite Meteorology Section, Environment Canada, Canada
Contact: bedard.joel@gmail.com

Although increasing NWP model resolution helps improve forecast skills in the lower troposphere, the main sources of near-surface wind forecast errors are still the analysis inaccuracy due to the limited number of assimilated near-surface wind observations, the atmospheric boundary layer modeling, and the growth of large-scale errors in the analyses. The main objective of this project is to improve lower tropospheric analyses by assimilating near-surface wind observations (over land) in the ensemble variational (EnVar) data assimilation system developed at Environment Canada. To achieve this, it is necessary to complete: 1) an evaluation of near-surface background error correlation with the upper air atmosphere; 2) the development of a geo-statistical observation operator including systematic and representativeness error corrections; 3) the estimation of the observation error covariances; and 4) a validation of the method where observation system experiments are performed, assimilating only near-surface wind observations. The resulting analyses are verified against non-assimilated collocated radiosondes to assess the vertical corrections. This approach allows an estimation of the observation error statistics based on independent observations. Propagation of the information in the vertical has been evaluated when using both static and flow dependent background error covariances. Results from one month of assimilation experiments show that the geo-statistical operator eliminates observation biases and reduces representativeness errors standard deviation by ~0.3m/s. When compared to a bilinear interpolation, the geo-statistical operator improves the near-surface wind analysis by 5%-10%, mainly over complex sites. While the bias correction is a key component, representativeness error is also significantly contributing to the improvement.

4B4.2 ID:7048 **11:15**

Environment Canada's Regional Ensemble Kalman Filter

Seung-Jong Baek [1], *Luc Fillion* [2], *Peter Houtekamer* [2]
[1] Atmospheric and Oceanic Sciences, McGill University
[2] Meteorological Research Division, Environment Canada
Contact: seung.j.baek@mcgill.ca

A full-fledged Canadian version of a Regional Ensemble Kalman Filter (REnKF) has recently been produced in view of operational transfer to the Canadian Meteorological Center in 2015. This system is a prerequisite for a specific coherent data assimilation system for (1) the operational Canadian Regional Ensemble Prediction System (REPS) and (2) the upcoming Canadian Regional Deterministic Prediction System (RDPS at 2.5 km), . This REnKF system currently runs at 15 km horizontal resolution with 192 members and will provide ensemble members to be used by the Regional Ensemble Variational Analysis (REnVar). The cycling procedure of the REnKF together with its design will be compared with the Canadian operational global EnKF system (GEnKF). Results of continuous one way cycling for summer and winters test cases with REnKF will be presented and inter-compared with GEnKF. Added values of the REnKF over the GEnKF will be presented.

4B4.3 ID:7163 **11:30**

Impacts of the Saharan Air Layer on hurricane development

Jianyu Liang, *Yongsheng Chen*
York University
Contact: yochen@yorku.ca

Observational studies suggested that the Saharan Air Layer (SAL) may impose either negative or positive impacts on the evolution of Atlantic hurricanes. Hurricane Earl (2010) was influenced by SAL in the early development stage. The influence was studied in a numerical simulation and data assimilation experiment using the Weather Research and Forecasting (WRF) model and an ensemble Kalman filter (EnKF). In addition to the conventional observations, the Atmospheric Infrared Sounder (AIRS) temperature and specific humidity retrievals that can represent the features of the SAL were assimilated into the WRF/EnKF system for a period of 4 days, followed by 5-day ensemble forecasts. When only the conventional observations were assimilated, the storm failed to intensify and the track errors were large even at the beginning of the forecast. Assimilating AIRS observations significantly reduced the warm bias in the troposphere. The track and intensity analyses and forecasts were improved dramatically. The role of the SAL played in Hurricane Earl (2010) development will be investigated in details.

4B4.4 ID:7313 **11:45**

The Reduced Rank Sigma Point Kalman Filter for Data Assimilation

Manoj Kk Kk, *Youmin Tang*
University of Northern British Columbia
Contact: kizhakk@unbc.ca

In this study, we presnt two algorithms to construct a Reduced Rank Sigma Point Unscented

Kalman Filter(RRSPUKF). In both the techniques, we use the truncated singular value decomposition (TSVD) method to obtain the square root of the error covariance matrix and singular values are used to construct the reduced sigma points. Specifically, TSVD is applied on the covariance matrix constructed, in the data space (RRSPUKF(D)) and in the ensemble space (RRSPUKF(E)) for the first and second techniques respectively. Their performance is analyzed comparing assimilation results on a El Niño-southern Oscillation (ENSO) prediction model (LDEO5).

4B4.5 ID:7123 12:00

The new 4D-EnVAR Regional Deterministic Prediction System at the Canadian Meteorological Center

Thomas Milewski [1], *Jean-Francois Caron* [2], *Mateusz Reszka* [1], *Luc Fillion* [2], *Mark Buehner* [2], *Judy St-James* [1]
[1] Data Assimilation and Quality Control Development Section , Environment Canada
[2] Data Assimilation and Satellite Meteorology Research Section, Environment Canada
Contact: thomas.milewski@mail.mcgill.ca

A new four-dimensional (4D) ensemble-variational (EnVAR) data assimilation scheme incorporated in the Regional Deterministic Prediction System (RDPS) has been developed and is being evaluated at the Canadian Meteorological Centre (CMC). The new system is expected to replace the current operational 4DVAR-based RDPS in the near future. The main characteristic of the new EnVAR technique lies in the use of operationally-available ensemble members from the CMC global ensemble Kalman filter system to produce 4D background error covariances. These covariances are combined with climatological ones and used in the variational assimilation of observations to produce an analysis for both the global driver and the limited-area model. The advantages of the new RDPS over the current operational one will be outlined in terms of forecast skill diagnostics such as surface and upper-air verification scores and individual case studies, and in terms of reduced computational expense. Additional features, such as ground-based GPS data assimilation, spatial and temporal treatment of radiosonde data will also be discussed.

4B4.6 ID:7005 12:15

Assimilation of radar QPE in the Canadian Precipitation Analysis (CaPA)

Vincent Fortin [1], *Guy Roy* [2], *Norman Donaldson* [1]
[1] Meteorological Research Division, Environment Canada
[2] Meteorological Service of Canada, Environment Canada
Contact: guy.roy@ec.gc.ca

The Canadian Precipitation Analysis (CaPA) is a data assimilation system used operationally at the Canadian Meteorological Center (CMC) to produce gridded precipitation estimates in near real-time on a 10 km grid covering all of North America. Due to the low density of the observational network in most of Canada, the system relies on a background field provided by the GEM numerical weather prediction (NWP) model, in addition to gauges. While the operational configuration of CaPA does not assimilate radar quantitative precipitation estimates (QPEs), an experimental version which does assimilate radar QPE is under development, and is

expected to be operational in the fall of 2014. In the process of developing this new version of CaPA, a robust bias-correction and quality control procedure for radar QPE was put in place. In this paper, we describe this procedure and assess its impact on the skill of CaPA.

High latitude estuarine systems in a changing climate / Estuaires de hautes latitudes dans un climat changeant

Room / Endroit (Parent), Chair / Président (Robie Macdonald, Clark Richards & Peter Galbraith), Date (05/06/2014), Time / Heure (11:00 - 12:30)

4B5.1 ID:7152 **11:00**

Mixing and oceanic fronts in the Amundsen Gulf the surface layer

Caroline Sévigny [1], *Peter Galbraith* [2], *Yves Gratton* [3]
[1] INRS-Eau, terre et environnment
[2] MPO-Institut Maurice-Lamontagne
[3] INRS-Eau, terre et environnement
Contact: yves_gratton@ete.inrs.ca

The near-surface temperature structure in the southeastern Beaufort Sea is shown to have been largely dependent on frontal dynamics in spring 2004, which may be typical for the region. Easterly wind events generated coastal upwelling along the Cap Bathurst peninsula; a recurring event in that area. Further west, a large mesoscale anticyclone simultaneously developed and subsequently controlled the sea surface circulation in the central Amundsen Gulf. Sharp temperature and density fronts were created at the surface at both eastern and western ends of the domain. Sampling north of Cape Bathurst and Cape Parry showed evidence of frontal intensification. Frontal features were detected near the 50-200 m isobaths, at the mouth of the gulf, where density-compensated near-surface intrusions driven by agesotrophic vertical circulation were identified. These warm water tongues traveled outcropping isopycnal layers as they dipped down between 5 and 25 m depth over the Mackenzie Shelf, crossing density surfaces with an inverse slope consistent with N/f as predicted for quasi-geostrophic flows. The front event ended prior to the breakup of the landfast-ice bridge in late June with sea-surface temperature undergoing quick and widespread changes throughout the Amundsen Gulf.

4B5.2 ID:7033 **11:15**

Deep and intermediate water renewal in the Saguenay fjord

Mélany Belzile [1], *Daniel Bourgault* [1], *Peter S. Galbraith* [2]
[1] Institut des sciences de la mer de Rimouski, Rimouski, Canada
[2] Institut Maurice-Lamontagne, Mont-Joli, Canada

Contact: melany.belzile01@uqar.ca

The Saguenay fjord, located in the subarctic region of eastern Canada, contributes an important portion of the freshwater flowing into the St. Lawrence estuary. The fjord is part of the first national saltwater conservation park in Canada. While the summer conditions of the Saguenay have been widely studied, very little was known about the fjord dynamics during the winter season. Two moorings were thus deployed in the inner basin of the fjord in 2011 to collect its first historical current observations under ice cover. The moorings included acoustic Doppler current profilers (ADCP) which provided current data over the entire water column as well as temperature-salinity sensors. The observations showed that the fjord dynamics are more complex than anticipated. For example, the deep and intermediate waters of the inner basin appear to be renewed by a series of rapid and small-scale recirculation patterns rather than by occasional complete renewal events. Although there is currently no evidence that the changing climate is affecting the physical processes of the Saguenay, there is a great interest in building general knowledge on subarctic fjords in order to foresee the impact of those imminent changes. This study is a step towards that goal by providing a clearer quantitative picture of intermediate and deep water renewals in a seasonally ice-covered fjord.

4B5.3 ID:7170 11:30

Environmental control of phytoplankton size structure and taxonomic composition in Labrador fjords

Armelle Galine Simo Matchim [1], *Mathieu Ardyna* [2], *Marjolaine Blais* [1], *Michel Gosselin* [1]
[1] UQAR-ISMER
[2] Takuvik Joint International Laboratory, Laval University (Canada) – CNRS (France), Canada
Contact: ArmelleGaline.SimoMatchim@uqar.ca

In subarctic fjord-type estuaries, the structure and taxonomic composition of phytoplankton communities are highly variable, both in space and time, with respect to changing environmental forcing (i.e. irradiance, temperature, salinity, nutrient availability and stratification of the water column). The objectives of this study were (1) to describe the size structure and the taxonomic composition of the phytoplankton communities in four different subarctic Nunatsiavut fjords (Nachvak, Saglek, Okak and Anaktalak) during summer, early fall and late fall, and (2) to determine the influence of environmental factors on their variability. Cell abundances and taxonomic composition were determined by flow cytometry and inverted microscopy, respectively. Throughout the sampling periods, the algal community in the euphotic zone was numerically dominated by picophytoplankton (0.2-2 µm), except at the subsurface chlorophyll maximum (SCM) of Nachvak and Saglek fjords during summer. Nanophytoplankton (2-20 µm) abundance was higher during summer. The relative abundance of microplankton (> 20 µm) was always very low (< 4% of the total cell abundance). For the whole sampling period, picophytoplankton was positively correlated with water temperature. At the SCM, nanophytoplankton was positively correlated with incident irradiance and stratification index, but negatively with salinity and nutrient concentrations. Microplankton was positively correlated with incident irradiance. During summer, the well-lit and stratified surface layer was numerically dominated by diatoms and prymnesiophytes. In contrast, during early and late fall, when the average irradiance in the euphotic zone was lower and the upper water column was less stratified, the community was characterized by dinoflagellates, cryptophytes and heterotrophic

protists. These results clearly show how environmental factors are controlling the seasonal changes in size structure and taxonomic composition of phytoplankton communities in Labrador fjords.

4B5.4 ID:7255 11:45

Sea-ice and oceanic climate prediction in Canadian inland seas: Estuary and Gulf of St. Lawrence and Hudson Bay system.

Simon Senneville , Simon St-Onge Drouin
UQAR-ISMER
Contact: simon_senneville@uqar.qc.ca

Previous works from Senneville and Saucier (2007) and Joly et al. (2010) describe a sensitivity analysis of the Gulf of St. Lawrence and Hudson Bay system to air temperature with the change factor method. Recent work of Senneville and St- Onge Drouin (in prep) seems to shows that this method does not correctly predict the reduction of the sea-ice season with respect to climate change. The present work uses two 120 year prognostic simulations to study the oceanic and sea-ice climate from 1980 to 2100 for each domain. For the period around year 2055 (averaged over 2041-2070), in the EGSL system, we predict a diminution of 67 % of the sea-ice season (36 days) with a diminution of 69 % (20 km^3) of maximum ice volume. The mean sea surface temperature increases of 0.98 degrees Celsius. For the Hudson Bay system, we predict a diminution of 15 % of the sea-ice season (39 days) with a diminution of 20 % (376 km^3) of maximum ice volume. The mean sea surface temperature increases of 0.33 degrees Celsius. In the EGSL, the trend of sea-ice depletion seems to have two regimes due to oceanic forcing. A first one involves ice formation over shallow regions and deep water up to year 2040 and a second one where the ice formation mostly occurs over shallow region where the heat accumulated in the water column does not prevent ice formation.

4B5.5 ID:7200 12:00

Detection and characterization of glacier calving from measurements of ocean waves

Clark Richards , Fiamma Straneo
Woods Hole Oceanographic Institution
Contact: clark.richards@gmail.com

Recent rapid mass loss of the Greenland and Antarctic ice sheets has spurred an intense interest in understanding glacial dynamics. Much of the emphasis has been on prediction, particularly in the context of future sea-level rise under a warming climate. Calving has long been recognized as an important mode of glacier ice loss, but the mechanisms are not yet well understood, owing to a scarcity of observations. We present a method for detecting and characterizing glacier calving events based on measurements of glaciogenic ocean surface waves. The method is applied to a tidewater glacial fjord in West Greenland, Sarqardleq fjord, using data from July 2012 and 2013. Preliminary results suggest that glacier calving averages 3 events per hour, with higher rates close to a submarine glacial runoff plume. More generally, our results suggest that the method has great potential for long-term monitoring of ice calving in remote glacial locations.

4B5.6 ID:7165 **12:15**

Configuration of the NEMO model for the Strait of Georgia

Nancy Soontiens [1], *Susan Allen* [1], *Kate Le Souef* [1], *Doug Latornell* [1], *Youyu Lu* [2], *Keith Thompson* [3], *Jean-Philippe Paquin* [3], *Vasily Korabel* [3]
[1] University of British Columbia
[2] Fisheries and Oceans Canada
[3] Dalhousie University
Contact: nancy.soontiens@gmail.com

The Salish Sea MEOPAR project aims to develop a three dimensional ocean model for the Strait of Georgia based on the NEMO modelling architecture. The Strait of Georgia is a strongly stratified, partially enclosed water basin between Vancouver Island and the mainland of British Columbia. It is connected to the Pacific Ocean by strongly tidally mixed Straits: Boundary Pass, Haro Strait and the Strait of Juan de Fuca. An overview of the early stages of model development will be presented. This includes a discussion on the choices for model grid, bathymetry, forcing and initial conditions, and mixing parameterizations. Evaluation of the model performance based on tidal amplitude and phases, as well as vertical mixing within the Haro Strait region will be presented. We will also show preliminary results on storm surge hindcasts. This project is funded by the Marine Environmental Observation Prediction and Response network (MEOPAR), a member of the Networks of Centres of Excellence of Canada (NCE).