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Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

June / juin 2012 Vol.40 No.3

Canadian Ocean Tracking Network

Réseau canadien de suivi des océans

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Oceanographic specialists/
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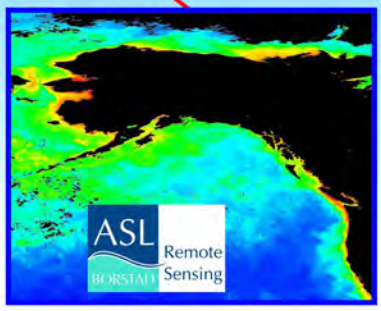

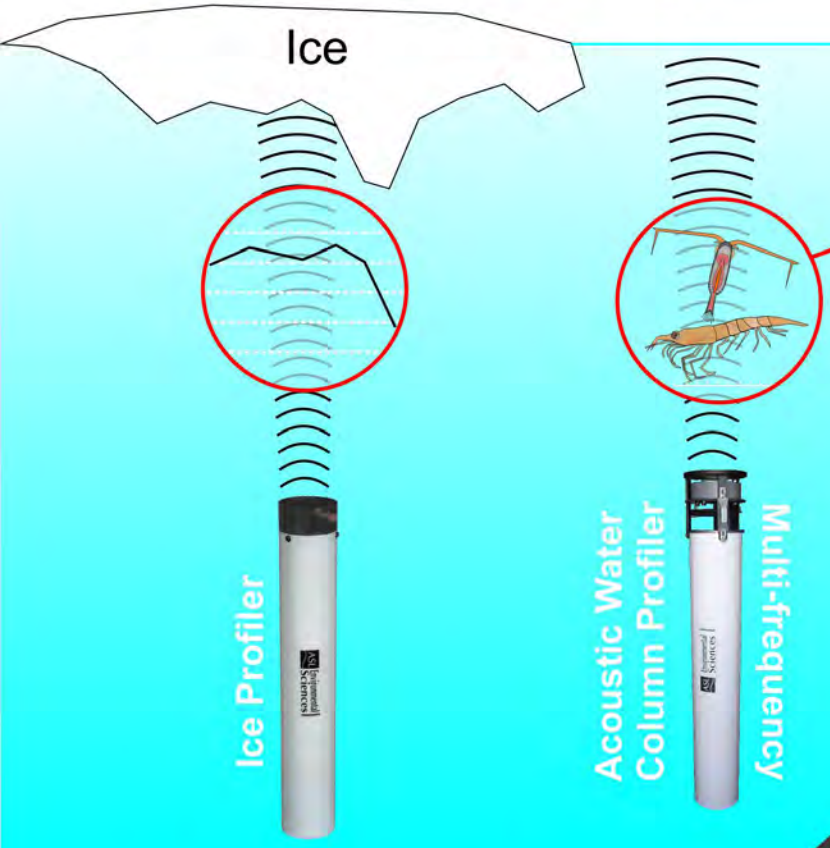

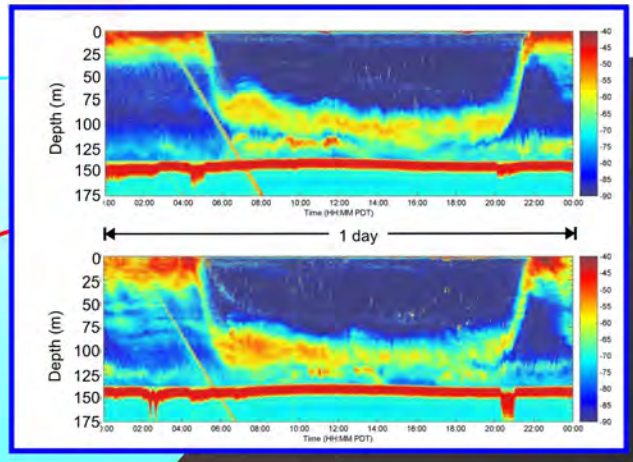

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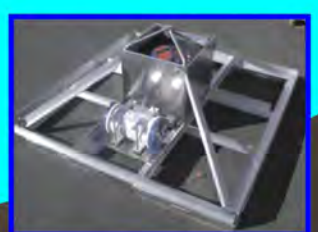

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....from the Presidents' Desks

Friends and colleagues:

Norman McFarlane
Outgoing President CMOS
Président sortant de la SCMO

This issue of the *CMOS Bulletin SCMO* will go to press shortly before the CMOS Congress gets under way in Montreal. We are looking forward to a busy and rewarding week at the combined CMOS/AMS Congress 2012, with an exciting scientific program, many interesting exhibits, excellent plenary and public talks and very enjoyable social events. The Local Arrangements Committee, chaired by Louis Lefaivre, and the Scientific Program Committee led by Pierre Gauthier and Bruce Telfeyan, along with a dedicated team of volunteers have been devoting many days and hours over the past two years to making the Congress an outstanding event.

The 2013 Congress in Saskatoon will once again be a joint Congress with the Canadian Geophysical Union and the Canadian Water Resources Association, marking another of the joint Conferences with the CGU that have become a tradition every third year following the highly successful examples in previous years. We are looking forward to having the CWRA as an additional partner for the 2013 Congress. Preparations for it are already well under way under the leadership of Craig Smith as Chair of the Local Arrangements Committee, Geoff Strong, Rod Blais and Bob Halliday as Co-Chairs of the Scientific Program Committee.

The Annual General Meeting at the CMOS Congress will mark the transition of the CMOS Exectutive to the Montreal Centre. I take the opportunity of writing this last column as President of CMOS to sincerely thank all of the outgoing Executive members for their dedicated service to CMOS. David Fissel will step down as Past President, having completed terms as Vice-president and President. Sophie Johannessen, Jane Eert and Rich Pawlowicz will end their three-year terms as Recording Secretary, Corresponding Secretary and Treasurer. Charles Lin will end his term as Councillor-at-Large. It has been a very rewarding privilege to work with them. I thank them especially for their help and advice over the past year that I have been President of CMOS.

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Cover page: Positions of OTN (magenta), Atlantic Salmon Federation (orange), Department of Fisheries and Oceans (blue), OTN Canada (yellow), Pacific Ocean Shelf Tracking (green) acoustic arrays in North America are shown on the cover page. White stars indicate ocean moorings owned by DFO and Université du Québec à Rimouski to which OTN attaches ocean monitoring equipment. To learn more, read OTN article written by N. Beauchamp and R. Dudley on **page 92.**

Page couverture: L'emplacement des réseaux acoustiques en Amérique du Nord figure sur la page couverture: OTN (magenta); Fédération du saumon Atlantique (orange); ministère des Pêches et des Océans (bleu); OTN canadien (jaune); Pacific Ocean Shelf Tracking (vert).Les croix blanches indiquent les appareils de surveillance des océans de l'OTN arrimés sur des mouillages appartenant au MPO et à l'Université du Québec à Rimouski. Pour en apprendre plus, lire l'article écrit par N. Beauchamp et R. Dudley en **page 92.**

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Executive / Exécutif

....from the Presidents' Desks (Continued / Suite)

I will have the privilege of welcoming Peter Bartello in his new role as the President of CMOS with the symbolic presentation of his Presidential medallion during the banquet at the CMOS Congress. He will bring with him the new members of the CMOS Executive who have been elected at the Annual General Meeting, continuing the CMOS tradition of three-year terms for CMOS Centres to host the Executive of the Society. I have valued highly Peter's help and advice over the past year in his role as Vice-president and I am looking forward to serving under his leadership for the next year in my role as Past-President of CMOS.

And now, over to you Peter....

Norman McFarlane
Outgoing CMOS President
Président sortant de la SCMO

Peter Bartello
Incoming CMOS President
Nouveau président de la SCMO

It is indeed a pleasure to be in a position to help advance the important initiatives begun by last year's executive under the leadership of Norman McFarlane and David Fissel before him, while continuing to lean heavily on the wise guidance provided by our executive director, Ian Rutherford. I would like to add my thanks to the members of the executive who are stepping down this year. I am sure we will find other ways for them to continue their strong contribution to the Society. I would also like to thank Norm for his year as President. He has been a friend and mentor for me for decades and last year was certainly no exception. I also welcome new members of the executive: André Giguère (Recording Secretary) , David Huard (Corresponding Secretary), Nacéra Chergui (Treasurer) and Pierre Gauthier (Vice-President), all from the Montréal area, as well as Tetjana Ross (councillor-at-large) from Dalhousie University. I look forward to working with them and those who will be continuing in their current roles.

As I write this in late April, I suppose I now feel the same way as many CMOS Vice-Presidents have before me. In the last year, I have realized that the perspective from my day job is an incomplete one. By getting involved with CMOS, I have been exposed to the full range of what our science does and the important role it plays in Canadian society. Our science includes, without exaggeration, almost all of modern science and its subject matter could not be of more practical importance to all of us living on earth. Unlike some previous CMOS Vice-Presidents, however, I feel a sense of gloom at this moment. The current federal ruling party does not hide that it thinks that government ought to be smaller, do less, and that Canadians should rethink how to finance activities government used to undertake. Without arguing the merits of this, it appears to be leading to considerable short-term damage to our community since government has traditionally played such a central role in leading it. If there is to be a radical reorganization of the way our science is carried out, there needs to be sufficient lead-time (and resources) to plan a smooth transition. This is particularly important on the research side if we are to retain the highly-qualified human resources built up over these last years of CFCAS funding.

The near future will very probably bring new challenges and may well require some important decisions, not only from the Society, but from many of its members individually. At the very top of the CMOS web site and in every issue of the *CMOS Bulletin SCMO* it says "**The Society exists for the advancement of meteorology and oceanography in Canada**". How can we best use our rather limited resources to accomplish this? As the new executive members roll up their sleeves, I would like to invite feedback from the membership on this important question.

Peter Bartello
Incoming CMOS President
Nouveau président de la SCMO

CMOS exists for the advancement of meteorology and oceanography in Canada.

Le but de la SCMO est de stimuler l'intérêt pour la météorologie et l'océanographie au Canada.

Comments on article by Richard Asselin "The climate of Ottawa: day by day" *CMOS Bulletin SCMO* Vol.40 No.2, April 2012, p. 54-62

by Madhav L Khandekar*

In his article "The Climate of Ottawa: day by day" *(CMOS Bulletin SCMO*, April 2012), Richard Asselin has brought out a number of interesting issues re: climate change in Ottawa and by extension elsewhere in Canada. Richard concludes that "*the averaged daily maximum temperature in Ottawa has increased by 1.09 °C in 120 years, while the minimum has increased by 2.13 °C during the same period!".* It is important to consider these temperature changes in Ottawa in relation to such temperature changes in other regions of Canada and also in various parts of the world.

It is now well-established that the mean temperature for Canada as a whole has increased in the last 100 years by about 0.8 °C or a bit higher; however, this increase is NOT uniform everywhere! In a comprehensive analysis of temperature and precipitation trends in Canada (*Xubin Zhang et al 'Atmosphere-Ocean' 2000)* the authors use temperature data over a period 1950-98 and show how 'daily maximum temperatures' have sharply increased in western Canada, especially during the winter months, while daily minimum temperatures have decreased significantly in the Canadian Atlantic Provinces and also in Northwest Atlantic. These authors further point out that that while the maximum temperature has increased by more than 3C in some regions of western Canada during 1950-98 period, it has cooled by more than 2 °C in parts of Canadian Atlantic Provinces. In another related study Barry Bonsal and his coworkers (*Bonsal et al 2001, Journal of Climate)* have analyzed the characteristics of daily extreme temperatures over Canada (for 82 stations in southern Canada, south of 60°N) and their findings can be summarized as:

- The minimum temperature has been steadily rising throughout the twentieth century (with evidence of inter-annual and inter-decadal variability), while the maximum temperature shows no evidence of a long-term trend in the latter half of the century.
- Some of the highest maximum temperatures were recorded during the 1930s and early 1940s, these years being associated with the "Dust Bowl" years on the American/Canadian Prairies.
- Canada as a whole is *"not getting hotter but less cold!".*

Asselin's analysis also brings out another interesting issue namely that '*the minimum temperature has increased by more than 1 °C over maximum temperature in Ottawa in 120 years'.* This is true of many other locations in Canada (and elsewhere as well) where the minimum temperature has increased more rapidly than maximum temperature and this is most certainly related to the urbanization and land-use change impact. In a landmark paper, Prof Pielke sr and his colleagues (Pielke et al 2002) have identified impact of urbanization and landscape dynamics on earth's climate system and in a more recent paper Mahmood et al (2010) demonstrate that *'LULCC (Land-Use and Land-Cover Changes) represent a first-order human climate forcing and its impact must be assessed in detail in all future climate change assessment'.* Pielke, Mahmood and coworkers have shown conclusively the importance of urbanization and land-use changes in the earth's climate system, something that is not adequately included in most climate models today.

The urban impact on mean temperature has been documented extensively in many other studies published in the last five years. In the latest paper (Ludecke et al 2011), the authors carefully analyze temperature trends at 2250 observing stations world-wide (stations chosen based on least number of missing observations) and document urban impact which they link to population density of towns (and cities) where observations are recorded. Among some of the important conclusions of this latest study are:

- For the period 1906-2005, a global warming of 0.58 °C was calculated and this warming is reduced to 0.41 °C if only stations with population less than 1000 people are used in the calculations;
- About a quarter of all records show a decrease in the mean temperature over the 100-year period;
- The temperature data document a strong UHI (Urban Heat Island) effect and increased warming with station elevation.

The above authors further conclude that most of the warming appears to be "natural" with AGW contribution (Anthropogenic Global Warming, OR warming due to human-added CO_2) as only marginal.

There are many other issues re: mean temperature trend and its possible linkage to human-added CO_2 or other forcings (like urban impact etc) that Asselin's analysis has brought out. It is important that similar analysis be done for several other locations in Canada, especially for large cities like Toronto, Montréal and Vancouver to determine the urban impact which seems to provide an important forcing for present as well as future climate change assessment.

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*Madhav Khandekar is a Retired Research Scientist from Environment Canada and was an Expert Reviewer for the IPCC (Intergovernmental Panel on Climate Change) 2007 Climate Change Documents.

ARTICLES

WMO annual statement confirms 2011 as 11th warmest on record

Résumé: D'après la Déclaration de l'OMM sur l'état du climat mondial en 2011, cette année se classe au onzième rang des plus chaudes depuis 1850, date des premiers relevés. Cela confirme les conclusions préliminaires selon lesquelles 2011 est la plus chaude qui ait été constatée dans le cas d'une année à Niña, phénomène qui induit un refroidissement. La température moyenne en 2011 présente une anomalie estimée à +0,40°C par rapport à la normale calculée pour la période 1961-1990, qui est de 14°C. Les extrêmes de précipitations, souvent liés à l'une des plus puissantes Niña des 60 dernières années, ont eu des répercussions considérables. Des inondations de grande ampleur se sont produites sur tous les continents, tandis que de graves sécheresses ont sévi en Afrique de l'Est et en Amérique du Nord. L'étendue de la banquise de l'Arctique a atteint des minima quasi records et l'activité cyclonique a été inférieure à la moyenne à l'échelle du globe, même si la saison des tornades est l'une des plus destructrices qu'aient connues les États-Unis d'Amérique.

Le compte rendu sur le climat en 2011 a été publié à l'occasion de la Journée météorologique mondiale, célébrée le 23 mars. L'OMM a aussi rendus publics les résultats préliminaires d'une évaluation du climat mondial pour la période 2001-2010, qui sera publiée sous peu. Il en ressort que le changement climatique s'est accéléré pendant cette décennie, la plus chaude jamais observée sur tous les continents du globe. Le rythme du réchauffement depuis 1971 est «remarquable», pour reprendre les termes de l'évaluation. Des phénomènes atmosphériques et océaniques comme La Niña ont refroidi temporairement le climat certaines années, sans interrompre pour autant la tendance générale au réchauffement. Le "recul spectaculaire et constant de la banquise de l'Arctique" est l'une des principales caractéristiques de l'évolution du climat pendant la décennie considérée, toujours selon cette évaluation. Moyennées à l'échelle du globe, les précipitations en 2011 se classent au deuxième rang des plus abondantes qui aient été enregistrées depuis 1901, et les inondations seraient le phénomène extrême le plus fréquent. Ce nouveau communiqué (# 943) confirme donc le communiqué de presse # 935 émis en novembre 2011 par l'OMM pour la conférence de Durban.

Geneva, 23 March 2012 (WMO) – The World Meteorological Organization's Annual Statement on the Status of the Global Climate said that 2011 was the 11th warmest since records began in 1850. It confirmed preliminary findings that 2011 was the warmest year on record with a La Niña, which has a cooling influence. Globally-averaged temperatures in 2011 were estimated to be 0.40° Centigrade above the 1961-1990 annual average of 14°C.

Precipitation extremes, many of them associated with one of the strongest La Niña events of the last 60 years, had major impacts on the world. Significant flooding occurred on all continents, whilst major droughts affected parts of east Africa and North America. Arctic sea ice extent fell to near record-low levels. Global tropical cyclone activity was below average, but the United States had one of its most destructive tornado seasons on record.

The annual statement for 2011 was released for World Meteorological Day 23 March. In addition, WMO also announced preliminary findings of the soon to be released Decadal Global Climate Summary, showing that climate change accelerated in 2001-2010, which was the warmest decade ever recorded in all continents of the globe.

The rate of increase since 1971 has been "*remarkable*" according to the preliminary assessment. Atmospheric and oceanic phenomena such as La Niña events had a temporary cooling influence in some years but did not halt the overriding warming trend.

The *"dramatic and continuing sea ice decline in the Arctic*" was one of the most prominent features of the changing state of the climate during the decade, according to the preliminary findings. Global average precipitation was the second highest since 1901 and flooding was reported as the most frequent extreme event, it said.

The full report will be released later in the year following further analysis of data received from National Meteorological and Hydrological Services and collaborating monitoring agencies. The decadal summary aims to increase understanding of our varying and changing climate from a longer-term perspective and complements WMO's annual reports.

"*This 2011 annual assessment confirms the findings of the previous WMO annual statements that climate change is happening now and is not some distant future threat. The world is warming because of human activities and this is resulting in far-reaching and potentially irreversible impacts on our Earth, atmosphere and oceans*," said WMO Secretary-General Michel Jarraud.

Temperatures

The decade 2001-2010 was the warmest since records began in 1850, with global land and sea surface temperatures estimated at 0.46°C above the long-term average (1961-1990) of 14.0°C. Nine of these years were among the ten warmest on record. The warmest year on record was 2010, closely followed by 2005, with a mean temperature estimated at 0.53°C above the long-term

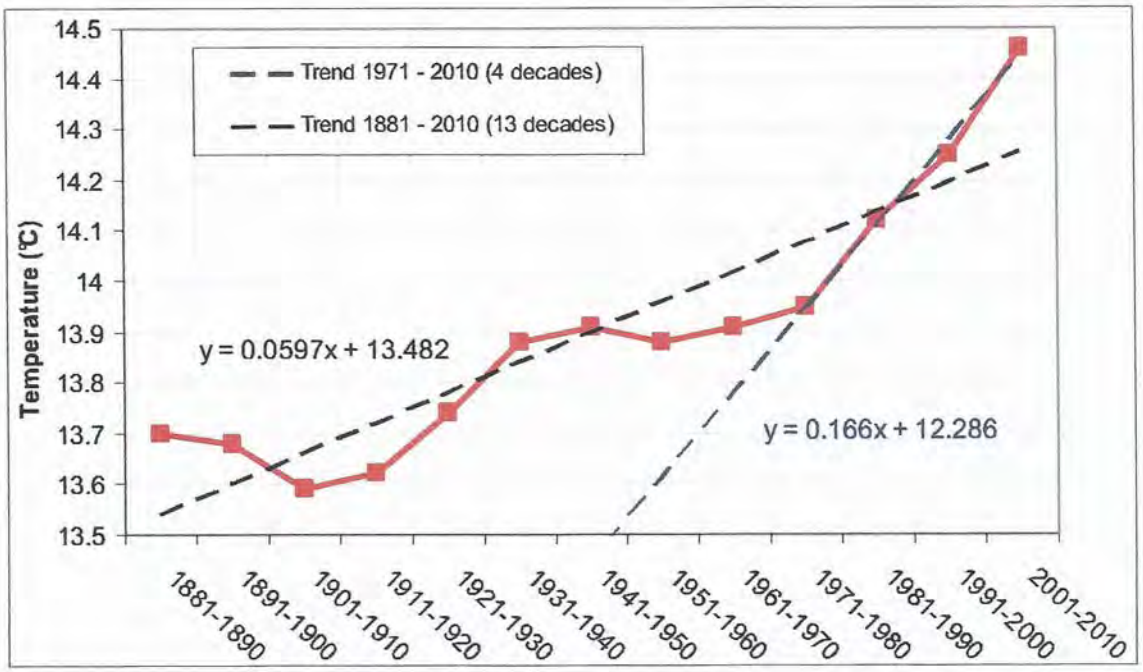

Figure 1:
Temperature trends

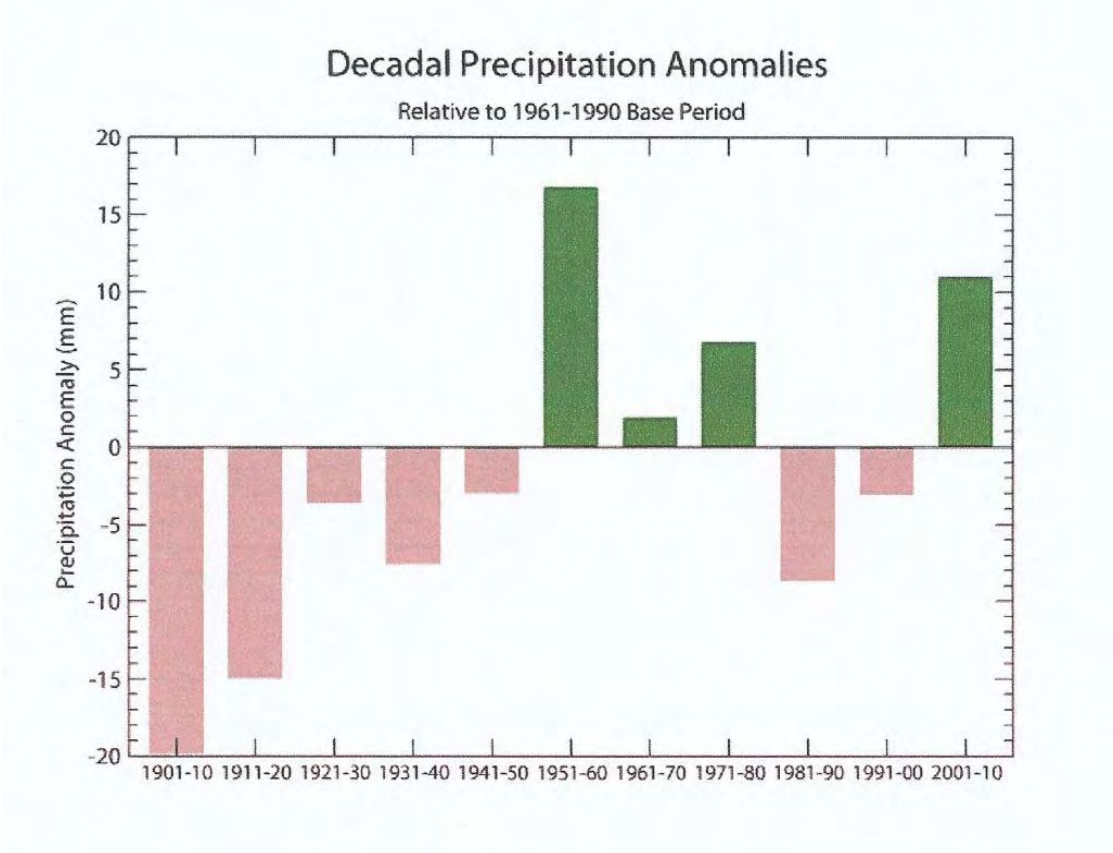

Figure 2: Decadal Precipitation Anomalies

The World Meteorological Organization is the United Nations System's authoritative voice on Weather, Climate and Water.

average. It was the warmest decade ever recorded for global land surface, sea surface and for every continent.

Most parts of Canada, Alaska, Greenland, Asia and northern Africa recorded temperatures for the decade between 1°C and 3°C above the 1961-1990 average.

Nearly 90% of the countries involved in the assessment experienced their warmest decade on record.

The global temperature increase rate has been "remarkable" during the previous four decades, according to the preliminary summary. The global temperature has increased since 1971 at an average estimated rate of 0.166°C per decade compared to the average rate of 0.06°C per decade computed over the full period 1881-2010. [See figure 1 on previous page].

Precipitation

Global precipitation (rain, snow etc) over land in 2001-2010 was the second highest average after 1951-60 since 1901. Within this global average, there were big regional and annual differences.

Large parts of the Northern Hemisphere recorded wetter-than-average conditions during the decade, especially the eastern United States of America, northern and eastern Canada, and many parts of Europe and central Asia. South America, including Colombia, parts of northern and southern Brazil, Uruguay and northeastern Argentina experienced wetter-than-average conditions, as did most parts of South Africa, Indonesia and northern Australia.

In contrast, other regions experienced, on average, below normal precipitation. The western United States, southwestern Canada, Alaska, most parts of southern and western Europe, most parts of southern Asia, central Africa, central South America, and eastern and southeastern Australia were the most affected. [See figure 2 on previous page].

Extreme Events

Numerous weather and climate extremes affected almost every part of the globe with flooding, droughts, cyclones, heat waves, and cold waves. Two exceptional heat waves hit Europe and Russia during summer 2003 and 2010 respectively with disastrous impacts and thousands of deaths and outbreaks of prolonged bush fires.

Flooding was the most reported extreme event during the decade with many parts of the world affected. Historical widespread and prolonged flooding affected Eastern Europe in 2001 and 2005, Africa in 2008, Asia (in particular Pakistan) in 2010 and India in 2005, and Australia in 2010.

A large number of countries reported extreme drought conditions, including Australia, eastern Africa, the Amazonia region and the western United States. Humanitarian consequences were significant in eastern Africa during the first half of the decade, with widespread shortage of food and loss of lives and livestock.

Forty-eight out of 102 countries (47 per cent) reported that their highest national maximum temperature was recorded in 2001-2010, compared to 20 per cent for 1991-2000 and around 10 per cent for the earlier decades.

The decade saw the highest level of tropical cyclone activity on record for the North Atlantic basin. In 2005 category 5 hurricane Katrina was the most costly hurricane to hit the United States, with a significant human toll of more than 1,800 deaths. In 2008, tropical cyclone Nargis was the worst natural disaster in Myanmar and the world's deadliest tropical cyclone during the decade, killing more than 70 000 people.

Sea Ice

The decline in the Arctic sea-ice, observed since the end of the 1960s, continued throughout 2001-2010. A historical low Arctic sea-ice extent at the melting period in September was recorded in 2007.

Arctic sea ice extent was again well below average in 2011. The seasonal minimum, reached on 9 September, was 4.33 million square kilometres (35% below the 1979-2000 average) according to the U.S. National Snow and Ice Data Center. This was the second-lowest seasonal minimum on record, 0.16 million square kilometres above the record low set in 2007. Sea ice volume was even further below average and was estimated at a new record low of 4200 cubic kilometres, surpassing the record of 4580 cubic kilometres set in 2010.

Satellites have shown the fluctuation in sea ice from year to year since 1972. According to scientific measurements, both the thickness and sea ice extent in the Arctic have shown a marked decline over the past 35 years. Data indicate, however, an even more dramatic reduction in Arctic sea ice cover in recent years. The last six years of the decade (2005 to 2010) recorded the lowest five September extents, with 2007 recording the record minimum extent with 4.28 million km^2, 39 % below the 1979-2000 reference period.

Note from the Editor: WMO Press Release # 943 released for the World Meteorological Day, March 23. This press release confirms WMO Press Release # 935 published in November 2011 for Durban Conference. – "*2011: World's 10th warmest year, warmest year with La Niña event, lowest Arctic sea ice volume*". This press release was also published in *CMOS Bulletin SCMO*, Vol.40, No.1, pp 7-11.

Source: WMO Website http://www.wmo.int visited March 27, 2012.

Initial operation and global development of the marine animal tagging and tracking network (Ocean Tracking Network)

by N. Beauchamp[1], R. Dudley[2]

Abstact: The Ocean Tracking Network is both a global technology infrastructure, and a science collaboration, focussed on acoustically tracking marine animals and detailing the environmental conditions they are encountering. Research work is documenting the movements and survival of target organisms, and examining how both are influenced by oceanographic conditions. The latter are monitored by oceanographic sensors deployed in association with acoustic equipment, through sensors on a fleet of underwater autonomous vehicles, and by obtaining data from national repositories. The OTN is providing unprecedented knowledge of the movement patterns and habitat use by marine species, and is an important tool to show how valuable marine species are responding to changing ocean conditions. Network investigators are also working with industry to develop the next generation of technologies for tracking animals.

Data from the OTN infrastructure is fed into a central warehouse at Dalhousie University for use by members of the global ocean research community. With support from Canarie, a data platform to manage and overlay independent data streams has been developed (POKM – Platform for Ocean Knowledge Management). POKM also serves as a repository for R script tracking data analysis programs, whose authors have made them available for use by network investigators. OTN Data policies balance the need to protect the intellectual property of individual investigators with the benefits that can accrue from what will become a comprehensive, large, open-access database on marine animal movements. The knowledge generated will enable researchers and social scientists to inform current ocean governance strategies so that they better protect and manage ocean resources.

Résumé: L'Ocean Tracking Network (Réseau de suivi des océans ou OTN) est à la fois une infrastructure technologique mondiale et une collaboration scientifique. Il met l'accent sur le suivi acoustique des animaux marins et sur la caractérisation des conditions environnementales dans lesquelles ceux-ci évoluent. Les travaux de recherche servent à documenter les déplacements et la survie des organismes ciblés, et à examiner comment les conditions océanographiques influent sur ces deux aspects. Ces conditions sont surveillées par des sondes océanographiques, déployées parallèlement à de l'équipement acoustique, à partir de capteurs posés sur une flotte de véhicule sous-marin autonome, ainsi que par l'analyse des données archivées dans des banques de données nationales. L'OTN fournit des connaissances inédites sur les déplacements des espèces marines et leur habitat. Il s'avère un outil de premier plan pour montrer la réaction des espèces marines utiles subissant des conditions océaniques changeantes. Les chercheurs du réseau travaillent aussi en collaboration avec l'industrie pour concevoir des techniques de prochaine génération applicables au suivi des animaux.

Les données issues de l'infrastructure de l'OTN alimentent un répertoire central situé à la Dalhousie University et sont mises à la disposition de la communauté internationale des spécialistes de l'océan. Une plateforme de données servant à gérer et à superposer des ensembles de données indépendantes (Plateforme de gestion des connaissances océaniques – POKM) a été mise sur pied grâce au soutien du CANARIE. La POKM sert aussi de service d'archives pour les programmes (en langage R) d'analyses de données de suivi, que leurs auteurs offrent aux chercheurs du réseau. Les politiques relatives aux données de l'OTN tiennent compte du besoin de protéger la propriété intellectuelle de chaque chercheur, et des avantages qui découlent d'une base de données complète, volumineuse et libre d'accès concernant les déplacements des animaux marins. Les connaissances ainsi générées permettront aux chercheurs et aux spécialistes des sciences sociales d'influer sur les stratégies actuelles de gouvernance des océans, de façon que celles-ci protègent les ressources océaniques et en permettent la gestion adéquate.

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Ocean Tracking Network: initial deployments and global network objectives

The Ocean Tracking Network (OTN) is a Canada Foundation for Innovation (CFI)-International Joint Ventures Fund global research and technology development initiative headquartered at Dalhousie University, Halifax, Nova Scotia. Starting in 2008, OTN began deploying Canadian state-of-the-art acoustic receivers and oceanographic monitoring equipment in key ocean locations. Acoustic tags are being used to document the movements and survival of marine animals and to examine how both are influenced by oceanographic conditions, which are monitored by benthic pods and a fleet of underwater autonomous vehicles.

The OTN infrastructure is unique in its ability to provide high priority knowledge and unprecedented research on local-to-global movements of animals to meet pressing environmental and ecological needs. OTN deployments will occur in all of the world's five oceans and span seven continents. This will include lines in Australia (Perth and Tasmania), South Africa, the Strait of Gibraltar, the United States (including mainland coasts, Alaska, Hawaii, and Puerto Rico), Canada (Pacific, Atlantic, and Arctic Oceans, and Great Lakes shared with the United States), Reunion Island (Indian Ocean, French territory), Norway, Chile, Brazil, and the Sudan.

Over 200 international researchers from 15 countries are currently participating in the OTN global network that tracks marine mammals, sea turtles, squid, and fishes including sharks, sturgeon, eels, tuna, salmon, and cod. OTN equipment can be positioned at fixed locations to provide long-term monitoring of animal movements and oceanographic parameters, yet can be rapidly and cost-effectively redeployed to meet changing data and research needs. OTN's present round of deployments was set by the international researchers involved in the original proposal for the facility and by a Canadian effort that established OTN Canada.

OTN Canada

OTN Canada, launched in January 2010, is a countrywide interdisciplinary network of science teams working within the OTN infrastructure to address key scientific questions of both national and international concern and relevance (Cooke et al. 2011). OTN Canada is focussed in three different arenas (Pacific, Arctic and Atlantic) to reach and respond to questions in vastly different ocean ecosystems across the country. OTN Canada strives to create knowledge about continental shelf ecosystems through cutting-edge research and to contribute to the global observation of coastal and ocean ecosystems. A primary objective is to support and train students and to foster synergy among Canadian participants, as well as potential international partners. Included for each arena are measurements of oceanographic characteristics and variability at various spatial and temporal scales, movements of key species at several trophic levels, and analysis of key "bioprobes" (animals that carry tags which record locations visited, ocean conditions and interactions with other tagged animals in the open ocean) and "roboprobes" (remotely controlled gliders) to complement measurements from fixed OTN receivers. Figure 1 shown in color on the cover page illustrates Canadian arrays in the three arenas. Ultimately, information obtained will be used to address socioeconomic and resource management issues and to inform policy. To accomplish this, OTN includes a strong contingent of social scientists in the network.

The Natural Sciences and Engineering Research Council of Canada (NSERC) supports OTN Canada through a $10M research network grant. The Social Sciences and Humanities Research Council of Canada (SSHRC) funds $327K for social sciences participation in OTN over five years. Principal funding comes from CFI in the amount of $35M. International partners are investing more than $100M in in-kind support.

Network themes

The OTN scientific community has established a series of research themes that have guided the research questions addressed and concomitantly the choice of the equipment used and the deployments that are in progress within the OTN infrastructure. The themes for OTN research are:

- Ocean physics and modeling;
- Biology and behaviour of migratory living marine resources;
- Trophic interactions;
- The impacts of climate variability on all of the above;
- The significance of the research results for ocean governance.

OTN Canada researchers meet in part or as a whole throughout each year to continually review progress, realign priorities, refocus existing research and establish new research directions. The OTN Global scientific community conducts a similar exercise on a biennial basis.

Data Warehousing and Knowledge Management

1) Status -The OTN is principally tasked with making the world's ocean tracking data and related information freely accessible to the broader science community, while respecting the intellectual property rights of its providers, as well as fostering and promoting the creation of new and innovative computing tools to synthesize, analyze and visualize the different types of data collected by OTN's global infrastructure. The OTN Data Centre (OTNDC) staff are developing and operating an open source, standards-based 'data warehouse system' for use by a multidisciplinary team of computer science, marine biology and oceanography researchers engaged in developing a state-of-the-art e-research Platform for Ocean Knowledge Management (POKM).

The OTNDC and POKM together are expected to provide marine scientists with the ability to:

- Collect, quality control, index and archive all data produced by the various instruments deployed by OTN sponsored and related projects around the world;

- Facilitate operational interaction between independent groups of deployment operators and trackers;

- Share, select, access, handle and integrate high volumes of multimodal ocean and marine life data stored at global data repositories;

- Design and execute customized experiments using a range of data and quantitative models;

- Analyze and visualize both raw data and model output.

The OTNDC adapted and used Pacific Ocean Shelf Tracking (POST) templates to initially collect data from OTN's Halifax, Cabot Strait and Perth Lines and from animal taggers releasing fish detected on these lines. As well, Ocean Biogeographic Information System (OBIS) formatted data from the Greenland Shark Elasmobranch Education and Research Group (GEERG) and Canadian Sea Turtle Network (CSTN) projects were prepared. As a result, OTN built up its basic data processing capacity for handling both acoustic telemetry and satellite-based tracking data at the same time as providing input for development of POKM. At the end of 2010, OTN's warehouse contained ~1.3 million records from 33 projects on 19 species. All data received were loaded into the data warehouse, more than quadrupling its size from the pre-2010 period.

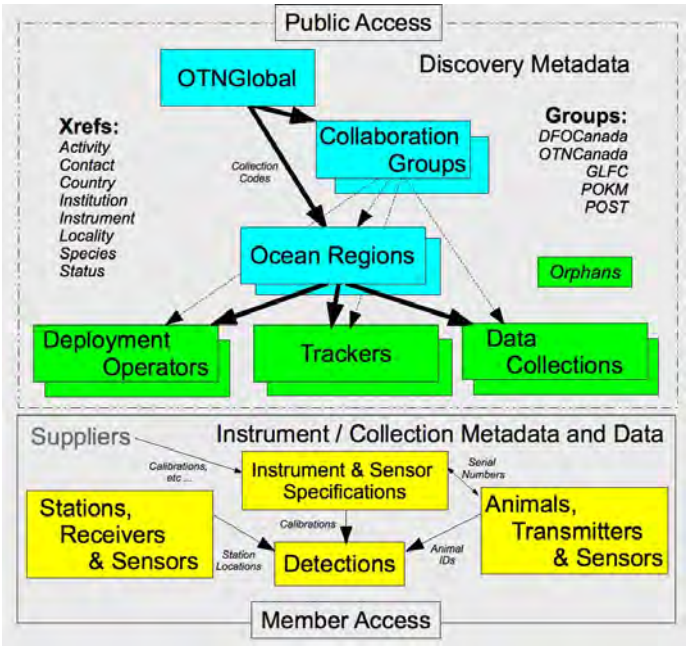

Figure 2. Scheme of the OTN data warehousing system (DFOCanada, Department of Fisheries and Oceans Canada; OTN Canada, Ocean Tracking Network Canada; GLFC, Great Lakes Fisheries Commission; POKM, Platform for Ocean Knowledge Management; POST, Pacific Ocean Shelf Tracking). Project descriptions are cross-referenced by terms indicated under "Xrefs".

The OTN data warehouse system (Figure 2) as of April 3, 2012, contains ~9.1 million records including manufactures' instrument specifications, mooring deployment metadata, animal and tag release metadata and detections data. Taken together these metadata and data provide researchers with a quantitative basis for modeling animal behaviour under a wide variety of circumstances. The metadata and data are organized into projects, access to which is controlled by a designated principal investigator. The OTN warehouse currently provides data management support for researchers in five countries and 77 projects working on 25 species. Detailed discovery metadata (project descriptions) are cross-referenced by several terms including: Collaboration Group, Collaboration Type, Collection Name, Contact Name, Country, Date Last Modified, Institution Name, Descriptive Keyword, Ocean Region, Species, Status and Record Count. The institution and contact metadata, for example, describe who is working on what/where while keywords provide details on types and models of instruments being used.

In February 2011, POKM a data management and analysis platform, was first demonstrated to OTN Canada researchers using a variety of ecosystem phenomena, including migration patterns of leatherback turtles and Atlantic sturgeon in the Northwest Atlantic. POKM was shown to effectively provide a unique knowledge management perspective to support scientific investigations by working with the semantic descriptions, enabling seamless handling of large volumes of data, visualization, data analysis, and design of experimental workflows. In June 2012, POKM will be launched via a hands-on workshop at OTN Canada's annual symposium. The workshop will focus on POKM's data fetching, visualization, analysis and collaboration services. Over time, it is anticipated that POKM will become the principal platform for accessing, analyzing and visualizing OTN data and for collaboration among OTN researchers through built-in secure web-sharing and e-publication services. Figure 3 shows an example of POKM's data visualization output.

2) Open Source Software and Associated Standards - The OTN data warehouse is a PostgreSQL relational database system where the schema has been derived from the internationally accepted Ocean Biogeographic Information System (OBIS) and Biodiversity Information Facility (GBIF) projects. OBIS and GBIF are in turn both based on the Darwin Core (DwC).

"*Darwin Core is a body of standards. It includes a glossary of terms (in other contexts these might be called properties, elements, fields, columns, attributes, or concepts) intended to facilitate the sharing of information about biological diversity by providing reference definitions, examples, and commentaries...*" - http://www.tdwg.org

The PostgreSQL database records are then spatially enabled using POSTGIS and published as product layers on the internet using GEOSERVER.

"*GeoServer is the reference implementation of the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Coverage Service (WCS) standards, as well as a high performance certified compliant Web Map Service (WMS). GeoServer forms a core component of the Geospatial Web…*" - http://geoserver.org

3) Available Products - Deployment product layers include: current status of moorings, lists of mystery tags (i.e. tags of unknown origin), and detailed instrument histories and basic detection results (i.e. no tag release details), whereas tracking product layers include: basic release information, release details and associated detections plus animal tracks by station and sub-array. Mooring status and basic release information both appear in OTN public discovery metadata reports and its GoogleEarth flyover. Access to the other research quality data layers, require researchers to join the OTN members' site and join project user groups. This site currently has 400 members.

Acoustic tag and receiver component of OTN

VEMCO acoustic tags and receivers (VR2Ws, VR3s, and VR4s) are the backbone of the OTN acoustic detection systems.

The tags come in a variety of sizes, with larger tags containing larger batteries, which extend the life of the tag. Each tag has a unique individual identification that is transmitted at preprogrammed intervals. The larger tags are also capable of incorporating additional sensors on board (e.g., temperature, depth).

However, the size of the animal to be tagged limits the size of the tag that can be used. The life spans of the smaller tags are measured in days, whereas the largest tags available can last for decades. Presently, acoustic tags small enough to tag marine animals in the 5-10 cm length range are available. This means that the movements of most marine species can be followed with the use of acoustic telemetry.

Acoustic receivers are typically deployed in fixed positions, most frequently in lines with individual receivers in the line spaced approximately 800m apart. This deployment picks up movements of animals along migration routes in the oceans. The time and date of the detections of any sonic tag are logged into the memory of the receiver unit, and retrieved at intervals by the OTN teams.

OTN was a driving force in the development of the VR4 receiver, which has significantly enhanced capacities over the VR2 receiver; it listens to two frequencies (as opposed to only one in the VR2), has enhanced battery capacity that permitted them to be deployed continuously for up to six years (as opposed to one for the VR2), and most importantly, can communicate remotely to upload any data collected via an acoustic modem. Remote communications means the receiver can stay at its position anchored in the water and upload data via a hydrophone.

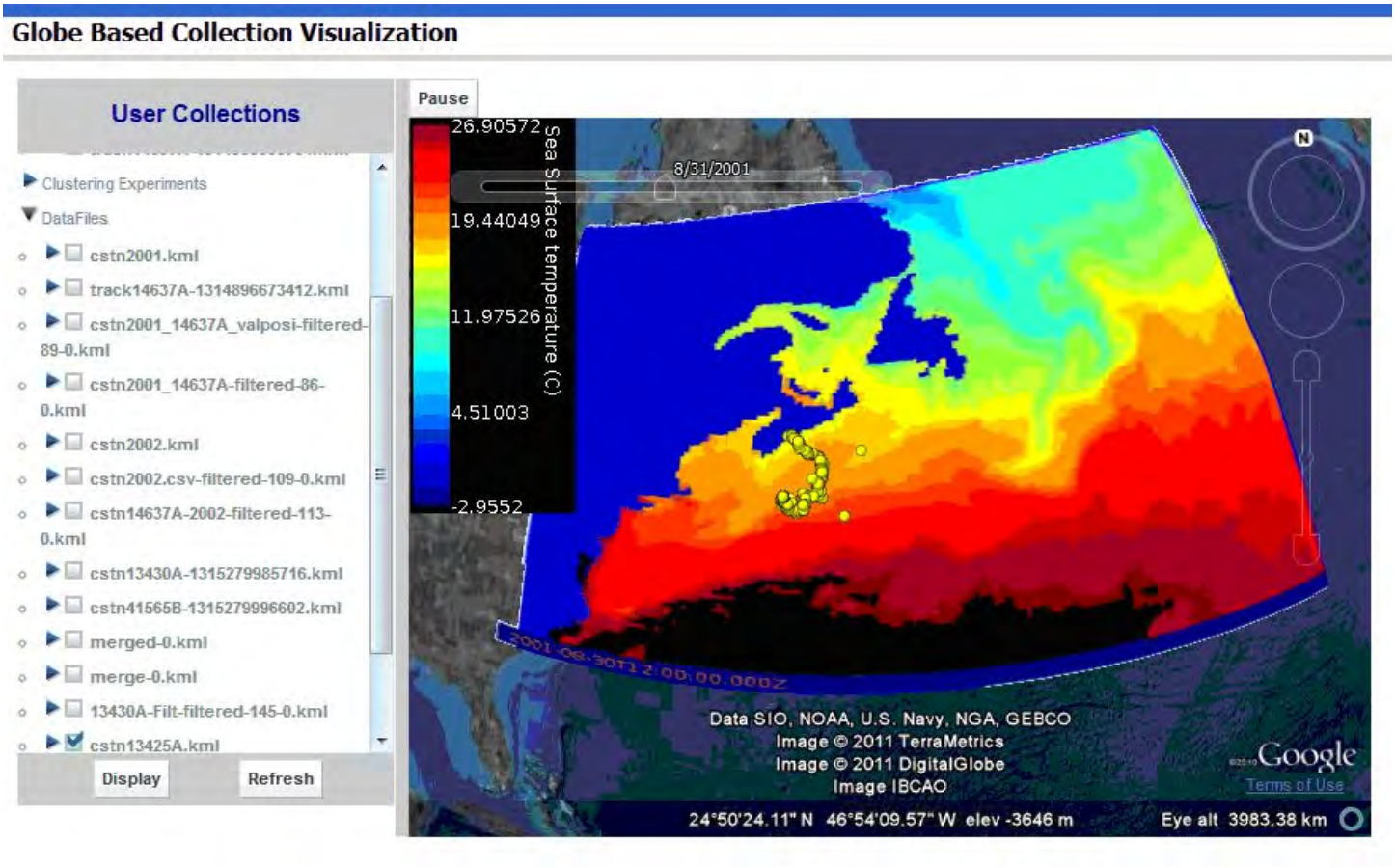

Figure 3. Example of data visualization output from POKM showing modeled sea surface temperature.

A larger number of lines over broader geographic areas give a finer resolution of the movements of the animals. OTN receiver deployments are strategic, and aim to provide capabilities that scientists need but which do not presently exist, and which also complement existing acoustic capabilities maintained by partners with the goal of building critical masses of receivers in regional ocean areas.

OTN has also helped beta-test other VEMCO products, one of which is the VEMCO Mobile Transceiver (VMT). VMTs are both tag and receiver, and can be carried on large animals as "bioprobes." The OTN Canada team is fitting grey seals with these tags to study interactions of seals with other tagged marine animals, to investigate predator-prey interactions, and to collect oceanographic data to inform and validate ocean models.

To retrieve data from the VMT, recapture of the animal is currently necessary. However, OTN is collaborating with VEMCO and other industrial partners to develop additional technical capacity that should translate into new products for Canadian manufacturers. In collaboration with the Scottish Marine Mammal Unit and OTN, VEMCO is pushing the development of the VMT to link it to satellite communication systems via Bluetooth. When this is done, data collected by a VMT will be transmitted in near real-time when the animal surfaces. This will allow the VMT to be used on other marine species and in other ecosystems, in which the animal cannot be reliably recaptured for tag retrieval and will also speed up data collection.

Glider component of OTN Canada

Slocum Gliders (figure 4) are unmanned maritime vehicles that continuously and precisely measure ocean parameters for researcher analysis and reaction. Developed by Teledyne Webb Research in Massachusetts, Slocum gliders function by changing their buoyancy and translating the resultant vertical displacement into horizontal movement via wings attached at 35 degree angles. Changes in buoyancy are caused by moving a small piston in the nose,

thereby changing the volume of the glider. The glider travels in a saw tooth pattern, rising at ~0.18 m/s and traveling horizontally at ~0.28 m/s.

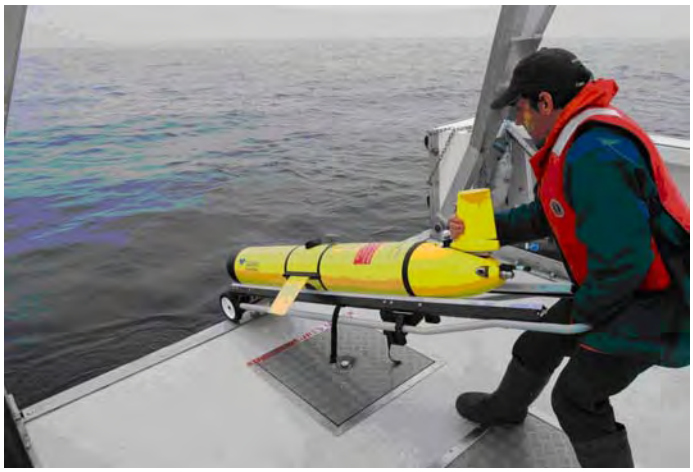

Figure 4: A research assistant deploys a Slocum glider in the Atlantic Arena.

The goal of the glider component of OTN Canada is to conduct interdisciplinary autonomous surveys of ocean ecosystems in order to provide context for measurements of animal movements. In order to do this, the glider group strives to deploy a glider on the Halifax line, a major OTN installation covering the continental shelf and designed to identify north-south movements of marine animals. Since May 2011, the OTN Canada gliders have logged 3,300 km on the Halifax line over 138 days.

Gliders are deployed on preprogrammed missions with mission parameters set by the researchers. Once at sea, the glider surfaces every six hours to obtain a GPS fix and to connect to a shore computer via Iridium Satellite Communications. Once connected, the glider uploads a small subset of data and steering instructions and looks to see if there are new mission files available. Before diving, the glider compares its current GPS location to its dead-reckoned location and adjusts its heading accordingly in order to proceed to the next programmed waypoint. The difference between the two locations is caused by currents pushing the glider out of its path. An estimate of depth-averaged currents can be obtained by using this information. An investigation comparing these currents with measurements from bottom-mounted Acoustic Doppler Current Profiler instruments along the Halifax line is currently underway by Dalhousie graduate students.

Figure 5 shows a typical track of a glider deployed by OTN Canada. The green arrows indicate the direction and strength of the depth-averaged currents. The Scotian Current, a regular feature off the coast of Nova Scotia (Loder et al. 2003) can be clearly seen in the current estimates as the glider progresses offshore.

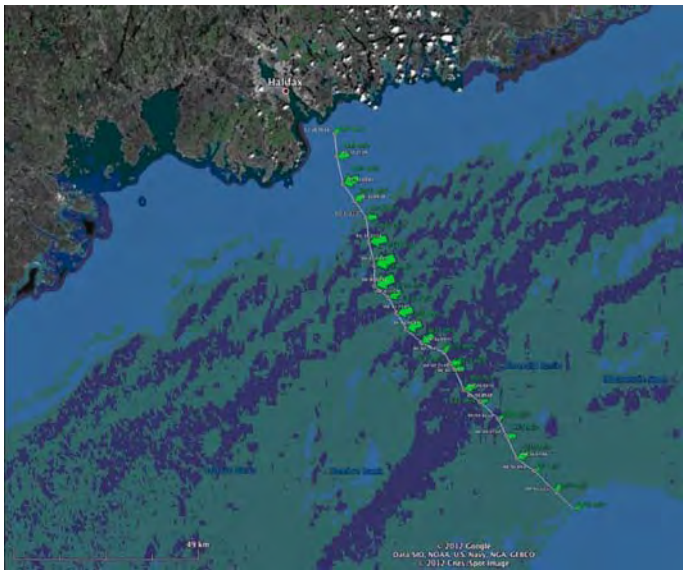

Figure 5. Track of a Slocum glider deployed March 30, 2012. Green arrows indicate the force of the southward moving Nova Scotia current, based on glider.

While data from the equipment is retrieved at preplanned intervals, OTN is actively working with industry collaborators to develop mechanisms to provide real-time and near-real-time retrieval capabilities. This will open up new research opportunities and could significantly alter present management capabilities for valued marine living resources. We are also experimenting with the development of ways of mounting acoustic receivers on the gliders in order to turn them into mobile receivers.

Glider modifications, payloads and sensors

OTN Canada gliders are equipped with a suite of sensors for measuring physical, geochemical and bio-optical parameters in the water column. The glider has a variety of on-board sensors. Its Sea-Bird CTD (Conductivity, Temperature, Depth) measures pressure, temperature, salinity, density and sound velocity among other parameters. Measurements of downwelling irradiance by a Satlantic OCR504 radiometer at four different wavelengths (412, 443, 490 and 555nm) provide not only absolute values of light intensity but also allow for estimating concentrations

of dissolved and particulate matter in the water column by inserting ratios of the wavebands into regionally-tuned algorithms. Two WET Labs triplet optical sensors measure fluorescence from chlorophyll and dissolved organic matter as well as backscattering of light at four wavelengths (470, 532, 650 and 880nm). By choosing the excitation and emission wavelengths properly, measuring fluorescence can give an estimate of a particular compound's concentration that is relatively free of contamination from compounds that are not of interest. Fluorescence is not a direct measure of concentration of either chlorophyll or dissolved organic matter, the former due to physiological and ecological variability of the chlorophyll containing phytoplankton and the latter due to the unresolved nature of the various organic compounds in the water column.

Finally, oxygen concentrations are measured using an Aanderaa optode that uses fluorescence changes in a small piece of oxygen-sensitive foil to estimate oxygen concentration. These optodes are relatively stable compared to membrane-based sensors, but suffer from slow response times.

Figure 6 and 7 respectively, show temperature and chlorophyll fluorescence transects as the glider moved back towards shore, offshore from Halifax, during a deployment in August 2011. Chlorophyll fluorescence is a qualitative estimate of absolute units using a conversion factor supplied by the manufacturer. The temperature transect shows a temperature inversion in Emerald Basin and at the shelf break that is commonly found off Halifax (Loder et al. 2003). Chlorophyll estimates are low and subsurface, consistent both with ecological and physiological expectations at this time of year (Cullen 1982).

The OTN Canada glider group has implemented a water-sampling program to calibrate and validate measurements made by the glider. Each time a glider is deployed or recovered, vertical profiles of temperature, salinity, chlorophyll fluorescence and downwelling irradiance are taken. At the same time water is collected from 2-4 depths for further detailed analysis back in the lab. To expand water sampling opportunities, personnel accompany DFO in bi-monthly sampling trips to Station 2 of the acoustic Halifax Line.

Additional technology used by OTN

Lotek Wireless Inc. is a Canadian firm that has developed sophisticated geolocation tags. These have light sensors that record day length, from which approximations may be gained of the latitude and longitude of an animal. Some models of tags can carry additional sensors (e.g., depth, water temperature) that can provide valuable information about the positioning of an animal in the ocean. OTN has collaborated with Lotek to develop the smallest geolocation archival tag available anywhere. It is presently being tested with its first full field deployment on an OTN Canada program tagging Atlantic salmon by researchers at Memorial University. Geolocation tags are archival, which means all observations are logged into memory within the tag, which requires that investigators retrieve their tags to get their data. OTN has been collaborating with Lotek Wireless to develop a new, miniaturized model of a geolocation tag that will fit on smaller marine animals than have been tagged before. Field trials of the first version of this tag are presently underway.

Liquid Robotics, a U.S. based company, manufactures an autonomous vehicle called the Wave Glider that can harvest VR4 data. It is positioned over a VR4 receiver and uses the acoustic modem system to collect any data the receiver has collected. Wave Gliders are less costly than using ships, may be capable of providing near real-time data and will be much safer for data collection, especially on lines that extend more than 100 km.

Romor is a small Halifax firm that designs and manufactures flotation systems in addition to providing maintenance services for marine equipment. OTN assists Romor with the design and testing of their flotation products. Romor services OTN's marine equipment.

Kintama, based on Vancouver Island, British Columbia, provides OTN with array design services and flotation equipment

Satlantic benthic pods are instrument packages developed by Satlantic to be moored along lines of receivers, or at other locations, to log oceanographic measurements (such as temperature, salinity, depth, oxygen and conductivity). These data, along with those of the gliders, support modeling efforts of ocean conditions. Each benthic pod consists of Satlantic STOR-X (and connected Satlantic 15V, 102ah Alkaline battery pack) programmed to request sampling from the three connected sensors. A Paroscientific Inc. Digiquartz Pressure Instrument is housed inside the STOR-X, a AADI Oxygen Optode (model 3830 and rest model 4330 also measures temperature) is connected to the top of the STOR-X, and a Sea-Bird SBE 37-SIP Microcat, a high-accuracy conductivity and temperature sensor is connected by cable to the STOR-X. OTN uses benthic pods designed with maximum depth range of 330m.

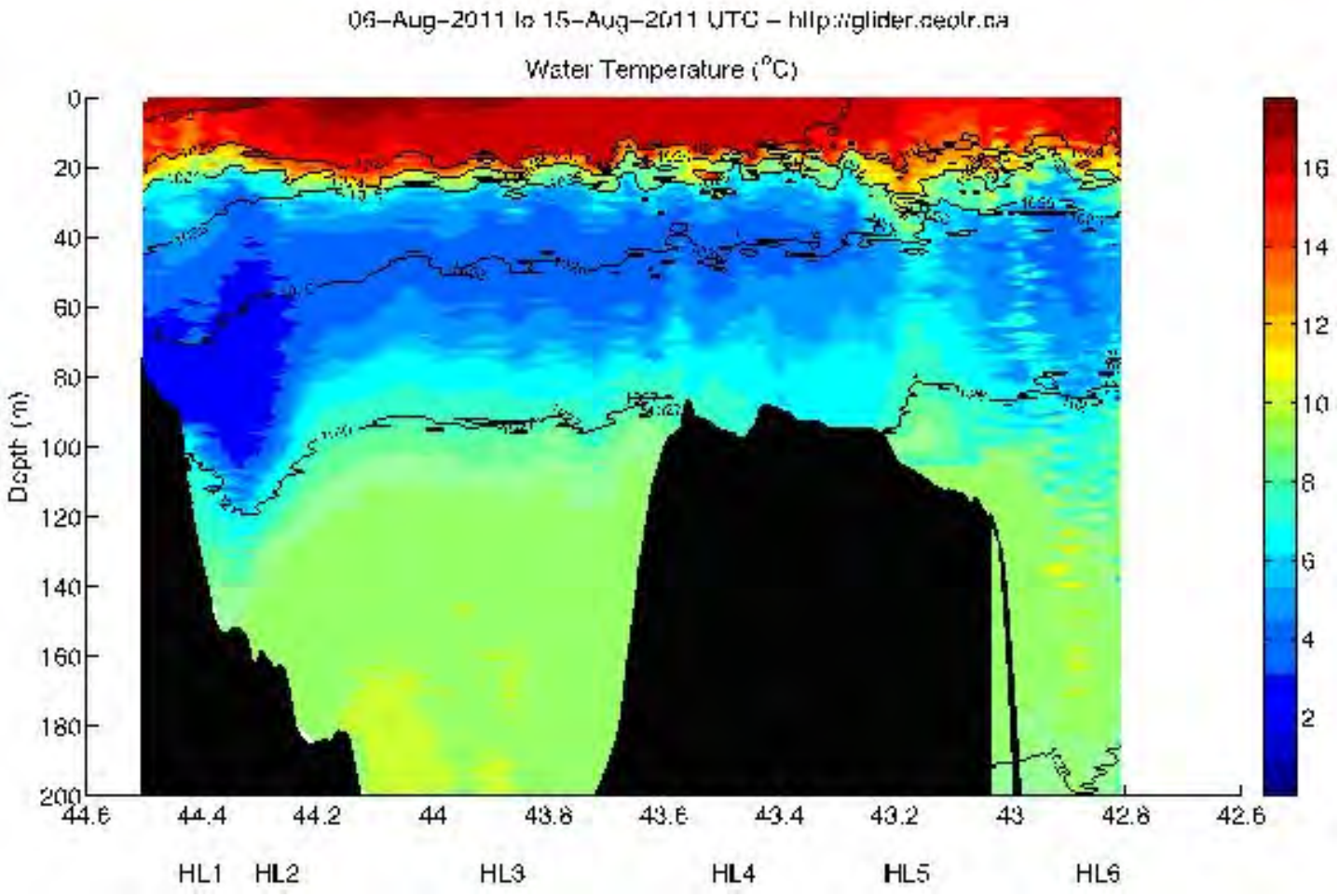

Figure 6. Transect of temperature along the Halifax Line in August 2011 as measured by an underwater glider.

OTN researchers also use satellite archival tags from various manufacturers, including Lotek Wireless, to track large fish such as Bluefin tuna and sturgeon. These tags store their readings in memory contained within the tags. They are slightly positively buoyant, and will float when released from an animal, hence the nickname "pop-up tags." This will occur automatically if the animal dies, or can be programmed for a predetermined date by investigators at the time the tag is placed on an animal. When it reaches the surface, the tag broadcasts a summary of the data that it contains to a satellite, which relays the information to the investigators. The raw data files remain on board the tag, and should it be retrieved, also become available for analysis.

Social sciences and OTN

Saving threatened and endangered marine species in light of increasing human pressures, resource demands and climate change impacts is likely to become one of the major challenges of the century. The knowledge generated by OTN scientists could play a key role in devising strategies for endangered species protection and restoration. OTN has developed a strong global partnership combining natural and social sciences to exponentially raise societal and political understanding of the risks facing key marine species at risk. Research into both national and international interdisciplinary comparisons of how adequately marine species at risk are being protected, with a focus on the roles of science, socio-economics, ethics, and political factors in designating species for legal protection, granting incidental take permits, identifying critical habitats, and developing recovery plans is evaluating the existing fragmented array of international species protection agreements and arrangements.

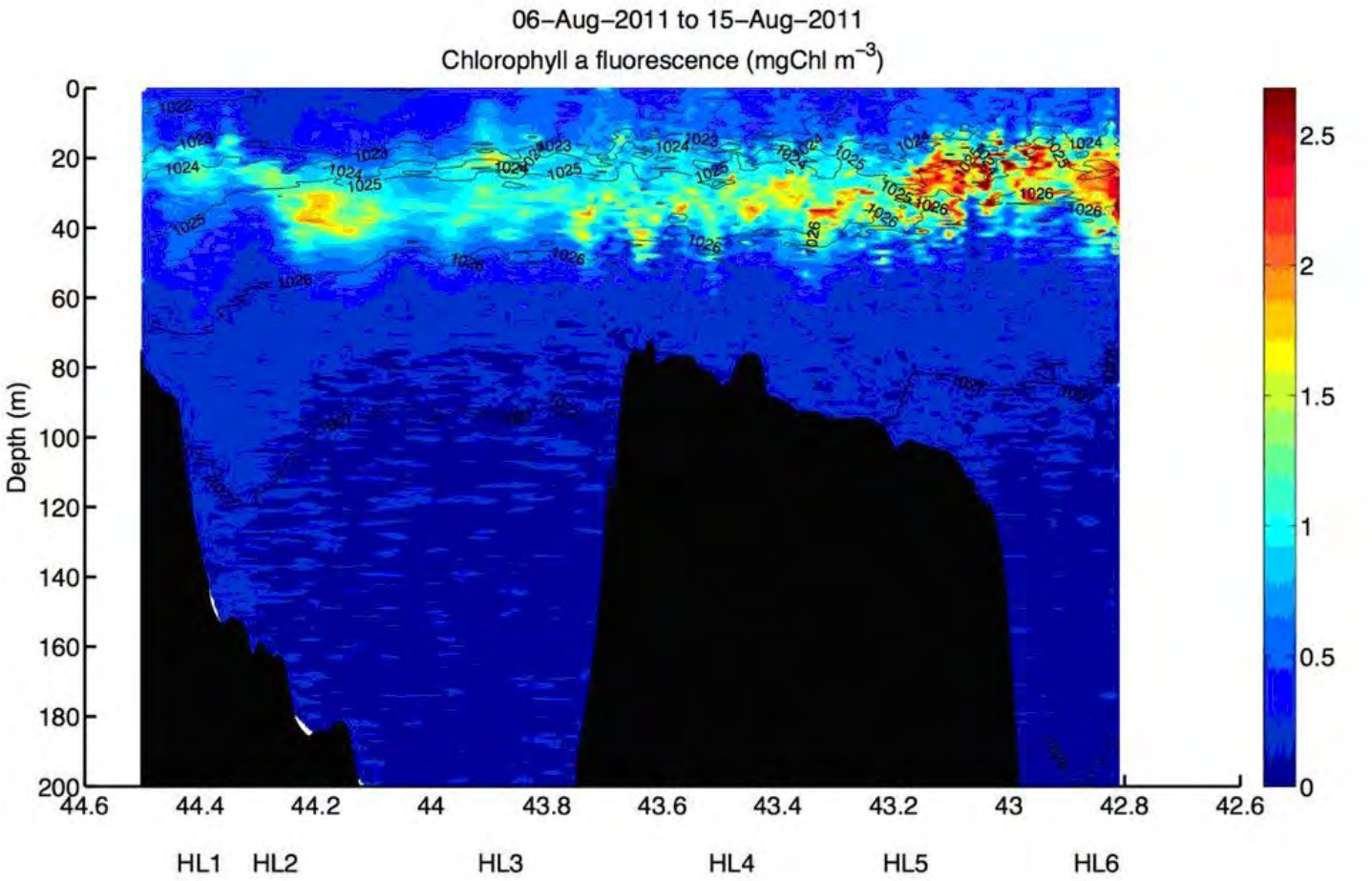

Figure 7. Transect of chlorophyll concentration estimated using fluorescence along the Halifax Line in August 2011 as measured by an underwater glider.

Researchers from throughout Canada will cooperate in gauging whether existing governance arrangements are adequate to protect key marine species, and if not, to suggest governance improvements.

Social integration of the OTN knowledge bank

OTN is creating knowledge that will have a transformative effect on ocean governance. While OTN and similar projects have clear data policies, they are mostly driven by an academic point of view. What is required is research into knowledge governance and knowledge use to investigate the various ways that OTN knowledge moves through society as well as how it is applied by particular stakeholder groups. To better understand these challenges and their outcomes, social scientists working with the network are looking at two interrelated processes. First, they are investigating processes of knowledge transfer, mobilization, and implementation (KTMI) by user groups involved with OTN activities. While KTMI has long been an identified goal of scientific research, it remains a poorly understood process, particularly when multiple stakeholder groups are involved. Much of the current literature still assumes that what goes on inside the realm of formal science is procedurally distinct from what goes on outside – scientists

generate knowledge that is then picked up by other actors as it enters the public domain. Instead, this work is investigating KTMI as an iterative or multi-directional process that involves multiple actors both inside and outside of formal science. Second, it is also investigating mechanisms for knowledge governance in the free information environment created by OTN's research and mandate.

Comparing national approaches and challenges in marine species at risk

1) Canada-Australia Comparison - Special emphasis is being given to comparing Canadian and Australian approaches and challenges in protecting marine species at risk. Building on the existing Australian-Canadian Ocean Research Network (ACORN), formed in 1993 to foster Canadian and Australian ocean law and policy research, researchers are collaborating in writing a specific volume of case studies with the twin goals of understanding the science/society nexus, and identifying "best practice" lessons.

2) Canada-U.S. Comparison - Since OTN acoustic receiver lines are in place or planned for both the Pacific and Atlantic Arenas and because Canada and the United States share many marine species of concern (marine mammals and fish stocks such as salmon) this research sub-component brings together scientists from both Canada and the United States to investigate trans-boundary scientific and management issues. Atlantic and Pacific case studies are being developed.

3) Canada-Other Country Comparison - Teams of natural and social scientists from a broader range of countries will undertake comparative studies of how effectively marine species at risk are being tracked and protected.

Summary and invitation

OTN's initial studies have yielded unprecedented knowledge of marine animal movement, migration and interaction. As a research infrastructure, OTN supports the scientific community in the pursuit of their research projects and programs. OTN activities are consequently driven by the needs of this community. Deployments that are underway and requests for future expansion of our capacity have been and will be guided by input from this community. OTN strategic planning must remain open and receptive to this need.

Acknowledgements

The OTN infrastructure has seen phenomenal growth since its inception. Employing a number of industrial and global partners for unprecedented data collection has allowed a much stronger backing knowledge to influence environmental protection policies. OTN Canada acknowledges the generous support of NSERC, CFI and SSHRC as well as the interest and participation from members of the scientific communities, in-kind donations and grant awards from the many other national and international partners and collaborators.

List of Contributors

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Internet Links

OTN Canada: http://otncanada.org/
OTN Global: http://oceantrackingnetwork.org/
NSERC: http://www.nserc-crsng.gc.ca/index_eng.asp
CFI: http://www.innovation.ca/
SSHRC: http://www.sshrc-crsh.gc.ca/Default.aspx

OTN related links
http://oceantrackingnetwork.org/links/index.html

Five Weather Observations

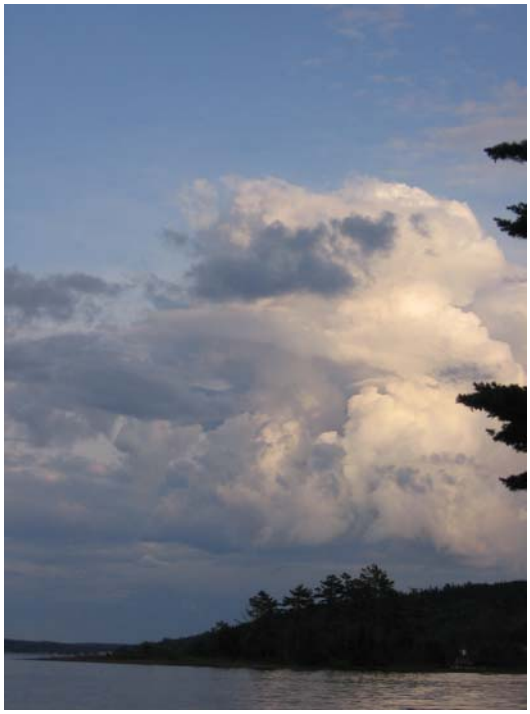

Photo credit: Robert Dawson

1100 Dry leaves whirl in air:
look, the baby gust of wind
playing tornado!

1400 Cumulonimbus,
proud cauliflowers of Babel
build toward heaven.

1500 Rumours of rain… ah!
The leaves are shivering
with anticipation.

1537 Flash (jagged silver
needle stitches sky to earth)…
one… two… three… four **BANG!**

2200 The night wind, so tired,
sinking down the mountainside
under its own weight.

Robert Dawson
Halifax, Nova Scotia

CLIMATE CHANGE / CHANGEMENT CLIMATIQUE

ECHOES from MONTRÉAL IPY CONFERENCE / ÉCHOS de la CONFÉRENCE de MONTRÉAL sur l'API

"RESEARCH REALLY MATTERS!"

Dr. Gro Harlem Brundtland, Member of the UN Secretary-General's High Level Panel on Global Sustainability since its launch in August 2010 and former Prime Minister of Norway on Opening keynote address, Monday 23, 2012 at the IPY Montréal Conference.

Poll result: Majority Support Teaching More Arctic Content in Schools
&
Dr. Louis Fortier awarded $50K prize for Lifetime Achievement at International Polar Year Conference

Toronto, ON & Montréal, QC – April 25, 2012 – Against the backdrop of a new survey that reveals an overwhelming majority (94 percent) of Canadians agree that students should learn more about Canada's arctic resources and the role of northern science, The W. Garfield Weston Foundation has announced that Dr. Louis Fortier has been awarded the $50,000 Weston Family Prize for Lifetime Achievement in Northern Research for his work focussed on the impacts of climate change on the Arctic. The results of the survey, commissioned by The Churchill Northern Studies Centre with the support of the Foundation, along with the prize winner were announced today at the International Polar Year Conference in Montréal.

"*Dr. Fortier embodies what a lifetime of research can achieve*," says Michael Goodyear, Executive Director, Churchill Northern Studies Centre. "*By actively engaging northerners in the early planning stages of ArcticNet and through his dedication to the multidisciplinary use of the Canadian Research Icebreaker Amundsen, Dr. Fortier has helped ensure that arctic science not only remains top of mind for Canadians, but also serves the people of the North*".

Canadians also support the ongoing work of researchers in the North. The poll shows that 80 per cent of Canadians agree that "***northern research can help make informed decisions about the potential impacts of developmental progress in the North***".

"*My work reflects the ongoing collaboration and open dialogue on key arctic issues with colleagues around the world, Inuit partners, the private sector, and policy-makers in several Federal departments. Together we have been able to explore, document, and synthesize the impacts of climate change and modernization on all aspects of the Arctic world, including the human dimension*," said Dr. Louis Fortier, who is the Canada Research Chair on the Response of Arctic Marine Ecosystems to Climate Change and a Professor at Université Laval since 1989. "*The Weston Family Prize truly reflects a lifetime of national and international networking in many disciplines, and I'm thrilled to receive this honour*".

Photo caption: Dr. Louis Fortier (centre) accepts The Weston Family Prize for Lifetime Achievement in Northern Research from Christian Bauta, Director, The W. Garfield Weston Foundation (far right) and Michael Goodyear, Executive Director, Churchill Northern Studies Centre (far left), at the 2012 International Polar Year Conference in Montréal.

Northern Researchers Important to Canadians

The survey also reveals that Canadians are keen to provide a refuge for northern species: nine out of 10 respondents support wildlife reserves for northern animals and plant species.

"*Canadians overwhelmingly tell us that northern research is critical to appreciating the importance of the Arctic. Knowledge and discovery about the north should be a fundamental part of our Canadian identity*," said Christian Bauta, member of the Northern Committee and a director of The W. Garfield Weston Foundation. "*One of the primary goals of the Foundation is to advance the natural sciences in Canada's North, which could not be accomplished without the achievements of researchers like Dr. Fortier*".

Wildlife Remains a Priority
Asked how they would like to spend a day as a northern researcher, Canadians prefer to spend time with animals: one third (35 percent) say they would like to observe marine life such as whales and seals, while another third (31 percent) say they would follow the polar bears. The final third was almost split evenly between gathering samples of unique plant life (15 percent) and following the migration of northern birds (13 percent).

Recognizing Arctic Research
The Weston Family Prize for Lifetime Achievement in Northern Research was created to honour leading northern researchers who have increased our understanding of Canada's northern environment, and significantly contributed to better understanding of the physical and biological environments, ecosystems, demographics of the North, and the effects of climate change. This annual prize, administered by the Association of Canadian Universities for Northern Studies (ACUNS), is adjudicated by a committee of northern scholars, chaired by the President of ACUNS.

Since 2007, The W. Garfield Weston Foundation has worked with ACUNS to offer awards to Masters and PhD students who demonstrate academic excellence and leadership in northern science research. To-date, the Foundation has granted over $2.5 million in support of northern science and research scholarship, with much of the research taking place at stations such as the CNSC.

About the Survey
The survey results are based on a telephone survey conducted by Research House with a nationally representative random sample of 1,000 adults 18 years or older between February 21 - 24, 2012. A sample of this size produces a margin of sampling error plus or minus 3.10 percentage points, 19 times out of 20.

The W. Garfield Weston Foundation
The W. Garfield Weston Foundation is a private Canadian family foundation, established in the 1950s by Willard Garfield Weston and his wife Reta. For three generations, The W. Garfield Weston Foundation has maintained a family tradition of supporting charitable organizations across Canada. Today the Foundation directs the majority of its funds to projects in the fields of land conservation, education and science in Canada's North.

About Churchill Northern Studies Centre
Founded in 1976, the Churchill Northern Studies Centre is an independent, non-profit research and education facility located 23 km east of the town of Churchill, Manitoba. In addition to research, the Centre facilitates a wide range of educational programming ranging from general interest courses for the visiting public to university credit courses for students.

About ACUNS
For over thirty years the Association of Canadian Universities for Northern Studies (ACUNS) has successfully promoted the advancement of northern scholarship through its mandate and programs. Established in 1978, ACUNS is a registered charitable organization operating with an office in Ottawa, and active volunteer representatives at over 40 member institutions across the country.

New $1 Million Arctic Inspiration Prize Launched

MONTREAL, April 23, 2012 /CNW Telbec/ – The new $1 million CAD Arctic Inspiration Prize was launched today at the International Polar Year 2012 conference. The Prize will be awarded annually to recognize and promote the extraordinary contribution made by teams in the gathering of Arctic knowledge and their plans to implement this knowledge into real world applications for the benefit of the Canadian Arctic, its Peoples and, therefore, Canada as a whole.

The Arctic Inspiration Prize is made possible through the generous endowment of the S. and A. Inspiration Foundation, the commitment of the ArcticNet Network of Centres of Excellence to voluntarily manage the Prize, as well as the contribution of numerous volunteers and partners.

"*The motivation for the Arctic Inspiration Prize is derived from our wish as immigrants to contribute to the future of our adopted country of choice with a focus on the Canadian Arctic and the major challenges to its rapidly changing environment, culture, technology and economy. It is our dream and hope, that in addition to our contribution, other individuals and organizations from north and south will contribute and help make the Arctic Inspiration Prize a long lasting success*" said Arnold Witzig, Director of the S. and A. Inspiration Foundation.

The Prize recognizes and encourages teamwork and collaboration among diverse groups and organizations in addressing the causes rather than the symptoms of issues of importance to the Canadian Arctic and its Peoples.

"*ArcticNet is proud and honoured to manage the Arctic Inspiration Prize. The Prize is clearly aligned with our Network's vision of a future where knowledge exchange, monitoring, modeling and capacity building will have enabled scientists, Northerners and decision makers to jointly attenuate the negative impacts and maximize the positive outcomes of the transformation of the Canadian Arctic*" said Martin Fortier, ArcticNet's Executive Director.

A Selection Committee composed of distinguished individuals known for their commitment to the Canadian Arctic and its inhabitants will select from one to five Prize winners annually, with associated awards totalling $1 million. Current members of the Selection Committee include Inuit Nobel Peace Prize nominee Sheila Watt-Cloutier, Inuit Juno award winner Susan Aglugark, CBC's Chief correspondent Peter Mansbridge, Rhodes scholar and founder of Dechinta, Erin Freeland Ballantyne and Queens University professor and Chair of the International Polar Year 2012 Conference, Peter Harrison.

Teams may not apply directly for the Prize but need to be nominated. Nomination Forms will be available on the Arctic Inspiration Prize website on 31 May 2012.

The first Arctic Inspiration Prize Awards Ceremony will be held in conjunction with the ArcticNet Annual Scientific Meeting on the evening of Wednesday 12 December in Vancouver B.C.

Additional information:
The S. and A. Inspiration Foundation was founded by Ms. Sima Sharifi and Mr. Arnold Witzig in 2008 as a not-for-profit corporation, located in Vancouver, B.C. The Foundation has been active in charitable endeavours in the fields of education and gender equality throughout the developing world. In 2011, they decided to focus the activities of their foundation in Canada, their homeland of choice.

ArcticNet is a Network of Centres of Excellence of Canada that brings together scientists and managers in the natural, human health and social sciences with their partners from Inuit organizations, northern communities, federal and provincial agencies and the private sector to study the impacts of climate change and modernisation in the Canadian Arctic. Over 150 ArcticNet researchers and 700 graduate students, postdoctoral fellows, research associates and technicians from 30 Canadian universities and 20 federal and provincial departments and agencies collaborate on 36 research projects with more than 100 partner organizations from 15 countries.

For further information, please contact Martin Fortier, Executive Director, Arctic Inspiration Prize, martin.fortier@arcticnet.ulaval.ca

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More than 2,000 Scientists Worldwide Urge Protection of Central Arctic Ocean Fisheries

MONTREAL, April 22, 2012 /PRNewswire via COMTEX/ -- More than 2,000 scientists from 67 countries urged Arctic leaders, in an open letter released today by the Pew Environment Group, to develop an international fisheries accord that would protect the unregulated waters of the Central Arctic Ocean. New maps show that the loss of permanent sea ice has opened up as much as 40 percent of this pristine region during recent summers, making industrial fishing viable for the first time.

"*Scientists recognize the crucial need for an international agreement that will prohibit the start of commercial fishing until research-based management measures can be put in place*", said Henry Huntington, the Pew Environment Group's Arctic science director. "*There's no margin for error in a region where the melting sea ice is rapidly changing the marine ecosystem*".

More than 60 percent of the scientists who signed the letter, released on the first day of the International Polar Year 2012 science conference in Montreal, are from one of the five Arctic coastal countries--Canada, the United States, Russia, Norway and Greenland/Denmark.

The scientists recommend that Arctic countries work together to protect the Central Arctic Ocean, an area as big as the Mediterranean Sea, by:

- Taking the lead in developing a precautionary international fisheries management accord;
- Starting with a catch level of zero until sufficient research can assess the impacts of fisheries on the central Arctic ecosystem;
- Setting up a robust management, monitoring and enforcement system before commercial fishing begins.

The United States adopted a precautionary approach by closing its Arctic waters to commercial fishing in 2009 to allow scientists to assess the evolving environment. Canada is drafting its own fisheries policy for the adjoining Beaufort Sea.

Although industrial fishing has not yet occurred in the northernmost part of the Arctic, its newly opened waters are closer to Asian ports than Antarctica's waters are. Large bottom trawlers regularly catch krill and toothfish in the Southern Ocean, placing stress on populations of these fish. The lack of regulation in the Arctic region could make it an appealing target for similar activities.

"*Atlantic Canada has experienced the damage that unregulated fishing can cause, even when it is outside the 200-mile limit,*" said Trevor Taylor, policy director for Oceans North Canada, a collaboration of the Pew Environment Group and Ducks Unlimited Canada, and a former fisherman and fisheries minister for Newfoundland and Labrador. "*Canada should take the lead in helping craft an international accord to prevent the start of industrial fishing. This will protect the environment and strengthen Canadian sovereignty in the Arctic*".

Pew's campaign is working with Arctic countries, scientists, the fishing industry and indigenous peoples to achieve expanded support for an agreement that will protect the international waters of the Central Arctic Ocean and its living marine resources from premature, unregulated or unsustainable commercial fishing.

The Pew Environment Group is the conservation arm of The Pew Charitable Trusts, a nongovernmental organization that works globally to establish pragmatic, science-based policies that protect our oceans, preserve our wildlands, and promote clean energy. For more information, visit www.PewEnvironment.org or www.OceansNorth.org/International

CMOS BUSINESS / AFFAIRES DE LA SCMO

Next CMOS Congress

The first annual joint conference between CMOS, CGU and CWRA 2013

The 47th annual congress of the Canadian Meteorological and Oceanographic Society (CMOS) will take place from May 26 to 30, 2013 in Saskatoon (Saskatchewan). This congress is organized jointly with the 39th Annual Canadian Geophysical Union (CGU) annual meeting and 66th Annual Canadian Water Resources Association (CWRA) conference. This is the first joint meeting of all three organizations. This congress will be one of the largest gatherings of atmospheric, water, solid earth and ocean expertise ever to be convened in Canada.

Saskatoon is known as the "*Paris of the Prairies*" for its numerous bridges crossing the South-Saskatchewan River.

The venue for this meeting will be Teachers Credit Union Place (TCU Place), Saskatoon's premiere conference centre, and the Hilton Garden Inn, both located in beautiful downtown Saskatoon. TCU Place is considered to be one of the best conference facilities in Western Canada and is within walking distance of the beautiful South Saskatchewan River valley and all major downtown hotels. The city of Saskatoon is Saskatchewan's "bridge city" with seven bridges crossing the South Saskatchewan River and over 300 acres of riverbank trails and parks to explore along our Meewasin Trail.

Saskatoon is also well known for having more hours of sunshine (2294 hours) than any other Canadian city. During the month of May, Saskatoon has an average monthly temperature of 11.6 °C but has been known to get as warm as 35.0°C (May 30, 1988). Saskatoon generally receives about 44 mm of precipitation during the entire month of May.

Congress Theme and Scientific Program
The theme for 2013 is **Bridging Environmental Science, Policy and Resource Management**. This theme was chosen to demonstrate that all three are important, linked, and especially relevant to our resource rich country. As delegates visit Saskatchewan, it will be immediately apparent how important management of our resources is to our province and country, the significance of policy related decision making, and, of course, the relevance of science behind those decisions.

A joint Scientific Committee has been formed to organize at least 14 concurrent science sessions taking place during the four day meeting. The 14 break-out sessions will include special sessions on the Mathematics of Planet Earth (MOPE), Canadian National Committee on Irrigation and Drainage (CANCID), Canadian Society for Hydrological Sciences (CSHS), Canadian Society of Agricultural and Forest Meteorology (CSAFM), Weather/Climate Impacts, Meteorological Observations and Instrumentation, and Water Security Issues. The list of special sessions is continually evolving. Stay tuned for the call for special sessions in the fall of 2012, with the call for abstracts occurring in the winter of 2012/2013.

Please visit www.cmos.ca/congress2013 for updates.

Prochain congrès de la SCMO

Premier congrès annuel conjoint 2013 de la SCMO, de l'UGC et de l'ACRH

Le 47e Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO) se tiendra du 26 au 30 mai, à Saskatoon (Saskatchewan). Ce congrès est organisé parallèlement à la 39e Assemblée annuelle de l'Union géophysique canadienne (UGC) et au 66e Congrès de l'Association canadienne des ressources hydriques. Il s'agit du premier congrès réunissant ces trois organisations. Il représentera l'un des plus grands rassemblements d'experts à se produire au Canada en ce qui a trait à l'atmosphère, à l'eau, au solide terrestre et à l'océan.

La rencontre aura lieu au Teachers Credit Union Place (TCU Place), le plus important centre des congrès à Saskatoon. Le Hilton Garden Inn, situé au centre-ville de Saskatoon, assurera l'hébergement. TCU Place est considéré comme l'un des meilleurs centres des congrès de l'Ouest canadien. Il se situe à distance de marche de la superbe rivière Saskatchewan Sud et de tous les grands hôtels du centre-ville. La ville de Saskatoon est la "ville des ponts" de la province. Sept ponts traversent la rivière Saskatchewan Sud et il existe plus de 300 acres de sentiers riverains et de parcs à explorer tout le long du sentier

Meewasin.

Saskatoon est reconnue pour avoir plus d'heures d'ensoleillement (2294 heures) que toute autre ville canadienne. En mai, la température moyenne mensuelle de Saskatoon atteint 11,6 °C, mais il peut y faire jusqu'à 35,0 °C (30 mai 1988). Saskatoon reçoit généralement environ 44 mm de précipitations au cours du mois de mai.

Thème du Congrès et programme scientifique
Le thème choisi pour 2013 aborde l'Intégration des sciences de l'environnement, de la politique et de la gestion des ressources. Il vise à démontrer que ces trois aspects sont reliés, qu'ils sont importants et qu'ils s'avèrent particulièrement pertinents au sein de notre pays riche en ressources. Quand les délégués visiteront la Saskatchewan, ils comprendront immédiatement l'importance de la gestion des ressources pour cette province et notre pays, la signification des prises de décisions liées aux politiques et bien sûr la pertinence de la science derrière ces décisions.

Un comité du programme scientifique a été créé pour organiser au moins 14 séances scientifiques simultanées, qui auront lieu durant la rencontre de 4 jours. Ces 14 séances en petits groupes incluront des séances spéciales concernant les Mathématiques de la planète Terre (MPT), le Comité national canadien de l'irrigation et du drainage (CNCID), la Société canadienne des sciences hydrologiques (SCSH), la Société canadienne de météorologie agricole et forestière (SCMAF), les impacts météorologiques et climatiques, les observations et l'instrumentation météorologiques, et la sécurité de l'eau. La liste des séances spéciales évolue constamment. À venir bientôt : l'appel pour les séances spéciales à l'automne 2012 et l'appel de résumés à l'hiver 2012-2013.

Veuillez consulter le site Web www.scmo.ca/congress2013 pour tout renseignement à jour.

It was once said!

Two kinds of people predict the future - those who are wrong, and those who know they are wrong.

- Albert Einstein

Source: The 2012 Canadian Weather Trivia Calendar, by David Phillips.

Toronto typical scene

Quadrennial Ozone Symposium 2012
Toronto, Ontario, Canada
August 27 - 31, 2012

The International Ozone Commission (IO3C) of the International Association for Meteorology and Atmospheric Sciences (IAMAS) will hold the next International Quadrennial Ozone Symposium -- QOS2012 -- at the Downtown Sheraton Hotel, Toronto, Canada from August 27 to August 31, 2012. An icebreaker reception is planned for the evening of August 26 and a social event on Saturday, September 1, 2012.

Scientific themes: The Symposium will cover the following themes of atmospheric ozone including:

1. Observations and analyses of total and vertical ozone distributions;
2. Observation techniques and intercomparisons;
3. Tropospheric ozone; past and future budgets and trends and long-range transport;
4. Observations and budgets of trace constituents related to atmospheric ozone;
5. Ozone chemistry, sources, sinks and budgets;
6. Model calculations: dynamics and chemistry coupling;
7. Ozone climate interactions;
8. Ozone and ultraviolet radiation;
9. Polar ozone: troposphere and stratosphere;
10. Measurements of ozone from space; and
11. Others.

Scientific Program and Format: As in past years, the members of the International Ozone Commission will serve as the Scientific Program. As has been the case at previous symposia, there will be no parallel sessions. Papers representative of the conference topics will be chosen for oral presentation. The other contributions selected will be accepted as poster papers. There will be three poster sessions during the meeting at which refreshments will be served.

Hosts: The QOS2012 is being hosted jointly by Environment Canada, the University of Toronto, York University and the Canadian Meteorological and Oceanographic Society (CMOS).

Registration is now available on the QOS2012 website at http://www.cmos.ca/QOS2012/

CMOS SCMO Taylor & Francis Taylor & Francis Group
Atmosphere-Ocean
ISSN 0705-5900

Change of Editors for *Atmosphere-Ocean*

At a recent meeting the CMOS Council recognized the need for additional staff for a growing *Atmosphere-Ocean* and approved a change from two co-editors to three editors. William Hsieh, currently co-editor (meteorology and hydrology) will become editor (climate science) and Douw Steyn, currently an associate editor will become editor (meteorology and hydrology); Guoqi Han will remain as editor (oceanography). All three *A-O* editors have significant journal experience and are on the editorial boards of several other journals.

CMOS SCMO Taylor & Francis Taylor & Francis Group
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Changement de directeurs scientifiques pour *Atmosphere-Ocean*

Lors d'une récente réunion, le Bureau de la SCMO a reconnu le besoin de personnel additionnel pour gérer la croissance de *Atmosphere-Ocean* et a approuvé le passage de deux co-directeurs à trois directeurs. William Hsieh, présentement co-directeur (météorologie et hydrologie) deviendra directeur (science climatique) et Douw Steyn, passera de directeur associé à directeur (météorologie et hydrologie); Guoqi Han demeurera comme directeur (océanographie). Ces trois directeurs possèdent beaucoup d'expérience au sein des revues scientifiques et siègent sur plusieurs comités éditoriaux.

William Hsieh a professor emeritus in the Department of Earth, Ocean and Atmospheric Sciences at the University of British Columbia who specializes in atmosphere-ocean climate variability and machine learning methods, is a fellow of CMOS and recipient of the President's prize (1999). He has served on the A-O editorial board since 2010 and is currently chair of the CMOS BC Lower Mainland Centre.

http://www.eos.ubc.ca/public/people/faculty/W.Hsieh.html

William Hsieh, professeur émérite au département de Terre, océan et sciences atmosphériques de l'Université de Colombie-Britannique, se spécialise en variabilité du climat atmosphère-océan et en méthodes d'apprentissage automatisé; il est Membre émérite de la SCMO et récipiendaire du Prix du président (1999). Il fait partie du comité éditorial depuis 2010 et préside le Centre BC Lower Mainland de la SCMO.

Douw Steyn is a professor in the Department of Earth, Ocean and Atmospheric Science at The University of British Columbia, where he specializes in Boundary Layer Meteorology, Mesoscale Meteorology and Air Pollution Meteorology. He received the CMOS Graduate Student's Prize (1980). Douw has served on several CMOS committees and is currently chair of the Accreditation Committee and the Privacy officer for the Society.

http://www.eos.ubc.ca/public/people/faculty/D.Steyn.html

Douw Steyn est professeur au département de Terre, océan et sciences atmosphériques de l'Université de Colombie-Britannique où il se spécialise en météorologie de la couche limite et de la pollution de l'air. Il a reçu le Prix de l'étudiant gradué (1980). Douw s'est dévoué sur plusieurs comités de la SCMO et préside en ce moment le Comité d'accréditation tout en servant d'Agent chargé de la protection des renseignements personnels pour la Société.

Guoqi Han is a research scientist at the Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada and an adjunct professor at Memorial University. He specializes in ocean modeling, satellite remote sensing, and ocean climate variability. In 2007, he chaired the Scientific Program Committee for the Joint CMOS-CGU-AMS Congress in St-John's NL. He is the recipient (group) of the CMOS Prize in Applied Oceanography (1998).

http://www.meds-sdmm.dfo-mpo.gc.ca/sdb-bds/profile-profil.do?id=941&lang=eng

Guoqi Han est chercheur au Centre des pêches de l'Atlantique Nord-Ouest et professeur adjoint à l'université Memorial. Il se spécialise en modèles océaniques, télédétection satellitaire et variabilité climatique. En 2007 il présidait le Comité du programme scientifique du congrès conjoint SCMO-UGC-AMS à St-jean TN. Il fait partie du groupe récipiendaire du Prix en océanographie appliquée (1998) de la SCMO.

To effect the transition and manage the growth of *Atmosphere-Ocean*, all three editors will be seeking a number of new associate editors. To make sure that they are all kept busy, all members are encouraged to submit their best research papers.

Richard Asselin
Director of publications

En effectuant la transition et gérant la croissance de *Atmosphere-Ocean*, les trois directeurs scientifiques seront à la recherche de plusieurs nouveaux directeurs-associés. Il incombe à tous les membres de fournir du travail à tout le comité éditorial en soumettant leurs meilleurs articles de recherche!

Richard Asselin
Directeur des publications

Atmosphere-Ocean 50-2 Paper Order

Ocean and Climate Dynamics a Tribute to Professor Lawrence A. Mysak

Preface / Avant-Propos
Ocean and Climate Dynamics — a Tribute to Professor Lawrence A. Mysak / Dynamique des océans et du climat : hommage au professeur Lawrence A. Mysak, by William W. Hsieh.

AO-2011-0047
Thermohaline Staircases in a British Columbia Fjord, by David J. Spear and Richard E. Thomson.

AO-2011-0001
Geostrophic Adjustment Problems in a Polar Basin, by Maria V. Luneva, Andrew J. Willmott and Miguel Angel Morales Maqueda.

AO-2011-0009
Long-Term Variability of Volume and Heat Transport in the Nordic Seas: A Model Study, by Sarah Lundrigan and Entcho Demirov.

AO-2011-0006
Sereno Bishop, Rollo Russell, Bishop's Ring and the Discovery of the "Krakatoa Easterlies", by Kevin Hamilton.

AO-1307
Downscaling of Precipitation over Vancouver Island using a Synoptic Typing Approach, by Stephen Sobie and Andrew J. Weaver.

AO-2010-0007
Drivers of Future Northern Latitude Runoff Change, by Kelly A. Nugent and H. Damon Matthews.

AO-2011-0054
Non-Linear Post-Processing of Numerical Seasonal Climate Forecasts, by Joel Finnis, William W. Hsieh, Hai Lin and William J. Merryfield.

AO-2011-0003
Stained Glass and Climate Change: How are they Connected?, by C. T. Simmons and L. A. Mysak.

Note: The abstracts of the above papers were published in the April issue of *CMOS Bulletin SCMO,* Vol.40, No.2, pages 74-77. As the abstract for AO-2011-0009 was not available at time of printing, it is reproduced here.

Les résumés de ces articles ont été publiés dans le numéro d'avril du *CMOS Bulletin SCMO*, Vol.40, No.2, pages 74-77. Comme le résumé de AO-2011-009 n'était pas disponible au moment d'aller sous-presse, il est reproduit ici.

Long-Term Variability of Volume and Heat Transport in the Nordic Seas: A Model Study
by Sarah Lundrigan and Entcho Demirov

Abstract
This article presents results from a model study of interannual and decadal variability in the Nordic Seas. Fifty years of simulations were conducted in an initial condition ensemble mode forced with the National Centers for Environmental Prediction (NCEP) reanalysis. We studied two major events in the interannual and interdecadal variability of the Nordic Seas during the past fifty years: the Great Salinity Anomaly in the 1960s and early 1970s and the warming of the Arctic and subarctic oceans in the late 1990s.

Previous studies demonstrated that the Great Salinity Anomaly observed in the subarctic ocean in 1960 was originally generated by intensified sea-ice and fresh water inflow from the Arctic Ocean. Our model results demonstrate that the increase in the transport of fresh and cold waters through Fram Strait in the 1960s was concurrent with a reduction in the meridional water exchange over the Greenland–Scotland Ridge. The resulting imbalance in salinity and heat fluxes through the strait and over the ridge also contributed to the freshening of the water masses of the Nordic Seas and intensified the Great Salinity Anomaly in the Nordic Seas.

The warming of the Atlantic Waters in the Nordic Seas and Arctic Ocean during the past two decades had an important impact on the variability of these two ocean basins. Some previous observational and model studies demonstrated that the warming of the subpolar Atlantic Ocean in the late 1990s and the meridional transport of the Atlantic Water mass (AW) into the Nordic Seas and Arctic Ocean contributed to this process. At the same time, observations show that the warming of the AW in the Nordic Seas started in the 1980s (i.e., earlier than the warming of subpolar North Atlantic Ocean). Our model results suggest that this process was triggered by an imbalance in the lateral heat fluxes through Fram Strait and over the Greenland–Scotland Ridge. In the late 1980s the AW transport over the Greenland–Scotland Ridge was stronger than normal while the exchange through Fram Strait was close to normal. The related imbalance in the lateral heat fluxes through the Strait and over the Ridge warmed the Nordic Seas and caused an increase in the temperature of the AW inflow to the Arctic Ocean in the late 1980s (i.e., about a decade earlier than the warming of the source of the AW in the subpolar North Atlantic Ocean). Thus the model results suggest that the imbalance in lateral heat and salinity fluxes through the Strait and over the Ridge connecting the Nordic Seas to the North Atlantic and Arctic oceans could amplify the interannual variability in the subarctic ocean.

Résumé [Traduit par la rédaction]
Cet article présente les résultats d'une étude par modèle de la variabilité interannuelle et décennale dans les mers nordiques. Nous avons effectué des simulations sur une période de cinquante ans en mode d'ensemble de conditions initiales forcé avec les réanalyses des NCEP (National Centers for Environmental Prediction). Nous avons étudié deux événements majeurs survenus dans la variabilité interannuelle et décennale des mers nordiques au cours des cinquante dernières années : la grande anomalie de salinité des années 1960 et du début des années 1970 et le réchauffement des océans Arctique et subarctique vers la fin des années 1990.

Des études précédentes ont démontrées que la grande anomalie de salinité observée dans l'océan subarctique en 1960 a été causée par une intensification de l'apport de glace de mer et d'eau douce depuis l'océan Arctique. Les résultats que nous avons obtenus du modèle montrent que l'accroissement du transport d'eau douce et froide à travers le détroit de Fram dans les années 1960 s'est produit en même temps qu'une réduction dans l'échange méridien d'eau au-dessus de la crête Groenland–Écosse. Le déséquilibre résultant dans les flux de salinité et de chaleur à travers le détroit et au-dessus de la crête a aussi contribué à l'adoucissement des masses d'eau des mers nordiques et a intensifié la grande anomalie de salinité dans les mers nordiques.

Le réchauffement des eaux atlantiques dans les mers nordiques et dans l'océan Arctique au cours des deux dernières décennies a eu un impact important sur la variabilité de ces deux bassins océaniques. Des études observationnelles et par modèle précédentes ont établi que le réchauffement de l'océan Atlantique subpolaire dans les années 1990 et le transport méridien de la masse d'eau atlantique dans les mers nordiques et dans l'océan Arctique ont contribué à ce processus. En même temps, les observations montrent que le réchauffement des eaux atlantiques dans les mers nordiques a commencé dans les années 1980 (c.-à-d. plus tôt que le réchauffement de l'océan Nord-Atlantique subpolaire). Les résultats du modèle suggèrent que ce processus a été déclenché par un déséquilibre dans les flux de chaleur latéraux à travers le détroit de Fram et au-dessus de la crête Groenland–Écosse. À la fin des années 1980, le transport des eaux atlantiques au-dessus de la crête Groenland–Écosse était plus fort que la normale alors que l'échange à travers le détroit de Fram était près de la normale. Le déséquilibre résultant dans les flux de chaleur latéraux à travers le détroit et au-dessus de la crête a réchauffé les mers nordiques et causé une augmentation de la température des eaux atlantiques parvenant à l'océan Arctique à la fin des années 1980 (c.-à-d. environ une décennie avant le réchauffement de la source d'eaux atlantiques dans l'océan Nord-Atlantique subpolaire). Donc, les résultats du modèle suggèrent que le déséquilibre dans les flux de chaleur et de salinité latéraux à travers le détroit et au-dessus de la crête reliant les mers nordiques à l'Atlantique Nord et à l'Arctique pourrait amplifier la variabilité interannuelle dans l'océan subarctique.

BOOK REVIEWS / REVUES de LITTÉRATURE

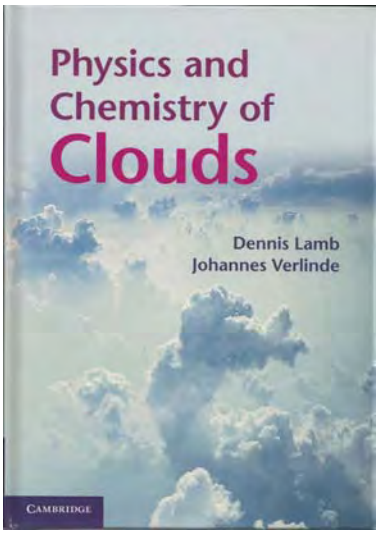
Physics and Chemistry of Clouds

by Dennis Lamb and Johannes Verlinde

Cambridge University Press, 2011
ISBN 978-052-189910-9, 600 pages, Hardback, US$85

Book reviewed by Daniel Johnston[1]

Drs. Lamb and Verlinde combine their teaching and professional meteorology experiences into a well-written textbook on the physics and chemistry of clouds. They state in the preface that "the need for a new textbook arose partly out of [their] frustration with identifying textbooks suitable for teaching cloud physics at the graduate and undergraduate level" (xii). It is the authors' intention that this textbook aids or replaces the current textbooks, such as *A Short Course in Cloud Physics* by R. Rogers and M. Yau published in 1989, that upper-level undergraduates and first year graduates use to learn the subject matter.



The text begins by addressing the elementary levels of meteorology and clouds and ends with a deep understanding of "*how clouds operate in the real atmosphere*" (xi). For example, the introduction into the atmospheric gases of chapter two is heavily built upon during the explanation of cloud chemistry and pollution in the last chapters of the text. The problem sets at the end of each chapter complement the students' understanding of the five-part text by merging theory-based information with real-world applications. Not providing answers to the problem sets in the text encourages the student to visit the professor for further clarification, utilize other texts on the subject manner, and work with other classmates; all dependent on the strength of the question. This approach increases the student's knowledge of the subject matter. There are 3 appendices in addition to a general reference book list at the end of the text. Each appendix presents a fundamental concept relating to clouds–a quick-reference tool that complements recurring ideas and formulas used throughout the text. The reference list allows for the reader to further their own interest in a general area without jeopardizing their studying of a specific chapter. This main reference list is in addition to the detailed individual reference list at the end of each chapter.

The introductory chapters allow the student to grasp the broad concepts of cloud formation through observational and empirical means. This part of the text contains pictures of recent cloud formations from Hurricane Katrina over the Gulf of Mexico to squall lines in the Midwest United States to show how the molecular scale of clouds is seen on a macroscale level. The diagrams and close-up photos of precipitation types also complement the authors' explanations of each section. Mathematical formulas and basic meteorological equations introduced are well-explained and contribute to the entry-level understanding of clouds. Finally, the chemistry section covering cloud composition is an overall description of atmospheric chemistry and the effects of pollution on cloud formation.

Using part one's basic mathematical and meteorological information, part two combines molecular-level interactions with thermodynamic processes to provide explanations of phase relationships via intense diagrams and step-by-step mathematical integrals. The authors use this pragmatic approach to expose the student to critical cloud changing concepts such as the Köhler theory, Raoult's Law and the Poynting equation.

The two middle parts of the text highlight the importance of the phase change of water and how it affects cloud formation. Understanding how "*the macroscale air motions…cool the air and generating excess water vapour [and how] the microphysical processes...determine how the excess vapour is utilized within the cloud*" (242) is crucial to comprehending "*how cloud particles form in the first place*" (277). The information contained in these sections often overlap. Therefore, it's advised that a student should read them together to increase their understanding of cloud macrophysics and microphysics. These middle sections are also the most important ones and contain more formula derivations and assumptions than other sections. A student may need to review the appendices and their previous chapter notes frequently while reading these sections. The layout of these appendices eases half of this review. Conversely, the other sections and chapters of the book could be read individually without frequent use of the appendices. Teaching cloud macrophysics through the combination of Skew-T profiles from a day with tornadic storms with meteorological formula manipulations and describing the microphysical processes of cloud particle formation to determine such details as precipitation and lightning formation continues the authors' practical combination of real-world applications to theory-based topics.

[1] Pelmorex, Burlington, Ontario, Canada

Part five of the text describes the following three areas well: 1) how the thermodynamic processes of phase changes inside clouds occur; 2) describes the importance of warm and cold clouds; and, 3) revisits the composition of the atmosphere. Students will benefit from the incorporation of the Marshall-Palmer drop spectra distribution, a new concept, with the adiabatic equations and the Bergeron process, both introduced in previous chapters of the text. The final chapters of this section, cloud chemistry and cloud electrification, are also the most beneficial ones of this part of the text. The end-of-chapter problems and list texts for further reading on these topics would be most beneficial to a student who is looking for a deeper understanding of the subject matter.

Drs. Lamb and Verlinde intended this book to become a main college-level textbook in the field of cloud physics for upper-level undergraduates, graduate level courses and for professionals looking for a reference book that *"can be classified between a short course [textbook] and an extensive research book*" (xii). This text meets its intended purpose. It adequately synthesizes the subject material and provides supporting material such as text reference lists and problem sets that enhance the understanding of cloud processes in an easy-to-understand manner.

Rising Waters: The Causes and Consequences of Flooding in the Unites States

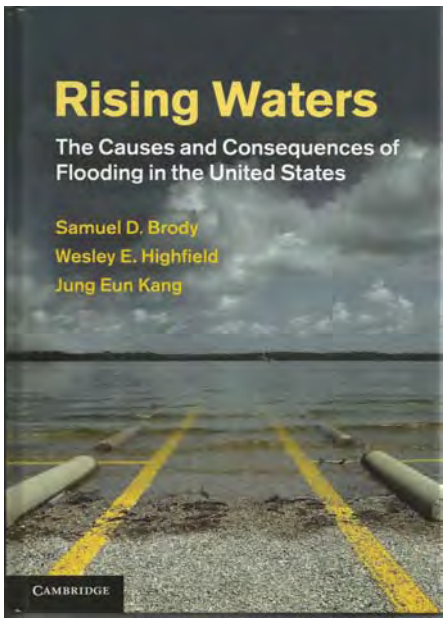
by Samuel D. Brody, Wesley E. Highfield and Jung Eun Kang

Cambridge University Press, ISBN 978-0-521-19321-4
Hardback, 206 pages, US$99

Book reviewed by Daniel Johnston[2]

"Floods pose the greatest threat to the property, safety, and economic well-being of local communities across the nation" (p. 11).

The authors present a detailed understanding of the problems and possible mitigation techniques implemented to reduce the adverse impacts of floods in small communities. They begin by stating that although major floods such as "*The Great Flood of 1993*" and "*The Red River Flood of 1997*" received national media coverage, smaller and more frequent localized floods are not covered outside of their immediate area's media market. This lack of national coverage has led to a discontinuity among local and national agencies' efforts to mitigate flooding's disastrous effects causing contradictory and/or nonexistent flood prevention policies is the book's main theme. Flood research data was obtained and repeatedly analysed from the NWS, the National Flood Insurance Program (NFIP) and the Spatial Hazard Events and Losses Database for the United States (SHELDUS) to obtain a complete picture of the number of floods and their subsequent impacts across the United States (US). After the analysis, the coastal areas of Texas and the entire state of Florida were focussed on "*because of their population and location along the Gulf of Mexico*" (p. 4). The book is divided into four main parts. The first part of the book describes impact of floods on the United States. Part two studies the influence of floods from a local level upward to the federal level. Part three examines specific communities in Texas and Florida as case studies of how each community addresses its flood hazards. The last part combines the authors' empirical research with suggestions for policy-makers on the future steps for mitigating floods in local communities.



The first part of the book focussed on compiling and analyzing flood damage data ranging from insurance payouts and loss of residents to the cost of rebuilding entire communities or parts thereof. The results of this process were discussed and evaluated from a national level to a zip code-centric focus to ensure unbiased conclusions were obtained. The authors provided a basic and thorough explanation of the relationship between floodplain management and the Federal Government's financial protection against flood loss in communities across the US through NFIP. The NFIP policy "*provides flood insurance to flood plain residents and businesses [via] insurance credits*" in the US that allows for communities and states to choose their own plan to mitigate upcoming flood damages. This planning has led to multiple interpretations of how to create flood mitigation policies across the country. The states of Texas and Florida were chosen for a closer examination because each state has chosen an opposite approach to handling flood mitigation in their communities; Texas where local laws are more important than state laws and Florida where local laws are created after state laws. These different styles of flood mitigation techniques were continually studied throughout the book.

[2] Pelmorex, Burlington, Ontario, Canada

The second part of the book scrutinizes how communities respond after a flood because "*communities with plans are better prepared for flood disasters than those without plans*" (p. 83). It is the most energetic and detail-rich section of the book because it exemplifies well the combination of each author's professional expertise. This section begins with a review of the natural, man-made, organizational and socioeconomic structures across coastal Texas and Florida. It's followed by an intense and unbiased discussion of how mitigation plans must correlate with floodplain boundaries and not with political boundaries. The authors argue that the United States Army Corps of Engineers (USACE), a major federal agency designed to help communities mitigate floods, is lax in its role of flood mitigation. Their chapter-long argument begins with a study of the USACE's permit granting and follow-up process and ends with describing the effects this process has on wetlands in Florida and Texas.

The culmination of the state-wide data gathered and assessed for Texas and Florida are further explained in section three by applying it to a sample of multiple cities in those states. An entire chapter is devoted to these cities and communities to describe how important the analysis of the chosen communities' socioeconomic, historical, geographical data is to flood mitigation. The authors use these analyses to explain the necessity of continual re-evaluation of flood mitigation techniques for each community. They explain that a routine assessment should include monitoring and reporting population movement within a community and updating historical flood records after a period of time has elapsed. These two processes are evidence of findings previously discussed in section two. Finally, the authors reiterate their view that further studies of flood mitigation are welcomed and how these studies should influence policy decisions in the US.

The authors' approach to flood mitigation is well documented throughout this book. They reiterate the book's findings and data should be used as a starting point for further, in-depth studies on flood mitigation techniques in Texas, Florida and the US as a whole. Their choice of writing a book discussing flood mitigation is within the professional knowledge of each author. They recommend this book for upper-level university students to seasoned government employees and researchers whose focus is hazard mitigation, hydrology, geography, environmental planning and public policy — and I concur.

Wheather Quiz

When was the rain gauge invented?

1) 1441; 2) 1497; 3) 1850; 4) 1917; 5) 1931.

Find the answer on last page. Source: The 2012 Canadian Weather Trivia Calendar by David Phillips.

Books in search of a Reviewer (Partial list)
Livres en quête d'un critique (Liste partielle)

Latest Books received / Derniers livres reçus

2011-32) *The Theory of Large-Scale Ocean Circulation*, R.M. Samelson, Cambridge University Press, ISBN 978-1-107-00188-6, Hardback, US$85, 193pp.

2011-34) *Modeling Methods for Marine Science*, David M. Glover, William J. Jenkins and Scott C. Doney, Cambridge University Press, Hardback, US$85, 571pp.

2011-36) *Ocean Dynamics and the Carbon Cycle, Principles and Mechanisms*, Richard G. Williams, Michael J. Follows, Cambridge University Press, ISBN 978-0-521-84369-0, Hardbback, US$73, 404pp.

2011-38) *Ocean Surface Waves, Breaking and Dissipation of*, Alexander Babanin, Cambridge University Press, ISBN 978-1-107-00158-9, Hardback, US$130, 463pp.

2011-40) *Climate Change in the Polar Regions,* John Turner and Gareth J. Marshall, Cambridge University Press, ISBN 978-0-521-85010-0, Hardback, US$115, 434pp.

2011-42) *Physics and Chemistry of Clouds*, Dennis Lamb and Johannes Verlinde, Cambridge University Press, ISBN 978-0-521-89910-9, Hardback, US$85, 584pp.

2011-45) *Midlatitude Synoptic Meteorology, Dynamics, Analysis & Forecasting*, by Gary Lackmann, American Meteorological and Oceanographic Society, ISBN 978-1-878220-10-3, Paperback, 345pp, US$100.

2011-49) *Introduction to Modern Climate Change*, by Andrew E. Dessler, Cambridge University Press, ISBN 978-1-107-00189-3, Hardback, 238 pp, US$ 110.

2012-06) *Physics of the Atmosphere and Climate*, by Murry L. Salby, Cambridge University Press, ISBN 978-0-521-76718-7, Hardback, 666 pp, US$90.

2012-08) *Dryland Climatology*, by Sharon E. Nicholson, Cambridge University Press, ISBN 978-0-521-51649-5, Hardback, 516 pp, US$150.

2012-10) *Phytoplankton Pigments, Characterization, Chemotaxonomy and Applications in Oceanography,* Edited by Suzanne Roy, Carole A. Llewellyn, Einar Skarstad Egeland and Geir Johnsen, 2011, Cambridge University Press, ISBN 978-1-107-00066-7, Hardback, 845 pp, US$140.

2012-12 *Buoyancy-Driven Flows*, Edited by Eric P. Chassignet, Claudia Cenedese and Jacques Verron, 2012, Cambridge University Press, ISBN 978-1-107-00887-8, Hardback, 436 pp, US$120.

New Weather and Climate Information System Becomes Operational

Geneva, 31 January 2012 (WMO) – A new international information system to improve and expand the current exchange of weather, climate and water data – and cut the costs involved - has become operational.

The World Meteorological Organization (WMO) Information System will make it easier to find and use meteorological observations and products and to share them with a wide variety of stakeholders such as the research and disaster risk reduction communities.

It builds on the proven success of the **Global Telecommunication System (GTS)** of WMO's World Weather Watch which has been the backbone of meteorological information exchange for the past 40 years and is used for daily weather observations and forecasts, tropical cyclone warnings and Tsunami alerts – to name but a few applications.

"*The WMO Information System is the pillar of our strategy for managing and moving weather, climate and water information in the 21st century,*" said WMO Secretary-General Michel Jarraud.

"*It will reduce the costs of information exchange incurred by National Meteorological and Hydrological Services and maximize exploitation of advances in communications technology,* " he said.

"*It will allow users outside the meteorological community to have free access to this information for the first time. This will be especially important as WMO moves ahead with other U.N. and international partners with the Global Framework for Climate Services which aims to provide basic climate services for all in the food security, water management, disaster risk reduction and health sectors*," said Mr Jarraud.

The **WMO Information System**, or **WIS**, connects and integrates information from three types of data centres:

1) National Centres collect and distribute data on a national basis. They generate quality controlled analysis and forecast products, and services, including archiving national climate information. The National Meteorological or Hydrological Service coordinate or authorize the use of the WIS by national users.

2) Data Collection or Production Centres are similar to National Centres but focus on thematic, regional or global collection and/or production of sets of data, forecast products, processed or value-added information, and/or for providing archiving services.

3) Global Information System Centres connect to each other through a high speed private network. They rapidly share information meant for routine global dissemination that they collect from National Centres and Data Collection or Production Centres in their area of responsibility . They also serve as distribution centres into their areas of responsibilities. Global Information System Centres provide entry points, through unified portals and comprehensive metadata catalogues, for any request for data exchanged within the WIS. They also provide the connection to other information systems such as the Global Earth Observation System of Systems.

WMO's governing World Meteorological Congress has approved several Global Information System Centres which meet the required standards. Three of these, Beijing, China; Tokyo, Japan, and Offenbach, Germany, have been running in pre-operational mode since the middle of 2011 and will be officially operational from the end of January 2012. Others will shortly become operational.

Background information:

The World Meteorological Congress in 2003 formally adopted the concept of the WMO Information System to provide an integrated data management approach for all WMO and related international programmes. Congress said it should have a flexible structure; and build on the successful Global Telecommunication System for highly reliable delivery of time-critical data and products.

The World Meteorological Congress in 2007 required the WMO Information System to be implemented in two parallel parts. Part A, the continued evolution of the Global Telecommunications System, is already operational. Part B provides new functionalities and provides the more flexible connection between WMO Members and contributors; this is newly operational.

The World Meteorological Congress in May 2011 set the implementation of the WMO Information System as one of the top priorities for the next four years and gave the green light for WIS to become operational in January 2012.

WIS provides three fundamental types of services (as agreed by Congress):

1. Routine collection and dissemination service for time-critical and operation-critical data and products: This service is based on real-time "push" mechanism including multicast and broadcast; it is implemented essentially through dedicated telecommunication means providing a guaranteed quality of service. This includes a dedicated service for the rapid international exchange of warnings and

related messages.

2. Data Discovery, Access and Retrieval service: This service is based on request/reply "pull" mechanism with relevant data management functions; it is implemented essentially through the internet.

3. Timely delivery service for data and products: This service is based on delayed mode "push" mechanism; it is implemented through a combination of dedicated telecommunication means and of public data-communication networks, especially the internet.

The World Meteorological Organization is the United Nations System's authoritative voice on Weather, Climate and Water

Notes from the Editor: 1) Further details are available at www.wmo.int/wis 2) Access to the Global Information System Centres can be found via www.wmo.int/giscs

Source: WMO Press Release No. 939;
website http://www.wmo.int visited on March 27, 2012.

Un nouveau système d'information sur le temps et le climat devient opérationnel

Genève, 31janvier 2012 (OMM) – Un nouveau système d'information international destiné à faciliter et développer l'échange de données météorologiques, climatiques et hydrologiques – et à réduire les dépenses correspondantes – est désormais opérationnel.

Le Système d'information de l'Organisation météorologique mondiale (OMM) facilitera la recherche et l'utilisation des observations et produits météorologiques ainsi que leur échange avec un large éventail de partenaires, et notamment les milieux de la recherche et de la réduction des risques de catastrophes.

Ce système se fonde sur le succès indiscutable du **Système mondial de télécommunications** de la Veille météorologique mondiale de l'OMM, qui a été la pierre angulaire de l'échange d'informations météorologiques depuis 40ans et qui assure chaque jour la diffusion de données d'observation et de prévisions météorologiques, d'avis de cyclones tropicaux et d'alertes aux tsunamis – pour ne citer que ces quelques applications.

"*Le Système d'information de l'OMM est le pilier de notre stratégie de gestion et de diffusion des informations sur le temps, le climat et l'eau au XXI^e^siècle*" a déclaré le Secrétaire général de l'OMM, M.Michel Jarraud.

Selon lui, "*ce système réduira les coûts de l'échange d'informations supportés par les Services météorologiques et hydrologiques nationaux et permettra de tirer profit au mieux des avancées des technologies de la communication*".

"*Le Système d'information de l'OMM permettra en outre aux utilisateurs qui ne font pas partie de la communauté météorologique d'avoir, pour la première fois, libre accès à ces informations. Cela importe d'autant plus que l'OMM s'emploie actuellement, avec le concours d'autres organismes des Nations Unies et de partenaires internationaux, à mettre en place le Cadre mondial pour les services climatologiques, qui vise à fournir des services climatologiques de base à toutes les parties intéressées des secteurs de la sécurité alimentaire, de la gestion des ressources en eau, de la réduction des risques de catastrophes et de la santé*" a-t-il ajouté.

Le **Système d'information de l'OMM** (ou **SIO**) assure la liaison entre – et prend en compte l'information émanant de – trois types de centres de données:

1) Les centres nationaux, qui recueillent et diffusent des données à l'échelon national. Ils élaborent des produits d'analyse et de prévision qui font l'objet d'un contrôle de la qualité et proposent des services tels que l'archivage des informations climatologiques nationales. Les Services météorologiques et hydrologiques nationaux coordonnent ou autorisent l'utilisation du SIO par les utilisateurs nationaux;

2) Les centres de production ou de collecte de données, qui sont analogues aux centres nationaux, mais se spécialisent dans la collecte et/ou la production thématique, régionale ou mondiale de jeux de données, de produits de prévision et d'informations traitées ou à valeur ajoutée et/ou dans la fourniture de services d'archivage;

3) Les centres mondiaux du système d'information, qui sont reliés entre eux par un réseau privé à haute vitesse. Ils échangent rapidement les informations destinées à une diffusion régulière à l'échelle du globe que leur transmettent les centres nationaux et les centres de production ou de collecte de données se trouvant dans leurs zones de responsabilité respectives. Ils servent aussi de centres de distribution dans ces mêmes zones. De plus, grâce à des portails unifiés et à des catalogues très complets de métadonnées, ils constituent des points d'accès pour toute demande concernant des données échangées par le biais du SIO. Enfin, ils assurent la liaison avec d'autres systèmes d'information tels que le Système mondial des systèmes d'observation de la Terre.

Le Congrès météorologique mondial, qui est l'organisme suprême de l'OMM, a approuvé la désignation de plusieurs centres mondiaux du système d'information, qui répondent aux critères définis. Trois de ces centres, à savoir ceux de Beijing (Chine), de Tokyo (Japon) et d'Offenbach (Allemagne), sont exploités en mode préopérationnel

depuis le milieu de l'année 2011 et deviendront officiellement opérationnels à la fin du mois de janvier 2012. D'autres centres devraient aussi le devenir prochainement.

Rappel des faits:

Le Congrès météorologique mondial a officiellement adopté en 2003 le concept de Système d'information de l'OMM, afin de définir une approche intégrée de la gestion des données pour tous les programmes de l'Organisation et les programmes internationaux connexes. Le Congrès a précisé que ce système devrait avoir une structure souple et s'appuyer sur le succès du Système mondial de télécommunications pour atteindre le haut degré de fiabilité requis en ce qui concerne la diffusion de données et produits pour lesquels le facteur temps est essentiel.

En 2007, le Congrès météorologique mondial a préconisé que le Système d'information de l'OMM soit mis en place en deux parties parallèles. La partieA, qui consiste à poursuivre l'évolution du Système mondial de télécommunications, en est déjà au stade opérationnel. La partieB, qui offre de nouvelles fonctionnalités et assure une connexion très souple entre les Membres de l'OMM et les contributeurs, est opérationnelle depuis peu.

En mai 2011, le Congrès météorologique mondial a considéré que la mise en œuvre du Système d'information de l'OMM constituait l'une des principales priorités pour les quatre prochaines années et a donné son accord pour que le SIO devienne opérationnel en janvier 2012.

Le SIO assure trois types fondamentaux de services (comme l'a approuvé le Congrès):

1. Un service courant de collecte et de diffusion de données et de produits pour lesquels le facteur temps et le facteur exploitation sont déterminants: ce service, fondé sur un système à flux poussé en temps réel comprenant des outils de multidiffusion et de radiodiffusion, est essentiellement mis en œuvre par le biais de moyens de télécommunication spécialisés offrant une qualité de service garantie, y compris un service spécialisé pour l'échange international rapide de messages d'alerte et autres messages connexes.

2. Un service de recherche, de consultation et d'extraction de données: ce service, fondé sur un système de demande/réponse à flux tiré comportant des fonctions de gestion des données appropriées, est essentiellement mis en œuvre par le biais de l'Internet.

3. Un service de diffusion en temps utile des données et produits: ce service, fondé sur un système à flux poussé en mode différé, est mis en œuvre en combinant des moyens de télécommunication spécialisés et des réseaux publics de transmission de données (en particulier l'Internet).

L'Organisation météorologique mondiale est l'organisme des Nations Unies qui fait autorité pour les questions relatives au temps, au climat et à l'eau

Notes de la rédaction: 1) Pour plus de précisions, on consultera le site du SIO à l'adresse suivante: www.wmo.int/wis 2) Il est possible d'accéder aux sites des centres mondiaux du système d'information via http://www.wmo.int/giscs

Source: Communiqué de presse No. 939 de l'OMM; site web http://www.wmo.int visité le 27 mars 2012.

Weather Quiz

Answer: The rain gauge was invented in 1441.

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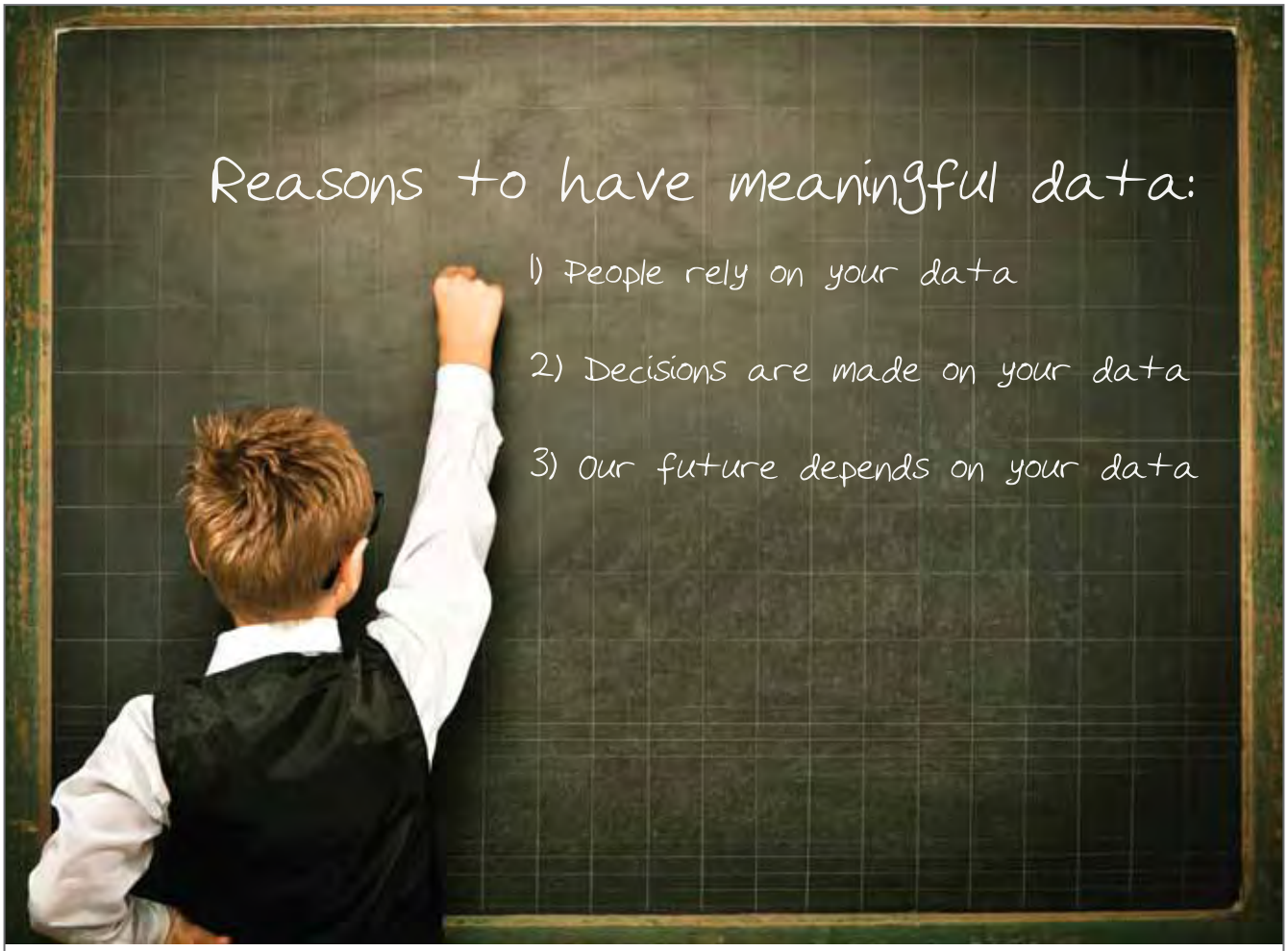
CWRA ACRH
Canadian Water Resources Association
Association Canadienne des Ressources Hydriques

CMOS SCMO
Canadian Meteorological and Oceanographic Society
Société canadienne de météorologie et d'océanographie

Canadian Geophysical Union
Union Géophysique Canadienne



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