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December 31, 2021: André Robert: One of the very first scientists to successfully perform a simulation of the atmosphere's general circulation at the global scale using a computer model (EN)

André Robert: One of the very first scientists to successfully perform a simulation of the atmosphere's general circulation at the global scale using a computer model

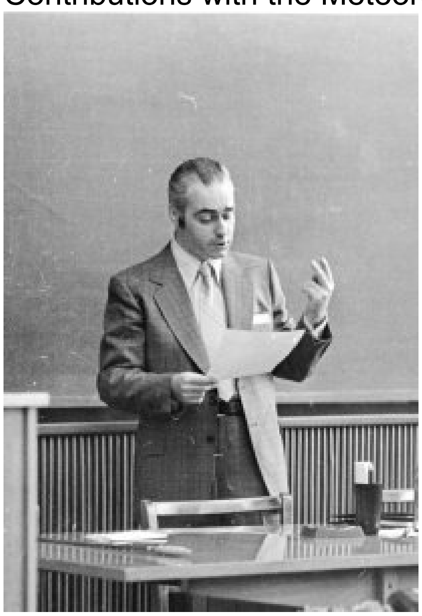
WRITTEN BY CMOS BULLETIN SCMO ON DECEMBER 31, 2021. POSTED IN ATMOSPHERE, UNCATEGORIZED, WEATHER, WHAT'S CURRENT.

– By Christopher Smith –

Background

Dr. André Robert (April 28, 1929 – November 18, 1993) was a Canadian meteorologist and research pioneer in modelling the Earth's atmospheric circulation. After completing a B.Sc. in Mathematics from Laval University, André Robert started his career as a weather forecaster with the Meteorological Service of Canada (MSC) in 1952, and then shifted his attention to the development of atmospheric models for short and medium-range forecasts. For his PhD (awarded in 1965), André Robert worked at McGill University on the spectral model using spherical harmonics for the representation of atmospheric fields in global climate and Numerical Weather Prediction (NWP) models. Dr. Robert was among the very first scientists to successfully perform a simulation of the atmosphere's general circulation using a computer model and became an internationally recognized leader and founding figure in NWP.

Contributions with the Meteorological Service of Canada



After transitioning from forecasting to research in 1959, André Robert made a monumental impact on early Canadian efforts in NWP. So much so, that he can be said to be one of the founders of operational NWP in Canada. André Robert designed and implemented the first two Canadian models, a barotropic grid point model in 1963, and a baroclinic grid point model in 1968. Largely due to his pivotal work on the spectral method in the 1960s, Canada was the first country to use a spectral model to produce operational forecasts.

In 1974, André Robert was the director of the Canadian Meteorological Centre (CMC) when it was relocated to its current location in Dorval, Québec. As the director, he primarily focused on the modernization of operational forecasting systems and, in particular, laid the foundations for the automation of forecasts. André Robert was one of many pioneers at the CMC (including Roger Daley, Amos Eddy, Michael Kwizak, Ian Rutherford, and Andrew Staniforth, among others) that advanced Environment and Climate Change Canada's early NWP expertise. More details on CMC's contribution to NWP can be found in Recherche en Prévision Numérique / Contributions to Numerical Weather Prediction by Hal Ritchie, et al., (2021).

> QUESTION: What was the mood in the group? Was there a lot of enthusiasm?
> ANSWER: Oh yes, it was very enthusiastic. Playing with computers was a lot of fun in those days and for that reason everybody was highly motivated. Also, we thought that Numerical Weather Prediction would really eventually cause a revolution in meteorology. So, for that reason, we were also very highly motivated. That feeling existed everywhere around the world at that time.

André Robert on the early days of NWP (Interview by H. Ritchie, 1987)

Dr. Robert was known as an outstanding and pragmatic applied mathematician who constantly aimed at developing "efficient" algorithms that would give the best performance (accuracy, stability) for a given computation time. Beyond his personal scientific and mathematical achievements, Dr. Robert also led his research teams to the highest level of rigour and world-class quality. This resulted in a culture of excellence and innovation that continued long after his passing. Dr. Robert's innovative methods for the efficient integration of atmospheric equations allowed MSC and therefore Canada to develop and operate world-class forecasting models using lesser computing resources than other countries.

Advancing the science of Numerical Weather Prediction

While working for the MSC between 1963 and 1970, Dr. Robert developed the semi-implicit time integration algorithm for efficient integration of the primitive equations for NWP and climate models. The development of this technique was significant as it decreased the time required to make a prediction by a factor of six without affecting the accuracy of the forecasts produced. Several weather centres in the world adopted this algorithm for their models, including Canada in 1974, Australia in 1976, European Centre for Medium-Range Weather Forecasts (ECMWF) in 1977, USA in 1980. Today, this method is used by many meteorological centres around the world. Dr. Robert also designed a novel semi-Lagrangian technique for an efficient treatment of transport terms. Combined with the semi-implicit scheme, this permits the time step in atmospheric models to be increased by a further factor of six without reducing the accuracy of the forecasts. Dr. Robert also made pioneering contributions to the treatment of the spatial derivatives using the spectral technique, helping Canada become the first country to use a spectral model to produce operational forecasts.

QUESTION: Are you concerned about the public's general perception of our ability to predict the weather? Do you think the public may have unreasonable expectations of what we can forecast?

ANSWER: They seem to be unreasonable to us, but they are not unreasonable to me because that is exactly the kind of expectations that I have: the same as the public. I will only be satisfied once we produce exact forecasts, just like astronomers tell you when the next eclipse is going to take place three years in advance. I think that is the kind of goal we should aim for in Numerical Weather Prediction: produce exact forecasts as long in advance as we possibly can.

André Robert on his expectations for NWP (Interview by H. Ritchie, 1987)

After retiring from Environment Canada in 1987, Dr. Robert took an academic position at the Université du Québec à Montréal (UQAM). In collaboration with colleagues, he demonstrated that the use of the combination of the semi-implicit and semi-Lagrangian schemes allowed an efficient integration of the fully elastic, non-hydrostatic equations (without major approximation to the physical equations). This paved the way to a more general atmospheric dynamical framework, applicable for a wide range of scales. The prototype model became known as the MC2 (mesoscale compressible community) model. Still today, the operational GEM model uses this efficient formulation, which allows its use for global (GDPS), regional (RDPS) and very high resolution, convection-permitting (HRDPS) weather forecasts. Put simply, MSC's operational NWP systems are still using the efficient approaches developed by Dr. Robert for global, regional, and local weather forecasts.

Both in academia and in his professional life, Dr. Robert was an exceptional trainer and science communicator. He trained a large number of students and passed on to them his thoroughness, his ambitions for science, and his unique way of approaching challenges.

International influence and legacy

Dr. Robert had a strong influence on the international climate modelling community, producing global analyses in connection with World Meteorological Organization (WMO) research projects, long before Canada began making operational global forecasts. He was a founding member and one of the first chairs of the Working Group on Numerical Experimentation (WGNE), a very influential group of researchers established in the early 1970s that oversaw the development of modern-day climate science and meteorology. He was also an editor of publications on NWP for the WMO from 1972 to 1976. Between 1974-1975, Dr. Robert was the president of the Canadian Meteorological and Oceanographic Society. In 1974, he chaired the International Symposium on Spectral Methods in NWP in Copenhagen, Denmark. In 1975, he was a member of the Canadian delegation to the 7th WMO Congress. From 1980 to 1983, he was a member of the Natural Sciences and Engineering Research Council's selection committee for fellowships in meteorology, astronomy and aeronomy.

In summary, Dr. Robert was not just a pioneer in Canada, but a global titan in using mathematical approaches to simulate the evolution of the atmosphere with computers. His influence and work continue to have profound effects today. NWP has revolutionized our ability to forecast weather and climate change. Weather models now allow us to forecast 5 days ahead with greater accuracy than 24-hour forecasts 50 years ago. Dr. Robert's scientific innovations accelerated development within this field and laid the groundwork for much of the modern conception of weather prediction.

Recognition and awards

Dr. Robert was an inspiration to many in the field. His clear and compact explanations and presentations were memorable and impactful and he was frequently invited to lecture in the USA and Europe. He was invited to the National Center for Atmospheric Research in the USA, the United Kingdom

Meteorological Office, the École normale supérieure in Paris, France, and the WMO in Geneva, Switzerland.
Dr. Robert received these awards and recognitions over the course of his life:

- 1967 and 1971, was awarded the President's Prize from the Canadian Meteorological and Oceanographic Society.
- 1968, became a Fellow of the American Meteorological Society.
- 1974-75, served as President of Canadian Meteorological and Oceanographic Society.
- 1981, awarded the Second Half Century Award by the American Meteorological Society.
- 1982, became a Fellow of the Royal Society of Canada.
- 1986, received the Patterson Medal from the Atmospheric Environment Service (former name of the Meteorological Service of Canada).
- From 1987 to 1993, was a Scientist Emeritus for the Atmospheric Environment Service.

Posthumously, Dr. Robert's recognition continued. Following his passing, seminars on Dr. Robert's work were periodically held in Montreal. Later, in 1997, CMOS published the André J. Robert Memorial Volume, a compilation of his most important published papers.
Dr. Robert's legacy is not limited to the history of the CMC; his vision, creativity and innovative approaches live on and continue to inspire MSC as an organization today. Looking further, Dr. Robert is one of the "heroes of the 1970s" whose intellectual capital still informs major elements of the numerical treatments employed in current operational forecasting systems around the world today.

1871 | 2021
1971 | 2021

50e anniversaire d'Environnement et Changement climatique Canada
Environment and Climate Change Canada's 50th anniversary

150e anniversaire du Service météorologique du Canada
Meteorological Service of Canada's 150th anniversary

Sources

- Ritchie, H., Bélair, S., Bernier, N.B., Charron, M., Fortin, V., Garand, L., Houtekamer, P., Husain, S., Laroche, S., Lemieux, J.-F., Lin, H., McTaggart-Cowan, R., Milbrandt, J., Mitchell, H., Pellerin, P., Pudykiewicz, J., Separov, L., Smith, G.C., Tanguay, M. & Vaillancourt, P.A. (2021). Recherche en Prévision Numérique Contributions to Numerical Weather Prediction, Atmosphere-Ocean, 59, accepted.
- Harold Ritchie & André Robert (1997) A Historical Perspective on Numerical Weather Prediction: A 1987 Interview with André Robert,

Atmosphere-Ocean, 35:sup1, 1-24, DOI: 10.1080/07055900.1997.9687340

- Laprise, R., 1994 : André Robert 1929-1993 (biographie). Le Climat 12(1), 81-94.
- Andrew Staniforth (1997) André Robert (1929–1993): His Pioneering Contributions to Numerical Modelling, Atmosphere-Ocean, 35:sup1, 25-54, DOI: 10.1080/07055900.1997.9687341
- “Zephyr” – Environment Canada Atmospheric Environment. March, 1974.
- “André Robert, Climatologist: The first Canadian scientist to successfully perform a simulation of the atmosphere’s general circulation using a computer model” – Science.ca Scientist Profile
- CMOS Bulletin. August 1994. Vol. 22, No 4.
- The CMOS Archives provided photos, source material, references, and editing support

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__Christopher Smith__ is an analyst for the Meteorological Service of Canada. He wrote this profile with support from many current and former Environment and Climate Change Canada employees, the Canadian Meteorological and Oceanographic Society (CMOS), as well as former students, former colleagues, and the family of André Robert.

December 16, 2021: Advancing Canadian Researcher Involvement in the UN Decade of Ocean Science for Sustainable Development: Town Hall Outcomes from December 3, 2021 (EN)

Advancing Canadian Researcher Involvement in the UN Decade of Ocean Science for Sustainable Development: Town Hall Outcomes from December 3, 2021

WRITTEN BY CMOS BULLETIN SCMO ON DECEMBER 16, 2021. POSTED IN NEWS & EVENTS, OCEANS, WHAT'S CURRENT.

– By Alexa Goodman –

Friday, December 3, 2021: An interdisciplinary and intergenerational group of 40 Canadian marine researchers came together for a town hall to sketch an actionable path forward towards collaboration under the UN Decade of Ocean Science for Sustainable Development. The town hall was co-hosted by MEOPAR, CMOS, CNC-SCOR and UQAR, with support from ArcticNet, ASLO, Québec Océan, Réseau Quebec Maritime, and the Tula Foundation/Hakai Insititute, all of which are part of the consortium of organizations initiating the United Nations Decade of Ocean Sciences for Sustainable Development Community of Practice (CoP).

The focus of the CoP is on ocean science (natural and social) and will work with other over-arching organizations with complementary mandates in supporting UN Decade initiatives in Canada. The CoP offers support for idea development, and membership will be fully open to institutions, University-based research centres, industry organizations as well as to individual researchers, including Early Career Researchers (ECRs) (e.g., students, postdocs), and community researchers. Specific activities of this CoP will be decided by its membership and will focus on organization, communication and action. If you're interested in becoming a member of the CoP, and/or staying up to date on their activities, you can add your email to the mailing list.

What is the UN Decade of Ocean Science for Sustainable Development?

The United Nations declared 2021 to 2030 as the Decade of Ocean Science for Sustainable Development. With the mission of 'transformative ocean science solutions for sustainable development, connecting people and our ocean', the Decade provides a common framework to ensure that ocean science can fully support individual countries' efforts to achieve the UN's 2030 Agenda for Sustainable Development.

The Decade is a 'once in a lifetime' opportunity to create a new foundation, across the science-policy interface, to strengthen the management of our ocean and coastlines for future generations. The Decade requires engagement with scientists, governments, academics, policymakers, businesses, industry, indigenous communities, and civil society to stimulate new ideas, solutions, partnerships, and activities. The town hall marked the first step in bringing together Canadian marine researchers wanting to work collaboratively on proposing applied research related decade activities and actions for Ocean Decade Endorsement later in 2022.

What did we learn from the Town Hall?

During the session, participants were invited to share their ideas and perspectives, highlighting how Canadian researchers can collaborate on existing initiatives and begin to develop our own. The conversation centred on the current need for improved communication around UN Decade activities, international collaboration and interdisciplinary and intersectional projects and programmes that incorporate health, natural and social sciences at a national scale. Emphasis was made on using bottom-up approaches to address community needs, especially with respect to climate change.

As participants pointed out, Canada has taken leadership in indigenous engagement, involvement of early career ocean professionals (ECOPs), and incorporating equity, diversity, inclusion and accessibility (EDIA) into research and management. These principles should and will transcend into research projects and actions submitted for endorsement, in addition to all facets of the CoP, where Canada set an example for other nations at an international scale by taking leadership on endorsed actions.

Where do we go from here?

One of the first steps: Improving access to information. There is a clear need for centralizing information about individuals and groups working on UN Decade Actions as mandated in their strategic plans, plus an inventory of UN Decade events and activities. This information needs to be made accessible and as clearly as possible to improve knowledge mobilization, and connect a broader range of stakeholders to ensure interdisciplinary collaboration. Once the CoP is officially enacted in early 2022, their research assistant will be conducting an

ongoing inventory review and will share the results in a variety of ways including a webpage, slack channel and mailing list.
In terms of developing new initiatives for Ocean Decade Endorsement in 2022, the group discussed focusing on an all-encompassing interdisciplinary and intersectional programme to address climate action in Canada, with a public and indigenous engagement component and international partnerships. This idea will be flushed out during the next Town Hall at MEOPAR's Annual Scientific Meeting on Thursday, February 3, 2022, from 1-2 PM ADT. If you're interested in participating and would like to stay up to date with the Community of Practice, be sure to sign up for the mailing list.

Alexa Goodman (she/they) *is a marine manager passionate about doing good for our planet and its people. They joined the MEOPAR team in May 2021 as Training Program Manager to equip the next generation of marine researchers with the knowledge and tools needed to excel in their careers. Alexa is a scientist with a background in marine biology and environmental sustainability, and is an environmental justice activist, lover of the ocean, and a driving force in managing abandoned, lost, and discarded fishing gear, also called 'ghost gear'. They've been a Sustainable Oceans Alliance Youth Leader since 2018 and have continued making waves of change since!*

December 9, 2021: CMOS Bulletin Solidarity Statement with Wet'suwet'en land defenders (EN)

CMOS Bulletin Solidarity Statement with Wet'suwet'en land defenders

WRITTEN BY CMOS BULLETIN SCMO ON DECEMBER 9, 2021. POSTED IN CLIMATE, OTHER, WHAT'S CURRENT.

The CMOS Bulletin stands in solidarity with members of the Wet'suwet'en Nation as they peacefully defend their unceded territories in the face of militarized police action, raids and arrests by armed RCMP officers. As a science communications platform that exists for the advancement of climatology, meteorology and oceanography in a time of climate emergency, the Bulletin understands our specific responsibility to support Indigenous peoples' efforts to protect their lands, waters and peoples against the expansion of fossil fuel infrastructure.

https://justseeds.org/graphic/defend-yintah/

The Wet'suwet'en hereditary leadership has held continuous and full jurisdiction over the nation's 22,000 square kilometres of unceded territory for time immemorial. In the 1997 Delgamuukw-Gisday'wa court case, the Supreme Court of Canada ruled that the Wet'suwet'en people—as represented by their hereditary leaders—have never given up rights and title to their lands. What's

more, both Canada and British Columbia have moved to implement the United Nations Declaration on the Rights of Indigenous peoples which includes provisions recognizing the right to self-determination, the need to obtain the Free, Prior and Informed Consent of Indigenous nations when development is proposed in their territories, and expressly condemns the forced removal of Indigenous peoples from their lands and territories.
The recent raids and arrests by the RCMP on Wet'suwet'en land defenders as well as the ongoing efforts to construct the Coastal GasLink pipeline through Wet'suwet'en territory are in direct violation of Wet'suwet'en law, Canadian law, B.C. law and internationally recognized rights for Indigenous peoples.
We urge the federal and provincial governments to adhere to the demands of the Wet'suwet'en Hereditary Chiefs, as stated here:

- That the province of B.C. cease construction of the Coastal Gaslink Pipeline project and suspend permits.
- That the UNDRIP and Wet'suwet'en right to free, prior and informed consent (FPIC) is respected by the state and RCMP.
- That the RCMP and associated security and policing services be withdrawn from Wet'suwet'en lands, in agreement with the letter provided by the United Nations Committee on the Elimination of Racial Discrimiation's (CERD) request.
- That the provincial and federal government, RCMP and private industry employed by CGL respect Wet'suwet'en laws and our governance system and refrain from using any force to access Wet'suwet'en lands or remove Wet'suwet'en people.

What's more, we call on our readership to respond to the Wet'suwet'en land defenders' call for solidarity as outlined here and in the Wet'suwet'en Supporter's Toolkit.

November 1, 2021: A field laboratory class from home to study snow characteristics (EN)

A field laboratory class from home to study snow characteristics

WRITTEN BY CMOS BULLETIN SCMO ON NOVEMBER 1, 2021. POSTED IN ATMOSPHERE, UNCATEGORIZED, WEATHER, WHAT'S CURRENT.
– By Julie Mireille Thériault, Émilie Gauthier, Mathieu Lachapelle and René Laprise –
Learning atmospheric sciences
A degree in atmospheric sciences can lead to a variety of professions such as weather forecaster, climate analyst, field measurement specialist or a career in communications. It is, therefore, essential to provide students with training that uses the multiple approaches that reflect those career opportunities. This is the objective of the new undergraduate program in atmospheric sciences, implemented at UQAM in 2019 (Laprise and Thériault, 2019). The program includes three new laboratory courses on the topics of: (1) synoptic meteorology,

(2) field measurements and laboratory experiments, and (3) numerical model simulations.

The laboratory class, which covered field measurements and laboratory experiments, was given for the first time during the winter 2021 semester. Given all the restrictions brought on due to the pandemic, this laboratory required a creative approach. Students were asked to collect data from around their homes during a winter storm. This meant that all the students documented the same storm and then analyzed the spatial and temporal evolution of the amounts and types of precipitation. These manual measurements were compared to automatic measurements. This approach proved to be successful and will likely remain as part of the course curriculum, with additional data collection in the field.

The goal of the field laboratory class

The goal of the laboratory is to teach students how to answer a scientific question according to the scientific method. Five experiments were conducted, during which students were asked to answer a scientific question using specific meteorological instruments as well as the manual data that were collected from their homes, located across the province of Québec (Fig. 1).

The weather station that is used is installed on the roof of the Université du Québec à Montréal (UQAM) President-Kennedy Building in downtown Montréal (Fig. 1). It is equipped with a standard thermometer, anemometer and precipitation gauge. Sophisticated instruments are also used at this station: an optical-laser disdrometer to characterize the size and fall speeds of precipitation particles, and a Micro Rain Radar to characterize the precipitation aloft.

In addition to automatic measurements, the students were given a 60x smartphone microscope, a baking pan, a kitchen scale and a ruler (Fig. 1). These were used to document snow crystals as well as to measure snow depth and density, as presented in Kumjian et al. (2020).

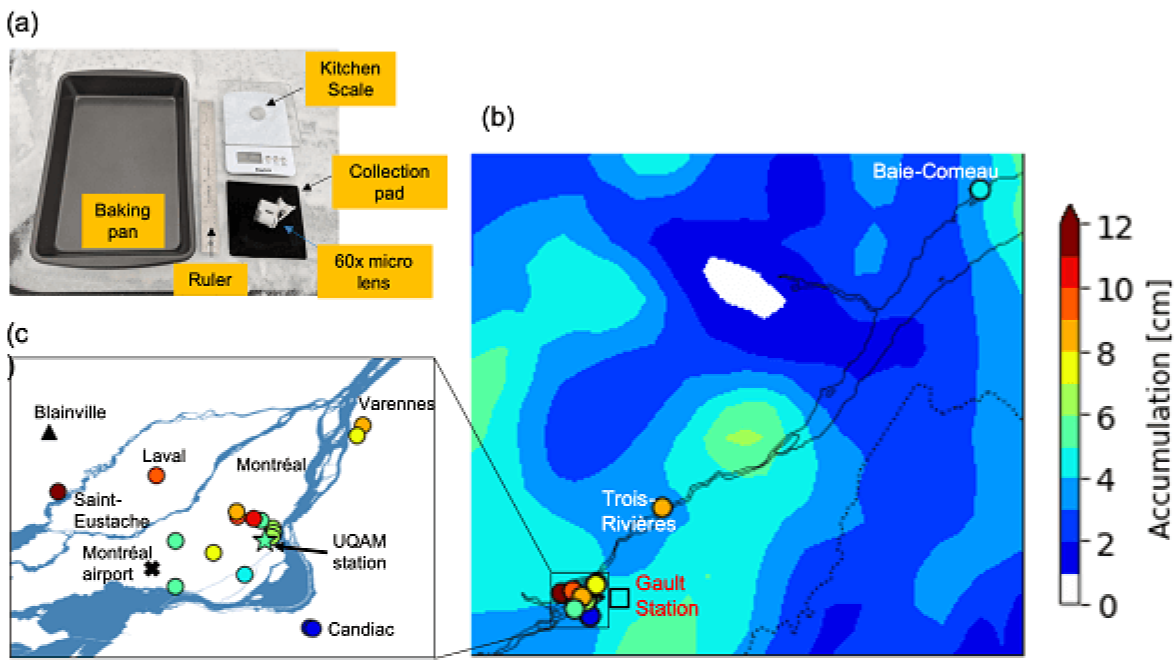

Figure 1: (a) Tools used to measure accumulated snow, snow density and to photograph precipitation particles. (b and c) Spatial distribution of students around Montréal and across the province of Québec. The circles indicate the amount of precipitation measured by each observer and the triangle is the location of the Environment and Climate Change (ECCC) S-band radar at Blainville. The accumulated precipitation ranged from 1400 UTC 5 February to 1700 UTC 6 February 2021, while a low-pressure system moved from Montréal to Baie-Comeau. The colour contours indicate the accumulated solid precipitation data obtained from ERA5 liquid water equivalent accumulated precipitation (x 10 to convert into snow depth).

During their first experiment, the students learned how to use the smartphone microscope and how to perform manual snow measurements. The following three experiments focused on analyzing the data obtained from the meteorological instruments using the Python programming language. Basic computing codes were provided to the students using Jupyter Notebook to read and analyze the data. The last experiment was to conduct a case study by collecting precipitation data across Québec Province (Fig. 1) and analyzing the large-scale atmospheric conditions using ERA5 reanalysis data (Hersbach et al., 2020). The precipitation data that were collected included manual measurements of snowfall and snow particles, as well as documentation of the precipitation type, degree of riming, and degree of aggregation.

Finally, a group of students was responsible for producing daily weather forecasts to determine which event to document. Luckily, a snowstorm occurred at the exact time that the class was scheduled for the students in the Montréal area, but the storm occurred at a later time (after the storm passed) for those in eastern Québec.

Documented snowfall event

On 5 February 2021, an occluded front, first located over the Great Lakes region and associated with a low-pressure system, moved northeastward across the province of Québec. Precipitation started in the Montréal area at around 1430 UTC 5 February 2021 and reached Baie-Comeau 21 h later.

Up to 12.7 cm of snow was measured across the province by the students located in the Montréal area, Trois-Rivières and Baie-Comeau (Fig. 1). The measurements from the students varied from 2 cm to 12.7 cm across the Montréal region. The UQAM weather station single-Alter Geonor measured 5.4 mm in liquid water equivalent, whereas the Environment and Climate Change Canada station at the Montréal-Trudeau Airport measured 3.8 cm of snow. As another comparison, the ERA5 accumulated precipitation is shown in Fig. 1, with similar amounts of precipitation for the Montréal area (4–5 cm of snow).

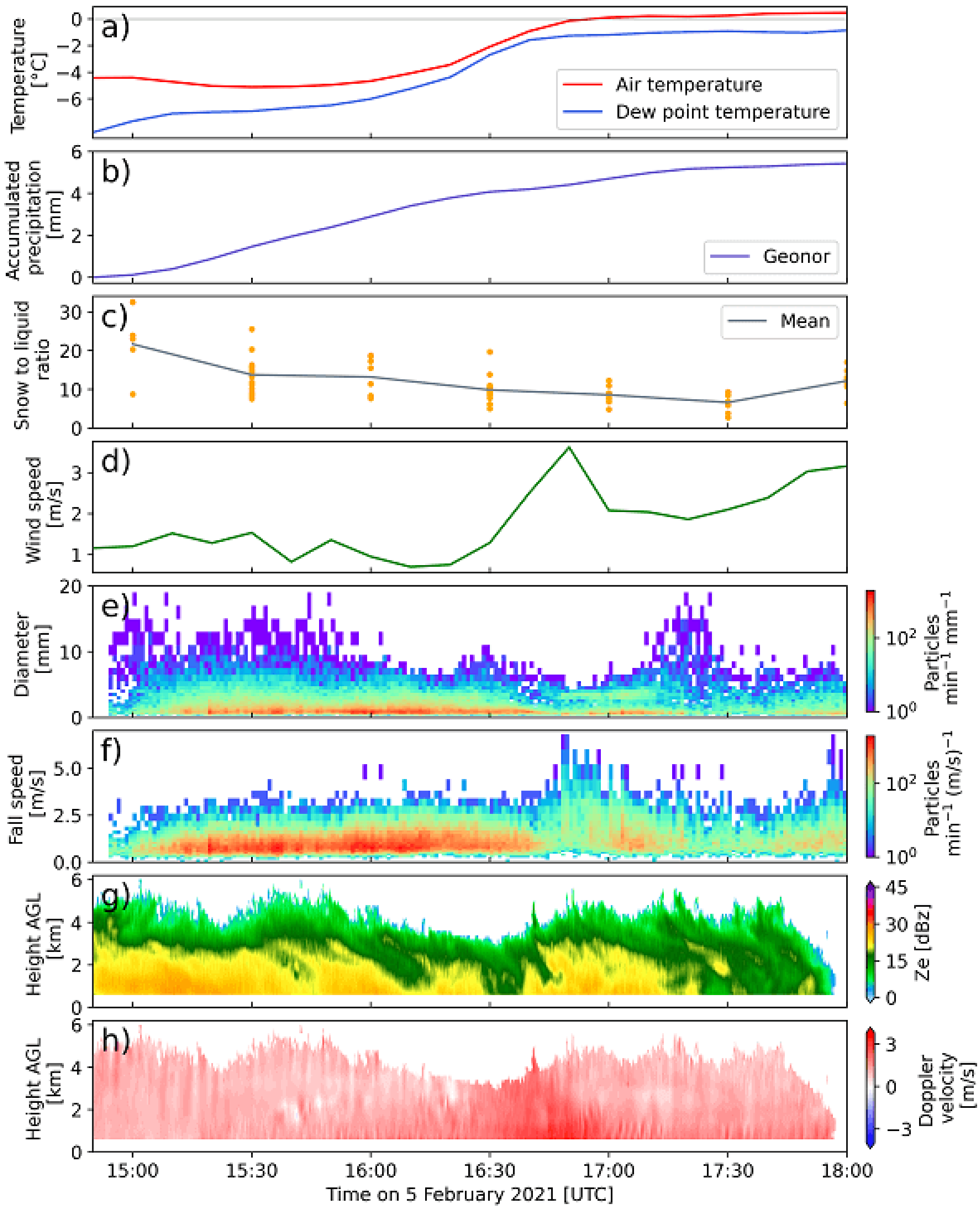

Figure 2: Timeseries of the weather conditions on 5 February 2021 at the UQAM station. The images above show (a) air temperature and dew point temperature timeseries, (b) accumulated precipitation, (c) snow-to-liquid ratio, (d) wind speed, (e) particle size distribution, (f) particle fall speed distribution, and (g and h) Micro Rain Radar (MRR) reflectivity (Ze) and particle Doppler velocity.

A range of accumulated snow was measured by the students. The snow density measurements from the Montréal area varied from 31 to 361 kg/m3, which corresponds to the range for snow-to-liquid ratio of 2.76:1 to 32.45:1 (Fig. 2). Spatial variation of snow accumulation in the Montréal area was obtained, which could be due to the local-scale variations or experimental errors such as whether the baking pan was placed in a windy environment or near vegetation. Higher precipitation amounts were measured west of Montréal and decreased to the east, from 12.7 cm in Laval to 7–8 cm in Varennes (Fig. 1). Stations located farther west were closer to the centre of the low-pressure system. Reflectivity measured by the scanning Environment and Climate Change S-band radar located in Blainville also showed spatial variability (not shown). Finally, snow density increased during the event, which is consistent with the increasing environmental air temperatures of -4.43°C to 0.47°C. Lower amounts of snow accumulation were measured in southern locations such as Candiac, where snow was reported to have melted.

Many types of ice crystals were also reported by the students. Mainly dendrites, needles and plates were observed at the onset of precipitation, whereas smaller plates and snow pellets were reported at the end of the event. Students also reported the occurrence of rimed snowflakes during the event (Fig. 3). Less riming was observed at the start of the precipitation event over the Montréal area. At these locations, the degree of riming increased during the event until particles were completely rimed. Completely rimed particles referred to as snow pellets, were also reported by students in Montréal, Laval, Varennes and Candiac during the last hour of the event, when the environmental air temperature was at its highest, at 0.47°C. Overall, various degrees of aggregation (not shown) and riming were reported during the precipitation event.

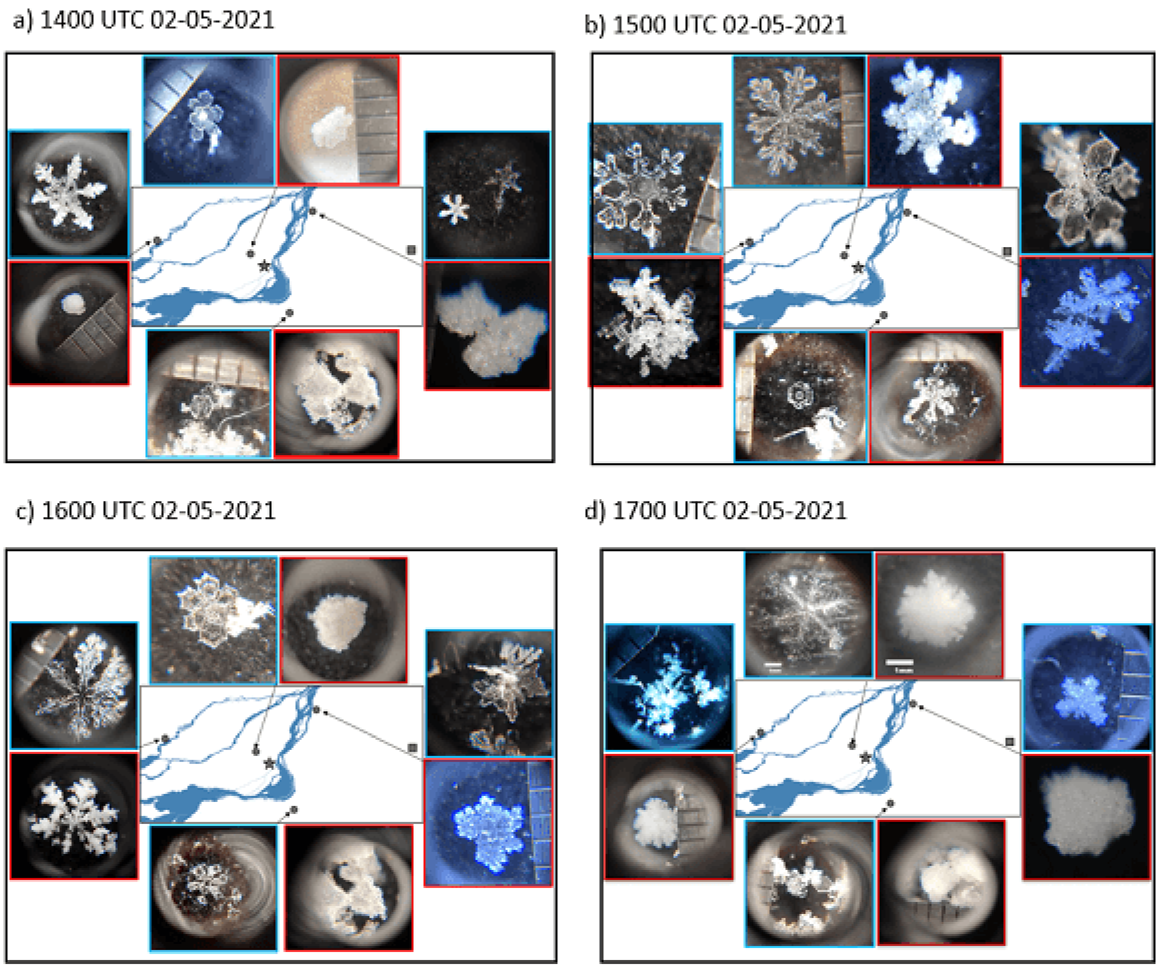

Figure 3: Spatial and temporal variations of solid precipitation particles in the Montréal area at various times on the 5 February 2021: (a) 1400 UTC, (b) 1500 UTC, (c) 1600 UTC, and (d) 1700 UTC. The locations of the four stations shown in the maps are provided/detailed in Fig. 1c. The photos in blue and red indicate, respectively, lowest and highest amount of riming.

The sizes of the snow particles that were measured were compared with those from the OTT Parsivel laser-disdrometer and the vertically pointing radar (Micro Rain Radar, MRR) located at UQAM (Fig. 2). The particles measured by the disdrometer were between 0.2 mm and 20 mm, with an average of approximately 1 mm. This is the same range of sizes estimated by the students. Although smaller particles with various degrees of riming were predominant, all students also reported the occurrence of aggregated ice crystals. Several students reported large aggregates that were often too large to photograph with the micro lens. Growth by aggregation may have occurred, as suggested by the relatively constant particle Doppler velocity (~1 m/s) and the increased reflectivity towards the surface, as measured by the vertical-pointing radar at UQAM. The atmospheric sounding launched at 1500 UTC 5 February 2021 suggests relatively warm atmospheric conditions aloft, which are favourable for aggregational growth (Fig. 4).

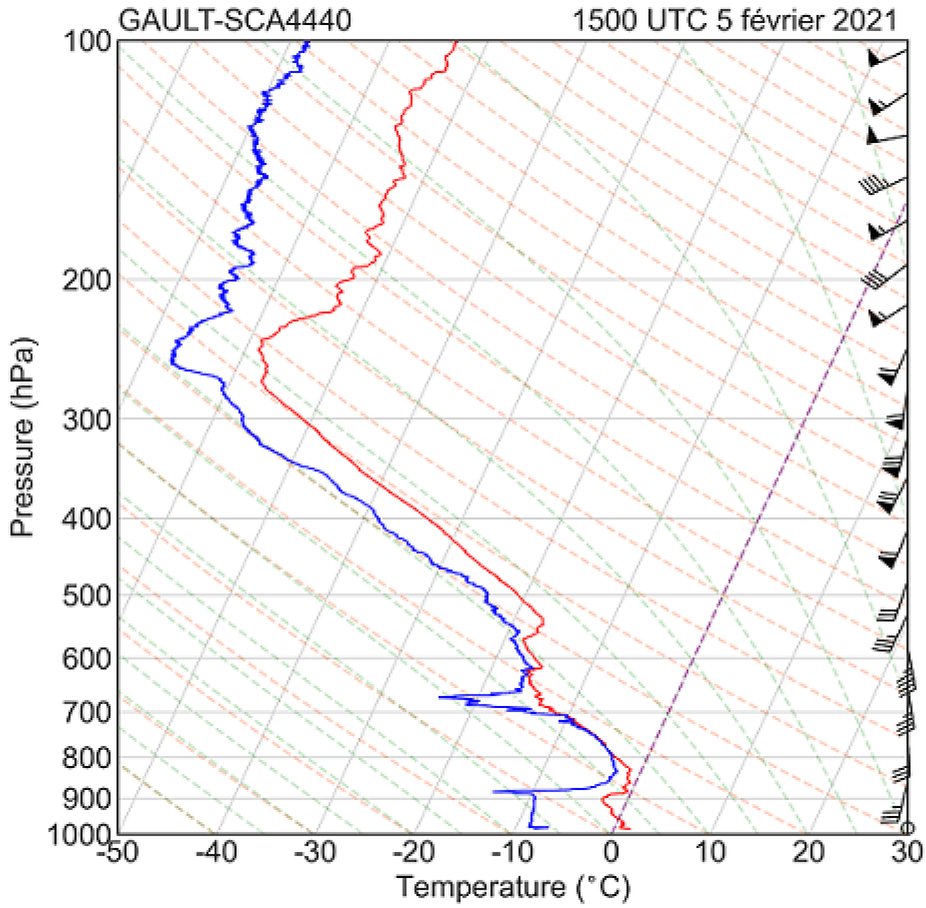

Figure 4: Atmospheric sounding launched from the Gault station (Fig. 1). The red line is the environmental air temperature and the blue line is the dew point temperature. The wind speed and direction are indicated by the wind barbs.

The outcome

The 2021 winter term saw 19 students registered in the field measurements and laboratory experiments class, including one student from outside the program. Up to 500 microphotographs of ice crystals were collected across the province of Québec, from Montréal to Baie Comeau. Students learned how to conduct a small field research project by collecting and analyzing field data and summarizing the findings in scientific reports. In the future, the students will go one step further by designing an experiment and installing the instruments themselves to document atmospheric conditions during a storm.

Finally, students were well prepared for this laboratory as they had learned how to read and interpret synoptic weather charts, atmospheric soundings and synoptic-station data during their first laboratory class on synoptic meteorology.

In addition to gaining experience in the field, the analysis of field data also taught students about winter weather phenomena (in this case). They can now look forward to learning more about the physical processes that are involved. The knowledge gained here serves as a good transition to the third laboratory class, during which numerical model simulations will be used to verify hypotheses that are related to either phenomenon observed during the second laboratory class or various atmospheric-related fundamentals that were covered in other courses. Together, these three laboratory classes provide key tools for studying atmospheric-related phenomena using a practical approach.

***Julie M. Thériault** holds a Canada Research Chair in Extreme Winter Weather Events and is a professor at the Department of Earth and Atmospheric Sciences at the Université du Québec à Montréal.*
***Émilie Gauthier** is an undergraduate student in atmospheric sciences at the Université du Québec à Montréal and was registered to the class.*
***Mathieu Lachapelle** is a PhD candidate in atmospheric sciences at the Université du Québec à Montréal and contributed to the experimental design.*
***René Laprise** is the chair of the undergraduate program in Earth and Atmospheric Sciences and professor at the Université du Québec à Montréal.*

October 25, 2021: The Weather Forecast Research Team: A Nexus of Operational Weather Forecasting and Research in Western Canada (EN)

The Weather Forecast Research Team: A Nexus of Operational Weather Forecasting and Research in Western Canada

WRITTEN BY CMOS BULLETIN SCMO ON OCTOBER 25, 2021. POSTED IN UNCATEGORIZED, WEATHER, WHAT'S CURRENT.

– By Julia Jeworrek, Dr. Rosie Howard and Prof. Roland B. Stull –

Foundations

In 1995, the Weather Forecast Research Team (WFRT) [1] was formed by Prof. Roland Stull at UBC with four Ph.D. students. Living in the complex mountainous and coastal terrain of British Columbia (BC; Fig. 1a), Prof. Stull witnessed the challenges involved in making accurate forecasts for western Canada. As a result, he expanded his focus from atmospheric boundary layers to numerical weather prediction (NWP), with the ultimate goal of improving forecasts for western Canada.

The WFRT began making daily operational forecasts using a small ensemble of two NWP models in 1996. As the team grew, so did the ensemble size and range of research projects, drawing the interest of external collaborators and clients. By combining research with operational weather forecast services for the last 25 years, the WFRT has become one of the largest ensemble weather-forecast providers in Canada outside of Environment and Climate Change Canada (ECCC).

Today, the WFRT consists of over 20 people including senior academics, graduate and undergraduate students, IT staff and technicians, adjunct professors, and visiting scientists. This international team brings together people from diverse academic and cultural backgrounds; the resulting exchange of ideas and expertise is key to their scientific innovation.

The team's operational NWP ensemble suite includes initial and boundary conditions from six global or continental models [2], fed into four NWP models [3] with various grid lengths, domain sizes (Fig. 1b), forecast horizons, and physics parameterizations. Their largest ensemble of 48 members is run using initialization fields from 00 UTC, and reduced-member ensembles are initialized at 06, 12, and 18 UTC. To provide the best accuracy and optimal utility, these deterministic weather forecasts are post-processed in several different ways; downscaled to weather stations and forecast locations of interest, statistically bias-corrected, and combined into calibrated probabilistic ensemble forecasts, to name a few. These post-processing components are key to combating the challenges presented by complex terrain and the relative lack of upstream data over the Pacific Ocean. An automated real-time verification tool is currently being developed for quality control and to facilitate further relevant research.

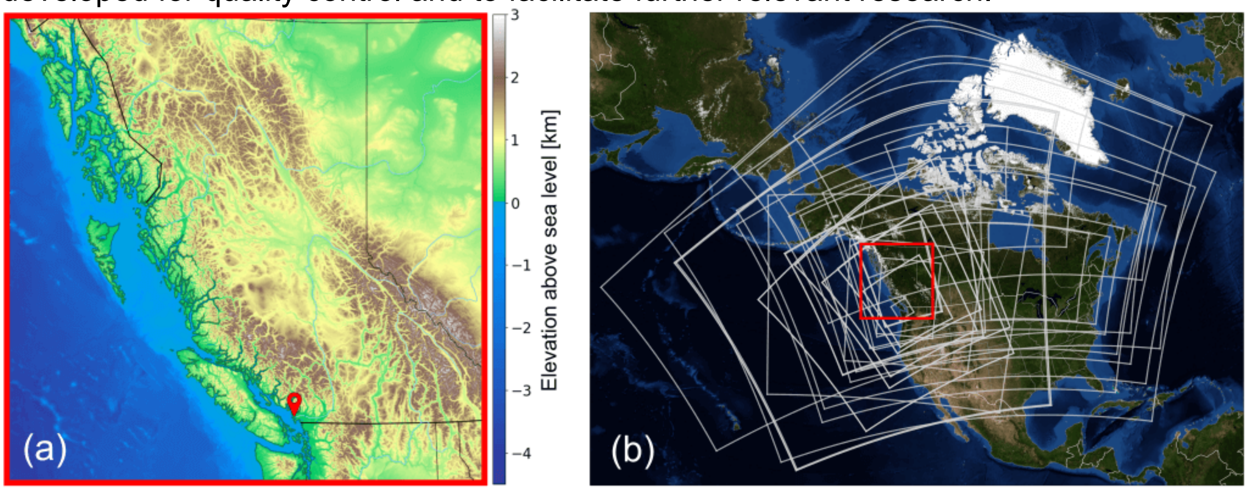

Figure 1. (a) Elevation map of BC displaying its complex terrain and coastline; red pin indicates UBC in Vancouver. (b) WRF model domains used in the WFRT ensemble (explore the individual model domains in Google Maps); red inset frames the area shown in Fig. 1a. Note that the MPAS (global) and MM5 (regional) domains are not shown.

To accommodate the vast number of operational model runs, data-processing routines, and research needs, the WFRT employs high-performance computing resources including their own 552-core Linux cluster, the Google Cloud Platform, and Compute Canada allocations, as well as dozens of auxiliary servers for post-processing and data storage. A multitude of forecast products (e.g., animated maps, graphs, text files) are prepared to serve the unique requirements of our clients in a timely manner. The synergy between (a) their forecasting services for external clients, which provides funding to keep the non-profit team operating, and (b) their cutting-edge research, which continuously improves forecast quality, mutually benefits enhancements in scientific and economic applications.

Throughout the years, the team's research has sprouted many branches and attracted a wide range of clients. The following sections cover two of their primary research and development themes.

Clean Energy

Close collaboration with BC's primary electric utility, BC Hydro, began in 1997 and has sparked diverse research projects in support of clean energy. This long-standing partnership ultimately aims to improve the safety, reliability, and economic productivity of electric power operations. Also, in the face of the current climate crisis, clean-energy efficiency continues to be an area of growing significance. Over the years, the WFRT has built and maintained a customized suite of NWP products that are reliable, innovative, cost-effective, and state-of-the-art. Regular communication ensures that the WFRT can target new requests effectively and attend to technical issues promptly.

BC Hydro requires daily hydrometeorological forecasts for their reservoir operations and planning. WFRT products include hourly and daily, deterministic and probabilistic, bias-corrected point and gridded forecasts of precipitation and temperature. One example is a 15-day "superensemble" consisting of 167 individually post-processed weather forecasts, spanning a large range of possible atmospheric scenarios (Fig. 2). The resulting probabilistic forecasts assist BC Hydro in their everyday decision-making based on their risk tolerance for certain events.

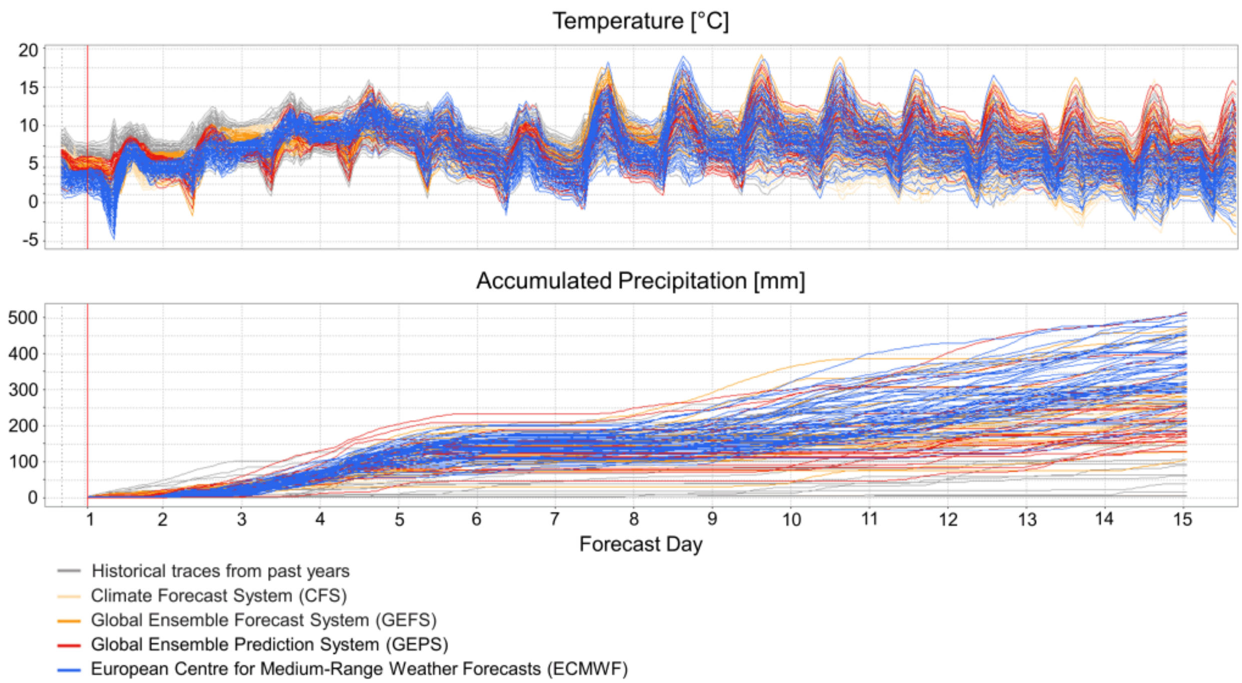

Figure 2. Example of temperature and accumulated precipitation forecasts from the superensemble.

Various active research projects are being conducted to further enhance the hydrometeorological forecasts:

- Comprehensive precipitation evaluation studies of systematically varied NWP physics parameterizations over one year and for certain meteorological cases are helping to identify strengths and flaws among different model setups. The team is also investigating whether verification

using ground-based dual-polarization radar observations can inform improvements of hydrometeor representation in microphysics parameterizations.
- Extreme rainfall events are often challenging to forecast and statistical and machine learning (ML) post-processing methods improve accuracy. One of the WFRT advances is a new technique that combines analog ensembles, Schaake shuffle, and convolutional neural networks.
- Since run-of-river hydroelectric power output depends on stream inflow, a current study is developing an ensemble of streamflow forecasts.

Although hydroelectricity contributes by far the most (~ 91%) to BC's total electricity generation capacity, wind power also provides a small (~ 4%) but important proportion. The WFRT produces hourly probabilistic 7-day wind speed forecasts each day for 18 wind farms in BC and the Columbia River Gorge. Where available, wind-speed observations are used for bias correction. Wind forecast performance is verified using various metrics on a weekly and seasonal basis. Additionally, the WFRT produces wind power and energy production forecasts based on wind-farm power curves. The following projects exemplify efforts to continually improve these forecasts:

- Physics parameterizations that previously performed well for hub-height winds and precipitation forecasts also gave good results in recent windstorm case studies. This consensus among studies investigating different variables helps identify optimal model configurations for BC.
- A hybrid dynamical-statistical downscaling method is currently in development to derive wind forecasts on finer spatial scales, incorporating ML techniques.
- Another project attempts to enhance the local topography representation in a weather model.
- Artificial neural networks with NWP input were trained on observations from two wind-farms to predict wind power up to 7 days ahead.

Additional projects have targeted improvements in power grid operations (e.g., electric load predictions, forecasts for transmission lines), solar power forecasts (e.g., parameterizations for solar radiation based on cloud cover), and biomass energy operations (e.g., dispersion forecasts for odor alerts).

BlueSky-Canada: Fire Weather and Smoke Forecasting

Wildfires and smoke affect the safety of Canadian residents and tourists every year. To mitigate these issues, in 2007 the WFRT began researching and developing smoke forecasts with support from BC and Alberta provincial health agencies. Since 2010, the team has been running the BlueSky smoke modelling framework operationally, adapted for use in Canada, to produce ground-level smoke concentration forecasts every day (Fig. 3).

In recent years, several provinces have seen an increase in wildfire frequency and extent. Also, it is predicted that future forest-fire seasons in North America will bring increased levels of fire and smoke activity. To help determine potential fire behaviour across the country, fire-weather forecasts were added to the team's portfolio in 2019.

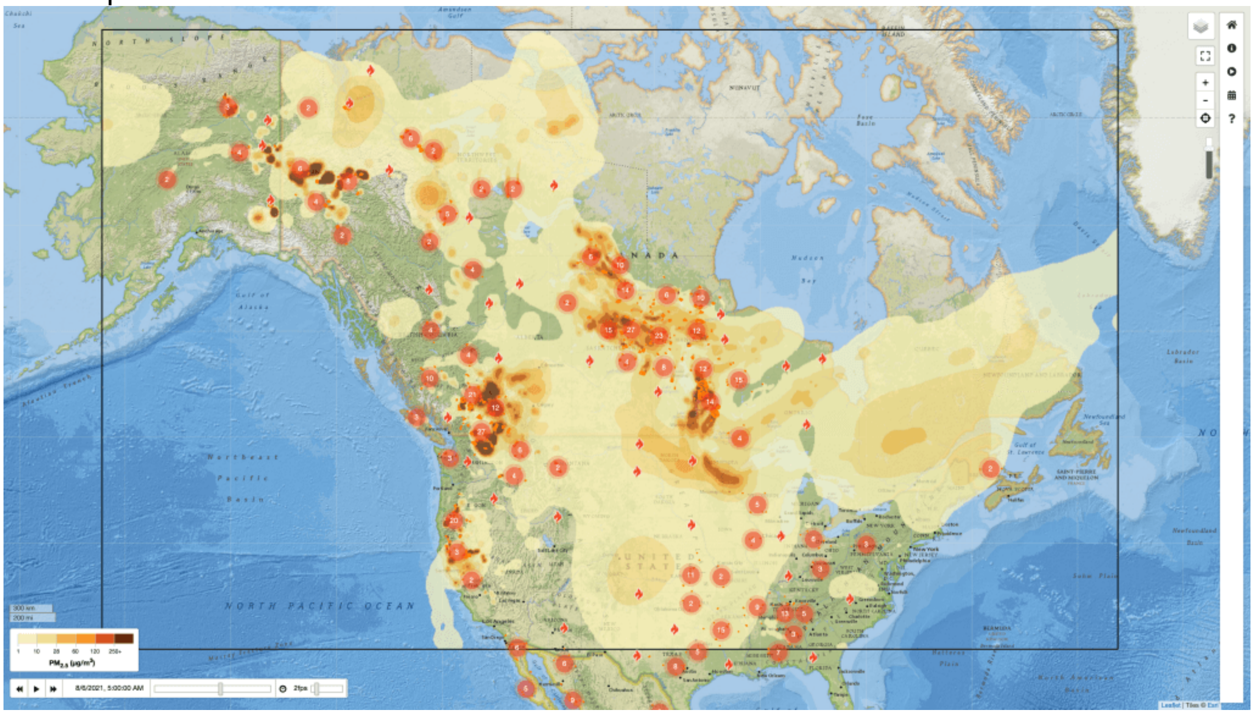

Figure 3. Ground-level smoke (PM2.5) concentrations predicted by BlueSky-Canada for North America on 5 August 2021. Black box indicates the domain which has 12-km grid spacing. Contours indicate smoke, red icons are fires, and red circles are clusters of fires. (Source: https://firesmoke.ca)

BlueSky is a complex pipeline of models driven by inputs of (a) fire information such as satellite hotspots and ground reports, and (b) meteorology from one of the team's NWP models. Using these, it calculates fire emissions, smoke plume rise, and dispersion, with updates every six hours. During the fire season (April–October), a website displays the output on animated maps (see user tutorials). The modelling chain of the pipeline provides plenty of opportunities for improvement and further research:

- A new plume-rise parameterization for predicting smoke injection height was recently developed using large-eddy simulations for a wide range of wildfire and atmospheric scenarios. This is currently being implemented into BlueSky for comparison with the old scheme, which was designed for smoke chimney stacks, not wildfires.
- Estimating emissions relies on accurate fire growth predictions; BlueSky currently assumes linear growth with 3-day persistence. The WFRT is working on a new hybrid empirical-ML model to replace this simplistic approach.
- The team's near-real-time quantitative verification system actively helps identify forecast issues. It is being further developed to include a column-integrated smoke product that can be validated fairly and qualitatively using satellite images.

- Wet deposition can remove smoke from the atmosphere during dispersion; case studies are currently being conducted to tune parameters that model this process with the goal of reducing the false alarm rate.

Outlook
The WRFT plans to move more of their research and operations to cloud computation services. They also continue exploring artificial-intelligence tools, while broadening their research towards regional climate projections. To read more about the UBC WFRT, including past and current projects, visit their website.

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[1] The WFRT is a research facility of the Department of Earth, Ocean and Atmospheric Sciences (EOAS) at the University of British Columbia (UBC) in Vancouver, Canada.
[2] 0.25° and 0.5° Global Forecast System (GFS), 0.5° Navy Global Environmental Model (NAVGEM), 32-km North American Mesoscale Model (NAM), 15-km Global Deterministic Forecast System (GDPS), 0.5° Action de Recherche Petite Échelle Grande Échelle (ARPEGE), and 0.25° Icosahedral Nonhydrostatic model (ICON).
[3] Weather Research and Forecasting (WRF) model with Advanced Research WRF (ARW) and Nonhydrostatic Mesoscale Model (NMM) cores, Pennsylvania State University / National Center for Atmospheric Research mesoscale model (MM5), and the Model for Prediction Across Scales (MPAS).

***Julia Jeworrek** is a PhD Candidate in Atmospheric Sciences with the Department of Earth, Ocean and Atmospheric Sciences at UBC. Her research area is in precipitation predictability. She previously obtained a BSc in Meteorology in Germany and a MSc in Meteorology in Sweden.*
***Dr. Rosie Howard** is a UBC Research Associate and WFRT Associate Director. Her current research focus is wildfire smoke modelling. She also keeps the team operating with her leadership and supervision across the board.*
***Prof. Roland B. Stull** is a professor of atmospheric sciences at UBC. He is a fellow of both the Canadian Meteorological and Oceanographic Society (CMOS) and the American Meteorological Society (AMS), and winner of the Killam Teaching Prize.*

September 27, 2021: CoCoRaHS Precipitation Network (EN)
CoCoRaHS Precipitation Network
WRITTEN BY CMOS BULLETIN SCMO ON SEPTEMBER 27, 2021. POSTED IN WEATHER, WHAT'S CURRENT.
– By Rick Fleetwood –
CoCoRaHS (Community Collaborative Rain Hail and Snow) is a volunteer network of mostly community members and organizations (e.g. watershed groups, conservation authorities, agriculture organizations, etc.) that measure and report precipitation daily through the CoCoRaHS website or Smartphone

App. CoCoRaHS began in Colorado in 1998 and expanded into Canada in 2011 following a massive flood in Manitoba and Saskatchewan. The goal of starting CoCoRaHS was to increase the coverage of high quality precipitation data including rainfall, snowfall and snow depth which can vary significantly even over relatively short distances. This data is important to many different users including flood forecast agencies.

CoCoRaHS precipitation gauge after a heavy rainfall.

Today in Canada, the Meteorological Service of Canada (MSC) uses CoCoRaHS data to help monitor the extent and severity of storm systems. Agriculture and Agri-Food Canada use it in monitoring for droughts. Many other organizations and individuals use this important information regularly, including the agriculture sector, emergency responders and the media. The network helps fill in data gaps that the MSC would not be able to fill in on its own. Anyone can access the data and is available freely at the CoCoRaHS website.

CoCoRaHS Canada volunteers sign up for the program online and are required to purchase the official CoCoRaHS precipitation gauge which is available at a discounted price. This ensures measurements are consistent across the network. Volunteers receive detailed instructions about how to take accurate measurements from the CoCoRaHS website. All the required information is available there (including videos) in both English and French to allow volunteers to review the material and get started reporting once they receive their gauge.

CoCoRaHS volunteer measuring snowfall and snow pack depth

Participants are encouraged to take measurements daily but this isn't always possible. When volunteers are away, they simply submit a multi-day report (total amount of precipitation accumulated in your gauge while away) on the first day that they resume reporting.
As observations are received, the CoCoRaHS maps and database are continuously updated so data can be viewed almost immediately after a report is submitted. Many volunteers find it interesting to see what others are reporting in their area…did you have the biggest rainfall or snowfall?…the CoCoRaHS map will let you know! Many volunteers like participating because they are interested in the weather and measuring precipitation is one way to be better informed about weather events plus they can access this data from anywhere across their province or Canada. There is also the satisfaction of knowing their daily efforts to collect this data is important and is used by many different users/organizations. Many media weather personalities are using this data regularly and crediting Cocorahs Canada which provides some satisfaction to volunteers to see their reports on TV and Social Media pages.

There are thousands of CoCoRaHS volunteers across the US and Canada. It's fun and educational!

The CoCoRaHS volunteer precipitation monitoring network has grown substantially since it was first established in Manitoba in 2011. The network now has over 750 volunteers across all provinces and most territories and continues to grow. The data is used by many organizations and is recognized as a reliable and valuable source of precipitation information. CoCoRaHS is always looking for new volunteers so if are interested in participating you can register here.
To find out more or become a volunteer check out the CoCoRaHS Canada info pade and check out this great introductory video.

Rick Fleetwood *is a meteorologist with the Meteorological Service of Canada (MSC) located in Fredericton NB. He has been managing the Applied Climatological Services program for Atlantic Canada since 2004. He spent the first half of his career as an operational meteorologist forecasting at weather centres in Edmonton, Halifax and Fredericton. In addition to his regional climate role, he has managed some national climate projects including the partnership with CoCoRaHS Canada since it was established in 2012.*

August 23, 2021: UN Decade of Ocean Science for Sustainable Development – Profiled at the 2021 CMOS Congress Town Hall Session (EN)

UN Decade of Ocean Science for Sustainable Development – Profiled at the 2021 CMOS Congress Town Hall Session

WRITTEN BY CMOS BULLETIN SCMO ON AUGUST 23, 2021. POSTED IN OCEANS, WHAT'S CURRENT.

– By Andi White and Helen Joseph –

Overview

The 2021 CMOS Congress, under the theme of Climate Change – Risk, Resilience, Response, provided an opportunity to showcase efforts emerging under the UN Decade of Ocean Science for Sustainable Development (the 'Ocean Decade') and discuss Canada's role. The Ocean Decade (2021-2030) will deliver “the ocean we need for the future we want” and offers a once-in-a-lifetime opportunity for all ocean stakeholders to apply critical ocean science and knowledge to reverse the cycle of decline in ocean health and support the sustainable development of our ocean. For Canada to successfully support the Ocean Decade and achieve meaningful and long-lasting impact will require a coordinated approach to identify and execute collaborative ocean initiatives that are inclusive of all members of the ocean community. Together, we must transform how we currently do ocean science through the creation of new ideas, solutions, partnerships, and applications.

HCJ Consulting and Fisheries and Oceans Canada (DFO) hosted a Town Hall style session about the Ocean Decade on June 11 as part of the 2021 CMOS Congress programming. The session informed participants about the Ocean Decade, featured a suite of speakers who highlighted examples of collaborative Canadian science projects and programs relevant to the Ocean Decade ambitions, and provided an opportunity to discuss how together, the Canadian ocean community can generate and share ocean-related data and knowledge to help advance the Ocean Decade. In addition, they hosted a poster session related to the same theme with an opportunity for discussion.

Buoy Sampler

Andrea (Andi) White (Senior Science Advisor, DFO) gave an overview presentation about the Ocean Decade, its vision, mission, and objectives (i.e. Outcomes and Challenges). Of particular interest was that the Ocean Decade defines ‘ocean science’ quite broadly and includes not only natural and physical sciences but also social sciences, Indigenous knowledge, local and experiential knowledge, policy, humanities, etc. This inclusivity across disciplines aligns with the intention that the Ocean Decade will be transformative, innovative and more inclusive, taking a transdisciplinary approach to addressing issues and designing solutions. Andi highlighted that in order to advance progress under the Decade, the Canadian ocean community will need to work collaboratively to shift to a new way of working together, by leveraging and enhancing existing partnerships and by building new ones within Canada and beyond.

Supporting the Ocean Decade: Canadian Case Studies

A series of five presentations followed this overview of the Ocean Decade, featuring initiatives that are well-positioned to help advance progress towards various aspects of the Ocean Decade. The presenters outlined their experiences in conducting ocean science in Canada in the context of a specific thematic area, with a particular focus on the challenges and opportunities they have encountered with respect to co-designing, co-producing, and co-delivering of ocean science.

Shayla Fitzsimmons (Executive Director, Atlantic Regional Association of the Canadian Integrated Ocean Observing System (CIOOS)), spoke of her work, both regionally and nationally, and how these efforts will advance progress under Ocean Decade Outcome #6, “An Accessible Ocean”. CIOOS is working across the country and across sectors to unite the knowledge, expertise and digital infrastructure of Canada’s ocean observing community. Shayla emphasized the desire of Canadians to work together on ocean data management as the driving force behind CIOOS. However, the biggest challenges to achieving this were described to be siloed data – a “collect and forget” attitude, a lack in the skillsets necessary for ocean data management, the difficulty to know what data exists, and the recognition of the value of any lost data.

Kim Juniper (Chief Scientist, Ocean Networks Canada) highlighted projects that showcase the benefits of collaborating with Indigenous knowledge holders and local experts to foster ocean literacy in Canada – a key pillar of Ocean Decade Outcome #7, “An Inspiring and Engaging Ocean”. Kim stated that Indigenous engagement was well articulated at the 2019 Ocean Obs conference and that those discussions provide a foundation for meaningful engagement and partnerships going forward under the Ocean Decade. He also emphasized the importance of youth engagement through ocean literacy initiatives and that inclusion of, and training opportunities for, early career ocean professionals was critical if we are to make progress towards Ocean Decade outcomes. He also noted that the Ocean Decade mantra of “leave no one behind” must be a guiding principle for our collaborations in ocean science.

Paul Myers (Physical oceanographer, Professor, and Co-Associate Dean Research, University of Alberta; Chair of the Canadian National Committee for the Scientific Committee for Oceanic Research (SCOR)) discussed Canadian ocean modelling efforts and how this work can contribute to progress under Ocean Decade Outcome #4, “A Predicted Ocean”. In his comments, Paul observed that while ocean modelling and prediction work is clearly in support of Outcome #4, these efforts underpin other Ocean Decade Outcomes including “A

Safe Ocean", "A Sustainably Harvested Ocean", "A Healthy and Resilient Ocean", among others. He discussed the need for efforts to further engage scientists in the Ocean Decade, including a specific communication strategy and national mechanisms to support coordinated efforts to engage in Decade activities. He described efforts within Canada to build towards an integrated Canadian ocean modelling community that includes an initial framework for the Canadian NEMO Ocean Modeling Forum, as well as establishing a virtual Ocean Modelling Community of Practice. Although Paul acknowledged the importance of science in underpinning policy and decision-making, he emphasized the need for the continued support of 'big idea' and exploratory science and fundamental research.

ECOP on CCG vessel

Melissa Anderson (Assistant Professor of Economic Geology, University of Toronto; Co-Chair of Canada's National Research Vessel Task Team) provided an overview of the National Research Vessel Task Team, whose mission is to improve researcher's access to ships and infrastructure, and its Modular Ocean Research Infrastructure as examples of effective cooperative ocean research coordination. She also presented some of the challenges and opportunities that arise with large-scale cooperative projects, including how these kinds of efforts may more rapidly advance progress under the Ocean Decade and the reliance on certain types of research that require access to research vessels and a plethora of large-scale infrastructure. Melissa noted the need for collaborative efforts, often at an international level, to help fulfil the domestic need for research vessel time, given that large-scale equipment is expensive and that access to domestic vessels is limited.

Eric Peterson (Co-founder, Tula Foundation; Director, Hakai Institute) indicated that Hakai aims to be a catalyst – drawing together partners from different parts of Canada's ocean community. Eric spoke about his experience in conducting and coordinating co-designed ocean research and described his idea to convene a cross-border Collaborative Centre for the Cascadia region and the Northeast Pacific Ocean basin. He noted that there are many active collaborations across the region and that Hakai is well-positioned to serve as a connection between these existing programs while seeking out and integrating new initiatives and blending in any new Ocean Decade Actions. He noted that the current proposed Ocean Decade Actions will spawn regional projects as case studies and nodes via coordinated experiments.

Town Hall Discussion

This session also included an interactive dialogue session that discussed considerations for advancing Canadian co-designed research that would support the Ocean Decade. This portion of the event was moderated by Douglas Wallace (Professor, Dalhousie University; Scientific Director of MEOPAR).

The need for *access to ocean data* emerged as a common theme. Discussants noted that while predictions may underpin many of the Ocean Decade Outcomes, ocean data defines the foundation for these predictions. The discussion noted the need for capable ocean data managers as a skill in which Canada may have a gap and that funding and recruitment efforts could focus on this area.

The need for *effective communication* was another challenge area that the group identified for the Canadian ocean science community. The discussion emphasized communication in terms of sharing ocean science data and results, as well as sharing ideas and information. In order to build knowledge and capacity, communication must flow on who is doing what work and how individuals can get involved in initiatives.

Pacific diver

The discussion prioritized the challenge of *access to Canadian research vessel time,* noting the lack of available vessel time as a barrier to research programs, particularly for Early Career Scientists who may lack established networks of contacts to explore opportunities. Discussants reiterated that in many cases, Canadian researchers have had, and will continue, to seek international collaborators in order to access research vessels, including for some missions that occur with Canadian waters.

Participants expressed the *value of Canadians seeking collaboration beyond the borders of Canada* and that the Canadian ocean science community should reflect on where they could make the most impact, particularly through the lens of *capacity building and exchange*. Noting that the Ocean Decade prioritizes this issue, the group challenged the Canadian community to organize better in order to become more effective in this regard.

The discussion highlighted *adequate and available financial support* as a perennial issue that has the potential to become more challenging if we are realistically to move to a more co-designed approach to research. In particular, the group noted the need for funding for Early Career Ocean Professionals, especially for those located internationally, not only for research but also for training and other development opportunities.

There was also discussion around the concept that academia should ensure that they undertake *science relevant to policy and decision-making*. Although many agreed on the importance of producing results that serve this purpose, many strong voices advocated for discovery science as critical to advancing knowledge and innovation, and as the primary role of academic research. In the context of this discussion, participants floated the idea of integrating training for graduate students and postdoctoral fellows to help them consider broader policy objectives when designing research projects, noting that the current setup of the academic 'reward system' does not necessarily support this approach.

There was also mention that *gender equity* issues, including exposure to harassment and bias, remain as very real barriers for women, and non-binary individuals in Canadian ocean science, particularly in certain sectors.

Poster Session

In addition to the Town Hall Session, four poster presentations nested under the Ocean Decade theme at the Congress focused on data management, vessels, and infrastructure; the CMOS Congress program provides further details. The poster session provided authors with the opportunity to present the content of their posters, as well as highlight the linkages to the Ocean Decade. A brief discussion with session participants generated ideas about how data collection and management might evolve over the Ocean Decade, particularly to support medium- to long-term monitoring of marine protected areas. Examples included transitioning from cabled observatories to moveable infrastructure (e.g. onto vessels) and increased participation of vessels of opportunity in data collection initiatives. Discussants mentioned that achieving the Ocean Decade objectives will require increased collaboration and sharing of vessels and infrastructure more broadly.

Next Steps

As the Ocean Decade continues to gain momentum, ongoing opportunities will emerge for engagement, including the upcoming 'Ocean Decade Laboratories'. Laboratories are globally focused, interactive sessions addressing each of the seven Ocean Decade Outcomes. Check out this link for more information and note the upcoming Laboratories regarding the 'Predicted Ocean' and 'Productive Ocean' are scheduled for Fall 2021. In addition, you can find more information here via the Intergovernmental Oceanographic Commission and on DFO's Ocean Decade website. DFO's Ocean Decade Office invites you to reach out for information and to discuss ways in which you can get involved.

After 32 years in the Government of Canada working on the science-policy interface of ocean science, climate change, Arctic, and international ocean issues, Helen Joseph launched HCJ Consulting in 2014 to provide advisory and management consulting services. To date, Helen's services have been provided to the Canadian government and academic clients, as well as to international clients. Highlights include work on the External Review of the Sustaining Arctic Observing Networks (SAON), the Canadian Network of Northern Research Operators (CNNRO), and the Canadian Consortium of Ocean Research Universities as a follow-up from the Council of Canadian Academies assessments on ocean science. Helen is a past-Chair of the Canadian Meteorological and Oceanographic Society's Arctic Special Interest Group.

***Andi White** is the Manager of International Science Initiatives at Fisheries and Oceans Canada (DFO), where she plays a leadership and coordination role for*

Canadian engagement in the UN Decade of Ocean Science for Sustainable Development, as well as other international commitments related to ocean science. Through her work at DFO, she champions domestic and international efforts to promote gender equity in ocean science and is keen to inspire youth and early career ocean professionals to become the next generation of leaders. Andi has a Master's of Science in Environmental Toxicology and Chemistry and nearly 20 years of federal government experience that includes conducting scientific research, providing science advice, and bridging the science-policy interface.

August 13, 2021: Micrometeorology Field Season in the NWT, 2021: A Photo Story (EN)

Micrometeorology Field Season in the NWT, 2021: A Photo Story

WRITTEN BY CMOS BULLETIN SCMO ON AUGUST 13, 2021. POSTED IN ATMOSPHERE, CLIMATE, WHAT'S CURRENT.

– By Kathryn Bennett –

Image 1: Camp. In May-June 2021 I spent 4 weeks living and working on the tundra at Trail Valley Creek Research Station (TVC) north of Inuvik, North West Territories. I was at TVC with 6 other researchers from the Université de

Montréal, Wilfred Laurier University, and the University of Eastern Finland. The weather wasn't always ideal, varying from snow and freezing temperatures as pictured here, to sunny and warm with lots of mosquitoes, but we always made the best of it! While at TVC we sleep in the smaller tents and use the larger structures for shared living and working space. The research camp is accessible by air, by land using snowmobiles in the winter or by a short hike from the nearby Inuvik-Tuktoyaktuk Highway in the warmer months.

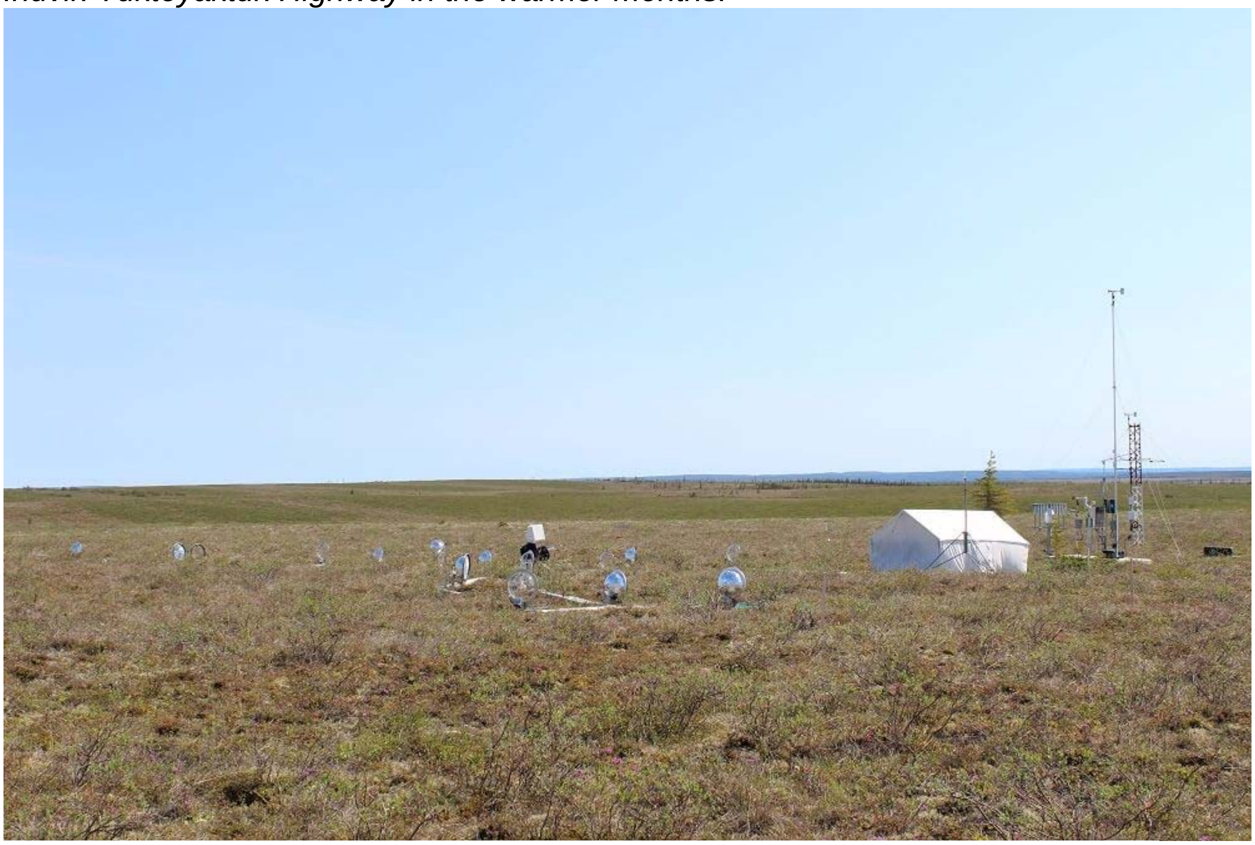

Image 2: Chambers. I work with a variety of equipment at TVC to measure carbon dioxide (CO2) and methane (CH4) fluxes from this tundra ecosystem at different spatial scales. This equipment includes an automated chamber system (foreground), manual chambers (not pictured), and an eddy covariance tower (the red and white tower on the right). The tent in this image houses the analyzer and computer system that allows us to see greenhouse gas fluxes measured by the automated chambers in real-time and check on the system from anywhere in the world.

Image 3: Soil gas. I collect soil gas to understand below-ground processes that influence the fluxes I measure at the surface. At this tundra site, I am using a hollow stainless-steel tube connected to a plastic syringe to collect a sample of gas from below ground. I took this sample from beside a collar (right) that I have installed to measure above-ground fluxes. The collar ensures that I am measuring the same location since I return multiple times throughout the field season to take measurements. When I place the chamber on top, the collar allows me to create a sealed "mini-atmosphere" (see image 4) to measure gas fluxes. Photo was taken by Carolina Voigt.

Image 4: Manual chambers. To measure CO_2 and CH_4 fluxes in harder to reach places, like this slope next to a lake, I use a manual chamber set-up. The manual chamber (right) is placed on an installed collar (image 3) and connected to a Picarro GasScouter (left) that analyzes the greenhouse gas concentrations within the chamber over time. I use a laptop to watch the fluxes in real-time and save a copy of the data. This is one of my favourite sites because of the beautiful lake view!

Image 5: Thermokarst Lake. I am also interested in greenhouse gas emissions from thermokarst lakes which are formed by the thaw of ice-rich permafrost. I a use a syringe to collect a water sample to measure the dissolved CO2 and CH4 concentrations of this ice-covered lake. I was delighted to see the beautiful light blue and orange colours of the melting lake ice.

Image 6: Reindeer. We don’t get many visitors at TVC. This is one of three caribou that I saw outside our camp in early June. Photo taken by Joëlle Voglimacci-Stephanopoli.

Image 7: Sunset. During the summer months, the sun does not set north of the Arctic Circle, allowing for beautiful views 24/7. I took this photo outside my tent at midnight.

Kathryn Bennett (she/her) *is a research professional working on a variety of projects examining the impacts of permafrost thaw and climate change on carbon and nitrogen cycling in boreal-Arctic ecosystems with the Atmosbios Lab at the Université de Montréal. Prior to this role, she completed my B.Sc. in Environmental Science and Sustainability at the University of New Hampshire and an M.Sc. in Earth Sciences also at the University of New Hampshire. Her research interests include greenhouse gas flux dynamics, stable isotopes, and aquatic biogeochemistry in northern ecosystems.*

August 2, 2021: Ocean School – An unforgettable virtual experience (EN)

Ocean School – An unforgettable virtual experience

WRITTEN BY CMOS BULLETIN SCMO ON AUGUST 2, 2021. POSTED IN OCEANS, WHAT'S CURRENT.
– By Heather Delagran and Sonya Lee –

Imagine you are flying over the lush temperate rainforest of British Columbia's central coast. Thick vegetation covers the ground between towering trees. Two bears wander along a log-strewn beach. In the distance, there are rounded mountain peaks. Sunlight shines through the trees on a snowy mountainside. You look down and see a stream cutting through the forest, packed with salmon, their shining backs cutting the surface of the water. You dive in and swim upstream alongside the shimmering, ghostly bodies of transforming salmon.

These are the kinds of experiences that can help build a connection with the ocean and motivate us to protect our ocean and the watersheds that lead to them. These are the kind of virtual experiences Ocean School is bringing into classrooms. In this article, we will share a bit about Ocean School, and the process behind the creation of our latest module, the Harvest.

Ocean School at Fogo Island

About Ocean School. Ocean School is a free educational website produced by the National Film Board of Canada in collaboration with the Ocean Frontier Institute at Dalhousie University. Our mission is to promote ocean literacy in youth, ages 11 to 15 years old so that they understand our influence on the ocean and the ocean's influence on us. We combine documentary footage of marine science work with 360 video, virtual reality, and activities for the classroom that teachers can download and use.

Ocean School has over 65 pieces of media organized in five themed modules – Healthy Habitats, Evolving Ecosystems, Protecting Populations, Marine Migration, and, coming soon, The Harvest!

The Harvest module was filmed with the Haíłzaqv Nation and the community of Bella Bella. It explores the deep inter-relationships between land, sea and people. In this module, you will learn how herring, salmon, and Haíłzaqv people are interconnected in the rich ecosystem of what is now known as British Columbia's Central Coast. This module celebrates the reciprocal relationship between the Haíłzaqv and these keystone species—a relationship that's over 14 000 years old!

We are grateful to the Haíłzaqv Nation and the community of Bella Bella for making this module possible. The community shared invaluable time, knowledge and patience with the Ocean School team. There were four key pillars to our approach in the creation of this module and working with the Haíłzaqv (Heiltsuk) Nation that are described in the following section. These were largely informed by Jess Housty's article, "You're not the Indian I had in mind".

Openness and authenticity. We approached the research and development of the module filmed in Haíłzaqv Nation with open minds. We did not form a production plan until we consulted extensively with the community and established a relationship of trust and understanding. It was important for us to find ways to invite Haíłzaqv voices and perspectives into our process and find out what stories, science (traditional and western), issues and questions the community wanted to address.

Community collaboration. We collaboratively developed the educational framework for the module with educators, community leaders, Hereditary Chiefs, Heiltsuk Integrated Resource Management Department (HIRMD) and the Coastal Guardian Watchmen. The community helped to identify people, projects and stories to feature, including our youth host, Jordan Wilson. We also spent several days with Haíłzaqv educators to develop the activities that accompany the filmed content. Together, we established a process to validate the final activities and usage of the Haíłzaqv language in our content.

Ocean School at Cocos Island

Ownership, cultural heritage and intellectual property. Throughout the production, we had conversations with key community members about ownership and transmission of knowledge and culture — Are there things that we shouldn't film, or that we should only film with explicit permission? Ocean School returned to the community to gather feedback on early edits of the filmed content from HIRMD and community educators. We learned an incredible amount and came away with invaluable feedback. Working with our community liaison, we revised our content to address concerns from the community. Finally, we shared the revised media with the community for approval, before making them public.

Incorporating language. British Columbia is one of the most linguistically diverse places in the world, with over 34 unique Indigenous languages. Due to colonization and policies of forced assimilation, many of these languages, including Haíłzaqv, are endangered. Language is a source of cultural heritage and knowledge. Many Indigenous languages have words to describe concepts that do not exist in English. Ocean School incorporated Haíłzaqv language whenever appropriate into the Harvest module. This effort was made possible by the help and guidance of Haíłzaqv educators, community leaders, Elder Elizabeth Brown and the community Language Committee.

Giving back and building capacity. We thought critically about how the community could benefit from collaborating with Ocean School. In our initial conversations with the community, we asked how we could give back. Our consulting educators identified a resource gap for educational materials that explored herring. This module intends to help fill that gap. We also provided usb sticks with all of the content so that community members and educators could access the content without needing high speed internet. Finally, once more covid restrictions are lifted, we hope to celebrate the completion of the module with the community.

That was our process in a nutshell! We are looking forward to sharing this module with Canada and the world in September 2021, as we continue to build partnerships that will allow us to create new content to address issues like biodiversity loss, plastic pollution and climate change.

Ocean School is empowering the next generation of ocean citizens, researchers, and innovators, with the knowledge and tools to investigate and design innovative solutions for the accelerating challenges that face the world's ocean. Check out the trailer for the new module, The Harvest, and visit the Ocean School today!

Heather Delagran *is an Education Producer with Ocean School and is an education specialist with an M.A in Educational Technology from Concordia University in Montreal, Quebec. Heather started her career as a secondary-school geography teacher in England and the Bahamas. She strongly believes in student-centred, inquiry-based learning. Heather is the author of the Burgundy Jazz Educator's Guide and several human rights education materials and trainings. Heather has been a producer with Ocean School since 2017.*

Sonya Lee *is a Science Producer with Ocean School who holds a B.Sc from Dalhousie University in marine biology and international development studies. She started her career as a Science Educators at the Discovery Centre, teaching science workshops to grades P-12. As an advocate of promoting ocean literacy,* *Sonya was on the Canadian Network for Ocean Education's board of directors from 2015-2017.*

July 16, 2021: Weather and Situation Awareness in Aviation (EN)

WRITTEN BY CMOS BULLETIN SCMO ON JULY 16, 2021. POSTED IN AVIATION, WEATHER, WHAT'S CURRENT.
– By Hyun Su Seong –

Introduction

Pilots in general or commercial aviation rely on accurate weather forecasts to avoid dangerous cell activities during instrument meteorological conditions. Pilots use several weather products to make decisions for their pre-flight activities and in-flight. There are two types of weather products: Alphanumeric (METAR, TAF, SIGMET, PIREP, AIRMET) and Graphical (Upper-Air Analysis, Surface Analysis etc). The former is a text and does not contain images, whereas the latter is a graphical visualization of where convective weather occurs in a specified region. Below is an example of METAR.
METAR CYXU 141600Z 34009KT 270V360 15SM SCT026 20/13 A2985 RMK CU3 SLP109 DENSI ALT 1900FT=
The translation is as follows: London International Airport / June 14th, 1600 UTC / Wind 340 True at 9 knots with variation 270 to 360 degrees / Visibility 15 statute miles / Scattered clouds (3 – 4 oktas) at 2600ft / Temperature 20°C and dew point 13°C / Altimeter 29.85 inches of mercury/ Remarks: the lowest reported cloud is Cumulus with 3 oktas / Mean sea level pressure 1010.9 hPa / Density altitude 1900ft.
Outside the aviation community, METAR may look like a mix of incoherent words and numbers. I have always wondered how pilots focus on flying an aircraft while monitoring and decoding such a complicated text. I found out that this is largely because pilots have good situation awareness.
Weather and Situational Awareness
Pilots and ground controllers are used to seeing much more complicated forecasts than above. With experience, they have gotten used to decoding and understanding alphanumeric forecasts without the need to frequently revisit aeronautical information manuals. Experience allows the development of heuristics (or mental shortcuts) and therefore helps in processing only the necessary information faster. There is a possibility that introducing a new system to replace alphanumeric products might cause confusion for some pilots because

there would be a steep learning curve in adapting to new design specifications. This can be illustrated with a simple example of computer coding. Suppose there is a programming module a programmer wants to import into his code. He was familiar with the module and had prior experience in using it. Unfortunately, his codes fail to execute several times because the program could not locate certain functions from the module. He visits the module's documentation and finds that much of the old functions now have been deprecated (it means they are replaced by newer codes in codebase). This means that he must rewrite the code in a different way to successfully load the desired function. It will take time for the programmer to navigate and learn how to write a code using that module again. Thus, just because a new system (or product) is introduced does not mean that one can easily adapt to it. It takes time to replace previous knowledge.

In the case of aviation weather, a new system may result in either a pilot struggling to interpret weather or become complacent (that is, they trust the new system so much that they eventually lose the ability to decode alphanumeric forecasts). The problem with complacency is that when the new system fails, a pilot flying (PF) is forced to go back to traditional alphanumeric products which he or she may have forgotten how to understand. Whatever the case, it is not ideal in an occupation where multiple decisions in the span of few minutes must be made to protect the lives of passengers. This is the reason why a new system or product must be rigorously scrutinized and tested before it is introduced to the market. If it is introduced without a careful examination, a user will not be able to maintain situation awareness. This will negatively affect user's performance.

In human factors engineering, situation awareness (SA) is defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1995). The definition contains the three levels of SA: Perception, Comprehension, and Projection (Endsley, 1995). SA is not an action (Wickens, 2008). Rather, SA is a constant evaluation and conjoining of elements found in the current environment to make sense of the surrounding situation. Here is a simple example in the context of aviation meteorology. Suppose there is downpour and strong gust while a PF is preparing for landing and he or she recognizes turbulent weather during the descent (level 1). The PF would naturally look for recently issued SIGMET or METAR to understand the current weather at the destination airport (level 2). Finally, the PF sees the need for incorporating SIGMET information into the calculation of landing distance to avoid runway excursion or overrun (level 3). After this, the PF will execute an action (calculation of landing distance).

There are some interesting human factors studies that have practical implications for weather and SA. For quantifying SA, I refer interested readers to the research by Lim and Johnson (2012) which looked at the effect of different types of cockpit weather displays on pilot performance under two weather scenarios: convective and turbulence potential. This research may help readers understand why a certain weather display is still effective for SA than other types of displays. For the effect of pilots' licenses and rating on their weather analysis skills, I refer readers to Blickensderfer et al. (2017) and DeFilippis et al. (2018). Both articles also provide useful insights on how to effectively train pilots for weather. Lastly, an article by King et al. (2018) shows why new products may cause more confusion and why many pilots struggle with weather analysis.

Implications

So, what implications do weather and SA have for a human factors engineer? If the engineer wants to improve ab initio pilots' understanding of weather, he or she needs to choose which type of product to develop. When this is done, the engineer must consider the needs of pilots who are not well-versed in aviation meteorology. An exchange of their opinions via interview will help the engineer in brainstorming design specifications for a new product. Here, I should clarify that a 'product' could be a mobile app, computer software, website, or educational material. Next, the engineer – in cooperation with a subject matter expert (SME) such as a meteorologist – should clarify the purpose of the product development and establish a shared mental model to achieve a common goal.

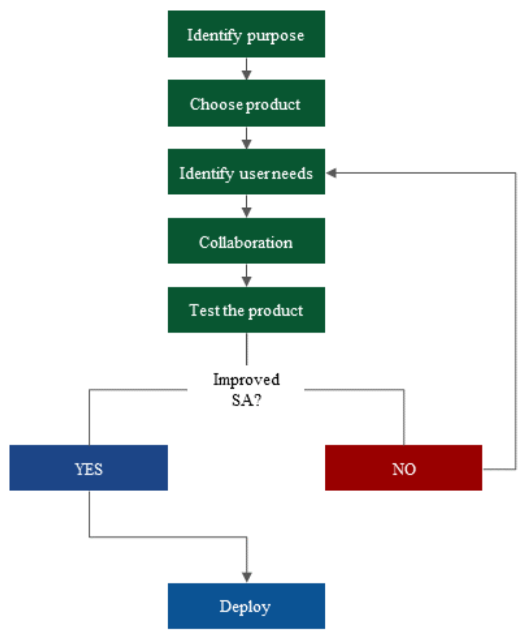

Figure 1. A workflow chart for a product design. Chart created by the author.

The engineer should test the prototype by inviting participants to try it out. For instance, the engineer must confirm that the mobile app – in the opinion of the pilots – is a user-friendly product that does not interfere with their decision-making ability and ultimately SA. If it was found that the app takes too much time to toggle back and forth between interfaces or is cluttered with information, the engineer may need to fix and incorporate the new feedback from potential users. Again, the process of creating a new product is difficult and time-consuming. However, a well-designed product can have an everlasting impact on the performance of users. In this case, it would be maintaining good situation awareness by being well-versed in meteorological concepts.

Hyun Su Seong *is a PhD candidate in systems design engineering at the University of Waterloo. His specialization is human factors and ergonomics. His research area is competency-based education with a specific focus on avialinguistics and miscommunication in pilot-ATC communication. He holds bachelor's in commercial aviation management and master's in geography. His master's research area was aviation meteorology with a specific focus on tropical cyclones and their economic impacts on airports.*

July 9, 2021: Incoming President's Message from Jim Abraham (EN)

Incoming President's Message from Jim Abraham

WRITTEN BY CMOS BULLETIN SCMO ON JULY 9, 2021. POSTED IN MEMBERS, NEWS & EVENTS, WHAT'S CURRENT.

Early in my career, while training to be an operational meteorologist 43 years ago, I signed up to become a member of CMOS. It was an exciting time. Since then, CMOS membership has enabled me to remain connected with friends and colleagues, and develop new relationships with many others from the private sector, other government departments, and universities.

I am therefore honoured to have been chosen as CMOS President. The past year as Vice-President was certainly enlightening. I now appreciate the scope and number of activities undertaken by Gordon, in a part-time position as Executive Director. It was very rewarding working with the Executive team from Southern Ontario, as well as my colleagues from the Centres.

Man with animated hands giving a speach at a podium
Jim Abraham chairing a session at the 2018 Halifax Congress.

I was so happy to get to know our now Past-President, Marek Stastna. We share very similar perspectives on many of our challenges and opportunities; and I congratulate him for his leadership in developing the Strategic and Action Plans that will provide guidance to Gordon, Executive and Council on priorities needing our attention. Marek and I also both enjoy a good craft beer, and looking forward to the chance to actually meet our Past-President in person, and share a pint with him sometime over the coming year.

I would also like to welcome and thank my colleagues from the Halifax Centre who are new to Council this year, and who will be actively providing leadership within the Society while Halifax hosts the new Executive. For 2021-22, Serge Desjardins will be Vice-President, Jinyu Sheng Treasurer, and Emily MacPherson and Abdoulaye Harou, Councillors-at-Large.

My past involvement with CMOS has mostly been through gatherings like Congress, Operational Workshops, and seminars; and several years as the Halifax Centre Chair. However, the area that I see so much potential is support for the youth, our future scientific leaders. Our emerging partnership with the Canadian Water Resources Association's Project WET will enable connecting our weather, water, ocean and climate science with the learning needs of K-12. I would also like to see us enhance our scholarship program to encourage High School and Undergraduate students to continue studies and consider careers in

Earth System Science. I’m thinking we should target some donations and bequests for this purpose.

Since I do enjoy connecting with people, I am considering preparing a regular Newsletter to complement the Bulletin, to keep you all informed of Executive and Council activities, upcoming events, and any news and opportunities relevant to our membership. Thinking of calling it: CMOS Wave?? I welcome any thoughts on this idea. As well, during the Congress, there was some discussion on developing a media strategy. There is a lot of great science to share, and the public should benefit from an improved understanding. Climate drivers of the recent heat extremes in Western Canada would be a good example.

I would like to congratulate David Fissel, Ken Denman and the Victoria Congress team for their extremely hard work in producing an incredibly successful meeting, with an unprecedented number of great presentations and participation.

I welcome the opportunity to connect with as many of you as possible over the next year and really look forward to a return to personal interaction at the 2022 Congress in Saskatoon.