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Story Inside: *Extreme 2014 Wildfire Season in the Northwest Territories, p. 12*

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

Le but de la SCMO est de promouvoir l'avancement de la météorologie et l'océanographie au Canada.

Words from the President

Building Resilience to Climate Change, With Grace Under Pressure

**Editor's correction: The original version of this post contained an error concerning injuries related to the 2019 flood event. We apologize for this error.*

The warnings started in mid April: a deep and rapidly melting central/eastern Canadian snowpack and many days of intensive rain were set to bring unprecedented flooding to riverfront communities across Ontario, Quebec, and New Brunswick. Ottawa River water levels smashed previous records set during the flooding in spring of 2017. Thousands of homes and residents were affected as rising floodwaters combined with strained infrastructure drove sometimes sudden evacuations. Now, in the second week of May, flood waters are subsiding but recovery from this damaging event will be a real long-term challenge.*

The role that climate change plays the almost back-to-back flooding years of 2017 and 2019 is forcing citizens and planners to grapple with tough questions about how to relate to the powerful rivers around which much of Canada's urban infrastructure is built. Such decision making requires scientific understanding of a complex set of problems at a deep level. For example, we have learned, thanks to the work of CMOS 2019 Eastern Tour Speaker Laxmi Sushama's group that an important driver of the Ottawa River Basin region's previous flood, in May 2017, was made more likely by anthropogenic climate change. Specifically, major rain events occurring at this season are two to three times more likely because of human influence. It seems that the April-May 2019 floods shared some of these characteristics and might be a continuation of that pattern. But hydrological science is complex, as Prof. Sushama's paper and Canada's Changing Climate Report (see Chapter 6) make clear. According to the CCCR, "… [projected] increases in extreme rainfall in a warmer climate are expected to increase the likelihood of rain-generated flooding in some regions. Snowmelt-related floods are expected to occur earlier in the year, but it is uncertain how projected warming and reductions in snow cover will combine to affect their frequency and magnitude."

Forecasting the future of flood behaviour in regions like eastern Canada is but one example of major scientific challenges that climate science is dealing with right now. The latest generation of the global climate models used to project future climate change, which are becoming more realistic overall, are also showing that the climate system may be even more susceptible to warming due to greenhouse gases than previously thought. According to the scientists interviewed in the linked article (including Canada's own Dr. John Fyfe), the new results are being met with a range of views. On balance, however, it seems to me that the next round of climate assessments will project a greater degree of warming than previously concluded, which will suggest even more pressure and urgency to act on climate change.

While climate scientists sort out our understanding, citizens, politicians, and other decision makers need to make do with the best up to date information that can be provided. There is plenty of evidence to suggest urgent climate action, as our CMOS position statement on 1.5 degrees of global warming. Pressure is building for decisive climate action, from youth protests and school strikes at home and internationally, to wins at the ballot box for environmentally focused candidates, again both here and abroad. It is my firm continued belief that CMOS's most valuable role in this setting is to bring the best science knowledge forward to decision makers, while ensuring that its own operation as a volunteer organization becomes more sustainable.

Therefore it is fitting that the Scientific Programming Committee (Drs. Gordon McBean and Leonard Barrie, chairs) for CMOS Congress 2020 in Ottawa have proposed the theme of "Building Societal Resilience to Changing Weather, Climate and Environment" for this important meeting. This theme will reflect how Canadian society will need to turn to the know-how of the CMOS community in weather, climate, and environmental forecasting and analysis as we grapple with the building pressure from our changing climate. I warmly support this proposal, look forward to attending the meeting in May 2020, and hope that every effort can be made to make the meeting sustainable, for example by ensuring that online access is available.

Speaking of resilience: for an excellent example of grace under pressure, check out CMOS Ottawa Centre Executive member Mike Steeve's 'Indoor Fishing Techniques from Fitzroy in the Flood Zone', a video shot in Mike's flooded garage in Fitzroy Harbour ON. We wish Mike, his family, and his community the best as they recover from the damage of the Ottawa flood. A good sense of humour will be important as the pressure and urgency to deal with climate change and its impacts builds.

Paul Kushner

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Renforcer la résilience en affrontant les changements climatiques avec aplomb

Les avertissements ont commencé à la mi-avril 2019 : un couvert de neige profond et fondant rapidement dans le centre et l'est du Canada, ainsi que de nombreux jours de pluies intenses promettaient des inondations sans précédent dans les communautés riveraines de l'Ontario, du Québec et du Nouveau-Brunswick. Les niveaux d'eau de la rivière des Outaouais ont fracassé des records établis lors des inondations du printemps 2017. L'effet combiné de la crue des eaux et d'une infrastructure fragilisée a touché des milliers de résidences et de citoyens, et entraîné parfois des évacuations précipitées. Au cours de la deuxième semaine de mai, les eaux de crue baissent, mais le rétablissement à la suite de cet événement néfaste restera un véritable casse-tête à long terme.

L'influence des changements climatiques sur les inondations presque consécutives de 2017 et 2019 oblige les citoyens et les planificateurs à réfléchir sérieusement à la façon de percevoir les puissants cours d'eau sur les rives desquels est bâtie une bonne partie de l'infrastructure urbaine du Canada. Une telle réflexion exige la compréhension scientifique d'un ensemble complexe de problèmes à un niveau considérable d'approfondissement. Par exemple, nous avons appris, grâce au travail du groupe de Laxmi Sushama, conférencière itinérante de la SCMO dans l'est du pays en 2019, que les changements climatiques anthropiques ont augmenté la probabilité de l'un des facteurs importants ayant entraîné les inondations qui ont frappé la région du bassin de la rivière des Outaouais en mai 2017. Notamment, les épisodes de pluies abondantes qui se produisent au cours de cette saison sont deux à trois fois plus probables en raison de l'influence humaine. Il semble que les inondations d'avril et mai 2019 présentaient aussi certaines de ces caractéristiques et qu'il pourrait s'agir d'une suite à cette tendance. Mais le domaine de l'hydrologie reste complexe, comme le montrent sans équivoque l'article de la professeure Sushama et le Rapport sur le climat changeant du Canada (voir le chapitre 6 du RCCC). Selon ce rapport, « On s'attend à ce que les augmentations prévues des précipitations extrêmes dans un climat plus chaud augmentent la probabilité d'inondation produite par la pluie dans certaines régions. Les inondations liées à la fonte des neiges devraient se produire plus tôt dans l'année, mais il n'est pas clair de la manière dont [sic] le réchauffement projeté et les réductions de la couverture de neige se combineront pour influer sur leur fréquence et leur ampleur. »

Prévoir le comportement des inondations dans des régions comme l'est du Canada n'est qu'un exemple des grands enjeux scientifiques auxquels les climatologues doivent s'attaquer. Les récents modèles globaux du

climat servant à prévoir les changements climatiques s'améliorent dans l'ensemble et montrent que le système climatique pourrait se réchauffer plus que prévu précédemment en raison des gaz à effet de serre. Selon les spécialistes interviewés dans l'article lié (y compris le chercheur canadien John Fyfe), les nouveaux résultats suscitent un large éventail de réactions. Dans l'ensemble, cependant, il me semble que la prochaine série d'évaluations du climat projettera un réchauffement plus important que celui précédemment prévu. Cette situation laisse penser que la pression et l'urgence d'agir face aux changements climatiques s'intensifient.

Tandis que les climatologues raffinent nos connaissances, les citoyens, les politiciens et les autres décideurs doivent se fier à la meilleure information existante fournie. De nombreuses preuves laissent voir qu'une action urgente s'impose, comme l'indique clairement l'énoncé de position de la SCMO sur le réchauffement planétaire de 1,5 °C. La pression s'intensifie en ce qui concerne une action décisive en faveur du climat, qu'il s'agisse de manifestations de jeunes ou de grèves scolaires, aux échelles nationale ou internationale, ou de victoires électorales de candidats écologistes, ici et à l'étranger. J'ai toujours la ferme conviction que la fonction principale de la SCMO reste dans ce contexte de transmettre les meilleures connaissances scientifiques possible aux décideurs, tout en veillant à ce que son propre fonctionnement en tant qu'organisme bénévole repose sur une durabilité accrue.

Par conséquent, il va de soi que, pour le Congrès 2020 de la SCMO à Ottawa, le comité du programme scientifique (avec Gordon McBean et Leonard Barrie à la présidence) propose pour cet important événement le thème « Renforcer la résilience de la société face à l'évolution du temps, du climat et de l'environnement ». Ce thème reflète la façon dont la société canadienne devra se fier au savoir-faire des spécialistes de la SCMO en matière d'analyses et de prévisions météorologiques, climatologiques et environnementales afin de résister à la pression croissante qu'exercent les changements climatiques. Je soutiens ardemment cette proposition et me réjouis d'assister au congrès de mai 2020, espérant que tous les efforts seront déployés pour faire de cette rencontre un événement durable, par exemple en offrant un accès en ligne.

À propos de résilience : pour un excellent exemple d'aplomb sous la pression, jetez un coup d'œil à la vidéo de Mike Steeves (membre de la direction du centre d'Ottawa) intitulée Indoor Fishing Techniques from Fitzroy in the Flood Zone, tournée dans le garage inondé de Mike à Fitzroy Harbour (ON). Nous souhaitons à Mike, à sa famille et à sa communauté un prompt retour à la normale à la suite des dommages qu'ont causés les inondations à Ottawa. Un bon sens de l'humour restera salutaire à mesure que la pression et l'urgence de faire face aux changements climatiques et à leurs répercussions se feront sentir.

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Article: CCCR

Canada's Changing Climate Report (CCCR)

Scientists from Environment and Climate Change Canada, Fisheries and Oceans Canada and Natural Resources Canada, and university experts collaborated to produce **Canada's Changing Climate Report (CCCR)**. Released at the beginning of April, this report is about why Canada's climate has changed, how it is changing, and what changes the future holds. This document is the first of a series to be released as part of a National Assessment to look at the impacts of climate change on Canadians and possible adaptation measures. It covers changes across Canada in temperature, precipitation, climate extremes, snow, ice, permafrost, freshwater availability, and sea level and other changes to our oceans.

This report quickly made headlines with the news that Canada is, on average, warming twice as fast as the global average. Canada's North is one of the fastest warming regions on the planet, seeing an average temperature rise of 2.3°C since 1948, bringing the national average to approximately 1.7°C (since 1948). The report tells us that future warming in Canada will continue to be about double the magnitude of global warming, with the human factor the dominant contribution to this change.

To keep future warming as low as possible (for example, following the low emission scenario known as RCP2.6) the report highlights that global greenhouse gas emissions need to peak almost immediately, and that rapid and deep reductions in these emissions must follow.

In regards to precipitation, the report notes that in general, because of warming, there has been a shift to more rain and less snow, with observations indicating that Canada's annual precipitation has increased since 1948. This trend is expected to continue.

As for climate extremes, warming means that heat extremes will become more severe, while cold extremes will lessen. In the future, heat extremes will become more frequent and intense, resulting in a risk of increased drought and wildfires. Alongside these predictions of increased drought extremes, there is a prediction that more intense rainfall events will increase the potential for urban flooding.

The authors state that observed changes in snow and ice in Canada are consistent with a warming climate, with a decrease in fall and spring snow cover and summer sea ice extent, and a warming of permafrost. These trends are expected to continue. Glaciers are also thinning, and it is estimated that even under a medium emissions scenario, most small ice caps and ice shelves in the Canadian Arctic will disappear by 2100.

Freshwater supply is also threatened, as the changing seasonal availability of freshwater means an increased risk of water supply shortages in summer.

Canada's adjacent oceans have warmed, and are projected to continue to warm. They have also become more acidic, and less oxygenated. The authors give a very clear warning about the risk here:

"Ocean warming and loss of oxygen will intensify with further emissions of all greenhouse gases, whereas ocean acidification will increase in response to additional carbon dioxide emissions. These changes threaten the health of marine ecosystems."

Local sea-level rise is also going to increase the risk of coastal flooding as sea level is projected to continue to rise along many of our coastlines, increasing the frequency and magnitude of extreme high water-level events. In some areas, Hudson Bay for example, the land is uplifting faster than the global sea level is rising and therefore in these areas the local sea level is projected to fall.

The report concludes with a chapter on our future, and the fact that the choices we make right now will directly impact the extent of climate change.

"The rate and magnitude of climate change under high versus low emission scenarios project two very different futures for Canada…Beyond the next few decades, the largest uncertainty about the magnitude of future climate change is rooted in uncertainty about human behaviour…"

CMOS commends the work of Canada's research community in bringing the kind of high quality and rigorous scientific information embodied in this report to the attention of Canadians. We believe that this and upcoming reports will benefit Canada's decision makers and its broader public, at all levels and in all regions. Such reports make us aware of the present and ongoing risks associated with climate change, the need to adapt to anticipated climate change and the timescales involved, and the importance of rapid action using, for example, the Pan-Canadian Framework on Clean Growth and Climate Change, to reduce greenhouse gas emissions and do our part to mitigate the most dangerous impacts of climate change.

Comments on the CCCR From Our Experts

"The CCCR 2019 report presents a careful and detailed assessment of past and future climate across Canada. The main messages from this report tie in closely with the picture of a warming global climate, and with the picture of climate change over North America, that has been presented by the Intergovernmental Panel on Climate Change (IPCC) in their series of five comprehensive assessment reports since the 1990s. However, what is novel in the CCCR 2019 is the central focus on Canada, and the integrative assessment of projected changes in extreme weather, mean climate, freshwater resources and Canada's ocean waters.

From my own research perspective, the projections for snow and ice are very closely aligned with work that I was involved with from the Canadian Sea Ice and Snow Evolution (CanSISE) network. That network concluded that Canada is likely to experience significant, and accelerating, changes to its cryosphere over the coming century. CanSISE also evaluated Canada's earth system model (CanESM2), and concluded that the model does a very good job when compared with other models from its generation, and therefore Canada is in a strong position scientifically to make progress on quantifying changes in snow and ice."

– Dr. Chris Fletcher, Climate modelling and analysis group, Department of Geography and Environmental Management, University of Waterloo

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"Although I am more involved with weather prediction research and development, interactions and collaborations with climate change experts over the decades have convinced me that human induced climate change is serious and requires national and international cooperation. This report highlights that we need open, democratic discussion and decisive action as we wrestle with the accelerating changes that face us within Canada and globally."

– Dr. Hal Ritchie, Meteorological Research Division, Environment and Climate Change Canada (ECCC)

"This report highlights the ongoing changes and concerns in ocean chemistry, and thus how ocean acidification may be a major issue in the waters around Canada in the near future.

With rising sea level, it also highlights that where there will be relative sea level rise (e.g. Beaufort in the Arctic and much of the Atlantic and Pacific coasts), this higher baseline combined with increased likelihood of major storms will mean the frequency and magnitude of extreme high water level events will increase."

– Dr Paul Myers, Dept. of Earth and Atmospheric Sciences, University of Alberta, and Chair of the Canadian National Committee for the Scientific Committee on Oceanic Research (CNC-SCOR)

Canadian Weathercasters as Climate Change Communicators

Bronwyn McIlroy-Young, Institute for Resources, Environment, and Sustainability,
University of British Columbia

Canadians are increasingly looking for information about how their community is being affected by climate change. New research reveals that TV weathercasters could be very effective at informing the public about what climate change is and how it is transforming local environments across Canada.

The Challenges of Climate Change Communication

Communicating about climate change is a tricky business. For decades, there has been a persistent gap between the actions that climatologists are calling for and what the public is doing about climate change. Climate change communication research aims to address this gap.

Historically, public disagreement about climate change and other science topics has been attributed to a "knowledge deficit": if people only had the facts they would come to agree with the scientists and the controversy would be eliminated. Unfortunately, a wide variety of research has demonstrated that simply presenting the science is not sufficient for changing hearts and minds about climate change.

Documentary filmmaker Albert Nerenberg walks down a flooded Montreal street in May 2017, during a shoot for the film "You Are What You Act". Photo: Frederic Bohbot

Despite being able to access the science, many people's thinking about climate change is characterized by "psychological distance": climate change is perceived as something happening far away, to other people and in a hypothetical future. Not as something happening here and now that is relevant and actionable for the average Canadian.

There are various factors that contribute to psychological distance around climate change. By way of political narratives presented in the media, climate change has become a polarizing issue creating doubt about the reality and seriousness of the issue.

Climate change is also conceptually difficult for people to understand. The notion of natural, stochastic changes in local weather happening against the backdrop of a gradual, human-caused shift in the global system is hard for people to wrap their heads around.

Further, many scientists struggle to adapt their messages about climate change to a lay audience. Climatologists deal with statistical data about possible climate scenarios; however, this type of information often fails to resonate with the general public who are more likely to base their opinions of climate change off of their observations of local, short-term weather.

Weathercasters as Climate Change Communicators

Research has identified that weather broadcasters have potential to manage these challenges and effectively communicate about climate change to the general public. First and foremost, weathercasters have tremendous reach: they are in the living rooms of Canadians across the country multiple times each day.

Weathercasters are also familiar figures within their broadcast regions and have knowledge about their local communities. They are apolitical, and this gives them an advantage over other sources for which we might suspect ulterior motives.

Additionally, weathercasters are highly-skilled communicators: they are situated at a critical boundary between meteorologists and climatologists and the lay public, and they work everyday to translate knowledge in atmospheric science between those groups. And finally, local TV weathercasts focus on local weather and related topics, creating a natural opportunity to teach audience members about the local relevance of climate change.

Research groups in the US and the World Meteorological Organization have already recognized the potential of weathercasters as climate change communicators. The Climate Matters program provides weekly resource packages to weathercasters across the US to help them communicate about the local relevance of climate change to their broadcast region.

Weathercasters and Climate Change Communication in Canada

Climate Matters meteorologist Jim Gandy. Used with permission.

A recent study explored weathercasters' current and potential status as climate change communicators in Canada.[1] The study interviewed highly respected professionals in the Canadian weather communication community to ask them of their attitudes, knowledge and behaviours around climate change reporting.

Considering the difficulties of communicating about climate change, the research focused on exploring how a Canadian weathercaster might communicate about climate change in a way that is appropriate for their medium, responsible to the science that they're communicating, and engaging to their audience.

As it turns out, the group interviewed had a lot of ideas as to how weathercasters can do this. They provided many examples of how weathercasters could use the broadcast platform to draw the story between climate change and people's daily lives.

The weathercast medium presents many natural opportunities to talk about local, climate change-related events, such as how leaves are changing later in the season, changes in the crop-yields from local farmers, or how the ski season is becoming shorter and less reliable. Each of these phenomena are indicative of a changing climate and also meaningful to the average Canadian.

An important consideration for weathercasters is that their communication is responsible to the science. Climate change happens at a different temporal and geographic scale than local weather, and the relationship between climate change and local weather is not straightforward. However, this does not mean that it cannot be described in a way that is meaningful to the general public.

There are many examples of how a weathercaster could communicate responsibly about the relationship between local weather and climate change. For example, extreme weather, such as ice storms, can be discussed as an event that's likely to become more frequent as a consequence of climate change.

Our weather has already changed as a result of climate change, so weathercasters noted that climate change gives appropriate context for the stories they tell about local weather and environmental events. For example, if current weather where compared to averages from when records began, almost every season and weather event would be extreme. Climate change has shifted the baseline for what is considered normal weather.

In addition, many weathercasters are beloved members of their communities and are often asked to attend town fairs and other public events, which gives them credibility in discussing climate change.

Article: Weathercasters as CC Communicators

Barriers to Communicating About Climate Change

Despite weathercasters' potential to communicate about climate change, it seems that it is rarely brought up on-air.

So why aren't Canadian weathercasters talking about climate change?

First, there is a lot of uncertainty as to who is qualified to present on the relationship between local weather and climate change. Weather broadcasters have varying levels of ability and confidence in presenting on climate change depending on the extent of their expertise in atmospheric science.

Second, all the interviewees discussed that the reason people watch the weather is for weather forecast information. Including content about climate change could be poorly received by certain audiences or unacceptable to the station management. At the same time, there could be an opportunity to meet growing demand in some markets for more information on the link between climate change and our communities.

A third barrier to weathercasters bringing climate change into their regular broadcasts are restraints on time as well as information and narrative resources. Weather broadcasters and their colleagues often struggle to prepare forecasts and visual aids in time each day, and then to effectively communicate that information in only two to three-minutes of air time.

Enabling Weathercasters to Communicate About Climate Change

According to the study, there are currently no climate change communication resources for weather broadcasters in Canada.

Unlike meteorologists, weathercasters do not have a unified professional forum by which to develop a mandate about climate change communication and distribute resources. All the interviewees said that resources provided by organizations such as CMOS and Environment Canada could help weathercasters effectively communicate about climate change to their viewerships. For example, these organizations could offer training in climate science and communications for weathercasters, or provide region-specific climate data. These resources could increase weathercasters' capacity to communicate about climate science while helping them to manage time restraints.

Finally, leadership among station managers eager to discuss climate change on air would set an example that weathercasters could follow.

These findings reveal an exciting leadership opportunity. With further research and resource development, weathercasters will be equipped to communicate critical climate information in a way that resonates with the general public.

As the effects of climate change become more apparent, Canadians will be searching for explanations for the dramatic changes in their environment, and weather broadcasters will be there to guide them.

References

1. Mcilroy-Young, B., & Thistlethwaite, J. (2019). Canadian Weathercasters' Current and Potential Role as Climate Change Communicators. Environmental Communication, 1-13. doi:10.1080/17524032.2018.1557726

About the Author

Bronwyn McIlroy-Young is a Masters student at the University of British Columbia studying at the Institute for Resources, Environment, and Sustainability.

She is interested in weather and climate communication, science for policy and environmental justice.

Her current research explores scientific controversy around emerging contaminants.

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Extreme 2014 Wildfire Season in the Northwest Territories

Bob Kochtubajda[1], Ron Stewart[2], Mike Flannigan[3], Barrie Bonsal[1], Charles Cuell[4], and Curtis Mooney[1]

1. Environment and Climate Change Canada; 2. University of Manitoba, Winnipeg, MB; 3. University of Alberta, Edmonton, AB; 4. CHMR Climate Resilience Consulting, Kaslo, BC.

Media reports around the world have highlighted the extreme and unprecedented nature of wildfires in recent years (e.g. Chile 2017, Portugal 2017, Greece 2018, California 2017 and 2018). In Canada, the 2016 Fort McMurray wildfire was the third largest in Alberta's history and became the costliest natural disaster in Canadian history, with approximately $3.6 billion in insured losses (1). Wildfires in British Columbia scorched record areas of forest in 2017 and again in 2018. In Ontario, the total number of wildfires and area burned during the 2018 wildfire season were nearly double the latest provincial 10-year average (2). During the summer of 2014, wildfires burned a record 3.39 Mha (33,900 km2, an area slightly larger than Vancouver Island) of boreal forest in the Northwest Territories (NWT).

Our recent study published in Atmosphere-Ocean (DOI: 10.1080/07055900.2019.1576023) examines the surface and atmospheric conditions during that season including their comparison within the historical record. Detailed analyses of such extreme wildfire seasons contribute to better understanding the many associated interactions of weather, lightning and mid-tropospheric circulation patterns.

Wildfire represents an important disturbance in NWT. It shapes landscape diversity, controls insects and diseases and maintains biological diversity, but it also represents a threat to human life, property, and valuable commercial resources (3). The history of wildfires in NWT from 1970 to 2015, shown in Fig. 1, highlights the exceptional 2014 fire season. There are three factors that influence wildfire activity: dry fuel, an ignition source and weather conditions (4). The variability in the number of wildfires and areas burned is due to year-to-year differences in those factors.

The majority of the 2014 wildfires occurred in regions surrounding Great Slave Lake, and smoke from the mostly lightning-caused wildfires led to dramatically poor air quality and visibility reductions that resulted in numerous

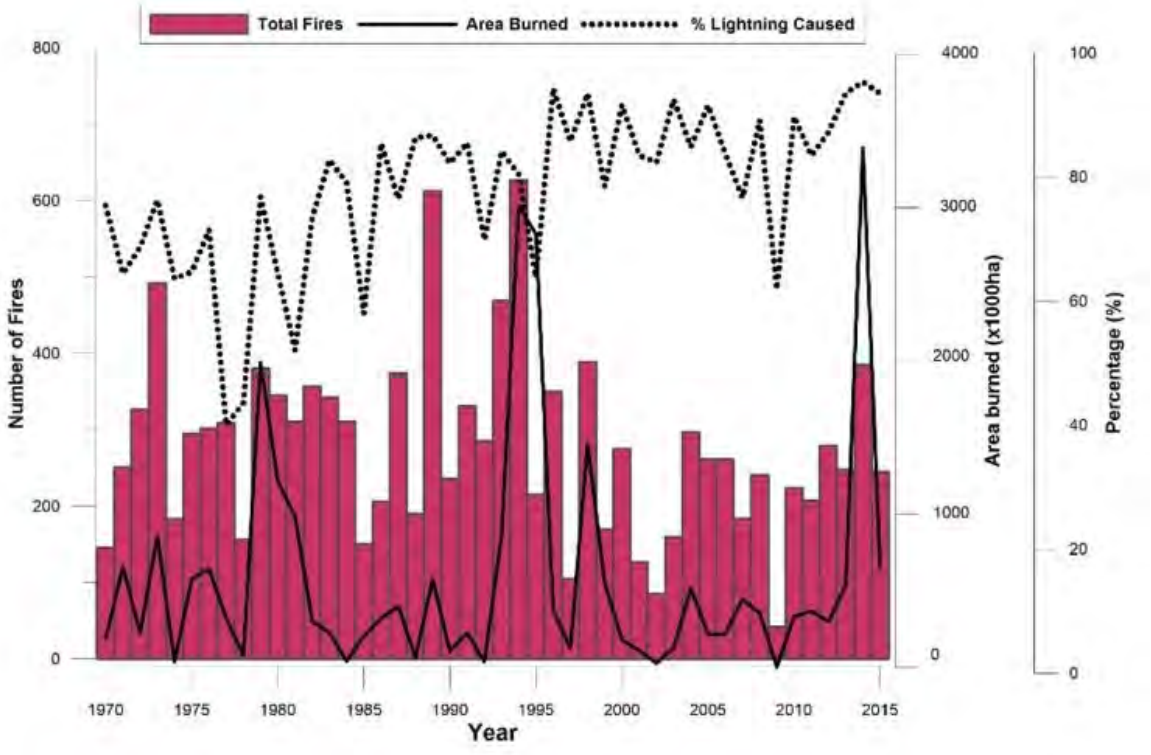

Figure 1. NWT fire history from 1970 to 2015 showing the annual variation of wildfires (bars), areas burned (solid line), and percentage of fires for which lightning was the ignition source (dotted line). [A data error was discovered in the corresponding figure (Fig. 5) in the published paper. A replacement figure and correction notice has been submitted.]

health alerts, road closures and frequent exceedances of PM2.5 ambient air quality standards. For example, Fig. 2 shows numerous hotspots near Great Slave Lake and the extensive smoke plumes on July 29, 2014. Such prolonged smoke events impacted the mental and emotional well-being of residents as well as their livelihoods among affected communities (5). If we assume an average emission from forest fires of about 170 tonnes of carbon dioxide equivalent per hectare (6), the wildfires in NWT in 2014 were estimated to release 580 megatonnes of CO2 equivalent, which is about 79% of Canada's annual GHG emissions (this excludes emissions from wildfires and various land-use and forestry activities).

This study analyzed a variety of observational and model data sources. These included the archived lightning flash data from the Canadian Lightning Detection Network; fire data from the National Forestry Fire database; climate data from the Environment and Climate Change Canada database; and NCEP-NCAR reanalysis data. Mid-tropospheric atmospheric circulation over a large region including NWT during the period 1948-2015 was classified into the six most common summer patterns using a cluster analysis (7). An assessment of circulation patterns over NWT in 2014 showed that the frequencies of ridging and subsequent ridge displacement or breakdown patterns were much higher than normal (Fig. 3). Ridge patterns are commonly associated with warm, dry conditions which tend to dry the surface and forest floor. The breakdown of these ridges often leads to thunderstorm formation from which lightning can ignite wildfires.

The overall analysis results indicate that the 2014 extreme wildfire season was linked to several factors. Very dry surface conditions in the fall of 2013 continued through the winter and the following spring and this led to conditions that were suitable for extreme fires. These conditions, combined with a persistence of mid-tropospheric ridging and ridge breakdown patterns during the summer, led to record numbers of cloud-to-ground (CG) flashes, lightning-initiated forest fires and area burned. A record number of positive-polarity CGs (bringing positive charge to the surface) was also detected and this is consistent with the findings of previous studies of thunderstorms in smoke-filled environments. The common view is that such positive flashes are more likely to ignite wildfires than negative ones. However, our assessment showed that more wildfires were associated with negative-only CGs than positive-only ones but their ignition efficiencies (wildfire ignitions per number of flashes) were similar.

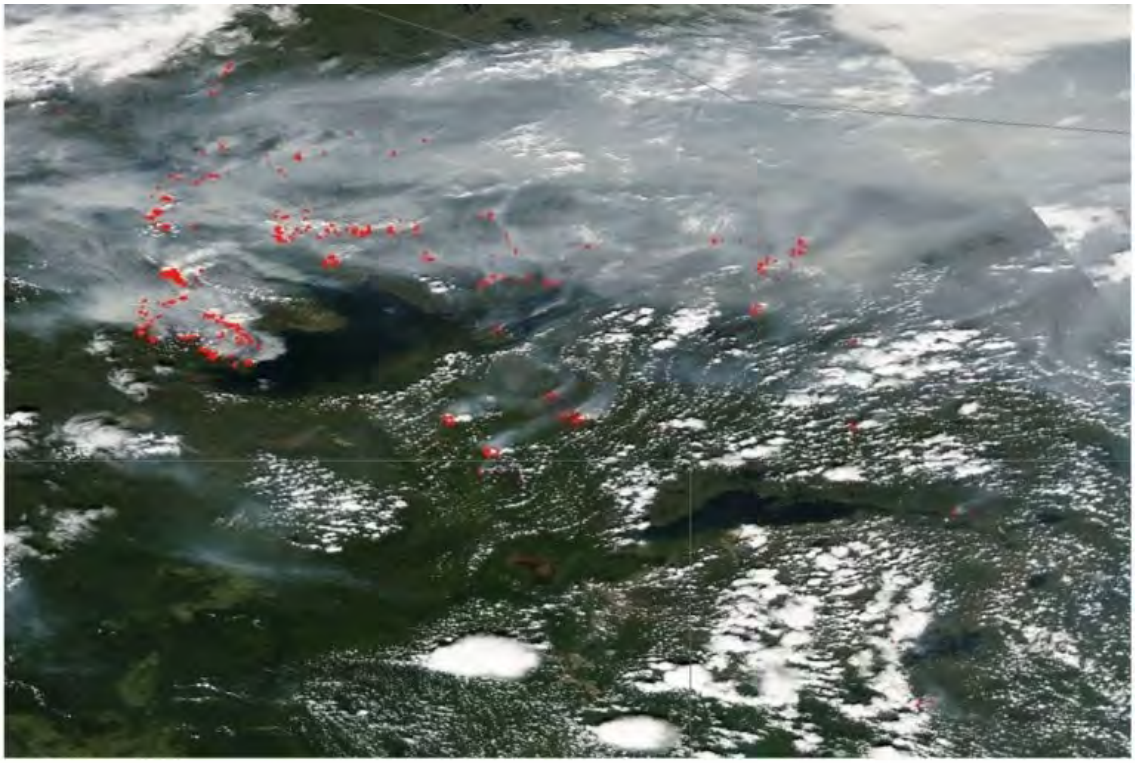

Figure 2. Satellite image of hotspots (red areas) surrounding Great Slave Lake (left of centre) and associated smoke plumes on July 29, 2014. (NASA, Worldview). A hotspot is a satellite image pixel with high infrared intensity, representing a heat source from vegetation fires, which can be in forest, grass, cropland, or logging debris. (Source: http://cwfis.cfs.nrcan.gc.ca/maps/fm3?type=tri). The horizontal span across the image is approximately 850 km.

In conclusion, this study has advanced our understanding of the roles of weather, lightning and mid-tropospheric circulation patterns in the 2014 wildfire season. As the future climate warms, northern latitudes may experience greater persistence of large-scale circulation patterns (8) and an increase in the occurrence of extreme events (9). Several studies have also suggested that fire weather is projected to become more severe; lightning, area burned and the frequency of extreme fire weather days are expected to increase; fuels will be drier; and fire seasons are predicted to be longer (10). Such future conditions would likely make NWT more prone to extreme dry and warm conditions and extreme fire seasons.

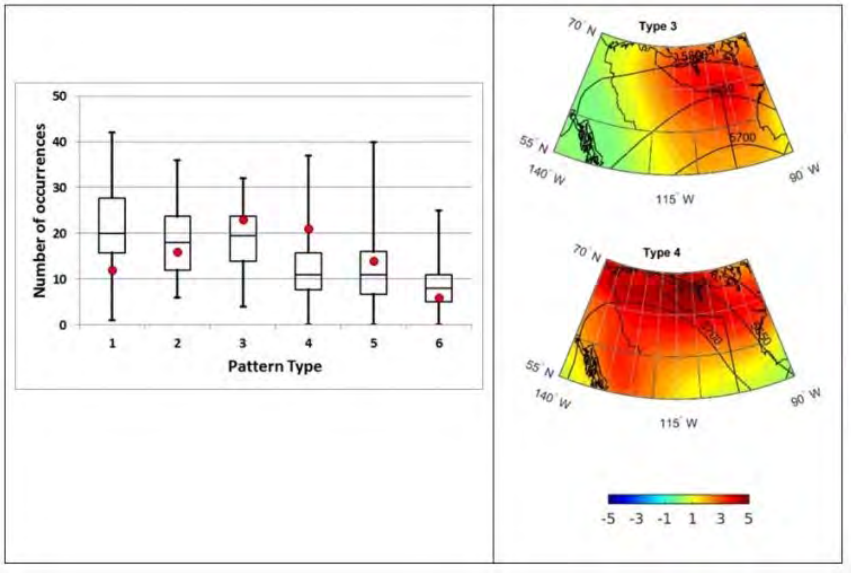

Figure 3. The left panel shows boxplots displaying the median, quartiles and extremes for the six summer synoptic pattern types from 1948-2015. Solid dots show the frequencies during the summer of 2014. The panel on the right shows contours of the mean 500 hPa geopotential height and shaded surface temperature anomalies for ridge displacement (Type 3) and ridge (Type 4) patterns.

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Bob Kochtubajda is a physical scientist with Environment and Climate Change Canada (Prediction Services West Division of the Meteorological Service) in Edmonton.

His areas of interest are in hydro-meteorological extremes and atmospheric hazards processes and in the use of lightning data for meteorological applications.

This study was a joint ECCC-University collaboration contributing to the recently completed Changing Cold Regions Network.

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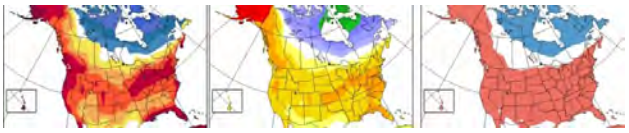

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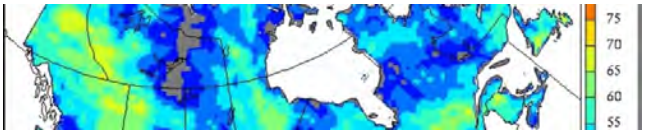

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In Memoriam: Wayne Evans

Wayne Evans

Dr. Wayne Evans, Adjunct Professor in the Centre for Research in Earth and Space Science (CRESS) at York University from 1976 onwards, passed away in Seattle, Washington on April 27th, 2019. Although he never held a faculty position at York, during his time at Environment Canada and Trent University he maintained continued collaborations with CRESS, and contributed a great deal to its research activities.

Wayne F. J. Evans was born in Saskatchewan and received his B.A. (Physics) in 1961, at the University of Saskatchewan, followed by an M.A. (Physics) in 1963 and a Ph.D. in 1968. In 1997 the University added the prestigious D.Sc. After getting his Ph.D in 1968, Wayne joined the new Department of Environment (Atmospheric Environment Service), spending the next two decades there doing much groundbreaking research. He was a Research Scientist in the Experimental Studies Division from 1972 to 1976, and Chief of the Environmental Studies Division from 1976 to 1990. He then became Professor of Environmental Science, 1990 – 2006, at Trent University in Peterborough. After that he retired to Seattle, Washington, U.S.A., where he collaborated with NorthWest Research Associates in Redmond. During all of this time, he maintained a strong interaction with York University as an Adjunct Professor from 1976 onwards. As part of this he was co-supervisor, with John McConnell, of Ph.D. student Chris Sioris, now at Environment and Climate Change Canada. As well, while at EC he taught an undergraduate EATS (Earth and Atmospheric Science) course at York University, and part of one graduate course. He was a co-supervisor for Ph.D. students Paul Shepherd and Chris Sioris.

Wayne had a lengthy association with CMOS. He was a member for at least 45 years. He won the 1976 President's Prize for his important contributions to the AES Stratospheric Pollution program (Project STRATOPROBE) both as a member of the program and in communicating the results which appeared in a special issue of Atmosphere. He was Chair of the Toronto Centre in 1989 and 1990, and was on their executive as a Member-at-large from 1997 to 2008. He also attended numerous Congresses presenting research results. The photo shows Wayne at the 2013 Congress in Saskatoon.

While still at the University of Saskatchewan, he participated in perhaps the first atmospheric balloon launches in Canada. That scientific package was small enough to be carried by a fast runner, Stephen Peteherych perhaps, before releasing it. This laid the groundwork for his first projects at the Atmospheric Environment Service within EC where he initiated the STRATOPROBE project; large balloons for measurements of the stratosphere, well ahead of its time. In STRATOPROBE I, ozone was studied, well before the ozone hole was discovered. The first flight was in 1974 and was flown at 35 km altitude, measuring HNO3, NO2, NO and O3. Half of the experiments were provided by AES and the other half by Canadian universities. Chlorine components were added in STRATOPROBE II, one year later. In 1996 chlorine and nitrogen were measured during STRATOPROBE III.

In 1984, Canada's first astronaut, Marc Garneau, flew on space shuttle mission STS 41-G, conducting ten Canadian experiments, including SPEAM (Sun Photometer Earth Atmosphere Measurements), led by Wayne Evans in collaboration with CRESS at York University. In 2001, Canada provided an instrument called OSIRIS (Optical Spectrograph and Infra Red Imaging System) on the Swedish Odin satellite, in which Evans played a significant role. In 2003 the ACE (Atmospheric Chemistry Experiment) on the Canadian SCISAT satellite was launched, which measured a wide variety of different species and is still measuring them today. Again Wayne Evans was much involved. For these activities, he became a Fellow of the Royal Society of Canada in 1989.

The Canadian Wind Imaging Interferometer (WINDII) was launched on NASA's Upper Atmosphere Research Satellite (UARS) in 1991 with Evans as a co-investigator. Here he led in the study of Polar Mesospheric Clouds, high altitude (82 km) clouds in the high-latitude summer atmosphere. These are formed from water vapour in the very cold atmosphere at this season and latitude.

He is the author of over 200 publications with 138 in peer reviewed journals. He was a reviewer of the IPCC 2001 and 2007 Assessment Reports and was an expert on the interaction of the energy industry with the Kyoto accord. It is clear from this record that he was an energetic and insightful atmosphere scientist that supported major Canadian space activities, and transmitted that enthusiasm to many students who fondly remember him at this time.

Information provided by Gordon Shepherd, York U.; photo and CMOS information from Bob Jones

Students Win Society Awards – Then and Now

Bob Jones, CMOS Archivist

Two recent events in the CMOS Archives and the Ottawa Centre are illustrated by great photos. They show that our science marches on over the generations and I thought Bulletin readers would appreciate seeing them.

The first event was when Geoff Strong (CMOS President 2006-07) wrote to tell us he found a rare photo in his collections from the 1975 CMS (we had not yet become CMOS then) Congress in Vancouver. Here we see Geoff receiving the Graduate Student Prize (now called the Tertia Hughes Memorial Graduate Student Prize) for his thesis, *The Objective Measurement of Alberta Hailfall*. This photo is rare because so far we have no other photos from that Congress. Then outgoing President, André Robert is |presenting the prize to Geoff.

The second event took place at the Ottawa Regional Science Fair on April 6th 2019. CMOS Ottawa Centre sends judges to the Fair each year to review all suitable projects and to present cash prizes. Another wonderful photo shows this year's winner, grade eight student Alex Kent of the Macdonald-Cartier Academy in Ottawa, receiving first prize for his project, *The effect of acid rain on building materials*, from judge Gregory Steeves. Gregory is a student representative on the Ottawa Centre executive and has completed his undergraduate degree in environmental studies. Finally, the trophy shown in this photo is also an archival item which was created in 1977 by the Ottawa Centre. It has been making annual visits to various schools since then.

These two photos show four generations of scientists in our fields, André Robert, Geoff Strong, Gregory Steeves and Alex Kent. Amazing!

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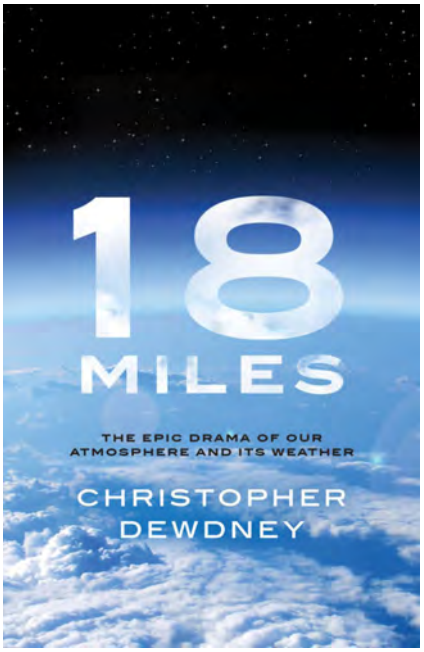
CMOS News

New Book Available for Review



18 Miles: The Epic Drama of Our Atmosphere and Its Weather, 2018. By Christopher Dewdney, ECW Press, ISBN 978-1-77041-346-7 (Paperback), 251 page, $21.95. (2019-1)

Other recent titles still available for review by a CMOS member:

A Bright Future: How Some Countries Have Solved Climate Change and the Rest Can Follow*,* 2019. By Joshua S. Goldstein and Staffan A. Qvist, Hachette Book Group, ISBNs 978-l-5417-241O-5 (hardcover), 978-1-5417-2409-9 (e-book), 288 pages, $34.00. (2018-9)

Trends and Changes in Hydroclimatic Variables: Links to Climate Variability and Change, 2019. Edited by Ramesh Teegavarapu, Elsevier Inc., ISBN 978-0-12-810985-4, 400 pages, US$127 (2017-10)

Tropical Extremes: Natural Variabilities and Trends, 2019. Edited by V. Venugopal, Jai Sukhatme, Raghu Murtugudde, Remy Roca, Elsevier Inc. ISBN 978-0-12.809248-4, 333 pages, US$110 (2018-11)

World Seas, An Environmental Evaluation. VOLUME III: Ecological Issues and Environmental Impacts, Second Edition, 2019. Edited by Charles Sheppard, Elsevier Inc. ISBN 978-0-12-805052-1, 633 pages, US$250. (2018-12)

Synoptic Analysis and Forecasting, An Introductory Toolkit, 2017. By Shawn Milrad, Elsevier, ISBN 9780128092477, 246 pages, US$125.00 (2018-1)

Ice Caves*,* 2017. Edited by Aurel Persoiu, Elsevier, ISBN 9780128117392, 752 pages, $225.00 (2018-2)

Rainbows: Nature and Culture, 2018. By Daniel MacCannell, The University of Chicago Press and Reaktion Books Ltd, ISBN 9781780239200, 208 pages, US$24.95 (2018-4)

Verner Suomi: The Life and Work of the Founder of Satellite Meteorology*,* 2018. By John M. Lewis, The University of Chicago Press and the American Meteorological Society, ISBN 9781944970222, paperback,168 pages, US$30.00. (2018-5)

The Deep Pull: A Major Advance in the Science of Ocean Tides*.*
By Walter Hayduk, FriesenPress, ISBN 9781525518706 (hardcover) $35.49, 9781525518713 (softcover) $27.49, 9781525517820 (eBook) $11.99, 251 pages. (2018-7)

Never reviewed a book before? No problem! Check out some of these past reviews for ideas: Ice: Nature and Culture; Weather in the Courtroom; Convenient Mistruths: A Novel of Intrigue, Danger and Global Warming.

If you a review a book it is yours to keep! Contact the Editor to get involved.

ECCC says farewell to Dr. David Sills

After 20 years at ECCC, Dr. David Sills is leaving ECCC and moving to London to go to Western University in London as Executive Director of the Northern Tornadoes Project.

David is a Severe Weather Scientist whose research interests include low-level convergence boundaries (lake-breeze fronts, thunderstorm gust fronts, drylines) and their relationship to severe weather and hazardous levels of air pollutants, tornadoes, lightning, development of tools and techniques for severe weather nowcasting, and more. In 2017 he was the recipient of the CMOS Rube Hornstein Medal in Operational Meteorology, and in 2016 he was awarded the Geoff Howell Citation of Excellence for Innovation.

His last day at ECCC was April 26, 2019. Best of luck to David in his new position!

2019 CMOS Congress at IUGG, Montreal, July 8-13.

CMOS Congress at the 27th General Assembly of the IUGG: Student activities

Thesis in 180 seconds (3pm to 5pm on July 8)

Students participating in this activity will have three minutes to present their research with up to three slides. Judges will attend the event and winners will receive cash prizes ($ 250, $ 150, $ 100). To register, write to cmos2019students@yahoo.com with 180 seconds in the subject.

5@7 (6 pm on July 8)

A 5@7 will be held in a nearby bar following the 180-second PhD student activity for CMOS students. This is the perfect opportunity to meet students from across the country and interact with them.

"Lunch & learn" (12h on July 10)

Students will be able to eat at a restaurant near the Convention Center (Chinatown), where they will sit 6 to 8 per table. CMOS faculty and / or researchers will move from table to table to discuss and discuss topics with students. The cost of the meal for students will be partially covered by CMOS. To register, write to cmos2019students@yahoo.com with lunch and learn in the subject.

Congrès de la SCMO, et la 27e Assemblée générale de l'UGGI: Activités étudiantes

***Thèse en 180 secondes* (15h à 17h le 8 juillet)**

Les étudiants participant à cette activité auront trois minutes pour présenter leurs travaux de recherche avec un maximum de trois diapositives. Des juges assisteront à l'activité et les gagnants recevront des prix en argent (250$, 150$ 100$). Pour s'inscrire, écrivez à cmos2019students@yahoo.com avec *180 secondes* en sujet.

***5 à 7* (18h le 8 juillet)**

Un 5 à 7 aura lieu dans un bar à proximité suite à l'activité de « thèse en 180 secondes » pour les étudiants membres de la SCMO. C'est l'occasion idéale de rencontrer des étudiants de partout au pays et d'échanger avec eux.

***"Bouffe & Cause"* (12h le 10 juillet)**

Les étudiants pourront aller manger dans un restaurant près du Palais des congrès (Chinatown), où ils seront assis de 6 à 8 par table. Des professeurs et/ou chercheurs membres de la SCMO passeront de table en table pour discuter et échanger sur divers sujets avec les étudiants. Le coût du repas pour les étudiants sera en partie couvert par la SCMO. Pour s'inscrire, écrivez à cmos2019students@yahoo.com avec *bouffe et cause* en sujet.

2019 CMOS Congress at IUGG, Montreal, July 8-13.

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Thank you to Bob Jones and Paul-André Bolduc, for their continued editorial assistance and guidance.

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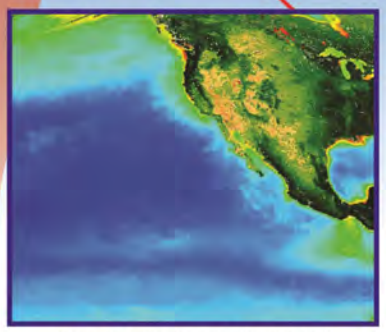

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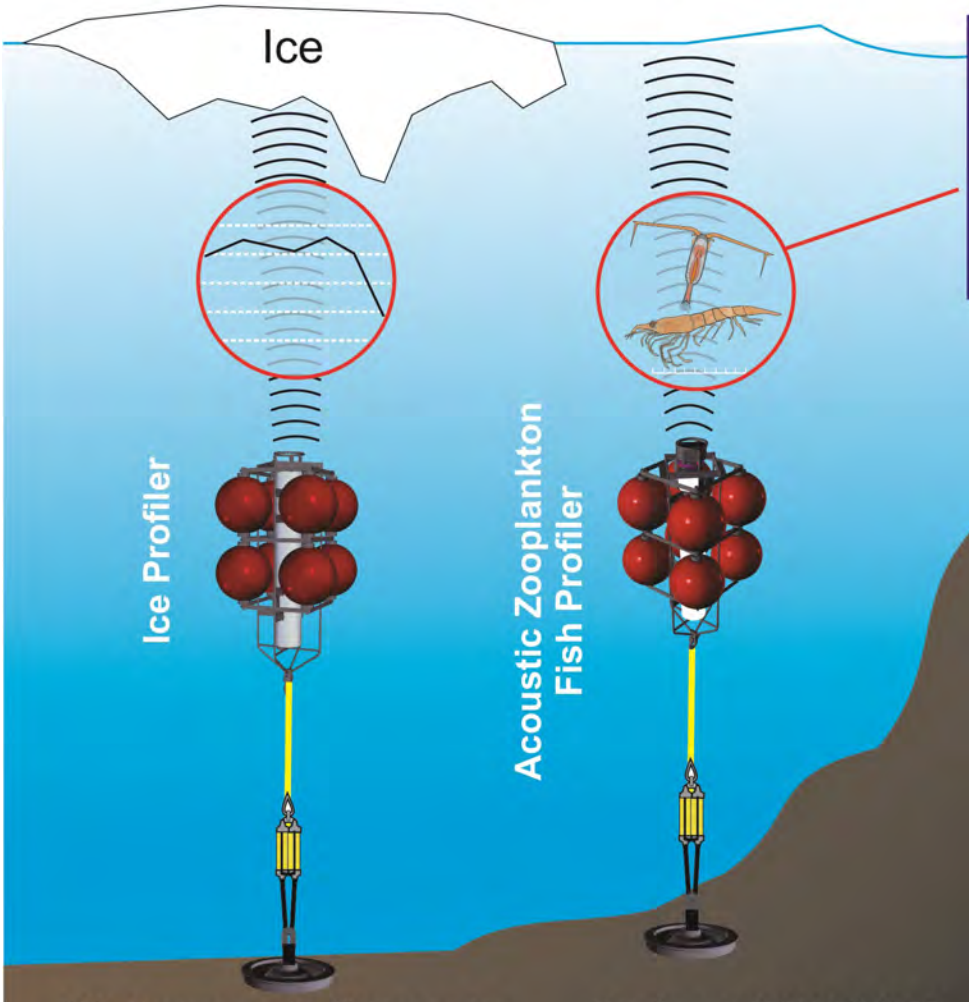

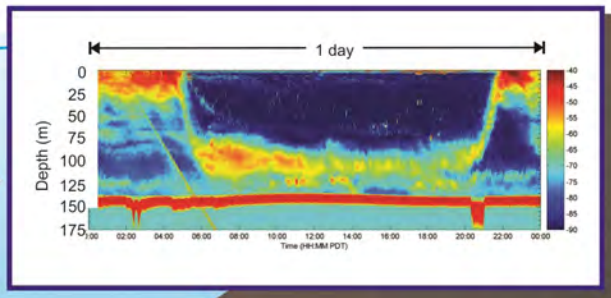

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