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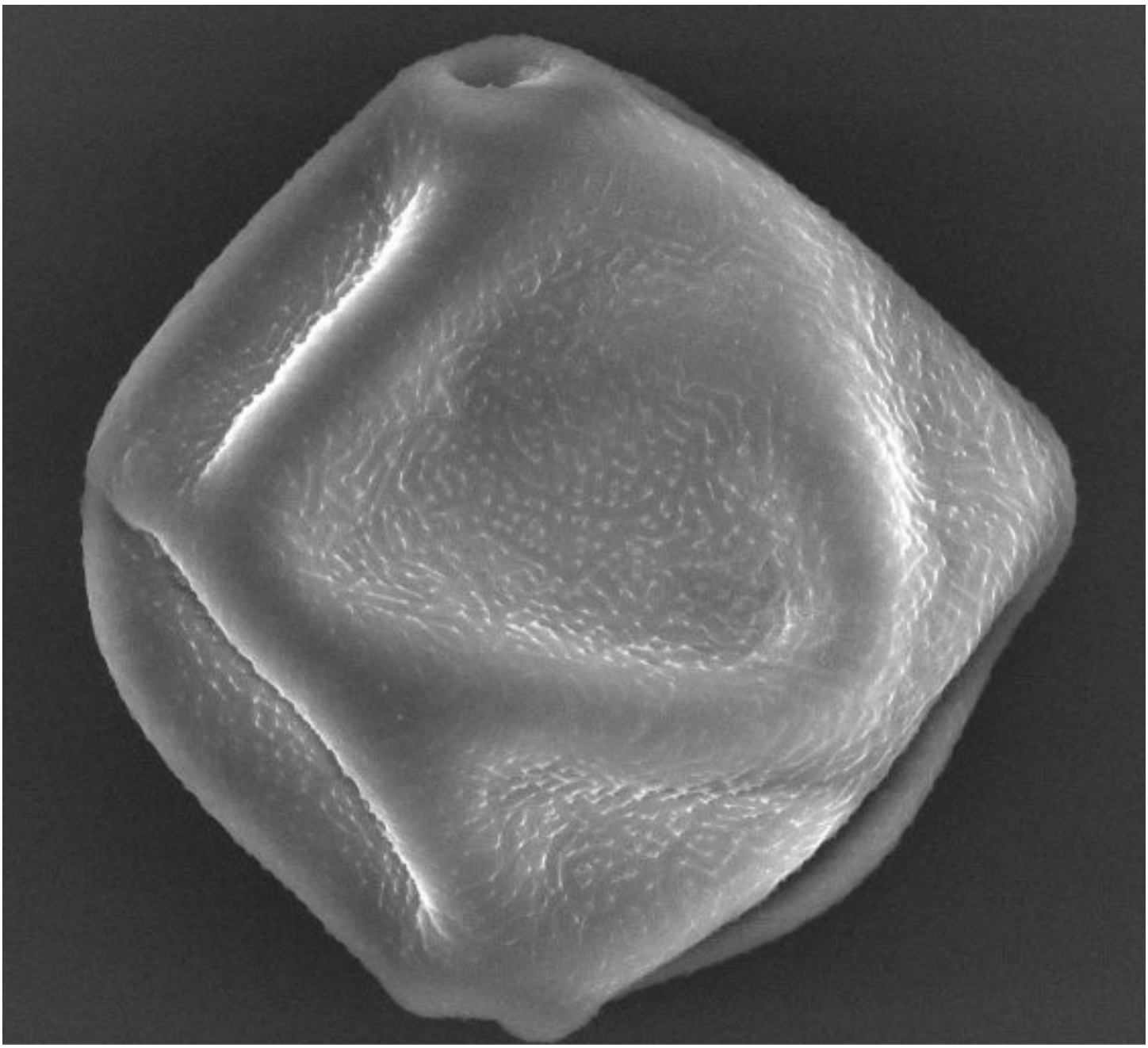

Story Inside: ***Pollen, Chemistry and Clouds / Pollen, chemie et nuages*****. p 6.**

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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

Standing Together: Effective Advocacy for CMOS

This month I want to focus on the stewardship theme of advocacy for our CMOS community. Advocacy covers many facets of our activities, including:

- professional representation of you, the CMOS membership;
- speaking up for our scientific research and its support;
- developing a thriving, entrepreneurial, and cutting-edge private-sector environment;
- enhancing our role in education, training, communication, and outreach, and;
- bridging our activities towards the public sphere, and policy and decision making.

How can CMOS be an effective advocate for the community we represent?

CMOS has over the last fifty years established a sound structure for representing you as a community, including its Executive and Council, as well as its Scientific, Private-Sector, and University/Professional-Education Committees. In addition, our Special Interest Groups (SIGs) for the Arctic and for Atmosphere-Related Research in Canadian Universities (ARRCU) bring attention to areas that fall within and extend outside the CMOS community. Our partnership with colleagues in other disciplines, for example the Partnership Group for Science and Engineering (PAGSE), the Canadian Consortium on Research (CCR) increases our leverage and ability to advocate for common interests. But do CMOS members as a community feel well represented by the Society, and what evidence do we have that our advocacy is working? These are challenging questions for myself and all of us. I believe that as a volunteer driven organization with limited paid staff, we have done well. But we can and need to do more to better serve our community.

Just like an Alberta clipper, our working environment moves fast – from news of climate change and weather extremes, to rapidly evolving government policy, to fast paced changes in the technical and business aspects of our field. And just as an effective response to severe weather events requires long-term planning, CMOS needs to work strategically to account for anticipated changes, so that we can engage in effective advocacy when required. Below are a few examples.

- The ARRCU-SIG is developing white papers on partnerships with industry and on education to complement its existing white papers on our research community and on academic government partnerships.
- This strategic planning put the CMOS in a position to quickly speak up and work with other science advocacy groups to let the federal government know of our research support needs.
- Thoughtful consideration of the way we use data helped the CMOS Scientific Committee provide input to the federal government on its proposed new policy on data management. This gave feedback on an issue that will impact the working environment of our entire membership.
- This month, contacts developed through ARRCU-SIG allowed us to add our support to a letter to the Minister of Environment and Climate Change that speaks to how NSERC's proposed changes to its research partnership programs might adversely impact partnerships with ECCC.

Advocacy is always a work-in-progress, but gets a lot easier – and, yes, even gets fun — when we make it a habit and build more awareness of what we can do as a community.

I'll have more to say on this theme later in the year. In the meantime, I encourage all of you to become engaged in the advocacy work of CMOS, and, as always, to contact me with your thoughts on this, at president@cmos.ca.

Sincerely,

Paul Kushner

CMOS President and Professor, Department of Physics, University of Toronto
Email: president@cmos.ca
Tel: 416-946-3683

Mot du président

Debout ensemble : défendre efficacement les intérêts des membres de la SCMO

Ce mois-ci, je mets l'accent sur la gestion de la défense des intérêts de notre communauté. La défense de nos intérêts couvre de nombreuses facettes de nos activités, y compris:

- la représentation professionnelle des membres de la SCMO;
- la promotion et le soutien de nos travaux scientifiques;
- la mise en place d'un secteur privé prospère, actif et à l'avant-garde;
- le renforcement de notre rôle en matière d'éducation, de formation, de communication et de sensibilisation;
- l'orientation de nos activités vers la sphère publique, les politiques et la prise de décision.

Comment la SCMO peut-elle défendre efficacement les intérêts de la communauté qu'elle représente?

Au cours des cinquante dernières années, la SCMO a bâti une structure solide, y compris son comité exécutif et son conseil d'administration, ainsi que ses comités scientifique, du secteur privé, et de l'éducation professionnelle et universitaire, afin de représenter ses membres en tant que communauté. De plus, nos groupes d'intérêts spéciaux (GIS) pour l'Arctique et pour la recherche reliée à l'atmosphère dans les universités canadiennes (ARRCU) attirent l'attention sur des domaines qui intéressent notre communauté et qui s'étendent au-delà. Notre partenariat avec des collègues d'autres disciplines, par exemple le Partenariat en faveur des sciences et de la technologie (PFST) et le Consortium canadien pour la recherche (CCR), accroît notre influence et notre capacité à défendre des intérêts communs. Mais les membres de la SCMO se sentent-ils bien représentés par la Société et quelles preuves avons-nous de l'efficacité de nos activités? Ce sont là des questions difficiles pour moi, pour nous tous. Je crois qu'en tant qu'organisme soutenu par des bénévoles et très peu de personnel rémunéré, nous avons obtenu de bons résultats. Mais nous pouvons et devons faire plus pour mieux servir notre communauté.

Tout comme un clipper albertain, notre milieu de travail évolue rapidement : des nouvelles sur les changements climatiques et les conditions météorologiques extrêmes jusqu'à l'évolution rapide des politiques gouvernementales et aux transformations constantes des aspects techniques et commerciaux de notre domaine. Et tout comme une intervention efficace en cas de temps violent exige une planification à long terme, la SCMO doit se donner une stratégie qui tient compte des changements anticipés, afin de défendre efficacement nos intérêts le moment venu. En voici quelques exemples :

- Le GIS pour l'ARRCU prépare des livres blancs sur des partenariats avec l'industrie et sur l'éducation pour ajouter à ses livres blancs existants sur notre communauté de recherche et sur les partenariats universités-gouvernement.
- Cette planification stratégique permet à la SCMO de se faire entendre rapidement et de travailler avec d'autres groupes de défense des intérêts scientifiques afin de transmettre au gouvernement fédéral nos besoins en matière de soutien à la recherche.
- Un examen attentif de la façon dont nous utilisons les données a permis au comité scientifique de la SCMO de fournir des commentaires au gouvernement fédéral en ce qui concerne son nouveau projet de politique en matière de gestion des données. Cela nous a permis d'intervenir sur une question qui aura une incidence sur le milieu de travail de l'ensemble de nos membres.
- Ce mois-ci, les contacts établis par l'entremise du GIS pour l'ARRCU nous ont permis d'ajouter notre appui à une lettre adressée à la ministre de l'Environnement et du Changement climatique et qui explique comment les changements proposés par le CRSNG à ses programmes de partenariat de recherche pourraient avoir un impact négatif sur les partenariats avec ECCC.

La défense de nos intérêts reste un travail de tous les jours, mais celui-ci devient facile et même amusant (eh oui), lorsque nous en prenons l'habitude et que nous démontrons notre utilité en tant que communauté. J'aurai plus de choses à dire sur ce thème plus tard dans l'année. Entre-temps, je vous encourage tous à participer aux activités de défense des intérêts de la SCMO et, comme toujours, à me faire part de vos idées à ce sujet, à l'adresse president@cmos.ca.

Paul Kushner

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Article: Pollen and Ice Cloud Formation

Pollen, Chemistry and Clouds

By Ellen Gute, Abbatt Research Group, University of Toronto

Clouds are a crucial part of our Earth's atmosphere as they redistribute water resources and contribute to the atmosphere's radiative forcing (Pruppacher and Klett 1997; Lohmann 2006). Ice is present in many clouds and is known to play a central role in precipitation formation. Despite the important role in climate, processes associated with clouds represent some of the largest uncertainties in climate models (Boucher et al. 2013), with ice formation only partially understood. To better represent clouds in climate models, our fundamental understanding of the underlying processes controlling their formation and evolution need to be improved. Challenges span from the need to investigate microphysical processes, occurring on the molecular scale, to the macro structure of clouds, driven by radiation and dynamics. Findings from experimental research in the field or laboratory need to be developed into a quantitative format for inclusion in complex climate models. With clouds having a significant impact on the climate and water resources, their representation in climate models requires well developed parametrizations of the experimental and modelling studies. With respect to the specific microphysics of ice-forming processes in the atmosphere, more studies on the pathways on the components involved or impacting the ice forming stage are needed. With my research I contribute to a better understanding of the microscale processes of ice formation under cloud conditions and specifically focus on biological materials in the atmosphere and their ability to facilitate ice nucleation. In the following brief article, I will give an insight to my ice nucleation research on pollen particles.

Ice Nucleation

In the atmosphere, the ice phase can form either homogenously, where water is supercooled to temperatures below -38°C and subsequently freezes; or heterogeneously at higher temperatures, where ice nucleating particles (INPs) with specific surface properties initiate the freezing process by lowering the energy barrier for ice crystallization. To date, the specifics of INP surfaces which make ice nucleation a highly selective process are not fully understood. With INP concentrations in the atmosphere being extremely low – only 1 in 10^5 particles in the atmosphere serves as an INP (Rogers et al. 1998; DeMott et al. 2010) – the ice nucleation process of these IN active particles is highly efficient. Particles which are found to be good INPs are mineral dust, some specific inorganic and organic materials, as well as select biological particles such as fungal spores, bacteria and pollen (Hoose and Möhler 2012; Möhler et al. 2007).

Throughout their atmospheric lifetime, these INPs may be exposed to chemical or physical alterations, potentially leading to modifications of their shape, morphology and chemical structure; and impacting the

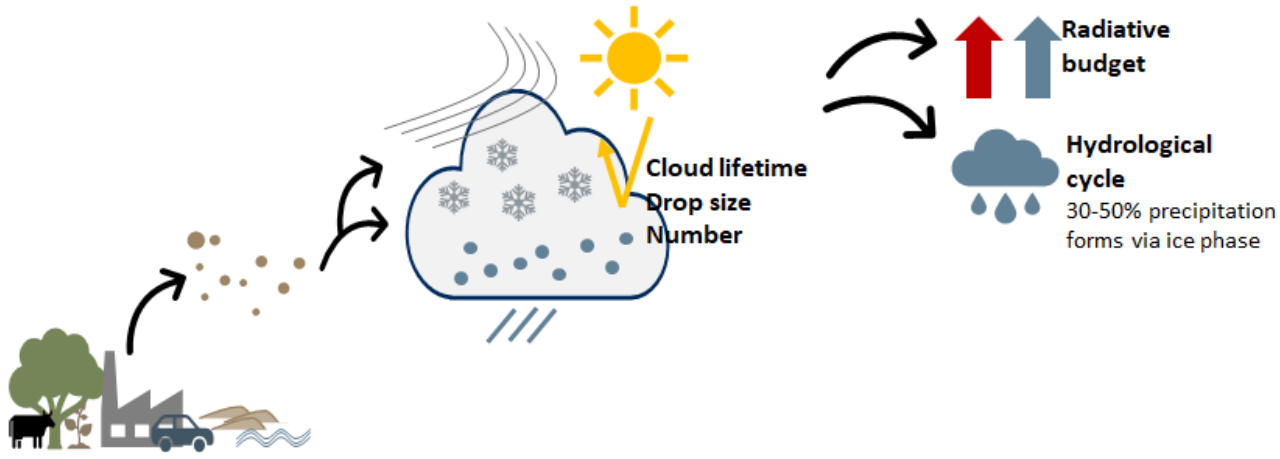

Figure 1. Particles from various sources – including deserts, oceans and urban areas – get emitted into the atmosphere in large quantities. When experiencing cloud conditions with low temperatures and high relative humidity, some of the particles have properties which facilitate ice nucleation. These particles are referred to as ice nucleating particles (INPs) and impact cloud properties, radiative forcing and precipitation formation.

particle's IN ability, and hence its role in cloud processes. Better understanding of INPs and their role in cloud processes requires a comprehensive investigation of INP processing pathways possible in the atmosphere.

Pollen INPs

From the variety of INPs, biological particles have received much attention in recent years after the estimated amounts of primary biological aerosol particles (PBAPs) emitted into the atmosphere were increased substantially (Jaenicke 2005) but remain poorly quantified. Given their organic composition, such biological INPs may experience chemical processing in the atmosphere. In particular, their surfaces consist of numerous chemical functional groups which are highly susceptible to chemical reaction, especially oxidation via common atmospheric oxidants such as ozone and the hydroxyl radical (OH). OH, for example, is highly electrophilic ("electron loving") so that it can react at multiple locations within large biological molecules, potentially altering the surface structure of the INPs to a degree that ice nucleation becomes less efficient. These effects of atmospheric oxidants on biological INPs are unexplored.

In my study, I focused on pollen INPs, which are emitted into the atmosphere in large numbers during vegetation blooming seasons, and investigated their IN ability when exposed to the hydroxyl radical in simulated cloud water (Gute and Abbatt 2018). Pollen comprise significant amounts of water extractable compounds which are also referred to as subpollen particles (SPP) on their surface and inside the grains. The SPPs are of submicron sizes, which compared to the relatively large pollen grains (few tens of micrometers) can be easily suspended and transported by atmospheric winds. These small particles are believed to be polysaccharides and have been shown to be active as INPs.

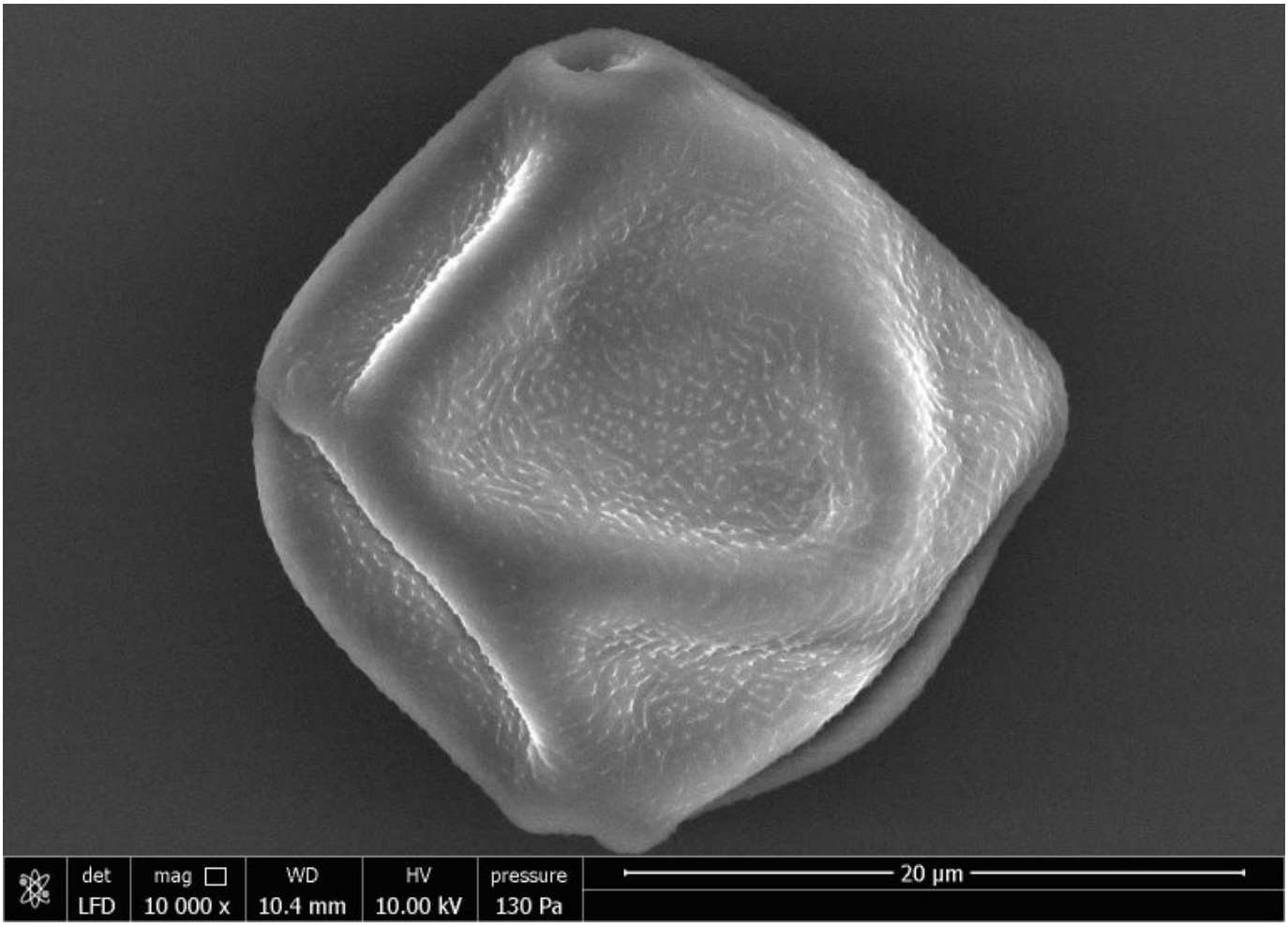

Figure 2. Scanning Electron Microscope (SEM) image of an intact silver birch (Betula pendula) pollen grain. Full birch pollen grains have sizes between 16 and 27 µm. Image taken by Ilya Gourevich, University of Toronto.

Based on this knowledge and motivated by the very small number of prior studies, which investigated the effect of ozone on organic and biological INPs, I investigated OH oxidation in simulated cloud water and its effect on the INP activity of pollen SPP.

Silver birch (*Betula pendula*) and grey alder (*Alnus incana*) pollen were suspended in water and only the water extractable compounds, which contain the SPP, were used for oxidation experiments. The oxidized pollen particles were then dried and examined for their IN activity at cold cloud conditions using the University of Toronto Continuous Flow Diffusion Chamber (UT-CFDC). More details of the full experimental procedure are available in Gute and Abbatt (2018).

In this initial study, I found the IN activity for both birch and alder pollen to significantly decrease upon OH oxidation. Additional chemical analysis points towards the molecular structure of the pollen material being altered by the OH radical. With relatively high OH concentrations used to oxidize the pollen, this study represents just the first steps in exploration of the importance of chemical processing of biological INPs. Future work will involve oxidation under more atmospherically relevant conditions, working with a wider variation of biological INPs, and studying ice nucleation under different modes than deposition freezing. The ultimate goal is to arrive at a parametrization of the chemistry that could be included in climate models that assess the role of ice nucleation in the atmosphere.

About the Author

Ellen Gute holds a Diplom Meteorology Degree (equivalent to Master Degree) from the University of Mainz (Germany) and is currently conducting PhD research in the Abbatt Research Group at the University of Toronto.

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Article: Tracing PM2.5

Using Back-Trajectories to Trace the Origins of Fine Particulate Matter (PM2.5) / Origine des particules fines (PM2.5) : méthodologie des rétrotrajectoires

Jean-Philippe Gilbert, Richard Leduc and Natalie Barrette, Geography Department, Université Laval

Air pollution in the province of Québec, Canada, is monitored daily to allow for a rapid response to public health issues. However, there are few studies concerning the long-distance trend of pollutants, and those studies that do exist focus on a small area of study. The objective of this paper is to determine the sources of certain pollutants coming in to Québec, across all of the borders to the north, south, east and west.

This study focused on the source of fine particulate matter (PM), in the $PM_{2.5}$ category. In this category are particles that are smaller than 2.5 micrometres in diameter. Sources include fossil fuel burning, forest fires, and dust storms. These particles pose a particular health risk as because they are so small and light they stay airborne for longer than larger particles, increasing the chances of inhalation by humans and animals.

The back-trajectory method is used in order to analyse the great distances traveled $PM_{2.5}$. This method traces the path of an air mass in reverse, from the point of arrival to the point of departure. In this study, this method shows that the greatest source of $PM_{2.5}$ is the Great Lakes region.

***Note: For all articles, the policy of the CMOS Bulletin is to print the article in the language (English or French) in which it was written, providing a summary in the alternate language.**

Introduction

La pollution atmosphérique est une problématique qui est grandement étudiée à travers le monde, sous divers angles, afin de mieux comprendre les défis des populations face à ce problème. Pour ce faire, l'une des techniques utilisées est la méthode des rétrotrajectoires [1-6]. Gilbert (2018) a récemment publié une analyse spatio-temporelle des concentration d'ozone et des matières particulaires mesurés sur la période 1974 à 2015. Cet article est un bref aperçu des résultats des rétrotrajectoires pour les particules fines ($PM_{2.5}$) mesurées à une station (Deschambault).

Méthodologie des rétrotrajectoires

Les rétrotrajectoires sont souvent utilisées pour illustrer la provenance probable d'un contaminant pouvant voyager sur de longues distances. Il s'agit d'une méthode permettant de déterminer le lieu probable d'une parcelle d'air de son point d'arrivée vers son point d'origine [7]. Cette méthode est de plus en plus utilisée dans les études sur la qualité de l'air et la dispersion des polluants atmosphériques [1]. Il existe plusieurs méthodes pour calculer les rétrotrajectoires. Pour notre étude, l'utilisation des données du modèle météorologique numériques d'Environnement Canada est préconisée. La méthode est plutôt simple, puisqu'elle assume que les parcelles d'air vont garder les mêmes propriétés tout au long de leur déplacement. Cette méthode est largement utilisée pour la détermination de l'origine des polluants sur une courte période de temps. Elle permet de calculer, avec les données de directions et de vitesses de vent, le déplacement d'une parcelle d'air, pour un pas de temps de 6 h [7-10]. Par la suite, à l'aide de la station météorologique la plus proche, un autre retour est

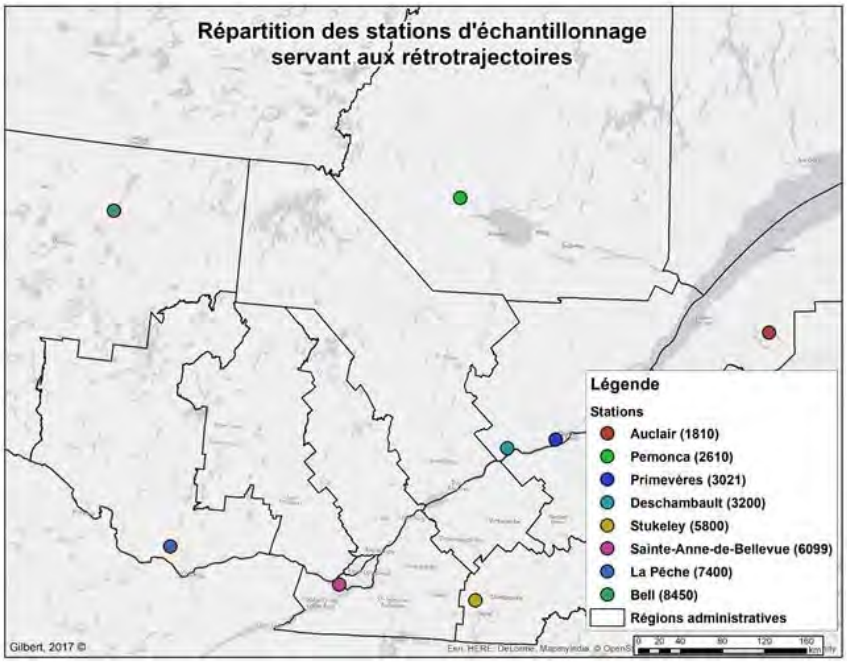

Figure 1 : Répartition des stations d'échantillonnage servant aux rétrotrajectoires.

calculé pour un pas de temps de 6 h, et ainsi de suite jusqu'à un retour de 36 h. Les masses d'air à une pression de 925 mb (ce qui correspond à environ 760 m d'altitude) sont utilisées, puisque, selon la littérature scientifique, ce sont les masses d'air qui représentent le mieux le transport des polluants dans le nord-est de l'Amérique [9, 11].

Ces rétrotrajectoires sont jumelées avec les moyennes journalières de $PM_{2.5}$ calculées entre 2006 et 2015, pour huit stations d'échantillonnages (Fig. 1). Ces stations ont été choisies pour leurs emplacements qui représentent l'ensemble du territoire à l'étude. Les données sur le polluant sont fournies par le ministère du Développement durable, Environnement et Lutte contre les Changements Climatiques. Le fichier des rétrotrajectoires est divisé en série de points représentant un quadrillage. Chaque point représente une coordonnée géographique et ce point correspond au sommet inférieur gauche d'une cellule d'un quadrillage. Il est donc possible de convertir ce quadrillage de point en une grille de cellule où chaque cellule représente 190 km par 190 km. Puis, selon la distribution statistique des concentrations, les rétrotrajectoires sont divisées pour créer trois cartes : la première avec le tiers des concentrations les plus basses (33 centiles), la deuxième avec le tiers des concentrations mitoyennes (entre 33 centiles et 66 centiles) et la dernière avec le tiers des concentrations les plus élevées (66 centiles). On peut ainsi obtenir la fréquence (ou probabilité empirique) d'origine des parcelles pour chacune des classes de concentration (faibles, intermédiaires, hautes) associée aux secteurs de la grille. Par exemple, pour Deschambault, la première classe comprend les cas avec une moyenne quotidienne de $PM_{2.5}$ inférieure à 4.63 $\mu g/m^3$, la deuxième de 4.63 à 7.83 $\mu g/m^3$ et la dernière les cas avec plus de 7.83 $\mu g/m^3$. Chacun de ces seuils de concentrations est calculé par rapport à la distribution statistique de la station. Cela signifie que chaque station à des seuils différents, dépendamment des niveaux de concentrations à cet endroit.

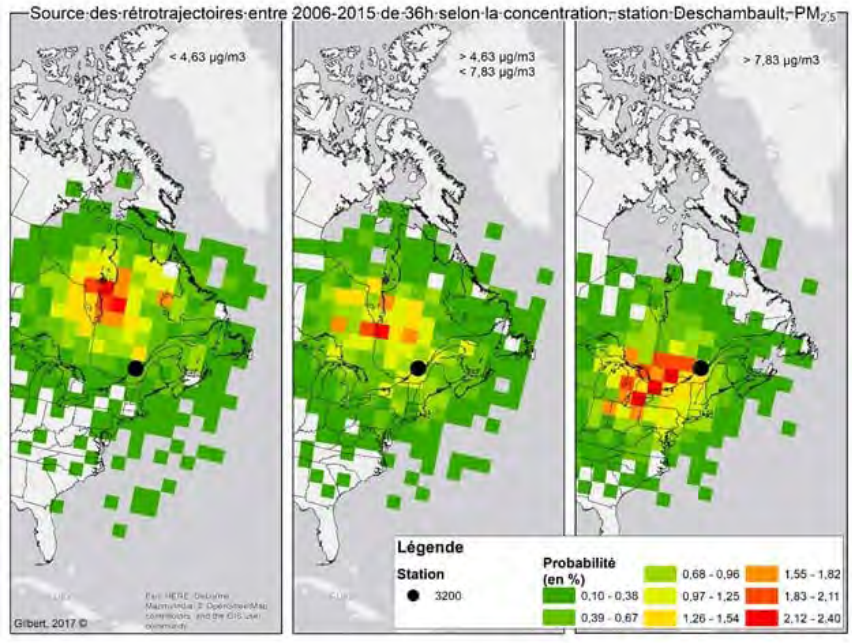

Figure 2: Source des rétrotrajectoires entre 2006-2015 de 36 h selon la concentration des PM2.5, station Deschambault

On notera que les seuils des classes diffèrent pour chaque station au lieu de considérer des seuils fixes; cette procédure permet d'assurer que le nombre d'effectifs est le même pour chaque classe à chaque station.

Les Origines des $PM_{2.5}$

La Fig. 2 représente la station Deschambault, qui représente le patron de déplacement pour l'ensemble des huit stations des rétrotrajectoires. Les concentrations basses des $PM_{2.5}$ correspondent à des rétrotrajectoires originaires du nord, principalement au-dessus de la baie James. Plus les concentrations augmentent, plus l'origine

des rétrotrajectoires se dirige vers le sud, particulièrement pour le tiers des concentrations les plus élevées. En effet, pour ce tiers, les rétrotrajectoires sont originaires principalement du sud-ouest du Québec, du sud-est de l'Ontario ainsi qu'au-dessus de la région des Grands Lacs.

Pour les basses concentrations, les rétrotrajectoires sont originaires du nord du pays. Il s'agit de secteurs peu occupés et n'ayant peu d'industries[12]. Les sources naturelles sont donc responsables des faibles concentrations de particules fines pour le territoire à l'étude. Puis, lorsque les concentrations augmentent, les origines des rétrotrajectoires se trouvent principalement dans le sud du pays, à la frontière entre le Canada et les États-Unis. Ce secteur jouit d'un écoumène continu, particulièrement dans la portion sud de l'Ontario [12]. De plus, il y a un large bassin de population de part et d'autre de la frontière, bassin contenant autour de 42 millions de personnes [13]. Les Grands Lacs sont une région fortement industrialisée par l'industrie automobile, chimique, papetière et sidérurgique [13]. Puisque les industries font partie des émetteurs des particules fines [14], il est donc possible de dire que les industries des Grands Lacs contribuent aux hautes concentrations des particules fines pour ces deux stations. Ces résultats sont semblables pour les huit stations à l'étude.

En conclusion, une analyse détaillée de la qualité de l'air relativement à l'ozone et aux particules au Québec sur la période 1974 à 2015 a été réalisée par Gilbert (2018) et sont présenté ici les résultats combinant les particules fines et les rétrotrajectoires pour la station de Deschambault. Les sources des rétrotrajectoires permettent de mettre en lumière des phénomènes qui permettent de déterminer les possibles causes de la pollution atmosphérique sur un territoire, qui à première vue, ne comporte pas nécessairement des sources de polluants à proximité. De plus, cela permet de voir l'importance de l'être humain sur la pollution atmosphérique, particulièrement pour les particules fines.

Remerciements

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À propos d'auteur

Jean-Philippe Gilbert est un étudiant au doctorat en sciences géographiques de l'Université Laval, plus particulièrement en climatologie. Ses champs d'expertises sont la climatologie, la pollution atmosphérique (particulièrement l'ozone et les particules) et les changements climatiques.

Ses champs d'intérêts (autres que ses champs d'expertises) sont le traitement des bases de données massives, les SIG, la programmation et les problématiques environnementales (air, eau, sol).

Article: IFMS

IFMS: Uniting Meteorologists Around the World / IFMS : unir les météorologistes du monde entier

An Interview with Harinder Ahluwalia, IFMS President, by Bulletin Editor Sarah Knight

What does the IFMS do?


Harinder Ahluwalia, IFMS President

The International Forum of Meteorological Societies (IFMS) represents National Hydro-Met Societies (NHMSocs) and creates collaboration between them in the same way as the World Meteorological Organization (WMO), which is an agency of the United Nations, does for National Hydro-Met Services (NHMS) of various nations.

IFMS generates science and technology collaborations between NHMSocs, allowing them to share resources and build capacity. IFMS also helps create new NHMSocs in those nations where none exists today. We collaborate with WMO and GFDRR-WBG (Global Facility for Disaster Reduction and Recovery of the World Bank Group) in their Global Weather Enterprise initiative.

How did you get involved?

IFMS was created in 2010 and after initial enthusiasm it became a dormant organization. During the World Weather Open Science Conference of August 2014 (WWOSC-2014) held in Montreal, I (as the President of CMOS) and Bill Gail (as the President of the American Meteorological Society – AMS) were asked to organize three sessions on the future of the Weather Enterprise. We formed an Organizing Committee for that event and decided to invite "who is who of the weather world" to complete the following three panels:

- Panel 1: Weather Services Infrastructure: Sustaining what we have and building for tomorrow
- Panel 2: Weather Services – Present Status, Trends, and Innovations
- Panel 3: Enhancing Weather Community Collaboration to Meet Shared Goals for the Weather Enterprise

We created a very interesting Report, which I believe was used by WMO in its 2015 Congress to launch the Global Weather Enterprise (GWE) Initiative. The following were the conclusions derived from the three sessions for strengthening our fight against Global Warming: (1) International Cooperation is mandatory for progress on this important issue, (2) Public, Private and Academic (PPA) Sectors must cooperate for the progress of S&T and provision of services, (3) Capacity building in Least Developed and Developing countries is absolutely necessary and (4) At least basic infrastructure needs to be installed in the least developed and developing countries.

I started thinking that it is easy to have meetings and provide advice but what about acting on that advice to make a difference?

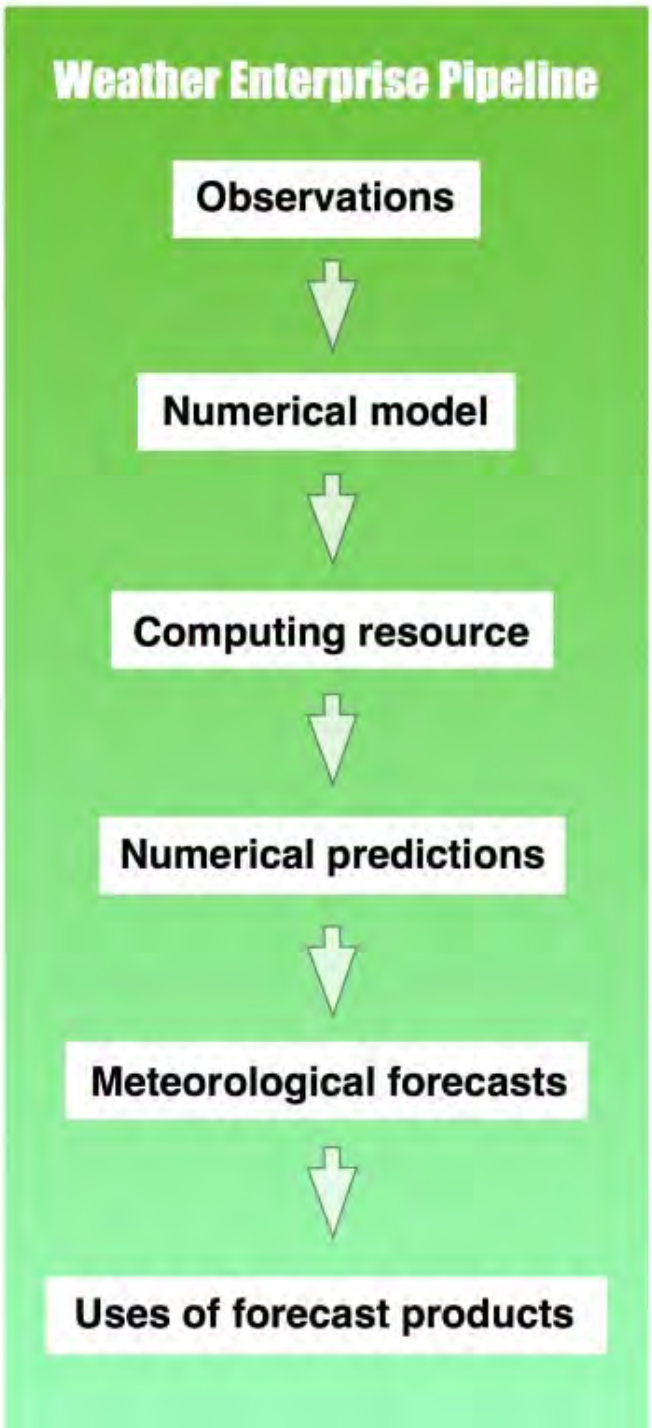
I discussed with AMS to help CMOS to activate and strengthen IFMS, in order to use it as a glue to unite NHMSocs of the world. AMS agreed and fully cooperated to hold a meeting of the IFMS Member Societies in New Orleans in January 2015 concurrently with the AMS Conference. In that meeting, we decided to create a Council, incorporate IFMS, create a Value Proposition and start creating infrastructure for communication, collaboration and capacity building. Many of these activities have been completed and the rest of them are under execution. We have also signed an MOU for cooperation with WMO.

Through organizations like the IFMS and CMOS, is the platform strong enough for public, private and academic enterprises to truly work together?

National Hydro-Met Societies (NHMSocs) are an important building block of the GWE. Many NHMSocs have membership from all sectors – Public, Private and Academic (PPA). Therefore, they present a congenial non-partisan venue for discussing collaboration.

A society like CMOS has a Private Sector Committee (PSC) and it represents the point of view of the Private Sector. Although more work is required for true collaboration, at least the building block is there. WMO and its recently created committee GWEF (GWE Forum) are working on steps to assist NHMSs to be a willing partners in GWE. The recommendations will be used by IFMS to assist NHMSocs to promote this vision.

WMO is promoting very strongly the GWE initiative which is supported by GFDRR-WBG and HMEI (Hydro-Met Equipment Industry). There will be many road blocks and challenges to this concept of PPA collaboration in various countries for different reasons but eventually it is expected to succeed because of the fact that the development of S&T and services to handle the future challenges cannot be handled without full cooperation of the three sectors.



Source: https://public.wmo.int/en/resources/bulletin/weather-enterprise-global-public-private-partnership

Where do you see the field going? In ten years time, what will the technological capability and social understanding look like?

Due to the Global Warming, innovative solutions are required more urgently than ever before. This can only be achieved through collaboration between PPA sectors. Thanks to the efforts of WMO and the GFDRR, GWE is expected to grow substantially over coming years – some estimates state 10 times over the next 10 years. The World Bank Group (WBG) has significantly increased its support to NHMSs in developing countries. Since 2010, the WBG portfolio increased from 25 projects with a total funding $270 million to 67 projects with funding reaching $900 million. Even this amount is not considered sufficient and GWE promoters believe that larger scale and more efficient engagement between the public and private sectors is essential, and that should also include academia. The private sector's contribution to GWE has grown from $2-4 Billion in 2012, to over $9 Billion in 2017. The technology capability will increase greatly with collaborative PPA participation.

Worldwide losses from Natural Disasters in 2017 were US$330 Billion, with thousands of lives lost. With proper information and planning those losses could have been reduced greatly. Only a fraction of the above amount can provide all the required infrastructure and a great boost to S&T. Instead of being reactive to weather disasters, we need to be proactive. It appears that we have not been able to make a strong enough case to our Governments to support more investment in this field to safeguard humanity against the natural disasters. As the President of the IFMS, I am urging WMO to prepare a strong Value Proposition for convincing National Governments to invest more in our field and also prepare material for educating public about the value of investment in our field. The politicians listen to public pressure.

You served as CMOS President in 2014-2015. Given your experience with the IFMS and your knowledge of other meteorological societies around the world, how does CMOS compare?

The financial situation of AMS is strong and US companies are very generous in making financial contributions. AMS is the strongest Met Society which has almost everything a

society can hope for. They also have an International Affairs Committee which plans, executes and keeps track of their international activities. In contract, in Canada it is quite hard to get donations from large corporations which use meteorology as a part of their daily business.

CMOS' flagship activity is its Conference which attracts reasonably large number of participants and speakers. If the Society could convince larger users to make financial contributions more would be possible, including having a full time Executive Director and possibly an assistant, existing Programs strengthened, a strong mentoring program, the certification program restarted, and greater participation in international activities.

What areas is CMOS missing that we could be putting more attention to, given the restrictions of a non-profit society?

During my term as the President, I tried to achieve a lot of things such as Webinars, Mentoring, international cooperation, involving large users of hydro-meteorology and oceanography, etc. One year was too short a period to make big changes. These ideas should be given high priority if CMOS is to become a powerful organization. Its number one priority should be convincing large users to provide financial sponsorship to CMOS.

Financing is the most common problem for almost all such societies. The IFMS is forming a Committee to develop Value Proposition for convincing donors to contribute to their local Met Societies as well as to IFMS to strengthen all Met Societies. This should be helpful for CMOS too.

Does the Canadian government support CMOS to the same level that other Met Societies around the world are?

The Canadian Government's support for CMOS is in line with that of other Governments. But I strongly believe that the Meteorological Societies in general have not been able to make their governments understand the value of such societies which are staffed by volunteers, many of them very dedicated to the cause. Therefore, we have to make a stronger case for bigger support by local government.

We also need to educate public at large about the Global Warming and the disasters caused by it as well as the role a benevolent society like CMOS can play. Considering the value a society like CMOS can provide for the nation in this important field, bigger financial and moral support from National and State Governments is logical. We need to work harder to achieve this.

How can Canadian meteorologists get involved with the IFMS?

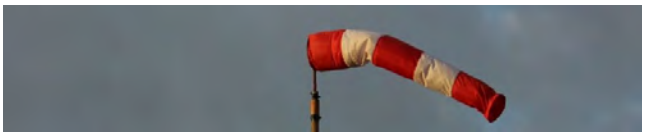
At this time IFMS is in a formative stage and we ask, like President Kennedy did, "Ask not what IFMS can do for you, ask what you can do for IFMS" and then see what IFMS can do for you.

Major goals of IFMS are to create collaborations, between Societies and their members, provide strong means of communications through Website, Newsletter and Social Media, and assist WMO and WBG in creating Capacity, leverage each other's strengths. We are looking for Volunteers to run many of our programs and are requesting all societies to help. What we do will be useful for all societies.

On the other hand, CMOS members should start using the facilities provided by IFMS which include collaboration, infrastructure, and communications like the IFMS Newsletter and the website to spread their messages.

In case you missed it...

From CMOS Bulletin Volume 46, Number 4:



[Comparison of wind forecasts and observations at Lake Saint-Charles, Quebec / Comparaison des prévisions et des observations de vent au lac-St-Charles, Québec]
by Richard Leduc and Maude Chartrand

[The Lunar Atmosphere: a surface-bounded exosphere that builds a record of delivery of water to the Earth's oceans]
by Paul Godin, Jacob Kloos, Tue Giang Nguyen, Jasmeer Sangha and John Moores

[The Passing of Morley Thomas, 1918-2018]
by David Phillips

[Message from the President for August 2018: It's All About Stewardship]
by Paul Kushner

[Members Updates]
Meeting Notifications, Books for Review, and more

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After 45 years in print, the Bulletin of the Canadian Meteorological and Oceanographic Society (CMOS) has gone virtual. See bulletin.cmos.ca for articles, news, events and updates from Canada's top meteorologists, climatologists and oceanographers.

Après 45 années de publication papier, le Bulletin de la Société canadienne de météorologie et d'océanographie (SCMO) passe en mode virtuel. Consultez le site bulletin.scmo.ca pour lire des articles, des nouvelles, des annonces d'événements et des faits nouveaux que partagent les éminents météorologues, climatologues et océanographes du Canada.

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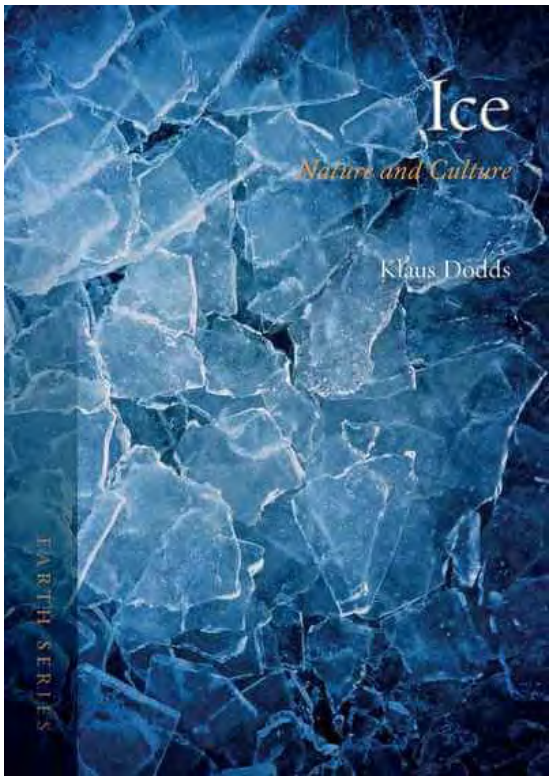
Book Review

Ice: Nature and Culture

Review by Bob Jones, CMOS Archivist



By Klaus Dodds
Published by Reaktion Books
Distributed by University of Chicago Press
Paperback, 229 pages, $ 24.95 (USD)
ISBN-13: 978-1-78023-905-7

Ice is not a science textbook about ice, nor is it a manual of Ice Forecasting (the reviewer will know as he was an Ice Forecaster with the Meteorological Service of Canada in a former life). Rather it is a wide-ranging exploration of the cultural, natural and geopolitical history of ice. It is very readable by all and forms part of a series of 24 other books on natural phenomena written by various experts. These books, including *Ice*, are edited by David Allen, University of Canterbury UK, who started the series in 2012. Some others in the series are *Air, Clouds, Flood, Lightning, Rainbows, Storm* and *Tsunami*. Several of these have arrived at the CMOS Office for review.

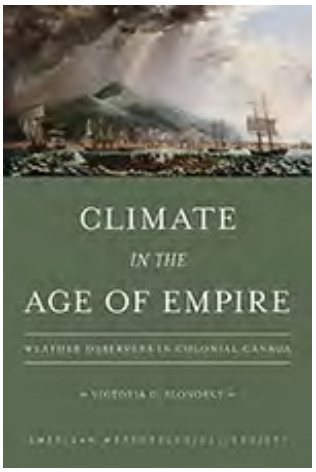
Ice is well indexed, illustrated and has an excellent prologue. The terminology used throughout is accurate and up to date. There are only seven chapters, followed by the conclusion called *Farewell to Ice*, reflecting the global decrease in natural ice as caused by climate change. Chapter one, *A World of Ice*, defines ice and where it is in the globe. All forms of ice including glaciers, icebergs, sea ice (including multi-year), river and lake ice, etc. are described. Chapter two, *Exploring and Conquering Ice*, describes the many expeditions into ice-covered land and sea areas, islands, Greenland and Antarctica, as part of the human discovery and land claiming over the centuries. The Franklin Expedition is included. Chapter three, *Imagining and Representing Ice*, covers how the indigenous peoples of the northern hemisphere have lived in harmony with ice. It concludes with the role icebergs played in the Titanic disaster.

Chapter four, *Icy Geopolitics*, focuses on the author's main interest and makes fascinating reading about the way international borders are constantly shifting because of ice, and concludes with how Antarctica has been organized under the Antarctic Treaty System. Good coverage is given of the voyage of the Manhattan through the Northwest Passage and the still unresolved political issues there. The remaining chapters cover many topics about working with ice, sport and recreation on ice, and adapting to ice. Canadian readers will devour these chapters because of our close connection with snow and ice, often for many months each year. The author knows this and much space is dedicated to skiing, skating, tobogganing, ice fishing, ice festivals and hotels built of ice. The development of the Winter Olympics comprising mostly on-ice sports is covered. It was surprising to me that skiing began 12,000 years ago in China as a form of transport, predating the wheel! The omission of curling as an on-ice sport and the Quebec City Ice Hotel was missed. The role of ice, carved from rivers and lakes and saved in sawdust, as the beginning of food refrigeration is described. There is a good section on all aspects of ice cores from deep glaciers.

There is much more I did not mention; suffice to say in conclusion that *Ice* is an easy and interesting read for anyone wanting to become an instant expert on all things ice.

CMOS News

New Book Available for Review



Climate in the Age of Empire: Weather Observers in Colonial Canada*,* 2018. By Victoria C. Slonosky, American Meteorological Society, ISBN 978-1-944970-20-8, US$35, 311 pages. More information available at https://press.uchicago.edu/ucp/books/book/distributed/C/bo28556192.html (2018-8)

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

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)

Sea Ice Analysis and Forecasting: Towards an Increased Reliance on Automated Prediction Systems*,* 2017. Edited by Tom Carrieres, Mark Buehner, Jean-François Lemieux and Leif Toudal Pedersen, Cambridge University Press, ISBN 9781108417426, 236 pages, $143.95 (2018-3)

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)

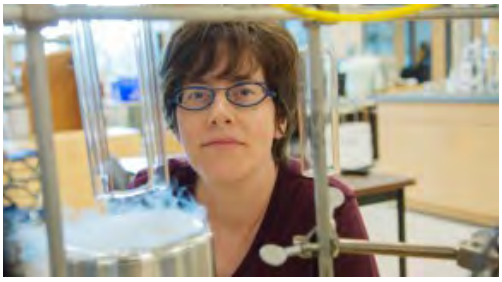
The Deep Pull: A Major Advance in the Science of Ocean Tides*.*
By Walter Hayduk, FriesenPress, ISBN 9781525518706 (hardcover) $35.49, 9781525518713 (softcover) $27.49, 9781525517820 (eBook) $11.99, 251 pages. (2018-7)

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; Weather, A Very Short Introduction; Nonlinear and Stochastic Climate Dynamics.

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

CMOS Speaker's Tour features oceanographer Roberta Hamme



Roberta Hamme is a chemical oceanographer who studies the marine carbon cycle. She works on understanding and quantifying the natural mechanisms that transport carbon from the surface ocean to the deep, reducing atmospheric carbon dioxide levels. She holds a Canada Research Chair in Ocean Carbon Dynamics at University of Victoria's School of Earth and Ocean Sciences. Roberta will travel Western Canada in the fall and spring with her talk **Ocean Oxygen Cycling from Robotic and Shipboard Observations**.

Ocean oxygen concentrations control where organisms thrive in the ocean and provide important clues to biological productivity rates and the impacts of climate change. Yet despite being one of the oldest and most robust oceanographic chemical measurements, our understanding of oxygen cycling and variability has been limited by the infrequency of shipboard observations. Oxygen sensors mounted on Argo floats offer the means of vastly expanding the ocean oxygen database. These autonomous robotic floats change their density to profile through the water column. Shipboard observations remain important to calibrate sensors, to deploy floats, and especially to conduct intensive studies to understand the processes affecting observed oxygen variations. Oxygen data from Argo floats in the Labrador Sea, one of the few sites in the world where surface waters move into the deep ocean, have been used to determine the low oxygen content of these newly formed water masses. Oxygen data from Argo floats in the North Pacific Ocean have been used to estimate biological productivity rates over an annual cycle. Some of the new questions that can be answered using such observations include documenting and understanding recent downward trends in oxygen throughout most of the ocean's subsurface waters (known as ocean deoxygenation) and linking oxygen cycles with other sensors now being deployed on Argo floats such as pH, nitrate, and optical properties.

For Roberta's tour schedule visit https://cmos.ca/site/speakers

Other News

Developments in Arctic Shipping Operations & Infrastructure, March 13th-14th, 2019, Montreal

The two day conference will consist of a number of informative presentations followed by interactive Q&A sessions and panel discussions to further involve the delegates. These talks will give a deep insight into the views shared on the different aspects of Arctic Shipping.

Key Topics This Year Include:

- Operating Successfully in a Hostile Environment
- Overcoming Practical Challenges to Reach Polar Code Compliancy
- Freedom of Trade in the Arctic
- Coordinating Global Aims for Arctic Development
- Improving Communication Systems in the Arctic to Advance Shipping Capabilities
- Keeping Up with Growing Demand for Vessels with Ice breaking Capacity
- Shipping Opportunities Arising from Arctic Mining and Extraction Projects
- Emerging Arctic Markets and Trade Routes
- Updating Infrastructure in Line With Increasing Maritime Activity
- Developing Arctic Tourism while Ensuring the Safety of Passengers, Crew and Local Communities and Wildlife

More information can be found on https://www.wplgroup.com/aci/event/arctic-shipping-summit/

Canada's Catastrophe Conference CatIQ Connect 2019 Student Delegate Program

CatIQ Connect's Student Delegate Program has been created to provide networking opportunities to graduate students attending Canadian universities and who are working in fields, or researching topics related to, resilience from catastrophes. We are now accepting submissions through Nov 16.

Three (3) opportunities are available which include:

- Full conference registration
- Thesis presentation on Tuesday, February 5th (Day 2)
- Display space during cocktail reception on Tuesday, February 5th (Day 2), for further discussion $1,000 academic award

**CatIQ Connect will also be offering up to 7 additional students the opportunity to showcase their research at the cocktail reception/poster session on Tuesday, February 5th.

***CatIQ's Student Delegate Program is now accepting submissions.

If you have questions regarding our Student Delegate Program, please do not hesitate to contact Becky Sheffman at 416-368-0777 x28 or becky.sheffman@catiq.com

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The CMOS Bulletin has moved on-line to http://bulletin.cmos.ca. Please continue to send articles, notes, workshop reports and news items to bulletin@cmos.ca. We will be accepting, reviewing, and publishing content on an on-going basis.

This publication is produced under the authority of the Canadian Meteorological and Oceanographic Society. Except where explicitly stated, opinions expressed in this publication are those of the authors and are not necessarily endorsed by the Society.

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Le *Bulletin de la SCMO* se trouve maintenant en ligne à http://bulletin.scmo.ca/. N'hésitez pas à soumettre notes, rapports d'atelier et nouvelles à l'adresse bulletin@scmo.ca. Nous accepterons, réviserons et publierons vos contenus sur une base continue.

Cette publication est produite sous la responsabilité de la Société canadienne de météorologie et d'océanographie. À moins d'avis contraire, les opinions exprimées sont celles des auteurs et ne reflètent pas nécessairement celles de la Société.

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

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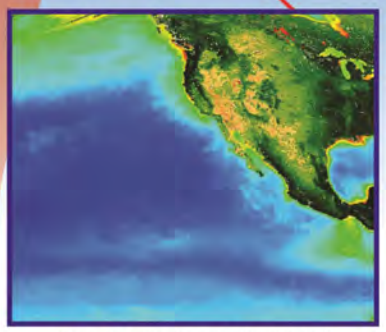
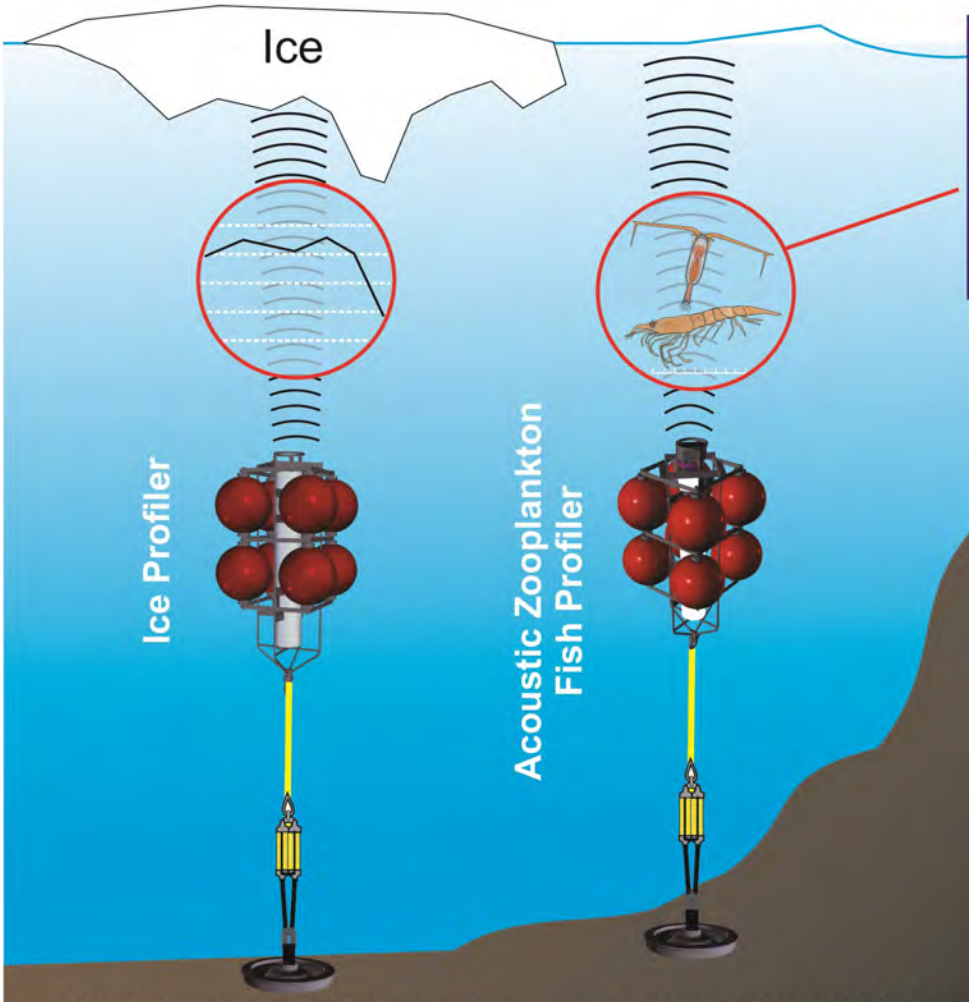
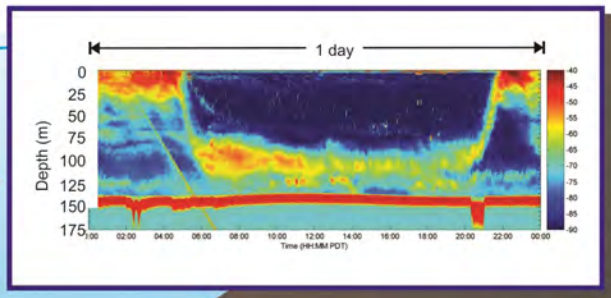


Ocean colours are chlorophyll concentrations and land colours are NDVI





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