ISSN 1929-7726 (Online / En ligne)

CMOS BULLETIN SCMO

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

May / mai 2020 Vol. 48 No. 2

Phil "the forecaster" Chadwick's painting of the eastern shore of Singleton Lake with contrails overhead

Story Inside p. 6.

Photo Credit to Phil Chadwick.

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Reliable.Compatible.Customizable.

Take advantage of 40 years of experience in the field and create a monitoring system that fits your data collection requirments.

Reliable measurment systems supported by world class tech support to save you time and money.

Multiple communication and software options to choose from to help you collect your data anytime, anywhere.

ClimaVUE™50

All-In-One Meteorological Sensor

***Cost effective and easy to deploy**

campbellsci.ca/climavue-50

SDMS40

Multipoint Scanning Snowfall Sensor

***Ideal for snow depth or water depth measurements**

campbellsci.ca/sdms40

CR6

Measurement and Control Datalogger with countless applications

campbellsci.ca/cr6

SP Lite2

Silicon Pyranometer

***Designed for routine measurement of solar radiation**

campbellsci.ca/splite2

For our full product line please visit www.campbellsci.ca

CMOS Bulletin SCMO
Volume 48 No. 2
May / mai 2020

CMOS Bulletin SCMO
"at the service of its members / au service de ses membres"

Editor / Rédactrice: Nicole Renaud
Director of Publications / Directeur des publications: Douw Steyn

Canadian Meteorological and Oceanographic Society / Société canadienne de météorologie et d'océanographie
E-mail: bulletin@cmos.ca
Courriel: bulletin@scmo.ca

CMOS Office / Bureau de la SCMO

P.O. Box 3211, Station D
Ottawa, Ontario, Canada, K1P 6H7
Homepage: http://www.cmos.ca
Page d'accueil: http://www.scmo.ca

Gordon Griffith, Ing., P. Eng., FEC
Executive Director - Directeur général
Tel/Tél.: 613-990-0300
E-mail/Courriel: cmos@cmos.ca

Ms. Qing Liao
Office Manager - Chef de bureau
Tel/Tél.: 613-990-0077
E-mail/Courriel: accounts@cmos.ca

CMOS Accredited Consultant
Expert-Conseil accrédité de la SCMO

Douw G. Steyn

Air Pollution Meteorology
Boundary Layer & Meso-Scale Meteorology

4064 West 19th Avenue Vancouver,
British Columbia
V6S 1E3 Canada
Tel: 604-364-1266; Home: 604-222-1266
Email: dsteyn@eoas.ubc.ca

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

Alternative Congress & Virtual Sessions

Dear CMOS Friends and Colleagues,

Over the last two months, we have all had to adjust to the disruptions caused by the COVID-19 pandemic, and CMOS is no exception. In March, we monitored the rapidly evolving COVID-19 situation on a daily basis, and on April 3, we decided to cancel the 54th Congress, which was scheduled for May 24-28 in Ottawa. This decision was based on the recommendations of local, provincial, and federal governments and public health agencies regarding actions needed to slow the spread of COVID-19 and protect our communities. It was made in collaboration with the Local Arrangements Committee (LAC), the Scientific Program Committee (SPC), the CMOS Executive and Council, and the Delta Hotel.

However, the annual CMOS Congress is an important event for maintaining connections within our scientific community, with 350 abstracts submitted this year. Wanting to continue with some event for our members, we explored options for a virtual format and received enthusiastic support for moving the Congress online. An alternative Congress is therefore taking place over three weeks from Tuesday, May 26 to Thursday, June 11, 2020. We worked with convenors to create an online forum consisting of 16 virtual sessions spread out over those three weeks. These sessions cover a broad range of topics related to the Congress theme of “Building Societal Resilience to Changing Weather, Climate, Oceans and Environment”.

The Congress website has been reconfigured to support the new format, and the revised program can be found there. The sessions will be hosted by their convenors and will be live-streamed, primarily using Zoom. There are no fees associated with joining this online event, but all participants must register on the Congress website; registration will provide access to all virtual sessions. The new format adopted this year will be an experiment for CMOS, one that we hope provides useful lessons for adding a virtual component to future Congresses.

In addition to the scientific forum, the CMOS Annual General Meeting will be taking place towards the fourth week of June. All CMOS members are welcome to attend via this Webex link and the meeting documentation will be made available in this Google Drive folder. The AGM is an important meeting for CMOS, one where members receive Annual Reports from Executive members, Committees, and local Centres, and discuss and vote on By-Law changes, the budget, and policy issues. This year, we will be presenting the CMOS member Code of Conduct after a period of consultation that began at last year’s AGM. Because we are unable to hold the traditional CMOS Banquet, this year’s recipients of CMOS prizes, awards, and fellowships will also be announced at the AGM in conjunction with a press release. We look forward to highlighting the excellent contributions the winners have made to the fields of meteorology and oceanography.

I would like to take this opportunity to thank all members of the LAC, the SPC, the Ottawa Centre, CMOS staff and Executive, and our session convenors for the tremendous effort that they have put into organizing the 2020 CMOS Congress, both the original version and the subsequent alternative format. Even though we will not be able to meet in person this year, we will still have an excellent scientific program.

I look forward to seeing you online at the alternative Congress and at our Annual General Meeting!

Kim

Kimberly Strong, CMOS President and Professor & Chair, Department of Physics, University of Toronto

president@cmos.ca

Mot de la présidente

Congrès nouveau genre & séances virtuelles

Amis et collègues de la SCMO,

Au cours des deux derniers mois, nous avons tous dû nous adapter aux perturbations que cause la pandémie de COVID-19, et la SCMO ne fait pas exception. En mars, nous avons suivi quotidiennement l'évolution rapide de la situation liée au virus. Le 3 avril, nous avons décidé d'annuler le 54e Congrès, qui devait se dérouler du 24 au 28 mai à Ottawa. Cette décision se fonde sur les recommandations des gouvernements locaux, provinciaux et fédéral et des organismes de santé publique concernant les mesures nécessaires pour ralentir la propagation de la COVID-19 et protéger nos communautés. Elle a été prise en collaboration avec le comité local d'organisation, le comité du programme scientifique, le comité exécutif et le conseil d'administration de la SCMO, ainsi que l'hôtel Delta.

Toutefois, le congrès annuel de la SCMO demeure un événement important au maintien des liens au sein de notre communauté scientifique, comme en témoignent les 350 communications soumises cette année. Comme nous souhaitions tout de même organiser une activité pour nos membres, nous avons étudié la possibilité d'un format virtuel. Nous avons reçu un soutien enthousiaste pour la mise en ligne du Congrès. Un congrès nouveau genre s'étendra donc sur trois semaines, du mardi le 26 mai au jeudi le 11 juin 2020. Nous avons travaillé avec les organisateurs afin de créer un forum en ligne composé de 16 séances virtuelles, réparties sur ces trois semaines. Ces séances couvrent un large éventail de sujets liés au thème du Congrès, « Bâtir une résilience sociétale face à l'évolution du temps, du climat, des océans et de l'environnement ».

Le site Web du Congrès a été reconfiguré pour prendre en charge le nouveau format. Le programme révisé s'y trouve aussi. Les séances seront animées par l'organisateur de chacune et seront diffusées en direct, principalement à l'aide de Zoom. La participation à cet événement en ligne est gratuite, mais les participants doivent s'inscrire sur le site Web du Congrès. L'inscription permettra d'accéder à toutes les séances virtuelles. Ce format expérimental, nous l'espérons, fournira des pistes de solution utiles pour ajouter une composante virtuelle aux futurs congrès.

En plus du forum scientifique, l'assemblée générale annuelle de la SCMO prévue pour lundi le 25 mai 2020 a été reportée et aura lieu en place la quatrième semaine du mois de juin. Tous les membres de la SCMO sont invités à y participer en suivant ce lien Webex. Les documents pertinents à l'assemblée seront déposés dans ce dossier sur Google Drive. L'AGA est une réunion importante pour la SCMO. Les membres y prennent connaissance des rapports annuels émanant du comité exécutif, des divers comités et des centres locaux. Ils discutent des modifications au Règlement, du budget et des politiques, et votent en conséquence. Cette année, nous présenterons le Code de conduite des membres de la SCMO, à la suite d'une période de consultation qui a commencé à l'AGA, l'an dernier. Comme nous ne pouvons organiser notre traditionnel banquet, les lauréats des prix, des distinctions et des bourses de la SCMO seront annoncés dans le cadre de l'AGA de cette année, et un communiqué de presse paraîtra parallèlement. Nous sommes impatients de souligner l'excellente contribution des lauréats dans les domaines de la météorologie et de l'océanographie.

Je profite de cette occasion pour remercier les membres du comité local d'organisation, du comité du programme scientifique et du centre d'Ottawa, le personnel et le comité exécutif de la SCMO, ainsi que les organisateurs des séances pour les efforts considérables qu'ils ont déployés pour organiser le Congrès 2020 de la SCMO, tant dans sa version traditionnelle que nouvelle. Même si une rencontre en personne s'avère impossible cette année, nous proposons tout de même un excellent programme scientifique.

Au plaisir de vous voir en grand nombre au Congrès et à l'assemblée générale annuelle en ligne.

Kim

Kimberly Strong, Présidente de la SCMO et directrice du département de physique de l'Université de Toronto
president@scmo.ca

Blue Sky Blues or the Three Degrees of Aircraft Pollution

By Phil Chadwick

The title of this 2012 painting below, numbered 1260 in my artistic journey, is “Three Degrees”. That title might sound cryptic. Let me explain.

All air traffic was grounded over North America for three or four days after the terror attacks of 9/11 on September 11th, 2001. A couple of curious meteorologists investigated the impact of grounding those aircraft. They discovered that the skies were much clearer and that temperatures responded correspondingly.

#1260 “Three Degrees” Laying in the composition

The direct effect was that night time temperatures under clear skies dropped on average three (maybe four) degrees Fahrenheit below the averages established prior to 9/11. The infra-red radiation from the ground those nights was not intercepted by the jet contrails and returned to earth. Simply, the nights were clearer and cooler with no air traffic and no contrails. Here is the title of that research: “Impact of unusually clear weather on United States daily temperature range following 9/11/2001” by Adam J. Kalkstein, Robert C. Balling Jr of the Department of Geography, Arizona State University, Tempe, Arizona 85287-0104, USA.

There was a follow-up article that claimed that the investigators did not correctly include the effects of a warm-front in their calculations. That may or may not be the case but any reasonable observer cannot deny the impacts of pollution. Corporations that profit from the burning of fossil fuels spend millions (typically about $201 million every year) to delay or block policies to tackle climate change. The goal is to discredit research that studies the impacts of greenhouse gases and climate change. Confuse, complicate and contradict basic science that has been well known since the 1820’s. These despicable tactics are sadly effective and encourage inaction and ongoing profiteering. An informed and knowledgeable populace is the solution and the thrust of this effort.

Still composing

Anthropogenic contrails are manmade cirrus clouds formed when water vapour from the exhaust of a jet engine condenses on particles which can come from either the surrounding atmosphere or the effluent itself. The aircraft soot from combustion is comprised of tiny particles which make for efficient condensation nuclei.

The water vapour freezes into ice crystals on these soot particles leaving a visible trail behind the aircraft. Any linear “veil clouds” that last more than 10 minutes behind the aircraft are called “persistent contrails”. These long lasting bands of ice crystals diffuse outward with time and have become better known as “contrail cirrus” being indistinguishable from naturally produced ice cloud. In fact the lines can spread into sheets composed of sub visible ice crystals that make the sky appear greyer. These blankets of ice crystals interfere with the escape of infra-red radiation from the earth surface. The distortion of the radiation balance generates a net warming at the surface.

Article: Blue Sky Blues

Russian scientists have been experimenting with artificial clouds for decades. Indeed weather modification has been attempted since the first time rain fell on somebody's parade. The seeding of individual clouds to encourage convective rain or to reduce the size of hail can have impact but the requirements in energy and material to do so are typically prohibitive. Meanwhile the climate engineering experiment of global warming has been underway since the industrial revolution first spewed fossil fuel exhaust into the atmosphere in 1760. The accumulated pollution over the years has changed the globe.

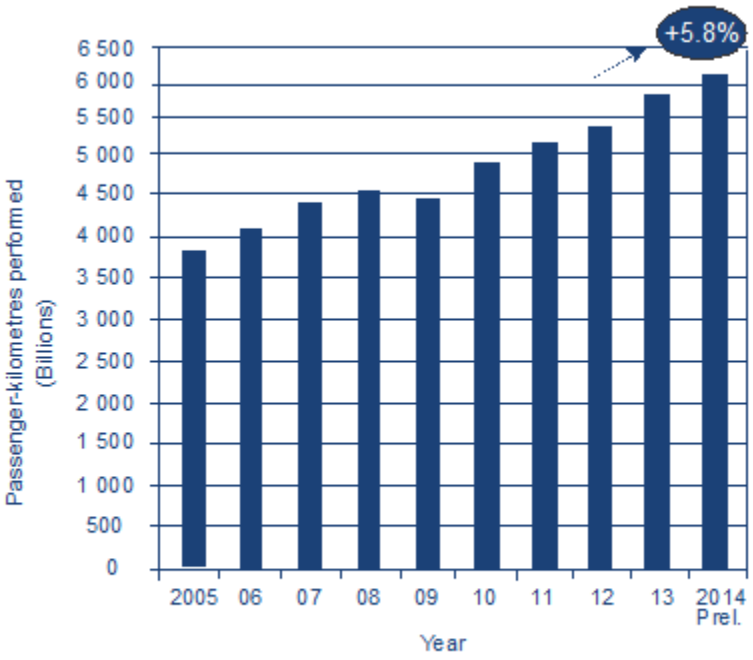
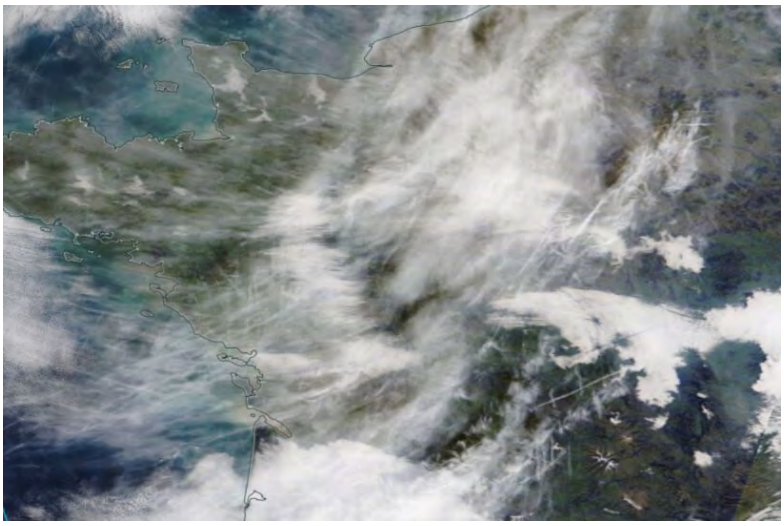


Figure 1. Total scheduled traffic (revenue passenger-kilometres performed, 2005-2014)

ICAO Report 2014

Relatively cheap, fast and generally safe air travel continues to increase by about 4 to 6 percent a year. Market factors can influence this but contrails are certainly increasing and I witness that fact in the skies that I paint. The International Civil Aviation Organization (ICAO) is a UN specialized agency established in 1944 to manage the administration and governance of the Convention on International Civil Aviation. The ICAO Annual Report of 2014 included the following graphic which shows air traffic increasing at about 6% a year.



NASA EOSDIS France 29 December 2019 Typical Contrails

There is a price to be paid for this particular high level atmospheric pollution. Unless we act, that expense will be felt by and paid for by future generations. Contrails influence more than just the colour of the sky and the lives of sky gazers like astronomers, meteorologists and artists. Solar power generation and agriculture feel the impacts immediately. A typical contrail filled sky drops my solar generation by about 10 percent – which is on par with other solar power studies completed around the globe.

Agricultural research has measured the "one percent rule". Crops and vegetation respond to a one percent increase or decrease of solar radiation with an equal impact on growth and productivity. A study in Holland has measured this relationship as being between 0.5 and 1.0 with most results skewed toward 1.0. Most flights are during the day when solar power is generated and plants rely on photosynthesis. Contrails quietly threaten a staggering impact on the green circular economy.

Peter Bosman, a friend in the Netherlands, has been studying the impacts of contrails and has prepared a documentary on the topic with a preview available here. Using EODIS NASA Data, Peter found that 50% of the days in the past four years had contrails while about 30-35 days per year had extreme contrail coverage.

Article: Blue Sky Blues

As I watch and try to better understand the skies and the weather, I continue to be disappointed at how much cloud is actually man-made pollution. Jet contrails account for a large percentage of the ice crystals in the upper atmosphere. What should be blue skies with a ridge of high pressure are almost always tainted by jet contrails spreading out with the winds aloft. The blue skies become transformed into overcast thin cirrostratus.

This painting view looking westward from the eastern shore of Singleton Lake is a typical ridge of high pressure. I think that all of the cirrus clouds in this painting are the results of jets flying in and out of Pearson International and the other major airports of North America. There are three main contrails in this particular painting which also contributes to the title I picked. Several jets left their mark in the sky while I painted. I included just one of these contrails coming from Europe along the preferred great circle route. The higher contrail cast a shadow on the lower layer of cirrostratus.

So if I am ever given the "third degree" on why I painted "Three Degrees", this will be my answer and I am sticking to it. It is a bit of science mixed with climate change and art. And it is all true.

Done on location

About the Author

Phil "the Forecaster" Chadwick

A man of many hats, Phil was born and raised along the St. Lawrence of Ontario, Canada and studied at Queen's University as a nuclear physicist. A meteorologist for Environment Canada since 1976, Phil specializes in severe weather and training. Remote sensing is his forte – you might want to see a tornado before you die… but not just before you die!

He has farmed, raised bees, written weather and nature books and articles, lectured and instructed classes, seminars and presentations in art, meteorology and the science of Tom Thomson. An avid canoeist, birder and naturalist, Phil paints mostly 'en plein air' hoping his passion for life and the environment shines through the canvas.

He started painting in 1967 in oils and never stopped.

Visibility Forecast in Wildfire Smoke: An August 2018 Case Study

by Yimei Li, Canadian Meteorological Aviation Centre, Environment and Climate Change Canada

In recent years, wildfire smoke has become an increasingly alarming natural disaster in Western Canada. In 2017 and 2018, the British Columbia provincial government declared a state of emergency for two consecutive summers in response to the wildfire situation (1). These were the third and fourth declarations in history and the previous ones were in 1996 and 2003. The duration of the declarations were from July 7, 2017 to September 15, 2017 and from August 15, 2018 to September 7, 2018. Although the duration of the declaration was shorter in 2018, the impact of smoke on the aviation community was greater than the previous year because the horizontal visibility at the airports dropped lower for an extended period of time. Flights were either cancelled or rescheduled at several BC interior airports (2).

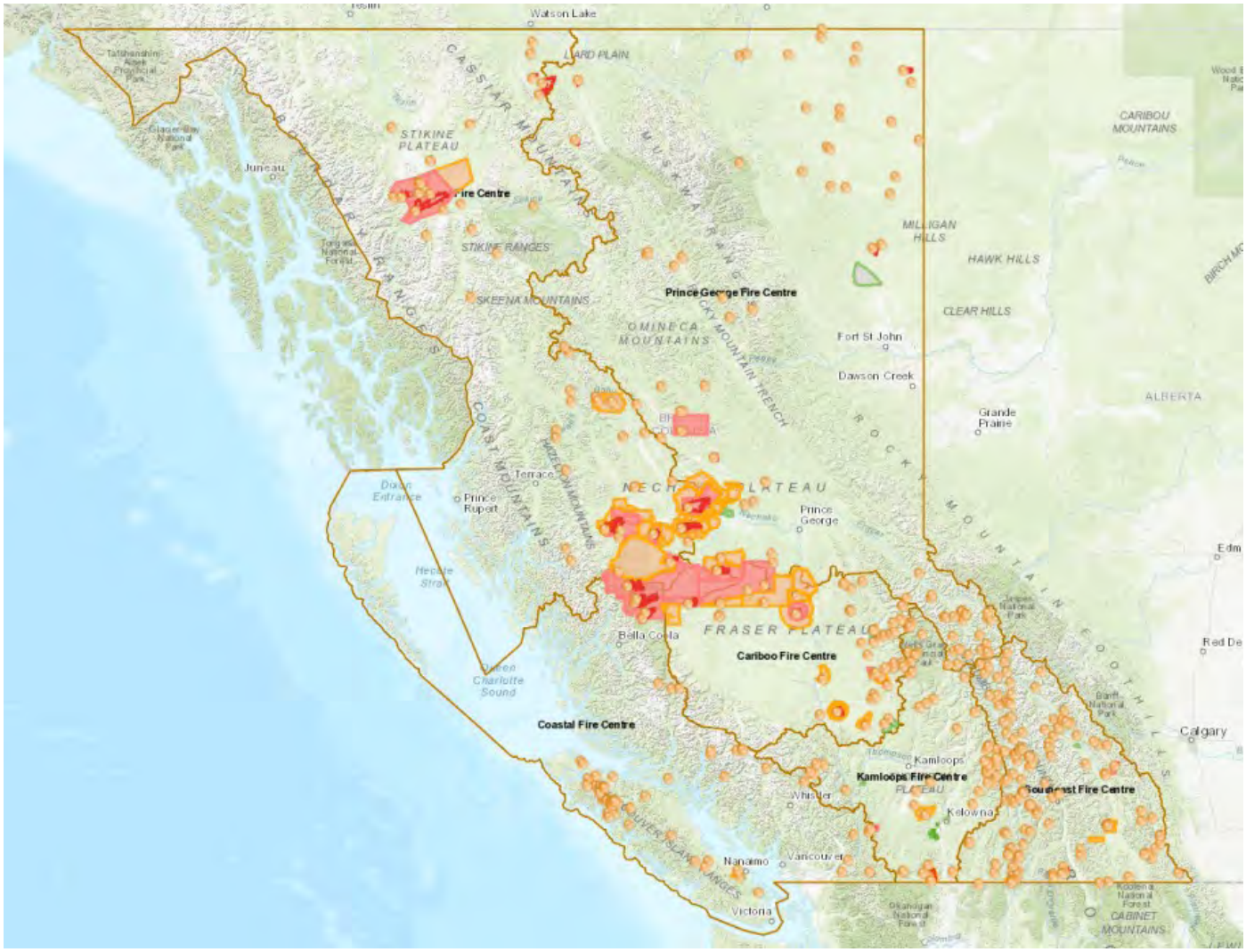


Figure 1. Wildfires in August 2018. Smaller fires are indicated with circular orange dots (Source: Map from BC Wildfire Service).

The aviation meteorologists at the Canadian Meteorological Aviation Centre in Edmonton received numerous early morning calls inquiring about the visibility trend at the smoky BC airports in August 2018. However, it was a difficult question to answer because it was unusual to have prolonged widespread low visibility due to smoke in the past and it was difficult to have a grasp on the intensity of smoke when hundreds of fires were burning simultaneously. Due to the health concerns from inhaling small particulate matter, PM2.5 concentrations are computed by the dispersion models to help forecasting air quality during wildfire smoke episodes. However, visibility is not yet an output from the available dispersion models, so PM2.5 model outputs

were also used to help forecasting visibility. In order to make better use of PM2.5 model outputs, my August 2018 smoke case study investigated the relationship between PM2.5 and visibility to help forecasting visibility severity in wildfire smoke. The typical upper ridge of high pressure pattern over British Columbia gives clear skies in summer and dries out fuels conducive to huge wildfires. Most of the wildfires result from lightning strikes igniting the initial fires and a few wildfires are human-caused. In late July and majority of August 2018, an upper ridge of high pressure was predominantly in place and it was the ideal setup to dry out the fuels to burn. The largest fires developed in central and northwestern British Columbia and hundreds of smaller fires were burning all over the province (Figure 1). Smoke from these fires not only choked British Columbia but also spread into the Prairies and gave low visibility and poor air quality (Figure 2).

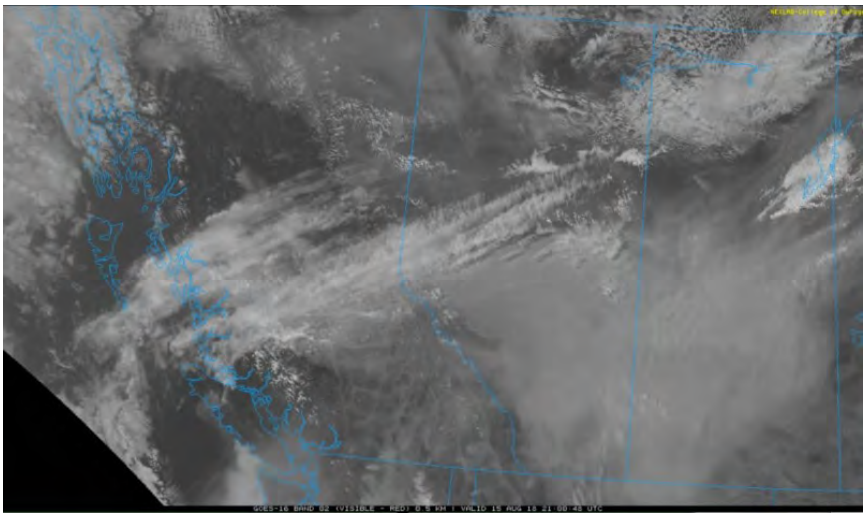
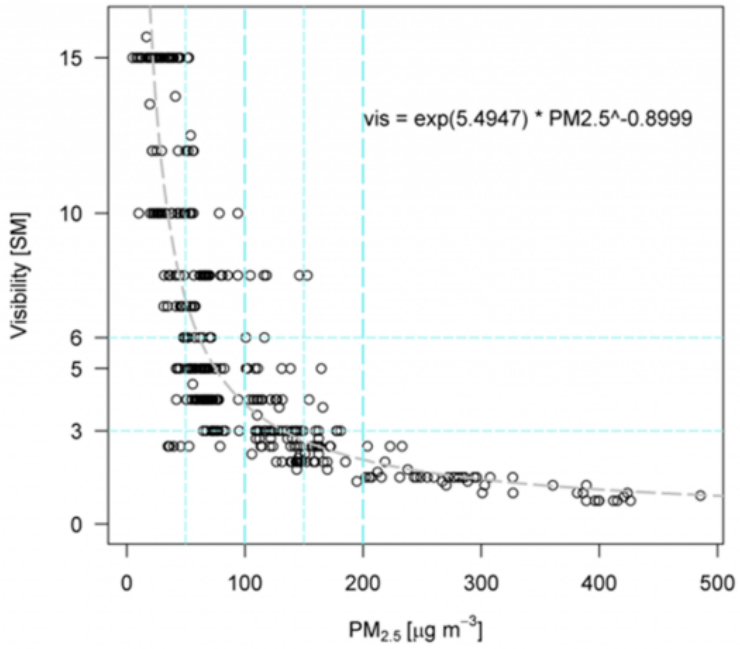


Figure 2. GEOS-16 Visible Imagery at Aug 15, 2018 21Z. Thick smoke plume was evident in Western Canada. (Source: Satellite imagery captured from College of DuPage website https://weather.cod.edu)

My case study examines the relationship between visibility and PM2.5 using August 2018 data from 15 sites in British Columbia and Alberta, where the worst visibilities were observed. It is evident that as PM2.5 concentration rises, visibility drops (Figure 3). To fit a prediction curve without the complication of nonlinear regression, a linear regression was applied to ln(visibility) vs. ln(PM2.5) (Figure 4). By applying exponential to the ln equation, a power function was established to relate visibility and PM2.5 at each site. The math is shown below:

$$\ln(vis) = b + a * \ln(PM2.5)$$
$$vis = \exp(b) * PM2.5^{a}$$



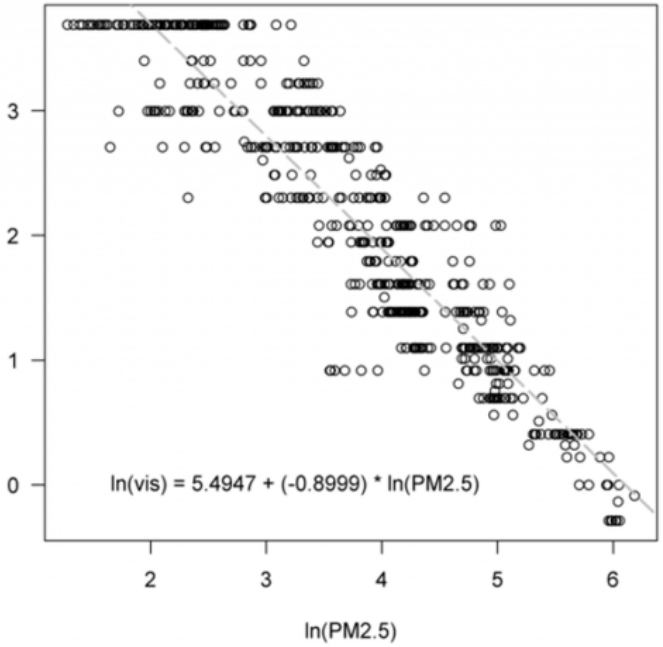
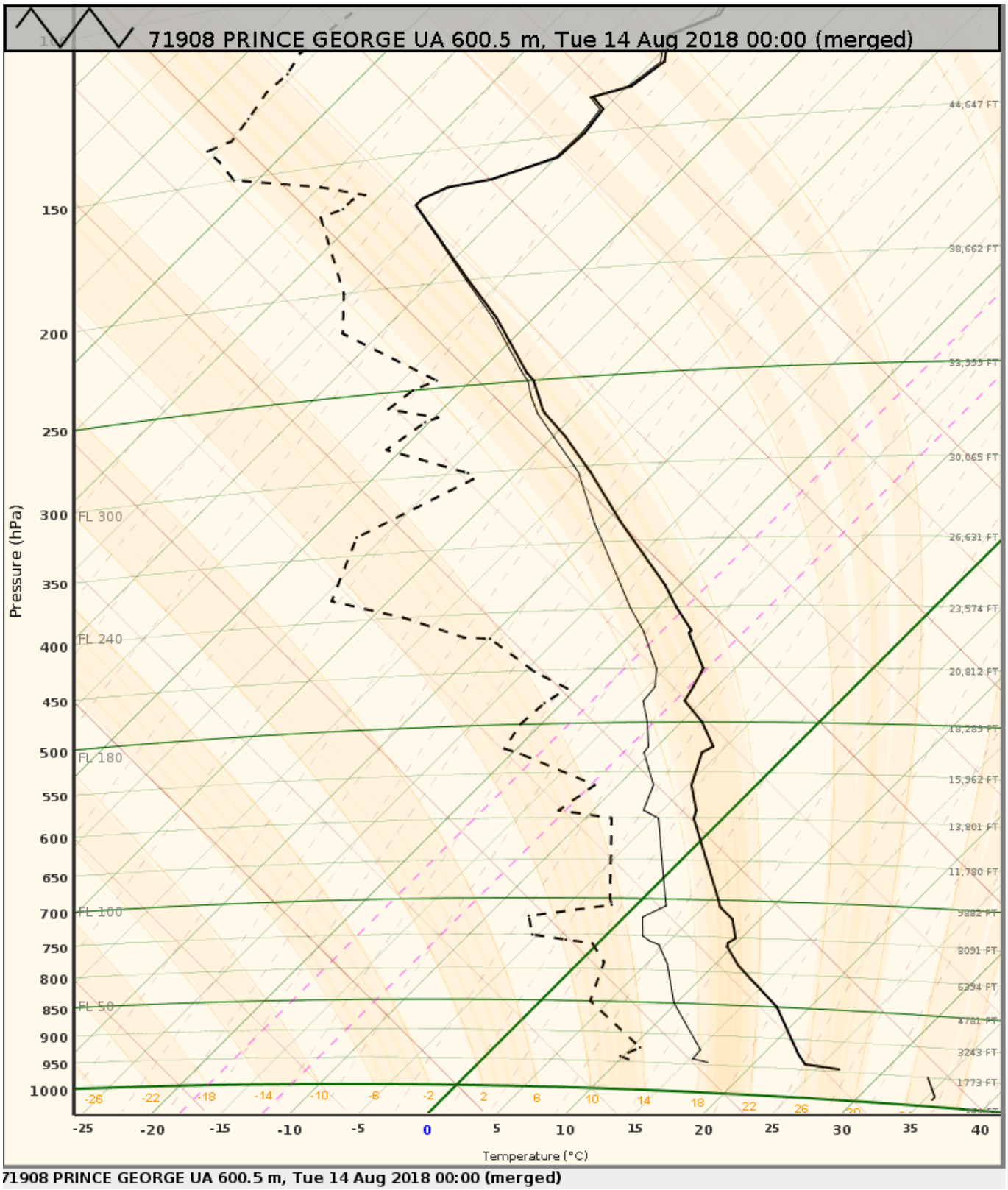


Figure 3 (Left). Scatterplot of Visibility (from Kamloops airport, CYKA) vs. PM2.5 (from Kamloops Federal Building). The fitted curve was calculated based on the linear regression from Figure 4.
Figure 4 (Right). Scatterplot of ln(vis) vs. ln(PM2.5) and the fitted linear regression line.



71908 PRINCE GEORGE UA 600.5 m, Tue 14 Aug 2018 00:00 (merged)

Figure 5. Aug 14, 2018 00Z temperature sounding at Prince George, BC.

When it comes to operational forecasting, a general rule of thumb is always more useful than equations. The relationship between visibility and PM2.5 based on all the scatterplots is summarized in Table 1. Visibility forecast for airports is particularly important when the flight category changes. A general concern is when visibility drops to Instrument Flight Rules (IFR), defined as below 3 statute miles in horizontal visibility. All the sites gave IFR visibility when PM2.5 rose above 200 µg m-3. When PM2.5 was in the 100 – 200 µg m-3 range, IFR visibility was also a possibility. An interesting note here is that when PM2.5 is above 200 µg m-3, PM2.5 alone will give Air Quality Health Index (AQHI) of 7 or above, which is categorized as high health risk.

PM2.5 [µg m^{-3}]	Visibility [SM]
<50	VFR
50-100	MVFR/VFR
100-200	IFR/MVFR
>200	IFR

Table 1. A general rule of thumb for the relationship between $PM_{2.5}$ and visibility.

Definition of Flight Categories

IFR: <3SM

MVFR: ≥3SM & <6SM

VFR: ≥6SM

The scatterplot for Kamloops shows a few occasions when visibility dropped with low PM2.5. In this case, visibility reduction was likely due to mist/fog, or a combination of mist/fog, and smoke. When fog is the main reason for visibility reduction, visibility should improve with a diurnal trend in summer. However, when smoke is the main reason for visibility reduction, visibility may drop in the afternoon instead of improving. When there is a temperature inversion at mid-levels, the smoke plume would be trapped under the inversion layer. For example, the 00Z temperature sounding at Prince George on August 14, 2018 had a temperature inversion at around 700hPa (Figure 5). This inhibited the smoke plume to disperse to a higher altitude. The surface warmed up in solar radiation and it destabilized the surface layer. This surface instability dispersed smoke plume from aloft to the surface. As a result visibility got worse during the day.

Figure 6 (Left). Snowy Mountain, BC in August 2018 (Source: Photo from BC Wildfire Service).
Figure 7 (Right). Shovel Lake, BC in August 2018 (Source: Photo from BC Wildfire Service).

Visibility Forecast in Wildfire Smoke

How did the wildfires do in Western Canada in the summer of 2019 compared to the previous two years? In 2019, several “out-of-control” wildfires were burning in May over northern Alberta. The huge fires in northern Alberta established much earlier than the previous two years when the major fires were located in British Columbia. The fuel was likely prepared to burn as early as May due to the dry winter in the Prairies. When the widespread smoke travelled to Edmonton, PM2.5 peaked as high as 1880 µg m-3. For the rest of the summer, smoke was kept north of the major cities in Alberta as thunderstorm season started.

The typical upper ridge pattern over British Columbia was all short-lived in the summer of 2019 and instead we had several low pressure systems giving precipitation and preventing major wildfires to establish. However, a ridge of high pressure was often in place in Yukon. Wildfires in Alaska and Yukon kept Northwestern Canada fairly smoky due to a lack of precipitation. In summary, smoke was also an issue for Western Canada in 2019 but it only affected the less populated areas.

When a stagnant ridge of high pressure over BC dominates in summer for a month or more, wildfire smoke will likely return again. The extent and severity of smoke at the surface depends on the atmospheric temperature profiles during the wildfire smoke episode. My smoke case study for August 2018 has established the relationship between PM2.5 and visibility to help operational meteorologists predict visibility given the PM2.5 model outputs. My case study can also be beneficial to air quality forecast for communities where air quality sensors are unavailable but visibility is monitored at the airports.

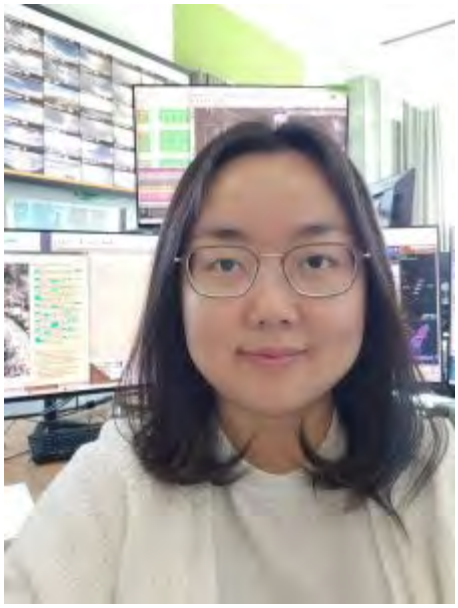
References

(1) BC Government News. (August 15, 2018). *Provincial State of Emergency Declared*. https://news.gov.bc.ca/releases/2018PSSG0061-001584

(2) CBC. (August 19, 2018). *B.C. Wildfires 2018: Flights cancelled as smoke chokes airports*. https://www.cbc.ca/news/canada/british-columbia/bc-wildfires-1.4791099

About the Author

Yimei Li is an operational meteorologist at the Canadian Meteorological Aviation Centre located in Edmonton, Alberta. She studied atmospheric science at the University of British Columbia. Her interest in air pollution meteorology is developed from air pollution research projects at UBC and co-op work terms at the Pacific Storm Prediction Centre. She was a trainee of the CREATE-AAP (Atmospheric Aerosol Program funded by NSERC) during her Master’s studies in air pollution meteorology. She will continue to contribute in weather forecasting and air pollution meteorology for years down the road.



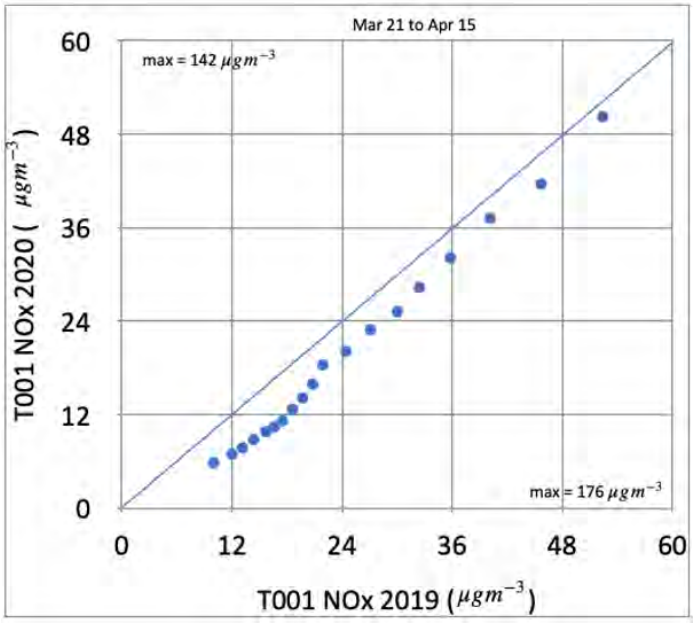
Air Pollution in the Time of COVID-19

by D.G. Steyn, Department of Earth, Ocean and Atmospheric Sciences, The University of British Columbia, Vancouver, B.C., and Kyle Howe, Air Quality and Climate Change, Metro Vancouver Regional District, Burnaby, B.C

The COVID-19 pandemic is disrupting many aspects of society globally, nationally and locally. The most direct effect is the human health tragedy of increased morbidity and mortality caused by the disease. Beyond that, the legislated curtailment of human movement to slow the spread of the virus has resulted in economies being placed in what has been called a “medically induced coma”. Closely associated with the sharp slowdown in economic activity has been the reduction in fossil fuel consumption from most source sectors. A particular consequence of this reduction has been an improvement in local air quality, and an associated reduction in greenhouse gas emissions in all jurisdictions. The improvement in air quality has been noted in many locations. The popular press abounds with photographs of previously seldom-seen mountain vistas, now visible. Some organizations have used satellite – or mobile monitoring data – to provide semi-quantitative analyses of the improvement in air quality by contrasting before-COVID-19 conditions with present conditions.

Our objective here is not to understand changes in ambient air quality conditions due to the pandemic, but to understand resultant emissions reductions. This preliminary study is intended to serve as a starting point for detailed emissions analyses, and the following ambient air quality modelling studies. These studies will be needed by regulatory agencies in fulfilling their air quality and greenhouse gas management strategies as the COVID-19 pandemic could offer a glimpse at the magnitude of emission reductions which may be needed to achieve the benchmarks set in these strategies.

We base our analysis on ambient air quality data from fixed point monitors in traffic-dominated locations. To provide an indicator of traffic emissions, we analyze NOx (the sum of NO and NO2) as this mixture is a good indicator of total traffic emission and accounts for chemical transformations between NO and NO2. The data will be drawn from monitoring locations very close to high traffic roadways so as to avoid the effects of chemical transformation of NO to NO2.



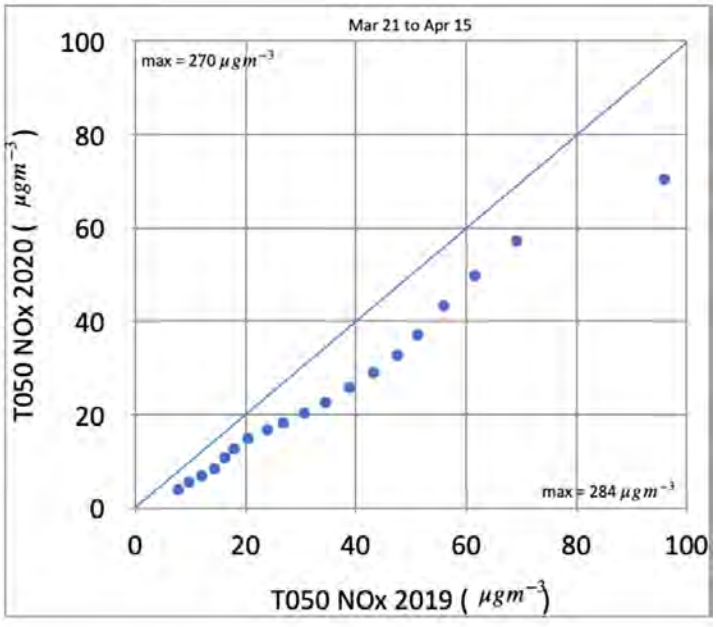


Figure 1 (Left). Q-Q plot of ambient NOx for 2020 vs 2019 at T001
Figure 2 (Right). Q-Q plot of ambient NOx for 2020 vs 2019 at T050

We chose two monitoring sites which are representative of traffic emissions from the Lower Fraser Valley Air Quality Monitoring Network and both happen to be in the City of Vancouver as representative of traffic emissions. The sites are: T001 – Robson Square (a location in the central business district of downtown Vancouver, dominated by light-duty vehicles) and T050 – Clark Drive at 11th Avenue (a near-road location at a busy intersection with a higher proportion of truck traffic than at T001). Both stations are known to represent locations dominated by traffic emissions. Our analysis uses data from 2020.03.21 (when all non-essential businesses in B.C. were closed) to 2020.04.15 to represent emissions during the pandemic and contrast those with measurements from the corresponding period in 2019. We note that an analysis of springtime data will avoid warmer conditions when chemical transformation is likely to be increasingly important. The core of our analysis will be quantile-quantile (Q-Q) plots of NOx for the springtime period at the two stations. Figures 1 (for T001) and 2 (for T050) present the 5th to 95th percentiles (in 5 percentile steps). We omit the upper 5 percentile in order to exclude conditions under which meteorology might dominate over emissions, but make no further effort to control for meteorological variability. We note that during the period of analysis, weather on the south coast of British Columbia was dominated by a ridge of high pressure with reduced cloudiness, almost no precipitation, low nighttime temperatures and modest daytime high temperatures. By contrast with typical Vancouver springtime conditions, this would result in a modest increase in mean ambient air pollution concentrations. We assume that the length of record (20 days, 500 hourly averages) will result in statistically meaningful results.

The Q-Q plots in Figures 1 and 2 clearly show reduced NOx at both T001 and T050 for all percentiles in 2020, compared to 2019. This is a strong indication that traffic related emissions have been reduced due to the societal restrictions during the early phases of the COVID-19 pandemic. This finding is consistent with traffic counts from the City of Vancouver which show a mean reduction of approximately 50% in and out of the downtown core. At the Metro Vancouver T050 station, a reduction of total vehicle volume of nearly 40% was measured, compared to the same period in 2019.

While the objective of this simple statistical analysis is to illustrate differences in emissions, a number of broader conclusions can be drawn. The results point to the need for more thorough analyses of emissions during the pandemic, and as societal restrictions are relaxed. An analysis of improved ambient conditions during this “involuntary experiment” could be used to understand the level of emissions reductions needed to achieve more long-lasting improvement of ambient conditions, though clearly such emissions reductions cannot come about through restriction of economic activity as this would be societally unsustainable.

About the Authors

Dr. Douw Steyn

Douw Steyn, PhD, ACM, FCMOS is a Professor Emeritus of Atmospheric Science at The University of British Columbia, in the Department of Earth Ocean and Atmospheric Sciences. His professional, teaching and research activities are in the fields of air pollution meteorology, boundary layer meteorology, mesoscale meteorology, environmental science and interdisciplinary science. His research involves measurement and modelling studies of regional air pollution, especially in regions with complex terrain. He has worked extensively on the statistics of air pollution, air pollution monitoring and monitoring network design. He is a winner of the UBC Killam Teaching Prize, the Canadian Meteorological and Oceanographic Society Andrew Thompson Prize in Applied Meteorology, and the Canadian Federation for Earth Sciences Mentorship Medal. He has served as Chair of the scientific committee that leads the International Technical Meeting series on Air Pollution Modelling and its Application. He publishes regularly in international peer reviewed literature, and is Director of Publications for the Canadian Meteorological and Oceanographic Society. He is an Accredited Consulting Meteorologist, has international consultancy experience in his areas of expertise, and has provided expert testimony in numerous court cases and appeal board hearings in British Columbia.

Article: Air Pollution in the Time of COVID-19

Kyle Howe

Kyle Howe, MSc., is an Air Quality Planner at the Metro Vancouver Regional District in the Air Quality and Climate Change Division. He holds a master's degree in Meteorology from the Pennsylvania State University and has worked professionally in the field of air quality in British Columbia since 2010. He has worked extensively in dispersion modelling and has participated in numerous environmental assessments. He has provided expert testimony related to dispersion modelling and air quality for both appeal board hearings and in legal cases. His work at the Metro Vancouver Regional District includes overseeing the data acquisition from the Lower Fraser Valley Ambient Air Quality Network as well as developing analytical techniques and tools to enhance our understanding of air quality trends and emerging air quality issues in the region.

CMOS SCMO

54th CONGRESS / 54e CONGRÈS

Canadian Meteorological and Oceanographic Society (CMOS) Annual Congress

Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO)

BUILDING SOCIETAL RESILIENCE

to Changing Weather, Climate, Oceans and Environment

BÂTIR UNE RÉSILIENCE SOCIÉTALE

face à l'évolution du temps, du climat, des océans et de l'environnement

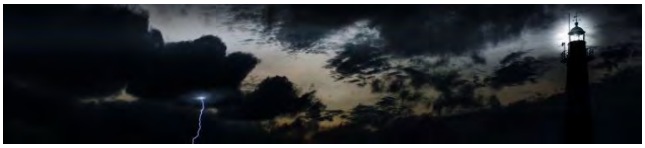
Sunday May 24, 2020 to Thursday May 28, 2020 at the Delta Hotel, 101 Lyon St., Ottawa

Dimanche le 24 mai 2020 au jeudi le 28 mai 2020 à l'hôtel Delta, 101, rue Lyon, Ottawa

cmos.ca / scmo.ca

In case you missed it...

From CMOS Bulletin Volume 48, Number 1:

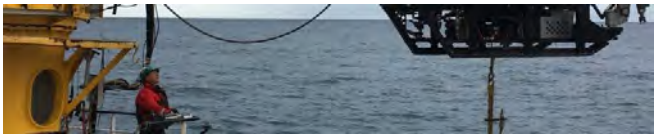


Message from the CMOS President: Resilience and Possibility in Challenging Times / Mot de la présidente Kimberly Strong: Résilience et possibilité en ces temps troublés

Message from the Incoming Bulletin Editor, Nicole Renaud / Une annonce de la nouvelle rédactrice du bulletin SCMO, Nicole Renaud

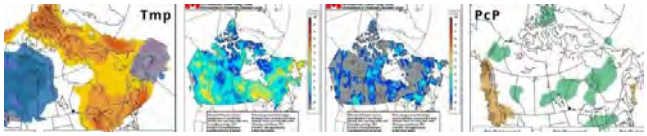
Towards Quantifying Area-fugitive Greenhouse Gas (GHG Emissions from Open-Pit Mines
by Amir Nezam et al.

Modular Ocean Research Infrastructure (MORI): A Flexible, Scalable and Affordable Approach to Ocean-going Research in Canada and Worldwide
by Doug Wallace and Doug Bancroft



Observing Snow from the Sky: Breakthroughs in Mapping Tundra Snow with Drones
by Branden Walker and Philip Marsh

Seasonal Outlook for Spring 2020 (MAM) Based on CANSIPS Forecast Issued Feb. 29, 2020
by Marko Markovic et al.



Members Updates
Meeting Notifications, Books for Review, and more

These articles, and more, in the online CMOS BULLETIN.

http://bulletin.cmos.ca (english)
http://bulletin.scmo.ca (français)

Subscribe here to receive your bi-monthly e-update.

ONLINE / EN LIGNE

CMOS BULLETIN SCMO

Canadian Meteorological and Oceanographic Society
La Société Canadienne de Météorologie et d'Océanographie

Weather - Climate - Ocean - Atmosphere
Météo - Climat - Océan - Atmosphère

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.

http://bulletin.cmos.ca
http://bulletin.scmo.ca

CMOS Annual General Meeting has been Postponed

Dear CMOS Members,

The Annual General Meeting scheduled for Monday, May 25, 2020 has been postponed. It will be rescheduled during the fourth week of June.

CMOS Council made this decision due to delays in receiving all information required to complete the audit of the financial statements for the year ending December 31, 2019.

The postponement will allow the financial statements to be completed in the next couple of weeks. They will then be shared with you to give you an opportunity to review before our June meeting.
I apologize for any inconvenience this may cause, but I appreciate your understanding.

Gordon Griffith, P.Eng., ing., FEC
Executive Director - Directeur général
CMOS - SCMO

L'assemblée générale annuelle de la SCMO a été reportée

Chers membres de la SCMO,

L'assemblée générale annuelle prévue pour le lundi 25 mai 2020 a été reportée. Elle aura lieu au cours de la quatrième semaine du mois de juin.

Le Conseil d'administration de la SCMO a pris cette décision en raison de retards dans la réception de toutes les informations requises pour achever l'audit des états financiers de l'exercice se terminant le 31 décembre 2019.

Le report permettra de terminer les états financiers au cours des deux prochaines semaines. Ils seront ensuite partagés avec vous pour vous donner l'occasion de les examiner avant notre réunion du mois de juin.
Je suis désolé pour tout inconvénient que cela pourrait causer, mais j'apprécie votre compréhension.

Gordon Griffith, P.Eng., ing., FEC
Executive Director - Directeur général
CMOS - SCMO

Open Consultative Platform of the World Meteorological Organization

Those who are interested in learning about the newly launched World Meteorological Organization's OCP (Open Consultative Platform), please go to this link which also includes videos of the program launch.

CMOS News

CMOS Membership Renewal Time!

Every year at this time, we send you reminders to renew your membership. Please help the Society save money on postage and renew online. Outstanding invoices will be mailed out if required.

I trust you will continue to be part of the CMOS community. Take the time to renew online at **http://www.cmos.ca/**. When doing so please consider making a voluntary donation to one of the CMOS funds – your generosity will greatly enrich our CMOS activities. In addition, please continue to use our website as a useful resource of our events, publications, news and announcements.

Thank you for being a member of our Canadian Meteorological and Oceanographic Society. I hope to see you at our 2020 Alternative Congress. I speak on behalf of our Society to thank you and express my appreciation of your active participation in our community!

Sincerely yours,

Gordon Griffith, P.Eng., ing., FEC, CMOS Executive Director

Renouveler votre adhesion!

Chaque année, à cette époque, nous vous invitons à renouveler votre adhésion. S'il vous plaît, aidez la Société à économiser sur les frais des timbres et à renouveler en ligne. Les factures en suspens seront expédiées si nécessaire.

J'espère que vous continuerez à faire partie de la communauté de la SCMO. Prenez le temps de renouveler votre adhésion en ligne à : http://www.scmo.ca/. Merci de considérer de faire un don à l'un des fonds de la SCMO — votre générosité enrichira considérablement les activités de la SCMO. De plus, merci de continuer à utiliser notre site Web en tant que ressource utile pour en savoir plus sur nos événements, publications, nouvelles et annonces.

Merci d'être membre de la Société canadienne de météorologie et d'océanographie. J'espère vous voir à notre congrès de 2020 nouveau genre. Au nom de notre société, je vous remercie de votre participation active au sein de notre communauté!

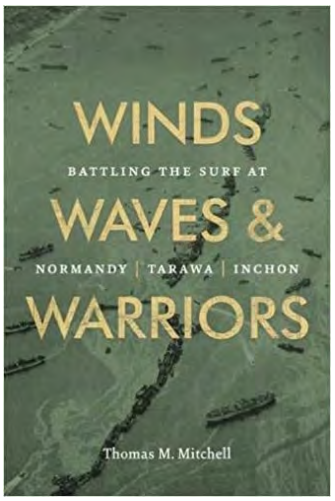
Sincères salutations,

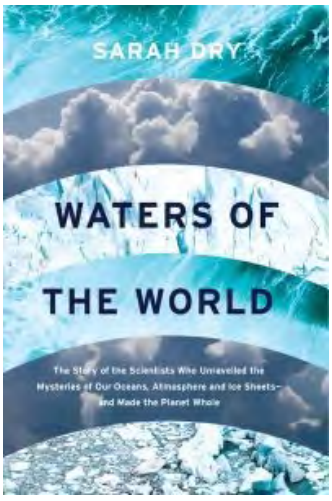
Gordon Griffith, ing., P.Eng., FEC, Directeur general de la SCMO

NEW Books Available for Review

Winds, Waves and Warriors: Battling the Surf at Normandy, Tarawa, Inchon, 2019. By Thomas M. Mitchell, Lousiana State University Press. ISBN 978-0-8-71-7223-0 (Cloth), 168 pages, $39.95 USD (2020-1)

Waters of the World: The Story of the Scientists Who Unraveled the Mysteries of Our Oceans, Atmosphere, and Ice Sheets and Made the Planet Whole, 2019. By Sarah Dry, University of Chicago Press. ISBN 978-0-226-50770-5 (Cloth), 368 pages, $30.00 USD (2019-4)



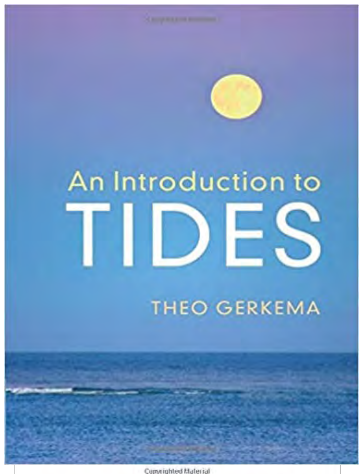


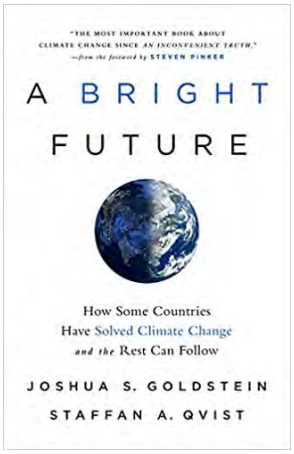
Other recent titles still available for review by a CMOS member:

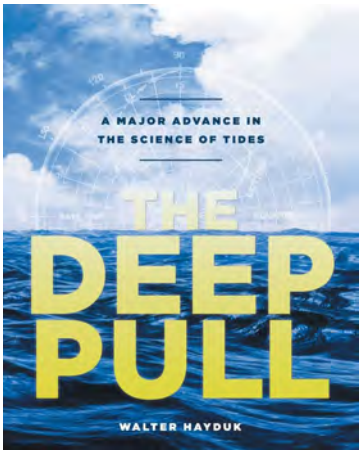
- **An Introduction to Tides**, 2019. By Theo Gerkema, Cambridge University Press, ISBN 978-1-108-46405-5 (Paperback), 211 pages, $51.95 USD (2019-3)
- **A Bright Future: How Some Countries Have Solved Climate Change and the Rest Can Follow**, 2019. By Joshua S. Goldstein and Staffan A. Qvist, Hachette Book Group, ISBNs 978-l-5417-241O-5 (hardcover), 978-1-5417-2409-9 (e-book), 288 pages, $34.00. (2018-9)
- **Tropical Extremes: Natural Variability 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)
- **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)
- **The Deep Pull: A Major Advance in the Science of Ocean Tides**, 2018. By Walter Hayduk, Friesen-Press, ISBN 9781525518706 (hardcover) $35.49, 9781525518713 (softcover) $27.49, 9781525517820 (eBook) $11.99, 251 pages. (2018-7)

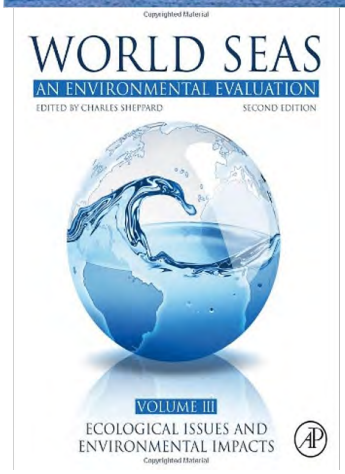
Never reviewed a book before? No problem! Check out some of these past reviews for ideas: Ice: Nature and Culture; Weather in the Courtroom; Convenient Mistruths: A Novel of Intrigue, Danger and Global Warming; Weather, A Very Short Introduction; Nonlinear and Stochastic Climate Dynamics.

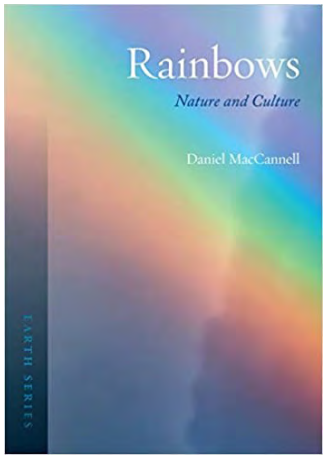
If you a review a book it is yours to keep! Contact the Editor to get involved.

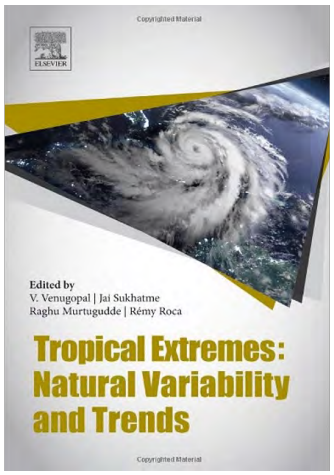












DATA, MODELS AND ANALYSIS

The Highest Impact Articles in *Atmosphere-Ocean*

Available from CMOS for $40 CDN (taxes included) + shipping.

Edited by

GUOQI HAN, HAI LIN and DOUW STEYN

CMOS SCMO

ROUTLEDGE

Council / Conseil d'administration

CMOS Bulletin SCMO at bulletin.cmos.ca

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.

CMOS Bulletin SCMO at bulletin.scmo.ca

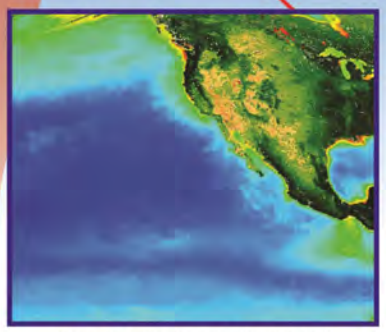
Cette publication est produite sous la responsabilité de la Société canadienne de météorologie et d'océanographie. À moins d'avis contraire, les opinions exprimées sont celles des auteurs et ne reflètent pas nécessairement celles de la Société.

Thank you to Bob Jones for his continued editorial assistance and guidance.

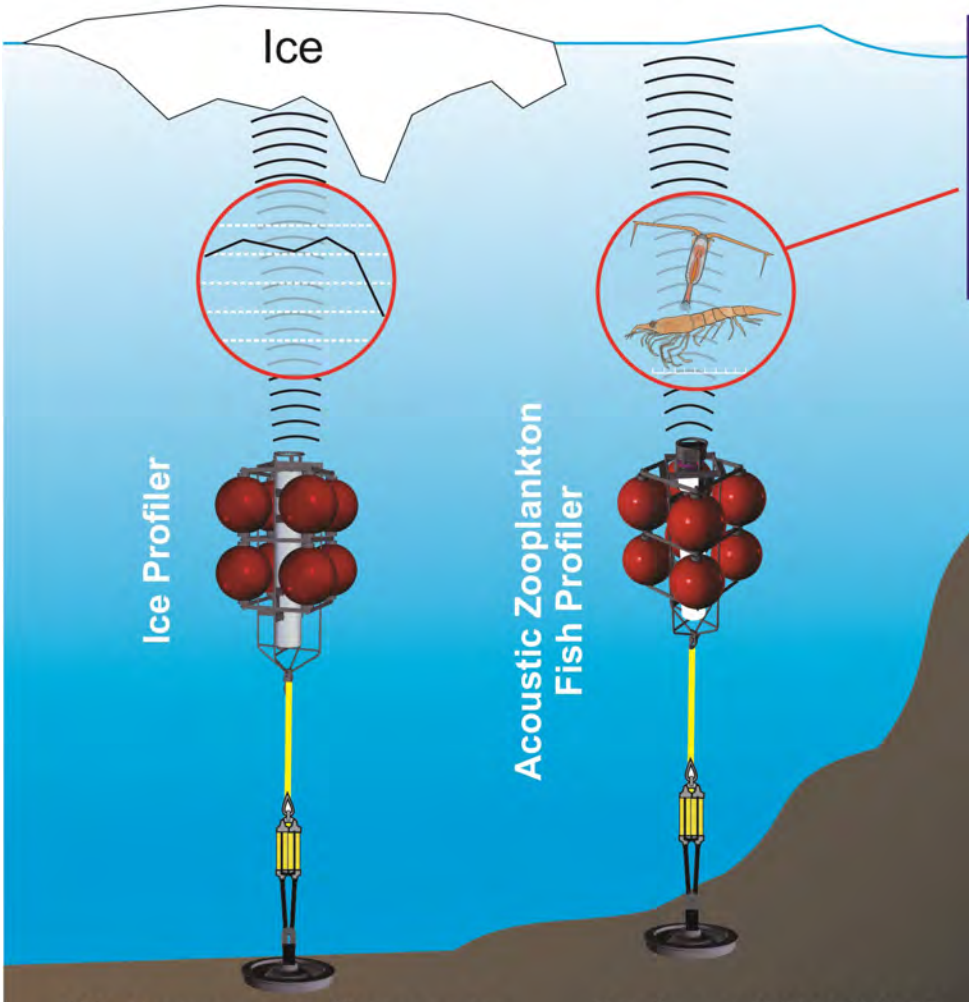
ASL Environmental Sciences

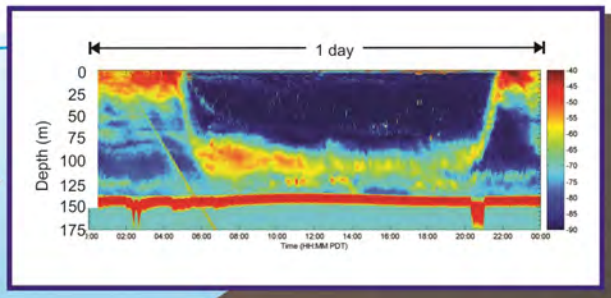
40 YEARS
1977-2017

Oceanographic specialists/
Spécialistes océanographiques



Ocean colours are chlorophyll concentrations and land colours are NDVI





ASL offers:

Ice Profiler and SWIP
Acoustic Zooplankton Fish Profiler
Teledyne RD Instruments
Teledyne Oceanscience
Teledyne Benthos
WERA NorthernRadar
Airborne/Spaceborne Remote Sensing

ASL offers an extensive equipment lease pool

ASL Environmental Sciences Inc.
#1-6703 Rajpur Place
Victoria, British Columbia
V8M 1Z5 Canada

Toll-free: 1-877-656-0177
Fax: +1 250 656-2162
email: aslenv@aslenv.com
website: www.aslenv.com