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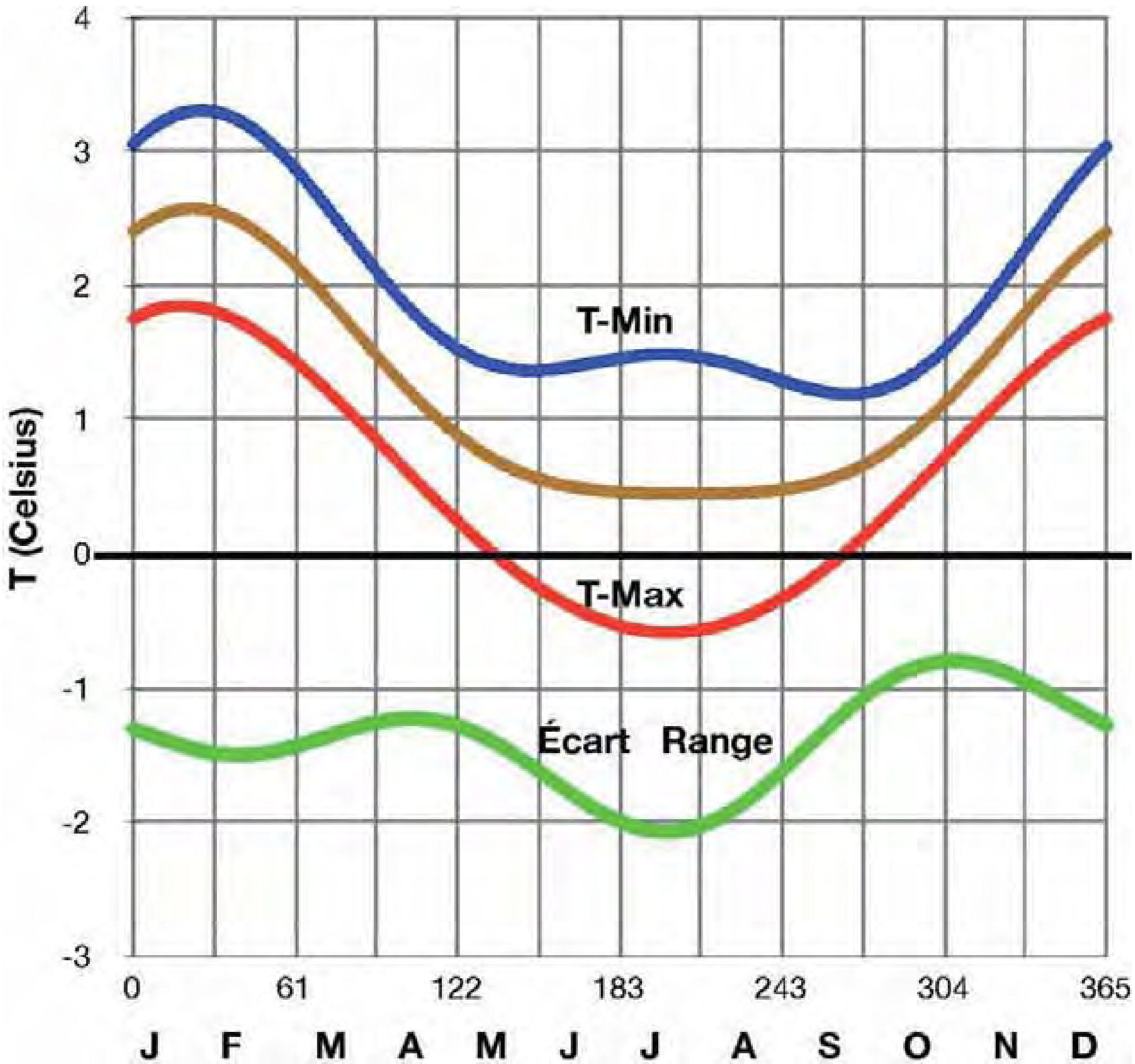
CMOS BULLETIN SCMO

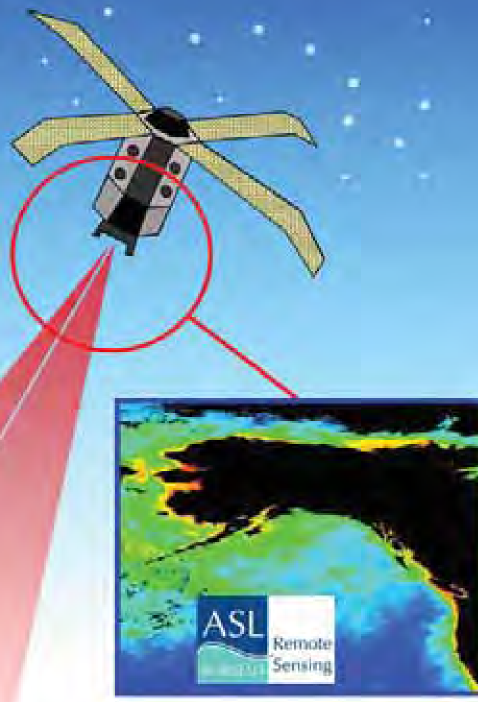
Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

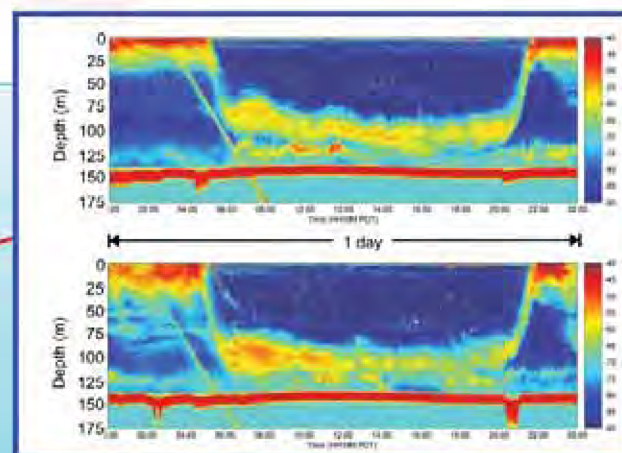
April / avril 2012 Vol.40 No.2

Climate Change in Ottawa 1891-2010
Changement climatique à Ottawa





ASL
Remote Sensing



Depth (m)
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50
75
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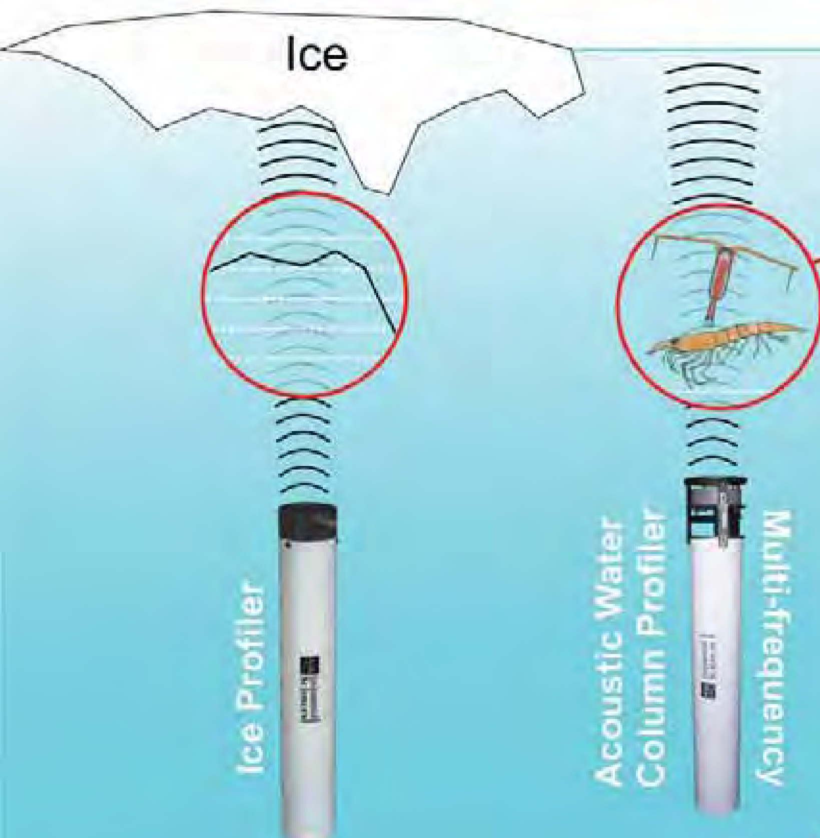
150
175
1 day



Ice
Ice Profiler
Acoustic Water Column Profiler
Multi-frequency

....from the President's Desk

Friends and colleagues:

Norman McFarlane
President CMOS
Président de la SCMO

The 46th CMOS Congress, held jointly with the 21st AMS Conference on Numerical Weather Prediction and the 25th AMS Conference on Weather Analysis and Forecasting, promises to be another excellent congress with all of the ingredients that we have come to expect from previous congresses: a scientific program featuring exciting and important new research work, many exhibitor booths informing of new developments, activities, and services related to meteorology and oceanography in Canada, plenary and public lectures by leading researchers and specialists that highlight new and emerging topics and activities, special side events such as the Teachers' Day that promote educational ideas and activities. Finally, but just as important as these, are the social activities that celebrate and reward achievement and bring our community together. Add to this the abundant opportunities for informal chance meetings with friends and colleagues that often only happen at conferences but are so important for networking and establishing personal interactions that are the critical ingredients for the collaboration and cooperation that underpins so many successful activities and achievements in modern science. When you receive this issue of the Bulletin it will still be possible to register to attend, and you will find it a very rewarding event. Please visit the Congress Web site (www.cmos.ca/congress2012/index.htm) to register and learn more about the Congress. I thank Louis Lefaivre, Chair of the Local Arrangements Committee, Pierre Gauthier, Chair of the Scientific Program Committee, their committee colleagues and the large number of volunteers who have been working hard for most of the last two years to make CMOS 2012 a success. I hope to see you during May 29 to June 1 at the CMOS Congress in Montreal!

Some recent discussions with my colleagues on the CMOS Executive made me realize that there are many CMOS activities and services that I, like perhaps many CMOS members, have overlooked or are unaware of even after being a CMOS member for many years. The CMOS web site (http://www.cmos.ca/) is packed with information on the

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Inside / En Bref

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

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Cover page: The normal temperature (brown) in Ottawa has increased significantly between 1891 and 2010, especially in winter. The daily minimum temperature (blue) has increased the most and in all months. On average the maximum daily temperature (red) has also increased even though it has decreased in the summer months. The daily range of temperature (green) has decreased significantly throughout the year. As a result, the climate has become more uniform on both a daily basis and an annual basis. To learn more, read Richard Asselin's article on **page 54.**

Page couverture: La température normale (brun) à Ottawa a augmenté considérablement entre 1891 et 2010, particulièrement en hiver. C'est la température journalière minimum (bleue) qui a augmenté le plus, et ceci pour tous les mois. En moyenne, la température maximum journalière (rouge) a aussi augmenté même si elle a diminué en été. L'écart journalier de température (vert) a diminué considérablement en tout temps de l'année. Le résultat net est que le climat est devenu plus uniforme quant aux variations journalières et annuelles. Pour en apprendre plus, lire l'article de Richard Asselin en **page 54.**

....from the President's Desk (Continued / Suite)

many facets and activities of CMOS, most of it available in both official languages. You will, of course, find links to 2012 Congress web site there by clicking on the link to that topic right near the top of the home page. In addition you will find the opening pages of the web site for the 2013 Congress in Saskatoon, now under construction. That event will be a joint Congress with the Canadian Geophysical Union and the Canadian Water Resources Association, following on from previous very successful joint congresses, most recently the 2010 Congress in Ottawa. You will also find links to pages displaying highlights and photos of recent Congresses. Following down from "*Congresses*" on the home page there are links to informative pages on a wide range of topics which answer almost any question concerning CMOS that one can think of and provide an abundance of information on other related topics as well, including postings on employment opportunities in meteorology and oceanography that are easily accessed by clicking on the "*Help or Employment Wanted*" link. Visitors to the web site who would like information on CMOS sponsorship of meetings or workshops can find it by clicking on the "*Policy and Position Statements*" link and scrolling down to "*Policy on Sponsoring of Conferences and Workshops*". Clicking on that will display a page that provides detailed information on this topic.

Many pages could be devoted to discussing what can be found at the CMOS web site. I leave to the reader the pleasure of exploring it at their leisure. All of this is the result of the efforts of our CMOS webmaster, Bob Jones, over many years in maintaining the CMOS web site as an up to date and indispensable service to our community, including partner groups such as CNC-SCOR, and the Private Sector area whose pages can also be accessed from the home page of the CMOS web site. Don't fail to visit the Photos pages which include the wonderful galleries of historical photos that Bob has devoted many hours to assembling. This collection has grown steadily since it was first begun in response to a suggestion by Susan Woodbury, who is a former CMOS President and currently continues to serve as Chair of the Fellows Committee. It has served as an important piece of "community glue" that draws many groups, not just MTs, oceanographers and researchers, toward CMOS. Many thanks, Bob, for your abiding efforts and enthusiasm!

I will end this brief overview by noting that, for CMOS members, there is yet another web site world that can be explored by entering the "*Membership Renewal and other Members' Services*" section using your membership name and password. This allows you to enter the Members-only secure web site, (https://www1.cmos.ca). This was first created in 2003 but has since been much modified by CMOS office staff, particularly Ian Rutherford, Richard Asselin, and Caroline Cheng so that it is now a fairly unique facility that has also been used to provide services to third parties who have chosen to make use of the CMOS expertise and capabilities notably for major Congresses such as the 2010 IGAC Conference in Halifax and the upcoming Quadrennial Ozone Symposium. In addition to links for a range of services, including, membership renewals, registering and submitting abstracts for Congresses and other CMOS sponsored meetings, you can also read current and past issues of Atmosphere-Ocean and the CMOS Bulletin as well as a range of other CMOS publications and reports.

I will now turn to a different but abidingly important topic. When you receive this issue of the Bulletin the mandate of the Canadian Foundation for Climate and Atmospheric Sciences (**CFCAS**) to act as an agency for Federal research funding will have ended. Over the last decade CFCAS has issued more than $100 million in research grants and more than doubled their impact through the partnerships between universities, government research groups and private sector partners. This has produced many outstanding research achievements, facilitated development of research infrastructure in Canada and produced a large cadre of highly qualified personnel. The ending of the CFCAS mandate marks a significant diminishing of the level and scope of support for climate and atmospheric research that has not been replaced through new programs from NSERC and other Canadian sources of research funding. The impacts of this are beginning to be realized. Many of the CFCAS funded research networks that fostered the aforementioned highly successful partnerships have wrapped up their activities. Many highly qualified early and mid-career scientists in the fields of climate and atmospheric sciences are seeking and finding employment outside of Canada. Some key research facilities that received critical support from CFCAS are facing the prospect of curtailing or ceasing their operations in the face of difficulties in securing needed funding in the much more restrictive funding environment that now exists in Canada. A much-publicized example at the time of writing is the recently announced closing on April 30, 2012 of the year-round operations of the Polar Environment Atmospheric Research Laboratory (**PEARL**) in **Eureka**, Nunavut. This facility, which has been operated by the Canadian Network for Detection of Atmospheric Change (**CANDAC**) with a substantial contribution to its funding from CFCAS, must cease its year-round operations because CANDAC has not been able to secure the modest amount of funding needed (approximately $1.5 million per year) to permit it to continue a year-round program especially during the winter period.

PEARL is a unique facility that has been making key measurements and accumulating information on air quality, ozone, and climate change since 2005. It has developed links and partnerships with many international programs and networks that have measurement and research activities that focus on detecting and understanding changes in the high Arctic environment. Its measurement and analysis activities during the winter-spring of 2010-11 played a key role in detecting and analyzing the largest ozone hole ever detected over the Arctic. Stratospheric temperatures reached record lows in the Spring of 2011 giving rise to chemical depletion of ozone that for the first time in the history of Arctic measurements was comparable to that which has been observed over Antarctica. Given its critical high Arctic location and unique capacity to operate during the Polar night, cessation of year-round operations at PEARL leaves a critical gap in observations and research activities at a time when the rapid environmental changes are occurring in the high Arctic. Although the Federal Government has committed to establishing the High Arctic Research Station in Cambridge Bay, 1300 km south of the PEARL site, it will not become operational until 2017 and, given its much more southerly location, it will not replace the unique capacity of the PEARL site. Permitting this time and space gap to develop is very short-sighted and starkly at variance with the Northern Strategy of the Federal Government which, on its official web site, states that "*World-leading Arctic science and technology underpin the Northern Strategy and help ensure sound decision-making*" (http://www.northernstrategy.gc.ca). Interested readers may find more information on PEARL at http://www.candac.ca.

Norman McFarlane
CMOS President
Président de la SCMO

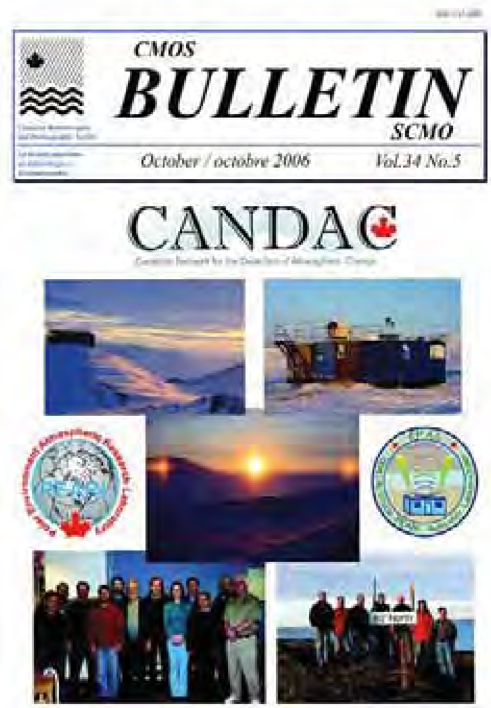
Note from the Editor: For further reading on PEARL, CANDAC and EUREKA, please see *CMOS Bulletin SCMO*, Volume 34, No.5, October 2006. This now historical issue is available on CMOS website in the Members only section.

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

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

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.

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.



Greenhouse gas concentrations in atmosphere, notably nitrous oxide, continue climbing

Geneva, 21 November 2011 (WMO) –The amount of greenhouse gases in the atmosphere reached a new high in 2010 since pre-industrial time and the rate of increase has accelerated, according to the World Meteorological Organization's Greenhouse Gas Bulletin. It focussed special attention on rising nitrous oxide concentrations.

Between 1990 and 2010, according to the report, there was a 29% increase in radiative forcing - the warming effect on our climate system - from greenhouse gases. Carbon dioxide accounted for 80% of this increase.

"*The atmospheric burden of greenhouse gases due to human activities has yet again reached record levels since pre-industrial time*," said WMO Secretary-General Michel Jarraud. "*Even if we managed to halt our greenhouse gas emissions today – and this is far from the case – they would continue to linger in the atmosphere for decades to come and so continue to affect the delicate balance of our living planet and our climate*."

"*Now more than ever before, we need to understand the complex, and sometimes unexpected, interactions between greenhouse gases in the atmosphere, Earth's biosphere and oceans. WMO will continue to collect data to further our scientific knowledge through its Global Atmosphere Watch network spanning more than 50 countries, including stations high in the Andes and Himalayas, in the remote expanses of Alaska and in the far South Pacific,*" he said.

Greenhouse gases trap radiation within the Earth's atmosphere causing it to warm. Human activities, such as fossil fuel burning and agriculture, are major emitters of greenhouse gases which are drivers of climate change. After water vapour, the three most prevalent long-lived greenhouse gases are carbon dioxide, methane and nitrous oxide.

Carbon dioxide (CO_2) is the single most important man-made greenhouse gas in the atmosphere and contributes about 64% to total increase in climate forcing by greenhouse gases. Since the start of the industrial era in 1750, its atmospheric abundance has increased by 39% to 389 parts per million (number of molecules of the gas per million molecules of dry air). This is primarily because of emissions from combustion of fossil fuels, deforestation and changes in land-use.

Between 2009 and 2010, its atmospheric abundance increased by 2.3 parts per million – higher than the average for both the 1990s (1.5 parts per million) and the past decade (2.0 parts per million).

For about 10,000 years before the start of the industrial era in the mid-18th century, atmospheric carbon dioxide remained almost constant at around 280 parts per million.

Methane (CH_4) contributes about 18% to the overall global increase in radiative forcing since 1750 and is the second most important greenhouse gas after carbon dioxide.

Before the start of the industrial era, atmospheric methane was about 700 parts per billion (number of molecules of the gas per billion molecules of dry air) Since 1750, it has increased 158%, mostly because of activities such as cattle-rearing, rice planting, fossil fuel exploitation and landfills. Human activities now account for 60% of methane emissions, with the remaining 40% being from natural sources such as wetlands.

After a period of temporary relative stabilization from 1999 to 2006, atmospheric methane has again risen. Scientists are conducting research into the reasons for this, including the potential role of the thawing of the methane-rich Northern permafrost and increased emissions from tropical wetlands.

Nitrous oxide (N_2O) contributes about 6% to the overall global increase in radiative forcing since 1750. It is emitted into the atmosphere from natural and man-made sources, including the oceans, biomass burning, fertilizer use and various industrial processes. It is now the third most important greenhouse gas.

The atmospheric burden of nitrous oxide in 2010 was 323.2 parts per billion - 20% higher than in the pre-industrial era. It has grown at an average of about 0.75 parts per billion over the past ten years, mainly as a result of the use of nitrogen containing fertilizers, including manure, which has profoundly affected the global nitrogen cycle.
Its impact on climate, over a 100 year period, is 298 times greater than equal emissions of carbon dioxide. It also plays an important role in the destruction of the stratospheric ozone layer which protects us from the harmful ultraviolet rays of the sun.

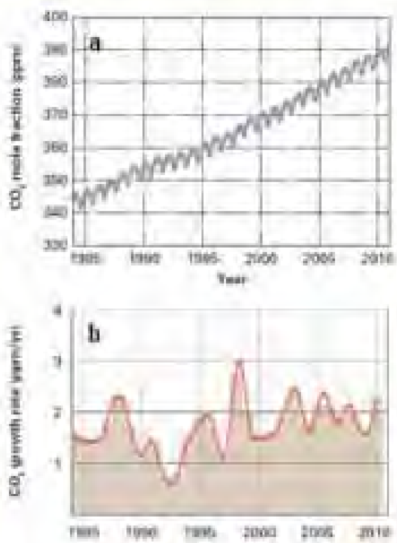


Figure 3. Globally averaged CO_2 mole fraction (a) and its growth rate (b) from 1984 to 2010. Annually averaged growth rate is shown by columns at (b).

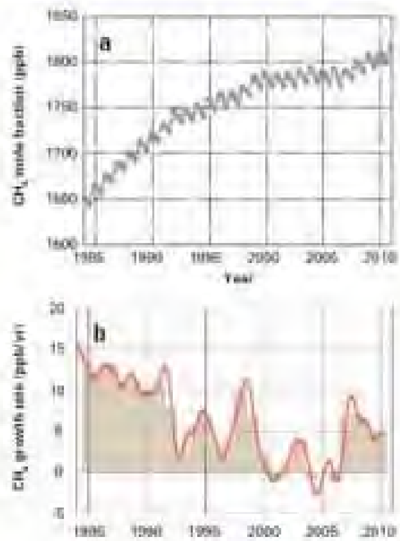


Figure 4. Globally averaged CH_4 mole fraction (a) and its growth rate (b) from 1984 to 2010. Annually averaged growth rate is shown by columns at (b).

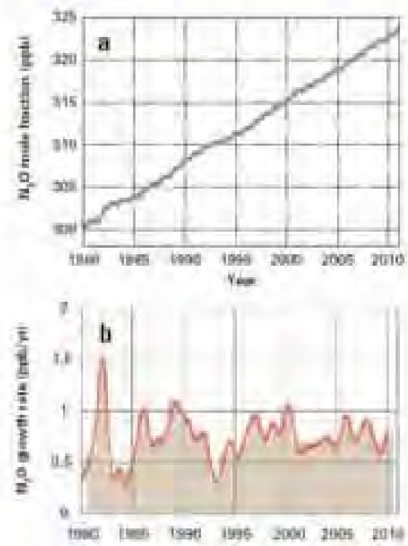


Figure 5. Globally averaged N_2O mole fraction (a) and its growth rate (b) from 1980 to 2010. Annually averaged growth rate is shown by columns at (b).

Other greenhouse gases: The combined radiative forcing by halocarbons is 12%. Some halocarbons such as chlorofluorocarbons (CFCs), previously used as refrigerants, as propellants in spray cans and as solvents, are decreasing slowly as a result of international action to preserve the Earth's protective ozone layer.

However, concentrations of other gases such as HCFCs and HFCs, which are used to substitute CFCs because they are less damaging to the ozone layer, are increasing rapidly. These two classes of compounds are very potent greenhouse gases and last much longer in the atmosphere than carbon dioxide.

Global Atmosphere Watch Programme

WMO, through its Global Atmosphere Watch Programme, coordinates the observations of greenhouse gases in the atmosphere through a network of stations located in more than 50 countries. The measurement data are quality controlled, archived and distributed by WMO's World Data Centre for Greenhouse Gases, hosted by the Japan Meteorological Agency (JMA).

The new Greenhouse Gas Bulletin is the seventh in the series, which began in 2004. This bulletin reports the atmospheric burdens and rates of change of the most important long-lived greenhouse gases – carbon dioxide, methane, nitrous oxide, CFC-12 and CFC-11 – and provides a summary of the contributions of the lesser gases.

WMO is the United Nations' authoritative voice on weather, climate and water

Source: WMO Website http://www.wmo.int visited on December 01, 2011.

Les concentrations de gaz à effet de serre dans l'atmosphère, notamment celle du protoxyde d'azote, continuent de croître

Genève, le 21 novembre 2011 (OMM) – Les concentrations de gaz à effet de serre dans l'atmosphère ont atteint de nouveaux pics en 2010, et le taux d'accroissement de ces gaz s'est accéléré, d'après le dernier bulletin de l'Organisation météorologique mondiale (OMM) sur les gaz à effet de serre, qui met particulièrement l'accent sur l'augmentation de la concentration de protoxyde d'azote.

D'après ce bulletin, le forçage radiatif de l'atmosphère par les gaz à effet de serre, qui induit un réchauffement du système climatique, s'est accru de 29 % entre 1990 et 2010, le dioxyde de carbone contribuant pour 80 % à cette augmentation.

"*La teneur de l'atmosphère en gaz à effet de serre d'origine anthropique a atteint une fois de plus des niveaux jamais enregistrés depuis l'époque préindustrielle*", a déclaré le Secrétaire général de l'OMM, Michel Jarraud. "*Même si nous parvenions à stopper aujourd'hui nos émissions de gaz à effet de serre, ce qui est loin d'être le cas, les gaz déjà présents dans l'atmosphère y subsisteraient encore pendant des dizaines d'années et continueraient de perturber le fragile équilibre de la Terre, planète vivante, et du climat*".

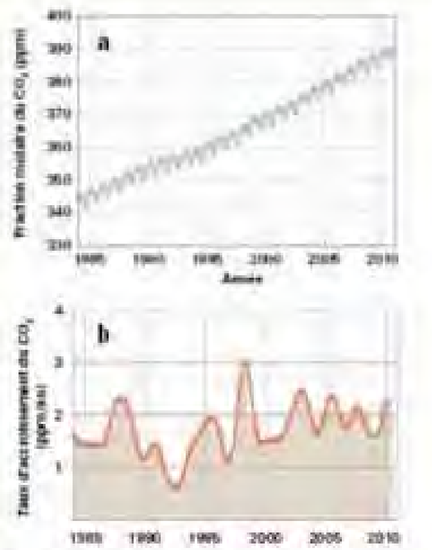
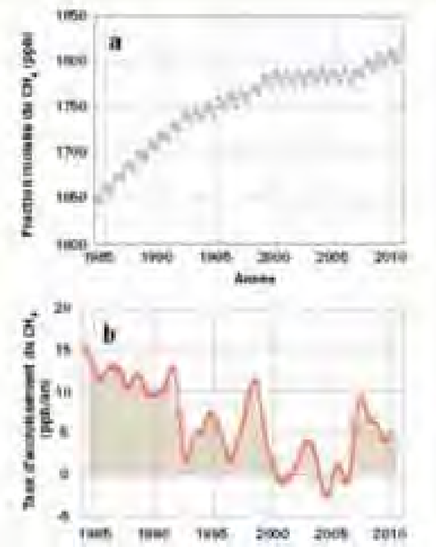


Figure 3. Évolution de la valeur moyenne à l'échelle du globe de la fraction molaire du CO_2 a) et de son taux d'accroissement b) pendant la période comprise entre 1984 et 2010. Le taux d'accroissement annuel moyen est représenté sous forme de colonnes en b).



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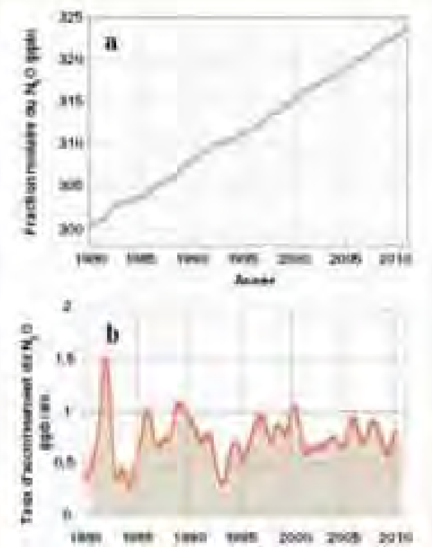


Figure 5. Évolution de la valeur moyenne à l'échelle du globe de la fraction molaire du N_2O a) et de son taux d'accroissement b) pendant la période comprise entre 1980 et 2010. Le taux d'accroissement annuel moyen est représenté sous forme de colonnes en b).

"*Aujourd'hui plus que jamais, nous avons besoin de comprendre les interactions complexes, parfois inattendues, entre les gaz à effet de serre présents dans l'atmosphère, la biosphère et les océans. Pour les besoins de la science, l'OMM continuera de rassembler des données par le biais du réseau de la Veille de l'atmosphère globale (VAG) qui couvre plus de 50 pays et comporte notamment des stations situées à haute altitude dans les Andes et l'Himalaya, dans les étendues reculées de l'Alaska et à l'extrême sud du Pacifique*", a-t-il ajouté.

Les gaz à effet de serre captent une partie du rayonnement traversant l'atmosphère terrestre qui, de ce fait, se réchauffe. Les activités humaines telles que l'agriculture et l'exploitation des combustibles fossiles émettent une grande quantité de ces gaz, qui font partie des causes du changement climatique. Après la vapeur d'eau, les trois gaz à effet de serre persistants les plus abondants dans l'atmosphère sont le dioxyde de carbone, le méthane et le protoxyde d'azote.

Le dioxyde de carbone (CO_2) est le gaz à effet de serre d'origine humaine le plus important et contribue pour quelque 64 % à l'accroissement du forçage radiatif mondial dû à l'ensemble des gaz à effet de serre persistants. Depuis le début de l'ère industrielle, en 1750, sa teneur dans l'atmosphère a augmenté de 39 % pour atteindre 389 parties par million (ppm, nombre de molécules du gaz considéré par million de molécules d'air sec), essentiellement à cause des émissions liées à l'exploitation des combustibles fossiles, au déboisement et au changement d'affectation des terres.

Entre 2009 et 2010, sa concentration dans l'atmosphère a augmenté de 2,3 ppm, soit plus que la moyenne des années 1990 (1,5 ppm) et de la décennie écoulée (2,0 ppm).

Pendant la dizaine de milliers d'années qui ont précédé la révolution industrielle, vers le milieu du XVIIIe siècle, la teneur de l'atmosphère en CO_2 est restée pratiquement constante, se chiffrant à quelque 280 ppm.

Le méthane (CH_4) contribue pour quelque 18 % à l'accroissement du forçage radiatif mondial depuis 1750, et c'est le deuxième plus important gaz à effet de serre après le dioxyde de carbone.

Avant l'ère industrielle, la teneur en méthane de l'atmosphère était d'environ 700 parties par milliard (ppb, nombre de molécules du gaz considéré par milliard de molécules d'air sec). Depuis 1750, cette teneur a augmenté de 158 %, principalement du fait des activités humaines telles que l'élevage de bovins, la riziculture, l'exploitation des combustibles fossiles et la mise en décharge des déchets. Environ 60 % des émissions de méthane sont d'origine humaine, les 40 % restants étant d'origine naturelle (zones humides, etc.).

Après une période de stabilisation temporaire relative (1999-2006), la concentration de méthane dans l'atmosphère est repartie à la hausse. Les scientifiques s'efforcent d'en découvrir les causes, en étudiant notamment le rôle que pourraient jouer dans ce domaine la fonte du pergélisol, riche en méthane, dans les régions nordiques et l'accroissement des émissions dans les zones humides tropicales.

Le protoxyde d'azote (N_2O) contribue pour quelque 6 % à l'accroissement du forçage radiatif mondial depuis 1750. Ses émissions dans l'atmosphère sont d'origine naturelle et humaine, puisqu'elles proviennent notamment des océans, de la combustion de la biomasse, de l'épandage d'engrais et de divers procédés industriels. Il se place aujourd'hui au troisième rang des gaz à effet de serre par ordre d'importance.

En 2010, la teneur de l'atmosphère en protoxyde d'azote était de 323,2 ppb, soit une progression de 20 % par rapport à l'époque préindustrielle. Le taux d'accroissement moyen est d'environ 0,75 ppb par an sur les dix dernières années, ce qui est dû principalement à l'utilisation d'engrais azotés, notamment de fumier, qui a profondément perturbé le cycle mondial de l'azote.

À horizon de 100 ans, l'impact du protoxyde d'azote sur le climat est 298 fois supérieur à celui du dioxyde de carbone, à émissions égales. Ce gaz joue aussi un rôle important dans la destruction de la couche d'ozone stratosphérique qui nous protège des rayons ultraviolets nocifs émis par le soleil.

Autres gaz à effet de serre: L'ensemble des hydrocarbures halogénés contribuent pour 12 % au forçage radiatif. Certains d'entre eux, comme les chlorofluorocarbures (CFC), utilisés auparavant comme réfrigérants, propulseurs dans les bombes aérosols et solvants, voient leur concentration diminuer lentement par suite de l'action engagée sur le plan international pour préserver la couche d'ozone protectrice de la Terre.

Toutefois, la concentration d'autres gaz tels que les hydrochlorofluorocarbures (HCFC) et les hydrofluorocarbures (HFC), utilisés comme substituts des CFC parce qu'ils portent moins atteinte à la couche d'ozone, augmente rapidement. Ces deux familles de composés sont des gaz à effet de serre très puissants dont la durée de vie dans l'atmosphère est bien supérieure à celle du dioxyde de carbone.

Programme de la Veille de l'atmosphère globale

L'OMM, par le biais de son Programme de la Veille de l'atmosphère globale (VAG), coordonne les observations des gaz à effet de serre dans l'atmosphère effectuées au moyen d'un réseau de stations réparties dans plus de 50 pays. Les données recueillies, qui font l'objet d'un contrôle de la qualité, sont archivées et distribuées par le Centre mondial de données relatives aux gaz à effet de serre de l'OMM, qui est hébergé par le Service météorologique japonais (JMA).

Le présent Bulletin de l'OMM sur les gaz à effet de serre est le septième de la série, amorcée en 2004. Il rend compte de l'évolution de la concentration atmosphérique des principaux gaz à effet de serre persistants (dioxyde de carbone, méthane, protoxyde d'azote, CFC-12 et CFC-11) et présente un récapitulatif de la contribution des autres gaz.

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

Source: Site web OMM http://www.wmo.int visité le 1er décembre 2011

Weather, the Diefenbunker and CMOS

by John D. Reid, Bob Jones and Sheila Bourque[1]

In August 1958, Prime Minister John Diefenbaker announced the "*…development of a decentralized federal system of emergency government with central, regional and zonal elements*". Construction of a federal facility resulted at Carp, 30 km west of Parliament Hill in an abandoned gravel pit. Numerous provincial sites were also built. The four-level subterranean facility at Carp afforded protection against a blast equivalent to 5 million tons of TNT exploding about a mile away.

The structure was described as "*a monolithic heavily reinforced high strength concrete box*," 154 feet on each side, resting on a 5 ½ foot bed of gravel and surrounded by 5 feet of gravel. The walls are 4 feet thick; the floors 2 feet. In total 32,000 tons of concrete and 5,000 tons of reinforcing steel were used.

Dorothy Neale Connection

Over 1000 workers were employed during the construction which was contracted to the Foundation Company of Canada. Responsibility was assigned to the company Montreal-based vice president for special projects, Robert Shaw. His young executive secretary at the time was Dorothy Neale, now CMOS Executive Secretary Emeritus and also Associate Editor of the *CMOS Bulletin SCMO*.

The bunker became operational in 1961 providing a protected working environment for 535 people for up to 30

[1] All members CMOS Ottawa Centre, Ontario, Canada

days. This included meteorological staff.

That was not the level to which the facility was permanently staffed. One of the working assumptions was that there would be a period of escalating tensions prior to any nuclear attack, during which the bunker could be brought to full operational status. Fortunately that never happened.

The Governor General, cabinet ministers, deputy ministers and very limited staff would have found a place in the bunker. However, their wives were not permitted; a situation about which Diefenbaker was unhappy. We can only imagine Olive Diefenbaker's sentiments. Later Robert Shaw, who became the first Deputy Minister of Environment Canada, was similarly uncomfortable that his wife could not be with him in the bunker. That information comes from Dorothy Neale who was designated to accompany him!

Canada's Cold War Museum

The facility, decommissioned in December 1994, was eventually acquired by a charitable corporation, and operates as the Diefenbunker, Canada's Cold War Museum and, a National Historic Site (www.diefenbunker.ca/).

Unfortunately, by the time the transfer was accomplished, most of the interior furniture and equipment had been removed and sent to the dump or Crown assets for disposal. The organization is attempting to restore the facility to operational readiness appearance that it might have had in the early 1980s. CMOS has been approached to assist with re-creating the weather office.

Bob Jones, Sheila Bourque and, behind her, Emily Bourque while visiting the bunker. Photo credit: John Reid, December 2011.

In early December 2011 a group of four CMOS members from the Ottawa Centre, Emily and Sheila Bourque, Bob Jones and John D. Reid toured the facility to assess what might be done. Many rooms are furnished with period equipment to give the appearance of being functional. There is a large operations room on the third level with panels showing fallout patterns as they might have been predicted.

A major input to fallout prediction is meteorological information – provided through a weather office adjacent to the operations room. The office is 10 feet by 16 feet with painted steel plates bolted to two walls and sparsely equipped with a desk and filing cabinet. The only exceptional features are a wall-mounted video camera with manual positioning, a 1990s cloud chart and a couple of meteorological textbooks.

How to restore the weather office?

Some questions that occurred to the group included:

- Who staffed the weather office – AES or CFWS?

- What was the office's function or mandate – briefings only, or did analysis and forecasting?

- What were the arrangements for receiving incoming meteorological data, recognizing that normal communications are disrupted in time of war?

The answers will affect the equipment required for an accurate restoration. If analysis and forecasting were carried out then equipment might include a light table, hodograph, and lots of pencils, papers and crayons for weather maps, etc. The room could benefit from tephigrams and some standard met office weather maps secured to the walls with standard met office magnets, a "whirling dervish" with bulldog clips, and at least two teletype machines (the model 40s might suit the room).

Before developing a full inventory of the equipment which might have been in the weather office of the era we are asking for the advice of any CMOS member or other person involved in staffing, or potentially staffing, this or a similar office in the early 1980s. Can you help preserve this unique part of Canada's meteorological history?

Also, if you know of equipment from the period that might be available please let us know. You can contact us by email at webmaster@cmos.ca

Acknowledgements

Thanks to Doug Beaton, Dorothy Neale and Bruce Ricketts.

Note from the Editor: To find more about this bunker, you may wish to visit the following website:

http://www.mysteriesofcanada.com/Military/diefenbunker.htm

The Climate of Ottawa: day by day

by Richard Asselin[1]

Abstract: This study extracts detailed climatological information out of the daily temperature record at Ottawa, going back 120 years. First, the long-term average for each day is calculated and expressed as a simple function of day-of-the-year. This smooth representation is then removed from the individual years and the residual is examined to detect any hidden characteristics. Even after 120 years the residual exhibits some persistent anomalies, particularly in January to April. These anomalies are evident in most of the 12 decades of the record.

The annual temperature average is calculated for each decade. It is found that the averaged daily maximum temperature has increased by 1.09 degrees in 120 years, while the minimum increased by 2.13 degrees, giving rise to a daily mean temperature increase of 1.61 as previously found. However, the daily temperature range is found to have decreased by about 20% during this period. All changes show a marked seasonal variation. It is speculated that the winter anomalies are related to the appearance of the snow cover in November-December, and that other anomalies are also related to the rapid changes in albedo that occur at certain periods of the year due to vegetation.

Résumé: Cette étude soutire de l'information climatologique détaillée à partir des dossiers de 120 ans de température journalière à Ottawa. La moyenne à long terme est calculée pour chaque jour et exprimée au moyen d'une fonction simple. Cette fonction lisse est ensuite soustraite des données de chaque année et le résidu est examiné afin de détecter les caractéristiques cachées. Des anomalies persistent même après 120 ans, surtout de janvier à avril, et se manifestent dans la plupart des décennies.

La moyenne annuelle de la température est ensuite calculée pour chaque décade. On trouve que la température maximale a augmenté en moyenne de 1,09 degrés en 120 ans, alors que la température minimale a augmenté de 2,13 degré, ce qui fait que la température moyenne a augmenté de 1,61 degré, comme d'autres ont déjà trouvé. Toutefois, l'écart journalier de température a diminué d'environ 20% durant la même période. Une forte saisonnalité est évidente dans tous les changements. Il est postulé que les anomalies d'hiver sont reliées à l'apparition de la couverture neigeuse en novembre-décembre et que d'autres anomalies seraient aussi reliées aux changements rapides d'albédo qui se produisent à certaines périodes en relation avec la végétation.

Introduction

In a previous study of the climate of Ottawa (Asselin, 2011 **[2]**), based on the 120-year climatological record for Ottawa (CDA), a station now situated in the middle of the national capital region, I had shown that the annual mean temperature has increased by about 1.6 degrees. During the same period, the absolute minimum temperature reached in each year has increased considerably while the absolute maximum temperature in each year has remained steady or decreased a little. It seemed therefore that the increase of the mean temperature was due to the significant increase of the minimum temperature. These findings were consistent with other published studies of the climate of Canada and seemed to correlate with a general increase in cloudiness, or indirectly with the fact that the occurrence of rain in Ottawa has increased from 150 days per year to 200 days per year.

In a climate blog (R. A. Pielke Sr., reference lost) seen in 2011, I read the statement that if the temperature of the globe is increasing, this should be reflected not only in the mean daily temperature, but also in the maximum temperature. I decided to re-examine the Ottawa record more finely and to look at what has happened to the maximum daily temperatures, not only in terms of the absolute value reached each year or the average annual value, but for each day of the year.

Method

Calculating average temperatures for a complete year simply requires adding the values and dividing by the number of days. However, when averaging for each day over all the years, the problem of leap years and 29 February must be addressed; otherwise the years cannot be added up properly. Since I was expecting to find only small changes in the maximum temperature, I decided to proceed very carefully.

The first manipulation was to lengthen each non-leap year (including 1900), to 366 days by adding the value for the preceding day at the beginning of the year or the value for the following day at the end of the year. The decision for adding at the beginning or at the end of the year was made such that the first day of each year corresponds as closely as possible to the same position of the Earth on its orbit. In

[1] Director of Publication, CMOS, Ottawa, Ontario, Canada

this manner, 4 groups of 30 years were formed, in which all the years start within 0, 6, 12 or 18 hours from the same orbital position. Thereafter in this article, 1 January is referred to as day 0 and 31December as day 365, which is close enough.

Results

To determine the long-term normal (120 years), the temperature was averaged for each day within each orbital group. The result containing the four groups is shown in figure 1a for the maximum temperature. In this graph, the abscissa has been extended by one month and the values repeated at each end in order to facilitate visualisation of the annual cycle. The scatter is made up of 1461 values at 6 hour intervals, each being the average of 30 years. Also on this graph is the best fit fourth-order "trend line" calculated by Excel (MAC.s Numbers).

Unfortunately, the 4^{th} order trend line does not have the same value, slope or curvature at both ends of the year, as would be required for a climatological average. In figure 1b, a second order polynomial of the cosine function has been fitted to the same data. (See appendix given below for details). This type of polynomial is hereafter used to represent normal temperature distributions for Ottawa. The small variations visible along the normal curve are the residuals from the original values shown in 1a), smoothed so as to remove the fluctuations shorter than about 48 hours. These variations are now referred to as anomalies, and are shown on an expanded scale in fig 1c).

The long-term anomalies are quite pronounced and seem to display some seasonal persistence. To confirm this impression, the anomalies are shown for each decade in figure 2, and the long-term anomaly (fig 1c) is repeated in the bottom graph on the same scale as the graphs above, to facilitate comparison. We can see a high degree of inter-decadal persistence, indicating that some kind of seasonal climatic phenomenon is present in the data, but has not been captured by the fitted long-term normal.

From the decadal averages shown in Fig 2, the annual mean maximum temperature anomalies (departures from the long-term normal) are calculated and shown in figure 3a. This shows that the annual average of the maximum temperature in Ottawa has increased by 1.09 degrees over the last 120 years, and that the increase was all in the last three decades. The minor decreases in the 1930s and 1960-1970s could possibly be attributed to dust blowing from the Prairies and to pollution from coal-fired generators in those periods, but that would require a new study. For a good discussion on the effects of atmospheric contaminants on solar energy, see Wild, 2012, **[5]**.

When the same treatment as described above is applied to the minimum temperature, the results are similar (not shown). The decadal change is shown in figure 3b, indicating an increase of 2.11 degrees in 120 years. The average mean temperature increase is therefore 1.6 degrees, as has been found before.

The long-term normal curves for the maximum and minimum temperature are shown in figure 4 (top and bottom curves). Note the lag by about 4 days of the minimum temperature with respect to the maximum temperature. From these two curves, the long-term mean and the long term daily temperature range (DTR) can be calculated by averaging and subtraction, and these curves are also shown in figure 4. The long term daily temperature range is found to vary from 8.9 in early winter to 12.4 degrees in mid summer. For additional reference, various significant characteristics of the solar cycle are also indicated in figure 4.

It is well-known that the summer temperature does not peak on the summer solstice, when maximum solar insolation occurs. Figure 5 shows the solar input in terms of the length of day at the latitude of Ottawa (~45^{o}) modulated by the inverse square of the distance of the Earth from the sun along the orbit (the calculation method is from Glamer **[3]**). This curve is very similar to the temperature curves in figure 4. Note that the abscissa has been shifted left by one month to simulate the observed lag of the temperature by about 29 days in Ottawa. This lag is attributed to the slow absorption and release of energy from the soil over the course of the seasons.

Seasonal Anomaly

Going back to figure 1c, it is possible to fit the anomaly curve with a polynomial and to include this function into the Ottawa normal, but since the physical significance has not been established, this was not done in this article. Nevertheless, the amplitude of the maximum temperature anomaly (almost 2.5 degrees) must be acknowledged, and this may have a practical application (eg: for the scheduling of winter events). I believe that it is an under-documented part of the climate of Ottawa.

For example, a close examination of figures 1a,1b and 1c reveals a relative maximum of about 1.4 degrees (this is a smoothed value) above the long-term normal centered on January 22, which may be considered the normal date of the so-called January thaw. Indeed, during the week centered on 22 January, 20 of the years had at least one day with a minimum temperature . 0, compared to 11 years for the previous week and 10 for the following week. Similarly, 24 years had at least one day with a maximum temperature 0.5 during the week centered on 22 January, compared to 19 years for the preceding week and 17 for the following week.

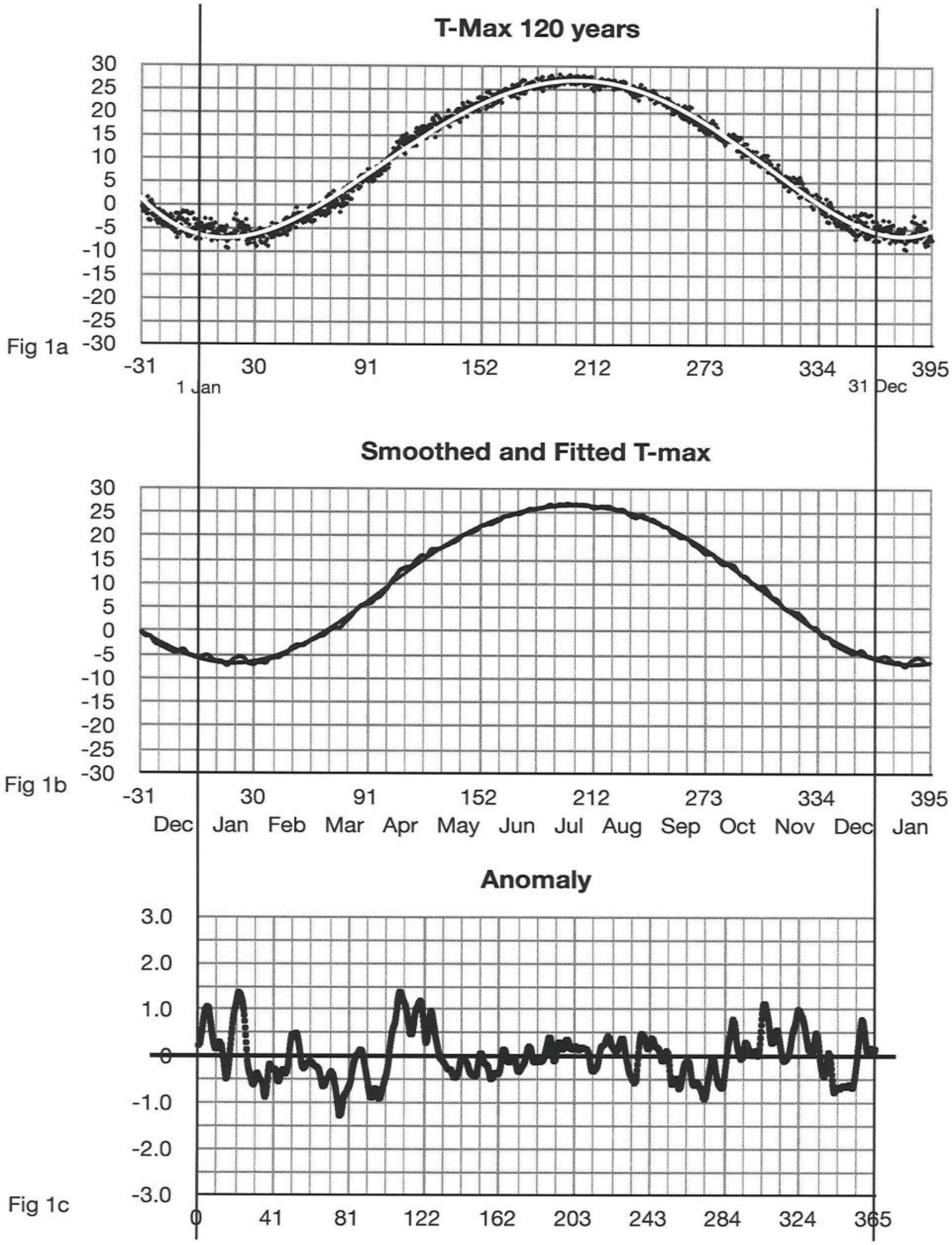


Figure 1: a) Daily long-term maximum normal temperature in ^{o}C based on 120 years of data; b) Second-order polynomial cosine function fitted to data shown in a) and the smooothed residuals values; c) Residuals values shown as anomalies on an expanded vertical scale.

Fig 2

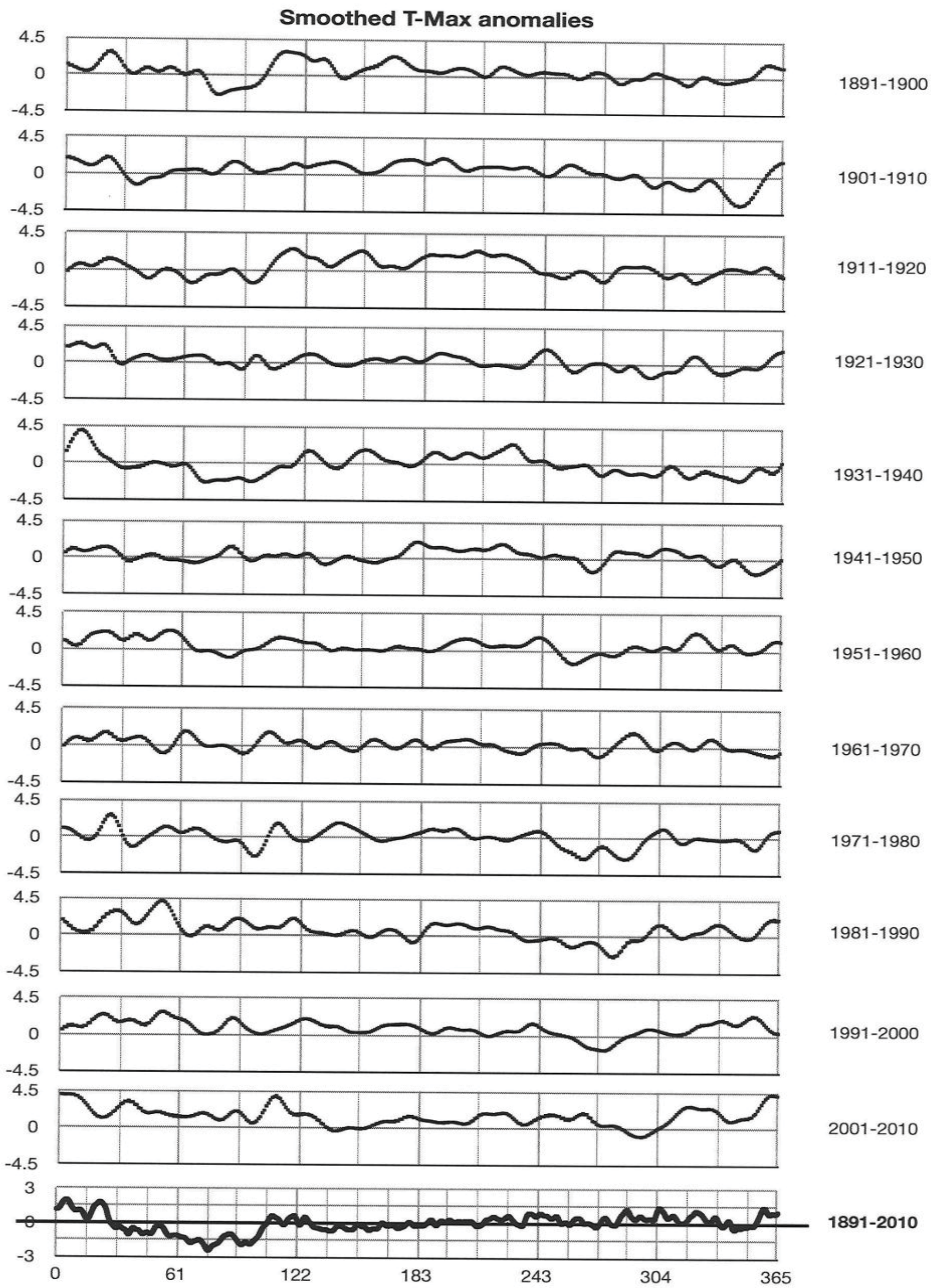


Figure 2: Decadal average by day of the smoothed residuals for twelve 10-year periods. The bottom panel is figure 1c) repeated at bottom for comparison purposes. All temperatures are expressed in ºC.

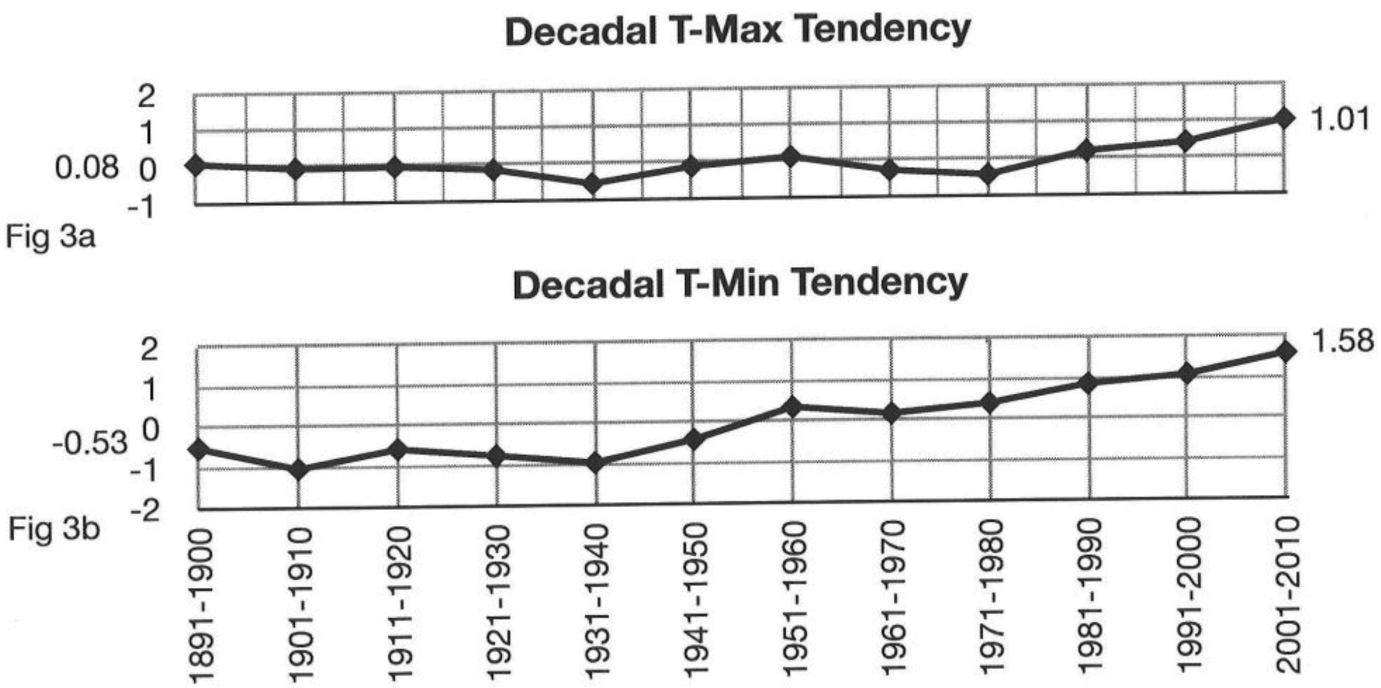


Figure 3: a) Mean maximum temperature anomalies (departures from the long-term normal) showing the tendency over the 120 year period; b) Mean minimum temperature anomalies as for a). All temperature values are expressed in ^{o}C.

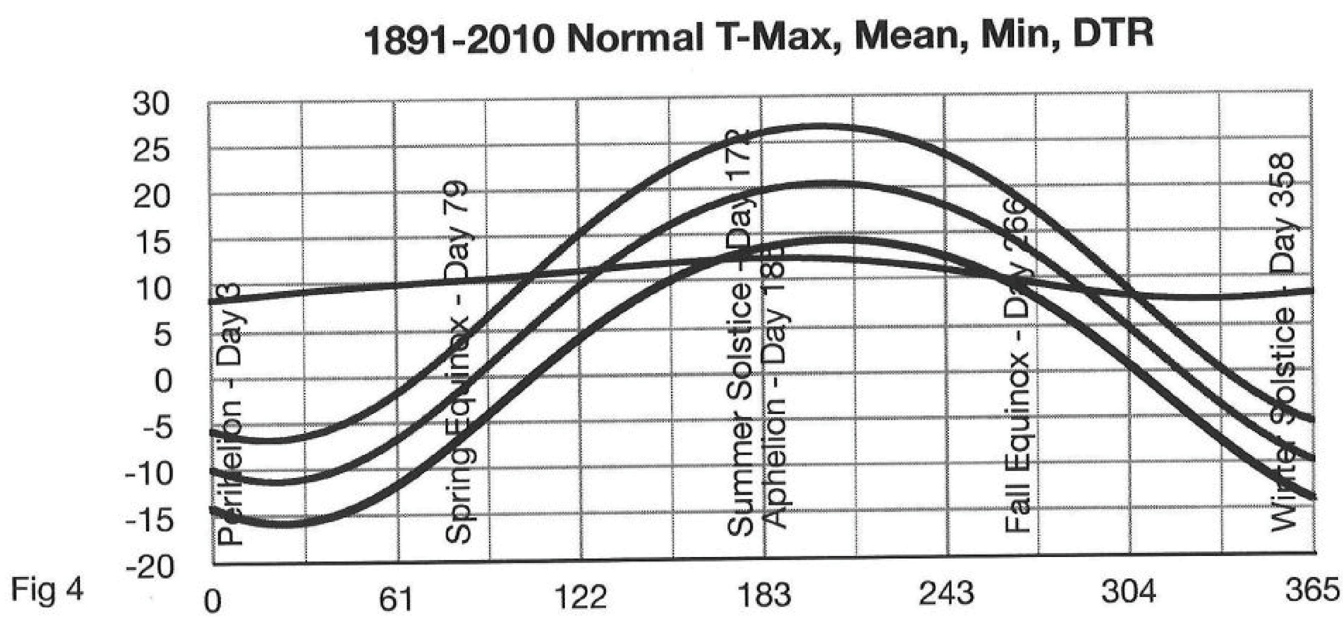


Figure 4: Long-term normal maximum and minimum (top and bottom curves), mean (middle curve) and daily temperature range (DTR). Temperatures are expressed in ^{o}C.

I here speculate that the anomaly pattern visible after 120 years of averaging is related to the abrupt variations of the surface albedo during the year, due particularly to the appearance and disappearance of the snow cover, leafing and defoliation. A warm anomaly would be related to a low albedo in the range of 0.15, perhaps corresponding to wet bare soil. A cold anomaly would relate to a very high albedo (0.4 to 0.8) corresponding to snow cover over the region. A near zero anomaly might correspond to an albedo of about 0.25, characteristic of a mixed vegetation cover.

Assuming that the effect of the changing albedo would also be reflected in the surface temperature with a one-month lag, the anomaly curve might be interpreted as a result of bare soil cover until around 22 December, followed by snow cover until mid-March, bare wet soil from mid-March to mid-April, followed by increasing growth of vegetative cover until leaf loss at the end of October. The annual variation of the albedo could probably be modeled by interpreting the precipitation record in terms of albedo together with a simple vegetation growth model.

Of course, there is some artificiality in the magnitude of the anomaly because it is the difference between a 120-year average of temperature and an imperfectly fitted longterm normal, and it is also smoothed. Therefore, the amplitude of the anomaly must be understood as lying within a fairly wide error band.

The sudden arrival of the snow cover in Ottawa is triggered by the passage of a synoptic system, and the timing of this event can vary by more than one month from year to year. So, if a lagged correlation between the climatological temperature anomaly and the albedo can be established, then it might be possible to "forecast" the timing of the January-March anomalies well ahead of time! Any such result will require much more work.

The 30-year Normal

The World Meteorological Organisation recommends the use of 30-year averages to represent the normal climate at a location. Having processed the temperature record into decades, it is now a simple step to calculate the 30-year normals that can be used in many applications, including daily weather forecasts. According to Shannon Allen (private communication) **[1]**, the daily normal values of maximum and minimum temperature published on the Environment Canada (EC) web site are calculated simply by fitting a cubic spline to the monthly normal values. The actual method was developed by NOAA **[4]**. These EC values are very similar to the normals calculated by fitting a polynomial to the daily values as described in this study, and lie on a similarly smooth curve.

In figure 6 the change in the 30-year normals between the first period of the Ottawa record (1891-1920) and the last period (1981-2010) are shown for T-Min, T-Mean and T-max. (Note that the change in T-Min is at the top of the three curves). The general message of this figure is again that the normal minimum, maximum and mean temperatures have increased by 1.88, 0.55 and 1.21 degrees respectively, but now we note significant variations during the year, showing that the winter months have warmed the most, and that the maximum temperature has even decreased in the summer months. More detailed numbers for the changes between the two normal periods can be found in the appendix.

Fig 5

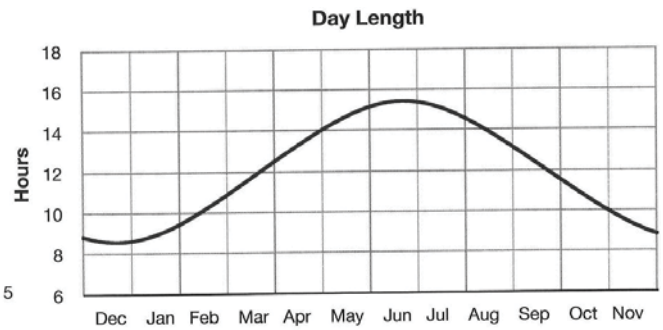


Figure 5: Solar input (length of day) modulated by the inverse square of the distance of the Earth from the sun along its orbit at 45°N.

Figure 6 also shows that the daily temperature range has decreased significantly (about 20%) between the two periods. Note however that this curve is a difference of differences, so that it may owe its magnitude as much to the method used to develop the polynomials as to reality. The change is negative because it represents a decrease. Although the curves in figure 6 are very simple, the explanation for their behaviour is not so simple. In the previous paper by Asselin1 and in other studies, the general regional rise in temperature has been linked (but not necessarily attributed) to the relatively well documented increase in cloudiness, which prevents the nighttime temperature from cooling too low and also prevents the daytime temperature from rising too high, presumably in all months. I am not aware whether a direct link with the increase of greenhouse gases has been established, but this would be a consistent explanation.

Another cause for the rise in temperature is suggested by the presence of the anomalies discovered above in this article: a long-term decrease of the regional albedo in winter might contribute directly to increase the maximum temperature by reflecting less solar radiation, and also indirectly raise the minimum temperature. The gradual decrease of the albedo would be due to an increase in the surface of the land that is covered by bare asphalt or buildings in the region of Ottawa, to more snow being removed from the streets and to the snow being dirtier than in the past as a result of deposition of soil and other particulates of anthropogenic origin (a radiative heat island effect?).

Fig 6

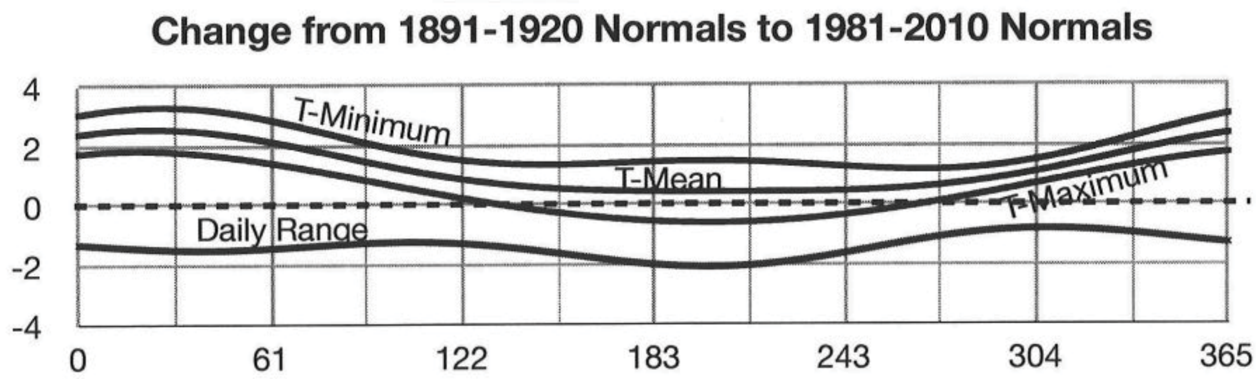


Figure 6: Change in the 30-year normals between the first period of the Ottawa record (1891-1920) and the last period (1981-2010) for T-min, T-mean and T-max and Daily Temperature range. Temperatures are expressed in °C. Also shown in colour on cover page for a better appreciation.

These explanations may be overly simplistic. Other causes for the change of the Ottawa climate could be the general increase of CO_2 concentration, major alteration of the general circulation, or urban heat island effect (advection, boundary layer). To address the question more carefully would require examining the difference in the energy balance applicable to the same day in each of the two normal periods. I would assume that several factors would be substantially the same for both periods (which are 30 year averages after all!) and could therefore be neglected, leaving only a few terms for which a physical explanation would be sought. This may be attempted in a future study.

Finally, I examined the question: is the climate of Ottawa more variable than in the past? I calculated the mean square difference between the maximum temperature for each day of each year and the value of the cosine polynomial for the corresponding day for the first normal period (1891-1920) and did the same for the last period (1981-2010) (each polynomials representing the respective 30 year average). The average mean square difference did increase from 26.81 to 27.31 (degrees square, or from 5.18 degrees to 5.23 degrees), but the inter-annual variability was large (from 19.3 to 33.4 in the first period and from 23.3 to 35.8 in the second), so that I cannot conclude decisively from this calculation that the maximum daily temperature is more variable now than in the past.

Conclusion

In general, the findings of this study are consistent with other studies applicable to the east-central region of Canada. However, whereas other studies have considered monthly or seasonal averages, this study was able to reveal considerably more details about the annual cycle by retaining the shorter term variations. These seasonal climate perturbations have not yet been expressed mathematically nor explained physically. I have confirmed however that the temperature in Ottawa has been increasing as a result of an increase in both the minimum and maximum daily temperatures.

I also found that there is a marked variation in the rate of temperature increase during the year, and that the maximum temperatures have even decreased during the 3-4 summer months over the long time period. The winter months experienced the largest changes (increases), and this appears consistent with a suggestion that the albedo of the snow-covered region is gradually decreasing.

By revealing details of the climate of Ottawa on a daily basis this study raises many questions about the nature of the energy balance, but provides no definitive answers.

Considerably more work by more qualified scientists may be required to test out the albedo theory that has been put forward here. It would also be useful to carry out similar studies for other locations to verify the degree of consistency that can be found, and to unravel additional particularities.

Finally, a method has been developed to accurately represent the complete normal annual temperature cycle with only four physically significant numbers. This method should have applicability at most other locations.

References

[1] Allen, Shannon: Weather and Environmental Monitoring Services of Environment Canada.

[2] Asselin, Richard: Le réchauffement climatique en termes pratiques: la situation à Ottawa, CMOS Bulletin SCMO, Vol 39 no 2, Apr2011, p.59.

[3] Glamer, Herbert: URL: herbert.grandraxa.com/lenght_of_day.xml

[4] NOAA http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html#CLIM84.

[5] Wild, Martin: Enlightening global dimming and brightening, BAMS, Janurary 2012.

Appendix

Mathematical representation of the annual temperature cycle

We wish to find a function that approximates a given series of temperature values for each day of the year by minimising the square of the differences between the temperature on a given day and the function evaluated for the same day. The series of temperature data that we have is actually a one-year window on a series of infinite length with one year periodicity.

To take advantage of the "trend-line" calculations available in Excel (and Mac's Numbers), we will use a polynomial expansion of the form:

$$y(x) = a + b x + c x^2 + d x^3 + e x^4 \; ..... \qquad (1)$$

To reflect the periodicity of the data, this polynomial needs to have the property that y(1) = y(-1), y'(1) = y'(-1) and y"(1) = y"(-1), where the superscripts represent the first and second derivative.

After applying these constraints, the polynomial reduces to

$y(x) = a - 2ex^2 + ex^4$, which can be expressed as a linear function

$$y(z) = a + ez \qquad (2)$$

for the transformed coordinate

$$z = x^4 - 2x^2 \qquad (3)$$

This function z looks like a cosine for $-1 \leq x \leq 1$, but is not cyclical outside of the range of x.

The above function (2) and (3) can be used to represent the annual temperature distribution, and it does provide a very good fit. However, since the annual variation of temperature is very similar to a cosine function, we chose instead to use a polynomial in powers of the cosine function. So, we define

$$x = \cos(\prod ((day - L) / 183-1)), \qquad -1 \leq x \leq 1 \qquad (4)$$

where "day" is the day number and L is a lag constant to be determined. When substituted into the polynomial, (4) amounts to a co-ordinate transformation.

In practice we find that a second order polynomial provides excellent results, ie:

$$y(x) = a + bx + cx^2 \qquad (5)$$

The maximum, minimum and mean values of polynomial (5) with (4) are

$y(0)_{max} = a+b+c+d+e$
$y(\pm1)_{min} = a-b+c-d+e$
$y_{mean} = a+c/2$

The optimal value of L can be found in two iterations, starting with a number estimated from the day at which the plotted data reaches its maximum (about 19 days after day 183 in our case) while minimizing the mean square difference between the data and the polynomial.

The complete solution can easily be programmed on an Excel spreadsheet.

Despite its simplicity, it is found that polynomial (5) with coordinate transformation (4) can represent the Ottawa annual temperature pattern very accurately, provided that the x-axis is shifted by the appropriate number L.

The complex trigonometric function representing the variation of the solar input can also be represented extremely accurately. The row titled Mean square error in the table below shows the closeness of the fit.

The following table gives the parameters that were developed to fit the annual temperatures for the periods analysed in this study.

Examining the difference in values for the first and last 30-year periods, one can see a decrease in the amplitude of the annual temperature cycle (by 2.26 degrees for the maximum and 1.816 degrees for the minimum). We note also that the peak of the minimum temperature is about 4 days behind the peak of the maximum temperature, itself about 29 days behind the maximum of the solar input (solstice, at day 172). The daily temperature range has decreased between the first and last 30 year period (in 90 years) by 1.6 degree in winter and 2.07 degree in summer.

	1891 - 1920 First 30-year Normal		1981 - 2010 Last 30-year Normal		1891 - 2010 Full 120-year Record		Solar Input
Polynomial Parameters	**T-Max ^{0}C**	**T-Min ^{0}C**	**T-Max ^{0}C**	**T-Min ^{0}C**	**T-Max ^{0}C**	**T-Min ^{0}C**	**Hours**
a	11.9900	1.6933	12.4930	3.1502	11.9570	2.2558	11.9890
b	17.2370	15.4900	16.1060	14.5820	16.7530	15.0320	3.3490
c	-2.0033	-3.2977	-2.0204	-2.4243	-2.0335	-2.9670	0.0080
L (lag in days behind day 183)	17.75	22	17.75	21.5	19.5	23.25	-9.25
Mean square error	1.0017	1.2300	0.9091	1.3479	1.0730	1.5330	0.0029

Physical Significance

	1891 - 1920 First 30-year Normal		1981 - 2010 Last 30-year Normal		1891 - 2010 Full 120-year Record		Solar Input
Amplitude of Cycle (2*b)	34.474	30.98	32.212	29.164	33.506	30.064	6.698
Lowest value (a-b+c)	-7.2503	-17.0944	-5.6334	-13.86	-6.8295	-15.7432	8.648
Highest value (a+b+c)	27.2237	13.8856	26.5786	15.3080	26.6765	14.3208	15.3460
Average value (a+c/2	10.9884	0.0445	11.4828	1.9380	10.9403	0.7723	11.9930
Winter Daily Range	9.8441		8.2266		8.9137		
Summer Daily Range	13.3381		11.2706		12.3557		

Mark your calendar

Earth Day: **22 April 2012**

World Ocean Day: **8 June 2012**

À inscrire sur votre agenda

Jour de la terre: **22 avril 2012**

Journée mondiale des océans: **8 juin 2012**

Next Issue *CMOS Bulletin SCMO*

Next issue of the *CMOS Bulletin SCMO* will be published in **June 2012.** Please send your articles, notes, workshop reports or news items before **May 4, 2012** to the address given on page 2. We have an URGENT need for your written contributions.

Prochain numéro du *CMOS Bulletin SCMO*

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en **juin 2012.** Prière de nous faire parvenir avant le **4 mai 2012** vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée à la page 2. Nous avons un besoin URGENT de vos contributions écrites.

L'estuaire tourne au vinaigre[1]

par Dominique Forget

Abstract: I wish to bring to your attention a science article that was recently published (September, 2011) in *Atmosphere-Ocean*, a periodical of the Canadian Meteorological and Oceanographic Society (CMOS). This is a peer-reviewed journal that generally publishes articles in physical oceanography and meteorology. The article presented here is signed by four Quebec university and federal government researchers and deals with the acidification of the bottom waters of the Gulf and Lower St. Lawrence Estuary.

As you may know, the carbon dioxide (CO_2) concentration in the atmosphere has increased significantly since the beginning of the industrial revolution, from 280 parts per million (ppm) to more than 390 ppm. This increase is due to a number of factors but mostly to fossil fuel burning. A large fraction (30%) of the anthropogenic CO_2 emitted to the atmosphere has been absorbed by the oceans. Once dissolved in seawater, CO_2 forms a weak acid (carbonic acid) which dissociates and liberates hydrogen ions (H^+) to the solution. Consequently, the absorption of anthropogenic CO_2 had led to an increase in the hydrogen ion concentration ([H^+]) and a decrease in seawater pH (~ -log [H^+]). Since the beginning of the industrial revolution, the increase in atmospheric CO_2 has decreased ocean surface water pH by 0.12, corresponding to a 30% increase in [H^+], the greatest decrease in seawater pH over the past several million years. According to the Intergovernmental Panel on Climate Change (IPCC) "business as usual" emission scenario IS92a and general circulation models, atmospheric CO_2 levels may reach 800 ppm by 2100 which would cause the ocean surface pH to decrease by an additional 0.3–0.4, corresponding to a further 100% increase in [H^+]. These variations may appear trivial, but many marine organisms are extremely sensitive to small variations in pH, especially those that rely on the precipitation of calcium carbonate ($CaCO_3$) shells such as coccolithophores, that sit at the very bottom of the food chain, as well as others like foraminifera, gastropods, bivalves and corals.

Ocean acidification can also occur when water masses are isolated from the atmosphere as organic matter settling through the water column from the surface is respired by micro-organisms and metabolites, including CO_2, are released to the water. Such a condition is encountered in the bottom waters of the Lower St. Lawrence Estuary (between Tadoussac and Pointes-des-Monts) where we have measured pH decreases on the order of 0.3 over the past 75 years. These waters originate from the Northwestern Atlantic Ocean and have been isolated from the atmosphere for about 20 years. The pH decrease is similar to the change in surface ocean pH anticipated over the next century. Hence, the bottom waters of the Lower St. Lawrence Estuary would be an analogue of the status of the surface oceans by the end of this century. In this article, we report historical data from the early 1930s to 2007 and attempt to reproduce pH variations for the last 75 years by assuming that the acidification resulted from both the increase in the atmospheric CO_2 concentration and CO_2 originating from the respiration of organic matter delivered from the surface. Through this exercise and by identifying the origin of the water masses that feed the Laurentian Channel through Cabot Strait, we determined, for the first time, the average age of bottom waters in the Lower St. Lawrence Estuary, in other words, the number of years since these waters were last in contact with the atmosphere or resided in the surface mixed layer. Results of our calculations reveal that the mean age of these waters is 19 +/- 3 years. The approach developed to compute this age has never been used previously.

Abstract written by Professor Alfonso Mucci, McGill University.

Les eaux du fond de l'estuaire du Saint-Laurent s'acidifient plus vite que les océans. La faune marine encaisse déjà le coup.

C'est un peu grâce à des membres du clergé morts depuis longtemps, que trois océanographes et un écologiste ont levé le voile sur ce qui se trame au fond du plus grand estuaire du monde. À bord du navire de recherche Coriolis II, l'équipe a affronté la houle pour échantillonner les eaux du Saint-Laurent, entre le fjord du Saguenay et Sept-Îles. Puis elle a comparé ses données avec celles colligées par la poignée d'hommes en soutane qui opéraient la station biologique de Trois-Pistoles durant les années 1930 pour l'Université Laval. Elle a ainsi constaté que les eaux profondes de cette portion du fleuve s'acidifient plus rapidement que la moyenne des océans de la planète.

Sur l'échelle du pH – qui tend vers 0 pour un acide et vers 14 pour une base –, les eaux au fond de l'estuaire auraient perdu de 0,2 à 0,3 point au cours des 75 dernières années.

[1] Source : Magazine Québec Science, février 2012, Les 10 découvertes de l'année. L'article présenté ici était le huitième dans la liste des découvertes présentées par Québec Science. http://www.quebecscience.qc.ca/les-10-decouvertes-2011/8-estuaire-tourne-au-vinaigre. Reproduit avec la permission expresse du magazine Québec Science.

En comparaison, les océans auraient vu leur pH s'abaisser en moyenne de 0,1 point, à cause de la concentration croissante de dioxyde de carbone (CO_2) dans l'atmosphère et, par vases communicants, dans l'eau. Comme l'échelle du pH est logarithmique, chaque baisse de 0,1 point correspond à une hausse de 30% de la concentration en acide.

La découverte, publiée en juillet dernier dans la revue ATMOSPHERE-OCEAN (Mucci A., Starr M., Gilbert D. and Sundby B., 2011, Acidification of Lower St. Lawrence Estuary bottom waters. *Atmosphere-Ocean* **49:** 206-213. doi:10.1080/07055900.2011.599265) explique pourquoi certains mollusques n'arrivent plus à former leurs coquilles de carbonate de calcium, qui se dissolvent dans les eaux trop acides.

L'équipe a dû mener cinq missions à bord du Coriolis II avant de recueillir suffisamment d'échantillons pour tirer ses conclusions. "*L'estuaire du Saint-Laurent est immense*", me répond Alfonso Mucci, océanographe chimiste et professeur à l'Université McGill, quand je lui demande pourquoi autant d'expéditions ont été nécessaires.

Il ne s'en plaint pas. Le Coriolis II est un hôtel de luxe comparé au Alcide C. Horth, l'ancien chalutier sur lequel les chercheurs avaient l'habitude de voguer pour explorer l'écosystème du Saint-Laurent. *"À l'époque, on était quatre par cabine, et ceux qui occupaient la couchette du haut se frottaient le bout du nez contre le plafond*", se rappelle le professeur Mucci.

En 2002, un consortium réunissant des chercheurs de l'Université du Québec à Rimouski, de l'Université McGill, de l'Université Laval et de l'Université du Québec à Montréal a obtenu 10 millions de dollars de la Fondation canadienne pour l'innovation afin de transformer un bateau abandonné par la Garde côtière canadienne et en faire un navire de recherche de première classe, équipé de matériel de forage, de laboratoires et de cabines confortables. Sur le Coriolis II, 14 scientifiques peuvent prendre place et autant de membres d'équipage.

La nourriture servie à bord, concoctée par un chef d'origine alsacienne, fait l'envie de scientifiques partout au Canada. Heureusement pour le professeur Mucci! Lorsqu'il a entrepris ses études doctorales en océanographie à Miami, il a constaté à son grand désarroi qu'il souffrait terriblement du mal de mer. *"Depuis, j'ai découvert la solution magique: je mange sans arrêt à bord"*, rigole le chercheur qui est pourtant mince comme un clou.

Reste que les expéditions scientifiques n'ont rien d'une croisière. À 18 000 $ la journée – c'est ce que coûte une sortie du Coriolis II –, il n'y a pas une minute à perdre. Dès que le bateau arrive à un point d'échantillonnage, l'équipe lance à l'eau des «rosettes» qui ressemblent au barillet d'un revolver, en beaucoup plus gros. Plutôt que de contenir des balles, chaque cavité est occupée par une bouteille de prélèvement.

Au fur et à mesure que l'équipement s'enfonce sous la surface, des sondes reliées à un ordinateur à bord du bateau mesurent la profondeur, la pression, la salinité et la température de l'eau. Au moment opportun, les chercheurs déclenchent la fermeture d'un flacon grâce à un signal électronique. "*Les chercheurs des années 1930 relâchaient un plomb le long d'un câble pour faire basculer la bouteille et, du même coup, déclencher un mécanisme de fermeture*", explique Alfonso Mucci.

Pour comparer les eaux qui balaient le fond de l'estuaire aujourd'hui à celles des années 1930, il a dépoussiéré quelques vieux manuels de référence. Il voulait comprendre la méthodologie employée par les membres du clergé à une époque ou l'on commençait à peine à définir le pH. "*Quand je pense à ce qu'ils avaient à leur disposition, je suis impressionné par la qualité de leur travail*", dit le chercheur.

L'acidification des eaux au fond de l'estuaire n'a pas surpris l'équipe scientifique. On constate depuis plusieurs années que les plans d'eau de la planète sont en voie de s'acidifier à cause de l'augmentation de la concentration dans l'atmosphère du CO_2 qui, lorsqu'il se dissout dans l'eau, produit de l'acide carbonique.

"*Dans les profondeurs de l'estuaire, les choses ne sont pas aussi simples*", souligne toutefois Bjorn Sundby, océanographe chimiste et professeur à l'Institut des sciences de la mer de Rimouski, "*car les eaux du fond ne se mélangent pas avec celles de la surface et sont donc isolées de l'atmosphère*".

Le rejet de CO_2 anthropique (produit par les humains) serait malgré tout responsable d'une partie de l'acidification observée par l'équipe qui comprend également Denis Gilbert et Michel Starr, chercheurs à l'Institut Maurice-Lamontagne de Pêches et Océans Canada. "*Les eaux entrent dans le fleuve par le détroit de Cabot en provenance de deux sources, la mer du Labrador et le nord-ouest de l'Atlantique, qui correspond grosso modo au Gulf Stream*", explique Bjorn Sundby. "*Or, ces eaux sont plus acides qu'autrefois*". À l'entrée du Saint-Laurent, ces deux masses d'eau plongent dans les profondeurs de l'estuaire et rasent le fond pendant quatre à sept ans avant d'atteindre l'embouchure du Saguenay. Elles remontent alors vers la surface et rebroussent chemin vers le golfe du Saint-Laurent.

Deux autres pistes sont avancées pour expliquer l'acidification accélérée du fond de l'estuaire. D'abord, la production de matière organique à la surface du Saint-Laurent s'est amplifiée avec les années. On soupçonne l'apport accru en nutriments provenant des effluents municipaux, industriels ou agricoles. Les nitrates, notamment, accélèrent la production de phytoplancton à la surface du fleuve. Celui-ci sert de nourriture au zooplancton qui, à son tour, nourrit d'autres organismes. Ces derniers finissent par mourir et tomber doucement dans les profondeurs du fleuve. "*Des bactéries décomposent cette matière organique et, ce faisant, consomment l'oxygène dissous et dégagent du* CO_2", explique Alfonso Mucci.

Deuxième piste d'explication: le réchauffement des eaux. À cause de changements dans la circulation océanique, l'apport d'eau en provenance du nord-ouest de l'Atlantique s'est accru dans l'estuaire du Saint-Laurent, alors que l'eau issue de la mer du Labrador a diminué.

Le nouveau mélange fait en sorte que les eaux de fond ont gagné quelques degrés, ce qui accélère la décomposition de la matière organique par les bactéries. L'équipe hésite à pointer du doigt les changements climatiques pour expliquer la modification de la circulation océanique. "*Ce n'est pas confirmé*", dit Bjorn Sundby. "*Ça pourrait aussi être dû à une variation naturelle*".

Les scientifiques commencent à peine à anticiper les impacts de l'acidification sur la biodiversité du fleuve."*Ce sera l'un des objectifs des prochaines missions*", signale le professeur Mucci. Le chef alsacien du Coriolis II est mieux de préparer quelques recettes.

CLIMATE CHANGE / CHANGEMENT CLIMATIQUE

Climate change and our gardens

by Dianne Saxe and Jackie Campbell

As passionate gardeners, we keep wondering how the changing climate is affecting our gardens. (We last wrote about climate change in this space during the heat of summer in 2010.) We therefore noticed when the U.S. Department of Agriculture (USDA) updated its plant hardiness zone map on January 25, 2012. Throughout much of the U.S., the map is a half-zone (5^{o} Fahrenheit) warmer than its 1990 predecessor.

Gardeners rely on plant hardiness zone maps ("PHM"), which set out the different climate zones where specific trees, shrubs and flowers are likely to survive. The new U.S. map includes 13 zones (up from 11). At least in part, this change results from data being collected at many more weather stations than the predecessor map (1990), and over a longer, more current time period (i.e., 30 years, from 1976 to 2005 as opposed to the original 13 years). As in the past, the map was developed using the coldest annual temperature at various locations. As well, more sophisticated methods were used, including calculations that considered factors like elevation changes, proximity to large bodies of water and terrain position. Map users can locate more relevant data for their zones by entering their postal codes. The 1990 map included Canada and Mexico; the 2012 version, alas, does not.

The USDA notes that changes in climate are generally determined based on average temperatures over a 50 to 100 year period (not just the coldest days of the year). They caution that changes in zones do not accurately reflect whether global warming has occurred. Others disagree, arguing that the map reflects warming trend and the "new normal".

The U.S. Environmental Protection Agency (EPA) compared hardiness zone maps from 1990 and 2006 (the latter prepared by the Arbor Day Foundation). Over that 16 year period, the hardiness zones in the continental U.S. (excluding Alaska) shifted northward, because of warmer winter temperatures. Large areas of some states warmed by at least one hardiness zone, reflecting a significant increase in average low temperatures. A few small areas, mainly in the western U.S., have become cooler by one or two hardiness zones. As well, the last spring frost occurs earlier, and the first autumn frosts are later. Thus, the average growing season has increased by approximately 2 weeks since 1900; this increase has been particularly significant since 1980.

The U.S. EPA estimates that climate change will bring higher temperatures and a longer growing season in cool regions, which could permit farmers to diversify their crops and perhaps see multiple harvests each season. Some areas may become too hot for traditional crops to grow. Climate change will alter regional biodiversity. For example, invasive plants will move into new areas, harming native plants, and animals will move from their current locations to seek their preferred sources of food. Already, some bird species have shifted their wintering grounds up to 400 miles northward. As well, allergy seasons may arrive earlier and last longer.

(In contrast to the hardiness zone maps, which are based on coldest temperatures, the American Horticultural Society recognizes that plants are now often coded according to heat tolerance. The Society publishes a plant heat zone map that divides the U.S. into 12 zones and provides the average number of days every year that a region has temperatures over 86^{o} Fahrenheit (30^{o} Celsius). The map was published in 1997 and appears not to have been updated).

In Canada, plant hardiness maps are based on the average climate conditions in each region, as well as several on other variables like minimum and maximum temperatures, the duration of the frost-free period, amount of rain in the summer, snow cover, and wind speed. The original hardiness zone maps were developed in the 1960s. In 2000, Canada introduced its new plant hardiness zone map, which is based on "more recent" data (from 1961 to 1990), and on improved climate prediction models.

Natural Resources Canada wants the public to participate in making hardiness zone mapping more accurate, by submitting data about which plants survive at their locations. This includes identifying plants, their precise geographical location, and, where known, details such as how long the species has been at the location, sun/shade exposure, winter protection, soil type and how the plant performs at the location.

They want to develop and map a climate profile for every plant species; ultimately, these profiles should indicate the range where each species will grow.

It is frustrating to try and interpret broad climate trends in the context of our own piece of turf. It's harder to know when to plant what. Warmer hardiness zones and longer growing seasons can be good news for some plants, but the uncertain winters and lack of snow cover can devastate others. I guess we'll have to keep experimenting, and remember to be flexible!

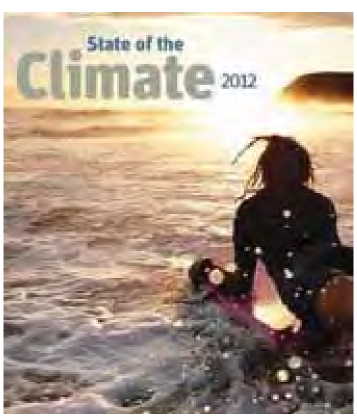
Note from Editor: This is an article from a series of monthly columns by Environmental Law Specialist Dianne Saxe, one of the top 25 environmental lawyers in the world, and Ms. Jackie Campbell. For more information, visit http://envirolaw.com.

State of the Climate 2012: Australia continues to warm

Media Release CSIRO/BOM — Wednesday, 14 March 2012

Australia's land and oceans have continued to warm in response to rising CO_2 emissions from the burning of fossil fuels.

This is the headline finding in the State of the Climate 2012, an updated summary of Australia's long term climate trends released by CSIRO (Commonwealth Scientific and Industrial Research Organisation) and the Bureau of Meteorology today.



CSIRO Chief Executive, Dr Megan Clark, said the latest analysis painted a clear decade-to-decade picture of Australia's climate, while at the same time noting its highly variable nature from one year to the next. "*Much of Australia may have lurched from drought to floods since the previous State of the Climate, but this has occurred against a backdrop of steadily increasing air and ocean temperatures and rising sea levels. What's more, the rate of change is increasing*".

"*The fundamental physical and chemical processes leading to climate change are well understood, and CSIRO and the Bureau of Meteorology observations demonstrate that change is occurring now*," said Dr Clark.

Bureau of Meteorology Acting Director, Dr Rob Vertessy, said this updated summary was based on improved understanding drawn from detailed analysis of our national climate record, which goes back more than a hundred years.

"*Ground, ocean and satellite based observations are giving us highly consistent observations of this warming trend. State of the Climate 2012 confirms that each decade has been warmer than the previous decade since the 1950s, with an increase in the number of warm nights, and more monthly maximum temperature records being broken*".

"*CSIRO and the Bureau of Meteorology will continue to provide observations, projections, research, and analysis so that Australia's responses to the challenges of a changing climate are underpinned by robust scientific evidence of the highest quality*", said Dr Vertessy. State of the Climate 2012 showed a general trend toward increased spring and summer monsoonal rainfall across Australia's north, and a decline in late autumn and winter rainfall across southern Australia.

Sea-levels had risen around Australia at rates equal to or greater than the global average, and sea-surface temperatures in the region had increased faster than the global average. State of the Climate 2012 documents the annual growth in global fossil-fuel CO_2 emissions and other greenhouse gases. The CO_2 concentration of the atmosphere had risen to around 390 parts per million in 2011, a level unprecedented in the past 800,000 years. During the past decade it has risen at more than 3% per year, which is projected to cause significant further global warming.

For more reading:
http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx

REPORT / RAPPORT

2007-2010 IAPSO report: Four years of Physical Oceanography in Canada

by Blair Greenan[1] and Jody Klymak[2]

Physical oceanography research in Canada has been extremely productive for the period of 2007-2010, with over 750 peer-reviewed journal articles by over 600 individual researchers from 111 institutions, departments, or companies from across the country. These accomplishments are recorded in the 2011 report to the International Association for the Physical Sciences of the Oceans (IAPSO) compiled by Blair Greenan and Jody Klymak with assistance from Tineke van der Baaren. This report is provided in three components (bibliography with full abstracts, alphabetical listing of the bibliography and a list of Canadian researchers and organizations). The documents are available on the CNC-SCOR web site at http://www.cmos.ca/scor/scorindexe.html. The bibliography is also available on the Mendeley website at http://www.mendeley.com/groups/1305293/canadian-iapso-2007-2010/.

The following criteria were used in the compilation of this report:

1) Canadian publications are those published by researchers in Canadian institutions such as universities or government labs. It does not include publications by Canadian researchers working at institutions outside Canada.

2) This survey only includes peer-reviewed journal articles (no technical reports, data reports, white papers, etc.).

3) The time frame of the survey is 1 Jan 2007 to 31 Dec 2010.

The report consists of a categorized bibliography summarizing abstracts from Canadian scientists conducting physical oceanography research. Topics span the breadth of the global oceans, with Canadian contributions, including observations of the oceans on all scales, laboratory studies, numerical studies, and theoretical work. The list of papers makes clear that Canadians are sought after for many international collaborations, as well as working on problems of national significance. In addition, the impact of student training on the papers is clear, with many of the 600 Canadian researchers mentioned above being students when the cited work was written.

The report is deliberately broad in its interpretation of "physical science of the oceans", and includes a number of climate papers, papers on atmospheric flows, and a significant number of papers on the chemistry of the oceans. We hope no one is offended if their work ended up on one side of the line or the other and it is certainly possible that we have omitted some publications in error. Hence, we would encourage the community to provide feedback to us.

The numbers above are an impressive body of research for a four year period, and it is worth noting where the support for these programs came from:

1) First, and most noteworthy, this was the period when the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) was being actively funded. This allowed support for graduate students, post-docs, and technicians that made many of these papers possible.

2) This period also encompassed the first batch of papers from the International Polar Year (2007-2008). Physical oceanographers participated in the C3O project, the Circumpolar Flaw Lead System Study, along with significant effort put into Arctic climate and ice changes during these years. This effort was reflected in a recent special issue of *Atmosphere-Ocean.*

3) NSERC Discovery Grants still remained an important source of funding of the University system, funding diverse programs across the discipline.

4) Research in the federal government lab system was supported through departmental core A-base funding as well at targeted funding through programs such as CSA-GRIP and PERD.

Arguably, the backbone of observational physical oceanography in Canada remains the government laboratories operated by Fisheries and Oceans Canada

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(DFO). These labs have a mission that attempts to balance efforts in environmental monitoring with directed research. The Bedford Institute of Oceanography (BIO), St. Andrews Biological Station, Maurice Lamontagne Institute and the Northwest Atlantic Fisheries Centre have well-established long-term monitoring programs both on and off the continental shelves of the Northwest Atlantic. The Institute of Ocean Sciences (IOS) maintains the Station Papa time series, monitoring of the Strait of Georgia, and the west coast of Vancouver Island. Work regularly takes place by Arctic groups from BIO, IOS, and the Freshwater Institute Science Laboratory on the Coast Guard icebreakers. These efforts are complemented through academia with platforms such as the CCGS Amundsen, which focuses on Arctic research.

The successes of previous years point towards challenges for the future. Firstly, CFCAS is no longer being funded by the federal government. This is a major loss for physical oceanographers, as our efforts do not always fit in well with multidisciplinary programs and networks, and CFCAS was a good way to keep small independent efforts funded. Secondly, federal spending is restrained and this has and will continue to have an impact on federal laboratories. Third, shiptime for government and academia will continue to be constrained by the availability of platforms.

Academia can possibly take up some of this slack, and perhaps universities are an appropriate place for basic research to be carried out. However, it is quite difficult to get adequate funding from NSERC for field-going programs without assembling something on the scale of a Network Centre of Excellence. We would argue more medium-scale funding needs to be made available, and the unique nature of seagoing research needs to be argued for vigorously if Canada is to remain internationally relevant in oceanography.

These challenges are mitigated by many advances that are being made in physical oceanography that Canadian scientists can take advantage of. Autonomous instruments are becoming cheaper and much more flexible. Canada already plays an important role in the Argo profiling float program. We are starting to gain expertise in gliders and other floats. Improvements in battery technology and data telemetry via Iridium satellites makes collecting comprehensive data sets with these instruments possible for a fraction of the cost of using a ship. Of course, in the meantime improved numerical models and laboratory experiments will continue to guide our understanding of physical oceanography.

In summary, the document we assembled is perhaps idiosyncratic in scope, but it highlights the comprehensive work being done by Canadian oceanographers. Assembling these reports is a significant effort, and we would be interested in ideas as to how to improve it in the future. In particular, as we argue for our science to our funding agencies, it would really help to indicate what investments pay off in terms of impact on the scientific community. Future efforts will be directed towards assembling those metrics, but based on this effort we suspect Canada is getting a phenomenal return for its investment in our research, and further renewal and investment are necessary to keep the discipline alive and healthy.

Note from the Editor: At the First IUGG General Assembly (Rome, 1922), the Section d'Océanographie became one of the constituent Sections of the Union. At the IV IUGG General Assembly (Stockholm, 1930) it became the International Association of Physical Oceanography. It took its present name at the XIV IUGG General Assembly (Zurich, 1967).

IAPSO promotes the study of the physical sciences of the oceans and the interactions taking place at the sea floor, coastal, and atmospheric boundaries by organising international forums and publishing written materials for ocean scientists throughout the world. Commissions, sub-committees, and workshops encourage new and advanced international research activities. In addition, IAPSO provides basic services such as the Permanent Service for Mean Sea Level and the IAPSO Standard Seawater Service. IAPSO collaborates closely with UNESCO's Intergovernmental Oceanographic Commission (IOC) and ICSU's Scientific Committee on Oceanic Research (SCOR). The president of IAPSO is a member of the SCOR Executive Committee as is the president of IAMAS. IAPSO has International Commissions on the following topics:

Mean Sea Level and Tides;
Sea Ice;
Co-Operation with Developing Countries;
Tsunami Commission (Joint with IASPEI and IAVCEI).

Johan RODHE, University of Gothenburg, Sweden, is the IAPSO Secretary General.

Rapport 2007-2010 de l'IAPSO : Quatre années d'océanographie physique au Canada

par Blair Greenan[1] et Jody Klymak[2]

Au cours des années 2007 à 2010, le domaine de l'océanographie physique s'est révélé extrêmement productif, comme le démontre la publication de 750 articles révisés par les pairs, rédigés par plus de 600 chercheurs différents provenant de 111 organisations, départements ou entreprises de partout au pays. Ces réalisations figurent dans le rapport de 2011 de l'Association internationale des sciences physiques de l'océan (IAPSO). Blair Greenan et Jody Klymak les ont compilées avec l'aide de Tineke van der Baaren. Trois éléments constituent ce rapport : une bibliographie comprenant les résumés complets, une liste alphabétique de la bibliographie et une liste des organisations et des chercheurs canadiens. Ces documents sont accessibles sur le site Web du Comité national canadien pour le Comité scientifique de la recherche océanique (CNC/CSRO) à l'adresse http://www.cmos.ca/scor/scorindexf.html. La bibliographie est aussi accessible sur le site de Mendeley à l'adresse http://www.mendeley.com/groups/1305293/canadian-iapso-2007-2010/.

Les critères suivants ont guidé à la compilation du rapport :

1) Les publications canadiennes sont celles publiées par les chercheurs d'organisations canadiennes, comme les universités et les laboratoires gouvernementaux. Elles n'incluent pas les articles rédigés par des chercheurs canadiens qui travaillent pour des organismes à l'extérieur du Canada.

2) Ce sondage ne porte que sur les articles évalués par les pairs (et exclut les rapports techniques, la communication de données, les livres blancs, etc.).

3) La période du sondage s'étend du 1er janvier 2007 au 31 décembre 2010.

Le rapport contient une bibliographie divisée en catégories, où figurent des résumés provenant de scientifiques canadiens menant des recherches en océanographie physique. Les sujets, qui font l'objet d'une contribution canadienne, couvrent tous les océans de la planète et comprennent l'observation des océans à toutes les échelles, les études en laboratoire, les études numériques et les travaux théoriques. La liste des articles démontre sans équivoque qu'on fait appel aux Canadiens pour de nombreuses collaborations internationales et pour traiter de problèmes d'importance nationale. De plus, l'incidence de la formation universitaire sur les articles est évidente. Plusieurs des 600 chercheurs mentionnés ci-dessous étaient des étudiants quand ils ont écrit les articles cités.

Le rapport emploie une définition intentionnellement large de "science physique des océans" et inclut des articles sur le climat et sur la circulation atmosphérique, ainsi qu'un nombre considérable d'articles sur la chimie des océans. Nous espérons n'offusquer personne, que leurs travaux soient inclus ou non. Il est bien sûr possible que nous ayons omis par erreur quelques publications. En ce sens, nous encourageons les parties intéressées à nous transmettre leurs commentaires.

Les données présentées ci-dessus représentent un corpus de recherche remarquable pour une période de seulement quatre ans. Il convient donc de souligner la provenance du financement de ces programmes :

1) Premièrement, et des plus notables, il s'agit de la période au cours de laquelle la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA) a obtenu un financement stable. Ce qui a permis de financer des étudiants postdoctoraux, et de 2^{e} et 3^{e} cycles, ainsi que des techniciens, qui ont rendu possibles plusieurs de ces articles.

2) Cette période englobe aussi la première série d'articles relatifs à l'Année polaire internationale (2007-2008). Au cours de ces années, les spécialistes en océanographie physique ont participé au projet C3O (mission de recherche sur les trois océans du Canada), à l'Étude sur le chenal de séparation circumpolaire, ainsi qu'aux activités liées aux modifications du climat et de la glace. Ces activités ont fait l'objet d'une édition spéciale d'*Atmosphere-Ocean*.

3) Le Programme de subventions à la découverte du CRSNG est demeuré une source importante de financement pour les universités et a appuyé différents programmes dans divers domaines.

4) Le financement de la recherche dans les laboratoires du gouvernement fédéral est assuré par les services votés et les affectations ciblées issues de programmes comme le Programme d'initiatives gouvernementales en observation de la Terre (IGOT) de l'Agence spatiale canadienne (ASC),

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et le Programme de recherche et de développement énergétiques (PRDE).

De toute évidence, les laboratoires gouvernementaux exploités par Pêches et Océans Canada demeurent le pivot de l'observation en océanographie physique au Canada. Ces laboratoires s'efforcent de par leur mandat à trouver un équilibre entre la surveillance environnementale et la recherche dirigée. L'Institut océanographique de Bedford (IOB), la station biologique de St. Andrews, l'Institut Maurice-Lamontagne et le Centre des pêches de l'Atlantique nord-ouest gèrent des programmes bien établis de surveillance à longue échéance, sur les plateaux continentaux de l'Atlantique Nord-Ouest et au-delà. L'Institut des sciences de la mer (ISM) est responsable de la série temporelle de la station Papa, ainsi que de la surveillance du détroit de Géorgie et de la côte ouest de l'île de Vancouver. Les groupes d'étude de l'Arctique provenant de l'IOB, de l'ISM et du laboratoire scientifique de l'Institut des eaux douces entreprennent régulièrement des travaux à partir des brise-glaces de la Garde côtière canadienne. Le milieu universitaire complète ces activités à l'aide de plate-formes comme le NGCC *Amundsen*, qui participe à la recherche sur l'Arctique.

Les réussites des années passées pointent vers les défis des années à venir. Premièrement, le gouvernement fédéral ne finance plus la FCSCA. Ce qui représente une perte majeure pour les spécialistes en océanographie physique, puisque nos activités ne s'insèrent pas toujours très bien dans les programmes et les réseaux pluridisciplinaires. La FCSCA s'avérait une bonne façon de financer les petits projets indépendants. Deuxièmement, le gouvernement fédéral limite ses dépenses. Ce qui a déjà, et aura dans l'avenir, une incidence sur les laboratoires fédéraux. Troisièmement, la disponibilité des plateformes continue de restreindre le temps-navire mis à la disposition des chercheurs gouvernementaux et universitaires.

Le milieu universitaire pourrait combler partiellement le vide et peut-être que les universités représentent l'endroit adéquat pour mener la recherche de base. Toutefois, il est très difficile de recevoir un financement adéquat du CRSNG pour les programmes sur le terrain, à moins de mettre sur pied des projets de l'ordre de ceux des Réseaux de centres d'excellence. Nous sommes d'avis que du financement à moyenne échelle devrait être offert. La nature unique de la recherche en mer doit être défendue vigoureusement si le Canada souhaite maintenir sa pertinence internationale en océanographie.

Les progrès continus qu’on accomplit en océanographie physique, et dont les scientifiques canadiens peuvent tirer profit, atténuent ces problèmes. Les instruments autonomes sont maintenant polyvalents et leurs coûts baissent de plus en plus. Le Canada joue déjà un rôle important dans le programme de flotteurs profilants Argo. Notre expertise en matière de planeurs océaniques et d'autres flotteurs augmente de plus en plus. L'amélioration de la technologie relative aux accumulateurs et la télémesure à l'aide des satellites d'Iridium permettent une collecte de données exhaustive, à une fraction des coûts d'utilisation d’un navire. Bien entendu, les modèles numériques améliorés et les expériences en laboratoires continueront de guider notre compréhension de l'océanographie physique.

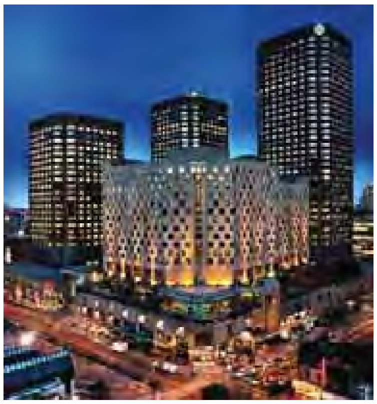
En résumé, le document que nous avons assemblé peut sembler de portée particulière, mais il met en lumière les travaux exhaustifs qu'effectuent les océanographes canadiens. L'assemblage de ces rapports a demandé un effort considérable et nous souhaitons recevoir vos commentaires sur la manière de l'améliorer dans le futur. Notamment, en ce qui a trait à la justification des fonds destinés à notre science et offerts par les organismes de financement. Il serait utile de savoir quels investissements s’avèrent les plus profitables, en ce qui concerne leurs impacts sur la communauté scientifique. Les tâches à venir porteront sur le regroupement de ces données, mais nous soupçonnons que le Canada retire un profit phénoménal de ses investissements dans notre recherche. La reconduction de subventions et l'affectation de nouveaux fonds apparaissent nécessaires à la survie et à la santé de notre discipline.

<u>Note du rédacteur:</u> À la première Assemblée Générale de l’UGGI (Rome, 1922), la Section d’Océnographie devint une des parties constituantes de l’Union. À la IV Assemblée Générale de l’UGGI (Stockholm, 1930), elle devint l’ “International Association of Physical Oceanography”. L’association prit son nom actuel (Association internationale des sciences physiques de l’océan) à la XIV Assemblée Générale de l’UGGI (Zurich, 1967).

L’AISPO assure la promotion de l’étude des sciences physiques des océans et des interactions ayant lieur dans les fonds sous-marins, sur les côtes et dans l’atmosphère en organisant des forums internationaux, en publiant des matériaux écrits pour les scientifiques du monde entier spécialisés dans les océans. Les Commissions, les sous-commissions et les ateliers encouragent de nouvelles activités de recherche internationale de pointe. En outre, l’AISPO offre des services de base tels que le Service Permanent pour le Niveau Moyen de la Mer (Permanent Service for Mean Sea Level) et le Service d’Eau de Mer Standard (Standard Seawater Service). L’AISPO collabore étroitement avec la Commission Océanographique Intergouvernementale de l’UNESCO (COI) et le Comité Scientifique des Recherches Océanographiques du CIUS (SCOR). L’AISPO possède des Commissions Internationales chargées des sujets suivants:

Niveau moyen de la mer et marées;
Glace marine;
Coopération avec les pays en voie de développement;
Commission Tsunami (conjointement avec l’AISPIT et l’AIVCIT).

Congrès conjoint de la SCMO 2012 avec les conférences de l'AMS sur la Prévision numérique du temps et sur la Prévision et l'analyse météorologique



Complexe hôtelier la nuit

Le 46e congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO) se tiendra du 29 mai au 1er juin 2012 à l'hôtel Hyatt-Regency de Montréal (Québec) au Complexe Desjardins. Ce congrès est organisé conjointement avec la 21e Conférence de l'"American Meteorological Society" (AMS) sur la Prévision Numérique du Temps (21st Conference on Numerical Weather Prediction) et la 25e Conférence de l'AMS sur la Prévision et l'analyse météorologique (25th Conference on Weather Analysis and Forecasting). Ces deux conférences se tiennent une fois sur deux à l'extérieur de la réunion annuelle de l'AMS et en 2012, elles se tiendront à Montréal et seront organisées en collaboration avec la SCMO. Un Comité conjoint du programme scientifique a déjà été formé pour organiser les sessions portant sur la prévision numérique du temps et la météorologie opérationnelle, des thèmes communs aux deux partenaires. Un effort particulier sera fait pour encourager une participation internationale sur ces thèmes.

Dates importantes à retenir en 2012:

Date limite pour l'inscription anticipée: 13 avril 2012;
Date limite pour les réservations d'hôtel: 27 avril 2012;
Date limite pour les inscriptions à la journée des enseignants: 15 mai 2012
Début du congrès: 29 mai 2012.

Conférenciers invités:

David Grimes, Président de l'OMM;
Professeur Christian Kummerow, Colorado State University;
Dr. Jeffrey K. Lazo, Centre national pour la recherche atmosphérique, États-Unis;
Dr. Dave Burridge, anciennement Directeur, Centre européen pour les prévisions météorologiques à moyen terme;
Dr. Marcel Babin, Titulaire de la Chaire d'excellence du Canada sur la télédétection de la nouvelle frontière arctique du Canada à l'Université Laval;
Professeur Gary Lackmann, Professeur de sciences atmosphériques à la North Carolina State University;
Dick Dee, dirige les activités de réanalyse au Centre européen pour les prévisions météorologiques à moyen terme;
Dr. Matthew Martin, travaille à l'assimilation des données océanographiques au United Kingdom Meteorological Office;

Pour plus de renseignements, communiquez avec le Comité conjoint du programme scientifique (Courriel: spc@cmos.ca) ou le Comité organisateur (Courriel: lac@cmos.ca).

Joint 2012 CMOS congress with the AMS Numerical Weather Prediction and Weather Analysis and Forecasting conferences

The 46th congress of the Canadian Meteorological and Oceanographic Society (CMOS) will take place from May 29 to June 1st 2012 at the Montréal Hyatt-Regency hotel in Complexe Desjardins in Montréal (Québec). This congress is organized jointly with the 21st American Meteorological Society (AMS) Conference on Numerical Weather Prediction (NWP) and the 25th AMS Conference on Weather Analysis and Forecasting (WAF). These two conferences are organized one out of two outside the annual AMS meeting and in 2012, they will be held in Montréal and organized in collaboration with CMOS. A joint scientific committee has already been formed to organize the sessions on NWP and WAF, themes that are common to the two groups. A special effort will be made to seek an international participation on those topics.

Typical scenery of Montreal

Important Dates to Remember in 2012:

Early Bird Congress registration: April 13, 2012;
Early Hotel booking deadline: April 27, 2012;
Teacher's Day registration deadline: May 15, 2012;
Congress starts: May 29, 2012.

Plenary Speakers

David Grimes, President of WMO;
Professor Christian Kummerow, Colorado State University;
Dr. Jeffrey K. Lazo, National Center for Atmospheric Research, US;
Dr. Dave Burridge, former Director of the European Centre for Medium-Range Weather Forecasts;
Dr. Marcel Babin, Chairholder CERC in Remote Sensing of Canada's New Arctic Frontier at Université Laval;
Professor Gary Lackmann, Professor of Atmospheric Sciences, North Carolina State University;
Dick Dee, in charge of reanalysis activities at the European Centre for Medium-Range Weather Forecasts;
Dr. Matthew Martin, worked on data assimilation at the UK Met Office.

For more information, please contact the Joint Scientific Program Committee (Email: spc@cmos.ca) or the Local Arrangements Committee (Email: lac@cmos.ca).

Atmosphere-Ocean 50-2 Special Issue

PREFACE

Ocean and Climate Dynamics

a Tribute to Professor Lawrence A. Mysak

Drawing on a broad background in mathematics, physics, the engineering sciences and geophysical fluid dynamics, Professor Lawrence Mysak has made numerous fundamental contributions to applied mathematics, oceanography and climate dynamics. The many research awards and academic honours that he has received attest to the remarkable productivity of an academic career spanning more than four decades. Those of us who have had the good fortune to have him as a research supervisor were all greatly influenced by his infectious enthusiasm, sharp intellect, inexhaustible energy and his remarkable ability to develop a huge network of scientific friends.

Born in Saskatoon, Lawrence's academic career began at the University of Alberta, Edmonton; he graduated from there in 1961 with a B.Sc. (hons.) in Applied Mathematics. Subsequently, under the supervision of George Szekeres at the University of Adelaide, his research on Schwarzschild singularities (i.e. black holes) led to an M.Sc. in Mathematics (1963) and his first journal publication. At Harvard University, under the supervision of Allan Robinson, he wrote his Ph.D. thesis (1966) on continental shelf waves, providing one of the earliest theoretical treatments of a new phenomenon first detected in 1962.

During 1967-86, Lawrence taught at the University of British Columbia, eventually becoming Professor in the departments of Mathematics and Oceanography. His research during this period was focussed mainly on the generation and propagation of ocean waves, and the stability and meandering of oceanic boundary currents. With Paul LeBlond, he co-wrote an advanced-level textbook *Waves in the Ocean*, published in 1978, which quickly became a classic. Intrigued by the influence of El Niño on west coast fisheries, Lawrence began shifting his research interest towards climate problems. Since moving to McGill University in 1986, he has focussed on the study of high-latitude and Arctic natural climate variability on interannual, decade-to-century and millennial timescales. In addition, he has worked on the thermohaline circulation and its role in climate, vegetation-climate interactions, glacial inceptions and paleoclimates.

During the summer of 2010, Lawrence became professor emeritus at McGill. The 44th Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS), held in Ottawa, presented a not-to-be-missed opportunity to bring his former students, post-doctoral fellows and academic friends together. Hence, a special session in Lawrence's honour was organized at the CMOS Congress during 1–2 June 2010 by two former students (Bruno Tremblay and me). This special issue contains eight papers, four of them following from oral presentations made at the special session and four from colleagues who were unable to attend. The review process for the manuscripts was kindly handled by two guest editors, Patrick Cummins (also a former student) and Steven Lambert.

William W. Hsieh
Atmosphere-Ocean Co-editor
Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC

AVANT-PROPOS

Dynamique des océans et du climat

hommage au professeur Lawrence A. Mysak

S'appuyant sur son imposant bagage en mathématiques, en physique, en sciences de l'ingénierie et en dynamique des fluides géophysiques, le professeur Lawrence Mysak a fourni sa contribution fondamentale à maintes reprises aux mathématiques appliquées, à l'océanographie et à la dynamique du climat. Ce chercheur prolifique a reçu de nombreuses bourses de recherche et distinctions universitaires au cours de sa carrière académique, qui s'est étendue sur une quarantaine d'années. Ceux d'entre nous qui ont eu le privilège de l'avoir comme directeur de recherche ont tous été influencés par son enthousiasme contagieux, sa vive intelligence, son énergie inépuisable et son sens de l'organisation qui lui a servi à mettre en place un vaste réseau d'amis scientifiques.

Né à Saskatoon, Lawrence a amorcé son parcours universitaire à l'Université de l'Alberta à Edmonton. C'est là qu'il a obtenu en 1961 son baccalauréat ès sciences (avec distinction) en mathématiques appliquées. Il a poursuivi ses études sous la direction de George Szekeres à l'Université d'Adélaïde: sa recherche sur les singularités de Schwarzschild (les trous noirs) lui a permis de décrocher sa maîtrise ès sciences en mathématiques (1963) et de publier son premier article dans une revue spécialisée. Il a fait son doctorat à l'Université Harvard, sous la direction d'Allan Robinson (1966): il a rédigé sa thèse sur les vagues du plateau continental, ce qui était en fait l'un des premiers exposés théoriques sur un phénomène nouveau, découvert en 1962.

De 1967 à 1986, il a enseigné à l'Université de la Colombie-Britannique, où il est devenu professeur aux départements de mathématiques et d'océanographie. Au cours de cette période, ses champs de recherche étaient la production et la propagation des vagues océaniques ainsi que la stabilité et les méandres des courants côtiers océaniques. En collaboration avec Paul LeBlond, il a rédigé un manuel avancé intitulé *Waves in the Ocean*, paru en 1978, qui n'a pas tardé à devenir un classique. Intrigué par l'influence d'El Niño sur les pêches de la côte ouest, il a commencé à se pencher sur les problèmes climatiques. Depuis son arrivée à l'Université McGill en 1986, il s'intéresse à la variabilité climatique naturelle en haute altitude et dans l'Arctique, sur des échelles interannuelle, décennale, séculaire et millénaire. De plus, il étudie la circulation thermohaline et son rôle dans le climat, les interactions entre la végétation et le climat, le début des glaciations et les paléoclimats.

À l'été 2010, il est devenu professeur émérite à l'Université McGill. Le 44e Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO), qui s'est tenu à Ottawa, était l'occasion idéale pour réunir ses anciens étudiants, les titulaires de bourse de perfectionnement postdoctoral et ses amis et collègues à l'université. Une séance spéciale a donc été organisée en son honneur au congrès de la SCMO, les 1er et 2 juin 2010, par deux anciens étudiants (Bruno Tremblay et moi-même). Ce numéro spécial offre huit articles, dont quatre rédigés à partir d'exposés oraux présentés à la séance spéciale et quatre de collègues qui ont été dans l'impossibilité d'y assister. Deux rédacteurs invités, Patrick Cummins (ancien étudiant également) et Steven Lambert, ont gentiment accepté de réviser les manuscrits.

William W. Hsieh
Corédacteur d'*Atmosphere-Ocean*
Département des sciences de la Terre et d'océanographie, Université de la Colombie-Britannique, Vancouver, C.-B.

Atmosphere-Ocean 50-2 Paper Order

Non-linear post-processing of numerical seasonal climate forecasts by Joel Finnis, William W. Hsieh, Hai Lin and William J. Merryfield.

Stained glass and climate change: How are they connected? by C. T. Simmons and L. A. Mysak.

Long-term Variability of volume and heat transport in the Nordic Seas: a model study by Lundrigan and Demirov.

CMOS SCMO Taylor & Francis Taylor & Francis Group Atmosphere-Ocean

A-O Abstracts Preview

Avant Première des résumés de A-O

The following abstracts will soon be published in your next *Atmosphere-Ocean* publication **(50-2)**.

Les résumés qui suivent paraîtront sous peu dans votre prochaine revue *Atmosphere-Ocean* **(50-2).**

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

Abstract
The geostrophic adjustment of homogeneous fluid in a circular basin with idealized topography is addressed using a numerical ocean circulation model and analytical process models. When the basin is uniformly rotating, the adjustment takes place via excitation of boundary propagating waves and when topography is present, via topographic Rossby waves. In the numerically derived solution, the waves are damped because of bottom friction, and a quasi-steady geostrophically balanced state emerges that subsequently spins-down on a long time scale. On the f-plane, numerical quasi-steady state solutions are attained well before the system's mechanical energy is entirely dissipated by friction. It is demonstrated that the adjusted states emerging in a circular basin with a step escarpment or a top hat ridge, centred on a line of symmetry, are equivalent to that in a uniform depth semicircular basin, for a given initial condition. These quasi-steady solutions agree well with linear analytical solutions for the latter case in the inviscid limit.

On the polar plane, the high latitude equivalent to the β-plane, no quasi-steady adjusted state emerges from the adjustment process. In the intermediate time scales, after the fast Poincaré/Kelvin waves are damped by friction, the solutions take the form of steady-state adjusted solutions on the f-plane. At longer time scales, planetary waves control the flow evolution. An interesting property of planetary waves on a polar plane is a nearly zero eastward group velocity for the waves with a radial mode higher than two and the resulting formation of eddy-like small-scale barotropic structures that remain trapped near the western side of topographic features.

Résumé [Traduit par la rédaction]
Nous étudions l'ajustement géostrophique d'un fluide homogène dans un bassin circulaire ayant une topographie idéalisée à l'aide d'un modèle numérique de circulation océanique et de modèles analytiques de processus. Quand le bassin est en rotation uniforme, l'ajustement se fait par l'excitation d'ondes de propagation aux limites, et en présence de topographie, par des ondes de Rossby topographiques. Dans la solution numériquement dérivée, les ondes sont amorties à cause frottement contre le fond, et un état quasi-stable géostrophiquement équilibré s'établit pour ensuite décélérer sur une longue période de temps. Sur le plan *f*, les solutions numériques d'états quasi-stables sont atteintes bien avant que l'énergie du système mécanique soit entièrement dissipée par le frottement. Nous démontrons que les états ajustés apparaissant dans un bassin circulaire avec un accore en forme de marche ou une crête en forme de merlon, centrés sur une ligne de symétrie, sont équivalents à ceux d'un bassin semi-circulaire de profondeur uniforme pour une condition initiale donnée. Les solutions quasi-stables s'accordent bien avec les solutions analytiques linéaires pour le dernier cas dans la limite de la non-viscosité.

Sur le plan polaire, la haute latitude équivalente au plan β, le processus d'ajustement n'aboutit à aucun état ajusté quasi-stable. Aux échelles de temps intermédiaires, après l'amortissement des ondes rapides de Poincaré et Kelvin par le frottement, les solutions prennent la forme de solutions ajustées d'états stables sur le plan *f*. Aux échelles de temps plus longues, les ondes planétaires déterminent l'évolution de l'écoulement. Une propriété intéressante des ondes planétaires sur un plan polaire est une vitesse de groupe presque nulle vers l'est pour les ondes ayant un mode radial plus grand que deux et la formation résultante de structures barotropiques de petite échelle de type remous qui demeurent emprisonnées près du bord ouest des caractéristiques topographiques.

Thermohaline Staircases in a British Columbia Fjord
by David J. Spear and Richard E. Thomson

Abstract
We present the first documented evidence of thermohaline staircases generated by double-diffusion in a coastal environment. Results are based on high (centimetre scale) resolution profiles of temperature, salinity and dissolved oxygen concentration collected on 20 July 2009 at seven stations along the axis of Belize Inlet on the mainland coast of British Columbia, Canada (Fig. 1). Except for stations nearest the narrow Pacific Ocean entrance to the inlet, the observed temperature and salinity gradients between 70 and 210 m depth were of the same sign, therefore conducive to double-diffusive phenomena. Thermohaline features were especially well developed near the head of the inlet. Salt-fingering staircases of approximately 10 m thickness were observed above the temperature and salinity minima at 150 m depth and diffusive-convection staircases of approximately 1 m thickness were observed below this depth. We speculate that conditions favourable to double diffusion were initiated by a mid-depth intrusion of relatively cold, low salinity, oxygen-rich water that likely originated with intense tidal mixing in the narrow oceanic passage leading to the inlet. Findings confirm the existence of

double diffusion in coastal oceanic regions and indicate that Belize Inlet may be a natural laboratory for the study of thermohaline processes in the ocean.

Résumé [Traduit par la rédaction]
Nous présentons la première observation documentée d'une structure thermohaline en escalier produite par double diffusion dans un environnement côtier. Les résultats sont basés sur des profils à haute résolution (échelle centimétrique) de la température, de la salinité et de la concentration en oxygène dissout établis le 20 juillet 2009 à sept stations le long de l'axe de l'anse Belize sur la côte continentale de la Colombie-Britannique, au Canada (fig. 1). À l'exception des stations les plus proches de l'étroite entrée de l'océan Pacifique vers l'anse, les gradients de température et de salinité entre 70 et 210 m de profondeur étaient du même signe et donc favorables au phénomène de double diffusion. Les caractéristiques thermohalines étaient particulièrement nettes près de la tête de l'anse. Des doigts de sel en forme de marches d'approximativement 10 m d'épaisseur ont été observés au-dessus des minimums de température et de salinité à 150 m de profondeur et des marches de convection diffusive d'environ 1 m d'épaisseur ont été observées au-dessous de cette profondeur. Nous formulons l'hypothèse que les conditions favorables à la double diffusion sont apparues par suite d'une intrusion à mi-profondeur d'eau relativement froide, de faible salinité et riche en oxygène provenant vraisemblablement d'un intense brassage maréal dans l'étroit passage océanique menant à l'anse. Les résultats confirment l'existence d'une double diffusion dans les régions océaniques côtières et indiquent que l'anse Belize peut être un laboratoire naturel pour l'étude des processus thermohalins dans l'océan.

Sereno Bishop, Rollo Russell, Bishop's Ring and the Discovery of the "Krakatoa Easterlies"

by Kevin Hamilton

Abstract
The 1883 eruption of Krakatoa was a seminal event in the study of several atmospheric phenomena. This paper reviews the work that led to the first determination of the wind in the tropical stratosphere and provides some biographical background on two quite remarkable amateur scientists whose observations and analyses in the aftermath of the eruption contributed greatly to our knowledge of the stratospheric circulation. This paper will trace the path from their work in the 1880s to the mid-twentieth century when it provided the background to the surprising discovery of the stratospheric Quasibiennial Oscillation.

Résumé
L'éruption du Krakatoa, en 1883, a été un événement fécond pour l'étude de plusieurs phénomènes atmosphériques. Le présent article examine le travail ayant mené à la première détermination du vent dans la stratosphère tropicale et fournit des renseignements biographiques sur deux scientifiques amateurs fort remarquables dont les observations et les analyses suite à l'éruption ont grandement contribué à notre connaissance de la circulation stratosphérique. Cet article retrace le chemin séparant leur travail dans les années 1880 et le milieu du vingtième siècle, moment où il a servi de toile de fond à la surprenante découverte de l'oscillation stratosphérique quasi-biennale.

Downscaling of Precipitation over Vancouver Island using a Synoptic Typing Approach

by Stephen Sobie and Andrew J. Weaver

Abstract
A statistical downscaling technique is employed to link atmospheric circulation produced by an ensemble of global climate model (GCM) simulations over the twenty-first century to precipitation recorded at weather stations on Vancouver Island. Relationships between the different spatial scales are established with synoptic typing, coupled with non-homogeneous Markov models to simulate precipitation intensity and occurrence. Types are generated from daily precipitation observations spanning 1971 to 2000. Atmospheric predictors used to influence the Markov models are derived from two versions of GCM output: averages of GCM grid cells selected by correlation maps of circulation and precipitation data and an approach involving common Empirical Orthogonal Functions (EOFs) calculated from GCM output over the northeast Pacific Ocean. Projections for 2081 to 2100 made using averaged grid cells find that winter (November–February) precipitation anomalies produce modestly positive values, with gains of 7.5% in average precipitation, typical increases of 9.0% rising to 20% in the case of high-intensity precipitation, and little spatial dependence. In contrast, average and high-intensity summer precipitation (June–September) decline negligibly at most island weather stations with the exception of those in the southwestern sections, which experience reductions of 15% relative to 1971 to 2000. Projections made using common EOFs display a strong spatial dependence. Future winter precipitation is expected to increase only on the west coast of the island by 11% on average, while the southeastern coast will experience decreases of 5% to 10%. The same pattern repeats in summer, though with negligible increases on the west coast and declines of 12% to 16% on the southeastern coast. The reliability of this novel EOF method remains to be confirmed definitively, however. In both seasons precipitation occurrence decreases slightly at all stations with declines in the total days with measurable precipitation ranging from 2% to 8%.

Résumé
Nous employons une technique statistique de réduction d'échelle pour lier la circulation atmosphérique produite par un ensemble de simulations du GCM (Global Climate Model) durant le XXI^{e} siècle aux précipitations enregistrées à des stations météorologiques sur l'île de Vancouver. Les relations entre les différentes échelles spatiales sont établies au moyen d'un typage synoptique couplé avec des modèles markoviens non homogènes pour simuler l'intensité et la fréquence des précipitations. Les types sont générés à partir des observations quotidiennes de précipitations au cours de la période 1971–2000. Les prédicteurs atmosphériques utilisés pour influencer les modèles markoviens sont dérivés de deux versions de sorties du GCM : les moyennes de mailles du GCM sélectionnées par tables de corrélation des données de circulation et de précipitations et une approche fondée sur les fonctions orthogonales empiriques (EOF) communes calculées d'après la sortie du GCM pour le nord-est du Pacifique. Les projections pour la période 2081–2100 basées sur des moyennes de mailles montrent que les anomalies de précipitations hivernales (novembre–février) produisent de faibles valeurs positives, avec des gains de 7,5 % dans les précipitations moyennes, des accroissements caractéristiques de 9,0 % augmentant à 20 % dans le cas des précipitations de forte intensité, et peu de dépendance spatiale. En revanche, les précipitations estivales (juin–septembre) moyennes et de forte

intensité diminuent de façon négligeable à la plupart des stations météorologiques de l'île, à l'exception de celles situées dans secteur sud-ouest qui subissent une réduction de 15 % par rapport à 1971–2000. Les projections faites à l'aide des fonctions orthogonales empiriques communes exhibent une forte dépendance spatiale. Les précipitations hivernales futures devraient augmenter seulement sur la côte ouest de l'île de 11 % en moyenne alors que la côte sud-est connaîtra des diminutions de 5 à 10 %. La même configuration se répète en été, bien qu'avec des accroissements négligeables sur la côte ouest et des diminutions de 12 à 16 % sur la côte sud-est. La fiabilité de cette nouvelle méthode EOF reste toutefois à établir. Dans les deux saisons, la fréquence des précipitations diminue légèrement à toutes les stations, les diminutions du nombre total de jours avec précipitations mesurables variant entre 2 et 8 %.

Drivers of Future Northern Latitude Runoff Change
by Kelly A. Nugent and H. Damon Matthews

Abstract
Identifying the drivers of changing continental runoff is key to understanding current and predicting future hydrological responses to climate change. Potential drivers of runoff change include changes in precipitation and evaporation caused by climate warming, physiological responses of vegetation to elevated atmospheric CO_2 concentrations, increases in lower-atmosphere aerosols and anthropogenic land cover change. In this study, we present a series of simulations using an intermediate-complexity climate and carbon cycle model to assess the contribution of each of these drivers to historical and future continental runoff changes. We present results for global runoff, in addition to northern latitude runoff that discharges into the Arctic and North Atlantic oceans, to identify any potential contribution of increased continental freshwater discharge to changes in North Atlantic deep-water formation. Between 1800 and 2100, the model simulated a 26% increase in global runoff and a 32% runoff increase in the northern latitude region. This increase was driven by a combination of increased precipitation from climate warming and decreased evapotranspiration caused by the physiological response of vegetation to elevated CO_2. When isolated, climate warming (and associated changes in precipitation) increased runoff by 16% globally and by 27% at northern latitudes. Vegetation responses to elevated CO_2 led to a 13% increase in global runoff and a 12% increase in the northern latitude region. These changes in runoff, however, did not affect the strength of the Atlantic Meridional Overturning Circulation, which was affected by surface ocean warming rather than by runoff-induced salinity changes. This study indicates that physiological responses of vegetation to elevated CO_2 may contribute to changes in continental runoff at a level similar to that of the direct effect of climate warming.

Résumé [Traduit par la rédaction]
Il est primordial de déterminer les causes premières des changements dans le ruissellement continental afin de comprendre les réactions hydrologiques par rapport aux changements climatiques à l'heure actuelle et de les prédire. Voici des facteurs éventuellement responsables : les changements dans les précipitations et l'évaporation causés par le réchauffement climatique, la réaction physiologique des plantes à l'augmentation des concentrations de CO_2 dans l'atmosphère, l'augmentation de la concentration d'aérosols dans la basse atmosphère et les changements dans la couverture terrestre, qui découlent des activités humaines. Dans notre étude, nous présentons une série de simulations fondées sur un modèle du climat et du cycle du carbone de complexité intermédiaire afin d'évaluer le rôle de chacun de ces facteurs dans les changements du ruissellement continental dans le passé et à l'avenir. Nous présentons des résultats pour le ruissellement dans le monde, en plus du ruissellement sous les latitudes nordiques qui se déversent dans les océans Arctique et Atlantique Nord, afin d'établir la contribution éventuelle de l'augmentation de la décharge d'eau douce en provenance du continent dans les changements dans la formation d'eaux profondes dans l'océan Atlantique Nord. Entre 1800 et 2100, le modèle a simulé une augmentation de 26 % du ruissellement mondial et de 32 % du ruissellement sous les latitudes nordiques. Cette progression s'expliquait par la hausse des précipitations conjuguée au réchauffement climatique et à la diminution de l'évapotranspiration attribuable à la réaction physiologique des plantes à l'augmentation des concentrations de CO_2. Quand nous avons isolé ces facteurs, nous avons constaté que le réchauffement climatique (et les changements survenus dans les précipitations, induits par ce réchauffement) a augmenté de 16 % le ruissellement à l'échelle mondiale et de 27 % le ruissellement sous les latitudes nordiques. La réaction physiologique des plantes à l'augmentation des concentrations de CO_2 a entraîné une progression de l'ordre de 13 % du ruissellement mondial et de 12 % du ruissellement sous les latitudes nordiques. Cependant, ces changements ne se sont pas répercutés sur la circulation de renversement méridienne de l'Atlantique, qui était affectée par le réchauffement de la surface des océans plutôt que par des changements dans la salinité induits par le ruissellement. Notre étude démontre que la réaction physiologique des plantes à l'augmentation des concentrations de CO_2 peut entraîner des changements dans le ruissellement continental comparables à l'effet direct du réchauffement climatique.

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

Abstract
Although numerical models are increasingly being used to generate operational seasonal forecasts, the reliability of these products remains relatively low. Regression-based post-processing methods have proven useful in increasing forecast skill, but efforts have focussed on linear regression. Given the non-linear nature of the climate system and sources of model error, non-linear analogues of these post-processing methods may offer considerable improvements. The current study tests this hypothesis, applying both linear and non-linear regression to the correction of climate hindcasts produced with general circulation models. Results indicate that non-linear support vector regression is better able to extract indices of the Pacific/North American teleconnection pattern and the North Atlantic Oscillation from coupled model output, while linear approaches are better suited to atmosphere-only model output. Statistically significant predictions are produced at lead times of up to nine months and can be obtained from model output with no forecast skill prior to processing.

Résumé
Même si les modèles numériques sont de plus en plus utilisés pour produire des prévisions saisonnières opérationnelles, la fiabilité de ces produits reste plutôt faible. Des méthodes de post-traitement utilisant la régression se sont avérées utiles pour

améliorer l'habileté des prévisions, mais les efforts ont surtout porté sur la régression linéaire. Étant donné la nature non linéaire du système climatique et des sources d'erreur des modèles, des analogues non linéaires de ces méthodes de post-traitement pourraient permettre des améliorations importantes. La présente étude cherche à vérifier cette hypothèse en appliquant une régression linéaire et une régression non linéaire à la correction de prévisions climatiques a posteriori produites à l'aide de modèles de circulation générale. Les résultats indiquent que la régression non linéaire des vecteurs de support arrive à mieux extraire les indices de configuration de la téléconnexion Pacifique/Amérique du Nord et de l'oscillation nord-atlantique de la sortie de modèles couplés alors que les approches linéaires font mieux avec la sortie de modèles atmosphériques seulement. Des prévisions statistiquement significatives sont produites pour jusqu'à neuf mois dans le futur et peuvent être obtenues de la sortie d'un modèle sans habileté de prévision avant le traitement.

Stained Glass and Climate Change: How are they Connected?
by C. T. Simmons and L. A. Mysak

Abstract
As expressions of regional architecture, sacred (Christian) Gothic structures often possess several adaptations to their prevailing climate regime. The late medieval (Gothic) period in northern Europe is also, according to the evidence presented here, marked by a transition from warm and sunny to cooler and cloudier conditions. It is within the context of this climate change that we consider one of the most important features in Gothic churches — interior daylighting — during the transitional period (the thirteenth to the end of the fifteenth centuries) between the Medieval Warm Period (MWP) and the Little Ice Age (LIA). This paper seeks to determine whether increasingly cloudy conditions over northern continental Europe, in part due to a shift in North Atlantic Oscillation (NAO) phase, may have influenced the use of more white glass in the fourteenth century. To the best of our knowledge, this is the first time an extensive daylighting data set has been collected in medieval sacred interiors. From an analysis of these illuminance and luminance data collected in European churches and cathedrals, we find that high-translucency glazing is associated with limited lighting gains compared to full-colour programs under sunny conditions but substantial lighting improvements (up to an order of magnitude) for cloudy conditions. Additionally, we find that backlighting from direct sunlight produces significant obscuration of some of the iconographical glass when interiors are dominated by high-translucency glazing, further suggesting that these interiors are not ideal for sunny conditions.

Résumé [Traduit par la rédaction]
Étant donné que les cathédrales gothiques (chrétiennes) sont des expressions de l'architecture régionale, plusieurs adaptations au climat de l'époque y ont souvent été apportées. À la fin du Moyen Âge (période du gothique), le climat chaud et ensoleillé en Europe du nord continentale a fait place à un climat plus froid et plus nuageux, d'après les preuves que nous présentons ici. C'est donc dans la perspective de ce changement climatique que nous nous penchons sur l'un des éléments les plus importants de l'architecture des églises gothique, l'éclairage naturel intérieur, durant la transition (du XIII^e siècle à la fin du XV^e siècle) entre la période chaude médiévale (MWP) et le petit âge glaciaire (LIA). Dans le présent article, nous voulons notamment évaluer si l'utilisation de plus en plus fréquente du vitrail blanc au XIV^e siècle s'expliquerait par les conditions plus nuageuses en Europe du nord continentale, attribuables en partie à un changement dans l'indice d'oscillation nord-atlantique (NAO). À notre connaissance, c'est la première fois qu'une série élaborée de données a été recueillie sur l'éclairage à l'intérieur des cathédrales gothiques. L'analyse des données sur l'éclairement lumineux et la luminance lumineuse dans les églises et les cathédrales d'Europe nous permet de constater que le verre très translucide présente peu d'avantages comparativement au verre plein coloré dans des conditions ensoleillées, mais qu'il améliore considérablement l'éclairage dans des conditions nuageuses (jusqu'à 10 fois). De plus, nous constatons que l'éclairage en contre-jour produit par l'ensoleillement direct obscurcit une partie des pièces de verre ornées d'icônes lorsque le verre très translucide domine à l'intérieur, ce qui confirme une fois de plus qu'il ne s'agit pas d'un aménagement idéal pour les conditions ensoleillées.

Long-term Variability of volume and heat transport in the Nordic Seas: a model study by Lundrigan and Demirov

Abstract not available at time of printing.

Résumé non disponible au moment d'aller sous presse.

Invitation for comments!

Readers may have noticed that our practice of republishing the abstracts of all papers in *Atmosphere-Ocean* is starting to have an impact on the size of the *CMOS Bulletin SCMO*. As *Atmosphere-Ocean* progresses toward its goal of 100 articles per year, the impact on your Bulletin may become overwhelming. In order to continue to promote the work of our scientists, we would like to publish instead a précis of some of the articles, explaining their significance in common language. The précis could be written by the author of the article, an interested volunteer or a paid communications specialist. Please tell us what you think!

The Editor

Donnez-nous votre avis!

Nos lecteurs ont sans doute noté que notre habitude de republier les résumés de tous les articles de *Atmosphere-Ocean* commence à avoir un impact sur l'épaisseur du *CMOS Bulletin SCMO*. À mesure que *Atmosphere-Ocean* avance vers son objectif de 100 articles par année, l'impact sur votre revue deviendra dominant. Afin de continuer à promouvoir le travail de nos scientifiques, nous aimerions plutôt publier des abrégés faisant ressortir l'importance de certains des articles et rédigés en langage commun. Les abrégés pourraient être préparés par l'auteur de l'article, un bénévole intéressé ou même un spécialiste en communications. Qu'en pensez-vous?

La rédaction

Invitation to Reviewers

As has recently been reported, *Atmosphere-Ocean* is experiencing a strong growth spur and is planning to increase its publication rate to 100 articles per year by 2014 or so. All of the editorial staff are highly committed to reaching this goal and to maintain the high quality for which *A-O* is known. The introduction of the online manuscript submission and review system ScholarOne, provided by our partner Taylor & Francis, has already contributed to a significant increase in publication speed by virtue of its system of automated messages that considerably decreases the time demand on editors. Another source of publication delay is the review process. Members of the editorial board lose time searching and inviting potential reviewers, which could be reduced if our database of reviewers were more extensive and covered our topics better.

Reviewers make an essential contribution to a scientific journal by identifying quality papers, advising the editor and frequently assisting authors. With an acceptance rate of about 60%, three to four reviewers are required for each published paper. Conversely, each publishing scientist should expect to review 3 to 4 times as many papers as he or she publishes: reviewing is a duty. Reviewing is also a skill that must be practised, and good reviewers may eventually find a role on the editorial board of a journal, leading to editor-in-chief positions.

If you would like to develop your reviewing skills and offer your services to *Atmosphere-Ocean*, please contact a member of the editorial board (http://www.tandfonline.com/action/aboutThisJournal?show=editorialBoard&journalCode=tato20) or one of the co-editors below, indicating the fields that interest you. You will be entered in our database and your name will come up readily when needed. Your reward will be the increasing renown of your journal.

Gouqi Han (hang@dfo-mpo.gc.ca) Co-Editor (Oceanograpphy)

William Hsieh (whsieh@eos.ubc.ca) Co-Editor (Meteorology)

Invitation aux relecteurs et relectrices

Tel que rapporté récemment, *Atmosphere-Ocean* est en pleine croissance et planifie d'accroître son rythme de publication à 100 articles par année vers 2014. Toute l'équipe éditoriale est engagée vers cet objectif ainsi qu'au maintien de haute qualité pour laquelle *A-O* est renommée. L'arrivée du système en ligne pour la soumission et la revue des manuscrits ScholarOne, fourni par notre partenaire Taylor & Francis, a déjà contribué à accroître de manière significative la rapidité de publication, grâce aux messages automatisés qui requièrent beaucoup moins de temps de la part des éditeurs. Le processus de relecture est une autre cause du retard de publication. Les éditeurs perdent du temps à rechercher et à inviter des relecteurs potentiels, ce qui serait facilité si notre banque de relecteurs était plus étendue et couvrait mieux nos sujets.

Les relecteurs font une contribution essentielle à une revue scientifique en identifiant les articles de qualité, conseillant les éditeurs et fréquemment, en aidant les auteurs. Étant donné un taux d'acceptation d'environ 60%, il faut environ 3 à 4 relecteurs pour chaque article publié. Inversement, chaque scientifique qui publie doit s'attendre à devoir relire de 3 à 4 fois plus d'articles qu'il ou elle publie : la relecture est un devoir. La relecture est aussi une habilité qui doit être développée, et les bons relecteurs seront probablement ceux qui trouveront place au sein des comités éditoriaux, menant aux postes d'éditeur en chef.

Si vous désirez développer vos habiletés de relecture et offrir vos services à *Atmosphere-Ocean*, veuillez contacter un des membres du comité éditorial (http://www.tandfonline.com/action/aboutThisJournal?show=editorialBoard&journalCode=tato20) ou un des co-éditeurs ci-bas, en précisant les domaines qui vous intéressent. Votre nom sera inscrit dans notre banque de données et sera porté à l'attention des éditeurs au besoin. Vous trouverez votre récompense dans la renommée grandissante de votre revue.

William Hsieh (whsieh@eos.ubc.ca) Co-directeur scientifique (météorologie)

Gouqi Han (hang@dfo-mpo.gc.ca) Co-directeur scientifique (océanographie)

BOOK REVIEWS / REVUES de LITTÉRATURE

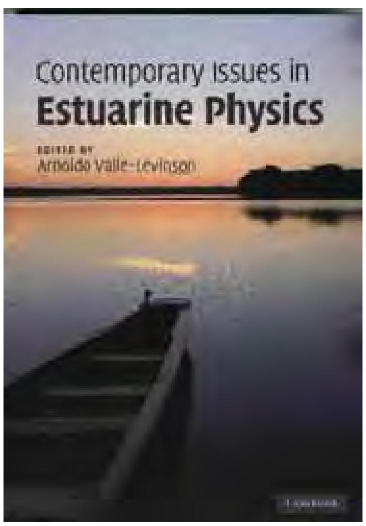
Contemporary Issues in Estuarine Physics

Edited by Arnoldo Valle-Levinson

Cambridge University Press ISBN 978-0-521-89967-3
2011, Hardback, 315 pages, US$120.00

Book reviewed by T. Colleen Farrell[1]

Twenty-two of the thirty-two largest cities in the world are located on river estuaries. In the Foreword, this book is said to provide a concise foundation on estuarine, lagoon and coastal hydrodynamics for academic researchers, advanced undergraduate or graduate students, and coastal resource managers. What interest could a meteorologist have in estuarine dynamics? My interest stems from my master's thesis which involved modelling water quality in a polluted estuary, so while this book could have a wider appeal, in reality, it is meant to be a reference for professionals and students in the field of hydrology.



The book is comprised of a series of lectures held by the Pan American Advanced Studies Institute (PASI) in 2007. Each chapter is by a different subject expert and all are followed by a sometimes exhaustive reference list (e.g. Chapter **8**). Some chapters offer summaries, others include acknowledgements, dependent on each author's unique style. There are lots of illustrative diagrams, graphs and maps, all in black and white, and an index at the back, as you might expect in a textbook. The organization and rationale of the book's flow is described in the Preface: estuarine classification (Chapter **1**); basic hydrodynamics, estuarine circulation and stratification (Chapter **2**); tidal effects and variability (Chapters **3 & 4**); bathymetry effects and secondary circulation (Chapters **5 & 6**); turbulence (Chapter **7**); fronts and continental shelves (Chapter 8); low-inflow estuaries (Chapter **9**); and water quality (Chapter **10**).

[1] Environment Canada, Dartmouth, Nova Scotia, Canada.

The most widely used definition of an estuary is from Cameron and Pritchard in 1963: "*An estuary is a semi-enclosed and coastal body of water with free communication to the ocean and within which ocean water is diluted by freshwater derived from land*". This definition applies to classic estuaries, but things are never so simple. Arid, tropical or subtropical basins can have little or no freshwater influence.

In Chapter **1**, the classification of estuaries is shown by water balance (positive, inverse or low-inflow), geomorphology (coastal plain, fjord, bar-built or tectonic), water column stratification or hydrodynamics (circulation). The formation of different kinds of estuaries and examples are given. For example, Chesapeake Bay is a coastal plain or drowned river valley, formed by sea level rise (starting ~15,000 YBP). Fjords are at high latitudes (ex. In Scandinavia, New Zealand, Antarctica and Chile, and Alaska and British Columbia,) with glacial activity (active or extinct; the latter are referred to as riverine fjords). Tectonic estuaries, such as San Francisco Bay, are formed when faults cause the earth's crust to sink and the hollow is filled in by the ocean. The Mississippi is classified as a salt wedge estuary due to its large freshwater discharge and weak tidal forcing.

Equations first appear in Chapter **2**, where salinity gradients and circulation are discussed. This is where my interest started to wane, but for someone in the know, this would be a handy volume to have in their library. I am passing this copy along to a hydrologist, who may have more use of it as a reference than I.

The Climate Connexion
Climate Change and Modern Human Evolution

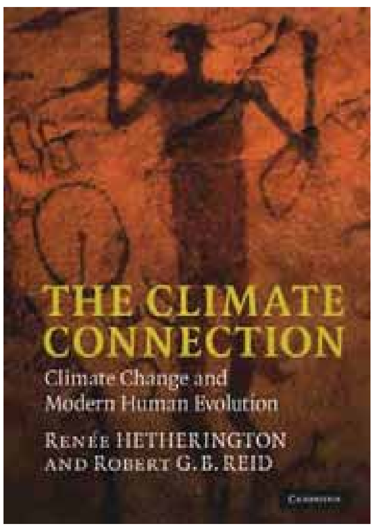
by Renée Hetherington and Robert G. B. Reid

Cambridge University Press ISBN 978-0-521-14723-1
2010, Paperback, 422 pages, US$44.00

Book reviewed by T. Colleen Farrell[1]

It was not a good sign when I had to pull out a dictionary before finishing the first sentence on the very first page of a pre-foreword introduction to the authors. This may foretell that this book is not for the masses or passive bystander to the debate, but I persevered. The conjecture is that to deal effectively with climate change, society must first be better informed of the historical connection between climate and humans. The connections between the impact of climate on human evolution and the impact of humans on climate, as well as linking human history with climate history, are explored here.

Most of us are aware that at sometime in the past, the Earth's climate was different than it is today. Changes in climate have compelled our ancestors to migrate and develop tools to cope with their environment (a characteristic of "adaptability" in humans rather than "adaptation"). The process of adaptation is too slow to respond to sudden changes in our environment. Adaptability is an individual's physiological or behavioural response (ex. application of intelligence) to change. This distinction is only one of many examples of terms that I may have thrown about too loosely in the past. If I've learned anything whilst reading this book, it is that one must be careful in the use of terminology surrounding climate change and human evolution, at least around the authors or anyone deeply involved in either of these sciences.



The Foreword gives me further cause to Google "bolide", where I find there may be no consensus on its definition, but we can use it to mean an extraterrestrial body in the 1-10 km size range. I am satisfied with that interpretation. While I had hopes that the body of the text would be less demanding, I quickly came to the conclusion that I had much more to learn. In this sense, I found this to be an important book in helping me understand what a privileged (if not only serendipitous) place humans have come to occupy on this planet, and with privilege comes great responsibility. Throughout human history, catastrophe has been the impetus for social evolution; communication and cooperation among humans are required to survive and thrive despite it. If recent global economic and social unease are any indication of what lies ahead for Homo sapiens, the speculation that dealing with climate change will be about dealing with domestic and global security seems to be especially prophetic. The decarbonization of the world's energy requirement may need to come about more rapidly in response to a security or social crisis than purely because of an environmental impetus.

The Introduction (Chapter **1**) consists of a synopsis life on Earth in the past 4.5 billion years. Part I, *Early Human History*, contains 3 chapters: **2**) From ape to human, **3**) Human behavioural evolution and **4**) The migrations and diaspora of *Homo*. Part II presents *Climate during the last glacial cycle* including **5**) Climate change over the last 135,000 years and **6**) The effect of changing climate on the global landscape. Part III is *The interaction between climate and humans*: Chapter **7**) The interaction between climate and humans, **8**) Climate and agriculture and 9) Climate and our future.

There are 3 appendices: A) Evolutionary theory, B) Developmental evolution and C) Human adaptability: the physiological foundation. There is also an extensive list of references and an alphabetical index at the back.

I found this book to be fascinating and, as one having more than a just passing interest in climate change and history, taking the approach of the last 135 000 years rather than zeroing in on the period since the Industrial Revolution, made it particularly entertaining for me. One certainly does not need to be a scientist or historian to get a lot out of this book and I would whole-heartedly recommend it to anyone, university-age and up. If you are like me, however, keep a dictionary close by.

Note from the Editor: A review of the same book can be found at: *CMOS Bulletin SCMO*, Vol.38, No.6, pages 226-227.

Rising Waters: The causes and consequences of flooding in the United States

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

Cambridge University Press, ISBN 978-0-521-19321-4
Hardback, 206 pages,
List Price: CDN$ 100.95

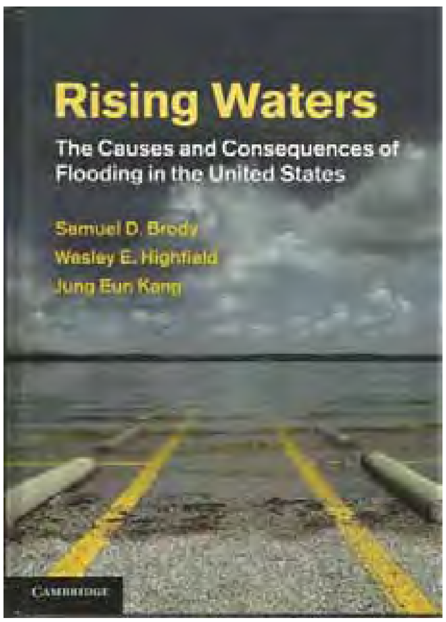
Book reviewed by Anthony Liu[2]

Floods are one of the most costly natural disasters around the world in terms of their impacts on human populations, their livelihoods and on national infrastructure. Various national and local flood management strategies have been implemented in an effort to mitigate the impacts of these devastating events.

This book, organized in four parts, summarizes the results of five years of multi-disciplinary research on the causes and consequences of flooding in the United States. In part one, **The consequences of floods,** the authors examine the impacts, costs and trends of floods in the United States in general, and also add new data and results focussing on

[2] Environment Canada
Canadian Meteorological Centre
Edmonton, Alberta, Canada

the two most vulnerable states, Texas and Florida. The authors also provide a review of the existing flood mitigation policies from all levels of governments. Part two, **Planning decisions and flood attenuation**, investigates the major factors that contribute to the severity of flooding and flood damages, including hydrometeorological and geophysical features, build-environment patterns, socioeconomic characteristics, flood mitigation techniques and organizational capacity. In part three, **What are we learning?,** the authors demonstrate how communities can improve flood mitigation capacities with continuous policy learning and adaptation. The last part of the book, **Policy implications and recommendations**, generalizes the findings from the study area to communities in general. The authors propose a set of integrated planning recommendations for improving the ability of local communities to reduce future flooding effects and identify some specific future research needs that could assist in building more resilient communities in the future.



Overall, I found this book to be well written, and enjoyable to read. By presenting results of multi-scale empirical studies, the authors provide strong evidence to support their argument that an interdisciplinary conceptual and quantitative approach is necessary for regional flood modeling and risk assessment. The authors describe major factors that contribute to the severity of flooding, including geophysical characteristics, built-environment characteristics, socioeconomic factors, flood mitigation techniques and organizational capacity. I found the detailed analyses of flooding frequencies and damage down to the zip code level in Texas and Florida fascinating. These results provide readers a better understanding of the spatial and temporal patterns of repetitive flooding events. Some of the methods applied in the detailed flooding studies in Texas and Florida could be helpful in examining other regions. The critical role of local development planning and decision making in flood mitigation is also emphasized in the book. Hydrologists may find the investigation on hydrometeorological and geophysical factors very general and simple. For example, the analysis of trends in flooding and flood damage should have been put under the context of climate change. Missing from the discussion is the investigation of increasing extreme precipitation events and their impact on future flooding frequencies and damage.

This book will serve as a useful reference for anyone involved or interested in flood mitigation/management including students and researchers in hazard mitigation, hydrologists, geographers, environmental planners and public policy makers.

Eruptions that Shook the World

by Clive Oppenheimer

Cambridge University Press, 2011,
ISBN 978-0-521-64112-8, Hardback
392 pages, US$30

Book reviewed by Dov Bensimon[3]

As someone who is not a volcanologist but who is interested in learning more about volcanoes, I found this book to be very instructive. The author has done many years of research in the field of volcanology. He mentions taking a long time to write the book – it was originally meant to be finished in 1999, but was only published in 2011 – but this lengthy time may have helped coming up with a good product in the end. The recent completion of the book allowed the author to reference events that occurred in the last few years that many readers will have heard of: the eruption of Eyjafjallajökull in 2010 and the Dec. 26th, 2004 tsunami which devastated parts of Southeast Asia are two examples. The book is written in a very candid style and sprinkles it with good humour. The author communicates his comprehensive knowledge of the subject in a clear, easy-to-understand style.

The book is divided into 14 chapters, with each chapter typically subdivided into 5 or 6 sections. The first two chapters cover the basics: how volcanoes work and the types of eruptions they can exhibit. The topics of earthquakes and tsunamis are also touched upon, which I found useful since these are natural phenomena that one typically hears about, though not necessarily in the context of volcanic eruptions. It is mentioned that larger eruptions are often preceded by an increase in earthquake activity because of magma moving towards the surface or accumulating at a shallow depth in the Earth's crust.

The third chapter may be of greatest interest to CMOS Bulletin readers: it discusses volcanoes and global climate change. The eruption of Mount Pinatubo in 1991 is

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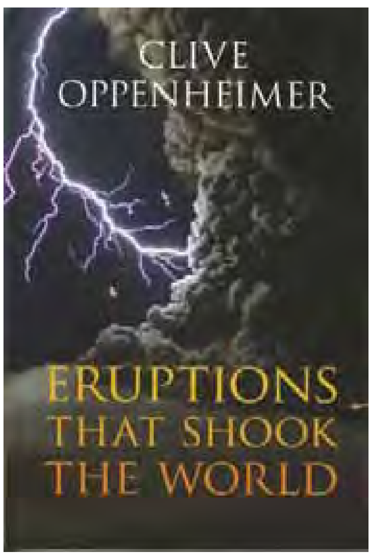
discussed in detail since it taught scientists a great deal about how volcanoes affect climate. Before some steam explosions occurred in April 1991 (the main eruption took place on 15 June 1991), Pinatubo hadn't even been identified as a potentially active volcano. This illustrates how little is known about which volcanoes are most likely to have significant eruptions. Volcanic debris made it into the stratosphere (up to around 35 km height) and the aerosols from the eruption led to many optical effects, including vividly coloured sunsets. The veil of aerosols in the stratosphere was sufficiently dense to lead to a cooling of the summer of the eruption as well as a relatively warm winter thereafter. There was also a significant drop in rainfall over land during the year following the eruption and sea surface temperatures dropped by about 0.4 degrees C (global average). It is the emission of sulphur gases into the atmosphere that ultimately leads to a perturbation of the Earth's heat budget.



In comparison, the eruptions of Okmok and Kasatochi (in Alaska in July and August 2008, respectively) did not have nearly as large an impact on climate: in the case of the former because the eruption was too small and in the case of the latter because it happened too late in the year to have a significant impact on radiative forcing.

The next chapters discuss historical eruptions, through forensic volcanology as well as via oral traditions, myths and chronicles. Archeological evidence is explored for eruptions in El Salvador, Costa Rica and Papua New Guinea and the author presents theories of how societies in these locations survived and adapted to volcanic activity. For other cases (Pinatubo, Kilauea and Crater Lake), oral traditions that attempt to explain or foretell eruptions are presented. The legends presented are quite colourful and were likely the most believable explanations of these eruptions for centuries or millennia. Another chapter relates how the migration paths of early humans along rift valleys illustrate how the geology of the Earth may have had a strong influence on where people settled. It is also surmised that the volcanic activity in the African rift valley stimulated human evolution by forcing people to be more mobile and deal with ill effects of major eruptions.

An entire chapter is devoted to tremendous eruptions, notably that of the Younger Toba Tuff in northern Sumatra 73,000 years ago. This was one of the largest eruptions ever documented and is thought to have a similar magnitude to that of the Fish Canyon Tuff in Colorado and Yelllowstone. The first appendix to the book lists the 25 largest documented eruptions during the Holocene.

Different times and places in history are then explored for other significant volcanic activity, as explored in subsequent chapters. These include the eruption of Santorini and the decline of Minoan civilization. Archeological evidence suggests that this society became increasingly unstable within a couple of generations of the eruption roughly 3600 years ago and eventually were taken over by invaders from the Greek mainland. This may have been as a result of the impacts of earthquakes, ash falls and tsunamis, which could have destroyed existing infrastructures and led to food shortages or famines.

The final chapter discusses volcanic catastrophic risk. The likelihood of such events and their potential impacts (especially on major cities close to active volcanoes like Tokyo) are examined. Risk management and actions taken to mitigate these are difficult to plan since the scenarios that would have the most impact are a kind of "science fiction" (author's term) and are unlikely to occur.

This book is a good source of information for anyone wanting to learn more about volcanology, whether casual readers or students taking an introductory course on the topic. For those interested in reading more on the topic, an extensive bibliography and references are provided at the end of the book.

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

Latest Books received / Derniers livres reçus

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

2012-04) *The Cryosphere*, by Shawn J. Marshall, Princeton University Press, ISBN 978-0-691-14526-6, Paperback, 288pp, $US24.95.

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

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

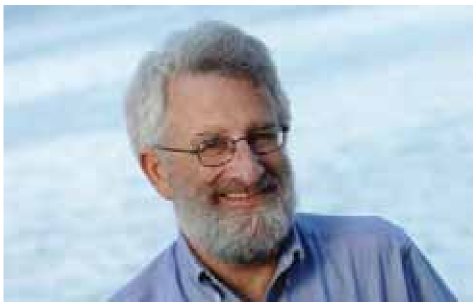
2012-09) *Fundamentals of Numerical Weather Prediction*, by Jean Coiffier, Cambridge University Press, ISBN 978-1-107-00103-9, Hardback, 340 pp, US$85.

BRIEF NEWS / NOUVELLES BRÈVES

John Cullen, Environmental Award Winner[1]

by Regis Dudley

To some people, iron fertilization was the opportunity of a lifetime: get rich and help stop climate change, all at once! But Dalhousie's John Cullen wasn't buying it.



Dr. John Cullen (Danny Abriel Photo)

For twenty years, Dr. Cullen worked to bring attention to the uncertainties and potential dangers of large-scale iron fertilization, a process whereby iron is released into the ocean to prompt phytoplankton growth. The idea was that phytoplankton would soak up carbon dioxide, a high-profile greenhouse gas. The carbon would then be stored in the deep sea, keeping it out of the atmosphere. It was hyped as a simple solution to climate change.

Dr. Cullen disagreed. In order to store significant amounts of carbon, he argued, huge sections of ocean would need to be fertilized and fundamentally changed, with uncertain and potentially catastrophic ecological impacts.

Dr. Cullen and his colleague, Sallie W. (Penny) Chisholm from MIT, recently received the Ruth Patrick Award from the American Society for Limnology and Oceanography. The award honours outstanding research by a scientist in the application of basic aquatic science principles to the identification, analysis and/or solution of important environmental problems. Previous recipients include the noted aquatic ecologist David Schindler of the University of Alberta.

In the beginning

Reflecting on his two decades of research and advocacy, Dr. Cullen remembers a long struggle to apply scientific research for protection of the ocean.

In 1988, new discoveries by oceanographer John Martin suggested that small amounts of iron from natural or artificial sources could increase production of phytoplankton in the ocean. The issue became controversial because if Dr. Martin's "**Iron Hypothesis**" were true, fertilization of the ocean with iron might be used to slow global warming driven by increasing carbon dioxide in the atmosphere.

Cullen and leading ocean scientist Penny Chisholm co-chaired an international symposium in 1991, with the goal of fostering communication among scientists about iron fertilization. At the end of the meeting, participants constructed a consensus resolution concluding that the topic of iron and marine productivity was a priority for research, but governments should not think of it as a solution to offset carbon dioxide emissions.

This symposium paved the way for highly influential research, including open-ocean fertilization experiments that demonstrated significant promotion of ocean productivity by iron. Although the results of these relatively small-scale experiments could not be used to predict effects on climate with scientific confidence, commercial interest blossomed. Patents were issued and at least one business began advertising that they would fertilize the ocean and end the greenhouse effect, all the while making investors rich.

"*By 2001 it was getting pretty intense*," recalls Dr. Cullen. "*There were a lot of businesses looking into fertilizing the ocean for profit by generating carbon credits*".

Discrediting ocean fertilization

Over the next few years, commercial interest continued to increase. Dr. Cullen, along with Dr. Chisholm and Paul Falkowski of Rutgers University, began to fear for the integrity of oceans subjected to commercially driven habitat modification on a global scale. They argued in the journal Science that fertilization of the ocean for profit should never be allowed.

Over the following years, a debate developed, with some scientists in favour of commercially supported research, and others opposed. Dr. Chisholm and Dr. Cullen argued for a cautionary approach: there were risks that could not be assessed unless experiments were done on huge expanses of the sea and by the time the negative effects became known, it would be impossible to reverse the damage done.

Through the years of debate, Dr. Cullen reiterated a central message: "*Unless you can dismiss these scientific arguments, we should not proceed with ocean fertilization for climate mitigation*". All along, Dr. Cullen and colleagues have strongly supported basic research on iron, ocean productivity and climate.

International oversight

Today the International Maritime Organization (IMO) and The UN Convention on Biodiversity are involved in the ocean fertilization issue. Scientists interested in ocean fertilization have collaborated and adopted guidelines for research – "*A great improvement to the previous unstructured approach*," says Dr. Cullen.

"*It's quite an honour to be recognized for this*", he adds. "*When you see something important to the world, you apply what you know to the problem and hope that it helps governments and international bodies to make decisions based on science. When they do that, I can't ask for anything more.*"

[1] Source: Dalhousie University Web site visited on February 29, 2012. Reproduced here with the written authorization of the author and Communications Officer, Regis Dudley.

http://www.dal.ca/news/2012/02/27/twenty-years-advocating-for-oceans-science.html?utm_source=NoticeDigest&utm_medium=email&utm_campaign=dalnews

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Herzberg Gold for Climate Researcher


Dr. Richard Peltier

Dr. Richard Peltier, University Professor of Physics at the University of Toronto and founding director of U of T's Centre for Global Change Science, is this year's winner of Canada's highest prize for science, the Gerhard Herzberg Canada Gold Medal for Science and Engineering. Dr. Peltier is a pioneer of "**Earth Systems Science**", the multi-disciplinary field that attempts to explain the whole functioning of the dynamic earth by looking at the complex interaction between things generally studied separately in geophysics, oceanography, atmospheric science, and more. In recent years, Dr. Peltier has been active in developing and validating the climate models that are being used to predict how our climate will respond to our increasing emissions of greenhouse gases.

Congratulations to Dr. Peltier for this outstanding achievement!

2011 Billion-Dollar Weather Disasters Article

Are the 2011 Billion-Dollar U.S. Weather Disasters Related to Climate Change?

In 2011, the United States experienced an unprecedented number of billion-dollar weather disasters ranging from tornados and severe thunderstorms to floods. Can we attribute the increasing number of weather-related disasters to better communications, increases in population, and advances in weather radar and damage surveys? Or, is global warming causing climate instability and natural weather extremes?

Dr. Jeff Masters, meteorologist and co-founder of the premier weather blog Weather Underground, examines these questions in a recent article **"2011's Billion-Dollar Disasters: Is Climate Change to Blame**?" published in the March/April issue of Weatherwise magazine.

"*In all, 14 billion-dollar weather disasters pummeled the United States in 2011, killing more than 1,000 and costing $55 billion,"* states Jeff Masters*. "During my 30 years as a meteorologist, I've never seen a year that comes close to matching 2011 for the number of astounding U.S. extreme weather events*".

For free access to the article "*2011's Billion-Dollar Disasters: Is Climate Change to Blame?*" visit: http://www.weatherwise.org/Archives/Back%20Issues/2012/March-April%202012/dollar-disasters-full.html. Weatherwise, America's only magazine devoted to weather provides intriguing articles and spectacular photographs that showcase the power, beauty and excitement of weather. The magazine presents the latest discoveries and hot topics in meteorology and climatology and focusses on the connection between weather and technology, history, culture, art and society.

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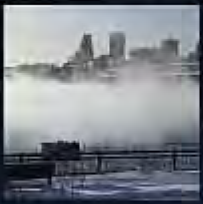
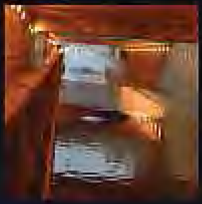

46e congrès SCMO | 46th CMOS Congress
25th Conference on Weather Analysis and Forecasting
21st Conference on Numerical Weather Prediction

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

L'Environnement en évolution et son impact sur les services pour le climat, les océans et la météo

The Changing Environment and its Impact on Climate, Ocean and Weather Services

Montréal 2012
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