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La Société canadienne de météorologie et d'océanographie

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The 1988 Toronto Conference
La conférence de Toronto en 1988

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

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Cover page: 27 July 2008 marked the 20th anniversary of an important international conference hosted by Canada in Toronto and entitled *The Changing Atmosphere: Implications for Global Security*. The Conference was attended by more than 300 scientists and policy-makers from 46 countries. The Conference outlined the need to take action to reduce the impending crisis caused by pollution of the atmosphere. To learn more on this 20th anniversary, please read the article on **page 159.** The photo shows the Environment Canada Group, headed by Howard Ferguson, that organized this seminal event.

Page couverture: Le 27 juillet 2008 marque le 20e anniversaire d'une importante conférence internationale organisée par le Canada à Toronto et intitulée *L'atmosphère en évolution: implications pour la sécurité du globe*. Plus de 300 scientifiques et décideurs venant de 46 pays différents ont assisté aux débats de la Conférence. La Conférence a mis-en-lumière la nécessité de prendre des mesures immédiates pour atténuer la crise imminente qu'entraînera la pollution de l'atmosphère. Pour en apprendre plus sur ce 20e anniversaire, prière de lire l'article en **page 159.** La photo illustre Howard Ferguson à ta tête du groupe organisateur d'Environnement Canada qui a géré cet événement déclencheur.

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....from the President's Desk

Friends and colleagues:

Andy Bush
President of CMOS / Président de la SCMO

I hope that everyone had an enjoyable and productive summer. For many of us, with term about to begin and teaching duties looming, this is a very busy time of the year. And, as Paul Myers has warned me, this is also the time when presidential duties escalate.

Over the summer I have been in contact with the presidents of both the American Meteorological Society (Walter Dabberdt) and the American Geophysical Union (Michael McPhaden). The AMS is seeking our participation at their congress in Phoenix, Arizona in January, 2009. They are trying to develop coordination and communication amongst the ~65 meteorological societies around the world in order to promote a united front on issues such as public statements, education and outreach, and publication practices. I think this is a great initiative and am a strong proponent of CMOS participation.

The AGU is also eager to coordinate future congresses with CMOS, and we are in contact with their meeting organizer. Although this initiative is long-term (since meetings are typically already in the planning stage two years in advance) I believe that building stronger ties with the AGU and coordinating with them either joint congresses or, if not possible, then preventing any scheduling conflicts between respective meetings will prove to be beneficial.

Our journal, ATMOSPHERE-OCEAN, continues to produce high quality articles and we have a number of excellent special issues lined up over the next couple of years.

Finally, I'd like to wish everybody a productive fall and extend my thanks to everybody serving on the CMOS executive.

Andy Bush
President / Président
Canadian Meteorological and Oceanographic Society
Société canadienne de météorologie et d'océanographie

Volume 36 No.5
October 2008 — Octobre 2008

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Articles

Our regular sections / Nos chroniques régulières

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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.

Highlights of Recent CMOS Meetings

June Executive Meeting

- Discussion of Kelowna 2008 congress budget and participation;
- Update on upcoming congresses in Halifax 2009 and Ottawa 2010;
- Discussion about initiating more dialogue with the American Geophysical Union;
- Announcement of a new letter to Prime Minister Harper, drafted by Gordon McBean and containing a large number of CMOS signatories, concerning Canadian action on climate change (Ref.: *CMOS Bulletin SCMO*, Vol.36, No.4, p.117);
- Adjournment for the summer !

Andy Bush,
CMOS President
Président de la SCMO

URGENT - URGENT - URGENT - URGENT

Next Issue *CMOS Bulletin SCMO*

Next issue of the *CMOS Bulletin SCMO* will be published in **December 2008.** Please send your articles, notes, workshop reports or news items before **November 7, 2008** to the address given on page ii. We have an URGENT need for your written contributions.

Prochain numéro du *CMOS Bulletin SCMO*

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en **décembre 2008.** Prière de nous faire parvenir avant le **7 novembre 2008** vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée à la page ii. Nous avons un besoin URGENT de vos contributions écrites.

The Third Argo Science Workshop:

The Future of Argo

Call for Papers and Registration

25, 26 and 27 March 2009
Hangzhou, China

Hosted by the Second Institute of Oceanography,SOA and the State Key Laboratory of Satellite Ocean Environment Dynamics

Talks and posters are invited on any topic based on substantial use of Argo data. The purpose of the workshop is to assess the scientific and wider utility of Argo and to consider the future evolution of the Argo program.

The deadline for abstract submissions is 19 December 2008, the deadline for registration is 23 January 2009.

For further information visit the workshop web site:
www.argo.ucsd.edu/ASW3.html

Sponsored by the Argo Steering Team and PICES, the N. Pacific Marine Science Organization.

Correspondence / Correspondance

From: George W. Robertson
CMOS Member, Ottawa Centre

To: Editor, CMOS Bulletin SCMO

Date: June 20, 2008

Subject: Public Service Awards of Excellence

During the afternoon of June 16, 2008, I had the good fortune to attend the presentation of the Public Service Awards of Excellence at the Hilton Lac Leamy Hotel and Conference Centre in Gatineau, Québec. Among the 40 recipients two CMOS members received awards.

It occurred to me that CMOS members would like to congratulate Dr. Raymond Desjardins and Dr. Paul Joe on receiving this coveted award and wish them well in their future endeavours.

Drs. Paul Joe and Raymond Desjardins
Recipients of "The Public Service Award of Excellence"

Dr. Raymond L. Desjardins
Agriculture and Agri-Food Canada, Ottawa, ON.

Dr. Desjardins is a pioneer and a leading researcher of the impact of agriculture on greenhouse gas emissions. Among other things, his work has helped establish the scientific basis for today's main network of sites for measuring carbon dioxide and water vapour exchange in Canada, the United States and Europe.

He spearheaded many research projects that have not only served to advance knowledge, but also enabled Canada to play a leading role in international efforts to fight climatic change.

Over the past 45 years, Dr. Desjardins has passed on to his colleagues his enthusiasm and determination to understand and learn agriculture's impact on the atmosphere. Throughout his career he has been a mentor to many young Canadians and foreign researchers.

Dr. Desjardins is admired for his originality, his influence and the quality of his research.

Dr. Paul Joe
Environment Canada, Toronto, ON.

Dr. Joe's innovations have placed Canada as a world leader in using radar systems for determining and predicting high-impact and severe weather.

Dr. Joe is a Doppler Radar Scientist. He led the National Radar Science Program at Environment Canada, overseeing the development of a national radar network made up of single radar stations spread across the country. This revolutionized the way forecasters observe, detect and predict severe and hazardous weather, and issue advance warnings to Canadians about such events. He is recognized internationally for his innovative work in this field.

He has also dedicated an enormous amount of time and effort to training others from Canada and elsewhere in the use of the doppler radar network and in evaluating and applying the new knowledge so gained about weather systems.

As an example of the modern application of doppler weather radar knowledge, Dr. Joe is heavily involved in the upcoming Beijing 2008 Olympic Weather Forecast Demonstration Project.

Acknowledgements:

Information concerning the individuals was extracted from the citations read at the presentations.

Additional information was obtained from the Public Service Agency of Canada Web Site at:

http://www.psagency-agencefp.gc.ca/arp/aepe08-eng.asp

Note from the editor:

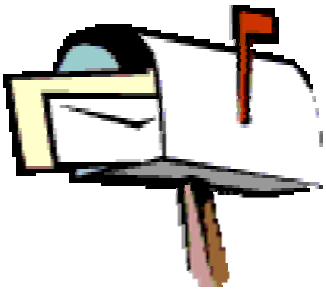
The photograph was taken and edited by George Robertson.

From: Gordon M. Shimizu
West Vancouver, BC

To: Editor, CMOS Bulletin SCMO

Date: 31 July, 2008

Subject: Professor Edward Lorenz Obituary



Your June issue (Vol.36, No.3, p.110) obituary of the outstanding American meteorologist, Edward Lorenz, notes that he is best known for his 1972 paper "Predictability: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?" presented at the Washington meeting of the AAAS. There is a **Canadian** connection here.

In his book - The Essence of Chaos - (University of Washington - 1993), Prof. Lorenz writes (p. 15) "*Before the Washington meeting I had sometimes used a seagull as a symbol for sensitive dependence. The switch to a butterfly was actually made by the session convenor, the meteorologist* ***Philip Merilees****, who was unable to check with me when he had to submit the program titles*".

Dr. Merilees is an eminent Canadian meteorologist. He taught at McGill, was the first Chief Scientist at the Canadian Climate Centre and later Director-General of Atmospheric Research, AES, Environment Canada. He also held senior positions at the US Naval Research Laboratory -Monterey, California and at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Phil Merilees is a very active CMOS member and was President of the Society in 1975.

Meteorologists who worked in Montréal in the 1960s may recall the interesting McGill-CAO (Central Analysis Office) series of lectures on Numerical Weather Prediction. Prof. Lorenz was one of the lecturers. He spoke on his ideas on "*the limits of predictability*" which developed into his Chaos theory.

From: Ian Rutherford
Executive Director, CMOS

To: Gordon M. Shimizu
West Vancouver, BC

Date: 5 August, 2008

Subject: Professor Edward Lorenz Obituary

Thanks very much for pointing out the fact that Lorenz gives the credit for naming the butterfly effect to Phil Merilees. I was aware of this, having ordered a copy of Lorenz's book through the EC library many years ago, after Phil told me the story and noted that Lorenz had even mentioned it in his book. The series of lectures you refer to are, of course, the famous McGill Stanstead Summer School in Meteorology lectures organised by Barney Boville. I wasn't aware that there was a CAO connection but it certainly could be. I was a student at McGill from 1966 to 1969 and attended that particular Stanstead lecture series on atmospheric predictability in which both Ed Lorenz and Phil Merilees gave presentations. I suspect Phil actually organised that event.

From: Madhav L Khandekar
Markham Ontario

To: Editor, CMOS Bulletin SCMO

Date: 5 September, 2008

Subject: Heat Alert in Toronto at 24°C! Have We Lowered Our Tolerance Bar?

The week-end of 22-24 August 2008 was one of the relatively warmer week-ends in Toronto this summer, which has so far been decidedly on the cooler side in southern Ontario as well as in most parts of Canada. While working in my back-yard vegetable patch I was preparing for an outside barbecue dinner with my neighbours as a pleasant westerly breeze was blowing with a balmy 25-27°C temperature, ideal weather for a back-yard get-together. As I was getting ready with some hamburgers and cold beer, I casually switched on to the TV weather channel and almost fell off my chair to hear the weathercaster saying "*there is a heat alert in Toronto with temperature 24°C and humidex of 32°C!"* I was completely dumbfounded! Here I am getting ready for a pleasant evening dinner with typical cool southern Ontario weather and the weathercaster is trying to "rain" on my party! Anyway I ignored the heat alert warning for the time being and went ahead getting ready with my evening get-together. A couple of hours later as I started serving food and drinks to my neighbours, someone switched on to an "all news & weather" radio station to get an update on the evening's weather and once again the radio meteorologist proclaimed *"Temperature in downtown Toronto 24°C, humidex 32°C and there is a heat alert in effect.* One of my neighbours almost burst into a fit of laughter saying "Is this a joke! Here we are having a great time outdoors with almost perfect weather for an evening barbecue and who is this smart alec telling us *"There is a heat alert!"* I nodded in agreement with my neighbour and suggested that come next fall, we could be hearing a *"cold alert with air temperature 5°C and a windchill value of just about 0°C!"*

The point I am making here is: Is there any threshold value of temperature at which a heat alert (OR a cold alert) is called OR is it totally arbitrary? If there is a threshold value, is there a scientific criterion or just a perception that a 32°C humidex value can be uncomfortable to human body? What

is the guideline to declare a heat alert OR a cold alert for a city like Toronto with a sizeable population of immigrants from countries where 27-30°C temperature is a norm and a 0°C temperature is considered as *extremely cold.*

Canadians from coast to coast are known to be hardy people who are used to hot and cold weather extremes. On the east coast, Newfoundland has perhaps the world's toughest weather, with cold, snow, wind and fog sometimes occurring almost within a span of just a few hours. The Great Lakes region often provides a trigger for intense summer rainstorms and for locally heavy winter snowsqualls in southern and central Ontario. The Canadian Prairies are known for climate extremes, with temperature records of +45°C in Saskatchewan and -45°C and below in Winnipeg and Edmonton. On the west coast, Vancouver Island is often pummeled by pre-winter storms with wind gusting to hurricane force and waves of 6 m and higher at Tofino's Long Beach. Learning to live with extreme winter and summer weather has become our *National Heritage.* Against this background, I find it amusing and puzzling that weathercasters and meteorologists in Toronto were prompted to issue a heat alert when the air temperature was a mere 24°C!

Have we lowered our tolerance bar for heat? More importantly, do such proclamations have any utility in a society where different people have different tolerance levels for hot and cold weather?

Stop the Press !

CMOS Member awarded the Order of Canada

On July 1st, 2008, Timothy R. Oke was awarded the Order of Canada for his contributions to meteorology and urban climatology, as well as for his mentoring of generations of geographers. The Order is the highest civilian honour bestowed by Canada. Tim is a professor emeritus of geography at the University of British Columbia and a Fellow of the Royal Society of Canada. He is a Fellow of CMOS, and Accredited Consultant Meteorologist, past editor-in-chief of ATMOSPHERE-OCEAN, a winner of the CMOS President's Prize and both the Patterson and Massey Medals.

Congratulations to Professor Oke !

Les membres du Comité organisateur sont:

- Michel Béland, Environnement Canada, Président;
- Michèle Bourgeois-Doyle, Conseil national de recherches Canada
- Jacques Derome, Université McGill, Coordonnateur du programme scientifique;
- Pierre Dubreuil, Secrétaire exécutif;
- Laurier Forget, Conseil national de recherches Canada Directeur de l'assemblée;
- Michel Jean, Environnement Canada;
- Charles Lin, AIMSA, Environnement Canada;
- Scott Munro, AISC, University of Toronto;
- Lawrence Mysak, AISPO, Université McGill; and
- Helen Joseph, Pêches et Océans Canada.

Pour plus d'information, prière de visiter www. Iamas-iapso-iacs-2009-montreal.ca dès aujourd'hui. Pour plus de renseignements, veuillez communiquer avec le bureau de gestion de l'assemblée à montreal2009@nrc.gc.ca

AIMSA: Association internationale de météorologie et des sciences atmosphériques; **AISPO:** Association internationale des sciences physiques des océans; **AISC:** Association internationale des sciences cryosphériques.

Pen Portrait - W.E.K. Middleton

by Andrew K. Overton[1] and Ian Strangeways[2]

It is hard to imagine in this era of rigid specialisation a scientist of Knowles Middleton's breed achieving contemporary success. A genuine polymath and polyglot he published around 100 scientific papers (Thomas, 1998) and 17 books of international importance on meteorology, climatology, optics, instrumentation and scientific history, travelling throughout North America and Europe in the course of his researches, studying original Latin manuscripts in Italy and writing and translating work in German and French (Devine K, Science.ca website). As far as meteorologists are concerned, the most important of his books were *Invention of the Meteorological Instruments* (Middleton, 1941), *The History of the Barometer* (Middleton, 1964), *A History of the Theories of Rain and Other Forms of Precipitation* (Middleton, 1965) and *A History of the Thermometer and its Uses in Meteorology* (Middleton, 1966). His wide ranging interests were reflected by his memberships of the Inter-Society Colour Council, Optical Society of America, Royal Meteorological Society, Royal Photographic Society and Royal Society of Canada (National Research Council, 1962). A practical man as well as a scholar, he built some of his own furniture for his family's apartment in Toronto at a time when finances were stretched (Devine, personal correspondence).

William Edgar Knowles Middleton was born on June 23, 1902 in Walsall, West Midlands, son of Richard Edgar Middleton and Margaret Jane (nee Knowles). Known as 'Bill' from his youth, he emigrated to Canada with his family at the age of nine when his father, a chemistry diploma holder from Leipzig University, bought a farm at Qu'Appelle, Saskatchewan, before later moving to Regina in 1918. In 1921, at the age of 21, he commenced studies at Purdue University but lack of money forced him to return home after two years and find employment. In 1925 he recommenced his studies, this time at the University of Saskatchewan. His family were not well off and his time at Purdue was financed by his mother's typing work for the Red Cross and Middleton had to work on survey crews whilst at Saskatchewan to subsidise his education, from which he graduated with a B.Sc. in May 1927 (Middleton, undated). He was already noted as a student with wide-ranging interests - his graduation photograph's citation noting, "Seldom has the Goddess of Genetics permitted the existence of an individual possessing as many admirable characteristics as this versatile physicist ... he has already attained prominence in dramatics, art, writing and science. A great sense of humour, a keen mind, and a knowledge and interest in every subject have made him welcome to any company" (University of Saskatchewan Archives, 1927). With the help of a bursary from The National Research Council of Canada (NRC) he obtained his M.Sc. from Saskatchewan two years later (Bacon, 2005; Thomas, 2001) and was cutting quite a figure in the social round of the University. An affectionate citation accompanies his 1929 graduation photograph-

'"Bill" smokes a pipe and goes to Mess Dinners.
"William Knowles Middleton" smokes a pipe, carries a cane and goes to tea-parties and concerts.
"Middleton" smokes a pipe, wears a Lab coat and chases atoms and fearful formulae all over the Physics Building.
"Knowles Middleton" smokes a pipe, wears stout, well-polished Oxfords and calls down the wrath of his ancestors and the Gods of Capitalism on all unbelievers.
"Edgar Middleton" smokes a pipe, plays the violin, draws, paints, writes poetry and composes sonatas.
But there is only one W. E. K. M.'

(University of Saskatchewan Archives, 1929)

Figure 1

Official retirement photograph of W E K Middleton taken in 1963 by the National Research Council. (©NRC, Canada.)

On leaving university he worked as a researcher and salesman for the Gypsum, Lime and Alabastine Company in Toronto but the Great Depression was to change entirely the course of Middleton's career. He had only recently married Dorothy Day from Saskatoon in Galt, Ontario on 1 February 1930 when, on 31 May he was made redundant but fortunately found three alternative job offers: Kodak in Rochester, NRC in Ottawa and the Meteorological Service of Canada (MSC) in Toronto - he chose the latter since he could not afford to move. The beginning of the 1930s saw an explosion in the demand for aviation meteorological services in Canada and Middleton was put to work training as a forecaster. But he must have felt that he had jumped out of the frying pan and into the fire when funding cuts due to the Depression virtually eliminated this work by 1932, although the demand for forecasting for other purposes continued to grow and MSC decided to lay the foundations for recovery by increasing attention on training, research and development (Thomas, 1971 a). In 1932 he was

[1] Doncaster, South Yorkshire, UK

[2] Terradata Ltd, Wallingford, UK

employed as a station inspector in eastern Canada and in 1933 he travelled to the Canadian Arctic on the RMS *Nascopie* to inspect stations during the Second Polar Year, publishing reports on the climate and weather of Canada's eastern Arctic and Atlantic coasts. It was at this time that his first notable foray into instrumentation development was made when he devised equipment to be used during motor-car traverses to measure surface temperatures, co-authoring the classic, seminal paper *Temperature Profiles in Toronto* (Middleton & Millar, 1936), one of the first on urban temperature mesoclimate. 1930 saw the birth of a son, John, and in 1933 a daughter, Diana, was born.

Undoubtedly, his researches led to him being offered the post of honorary lecturer in the Department of Physics at the University of Toronto in 1933 - a post he held until 1939. His principal studies were into optics and meteorological visibility but he was also lecturing to the meteorology Masters students on instrumentation (Devine, 2005). In 1935 he published *Visibility in Meteorology, the Theory and Practice of the Measurement of the Visual Range* (Middleton, 1935) with the University of Toronto Press, with a second edition in 1947. In 1936 he had joined the Optical Society of America and on 17 November 1937 he was elected a member of RMetS (RMetS files), transferring to the Canadian Branch on its formation in 1939 and holding the post of President in 1945 & 1946. Middleton was clearly an influential member of the Branch from the outset, being present in the group photograph of RMetS and the American Meteorological Society in Toronto 28-29 August, 1939 at which the official announcement of the Branch's formation was made (CMOS History webpage; CMOS Photo Archive webpage a). During the first half of the 1940s Middleton continued work in the field of instrumentation within MSC whilst continuing to lecture and was active in leading research and development, with R.C. Jacobsen, into the Canadian radiosonde instrument, an automatic weather reporting buoy, a new thermometer screen ventilating system and a new cloud-height sensor (Thomas, 1971 b). In 1941 he authored *Meteorological Instruments*, published by the University of Toronto Press. The book reappeared in second and third editions in 1943 and 1953, the latter co-authored with Athelstan F Spilhaus, with a reprint in 1965. At 286 pages this was a description of current instrumentation of its time and was widely used as a text book for a few decades. He was elected a Fellow of the Royal Society of Canada in 1943 and when, in 1946, the decision was made to form a dedicated Instrument Division of MSC he was appointed as its first Chief.

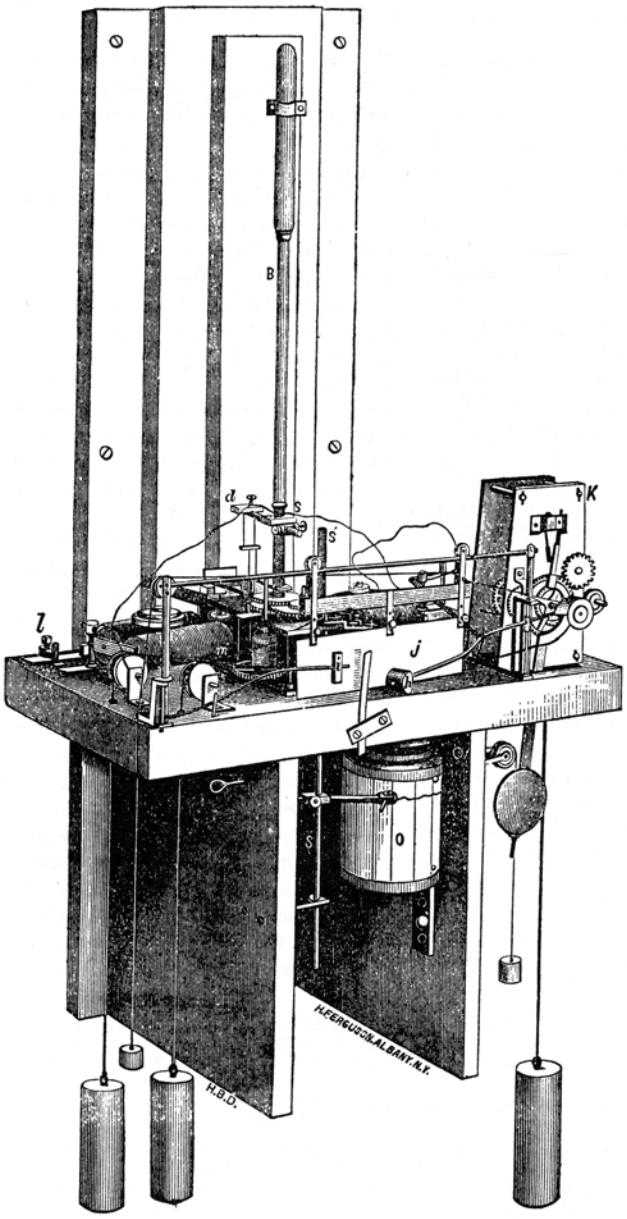


Figure 2

Line drawing of a barograph by W E K Middleton, from *The History of the Barometer*. (© Baros Books, Trowbridge, Wilts.)

As the Second World War ended and the reduction in military requirements caused a reduction of staff within MSC, Middleton appeared to be secure and unaffected. It is, therefore, somewhat surprising that shortly after taking over the Instrument Division he left the Meteorological Service on 1 June 1946 to take up the position of Research Officer in the Photometry and Optical Instruments Section of the Physics Division of the NRC in Ottawa, specialising in colourimetry - quite a change in direction and obliging him to decline the nomination of first President of the International Meteorological Organisation (IMO) Commission for Instruments and Methods of Observation in 1947. However, this did not prevent him accepting an

Note: A shorter version of this paper was first published in *Weather* Volume 63, No. 6, Copyright © Royal Meteorological Society, published by John Wiley & Sons, Ltd. and the longer version is reproduced here by kind permission. This version includes some revisions reflecting more recent information.

ordinary position on the Commission (CMOS Photo Archive webpage b). During his tenure at NRC his knowledge was brought to bear on several committees attached to the Canadian Standards Association, the Defence Research Board, the American Society for Testing Materials, the Illuminating Engineering Society, the US Armed Forces - NRC Vision Committee and committees of the IMO/WMO - a quite remarkable scope of expertise. These years were punctuated by awards and fellowships, acknowledging his contribution to his fields: an Honorary Doctorate of Science from Boston University in 1957, the Frederic Ives Medal from the Optical Society of America in 1959 for distinguished work in optics, followed by a Fellowship in 1960. As well as his studies into meteorology, during his employment years Middleton also produced around 30 papers on visibility and the optical properties of the atmosphere and in 1952 he published *Vision in the Atmosphere* (Middleton, 1952), but there is not space to look at these here. He was a prolific writer; a busy man who probably rarely stopped. By 1962 he was Head of his Section and took early retirement in 1963 (Figure 1).

Early retirement was only relative for a mind such as Middleton's and simply allowed him to concentrate efforts on further study. The income from his books helped to finance expeditions to Europe to research further writing. In 1964 he wrote *The History of the Barometer*, published by Johns Hopkins Press with a second printing in 1968 (the publication-rights are now with Baros Books, Trowbridge, UK, who published a copy in 1994). This book elaborated, considerably, on the chapter on barometers in *Invention of the Meteorological Instruments*, with 489 pages (23 pages being index) making it his longest. There were 207 figures, again mostly old line-drawings. The same atmosphere fills its pages, emanating detail and precision and time spent in careful research in museums and around Europe. Some of the illustrations of instruments now look more like Heath Robinson contraptions than the cutting-edge technology they would once have been (Figure 2). Looking at the mechanical complexity of these instruments, it is also interesting to reflect on how the same things can usually now be done with a small electronics board and a compact sensor, all at a fraction of the cost, the complexity and clever design now being invisible, reduced to microscopic levels in the bland little nondescript components. But who would forgo the beauty of a mercury barometer, or a Campbell Stokes sunshine recorder? Some of the designs illustrated are very complex and even a bit difficult to understand at times. Mostly the book follows the progress of mercury barometers and it is not until page 396 that we get to aneroid instruments, the penultimate figure being of a capacitive aneroid sensor in a tuned-grid, triode valve, oscillator circuit. Middleton seems quite at home with this electronics and, if he had so chosen, he could probably have progressed with ease to describe the electronic instruments of the second half of the 20th century. It seems he chose to do something different instead.

In 1965 there followed *A History of the Theories of Rain and Other Forms of Precipitation,* published by Oldbourne, London. With 223 pages it is the shortest of the four books described here, perhaps because it has no figures, except for the front cover which is of an aneroid barometer scale pointing to 'Rain'. Perhaps the lack of figures is because this book is not about how rain is measured (whereas his other books were essentially about instruments), but about how rain forms and the complex story of how we gradually learnt of the processes involved, the first chapter spanning the long period from the Ancient Greeks up to the invention of the barometer. The next three centuries saw most of the expansion of understanding and Middleton divides his analysis of this period into the structure and suspension of clouds, interpretations of barometer readings (some quite fanciful), and developing views on water vapour, rain, hail, snow, dew and frost. There is not even an entry in the index for 'raingauge' and no discussion in the text of how rain is measured, although there are brief comments on the problem of wind errors in measuring rainfall. In view of his previous books, this is strange. But the idea for the book, explains Middleton in its *Preface*, came from writing his previous book on barometers, during which he researched the interpretations of the variations in barometer readings, which led on to a curiosity about all the other processes involved in rain formation. Probably, of all his books, this one still has the most relevance today since there is no technology in it that can date. It is about ideas, dealt with in Middleton's detailed and carefully crafted way.

In 1966, Johns Hopkins Press published Middleton's *A History of the Thermometer and its Uses in Meteorology*. Short again, at 249 pages, there was, however, a return to his former concern with measurement and instruments, with the same style as in his first two books described above. We get a very good introduction to the development of the early thermometers, with all the contributors discussed in detail, including Amontons, Bartolo, Boullian, Boyle, Celsius, Dalencé, de la Hire, Delisle, Drebbel, Ekström, Eschinardi, Fahrenheit, Ferdinand II, Fludd, Galileo, Hauksbee, Horrebow, Huygens, Linnaeus, Christin, Micheli, Newton, Patrick, Porta, Réaumur, Renaldini, Rey, Rømer, Santori, Strömer and Thompson. The question of scales and fixed points and who invented the centigrade scale are all dealt with and it is well worth reading for these clarifications alone. The bulk of the book concerns air thermometers and liquid-in-glass instruments with just a very short later chapter on electrical instruments, principally platinum resistance thermometers. The final chapter is a good summary of the various screens and shelters that were developed in the 19th century to protect thermometers from radiation and rain. In the end it was the Stevenson screen that won the day, but around the world many different versions of it can now be seen, from small to large, low to high; there is not any true standard. As with his other books, the treatment of the subject ends around the mid 20th century.

Finally, in 1969, *Invention of the Meteorological Instruments* was published by Johns Hopkins Press, Baltimore. This 362 page book contained chapters on barometers, thermometers, raingauges, humidity and evaporation instruments, windvanes, anemometers, sunshine recorders, meteorographs (early Automatic Weather Stations), the

measurement of upper-air winds and clouds and early radiosondes, with 224 figures, mostly old line-drawings with just a few photographs of the later instruments. In common with his other three books on meteorology, it avoided mathematics, making it accessible to a wider readership. Today the book is mainly of interest to historians of meteorology, no longer having practical use as a handbook, but as a record of early meteorological instruments and of their evolution it is unique and invaluable. There are also many interesting figures to browse through, and these help give the reader insight not only into how the instruments operate but also into how the ideas about the variables themselves developed. This dual aspect of the figures comes about since, at the start of scientific awakening a few hundred years ago, the science and the instruments were developed by the same people hand-in-hand, one leading to the other. Alas, today they are largely separated, much to the disadvantage of both.

His retirement years saw a worsening of his relationship with RMetS, with records of yearly correspondence from 1967 with the Executive Secretary showing dissatisfaction with the amount of his membership subscription. The Canadian Branch had been dissolved at the end of 1966 with the formation of the Canadian Meteorological Society, with some 200 members out of 430 electing to retain membership of RMetS in the UK, of which Middleton was one. At that time the subscription structure of the Society did not give any concessions to long-standing or retired members, nor to those not taking the Quarterly Journal. As Middleton was seldom in the UK he felt he was paying rather a high price just to receive *Weather*, especially with the rampant inflation of the early 1970s pushing up his subscription but not his income in Canadian dollars. Finally, in 1978 Middleton was moved to resign his membership after being advised he was in arrears and would no longer receive the magazine until this was cleared. He never rejoined.

In 1967 he had returned from Europe to Canada to live in Vancouver, taking up the post of Professor Emeritus and Honorary Lecturer in the Department of History of Medicine and Science at the University of British Columbia until 1978, being further honoured in 1976 by McGill University who awarded him an honorary Doctorate of Science. 1979 saw, perhaps, the highest recognition in his long and distinguished career when the Meteorological Service of Canada at the Canadian Meteorological and Oceanographic Society (CMOS) Congress awarded him the Patterson Medal in recognition of distinguished service to meteorology in Canada, their highest award. It is perhaps surprising to find that Middleton does not appear to have ever been a member of CMOS, or its predecessor CMS (Rutherford, 2007). His final recognition came in 1996 when he was made an Honorary Member of the American Meteorological Society. W.E. Knowles Middleton died peacefully in his sleep at the age of 95 on 30 January 1998 at his home in Edmonton, Alberta, Canada, ending a remarkable life of scientific study and writing. He was survived by his wife and both children.

It is difficult to overestimate the importance of W.E.K. Middleton in his fields of interest. His books on instrumentation were standard texts for students for many decades and it is arguable that they have only been superseded in the last 10 years or so; his books on optics have yet to be replaced. In reading all of these books, one values the care to technical detail and the subtleties of history that Middleton explains. You come away from them not only knowing a great deal about the topic but also with a strong feel about the author, about the people who did the work that he is describing and of the times during which the work was done. The indexes of Middleton's books are all very detailed and reflect his overall thoroughness and care. Anyone who has tried to compile an index will understand the tedium of doing it and will be grateful to the author for his time spent in helping speed up a search. For anyone looking for help with modern instruments, his books provide no answers, but Middleton explains his reluctance to move into the modern era by saying that once the electronic phase began he was left behind by the technology and felt that his readers would be also, although he would probably have been more than capable of dealing with it if he had so wished. Transistors and integrated microelectronics were still some way off, but soon to change everything radically. Reading his books is like going into a science museum, the small History of Science museum in Oxford comes to mind, with its copper, wood and glass instruments and the feeling of Charles Darwin being around. After visiting the museum or browsing his books you step out into today's world with mobile phones, colour television and data transmitted via satellite. What a change 40 years brought, and what is to follow next? One feels that Middleton would have enjoyed seeing it all and would have written authoritatively about the latest technologies, including satellite instruments. Middleton has not been as fully recognised in meteorology as he should have been. Hopefully this article will go some small way to correcting this.

Acknowledgements

The authors generously acknowledge the especial help given in the preparation of this paper by Ken Devine, Ontario, Canada who made available his own researches into W E K Middleton, including access to unpublished sources. We are also grateful to Diana Bacon and John Middleton for permission to use material from family archives. We would also like to thank Ian Rutherford, Executive Director of CMOS; Bernard Dugay, Morley Thomas and the staff of Environment Canada; Steve Jebson of the Met Office Library; Steven Leclair at NRC; Tim Hutchinson at the University of Saskatchewan Archives; and Malcolm Walker - all of whom searched archives and/or provided documents; and Barry Shell at http://www.science.ca for providing a key contact. *Figure 1* is reproduced by kind permission of NRC and *Figure 2* is reproduced by kind permission of Baros Books, Trowbridge, Wilts.

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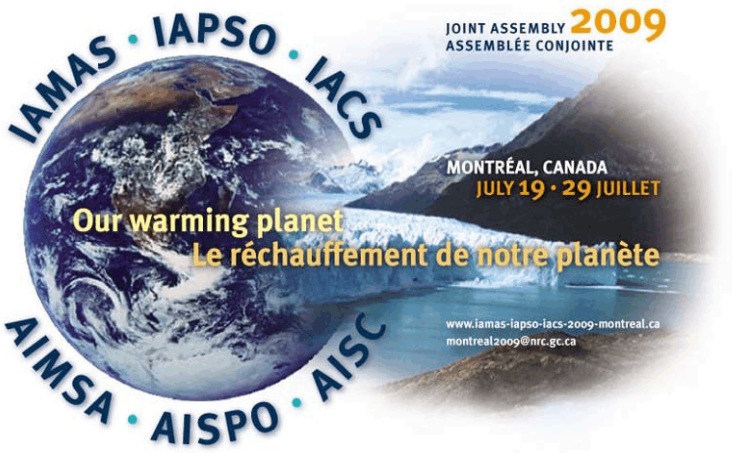

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IAMAS: International Association of Meteorology and Atmospheric Sciences; **IAPSO:** International Association for the Physical Sciences of the Oceans; **IACS:** International Association for the Cryospheric Sciences

Twentieth Anniversary of the Toronto Conference on Our Changing Atmosphere: Implications for Global Security

by H. L. Ferguson

A meeting of key Canadian participants was held recently in Toronto to commemorate the historic international meeting of June 27-30, 1988. That conference issued a compelling warning to the world:

"Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war."

The conference was the first to set a target for greenhouse gas emission reductions (of 20% below 1988 levels by 2005). The Conference Statement marked the consensus agreement of over 300 expert invitees representing 46 nations, many from the developing world.

The seminal event leading to the conference was a visit to Canada in May 1986 by the two senior officials of the World Commission on Environment and Development (WCED), also known as the Brundtland Commission. Gro Harlem Brundtland, the Chair, and Canadian Dr Jim MacNeill, the Secretary-General, were on a world tour to promote the forthcoming final WCED Report "Our Common Future", with its emphasis on sustainable development.

Planning for the Canadian response began prior to the visit and resulted in a pledge made by the Minister of the Environment, Tom McMillan. Canada promised to convene an international meeting relevant to issues raised by the WCED. Proposals for the subject of the meeting were discussed by the Senior Management Committee of Environment Canada and the author's recommendation for a conference on international atmospheric issues, including climate change, was approved by the minister.

The Atmospheric Environment Service (unfortunately renamed the Meteorological Service of Canada in 1999) was designated lead agency. The author, as Assistant Deputy Minister of AES, was named Conference Director, to lead the planning and running of the conference, and was responsible for the conference title and sub-title. That sub-title "Implications for Global Security" was seen as overly pessimistic by some critics but has stood the test of time.

The decision to hold the conference in Toronto was based on several considerations. The Headquarters of AES, from which most of the personnel support would be drawn, was located in the Toronto suburb of Downsview. Toronto is the media and economic capital of the country, with excellent conference facilities. The venue chosen was the Toronto Conference Centre. As it happened, a G7 Meeting of government leaders was held at the same location just before the atmospheric meeting.

Planning for the Toronto Conference began in 1986. Several major issues had to be dealt with at an early stage, including the compositions of six national and international committees, the establishment of a Conference Secretariat, and the development of a list of prospective expert international participants. Due to budget limitations and other factors attendance had to be by invitation only.

Diane McKay was seconded to Downsview as the first Conference Secretary, but was terminally ill and after a few months passed away. At the suggestion of Ian Rutherford, climatologist Gordon McKay (no relation) was enticed out of retirement to fill the role of Conference Secretary under contract. The number of AES Downsview personnel working from time to time on the conference exceeded fifty. The AES teamwork was an outstanding example of *esprit de corps*, and was strongly supported by other EC components and other government departments.

Howard Ferguson chairing a plenary session

The invitation list was based on what might be termed "comprehensive inclusiveness". In addition to involving as many countries as possible, the list was to include not only meteorologists but experts from other "stakeholder" disciplines such as oceanography, water resources, agronomy and forestry. Also included were world-class experts in energy, human health, economics and environmental law, government ministers, ambassadors, senior policy advisors and representatives of NGOs, industry, municipal and provincial governments and international organizations.

The participation of government ministers and other high-profile international personalities posed some interesting diplomatic challenges. For many of these individuals, "sherpas" were assigned for their convenience and protection.

The initial invitation list was based on a WCED list, provided by Jim MacNeill, and several other sources. As it turned out some of the first invitees declined our invitation because of previous commitments or because they felt that they were not given appropriately prestigious roles in the draft conference plan. However, many alternate high-profile experts were happy to participate. A problem for the author was the necessity of severely limiting the number of Canadian participants because 46 countries were to be represented. Many worthy Canadian colleagues could not be included.

An official invitation was issued to the U.S. government to send a representative. This was declined by the Reagan administration. The highest-placed U.S. official to attend was Senator Timothy Worth, a Democrat from Colorado. However, many U.S. technical experts took part and contributed significantly to the discussions and results.

Several relevant international meetings had taken place in the 1980s but most of those were relatively small and involved, predominantly, meteorologists. The most important precursors for the Toronto meeting were two meetings in Villach, Austria and a meeting in Bellagio, Italy in November 1987. The second Villach meeting had been chaired by Jim Bruce, with Henry Hengeveld and the author also participating. The Bellagio meeting included most of the members of the International Advisory Group and the Statement Committee for the Toronto Conference, whose planning was by then well under way.

The Planning Committee wanted to name a distinguished and world-renowned Canadian as General Conference Chairman to attract acceptance of our invitations by very busy and highly-placed international invitees. At Jim MacNeill's suggestion we invited Stephen Lewis, Canada's Ambassador to the United Nations, to fill this role.

As it turned out, the author chaired most of the morning and afternoon plenary sessions. Stephen Lewis handled the final plenary session where his brilliant persuasive powers achieved a consensus agreement on the Conference Statement.

Work on the draft Conference Statement had begun in January 1988. As this was the most important result of the Conference, it is appropriate to list the members of the Conference Statement Committee, who also served on the International Planning Committee. They were Gordon Goodman and Jill Jaeger (Beijer Institute of Stockholm), Jim MacNeill (WCED), Jim Bruce (WMO), Peter Usher (UNEP), Michael Oppenheimer (USA) and the author. This committee met several times before the Conference. During the Conference itself they continually fine-tuned the statement based on outputs from the Working Groups at the meeting.

On the second last day, Stephen Lewis met with representatives of developing countries to review the Conference Statement. Several wording changes were made to address their concerns, and this contributed to the success of the final plenary session.

Elizabeth May was at the time a Special Advisor to Environment Minister Tom McMillan and a member of the Departmental Conference Advisory Committee. She arranged and chaired evening meetings of NGOs and other interested individuals which were well attended and very successful.

The international visibility of the Toronto Conference was greatly enhanced by the presence, at the opening ceremony, of Prime Minister Mulroney and Mrs. Brundtland, who had become Prime Minister of Norway.

The City of Toronto was the first jurisdiction to formally adopt the recommendations of the Conference. It was quickly followed by other sub-national jurisdictions around the world.

It is useful to reflect on the Canadian environmental context of the 1980s. At the risk of appearing overly nostalgic, it is safe to say that the 80s decade was, relatively speaking, a golden age for those working on atmospheric environmental issues. Scientific experts in the public service and their senior managers were readily available to the media and free to discuss their environmental concerns. Canada, and the AES in particular, were highly regarded for technical expertise and their direct involvement in global environmental issues. For example, the AES operated one of the three or four best computer models in the world for the study of climate and climate change scenarios.

An opinion poll just before the Toronto Conference placed the environment as the leading concern of the Canadian public. The government of the time was very supportive of the international work of Canadians on climate change and related atmospheric issues. Thus the Conference was very timely. Within the next few years public priorities shifted toward economic issues.

At the Toronto Conference the Secretary-General of WMO, accompanied by Jim Bruce, persuaded Bert Bolin, a leading Swedish meteorologist, to let his name stand as a candidate for chair of the newly-formed Inter-governmental Panel on Climate Change (IPCC). Following planning meetings in Geneva the first operational meeting of the IPCC, with delegations from all interested countries, was convened in Nairobi in June, 1989, with Bolin in the chair. The IPCC has continued the practice of "comprehensive inclusiveness", and, of course, its 20th Anniversary was celebrated with the award of the Nobel Prize.

The Toronto Conference has been described as an important stepping stone on the long and winding road toward international agreements addressing climate change. The Second World Climate Conference (SWCC) held in Geneva in October 1990 attracted over 1500 participants representing about 80% of the countries in the United Nations. There were about 300 media

representatives, marking the largest ever media involvement at a Geneva meeting up to that time. The results of SWCC were presented to the UN General Assembly in New York and led to the Rio de Janiero conference and subsequently the Kyoto meeting.

Minister McMillan (Environment) and Prime Ministers Brundtland (Norway) and Mulroney (Canada)

To summarize, the Toronto meeting was unique in several ways:

(1) Its size and inclusiveness;
(2) Its subtitle, which has stood the test of time;
(3) Its inclusion of related issues of acid rain and stratospheric ozone depletion;
(4) Its Conference Statement which was outspoken, far-seeing and challenging.

What is the current situation 20 years after the Toronto Conference? A few nations, such as Sweden, Germany and Denmark are making real efforts to address the climate change issue. Many other industrialized countries with advanced economies argue that it is useless for them to limit their greenhouse gas emissions without the emerging economic giants of China and India agreeing to the same limitations. This conveniently ignores the fact that the advanced countries created the problem in the first place and should logically take the immediate short-term lead in real corrective actions to limit their emissions. Through their leadership example (in the most advanced countries the per capita emissions are about twenty-five times those in some developing countries), and their development of alternative energy sources and technology transfer, developing nations could soon follow suit.

Continued procrastination by most of the industrialized world will lead to much higher costs in the long run. Ignoring the possibility of a "tipping point", beyond which climate warming could no longer be controlled, risks the threat of a global environmental and economic disaster.

To read more visit:
http://www.cmos.ca/ChangingAtmosphere1988e.pdf for the English version and http://www.cmos.ca/ChangingAtmosphere1988f.pdf pour la version française.

The Changing Atmosphere:
Implications for Global Security

1988 Toronto Conference Statement Summary

Humanity is conducting an unintended, uncontrolled, globally-pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being changed at an un-precedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe.

Far-reaching impacts will be caused by global warming and sea-level rise, which are becoming increasingly evident as a result of continued growth in atmospheric concentrations of carbon dioxide and other greenhouse gases. Other major impacts are occurring from ozone-layer depletion resulting in increased damage from ultra-violet radiation. The best predictions available indicate potentially severe economic and social dislocation for present and future generations, which will worsen international tensions and increase risk of conflicts among and within nations. It is imperative to act now.

These are the major conclusions of the World Conference of The Changing Atmosphere: Implications for Global Security, held in Toronto, Ontario, Canada, June 27-30, 1988. More than 300 scientists and policy makers from 46 countries, United Nations organizations, other international bodies and non-governmental organizations participated in the sessions.

The Conference called upon governments, the United Nations and its specialized agencies, industry, educational institutions, non-governmental organizations and individuals to take specific actions to reduce the impending crisis caused by pollution of the atmosphere. No country can tackle this problem in isolation. International cooperation in the management and monitoring of, and research on, this shared resource is essential.

The Conference called upon governments to work with urgency towards an *Action Plan for the Protection of the Atmosphere*. This should include an international framework convention, while encouraging other standard-setting agreements along the way, as well as national legislation to provide for protection of the global atmosphere. The Conference also called upon governments to establish a *World Atmosphere Fund* financed in part by a levy on the fossil fuel consumption of industrialized countries to mobilize a substantial part of the resources needed for these measures.

Correcting the Wind Bias in Snowfall Measurements Made with a Geonor T-200B Precipitation Gauge and Alter Wind Shield

by Craig D. Smith[1]

Résumé [Traduit par la direction] : Pour plusieurs réseaux nationaux d'observation, incluant le Réseau canadien de stations climatologiques de référence, le capteur des précipitations Geonor T-200B avec un seul écran de vent d'Alter sert d'aménagement standard aux capteurs des précipitations, quelles que soient les conditions météorologiques. Étant donné que la plupart des observations des capteurs des précipitations sont enclins à fournir de grandes erreurs du biais-vent (en particulier lorsqu'on mesure des précipitations neigeuses), on se devait de trouver une relation dans l'ajustement du biais. Les rendements de capture du capteur Geonor T-200B, à la fois aménagé avec un seul écran de vent d'Alter et un grand écran à double paroi, ont été comparés à la capture du capteur de Référence Comparative aménagé avec écran à Double Paroi (RCDP) au lac Bratt en Saskatchewan. En conséquence, la relation de capture efficacité-vitesse du vent peut être utilisée pour ajuster le biais-vent de n'importe quel autre capteur. En règle générale, ces relations de capture efficacité-vitesse du vent ont été développées en utilisant les observations quotidiennes des précipitations produisant des données quotidiennes ajustées. Pour des observations des précipitations faites manuellement sur une base quotidienne, on a dû apporter un ensemble de règles pour les ajustements quotidiens. Toutefois, comme les observations des précipitations deviennent de plus en plus automatisées et fournissent des mesures à des échelles de temps plus petites (par exemple de façon horaire), on a besoin évidemment d'un nouvel ensemble de règles pour les ajustements. En utilisant comme référence une grande résolution automatisée, cet étude examine la faisabilité de développer des relations pour les ajustements avec l'objectif d'ajuster le biais-vent à une grande résolution temporelle.

1. Introduction

The most significant systematic environmental error in the measurement of precipitation is due to wind. Any precipitation gauge installed above the surface of the ground introduces a barrier to the flow of air around (and over) the gauge. The severity of this deflection is related to the profile of the gauge, the height of the gauge above the surface and the wind speed at the height of the gauge (Sevruk et al, 1991). Turbulent air flowing over the gauge orifice deflects falling hydrometeors, preventing them from entering the collector and therefore creating an under-estimation of true precipitation. This under-estimation is exacerbated for solid precipitation (Goodison, 1978; Goodison et al, 1989) since frozen hydrometeors typically have slower fall speeds than liquid hydrometeors and are therefore affected more by wind turbulence around a precipitation gauge. As a result, winter precipitation events in cold regions can be under-estimated by up to 100% (Goodison and Yang, 1995).

Climate studies, hydrological modelling and water resource and weather forecasters require homogenous precipitation data. However, the homogenization of precipitation data is not trivial because the severity of the wind bias is dependent on other factors besides those that are environmental. Every gauge type and wind shield configuration will be affected differently by wind and therefore need to be examined. Several national agencies including those in Canada, the United States and Europe have been using the Geonor T-200B accumulating precipitation gauge and Alter shield to measure winter precipitation for more than a decade in their national observation networks and research programs. The wide-spread use of this gauge in various climatic regimes necessitates continued development of bias adjustment and homogenization procedures for this instrument.

2. Study Site and Instrumentation

Environment Canada has several precipitation gauge intercomparison facilities in contrasting climate regimes across Canada. In 2003, the Bratt's Lake, Saskatchewan facility was upgraded to include Geonor precipitation gauges. The research facility is located approximately 20 km south of Regina, Saskatchewan, Canada (Figure 1), and is centered in an agricultural area which exhibits very little topographical relief and only short vegetation cover. This long fetch and high exposure results in relatively high wind speeds at any time of the year, which makes this facility unique from the other Environment Canada intercomparison sites. The average annual temperature and precipitation for this region is 2.8 ºC and 388 mm respectively with snowfall (> 0.2 cm) occurring an average of 57 days of the year (comprising 22% of the annual precipitation).

Note from the Author: This article was originally submitted as an extended abstract to the *14th Symposium on Observations and Instrumentation* hosted by the American Meteorological Society in San Antonio, Texas, and is included in the 2007 proceedings of the AMS annual meeting.

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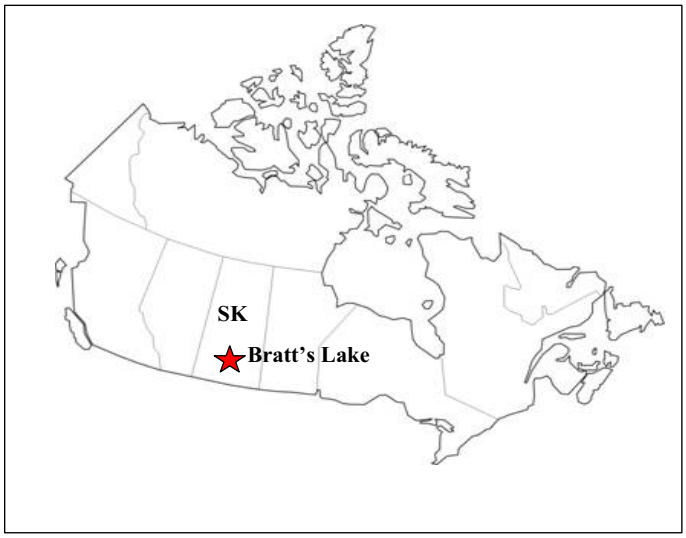

Figure 1: Location of the Bratt's Lake intercomparison facility on the Canadian prairies.

The Bratt's Lake facility hosts a Double Fence Intercomparison Reference (DFIR) gauge which is the World Meteorological Organization (WMO) reference for the measurement of solid precipitation (see Goodison et al, 1998 for design specifications). Manual DFIR observations were made daily or twice daily. Geonor T-200B gauges were installed in two configurations: the single Alter (which is currently the standard configuration in the Canadian Reference Climate Station network) and the large double octagonal fence (with the same dimensions as the DFIR). These configurations are shown in Figure 2. Geonor bucket weights were obtained every 15 minutes with the differential bucket weights used to determine accumulated precipitation over the desired period. Wind speed was measured at 2 m (approximately gauge height) and temperature at 1 m. Both wind speed and temperature were observed one per minute and averaged over the desired period. Precipitation type was observed manually coinciding with the DFIR observation. A Doppler based Precipitation Occurrence Sensing System (POSS) was operational at the site since February 2005 and used occasionally to confirm precipitation type between manual observations. Several other types of precipitation instrumentation were operational at the site but not discussed here.

Figure 2: Alter-shielded Geonor T-200B (left) and a Geonor T-200B in a large octagonal double fence (right).

3. Methodology

During the 2003-2006 cold seasons, 21 observation periods with lengths between 8 and 26 hours experienced snowfall greater than 2 mm (snow water equivalent as measured by the DFIR). Measurements less than 2 mm were eliminated from the analysis to avoid high relative errors in the calculation of catch gauge catch efficiency (CE). The wetting loss error for the DFIR was determined experimentally from procedures outlined in Goodison et al (1998) to be 0.13 ± 0.03 mm. Every DFIR measurement was corrected for wetting loss prior to being adjusted for wind under-estimation. The DFIR wind adjustment was based on the DFIR catch efficiency (CE) for dry snow as compared to a bush gauge (Yang et al, 1993). The CE (expressed as a percentage of "true" catch) for the DFIR is described as:

$$CE(\%) = 100 + 1.89Ws + 6.54*10^{-4}Ws^3 + 6.54*10^{-5}Ws^5 \quad (1)$$

where Ws is the wind speed (m s^{-1}) measured at gauge height and averaged over the observation period. No corrections were made for evaporation.

For intercomparison with the DFIR, the 15-minute precipitation measurements made with the Geonor gauges were accumulated to the same period as the DFIR observations. Because the Geonor gauges are weighing gauges, no adjustments were necessary for wetting loss. Light weight motor oil was used to prevent evaporation and a 2:3 mixture of propylene glycol and methanol was used to melt collected snowfall. The CE was calculated for each observation as a ratio of the Geonor accumulated catch to the adjusted DFIR observation.

4. Results

4.1 Relative catch efficiency

The relative catch efficiencies for snow and rain for the 2003-2006 periods are shown in Figure 3. During the 21 observation periods where precipitation was greater than 2 mm, a total of 122 mm was measured by the DFIR. The relative catch of the Geonor in the double fence (Geonor-DF) was 86% while the relative catch of the Alter-shielded Geonor (Geonor-Alt) was 36%. The average wind speed during these snowfall events was greater than 5 m s^{-1}.

These CE data showed that the catch for the Geonor-DF is relatively high but the Geonor-Alt catch is substantially lower. It is believed that these CE values are typical for most precipitation measurements made throughout the Canadian prairies and arctic. Although a wind correction for the Geonor-DF is desirable, a correction for the Geonor-Alt is absolutely necessary.

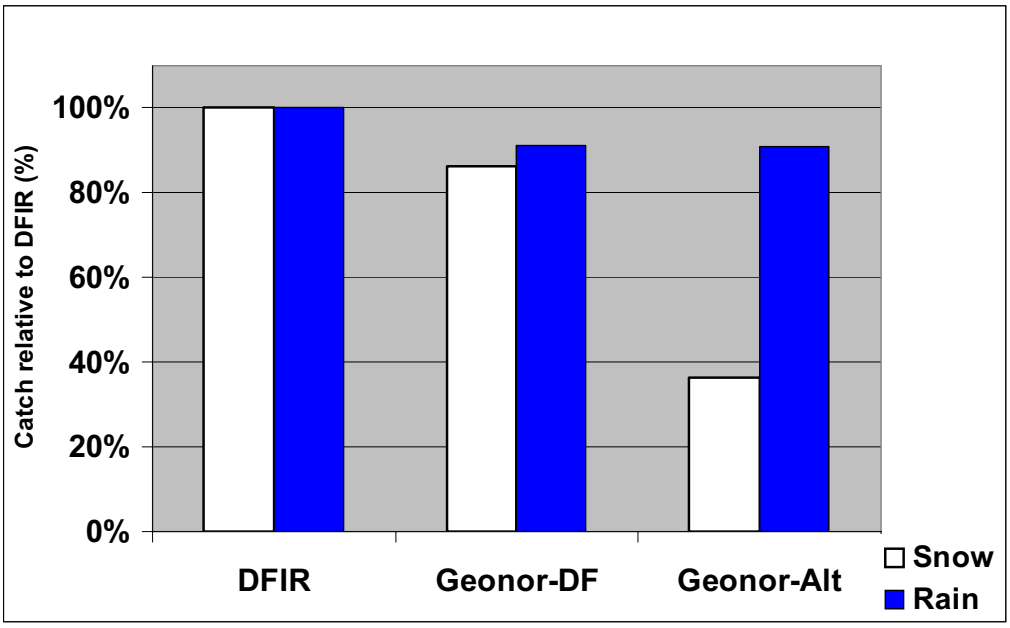

Figure 3: Relative catch of snow and rain (for observations > 2 mm) as compared to the DFIR for the 2003-2006 period at Bratt's Lake, SK..

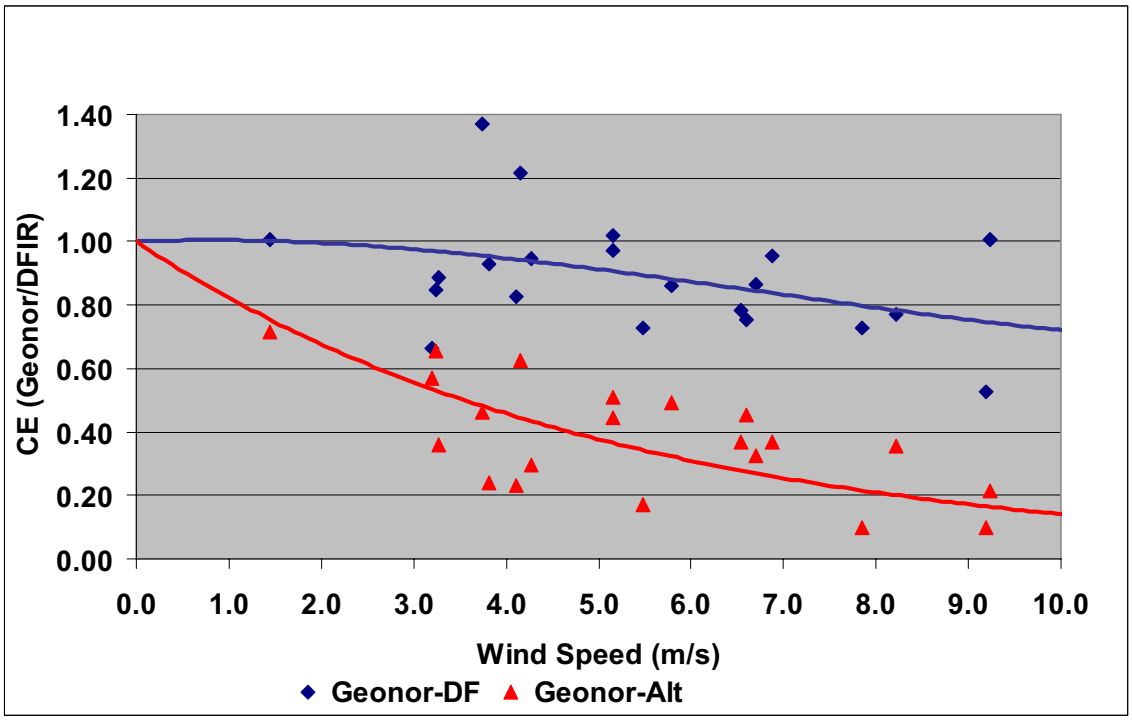

Figure 4: Relationships between catch efficiency for snow and wind speed at gauge height for the Geonor-DF (blue) and the Geonor-Alt (red).

4.2 Catch efficiency – wind speed relationships

Figure 4 shows the relationships between Geonor (-DF and -Alt) CE and wind speed at gauge height for the 21 snowfall events observed at Bratt's Lake. The best simple non-linear fit for the Geonor-DF was a 3rd order polynomial (Equation 2) exhibiting a correlation coefficient (r) of -0.40. The best fit for the Geonor-Alt was exponential (Equation 3) with a correlation of -0.60. Both curves had a forced intercept of 1.0 which followed the assumption that CE increases to 1 as wind speeds decrease to 0 m s^{-1}.

$$CE_{(Geonor\text{-}DF)} = 0.0004Ws^3 - 0.0077Ws^2 + 0.0118Ws + 1 \quad (2)$$

$$CE_{(Geonor\text{-}Alt)} = \exp(-0.20Ws) \quad (3)$$

4.3 Adjusted precipitation

An adjustment factor for the two gauge configurations can be calculated as 1/CE, where CE is determined using Equations 2 and 3 with the average wind speed during the observation. After applying the adjustment, the root mean square error for the Geonor-DF and Geonor-Alt were 1.3 and 2.6 mm respectively (as compared to 1.6 and 4.3 mm prior to adjustment). Adjusted and unadjusted precipitation accumulations for the 21 periods for each gauge configuration are shown in Figure 5.

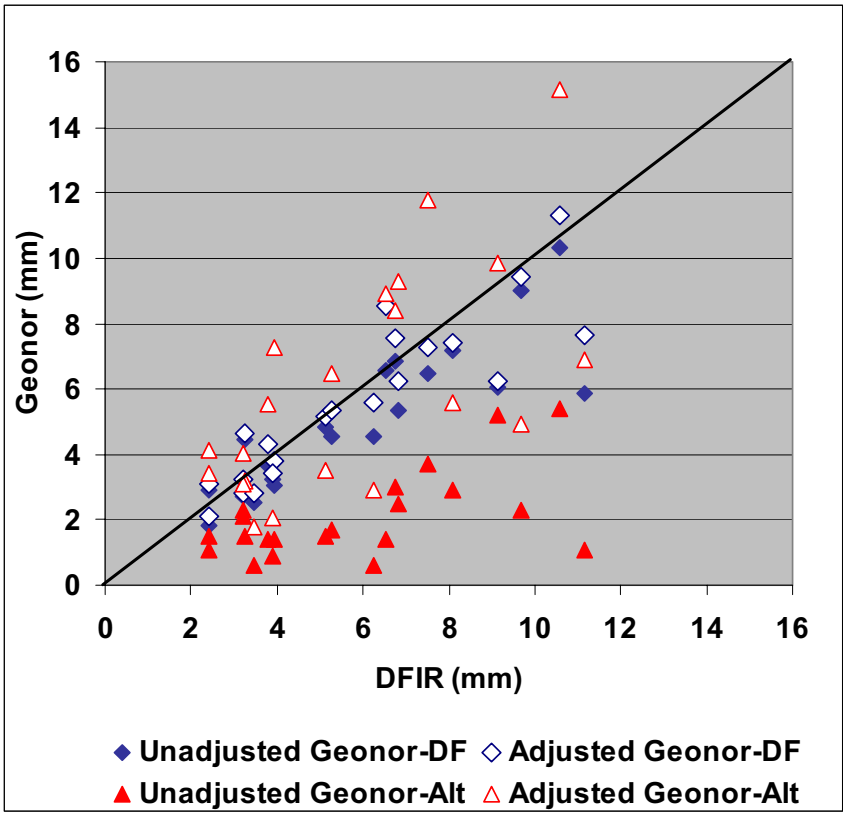

Figure 5: Adjusted and unadjusted accumulated precipitation for each of the 21 observation periods measured by the Geonor-DF (blue) and Geonor-Alt (red) as compared to the DFIR. 1:1 line is shown in black.

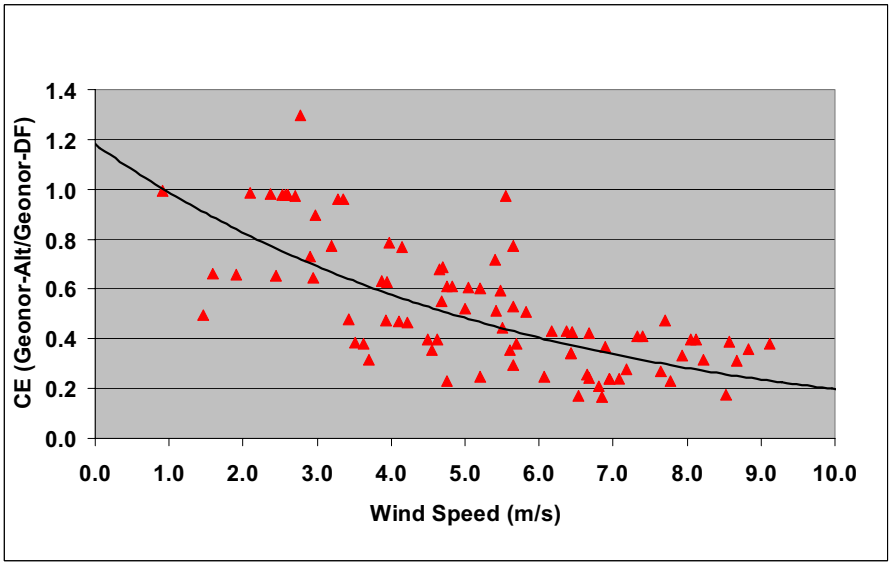

Figure 6: Relationship between catch efficiency of snow and wind speed for the Geonor-Alt where CE is determined using the adjusted Geonor-DF as the reference at intervals of 1-hour.

4.4 Adjustments at various time scales

Accurate snowfall observations are often required in near real-time. There are several issues that prevent real-time bias corrections in Canada. Firstly, most, if not all wind bias relationships have been developed for longer time periods (i.e. 12 to 24 hours). This is largely because of the limitations of manual observations (either precipitation or wind speed). With near continuous high-resolution measurements of precipitation and wind speed, this is no longer an issue. Secondly, there are usually limitations to continuous precipitation typing. Adjustment algorithms are dependent on precipitation type so this information is required for near-real time adjustments. Although beyond the scope of this paper, solutions are becoming available.

The adjustment curves for the Geonor-DF and Geonor-Alt (Equations 2 and 3; Figure 4) were applied directly to the 15-minute observations that comprise the 21 observations periods discussed above. The result was favourable for the Geonor-DF (bringing the adjusted accumulated total up to 99%) but produced an over-adjustment of approximately 16% for the Geonor-Alt. Equation 3 tends to over-adjust the Geonor-Alt at higher wind speeds, more so than Equation 2 with the Geonor-DF adjustments. This is exacerbated by

the fact that wind speeds were typically higher when the average was confined to shorter intervals during precipitation (rather than averaging over the entire observation period). This suggests that a new relationship and adjustment protocols are required for the Geonor-Alt at shorter intervals.

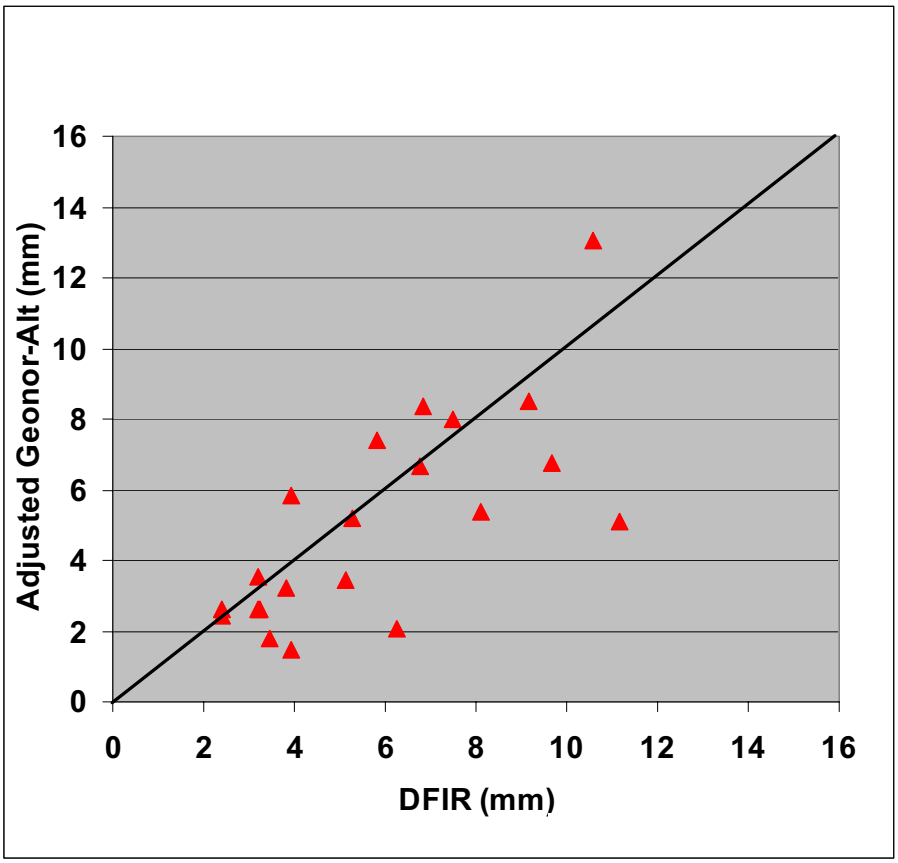

Figure 7: Adjusted (1-hour intervals) Geonor-Alt vs. the DFIR for each of the 21 observation periods (1:1 line shown in black).

Because the DFIR measurements are only made 1x or 2x daily, it cannot be used to calculate CE at shorter intervals. For this purpose, the Geonor-DF was adjusted for wind at 1-hour intervals using Equation 2 and used as the reference for calculating hourly CE for the Geonor-Alt. Observations less than 0.2 mm were eliminated to avoid large relative errors in the CE calculations. CE was then compared to the hourly averaged wind speeds resulting in an adjustment curve (Figure 6). As in Equation 3, the relationship is exponential with a correlation of -0.72 (Equation 4).

$$CE_{(Geonor\text{-}Alt)} = 1.18 * \exp(-0.18Ws) \qquad (4)$$

From Figure 6, the exponential decrease in CE of the Geonor-Alt with increasing wind is similar to that shown in Figure 4 (Equation 3). However, this relationship is not forced through an intercept of 1. Unlike Figure 4, the 1-hour data suggests that CE for the Geonor-Alt is 1 at wind speeds up to 1.2 m s^{-1}. After applying Equation 4 with 1-hour average wind speeds to adjust the 1-hour Geonor-Alt observations, the total accumulated catch for the 21 observation periods became 87% of the DFIR catch. The comparison for each of the 21 observations is shown in Figure 7. Equation 4 was also applied to the high resolution 15-minute precipitation observations using 15-minute wind speeds. The accumulated results were very similar to those shown in Figure 7.

5. Discussion

The precipitation catch efficiency data shown above for the Geonor T-200B is typical for a relatively cold, dry, and windy environment such as the Canadian prairies and arctic. Gauge catch with an Alter shield configuration was shown to decrease exponentially with increasing wind speed. This result is consistent with other accumulating automatic gauges with similar profiles and Alter wind shields (for example, see Goodison, 1978 and Goodison et al, 1998).

The lack of precipitation observations at lower wind speeds (< 3 m s^{-1}) at the Bratt's Lake facility (Figure 4) reduces the confidence in adjustments at lower wind speeds. However, intercomparison data collected as part of the WMO Solid Precipitation Measurement Intercomparison (Goodison et al, 1998) in Finland suggests a very similar curve for the Geonor T-200B at lower wind speeds (Yang, personal communication).

The application of the relationships seen in Figure 4 (Equations 2 and 3) at shorter time intervals adequately adjusted the Geonor-DF but resulted in an over adjustment of the Geonor-Alt and produced large errors in some individual observation periods. Equation 3 tended to over-adjust observations at higher wind speeds. Also, 1-hour wind speed averages confined to the occurrence of precipitation usually resulted in higher wind speed averages. By using the higher resolution observations of wind speed and adjusted Geonor-DF precipitation as the reference, a more robust relationship was developed so that precipitation could be adjusted at shorter intervals. Results showed that the CE calculated at shorter intervals also decreased exponentially with increasing wind speeds. However, it appeared that the CE for the Geonor-Alt remained 1 at wind speeds up to 1.2 m s^{-1}. This was not unexpected as the shield should nearly eliminate the turbulent effects of the wind on catch up to some wind speed threshold. The large double fence had the same effect up to a higher wind speed (4-5 m s^{-1}).

After adjusting the 1-hour Geonor-Alt measurements, the total precipitation accumulated over the 21 periods was 106 mm, or 87% of the DFIR total. Although significantly better than the original unadjusted total of 36%, the 1-hour adjustment still produced an under-estimate. The problem appears to be inherent in the 1-hour adjustment of the Geonor-DF using Equation 2, followed by the use of the adjusted Geonor-DF as the reference in the development of Equation 4. This, combined with random error, resulted in the under-adjustment of the accumulated 1-hour Geonor-Alt observations. More validation periods are required to assess this adjustment procedure.

Accurately measuring precipitation, especially snowfall, is still very difficult. Because of the large systematic errors involved in measuring snowfall, each precipitation gauge type and wind shield configuration needs to be closely compared to the WMO reference in order to develop adjustment curves for wind. In addition, snowfall measurements need to be compared to a reference at various time scales since the adjustment curve will change as the accumulation (and wind averaging) period becomes shorter. At observation periods less than 12 hours, the utility of the DFIR as the reference for snowfall becomes less. It is suggested that an automated reference be examined to replace the manual DFIR for future automated gauge intercomparisons.

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An Evaluation of the Effectiveness of the Double Alter Wind Shield for Increasing the Catch Efficiency of the Geonor T-200B Precipitation Gauge

by Stephnie Watson[1], Craig D. Smith[2], Marvin Lassi[3] and Joe Misfeldt[1]

Résumé [Traduit par la direction] : On sait très bien que le vent est responsable des nombreuses erreurs systématiques lors de la mesure des précipitations avec le capteur. Avec des vents présentant des degrés variés d'efficacité, on a utilisé différentes dispositions de l'écran de vent pour réduire le biais lors de la capture des précipitations par le capteur. Cette étude examine les rendements de capture relatifs entre l'écran double de vent d'Alter, et à la fois avec un seul écran d'Alter et un grand écran à double paroi octogonale, chacun utilisant un capteur de précipitations Geonor T-200B. Les données comparatives ont été observées de novembre 2006 à mai 2008 à trois endroits différents au Canada; au lac Bratt, SK, au lac Pickle, ON et à Thunder Bay, ON. Pour la pluie, les résultats montrent que les dispositions de l'écran de vent sont efficaces, car on a constaté que le biais-vent est presque éliminé. Pour la neige, on a montré que l'utilisation de l'écran double de vent d'Alter réduit le biais-vent si on le compare avec un seul écran d'Alter, mais la réduction n'est pas aussi efficace que l'utilisation d'un grand écran à double paroi octogonale. En utilisant un biais-vent ajusté au capteur Geonor pour un grand écran de vent à double paroi comme référence, on a développé, pour l'écran double de vent d'Alter avec capteur Geonor du lac Bratt, une relation de capture efficacité-vitesse du vent. Cette relation peut être utilisée pour ajuster le biais-vent de n'importe quel autre écran double de vent d'Alter avec capteur Geonor pour des observations de précipitations neigeuses.

1. Introduction

There are several sources of error associated with the gauge measurement of precipitation. These include evaporation, wetting loss, splashing, blowing snow, wind under-catch and random error. The most significant of these errors is usually the systematic under-catch of precipitation caused by wind. This phenomenon is well documented and is explained in greater detail by Goodison et al. (1981), Sevruk (1982), Sevruk and Hamon (1984) and Goodison et al. (1998). When a precipitation gauge is installed above the surface of the ground, it creates a barrier to the flow of air around the gauge and causes airflow to be deflected over the top of the gauge. During precipitation, airflow over the orifice of the gauge can deflect falling hydrometeors and prevent them from entering the gauge. This creates a negative bias in the measurement. The gauge bias due to wind is exacerbated for the measurement of snow due to the slower fall speeds of snow as compared to rain, leading to a higher probability of deflection by wind flowing around and over the gauge. The bias is also influenced by the profile and height of the gauge, the configuration of the wind shield and, of course, the wind speed at gauge height.

Various wind shields have been used as a means to reduce the wind bias in gauge measurements. Goodison et al. (1998) provides a comprehensive description and intercomparison of various wind shields for increasing the gauge catch efficiency of snow. Some of the more commonly used wind shield designs in Canada are the Nipher, the large octagonal double fence (which, when paired with a manually observed Tretyakov gauge, comprises the World Meteorological Organization Double Fence Intercomparison Reference or DFIR) and the Alter shield. This study examines the relative effectiveness of the single and double Alter shields, as compared to the large octagonal double fence, for increasing the gauge catch of precipitation.

The large octagonal double fence wind shield has an outside fence diameter of 12 m and stands at a height of 3.5 m. The inner fence has a diameter of 4 m and a height of 3 m. As noted above, the large double fence is often paired with a Tretyakov precipitation gauge that is mounted 3 m off the ground, thus comprising the DFIR. However, it can be paired with any precipitation gauge such as the Geonor T-200B. The single Alter shield has a 1.2 m diameter ring from which hangs free swinging metal fins that surround the gauge in the centre. The double Alter shield has a similar design but employs a second larger outside ring (usually with a diameter of 2.4 m). Each of these designs has been shown to increase the catch efficiency (especially for snowfall) of the precipitation gauge with which they are paired (relative to no wind shield) but this effectiveness varies substantially depending on the gauge/shield configuration (Goodison, et al. 1998). Understanding how effective these various configurations are at reducing the wind bias is important so that appropriate adjustments can be made to assure data homogenization.

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Site	Latitude	Longitude	Elevation (m)	Annual Precipitation (mm)	Average Temperature (°C)	Average Snowfall (cm)	Average Wind Speed (m/s)
Bratt's Lake	50°12' N	104°42' W	584	388	2.8	105.9	5.2
Pickle Lake	51°27' N	90°12' W	391	717	-0.4	263.2	3.5
Thunder Bay	48°22' N	89°19' W	199	712	2.5	187.6	3.3

Table 1: Intercomparison sites description

The objective of this study is to evaluate the effectiveness of the double Alter wind shield when used with a Geonor T-200B precipitation gauge in reducing the measurement errors associated with the wind. A secondary objective is to be able to make recommendations on the practicality of upgrading Geonor T-200B installations from a single Alter to double Alter configurations. Currently, the Geonor T-200B with a single Alter configuration is the standard all-weather precipitation gauge in the Canadian Reference Climate Station (CRCS) network.

Figure 1: Location of the intercomparison sites at Bratt's Lake, SK (XBK), Pickle Lake, ON (WPL) and Thunder Bay, ON (ZTB).

2. Site Description

The three intercomparison sites used in this analysis are located at Bratt's Lake, Saskatchewan, Thunder Bay, Ontario and Pickle Lake, Ontario. The location of these sites is shown in Figure 1 and summarized in Table 1.

2.1 Bratt's Lake

The Bratt's Lake precipitation gauge intercomparison site (XBK) is located 34 km SW of Regina and is collocated with a Baseline Surface Radiation Network (BSRN) site operated by Environment Canada. The compound is located in an agricultural landscape which consists of little vegetation of substantial height and has little to no topographic relief. The result of this landscape is a very exposed site that experiences significant wind during most precipitation events. It is the windiest of the three sites with an average annual 10 m wind speed of 5.2 m/s.

The Bratt's Lake facility has been used as a precipitation gauge test bed facility for more than 10 years and hosts one of the few remaining true DFIR gauges in Canada. The site also hosts several Geonor T-200B gauges configured with various wind shields including single Alter (Geonor-SA), double Alter (Geonor-DA) and a large double fence (Geonor-DF), all shown in Figure 2. The Geonor-DA shield was installed in August 2006 while the other gauge configurations have been at the site for several years. Other precipitation instruments include a Belfort 3000 (single Alter), Hydrological Services TB3 (no shield), Vaisala VRG101 (double Alter), Canadian Nipher, SR50 sonic snow depth measurements and a standard pit gauge. These gauges are not employed in this analysis. Supporting meteorological measurements include air temperature and wind speed at a height of 2 m (which is approximately the height of the Geonor gauges).

2.2 Thunder Bay and Pickle Lake

The Thunder Bay and Pickle Lake sites are located at airports with the instrumentation set adjacent to the runway complexes. Average wind speeds at these sites are lower than at Bratt's Lake but the sites receive significantly more snowfall (Table 1).

The site at Thunder Bay airport (ZTB; Figure 3a) is surrounded by city and forest. The instrumentation is located in an exposed flat area with trimmed grass. The Pickle Lake airport site (WPL; Figure 3b) is located in a flat unvegetated clearing near the top of a hill surrounded by boreal forest. Both ZTB and WPL are equipped with a Geonor-SA and a Geonor-DA approximately 8 m apart. Both sites host supporting meteorological measurements such as wind speed at gauge height (2 m) and air temperature. Other precipitation instrumentation includes a Hydrological Services TB3 tipping bucket rain gauge and triple Campbell Scientific SR50 snow depth sensors.

3. Methods

The Geonor gauges at each of the three intercomparison sites measure bucket weights every 15 minutes, the differential weight being the 15-minute precipitation accumulations. The 15-minute data was manually quality controlled to remove any noise or false precipitation reports and the 15-minute data was accumulated for 24-hour periods. Both temperature and wind speeds observed at the sites were also averaged over the same 24-hour periods.

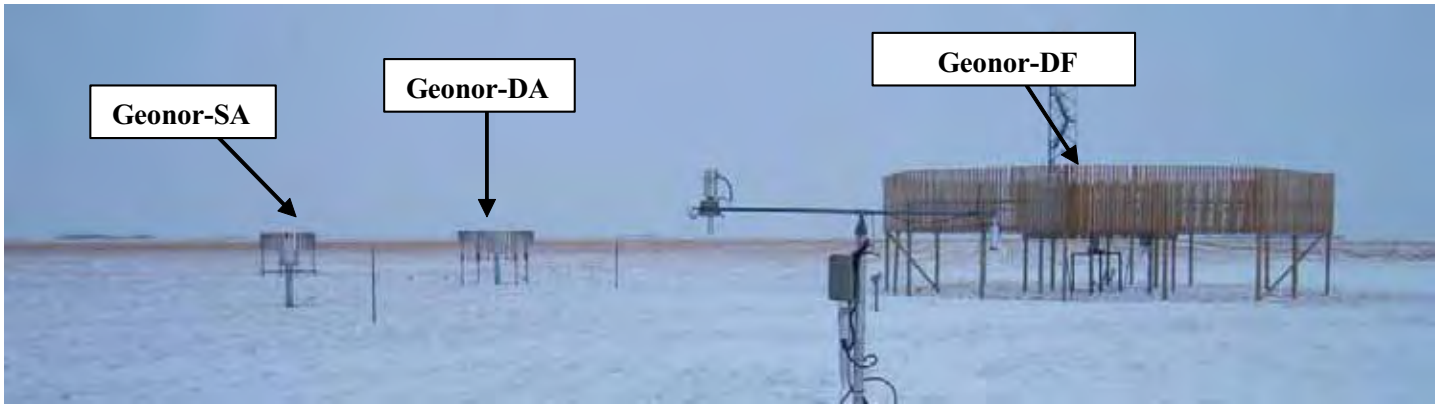


Figure 2: The Bratt's Lake intercomparison site containing Geonor T-200B precipitation gauges configured in a large octagonal double fence (right), a double Alter (center) and a single Alter (left) wind shield.

Figure 3: Top)Thunder Bay Geonor gauges with the single Alter shield in the foreground and the double Alter shield in the background. Bottom) Pickle Lake Geonors with the single Alter shield on the left and the double Alter shield on the right.

Daily accumulations less than 1 mm were eliminated from the analysis to avoid the occurrence of large relative errors in the catch ratio calculations. Precipitation events were divided into snow, rain and mixed precipitation by cross referencing the high frequency precipitation observations with hourly manual weather observations (when available) at the airports (the Regina airport observations were used to determine precipitation type for Bratt's Lake). Since no manual weather observations are made overnight at WPL, the last observation of the previous day and the first observation of the following day, as well as the evolution of overnight air temperature, were used to make an educated guess at dominant precipitation type.

4. Results

4.1 DA vs Geonor-DF

For the following analysis the Geonor-DF at Bratt's Lake was employed as the reference precipitation gauge. Previous intercomparisons between the Geonor-DF and the DFIR at Bratt's Lake (Smith, 2007) shows that the unadjusted Geonor-DF has a negative wind bias for snowfall of approximately 14%. From Smith (2007), the relationship between the gauge catch efficiency for snow and wind speed for the Geonor-DF (as compared to the DFIR) is:

$$CE_{DF} = 0.0004W_s^3 - 0.0077W_s^2 + 0.0118W_s + 1 \quad (1)$$

where CE is the gauge catch efficiency and W_s is the daily average wind speed in m/s. Daily Geonor-DF snowfall measurements during precipitation events with an average wind speed exceeding 5 m/s were corrected using Equation 1 and used as the reference for intercomparisons with the Geonor-DA. No wind bias adjustments were made for rainfall observations. Mixed observations were eliminated entirely.

The intercomparison of the catch of rainfall between the Geonor-DA and Geonor-DF shows that the Geonor-DA catches slightly more than the Geonor-DF (Figure 4a). This discrepancy is small and is a result of random error associated with one or two events (Figure 5a). However, the Geonor-DA only caught 66% of the total snowfall measured by the Geonor-DF (Figure 4b). This under-catch is obvious in Figure 5b and is correlated to wind speed. The relationship between wind speed and catch efficiency for the Geonor-DA (using the adjusted Geonor-DF as the reference) is:

$$CE_{DA} = \exp(-0.07W_s) \quad (2)$$

and is shown in Figure 6. The correlation (r^2) for this relationship is 0.35.

4.2 SA vs DA

It would be preferable to compare the relative catch of the Geonor-DA to Geonor-DF at all intercomparison sites but unfortunately this reference gauge is only available at XBK. However, the relative catch of the Geonor-DA can be compared to the catch of the Geonor-SA at all three sites. Figure 4a shows that the relative catch of rainfall is again very similar with differences less that 2% between the gauge configurations at each of the sites. This is confirmed by Figure 7a showing nearly a 1:1 catch ratio for each event at all sites. However, Figure 4b suggests that the Geonor-DA consistently catches more snowfall that the Geonor-SA. At XBK the Geonor-DA caught 54% more snow than the Geonor-SA. At WPL and ZTB the difference in snowfall catch between Geonor-DA and Geonor-SA was 15% and 21% respectively.This is illustrated further in Figure 7b which shows that the Geonor-DA is consistently catching more snowfall than the Geonor-SA at all sites.

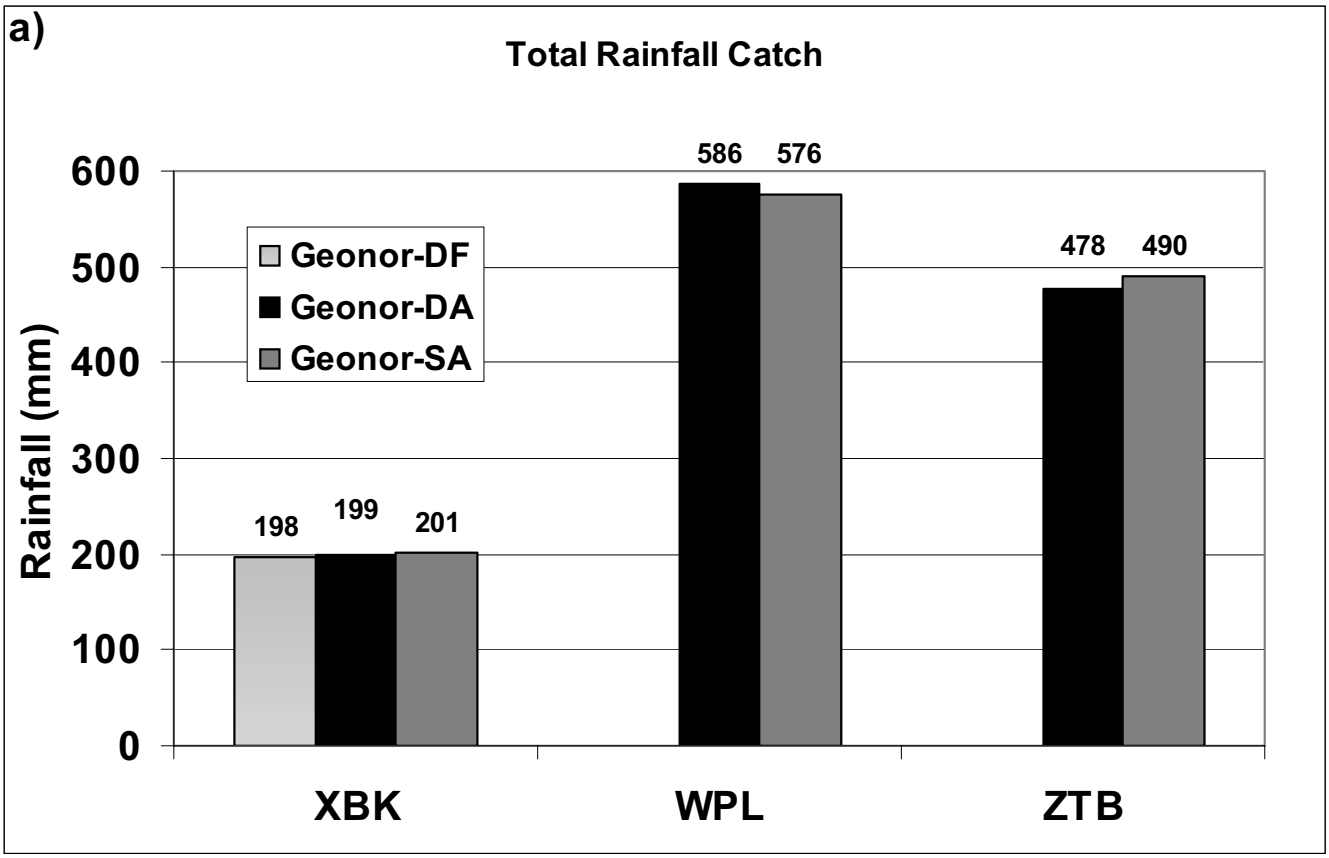
5. Discussion and Conclusions

The intercomparison between the Geonor-DF, Geonor-DA and Geonor-SA has shown that the Geonor T-200B experiences a substantial wind bias when measuring snowfall with either a single or double Alter configuration. However, the double Alter configurations consistently catch more snowfall than the single Alter configurations. At XBK, the snowfall CE of the Geonor-DA was 66% while the CE of the Geonor-SA was only 43%, representing a total increase in catch of 23% as referenced to the Geonor-DF. The r^2 for the CE_{DA} –Wind Speed relationship (Equation 2) of 0.35 is very similar to that of the previously reported relationship developed for the Geonor-SA (Smith, 2007).

The difference in relative catch of the Geonor-DA and –SA is largely dependent on wind speed with the discrepancy being lower at the less windy sites (15-21% at WPL and ZTB) and higher at the windy sites (54% at XBK). For rainfall, the difference in catch between the configurations is negligible.

An increase in the total catch of snowfall of 23% (at XBK) is substantial but still results in a negative bias of 34% (as compared to the Geonor-DF). Although this is significantly lower than the single Alter bias, an adjustment is still critical, especially at windier sites.

Based on this study, there are both advantages and disadvantages to the double Alter configuration employed with the Geonor T-200B. It has been shown that neither the single Alter nor the double Alter configurations are effective at eliminating the wind bias in the gauge measurement of snowfall so an adjustment of observations made with either configuration is necessary. Since the double Alter configuration substantially increases the catch of snowfall at windier sites, there are advantages in making wind bias adjustments to these larger values. This would serve to decrease the uncertainty in the adjusted value. A more complete assessment of this uncertainty is required.



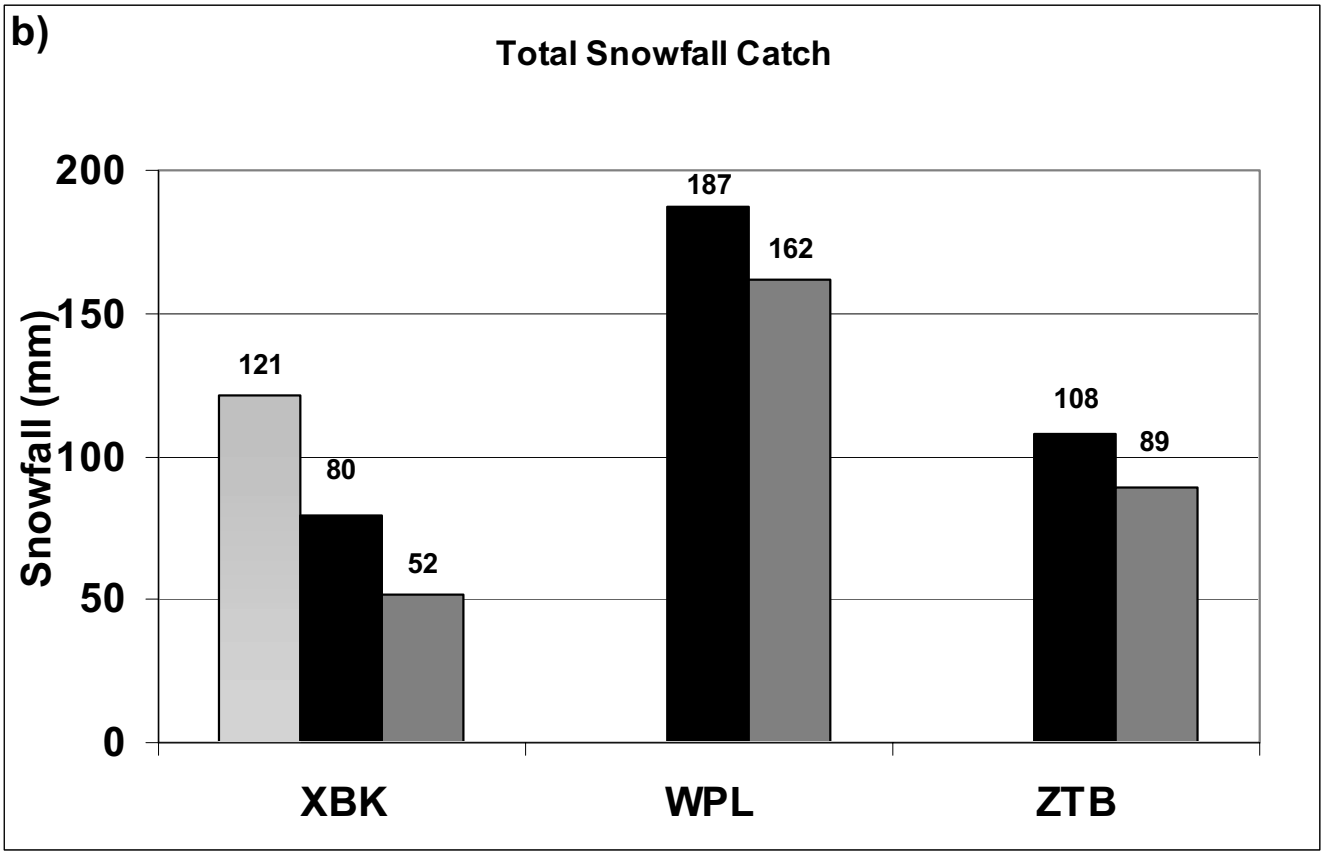


Figure 4: Comparison of total catch for Geonor-DF, Geonor-DA, and Geonor-SA gauge configurations for precipitation events greater than 1 mm from November 2006 through March 2008 at Bratt's Lake (XBK), Pickle Lake (WPL), and Thunder Bay (ZTB) for a)rain and b)snow.

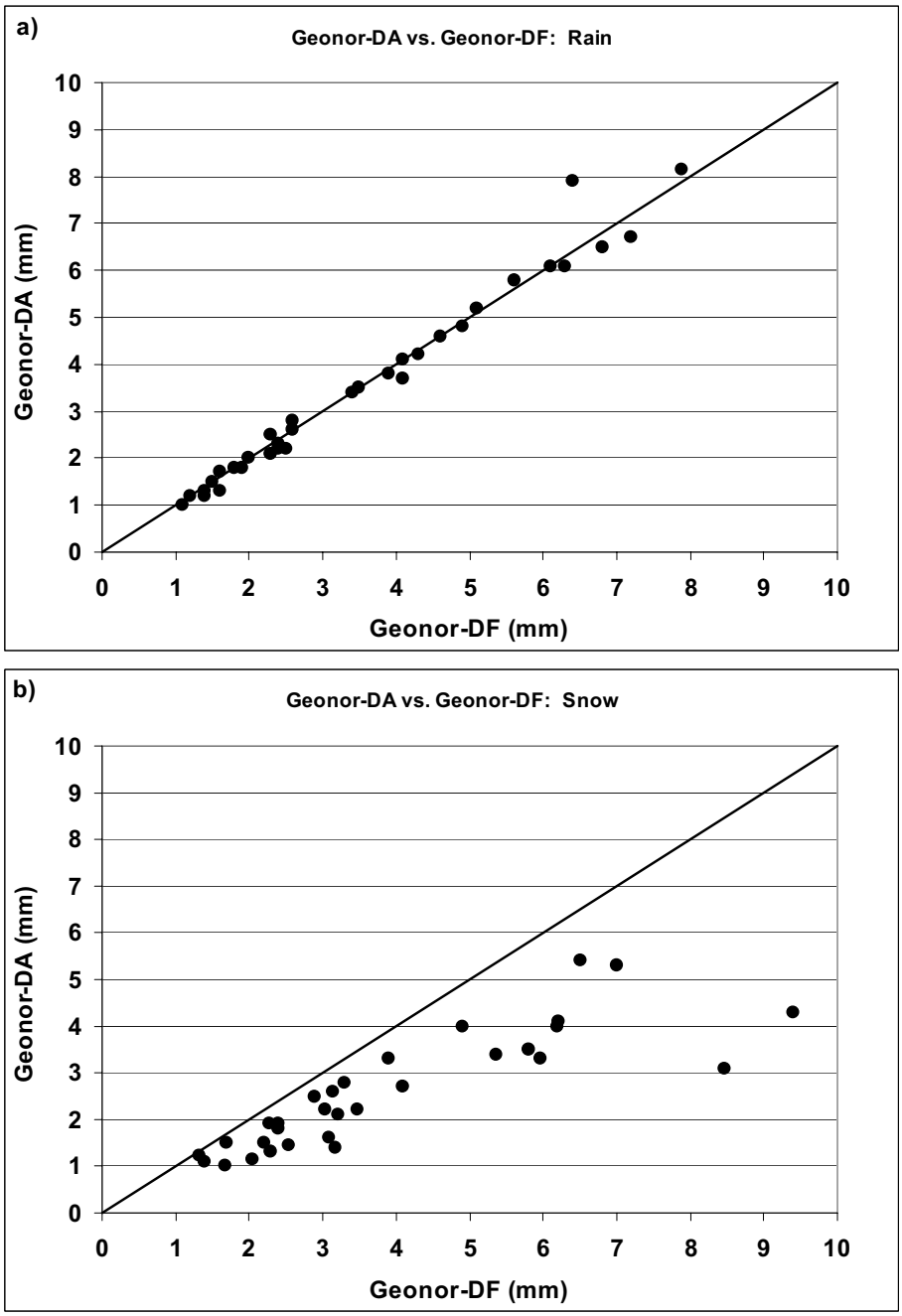


Figure 5: Precipitation gauge catch for the Geonor-DA as compared to the adjusted Geonor-DF for a) rain and b) snow at Bratt's Lake.

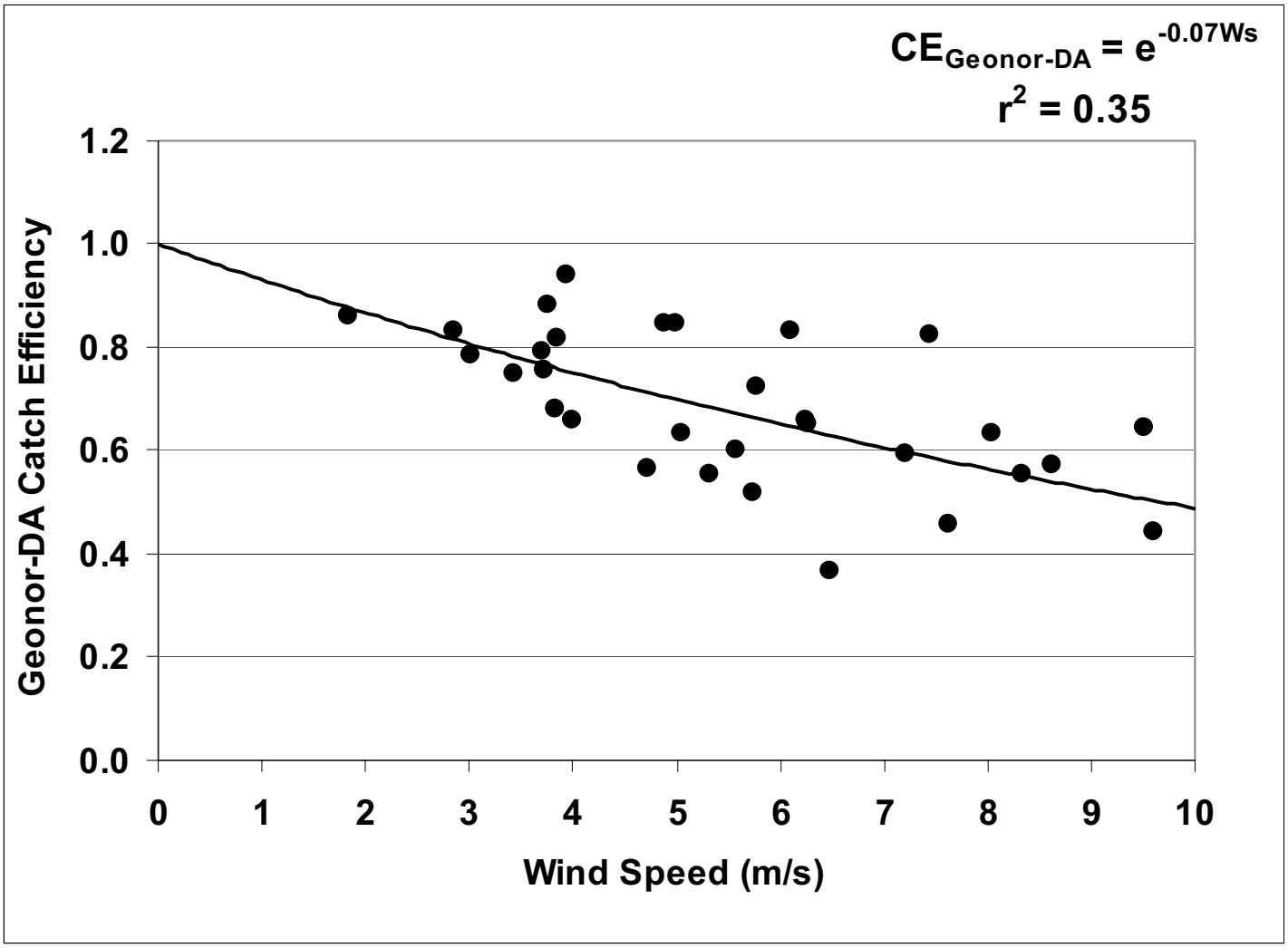


Figure 6: Catch Efficiency of the Geonor-DA as a function of wind speed. Catch efficiency is determined using the adjusted Geonor-DF as the reference.

There are several disadvantages to switching to the double Alter configuration. The installation of a double Alter wind shield (either at a new site or upgrading an existing site from a single Alter) represents a significant cost both in labour and in materials, albeit at a considerably less cost than for the large double fence. The other risk in upgrading existing or new gauge installations is to data homogeneity, where introducing yet another gauge/shield configuration into the observation network may be undesirable. This suggests that the decision to change the precipitation observation standard from the single Alter to the double Alter, whether at select windy sites or across a whole network, needs to be considered carefully.

Further double Alter intercomparisons are continuing and some modifications will be made to the configurations at XBK. The Geonor-DA configuration at XBK is currently installed with the top of both shield rings at 13mm above the gauge orifice (as recommended by the manufacturer for the single Alter installation). However, other intercomparisons of the Geonor-DA have shown that increasing the height of the outer ring (similarly scaled to the heights of the large double fence) may further alter the aerodynamics and improve the CE of the gauge (Bruce Baker, personal communication). This test will occur during the 2008-2009 snowfall season. Also, it is desirable to examine the CE – Wind Speed relationships for the Geonor-DA using a high quality reference (i.e. the Geonor-DF) at other intercomparison facilities in various climate regimes. As a beginning, this intercomparison is planned for the facility at the Centre for Atmospheric Research Experiments (CARE) in southern Ontario.

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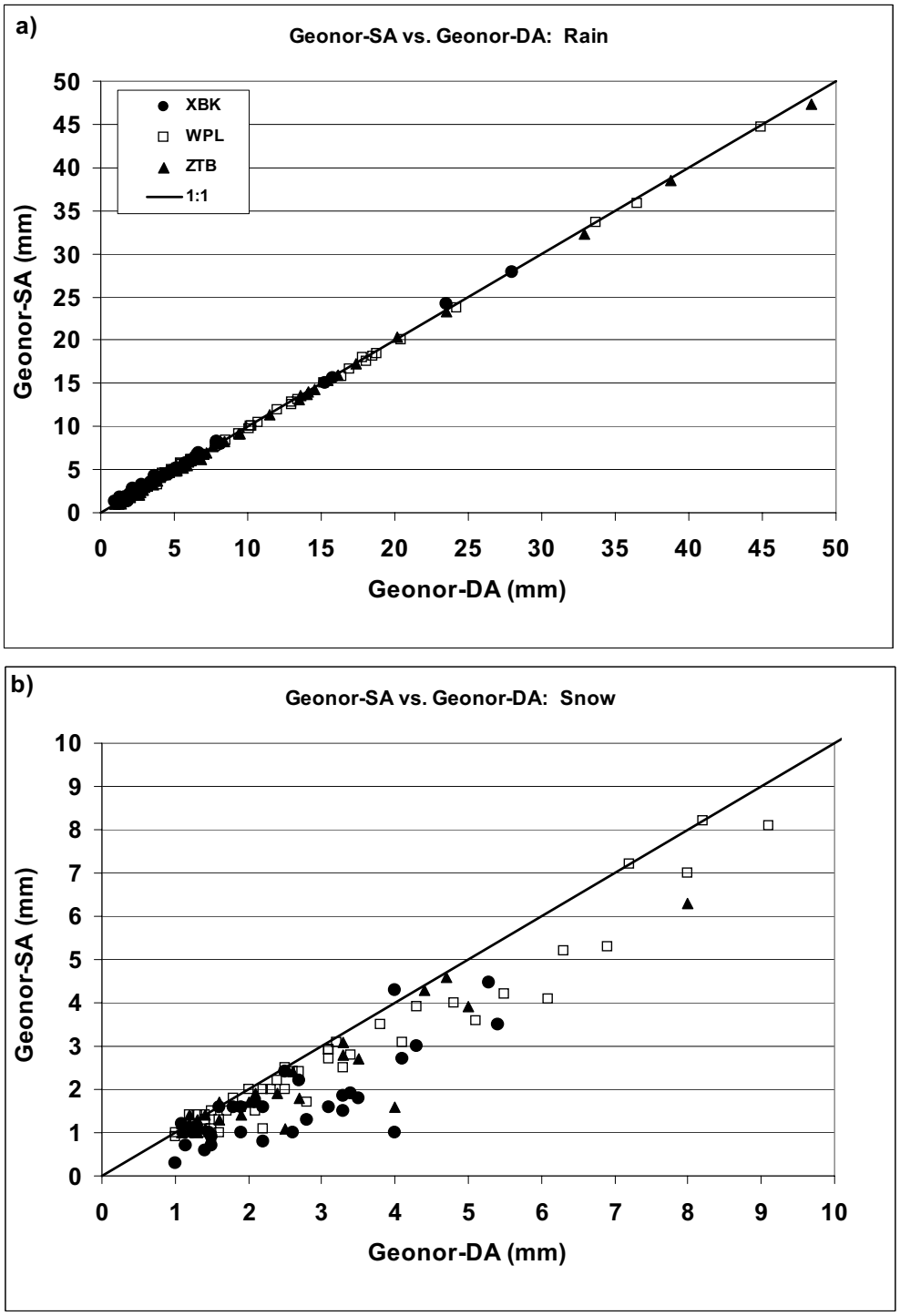

Figure 7: Precipitation gauge catch for the Geonor-SA as compared to the Geonor-DA for a)rain and b)snow at Bratt's Lake (XBK), Pickle Lake (WPL) and Thunder Bay (ZTB).

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Sea level responses to climatic variability and change in Northern British Columbia

DILUMIE S. ABEYSIRIGUNAWARDENA and IAN J. WAKER

Abstract already published in *CMOS Bulletin SCMO* Volume 36, No.3, June 2008, pp. 108-109 and reproduced here for convenient purpose to A-O readers.

Abstract
Sea level responses to climatic variability (CV) and change (CC) signals at multiple temporal scales (inter-decadal to monthly) are statistically examined using long-term water level records from Prince Rupert (PR) on the north coast of British Columbia. Analysis of observed sea level data from PR, the longest available record in the region, indicates an annual average mean sea level (MSL) trend of +1.4±0.6 mm yr^{-1} for the period (1939-2003), as opposed to the longer term trend of 1±0.4 mm yr^{-1} (1909-2003). This suggests a possible acceleration in MSL trends during the latter half of the twentieth century. According to the results of this study, the causes behind this acceleration can be attributed not only to the effects of global warming but also to cyclic climate variability patterns such as the strong positive Pacific Decadal Oscillation (PDO) phase that has been in existence since mid-1970s. The linear regression model based on highest sea levels (MAXSL) of each calendar year showed a trend (3.4 mm yr^{-1}) exceeding twice that of MSL. Previous work shows that the influence of vertical crustal motion on relative sea level is negligible at PR.

Relations between sea levels and known CV indices (e.g., the Multivariate ENSO Index (MEI), PDO, Northern Oscillation Index (NOI), and Aleutian Low Pressure Index (ALPI)) are explored to identify potential controls of CV phenomena (e.g., the El Niño Southern Oscillation (ENSO) and PDO) on regional MSL and MAXSL. Linear and non-linear statistical methods including: correlation analyses, multiple regression, Cumulative Sum (CumSum) analysis, and Superposed Epoch Analysis (SEA) are used. Results suggest that ENSO forcing (as shown by the MEI and NOI indices) exerts significant influence on winter sea level fluctuations, while the PDO dominates summer sea level variability. The observational evidence at PR also shows that, during the period 1939-2003, these cyclic shorter temporal scale sea level fluctuations in response to CV were significantly greater than the longer term sea-level rise trend, by as much as an order of magnitude and with trends over twice that of MSL. Such extreme sea level fluctuations related to CV events should be the immediate priority for the development of coastal adaptation strategies, as they are superimposed on long term MSL trends, resulting in greater hazard than longer term MSL rise trends alone.

Résumé [traduit par la rédaction]
Nous examinons, du point de vue statistique, les réponses du niveau de la mer aux signaux de variabilité climatique (VC) et de changement climatique (CC) à des échelles temporelles multiples (d'interdécennale à mensuelle) à l'aide des enregistrements de niveaux d'eau à long terme de Prince Rupert (PR) sur la côte nord de la Colombie-Britannique. L'analyse des données d'observation du niveau de la mer de PR, la plus longue série d'enregistrements dans la région, indique une tendance annuelle moyenne du niveau moyen de la mer (NMM) de +1,4±0,6 mm an^{-1} pour la période (1939–2003) comparativement à la tendance à plus long terme de +1±0,4 mm an^{-1} (1909–2003). Cela suggère une possible accélération des tendances du NMM durant la deuxième moitié du XXe siècle. Selon les résultats de cette étude, on peut attribuer les causes de cette accélération non seulement aux effets du réchauffement planétaire mais aussi à des configurations de variabilité climatique cycliques, comme la forte phase positive de l'oscillation décennale du Pacifique (ODP) qui perdure depuis le milieu des années 1970. Le modèle de régression linéaire basé sur les plus hauts niveaux de la mer (MAXSL) de chaque année civile a montré une tendance (3,4 mm an^{-1}) de plus du double de celle du NMM. Des travaux précédents montrent que l'effet des mouvements verticaux de la croûte terrestre sur le niveau relatif de la mer sont négligeables à PR.

Nous explorons les relations entre les niveaux de la mer et les indices VC connus — p. ex. l'indice ENSO multivarié (MEI), l'ODP, l'indice d'oscillation boréale (IOB) et l'indice de dépression des Aléoutiennes (ALPI) — pour identifier l'influence potentielle des phénomènes de VC — p. ex. le El Niño—oscillation australe (ENSO) et l'ODP — sur le NMM et le MAXSL régionaux. Nous utilisons des méthodes statistiques linéaires et non linéaires, notamment les analyses de corrélation, la régression multiple, l'analyse des sommes cumulées (CumSum) et l'analyse par époques superposées (SEA). Les résultats suggèrent que le forçage ENSO (comme le montrent les indices MEI et IOB) exercent une influence appréciable sur les fluctuations du niveau de la mer en hiver alors que l'ODP domine la variabilité du niveau de la mer en été. Les preuves observationnelles à PR montrent aussi que, durant la période 1939–2003, ces fluctuations cycliques du niveau de la mer de plus petite échelle temporelle en réponse aux phénomènes de VC étaient nettement plus importante que la tendance à la hausse du niveau de la

mer à plus long terme, par jusqu'à un ordre de grandeur et avec des tendances plus de deux fois plus grandes que celle du NMM. Des fluctuations du niveau de la mer aussi extrêmes liées aux événements de VC devraient constituer la priorité immédiate pour l'élaboration de stratégies d'adaptation côtière, puisqu'elles se superposent aux tendances du NMM à long terme et aggravent les dangers qui résultent de la seule tendance à la hausse du NMM à plus long terme.

Cloud type observations and trends in Canada 1953-2003

E. J. MILEWSKA

Abstract already published in *CMOS Bulletin SCMO* Volume 36, No.3, June 2008, pp. 107-108 and reproduced here for convenient purpose to A-O readers.

Abstract
The monitoring of cloud amount and type in Canada is discussed in detail, including observing, archiving, data transmission procedures and practices, and automation.

There have been some major monitoring challenges since 1953. In 1977, the network-wide replacement of detailed cloud layer amounts and obscuring phenomena by broad sky conditions, based on summation amounts, imposed analysis of frequency of occurrence of mainly cloudy conditions rather than actual amounts. Partial automation with Automated Weather Observing Systems resulted in the cessation of observations of higher clouds and cloud types, as well as the incompatibility of sky coverage with human observations at eight percent of stations.

For every hourly report from eighty-four airport stations, from 1953 to 2003, each layer is classified according to cloud type and related standard base height into three levels of low, middle, and high clouds. Trends in occurrence of summation amounts of mainly cloudy conditions at each of these three levels are computed on annual, seasonal, daytime and nighttime scales, together with annual trends in occurrence of selected convective and stratiform clouds. Based on annual anomalies averaged over the country and provinces, no major network-wide systematic discontinuities were noted; on average, on an annual basis over the entire network, slight decreasing trends are noted for summation amounts of mainly cloudy conditions at low and middle levels, and increasing trends at high levels.

The increasing trend at high levels is indeed remarkable. The rate of increase, especially rapid until 1974, has been shown to be caused by a prominent increase in cirrus cloud reports. The link between this rise and the increase in air traffic was established by others in the United States. This link may also apply in Canada, which experienced a similar expansion in aviation.

Notably, the largest increase in high nighttime cloudiness and decrease in low-middle cloudiness is evident in western Canada, possibly contributing to the recently observed warming of daily minimum and maximum temperatures there.

The occurrence of stratiform clouds at all levels exhibits significant decreasing trends across the country, except for southern Ontario. Clouds of intense convection show pronounced decreasing trends in western Canada, while not much change is evident elsewhere. Similar to cirrus, stratocumulus is notable as it shows strong positive trends everywhere in the country. On the other hand combined stratus and stratus fractus clouds exhibit decreasing trends except over British Columbia where the opposite occurs. The findings concerning stratocumulus, stratus and stratus fractus clouds in Canada are similar to the findings in the United States.

Résumé
Nous discutons en détail de la surveillance de l'étendue et du type des nuages au Canada, y compris l'observation, l'archivage, les procédures et pratiques de transmission des données et l'automatisation.

La surveillance a posé d'importants défis depuis 1953. En 1977, le remplacement à la grandeur du réseau des étendues détaillées des couches nuageuses et des phénomènes obscurcissants par des états du ciel généraux fondés sur les étendues cumulatives a imposé l'analyse de la fréquence des conditions principalement nuageuses plutôt que des étendues réelles. L'automatisation partielle au moyen de systèmes d'observation météorologique automatiques a entraîné la fin de l'observation du type de nuages et des nuages élevés de même qu'une incompatibilité de la couverture nuageuse avec les observations faites par des humains à huit pour cent des stations.

Pour chaque observation horaire à 84 stations d'aéroports, de 1953 à 2003, chaque couche est classée, selon le type de nuage et la hauteur de base normalisée correspondante, dans trois niveaux : nuages bas, moyens et élevés. Les tendances dans l'occurrence des étendues cumulatives des conditions principalement nuageuses à chacun de ces trois niveaux sont calculées aux échelles annuelle, saisonnière, diurne et nocturne en même temps que les tendances annuelles dans l'occurrence de nuages convectifs et stratiformes sélectionnés. D'après les anomalies annuelles moyennées pour le pays et les provinces, aucune discontinuité systématique importante dans l'ensemble du réseau n'a été trouvée; en moyenne, au cours d'une année dans l'ensemble du réseau, on observe de faibles tendances à la baisse pour les étendues cumulatives des conditions principalement nuageuses dans les niveaux bas et moyens et des tendances à la hausse dans les niveaux élevés.

La tendance à la hausse dans les niveaux élevés est en fait remarquable. Le taux d'accroissement, particulièrement rapide jusqu'en 1974, a été expliqué par

un accroissement important des observations de cirrus. D'autres chercheurs aux États-Unis ont établi le lien entre cet accroissement et l'accroissement du trafic aérien. Ce lien peut aussi s'appliquer au Canada, où le secteur de l'aviation a connu une expansion semblable.

Détail d'intérêt, la plus forte augmentation de nuages élevés la nuit et diminution de nuages bas ou moyens se produit dans l'ouest du Canada, ce qui contribue peut-être à la hausse des températures journalières minimales et maximales récemment observée dans cette région.

L'occurrence de nuages stratiformes à tous les niveaux accuse une tendance à la baisse appréciable dans tout le pays sauf dans le sud de l'Ontario. Les nuages de convection intense affichent une tendance à la baisse prononcée dans l'ouest du Canada alors qu'on ne constate pas beaucoup de changement ailleurs. Comme pour le cirrus, le stratocumulus est remarquable par les fortes tendances positives qu'il affiche partout au pays. D'autre part, le stratus et le stratus fractus combinés affichent des tendances à la baisse sauf en Colombie-Britannique où l'inverse se produit. Les conclusions tirées à propos du stratocumulus, du stratus et du stratus fractus au Canada concordent avec les conclusions tirées aux États-Unis.

Glacial Inceptions: Past and Future

LAWRENCE A. MYSAK

Abstract
The realistic simulation of northern hemisphere glacial inceptions, which occurred during the Quaternary period, has challenged scores of climate theoreticians and modellers. After reviewing the Milankovitch theory of glaciation, a number of earlier modelling studies on the last glacial inception (LGI) which have employed either high-resolution General Circulation Models (GCMs) or Earth system Models of Intermediate Complexity (EMICs) are described. The latter class of models has been developed over the past two decades in order to investigate the many interactions and feedbacks among the geophysical and biospheric components of the Earth system that take place over long time scales.

Following a description of the McGill Paleoclimate Model (MPM) and other EMICs, we present some recent McGill simulations of the LGI in response to orbital (Milankovitch) and radiative (atmospheric CO_2) forcings. Special attention is given to determining the relative roles of the ocean's thermohaline circulation, freshwater fluxes into the ocean, orography, cryospheric processes and vegetation dynamics during the inception phase. In particular, it is shown that with the vegetation-albedo feedback included in the model, the buildup of ice sheets over North America is larger than over Eurasia, in agreement with the observations.

This paper concludes with a discussion on the (possible) occurrence of the next glacial period. To address this issue, which has been inspired by recent publications of Berger and Loutre, MPM simulations of the climate for the next 100 kyr, which are forced by various prescribed atmospheric CO_2 levels, as well as the future insolation changes as calculated by the Berger algorithm are presented. The influence of a near-term global warming scenario on glacial inception is also examined. If it is assumed that after such a warming scenario the concentration of atmospheric CO_2 in the atmosphere returns to pre-industrial levels (in the range of 280-290 ppm), then the MPM predicts that the next glacial would start at around 50 kyr after present, which is consistent with results of Berger and Loutre. Finally, recent simulations of future glacial inceptions using the Potsdam EMIC which includes an atmosphere-ocean carbon cycle component are described. From one of these simulations in which 5000 GtC are released into the atmosphere due to human activities, it is concluded that the current interglacial will last for at least another half-million years because of the limited ability of the oceans to absorb such a large carbon release to the atmosphere.

Résumé [Traduit par la rédaction]
La simulation réaliste des débuts des périodes glaciaires qui se sont produites durant le Quaternaire dans l'hémisphère Nord a constitué un défi pour nombre de théoriciens et de modélisateurs du climat. Après un examen de la théorie de Milankovitch sur les glaciations, nous décrivons un certain nombre d'études de modélisation du début de la dernière période glaciaire (DDPG) faites précédemment et qui ont utilisé des modèles de circulation générale (MCG) à haute résolution ou des modèles de système terrestre de complexité intermédiaire (EMIC). Cette dernière classe de modèles a été mise au point au cours des deux dernières décennies dans le but d'étudier les nombreuses interactions et rétroactions se produisant entre les éléments géophysiques et biosphériques du système terrestre sur de grandes échelles de temps.

Après une description du modèle paléoclimatique de McGill (MPM) et d'autres EMIC, nous présentons certaines simulations récentes de McGill du DDPG en réponse aux forçages orbital (Milankovitch) et radiatif (CO_2 atmosphérique). Nous nous efforçons en particulier de déterminer les rôles relatifs de la circulation thermohaline océanique, des flux d'eau douce vers l'océan, de l'orographie, des processus cryosphériques et de la dynamique de la végétation durant la phase initiale. Nous montrons notamment qu'avec la rétroaction végétation-albédo incluse dans le modèle, l'accumulation de couches glaciaires sur l'Amérique du Nord est plus grande que sur l'Eurasie, conformément aux observations.

Cet article se termine par une discussion sur la (possible) prochaine période glaciaire. Pour étudier cette question, qui s'inscrit dans la foulée de publications récentes de Berger et Loutre, nous présentons des simulations du

MPM du climat des 100 000 prochaines années, qui sont basées sur un forçage par différents niveaux de CO_2 atmosphérique spécifiés de même que sur les variations futures de l'insolation telles que calculées au moyen de l'algorithme de Berger. Nous examinons aussi l'influence d'un scénario de réchauffement de la planète dans un avenir rapproché sur l'amorce d'une période glaciaire. Si l'on suppose qu'après un tel scénario de réchauffement, la concentration en CO_2 atmosphérique revient aux niveaux préindustriels (dans l'intervalle 280-290 ppm), alors le MPM prévoit que la prochaine glaciation commencerait dans environ 50 000 ans, ce qui correspond aux résultats de Berger et Loutre. Finalement, nous décrivons des simulations récentes de futurs débuts de période glaciaire réalisées avec l'EMIC de Potsdam, qui comporte une composante de cycle de carbone atmosphère-océan. L'une de ces simulations, dans laquelle 5 000 GtC sont libérées dans l'atmosphère par les activités humaines, mène à la conclusion que l'époque interglaciale actuelle durera au moins un autre demi-million d'années, à cause de la capacité limitée des océans d'absorber une aussi importante libération de carbone dans l'atmosphère.

Locally Generated Tsunamis Recorded on the Coast of British Columbia

ALEXANDER B. RABINOVICH, RICHARD E. THOMSON, VASILY V. TITOV, FRED E. STEPHENSON and GARRY C. ROGERS

Abstract

This study presents analyses and numerical simulation of local tsunamis generated by two recent earthquakes off the coast of British Columbia. The Queen Charlotte Islands earthquake (M_w = 6.1) on 12 October 2001 generated waves that were recorded by tide gauges at Bamfield, Tofino, Winter Harbour and Port Hardy on the coast of Vancouver Island, with maximum measured wave heights of 11.3, 18.2, 22.7 and 14.5 cm, respectively. The Explorer Plate earthquake off Vancouver Island (M_w = 6.6) on 2 November 2004 generated waves recorded only at Bamfield and Tofino, with smaller heights of 7.5 cm and 10.8 cm, respectively. The generation of tsunamis by these moderate M_w = 6.1-6.6 local earthquakes suggests the possibility of destructive tsunamis from local sources other than the Cascadia Subduction Zone. This, in turn, has implications for tsunami hazards for this seismically active region of coastal North America.

Résumé

Cette étude présente les analyses et la simulation numérique de tsunamis locaux produits par deux récents tremblements de terre au large des côtes de la Colombie-Britannique. Le tremblement de terre des îles de la Reine-Charlotte (M_w = 6,1), le 12 octobre 2001, a produit des vagues qui ont été enregistrées par des marégraphes à Bamfield, Tofino, Winter Harbour et Port Hardy sur la côte de l'île de Vancouver, avec des hauteurs de vagues maximales mesurées de 11,3, 18,2, 22,7 et 14,5 cm, respectivement. Le tremblement de terre de la plaque Explorer au large de l'île de Vancouver (M_w = 6,6), le 2 novembre 2004, a produit des vagues enregistrées seulement à Bamfield et Tofino, avec de plus faibles hauteurs, de 7,5 et 10,8 cm, respectivement. La production de tsunamis par ces tremblements de terre locaux d'intensité modérée (M_w = 6,1–6,6) suggère la possibilité de tsunamis destructeurs de sources locales autres que la zone de subduction Cascadia. Cela en retour donne à entrevoir les dangers liés aux tsunamis dans cette région d'activité sismique de l'Amérique du Nord côtière.

Southern Indian Ocean SST Variability and its Relationship with Indian Summer Monsoon

SHAILENDRA RAI and A.C. PANDEY

Abstract

Sea surface temperature (SST) variability in the Southern Indian Ocean (SIO) region and its relationship to Indian summer monsoon rainfall is investigated. Correlation analysis is used to determine the effect of SIO SST variability on Indian monsoons over a period of two years (eight seasons). A significant positive correlation is found between tropical SIO SST and the All India Rainfall Index (AIRI) in the March-May and December-February seasons before the onset of monsoon. The SST in the region south of 35°S is positively correlated with AIRI six, seven, and eight seasons before the onset of monsoon. A maximum correlation of 0.47 is found for the region south of 35°S, with a confidence level of 99%. Based on this correlation, we have defined SST indices for central SIO (CSIO), northwest of Australia (NWA), SIO, and Antarctic Circumpolar Current (ACC). These indices seem to be early predictors of Indian monsoons when their relationship with AIRI is examined. The predictive skill of these indices is also tested by multivariate linear regression. The consistency of this relationship is verified by the removal of the El Niño Southern Oscillation (ENSO) signal from SST data and is found to be unaffected by the ENSO signal, except in the region west of Australia.

Résumé

Nous étudions la variabilité de la température de la surface de la mer (TSM) dans la région de l'océan Indien méridional (OIM) et sa relation avec les pluies de mousson estivale dans l'Indien. Nous nous servons d'une analyse de corrélation pour déterminer l'effet de la variabilité de la TSM dans l'OIM sur les moussons dans l'Indien durant une période de deux ans (huit saisons). Nous trouvons une corrélation positive significative entre la TSM dans l'OIM tropical et le *All India Rainfall Index (AIRI)* durant les saisons mars–mai et décembre–février, avant l'établissement de la mousson. La TSM dans la région au sud de 35°S est positivement corrélée avec l'AIRI six, sept et huit saisons avant l'établissement de la

mousson. Nous trouvons une corrélation maximale de 0,47 pour la région au sud de 35°S, avec un degré de confiance de 99 %. En nous basant sur cette corrélation, nous avons défini des indices de TSM pour le centre de l'OIM (COIM), le nord-ouest de l'Australie (NOA), le OIM et le courant circumpolaire antarctique (CCA). Ces indices semblent être des prédicteurs précoces des moussons dans l'Indien quand nous examinons leur relation avec l'AIRI. Nous étudions aussi l'habileté prédictive de ces indices au moyen d'une analyse de régression multivariée. Nous vérifions la cohérence de cette relation par le retrait du signal de l'El Niño–Oscillation australe (ENSO) des données de TSM et nous trouvons qu'elle n'est pas influencée par le signal ENSO, sauf dans la région à l'ouest de l'Australie.

Multi-year observations of deep water renewal in Foxe Basin, Canada

M. DEFOSSEZ, F.J. SAUCIER, P.G. MYERS, D. CAYA and J.-F. DUMAIS

Abstract
New oceanographic mooring data recorded between 2004 and 2006 show an abrupt arrival of cold and saline water at the bottom of Foxe Channel each year. Foxe Channel is the deepest part of Foxe Basin, an Arctic/Subarctic inland sea in the Hudson Bay system. This dense water mass is detected at depth in the middle of the channel at the beginning of spring. It is characterized by a sharp temperature drop and salinity rise. This pulse-like phenomenon is recurrent, although there is some interannual variability depending on the severity of the preceding winter. The dense water probably originates from coastal polynyas of western Foxe Basin. A gravity current in Foxe Channel flows southeastwards and significantly modifies the water column along the channel by raising the isotherms by 140 m. The water column responds to the dense water pulse with a time lag of one month. Although the pulse lasts only three months, it renews more than two-thirds of the deep water in Foxe Channel and is therefore an important component of the general circulation in Foxe Basin. This shows that the pulse is an energetic event and that the newly advected dense water may have enough kinetic energy to overflow the sill between Foxe Basin and Hudson Bay.

Résumé
Les nouvelles données de mouillage océanique recueillies entre 2004 et 2006 montrent une brusque arrivée d'eaux froides et salées au fond du détroit de Foxe chaque année. Le détroit de Foxe est la partie la plus profonde du bassin de Foxe, une mer intérieure arctique/subarctique dans le système de la baie d'Hudson. Cette masse d'eau dense est détectée en profondeur au milieu du détroit au début du printemps. Elle se révèle par une baisse de température marquée et une augmentation de la salinité. Ce phénomène analogue à une pulsation est récurrent, bien qu'il affiche une certaine variabilité interannuelle liée à la rigueur de l'hiver précédent. Les eaux denses proviennent probablement des polynies côtières de l'ouest du bassin de Foxe. Un courant de gravité dans le détroit de Foxe circule vers le sud-est et modifie de façon appréciable la colonne d'eau le long du détroit en élevant les isothermes de 140 m. La colonne d'eau répond à la pulsation d'eaux denses avec un retard d'un mois. Même si la pulsation ne dure que trois mois, elle renouvelle plus des deux tiers des eaux profondes dans le détroit de Foxe et forme ainsi une composante importante de la circulation générale dans le bassin de Foxe. Ceci montre que la pulsation est un phénomène dynamique et que les eaux denses nouvellement advectées peuvent avoir assez d'énergie cinétique pour franchir le seuil séparant le bassin de Foxe de la baie d'Hudson.

Atmosphere-Ocean 46-3 Paper Order for which abstracts are reproduced above

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Changes for ATMOSPHERE-OCEAN

At the 42nd Annual CMOS Congress in Kelowna B.C., decisions were taken that will change the Society's publishing procedures for ATMOSPHERE–OCEAN (*A-O*). These decisions arose from a discussion at the Publications Committee meeting about open access publishing (Open access journals are those for which the content is available for free on the internet). Two recommendations arose in the meeting that were approved by Council, the first being that open access be applied to *A-O* papers older than three years. This change was implemented over the course of the summer. Council also approved a recommendation that the full texts of A-O papers be made available on the web to subscribers as soon as they are approved for publication.

The mechanism for this change in procedure is currently being arranged.

Before proceeding any further on the matter of open access for *A-O*, the Committee recommended that users be consulted about the approach. The Committee would very much like to receive your comments on the question. Please take about two minutes to reply to our questionnaire at :

http://www.cmos.ca/Ao/OpenAccessSurvey.pdf

and offer your comments and advice.

Thank you in advance for your collaboration.

Richard Asselin,
Director CMOS Publications

Changements à ATMOSPHERE-OCEAN

Des décisions concernant les procédures de publication de ATMOSPHERE-OCEAN (*A-O*) ont été prises lors du 42ème congrès à Kelowna, BC. Ces décisions découlent de discussions à la réunion du comité des publications concernant le libre-accès (les revues à accès libre sont celle dont le contenu est disponible gratuitement sur la toile). Deux recommandations du comité furent approuvées par le Bureau. La première est que tous les articles vieux de plus de trois ans deviennent libres d'accès, ce qui a été mis en place au cours de l'été. Le Bureau a aussi approuvé que le texte intégral soit disponible aux abonnés sur la toile dès que l'article a été accepté pour publication dans *A-O*. On travaille en ce moment à la manière d'exécuter ce changement.

De plus, avant d'aller plus loin sur la question du libre-accès à *A-O*, le comité a recommandé une consultation des intéressés. Le comité aimerait beaucoup recevoir vos commentaires sur le sujet; veuillez prendre environ deux minutes pour compléter le questionnaire à :

http://www.cmos.ca/Ao/OpenAccessSurvey_F.pdf

et offrir vos commentaires et suggestions.

Merci d'avance pour votre collaboration.

Richard Asselin,
Directeur des publications de la SCMO

Réductions des Frais d'Adhésion pour 2009

Suite aux décisions prises par l'Assemblée Générale Annuelle tenue le 29 mai 2008 à Kelowna, il y aura des réductions importantes aux frais d'adhésion 2009 pour les membres étudiants et les membres corporatifs :

1) Les frais pour membres étudiant(e)s ont été réduits de 40$ à 20$. Ces frais comprennent l'abonnement au *CMOS Bulletin SCMO* ainsi que l'abonnement A-O en ligne, mais non la version imprimée.

2) Les frais pour les membres corporatifs ont été réduits à 160$ mais les publications ne sont plus incluses, sauf le *CMOS Bulletin SCMO*. D'autres publications sont disponibles sur demande. Plusieurs de nos membres corporatifs préféreront s'abonner au répertoire du secteur privé et au service de référence de demandes, dont les frais ont grimpé à 140$, afin de couvrir les vrais coûts de ces services qui étaient auparavant fournis par un bénévole.

3) L'abonnement à un nouvel ensemble de publications destiné principalement aux bibliothèques est maintenant disponible. Toutes les publications fournies auparavant aux membres corporatifs sont incluses. Par contre, le nouvel ensemble n'inclut pas les privilèges d'adhésion à la SCMO. Les frais pour 2009 sont 333$, le même prix que l'adhésion corporative pour 2008.

Membership Fee Reductions for 2009

As a result of decisions taken at the Annual General Meeting held 29 May 2008 in Kelowna, there are significant membership fee reductions for student members and corporate members for 2009, as follows:

1) The Student Member fee for 2009 has been reduced from $40 to $20. It includes a subscription to the *CMOS Bulletin SCMO* and A-O on-line but not the A-O print edition.

2) The Corporate Member fee has been reduced to $160 but it no longer includes publications other than the *CMOS Bulletin SCMO*. Additional publications can be ordered by corporate members if needed. Many will prefer to subscribe to the CMOS Private Sector Directory and Referral Service, for which the fee for 2009 has been set at $140, a significant increase made necessary by the need for CMOS to cover the real cost of providing these services, formerly provided by a volunteer.

3) A new Publications Package has been established, intended mainly for libraries. It includes all CMOS publications previously included in Corporate Membership. However, the new package comes without CMOS membership privileges. The fee for 2009 is $333, the same as last year's Corporate Membership fee.

François-J. Saucier

1961 - 2008

Monsieur François-J. Saucier, professeur et chercheur en océanographie physique à l'Institut des sciences de la mer (ISMER-UQAR) est décédé le 6 juillet 2008 des suites du cancer à l'âge de 47 ans et un mois.

M. Saucier a été étudiant à l'UQAR de 1982 à 1985 en physique et faisait partie depuis janvier 2005 du corps professoral de l'UQAR à titre de chercheur en océanographie physique à l'ISMER. Obtenant un baccalauréat en physique à l'UQAR en 1985, alors que l'Université offrait ce programme, il a par la suite poursuivi ses études jusqu'au doctorat en géodynamique, diplôme (Ph.D.) que l'Université de l'Oregon lui avait décerné en 1991. Il avait alors étudié la déformation des continents aux marges océaniques. De 1991 jusqu'à 2004, il a été chercheur scientifique à l'Institut Maurice-Lamontagne, de Mont-Joli.

Dernièrement, M. Saucier avait reçu le prix du président de la Société canadienne de météorologie et d'océanographie (SCMO) (*CMOS Bulletin SCMO*, Vol.36, No.4, page 134). Ce prix avait été attribué pour deux articles scientifiques rédigés par M. Saucier et qui portait sur la modélisation océan-glaces au Canada. L'un des articles a paru dans le Journal of Geophysical Research, en 2003, et l'autre dans Climate Dynamics, en 2004. Ces articles représentent une avancée majeure dans notre connaissance du Golfe du Saint-Laurent et de la Baie d'Hudson.

Les travaux de M. Saucier à l'IML ont contribué à la mise en place des premiers services de prévisions maritimes au Canada et à la publication, en 1997, de l'Atlas des courants de marée de l'estuaire du Saint-Laurent. À l'UQAR, il a collaboré à plusieurs dizaines de publications scientifiques et ses talents de vulgarisateur ont toujours été appréciés.

Monsieur Saucier laisse dans le deuil sa conjointe, Mme Nancy Otis, ses parents, M. Jules Saucier et Mme Thérèse Gauthier, son frère Christian et sa soeur Jacqueline. Nos plus sincères sympathies à toute la famille de François ainsi qu'à ses collègues de l'ISMER.

Présentation du prix du Président de la SCMO faite le 3 juin 2008 dans les jardins de l'Institut des Sciences de la Mer, Université du Québec à Rimouski. De gauche à droite: Professeurs Jean-Claude Brethes, Serge Demers, Suzanne Roy (Présidente Centre de Rimouski SCMO 2008), **François Saucier**, Jean Ferron, Jean-François Dumais. Photographie gracieuseté de Mario Bélanger.

William Maxwell Cameron

William Cameron died peacefully in Vancouver B.C. on July 4, 2008. Dr. Cameron's vision and leadership were instrumental to the growth and development of oceanography in Canada. As well as playing a major role in establishing the Department of Oceanography at U.B.C., he oversaw the establishment of the Institute of Ocean Sciences and the Canada Centre for Inland Waters and was one of the founders of the Bedford Institute of Oceanography in Nova Scotia. In 2004, he was named as a Member to the Order of Canada.

Bill Cameron studied zoology at UBC (BSc and MSc) with the initial intention of going to medical school. His interests, however, changed and he joined the Biological Station at Nanaimo in 1938. Given his talents in mathematics he collaborated with Jack Tully on modelling work on the Alberni Inlet and they became good friends. During the war years, he was involved in meteorology and forecasting for Western Air Command. It was at this time that he became interested in oceanography as a discipline, rather than just the modelling work he had been doing with Tully. In 1951, he went to Scripps Institute of Oceanography to do his PhD under Dr. Sverdrup. He took the "Sverdrup Curriculum" based on the book entitled Oceans: Their Physics, Chemistry and general Biology (1942 by Sverdrup, Johnson and Flemming). This training in multi-disciplinary approach to the study of the oceans was to have a major influence on his career and on Canadian Oceanography. He came first in his class of 18, and became involved in a network of many of the leading oceanographers of the day. His thesis was on the physical oceanography of estuaries based on data from the Alberni Inlet.

Following graduation he returned to Nanaimo. During this time period (early 1950s), he also made an important contribution to Arctic Ocean oceanography. Dr. Waldo Lyon, who worked at the Naval Electronic Laboratory in the U.S. on polar submarine was keen to establish a joint USA/Canada series of Arctic expeditions. He recruited Tully and Cameron and joint work was undertaken from 1951 – 1954 (two vessels working together).

Dr. Cameron was one of a team of three who established the Institute of Oceanography at UBC in the 1950s. Dr. Clemons (who had hired Cameron in 1938 when he was Head of the Biological Station at Nanaimo) was the Head of the Department of Zoology at UBC in the 1950s. He, Dr. Shrum of the Defence Research Board and Cameron got together to plan the Institute. Shrum deployed Cameron from the Fisheries Research Board to the DRB, and then transferred the position to this new Institute (joint UBC/DRB). Cameron was the DRB contribution to the Institute.

Dr. Cameron was also instrumental in the establishment of the Bedford Institute of Oceanography under the Department of Energy, Mines and Technical Services. In an interview with Eric Mills he states how this occurred. The focus on the need for enhanced oceanographic capacity within the Canadian Public Service happened because "… The Baffin ran on the rocks." This was the first issue that hit the then new Deputy Minister of Energy, Mines and Technical Services, Dr. Van Steenburgh (who had just been transferred from the Department of Agriculture). It was a significant embarrassment for the government, which led to Van Steenburgh's goal of more oceanographic science within the Hydrographic Service. He recruited Dr. Cameron to take the lead role in establishing the Bedford Institute of Oceanography. When initially asked to take this task on, Cameron refused. He was content back at Nanaimo. Recruitment efforts by Van Steenburgh in the USA kept bringing up the recommendation that Cameron would be the best choice.

"So I finally said, well I'll go over and see what I can do, and I never regretted it." His model for BIO was based on the "Sverdrup Curriculum", multi-disciplinary research with oceanographic vessels capable of making state-of-the-art observations. With Van Steenburgh's influence within the Public Service, and Cameron's knowledge of oceanography, they were a good team.

Note from the Editor:
Much of the foregoing story was extracted by Mike Sinclair, BIO, from an interview in November 11, 1991 between Dr. Cameron and Dr. Eric Mills (an historian and biological oceanographer at Dalhousie University). Original text published in Canadian Ocean Science Newsletter, No. 38, August 2008. Reproduced here with the authorization of the Editor.

Photo caption: Photo taken in 1984 on the occasion of the dedication of Oceanographic / Hydrographic Research Vessel CSS John P. Tully at the Institute of Ocean Sciences, Sidney, BC. Shown on the picture from left to right are Sus Tabata, **Bill Cameron**, Neil Campbell, Pat Nasmyth, Paul LeBlond and George Pickard. Photo extracted from CNC/SCOR Historical Oceanographic Photos located on CMOS website.

Human Impacts on Weather and Climate

by William R Cotton and Roger A Pielke Sr.

Cambridge, University Press, 2007
ISBN 978-0-521-60056-9, Paperback, US$55
pp.308 + 12 colour plates

Book Reviewed by John Stone[1]

This is the second edition of a book that was first published in 1995. It is written by two distinguished American meteorologists who are now both associated with Colorado State University. They are perhaps best known for the Regional Atmospheric Modeling Systems (RAMS), an interactive, nested grid model capable of explicitly simulating clouds and storms as well as a variety of mesoscale phenomena. They have both worked at NOAA's Experimental Meteorological Laboratory. where they were involved in weather modification research.

This is not an easy book to read. Indeed, it is really two books. The first (Part I) deals with weather modification and benefits from the authors' lifetime experience. The second (Part III) addresses global warming and suffers from being used as a platform for the authors to express their somewhat sceptical views on the issue. In between (Part II) there is a useful review of the effects of land use changes on weather and climate. The book concludes with an Epilogue that discusses the interface between science and policy.

The section on weather modification may be of some academic interest but less so for practical instruction for, as the authors state, the technology of weather modification by cloud seeding is scientifically unproven. Unfortunately, much of the section on climate change has been superseded by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) which would be a better resource for students. The section deals mainly with atmospheric radiative processes – including a digression into solar variability and sun spots. The oceans and cryosphere are given less attention. The real disappointment in this section is the lack of discussion on empirical evidence such as the careful statistical analyses of past climate change.

The book tries somewhat unsuccessfully to draw some parallels between the failures of weather modification and the tackling of climate change. The first was often grossly oversold both by government agencies that needed quick results and by scientists who saw the possibility of increased funding for research to understand the complex behaviour of clouds and aerosols. As the authors admit, "we greatly underestimated the complexity of the scientific and technological problems".

In the case of climate change, although predicting exactly where, when and how the impacts will be experienced, is not possible at this time, the unprecedented increase in greenhouse gas concentrations in the atmosphere as a result of human activities and our understanding of the climate system is sufficient to sound a siren alarm that action is now urgent. We may have a debate on what to do about it but the scientific case for climate change is solid. Furthermore, it is misleading for the authors to suggest that climate modellers have claimed to be able to predict future climate. The models are used to explore plausible futures and actions. If there is a lesson to be learnt it is that we must be wary of geo-engineering solutions.

As the authors point out, one important factor in both cases is that of the natural variability of the weather and the climate. Thus, with cloud seeding one never knows for certain whether when it rains it is due to one's intervention or not. However, this is one area where the authors get into difficulties regarding climate change. While the climate system has displayed and will continue to display sudden shifts or surprises which models are never likely to predict – the human hand in affecting the climate has been discernible – that is to say we can distinguish the anthropogenic signal against the noise of natural variability. This conclusion was in the IPCC's Second Assessment Report (SAR), strengthened in the Third Assessment (TAR) and now in the AR4 we are able to put a level of confidence on this conclusion as very likely (more that 90%).

Of course, the issue of climate change cannot end with its detection. As mentioned above, the increase in greenhouse gases itself poses a threat to our environment, economy and society that we must not ignore. The issue then becomes one of how to respond. The authors accuse some scientists of being advocates for action. The authors admit that "if the informed scientists do not take an advocacy role in recommending action, then no-one else will". Certainly some scientists such as Jim Hansen and Stephen Schneider have become quite vocal and more so with their frustration over the lack of action. But most of these have well-established reputations and well-funded research programs. They cannot be accused of vested interest except in that what defines us as a civilized race is our concern for each other and the environment.

The authors also raise the issue of scientific consensus and suggest that "those scientists that question the science [of

[1] Retired Meteorologist and adjunct Professor in the Department of Geography and Environmental Studies at Carleton University, Ottawa, Canada

climate change] are labelled as skeptics or, alternatively, contrarians". They accuse some scientists of pushing their own agendas with international bodies such as the IPCC and seeking the endorsement of a consensus of scientists. The notion of a scientific consensus is foreign to much of the scientific community, it is often journalistic shorthand and underplays the crucial role of scientific criticism carried out through peer-reviewed papers and conferences. Determining what is scientifically valid is based on reproducible observations and tested hypotheses – it is not a beauty competition, nor is it determined by public polling. Anyone who has been involved in the IPCC process knows the intense but open and impartial scrutiny to which all statements are subjected. It is well understood by all authors in the IPCC enterprise how absolutely crucial it is that the integrity of the process be safeguarded for without this the community's reputation is undermined and the value of the Assessments reduced. If there is a fault in this process it is that the IPCC conclusions are sometimes conservative.

When it comes to taking action, the authors join those who have criticized the Kyoto Protocol. They refer to it as a "political placebo", rationalized by the results of climate models, in order to give citizens the sense of action. It may have been the case in weather modification that the "rush for policy action" was "to do something rather than sit idly by and do nothing". There is also some truth in the observation that sections of the public believed signing the Kyoto Protocol was action enough - indeed the Protocol has not led to the promised drop in emissions. While the authors may give a sobering assessment of the climate change negotiations to date, to look for a parallel with weather modification may be misleading. Unlike calling down rain to end a local drought in the Prairies, addressing climate change is a global challenge. Since it does not matter where the emissions originate, we need a global and long-term commitment. After more than two decades of talking we have yet to summon the necessary political leadership. There are now many books that plainly set out the urgency for action and lay out the solutions that already exist – this book is not one of them.

Books in search of a Reviewer
Livres en quête d'un critique

Marine Habitat and Cover, Their Importance for Productive Coastal Fishery Resources, John F. Caddy, Oceanographic Methodology Series, UNESCO Publishing, ISBN 978-92-3-104035-1, 2007, Hardback, pp.253.

The Geomorphology of the Great Barrier Reef, by David Hopley, Scott G. Smithers and Kevin E. Parnell, Cambridge University Press, ISBN 978-0-521-85302-6, 2007, pp.532, US$150.

Lagrangian Analysis and Prediction of Coastal and Ocean Dymanics, Edited by Annalisa Griffa, A.D. Kirman, Jr,, Arthur J. Mariano, Tamay Özgökmen, and Thomas Rossby, Cambridge University Press, ISBN 978-0-521-87018-4, 2007, Hardback, US$160.

An Introduction to Atmospheric Thermodynamics, by Anastasios A., Tsonis, Cambridge University Press, ISBN 978-0-521-69628-9, 2007, pp.187, US$55.

Ebb and Flow: Tides and Life on our Once and Future Planet, by Tom Koppel, The Dundurn Group, Toronto, Canada, ISBN 978-1-55002-726-6, Paperback, pp.292, CDN$26.99.

Survival: Survival of the Human Race, Edited by Emily Shuckburgh, Cambridge University Press, ISBN 978-0-521-71020-6, 2008, pp.233, Paperback, US$25.

The Dynamics of Coastal Models, by Clifford J. Hearn, Cambridge University Press, ISBN 978-0-521-80740-1, 2008, pp.488, Hardback, US$100.

Basics of the Solar Wind, by Nicole Meyer-Vernet, Cambridge University Press, ISBN 978-0-521-81420-1, 2008, pp.463, Hardback, US$132.

Mesoscale Dynamics, by Yuh-Lang Lin, Cambridge University Press, ISBN 978-0-521-80875-0, 2008, pp.630, Hardback, US$165. 2 copies available.

Oil, Water and Climate: An Introduction, by Catherine Gautier, Cambridge University Press, ISBN 978-0-521-70919-4, 2008, pp.366, Paperback, US$49. 2 copies available.

Chemical Oceanography and the Marine Carbon Cycle, by Steven Emerson and John I. Hedges, Cambridge University Press, ISBN 978-0-521-83313-4, 2008, pp.366, Paperback, US$90. 2 copies available.

An Introduction to Ocean Turbulence, by S. A. Thorpe, Cambridge University Press, ISBN 978-0-521-67680-9, 2007, pp.240, Paperback, US$60.

Snow and Climate: Physical Processes, Surface Energy Exchange and Modeling, Edited by Richard L. Armstrong and Eric Brun, Cambridge University Press, ISBN 978-0-521-85454-2, 2008, pp.222, Hardback, US$130.

Climate Extremes and Society, Edited by Henry F. Diaz and Richard J. Murnane, Cambridge University Press, ISBN 978-0-521-87028-3, 2008, pp.340, Hardback, US$140.

The Asian Monsoon, Causes, History and Effects, by Peter D. Clift and R. Alan Plumb, Cambridge University Press, ISBN 978-0-521-84799-5, pp.270, Hardback, US$150. 2 copies available.

Hurricanes: Causes, Effects and the Future, by Stephen P. Leatherman and Jack Williams, World Life Library, Voyageur Press, ISBN 978-0-7603-2992-4, 2008, pp.72, Paperback, CDN$19.95.

Researching the World's Largest Nordic Inland Sea

Early explorers made Hudson Bay the base of a fur trade that changed North American history. Today, scientists are re-exploring the Bay to look at its future.

Stretching 1,500 kilometres at its widest extent, Hudson Bay is the world's largest nordic inland sea. But in the icy region, the amount of systematic research has been small.

To fill the gap, the Québec Region of the Department of Fisheries and Oceans (DFO) is leading a multi-disciplinary study known as MERICA. The collaborative program will bring the Hudson Bay complex, including Hudson Strait to the east and Foxe Basin to the north, into sharper scientific focus.

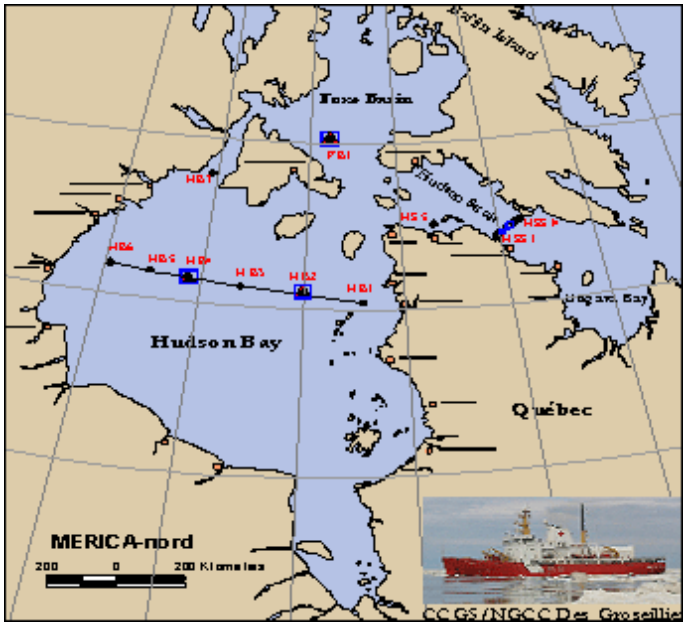
The MERICA program (short for "études des MERs Intérieures du CAnada," studies of Canada's inland seas) evolved in part from DFO's Atlantic Zone Monitoring Program, which documents ocean temperatures, salinities, biological life, and other variables. The Québec Region's partners in MERICA include DFO's Bedford Institute of Oceanography in Nova Scotia and its Freshwater Institute in Manitoba, l'Université du Québec, l'Université Laval, and the Massachusetts-based Woods Hole Oceanographic Institution (WHOI). Natural Resources Canada helps with the funding.

"A lot of the impetus came from the current concerns about climate change," says Dr. Michel Harvey, research scientist at DFO'S Maurice Lamontagne Institute (MLI) in Mont-Joli, Québec. "Hudson Bay is not only vulnerable, it may itself influence climate change, through the global conveyor belt".

The "global conveyor belt" is scientific shorthand for the system of ocean currents transporting heat around the planet. In the Labrador Sea and waters east of Greenland, surface waters cool and sink, powering submerged currents that travel southward in the Atlantic Ocean and then eastward into the Pacific. These deep, slow currents – it can take centuries for a drop of water to travel from the Atlantic to the Pacific – are tied in with the global climate system.

The initial sinking depends on surface water becoming denser than the layers beneath. Water density depends on its temperature and salinity. In recent years, the surface layers have become less salty and thus less dense, and so do not sink so readily. This has raised fears of disrupting the global conveyor belt, with potentially vast consequences.

The decreasing salinity is related to factors including global air temperature change, sea-ice melting, and the outflow of northern rivers, including the many feeding into Hudson Bay. The low-salinity water from Hudson Bay amounts to less than one-fifth of the amount entering the northwest Atlantic, but researchers need to know more about that interaction and Hudson Bay in general.



The Hudson Bay complex including Foxe Basin and Hudson Strait. Inset: the Coast Guard's Des Groseillers. The lines show vessel transects; red lettering indicates detailed observation points; squares show fixed scientific moorings.

Existing data have already shown one startling change. Summer ice coverage has dropped sharply in recent decades. Climate-change scenarios suggest that by the end of the century, the Hudson Bay complex will be nearly ice-free, affecting the ecosystem and the lives of Inuit.

MERICA's ship-based research began in 2003. Each year, DFO's Canadian Coast Guard makes ship time available on the Pierre Radisson, a 98-metre icebreaker, or its sister ship the Des Groseillers, both named after historic explorers of the region.

"At MLI, we maintain containerized labs for ship work," says Michel Harvey, chief scientist of the MERICA mission. "We put three containers aboard the vessel in June, when she's starting her annual northern voyage for ice-breaking and other duties. Then, in August and September, the scientists fly up for the field work".

The vessels make well-defined transects, gathering data for year-to-year comparisons. Scientific work begins at 6 a.m. and continues into the evening.

Monitoring starts at the bottom. Besides sampling benthic organisms, researchers drill for core samples. The composition of the bottom sediment reveals secrets of plant and animal life and climatic conditions going back many millennia. The scientists also maintain year-round sediment traps in the water column at three locations.

Lowering a "rosette" for water sampling. Electronics control the closure of bottles at different depths.

Researchers and ship's crew also lower instruments into the water column to measure salinity, temperature, and depth, to collect plankton, and to take water samples at different depths for laboratory analysis. The salinity; the amount of nutrients, oxygen, and other components; the opacity of the water; the presence of chemical tracers – such data hold keys to ocean behaviour and biological abundance.

The researchers are in many respects still collecting "baseline" data that will reveal longer-term patterns and enable predictive modelling. But already, some findings stand out.

The new research has detailed the relative weakness of Hudson Bay's "primary production" – the growth, through photosynthesis, of the phytoplankton (microscopic plant life) that form the base of the aquatic food chain. Dr. Harvey, a specialist in plankton, points out that the Bay has far lower levels of phytoplankton and zooplankton (tiny, drifting animals and larvae) than either Hudson Strait or Foxe Basin. The Bay's biomass of zooplankton is only one-sixth that of the neighbouring areas.

Why is Hudson Bay less productive than nearby waters? The limited availability of nitrates holds back production of phytoplankton. Hudson Strait, despite its greater depth, has more upwelling in the water column, bringing more nitrates and other nutrients to the surface to support photosynthesis.

Climate researchers are looking with special interest at the freshwater outflow from Hudson Bay to the Atlantic. Underwater moorings deployed year-round by the Maurice Lamontagne Institute and the Woods Hole Oceanographic Institution, one of the MERICA partners, hold an array of instruments to record water composition and flow. While it's important to get information from the surface layers where fresh water accumulates, it's also risky, because moving ice can entangle instruments. Thus, one mooring automatically sends up the topmost instruments only briefly and retracts them by cable.

The thousands of MERICA measurements will gradually produce an integrated picture of all its complexity. This in turn will help guide future activities and policies for the region.

"The more we fill in the facts for Hudson Bay," Dr. Harvey says, "the better equipped we are for future challenges, whether in climate change or the northern ecosystem in general."

Source: Department of Fisheries and Oceans website visited June 16, 2008. Published here with the written authorization of Dr. Michael Harvey.

IMDIS 2008

The International Conference on Marine Data and Information Systems - IMDIS 2008 - was held on 31 March - 2 April 2008 in Athens, Greece. IMDIS 2008 focussed on: marine environmental databases; standards and interoperability; user oriented services and products; and databases and tools for education. The presentations and a synopsis are available at http://hnodc.hcmr.gr/imdis-2008/presentations.htm.

Ocean Climate Variability Studies on the Outer Halifax Line

Reported by John Loder and Ross Hendry
Bedford Institute of Oceanography
Dartmouth, NS, Canada

Variability in the production and modification of water masses in the Labrador Sea is an important influence on the ocean climate of the shelf and slope waters off Atlantic Canada, and on the North Atlantic's "ocean conveyor belt" which is an integral component of the global climate system. Scientists at the Bedford Institute of Oceanography (BIO) have been carrying out observational studies of the Labrador Sea and other parts of the North Atlantic's subpolar gyre since the 1960s. In 1990 an annual survey of hydrographic and chemical properties on a section across the Labrador Sea was initiated as a contribution to the international World Ocean Circulation Experiment (WOCE). A biological component was added in 1994 as a contribution to the international Joint Global Flux Study (JGOFS). This Labrador Sea Monitoring Program is now an important DFO and Canadian contribution to the Global Climate Observation System (GCOS) of the World Climate Research Program. Significant changes in the properties of the deep "overflow" waters originating in the Northeast Atlantic and of the locally-formed middepth Labrador Sea Water (which together form the lower limb of the conveyor belt) are being observed, with apparent influences from both natural variability and climate change. The properties and transport of these subsurface waters as they move

southward in the North Atlantic are the subject of a coordinated international research program in the United States (USA) and United Kingdom (UK), aimed at determining whether the conveyor belt is changing (such as the potential slow-down projected in some climate change scenarios). A significant portion of these waters flow along the lower Scotian Slope and Rise, near the outer end (2700-m isobath) of the Halifax Line of DFO's Atlantic Zone Monitoring Program (AZMP). In recent years the Ocean Sciences and Ecosystem Research Divisions at BIO have undertaken a physical-biological-chemical survey of this line on the CCGS Hudson's June return trip from the annual Labrador Sea expedition, as part of AZMP. Since 2006, three or four deep-water stations have been added to the June survey of the line to sample the physical, chemical and biological properties of the deep overflow waters (often referred to as the Deep Western Boundary Current) out to the 4300-m isobath. This expanded surve y also provides improved sampling of the Labrador and Warm Slope Waters whose variability and on-shelf intrusions can have large effects on the entire Scotia-Maine region, and thereby complements the core AZMP. The signatures of Labrador Sea Water and the Deep Western Boundary Current can be clearly seen in the data from the 2006 and 2007 surveys.

Sampling on the "extended" Halifax Line is also being coordinated with the UK Rapid Climate Change (RAPID) program, a 12-year research initiative which is entering its second 6-year phase. Since 2004, OSD has been collaborating with the UK's Proudman Oceanographic Laboratory (POL) in the deployment of moorings to monitor the currents and water mass properties over the Scotian Slope/Rise off Halifax, funded by the Panel for Energy Research and Development (PERD) and UK RAPID. RAPID has also been contributing to the physical and chemical sampling on the extended Halifax Line, in an evolving and mutually-beneficial cooperation between BIO and POL.. A further collaboration is being planned as part of the 2008-13 RAPID-WATCH program, involving the deployment of moored current meters, and temperature-salinity and bottom pressure recorders between the 1000- and 4300-m isobaths on the line, together with profiles of hydrographic and chemical properties including tracers. This collaboration will provide a small and opportunistic additional DFO contribution to international climate change research programs in the North Atlantic, complementing both the Labrador Sea Monitoring Program and joint UK-USA programs making measurements on a line ("W") south of Woods Hole and another across the Atlantic along 26.5°N. Through these collaborations with international programs sampling the Scotian Slope/Rise and adjacent regions, DFO is collecting valuable information on how the ocean conveyor belt and slope waters are changing off Atlantic Canada.

Source: Canadian Ocean Science Newsletter, No.36, May 2008. Reproduced here with the authorization of the Editor.

International Arctic Change 2008 Conference

Québec City, Canada

9 - 12 December 2008

The Arctic Network of Centres of Excellence of Canada and its national and national partners are welcoming the international arctic research community to Québec City for the International Arctic Change 2008 Conference. Coinciding with the pinnacle of the International Polar Year and the 400th anniversary of Québec City, Arctic Change 2008 invites researchers, students, policy-makers and stakeholders from all fields of arctic research and all countries to address the global challenges and opportunities brought by climate change in the circum-Arctic. With over 600 participants expected to attend, Arctic Change 2008 will be the largest trans-sectoral international arctic research conference ever held in Canada. The Conference will be held at the Québec City Convention Centre from 9 to 12 December 2008. Detailed information on session format, conference topics and the conference venue is available at:

http://www.arcticchange2008.com

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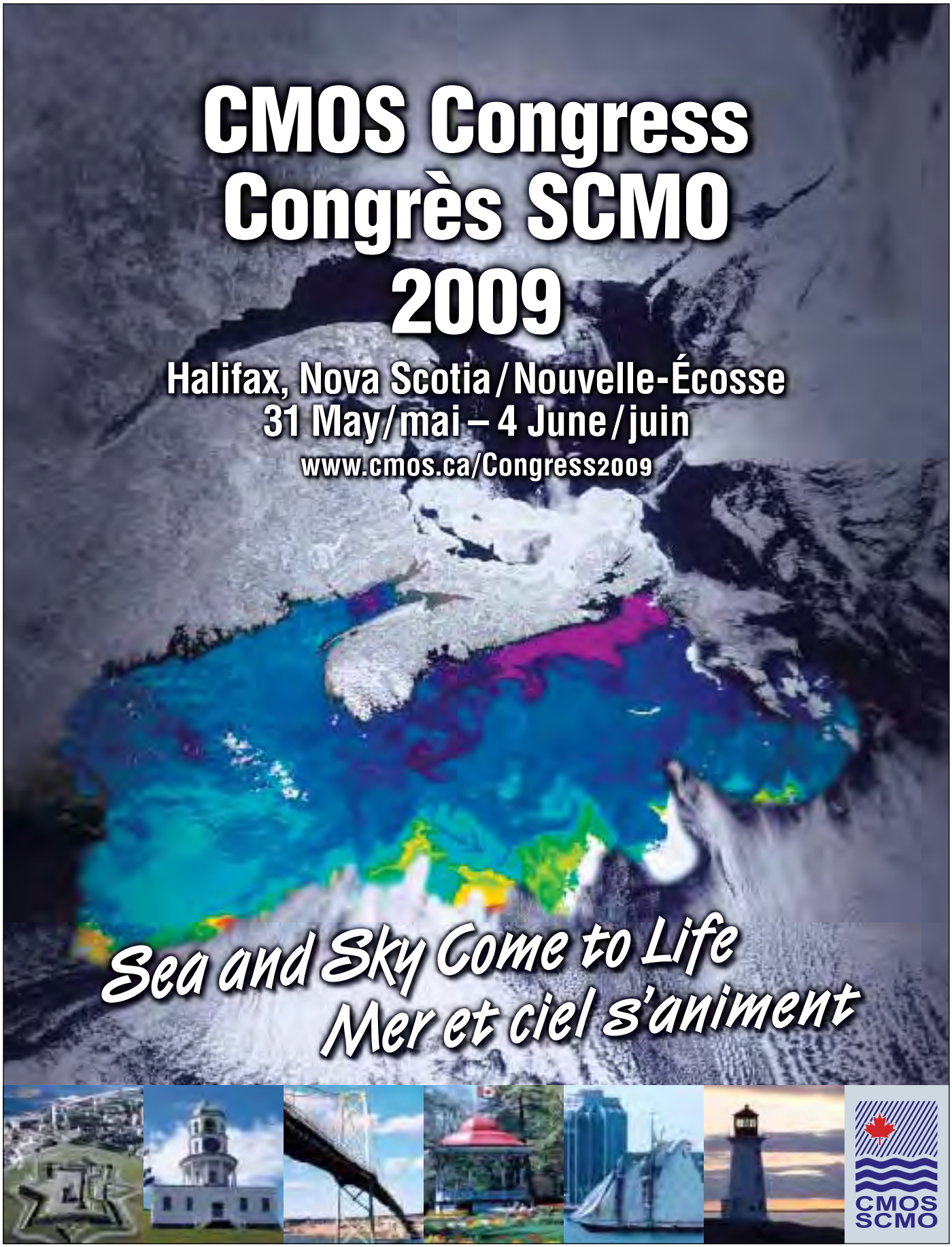

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