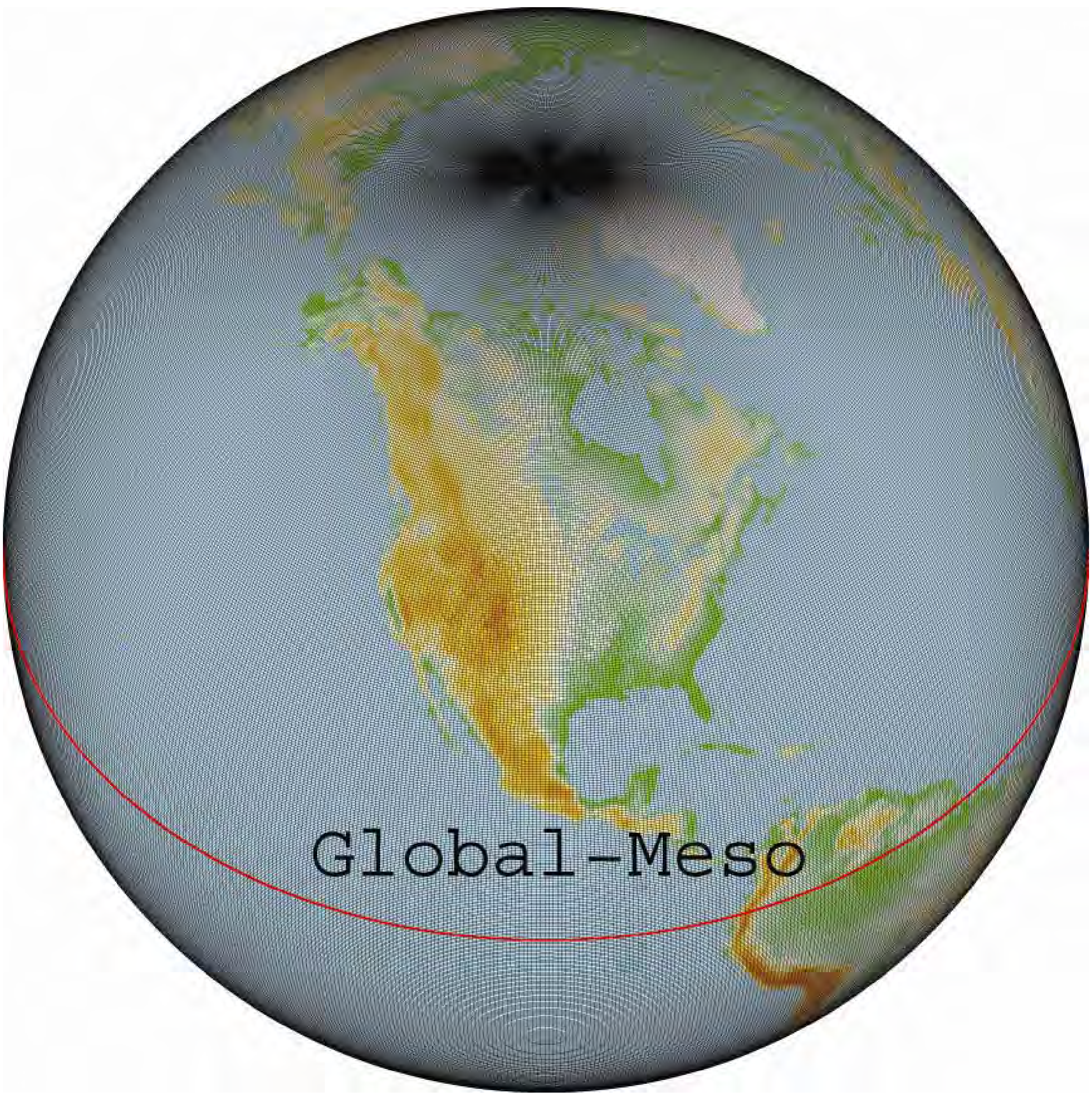
ISSN 1195-8898

Canadian Meteorological and Oceanographic Society

CMOS BULLETIN SCMO

La Société canadienne de météorologie et d'océanographie

June / juin 2007 Vol.35 No.3



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

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Cover page : A new high-resolution version of the Global Environmental Multiscale (GEM) atmospheric model has been implemented for global numerical weather prediction at the Canadian Meteorological Centre (CMC). This model includes numerous changes to both its dynamical and physical configurations, and was shown to substantially improve medium-range weather prediction. The 33-km horizontal calculation grid of this global GEM, with 801x600 points, is shown on the cover page. To learn more, please read the article on **page 77**.

Page couverture: Une nouvelle version haute résolution du modèle atmosphérique Global Environnemental Multi-échelle (GEM) a été implémentée pour la prévision numérique du temps global aux opérations du Centre Météorologique Canadien (CMC). Ce modèle inclut de nombreuses modifications à ses composantes dynamique et physique, et améliore de manière significative les prévisions numérique du temps à la moyenne échéance. La grille horizontale de calcul de cette nouvelle version de GEM, à 33 km avec 801x600 points, est montrée en page couverture. Pour en apprendre plus, prière de lire l'article en **page 77.**

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Canadian Oceanographic Historical Photos
Photos historiques de l'océanographie canadienne

1984: On the Occasion of the Dedication of the Oceanographic/hydrographic vessel CSS John P. Tully
Sus Tabata, Bill Cameron, Neil Campbell, Pat Naismith, Paul LeBlond, George Pickard

At the North Pole with Louis S. St. Laurent - August 1994
Top row (l to r): Doug Sieberg, Louise Adamson, Eddy Carmack, Fiona McLaughlin, Rick Pearson, Rob Macdonald.
Kneeling: Dave Paton, Darren Tuele, Janet Barwell-Clarke.

....from the Presidents' Desks

Friends and colleagues:

Geoff Strong
CMOS outgoing President
Président sortant de la SCMO

I can hardly believe that it has already been one year since I took over as president of CMOS from Susan Woodbury. I believe my time-warp is simply a reflection of the busyness of what is supposed to be a part-time volunteer position, which at times just swamps your life.

I have little or nothing to claim for this year on my own, but with the Executive team, we did accomplish a few things – for example: getting the new Strategic Planning and Student Committees, initiated by the previous executive, up and running; extending our cooperation with CGU and starting the ball moving on what should become an important national collaborative committee involving CGU, CMOS, and other related scientific societies; keeping climate change in the forefront with updated scientific statements (see this issue of the Bulletin); setting the wheels in motion to hire a much-needed Communications Officer for CMOS; and recommending a new fee structure for CMOS through our Finance and Investment Committee (this won't get us many kudos among the general membership, but it *is* very necessary for us to survive). I won't bore our readers reviewing the details of these initiatives, as they are recorded elsewhere.

One tends to dwell more on things that one may have over-looked, which made me curious to review what previous CMOS presidents said at their end of term in this millennium. Every single one of them expressed feelings of challenges and of some accomplishment, but mainly of gratitude for having been given the opportunity to serve, and for the efforts of the Ottawa staff and many CMOS volunteers across the country. It is also clear, and needs to be emphasized, that *CMOS continues to represent and promote meteorology and oceanography in Canada*, and does it well, not that we can't improve, and will. CMOS is the primary coordinating body in Canada for accomplishing this, through scientific meetings and talks in our Centres, through our CMOS publications, sponsoring local workshops, and especially our annual Congress. These things should be recognized as being at the very core of most of our careers, for which we should be thankful. Therefore, as with all previous outgoing presidents, I highly recommend members to get involved as CMOS volunteers in your Centres, and on national committees or Council.

(Continued on next page / Suite à la page suivante)

Volume 35 No.3
June 2007 — Juin 2007

Inside / En Bref

Printed in Kanata, Ontario, by Gilmore Printing Services Inc.
Imprimé sous les presses de Gilmore Printing Services Inc., Kanata, Ontario.

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.

I am indebted to the efforts of our Executive, Council members, and especially our Ottawa staff led by Executive Director, Ian Rutherford. Finally, let me extend my very best wishes for continued success under our incoming new President, Paul Myers of the University of Alberta.

Thank you all for my opportunities to serve in CMOS, which I hope to continue in different capacities, as usual.

Geoff Strong, outgoing President, 2006-07

Paul Myers
Incoming CMOS President
Nouveau président de la SCMO

I will start this address from the incoming President with a strong statement of thanks to our outgoing President Geoff Strong for all the hard work and effort he has put into the position over the past year. As someone in a position to observe the workings of the CMOS executive, I want to acknowledge this and his continual desire to do whatever he can for CMOS, even in potentially trying times. Which, of course, makes me apprehensive of the effort I will need to put in this up-coming year so that CMOS can continue to play an important role in representing meteorology and oceanography in Canada.

As probably the first CMOS President who has been an oceanographer from a Prairie province, one issue that I would like to see come to the forefront during my upcoming year as CMOS President is the involvement of the oceanographic and marine sciences communities in CMOS. Unlike the atmospheric sciences, where CMOS is widely regarded as the main professional society for practitioners (except for maybe hydrologists who are split between CMOS and CGU), there is no such general view for marine scientists. Many physical oceanographers are indeed involved with CMOS, but fewer chemical, biological or fisheries oceanographers. Yet, in many respects, it would be beneficial for the community to have greater linkages within one society. More generally, the issue of membership is an important one, as it affects many issues from whether CMOS can truly represent our fields of science in Canada to more mundane issues like Society costs and the breadth of membership to support those costs. Consistent with the statement above with respect to marine sciences, I view CMOS as an all-encompassing organization that should be able to represent any area of atmospheric or marine sciences – thus I think it is important for the Society to work to bring in members from all related areas – forecasting, aviation meteorology, atmospheric chemistry, the cryosphere, etc.

Another issue that will continue to be important is how best for our Society to represent the views of our members and our sciences to the public, especially with all the debate presently occurring over climate change. But beyond that, I think this public debate has revealed that most Canadians don't really have an understanding of our sciences (whether atmospheric or oceanic). So I think this is something the Society needs to work on, from getting people to understand what is actually presented in a weather forecast, to the fact ours is a quantitative science with a large body of physics and mathematics behind it, to the difference between weather and climate. And as part of this, I think one area where we need to significantly work is at the school (K-13) level, as for the most part, despite the day-to-day impact the atmosphere and the oceans have on most Canadians, little of it is taught at a junior level. We instead need to develop a situation whereby good students come out of school wanting to study and learn about our fields, instead of the present situation when few of them know of our existence. This poor perception of our sciences may also help to explain the growing funding crisis that many in our fields are presently grappling with - and which CMOS as a Society must find a way to help.

Paul Myers, incoming President, 2007-08

Highlights of Recent CMOS Meetings

March - April 2007

The following is a list of CMOS meetings during this period, including some abbreviated points on issues covered.

March 04 – Participated in CFCAS Board meeting.

March 14, April 04 and 25 – Convened meetings of CFCAS Nominations Committee to find three new members of Board of Trustees.

March 28 – 3rd CMOS Council Meeting – Approved publication of updated Climate Change Statement prepared by Scientific Committee (in this issue of Bulletin); draft of 2008 CMOS budget discussed; report on decisions from Awards and Fellows Committees received.

May 01 – 7th CMOS Executive Meeting – conducted routine CMOS business.

Upcoming CMOS meetings:

- First formal meeting of CMOS/CGU Executives, to form national collaborative committee at CMOS/CGU Congress, St. John's, 27 May.

■ 4th CMOS Council Meeting, at CMOS/CGU Congress, St. John's, 28 May.

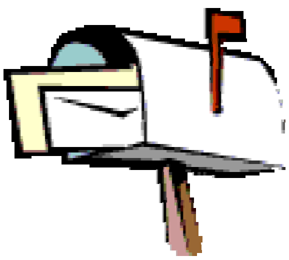
■ Other CMOS and CGU Business/Committee meetings at Congress, 28 May;

■ CMOS Annual General Meeting at Congress, St. John's, 30 May.

Letters to the Editor

Date: 23 February 2007

Subject: Unusual Snow Drifting on the Ottawa River at Lac Deschênes



An excellent view of Lac Deschênes, the widening of the Ottawa River just before it turns east to pass through the city of Ottawa, is possible from our apartment on the sixteenth floor of a condominium located on the south shore just east of Andrew Haydon Park. The panorama view extends from the Ontario shore on the west to the Québec shore on the east and northwestward about 20 km up the Ottawa River to about Breckenridge, Québec.

After 10 years of observations from this site, many unusual events have been noted associated with the effect of changing seasons on the river. One of the most spectacular events was the freeze-up and snowfall early in January 2003.

Figure 1: Panorama view of snow drifts over the smooth ice on Lac Deschênes, looking northwest on Jan.8th, 2003.

That year the river froze over undisturbed by wind, snow, or rain and by January 7th was covered by an extensive sheet of mirror-smooth ice. Skaters and ice sail boats took advantage of the condition since by that time the ice was thick enough to support such activities.

Figure 2: Enlargement (3.5X) of a section of figure 1 showing repetition in the micro-structure of the drifts.

Dry, powdery snow fell early in the night of the 7th and next morning it was obvious that severe drifting had occurred by wind from two directions: northeast and northwest. As the day advanced, the wind shifted to the southwest and new erosion and redrifting took place. The effect was a more or less regular pattern in the snow drifts over the lake. I took the picture, Figure 1, at 3.17 pm after the third erosion and redrifting had taken place.

The micro-structure of the erosion and redrifting is indicated in Figure 2, a 3.5X enlargement of part of Figure 1. The striking feature here is the repetition of the pattern from drift to drift. This pattern appears to vary from one part of the lake to another, probably depending on the structure of the turbulent wind flow as it comes from different parts of the shore and has various lengths of fetch over the snow-covered ice surface.

George W. Robertson
CMOS Member, Ottawa Centre

Date: 19 March 2007

Subject: Meteorological Stamps

I very much enjoyed the recent Bulletin article on meteorological stamps (*CMOS Bulletin SCMO,* Vol.34, No.6, December 2006). But I have always had a problem with the Canadian meteorological stamps since they always show American instruments. The 1968 five-cent stamp may have been the worst since the anemometer shown was never used in Canada. Another problem with that stamp is that earliest instrumented observations in Canada were by Jean-François Gaulthier in Québec city from 1742 to 1756 which are noticeably older than the 1768 observations mentioned on the stamp. According to Morley Thomas those Québec observations were not known commonly in the 1960s.

Ken Devine
CMOS Member, Toronto Centre

Table 2

Configuration and air volume consumption data for Airbus A320 airplane (Corrected values)

Process	Throttle (%)	Speed (Km/h)	Core airflow kg / s	Rate (L) / s	Minutes	Air Volume consumed (L)	Human-days for 2 engines
During Take-off							
Terminal	40	0	10.65	8,341	30	$1.5x10^7$	3,096
Taxiing	55	10	22.53	17,646	5	$5.3x10^6$	1,091
Runway	90	285	34.2	26,786	1	$1.6x10^6$	331
During Landing							
Landing	60	217	34	26,629	2	$3.2x10^6$	659
Taxiing	55	10	22.53	17,646	5	$5.3x10^6$	1,091
Terminal	40	0	10.65	8,341	15	$7.5x10^6$	1,548
					Total =	**$3.8x10^7$**	

Source: Lewis Poulin, Estimating volumes of air through various engines in an urban setting, *CMOS Bulletin SCMO* Vol. 34, No. 4, p. 117, August 2006.

Date: 2 March 2007

Subject: Estimating volumes of air for combustion engines: Table 2 shown above

Since the publication of **Estimating volumes of air through various engines in an urban setting** *(CMOS Bulletin SCMO* Vol. 34, No. 4 August 2006), a clarification to the original publication is required and air volume calculators are now available.

(1) I had to make a few corrections to Table 2 of the original publication. If you would like to publish this correction you can find the info at: http://collaboration.cmc.ec.gc.ca/cmc/cmoi/AirVolumes/cmosBULLETINscmo/AirVolumes_Corrected_Table2.pdf

These corrections are cosmetic to Table 2 and do not alter the conclusions of the document. These mistakes occurred when I transcribed the data into table 2. If you ever make the corrections in your original pdf version, would it be possible to send me a copy with the corrected Table 2 ?

2) Air Volume info now on ptaff.ca: Miguel Tremblay and Patrice Levesque have generously translated the original English document into French and have made both a French and English copy available to the general public on their web site. They have also developed a simple air volume footprint calculator, based on the original publication, which the public can use to learn more about air volumes used in their daily lives. A link on their site also brings users to my more advanced (Excel based) version of an air volume calculator which could be used as a basis for science projects.

This web site is now activated and is available at:

Version française:
http://ptaff.ca/air/ or http://ptaff.ca/air/budget/

English version::
http://ptaff.ca/air/?lang=en_CA
http://ptaff.ca/air/budget/?lang=en_CA

If you see fit, I would invite you to mention these new developments in a future issue of the *CMOS Bulletin SCMO.*

Lewis Poulin, Centre Météorologique Canadien
Dorval, Québec

Reply from the Editor:

The two web sites in question are mentioned above. A corrected Table 2 is shown above. The corrected pdf version has been copied on CMOS web site available for Members only.

Operational Implementation of a 33-km Version of GEM for Global Medium-Range Weather Prediction at CMC

by Stéphane Bélair[1], Stéphane Laroche[1], Michel Roch[1], Anne-Marie Leduc[2], Paul Vaillancourt[1], Jean-Marc Bélanger[1], François Lemay[2], Doug Bender[2], Gilbert Brunet[1], Cécilien Charette[1], Martin Charron[1], André Giguère[2], Claude Girard[1], Jacques Hallé[2], Pierre Koclas[2], Manon Lajoie[2], Ervig Lapalme[2], Louis Lefaivre[2], Jocelyn Mailhot[1], André Méthot[2], Richard Moffet[2], Josée Morneau[2], Alain Patoine[2], Simon Pellerin[1], Yves Pelletier[2], Paul Pestieau[2], André Plante[2], Lewis Poulin[2], Abdessamad Qaddouri[1], Tom Robinson[2], Donald Talbot[2], Monique Tanguay[1], André Tremblay[1], Gilles Verner[2] and Ayrton Zadra[1]

Résumé: Le 31 octobre 2006, une version 33 km du modèle Global Environnemental Multi-échelle (GEM) a été implémentée aux opérations du Centre Météorologique Canadien (CMC) pour la prévision numérique globale à moyenne échéance. Les vérifications faites durant la phase de développement et la passe parallèle montrent que les prévisions avec ce nouveau système sont significativement meilleures que celles avec l'ancien modèle global. Cette amélioration est observée pour toutes les variables examinées, et pour toutes les régions du monde. En terme de temps de développement, de ressources requises (humaines et informatiques), et d'améliorations aux prévisions numériques, ce transfert opérationnel est considéré comme un des plus importants fait au CMC.

1. Global medium-range NWP at CMC

On 31 October 2006, a new version of the Global Environmental Multi-scale (GEM, Côté et al. 1998) model was operationally implemented at the Canadian Meteorological Centre (CMC) for global medium-range numerical weather prediction (NWP). This implementation required several years of research and development, and included contributions from many scientists, research assistants, operational meteorologists, computer experts, and managers. In terms of development time, resources allocated (human and computer), and NWP improvements, this operational transfer ranks as one of the most sizeable ever done at CMC.

A change of this magnitude to the global forecast model was necessary to assure CMC's competitive edge in the years to come. Except for the inclusion of low-level blocking due to subgrid-scale orography that led to significant improvement in 2001 (Zadra et al. 2003), most of CMC's gain in the last decade for global medium-range NWP came in response to improvements to the data assimilation component of the global forecast system. The most memorable of these changes was the implementation in 2005 of a four-dimensional variational data assimilation (4D-Var) system (Gauthier et al. 2006, Laroche et al. 2006). The modeling component, in contrast, has not changed much during that time. The grid size of the global model remained approximately the same (100 km) since 1995, with the same number of vertical levels (i.e., 28). And except for the inclusion of low-level blocking, the physics essentially stayed unchanged since 1993, when condensation and radiation physics were modified.

In the October 2006 implementation, both horizontal and vertical resolutions of the global forecast system were significantly increased. The horizontal grid size was reduced from 100 km to 33 km. And in the vertical, the number of levels was increased from 28 to 58. In addition, the representation of several physical processes were improved, including clouds and precipitation, surface processes, and vertical diffusion associated with turbulence.

The main objectives of this paper are to report this important change in Canada's operational forecast system, give some details about the new system's configuration, and show some of the outstanding improvements that resulted from this operational implementation.

2. New global forecast system

As shown in Table 1, the differences between CMC's new and old global forecast systems are broader and more general than just increasing the resolution. As described below, important changes were done to the numerics/dynamics and physics packages of GEM, as well as to the 4D-Var system that provides the model's initial conditions.

[1] Meteorological Research Division, Environment Canada

[2] Canadian Meteorological Centre, Environment Canada

	Old	New
Numerics/dynamics		
Horizontal grid	400x200	800x600
Vertical levels	28	58
Timestep	45 min	15 min
Computational poles	North Pacific, South Atlantic	Geographic poles
Sponge layer at model top	1 level	4 levels
Orography	US Navy	Filtered USGS
Physics		
Shallow convection	none	Kuo Transient
Deep convection	Kuo	Kain-Fritsch
Stable condensation	Sundqvist	Modified Sundqvist
Turbulent mixing length	Blackadar	Bougeanult-Lacarrère
Surface roughness over water	Charnock	Constant in Tropics, Charnock elsewhere
Land surface scheme	Force-restore	ISBA
Data assimilation		
Land surface	Climatology	OI sequential assimilation for surface temperatures and soil moisture
Background error statistics	NMC method	NMC, but updated with new model
Inner loop iterations	40+30	30+25
Physics for non-linear model	Same as physics in old operational version	Same as physics in new operational version

Table 1: Main modifications to the operational medium-range forecast system.

For the numerical/dynamical configuration of global GEM, the timestep was decreased from 45 minutes to 15 minutes; the poles of the computational grid are now located at the geographic poles instead of having a rotated grid with the numerical poles in the North Pacific and in the South Atlantic oceans; the sponge layer at the top of the model (to minimize the negative impact of spurious waves reflecting from the model top) was increased from 1 to 4 levels; and a database from the United States Geological Survey (USGS) is now used to specify the model orography instead of the previous database from the US Navy.

The modifications that were done to the physical package are even more compelling, as they relate to many important physical processes. One major objective with this new global model was to represent condensation and precipitation in a way similar to what is done in CMC's mesoscale regional operational forecast system (Bélair et al. 2000, Mailhot et al. 2006). To achieve this, the Kain and Fritsch (1990, 1993) scheme for deep convection was included, together with a new scheme for shallow convection (Kuo Transient, based on the work of Girard and colleagues, see Bélair et al. 2005). In the turbulent vertical diffusion scheme, the Bougeault and Lacarrère (1989) mixing length is now used (see also Bélair et al. 1999). The land surface scheme ISBA (Interactions between Surface, Biosphere and Atmosphere, see Noilhan and Planton 1989) is now replacing the previous force-restore scheme, with initial conditions provided by a sequential data assimilation based on optimal interpolation (see Bélair et al. 2003a,b for details).

Finally, some adjustments and optimisations were required to run the 4D-Var scheme with the new model. For instance, the background error statistics have been recalculated for the new model (with the new set of vertical levels). The number of inner-loop integrations has been reduced to a total of 55 (30 in a first series of integrations and 25 in a second series), compared to 70 (40+30) in the previous operational configuration. And the physics for the inner-loop integrations is now based on the configuration of the non-linear high-resolution forecast model (described above).

3. Evaluation

From the very beginning of this project, it was clear that meteorological systems predicted by the new global GEM configuration evolved in a more realistic manner compared to those produced by the previous operational system. Consistent with our mesoscale NWP experience with the regional forecast system, the new high-resolution global model is able to produce smaller-scale structures (on the mesoscale) not resolved with the previous operational model. Part of these features are the narrow precipitation bands often observed in large-scale weather systems and tropical cyclones, which are found in general to be much better predicted with the new model. It was also noted that the intertropical convergence zone (ITCZ) is also better defined.

As an example of the new system's ability to better represent weather systems mesoscale structures, results from a 60-h numerical forecast of a winter storm over Eastern Canada and United States are shown in Figure 1. The model precipitation rates, given in the left and central panels, are quite different for the two models. Precipitation from the new model compares better with radar reflectivities (right panel), especially in the southern portion of the large-scale system where the new model is able to produce a more intense and narrower precipitation band, in better agreement with observations.

This improved representation of mesoscale features is also noted for tropical systems, as shown in Figure 2's depiction of hurricane Floyd (September 1999). The panels on the left show five-day forecasts of precipitation rate and sea-level pressure, whereas the right panel displays the visible satellite image valid at the same time. The predicted pressure pattern is tighter with the new system, and precipitation bands are better defined, showing structures more similar to the satellite image. Moreover, the minimum central pressure is closer to the observed eye of the storm and has a smaller value (not shown), also more in agreement with observations.

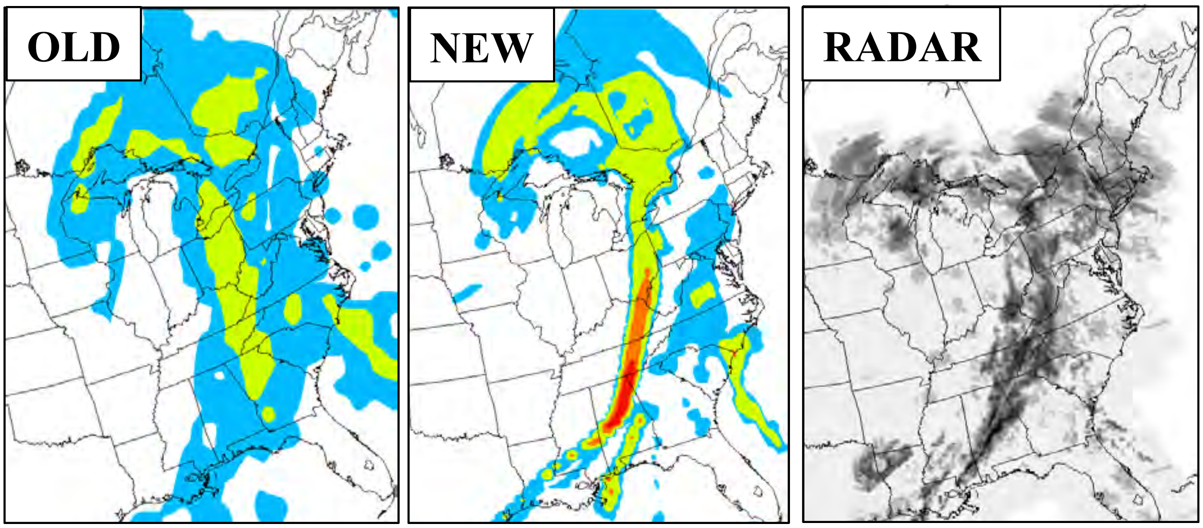


Figure 1: 60-h forecasts of instantaneous precipitation rates valid at 1200 UTC 25 February 2001 using the old and new global model. Contours are for rates of 0.1, 1, 5, 10, and 25 mm h^{-1}. The panel on the right shows the radar reflectivities valid at the same time.

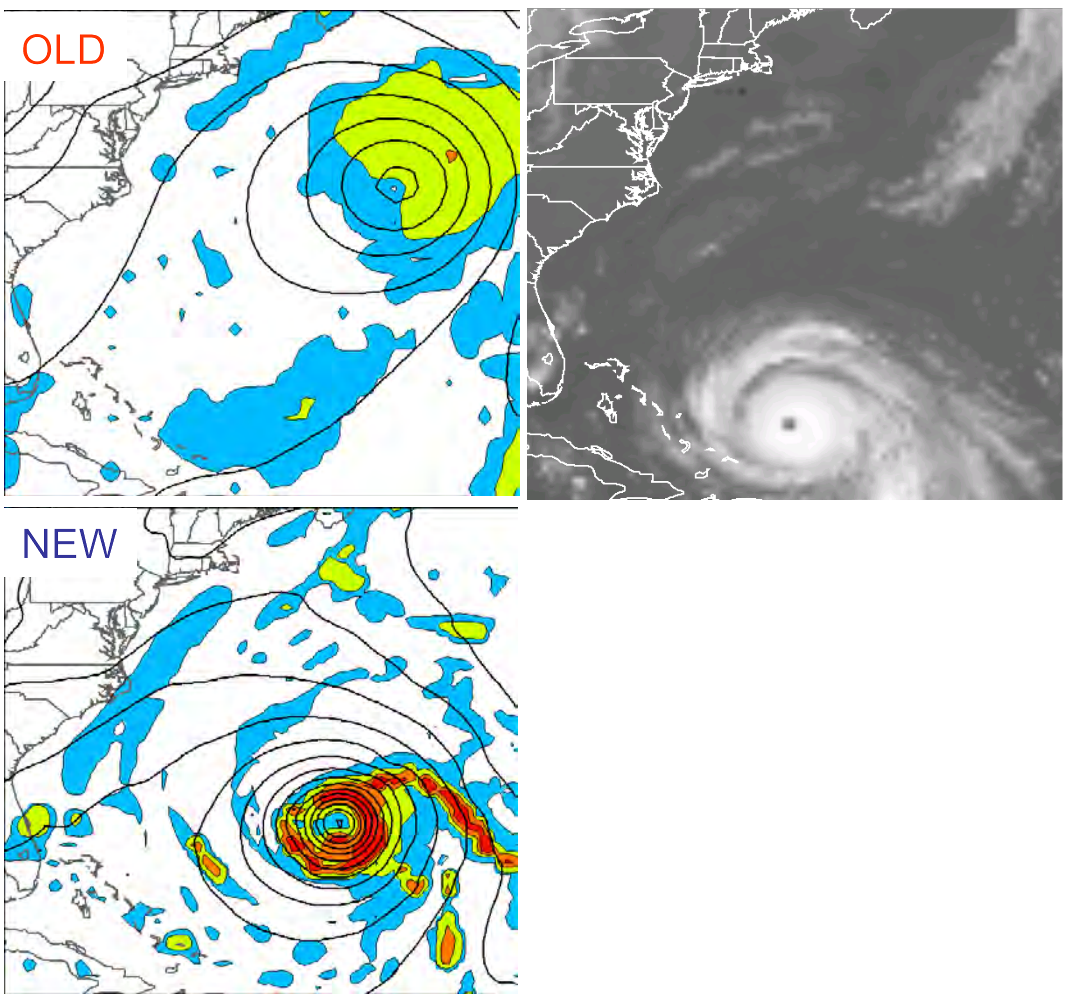


Figure 2: Five-day forecasts (left panels) of sea-level pressure and of instantaneous precipitation rate for Hurricane Floyd (September 1999). Satellite imagery at the same time is shown in the right panel.

This type of improvement for the prediction of hurricanes is not an exception, but rather the rule. An objective evaluation of 29 hurricanes and typhoons in 2004 and 2005 revealed significant improvement for three and five day forecasts of the intensity (minimum central pressure) and position of these systems. These results will be presented in a forthcoming article.

Comprehensive series of tests were done to objectively confirm these perceived improvements. Ten-day forecasts initialized with 4D-Var analyses from two data assimilation cycles (one for the cold season from 15 December 2004 to 15 February 2005, and another for the warm season from 15 July to 15 September 2004) were objectively evaluated against radiosondes, surface stations, and upper-air analyses. Because of the large number of cases (over 100 runs for each season), the error statistics obtained from the evaluations are quite stable (i.e., they do not change much if we remove or add cases). Of course, the model performance for a particular season is expected to vary from year to year, depending on the dominant circulations and persistent patterns, but the tests required for multi-year evaluations are computationally prohibitive.

Figure 3, an example of the type of products examined during the evaluation process, shows a comparison of 96-h forecasts, issued for the cold season cycle, against Northern Hemisphere radiosondes. The evaluation indicates that root-mean-square errors (RMSE) with the new model are substantially decreased for temperature and geopotential height, whereas the improvement is less for winds (results for humidity are not shown). Biases are quite similar for winds in the two forecast systems, but were improved for tropospheric geopotential height and temperature. Of course, the impact of the new system depends on the region and on the season. Although the evaluation results are too numerous to be presented here, we can indicate that they reveal improvements for every region of the world, for both warm and cold seasons. The positive impact was found to be larger in the Tropics and in Asia.

One particularly successful aspect of this implementation, and this was expected considering the changes made to the condensation/clouds physics and to the horizontal resolution, is related to precipitation. With the new global model, quantitative precipitation forecasts (QPFs) over North America are much improved and are now more similar to QPFs from the short-range regional system than to QPFs from the previous low-resolution global model. This improvement is shown in the biases and equitable threat scores (ETS) for day-3 QPFs over the United States [comparison against the Standard Hydrometeorological Exchange Format (SHEF) network, see Figure 4]. In a systematic manner, i.e., for all lead times and for all regions, the new system reduced the positive biases for small precipitation accumulations (less than 5 mm/day), as well as the negative biases for larger accumulations (greater than 10 mm/day). Also impressive is the increase in ETS for small and large precipitation amounts.

Prior to definitive implementation, the new forecast system was run in parallel in CMC's operational suite to confirm the positive results obtained during development and to examine the impact on other CMC forecast components connected to the global assimilation and forecast system (e.g., regional short-range, ensemble prediction system, etc.). This parallel run lasted from 31 August to 31 October 2006. It led to the same conclusions as those from the development tests and was followed on 31 October 2006 by the operational implementation of the new high-resolution global forecast system.

Another reason for having a two-month parallel run was to allow CMC forecasters to subjectively evaluate the new model. Throughout the two-month period, CMC's operational forecasters systematically compared the new and old systems based on a predetermined evaluation table. The evaluation was done for several regions (Pacific, North America, Atlantic, and Arctic). In situations when the numerical prediction from either one of the models was found to be substantially better than the other model, capital letters were used ("O" for the previous operational system, and "N" for the new one). When the difference was considered less significant, but still in favour of one of the two systems, then the letters "o" and "n" were used. When the two systems were judged to produce predictions of the same quality, the letter "e" (for "even") was used.

According to this subjective evaluation, summarized in Table 2, the new system was found to be better or equivalent to the old system more than 70% of the time. For precipitation, this score increases to more than 80% of the time. On average, the old and new global systems were found to be even for about 40-45% of the time. For sea-level pressure (SLP) and 500-hPa geopotential height (GZ500), the greatest improvements were over the Atlantic region, where N=8.3% versus O=2.5%, and n=30.0% versus o=17.7%. For all the regions taken together, the numbers for SLP and GZ500 are: N=5.6% versus O=2.9%, and n=27.5% versus o=19.6%. As expected, even greater improvements were observed for QPFs, with N=5.3% versus O=1.4%, and n=39.0% versus n=16.9%.

These results are obviously quite satisfactory and confirmed those from the objective evaluations against radiosondes, analyses, and surface stations. Both objective and subjective results were presented on 17 October 2006 to CMC's Committee for Operational and Parallel Runs, which accepted our proposition to operationally implement the new global forecast system.

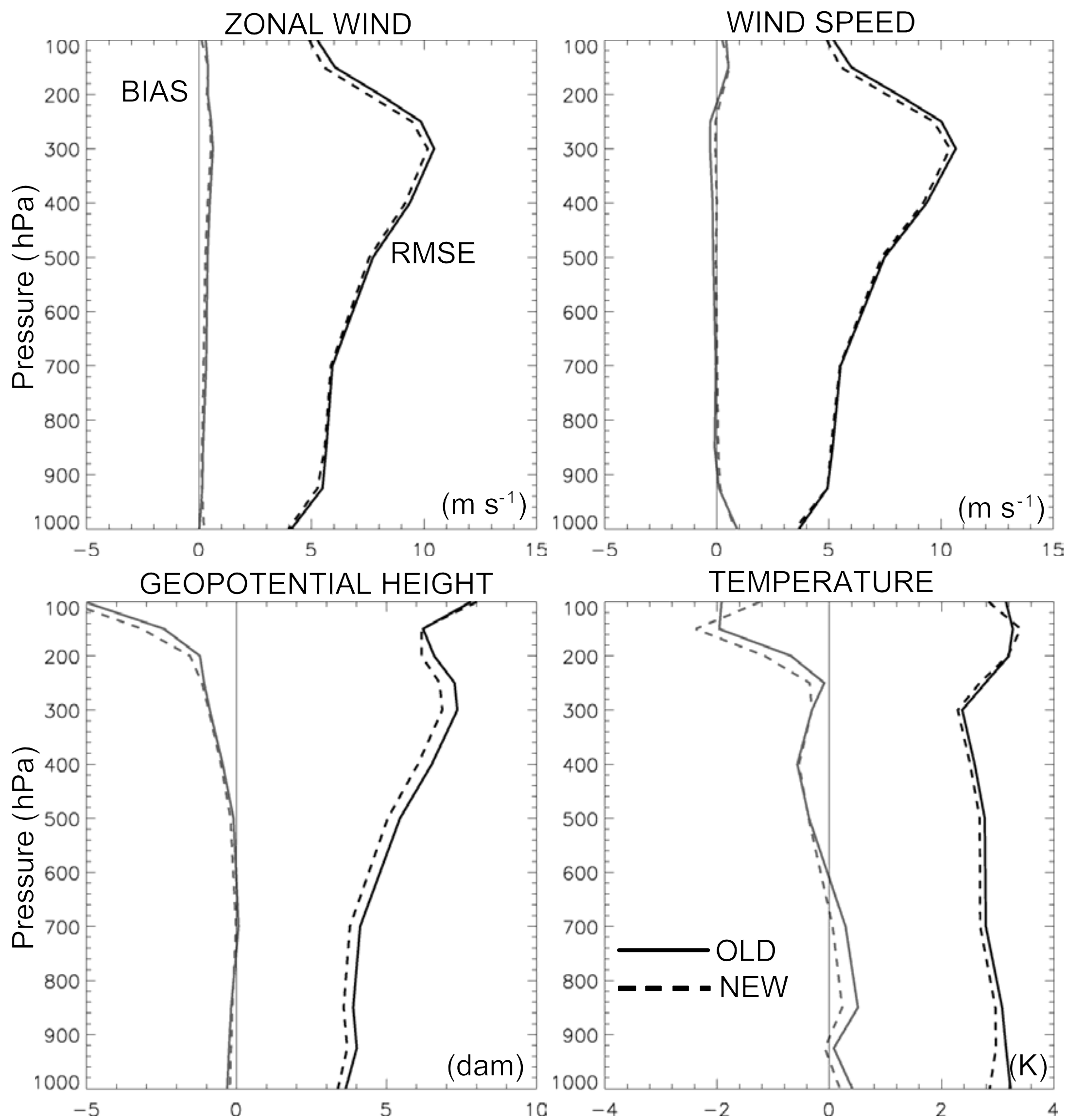


Figure 3. Objective evaluation of 96-h forecasts against radiosondes for the old (full lines) and new (dash lines) operational global models. Root-mean-square error (RMSE, black lines) and bias (grey lines) are shown. Verification is done over the Northern Hemisphere, for a set of 125 integrations initialized from 4D-Var analyses between 15 December 2004 and 15 February 2005.

Variables	Regions	O (%)	N (%)	e (%)	o (%)	n (%)
SLP+GZ500	Pacific	3.3	4.2	45.0	21.5	26.0
SLP+GZ500	North America	2.5	5.0	460	17.7	28.8
SLP+GZ500	Atlantic	2.5	8.3	41.5	17.7	30.0
SLP+GZ500	Arctic	3.3	5.0	44.6	21.7	25.4
SLP+GZ500	All	2.9	5.6	44.4	19.6	27.5
GZ500	All	2.7	5.8	43.1	19.9	28.5
SLP	All	3.1	5.5	45.6	19.3	26.5
QPF	All	1.4	5.3	37.4	16.9	39.0

Table 2: Summary of CMC's subjective evaluation during the parallel implementation run. The evaluation was done from 4 September to 17 October 2006, even though the parallel runs ended with the operational implementation on 31 October 2006. Runs initialized at 00 and 12 UTC each day have been evaluated, i.e., over 80 cases. The variables examined are the sea-level pressure (SLP), the geopotential height at 500 hPa (GZ500), and quantitative precipitation forecast (QPF). The evaluation was done over the Pacific, North America, Atlantic, and Arctic regions. The letters "o" and "n" indicate that either the old or new system was preferred. Capital letters "O" and "N" indicate that the differences between the forecasts were considered to be major. And the letter "e" indicates that the forecasts from the old and new systems were determined to be "even".

4. Conclusions

A new global forecast system for medium-range NWP was implemented at CMC-operations on 31 October 2006. Verifications performed during the development and parallel phases of the project have shown that predictions issued from this new system are significantly improved compared to those from the previous operational system. The improvement is for all the variables examined, and for all the regions of the world.

On the international scene, it should be expected that predictions issued from CMC's new global model will compare more favorably against products from other major meteorological centres, such as the European Centre for Medium-Range Weather Forecasts (ECMWF) and the United States National Centers for Environmental Predictions (NCEP). Figure 5 shows a verification against Northern Hemisphere radiosondes for 500-hPa geopotential heights from a few centres (ECMWF, NCEP, Japan Meteorological Agency - JMA, and the United Kingdom Meteorological Office – UKMet), including the old and new CMC global models. The evaluation was done for the first month of the parallel run, i.e., September 2006. The differences between the old and new systems are again evident in this figure, with errors from the new system consistently lower than those from the previous system. It is remarkable to note that the new high-resolution model compares much better with other centres, often being second only to ECMWF. Of course this verification is only for a single month, and examination of the new system's performance over a much longer period is required to draw solid conclusions about the new position of CMC's global forecast system relative to other centres. Nevertheless, this preliminary inter-comparison is quite encouraging.

The global forecast and assimilation system should continue to improve in the months and years to come. According to plans, the next operational implementation, expected for mid-2007, should deal with the inclusion of new observations (AIRS: Atmospheric InfraRed Sounder, and SSM/I: Special Sensor Microwave Imager) in the 4D-Var scheme. In 2008, a stratospheric version of GEM, together with a radiation code from the Canadian Centre for Climate Modelling and Analysis (CCCma), should be proposed for operational implementation. Other changes are also currently examined, including improvements to the representation and data assimilation of surface processes, and modifications to the 4D-Var configuration.

Acknowledgements

A large number of people were involved during the course of this project, many of them listed as authors of this paper. We would like to thank all the others who are not on this list, from management, research, development, analysis and prognostics, implementation, and operations. We would like in particular to thank Katja Winger for providing the figure showing the computational grid of the new high-resolution global GEM, which appears on the cover of this *CMOS Bulletin SCMO* issue.

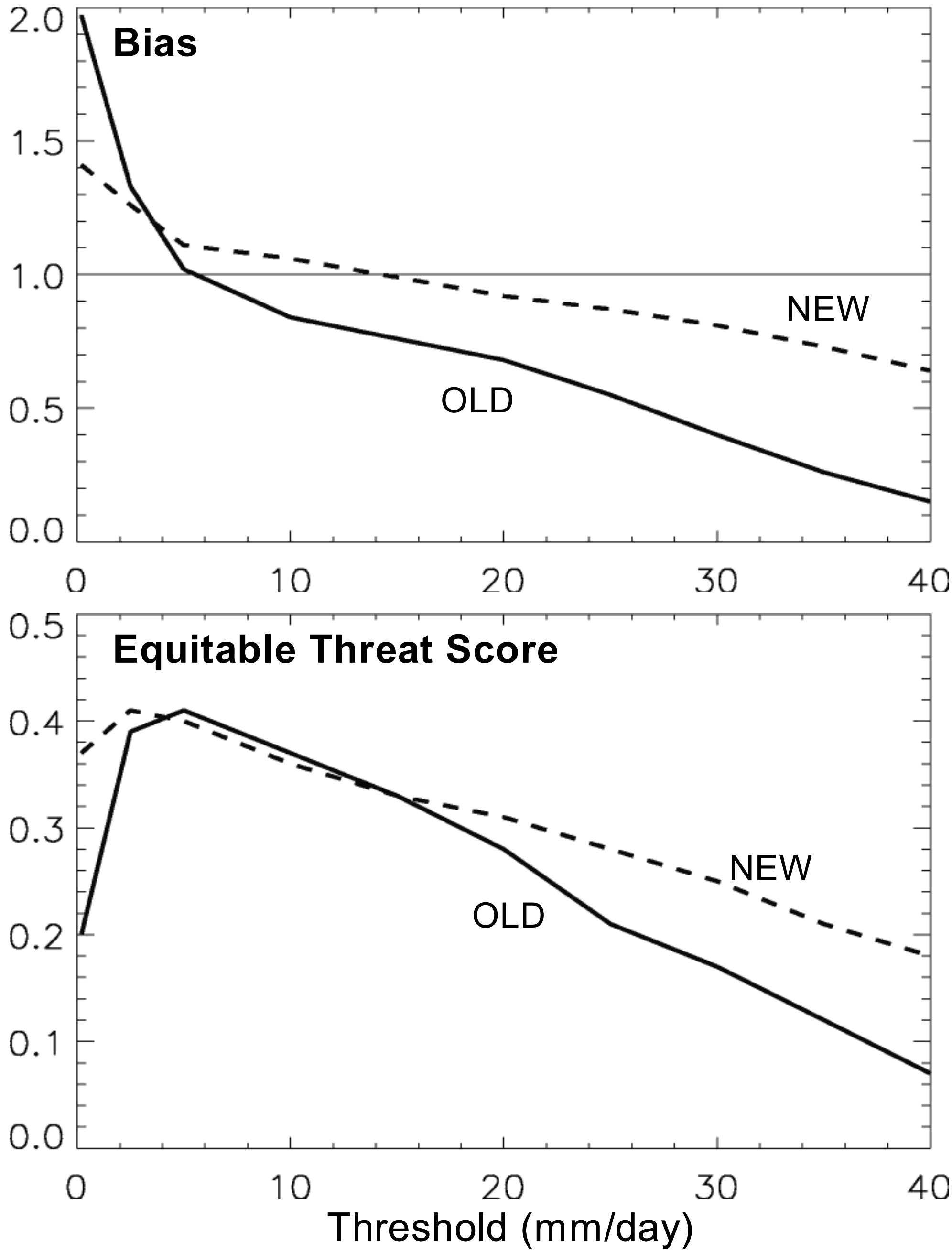


Figure 4: Objective evaluation of 24-h precipitation accumulation against surface measurements, for 48 to 72-h forecasts (i.e., day 3). Surface measurements come from the SHEF observation network over the contiguous United States. The evaluation is done for the same 125 cases that were used for the upper-air evaluation (see Fig. 3). Bias and equitable threat scores for the old and new models are shown in full and dash lines, respectively.

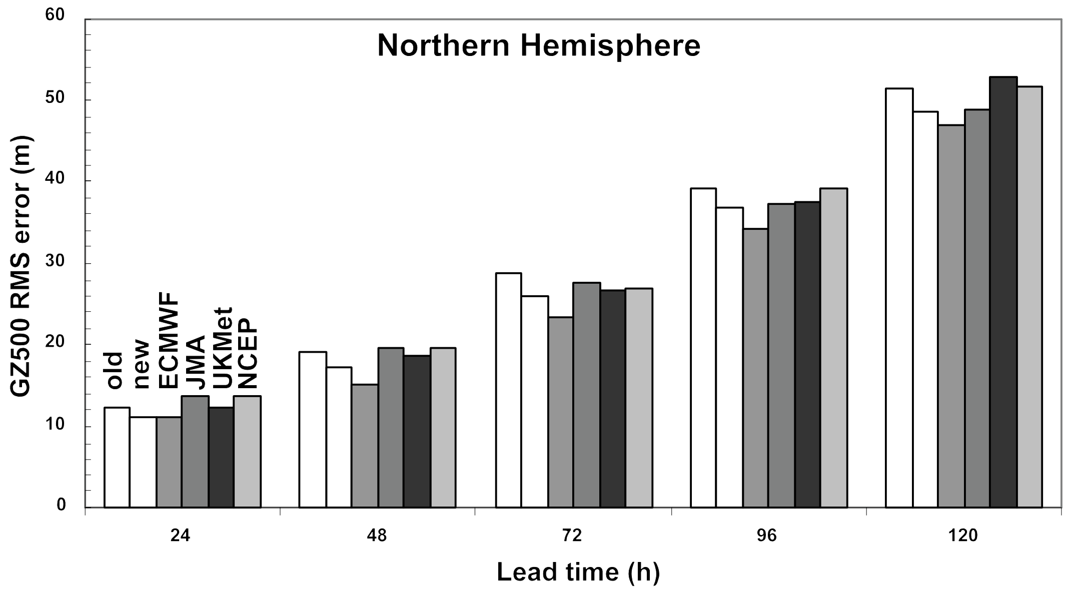


Figure 5: Comparison of CMC's old and new operational systems against other major meteorological centres, i.e., European Meteorological Centre for Medium-Range Weather Forecasts (ECMWF), Japan Meteorological Agency (JMA), United Kingdom Meteorological office (UKMet), and the United States National Centers for Environmental Predictions (NCEP). The comparison is done for 500-hPa geopotential height, verified against northern hemisphere radiosondes. The period of verification is September 2006 (during the first month of the parallel run).

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A Conceptual Model for Service-oriented Discovery of Marine Metadata Descriptions

by Anthony Isenor[1] and Tobias W. Spears[2]

Résumé (traduit par la direction): On a décrit un modèle conceptuel qui utilise une architecture axée sur le service de la distribution des métadonnées de la marine. Le modèle utilise des normes pour la description des métadonnées et le contenu des mots clés. Pour la description des métadonnées, le modèle peut utiliser soit la norme CSDGM (Content Standard for Digital Geospatial Metadata) du FGDC (Federal Geographic Data Committee) ou la norme de l'Organisation internationale de normalisation 19115 sur l'Information des métadonnées géographiques. On obtient le contenu des mots clés dans les métadonnées structurées par l'utilisation du Répertoire de base du changement planétaire des mots clés. On a recommandé une approche décentralisée des archives pour le stockage des descriptions des métadonnées. Pour fins de communication, le modèle se réfère à une architecture axée entre des portails de métadonnées.

Introduction

There have been many marine groups working towards the 'wishful' goal of data sharing, or as it is often referred to, data interoperability. These efforts have covered the international, national and local scales. At the international level, activities typically involve the evaluation of applicable technologies and suggestions for the application of specific technologies. National efforts are usually more specific, and involve the direct application of techniques to help meet departmental data management requirements. The local efforts are typically project driven, often adopting a phased approach thereby leveraging numerous projects to meet a specific data sharing goal.

Typically, the developments resulting from these groups allow clients to access the provider's data via a network interface, such as a web browser. More recent efforts have concentrated on providing access to graphical or map representations of the data. Visual representations are extremely important for providing client familiarization with available products. As well, the map representations are very intuitive for users. However, for interoperability it is important we do not limit data usage to only visual representations. In order to achieve data interoperability, the data themselves must also be available. As well, to enable the automated fusion of data sources, there must also be quantitative metadata available to allow data discovery and utilization without human intervention.

This paper describes a conceptual model that utilizes metadata descriptions that support data discovery. The model considers national marine data management plans, and also the utilization of international metadata standards. The paper first reviews the purpose of the effort, followed by a description of applicable metadata standards and a conceptual model of how a discovery system could be constructed. The service-oriented architecture is introduced and its applicability to product delivery is described. This is followed by a discussion of the metadata and content standards needed to support the conceptual model.

Purpose

The basic concept presented here is the application of international metadata standards to aid users in the discovery of data assets. Local archives hold a wealth of marine data, but discovering these data is often a difficult process. The difficulty arises from a lack of content to be used in the discovery process and also a lack of uniform context-based searching. Presently, the best method of discovering a data asset is by using common internet search engines. However, these engines require the entry of search terms. For a successful search, the entered terms must also be those terms used in the web description of the asset. If not, the asset will not be discovered by the search engine.

The search-term problem can be alleviated through the use of metadata descriptions. Additionally, metadata descriptions that use a common metadata standard provide help beyond the search-term problem. First, the metadata description provides a descriptive layer between the asset and the client. This layer permits the mapping of asset-specific terminology to common search terms. This means that the diverse naming conventions used within the assets can remain specific to the asset, while the search criteria can use more common vocabularies. Second, the metadata description reduces the search overhead. In the marine case, the large volume of data makes it impractical for consumers to search all data in all assets in a timely fashion. Metadata descriptions should provide faster search results because of the reduced volume. Finally, the use of a common metadata standard provides consistency across data providers. The consistency allows the construction of common and automated tools for the discovery, access and mining of the content within the metadata descriptions.

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Metadata Standards

The metadata provides descriptive information about the data asset. Metadata can also provide links to the actual data asset. The delivery of data assets provides the additional problem of volume; data assets can become very large depending on the source. The delivery of the asset may be in electronic or physical form, or may only support the delivery of subsets of the asset. However, for the purpose of this report, the specific data assets are not considered. Here, we limit our discussion to metadata.

Metadata are the *values of characteristics that qualitatively or quantitatively describe or support a resource* [1]. For a data asset, the metadata would describe attributes such as who, what, when and where. A metadata standard is simply a specification of a structure designed to contain this information. The content of the structure represents the metadata description of the asset and may or may not be included in the metadata standard itself. In the process of discovery, the metadata structure performs a key role in identifying the critically important content requirements for the discovery process.

The content of the metadata description is an important component of the discovery process. The content represents the searchable terms, similar to the terms used in internet search engines. In its entirety, the content represents a summary of the data asset.

From a structural perspective, the metadata description consists of three essential parts: label, structure and value [2]. By standardizing as much as possible in all three parts, we aim to provide consistency in metadata descriptions across metadata sources. The description consistency means that common processes and software can be used to access metadata from many providers.

Standardization of the metadata label and structure can be accomplished by designing a system that uses a metadata standard. Of course, most organisations have their own standards for describing their assets. However, here we are interested in achieving data interoperability on a larger scale than a single organisation. Thus, we use the word *standard* to explicitly identify only those metadata structures which have international use. Two such standards associated with geospatial metadata exist: one from the International Organisation for Standardization (ISO) and a second from the United States Federal Geographic Data Committee (FGDC). These standards are referred to as the ISO 19115 [3] and the FGDC Content Standard for Digital Geospatial Metadata (CSDGM) [4]. These standards set the label and structure rules used to describe the data asset.

These standards are not fixed data formats. The standards may be considered outlines of mandatory and optional content, and the associated ordering of that content. The standards were developed for greatly varying application, and as such, the entire standard may not apply to every application. Organisations commonly choose to develop specialized representations of the standards, which are referred to as profiles. The profiles define a community-specific subset of labels, adhering to the structural constraints of the standard.

The United States has mandated the use of the CSDGM thus creating a large user base in both continental US and international efforts with US involvement [5]. Recent Australian (AU) efforts directed towards forming a local AU marine data community are concentrating on the ISO 19115 standard [6]. The Treasury Board of Canada is currently drafting an Information Technology Standard indicating the use of ISO 19115 as a government standard.

In terms of aiding the discovery process, the use of either standard would be a progressive step, regardless of which one was chosen. Although the ISO 19115 is the only internationally developed standard, we cannot ignore the US user base supporting the CSDGM, or the established support of CSDGM by open source and commercial metadata management tools (e.g., ISite [7]). There is also the issue of specification ease-of-use ([8] contains a brief comparison). In the longer term, there are efforts underway [9] to consolidate the ISO 19115 and CSDGM standards. This would create a single international standard under the ISO.

The decision to use a particular standard over the other needs to be made on a case-by-case basis, by considering tools, understanding of the specifications and collaborative partners. The CSDGM is widely used and at this point, contextually better understood. It is also easily accessible in many metadata authoring environments. However, the end goal for the US and Canada will be the adoption of ISO 19115.

Given the difficult choice between standards, some projects are attempting to provide consumers with either metadata description. In the United Kingdom, the NERC DataGrid (NDG) project has developed a meta-metadata structure [10]. The NDG structure contains the content required to create either the ISO 19115 or the CSDGM structures.

For the architecture described here, either metadata standard will provide sufficient data asset descriptions for the marine community. In fact, individual provider sites could use either standard, with communication between sites providing the necessary transformation of search criteria to meet the requirements of the individual standard (although the reader should recognize these transformations are nontrivial). Thus, we recommend the use of one of these standards but do not favour one standard over the other. Local and community efforts also play a critical role in the decision, thus making it difficult for the authors to identify a single solution.

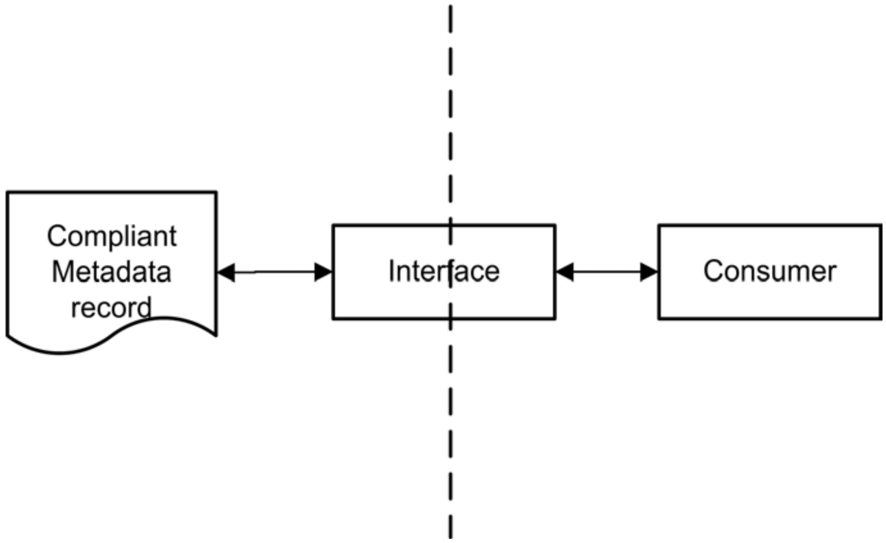

Figure 1: The conceptual model for metadata delivery. The metadata are created at the data source location. The consumer accesses the metadata through an interface that understands both the consumer requests and the system containing the metadata. The distinction between the consumer access side and the infrastructure tier is denoted by a dashed line.

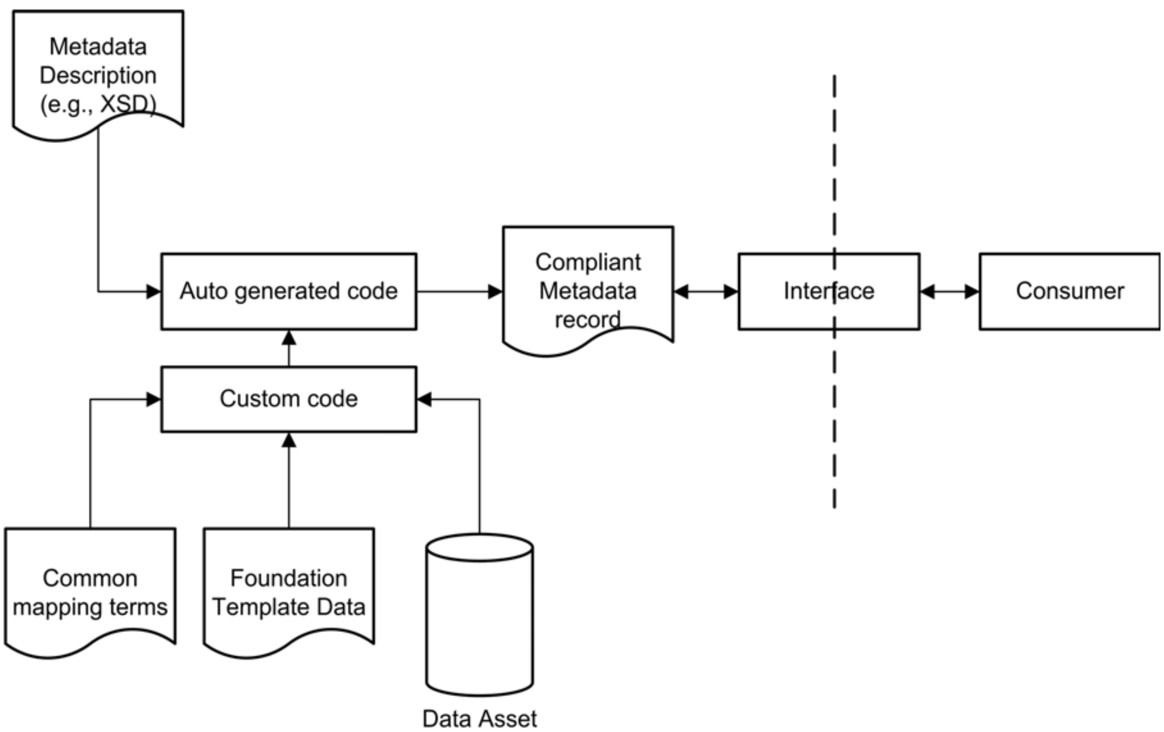

Figure 2: The conceptual model for providing metadata descriptions. The explicit metadata description, represented as a document type definition (DTD) or XML schema definition (XSD) document, is used to automatically generate code. Custom built code is used to access the data, foundation template data, and the mapping of data type terminology, combining the sources and describing the data asset in a standards-based metadata description.

Vocabularies Defined within the Metadata Standard
As noted previously, the content of the metadata structure represents the metadata description. The permitted content for a specific metadata attribute is defined as the domain of values for the attribute. The domain can be restricted by type (e.g., character) but remain unrestricted in form (e.g., free text). Domains can also be restricted by using lists of allowed values. For example, the CSDGM standard contains a metadata attribute for "progress", referring to the progress made on processing a data asset. The allowed list of values for "progress" is: "Complete", "In work", and "Planned". This list of values represents a vocabulary defined within the standard. This is a form of a controlled vocabulary. Note that this vocabulary is defined within the metadata standard. However, vocabularies may also be defined external to the metadata standard.

Vocabularies Defined External to the Metadata Standard
Each data provider typically has a unique vocabulary that is often an integral part of their data asset. The vocabulary provides a naming for the specific content of the asset. However, the vocabulary is often unique to the data provider. Control of this vocabulary is maintained by the provider, often because the vocabulary is used within the local processing systems.

As noted previously, metadata content provides a descriptive layer between the asset and the client. This layering provides the opportunity to use a different vocabulary to describe the contents of the asset, as compared to the vocabulary within the asset. The use of a different vocabulary does introduce a requirement for a mapping between vocabulary terms. Such mappings can be difficult, due in part to the exact and explicit requirements of the mapping, both of which are required to ensure interoperability between data assets.

For the current discussion, consider the use of two external vocabularies; one vocabulary used within the data asset and a second used within the metadata description. If the purpose of the metadata description is discovery of the asset, then the vocabulary in the metadata description may be called a discovery vocabulary [11]. A discovery vocabulary typically contains common language terms (e.g., "sound velocity"). These terms are often referred to as keywords. There is typically a non-rigorous definition associated with the keywords.

The collection of terminology associated with individual data items within the asset may be called a usage vocabulary. This terminology may be a cryptic code (e.g., "SVEL") that is unique to the providing data set. There is typically a rigorous definition associated with each term in the usage vocabulary. As well, it is typical that many terms in the usage vocabulary map relates to a single term in the discovery vocabulary.

It is important to use a discovery vocabulary in the associated metadata records rather than the usage vocabulary. This is because searches will utilize common language terms as opposed to the often cryptic terminology used in a usage vocabulary. Discovery vocabularies are very well suited for discovery of assets from Internet portals, and for this reason are considered in this model.

One well-recognised discovery vocabulary is the Global Change Master Directory (GCMD). The GCMD vocabulary was first offered as a keyword list in 1995. This vocabulary is also being suggested for use in a Canadian code-mapping exercise (more in the next section), for use in a collaborative Canadian-Australian data asset discovery system, and is also noted in keyword examples in documentation of the US Integrated Ocean Observing System (IOOS) [12].

The GCMD specification appears in wide use in the marine community. However, GCMD topics cover a wide range of categories (e.g., agriculture, atmosphere, human dimensions, land surface, etc. [13]) and thus can be applicable to many domains. Thus, we consider the use of GCMD terminology as a reasonable choice for the discovery of data content. Either metadata standard can accept GCMD terminology using the theme key elements. If providers wished, they could also include details on the particular usage vocabulary. In the CSDGM, this would take the form of an entity description while in the ISO 19115 it would be contained in Content Information.

Conceptual Architecture - Decentralized and Service Oriented
The standards and vocabularies noted above are used to build the metadata descriptions. From the descriptions, we can begin to form a conceptual model using three critical components: the metadata description, a consumer, and an interface between the metadata and consumer (Figure 1).

The metadata description may be created through manual process, where staff familiar with the data asset digitizes the required metadata content. However, this would be slow and inefficient. Ideally, compliant metadata descriptions would be created in an automated fashion using the data assets as input. The automated process could use a combination of automatically generated and custom developed software (see Figure 2).
The automatically generated software would provide developers with easier access to the individual data elements in the metadata structure. Generation tools, some of which are open source and freely available (e.g., The Castor Project [14], Zeus [15]), read formal definitions of the metadata structure and create software that interfaces with the structure. The formal definitions are typically described using the eXtensible Markup Language (XML) document type definition (DTD) or XML schema definition (XSD). The customized code would then utilize the auto-generated code to provide the content to the metadata structure elements in XML.

The custom built code has two other important inputs: the foundation template data and the mapping to a common vocabulary. The foundation template data contains quasi-static data asset metadata that is required in the metadata description. For example, metadata descriptions often contain an abstract that describes the asset. Such abstracts are often not part of the data archive. As well, the abstracts are somewhat static, in that they do not typically change with updates to the archive. The abstracts associated with data assets are an example of foundation template data. Other examples include the individuals or organisations identified as contacts for data asset information. The foundation template data would be created once and stored separately from the data, and reused to populate applicable elements either from within entry tools or automated processing.

The mapping to a common vocabulary is also quasi-static. The mapping stores the relationships between the organisations usage vocabulary and those terms defined by the discovery vocabulary. This is an essential part of the final metadata description, as it provides commonality of data type naming. The commonality allows automated searching to be based on a common vocabulary, even if the local data asset utilizes a local usage vocabulary.

There is an effort underway at the Canadian Integrated Science Data Management (ISDM, formerly the Marine Environmental Data Service, or MEDS) to manage the vocabulary mappings at the national level. In Canada, a formal mapping exercise took place as a result of a collaborative Department of National Defence and Fisheries and Oceans effort to define an XML-based structure for data exchange [16]. This mapping effort utilized data vocabularies from the Institute of Ocean Sciences, Bedford Institute of Oceanography and MEDS. This initial effort, combined with the present more formal effort underway at ISDM, can form the basis of the mapping requirement described here.

The single interface shown in Figures 1 and 2 may suggest a single access point for consumers to acquire the metadata descriptions. A single access point suggests (although not always the case) a central authority and perhaps a central archive for the management of the metadata descriptions. However, the figures may also represent one node of a decentralized model.

Both the centralized and decentralized archive models offer certain advantages. The centralized archive model offers resource savings, as only one location needs to manage the services. For example, only the central archive would need development and maintenance of the software that provides the service, or the supporting infrastructure including hardware and backup functions. However, for sustainability the centralized model requires a contiguous line of authority and responsibility from the data provider to the central archive. Alternately stated, the data provider needs the ability to directly influence the central archive (the opposite is also true). Otherwise, the central archive can alter its management functions without considering the data providers.

Central archives also have administrative issues related to such things as governance, collaboration and protected information. An example of governance issues includes things like a lack of response by the central authority to identified problems. Again, this is often a result of data providers having no line of authority within the central archive. Central archives may also place restrictions on the autonomy of local providers, by mandating requirements based on the existing systems at the central archive. There may also be issues related to private or protected information, where distribution to an archive outside the organisation is not permitted, but where metadata descriptions are still useful for internal usage.

Within an organisation or managerial unit, the centralized model can work effectively. However, the contiguous line of authority is broken when considering inter-departmental or international collaboration. When the line of authority is broken, a decentralized model is more sustainable.

A decentralized model relies on a distributed set of nodes. The cornerstone of decentralization is the implementation of standards, where each node provides access to a set of services in a structured, defined and consistent manner. In this case, the services provide access to the metadata descriptions.

Decentralization allows the metadata description to remain local (or closer) to the data provider. In fact, the metadata description remains within the authority line of the data provider. Thus, the decentralized nodes that span inter-departmental or international boundaries could form individual centralized nodes within independent organisational units. Effectively, the centralized archive for an organisation is one node in a decentralized set of nodes.

In this type of hybrid model, the metadata description remains closer to, and within direct line of authority with, the data provider from which it originated. As well, decentralization allows other organisations, which are compliant with the implementation standards, to contribute to the set of decentralized nodes. This aspect allows collaboration from unexpected sources.

In the past, the decentralized model has been technically difficult while the centralized model has been much easier to implement. For example, product delivery to a central archive could take the form of an attachment to an email message, or as an ftp-style GET or PUT function between parties. However, this type of delivery is labour-intensive, involving staff to physically deal with the delivered product. Harvester software was then developed to reduce the staff requirements, automating the delivery process. However, harvester software often has issues associated with the opening of specific computer ports, which in turn has implications for firewall administration and local and/or national computer security policy.

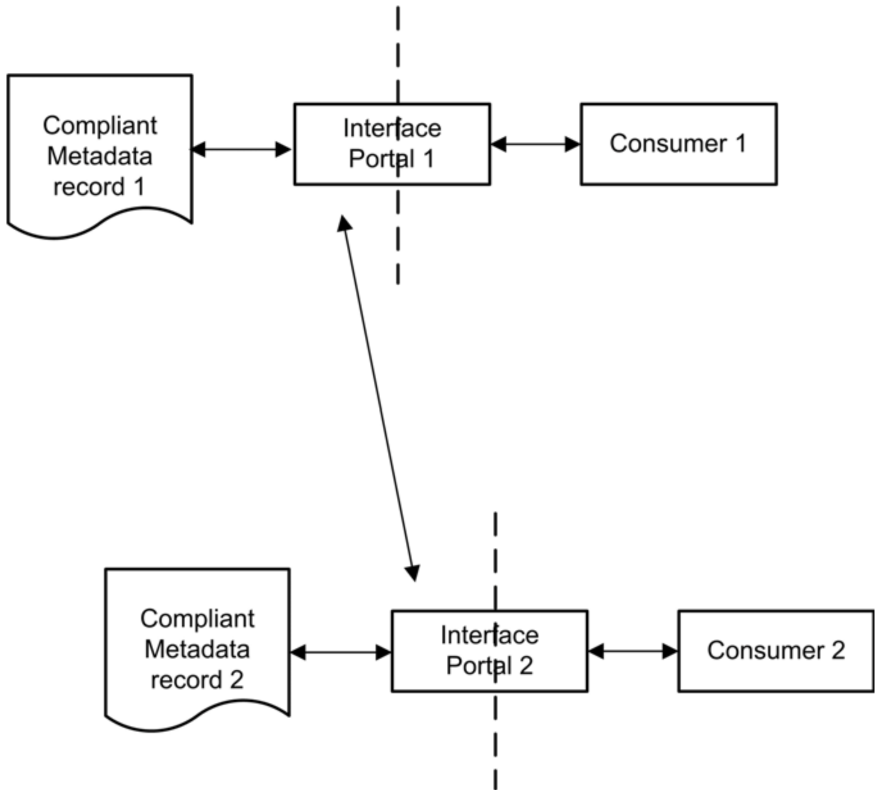

Figure 3: In the decentralized model, Consumer 1 and Consumer 2 can search both metadata descriptions regardless of the Interface entry point.

Fortunately, the development of service-oriented architecture (SOA) allows a much easier joining of the centralized archives into a decentralized set of archives. In the simplest of terms, a service-oriented architecture supports computer-to-computer interactions, with the interface to the available services being described in a computer processible form. Queries to and results from the service can be delivered over hypertext transfer protocol (HTTP), and are also processible due to service communication standards (e.g., Simple Object Access Protocol, or SOAP). The automation aspect of SOA nullifies the staff requirement, while the HTTP communication aspect nullifies the computer security issues associated with more traditional harvester software. In effect, SOA provides a technical solution with administrative benefits.

The implementation of SOA in a decentralized model has an additional benefit. The SOA easily allows communication between interfaces (Figure 3). In this approach, the interfaces become what are referred to as Portals. Portals communicate with one another, providing the consumer with seamless access to the products at all the inter-connected provider sites. As well, this type of architecture allows redundancy in consumer entry points, while the central model has a single entry point and thus a single point of failure.

Summary

The conceptual model presented here highlights four important points related to marine metadata descriptions. First, we recommend the use of a geospatial metadata standard, either the ISO 19115 or the CSDGM. The metadata descriptions are well-suited to an XML structure as this allows use of available tools. Second, we recommend the use of GCMD keywords as the basis of the discovery vocabulary. The GCMD keywords provide an English language description of data types in the archives. This permits the usage of more common search words for the discovery of the data asset. Third, we recommend a decentralized architecture built from centralized archives that exist within contiguous lines of authority in an organisation. This type of architecture provides benefits such as easily allowing participation of other interested organisations and access-path redundancy. Finally, we recommend the use of a service-oriented architecture as the basis of the communication mechanism between organisational-based nodes.

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Next Issue *CMOS Bulletin SCMO*

Next issue of the *CMOS Bulletin SCMO* will be published in **August 2007.** Please send your articles, notes, workshop reports or news items before **July 6, 2007** 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 **août 2007.** Prière de nous faire parvenir avant le **6 juillet 2007** 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.

REMINDER - REMINDER - REMINDER

CMOS has negotiated great membership deals for its members. CMOS members are eligible for a 25% discount off membership fees for the Royal Meteorological Society (RMetS) and the Canadian Geophysical Union (CGU) as associate members. Members of both these societies are also eligible for associate membership in CMOS; so please encourage your colleagues in those societies to join CMOS too.

RAPPEL - RAPPEL - RAPPEL

La SCMO a négocié des tarifs intéressants pour ses membres qui désirent devenir membre de la Société royale de météorologie (RMetS) et de l'Union géophysique canadienne (CGU). Un rabais de 25% est appliqué lorsque vous devenez membre associé de ces deux sociétés savantes. Les membres de ces deux sociétés ont également le privilège de devenir membre associé de la SCMO; dites-le à vos collègues et encouragez-les à joindre la SCMO.

Canadian Oceanographic Historical Photos

In 2005, the Canadian National Committee for SCOR www.cncscor.ca initiated a project to establish an on-line archive of Canadian oceanographic photographs. There are presently 47 photos in the archive. In the main, submissions have been scanned photos sent by email. In a few instances some providers did not have such capabilities; in these cases arrangements were made with a third party for scanning and submission to the archive. The host site has been established through the efforts of CMOS at :

http://www.cmos.ca/Oceanphotos/photoindex.html

A dedicated search engine is on the site to enable readers to locate individuals in the archive. A parallel effort for Canadian meteorological photos may be found at :

http://cmos.ca/Metphotos/photoindex.html

Photos are meant be reasonably clear to be able to identify individuals in the photo, and have a caption that would explain the event (a cruise, conference, university faculty, etc.), a date (year) of the event, and an organized list of (many) of those in the photo. Obviously we are looking for Canadian content, but international content would also be useful if there were several Canadian oceanographic participants. Realizing the significance of "ships" to oceanographic effort we have also tried to obtain photos of Canadian oceanographic vessels as well as photos of people. The principal criteria is to have a good clear input photo. JPEG is the preferred format.

If you are able to help out, it would be appreciated if you could send a few scanned photos to **Dick Stoddart** (dick.stoddart@sympatico.ca) at your convenience. If you have better quality (clearer) photos that could replace some of the more blurry photos in the existing archive, that would help the archive greatly. Check your shoeboxes and see if you could supply one or more. To spur your appetite to supply some photos, we have shown on the inside back cover page (Page iii) two representative photos from the current archive.

Photos historiques de l'océanographie canadienne

En l'année 2005, le Comité national canadien pour SCOR www.cncscor.ca a amorcé le projet d'instaurer sur internet des archives de photographies de l'océanographie canadienne. On y trouve présentement 47 photos archivées. En général, on nous a envoyé par courriel des photos numérisées. Toutefois, dans quelques cas, comme plusieurs personnes ne pouvaient pas utiliser cette façon de faire, on a dû recourir à une tierce personne pour la numérisation des photos afin de les soumettre pour les archives. Grâce aux efforts de la SCMO, on utilise le site web suivant :

http://www.cmos.ca/Oceanphotos/photoindex.html

Afin de donner l'opportunité aux lecteurs de localiser certains individus, on a installé un moteur de recherche. Un effort semblable a été fait pour trouver les photos de la météorologie canadienne :

http://cmos.ca/Metphotos/photoindex.html.

On désire que les photos soient claires afin d'identifier les individus sur celles-ci. On demande aussi que chaque photo ait : une légende qui expliquerait l'événement (comme une croisière, une conférence, une rencontre universitaire, etc.), une date (année) de l'événement et une liste identifiant les noms des individus qui se trouvent sur la photo. Évidemment, on recherche principalement un contenu canadien, toutefois on accepterait un contenu international dans le cas où une photo montrerait plusieurs participants de l'océanographie canadienne. Comme on réalise l'importance des "navires" à l'effort océanographique, nous avons aussi essayé d'obtenir autant des photos de vaisseaux de l'océanographie canadienne que des photos d'individus. En ce qui nous concerne, le critère principal pour accepter une photo, c'est qu'elle soit de bonne clarté. Le format JPEG est préférable.

Si vous possédez quelques photos, nous vous serions reconnaissant d'en faire parvenir quelques-unes numérisées à **Dick Stoddart** (dick.stoddart@sympatico.ca). Dans le cas où vous posséderiez des photos de meilleures qualités (plus claires) que celles qui existent dans les archives, nous apprécierions de les recevoir. Vérifiez vos boîtes de rangement et albums de photos pour voir si vous n'en posséderiez pas quelques-unes. Pour vous donner une bonne idée à nous fournir quelques photos, regardez sur la page couverture arrière intérieure (page iii) deux photos représentatives des photos que l'on retrouve présentement dans nos archives.

Climate Change and Africa

Editor: Pak Sum Low

Cambridge University Press, New York, August 2005
Hardback ISBN: 0-521-83634-4, 369 pages, US$ 150

Book Reviewed by Pat Spearey[1]

The book project "*Climate Change and Africa*" provides a picture of the challenges, impacts and opportunities that African countries are facing with existing climate variabilities and the early stages of climate change. It covers issues of most relevance to this continent including: past and present climates; desertification; biomass burning and atmospheric chemistry implications; ENSO induced drought and flood; sea level rise; energy generation; adaptation; disaster risk reduction; and sustainable development.

The project was initiated in 1999 and brought to fruition in 2005. The book comprises 31 chapters (papers) written by 62 authors either individually or jointly. 62 peer reviewers are also named. In approximately equal numbers, nearly all the contributors were employed at or associated with US, European and African universities and organizations with climate-related roles. Three Canadians were contributors. Forty per cent of the papers were written by Africans alone or with colleagues of other non-African countries. This is an encouraging number as Africans strive towards the difficult goal of self-reliance in many fields of endeavour. Interestingly, the editor notes that, unfortunately, he was unsuccessful in obtaining papers from francophone African experts.

The papers are arranged in five sections: Science (9 chapters); Sustainable Energy Development, Mitigation and Policy (8); Vulnerability (8); Capacity Building (3); and Lessons from the Montréal Protocol (3). Papers average ten pages in length and comprise mainly narratives with some figures and tables. At the end of each are numerous references to sources and further reading (some dated as late as 2005). A thorough index of 31 pages with approximately 3700 entries concludes the book.

The introductory Science section papers cover Pre-Holocene and Holocene climates, with emphasis on hydrological fluctuations, desertification and environmental oscillations - all topics that many authors admit are not yet fully understood and upon which much work remains to be done. There are also question marks raised concerning the relevance of existing global climate models for the African continent. Other papers range over: atmospheric chemistry in the tropics; volatile organic compounds emissions from biomass burning and mitigation efforts; the impact of biogenic trace gases on atmospheric chemistry; and monitoring and management techniques. A point made in more than one paper indicates that initial adaptation and mitigation steps should address the reduction of vulnerability to recent climate variabilities, lessons from which are likely to be also relevant to longer-term or sudden climate changes.

The Sustainable Energy Development, Mitigation and Policy section chapters : overlap with Science section chapters on biomass energy; and cover the Clean Development Mechanism for sustainable development; clean energy options; how regional approaches to climate change should complement national efforts (a Canadian author) ; and the need for assistance to Sub-Saharan countries. The necessity for outside financial and technical help is a dominant theme of this section.

Section III - Vulnerability and Adaptation takes the reader through: accelerated sea level rise impacts; biodiversity loss; the impacts of ENSO in Africa and continuing improvements in mitigation measures (one paper being authored by Godwin O.P.Obasi while he was still the Secretary General of the WMO); requirements for integrated assessment modelling; and the United Nations International Strategy for Disaster Reduction outreach in Africa.

In the Capacity Building section, climate change mitigation analysis efforts in Botswana, Tanzania and Zambia involving both government and private organisations and ranging over the energy sector, forestry and land-use options, and household energy are presented. Outside help to build national efforts, education and public awareness of energy minimization actions are highlighted in other papers.

The final section, Lessons from the Montréal Protocol, explores whether lessons learned from measures implemented to protect the ozone layer can be applied to the projected climate change threat. There are some similarities in the two situations but numerous differences show that climate protection is more daunting and difficult than ozone layer protection because: greenhouse gas emissions are very much longer lasting; there are much wider ranging source differences and amounts; costs of mitigation and adaptation for climate change are considerably greater; the complexity of the science is greater for climate change; the politics are more complex; and while ozone depletion is essentially negative, climate change can be positive and negative.

This is a book for scientists and policy-makers although its cost may limit its distribution. There is a good mix of general and detailed papers, all with welcome and clear introductory paragraphs.

[1] CMOS Member; Ottawa Centre

The papers are well written, presented and edited. My view that African countries contribute least to anthropogenic emissions of greenhouse gases but for many years to come will be highly vulnerable to the ecological, economic and social impacts of climate change and are the least able currently to adapt, was confirmed.

The Arctic Climate System

by Mark C. Serreze and Roger G. Barry

Cambridge University Press, September, 2005,
Hardback, ISBN 0-521-81418-9, 385 pages, US$130

Book reviewed by Charles Schafer

Serreze and Barry have used an integrated systems approach to explore the Arctic's atmospheric heat budget, atmospheric circulation, surface energy budget, the hydrologic cycle of associated northern river systems, and interactions between ocean, atmosphere and sea ice. Recent satellite remote sensing data and results from field programs have been exploited often to illustrate key processes. Acronyms and abbreviations for the many programs and studies that are found throughout the text are defined and located conveniently at the beginning of the book. The first chapter begins with the 16th century world's view of the Arctic as a potential route to China. Moving forward about 400 years brings us to the time of establishment of the DEWLINE that would ultimately yield a 30-year-long record of Arctic weather. By the end of the 20th century, numerical modeling aimed at elucidating greater understandings about sea ice growth and ice-ocean-atmosphere interactions has started to appear. In chapter 2, the collective knowledge of past centuries is used to develop a basic foundation of the Arctic's physical characteristics. Surface temperatures are described as showing remarkable regional and seasonal variability and mean annual precipitation is shown to range widely from one location to another. The remainder of this chapter deals with the features of the Arctic Ocean, the characteristics of the Arctic's terrestrial areas and a suite of key climate elements. [2] Chapters 3 and 4 condense a comprehensive perspective on the Arctic's atmospheric heat budget and circulation. Chapter 3 presents a description of the energy budget through the course of an annual cycle and a detailed summary of the plethora of factors that cause the system to shift away from radiative equilibrium conditions. The authors begin chapter 4 with a historical perspective on Arctic atmospheric circulation, which they proceed to analyse using a "top down", approach i.e., stratosphere → tropopause → troposphere → surface. Mean winter circulation at sea level is shown to be dominated by the Icelandic Low and the Siberian High. The writers emphasise that major advances in Arctic climatology and frontology were made during the mid- 20th century through the work of Hare and others at McGill University and by Reed and others at the University of Washington. The summary of ozone conditions included near the end of chapter 4 provides a helpful perspective for understanding some of the current research on linkages between tropospheric ozone and Arctic warming.

Chapter 5 offers an in-depth review of the Arctic's surface energy budget using an energy balance equation approach. The later sections of this chapter describe how net radiation is modulated by various surfaces such as sea ice, open ocean, tundra, and boreal forest during various seasons and then goes on to consider the implications of climate feedbacks (e.g., ice-albedo, cloud radiation, water vapour, cloud temperature, cloud phase, and precipitation). Chapter 6 is devoted to an analysis of precipitation, evapo-transpiration and net precipitation, mean annual cycles for the major terrestrial drainages, and river discharge and runoff. Precipitation is considered in regard to problems inherent to the Arctic's weather station network. These include gauge "undercatch" of solid precipitation, the variety of gauge types and reporting practices used by different countries, and by a switch to automated stations for some locations (e.g., Canada). The authors note that "one of the keys to understanding the Arctic climate system is the determination of freshwater transfers" which originate primarily from discharges from the Ob, Yenisey, Lena and MacKenzie rivers. Annual freshwater runoff reaching the Arctic Ocean is viewed as being controlled by a number of variables such as the efficiency at which precipitation is converted to runoff and the regional variation of evapo-transpiration (ET).

The following two chapters (7 and 8) are devoted respectively to Arctic Ocean - sea ice - climate interactions and to a summary of the key climate regimes of the Arctic. In chapter 7, the authors evaluate the characteristics of sea ice in regard to its formation, growth and melt, its mean circulation, ice zones and their typical concentration of ice, and sea ice motion. The chapter then moves forward to consider several examples of large-scale ocean-sea ice-climate interactions in both the spatial and temporal domains. The growth of multiyear ice is shown to be complicated by non-linear vertical temperature gradients. In addition, ocean water salinity variations can change vertical mixing in ways that control the timing of ice formation through various stages (e.g., frazil, grease and pancake ice). The later sections of Chapter 7 examine ice circulation issues. About 20% of the total ice area of the Arctic basin exits annually through Fram Strait. Sea ice thickness, distribution and its annual cycle is still poorly known and there appears to be considerable inter-annual variability in mean ice thickness. The next part of Chapter 7 covers examples of large-scale ocean-sea ice-climate interactions. Some reduced ice years appear to be a function of both "preconditioning" imposed in the previous year and subsequent summer atmospheric forcing. Other low ice extent years are explained by preconditioning that

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[2] Charles Schafer, Emeritus Scientist, Bedford Institute of Oceanography, Dartmouth, NS,

has been estimated to go back more than 5 years. In the last several pages of this chapter, Serreze and Barry examine relationships between Fram Strait overflow and thermohaline circulation (THC) and discuss possible linkages between THC (the so called Arctic "back door") and the Great Salinity Anomaly that occurred between 1968 and 1982.

Chapter 8 consists of an overview of key Arctic climate regimes. The authors begin by reminding the reader that the "Arctic is home to a wide variety of climate conditions". Polar desert is widespread throughout the Canadian Arctic Archipelago and represents the most extreme form of tundra types. However, in some inland areas summer conditions are surprisingly mild. For example, there are 65 frost-free days at Tanquary Fiord (81.4^{0}N) so that "one could conceivably grow lettuce". In contrast, maritime Arctic conditions are characterized by extensive cloudiness, relatively high humidity and a comparatively small range of annual temperature. Svalbard and Barrow are offered as examples. Upland mountain and ice cap climates are quite diverse but can be characterized broadly in terms of the effects of elevation, the high albedo of snow and ice surfaces and by the action of summer melt in depressing surface air temperatures.

Chapter 9 focuses on modeling the Arctic climate system. Within its 32 pages, the writers discuss major directions of modeling and some of the key problems (i.e., model strengths and weaknesses) inherent in this approach. They remark that the Arctic Ocean Model Inter-comparison Project aims to identify and diagnose systematic errors in a variety of Arctic Ocean models under realistic forcing conditions. In the case of global climate models, some of the observed differences in model projections are attributed to the range of model complexity or to deficiencies in their parameterizations of Arctic processes (e.g., feedback loops between sea ice, atmosphere, ocean and clouds). Serreze and Barry point out that the evaluation of model performance is made difficult due to large uncertainties in observed precipitation which is attributed to both gauge biases and the sparse observational network - especially over the Arctic Ocean. Their summary of model errors include (i) sub-optimal parameterization of snow and ice albedo, (ii) accurate simulation of arctic cloud cover, (iii) coarse representations of topography, sea ice margins and coasts, and (iv) different assumptions regarding ice interactions. The authors stress that "model outputs must always be viewed with appropriate caveats".

Chapters 10 and 11 explore Arctic paleoclimates, recent arctic climate variability, current climate trends, and the future. The focus in chapter 10 is on the Quaternary, i.e., the last 1.8 million years. The most complete and detailed paleoclimate information for the Arctic starts about 124,000 YBP which is around the time of the Emian interglacial - an interval during which January mean temperatures were apparently 2-3^0 C higher than now in N.W. Russia and as much as 12^0 C higher in the lower Lena River Basin. Arctic climates during the last glacial cycle are described as being extremely variable. Seasonal freezing of the Arctic Ocean started in the late Pliocene with a perennial sea ice cover present by about 850,000 YBP. GISP2 ice core records indicate that temperature changes comparable to those associated with glacial-interglacial extremes often occurred over periods of decades. Reconstructions from many different sources of proxy data suggest that during the Holocene Thermal Maximum (or "Climatic Optimum") from about 9,500 to 6,300 YBP, global average temperatures were considerably higher in the Arctic than those observed during the 20th century. Apparently, the pattern of warming between regions at the time of the Climatic Optimum was distinctly heterogeneous. The final section of Chapter 10 reviews observations about 20th century climate - which is identified as the warmest period in the Arctic of the past 400 years. The authors emphasize that, while human influence on recent Arctic warming is suggested from these results, this subject remains "a lively area of debate".

The final chapter of the book (11) considers Arctic climate variability on scales of years to decades. Over the period of instrumental records, the Arctic climate system has exhibited pronounced variability on inter-annual, decadal and multi-decadal scales. The North Atlantic Oscillation (NAO) is identified as one source of this variability. Once again the writers caution that perceived recent Arctic surface air temperature changes are "sensitive to the period selected for analysis, the data source, and the way in which data are analysed". They mention specifically that an evaluation for the 1901-1997 period suggests that the difference in the Northern Hemisphere warming trend and that for the Arctic is statistically insignificant. "Amplified high latitude warming hence does not seem to hold when recent decades are placed in longer-term context". One of the research papers used for this section of chapter 11 points out that if one computes a high-latitude (north of 62^0 N) temperature trend from 1920 onwards using annual means, a small cooling trend (that apparently encompasses the lower order warming trend witnessed since about 1990) can be resolved.

The next section of chapter 11 is devoted to a review and interpretation of sea ice, cloud, precipitation, river discharge and terrestrial ecosystem trends and some of the forces driving these changes. It is followed by an in-depth examination of the North Atlantic Oscillation (NAO) and the Arctic oscillation (AO). The AO is best expressed during the winter season and its center of action has been determined to correspond closely to that of the NAO. The upward tendency of the NAO from a negative to a positive state in recent decades is thought of as being forced from the surface by slowly varying North Atlantic or tropical sea surface temperatures. In contrast, AO framework thinking focusses on either linkages with stratospheric ozone depletion or the buildup of greenhouse gases that are associated with stratospheric cooling. According to some climatologists, roughly half of the warming over Siberia between 1989 and 1997 and all of the cooling over Eastern Canada during the same period are linearly related to the

AO trend that transforms it from a strong negative to a positive state. The chapter moves on to a rigorous discussion of sea ice trends and multi year climate variability before arriving at a final section that tackles the future using climate model results and the 2001 Intergovernmental Panel on Climate Change (IPCC) assessments. The writers observe that low frequency variability in the Arctic can make it difficult to resolve natural Arctic climate fluctuations from those due to trace gas loading. Models project the strongest warming over the Arctic Ocean during autumn and winter. However, the authors note that direct observations point to the strongest warming over land areas during winter and spring seasons. The overview leaves the reader with a strong sense of the scatter among the five models that have been selected for the comparison. In their final remarks, Serreze and Barry conclude that the study of Arctic climate requires both improved models and the development of a more system-oriented approach that transcends traditional disciplinary barriers.

In some discussions about this book with several of my climate science colleagues, a few important perspectives were mentioned that non-specialist readers should keep in mind. Starting somewhere in the middle of the book, there appears to be a bias toward finding models to be acceptable despite a recognition of their weaknesses (e.g., with respect to clouds and solar cycles). These apparent shortcomings could detract from, or cause an amendment to, recommendations and advisories already published by the IPCC and passed to policy makers and planners. In addition, although they have been shown to be significant modulators of climate, there is no reference made to the four solar cycles (e.g., the Schwabe quasi-decadal cycle is now generally accepted as being responsible for decadal temperature variability of about the same magnitude as the observed continental trend change of 0.6^{o} C). Other minor criticisms received from "around the table" include:

▪The Arctic ice situation: According to the latest analysis issued by the Canadian Ice Centre in Ottawa, there was a dramatic reduction in Arctic ice between 1996 and 1998. However, since then, there has been a steady increase back toward the post-1951 average.

▪Heat island effects: These effects are now occurring in polar villages. However, there is no mention of corrections being made to provide continuity with data from earlier decades when the populations of these villages were considerably smaller.

▪In the section on modeling, no mention is made of the lack of homogeneity in ocean temperature data with that collected over terrestrial surfaces.

Notwithstanding these issues, this textbook contains virtually everything one needs to know to become conversant with the topic of Arctic climate. Serreze and Barry suggest that the book provides a comprehensive and accessible overview of Arctic climate that will be of interest to advanced students in a wide range of natural science disciplines. I completely agree with them but would suggest further that it can also be considered as a comprehensive and particularly well written reference for science reporters and for Canadian government bureaucrats charged with the operation of agencies responsible for planning and carrying out Canada's Arctic research mandates. The only surprise that I encountered was the rather abrupt appearance of a series of coloured and untitled plates that have been placed within chapter 6. As I continued to read, I found their black and white twins and realized immediately that the coloured versions provide a much more satisfying and clearer representation of the subjects under discussion. One of my BIO draft manuscript reviewers kindly directed me to the brief reference to the plates on page ix.

Well Weathered: My Sixty-five Years in Meteorology

by Morley K. Thomas

Self Published 2006; ISBN 0-9694039-2-5; 178pp.
Soft Covered; No Price

Book reviewed by Jim McCulloch[3]

This is an autobiography, a very personal one. Anybody who crossed paths with him during the sixty-five years of which he speaks in the title (and many of us have) will find it absorbing. He describes events and names co-workers and friends. The book should also be of considerable interest to those following the history of the Met Section/ Met Division /Met Service/AES/Meteorological Service of Canada, from the beginning of the Second World War until he finally left the "History Project". I hope Morley will forgive me if, at the outset, I call him "one of the Grand Old Men of weather service in Canada". His career spans the period from 1941 to retirement in 1982; since then, he has been the voluntary "Historian" for the Canadian Weather Service. While the book is very personal, it covers much of the history of the Service, at least at the headquarters level, but especially in Climatology.

This history is presented in one "Foreword", twelve chapters, and one appendix. Each chapter deals with a phase of his career, and appears to have been written just after the time described in it. Thus, the chapters are normally self-contained. This leads to some repetition, a fact noted by reviewers of his earlier books. Nevertheless, the repetition is necessary for each chapter to be complete in itself, and to save the reader from searching earlier chapters to find the connection of a person named. The "Foreword" introduces the author and gives an overview of his career. It also introduces his wife, Clara, a Professor at York

[3] Retired, Canadian Meteorological Service

University, and acknowledges her contribution to his career and to this autobiography.

Chapter 1, "*Metman with the R.C.A.F." outlines* the events leading up to him joining the Meteorological Division of the Canada Department of Transport, and his training to serve airmen, themselves learning to fly. Then, he describes his postings to R.C.A.F. Training Bases in central Canada – Dauphin, Manitoba, and Dunnville and Kingston in Ontario. When the war in Europe was over, Morley asked to be transferred to Climatology Division in Toronto.

Chapter 2, "*Climatology*". He had become interested in climatology while at R.C.A.F. bases, so he requested a transfer to that area of the headquarters when the war effort was running down. His work was as an unofficial assistant to Clarence Boughner, then head of the section. Among his tasks was to introduce new quality-control procedures for climate data. During this period in the Service, city weather offices (Dominion Public Weather Offices - DPWOs) were collocated with the District Aviation Forecast Offices (DAFOs) in each Region. As well, punched cards were introduced for archiving and analysis of data from the observing networks.

Chapter 3, "*Graduate School*". Morley negotiated his way onto the M.A. course in 1948; he came as a "retread", someone who had taken the "Short Course" earlier and had served at R.C.A.F. bases. Apparently, the practical courses were easy for him, but the more theoretical ones gave him some difficulty. Nevertheless, he passed, but almost missed Convocation because his son became sick, and the trip to the drugstore put him behind schedule.

Chapter 4, "*A Building Research Meteorologist*". In 1951, Morley was seconded to the Division of Building Research (DBR) of the National Research Council. The practice of seconding meteorologists from Met Branch to other government elements was started by Andrew Thomson, the head of the Service at the time. Morley was the first. The head of the DBR felt the need for someone to create specifications for various types of building based on Climatological data for the site (the National Building Code), and offered Morley the job. Rather than let him go, Dr. Thomson decided on a secondment. The Met Service and the NRC jointly published the first Climatological Atlas of Canada based on his work after he returned to Met Branch. His Bibliography of Canadian Climate was also published at that time.

Chapter 5, "*Growth Years in Climatology*". In 1949-1950, Climatology had a staff of twenty. The number grew to 130 in 1969. This growth reflected the growth in the Meteorological Service as a whole. The conversion to punched cards, and then to magnetic tape, along with increased quality controls on data accounted for much of the increase, but there was also an increase in professional staff. The larger numbers forced many moves. Morley lists the six moves of the Climatology staff from the basement of 315 Bloor Street and ultimately to 4905 Dufferin in 1970. Computers were introduced, new publications were started (and old ones brought up to date), and activities in Hydrometeorology begun. During this period, Scientific Services units were begun at Regional Offices to answer most questions from the public, and to undertake studies of weather in the Region.

Chapter 6, "*Growth Years (part 2) – Personal*". In this chapter Morley presents a more personal perspective on this period – publishing the first Bibliography of Canadian Climate, a trip to Nigeria to recommend on met data processing, becoming involved in WMO activities Technical Commission on Climatology (and met applications), and participation in some national committees.

Chapter 7. "*Reorganization Years"*. Meteorology was part of the Marine Division of Transport Canada until in1936 when it became the Meteorological Division of Air Services Branch of Transport Canada. Its title changed to The Meteorological Branch of Air Services in 1956 then to the Canadian Meteorological Service of Transport Canada in early 1970. Then later in 1970, Environment Canada was created with the Atmospheric Environment Service (AES) a major element of the new Department. At this time, Meteorological Applications Branch (MAB), which included Climatology, was formed. There were many other internal changes both at the Headquarters and in Regions.

Chapter 8, "*Central Services Directorate (CSD)*". When the AES was created, it consisted of Met Applications Branch, Training Branch, and Ice Branch. A few years later, the Instruments Division was added and renamed the Data Acquisition Branch. Training Branch at that time was an important provider of meteorologists and technical staff to all elements of the Service, especially Regions. It became a constant battle with senior managers in Ottawa who did not believe in "in-house" training in meteorology, and lusted after the person-years that the AES expended in that task. The one argument that held them off for a number of years is that there was no outside supplier of trained meteorologists or met technicians. (The battle was finally lost in the 1990s.) Meanwhile, the Ice Branch was introducing remote sensing for observing ice from reconnaissance aircraft – Airborne Radiation Thermometers (ART) and Side Looking Airborne RADAR (SLAR). During this period also, MAB was converting the archives to metric and to magnetic tape. Morley himself, after being involved in World Meteorological Organization's (WMO) Commission for Climatology (CCI) and its predecessors for many years was elected the President of CCI in 1978. He also published his updated list of meteorological publications.

Chapter 9, "*Establishing the Canadian Climate Centre*". This is a brief account of Morley's interest in the changing climate from the 1940s, the lack of interest at the top until the late 1970s, and the disputes with the Research Directorate over how a "Canadian Climate Centre" should be constituted and managed.

Chapter 10, "*The Canadian Climate Centre Years*". The CCC was created by transferring the Meteorological Applications Branch (data management, applications studies, and information services) from CSD (90 persons), and 16 persons from the Atmospheric Directorate (ARD). Because of government cuts, there were no new positions created".The Canadian Climate Board" with Dr. Ken Hare was created in 1979 in an attempt to involve other federal and provincial departments, as well as the academic world. There were regional Climate advisory committees in all provinces (except Ontario) and the territories. The research wing worked on climate prediction models and climate forecasts, while Met Applications Branch continued climate studies, and publishing the 1951 to 1980 "Normals".

Chapter 11, "*The History Project*". On retirement in 1982, Morley started the History Project with the blessing, and support, of the AES. Scanning through the official "business" records held by the Public Archives, and using his unofficial archives, over the next 24 years he wrote many articles and three books. These were published with financial support of the AES. The books are: "Beginnings of Canadian Meteorology" (published in 1991); "Forecasts for Flying: Meteorology in Canada 1918 - 1939", (1996); and, Metmen in Wartime: Meteorology in Canada 1939 – 1945" (2001). He continued to write articles of historic interest until he finally retired in 2006. During this period he served another four-year term as President of the WMO Commission for Climatology.

Chapter 12, "*World Meteorological Organization"*. As the author states, "For more than twenty-five years, as part of my work with the Meteorological Service, I was privileged to take part in the activities of the World Meteorological Organization (WMO)". This chapter starts with a history of the organization, an outline of its structure and governance, the history of the Commission for Climatology, and Morley's involvement in CCl.

Appendix, "*The Bulletin Interview*". Here is reproduced a 2001 interview of Morley for the WMO Bulletin by Dr. Taba of the WMO Secretariat.

As stated at the outset, this book is a very personal autobiography. It should prove very interesting both to those who knew and worked with Morley and persons interested in the history of the Canadian Meteorological Service since the Second World War. There are references to material written by earlier "Heads of Service" for the time prior to that conflict. One of the things it did for me was to fill in some holes in my knowledge of the history and development of the Meteorological Service.

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

Flood Risk Simulation, by F.C.B. Mascarenhas, co-authored with K. Toda, M.G. Miguez and K. Inoue, WIT Press, January 2005, ISBN 1-85312-751-5, Hardback, US$258.00.

Statistical Analysis of Environmental Space-Time Processes, by Nhu D. Le and James V. Zidek, Springer Science+Business Media Inc., 2006, ISBN 0-387-26209-1, Hardback, US$79.95.

Nonlinear Dynamics and Statistical Theories for Basic Geophysical Flows, by Andrew J. Majda and Xiaoming Wang, Cambridge University Press, 2006, pp.551, ISBN 0-521-83441-4, Hardback, US$90.00, 2 copies available.

The Equations of Oceanic Motions, by Peter Müller, Cambridge University Press, ISBN # 0-521-85513-6, 2006, Hardback, US$80.

The Chronologers' Quest: The Search for the Age of the Earth, by Patrick Wyse Jackson, Cambridge University Press, ISBN # 0-521-81332-8, Hardback, pp.291, US$30, 2 copies available.

Numerical Weather Prediction: Richardson's Dream, by Peter Lynch, Cambridge University Press, ISBN # 0-521-85729-5, Hardback, pp.279, US$75.

The Gulf Stream, by Bruno Voituriez, IOC Ocean Forum Series, UNESCO publishing, ISBN# 978-92-3-103995-9, Paris, 2006, pp.223.

Le Gulf Stream, par Bruno Voituriez, Collection COI Forum Océans, Éditions UNESCO, ISBN# 978-92-3-203995-8, Paris, 2006, pp.209.

The Economics of Climate Change, The Stern Review, Nicholas Stern, Cambridge University Press, ISBN 978-0-521-70080-1, 2007, Paperback, pp.692, US$50.

Solitary Waves in Fluids, Editor: R.H.J. Grimshaw, Wessex Institute of Technology Press, ISBN 978-1-84564-157-3, pp.183, Hardback, February 2007, pp.183, US$130.

Waves in Oceanic and Coastal Waters, Leo H. Holthuijsen, Cambridge University Press, ISBN 978-0-521-86028-4, 2007, pp.387, Hardback, US$80, 2 copies available.

Inter-Basin Water Transfer, Case Studies from Australia, United States, Canada, China and India, Fereidoun Ghassemi and Ian White, International Hydrology Series, Cambridge University Press, ISBN 978-0-521-86969-0, Hardback, pp.435, US$165.

A note on the CMOS Science Position Statement on Climate Change published in this issue

CMOS Council decided in September 2006 to ask the CMOS Scientific Committee to elaborate a comprehensive CMOS Statement of Position on the science of climate change. After extensive work by the members of the committee and review by the Executive, it was approved by the CMOS Council in December, subject to the insertion of comments on the emerging issue of ocean acidification. The revised version, published here following, was approved for publication by the Executive and Council in March 2007.

Canadian Meteorological and Oceanographic Society

Statement on Climate Change

The Canadian Meteorological and Oceanographic Society (CMOS) is the national society of individuals and organisations dedicated to advancing atmospheric and oceanic sciences and related environmental disciplines in Canada. CMOS has more than 800 members from Canada's major research centres, universities, private corporations and government institutes.

CMOS is uniquely positioned to provide expert advice to Canadians on the science of climate change. Many of its members are internationally recognized scientific experts who are extensively involved in comprehensive assessments of the current state of knowledge with respect to this complex issue. Such assessments require atmospheric and ocean scientists working together with scientists in related environmental, social and economic disciplines.

As an input into the current public and political debate on this important issue, the following statement is issued on the state of the science of climate change and the need for immediate action:

The state of the science

Canada's climate is changing dramatically

- On a global scale, average surface temperatures have increased by about 0.7° C during the past century. The nine warmest years of this period have all occurred within the past decade.

- While there remain significant uncertainties about trends in global temperatures prior to the past century, there is convincing evidence that the past 50 years have been warmer than at any time during the past 1300 years.

- Average surface temperatures across Canada are now about 1° C warmer than they were when systematic nation-wide weather observations began in 1948.

- Many other aspects of Canada's climate, including glacier size, snow cover, lake and river ice cover, Arctic sea ice thickness, extent and permafrost depth and sea levels show trends that are consistent with a warmer Canada.

- The changes in climate are affecting Canadian ecosystems and wildlife. Some impacts, such as the increased length and warmth of growing seasons, are beneficial. Others, such as the increased loss of forest biomass to insects and wildfire and the stress on animal species such as the polar bear and Arctic ungulates, are harmful.

- There is significant evidence that some extreme climate events, particularly heat waves and intense precipitation events, are increasing on a global scale. In recent decades, the intensity of energy dissipated by intense tropical storms appears to have increased.

- Arguments by a few individuals that recent temperature trends may not be unprecedented within the past thousand years and can therefore be fully explained by natural variability and causes for change (often referred to as the 'hockey stick debate') are based on limited assessments and are seriously flawed. While some uncertainty is an inherent aspect of all science, related international research studies continue consistently to refute such conclusions.

There is strong evidence that changes in climate during the past 50 years are human-induced

- The most comprehensive projections of future climate rely on numerical models of the climate system. These models are based on fundamental physical principles. After decades of intensive research by scientists within Canada and abroad, models are now able to replicate current and past climates with increasing confidence.

- Simulations with these models, together with observational evidence, demonstrate that there is a natural greenhouse effect that is an essential aspect of the global climate system, and that increases and decreases in the concentration of greenhouse gases over time cause the intensity of this effect to be enhanced or diminished, respectively.

- There is clear evidence, based on direct observational data and indirect indicators from proxy sources such as polar ice cores, that current concentrations of major greenhouse gases, particularly carbon dioxide and methane, are now higher than at any time during the last 650,000 years.

- The increase in atmospheric carbon dioxide concentration since the late 1800s is mostly as the result of fossil fuel burning, and partly from clearing of forest vegetation.

- A broad range of simulations of past climate using climate models consistently indicate that changes in temperatures at global and continental scales during the past 50 years are fully consistent with forcings related to human emissions of greenhouse gases and aerosols.

- The changes in temperatures cannot be adequately explained by either natural variability or natural causes of change such as solar variability or volcanic eruptions. Hence, researchers involved in these studies conclude with 95% confidence that recent changes in climate at global and continental scales are caused by human emissions.

- Similar conclusions cannot as yet be made for most sub-continental scale changes. One exception is the major 2003 heat wave over Europe, which can be attributed with confidence to rising global temperatures.

- Canadian trends in climate are fully consistent with those expected due to human-induced changes in climate.

Projections for future increases in greenhouse gas concentrations and related climate change are of concern to scientists in CMOS

- Given the already significant atmospheric load of greenhouse gases since the industrial revolution, as well as the huge inertia and long delays characterizing the atmosphere-ocean-biosphere system's response to greenhouse gas climate forcing, further changes in the climate over the coming decades are inevitable.

- Nearly half of all the carbon dioxide that humans have emitted since the start of the nineteenth century has been absorbed by the ocean, resulting in an increase of the partial pressure of carbon dioxide (pCO_2) of surface waters. The change in pCO_2 is certain to reduce the capacity of the ocean to buffer further increases in atmospheric CO_2.

- Possibly as much as 20% of anthropogenic CO_2 emissions will continue to contribute to warming and sea level rise for thousands of years, because of the long time scales required for buffering by the ocean, including dissolution of $CaCO_3$ sediments.

- Further increases in greenhouse gas are virtually certain to produce further increases in temperature.

- Considering the uncertainties in both the future increases of greenhouse gas concentrations and in the climate system response to such increases, experts now project that, by 2100, average surface temperatures will rise by at least another 2^{o} C and possibly by as much as 7^{o} C.

- Observations over the 20^{th} century indicate that the warming was disproportionately larger over Canada, particularly over the Arctic region, where temperature trends exceeded North Hemispheric trends by 50%. Projected trends show an even stronger signal for the 21^{st} century, with a temperature increase for the Arctic of at least 4^{o} C.

- Clean-air legislation, although essential to human health, will curb the emissions of aerosols and the precursor gases that form aerosols following atmospheric chemical reactions. Some aerosols in the atmosphere act to cool the planet, and their reduction would diminish their role as counterweight to greenhouse gases and lead to a short term increase in the rate of global warming.

● Ocean warming and melting land ice are likely to cause a rise in sea level by about 20 to 60 cm over the next century, and much more over subsequent centuries. Sustained warming will likely, over millennia, lead to complete melting of the Greenland ice sheet and a related sea level rise of 6 to 7 metres.

● Other implications for Canada's climate and weather include:

○ Reduced extent and shorter seasons for snow cover over land and ice cover on lakes and rivers;
○ Widespread increases in summer thaw depth over permafrost regions.
○ Shrinkage of Arctic sea ice cover, with possible total disappearance in late-summer by the latter part of this century;
○ A continued increase in the frequency and intensity of hot extremes, heat waves, and heavy precipitation events;
○ A slight poleward movement of storm tracks, with related increases in wind and precipitation events in polar regions;
○ Wetter conditions, on average, across northern regions of Canada, but a potential increase in the frequency of severe droughts in southern Canada.

Projected changes in climate will have serious implications for global and Canadian ecosystems and socio-economic infrastructure

● Within Canada, warmer temperatures and changing weather patterns are expected to cause:

○ Significant benefits in terms of reduced winter-season space-heating energy requirements, longer and warmer growing seasons, longer marine navigation seasons, and enhanced ecological productivity; but
○ A dramatic change in Arctic ecological and social systems caused by reduced sea, lake and river ice cover, increased land instability due to permafrost melting and changes in weather;
○ Increased loss of forests to insect infestations and fire;
○ Increased number of summer hot days and heat spells, with associated degradation in air quality, rise in related pulmonary and cardio-vascular health concerns, and an increase in summer energy requirements for space cooling which in turn leads to further air quality degradation;
○ Increase in intense precipitation events with implications for water resource management and flooding;
○ Increased risk of summer drought, particularly in regions where the stream-flow is provided by spring and summer runoff, due to a decrease in snow-pack and melting of Rocky Mountain glaciers;
○ Increased risk of damage by storm surges to coastal regions due to higher sea levels, and more vigorous weather systems.

● Increased threat to endangered animal, bird and fish species where climate changes negatively affect their habitat and food supply. Of particular concerns are species such as the polar bear, Arctic seals and fresh water fish species, including migrating Pacific salmon species. Globally, impacts will be disproportionately adverse for developing nations. Because of prevalent poverty within most of these nations, they have limited adaptive capacity. Furthermore, since most are located in warm and often arid regions at lower latitudes, warmer temperatures increase stress levels for both ecosystems and society, while increased drought risks significantly enhance the risk of starvation.

● Ocean acidification due to carbon dioxide uptake will impact marine ecosystems. These impacts may include a reduction in the ability of seashell creatures and corals to produce the calcium carbonate required for their shells and skeletal structures.

● Well-respected economists, and most recently the Stern Review on the Economics of Climate Change, indicate that, by the latter part of the 21st century, potential annual global economic costs of warmer climates may be trillions of dollars.

Greenhouse gas emission reductions, and adaptation and mitigation measures are essential to reduce the damage that will result from climate change

● Once introduced in the atmosphere, carbon dioxide remains for at least a few hundred years, with 15-20% remaining for tens of thousands of years - which virtually guarantees sustained future warming and sea level rise. Hence Canada must inevitably deal with adaptation and even mitigation in the coming decades to reduce the negative consequences and take advantage of the potential opportunities of climate change.

- The most direct human impact on climate change is through emissions of greenhouse gases. Immediate reduction of global greenhouse gas emissions can be part of the approach to mitigate the negative consequences of forthcoming further global change.

Improved scientific understanding is critical

- There is strong evidence that climate is changing, and that humans have significantly contributed to this change. However, the atmosphere-ocean-biosphere system is highly complex, and there remain a number of uncertainties that need to be addressed in order to increase confidence in climate projections. Effective adaptation and mitigation policies critically depend on improved scientific understanding, which will provide more accurate forecasts of what changes we will need to adapt to, and how the impacts can be reduced. The need for further scientific research on climate should not, however, justify delays in implementing mitigation actions to reduce greenhouse gas emissions.

A call to action

- Climate-change science is a rigorous field of study. Its findings are periodically reviewed and assessed as part of an international effort led by the United Nations and the World Meteorological Organisation (WMO), known as the Intergovernmental Panel on Climate Change (IPCC). The Third IPCC Assessment Report (2001) concluded that the balance of evidence suggests a discernible human influence on global climate. Results published since then in peer reviewed journals have only strengthened this conclusion (The Fourth IPCC Assessment Report will be published in early 2007).

- Given the current and increasing significant load of greenhouse gases in the atmosphere, future warming is inevitable. Because the changes will occur more rapidly than at any time during at least the last 650,000 years, appropriate adaptation policies and programs must be designed to help increase our adaptive capacity. Climate-change protection is needed now.

- The global reduction of greenhouse gas emissions cannot be achieved by any single country, but each country must contribute its share towards accomplishing the global goal.

- The atmosphere-ocean-biosphere constitutes a highly complex system. Our ability to make comprehensive climate projections is hindered by the lack of accurate characterization of important processes and feedbacks. Further process-studies, assessments of paleoclimate evidence, modelling and observations, are needed to understand and to improve predictions of climate change at the global and especially regional scales. Research is essential to our ability to mitigate and adapt to climate change.

Note sur l'énoncé de la position scientifique de la SCMO à propos du changement climatique publiée dans la présente édition

Le Conseil de la SCMO a décidé, en septembre 2006, de demander au comité scientifique de la SCMO de préparer un énoncé de position détaillé de la SCMO au sujet de la science du changement climatique. À la suite du travail considérable réalisé par les membres du comité et à la révision par la direction, l'énoncé a été approuvé par le Conseil de la SCMO en décembre, sujet à l'insertion de commentaires à propos du nouvel enjeu de l'acidification des océans. La version révisée, publiée ci-après, a été approuvée par la direction et le Conseil en mars 2007 afin d'être publiée.

Société canadienne de météorologie et d'océanographie

Énoncé au sujet du changement climatique

La Société canadienne de météorologie et d'océanographie (SCMO) est une société d'envergure nationale composée de personnes et d'organismes qui se consacrent à l'avancement des sciences océanographiques et atmosphériques ainsi que des domaines environnementaux connexes au Canada. La SCMO compte plus de 800 membres issus d'importants centres de recherche, universités, entreprises privées et institutions gouvernementales au Canada.

La SCMO a pour but d'offrir des conseils d'experts aux Canadiens au sujet de la science du changement climatique. Bon nombre des membres de la Société sont des spécialistes des sciences reconnus à l'échelle internationale qui participent étroitement aux évaluations approfondies de l'état actuel de la connaissance relative à cet enjeu complexe. Ce type d'évaluation exige que les scientifiques des domaines atmosphériques et océanographiques travaillent de concert avec les scientifiques des domaines environnementaux, sociaux et économiques qui y sont liés.

En guise de contribution à l'actuel débat public et politique sur cet enjeu important, l'énoncé qui suit porte sur l'état de la science du changement climatique et sur le besoin d'entreprendre une action immédiate :

L'état de la science

Le climat du Canada change de façon drastique

- À l'échelle planétaire, les températures en surface moyennes ont augmenté d'environ 0,7 °C au cours du siècle dernier. Les neuf années les plus chaudes de cette période ont toutes été recensées au cours de la dernière décennie.

- Bien qu'il subsiste des incertitudes considérables à propos des tendances des températures planétaires antérieures au siècle dernier, il existe des preuves convaincantes indiquant que les 50 dernières années ont été les plus chaudes des 1300 dernières années.

- Les températures en surface moyennes pour l'ensemble du Canada sont désormais d'environ 1 °C plus élevées qu'elles ne l'étaient lorsque les observations météorologiques systématiques à la grandeur du pays ont commencé en 1948.

- De nombreux autres aspects du climat du Canada, dont la dimension des glaciers, la couche de neige, la couche de glace sur les lacs et rivières, l'épaisseur de la glace sur l'Océan Arctique, l'étendue et la profondeur du pergélisol ainsi que les niveaux de la mer indiquent des tendances qui témoignent d'un Canada plus chaud.

- Les changements climatiques affectent les écosystèmes et la faune du Canada. Certains impacts, comme l'augmentation de la durée et de la chaleur des saisons de végétation, sont bénéfiques. Par contre, d'autres impacts tels que la diminution de la biomasse forestière pour les insectes et la faune, ainsi que le stress subi par des espèces animales comme l'ours polaire et l'ongulé de l'Arctique sont nuisibles.

- Il existe une preuve importante voulant que certains événements climatiques extrêmes, surtout les vagues de chaleur et les précipitations abondantes, se produisent de plus en plus couramment à l'échelle internationale. Au cours des récentes décennies, l'intensité de l'énergie dissipée par les tempêtes tropicales intenses semble avoir augmenté.

- L'avis de certaines personnes selon lequel les dernières tendances climatiques ne sont pas sans précédent au cours des derniers milliers d'années et qu'elles peuvent ainsi s'expliquer parfaitement par la variabilité de la nature qui entraîne des changements (souvent désigné comme le « débat du bâton de hockey ») est basé sur des évaluations limitées qui comportent des failles évidentes. Bien que l'incertitude fasse partie de toutes les sciences, les recherches internationales sur le sujet continuent de réfuter constamment de telles conclusions.

Il existe une forte indication que les changements climatiques des 50 dernières années sont causés par l'homme

- Les projections les plus complètes du climat futur reposent sur des modèles numériques du système climatique. Ces modèles sont basés sur des principes physiques fondamentaux. Après des décennies de recherche intensive par les scientifiques du Canada et d'ailleurs, les modèles peuvent à présent reproduire les conditions climatiques passées et actuelles avec une précision qui ne cesse d'augmenter.

- Des simulations effectuées à partir de ces modèles, appuyées par des preuves observables, démontrent la présence d'un effet de serre naturel qui représente un aspect essentiel du système climatique planétaire, et qui augmente et diminue dans la concentration de gaz à effet de serre avec le temps, ce qui augmente ou diminue l'intensité de cet effet, et vice versa.

- Il existe une preuve évidente, basée sur des données d'observation directe et des indicateurs indirects provenant de sources témoins comme les noyaux de glace polaire, qui confirme que les concentrations actuelles de gaz à effet de serre importants, surtout le dioxyde de carbone et le méthane, sont actuellement plus élevées qu'elles ne l'ont jamais été au cours des 650 000 dernières années.

- L'augmentation de la concentration de dioxyde de carbone depuis la fin des années 1800 est surtout attribuable à la combustion de combustible fossile et en partie à l'appauvrissement de la végétation forestière.

● Une vaste gamme de simulations des conditions climatiques antérieures effectuées à l'aide de modèles climatiques indiquent avec régularité que les changements de température à l'échelle planétaire et continentale survenus au cours des 50 dernières années correspondent parfaitement aux forçages liés aux émissions anthropogènes de gaz à effet de serre et d'aérosols.

● Les changements de température ne peuvent être expliqués correctement par la variabilité naturelle ou par des causes naturelles de changement comme la variabilité de l'activité solaire ou les éruptions volcaniques. Par conséquent, les chercheurs participant à ces recherches sont convaincus à 95 % que les récents changements climatiques à l'échelle planétaire et continentale sont causés par les émissions anthropogènes.

● Il n'est pas encore possible d'en arriver à des conclusions semblables pour la plupart des changements à l'échelle sous-continentale, exception faite de l'importante vague de chaleur de 2003 qui a frappé l'Europe, qui est raisonnablement attribuable à l'augmentation des températures planétaires.

● Les tendances climatiques au Canada correspondent parfaitement aux conditions envisagées en raison des changements climatiques provoqués par l'homme.

Les projections relatives à l'augmentation future des concentrations de gaz à effet de serre et les conditions climatiques qui y sont liées préoccupent les scientifiques de la SCMO

● Compte tenu de la charge atmosphérique déjà importante de gaz à effet de serre depuis la révolution industrielle, ainsi que de la très forte inertie et des longs délais qui caractérisent la réponse au forçage des gaz à effet de serre du système atmosphérique, océanique et de la biosphère, les changements climatiques à venir au cours des prochaines décennies sont inévitables.

● Près de la moitié de tout le dioxyde de carbone émis par l'homme depuis le début du 19^{e} siècle a été absorbé par les océans, ce qui a causé une augmentation de la pression partielle du dioxyde de carbone (pCO_2) au niveau des eaux de surface. Le changement de la pCO_2 réduira certainement la capacité d'absorption des océans lors des augmentations futures de gaz carbonique atmosphérique.

● Il est possible que jusqu'à 20 % des émissions anthropogènes de CO_2 continueront de contribuer au réchauffement de la planète et à l'élévation du niveau de la mer pendant des milliers d'années en raison des longues périodes requises pour l'absorption par les océans, ce qui comprend la dissolution des sédiments de $CaCO_3$.

● Les augmentations futures des concentrations de gaz à effet de serre entraîneront pratiquement à coup sûr de plus amples augmentations des températures.

● Compte tenu des incertitudes relatives aux augmentations futures des concentrations de gaz à effet de serre et à la réponse du système atmosphérique face à ces augmentations, les spécialistes prédisent que d'ici 2100, les températures en surface augmenteront d'au moins 2 °C et pourront possiblement atteindre une augmentation de 7 °C.

● Les observations réalisées au cours du 20^{e} siècle indiquent que le réchauffement était disproportionnellement plus grand au-dessus du Canada, surtout au-dessus de la région de l'Arctique, où les tendances de température ont excédé les tendances de l'hémisphère Nord de 50 %. Les tendances projetées indiquent un signal encore plus important pour le 21^{e} siècle, avec une augmentation de température d'au moins 4 °C pour l'Arctique.

● La réglementation sur la pollution atmosphérique, bien qu'elle soit essentielle à la santé humaine, aura pour effet de freiner les émissions d'aérosols et de gaz précurseurs qui créent des aérosols à la suite des réactions chimiques atmosphériques. Certains aérosols contenus dans l'atmosphère contribuent à refroidir la planète, et leur réduction affaiblit leur rôle visant à contrebalancer les gaz à effet de serre et mène à une augmentation à court terme du taux de réchauffement planétaire.

● Le réchauffement océanique et la fonte des glaces terrestres causeront probablement une élévation du niveau de la mer d'environ 20 à 60 cm au cours du prochain siècle et encore bien plus au cours des siècles subséquents. Le réchauffement continu, au fil des millénaires, provoquera probablement la fonte complète de la couche de glace du Groenland, ce qui entraînera une élévation du niveau de la mer de 6 ou 7 mètres.

● Les autres conséquences relatives au climat et aux conditions atmosphériques au Canada comprennent les suivantes :

○ réduction de l'étendue et saisons raccourcies des couches de neige terrestres ainsi que des couches de glace sur les lacs et rivières;
○ augmentations répandues de la profondeur du dégel en été dans les régions du pergélisol;
○ rétrécissement de la couverture des glaces de la mer Arctique, y compris une possibilité de disparition complète en fin d'été vers la fin du présent siècle;
○ une augmentation continue de la fréquence et de l'intensité des chaleurs extrêmes, des vagues de chaleur et des précipitations abondantes;
○ un léger déplacement vers le pôle des trajectoires de tempêtes, y compris une augmentation de l'intensité des vents et des précipitations dans les régions polaires; et
○ des conditions plus humides, en moyenne, pour l'ensemble des régions nordiques du Canada et une augmentation potentielle de la fréquence des sécheresses intenses dans le sud du Canada.

Les changements climatiques prévus auront des conséquences importantes sur les écosystèmes du Canada et de la planète, ainsi que sur l'infrastructure socio-économique

● Au Canada, on prévoit que l'augmentation des températures et les changements météorologiques entraîneront :

○ des bénéfices considérables par rapport aux besoins énergétiques pour le chauffage en raison de la saison hivernale raccourcie, de saisons de croissance plus longues et plus chaudes, de saisons de navigation maritime prolongées et d'amélioration de la productivité écologique; cependant

○ un changement drastique dans le système social et écologique de l'Arctique causé par une réduction des couches de glace sur les mers, lacs et rivières, ainsi qu'une instabilité terrestre accrue en raison de la fonte du pergélisol et des changements météorologiques;

○ des pertes accrues de forêts causées par des infestations d'insectes et des incendies;

○ un nombre accru de journées d'été chaudes et de vagues de chaleur, y compris une dégradation relative de la qualité de l'air, une augmentation des problèmes de santé d'ordres pulmonaire et cardio-vasculaire, ainsi qu'une augmentation des besoins énergétiques pour la climatisation des espaces, ce qui à son tour aura pour effet de dégrader la qualité de l'air;

○ une augmentation des précipitations abondantes ayant des répercussions sur la gestion des ressources d'eau et sur les inondations;

○ un plus grand risque de sécheresse en période estivale, surtout dans les régions où le débit des cours d'eau provient du ruissellement printanier et estival, causé par une diminution de l'accumulation de neige et par la fonte des glaciers des montagnes Rocheuses; et

○ une augmentation du risque de dommages causés par les ondes de tempêtes dans les régions côtières en raison des niveaux de la mer élevés, et des systèmes météorologiques plus intenses.

● Plus grands dangers pour les animaux en voie de disparition, oiseaux et poissons où les changements climatiques ont un effet néfaste sur leur habitat et leur approvisionnement alimentaire. Certaines espèces comme l'ours polaire, le phoque de l'Arctique, les poissons dulçaquicoles et les espèces migratrices de saumons du Pacifique soulèvent des préoccupations particulières. À l'échelle planétaire, les impacts seront disproportionnellement néfastes pour les pays en développement. En raison de la pauvreté généralisée de la plupart de ces pays, leur capacité d'adaptation est limitée. De plus, comme la plupart de ces pays sont situés dans des endroits chauds et secs à des latitudes inférieures, les températures plus chaudes augmentent les niveaux de stress subi par les écosystèmes et la société, alors que l'augmentation des sécheresses accroît considérablement les risques de famine.

● L'acidification océanique causée par le dioxyde de carbone aura un impact sur les écosystèmes marins. Ces impacts peuvent comprendre une réduction de la capacité des créatures à coquillage et des coraux de produire le carbonate de calcium dont ils ont besoin pour leurs carapaces et leurs structures squelettiques.

● Des économistes reconnus, et plus récemment la *Stern Review on the Economics of Climate Change,* indiquent que, vers la fin du 21e siècle, les coûts annuels potentiels à l'échelle planétaire engendrés par le réchauffement climatique risquent d'atteindre les billions de dollars.

La réduction des émissions de gaz à effet de serre ainsi les mesures d'adaptation et d'atténuation sont essentielles à la réduction des dommages causés par le changement climatique

- Une fois introduit dans l'atmosphère, le dioxyde de carbone demeure en suspens pendant au moins quelques centaines d'années, et 15 à 20 % de ce gaz demeure dans l'atmosphère pendant des dizaines de milliers d'années, ce qui garantit pratiquement une continuité du réchauffement de la planète et de l'élévation du niveau de la mer. Par conséquent, le Canada doit absolument s'occuper des mesures d'adaptation et même d'atténuation au cours des décennies à venir afin de réduire les conséquences néfastes et de tirer avantage des possibilités offertes par le changement climatique.

- L'impact le plus direct qu'a l'humain sur le changement climatique est attribuable aux émissions de gaz à effet de serre. La réduction immédiate des émissions de gaz à effet de serre à l'échelle planétaire peut faire partie de l'approche visant à atténuer les conséquences néfastes des changements planétaires prévus.

L'amélioration de la compréhension scientifique est essentielle

- Il existe une forte indication selon laquelle le climat subit un changement et les humains ont contribué de façon importante à ce changement. Cependant, les systèmes atmosphériques, océaniques et celui de la biosphère sont très complexes, et il subsiste des incertitudes qui doivent être abordées afin d'augmenter la précision des projections climatiques. L'efficacité des politiques d'adaptation et d'atténuation dépend essentiellement de l'amélioration de la compréhension scientifique, qui permettra d'en arriver à des prévisions plus précises à propos des changements nécessaires à l'adaptation et à la façon de réduire les impacts. Cependant, le besoin de poursuivre la recherche scientifique sur le climat ne doit pas justifier les délais dans la mise en œuvre de mesures d'atténuation visant à réduire les émissions de gaz à effet de serre.

Appel à l'action

- La science du changement climatique est un domaine d'étude rigoureux. Les découvertes qui y sont faites sont étudiées et évaluées périodiquement dans le cadre d'un effort international dirigé par les Nations Unies et l'Organisation météorologique mondiale (OMM), connue sous le nom du Groupe d'experts intergouvernemental sur l'évolution du climat (IPCC). Le troisième rapport d'évaluation de l'IPCC (2001) a permis de conclure que la prépondérance de la preuve suggère que l'humain a une influence visible sur le climat à l'échelle planétaire. Les résultats publiés depuis ce temps dans les revues révisées par les pairs n'ont fait que renforcer cette conclusion (le quatrième rapport d'évaluation de l'IPCC sera publié au début de 2007).

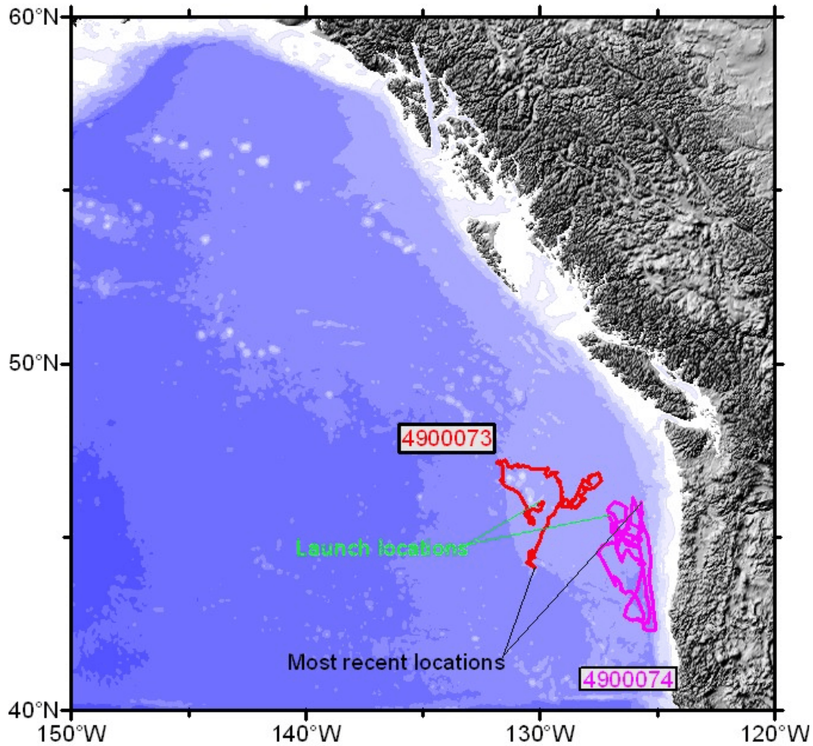
- Compte tenu de la charge actuelle et croissante des gaz à effet de serre dans l'atmosphère, le réchauffement futur est inévitable. Puisque les changements se produiront plus rapidement qu'à n'importe quelle époque au cours des 650 000 dernières années, les politiques et programmes d'adaptation adéquats doivent être mis en place pour nous aider à augmenter notre capacité d'adaptation. Nous avons un besoin immédiat de protection contre le changement climatique.

- La réduction des émissions de gaz à effet de serre à l'échelle planétaire ne peut être le fruit des efforts d'un seul pays; tous les pays doivent en effet contribuer à l'atteinte de cet objectif mondial.

- Les systèmes atmosphériques, océaniques et de la biosphère sont très complexes. Notre capacité de faire des projections climatiques détaillées est retardée par le manque de précision sur le plan de la caractérisation des rétroactions et des processus importants. De plus amples études des processus, évaluations des renseignements sur le paléoclimat, modélisations et observations sont nécessaires afin de comprendre et d'améliorer les prévisions relatives au changement climatique à l'échelle planétaire et, surtout, régionale. La recherche est essentielle à notre capacité d'adaptation aux effets du changement climatique et à leur atténuation.

Happy Birthday Buoys 4900073 and 4900074

On the 14th and 15th February 2007 two Canadian Argo floats transmitted perfect profiles of Temperature and Salinity versus pressure. Known by their WMO numbers 4900073 and 4900074 delivered their 183rd profile. Sampling at 10-day intervals, that works out as 1830 days of continuous operation, and 1830/365 = 5.01 years. This is a major milestone for these two Canadian floats wrote Dr. Howard Freeland from the Institute of Ocean Sciences in the March 2007 issue of the Canadian Ocean Science Newsletter. So "happy birthday" to each of these floats for five years of continuous operation. According to Dr. Freeland, all the data collected by these two buoys are available through the Global Argo Data Centre.



For each of the buoys, the battery voltage started around 14 volts; 4900073 is now down to 8.5 volts. It is a small miracle that it managed to complete the last profile. It probably cannot survive many more weeks. However, the voltage for 4900074 remains rather high at about 11.4 volts and appears to have a lot more profiles to deliver. The attached map shows that neither went very fast and very far. Indeed, taking the starting and most recent positions 4900073 and 4900074 showed an average velocity of 0.11 cm/s and 0.08 cm/s respectively. Perhaps we have discovered the key to longevity, a quiet and uneventful lifetime.

Canada's Newest Marine Protected Area (MPA): Musquash Estuary

Musquash Estuary was officially designated as Canada's sixth Marine Protected Area (MPA). The new MPA is one of the last ecologically intact estuaries in the Bay of Fundy. It is a rural, relatively pristine area with little development, and an outstanding example of a fully functioning estuary and salt marsh complex.

Musquash Estuary is located on the Bay of Fundy, approximately 20 kilometres southwest of the city of Saint John, New Brunswick. The Musquash ecosystem provides a rich habitat for a variety of plants, commercial and non-commercial fish species, and other wildlife. The Musquash Estuary is highly valued by local residents, government agencies, and conservation organizations in the region.

It was named an Area of Interest in 2000 and entered the final consultation phase in June 2005. Since this time, departmental officials have worked to gather as much information on the estuary as possible, and has sought the input and support of other levels of government, community, Aboriginal and environmental groups to support the designation.

Close work to the Government of New Brunswick was done to ensure this productive area, where fresh and salt water mix, continues to support unique habitats for a large variety of species. To ensure that the intertidal area was included in the MPA, a federal-provincial arrangement was developed. The Government of New Brunswick transferred the administration of 11 square kilometres provincial intertidal lands to DFO for inclusion in the MPA in December 2006.

Fisheries and Oceans Canada, Environment Canada, and Parks Canada each deliver distinct programs to protect marine life, migratory birds, and their habitats. The three departments are working together under Canada's *Federal Marine Protected Areas Strategy* to establish a network of marine protected areas. This coordinated approach will more effectively contribute to the improved health, integrity and productivity of our ocean ecosystems for generations to come.

Reconstruction of the van Steenburgh Science Building

DARTMOUTH, N.S. – Canada's Federal Government announced a $17 million investment to reconstruct the van Steenburgh Science Building at the Bedford Institute of Oceanography (BIO) in Dartmouth, Nova Scotia.

" With so much public interest in climate change, and the future of our oceans' ecosystems and fish stocks, the work done by DFO's scientists is becoming increasingly important to the global community,"said the Honourable Loyola Hearn, Minister of Fisheries and Oceans.

BIO research plays a crucial role in understanding the ocean ecosystem, the ocean's role in local and global climate, and fish science. "Modern laboratories are essential to ocean research," added Minister Hearn. Constructed in the early 1960s, the van Steenburgh building is one of oldest original buildings on the BIO campus. Reconstruction is required to modernize the facility. The building houses mixed science laboratories, engineering workshops and research offices. Research conducted from the van Steenburgh building includes physical and chemical oceanography focussed on climate change, ice research, ecosystem and biodiversity research, oil and gas environmental research, and ocean instrument development.

The project will involve reconstruction of the entire interior and exterior of the building, except for major structural elements. The building envelope, roof, exterior walls, windows, mechanical and electrical systems will all be replaced. This total upgrade of BIO's van Steenburgh building will provide an up-to-date facility to support this important research. Construction is scheduled to begin early spring 2007, and is expected to take about three years to complete.

Source: DFO Website in April 2007.

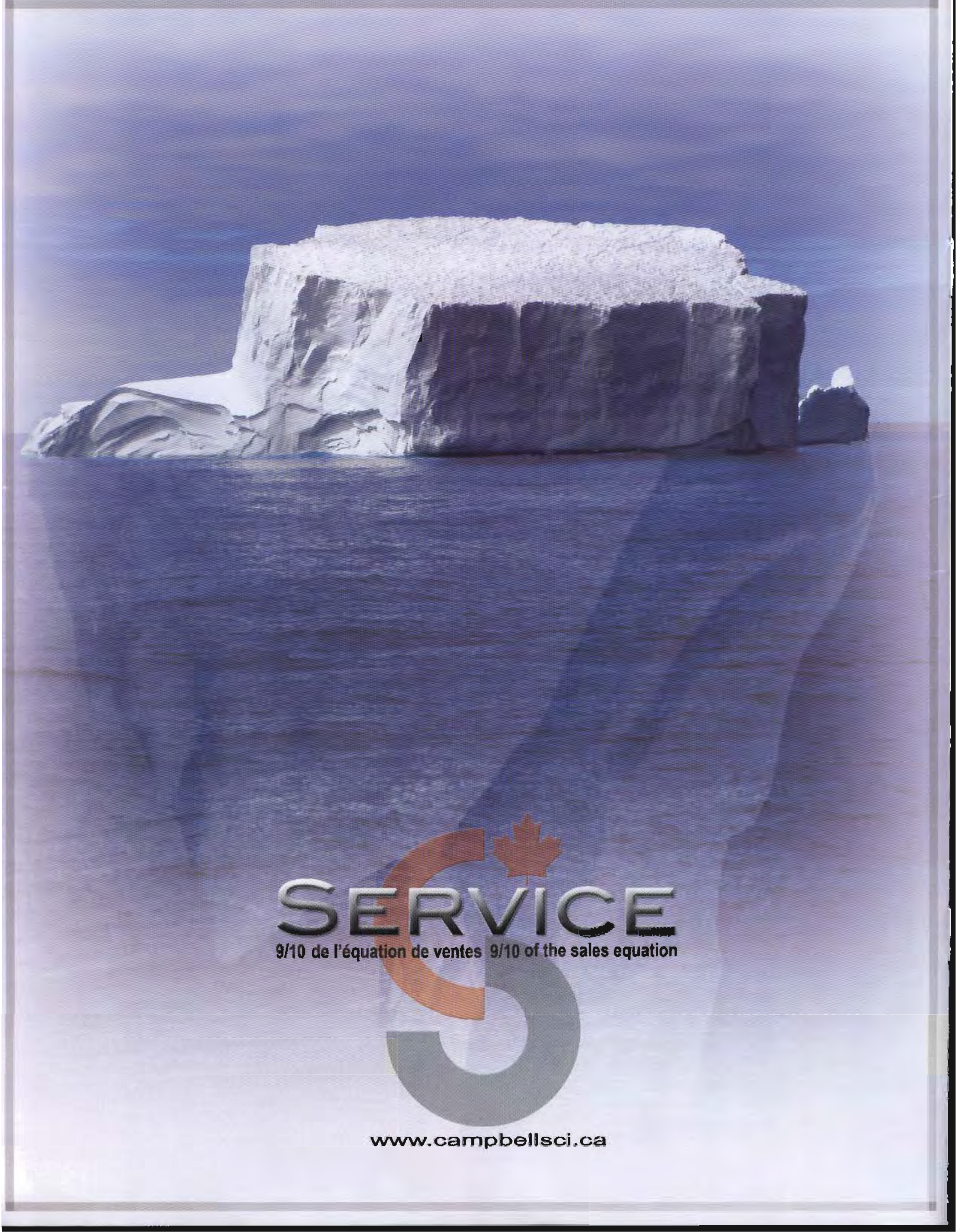
Participation de le SCMO à la journée de la Terre le 21avril 2007

Le 21 avril dernier, se tenait à Québec une exposition pour le grand public dans le cadre de la "Journée internationale de la Terre" inscrite au calendrier de l'ONU depuis 1971. Lors de cet événement, le centre de Québec de la SCMO, aussi connu sous le nom de Société de Météorologie de Québec (SMQ, http://www.societe-meteo-quebec.org/) présentait un kiosque. Le public a ainsi pu poser des questions aux animateurs présents et obtenir des informations sur les sciences de l'océan et de l'atmosphère. Le kiosque présentait également quelques appareils de mesures océanographiques et météorologiques.

Le kiosque de la SCMO tenu par le Centre de Québec au centre commercial "Place Laurier" le 21 avril 2007.

Malgré une journée exceptionnellement ensoleillée de nombreuses personnes ont fait le déplacement au centre commercial "Place Laurier" de Québec pour venir à la rencontre des exposant présents. L'intérêt du public pour les sciences de la Terre en général et particulièrement pour celles représentées par la SCMO fut une fois de plus démontré et les discussions furent nombreuses, particulièrement avec les plus jeunes visiteurs. La réussite de l'événement fut au-delà des espérances et un rendez-vous fut pris pour l'année prochaine.

CMOS Accredited Consultants / Experts-Conseils accrédités de la SCMO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