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Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

October / octobre 2013 Vol.41 No.5

Changements climatiques : les élèves passent à l'action

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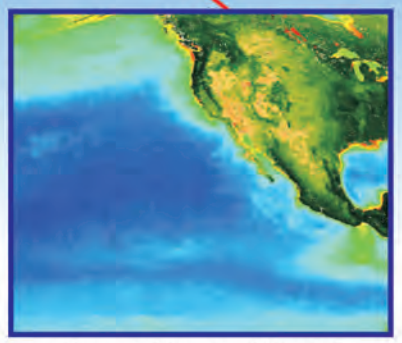

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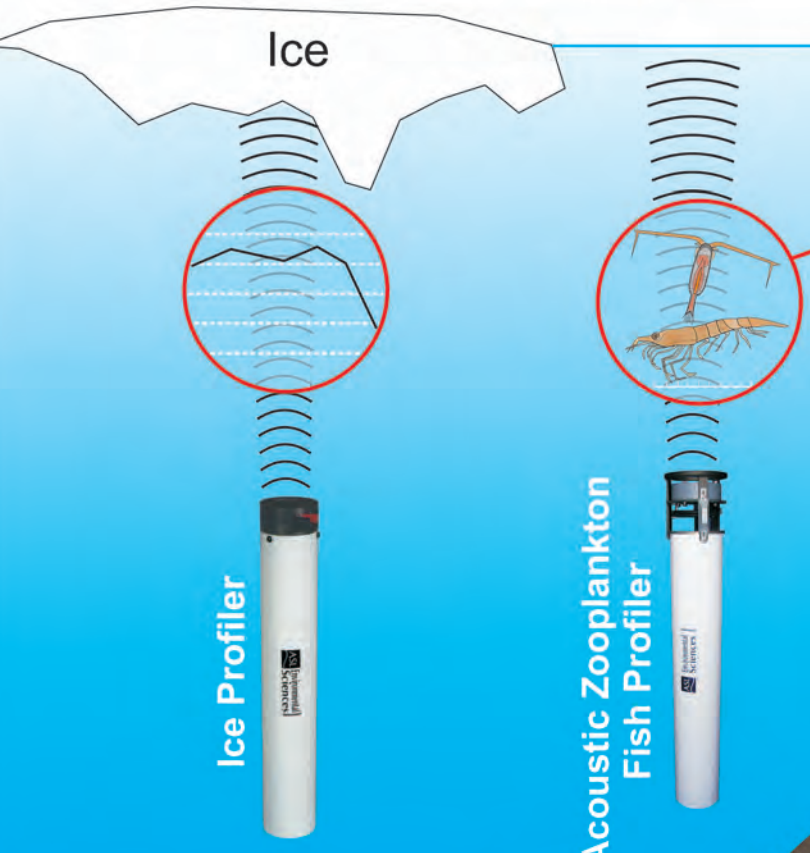

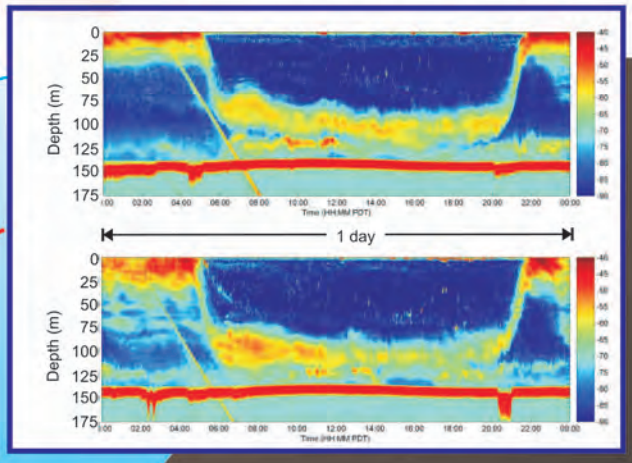

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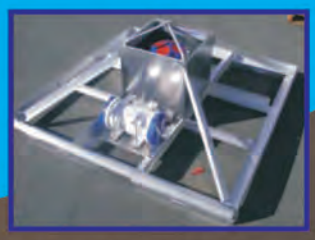

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....from the President's Desk / Allocution du président

Friends and colleagues:

Pierre Gauthier
Président de la SCMO
CMOS President

Summer is now over and with autumn comes a flurry of activities. In universities, the students are back, courses resume and it is also for many of us the time to fill in our proposals for NSERC and other funding organizations. For many years, research in atmospheric and oceanic sciences benefited from special programs such as that of the Canadian Foundation for Climate and Atmospheric Sciences which has been without a doubt the main source of funding for academic research in climate and atmospheric science. For our community, research funds are now scarcer than they used to be and we need to rely more on funding sources on which all scientific research fields rely, namely NSERC, which is the main source of funding outside of health-related fields. This raises the issue of funding of research in Canada. Even though the needs are growing, funding is not, despite the level of excellence of Canadian scientists. CMOS is concerned by this. On other occasions, when we expressed our concern by sending letters to ministers, the results have so far been disappointing.

Recently, the Climate Change and Atmospheric Research (CCAR) program funded seven big five-year projects which will certainly give an impetus to the research themes that were successful. However, this leaves out in the cold a large part of our community as the CCAR program is a one-time shot. The program also focused on priorities of the government but did not cover the complete range of research topics. Research requires continuous support and is hit hard when funding stops abruptly. Many excellent scientists have had to leave to pursue their career outside of Canada and when a new program is created the lost expertise needs to be rebuilt.

(Continued on page 147 / Suite à la page 147)

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

CMOS Bulletin SCMO
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Inside / En Bref

Articles

Climate Change / Changements climatiques

Our regular sections / Nos chroniques régulières

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Cover page: *Cities As Green Leaders*™ is a youth-driven, community-based pilot program focused on turning climate knowledge into climate action. Launched in Edmonton and debuted at the recent national CMOS Congress held jointly with CGU and CWRA in Saskatoon, the pilot has been built to roll out nationally and globally through scientists' premium green networks using municipal governments and education systems as entry points in their communities. The photo on the cover page shows six students representing three high schools across the city of Edmonton who volunteered as a writing team to compose, "*Cities As Green Leaders™: A White Paper by Edmonton's Youth*." Two students, Amy Mallon and Osama Javid, travelled to Saskatoon last May to deliver the paper to the CMOS Congress. Back Row/ left to right: Peter Johnson (LSL); Amy Mallon (LSL); Osama Javid (QEH); Vanessa Traub (QEH). Front Row/ left to right: Zeynep Ozdemir (QEH); Joyce Chiang (JP). To learn more read the articles shown on pages **165** and **166**.

Note: LSL – Louis St. Laurent Catholic School; QEH – Queen Elizabeth High School; JP – Jasper Place High School. Three other Edmonton schools were involved in the project: Holy Trinity, Oscar Romero and Amiskwaciy Academy.

Page couverture: Vous pouvez lire la description de la page couverture au bas de la page suivante.

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

Having relied on CFCAS for many years, our community is now less present, but not absent, from NSERC selection committees. Most apply to the NSERC committee on geosciences which covers a broad range of topics including geophysics, geography and other fields. A quick look at the composition of the committee indicates that their expertise doesn't cover the breadth of disciplines represented by CMOS. It is often reported that even though external reviewers may give excellent comments on a project, it is nevertheless rejected. I think that those who volunteer to serve on these committees work very hard to do their best but the rules and procedures that they need to follow leave them little room to do the job they would like to. For geosciences, not all communities in the geosciences have the same requirements (field work, group size, etc.) and so it may not be appropriate to apply uniform metrics across the entire committee. A rigid application of this "one size fits all" approach can produce unreasonable results. The consequences are often harmful to those who are left out as there are few other funding sources. CMOS has joined with other learned societies (e.g., Canadian Societies for the Geophysical Sciences, CSGS) which share our concerns. Efforts need to be made to voice strongly our concerns hoping that this message will be heard and lead to improvements in the means of the scientific community. We need to be able to offer hope and a future in Canada to the many young scientists we see first as students in our classes.

Finally, CMOS lost one of its most respected and loved members in Prof. J.C. McConnell who passed away this summer. The news went all across the world and many people are in shock. He was so appreciated by so many in the Canadian meteorological community in particular. I have personally had the privilege to collaborate with him on some research projects. His enthusiasm and the perspective he brought to issues made him very special, very very special. It was always a pleasure to meet and discuss with him. He had a stimulating influence on people and has contributed to the meteorological community in so many ways. I send my condolences to his family and friends on behalf, I am sure, of all of us [Please read page 181 in this issue].

Pierre Gauthier, Président de la SCMO / CMOS President

Page couverture: le programme pilote communautaire *Cities As Green Leaders*™ est mené par des jeunes et vise à "passer de la théorie à la pratique en matière de climat", une formule empruntée au Pacific Institute for Climate Solution (PICS), avec sa permission. Ce programme a été lancé à Edmonton et a fait ses débuts au dernier Congrès national conjoint SCMO-UGC-ACRH, tenu à Saskatoon. Il a été conçu pour être diffusé aux échelles nationale et mondiale, grâce aux excellents réseaux de spécialistes en écologie, et en utilisant, comme porte d'entrée auprès des communautés, les gouvernements municipaux et les systèmes éducatifs. La photo de la page couverture montre six élèves représentant trois écoles secondaires d'Edmonton. Cette équipe s'est portée volontaire pour rédiger le document intitulé : *Cities As Green Leaders™: A White Paper by Edmonton's Youth* (un livre blanc rédigé par des jeunes d'Edmonton sur les pratiques écologiques municipales). Deux élèves, Amy Mallon et Osama Javid, sont allés à Saskatoon en mai dernier, afin de présenter le document au Congrès de la SCMO. Dernière rangée (de g. à d.) : Peter Johnson (LSL), Amy Mallon (LSL), Osama Javid (QEH) et Vanessa Traub (QEH). Première rangée (de g. à d.) : Zeynep Ozdemir (QEH) et Joyce Chiang (JP). Pour de plus amples informations, consultez les pages **165** et **166**.

Note: LSL – Louis St. Laurent Catholic School; QEH – Queen Elizabeth High School; JP – Jasper Place High School. Trois autres écoles d'Edmonton ont également été impliquées dans le projet: Holy Trinity, Oscar Romero et Amiskwaciy Academy.

Bonne nouvelle!

C'est maintenant officiel. Débutant avec le numéro de février 2014, le *CMOS Bulletin SCMO* sera publié en utilisant un procédé digital en couleurs au lieu d'offset en noir et blanc pour son édition imprimée. La version couleur électronique continuera d'être disponible sur le site web de la SCMO dans la section pour les membres seulement. Pour ceux qui désirent profiter de cette opportunité pour publier une annonce couleur dans nos pages, veuillez consulter nos prix indiqués à la page suivante.

Great News!

It is now official. Starting with the February 2014 issue, the paper edition of the *CMOS Bulletin SCMO* will be produced using a full-colour digital printing process rather than black and white offset. The colour electronic version will still be available on CMOS web site in the section for Members only. For those who wish to use this opportunity to publish a colour ad in the Bulletin, please consult the price list shown on next page.

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ARTICLES

Spatial-Temporal Rainfall Storm Characteristics

Part IV: Alternative Design Storm Method

by Daniel Jobin[1] and Peter Jolly[1] and Steven Chan[2]

Abstract: A series of four papers summarizes the key findings of over ten years of research in hydrometeorology using weather radar-derived rainfall data at and near the City of Edmonton, Canada. Although the initial study objective was to determine spatial characteristics of rainfall storms, subsequent analyses provided much more complex storm attributes such as areal reduction factors, "Spatial Design Storms", storm-cell spacing statistics and, "Depth-Duration-Area-Frequency" curves. These advanced spatial characteristics are of great interest to water resources professionals who are tasked with designing water-related infrastructures and currently use overly simplistic approaches in determining rainfall inputs. The breadth of the research eventually enabled the development of promising alternative methodologies for creating spatiotemporal "Design Storms"; results that could significantly impact how costly water-related structures are designed.

Résumé: Une série de quatre articles présente une synthèse des dix ans et plus de recherche en hydrométéorologie utilisant des données de précipitation radar aux alentours de la ville d'Edmonton, Canada. Bien que le but initial du projet de recherche était de seulement calculer des caractéristiques spatiales des événements pluvieux, les analyses ultérieures éventuellement abordèrent des attributs complexes notamment; des fonctions de décroissance spatiale des intensités, des 'Averses de projets', des statistiques de distances intercellulaires d'orage et, des fonctions 'Profondeur-Durée-Surface-Fréquence. Ces dernières caractéristiques d'averses sont particulièrement importantes en génie de ressources hydriques ou les professionnels utilisent maintenant que des méthodes simplistes pour évaluer l'apport pluvieux dans leurs calculs de dimensionnement d'ouvrage de drainage. L'envergure des travaux de recherche a permis éventuellement d'élaborer des méthodologies spatio-temporelles innovatrices de calculer les "Averses de projet" - des résultats qui pourraient changer de façon importante l'approche courante de concevoir l'infrastructure de drainage.

Preamble

This article is the result of over ten years of applied research and development in hydrometeorology; specifically, determining spatio-temporal characteristics of summer rainfall storms that occur at and near the City of Edmonton, Canada. Although the initial project's objective was to focus on the development of spatial characteristics of rainfall storms based on using weather radar data, the second follow-up study pushed the endeavors well beyond their intended purposes and resulted in important findings for water resources applications.

The large amount of research findings was organized into a series of four technical papers that progressively guide a reader toward more complex analysis results and, ultimately, proposed alternatives to the current simplistic "Design Storm" methodology.

The topics of the four papers are:

1. Building a Storm Database
2. General Storm Characteristics
3. Areal Reductions Factors
4. **Alternative Design Storm Method**

The impetus and objectives of this project, as well as the methodology that was developed in creating a spatial-temporal database of rainfall storm attributes, was outlined in the first paper. While the second paper presented several derived rainfall storm characteristics and statistics contained in the **Rainfall Storm Database**, the third article focused entirely on the development of rainfall Areal Reduction Factors (ARF) using weather-radar data near the City of Edmonton. This last article in the series presents a comprehensive application of the research findings - an alternative method of developing rainfall design storms for water resources applications based on using spatial-temporal storm characteristics.

[1] Kije Sipi Ltd - RadHyPS Inc [2] City of Edmondon

Introdution

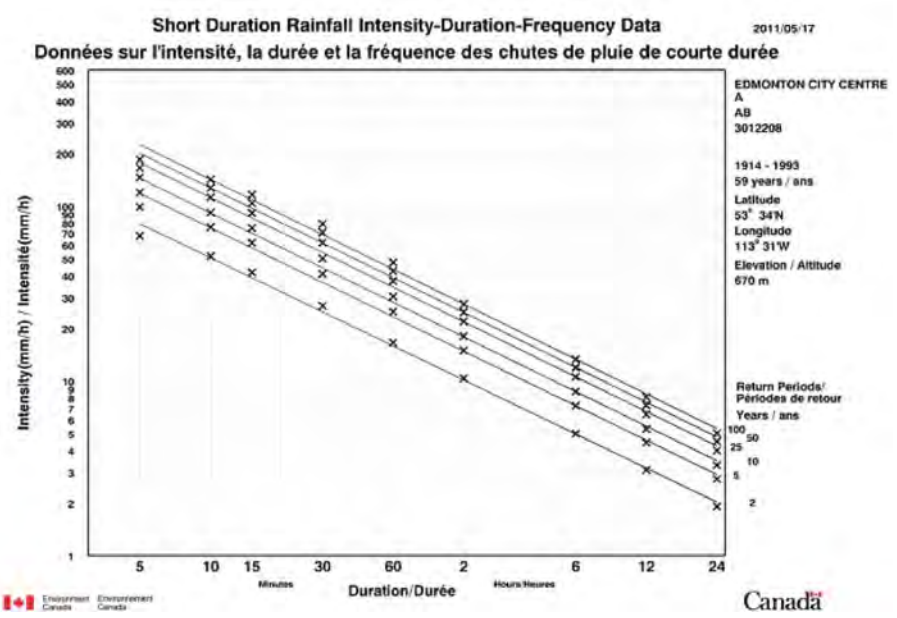

Figure 1: Intensity-Duration-Frequency Data (Edmonton)

Water resources managers and engineers often need rainfall data for planning and design purposes. In fact, methodologies for sizing flood control and water supply reservoirs, dams, spillways, irrigation and drainage channels, aqueducts, storm and combined sewers require rainfall statistics to define the input quantities used in designs. Currently, this statistical information is derived from rain gauge data and commonly available in the form of Intensity-Duration-Frequency (IDF) data products. The underlying purpose of using IDF data is to identify a target rainfall amount (depth) that is subsequently transformed into runoff volumes and flows that directly influence the hydraulic design of structures. While water resources managers and engineers recognize that the fundamental assumptions associated with using point rainfall statistics for hydrologic design applications in watersheds is incorrect, they nevertheless continue using the same design methodologies given the lack of alternatives. However, results from this research present a tangible path toward the development of a new approach in quantifying rainfall input for drainage design problems - a methodology based on **spatial-temporal storm characteristics** rather than point rainfall statistics.

This new approach integrates many of the current research findings and considers both temporal and spatial regional storm characteristics in defining the most significant design input variable to all water resources system: rainfall.

The following sections will briefly review the limitations of the current IDF-based approaches as well as present the alternative methodology.

Current IDF Design Storm Method

Water resources engineers use a variety of computational methods to determine the design runoff volumes and peak flows. However, the current methods generally require: 1) establishing the given structure's design life and, 2) determining the hydrologic time of concentration of the watershed upstream of the subject structure. These two metrics are used with regional IDF data to identify the design total rainfall depth. This is accomplished by selecting: 1) a rainfall frequency, or return period, that is at least equal to the structures expected design life and, 2) a duration that is also at least equal to the contributing surface's time of concentration. Given these two variables, the total rainfall depth is easily identified on IDF data products such as figure 1.

An Areal Reduction Factor (ARF) is sometimes applied to the total rainfall depth when basins are generally larger than 25 km^2. The WMO (World Meteorological Organization) relation that was developed from rain gauge data (see Article 3 in the series) is typically used for this purpose. Finally, the resulting total rainfall depth is then distributed in time using a "Synthetic Design Storm" while uniformly applied over the entire watershed surface in order to calculate runoff and stream flow quantities via hydrologic simulations. This is accomplished by applying any number of available Synthetic Design Storms, including the AES rainfall intensity temporal distributions developed by W.D. Hogg using Canadian rain gauge data.

Unfortunately, there are a number of significant issues in using the previously described IDF-based method that were partly described in the first article of this series; however, a more elaborate list includes:

1. Data Representativeness Issue

IDF data are statistics based on rain gauge observations that record rainfalls only over a very small footprint of any given storm event while watersheds typically experience a significantly larger amount, if not all of the total storm rainfall. Furthermore, the probability that a rain gauge will ever record a storm's maximum rainfall is very small while watersheds will often experience the entire extent of the storm including the peak rainfall (RMax). As a result, rain gauge rainfall statistics always underestimate a maximum total rainfall input to watersheds. Considering that the sizing of various hydraulic structures are based on maximum flows for given durations and frequencies, the designed dimensions would also be undersized for any given level of service.

2. Differences in Regime Issue
Rainfall time series can be considered as a set of independent discrete periods of rain and no rain. However, stream flows are continuous time series influenced not only by current rainfall but also the antecedent precipitation conditions that are generally controlled by soil properties and terrain characteristics. The type of soils and the land cover type as well as the topography combine to create interception, buffering and retention characteristics that significantly influence the transformation of rainfall into runoff and stream flows. As a result, rainfall and flow time series have quite different regimes. Consider as example, a situation with two closely occurring and quite identical storms. Although each storm would yield equal statistical weight in IDF calculations, the second event would typically generate far more runoff and higher flows due to previously wetting of the soil matrix from the first storm event; hence, would have a proportionately larger weight on stream flow statistics. Since stream flow statistics are the direct input into water resources design, IDF-based techniques generally do not capture the interrelation among storm events and also result in underestimating the impact of closely occurring storm events.

3. Climate Change Issue
The impact of climate change on IDF statistics has already resulted in many regulatory agencies imposing increases (i.e. +10%) in calculating design peak stream flows. Considering the previously established issues and in absence of local storm-based trend analyses these increases appear arbitrary in nature.

4. Areal Reduction Factor (ARF) Issue
All ARF relations used in water resources applications are based on rain gauge networks rather than storm-based analyses. As a result, the rainfall decay factors are typically underestimated and show a lack in representativeness when applied at watershed scales as was discussed in the first issue.

5. Conservative Approach Issue
The IDF-based methodology is often thought as a conservative approach of calculating design runoffs and peaks flows. It is believed that by uniformly applying the point-based (rain gauge) rainfall data over an entire watershed, the resulting runoff and peak flows are assuredly overestimated; hence the infrastructure safely over-designed. A review of the previously listed issues cast serious doubts on this belief. Furthermore, there is no current method of estimating the level of over/under design, also known in engineering as safety factors. Water resources practitioners assume their designs are truly equal or safer than the intended level of service.

As previously mentioned, many of these issues have long been recognized; however, in absence of any alternative, the IDF-based methods remain the state-of-practice in water resources engineering. While the objective of this study was originally focused on determining the spatial characteristics of rainfall storms, the scope of the research findings eventually led the study team in recognizing many elements of an alternative method for determining input rainfall to water resources designs. The study team's initial thoughts and assumptions are presented in the following sections.

Alternative Design Storm Method
The proposed alternative method of determining the design rainfall storm for water resources applications is based on **regional rainfall storm characteristics** obtained from calibrated weather radar data as opposed to point-source rainfall data collected by rain gauge. The weather radar data provides contiguous ($1km^2$ resolution) and continuous (5-minute interval) spatial-temporal observations of an entire rainfall storm; specifically, static and dynamic information on each storm's position, extent, volume, maximum total accumulation, duration, intensity, speed and direction. Assuming that all storms within the effective and error-free areas of the weather-radar belong to the same hydro-climatic region, spatial and temporal statistics can be calculated to provide the basic elements of an alternative method.

The alternative method is referred here as the "**Watershed Design Storm**" or simply, **WDS**. The method is composed of the following five analyses:

1. Determination of design RMax using:
   a) Depth–Duration–Area-Frequency data, or;
   b) RMax statistics, or;
   c) Rainfall Storm Severity Scale;

2. Adjustment for climate change using storm trend analysis data;

3. Development of initial Spatial Design Storm using RMax and normalized design storms;

4. Development of Watershed Spatial Design Storm by adjusting the Initial Spatial Design Storm for multiple storm cells using storm cell spacing statistics, and;

5. Development of Watershed Design Storm by temporal distribution of the Watershed Spatial Design Storm using:
   a) temporal design storms, or;
   b) synthetic temporal design storms.

The following sections will discuss each of the five steps in developing the WDS including how they address current limitations of the IDF method. Also, the research findings over and near the City of Edmonton will be used to develop an example WDS; however, this article is not meant as a detailed technical user's guide but rather an introductory paper on an innovative alternative approach. Also note that as is the case for the IDF method, hydrologists would require previously-determined basic application-specific

information in order to actually develop the design rainfall storm; namely,

- the watershed's shape, terrain elevation and area;
- the watershed's time of concentration; and
- the desired design level of service (i.e. return period) or the target safety factor.

Step 1: Determination of Design Maximum Rainfall (RMax)

This first step of the alternative method establishes the maximum total rainfall (depth over 1-km^2) over the given watershed. Three alternative approaches in determining this quantity are presented; however, it is important to note that all three approaches are derived from storm maximum 1-km^2 total rainfall data or, RMax. This is a significant departure from the traditional method of estimating design total rainfall amounts. This alternative approach uses rainfall statistics of only storm maximum totals within the given region of interest, as opposed to a single point in space (rain gauges) that mostly captures edges of storm events and rarely the storm's maximum point of rainfall. Considering a large enough sampling area and sufficient period of time, hydrologist, are reasonably assured of obtaining representative maximum total rainfall values thus avoiding underestimating the maximum total rainfall occurring within watersheds. While this study has analyzed thousands of storms over an area of approximately 22,500 km^2 over a period of eleven years, a smaller set of storms appears adequate to generate stable statistics.

A significant advantage of using RMax values is the possibility of estimating design runoff and design flow safety factors that are based on realistic upper limit total storm rainfall. This is a major departure from the current IDF method based on point-based rain gauge data as was discussed previously.

a) Regional DDAF Approach

Given the watershed area, a duration equal to the watershed's time of concentration and, a design level of service (return period), the design maximum rainfall (RMax) is obtained from a regionally developed DDAF diagram based on storm annual maximum storm RMax values. Figure 2 presents a sample set of DDAF curves that was developed during this study near Edmonton for a 2- and 6-hour duration and a return period of 2-, 10- and 20-years.

As example, given a watershed size of 120 km^2, a watershed time of concentration or duration of 2 hours and, a 10-year return period design, the design RMax would be equal to 30 mm.

b) Regional RMax Approach

Considering all regional rainfall storms belong to the same hydroclimatic regime, it can reasonably be assumed that observed storm events could occur anywhere within the given region, including the subject watershed.

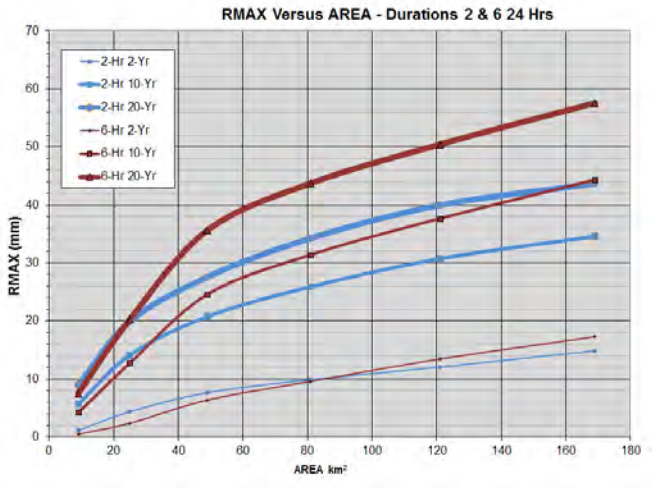

Figure 2: DDAF Average Annual Maximum (Duration 2/6 hrs, 1 km^2)

Consequently, probability theory can be used with a large dataset to identify an RMax value for design, say an RMax with a 1% probability of occurrence (large event). In essence, this approach leads to selecting a design RMax solely based on the observed population of all regional rainfall storm RMax that could also be segregated by duration. The advantage of this approach is the simplicity in calculating the underlying statistics. However, it cannot be related to the infrastructure's design life but it does reflect the probability of the magnitude of RMax within the region.

Figure 3 presents a fitted Wakeby distribution of over 200 storms (RMax) that were observed over an eleven-year period near Edmonton and have a "nominal" duration of 2 hours (2 hrs +/- 30 mins).

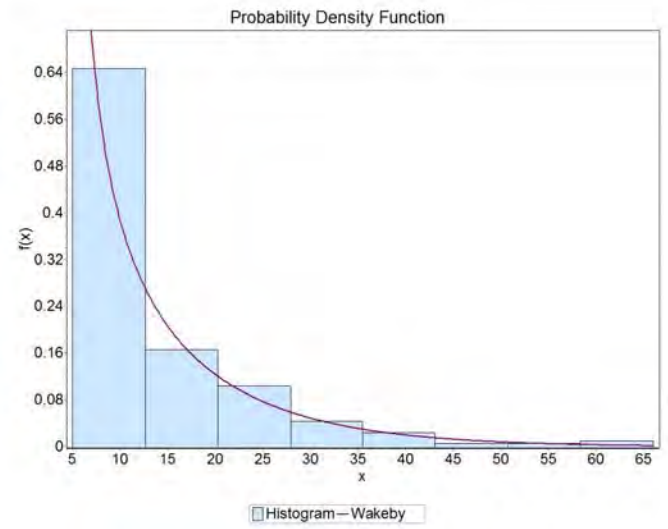

Figure 3: Regional 2-hour RMax

Using the same example as before (a duration of 2 hours and an RMax probability of 10%) the design RMax using this second approach would be 26 mm using Figure 3. This is slightly smaller than using the regional DDAF approach

that incorporates area and frequency of occurrence statistics. However, a frequency analysis of the regional maximum annual 2-hr RMax values for the same eleven-year period yields a design RMax value of 58 mm for a 2-hour storm duration and a 10-year return period. As a comparison, an analysis of current Edmonton IDF data for the same period of record and parameters produces a total rainfall of 24 mm.

c) Regional Rainfall Storm Severity Scale

A third approach in determining the design RMax would be to use a regionally developed Rainfall Storm Severity Scale similar to the Saffir-Simpson hurricane wind scale. The severity scale would be based on storm characteristics and flood-related damages. A key motivation in developing this approach is to provide a methodology based on fixed level of services (i.e. Category 2 Rainfall Storm). This approach is entirely independent rainfall statistics; hence, circumvents IDF related frequency issues. Although research has been initiated on this approach, it will be the subject of a separate paper.

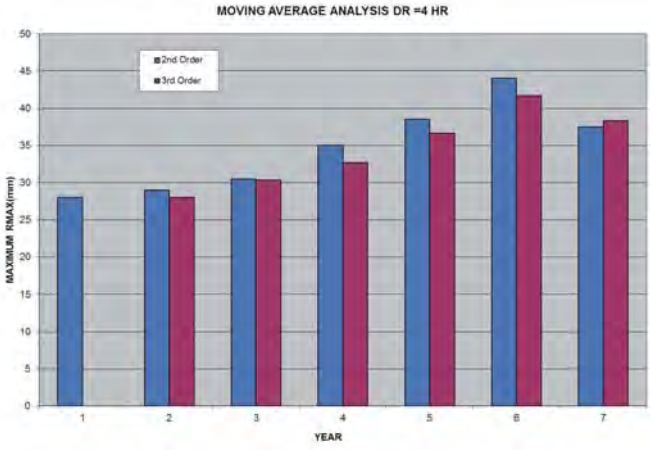

Figure 4: Regional 2-hour Rmax - Wakeby

Step 2: Adjustment for Climate Change of RMax

The next step in developing the WDS is to adjust the previously determined RMax value in order to account for the anticipated climate change impacts over the life of a given structure. This can be accomplished by using trend analyses of the regional storm RMax for different durations. Figure 4 presents the annual changes in the average RMax in the region of Edmonton for 4-hour duration storms using 2nd and 3rd order moving averages.

Similar analyses were also completed for periods of 2-, 6-, 12- and 24-hours. The preliminary findings, considering eleven years of storm data near Edmonton, suggest a negative trend for storms with 2-hour or less duration while positive trends for durations of 4 to 24 hours. An annual increase in RMax of 4% was calculated for durations of 4 to 12 hours while 7% for storms of 24 hours. Considering the smaller dataset for 2-hour duration storms, changes in RMax are not recommended for this duration at this time.

The projected trend increase in RMax for durations of 4- to 24-hours (+4%) is substantial. Given a 25-year design life, water resources structures could anticipate, based on this trend, a doubling of the design storm RMax. Some provincial regulatory agencies are already imposing, albeit smaller, increases of the design peak flows. An analysis of the impacts of applying the study findings and the availability of additional storm data should provide future guidance on this component of the alternative method.

Step 3: Development of Initial Spatial Design Storm

The next step in the proposed alternative method is to create an initial spatial design storm based on the central 1-km^2 peak total rainfall, RMax. Contrary to the IDF method, the proposed alternative method does not apply the design total rainfall uniformly across the entire watershed. Instead, the alternative method used normalized spatial storm decay patterns as a means to establish the design rainfall over the given watershed. Although spatial decay relations have been available for many years and generally are only applied on large watersheds in an attempt to compensate for the limited extent of rainfall storms, they cannot be applied unaltered across large watersheds. However, this study research has clearly shown that steep storm rainfall decay patterns occur from the central peak (RMax), as compared with the traditionally used WMO decay curves. The study has also developed spatial distribution rainfall decay ratio patterns for several storm durations as shown in Figure 5.

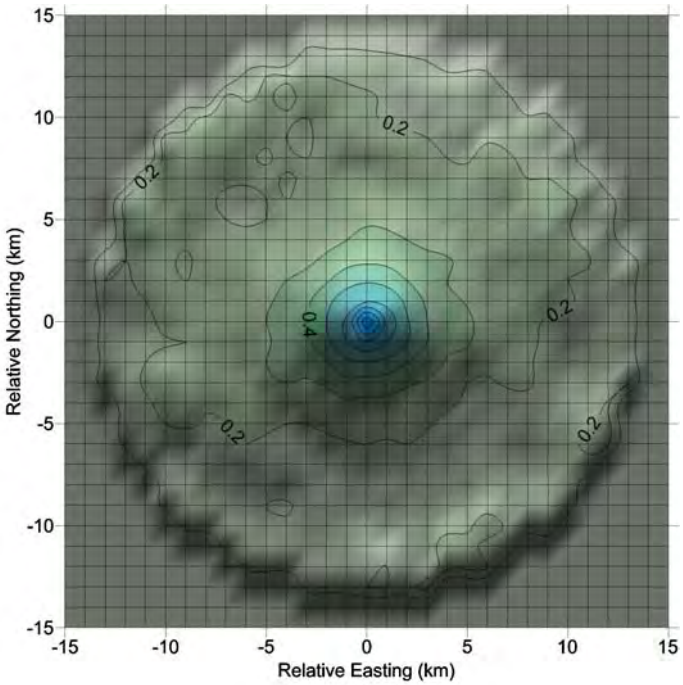

Figure 5: 2-Hour Normalized Storm Pattern

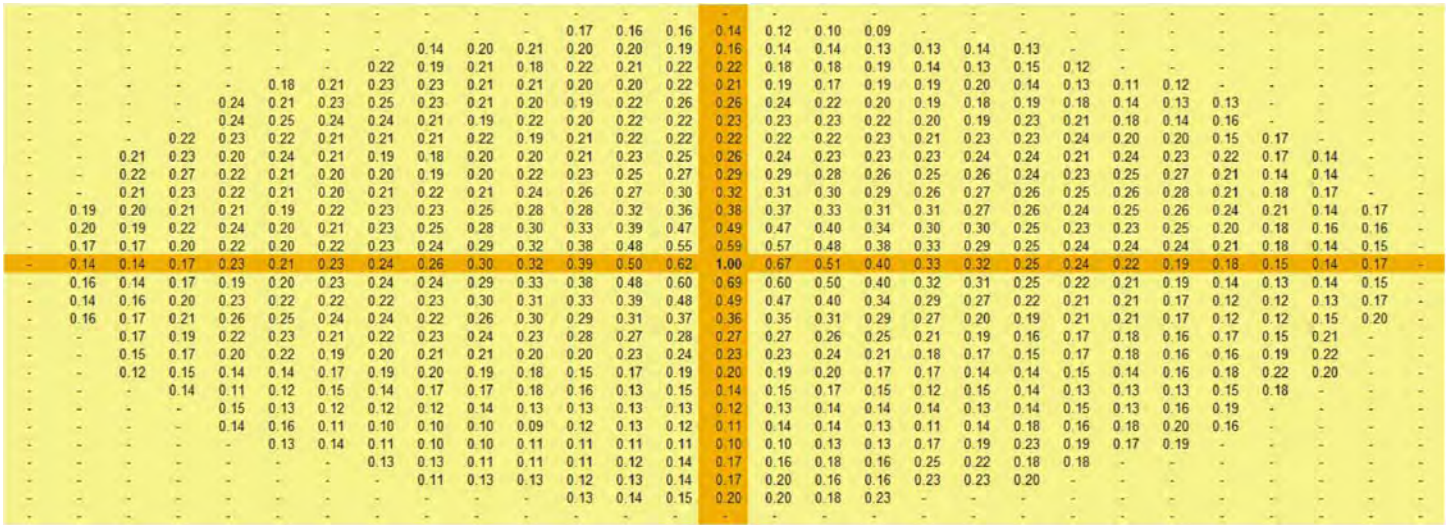

Table 1: 2-Hour Normalized Strom Decay Pattern Values

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	10	10	10	8	7	6	5	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	8	11	12	12	12	11	9	8	8	7	7	8	7	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	13	11	12	10	13	12	13	13	10	10	11	8	8	9	7	0	0	0	0	0	0	0	0
0	0	0	0	0	11	12	13	13	12	12	11	11	13	12	11	10	11	11	11	8	7	6	7	0	0	0	0	0	0
0	0	0	0	14	12	13	14	13	12	12	11	13	15	15	14	12	12	11	11	11	10	8	8	8	0	0	0	0	0
0	0	0	0	14	14	14	14	12	11	12	12	13	13	14	14	13	13	11	11	13	12	11	8	9	0	0	0	0	0
0	0	0	13	14	13	12	12	12	13	11	12	13	13	13	13	13	13	12	13	13	14	11	11	9	10	0	0	0	0
0	0	12	13	12	14	12	11	10	11	12	12	13	15	15	14	13	14	13	14	14	12	14	13	13	10	8	0	0	0
0	0	13	16	13	12	11	12	11	12	13	13	15	16	17	17	16	15	15	15	14	14	14	16	12	8	8	0	0	0
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0	8	8	10	14	12	13	14	15	17	19	22	29	36	58	39	30	23	19	18	15	14	13	11	11	9	8	10	0	0
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0	8	9	11	13	13	13	13	13	17	18	19	23	28	28	27	23	19	17	16	13	12	12	10	7	7	8	10	0	0
0	9	10	12	15	14	14	14	13	15	17	17	18	21	21	20	18	17	15	12	11	12	12	10	7	7	9	11	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2: Initial Design Storm (Rmax = 58 mm, 2-Hour Storm)

0	5	4	5	6	6	7	7	7	9	10	11	14	18	21	18	15	12	10	9	7	7	6	6	4	4	4	4	0
4	7	8	6	7	7	7	6	7	9	9	15	17	19	19	18	15	13	9	8	7	6	6	5	4	4	9	10	5
4	9	9	10	12	11	7	7	11	14	15	15	15	17	16	15	13	12	12	10	10	6	6	9	10	10	10	12	6
5	5	11	10	11	11	10	13	13	14	12	15	14	15	15	13	13	13	10	10	9	9	12	11	11	10	13	6	7
6	5	10	11	12	16	16	16	17	13	13	12	13	14	13	13	12	12	11	11	14	15	15	15	11	12	13	6	7
7	6	10	10	17	16	17	17	17	16	11	10	12	13	14	13	12	11	11	17	16	17	16	16	15	13	12	7	8
7	7	7	10	16	18	18	17	16	16	12	11	10	11	11	12	12	11	10	18	18	17	17	14	15	12	6	6	7
7	7	7	13	18	17	17	16	16	15	15	10	10	10	10	10	11	11	17	18	18	18	16	17	17	11	6	6	7
7	7	13	14	18	19	16	16	15	16	14	14	11	11	11	11	11	17	17	18	20	17	19	18	17	11	11	7	8
9	8	14	16	14	17	17	17	17	15	14	14	11	11	12	12	12	18	21	20	20	18	19	20	12	11	11	8	8
9	9	15	15	15	14	14	18	19	16	16	16	12	13	15	14	14	20	22	21	20	19	14	15	13	13	13	8	9
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14	18	16	16	16	14	13	14	15	14	14	19	21	19	21	20	23	23	16	16	14	13	14	15	14	14	15	17	14
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6	11	11	13	13	12	6	7	10	11	12	12	13	15	16	17	15	14	16	15	14	7	8	11	11	10	8	9	4
6	11	13	6	7	6	6	7	8	8	9	14	16	19	21	20	17	17	9	9	8	7	7	7	6	5	9	9	5
0	5	5	6	6	6	7	7	7	9	10	11	14	17	18	17	15	11	10	9	8	7	7	7	6	5	4	5	0

Table 3: Watershed Spatial Design Storm (Rmax = 58 mm, 2-Hour Storm, Multiple Storm Cells)

These normalized spatial decay patterns were developed from actual regional storm data. Figure 5 presents the 2-hour normalized storm pattern, while Table 1 gives the actual underlying 1-km^2 data (relative UTM grid cells) in a matrix format that is more convenient for developing the watershed design storm. These figure and table data were derived from regional storm radar datasets; hence they depict normalized storm accumulation patterns.

The central grid represents the position of RMax; and has an ARF ratio of 1.0, whereas all other grid-cells are a fraction, <1.0. The figure and table show a maximum decay extent area of 13 km by 13 km.

A careful inspection of the relative decay values shows a subtle, but noticeable, smaller east-west decay trend that corresponds to the predominant storm direction near Edmonton.

The 2-hour decay pattern shows a noticeably rapid reduction of the central storm value; whereas a 50 % reduction in central peak rainfall (RMax) is reached at a distance of approximately 2.5 km from the centre. A 75% reduction in RMax is reached at only 6.5 km from the centre.

Continuing with the previous example of developing a watershed design storm, the design RMax value of 58 mm determined in Step 1 and, not adjusted for climate change in Step 2, would then be applied to each grid cell decay ratio of the 2-hour normalized storm (Table 1) in order to produce the initial design storm shown in Table 2.

In water resources applications, such as hydrologic simulations, this spatially distributed design storm would be positioned over the watershed, at a location near the centroid of the watershed in order to generate a maximum runoff and peak flow. Sub-watershed rainfall amounts can also be easily obtained by averaging and aggregating the appropriate adjacent grid-cells.

Step 4: Adjustment for Multiple Storm Cells

As discussed in the second paper, convective rainfall storm cells often occur in clusters over medium-to-large watersheds that experience the combined effects of these events, resulting in a direct impact on hydrology and stream flows. The current study findings indicate that multiple storm cells can occur near Edmonton on watersheds larger than 14 km across which also corresponds to the average distance among storm cells. Hence, the **Watershed Spatial**

Design Storms should be adjusted to account for this potential hydrologic impact.

The proposed **Watershed Spatial Design Storm** is therefore composed of additional rainfall by overlaying multiple initial design storms while respecting the 15 km centre-to-centre separation. Accordingly, and continuing with the previous example, Table 3 now presents the results of adding four storm cells (i.e. identical to the initial design storm in Table 2) at the cardinal point locations or, 15 km from the centre peak storm cell. Table 3 is effectively the **Watershed Spatial Design Storm** that, once positioned over the watershed, can be used to estimate the total design rainfall amounts over each 1-km^2 of the watershed.

Although the **Watershed Spatial Design Storm** has a nominal 1-km^2 resolution, nothing prevents averaging of grid-cells if deemed appropriate in order to ultimately reduce the number of rainfall time series, especially if lumped, conceptual hydrologic models are being applied as opposed to distributed grid-based hydrologic models.

Furthermore, considering the **Watershed Spatial Design Storm** represents a realistic maximum total rainfall based on regional storm maxima, it can serve as a basis to apply further design safety factors that could incorporate climate change and other risk factors.

Step 5: Temporal Distribution of Spatial Design Storm
The last step in developing the **Watershed Design Storm** is required in order to generate time series for each previously determined grid-cell total rainfall; hence temporally distribute the grid-based **Watershed Spatial Design Storm**. The result could either be a set grid cell-based rainfall intensity series (hyetographs) or a set of matrices containing the per-grid cell total rainfall for each given time interval.

Two potential approaches are suggested, including: 1) the application of a regionally developed Temporal Design Storm or, 2) the use of a well-known temporal distribution such as the Environment Canada-AES design storms. Unfortunately, as of this writing, the normalized regional temporal distributions from RMax data are being developed and will be the subject of a subsequent paper; hence a synthetic temporal design storm is currently required.

Conclusions and Next Steps
This last article, of a four-part series, focused on an application of several spatial-temporal storm characteristics that were presented in the first three papers. The storm characteristics were derived from a storm-cell database that was compiled at an interval of 15-minutes and a spatial resolution of 1-km^2 over a study area of approximately 22,500 km^2 that includes the City of Edmonton. In fact, the seemingly disparate spatial-temporal rainfall storm characteristics were used in developing a potential alternative method in determining watershed rainfall quantities for water resources design applications – known as the **Watershed Design Storm**.

This alternative method is put forward as a more realistic approach of estimating total design rainfall for water resources structure design, as compared to the rain gauge-based Intensity-Duration-Frequency (IDF) method. The new method provides solutions to IDF method issues associated with: 1) data representativeness of using rain gauge data for watershed applications, 2) differences in rainfall data series and stream flow regime, 3) climate change, 4) areal reduction factors developed from sparse point-source rain gauge data and, perhaps more importantly, 5) the perception that using IDF-based methods leads to deriving conservative design flow rates.

The proposed, **Watershed Design Storm** alternative method to define watershed rainfall consists of five steps:

1. Determination of a design RMax;
2. Adjustment for climate change;
3. Initial Spatial Design Storm;
4. Development of Spatial Design Storm by adjusting for multiple storm cells; and
5. Temporal distribution of Spatial Design Storm.

The current research and development efforts are focussing on:

- the addition of another four years of storm data (15 years in total);
- the update of all pertinent storm characteristics based on using the additional years of available storm data;
- the development of normalized regional temporal design storms based on RMax total rainfall, and;
- testing and evaluation of the alternative **Watershed Design Storm** method as well as comparison to the current IDF method.

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2001-2010 - A Decade of Climate Extremes

GENEVA, 3 July 2013 - The world experienced unprecedented high-impact climate extremes during the 2001-2010 decade, which was the warmest since the start of modern measurements in 1850 and continued an extended period of pronounced global warming. More national temperature records were reported broken than in any previous decade, according to a new report by the World Meteorological Organization (WMO).

The report, The Global Climate 2001-2010, A Decade of Climate Extremes, analysed global and regional temperatures and precipitation, as well as extreme events such as the heat waves in Europe and Russia, Hurricane Katrina in the United States of America, Tropical Cyclone Nargis in Myanmar, droughts in the Amazon Basin, Australia and East Africa and floods in Pakistan.

The decade was the warmest for both hemispheres and for both land and ocean surface temperatures. The record warmth was accompanied by a rapid decline in Arctic sea ice, and accelerating loss of net mass from the Greenland and Antarctic ice sheets and from the world's glaciers. As a result of this widespread melting and the thermal expansion of sea water, global mean sea levels rose about 3 millimetres (mm) per year, about double the observed 20th century trend of 1.6 mm per year. Global sea level averaged over the decade was about 20 cm higher than that of 1880, according to the report.

The WMO report charted rising atmospheric concentrations of greenhouse gases. Global-average concentrations of carbon dioxide in the atmosphere rose to 389 parts per million in 2010 (an increase of 39% since the start of the industrial era in 1750), methane to 1808.0parts per billion (158%) and nitrous oxide to 323.2 parts per billion (20%).

"*A decade is the minimum possible timeframe for meaningful assessments of climate change*," said WMO Secretary-General Michel Jarraud. "*WMO's report shows that global warming was significant from 1971 to 2010 and that the decadal rate of increase between 1991-2000 and 2001-2010 was unprecedented. Rising concentrations of heat-trapping greenhouse gases are changing our climate, with far reaching implications for our environment and our oceans, which are absorbing both carbon dioxide and heat*."

"*Natural climate variability, caused in part by interactions between our atmosphere and oceans – as evidenced by El Niño and La Niña events - means that some years are cooler than others. On an annual basis, the global temperature curve is not a smooth one. On a long-term basis the underlying trend is clearly in an upward direction, more so in recent times*" said Mr Jarraud.

Between 2001 and 2010, there was no major El Niño event, which normally leads to higher temperatures (as occurred in the then-record warm year of 1998). Much of the decade experienced either cooling La Niña or neutral conditions, except for the 2009/2010 moderate to strong El Niño.

The 100-page report and an executive summary, incorporating findings from a unique survey of 139 National Meteorological and Hydrological Services and socio-economic data and analysis from several UN agencies and partners, were released to coincide with the first session of the Intergovernmental Board on Climate Services. This Board is overseeing the implementation of the Global Framework for Climate Services – an international initiative to improve and expand scientifically-based climate information to help society cope with the natural variability of our climate and human induced climate change.

'"*A decadal perspective makes it possible to assess trends in the climate system and anticipate the future. It can also inform efforts to develop operational climate services that provide information and forecasts for decision-making in agriculture, health, disaster risk, water resources and other sectors. These efforts are being coordinated through the WMO-led Global Framework for Climate Services*," said Mr Jarraud.

"*Climate services are more necessary than ever to help us cope with global changes in our climate, which are accentuated at regional and national scales. Despite the significant decrease in casualties due to severe storms and*

flooding, the WMO report highlighted an alarming impact on health and mortality rates caused by the European and Russian heat-waves. Given that climate change is expected to lead to more frequent and intense heat-waves, we need to be prepared,'' said Mr. Jarraud.

Temperatures: The average land and ocean-surface temperature for the decade 2001-2010 was estimated to be 14.47°C, or 0.47°C above the 1961–1990 global average and +0.21°C above the 1991–2000 global average (with a factor of uncertainty of ± 0.1°C).

The decadal rate of increase in the global temperature accelerated between 1971 and 2010. The global temperature increased at an average estimated rate of 0.17°C per decade during that period, compared with 0.062°C per decade for the entire 1880-2010 period. The average 2001-2010 decadal temperature was 0.21°C warmer than 1991–2000, which in turn was +0.14°C warmer than 1981-1990.

Every year of the decade except 2008 was among the 10 warmest years on record. The warmest year ever recorded was 2010, with a temperature estimated at 0.54°C above the 14.0°C long term average of 1961-1990 base period, followed closely by 2005.

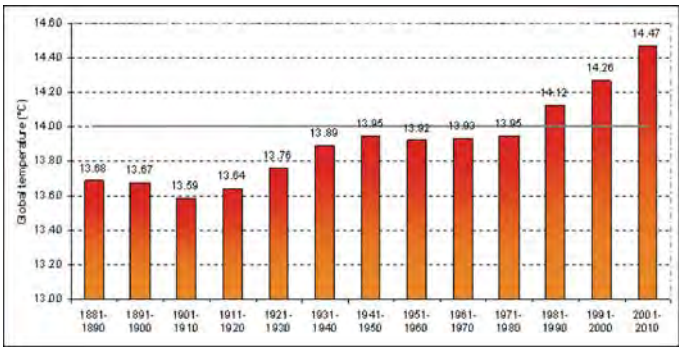


Figure Caption: Decadal global combined surface-air temperature over land and sea-surface temperature (°C) obtained from the average over the three independent datasets maintained by the HadCRU, NOAA-NCDCand NASA-GISS.The Horizontal grey line indicates the long term average value (14°C).

Above-average temperatures were observed over most parts of the globe in 2001-2010. This was particularly marked in the higher latitudes of the northern hemisphere. Greenland recorded the largest decadal temperature anomaly, at +1.71°C above the long-term average and with a temperature in 2010 of +3.2°C above average. Africa experienced warmer than normal conditions in every year of the decade.

Results from WMO's survey showed that nearly 94% of reporting countries had their warmest decade in 2001-2010 and no country reported a nationwide average decadal temperature anomaly cooler than the long term average.

Some 44% of countries in the survey reported nationwide hottest temperature records in 2001-2010, compared to 24% in 1991-2000. Coldest daily minimum temperature absolute records showed an opposite pattern: In 1961-1970, nearly 32 % of the countries reported nationwide lowest minimum temperature values. The percentage decreased to 11% in 2001-2010.

Precipitation and floods: The 2001-2010 decade was the second wettest since 1901. Globally, 2010 was the wettest year since the start of instrumental records.

Most parts of the globe had above-normal precipitation during the decade. The eastern USA, northern and eastern Canada, and many parts of Europe and central Asia were particularly wet.

According to the WMO survey, floods were the most frequently experienced extreme events over the course of the decade. Eastern Europe was particularly affected in 2001 and 2005, India in 2005, Africa in 2008, Asia (notably Pakistan, where 2 000 people died and 20 million were affected) in 2010, and Australia, also in 2010.

Droughts affect more people than any other kind of natural hazards owing to their large scale and long-lasting nature. The decade 2001–2010 saw droughts occur in all parts of the world. Some of the highest-impact and long-term droughts struck Australia (in 2002 and other years), East Africa (2004 and 2005, resulting in widespread loss of life) and the Amazon Basin (2010) with negative environmental impacts.

Tropical cyclones: Between 2001 and 2010, there were 511 tropical cyclone related events which resulted in a total of nearly 170,000 persons reported killed, over 250 million people reported affected and estimated economic damages of US$ 380 billion.

According to the U.S. National Oceanic and Atmospheric Administration, 2001-2010 was the most active decade since 1855 in terms of tropical cyclone activity in the North Atlantic Basin. An average of 15 named storms per year was recorded, well above the long-term average of 12.

The North Indian Ocean saw the deadliest tropical cyclone recorded during the decade, when Tropical Cyclone *Nargis* struck Myanmar in early May 2008. More than 138 000 people were reported killed or missing, eight million people were affected and thousands of homes were destroyed.

Impacts: During the decade 2001-2010, more than 370,000 people died as a result of extreme weather and climate conditions, including heat waves, cold spells, drought, storms and floods, according to the data provided by the Centre for Research on the Epidemiology of Disasters (CRED). This was 20% higher than 1991-2000. This increase is due mainly to the 2003 heat wave in Europe and

the 2010 in Russia which contributed to an increase of more than 2000% in the global death toll from heat waves (from less than 6000 in 1991-2000 to 136 000 in 2001-2010).

On the other hand, there was a 16% decline in deaths due to storms and 43% decline in deaths from floods, thanks mainly to better early warning systems and increased preparedness and despite an increase in populations in disaster-prone areas.

According to the 2011 Global Assessment Report, the average population exposed to flooding every year increased by 114% globally between 1970 and 2010, a period in which the world's population increased by 87% from 3.7 billion to 6.9 billion. The number of people exposed to severe storms almost tripled in cyclone-prone areas, increasing by 192%, in the same period.

Much research is being conducted into whether it is possible to attribute individual extreme events to climate change rather than natural variability. Scientists increasingly conclude that the likelihood of an event such as the 2003 European heat wave was probably substantially increased by rising global temperatures. It is therefore important to develop this research to strengthen climate science and to use it to improve climate services to help society adapt to climate change.

WMO Press Release No. 976, Website visited on August 6, 2013.

The World Meteorological Organization is the United Nations System's authoritative voice on Weather, Climate and Water.

2001-2010 - une décennie d'extrêmes climatiques

GENÈVE, le 3 juillet 2013 – Le monde a connu des phénomènes climatiques extrêmes à fort impact pendant la décennie 2001-2010, la plus chaude qui ait été constatée depuis le début des mesures systématiques, en 1850. Faisant suite à une longue période caractérisée par un réchauffement prononcé du climat, cette décennie a vu plus de records nationaux de température battus que n'importe quelle autre décennie précédente, selon un nouveau rapport publié par l'Organisation météorologique mondiale (OMM).

Intitulée The Global Climate 2001-2010, A Decade of Climate Extremes (Le climat dans le monde (2001-2010), une décennie d'extrêmes climatiques), cette étude porte sur les températures et les précipitations mondiales et régionales et sur les phénomènes extrêmes tels que les vagues de chaleur qui se sont abattues sur l'Europe et la Fédération de Russie, l'ouragan Katrina et le cyclone tropical Nargis qui ont balayé respectivement les États-Unis d'Amérique et le Myanmar, les sécheresses qui ont sévi dans le bassin de l'Amazone et en Afrique de l'Est et les inondations qui ont frappé le Pakistan.

La décennie 2001-2010 est la plus chaude qu'aient connue les deux hémisphères, que l'on considère les températures relevées à la surface des terres ou celles mesurées à la surface des océans. Cette chaleur record s'est accompagnée d'un recul rapide de la banquise de l'Arctique et d'une perte accélérée de masse nette des inlandsis du Groenland et de l'Antarctique et des glaciers de la planète. En raison de cette fonte généralisée de la neige et de la glace et de l'expansion thermique de l'eau de mer, le niveau moyen de la mer a augmenté au rythme de quelque 3 mm par an, soit environ le double de celui qui a été constaté au XXe siècle (1,6 mm par an). Moyenné sur la décennie, le niveau de la mer accusait une hausse d'environ 20 cm par rapport aux années 1880 selon cette étude.

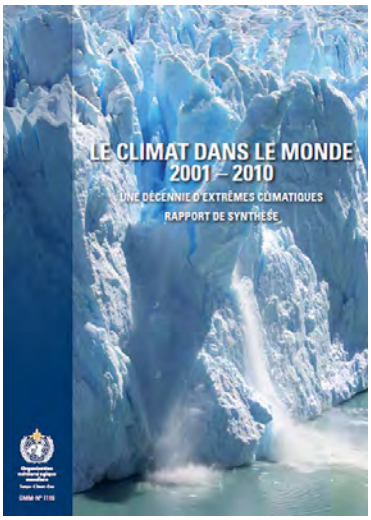
Le rapport en question met en évidence la hausse des concentrations atmosphériques de gaz à effet de serre. La teneur de l'atmosphère, moyennée à l'échelle du globe, en dioxyde de carbone a atteint 389 parties par million en 2010 (soit une augmentation de 39% depuis le début de l'ère industrielle, en 1750), tandis que les concentrations de méthane et de protoxyde d'azote atteignaient respectivement 1808,0 parties par milliard (158%) et 323,2 parties par milliard (20%).

«*Pour évaluer de façon rationnelle le changement climatique, l'échelle de temps la plus courte reste la décennie*», a déclaré le Secrétaire général de l'OMM, Michel Jarraud. «*Le rapport de l'OMM révèle que le climat s'est nettement réchauffé entre 1971 et 2010 et que le rythme décennal d'augmentation des températures sur les périodes 1991-2000 et 2001-2010 est sans précédent. Les concentrations croissantes de gaz à effet de serre, dont la spécificité est de piéger la chaleur, sont en train de transformer notre climat, avec les bouleversements que cela suppose pour l'environnement et les océans, qui absorbent à la fois le dioxyde de carbone et la chaleur*.»

«*En raison de la variabilité naturelle du climat, qui résulte en partie des interactions entre l'atmosphère et les océans – les phénomènes El Niño et La Niña en sont une illustration –, certaines années sont plus froides que d'autres. Aussi l'évolution interannuelle des températures mondiales n'est-elle pas régulière, mais sur le long terme, la tendance est clairement à la hausse, et c'est encore plus net ces derniers temps*», a indiqué M. Jarraud.

La décennie 2001-2010 n'a pas connu d'épisode El Niño de grande ampleur, associé en général avec un réchauffement du climat mondial (comme ce fut le cas par exemple en 1998, année qui battait alors tous les records de chaleur). La majeure partie de cette période a été marquée par des épisodes La Niña, qui ont normalement pour effet de refroidir le climat, ou par des conditions neutres, si l'on

excepte l'épisode El Niño 2009/10 dont l'intensité était modérée à forte.



Le rapport, qui fait une centaine de pages, et sa version abrégée, le rapport de synthèse, qui intègrent les résultats d'une enquête effectuée auprès de 139 Services météorologiques et hydrologiques nationaux ainsi que des données socio-économiques et des analyses émanant de plusieurs partenaires et institutions des Nations Unies, sont rendus publics à l'occasion de la première session du Conseil intergouvernemental des services climatologiques. Ce dernier supervise la mise en place du Cadre mondial pour les services climatologiques, fruit d'une initiative internationale qui consiste à améliorer et étoffer l'offre d'informations climatologiques scientifiquement étayées pour aider la société à faire face à la variabilité naturelle du climat et au changement climatique anthropique.

«*Une perspective sur dix ans nous permet d'évaluer les tendances et d'anticiper l'avenir*», a fait valoir M. Jarraud. «*Elle peut également étayer les mesures qui seront prises pour mettre au point des services climatologiques opérationnels capables de fournir des informations et des prévisions utiles aux décideurs dans les domaines notamment de l'agriculture, de la santé, de la prévention des catastrophes et des ressources en eau. Ces mesures sont coordonnées par l'intermédiaire du Cadre mondial pour les services climatologiques, dont l'OMM est le fer de lance*.»

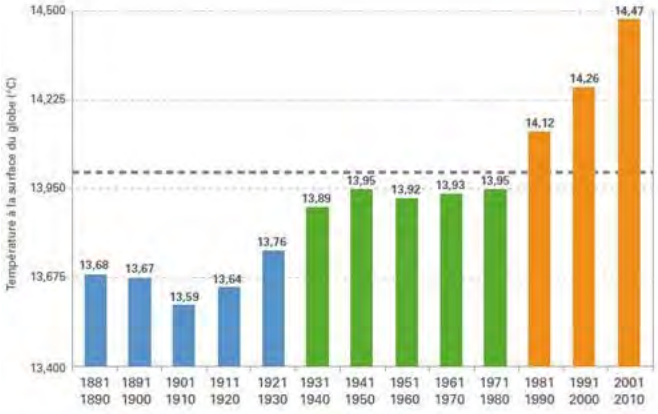
«*Les services climatologiques nous sont plus que jamais nécessaires pour relever les défis que pose l'évolution du climat, encore plus sensible à l'échelle nationale et régionale. Malgré la baisse significative du nombre de décès imputables aux inondations et aux fortes tempêtes, le rapport de l'OMM fait état des conséquences alarmantes, sur la santé et les taux de mortalité, des vagues de chaleur qui ont frappé l'Europe et la Fédération de Russie. On s'attend à ce que les vagues de chaleur deviennent plus fréquentes et plus intenses sous l'effet des changements climatiques et nous devons par conséquent nous y préparer*», a souligné M. Jarraud.

Températures: La température moyenne à la surface des terres émergées et des océans pour la décennie 2001-2010 est estimée à 14,47°C, soit un écart de +0,47°C par rapport à la normale calculée pour la période 1961-1990 et de +0,21°C par rapport à la moyenne de la période 1991-2000 (avec un facteur d'incertitude de ± 0,1°C).

Le rythme décennal d'augmentation de la température à l'échelle du globe s'est accéléré entre 1971 et 2010, atteignant, en moyenne estimative, 0,17°C durant cette période, contre 0,062°C par décennie sur toute la période 1880-2010. En outre, l'augmentation de 0,21°C entre la température moyenne de la décennie 1991-2000 et celle de la décennie 2001-2010 est plus marquée que celle qui a été constatée entre les décennies 1981-1990 et 1991-2000 (+0,14°C).

À l'exception de 2008, chacune des années de la décennie 2001-2010 compte parmi les dix plus chaudes jamais enregistrées, le record étant détenu par 2010, qui présente une anomalie positive de la température moyenne de 0,54°C par rapport à la normale calculée pour la période de référence 1961-1990 (14,0°C), suivie de près par 2005.

La plupart des régions du monde ont connu des températures supérieures à la normale pendant la décennie 2001-2010, en particulier aux hautes latitudes de l'hémisphère Nord. C'est au Groenland que la moyenne décennale des températures a accusé l'anomalie la plus forte – +1,71°C –, l'écart par rapport à la normale atteignant +3,2°C en 2010. En Afrique, chacune des années de la décennie a été caractérisée par des températures supérieures à la normale.



Légende: Moyenne décennale des températures à la surface du globe (terres émergées et océans confondus) (°C) obtenue à partir de trois jeux de données distincts tenus à jour respectivement par le Centre Hadley du Service météorologique national et la Section de recherche sur le climat de l'Université d'East Anglia (HadCRU) (Royaume-Uni), par le Centre national de données climatologiques (NCDC) relevant de la NOAA (États-Unis d'Amérique) et par le Godard Institute for Space Studies (GISS) relevant de l'Administration américaine pour l'aéronautique et l'espace (NASA). La ligne horizontale grise correspond à la normale.

D'après les résultats de l'enquête menée par l'OMM, la décennie 2001-2010 est la plus chaude qu'aient connue près de 94% des pays sondés, et aucun pays n'a signalé une moyenne décennale de la température inférieure à la normale au niveau national.

C'est entre 2001 et 2010 que des records de chaleur nationaux ont été enregistrés dans environ 44% des pays sondés, et entre 1991 et 2000 dans 24% d'entre eux. À l'inverse, alors que dans près de 32% des pays sondés, les records de froid remontent à la période 1961-1970, ce pourcentage n'est plus que de 11% en ce qui concerne la décennie 2001-2010.

Précipitations et inondations: La décennie 2001-2010 se classe au deuxième rang des plus arrosées depuis 1901, et 2010 est l'année la plus pluvieuse qui ait été enregistrée à l'échelle du globe depuis le début des relevés instrumentaux.

Les précipitations ont été supérieures à la normale un peu partout dans le monde pendant cette décennie. L'est des États-Unis d'Amérique, le nord et l'est du Canada et de nombreuses régions d'Europe et d'Asie centrale ont connu des précipitations particulièrement abondantes.

D'après les données dont dispose l'OMM, les inondations représentent le phénomène extrême le plus fréquemment observé tout au long de la décennie. L'Europe orientale a été particulièrement touchée en 2001 et 2005, l'Inde en 2005, l'Afrique en 2008, l'Asie (en particulier le Pakistan où 20millions de personnes ont été sinistrées et 2 000 ont trouvé la mort) en 2010 et l'Australie également en 2010.

Les sécheresses touchent plus de personnes que n'importe quelle autre catastrophe naturelle vu qu'elles surviennent à grande échelle et qu'elles ont un caractère persistant. Toutes les régions du monde en ont subi les effets entre 2001 et 2010. Des sécheresses persistantes et particulièrement dévastatrices ont frappé l'Australie (notamment en 2002), l'Afrique de l'Est (en 2004 et 2005, entraînant des pertes en vies humaines à grande échelle) et le bassin de l'Amazone (en 2010), avec des conséquences néfastes pour l'environnement.

Cyclones tropicaux: À l'échelle du globe, un total de 511 tempêtes a été observé pendant la décennie 2001-2010. Elles ont fait près de 170000 victimes et plus de 250 millions de sinistrés, et provoqué des dommages estimés à 380 milliards de dollars.

D'après l'Administration américaine pour les océans et l'atmosphère (NOAA), la décennie 2001-2010 est celle où l'activité cyclonique dans le bassin de l'Atlantique Nord a été la plus marquée depuis1855. La moyenne annuelle de tempêtes baptisées s'établit à 15 pour cette décennie, contre 12 pour la période 1981-2010.

C'est dans le nord de l'océan Indien qu'a pris naissance le cyclone tropical le plus meurtrier de la décennie, *Nargis,* qui s'est abattu sur le Myanmar en 2008, au début du mois de mai. Plus de 138000 personnes ont été tuées ou portées disparues lors du passage du cyclone, qui a fait 8millions de sinistrés et détruit des milliers de foyers.

Conséquences: Entre 2001 et 2010, plus de 370000 personnes ont trouvé la mort en raison de conditions météorologiques et climatiques extrêmes telles que vagues de froid ou de chaleur, sécheresses, tempêtes et inondations, selon les données fournies par le Centre de recherche sur l'épidémiologie des désastres (CRED), soit une hausse de 20% par rapport à la décennie 1991-2000. Cette situation est due essentiellement aux vagues de chaleur qui ont frappé l'Europe en 2003 et la Fédération de Russie en 2010 et qui ont participé à l'augmentation exponentielle (plus de 2000%) du nombre de victimes imputables aux vagues de chaleur à l'échelle du globe (de moins de 6000 pour la période 1991-2000 à 136000 pour la période 2001-2010).

En revanche, tempêtes et inondations ont fait moins de victimes. La baisse de 16% et de 43% observée respectivement est due en grande partie à l'amélioration des systèmes d'alerte précoce et des mesures de prévention, alors même que les régions exposées aux catastrophes sont de plus en plus peuplées.

Selon le Bilan mondial 2011, entre 1970 et 2010, l'effectif moyen de la population exposée aux inondations chaque année a augmenté de 114 % à l'échelle du globe, alors que la population mondiale augmentait de 87 %, passant de 3,7 milliards à 6,9 milliards. Le nombre de personnes exposées aux fortes tempêtes a presque triplé dans les régions sujettes aux cyclones, soit une hausse de 192 %.

De nombreux travaux de recherche portent sur la question de savoir s'il est possible d'imputer des phénomènes extrêmes isolés au changement climatique plutôt qu'à la variabilité naturelle du climat. Les scientifiques arrivent de plus en plus souvent à la conclusion que la hausse généralisée des températures a sans doute nettement accru la probabilité d'une vague de chaleur comme celle qui a frappé l'Europe en 2003. Il importe par conséquent d'approfondir ces recherches afin de consolider la science du climat et d'aider la société, grâce à des services climatologiques de meilleure qualité, à s'adapter au changement climatique.

Communiqué de presse N° 976. Site web visité le 6 août 2013.

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

CLIMATE CHANGE / CHANGEMENTS CLIMATIQUES

Reflections on the 1988 Toronto Conference on Our Changing Atmosphere

25 Years Later

by H.L.Ferguson[1]

Foreword

The 1988 Toronto Conference on *Our Changing Atmosphere* has been called a landmark and seminal event in the continuing struggle to inspire international political action to reduce greenhouse gas emissions.

As Assistant Deputy Minister in charge of the Atmospheric Environment Service at the time, Howard Ferguson was the Director and Chief planner of the Conference. In a 2008 article in the *CMOS Bulletin SCMO* (Vol.36 No.5, pages 159-161) he described how the Conference evolved and the results achieved.

On June 28th of this year, the University of Toronto hosted a Symposium to commemorate the 25th anniversary of the Toronto Conference. Ferguson was an invited speaker. The following article is based on his speech notes, with some minor editing for publication.

It's very gratifying to have the Toronto conference and its significance remembered by this symposium. The success of that conference was due to the hard work of a large team of dedicated people. More than 50 members of the meteorological service were involved in the preparations and logistical running of the conference. There was crucial input from global climate experts, but also from prominent international representatives of many different "stakeholder" disciplines.

It's unfortunate that today's symposium commemoration can't be more of a celebration. There remains a lot of unfinished business. The drafters of the 1988 Toronto conference statements were well aware that it would take decades of sustained effort and political will to turn energy policies of developed nations away from hydrocarbons.

Of course, we hoped that much more progress would be made than has been the case so far.

There has been a long parade of big multi-government conferences on the climate change issue since 1988. Most of these have resulted in nothing more than expressions of good intentions, decisions on future dates and photo opportunities.

On this issue we seem to be caught in an ice age of geopolitical inaction. Many glaciers are retreating faster than governments are advancing on climate change.

In 1988, our objective was an international treaty with specific targets for the reduction of greenhouse gas emissions and with enforceable economic penalties for non-compliance.

I now believe that our chances of success will be better if we can achieve, in the long run, an International Carbon Tax Treaty (ICTT for short). Obviously, such a treaty must hinge on the co-operation and leadership of the USA and China. They have the economic power and influence to make an ICTT possible and to make it work.

H.L. Ferguson, chairing a plenary session at the 1988 Toronto Conference

It is vitally important that American voters, in particular, be persuaded to push their political leaders for more action on climate change. This is no small challenge when one poll tells us that, while 98% of Canadians believe there is a serious climate change problem, only 70% of Americans have been convinced so far. (Poll results depend on how

[1] Formerly Assistant Deputy Minister, Atmospheric Environment Service, Environment Canada

the questions are asked; the point is that Americans have more doubts than Canadians.)

While the present U.S. Congress seems dysfunctional, President Obama's June 25th announcement[2] about U.S power plant emission reductions is very encouraging, and could signal the beginning of a sea change in international political responses to the problem.

A word of caution, however , from an old campaigner. What will happen to President Obama's emissions reduction program if the next U.S. President is a Republican?

An international carbon tax treaty, or ICTT, should be expedited and monitored by existing and powerful economic agencies such as the OECD, the IMFf and the World Trade Organization. The involvement of such agencies is, I believe, essential.

Tax is a dirty word to most people. Stephane Dion's proposal for a carbon tax was soundly rejected by the Canadian electorate. However, a carbon tax could be more palatable if it were revenue neutral, or nearly so. For example, carbon tax revenues could be directed partly to reductions in personal income tax. As Mary Poppins said *"A spoonful of sugar helps the medicine go down*".

A carbon tax is not the only effective approach to limiting greenhouse gas emissions. It should be accompanied by more effective government actions rewarding the private sector for pursuing a greener economy, promoting conservation and reducing our profligate waste of energy.

Economic development on the scale we are now seeing in China and India has to be made more ecologically sustainable. An economic incentive such as a carbon tax is needed – and soon.

What about sustainable development?

Does the typical man in the street really understand what the World Commission on Environment and Development meant when they coined that term in the late 1980's? It seems that, to some of the critically- important electorate in Canada and the United States, sustainable development means long-term self-sufficiency in oil and gas supplies.

The USA and Canada seem headed in the direction of hydrocarbon self-sufficiency with the new emphasis on fracking for shale oil and gas. But, fracking is not all it's cracked up to be! Not enough public information is being disclosed regarding the massive amounts of water required, and the toxic threat posed by the effluent waste-water, which contains carcinogens such as benzene and formaldehyde. Potable groundwater supplies are already being seriously depleted in some North American areas, notably in the American Midwest.

A key challenge ahead is to convince the man in the street (and some governments, I might add) that sustainable development is in everyone's best interest and that environmental protection and economic growth are not black and white, mutually exclusive, goals.

As we know, sustainable development can yield economic benefits in the form of new industries and jobs, as well as savings in avoided clean-up and health care costs.

My reflections are not all gloomy. Let's look at some successes.

We have come a long way since 1988 in convincing media leaders that anthropogenic climate change is happening and that more media time needs to be devoted to the scientific experts than to opposing vested interests and a relatively tiny group of amateur and professional deniers. The old American fairness doctrine gave equal media time to opposing sides of a debate. There is no longer a real debate when expert, overwhelming scientific evidence, such as ice depletion in the Canadian Arctic, is there for all to see.

This change in media coverage is no small accomplishment, and is an important milestone in the battle to win hearts and minds.

Another reason for optimism is that many national and sub-national jurisdictions are achieving reductions in greenhouse gas emissions with little or no impacts on their economies. The Caribbean Island of Aruba expects to be emissions- free by the year 2020.

The sub-title I chose for the Toronto conference was ***"implications for global security***". In 1988, some thought this was a fanciful exaggeration , but it has certainly been validated. There are now said to be 42 million environmental refugees in the world, mostly in Africa and Bangladesh. Those regions have some of the smallest per capita carbon footprints in the world, but so far are paying the heaviest price for international neglect of the climate change problem. Where is the social justice in this situation?

Instability of climate has been increasing, in a manner similar to stock market volatility. Both are symptomatic of global mismanagement.

Catastrophic severe weather events appear to be on the increase.

[2] The best-known quote from his speech at Georgetown University was "*We don't have time for a meeting of the flat earth society*".

In the American homeland hurricanes *Katrina* and *Sandy* and the super-tornados in Oklahoma have caused not only loss of life, but also the ruin of hundreds of thousands of lives, plus damages in the tens of billions of dollars. Such events are changing many people's minds about climate change, most importantly in the United States.

Of course we cannot tie these individual events to global warming in a direct cause and effect way. But basic meteorological physics tells us that more frequent and powerful storms can be expected due to the warming of the earth's surface.

Last year we saw a serious drought in the U.S. Midwest. In the last few months we've witnessed major flood disasters in Alberta and Europe.

Since 1988 the huge increase in world-wide insurance claims, resulting from weather and climate- related disasters, has been remarkable. Premiums are rising accordingly. The unfortunate uninsured, many of them now destitute, are faced with massive personal costs of rebuilding.

Can there possibly be a silver lining to such tragedies? We can hope that these spiralling economic costs of government inaction may, finally, persuade even the most reluctant governments to take effective action to limit climate change.

Many countries, especially in Europe, have instituted carbon taxes in one form or another. Negotiation of an international treaty would involve an evaluation of each nation's existing carbon taxes and harmonization on a global scale.

Australia and British Columbia are among the jurisdictions that have instituted carbon taxes. An article in the Toronto Globe and Mail on February 8th of this year had the headline *"Australia taxed carbon and the sky didn't fall*"- a nice turn of phrase to a meteorologist. The Australian economy remains among the strongest in the world.

British Columbia has taxed carbon since 2008. A 2012 review by Dr. Stewart Elgie of the University of Ottawa paints a very favourable picture of the ensuing benefits to the province's economy, as well as its environment.

Yet another cause for optimism is the growing environmental awareness of our children and grandchildren.

Some politicians, as well as many climate experts, have characterized climate change as the key challenge of this generation. Over the last 25 years we've accomplished a lot, and gathered more climate data and empirical evidence to greatly improve climate prediction models. But much remains to be done.

On behalf of the dedicated, but aging, team that produced the 1988 Toronto conference, I offer our congratulations and thanks to all of the younger experts who are staying the course in the long struggle for significant political action on climate change.

CCGS *Amundsen* Heads Back to Arctic

Quebec City, July 26, 2103 – The Honourable Gail Shea, Minister of Fisheries and Oceans, is pleased to wish bon voyage to the Canadian Coast Guard crew members and the scientists who will participate in the 2013 mission of research icebreaker *CCGS Amundsen* in the Canadian Arctic.

"*This year marks the 10th anniversary of the CCGS Amundsen, a state-of-the-art multidisciplinary research icebreaker*," said Minister Shea. "*In addition to being the only Canadian icebreaker to have navigated the Arctic in the winter, the CCGS Amundsen has distinguished itself by supporting major international scientific missions in Canada's Far North*."

The *CCGS Amundsen* is one of the few Canadian icebreakers to have a dual purpose. In winter, she is assigned to the CCG icebreaking program whereas every summer, she is chartered by ArcticNet, a scientific consortium. This year, the *CCGS Amundsen* will navigate the Labrador Sea, Baffin Bay, the Northwest Passage and the Beaufort Sea to study the impact of climate change and modernization on the arctic marine ecosystem.

NGCC *Amundsen* reprend la route de l'Arctique

Québec, le 26 juillet 2013 - L'honorable Gail Shea, ministre des Pêches et des Océans, est heureuse de souhaiter bon voyage aux membres d'équipage de la Garde côtière canadienne (GCC) et aux scientifiques qui participeront à la mission 2013 du brise-glace de recherche *NGCC Amundsen* dans l'Arctique canadien.

"*Cette année marque le 10e anniversaire du NGCC Amundsen, un brise-glace de recherche multidisciplinaire ultramoderne"*, a déclaré la ministre Gail Shea. "*En plus d'être le seul brise-glace canadien à avoir navigué en Arctique pendant les mois d'hiver, le NGCC Amundsen s'est illustré par son appui à d'importantes missions scientifiques internationales dans le Grand Nord canadien*."

Le *NGCC Amundsen* est l'un des rares brise-glace canadien à avoir une double vocation. L'hiver il est assigné au programme de déglaçage de la GCC alors que chaque été, il est affrété par le consortium scientifique ArcticNet. Cette année, le *NGCC Amundsen* naviguera dans les eaux de la mer du Labrador, de la baie de Baffin, du Passage du Nord-Ouest et de la mer de Beaufort pour étudier l'impact des changements climatiques et de la modernisation sur l'écosystème marin arctique.

Engaging Grass Roots on Climate Change

by Geoff Strong[1], Sheryel Raymes[2] and Victor Dorian[3]

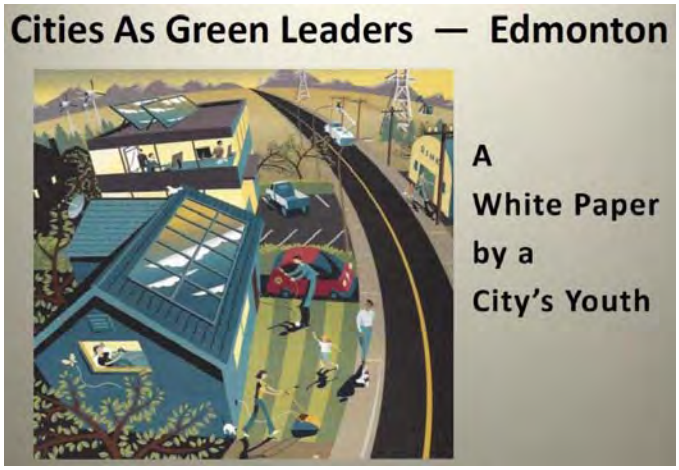
Cities as Green Leaders™ is a grass roots endeavour established to draw public attention to anthropogenic global warming (AGW), its impacts, and ethical aspects, and to involve youth as the future leaders. Public education goals are to demystify confusion between natural climate change and anthropogenic global warming (AGW), explain the role that greenhouse gases play, and draw attention to the negative impacts of global warming throughout the world. A secondary objective is to help initiate non-confrontational dialogue on climate change between scientists, government, industry, and the general public. These goals were initiated with zero funding, but with a common concern and passion for the environment. Participants share an intense desire to influence public opinion by explaining the science in non-technical terms through public education employing various media, public presentations and video conferencing, and wherever possible, involving youth.

Efforts were directed towards linking with the Edmonton Public and Catholic school systems, collaborating with Mr. Terry Godwaldt, International Facilitator of the Centre for Global Education (http://tcge.tiged.org/) at Queen Elizabeth High School in Edmonton. A first event was a public presentation on global warming impacts at Edmonton City Hall on April 16, with participation by students from six high schools

http://www.edmonton.ca/city_government/city_vision_and_strategic_plan/Climate-Change-Impacts-Why-Reduce-Greenhouse-Gas-Emissions.aspx?doAutoPlay=true

Under Mr. Godwaldt's leadership, several hundred students from six high schools linked together through video-conferencing during a month-long program in May 2013.

Note from the Editor: *Cities as Green Leaders* is a Trademark of LINK Communications. The six Edmonton schools involved in the project are: Louis St. Laurent Catholic School, Queen Elizabeth High School, Jasper Place High School, Holy Trinity, Oscar Romero and Amiskwaciy Academy.



The students' primary objective was to use the knowledge they acquired on climate change, and apply it down to the small-scale (city) level where they might have some positive influence. They accomplished this by engaging the City of Edmonton through a series of questions on and suggestions of how the city can reduce its carbon footprint. The article following this introduction [see next page] describes those efforts by high school students in Edmonton to date, as summarized by Amy Mallon, Grade 11, Louis St. Laurent HS and Osama Javid, Grade 10, Queen Elizabeth HS, and their teacher/facilitator, Terry Godwaldt.

The overall program has evolved into a replicable community response program, which we call *Cities as Green Leaders*™, and which has potential for regional, national and global roll-out. The focus is on turning climate knowledge into climate action by linking curriculum relevant studies with established municipal government green goals such as Edmonton's *The Way We Green*. Other efforts include organizing a panel discussion event focused on AGW impacts and mitigating actions with panel members representing academia, government, industry, media, and education. We continue to encourage youth to make a difference in their communities through civic engagement on environmental issues.

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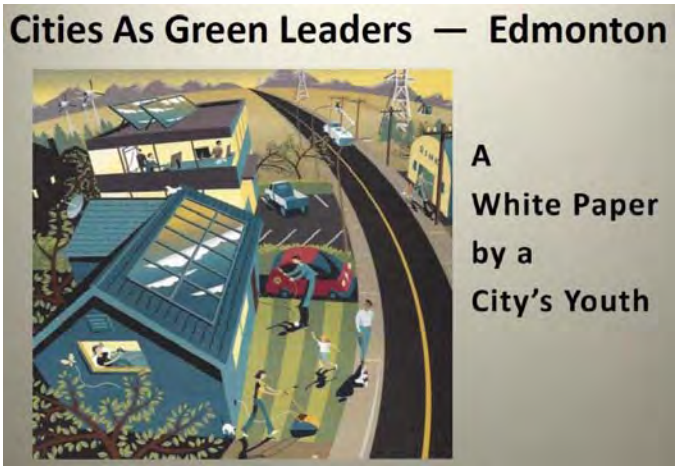
Cities As Green Leaders™: A White Paper by Edmonton's Youth

by Amy Mallon[1], Osama Javid[2] and Terry Godwaldt[3]

Cities as Green Leaders™: A White Paper by Edmonton's Youth, was written by a committee of students representing six high schools in the City of Edmonton, three each from the ECSD and the EPSB school systems.



The evolution of the White Paper involved equipping student leaders from each school with web 2.0 technology and H.323 conference video tools, teaching them about the intricacies of climate change and their city's strategic environmental plan, *The Way We Green*. These student leaders then facilitated a larger conversation with their peers, beginning with four key questions. Responses were generated and shared with the collective student body for feedback and direction. Results were synthesized and summarized in a White Paper and presented to the City of Edmonton suggesting several initiatives in response to each of the four questions. This paper represents the voice of youth in Edmonton, sharing a passion for the environment and wanting to contribute to the dialogue taking place on the future of Edmonton and climate change at the local (city) level.

The results were then presented in a Policy and Environmental Management session at the 2013 CMOS/CGU/CWRA Congress in Saskatoon. Part A of the following is a summary of that presentation, while Part B summarizes the students' answers to questions following their presentation.

PART A: Main Presentation at Congress 2013

Question 1. TRANSPORTATION: How can the City of Edmonton reduce Edmonton's carbon footprint through transportation?

Three initiatives were identified in response to this question.

ACCELERATE expansion of the LRT (Light Rail Transit) system.

The City needs to extend the LRT in a timely fashion as extensions provide more accessibility to the greater part of Edmonton making it a more reasonable method of transportation compared to private transportation thus reducing GHGs.

PRIORITIZE the creation of a transportation system with bus routes planned to efficiently connect neighbourhoods.

The youth believe the City should continue to work towards designing an effective, accessible and efficient transportation system network. However, the present pace of this process is not acceptable and needs to be quickened. Compact urban development would make it easier to design a more effective transit system.

REDEFINE transit centres to become neighbourhood hubs, integrating them into neighbourhood life and activities.

Citizens today perceive single use bus terminals as uncomfortable, unsafe and uninviting. The City should take initiatives by transforming these stations into neighbourhood hubs. This can be achieved by adding shops and services such as small convenience stores, entertainment spots or cafes which will not only possibly increase the use by non-frequent users but also improve safety of these areas by increased density and activity of these terminals.

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[2] Queen Elizabeth High (G10, Edmonton Public School Board - EPSB)

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Question 2. BUILDING STOCK and INFRASTRUCTURE: How can the City of Edmonton use its building stock and infrastructure to reduce our carbon footprint?

Three initiatives were identified in response to this question.

REDUCE the consumption of energy sources used in buildings and move towards the development of more sustainable energy supplies.

In Edmonton 67% of energy is consumed by building stock and infrastructure, according to The Way We Green; which the youth emphasize as an area for concern. There needs to be investment in place for green infrastructure because youth have expressed urgency in switching to a more sustainable future.

PROVIDE the incentives and the means for citizens to access greener infrastructure and improvements to existing facilities.

There should be greater encouragement from the city to install green infrastructure in personal homes as well as existing facilities. The economic incentive and education must be in place for processes like this to become effective. The youth identified the need for more action in switching from carbon based energies to other alternatives. It is crucial to see meaningful change occur towards the direction of Edmonton's energy future.

DESIGN neighbourhoods and industrial locations to provide complementing services within neighbourhoods to reduce wasted GHG emission from urban expansion.

Neighbourhoods must be designed so that citizens can have access to facilities in commerce, education and transportation. The city needs to provide its citizens with the means to use its resources more effectively. The wasting of GHG emissions caused by urban expansion is a concern for the youth of Edmonton and has been identified as an area that needs to be urgently addressed.

Question 3. ENERGY PRODUCTION and CONSUMPTION: How can Edmonton take actions to improve green energy production and consumption to reduce greenhouse gases?

Three initiatives were identified in response to this question.

TRANSITION from a heavy reliance on high carbon fossil fuels such as coal to cleaner alternative forms of energy.

The youth of Edmonton would like to see transportation implemented with great urgency towards using renewable energy sources instead of non-renewable sources.

PROVIDE incentives for users and producers of renewable energy in order to increase demand for these energy sources.

Alternative energy can be made more attractive by the strategic use of the supply and demand charge. Increase the demand for alternative energy and this will cause the larger industry to follow towards clean energy production. This will accelerate the transition process to using renewable energy.

PROVIDE a means to address a lack of access and availability of renewable energy to the general public.

Youth feels strongly about the use of coal as a predominant energy source in Edmonton. Youth understands the relationship between Edmonton and EPCOR (the major utility company in Edmonton). Over time, the dependency on coal can decrease urgent pressure towards EPCOR and other energy corporations to adopt a new energy plan. Youth across the City of Edmonton, urge immediate engagement with EPCOR to transition to renewable energy.

Question 4. ENGAGEMENT: How can the City of Edmonton engage the populace to make this happen? How can Edmonton's youth engage in action with the city?

Three initiatives were identified in response to this question.

ENRICH school curriculums and programs to align with city initiatives within the context of the schools' neighbourhoods.

The youth have acknowledged that change can be implanted in a school environment with the help of the City in developing activities and learning resources. These items must be co-created with the City and educators as well as the youth, in order to carry out the views of all citizens. The youth have clearly communicated the need for education and programs to be established in order to make change at the community level.

ENCOURAGE student-led green programs that engage the community to address unique neighbourhood issues and opportunities.

The youth of Edmonton have actively acknowledged the need to implement these initiatives within key central locations to expose business to a sustainable future. Youth led programs need to engage communities actively with problems and solutions in their communities to create real and meaningful change.

EDUCATE youth on their political power and voice in addition to the resources existing and necessary to empower them.

The involvement of youth in decisions is essential in creating change and must be facilitated by City Councillors. A healthy relationship and transparency amongst councillors and youth can pave the way for understanding on how to alleviate barriers towards reducing the City's carbon footprint. The youth feel the time for change is now. They have passionately expressed interest in policy and decision making towards the most pressing issues affecting us today.

PART B: Responses to Questions asked by Audience

Part B is composed of questions that were asked by the audience at the conference following the formal presentation and the answers given by the students.

Q1: What was the primary purpose of your 'White Paper'?

A1: The White Paper reflects the students' opinions of and their overall goals for the City of Edmonton to achieve. On behalf of the participating students, we want to be active participants in securing our futures. We want this document to be carefully considered.

Q2: Do you think your suggestions will make any impact on the city's environmental plans?

A2: We know that Edmonton's Environmental Plan is a high level document, but in a time when some councillors are moving into a municipal election and talking about low taxes for voter appeal, it is also just as important to address and reduce Edmonton's carbon footprint as fast as possible – 2050 is comfortable but it is too far off.

Q3: How do you plan to follow this up?

A3: We want to work with the councillors of the wards where our six schools are located and we have started to contact our School Trustees and our School Councils for their support too.

We have been told we can present our White Paper to the City in September and we have also been told that we should think about whether we want to present it to the old Council before the October election, or to wait until after the election to present to the new Council that has been voted into power.

Q4: Are you doing any specific project at your schools to promote your ideas?

A4: In addition to wanting to help the City implement their ideas, we are building a student project to measure our school's consumption of energy with smart meters. We want to use the costs saved to invest in more green projects. We are working to attract partnerships now. We want to show how you can do something if you really want to.

Q5: Do you have partners in this endeavour outside of your schools?

A5: We have interest and support from the Edmonton Journal and CTV. We plan to ask for their help in keeping interest in what we are doing.

Q6: What impact do you think this will have on future planning in Edmonton?

A6: We, the youth of Edmonton, are a tremendous resource. We want to support the city in taking difficult, complex steps to become low-carbon and resilient. We know how to use social media and organize in this political era. Please use us. Please let us in. We can help and we will be a powerful ally.

Q7: What level of influence can high school students have in Edmonton and elsewhere?

A7: In Edmonton there are thousands of us who want to participate and there are millions of us around the globe who can do this too. Youth has power at the community level. This is where and how we need to begin.

Q8: Why do you direct this influence at the city level (rather than provincial or national)?

A8: We found that much of the dialogue about climate change is happening at national and international levels. We feel that engagement needs to happen at the city and community levels, and youth need to engage in a meaningful way. This is where we are in schools and with our families.

Q9: Since climate change is a 'global problem', why or how do you think cities can influence solutions?

A9: We believe that engagement has to start at the smaller (city) scale in order to be implemented at the larger scales. Youth need to bring these initiatives and green solutions to City Councillors and communities, and to help implement useful solutions to reduce our carbon footprint.

SUMMARY

The overall experience in the *Cities as Green leaders*™ was amazing, and insightful. Not only did students get to utilize today's technology (something the youth of today are very good at) through the Digital Classrooms, they also were given the chance to get involved with not just our community but our city as well. They also had the opportunity to meet new people, from scientists to other kids just like us, and it was shown that starting out small in your

community is okay because then it has the opportunity to grow.

One of the benefits of the experience was that students were not marginalized as kids, and their opinions and ideas were heard. Today's youth care much more about today's issues than society thinks. While they do not have the power to vote, have high ranking jobs, or have a lot of power in "the system", they represent the immediate future, an important point to remember.

The *Cities as Green Leaders*™ was a wonderful experience for the students involved, allowing them to apply new-found knowledge. I would suggest to any students out there to get involved with similar organizations put on in their communities, and for other cities to consider what we are doing here in Edmonton for their cities as well.

DERNIÈRE HEURE

La mission scientifique de l'*Amundsen* dans l'Arctique compromise par un écrasement d'un hélicoptère

Radio-Canada, Mise à jour le mardi 10 septembre 2013 à 15 h 26 HAE - Trois personnes membres de l'équipe du navire de recherche *Amundsen* ont péri dans l'écrasement d'un hélicoptère de la Garde côtière canadienne dans le Grand Nord canadien lundi.

La Garde côtière canadienne a confirmé mardi midi la mort des deux Québécois, Daniel Dubé, pilote de la Garde côtière, Marc Thibault, commandant de l'Amundsen de même que celle du chercheur Klaus Hochheim de l'Université du Manitoba, spécialiste de l'évolution des glaces et des banquises.

L'accident est survenu dans le détroit de McClure, à 670 kilomètres à l'ouest de Resolute Bay, au nord des Territoires du Nord-Ouest. C'est en soirée lundi que les corps et l'hélicoptère, qui revenait vers le navire Amundsen, ont été retrouvés.

Les membres à bord de l'hélicoptère participaient à une mission d'évaluation de l'état des glaces. Selon la Garde côtière, les conditions climatiques étaient bonnes au moment de l'accident. Le brise-glace de recherche canadien avait quitté Québec le 26 juillet pour une expédition de 82 jours dans l'océan Arctique qui devait se terminer en octobre (Voir le *CMOS Bulletin SCMO*, ce numéro en page 164).

Des collègues sous le choc

La Garde côtière et le directeur scientifique du réseau ArcticNet qui mène les recherches à bord de l'Amundsen, Louis Fortier, se sont dits atterrés par la nouvelle.

"*À la Garde côtière, nous sommes très consternés par cette tragédie. Nos condoléances vont aux familles de nos collègues qui étaient aussi nos amis*", a déclaré Mario Pelletier.

Le scientifique de l'Université Laval Louis Fortier a aussi souligné qu'il venait de perdre de valeureux collègues.

"*J'ai très vite compris qu'on avait affaire à notre première grande catastrophe depuis le début des opérations de l'Amundsen, il y a 10 ans de ça. [...] D'un coup sec, on a perdu trois amis, trois collaborateurs*", a dit le chercheur scientifique bien connu Louis Fortier.

Nouvelle de dernière minute

Nouveau Directeur général – SCMO/CMOS

Dr Ian Rutherford annonçant la nomination de Dr. Andrew Bell comme Directeur général de la SCMO au dernier dîner-causerie du Centre d'Ottawa de la SCMO tenu le 19 septembre.

Dans le numéro de juin du *CMOS Bulletin SCMO* le conseil d'administration de la SCMO a annoncé la recherche de candidats pour le poste de directeur général, dans l'anticipation de la retraite du titulaire, Dr. Ian Rutherford. Quatre applications ont été reçues dont deux ont été retirées subséquemment. Suivant les entrevues et la vérification des références, le conseil est très heureux d'annoncer qu'une offre a été faite à Dr. Andrew Bell d'Ottawa et que M. Bell a accepté. Dr. Bell assumera ses nouvelles fonctions dès le premier octobre.

CMOS BUSINESS / AFFAIRES DE LA SCMO

Atmosphere-Ocean 51-4 Special Issue

PREFACE

From Icefield to Estuary: A Brief Overview and Preface to the Special Issue on the Columbia Basin

by Sean W. Fleming[1]

No matter how large or small, every stream or river has its own set of scientific puzzles; its own social, economic, and ecological relevancies; its own suite of management or engineering challenges; and its own beauty. That having been said, it seems amply reasonable to single out the Columbia as one of the world's great rivers.

The statistics alone are astonishing. Measured by annual mean flow, the Columbia Basin is the largest river on the Pacific coast of the Americas and the eighteenth largest globally (Leopold, 1994). The river is almost 2000 km long, and at well over half a million square kilometres, its drainage area is larger than France (Leopold, 1994; Muckleston, 2003). Observed peak streamflow at The Dalles — a downstream location on the river, yet still upstream of some major tributaries — has been as high as 3.5×10^4 m^3 s^{-1} (US Geological Survey, 2012). Storage projects on the Columbia and Lower Snake basins contain more than 53 billion cubic metres of water for flood control, hydroelectric energy generation, irrigation, and navigation. It is estimated that just in 2005, flood control in the Columbia Basin prevented nearly US$150 million in damages (Columbia River Water Management Group, 2005). Hydroelectric generation capacity is well over 5000 MW in the Canadian headwaters portion of the basin alone (BC Hydro, 2000); maximum nameplate capacity over the system is about 22,500 MW (System Operation Review, 2001); and the total average yearly value of power produced in the basin has been estimated at almost US$1 billion (Bureau of Reclamation, 2008).

The geophysical characteristics, richness, and significance of the Columbia Basin are also noteworthy in several respects. It is a land of diversity and sharp contrasts. The glaciers and icefields of the Kootenays and Canadian Rocky Mountains, the dense temperate rainforests of the Coast Range, the high desert of south-central British Columbia and eastern Washington and Oregon (complete with cacti and rattlesnakes), the snowy mountains of western Montana and Wyoming, a number of highly productive agricultural valleys like the Okanagan, and the soaring volcanoes of the Cascade Range all lie within its boundaries — and often within only a few tens of kilometres of each other. All these features in some way reflect and also combine to help determine the hydrology and climate of the basin. The river's influence also extends far offshore. Plumes of fresh water and sediment from the Columbia River significantly affect the physical, chemical, geological, and biological oceanography of the US Pacific Northwest coast (e.g., Hickey & Banas, 2003). And the Columbia's list of notable accomplishments also extends far into the past: as substantial as its flows are today, these pale in comparison to the Missoula Floods. These were an extended series of massive glacial outburst events during the last ice age; the largest involved rapidly dropping over 1500 km^3 of ice- and rock-laden water from an elevation of about 1300 m in Montana to 100 m below modern sea level, releasing energy nearly equal to that of the asteroid impact that helped end the age of the dinosaurs (e.g., Allen, Burns, & Sargent, 2002). These Columbia floods shaped much of the landscape of the basin as we now see it, scouring out the scablands of eastern Washington and depositing the agriculturally rich, flat-lying silts of the Willamette Valley in western Oregon.

The Columbia River also carries deep cultural and historical significance extending far beyond the statistics of economic activity described above. The river is a cornerstone of cultural identity through much of the Pacific Northwest, even lending its name to the Canadian province of British Columbia. The basin is also not without controversy and challenges. For example, prehistoric salmon runs were estimated at 10 to 16 million annually but have reportedly declined to about 1 million, of which approximately 80% are reared in hatcheries (Bottom, Jones, Simenstad, & Smith, 2009). This precipitous decline likely reflects a combination of factors, including dam construction, habitat loss, pollution, overharvesting, and open-ocean conditions. Damage to the basin's extraordinarily rich salmon fisheries have deeply impacted First Nations in the basin (Columbia River Inter-Tribal Fish Commission, 2003), among others.

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Along different lines, the 1948 flood — essentially the result of a basin-wide rain-onsnow event — was disastrous, destroying the Portland suburb of Vanport following a dyke failure and leading to the deaths of 22 people (Speers, Barcellos, & Wortman, 1990). This single hydrometeorological event had a surprisingly wide range of social implications, including an influence on local race relations (McGregor, 2003). Additionally, increased demand for flood control, resulting in part from this event, eventually led to an intense period of dam building throughout the basin — which in turn had social ramifications, including resettlement of long-time residents from low-lying agricultural areas north of the border. The Columbia even helped define the course of global history, the future of warfare, and new threats to humanity's survival: the Hanford site in Washington depended on abundant hydroelectric energy from the Grand Coulee and Bonneville dams to produce plutonium for the Trinity test in New Mexico and the Fat Man nuclear bomb used over Nagasaki. And as a major transboundary river, it even has its own international treaty — Treaty Relating to Cooperative Development of the Water Resources of the Columbia River Basin, United States of America – Canada [hereinafter Columbia River Treaty] (1961–1964) — which governs joint Canadian–American management of the basin.

With accelerating population growth and corresponding development pressures, escalating demand for natural resources including water supply and hydropower, natural and anthropogenic changes in regional and global climate, and mounting concern for environmental sustainability, the need for improved scientific understanding of the basin has never been greater. It bears explicitly noting that the benefits of improved geophysical knowledge are not some vague conceptual ideal. As just one example, Hamlet, Huppert, and Lettenmaier (2002) used a reservoir simulation model incorporating operational constraints to estimate that improved, climate-based water supply forecasts for the Columbia Basin could increase nonfirm energy production from major Columbia hydropower facilities by as much as 5.5 million MWh per year, with a corresponding increase in annual revenue of approximately US$153 million. Clearly, a better understanding of the climate and hydrology of the basin has a very substantial dollar value. The impending arrival of key dates around the Columbia River Treaty further militates for a deeper knowledge of the river and the changes it may face in the future.

This special issue provides a forum for sharing some key knowledge and recent developments on science and engineering questions about the Columbia Basin as relevant to the readership of Atmosphere-Ocean. A diverse range of topics is addressed by scientists and engineers from institutions on both sides of the border, though a general emphasis is placed on past and future climatic variability. Chang and coworkers (Portland State University, US Geological Survey) apply water vulnerability indicators at the county scale to understand spatial patterns and controls of water supply, demand, and quality issues in the basin. Werner and coauthors (Pacific Climate Impacts Consortium) explore the impacts of possible future climate trajectories using a distributed hydrologic model, calibrated at two dozen points in the upper Columbia Basin and forced with downscaled projections from a range of global climate models (GCMs) and emissions scenarios. The effects of various large-scale modes of climate variability on river flows, and their potential for improving seasonal water supply forecasts, are investigated by Gobena and co-authors (BC Hydro, Environment Canada). Hamlet and co-workers (University of Washington, US Bureau of Reclamation) provide a summary and synthesis of their extensive GCM-driven hydrologic modelling work across the Columbia Basin. Alpine glaciers and ice fields are an integral component of the watershed hydrologic cycle in many headwater basins to the Columbia, and Hirose and Marshall (University of Calgary) investigate these questions in detail for the Illecillewaet River. Hatcher and Jones (Oregon State University) compare long-term observational hydroclimatic trends between headwater and downstream locations to assess ecological and engineering resilience to climate change. Murdock and co-authors (Pacific Climate Impacts Consortium) analyze regional climate model results to investigate the sensitivity of meteorological extremes to projected climatic changes.

As the convenor for this special issue, I wish to sincerely thank all the authors for their contributions, as well as the editorial staff whose hard work helped make this endeavour a success. Editorial duties were performed by guest editor Stephen Déry, with support by guest editor John Pomeroy and editor-in-chief William Hsieh. Technical editor Sheila Bourque and publications director Richard Asselin also provided valuable input.

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AVANT-PROPOS

Du champ de glace à l'estuaire : Un aperçu et la préface du numéro spécial sur le bassin du Columbia

par Sean W. Fleming[2]

Quelle que soit sa taille, chaque cours d'eau possède sa propre réalité scientifique; sa propre importance sociale, économique et écologique; ses propres exigences de gestion ou d'ingénierie; et une beauté qui lui est propre. Cela dit, on peut ajouter sans crainte de se tromper que le Columbia est l'un des grands cours d'eau du monde.

Les chiffres parlent d'eux-mêmes. De par son débit annuel moyen, le Columbia est le plus gros fleuve de la côte Pacifique des Amériques et le huitième plus gros de la planète (Leopold,1994). Le fleuve a une longueur de près de 2000 km et, avec une superficie de bien plus d'un demi-million de kilomètres carrés, son bassin hydrographique est plus grand que la France (Leopold, 1994; Muckleston, 2003). L'écoulement de pointe observé à The Dalles — une localité située dans le secteur aval du fleuve, mais encore en amont de certains affluents importants — a déjà atteint $3{,}5 \times 104\ m^3\ s{-}1$ (US Geological Survey, 2012). Les ouvrages de retenue dans les bassins du Columbia et de la rivière Snake inférieure renferment plus de 53 milliards de mètres cubes d'eau servant à la protection contre les inondations, à la production d'énergie hydroélectrique, à l'irrigation et à la navigation. On estime qu'en 2005 seulement, la protection contre les inondations dans le bassin du Columbia a évité des dommages de près de 150

[2] Service météorologique du Canada, Division de la science, Section de la recherche et du développement des sciences environnementales, Vancouver, Colombie–Britannique, Canada; et Cooperative Institute for Coastal and Mountain Meteorology and Hydrology, Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, British Columbia, Canada.

millions de dollars US (Columbia River Water Management Group, 2005). La capacité de production hydroélectrique dépasse amplement les 5000 MW dans la seule partie amont canadienne du bassin (BC Hydro, 2000); la capacité maximale nominale de l'ensemble du système est d'environ 22 500 MW (System Operation Review, 2001); et la valeur annuelle totale moyenne de l'énergie produite dans le bassin a été estimée à presque un milliard de dollars US (Bureau of Reclamation, 2008).

Les caractéristiques géophysiques, la richesse et l'importance du bassin du Columbia sont également remarquables à plusieurs égards. C'est une région de diversité et de forts contrastes. Les glaciers et les champs de glace des Kootenays et des Rocheuses canadiennes, les denses forêts pluviales tempérées de la chaîne Côtière, les hautes terres désertiques du centre-sud de la Colombie–Britannique et de l'est des États de Washington et de l'Oregon (agrémentées de cactus et de serpents à sonnette), les sommets enneigés de l'ouest du Montana et du Wyoming, des vallées où se pratique une agriculture intensive, comme l'Okanagan, et les volcans en activité de la chaîne des Cascades sont tous situés à l'intérieur de ses limites et sont parfois à quelques dizaines de kilomètres l'un de l'autre. Toutes ces caractéristiques reflètent d'une certaine façon et aussi se combinent pour déterminer en partie l'hydrologie et le climat du bassin. L'influence du fleuve se fait aussi sentir loin au large. Des panaches d'eau douce et de sédiments du Columbia ont un effet marqué sur l'océanographie physique, chimique, géologique et biologique de la côte pacifique nord-ouest des États–Unis (p. ex. Hickey et Banas, 2003). Et la liste des hauts faits du Columbia remonte également loin dans le temps : aussi intense que soit son débit aujourd'hui, ça n'est rien comparativement aux inondations de Missoula. Il s'agit d'une longue série de débâcles glaciaires survenues durant la dernière période glaciaire; la pire de celles-ci a rapidement déversé plus de 1500 km^3 d'eau chargée de glace et de roches d'une élévation de 1300 m dans le Montana jusqu'à 100 m sous le niveau actuel de la mer, relâchant une énergie comparable à celle de l'impact de l'astéroïde qui a contribué à mettre fin à l'ère des dinosaures (p. ex. Allen, Burns, & Sargent, 2002). Ces inondations du Columbia ont façonné en bonne partie les paysages du bassin que l'on voit aujourd'hui, en érodant les «scablands » de l'est de l'État de Washington et en formant les dépôts plats de limon fertile de la vallée de la Willamette dans l'ouest de l'Oregon.

Le fleuve Columbia a aussi une importance culturelle et historique qui va bien au-delà des statistiques sur l'activité économique présentées ci-dessus. Le fleuve est la pierre angulaire de l'identité culturelle dans une grande partie de la région Pacifique nord-ouest, donnant même son nom à la province canadienne de la Colombie–Britannique. Le bassin n'est pas non plus sans soulever la controverse et sans poser certains défis. Par exemple, on estime que, dans la préhistoire, de 10 à 16 millions de saumons effectuaient une migration anadrome annuellement, mais ce nombre serait passé à 1 million, dont environ 80% sont élevés dans des écloseries (Bottom, Jones, Simenstad, & Smith, 2009). Ce brusque déclin est vraisemblablement le résultat d'une combinaison de facteurs, comme la construction de barrages, la perte d'habitats, la pollution, la surpêche et les conditions en haute mer. Les dommages infligés aux stocks de saumons extraordinairement riches du bassin ont eu de profondes répercussions sur les Premières Nations (Columbia River Inter-Tribal Fish Commission, 2003), entre autres. Pour en rajouter, l'inondation de 1948 — essentiellement le résultat d'un épisode de pluie sur neige dans tout le bassin — a été désastreuse, détruisant Vanport en banlieue de Portland par suite de la rupture d'une digue et entraînant la mort de 22 personnes (Speers, Barcellos, & Wortman, 1990). Cet événement hydrométéorologique unique a eu des conséquences sociales étonnamment variées, notamment une influence sur les relations interraciales locales (McGregor, 2003). De plus, la demande plus insistante de protection contre les inondations, en partie due à cet événement, a éventuellement mené à une période de construction accélérée de barrages dans tout le bassin — ce qui, par le fait même, a eu des répercussions sociales, comme le déplacement de gens qui habitaient depuis longtemps des régions de bassesterres agricoles au nord de la frontière. Le Columbia a même contribué à définir le cours de l'histoire du monde, l'avenir de la guerre et de nouvelles menaces pour la survie de l'humanité : le site de Hanford dans l'État de Washington a utilisé l'abondante énergie hydroélectrique des barrages de Grand Coulee et de Bonneville pour produire le plutonium nécessaire à l'essai de Trinity au Nouveau–Mexique et à la bombe nucléaire Fat Man lancée contre Nagasaki. Et comme il s'agit d'un fleuve transfrontalier majeur, il a même son propre traité international — Treaty Relating to Cooperative Development of the Water Resources of the Columbia River Basin, United States of America – Canada [ci-après Traité du fleuve Columbia] (1961–1964) — qui régit la gestion canado-américaine conjointe du bassin.

Avec l'accroissement de la population qui s'accélère et les pressions que le développement correspondant engendre, avec la demande de plus en plus soutenue de ressources naturelles, y compris l'approvisionnement en eau et l'hydroélectricité, avec les changements naturels et anthropiques dans le climat régional et mondial et compte tenu des soucis grandissants quant à la durabilité de l'environnement, le besoin d'une meilleure connaissance scientifique du bassin n'a jamais été aussi grand. Il convient ici de souligner que les avantages d'une connaissance géophysique accrue sont tout à fait concrets. À titre d'exemple, Hamlet, Huppert, and Lettenmaier (2002) ont utilisé un modèle de simulation de réservoir incorporant des contraintes opérationnelles pour estimer que des prévisions améliorées d'apport d'eau axées sur le climat pour le bassin du Columbia pourraient augmenter la production d'énergie non ferme par les grandes installations hydroélectriques du

Columbia de 5,5 millions MWh par année et générer des revenus annuels additionnels d'approximativement 153 millions de dollars US. Il est clair qu'une meilleure compréhension du climat et de l'hydrologie du bassin a une valeur financière très importante. L'arrivée imminente de dates importantes relativement au Traité du fleuve Columbia milite aussi en faveur d'une connaissance plus approfondie du fleuve et des changements qui pourrait l'affecter dans le futur.

Ce numéro spécial fournit un forum pour le partage de connaissances clés et d'avancées récentes dans des questions de science et d'ingénierie portant sur le bassin du Columbia et d'intérêt pour les lecteurs d'Atmosphere–Ocean. Des scientifiques et des ingénieurs d'institutions situées de part et d'autre de la frontière y abordent une gamme de sujets variée, encore qu'une attention spéciale soit accordée à la variabilité climatique passée et future. Chang et ses collègues (Portland State University, US Geological Survey) appliquent des indicateurs de vulnérabilité de l'eau à l'échelle du pays pour comprendre la configuration spatiale et les facteurs déterminants de l'apport d'eau, de la demande en eau et de la qualité de l'eau dans le bassin. Werner et coauteurs (Pacific Climate Impacts Consortium) explorent les effets de possibles trajectoires climatiques futures au moyen d'un modèle hydrologique distribué, étalonné à deux douzaines de points dans le bassin du Haut-Columbia et forcé avec des projections à échelle réduite à partir d'un ensemble de modèles climatiques planétaires et de scénarios d'émissions. Les effets de divers modes de variabilité climatique à grande échelle sur les débits fluviaux et la possibilité qu'ils permettent d'améliorer les prévisions d'apport d'eau sont étudiés par Gobena et coauteurs (BC Hydro, Environnement Canada). Hamlet et ses collègues (University of Washington, US Bureau of Reclamation) fournissent un résumé et une synthèse du travail considérable de modélisation hydrologique par GCM dans le bassin du Columbia. Les glaciers et champs de glace alpins sont une partie intégrante du cycle hydrologique du bassin hydrographique dans plusieurs bassins de tête du Columbia, et Hirose et Marshall (University of Calgary) étudient ces questions en détail pour la rivière Illecillewaet. Hatcher et Jones (Oregon State University) comparent les tendances hydroclimatiques à long terme observées entre des sites d'amont et d'aval pour évaluer la résilience écologique et d'ingénierie au changement climatique. Murdock et coauteurs (Pacific Climate Impacts Consortium) analysent les résultats de modèles climatiques régionaux pour étudier la sensibilité des extrêmes météorologiques aux changements climatiques projetés.

En tant que responsable pour ce numéro spécial, je voudrais sincèrement remercier tous les auteurs pour leurs contributions ainsi que les membres de la rédaction dont l'excellent travail a aidé au succès de ce projet. Les tâches rédactionnelles ont été effectuées par le directeur scientifique invité Stephen Déry, avec l'aide du directeur scientifique invité John Pomeroy et du rédacteur en chef William Hsieh. La rédactrice technique Sheila Bourque et le directeur des publications Richard Asselin ont également apporté une contribution utile.

Note du rédacteur: La liste des références est présentée à la page 171 du présent numéro.

Atmosphere-Ocean 50-2 Paper Order

Guest Editors / Rédacteurs invités :
Stephen Déry and John Pomeroy

From Icefield to Estuary: A Brief Overview and Preface to the Special Issue on the Columbia Basin / Du champ de glace à l'estuaire : Un aperçu et la préface du numéro spécial sur le bassin du Columbia *Sean W. Fleming*

Water Supply, Demand, and Quality Indicators for Assessing the Spatial Distribution of Water Resource Vulnerability in the Columbia River Basin *Heejun Chang, Il-Won Jung, Angela Strecker, Daniel Wise, Martin Lafrenz, Vivek Shandas, Hamid Moradkhani, Alan Yeakley, Yangdong Pan, Robert Bean, Gunnar Johnson and Mike Psaris*

Spatial and Temporal Changes in Streamflow in the Canadian Portion of the Columbia River Basin under Three Emissions Scenarios *A.T. Werner, M.A. Schnorbus, R. R. Shrestha and H. Eckstrand*

The Role of Large-Scale Climate Modes in Regional Streamflow Variability and Implications for Water Supply Forecasting: A Case Study of the Canadian Columbia River Basin *Adam K. Gobena, Frank A. Weber and Sean W. Fleming*

An Overview of the Columbia Basin Climate Change Scenarios Project: Approach, Methods, and Summary of Key Results *Alan F. Hamlet, Marketa McGuire Elsner, Guillaume Mauger, Se-Yeun Lee, Ingrid Tohver and Robert Norheim*

Glacier Meltwater Contributions and Glaciometeorological Regime of the Illecillewaet River Basin, British Columbia, Canada *J.M.R. Hirose and S.J. Marshall*

Climate and Streamflow Trends in the Columbia River Basin: Evidence for Ecological and Engineering Resilience to Climate Change *Kendra L. Hatcher and Julia A. Jones*

Climate Change and Extremes in the Canadian Columbia Basin Trevor Q. Murdock, Stephen R. Sobie, Francis W. Zwiers, and Hailey D. Eckstrand

Did you know?[1]

Canada ranks sixth and seventh in the world in terms of the number of oceanographic or atmospheric science papers published, behind USA, China (not for oceanography), UK, Germany, Japan and France.

Canada publishes 263 scientific journals, dominated by medicine, biology and engineering. Among the journals in which CMOS members might publish we find, in order of impact and prestige: Canadian Journal of Fisheries and Aquatic Sciences (CJFAS), Canadian Journal of Forest Research (CJFR), Atmosphere-Ocean (A-O) , International Journal of Numerical Analysis and Modeling, Canadian Journal of Earth Sciences, Canadian Journal of Remote Sensing, Canadian Journal of Soil Science, Canadian Journal of Physics and Canadian Water Resources Journal.

Atmosphere-Ocean is among Canada's premier scientific journals; although it ranks 87 out of 263 Canadian journals in terms of number of articles, it ranks 23rd in terms of impact factor, just behind CJFAS (14th)and CJFR (21st). Compared to all other international earth and planetary science journals (with at least 50 citable documents over the last three years), A-O ranks 33rd out of 67 for meteorology and 32rd out of 77 for oceanography.

[1] Source: SCImago and SCOPUS (http://www.scimagojr.com/index.php) Note: to find A-O, you must type Atmosphere – Ocean, with a space on either side of the middle dash)

Richard Asselin
Director of CMOS Publications

Le saviez-vous?[2]

Le Canada occupe les sixième et septième places pour le nombre d'articles scientifiques publiés portant sur l'océan ou l'atmosphère, et ce, juste derrière les États-Unis, la Chine (sauf en océanographie), le Royaume-Uni, l'Allemagne, le Japon et la France.

Il se publie au Canada 263 revues scientifiques, où prédominent la médecine, la biologie et l'ingénierie. Parmi les revues dans lesquelles les membres de la SCMO sont susceptibles de publier leurs articles, on retrouve, en commençant par les plus influentes et prestigieuses, le *Canadian Journal of Fisheries and Aquatic Sciences* (CJFAS), le *Canadian Journal of Forest Research* (CJFR), *Atmosphere-Ocean* (A-O) , *l'International Journal of Numerical Analysis and Modeling*, le *Canadian Journal of Earth Sciences*, le *Canadian Journal of Remote Sensing*, le *Canadian Journal of Soil Science*, le *Canadian Journal of Physics* et le *Canadian Water Resources Journal*.

Atmosphere-Ocean figure parmi les meilleures revues scientifiques canadiennes. Bien qu'elle se classe au 87e rang des 263 revues canadiennes, pour le nombre d'articles, elle occupe le 23e rang en ce qui a trait au facteur d'impact, juste derrière le CJFAS (14e) et le CJFR (21e). Quand on la compare aux autres revues internationales sur les sciences planétaires et de la terre (avec au moins 50 documents citables au cours des trois dernières années), A-O prend la 33e place sur 67 pour la météorologie et la 32e place sur 77 pour l'océanographie.

[2] Source : SCImago et SCOPUS (http://www.scimagojr.com/index.php). Remarque : pour trouver les résultats correspondants à A-O, vous devez taper *Atmosphere – Ocean* avec une espace de chaque côté du tiret.

Richard Asselin
Directeur, Publications de la SCMO

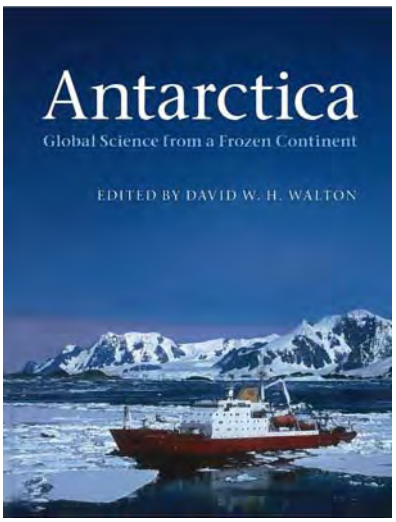
BOOK REVIEW / REVUE de LITTÉRATURE

Antarctica: Global Science from a Frozen Continent

Edited by David W.H. Walton

Cambridge University Press, ISBN 978-1-107-00392-7
2013, Hardback, xii + 342 pages, $55.95

Book reviewed by J.J.P. Smith[3]



Polar studies are a burgeoning area for many of us in the natural sciences. Several factors account for the rise in research, policy and governance interest in the earth's polar regions including the recent Fourth International Polar Year, the emergent effects of anthropogenic climate change, anniversaries of polar expeditions, a popular public consciousness of environmental matters, and expanding national territorial claims - Canada's for an extended continental shelf in the Arctic being the latest exemplar. For many of us, reading around the subject of polar science policy and research is a must, necessary for cross-disciplinary understanding and to situate (if not justify) our work. And for Canadian scientists concerned with the Arctic, a comparative understanding of the development of scientific research in Antarctica always proves useful.

Antarctica: Global Science from a Frozen Continent is a fine book. For those who study the earth's polar regions, or teach the history and current political-economic development of them, the book is a valuable resource in a field now crowded with a great deal of literature. It ably answers the question of what is the current state of natural science research in Antarctica. David Walton, an English academic with 45 years of experience in the British Antarctic Survey and editor of *Antarctic Science*, has brought together an impressive collection of readable and well-integrated essays. The book is empirical and broad-ranging in scope, addressing the history of the discovery of the southern continent and emergence of scientific missions and particular projects (for example stratospheric ozone monitoring, the large-scale distribution of water masses in the Southern Ocean, and nearshore ice polynya assessments). The contributors, leading physical scientists from several western nations, write qualitatively about a number of subjects, including the guiding role of the multilateral Scientific Committee on Antarctic Research, meteorology on the frozen continent, fisheries, space research, terrestrial and oceanic ecosystems, Southern Ocean circulation and the operation of the *Antarctic Treaty*. A particularly interesting chapter is that about "living and working in the cold". The relationships and scientific cooperation among states with a presence in Antarctica is also canvassed across several chapters, with some evident lessons for the advancement of international cooperation in the Arctic.

Inevitably with multiple contributors, the book has some overlap across certain subjects, including climate change and the history of research development. The book would have benefitted from a detailed map of Antarctica. The editor could usefully have added a chapter on the interplay of the *Antarctic Treaty* with related conventions, including the *UN Law of the Sea Convention* and the *Convention on the Conservation of Antarctic Marine Living Resources* (the CCAMLR). But these are minor concerns in an otherwise first rate survey work. The list of additional references at an appendix is an indication of this, as are the numerous illustrations and inset text boxes.

Antarctica: Global Science from a Frozen Continent is a recommended addition to the libraries of those who think about polar scientific research, and to students and scholars of polar development.

[3] McGill and Carleton Universities, and the government of the Saharawi Arab Democratic Republic.

Next Issue *CMOS Bulletin SCMO*

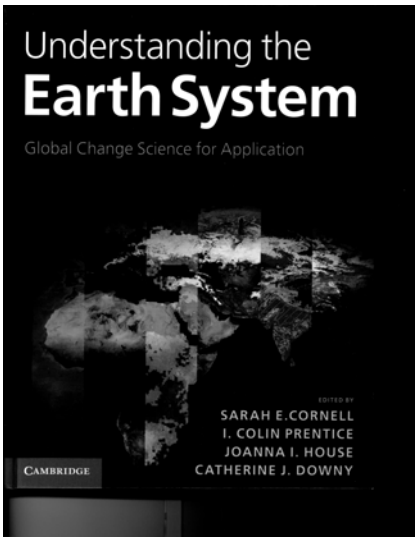
Next issue of the *CMOS Bulletin SCMO* will be published in **December 2013.** Please send your articles, notes, workshop reports or news items before **November 1, 2013** to the address given at the top of page 146. We have an URGENT need for your written contributions.

Understanding the Earth System

Edited by Sarah E. Cornell, I. Colin Prentice, Joanna I. House and Catherine J. Downy

Cambridge University Press ISBN 978-1-107-00936-3, 2012, Hardback, 267 pages, $81.95

Book Reviewed by John Stone[4]



Earth system science has been described as "*science struggling with problems too large for its participants but too important to ignore*". In September, 1984, the International Council of Scientific Unions (ICSU) - now known as the International Council for Science - held its 20th General Assembly in Ottawa. At that meeting Bert Bolin, who was later to play a central role in the Intergovernmental Panel on Climate Change (IPCC), led some discussions on the creation of an international research programme to understand the Earth's systems. Two years after the Ottawa meeting the International Geosphere-Biosphere Programme (IGBP) was established to look at "*the total Earth system, the changes that are occurring and the manner in which changes are influenced by human action*". For a while Canada even had its own national global change programme under the Royal Society of Canada led by the late Digby Mclaren.

Several projects were created under the IGBP umbrella, such as the Land-Ocean Interaction in the Coastal Zone (LOICZ), and many continue to this day. Such was the success that the IGBP has now expanded to involve the World Climate Research Programme and the International Human Dimensions Programme in the grand Earth Systems Science Partnership. I had the privilege to be involved in many initiatives. It was a time when we had the financial resources to be able to have an influence on the scientific development.

This mammoth research effort not surprisingly created its own bureaucracy but it did produce an enormous wealth of new science. We now have a much richer understanding of the myriad interacting processes that govern the way our planet works. Not surprisingly, it has also produced a number of books reviewing our state of knowledge such as the IGBP landmark synthesis, *Global Change and the Earth System*, in 2004. One of the most recent reviews, published about a decade later, is *Understanding the Earth System*. This physically slim but scientifically solid book is the product of a programme led by the Natural Environment Research Council in the United Kingdom that went under the name: Quantifying and Understanding the Earth System (QUEST). While most of the participants were from the UK (but including one Canadian) the breadth of references is global.

It would be too much to expect any one tome to be able to cover all Earth systems science, including not only the physical but also the social disciplines. Most of the authors are well-known experts in geobiochemical processes and their research interests are reflected in the book. Furthermore, like many such reviews the material in this book relates not to global change writ large but mainly to climate change. This is quite understandable given the enormous amount of scientific resources being directed to tackling what UN Secretary General Ban Ki-moon says is the greatest challenge facing our World. Also, like other similar reviews, the material in this book will not only be superseded by new research but the book itself may be over-shadowed by the Fifth Assessment Report from the IPCC.

The book is a little uneven as you might expect when each chapter is written by a different team of scientists. For example, Chapter 2 is a very carefully written and balanced review of the scientific fundamentals of climate change including observations, radiative forcing and terrestrial ecosystem processes. It makes the point that "there is no scientific basis for the widely assumed existence of a safe limit of 2 degrees or any other specific level of warming". In contrast Chapter 7 is a detailed discussion of the potential use of the terrestrial biosphere in climate change mitigation through, for example, the management of forests, agricultural practices and bio-energy. It gives an honest assessment of the accounting difficulties in taking credit for carbon "sinks" under the UN Framework Convention on Climate Change – a tangled web of rules that took several years to negotiate and is still somewhat arbitrary.

The book's attempt to deal with the importance of the "*problematic human*" in tackling our planet's systems is unsatisfying. The authors of the first chapter, which has a focus on the Anthropocene, admit that our models of global change have persistently been inadequate in addressing the role of the socio-economic context. They argue that

[4] Adjunct Research Professor in the Department of Geography and Environmental Studies at Carleton University, Ottawa, ON, Canada. Lead author of the 4th Report (Polar Regions) for the IPCC Fifth Assessment Report.

while the power of our climate models may be impressive, the models are not necessary useful in themselves for policy-making. After some technical chapters on system feedbacks, modelling and future climate change, the authors return to society's responses in the final chapter. They note that policy-making is not just a conversation between policy-makers and scientists but a much noisier and less tidy one that involves a wider, and ideally well-informed public. While the book's analysis is sobering, including the now well-rehearsed criticisms of the IPCC and its authors, new ideas on possible solutions are lacking. An ironic conclusion seems to be that rather than relying solely on complex models, in the end a better approach might be to limit their use to informing a "learning by doing" approach.

This is a beautifully produced book with some clear and original figures. It would be an excellent primer for geosciences graduate students. However, this reviewer found the type face of many of the boxes and especially the figures, whose captions are in a lighter type, to be almost impossible to read. The book also seems to suffer from being written as independent chapters with the result there is some duplication and little synthesis. Nevertheless, in comparison with the wealth of science and provoking thoughtfulness, these criticisms are minor. As Susan Solomon writes in her review of the book, it "*provides a deep yet comprehensive view of the Earth system in all its facets*". I expect to see it on many bookshelves.

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

Latest Books received / Derniers livres reçus

2011-34) *Modeling Methods for Marine Science*, David M. Glover, William J. Jenkins and Scott C. Doney, Cambridge University Press, Hardback, 571pages, US$85.

2012-03) *Ocean Dynamics and the Carbon Cycle, Principles and Mechanisms*, by Richard G. Williams and Michael J. Follows, Cambridge University Press, ISBN 978-0-521-84369-0, Hardback, 404 pages, US$ 73.

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

2012-10) *Phytoplankton Pigments, Characterization, Chemotaxonomy and Applications in Oceanography,* Edited by Suzanne Roy, Carole A. Llewellyn, Einar Skarstad Egeland and Geir Johnsen, 2011, Cambridge University Press, ISBN 978-1-107-00066-7, Hardback, 845 pages, US$140.

2012-12 *Buoyancy-Driven Flows*, Edited by Eric P. Chassignet, Claudia Cenedese and Jacques Verron, 2012, Cambridge University Press, ISBN 978-1-107-00887-8, Hardback, 436 pages, US$120.

2012-18) *Chemistry and the Environment*, by Sven E. Harnung and Matthew S. Johnson, Cambridge University Press, ISBN 978-110-768257-3, Paperback, 427 pages. CDN$76.95.

2013-01) *Introduction to Chemistry of the Sea*, by Michael, E.Q. Pilson, Cambridge University Press, ISBN 978-0-521-88707-6, Hardback, 524 pages, CDN$81.95.

2013-02) *Mesoscale-Convective Processes in the Atmosphere*, by Robert J. Trapp, Cambridge University Press, ISBN 978-0-521-88942-1, Hardback, 346 pages, CDN$86.95.

2013-04) *Non-Linear Climate Dynamics*, by Henk A. Dijkstra, Cambridge University Press, ISBN 978-0-521-87917-0, Hardback, CDN$76.95, 357 pages.

2013-05) *The Weather and Climate, Emergent Laws and Multifractal Cascades*, by Shaun Lovejoy and Daniel Schertzer, Cambridge University Press, ISBN 978-1-107-01898-3, Hardback, CDN$132.95, 475 pages.

2013-06) *The Self-Potential Method, Theory and Applications in Environmental Geosciences*, by André Revil and Abderrahim Jardani, Cambridge University Press, ISBN 978-1-107-01927-0, Hardback, CDN$121.95, 369 pages.

Prochain numéro du *CMOS Bulletin SCMO*

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en **décembre 2013.** Prière de nous faire parvenir avant le **1 novembre 2013** vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée au haut de la page 146. Nous avons un besoin URGENT de vos contributions écrites.

BRIEF NEWS / NOUVELLES BRÈVES

Dr. Ian Rutherford announcing the appointment of Dr. Andrew Bell as Executive Director of CMOS at the CMOS Ottawa Centre Luncheon on September 19th.

Late breaking News

New Executive Director for CMOS/SCMO

In the June issue of *the CMOS bulletin SCMO* the CMOS Council announced that it was seeking applicants for the position of Executive Director, in anticipation of the retirement of the incumbent, Dr. Ian Rutherford. Four applications were received two of which were subsequently withdrawn. Following interviews and reference checks, Council is now pleased to announce that an offer was made to and accepted by Dr. Andrew Bell of Ottawa. Dr. Bell will take over his new duties on 1 October.

AGU Press Release No. 13-38

American Geophysical Union Releases Revised Position Statement on Climate Change

Statement Highlights How Human Activities Are Changing Earth's Climate and the Harmful Impact of that Change on Society

WASHINGTON, DC, 5 August 2013 — The American Geophysical Union today released a revised version of its position statement on climate change. Titled "***Human-induced Climate Change Requires Urgent Action***," the statement declares that "***humanity is the major influence on the global climate change observed over the past 50 years***" and that "***rapid societal responses can significantly lessen negative outcomes***." AGU develops position statements to provide scientific expertise on significant policy issues related to Earth and space science. These statements are limited to positions that are within the range of available geophysical data or norms of legitimate scientific debate.

"*AGU has a responsibility to help policy makers and the public understand the impacts our science can have on public health and safety, economic stability and growth, and national security*," said Gerald North, chair of AGU's Climate Change Position Statement Review Panel. "*Because our understanding of climate change and its impacts on the world around us has advanced so significantly in the last few years, it was vitally important that AGU update its position statement. The new statement is more reflective of the current state of scientific knowledge. It also calls greater attention to the specific societal impacts we face and actions that can diminish the threat*."

AGU's position statements are renewed every 4 years. The climate change position statement was first adopted in December 2003. It was then revised and reaffirmed in December 2007, and again in February 2012.

AGU's Position Statement Task Force reviews each statement to determine if it should be renewed as is, modified, or eliminated. In March 2012, the Task Force determined that the climate change position statement would require updating prior to renewal.

With input from AGU's Council, relevant section and focus group leadership, the Position Statement Task Force, and staff, a panel of experts was subsequently formed to review the statement and make any necessary modifications. A draft of the updated statement was printed in Eos in November 2012, and all AGU members were encouraged to submit comments. After further revisions by the review panel based on the comments received, the statement was then adopted by the AGU Council in June 2013 and by the AGU Board in August 2013.

The newly approved statement will be reported to the AGU membership in the 20 August 2013 issue of Eos, the source of record for all AGU proceedings.

New Development Modules from COMET Program

The COMET program has recently announced the development of the following new modules.

1) Nighttime Radiation

The COMET Program is pleased to announce the publication of, "*Nighttime Radiation and Cooling of the Lower Atmosphere*". It is our common experience to observe that the lowest levels of the atmosphere cool down more slowly on humid nights than on dry nights. When the sky is cloudy we observe the atmosphere to cool even more slowly. Can longwave radiation fluxes alone explain these observations? This learning object uses a simple interactive model to demonstrate the role of radiation in nighttime cooling. As a short learning object, it is meant to supplement other teaching material in a course by elucidating a specific concept. By adjusting the emissivity

and temperature of earth and atmospheric layers, the student can derive the role of radiation in nighttime cooling. A series of questions explore the effects of dry, humid and cloudy conditions in the lower atmosphere.

The intended audience for "*Nighttime Radiation and Cooling of the Lower Atmosphere*" is the novice meteorologist learning the fundamental processes in meteorology. The material is less than half an hour of exploratory content. Please follow this link to the MetEd description page that provides additional information and a link to begin: Nighttime Radiation and Cooling of the Lower Atmosphere:

http://meted.ucar.edu/training_module.php?id=1074

2) Multispectral Satellite Applications

The COMET Program is pleased to announce the publication of "*Multispectral Satellite Applications: Monitoring the Wildland Fire Cycle, 2nd Edition*." This lesson describes current and future satellites sensors and products used for monitoring the fire cycle, with an emphasis on polar-orbiting satellites. Product information is presented in the context of the fire lifecycle: from assessing the pre- and post-fire environment to detecting and monitoring active fires, smoke, and aerosols. Product information is also consolidated in the Fire Product Suite. The lesson concludes with an interactive fire case study, supplemented with observations from a National Weather Service trainer/forecaster who experienced the fire. The lesson is intended for the wide range of users involved with wildfire detection and monitoring, from land use managers and hydrologists to weather forecasters and researchers. Note that this lesson is an update to the original 2007 version and includes new information on the VIIRS and upcoming GOES-R sensors and their fire-related applications.

Please follow this link to the MetEd description page that provides additional information and a link to begin the lesson: Multispectral Satellite Applications: Monitoring the Wildland Fire Cycle, 2nd Edition:

https://www.meted.ucar.edu/training_module.php?id=1064

3) Weather Decision Support

The COMET Program is pleased to announce the publication of the new lesson, "*Weather Decision Support for the National Airspace System*." This 3-hour lesson is divided into an introductory section and several cases examining the role of forecasters in providing targeted weather information to aviation decision-makers. The content emphasizes best practices for aviation forecasters, including identifying and communicating the threat, understanding partners' needs, and anticipating the impacts to airspace operations.

The intended audience for "*Weather Decision Support for the National Airspace System*" is any operational forecaster tasked with providing information for aviation operations, from Aerodrome Forecast writers at local Weather Forecast Offices to dedicated aviation meteorologists directly supporting the FAA. Please follow this link to the MetEd description page that provides additional information and a link to begin the lesson:

http://www.meted.ucar.edu/training_module.php?id=1004

4) Advanced Satellite Sounding

The COMET Program is pleased to announce the publication of an updated lesson, "Advanced Satellite Sounding: The Benefits of Hyperspectral Observation - 2nd Edition." This one-hour lesson is an update to the 2008 expert lecture on hyperspectral observations presented by Dr. Mitch Goldberg, Program Scientist for NOAA's Joint Polar Satellite System (JPSS) Program. The lesson has been updated from the original presentation to include information about NASA and NOAA's new polar orbiting programs and CrIS, the Cross-track Infrared Sounder on the Suomi NPP polar orbiter.

The content includes discussions about what hyperspectral observations are, how they are made, some current products, their contributions to improved monitoring of the atmosphere, oceans, and land surfaces, as well as their impact on numerical weather prediction. It begins by discussing the importance of satellite observing systems. From there, it reviews the principles of remote sensing that are needed for deriving products from hyperspectral infrared observations. The third and largest section of the lesson examines results from and operational applications of the AIRS, IASI, and CrIS hyperspectral sounders. The final section discusses the importance of hyperspectral soundings from geostationary satellites. Please follow this link to the MetEd description page that provides additional information and a link to begin the lesson:

https://www.meted.ucar.edu/training_module.php?id=1071

5) Writing TAFs for Ceilings and Visibily

The COMET Program is pleased to announce the publication of the new lesson, "Writing TAFs for Ceilings and Visibility, Africa Edition." This 1.5-hour lesson outlines the processes for developing an effective Terminal Aerodrome Forecast (TAF) that meets International Civil Aviation Organization (ICAO) guidelines. Forecasters completing the lesson will gain practice applying the ICAO guidelines to create effective TAFs for their aviation customers.

The intended audience for Writing TAFs for Ceilings and Visibility, Africa Edition includes all operational forecasters tasked with providing information for aviation operations in Africa. The lesson includes a case study for an event impacting Cape Town International Airport to provide practice applying the processes to real-life forecast

situations. Please follow this link to the MetEd description page that provides additional information and a link to begin the lesson:

https://www.meted.ucar.edu/training_module.php?id=1012

6) General Information

All COMET lessons and the MetEd website rely on JavaScript, and some lessons rely on Adobe® Flash® for navigation, animation, and/or presentation of multimedia elements. Ensure that you have a browser updated to its latest version with JavaScript enabled and the latest version of the Adobe FlashPlayer installed (http://get.adobe.com/flashplayer/). For technical support for this lesson please visit our Registration and Support FAQs at https://www.meted.ucar.edu/resources_faq.php

We welcome any comments or questions you may have regarding the content, instructional approach, or use of this lesson. Please e-mail your comments or questions to Liz Page (epage@ucar.edu) or Amy Stevermer (stevermer@comet.ucar.edu).

In Memoriam

John "Jack" McConnell
1945 - 2013

Eulogy

Friends, family and colleagues; good morning.

I am Tom McElroy. I have worked and published with Jack McConnell since the mid-seventies while I worked for Environment Canada. He was a member of my Ph.D. committee. He was a strong advocate for the establishment of my Industrial Research Chair at York University, and a good friend.

There was a story that circulated around NASA 10 or 20 years ago. It spoke of a NASA manager who died and went to heaven. When he reached the pearly gates, St. Peter challenged him to recount what he had done in his life to justify entry into the Kingdom of Heaven. The manager drew himself up to his full height and - grasping his skinny tie - called out "*Could I have the first slide please?*"

The author Graeme Greene wrote of a "*Journey Without Maps*". For a modern speaker - especially a scientist - it is more "*A presentation without Powerpoint*".

However...I am still going to speak.

It is a singular honour to be invited by Jack McConnell's family to speak about his life today. They did give me their marching orders, however. In five minutes or less I'm supposed to convey the content and the importance of the contributions he made to science in Canada and internationally - and use words of less than three syllables. I think this would've been a challenge for Jack! Let alone for me...


John McConnell

Jack started his research career with the work he did with Michael McElroy at Harvard on understanding the chemistry of the atmospheres of Mars and Venus. That endeavour is recorded in a number of journal publications from the early 1970s. This set the course for his lifelong task of constructing mathematical representations of the chemistry of atmospheres. The early, simple models of 'chemistry in a bowl' as it were – box models as they are called – gave way to increasingly complex models that depicted the temporal evolution and 3-dimensional structure of the atmosphere and lately to include very complicated mathematics to allow observations of the atmosphere to influence the models and improve predictability.

Jack's close collaboration with Environment Canada (EC) in a number of areas - including work that he and I shared - was important for both York and EC. One of the research coups achieved by Jack's group was the poring over of the Canadian weather forecast model from a supercomputer in Montréal at the Centre Météorologique du Canada and making it work on a much smaller workstation computer at York. In Montréal the model was supported by a group of 10 or 20 people. At York it was supported by Jack and a handful of students and research associates. In spite of this modest effort level, Jack was able to not only insert chemistry into the global forecast model, he uncovered bugs in the core of the model as well. He also demonstrated that the top of the model needed to be moved to much higher altitudes if the forecast were to be made more accurate and useful on longer time scales. As a result, his work on the forecast model made the daily weather forecasts more accurate for all Canadians.

Over the years Jack participated in a number of international science teams at ESA - the European Space Agency, NASA - the US National Aeronautics and Space Administration, and as part of the science team for the upcoming Global Environmental Monitoring Spectrometer that Korea will be launching in the near future. He was the mission scientist for the planned scientific component of the Canadian Polar Communications and Weather satellite, intended to monitor the weather and atmospheric composition and provide communications in the high Arctic. Everyone seems to know about Jack's prodigious work load. He felt a responsibility to use his talents and shared

them unstintingly. But at the same time, it gave him great rewards to contribute - especially if it energized others to contribute as well.

Jack participated in one of the most important international scientific activities of our time - the Intergovernmental Panel on Climate Change - and, as a result, shared recognition with former US Vice-president Al Gore and other scientists around the world, in the 2007 Nobel Peace Prize.

The numerous emails that we have received from colleagues all over the world attest to the international impact of Jack's science and the gentle persuasiveness of his personality. His awards speak of the respect the community has for his work. I never heard him say anything bad about anyone - even if they richly deserved it!

That gives a flavor of the impact that Jack's activities had on the national and international stage. But he had possibly an even greater impact locally in terms of his ability to teach complex scientific concepts to undergraduates, graduate students and postdoctoral fellows. It was a joy to watch Jack teach the somewhat esoteric mathematics of fluid mechanics with chalk in hand at a blackboard with no notes in sight. He would stand there and search his mind for the physical concept that accompanied each term in the equation and then translate that into the mathematical expression that needed to be added to complete the description of motion. It was clear that the mathematics and the physics were intimately intertwined in his mind and that he could see in his mind's eye the way the atmosphere worked. An inspiration for all of his students - many of whom have become important to the global research community. However, he did have a predilection for asking simple, but obscure, questions that students had a lot of trouble handling in their oral exams but usually stumbled their way through to a successful end.

Jack's influence will be sorely missed at York and around the world.

In closing, I would like to borrow a few words from John Donne. Words often quoted but still often appropriate. *"No man is an island, entire unto himself. The death of any man diminishes us all. Ask not for whom the bell tools. It tolls for thee*."

Thank you.

Tom McElroy

Note from the Editor: Tom McElroy is Chair of the CMOS Toronto Centre and was awarded a CMOS Fellow at the last CMOS Congress held in Saskatoon last May.

Dr. Bernard Roderick Pelletier
1923 - 2013

Salute to a Dedicated Marine Scientist

When I first heard Dr. Bernard Pelletier speak about some of his WW II experiences, I was left wondering if his small stature enhanced his safety during the heat of battle. Over the years I learned about the high moral and professional standards of the man hidden inside of that small frame. In one of his many wartime recollections, Bern describes a brush with the grim reaper during the battle to take the monastery at Monte Cassino in the winter of 1944. At that time, Bern finds himself on a hillside below the monastery manning a machine gun position. At one point a German fighter swoops down to take him out but the pilot starts his dive a bit too late. As a result, by the time the two streams of bullets from the fighter's wing-mounted machine guns reach Bern's position, they are hitting the ground along two lines that are several metres apart, falling to the left and right of where Bern has taken cover. A second fighter makes another attempt and, according to our Saskatoon Light Infantry soldier on the scene, as the German plane passes by, Bern notices the face of the pilot as he sends a burst of rounds from his machine gun into the plane's fuselage. According to Bern, the aircraft disappears over the horizon leaving a thin trail of smoke behind. Unfortunately, Bern never learns if the fighter crashed or if the pilot survived.

Fast forward to the end of the war where we find Bern completing his high school education and then moving on to McGill to earn his Bsc. His next traverse along the education highway brings him to McMaster University where he completes an MSc in geology. Finally, a scholarship takes him to Johns Hopkins for a PhD in geology with a specialization in sedimentology and sedimentary rocks that inspires a strong interest in marine sediment textures and sediment dynamics after his arrival at BIO in the latter years of the 1960's. However, during the first part of his career, we find him at the GSC in Ottawa where he has become involved in a series of hard rock investigations in the Rockies and the Canadian arctic.

Bern's tenure at BIO is marked by his sedimentology interests that result in the publication of a diverse number of papers while simultaneously managing a Marine Geology Section of young and ambitious scientists eager to add to the still meager understanding of the vast ocean environments that fall within Canada's jurisdiction. One of his early publications is a 1969 study of descriptive models of sediment transport in Hudson Bay and, by 1970 he has published one of the first papers on sediment sampling using a diver lock-out submersible. The fall of 1970 finds Bern along with a small cadre of BIO colleagues on board *CSS Hudson* for the western arctic leg of the *Hudson 70* expedition. That survey leads to a number of arctic-related papers starting with a 1975 GSC Technical Report on

sediment dispersal in the southern Beaufort Sea and ends with a series of arctic atlases that he worked on while an emeritus RS until shortly before his death on May 20th. The atlas that remains to be completed is focused on the environments of the coastal zone of the southern Arctic Ocean.

Bern's strong commitment to the study of things sedimentological is highlighted by a number of papers that were published during the 1970s and early 1980s. In 1972, he co-authours with Dr. Mike McMullen on sedimentation patterns in the Bay of Fundy and the Minas Basin and, in 1973, with Swift, Lyall and Miller in a comprehensive overview of Quaternary sedimentation in the Bay of Fundy. In the same year, he reports on a re-examination of the use of the silt/clay ratio as an indicator of sedimentary environments, a paper that is described in its title as *"A Study for Students*". By 1974, we find him documenting his thoughts on sedimentary textures and relative entropy and their relationship to the hydrodynamic environment of the Bay of Fundy for Volume I of *Offshore Geology of Eastern Canada* for which he also served as editor. The first years of the1980s, he is involved in a collaboration with Sly and Thomas on a paper that compares sediment-energy textural relationships in marine and lacustrine environments (1982) that is soon followed by a second paper in 1983 with the same co-authours on the interpretation of moment measures derived from water-lain sediments.

Bosun Joe Avery and Bernie Pelletier erecting a plaque at Resolute Bay in 1970

I eventually had a chance to learn about the less formal and less serious side of Dr. Bernard Pelletier during one of Dr. Bosko Loncarevic's Mid-Atlantic Ridge (MAR) expeditions in 1969. Along with those from the *Hudson 70* expedition, publications from MAR surveys represent some of the earliest Canadian contributions to the International Decade of Ocean Exploration. I was invited to participate in the 1969 MAR cruise by Mr. John Brooke. John and his creative team of ocean engineers and technicians had spent several years working on a deep sea rock core drill (the BIO Hydrostatic Rock Core Drill) that was going to sea for another round of field tests among the rugged basaltic and carbonate rock-veneered peaks that characterize much of the MAR's terrain near 45^0N. During the many long hours of waiting for the drill to be lowered, activated and retrieved, I learned about the other Bern Pelletier along with a few of the melodies generated by his ever handy harmonica. Seems that he had developed his liking for music after joining the Queen's York Rangers band while in high school. Up to our time together on *Hudson*, he had never really let on about that element of his diverse skill set.

Throughout his long and distinguished scientific career his accomplishments are many, but in those early years of BIO's voyage of discovery Bernard Pelletier is among the leaders that established the high standard of scientific excellence that would go on to define BIO's national and worldwide reputation.

As a soldier in Canada's last big war, Bern had a keen interest in veterans affairs that was manifested by a long, enjoyable and productive experience as a member of his local Legion in Ottawa (Branch 593 – Bells Corners) that was highlighted by several visits to former battlefields in Europe with friends and family to pay tribute to those of his fellow Canadian soldiers that had died in combat and were buried in foreign soil. One of the lines in his obituary seems to be a perfect fit in defining the Bern Pelletier that many of us recall with a special fondness. It states that *"Pride in the accomplishments of his family, a wonderful sense of humour, a love for the outdoors, and a deep commitment to [the study of] Canada's natural resources mark his long [90 years] and productive life*". Sail on Dr. Pelletier, we'll catch you later.

Charles Schafer

Note from the Editor: Reproduced here with the kind authorization of the Arctic Fossil Garden. This BIO publication was developed by Claudia Currie (Emeritus NRCAN), Dr. Ruth Jackson (Emeritus NRCAN) and Patrick Potter (NRCAN).

Note from Claudia Currie: New Fossil Forest Development:

On May 21st, 2013, Dr. Bernard Pelletier passed away in Ottawa. He was one of the founding scientist-pioneers of BIO's early days. Bernie was still doing Arctic Geology at age 90 when he died. Dr. Pelletier was serving as Chief Scientist aboard CSS Hudson on one of the final legs of the famous Hudson 70 expedition.

He participated in the Hudson70 reunion in 2009 at BIO and is pictured across with Bosun Joe Avery in the famous Hudson 70 plaque-laying photograph at Resolute Bay in 1970.

Bernie also attended the 2012 BIO 50th Anniversary Gala on October 25th, 2012. To his credit after being transferred to Ottawa Bern's heart was never far from BIO.

So when Bernard Pelletier's daughter Marianne contacted BIO for ideas about how to honour her father's memory, staff at BIO proposed to formally name the Fossil garden the " *Bernard Pelletier Arctic Fossil Forest at BIO*" in memory of "Bernie" and to honor his contribution to marine science in Canada most notably the Arctic.

STOP PRESS

Robert Edward (Ted) Munn
1919 - 2013

BA (McMaster), MA (University of Toronto)
PhD (University of Michigan), FRSC

At the beginning of a much anticipated east coast adventure, Ted died peacefully in Digby, Nova Scotia with his youngest son, Dr. Rob Munn by his side.

As a child, Ted enjoyed holidays with his grandparents in McGregor Bay. While at McMaster, he spent his summers sailing the Great Lakes as he played violin in the orchestra on the SS Manitoulin. In WWII he forecast weather from Gander NL for trans-Atlantic flights and North Atlantic operational patrols.

He was a prolific scientific author with a distinguished international career. He worked at Environment Canada and the Institute of Environmental Studies (University of Toronto). In Paris, with the Scientific Committee on Problems of the Environment, his pioneering efforts brought together the scientific and decision-making communities. With the UN Environment Program, he helped to forge an analysis of emerging issues for the 21st Century. In Vienna, he was Leader of the Environment Program at the International Institute of Applied Systems Analysis. He was proud to be part of this "East-West Think Tank" during the Cold War.

Amongst many honours and awards, a highlight was being a Fellow of the Royal Society of Canada (FRSC). He was Chair of CMOS in 1964-1966 and was elected Fellow of the Society in 2000. Lately, he wrote several book reviews for the *CMOS Bulletin SCMO*.

Post-retirement, his five volume "*Encyclopedia of Global Environmental Change*", was published (2001), while as a devoted husband he provided care for Joyce. He continued to enjoy being consulted on publications and scientific documents. Just days before he died, he completed his final book, "*The World Environment: 450BC to 2100 AD*". He always had a plan for his next project.

Ted was happily a mentor to many - always kind and encouraging. Even at age 94, a monthly highlight was hosting "The Lads" (former students, colleagues and others he felt would lend multi-disciplinary insights into emerging environmental issues).

Ted loved music. After two Opera-tours to Vienna and NYC for Wagner's Ring Cycle, he had high hopes for a third in 2014. Alas, it was not meant to be! He never lost his appetite for good music, good food, good parties, good friends and a daily dose of the London Times. He lived life to the fullest, his age was irrelevant.

The *Amundsen* Arctic Scientific Mission hit by a Helicopter Crash

CBC News, Posted: Sep 10, 2013 9:33 AM CT, Last Updated: Sep 10, 2013 3:08 PM CT - Canada's Transportation Safety Board is investigating a tragic incident in which three men were killed Monday (Septembre 9th) when the helicopter they were on crashed into the Arctic Ocean.

The helicopter was on a reconnaissance mission at the time, travelling with the *Amundsen*, a coast guard icebreaker. There were no survivors.

The men who died were **Marc Thibault**, commanding officer of the *CCGS Amundsen*, **Daniel Dubé**, helicopter pilot and **Klaus Hochheim**, an Arctic scientist affiliated with the University of Manitoba.

The *Amundsen* had recently departed Resolute on a research voyage (Read *CMOS Bulletin SCMO*, this issue on page 164).

The crash occurred at 8 p.m. ET (6 p.m. MT) Monday (Septembre 9th) in the McClure Strait, about 600 kilometres west of Resolute. The McClure Strait is north of Banks Island on the opposite side of the island from Sachs Harbour, N.W.T.

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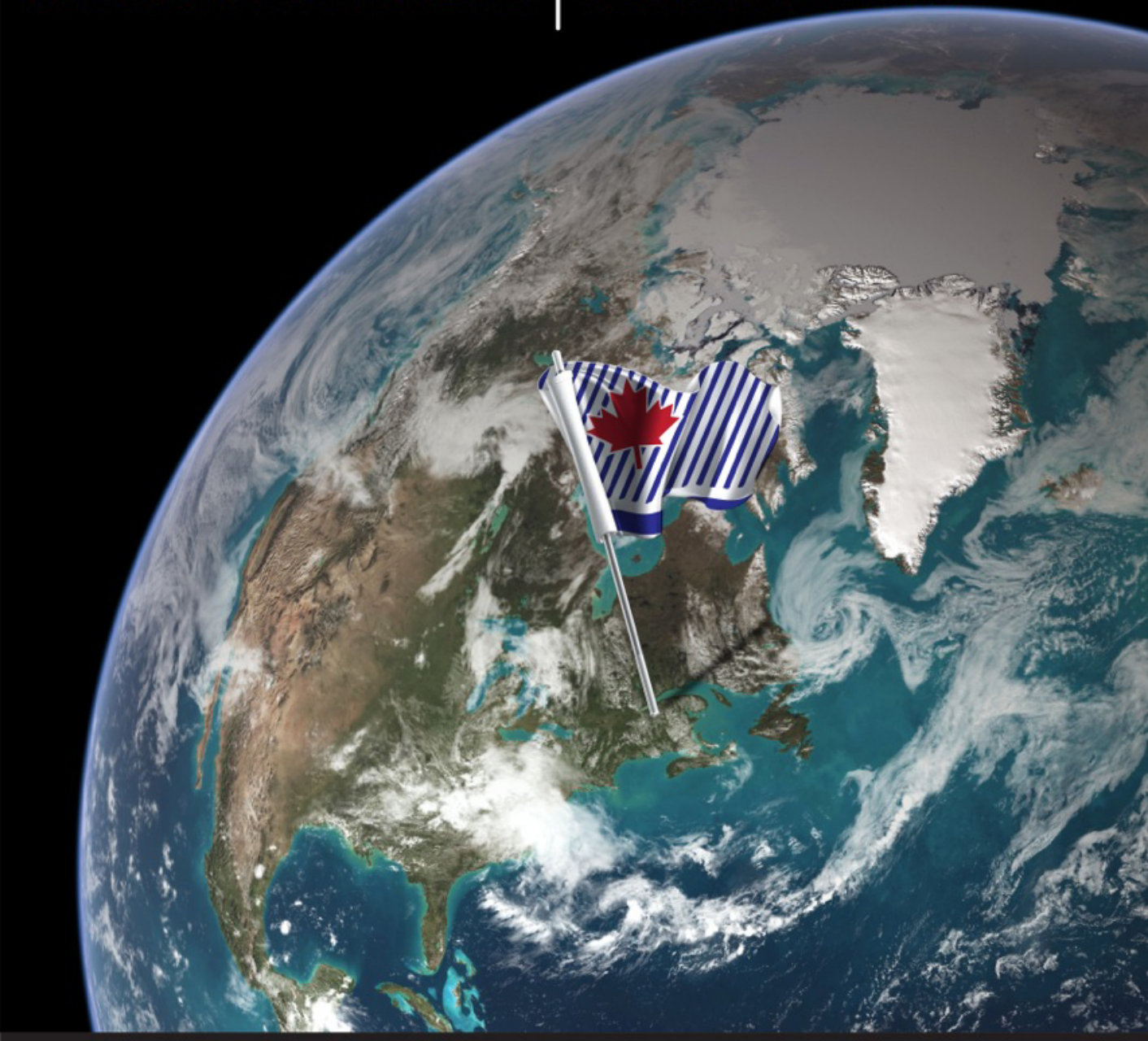

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