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CMOS BULLETIN SCMO

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

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CMOS Bulletin SCMO

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

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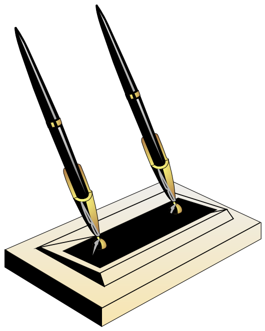
Cover page : An artist's rendition of a fictional F4 tornado crossing the southern part of the City of Winnipeg. Modelled after the 1987 Edmonton event, this "virtual" tornado was placed upon Winnipeg to predict damage, injuries and deaths. This "what if?" scenario approach allows communities to better understand the potential impacts of tornadoes and thus to better prepare for them. To learn more, please read the article on **page 88**.

Page couverture: Une vue d'artiste d'une tornade F4 traversant la partie sud de la cité de Winnipeg. Utilisant un modèle défini à partir de l'événement survenu à Edmonton en 1987, cette tornade virtuelle est déplacée sur Winnipeg dans le but de prédire les dommages, les blessures et les morts. Cette approche de "qu'est-ce que si" permet aux communautés de mieux comprendre les impacts potentiels des tornades et ainsi de mieux se préparer pour leur faire face. Pour en apprendre plus, prière de lire l'article en **page 88.**

....from the President's Desk

CMOS friends and colleagues:



Because I was asked to participate in a *Women in Science and Technology* Panel Discussion about my career, I have been reflecting on some of the events which have occurred since my first course in Climatology with Svenn Orvig at McGill University in 1965. There have been many highlights, but it is very safe to say that being given the opportunity to make a positive contribution to the advancement of meteorology and oceanography in Canada, while serving as President of CMOS, has been a very great honour and privilege. Thank you so much.

During the past year we have taken several actions as a result of a review of the CMOS Vision Paper. These included the inauguration of an annual CMOS Photo Contest and the formation of the Finance and Investment and the Ad Hoc Student Committees. The Private Sector Committee, in conjunction with MSC, completed a regional tour of five MSC offices and formulated further plans for the formation of a Private Sector Industry Association. The Scientific Committee wrote a letter to Prime Minister Harper regarding the climate change debate (see page 71), and three new accredited consultants were appointed by the Accreditation Committee. We supported Pelmorex in their bid before the CRTC for an All Channel Alert system. A host of activities have been accomplished at the local Centre level with interesting talks, involvement in science fairs and a very successful speaking tour by Phil, *The Forecaster,* Chadwick. The major focus of each year is the annual congress and we are indebted to Dave Hudak and Paul Kushner and their energetic committees for producing our 40th Annual Congress in Toronto. Meanwhile, teams of people have already started to plan for 2007 in St. John's, 2008 in Kelowna and 2009 in Halifax.

CMOS Publications have met their usual high standard thanks to the dedication of Richard Asselin and Paul-André Bolduc and their crews. I commend the entire CMOS National Office staff, under the very capable leadership of Ian Rutherford, for their commitment to CMOS and its aims. Many thanks to Bob Jones for upgrading and maintaining our website and to Lise Harvey for her efficient administration of all the accounts, for implementing individual files for each member and for pointing out numerous software bugs areas where procedures could be streamlined. It is truly amazing how much is accomplished by our enthusiastic staff and volunteers.

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

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Inside / En Bref

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

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

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

Also, I would like to express my thanks to the Executive – Bridget Thomas, Geoff Strong, Dan Kelley, Mike Dowd, Harold Ritchie, Rich Pawlowicz, Fraser Davidson, and Neil Campbell – for their tireless efforts on your behalf. It is with considerable pleasure that I turn the reins of office over to Geoff Strong and his western Canadian team. I am looking forward to working with them during the next year.

Finally, I hope you will consider becoming an active CMOS volunteer at the local or national level. The work is challenging and rewarding and it is a great way to make new friends and renew old acquaintances.

Thank you.

Susan Woodbury, ACM, FCMOS
Outgoing President / Présidente sortante

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

The High-Latitude Ionosphere and its Effects on Radio Propagation, by Robert Hunsucker and John Hargreaves, Cambridge University Press, Hardback, 0-521-33083-1, US$140.00.

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

Sounds in the Sea, From Ocean Acoustics to Acoustical Oceanography, by Herman Medwin and colleagues, Cambridge University Press, July 2005, ISBN -0521-82950-X, Hardback, US$100.00.

The Gulf of Alaska, Biology and Oceanography, by Phillip R. Mundy, Editor, Published by Alaska Sea Grant College Program, University of Alaska at Fairbanks, 2005, ISBN 1-56612-090-X, Paperback, US$25.00.

Sustainable Fossil Fuels, by Mark Jaccard, Cambridge University Press, 2006, pp. 381, ISBN 0-521-67979-6, Paperback, US$24.99.

The Arctic Climate System, by Mark C. Serreze and Roger G. Barry, Cambridge University Press, 2006, pp. 385, ISBN 0-521-81418-9, Hardback, US$130.00.

Avoiding Dangerous Climate Change, edited by Hans Joachim Schellnhuber, Wolfgang Cramer, Nebojsa Nakicenovic, Tom Wigley and Gary Yohe, Cambridge University Press, 2006, pp. 392, ISBN 0-521-86471-2, Hardback, US$130.00.

Carbon Dioxide Capture and Storage, Intergovernmental Panel on Climate Change, Cambridge University Press, 2005, pp. 431, ISBN 0-521-68551-6, Paperback, US$70.00.

Arctic Climate Impact Assessment (ACIA), ACIA - Scientific Report, Cambridge University Press, 2005, pp. 1042, ISBN 0-521-86509-3, Hardback, US$200.00.

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If you are interested in reviewing one of these books for the *CMOS Bulletin SCMO*, please contact the Editor at the e-mail address provided below. Of course, when completed, the book is yours. Thank you in advance for your collaboration.

Si vous êtes intéressés à faire la critique d'un de ces livres pour le *CMOS Bulletin SCMO*, prière de contacter le rédacteur-en-chef à l'adresse électronique mentionnée ci-dessous. Bien entendu, le livre vous appartient lorsque vous avez terminé la critique. Merci d'avance pour votre collaboration.

Paul-André Bolduc, Editor / Rédacteur-en-chef
CMOS Bulletin SCMO
bulletin@cmos.ca or/ou bulletin@scmo.ca

REMINDER - REMINDER - REMINDER

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

Next Issue *CMOS Bulletin SCMO*

Next issue of the *CMOS Bulletin SCMO* will be published in **August 2006**. Please send your articles, notes, workshop reports or news items before **July 3, 2006** to the address given on page ii. We have an URGENT need for your written contributions.

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Prochain numéro du *CMOS Bulletin SCMO*

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en **août 2006**. Prière de nous faire parvenir avant le **3 juillet 2006** vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée à la page ii. Nous avons un besoin URGENT de vos contributions écrites.

Background Information

With the election of a new government in Ottawa, the controversy about climate change has gained a new impetus. Different parties are once more debating in public their point of view, wanting to make theirs first and most visible.

Although acknowledging this new background, the CMOS position on Climate Change is still basically the same as stated in the CMOS Policy Statement on Climate Change (Reference *CMOS Bulletin SCMO*: Vol.27, No.6, page 189, December 1999 and Vol.30, No.3, page 93, June 2002).

The CMOS Open Letter was sent to the PM, the Minister of Environment, the Minister of Natural Resources and the Minister of Fisheries and Oceans, as well as a number of media contacts. CMOS received acknowledgement only from the office of the PM.

For the benefit of our readers, we are reproducing here the letter sent by CMOS to Prime Minister Stephen Harper last April.

CMOS Bulletin Editorial Board

CMOS Open Letter to PM

20 April 2006

The Right Honourable Stephen Harper, P.C., M.P.
Prime Minister of Canada
Ottawa, ON K1A 0A3

Dear Prime Minister,

The Canadian Meteorological and Oceanographic Society (CMOS), a non-profit scientific organization which represents over 800 Canadian atmospheric and oceanic scientists and professionals, wishes to refute some of the statements made by the authors of an open letter to you in the National Post, April 6, 2006 titled "Open Kyoto to debate". We would also like to comment on their request for public-consultation sessions to examine the scientific foundation of the federal climate-change plans. We fully endorse the views expressed to you in a second open letter dated April 19 sent by over 90 Canadian climate science leaders.

Contrary to the statement "no formal, independent climate-science review has been conducted in Canada", Canadian climate scientists from universities, government and the private sector have participated actively in an international review conducted by the Intergovernmental Panel on Climate Change (IPCC). This panel is comprised of thousands of experts from all over the world including some of those listed in the open letter. The IPCC assessments are based on strict evaluations and open reviews of all aspects of published global climate change science. Through the IPCC, Canada has benefited from access to the best climate science expertise available not only in Canada, but around the world. Climate knows no boundary. Climate science knows no boundary.

The authors claim that there is no 'consensus' among climate scientists. They are confusing 'consensus' with 'unanimity'. A consensus is a majority view, and the IPCC reports reflect the majority view of climate scientists. The view, or 'consensus', as expressed in the Third IPCC Assessment Report, is that "*There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."* CMOS fully endorses this conclusion.

The authors are equating 'emerging science' with 'unproven science'. Few fields of study undergo the periodic and rigorous evaluation to which climate change science has been submitted through the IPCC assessments. Nearly 20 years ago the IPCC was established by the UN and the WMO in response to rising concerns over climate change, and in that period there has been a monumental increase in our scientific understanding of the phenomena.

CMOS is a strong advocate of public education on the subjects of atmospheric and oceanographic sciences. Also, it believes that governments must take important decisions that will have to be supported by the electorate and, therefore, a well-informed public is essential. CMOS supports the idea of <u>public information</u> sessions on the subject of climate change. However, we do not believe that <u>public consultation</u> sessions are a credible means of <u>assessing the science</u> of climate change. With its review of all published peer-reviewed science available in the public domain, the IPCC assessment reports truly reflect our current understanding of the complex issue of climate change. CMOS recommends that these reports, and not public consultations, must be the scientific underpinning for your government's decisions on the Kyoto Protocol.

Yours sincerely,

Susan K. Woodbury, ACM, FCMOS
President

cc: Honourable Rona Ambrose, Minister of the Environment

cc: Honourable Gary Lunn, Minister of Natural Resources

cc: Honourable Loyola Hearn, Minister of Fisheries and Oceans.

Information complémentaire

Avec l'élection d'un nouveau gouvernement à Ottawa, la polémique sur les changements climatiques a repris de la vigueur. Les différents protagonistes débattent de nouveau en public, faisant valoir leur point de vue et désirant le rendre visible.

Reconnaissant cette nouvelle donne, la position de la SCMO sur les changements climatiques demeure essentiellement la même que celle spécifiée dans l'énoncé de politique de la SCMO sur les changements climatiques (Référence *CMOS Bulletin SCMO*, Vol.27, No.6, page 188, décembre 1999 et Vol.30, No.3, page 94, juin 2002).

La lettre ouverte de la SCMO a été envoyée au Premier ministre, au Ministre de l'Environnement, au Ministre des ressources naturelles, au Ministre de Pêches et Océans ainsi qu'à certains médias.

Seul le bureau du Premier ministre a envoyé un accusé de réception à la SCMO.

Pour le bénéfice de nos lecteurs, nous reproduisons ici la lettre envoyée par la SCMO au Premier ministre Stephen Harper au mois d'avril dernier.

Conseil de rédaction du CMOS Bulletin SCMO

Lettre ouverte de la SCMO au PM

Le 20 avril 2006

Le très honorable Stephen Harper, P.C., M.P.
Premier ministre du Canada
Ottawa, ON K1A 0A3

Monsieur le Premier ministre,

La Société canadienne de météorologie et d'océanographie (SCMO), une organisation scientifique à but non lucratif qui représente plus de 800 scientifiques et professionnels canadiens du domaine des sciences atmosphériques et océanographiques, désire réfuter certaines des déclarations faites par les auteurs d'une lettre ouverte qui vous était destinée dans le *National Post* du 6 avril 2006, sous le titre de "Open Kyoto to debate". Nous aimerions également commenter leur demande pour des sessions de consultation publique visant à examiner le fondement scientifique des projets fédéraux concernant les changements climatiques. Nous appuyons totalement les opinions qui vous ont été exprimées dans une deuxième lettre ouverte datée du 19 avril et envoyée par plus de 90 leaders canadiens du domaine des sciences du climat.

Contrairement à la déclaration qui dit qu' «aucune revue formelle et indépendante des sciences du climat a été menée au Canada», des scientifiques canadiens du domaine des sciences du climat provenant d'universités, du gouvernement et du secteur privé ont participé activement à une revue internationale menée par le Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC). Ce groupe est composé de milliers d'experts de partout à travers le monde dont certains figurent comme signataires de la lettre ouverte. Les examens du GIEC sont basés sur des évaluations strictes et des revues ouvertes portant sur tous les aspects publiés au sujet du changement du climat de la planète. Grâce au GIEC, le Canada a bénéficié d'un accès à la meilleure expertise du domaine des sciences du climat disponible non seulement au Canada, mais aussi à travers le monde. Le climat ne connaît pas de frontières tout comme, d'ailleurs, les sciences du climat.

Les auteurs prétendent qu'il n'y a pas de ''consensus'' parmi les scientifiques du climat. Ils confondent ''consensus'' avec ''unanimité''. Un consensus est l'opinion de la majorité, et les rapports du GIEC reflètent l'opinion de la majorité des scientifiques du climat. L'opinion, ou le ''consensus'', tel qu'il est exprimé dans le Troisième rapport d'évaluation du GIEC, se résume ainsi : «*Il y a de nouvelles et solides preuves que le réchauffement de la planète observé depuis les 50 dernières années est attribuable en grande partie aux activités humaines »*. La SCMO appuie totalement cette conclusion.

Les auteurs assimilent la ''science émergente'' avec la ''science non prouvée''. Peu de champs d'études subissent l'évaluation périodique et rigoureuse à laquelle la science du changement climatique a été soumise pendant les évaluations du GIEC. Il y a près de 20 ans, le GIEC a été mis sur pied par l'ONU et l'OMM en réponse aux inquiétudes grandissantes concernant les changements climatiques, et, durant cette période, il y a eu une augmentation monumentale de la compréhension scientifique du phénomène.

La SCMO encourage ardemment l'éducation du public sur le thème des sciences atmosphériques et océanographiques. Elle croit également que les gouvernements doivent prendre des décisions importantes qui devront être soutenues par l'électorat. Par conséquent, il est essentiel que le public soit bien informé. La SCMO soutient l'idée d'offrir des sessions d'information publiques sur le thème des changements climatiques. Cependant, nous ne croyons pas que des sessions de consultation du public constituent un moyen crédible pour évaluer la science des changements climatiques. Les rapports d'évaluation du GIEC, basés sur une revue de la littérature scientifique disponible dans le domaine public et révisée par des pairs, reflètent vraiment notre compréhension actuelle du problème complexe que représentent les changements climatiques. La SCMO recommande que ces rapports, et non des consultations publiques, constituent le fondement scientifique pour les décisions de votre gouvernement concernant le Protocole de Kyoto.

Recevez, Monsieur le Premier Ministre, nos salutations distinguées.

Susan K. Woodbury, ACM, FCMOS
Présidente

c.c. L'honorable Rona Ambrose, Ministre de l'Environnement

c.c. L'honorable Gary Lunn, Ministre des Ressources Naturelles

c.c. L'honorable Loyola Hearn, Ministre des Pêches et Océans.

From the Johns Hopkins University Press Release March 6, 2006

Hurricanes, Other Vortices Seize Energy via "Hostile Takeovers"

Research Could Lead to Better Understanding of Typhoons and Oceanic Flows

For decades, scientists who study hurricanes, whirlpools and other large fluid vortices have puzzled over precisely how these vast swirling masses of gas or liquid sustain themselves. How do they acquire the energy to keep moving? The most common theory sounded like it was lifted from Wall Street: The large vortices collect power as smaller vortices merge and combine their assets, in the same way that small companies join forces to create a mega corporation.

But researchers from The Johns Hopkins University and Los Alamos National Laboratory now believe the better model is a much different business tactic: the hostile takeover. Working with theoretical analysis, computer simulations and lab experiments, the team has concluded that large fluid vortices raid their smaller neighbors in an energy grab and then leave their depleted victims either to wither away or to renew their resources by draining still smaller vortices.

The findings were published in the March 3 issue of the journal Physical Review Letters. "This discovery is important because it could lead to a better understanding of how hurricanes and large ocean eddies form," said Shiyi Chen, an author of the paper. "It should also help us to create better computer models to make more accurate predictions about these conditions."

Chen is a professor in the Department of Mechanical Engineering at Johns Hopkins, where he occupies the Alonzo G. Decker Jr. Chair in Engineering and Science. He supervised the computer simulations in this two-and-a-half-year research project.

The team looked at large energetic vortex structures that form in irregular or turbulent two-dimensional flows of gas or liquid. Common examples are the Red Spot on Jupiter and hurricanes or typhoons on Earth. The researchers wanted to figure out how energy is transferred from smaller vortices to these large scale circulation patterns. The basic phenomenon, called "inverse energy cascade," was predicted almost 40 years ago by pioneering turbulence theorist Robert H. Kraichnan. However, the dynamical mechanism underlying the inverse cascade has remained obscure. Does it occur, as some scientists suggested, through a merger of small vortices to form a new larger one?

"We went into this with an open mind, but we found that the popular idea of mergers was not correct," said Gregory Eyink, a Johns Hopkins professor of applied mathematics and statistics and currently the 2006 Ulam Scholar at Los Alamos Laboratory's Center for Nonlinear Studies.

He said the energy transfer actually occurs through a process described as a "thinning mechanism."

"You have a large vortex spinning around, with a smaller one inside," Eyink said. "The large vortex has a shearing effect on the smaller one, like cake batter being stirred. The large scale vortex acts like a giant mixer, stretching and thinning out the smaller one, transferring its energy into the larger vortex. The large scale vortex actually acts like a vampire, sucking the energy out of the smaller one."

This phenomenon sustains a steady state inverse energy cascade. "We end up with a group of large predator vortices preying on smaller ones, which in turn prey on smaller ones still, forming a food chain of vortices," Eyink said.

Through computer modeling at Johns Hopkins and laboratory experiments at Los Alamos on thin salt water layers, the scientists were able to observe the physical processes and measure the energy transfer. This confirmed their theory that an energy transfer by stretching of small scale vortices is what sustains large scale vortices.

"This is the first time a quantitative connection has been made between the process of vortex thinning and inverse energy cascade," said Robert Ecke, director of the Center for Nonlinear Studies at Los Alamos, an author of the journal article and supervisor of the lab experiments.

The team's research was supported by grants from the National Science Foundation and the U.S. Department of Energy. Co-authors include Michael Rivera of the Los Alamos Materials Science and Technology Division; and Minping Wan and Zuoili Xiao, both graduate students in the Department of Mechanical Engineering at Johns Hopkins.

Related links:

• Johns Hopkins Department of Mechanical Engineering: http://www.me.jhu.edu/

• Johns Hopkins Department of Applied Mathematics and Statistics: http://www.ams.jhu.edu/

• Los Alamos National Laboratory: http://www.lanl.gov/

The Extratropical Transition of Tropical Storm *Ophelia* (2005): Summary of Forecasts and Meteorological Observations

by Chris Fogarty[1]

Résumé (traduit par la direction): Le 6 septembre 2005, l'ouragan *Ophelia* est né d'une dépression tropicale qui s'est développée sur le nord-ouest des Bahamas (voir figure 1). Le 8 septembre, à l'est du cap Canaveral en Floride, *Ophelia* a atteint le statut d'ouragan avec des vents de près de 65 nœuds. Après s'être immobilisée à cet endroit, la tempête s'est affaiblie pour atteindre la force d'une tempête tropicale. Par la suite, en se déplaçant vers le nord, elle a repris le statut d'ouragan (Vents Soutenus Maximaux (VSM) de 75 nœuds) avec un Minimum de Pression au Niveau de la Mer (MPNM) de 977 mb, le 10 septembre. L'ouragan *Ophelia* s'est affaibli à nouveau lorsqu'il s'est immobilisé bien au sud du cap Hatteras. Le 13 septembre, à l'abri de la remontée d'eau froide, la tempête a commencé à se déplacer vers la côte de la Caroline du Sud et a repris encore une fois la force d'un ouragan. Celui-ci s'est déplacé lentement vers le nord, puis vers le nord-est, et les 14 et 15 septembre, il a longé, parallèlement, les bancs au large de la Caroline du Nord avec des VSM atteignant 80 nœuds et un MPNM de 979 mb. Le 16 septembre, l'ouragan *Ophelia* s'est affaibli pour devenir une tempête tropicale et commencer son accélération vers le nord-nord-est. Pendant ce temps, les premiers stades de la Transition Extratropicale (TE) commençaient à se produire lorsque l'air sec, provenant de l'ouest, a débuté sa pénétration dans le déplacement de la tempête. Le 17 septembre, la tempête a continué d'accélérer vers le nord-est pendant que la configuration des nuages épais a subi un fort cisaillement vers le nord-est dû aux vents en altitude. Les VSM ont chuté à 45 nœuds au moment où la tempête se déplaçait, pas très loin, au sud de l'ouest de la Nouvelle-Écosse. Le 18 septembre à 06 TUC environ, la tempête a touché le sol près de Sheet Harbour, Nouvelle-Écosse et a été déclarée une tempête extratropicale (post-tropicale). L'ex-ouragan, devenu une dépression, a traversé l'est de Terre-Neuve le 18 septembre.

1. Storm history

Hurricane *Ophelia* formed from a tropical depression that developed over the northwestern Bahamas on 06 September 2005 (see Fig. 1). *Ophelia* first attained hurricane status with winds near 65 knots on 08 September east of Cape Canaveral, Florida. After stalling there, the storm weakened back to tropical storm strength, and then moved to the north where it regained hurricane status (maximum sustained winds (MSW) near 75 knots) with a minimum sea level pressure (MSLP) of 977 mb on 10 September. *Ophelia* then weakened while stalled well south of Cape Hatteras. On 13 September the storm began to move toward the South Carolina coast, away from the cool water it had upwelled, and regained hurricane strength once again. The hurricane moved slowly toward the north, then northeast, paralleling the outer banks of North Carolina on 14 and 15 September with MSW reaching 80 knots and a MSLP of 979 mb.

On 16 September, *Ophelia* weakened to a tropical storm and began accelerating toward the north-northeast. During this time, the early stages of extratropical transition (ET) were beginning to take place as dry air began wrapping into the storm circulation from the west. The storm continued to accelerate toward the northeast on 17 September while the deep cloud pattern became heavily sheared toward the northeast by upper-level winds. The MSW dropped to 45 knots as it tracked not far south of western Nova Scotia. The storm made landfall near Sheet Harbour, Nova Scotia near 06 UTC 18 September by which time it was declared an extratropical (post-tropical) storm. The remnant low pressure area crossed eastern Newfoundland on 18 September.

2. Synoptic analysis

Figure 2 shows a composite of satellite images from late on 16 September as *Ophelia* was beginning to undergo ET. Conventional GOES-12 infrared and visible images, shown in panels a and b, reveal a front or "cloud tail" forming to the south of the storm. Passive microwave imagery from the Special Sensor Microwave/Imager (SSM/I) instrument, shown in panels c and d, indicate that the deep, rain-producing convection had shifted toward the northeast sector of the storm. The red colours (in the colour version) of Fig. 2d denote the heavy precipitation area while shallower cloud/moisture shows up as green tones (colour version). A more complete explanation of the microwave imagery and how to interpret it is available at the Naval Research Laboratory tropical cyclone page at http://www.nrlmry.navy.mil/tc_pages/tc_home.html.

A research aircraft was also investigating Tropical Storm *Ophelia* near the time valid in the satellite images. Data from dropsondes showed that dry air was wrapping around the storm centre from the west, encircling ¾ of the storm core. This was also apparent in land-based radar at 18 UTC 16 September (hereafter 18/16) shown in Fig. 3. The radar and satellite signatures became much more "ragged" by 21/16, a sign that the storm was weakening. More information and analyses from the dropsondes will be presented in the following section.

[1] Canadian Hurricane Centre
Dartmouth, NS, Canada

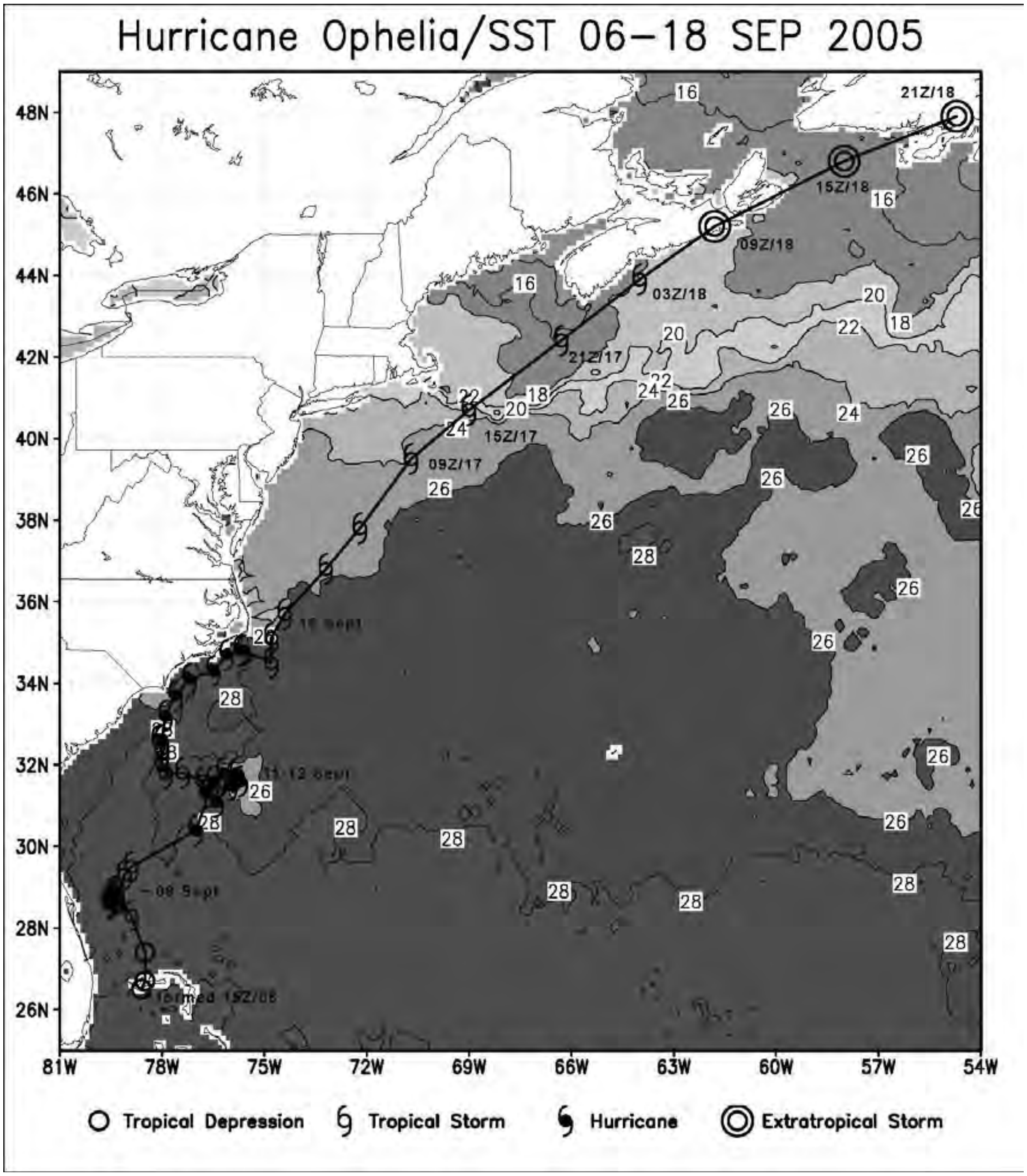

Fig. 1. Storm track for Hurricane Ophelia from National Hurricane Center and Canadian Hurricane Centre bulletins. Sea surface temperature analysis from the National Environmental Satellite, Data, and Information Service at http://www.class.noaa.gov/nsaa/products/welcome (contoured every 2°C) valid at 00/16 is also shown.

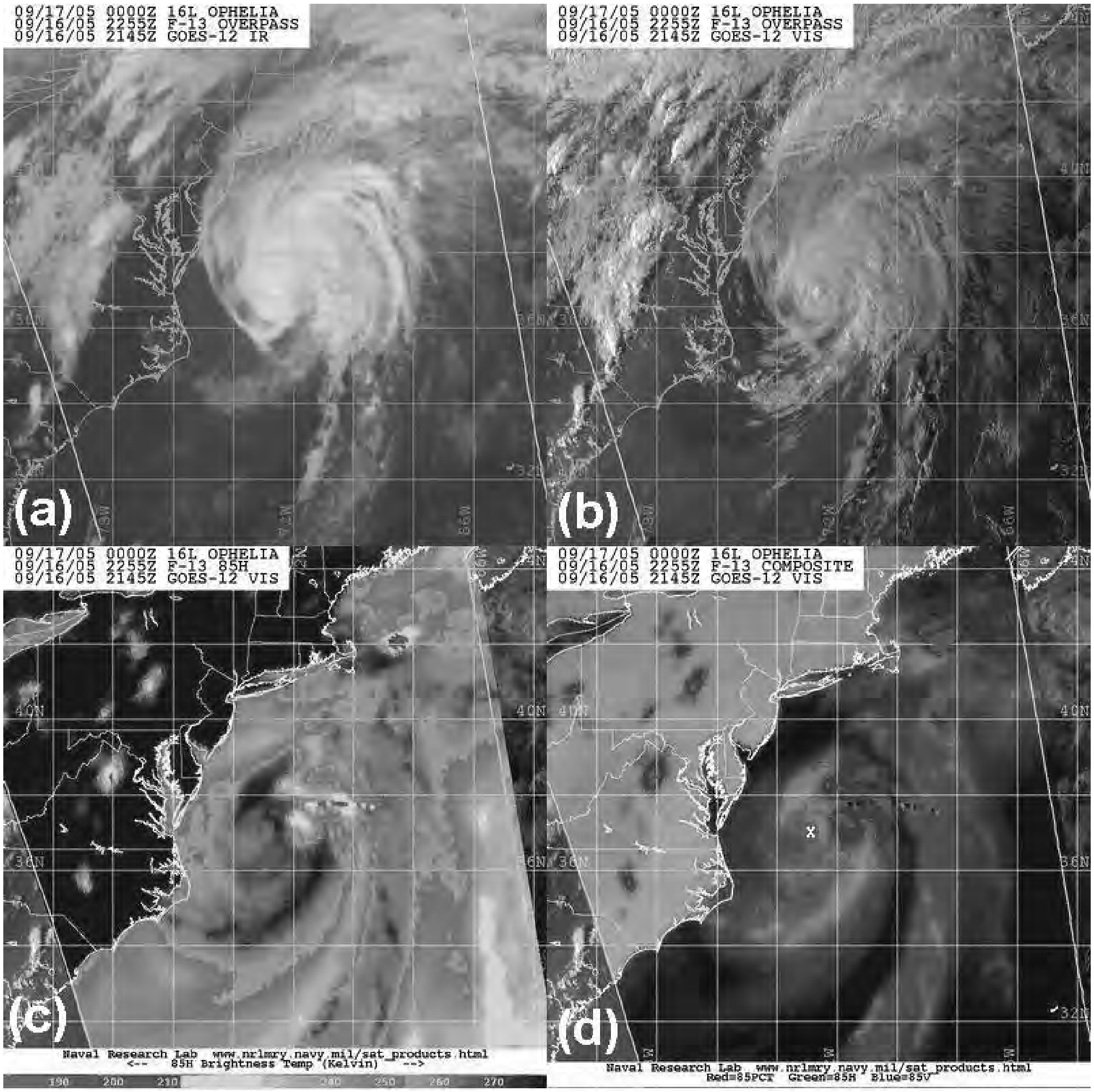

Fig. 2. Multisensor satellite imagery from the Naval Research Laboratory tropical cyclone webpage from 2145/16 and 2255/16. The location of the surface centre of TS Ophelia is indicated with a white X in panel d.

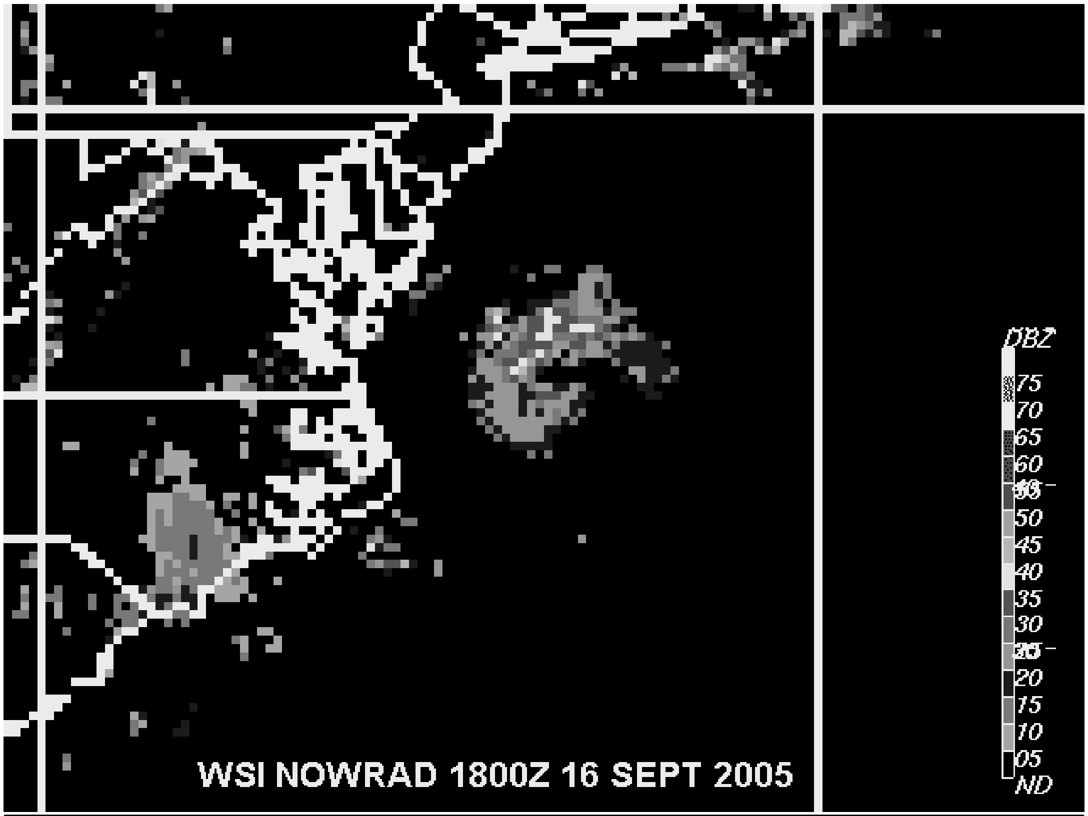

Fig. 3. WSI NOWRAD radar reflectivity valid at 18/16.

Analyses of sea level pressure and 500-mb geopotential heights and vorticity valid at 00/17 are shown in Fig. 4. Images are from the DIFAX archive of weather charts at the Canadian Meteorological Centre (CMC). In Fig. 4a, a baroclinic wave and associated low pressure area were situated over western Pennsylvania, while a 500-mb trough was migrating eastward across the Great Lakes (Fig. 4b). A general northeastward flow was seen in the vicinity of *Ophelia*, which was responsible for moving the storm in a direction toward Nova Scotia.

The low level circulation of *Ophelia* had become completely exposed by the morning of 17 September when the storm was passing to the southeast of Cape Cod. Satellite imagery from GOES and the SSM/I in Fig. 5 show the sheared cloud pattern. Deep convection and precipitation was confined to the north-northeast of the low-level centre, which can be discerned from the curvature in low-level cloud bands in Fig. 5d (green tones in colour version). Throughout the day, the shear appeared to become more westerly. For instance, the skewness of deep convection had rotated anticyclonically to the east-northeast of the low level centre. This is consistent with the storm moving faster than the shortwave trough over the Great Lakes and beginning to move into the more zonal flow pattern closer to a ridge located downstream near Newfoundland.

By 00/18, *Ophelia* had almost completed transition to an extratropical low. Analyses of sea level pressure and 500-mb geopotential heights and vorticity from CMC valid at 00/18 are shown in Fig. 6. The centre of *Ophelia* was moving south of Nova Scotia at that time, with a quasi-stationary warm front situated north of the storm's circulation (Fig. 6a) where heavy rain had been falling throughout much of the day on 17 September. At the time of aircraft observations (17-22 UTC) and based on the 500-mb analysis, the circulation centre of *Ophelia* no longer existed at that level. The top of the storm had essentially been blown off. Also, the storm moved out ahead of the 500-mb shortwave trough as shown in Fig. 6b, leading to a more eastward track.

The centre of post-tropical storm *Ophelia* arrived at the coast on the eastern mainland of Nova Scotia and moved very near a private weather station operated by Danny McInnis in the Country Harbour area of Guysborough County. Figure 7 shows a sea level pressure trace from that station, showing the gradual fall and rise of pressure. This is evidence that the once tight pressure pattern of the tropical storm had broadened, and thus had undergone ET.

Occasionally the weather office will prepare summaries of weather events, such as tropical cyclones. These summaries are usually brief, and serve as a timely source of information for media. Table 1 shown above is the operational storm summary for this event, prepared by the hurricane forecasters, with wind and rainfall data.

Table 1: Operational storm summary for Tropical Storm *Ophelia* prepared by the hurricane forecasters including wind and rainfall data.

AWCN11 CWHX 190048
SPECIAL STORM SUMMARY MESSAGE FOR NOVA SCOTIA ISSUED BY ENVIRONMENT CANADA AT 9:48 PM ADT SUNDAY 18 SEPTEMBER 2005.

TROPICAL STORM *OPHELIA* TRACKED JUST SOUTH OF WESTERN NOVA SCOTIA AND HALIFAX SATURDAY NIGHT AND MADE LANDFALL AS A POST-TROPICAL STORM NEAR SHEET HARBOUR..HALIFAX COUNTY WITH MAXIMUM SUSTAINED WINDS OVER WATER NEAR 45 KNOTS. THE CENTRE WENT OVER SYDNEY THEN MOVED THROUGH SOUTHEASTERN NEWFOUNDLAND SUNDAY EVENING.

THE PREDICTED HEAVY RAINFALLS DID OCCUR FOR THE MOST PART..HOWEVER..STRONG WINDS WERE NOT EXPERIENCED OVER NOVA SCOTIA BECAUSE THE STORM GENERALLY TRACKED SOUTH OF THE PROVINCE WHICH WAS FURTHER SOUTH THAN WE EXPECTED BEFORE THE WEEKEND. HAD THE TRACK BEEN A BIT FURTHER NORTH..THERE WOULD VERY LIKELY HAVE BEEN SOME HIGH WIND GUSTS OVER NOVA SCOTIA. THE STRONGEST WIND GUST IN NOVA SCOTIA WAS 80 KM/H FROM THE EAST-SOUTHEAST..REPORTED AT THE WELL-EXPOSED BEAVER ISLAND WEATHER STATION IN EASTERN HALIFAX COUNTY.

IN NEWFOUNDLAND..THERE WERE SOME STRONG COASTAL WIND GUSTS. AT BURGEO..A GUST OF 96 KM/H WAS REPORTED FROM THE NORTHEAST. THIS WOULD HAVE BEEN A LOCAL EFFECT DUE TO CHANNELING OF WIND FROM HIGHER TERRAIN.

HEAVIEST RAINFALL AMOUNTS WERE OVER NOVA SCOTIA. HERE ARE THE STORM TOTAL RAINFALLS AND MAXIMUM WIND GUSTS FOR SELECTED STATIONS:

	RAINFALL	**WIND GUSTS**	**LAT/LON (minutes)**	**ELEV**
NOVA SCOTIA...				
CAPE SABLE ISLAND	88.0 MM	72 KM/H	43'27N 65'28W	13m
YARMOUTH	69.4 MM	37 KM/H	43'52N 66'06W	9m
KEJIMKUJIK	28.6 MM		44'26N 65'12W	125m
GREENWOOD	20.6 MM	32 KM/H	44'59N 64'55W	28m
WESTERN HEAD	46.0 MM	41 KM/H	43'59N 64'40W	9m
LIVERPOOL	67.3 MM		44'00N 64'50W	90m
SHEARWATER	60.7 MM		44'38N 63'30W	51m
CLAYTON PARK	60.0 MM		44'39N 63'45W	90m
LOWER SACKVILLE	47.0 MM			
OSBORNE HEAD		65 KM/H		
HALIFAX INT'L ARPT	62.0 MM	39 KM/H	44'53N 63'31W	145m
BEAVER ISLAND		80 KM/H		
SYDNEY	31.0 MM	57 KM/H	46'10N 60'03W	62m
NEW GLASGOW	36.8 MM	31 KM/H	45'36N 62'42W	37m
CARIBOU POINT	53.2 MM	44 KM/H	45'46N 62'41W	2m
TRACADIE NS	29.6 MM	54 KM/H	45'33N 61'52W	10m
PARRSBORO	27.6 MM	35 KM/H	45'21N 64'24W	30m
DEBERT	55.0 MM	37 KM/H	45'22N 63'16W	40m
INGONISH BEACH	82.6 MM	65 KM/H	46'38N 60'27W	100m
HART ISLAND		70 KM/H	45'21N 60'59W	4m
NEW BRUNSWICK...				
MONCTON	18.8 MM	41 KM/H	46'07N 64'41W	72m
FREDERICTON	19.5 MM	32 KM/H	45'52N 66'32W	20m
SAINT JOHN	14.0 MM	33 KM/H	45'19N 65'53W	109m
POINT LEPREAU	17.1 MM	52 KM/H	45'04N 66'28W	1m
SAINT STEPHEN	20.7 MM	37 KM/H	45'13N 67'15W	26m
BATHURST	12.0 MM		47'38N 65'45W	59m
ST LEONARD	17.2 MM		47'09N 67'50W	41m
PRINCE EDWARD ISLAND...				
ELMWOOD	42.4 MM			
CHARLOTTETOWN	39.4 MM	28 KM/H	46'17N 63'08W	54m
SUMMERSIDE	39.2 MM	39 KM/H	46'26N 63'50W	21m
EAST POINT	38.7 MM	50 KM/H	46'27N 61'58W	13m
ILES DE LA MADELEINE...				
GRINDSTONE ISLAND	33.6 MM	56 KM/H	47'25N 61'47W	10m

Table 1 (Continued): Operational storm summary for Tropical storm *Ophelia* prepared by the hurricane forecasters including wind and rainfall data.

NEWFOUNDLAND...

	RAINFALL	WIND GUSTS	LAT/LON (minutes)	ELEV
NEW BRUNSWICK...				
MONCTON	18.8 MM	41 KM/H	46'07N 64'41W	72m
FREDERICTON	19.5 MM	32 KM/H	45'52N 66'32W	20m
SAINT JOHN	14.0 MM	33 KM/H	45'19N 65'53W	109m
POINT LEPREAU	17.1 MM	52 KM/H	45'04N 66'28W	1m
SAINT STEPHEN	20.7 MM	37 KM/H	45'13N 67'15W	26m
BATHURST	12.0 MM		47'38N 65'45W	59m
ST LEONARD	17.2 MM		47'09N 67'50W	41m
PRINCE EDWARD ISLAND...				
ELMWOOD	42.4 MM			
CHARLOTTETOWN	39.4 MM	28 KM/H	46'17N 63'08W	54m
SUMMERSIDE	39.2 MM	39 KM/H	46'26N 63'50W	21m
EAST POINT	38.7 MM	50 KM/H	46'27N 61'58W	13m
ILES DE LA MADELEINE...				
GRINDSTONE ISLAND	33.6 MM	56 KM/H	47'25N 61'47W	10m
PORT-AUX-BASQUES	38.5 MM	63 KM/H	47'34N 59'10W	40m
BURGEO	50.6 MM	96 KM/H	47'37N 57'37W	12m
ST LAWRENCE	32.5 MM	67 KM/H	46'55N 55'23W	49m
ARGENTIA	21.8 MM	65 KM/H	47'18N 54'00W	13m
CAPE RACE	17.5 MM	74 KM/H	46'39N 53'04W	28m
SAINT JOHNS	29.0 MM	37 KM/H	47'37N 52'45W	140m
STEPHENVILLE	28.2 MM		48'33N 58'34W	60m
DEER LAKE	13.2 MM		49'13N 57'23W	22m
SAGONA ISLAND		63 KM/H		
GANDER	41.2 MM		48'57N 54'34W	151m
BONAVSITA	37.0 MM	93 KM/H	48'40N 53'07W	29m
TWILLINGATE	15.8 MM			
TERRA NOVA	53.7 MM		48'45N 54'00W	50m

OVER THE OCEAN ..MAXIMUM WINDS OF 40 KNOTS WERE REPORTED BY LAHAVE BANK BUOY WITH A MAXIMUM WAVE OF 11.0 M AS THE STORM PASSED BY TO THE NORTH.

END MCILDOON/FOGARTY

3. Research aircraft observations

Two ET research flights into Tropical Storm *Ophelia* were conducted by the Hurricane Research Division (HRD) in Miami in collaboration with Jim Abraham at the Meteorological Service of Canada using a P3 research aircraft. Several GPS dropsondes were deployed in the vicinity of the storm and its environment during the missions. The first mission was flown on 16 September and the second on 17 September while *Ophelia* was approaching Nova Scotia. More information on these flights can be found on the web at:

http://www.aoml.noaa.gov/hrd/Storm_pages/ophelia2005/mission.html.

As noted in the previous section, signs of ET were evident in satellite imagery and dropsonde profiles on 16 September. A cross section of relative humidity along a southwest-to-northeast transect through the storm centre is shown in Fig. 8. Although the cruising altitude of the aircraft was quite low, there is a hint of tilt toward the north in the humidity pattern below ~700 mb. Drier air can also be seen intruding into the low levels on the north side of the core, consistent with the wrap-around of dry air suggested in the coastal radar (Fig. 3) reflectivity pattern at 18/16. The cross section was constructed from 5 sondes launched between 1713 UTC and 1850 UTC.

A highly asymmetric wind field with considerable boundary layer wind speed shear was observed on the second day of flights. In addition, the aircraft did not observe a circulation at 500 mb. A dropsonde profile of wind speed and direction located ~200 km east-southeast of the storm's surface centre is shown in Fig. 9. Hurricane force winds (33 m s^{-1} / 64 knots) were observed at 200 m above the ocean surface, while winds were much less (18.5 m s^{-1} / 36 knots) at the surface (12 m). This shear was comparable to that observed during Hurricane Michael (Abraham et al. 2004). Had *Ophelia* tracked over land, these winds could have been possible at the surface in the form of wind gusts. This may seem surprising for a 997-mb low, but forecasters should be aware of the likelihood of these strong winds above the boundary layer in transitioning tropical systems, particularly over cool sea surface temperatures where wind shear becomes enhanced. In October, 2001, Tropical Storm *Karen* made landfall over western Nova Scotia as a 998-mb storm, but maximum coastal wind gusts reached 100 km/h (54 knots / 28 m s^{-1}) east of the center in Halifax Harbour. Winds near hurricane force were observed by aircraft near the top of the boundary layer (Fogarty et al. 2002).

4. Summary of numerical model forecasts

Various numerical forecast model results are available to forecasters at the Canadian Hurricane Centre (CHC). Forecasters have access to track and intensity forecasts from models run at various agencies around the world which are available on the internet. The primary numerical guidance in Canada is the Canadian Global Environmental Multiscale (GEM) model. Generally speaking, the GEM model does not predict tropical cyclones very well, primarily due to the scarcity of storm observations necessary to provide good initial conditions for the model. During *Ophelia*, some aircraft data were being assimilated into the model, and since the storm had passed close to the coastal buoy network off Cape Hatteras, more data from the storm region was available for improving the model initial conditions than is normally the case. Therefore, the GEM model appeared to be resolving the storm circulation reasonably well during its forecast cycles; however, it over-predicted *Ophelia*'s intensity and tracked it too far to the north across Nova Scotia.

Track predictions issued at 12/16 from various sources are shown in Fig. 10, showing the storm tracking over or near Nova Scotia. This plot is courtesy of Dr. Krishnamurti at Florida State University (Williford et al. 2003). These models predicted maximum sustained winds between 45 and 55 knots at the 36-HR mark. The Global Forecast System (GFS) model turned out to have one of the best tracks for any of the numerical models for this event.

The operational CHC forecast (discussed in more detail in the following section) followed a scenario that would bring the remnants of *Ophelia* across Nova Scotia (worst case scenario). This situation was being predicted by the GEM model, but did not materialize. The failed forecasts le to many questions following the event.

Several forecasters were (somewhat) surprised by the degree to which the storm became sheared/decoupled. Upon closer inspection of the output from the GEM model, it was no surprise that the storm became sheared apart. For instance, the 24-HR GEM forecast valid at 00/18 depicted the intrusion of dry air into the storm circulation by stronger winds above 700 mb (Fig. 11a). This pattern compares with the cross section of relative humidity from dropsonde data (Fig. 11b). The cross sections were taken along a 350-km line from northwest to southeast, not far ahead of the storm.

Although the model represented the sheared moisture pattern reasonably well, there were some fundamental differences in the "mass fields" compared with data at the surface and aloft. The difference between analyzed sea level pressure from the CMC global analysis and the 24-HR GEM forecast is shown in Fig. 12. The model predicted lower than observed pressures west of the storm and higher than observed pressures to the east. This could explain why the model track had a westward tendency. The 500-mb winds from the CMC analysis valid at 00/18 (which are a good representation of steering flow) had a stronger eastward component than forecast by the model, as shown in Fig. 13.

The GEM model has been noted for tracking tropical type systems too far to the west in the past (personal experience). This happened during the ET of *Wilma* in late October, 2005, and during Hurricane *Michael* in October, 2000 (Abraham et al. 2004, Fogarty 2002). Further study is needed to determine the source of this bias.

5. Summary of Canadian Hurricane Centre forecasts

As with most extratropically-transitioning tropical storms in this region, the CHC had a challenging job forecasting *Ophelia*. This was complicated by the fact that the storm was approaching Nova Scotia at an oblique angle (see track in Fig. 1). The Centre erred on the side of caution with regard to track and intensity guidance by going with the scenario of a 50-kt storm moving along or just inland from the coast of Nova Scotia. This was suggested by the GEM, the Geophysical Fluid Dynamics Laboratory model (GFDL, Bender and Ginis 2000) (see Fig. 10) and an in-house experimental hurricane model using a weak cyclone bogus for initial conditions. A landfalling tropical cyclone of 50 knots typically brings inland gusts to 50 knots or more, which is the threshold for wind warnings in this region. Wind and heavy rainfall warnings were issued for Nova Scotia, Prince Edward Island and parts of southern New Brunswick. In addition, tropical storm warnings were posted for many regions. This was the first time that tropical-type warnings were used in Canada, which generated extra media attention. In hindsight, traditional rainfall warnings would have sufficed given the actual track and extratropical state of the storm.

During the morning of 17 September it became apparent that *Ophelia* was moving faster and farther east than expected. The forecast track was moved just off the coast of Nova Scotia, but most weather warnings were retained *with the expectation that there may be some modest reintensification* in the weakly baroclinic environment. That behaviour was suggested by the GEM and GFDL models, which had been resolving the storm quite adequately up until that time. The strongest winds remained well offshore to the right of the storm's motion, so *Ophelia* would probably had to have tracked over central or northern Nova Scotia for some of those winds to be experienced.

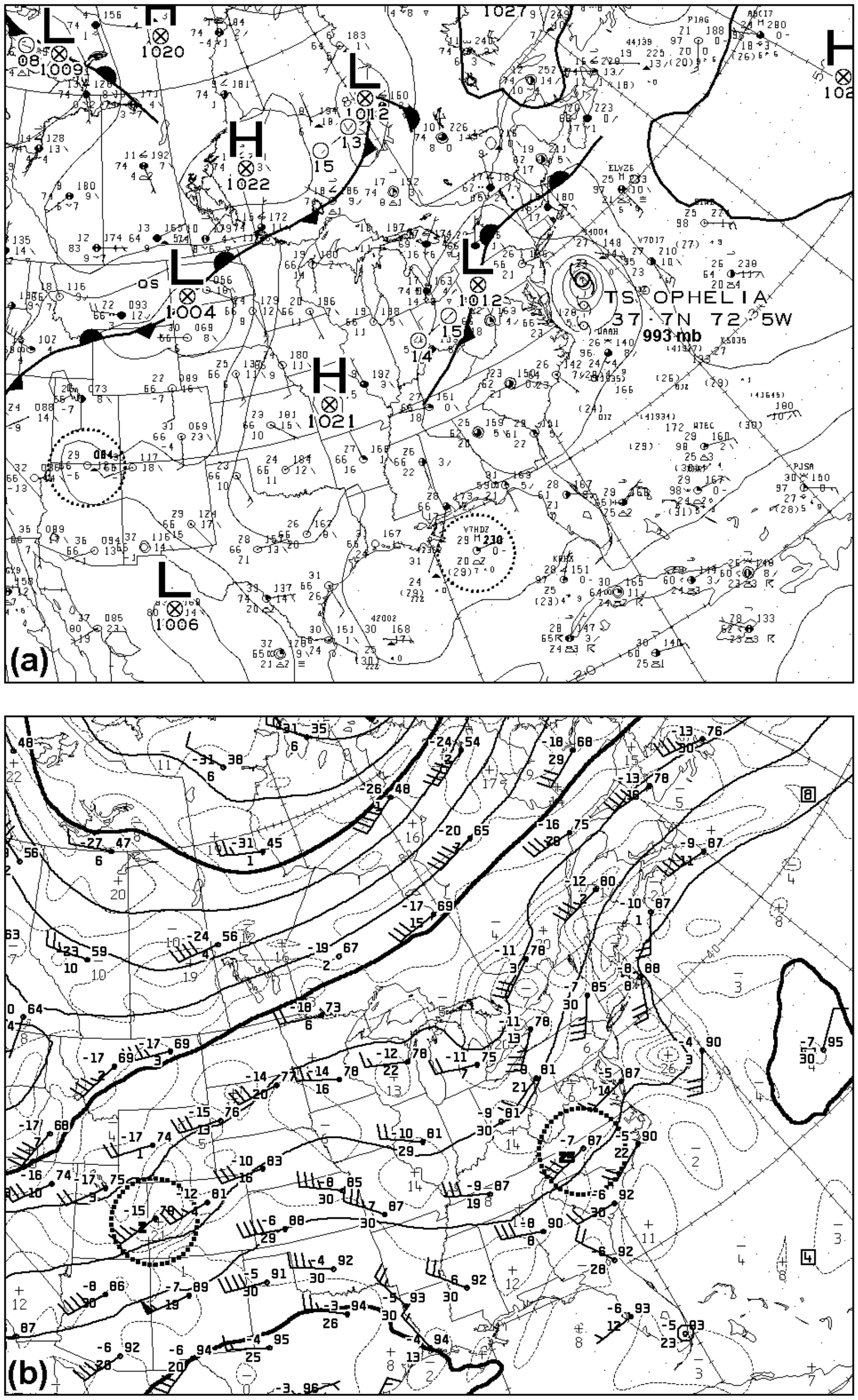

Fig. 4. Surface synoptic weather plot (conventional notation) with sea level pressure analysis (a), and 500-mb geopotential height and vorticity analysis (b), valid at 00/17. Analyses are taken from the Canadian Meteorological Centre DIFAX chart archives.

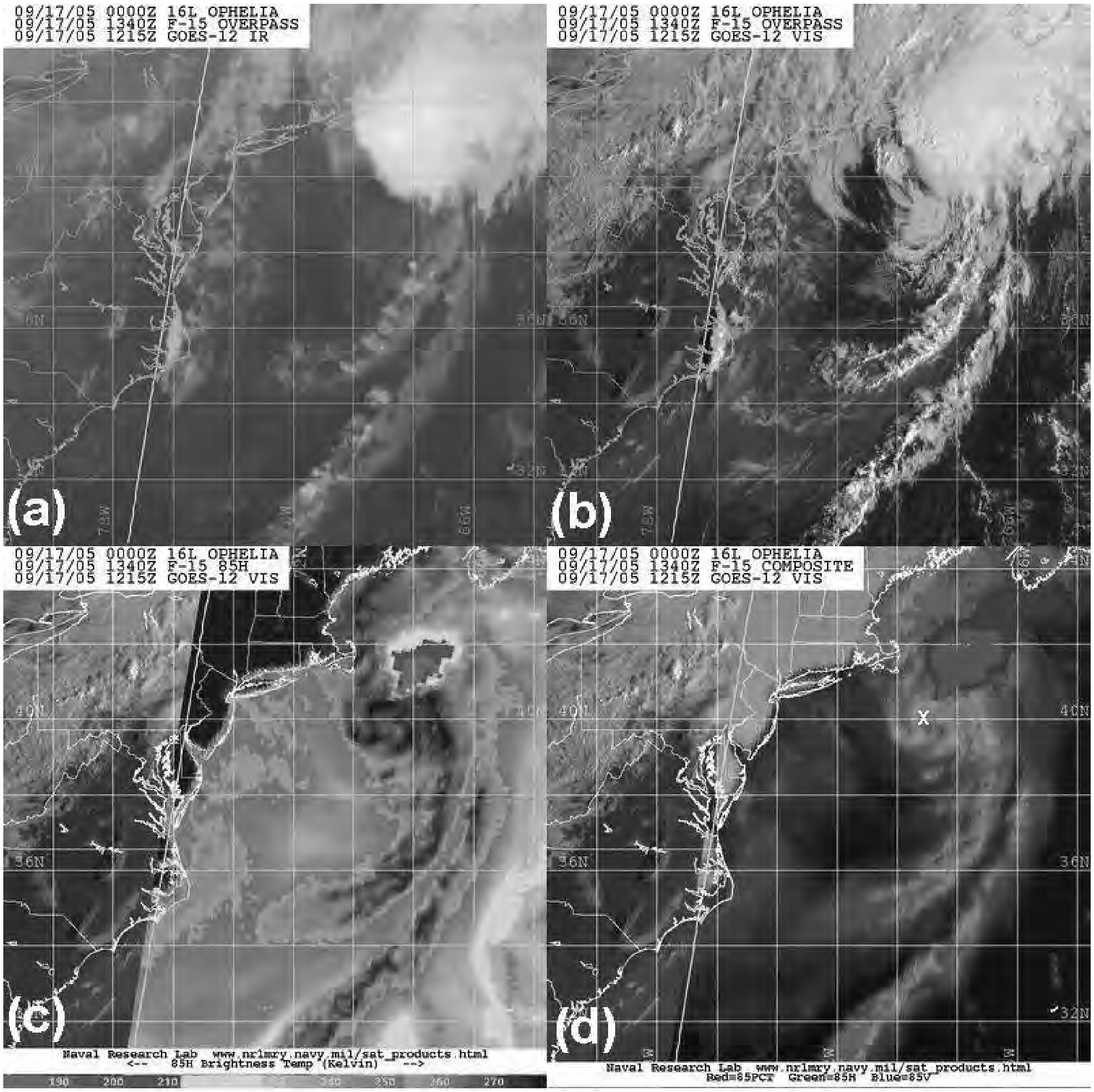

Fig. 5. Multisensor satellite imagery from the Naval Research Laboratory tropical cyclone webpage from 1215/17 and 1340/17. The location of the surface centre of TS Ophelia is indicated with a white X in panel d.

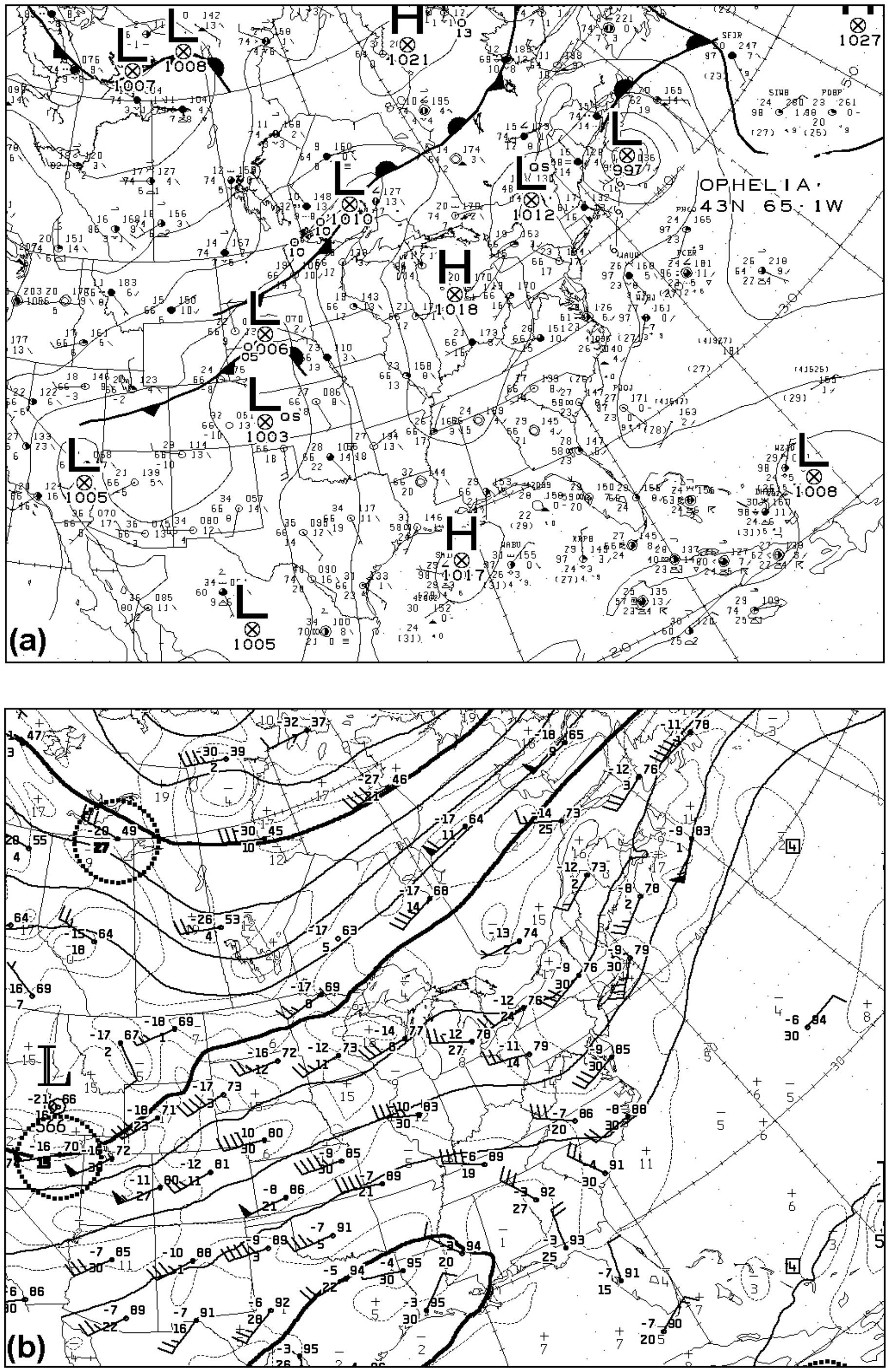

Fig. 6. Surface synoptic weather plot (conventional notation) with sea level pressure analysis (a), and 500-mb geopotential height and vorticity analysis (b), valid at 00/18. Analyses are taken from the Canadian Meteorological Centre DIFAX chart archives.

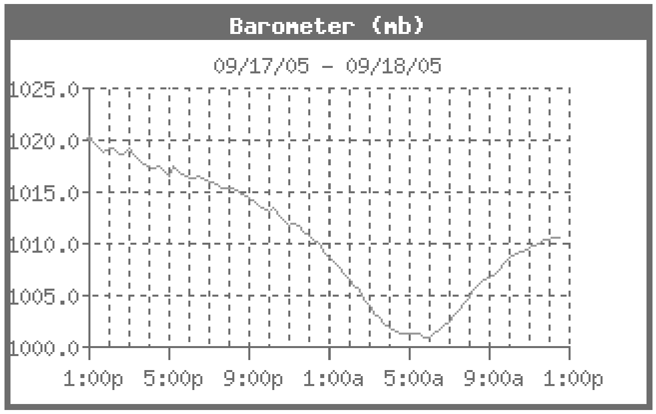

Fig. 7. Sea level pressure trace (mb) versus local time at a private weather station located near where Ophelia made landfall.

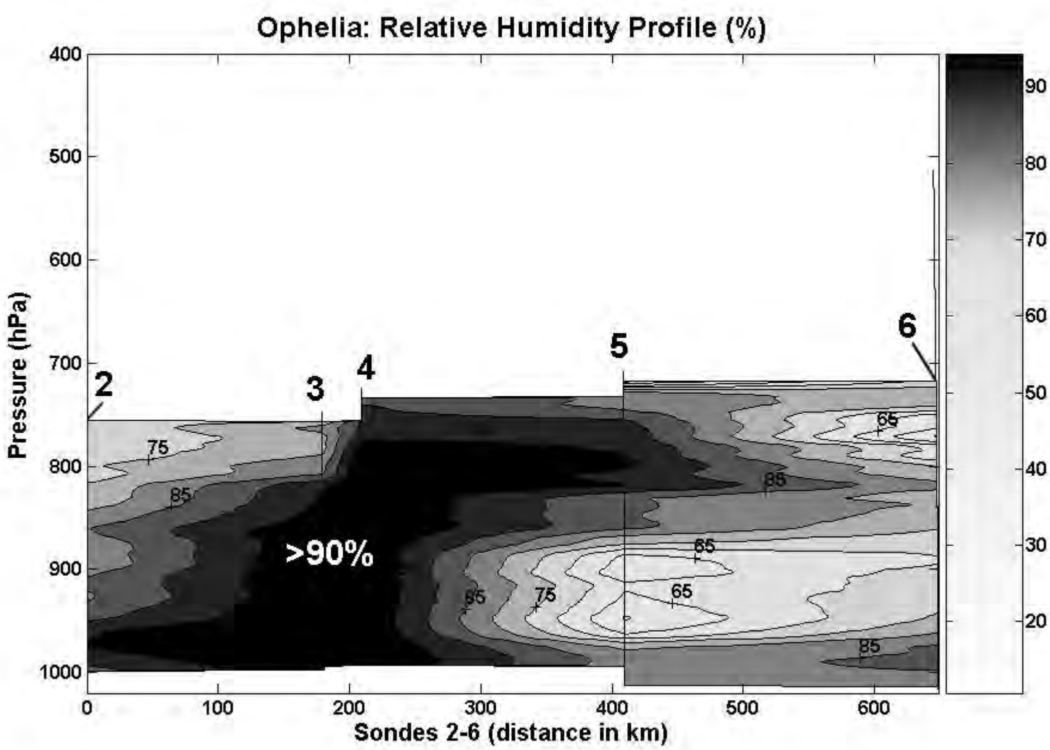

Fig. 8. Cross section (southwest to northeast) of relative humidity (every 5%) from dropsonde data between 1713/16 and 1850/16. Dropsonde locations are shown by numbers (2 through 6) in the plot.

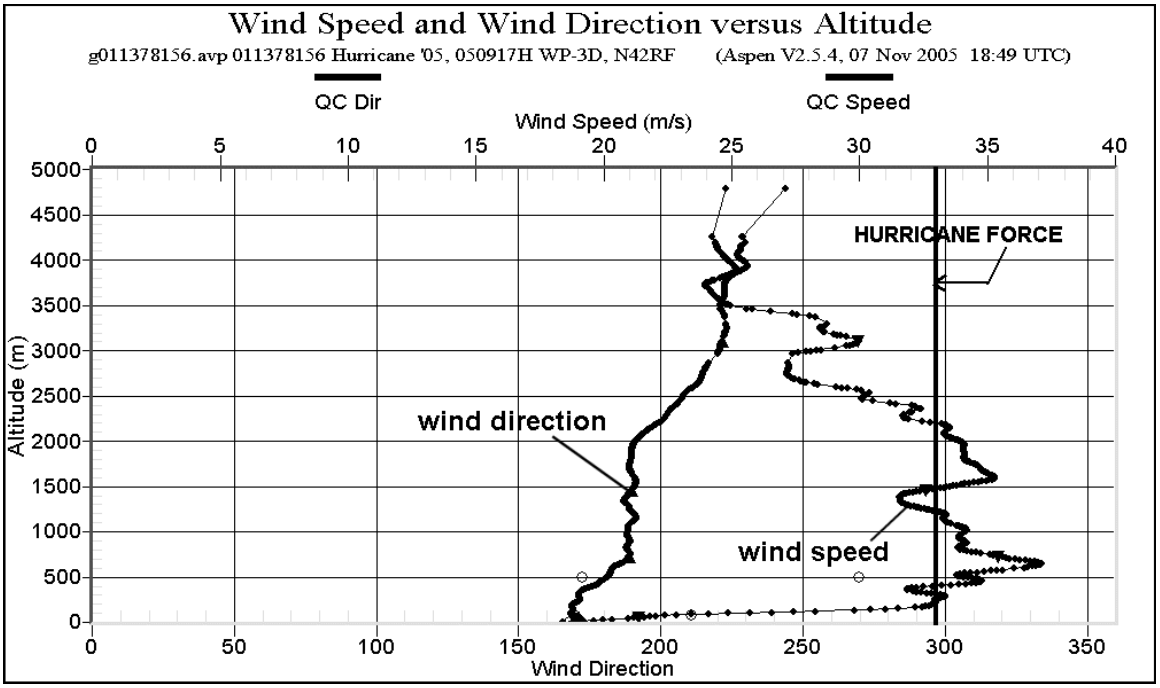

Fig. 9. Vertical wind speed and direction profile from a dropsonde located 200 km east-southeast of the storm centre at 1718/17.

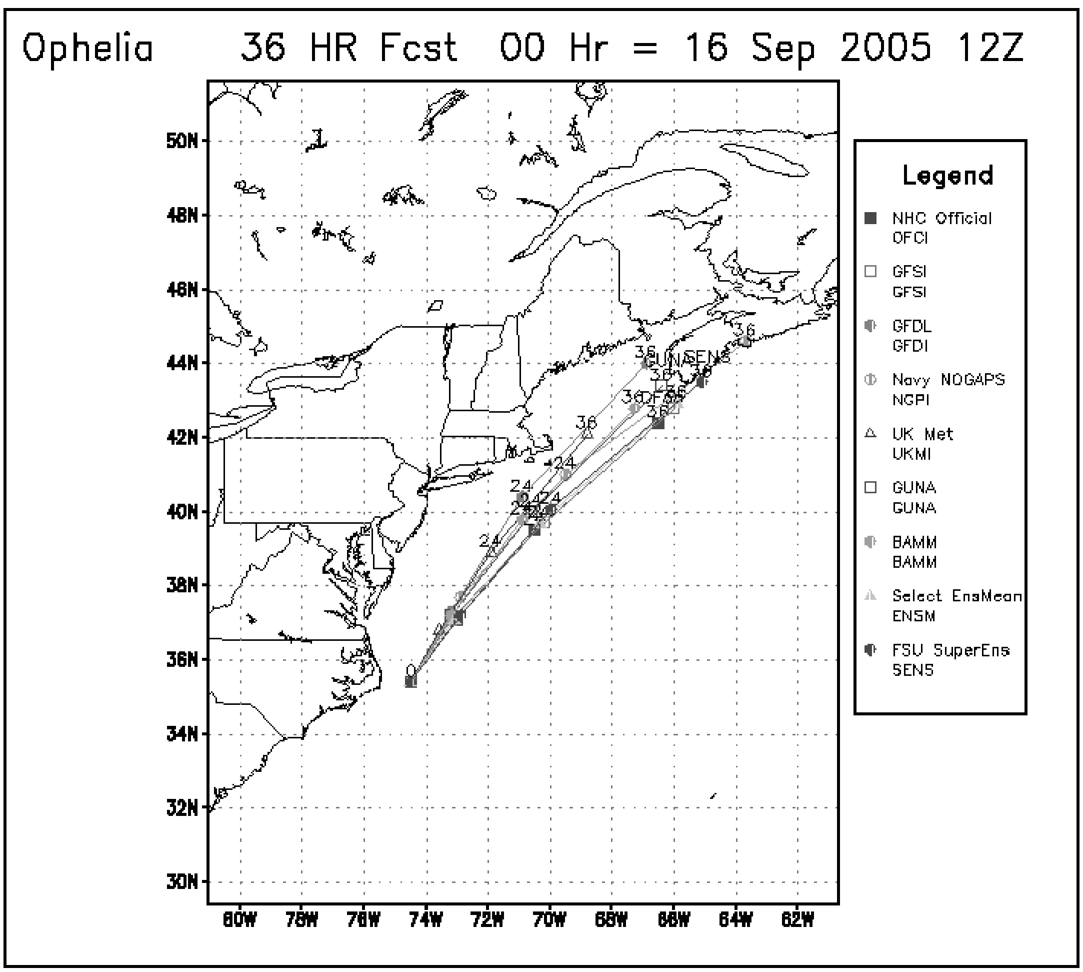

Fig. 10. Track forecasts with initial time 12/16 from various numerical models including the official National Hurricane Center (NHC) forecast and the Florida State Superensemble (FSU).

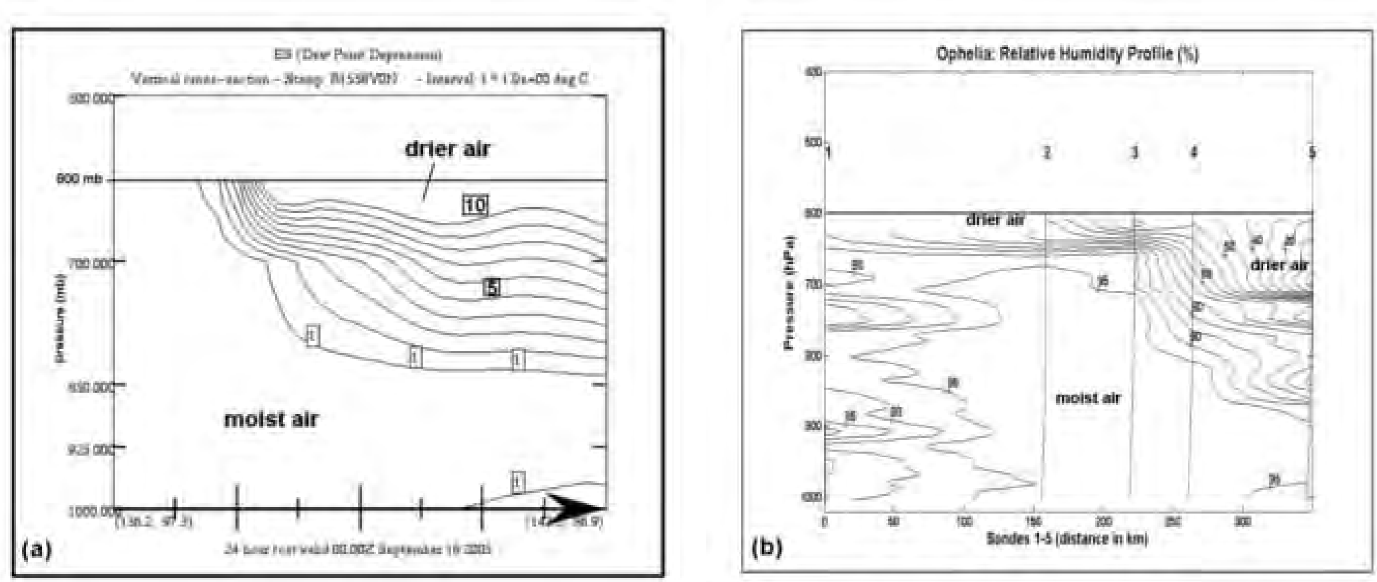

Fig. 11. Cross-sections showing vertical moisture structure ahead of Tropical Storm Ophelia on 16 September: (a) dew point depressions (every 1°C) from the 24-HR GEM forecast, and (b) relative humidity (every 5%) from dropsonde data. Low relative humidity correlates with large dew point depressions. The location of the dropsondes are shown with numbers and vertical lines in panel b. The centre of the storm is near the middle of the cross-sections.

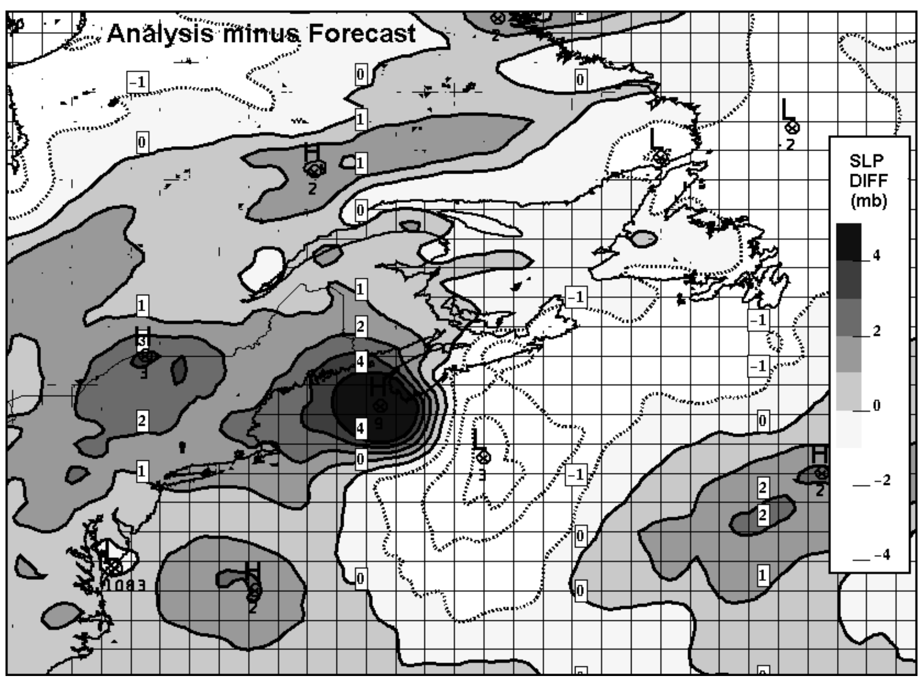

Fig. 12. Difference in sea level pressure between analysis and 24-HR GEM forecast (analysis minus forecast) valid at 00/18. Negative values are outlined with dotted contours (every 1 mb).

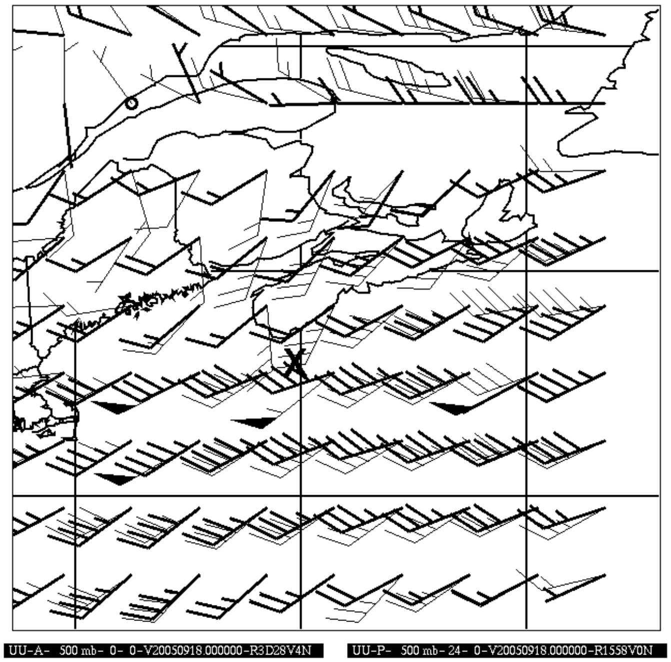

Fig. 13. Plot of 500-mb winds from the CMC analysis (bold barbs) and 24-HR GEM forecast (thin barbs) valid at 00/18. The observed surface position of Ophelia is denoted with a black X. By the time forecasters realized the winds with this system were not going to materialize, it was "too late" - the media had already been going full force with their story of a nasty wind and rain storm forecast to hit Nova Scotia.

In hindsight, the forecast rationale during this event was reasonable and justifiable. Specific lessons learned from this storm are summarized below:

■ Forecasters should be aware of the known westward bias in the GEM model for storms undergoing ET. More study is needed on this.

■ Refrain from speaking of details of impacts until the situation becomes clearer. For example, mention was made of the possibility of tree branches breaking and power outages. The media had blown this out of proportion by occasionally mentioning "trees blowing down" and "widespread power outages". A lot of this is unfortunately outside the forecaster's control.

■ Only initiate tropical-type warnings for high-end tropical storms and hurricanes that are not expected to be well into the ET phase. This is, however, a very difficult and inherently subjective decision. When tropical-type warnings or watches are issued, media interest increases markedly.

■ Begin downplaying the storm as soon as data indicate a less threatening scenario. Quick action was taken during the ET of Wilma once it became clear that it would track well south of inland regions. It is important to react quickly, because there will be a lapse in time before the changes get relayed to the public.

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More analyses and information on this storm are available on the web at:

http://projects.novaweather.net/work.html

RAPPEL - RAPPEL - RAPPEL

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

A Winnipeg F4 Tornado – A Virtual Damage Assessment

by Patrick McCarthy[1], Mike Russo[1] and John Hanesiak[2]

Scénario: (traduit par la direction) Par une journée chaude et humide, sur l'heure du souper, une colonne étroite en forme d'entonnoir, tourbillonnant rapidement, apparaît à la base d'un orage fort près de Headingley, une petite communauté juste à l'ouest de Winnipeg au Manitoba. À la surprise des résidents, la colonne étroite en forme d'entonnoir s'allonge rapidement vers le bas et touche le sol, soulevant les ordures et arrachant les récoltes dans un champ tout près. La colonne tourbillonne dans le voisinage avant de se diriger vers le sud-ouest traversant la route Transcanadienne. La tornade s'agite davantage tout en progressant à travers d'autres secteurs. Graduellement, la tornade se dirige vers l'est, s'élargit et fonce vers la périphérie de Winnipeg. Dans une demi-heure, ce qui devrait être l'orage le plus destructeur dans l'histoire du Canada aura fait de nombreux dégâts à travers la capitale du Manitoba. Heureusement que ce phénomène ne s'est pas …encore produit. Toutefois, lorsqu'on fait des recherches de tempêtes similaires en temps réel, des scénarios de tornade, tel que le phénomène qu'on vient d'imaginer, peuvent être représentés afin d'anticiper les impacts sur les communautés. Cet article relate le trajet de la tornade de force F4 qui s'est produite à Edmonton en 1987 et l'applique sur une partie de la ville de Winnipeg. Les dommages, les blessés et les morts reliés à ce scénario ont fait l'objet d'une évaluation et on discute des suggestions pour leur diminution afin d'aider les communautés à se préparer à faire face à de tels phénomènes.

Scenario: On a hot muggy day in early July, around suppertime, a narrow funnel forms from the rapidly rotating base of a severe thunderstorm near Headingley; a small community just west of Winnipeg, MB. To the surprised residents, the narrow funnel quickly stretches downward to touch the ground, kicking up dirt and tearing at the crops in a nearby field. The funnel spins through part of a neighbourhood before turning southeastward across the Trans-Canada Highway. It then churns through a number of acreages. Gradually, the funnel turns to the east, widens and charges toward the edge of Winnipeg. Over the next half hour, what would become the most destructive thunderstorm in Canadian history will wreak havoc across Manitoba's capital. Thankfully, this event has not happened…yet. However, through research of similar real-life storms, tornado scenarios such as this imaginary event can be performed to anticipate its impact on communities. This paper takes the path of the 1987 F4 Edmonton Tornado and lays it upon part of the City of Winnipeg. Damage, injuries and deaths related to this scenario are estimated and suggestions for mitigation are discussed to help communities prepare for such events.

Introduction

On May 3, 1999, a major tornado outbreak struck Tornado Alley in the United States. One of those tornadoes, an F5 on the Fujita scale (Table 1), struck metropolitan Oklahoma City, OK, causing over $1 billion (USD) in damage, injuring hundreds and leaving 38 people dead. The impacts of this tornado were extensively documented. The North Central Texas Council of Governments saw an opportunity to use this information to make a risk assessment of a similar tornado striking Dallas, TX (Rae, 2000 and Rae et al, 2000). Using the Oklahoma City tornado path and its various intensities, numerous fictional tracks were laid across the Dallas-Forth Worth area. The tracks were combined digitally with other databases including property assessments, demographics, land-use classifications, etc., to predict the impact on the city. The final assessments calculated the total property damage and estimated the number of people affected. This information was used by the city to become better prepared to face a major tornado disaster.

A similar assessment can be made for Canadian communities. Canada's cities are not immune from major tornadoes. The cities of Regina (1912), Windsor (1974), Barrie (1985), and Edmonton (1987) have had devastating tornado disasters. Like Oklahoma City, the Edmonton tornado was extensively surveyed (Wallace, 1987). This paper examines the impact of a fictitious Edmonton-like tornado on the City of Winnipeg. Research on recent events has also highlighted opportunities to mitigate the effects of these events. Some of those lessons will be discussed.

2. Methodology

a. Choosing a location

The majority of reported tornadoes in Canada occur on the Canadian Prairies, with about 37 annually (McDonald, 2006). Three of the top 4 killer tornadoes in Canadian history have occurred in this region (Table 2). For this paper, a prairie city was chosen; in this case Winnipeg, the last remaining Prairie provincial capital unaffected by a major tornado. Tornadoes are not uncommon in Manitoba, with an average of 8 reported annually (McDonald, 2006). Winnipeg has also had 11 tornadoes within its urban limits since 1826 (Anderson, 2006). Large tornadoes have occurred recently in Manitoba (Figure 1), including the last F4 tornado in Canada near Birtle, Manitoba in 1995. Given the area's climatology and the growing size of the city, it is inevitable that a major tornado will impact part of Winnipeg.

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b. Choosing a path

The path of the tornado was chosen to best represent the climatological direction of a major Manitoba tornado track. The majority of large tornadoes in this region occur with supercell thunderstorms forming within a southwesterly upper level flow. The supercells typically move to the right of this upper level flow. Most recent major Manitoba tornadoes – such as the F4 Birtle tornado and the 1977 F4 Rosa tornado - have generally tracked from west to east. The last major supercell to track across Winnipeg was in 1996 and its path was from the west-northwest to the east-southeast (McCarthy et al, 2000).

The path of the tornado was chosen to resemble that of the Edmonton tornado; it was approximately 37 kilometres long and, at its widest, was 1.3 kilometres across (Wallace, 1987). It first touched down near the town of Beaumont approximately 8 kilometres outside the city's limits. After tracking through rural areas, it moved into Edmonton through roughly 5 kilometres of residential and 10 kilometres of industrial areas, before dissipating in a rural area northeast of the city. The path chosen for the Winnipeg scenario (Figure 2) reflects this Edmonton track. The tornado begins about 8 kilometres west of the city near the community of Headingley, tracks through residential, industrial and open areas of Winnipeg before dissipating in the rural areas southeast of the city.

Scale	Wind Speed	Damage
0	64 - 116 km/hr	Broken branches, minor shingle damage, signs knocked over
1	117 - 180 km/hr	Shingles removed, minor sheathing damage, mobile homes knocked off foundations/overturned, garages damaged, many damaged trees, some downed power lines
2	181 - 252 km/hr	Significant roof damage to homes and industrial buildings, mobile homes obliterated, vehicles overturned, some projectile damage to walls/siding, transmission towers heavily damaged, widespread tree and power pole damage, rail cars pushed over
3	253 - 330 km/hr	Roofs and some walls removed, cars tossed, trains overturned, heavy damage to large industrial buildings
4	331 - 417 km/hr	Houses leveled, industrial builings destroyed, cars and debris thrown large distances
5	418 - 509 km/hr	Buildings debris removed from foundations and scattered, steel-reinforced concrete structures heavily damaged

Table 1. Fujita Scale

Location	Date	Deaths	Injuries
Regina, SK	June 30, 1912	28 (30 total)	Hundreds
Edmonton, AB	July 31, 1987	27	Hundreds
Windsor, ON	June 17, 1946	17	Hundreds
Pine Lake, AB	July 14, 2000	12	140
Valleyfield, QC	August 16, 1888	9	14
Windsor, ON	April 3, 1974	9	30
Barrie, ON	May 31, 1985	8	155

Table 2. Tornadoes with the highest fatalities in Canada (source: Environment Canada, 2006)

A number of tracks were considered. The chosen path crosses approximately 15 kilometres of residential and industrial property, as did the Edmonton tornado. One notable difference between the two tracks is that the Edmonton path was predominantly industrial while the Winnipeg path is predominantly residential. However, had the Edmonton tornado tracked just 1 kilometre farther west, the affected area would have been mostly residential. Although the Winnipeg track has a much higher proportion of residential property than in the Edmonton case, it does not necessarily represent a worst-case scenario among the many possible tracks that could have been chosen.

c. Choosing a time of day

Climatologically, most Manitoba tornadoes occur in the late afternoon and early to mid-evening and most often in late June through the first half of July (Anderson, 2006). Statistically, a tornado should be equally possible on any day of the week, therefore, one is more likely to occur on one of the five weekdays than on a weekend. For the purpose of this project, the fictitious tornado occurs on a weekday between 5 PM and 6 PM CDT in early July.

d. Determining potential damage, injuries and deaths

A manual approach was used rather than the more sophisticated GIS-based Dallas-Fort Worth project. Once the tornado path was chosen, a custom map for this project was purchased from the City of Winnipeg. This 2005 map included residential and commercial lots, commercial buildings, school buildings, hospitals, fire and paramedic stations, all roads, rail lines, park areas, and rivers. The path, with various tornado intensity contours, was overlaid upon this map. The contours were divided into 3 damage potential areas: F0-F1, F2, and F3-F4. The entire path was divided into 11 areas: 2 rural, 8 residential and industrial, and 1 commercial (for example, Figure 3).

Each residential lot was assumed to have one house. The property value of each lot is quite varied, even within the same neighborhood. Using the City of Winnipeg's property assessment website (City of Winnipeg, 2003), mean property values (based on the assessed lot and structure values in 2003) were approximated and assigned to each residential area along the tornado's path. The website also provided assessed values for commercial properties affected by the tornado. Mean property values of commercial structures were assigned for various building sizes.

For affected areas beyond the city limits, the number of the various structure types affected was determined from an on-site survey. Home and lot values were approximated using real estate listing prices as of January 2006. This approximation was then reduced by 15% to bring them in line with the 2003 values used for Winnipeg City.

The City of Winnipeg 2001 census (City of Winnipeg, 2001) was used to determine the average number of people living at each residence in each neighborhood. The lowest average value was used for the areas outside the city. While it is unlikely that every resident would be at home during this scenario, the average value was applied to all properties to roughly account for people in businesses, stores, and other facilities along the track. Given the time of year and time of day of this scenario, it was assumed that no-one was in affected schools nor was using outdoor sports facilities.

Area	Property Value	F0-F1	F2	F3-F4	Damage in $ Million
1	$170,000	26	4	0	$3
2	$100,000	528	44	0	$30
3	$170,000	702	1670	0	$299
4					
5	$275,000	288	298	102	$133
6					
7	$100,000	134	111	438	$55
8	$125,000	93	60	164	$30
9	$125,000	266	249	231	$68
10	$125,000	925	514	0	$111
11	$300,000	2	8	7	$4
				Total	**$733**

Table 3. Number of houses affected by various tornado intensities plus estimated tornado-related damage (including contents).

An attempt was made to approximate the number of cars on the road in the tornado's path using the 2004 Traffic Flow Map from the City's website (City of Winnipeg, 2004); however, hourly information was unavailable, and the approximate number of vehicles in the tornado's path could not be properly determined. Still, the City does have this information, and a GIS-based approach would allow it to be included in this type of scenario. It should be noted that the Dallas tornado study suggested that the potential number of vehicles in the tornado's path increased dramatically due to increased traffic congestion at this time of day. This would put thousands of people in very vulnerable positions in a tornado scenario. A large percentage of the deaths in the 1989 Huntsville, Alabama (Wikipedia, 2005) and the 1979 Wichita Falls (NOAA, 1980) tornadoes were vehicle-related. For the purpose of the Winnipeg tornado scenario, the specific risk to people in cars was not assessed, though a simple proxy (described later) was used in the final assessment.

Type	Average Property Value in $Million	F0-F1	F2	F3-F4	Damage in $ Million
School	$4	5	4	1	$29
Condo/ Apart-ment	$8	20	0	0	$79
Small com. /ind.	$0.75	81	25	35	$80
Medium com./ ind.	$4	17	5	12	$111
Large com./ ind.	$18	9	10	1	$256
Very Large com./ ind.	$30	0	1	1	$64
Major mall com-plex	$148	0	1	0	$125
				Total	**$744**

Table 4. Number of commercial/public buildings affected by various tornado intesities and the calculated damage costs (including contents).

The Edmonton storm also included a large area of damaging hail (Charlton et al, 1998) and that hail swath was superimposed over Winnipeg (Figure 2). Damage was approximated based upon the damage inflicted upon Edmonton and other similar historical hail events for large urban centres.

3. Results

The primary cause of damage in a tornado is due, intuitively, to the associated winds. Secondary damage results from debris impact, fire, hail, flooding, etc. For this scenario, an assessment of the damage produced by the tornado, hail and other factors was made.

City	Year	Estimated Insured Loss in $ Million (2005 $CDN)	Comments
St. Louis, USA[2]	2001	$3,000	Included damage at airports
Minneapolis, USA[1]	1998	$2,100	Included damage at airports
Munich, Germany[1]	1984	$1,500	Additional economic loss estimated at $3 billion. 400 people injured. Included aircraft damage. 200,000 cars damaged. Total loss affected areas beyond the City of Munich
Sydney, Australia[1]	1999	$1,400	
Fort Worth, USA[1]	1995	$1,300	Hundreds injured
Denver, USA[3]	1990	$990	47 people injured at amusement park
Calgary, AB[4]	1991	$440	Plus estimated $500 million in economic loss. 54,000 vehicle claims. 60,000 house damage claims
Calgary, AB[4]	1996	$330	
Winnipeg, MB[4]	1996	$170	Over 24,000 vehicle claims

Table 5. Major urban hailstorms (inflation adjusted 2005 $CDN). Sources: Bankhaussen[1] (1999), Sullivan[2] (2002), RMIIA[3] (1998), Insurance Bureau of Canada[4] (2004)

The majority of deaths and injuries during a major tornado event will be caused directly by the destruction related to the tornado (Brown et al, 2002). For this scenario, an estimate of the deaths and injuries produced by the tornado was also attempted.

a. Damage due to the tornado

Dr. Theodore Fujita (Fujita, 1971) devised a scale (Table 1) to correlate tornado intensity with the damage inflicted. The damage evidence is based only upon whether there was something to damage and the integrity of those structures; therefore, the actual strength of the tornado along its entire path is normally impossible to assess. For example, the intensity of the Edmonton tornado could only be assessed based upon the damage inflicted. Where the tornado tracked through open areas, a low rating was assigned since there was little to damage. However, the actual damage potential in that area may have been much greater. For the Winnipeg scenario, it was assumed that the tornado's intensity along its entire path matched precisely what was assessed during the Edmonton tornado.

Figure 1a, credit: P. McCarthy, 2000

Figure 1b, credit: W. Brault, 2005

Figure 1. Examples of recent large Manitoba tornadoes. a) near Brunkild, MB and b) near Pilot Mound, MB.

The City of Winnipeg includes only the value of the lot and structures in its property assessments. In this tornado scenario, only structures and their contents would be damaged, while the value of the lot remained unaffected. Based on the City's property assessments and the values of vacant lots, a value of 80% of the property assessment was used for structures for each lot. The contents of structures vary widely in any neighbourhood. For the purpose of this scenario, based upon a small survey of insurance agents in Winnipeg, a value of 50% of the property assessment was used for property content value. This approach would be different in other cities as property values vary greatly from location to location, though the value of contents in similarly-sized homes should remain generally consistent.

The lead author of this paper has 22 years of storm damage survey experience, including the Edmonton and Birtle F4 tornadoes. His experience suggested that the expected structural and content value loss in the F0-F1 areas would be, on average, 10 to 20%. For the F2 areas, the average loss would be roughly 30 to 50%, and for the F3-F4 regions the average loss would be 100%. This is similar to a preliminary study of property losses found (Kruse et al, 2005 [draft]) in the Oklahoma City event. Their analysis suggested a linear relationship with the F-scale and the amount of damage that would occur. Based upon the "damage weighting factor" found in that ongoing study, the structural and contents damage in the Winnipeg scenario was calculated as follows:

Total Damage = [(PxS)xf] + [(PxC)xf]

Where:

P = property assessment
P x S = value of structures
P x C = Value of contents
S = value of structure weighting factor = 0.8 (for Winnipeg)
C = value of contents weighting factor = 0.5 (for Winnipeg)
f = damage weighting factor = 0.2211 + 0.2164F
F = mean Fujita rank.

For various neighbourhoods along the tornado path, total damage was calculated using the above formula. As expected, a major tornado tracking through a large urban centre would produce significant damage (Table 3 and Table 4). Over 6800 residences would be damaged including close to 1000 being destroyed by this scenario. In addition, 10 schools, 20 condominium/apartment complexes, dozens of commercial and industrial structures, and one major shopping mall would be impacted. The total estimated damage to all structures and their contents was $1.5 billion (all following dollar figures are in $CDN). While this assessment is only an estimate, the value is consistent with the property losses of the 1999 Oklahoma City tornado.

b. Damage due to hail

The Edmonton tornado was also a major urban hail event, the worst on record at the time (Charlton et al, 1995). In the Winnipeg scenario, the Edmonton hail swath (Charlton, et al, 1998) was also placed upon the city (Figure 2). Since the hail swath for this scenario is assumed to be similar to the Edmonton event, so is the number of homes damaged by hail: approximately 27,000. Over the past 10 years, the average insured hail loss to property has been about $5400, in 2003 dollars (Insurance Bureau of Canada, 2004). This would result in almost $150 million in damage.

The swath also affects about 3 times the area of the 1996 Winnipeg hailstorm. In that event, Manitoba Public Insurance (MPI, 2003) had 24,294 vehicle hail claims averaging about $2200 per claim. This dollar value is almost identical to the Insurance Bureau's of Canada's average vehicle claims for hail since 1995 (Insurance Bureau of Canada, 2004). However, a major hailstorm in southern Manitoba in 2003 produced average claims of about $2700 (MPI, 2003). For the Winnipeg scenario, 50,000 vehicle claims were assumed, producing approximately $135 million in damage and bringing the total estimated damage from hail to $285 million.

This estimate may actually be quite low. The hail swath also impacts the Winnipeg International Airport, and many downtown office buildings. Potential damage costs could be much higher in these areas; similar major hailstorms have resulted in far more significant damage (Table 5).

c. Other damage

A significant portion of Winnipeg north of the tornado track will be affected by very heavy rain. In the Edmonton event, 271 basements were flooded (Charlton et al, 1998). Due to an older style sewer system in parts of Winnipeg, these areas are prone to basement flooding during heavy precipitation events. In 1993, a series of severe thunderstorms over a two-week period produced almost $220 million in damage to the Winnipeg area (Insurance Bureau of Canada, 2004). In that event, the flooding problem was compounded by earlier storms that had left the ground saturated; antecedent conditions could turn a minor flooding problem from this severe thunderstorm to a major one. Without those antecedent conditions, it is impossible to determine the degree of flooding for this event. As a result, the damage due to flooding was excluded from our results. However, disaster planners need to be cognizant of the potential for significant flooding from a major severe thunderstorm, including blocked roads in low lying areas and underpasses.

A tornado will also impact critical infrastructure. Though not affected in this study, other scenarios could have included the tornado tracking through hospitals, water treatment plants, etc. In the Edmonton tornado, 66 steel power-line towers and over 200 wooden power poles were toppled (Charlton et al, 1998). The Winnipeg tornado crosses major hydro-electric transmission lines at a number of locations. Losses here would be both structural and economical, and could potentially result in widespread power failures. These power failures could also stress emergency backup power systems at other critical facilities. For the purpose of this paper, these costs were not included in the final assessment.

Damage resulting from the tornado could also unleash a number of environmental hazards, particularly in the industrial areas affected. For example, the tornado crosses a number of rail lines. Trains derailed by the tornado could be carrying hazardous goods and this could result in localized environmental emergencies.

Finally, the tornado would result in major economic losses to the area. People will be displaced, businesses will have been destroyed, and a part of the economy will have to shift from production to recovery and repair. As in similar events (e.g. Table 5), the economic losses could easily equal the total damage costs.

Event	Date	Time of occurrence	F Scale	Deaths	Injuries	Homes damaged/ destroyed
Barrie, ON[1]	31 May 1985	4:30 PM	F4	12	155	605
Spencer, South Dakota, USA[2]	30 May 1998	8:30 PM	F4	6	153	175
Wichita Falls, Texas, USA[3]	10 April 1979	6:00 PM	F4	42	1740	3695
Plainfield, Illinois, USA[4]	28 August 1990	3:45 PM	F5	29	350	~ 1000
Huntsville, Alabama, USA[5]	15 November 1989	4:30 PM	F4	21	463	537
Oklahoma City, Oklahoma, USA[6,7]	03 May 1999	7:00 PM	F5	45	645	8330

Table 6. Historic tornado events used to assess deaths and injuries. (Source: [1]Etkin, et al (2002), [2]Edwards,R. (2005), [3]National Weather Service (2004), [4]Plainfield Public Library District, (2005), [5]National Weather Service (1990), [6]Daley, et al, (2005), [7]National Weather Service (2004)

d. Injuries and deaths

Determining the number of deaths and injuries for a hypothetical tornadic event is a complex problem and involves a number of factors. Basic questions such as tornado size and intensity, number of persons in the path of the tornado, time of day, and the day of week must be considered. More involved questions such as the strength and type of structure where one seeks protection and an individual's knowledge of tornado preparedness must also be examined (e.g. Carter et al, 1989). Sophisticated tornado damage risk assessment studies such as the Dallas-Fort Worth Metroplex study (Rae, 2000) have gone to great lengths to determine the number of residents and employees living or working in the path of a tornado, but estimates of deaths or injuries were not calculated.

The deaths and injuries for tornado events occur under numerous circumstances, often outside of residential homes. Knowing precisely the number of people in vehicles, building types, and being outdoors and calculating the likely number of deaths and injuries for each circumstance, was beyond the scope of this paper.

In this study, a simple analog approach was utilized. Six historical tornado events were selected based upon similar tornado intensity, time of occurrence, and having a high percentage of residential homes damaged or destroyed. The Edmonton event was excluded since residential damage was limited and the residential deaths were confined to a trailer park. The events selected are provided in Table 6 shown above.

The number of damaged/destroyed homes served as a proxy for all the possible locations for potential deaths and injuries, such as houses, vehicles, apartment complexes, commercial buildings, offices, etc. For each case, the number of deaths and injuries was compared to the number of homes destroyed or damaged. The results were then plotted and a linear regression applied (see Figures 4 & 5).

Preliminary examination of the results revealed one major outlier from the sample: the Oklahoma City case. It was unique in a number of respects. Firstly, tornadoes are part of Oklahoma culture. By living in part of "tornado alley", people are more aware of the dangers associated with a tornadic event than in other areas. As a result, tornado preparedness is arguably greater in this part of North America than in other parts of the continent. Secondly, this case was handled extremely well by the National Weather Service and local media. Residents were kept apprised of the changing conditions through live television and radio reports, warning sirens, and NOAA weather radios. Oklahoma City had up to two-and-one-half-hours-notice that a dangerous storm was on the way (weather.com 2005) followed by tornado warnings with extraordinary lead times of 32 minutes (Doswell, 1999). As a result, most people had adequate time to implement their emergency plans. The distinctiveness of this event led to its omission and a subsequent recalculation of the regression equation (Figures 4 and 5). The well-warned Wichita Falls event was included since the level of preparedness, weather detection, and prediction was less sophisticated than present day, despite it also occurring in part of "tornado alley". When the results of the linear regression are applied to the Winnipeg case, just over 100 deaths and 3200 injuries are estimated along the tornado's path.

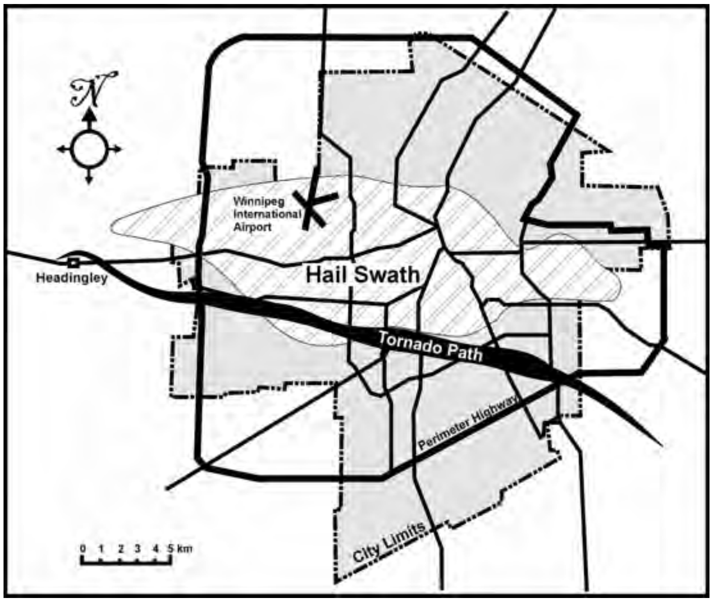

Figure 2. Map of tornado path and hail swath

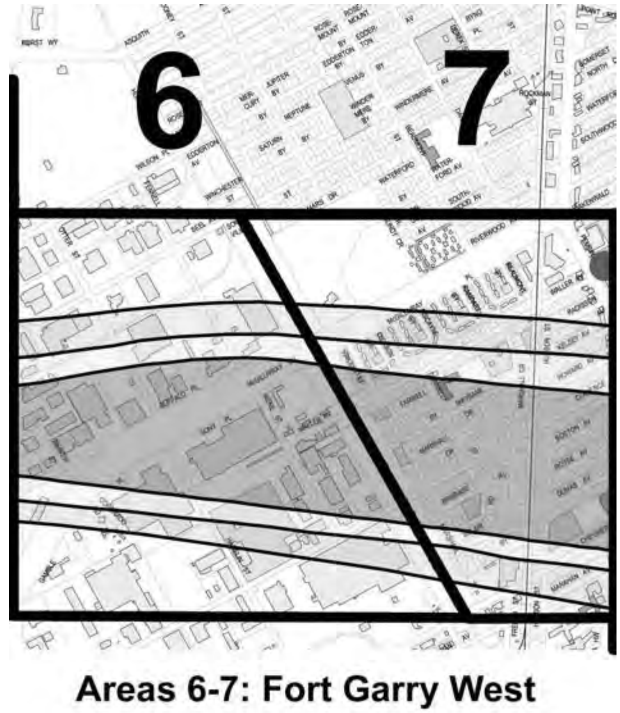

Figure 3. Examples of the tornado track over detailed map of residential and industrial areas. Damage intensities are represented in colour: green = F0-F1, Yellow = F2, Red = F3-F4.

A few noteworthy comments are fitting at this juncture. The assessment of the Oklahoma City tornado-related death rates (Daley et al, 2005) found that houses were much safer than other structures. Persons were three times more likely to die in public and commercial buildings, 20 times more likely to die in apartments, and 35 times more likely to die in mobile homes. In the Winnipeg scenario (Table 3), 86 commercial and industrial structures would be affected by F2-F4 winds, 20 condominium/apartment buildings would be affected by F0-F1 winds, while part of one mobile park would be affected by F0-F1 winds. Furthermore, additional deaths and injuries can also occur prior to or following the event (Brown et al, 2002). Persons who are attempting to flee from the path of the tornado or preparing to seek shelter can often harm themselves when acting in haste. Post-event injuries can also be sustained during cleanup efforts or during attempts to assist others.

4. Discussion and conclusions

a. Results of the tornado scenario

The virtual Winnipeg tornado scenario resulted in \$1.5 billion in tornado damage and \$285 million in hail damage for a total of almost \$1.8 billion. More tragically, this scenario resulted in roughly 3200 injuries and just over 100 deaths. This event would rank as one of North America's most notorious tornadoes.

The scenario chosen, while devastating, was not a "worst-case" scenario. No hospitals, fire halls, or police or paramedic facilities were struck in this imaginary event. The tornado occurred outside of the school year and it was assumed that no outdoor activities were occurring. Only one of the 7 Winnipeg area mobile home parks was struck, and even then it was only partially affected. People stuck in late rush-hour traffic in the path of the tornado were not considered. Like the Dallas-Fort Worth exercise, many other scenarios could be imagined, some of which would potentially have been far more destructive and deadly.

b. Mitigating damage

Developing virtual tornado scenarios gives society an opportunity to prepare and mitigate the destructive potential of similar events.

Engineering studies (e.g. Riley, 2002) and storm surveys (e.g. Doswell, et al, 2002) after the Oklahoma City tornado point to a number of areas where construction quality can be improved. Most structures outside of hurricane regions of North America are designed primarily for gravity loads rather than extreme wind loads; however, the lateral force of strong winds can compromise the structural integrity of a building, leading to structural failure. Building codes could be modified to address this issue (Gould, et al, 2004), and in most cases the additional cost to new construction would be relatively small. Retrofitting older structures would be more expensive. Wind load enhancement would primarily reinforce the attachment of the roof to the walls with simple metal clips and strapping, and the attachment of the wall to the foundation with stronger and better designed bolting systems.

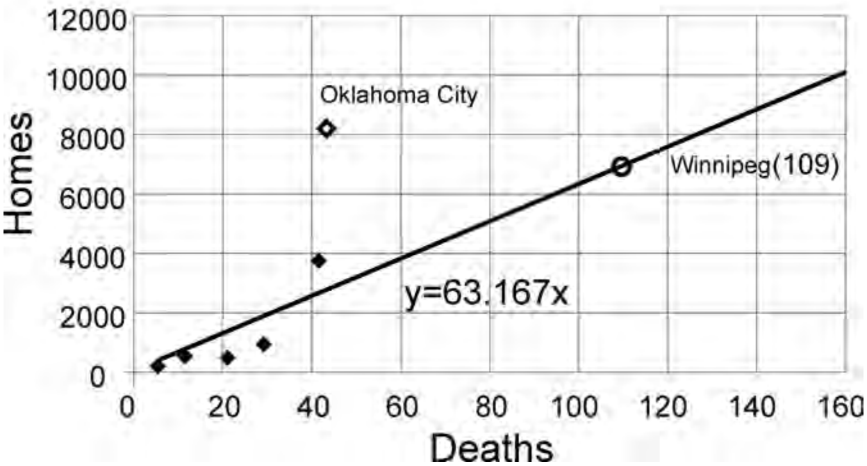

Figure 4. Comparison of tornado deaths vs damaged and destroyed homes

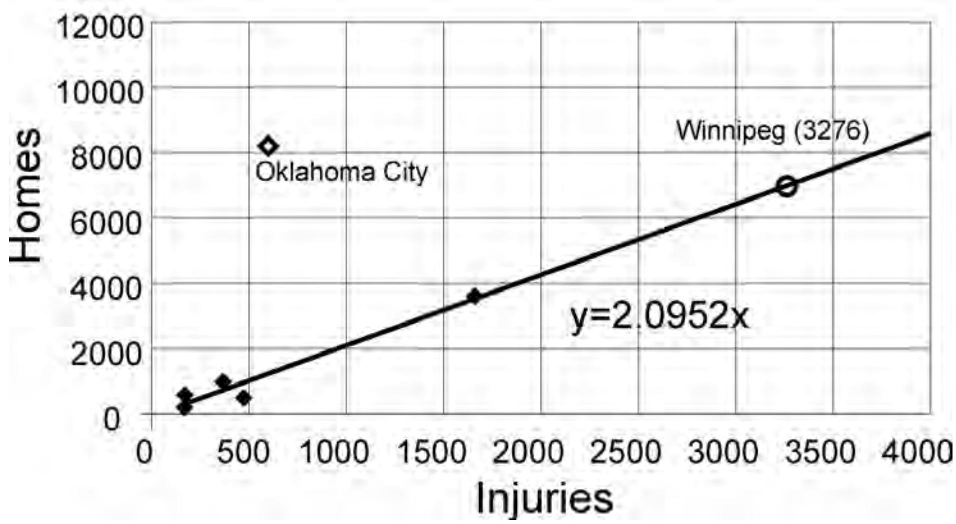

Figure 5. Comparison of tornado injuries vs damaged and destroyed homes

As with hurricane damage, the Oklahoma City tornado evidence (Riley, 2002) pointed to flying debris impacting buildings as one notable cause leading to structural failure. Hurricane-prone areas have adopted building codes to mitigate damage from wind-borne debris (e.g. State of Florida, 2005). These codes include damage–resistant windows and more rigorous construction methods. Addressing wind-borne debris in hurricane–prone regions is important, though these approaches may be too cost-prohibitive in Canada. Finally, poor finishing was also noted in the Oklahoma damage surveys (Riley, 2005) as contributing to the overall weakness of structures. Buildings fail at their weakest point. Poor construction practices, substandard exterior finishing, etc., often compromise the integrity of buildings. More diligent inspections during construction could be one simple approach to address this issue.

The assessment of tornado damage is also being refined. An enhanced version of the Fujita scale (Texas Tech University, 2004) has been developed to better assess the damage produced by tornadoes. Ongoing research in this area will further strengthen our understanding of the tornado impact on structures and of how best to mitigate that impact.

c. Mitigating deaths and injuries

The greatest opportunity for mitigation is in reducing the number of deaths and injuries from tornadoes. While there is still room to improve the integrity of buildings, this scenario demonstrated that the majority of people in the path of the tornado survived without injury. As noted earlier, commercial and industrial buildings, apartments and, especially, mobile homes are particularly vulnerable to tornadoes. While overall tornado death rates have been falling, mobile home mortality rates have not (Brooks, et al, 2002). “Safe areas”, whether within the structure or nearby, need to be incorporated into the design of mobile home parks and large campgrounds, apartment buildings and condominiums, schools, industrial buildings, malls, etc.

Beyond safer structures, deaths and injuries can be mitigated by improved prediction and detection of these events, better communication of warnings, and a population prepared and willing to take the right action.

Doppler radar (Simmons, et al, 2005) has been recognized as having a positive effect at reducing tornado deaths and injuries, in the U.S. Environment Canada’s Doppler radars are located near Canada’s major population centres and, therefore, a major tornado affecting a large metropolitan area is unlikely to strike undetected. In addition, meteorologists are better trained, the science of severe thunderstorm prediction continues to improve, and the forecasters' tools are becoming more sophisticated.

In this Winnipeg Tornado scenario, the meteorological conditions would have been recognized by forecasters as favourable to the development of tornadic thunderstorms. Severe Thunderstorm or Tornado Watches would have been issued earlier in the day giving the public an ample heads-up of severe thunderstorm potential. As the severe thunderstorm approached the city, Severe Thunderstorm or Tornado Warnings would have been issued. For the people west of the city limits, the lead time of the warning would be relatively short, while the people in the tornado's path within Winnipeg would have had sufficient notice to take action. This was the same scenario as the 1987 Edmonton tornado, yet it still caused 27 deaths and injured over 300 people (Bullas, et al, 1988).

In the review (Hage, 1987) of the weather warning system after the Edmonton tornado, a number of factors contributing to deaths and injuries were noted, the most significant ones related to communications and preparedness. Public and emergency officials need to hear the warnings. This warning information must be quickly and repeatedly communicated by radio and television, and via government warning systems such as Weatheradio and Alberta's Emergency Public Warning System. The efforts of the U.S. National Weather Service and the media were important in keeping the deaths and injuries relatively low in Oklahoma City (Hamill, et al, 2005).

Once people hear the warning, they need to take proper action to protect themselves, their family, their employees, people under their care, etc. People need to know what to do whether they only have 10 seconds or 10 minutes of warning. In a study of the Oklahoma City public response to warnings (Hammer et al, 2002), making the right decisions can mean the difference between life and death. The total number of deaths and injuries in Oklahoma City was statistically small. Using the tornado death and injury relationships in Figures 4 and 5, the projected death and injury toll for the Oklahoma City event should have been approximately 130 and 4000, respectively. The actual number of casualties (Table 6) was significantly less, and can be primarily attributed to a well-warned and disseminated event, as well as a relatively knowledgeable and prepared population.

Families, schools, daycares, hospitals, office and industrial buildings, malls, nursing homes, mobile home parks, condominiums and apartments, emergency preparedness agencies, etc., should all have plans to respond to an imminent tornado threat (Brown, et al, 2002). These plans should be routinely tested. A small number of deaths and injuries in the Oklahoma City (Daley, et al, 2005) and similar events (e.g. Bellala, et al, 2005) were the result of trying to take shelter; therefore, quick, knowledgeable, and practised action will save lives and reduce injury. Most safety plans in Canada do not include comprehensive tornado safety procedures. One simple way to improve this would be to include disaster preparedness in school curricula through a number of grade levels.

d. Disaster response

A disaster of this magnitude would tremendously stress the most sophisticated disaster response system. With debris impeding emergency vehicles, widespread power outages, a compromised communications system, possible environmental hazards, and with rescues required over a wide area, emergency responders' response and site management would be significantly tested.

Understanding the magnitude of a potential catastrophe is the first step in developing contingencies to effectively respond. The approach used in the Winnipeg scenario provides a detailed, though somewhat crude, hazard assessment for emergency planners. The more sophisticated GIS-based approach used for the Dallas-Fort Worth area allows planners to look at many scenarios and to then identify many more emergency management challenges. Disaster exercises can be more realistically designed to allow better practice for responders and planners, and to help identify deficiencies. Cities should work with experts such as the weather service, scientists, and with emergency officials with experience in similar disasters, to help refine their plans.

Another opportunity is to have emergency responders work more closely with the weather service during a potential weather disaster. A draft proposal (McCarthy et al, 2005) by Environment Canada recommends that the Storm Prediction Centres of the Meteorological Service of Canada evolve into "fusion centres". This concept would have Environment Canada meteorologists and environmental emergency response specialists working more closely with public and private emergency officials, other government agencies, and critical infrastructure staff. Each group would actively share each other's information to provide an integrated real-time response to impending or occurring environmental disasters. These fusion centres would also incorporate scientists and researchers working on disaster-related science. This or a similar approach could help prioritize the research so that it is focussed on the most critical issues, while ensuring that the integrated response is using the latest science and techniques.

e. Further research

The exercise demonstrates that a major tornado disaster can be modeled. While this approach here provides a rough assessment, a more sophisticated GIS-based approach could take advantage of the vast stores of information growing in municipal digital databases. Based upon epidemiological studies of past tornado disasters, potential death and injuries could be more precisely estimated for various building types, vehicles, outdoor activities, etc. Planners, working with weather experts and other researchers, could model many realistic scenarios. With that information, emergency managers could develop more sophisticated emergency plans. Additional research and development in areas of building practices, weather prediction, storm detection, and emergency preparedness will further help mitigate the impacts of the inevitable disasters of the future.

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CNC/SCOR Tour Speakers: (i) Fall of 2006, and (ii) Spring of 2007

Dr. Kevin Lamb, Professor, Department of Applied Mathematics, University of Waterloo will undertake the Western tour in the Fall of 2006, likely in October/November. Kevin's area of research is on nonlinear internal waves in the ocean and lakes. His other research interests include hydrodynamic instabilities, computational fluid dynamics, and a variety of stratified flow phenomena. **Dr.Erica Head**, Research Scientist, Biological Oceanography, Bedford Institute of Oceanography will undertake a Western tour in early 2007, likely in February/March. Erica's research interests are on the distribution and life cycles of *Calanus finmarchicus* in the North Atlantic. This zooplankton is a principal forage species in the sub-polar gyre of the North Atlantic. Both Kevin and Erica's tours are being organized by Susan Allen (sallen@eos.ubc.ca) and Paul Myers (pmyers@ualberta.ca). Interested groups should contact either of these individuals to ensure scheduling opportunities are optimized for either or both speakers.

Dr. Andy Bush, Professor, Earth and Atmospheric Sciences, University of Alberta will undertake an Eastern tour in the Fall of 2006, likely in November. Andy's research interests are the use of climate modelling to investigate the impact of orbital parameters on the coupled system, the maintenance of the equatorial thermocline, and the roles that phenomena such as El Niño have played in the paleoclimates of Earth's history. **Dr. Rob MacDonald**, Research Scientist, Ocean Sciences Division, Institute of Ocean Sciences will undertake an Eastern tour in early 2007, likely in February. Rob's research interests are in interdisciplinary programs to study the environmental pathways of contaminants including their delivery, transport, and elimination from aquatic systems in Arctic shelves and basins, British Columbia fjords, the Strait of Georgia, and lakes in the Fraser River basin. Both Andy and Rob's tours are being organized by Jinyu Sheng (jinyu.sheng@dal.ca). Interested groups should contact him to ensure scheduling opportunities are optimized for either or both speakers.

Reference: SCOR, Canadian Ocean Science Newsletter, May 2006.

Scattering, Absorption, and Emission of Light by Small Particles

by Michael I. Mishchenko, Larry D. Travis and Andrew A. Lacis

Cambridge University Press, 2002, 445 pp, US$90.00
ISBN 0-521-78252-X

Book reviewed by Syd Peel[1]

Electromagnetic scattering figures prominently in meteorology, climatology and oceanography. Radar loops of thunderstorms and synoptic-scale precipitation fields are crucial to timely, accurate weather forecasts and warnings. Satellite-based instruments, sampling a wide range of the electromagnetic spectrum, not only permit the observation of weather patterns on a larger scale than can be observed in radar imagery, but also monitor a diverse assortment of environmental fields, from the temperature of the ocean surface to the thickness of the stratospheric ozone layer. Satellite-based radars map the extent and thickness of sea ice, provide global-scale rainfall estimates, and measure winds and waves over the oceans.

A firm grasp of the theory of electromagnetic scattering is important not only for the correct interpretation of the output generated by the myriad instruments which remotely monitor the state of the environment. Weather is simply a manifestation of the mechanical work done by the tropospheric heat engine, and the energy fuelling this engine derives from the solar radiation absorbed by the earth and its atmosphere.

In their book *Scattering, Absorption, and Emission of Light by Small Particles*, Mischenko, Travis, and Lacis survey the current state of the field, with a particular emphasis on numerical solutions. The book is comprised of three parts, beginning with the theoretical underpinnings for the subject, proceeding to the computational aspects of the problem, and finally sampling some results of the application of the theory and numerical methods developed earlier in the book.

The first part of the book focusses on the scattering and phase matrices which describe the attenuation and change in polarization experienced by the beam upon scattering. These matrices are examined in considerable detail, particularly their transformation properties and simplifications which obtain when the scattering system possesses certain symmetries. These simplifications can dramatically improve computational performance when attempting to solve complex scattering problems which closely approximate real-world conditions. The radiative transfer equation is also introduced and explained, including the limits of its applicability.

The lion's share of the discussion in the second part of the book on computational methods is devoted to the T-matrix technique. The incident and scattered electromagnetic fields are projected onto a basis of vector spherical wave functions, their radial dependence given by spherical Bessel functions and their angular dependence by associated Legendre functions. The T (transition) -matrix relates the coefficients of the expansion of the scattered beam in this basis to the coefficients of the incident beam in the same basis. Properties of the T-matrix are derived which can greatly simplify its computation, and the steps to follow in the application of the T-matrix method to the solution of a scattering problem are explicitly prescribed. The chapter concludes with a discussion of computer programs implementing the Lorenz-Mie and T-matrix methods, including detailed descriptions of the parameters input to, and the output produced by, the software considered, illustrated with applications to a variety of scattering configurations.

Other differential- and integral-equation techniques for the solution of scattering problems, such as separation of variables, finite-element, and finite-difference methods are also mentioned. However, as the authors freely admit, considerably less attention is paid to these approaches than was devoted to the T-matrix and Lorenz-Mie techniques. The penultimate chapter in this part of the book is devoted to some common approximations invoked to simplify the scattering problem, including the Rayleigh, Rayleigh-Gans (or Born) and geometrical optics approximations.

The middle part of the book culminates in a brief chapter on experimental electromagnetic scattering. The authors contrast the physical characteristics intrinsic to experiments conducted at the visible and infrared versus the microwave segments of the spectrum, outline the practical and theoretical ramifications for the experimenter, and summarize experimental work to date.

The third part of the book surveys the current state of knowledge of the scattering and absorption of radiation. Homogeneous spheres are considered first since their symmetry affords analytic solution by the Lorentz-Mie theory, and many scattering systems can be approximated reasonably well by such spheres. In the final chapter the T-matrix technique is brought to bear on more complicated scattering configurations which arise in a wide array of real-world situations. These applications are by far the most interesting part of the book. While the discussions are tantalizingly brief, the voluminous references to the literature permit the interested reader to explore in greater depth those problems pertinent to their own particular interests.

This book is very well written, delivering a vivid presentation of the subject, assisted in this regard by an abundance of clear, often colourful, illustrations. Derivation of the equations is generally quite lucid, often explicit, facilitated by meticulous attention to a clear, consistent notation. While focussing on computational approaches to the problem, the underlying physical principles are never neglected. Indeed,

[1] Meteorological Research Division/RPN
Meteorological Service of Canada

the powerful numerical techniques examined in the book are exploited to elucidate scattering phenomena in such highly complicated configurations as arise, for example, in applications to the remote sensing of the atmosphere.

While certainly an invaluable reference for the practitioner in the field, this is hardly the book to initiate the neophyte. In principle, the exposition is largely self-contained, predicated upon a familiarity with Maxwell's equations, which are the launching point for the book. In practice, mastery of electrodynamics at the level of a text such as J.D. Jackson's classic in the field, particularly the use of Green's function techniques and the dyadic representation of second-rank tensors, would ease the assimilation of the material. Clebsch-Gordan coefficients and Wigner 3j symbols are employed liberally in the development of the Lorenz-Mie theory and the T-matrix method - while there is an appendix devoted to them there is little in the way of orientation or motivation, and some previous exposure to these techniques would be helpful.

The newcomer to the field should first consult an introductory text such as Liou's *An Introduction to Atmospheric Radiation*. If this serves only to whet their appetite for further investigation into the subject, then they'd certainly profit from the book of Mischenko et al. The book contains a reference to the web page http://www.giss.nasa.gov/~crmim, hosted at the NASA Goddard Institute for Space Studies. Code for the solutions of scattering problems, in particular those implementing the Lorenz-Mie and T-matrix methods, can be found at this site, as well as an electronic version of their book. With this software, and the book to guide in its application, readers can conduct their own scattering experiments - certainly the best way to master the field and ultimately make their own contribution to a fertile science with far-reaching application to meteorology and oceanography.

And Now ... The WEATHER

by Keith C. Heidorn

Fifth House Ltd., 2005, Paperback, ISBN 1 - 894856 -65 - 1, 272 pages, Can$ 22.95, US$ 17.95

Book reviewed by Pat Spearey[2]

"*And Now ... The Weather*" is a popular and joyous account for a North American readership of weather processes, science, history and watching by an author who has obviously derived lifelong enjoyment from all aspects of day-to-day meteorological events, especially the pageantry of the skies and the drama of weather.

The book comprises 63 short narrative essays (from two to eight pages), supplemented by black and white figures, photographs and maps.They are arranged chronologically in four main sections that follow the northern hemisphere solar calendar, beginning in late December: winter, spring, summer and fall. The author's expressive enthusiasms and inclinations are conveyed by some of the titles of the essays: "The Joys of Weather Watching"; "Snowflakes: Winter's Crystal Lace"; "A Cloud Watching Kind of Day"; "Let's Rumble: Thunderstorms"; "Hail to Thee"; "A Jet Stream Runs Through It"; and "Ice Storms: Beauty Amid Destruction". More basic titles include: "Snowdrifting"; "Making Clouds and Rain"; "Dust Devils"; "Halos and Sundogs"; "Clippers and Nor'easters"; and "The Chinook".

Most scenarios are well presented usually with an interesting blend of scientific, historic, artistic, and personal visual information, laced at times with humour. There is, necessarily, some repetition of subject matter. To conclude, there is a short glossary of terms that are not fully defined in the essays, a brief bibliography of books with an emphasis on clouds, snow, optical phenomena and popular general texts, and an index of a little over three pages, generally adequate but in which I would have liked to see more entries.

If read sequentially, a reader will obtain a good popular grounding in the range of weather experienced in the middle latitudes of the North American continent. It will probably appeal to others as a book to dip into on a random basis or to peruse particular subjects. For example, the "Lake Breezes" and "Lake-Effects Snowfalls" pages are well presented and include a good discussion topic, the author opining that the richest variety of weather found anywhere on Earth occurs in the Great Lakes region. "The March of Spring" essay covers the science of phenology with its links with climate change, a subject only marginally addressed in a book mostly devoted to the fascinations of current weather phenomena. "Lightning: A Storm's Flashy Dancer" contains sound scientific and safety advice. "The Winds of November" presents some interesting historical details of damaging Great Lakes storms and associated ship losses. The author's interest in optical phenomena and illusions is well aired in "Mirages: Not Just for Deserts Anymore". In "January Thaw" and "Indian Summer", lore and weather singularities are examined.

Meteorology is probably the most personal of the non-life sciences and this is aptly illustrated by the author. The book both parallels and complements facts and stories seen on North American TV weather channels and on the author's own web site. It should appeal to many weather enthusiasts, be a satisfying light refreshment for many *CMOS Bulletin SCMO* readers, encourage others to take a greater interest in the weather, and help reassure those who regard atmospheric elements with unease.

I can personally appreciate the lifelong joys and enthusiasms kindled at an early age that are expressed in the essays. I was at times reminded of the variations of the effects of the elements which are conveyed when listening to Vivaldi's "The Four Seasons" composition. Music, art, visual and aural perceptions and the weather are good companions for each other and for us.

You wish to do a book review ? Just contact the Editor at bulletin@cmos.ca

Vous voulez faire une critique de livre? Contacter tout simplement le Rédacteur à Bulletin@scmo.ca

[2] CMOS Member, Ottawa Centre

Yves Delage

1944 - 2005

Yves Delage est né à Québec le 30 septembre 1944 et est décédé à Montréal le 4 août 2005. Sa bataille contre un cancer diagnostiqué le 20 juin 2005 a été très courte et très difficile.

Après ses études classiques, Yves a obtenu un baccalauréat en physique à l'Université Laval en 1968. Il s'est alors dirigé en météorologie. Il a obtenu une maîtrise en physique atmosphérique à l'Université de Toronto en 1970. Ensuite, il a déménagé en Angleterre avec sa famille et a obtenu un doctorat, sous la supervision de Peter Taylor, à l'Université de Southampton en 1973.

At Southampton in the early 1970s, when computer resources were more of a limitation than they are now, Yves developed an adaptive way to provide high resolution at the surface and at the top of the boundary layer and produced some of the first numerical model results for the nocturnal boundary layer. He wrote a paper that is still important in the study of nocturnal and stable boundary layers.

Par la suite, Yves entreprit une carrière de chercheur à la Division de recherche en prévision numérique (RPN) d'Environnement Canada à Montréal. Spécialiste de la couche limite atmosphérique, il était reconnu mondialement à travers ses nombreuses publications scientifiques et présentations à des conférences et ateliers. Yves était aussi régulièrement invité à réviser des articles publiés dans des revues reconnues ainsi que des thèses de maîtrise et de doctorat.

Yves a développé au cours des années une expertise très précieuse dans la modélisation de la couche de surface et a produit des formulations qui sont à la fois d'une grande précision et d'une grande flexibilité. Ces formulations se retrouvent aussi bien dans des modèles de recherche que dans ceux exploités par le CMC. Il a en outre contribué avec enthousiasme et de façon soutenue à l'amélioration des prévisions météorologiques en élaborant méthodes et techniques permettant une prévision de plus en plus exacte des éléments du temps (vents, précipitations, brouillard, etc.).

En 1980, Yves recevait le prix de la SCMO Andrew Thomson en météorologie appliquée pour ses contributions au développement du modèle spectral canadien. En 2000, il était invité à agir comme coéditeur du numéro spécial de *ATMOSPHERE-OCEAN* dédié à CLASS (Canadian LAnd Surface Scheme).

Dernièrement et depuis plusieurs années, Yves travaillait au développement de METRo (Model of the Environment and Temperature of Roads), un système de prévisions des conditions routières. Ce projet, qui comprenait la conception, la construction et l'implantation du modèle dans les bureaux régionaux, a été planifié, dirigé et réalisé en un temps record par Yves.

Yves first began to take an interest in CLASS in the early 1990s, at a time when the effect of the treatment of the land surface in atmospheric models was just beginning to be appreciated and he started collaborating with Diana Verseghy. In the mid-1990s, Yves spearheaded efforts at RPN/CMC to explore the effects of a more complex treatment of the land surface on weather forecasting. Among others things, Yves contributed to CLASS by improving the formulation of the surface turbulent transfer coefficients and by providing more rigorous calculations of screen-level diagnostic variables.

Through 2004, plans were in place at the HAL (Hydrometeorology Arctic Laboratory) in Saskatoon to integrate code developed at the University of Waterloo alongside CLASS into the MEC (Modelling Environmental Community) system designed at RPN to allow full interchangeability of atmospheric, sea ice, land surface and hydrological modules for environmental modelling applications. Yves was a great champion of this effort. He participated in workshops held by the hydrological modelers in Saskatoon in January and May 2005. At the May meeting, Yves introduced colleagues to the HYDROS initiative, a project to generate soil moisture fields from satellite data and he planned the modifications to CLASS to meet the requirements of HYDROS as well as hydrological modelling applications. He departed full of energy and enthusiasm, anticipating a follow-up meeting in Montréal sometime in the fall 2005.

During the summer, after the diagnosis that he had perhaps three or four months to live, Yves spoke of how he had enjoyed working with CLASS and how he had loved being part of the new MEC/CLASS/hydrology effort. Even sick, he promised to see to the handing on of his tasks to others. Yves' courtesy and keen scientific mind made it a delight to work with him and he leaves behind a legacy of important achievements.

C'est avec beaucoup de tristesse que nous avons appris le diagnostic de la maladie de Yves en juin et son décès au début du mois d'août. Sa générosité, sa gentillesse, son respect des autres et son sens de l'humour faisaient de lui un collègue apprécié et respecté de tous. Yves était aussi d'un professionnalisme exemplaire. Par ailleurs, il était toujours parmi les premiers à se porter volontaire pour participer à l'organisation d'activités sociales à RPN. Yves fut l'instigateur de l'équipe de badminton RPN/CMC; ceux d'entre nous qui ont eu le plaisir de jouer avec lui se souviendront toujours de sa bonne humeur. Yves nous laisse de beaux souvenirs et il nous manquera beaucoup à tous, ses collègues et amis.

Nous offrons nos sincères condoléances à sa conjointe Josette, à ses enfants Annick, Martin et Pierre ainsi qu'à toute sa famille.

Tes collègues et amis

Phil Cote

1941 - 2006

The Passing of a Friend

Philip Wayne Cote, known to us all as Phil, passed on with his family at his side at the Woodstock General Hospital on Wednesday, March 29, 2006 in his 66th year. Phil was a member of the Canadian Meteorological and Oceanographic Society for over 35 years. He is best known professionally as the ice climatology expert at the Canadian Ice Service in Ottawa, where he worked for most of his career with Environment Canada. Phil was admired and respected for his quiet, professional manner and was internationally known for his knowledge of sea ice conditions in Canadian waters. Phil's legacy includes many publications on sea ice in Canada most notably his contribution to the ice atlases that today form a cornerstone for much of the climate change research taking place today. In extending our sympathies to his family, CMOS recognizes the valuable contribution that Phil Cote made to Canada and to Canadians to help understand their ice environment and the changes it is undergoing.

Phil is survived by his wife, Susan, four children and two grandchildren.

John Falkingham
CMOS Ottawa Centre

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CMOS Member Honoured

Dr. Lawrence Mysak has been awarded on April 5th in Vienna at the annual EGU assembly, the Alfred Wegener Medal and Honorary Membership in the European Geosciences Union. The Medal was awarded "*in recognition of his leadership in oceanography and his fundamental contributions in ocean dynamics, sea ice and climate*". After receiving this top award of EGU, Dr. Mysak gave a "public" medal address, which was entitled: "*Glacial inception: Past and Future*".

This medal and honorary membership is one of three equally-ranked Union-wide awards -- the other two are in the areas of space sciences and earth sciences. The Alfred Wegener Medal is for contributions in atmospheric-oceanic-hydrologic sciences.

Congratulations to Dr. Mysak from all the CMOS Community!

Time Series of the Northeast Pacific

As one of the longest running time series in the world, Ocean Station Papa (OSP: 50°N and 145°W) represents a unique dataset taht has improved our understanding of ocean processes. Meteorological and surface ocean sampling from a weather ship at OSP began in 1949. In 1956 observations were initiated at stations along a line between the coast of British Columbia and OSP. Since then, surveys along this line, now called Line-P, have been undertaken several times each year. Line-P is, however, only one of the ocean time series of the N.E. Pacific and previous research has benefited from comparisons among the various time series.

This symposium, sponsored by Fisheries and Oceans Canada, the North Pacific Marine Science Organization (PICES) and the international CLIVAR program office, will celebrate **50** years of oceanography along Line-P and at OSP. The workshop will explore the scientific value of both Line-P and the time series of the N.E. Pacific in general.

Both convenors from the Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Howard Freeland and Angelica Peña, invite you to attend this symposium which will include invited talks and extended sessions of contributed posters each day. Defined science themes are: 1) Overview of time series of the NE Pacific; 2) Physical, chemical and biological variability in NE Pacific time series; and, 3) Process studies in the NE Pacific. The symposium will take place July 5th - 8th, 2006, at the Victoria Conference Centre, Victoria, BC. For more information, please consult the www.pices.int website and then look for the conference logo.

CMOS Business

Highlights from Spring CMOS Council and Executive Meetings

■ The Council was very pleased to welcome Dick Stoddart as the chair of the Finance and Investment Committee and William Hsieh as the chair of the Prizes and Awards Committee.

■ Dr. Fraser Davidson, of Fisheries and Oceans Canada, St. John's, Newfoundland, will be asked to be the 2006/2007 CMOS Tour Speaker.

■ There will be an article on CMOS in the May issue of MSC's newsletter.

■ The CMOS Scientific Committee drafted a letter to Prime Minister Harper on the topic of Climate Change (**see page 71**).

Afffaires de la SCMO

Points saillants des réunions printannières du Conseil et de l'Éxécutif de la SCMO

■ Le Conseil était heureux d'accueillir Dick Stoddart en tant que président du comité sur les finances et investissements et Dr. William Hsieh comme président du comité des prix et récompenses.

■ La SCMO demandera au Dr. Fraser Davidson, de Pêches et Océans Canada, St-John's, Terre-Neuve, d'être le prochain conférencier itinérant.

■ Il y aura un article sur la SCMO dans la publication de mai du Bulletin de la SMC.

■ Le comité scientifique de la SCMO a écrit une lettre au Premier ministre Harper à propos des changements climatiques **(voir page 72)**.

Next CMOS Congress

The next CMOS Congress will be held in St.John's, Newfoundland and Labrador, from May 28 to June 1, 2007. The selected theme of the Congress is "*Air, Ocean, Earth and Ice on the Rock*". This will be the 41st Congress of the Society and will be held jointly with the Canadian Geophysical Union and the American Meteorological Society. This promises to be a major event in 2007. Please, mark these important dates on your calendar for next year.

Prochain congrès de la SCMO

Le prochain congrès de la SCMO se tiendra à St.John's, Terre-Neuve et Labrador, du 28 mai au 1er juin 2007. Le thème choisi pour le congrès est "*Air, Océan, Terre et Glace sur le Roc*". Ce sera le 41e congrès de la Société et il se tiendra conjointement avec l'Union géophysique canadienne et l'American Meteorological Society. Ce sera sans aucun doute un rendez-vous majeur en 2007. Prière de réserver ces dates sur votre calendrier pour l'an prochain.

Semaine canadienne de l'environnement

du 4 au 10 juin 2006

La Semaine canadienne de l'environnement se déroulera cette année au cours de la première semaine de juin afin de coïncider avec la **Journée mondiale de l'environnement** (5 juin). Cette journée spéciale a été proclamée par les Nations Unies en 1972 afin de stimuler l'intervention des politiciens en matière d'environnement et d'encourager les gens, aux quatre coins de la planète, à promouvoir activement la cause du développement durable et équitable.

La **Journée de l'air pur** (7 juin), qui se tient le mercredi de la Semaine canadienne de l'environnement, a été proclamée par le gouvernement du Canada afin de sensibiliser davantage le public à l'air pur. Elle donne aux Canadiens l'occasion de démontrer leur engagement en participant à des activités individuelles ou collectives qui contribuent à diminuer l'utilisation de l'énergie, à réduire leur production de déchets et à faire de bons choix en tant que consommateurs. Pour plus de renseignements sur ces événements, prière de consulter le site web du ministère de l'environnement à:

http://www.ec.gc.ca/e-week/index_f.htm

Canadian Environment Week

June 4-10, 2006

Canadian Environment Week will be held during the first week of June to coincide with **World Environment Day** (June 5). This special day was designated by the United Nations in 1972 to stimulate political action on the environment and empower people from every corner of the globe to become active agents of sustainable and equitable development.

Clean Air Day (June 7) is held annually on the Wednesday of Environment Week, and was proclaimed by the Government of Canada to increase public awareness and action on clean air. Canadians can show their commitment by participating in individual or community activities that help you use less energy, reduce waste and make smart consumer choices. For more information on these events, please consult Environment Canada website at:

http://www.ec.gc.ca/e-week/index_e.htm

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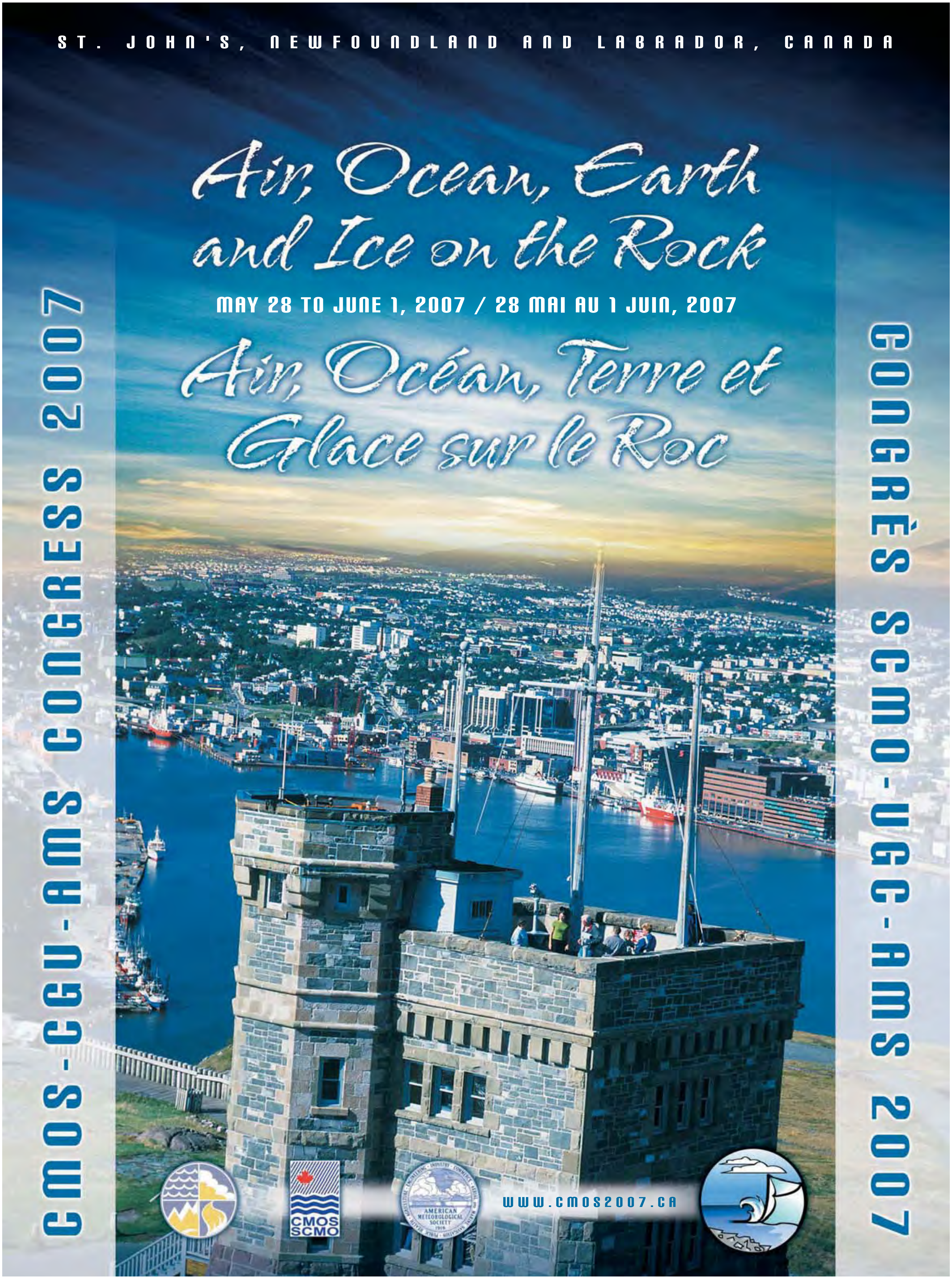

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Air, Ocean, Earth and Ice on the Rock
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