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La Société canadienne de météorologie et d'océanographie

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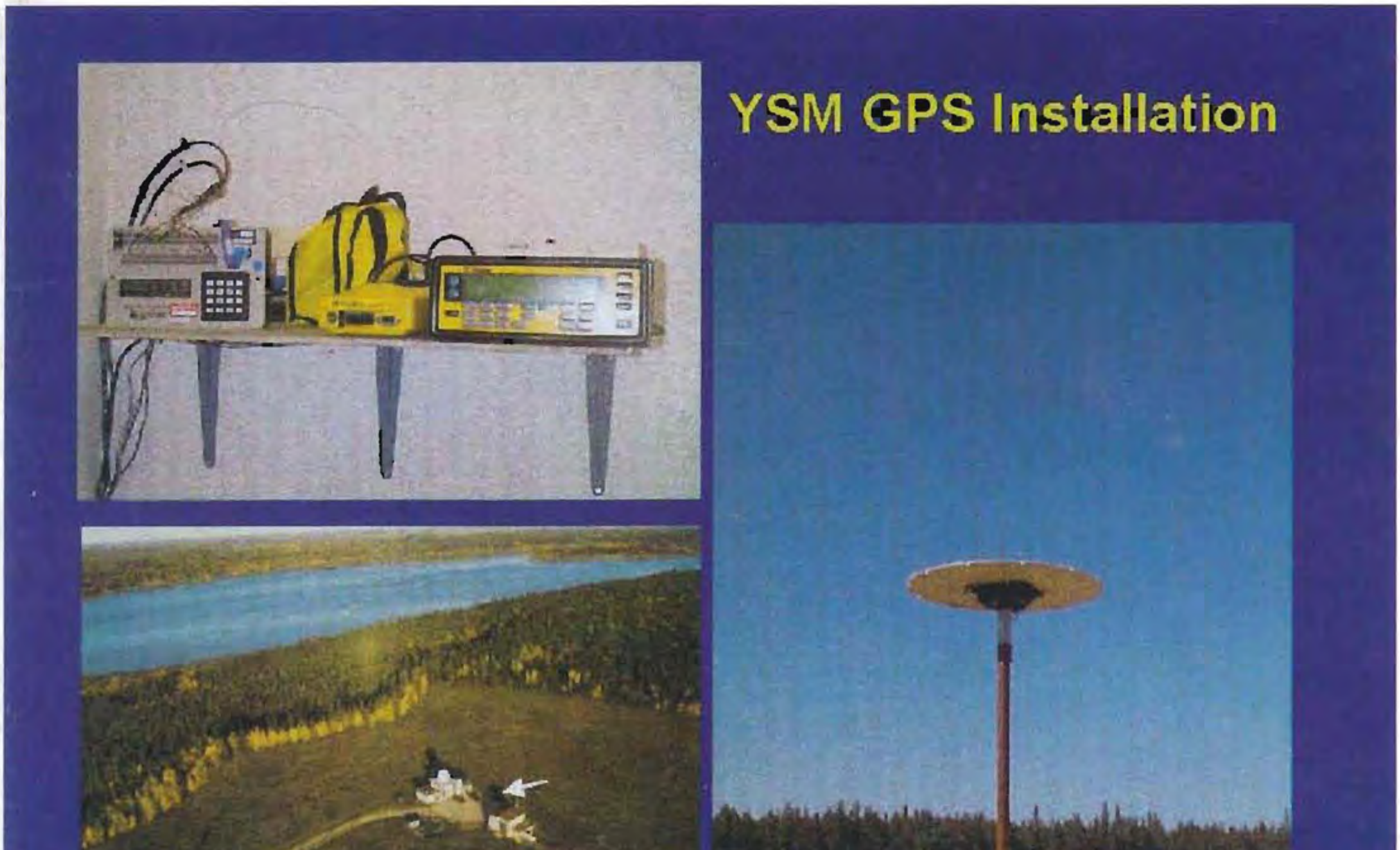

CMOS Bulletin SCMO

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

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Cover page: Photograph the dual frequency GPS antenna and ground plate mounted near the Meteorological Service of Canada upper-air facility in Ft. Smith NT, aerial vue of its location and illustration of the Trimble 4000ssi GPS receiver and Campbell Scientific data logger inside the facility. To learn more, read the article on page **107**.

Page couverture: Photo de l'antenne du système de positionnement global (GPS) à double fréquence installé à la base de radiosondage du Service météorologique du Canada à Fort Smith NT, vue aérienne de l'emplacement et vue du récepteur Trimble 4000ssi GPS et de l'enregistreur de données Campbell Scientific à l'intérieur du complexe. Pour en savoir plus, lire l'article en page **107**.

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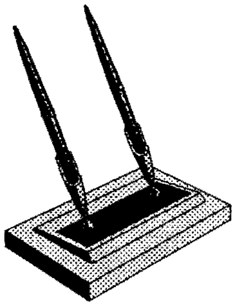
Canadian Meteorological and Oceanographic Society (CMOS)

Société canadienne de météorologie et d'océanographie (SCMO)

....from the President's Desk



CMOS Friends:

I am rather amazed to see that it's now August. Our summer is passing all too quickly.

Our climate is always a concern to us and this is certainly the case this summer for much of the country. With this far-reaching drought and its impacts, it hits home how important our work is to the country. There are 31 million people clamouring for more information on our climate, weather and oceans. It's always a nice feeling to be in a challenging scientific field such as ours but also be in a field that's so important to society.

It seems that 'science' is on the mind of government these days. It is an opportune time for our science-based Society to influence the government and its policies. In this regard, one effort that we are pursuing is the possibility of closer interactions with our Canadian Geophysical Union (CGU) colleagues. Collectively, we (CMOS) and CGU represent much of the geoscience community in Canada. It may very well be that 'speaking with one voice' on key issues facing our collective science can carry more of an impact. We'll keep you informed of these activities.

With regard to developments within CMOS, I wanted to mention recent changes in the Chairs of three of our Committees. The Society is only successful through the efforts of our volunteers and the chairs of our committees all deserve a round of applause.

Ambury Stuart has actively led the Private Sector Committee for the last few years. This Committee's major effort over much of this period has been the Private Sector initiative in conjunction with the Meteorological Service of Canada. Interactions between these groups involve many of our members in one way or another. This Committee is now under the leadership of Susan Woodbury.

Eldon Oja has maintained a very active School and Public Education Committee. This is a critical Committee for us and it, for example, champions our interactions with the elementary schools, high schools and CEGEPs. A major initiative by this Committee has been the Canadianization of the Project Atmosphere educational material that was originally established by the American Meteorological Society. (This can be viewed from our CMOS web site under: Education-Schools). The new Chair, Gilles Simard, has taken up the challenges of this Committee.

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Inside / En Bref

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Roland Stull has led the University and Professional Education Committee for the last few years. The Committee has maintained a dialogue to enhance our university programs and has discussed critical issues such as data access and hiring practices with government. The new Chair, Peter Bartello, is taking over this critical Committee and we look forward to a continuing, active group.

The Private Sector Task Force (mentioned above) has been very active this summer. HLB Decision Economics Inc. has been hired to prepare a study focusing on the roles of the private sector and Environment Canada with regard to weather services. This study will be delivered in draft on August 31 and will become an integral part of the Industrial Strategy being developed by the Committee.

As also mentioned above, a major concern of CMOS has been education at the elementary, high school and CEGEP level. It is crucial that we improve awareness of students at this level; the lack of awareness is undoubtedly having a negative impact at the undergraduate and graduate level. This reality is not just for our atmospheric and oceanographic sciences, however. It is a Canadian science issue and we've recently become aware of an NSERC-sponsored program, promoscience (www.nserc.ca/promoscience) that is aimed at non-profit organizations such as CMOS and allows them to carry out educational activities aimed at this level of student. This may offer us some possibilities for future activities that build on our successes.

Since everything these days is 'on the web', I hope that you periodically visit our CMOS web site (www.cmos.ca or www.scmo.ca). Bob Jones is constantly making improvements and is anxious to hear of new suggestions. Recent improvements, thanks to our Publications Director, Richard Asselin, include on-line updates of the latest Atmosphere-Ocean papers (at least the last year of full papers) and all A-O abstracts going back over ten years. Following the Winnipeg Congress, improvements were made to the "CMOS Lists" making the web site a main repository for prize winners, past presidents, 25-year members, corporate members, fellows, etc. See "About CMOS" for most of these lists. Finally, a start has been made on posting biographies and photos of CMOS officers and volunteers. For example, have a look at some smiling faces under the new "Contact Us" section of the web site.

Chat with you again in a couple of months.

Ronald Stewart,
President / Président

CMOS Bulletin SCMO
Next Issue - Prochain Numéro

Next issue of the *CMOS Bulletin SCMO* will be published in October 2001. Please send your articles, notes, workshop reports or news items at the earliest to the address given on page ii. We have an **URGENT** need for your articles.

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en octobre 2001. Prière de nous faire parvenir au plus tôt vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée à la page ii. Nous avons un besoin **URGENT** d'articles.

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

Nonlinear and Nonstationary Signal Processing, by W.J. Fitzgerald, R.L. Smith, A.T. Walden and P.C. Young, Cambridge University Press, Hardback Cover, 0-521-80044-7, March 2001, $95.00US.

Tsunami: The Underrated Hazard, by Edward Bryant, Cambridge University Press, Hardback Cover, 0-521-77799-X, July 2001, $74.95US.

The Earth's Plasmasphere, by J.F. Lemaire and K.I. Gringauz, January 1998, Cambridge University Press, Hardback Cover, 0-521-43091-7, 350 pages, $90.00US.

Air-Sea Interaction, by G.T. Csanady, Cambridge University Press, Paperback Cover, 0-521-79680-6, 2001, Price unknown.

El Niño and The Southern Oscillation, Multiscale Variability and Global and Regional Impacts, Edited by Henry F. Diaz and Vera Markgraf, Cambridge University Press, Hardback Cover, 0-521-62138-0, 2000, Price unknown.

Emissions Scenarios, Intergovernmental Panel on Climate Change, Cambridge University Press, Paper Cover, 0-521-80493-0, 2000, $44.95.

Methodological and Technological Issues in Technology Transfer, Intergovernmental Panel on Climate Change, Cambridge University Press, Paper Cover, 0-521-80494-9, 2000, $35.95.

Land Use, Land-Use Change and Forestry, Intergovernmental Panel on Climate Change, Cambridge University Press, Paper Cover, 0-521-80495-7, 2000, $29.95.

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. The instructions to be followed when reviewing a book for the *CMOS Bulletin SCMO* will be provided with the book. Thank you 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-bas. Bien entendu, le livre vous appartient lorsque vous avez terminé la critique. Les instructions qui doivent être suivies lors de la critique d'un livre dans le *CMOS Bulletin SCMO* vous parviendront avec le livre. Merci pour votre collaboration.

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Early Aviation Weather Services at Edmonton

Reminiscing about Prewar, Wartime and Postwar Developments 1938-1950

by George W. Robertson[1]

Morley Thomas's Books

Morley Thomas has written two excellent books both of which touch on this matter. The first one "Forecasting for Flying" was published in 1996 and covers aviation meteorology for all of Canada for the period 1918-1939. The second book, which I received just a month ago called "Metmen in Wartime" covers the period from 1939 to 1945. After reviewing these two books I wonder why I am here. Morley should be up here in my place.

Anyway, Morley's approach in his literary works has been to research the inside stories and facts; mine is going to be reminiscing about the experiences and activities of a field operator as I remember the facts some 50 to 60 years later. If there are any discrepancies between what Morley has written and what I say it's probably due to my fading memory.

Maclean's - 1937

As far as I'm concerned it all started back in the summer of 1937. I was still a Junior at the University of Alberta and it was at the height of the depression. An article in Maclean's Magazine proclaimed the intention of the Canadian Government to start a Trans-Canada air service (TCA) involving emergency landing fields every 100 or so miles across the country equipped with radio range stations and a few centres equipped with full aviation services including radio communications and weather services.

The weather services bit caught my eye. Two of my professors at U. of A. had talked a bit about meteorology, Dr. Ted Gowan was interested in climatic change and the receding of glaciers, particularly the Columbia Ice Fields. He was interested also in the measurement of ultra-violet solar radiation and had continuous records for some period of time. Prof. Nichols spent some time taking temperature readings by aircraft over the city and told weird stories about chinook conditions at 1000 ft. over the city when the surface temperature was near zero to -10 degrees F. To make a long story short, the interest that these professors had instilled in me, together with the fact I was quite weather conscious having been raised on a farm and having experienced the worst drought to hit the prairies in modern times, I decided that I wanted to become a weather man.

Salary, also, had a bit to do with this decision. Graduate electrical engineers at the time were being offered $80 per month by Canadian General Electric in Toronto or Peterborough; and $90 per month by Calgary Power. The Meteorological Service of Canada (MSC) was offering $135 per month for graduates in mathematics and physics. I was hoping to graduate in this field in the spring of 1938 so I applied for a job as a Meteorological Assistant Gr.3 at the Edmonton Airport.

The need was great and the MSC couldn't wait for me to graduate. They found someone else but they offered me a job as a Meteorological Assistant Gr. 2 at a salary of $110 per month providing I could start work immediately. After weighing all the factors and considering the difficulty of getting jobs during the depression, I accepted their offer.

My Career Starts

So I started work on February 4th,1938 before graduating. The Edmonton Weather Office was in No.1 hangar, the only one at that time, at the Municipal Airport. The office was on the top floor of the tower. Immediately below was the Radio Range staff and below them space was reserved for the future TCA Dispatch office.

Fig. 1 - Hangars #1 (left) & #2 (right) at the Edmonton Municipal Airport. GWR/39/04/19

Staff consisted of the Officer-in-Charge, Mr. Vanderburg (Van), and one other weather observer, Mr. Brinkman (Brink). The equipment consisted of a mercury barometer, an aneroid barograph, the recorder for the wind equipment mounted on a tower on top of the building, and a recorder for Dr. Gowan's ultra-violet radiation measurements.

[1]Based on a presentation to the 38th Annual Convention of the Canadian Aviation Historical Society, 25-27 May 2001 at Environment Canada Headquarters, Toronto, Canada.

Figure 2

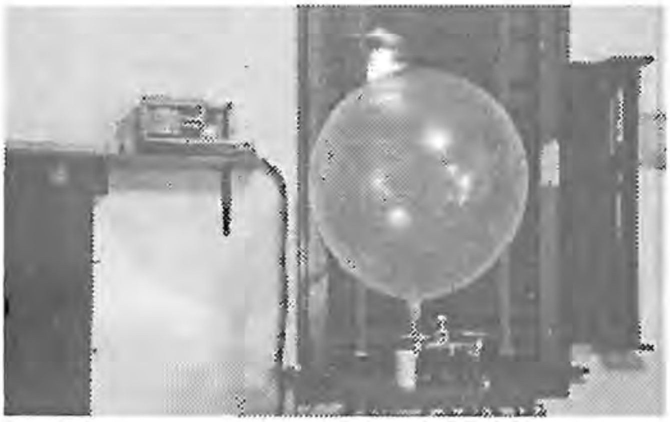

Figure 3

In the weather site some 100 ft east of the hangar there was a Stevenson Screen with maximum and minimum thermometers, wet and dry bulb thermometers, recording instruments for temperature and humidity, and a rain gauge. There was also hydrogen and equipment for filling and following balloons for measuring upper winds and low cloud ceilings.

Observations were taken hourly and these were sent via teletype to the main line teletype office in Lethbridge. With my arrival the 3-man staff could cover hourly observations for about 16 hours per day, 7 days a week.

It must be remembered we had no computers, no weather radar, no weather satellites, no internet, no cellular phones, and no television. Our only form of observation was eyeballing the weather elements and a few ground-based instruments. Our only form of communication was via telephone, telegraph, and teletype. We had to learn to operate the teletype at 40 words per minute. Four stations were on the teletype circuit: Edmonton (XD). Penhold (QF), Calgary (YC), and Lethbridge (QL). Lethbridge was relay point for all teletype messages and weather reports to and from the transcontinental air route between Winnipeg and Vancouver.

Figure 4

Figures. 2,3, & 4, - Scenes in the Edmonton Meteorological Office. GWR/39/12/05.

Shortly after my arrival at the Edmonton Weather Office a teletype operator, Charlie Hustwick, joined the staff with the understanding that he had to learn weather observing and take observations like the rest of us. After his brief training period the staff of four could now take hourly weather observations 24 hours per day for 7 days a week, synoptic observations every 6 hours, and upper wind observations with balloons every 6 hours. We were now nearly ready to provide TCA with weather briefing service for the feeder route from Edmonton to Calgary and Lethbridge.

Airplane Observations (APOBS)

About mid-summer 1938 Gerry Gill joined the staff as an upper air expert. His job was to organize and conduct airplane observations. Edmonton was the third station in Canada at which such observations were taken regularly: the other two being Toronto and a station in Newfoundland. Gerry taught me how to prepare the recording instruments and mount them on the aircraft struts. When the flight returned, temperature, pressure, and humidity data were scaled off and coded for transmission on the teletype circuit. Flights were made at daybreak and usually reached about 10,000 ft but on occasion the light aircraft used could be pushed to 12,000 ft.

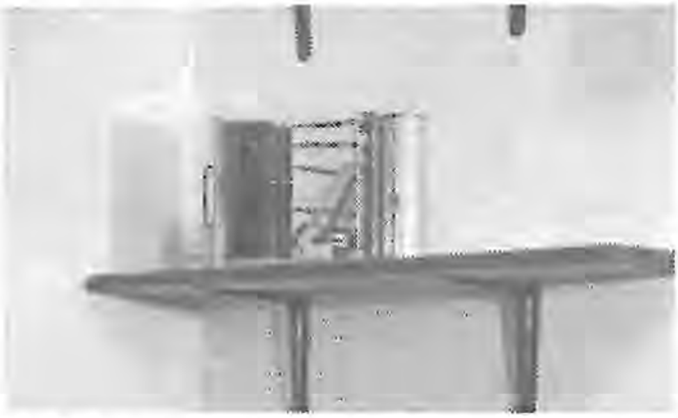

Fig. 5 - Meteorograph for APOB flight. Case is on floor below barometer in Fig. 4 GWR/39/12/05.

Figure 6. - APOB plane ready for take-off. Meteorograph is mounted on struts on right hand side of plane. Large red-reading mercury wet and dry bulb thermometers are mounted on struts on left hand side. GWR/40/07/12.

TCA Starts Service

In March 1938 TCA started flying the transcontinental route from Winnipeg to Vancouver and it was only a matter of time until the feeder route from Edmonton to Lethbridge would be opened. However, there was the matter of providing facilities at the Edmonton terminal which did not have a fully qualified meteorologist (forecaster).

This was rectified in August when Vanderburg was moved to Winnipeg and Dr. Tom How, a meteorologist, was assigned to the Edmonton Office as Officer-in-Charge. The staff now consisted of a meteorologist, a meteorological assistant Grade 2, a weather observer, and a teletype operator. Gerry Gill left shortly after How arrived and How and I looked after the APOB flights.

Occasionally, when the radio range operator had to visit the transmitter or help with range calibrations, the meteorological staff kept an eye on the radio operation downstairs and made the routine hourly-weather broadcast.

One of the few perks we had in our job was the opportunity for airplane rides. Jack Hunter occasionally visited Edmonton in the Department of Transport (DOT) plane, CF-CCT, for the purpose of calibrating the radio range station. This involved doing a number of passes around the range transmitter with CF-CCT to check the bearing of the null points between the A and N sectors. On one occasion Jack was in the weather office checking the weather before such a flight. During our conversation I made the remark that I had never flown in a plane other than small single engine Moth or Fleet aircraft. Immediately Jack invited me to accompany him on his calibration flight next afternoon. As it was my day off, I accepted.

Next day I made a flight I will never forget. It was a sunny afternoon - a perfect day for sight seeing. I was in a passenger seat behind Jack and his co-pilot and had only a side view. The flight was rather low and quite bumpy and the sharp turns and steep banks he made in connection with the calibration exercise upset my stomach. There were no facilities for air sickness on the plane. To make a long story short, after we landed I spent the rest of the afternoon and evening scrubbing out CCT.

TCA Route Edmonton to Lethbridge Inaugurated

Finally by March 1939 DOT had all airways facilities completed on the feeder route from Lethbridge to Edmonton. This included emergency landing fields, radio range stations, and weather reporting and briefing facilities.

But one item was overlooked when TCA made their inaugural flight on this route on the evening of April 1st from Edmonton. All the airline dignitaries as well as the Edmonton mayor, other politicians, and the press were on hand for the great event. All went well and Flight #10-1 left on schedule. When the plane disappeared from sight the dignitaries and press all went down town to celebrate. Ten minutes later TCA Flight #10 returned, landed and pulled up to the hanger. A mechanic ran out fastened down the hatch to the baggage compartment and away the flight went again. The Mayor of Calgary and other dignitaries never did find out why they had to wait an extra half hour for flight #10 from Edmonton.

Assignment to Calgary

A few weeks after this incident I received word from MSC headquarters that I was to spend three weeks in Calgary to relieve Clarence Milgate who was being posted to Edmonton for a short spell for personnel appraisal purposes. Later I found out that I was also being appraised in a new environment at Calgary.

The assignment in Calgary was an interesting one. The Met staff consisted of two members: Capt. Bromley, a former navy man, and the meteorological assistant Gr. 2 with whom I had been exchanged. Calgary was not considered a TCA terminal, only a brief stop on the feeder line from Lethbridge to Edmonton. It was not a busy airport and the two Met staff members worked two shifts: daytime and evening. The observation program was about the same as in Edmonton excepting that there were no airplane observations. TCA made two stops per day: one in the morning enroute to Edmonton and the other in the evening enroute to Lethbridge.

We had a lot of free time on their hands. I took the opportunity to prepare synoptic charts of weather conditions in western Canada; an exercise that Tom How had inaugurated at Edmonton. We were not allowed to make our own forecasts from these charts as this was the responsibility of the meteorologists at the District Aviation Forecasting Offices (DAFO's) at Winnipeg and Vancouver. Nevertheless the charts were convenient for briefing purposes and the TCA pilots appeared to appreciate them when they checked in for a briefing on their short stopovers in Calgary. When my three weeks were up I returned to Edmonton and Milgate returned to Calgary.

During the summer of 1939 a couple of changes took place in the technical aspects of weather observing and reporting. By international agreement, barometric pressure, which up to this time was measured and reported in inches of mercury, was replaced by the millibar, a unit of pressure in the metric scale. The six-hourly synoptic weather reports had been coded by means of words to facilitate the transmission of weather reports by telegraph and wireless. Now that there was a vast network of teletype stations connecting airports and weather offices throughout Canada and the USA, this word code was replaced by a numeric code. Each weather report consisted of a number of groups of 5 digits each. Each group referred to a given weather element: the first group identified the station and time, the second group gave the barometric pressure and temperature; the third group the wind direction and speed; and so on for the current weather type, cloud cover, precipitation type and amount and other elements. With a little practice the new numeric code was easier to decode than the old word code.

War Declared on Germany

Then on September, 10, 1939 Canada declared war on Germany. Weather information became classified and was no longer available to the media or the public. All reports that were transmitted by radio telegraphy had to be ciphered before transmission. The new numeric synoptic weather code lent itself readily for ciphering.

To encipher the weather reports the originator added secret numbers to the numeric synoptic code. At the receiving end the weather reports were deciphered by subtracting the same numbers. A code book was provided to all observing stations responsible for enciphering and a similar code book was available at weather offices that made official use of the reports.

The BCATP

It was soon realized that the war effort would require a large number of airmen: pilots, navigators, air observers, air gunners, and air bombers. By December the governments of Canada, Britain, Australia, and New Zealand had formulated an air training plan known as the British Commonwealth Air Training Plan (BCATP). On December 17, 1939, Canada and Britain signed the plan which basically was to provide training for air crew from the Commonwealth Nations on Canadian soil. Australia and New Zealand signed the agreement a few weeks later.

Earlier the Canadian Government had considered the meteorological requirements of civilian aviation, the airforce, the navy, and the army. After much discussion it was decided, for the sake of economy and to avoid duplication of services, that Canada would have only one Meteorological Service and that would be a civilian Division under the Air Services Branch of the Department of Transport (Canada).

No. 2 AOS, Edmonton

Eight months later, in August 1940, No. 2 Air Observer School (AOS) was opened at the Edmonton Municipal Airport and I was transferred from the Edmonton Aviation Weather Office to the Meteorological Section at the AOS. No. 1 AOS at Malton had been opened in May 1940. I was sent there for three weeks to work with Fred Turnbull and Fred Patterson and to observe how the Meteorological Section at an AOS functioned.

The Section had two main responsibilities: to instruct the enlisted students in practical aviation meteorology and to brief the civilian pilots and enlisted air crew trainees on the local weather condition for doing their flying exercises. Although I had finally graduated with a B.Sc. in mathematics and physics, I was still only an Assistant Gr. 2 and not qualified to prepare forecasts. Furthermore, the aviation forecasting office Edmonton would not open for several months. It was considered necessary that a full fledged meteorologist should be at the School so a number of meteorologists Gr.1 were sent, in turn, to provide briefing services. These included Fred Kelly, Syd Buckler, and Allin Jackson.

Meteorological training was undertaken by myself and three MetMen. These MetMen were university graduates with specialization in mathematics and physics and had been given a 3-month intensive training course in elementary meteorology at MSC HQ in Toronto.

Kelly and Buckler went elsewhere but Jackson remained in Edmonton. He was at the AOS for only a short time when he was moved over to the Edmonton Meteorological Office to assist Tom How with the task of organizing the Edmonton aviation forecasting office.

By this time the DAFO at Lethbridge was operational and with two meteorologists at the Edmonton Main Meteorological Office as backup it was now considered that the staff at the AOS Meteorological Office could manage with only MetMen. I was appointed Officer-in-Charge of the AOS Meteorological Office and at last promoted to Meteorological Assistant Gr. 3 with the enormous annual salary of $1620. The staff was periodically increased as the program at the School developed and by August 1941 consisted of five civilians: Denny Ross, Dick MacLean, Thorleif Fostvedt, Vic Adams and myself, and a supporting staff of five airmen.

Each class at the School consisted of about 25 airmen trainees. They received, among other courses, 32 hours of lectures in aviation meteorology delivered over a period of 22 weeks by the MetMen. Each MetMan lectured to two classes per day. He taught the same classes throughout the 22 weeks of their training. Each class would attend ground school for half a day and fly during the other half.

Although each MetMan lectured only two hours per day he had many other duties for the rest of the day. He had to prepare lecture material; tests had to be prepared and marked; surface and upper air charts had to be prepared every three hours; and briefings for training flights prepared and delivered. There were 25 3-hour flights per day with some night flying for astro-navigation training so the staff was kept quite busy.

Supplementary Observations

Even though the training flights were short, providing weather information in all directions around Edmonton was tricky. To the north and west were hills; to the southwest the mountains; to the south increasing land elevation; and in the east quadrant, the prairie. To make matters worse there were only two aviation weather stations reporting hourly in the area: Edmonton and Penhold (Red Deer). Often morning flights were sent out with little knowledge of the weather in the area: there could be extensive fog patches and/or areas of low cloud which didn't show up with the meagre observations available to us.

Wop May, the manager of the Civilian company responsible for flying the training planes came up with a brilliant idea to solve this problem. Every morning the Alberta Government Telephone AGT system made a line and equipment check by calling their operators in villages surrounding Edmonton. May and I met with the manager of the AGT, and worked out a program whereby the telephone operators reported the weather as they saw it on these early morning check calls. Some eight or ten operators around Edmonton within a hundred-mile radius were enlisted for this service and in time they became very proficient observers and proud of their contribution to the war effort.

Pearl Harbour

Meanwhile over at the Aviation Weather Office business was booming. As an indication of the airport activity, the newly established Control Tower handled an average of 800 flights per day in August 1941.

The Japanese bombed Pearl Harbour on December 7, 1941. Canada declared war on Japan immediately and the US and Britain declared war the next day. A couple of months earlier, Germany, Italy and Japan had signed a "Three-Power-Pact" pledging mutual assistance to each other. Therefore, the US declaration of war on Japan essentially brought them into conflict with Germany and Italy. In retaliation, Germany and Italy declared war on the US on December 11, 1941. These actions increased concerns about security in Northern Canada. Furthermore the USA needed an all-weather route to Alaska and the Pacific war theatre, safe from surprise naval and air attacks.

Both of these contributed to increasing air traffic on the route from Edmonton to Alaska via Whitehorse and from Edmonton into the Northwest Territories (NWT). Consequently the demand for weather services and information increased rapidly as northern flying increased.

The Northwest Staging Route

These developments led to plans to speed completion of the Northwest Staging Route from Edmonton to Alaska which the US Army Air Force (USAAF) could use for ferrying military aircraft to the Pacific war theatre as well as to the USSR. A Mackenzie Route from Edmonton to Norman Wells was also in the plans. This was needed to develop the oil field at Norman Wells which would supply fuel for the Northwest Staging Route. A pipeline was to be built from Norman Wells across the Mackenzie Mountains to a refinery at Whitehorse.

I remember the occasion when the first flying fortress landed at Edmonton. The pilot taxied up to No. 2 Hangar, locked the left wheel and made a sharp u-turn. The soft tarmac couldn't take it. The left wheel augured its way through the thin surface cover and down into the wet clay beneath. The crew spent an extra unscheduled stay in Edmonton.

Edmonton Aviation Forecasting Office Opened

By the summer of 1942 plans for a forecasting office at Edmonton were completed. This new office was opened for operation in No. 2 Hangar. The original staff of meteorologists consisted of Tom How, Allin Jackson, Don Currie, Stu Dewar and Al Gibb all of whom stayed on until after the war. Meteorologists Harry Tucker and Carl Mushkat were also stationed at the Edmonton office for a short period in 1942 but moved on to similar duties in other parts of the country.

An Airport Administration Building was now badly needed and one was rushed to completion and opened on October 21, 1942. Among other airport facilities, this housed the DOT offices, included the Radio Range staff, Control Tower, and the recently established aviation forecasting office. (For unknown reasons the Edmonton office was never classified as a DAFO).

The newly opened Edmonton Office provided aviation forecasts for the Northwest Staging Route from Edmonton to Alaska; for the Mackenzie route from Edmonton to Norman Wells; to the Arctic Coast when needed; and for the CANOL Route from Norman Wells across the Mackenzie Mountains to Whitehorse. Airlines using these routes, besides the RCAF and the USAAF, included, among others, Canadian Pacific Airlines, Pan American Airlines, and Alaska Airlines.

Weather Services along the Staging Route

In the meantime airports or emergency landing strips with radio range stations, radio communication links, and aviation weather observing and briefing services were built along the Northwest Staging Route at Grande Prairie, Fort St. John, Fort Nelson, Watson Lake, and Whitehorse. The meteorological services at each of these stations were provided by a MetMan and two meteorological assistants Gr. 2.

Along the Mackenzie Route airports or emergency landing strips were built at Ft. McMurray, Ft. Smith, Ft. Simpson, Ft. Norman, and Norman Wells. The Royal Canadian Corps of Signals (RCCS) provided synoptic weather observations every six hours as they had done for many years before the war. The MSC didn't have the staff to man these points so the USAAF provided staff for briefing and taking hourly observations.

By June 1942 air traffic along the Northwest Staging Route became very heavy due to the ferrying of military aircraft from Great Falls to Alaska via Edmonton. The USAAF found it necessary and advantageous to have their own military forecasters at offices established at Lethbridge, Calgary, Edmonton, Grande Prairie, Fort St. John, Fort Nelson, Watson Lake, and Whitehorse with links to the Canadian Offices via teletype. Another forecast office was established at Norman Wells to service air operations along the CANOL and Mackenzie Routes.

As air traffic continued to increase it became necessary to build additional radio range stations between those already existing along the route. By 1943 these included sites at Snag, Aishihik, Teslin, Smith River, and Beaton River. The MSC provided weather observers at each site so that hourly and synoptic weather observations could be taken around the clock. There was still a need by the USAAF for off-airline stations for which the Canadian Government couldn't provide staff so the US Government was given permission to establish weather stations as needed. By 1944 there were some 25 USAAF observing stations servicing the Northwest Staging Route and the CANOL Route.

Upper Air Observations Increased

Upper air observations had now increased manifold. APOBS were discontinued during 1941 and were replaced by radiosonde observations: small radio transmitters were carried aloft by hydrogen filled balloons and radioed back to ground base the measurements of pressure, temperature, and humidity. Canada equipped several of its observing stations with such facilities. The USAAF needed a denser network of stations than the MSC could supply so they provided a number of their own stations in Canada with radiosonde equipment. By 1944 there were some seven radiosonde stations in Western Canada making ascents every 12 hours.

Whitehorse Aviation Forecasting Office

In the spring of 1944 the MSC finally had sufficient staff to man a forecasting office in Whitehorse. This was staffed by meteorologists George Legg, Clarence Thompson, Ken Harry and Burn Lowe. They were able to provide 24-hour service and took over some of the responsibilities of the Edmonton Office, particularly the forecasts for the CANOL Route and the northern half of the Staging Route.

Namao Airport Built

Another problem that had to be overcome was overcrowding at the Edmonton Municipal Airport. In 1943 Canada gave authority for the US to build a new airport at Namao. This was completed in 1945 and the USAAF moved all their flying and ferrying operations, including meteorological services, to this new airport some 15 km north of Edmonton. At the time it was the largest in North America and the main runway, 14 000 ft long, was the longest in the world. At one time in later years this runway was considered as a 3rd alternative for landing the space shuttle.

As an indication of the amount of traffic that moved northward along the Staging Route, on August 2, 1945 some 800 B-29 flying fortresses with fighter support bombed Tokyo in a single day.

Back at # 2 AOS

Back at the AOS where I was still working things were operating smoothly. But there was one problem that bothered a number of us involved in the BCATP.

There were a number of Meteorological Assistants who had been hired before the war and who had never had any formal training in meteorology. Like myself, the others had been assigned to various schools in the BCATP. We had been clamouring for some time to be given the training that was given to the wartime MetMen but we all had been repeatedly given the same story that we could not be spared from our work and we were assured of continuing work after the war. Because of the number of MetMen who had been trained and were now getting valuable experience at military training schools, we pre-war assistants were not too sure of our future.

By late 1943, the MSC was catching up with the training of new MetMen and meteorologists. Finally, we meteorological assistants were given the opportunity for training in Toronto. One catch was that we had to pay our own travel and accommodation expenses. A number of us took the opportunity and spent three months on a so-called short course. Following this, some of us were offered an additional three months on the advanced meteorological course which was necessary if we wanted to become meteorologists (forecasters).

Finally, a Full-Fledged Meteorologist

Following this 6-month stint in Toronto, I was posted to the forecasting office at Edmonton where I joined How's group as a full fledged meteorologist forecaster at a respectable annual salary of $3600. It was April, 1944, just in time to get into the swirl of activity created by the USAAF undertakings along the Northwest Staging Route and the Mackenzie Route.

Those six months training in Toronto were considered as part of the M.A. course in meteorology at the University of Toronto. To complete the course and receive the degree it was necessary to write two U. of T. examinations: one in mathematical statistics and the other in differential equations. I finally wrote these and received the coveted M.A. degree in Physics (Meteorology) in 1948.

Japanese Balloons Bombard North America

Shortly after arriving at the Edmonton office someone returning from a flight to Whitehorse brought back a curious structure which had been found near the Staging Route. It was a bamboo hoop about 8 ft. in diameter. This hoop had obviously carried several small packages of material and shrouds were still attached. After much study it was concluded that it was of Japanese origin and had been carried by a balloon to North America. The pay load was incendiary bombs which had time- and pressure-release mechanisms. The hoop also carried several small sand bags as ballast which were released by a pressure sensitive mechanism when the balloon was too low. How many balloons were launched and how many arrived over North America is unknown but no damage or fires were ever reported.

Familiarization Flights

As a forecaster it was advantageous to have first-hand knowledge of the terrain along the routes and around the terminals for which we were responsible. We were given the opportunity to take familiarization trips on commercial, RCAF, and rarely on USAAF flights in our free time and when space was available. In the next six months I covered all the routes and terminals for which we were responsible, including those to Whitehorse, Norman Wells, Winnipeg via Saskatoon, Prince Rupert via Prince George, and Vancouver via Calgary.

Peace in Europe

During the remainder of 1944 and the early part of 1945 the war effort by the allies progressed well. Italy had surrendered in September 1943 and during 1944 the allies brought the rest of the Axis to their knees. Hitler was reported dead on May 1; Berlin surrendered on May 2; and on May 8, 1945 the surrender of Germany was ratified in Berlin.

The Final Push in the Pacific

The allies now threw all their efforts into the Pacific war theatre. The USAAF increased traffic along the Northwest Staging Route.

Canada accepted a role in the forthcoming invasion of Japan but they had to supply their own meteorologists. A call was sent out for recruits and I volunteered and was accepted with the rank of Flight Lieutenant. I had orders to report to Toronto for Officer Training early in August but before I could leave Edmonton a wire was received postponing my trip to Toronto until further notice, which was never received.

Japan Sues for Peace

On July 16, 1945 the US tested an experimental A-bomb in the New Mexico Desert. A few weeks later 800 B-29 flying fortresses attacked Tokyo. On August 6 the US dropped an A-bomb on Hiroshima and three days later one was dropped on Nagasaki. The next day Japan sued for peace and on August 15, 1945 Japan accepted the allies' peace terms but it was not until September 2, 1945 that Japan formally signed a peace treaty.

Following the signing of the peace treaty with Japan, the USAAF activities along the Northwest Staging Route and the Mackenzie Route wound down rapidly. The AOS at Edmonton had closed more than a year earlier in July 1944 shortly after D-Day in June. As the USAAF ceased operations in Canada they abandoned the many satellite weather stations they had established. The MSC took over the operation of the forecasting and briefing office at Norman Wells for a short time. The Namao Airport was turned over to the RCAF.

Nevertheless the demand for aviation forecasts at Edmonton continued at a high pace. TCA inaugurated a route from Winnipeg to Vancouver via Saskatoon and Edmonton. Northern flying continued as the Canadians took over bases left by the Americans. Several wartime pilots applied their flying skills and northern experience to form private companies which undertook charter flying and freighting into areas north of Edmonton and into the Northwest Territories. The newly booming oil industry in Alberta also demanded weather services both from the aviation forecasters and a newly established public weather service.

Public Weather Office

Changes began to take place in the Edmonton office. Restrictions were lifted on the provision of weather services and the public, agriculture, and industry began clamouring for special services. Following the disbanding of military operations there were now sufficient meteorologists to undertake public weather forecasting on a routine basis at the aviation forecasting offices.The Edmonton office was soon upgraded with the addition of four more meteorologists: Wilbur Sly, Bill Markham, Don Storr, and Alf Ingal. There were now two meteorologists on each shift: one with aviation responsibilities and the other with public weather responsibilities.

Staff changes were also made. Tom How was transferred to MSC headquarters in Toronto and replaced by Dean Smith from the Lethbridge office which was closed when TCA changed its routing from Winnipeg to Vancouver via Calgary instead of Lethbridge. Al Jackson was transferred to Vancouver and replaced by Clarence Thompson, also from the Lethbridge Office.

Near the end of the decade covered by this study, staffing at the combined aviation and public weather office at Edmonton was such that there was now a little time for some individual research. Up until this time research was undertaken mainly at MSC headquarters in Toronto.

Winter Ice Fog at the Edmonton Municipal Airport

During my stint at the AOS and more recently at the Edmonton forecasting office I experienced the frustration of forecasting winter ice fog at the Municipal Airport. The winter of 1949-50 was exceptionally cold and ice fog was a problem. Noting the steam plumes rising from chimneys on cold, calm mornings, it appeared obvious that the source of moisture for ice fogs might be the combustion of natural gas, the main heating fuel in the city.

Upon investigation it was found that visibility at the airport was related to temperature, wind direction, and wind speed. At that time the heaviest populated part of the city was in the SE quadrant from the airport and low visibility was associated with southerly winds when the temperature was below -20° F. Furthermore, data from Northwest Utilities, which supplied natural gas to Edmonton, indicated that the consumption of gas increased almost linearly with decreasing temperature. So the cause of winter ice fogs was resolved and their forecasting put on a more objective basis.

Some years later in Ottawa, while chatting with Jeff Williams, one-time Regional Director of Air Services in Edmonton, he informed me that my ice-fog study at Edmonton had been partly responsible for the location of the new Edmonton International Airport some distance south of the city limits.

In 1950 MSC opened a Central Weather Analysis Office in Ottawa and I was one of the fortunate few to be posted there in October. This brought my career as an aviation forecaster to an abrupt end.

Acknowledgement

I wish to thank Morley Thomas for suggesting this topic as a presentation to the Canadian Aviation Historical Society, for his encouragement in preparing it for publication, and for his review of the manuscript and suggestions.

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Determining total atmospheric precipitable water vapour using two Canadian GPS receivers

by Craig Smith[1], Frank Seglenieks[2], Brian Proctor[1] and E.D. Soulis[2]

Résumé: Les nouvelles possibilités qu'offre la technologie du système mondial de localisation (GPS) pour mesurer l'humidité atmosphérique constituent un outil prometteur pour les chercheurs en sciences atmosphériques et les prévisionnistes d'exploitation. Pour évaluer les capacités des systèmes GPS au Canada, on a installé deux récepteurs dans le cadre de l'étude GEWEX du Bassin du Mackenzie (MAGS) : l'un à Ft. Smith, dans les Territoires du Nord-Ouest, et l'autre à l'Université de Waterloo, dans le sud de l'Ontario. Les deux récepteurs ont continuellement produit des estimations de l'humidité atmosphérique à intervalles de 30 minutes durant l'année 2000. On a comparé les estimations de vapeur d'eau précipitable faites par GPS à Ft. Smith aux données de radiosondage provenant de la station colocalisée. Quant aux données GPS recueillies à Waterloo, elles ont été comparées à celles des stations de radiosondages les plus proches, soit Buffalo, dans l'état de New York, et Détroit, au Michigan. L'analyse de corrélation a donné des coefficients de corrélation supérieurs à 0,96 à Ft. Smith. Les corrélations, tout naturellement, étaient moins fortes à Waterloo en raison de l'éloignement géographique des stations.

1.0 Introduction

The use of Geographical Positioning System (GPS) technology for measuring water vapour content of the atmosphere is relatively new but has been demonstrated to give results comparable to more conventional techniques (Duan et al., 1996; Bevis et al., 1992; Businger et al., 1996). Due to the relatively low cost of operation and maintenance, GPS systems offer an alternative to more expensive methods to measure atmospheric moisture such as radiosondes and water vapour radiometers (WVR) resulting in the greater viability of denser observation networks. Networks of GPS systems have been established in Europe (Elgered, et al., 1997) and the United States (Ware, et al., 2000) to monitor atmospheric moisture at the continental scale. The technology makes it possible to determine atmospheric moisture continuously over very short time scales making this technique very appealing for atmospheric researchers and operational forecasters.

The use of GPS signals to measure atmospheric moisture has been widely explored and utilized in the United States and Europe but until recently has not been tested and applied in Canada. This paper examines the use of GPS receivers at two geographical locations in Canada, Ft. Smith in the Northwest Territories and Waterloo in southern Ontario. Both sites were installed as part of the MAGS project (Stewart, et al., 1998). These receivers provided data in both a dry and wet environment for the purpose of testing.

GPS specialists have known for some time that atmospheric constituents delay or alter the GPS signal between the receiver and the satellites (Davis, et al., 1985). Bevis et al., (1992) and Businger et al., (1996) provide a good discussion of this phenomenon as it relates to atmospheric moisture so only a summary appears below.

Usually expressed in units of path length, the delay caused by the atmosphere influences the accuracy of the GPS 3-dimensional location abilities. Geomatic scientists have put much effort into identifying these effects and removing them to reduce locational errors. They determined that GPS signals are delayed by both the dry atmosphere (hydrostatic delay) and atmospheric moisture (wet delay). The wet delay is due to the bi-polarization of water molecules in their gaseous state (liquid and solid water have little effect on the signal). The hydrostatic delay is largely dependent on the thickness of the atmosphere between the satellite and receiver and can therefore be determined with accuracies of 1 mm using a relationship with surface pressure (Elgered et al., 1991). The wet delay cannot be directly calculated but is determined as a residual after removing the hydrostatic delay from the total delay determined using signal information and very accurate satellite orbit information (Businger, et al., 1996). Because five to twelve satellites are observed at any given time, a cosine mapping function is used to transform multiple delays into a zenith delay. Therefore, the dry and wet delays are called the zenith hydrostatic delay (ZHD) and the zenith wet delay (ZWD). The total delay is referred to as the zenith total delay (ZTD).

After determining the ZWD through GPS post-processing techniques, integrated moisture (or precipitable water vapour, PWV) is determined using an empirical relationship (Bevis et al., 1994). This relationship was developed by comparing GPS-derived ZWD with WVR observations (Askne and Nordius, 1987). A WVR produces very accurate results but functions poorly during precipitation (Elgered, et al., 1991; Rocken, et al., 1993) and are very expensive to purchase and operate, making them a less viable option than GPS. GPS PWV has also been intensively compared to integrated moisture content obtained from radiosonde sensors (NOAA, 1995). For the

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purpose of operational numerical weather modeling and forecasting, radiosondes and radiosonde networks are currently the baseline for determining atmospheric water vapour content and often serve as control data for GPS PWV analysis. However, radiosonde networks are very expensive to operate, are geographically sparse, and typically only have twice-daily launches. There are also problems associated with instrument error. For these reasons, the use of GPS technology to measure PWV is growing.

2.0 Methodology

2.1 Data source

Two Trimble GPS receivers were installed at Ft. Smith NT and Waterloo ON for the purpose of testing and monitoring. The receivers were set up to record signal information on 30-second intervals that were then composed into 30-minute averages over the course of 2000. At both sites, surface pressure and temperature were obtained at 30-minute intervals. The Ft. Smith receiver was collocated with the MSC operational upper-air station that performed radiosonde launches twice daily at 1200 and 0000 UTC. Integrated radiosonde data from Ft. Smith serves as control data for examining GPS-derived PWV. The Waterloo receiver was installed at the University of Waterloo weather station. The site is unfortunately not collocated with an upper-air station. The nearest upper-air stations are located near Buffalo NY (250 km southeast) and Detroit MI (300 km southwest). Although of limited value, this data was also utilized for the sake of comparison with GPS-derived PWV. Operational GEM model analysis profiles of temperature and humidity were obtained for each of the two sites. This data is composed of Run-0 analysis data (Rutherford, 1976; Côté et. al., 1998) valid at 1200 and 0000 UTC. Run-0 data is a combination of assimilated data from the most recent model run (~25%) and gridded observations at the time of re-initialization (~75%). The purpose of using this data is two-fold: to produce integrated modelled PWV for comparison with the GPS data (which is not the focus of this paper) and to produce moisture weighted average profile temperatures that can be used in the PWV calculation (as discussed below).

2.2 GPS Post-Processing

To determine the total GPS signal delay associated with atmospheric constituents, post-processing of the raw GPS signal information is required. Post-processing was performed using the BERNESE software developed by the University of Bern (University of Bern, 1996).

In addition to the raw signal data logged by the site receiver, the BERNESE software requires data from a network of stations in order to process the site data. Network data from the nearest GPS stations were acquired from the International GPS Service (IGS) via the world-wide-web (Beutler, et al., 1998). Data from the following stations were combined with data from the Waterloo station: Algonquin Park, North Liberty (USA), Ottawa, and Westfort (USA). For the Fort Smith receiver the following stations were used: CFS Flin Flon, Calgary, Yellowknife, and Whitehorse.

Using the data from the Waterloo and Fort Smith GPS receivers combined with the data from the surrounding IGS network, the ZTD was calculated at 30-minute intervals. The ZTD can then be combined with meteorological data to produce PWV as discussed below.

2.3 Calculating ZHD, ZWD, and PWV

The ZHD is calculated using Equation 1 from Elgered et al., (1991):

$$ZHD = 2.2779\ P_s\ /\ f(\lambda,H) \qquad (1)$$

where P_s is surface pressure in hPa, f is a function dependent on latitude λ and elevation H.

ZHD can then be removed from the total zenith delay leaving only the ZWD. The ZWD can then be related to PWV through Equation 2 and 3 from Bevis et al., (1994):

$$PWV = \Pi \cdot ZWD \qquad (2)$$

$$\Pi = 10^6\ [\rho_w\ R_v\ (k_3/T_m + k_2')]^{-1} \qquad (3)$$

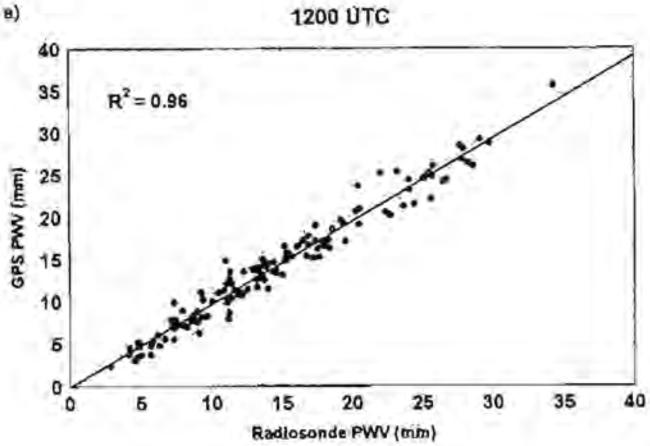
where ρ_w is the density of water vapour, R_v is the gas constant for water vapour, k_3 and k_2' are empirical constants related to the refractivity of moist air, and T_m is the moisture weighted average profile temperature of the atmosphere.

As shown in Equation 3, the proper method of mapping PWV onto Π is through the use of a weighted average profile temperature T_m. As stated in Section 2.1, this parameter was calculated using GEM model atmospheric profiles. Surface temperature was substituted into Equation 3 with satisfactory results as shown in Section 3.3.

3.0 Results

3.1 Comparison with operational radiosondes

The focus of this analysis is Ft. Smith due to the collocation of the GPS system and the upper-air station. The data obtained from the operational radiosonde launches time stamped at 1200 and 0000 UTC were compared to 30-minute GPS composites at times ending 1130 and 2330 UTC for DOY 136 to 297. The GPS composite period ending 1130 and 2330 was selected due to the nature of the radiosonde launches: launch times are typically 1115 and 2315 UTC and because of the concentration of moisture near the surface, the sensors record this moisture in the first 30 minutes after launch. Using the 1100-1130 and 2300-2330 UTC GPS composites was a necessary compromise.



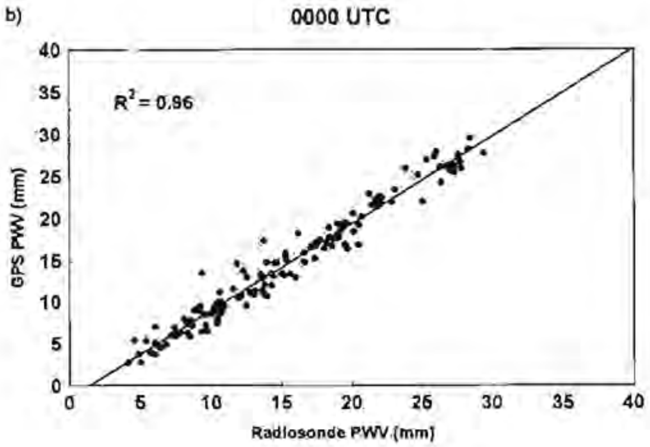


Figure 1: Comparison between Ft. Smith GPS PWV and radiosonde PWV at a) 1200 and b) 0000 UTC for the period 15 May to 23 October, 2000.

Figure 1 shows the scatter plots of GPS PWV vs. radiosonde PWV divided into the two operational radiosonde times of a) 1200 UTC and b) 0000 UTC for Ft. Smith. Regression analysis produced r squared values of 0.96 for both periods. The average bias for the 1200 and 0000 UTC periods were 0.3 and 0.8 mm respectively. This is suggesting that the radiosondes are systematically measuring more moisture than the GPS, especially at 0000 UTC. This bias may be attributed to a number of factors including drift in P_s, errors associated with the GPS technique, or errors in the radiosonde sensors. These are discussed in later sections. The standard deviation of the bias over this period was 1.3 and 1.4 mm for 1200 and 0000 UTC respectively. Figure 2 shows the deviation in the bias plotted by day. The figure shows that although most bias falls between 0 and 2 mm, it can be as large as +/- 4 mm on particular days.

Due to the absence of radiosonde sites near the Waterloo station, the radiosonde stations at Buffalo NY and Detroit MI were selected for the sake of comparison. Regression analysis produced r squared values ranging from 0.60 to 0.79. Averaging over longer time periods reduces errors in this analysis. For example, when daily PWV values are averaged by month, the average monthly bias for March through October are 0.5 mm for Detroit and 2.1 mm for Buffalo. The highest biases occur in the fall for both stations indicating different synoptic or evapotranspiration regimes towards fall and winter. Figure 3 shows the daily average PWV by month for the Waterloo GPS and the radiosonde sites. Even with the GPS located in Waterloo, it compares well with the radiosonde sites and is capturing the general trend in atmospheric moisture for southern Ontario.

3.3 Sensitivity to pressure and temperature

From Equations 1 and 3, surface pressure (P_s) and a temperature variable (T_m) are required to determine ZHD (and from this ZWD) and PWV. This analysis examines the sensitivity of the PWV calculations to the measurement of these variables.

Equation 1 shows the calculation of ZHD from surface pressure and station location. From this Equation, a 1 mb bias (only 0.1% of total pressure at P_s = 1000 mb) in surface pressure results in a ZHD of 2.2779 mm. At Ft. Smith, this translates into approximately 0.4 mm of precipitable water. Therefore, a 1 mb drift in a surface pressure instrument can lead to a significant systematic bias in PWV. Most automated pressure sensors measure pressure with accuracies of +/- 0.2 mb which translates to under 0.1 mm PWV. However, due to the sensitivity of the calculation to pressure, caution is still required to insure that pressure instruments are calibrated accurately. A negative 1 mb drift in P_s would explain much of the positive bias between the radiosondes and the GPS at Ft. Smith.

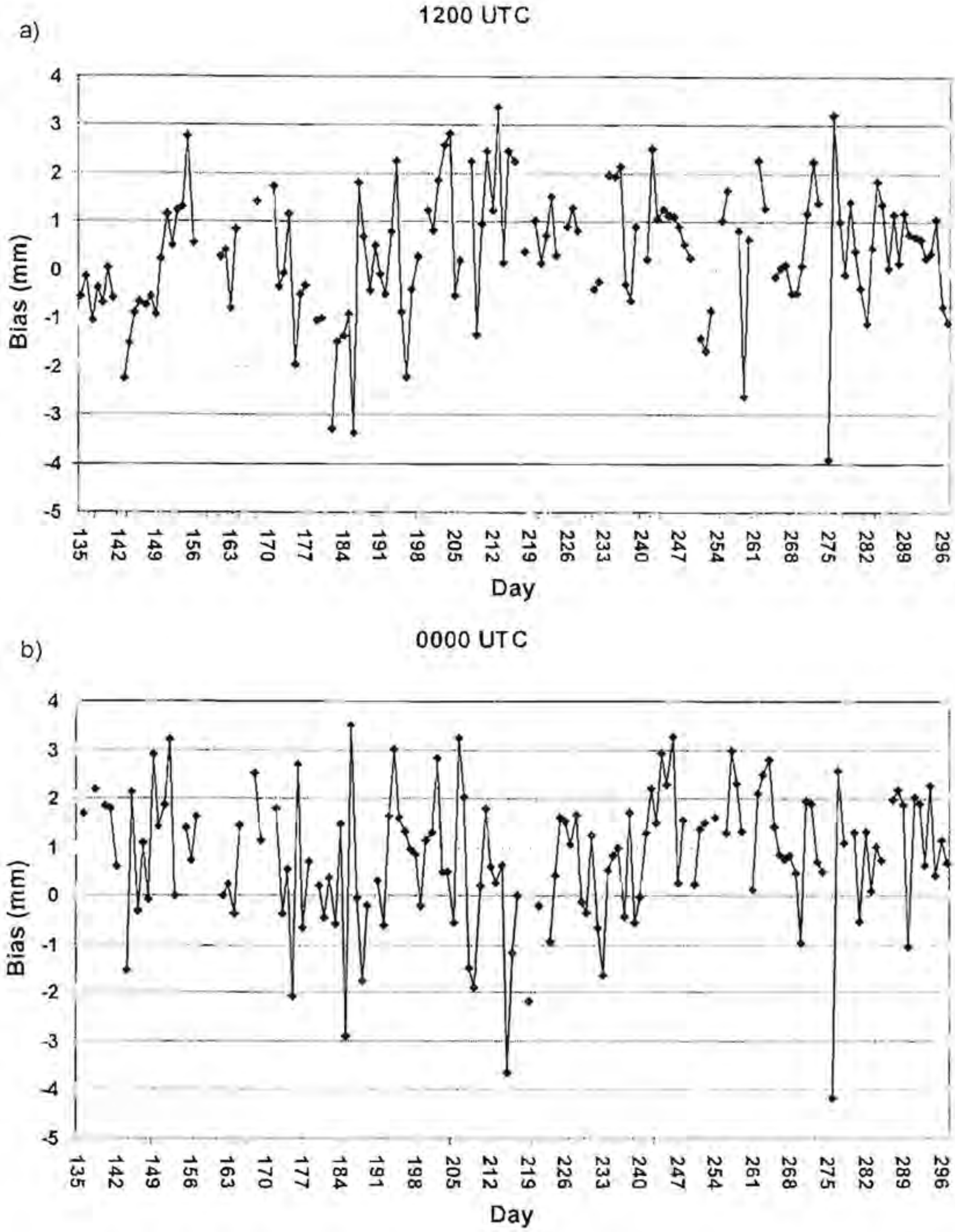


Figure 2: Bias between radiosonde and GPS PWV plotted daily from 15 May to 23 October 2000 for a) 1200 and b) 0000 UTC (Bias = radiosonde – GPS).

From Davis et al. (1985), the proper methodology to calculate PWV in Equation 3 is through the use of T_m that is defined as the moisture weighted average of temperature in the atmospheric profile. This value can be easily calculated if the profile of temperature and moisture is measured using radiosondes or modelled with a numerical weather prediction model such as GEM. However, even if radiosonde and/or model data is available, it is usually only available twice daily and would require interpolation for each GPS observation between those periods. This would likely introduce further errors. Bevis et al. (1992) developed relationships between T_s and T_m using radiosondes. They observed errors in estimated T_m of less than 2% using this methodology. Although not utilized in this study, these relationships (or developing new ones) are another alternative to this problem. This study simply used T_s as an estimate of T_m (and explores modelled T_m). T_s are much easier to obtain than T_m at higher temporal resolution using automated instrumentation. This substitution can also be validated considering that T_m is the moisture weighted average and is therefore heavily weighted to temperature near the surface where moisture concentrations are highest. Other alternatives will be explored in the future.

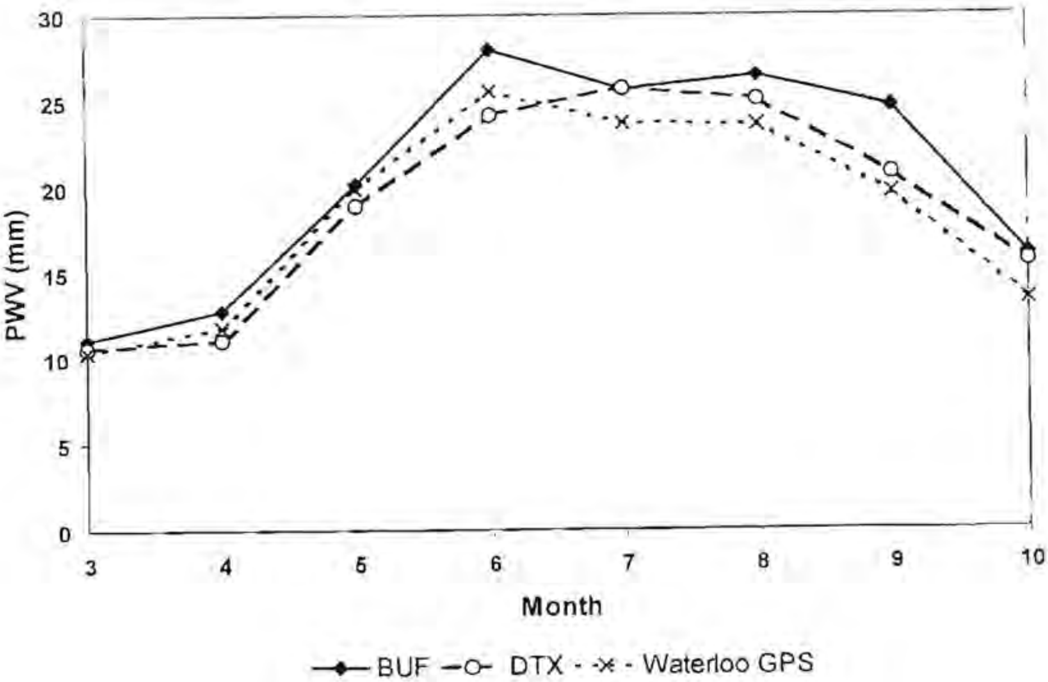


Figure 3: Average daily PWV for March through October 2000 for radiosondes at Buffalo NY (BUF) and Detroit MI (DTX) as well as the GPS PWV for Waterloo ON.

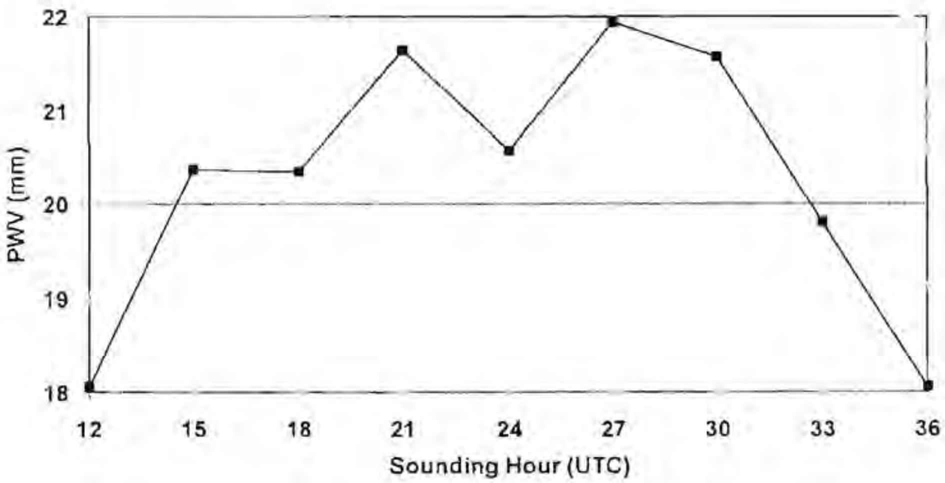


Figure 4: Two-week composite of hourly PWV measurements using radiosondes during the CAGES period of 1997 at Ft. Smith NT.

Testing the sensitivity of Equations 2 and 3 to temperature is purely mathematical. Given a constant ZHD and ZTD, adjusting temperature by 10° C results in a change in PWV of approximately 0.5 mm. This suggests that although temperature measurement is important, the calculations are relatively insensitive to this parameter.

To test the influence of using modelled T_m instead of T_s, average profile temperatures were calculated using GEM Run-0 modelled profiles. Modelled T_m was then substituted into Equation 3 to produce PWV. Modelled T_m was colder than T_s and therefore lowered GPS PWV. This increased the average bias between the radiosonde and the GPS from 0.4 mm (0.8 mm) to 0.6 mm (1.3 mm) at 1200 UTC (0000 UTC). The correlation coefficients and the standard deviation of the bias remained relatively unchanged. This suggests that there is no improvement in the comparisons between the radiosondes and the GPS when T_m is used instead of T_s. This makes the use of T_s more attractive due to simplicity.

3.4 Implications for determining diurnal and seasonal trends

One of the advantages of high frequency GPS derived PWV data is for use in determining diurnal and seasonal trends in atmospheric moisture. Figure 4 illustrates the use of increased radiosonde launches to determine diurnal trends in atmospheric moisture (Strong, et al., 2001). During the CAnadian Gewex Extended Study (CAGES), additional radiosonde launches were made at the Ft. Smith upper-air station. A composite averaged over a two-week period in 1997 is shown. This analysis suggests that if only the operational radiosondes (00/12 UTC) were used to determine diurnal moisture change, a moisture increase of 1.4 mm would have been missed. Unfortunately, radiosonde studies of this nature are very expensive. The promise of GPS PWV is a viable alternative.

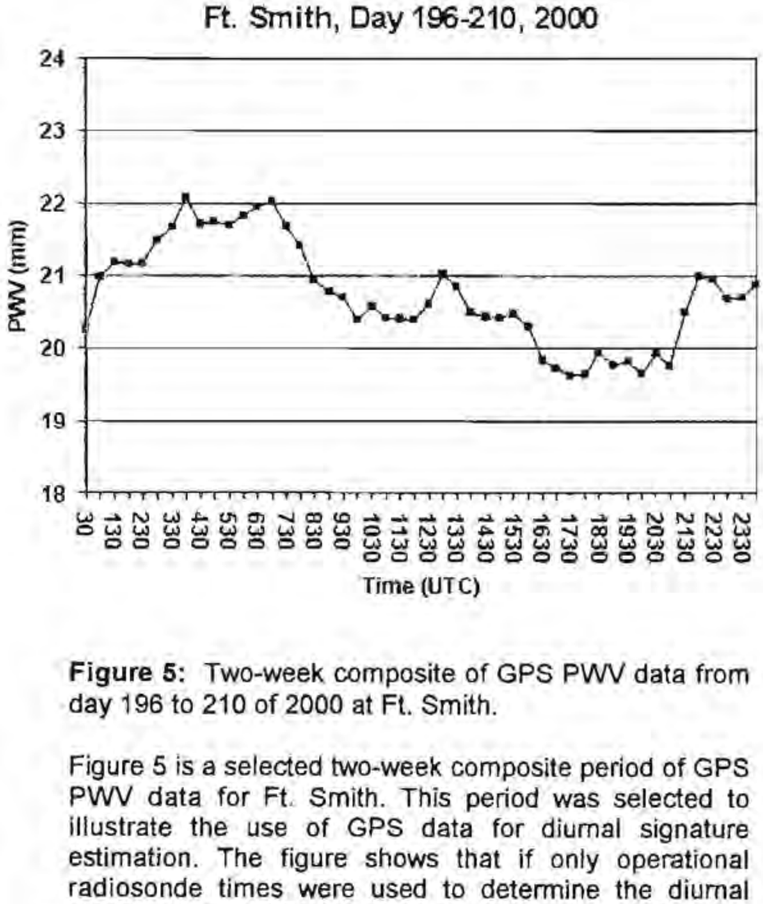


Figure 5: Two-week composite of GPS PWV data from day 196 to 210 of 2000 at Ft. Smith.

Figure 5 is a selected two-week composite period of GPS PWV data for Ft. Smith. This period was selected to illustrate the use of GPS data for diurnal signature estimation. The figure shows that if only operational radiosonde times were used to determine the diurnal signature, only 0.2 mm of moisture change would have been observed. However, if the times of minimum and maximum moisture contents are used, a total change of 2.5 mm of moisture is observed. This illustrates the importance of high-resolution data in determining diurnal trends in atmospheric moisture.

Of concern here is the variability in the bias between radiosondes and GPS PWV. The standard deviations in the bias, as noted in Section 3.1, are 1.3 to 1.4 mm. If we assume no radiosonde sensor errors, this large standard deviation reduces our confidence in accurate and precise moisture contents using GPS data. Error sources are discussed in Section 3.5.

Figure 6 illustrates the seasonal evolution of PWV at Ft. Smith over the course of 2000. This figure shows quite clearly the change in PWV over the time scales of storm tracks and seasons. This makes the application of GPS very useful for developing water vapour climatologies and assessing the impacts of synoptic systems on changes in atmospheric moisture.

3.5 Discussion of errors

There are several sources of error in calculating precipitable water from both GPS data and radiosonde data. Some of the error sources in the GPS technique are discussed above and involve the measurement of surface and atmospheric meteorological variables and the subsequent use of these variables to produce PWV from ZWD. However, there are also potential sources of error associated with the raw GPS signal data and post-processing techniques. These include ionosphere error, satellite clock error, orbit error, ionospheric delay, multi-path error, receiver errors, geometric effects, and selective availability (Parkinson, 1996). Most of these errors can be reduced or removed altogether with the application of differential correction. This involves simultaneously analyzing the data from a number of stations (IGS network stations in this case) within the same geographic region (as indicated in Section 2.2). The BERNESE software is then used to perform the differential correction.

The most significant error not handled by differential correction is multi-path error. This error is caused by reflected signals from surfaces near the receiver that can either interfere with or be mistaken for the signal that follows the straight-line path from the satellite. Buildings, water surfaces, or vegetation near the antenna could cause these reflections.

In order to reduce the occurrence of multi-path errors during this study both antennas were equipped with ground planes designed to reduce reflections of the satellite signals. As well, only satellites with elevation angles of at least 15° above the horizon were included in the processing as satellite with lower elevation angles are more prone to reflection and multi-path errors.

It is very difficult to determine the magnitude of these types of errors on the estimation of PWV. However, it is still important that we recognize that they are present and every effort is required to minimize them (as in the reduction of multi-path errors using antenna ground planes). More effort is required to quantify error sources in these data.

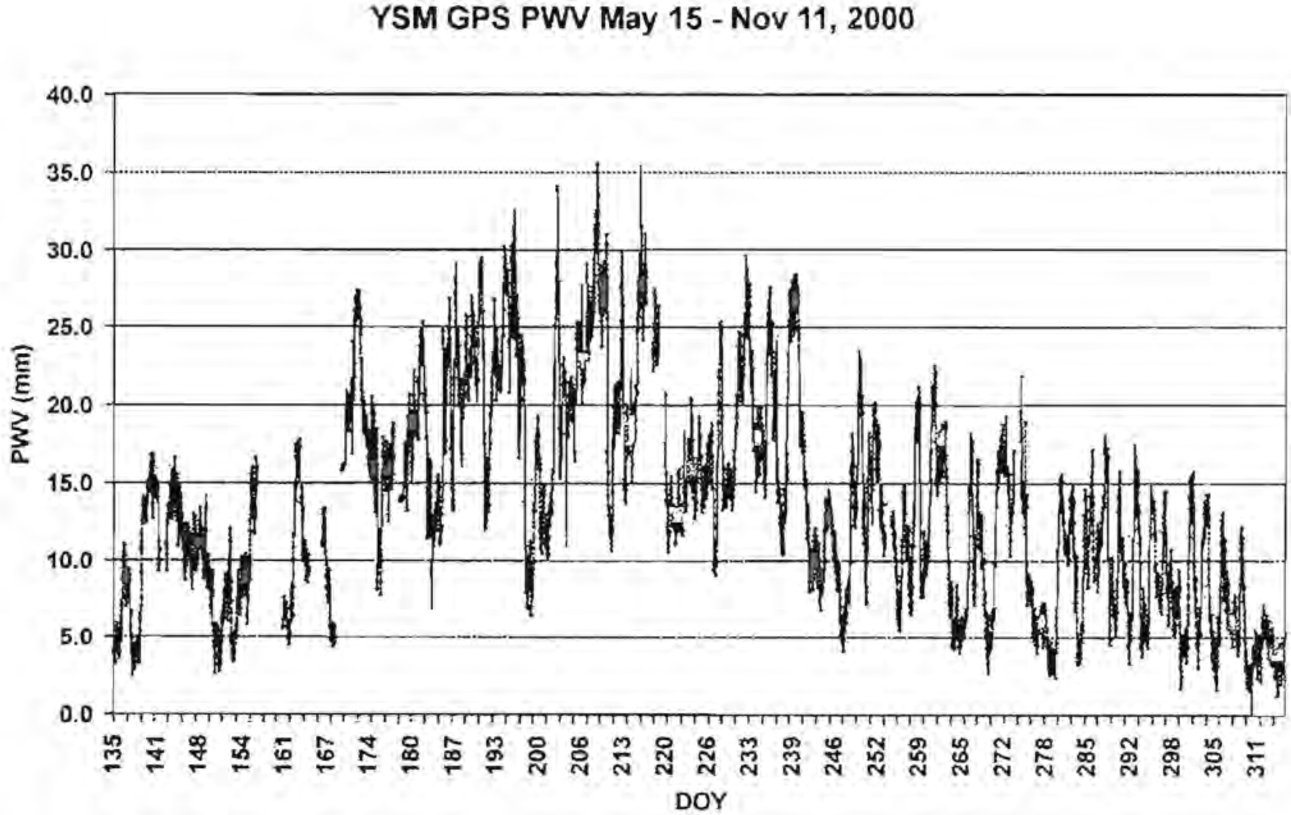


Figure 6: Evolution of precipitable water vapour at 30-minute intervals from May 15 (DOY 136) to November 11 (DOY 315), 2000

Until now, this study has been using radiosonde data as the absolute measurement for moisture in the atmosphere without considering sensor error. To properly address the accuracy of GPS PWV estimations, radiosonde sensor errors need to be addressed. Although this is not the focus of this paper, more analysis, literature review, and field measurements are planned to address this problem. For example, lag errors (instrument readings changing slower than their environment) are a common problem with many radiosonde humidity sensors, especially at low temperatures. If the radiosondes (and their associated humidity sensors) used in this project were experiencing lag errors after saturation, this may explain the positive bias between the radiosondes and GPS technique as shown above.

4.0 Summary and Conclusions

With the relatively recent emergence of GPS technology to sense atmospheric moisture, implications for research and forecasting are abundant. However, it becomes very important to recognize and minimize problems associated with this technique. It has been shown that the agreement between radiosonde and GPS-derived atmospheric moisture is quite good with correlation coefficients of 0.96. Even the correlations with GEM Run-0 data are good with correlation coefficients of up to 0.92. This analysis illustrates the capability of using GPS PWV data to validate operational forecast models by identifying deviations between modelled and observed atmospheric moisture.

A concern that has arisen from this work involves the positive bias between the radiosondes and the GPS technique. Results suggest that the radiosondes are observing more moisture than the GPS. It is very difficult to determine if the radiosonde sensors are providing an accurate assessment of atmospheric moisture for comparison with the GPS technique. It has been theorized that radiosonde humidity sensors take time to dry after passing through a saturated layer. This would explain why the radiosondes are measuring more moisture than the GPS. This theory requires further testing.

The implications of GPS technology in meteorology are far-reaching. Although real-time GPS PWV data required for operational forecasting are some time away and profiling ability is in its infant stages, the research applications for integrated moisture are endless. Continuous high resolution sampling of atmospheric moisture is vital to determining diurnal variability that leads to indirect estimates of evapotranspiration and provides us with the opportunity to further close atmospheric moisture budgets as shown in Strong et al., (2001). Other research opportunities include examining local evapotranspiration contributions to the atmosphere by collocating GPS receivers with flux measurements. PWV data is also valuable for validation of both research and operational atmospheric models and the analysis of precipitation processes. Although much work remains to be done, GPS technology will be a powerful tool available to atmospheric researchers.

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The Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)

La Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

The Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) announced on February 15, 2001, the approval of 15 research projects to Canadian universities totaling more than $3.9 million over a three-year period.

Established under the federal Budget 2000 with a $60 million one-time grant from the Government of Canada, the CFCAS funds research in the areas of climate system science and climate change (including greenhouse gases), extreme weather, air quality and marine environmental prediction.

Several projects in each of the following areas have been approved in Round One:

- Climate
- Greenhouse Gases
- Extreme Weather
- Air Quality

Round One Research Projects

Climate

Interdecadal Climate Variability in the Sub-Polar North Atlantic

The role of freshwater in the ocean/climate system of the Labrador Sea and other sub-polar areas of the North Atlantic Ocean will be studied as one of several aspects of a project aimed at providing a greater understanding of climate variability (with an emphasis on decadal variability) in the Atlantic region by Dr. Paul G. Myers of the Department of Physics and Physical Oceanography at Memorial University of Newfoundland (grant total $192,500/three years).

This project will involve the improvement of an existing regional model and quantifying the effects of freshwater transport through the Canadian Archipelago on the Labrador Sea region and its deep-water convection processes. It will also include developing parameters for some climate models.

The effect of decadal surface flux variability, associated with the North Atlantic Oscillation (NAO), as well as other phenomena, on the underlying ocean, and what effects this might have on the climate of the region, will be studied as well. The emphasis here, as in all other parts of this project, is on process studies to attempt to understand the physics of the individual processes associated with the climate system and how different elements of the system relate to each other.

The end result will be knowledge that can be used to parameterize regional scale processes in global climate models, as well an improved understanding of the workings of the physical world around us.

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Total: $192,500/3 years

Organic Aerosols as Cloud Condensation Nuclei:Laboratory and Global Climate Modeling Studies

The impact of atmospheric aerosol particles on clouds and global climate will be studied by Dr. Jonathan P.D. Abbatt of the University of Toronto Chemistry Department (grant total $260,000/three years). The potential for the 'indirect' effect that aerosols may have on cloud formation is viewed as one of the largest scientific uncertainties in making global climate change assessments. Recent measurements show that a range of organic species are present in most particles present in the lower atmosphere, but the impact of these organics on the ability of aerosols to promote liquid water droplet formation is poorly known.

The results from laboratory experiments will be incorporated into a state-of-the-art global climate model in order to make assessments of the role of organics on the formation of clouds, and the modification of global climate.

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Total: $260,000/3 years

Stratospheric Indicators of Climate Change

Stratospheric ozone and polar ozone depletion due to the release of CFCs are closely linked to the global climate system, even though these have often been regarded as separate issues. Understanding more about the relationship between ozone and climate change is among the objectives of a project on stratospheric indicators of climate change by Dr. Kimberly Strong of the Department of Physics at the University of Toronto (grant total $225,000/three years).

The proposed research is aimed at improving understanding of Arctic ozone loss and its links with the climate system. A UV-visible grating spectrometer will be deployed at Eureka, Nunavut for three spring periods, providing measurements of ozone and of other key trace gases in the time of year when the conditions leading to polar ozone depletion develop. These observations will then be analyzed, along with measurements from other instruments and meteorological data, in order to unravel the coupled chemical, dynamical, microphysical, and radiative processes of the climate system that determines the Arctic stratospheric ozone budget.

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Total: $225,000/3 years

Greenhouse Gases

Development and Application of In-Canopy Flux Measurement Techniques

Trace gases such as carbon dioxide, ozone and methane play important roles in many environmental issues, especially the greenhouse effect and air pollution. Vegetated surfaces, such as forests and cropland, play important roles both in emitting and absorbing different gases. Though there are many techniques that try to measure the movement of these trace gases, there are still many situations where a good measurement is very difficult.

Dr. Jon Warland of Land Resource Science Department at the University of Guelph (grant total $110,700/three years) will work to develop new methods of measuring the exchange of these gases in an effort to better understand sources and dispersion. The study has two experimental components, one in an Ontario forest and one at a research farm. In both places tests of new measurement techniques will be performed, while gathering more data on the exchanges of carbon dioxide and water.

The knowledge will be used to make new measurements of other trace gases, such as ozone, as well as provide new insight into various issues related to carbon dioxide exchange and water use.

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Total: $110,700/3 years

Understanding Interannual Variability of Nitrous Oxide Fluxes From Soils: A Field and Modelling Study

Nitrous oxide, an important greenhouse gas, originates mostly from soils, and is enhanced by nitrogen fertilizer use in agriculture. However, agricultural soils can be significant sinks for carbon dioxide, contributing to removal of carbon dioxide from the atmosphere (carbon sequestration). It is not clear how measures to increase carbon sequestration by agricultural soils will affect the emission of nitrous oxide, a greenhouse gas that is more potent than carbon dioxide.

Dr. Claudia Wagner-Riddle of the Land Resource Science Department at the University of Guelph (grant total $240,000/three years) will collect a crucial supporting data set of meteorological, soil and surface variables needed for air-surface modeling. Together with measurements from an ongoing field experiment to evaluate the effects of agricultural management practices on nitrous oxide emissions, these data will then be used to model carbon and nitrogen cycling in agricultural systems.

The results obtained in this research will contribute to the understanding of air-surface exchange as affected by climate change, and to the identification of agricultural soils as net sinks or sources of greenhouse gases.

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Total: \$240,000/3 years

Carbon Balance Estimation at Landscape Level From Atmospheric CO_2 and Isotope Concentration Measurements

Assessing terrestrial carbon balance is important in understanding the Earth's climate system. The eddy covariance technique has been proven to be currently the only reliable means for measuring the carbon balance of areas of about one square km. Dr. Jing M. Chen of the Department of Geography at the University of Toronto, (\$148,160/two years), in collaboration with Dr. Anne Lise Norman of the University of Calgary, Dr. Kaz Higutchi of the Meteorological Service of Canada, and Dr. Josef Cihlar of Canada Centre for Remote Sensing, will investigate the feasibility of deriving carbon cycle information from accumulated data at the Fraserdale site over the past decade.

The results will help validate climate models and improve the estimation of the carbon source and sink distribution.

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Total: \$148,160/2 years

Marine Nitrous Oxide Production and Loss Kinetics

Nitrous oxide (N_20) is a trace component of the atmosphere that is of interest as a greenhouse gas and because its chemistry in the upper atmosphere contributes to ozone destruction. Its atmospheric concentration is showing a long-term increase that is anticipated to continue because a component of its production comes from nitrogenous fertilizers. One of its sources is the ocean where it is produced by microbial processes. A major problem in the detailed study of N_20 in the ocean is that it is not easy to separate the production and loss processes, so that measurement can normally provide only the net result of both types of process.

Dr. Robert M. Moore and Steve Punshon of the Department of Oceanography at Dalhousie University (grant total \$65,532/three years) will develop and use methods designed to allow measurement of either production or loss without interference from the other. Detailed information on production and loss rates of nitrous oxide in the ocean, as well as in terrestrial systems, is necessary for predicting future concentrations of this gas in the atmosphere.

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Total: \$65,532/3 years

Extreme Weather

Effects of Lake Breezes on Weather ("ELBOW 2001")

Lake breezes are a frequent feature of summer weather in Southern Ontario. Recent studies have clearly linked lake breezes and similar flow patterns with both severe summer weather (intense thunderstorms, lightning and tornadoes) and air quality issues (ozone exceedences in particular). A pilot experiment was conducted in southwestern Ontario in 1997 and the "ELBOW 2001" field program will build on the experience gained there, and in subsequent modelling activities.

The project led by Dr. Peter A. Taylor of the Earth & Atmospheric Science Department at York University (grant total \$348,000/two years) will lead to considerable improvements in our understanding of severe weather in this highly populated part of Canada.

Results from the study will be used by meteorologists and severe weather specialists as guidance in improving their ability to forecast the location, intensity and timing of severe weather events associated with lake and sea breezes, and for the validation and improvement of high resolution weather forecast models.

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Total: \$348,000/2 years

Polarimetric Weather Radar Studies

Research by Dr. Enrico C. Torlaschi of the Department of Earth and Atmospheric Sciences at the Université du Québec à Montréal (grant total \$75,000/three years) will further the understanding of polarimetric radar in meteorology. The overall goal is the optimization of polarimetric weather radar designs and analysis, with a view to identifying different precipitation types.

The project will provide the scientific foundation for the operational implementation of polarimetric radar algorithms. Measurements of rain and snow are of great significance in all Canada, and the issue of polarimetric weather radars is a high priority research topic within the Meteorological Service of Canada.

Research results will improve the interpretation and forecasting of severe storm conditions for Canadians.

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Total: $75,000/3 years

Severe Winter Weather in the Great Lakes Region

During the late fall and winter, when cold and dry arctic air flows across the Great Lakes, intense snow squalls often develop over and downstream of the various lakes. These squalls typically develop in the northwesterly flow established after the passage of major low-pressure weather systems.They are known as "Lake Effect Snowstorms" and are a major source of snowfall and severe weather in the lee of the lakes.

Intense lake effect snowstorms can cause highly localized "blizzards" with blowing snow reducing visibility to zero while clear conditions are present just a few kilometres away.

Dr. Kent Moore of the Department of Physics at the University of Toronto (grant total $456,000/three years) will develop a coordinated program of observational and numerical modelling activities that will result in improved conceptual and quantitative models of lake effect snowstorms.This will ultimately lead to more accurate and timely forecasts of severe winter weather in the lee of the Great Lakes. It will also be of benefit to snow removal operations in their efforts to facilitate highway safety and airport operations. Furthermore, this project will increase our understanding of the general distribution patterns of, and the amount of fallen snow, which is extremely valuable in predicting spring flooding events.

Dr. Kent Moore, Associate Professor
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Total: $456,000/3 years

Rocketsonde Buoy System – Feasibility Study and Proof of Concept

Producing a reasonable weather-forecast in Canada for the winter period has reached a limit of about three days in Central and Eastern Canada, two days in the Prairie provinces, and one day or less in the West. This is because there are few upstream weather observations over the NE Pacific Ocean, a region known as the Pacific Data Void. For this reason, the World, US and Canadian Weather Research Programs endorse a major campaign called The Hemispheric Observing-System Research and Predictability Experiment (THORpex) to develop and deploy new in-situ weather instruments into this and other data-sparse regions.

Dr. Roland Stull of the Atmospheric Science Program at the University of British Columbia ($151,00/two years) will study the feasibility of building a buoy system for deployment in the deep ocean to serve as a platform for launching small weather rockets, and test a prototype of the system. If the results warrant, a further proposal will be made to build and deploy a network of buoys in the NE Pacific, each capable of launching two rocketsondes/day.

The resulting data will be transmitted to Canadian and world meteorological centres to improve short and medium-term weather forecasting.

Dr. Roland B. Stull, Professor
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Total: $151,000/2 years

Air Quality

Application of Stable Carbon Isotope Ratio Measurements in Volatile Organic Compounds to Study the Oxidizing Capacity of the Troposphere

Reducing one of the key uncertainties in chemical air pollution modelling is the aim of a study by Dr. Jochen J. Rudolph in the Department of Chemistry at York University (grant total: $594,800/three years). The research is designed to help assist in developing more efficient and effective air pollution control strategies by increasing reliability and predictability of numerical model simulations. The reaction with hydroxyl-radicals (OH-radicals) is the initial step for removal of many important trace gases from the atmosphere, and determines the rate of formation of many secondary pollutants (ozone, secondary particulate matter) that lead to smog.

Experimental data is quite rare that allows verification of model predictions for OH-radical concentrations, and no such data exists for Canada. This project will provide the research necessary to test, improve, and verify OH-radical concentrations used in model calculations.

Numerical simulation models are the most important tools to establish quantitative relationships between emissions of pollutants, their atmospheric concentrations, and the formation of secondary air pollution. Such models are widely used by both government agencies and the private sector (industry, consultants) to determine the necessity or extend of emission reductions required to achieve and maintain air quality standards. Reliable models verified by experimental data will be extremely valuable for both groups.

Dr. Jochen J. Rudolph, Professor
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Total: $594,800/3 years

Forests as Filters of Persistent Organic Pollutants

Recent measurements have suggested that forests are very efficient filters for selected toxic air pollutants, especially deciduous forest canopies that take up the pollutants from the atmosphere and transfer them to the forest floor with the falling leaves. This has the potential to significantly reduce the pollutant load in the atmosphere, decreasing the risk to humans and wildlife.

Dr. Frank Wania of the University of Toronto Division of Physical Sciences (grant total $280,000/three years) will use two different techniques to measure the uptake of selected pollutants, including the polychlorinated biphenyls (PCBs), in a deciduous canopy in Borden, Ontario. Eventually, the information gained from these field experiments will be used to improve mathematical models that government and university scientists employ to explain and predict pollutant behaviour in the Canadian environment.

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Total: $280,000/3 years

Modelling and Observation of Trans-Pacific Pollutant Transport:Impacts on Western Canada

Air pollution in western North America, including southern British Columbia, has generally been considered of regional scope and local origin. However, recent observations show that Eurasian air pollution and dust from semi-arid areas reaches western North America on a regular basis.

Dr. Ian G. McKendry of the University of British Columbia Department of Geography (grant total $228,560/two years) will develop and deploy a light aircraft-based vertical profiling system, model the role of mountains on intercepting layers of pollutants that pass across western North America. He will develop and apply methods that permit physical interpretation of observations.

These results will be used to (a) develop better air quality forecasts for the region and (b) through inclusion of trans-pacific contributions to local air quality, models will be better able to assess the impacts of local abatement strategies.

Dr. Ian G. McKendry, Associate Professor
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Total: $228,560/2 years

Measurement and parameterisation of heat and mass fluxes relevant to the role of cities in regional air quality and greenhouse gas exchange

Today cities are home to over half the world's population, and by 2025 that fraction will rise to two thirds. With a changing landscape caused by development, there is a concentration of waste releases, including air pollutants. These concentrations significantly alter meteorological processes and thereby create a new urban climate, and lead to reduced air quality in the region. While the effects are felt in the city, the urban pollutant "plume" can travel long distances.

Dr. Timothy R. Oke of the Department of Geography at the University of British Columbia ($222,932/three years) will study exchanges of heat, water and pollutants in cities and the way they modify urban climate and how pollutants are dispersed. The project will contribute to understanding key climate system processes including those connected to GHG sources and sinks, urban air quality, and assist in the construction of weather and air quality models, especially for cities.

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Total: $222,932/3 years

For more information on CFCAS or the projects described here, please visit the CFCAS website at: http://www.cfcas.org or contact:

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The Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)

La Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

Le 15 février 2001, la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA) annonçait qu'elle avait approuvé 15 projets de recherche dans les universités canadiennes, pour un financement global de 3,9 millions de dollars sur une période de trois ans.

Créée par le gouvernement du Canada avec le dépôt du budget de l'an 2000 et dotée d'une enveloppe non renouvelable de 60 millions de dollars, la FCSCA finance des recherches scientifiques sur la climatologie et les changements climatiques (y compris les gaz à effet de serre), les conditions météorologiques extrêmes, la qualité de l'air et les prévisions relatives à l'environnement marin.

Lors de la première ronde de financement, plusieurs projets ont reçu l'aval de la Fondation dans les domaines suivants:

- le climat
- les gaz à effet de serre
- les conditions météorologiques extrêmes
- la qualité de l'air

Projets de recherche – Première ronde

Climat

Variabilité décennale du climat dans la zone subpolaire de l'Atlantique Nord

Dans le cadre de ce projet, on examinera le rôle de l'eau douce dans le système océanique/climatique de la mer du Labrador et d'autres zones subpolaires de l'Atlantique Nord. Cette étude n'est qu'un volet du plus vaste projet entrepris par M. Paul G. Myers, du département de physique et d'océanographie physique de l'Université Memorial de Terre-Neuve (subvention globale de 192 500 $/trois ans), qui nous aidera à mieux comprendre la variabilité du climat (surtout d'une décennie à l'autre) dans la région de l'Atlantique.

Le projet servira à améliorer un modèle régional existant et à quantifier les effets des déplacements d'eau douce à travers l'archipel canadien, dans la mer du Labrador, et des phénomènes de convection en eau profonde qui s'y associent. Parallèlement, on établira des paramètres qui seront utilisés avec d'autres modèles climatiques.

Les chercheurs s'intéresseront aux effets que la variabilité décennale des flux de surface attribuable à l'oscillation de l'Atlantique Nord (OAN) et d'autres phénomènes pourraient avoir sur l'océan sous-jacent et détermineront leur incidence sur le climat dans cette région. Comme c'est le cas avec les autres volets du projet, on attachera une grande attention aux processus dans l'espoir d'éclaircir la physique des phénomènes associés au système climatique et de saisir les liens entre les composantes de ce système.

Les données recueillies s'avéreront utiles pour établir les paramètres des processus régionaux dans les modèles du climat planétaire et nous aideront à mieux comprendre comment fonctionne le monde qui nous entoure.

Paul G. Myers, Ph. D., professeur adjoint
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Total : 192 500 $/3 ans

Rôle des aérosols organiques dans les noyaux de condensation des nuages: études de modélisation en laboratoire et modélisation du climat planétaire

M. Jonathan P.D. Abbatt, du département de chimie de l'Université de Toronto (subvention globale de 260 000 $/trois ans), examinera l'incidence des particules d'aérosol en suspension dans l'air sur les nuages et le climat mondial. L'influence « indirecte » éventuelle des aérosols sur la formation des nuages est l'une des principales inconnues dans l'évaluation des changements climatiques que connaît la planète. Des relevés récents indiquent l'existence d'une multitude de composés organiques dans la plupart des particules en suspension dans la troposphère, mais on ignore largement comment ces composés modifient la capacité des aérosols à provoquer la formation de gouttelettes d'eau.

Les résultats des expériences effectuées en laboratoire seront intégrés à un modèle du climat mondial très perfectionné qui précisera le rôle des composés organiques dans la formation des nuages et l'évolution du climat planétaire.

Jonathan P.D. Abbatt, Ph. D., professeur
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Total : 260 000 $/3 ans

Indicateurs stratosphériques des changements climatiques

La destruction de l'ozone par les CFC dans la stratosphère et au-dessus du pôle est étroitement liée au système du climat mondial même si l'on croit souvent qu'il s'agit de deux problèmes distincts. Mieux comprendre les liens qui existent entre l'ozone et les changements climatiques figure parmi les objectifs du projet sur les indicateurs stratosphériques des changements climatiques entrepris par Mme Kimberly Strong, du département de physique de l'Université de Toronto (subvention globale de 225 000 $/trois ans).

Ces travaux nous renseigneront davantage sur la destruction de l'ozone dans l'Arctique et sur les relations entre ce phénomène et le système climatique. Un spectromètre à réseau pour la partie UV et visible du spectre sera installé à Eureka, au Nunavut, trois années de suite, au printemps, et mesurera l'ozone et d'autres importants gaz à l'état de traces au moment de l'année où les conditions sont les plus propices à l'appauvrissement de la couche d'ozone au-dessus du pôle. Ensuite, ces résultats ainsi que les relevés d'autres appareils et les données météorologiques seront analysés, ce qui dévoilera les processus chimiques, dynamiques, microphysiques et radiatifs du système climatique déterminant le bilan d'ozone dans la stratosphère au-dessus de l'Arctique.

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Total : 225 000 $/3 ans

Gaz à effet de serre

Élaboration et application de techniques de mesure des flux pour le couvert végétal

Les gaz à l'état de traces comme le dioxyde de carbone, l'ozone et le méthane jouent un rôle important dans maints problèmes liés à l'environnement, en particulier l'effet de serre et la pollution atmosphérique. Les surfaces recouvertes de végétation comme les forêts et les cultures libèrent et captent différents gaz. Bien qu'on ait mis au point de nombreuses techniques pour mesurer le déplacement des gaz à l'état de traces, il est encore très difficile d'obtenir des relevés dans beaucoup de situations.

M. Jon Warland, du département des sciences des ressources terrestres de l'Université de Guelph (subvention globale de 110 700 $/trois ans), s'efforcera d'élaborer de nouvelles méthodes pour mesurer les échanges de ces gaz et mieux comprendre d'où ils viennent et comment ils se dispersent. Le projet comporte deux volets expérimentaux. Le premier s'effectuera dans une forêt de l'Ontario et l'autre, dans une ferme expérimentale. Les nouvelles techniques de mesure seront testées aux deux endroits et on recueillera d'autres données sur les échanges de dioxyde de carbone et d'eau.

Les connaissances acquises permettront de quantifier d'autres gaz à l'état de traces comme l'ozone et nous éclaireront sur diverses facettes de l'échange de dioxyde de carbone et de l'utilisation de l'eau.

Jon Warland, Ph. D., professeur adjoint
Département des sciences des ressources terrestres
Université de Guelph
jwarland@lrs.uoguelph.ca

Total : 110 700 $/3 ans

Étude sur le terrain et modélisation de la variabilité annuelle des émissions d'hémioxyde d'azote provenant du sol

L'hémioxyde d'azote est un gaz à effet de serre important qui émane principalement du sol. L'emploi d'engrais azotés en agriculture en accroît les dégagements. Les terres cultivées peuvent toutefois piéger une forte quantité de dioxyde de carbone et concourir à retirer ce gaz de l'atmosphère (par séquestration du carbone). On ignore exactement quel effet une plus forte séquestration du carbone dans les terres agricoles aurait sur les émissions d'hémioxyde d'azote, car ce gaz intervient plus que le dioxyde de carbone dans l'effet de serre.

Mme Claudia Wagner-Riddle, du département des sciences des ressources terrestres de l'Université de Guelph (subvention globale de 240 000 $/trois ans), recueillera des données sur les variables relatives aux conditions météorologiques, au sol et à la surface essentielles à la création de modèles air-surface. Ces données et les résultats d'un essai continu sur le terrain devant établir l'incidence des pratiques agricoles sur les émissions d'hémioxyde d'azote serviront à modéliser le cycle du carbone et de l'azote dans les systèmes agricoles.

Le projet devrait nous en apprendre davantage sur les échanges air-surface et sur la manière dont les changements climatiques agissent sur eux, ainsi qu'à établir si les sols cultivés constituent des sources ou des puits nets de gaz à effet de serre.

Claudia Wagner-Riddle, Ph. D., professeure adjointe
Département des sciences des ressources terrestres
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criddle@lrs.uoguelph.ca

Total : 240 000 $/3 ans

Estimation du bilan du carbone dans le sol à partir des concentrations de CO_2 et d'isotopes dans l'atmosphère

Pour comprendre le système climatique planétaire, il faut d'abord connaître le bilan du carbone dans le sol. Pour l'instant, la seule méthode fiable pour le mesurer dans les terrains d'environ un kilomètre carré de superficie est la covariance des turbulences. M. Jing M. Chen, du département de géographie de l'Université de Toronto (subvention globale de 148 160 $/deux ans), collaborera avec Mme Anne-Lise Norman, de l'Université de Calgary, M. Kaz Higutchi, du Service météorologique du Canada et M. Josef Cihlar, du Centre canadien de télédétection, pour voir si on peut obtenir de l'information sur le cycle du carbone à partir des données recueillies au site de Fraserdale au cours des dix dernières années.

Les résultats serviront à valider les modèles climatiques et nous aideront à mieux estimer la distribution des puits et des sources de carbone.

Jing M. Chen, Ph. D., professeur
Département de géographie et Programme d'aménagement
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Total : 148 160 $/2 ans

Cinétique des mécanismes marins de production et de destruction de l'hémioxyde d'azote

L'hémioxyde d'azote (N_2O) est présent à l'état de traces dans l'atmosphère. Ce gaz nous intéresse parce qu'il intervient dans l'effet de serre et parce qu'il participe à la destruction de l'ozone par ses réactions chimiques dans la haute atmosphère. La concentration d'hémioxyde d'azote dans l'atmosphère a tendance à augmenter à long terme, tendance qui devrait se poursuivre parce que le gaz dérive en partie de l'utilisation des engrais azotés. Les microorganismes qui peuplent l'océan libèrent aussi de l'hémioxyde d'azote. Un des principaux problèmes que pose l'étude détaillée du N_2O dans l'océan est qu'il est difficile de séparer les processus de production et de destruction du gaz pour obtenir une valeur nette de chacun.

MM. Robert M. Moore et Steve Punshon, du département d'océanographie de l'Université Dalhousie (subvention globale de 65 532 $/trois ans), mettront au point des méthodes pour mesurer la production ou la destruction d'hémioxyde d'azote qui n'interfèrent pas entre elles. On a besoin de données détaillées sur le taux de production et de destruction de l'hémioxyde d'azote dans l'océan et dans les systèmes terrestres afin de prévoir les futures concentrations de ce gaz dans l'atmosphère.

Robert M. Moore, Ph. D., professeur
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Université Dalhousie
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Total : 65 532 $/3 ans

Temps violent

Effets de la brise de lac sur les condition météorologiques (« ELBOW 2001 »)

La brise de lac se manifeste souvent en été dans le sud de l'Ontario. Des recherches récentes ont montré clairement que la brise de lac et les phénomènes de déplacement d'air analogues ont un lien avec le temps violent en été (orages, foudre, tornades) et les problèmes de qualité de l'air (surtout une concentration excessive d'ozone). Le programme « ELBOW 2001 » s'appuiera sur l'expérience acquise lors du projet pilote de 1997 dans le sud-ouest de l'Ontario et sur les travaux de modélisation ultérieurs.

Le projet, dirigé par M. Peter A. Taylor, du département des sciences de la terre et de l'atmosphère de l'Université York (subvention globale de 348 000 $/deux ans), nous aidera considérablement à mieux comprendre les épisodes de temps violent dans cette région très peuplée du Canada.

Les météorologues et les spécialistes des épisodes de temps violent utiliseront les résultats des recherches pour se guider et mieux prévoir le lieu et le moment où la brise de lac ou de mer engendrera des épisodes de temps violent ainsi que l'intensité du phénomène. Grâce à ces données, ils valideront et perfectionneront les modèles de prévisions météorologiques à haute résolution.

Peter A. Taylor, Ph. D., professeur
Département des sciences de la terre et de l'atmosphère
Université York
pat@yorku.ca

Total : 348 000 $/2 ans

Étude des conditions météorologiques au radar polarimétrique

Les recherches de M. Enrico C. Torlaschi, du département des sciences de la terre et de l'atmosphère de l'Université du Québec à Montréal (subvention globale de 75 000 $/trois ans), nous éclaireront davantage sur l'usage du radar polarimétrique en météorologie. L'objectif général est d'optimiser les plans et les analyses de cet appareil afin de décrire différents types de précipitations.

Le projet posera les fondements scientifiques essentiels à l'application pratique des algorithmes de polarimétrie radar. Mesurer la pluie et la neige revêt une grande importance au Canada et l'usage du radar polarimétrique en météorologie figure au sommet de la liste des priorités de recherche au Service météorologique du Canada.

Les résultats du projet permettront de mieux interpréter et de mieux prévoir les conditions météorologiques à l'origine des orages au Canada.

Enrico C. Torlaschi, Ph. D., professeur adjoint
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Université du Québec à Montréal
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Total : 75 000 $/3 ans

Épisodes de temps violent en hiver dans la région des Grands Lacs

Vers la fin de l'automne et en hiver, quand les masses d'air froid et sec de l'Arctique traversent les Grands Lacs, de violentes tempêtes de neige s'abattent souvent au-dessus des différents lacs ou en aval de ceux-ci. Habituellement, ces tempêtes voient le jour dans le courant nord-ouest engendré par le passage de grands systèmes météorologiques à basse pression. Ces "tempêtes de neige d'effet de lac" donnent lieu à de fortes chutes de neige et à des épisodes de temps violent du côté sous le vent des lacs. Dans les cas les plus graves, ces tempêtes peuvent entraîner un " blizzard" très localisé doublé de poudrerie qui rend la visibilité totalement nulle, alors que le ciel est dégagé quelques kilomètres plus loin.

M. Kent Moore, du département de physique de l'Université de Toronto (subvention globale de 456 000 $/trois ans), élaborera un programme coordonné d'observations et de modélisation numérique qui permettra de perfectionner les modèles théoriques et quantitatifs reproduisant les tempêtes de neige d'effet de lac. On pourra éventuellement prévoir avec plus de précision et en temps plus opportun les épisodes de temps violent en hiver, du côté sous le vent des Grands Lacs.

Ce travail facilitera aussi les opérations de déneigement, ce qui rendra les routes plus sûres et améliorera le fonctionnement des aérogares. Enfin, le projet nous permettra de mieux comprendre la distribution de la neige, en général, et d'établir l'importance des chutes de neige, informations extrêmement précieuses lorsqu'on souhaite prévoir les inondations printanières.

Kent Moore, Ph. D., professeur adjoint
Département de physique
Université de Toronto
moore@atmosp.physics.utoronto.ca

Total : 456 000 $/3 ans

Plates-formes de lancement flottantes pour fusées météorologiques – Étude de faisabilité et démonstration du concept

Pour l'instant, au Canada, les prévisions météorologiques raisonnablement exactes sont limitées à trois jours en hiver dans le Centre et l'Est du pays, à deux jours dans les Prairies et à un jour ou moins dans l'Ouest. La raison est qu'il n'y a pas assez d'observations météorologiques en amont, dans le nord-est du Pacifique, région souvent affublée du sobriquet de "Pacific Data Void" (grand vide de données du Pacifique).

C'est pourquoi les programmes de recherche météorologique mondiaux, américains et canadiens ont entrepris une vaste campagne baptisée THORpex (The Hemispheric Observing-System Research and Predictability Experiment ou système hémisphérique expérimental d'observation et de prévision du temps) ayant pour but la création et le déploiement in situ d'appareils qui effectueront des relevés météorologiques dans cette partie du monde et d'autres régions où les données sont manquantes.

M. Roland Stull, du Programme des sciences de l'atmosphère de l'Université de la Colombie-Britannique (subvention globale de 151 000 $/deux ans), tentera de mettre au point des bouées qu'on lâchera en haute mer et qui serviront de plates-formes pour le lancement de petites fusées météorologiques avant de les mettre à l'essai. Si les résultats le justifient, le chercheur soumettra un second projet en vue de construire et de déployer un chapelet de bouées de ce genre dans le nord-est du Pacifique. Chaque bouée pourra lancer deux fusées météorologiques par jour.

Les données recueillies seront communiquées aux centres de prévisions météorologiques du Canada et du monde entier afin d'améliorer les prévisions à court et à moyen terme.

Roland B. Stull, Ph. D., professeur
Programme des sciences de l'atmosphère
Université de la Colombie-Britannique
rstull@eos.ubc.ca

Total : 151 000 $/2 ans

Qualité de l'air

Détermination du pouvoir oxydant de la troposphère d'après la concentration d'isotopes stables du carbone dans les composés organiques volatils

L'étude de M. Jochen J. Rudolph, du département de chimie de l'Université York (subvention globale de 594 800 $/trois ans), nous aidera à éclaircir une des grandes incertitudes de la modélisation de la pollution atmosphérique attribuable aux produits chimiques. Le projet facilitera l'élaboration de stratégies plus efficaces de lutte contre la pollution de l'air en accroissant la fiabilité et la capacité de prévision des modèles numériques. La première étape de l'élimination de nombreux gaz à l'état de traces importants présents dans l'atmosphère est leur réaction avec les radicaux hydroxyle (OH). C'est cette réaction qui détermine le taux de formation de maints polluants secondaires (ozone, particules) à l'origine du smog.

Les données expérimentales permettant de vérifier les concentrations de radicaux OH prévues au moyen des modèles sont très rares. De fait, il n'y en a pas au Canada. On entreprendra les recherches nécessaires pour tester, améliorer et contrôler les concentrations de radicaux OH utilisées par les modèles dans leurs calculs.

Les modèles numériques de simulation sont les outils les plus importants dont on dispose pour analyser les relations quantitatives entre les émissions de polluants, leurs concentrations dans l'atmosphère et les polluants secondaires. Les organismes gouvernementaux et le secteur privé (industrie, experts-conseils) recourent considérablement aux modèles de ce genre pour voir si les mesures de réduction des émissions sont utiles ou doivent être renforcées afin que les normes de qualité de l'air soient atteintes ou maintenues. Les deux groupes retireront énormément de ces modèles très fiables, dont on aura vérifié l'efficacité au moyen de données expérimentales.

Jochen J. Rudolph, Ph. D., professeur
Département de chimie
Université York
rudolphj@yorku.ca

Total : 594 800 $/3 ans

Filtration des polluants organiques persistants par les forêts

Des relevés récents laissent croire que les forêts filtrent très efficacement certains polluants atmosphériques toxiques. Il en va notamment ainsi des forêts de feuillus qui captent les polluants atmosphériques et les transfèrent au sol forestier à la chute des feuilles. Les forêts pourraient réduire sensiblement la charge de polluants dans l'atmosphère, ce qui atténuerait les risques que ces derniers engendrent pour l'être humain et la faune.

M. Frank Wania, de la division des sciences physiques de l'Université de Toronto (subvention globale de 280 000 $/trois ans), utilisera deux techniques différentes pour mesurer l'absorption de certains polluants, dont les biphényles polychlorés (BPC), dans une forêt d'arbres à feuilles caduques de Borden, en Ontario.

L'information glanée lors des essais sur le terrain servira éventuellement à perfectionner les modèles mathématiques auxquels recourent les chercheurs des universités et du gouvernement pour expliquer et prévoir le comportement des polluants dans l'environnement au Canada.

Frank Wania, Ph. D., professeur adjoint
Division des sciences physiques
Université de Toronto
frank.wania@utoronto.ca

Total : 280 000 $/3 ans

Observation et modélisation du transport des polluants à travers le Pacifique: incidences sur l'Ouest canadien

On estime généralement que la pollution atmosphérique dans l'ouest de l'Amérique du Nord, y compris dans le sud de la Colombie-Britannique, ne touche que la région et est d'origine locale. Des observations récentes révèlent cependant que les polluants atmosphériques et la poussière des régions semi-arides de l'Eurasie atteignent régulièrement l'ouest de l'Amérique du Nord.

M. Ian G. McKendry, du département de géographie de l'Université de la Colombie-Britannique (subvention globale de 228 560 $/deux ans), créera et installera un système de profilage vertical sur aéronef léger, puis modélisera le rôle des montagnes dans l'interception des couches de polluants qui passent au-dessus de l'ouest nord-américain. Il mettra aussi au point et utilisera des méthodes pour interpréter les observations sur le plan physique.

Les résultats contribueront a) à formuler de meilleures prévisions régionales sur la qualité de l'air et b) à tenir compte de l'effet des polluants trans-Pacifique sur la qualité de l'air local, si bien que les modèles évalueront mieux l'incidence des mesures locales de lutte contre la pollution.

Ian G. McKendry, Ph.D. professeur adjoint
Département de géographie
Université de la Colombie-Britannique
ian@geog.ubc.ca

Total : 228 560 $/2 ans

Quantification et paramétrisation des variations thermiques et massiques se rapportant à l'influence des villes sur la qualité de l'air et les échanges de gaz à effet de serre au niveau régional

Plus de la moitié de la population mondiale vit actuellement en milieu urbain. D'ici 2025, cette proportion atteindra les deux tiers. Avec la modification du relief attribuable à l'urbanisation, on assiste à des rejets plus importants de déchets, y compris de polluants atmosphériques. La concentration de ces polluants peut altérer de manière appréciable les processus météorologiques, voire engendrer un nouveau climat urbain et entraîner une détérioration de la qualité de l'air en région. Bien que ces effets se fassent surtout sentir en ville, la "zone de diffusion" des polluants urbains franchit parfois de longues distances.

M. Timothy R. Oke, du département de géographie de l'Université de la Colombie-Britannique (subvention globale de 222 932 $/trois ans), étudiera les échanges de chaleur, d'eau et de polluants dans les villes, la façon dont ces échanges modifient le climat urbain et la dispersion des polluants. Le projet nous renseignera sur les principaux processus du système climatique, y compris ceux associés aux sources et aux puits de gaz à effet de serre, ainsi que sur la qualité de l'air dans les villes et nous aidera à construire des modèles reproduisant les conditions météorologiques et la qualité de l'air, en particulier pour les villes.

Timothy R. Oke, Ph. D, professeur
Département de géographie
Université de la Colombie-Britannique
toke@geog.ubc.ca

Total : 222 932 $/3 ans

Pour en savoir plus sur la FCSCA ou sur les projets décrits ci-haut, visitez le site Web de la Fondation à l'adresse http://www.cfcas.org, ou communiquez avec:

Dawn Conway, Directrice générale
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)
Tél.: (613) 238-2223; Téléc.: (613) 238-2227
Courriel : conway@cfcas.org

A Name for the Prize in Applied Oceanography

Members of CMOS, your Executive has approved an initiative to seek an appropriate name of a Canadian oceanographer for "The Prize in Applied Oceanography". This particular CMOS Prize is the only unnamed prize of all our prizes. We would like to seek your views on this initiative on such things as to whether the name should be that of a living or deceased oceanographer, whether the terms of reference for the prize should be amended and any other suggestions you might like to offer.

If you have a name in mind send it to the Executive Director of CMOS along with your justification by the end of October, 2001.

Neil J. Campbell
Executive Director

Un nom pour le prix en océanographie appliquée

Membres de la SCMO, votre Exécutif a approuvé l'initiative de nommer le Prix en océanographie appliquée en l'honneur d'un océanographe canadien approprié. En ce moment, ce prix est le seul qui ne porte pas de nom. Nous désirons recevoir vos commentaires à propos de cette initiative, en particulier si le nom devrait être celui d'un océanographe vivant ou décédé, si les termes de référence devraient être amendés, ou toute autre suggestion.

Si vous avez un nom en tête, envoyez le au Directeur exécutif de la SCMO, avec votre justification, avant la fin d'octobre 2001.

Neil J. Campbell
Directeur exécutif

Christopher J. R. Garrett Honoured by the American Meteorological Society

Chris Garrett, Lansdowne Professor of Ocean Physics at the University of Victoria, has won the 2001 Stommel Award of the American Meteorological Society (AMS), the nation's leading professional society for scientists in the atmospheric and related sciences.

Garrett earned the award "for his rare ability to use simple models or concepts to expose the rich underlying physics that leads us all to a more profound understanding of ocean processes." The Stommel Research Award is granted to researchers in recognition of their outstanding contributions to the advancement of the understanding of the dynamics and physics of the ocean. Henry Stommel was known for his contributions to the dynamics of ocean currents, especially the Gulf Stream, and for his insight into the physics of the oceans and associated atmospheric phenomena.

A native of England, Garrett received his Ph.D. in geophysical fluid dynamics from the University of Cambridge in 1968. After a postdoctoral position at Scripps Institution of Oceanography and twenty years at Dalhousie University, he joined the University of Victoria in 1991.

His research has focused on theoretical studies of mixing and other oceanic processes, which need to be understood and properly represented in models used for climate prediction and other aspects of ocean management. He also has interests in the dynamics of flows in straits and semi-enclosed seas, and in a variety of applied problems including tidal power and oceanic waste disposal. He has served on several national and international advisory panels, including the British Columbia/Washington State Marine Science Panel, which advised the two governments on the management of their shared waters.

The award was presented in January 2001 at the AMS 81st Annual Meeting in Albuquerque, New Mexico.

Congratulations, Dr. Garrett, from all the CMOS members.

CMOS Annual Prizes Presented at the 35th Congress in Winnipeg

President's Prize (two awarded for 2000)

To: **Dr. Robie W. Macdonald** for major contributions toward understanding the pathways and interactions of contaminant chemistry in Canadian waters and specifically for his role as lead-author in the paper "*Contaminants in the Canadian Arctic: 5 years of progress in understanding sources, occurrence and pathways*" published in 2000 in The Science of the Total Environment, 254, pp. 93-234.

To: **Dr. Francis W. Zwiers** for outstanding contributions in the field of statistical climatology, including the application of statistical methods to climate change detection and attribution, and specifically for his highly praised book with co-author Dr. Hans von Storch entitled "*Statistical Analysis in Climate Research*" published in 1999 by Cambridge University Press.

Rube Hornstein Medal In Operational Meteorology

To: **Dr. Aldo Bellon** for outstanding theoretical and operational contributions in the field of radar meteorology, and for his pioneering development and application of operational software and products for radar-based nowcasting systems.

Tertia M.C. Hughes Memorial Prize (two awarded for 2000)

To: **Dr. Adam H. Monahan** for outstanding contributions to climate research through his highly rated doctoral thesis on "*Nonlinear principal component analysis of climate data*" and for publication of numerous first-author papers on climate variability.

To **Dr. Stephen Déry** for his outstanding doctoral thesis on "*The role of blowing snow in the hydrometeorology of the Mackenzie River Basin*" and his original and innovative contributions to the hydrometeorology of blowing snow and blizzards.

The CMOS/Weather Research House Postgraduate Scholarship

1) First year Scholarship

To: **Ronald McTaggart-Cowan**, Ph.D. candidate at McGill University for his thesis: *Using Moisture-Modified Potential Vorticity Inversions to Create Members for a Real Time Ensemble Forecasting System.*

2) Second Year Scholarship

To: **Tetjana A. Ross**, Ph.D. candidate in Oceanography, University of Victoria for outstanding academic achievement and to assist in pursuing physical-chemical interdisciplinary research in a Ph.D. program.

D.Sc. conferred on Jim Bruce at McMaster University Convocation

The Canadian Meteorological and Oceanographic Society congratulates Dr. Jim Bruce on the receipt of a D.Sc. from McMaster University during the convocation held in June 2001. He has been a CMOS member since 1948, first as a member of the RMS Canadian Branch. He has contributed to the Society as a Councilor (1986-87), as CMOS Vice-President (1968-69) and was made a life member of CMOS in 1993. During his career he has received numerous awards including the prestigious 1994 IMO Prize of the World Meteorological Organization for exceptional worldwide contributions in meteorology and hydrology, a D.E.S., honoris causa, from University of Waterloo in 1994, the 1996 Massey Medal of the Royal Canadian Geographical Society, the Order of Canada and is a Fellow of the Royal Society of Canada.

Jim Bruce has had a distinguished career in the fields of meteorology, climate and water resources, disaster mitigation and environment. He began his career as a weather forecaster, establishing the flood warning system for Ontario (1955-1959) and undertook research and teaching at the University of Toronto in Hydrometeorology. He was the first Director of the Canada Centre for Inland Waters in Burlington (1967) and later, Director General, Inland Waters Directorate for Canada based in Ottawa. In 1977 he was an Assistant Deputy Minister responsible for Environmental Management Service of Environment Canada comprising the Canadian Forestry Service, the Canadian Wildlife Service, and Inland Waters and Lands Directorates. In the 1970s, he was part of the Canadian team which negotiated the 1972 and 1978 Great Lakes Water Quality Agreements between Canada and USA and served as Canadian Co-Chair of the Science Advisory Board and later the Great Lakes Water Quality Board of the International Joint Commission. He has also chaired the federal-provincial Prairie Provinces Water Board, and the Mackenzie River Basin Board. In the 1980s, Jim Bruce served as Assistant Deputy Minister of the Atmospheric Environment Service responsible for weather forecast and warning services, the Canadian Climate Centre, national air quality monitoring, and atmospheric research. While there, he chaired a national steering committee on acid rain, the Economic Commission for Europe's Working Group which negotiated the Helsinki Protocol for SO_2 emissions reductions. He also chaired the Conference on Greenhouse Gas and Climate Change held in Villach, Austria in 1985 sponsored by the WMO/UNEP/ICSU.

In 1985, Jim left the federal government and has continued to provide leadership in important global endeavours. In 1986-89 he served as Director of Technical Cooperation and Acting Deputy Secretary-General for the World Meteorological Organization, Geneva. In these positions, he assisted in establishment of the Intergovernmental Panel on Climate Change (IPCC) and its Secretariat, promoted WMO's climate and environment programs and had general responsibility for Technical Cooperation projects including those for weather and disaster warning systems, water, climate, and air quality. In the early 1990s Bruce chaired the United Nations' scientific and technical committee for the International Decade for Natural Disaster Reduction. Between 1992-97 he was Chair of the Canadian Climate Program Board, Co-chair of Working Group 3 (Economic and Social Aspects) of IPCC, and Member of the Commission for Geosciences, Environment, and Resources, U.S. National Council.

He has been a frequent consultant, speaker and writer on climate change and disaster mitigation and author of several books and papers. He is currently Chair of the International Advisory Committee, UN University International Network for Water, Environment and Health, Member of the Canadian Global Change Program, member of the Board of International Institute for Sustainable Development, and is a Senior Associate with Global Change Strategies International in Ottawa.

CMOS Ottawa Centre Members Win Award for Scientific Excellence

The Norbert Gerbier Mumm International Award is to encourage and reward an original scientific paper on the influence of meteorology in a particular field of the physical, natural or human sciences or on the influence of one of these sciences on meteorology. The award aims at stimulating interest in such research, in support of WMO programmes. The annual award consists of a diploma, a medal bearing a likeness of Mr. Norbert Gerbier and a prize of fifty thousand French francs. Of the ten nominations received, the Selection Committee awarded the 2002 award to Ray Desjardins[1], E. Pattey[1] and W.N. Smith of AAFC[2] (Canada) for their research on the net flux of carbon from agricultural soils.

1: Ray Desjardins and Elizabeth Pattey are both CMOS Members.
2: AAFC is a Branch of Agriculture and Agri-Food Canada.

Global Warming & Extreme Weather
A Special Issue on Natural Hazards

The present ongoing debate on Global warming highlights the possiblity of increased incidences of extreme weather events world-wide, as the Earth's mean temperature is expected to rise steadily in response to increased concentrations of atmospheric greenhouse gases. Several recent studies and media reports point out the increased risk of more violent weather events in future (more severe cyclones and mid-latitude storms, increased thunderstorms, severe windstorms and accompanying localized and regional flooding, increased instances of regional and local droughts, etc.) as a result of increasing concentrations of greenhouse gases.

Due to the importance of this topic, a Special Issue of the Journal NATURAL HAZARDS (Kluwer Academic Pub., Netherlands) devoted to the general topic of **Global Warming & Extreme Weather (land and marine based)** is planned for publication by the Spring of 2002.

The Special Issue is aimed at focusing on the scientific basis of the possible link between Global Warming & Extreme Weather and on providing a suitable documentaion of the link through a careful analysis of available data.

Articles and papers (12 to 15 pages in length) as well as short essays dealing with any of the issues relating to Global Warming/Extreme Weather are sought. Scientists and researchers working in the general area of Global Warming are encouraged to submit papers for this Special Issue. All submitted manuscripts will be subject to a standard Journal review process. Manuscripts may be directly submitted to one of the following Guest Editors:

1. Dr. Madhav L. Khandekar, Consulting Meteorologist, 52 Montrose Crescent, Unionville, Ontario, L3R 7Z5, CANADA: E-mail: mkhandekar@home.com / Phone: 905-940-0105

2. Dr. Gabriele Goennert, Department of Port and River Engineering, Dalmannstr. 1-3, 20 457 Hamburg, GERMANY: E-mail: Gabigoennert@aol.com

Papers may be submitted by regular or elctronic mail. For additional details please contact the Guest Editors directly. Manuscripts may be submitted preferably before 31 December 2001.

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