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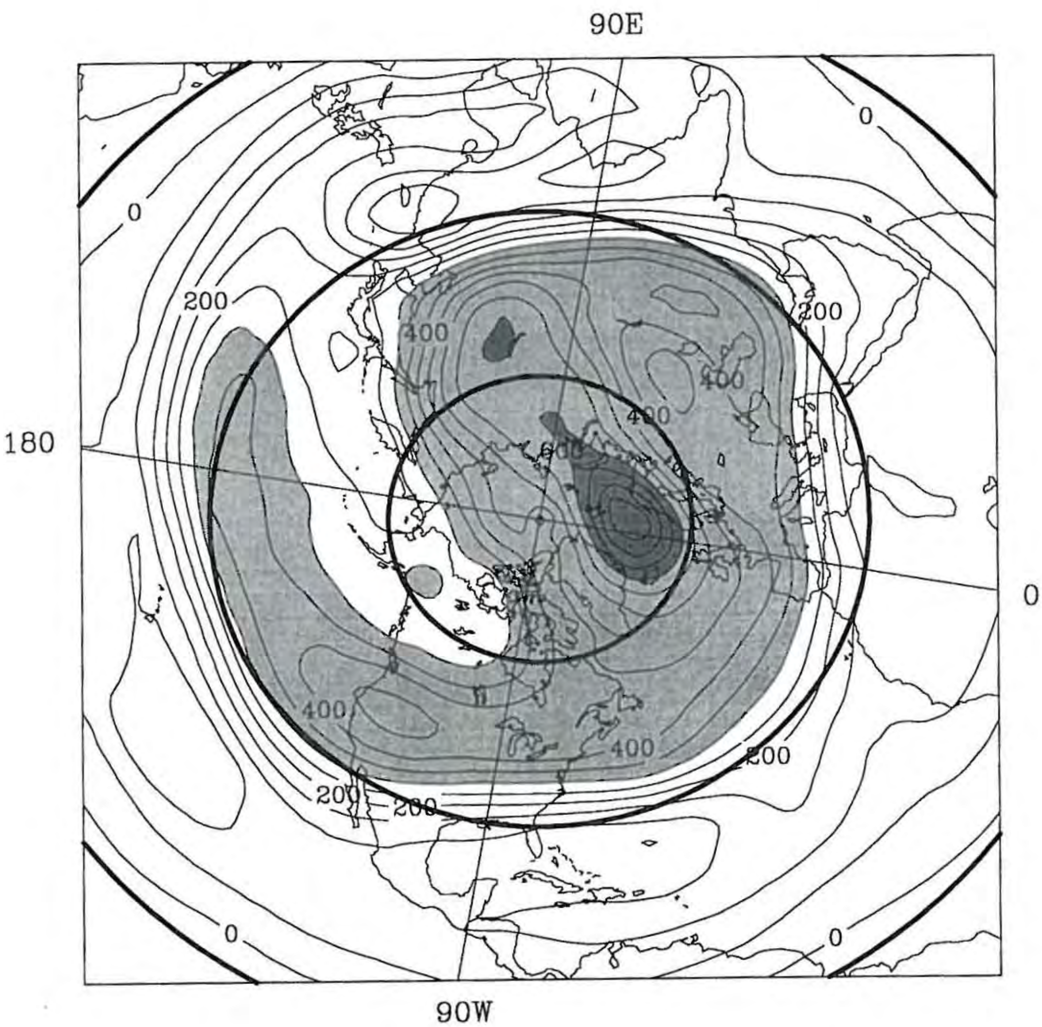
The Canadian MAM Project



CMOS Bulletin SCMO

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Inside / En bref

FRONT PAGE: **Potential vorticity** (PV) on the 850 K (≈10 mb) isentropic surface, calculated using data simulated by the Canadian Middle Atmosphere Model for a day in model December. The contour interval is 50 potential vorticity units (1 PVU = 10^{-6} Km^2kg^{-1} s^{-1}). Regions where PV ≥ 600 PVU are heavily shaded, and those where 300 PVU ≤ PV < 600 PVU are lightly shaded. Heavy concentric circles represent latitudes 60N, 30N and the equator (only partially visible) respectively.

The PV is depicted during a model stratospheric sudden warming. Under normal wintertime conditions, the heavily shaded cyclonic vortex lies directly over the pole and is associated with strong circumpolar westerlies and a cold pole. In the presence of pronounced planetary wave activity, the cyclonic vortex is forced off the pole by midlatitude air with relatively lower values of PV (the unshaded region north of 60N). The cyclonic vortex weakens and splits into a weaker double vortex pattern that is just beginning to immerge in this figure (the small heavily shaded region east of 90E). This development is accompanied by circumpolar easterlies and a much warmer pole. (Figure and caption are courtesy of John Koshyk.)

EDITOR'S COLUMN

The next issue of the ***BULLETIN*** **23** (2), April 1995, will go to press on April 25, 1995. Contributions are welcome and should be sent before April 12. We do not have a person for typing nor translating so I need your contribution in a form that can be readily inserted into the Bulletin. The most convenient way is via E-mail to the above address. I accept contributions submitted on floppy disk in standard DOS formats (i.e. WordPerfect (version 4.1 to 5.1), plain ASCII text files, MS Word - at the moment I use Word 6.0 for Windows), however, I can convert Macintosh files to DOS files. If you want to send graphics, then HPGL files can be sent as ASCII files over the networks, any other format will have to be sent on paper or on a floppy disc. It is recommended that whatever software prepares an HPGL file be configured for the HP7550 printer. If you have the option of selecting pen colours, please don't. If you send a file over the network, send a copy to yourself and examine the transmitted copy to check that it is all there. Do you have an interesting photograph, say, an interesting meteorological or oceanographic phenomenon? If so, write a caption and send me a high contrast black and white version for publication in the CMOS Newsletter. Savonius Rotor is still alive for anyone who has an unusual point to make.

Jean-Pierre Blanchet,
CMOS Bulletin Editor

SECTION DU RÉDACTEUR

Le prochain numéro du ***BULLETIN*** **23** (2), avril 1995 sera mis sous presse le 25 avril 1995. Vos contributions sont les bienvenues. Veuillez me les faire parvenir d'ici le 12 avril.

Nous ne disposons pas de personnel pour dactylographier ou traduire les textes soumis et je demande votre collaboration en m'envoyant vos textes sous forme électronique (poste internet ou disquette). Les fichiers sur disquettes doivent être dans un format standard DOS (WordPerfect 4.1 ou 5.1, MS Word, texte ASCII). J'emploie actuellement MS Word 6.0 pour Windows. Je peux convertir les fichiers Macintosh équivalents vers DOS. Si vous avez de bonnes photographies pour notre page couverture, s'il vous plaît m'en faire parvenir une copie en noir et blanc bien contrastée avec une légende appropriée.

Jean-Pierre Blanchet,
rédacteur du Bulletin de la SCMO

The Canadian MAM Project

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ABSTRACT

The central goal of the Canadian MAM project is to develop a Middle Atmosphere Model (MAM). By a MAM is meant a three-dimensional, time-dependent climate simulation model based on the meteorological primitive equations of motion, incorporating fully interactive chemistry and realistic radiative transfer, and capable of representing the atmospheric state from the surface of the earth up to heights of about 85 km (approximately the top of the electrically neutral atmosphere). Such a model is necessary to study the physics of the ozone layer and the problem of ozone depletion, for example. It is also the minimum needed to make scientifically credible predictions of climate change in the middle atmosphere associated with anthropogenic modifications.

Many countries (e.g. USA, UK, Germany, France, Japan) have made significant commitments to develop MAMs. Within Canada, such an effort has recently begun with support being provided jointly from an NSERC Strategic Grant and from the AES through the Canadian Climate Research Network. This initiative builds on the existing Canadian expertise in the area of General Circulation Models, which primarily resides in the Canadian Centre for Climate Modelling and Analysis (CCCMA) of AES, together with the considerable expertise that exists in Canadian universities in the areas of atmospheric chemistry, radiation, and dynamics. The principal development efforts that are required to produce the MAM are being carried out in the university community with the help of research associates, post-doctoral fellows, and graduate students, in close collaboration with CCCMA.

This article reviews the scientific background behind the MAM project, together with its present structure and objectives. A selection of results from the first (prototype) version of the MAM is presented. In order to better understand our plans for future development, and the challenges that we will likely face, a brief overview is provided of the salient (and distinctive) features of middle atmosphere dynamics.

1. Scientific background

The Green Plan Global Warming Science Program aims to train and mobilize expertise within the Canadian atmospheric science community, with the goal of fostering collaborative research that will help reduce the uncertainty associated with climate change and possible global warming. It is widely recognized that a major component of such research must be the development of reliable numerical models. Given the fact that our environment is, ultimately, a single coupled system, one might ideally hope to develop a single coupled model of this system. However, this is out of the question at the present time and for the forseeable future. Instead, it is necessary to focus on sub-components of the global environmental system, and on specific feedbacks or processes.

A pressing subject of great public and scientific concern is the depletion of the ozone layer. An appropriate modelling strategy to understand this problem must take account of the relevant physical factors. The time scales involved range from months to decades, though there is a strong seasonal cycle which initially is probably the most important feature to understand. A number of chemical species must be treated interactively, which demands sophisticated chemical-transport schemes. There is a strong interaction between gas-phase and heterogeneous chemistry on aerosols. The chemistry is strongly coupled to dynamics, especially to the vertical motion over the polar regions, and this vertical motion is driven by processes extending well into the mesosphere, including the drag exerted by breaking gravity waves. Thus a self-consistent model must extend from the surface of the earth to the top of the mesosphere, which requires a significant extension of the radiation schemes currently used in standard General Circulation Models (GCMs), as well as a realistic parameterization of gravity-wave drag. On the other hand, over the time scales of interest it is possible to perform scientifically credible simulations without an interactive ocean component to the model. (In other words, the ocean forcing can be specified.) Such three-dimensional climate models, representing the coupled interactions between radiation, dynamics, and chemistry, are usually referred to as "Middle Atmosphere Models" (MAMs) — though it should be stressed that they do not only model the so-called middle atmosphere (stratosphere and mesosphere) but include the troposphere as well. The modelling approach behind a MAM does not suffer from the inherent limitations of previous (1-D and 2-D) modelling approaches, and the reliability of the model predictions will increase with time as improved computational technology permits more accurate calculations.

The need for Middle Atmosphere Models is widely appreciated by the atmospheric community. The physics of the ozone layer and the problem of ozone depletion is an obvious justification; but there is a multitude of other issues that fall within the general heading of reducing the uncertainty of climate predictions. For example, problems of tropospheric chemistry are strongly affected by stratosphere-troposphere exchange, and there is strong evidence (Haynes *et al.*, 1991; Rosenlof and Holton 1993; Yulaeva, Holton and Wallace 1994) that this exchange is controlled to a large extent by middle-atmosphere dynamics. Also, the results of conventional GCMs — such as are used for climate-change studies — appear to have a significant dependence on the upper boundary condition (Boville and Cheng 1988). This is particularly the case if one is interested in regional effects (e.g. over North America), which are strongly dependent on the model's representation of planetary waves: planetary waves in GCMs are very sensitive to the location of the upper boundary (Boville and Baumhefner 1990). An understanding of possible systematic errors in GCMs therefore requires the use of a MAM. A final example is the problem of global (surface) warming itself, which appears to have a strong coupling to stratospheric ozone variations (Ramaswamy, Schwarzkopf and Shine 1992; Kiehl 1992). It is significant in this respect that all GCM calculations used to date to predict the extent of global warming have not included full interaction with ozone or CFCs.

For these and many other reasons, there has been a vigorous activity within the atmospheric community in recent years directed towards the development of MAMs. Models have been under development in the United States at the Geophysical Fluid Dynamics Laboratory in Princeton, at the National Center for Atmospheric Research in Boulder, at the Goddard Space Flight Center's Institute for Space Studies in New York, and at NASA Langley; in the United Kingdom at the Meteorological Office/Hooke Institute and by the Universities' Global Atmospheric Modelling Project; in France at the Centre National de Recherches Météorologiques in Toulouse; in Germany at the Meteorologisches Institut der Freien Universität Berlin and at the Max Planck Institut für Meteorologie in Hamburg; and in Japan at the Meteorological Research Institute. These are all long-term efforts. Until recently, no comparable effort existed within Canada.

Yet the need for Canada to have its own atmospheric models is clear. Many environmental concerns have specifically Canadian dimensions that will not necessarily be addressed by other countries. This is especially the case with middle-atmosphere climate change issues, most notably that of ozone depletion — with its implications for increased levels of surface ultraviolet radiation — which has particular importance for northern countries such as Canada.

2. Initial development

In response to the above concerns, a project to develop a Canadian MAM was initiated approximately two years ago through the mechanism of an NSERC Strategic Grant, augmented substantially by direct support from the Climate Research Branch of AES. One year ago, MAM became one of the projects supported by the AES's Green Plan Global Warming Science Program through the Canadian Climate Research Network. At the present time, MAM involves 12 Investigators, a four-person Core Group, and approximately 15 graduate students and post-doctoral fellows, representing five Canadian universities, CCCMA, and the Institute of Space and Terrestrial Science (North York, Ontario). Its combined budget exceeds half a million dollars per year.

The first objective of the MAM project was to develop a prototype MAM simulating the region 0-85 km, using what might be regarded as "off-the-shelf" components. To this end, the third-generation CCCMA GCM was extended upwards with its upper level put at 0.001 mb (approximately 97 km altitude). This model is a spectral model using a hydrid vertical coordinate system (Laprise and Girard 1990) that provides for a smooth transition between sigma and pressure coordinates. (Retaining sigma coordinates in the middle atmosphere would lead to unacceptable problems because of the strong vertical gradient of many chemical constituents: "horizontal" diffusion along the terrain-following sigma surfaces would generate overwhelming — and quite spurious — vertical transports.) In light of the fact that the middle atmosphere is driven dynamically from the troposphere, it was decided (in contrast to most other MAMs) to maintain the full tropospheric and lower stratospheric resolution of the GCM; this also had the advantage that we were beginning with a known tropospheric climate. Hence 25 levels were distributed below 25 km, with another 25 levels spaced at roughly 3 km vertical spacing above this. A Rayleigh-drag sponge layer was introduced over the top two scale heights of the model, turning on smoothly from about 80 km. This is required in order to prevent spurious reflection of upward-propagating waves (which have vertical wavelengths on the order of the scale height). The horizontal resolution was taken to be that of the existing GCM, namely T32 truncation. Although it is not possible to identify this with a particular spatial resolution, it roughly corresponds to a grid spacing of about 500 km at mid-latitudes (Laprise 1992).

This prototype MAM included only the existing GCM physics, which of course was not designed for middle atmosphere applications. The physical processes were therefore seriously deficient in many respects. For example, it is well known (e.g. Andrews, Holton and Leovy 1987, Chapter 7) that gravity-wave drag (GWD) is an important process in determining the circulation of the mesosphere. (See discussion in Section 3 below.) The existing GCM GWD scheme of McFarlane (1987) only parameterizes the effects of orographically-generated gravity waves with zero phase speeds. Although direct measurements of GWD in the atmosphere are scanty, indirect evidence strongly suggests that waves with non-zero phase speeds must play a crucial role, especially in the summer solstice where zero-phase-speed waves would presumably be absorbed at the zero wind line that exists in the middle stratosphere. The same indirect evidence also suggests that GWD is just as important in the Southern Hemisphere as in the Northern Hemisphere (in fact perhaps more so, in a relative sense, because of the

Figure 1: Zonally Averaged Temperature (^{0}K)

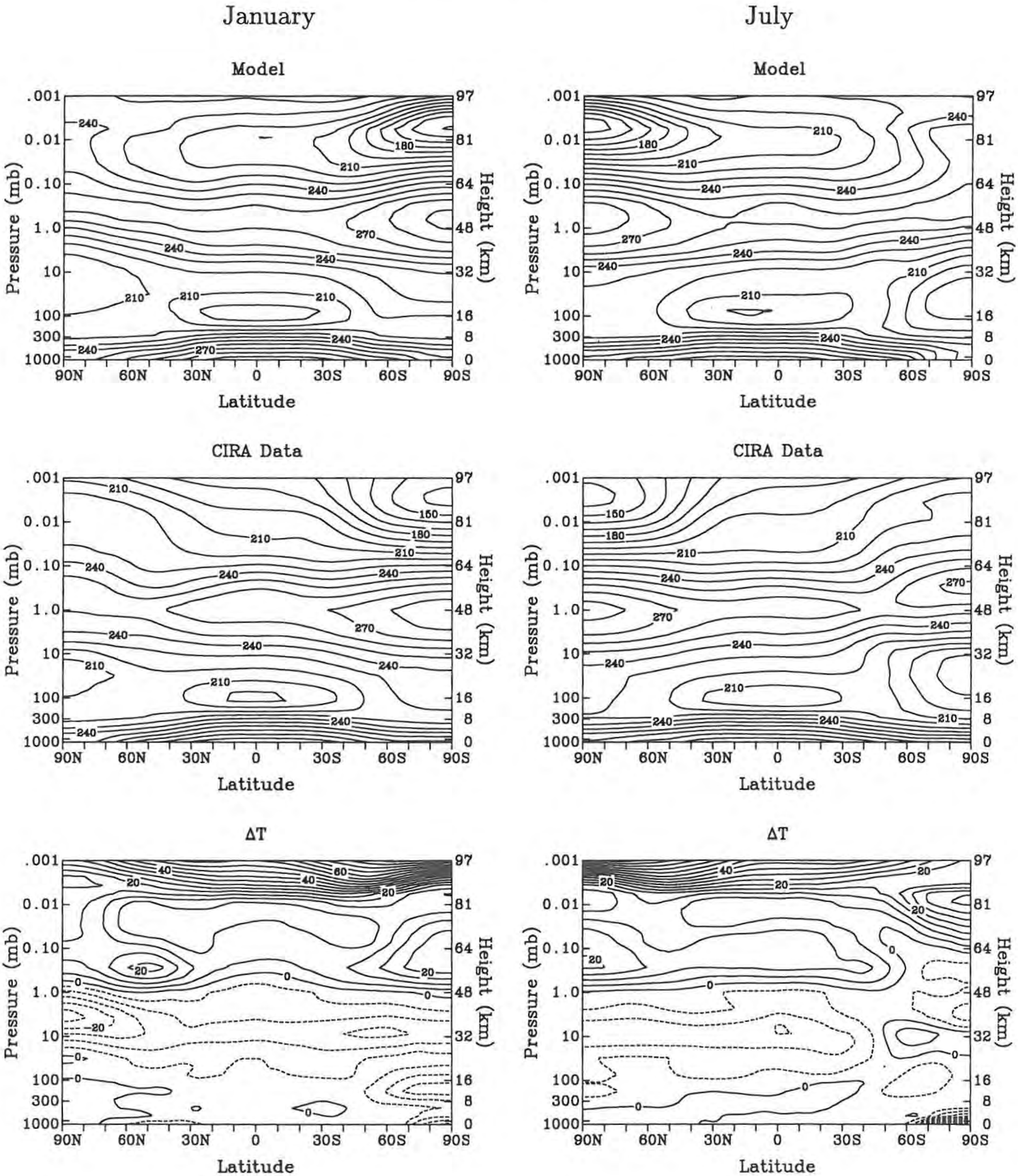


Figure 2: Zonally Averaged Zonal Wind (ms^{-1})

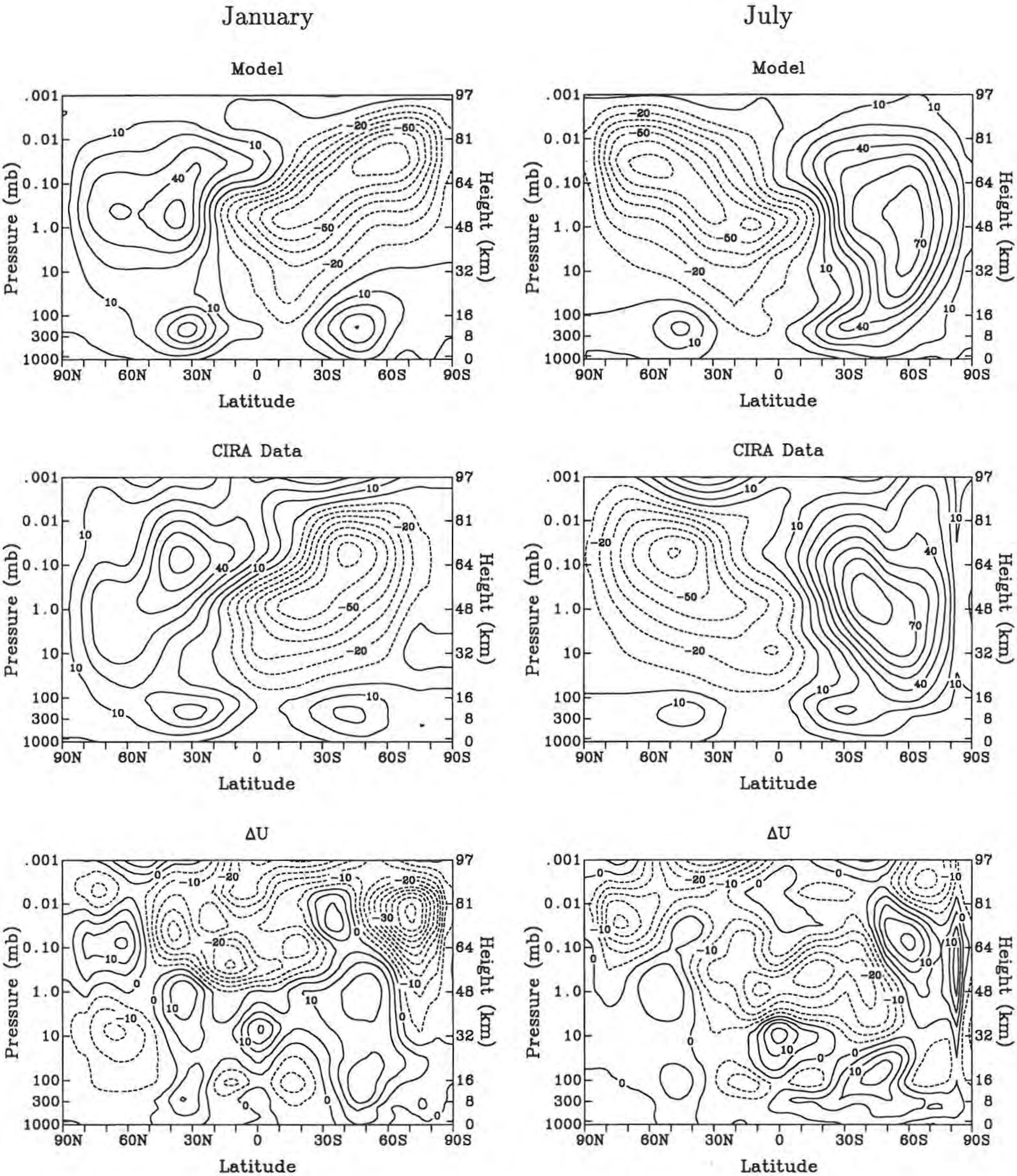
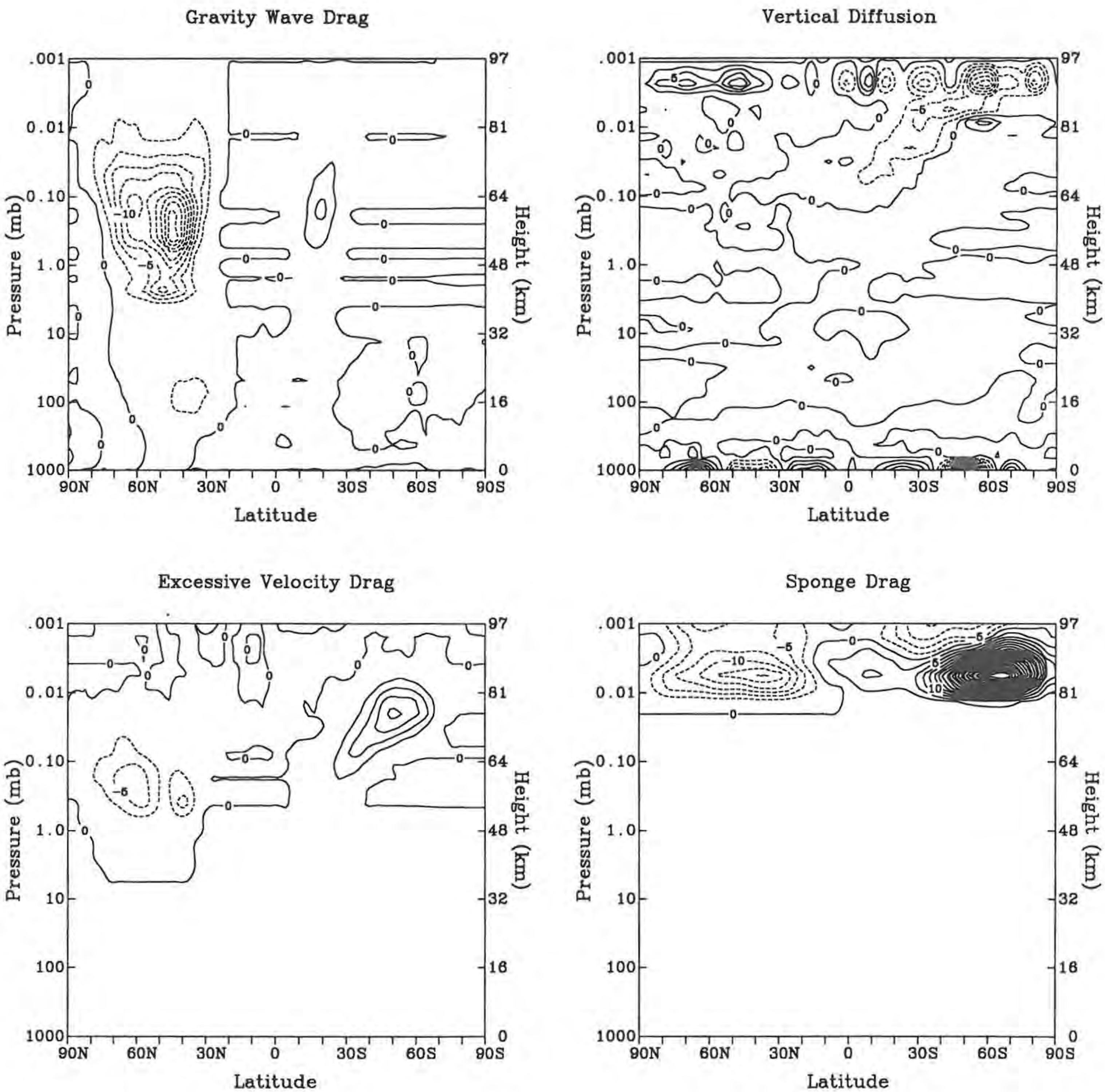


Figure 3: Zonally Averaged Parameterized Forcing (zonal component) ($ms^{-1}day^{-1}$)

January



weakness of planetary-wave activity in the SH). Yet its source there is presumably largely non-orographic because of the relative weakness of orography in the SH. Without some representation of non-orographic GWD, the middle atmosphere would be much too close to radiative equilibrium (see Section 3) and the polar night jet in the SH would therefore be much too strong. This would lead to problems of computational stability, and it was therefore decided for the purpose of the prototype version of MAM to introduce an "excessive velocity drag" which turns on whenever the jet speed exceeds 100 m/s.

In terms of radiation, the existing GCM scheme (see McFarlane *et al.*, 1992) ignores effects of Doppler broadening (Voigt profiles) on infrared cooling and is therefore expected to be accurate only up to the stratopause (about 50 km altitude). By making the plane-parallel approximation it also ignores sphericity effects on solar heating which have been shown to be important (Lary and Balluch 1993) at the edge of the polar night (the terminator): this is particularly significant for simulations of polar ozone-hole development. The chemical distributions which determine the radiative heating and cooling were specified from climatology. Above 30 mb (roughly 25 km altitude) this also included water vapour; the well-known deficiencies of Eulerian spectral transport of trace species (Rasch and Williamson 1990) would otherwise lead to numerical difficulties in this region.

In order to establish our baseline for further model development, this prototype version of MAM (known as MAM v.1) was run for a three-year period, using a 15-minute timestep and representing the full diurnal as well as seasonal cycle in radiative forcing. Zonal-averaged mean temperatures and zonal winds for January and July are shown in Figures 1 and 2. (Similar results were presented at the 1994 CMOS Congress by S.R. Beagley.) For purposes of comparison, observations based on the CIRA-86 data set (Fleming *et al.* 1990) are also shown, together with the difference fields. It must be cautioned that the CIRA-86 data set is subject to considerable uncertainties in the middle atmosphere, being based mainly on coarsely resolved satellite measurements of temperatures (the winds being recovered from gradient-wind balance). In any case, one cannot expect precise agreement because of the considerable interannual variability that exists in the middle atmosphere, especially in the NH winter.

Given all these caveats, there is much that can be gleaned already from this comparison. The overall temperature structure is captured reasonably well in a qualitative sense, but there are large quantitative errors. The principal observed temperature extrema are captured: e.g. the minimum at the tropical tropopause, the minimum at the wintertime polar mid-stratosphere, the maximum at the summertime polar stratopause, and the overall summer-to-winter-hemisphere temperature gradient in the mesosphere. But there is a systematic bias in the model temperatures with the mesosphere being generally too warm, and the stratosphere being generally too cold. The stratospheric cold bias is particularly extreme in the polar regions, exceeding 25 K around the 3 mb level in the NH polar night. This cold bias is not so severe in the SH polar night, being mitigated by a curious warm spot around 10 mb. But this is in fact more a reason for concern than satisfaction, because in the absence of significant wave drag in the SH (either resolved or parameterized) one would expect the cold bias to be *worse* in the SH than in the NH polar night, rather than better. This suggests that the artificial (i.e. numerical) drag processes may be playing a strong role in determining the temperature structure. In fact it is clear that the sponge layer must be acting as a surrogate for missing GWD; otherwise the model could not possibly have captured the observed reversal of the mesosphere pole-to-pole temperature gradient from that expected on radiative grounds (see Section 3).

The zonal wind field just reflects the temperature field, the former being determined from the latter by balance considerations. (As will be shown in Section 3, the direction of causality does indeed work in this rather than the opposite sense, at least to a first approximation.) The characteristics of the zonal wind field are captured in a gross sense, although the mesospheric jets (both winter and summer) are too far poleward, and the wintertime jet has a very poor structure.

It is instructive to examine the components of unresolved forcing in the zonal momentum equation; these act in concert with the resolved wave drag to determine the mean diabatic circulation, and thereby the temperature structure (see Section 3). Figure 3 displays the various components during the final January of the run. (Similar results were presented at the 1994 CMOS Congress by J.N. Koshyk.) The vertical diffusion is basically negligible, except in the planetary boundary layer (where the surface easterlies and westerlies are reflected in the alternating positive and negative regions); its effects in the sponge layer is small compared with the sponge drag itself. As expected, the parameterized GWD is strongly negative in the NH and virtually absent in the SH (except for a small feature at 20°S presumably generated by the Andes). The sponge layer evidently exerts significant drag. In the NH this is negligible compared with the GWD, because the GWD is acting at lower and therefore denser levels of the atmosphere. But in the SH the sponge layer must be accounting for most of the response. The excessive velocity drag likewise is producing a sizeable contribution to the total drag in the SH.

While the parameterized GWD and vertical diffusion may be regarded as physically credible (albeit imperfectly represented) effects, the sponge layer and excessive velocity drag are purely numerical devices with no physical basis. It is best to view them as "training wheels", to be removed when the rest of the model is able to stand on its own. (The sponge layer should arguably be applied only to the upward-propagating wave-like components of the motion, though this is easier said than done.)

The deficiencies of the prototype version of MAM lead naturally into a discussion of our future development. Before doing this, however, it is useful to review some fundamental aspects of middle atmosphere dynamics. The middle atmosphere differs in many significant ways from the troposphere, and its behaviour is therefore somewhat counterintuitive from the standpoint of conventional general circulation dynamics. This theoretical background also serves to provide the scientific rationale for the model development, and to identify the likely challenges.

3. Wave-drag control of the mean diabatic circulation

On a sufficiently long timescale, the circulation of the middle atmosphere can be understood as a balance between radiation and dynamics: radiation acts as a "spring" (Fels 1985) pulling the temperature towards its radiative-equilibrium value, while dynamics pulls the temperature away from radiative equilibrium through a mean meridional diabatic circulation that is driven by the drag exerted by dissipating waves. This wave drag is associated with planetary waves as well as (inertia-)gravity waves (and, in the tropics, with Kelvin waves), which are largely forced in the troposphere and propagate upwards. (This simple picture is complicated by *in situ* sources of waves in the middle atmosphere, but these are felt — rightly or wrongly; with the present observations it is difficult to say — to be a second-order effect.) The mean meridional diabatic circulation is also, to a good approximation, the transport circulation which carries chemical species (see e.g. Andrews, Holton and Leovy 1987, Chapter 9). Its accurate determination is thus crucial for a credible MAM.

This balance between wave drag and radiation is most easily seen by considering the following quasi-geostrophic form of the mean equations (though the reasoning extends with little essential modification to the full primitive-equations form; *op.cit.*). The thermodynamic balance is

$$\frac{N^2 T_0}{g}\overline{w}^* = Q = \text{diabatic heating and cooling,} \qquad (1)$$

which is a balance between adiabatic and diabatic heating and cooling; the mechanical balance (in the zonal momentum equation) is

$$-f\overline{v}^* = F = \text{ wave drag,} \qquad (2)$$

which is a balance between the Coriolis force and the force exerted by wave drag. F is the Eliassen-Palm flux divergence. The mean meridional diabatic circulation ($\overline{v}^*$, $\overline{w}^*$) is constrained by mass continuity

$$\frac{\partial \overline{v}^*}{\partial y} + \frac{1}{\rho_0}\frac{\partial\left(\rho_0 \overline{w}^*\right)}{\partial z} = 0. \qquad (3)$$

If one could determine the radiative forcing Q, then one would determine not only the mean meridional diabatic circulation, but also the mean temperature and therefore (by the thermal wind relation) the mean zonal wind.

The problem is that it is no more possible to determine Q from radiative considerations than it is to determine the force exerted by a spring from a knowledge of the properties of the spring. A spring is described by its rest position (equilibrium) and by the spring constant; in an analogous (though of course far more complicated!) manner, radiation in the middle atmosphere is described by the radiative equilibrium state and by the radiative relaxation properties (analogous to the spring constant). This means that the determinative control comes from F, and is exerted on the thermodynamic equation via the diabatic circulation. In other words, it is the vertical motion that drives the diabatic heating and cooling, not vice-versa. The temperature field then adjusts in order to provide the required Q, just as a spring adjusts its length to provide the required restoring force. With no force, a spring does not extend; in the absence of wave drag, the temperature would be in radiative equilibrium with Q = 0. As one turns on F, the atmosphere responds by departing from radiative equilibrium. In fact it responds *downward*, which has led to the concept of "downward control" (Haynes *et al.* 1991).

So in order to determine the mean state of the middle atmosphere, it essentially comes down to the following: the wave drag F determines the diabatic circulation, and hence Q; while the radiation determines the temperature field from Q, and thereby the zonal wind field. Of course this picture is drastically oversimplified; for example, the zonal wind field itself determines the characteristics of the wave drag, and the diabatic circulation affects the chemical distributions which determine the radiative equilibrium temperatures. Nevertheless, the picture provides a correct leading-order description of the situation, and allows us to understand the gross properties of the middle atmosphere circulation.

For example, there is significant wave drag in the middle latitudes of the stratosphere associated with convergence of planetary-wave activity. Planetary waves have negative (westward) intrinsic phase speeds; thus their wave drag is always negative, $F < 0$. As can be seen from (2), negative wave drag forces poleward motion in both hemispheres. This poleward motion drives upwelling in the tropics and downwelling over the poles — this is just the classical Brewer-Dobson transport circulation. The tropical upwelling cools the tropical lower stratosphere below radiative equilibrium, while the polar downwelling warms the polar lower stratosphere in both hemispheres above radiative equilibrium. In fact, the asymmetry in planetary-wave activity between the two hemispheres leads to an annual cycle in the net extratropical planetary wave drag, which shows up as an annual cycle in tropical lower stratospheric temperatures (Yulaeva, Holton and Wallace 1994): the tropical cooling is stronger in the NH winter than in the SH winter because the NH wintertime planetary waves are stronger than the SH wintertime planetary waves, and thus drive more tropical upwelling.

In the mesosphere, there is little direct observational evidence of wave drag but the observations of temperature (see Figures 1) show a *reversal* of the pole-to-pole temperature gradient from radiative equilibrium: the warmest temperatures are found in the winter hemisphere (which in the polar regions receives no sunlight whatsoever), while the coldest temperatures are found in the summer hemisphere. Indeed, at the wintertime polar stratopause the temperatures are nearly 100 K warmer than radiative equilibrium! All this implies a strong pole-to-pole gradient in mesospheric heating and cooling, which requires significant wave drag (of different signs in the two hemispheres, and changing signs between winter and summer). This wave drag is universally accepted to be associated with gravity waves, although direct observational evidence has so far been limited to singlestation measurements using MST radars and lidars, and we are very far from a quantitative understanding of this drag. Thus the evidence for GWD is still very much indirect.

The fact that GWD in the atmosphere is so poorly constrained by observations is a major problem for middle atmosphere modelling, because certain crucial aspects of the circulation appear to depend on GWD in a highly sensitive manner. This is particularly the case in the polar night, where anomalous ozone-hole chemistry depends strongly on both the downwelling rate $\overline{w}^*$ and the temperature T. The effect of F on the downwelling rate is most easily seen by combining (2) and (3), which leads to the expression

$$\overline{w}^*(z) = \frac{1}{\rho_0(z)} \int_z^\infty \frac{\partial}{\partial y}\left(\frac{\rho_0(z')}{f} F\right) dz'. \quad (4)$$

This is the steady-state (quasi-geostrophic) form of the so-called "downward control" principle (Haynes *et al.*, 1991): the mean rate of upwelling or downwelling at a given altitude z is determined by F above that altitude. Preliminary calculations by Haynes *et al.* (1991) suggest that, apart from the NH polar night where planetary wave drag is strong, polar mid-stratospheric values of $\overline{w}^*$, and therefore polar mid-stratospheric temperatures, are significantly controlled by wave drag above 65 km — presumably associated with breaking gravity waves. Further support for this sensitivity is provided by the model study of Boville and Garcia (1994): in the SH winter, for example, they find that 20% of the downwelling at 30 km, and a full 50% of the downwelling at 50 km, is driven by GWD.

The effect of F on temperatures is determined by the radiative heating required to balance the downwelling. If the radiative heating is taken to act in a simple Newtonian fashion (which is a qualitatively correct description in the middle atmosphere: Fels 1985), with a relaxation rate r, then this balance can be described by

$$\frac{N^2 T_0}{g}\overline{w}^* = Q \approx -r\left(T - T_{\rm rad}\right). \quad (5)$$

When the radiative relaxation time is long (this is the case in the polar night), r is small and a given Q therefore forces a large temperature departure from radiative equilibrium. A fractional error in $\overline{w}^*$ thus translates into a temperature error which is the same fraction of $T - T_{\rm rad}$. The greatest sensitivity is found at the wintertime polar stratopause, where $T - T_{\rm rad} \cong$ 100 K; in this case, a 10% underestimation of the downwelling rate would lead to temperatures that were 10 K too cold! (More accurate calculations with a realistic radiative scheme indicate that the Newtonian cooling approximation actually underestimates the temperature error: the radiative "spring" is nonlinear, and gets slacker as it is extended.) Since the observed GWD distribution is probably not known to within 50% — let alone 10% — it is clear that it is going to be difficult for a MAM to determine middle atmosphere temperatures with reasonable accuracy wherever GWD is a significant contributor to the diabatic circulation.

For these reasons, it is arguable that the single most challenging aspect of middle atmosphere modelling is going to be the representation of GWD. Indeed, one could regard the GWD parameterization problem as the middle atmosphere equivalent of the cumulus parameterization problem that so bedevils tropospheric climate models. Progress along these lines is going to require vastly improved observations together with a better understanding of how gravity waves are generated, propapate, and break.

Returning to the general circulation of the middle atmosphere, a notable feature of the situation described above, both in the stratosphere and in the mesosphere, is that the radiation is acting to warm the atmosphere where it is cool, and to cool it where it is warm. Thus the diabatic circulation is thermally indirect. This may at first seem surprising. After all, for the atmosphere as a whole there are strong arguments (e.g. Lorenz 1967) implying that the circulation must be thermally direct: since the mechanical forcing is dissipative, the only energy source is thermal. But the middle atmosphere is not subject to this constraint, because it is not a closed system. Its mass is only about 10% of the total mass of the atmosphere, and there is mechanical forcing from below because of the injection of wave activity. Indeed, since the thermal (diabatic) forcing is relaxational in the middle atmosphere, this means that the thermal forcing cannot really drive anything: it must be dissipative. Thus energetics and causality are consistent: the middle atmosphere is forced mechanically from below, and dissipates radiatively through a thermally indirect diabatic circulation. In this way it is very different from the troposphere!

4. Future development

The theoretical considerations of Section 3 suggest that in order to determine the mean state of the middle atmosphere one needs two things: (i) an accurate representation of the radiation; and (ii) an accurate representation of the wave drag. The way in which the MAM project is addressing these concerns is described below.

For radiation, Prof. J.-P. Blanchet's group at l'Université du Québec à Montréal (UQAM) is developing an improved radiation scheme for MAM. The long-wave (infrared) scheme has been extended (Fomichev and Blanchet 1995) to include Doppler line broadening as well as effects associated with departures from Local Thermodynamic Equilibrium; the importance of the latter has been the subject of debate, although recent results (Wintersteiner *et al.* 1992; Fomichev *et al.* 1995) suggest that LTE is a good approximation through the mesopause. The solar (ultraviolet) scheme is being extended to include narrow-band treatment of photochemistry as well as sphericity effects. A parametric representation of middle-atmosphere clouds (PSCs and PMCs) will also be incorporated.

For wave drag, the contribution from planetary waves is something that should in principle be provided explicitly by the model itself, through its resolved motions. It is for this reason that a good simulation of tropospheric dynamics is so crucial for a good MAM, and is why we have not been prepared to compromise on our representation of the troposphere. The contribution from gravity waves is much more difficult to handle. There will of course be some gravity waves explicitly resolved by MAM itself; indeed the philosophy of the MAM group at GFDL has been to run their model at a sufficiently high resolution to represent the gravity waves explicitly, thereby avoiding the difficulties associated with GWD parameterization. However, even at 1° X 1.2° (N90) latitude-longitude resolution — at which the model runs at 1/4 real time, making climate simulation nearly impossible — they have found that they are very far from capturing what is believed to be a realistic amount of GWD (Hamilton *et al.* 1995). Indeed there seems to be something of an "ultraviolet catastrophe": the GWD appears to fall off less steeply than k^{-1} with horizontal wavenumber k (Hamilton 1993) — and is thus divergent in the high-k limit — suggesting that direct simulation of GWD is infeasible. Under these circumstances, GWD parameterization is unavoidable. Prof. G.P. Klaassen's group at York University is therefore developing an improved GWD parameterization scheme for MAM (Medvedev and Klaassen 1995), in close consultation with Dr. N.A. McFarlane of CCCMA, and various GWD schemes are being tested in sensitivity studies by Dr. C. McLandress of ISTS.

Of course obtaining a reasonable simulation of the middle atmosphere is only the first step towards developing a comprehensive MAM. The ultimate goal is to be able to understand the chemical interactions, and the complex interplay between chemistry, radiation and dynamics. This will allow us to better estimate the possible effects of anthropogenic modifications of the chemical distributions. (Also, one cannot really claim to have simulated even the present climate when the chemical distributions are specified from climatology; to be self-consistent, the chemistry must be included in a fully interactive manner, determined internally and feeding back onto the radiation.) To this end, Prof. J.C. McConnell's group at York University is developing a chemical module (see Danilin and McConnell 1994 for the chemical scheme), building on their earlier studies of ozone-hole development with a chemical transport model (Kaminski *et al.* 1995; Kaminski and McConnell 1995) but using more efficient chemical solvers. Thirteen chemical species and families are currently included as prognostic variables (O_x, NO_x, HNO_3, HNO_4, ClO_x, HCl, Cl_2O_2, BrO_x, HBr, H_2O_2, H_2O, CH_4 and N_2O), with 21 other species treated time-dependently but without transport. The number of transported species will be increased when semi-Lagrangian transport is included (see below). The effects of heterogeneous reactions on aerosols will also be included. The experience of other MAM groups suggests that including fully interactive chemistry is a very challenging task; in particular, given that the "re-circulation" time for chemicals in the middle atmosphere (the time taken for a chemical injected at the tropical tropopause to be transported through the Brewer-Dobson circulation and re-injected into the troposphere in mid-latitudes) is something like four years (Rosenlof 1995), the time taken to achieve a statistical equilibrium could well run into many decades. Therefore, in the short term we will suppress the feedback of the chemistry on the radiation, with the goal of understanding the transport and chemical interactions themselves. This constraint — another example of "training wheels" — will be relaxed gradually, as we gain confidence in the behaviour of the model.

The issue of chemical transport has been mentioned above. This is a crucial ingredient in achieving an accurate representation of the chemical distributions. In light of the known deficiencies of Eulerian spectral advection schemes, Prof. R. Laprise's group at UQAM has been developing a conservative, positive-definite, three-dimensional semi-Lagrangian scheme for MAM (Laprise and Plante 1995). One interesting consequence of early tests with this scheme on the CCCMA GCM has been that the moisture distribution in the troposphere has altered substantially, leading to significant changes in the tropospheric climate itself. Similar effects have been noted by other groups (Rasch and Williamson 1991). This experience highlights the highly nonlinear, coupled nature of sophisticated climate models such as MAM, and serves as a warning that the systematic development of such models is far from straightforward.

Note that there would be little advantage to be gained in our case by making the dynamic portions of the code semi-Lagrangian, because the computational cost of a MAM is overwhelmingly dominated by chemistry and radiation.

The overall model development described above is directed by the MAM Scientific Steering Committee, which also discusses the major problem areas as they arise and decides on their resolution. As improved model components are developed, these components are presented (with appropriate test results) to the MAM SSC; once they are accepted, they are incorporated into the MAM itself. At appropriate intervals, the model is "frozen" in order to determine its climatology. Dr. S.R. Beagley at York University is the core group member responsible for the integration of the various components into the MAM, for documentation, and for performing the climate runs.

An essential aspect of model development is the concomitant development of diagnostic tools with which to understand the model behaviour and to help eliminate systematic errors. Some of these diagnostic tools are of course available in our case from the existing GCM, but those were designed for the analysis of tropospheric climate. As has been argued in Section 3, middle atmosphere modelling involves a rather different set of physical problems and this demands a rather different approach to model diagnostics. Dr. J.N. Koshyk at the University of Toronto is the core group member responsible for developing new diagnostic tools: these will include Lagrangian-motion diagnostics such as trajectory analyses, contour advection, and diabatic circulation diagnostics, as well as a "downward control" diagnostic. The latter is based directly on the theoretical considerations presented in Section 3. In the model, F consists not only of resolved and parameterized wave drag, but also of various numerical processes such as the excessive velocity drag and the sponge layer. These non-physical drag processes control the circulation in much the same way as the physical ones do, and it is essential for us to understand their effects.

Other diagnostic activities being carried out in the MAM project include the following. Prof. J. Derome's group at McGill University is focusing on the behaviour of planetary waves, and systematic errors associated with their representation. Prof. T.G. Shepherd's group at the University of Toronto is focusing on the dynamical control of the diabatic circulation, including its implications for stratosphere-troposphere exchange, and on the diagnosis of chemical transport and mixing. Dr. J.C. Fyfe at CCCMA is focusing on the model's interannual and intraseasonal variability and on stationary-transient interactions.

Complementary process studies are being carried out at ISTS by Dr. W.E. Ward, who is focusing on radiative-dynamical interactions, and by Dr. C. McLandress, who is focusing on tidal effects and on the interaction between gravity-wave drag and the large-scale circulation (McLandress and Ward 1994). Finally, diagnostic analyses of observations are being performed by Prof. A.H. Manson's group at the University of Saskatchewan (gravity waves) and by Prof. I.C. McDade's group at York University (chemical constituents).

5. Summary

The Canadian MAM project is a broadly based collaborative activity which has as its goal the development of a Middle Atmosphere Model. This model will eventually become available to the Canadian atmospheric science community as a tool with which to investigate a variety of important scientific issues, and to provide a credible scientific basis for policy decisions. The project takes advantage of the natural strengths of both the university and government research sectors, and promises to make a significant contribution to Canadian climate research. In so doing it will facilitate the training of qualified personnel, and extend the Canadian knowledge base in climate modelling. The MAM project also represents the principal mechanism for Canadian participation in the WCRP SPARC programme.

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Towards a Canadian Meteorological Society

(part 2)

by
Morley Thomas

3. Atmosphere

From their first meetings in 1959, members of the new Montreal Executive Committee undertook to develop an improved Canadian Branch publishing program. Authority was given to the Toronto Centre to publish the papers given at a February 1959, Symposium on the Great Lakes and this became volume IX, number 1 in the *CBP* series but the new Executive had little desire to continue the series. In the winter of 1959-60, president Stewart Marshall proposed to the Meteorological Branch that a joint scientific meteorological periodical, somewhat similar to the (American) *Monthly Weather Review*, be launched. However, Pat McTaggart-Cowan, then Controller of the Meteorological Branch, favoured exploring the possibility of beginning a Canadian Journal of Meteorology under National Research Council (NRC) sponsorship. In the meantime, he expressed a willingness to continue printing and to provide other assistance with the *CBP* series, should the Society wish to continue with it.

NRC sponsorship did not prove to be possible. To use NRC funds it would have been necessary to widen the scope of the periodical to include other branches of geophysics and, unfortunately, NRC could not be convinced that there were a sufficiently large number of manuscripts available to make the publication viable. There the matter rested until the fall of 1962 when Barney Boville, the new Branch president, tabled a proposal for a uniquely Canadian Branch periodical. An editorial board was created and it met in January 1963 under the chairmanship of Sven Orvig who was to become the editor.

Tentatively called the Bulletin of Canadian Meteorology, it was planned that the periodical would carry popular scientific papers, reviews of books, Society announcements and reports from meetings of the Centres. Under the name *Atmosphere*, the first issue appeared in March 1963. The second issue came a few months later and carried the agenda, paper abstracts and other pertinent information regarding the forthcoming Congress. Congress programs and abstracts, along with Annual Reports from the Executive committee, other committees and the Centres, were annual features of early volumes of *Atmosphere*. When the national Executive committee returned to Toronto in 1964, Svenn Orvig was asked to remain as editor and he did so until the summer of 1966. He had been responsible for a dozen issues of the periodical and much credit must be given to him for leading the editorial team and for procuring and editing manuscripts for publication.

Then, in the fall of 1966, Jim McCulloch took over as editor assisted by Ted Axton as business editor. By this time the Canadian Branch was moving towards independence and the new editors were faced with the necessity of expanding the scope of *Atmosphere* to make up for the loss to members of *Weather* and the *Quarterly Journal*. In an editorial titled "Our Outlook for Atmosphere," which appeared in the first issue they edited, the new editors wrote that they were seeking several articles for each issue as well as announcements, news and notes pertaining to meteorology and the new independent Society. They hoped to interest and sell subscriptions to school teachers and students, other scientists and people interested in the weather. To support the type of periodical they envisaged they felt it would be necessary to solicit advertising. In a larger size than before, in a new format and with the new Canadian Meteorological Society logo on the cover, the new *Atmosphere* appeared in March 1967.[1]

4. New Centres

Prior to 1959, when the national Executive committee was located in Toronto, no need was ever expressed to establish a local centre in that city. In the early 1950s, with the expansion of Meteorological Branch operations in Montreal and the introduction of a meteorology program at McGill University, local meteorologists asked for and obtained authority to set up a centre in 1953. Within a few years, this centre was so successful that the members volunteered to take over the national Executive committee. This was done in 1959 and that year a local centre was organized in Toronto.

Also early in the 1950s the Winnipeg area meteorologists became more than a litle interested in meteorological science beyond their operational duties with the result that a local centre was formed there early in 1955. As meteorological activities across the country expanded and the Canadian Branch developed under the guidance of the Montreal Executive officers, the idea of an independent society grew and with it the desire for more local centres. Another inducement for the establishment of local centres was the changing locale, each year, of the National Congress. This raised the visibility of meteorology in a city, local members participated in the planning and staging of the Congress and some centres were formed just before or just after a Congress was held in that city.

A review of the prospective new centre situation is contained in the minutes of the first Executive committee meeting held in September 1964, after responsibility was

[1] CMOS Archives, File 7-8, Executive committee meetings, 1959 to 1966 and *Atmosphere*, volumes 1-4.

returned to the Toronto members. It was reported that Les MacHattie was attempting to organize a centre in Ottawa; national president Ted Munn agreed to canvas members in the Halifax area; Steve Nikleva was asked to explore the possibility in Vancouver as was John Maybank in Saskatoon and the president was charged with corresponding with officers of the newly-formed Labrador Meteorological Society. By the time of the next meeting, Dick Longley reported little progress in Edmonton as there was an expected depletion of staff and Maybank reported there were too few members in Saskatoon to consider setting up a centre. But there were favourable reports that centres might soon be formed at Halifax, Ottawa and Vancouver.[2]

The organizing attempts continued with the result that four new centres, British Columbia (at Vancouver), Halifax, Alberta (at Edmonton) and Ottawa, were chartered and established over a few months in 1965-1966. Separate sections of this article are devoted to relating the activities of the various centres over the 1959 to 1966 period.

5. Scientific Affairs

For several years, from the beginning in the 1940s, the Canadian Branch each year appointed a Scientific Papers committee whose task was primarily to obtain manuscripts for reading at Branch meetings. Before this could be done, however, the papers had to be screened by a Referees committee and this frequently caused great delays. (The Referees committee did not last too long.) The Scientific Papers committee also tried to organize a nation-wide precipitation research project but was unsuccessful. As a result, the Scientific Papers committee was not re-established after 1954.

Possibily, the Canadian Branch officers thought a scientific committee of some sort was not needed during the next dozen years because of other activities in this sector. In the late 1940s, the National Research Council established an Associate Committee on Geodesy and Geophysics (ACGG) and that body set up a subcommittee on meteorology and hydrology. The purpose of an associate committee and its subcommittees was to advise NRC on the progress and problems in specific scientific disciplines and to ensure that Canada lived up to its international commitments. From the viewpoint of meteorologists, the linkage with hydrology was not completely satisfactory and so, in 1961, Andrew Thomson, retired Controller of the Meteorological Branch, sought and obtained authority from the ACGG to establish a meteorology subcommittee.

Although the Canadian Branch was not formally represented at the early meetings, several current and former Executive committee members were in attendance. By the fifth meeting, early in 1963, it was agreed that a representative of the Society should always be invited to the meetings. The subcommittee, soon to be called SOMAS (Subcommittee on meteorology and atmospheric science) was active in such efforts as promoting and coordinating a wide range of topics in meteorological research, in promoting government grants for research and in urging participation in planning and carrying out international research projects. Also, manuscripts were prepared for the annual publication of the *Geophysical Bulletin*, a volume containing reviews and bibliographies in the various sectors of geophysics and geodesy. Later, in 1972, when NRC decided to disband the parent Associate Committee, SOMAS became the responsibility of the Canadian Meteorological Society.[3]

6. Prizes and Awards

First presented in 1949, the President's Prize continued to be the prime Canadian Branch award during the 1959 to 1966 period. Annually, the Executive committee appointed a Prize committee to select the best scientific paper presented in the year just past. When the Royal Meteorological Society inaugurated a Darton Prize for "the most meritorious paper by a Canadian member published during the year in the Society's publications," the committee made a recommendation to the RMS regarding a winner or winners since two prizes were awarded for the first decade. No Canadian Darton Prizes were offered after the Canadian Branch separated from the RMS in 1967. The Canadian Branch Executive committee established a Prize in Applied Meteorology in the early 1960s and the first one was presented in 1962. Although a decision was made a few years later to establish an award for students this was not done until after the advent of the Canadian Meteorological Society in 1967.

The first President's Prize winner was Warren Godson and the first Darton Prize winners were Fred Burbidge and Warren Godson. The first Prize in Applied Meteorology was awarded to Reid Allen. On a wider basis, during these years, Royal Meteorological Society awards were made to three Canadians - the Napier Shaw Memorial Prize to Colin Hines in 1961, the Hugh Robert Mill Medal and Prize to Stewart Marshall in 1961 and the Buchan Prize to Warren Godson in 1963. A full account of the Canadian Branch awards, with winner's names and paper titles, was published in the *CMOS Newsletter*, vol. 21, no. 6, December 1993.

7. Finances and Fees

In January 1960, the Royal Meteorological Society abolished the Associate category of membership and all Canadian Branch members became Fellows. Annual fees, which had been $11.50 for Fellows and $9.00 for Associates were levelled at $10.00 for all members that year. The Canadian Branch treasurer collected this amount from members and forwarded an agreed to percentage of the fixed

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[2] CMOS Archives, File 7-8, Executive committee meeting minutes September 18 and October 28, 1964

[3] CMOS Archives, File 8-1, Scientific Committee of the Canadian Meteorological and Oceanographic Society, 1961-1977. (This notebook, containing a history of the committee and minutes of 35 meetings held between 1961 and 1977, was contributed to the CMOS Archives by John Maybank.

subscriptions, in pounds, to the parent society. The cost of the amount sent to London each year varied with the exchange rate. In 1960, the pound was worth $2.70 and from the $10.00 fee the Branch had $1.50 left for Branch expenses. By 1962, when the dollar had depreciated in terms of the pound, the Branch's share came to only 45 cents, Accordingly, that year, the annual fee was raised to $12.00 at the Annual Meeting and it remained at that level until the end of 1966. In 1964, a student membership fee of $5.00 was introduced.

With the slow growth of membership and the increase in fees noted above the Branch's total receipts each year climbed slowly from $3,300 in 1959 to $4,500 in 1966. Although a deficit was reported in a few years, the Branch was able to accumulate some assets which were invested. In 1959, the record shows the Branch held with a market value of $1030 ($1300 face value). Some stock was purchased in 1964 and, by the close of 1966, when the Branch assets were turned over to the new Canadian Meteorological Society, total assets amounted to more than $1,600. There had been a loss in 1966 on account of depreciation in market value of the stock and bonds and the Branch had incurred considerable travel expenses in bringing the RMS president, Dr. G.D. Robinson, to Sherbrooke for Congress and the Annual Meeting.

8. Montreal Meetings 1959-1966

In Toronto, prior to the move of the Executive committee to Montreal in 1959, all ordinary meetings were considered to be Canadian Branch meetings. In Montreal, however, this was not the case. The Montreal Centre officers continued to organize and stage the ordinary meetings while the national Executive were only involved in organizing a national Meteorological Congress each year. The Montreal Centre held their annual meeting in March of each year and the chairmen over the eight year period were S. Orvig, R.A. Strachan, N.N. Powe, R.A. Parry, W. Hitschfeld, W.S. Creswick, H.P. Wilson and B. O'Reilly.

In the fall of 1959, the Montreal Centre staged three meetings where Canadian meteorologists Barney Boville, George Gilbert and Mike Kwizak spoke on stratospheric meteorology, radioactive fallout and meteorology and numerical weather prediction, respectively. There were five meetings in 1960 which featured Captain George Lothian of Trans-Canada Airlines in February and George Cressman of the U.S. National Weather Service in May. Local speakers at the other meetings were Stewart Marshall, Kenneth Hare and Bernie Power. Eight papers were given in 1961 on six occasions with J.J. George of Eastern Airlines being the only outside speaker. Canadian speakers were Ken Gunn, E.J. Stansbury, Don McClellan, Warren Godson and G.B. Salmon. In May, an interesting report on the ice storm of 25-26 February 1961 was presented by Barney Boville, Ken Gunn, Dick Douglas and Wally Gutzman.

There were six meetings of the Montreal Centre in 1962. Invited outside speakers included E.G. Bowen speaking on "Singularities in rainfall," F. Muller and J.M. Havens on "Glaciology and glacial meteorology on Axel Heiberg Island," and E. Carte on "Hail swathes in Alberta." Other papers were given that year by Canadian meteorologists - Bob Vockeroth and Andre Robert. In December, several recent McGill M.Sc. graduates described their research. In 1963, there were six meetings, three to hear papers by Canadian meteorologists Roy Lee, Horace Wilson and Warren Godson. Also, the Centre was priviledged to hear a paper "Micrometeorology without mathematics" by visitor H.L. Penman and another by J.S. Turner of the Woods Hole Oceanographic Institute. On another occasion, there was a demonstration by Mike Kwizak and staff of the new Bendix G-20 electronic computer in the Central Analysis Office.

There were seven meetings of the Montreal Centre in 1964. A January dinner meeting was held in honour of Professor F.K. Hare who was about to leave Canada for King's College in London, England. At the other meetings speakers included Harold Schiff on chemical reactions of ozone, Brian Bird on the earth from space, Peter Summers on air pollution, R.S. Lindzen on non-adiabatic processes, P.M. Hamilton on precipitation vertical profiles, T.W. Wormell on lightning and Axel Wiin-Nielsen on energy transformations. In December, the American Association for the Advancement of Science annual meetings were held in Montreal and two half days were devoted to meteorology papers at sessions organized by the Montreal Centre meteorologists.

The number of Montreal Centre meetings decreased somewhat in 1965. Visitors continued to be featured, however, with W.A. Dwyer of Australia speaking on meteorology in that country and F.G. Shuman of the United States speaking on numerical models. Oscar Villeneuve, director of the Quebec Meteorological Service, spoke on the activities in his Service at one meeting and Andre Robert spoke on planetary waves at another. In 1966, the Centre organized a full slate of meetings. Visiting speakers included E.N. Lorenz on extended range prediction and the RMS president, G.D. Robinson, on research in the British Meteorological Office. Canadian speakers included Charlie Taggart, Don McIntyre, George Robertson and Norman Thyer. Finally, the last speaker of the year was Allan Brewer, president of the Canadian Branch and soon to become the first president of the Canadian Meteorological Society.[4]

9. Winnipeg Centre Meetings 1959-1966

Despite a limited number of meteorological personel in the area the Winnipeg Centre continued to plan and hold many interesting and useful meetings over the 1959 to 1966 period. Chairmen during these years were A.H. Lamont, J.J. Labelle, D.G. Black. D.S. McGeary, E. Einarsson, F.J. Sebastian and R.W. Walkden. In 1959, there were four meetings. Visitors Don McIntyre and Gordon McKay spoke on trends in meteorology and storm analysis and hydrolgy, respectively, while Van Gordon and Don McGeary reported on an AMS conference on stratosphere meteorology which they had attended. In March, Jack Labelle was the moderator of a very succesful panel discussion on forecasting stratus cloud.

[4] CMOS Archives, Box 4, Montreal Centre documents, 1953-1975.

Another succesful panel discussion was held in October 1960 on meteorological aspects of high level flight operations with Don Black as moderator. Mr. Petursson of the Greater Winnipeg Gas Company spoke on the dispatching of natural gas at a meeting and on other occasions, Hugh Cameron spoke on nuclear explosions and meteorology, Stewart Marshall spoke on weather radar and Bern Lowe on severe thunderstorms. The calendar year 1961 saw seven meetings with reports of conferences presented by Eric Dexter, Ross Armstrong and Clarence Penner. At other meetings, Warren Godson spoke on ozone, Bern Lowe on composite tornado charts, Gordon McKay on storm rainfall for spillway design and Jim Bruce on the Great Lakes research program. There were six meetings in 1962 at which Frank Upton presented a paper on aircraft icing and turbulence; George Pincock and Paul Johns reported on meetings and workshops held elsewhere; Pat McTaggart-Cowan spoke on weather and food, Dick Douglas on hail research and Blake Watson on the precipitation project at North Bay.

At two meetings in 1963, Balfour Currie discussed temperatures at the aurora level and Bill Clink spoke about the propagation of sound. On another occasion, members of the Centre visited the rocket assembly line at Bristol Aero Industries. Six meetings were held in 1964 with speakers Gordon McKay, John Maybank, Art Lamont and Morley Thomas on four occasions, a panel on weather radar chaired by George Pincock on another and a social evening with presentations by Don Black and Harold Troop.

In 1965 the Centre held seven meetings. One meeting was about the great lakes of Manitoba and the relationships of meteorology to seiches and other lake phenomena with speakers A.K. Mattick, G.H. MacKay, Bernie Lowe and Einar Einarsson. Other speakers that year were Dale Henry, Alf Davies, P. Larsson, Charlie Taggart, Peter Summers and Ted Munn. One featured meeting had Reg Noble, director of the Meteorological Branch, speaking on the history and growth of the Service with thoughts on future developments.

There were four meetings of the Centre in 1966 at which the speakers were Gary Schaefer, Rudy Treidl and Al Christie.[5]

10. Toronto Meetings 1959-1966

Note was made in the previous chapter of the organizing of a Toronto Centre and of two meetings held in the fall of 1959. New executive committees took over in June each year and the chairmen over these years were M.K. Thomas, K.T. McLeod, H.H. Bindon, J.P. Bruce, J. Clodman, R.E. Munn, J.L. Knox, J.D. Holland and G.L. Pincock.

There were seven meetings in 1960 including a June Open House at the Meteorological Branch's Scarborough building at which Meteorological Branch upper air training, research and instruments units exhibited the work underway at that site. Another open house was held at Malton Airport in November where operations at a forecast office were demonstrated. Visitors contributed papers at four other meetings - M. Estoque on micrometeorological research, Mike Kwizak on numerical weather prediction, Stewart Marshall on freezing nucleation and Bill Cameron on oceanography. At another session, three local meteorologists, Don McIntyre, Warren Godson and Jim Bruce reported on meteorological and hydrological conferences in Europe that year.

Visitors again provided most of the papers at Centre meetings in 1961. Four aviation people talked about visibility, J. Portman spoke on turbulence, Tuzo Wilson looked at the International Geophysical Year, Ken Hare spoke on the new Department of Meteorology at McGill and R.E. Dean talked about Great Lakes currents. Hugh Cameron, Bev Cudbird and Hugh Bindon took part in a symposium on automation, Clarence Penner told of a recent Pacific Science Congress and Joe Clodman described his high level turbulence work. In the summer of 1962, the Centre jointly sponsored a scientific session with the WMO Commission for Agricultural Meteorology which was meeting in Toronto. In addition there were eight Centre meetings including a panel session on future meteorology. Visiting speakers at other meetings included George Cressman on numerical models, V. Rath on aviation meteorology, George Platzman on hurricanes and W.E. Swinton on science and scientists. Local speakers that year included Warren Godson, Carl Mateer, Doug Holland and Keith McLeod.

Special meetings in 1963 included a visit to the University of Toronto's Institute of Aerophysics and a report on Canadian technical assistance provided to Nigeria by Morley Thomas and Bev Cudbird. At other meetings the speakers were Allan Brewer, B.J. Wiggin from the United States, Pat McTaggart-Cowan, D.R. Hay, H.L. Penman from England and Roland List. The featured meeting in 1964 was a 25th anniversary dinner when the speaker was Reg Noble, the newly appointed controller of the Meteorological Branch. On another occasion, members toured the meteorological facilities at the new terminal buildings at Toronto International Airport. Later, a panel on prediction was held with participants from economics, business, an insurance company, geophysics, political science, law and psychiatry. At other meetings visiting speakers were Svenn Orvig, Jim Leaver, W.C. Swinbank and Bill Markham.

Seven meetings were held in 1965 including a symposium on the urban effect on climate chaired by Clarence Boughner with panelists Frank Thompson, Don Boyd, Jim Bruce and Morley Thomas. At other meetings, visiting speakers were Ken Spengler from the American Meteorological Society, Paul Kutschenreuter of the US Weather Bureau, and Charlie Taggart from the Canadian Army. Local speakers were Ted Munn, Doug Holland, and Ken King from Guelph.

Applied meteorology was the subject at the first meetings of the Toronto Centre in 1966. E.R. Lemon, from Cornell University, spoke on agricultural meteorology and

[5] Information about Winnipeg and other Centre activities can be found in the Annual Reports of the Canadian Branch. From 1959-60 these are to be found in small booklets in File 7-9; from 1962-63 to 1964-65 in *Atmosphere* and for 1966 in File 7-9.

Gordon McKay and Don Storr gave accounts of their work in hydrometeorology in Western Canada. Other speakers were Wendell Hewson of the University of Michigan and Roland List of the University of Toronto. Finally there was a panel discussion on designing and using a meteorological observing system with Messers. Clodman, Vockeroth, Muller, Wiacek and Cudbird as principal speakers.

11. British Columbia Centre Meetings 1965-1966

The fourth centre of the Canadian Branch was organized at Vancouver in May 1965. Called the British Columbia Centre, the charter executive committee consisted of S. Nikleva as chairman, J.B. Wright as secretary-treasurer and J. Emslie as member. At the first meeting, papers on local weather were presented by Ken Harry and Jack Wright. In June, the Centre assisted in organizing the 1965 National Congress which was held at the University of British Columbia. At a meeting in the fall, Jack Turner gave a paper on atmospheric vortices. In 1966, S. Nikleva continued as chairman and there were four meetings at which Al Jackson, Norman Thyer, Don McIntyre and Allan Brewer spoke.

12. Halifax Centre Meetings 1965-1966

Another centre of the Canadian Branch was organized at Halifax in May 1965. The charter Executive committee consisted of two people - chairman R.V. Tyner and secretary J.R. Hendricks. Three meetings were held with speakers M.R. Morgan and Jim McCulloch speaking on hurricanes in the North Atlantic and air-sea interactions, respectively, and a third meeting at which a member reported on a recent hurricane conference in the United States. With the same executive committee, the Centre had four meetings in 1966 with speakers K.D. Gardner, Howard Ferguson, Arnie Mathus and Allan Brewer.

13. Alberta Centre Meetings 1965-1966

The Alberta Centre was formed at a meeting in Edmonton at the University of Alberta in July 1965. The charter Executive committee members were P.W. Summers, chairman; R.W. Longley, secretary, C.E. Thompson, treasurer; and I.Y. Ashwell, member. At this first meeting, Bernhard Haurwitz spoke on atmospheric tides and, at a fall meeting, John Maybank spoke on potential gradients in thunderclouds. In 1966, R.W. Longley became chairman and presided over six meetings, four in Edmonton and two in Calgary. In February there was a panel on forecasting hail in Alberta with participants Peter Summers, Dick Longley, Clarence Thompson and Wilbur Sly. At other meetings Peter Summers spoke on urban air pollution, Hugh Cameron on World Weather Watch, R.W. Gloyne of Edinburgh on agrometeorology and Allen Brewer on ozone in the stratosphere.

14. Ottawa Centre Meetings 1966

An Ottawa Centre was established in January 1966, when Reg Noble spoke on the history and future of the Canadian Meteorological Service. The charter executive officers of the Centre were G.W. Robertson as chairman, W.E.H. Cooper as vice-chairman and M.S. Webb as secretary-treasurer. Two other meetings were held that first year - Ted Munn spoke on applied micrometeorology and Charlie Taggart on satellite information for meteorology.

15. Planning for a CMS

An important matter for consideration by Branch members during the decade prior to 1967 was to decide whether or not Canadian meteorologists should have an independent Society. Much has already appeared in these articles about the matter under such section headings as fees, an independent society?, National Congresses and so on. The following paragraphs contain a brief summary of these considerations.

The possibility of separating from the Royal Meteorological Society began to surface in the post-World War II years when Canadian members complained about not receiving publications and the RMS officials were unhappy with their lack of up-to-date information on members and addresses. In the early 1950s, the Canadian Branch assumed responsibity for the annual fees and subscriptions of its members and for distributing all publications from Toronto. This quieted separation discussions for some time.

Later in the 1950s, the parent Society complained that the Society was losing money on the Canadian Associates and separation discussions began again. However, the Canadian Executive found that members did not want to pay the larger fees that would be necessary in an independent Society and that many did not want to lose the prestige of being an RMS Fellow. But, during the few years leading up to the Centenary celebrations of 1967, a feeling of nationalism swept over large segments of the Canadian population including meteorologists. Led by the then Montreal-based Executive committee, the idea of a Canadian Meteorological Society was thoroughly considered by members and plans were tabled at the National Congresses of 1964 and 1965. The independent move was favourably voted on before the 1966 Congress where the formal decision was made. Arrangements were made to have all assets, liabilities and responsiblities of the Canadian Branch transferred, with the concurrence of the parent Society, and the Canadian Meteorological Society came into being on January 1, 1967.

Theodore G. Shepherd
E.W.R. Steacie Memorial Fellowship

CMOS member Theodore G. Shepherd is one of four winners of NSERC's prestigious E.W.R. Steacie Memorial Fellowship for 1995. The Steacie Fellowship is awarded to enhance the career development of highly promising young scientists and engineers who are staff members of Canadian universities. It relieves them of teaching and administrative duties for up to two years, enabling them to devote all their time and energy to research. Ted Shepherd, an Associate Professor in the Physics Department at the University of Toronto, was recognized for his research contributions to nonlinear hydrodynamic stability theory and the Hamiltonian structure of geophysical fluid dynamics. NSERC also noted his leadership role in a major national collaboration (the MAM project) which has recently been launched to develop a state-of-the-art climate simulation model of the middle atmosphere. (See article in this issue.) It is only the third time that the Steacie Fellowship has been awarded in the field of atmospheric or oceanic science. The previous recipients were C.J.R. Garrett (1977) and W.R. Peltier (1978).

Theodore Shepherd, membre de la SCMO, est l'un des quatre récipiendaires de la prestigieuse Bourse commémorative E.W.R. Steacie du CRSNG pour l'année 1995. Cette bourse est décernée en vue de favoriser l'avancement de la carrière de jeunes chercheurs et ingénieurs d'avenir, membres du corps professoral d'une université canadienne. Les candidats choisis sont dégagés de toute charge administrative et d'enseignement, leur permettant de consacrer tout leur temps et leurs efforts à la recherche. Ted Shepherd, qui est professeur agrégé au département de physique de l'Université de Toronto, a été honoré en reconnaissance de ses contributions à la théorie de la stabilité hydrodynamique non linéaire, et de la structure hamiltonienne de la dynamique des écoulements géophysiques. Le CRSNG a également noté avec appréciation son rôle d'instigateur dans une récente collaboration nationale d'envergure (le project MAM) visant le développement d'un modèle de pointe pour la simulation climatique de l'atmosphère moyenne. (Voir l'article sur ce sujet dans le présent numéro.) Ce n'est que la troisième fois que la Bourse Steacie est accordée à un chercheur oeuvrant dans la domaine des sciences de l'atmosphère ou de l'océan. Les deux récipiendaires précédents furent C.J.R. Garrett (1977) et W.R. Peltier (1978).

Kevin P. Hamilton
Award for Research on Dynamics and Climate of Atmosphere and Ocean

[BOSTON] The American Meteorological Society (AMS) named Kevin P. Hamilton, research meteorologist, Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, Princeton University, Princeton, N.J., the 1995 recipient of its Clarence Leroy Meisinger Award. Warren Washington, 1994 AMS president, presented Hamilton with an award certificate during the Awards Banquet held on Jan. 18, 1995, as part of AMS's 75th Annual Meeting, Jan. 1520,1995, in Dallas, Texas. Hamilton was honoured "for prolific and wide-ranging research on dynamics and climate of the atmosphere and ocean."

The Clarence Leroy Meisinger Award is given to an individual in recognition of research achievement that Is, at least in part, aerological in character and concerns the observation, theory, and modelling of-atmospheric motions on all scales, Preference is to be given to young, promising atmospheric scientists who have recently shown outstanding ability,

The Canadian borne Hamilton earned his B,S, from Queen's University, Kingston, Canada, in 1976, his M.S. from McMaster University in Hamilton, Canada, in 1977, and his Ph.D. from Princeton University Princeton, N.J., in 1981. Upon graduation, Hamilton went to the National Center for Atmospheric Research (NCAR) for a year as a postdoctoral fellow. In 1982 he left NCAR and accepted a position as university research fellow with the University of British Columbia. He joined the faculty of McGill University in 1985 as an assistant professor. He remained at McGill until 1987, when he moved to the United States as a visiting research scientist at Princeton University. In 1988 he accepted his current position with the Geophysical Fluid Dynamics Laboratory at Princeton.

Hamilton has been active with AMS by serving on Its STAC (Science and Technical Activities Commission) commission on the middle atmosphere from 1986 to 1994. Outside of AMS, he is a member of the Canadian Atmospheric Environment Service Advisory Committee on Stratospheric Pollution, 1984-87; member of the International

Role In Climate) Steering Committee on Gravity Wave Processes and Parameterization, 1993 to present.

In 1993 Hamilton received the President Prize from the Canadian Meteorological and Oceanographic Society. He is the author of more than 45 peer-reviewed papers, which have been published in several AMS journals, including the Journal of the Atmospheric Sciences, Monthly Weather Review, the Journal of Climate, and the Journal of Physical Oceanography, and several non-AMS journals

The American Meteorological Society, founded in 1919 as a not-for-profit scientific and professional seciety, currently has more than 10,000 national and international members. The AMS actively promotes the development and dissemination of information on the atmospheric and related oceanic and hydrologic sciences and publishes nine atmospheric and related oceanic and hydrologic journals.

1994/95 CMOS Speaker Tour

As in past years, CMOS is arranging a tour speaker to the twelve centres. This year we are fortunate to have Dr. John R. N. Lazier, a long-time member of the scientific staff at the Bedford Institute of Oceanography. Dr. Lazier has spent much of the last decade investigating year to year variations in the temperature and salinity of the Labrador Sea which over the past 30 years have undergone the largest changes ever recorded in the open ocean.

In his lecture entitled "The North Atlantic Oscillation versus the Cold, Fresh, Fishless Labrador Sea", these observations will be presented following a review of climate changes through the ice ages and the thermohaline circulation in the Atlantic Ocean. This flow now supplies about 10^{15} watts of heat to the atmosphere north of 30°N and was probably shut off during the past cold periods because of excess fresh water in the northern seas. The present day conditions in the Labrador and Greenland Seas will then be discussed in relation to the on-off thermohaline circulation and the North Atlantic Oscillation in the atmosphere.

The lecture will close with a short review of the decline of the cod stocks off Newfoundland and the possible roles played by overfishing and the recently observed decreases in temperature and salinity. Timing details have being arranged and the tour is planed in March.

CMOS NEW MEMBERS
NOUVEAUX MEMBRES DE LA SCMO

Here is the list of new CMOS Members. It is important that you contact the new members in your area to verify their mailing address and to begin distribution of local Society material. National mailing and publications will be provided to the new members as soon as possible.

Mr. Jun Du	University of Toronto	Student
Mr. Huiquan	University of Toronto	Student
M. Louis Lefaivre	Météorologie St-Laurent	Régulier
Mr. Andy K. Yun	University of Saskatchewan	Regular
M. Paul Vaillancourt	McGill University	Étudiant
Mr. Terri Lang	Saskatoon	Regular
Mr. Warren G. Lee	Victoria	Regular
Ms Lezani Arris	Dunster	Regular
Dr John Newell	University of Saskatchewan	Regular
Mr Jimmy Dale Bird	McBride, BC	Student
Dr M. C. Reader	Victoria	Regular
Mr David Oxilia	McGill University	Étudiant
Dr David Neelin	UCLA	Regular
Mr Bernard Laval	McGill University	Student

CMOS Annual General Meeting
Assemblée générale annuelle du SCMO

The CMOS Annual General meeting will be held during the 29th Annual Congress at Okanagan University College, Kelowna at 7:30 PM, Tuesday, May 30, 1995. The exact location of the meeting will be posted at the Congress. The meeting will include the items listed under the By-law 7(c). The agenda for the Annual General Meeting will be published in the Annual Review.

L'Assemblée Générale Annuelle du SCMO aura lieu lors du 29e Congrès Annuel au Collège Universitaire Okanagan, Kelowna, à 19h30 mardi, 30 mai 1995. Le lieu précis de l'assemblée vous sera communiqué par courrier lors du congrès. L'assemblée traitera des points contenus dans l'Article7(c). Comme par le passé, l'ordre du jour sera publié dans la Revue Annuelle.

ELECTION OF COUNCIL - 1995/96

The elected officers to Council are the President, the Vice-President, the Treasurer, the Corresponding Secretary, the Recording Secretary, and three Councillors-at-Large. Only members in good standing are eligible to hold office in the Society. Nominations in writing from the membership will be accepted by the Recording Secretary up to May 1st, 1995, provided:

(i) that the nominee is eligible for the office for which he is nominated, (ii) that the nominee acknowledges, by signing the nomination for his willingness to accept office if elected, and, (iii) that the nomination is signed by four members, in addition to nominee and the member making the nomination. Nominations can be made to:

M. Louis Lefaivre, Secrétaire d'assemblée de la SCMO, Environment Canada, Centre météorologique canadien, 2121 Voie de service Nord, Route Transcanadienne, Dorval, QC H9P 1J3. Tel: (514) 421-4789, Fax: (514) 421-4600, e-mail: llefaivre@cidsv08.cid.aes.doe.ca

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Accreditation

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Professionalism vacant

Scientific

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Floating Ice

Dr. Simon Prinsenberg, Dep. of Fisheries and Oc., Bedford Inst. of Oceanography, P.O. Box 1006, Dartmouth, NS B2Y 4A2, Tel: (902) 426-3145, Fax: (902) 426-2256

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Mesoscale Meteorology

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29th Congress 1995 - Kelowna, B.C.

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Scientific Program Chairperson

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30th Congress 1996 - Toronto, Ontario

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Nominations made by the nominating , committee for 1995/96

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CMOS on World Wibe Web

CMOS 29th Congress Abstracts on World Wide Web and Gopher! The abstracts for the CMOS 29th Annual Congress can now be viewed from World Wide Web (WWW) and gopher systems (courtesy of D. Laplante, M. Allen and J. Shore). For WWW the URL is http://www.ocgy.ubc.ca-/1/cmos; gopher users should look at www.ocgy.ubc.ca. This arrangement lets you know in advance what papers will be presented and which colleagues will be presenting papers at the congress.

CMOS Congress Update

New Sessions at CMOS 29th Annual Congress at Kelowna, 29 May-2 June, 1995. Following suggestions from CMOS members, the following new sessions have been added: Session 32 BOREAS, and Session 33 Long-range forecasting Abstracts to these new sessions are most welcome. Dr William Hsieh, Dept. of Oceanography, Univ. of British Columbia, Vancouver, B.C., Canada V6T 1Z4 Tel: (604) 822-2821 fax: (604) 822-6091 e-mail: william@ocgy. ubc.ca

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—

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Name of Group: <u>CANADIAN METEOROLOGICAL & OCEANOGRAPHIC SOCIETY</u>
Please advise Residence at 491-0677 if you plan to arrive after 10:00 p.m. Late charges may apply for check ins after this hour. CHECK IN 3 - 10 p.m.

****

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ADDITIONAL INFORMATION: A one-nights cancellation charge applies if cancellation in writing is not received 72 hours prior to check-in date. If your room type is not available we will notify you.

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PAYMENT: Cash, cheque, Mastercard or Visa. Cheques made payable to Okanagan University College. Full payment due upon arrival in Canadian Funds.
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Canadian Meteorological and Oceanographic Society
29th Annual Congress

Kelowna, British Columbia
29 May - 2 June 1995

REGISTRATION FORM

Name:	____________	**Telephone**:	____________
Title:	____________	**Fax**:	____________
Address:	____________	**Affiliation**:	____________
	____________	**Date**:	____________

Full registration includes Icebreaker, Wine and Cheese, 3 lunches and one banquet.

Registration Fees:

			enter amount
Members of CMOS or CSAM		$300	______
Non-members		$350	______
Single day registration, excludes banquet	(members)	$100	______
	(non-members)	$150	______
Student registration (excludes banquet)		$100	______
Additional banquet tickets		$ 40	______
Single day student ?	Total:		______

Prices are in Canadian Dollars and include all applicable taxes.

Please submit completed form along with Cheque or money order payable to "CMOS Congress 1995" to: John Mullock, Registrar CMOS Congress 1995, Mountain Weather Services Office, 3140 College Way, Kelowna, BC V1V 1V9.

Budget Car Rental is a supporter of CMOS Congress 1995. We recommend Budget for those renting an automobile while in Kelowna. Reservations can be made through the airport office at 604-765-9882.

In addition to the on-site accommodation described on the following page, a block of rooms has been booked at the Coast Capri Hotel, in Kelowna. The Capri Hotel is approximately 12 km from the Congress site. When registering, please specify that you are attending the CMOS Congress. Reservations should be made directly with the hotel (phone 604-860-6060 or fax to 604-762-3430).

Société Canadienne Météorologique et Océanographique
29e Congrès Annuel

Kelowna, Colombie Britannique
29 mai - 2 juin 1995

FORMULAIRE D'INSCRIPTION

Nom:	____________	**Téléphone**:	____________
Titre:	____________	**Fac-similé**:	____________
Adresse:	____________	**Affiliation**:	____________
	____________	**Date**:	____________

Inscription complète inclut la réception, vin et fromage, 3 déjeuners et le banquet.

Inscription:

			inscrire les montants
Membres de la SCMO ou la CSAM		$300	______
Non-membres		$350	______
Inscription d'un seul jour, exclut le banquet	(membres)	$100	______
	(non-membres)	$150	______
Inscription des étudiants (exclut le banquet)		$100	______
Billets en sus pour le banquet		$ 40	______
	Totale:		______

Tous les prix incluent les taxes provinciale et fédérale, lorsqu'elles s'appliquent. S.V.P faire parvenir votre formulaire complété en incluant votre chèque ou mandat poste pour la somme totale, payable à l'ordre de "SCMO Congrès 1995", à:

John Mullock
Préposé aux inscriptions, SCMO Congrès 1995
Bureau de Services Météorologique des Montagnes
3140 College Way
Kelowna, BC V1V 1V9
ou fac-similé à 604-491-1506

En plus du logement disponible sur les lieux tel que décrit dans les pages qui suivent, plusiers chambres ont été réservées à l'hotel Coast Capri de Kelowna. Le Capri est situé à environ 12 km de l'endroit où se tiendra le Congrès. Lors de l-enregistrement, veuillez spécifier que vous faites partie du Congrès SCMO. Les réservations devraient être faites directement avec l'hotel. (téléphone 604-860-6060 ou fac-similé 604-762-3430).

AMS/NOAA Summer Workshops

Last year, CMOS, in conjunction with AES, was invited to select a Canadian teacher to be one of 24 participants in *Project Atmosphere*, a summer workshop for pre-college teachers of Atmospheric Science Topics. The workshop was sponsored by AMS/NOAA and took place during July at the National Weather Service Training Centre in Kansas City, Missouri. All expenses were paid by AMS/NOAA for the duration of the course except for travel to and from Kansas City.

Last year the Toronto CMOS Centre contributed $200 towards travel expenses for the successful candidate, Mr. Rod Murray of the Peel Board of Education. He was able to raise the rest of the funds from educational organizations.

This year CMOS has been invited to send one teacher-candidate to *Project Atmosphere*, Kansas City, 24 July - 4 August, 1995, and a second candidate-teacher to *Project Maury* for teachers of oceanographic sciences. The dates for *Project Maury* are July 17-18, 1995 at the United States Naval Academy, Annapolis, Maryland. All room, food, local travel and instructional costs for the 12-day programs are covered by AMS/NOAA.

CMOS has approved two subventions of $200 each for the successful teacher-candidates. Council, by way of this notice, is calling upon chapters and members to contact qualified teachers who would be interested in raising the necessary additional funds and participating in either of the two Workshops.

Rod Murray, the successful Canadian participant last year, describes his participation as the most significant professional development of his career. Presentations were made by some of the most respected American Scientists in the field. The participants left with material, resources and teaching modules readily adaptable to classroom presentations to all grade levels.

In order to be considered, applications must be received by May 10, 1995. Application forms and further information can be obtained from:

Ms. Sheila Bourque
Project Atmosphere-Project Maury
Environment Canada
Atmospheric Environment Service
Attn: Training and Education Services
4905 Dufferin Street
Downsview, Ontario
M3H 5T4
Phone : (416) 739-4220
Fax : (416) 739-4700

Ateliers d'été de l'AMS/NOAA

L'an dernier, conjointement avec le SEA, la SCMO a été invitée à choisir un enseignant canadien pour être parmi les 24 participants au *"Projet atmosphère"*, un atelier d'été portant sur les sciences atmosphériques pour les enseignants du niveau secondaire. L'atelier de travail était parrainé par l'AMS/NOAA et s'est tenu durant le mois de juillet à Kansas City, au Missouri, au Centre national de formation pour les services météorologiques américains. Toutes les dépenses ont été défrayées par l'AMS/NOAA à l'exception des dépenses de voyage aller-retour jusqu'à Kansas City.

Le Centre de Toronto a fait l'an dernier une contribution de 200$ pour défrayer les dépenses de voyage du candidat choisi, M. Rod Murray de la commission scolaire Peel. M. Murray a pu trouver les fonds manquants d'autres organismes éducatifs.

Cette année, la SCMO a été invitée à envoyer un enseignant- candidat au *"Projet atmosphère"*, à Kansas City, du 24 juillet au 4 août 1995 et un deuxième enseignant-candidat au *"Projet Maury"* pour des enseignants de sciences océanographiques. La date pour le *"Projet Maury"* est du 17 au 18 juillet 1995 à l'Académie navale des États-Unis située à Annapolis, Maryland. Tous les frais, incluant logement, nourriture, transport local et frais d'inscription au programme de 12 jours, sont couverts par l'AMS/NOAA.

La SCMO a approuvé une subvention de 200$ pour chaque enseignant- candidat choisi. Le Conseil, par l'entremise de cette annonce, demande aux Chapitres et aux Membres de contacter des enseignants qualifiés qui seraient intéressés à lever des fonds additionnels pour participer à l'un ou l'autre de ces ateliers.

Rod Murray, le candidat canadien choisi de l'année dernière, décrit sa participation à cet atelier comme étant le développement professionnel le plus significatif dans sa carrière. Les présentations ont été faites par les chercheurs américains les plus reconnus dans ce champ d'activité. Les participants sont partis avec du matériel didactique adaptable pour des présentations à des classes de tous les niveaux.

Pour être recevables, les demandes doivent être reçues avant le 10 mai, 1995. Pour plus d'information ou pour obtenir des formulaires de demande, prière de contacter:

Mme. Sheila Bourque
Projet Atmosphère - Projet Maury
Environnement Canada
Service de l'Environnement Atmosphérique
A/S Services d'éducation et de la formation
4905, rue Dufferin
Downsview, Ontario
M3H 5T4
Tél.: (416) 739-4220
Fax : (416) 739-4700

ACCESS III
ATMOSPHERIC CHEMISTRY COLLOQUIUM FOR EMERGING SENIOR SCIENTISTS

Call for Applications

The third biennial ACCESS (Atmospheric Chemistry Colloquium for Emerging Senior Scientists) research colloquium for new Ph.D.s in atmospheric chemistry will be convened at Brookhaven National Laboratory, Upton, Long Island, New York, on 15-17 June, 1993. Participants will be invited to attend both the colloquium and the Gordon Research Conference in Atmospheric Chemistry scheduled for 18-23 June, 1993. Transportation will be provided, including transportation from Long Island to the conference site in Rhode Island. The colloquium will be jointly sponsored by the National Science Foundation (NSF), the National Aeronautical and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), and the Department of Energy (DOE).

The purpose of the ACCESS Colloquium is to bring together-in scientific discussion and interaction-recent Ph.D.s in atmospheric chemistry and doctoral candidates soon to receive their degrees, together with representatives of the principal federal government agencies that fund atmospheric chemistry research. The meetings will provide an opportunity to forge future professional relationships, and the entire atmospheric science community will benefit by becoming more aware of innovations in atmospheric chemistry through these researchers' efforts.

To be eligible to be an invited speaker at the ACCESS Colloquium, an applicant must have received a doctorate from an accredited university after June 1, 1993, or, alternatively, provide certification that in all probability the applicant will receive a degree before June 1, 1996. The applicant's thesis or postdoctoral research must deal with an important problem in atmospheric chemistry. Attendance at the ACCESS Colloquium is limited to 25 participants.

Applications for attendance may be obtained from Leonard Newman- ACCESS, Environmental Chemistry Division, Building 426, Brookhaven National Laboratory, Upton NY 11973 (newman@bnl.gov). Completed applications must be received by March 13, 1993

Opportunities at Brookhaven National Laboratory Environmental Chemistry Division.

You have an opportunity to join the Environmental Chemistry Division and participate in its wide range of programs encompassing interpretive and theoretical studies, measurements methodology, laboratory experiments and field studies. area of Research include: (1) development of methods and practical instruments for detection and real-time measurement of a variety of atmospheric constituents for use in field studies and laboratory experiments; (2) development and application of gaseous tracers applicable at extremely low concentrations for studies of atmospheric transport and dispersion, building air infiltration and ventilation, geophysics of oil and gas recovery from production wells, and leak detection in fluid handling systems; (3) theoretical, laboratory, and field studies directed at understanding the formation an evolution of aerosols and their optical and radiative properties; (4) studies of the formation, transport, mixing, and removal of gaseous and particulate pollutants in ambient air; (5) modeling transport and reactions of atmospheric pollutants; (6) laboratory and field studies directed at the incorporation of sulfur and nitrogen oxides into cloudwater with the consequent formation of acid rain; (7) theoretical and observational studies of radiative transfer and flux in the atmosphere; and, (8) analysis of data and development of parameterizations relevant to global climate change.

Positions available:

Scientific Staff

- Scientist with interest and expertise in aerosol measurements [Position S-1]
- Aerosol scientist to join a group involved in aerosol optics and radiation influences; modeling of aerosol microphysics, radiative properties, chemistry and transport, and interpretation of field measurements. [Position S-2].

Research Associate

- Candidates should have a Ph.D. and a background in chemistry relevant to transport and photochemistry of ozone and other oxidants. [Position R-1].
- Ph.D. in chemistry of chemical engineering to study chemical and physical properties of atmospheric aerosol particles. [Position R-2].
- Recent Ph.D. in atmospheric chemistry, analytical chemistry, or kinetics and mechanics of either gas-phase or condensed-phase systems. [Position R-3].

Professional Staff

- Individual with 3 or more years experience in analytical chemistry, environmental chemistry, or related field. [Position P-1].

Candidates should refer to Position Number, and submit a curriculum vitae and the names of three references to: Dr. Leonard Newman, Environmental Chemical Division, Building 426, Brookhaven National Laboratory, P.O. Box 5000, Upton, NY 11973-5000. Equal Opportunity Employer M/F/D/V.

Entries on the following pages are restricted to CMOS Accredited Consultants. The accreditation process started in December, 1986. A complete list of CMOS accredited consultants can be obtained from the CMOS Business Office. Individuals interested in applying for accreditation may contact the CMOS Business Office at the Society's Ottawa address for a copy of the guidelines and an application form.

As set out in the document "CMOS Guidelines for Accreditation", the criteria are:

(1) The applicant must possess an appropriate undergraduate ... degree from a recognized university.

(2) The applicant must possess at least one of the following types of specialised training:

(i) post-graduate degree from a recognised university in meteorology or oceanography;

(ii) post-graduate degree from a recognised university in the natural or applied sciences or mathematics specializing in one or more branches of meteorology or oceanography; or

(iii) three years of on-the-job meteorological or oceanographic experience.

3) Upon completion of the above educational and training requirements, the applicant must have spent at least two years of satisfactory performance at the working level in the field of specialisation included in this document. This should include at least some consulting experience.

Les entrées sur les pages suivantes sont réservées aux experts-conseil accrédités de la SCMO. Le processus d'accréditation a débuté en décembre 1986. Une liste complète des experts-conseil accrédités de la SCMO peut être obtenue du bureau d'affaires. Les personnes désirant l'accréditation doivent entrer en contact avec la Société à Ottawa afin de recevoir une copie des règlements et un formulaire d'application.

Le document "Règlements de la SCMO pour l'accréditation" liste les critères suivants:

(1) L'applicant doit possèder un degré universitaire de premier cycle approprié d'une institution reconnue.

(2) L'applicant doit posséder au moins un des types suivants de formation spécialisée:

(i) degré de deuxième ou troisième cycle d'une université reconnue en météorologie ou océanographie;

(ii) degré de deuxième ou troisième cycle d'une université reconnue en sciences naturelles ou appliquées ou en mathématiques avec spécialisation dans une des branches de la météorologie ou de l'océanographie; ou

(iii) trois années d'expérience de travail en météorologie ou en océanographie.

(3) Une fois les exigences d'éducation et formation complétées, l'applicant doit avoir au moins deux années de travail, avec performance satisfaisante, dans un champ de spécialisation mentionné dans ce document. Une certaine expérience d'expert-conseil est nécessaire.

ACCREDITED CONSULTANTS
EXPERTS-CONSEILS ACCRÉDITÉS

Mory Hirt
CMOS Accredited Consultant
Applied Aviation & Operational Meteorology

Meteorology and Environmental Planning
401 Bently Street, Unit 4
Markham, Ontario, L3R 9T2 Canada
Tel: (416) 477-4120 Telex: 06-966599 (MEP MKHM)

Tom B. Low, Ph.D., P. Eng.
CMOS Accredited Consultant
Research and Development Meteorology

KelResearch Corporation
850-A Alness Street, Suite 9
Downsview, Ontario M3J 2H5 Canada
Tel: (416) 736-0521

Ian J. Miller, M.Sc.
CMOS Accredited Consultant
Marine Meteorology and Climatology, Applied Meteorology and Climatology, Storms, Waves, Operational Meteorology

MacLaren Plansearch Limited
Suite 701, Purdy's Wharf Tower
1959 Upper Water Street
Halifax, Nova Scotia B3J 3N2 Canada
Tel: (902) 421-3200 Telex 019-22718

Mike Lepage, M.S.
CMOS Accredited Consultant
Wind Engineering, Climate Data Management
Air Pollution Meteorology, Climate Research

Rowan Williams Davies & Irwin Inc.
650 Woodlawn Road West
Guelph, Ontario N1K 1B8 Canada
Tel: (519) 823-1311 Fax: (519) 823-1316

Douw G. Steyn
CMOS Accredited Consultant
Air Pollution Meteorology,
Boundary Layer Meteorology,
Meso-Scale Meteorology

4064 West 19th Avenue
Vancouver, British Columbia V6S 1E3 Canada
Tel: (604) 822-6407 Home: (604) 222-1266

Brian Wannamaker
CMOS Accredited Consultant
Remote Sensing, Instrumentation (oceanography)
Physical Oceanography, Sea Ice/Icebergs

Sea Scan
R. R. #3,
Caledon East, Ontario L0N 1E0 Canada
Tel: (416) 880-0528

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1994 MEMBERSHIP APPLICATION FORM-DEMANDE D'ADHESION 1994

(Please print in block letters - Ecrire en lettres moulées s.v.p.)

Title: Dr___ Mr___ Mrs___ Miss___ Ms___
Titre: M___ Mme___ Mlle___

Name/Nom ____________________

Address/Adresse ____________________

____

____

MEMBERSHIP CATEGORY-CATEGORIE DE MEMBRE
ANNUAL FEES - COTISATION ANNUELLE
(Please check one - cochez une case s.v.p.)

Regular Régulier	☐	$45.00/45,00$
Student Etudiant	☐	$20.00/20,00$
Retired Retraité	☐	$30.00/30,00$
Sustaining De soutien	☐	$170.00/170,00$ (minimum)
Corporate Moral	☐	$225.00/225,00$ (minimum)

Telephone res./Téléphone dom. ____________ bus./travail ____________

Occupation/Emploi ____________________

For records only: if student, please indicate institution and year studies will be completed.

Pour dossiers seulement: l'étudiant(e) doit inscrire le nom de son institution et l'année où il (elle) finira ses études.

____

PUBLICATION SUBSCRIPTIONS - ABONNEMENT AUX PERIODIQUES

ANNUAL RATES - FRAIS D'ABONNEMENT ANNUEL

		Members Membres	Non-members Non-membres	Institutions Institutions
ATMOSPHERE-OCEAN ATMOSPHERE-OCEAN	☐	$30.00 30,00$	$40.00 40,00$	$85.00 85,00$
CMOS Bulletin Bulletin SCMO	☐	$0.00 0,00$	$45.00 45.00$	$45.00 45,00$
Annual Congress Program and Abstracts Programme et résumés du congrès annuel	☐	$0.00 0,00$	$20.00 20,00$	$25.00 25,00$

NOTE: Students receive Atmosphere-Ocean free in their annual fee. All regular Society publications are sent to Corporate and Sustaining Members. Members resident in Canada please add 7% GST to annual rates

NOTE: Les membres étudiants reçoivent Atmosphère-Ocean gratuitement de la SCMO. Tous les périodiques réguliers de la Société sont envoyés aux membres moraux et de soutiens. Les membres résidant au Canada, veuillez SVP ajouter 7% (TPS) aux frais d'abonnement annuel.

PRIMARY FIELD OF INTEREST - SPHERE D'INTERET PRINCIPALE

Meteorology Météorologie	☐	Oceanography Océanographie	☐

SPECIAL INTEREST GROUP - GROUPE D'INTERET SPECIAL

(Indicate group if interested - Indiquez si vous avez des intérêts dans un des groupes.)

Hydrology Hydrologie	☐	Air pollution Pollution de l'air	☐	Agriculture and Forest Agriculture et forestrie	☐
Operational Meteorology Météorologie d'exploitation	☐	Floating Ice Glace flottant	☐	Mesoscale Meteorology Météorologie à la mésoéchelle	☐
Fisheries Oceanography Océanographie des pêches	☐			Other (specify) Autre (spécifiez)____________	☐

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CMOS-SCMO
Suite 903, 151 Slater Street
Ottawa, Ontario
K1P 5H3

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TORONTO

Please enroll me as a member of the Society. I attach a cheque to the amount of $__________ payable to the Canadian Meteorological and Oceanographic Society for membership fee and/or publication subscriptions. I also include a tax-deductible donation of $_______ for (indicate):

☐ The Society's Development Fund

☐ Other (specify) ______________________________

______________________________ (Signature) ______________ (Date)

If applying for student membership, please obtain signature of one of your professors.

______________________________ (Signature) ______________ (Date)

Mail completed form to CMOS at the address above.

Je désire devenir membre de la Société. J'inclus un chèque au montant de $ _________ payable à la Société canadienne de météorologie et d'océanographie pour la cotisation de membre et/ou les frais d'abonnement aux périodiques. J'inclus aussi un don déductible d'impôts de $ _________ pour (indiquez):

☐ Le fonds de développement de la Société

☐ Autre (spécifiez) ______________________________

______________________________ (Signature) ______________ (Date)

Si vous désirez devenir membre étudiant, veuillez SVP obtenir la signature d'un de vos professeurs.

______________________________ (Signature) ______________ (Date)

Faire parvenir la demande d'adhésion complétée à la SCMO à l'addresse ci-dessus.
