ISSN 1195-8898

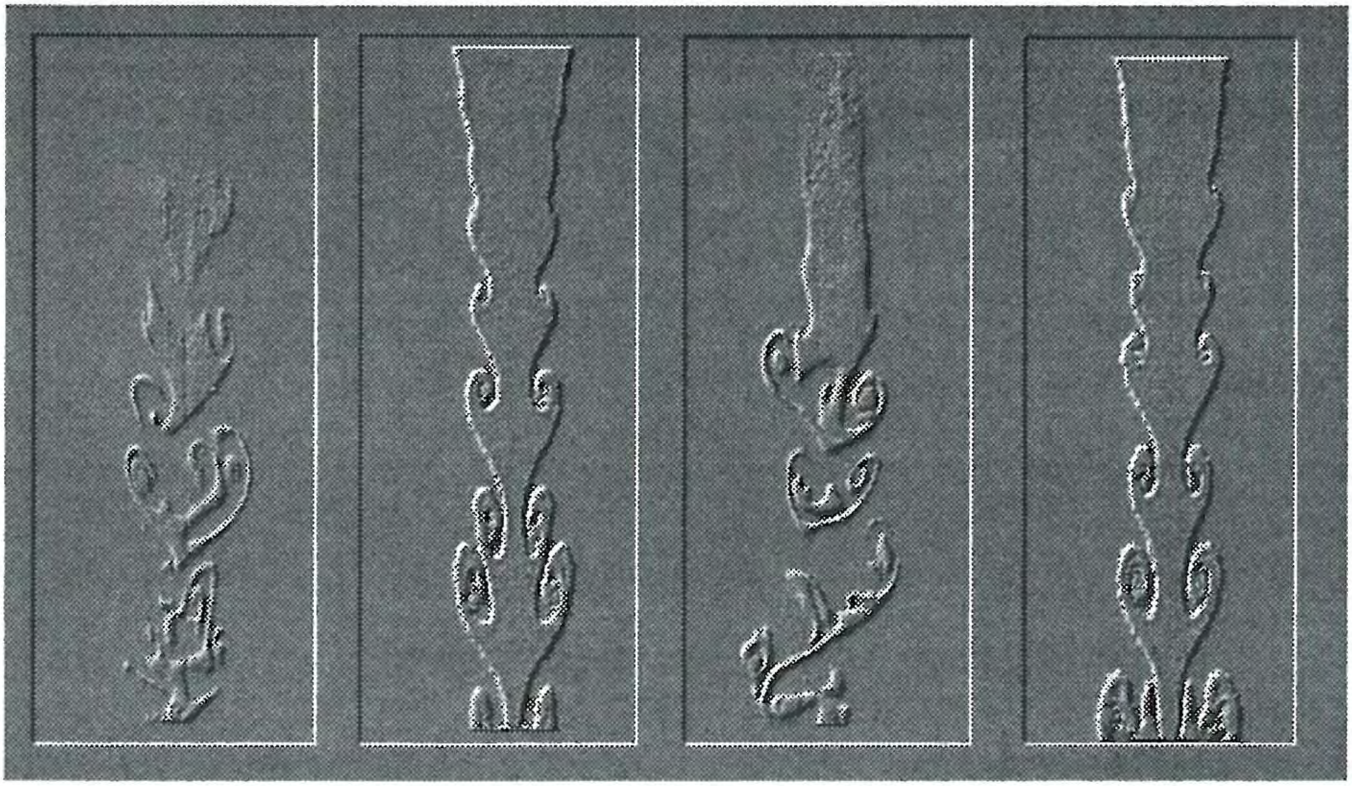
CMOS
BULLETIN
SCMO

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

April-June/avril-juin 1995 Vol. 23 No. 2-3

Fluid Modelling with MC^2



CMOS ***Bulletin*** *SCMO*

Canadian Meteorological and Oceanographic Society
La Société Canadienne de Météorologie et d'Océanographie
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Inside / En bref

FRONT PAGE: Comparison of laboratory experiment (panels 1 and 3) and numerical model simulation (panels 2 and 4) of cloud water distribution in a downdraft induced by cooling due to the evaporation of cloud droplets as they fall in a dry environment after their release at the top of the tube. The portion of the apparatus that is shown is roughly 40 cm high, and the model results correspond to two instants near the end of a 7 s simulated period (see the article by Pellerin et al. in this issue of the CMOS Newsletter.)

FRONTISPICE: Comparaison d'une expérience en laboratoire (panneaux 1 et 3) et d'une simulation numérique (panneaux 2 et 4) d'une distribution de gouttelettes d'eau dans un courant d'air descendant induit par le refroidissement dû à l'évaporation alors que les gouttelettes tombent dans un environnement sec après avoir été relâchées au sommet du tube.

EDITOR'S COLUMN

The next issue of the ***BULLETIN*** **23** (4), August 1995, will go to press on August 20, 1995. Contributions are welcome and should be sent before August 17. 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 diskette or E-mail to "**bulletin@osiris.phy.uqam.ca**". 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** (4), août 1995 sera mis sous presse le 20 août. Vos contributions sont les bienvenues. Veuillez me les faire parvenir d'ici le 17 août. Nous ne disposons pas de personnel pour dactylographier ou traduire les textes soumis. Je demande donc votre collaboration en m'envoyant vos textes sous forme électronique (poste Internet "**bulletin@osiris.phy.uqam.ca**" 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

ARTICLE

Comparison Between Downward Convection Produced in Laboratory and that Simulated by a Numerical Model

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ABSTRACT

A laboratory experiment of downward convection produced by evaporative cooling of cloud droplets immersed in a dry environment has been developed for studying some facets of the cloud physics and fluid mechanics. This experiment is interesting because many scales of turbulent motions develop in the flow. It serves here as truth to validate a numerical atmospheric model developed by the late André Robert, based on the Euler equations of motion solved with semi-implicit semi-Lagrangian scheme. Preliminary results show that the scales of motions simulated by this numerical model are similar to those produced in laboratory.

1. Introduction

With the increased availability of computers, numerical modelling techniques can be applied to simulate atmospheric phenomena on many scales. Being based on the known laws governing the evolution of physical variables in nature, these models constitute additional tools to further our understanding of a wide range of physical processes. Because a number of approximations are made to solve these models in practice, it is essential to assess the net effect of these approximations and to validate at least some model results with reality before exploring the unknown. Validation in the real atmosphere is difficult since the experiments cannot be fully controlled. For this reason, a laboratory experiment has been devised (Pellerin 1992) to serve as "truth" against which an atmospheric model results could be validated. The comparison will be made between the modelled and observed distributions of cloud water droplets evaporating as they fall in a sub-saturated environment. This experiment has the advantage of using an active as opposed to a passive tracer that is often used for the purpose monitoring the flow field.

A two-dimensional dynamical model based on the Euler equations solved with semi-implicit (SI) semi-Lagrangian (SL) scheme is used. The (SL) scheme offers a good solution to the advection-condensation problem. Potential problems such as numerical noise or excessive diffusion caused by approximations made in numerical models can be amplified by coupling with moist thermodynamics (Grabowski and Smolarkiewicz 1990). The comparison made by Pellerin et al. (95) between one-dimensional moist thermodynamics kinematic simulation results obtained with SL technique and those obtained with Eulerian methods showed the robustness of SL scheme. The SL results were characterised by a fairly low level of numerical noise, and there did not appear to be a demonstrated need to resort to special constraints to prevent false ripples from contaminating the physical solution. These one-dimensional tests, however, indicated that the SL scheme exhibits some implicit diffusion which, under some circumstances, might be non-negligible and hence risk to contaminate the physical solution that is sought.

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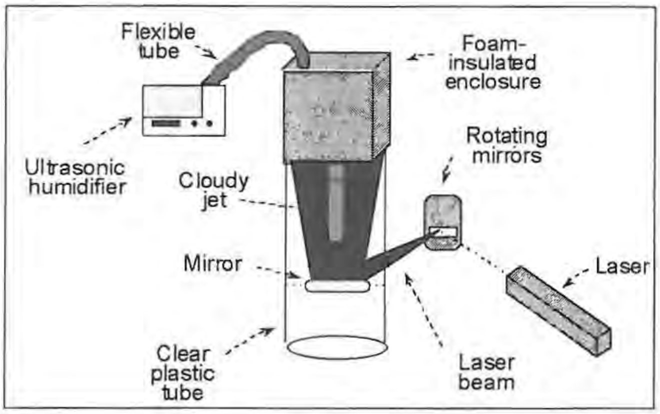

FIG. 1 Sketch of the laboratory apparatus for the evaporative cooling downward convection experiment. The experimental material comprises the following items: a laser (Spectra Physics, helium-neon, 10 mW); a ultrasonic humidifier (Bionaire, model BT-202); fixed and rotating mirrors (Lincoln Laser Company, model Xerox); a foam-insulated enclosure (width: 60 cm, length: 30 cm, height: 40 cm); a clear plastic tube (diameter: 28 cm, height: 150 cm); some flexible tube pipe; a metal plate with a circular opening of 3.3 cm diameter; a photographic camera (Canon AT1 automatic) using a Kodak 1600 ASA film.

The paper is organised as follows. The next section presents a laboratory experiment in which cooling due to cloud droplets evaporation causes downward convection. Section 2 describes the results of a two-dimensional moist convection experiment simulated by a dynamical model solving the moist Euler equations with semi-implicit SL scheme, comparing this simulation with the laboratory experiment. The results are summarised in the Conclusion.

2. Laboratory experiment

The experimental set-up developed by Pellerin (1992) consists of a vertical clear-plastic tube filled with sub-saturated air, at the top of which a jet of fine mist is inserted (Fig. 1). The "cloudy" air being denser than the environment will fall under the action of gravity, and the evaporative cooling of cloud droplets will enhance the negative buoyancy of the plume in its downward motion. This results in a substantial shear zone between the downward moving mist plume and the surrounding environment in the column; this shear eventually induces instabilities at the edge of the moist plume and the small cloud droplets serve as tracers to observe the eddies that develop in the tube. A laser beam scans a vertical cross-section of the tube to observe the falling cloud droplets as they are moved by the eddies.

An insulated enclosure is used to accumulate the mist generated by an ultrasonic humidifier and to reduce to a minimum the motion of cloudy air that will enter the plastic tube through a small circular opening. Scanning is achieved by projecting a fixed horizontal laser beam onto a rotating 24-faced mirror from a laser printer system; the beam is sent to another mirror fixed at a 45° angle and thus illuminates a vertical cross-section in the tube. The nominal diameter of the laser beam is 1 mm. The height of the tripod supporting the camera is adjusted to capture different stages of the jet evolution.

Once the insulated enclosure is filled with mist, the circular aperture is opened, and cloudy air starts flowing down the plastic tube. The initial buoyancy can be controlled by the temperature of the mist. The distribution of cloud liquid water content is visualised by the scanning laser beam. Initially, the cloud jet flows downward as a laminar fluid. Evaporation accelerates the jet in time, however, and undulations develop at the sides of the jet; eventually it becomes fully turbulent. The distributions of cloud liquid water content along a vertical cross-section, as visualised by the scanning laser beam, are shown on Fig. 2 (panels 1 and 3) at two different times once the waves have developed to substantial amplitudes. Rolls can clearly be seen on both sides of the jet. These rolls entrain dry air inside the falling cloudy jet. Mixing of air with smaller water vapour content results in evaporation of some of the mist, and mixing of momentum results in a reduction of the fall speed at the edge of the jet compared to its central fall speed that is estimated to be about 9 cm/s. The presence of rolls at the edge of the jet also tends to increase locally the fall speed near the core of the jet. A consequence of this is that the following roll is also accelerated downward, and eventually collides with the preceding one. Two examples of this type of roll collision are identified on Fig. 2 (panels 2 and 3) by the arrows marked "I". The light, apparently "cloud-free" regions in the lower part of the jet are simply a consequence of the meanders of the main jet core that make it move out of the vertical plane that the laser beam scans.

3. Numerical simulation

The atmospheric model used for this study, SISLAM, was developed by the late André Robert. This model is based on the fully elastic Euler equations solved by semi-implicit (SI) and semi-Lagrangian (SL) schemes (Tanguay et al. 1990, Robert 1993). The numerical formulation of the dry part of this model is almost the same as that of the MC2 (Mesoscale Compressible Community) model developed by Cooperative Centre for Mesoscale Meteorology (CCRM, Bergeron et al. 1994). This SI-SL numerical strategy has been shown to allow a high computational efficiency without having to approximate the field equations to filter fast moving elastic modes. A two-dimensional version of this model is used here in its moist version, solving interactively the water vapour and cloud water constituent equations along with the dynamical equations.

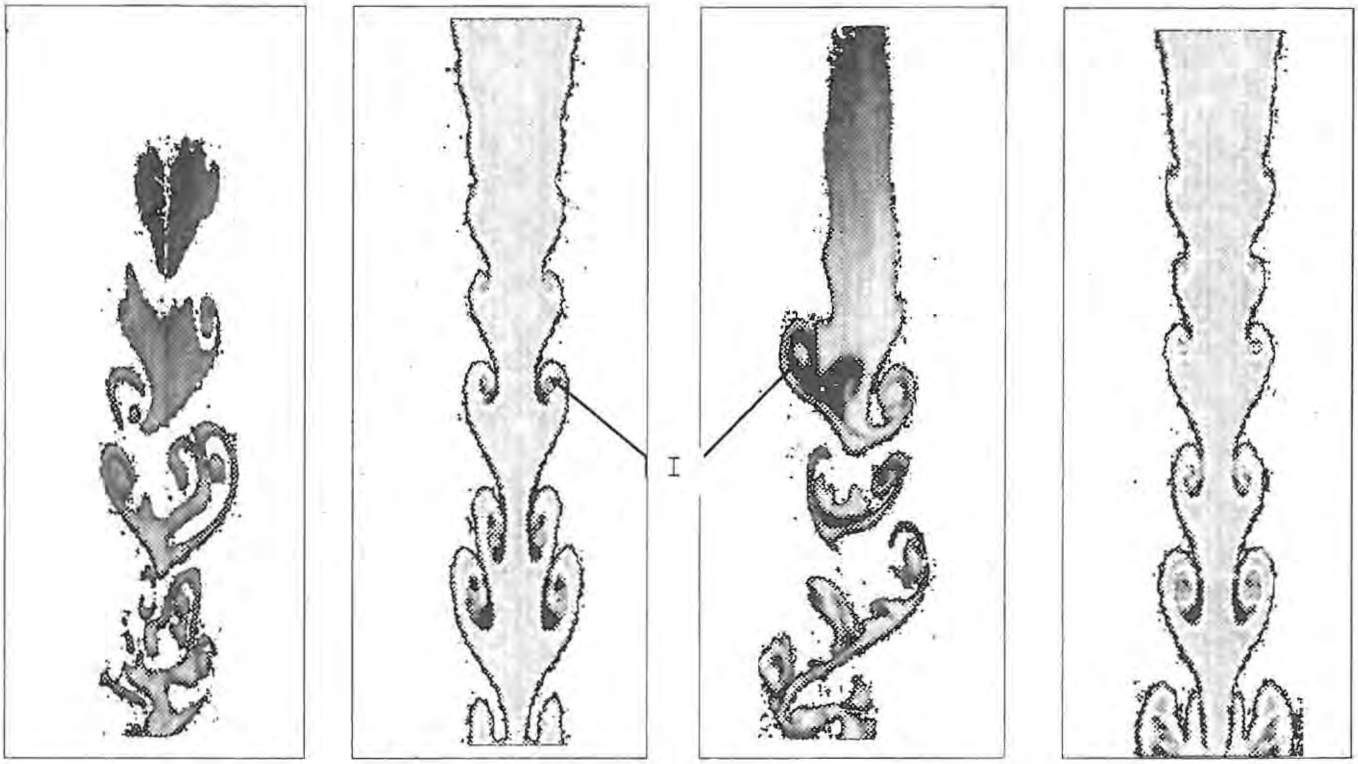

FIG. 2 : Comparison of laboratory experiment (panels 1 and 3) and numerical model simulation (panels 2 and 4) of cloud water distribution in a downdraft induced by cooling due to the evaporation of cloud droplets as they fall in a dry environment after their release at the top of the tube. The portion of the apparatus that is shown is roughly 40 cm high, and the model results correspond to two instants near the end of a 7 s simulated period (panel 2 corresponds to a simulated time after panel 4, and panel 1 follows panel 3).

The highly simplified bulk cloud microphysics consists here of a set of coupled field equations for heat and water substance in two phases, gaseous and condensed:

$$\frac{d\theta}{dt} = \frac{L\theta_o}{C_p T_o} C_d \tag{1}$$

$$\frac{dq_v}{dt} = - C_d \tag{2}$$

$$\frac{dq_c}{dt} = + C_d \tag{3}$$

Here T is the temperature, q is the potential temperature, q_v is the water vapour mixing ratio, q_c is the cloud water content, L is the latent heat of condensation of water, and C_p is the specific heat of air at constant pressure; the subscript o refers to initial values. The condensation rate C_d is determined as to convert supersaturation into cloud water when $q_v > q_{vs}$ ($C_d > 0$), and to evaporate cloud water in subsaturated air when $q_c > 0$ and $q_v < q_{vs}$ ($C_d < 0$), where q_{vs} is the saturated mixing ratio. Note that sedimentation, as well as molecular diffusion, are neglected here. Equations (1) - (3) are the Lagrangian equivalent of the Eulerian form used by Grabowski and Smolarkiewicz (1990) in their one-dimensional kinematic model. Here in SISLAM the velocity field will respond to the pressure variations that ensue from the temperature changes. No explicit diffusion other than that associated with the upstream interpolations is applied in these experiments, and the SL scheme uses a simple bi-cubic interpolation, without any positivity nor monotonicity constrains.

The main goal here is to demonstrate the ability of a semi-implicit semi-Lagrangian model to reproduce fine-scale details of cloud droplets motions that develop in the downward plume context described above. In order to have a very good spatial resolution without the computational cost of a full 3D model, only a two dimensional simulation will be performed with SISLAM. It is recognised that this is a major limitation to a detailed comparison with the laboratory experiment; the results will however prove to be encouraging, and a full 3D simulation will have to await a later date. The simulation domain is 90 cm high by 60 cm wide, the spatial resolution is 1.5 mm, thus the computational grid has 600 by 400 grid points, and the timestep is 25 ms.

The environment is initially adiabatic with a constant relative humidity of 80 %; surface temperature and pressure are 23 °C and 100 hPa, respectively. Cloud water content is specified initially and throughout the integration over a lower half disk of 3.3 cm radius, with its centre at 7.5 cm from the top of the model. In this incoming cloud region, the temperature is perturbed by -0.5 °C from the surrounding environmental value to reflect the effect of evaporative cooling in the insulated box, the water vapour is set to saturation and the cloud water content is specified to 30 g/Kg. This cloud water content is somewhat larger than the estimated value in the laboratory experiment. This value was chosen to reproduce the same fall speed as in the laboratory experiment. It is known that entrainment is less efficient in 2D than in 3D; the mixing that is responsible for the evaporation is thus reduced in 2D, as is the evaporative cooling that ensues. A larger could water content compensates for the reduced negative buoyancy creation in 2D.

Panels 4 and 2 on Fig. 2 present the cloud water content at two instants near the end of a 7-s long (280 time steps) numerical simulation. Near the top of the domain, the cloud water field reflects the laminar nature of the downward flow there. A little farther down, the jet undergoes a transition to turbulence, with undulations developing at the interface of the cloudy region. The rolls simulated by the model bear a striking resemblance to those observed in the laboratory experiment: their dimension and growth rate (as visualised by the increasing number of spiral threads in the rolls as they move in the lower part of the domain) are similar. The vortex collision process observed in the laboratory experiment is also present in the model simulation; an example of such an event is seen on panel 1. The main difference between model and laboratory results is the greater periodicity and symmetry of the model results; this is a direct consequence of the 2D nature of the model, and this limits the comparison with laboratory experiments. It is well established by now that the transition to turbulence is much richer in 3D than in 2D, as can be seen in the laboratory results. The symmetry of the 2D simulation could have been broken by adding some random perturbations to the flow fields, but we have not pursued this avenue here.

Despite its limitations, this comparison nonetheless serves to show that the SI-SL model adequately resolves the fine scales that develop under realistic experimental conditions. Fairly accurate results are achieved because, in accord with the findings of Pellerin et al. (1995) and Zawadzki et al. (1993), it is shown again here that the SL scheme produces fields that are very "coherent", i.e. relatively devoid of fictitious ripples, because the scheme has inherently small amount of numerical diffusion and little numerical noise to interfere with the proper development of the physical rolls.

Clearly these simulations should be extended to 3D framework for an adequate comparison with the laboratory results; these experiments are envisaged and will be reported elsewhere.

4. Conclusions

A new laboratory experiment that is relatively simple to realise has been developed to validate the results of a numerical atmospheric model. This experiment contributes to further our understanding of cloud-scale processes such as entrainment and detrainment phenomena. A 2-D fine-scale atmospheric model with a highly simplified bulk cloud microphysics has to been shown to reproduce with some fidelity the overall phenomenology of the laboratory results. The low level of numerical dispersion of the SL transport scheme is germane to reproducing with fidelity the laboratory results (Pellerin 1992). In a series of tests with a one-dimensional kinematic model of eq. (1) - (3), Pellerin et al. (1995) have shown that the SL scheme converges to a given solution with half the spatial resolution, and that half the number of time steps are required to achieve a given integration, thus resulting in nearly a factor 8 in computational saving in two-dimensional simulations.

For a thorough comparison with laboratory results, these two-dimensional simulations ought to be extended to the three-dimensional framework, also taking into account condensed water sedimentation. A parameterisation of subgrid-scale molecular diffusion would also have to be considered at these scales. The preliminary results are encouraging though, and accuracy and efficiency qualities of SI and SL techniques should allow to extend these simulations to the 3D framework in some near future.

It is interesting to point out that the experiment described here was originally part of a laboratory course at UQAM and that since it has inspired a similar set-up at the Geophysical Institute of Warsaw University for the study of turbulence.

Acknowledgements

The authors would like to pay tribute to the contribution of the late Professor André Robert (April 28, 1929 - November 18, 1993) who directed the numerical component of the MSc research of Pellerin (1992) from which these results are taken.

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The UNIX Integrated Environment at the Canadian Meteorological Centre

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ABSTRACT / RÉSUMÉ

Late in 1989, CMC decided to acquire the next generation of substantially more powerful computers. UNIX was chosen as their common operating system. A close examination of how we were doing things at that point convinced us that the new hardware could have a revolutionary effect on all operational components of CMC. We took advantage therefore of this juncture to completely redesign several important operational subsystems, with the goal of making the best possible use of the new computer tools. This article outlines the philosophy behind our approach and then briefly describes the improved operational systems.

À la fin de 1989, le CMC a décidé d'acquérir une nouvelle génération d'ordinateurs nettement plus performants et opérant sous un seul système d'exploitation; UNIX fut retenu. Ces décisions préfiguraient des changements qui représenteraient bien davantage qu'un simple ajustement pour les opérations du CMC. Il s'en est donc suivi une réflexion en profondeur sur notre façon de faire les choses et la meilleure approche à suivre pour tirer parti de ces nouveaux outils informatiques. Conséquence de cette démarche, plusieurs sous-systèmes opérationnels ont été refaçonnés. Cet article présente le cheminement qui a présidé à ces refontes de même que les grandes lignes de quelques-uns des plus importants sous-systèmes opérationnels qui ont vu le jour à cette occasion.

1. Introduction

In 1989, the Canadian Meteorological Centre (CMC) decided to acquire a new generation of both front end and back end computers along with graphical workstations. The switch to a single widely available operating system, UNIX, was an integral part of the plan. The following three years were a period of intense effort by all of CMC's personnel. As a result, UNIX has been the sole operating system in use at CMC since December 1992.

In this paper, it is impossible to describe all the work accomplished by a large team of colleagues and which covered all fields of activity at CMC during that three-year period. We will therefore focus on the most important aspects of the conversion process.

First, we will briefly describe our current hardware configuration. This will be followed by some considerations that strongly influenced the design of our operational system. The last part will describe the design and/or structure of some important operational subsystems.

2. Current Configuration

Figure 1 shows the milestones in hardware and software configurations since December 1989. Conversion took place in two steps. The first part was completed in June 1992 after the replacement of our two former CDC CYBER 830 front end computers, running NOS, by the MIPS 4680s. Part two was achieved six months later with the replacement of the CRAY-XMP by a NEC HNSX-3.

The two MIPS 4680s are the workhorses. Each of them has four 80 mips processors. One MIPS (coined CIDSV07) is dedicated to CMC operations while the second one (CIDSV08) is used for development and research. It also serves, if necessary, as the backup for the operational machine. The definition of "front end operations" may vary from Centre to Centre. At CMC, this expression covers data reception, bulletin parsing, decoding, monitoring, quality control, pre-processing for the objective analysis, chart/bulletin production, file maintenance and archiving. The NEC is used solely for the execution of objective analyses and numerical models. To summarize, any operational task that is not research or development nor numerically intensive is executed on CIDSV07. The two MIPS 4680s will be replaced by more powerful machines by February 1995.

3. Design Considerations

UNIX was retained as our operating system for several reasons. First, it is becoming a worldwide standard, available on all kinds of platforms. In addition, it frees us from a dependency on proprietary vendor software and so, will

	December 1989	June 1992	December 1992	November 1994
	CYBER 830	2 MIPS 4680 SV	----------->	2 MIPS 4680 SV
F		2 CDC 920 SV	----------->	2 CDC 920 SV
R		60 CDC 910 WS	----------->	60 CDC 910 WS
O		10 INDIGO WS	----------->	15 INDIGO WS
N				2 INDIGO-2 WS
T		1 CRIMSON (with Reality engine)	----------->	1 CRIMSON (with Reality engine)
E		75 X-TERMINALS	----------->	75 X-TERMINALS
N		20 SUN WS	----------->	20 SUN WS
D		7 H. Packard 9000 WS	----------->	10 H. Packard 9000 WS
S		50 PC (as PCs or dumb terminals)	----------->	50 PC (as PCs or dumb terminals)
	(NOS)	(UNIX)	----------->	(UNIX)
B	CRAY XMP	CRAY XMP	1 NEC SX- 3/44	1 NEC SX-3/44
A	4-32	4-32	4-1024	4-1024
C				1 NEC SX-3/44R
K				4-4096
E	(COS)	(COS)	(UNIX)	(UNIX)
N				
D	SV : server			
S	WS : workstation			
	PC : personal computer			

Fig. 1 Milestones in CMC hardware configuration since December 1989

ensure economies in the future. Finally, the replacement of the NOS-COS tandem by a single (though multi-flavoured) operating system means easier code maintenance and shorter development times.

Important factors in CMC's design decisions included deadlines linked to the end of contracts for old machines and obsolescence of existing software. Most software running on the front ends in 1989 was designed and written in the early eighties, if not before, during a period of vastly different priorities. For example, monitoring and quality control were a low priority then. Fulfilling a mandate in quality control on an overloaded machine with inflexible software would have been an impossible mission. No less important was the fact that our operational database was suffering from a few shortcomings. Another consideration was that the new workstations provided an excellent opportunity to develop graphical applications and, consequently, to redefine our plotting package.

Since one of our objectives was a better integrated environment, we paid particular attention to the needs expressed by various users in research, development and operations. This resulted in strengthened relationships among the three groups. The fact that we all share common program libraries and graphical applications is only one benefit of this approach.

Such considerations were at the origin of the changes that took place at CMC during the conversion period. These factors triggered a serious reflection about the way we were doing things and led us to examine carefully all aspects of our operations. We had not only to change JCL and Fortran codes but also had to adopt new approaches and find better ways of improving performance. We spent, not surprisingly, about 70% of the time developing and only 30% converting applications. In summary, the conversion, while important in itself, also presented us with the ideal opportunity to redesign many of our applications in order to better integrate them within the CMC operational environment.

4. Design of some Important Operational Subsystems

In this and the following sections, we will focus on four important aspects of our new operational system:

- the processing of incoming meteorological data;
- the structure and formats of our operational meteorological database;
- the development of a datafile management system;
- the development of a common set of graphical applications.

4.1 The processing of incoming meteorological data

Meteorological data are obtained from a variety of sources including an internal network (for Canadian data) and the Global Telecommunications System (GTS). Bulletins are received and accumulated on our Telecommunications computer, a TANDEM TXP Non-Stop. It is connected to CIDSV07 via a Personal Computer (PC), which is a cheap,

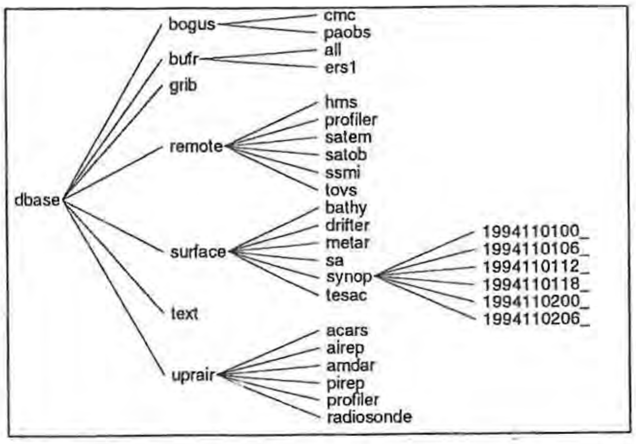

Fig. 2. Subset of our database illustrating its tree-like structure. For clarity, only SYNOP is fully shown. The last ten days of data are available on disk.

convenient and reliable interface. We distinguish three families of bulletins based on their format. These families are GRIB (Gridded Binary), BUFR (Binary Universal Form for the Representation of meteorological data) and ALPHANUM. GRIB is a World Meteorological Organization (WMO) binary format designed to describe model output gridded fields. BUFR is a complementary WMO binary format used to represent data from stations. ALPHANUM designates all types of alphanumerical bulletins, including the well known FM-XX WMO formats (ex. FM-12 for Synoptic observations).

The PC creates packets from bulletins obtained from the TANDEM. A packet comprises bulletins received during a three-minute period, although this is occasionally shorter as the maximum size of a packet is 100 Kbytes. The PC normally transfers such a packet to CIDSV07 at most every three minutes using FTP, while as many as eight packets can be transferred at a time during catchup periods. This is efficient buffering to cope with the irregular arrival of the bulletins or any downstream failure.

A daemon running on CIDSV07 senses, every thirty (30) seconds, the arrival of packets. If one is detected, it calls a job which directs bulletins to one of the three appropriate subsystems: GRIB, BUFR or ALPHANUM. The decoding process can now start. It is followed by insertion of the decoded data into the operational database.

When a packet is present, all relevant decoders are launched at once, resulting in the use of all available processors. One process per data type is currently allowed to run at a given time, although this could be increased. Consequently, a second SYNOP decode/insert process will not start unless the previous one is finished. In order to avoid locking problems, UNIX file locking is used by the insertion programs, so that they may only write to operational files.

4.2 The structure and format of our operational meteorological database

4.2.1 The structure

A subset of the operational database is illustrated in Figure 2 (next page). We take advantage of the tree-like structure of UNIX. Files are defined by data type (SYNOP, BUOY, SATEM etc.). Each file contains six hours of data that are centred on a main synoptic hour. This was chosen to make the connection to our data assimilation cycle easier. All files share similar identification ("YYMMDDHHHH"), composed of the "year_month_day_hour". The file name is meaningless unless one knows its pathname.

4.2.2 The "Standard Format"

We identify two kinds of data to be saved: model outputs and data from stations. Model outputs are saved at CMC in the RPN ("Recherches en Prévisions Numériques") Standard Format ("RPNSF"). This format has been in use for 11 years. One record contains all grid points associated with one variable at one level (height at 850 hPa, for example). Files are portable to 32 bit, 64 bit and 60 bit machines (because of the former CYBER 830 computers). This format, GRIB-like by design, has proved to be very compact, quite efficient and very appreciated by users. It is a well-established standard within CMC and is widely used within the Atmospheric Environment Service.

4.2.3 The "BURP" format

We were in need of a complementary format, one in which a single record would contain all data from all levels from one point ("station"). We had the choice to build it from scratch or from a commercial DataBase Management System (DBMS). Our main objectives and constraints were the following:

Objectives

- One station per record with capability of station grouping.
- Files portable to 32 bit and 64 bit machines.
- Flexibility (to meet present and future needs).
- Compactness of files.
- Rapidity of access to files.
- Adequate management of all types of variables pertaining to stations (observations, statistics, quality control flags, forecasts, analyses, etc.).
- Minimization of the number of input/output operations.

Constraints

- Conversion had to be completed by March 1992. This meant that our database had to be ready by September 1991 since this activity was quite far upstream in the sequence of events.
- We had to satisfy operational, development and research needs.

- The performance of the expected front end was in the range of 20 to 30 mips, single processor.
- We had to cope with three different sets of operating systems during the conversion (NOS-COS, UNIX-COS, UNIX).

Additional arguments militated against the use of commercial DBMSs: no expertise at CMC or within any other similar operational Centre, high costs (in terms of disk space, CPU and site license) and relatively low speeds. Given all this, we believed (and still do) that commercial DBMSs will belong to the domain of research and development for another five to ten years before becoming useful in a complex environment such as ours. We opted for the development of a local format which was named BURP (Binary Universal Report Protocol). Inspired from BUFR, its development was a joint venture with RPN. The most important feature we retained from BUFR was the use of the Table B universal descriptors.

Both RPNSF and BURP can be described as direct access formats that use a look-up table accessed sequentially. Each entry of this table is a subset of a record header and contains the various parameters needed to identify the contents of a record. Since the table is copied to main memory at the opening of a file, very good performance is achieved.

Overall, we are very satisfied with our choice. The performance (size of files and access time) of our local formats meets all our expectations. We now have the proper tools to work efficiently.

5. Datafile Management System (DMS)

We archive about 280 operational files in each six hour period. This includes all files read/written by the objective analyses and/or models executed in the various runs. A corresponding number of files must be deleted to maintain equilibrium. This deletion is one of the two main roles, archiving being the other, of the DMS. Archiving was an important problem initially because no satisfactory commercial tape archiving software seemed to exist on UNIX. We finally chose one and added bug fixes.

For the DMS, the history of a file can be divided in three parts: its identification, life and eventual deletion, with all three taking place on disk. Identification and deletion are mandatory while the reduction of the file and its archiving are two optional potential actions during its life.

5.1 The reduction of a file

The life span of a file may extend from a few hours to many days, depending on the nature of the data. Various types of data have various levels of importance. Some are needed only for a short period, as inputs to jobs executed later in the same run. Some are redundant or updated more quickly than others. Since a judicious use of disk space is of prime importance, a file reduction process may occur before, during or after the archiving itself. Reducing a file implies one of the following:

- removing unnecessary or redundant records; this is done on binary files;

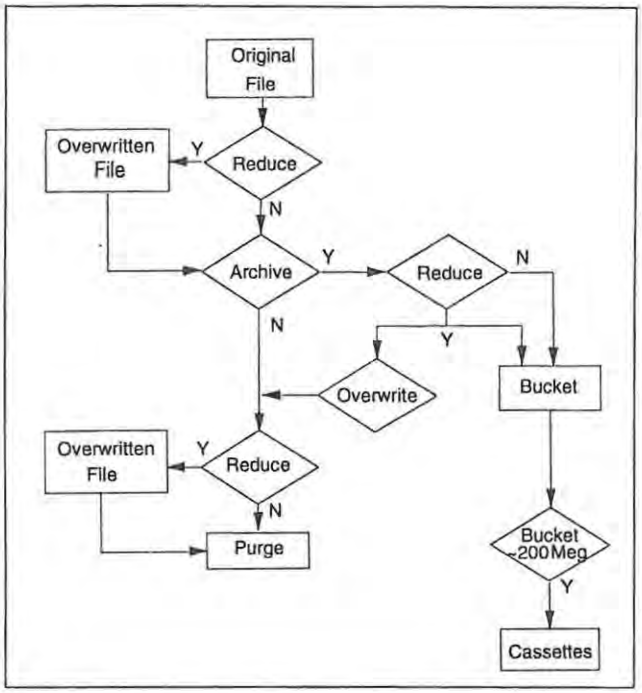

Fig. 3. Life of a file on the system disk and in archiving.

- compressing a text file; this is done on ASCII files.

In all cases, the resulting file overwrites its source, as shown in figure 3.

5.2 Archiving a file

Figure 3 shows the schematics of the whole archiving process. The archiving may take place after reduction in size of the file or not. The first step in archiving a file is to move it to a temporary file, called a bucket. Once the bucket reaches 200 Mbytes (the capacity of a cassette, our archiving medium), it is dumped onto a cassette. In this archiving process, we use about eighteen cassettes per day. This number includes those required to back up all the original archiving cassettes.

5.3 Control files

Permanent files called "protocole" tell the system what to do and when to take action on every file. When a file is identified, a relevant action file containing a timetable of all the actions to be executed sequentially on the file is created. Finally, a status file informs the system of the location of every operational file (on disk, in a bucket or on cassettes) known by it. All users have access to the contents of "protocole" files. We also maintain on line files giving information about the availability of all historical files. Users may check this on line information before launching a job to extract archived files or subsets of files.

6. Development of graphical applications

One of our objectives during the conversion was to avoid duplication of work. Our goal was that people working in operations, development or research would share, as much as possible, the same applications, since their needs would be either similar or complementary. Besides, some of our main libraries of routines had been common for several years.

We did not have enough time to develop one global application which could handle all needs. Nevertheless, we felt it was necessary to make sure that there would not be two applications performing similar tasks. Again this led us to build several applications that did what people needed. These applications read essentially the two formats, RPNSF and BURP, used operationally at CMC and within the Atmospheric Environment Service.

6.1 Plotting package

Our plotting package was revamped. The new one, SIGMA ("Système intégré de graphisme météorologique avancé") reads the two operational formats, BURP and RPNSF. Based on it, we developed several specialized graphical applications:

(1) DATAMON: reads BURP files and displays in real time the quantity of observations available by type and geographical region. It is used by operational meteorologists as a monitoring tool.

(2) EDIGRAF: allows us to create subjective prognoses on workstations and transmit them directly to the communications system. From RPNSF we will import forecast fields, such as mean sea level pressure, and modify them as necessary. Objects, such as fronts, clouds, text, etc. are added according to the type of prognosis being produced.

(3) MAX: reads BURP and RPNSF files. This application is used for contouring analyzed or forecast fields and plotting data. We can also enter bogus data. Macros can be defined. There is a predefined set for displaying derived fields and verifications. A powerful calculator does arithmetic, trigonometric and logarithmic calculations on fields. Various derivatives can also be calculated. All these operations may be combined as desired. Finally, several verification scores can be produced. MAX also displays vertical profiles and cross-sections.

(4) REC: allows us to display and animate the contents of RPNSF files. Parameters, such as color palette and animation speed are controlled interactively.

(5) TEPHI: as its name implies, it is used to display observed, analyzed and forecast tephigrams. Hodographs can be displayed as well.

(6) DISPLAY: this application was developed to display and animate raster files. Images from other applications can be captured, saved and then displayed side by side for easier comparison. Raster images can be saved in "carrousels" and used later for presentations or case studies.

Applications (3) to (6) are extensively used by meteorologists working either in operations, development or research. DATAMON and EDIGRAF are tailored tools for the use of operational meteorologists. One of our main objectives for all these applications was fast display. This objective was indeed achieved to the satisfaction of their various users. Readers who visited CMC within the last two years will attest to our success in meeting this goal.

7. Conclusion

During a three year period beginning in December 1989, CMC undertook major operational changes. We obtained a new generation of computers and switched from the former tandem of NOS-COS to UNIX and, at the same time, seized the opportunity to reconsider how we were doing things. This led us to redesign most of our system to take advantage of UNIX features, an efficient local computer network and the availability of workstations.

Most consultants would not recommend our approach to converting to a UNIX integrated environment with our multiple goals, constraints and strict deadlines. We were "forced" to succeed for several general reasons: external constraints (termination of contracts for example), "quantum leap" in technology and new needs to satisfy. Additional specific factors contributed to the success of the exercise. The three most important ones were proper training in UNIX and C language for all personnel involved in the conversion, a highly motivated staff, and an unwavering commitment from our management team.

During the last two years, we have gained considerable experience with our new operational subsystems. This experience has convinced us that we made the right decisions in our design of data handling and management software, database structure and graphical applications. Much work remains to be done. However, we are satisfied that, during this period, we built the tools that are necessary to fulfil our mandate as a National Meteorological Centre. We look forward to the future with confidence.

Acknowledgements

The authors would like to sincerely thank Gilles Verner and Charles Anderson for reading this paper and providing judicious comments.

Note: This paper is based on a presentation made at the Fourth Symposium on Meteorological Operational Systems held at the European Centre for Medium-Range Weather Forecasts (ECMWF) in November 1993.

L'EFFET DE SERRE FERA-T-IL GRIMPER LE MERCURE DU THERMOMETRE PLANÉTAIRE ?

Réflexion d'un groupe de travail multidisciplinaire et multiethnique constitué d'étudiants au doctorat et de professeurs en sciences de l'Environnement à l'UQAM.
(publié dans ***Le Devoir***, 18 avril 1995)

Étudiants: Dominique Bérubé, David Biron, Mohamed Djebrouni, Sékou Moussa Keita, Marconi Magalhaes, Marie-Pascale Sassine, Guoji Shan, Marie-Josée Simard, Louis Tessier, Christine Veiga-Pires, Leopoldo Yanes
Professeurs: Jean-Pierre Blanchet, Dave Hilbert et Marc Lucotte

La réunion de Berlin a rassemblé les quelques cent cinquante pays signataires de la convention de Rio afin de parvenir à une entente sur la réductions des émissions de gaz à effet de serre. Les décisions qui y ont été prises devraient être basées sur des arguments scientifiques. La connaissance du phénomène n'en est pourtant qu'à son balbutiement malgré quelques milliers d'articles publiés sur le sujet. Plutôt que de s'interroger sur la probabilité d'un réchauffement moyen de la planète, le point principal à la base des discussions devrait être l'introduction d'un déséquilibre majeur dans le système climatique.

Depuis quelques décennies, les surprises climatiques se multiplient au Québec et à l'échelle internationale. On se souvient de la destruction de vergers dans la région de Rougemont en hiver 1994 qui a été causée par des froids exceptionnels en janvier (temp. moyenne de -16.9°C, combinée à de grands écarts de température, -34.7° à 8.3°C, avec 14 mm de pluie en 24 heures). Ce Noël, pas de problèmes pour se rendre au réveillon alors que la température moyenne du mois de décembre 94 a été particulièrement douce, soit de 0.2°C comparativement à la normale de -2.7°C. De plus, Montréal a reçu deux fois moins de neige que la normale de 63 mm. En février 1995, la France et les Pays-Bas ont reçu des quantités anormales de pluie causant des inondations importantes, alors que l'Espagne subit une sécheresse grave depuis plusieurs années. Sécheresses et inondations successives affligent la Californie et on se souvient bien des inondations du Mid-West américain de l'année dernière. Mais ces surprises météorologiques ne reflètent pas forcément un changement climatique global.

L'effet de serre est un phénomène naturel, causé par la rétention de l'énergie par les gaz atmosphériques, qui est essentiel au maintien de températures acceptables à la surface de la Terre pour le développement de la vie. On calcule que sans cet effet, la température moyenne de la planète atteindrait à peine -18°C.

L'effet de serre

La température terrestre est déterminée par le bilan entre l'énergie solaire qui entre et celle qui sort. L'énergie solaire pénètre dans la haute atmosphère sous forme d'un ensemble de rayons caractérisés par leur longueur d'onde: les ultraviolets, le visible et les infrarouges. Une grande partie de ce rayonnement est réfléchie vers l'espace. L'atmosphère et la surface terrestre absorbent alors l'énergie restante et sont ainsi réchauffées. L'énergie thermique de la surface est réémise vers l'espace sous forme d'infrarouges. Une partie de cette énergie est absorbée en traversant l'atmosphère par des gaz dit à effet de serre tel que gaz carbonique, méthane, vapeur d'eau, CFCs. C'est ce phénomène de rétention d'énergie thermique qui est appelé effet de serre.

Depuis le début de l'ère industrielle et avec l'explosion démographique, l'humanité a contribué de façon significative à l'augmentation de ces gaz en utilisant pétrole, charbon, gaz naturel accumulés sous terre depuis des centaines de millions d'années. La consommation de ces ressources carbonées entraîne des rejets significatifs de CO2 dans l'atmosphère. Le même principe s'applique aux autres gaz comme le méthane, dégagé massivement par les terrains cultivés, inondés ou déboisés et l'élevage de bétail. L'ajout de nouveaux gaz atmosphériques, tels que les CFCs, séjournant des siècles dans l'atmosphère se montre encore plus efficace pour l'absorption des infrarouges. La variation de la concentration des gaz atmosphériques est-elle significative et quel lien peut-on faire avec les changements climatiques?

La concentration atmosphérique en CO2 a présenté des variations marquées au cours des différentes époques géologiques. Par l'étude des bulles d'air emprisonnées dans les glaciers, on peut déterminer la composition de l'air du passé. Ainsi la teneur de ce gaz est passé de 190 ppm (parties par millions) durant la dernière période glaciaire jusqu'à environ 300 ppm pendant la période interglaciaire actuelle. Cependant, les observations faites sur le volcan Mauna Loa à Hawaii depuis 1958, lieu éloigné de toute agglomération urbaine pouvant fausser les résultats, ont permis de constater que les activités anthropiques sont responsables de l'augmentation exponentielle des teneurs en ce gaz. Elles atteignent aujourd'hui un niveau inégalé de 350 ppm, soit 25 % de plus que la valeur initiale préindustrielle de 280 ppm. Si les émissions ne montrent que peu de fléchissement, on prévoit que celles-ci passeront de 5.5 gigatonnes de carbone par an, soit 100 000 fois celles attribuables à la circulation automobile canadienne annuelle, à 9 gigatonnes annuelles en 2025 et à 18 gigatonnes en 2050, ce qui mènerait à une concentration de 600 ppm. La contribution des autres gaz à effet de serre doit être aussi sérieusement évaluée. Parallèlement, comment se comporte la température de la planète?

Le climat a toujours eu un comportement chaotique à travers les différentes périodes géologiques. Depuis 6000 ans, l'humanité jouit d'une atypique stabilité climatique avec une température moyenne autour de 15°C, sur une échelle de temps qui lui a permis de se sédentariser et de se développer en société industrielle. Modéliser l'évolution de la température depuis le début du siècle est une tâche ardue. Les variations annuelles, le manque d'observations, la méconnaissance des températures océaniques, les changements de techniques d'analyse sont autant de facteurs qui nuisent à l'établissement d'une tendance générale. Malgré les incertitudes reliées à ces mesures, la communauté scientifique s'entend généralement pour dire que l'augmentation de la température mondiale moyenne aurait été de 0.2 à 0.7°C depuis 1850. Cette augmentation de température correspond globalement à celle des augmentations des gaz à effet de serre dans l'atmosphère. Cependant, de fortes anomalies peuvent être relevées entre ces deux paramètres, tel que le refroidissement général observé dans les années 40 à 70, non corroboré par un équivalent dans les concentrations gazeuses.

À l'heure de la conférence de Berlin, les politiciens ont à prendre des décisions quant à la réduction des gaz à effet de serre qui vont définir l'avenir de l'humanité. Elles devront reposer sur des considérations scientifiques: consensus sur un réchauffement global climatique et sur une importante augmentation des gaz à effet de serre. Toutefois, il est très difficile de faire un lien direct de cause à effet entre ces deux augmentations. L'étude des gaz à effet de serre pris isolément permettrait d'affirmer ce lien. Mais l'addition de nouveaux éléments agissant sur le système empêche de répondre à la question de manière absolue. On devrait considérer l'influence de la dynamique des océans, des synergies de réaction des gaz, de la formation des nuages et du cycle de l'eau, des poussières et aérosols, de l'amincissement de la couche d'ozone, etc. Même en l'absence de preuves, nous avons la responsabilité scientifique de prendre position en faveur de réductions massives des gaz à effet de serre. La menace du déséquilibre du climat est suffisamment grande pour obliger une action rapide de la part de la communauté internationale et cela même si il n'existe aucune garantie que les actions posées parviendront à enrayer le phénomène.

Les québécois influencent-ils le système climatique ?

(partie 2 publié dans ***Le Devoir*** le 19 avril 1995)

L'humanité injecte annuellement 7 milliards de tonnes de carbone sous forme de CO_2 dans l'atmosphère (4 kg de carbone/[humain x année x jour]): 5.4 milliards provenant de l'activité industrielle, du chauffage et des moyens de transport et 1.6 milliard de la déforestation et de l'utilisation du territoire. À la conférence de Berlin, tous les pays industrialisés ou en voie de développement, se sont fait interpeller quant à leur responsabilité passée ou future. Depuis l'ère industrielle (1850), l'activité humaine a augmenté la concentration atmosphérique des gaz à effet de serre à un taux extrêmement rapide. Le CO_2 est passé de 280 à 350 ppm, le CH_4 de 0.8 à 1.7 ppm, le N_2O de 0.28 à 0.31 ppm et l'O_3 de 0.01 à 0.05 ppm. Ce qui représente respectivement des augmentations de 27, 113, 10 et 400 %. De plus, l'activité anthropique contribue à l'ajout de gaz non naturels tels les CFCs (1,6 %/année). Ces augmentations, réalisées en quelques décennies, sont comparables à celles ayant pu se produire lors de périodes interglaciaires sur une échelle de temps de plusieurs millénaires. L'activité anthropique a modifié et modifie encore l'équilibre du système climatique.

L'interaction entre trois grands réservoirs, l'atmosphère, la biosphère et l'hydrosphère (océan), est la base de l'équilibre climatique et du cycle du CO_2, gaz qui contribue pour une large part à l'effet de serre. Deux processus principaux régissent l'absorption de CO_2 par l'océan, la boucle de convoyage et l'activité biologique. Annuellement l'océan va absorber 94 milliards de tonnes de CO_2 pour en rejeter dans l'atmosphère 90. Ce qui veut dire que 4 milliards de tonnes seront captées et fixées dans l'océan par des procédés biogéochimiques. L'océan sert de véhicule au CO_2 en captant celui-ci à hautes latitudes pour le relâcher aux tropiques. Ce processus est très lent, de 400 à 600 ans, et est assuré par la circulation océanique, appelée boucle de convoyage. L'eau froide du nord et de Antarctique se sature en CO_2, plonge et vient remplir le fond des océans Atlantique, Indien puis Pacifique. Cette eau remonte à la surface, relâche le CO_2 et pousse les courants chauds en surface qui influencent le climat de la planète. C'est ainsi que l'Europe jouit d'un climat tempéré grâce à l'arrivée du Golfe Stream près de ses côtes. L'activité biologique se manifeste dans la couche eutrophique où la lumière permet le développement du plancton qui utilise le $CO2$ dissous. Annuellement, la biosphère et l'atmosphère s'échangent mutuellement 110 milliards de tonnes de carbone. Le rôle de la biosphère est de 2 à 6 fois inférieur en ce qui concerne la rétention de carbone comparativement à l'océan qui en est le puits principal. Cependant, la déforestation est une menace importante si elle se poursuit au rythme actuel (les Amériques: 7.3 millions ha/année; l'Afrique: 4.8 millions ha/année; l'Asie: 4.7 millions ha/année). Un déboisement massif de la planète causerait probablement un refroidissement local et global lié à la hausse de l'albédo. La déforestation a également une incidence climatique locale et immédiate puisque la désertification entraîne une diminution majeure de la masse nuageuse et des précipitations. La contribution anthropique peut paraître faible par rapport aux échanges naturels entre l'atmosphère, l'océan et la biosphère. Cette injection amène une tendance à l'accumulation de CO_2 dans l'atmosphère (3.4 milliards de tonne de carbone par année). Il faut ajouter au CO_2 tous les autres gaz à effet de serre qui s'accumulent également dans l'atmosphère. La complexité des interactions a conduit à l'utilisation de la modélisation.

Les scientifiques ont élaboré des modèles mathématiques basés sur les lois physiques afin de comprendre et prévoir l'évolution du climat. Ceux-ci ont permis la considération de facteurs sous-estimés auparavant: la contribution solaire, le rayonnement infrarouge, l'apport des nuages, les aérosols, l'hydrologie, l'océan, la cryosphère, la topographie, etc. Quel que soit le modèle utilisé, les simulations indiquent une hausse de la température moyenne reliée à l'augmentation de la concentration atmosphérique des gaz à effet de serre. Cependant, l'ampleur de ces variations de l'ordre du degré diffère entre les modèles.

Des modèles prédisent d'ici 100 ans un accroissement de la température moyenne de 5 °C au nord du Québec et de 2 °C dans le sud ce qui semble a priori un avantage pour une région froide. Il pourrait résulter de ce réchauffement moyen plusieurs impacts écologiques négatifs: difficulté des forêts québécoises à s'adapter au nouveau climat, changement des conditions agricoles et des précipitations mensuelles et annuelles. Le réchauffement moyen serait accompagné de surprises climatiques ponctuelles et potentiellement catastrophiques (hausse du niveau de la mer, érosion des côtes, migration des moussons et tempêtes, arrêt de la boucle de convoyage de l'océan,...). L'adaptation de l'économie québécoise aux changements climatiques rapides engendrera des coûts énormes. Notre planète est régie par plusieurs sous-climats interdépendants. Le défi d'un modélisateur est d'établir la réaction de l'ensemble des sous-climats pour déterminer les effets locaux au Québec.

Toutes les nations de la terre sont concernées par ce problème mais elles ne sont pas toutes également responsables. Pour identifier avec justice la part de responsabilité d'un pays, il faudrait retenir au moins les paramètres suivants: les actions anthropiques antérieures négatives, la durée de séjour, les quantités et la catégorie des gaz à effet de serre émis. Les pays industriels sont les grands responsables des actions anthropiques négatives antérieures et du réchauffement actuel. Certains pays en voie de développement comme la Chine produisent plus de gaz à effet de serre que le Canada mais pas per capita (15 fois moins que le Canada). Chaque pays a sa part de responsabilité et doit développer des solutions adaptées à ses problèmes.

Le Canada est loin d'avoir pris un tournant vers une industrialisation propre. Il contribue pour environ 10% aux émissions mondiales des gaz à effet de serre. En 1987, il était le premier producteur de gaz à effet de serre per capita avec 4 500 tonnes de carbone et maintenant il occupe le deuxième rang après les États-Unis. Même les québécois doivent s'interroger sur la propreté de l'énergie hydroélectrique alors que les réservoirs pourraient être une source significative de méthane. Ce gaz a un potentiel de réchauffement global 10 fois supérieur au CO_2. On pourrait aussi comptabiliser les fuites de gaz naturels et les dégagements dus à l'agriculture. Les canadiens et les québécois ont une responsabilité du déséquilibre du système climatique et doivent diminuer leur production de gaz à effet de serre per capita pour exiger quoi que ce soit des autres citoyens de la terre. Comment demander à un brésilien d'arrêter de couper du bois dont sa survie dépend? Comment demander à un québécois d'arrêter d'utiliser son automobile?

Pour diminuer l'émission des gaz à effet de serre, les pays doivent se concerter pour déterminer des normes internationales et des sanctions aux contrevenants. La conscientisation populaire et sociale est un prérequis au succès d'une politique de réduction des émissions. Tout québécois peut contribuer à cette diminution. Voici quelques exemples d'actions concrètes: utilisation du transport en commun, le covoiturage, chauffer son domicile à l'électricité, recyclage du papier ou du carton, entretien du système d'échappement de votre véhicule, plantation de végétaux sur des terrains non cultivés, rotations des cultures, etc.

Suite à notre réflexion sur l'effet de serre et le réchauffement planétaire, notre groupe conclut qu'il y a un déséquilibre du système climatique causé par l'action anthropique. À l'heure actuelle, il est encore difficile de prédire les changements climatiques mondiaux, mais il est évident qu'il y aura des modifications importantes des conditions climatiques locales et globales si l'humanité ne réagit pas rapidement.

Credit: Bill Kiely, AES

Gordon A. McKay
(1921-1995)

Gordon McKay, a veteran Canadian meteorologist, died suddenly in Thornhill, Ontario on April 14, 1995. Gordon was well-known throughout Canada for his activities in meteorology and climatology and although he formally retired in 1984 he continued to visit 4905 AES headquarters at least once a week as he undertook various consulting and voluntary research projects. One of Gordon's greatest characteristics was his unfailing cheerfulness and optimism. He was interested in everything, not just climatology and meteorology. Many of his former colleagues and new friends in Toronto and elsewhere will greatly miss their contacts with him.

Over the years Gordon served CMOS and its predecessor in many ways. He was a member of the national Executive from 1971 to 1974 and served as president in 1972-73. In 1956 he was awarded a Darton Prize for his paper "A Method of Minimum Temperature Prediction" and in 1959 he and A.B. Lowe were awarded the President's Prize for their work on the tornado in Western Canada. The Society's Prize in Applied Meteorology was awarded to him in 1976 and in 1987 he was awarded the Patterson Medal, Canada's premier award for distinguished service to meteorology.

Gordon was born in 1921 in Winnipeg and was a 1943 graduate of the University of Manitoba. He then joined the Meteorological Service and spent the next two years as a meteorological officer at several wartime Royal Canadian Air Force stations. He was then a public and aviation weather forecaster at Montreal, Gander and Winnipeg during which time he obtained a graduate degree from McGill University and also began to write and publish research papers. Then, in 1959, he was seconded to the Prairie Farm Rehabilitation Administration offices in Regina as a hydrometeorologist where he provided advice to engineers and continued his research. In 1966 he was posted to the Toronto headquarters into a new position - superintendent of climatological research in the old Climatology Division.

At headquarters Gordon not only took on increasing administrative duties but continued his research in hydrometeorology and climate. In the 1970s he became intensely interested in climate change and its socioeconomic aspects particularily in the industry, energy, food and agriculture sectors. For 20 years or so he was frequently asked to write and speak on the subject and he contributed a great deal to the early literature. A pillar of the new Canadian Climate Centre as director of the Climatological Applications Branch he acted as director general of the Canadian Climate Centre for a year or so before his retirement.

As a meteorologist-climatologist Gordon served on many national committees over the years - NRC associate committees on geotechnical research, quaternary research and snow engineering, the International Biological Program, agricultural meteorology and more recently on committees having to do with climate change. Abroad, Gordon was one of Canada's best meteorological ambassadors. Fluently bilingual he participated in many WMO activities such as the Commission for Climatology working groups on climate change of which he was chairman from 1973 to 1983. He was a member of the Canadian delegation to the Commission sessions in 1973, 1978 and 1982 and a frequent visitor to the Geneva Secretariat for meetings and planning sessions over a decade or more.

Gordon had a remarkable and unique standing in climate circles in the United States. Besides participating in US/Canada joint projects he was a member of the American Meteorological Society's committee on applied meteorology for half a dozen years and was named a Fellow of the Society. From time to time he was called upon to provide advice to the National Science Foundation, the National Centre for Atmospheric Research, the American Association for the Advancement of Science, American government departments and universities. As recently as last November he was an invited participant at NCAR meetings on climate change. He is survived by his wife, Sandy, three daughters, a son and six grandchildren.

Geoff Holland Elected President of the Intergovernmental Oceanographic Commission

At the 18th Assembly of the Intergovernmental Oceanographic Commission (Paris, June 13-27) Geoff Holland became the second Canadian to be honoured with the important task of chairing this Commission (IOC). His term of office will be for the next two years.

Geoff is a well-known CMOS member. He was the chair of the Scientific Program Committee of the highly successful CMOS Congress held in Ottawa in 1994, and has been a supporter of the Society in many ways for a long time. We are all proud of the honour of having the President of the IOC as one of our members.

Geoff has been very acrive in the IOC over many years serving as First Vice-Chairman from 1993 -1995 as well as head of the Canadian Delegation for the past nine years.

He received a Bachelor of Science degree in mathematics and physics and a Master of Science degree in fluid dynamics from London University, and afterwards served in the Royal Navy from 1954 to 1956, spending the majority of his time with an operational minesweeping squadron in the North Sea. From 1957 to 1967 he worked at the Hydraulics Research Station, Wallingford, United Kingdom before emigrating to Canada where he turned his attention to aerodynamics. In 1968 he joined the federal government service to be responsible for the establishment of a program to monitor the wave acrivity around Canadian coasts.

Geoff has remained with the same ocean science organization ever since, gradually changing the emphasis of his work to matters concerning ocean science policy and administration, both in the national and international arenas. In his twenty-five years with the Canadian government , he has been involved with many international marine policy issues and organizations and has assumed several important international responsibilities. In particular he was chairman of the Joint World Meteorological Organization-Intergovernmental Oceanographic Commission Committee on Integrated Global Ocean Services Systems (1980-85) and Chairman of the London (Dumping) Convention 1986-1990) and is presently Chairman of the Arctic Ocean Sciences Board. He has contributed to Canadian policies on many issues related to maritme science policy and global and climate change initiatives such as the Law of The Sea and the UN Conference on Environment and Development.

Post-doctoral Positions

Up to four post-doctoral positions are expected to be funded in a research group on climate variability involving scientists from three Canadian universities and two government laboratories. Two positions will be in the Department of Atmospheric & Oceanic Sciences at McGill University, Montreal, Canada, under the supervision of Drs. C.A. Lin and J. Derome. The other two positions will be located at Recherche en pr,vision num,rique (RPN), a division of the Atmospheric Environment Service of Canada, about 15 km from McGill University. The appointments will be for one year, renewable subject to satisfactory performance and the availability of funds. Applicants should mail a curriculum vitae with a statement of research interests, and arrange to have three letters of recommendation sent to Dr. Jacques Derome, at the following address:

Dr. Jacques Derome
Department. of Atmospheric & Oceanic Sciences
McGill University
805 Sherbrook St W.,room 945
Montreal, PQ, Canada
H3A 2K6.

For further information on research topics of interest contact: DEROME@ZEPHYR.METEO.MCGILL.CA.

Postes postdoctoraux ouverts

Nous prévoyons que quatre postes postdoctoraux seront ouverts en recherche sur les fluctuations climatiques au sein d'une équipe de recherche regroupant des scientifiques de trois universités canadiennes et deux laboratoires gouvernementaux. Deux postes seront au Département des sciences atmosphériques et océaniques de l'Université McGill, sous la direction des professeurs C.A. Lin et J. Derome. Les deux autres postes seront au sein de la division de Recherche en prévision numérique (RPN) du Service de l'environnement atmosphérique du Canada, en banlieue de Montréal. Les affectations porteront sur une période de un an, renouvelables suite à une évaluation favorable de la recherche et au renouvellement du financement. Les candidats devront poster un curriculum vitae et une description de leurs intérêts de recherche à l'adresse suivante. Ils devront également demander à trois scientifiques de faire parvenir des lettres de recommandation à la même adresse. Les postes seront comblés dès que possible.

Dr. Jacques Derome
Dép. des sciences atmosphériques et océaniques
Université McGill
805 rue Sherbrooke O., local 945
Montréal, PQ, Canada
H3A 2K6.

Pour plus d'informations sur les projets de recherche, contacter : DEROME@ZEPHYR. METEO.MCGILL.CA.

Preliminary Announcement

Symposium on Representation of the Cryosphere in Climate and Hydrological Models

International Glaciological Society International Symposium on Representation of the Cryosphere in Climate and Hydrological Models, 12-15 August 1996, Victoria, CANADA

The International Glaciological Society International Symposium on Representation of the Cryosphere in Climate and Hydrological models, jointly sponsored by the Atmospheric Environment Service, the Institute of Ocean Sciences, University of Victoria Centre for Earth and Ocean Research, and the Canadian Meteorological and Oceanographic Society, will be held 12-15 August 1996 in Victoria, British Columbia.

The symposium will focus on how cryospheric processes, cryosphere/atmosphere/ocean coupling and cryosphere/terrestrial interactions are represented in climate and hydrological models. The emphasis will be on large-scale cryospheric components such as snow cover (including snowfall), sea ice, large ice sheets and permafrost. Of particular interest are the results of model experiments that identify the sensitivity of the climate system to cryospheric processes and/or parameters.

Suggested topics include: (1) representation of the cryosphere in models: parameterization, validation and identification of knowledge gaps; (2) coupling of cryosphere/atmosphere/ocean terrestrial processes; (3) use of models for sensitivity assessments of various cryospheric processes; and (4) validation of cryospheric components in models: remote sensing, conventional observations and process studies - including the accuracy, reliability, errors and availability of these data. Additional details will appear in future issues of the Bulletin.

For more information, please contact the Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK (tel:+44-1223 355974; fax:+44-1223 336543). Copies of the first circular can be obtained from Ross Brown (rbrown@cid.aes.doe.ca).

AMS -NOAA SUMMER WORKSHOPS

The successful candidates in the CMOS competion for the AMS-NOAA sponsored summer workshops are: Mrs. Carlee Hurl, a school teacher in Edmonton, Alberta, for Project Atmosphere which will be held in Kansas City, July 24-August 4, 1995 and Mr. David Worall of Mount Boucherie Secondary School, Kelowna B.C. for Project Maury which will be held in Annapolis, Maryland at the United States Navy Academy, July 17 - July 28. The successful candidates will receive $700 for travel from a fund set up by CMOS and an association of Canadian geography teachers. AMS and NOAA cover all workshop expenses including room and board, tuition and teaching materials for the two week period. Congratulations to both our successful candidates.

Sheila Bourque, CMOS Coordinator

Postdoctoral Research Fellow or Research Associate

A research position exists in the UBC group working on modelling of ozone episodes in the Lower Fraser Valley, B.C., Canada. Extensive measurement efforts are essentially complete, and modelling efforts are well underway. The group is using a combination of the Colorado State University - Regional Atmospheric Modelling System, and the Urban Airshed Model to explore source strength - ambient air quality relations during ozone episodes.

A vacancy exists at the Postdoctoral Research Fellow or Research Associate level for an air pollution specialist. Major tasks involve work on VOC emissions inventory, analysis of model output, preparation of emissions and meteorological scenarios for model runs, preparation of reports based on model results. There exist many opportunities for individual research within the larger project. Immediate collaboration is expected with project scientists (Dr. Douw Steyn at UBC, Dr. Don hastie at York University, Dr. Terry Gillespie at University of Guelph), Postdoctoral Research Fellows already active in the project (Dr. Sara Pryor, Dr. Xiaoming Cai and Dr. Beki Barthelmie) and research assistant (Roy Hourston). Possibilities exist for the successful applicant to contribute to teaching at UBC.

The vacancy is available immediately, and is funded until November, 1996. Annual salary for Postdoctoral Research Fellow is $27500 to $30000, and upward from $30000 for Research Associate.

Apply to Dr. D.G. Steyn, Atmospheric Science Programme, The University of British Columbia, Vancouver, B.C., V6T 1Z2. Voice (604) 822-6407; Fax (604) 822-6150; e-mail douw@geog.ubc.ca.

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Mr. Daniel Salkovitz	International & USA (USA)	Regular
Dr. T. Warn	Montreal Centre (QC)	Regular
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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.

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Mail completed form to CMOS at the address above.

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