Chinook

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LA REVUE CANADIENNE DE LA MÉTÉO ET DES OCÉANS

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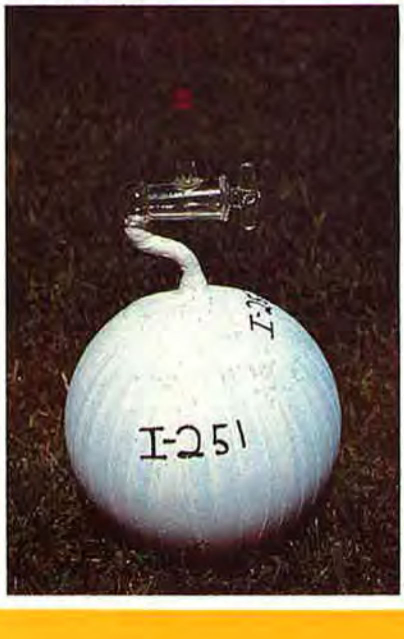

Answers to ARCH PUZZLE No. 19

We are happy to present a selection of responses to the mystery pictures that composed ARCH PUZZLE No. 19 (*Chinook* Vol. 5 No.3/Vol. 6 No.1, page 45). The lower picture of hailstones washed into a drift by rain was easily recognized judging from the answers, but the upper picture of microscopic craters in gelatin caused by the impact of cloud droplets was more difficult to identify.

We congratulate Bob Schemenauer of Willowdale, Ontario, for giving the best overall answer. *The Weather Book* is on its way to him. He wrote as follows:

"I thought I would pass along to you my interpretation of the two photos shown as ARCH PUZZLE #19,
Photo 1: This is a photograph taken through a microscope of droplet craters on a substratum; the surface is probably gelatin as it does not appear to be either formvar or silicone oil; the original droplets were likely water droplets with sizes ranging from 5 to 50 μm; no splashing is evident.
Photo 2: This is a photograph of an accumulation of hailstones on the ground; they are in a 'drift', likely as a result of the wind blowing them up against an obstacle such as small shrubs; they may also have drifted as a result of the flow of water on the surface of the ground."

R.A. Beauchamp of Rawdon, Québec, answered:
"The lower picture is a rather large deposit of hailstones after a hailstorm.
The upper picture is more difficult. It is, I believe, frozen raindrops on ice, that is, the rain fell on the ice and froze there.
Thanks for the fun I had, working on the photos."

Edward Lozowski of Edmonton, Alberta wrote:
"I believe I have the answer to your ARCH PUZZLE No. 19. The upper photograph is a microphotograph (possibly obtained using the Nomarski interference technique) of cloud droplet impacts on a gelatin coated slide. The lower photograph appears to be hailstones which have collected together in a grassy ditch."

Thanks to one and all for your responses.

**Contributions, enquiries, comments and suggestions from readers are welcome. They should be addressed to:
Editor, *Chinook*, Suite 805, 151 Slater Street, Ottawa, Ont. K1P 5H3.**

Chinook

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COVER

Water and carbon dioxide are essential for the proper growth of Prairie crops. Simple instruments like the cylindrical raingauge and the spherical flask are used to measure rainfall amounts and CO_2 concentrations. See the article on page 20.

COUVERTURE

L'eau et le gaz carbonique sont indispensables à la croissance normale des cultures dans les Prairies. On mesure la hauteur des précipitations et la concentration de CO_2 à l'aide de simples instruments dont le pluviomètre cylindrique et la bouteille sphérique. Voir l'article en page 20.

CLIMATE CHANGE IS FOOD FOR YOU

by John Maybank

The concentration of carbon dioxide (CO_2) in the earth's atmosphere is indeed increasing – from around 330 ppm (parts per million) on average in 1973 to 340 ppm in 1981. It is pretty well accepted that it will continue to increase, at least over the next 20–50 years. Effects of such an increase in CO_2 are two-fold for agriculture: (i) climatological, namely, a general temperature rise, probably accompanied by some change in the precipitation regime; and (ii) biological, a growth enhancement effect that will occur whether or not the earth warms up. I shall attempt to deal with each in turn.

CLIMATE WARMING

While the change generally ascribed to a doubling of the CO_2 level can be considered large in climatological terms (I shall here take it as +2 °C for Canadian latitudes), it is not a huge warming effect to the average layman. To put it into geographical context, consider the map of Saskatchewan shown in Figure 1. The mean annual temperature for Saskatoon (1941–70 normal) is 1.5 °C, that for Minot, N.D., 3.5 °C. Therefore, if it warms up by an annual amount of 2 °C, Saskatoon would get a climate roughly like that of Minot, N.D., and the rest of the province would experience similar northward shifts of 3–4° latitude (300–400 km). We get the agricultural climate in general of North Dakota, not exactly a banana belt, and agriculture proceeds then in Saskatchewan as it now does in that state. That is too simplistic, of course, ignoring as it does soil quality and day length effects (as well as the relevant precipitation regime). Nevertheless, agriculturalists and farmers both do not feel much concerned when the predicted warming trend is expressed in those terms.

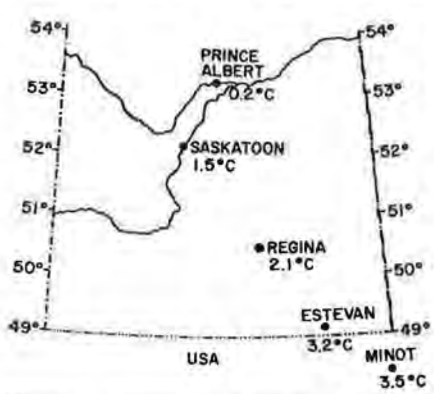

Figure 1 Annual mean temperatures at a few locations in southern Saskatchewan and northern North Dakota.

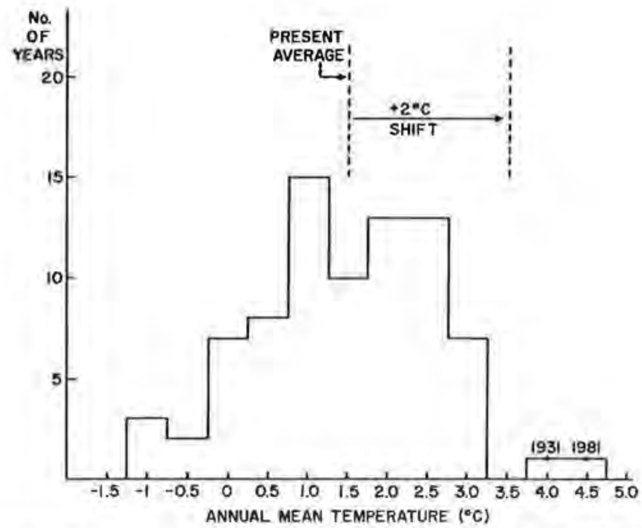

Figure 2 Distribution of annual mean temperatures at Saskatoon, 1900–1983.

When compared, however, with the long-term record at a single location, a 2 °C warming does appear more significant, but only when viewed on an annual or at least a seasonal basis. At Saskatoon, November 6 has a mean daily temperature of −2 °C. The coldest ever was −19 °C and the mildest was +9 °C – quite a range. It would be even greater for a January day, but less for a summer one. July 6, for instance, has a range from 9 to 27 °C at Saskatoon.

Each month is made up of days that are cooler than average, and days that are warmer. The result is that the monthly range is much reduced. The warmest July on record at Saskatoon was 22 °C in 1936, the coolest 14.6 °C in 1911. When several months are considered together (June, July and August, for instance) the range is even less; and when an entire year is averaged to get an annual mean temperature we have a quite stable value.

The long-term (84-year) average annual temperature for Saskatoon is 1.5 °C, and most years have a value differing from this by only 1 °C or less (see Figure 2).

One can easily appreciate the significance of a 2 °C warming. If we continue to get the same degree of variability as in the past, our average year would be warmer than all but two of the previous 84 years (1931 and 1981). Roughly one year in four would exceed even these in mean temperature.

When we look at specific agroclimate parameters even greater significance can be discerned for this warming. Consider those farming areas lying northwestwards of Saskatoon, as far as Alberta's Peace River area and to the east of Saskatoon into the Swan River district of Manitoba. In this "parkbelt region", as it is commonly called, farming success is more commonly limited by coolness than by dryness. In other words, the paucity of heat units (growing degree-days, or GDD) and the shortness of the frost-free season (FFS) tend to be the primary hazards.

Figure 3 shows how these would be affected, if our summers were on average warmer by 2 °C. For GDD, the curve of interest is the one for mean temperature ($\overline{T}$). Shifting all points on it upwards by 2 °C would indicate that GDD for the 170 days between April 25 and October 15 (where $\overline{T} \geq 5$ °C) would be increased by 340 units, which is 20% of the total of 1640 GDD at Saskatoon. The actual amount would not be exactly this, but close to it.

One GDD is counted for each degree that the mean temperature on a particular day is above 5 °C.

The FFS change is equally dramatic. Shifting the mean minimum line upwards by 2 °C would place 180 days at temperatures above 0 °C rather than

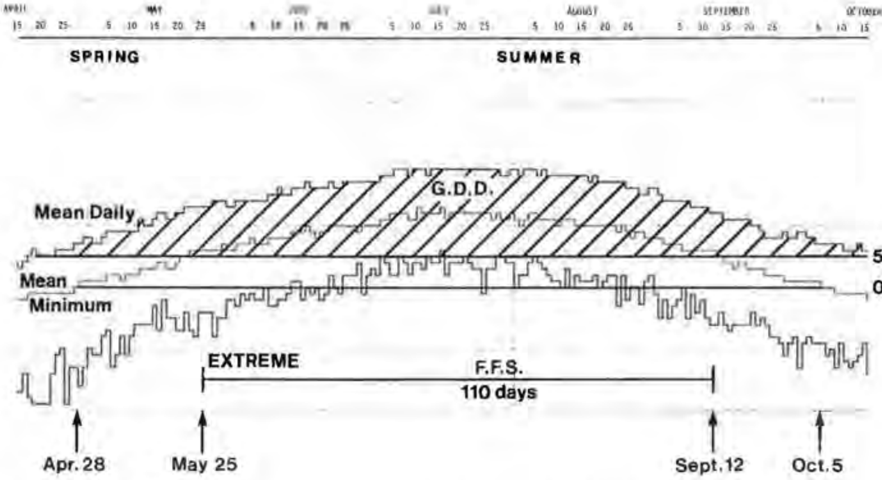

Figure 3 Daily temperature regime at Saskatoon, showing frost-free season (FFS) and growing degree-day (GDD) accumulation.

only 160 as at present. These dates do not translate into the true average FFS (based on averaging actual dates over past years in which $T_{min} \leq 0\,°C$) but the relative increase is roughly the same. Saskatoon, with an FFS of 110 days could expect to have 15 to 20 days added to this if the climate warmed 2 °C.

Such changes in GDD and FFS could be expected right across the northern edges of our parkbelt farm lands, and would indicate that agricultural activity could move farther north, if only the soils were there to permit it. In some areas, notably Alberta, they are there, but in others the existing soils abut the Precambrian Shield or poorly drained muskeg areas. Nevertheless, new crop varieties plus land drainage and increased fertilizer use could move farming well beyond its present limits in much of Canada.

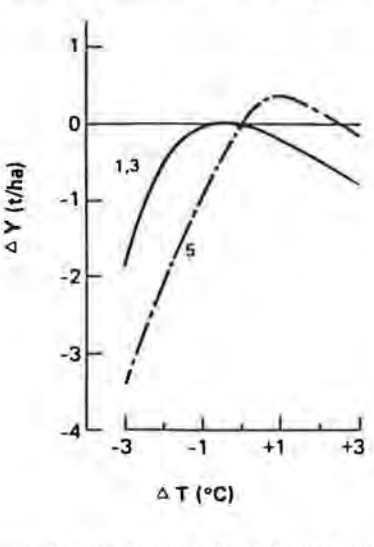

Figure 4 Changes in estimated dry matter yield (ΔY), with changes in mean temperature (ΔT) for cereals; 1 – south Saskatchewan; 3 – Prairie fringe; 5 – Peace River (from Bootsma et al., 1984); for no change in rainfall.

All this ignores the possible precipitation decrease that might accompany a warming, and the greater stress on crops that the warming might produce even with the same precipitation. While these effects are worrisome, especially for the southern grain-belt areas where lack of moisture, rather than coolness, appears as the limiting crop factor, I have ignored them for two reasons:

i) the precipitation pattern that would accompany any warming is even less certain than the magnitude and seasonal form of the warming itself; and even more important,

ii) the extra stress, supposedly placed on crops as a result of the warming, is either unreal or greatly exaggerated owing to the biological enhancement effect of CO_2.

GROWTH ENHANCEMENT

Growth enhancement is a vital factor missing at present whenever climate change scenarios are applied to agriculture (or to forestry for that matter). Figure 4 gives the effect that one scenario predicts for cereal crop production if the climate were to change through a doubling of CO_2. The two curves are the result of model calculations, based on production in past years, should the mean temperature either decrease by up to 3 °C or increase by this amount, with precipitation remaining unchanged. As might be expected, if the mean temperature change were zero, i.e., $\Delta T = 0\,°C$, the yields pass through zero change (i.e., same production as now). What is missing here is that if CO_2 were to double, yields would go up considerably even without any beneficial climate change. CO_2 is a vital plant food.

This fact has of course been known for a long time, but, except for using greenhouses, there was nothing a farmer could sensibly do to supply his crop with more CO_2. Over 400 controlled experiments were analyzed by B.A. Kimball (1983); he found that for almost every plant (the new exceptions being horticultural flower crops such as nasturtiums and poinsettias) production increased with increasing atmospheric CO_2 concentration (see Figure 5). A doubling of CO_2 was likely to provide an overall increase of 33% in yield (dry matter, grains or seeds) for the same weather conditions, with 99.9% confidence that the yield was between 24 and 43%. The best estimate for wheat was 32% for a CO_2 doubling, for barley 25%, for legumes 54% and for potatoes 25%.

WITH A DOUBLING OF CO_2 IN THE AIR
(FROM 330 TO 660 PPM):

1. MOST PLANT GROWTH WILL INCREASE BY 33%.
2. YIELDS FOR WHEAT, BARLEY, LEGUMES AND POTATOES WILL INCREASE BY 25 - 55%.
3. FOR WHEAT, THIS RATE OF INCREASE IS 0.1% FOR EACH 1 PPM INCREASE IN CO_2 LEVEL.
4. FOR WHEAT, THE PERCENTAGE INCREASE IS GREATER WHEN THE CROP IS WATER DEFICIENT THAN WHEN WATER SUPPLY IS ADEQUATE.

Figure 5 Conclusions from growth experiments at an elevated CO_2 level (Kimball, 1983).

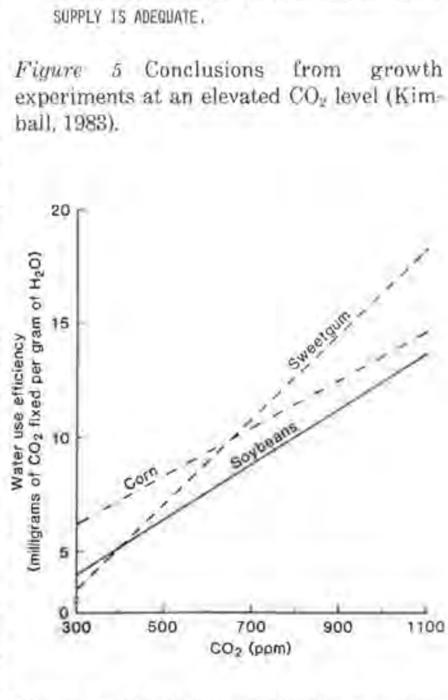

Figure 6 Water-use efficiencies for corn, soybeans and sweetgum at various CO_2 concentrations. Values were fitted by the method of least squares and are based on 46 observations for soybeans, 50 for corn and 15 for sweetgum (from Rogers et al., 1983).

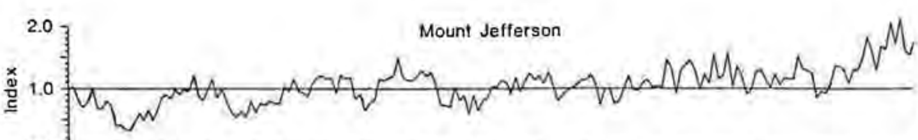

Figure 7 Ring width indices for limber pine, Mount Jefferson, Nevada, showing rapidly increasing growth since the 1960s (from LaMarche et al., 1984).

The data for wheat are particularly interesting since it has been studied fairly extensively. Individual tests resulted in increases of between 20 and 100% for control plots, with the greatest percentage increases tending to be found when water was limited (i.e., the wheat was being grown under drought or near-drought conditions). The reason for this finding lies in another observation that is receiving wide attention: plants tend to use water more efficiently at higher CO_2 levels. The stomata need not be open as wide, or for as long a time, to permit the same amount of CO_2 to be taken in; thus the water loss through transpiration would be reduced (see Figure 6).

The question naturally arises: Is there any evidence that plant growth is presently increasing, given the known rise in CO_2 levels since 1958 at least? The answer is "yes", for at least two species of trees. Detailed analyses of annual tree-ring growth for limber and bristle-cone pines in the western United States show an interesting upward trend over the past two decades (see Figure 7). This increase in tree mass persists even after the data are adjusted for climate trends.

To bring the situation a bit closer to home, consider the finding (Figure 5) that for wheat there would likely be (on the basis of growth trials to date) a 0.1% increase in yield for each part per million increase in CO_2 level, all other factors remaining the same. This implies that between 1973 and 1981 the added 10 ppm of CO_2 effected a wheat yield increase on the Prairies of 1%, i.e., a quarter bushel per acre above an expected 25 bu/acre value (17 kg/ha on a 1.7 tonne/ha crop). For a farmer with 500–1000 acres of wheat, this translates into an increase in gross return of some $500 to $1,000 that he would not otherwise have received that year. This is not an enormous increase; unfortunately all the other factors that affect yield make it impossible to separate, but nevertheless there it is.

PROMISES AND CHALLENGES

The promise for Canadian agriculture then is greater growth on today's farmland from higher CO_2 levels, potentially enhanced further by a warmer growing season, but possibly stressed a bit in some areas by moisture deficiency. Some northerly areas will be opened up to farming, while in some southerly areas further crop diversification will be possible.

As to challenges, it will become necessary to study the northerly grey-wooded soils more intensively, and to identify or develop crops and varieties that can grow there, not at today's CO_2 level and climate limits but at tomorrow's. It will be necessary to determine the "trade-off" between potential increases in moisture stress and increased water-use efficiency for different crops and crop varieties that could be introduced into the more southerly farming regions.

Each of these challenges is a major undertaking with many possible facets and problems. Many farming practices may have to be modified. As an example of yet another problem: Even the weeds will grow more efficiently at elevated CO_2 levels!

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Dr. John Maybank is Director of the Environment Sector, Saskatchewan Research Council, in Saskatoon. His research activities have encompassed studies on hail suppression, agricultural needs for weather modification, pollutant emissions and solar-terrestrial energy/weather interactions. He is Chairman of the Saskatchewan Committee on Agricultural Meteorology and serves as a member of various national and provincial committees dealing with the environment and the weather. Dr. Maybank was President of the Canadian Meteorological and Oceanographic Society in 1980–81.

RÉSUMÉ *Au milieu de la confusion qui entoure le sujet controversé communément connu sous le nom d'effet de serre, on reconnaît unanimement le fait que la concentration du* CO_2 *dans l'atmosphère augmente et ce, depuis au moins 1958. Cela implique des répercussions sur l'agriculture canadienne : premièrement une tendance vers un réchauffement éventuel avec ou sans changement des précipitations et deuxièmement, une accélération du taux de croissance.*

En ce qui concerne la première, l'évaluation la plus favorable à l'heure actuelle indique que si le CO_2 *dans l'atmosphère en vient à doubler, il en résultera une hausse moyenne de la température de l'ordre de 2–3 °C sous les latitudes canadiennes. Un tel réchauffement permettrait de pousser la production de récoltes vers le nord et d'obtenir de meilleurs rendements dans les régions d'exploitation agricole actuellement affectées par le froid. Cependant, il se peut que la qualité des sols restreigne ce mouvement vers le nord tandis qu'une diminution quelconque des précipitations accompagnant le réchauffement réduise considérablement la production des récoltes dans les régions sujettes à la sécheresse.*

La deuxième répercussion d'une concentration double de CO_2*, est encore plus importante pour l'avenir de l'agriculture au Canada. En effet, d'après les données actuelles, presque toutes les espèces végétales connaîtront un taux de croissance plus élevé par suite d'une plus grande concentration de* CO_2 *, avec une augmentation moyenne de 30 % pour la culture sèche si la concentration du* CO_2 *doublait. Pour une même concentration, les expériences faites jusqu'à présent indiquent une augmentation en production du blé de 20 à 100 %. De plus, le blé, comme la plupart des produits céréaliers et oléagineux emmagasineraient l'humidité disponible de façon plus efficace permettant ainsi aux fermiers de maintenir de bonnes récoltes même si les précipitations moyennes diminuaient.*

Donc, l'effet principal prévu d'une atmosphère plus riche en CO_2 *sera plus que bénéfique au potentiel de la production alimentaire du Canada. Bien que cela soit possible sans changement climatique, il va sans dire que toute tendance à un réchauffement, augmentant de façon significative la durée de la saison sans gel ou le total des degrés-jours de croissance, représenterait un avantage supplémentaire, à condition bien sûr que la hauteur de pluie pour la saison de croissance, ne soit pas trop réduite.*

THE METEOROLOGICAL SERVICE IN CHINA

by Wei Yan

There exists a long history of meteorological science and its applications in China. For example, the sidereal year was divided into 24 "solar terms" which were used to guide farmers more than 2,500 years ago, and raingauges were already standardized as early as the year 1425.

The ancient achievements of meteorological science in China have contributed much to her ever-increasing progress in food production and her influence on world civilization. However, feudalistic oppression has retarded the development of modern meteorology in China. It was not until the founding of the People's Republic in 1949 that a significant change took place. The Chinese population suffered terribly from natural disasters in the old days and were without adequate assistance from a well-organized meteorological warning system. Prior to the revolution in China, throughout the country's 9.6 million square kilometres, there were only 72 meteorological stations, which had low-quality imported equipment and produced records which were far from complete. As a result, the accuracy of weather forecasts was poor.

Since the founding of the new China, the government has attached great importance to meteorology and has provided strong leadership. Currently it is estimated that in the People's Republic, over 60,000 people work for the meteorological service or as specialists in the field of meteorology. The following is a brief review of the Chinese Meteorological Service and a description of its structure, operations and activities.

THE STRUCTURE OF THE METEOROLOGICAL SERVICE

The structure of the Meteorological Service in China reflects the country's administrative structure; it follows the hierarchy of state, province, prefecture and county. The national headquarters of the Meteorological Service is situated in the capital, Beijing. Under the direct leadership of the State Council of the Central Government, the State Meteorological Administration (SMA) is the body responsible for organizing and administering national meteorological activities.

The Chinese National Meteorological Centre at Beijing (SMA photograph).

Currently, the SMA has a staff of 58,000 (2,000 in Beijing alone) and controls 29 provincial meteorological bureaus, 240 meteorological observatories at the central, provincial and prefectural levels and over 2,700 weather stations, including 600 synoptic, 200 agrometeorological, 110 upper-air (radiosonde), 80 upper-air wind (pilot balloon) and 170 weather radar stations. The remainder are mostly climatological stations. Located in Beijing are the National Meteorological Centre, the Centre for Satellite Meteorology and the Academy of Meteorological Sciences.

Within the SMA, seven departments have separate responsibilities dealing with such areas as: routine operations management, research and education, planning and finance, equipment and supplies, external relations, technical development and personnel.

The National Meteorological Centre (NMC) is the meteorological operations headquarters comprising a central forecasting office, a telecommunications division for data collection and dissemination, and a data office for climatological statistics and publications. The NMC, which also functions as a regional telecommunications hub (RTH) in the World Weather Watch (WWW), is equipped with both Chinese and imported computers for meteorological telecommunications and operational numerical weather prediction using a four-level primitive equation model. The numerical forecasts are made once a day for 3 days ahead and distributed by facsimile throughout the country.

In the Centre for Satellite Meteorology, which was founded in the early seventies, some efforts are still being made to launch our own meteorological satellite. Most of the equipment, including the launching facilities and the satellites themselves, are produced in China. Currently imagery is received from the Japanese meteorological satellite.

The Academy of Meteorological Sciences comprises seven Research Institutes. The five in Beijing deal with synoptic meteorology and climatology, atmospheric soundings, weather modification, scientific and technical information, and meteorological methodology; the other two are the Institute for Tropical Meteorology in Guangzhou and the Typhoon Research Institute in Shanghai.

In addition, three meteorological training colleges and three specialized schools are situated at different locations in the country under the direction of the SMA. Many colleges and universities,

Measurements of humidity in a cotton plantation (SMA photograph).

supervised by the Ministry of Education, have departments of meteorology that offer courses and confer degrees in this field.

Each province, central governing municipality and autonomous region has a meteorological bureau that plays a very important role in the Chinese meteorological service under the administration of the SMA, viz., in organizing and supervising regional meteorological activities. A typical bureau has a staff of 400 to 600 employees. Similarly, but much less structured than the SMA, a bureau may have divisions of operations management, finance, equipment and supplies and personnel. Under the direction of a bureau, a provincial meteorological observatory is the regional operations centre responsible for routine weather forecasts for the whole province. Also, each bureau has a fairly small research institute unit for applied research that serves local needs, and a small data office collecting data and weather information. Some bureaus have a training school for the purpose of training technicians.

Under each provincial meteorological bureau, there are several prefectural observatories, which report to the bureau and manage all the county weather stations within the prefectures. The weather stations are mainly for data acquisition: some are synoptic and others are climatological. Here it should be noted that all the prefectural observatories and the county weather stations have forecast responsibilities serving local meteorological interests. In this aspect, they have different responsibilities than the weather offices and weather stations in Canada.

OPERATIONAL METEOROLOGICAL SERVICES

Apart from the administration by the SMA, a provincial meteorological bureau is partly controlled by the local provincial government and has very close relationships with various local administrative organizations.

Take the example of my own province - Zhejiang Province, located at the mean latitude of 29°N, south of Shanghai, and adjacent to the East China Sea - a province one tenth the size of Ontario. At present we have 1 provincial and 10 prefectural meteorological observatories; 2 radiosonde; 6 weather radar; and over 60 county weather stations. of which 15 are synoptic in the national weather network and the rest are climatological.

The Zhejiang Provincial Observatory of Meteorology, established in the fifties, has a staff of about 70. Half of these are meteorologists, working in three different operational divisions: the short-, medium- and long-range forecasting groups. The others are mostly technicians working in groups responsible for satellite picture reception, telecommunications and maintenance, chart plotting, and provision of service. The three forecasting groups are in charge of the weather forecasts issued for periods of up to 3 days, 3 to 10 days, and 10 days to several months. The head of the observatory reports to the director of the provincial bureau.

The backbone of the meteorological bureau is the observatory, while the core of the observatory is the short-range forecasting group. This is understandable, since people are more concerned about the weather for tomorrow rather than that for the next 10 days, and more so since the accuracy of a long-range forecast is still not too satisfactory. The short-range forecasting group in my observatory has 20 forecasters, the majority of whom are graduates from universities; some of them have more than 20 years of forecasting experience. Normally, one working shift requires 1 supervisor and 3 forecasters who are responsible for general public and marine forecasts and assistant duties. In order to monitor the weather systems successively, the shift length is 24 hours, within which there are several breaks for the shift forecasters. The main duties during the shift are manually analysing weather maps, producing the forecasts and answering routine telephone calls.

During a 24-hour shift, there is at least one formal discussion about the evolution of the weather system and the elements to be forecast. The final forecast is based on the collection of all the weather reports and information from weather charts, and data from subobservatories and weather stations. Reference is also made to satellite pictures and numerical weather prediction products issued by the NMC in Beijing and transmitted via automatic picture transmission (APT) facsimile circuits, and the exchange of ideas and opinions with forecasters from nearby observatories. The forecasts are then delivered to the radio broadcasting and television networks, which transmit them to the public three to four times a day. Even the small county weather stations produce their own local forecasts, which are disseminated by the county stations. Each morning at 8 o'clock in the forecast office in my observatory, there is a routine briefing when the shift is handed over to the next.

Satellite APT information is widely used at observatories in the provinces and in large cities. Also, some observatories have modern sounding, computing and data-transmitting equipment. A national radar network to detect and measure wind, precipitation and severe storms and a coastal radar system to warn of typhoons has been set up.

Chinese meteorologists often visit agricultural communities, pasture lands, mining centres and fishing areas to find out, at first hand, the specific needs of the people engaged in these activities so as to provide a better and more meaningful service. Agriculture is still the fundamental component of the Chinese economy. It must be remembered that China is the largest country in the world with a population of one billion. Since agriculture is directly subject to the impact of weather and climate, it is given first priority in the provision of meteorological services.

These include information, data and results from meteorological studies and weather modification activities, according to the farmer's requirements for different crops at different stages of growth. For example, meteorologists pay much attention to the prognosis of rain accompanied by low temperature during the spring season which may cause rotting of the rice seedlings. Also we provide farmers with the appropriate date to seed, as well as the long-range forecasts of precipitation amounts during the rainy season and the prediction of early frost in the fall. China is unique in having about 200 weather stations serving agriculture alone. Assisted by the synoptic background material prepared by forecast offices in the observatories, meteorologists in county weather stations use different types of statistical techniques to produce short-, medium-, and long-range weather forecasts that take local conditions into consideration. They are distributed to the farmers several times a day via rural stations.

Providing good meteorological services to fishermen is one of the important assignments of my observatory, since the largest fishing area of China is located in my province. In addition to the routine marine forecasts, which are issued several times a day, we also provide warnings to the fishing area authorities whenever we consider it necessary. Also, in winter, during the busiest season, our observatory assigns some meteorologists to the fishing area, to work closely with the meteorologists from other observatories in order to offer on-the-spot service.

The most catastrophic weather events in my province during the rainy and typhoon seasons are rainstorms that could flood farm lands and cause the collapse and bursting of reservoirs, typhoons which bring strong winds and heavy precipitation, and late spring hail. During these seasons, the meteorologists and technicians work many hours of overtime to deal with the emergencies, monitor the changes of the weather systems and issue the many watches and warnings. The hardest working person in my observatory is the head, who has more experience in coping with these

Cloud chamber, SMA, Beijing. (Photograph: R.S. Schemenauer, Environment Canada)

kinds of emergencies. After an emergency, meteorologists normally carry out investigations in order to gain from this forecasting experience.

One of the recent responsibilities at our observatory, and similarly at other observatories throughout the country, is the formation of a service group. Their responsibility is to collect general information about weather events in cooperation with the meteorologists at the forecast office. They present special weather forecasts that fit the individual requirements and special interests of some companies, factories, reservoirs, and specialized users through financial contracts arranged with them. This results in a closer relationship between meteorologists and the users of the forecast products, and to some extent combines one's personal interest with one's work and encourages meteorologists to provide a better service. This is in step with the economic reforms currently under way in China.

Nowadays, the general situation in China is very favourable. Some tremendous changes are expected in meteorology, which will certainly result from the reform of the economic structures. As a weather forecaster, I eagerly look forward to using electronic computers in our forecast offices in the near future. Forecasting the weather by depending on experience alone and by manually carrying out procedures is not really meeting the four objectives established to modernize our weather services. Computers will be a part of the new up-to-date operational system that will result in significant improvements in forecasting, particularly of potentially disastrous weather events, as well as in telecommunications, data processing and numerical weather prediction. We are trying to learn as much as possible from what is positive in other countries. There are promising opportunities for international scientific and technical cooperation, and a world-wide free flow of scientific ideas that will be brought about by academic exchange in the field of the atmospheric sciences. We will do our best to improve international cooperation. We are confident about the future of meteorology in China and further about our ability to contribute much more effectively to meteorological activities throughout the world.

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Wei Yan is a meteorologist with the People's Republic of China State Meteorological Administration, employed as a forecaster at the Zhejiang Provincial Observatory of Meteorology in Hangzhou, Zhejiang Province of east central China. During 1984–85 he participated in the Canadian International Development Agency/World University Service of Canada program, and while in Canada was assigned to various Atmospheric Environment Service units dealing with weather service operations and forecast research.

RÉSUMÉ *On décrit le Service météorologique chinois : l'organisation, l'exploitation et la recherche. Le personnel comprend 58 000 personnes, installées dans 29 bureaux provinciaux, 240 observatoires météorologiques à l'échelon central, provincial et préfectoral, 2700 stations météorologiques, trois instituts de formation et trois écoles spécialisées. Environ 2000 personnes travaillent à Beijing pour le Centre national de météorologie, le Centre d'applications météorologiques des satellites et la Société des sciences météorologiques.*

On décrit également les activités opérationnelles de l'Observatoire provincial de météorologie à Zhejiang. La moitié des 70 employés sont des météorologues qui fournissent les prévisions à court, à moyen et à long terme principalement destinées à l'agriculture, un élément essentiel de l'économie chinoise. L'Observatoire offre aussi un service de prévisions et d'avertissements aux pêcheurs qui travaillent dans la limite des frontières provinciales de la région de pêche la plus importante en Chine.

L'exploitation grandissante d'une technologie avancée, y compris les ordinateurs et le satellite météorologique chinois, confirme qu'il y aura une amélioration considérable des services de prévisions météorologiques dans les quelques années à venir.

CANADIAN PARTICIPATION IN THE U.S. NATIONAL WEATHER SERVICE'S OLYMPIC SUPPORT PROGRAM

by André Lachapelle

In the early 1980s, Dr. Richard Hallgren, the Assistant Administrator for National Weather Services (NWS) of the U.S. National Oceanic and Atmospheric Administration (NOAA), proposed international participation in future weather support for Olympic Games. He also proposed a trial of this concept using the Weather Support Unit for the XXIIIrd Olympiad, held in Los Angeles, California, in the summer of 1984.

To this end, Dr. Hallgren approached Mr. Jim Bruce, Assistant Deputy Minister of the Atmospheric Environment Service (AES) and Monsieur J. Labrousse, Directeur de la météorologie nationale of France. Each national service provided two meteorologists.

Monique Loiselle of the AES Ontario Region's Scientific Services Division and myself were the Canadians chosen. The two French meteorologists were Michel Anne, Chief of Meteorological Services, Regional Meteorological Centre, Bordeaux and René Mayençon, Chief of the Toulon Marine Meteorological Station.

The planning and establishing of the Olympic Support Units (one unit for all outdoor venues except yachting; the second for the sailing events) was the responsibility of the NWS Western Region Headquarters in Salt Lake City, Utah, and the Office of Meteorology in Maryland. Both Canadian meteorologists were assigned to the main unit. The total complement of the two support units consisted of twenty-two meteorologists, meteorological technicians, electronic technicians, and oceanographers. Many more had also been involved in the planning and preparing for this effort.

The NWS made the necessary arrangements for accommodations in the overtaxed tourist facilities of Los Angeles. Comprehensive training packages were prepared and sent to the AES participants well in advance of the beginning of the weather support activities. The training package provided an excellent familiarization with southern California weather.

Monique Loiselle and I arrived in Los Angeles on July 19, nine days before the Opening Ceremonies.

The first few days were used for training and familiarizing Monique and myself concerning the local topography and climatology, the standard NWS equipment including the AFOS system (Automation of Field Operations and Services), and special equipment set up for the Olympic Support Unit (OSU).

NOAA data buoy anchored offshore past the farthest yachting course. Data are automatically radioed to shore.

The work began in earnest during the week before the opening ceremonies. Much of the week was spent on doing a shake-down of the operations. The level of genuine interest and cooperation of all members of the OSU was excellent. This resulted in a rapid tailoring of product output and weather-radio broadcast schedules which had been proposed in the NWS planning document, "Serving the Weather Needs of the 1984 Olympics".

The OSU was collocated with the Los Angeles Weather Service Forecast Office (WSFO). This proximity was appreciated since it provided the members of the support team with a ready pool of expertise on the local climatology. Most of the American meteorologists of the OSU were from outside of the Los Angeles area including one from Arizona.

The hours of work might be considered unusual since the morning shift began at 5 a.m. and the afternoon shift at 1 p.m. There was no coverage between the hours of 9 p.m. and 5 a.m. by OSU members; however, the Los Angeles WSFO is a 24-hour operation and was aware of our product content.

The "Olympic Office" adjacent to the NWS Forecast Office in Los Angeles.

The "Weather Boat" used to monitor meteorological and oceanographic conditions in and around the yachting courses.

Activity inside the NWS trailer at Long Beach before briefing the crews.

The well-publicized security at the Olympics even extended to the OSU and its operations. As we were not within the confines of an Olympic Centre or Venue, we were unable to input our forecasts directly into the Olympics communication system. Instead they were received at one of the Olympic operations centres and were manually entered into their system. Our evening forecasts were published daily in the *Los Angeles Times*.

The data support for the forecast operation consisted of the regular southern California observing network augmented by nine Portable Automated Mesomet (PAM) weather stations and permanent Alert Weather Stations at the L.A. Coliseum and at Lake Casitas (site of the rowing/canoeing events). The PAM network equipment had been borrowed from the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. These stations were polled by the NCAR computer via the GOES West satellite. Micro-computers in the OSU would in turn retrieve the information from Boulder and pass it to the AFOS system. Additional wind data were also obtained from twenty automatic stations operated by the South Coast Air Quality Management District. In all, we had access to observations (manned and automated) from about 65 locations within a 150-kilometre radius. Not only did this fine-mesh data network provide the information necessary for the preparation of the venue forecasts, but the data were archived as part of "Project Basin", which had been set up to study the mesoscale weather patterns of the Los Angeles Basin, home to upwards of ten million people.

A NOAA Weather Radio (NWR) located at the WSFO disseminated weather information to the greater Los Angeles area. A second NWR was installed in the WSFO radio room and a second transmitter was deployed on Mount Wilson, site of the regular Los Angeles NWR transmitter. The Olympic NWR program comprised bilingual (English and French) broadcasts of the venue forecasts and nowcasts, the latter being short two-to-three hour forecasts of changes at each venue. Additionally, a "Weather Back Home" segment was prepared and broadcast in the evenings; this was an around-the-world summary of conditions in major cities.

The Long Beach support team served the needs of the sailing events and was housed in a large trailer situated in the middle of the yachting operations. Because of its distance from the Los Angeles WSFO, the Long Beach office was equipped in a manner similar to an NWS presentation office. The operational day began around 6 a.m. A mass briefing took place at 10 a.m. when about forty people, both crew members and national team meteorologists, would attend. A regular part of the daily routine involved the gathering of data offshore in areas very near the race courses. The Yachting Support Team had a 26-foot motor-boat at their disposal to do this. This boat was owned by a local businessman who had volunteered his time and the use of his boat to the NWS for the duration of the sailing competitions. The team members aboard the motor-boat gathered meteorological, wave and ocean current observations from various locations in and around the four race courses.

The weather for the two weeks of the Olympics and for the week preceding the Opening Ceremonies was generally excellent. All but two days were sunny with temperatures ranging from around 25 °C at the beaches to better than 35 °C about 15 kilometres inland. The most abnormal aspects of this period were the relatively high humidity and the very low air pollution. The high humidity frequently resulted in reduced visibility because of haze which many misinterpreted to be smog; however, throughout the period of the games, the pollution count was unusually low. "Catalina Eddies", small-scale low pressure centres which form near Catalina island, proved to be the trickier forecast problem for this area. These eddies have a significant impact on the wind development and flow over the Los Angeles Basin.

The international aspect of the weather support did not stop with just Canada and France. Korea also sent a representative, Mr. Moon-il Kim, to observe the NWS operations with a view to developing the weather support needed for the 1988 Summer Games to be held in Seoul.

On the social side, a number of Weather Support organizers and participants were able to gather together on a couple of occasions, adding to the cohesion of the group. Near the end of the Olympics, the Regional Director of the NWS Western Region, Mr. Hazen Bedke, presented a commemorative plaque to each member of the Support Teams, providing a beautiful keepsake of our participation in this unique venture.

One of the major benefits gained from this experience for Canada is for the planning and establishment of the weather support for the XVth Olympic Winter Games to be held in and around Calgary, Alberta in February 1988. A description of the anticipated weather support is being prepared, which will incorporate a number of the experiences gained by Monique and myself during the summer of 1984.

Finally, to answer many of the silent questions that the reader may have, a few personal notes. The work schedule averaged forty hours per week for the three and one-half week period of weather support. This left me ample time for many other activities, which included lounging around a pool, attending some of the events, exploring the sights and the restaurants of Los Angeles, visiting Disneyland, spending a day at the beach, and enjoying an outing on the NWS meteorological motorboat (despite the near two-metre waves). The off-hours period served to complement the already-unique work experience making the entire period one that I will remember fondly for years to come.

The morning briefing outside the NWS trailer at Long Beach.

Long Beach Harbour decked out for the Olympics, site of the yachting events.

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André Lachappelle is a supervising meteorologist at the AES Alberta Weather Centre in Edmonton, with many years of experience in climate applications and weather forecasting. Photographs are provided by the author.

RÉSUMÉ *L'auteur est un des deux météorologues canadiens choisis par le Service de l'environnement atmosphérique pour participer au travail de l'équipe responsable des services météorologiques pour les Jeux olympiques de 1984 à Los Angeles. Cette équipe se composait de prévisionnistes du NWS (National Weather Service des États-Unis) aidés de prévisionnistes français et canadiens qui, en plus de leurs tâches habituelles, offraient des services en français.*

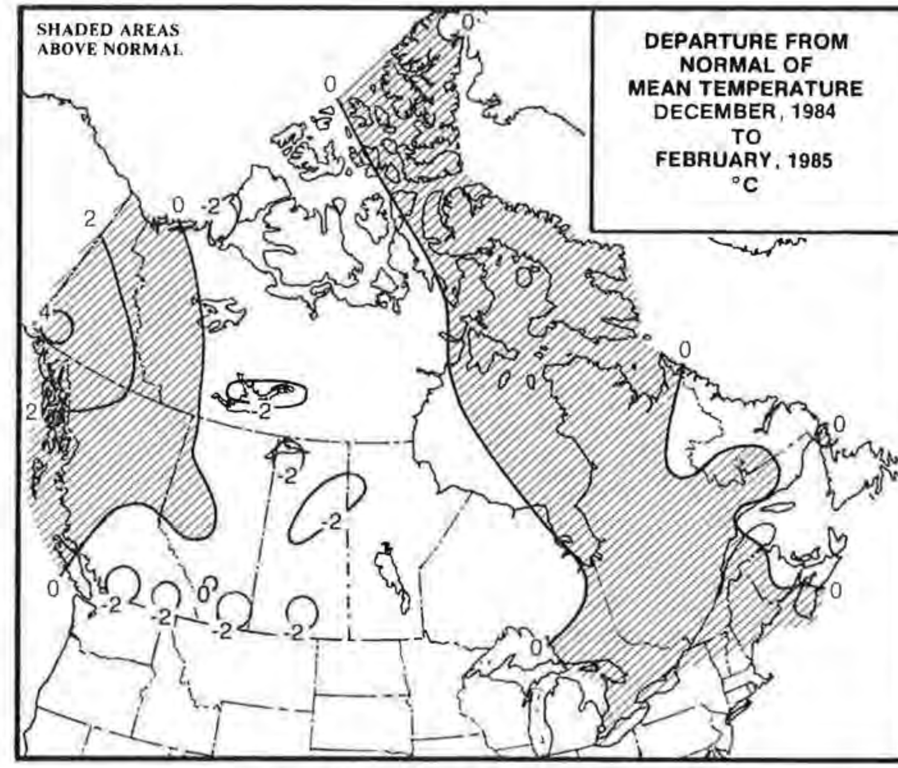
Parmi les nombreux services quotidiens, citons les prévisions du temps et les conditions météorologiques actuelles (nowcast) pour lieux de compétition en plein air et un service d'exposés météorologiques et de consultation pour les médias et les athlètes. L'équipe météorologique comprenait un groupe responsable des services pour les courses de voiliers à Long Beach et un groupe dont faisaient partie les deux météorologues canadiens, pour toutes les autres disciplines en plein air. Les prévisionnistes avaient à leur disposition les données du système américain d'accès à l'information météorologique AFOS du NWS et les données du réseau de stations d'observation automatiques, à tous les sites de compétition en plein air. Toutes ces données ont aidé à fournir en détail les renseignements météorologiques adaptés aux besoins des usagers.

CANADIAN WEATHER REVIEW: WINTER OF 1984-85

by Andy Radomski

Winter snowfalls in the Yukon and the Mackenzie District and along the Labrador coast were unusually heavy. Precipitation amounts were above normal in southern and central Ontario, where in a number of instances, total snowfalls were half as much again. Mean temperatures, were near or above normal, the only exception being Labrador; Yukon had the greatest departure from normal of between +2 and +4°C.

Weather throughout much of central Canada and southern British Columbia was cold and dry. Several Vancouver Island and southern B.C. localities recorded only half their normal winter precipitation. Temperatures in the Okanagan were 3° below normal. Snowfalls in southern Québec were below normal, but near normal elsewhere across the Province. Precipitation in the Maritimes was significantly below normal, mainly because of the lack of any appreciable rain in January and snow in February. New Brunswick had the least precipitation - seasonal totals were about half of normal.



DECEMBER

Winter was a season of wide ranging temperature fluctuations; December was no exception. Mild and well above normal temperatures in the Prairies early in the month tumbled as a bitterly cold Arctic air mass encompassed all of western Canada. Minimum temperatures in the Yukon hovered near the minus fifties for four consecutive days. At four B.C. locations including Vancouver, this was the coldest December ever recorded. Several long-standing monthly minimum temperature records were smashed. Gales were frequent along the B.C. coast; on December 28 and 29, near-blizzard conditions affected a large portion of the lower mainland. The extreme cold temporarily curtailed skiing in the Rockies, and shut down logging operations in the interior. The Arctic air remained firmly entrenched in the Prairies until January. On occasion, strong chinooks caused temperatures in Alberta to soar briefly to the double digits breaking numerous daily temperature records; strong winds associated with this warming gusted to over 100 km/h in the foothills. Numerous new minimum daily temperature records were established during the Christmas period. Blizzards and dangerous wind chills occurred frequently, but with a few exceptions, snowfalls were generally light.

Weather conditions in the eastern half of the country were relatively passive, excepting the above normal temperatures in the southern portions of Ontario and Québec and the below normal precipitation in the Atlantic Provinces. Southern Ontario received more than its fair share of freezing rain, while northwestern Ontario recorded double the normal snowfall amounts. Heavy rains over the Christmas season virtually eliminated the snow cover in southern and central Ontario temporarily closing down ski resorts.

In Québec, skiing got off to a good start. Two major snowstorms paralyzed the Eastern Townships, New Brunswick and Labrador, while heavy rains quenched the drought-stricken areas in Nova Scotia. Snowfalls ranged from 50 to 140 centimetres. Towards month's end an Arctic outbreak produced many daily and monthly minimum temperature records in Newfoundland.

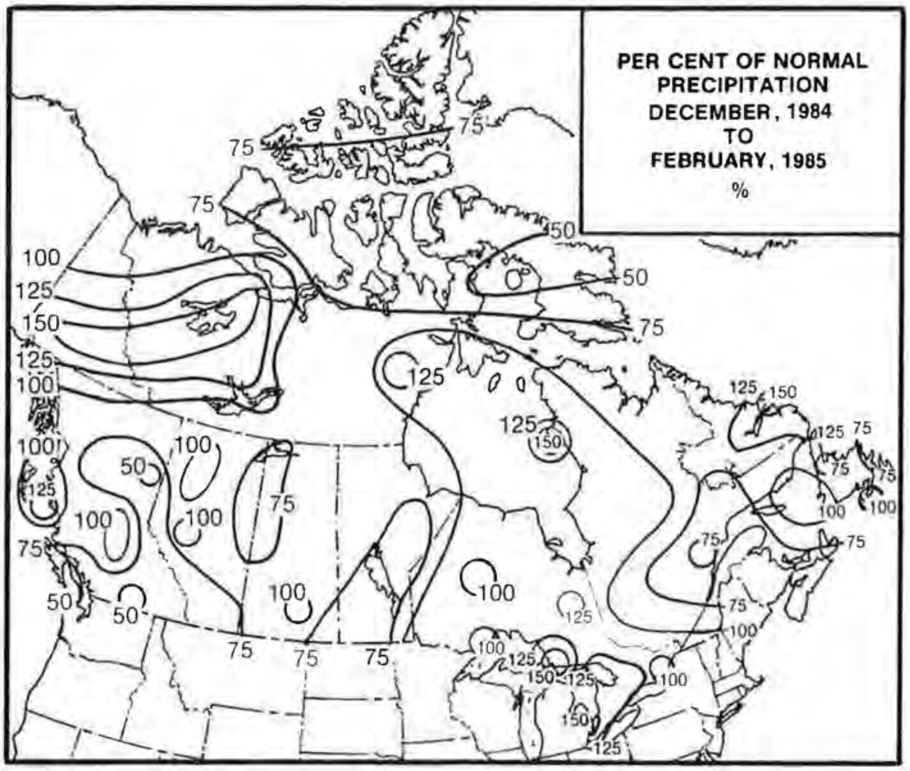
JANUARY

At the beginning of the new year a marked temperature reversal took place, when persistent mild Pacific air penetrated into western Canada, keeping cold outbreaks, blizzards and dangerous wind chills to a minimum. Highest January temperature anomalies were recorded in the northwest, where temperatures averaged between 10 and 20 degrees above normal. Many B.C. locations experienced their warmest January ever, along with unusually dry conditions. Fog plagued interior valleys and the southern coastline. Many new daily high temperature records were established in western Canada. In Alberta, chinooks played an important role, especially in the foothills, where winds frequently gusted to 100 km/h. With the storm track displaced to the north, snowfalls were unusually light in western Canada, especially in the southern agricultural districts, and were often less than half of normal. Banff received only one centimetre of new snow during January. However, snowfalls in the northwest, near the storm track, were above normal.

Winter was very pronounced in eastern Canada. Ontario snowfalls were above normal. During a 4-day period in mid-January, snow squalls and blizzards buried parts of southern Ontario closing highways and isolating many communities. Some southwestern areas received more than 40 cm of snow in a 24-hour period.

Sunny but cold weather prevailed in Québec and the Atlantic Provinces. Snowfalls along the St. Lawrence Valley and the North Shore were half of normal, but several major snowstorms struck the East Coast, leaving behind snowfalls that were above normal in Newfoundland and record-breaking in Labrador. Some Island areas received twice their normal amounts. Goose Bay and Cartwright set new January records of 235 and 237 centimetres, respectively. At the end of the month Cartwright had accumulated 300 cm of snow on the ground.

Ice formed rapidly on the St. Lawrence River and several ice jams blocked the shipping channel for a few days. Ice cover in the Gulf of St. Lawrence was more extensive than usual; the ice-pack along the East Coast drifted much farther south, and was more extensive than normal forcing five ocean drilling rigs to leave the Hibernia site. Canadian ice-breakers were busy keeping shipping routes open.



FEBRUARY

Strong onshore winds allowed a series of Pacific weather systems to approach the West Coast, and move inland. Gales were quite regular on the coast even gusting to 176 km/h on February 11. With the exception of the southern agricultural districts, snowfalls were unusually heavy in western Canada, especially in central and northern British Columbia, the Yukon, the Northwest Territories and northern Manitoba. Several new monthly snowfall records were set. In one, two-day period, communities on the north coast were inundated with more than 100 cm of snow, and two metres of fresh powder fell in the mountains.

Extremely cold Arctic air streamed southward from the Beaufort Sea frequently dropping temperatures to the minus fifties in the Yukon and Northwest Territories, and the mid-minus forties in the Prairies breaking many daily minimum records. Travellers warnings were issued systematically for the Yukon and the Mackenzie District owing to blowing snow and extreme wind chills. On February 8 and 9, southern Saskatchewan experienced a fierce blizzard. On February 14, heavy thunderstorms developed in the British Columbia interior and moved into the Grand Prairie district of Alberta accompanied by heavy snow squalls and damaging winds. Temperatures moderated significantly by the middle of the month and the weather became almost spring-like.

In Ontario there were sharp weather contrasts: bitter cold during early January was followed by more moderate temperatures. Mean temperatures were near or above normal throughout much of eastern Canada. Snowfalls were unusually heavy in southern and central Ontario. Heavy rainfalls were also experienced in southwestern areas contributing to heavy flooding in the Chatham District. Many monthly precipitation and snowfall records were broken in the south; Windsor had the snowiest February since 1965.

In Québec February was relatively tranquil but cloudy. Snowfalls were light, so that skiing conditions slowly deteriorated. Heavy rains fell in southwestern Québec during the latter part of the month, including a swath of freezing rain along the St. Lawrence Valley, which coated trees with several centimetres of ice.

The weather was generally seasonal in the Maritimes but changeable in Newfoundland. Total snowfall during February was well below normal even though several major storms buffetted the East Coast. The relatively dry and cold winter resulted in insufficient run-off for the generation of hydroelectricity, and more expensive oil-fired thermal generators had to be used in Newfoundland. Precipitation in the Maritimes since December (even since August) has consistently been below normal. Thus stream and river flows in the Maritimes have been at critically low levels and sometimes have not been as low since 1922. The driest area lies in and around the Canaan River area of New Brunswick, where only 19 per cent of the normal cumulative runoff has occurred since October 1984.

Mild weather during the latter half of February allowed earlier than normal ice break-up on the St. Lawrence River. Ice conditions in the Gulf were the heaviest in the last five years, but ice-breakers kept the shipping routes relatively trouble-free. The East Coast ice-pack remained much farther south than normal and at one time threatened the Venture drilling fields near Sable Island. Ferry service to Newfoundland was hampered owing to heavy ice drifting eastwards through Cabot Strait, and ice-breakers were frequently needed.

Andy Radomski is engaged in climate modelling and prediction studies in the Canadian Climate Centre and is Editor of the AES periodical *Climatic Perspectives*.

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Articles on topics of general interest in meteorology and oceanography, written in either English or French and suitable for a high school readership, are invited.

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Literature citations within the text are discouraged. Instead, it is suggested that credit for results and ideas be given by naming the authors or their institutions in the text, and including references at the end of the text in the form of a short "Suggested Reading" list. A reference to a journal article should include the authors' names and initials, year of publication, full title of article, and journal name, volume number and page numbers. A reference to a book should include the authors' names and initials, year of publication, title of book, and the publisher's name and address. All references should be listed in the alphabetical order of the first authors' surnames.

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Two double-spaced typewritten copies of the manuscript should be sent to: *Chinook* Editor, c/o Canadian Meteorological and Oceanographic Society, 151 Slater Street, Suite 805, Ottawa, Ontario, Canada K1P 5H3. Finished line drawings and good quality black-and-white photographs (one original and two photocopies of each) should be included. Colour illustrations or photographs are welcome as candidates for the front cover of each issue. Contributors are also asked to provide a short description (about 50 words) of their professional affiliation (if any) and their meteorological and oceanographic interests, and to indicate whether their contribution has been or will be published elsewhere.

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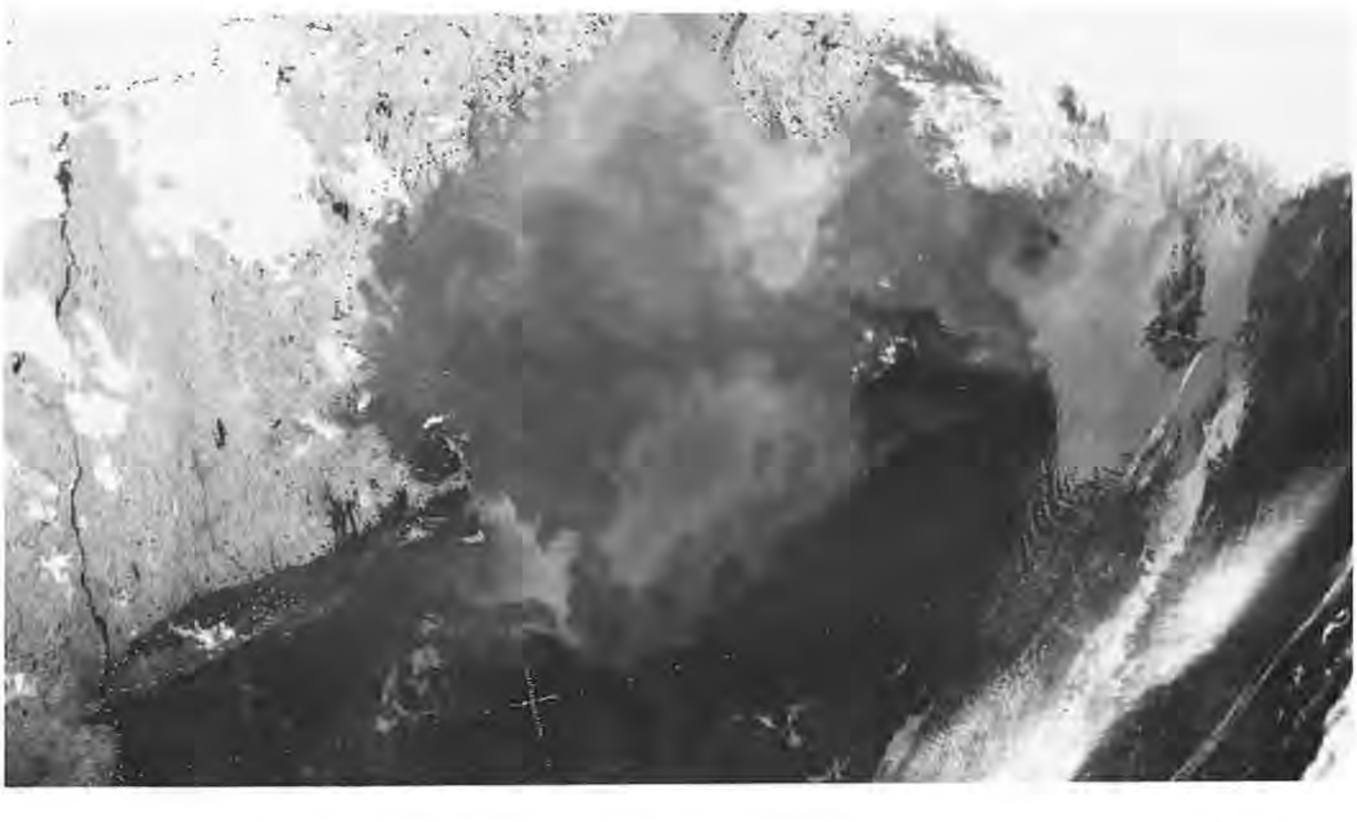

Infrared satellite image of the Gulf Stream area east of Cape Cod and south of Nova Scotia (August 13, 1985, 0738 G.M.T.)

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