Chinook

THE MAGAZINE OF WEATHER, ENVIRONMENT AND OCEANS

VOL. 6 NO. 2 SPRING 1984

INSIDE:

ABOUT GLOBAL CLIMATE CHANGE AND VARIABILITY

TWENTY-SEVEN CENTURIES OF WEATHER FORECASTING

FORECASTING THE WEATHER FOR D-DAY

CANADIAN WEATHER REVIEW: SPRING 1984

FROM THE EDITOR'S DESK

On August 21, 1984, *Chinook* was formally signed over by Michael Newark of Weather Enterprises to the Canadian Meteorological and Oceanographic Society. During its first meeting (1984/85) the CMOS Executive approved the establishment of an Editorial Board for *Chinook* and the nominations of eight Board Members (at right). All members have graciously accepted. As you will notice they represent a broad spectrum of environmental interests and include representations from secondary schools, colleges and universities.

It goes without saying that CMOS and the subscribers of *Chinook* are very grateful for the energy and dedication that Mike Newark has provided over the years to his magazine. We hope we can live up to the expectations he had for *Chinook*.

Sometime this fall the Board will meet to develop and approve appropriate guidelines and policy. Our initial aim is to ensure that the subscribers will receive four issues in 1984 (Vol. 6). Besides No. 2 we will also soon produce Nos. 3 and 4 as separate issues. We ask not only for your patience, but also for your assistance in providing us with interesting material for the magazine. We further appreciate your enquiries and reports on environmental topics and comments and suggestions.

It is our endeavour to make as few changes as possible to the overall format of *Chinook*. Our primary goal is to publish the magazine with the following broad aims:

- To increase public awareness of the scientific and technological aspects and achievements of meteorology and oceanography in Canada
- To stimulate public interest in and the understanding of the impact of climate, weather and oceans on Canadian society and economics
- To inform Canadians about the education, information and interpretative services available to them on climate, weather and oceans

We would also like to ensure that the readership of the magazine is a very broad but selective cross-section of Canadians, with specific emphasis on the following groups: secondary schools and community colleges; farmers, fishermen and foresters; those engaged in marine-recreation, sports and tourism; aviators; amateur observers of natural phenomena; specialists in atmospheric and oceanographic sciences; and environmentalists.

Hans VanLeeuwen
Chairman
Chinook Editorial Board

Chinook

Spring 1984 Volume 6 Number 2

ARTICLES

DEPARTMENTS

EDITORIAL BOARD

EDITOR Hans VanLeeuwen
TECHNICAL EDITOR Edward J. Truhlar
BUSINESS MANAGER J. Carr McLeod
PUBLISHER Canadian Meteorological and Oceanographic Society
FOUNDER AND EDITOR 1978-1984 Michael J. Newark
ISSN 0705-4572

Printed and produced in Canada and published quarterly by the Canadian Meteorological and Oceanographic Society, Suite 805, 151 Slater Street, Ottawa, Ont. K1P 5H3. Registered in Ottawa as second class mail, registration number 4508. Subscription rates for one year are $7.50 in Canada and the USA and $9.00 in other countries.

THE COVER

Climate changes can have a significant impact on agricultural production. Prolonged periods of drought or a shortened growing season can affect rape seed areas such as the one shown near Birch Hills, Saskatchewan.

ABOUT GLOBAL CLIMATE CHANGE AND VARIABILITY

by H.G. Hengeveld

The past decade has witnessed an increasing interest, both within the scientific community and the media concerning the issue of climate change. Reports on the results of research related to this issue, however, often imply major disagreements within the scientific community as to why and how climates change and how such changes affect society. Some reports postulate the imminent arrival of another ice-age, others suggest future global cooling due to increased volcanic activity, while many others consider that a major warming will soon occur owing to increasing global "greenhouse" effects. To the public, presented with these conflicting reports through the media, the result is confusion and skepticism.

In recent years a number of studies have attempted to remove some of this confusion by examining the composite effect of what are believed to be the primary causes of climate change on a common time-scale. The following summarizes some of their conclusions.

CAUSES OF CLIMATE CHANGE

Significant changes in global climate of durations over time-scales of decades and longer are largely related to factors that disturb the balance of the earth's heat budget (incoming solar radiation minus outgoing radiation from the earth and its atmosphere). The number of factors involved are actually relatively few. These relate to: a) changes in the flux of solar energy impinging upon the outer edge of the earth's atmosphere; b) alterations in the physical characteristics of the earth's surface; or c) changes in the composition of the earth's atmosphere. The latter two in turn affect the absorption of solar energy within the climate system and/or the emission of long-wave infrared radiation to space. While the direct impact of these factors on the energy balance may be quite small, they are often amplified (or dampened) by complex feedback mechanisms within the climate system.

PAST CLIMATES

The description and analysis of past climates are the fundamental bases for testing theories on climate change and advancing our understanding of climate. Sources of information for the study of these climates include paleoclimatological data, found in abundance on the earth's surface; written historical records over the past 1000 years; and instrumental records of climate data recorded over the past century. Although caution must be used in analysing climate trends and fluctuations within the reconstructed data sets to discover causal factors, these patterns can be used to test various theories on why climates change.

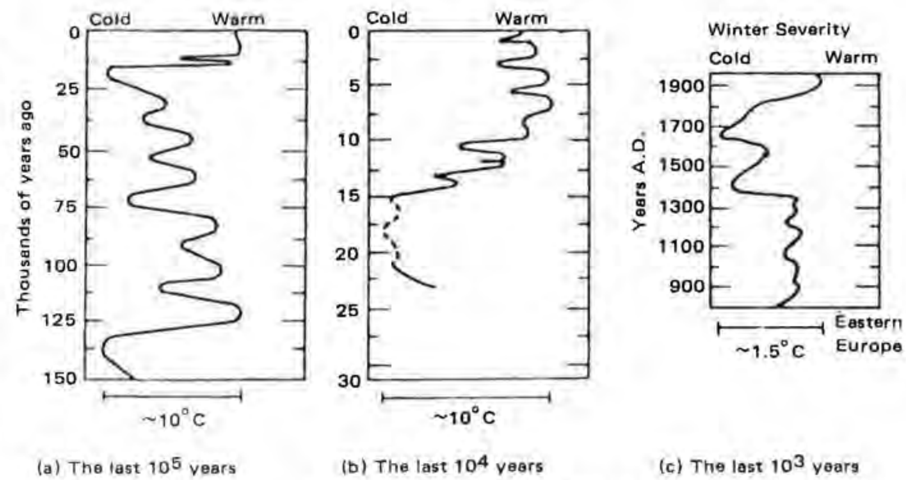


Figure 1 Past climate trends of the Northern Hemisphere (a, b) and eastern Europe (c) based on paleoclimatic data and historical records.

Figure 1a illustrates the general trend of Northern Hemisphere temperatures during the past 150,000 years as derived from paleoclimatological studies. Analyses of these trends suggest the presence of three dominant quasi-periodic cycles at frequencies of about 100,000, 40,000 and 20,000 years. Extreme minima, corresponding to the periods of maximum glaciation, occur 135,000 YBP (years before present) and 18,000 YBP. These minima have occurred at regular 100,000-year intervals for the past one million years. Each is followed by a dramatic 8-10°C warming to an interglacial state. The earth is presently in such an interglacial period. The 40,000- and 20,000-year patterns appear as smaller scale but significant anomalies superimposed upon this large-scale trend. Temperature trends for the past 10,000 years (Figure 1b) are dominated by the peaking of the present interglacial about 6,000–8,000 YBP followed by a gradual cooling since then. This warm peak is commonly referred to as the Altithermal, Hypsithermal, or Climate Optimum. Several "little ice-ages" appear superimposed upon the subsequent cooling trend at approximately 2500-year intervals, the latest occurring between 1430 AD and 1850 AD (Figure 1c). Today global average temperatures are believed to be about 1°C below that of 1,000 years ago, 1.5°C below that of the Altithermal and 2.5°C cooler than the last interglacial of 125,000 YBP.

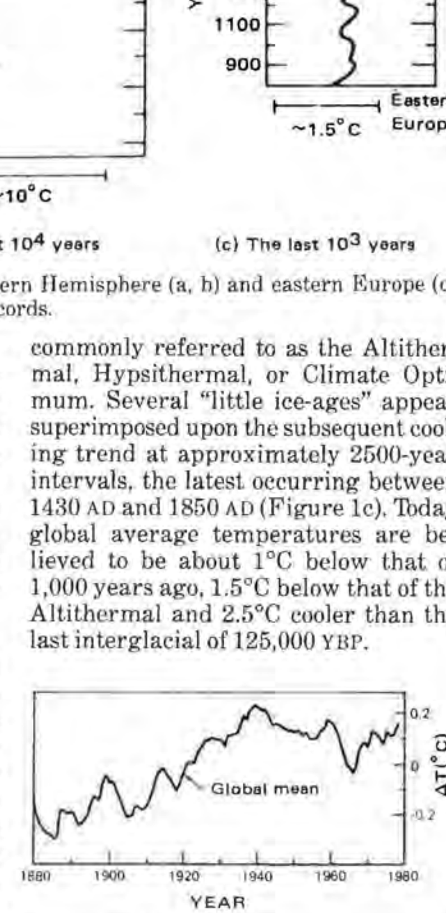


Figure 2 Mean global temperature trends for the past 100 years.

Figure 2 provides a detailed and comparatively accurate reconstruction of global temperatures for the past century. Following several decades of cold temperatures early in the period, a pronounced warming is evident between 1920 and 1945. More recently, the 1950s and 1960s exhibit a cooling trend, followed by the recurrence of the warming trend during the 1970s. The total range of temperature variation over the 100-year period has not exceeded 0.6°C.

Many efforts have been made to explain the temperature variations discussed above on the basis of postulated theories on the causes of climate change. Attribution of the 100,000, 40,000 and 20,000 quasi-periodic cycles in the records to well-defined variations in the earth's orbital pattern of the same periodicities, generally referred to as the Milankovitch mechanism, has gained wide acceptance. For fluctuations on a shorter time-scale, efforts at correlating observed solar irradiance cycles with quasi-periodic temperature patterns, particularly at 180- and 80-year intervals, have provided some encouraging results but to date have failed to demonstrate their statistical significance. The most substantial evidence for the good correlation of recent global temperatures with climate forcing factors appears to be associated with the atmospheric loading of volcanic dust and aerosols. Detailed correlation studies of the past 400 years of climate clearly show this parameter to have a primary role during this time period.

Several attempts have recently been made to quantify the relative magnitude of the climatic effects of various influencing factors over a decade time-scale and to compare the modelled cumulative effect with actual climate data of the past century. Although results are encouraging, the use of significantly different weighting factors in the studies to achieve basically similar results emphasizes that the forcing factors used are a plausible, but not necessarily the only, explanation for recent climatic events.

Future extended warming trends may release enormous amounts of water from such Arctic glaciers as those in northern Baffin Island shown above.

FUTURE CLIMATE

The anthropogenic influence on the global heat balance, particularly through the greenhouse effects of radiatively active gases, such as carbon dioxide, is likely to have an unprecedented and dominant effect on climate over the next few centuries. Scenarios for future climates must, however, take into account the potential for naturally induced climate change in addition to that attributable to man. Discussions of such potential changes are dominated by reference to the quasi-periodic or "cyclic" patterns observed in past climates. Although the statistical verification of their real presence in climate trends is as yet inadequate, the projection of these patterns into the future, assuming persistence, permits first-order estimates of factors to be considered in future climate scenarios. The following estimates are some of the dominant factors to be considered during the next few centuries:

1 Malankovitch mechanism: the interglacial following each major glaciation generally lasts $10{,}000 \pm 2{,}000$ years, and is followed by a significantly colder climate. Paleoclimatologists generally agree that a change to a colder climate could occur within several thousand years. If the change is episodic rather than sinusoidal, a finite although remote possibility exists that such an event could occur much sooner. It appears probable, however, that the present long-term cooling trend will continue for at least the next few centuries at the rate of less than *0.1°C/century*.

2 Solar variations. The 11- and 22-year cycles in sunspot behaviour appear unlikely to have substantial long-term effects on global trends, because of their short duration and small amplitudes. Apparent periodicities of 80 years and possibly 180 years may be more pronounced, as suggested in the isotopic data analysis of glacial ice cores. The amplitude of these affects appears *not to exceed 0.3°C*.

3 Volcanic Aerosols. Volcanic activity and its influence on climate are generally assumed to be episodic and largely unpredictable. The cooling effects of volcanic activity in past centuries are estimated to attain values up to *0.4°C*.

4 Anthopogenic influence. The increasing greenhouse effect due to accumulating concentrations of atmospheric CO_2 and other similar gases such as freon, methane and nitrous oxide, appears likely to result in a *3°C ± 1.5°C warming* in global climate over the next 100 years. The warming will likely continue beyond this level, with its magnitude and duration highly dependent on future energy policies and hence very unpredictable.

The above comparison of the various primary factors in projections of the climate for the next few centuries is over-simplified and based on inadequate, controversial and often confusing research results. Furthermore, other man-made influences such as increasing atmospheric aerosols, and land- and water-use changes may become important. Two overriding issues, however, appear to emerge. First, the anthropogenic CO_2 effect appears likely to dominate the climate patterns of the next few centuries, with volcanic and solar influences modulating the predominating trend. Second, the effect of a doubled CO_2 atmosphere may well be a short-lived anomaly on time-scales of millenia, with significant cooling occurring within several thousands of years or less.

Mr. Hengeveld is an Advisor to the Canadian Climate Centre in Toronto on carbon dioxide related matters including climate change.
His article is reprinted from *Climatic Perspectives* Vol. 6, April 1984 Monthly Supplement, published by the Atmospheric Environment Service.

TWENTY-SEVEN CENTURIES OF WEATHER FORECASTING

by R. Hornstein

In Canada most weather forecasts are issued by meteorologists who have had intensive university training in science and meteorology. Their forecasts represent the result of the processing of weather data in accordance with scientific principles based on physical laws. Yet, even the most dedicated and conscientious meteorologist will admit that weather forecasts are not always absolutely trustworthy.

Thus, it would appear that weather prediction could be considered to be an imperfect application of science. It is not, however, by any means a new art. Throughout the ages, man has tried, for his own advantage, to interpret the changing pattern of the weather.

Just when man first began to set down rules for predicting the weather will probably never be known. The recorded history of such undertakings is a long and crowded one. The British Museum Library has material that suggests that weather forecasting was practised extensively and officially as early as the seventh century before the Christian era.

The Assyrian astrologers and magicians, who were public functionaries, were charged with the responsibility of predicting a great variety of worldly events, besides the weather, droughts and floods. Their predictions were based on signs or omens of many kinds; these included such features as luminous circles around the sun and moon, known to us today as halos and coronas.

A drought or a flood, or the severity of the upcoming winter was as likely to be foretold from the appearance of the liver of a sacrificial animal, or the breast-bone of a domestic fowl, as from the aspect of the sky!

A striking example of this appears as late as 1681 in a book: "if a breast-bone of a duck be red, it signifieth a long winter; if white, the contrary."

A goosebone of 1927.

Even today similar predictions have persisted for thousands of years. Several versions of this have been related to me:

"When the goose-bone, exposed to air turns blue, it indicates rain; when it retains its colour, expect clear weather";

"The whiteness of a goose's breast-bone is thought to indicate or foreshadow the amount of snow during winter";

"Breast-bone of goose dark-coloured after cooking, no genial spring, and vice versa."

Among the ancient Greeks and Norsemen the weather elements were considered to be the personal concern of various major and minor gods. It was believed that those deities expressed resentment by causing some form of atmospheric violence, but that they might be appeased by a suitable sacrifice.

The Hebrews thought that a benevolent and paternal deity ordered natural events to follow an appointed course. They conceded that this course might, in special circumstances, be altered by adequate supplication. However, for the most part God might be depended upon to confer His benefits upon the just and the unjust alike. Which brings to mind a doggerel verse of unattributed origin:

The rain it raineth every day,
Upon the just and unjust fella
But mostly on the just, because
The unjust hath the just's umbrella.

Progress in weather forecasting, though, is slow. Those currently working to unveil the atmosphere's secrets are building on the achievements of a long series of predecessors ... philosophers, physicians, poets and historians.

The Babylonians of old discovered how to measure time. This, in turn,

wetters Also das ain yeder / er sey geleert oder
vngeleert / durch alle natürliche anzaygung die
änderung des wetters aygentlich vnd augſchein
lich wiſſen vnd erkennen mag / gezogen vnd ge-
gründt auß den Regeln der hochberümbtſten
Aſtrologen / vnd darzů durch die täglichen erfa-
rung (die ain mayſterin iſt aller kunſt) bewärt.

A sixteenth century weather forecasting guide. Title page of Reyman's *Wetterbuchlein*, a collection of ancient and medieval weather proverbs, many of which are still current. Many editions of the booklet were printed making it a best-seller for its day.

involved the recognition of a natural order of the seasons according to the position of the sun in its annual path through the heavenly constellations.

The ancient Greeks gave us geometry with which we are able to make the measurements that are so vital to our scientific studies. As a science, meteorology perhaps began with the physician Hippocrates. About 400 years before Christ he gained an appreciation of the influence of climate on man. About 100 years later Aristotle, the Greek philosopher, speculated about the physical causes of atmospheric changes. His writings became the standard authority on meteorological matters until comparatively recent times.

Theophrastus, one of Aristotle's pupils, made a careful study of the winds of Greece. He also compiled a collection of weather signs, and thus began the practical and proverbial side of the science; today we refer to it as weather lore, some of it useful, but much of it fanciful superstition.

Examples of the signs he recommended include:
"Sheep and herds fighting for their food more than usual indicate storm";
"When mice fight for chaff and carry it away, it is a sign of storm";
"The crow, if it caw thrice immediately after daybreak, indicates fair weather but crying in fine weather indicates a storm."

Aratus, a poet-physician of the third century, added appreciably to this stock of weather proverbs. Following is a sampling of his numerous compilations:

When autumn's days are nearly passed away,
And winter hastens to assume his sway,
Mark if the kine and sheep at eventide
Toss up their horned heads, with nostril wide
Imbibe the northern breeze, and furious beat
The echoing meadows with their cloven feet;
For tyrant winter comes with icy hand,
Heaping his snowy ridges on the land,
Blasting Pomona's hopes with shrivelling frost,
While Ceres mourns her golden treasures lost.

When through the dismal night the lone wolf howls,
Or when at eve around the house he prowls,
And, grown familiar, seeks to make his bed,
Careless of man, in some outlying shed,
Then mark: ere thrice Aurora shall arise,
A horrid storm will sweep the blackened skies.

E'en mice of oft-times prophetic are of rain,
Nor did our sires their auguries disdain,
When loudly piping with their voices shrill,
They frolicked, dancing on the downy hill.

When bounteous autumn crowns the circling year,
And fields and groves his russet livery wear,
If from the earth the numerous hornets rise,
Sweeping a living whirlwind through the skies;
Then close on autumn's steps will winter stern
With blustering winds and chilling rains return.
Pity the wretch who shelterless remains,
And the keen blast, half fed, half clad, sustains.

Virgil provided a Latin version of weather adages in his *Georgics*. A few excerpts from his writings are:

Above the rest, the sun who never lies
Foretells the change of weather in the skies;
For if he rise unwilling to his race,
Clouds on his brow and spots upon his face,
Or if through mists he shoot his sullen beams,
Frugal of light in loose and straggling streams,
Suspect a drizzling day and southern rain,
Fatal to fruits, and flocks, and promised grain.

When first the moon appears, if then she shrouds
Her silver crescent tipped with sable clouds,
Conclude she bodes a tempest on the main,
And brews for fields impetuous floods of rain;
Or if her face with fiery flushings glow,
Expect the rattling winds aloft to blow;
But four nights old (for that's the surest sign)
With sharpened horns, if glorious then she shine,
Next day, nor only that, but all the moon,
Till her revolving race be wholly run,
Are void of tempests both by land and sea.

Indeed, Greek and Latin literature is rich in weather lore. Much of it is mere astrological nonsense. It also contains, though, a certain element of wisdom that had been gradually acquired by farmers, sailors and others who led out-of-doors lives.

The water barometer erected by Pascal and Petit at Rouen in 1646 (after Tissandier).

Other authors, such as Francis Bacon and Dr. Alexander Buchan, began to prepare other kinds of publications. Some compiled weather calendars in which was recorded the normal succession of atmospheric events throughout the year. These were the forerunners of today's tables of climatic statistics, which have numerous valuable practical applications.

However, the value of the ancient calendars was lessened considerably because the data used in compiling them were often derived from places scattered over the shores and islands of the Mediterranean. Although the climates may have been different in these various places the publications do not provide specific details.

With the fall of the Roman Empire scientific study entered a period of stagnation. But when the Middle Ages finally drew to a close, the palmy days of weather prophecy began. A new style of literature came into vogue. It consisted of small documents, most of them written in Latin, each of which contained a prediction of the weather for a single year, prepared in accordance with the rules of astrology.

At that time a prediction was widely-circulated that a disastrous flood would occur in February 1524. "Authorities" were divided as to whether this was to be a universal deluge, similar to the one of Noah's time, or merely an exceptional rainy spell, with local inundations. The basis for the prediction of floods to occur that month was that three planets would at one time be in the watery constellation of Pisces.

The prediction caused general consternation. People everywhere left their homes and took refuge on hilltops, where they remained until the fatal month had passed.

As it turned out the weather proved to be entirely normal. Strangely enough, the reputations of the astrologers appear not to have suffered in the least from this fiasco. Somehow the modern meteorologist does not seem to fare as well. He finds that his fellow-citizens appear to remember only those occasions on which his forecast is in error and they criticize him severely; conveniently, they forget the times when he is right and he does not receive credit for his good work.

In the 17th century a new era arrived as experimental work was begun. This was made possible by the invention of instruments which today are considered basic in weather study.

In that century Galileo invented the thermometer, and his assistant, Torricelli, constructed the first barometer. Pascal discovered that pressure changes with height, and Boyle established the relationship between the volume of a parcel of air and its pressure. Dampier wrote a celebrated treatise on the winds of the globe, based on mapping done by Halley.

In that one century a great deal of groundwork in meteorology was laid by men who are famous for other accomplishments. The list of names above includes a religious enthusiast, an ascetic, a philosopher, a seaman, an astronomer, and a magnetician.

In the 18th and 19th centuries the story was the same. Further development of meteorology was fostered by lawyers, physicians, geologists, mathematicians, schoolmasters, chemists and admirals.

Finally, in our day the trend is to specialization, which is reaching its ultimate conclusion. Meteorologists seldom come out of the ranks of other professions. Rather, they enter their profession directly from university with postgraduate degrees in atmospheric science.

The scientific approach has made it necessary to build up an international organization capable of tracing weather systems over the entire globe. As an essential part of their task meteorologists must maintain a constant watch on the behaviour of the atmosphere. Using a combination of simple visual observations, old-fashioned instrumental readings, modern radar and laser equipment, and satellites and electronic computers they are gradually learning to produce useful models representing the processes occurring in the atmosphere, and are thereby able to determine what is cause and what is effect in a sequence of events.

Top Modern Weather forecasting is assisted by very powerful computers. The CRAY LS 1300 supercomputer at the Canadian Meteorological Centre in Montréal is capable of handling extremely complex calculations.
Bottom Today's operational meteorologist is provided with a large amount of data and information including satellite imagery.

Rube Hornstein is a Halifax meteorologist who spent his active career with the Canadian Meteorological Service (now known as the Atmospheric Environment Service). His radio and TV programs on weather lore have gained him national prominence.

Illustrations on pages 54, 55 are from *Tycos-Rochester*, Vols. 16, 17 and 18.

A VIEW FROM SPACE: A SATELLITE SEES MOISTURE

by Oscar Koren

It is well known that when water vapour in the atmosphere condenses, cloud patterns occur from which features of the atmospheric circulation can be deduced. In many instances water vapour is present in cloud-free areas. By monitoring the water vapour, important details are revealed about the atmospheric circulations and the associated atmospheric processes.

Figure 1 shows the water vapour image taken on 22 August 1984 at 1731 GMT. In this image the infrared radiation (6.7 μ m) sensitive to water vapour absorption and transmission from middle portions of the atmosphere is displayed. Most of the radiation emitted by water vapour in the atmosphere comes from a layer between 4.2 and 9.2 km, with a peak contribution coming from about 6.3 km. The whitest portions embedded in the grey areas are high cloud tops – mostly cirrus and cumulonimbus tops. The continuous grey shades represent regions that are moist aloft whereas the dark zones represent regions that are relatively dry aloft. Distinct moisture patterns delineated by dry areas result from ascending motions and moisture influx. The light grey shades depict the flow at higher levels of the atmosphere where the temperature is cold and the darker grey shades depict the flow at lower levels where the temperature is warmer.

Figure 2 shows the visible image taken at the same time as the water vapour image of Figure 1. In this image the white areas represent the reflected radiation from cloud tops whereas the dark areas are cloud-free.

By comparing these two images, it may be noted that the water vapour image defines the large-scale upper-level flow patterns better than the visible image, particularly in the cloud-free areas. Using these images a meteorologist can readily identify such large-scale features as jet streams, sharp changes in the wind flow, low pressure centres, and temperature gradients. This type of information is of great importance in weather analysis and forecasting.

Oscar Koren is a meteorologist with the Field Services Directorate of the Atmospheric Environment Service in Toronto who is interested in the meteorological applications of satellite data.

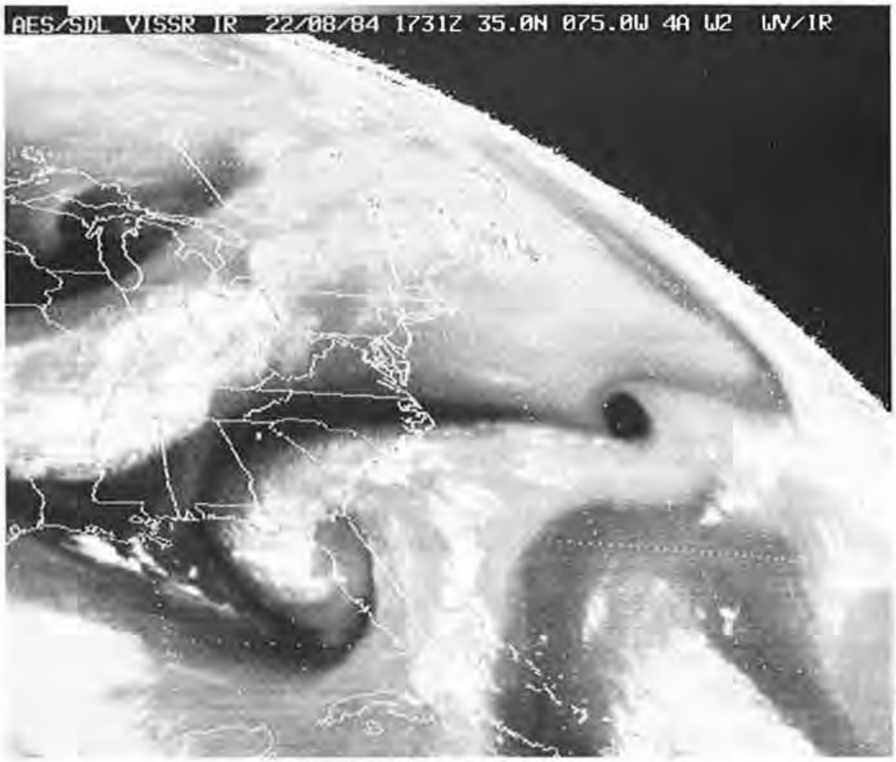


Figure 1 Water vapour image.

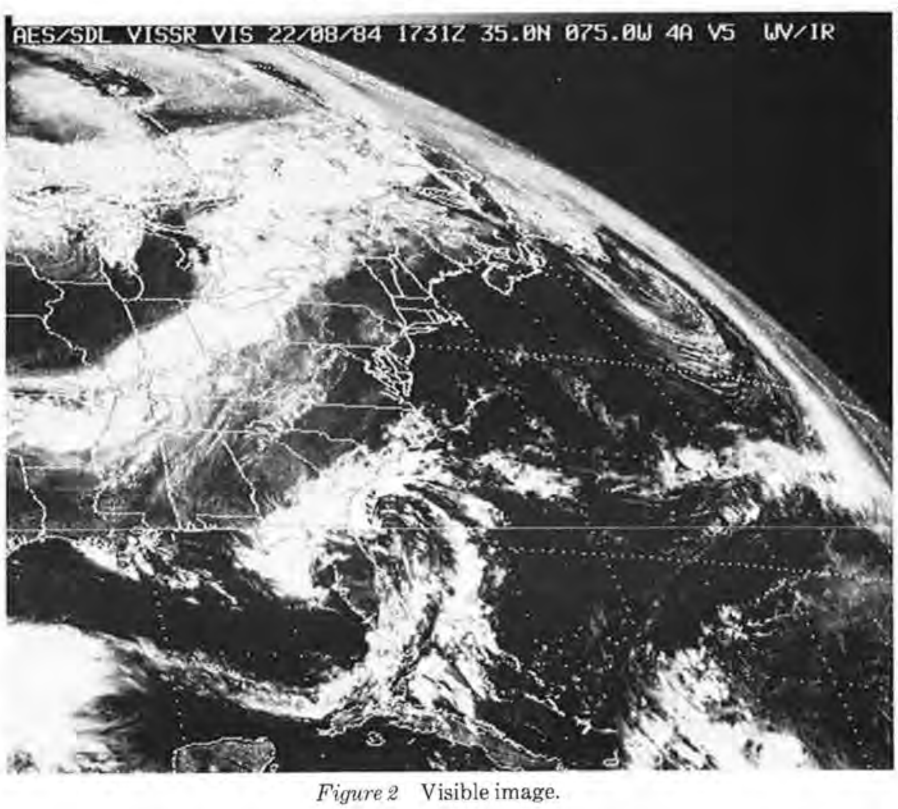


Figure 2 Visible image.

Courtesy Environment Canada

FORECASTING THE WEATHER FOR D-DAY

by Spence Silver

This article is respectfully dedicated to those members of the 3rd Canadian Infantry Division and the 2nd Canadian Armoured Brigade, the aircrews of the bombers of No. 6 Group and the fighters of No. 83 Group, and the sailors of the Royal Canadian Navy who fought and suffered at the Normandy beaches, June 6, 1944.

The meteorologist stood alone in the room, surrounded by powerful influential men: General Montgomery, General Eisenhower, Air Marshall Tedder, and others. They were waiting intently for his next words, since the decision whether or not to launch D-Day, the invasion of Europe, depended on what was said next ... If he were wrong, thousands of lives might be lost, the invasion could be stopped, and the liberation of Europe from the Nazis postponed for a year or indefinitely.

Who was this man? How did he get into such a position? What problems did he have to contend with? More important, what *was* his forecast going to be?

The meteorologist about to make the most important weather briefing of the century was Group Captain J.M. Stagg, of the Royal Air Force. Appointed as Chief Meteorological Officer to SHAEF in November, 1943, to assist in planning for D-Day, the invasion of German-occupied Europe, Group Captain Stagg found himself having to struggle with problems that would have proved daunting to the most experienced weather forecaster.

What was the nature of these problems? Stagg's difficulties can be divided into two classes: one being the nature of the assignment, and the other being the forecasting difficulties involved.

As to Stagg's assignment, the invasion day had to be chosen such that bombers and other aircraft would have enough moonlight for bombing and for dropping paratroops. Naval craft needed to be able to begin unloading troops three hours before high tide in order to avoid underwater obstacles. (Unfortunately, high tide began earlier on the western beaches of Normandy than on the eastern beaches.) The correct combination of low tide and phase of the moon made the number of suitable days in any one month just three.

Stagg's assignment, especially, was to obtain the best forecast of the weather for the days preceding, during and after D-Day. The forecast winds must be low, cloud bases high, visibility good, and cloud thickness thin. To have these weather parameters coincident with the moon and tide parameters was going to prove to be quite a gamble.

Stagg used the forecasts from three weather forecasting offices staffed by the American and British Services to develop a consensus forecast via telephone discussion. As is easy to imagine, however, each office had differing interpretations and forecasts of the important weather systems, which somehow *had* to be reconciled. Stagg also had weather charts going back 50 years for the English Channel. As Stagg himself wrote, "Even when the sequence of weather charts for one or two days looked identical with the sequence of another year, the immediate subsequent charts were almost invariably so dissimilar as to be useless for prognostic purposes".

A coastal gun position on Normandy's Utah Beach is a grim reminder of the heroic fight on June 6th, 1984.

It was decided to ignore May as a month for invasion in order to allow the industries of America and Great Britain to build more landing craft. June 5 was chosen as D-Day. Let us follow Stagg's weather problems up to and just before D-Day.

Monday, May 29, finds Stagg briefing the planners of D-Day in Southwick House, Eisenhower's Headquarters. Minor disturbances are forecast for the few days preceding D-Day.

Friday, June 2, three days before D-Day, Stagg explains that the whole situation is now potentially full of menace. However, some ships, in order to be in the English Channel by June 5, must begin their journey now.

During the evening of Saturday, June 3, three low pressure centres are forecast to move through the invasion area, giving strong winds, low cloud and fog. The chief planners agree not to postpone anything yet, even though the forecast is the worst possible one for the day of the invasion. To compound Stagg's problems, the weather at briefing time *right* outside Southwick House is just fine.

By Sunday, June 4, in the morning, Stagg has not changed the forecast, and Eisenhower and his deputies decide to postpone D-Day till June 6. But the weather just outside is clear and calm. The ships already enroute are told to return momentarily.

Canadian troops landed at Beny-sur-Mer on the Normandy coast. Today holidayers leisurely stroll along the sandy beach past the few abandoned bunkers that remain.

But, can Eisenhower trust the forecast? Should Eisenhower postpone the whole landing operation till later in the year? Perhaps waiting for *one more* briefing would be best before making the final decision ....

Monday morning, June 5 finds Group Captain Stagg standing in the small room at Eisenhower's Headquarters. "No one could have imagined weather charts less propitious for the greatest military operation in history .... " wrote Stagg. Before this conference Stagg had been forced once again to reconcile divergent views from the three weather forecasting offices.

If Eisenhower did not believe the forecast that Stagg was about to present, the operation would have to be postponed; this would result in the lowering of the morale of the troops, some of whom had been stuck in their ships for many days. Tactical surprise would also be lost, since the enemy could not fail to notice the gathering of the many ships involved. Also there was no guarantee that the next time favourable for the moon and tide would also be favourable weatherwise for a landing operation.

However, Stagg was confident that the weather would still break up and be favourable to a landing operation on Tuesday, June 6. Eisenhower believed him. "Immediately after I had finished speaking the tension seemed to evaporate and the Supreme Commander and his colleagues became as new men", says Stagg.

Others besides the three Allied weather offices did not share Stagg's confidence. Enemy meteorologists had also decided the weather situation was unsuitable for landing operations; Mother Nature herself, 24 hours before she was *supposed* to clear the skies, kept them overcast (and the trees swaying as well) in the vicinity of Eisenhower's Headquarters.

As history records, the weather *did* clear, and D-Day proceeded, if not uneventfully, at least successfully.

Beside Eisenhower and the combined operations staffs of Britain and America must also stand Group Captain Stagg to whom the success of the D-Day landings must be attributed. His work and his confidence in the veracity of the weather forecasts must bear a significant share of the praise for the success of the invasion of Europe, June 6, 1944.

FURTHER READING

Dwight D. Eisenhower, 1948: *Crusade in Europe.* Doubleday and Company.

David Howarth, 1959: *D-Day.* Bantam Books.

B.B. Schofield, 1952: *Operation Neptune.* Dept. of National Defence.

J.M. Stagg, 1971: *Forecast for Overlord.* Norton and Company.

Mr. Silver is the Base Meteorological Instructor, Canadian Forces Base Portage la Prairie, and also an amateur historian of WWII, especially its meteorological aspects.

Canadian Weather Review: Spring 1984

by Morley Thomas

In Canada spring is the season of rising temperatures – the transition period from winter to summer. In climatology spring is considered to be the months of March, April and May while in astronomy it is defined as the period extending from the vernal equinox on March 21 to the summer solstice on June 21.

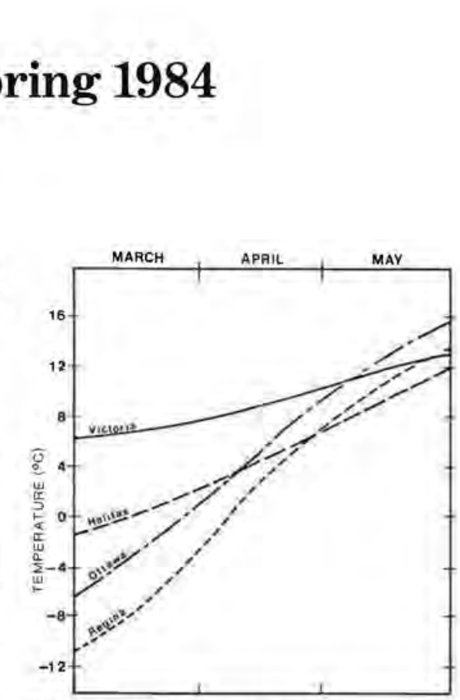
SOME CLIMATOLOGY

Springtime weather conditions vary considerably across southern Canada and markedly from southern to northern Canada in a "normal" year. On the Pacific coast at Victoria, where temperatures average above freezing all winter, the springtime warming raises the mean temperatures to no more than 13°C by the end of May. On the other hand, across the Pacific provinces this warming is most marked and typical of a continental-type climate: temperatures average about -11° at Regina on March 1 but climb to +14° by the end of May. This rapid increase in temperature is not as evident in most of southern Ontario owing to the moderating effect of the Great Lakes, but the continental effect appears again at Ottawa and in the upper St. Lawrence valley where mean temperatures increase from about -6° to +15° during spring. Although continental in some respects, the Atlantic Provinces also have a moderated climate: temperatures at Halifax increase from -2° to +12° during the season. By southern standards winter still continues in Arctic Canada where the temperature at Resolute increases from colder than -30° on March 1 to about -7° by May 31.

Although temperatures vary markedly throughout Canada during spring, the rising pattern is common. With precipitation very different patterns exist during the season in various parts of the country. On the west coast of British Columbia, precipitation is at its maximum in the winter, decreasing in spring to a summertime minimum. Across the Prairies on the other hand, precipitation begins to increase markedly during the late spring to a summertime maximum. In Ontario and Québec there is not as much difference between winter and summer precipitation but slightly more falls during summer. Halifax and most of Atlantic Canada experience a winter-time maximum with the spring months showing a decreasing trend. Across the north there is a summertime maximum but precipitation amounts are relatively light during the three spring months.

SPRING 1984

Spring 1984 will be remembered across western and northwestern Canada for its relative warmth in British Columbia with heavy precipitation, but across the southern Prairies for its dryness. The preceding winter of 1983-84 had been very mild in western Canada with snowfall amounts considerably below normal. In eastern Canada the winter was generally pleasant with average snowfalls and comfortable temperatures although a severe winter storm crossed southern Ontario and Québec during the last few days of February.



The "normal" increase in mean temperature at selected stations in the spring season.

Record cold, very strong winds and snowfalls produced blizzard-like weather in many communities from Saskatchewan to Newfoundland during the week of March 6 to 12.

Over the three spring months the greatest positive temperature anomalies were in northern Canada. Temperatures averaged 2 to 4° above normal in the District of Mackenzie and the Yukon, but were generally below normal in the eastern Arctic. Across southern Canada, temperatures ranged from normal to 2° above in the four western provinces, normal to 2° below normal in southern Ontario, southern Québec and New Brunswick but above normal again in the remainder of Atlantic Canada.

Precipitation during spring was generally above normal in British Columbia and much more above normal in the central and northern portions of the Prairie Provinces. It was, however, exceedingly dry in the southern belt of the Prairies where some stations received less than 50% of their normal precipitation. Conditions were relatively dry in northwestern Ontario and fairly normal throughout most of southern Ontario and Québec. In portions of the Atlantic provinces and in Labrador precipitation was heavy but across northern Canada was light.

YUKON AND NORTHWEST TERRITORIES

Light precipitation and above normal temperatures persisted across the Yukon during spring. March was the warmest such month in more than forty years at Whitehorse since establishment of a regular weather observing program there. Because of the warmth, ice cleared about two weeks ahead of normal in the Yukon River near Dawson; and because of the related dry conditions, several major forest fires were burning in the central Yukon near the end of the month. In the Northwest Territories the pattern of above normal temperatures in western portions and below normal in eastern portions continued throughout the season. Precipitation was generally light but variable.

BRITISH COLUMBIA

Sunny and mild weather persisted across southern British Columbia during the first half of February permitting gardening and sporting activities.

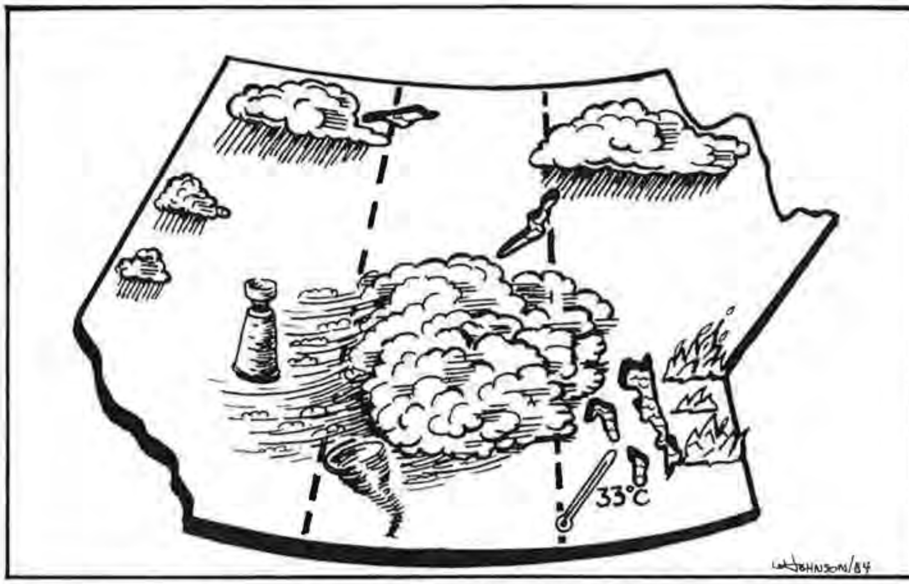
No major Arctic outbreaks of cold air occurred, with the result that several southern stations posted new record high temperature means for February. A marked change then occurred in the south, leaving most of April and May cloudy, cool and wet, although the warmer than normal conditions did persist into April in the north. A severe storm on April 15 with high wind speeds caused millions of dollars of property damage along the mid-coast and in the central interior to fishing boats, houses, and power and communication lines. It was colder than normal everywhere in May with several locations in the south establishing record low mean temperatures for the month. The weather was much too wet and cold for agriculture resulting in poor prospects for the fruit and berry crops.

PRAIRIE PROVINCES

Although the Prairies experienced a markedly cold spell during the first half of March, temperatures climbed to well above normal later that month and such conditions continued into April, the fourth consecutive month with above normal temperatures in Alberta. May turned out to be cool with frequent occurrences of frost all across the

A major spring snow storm accompanied by very strong winds and thunder spread heavy snow and freezing rain across a large portion of Manitoba and southeastern Saskatchewan during the last week of April.

Prairies. The lack of precipitation became a problem in the southern Prairies; by the end of February the snow cover was gone from most agricultural areas. Two severe storms occurred in southeastern Saskatchewan and southern Manitoba: the April 27 storm provided the worst blizzard in recent memory forcing highways to be closed and inflicting six million dollars of damage upon power and communication lines. While more than ample



Extreme weather – deluge of rain in the Peace River district, dust storms and tornadoes in Saskatchewan, and heat with forest fires in Manitoba during the week of May 15 to 21.

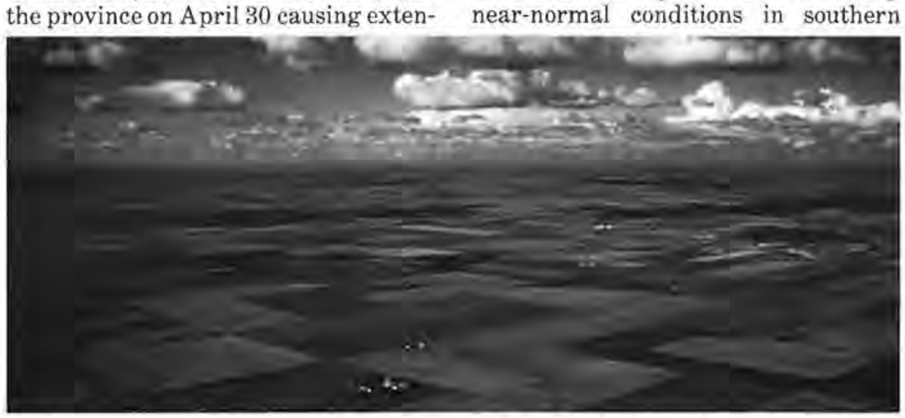
precipitation fell in a broad central band of the provinces in May, southern Saskatchewan remained dry allowing strong winds to create several days of blinding dust storms that resulted in serious soil erosion. In contrast, a heavy, wet snowstorm blanketed parts of southwestern Manitoba on May 24 causing power outages and hazardous driving conditions.

ONTARIO

The spring weather was extremely variable across Ontario. Following the warmest February ever, March was the coldest such month in 25 years at many weather reporting stations. The snow cover virtually disappeared from southern Ontario by the end of March. In April, record warmth and plenty of sunshine dominated northern Ontario's weather where many stations experienced their warmest April on record. In the south, a severe wind storm struck the province on April 30 causing extensive property damage. May brought cool and damp weather especially in the south. A late season storm on Mother's Day, May 13, left three to seven centimetres of snow on the ground in southwestern Ontario. The continuous snow cover disappeared by the first week of the month in northern Ontario but in the south, frost damaged the vegetable and tobacco crops on the morning of May 31. In parts of southern Ontario farm lands remained saturated at the end of the month, which delayed corn planting for several weeks.

QUÉBEC

Record cold temperatures were reported across southern Québec during the first half of March. At Montréal, March 1984 was colder than February 1984, the first occurrence in that city of such a reversal to the normal temperature trend. Milder weather during the latter half of April was followed by near-normal conditions in southern



Spring weather conditions appeared to frown upon the developing grain, particularly near Regina, Saskatchewan.

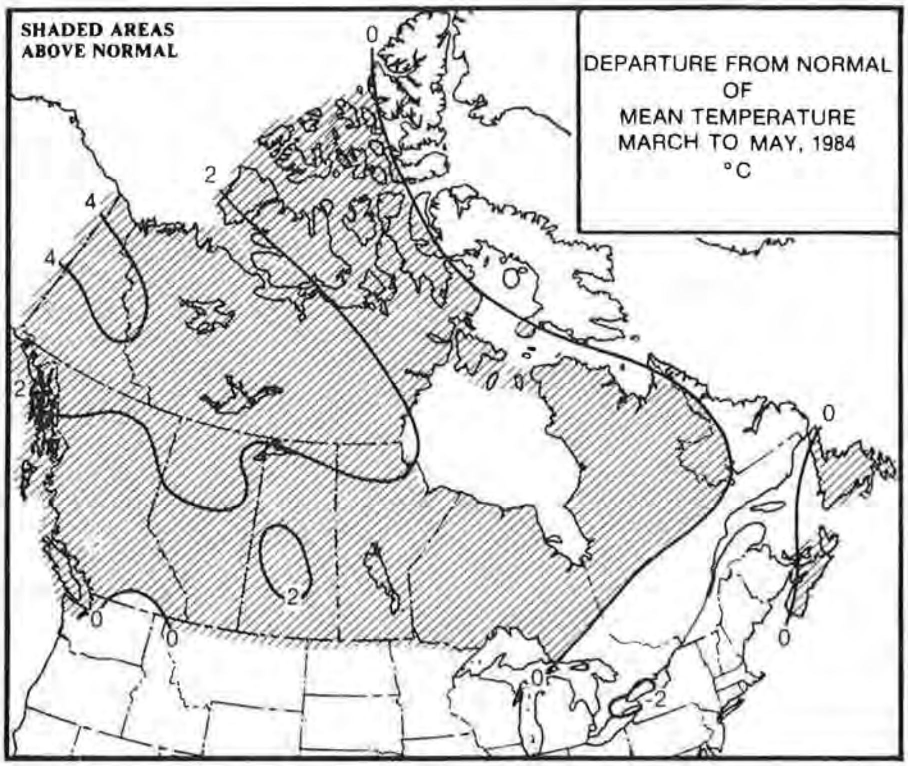
areas and pleasantly mild and dry weather in northern areas. In the south the weather was conducive to maple syrup production and because of the ample snow cover, spring skiing continued late into the month. Farmers got on the land late in April but unseasonable cold and wetness in the St. Lawrence valley during May harmed agriculture. The abnormally heavy precipitation raised river levels and caused some flooding in the Eastern Townships.

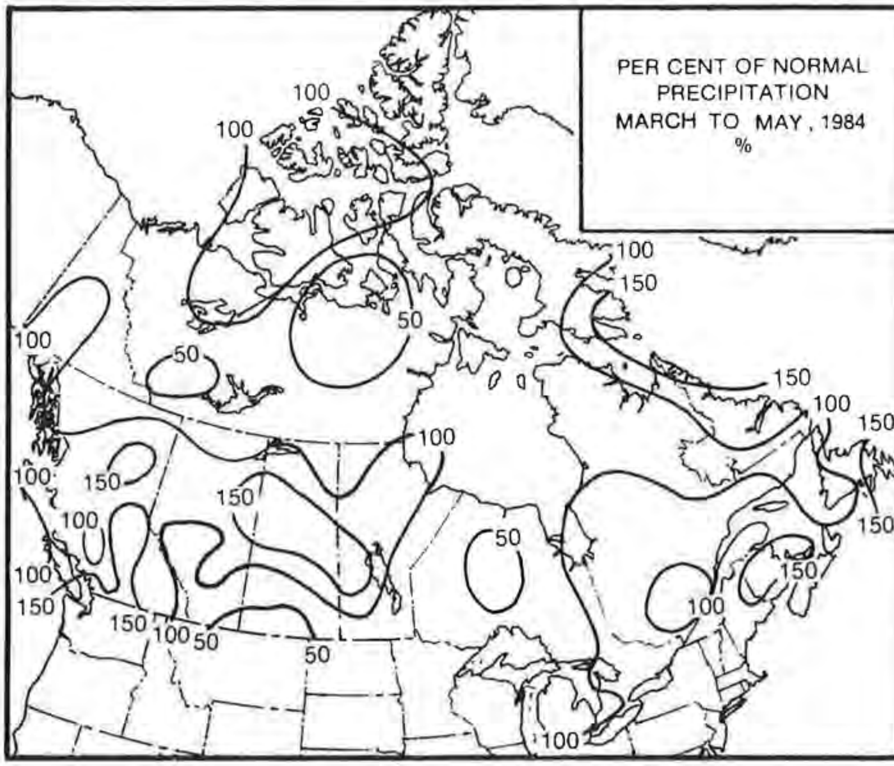
ATLANTIC PROVINCES

March was extremely stormy in Atlantic Canada with cold and dull weather prevailing across the Maritimes, although it was generally mild and sunny in Newfoundland during the first half of the month. Storms in mid-March contributed to excessive river run-offs throughout Nova Scotia while an ice storm with heavy ice accretion on wires left ten thousand homes without electricity on Cape Breton Island. A spring blizzard roared through the region during the last few days of March and this was followed by a winter-like April. Precipitation was generally excessive in April with Sydney, N.S. reporting double the normal amount and the wettest April in more than 45 years. On April 13 the Avalon Peninsula of Newfoundland was paralyzed by the worst ice storm in decades. Some communities were without electricity and heat for over a week. The month of May continued damp in the region but with above normal temperatures. In New Brunswick, fields were waterlogged and spring planting was several weeks behind schedule. By the end of May, Goose, Labrador had recorded 702 cm of snowfall for the 1983-84 season, a record amount.

SUMMARY

The spring of 1984 was warmer than normal in western Canada but slightly cooler than normal in most of eastern Canada. Precipitation was ample to excessive except in the southern Prairies. As might be expected, a great variety of conditions were experienced with temperatures ranging from -38.5° at Eureka, N.W.T. in March to 36.5° at Prairie stations in late May. More than 900 mm of precipitation fell at Ethelda Bay, B.C. while only 45 mm fell at Moose Jaw, Saskatchewan. Moncton, N.B. received a 113-cm snowfall in April, while on the last day of May 1984, Clyde, N.W.T. reported 99 cm of snow on the ground. These extraordinary conditions throughout the country were not at all unusual for spring, which is the most variable of the four Canadian seasons.





ACKNOWLEDGEMENTS

Use was made of *Climatic Perspectives*, Vol. 6, Nos. 9-21 in preparing this article. A. Shabbar's spring temperature and precipitation maps have been reproduced along with several of W. Johnson's drawings from that AES periodical. *Climatic Perspectives* is prepared in the Canadian Climate Centre and edited by A. Shabbar.

Morley Thomas has had a long and distinguished career with the Atmospheric Environment Service and the World Meteorological Organization. He is a former Director General of the AES Canadian Climate Centre and is currently Archivist for the Canadian Meteorological and Oceanographic Society.

PROFESSIONAL AND BUSINESS DIRECTORY

Associations

METEOROLOGY STUDY UNIT. Topical philately (weather and climate on stamps). Peter Robinson, Secretary MSU, 70 Pleasant St., Dedham, MA 02026 USA.

Services

FMC QUÉBEC. English to French translation by professional meteorologists. Box 1304, Cap Rouge, P.Q. G0A 1K0.

Consultants

CLIMATOLOGICAL CONSULTING CORPORATION. Route 2, Box 372, Asheville, NC 28805. (704) 298-4237.

FORENSIC METEOROLOGY | APPLIED CLIMATOLOGY

WALTER F. ZELTMANN

INTERNATIONAL WEATHER CORPORATION
719 BAY RIDGE AVE
BROOKLYN, N.Y. 11220
(212) 748-8066

METEOROLOGICAL & ENVIRONMENTAL PLANNING LTD., 7050 Woodbine Ave., Suite 100, Markham, Ontario L3R 4G8 (416) 661-5960 Telex 065-24747.

Environment

CAMPBELL SCIENTIFIC CANADA CORP. Consultant and Instrumentation. 4243 95th St., Edmonton, Alta. T6E 5R6. (403) 461-3241.

Instruments

Meteorological, Solar
Industrial and Laboratory Instruments

AIR FLOW

AIRFLOW DEVELOPMENTS (CANADA) LIMITED
1281 Matheson Blvd., Mississauga, Ontario, Canada, L4W 1R1
(416) 624-2133 Telex 06-960332

METEOROLOGICAL INSTRUMENTS

A complete range of instruments and systems to meet all your land based requirements.

- Temperature and Humidity recorders, sensors, indicators, transmitters
- Thermometers, maximum and minimum (to A.E.S. specifications)
- Wind recorders and transmitters
- Solar radiation and duration instruments
- Rain gauges, transmitters and recorders
- Precipitation and evaporation recorders
- Barographs and precision barometers
- Complete weather stations
- Compatible recorders, controllers and indicators

ENERCORP instruments ltd
P.O. Box 20, Stn. "U", Toronto, Ont. M8Z 5M4 (416) 231-5335

M.I.C. COMPANY. Acid Rain Collectors, Data Acquisition Systems, Mini-sondes. 37 Maple Ave., Thornhill, Ont. L4C 6P3. (416) 889-6653.

Canadian Meteorological and Oceanographic Society

La Societe Canadienne de Météorologie et d Océanographie

ATMOSPHERE-OCEAN

The scientific journal of international meteorological and oceanographic research. Quarterly publication.

CMOS NEWSLETTER

Keeps you in touch with the activities of the Canadian Meteorological and Oceanographic Society. Six times per year.

CLIMATOLOGICAL BULLETIN

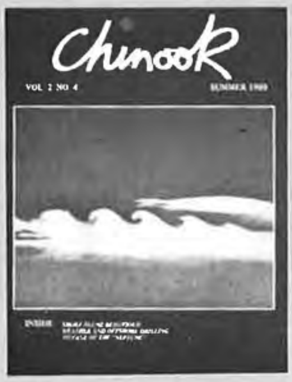
Climatological research and news. Twice yearly.

These publications are all available from **CMOS/SCMO**, Suite 805, 151 Slater St., Ottawa, Ontario, Canada. K1P 5H3.

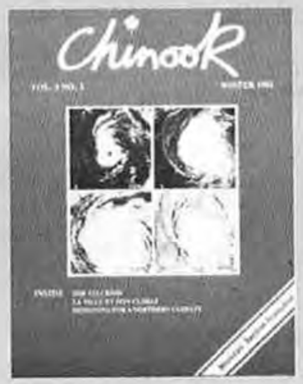
ACID RAIN

WOODSTOCK TORNADO

PERCY SALTZMAN'S STORY



OFFSHORE DRILLING



CO_2 CRISIS

GREAT STORMS OF 1913

You can't get enough of a good thing . . . . .

Some back issues of ***Chinook*** are no longer available and are now collectors' items (Vol. 1, nos. 1 & 2; Vol. 3, no. 1), but you can still obtain copies of the remaining issues at the original price of $1.50 each.

Not a collector? Then do your friends a favour and pass your copies along to them. You'll give them some good reading and you may help create a subscription for us.

SUBSCRIPTION ORDER

Please enter my subscription to *Chinook*
for one year (4 issues) $7.50

Rates outside Canada and U.S. 1 yr. $9.00

Name ______________________________ please print

Address ______________________________

______________________________ Postal Code Enclosed is $ ________

Mail to CMOS, Suite 805, 151 Slater Street, Ottawa, Ontario K1P 5H3

This is a ☐ NEW order; a ☐ subscription RENEWAL