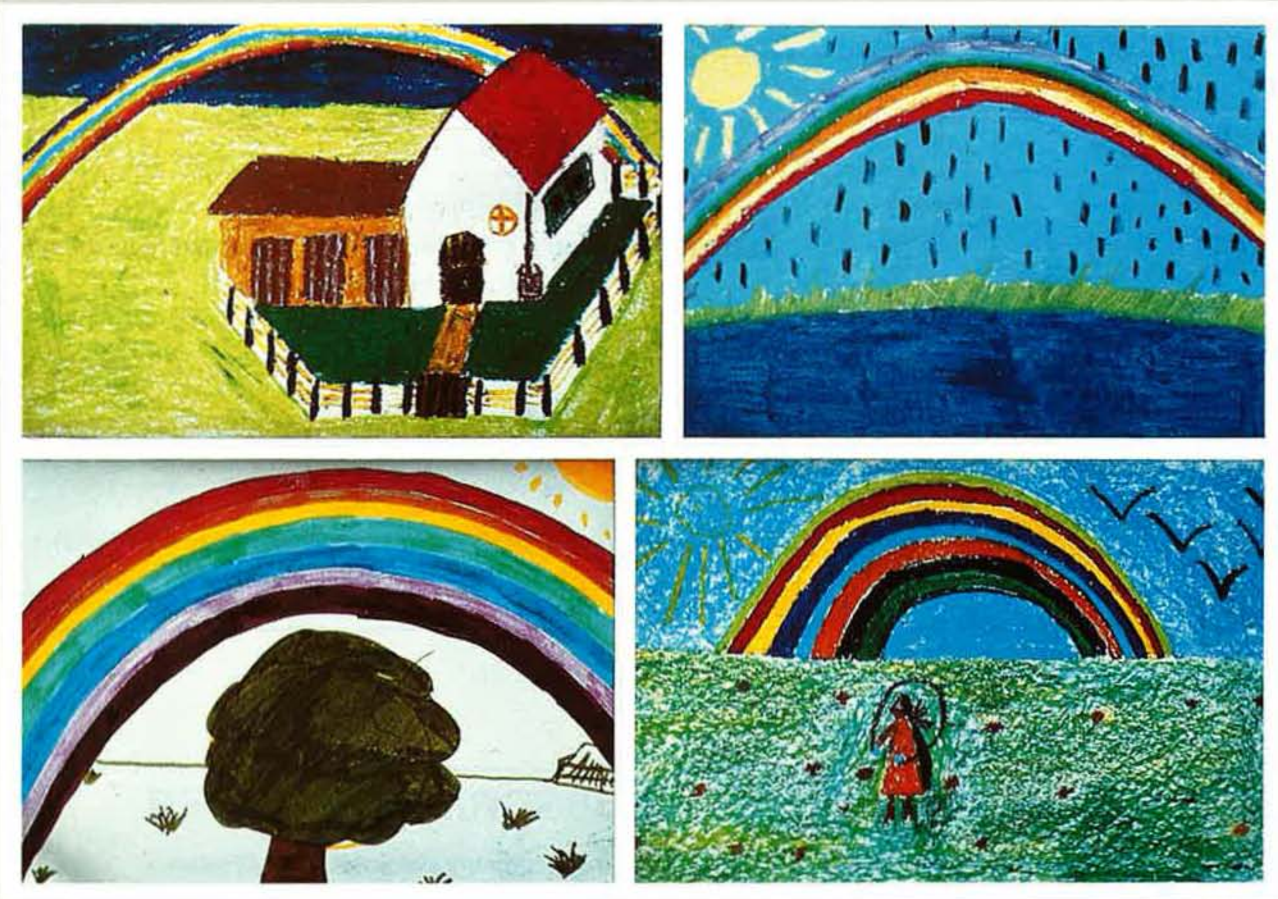
Chinook

THE CANADIAN MAGAZINE OF WEATHER AND OCEANS

LA REVUE CANADIENNE DE LA MÉTÉO ET DES OCÉANS

VOL.7 NO.4 FALL/AUTOMNE 1985



CRITIQUE

CONNAÎTRE LA MÉTÉOROLOGIE. Par Richard Leduc et Raymond Gervais. Presses de l'Université du Québec, Première édition, 1985, 300 pages, 24, 95$.

Ouvrage de vulgarisation scientifique, *Connaître la météorologie* explique en détail ce qu'il faut savoir sur l'atmosphère et la prévision du temps. Une place importante est faite aux phénomènes qui affectent le Québec sans pour cela oublier le reste du monde.

Les chapitres 1 à 3 décrivent les quantités fondamentales : la température, l'humidité, les nuages, la précipitation, la pression et le vent. Le modèle météorologique, aux chapitres 4 et 5, fait la synthèse des concepts qui ont trait à ces quantités. Le modèle météorologique est la façon efficace de digérer les données qui arrivent presque simultanément de milliers de points d'observation dans l'hémisphère nord. Le chapitre suivant est consacré au mauvais temps. Le chapitre 7 décrit la prévision technologique et se révèle également un excellent guide de prévision artisanale (style « faites le vous même »). Les observations sont le premier pas vers la prévision et le chapitre 8 décrit les instruments ainsi que les règles d'installation (qu'on pourra suivre chez soi). Un dernier chapitre traite des nombreux domaines d'applications.

J'ai trouvé ce livre excellent. On est d'abord impressioné par la clarté des figures, au nombre de 130. Le text est conçu de façon pédagogique et ponctué d'exemples qui aident à saisir rapidement des concepts abstraits. Les vues en coupe et tri-dimensionnelles sont bien réalisées. Tous les aspects scientifiques de la météorologie sont décrits sans avoir besoin de recourir aux mathématiques. J'ai trouvé très pratiques les conseils du chapitre 6 sur les précautions à observer en cas de mauvais temps. On retrouve également des tableaux utiles sur radiométéo et sur les normales climatiques. Il y a également des guides pour calculer le refroidissement éolien, l'humidex et l'heure des lever et coucher du soleil. Une annexe décrit les étapes de carrière en météorologie au Service fédéral de l'environnement atmosphérique.

En somme, un receuil d'information et aussi un manuel d'enseignement rédigé professionnellement. Un livre utile pour étudiants, journalistes, travailleurs, agriculteurs, sportifs, vacanciers, amateurs de plein air, pilotes et navigateurs.

Normand Bussières

Chinook

Fall/Automne 1985 Vol. 7 No. 4

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ISSN 0705-4572

Published by:
Canadian Meteorological and Oceanographic Society

Publié par :
La Société canadienne de météorologie et d'océanographie

Second Class Mail Registration No. 4508
Fall 1985 Date of issue – January 1986

Courrier de deuxième classe – enregistrement n° 4508
Automne 1985 Date de parution – janvier 1986

COVER

The rainbows were drawn by elementary school pupils, 10–12 years old, in the Netherlands to increase their enthusiasm for open air phenomena and their ability to make careful observations. For further details see the article on page 52.

COUVERTURE

Des arcs-en-ciel dessinés par des élèves de 10 à 12 ans, d'une école élémentaire des Pays-Bas, ont servi à éveiller leur enthousiasme pour les phénomènes atmosphériques et à développer leur aptitude à observer. L'article de la page 52 donne de plus amples détails.

THE RAINBOW IN THE ELEMENTARY SCHOOL CLASSROOM

by Cornelius Floor

The explanation of weather processes and atmospheric phenomena usually requires some basic knowledge of physics. Therefore these subjects cannot be discussed in the classroom until the later years of secondary school. Nevertheless, pupils already show an interest in the weather when they are much younger, since they know clouds, wind, rain and rainbows from everyday life. In my opinion, pupils should be stimulated to explore the everyday-life aspects of atmospheric phenomena long before they are able to grasp their physical principles. Some possible activities in meteorology lessons for pupils aged 13-15 have been discussed elsewhere (Floor, 1983). In this paper typical lessons on an atmospheric phenomenon for even younger pupils will be described. The subject was the rainbow which was treated in elementary schools where pupils were 10-12 years old. The purpose of the lessons was to increase the pupils' enthusiasm for rainbows and, more generally, for the beautiful phenomena that can be observed in the open air. The lessons were almost meant as an exercise in making careful observations. The physical explanation, of course, was beyond the scope of these elementary school lessons.

The design of the lessons on the rainbow can be summarized as follows. First, each of the pupils made a drawing (or a painting) that showed, among other things, a rainbow. Together with the class I looked at the drawings. In doing that we noticed that the rainbows on the drawings differed from each other in several respects. I continued by showing some slides (or photographs) of rainbows, paying special attention to the differences noted before. At the end of the lesson we drew some conclusions about the real appearance of the rainbow.

DRAWINGS

"Make a drawing or a painting showing a rainbow." This instruction should suffice to get a wonderful collection of rainbow drawings. More should not be said, except for asking for the location and time of each drawing, if they can be given. Pupils enjoy executing the task and very interesting paintings and drawings result. In addition, the teacher can see from the pupils' work what they already know about rainbows. All pupils in my classes had seen rainbows and all could fulfil the instruction. I collected the drawings and took them home to check them against a list of rainbow characteristics. The same list was used later in classroom discussions on the following rainbow characteristics:

1) The shape: A bow, so a part of a circle. This characteristic is known to all children and can be found on every drawing.
2) The wealth of colours: The most well known of all characteristics and also to be found on each drawing.
3) The number of colours; what colours: Now differences between the drawings can be noticed. The number of colours usually ranges from 3 to 8. This, of course, is a very difficult point. Perhaps you have heard about the seven colours of the rainbow, but is this number real? Rainbows in advertisements often show six colours or less; on mediaeval paintings rainbows have only two or three colours. Some pupils have black lines between the colour-bands of the rainbow. Is black one of the colours?
4) The order of the colours: Here different drawings also show different results. Besides, it is not always easy to compare the order of four colours on one drawing with the sequence of eight colours on another. However, it is possible, for instance, to notice that both rainbows have (or have not) a red outer rim.
5) Rain, dark skies or a dark raincloud can be seen on some drawings, but are missing on others.
6) The sun appears on quite a lot of drawings, Sometimes the sun is inside the rainbow, sometimes outside it, often in a corner of the sheet of paper. On other drawings the sun is missing. Has the sun nothing to do with a rainbow? Has it been forgotten? Or is it just sitting outside the field of view of the artist?
7) How big is the rainbow? Some pupils draw a very small bow that fits easily on the piece of paper used. Others draw a large bow, that requires a wide field of view.
8) How far away is the rainbow? This also can be seen to vary from one drawing to another. On some occasions the bow starts at or beyond the horizon. In others it is much nearer than the horizon and stands, for instance, between the artist and a house or a tree on the drawing.
9) Miscellaneous: Sometimes the drawings show other things that can be discussed, like the treasure at the foot of the rainbow, holiday landscapes or short poems.

COVER PICTURES

Upper Left Note the order of the colours. The sun cannot be seen. The bow is behind the house but nearer than the horizon.

Upper Right Sun and rain are shown. Note the order of the colours.

Lower Left The sun is just outside the bow. Clouds or rain cannot be seen. The bow is nearer than the horizon.

Lower Right Note the number and the order of the colours. The sun is just outside the bow. The background is a clear sky, without rain or dark cumulonimbus clouds. The bow is at or behind the horizon.

CLASSROOM DISCUSSION

The characteristics of the rainbow that were mentioned above were a guide for the classroom discussion. When looking at the drawings at home I noted the names of the pupils that had accentuated a special feature of the rainbow. In addition, I used the notes on location and time of occurrence that some pupils had added to their work. Examples of these notes are: "it rains and the sun is shining" or "a summer evening". The purpose of the discussion with the pupils was to make them discover some rules that are valid for rainbows. For example, there always appears to be some children who know that a rainbow is only visible with the sun in the back. Also some pupils have seen the rainbow colours, for instance, in an aquarium in the same order as in the real rainbow. If one asks, some pupils tell that they have seen a rainbow in a garden sprinkler, a fountain or in a waterfall. They therefore can agree if you conclude that "rain" is not necessary to create a rainbow, but that any source of water droplets will do. The classroom discussion also serves to make the pupils acquainted with the points in the list of characteristics that will be used when looking at the slides.

THE RAINBOW IN THE CLASSROOM

We would prefer, of course, to have a real rainbow in the classroom, to be able to compare it with our drawings and to decide which drawing corresponds best to a real rainbow. But, since this is impossible, we use photographs or slides of rainbows.

1) The shape of the rainbow on the slides can immediately be seen to be part of a circle. (However, be careful, do not make measurements, since photographic perspective may cause distortions of the pure circle.)
2) The wealth of colours can easily be seen on any colour-slide, except for some special cases – red rainbow, fogbow, lunar rainbow; see Boyer (1959), Greenler (1980), Humphreys (1964) and Minnaert (1954).
3) How many colours? What colours? This is a difficult topic. It is seen immediately that different colours can be discerned much easier on the drawings than on the slides. In the latter the colours gradually fade into each other (and they are never separated by black lines, as on some drawings). Sometimes it is difficult to observe whether there is some "orange" between the "red" and the "yellow". Furthermore, in some photographs the "blue" and the "violet" can easily be seen, while on others they seem to be missing. At the inner side sometimes supernumerary bows can be seen, reiterations of colours, usually with a pink or green turquoise tinge. The only conclusion we can draw from the slides about the number of colours in the bow is that there is no fixed number.
4) The order of the colours is the same as the order of the colours of the spectrum. (If we explain the spectrum as the colours of the rainbow, then a circular argument results.) If there are supernumerary bows then it is difficult to define the order of colours, since some reiterations occur.
5) Rain cannot easily be seen on photographs of the rainbow, but dark skies or a cumulonimbus cloud can usually be seen very clearly. The contrast of the photograph is best when the rainbow has a background of dark sky.
6) The sun never appears on rainbow slides. The photographer always had the sun in the back. Sometimes this can be seen from the shadows on the photograph; they point to the centre of the rainbow circle.
7) The size of the rainbow can only be seen on slides taken with a super wide-angle lens or a fish-eye lens. In other words: the field of view must be extra large. The size of the bow usually is expressed in degrees of arc. Since the diameter of the bow is about 84°, its size at low sun is nearly a quarter of the horizon. Therefore, we cannot place more than four rainbows at the horizon. Keeping this in mind, quite a few of the rainbows on the pupils' drawings must be judged too small.
8) At what distance is the rainbow? This question cannot be answered uniformly. The rainbow is seen in sunlit falling rain, if the observer stands in the right position. If the rain is near, then the rainbow can be concluded to be near also. If the rain is at a great distance, then the rainbow is also. In fact, the rainbow is not at a fixed place, but depends on the direction from which we view it, provided there are sunlit raindrops. Sometimes a few remarks can be made on the distance of the rainbows when studying the slides. A typical example arises when the rainbow can be seen to be situated in front of a building or other object on the slide. The part of the rainbow with the object as a background can then be seen to be less bright than its other parts where more droplets contribute to its brightness.
9) Miscellaneous. Some slides of the rainbow show that the rainbow phenomenon is more than just one colourful bright bow. Besides the primary bow, the complete phenomenon consists of a secondary bow and a characteristic dark area (Alexander's dark band) in between (see references for a detailed description).

The primary bow is a half-circle when the sun is on the horizon. When the sun's elevation increases, the rainbow sinks. At higher solar elevations (greater than 42°) the (primary) bow even disappears below the horizon. At mid-latitudes high solar elevations occur mainly in summertime just around noon. From the notes provided by the pupils with their drawings it perhaps could be concluded that no rainbows occur around that time of day. Furthermore, the occurrence of the rainbow is not restricted to the summer season; it can be observed all year long.

CONCLUSION

The drawings of pupils, their notes on the drawings together with slides or photographs of rainbows provide very useful material to present some lessons on the rainbow for pupils aged 10–12, for instance, following the guidelines given in this paper.

FURTHER READING

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Cornelius Floor is a meteorologist at the Royal Netherlands Meteorological Institute in De Bilt. He has worked in training physics teachers as well as in research. His special interest is physics in the world of nature and in particular, optical phenomena in the atmosphere.

The article is the result of a paper he presented at the First International Conference on School and Popular Meteorological Education held at Oxford in early July 1984. The photographs on the cover were provided by the author.

RÉSUMÉ *L'une des méthodes employées pour permettre à des élèves de 10 à 12 ans de se sensibiliser aux phénomènes atmosphériques consiste à donner des leçons sur les arcs-en-ciel. Ces leçons permettent aussi à l'écolier de développer son sens de l'observation. Les élèves représentent par le dessin des arcs-en-ciel dans des paysages. On compare ensuite ces arcs-en-ciel selon les paramètres suivants : la forme; la dimension; le nombre de couleurs utilisées, leur disposition et la richesse des teintes; la distance entre l'observateur et l'arc-en-ciel. On examine aussi les dessins du soleil, de la pluie et des nuages foncés.*

Les différences relevées, en ce qui concerne ces paramètres, font l'objet de discussions de classe. Des photographies ou des diapositives d'arcs-en-ciel sont ensuite passées aux élèves afin qu'ils les comparent à leurs dessins, encore selon la liste des paramètres. D'après l'enthousiasme des élèves, on peut conclure que cette méthode aide l'écolier à mieux prendre conscience de son environnement.

SNOW ROLLERS

by Allen Pankratz

Figure 1 Ruler in front of roller (Photograph: Brain Mottus, Grande Prairie Weather Office).

The evening of Valentine's Day, February 14, 1985 proved to be highly interesting for the residents of Grande Prairie, Alberta. Grande Prairie is a city of 24,000 in the foothills of the Rocky Mountains, 360 km northwest of Edmonton. Snow had fallen in the area during the previous night, and temperatures rose from - 18°C at 9 a.m. to -9°C by 2 p.m. under generally cloudy skies. For the most part, winds were calm. The sun broke through in the late afternoon and the mercury hit -5°C before darkness set in. By 8 p.m. temperatures had slumped to -10°C with light northerly winds. This set the stage for 4 hours of decidedly unusual winter weather.

An extremely intense cold low in the Gulf of Alaska (mean sea-level surface pressure of about 968 mb) had extended a trough across the mountains during the afternoon. This enabled a small low to form in the Peace country north of Grande Prairie. As a result, a strong westerly flow developed south of the low. The Arctic front moved off the foothills, allowing warmer Pacific air to reach the surface east of the Rockies. Aloft, strong southwesterly winds pushed cold air over northwestern Alberta in the wake of a fast-moving upper-level weather disturbance that had crossed the area during the late afternoon.

Surface convergence, instability, possible jet stream divergence aloft and an adequate moisture supply combined to produce buildups of cumulonimbus cloud. The temperature rose 14 degrees from 8 to 9 p.m. in advance of the buildups, coincident with the passage of a warm front. Shortly before 10 p.m., winds turned westerly at 75 km/h as thundershowers approached, and over the next half hour reached a peak gust of 120 km/h. This was only 2 km/h below the all-time record wind speed at the airport. Visibilities ranged from 0 to 1 km in rain, snow and blowing snow. Blue-green lightning of various types was observed as well, adding elements of a light show to the already wild and woolly weather.

Shortly before 11 p.m., the thunderstorms moved past the city and wind speeds dropped off to 55 km/h. Visibilities rose to 16 km in light snow and blowing snow. The snow stopped shortly afterward, but the winds remained moderate to strong, and temperatures hovered close to freezing for several hours.

The result of this expenditure of energy was a vast area covered with irregularly shaped snow balls and cylinders. Photographs from various sources showed thousands of rollers covering open fields, front lawns and even roofs of houses. The majority of the rollers seemed to be football size. Photographs (Figure 1) confirmed the existence of rollers with 30-cm diameters and estimated weights of 4–6 kg. The Officer-in-Charge of the Grande Prairie Weather Office said he had heard of even larger ones, which were verified by photographs obtained from the Alberta Forestry Service (Figure 2).

The rarity of the snow roller phenomenon is attributable to the requirement that several specific atmospheric and surface conditions must occur simultaneously. It is frequently necessary to begin with a layer of older snow that has had time to bond and form some type of surface crust. A subsequent fall of snow at temperatures near the freezing point combines with it to form a layer of snow possessing uncharacteristic cohesiveness and flexibility.

A roller is created when gravity or wind is able to gain some purchase on a piece of snow and move it across a surface of newly fallen snow. The initial piece can be part of the newly fallen snow or a projecting portion of the underlying, more structured snow cover. As it is pushed across the snow, it gains in volume as the flexible snow underneath is rolled around the core, in a manner similar to rolling up a sleeping bag. The result is an irregular ball or cylinder of snow moving along the surface, leaving a trench behind.

The extremely strong winds at Grande Prairie seemed to favour the formation of irregular ball-shaped rollers, since variable gusts and eddies pushed the snow in different directions. However, a less violent wind with a steadier speed frequently leads to the more cylindrically-shaped rollers. Such a roller of necessity moves in a fairly constant direction, and gains in surface area as it rolls, forming a cylinder with concave ends. Many cylindrical rollers have soft cores, and some have no core at all (Figure 3). Proof that snow rollers need not be a localized phenomenon was shown by the weather system that affected the Lloydminster area on March 6, 1984. A forecaster from the Alberta Weather Centre related that while driving to Saskatchewan, he had seen rollers in fields along 240 km of highway from just east of Edmonton right through to Lloydminster.

The size of snow rollers obviously varies considerably, depending on terrain and snow cover characteristics, snowfall and wind. Available literature suggests that diameters of 30–60 cm are quite common. Unconfirmed reports from the Lloydminster area mentioned diameters in excess of 75 cm. The largest rollers form where the combined forces of wind and gravity are able to push and pull a roller for long distances before the increasing mass finally brings it to a halt. Slopes inclined downwind are obviously the most suitable areas. However, it is not unheard of for rollers to form while moving uphill, given sufficiently strong winds.

In some cases, strong winds need not be present at all. One such incident was discussed in the January, 1981 issue of *Weather*. Snow rollers formed in the Troodhos Mountains on the island of Cyprus after a night of vigorous snow showers. Skies cleared and the sun rapidly melted the snow on exposed southern slopes the next day. Runoff or melting topsoil apparently dislodged small stones that rolled down the inclines and fell into the snow cover left in shadier areas. The snow happened to be of the required consistency and snow rollers formed and then continued to roll to the bottom of the hill. All were subsequently found to have pebbles at their centres.

Owing to the internal properties of the snow, rollers are frequently quite fragile immediately after initial formation. However, a drop in temperature can act to harden and preserve them for a period of time. The rollers at Grande Prairie remained for about 2 weeks, providing an interesting reminder of a strange winter storm.

Figure 2 Rollers against fence (Photograph: Alberta Forestry Service).

Figure 3 Hollow rollers (Photograph: Wilfred Burkett, Neilburg, Sask.).

Allen Pankratz is a meteorological technician working at the Alberta Weather Centre in Edmonton with experience at northern weather stations. He is a recent meteorological graduate from the University of Alberta and is currently taking the Meteorologist Operational Course at Downsview, Ontario.

WHY IS THE SKY BLUE?
Discovering the Atmosphere at Science North

by Alan Nursall

The author checks the Campbell-Stokes sunshine recorder. The glass sphere focuses the sun's rays on a strip of treated paper, burning a path to record the hours of bright sunshine.

It is perhaps sad but true that meteorology and climatology are not glamorous sciences in the minds of the general public. Even though this attitude is changing with the emergence of the Greenhouse Effect, El Niño and the Sahelian drought as popular media topics, far too often the atmospheric sciences are viewed as little more than vainglorious attempts at estimating next Thursday's probability of precipitation. I suspect that this attitude is the reason why the atmospheric sciences have usually received only a cursory treatment in most science museums.

With the opening of Science North in Sudbury, however, this oversight has been addressed, and the atmospheric sciences have been provided a high profile. This major new science centre contains an activity area devoted solely to the study of the atmosphere. All aspects of the discipline are treated, from the purely operational to the purely academic. It is a concerted effort to give members of the public some insight into how the atmosphere behaves and how that behaviour is studied.

THE PHILOSOPHY OF SCIENCE NORTH

Science North aims to be a science centre like no other. It was founded, not as a sister institution to the Ontario Science Centre, but rather as an independent museum with its own vision of how science should be brought to the public. While most centres attempt to give the visitor a hands-on experience, this is usually limited to pressing buttons or pulling levers in order to make something happen within a glass-walled enclosure. Even though this approach has been successful, the visitor still views science from a distance. There is little exposure to the tools of science, or to the thought processes that stimulate the scientific method. Furthermore, the visitor's experience is defined by the exhibits. He can learn no more than the very specific task that the exhibit is designed to accomplish.

At Science North, the hands-on idea has been taken another step. Most of the display areas are configured like large laboratories, where visitors mingle with staff members and take part in counter-top activities. The idea is not to define the visitor's experience by the activities provided for him, but rather to let the visitor actively determine what he experiences.

The personal communication between staff and visitors is the crucial element that allows this approach to work. All laboratory areas are manned by staff or well-trained volunteers, and visitors are encouraged to ask questions about what they see. They are given the opportunity to satisfy their curiosity and on many occasions leave with answers to questions that may have been nagging them for years.

We also make an effort to place the tools of science in the hands of the visitor. Microscopes, beakers, balances and computers are put on the counter to be used as a scientist would. For one visitor, a computer might be used to run a program on weather fronts, while for the next, it might be used to analyse Sudbury's 1984 temperature data. By retaining maximum flexibility, we can tailor our activities to suit the individual visitor.

ATMOSPHERIC SCIENCES

At the heart of the Atmosphere Lab is the Weather Station, as superbly equipped as any in Canada, thanks to generous capital donations from various components of Environment Canada including the Atmospheric Environment Service (AES). The outdoor observing site includes two Stevenson screens, standard and tipping-bucket rain-gauges, a Campbell-Stokes sunshine recorder, twin radiometers (for incoming and reflected solar radiation), a laser ceilometer, a visibility meter, a CAPMoN precipitation sampler and an anemometer. The values output from all these instruments (except the CAPMoN) are displayed on a wall of the Atmosphere Lab. Next to these readouts sit monitors displaying radar pictures from the antenna located in the village of Britt, and the latest images from both the GOES and NOAA satellites. The satellite images are controlled by the new AES Viewfax system, which allows them to be colour-enhanced, displayed in animated sequence and stored in computer memory.

In addition to this meteorological gear are several items not generally found in an operational weather station. Situated beside the radar and satellite monitors is the Lightning Locator System, provided by the Ontario Ministry of Natural Resources. During the summer, it pin-points the time and location of every cloud-to-ground lightning flash in Ontario and the Great Lakes region. Plots of lightning activity can be displayed in real-time or rerun from computer memory.

The final major gadget at our disposal is a fully operational air quality monitoring station, courtesy of the Ontario Ministry of the Environment. Seven air contaminants are measured and the data are used by the MOE in the province-wide air quality assessment program.

This ensemble of hardware is surrounded by the laboratory area where we try to make sense of it all for the visitor. The instrumentation provides an impressive backdrop, but it means little without the proper interpretation. We strive to make the Atmosphere Lab more than just an operational weather station. It is intended as a place where the behaviour of the atmosphere can be studied and where visitors can gain an appreciation of the atmospheric phenomena that surround them every day. Although we have the capability of carefully monitoring the weather across the continent, we must always remember to cater to the fellow who just wants to know why the sky is blue.

It is this sort of question that the Lab has been designed to handle. Any first-year student of climatology will testify that the atmosphere is an exceedingly complex tapestry of physical and chemical processes, each one seemingly interwoven with all the others. It is difficult to gain a global understanding of the atmosphere without first studying smaller components. Thus we try to design activities to answer specific questions. What is the shape of a raindrop? How do snowflakes form? What is lightning? Do wooly-bear caterpillars know something about the weather that we do not? Where do rainbows come from? What are the chemicals in acid rain? All of these (and many more) can be easily handled with simple counter-top activities. Each highlights a specific phenomenon, but they can all be interrelated as well.

In the spring of 1985, the Atmosphere Lab contained activities that explored weather folklore, the formation of hurricanes, the shapes of raindrops, the weight of the atmosphere, the energy from the sun and many more. By midsummer, half or all of these may be replaced by explorations of rainbows, clouds, acid rain, the Greenhouse Effect, or whatever else we find that piques the interest of visitors.

In fact, new demonstrations can appear and disappear as rapidly as the creativity of visitors and staff will allow. Because we have stocked the display area as a laboratory, with a good supply of beakers, clamps and assorted paraphanalia, demonstrations can be mounted on the spot in response to a visitor's inquiries. It is this flexibility of satisfying individual curiosity that is Science North's greatest strength.

Visitors will be able to operate a viewfax system, one of only three in existence, and the most up-to-date photo display system available.

One area no less important than the Lab is the Atmosphere Theatre. This small demonstration area seats about 30 people, and is suited for science magic shows, daily presentations of weather forecasts, slide shows and films and a host of other applications. Since the theatre also looks out through a large west-facing window, fortuitously framing Sudbury's famous Superstack, it is ideal for viewing advancing weather systems and studying plume activity under different atmospheric conditions.

LOOKING TO THE FUTURE

Since Science North is such a young institution, we are experiencing the inevitable growing pains. It is sometimes difficult to get our visitors as involved as we would like. It is also a challenge to manage the inescapable wear and tear on instruments exposed directly to the public. Because our exhibit program is still in its infancy, we are gradually learning what works and what does not and how to meet the incredibly varied expectations of our visitors.

The first 10 months of operation have delivered their fair share of frustration, but the rewards are beginning to show. As the exhibit program evolves, more and more members of the community are becoming frequent visitors and getting directly involved. I have already worked with several students from various grades on science fair projects. Volunteers man the weather station each weekend, and have also helped in writing computer programs, building new exhibits, and lending their expertise in instrumentation, to name but a few of their contributions. We offer organized school programs in weather and air pollution, and these have proved popular. All these activities lay the groundwork to make Science North an important educational resource centre for all of central Ontario.

The future of the Atmosphere Lab looks rosy. With superb facilities already in place, it is now a question of realizing its full potential. Discussions have begun with the local cable company to develop a weather channel for the Sudbury region. The local TV station is also interested in using the Lab as a venue for the weather segment of the Evening News, bringing Science North and state-of-the-art meteorology into living rooms across central and northern Ontario.

Projects for the summer of 1985 include the construction of a micrometeorological site and the development of software to highlight the importance of computers as tools in atmospheric research. We will also be working towards fully-automated data gathering in the weather station.

I extend a hearty invitation to all my academic and operational colleagues to pay us a visit or offer any ideas on future development. There is no reason why Science North should not become a leader in public education about the atmosphere. I personally believe we have suffered the reputation of being ball gazers and coin tossers for far too long. Increasing the public's understanding of weather can only serve to make our jobs much easier.

Alan Nursall is program planner for Atmospheric Sciences at Science North in Sudbury, Ontario. Photographs: Robert C. Ragsdale.

RÉSUMÉ *Science Nord est un centre des sciences unique en son genre. C'est un musée indépendant qui présente les sciences au public de façon unique. Les expositions invitent à la participation des visiteurs à diverses expériences. La communication est considérée comme importante et cruciale dans cette méthode.*

L'une des activités se rattachant aux sciences de l'atmosphère est basée sur un laboratoire de l'atmosphère qui renferme une station météorologique superbement équipée. Un vaste choix d'équipement moderne d'observation permet entre autre d'accéder aux données du radar et des satellites météorologiques orbital et géostationnaire.

Les activités sont conçues pour fournir aux visiteurs des réponses précises à des questions de base comme par exemple, quelle est la forme d'une goutte de pluie? Quels produits chimiques retrouve-t-on dans la pluie acide? et à bien d'autres questions.

LABOUR DAY WEEKEND TORNADO AT LONDON, ONTARIO

by Luigi Bertolone

The Labour Day weekend of 1984 will long be remembered by residents of London, Ontario. Late on Sunday afternoon, a narrow wedge of hot and humid tropical air was drawn across southwestern Ontario by the approach of a frontal wave. By suppertime, there could be no doubt in the mind of anyone who scanned the blackening skies and boiling clouds that the severe weather forecast in the Ontario Weather Centre weather warning issued one and a half hours earlier was no false alarm. Between 6:00 and 7:30 p.m., southern Ontario's major tornado outbreak of the season occurred. Altogether, eight confirmed tornadoes were reported along a stretch from Windsor to London, Ontario. This is the area looked upon as the "tornado alley" of southern Ontario. The most devastating of these storms ravaged a densely populated area in London.

At about 7:00 p.m. on September 2nd the sky darkened and lightning snaked across the sky, while a black whirling engine of destruction started ripping roofs and smashing windows along its path of havoc. This vicious storm pursued a nearly straight swath about 5 kilometres long across the southern end of the city. The width along its damage path was fairly uniform at about 120 metres. According to several eyewitnesses, the funnel remained visible for about five minutes, then it dissipated after moving at a translational speed of about 60 km/h.

Heavy rainfalls and large hail (6.5 cm in diameter) also accompanied the storm in several localities. The hail caused considerable damage to parked vehicles and completely destroyed an entire concession planted with tobacco near Langton, a small community not far from Tillsonburg.

Close to 7:15 p.m. John Purvis saw a funnel forming over a grassy field (A in Figure 1) approximately 200 metres northeast of his house. A few seconds later, he heard a loud noise and found himself on the floor – his house (Figure 2) was the first to be damaged by the twister. While the tornado moved eastwards, it blew the roof off several townhouses (Figure 3) located at B.

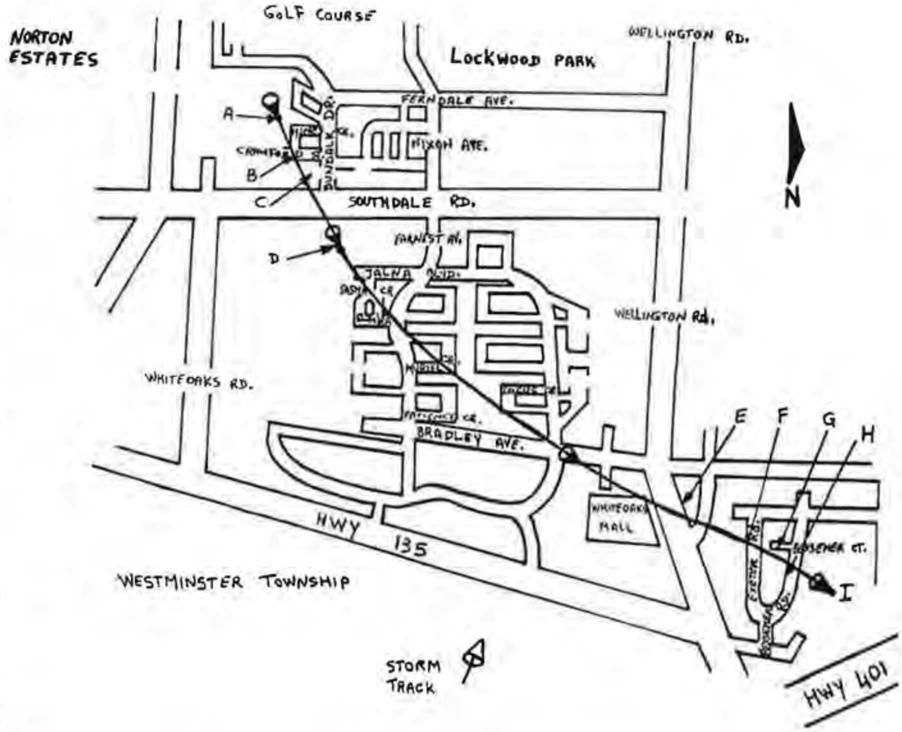


Figure 1 Partial map of the city of London, Ontario, indicating the damage path of the tornado (not to scale).

Figure 2 House at 11 Hines Crescent.

Figure 3 Townhouse complex on Crawford Street (B in Figure 1).

Figure 4 Apartment building on the north side of Southdale Road just west of Dundalk Drive (C in Figure 1).

Figure 5 Remains of two 18-metre construction trailers (D in Figure 1).

Then it passed between two apartment buildings (C) smashing all of their windows (Figure 4) and, shortly afterwards, completely destroyed two 18-metre construction trailers (Figure 5) at D. Then, the twister swept through a rather large subdivision of residential houses and over a steel-framed metal sign (E) bending it to the ground (Figure 6). This was the first damage inflicted on the commercial area. At this time the fury of the twister climaxed and thereafter caused nearly total destruction along the final portion of its swath (I). The total damage done to the industrial area was incredible. Typical examples of this destruction are shown in Figures 7, 8 and 9.

The scene was chaotic. The hydro was out. Police officers were busy directing the heavy traffic generated by confused motorists inching along without the aid of traffic lights. The evening darkness was frequently interrupted by the flashing lights of their emergency vehicles. All available fire-fighters and their equipment were deployed to respond to trouble spots. Public Utility Commission workers tried to restore electrical power, while Bell telephone employees did their best to replace telephone wires.

By 10 p.m., 140 city police and military personnel from Canadian Forces Base London had been called in to guard damaged buildings from being looted, and to set up an emergency shelter which was quickly accomplished at Cleardale Public School where victims obtained help. At least 30 people were injured by flying debris. Luckily, most had only superficial cuts and bruises. Just two of them were detained at Victoria Hospital for treatment of deeper lacerations, but they were in satisfactory condition the next day. Dazed victims spoke with deep gratitude about the wonderful response of groups of volunteers who gracefully offered aid to temporarily homeless families.

When one resident of Sasha Crescent found enough courage to emerge from his basement, he found that all the windows of his house were blown in and the shingles, aluminum siding and eavestroughs were blown off. Yard furnishings had also disappeared while the mail box at the corner of Sasha Crescent and Elvira Crescent had been replaced by a bathtub partly full of water that belonged to the Sedley family of 3 Sasha Crescent As the news of the destruction spread, local residents who left town for the long weekend rushed home. Marty Harrop, of 1 Hines Cres., had been watching the Canada Cup hockey game in Fergus. When news of the tornado flashed on the televison screen he left immediately and found his house had suffered a direct hit.

As a cool and cloudy Labour Day dawned, much more work had to be carried out in the twisted aftermath of the tornado. Industrial refuse dumps were opened to dispose of debris. Massive clean-up and restoration efforts were rapidly started by the victims themselves.

Tornado severity is commonly estimated by using the Fujita F-scale. As a

Figure 6 Motel sign. Sign post – 40 cm in diameter (E in Figure 1).

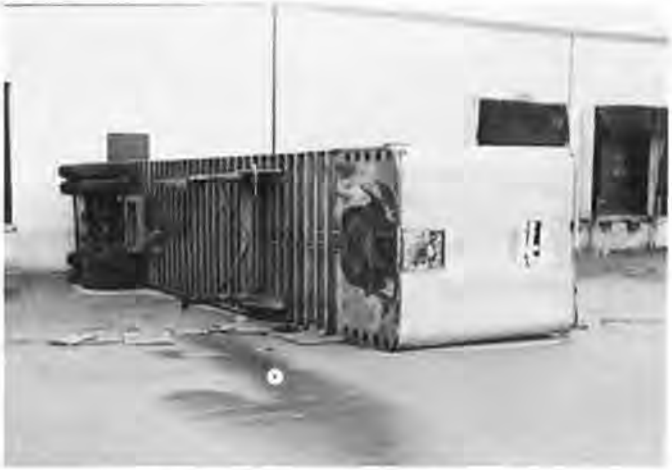


Figure 7 An 18-metre trailer (F in Figure 1).

Figure 8 Conference Cup building (G in Figure 1).

Figure 9 Christie Biscuit factory (H in Figure 1).

result of the damage inflicted, this tornado was classified as an F-3 tornado, which has characteristic wind speeds in the range from 250 to 330 km/h.

Although catastrophic, this blow was not as devastating as the 1979 Woodstock tornado, nor as severe as the one that hit Reeces Corners in 1983. However, it ranks higher, in the F-damage scale, than the Metropolitan Toronto tornado that occurred two weeks earlier. In spite of the strong winds and the damage inflicted (several millions of dollars), miraculously not a single human life was lost. Most likely, the reason for this is the tornado hit during a Sunday evening on a holiday weekend. On a regular working day people would have been at home in the evening, and several could have lost their lives.

Such shocking and devastating events have been considered freak accidents that rarely occur. Recently, however, tornadoes appear to be occurring more frequently. This apparent increase in tornado frequency may not be true: tornadoes are likely to have been just as frequent 80 years ago. The reason is that tornado detection depends on population density. With an increasing population, more tornadoes would be reported to Weather Service staff by the public.

Today the mass media have advanced public awareness and communication tremendously, which in turn has made citizens more aware of tornadoes. At the same time, the steady rise in population is making southern Ontario more vulnerable to tornado damage.

Luigi Bertolone is an operational meteorologist at the Ontario Weather Centre and has been involved particularly with the prediction of summer severe weather. The photographs are provided by the author.

RÉSUMÉ *Une forte tornade (F-3 sur l'échelle Fujita) a balayé la ville de London, Ontario pendant la fin de semaine de la Fête du travail de 1984. Son sillon destructeur, d'une longueur parcourue de près de 5 km, a traversé une région à forte densité de population et a semé le désordre complet ne laissant derrière que des zones ravagées. Néanmoins, personne n'a perdu la vie en dépit de cette tempête furieuse.*

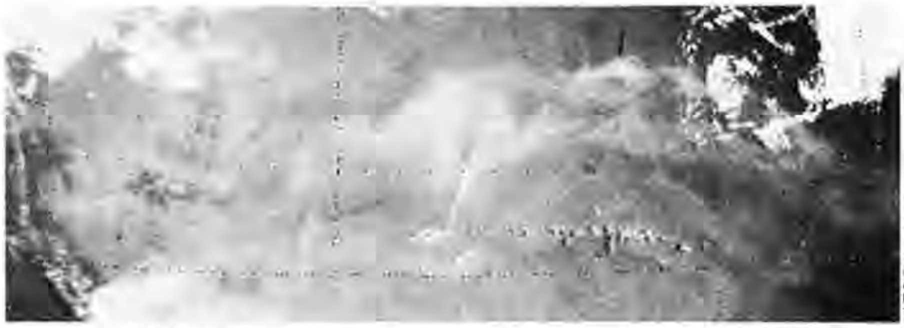
Les conditions météorologiques étaient propices au développement de temps violent même avant la formation de la tempête qui a engendré la tornade. Cela a incité le Centre météorologique de l'Ontario à diffuser un avertissement de la situation imminente de temps violent.

Cet article vise à décrire aux lecteurs tous les détails du phénomène, y compris les dommages subis, les répercussions du choc sur l'être humain, les mesures prises par la population et ses réactions face à la tempête.

SUMMER OF '85 – A SEASON OF EXTREMES AND COSTLY IMPACTS

by Amir Shabbar

Climatic anomalies severely strained local economies and some even resulted in massive evacuations of people and loss of lives.



AES Downsview

Smoke from B.C. forest fires streams across Saskatchewan on 12 July 1985 at 1441 GMT in this NOAA8 visual image.

Climate anomalies or variations are very much a part of Canada's natural climate, and usually are at their extremes during the summer months, June, July, and August. Persistent drought, forest fires, floods and violent tornadoes often bring economic hardship, extensive property damage and sometimes loss of lives. This year was no exception. Major forest fires burned valuable timber in British Columbia, severe drought plagued the southern Praires and tornadoes inflicted death and destruction on southern Ontario.

TEMPERATURE

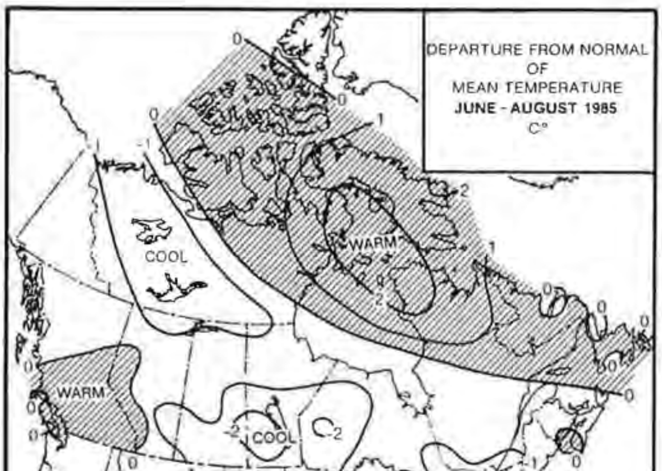
A vast area of the nation from the Rockies through the great Lakes Basin to the East Coast had a cooler than normal summer. Temperatures were near-normal in southern British Columbia, and only the northeastern Arctic experienced a significantly warmer summer (by about 2°C). Temperature departures were not extreme; the majority of the climate stations reported anomalies that were less than 2°C. Cool weather about 1°C below normal persisted throughout the season in southern Manitoba and southern Ontario. Although not a record, the warmest temperature was 41°C on July 30 at Lytton, B.C.

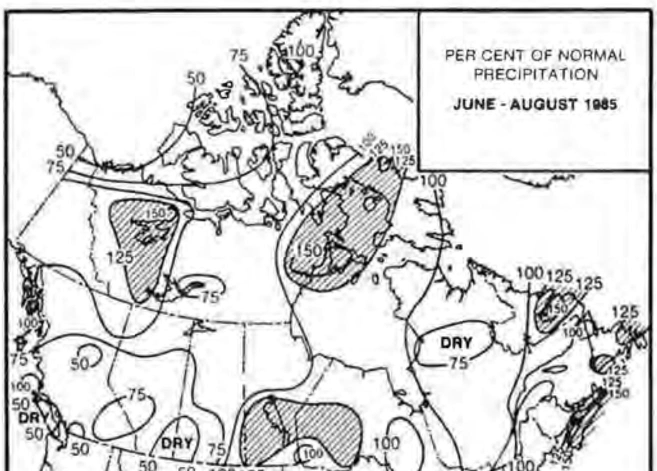
PRECIPITATION

Drier than normal weather prevailed from the West Coast to central Saskatchewan, and over central Québec and the northwestern Arctic Islands. Swift Current, Saskatchewan, was one of the driest locations, receiving only 41% of normal summer rainfall. Waterloo, Ontario, was the wettest locality with 412 mm of rain or 183% of normal. Southern Manitoba, Atlantic Canada and the northeastern Arctic were also wetter than normal.

SIGNIFICANT CLIMATIC IMPACTS

Summer's cool temperatures disappointed most Canadians this year. The Maritimes experienced one of the most dismal Junes in recent memory, owing to persistent cloudy, cool and wet weather. Only British Columbia enjoyed a prolonged hot spell in July. Sunshine





AES Pacific Region

Scene over southeastern British Columbia on the morning of 12 July 1985.
YCG Castlegar, YRV Revelstoke, YXC Cranbrook, WGE Golden, WSW Sparwood.

was also plentiful on the West Coast (400 hours of bright sunshine in July – a 71-year record at Victoria). However, the threat of forest fires discouraged tourists.

Less than 50% of normal precipitation during June and July together with oppressive heat resulted in the worst forest fire season ever in British Columbia, where major fires were ignited in southeastern areas. The fires threatened several communities, and forced the town of Canal Flats to be evacuated for several days. Over 240,000 hectares of prime timber were consumed compared with 19,500 hectares last year. At the height of the season, more than 6,300 fire-fighters were battling the blazes. Fire-fighting costs and timber losses exceeded $300 million in British Columbia,

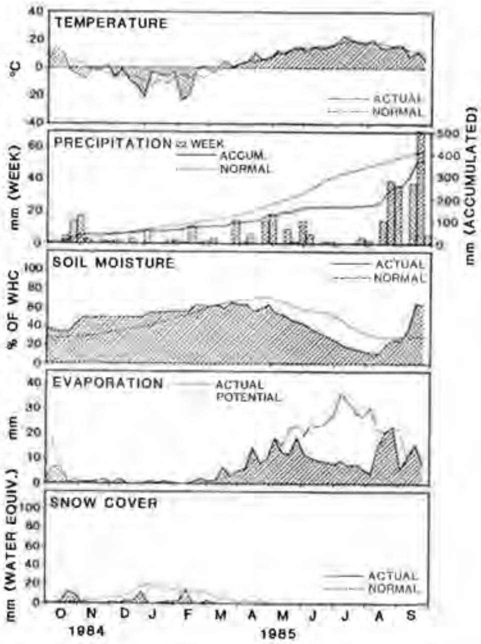
In early summer, major fires also erupted in Labrador, destroying large forest stands; according to forestry officials, this fire season was one of the worst in Newfoundland's history. On the other hand, Ontario and Québec enjoyed one of their quietest fire seasons in years: In Québec, fires destroyed less than 10% of the 5-year average (53,000 hectares).

Second successive year of drought in southwestern Saskatchewan and southern Alberta.

Violent tornadoes ushered in June across the lower Great Lakes and the St. Lawrence Valley. On May 31, the third-worst Canadian tornado disaster struck southern Ontario (see forthcoming article in *Chinook*, Volume 8). Twelve people were killed, and hundreds were injured or made homeless. Property losses exceeded $100 million. The City of Barrie was the hardest hit – 8 people lost their lives. Only two tornadoes in Canadian history have been worse: the "Windsor" Ontario tornado of June 17, 1947 (17 killed), and the "Regina" Saskatchewan tornado of June 30, 1912 (28 killed).

Severe summer storms caused extensive property and crop damage in southern Québec. On June 19, a tornado ripped through the town of St-Sylvère, three people suffered injuries and property damage was nearly $1 million. Again on July 29, a destructive hailstorm southeast of Montréal damaged 800,000 bushels of apples causing losses estimated at $3.5 million.

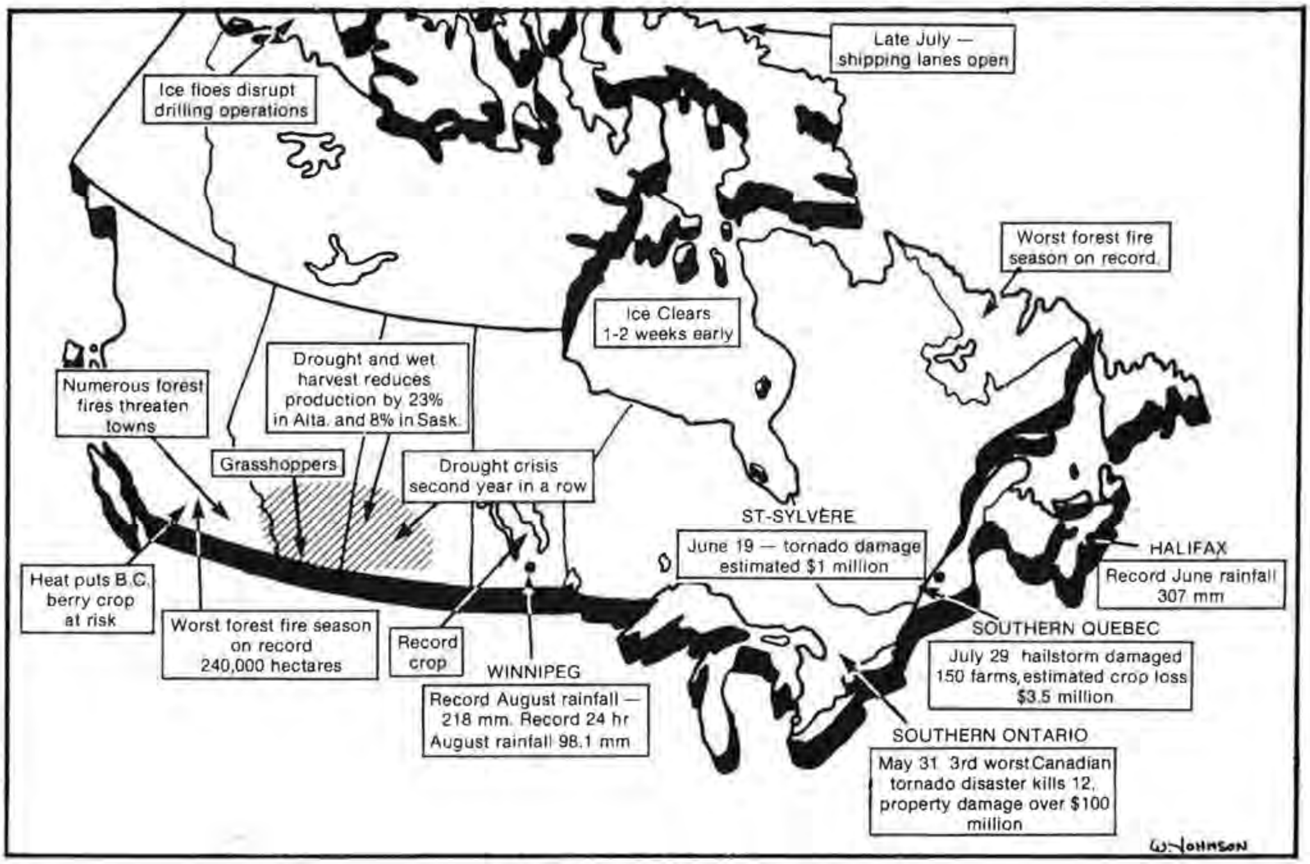
Of all the climate-related events, the Prairie drought had the greatest socio-economic impact in Canada this summer. For the second year in a row, severe drought plagued southwestern Saskatchewan and southern Alberta. Timely spring rains provided germination moisture, but the hot and dry weather during June and July stunted crop growth. Most of the locations in the drought-stricken area received less than 50% of normal summer rainfall; for example, the meagre 3 mm at Lethbridge set a 78-year record for the driest June; Shaunavon, Saskatchewan, had less than 10 mm during June and July. On the parched land, the soil was powder dry with a moisture index only 20% of its holding capacity. Strong winds lifted nutrient-rich soil causing extensive soil erosion. Grasshopper and flea-beetle infestation compounded the farmers' problems. In some Alberta communities, the drought was the worst since the turn of the century. The drought ended suddenly in late August when a general rain soaked the droughty areas. Estimates of crop yield ranged from record high in Manitoba to significantly below average in Alberta. Because of the favourable growing season in Manitoba, the total Prairie grain production was expected to be 5.5 million tonnes above average. However production in Alberta and Saskatchewan was forecast to be down by 23 and 8%, respectively. Statistics Canada estimates that grain farmers will suffer $1 billion of direct losses from the 1985 drought.



Time series of Water budget components at Lethbridge to 23 September 1985. Values are based on a 7-day mean or total. WHC is the water holding capacity of the soil.

Warmer than normal temperatures helped to disintegrate pack-ice along the Labrador Coast in June and July, about 1 week earlier than usual; and the iceberg population in the Labrador Sea was low. Eastern shipping lanes to the Arctic were open by late July. The clearing of ice in Hudson Bay was about 10 days earlier than usual. In the Beaufort Sea, onshore winds pushed the pack-ice perilously close to the drill sites where ice conditions were the worst since 1978.

Amir Shabbar is a meteorologist in the Canadian Climate Centre engaged in research, with a special interest in long-range prediction problems.



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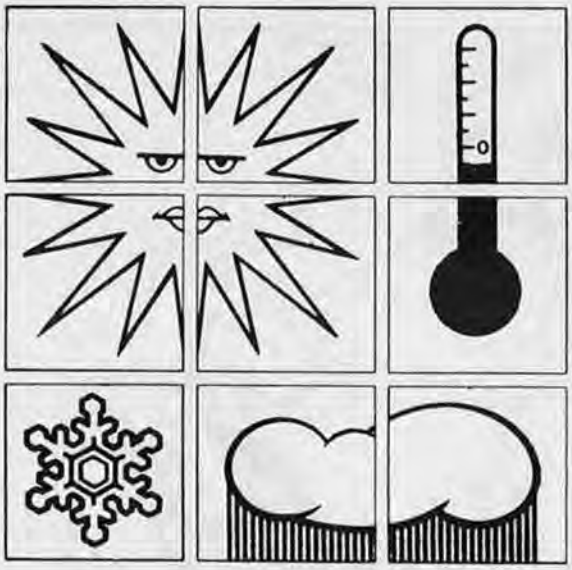

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