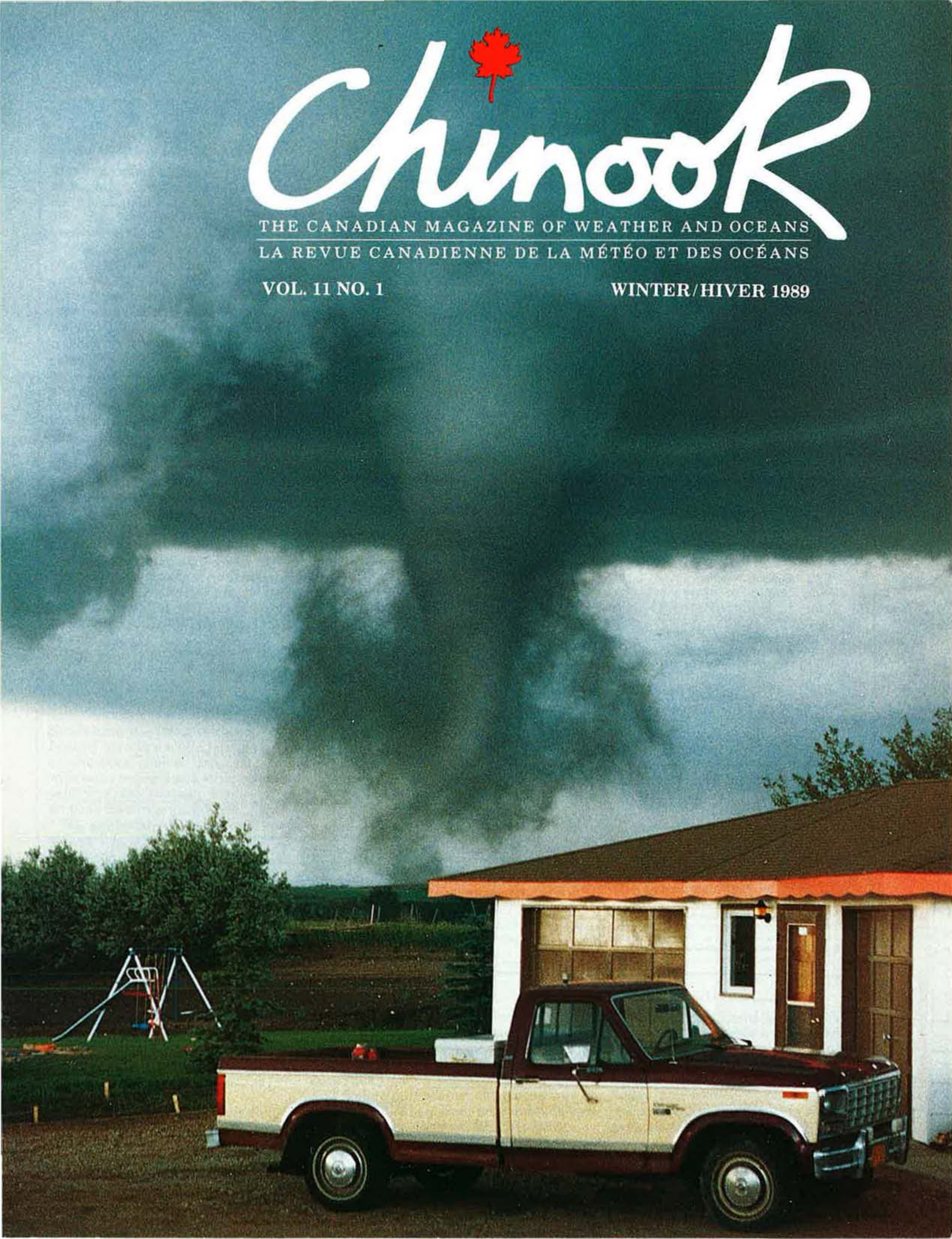
# Chinook

THE CANADIAN MAGAZINE OF WEATHER AND OCEANS
LA REVUE CANADIENNE DE LA MÉTÉO ET DES OCÉANS

VOL. 11 NO. 1 WINTER/HIVER 1989



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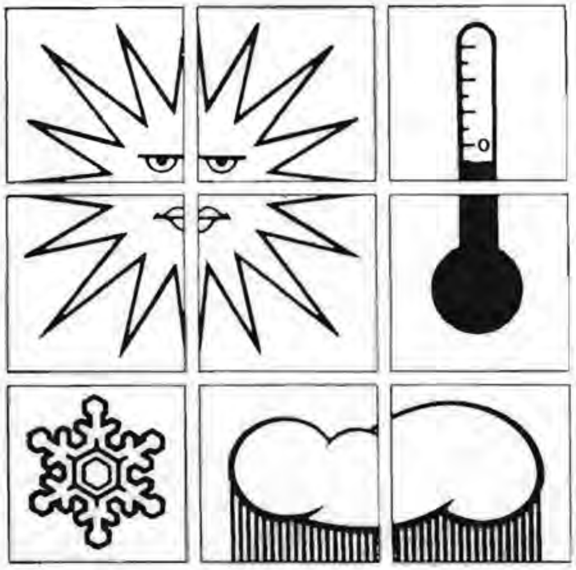

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Chinook

Winter / Hiver 1989 Vol. 11 No. 1





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FOUNDER AND EDITOR 1978–1984 Michael J. Newark FONDATEUR ÉDITEUR 1978–1984
ISSN 0705-4572

Published by:
Canadian Meteorological and Oceanographic Society

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

Printed and produced in Canada and published quarterly by the Canadian Meteorological and Oceanographic Society, P.O. Box 334, Newmarket, Ont. L3Y 4X7, Tel.: (416) 898-1040. Annual subscription rates are $10.00 for CMOS members, $12.00 for non-members and $15.00 for institutions.  All correspondence including requests for special permission or bulk orders should be addressed to *Chinook* at the above address.

Second Class Mail Registration No. 4508
Winter 1989 Date of issue – September 1989

Édité et imprimé au Canada. *Chinook* est publié tous les trois mois par la Société canadienne de météorologie et d'océanographie, C.P. 334, Newmarket, Ont. L3Y 4X7, Tél.: (416) 898-1040. Les frais d'abonnement annuel sont de 10,00 $ pour les membres de la SCMO, de 12,00 $ pour les non-membres et de 15,00 $ pour les institutions.  Toute correspondance doit être envoyée au *Chinook* à l'adresse ci-dessus, y compris les demandes de permission spéciale et les commandes en gros.

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## FROM THE EDITOR'S DESK

This issue offers a wide variety of interesting topics. A story about one of the early leaders in Canada's Weather Service, Dr. Frederic Stupart, takes us back to the North of old.

Mike Newark – our founder-editor, who is also *the* expert in Canada on tornadoes, tornado climatology, and the impacts on building codes – offers our readers an updated view of that most violent of storms in the Canadian scene.

Who can forget the droughts of past years? Prairie folk can remember the big ones. Peter Scholefield and colleagues provide us with an expert view of "what happened". We are likely to hear more about this phenomenon, which affects our Prairie economy so much.

Finally we have another Weather Map Series. We stay on the Prairies and take a look at a rather innocent system that resulted in some sharp pressure changes and a return to cooler weather, temporarily halting the snowmelt and the potential spring flooding.

We are very much interested in your comments and letters. Please drop us a line! We are also looking for any interesting features. As you will notice, we will publish your letters, and thank you for your observations.

*Hans VanLeeuwen*

## LETTERS

**Stretching the Imagination**

Luckily once in a while I decide to tidy up the book shelves and there along with some receipts and other bills to be paid was the renewal to one of my all-time favourite magazines.

My appreciation for synoptic meteorology has taken decades to develop – in fact up till 8 years ago I considered clouds just interesting artistic forms and shapes.

Fondly I remember articles about the sinking of the Spanish Armada, forest fires in Northern Ontario, and flying into a storm off our West Coast. How I envied the meteorologist who wrote that last article. You stretch my imagination and spur me on to learn more – dropsondes falling at millibars per second? It took a long time to understand the why and how and then suddenly to appreciate the sheer logic and wonder of it. I read that last article with a meteorology text at hand.

Lyn Ewing
Pinawa, Manitoba

### COVER

The Lloydminster tornado of July 8, 1983 passes within 800 m of the photographer's house located about 12 km southwest of Lloydminster, Alberta. Along its 10-km path from Paradise Valley to Blackfoot one person was injured and numerous farm animals were killed (Photograph: Wilf Kenyon).

### COUVERTURE

La tornade de Lloydminster, Alberta, du 8 juillet 1983 passe à près de 800 m de la maison du photographe située à 12 km au sud-ouest de Lloydminster. Sur sa trajectoire de 10 km, de Paradise Valley à Blackfoot, la tornade blesse une personne et tue plusieurs animaux de ferme (Photo : Wilf Kenyon).

# TORNADO!

**by Michael J. Newark**

*The firemen reported that they had seen a strange whirling cloud of debris passing over their heads without realizing that only 20 metres away, across the street, an industrial building had been badly damaged.*

Major Samuel Strickland, an influential Englishman, was a land developer who worked for the Canada Company. In May of 1829, while on one of his many trips through the forest on company business, he witnessed "an appalling land tornado" as he later described it in his book about life as a settler in Ontario. He observed "a black column in the shape of a cone ... gyrating with fearful velocity" that felled trees like a pack of cards and twisted them in every direction while it passed through the little village of Guelph. Several houses were unroofed, a barn demolished, and the floor of a loghouse was carried up through the roof.

This was not the first time such an event had occurred. On July 1, 1792, a violent tornado passed through the forest from present-day Fonthill to Port Robinson in Ontario's Niagara Peninsula. Although it levelled all the houses along its track, the storm was actually of some benefit to the early settlers because it cleared a path at a time when travel was very difficult and roads almost non-existent. This fleeting atmospheric tantrum left a tangible reminder of itself because today its track is still named Hurricane Road. One hundred and eighty years after the event, while my colleague Peter Elms and I were tracking down a more modern tornado event in the area, we were tempted to "liberate" one of the Hurricane Road name signs in order to preserve this piece of history for posterity because the local council was considering a name change. However, the change was not instituted, nor did we succumb to our anti-social urge.

The first known tornado casualty in Canada was a Mrs. McIntyre who was crushed by a falling tree on the evening of August 7, 1844, near Galt, Ontario. The most recent victims are still beloved memories in the minds of families and friends bereaved by the disastrous tornado in Edmonton on Friday July 31, 1987. In between these two events,

Scenes of tornado destruction near Reddickville, Ontario, on May 31, 1985 (Photograph: S. Leitch).

hundreds of other Canadians have been killed by tornadoes, many thousands injured and tens of thousands more made homeless. Amazingly, in spite of this, tornadoes have been thought by many to be an American phenomenon. Until fairly recently, it was almost as if the international border was considered to give us some magic immunity, and that tornadoes that did occur were somehow freakish events. Of course, a line on a map does not hinder the natural ebb and flow of storm systems in the atmosphere. Now that we have gathered systematic tornado statistics, it is clear that much of Canada's heartland from the Rockies to New Brunswick experiences tornadoes, and that southern portions of Manitoba and Ontario are part of the tornado-prone region that embraces central and eastern North America.

The 10 worst individual tornadoes in Canadian history

| Rank | Location | Year | Mo. | Day | Local Time | Dead | Injured |
|---|---|---|---|---|---|---|---|
| 1 | Regina, Sask. | 1912 | 6 | 30 | 1800 | 28 | hundreds |
| 2 | Edmonton, Alta. | 1987 | 7 | 31 | 1501 | 27 | hundreds |
| 3 | Windsor, Ont. | 1946 | 6 | 17 | 1800 | 17 | hundreds |
| 4 | Valleyfield, Que. | 1888 | 8 | 16 | 1800 | 9 | at least 14, (2 possible fatalities) |
| 5 | Windsor, Ont. | 1974 | 4 | 3 | 2010 | 9 | 30 |
| 6 | Barrie, Ont. | 1985 | 5 | 31 | 1630 | 8 | 155 |
| 7 | Sudbury, Ont. | 1970 | 8 | 20 | 0730 | 6 | 200 |
| 8 | St-Rose (Montréal), Que. | 1892 | 6 | 14 | 1400 | 6 | at least 26 |
| 9 | Buctouche, N.B. | 1879 | 8 | 6 | 1700 | 5 | 10 (2 possible fatalities) |
| 10 | Portage La Prairie, Man. | 1922 | 6 | 23 | 0200 | 5 | scores |

## THEY CANNOT BE CAPTURED AND BOTTLED

The reason for the lack of knowledge about tornadoes, which are nature's most violent form of atmospheric energy release, stems from their being very short-lived, typically lasting only a few minutes, and also very localized. They cannot be captured, bottled and placed under a laboratory microscope; with Canada's sparse population it is possible for them to occur undetected except for the tell-tale signs of forest damage (often visible many years later). Until fairly recently we had no comprehensive picture of their frequency. They appeared to be sporadic and sometimes might be reported in a newspaper if they occurred nearby. However, with increasing urbanization and industrialization and a growing population we should therefore expect that more and more tornado hits and significantly more damage will occur. With a modern means of communication, we can often see a tornado and its destruction on television almost while it is happening. Today, it even seems that a plague of tornadoes has descended upon us, when in fact it is simply that an existing hazard has become more visible by means of better reporting, and that there are now more targets.

What are the facts? How many do occur and where? How strong are they, and what is the risk of death or damage? What are they exactly? Tornadoes are actually very small-scale rotating storms (only tens or hundreds of metres in diameter) that are characterized by at least one vortex reaching the earth's surface from a parent thunderstorm. Most commonly they are found along the leading edges of cool air masses when these displace hot and humid air flowing northwards from the Gulf of Mexico. About 70 or 80 occur in Canada each year. Typically, they form under the rotating section of a thunderstorm located in its southwest flank where the tornado vortex extends down to the ground as a funnel-shaped cloud. A puzzle yet to be solved is why one thunderstorm will develop rotation, whereas a neighbouring storm in an apparently equally favourable environment of atmospheric instability and frontal activity will not. Exactly what triggers the rotation is also a mystery vexing meteorological researchers, but it appears to be related to the way in which the winds change direction up through the core of the thunderstorm.

Once formed, the funnel cloud almost always rotates in a cyclonic sense (clockwise in the Northern Hemisphere if viewed from directly below, which is not the recommended vantage point). Maximum rotational speeds of about 500 km/h have been estimated from movies of tornadoes, from Doppler radar information, and from engineering estimates of the wind speed necessary to overturn objects or propel them through the air. Efforts have been made in the southwestern United States to place an instrumented device named "TOTO" (the name of Dorothy's pet dog in the movie *Wizard of Oz*) in the path of oncoming tornadoes, but so far without much success in gathering data. An airborne researcher has also tried to shoot instrumented rockets into the vortex, but on at least one occasion was dismayed to find his small plane being drawn tail first towards the funnel as he circled around it.

## COMPLEX BEHAVIOUR

The behaviour of the tornado is usually very complex, and during its brief lifetime can transform from a single cone-shaped funnel into two or more that rotate around each other, sometimes retreating into the thunderstorm above, only to dart back to earth again a short time later. This can result in bizarre damage patterns in which houses on one side of a street are virtually untouched but houses on the other side are demolished. During an investigation of tornado damage in my home town of Brampton in 1980, I followed the track past an undamaged fire station. The firemen there told me that they had seen a strange whirling cloud of debris passing over their heads without realizing that only 20 metres away, across the street, an industrial building had been badly damaged.

Typically, tornadoes move across the earth's surface at a speed of 60 to 70 km/h, and are likely to approach from a west or southwesterly direction. At this speed they pass any given location in only a few seconds, and the sudden reduction in pressure at the centre of the vortex combined with the strongly rotating winds can cause extreme damage to structures. The momentum given to light-weight objects results in the spearing often observed after the event. It is common to see pieces of 2 by 4 lumber projected like missiles through walls or roofs of nearby buildings. Chickens have been found with their heads embedded in the earth, and straw stuck in the bark of trees. On August 16, 1888, near Valleyfield, Quebec, Guiseppe Sauve, his wife and two children were hurled by a tornado to their deaths in the St. Louis River. Monsieur Sauve was later found pinned to the mud-flats by a piece of picket fence that had pierced his neck and protruded from his left temple.

Although the stronger tornadoes can and do pick up people and animals and throw them through the air, the main threat to life is from flying debris, or

### What to do if a tornado strikes

1. Head for the basement. Fast!
2. No basement? Seek shelter under the stairs, under a sturdy table, in a closet or small room.
3. In a school auditorium or shopping mall? Seek shelter in an interior corridor.
4. If caught outside, abandon your car and lie flat in a ditch or depression.
5. In a small boat? Seek safe harbour at the first sign of an approaching thunderstorm.

### Nature's warning signs during a thunderstorm

- A vertical cone-shaped cloud reaching towards the ground
- Rotating dust, litter or other debris beneath a low-hanging segment of the thunderstorm
- Clouds tinted green or yellow
- A rumbling sound like a freight train, or a whistling sound like a jet plane
- Rotation in the thunderstorm cloud base
- Unusual behaviour of pet animals

from falling building materials. The best course of action to avoid being crushed or struck by debris is to seek refuge in the basement. If there is insufficient time to go downstairs, then shelter under a kitchen table or in a sturdy closet is the best alternative. Vehicles of all kinds, including cars and trucks, can also become airborne missiles and are best vacated if a tornado is seen approaching. In this event it is advised to take cover in a ditch, or at least to keep low.

## LESS THAN 1% ARE VIOLENT

It seems, however, that a tornado is not always recognized for what it is. The occupants of a car near La Rivière, Manitoba, thought they were witnessing a huge column of smoke from a burning farm. They drove over to give aid, only to find their car with themselves still inside being lifted into the air by what was really a fast moving and dangerous tornado funnel. It was they who needed assistance and who were rushed to hospital. While my colleague Peter and I were investigating the damage track of the tornado that slashed through Masson, Quebec, on June 27, 1978, we interviewed a number of eyewitnesses, including the volunteer fire chief of the community of Lac-du-Loup. He told us that he had called on the fire brigade to put out what he thought to be a nearby forest fire. While they approached the black cloud, they could not understand why it kept moving away from them until they finally realized that it must be a tornado.

Fortunately, not all the tornadoes that occur are strong enough to cause the extent of destruction seen in the Edmonton storm. In fact the majority in both Canada and the United States are relatively weak. On a scale of 0 to 5, devised by professor Theodore Fujita of the University of Chicago, and hence called the F-scale of intensity (see the table), 92% of all Canadian tornadoes are weak (F0 or F1), and only about 8% are severe (F2 or F3). Although less than 1% can be categorized as violent (F4), they account for two thirds of all the fatalities. None in the F5 category is known to have occurred here.

Since 1850, 29 tornado disasters have occurred across Canada (if we say that the loss of 3 or more lives constitutes a disaster), or approximately one every 5 years. A total of 187 people have been killed during these events and for each one killed, another 15 or so have been injured. The tornado that struck downtown Regina, Saskatchewan, on June 30, 1912, took 28 lives and ranks as our worst, but is followed very closely by the July 1987 tragedy in Edmonton.

We do not normally live in fear of losing our lives to some meteorological

The Fujita Scale of Tornado Intensity.

| Tornado Intensity | Scale | Wind Speed (km/h) | Expected Damage |
|---|---|---|---|
| Weak | F0 | 64–115 | Light |
| | F1 | 116–179 | Moderate |
| Severe | F2 | 180–250 | Considerable |
| | F3 | 251–330 | Severe |
| Violent | F4 | 331–416 | Devastating |
| | F5 | 417–509 | Little remains intact |

The categories from F0 to F5 rank tornado intensity according to the damage caused to well constructed buildings.

Aerial view of convergent tree damage caused by a May 31, 1985 tornado about 900 metres northeast of Conover, Ontario (Photograph: S. Leitch).

monster; therefore we are shocked by news of death and mayhem due to tornadoes in much the same way that we are shocked by news of aircraft crashes. Because of their sensational impact, it is perhaps easy to be convinced that we are in greater danger than is really the case. To put things in perspective, consider that on average only 2 people a year are killed by tornadoes in Canada, whereas lightning accounts for about 16 fatalities annually. In any given year the chance of an individual succumbing to a tornado is something like 10 or 12 million to one. However, the probability of having your home demolished is somewhat greater, particularly if you live in the higher risk regions of southern Ontario or southeastern Manitoba. Typically, a small city-sized area of approximately 200 square kilometres can expect tornado damage once every 15 years or so.

## ONCE EVERY 5 DAYS

Tornadoes occur all year long in the southern United States, then as spring approaches the area expands northwards reaching parts of Canada as early as April. At our more northern latitudes, the peak of the tornado season occurs in late June or early July with the area of storm activity finally shrinking southwards in October. An occasional winter tornado can be expected. It is interesting to compare this seasonal regime in North America with the situation in the United Kingdom, which has a climate dominated by the surrounding ocean. There the seasonal peak of activity is in November, and most tornadoes occur during the winter season, which of course is pretty well the opposite of the situation here where our climate is dominated by a huge land mass. Once every 5 days during the Canadian season a tornado can be expected somewhere in the country. Very often, several will occur during the same day in a particular region, something that meteorologists call a multiple outbreak. May 31, 1985, experienced an example of this type of behaviour when at least 12 tornadoes, including one at Barrie, ravaged southern Ontario and took a toll of 12 lives.

Any severe thunderstorm requires considerable energy, which in the final analysis comes from the sun. It is no surprise, therefore, to discover that tornadoes display a form of behaviour closely linked to the time of day. They are most likely to develop during the hours from 3 to 7 p.m., just after the time of maximum afternoon temperature, and are least likely during the night-time hours from midnight to sunrise. There are always the exceptions of course, such as the multiple outbreak of August 20, 1970, that struck the region stretching from the vicinity of Elliot Lake, Ontario, and eastwards into Quebec. At about 7 a.m., the Sudbury area was savagely awakened by a killer tornado that left 6 people dead in its trail. Two hundred and sixty kilometres in length, this particular damage track is the longest caused by any Canadian tornado.

**SOUNDS LIKE A FREIGHT TRAIN**

In 1883 the following editorial was written in the *Brampton Conservator:*

> While cyclones and tornadoes are almost daily carrying destruction in their paths through Missouri, Iowa, Illinois, Indiana and Wisconsin, at the worst, stiff breezes only play their pranks over the waving fields and green forests of beautiful Ontario. It must be anything but comforting to a citizen of these western states to dread that his house and family may be rocked in the bosom of a tornado, carried a hundred feet up in the air and landed a mile or so away from the place they took breakfast in the morning ... After all, suppose we have pretty cold weather in Canada in the winter season, there's comfort, plenty, and happiness in living beneath the shade of the Maple Leaf.

We have come a long way in understanding the magnitude of the tornado hazard since those smug and naive words were published. But there are still not enough Canadians who would know what to do the next time they see what appears to be a peculiar column of smoke, accompanied by a green thunderstorm sky, and a rumble like an approaching freight train.

## FURTHER READING


*Climatology*

1960 **McKay, G.A.** and **A.B. Lowe** The Tornado in Western Canada. *Bull. Am. Meteorol. Soc.*, Vol. 41, 1–8.

1970 **Ludlam, D.M.** Early American Tornadoes. Published by the Am. Meteorol. Soc., Boston.

1977 **Newark, M.J.** Tornadoes in Ontario Before 1900. *Ontario History*, Vol. 69, 257–276.

1980 **Schaefer, J.T.** (and 7 other authors) Tornadoes: When, Where, How Often. *Weatherwise*, Vol. 33, 52–59.

1984 **Elsom, D.M.** and **G.T. Meaden** Spatial and Temporal Distributions of Tornadoes in the United Kingdom 1960–1982. *Weather*, Vol. 39, 317–323.

1984 **Newark, M.J.** Canadian Tornadoes, 1950–1979. ATMOSPHERE-OCEAN, Vol. 22, 343–353.

1986 **Newark, M.J.** Tornado Climatology. *Chinook*, Vol. 8, 6.

1988 **Doswell, C.A.** and **D.W. Burgess** On Some Issues of United States Tornado Climatology. *Mon. Weather Rev.*, Vol. 116, 495–501.

1988 **Peterson, R.E.** Tornadoes in Italy: Pre-Modern Era. *J. Meteorol.*, Vol. 13, 216–223.

*General Interest*

1977 **Anon.** Tornado! *National Geographic World*, May 1977, 23–28.

1982 **Newark, M.J.** Tornado Warning. *Nature Canada*, Vol. 11, 4–9.

1987 **Miller, P.** Tornado! *National Geographic*, June 1987, 690–715.

*Preparedness*

1973 **NOAA** Tornado Preparedness Planning. National Oceanographic and Atmospheric Administration, U.S. Dep. of Commerce, Washington, D.C.

1980 **Glass, R.I.** (and 6 other authors) Injuries from the Wichita Falls Tornado: Implications for Prevention. *Science*, Vol. 207, 734–738.

1985 **Newark, M.J.** Tornado Preparedness. *Chinook*, Vol. 8, 12.

*Some Notable Canadian Tornadoes*

1912 **Anon.** *Regina Before and After Cyclone June 30, 1912*. Published by Evans and Fenney, Regina, Sask. (A rare book).

1954 **Hornstein, R.** The White Point Beach, Nova Scotia Tornado of January 1954. *Weather*, Vol. 9, 247–248.

1979 **Newark, M.J.** The Buctouche Tornado. *Chinook*, Vol. 1, 52–53.

1979 **Newark, M.J.** The Woodstock Tornado. *Chinook*, Vol. 2, 8–10.

1986 **Leduc, M.J.**, **O. Jacobsen** and **B. Greer** The "Black Friday" Tornado Outbreak in Ontario. *Chinook*, Vol. 8, 13–18.

1988 **Atchison, G.** Forecaster Tells Edmonton Tornado Story. *Chinook*, Vol. 10, 8–14.

*Structure and Dynamics*

1893 **Hazen, H.A.** The Mechanism of a Tornado. *Am. Meteorol. J.*, Vol. 10, 301–304.

1976 **Keller, D.** Wind Speed Estimation Based on the Penetration of Straws and Splinters Into Wood. *Weatherwise*, Vol. 29, 228–232.

1978 **Kern, R.A.** Doppler Radar: New Look Into Violent Weather. *Science*, Vol. 202, 1172–1174.

1984 **Snow, J.T.** The Tornado. *Scientific American*, Vol. 250, 86–96.



Michael Newark is the founder-editor of *Chinook* (1979–1984). He was for many years a forecaster in the Ontario Weather Centre and the Centre's Summer Severe Weather Meteorologist. He continues to specialize in severe storm studies in the Canadian Climate Centre.



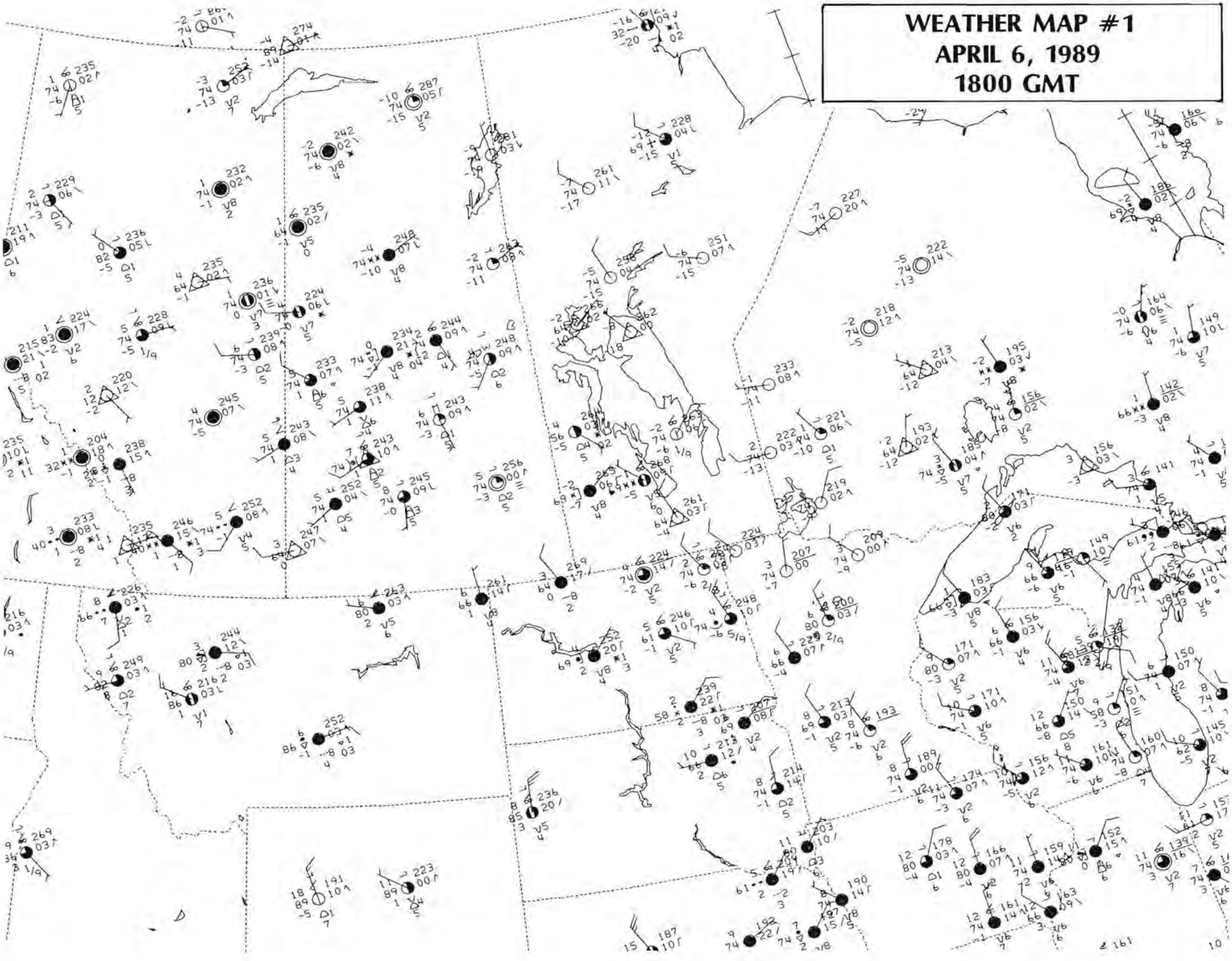
**RÉSUMÉ** *De tous les phénomènes naturels, les tornades sont l'un des plus dévastateurs. Il nous est toujours difficile d'estimer leur fréquence, surtout en raison du manque de stations d'observation; seules les parties les plus peuplées du pays nous permettent de nous faire une bonne idée de leur occurrence.*

*Les tornades sont des tempêtes en rotation à petite échelle; elles sont caractérisées par au moins un tourbillon touchant la surface terrestre. Leur fréquence est plus grande durant la saison chaude et humide, au printemps et en été, dans les courants d'air en provenance du golfe du Mexique et se déplaçant vers le nord. En général, malgré une variation importante et en fonction de notre habileté à les observer, on compte annuellement environ 70 à 80 tornades à travers le Canada.*

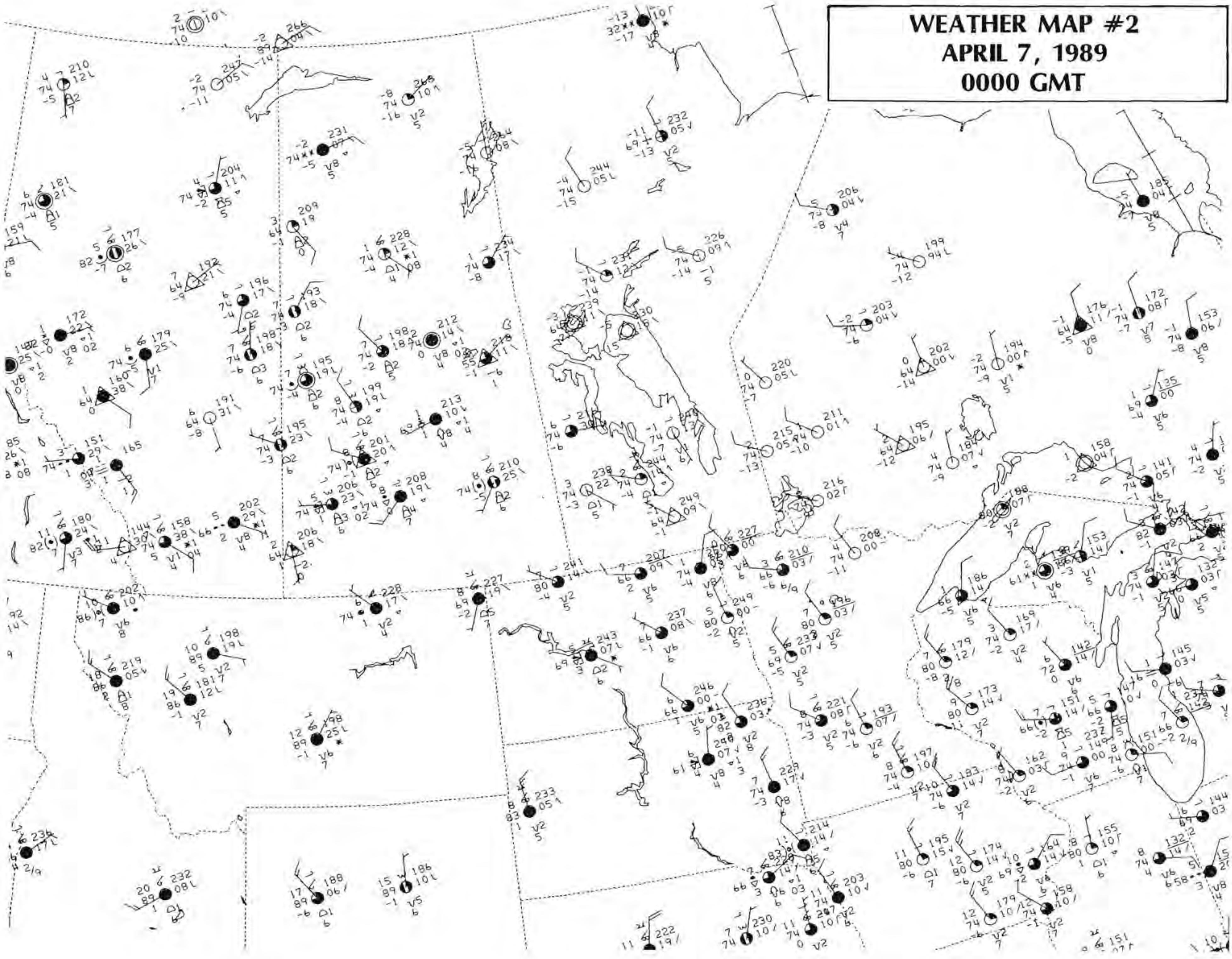
*Les tornades sont surtout associées avec des orages très intenses et très violents; au sol, elles se déplacent à près de 60 km/h. On a estimé les vents à près de 500 km/h dans le tourbillon. Bien que toutes les tornades soient dangereuses, il y en a qui ont tant de puissance que leurs forces destructrices réussissent à détruite presque tout ce que nous pouvons construire. Près de 1 % des tornades peuvent être classifiées comme tempêtes violentes qui ne laissent que débris sur leur passage.*

*Au Canada, Barrie en 1985 et Edmonton, en 1987 ont souffert de ces violentes tempêtes. Le tableau montre les caractéristiques des tornades. L'échelle de Fujita est utilisé pour classifier leurs intensités.*

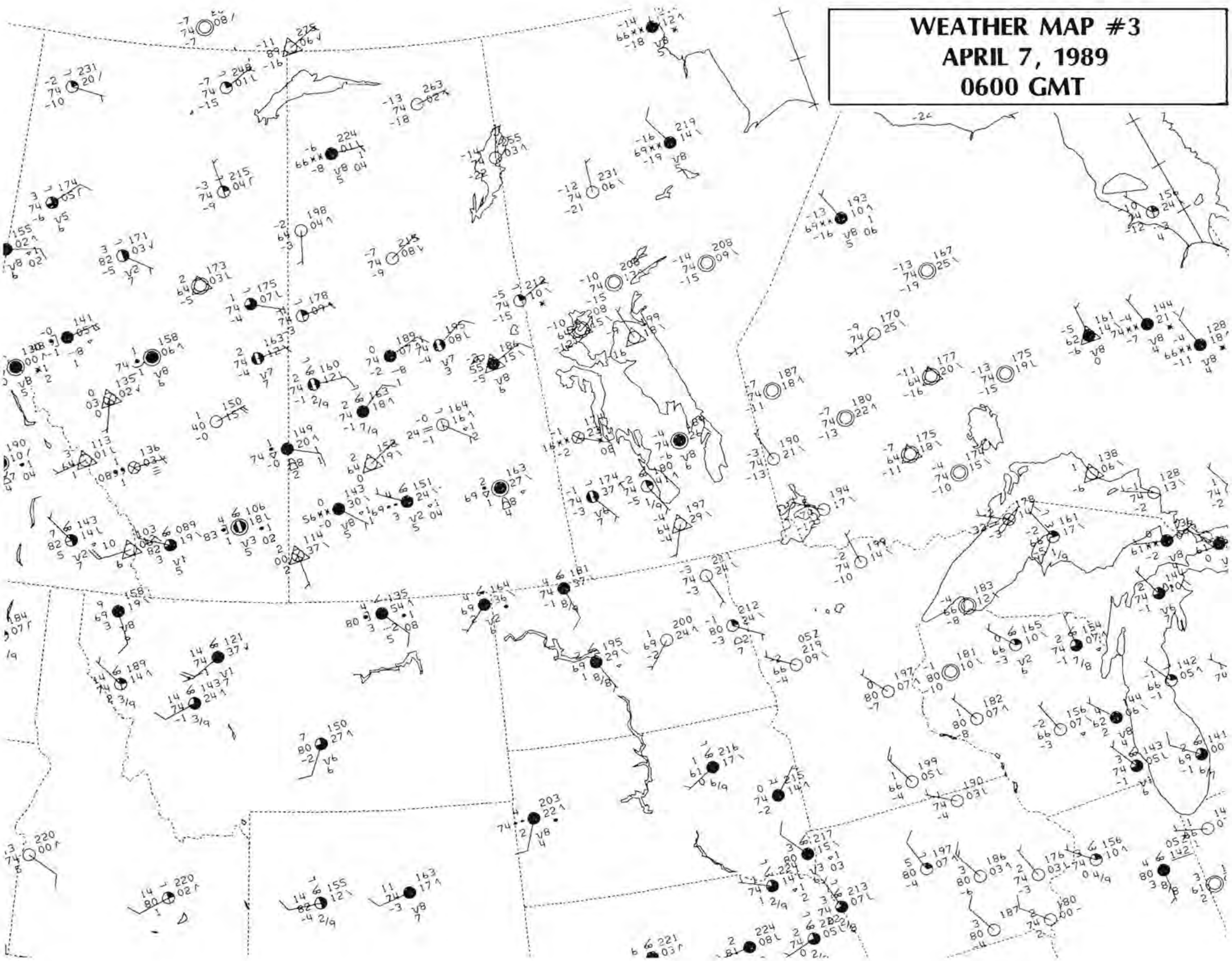
# WEATHER MAP #1
## APRIL 6, 1989
## 1800 GMT



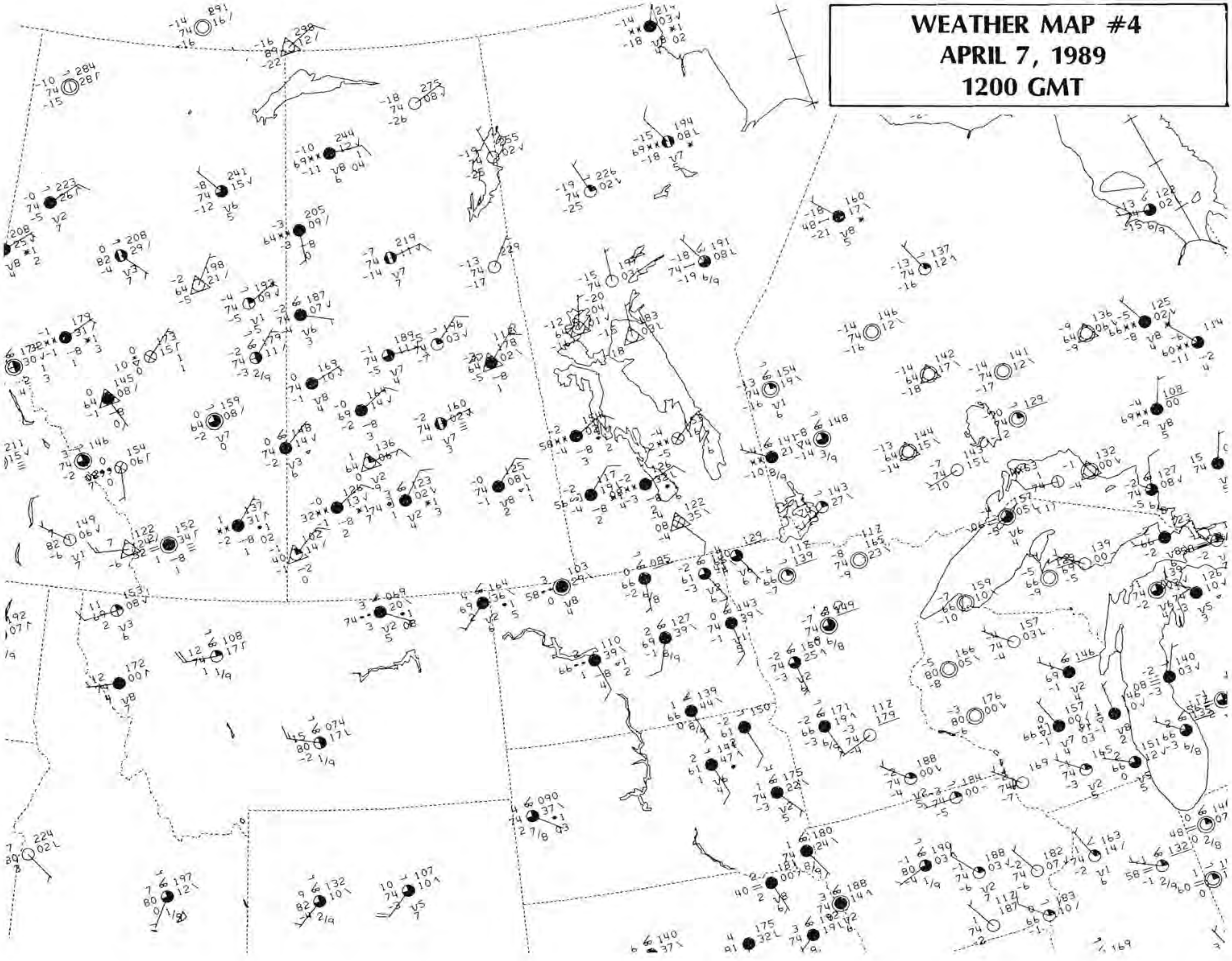
# WEATHER MAP #2
# APRIL 7, 1989
# 0000 GMT



# WEATHER MAP #3
## APRIL 7, 1989
## 0600 GMT



# WEATHER MAP #4
## APRIL 7, 1989
## 1200 GMT



# A PIONEERING CANADIAN WEATHERMAN

The most exciting day of my life was spent in the turmoil of a hurricane on Hudson Strait. It was a rather terrifying experience.

In my pioneering days, as one of the staff of the Canadian Meteorological Service, I established a meteorological station at Cape Prince of Wales, the northwest point of Ungava Bay, 55 years ago. One day in March there was a hurricane. The weather was 20 below zero. I had gone out to take the weather observations. The observatory was about 100 yards from my cottage. On my return – even in that short distance – I completely lost my way. It was impossible to see, I had no idea where I was.

Then, after what seemed ages, accidentally in my gropings, my hand caught the rung of a ladder – the ladder that was at the back of my house. For the next trip a life line was run from the observatory to the cottage, which, incidentally, had remained standing because of the cementing of the snow slabs.

Sir Frederic Stupart, director of the Canadian Meteorological Service, 1894–1929.

I lived among the Eskimos for a year and a half. At that time the real Eskimo hadn't been contaminated by the white people. I liked them. They were interesting. Among them were many really fine men and women.

I have seen an Eskimo mother carry her baby – naked – in the hood at the back of her coat – when it was 15 below zero. They are cute little babies, too.

One of the Eskimos at Cape Prince of Wales became a great friend of mine. His name was Uguluck, a good-looking attractive man. As he was a great favorite with my three assistants also, we used to exchange gifts. And he acquired five of our shirts, which he wore at the same time. But the longest shirt was always put on first, so that a piece of each would show at all times.

Uguluck was a peculiar man. He had two wives. One day he got tired of his mother. So, on his way back from the trading post, he just left her in the snow to die. Fortunately the Hudson Bay post people heard about this and rescued her.

During all our stay we never saw another ship, nor did we receive any mail. That was the time of the Northwest rebellion. I did not hear a word about it until my return to Toronto, when it was all over.

The trip up was thrilling. I had been deputed to accompany the expedition sent by the government to Hudson strait and bay, to report on the navigation of the strait.

We left Halifax in July in a Newfoundland sealing ship. As we approached the eastern entrance to the strait, a heavy easterly gale was blowing, and we lay hove to all day. With the ship rolling and pitching in mountainous seas, I well remember my difficulty in taking the meteorological observations. The following day we entered the strait, with a northwest gale blowing.

We established our first station in a small bay, named after the observer, Port Burwell, near the north point of Labrador. We found wonderful cod fishing. All we had to do was to throw over the line and pull in the cod.

Westward our ship passed through considerable scrub ice and on to the second station – located at the north bluff on the north shore, nearly midway through the strait. Crossing the south shore, we opened up our third station in a bay, afterwards called Stupart's Bay, near Cape Prince of Wales. And it was here that I, and my three assistants spent a year pioneering, taking magnetic weather observations, measuring the rise and fall of the tides, and watching the movement of the ice in the strait. The nearest Hudson's Bay post was 300 miles away. In January the average temperature was 23 below zero.

Some people might have found the living conditions rather uncomfortable, but I enjoyed the whole experience. Of course, from early boyhood I was fond of outdoor life. Nothing gave me greater pleasure than camping, fishing and hunting in northern Ontario. Nevertheless, it was pleasant to return from the far north to Toronto and the comforts of civilization.

Stupart's Bay meteorological station established in 1884 and named after the head of the observing party that remained there for almost a year (see *Chinook*, Vol. 10, pages 55–56).

An extract from "Lost in Search of Weather" by Sir Frederic Stupart as told to Elisabeth Mackay and published in *The Star Weekly*, Toronto, February 11, 1939.

# THE 1988 DROUGHT IN CANADA

**by Peter Scholefield, Tim Guezen and Rick Raddatz**

**A** severe drought situation developed across western and central Canada during 1988, and had actually evolved from, and was exacerbated by, a dry year in 1987. In this article, the evolution of the drought is traced by relating surface meteorological conditions to the upper atmospheric circulation patterns, with particular reference to the geopotential height anomalies at the 50-kPa level. The 1988 Prairie drought is compared with several previous major droughts.

### 1987

The year 1987 will, no doubt, be best remembered for its record mean annual temperatures that engulfed a huge portion of the country, extending from the Great Lakes Basin westward well into the western cordillera of British Columbia and southern areas of the Northwest Territories. It was also a drier than normal year, with central and western Canada receiving 80–90% of normal annual precipitation. Drought concerns arose on the Prairies in June following a very dry winter and spring, which seemed to be related to a persistent negative 50-kPa height anomaly in the North Pacific Ocean and associated pronounced ridging over western Canada. The breakdown of this pattern in July and August led to ample rainfalls across most of central and western Canada, although southern British Columbia was very dry during August. September was the start of a very dry fall for most of southern Canada west of the Great Lakes, while strong upper-level ridging predominated. B.C. conditions became critical since farmers and ranchers in the southern interior had to truck water because reservoir levels were dangerously low.

### WINTER 1987/88

As in 1987, the extended dry spell of the 1987/88 winter appears to have been related to a strong negative 50-kPa height

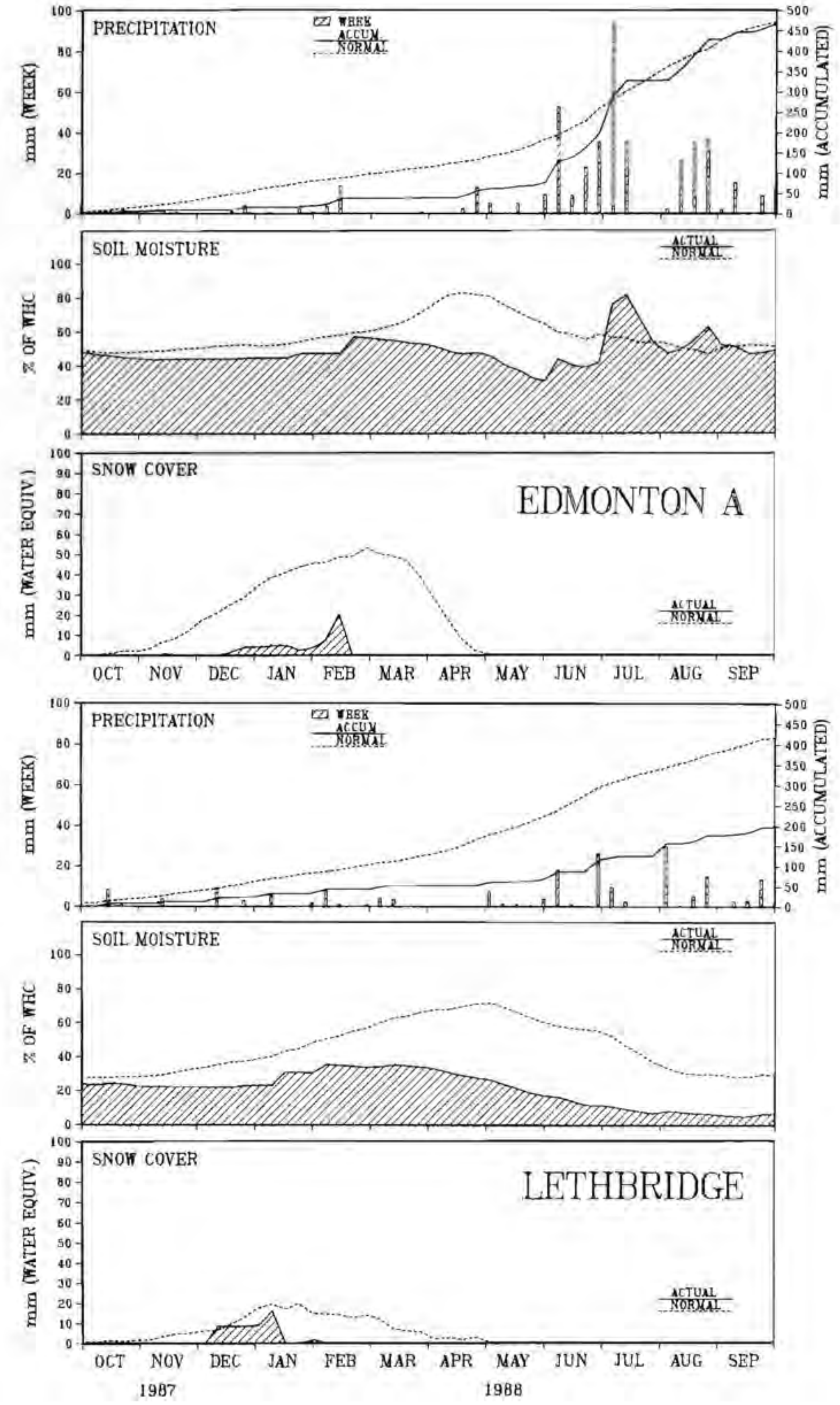



*Figure 1* Water budget time series for Edmonton and Lethbridge, 1 October 1987 to 30 September 1988. The plotted values are based on a 7-day mean or total.

anomaly that, in response to the ENSO (El Niño-Southern Oscillation) warming of the eastern tropical Pacific Ocean, became established over the North Pacific late in the fall and persisted into the winter. During November, a positive 50-kPa height anomaly over the eastern Prairies slowly shifted westward and by the end of December became firmly established over British Columbia. The persistent upper ridge over western Canada restricted the approach of moisture-bearing storms from the Pacific, deflecting them either northward into the Yukon and Northwest Territories or southward through the United States thus keeping the B.C. interior and the western Prairie Provinces drier than normal.

**SPRING 1988**

Finally, a breakdown of the persistent winter circulation pattern late in March permitted some Pacific weather systems to penetrate inland. The western upper ridge became re-established in April but in a position farther to the east, which permitted the influx of moist Pacific air masses into British Columbia, bringing drought relief to the southern interior valleys. The southern Prairies, however, remained very dry with some locations receiving only 10–20% of their normal April precipitation. A collapse of the upper ridge in western Canada at the end of April resulted in continued drought relief in southern British Columbia during the first two weeks of May. A couple of active weather systems moved into the southeastern Prairies and stalled near Lake Winnipegosis, dumping copious quantities of rain there. This resulted in a remarkable contrast: widespread flooding in this region, versus severe drought conditions in regions a few hundred kilometres to the south and west.

**SUMMER 1988**

Summer came early to the Prairies in 1988 when a pronounced upper ridge began building over the central and eastern Prairies during the latter part of May, producing a heat wave in southern Saskatchewan and Manitoba. This situation persisted through June, resulting in all-time record mean monthly temperatures across the southern Prairies which, along with a continued lack of rain, aggravated the drought conditions. June was also very dry in southern Ontario. The position of the upper ridge near the Saskatchewan-Manitoba border permitted the penetration of moist Pacific air into Alberta, particularly the northern half, where heavy rains brought a quick end to the drought there, but not in the south (see the water budget time series for Edmonton and Lethbridge in Figure 1). A major change in the upper atmospheric circulation occurred in early July when the upper ridge and associated positive 50-kPa height anomaly shifted eastward over the Great Lakes. This significant change in circulation brought some drought relief when cool, moist, unstable air invaded the Prairies. Figure 2 shows the extent of drought conditions in North America and especially the expansion of drought eastwards over the Great Lakes resulting from the changing circulation pattern. This shift in the drought from the Prairies to southern Ontario is shown in the water budget time series for Saskatoon and Toronto (Figure 3).

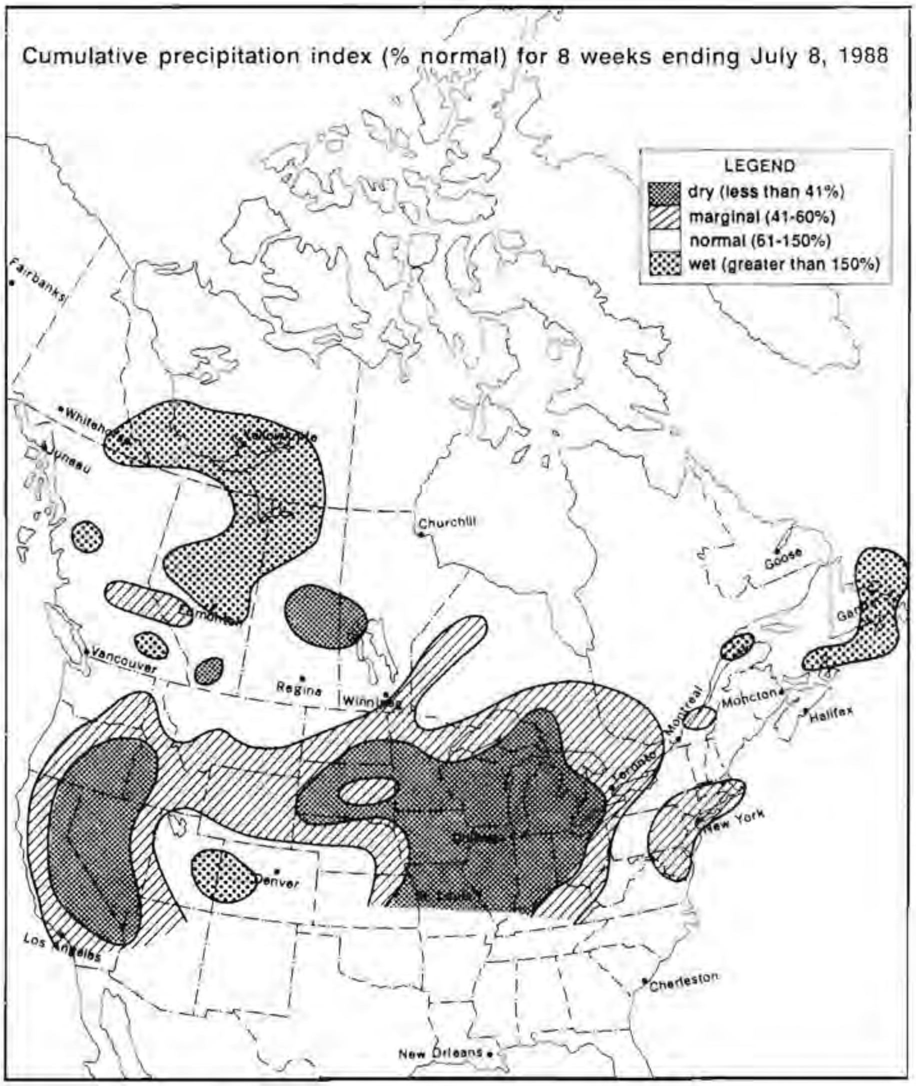



*Figure 2* Drought conditions across North America as measured by the cumulative precipitation index (% normal) for 8 weeks ending 8 July, 1988.

The positive 50-kPa height anomaly continued its slow eastward progression across the Great Lakes during July, resulting in the hottest July since 1955 in southern Ontario. At Toronto, it had been the second driest May-June period since records began in 1840 (the driest was in 1949). By mid-July, the drought worsened since cumulative rainfalls after 1 May were less than 40% of normal in southwestern Ontario. After the upper-level height anomaly moved east of the Great Lakes in mid-July, the trajectory of the upper-level flow into southern Ontario shifted from the parched regions of the American Midwest and Southwest to the more humid areas of the Gulf Coast. This influx of humid air effectively brought an end to the drought in southern Ontario by the end of July. By mid-August, the changed 50-kPa circulation pattern had alleviated most of the summer drought concerns in Canada. The mean 50-kPa flow pattern returned to near normal over Canada in August and substantial rain fell in regions that had previously suffered under drought conditions.

## THE 1988 PRAIRIE DROUGHT IN HISTORICAL PERSPECTIVE

Tim Guezen and Rick Raddatz compared the drought years of the 1980s with those of the 1930s, and produced the statistics in Table 1. They included the year 1961, which had been a memorable drought year between the decades of the thirties and the eighties. Using historical data from 9 selected stations across the Prairie provinces, they expressed the precipitation shortfall as a percentage of the 1951–80 normal total that is needed to bring the actual total up to normal over the period from 1 September of the preceding year to 31 August of the listed year. For example, the most severe 1988 shortfall occurred at Lethbridge, where the total was 45% short of the normal total, i.e., the total precipitation was 55% of the normal. Each yearly average at the bottom of the table was calculated using only those locations with positive shortfalls. It can be seen that 1988 was certainly a major drought event comparable to, but not any worse than, previous major drought years. Overall, 1961 was the most severe; hardships in the Thirties were in part the result of two consecutive dry years.

## SUMMARY

The upper atmospheric circulation patterns that led to two consecutive dry winters across central and western Canada were apparently related to the ENSO event of 1987/88 and were instrumental in setting the stage for the severe moisture shortages during the spring and summer of 1988. The development and dissipation of the drought events followed a chronological progression that began in British Columbia during the spring and ended in southern Ontario during July. These drought events were clearly related to a similar eastward progression of positive 50-kPa height anomalies. A return to more normal precipitation regimes progressed eastward across the country, so that surface drought conditions had dissipated by August at most locations; however, there remained isolated pockets of moisture shortages, mostly in the southern Prairies. Except for southern British Columbia, a deficit in soil moisture reserves remained at the end of September across southern areas of central and western Canada. This problem was aggravated by a dry September over the southern Prairies.

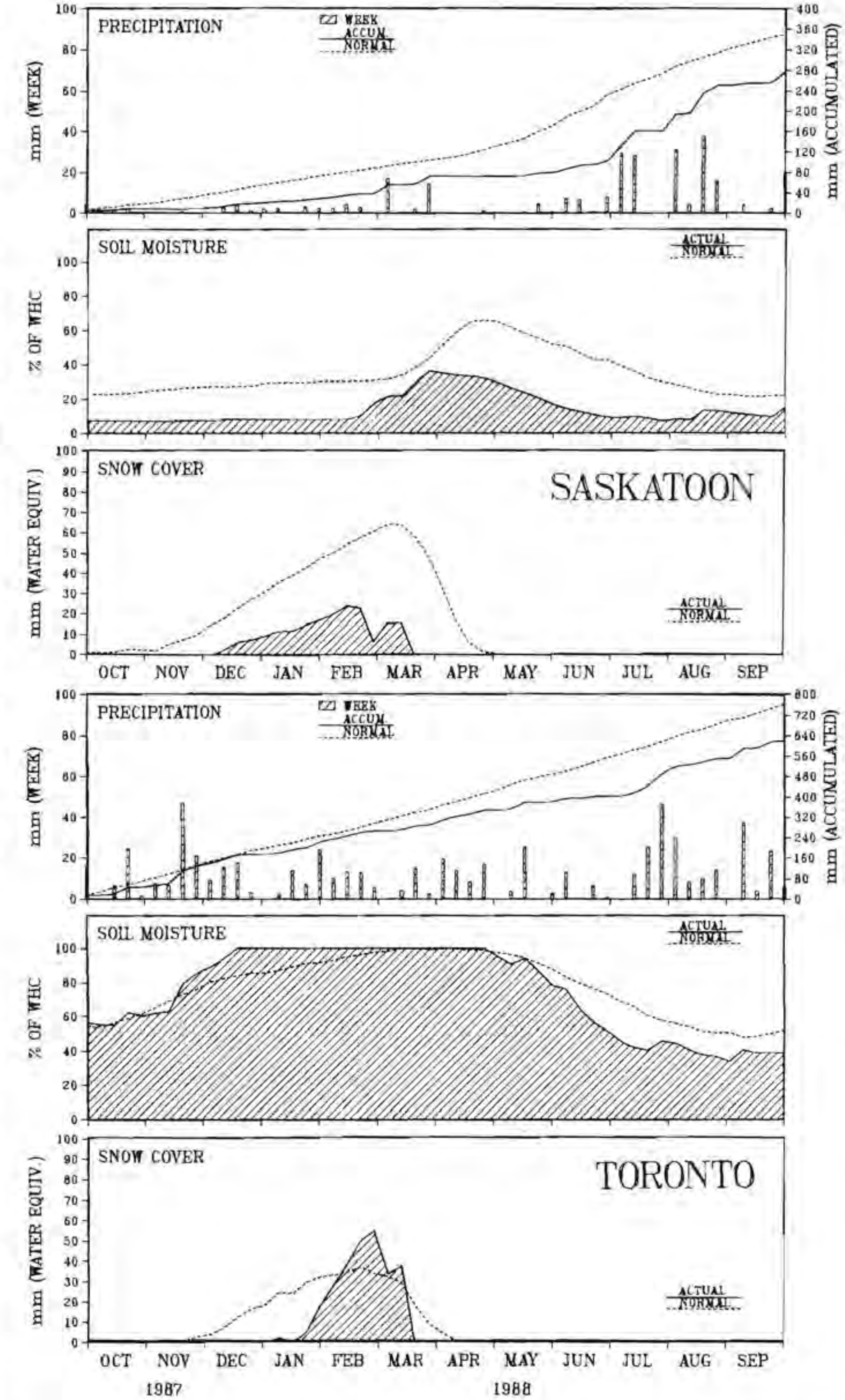



*Figure 3* Water budget time series for Saskatoon and Toronto, 1 October 1987 to 30 September 1988. The plotted values are based on a 7-day mean or total.


Peter Scholefield is the Head of the Monitoring and Prediction Section of the Canadian Climate Centre (Downsview, Ontario), and is the Managing Editor of the weekly publication, *Climatic Perspectives*.

| Station | 1936 | 1937 | 1961 | 1984 | 1988 |
|---|---|---|---|---|---|
| Winnipeg | 26 | 6 | 42 | 6 | 38 |
| Brandon | 31 | -35 | 43 | 6 | 22 |
| Saskatoon | 5 | 19 | 19 | 24 | 21 |
| Regina | 16 | 53 | 57 | 34 | 27 |
| Swift Current | 20 | 50 | 35 | 39 | 25 |
| Prince Albert | 33 | 13 | 23 | -34 | -3 |
| Lethbridge | 30 | 0 | 31 | 33 | 45 |
| Calgary | 37 | -1 | 12 | 32 | 10 |
| Edmonton | -5 | -1 | 20 | 32 | -18 |
| *Average* | 25 | 28 | 31 | 26 | 27 |

Table 1 Drought intensity at selected stations on the Canadian Prairies as indicated by the precipitation shortfall (%) for the period 1 September of the preceding year to 31 August of the year listed. A minus sign indicates an excess. See text for details.

Tim Guezen was a summer student assistant engaged in drought studies and who has aspirations of becoming a meteorologist.

Rick Raddatz is a Scientific Services Meteorologist working with the Atmospheric Environment Service at Winnipeg and specializing in agrometeorology.

**RÉSUMÉ** *En 1988, l'ouest et le centre du Canada ont subi une très importante sécheresse. Les conditions atmosphériques du printemps et de l'hiver précécant n'ont fait qu'amplifier le phénomène; l'année 1987 fut plus sèche que la normale. Le sud de la Colombie-Britannique était particulièrement touché. En raison d'une forte crête en altitude au-dessus de l'ouest du continent, les tempêtes qui apportent l'humidité du Pacifique se sont déplacées vers le nord, dans le Yukon et les Territoires du Nord-ouest, ce qui a contribué à garder le niveau d'eau des réservoirs très bas.*

*Les configurations en altitude ont cependant changé quelque peu, permettant un certain apport d'humidité en Colombie-Britannique; par contre, le sud des Prairies est resté sec, sauf pour les endroits frappés par des séries d'orages violents. En mai, l'est et le centre des Prairies étaient encore sous l'influence d'un forte crête en altitude.*

*Les figures 1 et 2 indiquent clairement l'étendue et l'intensité de cette importante sécheresse. Historiquement, en 1988, les conditions n'étaient pas aussi graves qu'en 1961. Le tableau 1 présente une bonne comparaison avec les sécheresses antérieures. Les configurations en altitude persistantes sont responsables du trajet normal des systèmes météo porteurs d'humidité. Les orages peuvent apporter un soulagement à l'échelle locale mais sont impuissants à fournir au sol l'humidité nécessaire sur de plus grandes régions.*

# FLUCTUATING PRESSURE PATTERNS

## Weather Map Series, April 6 and 7, 1989

### by Hans VanLeeuwen

The period around the first week of April on the Canadian Prairies was not a news-breaking one, that is, from the perspective of weather events. Temperatures were about normal for the time of year, the precipitation nothing too unusual. Perhaps the only important concern would be the potential threat of spring flooding, particularly on and along the Red River in Manitoba. Continued cool weather and below normal precipitation would favour a reduced possibility of rapid snow melt and disastrous flooding.

The Map Series starts with the weather data of April 6, as observed at noon CST (1800 UTC). The series then shows the weather information at the next three six-hourly intervals, that is, at 6 p.m. (0000 UTC) and midnight on April 6 (0600 UTC), and at 6 a.m. on April 7 (1200 UTC).

Perhaps in this situation it might be best to start our analysis with the isobaric pattern. Standard operating procedures: use a sharp pencil *and* the eraser, and start with the 1,020-mb (102.0 kPa) isobar, and then the isobars upwards or downwards every 2 mb (0.2 kPa). You will notice that, as you progress in time, the pressures have fallen significantly over the Prairies. For that reason I would like you to carry out another type of analysis, that of the *pressure tendencies*. Remember where they are located? The amount of three-hourly change and the actual tendency are plotted to the right of the station circle. Please review the codes!

Note that at individual stations the pressures have decreased significantly, particularly as you look at such sites as Regina, Saskatchewan, or Winnipeg, Manitoba. In the analysis of the pressure tendencies I suggest you use a sharp *red* pencil to analyse the *pressure falls* at every 1 mb (0.1 kPa), and a sharp *blue* pencil to analyse the *pressure rises*. Use a sharp *purple* pencil to indicate the line where the pressure tendencies were zero. Be careful that you draw these lines lightly.

What do you notice? Well, if all went as planned, you should be able to observe the formation of a weak low-pressure centre, at first not too well defined, and its eastward progression during the period of the map times. You notice its position at 6 a.m. on April 7 in southern Manitoba. Associated with it you should find a cold front extending westward, which is the leading edge of the noticeable colder air that is moving southward over the Prairies. I did not ask you to carry out an isotherm analysis, but looking at individual stations, it should be evident that the weather has cooled somewhat.

How would you describe this situation if you had to brief someone on the weather during this period? And how about a forecast for the next 24 hours for places like Regina, Winnipeg and Calgary? I would further suggest that you take a look at the precipitation patterns. What would you say about the flooding possibilities, good or bad?

For those who have difficulties with the codes, please refer to a previous *Chinook* issue, Vol. 8, No. 2, which contains a detailed explanation. If a copy of that issue is not available, then please mail a stamped, self-addressed envelope to the CMOS office in Ottawa, Attention: *Editor Chinook* (Weather Map Series, Vol. 11, No. 1). I would be very much interested in your comments.

# THE FALL OF 1988 IN REVIEW

## by Aaron Gergye

### UPPER ATMOSPHERIC CIRCULATION

The fall mean upper-air pattern over North American mid-latitudes was very similar to the long-term mean map. The striking difference occurred at high latitudes. The cold Arctic vortex, generally residing in Davis Strait, migrated into the Barents Sea. The result of this cold pool moving away from Canada was above normal temperatures in northwestern Canada. It is conceivable, though much less certain, that a ridge marginally stronger than normal settled in over the Prairies from September to November 1988 and was responsible for below normal precipitation over an extensive area of the Prairies. It is certainly too early to speculate whether the summer of 1989 would be dry. It is hoped that the final winter precipitation totals would not be a harbinger of despair.

### TEMPERATURE

Monthly temperature departures, generally above normal for most of the country, were less than 2°C during September, with the warm core lying over northern Manitoba and Mackenzie District. During October, an enhanced upper-level ridge over British Columbia, producing a northwesterly flow east of the ridge, cut a 1000-mile wide swath of below normal temperatures stretching from the Yukon to southern Quebec. The largest monthly departures were recorded through most of Ontario where temperatures were well below normal everywhere for the first time since February 1988.

These departures resulted in the coldest October since 1981 at many locations and the coldest ever in extreme southwestern Ontario. November was bitterly cold in the northern half of the Yukon and the western half of the Arctic when daily minimum temperatures sank into the -30 to -40°C range by the end of the second week. Across the rest of Canada, temperatures were above normal, especially over eastern Ontario and western Quebec. On November 27, for example, the influx of warm air into southwestern Quebec produced double-digit, record temperatures.

### PRECIPITATION

During September, the outstanding feature occurred in the western part of the Northwest Territories. Some areas received as much as 400% of the monthly normal, while Gulf of Alaska storms intensified and spawned vigorous low-pressure systems over the Territories. In contrast, northern Alberta was unusually dry, with some places receiving only about 25% of the monthly normals.

Precipitation was generous in central Ontario in October and some places experienced the wettest October since records began in 1847. Toronto tied the monthly maximum frequency record set in 1864: 19 days of precipitation. November saw generous amounts of precipitation along the B.C. coast and in southeastern Yukon. Some Yukon areas were blasted with up to 85 cm of snow during a two-day period late in the month.

November, traditionally a wet month for the Prairies, was no exception, especially over the northern half. Stormy weather was prominent in Newfoundland and Labrador as a series of intense low-pressure systems brought strong winds and heavy precipitation there. On November 21, a slow-moving storm dumped more than 40 cm of snow along the Labrador Coast and 55 cm of snow on the eastern end of Newfoundland.

### SEPTEMBER IMPACTS

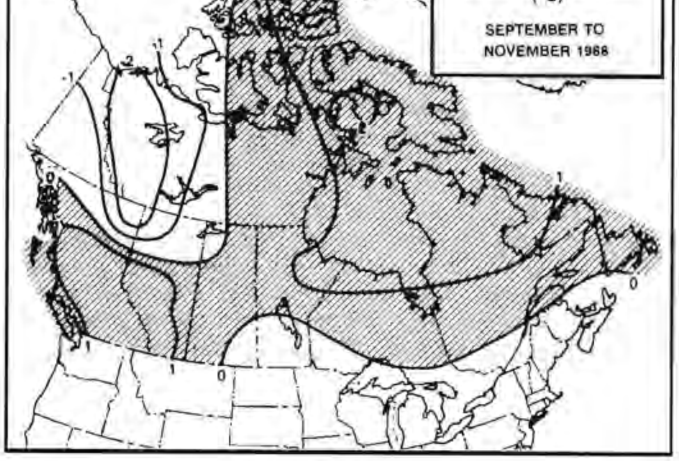
The Niagara Peninsula of Ontario had a vintage year for grapes. However, vegetable farmers in southern Ontario did not fare as well owing to late spring frosts, hail, strong winds and summer drought.

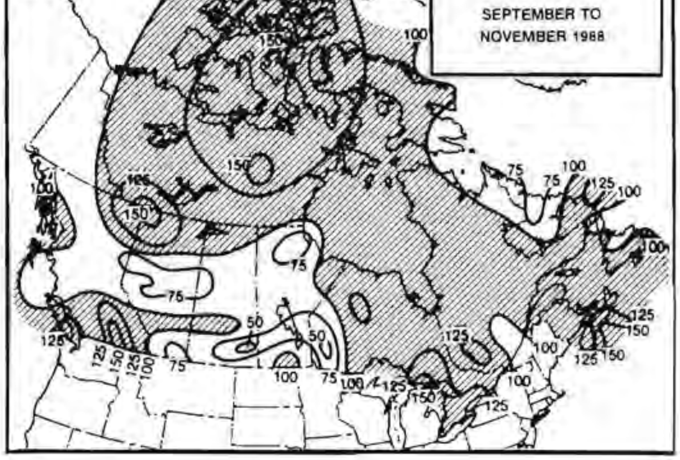
An intense storm in the Gulf of St. Lawrence on September 4 took the lives of three fishermen.

A bumper apple crop resulted in the Maritimes. The potato crop is the largest in a decade.

The total production of Prairie spring wheat was considerably less than 1987's. Surprisingly, ample summer rain yielded a bumper crop in northern and central Alberta.

Aaron Gergye is a climate meteorologist with the Canadian Climate Centre who is a member of the editorial staff of *Climatic Perspectives* and who works on the development and production of long-range weather forecasts.



Chinook

## THE CANADIAN MAGAZINE OF WEATHER AND OCEANS

**WHAT?** *Chinook* is a popular magazine concerned with two major components of the Canadian environment – the atmosphere and the oceans. It is published quarterly by the Canadian Meteorological and Oceanographic Society (CMOS).

Features in *Chinook* include articles, weather summaries, interpretations of satellite and other photographs, and news and notes. These appear in the language submitted (English or French). In addition, summaries of all articles appear in the other language.

**WHY?** The aims of *Chinook* are

- to increase public awareness of meteorology and oceanography in Canada and of their modern scientific and technological aspects and achievements
- to stimulate public interest in and 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

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- farmers, fishermen and foresters
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- specialists in other sciences
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On retrouve dans *Chinook* des articles, des sommaires du temps, des interprétations de photos satellitaires et autres, des articles d'actualité et des notes. Ces articles paraissent dans la langue originale, le francais ou l'anglais; tous les résumés sont rédigés dans l'autre langue.

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- éveiller la curiosité du public en ce qui a trait aux aspects de la météorologie et de l'océanographie au Canada et à l'informer des réalisations scientifiques et technologiques d'aujourd'hui;
- stimuler l'intérêt du public et l'aider à mieux comprendre les effets du climat, du temps et des océans sur la société et sur l'économie du Canada;
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- les aviateurs
- les observateurs amateurs de phénomènes naturels
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