Chinook

VOL. 4 NOS. 2/3 WINTER/SPRING 1982

INSIDE • HAILSTORMS • TEMPS VIOLENT AU QUÉBEC
• THE KELVINGTON TORNADO OF 1973

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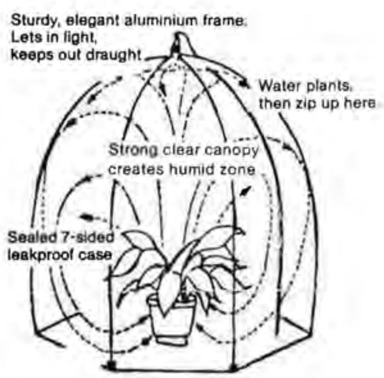

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Chinook Winter/Spring 1982 Volume 4 Numbers 2/3

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THE COVER

A tornado which trailed slowly across the community of Kelvington, Saskatchewan on July 5, 1973 was photographed by Mrs. Bauder of Edmonton. An annulus of dust can be seen surrounding the lower third of the funnel captured in this picture, which is one of a series of 18 taken by the photographer. For more, see The Kelvington Tornado of 1973 by K.D. Hage, page 27.

FROM THE EDITOR

CHINOOK HAS A SPONSOR

No doubt many of our readers will be wondering about the long delay between receiving the Fall 1981 issue and this Winter/Spring 1982 issue. As you may have suspected, tough financial times took their toll and ***Chinook*** came close to ceasing publication. However, we are very pleased to announce that the **Canadian Meteorological and Oceanographic Society (CMOS)** have undertaken sponsorship of the magazine. With their help three issues will be published this year which means that our subscribers will miss only one. The subscription list will be adjusted to take care of this situation so that all concerned will receive an extra issue before their subscription expires. We wish to take this opportunity to thank you for your patience in dealing with the publication delay.

Under **CMOS** sponsorship, the editorial objectives of ***Chinook*** will remain the same as before, namely to present meteorological and atmospheric topics in an authoritative yet popular fashion. But in addition, we wish to expand our subject matter and include oceanographic and environmental articles from time to time as well. In this way we hope to deal in a more balanced way with the world around us, and take a look at the work of Canadians who are involved in many interesting and exciting projects in these fields. So watch for, and don't be surprised by, a change in editorial emphasis.

CMOS President, **Richard Asselin,** has provided the statement which follows concerning the activities of the Society and its association with ***Chinook.***

The Editor

THE CANADIAN METEOROLOGICAL AND OCEANOGRAPHIC SOCIETY

CMOS exists for the advancement of meteorology and oceanography, is open to any interested person and hopes to serve all interests by becoming the main focal point for all meteorological and oceanographic matters in Canada.

It has 14 active centers which provide meeting opportunities for the members and serve to promote the two sciences in the schools and the public.

CMOS recognizes the primary importance of science through the publication of a renowned research journal, ***Atmosphere-Ocean,*** to which it will be adding the ***Climatological Bulletin.***

For those who wish to concentrate on hydrology, air pollution, agriculture and forestry, the society has established special interest groups. The society is actively pursuing the further development of this idea by sponsoring major themes at its congresses, such as Sea Ice at the 16th

Congress held recently in Ottawa. At the next congress in Banff from 3 to 5 May 1983, the theme will be Day-One Forecasting, and it is hoped that a special interest group in Operational Meteorology will be formed at this occasion.

CMOS is extremely pleased at this time to have the opportunity to expand its actions into the popular domain through ***Chinook***, thereby completing the link from the researcher, through the professional and finally to the greater community.

Several types of membership are available for **CMOS**, including Student and Associate memberships which would be of greatest interest to the readers of ***Chinook***.

LA SOCIÉTÉ CANADIENNE DE MÉTÉOROLOGIE ET D'OCÉANOGRAPHIE

La **SCMO** a pour but de stimuler l'intérêt pour la météorologie et l'océanographie; toute personne intéressée peut en faire partie car la Société espère desservir tous les intérêts en se plaçant au centre de l'activité météorologique et océanographique du Canada.

Il y a 14 centres d'activité régionaux se sont développés afin de permettre aux membres de se rencontrer et pour organiser l'action dans les écoles et le public.

La **SCMO** souligne l'importance de la science par la publication d'une revue de recherche reconnue, ***Atmosphère-Océan***, à laquelle s'ajoutera bientôt le ***Bulletin Climatologique***.

Pour ceux qui désirent se concentrer sur l'hydrologie, la pollution atmosphérique, l'agriculture et la forestrie, la Société a établi des groupes d'intérêt particulier. La Société poursuit activement le développement de cette idée en exploitant de grands thèmes à ses congrès, tel que la Glace de Mer lors du 16ème congrès tenu récemment à Ottawa. Lors du prochain congrès à Banff, du 3 au 5 mai 1983, le thème sera "La prévision pour le premier jour"; on espère bien qu'un groupe d'intérêt pour la Météorologie en Exploitation sera formé à cette occasion.

La **SCMO** est aujourd'hui très heureuse d'avoir l'opportunité d'étendre son champ d'action dans le domaine populaire grâce à ***Chinook***, complétant ainsi le lien entre le chercheur et la grande communauté, en passant par le professionnel.

La **SCMO** a plusieurs genres de membres, tel que membre étudiant ou membre associé, qui conviennent le mieux aux lecteurs de ***Chinook***.

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Richard Asselin
President

WEATHER AMATEURS IN NEW YORK STATE

I enjoyed reading "A Salute to the Weather Amateur" (Fall 1981). Our organization sponsors a network of weather observers in the interior of eastern New York State, and while the network has been in progress for only the past four years, some observers have been keeping weather records for quite a bit longer. In particular, one observer is now entering his sixty-fourth year of record keeping. We saluted his achievement in a recent Chapter newsletter.

Weather observers perform a valuable service to the meteorological community, and we are happy to see that we share with you an appreciation of their efforts.

Steve Colucci, President
IENY Chapter of the
American Meteorological Society

(Mr. Colucci is referring to Arlington Race of Chatham, N.Y., who is now retired but in the past supplied weather observations to the Albany office of the National Weather Service. Mr. Race is presently a co-operative observer for TV-10's weather network. In appreciation of his efforts over the past 64 years, the IENY Chapter of the AMS is presenting Mr. Race with a wind speed and direction measuring instrument. Ed.)

Photo Courtesy Calgary Herald

HAILSTORMS! — WHY ALBERTA

by G. S. STRONG
Alberta Research Council

On July 28, 1981 a severe thunderstorm cut a swath through the city of Calgary, dropping hailstones as large as golfballs. In its wake, the storm left two deaths from lightning and damage claims (from hail, rain, and wind) exceeding $100 million, putting it into the same damage class as the most devastating hurricanes and tornadoes experienced in the southeast U.S. The photo above shows some of the effects of the Calgary storm. While insurance payouts for this storm set a Canadian record for natural disasters, hailstorms of such severity are not unusual in southern Alberta. Perhaps five or six hail-producing thunderstorm systems of similar intensity, as well as some 50 lesser thunderstorms, occur each summer. Unfortunately, this particular storm simply happened to hit a large metropolitan area in addition to striking a severe blow to farms in its path!

Individual thunderstorms normally measure only 10-20 km across, but tend to cluster into groups of storms of greatly varying intensity. The cluster often measures 100 km or more across. This is still small in comparison with synoptic scale cyclonic disturbances which usually measure more than 1000 km in diameter. These are the large weather systems which we see as "lows" or troughs of low pressure on a surface weather map. Thunderstorms, however, have a propensity to concentrate energy into small regions, often resulting in destructive hail, heavy rain, wind, and sometimes tornadoes.

It is difficult enough to accurately measure thunderstorm hailfall and rainfall patterns, much less forecast when and where such storms will occur. These and other problems have been the subject of much research in Alberta for some 25 years, particularly by the Alberta Research Council (ARC). Annual crop losses due to hail in Alberta are now estimated to exceed $100 million. The heaviest losses occur between Edmonton and Calgary, which is why this region became the major study area for the ARC Hail Project and cloud seeding experimets. Figure 1 shows the annual frequency of hailfall by township over the ARC operations area. It is based on hail reports from the farming community. While the maximum number of hail occurrences average 6-8 per year, individual farmers have reported as many as 15 hailstorms in a given year. Hailstorms occur most often over the western half of the ARC area, towards but slightly east of the mountains.

Hailstorms in Canada are not confined to Alberta. Yet, the close proximity of the Rocky Mountain barrier in southwestern Alberta and frequent cyclonic disturbances over this region during summer, play a major role in the higher frequency and severity of hailstorms in Alberta. These two factors alone lead to the most favourable environment for severe hail-producing thunderstorms. Approaching cyclonic disturbances usually result in ascending air over a large region. This leads to 'lee troughing' or cyclogenesis (the formation of low pressure systems) in the surface pressure field over Alberta, and convergence of the low-level winds. The convergence often organizes the available moisture and any subsequent thunderstorms into a line parallel to the larger scale surface and upper troughs. The effect is enhanced by related factors such as a structure of winds which veer and increase with height.

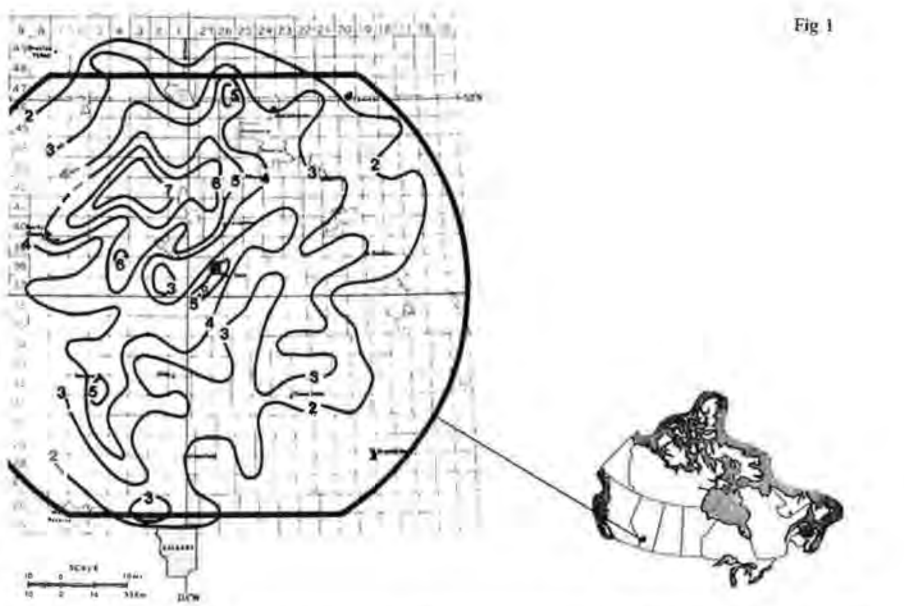
The effects of the mountains on Alberta storms are extremely complex, but the broader influences can be explained. Figure 2A illustrates typical conditions at about the time (t) of severe thunderstorm formation over Alberta. The mountain barrier acts to trap or stall low-level cold air (generally below 3 km) on the upstream side in British Columbia. Meanwhile, upper-level cold air penetrates to the Alberta (or lee) side, over-rides warm moist air there and thus increases instability. At mid-levels (say, 2-4 km above sea level), ascending and cooling air just crossing the barrier becomes modified by orographic subsidence in the immediate lee of the mountains. Because it is heavier than the underlying air, some of the colder air is forced to descend along the slopes. As it subsides to regions of higher pressures, it is heated by compresssion over the Alberta foothills, a kind of summer chinook! Soundings, or profiles of the variation of temperature with height over a location, can be used to show the effects of these processes. Figure 2B, scaled vertically to 2A, shows schematic soundings over the region of severe thunderstorm formation for three different times. The times are t-24 hours, t-1 hour, and t+12 hours with respect to storm formation time (t). The 'capping inversion' (where temperature increases with height over a shallow layer) at time (t-1) in Figure 2B is of particular significance. It is caused by the subsidence warming and serves to delay the formation of convective clouds. In this way, energy is not released until storm potential is maximized with surface heating.

Thus, a signal for possible severe storm formation for situations such as Figure 2 depicts, is the presence of subsidence warming and drying as revealed by a 'capping inversion' at low levels (about 1 km above ground). The inversion is topped by a warmed, dry layer up to 3-4 km MSL, and often cooling (from large-scale ascent caused by an approaching trough) above that. The dry layer above the inversion appears to favour ice crystal formation, and may therefore be necessary for large hail growth, since the formation of ice particles is primarily from tiny ice crystals rather than frozen water droplets. The capping inversion is quite marked if there has been earlier large-scale subsidence associated with an upper ridge passage in the preceding 24 hours or so. The effects simplified in Figure 2 can result in a rapid increase in instability over a few hours.

How this instability is realized into a severe thunderstorm system is more complex. The inversion initially trapping convection is at least partially removed through cooling from large-scale ascent, as synoptic scale events intensify over the region. A cold front and/or low-level easterly winds causing orographic lift can play the triggering role here. Once initiated, the motion and life cycle of the thunderstorm complex are probably still controlled by synoptic scale motions. However, there is still much controversy as to the exact nature of mechanisms at work here.

The influence of the mountains and synoptic scale cyclonic disturbances on Alberta thunderstorms can be illustrated for individual cases. Figures 3 and 4 provide background for a particularly severe storm of August 16, 1973. This

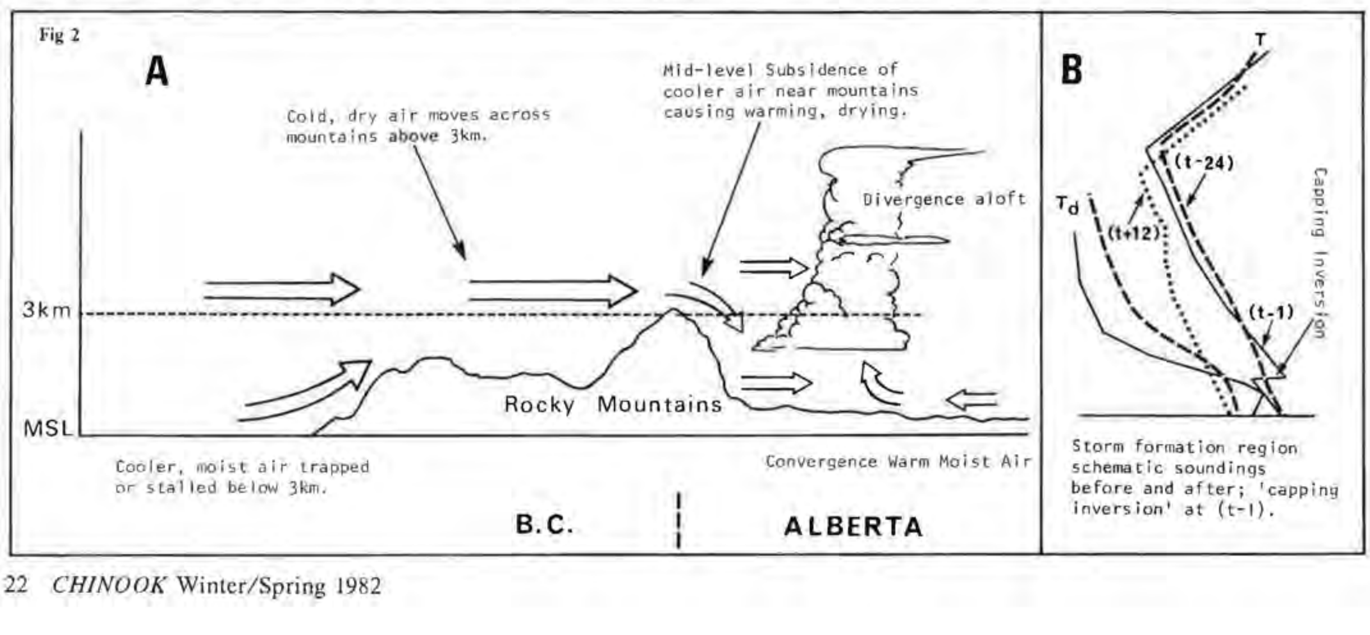
Fig 1



Average annual number of haildays per township, Alberta research Council Hail Project operations area, 1974-78. (After Renick, 1979).

(A) West-east flow leading to severe Alberta hailstorms. Orographic ascent/subsidence effects mask that of synoptic disturbances here. (B) Temperature (T) and dew point (Td) soundings modified by synoptic scale and orographic subsidence (warming), then synoptic ascent (cooling). Times are hours before or after thunderstorm formation time (t).

Fig 2



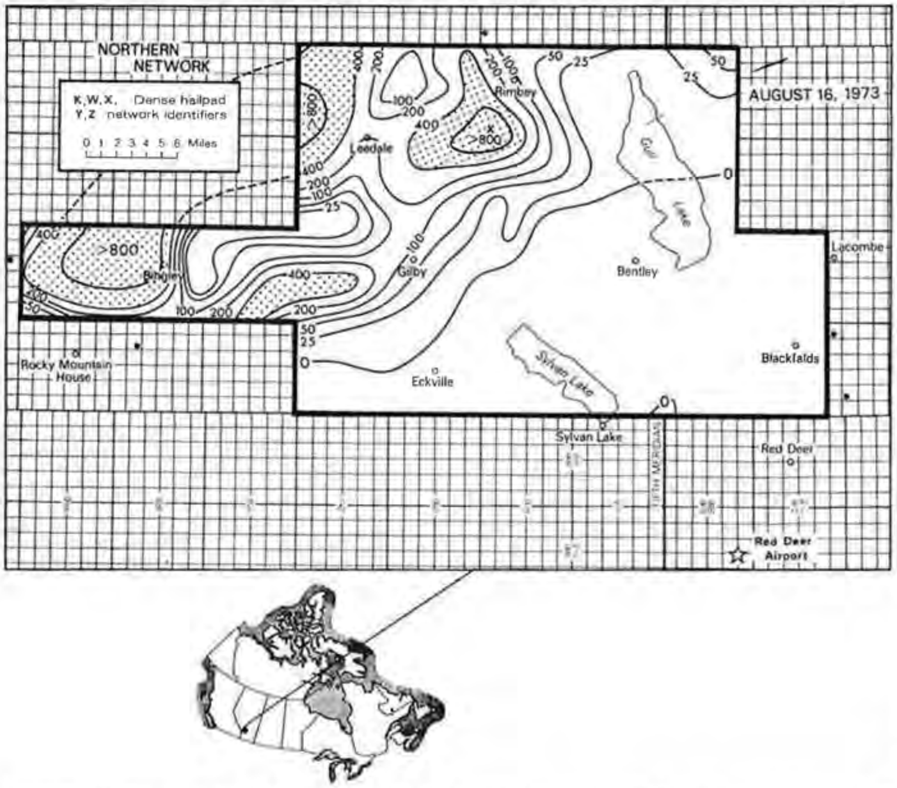


FIGURE 4. Hailswath analysis of impact energy (J m^{-2}) as inferred from hailpad dents, northwest portion ARC operations area, 16 August 1973 — Red Deer is lower right, Rocky Mountain House is centre left. (After Strong and Lozowski, 1977.)

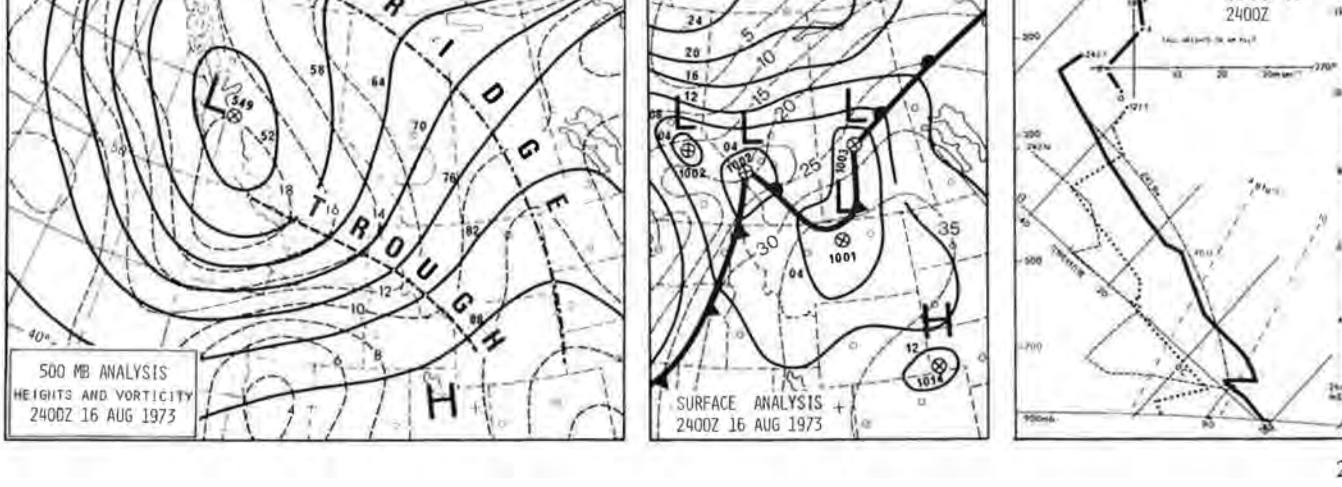
storm formed around 1800 MDT (2400 UTC) over the foothills southwest of Rocky Mountain House within the ARC operations area. Figure 3 shows the airflow at 500 mb (about 5.5 km above MSL), the surface pressure pattern around storm formation time, and a sounding for Rocky Mountain House. The latter is believed to be representative of conditions in the vicinity of but just prior to storm formation.

Noteworthy are the upper trough and ridge positions with respect to southern Alberta. During the previous 36 hours, subsidence associated with the ridge combined with orographic subsidence to create the capping inversion and stable mid-level warm layer. These two features are quite marked on the sounding in this instance. The surface frontal wave and cyclogenesis over southwestern Alberta are related to low-level convergence and large scale ascent preceding the upper trough. In this case, one can only surmise (for lack of sounding data) that the inversion cooled rather suddenly, since the whole thunderstorm complex was initiated in a matter of minutes, forming near the frontal crest. The disappearance of this inversion 'prior to' storm formation is suggested by the fact that maximum temperatures in the region never reached 20° C, while the theoretical convective temperature for the sounding here is 27° C.

Some rather detailed ground measurements of hailfall were obtained for this storm. Hailpads, one-foot square pieces of one-inch thick styrofoam, were used to record hail dents. Hail sizes from 5 to 50 mm diameter were inferred from the dents, and estimates of the kinetic energy of impact were computed. A representative portion of the two major hailswaths was sampled over the northern half of the ARC operations area, and is reproduced here in Figure 4. The shaded regions of Figure 4 encompass impact energy densities of 400 J m^{-2} or more. Values greater than this were found to almost ensure 100% crop damage. This presents some idea of the devastation (crops, farm structures, and, in some cases, livestock) caused by this particular storm. Such hailpad analyses have revealed fine-scale, yet uniform patterns of hailfall, rather than the sporadic patterns inferred from previous coarser data sources.

It is apparent that thunderstorms and even thunderstorm clusters cannot be considered or studied as single entities by themselves. Synoptic scale weather features, even though they may be centered a thousand kilometers or more away, usually play an important role in the initiation and life cycle of such storms. Meteorologists can now understand or at least recognize most of the individual atmospheric processes occurring during severe thunderstorms, but our knowledge of how all these processes interact is still lacking.

FIGURE 3. (A) 500 mb (about 5.5 km MSL) height/vorticity and (B) surface pressure/temperature analyses, and (C) Rocky Mountain House sounding (temperature — solid; dew point — broken; temperature 12 hours later — dotted line for 2400 UTC (1800 MDT), 16 August 1973.



LA PRÉVISION ET LA DÉTECTION DU TEMPS VIOLENT AU QUÉBEC

par Stanislaus Siok
Environnement Canada.

Une question se pose: qu'est-ce que le temps violent? La définition acceptée est: tout phénomène météorologique qui menace la propriété privée ou la vie. Ainsi, en hiver, les événements qui remplissent ces critères sont associés aux tempêtes de neige, à la pluie verglaçante dû aux vagues de froid. En été, les événements violents sont associés à la grêle dépassant 12 mm (c.à.d. — ½ po) diamètre, aux vents excédant 90 km/h en rafales, et aux inondations associées aux crues subites (accumulation — 25 mm/h) ou pluies abondantes (accumulation — 50 mm/24 h).

Avant chaque saison estivale, le personnel des centres météorologiques se refamiliarise avec les techniques de prévision du temps violent.

La raison: on a établi un programme de veilles et alertes afin de prévenir le public des conditions potentiellement destructives.

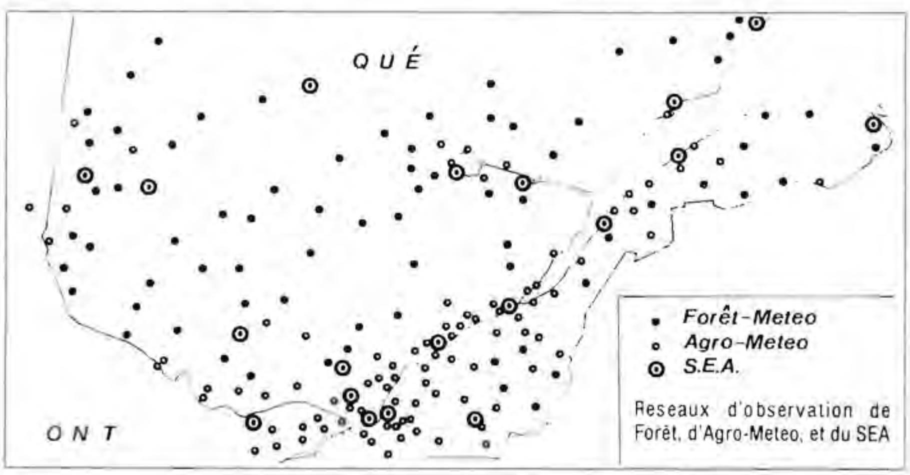
WWCN2 CWUL 302115
Alerte météorologique numéro 35 émise par Environnement Canada Montréal à 17H15 hae mardi le 30 juin 1981.
Pour diffusion immédiate
Le Centre de Prévision du Québec a émis une alerte météorologique pour les régions de l'extrême sud de la région de Trois-Rivières, Drummondville.
On observe sur le radar quelques fortes cellules orageuses près de Lacolle. Ces cellules donnent de la forte pluie possiblement de la grêle de deux centimètres et des rafales a 90 km/h et plus. Les localités au sud d'une ligne qui va de Hemmingford à Drummondville sont susceptibles d'être touchées.
Le public des régions concernées devrait prendre les précautions qui s'imposent et surveiller l'émission d'alertes subséquentes. Cette alerte est en vigueur de 17H15 hae à 20H15.
FIN

Plusieurs événements violents sont associés à la forte convection (i.e. orages violents). Ceci comprend les tornades, la grêle et les fortes rafales. Cependant, les inondations définies par des accumulations de pluie égales ou supérieures à 50 mm en 24 heures peuvent être reliées soit à la convection prononcée soit aux bandes de pluie continue associées aux systèmes synoptiques (c.à.d.à grande échelle).

En général les procédures de prévisions estivales s'occupent des phénomènes convectives. La délimination des secteurs où le temps violent est le plus probable, demande une analyse thermodynamique et dynamique rigoureuse. La forte convection se compose de forts courants ascendants et subsidants. Ainsi les données en altitude obtenues par radio sonde et pointées sur un téphigramme sont analysées afin de déterminer si le profil vertical de température et d'humidité supporterait de tels courants. Les cartes en surface et en altitude sont évaluées afin de déterminer les endroits qui favorisent le déclenchement et l'accentuation de la forte ascendance. A partir d'une telle analyse on est en mesure d'émettre une veille météorologique qui concerne une grande étendue couvrant une ou plusieurs régions de prévision

WWCN2 CWUL 301845
Veille météorologique numéro 34 émise par Environnement Canada Montréal à 14H15 hae mardi le 30 juin 1981.
Pour diffusion immédiate
Le centre de Prévision du Québec a émis une veille météorologique pour les régions de Montréal de Trois-Rivières Drummondville de Montagneuse de l'Estrie.
Les conditions favorisent la formation de fortes cellules orageuses sur ces régions. Certains de ces orages pourraient provoquer de la forte pluie et possiblement de la grêle de deux centimètres et plus et des rafales à 90 km/h. Cette veille est en vigueur jusqu'à 20H00 hae.
Le public devrait surveiller l'émission de veilles subséquentes ou d'une alerte météorologique qui sera émise lorque nous aurons plus de précisions.
FIN

La prochaine étape du programme consiste à surveiller l'évolution de la situation météorologique en utilisant les radars, les



Reseaux d'observation de Forêt, d'Agro-Meteo, et du SEA photos satellites de même que les observations prises à partir du sol. Quand les orages violents se sont formés ou sont sur le point de se développer, on émet une alerte météorologique pour une zone restreinte.

Des fortes cellules convectives sont des phénomènes convectives qui se produisent à petite échelle (moins de 20 km). Ainsi le réseau de stations du Service de l'Environnement Atmosphérique, (SEA) n'a pas une résolution suffisante pour vérifier l'occurrence du temps violent. Pour évaluer les événements violents de façon réaliste, il est nécessaire d'accroître le réseau de détection sur le Québec. Au Centre Météorologique du Québec (CMQ), on obtient une résolution plus fine par les réseaux d'observation de Forêt et Agro-Météo, et par les programmes d'observateurs volontaires.

Le réseau de Forêt-Météo consiste en 125 stations éparpillées à travers le Québec au sud du 55 ième parallèle nord qui prennent les observations deux fois par jour (8 heures et midi). En plus le temps, la température le vent et l'humidité relative, chaque station relève le cumul des précipitations de 18 et 24 heures et le type de phénomène convectif noté. Le code pour ce dernier se compose de neuf chiffres qui varient entre 0 pour pas d'orage et 9 pour un chablis (i.e. arbres abattus par le vent) détecté par une patrouille aérienne.

Le réseau Agro-Météo a 95 stations qui se trouvent au sud de 50 nord. Ces stations observent les températures minimales et maximales, de même que le cumul des précipitations de 24 heures. On utilise ce réseau pour vérifier les phénomènes qui appartiennent à la catégorie de pluie abondante.

Vu que les observations des réseaux Forêt et Agro-Météo sont émises à heure fixe, on ne peut les utiliser que pour la confirmation de l'occurrence des phénomènes violents au cours des 24 heures précédentes. L'exception est l'observation de midi de Forêt-Météo dont le code convectif peut-être utilisé pour apercevoir les forts développements orageux. En effet, dans quelques circonstances, ces dernières observations ont contribué à l'émission d'alertes météorologiques.

Malgré la densité de ces réseaux d'observations régulières, il est possible que certains événements échappent à la détection. Afin d'en minimiser les possibilités, on a établi deux programmes d'observateurs volontaires au CMQ. Le premier but de ces programmes est de fournir au CMQ l'information en temps réel sur la présence du temps violent. Le premier programme a 80 volontaires recrutés sur le nord-ouest Québécois. Le deuxième, qui couvre le sud Québécois, regroupe 191 volontaires du réseau climatologique contrôlé par le Service de la Météorologie du Québec.

CODE D'ORAGE ET TEMPS VIOLENT

0. Pas d'orage
1. Orage léger sans grêle.
2. Orage modéré sans grêle.
3. Orage fort sans grêle.
4. Orage avec grêle ≤ ½ po. (grosseur d'une bille).
5. Orage avec grêle > ½ po.
6. Orage avec grêle > ½ po. et rafales à 90km/h et +.
7. Orage sans grêle avec rafales à 90km/h et +.
8. Pas d'orage mais des vents de 50km/h avec rafales à 90km/h et +.
9. Pas d'orage mais chablis récent (dernière patrouille).

En combinant tous ces réseaux, on est passablement certain que la plupart des événements qui ont eu lieu au sud de 50N seront confirmés.

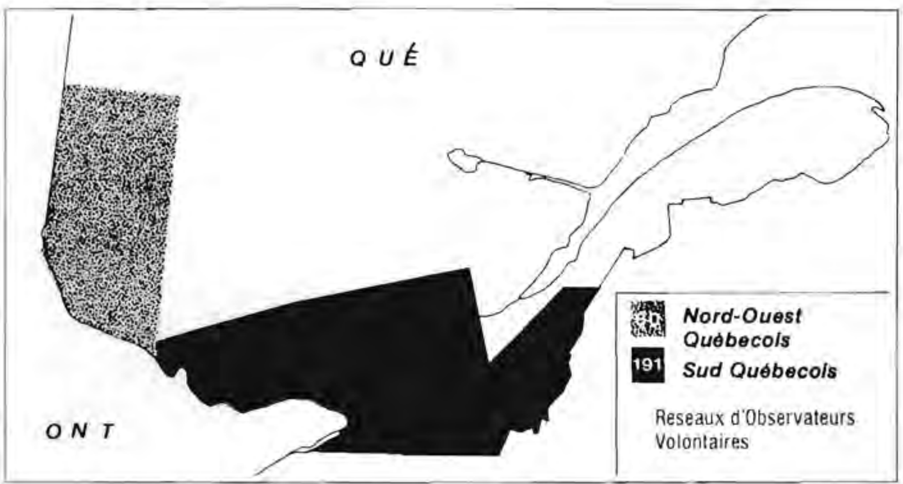
En 1981, il y a eu 70 événements violents dont 9 ont été confirmés par les programmes volontaires et le reste par les réseaux réguliers du SEA, Forêt et Agro-Météo. 55 de ces événements faisaient partie de la catégorie associée aux inondations, alors que 15 étaient reliés aux phénomènes purement convectif (c.a.d. grêle, rafale, tornade). Le 22 juin, 12 événements remplissant les critères de pluie abondante ont été enregistrés. Cette pluie répandue a été associée à un système à l'échelle synoptique.

En comparaison, 1980 était une année où les phénomènes convectives jouaient un rôle plus significatif.

En effet 28 des 51 événements détectés étaient des tornades, de la grêle ou des rafales. Des crues subites, le 1er et 2 septembre provoquant des pertes de vie sur la région montréalaise, étaient provoquées par des systèmes convectifs.

Il est évident que ces événements n'ont pas tous provoqués des pertes matérielles. D'autres facteurs, tels que la densité de la population et la topographie, sont des facteurs déterminants de l'impact économique d'un événement météorologique. Cependant une telle étude détaillée fournit des données indispensables sur la nature du temps violent au Québec.

Les procédures traditionnelles traitent le temps violent estival comme un phénomène purement convectif. Les résultats des saisons 1980 et 1981 indiquent que les inondations sont des phénomènes aussi importants sur le Québec. Ainsi les procédures devraient être plus exhaustives afin de traiter tous les phénomènes significatifs.



ÉVÉNEMENT VIOLENTS ESTIVAUX DURANT LA SAISON 80-81 SUR LE QUÉBEC

	1980	1981
Tornade	6	2
Grêle ≥ 1.2 mm	13	6
Rafale ≥ 90 km/h	9	7
Pluie abondante ≥ 50 mm/24 hr ou crue subite ≥ 25 mm/ 1hr	23	55


A2


A5


A6


A8


A9


A13


A15


A18

THE KELVINGTON TORNADO

OF 1973. By K.D. Hage.

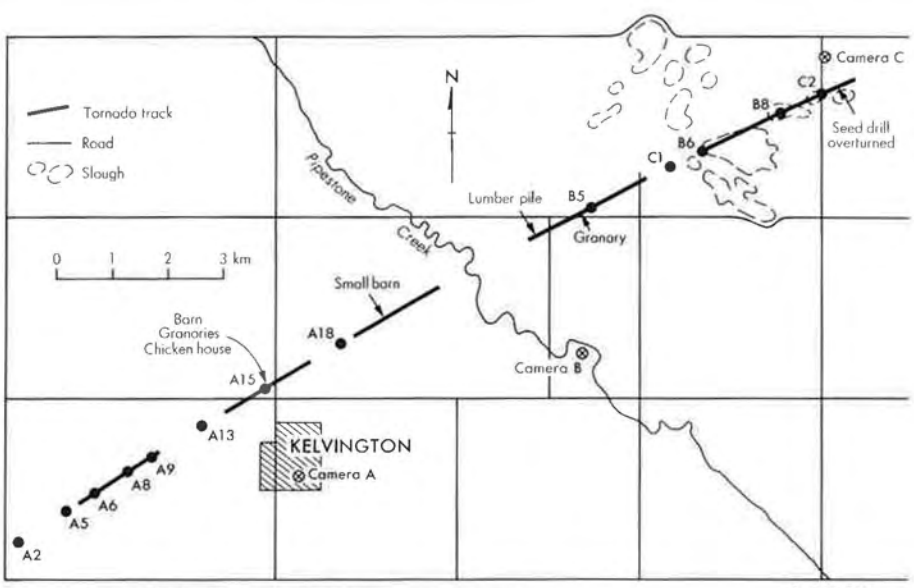


Figure 1. Tornado Path, Kelvington, Saskatchewan, 5 July, 1973.

"It came up from Lacombe way in the afternoon, travelling in a northeasterly direction, a great funnel-shaped, slow moving cloud with a swirling serpent-like tail that swooped down every now and again."
Edmonton Journal, 8 July, 1913, p. 1.

"The storm approached here from the southwest, and the cyclone made three distinct downward swoops." *Regina Morning Leader,* 25 June, 1913, p. 1.

"For a time Mossbank people watched the funnel shaped cloud which came within one mile from town near the Elmer Wighton farm. Here it raised and divided, descending in all its fury on the farm of John Ireland." *Regina Morning Leader,* 22 June, 1922, p. 1.

"The twister struck in a field and rooted up some grain, lifted, struck a little further on, lifted again, and then hit the Unger implement shed." *Regina Morning Leader,* 22 July, 1927, p. 1.

"Leaving Ramshaw's the storm seemed to lift and again dropped down at the edge of town where it threw the tank car unloader at the B.A. Oil property over on to a box car on the nearby track." *Saskatoon Star-Phoenix,* 6 July, 1944, p. 13.

Eyewitness reports like those quoted above help to explain some complex tornado damage patterns in western Canada but leave important questions unanswered. For example, is it possible for a single tornado vortex to regenerate or are sequential touchdowns the result of new vortices descending from different parts of one or more thunderstorm cloud bases?

Multiple tornado vortices resulting in damage along two or more paths are well known from eyewitness and photographic evidence. Now a remarkable series of photographs of the tornado of 5 July, 1973 near Kelvington, Saskatchewan revealed the apparent regeneration of a single vortex resulting in intermittient damage along a single track.

The first series of 18 colour slides by Mrs. Bauder of Edmonton was brought to my attention by Barry Karpiak, a student in an introductory course on weather. Three additional sets of photographs taken by local residents near the path of the tornado were discovered following a letter to the editor of the *Kelvington Radio.* The path of the storm was retraced by the author in May, 1980 and additional eyewitnesses were interviewed. At this time compass readings were taken at three of the original camera sites so that the funnel positions could be pinpointed along its path.

The track of the Kelvington tornado has been reconstructed in Figure 1 from property damage locations, eyewitness reports, and tree damage. Even in 1980, seven years after the event, the path of the storm was clearly defined in forested areas, especially east of Pipestone Creek. Evidently five touchdowns occurred along a single 16 kilometer path from southwest to northeast.

The surface weather map for 1800 GMT, about two to three hours before the tornado, is shown in Figure2. The tornado moved more or less parallel to the cold front toward the weak low pressure centre north of the town of Hudson Bay. A radiosonde ascent at The Pas, Manitoba at 0000 GMT on 6 July showed moist, unstable air with light southeasterly winds below 70 kPa and southwest winds of about 10 $m\,s^{-1}$ from 70 to 40 kPa. Above 40 kPa wind speeds increased to about 30 $m\,s^{-1}$.

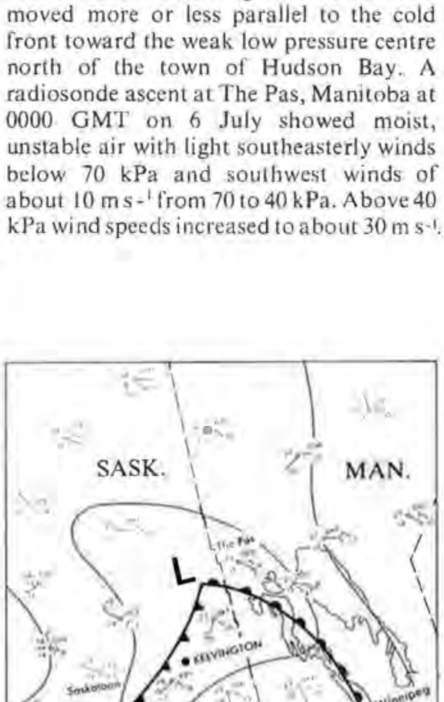


Figure 2. Surface Weather map, 1800 GMT, 5 July, 1973.

The tornado photographs accompanying this article are numbered in time sequence by camera location (Camera A, Mrs. Bauder, Kelvington; Camera B, Mrs. Babecy, Kelvington; Camera C, Mrs. Onyskiw, Nut Mountain). Photos from Camera D (Mrs. Carbno, Wadena) are not included because of its distance from the storm.

Photos A2, A5, A6, A8, A9 and A13 cover the first touchdown from the characteristic initial needle-point funnel aloft through the dust cloud which spiralled upward around the funnel from fallow below. In A13 the original dust cloud is still visible outside the funnel and well above ground.

Evidence for the second touchdown is seen in a new dust cloud near ground level in Photo A15. At this time the vortex, unaccompanied by a funnel to ground, crossed a farmyard where it demolished a barn, granary, and other property. Fragments of a self-feeder were later found 800 m northwest of the farmyard. Occupants of the house took shelter in the basement and no one was injured. Later they found their furniture in disarray, a door smashed through its stop the wrong way, and broken windows.

A new funnel aloft, within the dissipating collar-like cloud of the first, appeared in Photo A17 and is show more fully developed in Photo A18 to the northeast of Kelvington. Touchdown 3 followed with reports of damage to a small building. Eyewitness reports and Photos B1 to B4 (not included here) confirm a funnel aloft and no surface damage as the storm crossed Pipestone Creek valley. Touchdown 4 resulted in a scattered lumber pile, a damaged granary, and forest destruction. Although the lowest part is obscured in Photo B5 it has the appearance of a funnel to ground. Photo C1 and the absence of forest damage show that the tornado vortex and funnel then lifted and dissipated once again.

Touchdown 5 was accompanied by a funnel to ground (see Photo B6) and resulted in a path of broken and twisted mature aspen and spruce. The white patch near the base of the funnel in Photo B8 is a cloud of water droplets stirred up from a slough shown in Figure 1. The funnel and stirred water look much less formidable as seen looking south toward a bright sky in Photo C2. The flower-shaped pattern of water particles is indicative of strong upward motion near the funnel, centrifuging particles as they rose, and gravitational fall at the outer edges. After crossing the road from right to left in Photo C2 the tornado overturned a heavy seed drill. No further damage was observed even in the forest just a few hundred meters east of the road.

Fortuitous circumstances, including several interested observers, a slow-moving storm, and excellent visibility, combined to make possible a unique set of tornado photographs from a district in Saskatchewan where such storms are rare indeed. These photographs show that intermittent damage along a single track can result from successive regeneration of a vortex at ground level from one small area of a thunderstorm cloud base. The vortices were usually, but not always, accompanied by a funnel cloud to near ground level.

The author wishes to express his sincere gratitude for permission to share these photographs to Mrs. Bauder of Edmonton (series A), Mrs. Babecy of Kelvington (series B), and Mrs. onyskiw of Nut Mountain (series C).

Gary McNally, Marketing Manager

Vera McNally, Technical Services Manager

CHINOOK VISITS ENERCORP

As part of our continuing series featuring companies dealing with various aspects of the environment, ***Chinook*** visited **Enercorp Instruments Ltd.,** of Toronto, Ontario. At their pleasant and roomy premises located in the city's west end, we learned that this thriving company has successfully broadened its meteorological base by diversifying into the industrial field of system controls and indicators. It has also grown from being a manufacturer's representative to a company which runs a precision testing laboratory capable of repairing, overhauling, and calibrating many different types of sensors to National Research Council certification standards. Furthermore, it is one of the few Canadian companies in the meteorological field with the ability to design and manufacture original instrumentation.

This success is in no small measure due to the capability of two of the company's top officers, namely **Gary McNally** P.Eng (photo, top left) the Marketing Manager, and **Vera McNally** M.Sc (photo, right) **Enercorp's** Technical Services Manager. Their engineering and research qualifications have led to profitable time spent in research and development. The result has been the design of a digital psychrometer which can also be used as a digital thermometer in the process industry. They are currently working on the prototype of two other devices, a solid state humidity transducer and a dew cell, to be used in humidity measurement. "The reason for this," said Mr. McNally, "is that most conventional instruments do a poor job of measuring humidity in particular."

The advantage of the transducer is that it will have a linear output that is easy to interface to a computer or to a microprocessor. This in turn allows an industrial user to control humidifiers, ventilating and heating systems, and reduce the reject rate of their product (semi-conductors for example) due to variations of humidity and temperature within the manufacturing plant.

When asked about a company achievement of which he was particularly proud, Mr. NcNally mentioned a problem solved for a client in the business of manufacturing plastic items. Before the raw plastic enters an extruding machine it must be very dry. The common industry technique is to buy high wattage dryers which must be left running continuously for many hours. Faced with this problem, **Enercorp's** solution was to design a system which would monitor the dewpoint in the work area and cycle the dryers, thus saving the manufacturer thousands of dollars in energy costs.

Enercorp's business is split down the middle with regard to meteorological and industrial sales, "but it is a happy marriage" Mr. McNally explained, "because there is so much overlap between the two fields. We don't really have a competitor either," he continued "because there is no equivalent in the meteorological equipment business to a General Motors who wins all the orders."

Basically, the company marketing strategy can be broken into three components. Firstly they sell the sensors for measuring meteorological elements such as temperature (the most measured element according to Mr. McNally), the moisture content of the air, pressure, the wind, and solar radiation. Secondly they market the equipment that changes the signal from the sensors into useful information, and thirdly they sell the recorders and indicators that monitor the sensor signals. All together, this adds up to a complete package that can be adapted to many requirements. A system has been assembled that will measure Rocky Mountain avalanches for example, and another to measure rainfall in Ethiopia, while yet another monitors factory conditions in the aerospace industry where environmental factors must be precisely controlled.

The front end loading expense (research and development investment, sales calls, and promotion) necessary to launch any young organization are now paying off for this company, which was founded in 1977. Mr. McNally says that it is on a fast growth curve and is finding export markets in the U.S. The **Enercorp** name is placed on the entire instrument line of products, a fact which should encourage buyer confidence, because it means that the company guarantees, services and supports each item that it sells.

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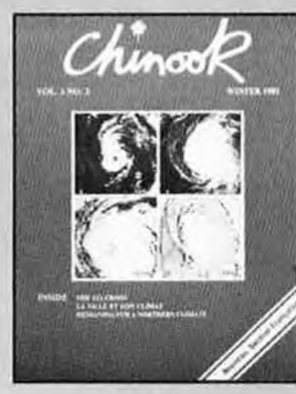

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