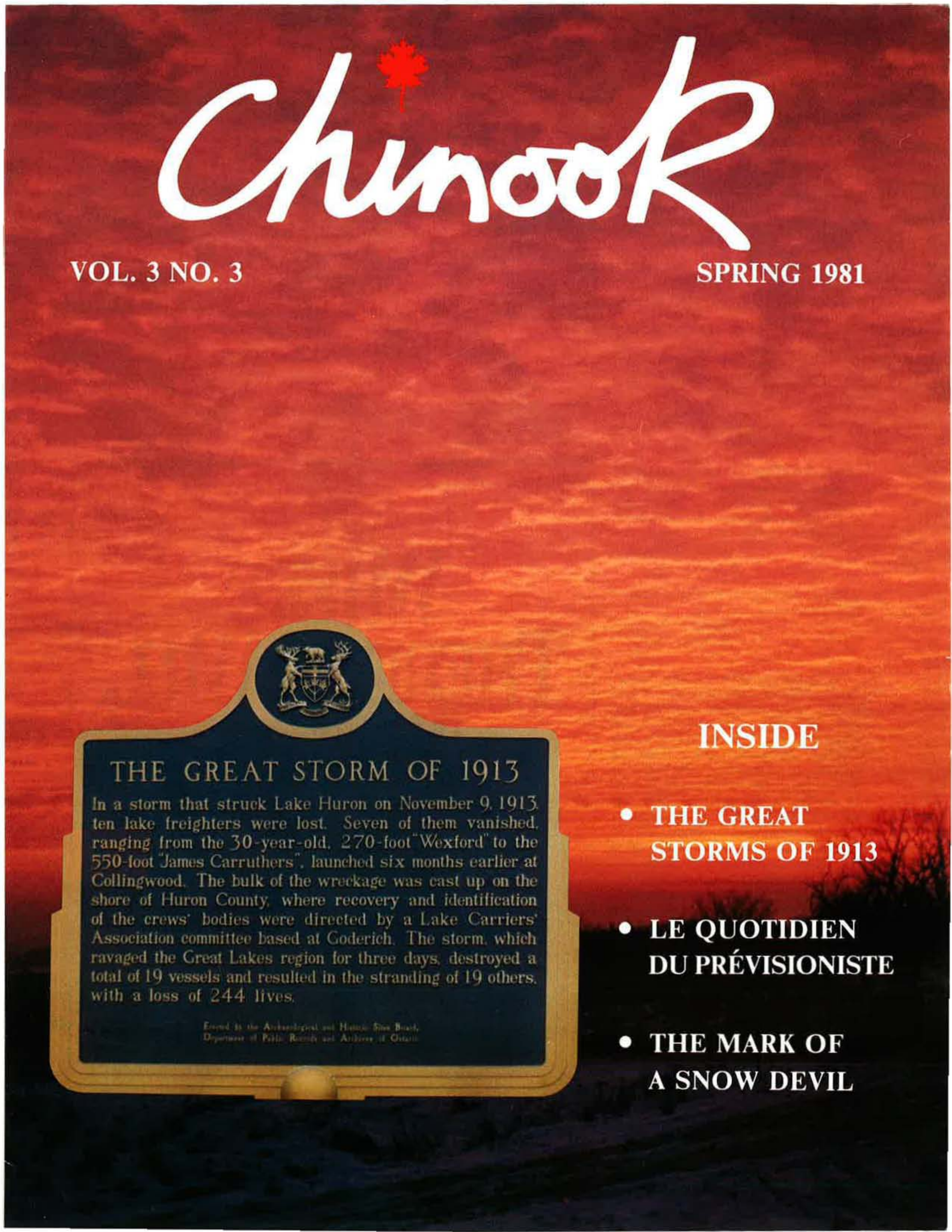
Chinook

VOL. 3 NO. 3

SPRING 1981



INSIDE

READER SEEKS FIRST TWO ISSUES OF *CHINOOK*

I wonder if any of your readers could help me in obtaining the first two issues (Vol. 1, numbers 1 and 2) of ***Chinook.*** I greatly enjoy the *Arch Puzzles.* Keep them up.

Ray P. Yochim
140 Anderson Cr, Saskatoon
Sask. S7H 4C2

ARCH PUZZLES. FOR AND AGAINST

Chinook is a very good magazine, but I would enjoy it even better if you dropped *Arch Puzzles* and devoted the corresponding space to weather related items.

Lambert C. Huneault
Windsor, Ont.

I have enjoyed your puzzles in ***Chinook*** very much.

Walter F. Zeltmann
Brooklyn, N.Y.

The fascination of the "Jumble Words" puzzle (***Chinook,*** Fall 1980, *Arch Puzzle* number 14) has prompted me to carry on with the story. Consequently I am submitting for publication in your excellent magazine, three follow-up snatches of conversation between the resident polar bear at the north pole and the visiting giraffe. Each is hidden, of course, in a sequence of jumble words.

Upon hearing from the giraffe that "he thought it was cool", the polar bear asked "--- ----- ---- ---- ---?" To discover the polar bear's question, unscramble the clues and then re-arrange the letters in the circles to form the five words of the question.

DRATONO OOO--O
KOHCOIN OOO---O
ELKNISY -OO--OO
SLOUCUUM OO----O-
SWEYTERL O-OO---O

H.H. Watson
Nepean, Ont.

(We would like to publish all three, but space permits only the one above. We
continued p. 35

Chinook **Spring** 1981 Volume 3 Number 3

Articles

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THE COVER

In Goderich, Ontario, a plaque commemorates the historic Great Lakes storm of November 9, 1913. Erected by the Archaeological and Historic Sites Board of Ontario, it embodies a small error. Of the 10 lake freighters which were lost, 8 (rather than 7) vanished on Lake Huron, and 2 on Lake Superior. For more about this storm, see page 40.

"The strongest vessel on the Lake,
Will never reach the shore.
The bravest sailors on the boats
Will see their friends no more." Anon.

TO THE EDITOR continued

will have to leave to the reader's imagination the reply to the polar bear's question.

Answer: Why stick your neck out?

MODELLING OF CO_2 NOT TRUE TO NATURE

As a subscriber and faithful reader of your magazine, I would like to compliment you on the continuing high quality and stimulating articles you put between the covers of each issue. Two items in the Winter 1981 edition (Vol 3, No. 2) were of particular interest and I would like to comment on them in the hope of provoking more articles like them in the future.

First, Dr. Buckmaster's article "The CO_2 Crisis". One of the perplexing aspects of the predicted warming induced by CO_2 is that despite the 4.3% increase in the consumption of fossil fuels since 1850, the earth's temperature has in fact been decreasing since 1938. This puts into some doubt, in my mind at least, the theoretical results quoted in the article that indicate as much as an 8 to 12 degree C increase in temperature in the polar regions, with a doubling of atmospheric CO_2 which in the author's estimation will take place by 2035, a scant 54 years from now.

On the other hand, the modelling of CO_2 in atmospheric models may simply not be true enough to nature at this time to simulate all of the processes at work. It was fascinating to see the author's assessment of the impact of the melting of the ice sheets in Antarctica and Greenland and, in particular, the areas of Europe inundated, given an increase of the sea level by 66 m. My question is, with a similar rise in the sea here, what parts of Canada and which Canadian cities would be affected?

My second point concerns the Severe Weather Log, 1980 Almanac Edition which contains up-to-date facts on deaths and injuries by province and cause. The use of the term "flash floods" as one of the "causes" concerns me because it is a phrase borrowed from our neighbours in the U.S. and, among flood forecasters, misunderstood even in that country. According to the *1979 Operations Manual* of the U.S. National Weather Service, a flash flood is "a flood which follows a causative event (such as excessive precipitation, dam failure, ice-jam break up) within a few hours". Another frequently quoted reference, the *Glossary of Meteorology*, defines it as "a flood that rises and falls quite rapidly with little or no advance warning, usually as a result of intense rainfall over a relatively small area". As two American hydrologists pointed out at a recent conference on flash floods (1), the "wall of water" flash flood is an event that occurs much less frequently and requires

continued p.45

BÉNARD CELLS

and other concepts of heat transfer in the lower atmosphere by **F. Fanaki**

Each and every minute of the day a constant amount of solar radiation (1.946 langleys[1]) streams from the sun to the outermost fringes of the earth's atmosphere. Due to the effects of the earth's curvature and the season, the undepleted amount of radiation available at the edges of the upper atmosphere (between 80 and 1000 km above the surface) ranges from zero to a maximum of only 1000 langleys or so per day. The amount actually reaching the earth's surface is reduced still further because some is scattered by dust in the atmosphere; some is reflected back into space by ice cover and clouds; and some is absorbed by atmospheric water vapour, carbon dioxide and ozone. On the average, only about 50% of the undepleted energy from the sun is available to warm the earth's surface, and thereby provide the primary source of heat which fuels the world's weather.

How is the transfer of heat through the air from the earth's surface accomplished? Generally speaking it is by four distinct processes, namely radiation, conduction, convection and advection. Convection describes the transfer of heat by the net translation of aggregates of air molecules. If the motion is predominantly along the vertical, the transfer is by convection; if it is predominantly along the horizontal, the transfer is by advection. Advection and convection usually are closely related in the atmosphere. All of these processes of heat transfer may occur simultaneously in the troposphere (the lower atmosphere) to varying degrees. Although they are quite well understood in general, opinions vary concerning the exact nature of the mechanism of transfer.

If we examine the case of radiation, we find that the primary components in the transfer are the incoming shortwave radiation from the sun, and outgoing long-wave radiation from the earth. The former is absorbed weakly by atmospheric water vapour and carbon dioxide, to the extent that it causes a change in air temperature ranging from 0.1°C to 0.7°C on the average day, depending upon the amount of water vapour present. The long-wave radiation on the other hand, is absorbed more strongly by these two elements. Although it is expected that the longer wave-lengths should therefore contribute more substantially to the heating of the air, it is difficult to obtain experimental measurements on the relative effects of these two types of radiation because of limitations in both the measuring techniques and the theory of radiation absorption.It has been estimated that local heat transfer by long-wave radiation in the day-time is comparable to that by the other modes of transfer only in the lowest one or two meters above the ground. At night however, experimental observations have indicated that the effect is important to heights well above that.

In the atmosphere, the height interval through which conduction is important remains uncertain. It is suggested that this interval is less that 1 centimeter, but observations on temperature fluctuations indicate that it should be no greater that 1 millimeter. Convection and advection are suppressed in this layer because of the proximity of the surface boundary. A large height-change of temperature (lapse rate), which may reach a value of hundreds of times larger than the normally prevailing dry adiabatic lapse rate (i.e. 5°C per meter) is observed generally in this region.

Some insight into the physical nature of the conduction layer may be derived from laboratory experiments. Observations on the air above a heated plate showed a "dust-free" layer just above the heated boundary. The upper surface of this thin layer (less that 1 millimeter in depth) is undulating. As the temperature of the plate increases, a thin, shimmering layer forms directly above the "dust-free" layer in which tongue-like columns rise and descend alternately. These phenomena are similar to those observed above hot barren soil during the summer. If conduction was the only process of transfer, the maximum air temperature a few meters above the ground would occur in the late evening of each day and the highest seasonal temperature would not be reached until the beginning of winter.

The earth's surface supplies heat to the thin air layer adjacent to it so rapidly that a third mechanism of heat transfer, namely convection, becomes important. It has been suggested that convection is the predominant mechanism at levels more than a few meters above the surface. At these heights, heat transfer by this means is several orders of magnitude greater than that by conduction. Convection is divided, for convenience, into three categories which depend on the magnitude of the wind. Forced convection occurs when a strong wind blows across a rough surface; the resulting turbulence provides an agent for transferring heat upwards. Free convection is present when the wind speed is low and buoyancy forces predominate. In the absence of wind, buoyancy forces alone are present and the regime of natural convection occurs. The present understanding of convection is based upon simple experiments in the laboratory and isolated observations in the field.

The concept of cellular patterns in atmospheric convection originated from experiments by Bénard in 1900. If a shallow layer of fluid is bounded above and below by two conductors at different temperatures, convective patterns will first appear in the form of hexagonal cells (Bénard cells) with fluid ascending at the center and descending at the edges of each cell (Fig. 1A). With a further increase in the temperature difference between the fluid boundaries, the convective cells changed into convective columns as in Fig. 1B. If the fluid moved laterally between the boundaries, all columnar cells would rotate in the same sense as in Figure 1C. It has been shown that the ratio of the cell diameter to the cell height is independent of the physical properties of the fluid. The ratio is 3 for boundary conditions similar to that of the atmosphere, i.e. a fluid bounded by a horizontal rigid surface at the bottom and by a free surface above.

Several authors have suggested that the convective cells of Bénard's type are found on a larger scale in the troposphere. The growth, movement and decay of cumulus clouds are subject to circulation in the hexagonal and columnar cells. Photographs (see page 37) of the tops of cloud layers by meteorological satellites frequently show these regular cellular patterns.

An alternative explanation of convection in the troposphere involves the transfer of heat by isolated parcels of air. Two types of air parcels have been suggested by various authors. One is a local volume of air (called a "thermal") which retains its identity as it rises while drawing in environmental air

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[1]One langley = one gram-calorie per cm^2. The solar constant (S = 1.946 ly min^{-1}) is the 30-year mean reported by the Smithsonian Institute. The value of S actually fluctuates by approximately 1 to 2 percent.

from around it. This concept of closed parcels is based upon laboratory studies on bubbles of air rising through liquid. The top of the thermal has a clearly defined curved surface, but its base is relatively flat and merges into a turbulent wake. Mixing with the environmental air occurs over the leading edge and at the rear. The core of the thermal rises faster than the periphery, so that the thermal resembles a spherical vortex as depicted in Fig. 2. If it is continuous, it resembles a column with a vortex ring at the top. Because of changes in topography and the reflectivity, or albedo, of the earth's surface, local hot spots occur which have definite borders. The air immediately above these warm areas forms into a closed buoyant thermal which rises through the atmosphere, and which are commonly utilized by glider pilots to soar to high altitudes.

The second type is an open parcel, which may be described as the vertical flow of air (whether turbulent or laminar) within a column or envelope (plume). This concept of open parcels or streaming filaments, is more complex than that of thermals, in that the filaments are generally in the form of turbulent eddies in the lower part of the troposphere, and in the form of columns or plumes at higher levels. The idea originated with the study of smoke rising from fires and chimneys, and has received considerable attention in the diffusion of pollutants in the atmosphere. An important extension to the theory of turbulence has been presented by Kolmogorov. He suggested that the energy of larger turbulent eddies (with a diameter of the order of a few kilometers) is passed on to other eddies of successively smaller diameter in a cascading process, until it reaches the smallest possible eddies (diameter of the order of a few millimeters). There it is finally dissipated by viscosity into heating of the air.

The present understanding of heat transfer in the lower atmosphere is immature. The daytime transfer by direct radiative flux divergence from the ground is probably important only in the lowest few meters, but field measurements to confirm this require improved instrumentation. The transfer by conduction apparently is even more limited, being confined to the lowest few millimeters; again, instrumentation difficulties have hampered studies of this physical process. Above the conducting layer, the physical nature of the plume model associated with laminar and turbulent flow also is open to question. There is an obvious need to clarify these problems. A clear picture of the transfer mechanism will help greatly in solving such meteorological problems as weather forecasting, the transport of pollutants, and the evaporation of lakes and seas.

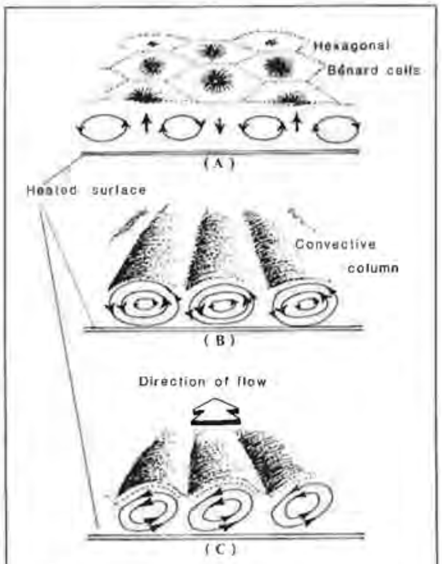


FIG. 1

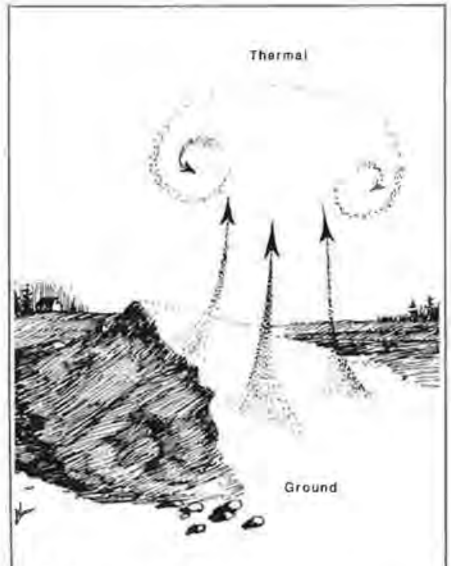


FIG. 2

PHOTO. A WEATHER SATELLITE (NOAA 6) PICTURE of the north Atlantic east of Labrador and south of Greenland, taken on March 11, 1980. Arctic winds sweeping offshore from the continental landmass are warmed and saturated from below by the ocean. In this picture, where the winds are light, a large field of hexagonal convective cloud cells (Bénard cells) has formed. FIGURE 1. A SCHEMATIC REPRESENTATION OF THE CHANGE WHICH OCCURS IN CONVECTIVE CELLS as the temperature differential between the upper and lower boundaries of the fluid increases. FIGURE 2. THE RISE OF A THERMAL due to local heating of the earth's surface by the sun in light wind conditions. In this case, the core is rising faster than the periphery resulting in the vortex at the top.

LE QUOTIDIEN DU PRÉVISIONISTE

Par Richard Moffet

La journée est à peine commencée que Monsieur Tout-le Monde a pris connaissance de la prévision météorologique par le journal du matin, la radio ou bien la télévision. Malgré l'omniprésence de l'information météorologique diffusée par les mass média, les auteurs de ces prévisions ainsi que leur travail restent mal connus et obscures pour la majorité des gens. Cette ignorance peut trouver sa source dans la nuit des temps à l'époque où l'on associait prévisions avec prédictions faites par les devins, clairvoyants ou autres. Dans le but de démystifier et de donner une image plus juste des prévisionistes, nous allons essayer de décrire le quotidien de ceux-ci.

Les prévisionistes à l'emploi du Service de l'Environnement Atmosphérique du Canada assurent un service de premier ordre aux Canadiens, 24 heures par jour et 7 jours par semaine. Le travail du prévisioniste consiste à procurer des prévisions ainsi qu'une veille météorologique continue pour le grand public et certains usagers particuliers.

De nos jours, son travail est complexe et plusieurs étapes composent la démarche qui aboutira à l'émission des prévisions. L'on pense généralement qu'il observe l'état du ciel dans l'accomplissement de sa tâche. Ce n'est pourtant pas le cas, les observations météorologiques sont prises régulièrement par des techniciens spécialisés qui sont en poste dans des stations disséminées à travers le monde. Les données météorologiques qu'ils recueillent, sont la matière première à la base du travail du prévisioniste. Lorsqu'il arrivera au bureau de prévisions, la première étape de son travail sera d'analyser et de digérer les données reçues, dans le but de bien comprendre l'état initial de l'atmosphère. Il analysera toutes les trois heures, une carte de surface qui regroupe l'ensemble des observations prises au sol. Il pourra analyser le champ de pression et identifier les systèmes météorologiques tels que les dépressions et anticyclones, les creux ou crêtes barométriques ou bien encore les fronts froids et chauds. Il évaluera aussi les phénomènes atmosphériques tels que l'étendue des nuages, l'intensité et la fréquence des précipitations, la direction et vélocité du vent etc....associés à ces systèmes.

Prévisions de la météo émises par Environnement Canada. Régions de l'Outaouais, Montréal, Trois-Rivières et Québec.
Faible neige passagère aujourd'hui Samedi, nuageux avec quelques flocons de neige. Maximum aujourd'hui et samedi près de 3. Minimum la nuit prochaine près de zéro.

D'un certain nombre de stations, on lance des ballon-sondes qui permettent d'obtenir un profil vertical de température, d'humidité et du vent. A partir des données prises par ces ballon-sondes et collectées à toutes les 12 heures, il analysera les champs de pression et d'humidité, les régimes de température ainsi que les courants en altitude à un certain nombre de niveaux pré-déterminés dans l'atmosphère.

Aujourd'hui il reçoit aussi, à toutes les demi-heures, des photo-satellites infrarouges et visuelles (jour seulement) qui lui permettent d'identifier les détails tri-dimensionnels des systèmes nuageux. Il a aussi à sa disposition le radar météorologique qui peut déceler le lieu et l'étendue des précipitations. Après avoir assimilé et synthétisé les données provenant de toutes ces sources, le prévisioniste a acquis une bonne vue d'ensemble de la structure tri-dimensionnelle de l'atmosphère. Toutes ces analyses s'incrivent dans le cadre d'un diagnostic de l'atmosphère qui doit être prospectif, car on ne doit pas oublier le but de la prévision.

La deuxième phase de son travail est de prévoir l'état de l'atmosphère dans les 6, 12, 24, 36 et 48 heures. Son analyse se limitera à l'échelle régionale pour des prévisions de 6 heures et s'étendra à l'échelle continentale pour des prévisions de 48 heures. Le prévisioniste possède un bagage de techniques de prévisions qui lui permettent de concevoir l'évolution de l'atmosphère et l'allure que prendront dans le futur les champs météorologiques qui l'intéressent. Ces techniques sont bonnes à court et à moyen terme (jusqu'à 24 hres) mais on a un succès mitigé à plus long terme. Au delà de 24 heures, les modèles numériques deviennent l'outil le plus important.

De nos jours, avec l'aide de puissants ordinateurs, on peut simuler numériquement le développement futur de l'atmosphère à partir de son état initial, en utilisant des modèles mathématiques sophistiqués. De multiples produits et champs prévus sont disponibles. Cependant ils sont loin d'être parfaits et le prévisioniste doit apprendre à s'en servir. De plus, certains champs comme les pressions de surface sont bien prévus alors que d'autres, comme les nuages, le sont moins bien. En général, les modèles numériques prévoient le déplacement des systèmes météorologiques avec une plus grande précision que les phénomènes atmosphériques associés à ceux-ci. Il reste qu'à plus de 24 heures et à grande échelle, ils demeurent le guide numéro 1 des météorologues.

Enfin comme les modèles manquent de résolution autant horizontale que verticale, le rôle du météorologue sera de tenir compte des phénomènes à échelles réduites comme les effets locaux. Utilisant donc une gamme de techniques et les produits numériques, il pourra concevoir la configuration future (6, 12..., 48 hres) des divers champs météorologiques qui l'intéressent.

Après avoir évalué ces champs prévus, la troisième phase de son travail sera de traduire cette information en mots ou messages codés, selon les besoins spécifiques des usagers. Nous sommes tous familiers avec les prévisions publiques entendues à la radio et à la télé. On y inclut l'état du ciel, les températures et parfois la durée ou la quantité des précipitations. Pour les agriculteurs, il faudra inclure les degré-jours de croissance ou les indices d'assèchement. Dans les prévisions maritimes, on ajoutera la visibilité et la direction des vents, alors que pour les entrepreneurs de déneigement, on spécifiera les quantités de neige. Pour l'aviation qui demeure l'un des usagers les plus importants, il faudra penser à la hauteur des couches nuageuses, aux visibilités, à la turbulence, au givrage, au niveau de congélation etc...Autant d'usagers, autant de bulletins différents avec l'information qui lui est pertinente.

Une fois les prévisions préparées puis transmises, son travail consiste à assurer une veille météorologique. Si les prévisions ne semblent pas se concrétiser ou si de nouvelles données viennent jeter un éclairage nouveau sur la situation météorologique, il devra modifier les prévisions. Dans le cas de situations météorologiques qui pourraient représenter une menace pour la propriété privée ou la vie, il émettra des avertissements spéciaux. Dans le cas particulier des prévisions à l'aviation, cette veille devient extrêmement importante pour la sécurité aérienne.

Pour accomplir toutes ces tâches, il faut être plusieurs. Habituellement, il y a au moins 3 météorologues en devoir par quart dans les principaux centres de prévision. Ils sont appuyés par une équipe de techniciens spécialisés. Généralement, un prévisioniste est assigné aux prévisions publiques et un autre aux prévisions à l'aviation. Le superviseur dirige le groupe, coordonne les différentes prévisions et prépare certains bulletins. Des analyses aux prévisions, les décisions sont prises en collégialité, quoique le superviseur ait la responsabilité des décisions finales.

Les prévisions sont acheminées via télex à tous les abonnés au circuit. La diffusion des prévisions météorologiques échappe au prévisioniste et est souvent une source de frustration pour lui. Typiquement, par exemple, lorsqu'il retournera chez lui après avoir travaillé toute une nuit, il verra sa prévision déformée par certains medias. A la radio, on mettra l'accent sur le soleil si la prévision inclut des passages ensoleillés ou bien, on lit un vieux bulletin météo qu'on ne manquera pas de critiquer, alors qu'un plus récent est disponible. Aussi beaucoup de média ont leur propre "expert" qui y va de sa propre variation. Tout cela crée dans le public une certaine atmosphère d'incohérence et d'inconsistance. Evidemment, la plus grande source de frustration, c'est le refus de mère nature à collaborer. Les prévisions sont aujourd'hui diffusées aussi sur ondes courtes par Radio-météo, dans ce cas, ce sont toujours les prévisions officielles les plus récentes qui sont données au public, puisque Radio-météo est controlée par le Service.

Malgré la moquerie dont il est l'objet, le prévisioniste a la satisfaction de voir le résultat de son travail et de traiter d'un sujet qui intéresse le public en général. L'importance que donne le public aux prévisions météorologiques, montre bien qu'il a une crédibilité certaine à la fin. Pas de cartes du ciel ni de boules de cristal mais des ordinateurs, des satellites et des radars sont les instruments utilisés quotidiennement. Pas d'incantations et de poudres magiques, mais bien une démarche scientifique et rigoureuse, voilà ce qui l'amène des données à la prévision, en utilisant des connaissances théoriques poussées. Cela ne l'empêche pas de, connaître ses limites et en ayant développé un certain sens de l'humour, d'avoir une carrière généralement ensoleillée.

PHOTO du haut. Al Keating, un superviseur au Centre de Prévision de l'Ontario, assume la responsabilité pour toutes les prévisions émises pour la région de l'Ontario. Aujourd'hui près de 200 prévisionnistes, disséminés à travers le pays dans 6 centres civiles de prévisions et plusiers bases militaires, sont demandés pour assumer les prévisions météorologiques.

PHOTO du bas. Par constraste en 1912 quand cette photo a été prise, au 315 de la rue Bloor Ouest, Toronto, un seul prévisionniste aidé d'un commis était responsable de l'émission des prévisions de l'océan Atlantique jusqu'aux montagnes rocheuses. Un autre prévisionniste situé à Gonzales, Victoria, s'occupait des prévisions pour la Colombie Britannique.

TOP LEFT (and clockwise). Ron Pennington, a retired Great Lakes sailor holds a life preserver from the *Carruthers.* A scrawled message "CREW 18 ALL. GON." attests to the ship's fate. The *Buffalo Lightship No. 82,* the only ship to sink in Lake Erie, went down off Point Abino with its crew of 6. It was later salvaged and taken into Buffalo. The *James B. Carruthers,* owned by the St. Lawrence & Chicago Steam Navigation Co. Ltd., of Toronto, was, at 7862 gross tons and 550 feet overall, the largest vessel lost. The *Barge Plymouth,* at dock in this picture and loaded with wood, was lost with 7 crew, and was the only vessel sunk in Lake Michigan. The monument in Maitland Cemetery, Goderich, erected in memory of 5 unknown sailors. Three were from the *Carruthers,* one from the *John A. McGean,* and one identified only as Kintail, the location near which he was found.

THE GREAT STORMS OF 1913

Ron Pennington, a Great Lakes sailor for over thirty years and at retirement Master of the *Martha Hindman*, stood in the bright sun of an unusually mild March day. He was holding an old life preserver which is on display in the Huron County Pioneer Museum at Goderich, Ontario. Showing very faintly under its darkened coat of old grey paint is the stenciled word "Carruthers", but more plainly visible is the inscription "Sun Nove 9th 1913. CREW 18 ALL. GON." which is crudely lettered in broad rusty red brush strokes around the life-ring. It was found buried deep in the sand of the Lake Huron shore nearby and, with the bodies of three unknown drowned seamen who rest in the Maitland Cemetery beside their two anonymous mates from other ships, is all that remains of the *James B Carruthers* which sank without trace in the terrible Great Lakes storm of November 9th and 10th, 1913.

Mr. Pennington said that the life preserver is displayed by sailors in an annual Mariner's Service held in Knox Church, Goderich the last Sunday of February before they return to their ships in the spring. It is symbolic of the twelve vessels that were lost with all hands (10 of them freighters ranging from 1453 to 7862 gross tonnage), and the fleet of twenty-six more which were wrecked or stranded. Details vary concerning the total number of sailors who perished. A historic plaque erected at Goderich by the Archaeological and Historic Sites Board of Ontario says that the loss was 244, while a similar plaque at Sanilac, Michigan says that the number was 235. "Of these", Mr. Pennington said, "about 70 were Canadians from 4 vessels, and the true total will likely never be known."

In the days following the storm, between 65 and 70 bodies were washed ashore along the Ontario side of Lake Huron. All but 10 were claimed, and in addition to the five buried in the Maitland Cemetery, Goderich, another five lay for many years in an unmarked grave in Kincardine Cemetery. Recently, by means of an advertisement in the local paper, Ron found two 85 year old men who remembered its location. The plot was staked out and the Kincardine Town Council voted $1000 to erect a monument.

Even yet the depths of the Lakes yield up reminders of that grim event. Scuba divers have found some of the sunken vessels and retrieved mementos from them. One of these, a port hole from the engine room of the *Charles S Price* (which sank with all hands) was recovered 65 years after the ship foundered, and is on display in the museum. It clearly shows the effects of being battered by the heavy seas which were constantly breaking over the vessels. Ships coming down the lakes on Sunday November 9th, were continually boarded by following seas which tore away their after-quarters, or kept them flooded to a depth of several feet and sweeping everything portable overboard. Ships heading into the winds which varied from north to northeasterly, and which raged at a steady 60 knots with gusts to 70 or 75 knots, were in danger of losing their pilot houses. Such a fate was suffered by the *Howard M Hanna Jr* before it broke in two on the Port Austin reef in Lake Huron. The wind and current was so strong that Captain P.A. Anderson of the *Centurion*, who had let go both his anchors with 60 fathoms of chain in the St. Clair River, said that his ship was dragged 2 miles at such a rate that a 20 lb. lead weight was carried right out of a man's hands.

Adding to the hazards of the storm was the fact that on the afternoon of the 9th, it began to snow so heavily that the shore vanished from view and helmsmen, without landmarks, couldn't tell exactly where they were or how fast they were travelling. With the temperature falling rapidly, and spray being blown as high as 75 feet, ships began to ice up. The steamer *J.F. Durston* which took 40 hours to traverse Lake Huron (normally a 22 hour run) came to anchor Monday afternoon (the 10th,) at Mackinaw covered with 1000 tons of ice.

Nor were conditions ashore much better. At Port Huron, Michigan, the northeasterly winds caused an estimated $100,000 damage to shoreline properties. Trees were uprooted, concrete walks swept away, roofs torn off, and the shoreline itself was eroded back to the very foundations of the houses. The mouth of the Port Huron canal was completely blocked by 640,000 cubic feet of sand which was washed over a protective breakwall. The Fort Gratiot lighthouse at the foot of Lake Huron was badly undermined by the action of the waves, while nearby on land, the blinding snow piled up in drifts from 4 to 5 feet high. At Cleveland, Ohio, from the morning of Sunday November 9th, when precipitation began as rain mixed with wet snow, until the afternoon of November 11th, when the snow ceased, a total of 22 inches accumulated.

Where was the origin of this terrible storm which caused such widespread havoc on all the Great Lakes except Lake Ontario? The *Monthly Weather Review* of November 1913 shows that there were actually two storm tracks. One began in Alberta to the lee of the Rocky Mountains on the 4th. Moving south of Lake Superior, it slowed and reached Lake Huron 4 days later on the 8th. There, a second and major storm centre took over. This had previously moved eastwards as an innocuous disturbance through the Gulf states in the U.S., to Georgia where it curved sharply northwards, deepened explosively, and crossed Lake Erie on the 9th. The following day after slowly crossing Georgian Bay it weakened and then raced away towards Newfoundland on the 11th. As the intensifying storm centre moved northwards towards Lake Erie, rapidly strengthening north to northeasterly winds developed over the Great Lakes, with the strongest over Lake Huron. There, the wind stranded many of the wrecked ships on the Michigan side near the mouth of Saginaw Bay, while the cold winds funneled snow to the foot of the lake, as well as to Lake Erie and beyond. When the storm centre departed, the winds switched

continued p. 42

continued from p. 41

to westerlies which carried bodies and debris to the Canadian side of the lake.

Catastrophic as this blow was, with the loss of at least 235 lives and an estimated cost of $3.7 million (1913 dollars) to Great Lakes shipping alone, it was not the only major storm of the year 1913 to move across the Great Lakes region. A previous calamity had already struck the mid-section of the U.S., from the Mississippi valley states into the province of Ontario, and was dubbed the "Good Friday Gale" of March 21, 1913. Everywhere along its track, destructive winds razed buildings, broke and uprooted trees, and felled telegraph and telephone poles. Tornadoes spawned by the storm added to the general mayhem. In the U.S., according to the *Monthly Weather Review*, a total of at least 15 people were killed and possibly another hundred injured, while property damage amounted to some $2 million.

On the morning of March 21st, the storm centre moved across Lake Huron into Ontario. Severe property damage was widespread throughout the province that day. At least 7 Canadians lost their lives as a result, most when they were trapped and crushed by falling building debris. Scores more were injured from Windsor in the south, where wind gusts reached a maximum of 88 m.p.h., to Cobalt in the north where the newly built Roman Catholic church of Father Arseneault fell about the ears of its departing congregation (luckily in this instance without injury). The worst incident occurred in Sturgeon Falls, Ontario where the town's firefighters were responding to their seventeenth storm-caused alarm. Just as they were leaving the fire hall, the tower blew down killing three of the men, as well as the horses drawing the reel.

Almost exactly 68 years later, on this particular March day in 1981, as Ron Pennington stood chatting to the group from ***Chinook*** and Mrs. Carter and Mr. Scotchmer of the Pioneer Museum, the almost springlike temperatures dispelled thoughts of such weather disasters. But we wondered if history could repeat the infamous Great Lakes storm of November 1913. Yes, but not likely with the same results we agreed. After all, in those days most of the ships were without radio communications, and it was not until the second world war that radar came along. Although storm warnings were issued by the U.S. and Canadian weather services, this information was relayed mainly by means of flags and signal devices flown on masts ashore. Poor communication combined with the rapid development of the storm must surely have been the main reasons why so many able mariners were caught unaware and lost without trace.

ARCH PUZZLE #17. GRAFFITO

Have you had a secret yearning to scribble an irreverent, facetious or humorous remark under a picture? Here's your chance. The original caption for this 1890 picture was "Jones home from the club, fears the storm" (of his wife's wrath). Send us your graffito caption (Arch Puzzle, Box 427, Brampton, Ont., L6V 2L4) by June 15, 1981. The best will be printed, and the winner, in Chinook's opinion, will receive the book "White Death, Blizzard of '77" by Erno Rossi.

Answers to Arch Puzzles #15 and #16

Arch Puzzle #15 is (a) an aerial view of sea ice, some of which is drifting pack ice, and some of which is fast against a land form. (b) The land form (top of picture) consists of a number of raised beaches of snow covered sand or gravel, and is devoid of trees. No bed rock is evident. The fast ice is largely homogeneous and snow covered. Ridge lines in the ice parallel to the shore line near the point of land probably indicate tidal action. There is no evidence of ice melt. The sea ice-pack consists of angular ice which is smooth except where it has been subjected to pressure. The resulting ridges are not eroded, or smoothed, by summer melt. These features are typical of first year ice. The pack ice is also snow covered and a snow drift pattern is evident. From 2 to 3 tenths of the ice surface is covered with hummocks (ice blocks or floes piled in a random fashion). Several cracks are clearly visible. (c) The raised beaches and tidal action are good clues that the location is Northern Hudson Bay. In fact the photograph was taken during a flight over Mansel Island. (d) The time of year is winter (actually January 11th). The prize for the best answer goes to **R.L. Jones** of Nepean, Ontario who points out that a wrecked grain ship is visible in the crack just to the right of the point of land. *(we really had to strain our eyes to see it. Ed).*

Arch Puzzle #16 is again (a) an aerial photograph of sea ice (on the right of the picture), and shallow open sea water. (b) All the ice has similar characteristics, namely a similar flow shape and an identical colour or tone. It is first year sea ice in an advanced state of deterioration through melt. At the middle upper left of the picture, the ice floe is so riddled with thaw holes that it has largely broken up. The large floe on the right is 2 to 3 tenths covered with puddles, many of which are joined together in a random drainage pattern. Note that lake ice develops neither thaw holes, nor a distinct drainage pattern as it thaws. It becomes thinner, remains in large floes, then suddenly "candles" and dissipates in situ. The dark area of the picture is a shallow area of open sea water over a silted bed. it is relatively clean, not muddy. A drift boundary, or zone between two currents is evident from lower centre to upper left, which probably indicates an outflow from a large river. (c) Pinpointing the location of this delta from the picture alone is difficult. It is actually a location on the shore of Isachsen Island in the Arctic Archepilago. (d) The time of year is the height of summer, either late July or early August. Our congratulations to **John M. Campbell** of Simcoe, Ontario who was judged the winner of this task.

Our thanks to the others who sent in responses to these tasks. All correctly identified some elements or other, but not enough to win. Better luck next time. Thanks also to **Torben Anderson,** an experienced ice observer with Environment Canada, who provided the analysis of the pictures.

THE MARK OF A SNOW DEVIL

Every day at 8.00 a.m., Mrs. Monteith takes her insulin. On the morning of December 14, 1980 this routine had just been completed when she and her husband Ed looked out the window of their home near Embro, Ontario and saw an unusual whirl of snow. Moving from the west, the funnel-shaped and rapidly rotating body of suspended snow skittered over the newly frozen surface of the pond just south of their house. It rotated there for a few moments in the same location and then dissipated.

The Monteiths had just witnessed one of nature's transitory atmospheric moods, a short-lived, small-scale vortex of air called a "snow whirl" (or "whirly"), or "snow devil". Related to the more familiar dust devils (whirlwinds) and tornadoes of the summer season, this winter phenomenon is believed in comparison to be a mechanically induced eddy (i.e. caused by topographical obstructions to the windflow). Snow devils have been observed in the polar regions of both the northern and southern hemispheres. They were observed at Adelie Land during the Australian Antarctic Expedition just before the first world war, where some had sufficient strength to pick up and move objects weighing about 700 kg. They were also seen during the "Danmark" Expedition to Greenland (1906-1908). More recently, snow devils were reported *(Atmosphere* 1976, vol. 14, no. 2, p. 135) to have been observed in Canada's western Arctic by a pilot. He landed on ice which they had scoured almost free of snow. Yet others were seen in the Kananaskis Valley, Alberta during January of 1971. Their life span was about 30 seconds to 2 minutes, and it was estimated that they were 4.5 to 9.0 m in diameter and about 12 to 15 m high. A photograph of one of these can be found in *Atmosphere,* volume 10, number 1, on page 23. Mr. Monteith was unable to photograph the snow devil itself, but he did take a picture immediately afterwards (this page) which showed something almost more remarkable, namely a "bulls-eye" pattern of broken ice in the form of a central hole surrounded by an annular ring of water where the the snow devil had spent its last few moments. No measurements of the dimensions were made, but as it can be best estimated from photographs and topographic maps of the location, the central hole was about 190 cm in diameter, the annulus was 55 cm wide, and the inside diameter of the annulus was about 8.4 m.

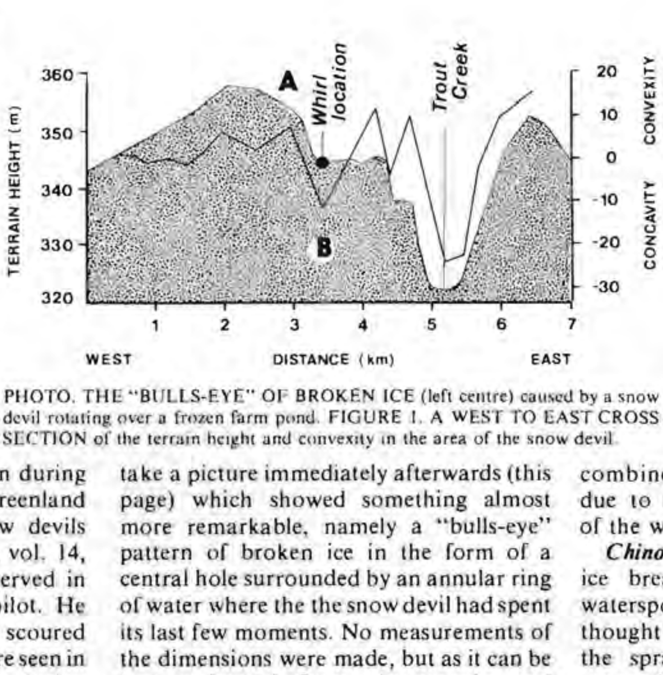


PHOTO. THE "BULLS-EYE" OF BROKEN ICE (left centre) caused by a snow devil rotating over a frozen farm pond. FIGURE 1. A WEST TO EAST CROSS SECTION of the terrain height and convexity in the area of the snow devil.

The weather preceding the event had been relatively mild and the pond had only just frozen over the night before (in fact, open water shows in the photograph as a dark patch on the right, or western end, of the pond). The ice thickness is unknown, but it must have been quite thin. Weather records for December 14, 1980 from nearby stations indicate that the surface winds were from the west and gusting to about 70 km/h. The temperature was minus 4°C and slowly falling as a cold front moved through the area at about the time of the whirl. Very poor and variable visibility due to blowing snow indicates that there was a great deal of turbulence in the atmosphere.

A cross section (from west to east, parallel to the wind direction) of the terrain height above sea-level is shown in Figure 1, and also its convexity (for an explanation of convexity see ***Chinook,*** volume 2, number 3, pp 36-37). It is apparent that the snow devil occurred in the lee of a ridge. It is also reasoned that the snow devil location was in an area where the terrain would cause a local gradient in the atmospheric pressure (high pressure where the air flow was compressed at A, and low pressure where the air flow expanded over B); and would cause horizontal wind shear (a stronger wind due to high values of convexity at A, a weaker wind due to low convexity values at B). It is conjectured that these factors, combined with the vertical motions due to turbulent eddies, were the cause of the whirl.

Chinook's explanation of the pattern of ice breakage follows from studies of waterspouts by Joseph H. Golden. It is thought that the annulus is analogous to the spray ring of a waterspout where tangential wind speeds reach a maximum. Within the ring is an "eye" of calmer wind (and hence unbroken ice), while at the very centre is an area of downward moving air, apparently with sufficient velocity in this case to push down, and thus break, the ice there. If our readers have any other thoughts about this matter, we invite your comments.

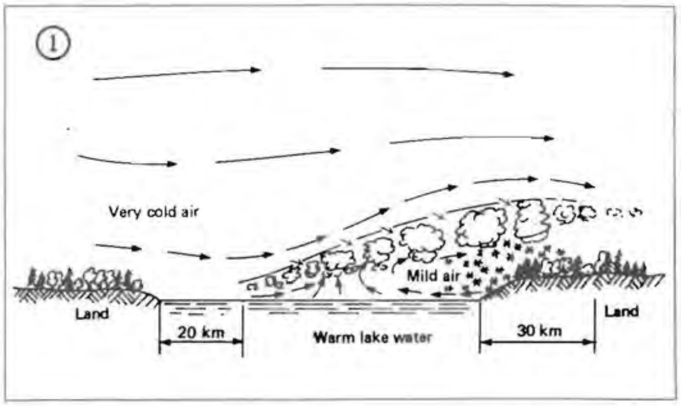
WEATHER PHENOMENA OVER THE GREAT LAKES

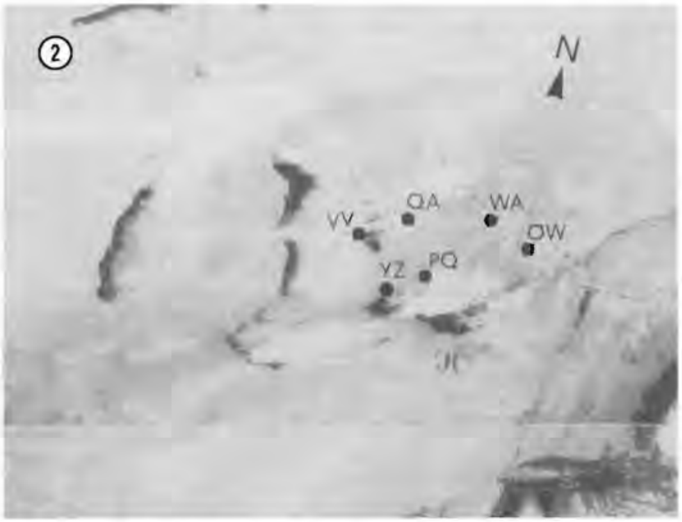
by Y.S. Chung and O. Koren

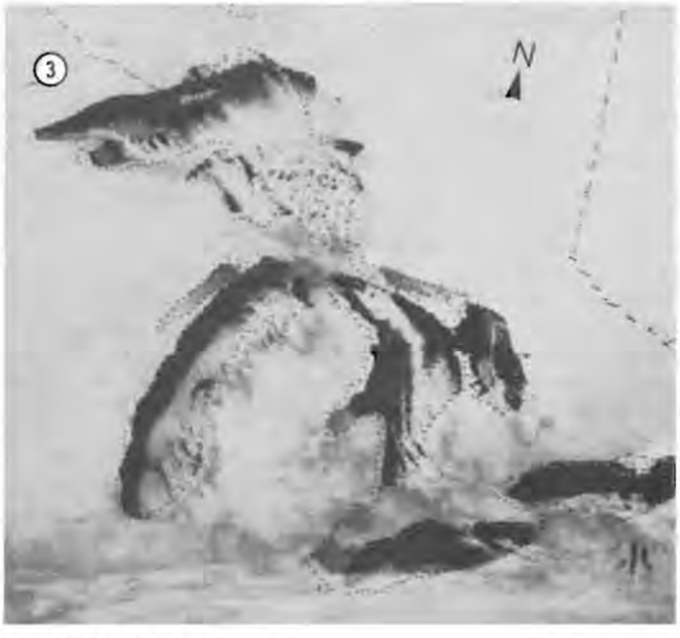
The Great Lakes, with a total water surface covering more than 243,000 km^2, have a profound effect upon the weather of the area and its surroundings. During the summer, the water cools the air passing over it and acts as a heat sink; during the winter, when the air is usually colder than the water, the reverse is true and the Lakes act as a heat source. In all seasons they are a source of atmospheric moisture. it is little wonder that many scientists have studied the modification of weather systems as they move across such large water bodies, because an increased understanding of the formation or change in weather patterns over varied topography may aid in significant improvements in local weather prediction. Here our purpose is to show visual examples of a few cases when clouds and associated snowstorms were generated over these relatively warm water bodies during the winter of 1978-79.

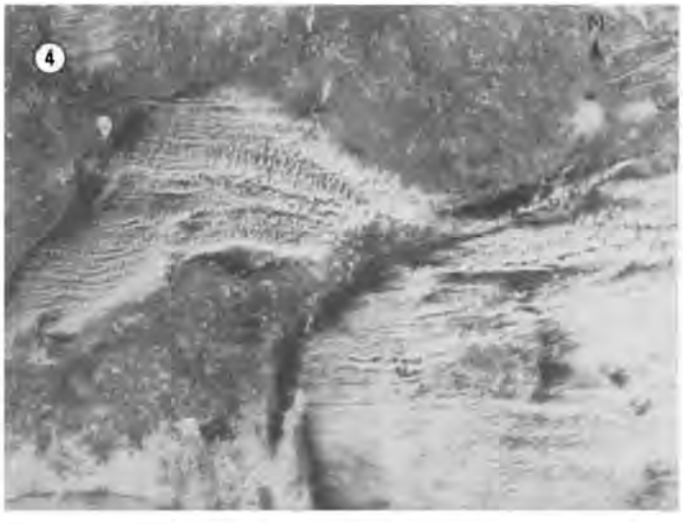
This process can be explained briefly as follows; cold air heated from below by warm water creates a zone of mixing in the lower levels of the atmosphere in which the snow-filled clouds form. The cold arctic air of winter over-running warm water bodies seems to produce a stationary "pseudo" front with modified milder air beneath, and unmodified dry air on top, as shown schematically in Fig. 1. Where the modified snow-producing air streams onshore, there is a snow-belt region which frequently extends 20 to 30 km inland.

Fig. 2 depicts a typical case (on January 4, 1979) of the formation of cloud which occurs over the Great Lakes. In this situation there was a pronounced outbreak of dry cold arctic air which almost entirely dominated eastern North America. All five lakes were free of ice (due to a previous prolonged period of warm days) during the period of January 3 to 6, 1979 when the cold air was prevalent, and were thus vigorous sources of heat and moisture. Although skies were clear over continental land areas, clouds formed over the warm









lake waters each day and were streamed eastwards by cold winds from the interior. It is interesting to identify cloud-free regions (black areas in the photograph) which are about 20 km wide and extend along the western (upwind) shore of each lake. Assuming an average windspeed of about 30 to 40 km/h, this means that it took about 30 to 40 minutes for lake moisture to saturate the dry airmass travelling across the water surface. During the four day period the total snowfall from the lake-induced clouds amounted to 45 cm at both Wiarton (VV) and Muskoka (QA) in Ontario. In contrast to the heavy snowfall at observing stations to the lee of the lakes, only very small accumulations, of less than 1.4 cm, were measured at stations such as Toronto (YZ), Peterborough (PQ), Petawawa (WA), and Ottawa (OW), which are all further downstream and thus more protected. The occurrence of similar major snowfalls is frequently observed along the western shores of Korea and Japan during mid-winter due to the modification of cold northwesterly winds from Asia by the warm ocean water offshore.

Another case showing the formation of cloud over warm water bodies on January 11, 1979 is illustrated by Fig. 3. In particular, the cloud pattern over Lake Michigan is similar to the shape of the lake. In this situation, the onset of the cloud formation is seen to take place about 50 to 70 km from the western shores. Figure 4 shows the formation of low-level clouds (on November 30, 1978) which extend over Lake Superior and the northern portions of Lake Michigan and Lake Huron. Features of particular interest in this photograph are the transverse wave patterns and billows within the cloud streaks, and also the shape of the cloud-free regions which parallel the shape of the adjacent shore. The spacing between the successive cloud streaks is about 1 km and the altitude of the cloud tops is about 1 to 2 km above the surface.

These cases illustrate just a few of the complexities involved in the interaction between water bodies and air masses. Besides snow, many other meteorological problems such as fog formation; temperature and wind modification; changes in thunderstorm behaviour; waterspouts; freezing spray; and seiches all conspire to confound the activities of those who find themselves in the proximity of large bodies of water.

Further Reading

Agee, E.M. and F.E. Lomax, 1978: **Structure of the mixed layer and inversion layer associated with patterns of mesoscale cellualar convection during AMTEX 75.** *J. Atmos. Sci.*, vol. 35 pp 2281-2301

Lawrynuik, W.D., 1973: **Hudson Bay as a Heat Source.** *Atmosphere*, Vol. 11, p 124.

To The Editor continued

much more prompt evasive action than the more common "hybrid flood" which crests in a matter of 4 to 10 hours after the causative event, compared to the 15 minutes to 3 hours associated with a true flash flood.

With the exception of ice-jam floods, Canadian floods are typically of the "hybrid" type, perhaps even more so because of the dominating and extended influence of snowmelt, and the lower amount of atmospheric moisture available for the production of heavy rainfall in this climate. That is not to say that flooding is a minor problem in this country. The *1975 Canada Water Year Book* fo example, lists 147 Canadian communities with potential flood problems and notes a total of $100 million of immediate flood damage assistance up to 1970. The main problem, then, is damage from floods which may take days, or even weeks, to develop as in the case of the Red River.

May I suggest that in future editions of the Severe Weather Log you link the type of flash flood to its cause (rainfall, ice jam, dam break) or, preferably, expand the term to "floods" and give some estimate of the annual flood damage as well as the number of flood victims, as you quoted for specific tornadoes for example.

(1) Schwartz, G. and D.R. Dingle, 1980: **The Not Quite Flash Flood — The Hybrid,** Preprints, Second Conference on Flash Floods (March 18-20, 1980, Atlanta, GA), American Meterological Society, Boston, pp 254-258.

William I. Pugsley
Willowdale, Ontario

READER WELCOMES SECTION FRANÇAISE

Just a word from a very satisfied ***Chinook*** subscriber. I really count the days between issues because much of the information is relevant to my physical geography and meteorology classes. Of particular interest in the last issue (Winter 1981) was Buckmaster's speculation concerning a 15 m sea level rise in 50 years. Our campus is only 5.4 m above sea level, and most of our students live Gulfward of the campus and on sites within 15 m of sea level. Specially welcomed in the same issue was the "Section Française". I'm probably among the few ***Chinook*** subscribers in the U.S. who are bilingual. Thibodaux is in southern Louisiana, (*an area named Nouvelle Acadie by its French speaking Cajun inhabitants. Ed*) and my great grandparents came here from Paris. Thus you have pleased at least one American subscriber by going bilingual.

Don L. Gary
Nicholls State University
Thibodaux, Louisiana

NEWS AND NOTES

JET STREAM, A NEW JOURNAL OF MONTHLY WEATHER

Westwind Services, 60 Talfourd Avenue, Reading, RG6 2BP, England informs us that the first issue of *Jet Stream* was published in March 1981. It is 28 pages in size and contains a detailed description and analysis of the world's weather and circulation during January and February 1981, articles, and maps of sea temperature anomalies. It is designed to appeal to anyone with an interest in weather and climate. This bi-monthly publication is available by annual subscription from Westwind Services at a minimum (surface mail) prepaid price of £13.20. Other rates apply to airmail, single issues, or bound copies.

FUTURE WEATHER

A new company, **Future Weather Inc.,** is now operating in London, Ontario. Its President, **Roger Smith,** says that the company specializes in international climatic research, particularly long range weather and climate prediction. An annual subscription to *Future Weather Trends* costs $20 for 12 monthly issues, and can be obtained by writing to Future Weather at Box 2632, Stn A, London, Ontario. N6A 4B9.

THE ALBERTA CLIMATOLOGICAL ASSOCIATION

The Alberta Climatological Association held it's fifth annual workshop and meeting in Edmonton near the end of February 1981. This association brings together a wide spectrum of researchers in climatology, meteorology, hydrology, agriculture and air quality from within the province. They meet once a year in a generally informal atmosphere for a one day workshop and business meeting.

I prefer to call it a portable Personal Micro-Climate Modification Device.....

TRADE WINDS Edited by Claude Labine

FISCAL YEAR-END BLUES

Bureaucratic procedures are a necessary daily evil. However I am somewhat surprised at how the system has evolved to such a point that it can drastically hinder a research program. I am referring specifically to the purchasing procedures in the field of instrumentation. Because most climatologists and meteorologists tend to have major research activities during the spring and summer months, the timing of the fiscal year-end often creates two significant problems. One arises when a researcher is told that there is year-end money available which must be spent in a relatively short time. This can result in "panic" buying and is not a very efficient method of proceeding. A more critical situation arises when the researcher does not know how much is in the new year's budget until a few months before the field program must begin. This creates a situation where the researcher is under pressure, waiting to hear how much is available, and with his hands tied in terms of preparation for the upcoming field season. Once the budget is approved, a mad scramble is necessary to order the equipment, receive and test it within the short time remaining before the field research can start.

To the supplier of instruments and sensors, this translates itself into a situation where, in the first case, urgent requests are received and the goods must be delivered in a much shorter time span than normal. In order to foresee this situation, the supplier can either keep a complete inventory on hand, or else try to forecast the year-end needs of the customers. The first solution can be prohibitively expensive while the second requires the supplier to have a sixth, seventh or even an eighth sense of instinct and to be able to predict the future. Neither are particularly reasonable solutions. It is recognized that certain risks come with the territory if the supplier is to plan on meeting all the needs of the customer, however these can be reduced if improved communication is established between the researcher and the supplier so that a greater lead time can be obtained.

As in any case where bureaucracy exists, researchers have developed ways to wiggle around it. Some of their solutions are indeed proof positive of their wit and intelligence. Nevertheless, researchers face enough problems within their own fields and do not need the extra difficulties due to bureaucratic procedures.

TRAINEES IN ENVIRONMENTAL MEASUREMENT

A brief survey of employment opportunities within meteorology/climatology shows that there is a strong demand for people who are trained to measure the environment. On one hand, there has been a decrease in the number of students, yet on the other, more and more agencies (private and governmental) need to undertake measurement activities. The people with the necessary training need not come only from within these fields themselves, but could also be graduates of a measurement technologist type of program.

If there is enough interest, TRADE WINDS is willing to list or describe programs or courses where students can receive training applicable to the field of environmental measurement. Send such information to: Trade Winds Editor, c/o Chinook, PO Box 427, Brampton, Ontario, L6V 2L4.

NEW PRODUCTS

Above, the *R4 Weather Recording System* available from AIRFLOW, utilizes a combination of multi-channel recorders instead of individual recorders — limiting the total number of chart drive motors to conserve battery power. Three recorder packages are available, from a two-parameter package providing a single chart print-out for wind speed and direction, to a six-parameter system with wind speed and direction and a choice of four of either barometric pressure, relative humidity, rainfall, temperature or solar radiation. These optional parameters are displayed on a four channel, single chart paper recorder. For more information, contact AIRFLOW DEVELOPMENTS (CANADA) LTD., 1281 Matheson Blvd., Mississauga, Ontario, L4W 1R1.

Right, R.W. MUNRO have just announced a new environmental monitoring product, a portable anemometer/wind vane, called the *Anemovane.* This is a completely self-contained system. Munro says that the minimum wind speed reliably measured by the anemometer is 3 knots. General applications will include field environmental monitoring, expeditions, surveying, crop spraying, private heliports and airfields, forestry, dust sampling and noise pollution. Overall height, including tripod, is about 1 meter and total weight is 3.3 kg. R.W. MUNRO LTD. Cline Rd. Bounds Green, London N11 2LY.

NEW CMOS DIRECTORY OF CONSULTANTS

The CANADIAN METEOROLOGICAL AND OCEANOGRAPHIC SOCIETY has recently compiled a directory of consultants (Meteorology and Oceanography). Copies of the directory are available upon request by writing to: Dr. R.B. Charlton, Chairman, Committee on Professionalism, Department of Geography, Division of Meteorology, University of Alberta, Edmonton, Alberta. T6G 2H4.

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