Chinook

THE CANADIAN MAGAZINE OF WEATHER AND OCEANS

LA REVUE CANADIENNE DE LA MÉTÉO ET DES OCÉANS

VOL. 11 NO. 4

FALL / AUTOMNE 1989

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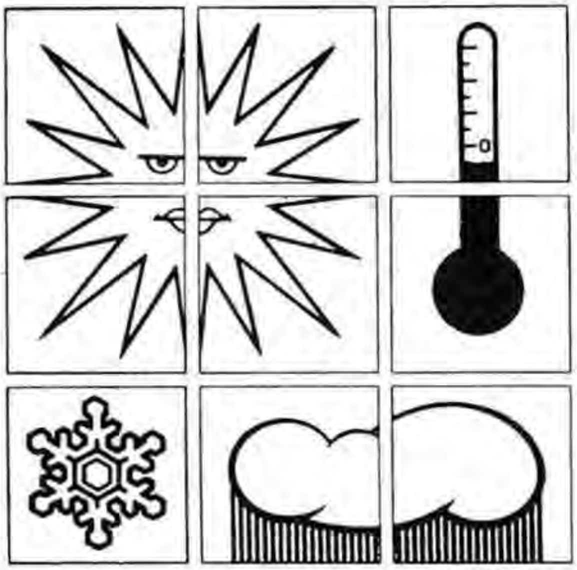

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FROM THE EDITOR'S DESK

As the President of our Society, Dr. Han-Ru Cho, has noted in his letter to readers, this is the last issue of *Chinook*. To terminate a publication is not an easy matter, particularly in these times when environmental concerns seem to be so much in everyone's conscious mind. As editor of *Chinook* since the fall of 1984, I have really enjoyed bringing the issues to you. That year the CMOS took over the publication from Michael Newark, and within a short period of time we managed to publish all the issues for 1984.

I want to thank the Society for their generous support during the past six years, in particular, the presidents and members of successive executives. Their support was a necessary ingredient for success. I owe a depth of gratitude to the members of the Editorial Board, many of whom have been very generous with their written contributions to *Chinook*.

The most important worker on the editorial team was Ed Truhlar, the technical editor. It was Ed who put the publication together, devised its esthetic quality and ensured linguistic and grammatical excellence. Without Ed's professionalism and dedication, *Chinook* would have died much sooner. The French translations were provided, first by Joanne Gagnon-Pacini, and later by Gilles Tardif. Their expert collaboration made the publication more accessible to those of the French language. The artwork, always of very high quality, was executed by Bill Kiely and Joan Badger. Since they are all employees of the Atmospheric Environment Service, I would like to thank the Service for allowing them the time to contribute to *Chinook*. The final production was carried out by the University of Toronto Press. *Chinook*'s excellent quality, particularly the covers, was the result of excellent cooperation between the team and the Press.

In almost six years' time we received many contributions from AES staff and the public. At times I have twisted arms, played the heavy, but all gladly contributed. We thank you for making this a real fun experience. My final wish and hope is that some day *Chinook* will rise again. Canada needs a publication of this kind; it is almost imperative that those in our schools and colleges be provided with state-of-the-art information and explanations concerning the intricate and complex behaviour and status of our atmosphere and oceans.

Hans VanLeeuwen

Chinook

Fall / Automne 1989 Vol. 11 No. 4

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ISSN 0705-4572

Second Class Mail Registration No. 4508
Fall 1989 Date of Issue – November 1990

Courrier de deuxième classe – enregistrement n° 4508
Automne 1989 Date de parution – novembre 1990

COVER

Chinook's goal during its eleven years of existence has been to demystify atmospheric and oceanic phenomena and to help reveal the beauty of our environment.

No extensive educational background in the environmental sciences is needed to appreciate the splendour displayed by the cloud forms that develop during the daytime and at sunset.

Canadian Meteorological and Oceanographic Society
La Société Canadienne de Météorologie et d'Océanographie

Business Office/Bureau administratif:
P.O. Box/C.P. 334, Newmarket, Ontario, L3Y 4X7 Tel: (416) 898-1040 Fax: (416) 898-7937

Executive Director/Directeur exécutif:
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Dear *Chinook* subscriber:

We send you this last issue of *Chinook* with mixed emotions. *Chinook* has been a challenge and a rewarding experience for many of us in the Society. It started as an attempt to serve the perceived interest of the public in matters related to the atmosphere and issues of the environment through a high quality periodical. To produce such a glossy magazine is expensive. Unfortunately there is not enough demand for *Chinook* to justify the cost and effort required for its production.

The decision to discontinue this publication has not caused us to give up the ideal represented by *Chinook*. We plan to continue publishing *Chinook*-type articles in other Society publications. We will continue our effort to serve the public and to fulfil our responsibilities to the Society.

On behalf of the Canadian Meteorological and Oceanographic Society I thank you for the support you have given to *Chinook*.

Cher(ère) abonné(e),

C'est avec une certaine émotion que nous vous faisons parvenir le dernier numéro de *Chinook*. Pour plusieurs d'entre nous, membres de la Société, *Chinook* s'est relevé un défi et une expérience enrichissante. On a tenté de satisfaire les besoins d'un public intéressé aux domaines de l'atmosphère et de l'environnement en présentant un périodique de haute qualité. Mais, la production d'une telle revue est très onéreuse et le nombre d'abonnés n'a jamais été assez élevé pour justifier les coûts et les efforts qu'une telle publication demande.

La revue ne sera plus publiée mais ses buts restent avec nous. Les domaines d'intérêt couverts par le *Chinook* seront le désormais dans les autres publications de la Société. On continuera nos efforts afin de bien servir le public et de rencontrer nos devoirs envers la Société.

Au nom de la Société canadienne de météorologie et d'océanographie je vous remercie de votre encouragement à *Chinook*.

Han-Ru Cho
PRESIDENT / PRÉSIDENT

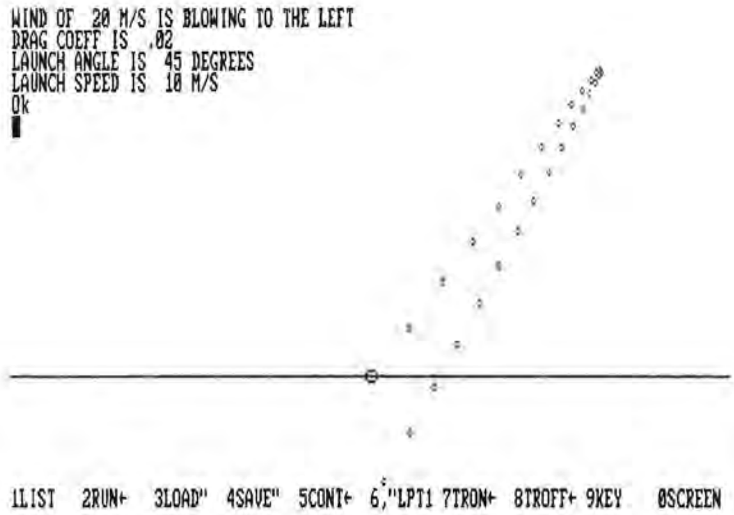
WIND.BAS

by Anton Jopko

I have always been amazed at the force that can be exerted by the invisible wind. With this in mind, I have written a program in BASIC to plot the path of a projectile, such as a ball, travelling through the air. It assumes the only forces acting are gravity and the air resistance, also called drag, which is proportional to the square of the velocity of the ball relative to the air. The wind speed, the launch angle, the launch speed and the drag coefficient must be specified. The computer screen displays a horizontal line near the bottom. At its centre is a small circle, which is the launch point. The program integrates Newton's law of motion in small steps and plots points on the screen in their required positions. If we choose a zero drag coefficient, then the path of the ball is the familiar parabola.

The effects of drag would be easiest to see by leaving all launch parameters fixed but increasing the drag coefficient and rerunning the program. It might also be enjoyable to use the Circle command to plot a small circle somewhere on the screen and try to choose the parameters so that the ball would pass through this circle.

In the figure, with the given parameters, one can see that the ball will nearly return to its launch point. By increasing the launch angle somewhat, the ball could indeed return to its starting point.



Computer screen plot of the path of a ball for selected launch conditions.

```
10    REM WIND.BAS
20    REM  projectile with air drag in a horizontal wind.
30    REM  Motion in a vertical plane only.
40    REM  Runge-kutte (4 th order ) method used to solve Newton's law of
50    REM  motion.
60    REM IF PATH GOES OFF SCREEN, PRESS "CONTROL C" , REVISE SCALE OR
70    REM OTHER VARIABLES AND RUN AGAIN
80    X=0 : Y=0
90    GG = 9.810001
100   REM  TO CHANGE WIND SPEED (IN M/S ) , CHANGE VW ( NEGATIVE VALUE
110   REM  MEANS WIND IS BLOWING TO THE LEFT )
120   VW = -20
130   REM  IF PROJECTILE PATH GOES OFF SCREEN, MAKE SCALE LARGER
140   REM AND RUN AGAIN
150   SCALE = .01
160   T=0
170   PI = 3.14159
180   REM  TO CHANGE LAUNCH ANGLE (IN DEGREES ) , CHANGE THD
190   THD = 45
200   TH=THD*PI/180
210   REM  TO CHANGE LAUNCH SPEED IN M/S , CHANGE VO
220   VO = 10
230   REM TO INCREASE DRAG, MAKE CDM LARGER
240   CDM=.02
250   VX=VO*COS(TH)
260   VY=VO*SIN(TH)
270   H=.05
280   CLS
290   SCREEN 2
300   IF VW < 0 THEN PRINT "WIND OF ";ABS(VW)"M/S IS BLOWING TO THE LEFT"
310   IF VW > 0 THEN PRINT "WIND OF ";VW"M/S IS BLOWING TO THE RIGHT"
320   PRINT"DRAG COEFF IS ";CDM
330   PRINT"LAUNCH ANGLE IS ";THD"DEGREES"
340   PRINT"LAUNCH SPEED IS ";VO"M/S"
350   LINE (0,150)-(639,150)
360   CIRCLE (320,150),5
370   FOR I = 1 TO 100
380   A = VX
390   B=VY
400   GOSUB 720
410   K1=H*F
420   GOSUB 740
430   L1=H*G
440   A=VX+K1/2
450   B=VY+L1/2
460   GOSUB 720
470   K2=H*F
480   GOSUB 740
490   L2=H*G
500   A=VX+K2/2
510   B=VY+L2/2
520   GOSUB 720
530   K3=H*F
540   GOSUB 740
550   L3=H*G
560   A=VX+K3
570   B=VY+L3
580   GOSUB 720
590   K4=H*F
600   GOSUB 740
610   L4=H*G
620   K=(K1+2*K2+2*K3+K4)/6
630   L=(L1+2*L2+2*L3+L4)/6
640   X = X+(2*VX+K)*H/2
650   Y = Y+(2*VY+L)*H/2
660   VX=VX+K
670   VY=VY+L
680   T=T+H
690   IX=INT(X/SCALE) :
          IY=INT(5*Y/(9*SCALE))
700   PSET(320+IX,150-IY)
710   NEXT I
720   F=-CDM*SQR((A-VW)^2+B^2)*(A-VW)
730   RETURN
740   G=-CDM*SQR((A-VW)^2+B^2)*B-GG
750   RETURN
760   END
```

Computer program in BASIC. Note that line 690, which should occupy one line, is offset to fit the page.

Anton Jopko has taught introductory courses in mathematics and physics at McMaster University in Hamilton. Currently he is a weather observer for Environment Canada, and enjoys farming with the help of his family.

SEA BREEZES AND ANABATIC WINDS IN THE MOUNTAINS

by Bill Pike

Smoke streams make excellent "tracers" when it comes to visualising the wind speed and direction. In terms of distance travelled, through study of satellite imagery, examples of "ship trails" and flares from oil/gas rigs have, on occasion, been found to cover 500 km with much less dispersion than had previously been thought possible (Scorer, 1986).

Figure 1 Sunndalsöra aluminium works, Norway, at about 1650 LT, 31 May 1972. There is an abrupt change of direction while the smoke enters Sunndalen. Photograph by the author.

More frequently, however, and particularly over the rougher land surface, smoke streams are dispersed by low-level turbulence, convection currents, etc., but not before indicating some interesting features of the wind motion. Figure 1 shows mostly clear skies when the author first noticed an apparent sea breeze turning abruptly at right angles into a side valley (Sunndalen in Figure 2) through the Norwegian mountains during a spring afternoon in 1972. The smoke stream rises over sunlit ground (subject to convection), then sinks over the shadowy north-facing slopes of Little Kalkjin and Kalfonna in cooler descending currents, before rising again and dispersing in the sunshine while it progresses east-southeastwards along the valley.

Pedgley (1974, p. 295) has, on several occasions, stationed observers around Cwm Idwal in Snowdonia to measure the wind around a semi-sheltered, upland lake while the surface currents eddy into this side valley, particularly in an easterly airflow situation. These winds were found to be quite intermittent in cloudy conditions (p. 296) and even more gusty on brighter days when convection effects were introduced! In the synoptic case of Sunndalsöra (62°39'N, 08°37'E), Figure 3 shows that surface winds on the N.W. Norwegian coast were generally northeasterly, moderate to fresh, and blowing at right angles to the mouth of Sunndalsfjord at 1500 UTC (1600 LT). A mature depression was then situated some 150 km to the south, and slowly filling while it drifted eastwards. The cirrus in Figure 1 is associated with an old occlusion lying well to the southeast over the Baltic and into Finland. Some mountain cumulus has also formed and is drifting northwestwards.

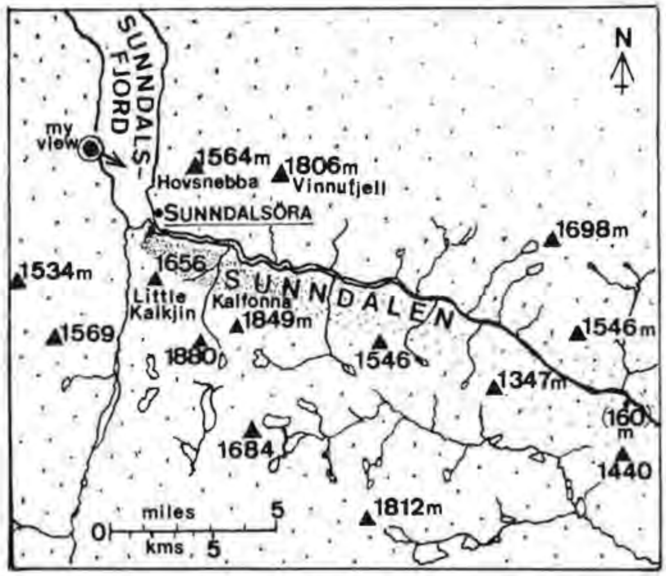


Figure 2 Sketch map baseed on "Cappelen Turistkart", scale 1:325,000 to show the altitudes of prominent mountains along Sunndalen, mid-western Norway.

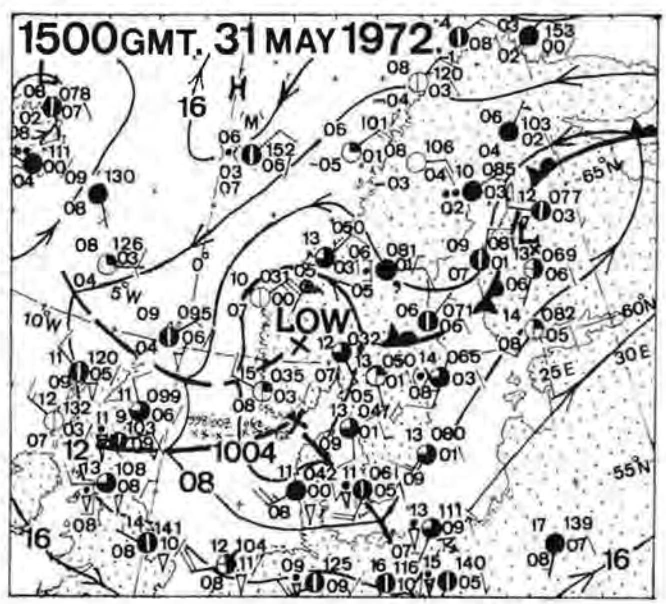


Figure 3 Surface synoptic chart based on the UK Meteorological Office Bracknell analysis for 1500 UTC (1600 LT in Norway) on 31 May 1972. Position of the Sunndalsöra observation is indicated by the roundel, ◉.

However, Sunndalsfjord is fully 60 km long (i.e., Sunndalsöra is forty miles from the open sea to the northwest) so that, at 1650 LT, the smoke stream was most likely flowing as a "valley counter wind" (i.e., against the theoretical easterly to southeasterly geostrophic wind), under the influence of a local sea breeze (the fjord surface temperature being still

Figure 4 Woodfibre pulp and paper works, B.C., Canada. Photograph by the author from atop the Stawamus Chief, alt. 651 m., showing an anabatic wind dispersing emissions inland to a height above the viewpoint, probably aided by sea breezes; 1640 PST, 27 July 1980 (a Sunday).

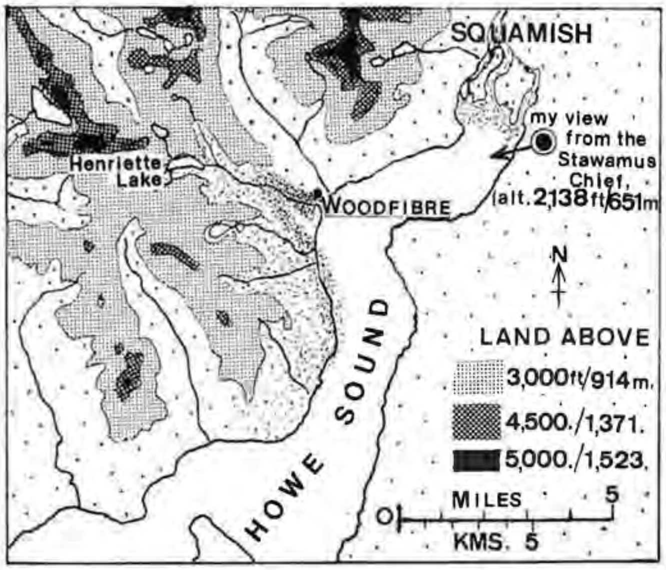


Figure 5 Topographic sketch map of the B.C. mountains photographed in Figure 4, with an indication of the dispersal path of the Woodfibre plume (based on a Dept. of Mines and Technical Surveys, 1st Edition (1959), 1:250,000 map of the Canadian "National Topographic System").

quite cold in late May), which then combines with an anabatic effect and probably some convection in moving along Sunndalen.

Figure 4 shows another late-afternoon situation, but this time in "high summer" while a more-pronounced smoke stream emanates from Woodfibre pulp and paper mill on the B.C. coast of Canada. Figure 5 shows the approximate plume location in relation to the backdrop of mountains. Figure 6 shows a synoptic situation of almost cloudless skies and subsidence caused by a massive ridge of high pressure from

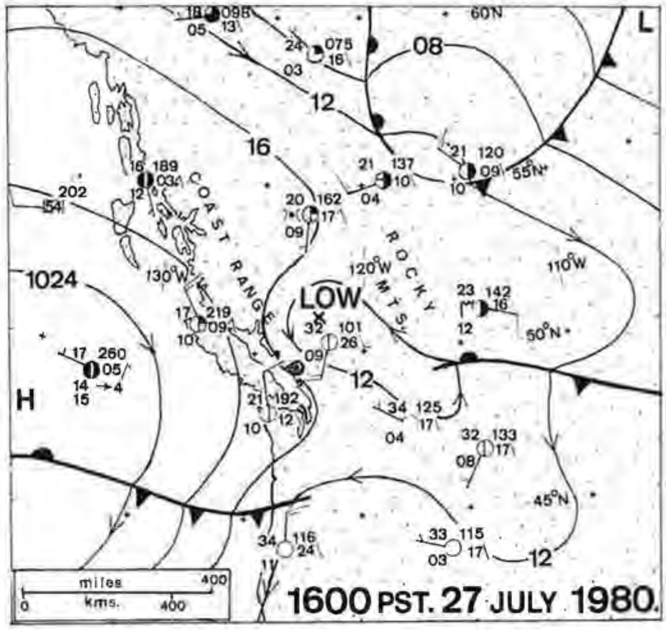


Figure 6 Surface synoptic chart based on the UK Meteorological Office Bracknell circumpolar analysis for 0000 UTC on 28 July 1980 (LT + 8 hours). Position of the Woodfibre observation is marked by a roundel, ◉.

the Pacific anticyclone. For several successive days, the sunshine encouraged an intermontane thermal depression (or "heat low") to form over south central British Columbia, with Woodfibre in a pronounced northwesterly pressure gradient between these two systems during the late afternoon on 27 July 1980.

Figure 4 gives clearer evidence of the presence of a definite anabatic wind than Figure 1 did. The Woodfibre plume firstly moves inland for a short distance with the sea breeze, then down Howe Sound with the gradient wind (to the left in the picture) but appears almost from the outset to be subject to ascending, upslope warm air currents that take the plume inland over Henriette Lake. This suggests that the sea breeze and anabatic wind have combined to force the smoke upwards beyond 1000-m altitude.

REFERENCES

Pedgley, D.E., 1974: Field Studies of Mountain Weather in Snowdonia. *Weather*, Vol. 29, pp. 284–297.

Scorer, R.S., 1986: *Cloud Investigation by Satellite*. Ellis Horwood, Chichester, England, 320 pp.

Bill Pike was an operational meteorologist (1966–72) with the UK Meteorological Office in England. He is now working "self-employed" as a free-lance meteorological writer and consultant, with special interest in mesoscale events and aviation weather. He is also a qualified artist with an MFA from the University of British Columbia and has been commissioned to paint "Public Art" for several hospitals. He is a fellow of the Royal Meteorological Society.

RÉSUMÉ *On peut suivre facilement les vents à basse altitude à l'aide des panaches de fumée, souvent sur plusieurs kilomètres, même au-dessus de terrains rugueux où la turbulence et la convection ont tendance à dissiper la fumée. On présente deux exemples utilisant des panaches de fumée industrielle comme traceurs de l'écoulement vers le haut (anabatique) de vents côtiers (brise de mer) qui soufflent dans la vallée d'un cours d'eau : l'un durant le printemps (brise de mer) dans les montagnes du nord-ouest de la Norvège et l'autre, durant l'été dans les montagnes de la Colombie-Britannique.*

FOGGY, CLOUDY AND DRIZZLY DAYS

Weather Map Series, April 5 and 6, 1989

by Hans VanLeeuwen

This issue's map series shows most of the Atlantic Provinces, the New England area, Quebec and part of eastern Ontario. The map area includes a fair amount of the ocean off the Atlantic coast, with some ship reports. Map 1 notes conditions on April 5 at 2 a.m. AST (0600 UTC), maps 2 and 3, six and twelve hours later, respectively, and map 4, the situation the following morning, April 6 at 8 a.m. AST.

The previous week, on the Easter weekend (see the *Chinook* Weather Map Series in the Vol. 11, No. 2 issue), a rather severe early-spring storm had moved through the area. Most of the Atlantic Provinces received significant amounts of snow and freezing rain from that system. On the two days of this series we note a steady air circulation from the Atlantic Ocean – what can be described as a southerly flow of warm and moist air. It is thus worth while in this situation to pick up a sharp, red pencil and carefully analyse the surface temperatures, say, every 2 or 4 °C.

A next step might be to try your hand at drawing streamlines, indicating the general direction of the air flow. Remember, we drew those in one of our previous series (See *Chinook* Vol. 11, No. 2). Note also the strength of the wind speeds. And talking about wind speeds, how would you evaluate the wind report on April 5 at 8 a.m., as reported by the ship just east of Long Island, New York, which shows a southeasterly wind at 90 knots. Looking at the data around that location, would you accept that information, or would you consider the wind speed to be in error, maybe a transmission or coding error? These are the dilemmas that weather forecasters often face. Decisions regarding the reasonableness of the data are an important part of their daily routine.

Another interesting point about these four maps is the moisture of the air, as indicated by the dew points. Dew points are excellent indicators of how much water vapour is actually in the air, measured in terms of x grams of water vapour per 1,000 grams of dry air. An example would be the "temperature" information on April 5 at 8 a.m., for the ship WVFQ (near 38°N, 69°W). The air temperature is reported as 19°C, the dew point 18°C, and the sea temperature 22°C. The difference between the temperature and the dew point is only 1°C, which means that the air is very close to saturation. (Note: The actual air temperature indicates the maximum capacity of the air to hold moisture.) In other words, the relative humidity would be very high, most likely in the high 90% range. You will also notice that the air temperature is slightly cooler than the sea temperature, which is not true at the ship to the southeast (PJYG).

The particular weather patterns for April 5 and 6 show how warm and moist air gradually gets cooled – during its motion northward – by contact with the gradually decreasing colder ocean temperatures, particularly while the air moves over and north of the Gulf Stream. Forced lifting of the air over the land (expansion cooling), some vertical mixing, passage over snow surfaces, or perhaps in certain locations some radiational cooling under partially clear skies at night, have resulted in rather extensive fog along the southern parts of the Atlantic Provinces, including the offshore coastal waters in the Bay of Fundy, the Gulf of Maine waters, and the waters around Newfoundland.

A final, but essential activity, is the isobaric analysis. Again I would suggest you start with one isobar, say the 1,016-mb (101.6-kPa) isobar and work upward and downward at 2-mb (0.2-kPa) intervals. This is not a very clear pressure pattern, but it indicates the general flow pattern. Also see if you can find some significant temperature gradients, or fronts on these days.

Those who are attempting this for the first time, and would like the decoding information, please consult a previous issue of *Chinook* (Vol. 8, No. 2), or mail a stamped, self-addressed envelope to the CMOS office in Ottawa: Attention: Editor, *Chinook* (Weather Map Series: Vol. 11, No. 4). Let us know how you succeeded.

LETTERS

Suggestions for Articles

With regard to your editorial in the fall 1988 issue of *Chinook*, yes we are reading it. There are interesting and informative articles in each issue but I would like to suggest some changes to make it more appealing to a greater variety of readers who nonetheless share a common interest in weather and oceans.

Firstly, I would like to see a computing department in *Chinook* that would treat some aspect of weather on a computer. Most younger people now have ready access to personal computers and such an application would be very enjoyable. With this in mind, I am enclosing a program written in BASIC with this letter that will allow the user to investigate the effects of gravity, wind, and air drag on the motion of a projectile. If you wish to publish this in *Chinook*, you are very welcome.

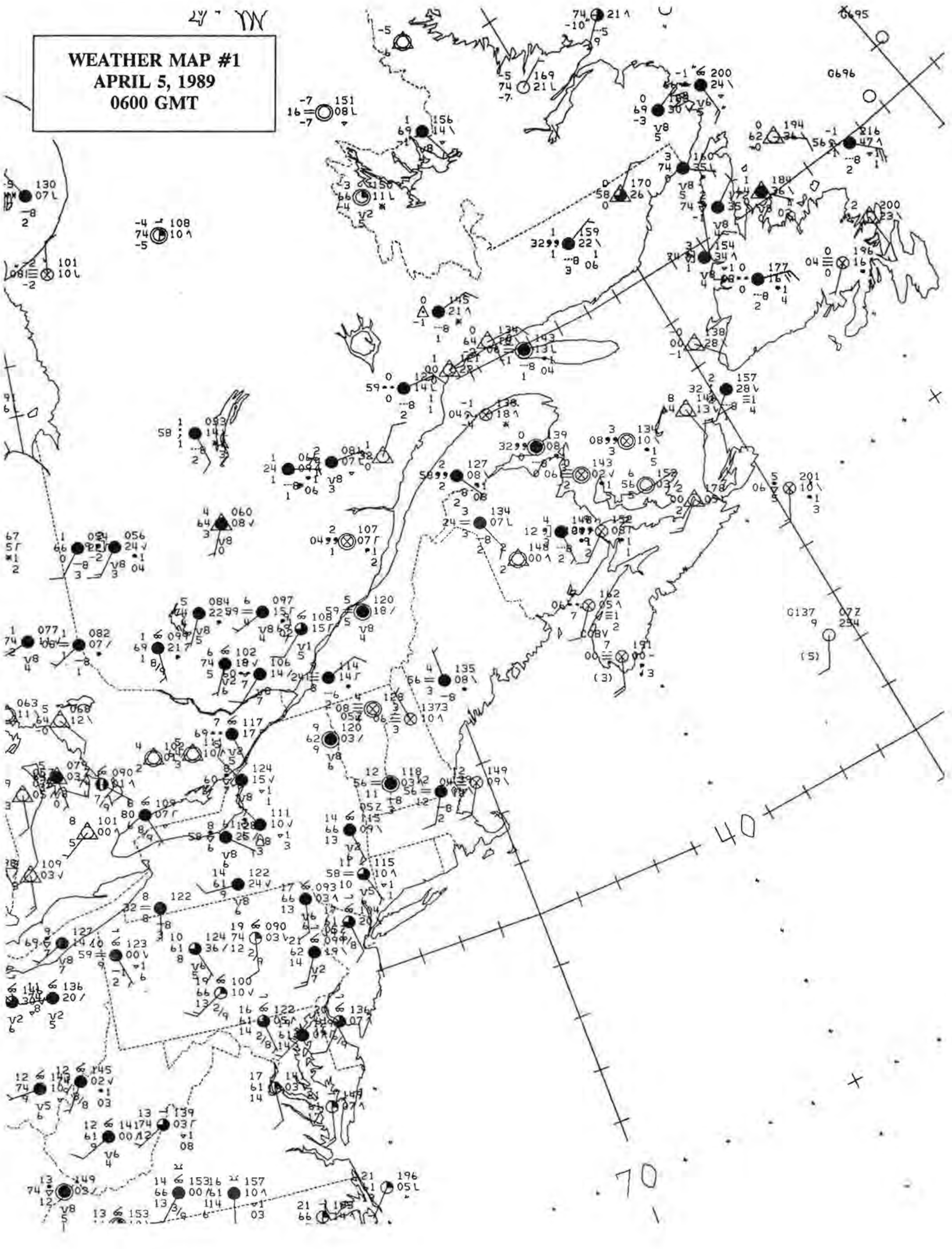
Secondly, it would be nice to see articles on making home-made weather-related instruments for the hobbyist. I recall many years ago an article in *Scientific American* about suspending a ping-pong ball on a thin thread and using it to measure wind speed by noting its deflection in degrees from the vertical.

Thirdly, short-wave radio enthusiasts are able to receive their own weather satellite photos with the appropriate equipment. An article on this would be very interesting. In fact, the Ontario DX Association has people who could very easily write such an article. If you wish, I could give you a couple of names to contact.

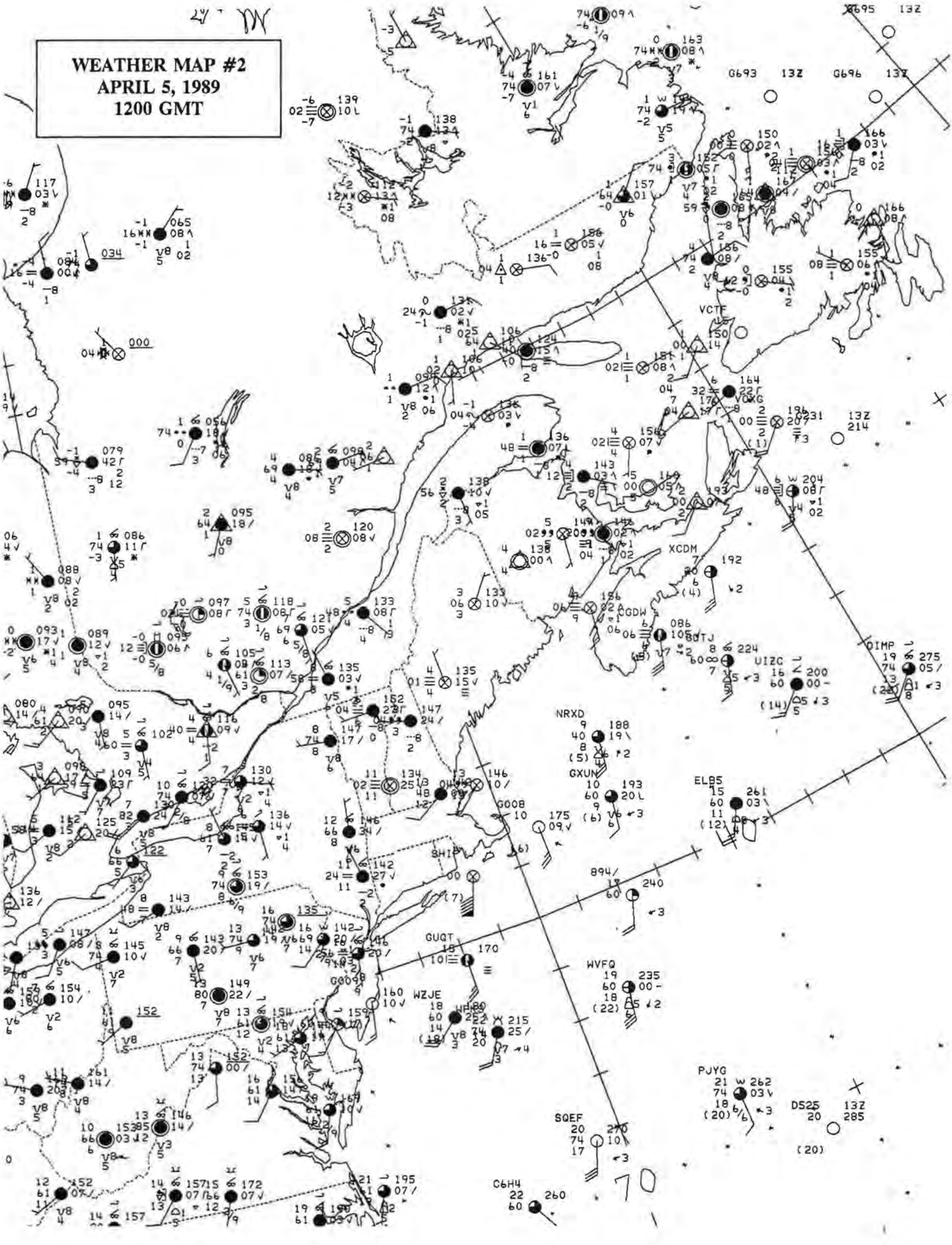
Fourthly, in the June issue of *Popular Communications* there was an article on ways to receive continuous weather forecasts via short-wave radio and portable scanners. This was devoted to the National Weather Service in the United States. A similar article devoted to Canadian weather forecasts would be most welcome. For example, why are the Environment Canada weather broadcasts from the CN Tower in Toronto only available at 162 MHz when these

Continued on page 95

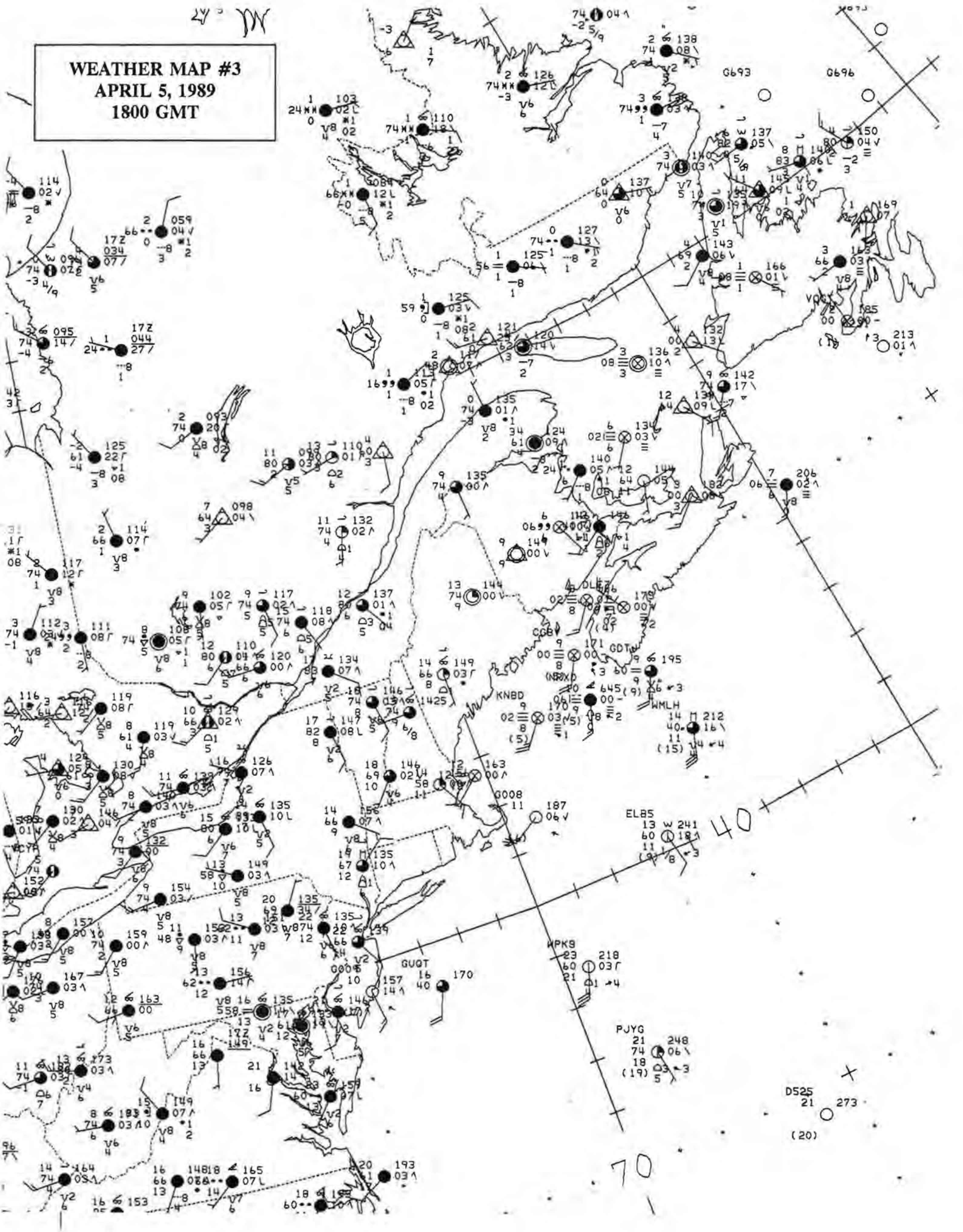
WEATHER MAP #1
APRIL 5, 1989
0600 GMT



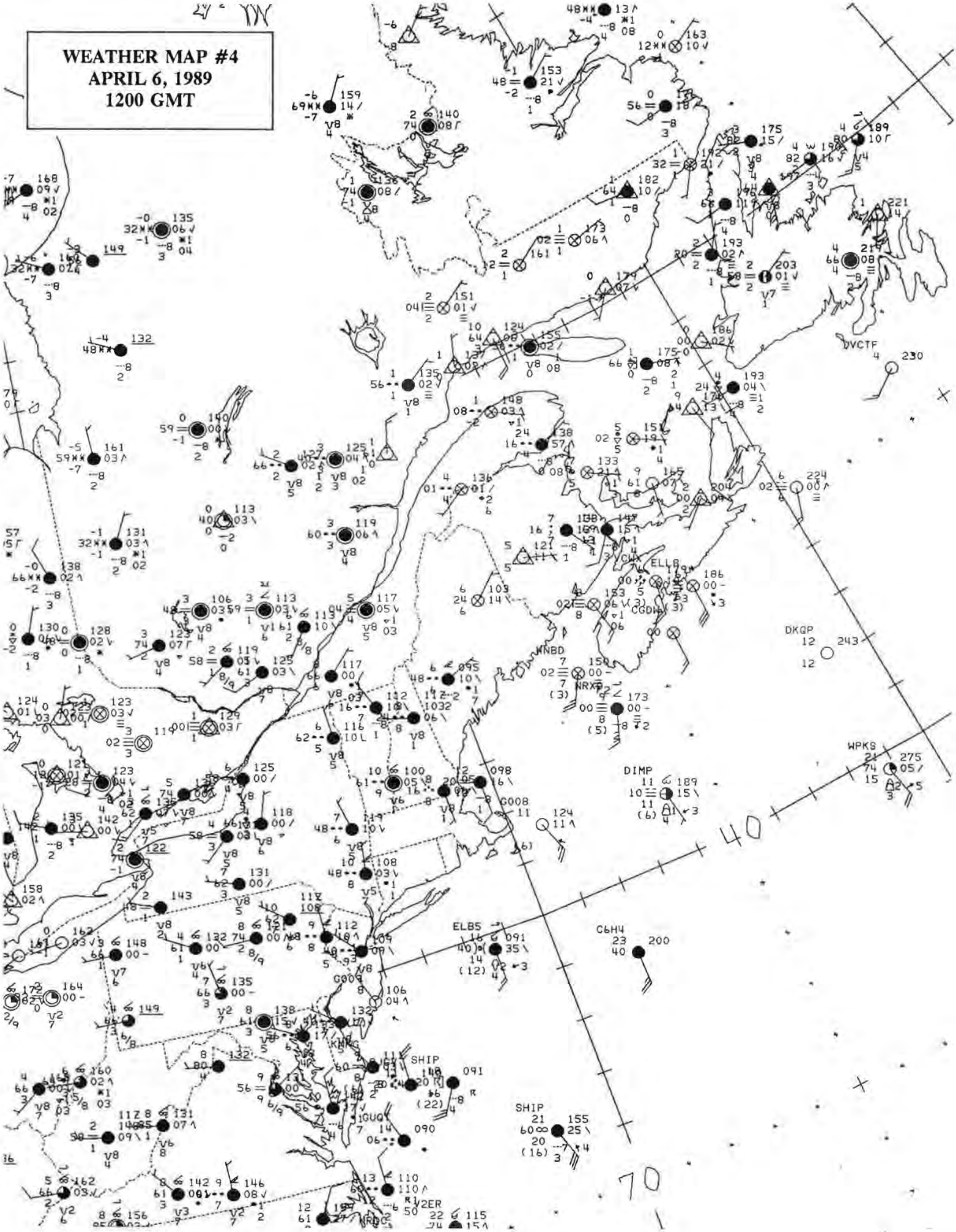
WEATHER MAP #2
APRIL 5, 1989
1200 GMT



WEATHER MAP #3
APRIL 5, 1989
1800 GMT



WEATHER MAP #4
APRIL 6, 1989
1200 GMT



ONE HUNDRED AND FIFTY YEARS AGO: FOUNDING THE TORONTO OBSERVATORY

by Morley Thomas

One hundred and fifty years ago a Magnetic and Meteorological Observatory was established in Toronto by the British Imperial Government. In the fall of 1839, officers and soldiers of the Royal Artillery arrived in Toronto to set up and staff the observatory and, during the winter of 1839–40, preliminary and partial observations were taken at the Bathurst Street Barracks. Early in September 1840 the instruments were moved to a permanent observatory on the grounds of King's College, then on the northwest outskirts of Toronto. Thus began a program of government-supported weather observing that was to spread throughout Canada in the decades to follow and lead to the formation of today's Atmospheric Environment Service. Also, with the new Observatory on College grounds, a relationship began between government science and the College that still exists. Today, the Atmospheric Environment Service, with its national headquarters in suburban Downsview, is the direct descendant of the original Toronto Observatory. King's College was the original college on which the University of Toronto was founded.

THE QUEST FOR MAGNETIC OBSERVATIONS

The Toronto Observatory was established as a result of the desire of British and European scientists in the 1820s and the 1830s to obtain a knowledge of the elementary facts of the natural magnetism of the earth and its atmosphere. Earlier, Baron Alexander von Humboldt and other European philosopher-scientists had travelled to remote areas to observe the direction and intensity of the earth's magnetic forces. Von Humboldt was particularly influential in the physical sciences of his time, and by the 1830s he and others realized that for a proper understanding of magnetic theory, data were required from "fixed" observatories as well as from expeditions to various parts of the globe. Such data would allow knowledge to be gained about the secular changes from year to year and the periodic variations of the magnetic forces. Fortunately for the science of meteorology, it was then commonly believed that meteorology was closely connected with terrestrial magnetism, and therefore simultaneous meteorological observations would also be required in order to study their interrelationships properly.

Major General Charles J.B. Riddell (1817–1903) founding director of the Toronto Observatory.

By 1836 the governments of several European countries had established fixed observatories. That year, von Humboldt wrote to the Duke of Sussex, then President of the Royal Society, to point out that, with possessions in all parts of the globe, the United Kingdom should consider contributing to magnetic science by setting up observatories at several locations where observations were particulary needed. Von Humboldt's challenge was undoubtedly orchestrated by Edward Sabine, a Royal Artillery officer who had become intensely interested in magnetism and who was to become the Dean of British physical scientists for decades.

Besides Sabine, another British scientist active in magnetic research was Professor Humphrey Lloyd, who had established an observatory for magnetic and meteorological observations at Trinity College, Dublin. Sabine and Lloyd had conducted the first magnetic survey of the British Isles and had visited von Humboldt in Berlin to discuss the value of fixed magnetic observatories at various locations in the British Empire. When von Humboldt's letter to Sussex did not spark an appeal to government from the Royal Society, the British Association for the Advancement of Science submitted a petition to Her Majesty's Government requesting that the observatories be established. Support for the proposal was then given by the Royal Society and soon the Government accepted responsibility for several "fixed" observatories.

THE COLONIAL OBSERVATORY PROGRAM

The resulting program called for magnetic and meteorological observations at four locations. Observatories were planned for each of Canada and Tasmania (Australia) since these were the areas where the magnetic forces were considered to be the most intense in the Northern and Southern hemispheres. The island of St. Helena and the Cape of Good Hope were the other locations selected. In the original planning, the observatories were to exist for three years, but Sabine and others who set up the program were careful not to mention their proposed limited life span with the hope, perhaps, that the period would be extended once the observatories were in place.

The Government decided to place three of the observatories, including the one in Canada, under the supervision of the Master-General of the Ordnance department. The Board of Ordnance controlled several corps, and since the Royal Engineers were then involved in carrying out the trigonometrical survey of Britain, the Master-General ruled that the magnetic observatories should be manned by the officers and soldiers of the Royal Artillery. Lieutenant Charles James Buchanan Riddell was chosen to be the officer-in-charge of the Canadian observatory. Riddell then selected for his staff Corporal James Johnston, Bombardier James Walker and Acting Bombardier Thomas Menzies as observers, and Gunners George Watson and Joseph Graham as orderly and servant, respectively. Because of the scientific nature of their work and the necessity of regular attendance at the Observatory, an allowance was to be added to the pay of each and, in an emergency, all were to be subject to ordinary military service.

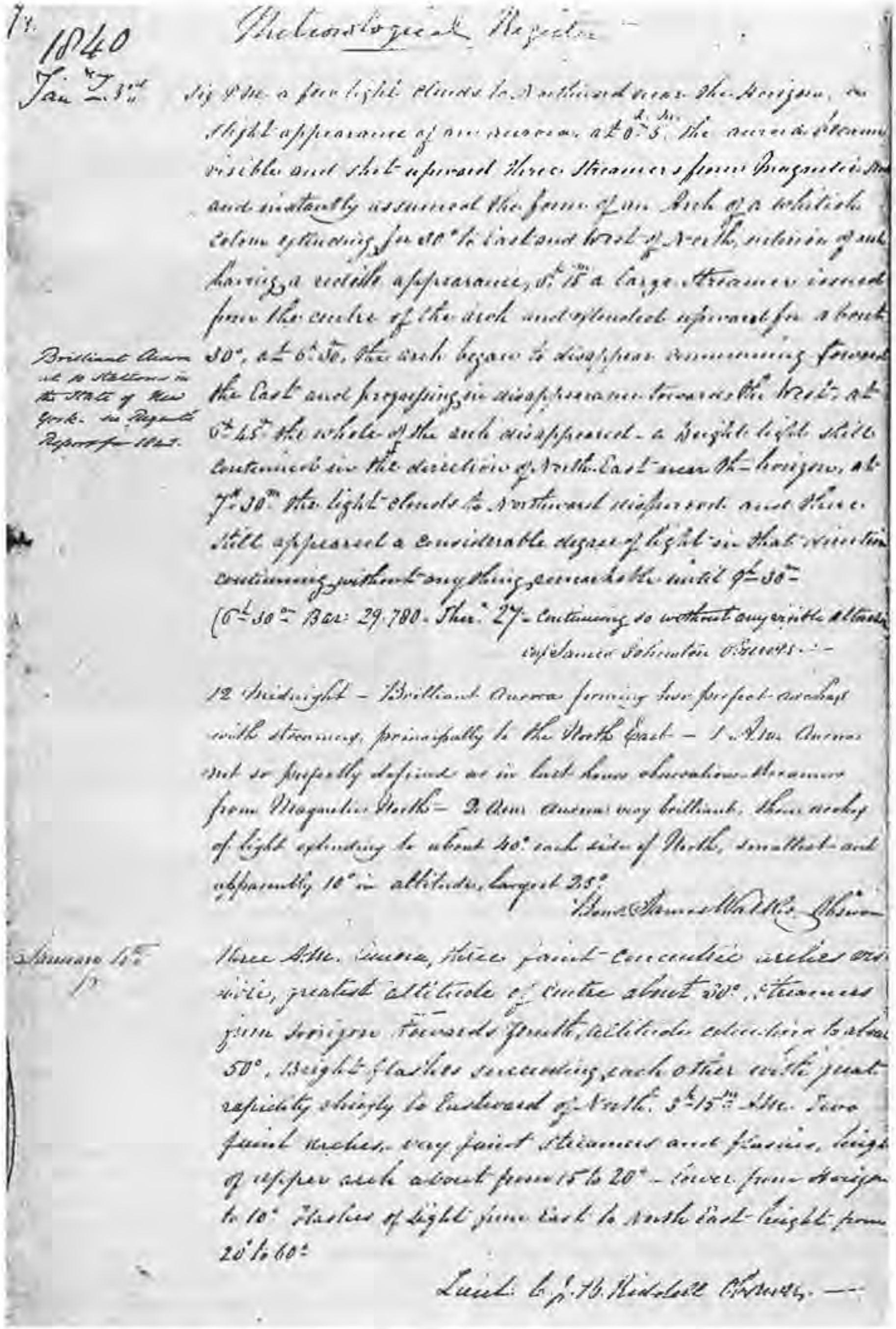
After acceptance of the observatory proposal by the British Government, the Royal Society appointed a committee to draw up instructions regarding the methods of observation and the care and use of the instruments. The instructions for the fixed observatories were largely prepared by Professor Lloyd and were based on his work at Dublin and in the earlier British magnetic survey. The designated officers-in-charge, including Riddell, were sent to the Dublin Observatory for personal instruction by Professor Lloyd. By the early autumn of 1839 the parties were ready to leave England.

Humphrey Lloyd and Edward Sabine were the scientists largely responsible for the British observatory program under which the Toronto Observatory was established. Lloyd was born in Ireland and after graduation from Trinity College became the professor of natural and experimental philosophy at that institution. In addition to his work in magnetism, optics and light he became an administrator at Trinity College and served a term as President of the British Association. Sabine, also born in Ireland, was educated at the Woolwich Royal Military Academy and was commissioned in the British Army in 1804. After the Napoleonic Wars he became interested in astronomy and magnetism and when the colonial observatory program was launched he became its Superintendent. His influence in Government science over the next few decades was considerable and he served as President of the Royal Society for a decade in the 1860s. Lieutenant Riddell, also a product of the Royal Military Academy, served in Canada and Jamaica before being chosen to establish and superintend the observatory in Canada.

SELECTING AN OBSERVATORY SITE

Early in the autumn of 1839, Riddell travelled by fast ship to New York and subsequently arrived in Montréal on September 28. Since the British Army's Canadian headquarters were in that city it was assumed that the observatory would be located there. Riddell's detachment, including the wives and five children of the Gunners, travelled on a slower ship with eight to ten tons of observatory instruments and equipment and arrived in Quebec City on November 1. Before their arrival, Riddell began to negotiate with the Army in Montréal regarding a site, and the construction of the observatory and quarters for himself and his detachment.

Finding that the only Ordnance property in Montréal suitable for an observatory was on St. Helen's Island, Riddell agreed to a site there and requested



Notes recorded in the Meteorological Register on January 3 and 4, 1840 at the temporary observatory.

that a log observatory be constructed at once. However, before this could take place, Riddell was advised by Captain W.H. Bayfield of the Royal Navy, who was conducting naval surveying nearby, that St. Helen's Island, or indeed any location along the St. Lawrence River, would not be suitable for a magnetic observatory because of the magnetic qualities of the underlying rock. Further, Bayfield suggested that Toronto must be free of such influences.

Lieutenant Riddell obtained permission to proceed to Toronto and arrived there on October 24. Because of the lateness of the season, there was no time to build a proper observatory and therefore he was forced to seek quarters for the winter in the Bathurst Street Barracks (now known as Old Fort York). Meanwhile, his observatory detachment proceeded from Quebec City to Toronto arriving on November 24 with forty or more cases of instruments and equip-

OBSERVATORY at Toronto Upper Canada Wednes day, the 21 of October 1840

ABSTRACT of Term-day Observations

Gött. Mean Time.	BAROMETER. Height.	BAROMETER. Temp.	THERMOM. Dry.	THERMOM. Wet.	Wind (~~ELECTROM.~~) Direction	Wind Description	State of the WEATHER.
10 P.M.	29.556	53.0	43.2	42.1	N.N.E.	Light	Raining since 7 P.M. Gott
11.	29.561	52.5	42.3	41.5	N.N.E.	Mod.	Raining without intermission
Midn.	29.570	53.0	41.6	40.8	N.N.E.	Mod.	Raining Do — Do —
1 A.M.	29.572	52.5	41.6	40.5	N.N.E.	Mod.	Raining Do — Do —
2.	29.575	53.0	41.5	40.0	N.N.E.	Mod.	Raining Do Do —
3 A.M.	29.578	53.0	41.0	39.7	N.	Mod.	Gusty, Drizzling Rain
Means.	29.568	52.8	41.9	40.8			Dew Point 39° at 2 AM. Gott
4 A.M.	29.582	53.0	40.5	39.2	N.	—	Totally overcast, Raining Slightly
5.	29.616	52.5	39.9	38.4	—	—	Heavy clouds & dense haze round hor. partially clear
6.	29.634	52.5	40.5	40.1	N.N.E.	Mod.	Partially clouded, dense haze & heavy clouds round horizon particularly in S.
7.	29.668	52.0	40.3	38.5	N.	Light	Almost entirely clouded with [illegible]
8.	29.682	52.0	39.7	37.6	N.	Nearly Calm	Clear to W. in Z. remainder clouded.
9 A.M.	29.700	52.0	37.2	35.8	Calm	—	Clear and unclouded.
Means.	29.665	52.3	39.7	38.3			Dew Point 34° at 8 AM.
10 A.M.	29.716	51.5	35.4	34.4	Calm	—	Clear and unclouded.
11.	29.716	51.0	34.8	33.8	Calm	—	Clear and unclouded.
Noon.	29.731	51.0	33.8	32.9	N.	Nearly Calm	Clear and unclouded
1 P.M.	29.741	51.0	35.1	34.4	Calm	—	Clear
2.	29.747	51.0	38.2	37.1	Calm	—	A few light [illegible] clear
3 P.M.	29.750	51.5	42.4	40.7	Calm	—	A few light [illegible] in Zenith.
Means.	29.735	51.2	36.6	35.5			Dew Point 36° at 2 P.M.
4 P.M.	29.736	52.0	44.4	42.9	Calm	—	A few light [illegible] in Zenith [illegible]
5.	29.736	52.5	45.8	44.3	S. by W.	Light	[illegible]
6.	29.712	53.0	49.3	47.1	S. by W.	Light	[illegible] remainder clear.
7.	29.652	54.0	49.4	46.5	S.W.	Mod.	with brisk gusts, partially clouded [illegible]
8.	29.626	54.0	51.6	46.7	S.W.	Light	[illegible] overcast with [illegible]
9 P.M.	29.634	54.0	51.2	47.1	S.W.	Light	with fresh gusts, overcast with [illegible]
10	551						Dew Point 42° at 8 P.M.
Means.	29.646	53.2	48.4	45.8			Max 49.8 — Min 33.4; Sun R 70.2 — Ter R. 25.2; Running Water at 8 AM 37.0 — 22 [illegible]

Observations recorded in the Observatory Abstract Book for October 21, 1840.

ment. An unused barracks building was assigned to Riddell, some repairs and renovations were made and an anemometer was set up on its roof. Some difficulties occurred but were soon cleared up and a preliminary magnetic and meteorological observing program was commenced at the close of 1839.

The establishment of an observatory in Canada was a complex matter for Riddell. For the observatory work he reported to the Master-General of Ordnance through the Deputy Adjutant General of the Royal Artillery. However, the real authority was Colonel Sabine, the Superintendent of Colonial Observatories. As an Artillery officer, Riddell was directly under the authority of the Toronto district board of Ordnance known as the Respective Officers. For land and buildings he had to look to the local Commanding Engineer and for supplies to the local Commissariat office. In addition, he had to deal with the local Commanding Royal Artillery officer as well as with the officer responsible for the local Toronto garrison. Perhaps most important, authority was required for many things from both the Military and Civil Secretaries to His Excellency the Commander of the Forces and Governor General, Sir John Colborne. It must be observed that this complex administrative web involved only representatives of the Imperial Government. The inhabitants of Canada, their parliamentarians and their bureaucrats had nothing to do whatsoever with the founding of the Observatory, nor with its program. Nor, of course, was the colonial government of Upper Canada, and after 1841 of the United Province of Canada, expected to pay anything towards the maintenance of the Observatory and its staff.

THE OBSERVING PROGRAM

By the close of 1839 the instruments had been installed in their temporary locations and it appears that regular meteorological observations were commenced on New Year's Day 1840. Entries in the station register start on that day and later, in May, "returns" or report forms for the first four months of 1840 were sent to England. Some "practice" observations were doubtlessly taken earlier; legend has it that the very first ones were taken on Christmas Eve, 1839.

Observations of barometric pressure and wet- and dry-bulb temperatures were taken every two hours, except from Saturday noon until Sunday noon each week. The relative humidity and vapour pressure were calculated for each observation. More complete observations, in which wind, weather and associated phenomena were also recorded, were taken at 2 and 8 a.m. and 2 and 8 p.m., except for the twenty-four hour gap over the weekend. Values of daily maximum and minimum temperatures, of solar and terrestrial radiation and of rainfall were recorded each day at 8 a.m. The wet- and dry-bulb and the maximum and minimum thermometers were exposed on a north wall; the solar and terrestrial radiation thermometers were freely exposed to the sun and sky according to the instructions. It must be noted that, because of the temporary location for the first several months, the recorded data for 1840 were not used in most Toronto statistics subsequently prepared at the Observatory or in England.

It was more difficult to get the magnetic instruments in working order: it was February 1, 1840 before the regular observations were commenced. Later,

The second Toronto Observatory compound at King's College, as painted by William Armstrong in 1852. On the left is Lieutenant Lefroy's house. Meteorological instruments are mounted atop the observatory. The transit room is located just behind the fence.

Sabine wrote that some instruments were found to be inadequate and that some methods of observation proved to be unsuitable, so that revisions were required to the instructions that were a subsequently published in 1842. Further, Sabine wrote that the observatory should not be considered as fully effective, and hence the data not the best, until that year.

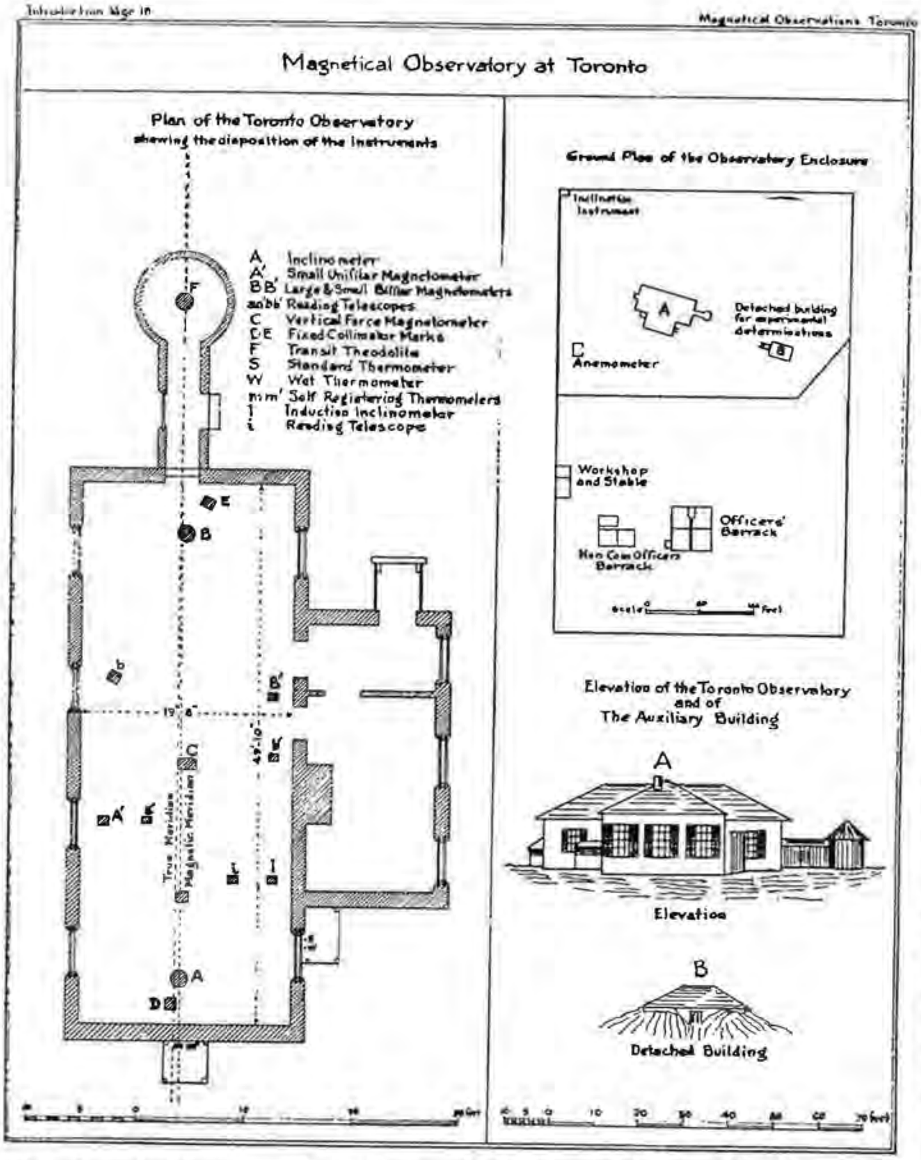
The magnetic observations were quite detailed. Declination, horizontal force and vertical force magnetometers were used to obtain values of the absolute declination, the absolute inclination and the horizontal intensity of the terrestrial magnetic force. An attempt was made to maintain hourly magnetic observations but this was not possible since considerable instrumental difficulties were experienced. Once each month, beginning in March 1840, "term observations" of both magnetism and meteorology were taken over a 24-hour period during which the declination was obtained twelve times each hour and the horizontal and vertical forces six times.

THE KING'S COLLEGE SITE

While getting the observing program started in the temporary location, Lieutenant Riddell was having difficulty in finding a suitable location for the permanent observatory. Because of the expected noise and confusion around the Barracks and the presence of iron in the artillery and musket pieces, Riddell objected to the Army's proposal to place the observatory immediately adjacent to the Barracks. Unfortunately, much of the remainder of the Military Reserve was low and swampy and therefore not suitable. At this point, a local member of the Council of King's College advised Riddell of the possibility of locating the observatory on the large tract of property recently purchased by the College, three kilometres northwest of the Barracks, on higher and relatively dry ground.

On December 19, 1839 Riddell wrote to the Bursar requesting that the President and Council of King's College consider granting about two acres of ground "for the erection of a magnetic and meteorological observatory and buildings for the accommodation of the superintending officer and his assistants, with a right of road way thereto". The matter was discussed at a meeting of Council on December 28 and, three days later, Riddell was advised that his proposal had been accepted. Riddell at once began writing to his superior military and civil officers in the complex web of command to seek authority to proceed. This was obtained in a few months and, under the supervision of the Royal Engineers, the observatory and buildings for the accommodation of Lieutenant Riddell and his staff were under construction during the spring and summer of 1840. These were probably the first buildings to be erected on what was to become the University of Toronto campus. The observatory was completed and ready for occupancy on September 5, 1840, observations were commenced at the new site and the detachment moved in within a few days.

The conditions under which the site was granted are interesting in that they



Plans drawn by Lieutenant Charles W. Younghusband, acting director of the Observatory, after Riddell's departure.

still affect the university-government meteorology relationship in Toronto. After his application was favourably received, Riddell advised his superiors that the President of the College had informed him that "the terms on which the grant will be made are that the ground shall not be appropriated for any other than the purpose of an observatory and in the event of the observatory being discontinued it shall revert to the college". It appears that the specific clause in the Agreement pertaining to the College's claim on the land, if the government cease to use it as an observatory, caused no difficulty to the British officers in Canada nor to the Governor General.

The Agreement gave the Board of Ordnance full power to erect or alter buildings for scientific purposes, but should Her Majesty's representatives use the premises "for any other than the purposes aforesaid" the Agreement would become null and void and the premises revert to the College. Thus began a property arrangement for meteorology between the university and the government that is still in effect today. The log observatory and the stone one that followed in a dozen or so years remained in place for nearly 70 years, a new Meteorological Service Headquarters building was erected at 315 Bloor Street West on university property in 1908–09 and then, in 1969–71, another Meteorological Headquarters building was constructed at 4905 Dufferin Street in suburban Downsview, also on University of Toronto land.

THE PERMANENT OBSERVATORY

The "permanent" log Observatory consisted of a building with "two apartments, a 50 feet by 20 one for the instruments and a 18 feet by 12 one for an office or computing room". The instrument room was bisected by a true north-south magnetic meridian line, then almost coincident with true north, to facilitate the magnetic observations. The walls were constructed of 12-inch logs, rough cast on the outside and plastered on the inside. More than 1200 square feet were enclosed in the building. No iron was used in the construction, the nails were copper and the locks and fasteners were made of brass. The magnetic instruments were mounted on stone pillars and the thermometers were fixed to the north and west walls under louvred sun shades. An anemometer house was built at a distance, as was a small shed for the inclination circle. Later, in 1842, a detached, partially submerged building was erected for experimental determinations and observations of absolute intensity. In addition, residence cottages were built for the officers and men to the west of the main Observatory building.

Before the Observatory was completed the Lords of the Treasury in England became disturbed over the amount of money required for construction and complained to the Board of Ordnance. It was charged that "additional expenses have been incurred and the building rendered of a more permanent nature than was originally intended". Although Riddell prepared considerable documentation in support of his actions, it is very likely that it was Sabine who ultimately satisfied the Treasury officers that the money was being well spent.

THE INSTRUMENTS

The observing program, begun in temporary quarters at the Barracks and described in earlier paragraphs, was transferred to the permanent observatory in September 1840. The Observatory was well equipped with excellent, "state-of-the-art" instruments made by such recognized English instrument makers as Newman and Adie. Two Newman barometers were employed and both had been compared with the standard barometer in the Royal Society's apartments in Somerset House in London before being shipped to Canada. One of these continued to be the standard for the Observatory and the Meteorological Service for well over a century. A standard thermometer made by Newman and a wet-bulb thermometer made by Adie were mounted beneath a roof on a north wall outside the Observatory. Venetian blind shutters were suspended on the other three sides to below the level of the thermometer bulbs. The thermometers, also checked against standards in England, were hung from strips of wood leaving eight to nine inches between them and a double-glazed window through which they could be read. Self-registering maximum and minimum thermometers were suspended under a different roof against a north wall, whereas the solar and terrestrial radiation thermometers were freely exposed to the sun and sky on the ground.

The Newman standard barometer, brought from England in 1839, remained in use for more than a century.

A Daniell's hygrometer was placed in use but was broken in October and not replaced until October 1843. However, the scale did not go low enough to be of value in the measurement of humidity in severely cold weather. An Osler's anemometer, made specially by Newman for the colonial observatories, was placed on a separate small building with the vane and pressure plate mounted thirty feet above the roof, and above the neighbouring small trees. An 1840's standard rain gauge was used but the depth of snowfall was not measured sufficiently accurately for recording and publication until January 1843. In contrast to the meteorological instruments, which usually bore the names of makers, the magnetometers used at the Toronto Observatory do not appear to have carried the names of the manufacturers although most must have been made from designs developed by Christopher Hansteen, Wilhelm Eduard Weber, the eminent Karl Friedrich Gauss, and Humphrey Lloyd.

RIDDELL DEPARTS

Lieutenant Riddell had become ill with dysentery while serving in Jamaica prior to his appointment to the observatory program. The condition became chronic in Toronto and late in 1840 he applied for sick leave in order to return to England for a few months. Fortunately, some months previously, Lieutenant Charles Wright Younghusband had arrived at the Toronto Observatory to work with Riddell in order to qualify himself to undertake, for the Ordnance department and the Royal Society, a magnetic survey of the northwest portion of British North America. A four months' leave of absence was granted to Riddell and he left Toronto on February 17, 1841 for England leaving Younghusband in charge of the Observatory. Riddell's health improved but he never returned to Canada. Instead, he became the Assistant Superintendent of Observatories under Sabine at Woolwich, then returned to his military career serving in both the Crimean War and the Indian Mutiny before retiring to England where he died in 1903. His successor at Toronto was John Henry Lefroy who also conducted the magnetic survey in the North West leaving Younghusband to supervise the work of the Toronto Observatory for several periods in the 1840s.

A LEGACY

Daily weather observations have continued until this day at or near the site of the original permanent Toronto Observatory. In 1853 the government of the Province of Canada took over responsibility for the Observatory and provided resources to the University of Toronto to operate it. Fifteen or so years later, in the late 1860s, the then Director, George Templeman Kingston, began to lobby for a national meteorological service and to encourage amateur enthusiasts to observe the weather. He obtained support from the new Dominion Government to collect climate data and to plan for a system to prepare and issue storm warnings and weather forecasts. Subsequently, the Meteorological Service of Canada was born on July 1, 1871 and, within a few years, a forecasting service was provided to Canadians. The Atmospheric Environment Service of today is a direct legacy from the planners and organizers, Sabine and Lloyd, and from Lieutenant Riddell and his staff of observers who manned the first Toronto Observatory one hundred and fifty years ago.

(This article is condensed from "Founding a Colonial Observatory", a manuscript chapter prepared by the author for the Atmospheric Environment Service's History of Canadian Meteorology Project.)

Editors note: In September 1990 the Atmospheric Environment Service and other organizations will celebrate the 150th Anniversary of Weather Observing, which began, of course, at the Toronto Observatory.

FURTHER READING

Jarrell, R.A., 1988: *The Cold Light of Dawn: A History of Canadian Astronomy*. University of Toronto Press, pp. 29–56. [Chapter Two deals with Government and Astronomy from 1840 to 1905, and in the early decades of this period astronomy was often closely connected with meteorology.]

Thomson, M.M., 1978: *The Beginning of the Long Dash: A History of Timekeeping in Canada*. University of Toronto Press, pp. 3–58. [The first two chapters deal with the origins and integration of time services when the Meteorological Service was responsible for the service in parts of Canada.]

Zeller, S., 1987: *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation*. University of Toronto Press, pp. 115–180. [Part II deals with Terrestrial Magnetism and Meteorology.]

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

RÉSUMÉ *L'observatoire magnétique et météorologique de Toronto fut établi par le Gouvernement britannique il y a 150 ans. Le scientiste européen Alexande von Humboldt fut à l'origine de la demande d'observations du magnétisme terrestre; dans l'Empire britannique, ces observatoires étaient sous la direction d'Edward Sabine, officier de l'armée. L'observatoire permanent de Toronto fut complété et occupé en septembre 1840, sur les terrains du King's College, aujourd'hui l'Université de Toronto. Le lieutenant C.J.B. Riddell, le premier directeur, retourna en Angleterre en congé de maladie au début de 1841. Le programme d'observations se continua et, trente ans plus tard, le Service national canadien de météorologie fut fondé par le directeur de l'époque, le professeur G.T. Kingston.*

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transmissions travel about 40 miles. Everyone does not live within 40 miles of Toronto!

Lastly, more pictures especially in colour would brighten up *Chinook* and give it a more realistic appearance as far as being weather-related is concerned. Perhaps the extra cost is unacceptable.

In conclusion, *Chinook* is very good but there is room for some changes.

Anton Jopko
Waterford, Ontario

P.S. Perhaps weather-related crossword puzzles could be used occasionally too.