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EDITORIAL

ATMOSPHERE - What next?

The editors of ATMOSPHERE could not attend the Congress in May, and so were unable to present in person the annual report. Dr. Munn substituted for us; for this we owe him our thanks.

Following the report, there was discussion concerning the future of ATMOSPHERE as well as questions concerning its past two issues. In answer to these questions, we can only say that we feel that we must make changes slowly. We must acquire experience and knowledge before we can safely commit the Society to the expense of, say, typesetting (- this would cost something between two and three times as much as the total costs of the last issue, including mailing). When we are sure of ourselves, only then shall we make such changes.

From the reports we have had of the discussion, there were two points of view regarding the character ATMOSPHERE should be assuming. One of these points of view was that ATMOSPHERE should not contain anything scientific. The other was diametrically opposed, that ATMOSPHERE should be in competition with the JOURNAL OF APPLIED METEOROLOGY, or the QUARTERLY JOURNAL of the ROYAL METEOROLOGICAL SOCIETY. We feel that both of these are unrealistic in our present circumstances.

To begin with, we can see no valid reason for the first of these ideas. If any of its proponents would care to write an article in its support, we would be pleased to print it as a guest editorial - equal space, if you will. Then, if the matter ever came to a nationwide vote, that information would be available to the members.

The other concept of ATMOSPHERE, that of a professional journal, is one that we are far from being able to afford. This seems to us to be a long-term goal of merit, but something that will take many years to properly achieve.

Our reasoning is this. A conservative estimate of the costs of a first-rate scientific journal is \$50.00 per page (this is 15% less than it costs to publish J.A.M. or J.A.S.). On the basis of 300 pages a year, and a membership of 375, this would mean that ATMOSPHERE alone would cost

$40.00 per year. If the C.M.S. fees were, say, $40.00 a year - advertising could perhaps pay for the rest of the costs of the Society - would we have 375 members? We don't think so.

On the other hand, we can build up our membership over a period of time. We can become better known internationally. Already we have had the occasional request for membership from outside Canada. Once we become well established internationally, and our membership increases, then the financial side of the picture becomes more realistic. At the same time it becomes more reasonable for a member to submit his paper to ATMOSPHERE, instead of one of the other internationally circulated journals.

We feel that our present path is the proper one. General articles, survey articles, news of the Society - these are things that fit in with our concept of what we can be at this point in time. We would be very interested in hearing from those of the membership who have any thoughts on any of the points of view noted above.

THE WEATHER THAT WAS – 1966

By M. K. Thomas

People sometimes call the Weather Office to ask for Canada's average annual precipitation. The innocent public has made this request for a single value many times and will doubtless continue to make it, although anyone who has ever thought about our various climates will realize that such a figure, even if available, would be meaningless. However, when we attempt to summarize the year's weather over a country of Canada's size, we wish that such a simplification were both practical and available.

With hourly and synoptic observations available from over 200 stations, and daily temperature and precipitation observations recorded at nearly 2,400 stations, the number of weather facts accumulated each year is exceedingly large, probably numbering well into the millions. Thus, in attempting to pick out the nation's weather features for any one year, we are forced to rely on summaries and summaries of summaries, even summaries of summaries of summaries. And having selected certain features of the weather for description, we must return then to the original documents for sufficient detail to properly describe the phenomena. These weather details - the actual hourly, synoptic and daily observations are important and anyone using Canadian weather data is dependent upon the faithful and accurate reporting of the hundreds of co-operative and professional weather observers.

In general, the weather in the year 1966 was very much like that of any other year in Canada. There were low and high temperatures, floods, and droughts, and each of you who reads this article will have his own highlights and features to remember, usually because the weather events were associated with events of personal importance. So, in many ways, the selecting of weather features <u>is</u> a personal thing, and after reading this review, many an amateur or professional weatherman will wonder why other and, to him, more important features were not included, or substituted for some of those described in this article.

Reducing the year's climatic data to the ultimate, it can be said that most of Canada experienced below normal temperatures during 1966. These negative anomalies exceeded 3° in southern Manitoba, the District of Mackenzie, and the Yukon Territory. Temperatures in most of British

Columbia, the rest of the Prairies and southern Ontario and Quebec, averaged about one degree below normal. Temperatures in the Maritime Provinces were near normal, but there was a positive anomaly of two to three degrees in northern Quebec, Labrador and the eastern Arctic, the only region of Canada where the year's temperatures averaged above normal.

There was also a well defined pattern in the departure from normal of the distribution of precipitation over the country. Totals were as much as 8 inches above normal on the west coast, and one to two inches above in the western sub-Arctic and Arctic. In a broad arc from Newfoundland through central Quebec to the upper Great Lakes in Ontario, there were excesses of between 5 and 10 inches. On the other hand, precipitation was below normal in that wide corridor of the country from the Prairie Provinces northeastward to Baffin Island. In southeastern Canada the drought continued with deficiencies of one to two inches in southern Ontario, but in Nova Scotia both the years 1965 and 1966 have had less precipitation than any other years in the past century - the deficiency at Halifax amounted to 17 inches last year.

In addition to the Nova Scotia drought, there were other weather features in 1966 which must have had social and economic implications for the Canadian people: the extreme cold in the Canadian Northwest during January and again in November, the unusually frequent occurrences of heavy snowstorms in some of our large metropolitan areas, and the favourable harvesting weather across the prairies during September. Other features which will be described in the following paragraphs include: the occurrence of heavy precipitation on the west coast of British Columbia in December; the late spring and early summer in Ontario; the exceptionally heavy January snowfall on British Columbia's north coast, and the comparatively few tornadoes and hurricanes reported during the year.

1. <u>January Deep Freeze in the Northwest</u>

The year 1966 began with arctic cold extending over the central interior and northwest of Canada. Across the southern prairies it was the coldest month since the record-breaking month of January 1950, and in the Yukon Territory this was the coldest month on record since 1917.

The deep freeze was centered in the Yukon. On January 4th the temperature dropped to -72° at both Carmacks and Fort Selkirk, and at many stations it remained below zero for the whole month. At Dawson the mean temperature was -46°F, some 28° below normal, while at Mayo Landing, where it was one degree warmer, the monthly mean was 32° below normal, a temperature anomaly which is seldom exceeded anywhere in Canada. Although Dawson reported the lowest mean daily temperature, it is likely that there would have been a lower value at Fort Selkirk had that station been equipped with a mercury thallium thermometer. As it was, maximum temperatures are missing for about half the days in the month, presumably since the mercury in the ordinary maximum thermometer froze when the temperature dropped lower than -38°.

The last occurrence of such cold weather lasting for a calendar month in the Yukon occurred in December 1917 when Carcross and Dawson were the only temperature observing stations. Carcross reported a mean temperature of -31°, with a minimum temperature of -67°, and Dawson reported a mean of -51°, with a minimum of -63°. Another indication of the severity of that December in the Yukon was the fact that the Dawson temperature never rose above -35°, and the town was bathed in ice fog for much of the month. The January 1966 minimum of -72° at Carmacks and Fort Selkirk was not a record in the Yukon, since the temperature has fallen as low as -81° at Snag - the Canadian record low which occurred on February 3, 1947.

Further south there were repeated outbreaks of cold arctic air over the southern prairies, giving the central interior region of Canada its coldest month since January 1950, a month which has the distinction of being the coldest month on record throughout most of western Canada. Mean temperatures in southern Alberta ranged from 0 to -15° during January 1966, and in southern Saskatchewan and Manitoba from -10 to -20°, all averaging about 15° below normal. Although Edmonton and Regina have had several colder months than this one, the mean of -16° at Winnipeg equals the record for coldness at that city. A minimum temperature of -57° on January 28 at Prince Albert was the lowest reported from a city in the Prairie Provinces.

2. Snowstorms in the Cities

Canada's major urban areas came in for more than their fair share of snow in both the early and closing months of 1966. Late in 1965, on December 27, both Vancouver and Victoria were blanketed by nine-inch snowfalls, more than had fallen on any one day in the last 40 years in either urban area. Also late in 1965, on December 30, Regina reported six inches, and Winnipeg 11 inches, more snow at both places than had ever previously fallen on any one day in December for the past fifty years.

In January 1966 snowfall was heavy in the urban areas of Ontario and Quebec. At Toronto the 24-hour fall over January 22-23 amounted to nearly 17 inches, the greatest one day January snowfall on record, and an amount second only to the famous December 11, 1944 storm when 19 inches fell on one day. During the month of January, Toronto reported 28, Ottawa 36, Montreal 37, and Quebec 63 inches of snowfall. None of these values was a record, but there was enough snow to substantially increase the cost of snow removal to the taxpayer.

The large urban areas of the country were relatively free of heavy snowstorms during February, but winter struck again in March, particularly at Winnipeg and at St. John's, Newfoundland. On March 4 Winnipeg experienced its worst winter storm since March 1902. Fourteen inches of snow fell from midnight until 9 p.m. while winds averaged 35 to 45 miles per hour, with gusts as high as 70. By 11 a.m., all Metro transit buses had stopped running and there was no public transportation for the next 24 hours. Cars and buses were stuck in huge drifts, and hundreds of people were stranded in downtown hotels, offices and department stores. It took many days of plowing and digging to get Winnipeg's streets back to normal.

About two weeks later, on March 16, a severe storm struck the east coast giving strong winds and heavy snowfall to the eastern sections of Newfoundland, including St. John's. At that city 11 inches of snow fell, wind speeds averaged in excess of 30 miles per hour, and gusts as high as 80 miles per hour were reported.

The winter of 1966-67 got off to an early start in southern Ontario when an intense storm moved through on November 2-3, bringing in excess of 12 inches of snow to Windsor, a record for so early in the season. November snowfall was heavy at some smaller cities, Timmins reporting 66 inches, and Prince George, B.C. 35 inches, while in December Bagotville reported 52 inches. From December 25 to 29, some 22 inches of new snow fell in Montreal to provide plenty of shovelling over the holiday period.

3. Heavy Snowfall on the West Coast

While a few inches of snowfall in a few hours can cause much chaos and confusion in the modern Canadian city, heavy snowfall is to be expected during the winter months in some mountainous areas of western Canada. An observing station near Kitimat, B.C. called Kemano (Kildala Pass) reported to the climatological observing programme system from 1953 through 1959. Some exceptionally heavy snowfalls were recorded at this station, especially in February 1954 when 202.5 inches of snowfall in 24 days were reported during the month. This is the only instance on record in Canada of a month's snowfall exceeding 200 inches at an observing station, but frequently there are winter months in British Columbia when several stations report in excess of 100 inches.

In January 1966 such heavy snowfall was reported from nine stations along the North Coast and in the Coast, Selkirk, Cariboo and Rocky Mountains. The greatest monthly total, 172 inches, was reported from the observing station at the firehall in Kitimat. The most snowfall on any one day was 24 inches on January 20, but there were also daily totals of 22 and 23 inches later in the month. The greatest daily snowfall ever reported in Canada was 43 inches on February 15, 1949 at Premier, also on the west coast of British Columbia.

4. Weather Weary Winnipeg

Of the major Canadian urban areas, Winnipeg probably has the best reasons to be "weather weary" at the close of 1966. The winters of 1965-66 and 1966-67 to date have not been kind to that city. November 1965 brought below normal temperatures, and almost three times normal snowfall. The storm on November 26-27 left ten inches, which, when drifted by strong winds, clogged streets and highways. December 1965 was generally mild, but the storm of December 30 left 12 inches of snowfall, as mentioned in the section above. January 1966, with a mean temperature of -16°, was as cold as any month on record back to the opening of the first weather station in 1872. In February the temperature dropped to -49° on the 18th, which was the second lowest temperature ever reported at Winnipeg, exceeded only by the -54° on December 24, 1879. Then in March, the worst storm in the past sixty years occurred. The heavy snow with this storm, which has been described above, added to the flood potential on the Red River and many special precautions were undertaken. However, there was little precipitation in the Red River Valley for the next six to seven weeks, and the resulting flood crests were not as high as those originally forecast. April did not pass, however, without a severe storm occurring on the 27th when nine inches of snow fell accompanied by high wind speeds, again causing hazardous driving. Even in May it remained cool at Winnipeg and spring was about two weeks late.

In summer the weather again conspired to try the Winnipegers. Thunderstorms, which began the previous evening, produced 2.95 inches of rainfall in the 24-hour period ending at 6 p.m. on August 31. The heavy rainfall flooded many basements and railway underpasses, and there were several power disruptions. Hail was reported from some parts of the city during the night. So much rain in 24 hours in August has only been exceeded once at Winnipeg - on August 11, 1962, when 3.30 inches fell.

After an uneventful autumn, the winter of 1966-67 began in earnest at Winnipeg in November, when over the month as a whole, the mean temperature was 14°, some 9° below normal and colder than any other November since 1935. On the 29th of November there were $4\frac{1}{2}$ hours of freezing rain, coating streets and sidewalks and slowing traffic almost to a halt. This was the worst occurrence of freezing rain in many years and was followed by an invasion of arctic air with snow and below zero temperatures. December temperatures were five degrees below normal, but in January 1967 temperatures were near normal. Over calendar year 1966 the mean temperature at Winnipeg was 33°; only two other years of this century have been colder.

5. Droughts in Nova Scotia and Ontario

Climatological news from the United States over the past year or two has featured the drought in the mid and north Atlantic States. In the eastern parts of Virginia, Pennsylvania and New York, the drought reached its greatest severity in August and conditions have improved since that time, but it is considered that the drought is still not definitely over. The northeastern extension of this drought area takes in Nova Scotia, where both 1965 and 1966 have been the driest years on record. For example, at Halifax, where the average annual precipitation is 55 inches, there were but 36 inches reported in 1965, and 37 inches last year. In 1966 at Halifax, it was only in the months of March, September and December that precipitation approached or exceeded normal. Drought conditions continued into January 1967 in most parts of the province.

There have been dry periods in southern Ontario, but the drought has been spotty. The Ottawa Valley counties suffered most in 1965. Two areas which experienced drought in 1966 were the Georgian Bay and west-central counties. The 40-day period from June 16 to July 26 at Guelph saw no appreciable rainfall (i.e. no day with 0.12" or more). This was the longest such drought period at Guelph since the turn of the century. Many lawns and pastures were burned dry in central southern Ontario, and effective relief did not come until August.

6. Unusual Mildness in the Eastern Sub-Arctic

The above normal temperatures reported from northern Quebec and Labrador early in 1966 may be another manifestation of the overall atmospheric circulation anomaly which has produced the abnormally dry areas along the North American Atlantic coast. Monthly departure temperatures in that area were 8 to 12^{o} above normal during each of the months of January through April. The pattern broke down with normal to slightly below normal temperature conditions during the months May through July, but for the period from August through January 1967, there have again been positive anomalies centered over the northern Ungava Peninsula and Baffin Island.

7. A Delayed Summer but Good Vacation Weather in the East

Summer was slow in coming to portions of southern Ontario and Quebec in 1966. Late-in-the-season snowfall was heavy in southern Ontario during April, where for example, Toronto experienced a total fall of nine inches, the greatest April total since 1874. It was the coldest May since 1924 in the Great Lakes/St. Lawrence region of southern Ontario, when the temperatures averaged just less than 50^{o}, some 6^{o} below normal. Precipitation was below normal in May, especially in the lower Great Lakes region. The first part of June continued cool, and it was not until the 21st that the first really warm spell set in over southern

Ontario and Quebec. July did, however, produce some of the best summer vacation weather that the holiday regions of Ontario have experienced in several years. Good vacation weather, however, often means drought conditions, and these occurred in early summer in some parts of southern Ontario as described above.

In New Brunswick, Prince Edward Island and Nova Scotia, May was sunny, cool and dry. Both June and July were normal months with plenty of sunshine, as had August and September. Although the summer did not bring any really hot weather, conditions favoured the vacationer in the Maritime Provinces with an abundance of sunshine and a minimum of rainy conditions.

8. Not Many Hot Spells

Almost everywhere in Canada the year 1966 was markedly free of unpleasantly hot weather as there were only a few reports of temperatures exceeding 100°. A temperature of 103° at Yellowgrass, Sask. on July 16 was the national high for the year. Twenty-nine years ago on July 5, 1937, Yellowgrass, along with other stations in southern Saskatchewan, reported 113°, the temperature which has been accepted as the official Canadian record. In general, July 16th last year was the hottest day across southern Saskatchewan, as Moose Jaw and Caron reported extremes of 100°, and several other stations, including Regina, had maxima in the high 90's on the same day.

Southern Canada escaped the exceedingly hot weather that plagued the eastern United States late in June, and the central interior early in July. Temperatures in the 90's were reported from many Ontario stations over the June 23-26 period, and again during the first three days of July, but they never reached the one hundred plus values that were common in the U.S.A. Another hot spell occurred in the southern interior valleys of British Columbia during the third week of August. The temperature reached 100° at both Lytton and Hope on August 23, and Lytton recorded 101° on August 24, the hottest temperature officially reported from British Columbia during 1966.

9. Good Western Harvest Weather

A dry, cool May provided favourable weather for spring seeding in the central grain of Alberta, Saskatchewan and Manitoba. Persistently strong and gusty winds caused severe soil drifting and considerable blowing dust across southern Saskatchewan during the latter half of the month. Cool, damp weather early in June was followed by plenty of rainfall in most areas during July and August. There were local drought conditions east of Edmonton and south of Regina early in the crop season, but in general, by late August prospects were bright for a good wheat crop. September produced good harvest weather with warmer than normal temperatures, clear sunny weather and little precipitation throughout the area allowing the successful harvest of an excellent crop.

10. Few Tornadoes and Hurricanes

Reports of tornado activity were at a minimum in Canada during the summer of 1966. Although a number of severe thunderstorms were reported, no tornadoes were sighted by any observing stations. A severe thunderstorm on July 28th in central southern Ontario caused considerable damage at Frenchman's Bay near Toronto when a sea plane was lifted out of the water and overturned. Also in July, on the 17th, a severe storm with hail in the Duck Mountain Forest Reserve, Manitoba, uprooted trees and damaged cottages and trailers.

Despite the occurrence of severe hurricane damage in the United States, Mexico and the Caribbean Islands, there were no hurricane threats to eastern Canada during 1966. Remnants of the early season storm "Alma" traversed the Bay of Fundy on June 15th as a very weak disturbance. The remnants of hurricane "Ceila" passed south of Nova Scotia harmlessly on July 21st, and the only other tropical storm affecting Canada at all was "Faith", which passed south of Nova Scotia on September 2, causing some rain and moderate winds in the southern marine areas.

11. November: West - Cold, East - Wet

November 1966 was an exceedingly cold month throughout central and northwestern Canada. Most of the three Prairie Provinces, Yukon Territory and the mainland portions of the Northwest Territories reported mean temperature for the month that averaged more than 8° below normal. The greatest negative anomalies occurred near Great Slave Lake, where Fort Reliance reported a mean temperature of -14°, some 21° below normal. Temperatures dropped to -50° at Smith River, B.C., and to -49° at Mayo Landing, Y.T. extremely low temperatures for anywhere in Canada for so early in the winter season. In fact, November 1966 was the coldest November in the last 35 years in that part of the country.

While the West was cold, Ontario and Quebec were wet. Precipitation totals exceeded four inches throughout southern Ontario and Quebec, and totals greater than eight inches were reported from the Lake Temiskaming, southern Laurentians and Sept-Iles areas. Toronto's 5.8 inches of precipitation made this the wettest November since 1846 at that city. Fortunately temperatures were mild throughout eastern Canada, and, except for northern Ontario where several stations reported in excess of 50 inches of snowfall, most of the precipitation fell as rain.

12. December in British Columbia - Mild and Wet

The south coast of British Columbia experienced one of the mildest and wettest December on record in 1966. The mild weather affected the entire province, and even the Cariboo, where temperatures as low as -20° had been reported during the first part of December, ended the month with above normal mean temperature. Positive anomalies were greatest in southeast interior where Kimberley, with a mean temperature of 26°, was 5° above normal. On the coast a number of stations, including Victoria, reported mean temperatures of 44°, some 2 to 3° above normal.

And it was wet: Vancouver Airport reported 9.58 inches of precipitation, making this the rainiest December since records began at the airport in 1938. Other synoptic observing stations with November high precipitation records were Tofino 27, and Estevan Point 30 inches. The heaviest precipitation during the month in the province, and in fact, during the year in the nation, was reported from Ucluelet Brynnor Mines, where a phenomenal 68.88 inches were reported, with daily totals exceeding five inches on each of five days. The greatest daily total was 9.74 inches on December 14, and rain fell on 30 of the 31 days in the month. These values, though, are not records for British Columbia, since Henderson Lake reported a one day maximum of 16.61 inches on December 30, 1926, and during November 1917 Swanson Bay reported 88.01 inches, both national records.

SUMMARY

Study of data from all of Canada's climatological observing stations over the past several decades reveals certain weather patterns that we know as Canada's climate. We know that summer has brought hot, humid days in the East in the past and will do so again in the future, and that most winters have been and will be rainy along the Pacific coast, but we also know that the day to day details are always different. Like every year in the past century, 1966 was unique.

CANADIAN WEATHER HIGHLIGHTS 1966
pressure 1059 mb. jan. 28 alert
6" snow aug. sachs harbour
-72° jan. 4 ft. selkirk carmacks
28" snow june cape dyer
coldest january in 50 years
warm june
warm july
coldest november in 35 years
172" snow in jan. kitimat
jan.-april
above normal temperatures
oct.-dec.
71" snow jan. gander
68.88" precip. in dec. ucluelet
good harvest weather sept.
103° july 16 yellow grass
-49° feb. 18 winnipeg
heavy november snowfall
continuing severe drought
17" snow jan. 22-23 toronto

A CASE STUDY OF A WEATHER SATELLITE PHOTOGRAPH MOSAIC

By M. S. Hirt

ABSTRACT

The Automatic Picture Transmission (or APT) System developed for weather satellites enables satellite data laboratories, such as the one at the Toronto International Airport, to prepare photographic mosaics covering almost the entire continent of North America. The mosaic can be completed within four hours after the satellite comes within range of approximately 2500 miles of the ground receiving station. One such mosaic is presented here. The cloud features are analyzed with the aid of the meteorological charts available in the forecast office. Conclusions drawn show that cloud patterns on the satellite photograph are readily associated with the features on the charts available in a forecast office. Conversely, the satellite photograph can be used as an aid in the analysis of these charts.

INTRODUCTION

With the beginning of space exploration by the United States and the U.S.S.R., meteorologists became aware of the value of weather satellites in the study of the weather. Within a short period of ten years, operational weather satellites have been perfected which today can transmit detailed cloud photographs, covering a large area of the earth's surface, to ground receiving stations using relatively inexpensive equipment. An important additional feature is that these pictures are in "real time", space-age jargon for the fact that they are in the hand of the user shortly after they are taken and, therefore, before their value has depreciated through the passing of time.

Cloud photography by satellites began in 1958 with the only partially successful Pioneer 1 and 2. Techniques and hardware improved through the flights of Vanguard II in 1959, Explorer VI in the same year and the TIROS (Television and Infra-Red Observation Satellite) series up to mid 1965.

Although the TIROS series was only experimental, the photographs were of good quality, and of significant value to global meteorology. They showed, however, some major shortcomings. Two of the most important were:

(a) because only two stations in the world could acquire the pictures, a great time lag between the taking of the picture, and reception of a reduced or coded version by the ultimate user occurred, reducing its value.

(b) the satellite usually viewed the earth obliquely, distorting the details from reality, and making them hard to interpret.

Technique has corrected (b) above and the development of Automatic Picture Transmission (APT) hardware has corrected (a). Now the operational forecaster can see the actual photograph shortly after it has been taken and transmitted to a relatively inexpensive APT ground station.

With Nimbus I, an experimental vehicle, the summer of 1964 saw the beginning of useful weather satellites equipped with the APT system. Nimbus I was earth-oriented so that all pictures were taken from vertically above the target area. The satellite was placed in a polar orbit. This allowed the entire earth's surface to be photographed in daylight once every twenty-four hours.

Early in 1966, the first of an operational series of weather satellites known as the TOSS (Tiros operational satellite system) was developed. Essa II was the first APT vehicle of this series. Nimbus II was also flown about the same time. Both ESSA and NIMBUS satellites are at present transmitting excellent photographs of cloud coverage to ground stations, equipped with the APT system. Nimbus satellites have, in addition to a television system, a high resolution infra-red scanning device, which enables ground stations to receive a photographic type of heat radiation image when the satellite is on the dark side of the globe.

The Canadian APT Ground Receiving Station

Canada was one of the first countries to appreciate the value of an APT system. As a result, the Meteorological Service of Canada formed the Satellite Data Laboratory, for which the Radio and Electrical Engineering Division of the National Research Council developed a prototype APT ground station.

The APT equipment developed here acquired the first APT pictures ever transmitted by TIROS VIII, and marked the occasion of the first directly received satellite photograph in Canada.

The camera employed in the present APT system has a 5.7 mm lens and a field view of 108 degrees. This results in an image of an area approximately 1200 miles to a side projected onto a one inch storage vidicon tube. The image is then converted directly into a series of electrical charges with an intensity directly proportional to the amount of light falling on it. These charges in turn are picked off the photoconductor layer by a moving electron beam, which scans the picture area with 800 lines at 4 lines per second. The signal is then transmitted to the ground receiving station which converts it back into the original image. The entire process of scanning and receiving takes 200 seconds for each exposure. Usually three or four exposures are possible during each pass.

The APT ground receiving station at the Toronto International Airport is presently using three types of readout equipment:

(a) The Photographic Facsimile detects the video signal and uses it to modulate a light source while scanning photographic paper. The $8\frac{1}{2}$ by $8\frac{1}{2}$ inch size print is automatically processed within the machine almost in phase with the transmission. It is delivered 20 seconds after transmission is completed.

(b) The Kinescope scans the detected signal in phase on the phosphor of a cathode ray tube, which is, in turn, photographed by a $2\frac{1}{2}$ by $2\frac{1}{2}$ inch polaroid camera.

(c) The Paper Facsimile produces a 9 x 9 inch image as a result of a signal-modulated current flowing from a writing bar through the paper to a rotating helix.

The completed $8\frac{1}{2}$ by $8\frac{1}{2}$ inch photographs, the type most suitable in the forecast office, are brought into the forecast office as soon as they are catalogued as to orbit number and time, and spot locations are put on. In the forecast office, they are analyzed using all available information to determine type of clouds and the weather process revealed by them.

FIGURE 1 is a mosaic made up of a series of photographs taken during three consecutive passes of ESSA II. This mosaic was completed within four hours after the beginning of the first pass. This mosaic encompasses an area from Greenland to the coast of South America and from Puerto Rico to the Gulf of Alaska.

Analysis of the Mosaic

The surface analysis for 1200Z (Figure 3) and the corresponding upper air charts, 850 mb, 700 mb, 500 mb, and 300 mb (FIGURES 6 to 9) are used in the analysis of the photographic mosaic (FIGURE 1). These charts, along with the Showalter stability index chart (FIGURE 5), and the frontal contour chart (FIGURE 4) enable one to associate the cloud patterns on the mosaic with available data in the forecast office.

There are a number of recognizable land features on the mosaic. The Great Lakes show up well, along with Nova Scotia in the east, and the coast of California in the southwest. One can distinguish Hudson Bay and Greenland in the north, and in the south, the Gulf of Mexico and Florida.

The major cloud area on the mosaic (FIGURE 1) and the major low and frontal system on the surface analysis (FIGURE 3) coincide. The low on both the mosaic and on the surface analysis appears to be well organized and located just off the coast of Labrador.

While it is easy to recognize the main low centre and frontal system, the mosaic yields more detail than is evident from an initial glance. FIGURE 2 with numbers one to thirteen is a key to the mosaic. The following discussion will attempt to relate the features on the mosaic with the information obtainable from FIGURES 3 to 9.

Key to the Mosaic

Number 1 shows a "bird-eye view" of a mature low centre over the Atlantic ocean east of Labrador, from an altitude of 800 miles. The low is made up of a central area of cloud surrounded by a relatively cloud-free area, which in turn gives way to middle cloud west and north of the centre. The cloud type in the central portion of the low cannot be confirmed by direct surface observations, but if this cloud is compared with the cloud over Newfoundland, one notices a similarity in texture and brightness. The cloud over Newfoundland is observed to be of the stratocumulus variety, hence, it is likely that the main cloud found in the low centre is stratocumulus. The middle cloud west and north of the main centre is characterized by its smooth texture and strong reflectivity. This middle cloud area corresponds, as would be expected, with the main isotherm ribbons at 850, 700, and 500 mbs (FIGURES 6 to 8). The frontal contour chart (FIGURE 4) shows a well-marked frontal surface, and the nephanalysis associated with FIGURE 3 confirms the organized middle cloud in this area.

Number 2 shows the main frontal band extending southward from the low, then curving westward into the United States. A comparison of the frontal contour chart (FIGURE 4) and the 1200Z frontal analysis (FIGURE 3) with this cloud band shows that it is associated with the maritime, arctic and polar frontal surfaces at around the 700 mb level. Further detail is pointed out by numbers 3 and 4. These features show two bands of cloud parallel to each other. The bands are emphasized as a result of the shadow of cloud tops cast by the sun as a faint line onto the lower clouds just to the west. The surface analysis FIGURE 3 shows these features to be associated with the Maritime cold front and polar-trowal-cold-front system. Reference to the frontal contour chart in FIGURE 4 substantiates the existence of the two front system in the positions indicated by the cloud bands of points 3 and 4.

Number 5 shows a uniform dark line extending from near Cape Cod curving south and east of Nova Scotia to just east of Newfoundland, then eastward south of Greenland. This line is the shadow cast onto the lower cloud by the translucent cirrus band which is often associated with a well-developed jet stream. The jet core is usually found 60 to 100 miles to the left of the cirrus edge. In this mosaic, the angle of the sun relative to the ESSA camera plane produces shadows on the west or northwest edge. With NIMBUS photographs, the shadows are more evident on the north side of clouds. The 300 mb analysis (FIGURE 9) shows the position of the analyzed jet stream. It corresponds very closely to where one would expect to find it from the analysis of the mosaic.

Number 6 points out a series of extrusions on the main frontal cloud band visible on the mosaic. These extrusions are at intervals of approximately 5 degrees of latitude. Close analysis of the 1200Z surface chart shows these extrusions to be associated with a series of stable waves along the polar front.

Number 7 shows a cloud mass covering a large portion of the Canadian Prairies. There appears to be little discernable form to this mass. The surface analysis shows this area to be under the influence of a trough and trowal system. The stability index chart, FIGURE 5, shows the area to have Showalter stability indices of between minus three and zero. The surface analysis, FIGURE 3, shows a number of thunderstorm observations in this area. This accounts for the pockets of very bright looking clouds and the characteristic shadow effect of the tops of numerous cumulonimbus clouds. The streaming effect of what looks to be a more wispy type of cloud could be the anvil tops of the cumulonimbus being carried downstream into Northwestern Ontario. The strong northwest flow shown by the 300 mb chart in FIGURE 5 extends from eastern Saskatchewan into the Great Lakes region.

Number 8 shows a narrow, but well-developed band of cloud in northern Canada. From the reflectivity and smooth texture, the cloud on the mosaic appears to be of the middle cloud variety. The neph-analysis of the surface chart, FIGURE 3, confirms this. Both the surface analysis and the frontal contour chart show this area of middle cloud to be associated with a well-developed Maritime front and wave system. The 850, 700 and 500 mb charts, FIGURE 6, shows a well-marked thermal gradient in this area.

Stability

It is possible to make some simple deductions as to stability of the air masses. Both low level instability and the more severe type associated with cumulonimbus development can be recognized from the mosaic.

The characteristic bumpiness and shadow effect shown in FIGURE 1 along the main frontal band over continental United States, number 2, and the cloud mass over the Canadian Prairies, number 7, coincides with areas of the stability index chart, FIGURE 5, having values of less than zero.

Low level instability is pointed out by number 9, in FIGURE 2, over Central Quebec. The stability index chart shows this area to be quite stable. Surface observations in this area, however, show the cloud to be mainly of the cumulus and stratocumulus variety. These individual cells do not show up on the mosaic, but appear to run together. This is a result of the inability of the satellite's camera system to resolve objects less than three miles in diameter. This results in a powdery appearance, which is characteristic of this type of cloud in a satellite photograph.

Other Interesting Features

Number 10 on FIGURE 2 shows a strong reflective area near New Orleans, with darker lines interspersed. This is characteristic of a well-developed area of thunderstorm activity. The stability index chart, FIGURE 5, shows values of less than minus three in this area. Ground observations, see analysis, FIGURE 3, confirms the thunderstorm activity.

Tropical storm "Celia" is shown by number 11. A few days after this photograph she became a full-fledged hurricane.

Number 12 shows a fog or stratus bank northeast of Newfoundland. It has a smooth fine texture, but is somewhat less brilliant or has less reflectivity than that of middle cloud. Shadows from higher clouds help to indicate that number 12 is a low cloud feature. Ship observations from the analysis, FIGURE 3, are the only means of substantiating the stratus in this area.

Number 13 shows dissipating ice along the southwest shoreline of Hudson Bay. The smooth appearance and sharp edges of the ice helps to distinguish it from the cloud band showing up just to the north. Further identification of the ice can be obtained by comparing photographs twenty-four hours apart and noting the persistence of the patterns.

Conclusions

The above discussion shows that typical cloud patterns on the mosaic can be related to the surface and upper air analysis used in the forecast office. Reference, then, to a mosaic such as that of FIGURE 1, can have significant value in a forecast office:

(a) Detailed Nephanalyses can be prepared in real time from the satellite photographs for use in analysis and forecasting.

(b) Meso-scale features such as thickening of middle cloud can assist in detecting weak stable waves along a front.

(c) Areas of low level instability cloud and instability in depth as indicated by the Showalter index can be recognized from the satellite photograph.

(d) Analysis of a frontal system can be made more accurate in areas where observations are sparse, in particular, over ocean areas. In the case of this mosaic, the maritime front in northern Canada can be analyzed more accurately.

(e) The mosaic has significant value in a briefing office where air crew on cross-country flights, especially over areas where very little surface data are available, can obtain a real picture of the cloud pattern over their route. With experience and proper interpretation techniques, the briefer should be able to indicate the cloud types, their locations and approximate heights.

Acknowledgment

I would like to acknowledge the assistance given me by Mr. C.I. Taggart, Officer-in-Charge of the Meteorological Satellite Data Laboratory at the Toronto International Airport, and his staff, and Mr. Roy Lee for valuable discussions on photo-interpretation and on the manuscript.

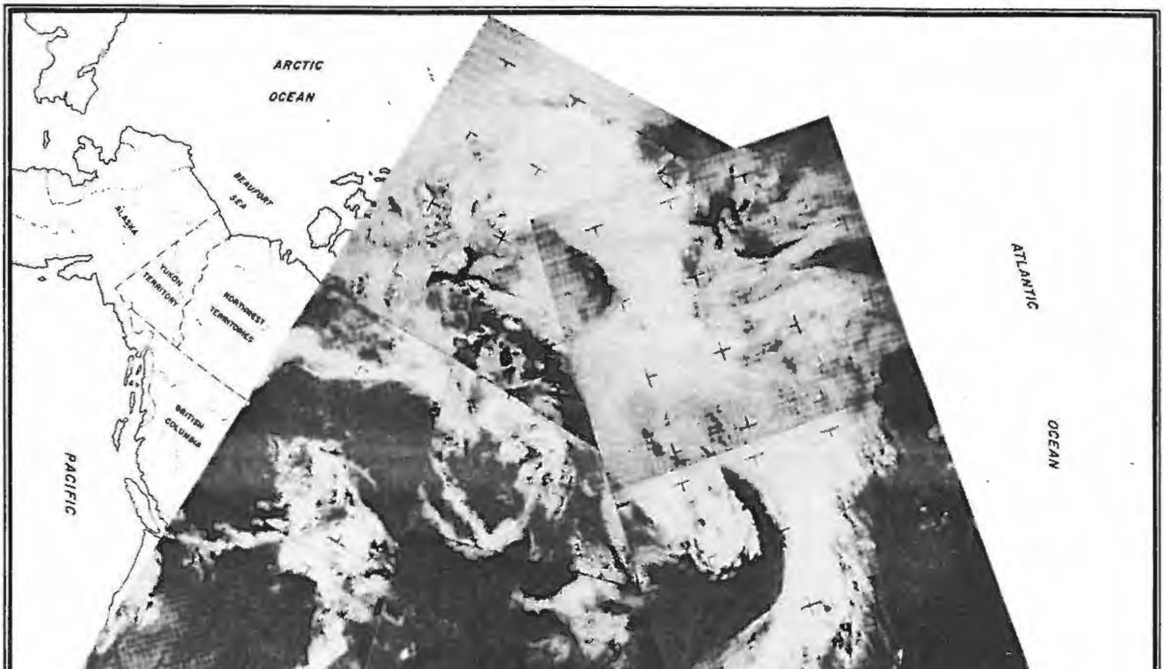

FIGURE I

MOSAIC SHOWING PHOTOGRAPHS FROM THREE PASSES OF ESSA II WEATHER SATELLITE RECEIVED BY THE SATELLITE DATA LABORATORY AT TORONTO INTERNATIONAL AIRPORT JULY 15, 1966.

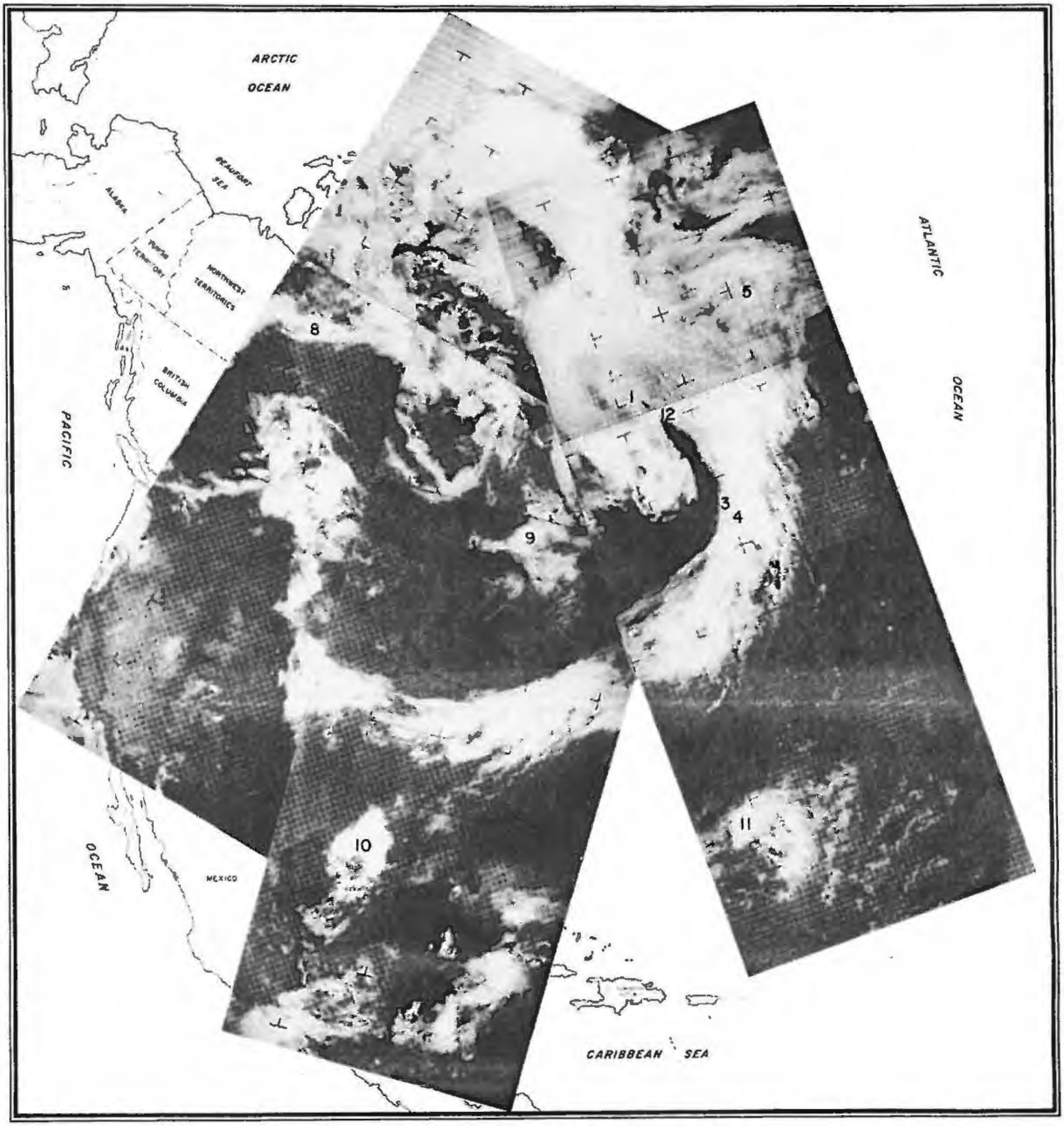

FIGURE 2
KEY TO MOSAIC

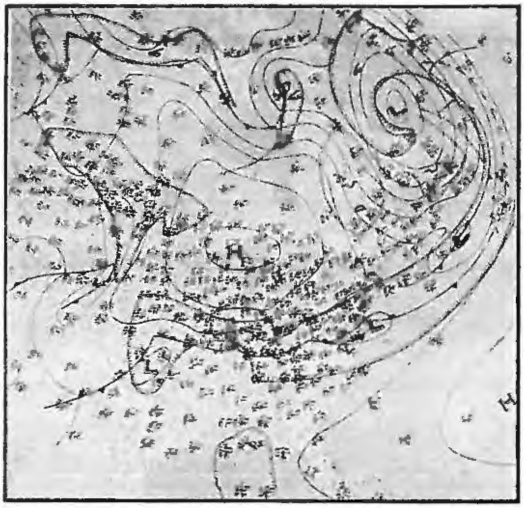

FIGURE 3

SURFACE ANALYSIS-1200 Z- JULY 15,1966.

Middle cloud neph-analysis.

Low cloud neph-analysis.

FIGURE 4

FRONTAL CONTOUR ANALYSIS-1200 Z-JULY 15,1966.

----Maritime frontal surface contours.

Polar frontal surface contours.

FIGURE 5

SHOWALTER STABILITY INDEX-1200 Z-JULY 15, 1966.

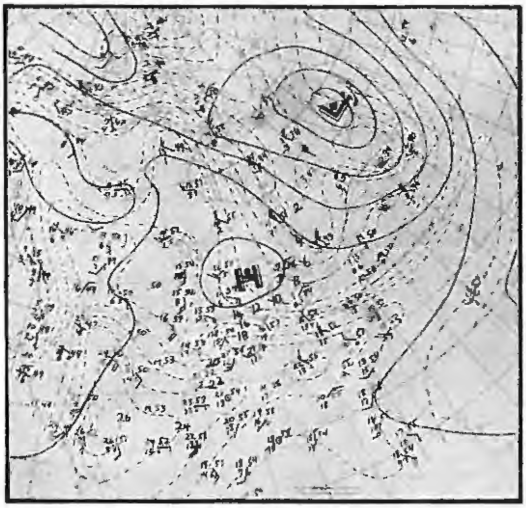

FIGURE 6

850 mb ANALYSIS - 1200 Z - JULY 15, 1966.

Contour lines.

---- Isotherms at 2 degree intervals.

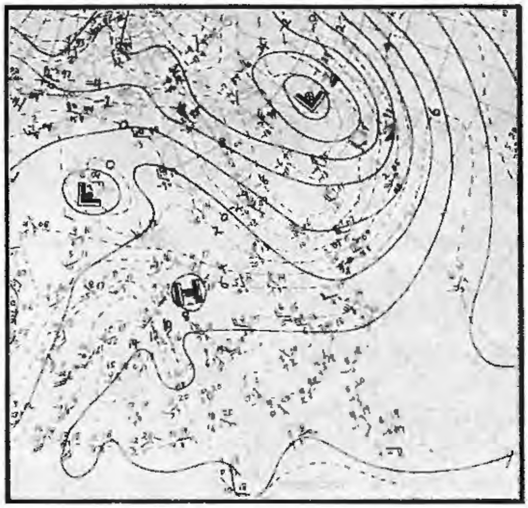

FIGURE 7

700 mb ANALYSIS - 1200 Z - JULY 15, 1966.

Contour lines.

---- Isotherms at 2 degree intervals.

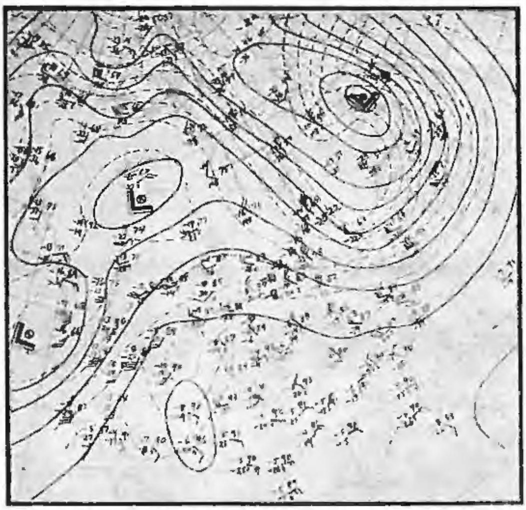

FIGURE 8

500mb ANALYSIS - 1200 Z - JULY 15, 1966.

Contour lines.

---- Isotherms at 2 degree intervals.

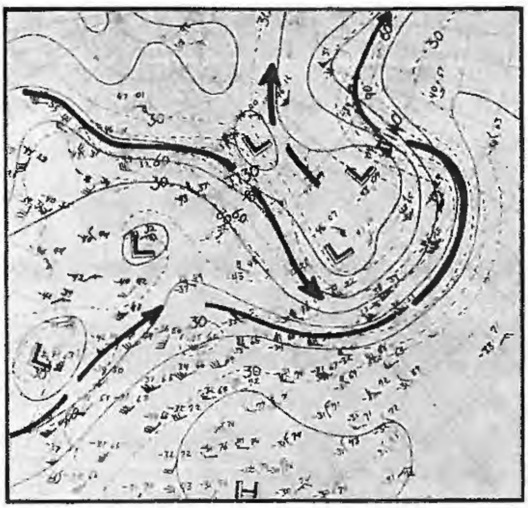

FIGURE 9

300mb ANALYSIS - 1200 Z - JULY 15, 1966.

Jet stream.

Contour lines.

---- Isotachs.

A STATISTICAL RELATIONSHIP BETWEEN SOLAR RADIATION, SUNSHINE AND RELATIVE HUMIDITY IN THE TROPICS

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ABSTRACT

A correlation of solar radiation in tropical countries has been established based on parameters more usually measured than solar radiation itself. The following empirical relationships between solar radiation Q, ratio of hours of bright sunshine to twelve hours, S, and relative humidity of the environment, R, have been obtained by statistical methods applied to the available data:

$$Q = 490S^{0.357}R^{-0.262}$$

$$Q = 460e^{0.607(S-R)}$$

$$Q = 464 + 265S - 248R$$

with limits on R and S as defined in the text. It is found that these equations give better estimates of solar radiation than the single-parameter relationship like

$$Q = a + bS$$

where a and b are statistical coefficients.

NOMENCLATURE

Q = Solar radiation received on a horizontal surface, langleys/day.

H_D = Direct component of solar radiation received on a horizontal surface, langleys/day.

Q_o = Solar radiation received on a horizontal surface for cloudless days, langleys/day.

R = Relative humidity, percent.

S = The ratio of the recorded hours of bright sunshine to a fixed reference of 12 hours (dimensionless).

INTRODUCTION

As far back as 1924, Ångstrom and others had suggested a linear relation of the form:

$$Q/Q_o = a + bS_A \qquad (1)$$

between solar radiation intensity and the hours of bright sunshine, where Q is the solar radiation received on a horizontal surface; Q_o the cloudless-day solar radiation on a horizontal surface; S_A the ratio of the hours of bright sunshine to the maximum possible; and a and b are statistical coefficients which can be estimated for a given set of data. Mateer (4), in his analytical work modified the above linear form to take into account the errors involved in the length of day and used the form:

$$Q/Q_o = a + bS(1 + cw^2) \qquad (2)$$

where w is the correction term for the length of day when the sun's altitude is less than 5^o and c is a statistical coefficient. Mateer found that treating year-round data with Eqn. (2) results in values of Q too high for the winter months and too low for the summer. He treated the data, therefore, under three categories: winter, summer and transition period. He found that the linear relationship gives a fairly good result for the summer months and the use of a complicated expression like Eqn. (2) does not improve the results sufficiently to justify the additional work.

In the foregoing, only sunshine has been employed to estimate solar radiation. But, the measurement of sunshine is rather restrictive. The equipment makes use of a spherical lens as a concentrating device which means that only the direct component of the radiation is used. Therefore, one normally expects the linear relation to work only in estimating the direct component of solar radiation. Nevertheless, it has been employed to estimate the total solar radiation. Some justification for this may be found in the computations of Sharma and Pal (3) who established a linear relationship between total and direct solar radiation.

The presence of water vapour has considerable influence on direct and sky radiation (5). Precipitable water vapour is used in many correlations, but is not as readily measured as is relative humidity. Relative humidity is an indication of the water vapour present in the atmosphere throughout the tropics, and so is used as a second parameter in correlating direct solar radiation.

In the present study, statistical methods have been employed to establish a more general relationship making use of two parameters; sunshine and screen-level relative humidity. Three different functions have been assumed and data obtained from Ibadan, Nigeria, applied to these functions.

METHOD OF APPROACH

To predict the amount of solar radiation incident on the earth's surface from sunshine and relative humidity measurements, consider the general function of the form:

$$Q = Q(R,S, \ldots) \qquad (3)$$

where Q is the solar radiation received on the earth's surface measured in langleys per day (1 langley = 1 gm cal/cm^2); R, the relative humidity; and S, the ratio of the recorded hours of bright sunshine to a fixed reference of 12 hours. Twelve hours have been chosen as a reference to define sunshine because within the tropics, the maximum daily sunshine scarcely ever exceeds 12 hours.

Three forms of (3) neglecting other physical parameters are:

$$Q = k_1 S^m R^n \qquad (4)$$

$$Q = k_2 e^{p(S-R)} \qquad (5)$$

$$Q = a + bS + dR \qquad (6)$$

where the coefficients and exponents are determined statistically for a given set of data. Eqn. (5) was chosen in the above form because solar radiation is a decreasing function of R and an increasing function of S. Using the least square method, a FORTRAN programme has been written to evaluate the coefficients in Eqn. (6) for the given set of data, but both Eqns. (4) and (5) need logarithmic transformation to:

$$\log Q = \log k_1 + m \log S + n \log R \qquad (7)$$

$$\log Q = \log k_2 + p(S-R) \qquad (8)$$

The standard errors of estimate and correlation coefficients for the set of data used in this study were also evaluated.

RESULTS

The following empirical relations are obtained for the set of data from Ibadan, Nigeria, on the Northern edge of tropical rain-forest climate area; for the four-month period February to May 1964 (6):

$$Q = 490 S^{0.357} R^{-0.262} \qquad (9)$$

$$Q = 460 e^{0.607(S-R)} \qquad (10)$$

$$Q = 464 + 265S - 248R \qquad (11)$$

From physical considerations, both R and S are positive and from their definitions, are bounded within certain limiting values. In the tropics the quantities S and R are limited to the values indicated in the following equations:

$$0 < S < 1.13 \qquad (12)$$

$$0 < R < 1.0 \qquad (13)$$

Considering Eqn. (9), the minimum value of Q is given by S equal to zero. The quantity Q is not necessarily zero for a zero value of S because of the diffuse solar radiation component. In order to overcome this limitation of the equation, new limits for S may be defined:

$$0.1 < S < 1.13 \qquad (14)$$

where the new lower limit of 0.1 for S has been arbitrarily chosen. At values of S lower than 0.1, a small change in the value of S causes a considerable change in Q. Thus, poor predicted values of Q result. The upper limit is retained because it is possible to record hours of sunshine greater than 12 hours and the function is quite stable at values of S greater than 1.0.

Estimates of Q from Eqn. (9) tend to infinity as R tends to zero. Therefore, new limits on R may be defined:

$$0.1 < R < 1.0 \qquad (15)$$

On the other hand, Eqns. (10) and (11) do not exhibit the same unstable characteristics as Eqn. (9) at values of S less than 0.1. However, the maximum value of Q predicted by Eqns. (10) and (11) may occasionally be overestimated. Thus the upper limit of 1.13 was also retained for S so that the following ranges for R and S were used:

$$0 < S < 1.13 \qquad (16)$$

$$\text{and} \quad 0 < R < 1.0 \qquad (13)$$

TABLE 1 is a summary of the results based on the foregoing analysis.

COMPARISON BETWEEN PRESENT AND PREVIOUS METHODS

The linear relationship between sunshine and solar radiation suggested by Ångström and others in 1924,

$$Q/Q_o = a + bS \tag{1}$$

becomes

$$Q = 274 + 313S \tag{17}$$

for the set of data for Ibadan, Nigeria, used in this work. The maxima predicted from the functions assumed in this study agree with most inferred values in the literature (1, 2). From TABLE 1, it is observed that the two-parameter estimators are superior to the single-parameter estimator for solar radiation. Thus, relative humidity is a significant estimator. Other single-parameter estimator equations were tested but the results (TABLE 2) either were very poor or gave correlation coefficients similar to those of Ångström.

TABLE 3 shows the comparison of estimated mean values and actual mean values of solar radiation obtained from three other stations in Nigeria: Benin (5-year record, tropical rain-forest climate), Kano (3-year record, desert climate), and Osodi Ikeja (11-month record, tropical rain-forest climate). The predicted values are higher than the recorded values except those predicted for Kano by simple linear relation. From information received concerning measuring techniques employed in Nigeria, the recorded values have a tendency to be on the low side and the error in the present study can be explained on this basis.

It might be questioned why the correlation coefficients and the standard errors of estimate in the present study are not as good as those of other previous work. Mateer (4) used monthly mean values of solar radiation which have smoothed out the daily fluctuations. For the present study, daily radiation is of more engineering interest than monthly means. Furthermore, Mateer used normalized quantities like Q/Q_o and total possible hours of bright sunshine to define sunshine rather than a fixed reference of twelve hours.

CONCLUSIONS

The equations derived in the present study make it possible to provide reasonable estimates of solar radiation in areas where no such data are available in the tropics. It is recognized that the span of data used in this study is short but the results obtained seem to offset most of the dangers anticipated in using such limited data. Thus, the information obtained in this way may be used as a basis for designing solar devices for areas within the tropics.

ACKNOWLEDGEMENT

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TABLE 1

Functional Form	Equation With Coefficients	Correlation Coefficient	Standard Error Of Estimate	Predicted Radiation ly/day	
				Min.	Max.
$Q = k_1 S^m R^n$	$Q = 490 S^{0.357} R^{-0.262}$	0.817	0.138*	216	936
$Q = k_2 e^{P(S-R)}$	$Q = 460 e^{0.607(S-R)}$	0.814	0.138*	250	914
$Q = a + bS + dR$	$Q = 464 + 265S - 248R$	0.805	61.3	216	764
$Q = a + bS$	$Q = 274 + 313S$	0.764	64.4	274	627

*Computed in the transformed form of equation

TABLE 2

DIFFERENT SINGLE-PARAMETER FUNCTIONS

Function	Correlation Index	Standard Error Of Estimate
$Q = a + bS$	0.764	64.4
$Q = kS^m$	0.784	0.193+
$Q = kR^n$	0.625	0.168+
$Q = ke^{PS}$	0.177	0.148+
$Q = ke^{PR}$	0.000	0.161+
$Q = a + bR$	0.610	71.6

+Computed from the transformed form of equation

TABLE 3

Place	Mean S	Mean R	Mean Measured Radiation ly/day	EQUATION 9		EQUATION 10		EQUATION 11		EQUATION 17	
				Q	% Diff.	Q	% Diff.	Q	% Diff.	Q	% Diff.
Benin	.410	69%	358.3	399	+11.5	388	+8.3	402	+12.2	402	+12.2
Kano	.704	32%	531.4	580	+ 9.1	580	+9.1	571	+ 7.4	495	- 6.8
Oshodi (Ikeja)	.427	73%	347.8	390	+12.1	380	+9.2	396	+13.9	408	+17.3

SOME HIGHLIGHTS OF CANADIAN WEATHER IN CENTENNIAL YEAR 1967

By M. K. Thomas

JANUARY. The first month of Centennial Year was relatively mild in British Columbia and eastern Canada, but on the Prairies, after a mild fortnight, very cold conditions were experienced. British Columbia was wetter than normal and frequent blizzards brought record January snowfall to many areas on the Prairies. The Toronto temperature rose to 61° on January 25, a higher value than any ever previously recorded in January. Precipitation in Nova Scotia was generally light, continuing the two-year drought.

FEBRUARY. British Columbia was again mild, but February was a cold wintry month throughout eastern and central Canada, as successive outbreaks of arctic air plunged down over the country. Winnipeg's mean temperature was -6°, some 10 degrees below normal. Heavier than usual precipitation was again experienced along the Pacific Coast, but most stations in the Prairie Provinces reported less than normal February amounts. Precipitation was normal in Ontario and Quebec, but Ottawa, Montreal and Quebec reported the coldest February in the last thirty years. It was a cold and stormy month in the Atlantic Provinces as a series of eight major storms crossed the area causing discomfort on land and tragedy at sea.

MARCH. March was a bitterly cold month throughout most of Canada. Stations in a broad band from Quebec to the Yukon Territory reported temperatures 10 to 13 degrees below normal, while in the more populated areas of the country temperatures ranged from near normal to 10 degrees below normal. Precipitation was generally above normal across southern Canada, except in southern Ontario and Quebec where less than 50% of normal was reported. Heavy storms again hit the Atlantic Provinces, culminating in the Easter weekend storm which left from one to two feet of snow over a wide band from Saint John to Sydney. In Newfoundland, low temperatures and heavy snowfall resulted in March being labelled the most severe month of the winter. On the Prairies an intense storm during the last few days of the month brought heavy snowfall to southern Alberta and disrupted communications and transportation in Saskatoon and Regina.

APRIL. Again in April temperatures were well below normal throughout practically all of Canada. The unseasonably low temperatures produced negative anomalies of from 7 to 11 degrees throughout the southern Prairie Provinces. Precipitation was light in the Atlantic Provinces and in British Columbia, but in central Canada both Manitoba and Alberta reported 3 to 4 times normal snowfall. Lethbridge measured 64 inches of new snow, greatly exceeding the earlier April record of 37 inches. Blizzard conditions produced drifts up to 8 feet deep resulting in disruptions of transportation and communications for several days. Severe thunderstorms and tornadoes were reported from a belt across Huron and Perth counties in southwestern Ontario on the 17th.

MAY. The month was dry and cool over most of Canada. Large areas of the central provinces reported less than 50 per cent of the normal precipitation although another spring snowstorm left 15 inches of fresh snow at Pincher Creek in southwestern Alberta on the 9th-11th. Rain during the last few days of the month produced severe flooding in and to the southwest of Calgary. May was an exceptionally cool month in southern Ontario, Quebec and the Atlantic Provinces where negative temperature anomalies varied from 4 to 8 degrees. Montreal reported the coldest May since 1924, and Halifax since Confederation.

JUNE. Heavy rains beginning June 7 in southern Ontario ended a slow backward spring and by mid-June the Montreal-Ottawa-Toronto-Windsor area was suffering from the first hot humid spell of the summer.

SOME WEATHER EXTREMES - WINTER 1966-67

Lowest temperature :	-70°	Fort Selkirk, Yukon Territory,	December 10	
Coldest calendar month:	-43°	Eureka, NWT,	February	
Most precipitation in one calendar month :	69"	Ucluelet Brynnor Mines, B.C.	December	
Most snowfall in one calendar month :	174"	Glacier NP Rogers Pass, B.C.	January	
Greatest temperature anomalies :	+11°	Cranbrook, B.C.	January	Mean 26°
		Aberfeldie, B.C.	January	Mean 30°
		Fort St. James, B.C.	February	Mean 26°
		Quesnel, B.C.	February	Mean 32°
	-19°	Yellowknife, NWT.	November	Mean 12°

MEETINGS

MONTREAL CENTRE

October 1966

The 1966-67 season opened on October 18th with a talk by Dr. N.H. Thyer of McGill University, on "Valley Winds".

Dr. Thyer began by stating that the effects of topography on airflow are of two types: dynamic and thermal. He then said that he would consider the thermal type. A synopsis of his lecture follows.

When a horizontal temperature gradient exists in the atmosphere, it causes a circulation in a vertical plane. Considering the air in a valley, during the day, solar heating causes the air close to the slope to become warmer than air at the same level away from the slope. Consequently, near the slope the air rises; elsewhere it descends. On a larger scale, the same thing happens with air over a plain near a mountain range, and there a low-level flow towards the mountains results. At night, surface cooling causes a reversal of the temperature gradient and so a reversal of the circulation.

Some basic facts concerning this type of circulation have long been known. But intensive investigations have only taken place in the last 20 years or so. For instance, there was some work started by the University of Washington some 10 years ago in a convenient location near Mt. Rainier. First experiments with pilot balloons showed valley winds in the day, and mountain winds at night. They also showed anti-winds (compensation currents) at higher levels. Few people had mentioned these anti-winds previously, although their existence can easily be deduced from continuity.

Later experiments, with frequent balloon observations, provided information about time variations of the wind at one place. Several stations operating simultaneously, either spaced along the axis of the valley or perpendicular to it, gave synoptic axial or lateral cross-sections of the circulation pattern. Vertical currents were only measured successfully at the ridge-top during the daytime. Simultaneous comparisons were also made between different valleys.

Dr. Thyer concluded his talk by presenting the results of a numerical model of a valley wind system. These compared favourably with the observations.

NOTE:

At the second meeting of the Montreal Centre, the Society's President, Prof. A.W. Brewer, spoke on the stratosphere and his personal experience with researches into the composition (particularly humidity and ozone, of course) and radiation. Unfortunately the recorder was absent during this meeting, and no one missed him until it was too late. However, Prof. Brewer's accomplishments in stratospheric research are well known by all the members of the Society.

January 1967

The third meeting of the 1966-67 season was held on January 31st. Dr. E. Vowinckel, of McGill University, spoke to the Centre on the subject of "Evaporation from Land Surfaces". He used the water budget equation as the basis for a discussion of evaporation and run off in Southern Canada.

In the first part of his lecture, Dr. Vowinckel discussed the different approaches to the determination of evaporation. The exchange formulae appear to be best suited for evaporation calculations for a point or small uniform area, but have a limited usefulness for large areas. The hydrological equations and all other budget equations, on the other hand, have an optimum applicability to large natural land areas. A few remarks on the construction of precipitation averages for catchments followed, and the possible errors in the run off data caused by ground water run off and changes in storage over a 5-year period were mentioned.

In the second part of his lecture, Dr. Vowinckel showed some evaporation and run off maps for Southern Canada, based on average results from catchments. He then discussed a method for calculating uniformly spaced grid point values of evaporation and run off, provided that average catchment evaporation, grid point values for precipitation, temperature, and slope of the ground are known. Some maps based on this method were then shown for the Prairie Provinces. A grid-point distance of $\frac{1}{4}^{\circ}$ latitude was used. Detailed evaporation patterns of considerable interest were apparent. As an example of how this method can be used to study individual components of terms in the water budget equation, the two different influences on run off, temperature-precipitation and slope, were depicted on separate maps.

A brief discussion of the conclusions to be drawn from the maps ended the lecture.

February 1967

The fourth meeting of the 1966-67 season was held on February 28th. Dr. R. Rogers, of McGill University, addressed the Centre on the subject "The Summer 1965 Hawaiian Warm Rain Studies".

During the months of July and August 1965, atmospheric scientists from the United States, Japan and Australia met on the island of Hawaii for an intensive investigation of certain aspects of the warm rain process. Dr. Rogers, who had participated in the programme while affiliated with Cornell Aeronautical Laboratory, described some of the more significant findings that have emerged, most of which have not yet been published. These findings range from new information about the island's mesoscale circulation, as determined by the groups from the University of Hawaii and C.S.I.R.O., Australia, to some rather unexpected results obtained by the team from Nagoya University in measurements of the electrical charge and salinity of raindrops.

The speaker's radar investigations provide new data on the updraft structure of Hawaiian rain, and in addition, indicate that the growth of precipitation, once the raindrops form, is by simple gravitational accretion. The cloud microphysics studies of Cornell revealed a significant difference in character between the condensation nuclei measured inland and at the coast. This difference was found to be reflected in aircraft measurements of cloud droplet concentrations and sizes.

The critical question of how the initial raindrops are formed so efficiently in these clouds was not definitively answered, but the programme generated valuable information about the warm rain process that ought to stimulate further research.

March 1967

There was a good turn out of wives of members for a "Ladies' Night" meeting of the Centre on March 21st. Dr. J.T. Parry, Department of Geography, McGill University, spoke on a subject most appropriate for this Centennial year: "Geomorphological Evolution of the Montreal Area". The mixed audience was thoroughly entertained by a sparkling 3-hour commentary on what must surely become a classic series of 150 colour slides, including many aerial photographs, featuring familiar natural landmarks of Southern Quebec. A few of the highlights of the talk are reported in the following paragraph.

A Geomorphologist studies naturally occurring shapes and forms on the Earth's surface. The Montreal area landscape is dominated by two basic geological facts. First, the Pre-Cambrian Canadian Shield lies just to the North. Second, the St. Lawrence Lowlands are formed of the same Paleozoic rocks as the Appalachians. The Pre-Cambrian Laurentians are a complicated mixture of sedimentary and igneous rocks which have been worn down to their present state by erosion. The mainly sedimentary

St. Lawrence Lowlands have also been subjected to erosion; and the more-resistant igneous intrusions, Mount Royal and the other isolated Monteregian rocks, have been left behind as striking features of an otherwise flat landscape. There is ample evidence that the St. Lawrence Lowlands constitute a rift valley with major rock fault lines to the North and South. For instance, there have been 5 perceptible Earth tremors in Montreal since 1900, and each year there are about 20 imperceptible minor shocks recorded by seismic instruments. During the Ice Ages, there have been occasions when the whole area was covered with a layer of ice 5,000 feet thick, causing the land underneath to be temporarily depressed by 700 feet. Consequently, as the ice of the last major glaciation retreated about 10,000 years ago, there was a marine transgression linking Lake Ontario with the Atlantic Ocean. This explains many of the more interesting details of the landscape, such as cobble beaches and marine clays in unlikely places in the Laurentians.

As a result of this pleasant evening spent listening to Dr. Parry, Montreal meteorologists will now have many interesting tit-bits of geomorphological information to impart to their sight-seeing EXPO guests during the summer.

INTER ALIA

C.C. BOUGHNER - Chief, Climatology Division, Meteorological Branch, was the 1966 winner of the Patterson Medal Award for distinguished service to meteorology in Canada. The presentation was made at the First Annual Congress of the Society. The citation noted the over 30 years contribution to the development of Climatology in Canada and the 20 years as a member of the W.M.O. Commission for Climatology, including the position of Commission president for the past 5 years.

R.E. MUNN - has been elected chairman of Committee TA-8 (Meteorology) of the Air Pollution Control Association. As such, he is a member of the Technical Council of the Association.