METEOROLOGICAL STATIONS IN HIGH LATITUDES.[1]

By SIR FREDERICK STUPART, Director, Meteorological Service of Canada.

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As the years go by, the public, in the many countries which maintain meteorological services, become more and more convinced of the necessity of an increased knowledge of the climatology of land and sea and also of the usefulness of weather forecasts, but even now governments which control national expenditure appear loth to supply the funds for special investigation, the expediency of which is obvious to the scientific worker.

Our legislators do certainly regard with favor the efforts of the meteorologist to supply data recognized as important in furthering the successful accomplishment of many activities in commerce and finance. They readily allow that a knowledge of the weather prevailing along trade routes is useful and that accurate weather forecasts for the coasting shipping is desirable. Also the data demands by engineers covering rainfall and snow over watersheds to be utilized either for irrigation or for electrical power is recognized as being indispensable.

When, however, it comes to granting funds for the equipment of an out-of-the-way Arctic station—or a lonely island station, the benefits to be derived are not quite obvious and difficulties may arise.

It is certain, moreover, that in order to have a full understanding of the atmospheric circulation data must be received from all portions of the globe. There is no other science in which the problems to be solved requires more international cooperation than does meteorology which deals with the atmosphere and its circulation. The initial stages in the development of a storm which may devastate a portion of the United States coast may have occurred in Canada and vice versa, and the successful warning of many a disastrous hurricane in the south has been from information received from Mexico and the West Indies.

In early days of the synoptic weather map, the data on which forecasts were based was very meager compared with that which we possess to-day. In looking over the early charts showing storm tracks it is interesting to note how fallacious were our ideas as to the real location of the tracks of depressions; many were shown as being near the fiftieth parallel, whereas the centers were in reality much farther north, and during the colder months were probably the offspring of deep barometric depressions off the northern coasts of Alaska. Then again, there was always doubt regarding the approach of anticyclones from the Northwest and it was not until the Northwest States and Manitoba were in the grip of the blizzard that warning of cold waves could be dispatched to the region of the Great Lakes.

Forecasts were not issued by the Canadian Service until October, 1876, and for several years Winnipeg was the most outlying telegraph-reporting station in the Northwest; it was several years later that Qu' Appelle, Battleford, Calgary, and Edmonton, became reporting stations, and it was not until 1890 that we had reports from British Columbia. During all these early years the Canadian Service, and I doubt not the American Weather Bureau, quite realized how much they were handicapped by the lack of data from the North, and many years were to pass before there was any marked improvement. Canada opened a telegraph station at Dawson City, Yukon Territory, in 1900, but the telegraph line was more often down than up and being so far distant from other stations, its usefulness was not equal to what it is to-day.

That meteorologists were of the opinion that a knowledge of pressure distribution in high latitudes is essential to a fuller understanding of atmospheric circulation is certain from the numerous discussions at the various meteorological conferences which were doubtless an important factor leading to the establishment of stations in Iceland and Spitzbergen and quite recently Jan Mayen Island.

In my opinion one of the greatest advances made in the weather map from the point of view of research workers in the United States and Canada occurred when, in 1912, the Alaskan stations began to transmit their reports to Washington. This was a splendid contribution.

About the same date also European reports were first received regularly in both Washington and Toronto, but unfortunately just as we were beginning to thoroughly appreciate their value, the war broke out and it was not until April, 1921, that they were resumed.

I am glad to be able to state that during the next summer Canada will place several wireless stations in the valley of the Mackenzie River, which will we trust afford valuable data supplementary to that received from Alaska, regarding the development of anticyclonic areas and cold waves.

It seems a far cry from Alaska to Great Britain and northwestern Europe but by great circle across the polar regions the distance after all is not so very great, and when we enter the barometric readings of Europe, Spitzbergen, Iceland, and Jan Mayen Island on a meteorological chart of polar projection and enter on the same chart the Alaska readings, together with the reports from regular American-Canadian weather chart it is usually possible to interpolate for the polar regions and connect and join up the isobars of northern Europe with those of northern America. Charts thus prepared show us a great deal and would appear to indicate that the general character of the winters of the Northwestern States and northwestern Canada and even of the Great Lakes depends very largely on the meteorological conditions over the North Pacific Ocean and Alaska. We know that during the winter months radiation over the wide land areas of Siberia and northern America leads to the formation of high pressure and intense cold. These maps make it clear, however, that in some winters at least, the North Pacific LOW plays a rôle which tends greatly to modify the pressure distribution in northern America. In these winters deep depressions come in over the Aleutian Islands and northern Alaska and seem actually to prevent the formation of anticyclones over the Mackenzie River Valley, and when this occurs mild winters may be looked for throughout northwestern America and even to the Great Lakes.

In other winters the North Pacific LOWS either lack energy or approach the American coast much farther south and then anticyclonic conditions take control in the north and great cold waves sweep southeastward over the continent. In such winters it would almost seem that the Siberian high pressures extended across as one system into America.

A study of these northwestern America early winter types of pressure distributions is exceedingly interesting, and it appears to me that there is perhaps no part of the

[1] Presidential address given before the American Meteorological Society, at Boston, Mass., Dec. 30, 1922.

continent where meteorological conditions can be more profitably studied, leading as they do to such far-reaching results.

It happens that within the past five years there have been marked examples of extreme types of both dominant anticyclonic and cyclonic conditions in these high latitudes. In December, 1917, the anticyclone was dominant in northwestern America. In December, 1918, it was the cyclone which dominated and southerly and southwesterly winds prevailed through the Canadian and American west even to the Great Lakes.

In view of the facts I have outlined, it appears to me to be desirable that the number of stations in the Arctic Zone should be augmented. The existing Alaskan stations are admirably situated, but another station at Point Barrow would be a great acquisition. A few stations in northeastern Siberia would be most instructive and one hopes that their establishment will not be long delayed. Canada, as before stated, will this coming summer place wireless stations at a few points in the valley of the Mackenzie River and one hopes that a couple of stations in Baffin land will be in existence within a year or so. The North American stations will then link up well with the Danish and Norwegian stations of Greenland, Jan Mayen, Spitzbergen, and others, thus affording splendid data for investigating changes in the polar front.

While advocating an increase in the number of meteorological stations in high latitudes, I am not unmindful of the fact that a meteorological survey of the Pacific Ocean with its varying currents and temperatures may be even more important than a land survey, as the variation in the intensity of Pacific cyclones may depend largely on variations in ocean temperatures.

Assuming now that the great importance of stations in the far northwestern portions of North America has been demonstrated, we might with perhaps equal certainty show that wireless stations on Hudson Bay and in Baffin land would be most useful. When great anticyclones come in over western America their dominating influence is usually lessening as they spread toward the Atlantic coast, and we find that some of the coldest waves in eastern Canada accompany high areas coming in over Labrador, which high areas develop over the northeastern, not the northwestern, portion of the continent; and again these Hudson Bay and Labrador high areas represent the conditions under which Atlantic coast depressions are apt to develop, and moving northeast give severe storms along the Atlantic steamship routes.

FREQUENCY DISTRIBUTIONS OF DAILY AND HOURLY AMOUNTS OF RAINFALL AT GALVESTON, TEX.

By I. R. TANNEHILL, Meteorologist.

[Weather Bureau, Galveston, Tex., December 15, 1922.]

The rapidly-increasing use of rain insurance invites attention to the frequency distribution of rainfall. There has been considerable discussion of this subject in recent years and little hope is offered for a mathematical solution. Frequency polygons and other graphical solutions have been presented and these are valuable in that they disclose certain peculiarities in the frequency distribution of rainfall, perhaps local, which must be taken into account in any complete description of the climate and which would otherwise escape attention.

One of these peculiarities is the skewness or assymmetry of rainfall distributions.[1] The study of a series of rainfall-frequency polygons shows that the distribution of annual amounts does not conform to the law of errors;[2] that negative departures occur somewhat more frequently than positive and that the amount occurring with the greatest frequency is less than the mean. In consideration of monthly amounts it is found that the distribution is less symmetrical and may be multimodal.[3] The frequency distribution of daily amounts bears no resemblance to the normal or Gaussian distribution of errors. It is best represented by a J-shaped curve.

Thus, we find that shortening the period of time in which the individual amounts fall apparently increases the skewness or asymmetry of the distribution.

Therefore the problem that confronts the insurance company in the establishment of rates for rain insurance is the most difficult, since hourly and daily amounts are insured against and chiefly the former.

We may obtain an average value of rain frequency for either the day or the hour in any given locality. In the long run these averages will be borne out approximately. Rain insurance is not issued for all hours of the day and night with the same frequency, nor for all seasons with the same frequency, and therefore the averages or means are not trustworthy.

Again, all amounts of rain are not insured against. The policies usually limit the amounts to 0.10 inch or more, or to 0.20 inch or more. Another artificial limit has been introduced which greatly complicates the problem.

In preparing a table of premium rates for rain insurance the insurer depends upon the records of the Weather Bureau. Rain data are usually in the form of means and totals together with rather limited information concerning the frequency of certain extremes or excessive amounts. Because of the fact that the distributions of rain frequency are unsymmetrical in monthly and annual amounts and altogether asymmetrical in daily and hourly amounts, these means are of doubtful value in determining the probability of occurrence of certain amounts.

For example, the Weather Bureau computes a normal fall of rain for each day in the year. This amount may be, say, 0.12 inch for January 1 in a given locality. This value, 0.12 inch, is of no particular value in determining the probability of rain on January 1. At Galveston the normal for January 1 is 0.15 inch. In the 50 years this station has been in operation, the amount 0.15 inch has never occurred on January 1.

It would be possible to compute a normal fall for each hour of the year. Such a value would have no particular use. How, then, is the insurer to arrive at any trustworthy conclusion as to the amount or amounts likely to occur with the greatest frequency and how is he to determine the frequency with which a certain amount will be exceeded?

Rate tables have been issued, however, and one company states that rain insurance is being written almost as freely as fire insurance. Apparently these rates are based upon the frequency of days with 0.01 inch or more of precipitation.

In the following, the frequency of daily and hourly amounts of precipitation will be discussed with reference to Galveston, Tex., in the attempt to show that the aver-

[1] Tolley, Howard Ross: Frequency Curves of Climatic Data: MO. WEATHER REV., November, 1916, 44: 634–642.
[2] Marvin, Charles Frederick: Elementary Notes on Least Squares, the Theory of Statistics and Correlation for Meteorology and Agriculture, MO. WEATHER REV., October, 1916, 44: 551–569.
[3] Weeks, John R.: Climate of Binghamton, N. Y., shown by the Histogram Method: MO. WEATHER REV., February, 1921, 49: 53–62.