No less interesting, as showing the prevalence of lengthy periods of extremely low water before the forests were removed, is the evidence of the "pictured" rocks in the bed of the river a short distance above Steubenville, Ohio. These large flat rocks lie on the bed of the river, and have been seen but a few times by white men and then for but a short time. On these rocks are cut pictures of men, animals, birds, and fish. The pictures were evidently cut a long time before white men settled in that section. Considering the crude cutting instruments which must have been available to the Indians or their predecessors a long time must have been required in the cutting, which could be done only at times of very low water.

The bottom lands in the forks of the river are usually level. On the strength of Col. Bouquet's statement that the overflow was 10 feet deep during the flood of January, 1762, an idea may be had of the elevation of the flood. The old blockhouse foundations are at an elevation of about 722 M. S. L.

The ground appears to have been raised about 1½ feet about the blockhouse walls since 1764. These assumptions are taken to be approximately correct, and from them it follows that the 1762 flood was about one-half foot higher than the flood of 1907. The area of the fort was probably raised about 6 feet above the bottom land with the material obtained from the wide and deep moat excavated along the three sides of the fort.

THE IMPORTANCE OF WIRELESS WEATHER REPORTS FROM GREENLAND.[1]

By V. BJERKNES.

[Bergen, Norway, Nov. 23, 1921.]

To the EDITOR:

I take pleasure in submitting to you a translation of a letter from Dr. V. Bjerknes, Bergen, Norway, to the Danish explorer, Mr. Einar Mikkelsen, referring to the importance of daily weather aerograms from Greenland. The letter was written at the request of Mr. Mikkelsen, who intended to publish it in the Copenhagen newspaper, *Nationaltidende*. On October 23, 1921, a storm had caused great damage and loss of life in the Danish waters, mostly because the storm had not been forecast by the meteorological institution. This brought the newspapers to discuss the possibility of increasing the efficiency of the weather forecasts, and especially the importance of a wireless station on Greenland. The letter from Bjerknes not only shows the importance of such a station for the forecaster in northern and middle Europe, but it also outlines several of the valuable results as to the formation and movements of cyclones across the Atlantic Ocean, recently obtained by Bjerknes and his collaborators. These results have been of great value for weather forecasting in Norway. It may thus be mentioned that the storm of October 23 was duly predicted from Bergen and Stockholm, where Bjerknes's methods were in use.

In sending me a copy of the letter, Prof. Bjerknes gave me permission to translate it to English and eventually to publish it. I therefore submit a translation to you, hoping space may be found for it in the MONTHLY WEATHER REVIEW.

Respectfully,
H. U. SVERDRUP.

WASHINGTON, D. C., *January 9, 1922*.

At your request for an expression referring to the value of daily weather telegrams from Greenland and related questions, I desire to make the following statement:

A line drawn from the south point of Greenland to the British Islands is crossed in one year by about 200 single depressions, all of which originate to the south or the west of the line and disappear to the north or the east. Every depression reaches an average age of about one week, and can be identified by a typical region of precipitation accompanied by a characteristic distribution of temperature, wind and barometric pressure. This distribution changes in a typical way with the age of the depression, so it is always possible to tell whether a depression is new born, developing, developed to full strength, or dying. A new-born or dying depression moves slowly, but one which is in the period of full strength can move very rapidly; the velocity may reach 150 kilometers an hour, which is sufficient for covering the distance from the south point of Greenland to Denmark in 21 hours. In this phase of development the depression in its structure reminds one of the tropical cyclones, hence the name cyclone, which is commonly used in the meteorological literature.

One of the most important observations during the last years is that these cyclones occur in well-defined groups. Each group consists of 3 to 6, usually 4, single cyclones. On the Norwegian weather maps the groups are now indicated with a number, and the single cyclones in the group with one of the letters, *A*, *B*, *C*, etc. The *A*-cyclone has its path most northerly, the *B*-cyclone is following a path a little more to south, the *C*-cyclone goes still more southerly, and so on. The *A*-cyclone of the next group appears then far north, the *B*-cyclone follows along a more southerly path, and the performance is repeated. A group of cyclones usually passes by in about 6 days. From January 1, 1921, until to-day, November 23, 59 cyclone groups have crossed the line from the south point of Greenland to the British Islands.

The coast of Norway, which has a long extension from south to north, is touched by practically all cyclone groups and usually by every cyclone in the group. The *A*-cyclones can as a rule be designated as arctic cyclones, which is of most consequence for the northern part of the country. The following cyclones, *B* and *C*, are pressing more against the coast, so that *C* often forces its way across the mountains and continues its path over Sweden and Finland. The *D*-cyclone does the same thing, or it chooses the way south of Norway over Denmark, the southern part of Sweden and the Baltic Sea. The *E*-cyclone takes usually a still more southerly path, if it is formed. The cyclone which brought the devasting hurricane over Denmark on October 23, thus, according to the Norwegian list, was an *E*-cyclone, No. *53E*, formed on October 21 west of the British Islands. *D*-cyclones and the following *E* and *F* may have effects as far as to the Mediterranean.

Within the frame of these constant laws the cyclones and groups of cyclones display great mutual differences in strength, velocity of progression, choice of path, and so on. These are the circumstances which make the forecasting of the weather so difficult. If this is to be made with desirable certainty, then the forecasting meteorologist at any time must have a full view not only of the nearest cyclone but of the whole group and its dispositions. One main defect of the weather maps with which the forecaster now has to be content is that they are of too small geographic extent to render this full view of the situation.

[1] Dr. H. U. Sverdrup, who communicated this translated letter, is temporarily in Washington on scientific work relative to the Amundsen polar expedition. This expedition, which contemplates a drift across the Artic Ocean from a point northwest of the Bering Strait to a point between Greenland and Iceland, has been temporarily delayed by an accident to the propellor of the *Maud*, and the vessel is now in dry dock at Seattle. A new start is contemplated in June.—*Editor*.

Here we are at the essential point. If a wireless station were sending daily weather telegrams from one or preferably from a greater number of Greenland meteorological stations, then a cyclone would not often be able to cross the line from Greenland to the British Islands unobserved. It would be possible at an early phase to carry through the classification, which now to a great extent takes place after the cyclones have raged off the coast of Norway. If the forecast can be based upon a reliable classification made at a sufficiently early phase, then one ought not often to be surprised by a devastating storm. For middle Europe, from Denmark to the south, the case will be about this: The cyclones *A*, *B*, and *C* will usually not give occasion for any anxiety. From a distance they will have influence upon the daily weather and be of importance for the forecasts, but they will rarely cause violent storms. But when the *D* cyclone comes, then the meteorologist must be alert.

A special reason why the *D* cyclone and those following often come as surprises is that they are often formed relatively close to the European coast, even within the European region. However, if the meteorologist has had opportunity to study the preceding *A*, *B*, and *C* cyclones closely, then he already at an early phase will know when and where a *D* cyclone may be formed. He further knows that the *D* cyclone in the first 24 hours will not develop any dangerous violence or move with unexpected velocity. But on the second or third day the wind velocities in the cyclone may reach the violence of a hurricane, as was the case with the October cyclone crossing Denmark. Also the tendencies in this respect are evident from the conditions under which the cyclone is formed. In the same way it will be possible at an early phase to decide whether an *E* cyclone will form after the *D* cyclone, and so on.

Therefore, in order to be able from the very beginning to follow this play of the cyclones, which determine the weather of Europe, a wireless station at the south point of Greenland will be of the highest importance. This station will be of great value for Denmark, and a fine gift to the whole of Europe. For the countries with the most exposed positions, Iceland, the British Islands, and Norway, the importance of this station can not be overestimated.

It is evident from the efforts these countries have made to obtain protection that great economic interests are dependant upon reliable weather forecasts. Wireless weather telegrams are now sent from English, Swedish, and Norwegian ships crossing the Atlantic Ocean, and French ships are expected soon to begin. This is a good support, which, however, can never replace a station on Greenland, because the routes of the steamships are so far south that the observations from the ships do not render the full view of the situation. Further, Norway has in this year experimentally established a weather station with wireless on the most inhospitable of all polar islands, Yan Mayen. This station has only been operated a few months, but has already proved so useful that there will hardly be thought of abandoning it. However, weather telegrams from Greenland would be of still higher importance, which is made evident by the following example:

During the period December 1, 1919, to March 15, 1920, between 70 and 80 storms occurred at that part of the Norwegian coast for which the forecasts at that time were issued from Bergen. Not less than 22 of these storms were either not predicted or the issued warnings came too late to be effective. I must add, that these unwarned storms on an average were the most violent. But only six came from the direction in which the station on Yan Mayen now makes us feel safe. The other 16 came the common way from the west, where only telegrams from Greenland can render corresponding safety.

Let me also mention that in addition to these unwarned storms, five or six cases of false alarms occurred. These cases are regarded as the worst mistakes of the forecasters, because they shake the confidence of the public in the storm warnings. But they appear inevitably, because the forecaster, one time after another, has to take a chance and send out a storm warning based upon the first uncertain indications. He knows that if he would wait for the next observation, then the warning would come too late. This is the situation of the forecaster in this and in other countries: on the one hand, the responsibility for great economic values and human life—on the other hand, the responsibility, not to mention the laughter that accompanies the false alarm. What makes the situation so awkward is that the forecaster usually has to form his opinions of the coming weather on an absolutely insufficient foundation. When work of this kind is demanded, then the foundation for such highly responsible decisions must be made as good as possible.

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DISCUSSION.

By A. J. HENRY.

The observation by Dr. Bjerknes regarding the occurrence of cyclones in well-developed groups must refer mainly to cyclones which have their origin to the westward of and pass over Northwestern Europe. It is important to emphasize this distinction, otherwise the impression may be created and perpetuated that the occurrence of cyclones in groups is a characteristic which belongs to all cyclones of the Northern Hemisphere.

Seasonal causes seem to control the place in latitude at which cyclones pass onto the Continent of North America. Cyclones of the winter enter the United States from the Pacific most frequently along the coast north of latitude 45°.

South of that latitude the occurrence of winter cyclones is much less frequent; indeed, several years may pass without the occurrence of a single cyclone south of San Francisco, hence we incline to the belief that the rule enumerated by Dr. Bjerknes does not apply to the Pacific coast storms. Bowie and Weightman [1] in their discussion of the different types of cyclones explain the movement in low latitudes as being due to high pressure in Alaska and the western Canadian Provinces. They say, in discussing storms of the Northern Pacific type:

> Storms of this class usually make their appearance on the Washington and Oregon coasts and thence move eastward in widely different courses. There are two, however, that are often followed—one due east along the northern border and the other southeastward from the North Pacific States to the Southern Plains States and at times quite to the Gulf coast and thence eastward or northeastward. During the time of appearance of lows of this type the Aleutian low is well defined, but somewhat south of its normal position, and the pressure is above normal over the interior of Alaska. The Alberta type of disturbance is no longer in evidence and in its stead the pressure is unusally high in that region, the Northern Plains States, and in the

[1] Storms of the United States, MO. WEATHER REV. SUPPLEMENT NO. 1, Washington, 1914.