

5. Where do typhoons originate? What is their fundamental cause?

6. What are the normal tracks of typhoons relative to their place of origin, to the season, etc.?

7. Do typhoons ultimately, say, when they enter the region of the Aleutian Islands, become normal extratropical cyclones?

8. Are the kona storms of the Hawaiian Archipelago a result of the extratropical cyclones?

9. If so, what are the circumstances of pressure distribution in the regions of the north Pacific high-pressure area and the Aleutian low-pressure area which combine to cause them?

10. What are the relations between the prevailing distribution of air pressure over the Pacific and the character of the weather in the Pacific area, such as hot or cold periods, wet or dry, extending at times over months, seasons or even years?

11. Similarly, what are the relations as affecting the weather of adjacent land areas?

12. What are the interrelations between surface winds and ocean currents?

13. What are the relations between surface-water temperatures of the Pacific and air temperatures and, consequently, the positions of "centers of action" and their shifts over that ocean and over adjacent land areas?

14. At what average elevations are the so-called antitrade winds found from place to place along the Tropics?

15. What are the diurnal, monthly, and annual variations in antitrade wind elevations?

16. What are the normal velocities of the antitrades and the departures therefrom?

17. What are the relations, if any, that exist between volcanic and seismic activity and weather changes?

18. What new facts, if any, can be established with regard to fog?

19. What steps should be taken to increase the practical application of meteorological knowledge?

20. What are the more special meteorological problems of Pan-Pacific countries?

As has been stated, some of the features of Pacific Ocean meteorology are already more or less well understood. This is true of those appearing under questions Nos. 1 to 6, inclusive. Additional knowledge in regard to these features can only result from the cooperative activities of the several Pan-Pacific nations.

Question No. 7, as to whether typhoons become extratropical cyclones, has not perhaps been satisfactorily answered and requires further study of observations from the regions lying between Japan and the Aleutian Islands. The suggestion has been made that in this as well as in other connections fixed or semifixed vessel weather stations should be employed in the less frequented regions to supplement reports from vessels on the established trade routes.

Questions Nos. 8 and 9 are in a fair way to be answered. Results might be hastened by the inauguration of the proposed system of vessel weather stations, which would make available data from certain untraveled waters.

Questions Nos. 10 and 11 may be answered as a result of the same methods of study but a longer period of time, possibly several or many years, may be required in so doing.

Questions Nos. 12 and 13 have been given general consideration for many years. The making of more widespread observations and of a more specific study of the temperatures of the ocean surface water and of

the temperatures, pressures, and winds in the Pacific region appear to be necessary before No. 13 can be answered.

Questions relating to the antitrade winds, comprised in Nos. 14, 15, and 16 have been considered only slightly and before they can be answered many pilot and sounding balloon observations will be required, as well as observations from land stations of high elevations along the Tropics.

Question No. 17, likewise, has received but slight attention. A long series of meteorological, volcanological and seismological observations throughout the Pan-Pacific region and a comparative study of the same will be required before an answer can be made to this question.

The specific meteorological problems of the several Pan-Pacific countries, referred to under the head of question No. 20, are so varied and complex that their presentation would go beyond the scope of this general survey and therefore no attempt is made to enumerate them. However, without knowing what these problems may be it is reasonable to assume that under the plan of intimate and hearty cooperation evolved at the Pan-Pacific Congress the mere suggestion on the part of any one nation of a desire for aid from other member nations will meet with a quick and intelligent response.

If methods of procedure were to be suggested at this time they would doubtless be based upon such general concepts as uniform scales and measures, synchronized observations, both on land and sea, standardized codes and signals, the more prompt exchange of reports, including a larger daily exchange, and a more liberal policy with respect to the translation from one language to another of books and papers on meteorological subjects.

551.5 (265.2)

METEOROLOGICAL CENTERS OF ACTION IN THE NORTH PACIFIC OCEAN.¹

By EDWARD A. BEALS, Meteorologist.

[Author's abstract.]

Since Teisserenc de Bort first called attention to the "centers of action" over Iceland and the Aleutian chain of islands, much study has been given the subject. It has been found that, besides these centers of action or LOWS, the permanent HIGHS over the Atlantic, Pacific, and Indian Oceans, and the winter HIGHS and summer LOWS over the continents are modifying factors.

The Pan-Pacific Conference is of interest to meteorologists because of the proposed scientific survey of the Pacific Ocean. Two powerful centers of action are located in the north Pacific.

It had previously been noted that falling pressure in the Iceland Low produced warmer, and rising pressure colder weather in central and northwestern Europe. Reasoning from analogy, similar changes in the Aleutian Low should produce corresponding changes in weather over North America.

The late Prof. Garriott maintained that when the depression over the Aleutians is abnormally low the north Pacific HIGH increases in size and overlaps the southwestern coast of the United States, causing temperatures below the seasonal average there. Offshoots from the Aleutian Low would then take a northern route in their progress eastward, and large areas in the United States would come under the influence of southerly winds, and the resulting weather would be unseasonably mild. Many

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examples of extreme weather conditions during the past 30 years seem to verify Prof. Garriott's conclusions.

Maj. E. H. Bowie, who has also given the subject considerable attention, has formulated many rules of value in forecasting. The two of perhaps the most consequence are the following:

"With high pressure over Alaska, more precipitation than usual occurs in the United States."

"Cold waves of more than short duration do not occur when the barometer is low over Alaska, whereas intensely cold weather over the United States east of the Rocky Mountains is generally associated with high barometer over Alaska."

The north Pacific HIGH forms where it does because of three conditions: (1) Differences in temperature between the north polar and the equatorial regions; (2) deflection of winds due to the rotation of the earth on its axis; and, (3) the ocean surface is coldest near the latitude where causes 1 and 2 operate to produce the formation of the HIGH.

It is assumed by the forecasters of the San Francisco Weather Bureau office that when the summer temperature in that city is above normal the north Pacific HIGH is weaker than usual, and when the summer temperature is below normal the contrary conditions exist. Dr. G. F. McEwen explains the cool waters off the north California coast as being due to the upwelling of cold waters. The prevailing westerly winds at San Francisco will be relatively warm or cool in accordance with the condition of the surface waters over which they blow before reaching the city.

When the north Pacific HIGH is weak, few, if any, offshoots will move eastward across the north Pacific States, and the pressure will be below normal in the interior of the country west of the Continental Divide. This will result in prolonged, unsettled weather without much rain, but with more than the usual amount of cloudiness. On the other hand, if the North Pacific HIGH is strong there will be offshoots from it crossing the north Pacific States with considerable regularity, and the weather will be settled and clear, with warm days and cool nights over a large portion of the Pacific Slope.

Ocean currents move slowly, and if it is possible to determine the temperature of the water off the California coast at or near where they are upwelling most strongly, then we would know two or three months in advance whether or not ocean currents fed by these waters would be warmer or cooler than usual. Such information would be of great value.

The Aleutian LOW is caused by a combination of the effects of the general circulation of the atmosphere and differences in temperature between the water and the mainland. It is probable that the activity of the LOW is increased when the water is warmer or the land is colder than usual. When the water is warmer than usual, observations of temperature of the Japan Current near Formosa (Taiwan) would probably give information of value by informing us three or four months beforehand that warmer water than usual was about to reach the Bering Sea. When the land becomes abnormally cold, weather reports from the interior of Siberia and Alaska are necessary. If it is possible to ascertain in advance that the Aleutian LOW is about to change its position or to become either more or less energetic, such information would have a direct bearing on the weather

that later will be experienced in the United States and Canada.

In studying the movements of LOWS and HIGHS a dozen widely separated stations are insufficient. Dr. Bjerknes found when making weather predictions in Norway during the Great War he had to increase the number of stations from less than 10 to about 90 before getting worth-while results. We should have instead of 10 in the neighborhood of the Aleutian LOW as at present, no less than 100 to secure satisfactory results.

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DROUGHTS WITH CIRRUS CLOUDS MOVING FROM THE NORTH.

During my many years of observations of the weather, I have always noticed that just before the beginning and during a protracted period of dry weather, the upper clouds, namely, cirrus, cirro-stratus, cirro- and alto-cumulus, which normally move from the SW., W., or WNW., suddenly change their direction and come from the NNW., N., and even NE. This was especially noted during the very recent drought in this section. At its commencement the cirrus moved abnormally fast from the NNE. During such dry periods, although the clouds may thicken to almost darkness, only a few sprinkles occur. On the other hand during conditions of ample rains, the upper cloud movement is from some southerly quarter. Surface winds are then generally from the north or east. Other observers have made similar observations especially in regard to the movement of cirrus clouds during long stretches of aridity and their tendency to move out of the North at such times.

Can not this dry condition be explained by the fact that the source of the rising air is far to the north as shown by the cirrus movement and such air coming from regions of low temperature has a low moisture content and therefore little or no rain results. When this condition is reversed and the movement of air is from the south in the upper atmosphere, copious rains fall because of the great increase of vapor capacity of air coming from these warmer regions and also for their greater buoyancy from latent heat when condensation starts.

As a general rule, when low-pressure areas are far to the north the tendency of the cirrus movements is from a northerly quadrant and vice versa, but during periods of abnormally dry or wet weather these conditions are greatly intensified and the cirrus may move rapidly or slowly from direct North or South as the conditions may be.—Douglas F. Manning, Alexandria Bay, N. Y., June 19, 1920.

Later note, June 10, 1921.—This district needs rain quite badly, in fact the general conditions appear very droughty. The cirrus cloud movement is as I have always observed under such conditions and which I have mentioned in other letters, "almost directly out of the north," perhaps a little east of north these days. About a week ago just before the arrival of the big HIGH from the north with its polar air, the cirrus changed their direction and came out of the southwest. But a few days after their direction reversed again. It has come to my notice without fail that cirrus movement from a southerly direction accompanies cool rainy weather. Perhaps this only holds good in this part of the country.—D. F. M.