That the United States Weather Bureau be urged to enlarge its Marine Division considerably, not only to care for the additional clerical work that such tabulation will entail, but also to conduct much needed studies of such data, and

That copies of this resolution be sent to the Director of the Scripps Institution of Oceanography, the chiefs of the United States Weather Bureau and the United States Hydrographic Office, the Director of the Budget, the United States Senators and Representatives from California, and to all Western Chapters of the A. A. E.

IS IT POSSIBLE TO PREDICT CALIFORNIA'S RAINFALL SEVERAL MONTHS IN ADVANCE? [1]

By E. A. BEALS

Outline for Hopeful Investigations

According to Dr. Charles F. Brooks, Professor of Meteorology and Climatology at Clark University, the most hopeful lines of investigation for solving the problems connected with long range weather forecasting are four, the salient features of which are: [2]

Under section A are included the grand atmospheric centers of action, sequences and cycles. Also the unity of world weather, whereby abnormal seasons are controlled by the variations in position and strength of these centers of action, and the correlations between the weather in widely separated parts of the world would be considered.

Under section B comes the primary causes of unseasonal changes. Solar changes as indicated by the solar constant, sunspots and other phenomena; lunar and terrestrial phenomena such as volcanic dust, eruptions, etc., would be studied to determine exactly their effect.

Under section C, Dr. Brooks has placed terrestrial phenomena, sustaining and ramifying initial changes. This would include the effects produced by ocean temperatures, cold and warm currents, snow on land and ice covering the polar oceans, and the whole complex ensemble of world wide sequences, which need to be investigated fully to see to what extent they synchronize with other phenomena.

Under section D the subjects are combination forecasts; keys to long range forecasts to be found in particular places; predict dominant factor for each place for each season, and find out how far applied to North America.

I believe the plan suggested by Dr. Brooks to be a very good one. My studies have been made mostly under the "A" head where atmospheric centers of action are considered and an outline of my discoveries will be given later.

Variations in the Warmth of the Sun

Dr. Abbot, Director of the Astrophysical Observatory of the Smithsonian Institution, leads in the work of studying the solar constant. He has

[1] Delivered before the California Academy of Science, May 8, 1927.
[2] Cf. February, 1927, BULLETIN, p. 31-32.

an observatory at Montezuma, Chile, another at Table Mountain, Calif., and still another, recently established at Mt. Brukkaros in southwestern Africa. The observers at these places measure daily, when the sky is clear, the amount of heat received from the sun. From these observations Dr. Abbot has gone considerably in advance of many scientists in claiming that the warmth from the sun varies from day to day, and that these variations may affect our weather and our daily life upon the earth. The sun we know has a temperature of something like 11,000 degrees on the Fahrenheit scale, and while the earth receives only one two-billionth part of its heat, it is sufficient to melt a layer of ice over 100 feet thick over the whole earth in one year. To put it another way, if the sun's rays fell vertically and unobstructed on a square mile of the earth's surface they would warm 500 tons of water from the freezing point to the boiling point in one minute. Even a small fraction of change in heat so great as this, obviously may mean a great deal in its effect on the climate of our earth.

Grand Centers of Action

The work under section "A," namely the study of atmospheric centers of action is the one with which most immediate results could be expected in making long range forecasts for a locality, such as California, and happens to be the one with which I am most familiar as the result of a quarter of a century of experience. There are not less than eight of these centers of action in the world's atmosphere with several small ones of less importance. My work has enabled me to observe four, and to make what I believe are discoveries about the way they act.

"Centers of action" is a comparatively new term in meteorology used to designate rather complicated phenomena. There are places on the earth, as you know, where the barometer is relatively low or high for long periods of time. This is caused by differences in temperature varying with the seasons, and to differences in the absorption and reflection of the sun's rays by the different portions of the earth's surface. The surface of our oceans is cooler than the land in summer, and warmer in winter. This causes the upper heated currents of air over the land in summer to flow toward the cooler oceans, and in winter to flow from above the warmer oceans to the land. Because of the revolution of the earth on its axis, and the differences in temperature between the equator and the poles, the flow of air from ocean to land and back again is not evenly distributed, but accumulates in some localities more than in others, and the places of greatest excess and deficiency are called centers of action.

Of the high pressure centers of action the most powerful one is central over Mongolia. It covers nearly all of Asia, beginning to form in the fall of the year, reaching its maximum in January and disappearing in the late spring. At this time another high pressure center of action is located over the Plateau region of western North America, which for

much of the time reaches out over the Pacific Ocean along the California coast.

The most important low pressure center of action in the Pacific Ocean is located over the Aleutian Islands, and it is co-existent with the two high pressure centers of action. All three disappear during the summer and at this time there is a large high pressure center of action, which covers more than half of the North Pacific Ocean, with its center about twelve hundred miles west of Humboldt Bay.

These are the centers of action that have interested me the most as they have a direct bearing on the weather in the Pacific States. The others are located in the South Pacific, Indian, and Atlantic Oceans, and while an interrelation exists between them, very little is known about its operation. The quantity of air pressing upon the earth does not vary, but its distribution does, therefore the above and below departures in the position and strength of the centers of action will be found in the transference of air between the hemispheres and between oceans and continents. The primary causes, it would seem are from variations in the sun's radiant energy, and in the absorptive conditions of the earth's atmosphere. If this surmise be true then the variations in the solar constant may prove extremely valuable for long range forecasts.

Plan for Predicting California's Rainfall

From a daily study of weather maps prepared under my supervision at Portland, San Francisco, and Honolulu for a quarter of a century, I have come to the conclusion that the most hopeful solution of the problem of long range forecasting in California lies in getting more detailed information about the winter high pressure center of action over Asia. Very little is known about this disturbance for the reason that the Chinese and Mongolians have not been interested in making weather observations along modern lines. The Russians have many meteorological stations in Siberia, but as our government does not recognize the Russian government, the recent data they have accumulated cannot be officially procured by the United States Weather Bureau, though it can be obtained by private individuals by corresponding directly with the Russian weather observers.

To California, the track the storm takes after leaving the Aleutian Islands on its way to the United States, is vital. The full maturing of our crops cannot take place without sufficient moisture, and much money and labor could be saved, or adequate preparations made, if the amount to be expected could be told with reasonable accuracy in advance. If the track the storms take from the Aleutian Islands is northern, we get no rain; if the storm enters the United States south of the mouth of the Columbia River, we do get rain; and the farther south the track the greater the amount.

I am convinced that the route they will take depends largely on the behavior of the winter high pressure center of action over Asia. This high pressure center of action is almost continually sending out off-

shoots, which apparently break away from the parent disturbance and slowly surge or pulsate eastward. Some of these off-shoots separate from the parent body from its southeastern, and some from its northeastern quarter. Those that separate from its northern portion drift eastward to the north of the Aleutian low, where our storms are born, and those that separate from its southern portion drift eastward to the south of the Aleutian low. The tendency for those moving east to the north of the Aleutian low, is to push that low farther south, and the farther south it happens to be when a storm is generated, the farther south will be the track it takes, and hence the greater the likelihood of its bringing rain to California. When off-shoots from the Asiatic high move east to the south of the Aleutian low, they have a tendency to push it farther north, and thus decrease the possibility of rain in California. Furthermore, off-shoots moving eastward to the south of the Aleutian low merge with the remnant of the Plateau high that overlaps the California coast, which increases its size, and thereby still further operates to prevent rain in California. No general rains can occur in California with a high barometric pressure hugging the coast with its center north of the 42nd parallel of latitude.

Off-shoots from the Asiatic high pressure center of action that pass to the north of the Aleutian low, besides pushing that low farther south and increasing the liability of rain in California, also merge with the cold air in Alaska and northwestern Canada causing such an excess of high pressure that it moves southeastward and brings a cold wave into the middle and eastern portions of the United States. The most severe cold waves in the United States are those from the Canadian Northwest, and it is quite likely that some of the air in them was first chilled over Siberia and we cannot blame Canada for manufacturing all of it.

It is my opinion that the bigger the Asiatic high, the more numerous will be the off-shoots pulsating from it, and very likely the size of this high will have a bearing on the place where the off-shoots most frequently separate from the main body. Our first problem of long range forecasting for California would thus be one of determining as far ahead as possible whether the Asiatic high will be above or below its average size during the coming winter.

The threads to be followed for this information lead to the interrelation of the centers of action in other parts of the world, for very probably a deficiency of air in one would be compensated by an excess in one or more of the others. Weather reports from ships have been gathered daily only within the last few years, and this service has enormously widened the field of observations. World wide weather reports now can be easily obtained, and the only thing lacking for their full utilization is an international controlling power to co-ordinate the work so as to prevent duplication and at the same time increase its efficiency. When this is done it will not be hard to concentrate work on these centers of action and thus obtain first hand information upon what now appears to be the key points in making long range forecasts.

Whether my plan for predicting California's rainfall several months in advance is sound I leave to your judgment; for myself I cannot help believe that the line of action I have pointed out will, if followed, lead to the accomplishment of practical results to the satisfaction of the vast economical interests that will thereby be benefited.

POSSIBLE GULF COAST-CALIFORNIA SEASONAL WEATHER SEQUENCE

May wind velocity at Galveston, Texas, I. R. Tannehill says, reached the highest average (15.3 mi/hr) on record there (57 years). April was also the windiest month of that name (14.5 mi/hr). Mr. Tannehill comments, "Undoubtedly this strong southerly circulation was connected with the heavy rainfall and unprecedented Mississippi Valley flood, as high southerly spring winds at Galveston are associated with a retreat of the rain area to the interior of the continent." He also calls attention to the rather close parallel, that has been maintained since 1916, between the May wind velocity at Galveston and the subsequent August-October sea temperature at La Jolla, California. Dr. McEwen has been using the latter for his trial forecasts of seasonal rainfall in southern California for the past 9 years (cf. October or November BULLETINS of the different years.) Unless this parallel is merely a chance one, we should expect warm water on the southern California coast this year: One might almost say that if the water there is not above normal in temperature after such a strong wind at Galveston there can be no important relation between the two.

SEASONAL SNOW SURVEY AND FORECAST OF STREAM FLOW, APRIL 1, 1927

Nevada Co-operative Snow Surveys

I. CENTRAL SIERRA QUADRANGLE

(Including the basins of the South Yuba to Tuolumne and Truckee to Walker. However, western outposts are still lacking for all western basins except the South Yuba).

SUMMARY

The snow cover this season is quite variable, especially at different altitudes because of winter melting.

The percentage of normal at the high altitude snow survey courses as of April 1, varied from 126.6 to 139.4, and it is probable that approximately similar percentages of normal would have resulted at lower altitudes had it not been for melting before the survey. As it was, the loss in low altitudes, as contrasted with the high, varied from 33.9% of normal in the Truckee basin to 45.7% of normal in the Walker basin.

Some of the premature melting occurred at the time of rains and abnormally high temperature late in December and early in January and