

Although the various seismological problems have been, for convenience, classified into three groups, it must not be inferred that they are sharply defined and distinct; each group will contribute to the problems of the others. Instruments that are primarily intended for world-wide problems will yield information bearing on local problems in their neighborhood; and instruments meant for local problems will also record the world-shaking earthquakes.

Relations to Other Sections of Geophysical Science

For convenience we divide science into branches, influenced largely by differences in the methods used. But nature knows no such dividing lines; and we find that many problems can be solved only by the cooperation of several branches. This is especially true of the geophysical sciences. The special section of seismology looks to all the other sections for help; to geodesy to determine the slow earth movements, horizontal or vertical, that lead up to earthquakes, and the sudden movements that take place at the time of the shock; to meteorology to tell us the atmospheric conditions when microseisms are prevalent; to physical oceanography for information about the deeps of the oceans, along whose borders submarine shocks are common.

The independence of earthquakes and volcanoes has been strongly emphasized during the last thirty years, because nearly all the strong earthquakes were unaccompanied by volcanic phenomena of any kind; and, on the other hand, the great volcanic outbursts, such as Krakatoa in 1883 and Mt. Pelée in 1902, caused only insignificant earth tremors. These facts cannot be contraverted; and still we must not forget that the volcanic belts lie in or near the great earthquake zones; and there may be some common cause of both classes of phenomena.

The influence of earthquakes on suspended magnets may be assigned, with much confidence, merely to the mechanical vibrations. But may not the altered state of strain, in the neighborhood of the generating fault, change the magnetic condition of the rock there if the rock contains magnetic minerals, so that the general magnetic field might be modified? Or may not the passage of violent earthquake waves through magnetic rock alter its magnetization, especially if that magnetization was assumed at some time when the earth's field was different from what it now is?

Seismology does not ask without giving. It can contribute its conclusions to the other branches of science and help them in the solution of their problems.

THE STATUS AND PROBLEMS OF METEOROLOGY

BY C. F. MARVIN

Meteorology is one of those sciences which developed on the side of practical application for the welfare of mankind to a far greater extent

than the development on the scientific or pure theory side of the problem. As a result, meteorologists responsible for the practical applications to human welfare are at a distinct disadvantage on account of the imperfect and incomplete theoretical development of the science.

The United States was distinctly the pioneer among all nations in officially and formally creating a meteorological service. This was done by a joint resolution of Congress in 1870, which provided that advices, warnings and forecasts concerning future weather conditions should be prepared and issued for the benefit of agriculture, commerce and navigation.

The greatest achievement of the Weather Bureau is doubtless that of creating the present organization of a service of applied meteorology from the nucleus resulting from this early legislation.

Taking the U. S. Weather Bureau as a prominent example of a well-developed, thoroughly organized agency for the application of the principles of meteorology to the welfare of man, it seems appropriate to outline below, in the briefest possible manner, the principal activities and subdivisions through which this public service is rendered.

THE WEATHER BUREAU

A Daily Service of the Science of Meteorology Applied to Human Welfare.—When Congress created the Weather Service in 1870, the primary object was to benefit and protect navigation on the Great Lakes and Atlantic coast by advance warnings of dangerous storms. Later the issue of flood warnings was added to its duties. To-day there is scarcely any important industry or activity of the nation which is not to a greater or less extent influenced by weather conditions, and therefore needs the advices, information and economic benefits which flow from the full and efficient administration of all its duties.

These benefits are of great variety and the information, advices and warnings of the Weather Bureau serve the immediate needs of practically every interest and industry of the nation. Great atmospheric disturbances visit with relative frequency one section of the country or another. Violent storms, cold waves, frosts, freezes, hurricanes, floods, heavy snows, and the like, repeatedly cause destruction of property, such as shipping on the Great Lakes and coastal waters of the nation, and, in recent times, the lives and property engaged in aerial navigation. Crops and farms in flooded districts are laid waste. Lambs, livestock, and meat animals in the stock ranges of the west are killed by blizzards and cold waves. Orchard crops, truck gardens, and vineyards everywhere are damaged by frosts and freezes. By forecasts and warnings, issued and disseminated well in advance, great economic benefits and saving accrue to the nation through the precautionary measures which can be taken on timely ad-

vices to minimize or ward off injuries which otherwise inevitably attend the great atmospheric phenomena mentioned.

The following comprise the principal items of service:

SUMMARY OF WEATHER BUREAU ACTIVITIES

1. WEATHER FORECASTS AND WARNINGS

Weather forecasts and warnings are based upon simultaneous observations of local weather conditions taken daily at 8 a.m. and 8 p.m., 75th Meridian time, at about 200 regular observing stations scattered throughout the United States, and upon similar reports received daily from points in the West Indies, Central America, Hawaiian Islands, Alaska, Canada, Bermuda, and a few other parts of the Northern Hemisphere. The reports are received by telegraph, charted, and the forecasts and warnings deduced therefrom are issued from district centres located at Washington, D. C., Chicago, Ill., New Orleans, La., Denver, Colo., and San Francisco, Calif. The forecasts and warnings are of varying classes as follows:

(a) *Daily Forecasts and Weather Information.*—These forecasts are issued twice daily in the a.m. and p.m. and are telegraphed to about 1,600 principal distributing points and thence they are further disseminated by telegraph, telephone, radio and mail to several thousand communities. They are furnished also to the press association and newspapers and are published by practically every daily newspaper in the United States, thus reaching all sections and every class of people. The weather observations on which the forecasts are based are printed in map and bulletin form and mailed or delivered to commercial, marine, agricultural, industrial organizations, educational institutions, etc.

These maps and bulletins are prepared, printed and distributed within three hours after the observations are taken.

The manifold uses to which the daily weather forecasts and weather information are applied are impracticable of enumeration as the life and activity of the whole population is more or less affected by the weather and receives more or less benefit therefrom.

(b) *Weekly Forecasts.*—Forecasts are made each Saturday for the six days beginning with the ensuing Monday. These forecasts are made separately for nine districts covering the entire United States, and necessarily are couched in general terms. They are immediately telegraphed to certain designated centres whence they are further disseminated by telegraph, telephone, and mail, and are published in Sunday and Monday newspapers following the day of issue.

These forecasts are intended more particularly for the agricultural interests, as a guide to their activities during the growing season; and the Weather Bureau is in receipt of many communications testifying to their great value.

(c) *Shippers' Forecasts.*—Forecasts of temperature expected within the following 24 to 36 hours that will be injurious to perishable products in shipment are made by officials in charge of the stations located in large commercial centres. They are issued only when temperatures of 32 degrees or lower, or 90 degrees or above, are expected.

Special distribution of these forecasts is made to railroads and shippers of perishable products. Shipments are to a large degree regulated by these forecasts. The saving affected thereby is enormous.

(d) *Storm and Hurricane Warnings.*—This service consists of the issuance to shipping interests on the Atlantic, Pacific and Gulf coasts and in the waters adjacent thereto and on the Great Lakes, of warnings of the approach of storms dangerous to shipping, and to the coasts of the South Atlantic and Gulf States and adjacent regions of the approach of hurricanes. These warnings are disseminated by means of flags by day and lanterns by night, displayed at about 425 ports. In addition, the warnings are tele-

phoned and telegraphed to practically all maritime interests and broadcasted by wireless to ships in the threatened regions. So nearly perfect has this service become that scarcely a storm of marked danger has occurred for years of which ample warnings have not been issued from 12 to 24 hours in advance.

The sailings of the immense number of vessels engaged in our ocean and lake traffic are largely determined by them. Warnings displayed for a single hurricane are known to have detained in port on our Atlantic coast vessels valued, including their cargoes, at over \$30,000,000. Fewer dangerous storms than usual occurred during 1919. However, one unusually severe one occurred on the Lakes in November, accompanied by wind velocities of over 80 miles an hour. Owing to the ample advance warnings not a single marine casualty was reported. Only one tropical hurricane occurred, namely, that of September 6-14, 1919, that passed over southern Florida, traversed the Gulf of Mexico and struck the coast of Texas near Corpus Christi. It was attended by large losses in life and property that were inevitable, but the saving to ships and other property as well as lives was incalculable because of the warnings that were distributed well in advance of the storm. This hurricane was of extraordinary intensity and the efficiency of the warnings was so complete that the portion of the Gulf of Mexico which it traversed was practically cleared of shipping; otherwise many ships valued at millions of dollars would have been caught in the storm. Few, if any, ships caught within the storm centre could have survived. This efficiency of service added to the difficulties of the forecaster, because he was unable to secure wireless reports from the region of the storm centre which were so necessary for an accurate determination of the hurricane's direction and progress.

(e) *Cold Wave Warnings*.—These are warnings of sudden and destructive temperature changes that frequently sweep across the country during the winter season. They are issued from 24 to 36 hours in advance and are disseminated throughout the threatened regions by means of flag displays, by telegraph, telephone and mail.

The uses made of these warnings are manifold. They are especially valuable to railroads in the making up of trains and the maintenance of schedules, to shippers of perishable goods, cattle growers, and innumerable business organizations. The warnings issued in a previous year for a single cold wave of exceptional severity and extent resulted, according to reliable reports, in a saving of over three and a half million dollars. No unusually severe cold waves occurred during 1919, although warnings were issued on about 30 different occasions for moderate cold waves.

(f) *Frost Warnings for Truckers, Tobacco, Cranberry and Sugar Growers*.—These warnings are issued whenever conditions indicate the occurrence of damaging frosts. The growers take advantage of these warnings to protect their crops by the various means in vogue. In many instances the growers are dependent upon the Weather Bureau for these warnings as without them their industries would be too hazardous to be profitable. This is especially true of early trucking in the South Atlantic and Gulf States. During the year 1919 rather fewer instances than usual of weather conditions necessitating these warnings occurred; but during the year previous it is of record that warnings of a damaging freeze saved nearly one-third of the entire sugar crop in Texas and Louisiana by enabling the growers to windrow the standing cane.

Special frost warnings are sent to all parts of the tobacco-growing section in Wisconsin and Connecticut. Information of current weather conditions during the growing season is also supplied to the other large producing areas.

Frost warnings are sent to the principal cranberry-growing sections of the country, which enable growers to protect their crops by flooding or other protective means. They are indispensable to this industry.

(g) *Fire Weather Warnings*.—These warnings are issued whenever conditions are favorable for hot, dry winds, which are favorable to the inception and spread of fires

in the National and other forested regions. They are distributed principally to Forest Service officials and others charged with forest protection.

The warnings aid in the protection of the forests by enabling crews and apparatus to be ready for action. Numerous testimonials of their value have been received, several in the form of resolutions passed at the conventions of Forestry Associations, urging appropriations.

(h) *Forecasts and Warnings for Stock Growers.*—This service covers the western and northwestern portions of the country and consists of warnings of cold waves, high winds and heavy snows. These warnings enable stock men to make proper provision for the protection of stock exposed on the ranges. They are of especial value to sheep men during the shearing and lambing periods as heavy losses sometimes occur when proper protection has not been provided, sometimes as much as 50 per cent of individual flocks. In the States of Washington, Oregon, and Idaho alone there are two million sheep valued at \$12,000,000, exposed to the weather and the sheep men depend largely on the Weather Bureau for information as to when protective measures should be taken.

(i) *Fruit Frost Warnings.*—This service is maintained in a number of important fruit growing sections of the country, particularly in California and Oregon. A killing frost without warnings or protective measures means disaster to the crops. So important has the work become that a trained meteorologist is assigned to important districts during the frost danger season to determine how low the temperature will fall and to advise as to the extent of the protective measures that must be taken.

(j) *Forecasts for Alfalfa Growers.*—Special warnings are issued for alfalfa seed growers in the principal seed producing sections of the West, and for alfalfa hay making in nearly all sections from the Mississippi Valley westward. Frosts are frequent at about the time alfalfa seed is maturing and are very damaging to unharvested crops. It is estimated that near harvest time, the crop increases in value at the rate of about five dollars an acre during each twenty-four hours; if it is cut too early, much loss is sustained but a heavier loss may result from frost if not cut early enough. On the receipt of a warning, the growers vigorously push harvesting operations to save as much seed as possible.

In addition to the seed growing service, fair weather warnings are sent to all the principal alfalfa growing districts of the West, during the hay-harvesting period. In Oklahoma alone two thousand alfalfa growers receive these special forecasts which are distributed through the County Agents of the Farm Extension Service.

(k) *Fruit Spraying Forecasts.*—A special fruit spraying service is maintained in New York and other important fruit growing districts, by which special forecasts are made for the benefit of fruit growers during the spraying season. The effectiveness of spraying depends largely upon the weather conditions at the time and immediately after spraying, and this service is of much value in supplying information as to the best time at which this work should be done. This service has been so successful that requests are on file for the establishment of similar work in a number of districts not now covered.

2. HIGHWAY WEATHER SERVICE

This service consists of the issue of bulletins, daily, semi-weekly, or weekly, depending on locality, giving the conditions of the main highways in the section in which the distribution centre is located, and their passability as affected by rains, heavy snows and other conditions. ~~Detours~~ and other pertinent information ~~are included.~~ Bulletins are issued at about 50 stations in 30 states. These bulletins are used by travelers in determining journeys and routes, in the dispatching of truck, determining loads, etc.

3. AEROLOGICAL INVESTIGATIONS; FORECASTS AND WARNINGS IN AID OF AVIATION

This work involves the obtaining of free air data in different parts of the United States for the purpose of making these data immediately available for the information and assistance of the forecasters of the bureau, army, navy, and post office fliers. The observations also are summarized, studied, and the data published for the purpose of furnishing reliable information as to free air conditions for the benefit of aviation in general and especially for the aviation and artillery services of the army and navy.

Advices to the Navy crews, for the trip from Newfoundland to the Azores, were based to a considerable extent upon free air observations over the ocean. The N. C. 4 reached her destination and the other two landed close enough to the Azores so that their crews were rescued. Without the wind assistance as predicted none of these seaplanes could have flown as far, and the crews would probably have perished.

The British dirigible R. 34 left this country for England just in time to prevent being swept away by a high wind. The forecaster based his warning partly upon upper air observations. Its officers have stated that had not the warning been received the air ship, valued at more than \$1,000,000, would have been lost.

The N. C. 4's recruiting trip during the autumn was successful from beginning to end largely because her pilot followed the weather forecasts, which were based partly on upper air observations.

There is no authenticated instance in which an aviator has had an accident due to bad weather, when favorable weather had been predicted.

4. MARINE METEOROLOGY IN AID OF NAVIGATION; VESSEL REPORTING

Meteorological observations taken on ships plying all the seas of the world are collected, charged, and discussed, and the information furnished to the Hydrographic Office of the Navy and published in the pilot chart issued by that office. The information is also made available for vessel owners, ship builders, and others engaged in work relating to ocean navigation. Moreover, the information is of value and assistance to the forecasters in preparing weather forecasts, storm, hurricane and other warnings. A full understanding of the meteorology of the ocean is of tremendous economic value in determining the safest and best voyage routes, the location of dangerous storm areas and meteorological facts of value to mariners.

Vessel reporting stations are maintained at Cape Henry, Va., Sand Key, Fla., Point Reys, Calif., and North Head, Neah Bay, Tatoosh and Port Angeles, Washington, for the purpose of reporting to ship owners the passage of vessels in and out of straits or capes at a distance from the port of destination. This gives owners several hours advance notice of the docking of ships and enables them to assemble stevedores and make other arrangements regarding loading and unloading, etc.

5. EVAPORATION AND RUN-OFF INVESTIGATIONS

Evaporation investigations are conducted in certain arid and semi-arid regions of the west for the purpose of determining the loss of storage water by evaporation. These results are of direct value to engineers in planning city water supply systems and water and irrigation reservoirs.

A special project is being conducted at Wagon Wheel Gap, Colorado, in coöperation with the Forest Service, which involves the study of the effect of forest covers on stream flow, erosion, and run-off. The scheme involves the making of continuous observations in two nearly similar water sheds in their natural forested condition for a term of years; then to denude one of the water sheds and continue the observations for a similar period of years for comparative purposes.

6. RIVER AND FLOOD WORK

This is one of the most valuable and important activities of the Weather Bureau. Service is maintained on all of the navigable rivers of the United States, their tributaries and water sheds. Gages are located at suitable intervals on the rivers for determining water stages and rain gages distributed throughout the water sheds. Stage readings and precipitation are telegraphed daily to district centers where the observations are tabulated, summarized and published on the daily weather maps or in bulletin form. When conditions warrant, warnings of floods are disseminated to all affected interests in the flood areas by telegraph, telephone and other means.

The saving which results from this service consists in transferring goods, stores and other movable property to places of safety. In the south and southwest live stock is pastured in river bottoms many of which are subject to overflow in time of flood. A notice of the coming of the flood permits the owner of the live stock to drive it out of the bottoms, and to safeguard any other movable property that may have been left in the threatened region. Forecasts of extreme low river stages are also of much value to navigation in many rivers.

7. MOUNTAIN SNOWFALL AND WATER SUPPLY INVESTIGATIONS

This service is maintained in the western states in order to give dependable information relative to the seasonal snow cover, its depth and water content. This information is valuable in determining the probable water supply that will be available both for irrigation and power purposes in those states having little or no rainfall in the summer months.

8. CLIMATOLOGICAL WORK

This work consists of the collecting, compiling, charting, and discussing climatological data of the United States, its adjacent oceans and outlying territories. In addition to the observations taken at the more than 200 regular stations of the Weather Bureau, observations of temperature, weather, precipitation, etc., are taken by cooperative observers located in practically every county of the United States. These observations are compiled and printed monthly and disseminated to the public, to commercial exchanges, farmers, engineers and home seekers and many other classes. The value of this work is incalculable. It affects and benefits the entire people; is used in the settling of damage claims, cases at law and for other purposes too numerous to mention. In New York City alone the weather records are brought into court by personal appearance of a Weather Bureau official more than 500 times a year. Several thousand certificates are issued annually over the seal and signature of the Secretary of Agriculture for court use. More than 100,000 people annually make inquiry and are furnished statements regarding past weather records. The economic value of the climatological work of the bureau is enormous.

9. AGRICULTURAL METEOROLOGY

This service consists in the collection and dissemination of information relative to the effect of current weather conditions on farm activities, the growth of vegetation and the development of crops and their advancement as compared with an average season. Advice is given and information disseminated relative to the utilization of the special forecasts and warnings issued by the Weather Bureau in the interest of various lines of agriculture and horticulture and stock raising. A number of lines of investigations are being conducted as to the relationship between weather conditions at various periods of the growing season and crop yields.

(a) *Weekly Weather and Crop Bulletins*.—The National Weather and Crop Bulletin issued weekly at Washington contains a detailed summary of the weather conditions throughout the country for the period covered by each issue and indicates the resulting

effects on the development of vegetation and farm activities in general. In addition, the Bulletin contains from time to time charts and discussions bearing on the relation of climate to crops and agricultural operations.

The value of this publication is evidenced by the popular demand for it, which has grown to such proportions as to severely tax the printing facilities of the Bureau. There are about nine hundred paid subscriptions to this publication and about twenty-seven hundred other recipients.

In addition, a weather and crop summary is issued during the active agricultural season at each state center, forty-two in number, which is disseminated by bulletins and through the public press.

These services are of much value to those interested in agricultural operations throughout the country, as they afford detailed information as to the prevailing weather in all sections and its effect on farming operations and crop development.

(b) *Corn and Wheat Service.*—This service is maintained during the active growing season of each year, April 1 to September 30, in sixteen principal grain states. Daily weather reports are received from one hundred and eighty-seven special reporting stations. Daily bulletins are issued from nineteen points. A weekly corn and wheat region bulletin is issued also at the regional center, Chicago, Ill.

This service is of especial benefit to farmers, dealers, millers and others interested in the cereal crops of the United States, and gives accurate information as to prevailing weather conditions throughout the principal producing areas during the period of crop development. There are constant and persistent demands for extensions of the service into regions not now covered.

(c) *Cotton Region Service.*—This service is similar in organization and operation to the corn and wheat region service, and covers the cotton growing states of the country. About two hundred reporting stations are maintained. Bulletins are issued from 26 stations located in the cotton belt. The service is maintained in the interest of cotton growers and others engaged in various lines connected with the industry. It is considered by cotton growers and dealers to be of indispensable value.

(d) *Cattle Region Service.*—This service is maintained for the collection and dissemination of information of current weather conditions over the great grazing districts of the west and southwest as affecting the stock industry. Weekly bulletins are issued from a number of central points throughout the year, giving information as to rainfall, temperature, snowfall, and general grazing conditions on the ranges.

10. SOLAR RADIATION INVESTIGATIONS

The importance of sunshine as a weather and climatological factor is fully recognized by meteorologists, climatologists, biologists and others. Until a comparatively recent time, only the duration of sunshine has been recorded. The object of the solar radiation investigations is to measure the intensity of the sun. These data have not only direct application to agriculture, but have a value in many other ways. Illuminating engineers have for a long time been asking for measurements of daylight or sunshine intensity expressed in light units. This information is of special value to them in connection with the designing of factories and other buildings to meet the requirements of state laws relative to natural light.

11. SEISMOLOGICAL INVESTIGATIONS

The object of these investigations is to determine how frequently on the average and how severely the various portions of the country are shaken by earthquakes. From the data thus collected, it is determined what sections of the country are seismic; just where the active cracks are, and their liability to further slips or movements. This information is of prime importance in enabling engineers to avoid the placing of aqueducts for city water supplies, dams and other structures on or across fault lines.

12. VOLCANOLOGICAL INVESTIGATIONS

This work is now confined to studies of the activity of the Kilauea Volcano located on the Island of Hawaii. It has been conducted by the Weather Bureau for little more than a year, is scientific in character, and it is impracticable at this time to assign thereto any pecuniary return to the people.

APPROPRIATION

The appropriation for the Weather Bureau for the fiscal year ending June 30, 1920, amounted to \$1,880,200, almost the whole of which is expended for public service, and under existing conditions but little is available for investigation and research. It is very easy to show that benefits accrue to the United States in the proportion of much more than one thousand to one.

PROBLEMS OF METEOROLOGY

It is now necessary to carry on all the practical routine functions of this service while the forecasters and officials are still doubtful concerning many of the most fundamental and important laws and causes of the atmospheric phenomena with which the science deals.

Education.—Very few of the great universities carry any courses in advanced meteorology. In fact, meteorology receives far less attention in the institutions of learning than is given to almost any other branch of science. Tendencies to the more profound recognition of meteorology in education are in evidence, and it is earnestly hoped that much more intensive attention can be given to this science in view of its enormous practical importance in the everyday life of humanity.

Meteorological Laboratories.—Progress in other lines of science has been made in many cases by leaps and bounds through the establishment of laboratories for the conduct of specific investigations. The really great problems of meteorology cannot be brought within the domain of a laboratory, and no real meteorological laboratory yet exists, although certain elemental phenomena of meteorology admit of investigation in the best physical laboratories. Progress is delayed, no doubt, because of the inability to subject the great major phenomena of meteorology to laboratory and controlled investigation. The difficulties involved in these considerations appear to be inherent and insurmountable, leaving to the student only the alternative of minutely analyzing the complex mass of meteorological data, with the view to working out the more or less indefinite correlations and the coefficients of involved equations representing all the factors in operation in arriving at any particular result. The masses of data available are enormous, and meteorology has been criticized for continuing to accumulate, as it must from other important considerations, observations of every sort of atmospheric condition while its discussion is sadly neglected. Students are needed to study this mass of data, and it is often difficult to know where to begin or how to proceed.

Meteorology of the Oceans.—While the mass of data available for land and continental areas is very great, the details of information available from the larger expanses of ocean areas are correspondingly meager and inadequate. Owing to the uniformity of conditions over the ocean areas, as well as their tremendous extent, we should expect the sequence of atmospheric phenomena to be more simple and easy of investigation. The collection of more complete data from ocean areas and its intimate analysis and discussion are, therefore, most important.

Aerology.—The term *aerology* has come recently to be applied to the meteorology of the free atmosphere in contrast to observational data dealing specifically with surface conditions. The appliances and agencies for conducting observations in the free air have been improved, multiplied and made highly practical, and the attainment of practical navigation of the air has not only added to the observational possibilities but has imposed new and important obligations on the meteorologist to make applications of his science to the aid of aerial navigation. Free air observations over the oceans especially are greatly desired, although very difficult to secure. The whole field of investigations in the free air is relatively only recently occupied and appears to be fruitful of the most important developments. The organization of systematic studies of upper air observations to be carried on concurrently with the making of the observations is at once among the foremost problems awaiting consideration.

WORLD METEOROLOGY

The development of the so-called world meteorology as typified by the collection, summarization, and publication of simultaneous weather reports from all civilized countries has been the goal of meteorologists for many years. The desires of a number of international meteorological conferences in pre-war days are being realized by the publication the "Réseau Mondial" by the Meteorological Office of England. The "Réseau Mondial," however, provides only for monthly summaries of pressure and temperature.

In 1914 the Weather Bureau began publication of a daily chart of pressure and temperature of the Northern Hemisphere from telegraphic and cable reports. The machinery for the collection of the data was put out of commission during the war and has not yet been restored.

In considering the resumption of this undertaking it may be viewed from a totally different angle than formerly, viz., is it not possible by sacrificing the time element to prepare a daily pressure and temperature map of the Northern Hemisphere—say 30 to 90 days after the current dates have elapsed, such maps to serve for study purposes only and to be reproduced in a small edition?

Closely coupled with the above proposition is the need already mentioned of more frequent meteorological observations over the oceans,

more especially the Pacific. In this connection reference may be made to the Committee of Exploration of the National Academy of Sciences which has had under consideration for several years plans for the exploration of the atmosphere over the Pacific. What I have more particularly in mind, however, is the necessity for more meteorological observations from vessels navigating the Pacific. The ordinary means at our command that can be applied to stimulating interest in meteorological observations by vessel masters may not be sufficient to procure an immediate response to this need. In any event it will be helpful and necessary to secure the active coöperation of all the great dominating interests concerned in the development of the Pacific area.

UNIFORMITY IN PUBLICATION

The one great handicap to the use of the accumulated meteorological data is the fact that adequate summaries for representative stations in different parts of the globe are not available. An important forward step will have been taken when the various meteorological services shall agree to compile according to some uniform plan and publish monthly and annual summaries for representative stations under their jurisdiction. This in effect would be an extension of the data now published by the English Meteorological Office to include other elements than pressure and temperature. The subject is one for international conference and consideration; meanwhile each country should begin the preparation of a digest of its own data for the needs of its own citizens.

TERRESTRIAL WEATHER AND SOLAR ACTIVITIES

A profound understanding of the problems of meteorology requires a correct discernment of the ultimate causes of weather. In recent years much attention has been directed to the establishment of detailed correlations between solar activities and terrestrial weather. It seems most important to proceed cautiously in a matter of this kind, since it would appear that the views being advocated by a few leaders in these investigations must be regarded with skepticism and distrust in the forms in which they have thus far been presented. All are in accord that the sun is the ultimate source of all our atmospheric phenomena commonly designated weather. It seems that the daily sequence of sunshine and darkness; the varied distribution of clear and cloudy skies; diversities of surface cover added to contacts of land and water areas, including the phenomena of evaporation, condensation, and precipitation; the cycle of the seasons, and above all the fluctuating but nevertheless perpetual contrasts of surface temperatures, ranging all the way from the heat of the tropics to the intense cold of the polar zones constitute a complex series of varied and changeable influences seemingly abundantly adequate to cause and explain every feature of our weather conditions, however changeable we may find them.

These differences and contrasts on the one hand perpetually disturb the orderly arrangement of air densities and pressures demanded by gravity. The latter, on the other hand, as perpetually and continuously sets portions of the air in motion, in order to establish and maintain a state of equilibrium, which, however, is never attained. We must clearly recognize that *the ceaseless complex changes in and motions of our atmosphere* represent in fact the only state of equilibrium possible between gravity on the one hand and solar heating of the earth on the other.

The disposition on the part of some to attribute important phenomena of terrestrial weather to minor solar activities is believed to be a mistake. It is in fact believed that apparent changes in solar activity, especially of the thermal character, are in reality altogether of terrestrial origin and that the imaginary correlations between terrestrial and solar activities are really the simple relations between atmospheric phenomena at one point and possibly those at another on the earth itself. It is most important that these major problems of cause-and-effect relation between solar and terrestrial activities should be observed, not only with the greatest possible accuracy but that the observational data themselves should be thoroughly analyzed and discussed, first, to establish the magnitude of the errors of the observation, and second, to determine the possible relations between solar and atmospheric effects.

Seemingly the greatest need in meteorology is that of a master mind to direct itself comprehendingly and intensively to the great problems which the science still presents.

SOME OF THE CHIEF PROBLEMS IN TERRESTRIAL MAGNETISM AND ELECTRICITY

BY LOUIS A. BAUER

1. *Analysis of the Earth's General Magnetic Field:* The early completion of the general magnetic survey of the globe, as undertaken by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and coöperating countries, will afford the necessary data for the investigation of some of the so-called "greater problems of the earth's magnetism." One of these is the determination of the various systems of magnetic and electric forces which together make up the total terrestrial magnetic field as observed at the earth's surface. It is known from previous analyses that the earth's magnetic field consists of an internal system of forces, which constitutes by far the major portion; secondly, an external system, supposedly to be ascribed to electric currents circulating in the earth's atmosphere; and, thirdly, a system possibly such as that of vertical electric currents which pass from the atmosphere into the earth and vice versa. The definite settlement of the question as to the existence of the third system is regarded by Sir Arthur Schuster as one