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Weather Bureau

During the second postwar year the trend of demands for weather service continued upward. The foremost problem facing the Weather Bureau was to meet these demands within the limits of available appropriations.

Small additions to staff and facilities were made at a few field units. These provided more highly specialized services to industry, commerce, and agriculture, within designated State areas, and general meteorological information and local forecasts were supplied to many communities heretofore lacking such weather service. To effect a greater utilization of the large quantity of meteorological data on file, the climatological program was modified so as to assist in planning agricultural operations and business enterprises.

The expansion of international aviation brought further new demands upon the Bureau for service and facilities. Many of these new requirements had official recognition in international agreements. Demobilization of military weather units abroad placed on the Weather Bureau the responsibility to staff and operate weather stations in a number of locations beyond our shores, to support air operations on international routes. Some of these activities were located on foreign soil, pending the rehabilitation of foreign weather services. In line with this policy the Weather Bureau undertook, with the cooperation of the State Department, to assist the Republic of the Philippines in organizing and establishing its own meteorological service.

Accepting the commercial radio as one of the most effective means of communicating weather forecasts and advices to the public, the Weather Bureau yielded to new requests for cooperation, and by the end of the year 157 commercial radio stations were broadcasting weather information direct from Weather Bureau offices, without cost to the Government.

During the fiscal year, there was additional improvement in river forecasting services, including the development of water supply forecasts in western areas. The restoration of weather reporting service from ships at sea was also undertaken during the year, with great success.

Exhaustive investigations of the causes and mechanisms of thunderstorms were begun in Florida; analysis of the results of these first investigations was started in 1947 and the field project was reorganized to undertake similar investigations in Ohio during the warm season of 1947.

The beginning of the fiscal year 1947 saw realization of the plans made previously to establish weather reporting stations in the Arctic. Early in the year a station was established in northern Greenland, and

National Oceanic and Atmospheric Administration Report of the Chief of the Weather Bureau

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before the close of the year another station was established at Eureka Sound, in far northern Canada.

The necessity for close international cooperation in meteorological work was emphasized by the Allied military operations during the war, and remains more important than ever before as the world is restored to more normal peacetime pursuits. Numerous international conferences, at which the Weather Bureau was represented, have devoted their attention to the problems of international weather exchanges and standardization of practice.

Several of these conferences were directed to making preliminary arrangements for the International Conference of Directors, to be held in the fall of 1947 at Washington, D. C.; this body normally meets every 4 years, and is scheduled for the first time in its history to meet outside of Europe.

Several new instruments were developed and put into experimental operation. Statistical and theoretical research concerning problems of forecasting the weather was continued and techniques for local forecasting were improved.

More detailed discussion of activities and developments in the Weather Bureau during the fiscal year 1947 is given below:

GENERAL WEATHER SERVICE

Extensive weather service to the general public continued during the year. In addition, arrangements were made for preparation and distribution of weather forecasts for a number of localities that have no direct contact with a Weather Bureau office. In most cases of this nature, forecasts were made available to the local radio stations for periodic broadcasts. Expansion was made in the programs of newspaper weather maps, radio broadcasts direct from our offices, and the dissemination of all warnings of severe weather. The program was designed, principally, for the individual having no particular meteorological background but who, nevertheless, has a genuine need for weather information. Automatic telephone service was continued in six of the large cities with the number of calls monthly averaging close to 1 million. Sampling of service contacts with the general public during representative weeks at the various seasons of the year yielded figures ranging from 109,000 contacts in July to 214,000 contacts in January.

The basic network of weather stations was decreased by 14. Twenty-nine field offices were closed and 15 new stations were opened at locations where demand for weather service was greatest.

Weather analysis center.—The weather analysis center of the Weather Bureau prepared complete daily analyses of weather over the United States and adjacent ocean and land areas for distribution to the meteorological offices of the Weather Bureau, Army, Navy, and commercial air lines. This distribution, which included weather prognostic charts, aided field offices in rendering service to the public by providing the basic meteorological information in an analyzed form. Before the close of the year plans were completed for the establishment of a joint Weather Bureau, Army, and Navy Analysis

Center. This will be a consolidation of the analysis centers of the three agencies.

Communications.—The United States international weather teletype system, known as Service O, was expanded so that all Weather Bureau forecast offices are connected to the system and receive reports from the entire Northern Hemisphere. This expansion has made possible the elimination of foreign reports from the domestic teletype system, Service C. This latter system is now carrying all reports, forecasts, analyses, etc., required by the average Weather Bureau office to provide the basis for a broad program of public, aviation, and special service to the surrounding community. At forecast offices where a more comprehensive picture of the synoptic situation is required, the Service O system supplements on a world-wide basis the reports received on Service C.

The Weather Bureau established a communications and bulletin unit in connection with the office at LaGuardia Field, New York. This unit prepares bulletins for the trans-Atlantic meteorological exchange over the WSY radioteletype network. The unit also edits bulletins received from Europe and Africa before transmission is made on the United States teletype system. This exchange of meteorological information was established to meet the requirements prescribed by the ICAO North Atlantic Regional Conferences.

Radio broadcasts.—The number of microphones installed in Weather Bureau offices by commercial radio stations was still further increased, bringing the total to 157 now broadcasting more than 300 programs daily direct from Weather Bureau offices. The large listener group reached through this medium assures widespread dissemination of all warnings of impending severe weather, which are emphasized in these broadcasts when appropriate.

In response to an increasing demand from aviation interests, a number of Weather Bureau offices expanded the content of these direct broadcasts to include some information of special interest to pilots. In many cases aviation weather data are broadcast in quantity and of suitable quality to enable the private pilot to plan his flights with some degree of safety even though he may be operating from a field located at a considerable distance from the nearest Weather Bureau office.

Newspaper weather maps.—The Weather Bureau continued its policy of providing, insofar as facilities permit, sketch maps which make possible the publication of weather maps by the press. In addition to the considerable number of weather maps published by newspapers through cooperation of individual local offices, the Weather Bureau also collaborated in the preparation of the wire-photo maps distributed through established wire-photo press services. One of the charts regularly distributed represents a departure from the usual type of weather map in that it portrays predicted conditions rather than current weather.

AVIATION WEATHER SERVICES

Domestic aviation.—The rapid postwar expansion of all phases of civil aviation resulted in a corresponding increase in the requirements

for aviation weather service. In some localities these demands exceeded the ability of the Bureau's facilities to meet them satisfactorily. As a consequence, 90 cooperative airway weather reporting stations were established to provide the reports required for scheduled air-carrier operation. The additional forecast load was assumed by the existing forecast centers without augmenting staffs.

Regional airway forecasts, prepared by 16 airway forecast centers, covered the entire area of the continental United States, while 3 centers forecast for the Alaskan area. Terminal forecasts by 21 forecast centers provided specific information concerning expected weather conditions at the major terminals throughout the country, including Alaska and the Hawaiian Islands.

The Flight Advisory Weather Service units, located in 26 airway traffic control centers throughout the United States, continued to provide a specialized type of weather service to controllers for the protection of aircraft in flight. Insofar as communication facilities permitted, the advices from these units were also relayed direct to the pilots of the aircraft.

International aviation.—In May 1947 the Provisional International Civil Aviation Organization (PICAO) became a permanent organization, ICAO. Since the United States is a member of ICAO, the Weather Bureau became directly concerned with and responsible for ICAO matters pertaining to meteorology.

During the fiscal year 1947 the Weather Bureau made preparations for and took part in the second session of the ICAO Meteorological Division, which convened in Montreal, Canada, and participated in three ICAO Regional Air Navigation Meetings: The Caribbean Regional Meeting held in Washington, D. C.; the Middle East Regional Meeting in Cairo, Egypt; and the South Pacific Regional Meeting in Melbourne, Australia. Preparations were also completed for the South American and South Atlantic ICAO Regional Air Navigation Meetings. The purpose of Weather Bureau participation in these meetings was to help develop a program for the establishment of meteorological facilities and services that would meet the needs of international aviation operations and provide for necessary standardization.

The Weather Bureau participated in a conference held in London to develop a program for the establishment of an adequate number of weather ships to be strategically located in the North Atlantic to provide weather information for international airways. The conference agreed that thirteen weather ship stations should be established in the North Atlantic, the cost of seven and one-half to be assumed by the United States. Action to implement this agreement is still pending.

To meet the needs of increased international air traffic, main meteorological offices (independent international aviation forecast centers) were established at Honolulu and San Juan, and additional personnel were provided at San Francisco and New York.

On November 1, 1946, ICAO procedures were put into effect at all Weather Bureau stations serving international air routes in the North Atlantic Region, in accordance with agreements under PICAO.

In accordance with an agreement completed early in the fiscal year 1947 between the Air Transport Command and the Weather Bureau, the latter assumed responsibility for staffing with observing and forecasting personnel approximately 50 foreign stations in Central and South America, Europe, North Africa, Asia, and numerous Pacific Islands. Approximately 200 men were so assigned. Under the technical direction of the Air Weather Service of the Army Air Forces, they provided essential meteorological services for both military flights and international commercial carriers.

Under authority of Executive Orders 9709 and 9797, the Weather Bureau assumed the operation of a number of meteorological stations formerly operated by the military services. Most of these stations were in the Alaskan area, with a few widely scattered stations in the Caribbean, North Atlantic, North African, and North Pacific areas. The type of services provided at these stations varied widely—ranging from outpost stations staffed with one or two weather observers to large meteorological offices providing complete forecasting, pilot briefing, and observational services.

CLIMATOLOGICAL SERVICES

Climatological reports and data.—Little change was made in the basic network of climatological reporting points which, for the most part, are located in small towns or at the homes of farmers throughout the United States and Alaska. There are more than 5,700 such stations manned primarily by unpaid cooperative observers who observe and record rainfall, temperature, and weather each day. These data were checked and tabulated in climatological section centers, most of which are located at State capitals. The tabulated data were published weekly, monthly, and annually in the climatological service bulletins of the Weather Bureau.

Climatological statistics were also gathered and published monthly and annually for all regular Weather Bureau stations manned by full-time personnel. These stations are located in large cities or at principal airports. The climatological information furnished by this network is used extensively by business, industry, and aviation in post-evaluation of operations, in planning future operations, and in determining design values.

Machine tabulation of climatological data.—A pilot project involving the processing of Weather Bureau records on tabulating cards was carried on during the year at New Orleans, La. This project involved the machine tabulation of weather records from the States of Mississippi, Louisiana, Arkansas, Oklahoma, Texas, and New Mexico. The project demonstrated the effectiveness, flexibility, and efficiency of the machine methods of processing weather records. Because of the success of this project, plans were made for its extension to other regions.

Master punched-card library.—Organized and implemented through the efforts of the Army, Navy, and Weather Bureau during early 1946, the joint library of weather data on punched cards, located at New Orleans, La., now contains 100,000,000 such cards. These represent weather observations recorded in the United States and abroad. Also

in the joint library is maintained a repository for all original Army and Navy weather records.

Special projects.—In addition to its routine climatological work, the Weather Bureau conducted several special climatological projects. The most noteworthy of these are:

1. Preparation of Wind Roses for the CAA: This project was undertaken at the Weather Bureau Tabulation Unit located at New Orleans, La. The project is financed by funds transferred from CAA to the Weather Bureau. The wind roses produced under this arrangement are used in planning the lay-out of runways for the Nation-wide airport construction program. Low-visibility wind roses are used in planning the installation of landing equipment.

2. The Navy Aerological Project: The Weather Bureau carried on a continuing project of summarizing Navy aerological records by punched-card methods. The project was financed by funds transferred from the Navy Department to the Weather Bureau.

3. Wind Factors Project: A tabulation of Weather Bureau upper air data, showing the net aiding and retarding effects of upper air winds along principal United States routes, was completed.

4. The Weather Guide Project: There has been an increasing demand for climatological data presented in terms of probabilities and frequency-of-occurrence tabulations for use as weather guides in the solution of long-range planning problems. To make plans as to how the Bureau may satisfy these demands, a pilot project, which translated the mass of weather data for Washington, D. C., into terms of frequencies and probabilities, was undertaken and completed during the year.

Other special projects include studies of the relationship of weather to various phases of business, industry, and agriculture, such as the relationship between corn maturity and autumn frost.

5. Trust Fund Activities: During the year there was a marked increase in the demand for special weather tabulations, the results of which could be stated in specific operational terms and applied to specific problems of business, industry, and agriculture. Since the Weather Bureau does not regularly furnish such special tabulations at public expense, arrangements were made whereby private individuals or enterprises could pay for the cost of such special requests through the use of trust funds, in accordance with the act of May 27, 1935, title 15 U. S. Code 189A, Public Law No. 74. The largest special project undertaken under this arrangement was a study involving the effect of weather on the growth of pineapples and sugarcane in the Hawaiian Islands. Other special projects carried out under the trust-fund arrangement were completed for the Glenn L. Martin Co., Pacific Mills Corp., Pan American Airways, General Electric Co., Du Pont Corp., and others.

HYDROLOGIC SERVICES

Water-supply forecasts.—Forecasts of water supply were issued for the Columbia, Colorado, Rio Grande, Platte, and Great Salt Lake Basins. Those forecasts were issued monthly in bulletin form from January through May to serve as a guide in planning water use for irrigation, electric power, and other activities requiring advanced

knowledge of water supply. Procedures were developed for other portions of the Great Basin.

River and flood forecasts.—Specialized river forecasting centers were established at Kansas City, Mo., and Cincinnati, Ohio, to serve the Lower Missouri and Ohio River Basins, respectively. These centers prepare integrated river forecasts for key points and transmit them to designated river district offices. The district offices are responsible for the localization, interpretation, and dissemination of the forecasts. Modern forecast procedures are being developed for all important points within these areas. Heretofore, the district offices were responsible for preparing the original forecast for one or more river basins in their district.

Flood warnings.—One of the vital services performed by the Weather Bureau is the flood-warning service. During the year, 45 major floods in the United States caused \$150,000,000 in damage to property. Reports covering the value of the flood warnings issued indicate that at least \$15,000,000 in damage was prevented by the timely issuance of warnings. Detailed reports on the floods that occurred are available in the pages of the Monthly Weather Review.

Hydrometeorological investigations.—Continuing its investigations for and in cooperation with the Corps of Engineers, War Department, and supported by \$103,000 of transferred flood-control funds, the Weather Bureau provided hydrometeorological information essential to proper design of flood-control structures.

Sixty-seven storm studies were completed during the year. From such data, estimates of maximum possible rainfall were prepared for 30 river basins throughout the United States. In addition, an intensive study was made of the maximum possible precipitation, including snowmelt contributions, over the Missouri River Basin between Garrison and Fort Randall. Comparable studies were being continued for the Osage and Meramec River Basins of Missouri. A similar investigation was approaching completion for the San Joaquin Basin, Calif. The preparation of isohyetal maps covering the United States east of the one hundred and fifth meridian was well advanced. These maps represent maximum possible precipitation for areas of 10, 200, and 500 square miles. Also, an exhaustive report on the theory, statistics, and hydrologic aspects of thunderstorm rainfall was nearing publication.

In another cooperative project, studies were conducted under funds transferred from the Bureau of Reclamation to determine from snowfall and rainfall data the maximum possible flood-producing conditions in the upper Colorado, Gunnison, Little Colorado, Muddy, and Mojave River Basins. These investigations provide information needed for the design of irrigation dams, spillways, and other engineering works.

Cooperative flood-control activities.—For several years the Weather Bureau has operated an extensive network of stations which make regular measurements of precipitation and furnish reports of river stages. These reports, together with synoptic weather observations and weather forecasts, are relayed direct to offices of the Corps of Engineers, War Department, and become the basis for the operation of flood-control works. Precipitation data from 4,342 stations are pub-

lished regularly in the monthly Hydrologic Bulletins, which serve a basic need in connection with the planning of flood-control activities. Another aid to flood control consists in the preparation of rainfall forecasts, made 24 to 48 hours in advance, and giving day-to-day estimates of the amounts of precipitation that are to be anticipated. During the year, the Bureau was strongly supported in the maintenance of its hydroclimatic networks through the transfer of approximately \$421,000 from flood-control funds of the Corps of Engineers. In addition, the Corps of Engineers provided about \$46,000 to cover the expenses of collection of current reports for flood-control operation.

SPECIALIZED SERVICES

Shippers' Temperature Bulletin.—To fill a need for temperature indications on a Nation-wide basis, the Shippers' Temperature Bulletin was inaugurated November 1, 1946. The Shippers' Temperature Bulletin consists of predictions of maximum and minimum temperatures for representative areas surrounding more than 70 important cities throughout the country. The bulletin is prepared in sections by the 12 district forecast centers and filed for Nation-wide transmission via teletype at 0930 EST, each day. Temperature predictions in the bulletin include the highest expected for the current day, the predicted maximum and minimum temperature for the second day, and, on occasion, predictions for the third day. The Shippers' Temperature Bulletin is intended to furnish general guidance to local Weather Bureau offices in preparing forecasts for long-distance shipments.

Specialized service centers.—To meet increased demands for weather service from agriculture, industry, and the general public, special public service centers were established at Albany, N. Y., Harrisburg, Pa., St. Louis, Mo., Des Moines, Iowa, Houston, Tex., and Portland, Oreg. These service centers are pilot projects to determine the most economical method of providing forecasts designed for particular interests.

Each service center was assigned responsibility for coordinating the specialized service program for an entire State. The principal duties were to adapt to specific activities and areas the general forecasts issued by district forecast offices. Special emphasis was placed on increased service to agriculture. Agricultural weather forecasts and other information for the use of farmers were widely distributed by direct broadcasts from Weather Bureau offices, on farm radio programs conducted by Extension Service agents, and on commercial radio farm programs. For special farm operations, such as spraying, dusting, and harvesting various types of crops, special programs were arranged in cooperation with the Extension Service and commercial radio stations to furnish farmers with specialized weather information needed to plan these activities successfully.

The service centers also provided localized forecasts to many communities where there is no Weather Bureau office. These communities formerly had available only the general forecasts applicable to large areas, which are not sufficiently particular to meet the needs of local interests and activities.

Fire-weather service.—Specialized fire-weather forecasts for use of Federal, State, county, and private fire-fighting organizations were in increased demand. This was partly because forestry agencies were embarking on continuous-crop (sustained-yield) programs in new areas, which necessitated greater protection from fire. Another contributing factor was the increased cost of reforestation which resulted in greater investment in future timber crops, making it more imperative than ever before to prevent destruction by fire. A third reason was greater use of the forests by the public, resulting in increased fire hazard. Although nearly 2,000 more fires occurred on national forest land alone, as compared with last year, the total area burned was 25,000 acres less than in 1946. Part of this creditable record was attributed to the fire-weather service.

In addition to existing fire-weather offices, more intensive fire-weather service was inaugurated in the New England States with the assignment of a fire-weather specialist to the regular forecast center at Boston, Mass. Also, two fire-weather subdistrict offices were established in the West, one at Olympia, Wash., and the other at Pendleton, Oreg., to provide more detailed forecasts for smaller subdivisions.

Mobile-unit service was continued in the seven western districts. These units permit temporary forecast offices to be set up at the scene of large forest fires to assist in directing control. This mobile service has become a vital adjunct to control techniques on large forest fires.

Three fire-weather forecasters were detailed to Idaho during May and June to furnish weather data for the Tussock Moth Control Project, sponsored by the United States Forest Service. Accurate forecasts were required regarding anticipated periods suitable for effective spraying and also of weather conditions affecting operation of the airplanes engaged in the project, in which a total of 413,469 acres of forest were sprayed at an estimated saving of \$60,000,000 in timber values.

Winter sports.—The winter of 1946-47 brought a large increase in the demand for winter-sport weather reports and forecasts for recreational areas in the West, the Lake States, and the Central Atlantic and North Atlantic States. The demand for this type of weather information was greater than in any previous year. The weather advices and data were needed not only by sports enthusiasts but also by those planning for their safety and comfort, including railroads, highway departments, hotels, lodges, rangers, and guides.

Reports on depth and type of snow, skiing conditions, etc., were made by voluntary observers serving without remuneration. The reports were sent to Weather Bureau centers, where they were combined with weather forecasts for the areas involved. The data were then distributed in the form of bulletins and dispatches furnished to the press, radio stations, auto clubs, chambers of commerce, ski clubs, and other interested groups. Western Union also telegraphed the information to clients who subscribed to that company's service. This latter service was an experimental program covering the area from Maine through Pennsylvania.

Marine service.—In July 1946, reactivation of the merchant-ship weather reporting program was begun following the removal of wartime restrictions on communications and the return of the merchant

fleet to private operators; and by year's end the program was rapidly approaching full operation, with more than 300 weather reports per day being received by radio from cooperating vessels in Atlantic, Gulf, and Pacific waters. In addition to the radio reporting vessels, several hundred more ships furnished reports by mail for use in preparing climatic and navigational charts.

The radio reports were used in providing weather service to shipping and maritime interests and to transoceanic aviation. In particular, they were of importance in preparing forecasts for coastal areas and in detecting and charting the progress of hurricanes and other destructive storms which form at sea.

During the year more than 800 United States vessels were enrolled as radio reporting ships, and in addition arrangements were made with foreign meteorological services of maritime nations to have vessels of their flag transmit weather reports to the United States from contiguous ocean areas. In return, arrangements were made to have United States vessels send observations to those meteorological services of other nations which have requested them—Great Britain, France, Brazil, Argentina, and the Philippines. Assistance is being given to the Republic of the Philippines in setting up a marine program for the western Pacific.

Because of the nature of the maritime service and the need for sustaining interest in the program, marine liaison men were assigned to the key port cities of New York, New Orleans, Houston, Seattle, Los Angeles, and San Francisco to contact new vessels, check instrumental equipment, and instruct and aid the observers with details of the work. Weather Bureau officials at other port cities also assisted in marine work.

Hurricane warning service.—The 1946 hurricane season in the United States was noteworthy for the relatively small property damage, estimated at less than \$10,000,000, and the fact that no loss of life was reported. While this was due in part to a less than average number and intensity of storms, it reflected also the increased efficiency of the warning service. The partial resumption of the merchant-vessel reporting program, including arrangements for collecting special reports from storm areas, and continuation of the military aircraft hurricane reconnaissance program were important factors.

The Atlantic, Gulf, and Caribbean area continued to be served from forecast offices at Boston, Washington, Miami, New Orleans, and San Juan, while the forecast office at Los Angeles served the west coast.

Following the close of the 1946 season, plans for coordination with the Army and Navy were reviewed and some modifications, based on experience, were agreed upon for the 1947 season. In June 1947, the hurricane forecast unit at Miami, which is the principle coordinating center for joint Army-Navy-Weather Bureau hurricane warning service activities, was moved to larger quarters in that city to provide more space for the increased program which was planned.

SPECIAL PROJECTS

Arctic weather stations.—As authorized by Public Law 296 (79th Cong., 2d sess.) the first two of a network of Arctic stations were

established—at Thule, Greenland, in cooperation with the Danish authorities, in August 1946 and at Eureka Sound, in cooperation with the Canadian authorities, in April 1947. The Eureka Sound station, at slightly north of 80° north latitude, is the northern outpost of weather stations in the Western Hemisphere. The Thule station began regular transmission of surface and upper air observations by radio to distribution circuits in September 1946. The Eureka Sound station began a similar transmission in May 1947. By the end of the year plans had been completed for the second phase of this project—the establishment of three additional stations in western Canadian Arctic islands. Supplies and personnel were scheduled to leave for the new base and for resupply of the first two stations during July 1947.

Thunderstorm project.—At the conclusion of the observation season near Orlando, Fla., in 1946, personnel of the project were returned to Chicago to analyze the extensive data gathered in the summer's operations. Equipment and supplies were shipped to Patterson Field for reconditioning and storage preparatory to the opening of the 1947 season.

During the 1946 season, which was terminated as of September 20, 179 thunderstorms occurred over the Florida network, 111 of which produced rainfall at 10 or more of the surface stations in the micro-network, and 91 were selected for detailed analysis. During the winter the analysis section in Chicago produced six preliminary reports on factors relating to the inception and activity of thunderstorms.

On April 1, 1947, operating personnel of the project reported to Clinton County Army Air Field, Wilmington, Ohio, where a network was established consisting of 55 automatic recording surface stations and 12 upper air sounding stations, one of which is being operated by the Army, and 5 manned stations for complete visual observations. Actual operations of tracking thunderstorms began on May 1, 1947, with the continued cooperation of the Army, Navy, and National Advisory Committee for Aeronautics.

New items injected into the project consisted of a study of the intensity of radar echoes as an indication of rainfall quantities; use of "kytoons" with a modified radiosonde for obtaining fixed low-level free air data; rain temperature measurements by use of an instrument specially designed by Weather Bureau thunderstorm personnel for obtaining the temperature of raindrops; beginning and ending of sunshine in its relation to the beginning and ending of rain; electrostatic field measurements, aloft and on the ground, to determine electrical differences aloft and near the surface; cumulus cloud studies by specially instrumented AT-6 planes and a specially equipped photoplane for photographing cumulus clouds and thunderstorms; and ground-water-level observations by the United States Geological Survey, in relation to rainfall, and stream gaging in relation to rainfall and runoff.

Philippine rehabilitation program.—The Weather Bureau was authorized by Public Law 370 (79th Cong., 2d sess.) to aid the Republic of the Philippines in the rehabilitation of its weather service. An initial survey of weather service requirements in the Philippines was made in July and August 1946, and employees were assigned to Manila

on January 1, 1947, to form the nucleus of the Weather Bureau staff. By June 30, 1947, the staff had increased to 25 employees (12 Americans and 13 citizens of the Philippines). One station was established before the close of the year. Material and supplies were assembled and working agreements with the Philippine Weather Bureau were perfected for the establishment of 49 additional stations.

International Meteorological Organization.—Preliminary plans and preparations were made for the Conference of Directors of the International Meteorological Organization to be held in Washington, D. C., from September 22 to October 7, 1947. Representatives of the Weather Bureau attended numerous conferences with State Department, Commerce Department, Army, Navy, and Coast Guard officials to make general arrangements for the Washington meeting and to coordinate all phases with interested agencies.

RESEARCH ACTIVITIES

Short-range forecasting.—New statistical techniques were developed and successfully applied to the analysis of weather data for short-range (24- to 48-hour) forecasting purposes. A systematic technique was developed for use in the district forecast centers to forecast 24-hour changes in the central barometric pressure of winter cyclones. This technique can be of assistance to the forecasters in determining the trend of development of stormy areas, and in anticipating the weather conditions associated with those developments.

Specific statistical aids for the improvement of weather forecasts for selected locations were found and put in use. These contributed, for example, to more accurate forecasting of the following conditions: Spring and summer thunderstorms at Washington, D. C., and New York City; the occurrence of snow at New York City; visibility at Washington National Airport; and quantity of precipitation during the summer months in eastern Kansas and central Virginia.

Research forecasters were assigned to district forecast centers at Boston and San Francisco, as part of a program to apply the results of research to specific local forecast problems.

Extended and long-range forecasting.—Research in long-range and extended forecasting was principally directed to the prognosis of the general flow pattern in the atmosphere, which is the first step in the preparation of long-range forecasts. This research entailed analysis of past weather charts, for sea level and various levels above the surface of the earth, to determine relationships between general circulation patterns at higher levels and weather conditions observed on the surface of the earth.

Preliminary findings from the statistical analysis of sea level pressure data, obtained from a long series of historical weather maps produced during the war, show the existence of variations in the distribution of the mass of air over the Northern Hemisphere, as observed between 1889 and 1939. These variations may be indicative of long-period fluctuations in the general atmospheric circulation, which, if they exist, are necessarily associated with long-term climatic variations.

Solar radiation.—In cooperation with the Office of Naval Research and the Army Air Forces, two pyrhemometers were mounted in a B-29 airplane to measure the radiation reaching the top of the airplane from above, and the bottom of the airplane from below. From these measurements, the reflectivity of the surface over which the airplane is flying may be determined. Measurements were made under various kinds of clouds and over different types of terrain.

Physical research.—A new division was established to plan, organize, and direct fundamental research in the physical sciences through quantitative studies looking to evaluation of basic weather processes of importance for improvement in weather forecasting.

Cooperative research.—The Weather Bureau conducted studies of special meteorological problems, in conjunction with several universities. These joint studies include an investigation of relationships between selected characteristics of surface and upper air weather charts and the occurrences and the amount of rainfall at Los Angeles during the winter months, conducted with the University of California at Los Angeles; research to improve long-range forecasts, with the Massachusetts Institute of Technology; and an investigation of techniques for the computation of vertical motion in the atmosphere and the application of vertical motion charts to weather forecasting, with New York University (and in cooperation with the Army and Navy).

The Weather Bureau has undertaken, in cooperation with the electronic computer project at the Institute for Advanced Study, Princeton, N. J., to determine possible application of the computer to the rapid solution of complex forecasting equations. In connection with the V-2 rocket-firing program at White Sands, N. Mex., the Weather Bureau advised staff scientists of that project as to the meteorological problems involved, and participated in the study of meteorological observations obtained by the rockets at very high altitudes. Also, the Weather Bureau has cooperated with the Atomic Energy Commission by assigning a meteorologist to assist in the study of atmospheric environment at Brookhaven Laboratory.

Technical publications.—Printing costs continue too high to permit publishing articles on meteorological and climatological research in the Monthly Weather Review. Separates of the following papers were published and distributed on a limited basis: Extended Forecasting by Mean Circulation Methods, by J. Namias; Progress Report on Objective Rainfall Forecasting Research Program for the Los Angeles Area, by J. C. Thompson; Maximum Recorded United States Point Rainfall, by A. L. Shands and D. Ammerman; and Pyrhemometers and Pyrhemometric Measurements, by I. F. Hand.

Exchange of publications with foreign weather services, which was discontinued at the beginning of World War II, was reestablished and is being expanded as rapidly as facilities will permit.

INSTRUMENTAL DEVELOPMENT

Direct-reading wind speed and direction-measuring equipment.—Construction and tests were completed on one model of an anemometer

of the generator type and a wind vane utilizing motors of the Selsyn type for transmitting the direction from the vane to the indicator. Both the speed and direction transmitters are housed in one unit. A contract was awarded for 40 transmitter units with indicators.

Tests were completed on several types of direct-reading wind equipment, and specifications embodying the most desirable features of available equipment were developed. A contract was awarded for 50 cup-driven magneto speed transmitters with a similar number of Selsyn type wind-direction transmitters, including speed and direction indicators. Recorders may be used with this equipment.

Recording telepsychrometer.—Delivery was made of 20 recording telepsychrometers. Each set consists of two units: (1) A special outdoor shelter housing a ventilation motor, water supply, and two thermohms; and (2) a micromax recorder which records the air temperature and depression of the wet bulb at alternate minute intervals. Performance specifications for this equipment were developed in 1944.

Ceilometer recorders.—One hundred and forty ceilometer recorders were installed. The installation of this equipment completed the program begun in the fiscal year 1946 to equip a selected number of stations with automatic ceiling measuring and recording equipment.

Radiosonde equipment.—A new high-frequency (397 megacycles) radiosonde with improved circuit characteristics was developed and a supply contract awarded. Another improvement made was the design of a dry-battery pack used with the radiosonde, which replaces a wet-type battery. These improvements will make upper air soundings more efficient and useful.

ADMINISTRATION

Personnel.—The number of former Weather Bureau employees returning from the armed forces fell off sharply during the year. Of 675 veterans placed on the rolls only 58 were former employees, less than one-seventh the total for the previous period.

Employment of 440 nonveterans brought the total of new appointments to 1,115. This was offset, however, by 985 separations. At the end of the fiscal year 4,744 people were employed full time and 3,065 part time. Of the full-time employees, 2,521 were war-service and temporary employees, 44 less than in the previous year. This paid staff was supplemented by 7,746 cooperative observers serving without compensation in limited observational activities.

Training.—Six employees were assigned to New York University for one school year of training in advanced meteorological studies. Another employee was selected by the Civil Service Commission for participation in its fourth administrative intern program.

Within the Bureau itself two professional intern classes were conducted to indoctrinate 31 new employees, professionally trained in meteorology but unfamiliar with Weather Bureau procedures. Re-

1946-47

gional training centers instructed 60 new observers in preparation of weather observations. A hurricane training conference held in Washington during March and April 1947 was participated in by 22 employees, and out of it grew the first draft of Notes for Hurricane Forecaster Training. Because of the installation of new equipment for cloud-height measurement, a ceilometer training program was inaugurated in June 1947, and 50 observers were instructed in elementary maintenance and record interpretation.

Organization of the Weather Bureau Field Service indicating types of stations and activities performed, as of June 30, 1947

Weather Bureau offices manned by full-time personnel.....	392
Functional activities:	
Regional Offices.....	8
General Forecasting Centers.....	17
Airway Forecasting Centers.....	22
Climatological Section Centers.....	43
River District Centers.....	86
Hydroclimatic Computing Units.....	7
Radiosonde Observation Stations.....	69
Pilot Balloon Observation Stations.....	165
Rawinsonde Observation Stations.....	33
Vessel Contact Stations.....	34
Number and type of substation reports (furnished by cooperative or part-time personnel):	
A. Activities under regular appropriations:	
1. Aviation Weather Service.....	422
(Frequent weather observations reported for aviation.)	
2. Climatological Service.....	5,727 ✓
(Weather data furnished to determine the climatological characteristics of the United States. These stations are for the most part manned by unpaid observers.)	
3. General Weather Service.....	939
(Observations reported for the benefit of agricultural interests, and stations maintained to provide warnings of approaching storms and hurricanes.)	
4. River and Flood Service.....	2,225
(River stage and rainfall reports furnished for the preparation of streamflow and flood forecasts.)	
Total substation activities related to regular appropriations.....	9,313
B. Activities under transfers from other appropriations:	
1. Hydroclimatic Service.....	3,067
(Reports from recording rain gages giving precipitation intensities for storm studies and flood control.)	
Total substation activities (separate types of reports, etc.).....	12,380
Total reporting stations.....	9,101
(Note.—The number of reporting stations is less than the number of activities as some stations are multiactivity stations.)	

Financial summary, fiscal year 1947

Obligations against direct appropriations:

<i>Purpose</i>	
1. Administration-----	\$1,394,444
2. Direct aid to aviation:	
(a) Terminal and route forecasting for domestic airways-----	\$573,255
(b) Terminal and route forecasting for inter- national airways-----	429,044
(c) Flight advisory weather service-----	808,990
(d) Localized airway weather services-----	1,763,323
Total, direct aid to aviation-----	3,574,612
3. General weather forecasting service-----	1,565,257
4. Localized daily weather services for the general public (non- specialized)-----	3,304,726
5. Specialized weather services for the general public:	
(a) Hurricane and storm warning services----	455,894
(b) Fruit-frost service-----	162,011
(c) Fire-weather service-----	282,109
(d) Farm operational advices-----	385,319
(e) Industrial and commercial weather advices--	569,057
Total, specialized weather services for the general public-----	1,854,190
6. Climatological and crop-weather services-----	2,683,708
7. Maintenance of stations serving both aviation and general pub- lic requirements-----	4,552,784
8. River and flood service-----	598,867
9. Research-----	500,657

Grand total, obligations against direct appropriations----- 20,029,245

Obligations against funds transferred from other appropriations:

<i>Source</i>	<i>Amount</i>
Flood control, Army, general (reporting networks, hydro- logic studies)-----	\$514,346
Air Corps, Army (statistics, research, maintenance of Army overseas' meteorological stations)-----	635,343
Aviation, Navy (statistics, research)-----	121,919
Reclamation fund, Interior (hydrometeorological studies, hydroclimatic network)-----	71,977
Civil Aeronautics Authority (statistical windrose study)-----	14,873
Improvement and maintenance of river and harbor works-----	797
Tennessee Valley Authority-----	303
Total obligations against transferred funds-----	1,359,558
Grand total obligations, all funds-----	21,888,803