CHAPTER IV

THE RELATIONSHIP BETWEEN OCEANOGRAPHY AND METEOROLOGY

THE relationship between oceanography and meteorology is of an order different from that between it and geology or biology, because meteorologic events do not take place within or under the water, as geologic and biologic do. But the state of the surface of the sea so directly affects that of the air above it that meteorologists are much concerned with certain phases of oceanography, while, on the other hand, the temperature, humidity, and movements of the air are as constantly tending to modify the physical state of the water below it. The economic importance of investigating the interdependence between air and sea is discussed in a subsequent chapter (page 237). The present section, contributed by Professor C. F. Brooks, is concerned with its more strictly geophysical phase.

Oceanography can contribute much to meteorology, for nearly three quarters of the atmosphere rests on the ocean, the heated surface of which provides all the water vapor for the air and controls its temperature to a considerable height. The oceanic factors involved in this discharge of vapor and in this heat regulation are not only the temperature of the surface, but also the salinity of the surface, the storage of heat below the surface and, through convection, its availability to the surface, and the horizontal movements of these waters in currents and drifts.

Since, because of their high thermal capacity, the surface waters of the oceans contain enormous amounts of available heat, they exert a steadying and moderating effect on the climates of the world. The oceans take in and give off heat slowly and regularly, and temperature conditions of the water tend to persist a long time and to travel slowly. Sea temperature observations across the ocean indicate the persistence of unusual warmth or coolness of extended masses of water for months — even for a year, or perhaps two — as, carried in the various currents and drifts, they make the circuit of the North Atlantic or cross the Pacific. This leads one to believe that (quoting Petterson), 'besides trying to predict the extremely variable state of the fickle atmosphere, one should give more attention to the conservative element of meteorology, the surface sheet of the ocean, where changes at one place may be observed months before' they reach, and affect the weather of some other region.

Indirectly, the sea has another effect on world weather. Differences in vapor content and in air temperature determine the contrasts in density and, therefore, in pressures of the atmosphere between different portions of the oceans and between the oceans and the lands. And these pressure differences cause the winds. Thus, knowledge of the temperatures of the surface of the sea, and their background, the storage of heat in the sea and the currents that carry this stored heat, is fundamental to meteorology.

The planetary belts of temperature, pressure, wind, and storm that dominate the world's climates are best developed over the sea. The general homogeneity of the sea surface favors approximately equal humidities and temperatures along any parallel of latitude as the sun goes through its seasonal swing northward and southward. And this even distribution of humidity and temperature (except near the continents) favors rather uniform belts of pressure and of winds, with their fair weather where the pressure is high (in latitudes about 20° to 40°) and their showery or stormy weather where the pressure is low, near the equator and from high middle to subpolar latitudes. Furthermore, the flatness of the surface of the ocean permits the maximum development of rotary storm movements, such as the winds of a West Indian hurricane.

Where lands lie athwart these wind and storm belts they receive a full measure of oceanic weather on their windward margins, as on the North Pacific coast of North America. If no high mountains form a barrier, marine influences are felt hundreds, even thousands of miles inland, as in Europe and the eastern United States. Winds and storms from the Gulf of Mexico and other tropical waters of the western Atlantic thus traverse eastern North America and provide the rainfall for this vast agricultural region.

The continents throw a diverse land surface across the latitudinal belts of moisture, temperature, pressure, winds, and storminess fostered by the oceans, and thereby interrupt the continuity of these belts. The low humidities of the air over the land, the high temperatures in summer and the low ones in winter, favor strongly contrasted pressure-conditions in the warm and cold seasons. In summer the continental air is expanded and a considerable quantity is forced to overflow over the cooler oceans; in winter the air over the land is chilled and contracted so much that great masses of air return aloft from over the sea. Thus continental air pressures tend to be low in summer and high in winter, while oceanic air pressures tend to be high in summer and low in winter. The major areas of high and low pressure, which are essentially the oceanic and continental sections of the planetary pressure belts modified, as just outlined, by the contrasted humidity and temperature conditions, have long been known as the grand centers of action. They are the large areas of high or low pressure around and from which or around and into which the prevailing winds blow.

Recalling that only one of the half-dozen centers of action by which the eastern half of the United States is dominated either in winter, or in summer, is continental, the importance of the oceanic centers is at once apparent.

If these centers of action went through their seasonal transformations with consistent regularity year after year, their nature and underlying causes would not give us much of a challenge; but such is not the case.

It is, of course, easy to surmise that if appreciable variations in sea surface temperature over large areas occur irregularly, there should be, through the changes in vapor discharge to the air and in the temperature of the air, a greater favoring of high atmospheric pressure when the sea is colder, and of low pressure when it is warmer. European meteorologists have long recognized this relation in the northeastern Atlantic. Two apparently significant examples may be cited in the western side of that ocean from the Gulf Stream. A body of unusually warm water coming through the straits of Florida in January, 1916, on spreading over the western Atlantic south and east of the northeastern United States appears to have been responsible for eastward deflection and intensification of many western low-pressure areas that reached the Atlantic seaboard, accompanied by prevailing northerly winds, cold weather, and frequent snows. In the same manner, unusually warm water passing through the straits of Florida in October, November, and December, 1925, may be assumed, paradoxically, to have favored the storminess and coldness that prevailed during these and later months in the eastern United States.

Recognizing the importance of a knowledge of the surface temperatures of the western Atlantic, from the meteorological viewpoint, the United States Weather Bureau, the Canadian Meteorological Office, the International Ice Patrol, Clark University, and the American Meteorological Society have, within the past three years, installed sea water thermographs to record surface profiles regularly across the area from the Grand Banks, Bermuda, and Porto Rico westward to Canada and the United States, and southwestward to Cuba, Honduras, and the Panama Canal Zone. A body of accurate sea-surface temperature data is thus being assembled for the study of such progressive movements and persistence of sea-surface temperature departures as may exist in the Gulf Stream and Antilles currents, and for comparison with the state of the atmosphere. But this is only an introduction, while this regular recording of surface temperatures should be extended to include determinations as well of the heat storage in the top twenty-five to one hundred meters, of the horizontal movements of these waters, and of the degree to which atmospheric humidity, temperature, and distribution of atmospheric pressure depend upon the temperature of the ocean surface.

We may also point out that oceanographic expeditions to the less traveled seas offer excellent opportunities, at little extra cost, for obtaining a wide variety of meteorologic data, for problems other than that of the interrelation between atmosphere and ocean surface.