happens in the warmer months of the year, anticyclones remain practically stationary for some time, the lowermost strata of the air become abnormally heated,—thus bringing about a vertical disturbance of the equilibrium of the atmosphere out of which whirlwinds originate. It is under these conditions that white squalls or fair-weather whirlwinds occur, the originating cause of this special form being the great dryness of the air due to its place in the anticyclone, and the abnormally rapid diminution of temperature and humidity with height owing to the strong insolation through the clear dry atmosphere. The clouds accompanying the white squalls are at a great height, but the commotion and boiling of the sea under them and following them as they drift onwards show that the squalls are true whirlwinds, the vapour column of the waterspout not being formed solely on account of the extreme dryness of the air which ascends the columns. The white squall accompanies fine weather, and its appearance is sudden, its duration brief, and its destructive power at times so dreadful that it has been known to strip a ship of every sail and mast in a few seconds, and leave it rolling a helpless log amidst the tremendous sea which follows it. In sailing through such regions a close lookout should be made, particularly when the weather looks singularly fine, the skies beautifully clear, the air calm or nearly so, and the temperature and moisture of the air on board the vessel noticeably high.

Diurnal Period of Hail.—The hail here referred to is round, hard, and compact, and in the form of clear or granular ice, the hailstones sometimes being found when broken across to be composed of alternate layers of these two states of ice. The following figures show the number of times it has occurred during the different hours of the day at Coimbra during the last six years :—

Midt. to 2 A.M.	0	8 A.M. to 10 A.M.	3	4 P.M. to 6 P.M.	3
2 A.M. ,, 4 ,,	1	10 ,, ,, Noon	20	6 ,, ,, 8 ,,	1
4 ,, ,, 6 ,,	2	Noon ,, 2 P.M.	15	8 ,, ,, 10 ,,	0
6 ,, ,, 8 ,,	1	2 P.M. ,, 4 ,,	13	10 ,, ,, Midt.	0

A diurnal period is thus well-marked at Coimbra, where forty-eight out of the fifty-nine cases have occurred from 10 A.M. to 4 P.M. This period is essentially the same as those calculated for a large number of places in representative climates, care having been taken to limit the inquiry to the particular hail described above. The important point to be noticed in the diurnal period of hail is that the time of maximum is about two hours earlier than the maximum period of thunderstorms. The maximum period for the thunderstorm is when the ascending current from the heated land is at its greatest force for the day; but the maximum period for hail is some time before the ascending current has fully established itself, or at that time of the day when the vertical disturbance of the atmosphere is greatest,—in other words, when atmospheric temperature and vapour fall with height at a much greater rate than the normal. In the higher latitudes hail falls almost exclusively during the warmer months of the year. In regions where the summer climate is practically rainless no hail falls; and where the rainfall is small and at distant intervals few cases of hail occur. Thus at Coimbra, where little rain falls in summer, hail was recorded as having fallen only once in the six years during the four dry hot months from June to September.

All hail is probably connected immediately with whirlwinds, more or less developed; and it is when the hailstorm is one of the phenomena attendant on the tornado or on a great thunderstorm that it assumes its most destructive form. The theory of the formation of hail has been stated by Ferrel in his *Meteorological Researches for the Use of the Coast Pilot*, part ii. p. 85. The vapour carried aloft by the gyrations of the tornado is below a certain height condensed into cloud and rain, but above that height into snow. Let the raindrops formed below be carried up into the snow region by the powerful ascending currents of the tornado and be kept suspended there a little while, and they become frozen into hail. If now these be thrown quite outside the gyrations of the tornado, they fall to the earth as a shower of compact homogeneous hailstones of clear ice of ordinary size. If, however, they are caught in the descent and carried in toward the vortex by the inflowing currents on all sides, they are again rapidly carried aloft into the freezing region. A number of such revolutions of ascent and descent may be made before they fall to the earth. While high up in the snow region, the hailstones receive a coating of snow; but, while traversing the region lower down where rain yet unfrozen is carried up, they receive a coating of solid ice. Thus alternate coatings of snow and ice are received, and the number of each sort indicates the number of revolutions described before the hailstones fell to the ground. When the nucleus is composed of compact snow, as is generally the case, the hailstone had its origin high up in the snow region as a small ball of snow, or soft hail (*Graupel* in German and *grésil* in French); but when it is composed of clear ice throughout it was formed in the rain region, carried up into the snow region and there frozen, and immediately afterwards fell to the ground.

MONTHLY, ANNUAL, AND IRREGULARLY RECURRING PHENOMENA

The Temperature of the Sea.—Figs. 8 and 9, representing the distribution of the temperature of the surface water of the ocean for the two extreme months February and August, are reproduced chiefly from *The Wind and Current Charts for Pacific, Atlantic, and Indian Oceans*, published by the British Admiralty in 1872.

In February (fig. 8) the temperature of the surface of the sea falls to the annual minimum over the northern hemisphere, and rises to the maximum in the southern hemisphere. The course of the isothermals more closely follows the latitudes in the Pacific, Indian, and South Atlantic Oceans; but the divergence from the latitudes is great and striking over the North Atlantic. The wider and more open the ocean the more does the distribution of the temperature approach the normal; and the more confined the ocean the greater is the divergence from the normal. The key to the anomalous distribution of the temperature of the ocean is furnished by the charts of the distribution of atmospheric pressure and the prevailing winds of the globe. So far as observation has gone it would appear that the surface currents are practically altogether caused by the prevailing winds over the respective oceans, subject to such deflexions in their courses as are occasioned by the land.

In the southern hemisphere the currents on the west side of the Indian Ocean flow southwards along the east coast of Africa, and, since the currents here pass from lower to higher latitudes, the temperature along the whole extent of this coast is raised considerably above the normal. On the other hand, since the currents on the west coast of Africa flow from south to north—in other words, from higher to lower latitudes—the ocean currents which impinge on this coast have a temperature much under the normal. The winds and currents on the coasts of South America are precisely analogous to those of Africa, and the distribution of the temperature of the sea is also similar. The temperature of the ocean on the east coast of that continent is for the same latitudes everywhere higher than on the west coast. Even in the smaller continent of Australia the same law holds good.

In the northern hemisphere a different distribution of the temperature of the sea is seen at this season. In the Atlantic the temperature is very much higher on the west of Europe than on the east of America. On the east of America from Wilmington to Boston occur the most rapid transitions in the mean temperature of the ocean anywhere on the globe, the temperature falling in that short distance from 70° to 30°, whereas on the eastern side of the Atlantic these isothermals pass Cape Verd Islands and Spitzbergen respectively. In the winter months the prevailing winds of the east side of North America are north-westerly, whilst in the central and eastern portion of the Atlantic they are south-westerly, thus pouring along the east coast of America the icy currents of the Arctic regions, but over the central Atlantic and along the western shores of Europe the warm waters of southern climates. The

easterly and south-easterly winds of Scandinavia in winter lower the isothermals along these coasts. A striking feature of the winter isothermals of the Atlantic is the singularly high temperature along the centre stretching from Spitzbergen towards the south-west and extending in a modified degree as far south as the West Indies. In the Pacific this feature of the mid-ocean temperature is much less pronounced, and the excess of temperature on the west of America over what occurs in the same latitudes of eastern Asia is not so great as the difference observable between the two sides of the Atlantic.

The highest mean temperature in February (85°) occurs in the Indian Ocean to the south-west of Sumatra, and there is a patch the

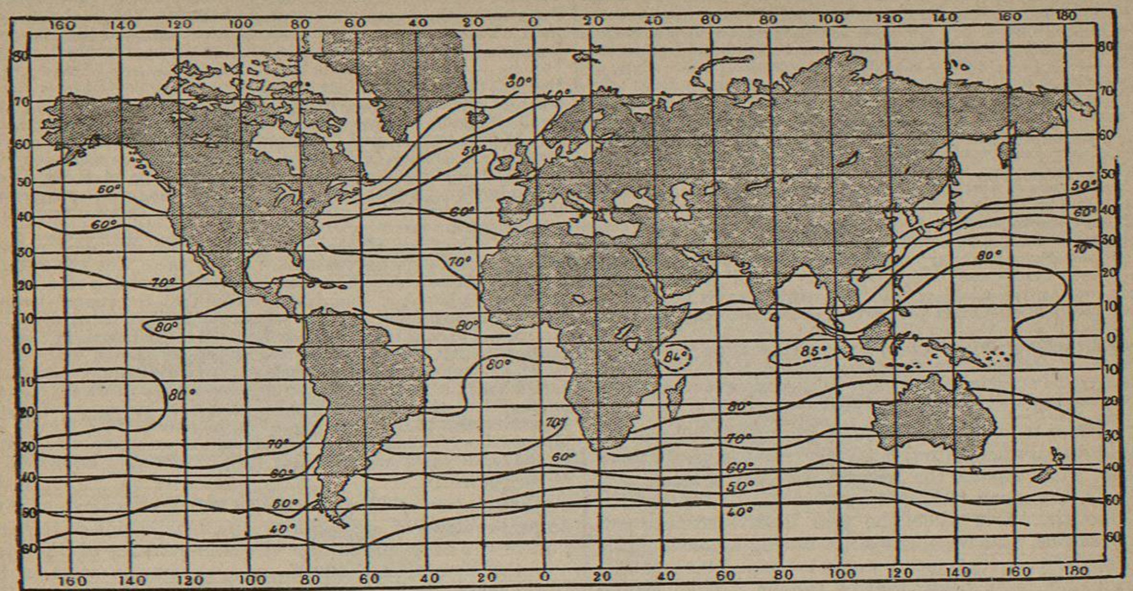

FIG. 8.—Isothermals of the Surface of the Sea for February.

temperature of which is 84° to the north of Madagascar. The highest means in the Atlantic are 82° in the north-east angle of the Gulf of Guinea, and 81° off the north-east coast of Brazil. In the Pacific the highest are 83° to the north of the Fiji Islands and 81° near the Marshall Islands.

In August (fig. 9) the southern half of the Red Sea shows a mean temperature of 90°, being the highest mean recorded for the ocean anywhere at any season. Patches showing a summer mean of 85° occur in the Chinese Sea to the east of Tonquin, in the Bay of Bengal to the east of southern India, about Socotra, and to the

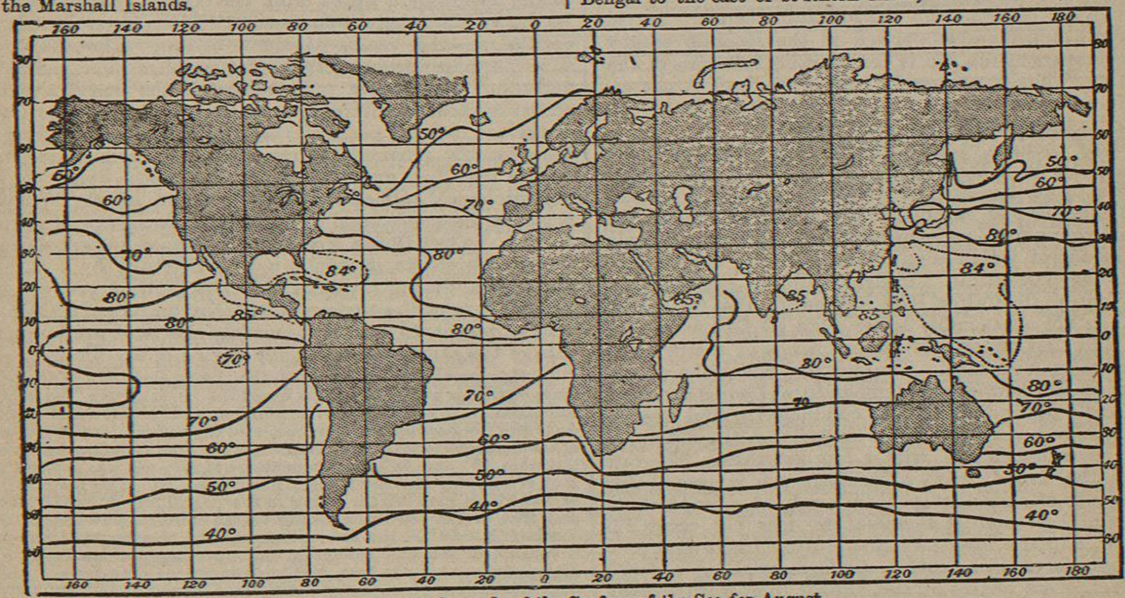

FIG. 9.—Isothermals of the Surface of the Sea for August.

west of Central America. But the most extensive regions of high temperature are in the west of the Pacific between long. 165° E. and the Philippines northward nearly to Japan and southward to New Guinea, and the Gulf of Mexico and the adjoining part of the Atlantic as far east as long. 57° W. A patch of remarkably low temperature occurs in the Pacific a little to the west of Galapagos, where the mean is only 70°, being 10° lower than what occurs anywhere else near the equator at this season.

The influence of currents is strongly expressed in the temperature of all the oceans. In the south of Asia the monsoons are S.W., S., and S.E. Under the impulse of these monsoonal winds an extensive surface drift of the waters of the equatorial regions is carried northwards towards southern Asia, and consequently very high temperatures characterize these seas in summer. It is instructive to note the effect on the temperature of the sea resulting from the region of high atmospheric pressure in the North Atlantic at this season. Out of this anticyclonic region the winds blow in all directions, giving rise to surface currents flowing in the same directions. Thus to the west of Africa the winds and currents are from north to south; and hence the temperature of this part of the ocean is abnormally reduced. On the other hand, on the west side of this high pressure area, the prevailing winds and currents are from south to north, and it will be seen that the temperature of the whole of the region swept by the southerly winds is abnormally raised. On the north side of the area, the winds and currents are westerly as far as about long. 35° W., and over that space the isothermals follow the parallels of latitude. Farther to eastward and northward the prevailing winds become south-westerly, thus propelling northwards along the western shores of Europe, by oceanic surface drifts, the warmer waters of southern latitudes. Meanwhile the currents of cold water and ice drifts from the Arctic regions keep the temperature off America to the north of Newfoundland at a figure considerably lower than is observed in any other region in the same latitudes. In August similar relations exist as in January between the east and west coasts respectively of South Africa, South America, and Australia, all of which are readily explained by the charts of mean atmospheric pressure and the resulting prevalent winds.

One of the most striking facts of ocean temperature is that the temperature of the Southern Ocean from about 50° to 60° S. lat. is practically the same in January and August, a circumstance due chiefly to the magnificent icebergs of that ocean.

The Temperature of the Land.—In regions where the rainfall is distributed through all the months of the year, and where snow covers the ground for only a small part of the year, the mean temperature of the soil nearly equals that of the air. But when the year is divided into wet and dry seasons, and when snow lies during a considerable portion of the year, the mean annual temperature of the soil may be above or below that of the air. The greatest difference between the temperature of the soil and that of the air occurs where the surface of the ground is covered during several months with snow. Snow is a bad conductor of heat, and thus obstructs the free propagation of the cold produced by radiation downwards into the soil, and the escape of heat from the soil into the air. In this way, over a considerable portion of the Russian empire, the temperature of the soil is considerably in excess of that of the air. Thus at a place 120 miles south of Archangel the temperature of the soil is 10° higher than that of the air; and at Semipalatinsk it is 9° higher.

The daily changes of temperature only affect the soil to depths of about 4 feet.* The precise depth varies with the degree of the sun-heat and with the nature of the soil. Similarly the heat of summer and the cold of winter give rise to a larger annual wave of heat propagated downwards, the amplitude of which diminishes with the depth till it ceases to be perceptible. Principal Forbes showed from observations on the Calton Hill, Edinburgh, that the annual variation is not appreciable lower than 40 feet below the surface, and that under 25 feet the change of temperature through the year is small. The depth at which the annual variation ceases, or where the temperature remains constant, is a variable depending on the conductivity and specific heat of the soil or rock, but particularly on the difference between the summer and winter temperatures. The rate at which the annual wave of temperature is propagated downwards is so slow that at Edinburgh, at a depth of 24 feet, the highest annual temperature does not occur till January 4, and the lowest till about July 13, thus reversing the seasons at this depth. At Greenwich, at a depth of 25½ feet, these phases of the annual temperature occur on November 30 and June 1.

* Professor Everett in the *Report of the British Association* for 1879 has summarized the results of the observations of underground temperature. The temperature of the surface of the ground is not sensibly influenced by the flow of heat from below upwards, but is determined by atmospheric and astronomical conditions. The temperature gradient is defined as the rate of increase of the temperature downwards, and it may be taken as averaging one degree Fahrenheit for every 50 or 60 feet, the exact rate in particular cases being very variable. Thus the temperature gradient of the soil is about five times steeper than the temperature gradient of the air. The temperature gradient is steepest beneath gorges and least steep beneath ridges; and hence the underground annual isothermals are flatter than the uneven surfaces above them. This is the case even with the uppermost isothermal of the soil, and the flattening increases as we pass downwards until at a considerable depth they become horizontal. Where the surface of the ground and the isothermal surfaces beneath it are horizontal, the flow of heat is vertical, and the same quantity of heat flows across all sections which lie in the same vertical. In this case the flow across a horizontal area of unit size is equal to the product of the temperature gradient by the conductivity, if the latter term be used in an extended sense, so that it includes convection by the percolation of water, as well as conduction proper; and hence, in comparing different strata in the same vertical, the gradient varies in the inverse ratio of the conductivity.

Since the effects of the cold generated by nocturnal radiation mostly accumulate on the surface of the earth, but the effects of solar radiation are spread to some height by ascending currents from the heated ground, it might be expected that the annual temperature of the surface layer of the soil would be lower than that of the air resting over them. Observations prove that such is the case. Springs which have their sources at greater depths than that to which the annual variation penetrates have a constant temperature throughout the year, and if they do come from a depth considerably greater than this they may be regarded as giving a very close approximation to the mean annual temperature of the place. The temperature of cellars is also very near the mean annual temperature of the locality; at any rate this temperature may be secured for cellars anywhere

Distribution of Temperature in the Atmosphere.—Of the larger problems of meteorology, the distribution of temperature in the atmosphere over the land surfaces of the globe was the first that received an approximate solution (by Humboldt). But as regards the ocean, which comprises three-fourths of the earth's surface, the question of the monthly and annual distribution of temperature in the atmosphere over it can scarcely yet be said to have been seriously looked at. The isothermals of the temperature of the atmosphere which cross the oceans continue still to be drawn essentially from observations made on the islands and along the coasts of these oceans. The first step towards the solution of this vital problem in climatology and other branches of meteorology is the construction of charts of mean monthly temperature of the surface water of the sea over all parts of the ocean from which observations for the purpose are available. In prosecuting this line of inquiry, excellent work has been done by the Meteorological Office as regards parts of the Atlantic between the tropics and the ocean to the south of Africa, and also by the Dutch, French, and German meteorologists. With such charts it would not be difficult, by a careful comparison during the same intervals of time between the temperature of the surface of the sea and that of the air resting over it, to construct monthly charts of the temperature of the atmosphere over the oceans of the globe.

In this connexion the whole of the observations of the temperatures of the air and sea made on board the "Challenger" have been examined, and sorted into one hundred and seventy-four groups according to geographical position, and the differences entered on a chart of the route of the expedition. In the Southern Ocean between latitudes 45° and 60° the temperature of the sea was lower than that of the air, the mean difference being 1°·4. The temperature of the air is here higher owing to the prevailing W.N.W. winds, and that of the sea lower owing to the numerous icebergs. To south of lat. 60° S. the sea was nearly 2°·0 warmer than the air, the result in this case being due to the open sea, which keeps up a higher surface temperature, and to an increased prevalence in these higher latitudes of southerly winds, thus lowering the temperature of the air.

The period during which the temperature of the sea exceeded that of the air was from June 1874 to March 1875, or during that part of the cruise from Sydney to New Zealand, and through the East India Islands to Hong Kong and thence to the Admiralty Islands. During the whole of this time, except when passing the north of Australia, the sea was much warmer than the air, the general excess being from 2° to 3°, rising even near Tongatabu to upwards of 4°. The climate of the southern part of this extensive region at the seasons visited has a large rainfall, much cloud, and consequently a comparatively small evaporation and sunshine. In June, when the "Challenger" passed the north of Australia, the climate was very dry, the sunshine strong, and the evaporation large, and there the sea was slightly colder than the air. In the Atlantic between lat. 20° N. and 20° S. the sea was everywhere warmer, the mean excess being about a degree; and in the Pacific between lat. 30° N. and 30° S. the sea was also warmer, the mean excess being a degree and a half.

On the other hand, in the Atlantic from lat. 40° to 20° N. the sea was, on the mean, half a degree colder than the air. This region is remarkable for the high pressure which overspreads it, for the winds and currents which flow out in all directions, for its clear skies, strong sunshine, and consequently large evaporation, by which the temperature of the surface of the sea is lowered, and that of the air resting on it, being open to the heating influence of the sun, is raised. Similarly in the North Pacific from lat. 40° to 30° the temperature of the surface of the sea was half a degree lower than that of the air.

These remarks apply only to the observations made strictly on the open sea. Near land very great differences were observed which varied with season. Thus at Hong Kong during the latter half of November 1874 the sea was 3°·7 warmer than the air, the low temperature of the air at this season being caused by the lower temperature of the land and the northerly winds which then prevail; on the other hand, at Valparaiso in November and December of the following year the sea was 5°·8 colder than the air during the three weeks the "Challenger" was there, the difference being due to the cold oceanic current which sweeps northwards past that coast, and the rapid increase in the temperature of the air at that time of the year. These results will help us in gaining some knowledge of the temperature of the air over the oceans of the globe in February and August, taken in connexion with a careful examination of the sea temperature of these months represented in figs. 8 and 9.

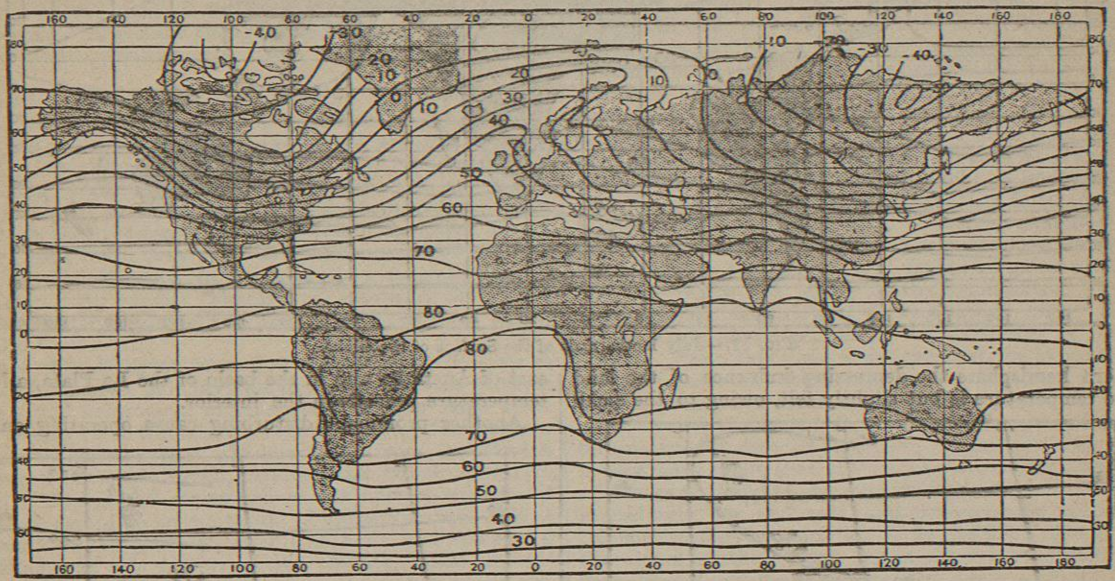

Fig. 10.—January Isothermals of the Surface of the Globe.

The distribution of temperature over the surface of the globe is shown by figs. 10 and 11, which represent the temperature of the two extreme months January and July for the eleven years 1870 to 1880. The region of highest temperature, which may be regarded as comprised between the north and south isothermals of 80°, forms an irregularly shaped zone, lying in tropical and partly in subtropical countries. On each side of this warm zone the temperature diminishes towards the poles, and the lines showing successively the gradual lowering of the temperature are, roughly speaking, arranged parallel to the equator, thus showing in an unmistakable manner the predominating influence of the sun as the source of terrestrial heat. While this decrease of temperature corresponds in a general way to what may be called the solar climate, there are great deviations brought about by disturbing causes.

Among these disturbing causes the unequal distribution of land and water holds a prominent place. In January the earth presents to the perpendicular rays of the sun the most uniform surface, or the largest water surface, and in July the most diversified surface, or the greatest extent of land. Hence the zone of the earth's surface comprised between the isothermals of 80° is less irregular, and also spreads over an area more restricted, in January than in July. In July the areas enclosed by the isothermals of 80° and 90° are much larger in the Old World than in the New, it being the former which presents the larger land surface to the perpendicular rays of the sun; and in January, the summer of the southern hemisphere, the most extensive area of high temperature occurs in Africa and the least in Australia, the high-temperature area of South America being intermediate. In contrast to this the belt of temperature exceeding 80° is of least breadth where it crosses the Pacific and Atlantic Oceans, the absolute minimum breadth being in July in the Pacific, the largest ocean, where the disturbing influence of the land is least.

During the cold months of the year, when the sun's heat is least and the effects of terrestrial radiation attain the maximum, the greatest cold is over the largest land surfaces which slant most to the sun. Thus the lowest mean temperature that occurs anywhere or at any season on the globe is −55°·8 at Werchojansk (lat. 67° 34′ N., long. 133° 51′ E.) in north-eastern Siberia. In Arctic America the lowest isothermal is −40°·0. During the winter the ocean everywhere maintains a higher temperature in all regions open to its influence, as is seen, not only in the higher latitudes to which the isothermals push their way as they cross the Atlantic and Pacific, but also in their irregular courses over and near the Mediterranean, Black, Caspian, and Baltic Seas, Hudson's Bay, the mouth of the St Lawrence, the American lakes, and all other large sheets of salt and fresh water. The disturbing influence of sheets of water on the temperature in all seasons is very strikingly shown when the isothermals are drawn for every degree, these marking out the prominent features of local climates, a knowledge of which is of so great importance to the agriculturist the horticulturist, and the invalid. Figs. 12 and 13 represent charts of temperature of this description for the British Islands for 1870–1880 from the *Jour. of Scot. Meteor. Soc.*, vol. vi. In the winter of the

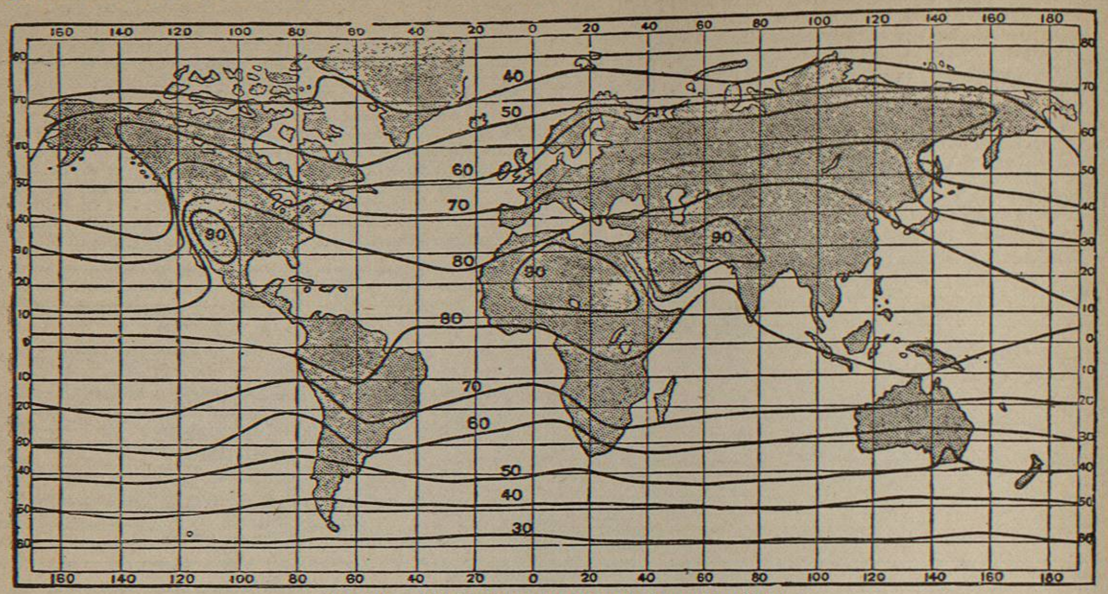

FIG. 11.—July Isothermals of the Surface of the Globe.

southern hemisphere the depressing influence of the land on the temperature is but slightly felt, owing to the small

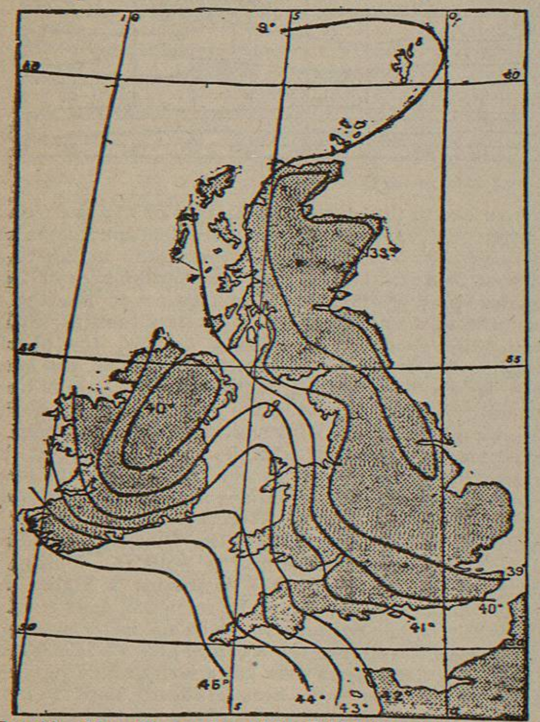

FIG. 12.—Mean Temperature of the British Islands in January.

extent of the land surfaces and the comparatively low latitudes to which they extend southwards. In the south-east of Australia and in the basin of the La Plata, a lower temperature prevails in the interior.

Another prominent disturbing cause operating on the

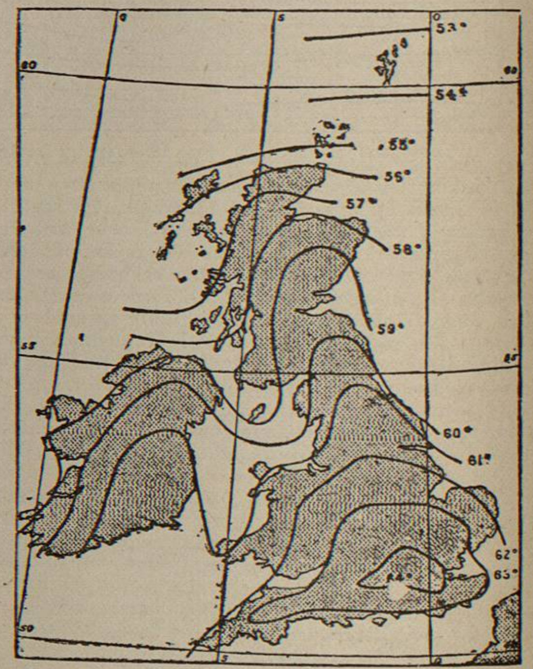

FIG. 13.—Mean Temperature of the British Islands in July.

mean temperature is to be found in the seasonal areas of low and high mean pressure in their connexion with the prevailing winds. Of these the most marked is the system of

low pressure about Iceland during the winter months (see fig. 14). Since this region of low pressure gives to western Europe its prevailing south-west and south winds, and to North America its north-west winds in winter, it is plain that the temperature of western Europe is thereby abnormally raised by the simple fact of its prevailing winds coming from the ocean and from lower latitudes, and that the temperature of North America is abnormally lowered by its prevailing winds coming from the Arctic regions and from land. The opposite action of these two winds, which are part and parcel of the same atmospheric disturbance about Iceland, is shown from the fact that, while the mean temperature of the south coast of Hudson's Bay in January is $-20°$, in the same latitude in the Atlantic to the west of Scotland it is as high as 44°, or 64° higher. A similar though less striking result accompanies the low-pressure area in the north of the Pacific in winter.

Another area of low mean pressure which powerfully affects the temperature is the low barometer which overspreads the interior of Asia during the summer months (see fig. 17). Since from this disposition of the pressure the prevailing winds of Europe and western Asia are north-west and west, and over eastern Asia south-east and east, it follows that the temperature is abnormally raised on the eastern side and depressed on the western side of the continent by the direction from which they severally receive their prevailing winds. This is well shown by the course of the summer isothermals of 80°, 70°, 60°, and 50° across the Old Continent.

Since the strongest insolation occurs where the air is driest, the hottest summer climates are met with in those tropical and subtropical regions where no rain falls. The most extensive of the rainless regions during the summer months is perhaps that which extends from the Punjab westwards through Persia, Arabia, and North Africa to Spain. This is the region where the hottest climates of the globe are to be encountered. Similarly no rain falls at this time of the year in lower California and the States adjoining, and this feature of the climate, taken in connexion with the relatively low temperature of the coast due to the winds and ocean currents from the north which sweep past it, results in sharp contrasts of temperature within short distances such as have no parallel in any other climate.

Of the areas of seasonal high mean pressure, the high barometer of Central Asia in winter stands out in characteristic prominence (see fig. 14). Now, since the prevailing winds which necessarily form a part of this feature are south and south-west over Russia and western Siberia, the temperature of these inland regions is considerably higher than would otherwise be the case. On the other hand, since the prevailing winds are north-west in eastern Asia, the temperature of these regions is thereby abnormally depressed. It is this consideration chiefly which explains how it is that, while the mean January temperature in latitude 60° and longitude 120° E. is $-30°$, in the same latitude but in longitude 43° E. the mean temperature is 10°, or 40° higher, even though both regions are equally continental in their character.

The high mean pressure in the summer in the Atlantic between Africa and the United States has with its system of winds the most decided influence in bringing about the abnormal distribution of the temperature of that and adjoining regions. Since on its west side the prevailing winds are necessarily southerly, the temperature of that region is abnormally raised, and, on the other hand, since on its east side the winds are northerly, the temperature of the region is abnormally depressed. The result of these two opposite winds is seen in the slanting direction of the isothermal of 80° across the Atlantic, which slanting direction is continued far into the interior of North America for the reasons already stated.

These important bearings of cyclonic and anticyclonic areas on temperature and climate may be thus summarized. The temperature is abnormally raised on the east sides of cyclonic areas, and abnormally depressed on the west sides; but, on the other hand, temperature is abnormally raised on the west sides of anticyclonic areas and depressed on their east sides. In the southern hemisphere these directions are reversed.

Another set of influences, powerfully affecting the temperature, come into play where the surface of the land rises above the sea into elevated plateaus, lofty peaks, or mountain ranges. Thus it has been observed on Ben Nevis and other mountains that the wind during the day in summer exhibits an ascensional tendency due to the circumstance that the temperature of the surface of the mountain is heated in a much greater degree than the air strata at the same levels all around it. An ascensional current consequently rises from the mountain, which is maintained at a steadily stronger rate than at lower levels, because the drain from the updraught is easily supplied from the free surrounding atmosphere. It is the strong insolation at high elevations in the summer months which explains the excessively high day-temperatures encountered in the Rocky Mountains; and from the same conditions, viz., the rarity and purity of the atmosphere, by which terrestrial radiation is but little checked, come the low temperatures of the nights of these climates in the same season. From this cause it follows that the elevated lands in the interior of continents tend to reduce mean atmospheric pressure in summer to a greater extent than would otherwise be the case. In winter, on the other hand, the temperature of elevated regions in the interior of continents is very much colder than that of the surrounding atmosphere at the same heights, because in such regions the air is exceedingly dry and rare, and consequently radiation to the cold regions of space but little checked. Hence down the slopes of these high lands there are poured in all directions descending currents of very cold air, which intensify the rigours of the winters experienced on the low lands round their base, where accordingly the lowest mean winter temperatures occur. These elevated lands thus materially add to the high atmospheric pressure of the interior of continents during the cold months of the year.

But it is ocean streams and ocean currents which produce the greatest abnormalities in the distribution of the temperature of the air, and a glance at figs. 10 and 11 will show that it is in the North Atlantic where this cause is most strikingly seen. The increase thus accruing to the winter temperature is greatest about the north of Norway. It is also very great in the British Islands; thus, if no more heat were received than is due to their position on the globe in respect of latitude, the mean winter temperature of Shetland would be 3° and that of London 17°. But mainly owing to the heat given out by the Gulf Stream and other warm currents of the Atlantic their mean winter temperatures are respectively about 39°·5 and 39°, Shetland being thus benefited 36°·5 and London 22°. The chart of the winter temperature of the British Islands well illustrates the influence of the surrounding ocean in maintaining a higher temperature. It will be seen that the south-west of Ireland is 7° warmer than the east coast of England in the same latitudes. The strong drift current from near Behring's Strait southward along the coast of America has a powerful influence, particularly in lowering the summer temperature of that coast,—thus bringing about, in conjunction with the dry rainless climate of the interior, what are perhaps the most violently contrasted climates, within