

hence likely to be warm, or from the polar regions, and cool.

The ascent of expanding warm air gives rise to the *cumulus* clouds, whose flat bases are all on a pretty uniform level. These subside and dissolve when they cease to be fed by rising currents of moist air; the thickness of the cumuli from base to peak is less in cold dry weather than on moist days. The *cirrus* clouds are probably formed independently by the radiation of heat outward into the highest regions of the atmosphere, in which case they are composed of snow-flakes or of spicules of ice; and they are also formed of the remnants of the storm clouds, in which case they are generally composed of warmer vapor. The strong winds that attend areas of low barometer give rise, through the influence of friction, etc., as before stated, to ascend strata of moist air, in which, by expansion or cooling, as the case may be, are produced the *scud* and rain-cloud, of which there is a fine example in the easterly rains of the Atlantic coast. This *scud*-cloud, which is at first like a *cumulus* of irregular shape, subsequently spreads into broad sheets of *stratus* and *nimbus*.

Two or more layers of clouds almost invariably coexist wherever extended rain storms prevail, the upper layer stretching far in advance of the lower, but descending and merging into the lower over the area on which rain is falling most abundant. In the rear of this area *cumulus* clouds are abundant. A general survey of the map will show that cumuli or the cirri first mentioned in the preceding sentence are not inconsistent with fair and clear weather, as these terms are popularly used. An increased accumulation of large *cumulus* clouds may become cloudy weather, but does not generally presage the extended storms of winter. The cirrus of the second class, sometimes called *cirro-stratus*, almost always precedes at some distance any extensive rain storm, whether of winter or summer. The *stratus* will generally be found to be reported in connection with threatening weather at the different stations.

Storms and Cyclones.

Whether of snow, rain, or wind, whether of greater or less violence, storms and cyclones have much similarity in their general features and behavior. Strong contrasts of temperature and of pressure, in contiguous currents of warm and cold air, mark the progress and also the origin of a storm. The Gulf Stream and the adjacent areas of colder water, the land bordering on oceans or lakes, whether frozen or open, mountains and plains and river valleys, are examples of regions over which moist and dry or warm and cold strata come in contact. But even more important, though imperfectly understood, are the sudden changes that take place overhead, which are apparently due to the elevation of moisture into the higher regions of the atmosphere. The storms that visit the United States may be described as of four types, as follows:

1st. The West India cyclones, originating in the southern regions of the zone of easterly

trade winds, and generally east of the Windward Islands, possibly even in the Meteorological Torrid Zone, or equatorial belt of calms and rains. A very low pressure and large humidity mark their central region. Toward this the winds blow from all points, and, deflecting to the right, pursue their spiral course inward and upward; at least, this is the only satisfactory explanation that has yet been offered for the various phenomena. The moisture brought by this wind condenses as the pressure is reduced, and clouds are formed, with heavy rain.

Around the centre of a cyclone an upward current is supposed to exist, and high above are found the *cirrus* clouds, which stream far away in advance on the upper currents of air. These storms are carried to the north and west until they pass into the Meteorological Temperate Zone, where the prevailing south and west winds control their motions. This generally happens on or opposite the South Atlantic coast, and as the storms then pursue a course nearly parallel with the Gulf Stream, with its attendant band of warm, moist air, they produce heavy easterly gales along our Atlantic coast, and finally are lost in the Northern Atlantic, but occasionally, doubtless, reach Iceland and the coast of Great Britain.

2d. The autumn, winter, and spring rains, which generally first announce themselves on the south west or western plains of this country, may be regarded as disturbances originating on the northern confines of the Tropical Zone and on the Pacific slope (as distinct from those of the preceding class that originate in the West Indies).

From the area of high pressure on the Pacific coast of Central and North America a volume of moist air is forced up over the Sierra Nevada and Rocky Mountains; its moisture is deposited, and a wave of rarified but probably dry air is started on its north east or eastern course. No sooner does this arrive, as a wave of low barometer, over the comparatively moist air of the Mississippi Valley, than, by relieving the surface stratum of its pressure, there at once begins the condensation of its moisture, which process, if the air is not too dry, goes on rapidly increasing.

Local currents arising in this surface stratum of air feed the central area of condensation, which soon becomes hazy and then cloudy, till rain begins. When the general progress of the storm-centre will be North-eastward, yet it is evident that wherever the moistest air exists, there the condensation will take place the most rapidly, there the barometer will also fall the most rapidly, and thither the storm will be strongest drawn. Such storms, naturally, therefore, move very rapidly up toward the lakes, and hang tenaciously over them, and move slowly away from them. In winter their course is eastward, in early autumn north-eastward.

The temperature of the upper regions must decide whether rain or snow will attend these storms. Their advance is almost invariably heralded by an increase of temperature, due apparently to latent heat evolved by the condensation going on in the circumjacent and

superior air and radiated downward to the earth, and to the increased facility with which the saturated air on the surface absorbs the heat radiated by the earth.

3-d. Well-defined, though generally weak disturbances, have been observed to pass from the north to the south, or the north-west to the south-east, but these are probably rare in the United States, and probably occur only in midwinter, when the north east winds and high pressure in British America are exceptionally strong. Continuous snow, succeeded by cold, dry weather, characterize these storms; and such a one, on one occasion, after striking the coast of Alabama and turning eastward, ascended the Gulf Stream to the north-eastward, thus coursing around the area of high pressure that had then been pushed southward over the lake region.

4th. The storms which are generally confined within the United States are the northers, tornadoes and thunder-storms. The latter are generally spread over a very narrow space, so that they may at times pass between the stations from which our reports are received. These storms evidently originate in the lower cloud stratum in local, but intense differences of temperature, moisture, and pressure, and are believed in general to prevail only on the western side or in the rear of areas of high pressure. The gyratory movements of these small storms depend upon local currents and resistances, rather than on the earth's rotation; they may, therefore, gyrate either toward the right or the left. In these storms the *cumulus* clouds are particularly remarkable for their height, and the *cirrus* clouds for their small extent. The presence of a surface area of dry air is sometimes sufficient to dissipate these storms, or to cause them to retire into the cloud regions. Similar storms form over mountain-tops, and are experienced by balloon voyagers when the air is quite undisturbed below. Several such smaller storms frequently simultaneously coexist, pursuing parallel paths circulating with the general winds about the continental areas of low barometer, and the area of local storms thus corresponds very nearly to what would be an area of general rain were the temperature lower over the region. The lightning which accompanies these storms is the effect of the concentration upon large drops of water of the electricity previously distributed throughout the invisible vapor; it is considered as a *result*, not a cause, of storms.

5th. It has been noticed that there is a tendency in the spring and summer toward an accumulation of barometric pressure over the middle and eastern Atlantic States. When this area of high barometer moves eastward, the easterly winds on its south side, driving on to the coast from Maryland to Massachusetts, produce clouds, and occasionally severe storms of small extent, which are driven north and westward until broken up among the Appalachian Mountains.

In general, areas of high barometer prepare the way for the succeeding low pressure and high winds, and have been not inaptly termed *storm-breeders*.