tion it is found that H_c follows the changes of P_9 with great accuracy, no matter what the variation of T_m may be; also that there is little connection between H_c and the water vapor. In other words, "if the air pressure at 9 kilometers is high, then H_c is large; and if the pressure is low, then H_c is small. It is certainly this pressure that matters; other things are of trifling or of no importance in comparison."

An appendix contains a table, with brief introduction of seasonal standard deviations of temperature, pressure, and air density in England (S. E.) from the surface to 13 kilometers.—*W. R. Gregg.*

VERTICAL TEMPERATURE DISTRIBUTION IN THE LOWEST 5 KILOMETERS OF CYCLONES AND ANTICYCLONES.

By WILLIS RAY GREGG, Meteorologist.

[Dated: Weather Bureau, Washington, October 30, 1919.]

It has been conclusively shown, not only in Mr. Dines' paper, a review of which is given above, but also in several others, that in Europe cyclones are colder than anticyclones at all altitudes in the troposphere, except at and near the earth's surface in winter. This condition is not indicated by observations made in the United States, and it is interesting to ascertain, if possible, the reasons for this difference in the two regions. First, though, it may not be amiss to inquire what has heretofore been the basis of classification whereby certain observations have been represented as having been made in cyclones or in anticyclones. Obviously, if the surface pressure has been the only guide, an entirely erroneous conclusion may have been reached, as a preponderance of observations in one quadrant of a cyclone or anticyclone would produce a result in no sense representative of the average conditions in the one system or the other, but rather those of that particular quadrant. Again, we occasionally have low-pressure [1] anticyclones and high-pressure [1] cyclones; if under such conditions the station pressure determined the classification we are likely to include many observations in one class which distinctly belong to the other. The question of the horizontal distance from the center to which the influence of a cyclone or an anticyclone may be said to extend is also a perplexing one. In general it is believed that the classification should be made from a careful inspection of the barometric distribution prevailing in each case, and that only such observations should be included as are well within the influence of the one system or the other, this determination being dependent, therefore, not only upon the station pressure itself, but also upon the character of the pressure gradient and upon the resultant wind conditions. Moreover, the observations should be as evenly distributed as possible among the various quadrants of the two systems, or, if this is impossible, the mean values in the quadrants should be taken, in order that equal weight may be given to each, for it is undoubtedly true, in this country at least, that the influence of a northerly or southerly component in the wind, characteristic of rising and falling pressure, respectively, upon air temperature is greater than that due to dynamic heating or cooling within the pressure systems themselves. This point will be referred to later.

In the table below are presented data based upon observations with kites at Mount Weather, Va., and Drexel, Nebr. The Mount Weather data are taken from the Bulletin of the Mount Weather Observatory, volume 6, part 4; those for Drexel have not yet been published. In all cases the classification has been made as indicated in the preceding paragraph. All quadrants are well represented at Drexel; not so well at Mount Weather, because of its location south of the storm tracks, thus making it impossible to obtain many observations in the northern parts of cyclones. Quadrants are numbered as follows: 1, northeast; 2, northwest; 3, southwest; and 4, southeast.

[1] Relative to normal, not relative to surrounding pressure.

TABLE 1.—*Mean free air temperatures, °C., in cyclones and anticyclones at Mount Weather, Va.*

Altitude above sea level (meters).	Cyclones.					Anticyclones.				
	1	2	3	4	Mean.	1	2	3	4	Mean.
SUMMER.										
526	22.8	20.6	20.9	20.5	21.2	18.1	23.0	20.3	18.9	20.1
1,000	19.9	17.3	18.0	17.8	18.2	15.3	19.3	16.7	15.6	16.7
2,000	14.7	11.3	11.5	11.5	12.2	10.5	13.2	11.5	10.9	11.5
3,000	......	5.2	5.8	5.6	(6.3)	5.9	8.3	6.8	5.2	6.6
4,000	......	−1.1	−.3	−2.1	(−.4)	1.3	......	2.3	0.2	(1.9)
5,000	......	−7.2	−6.9	......	......	−5.1	......	......	......	......
WINTER.										
526	−0.4	−1.6	2.3	2.5	0.7	−3.4	−1.1	−3.8	−3.2	−3.6
1,000	−1.3	−4.6	−.8	3.1	−.9	−5.7	−1.1	−3.1	−5.7	−3.9
2,000	−1.5	−6.3	−5.7	−1.1	−3.6	−6.7	−2.4	−1.0	−6.0	−4.0
3,000	−7.4	−9.9	−10.8	−6.5	−8.6	−10.2	−6.6	−5.1	−10.2	−8.0
4,000	......	−14.1	−15.9	−11.8	(−13.5)	−15.5	−12.0	−10.9	−15.1	−13.4
5,000	......	......	−20.0	......	......	−23.1	−17.6	−15.7	−24.2	−20.2

TABLE 2.—*Mean free air temperatures, °C., in cyclones and anticyclones at Drexel, Nebr.*

Altitude above sea level (meters).	Cyclones.					Anticyclones.				
	1	2	3	4	Mean.	1	2	3	4	Mean.
SUMMER.										
396	22.9	19.5	21.8	26.2	22.6	16.6	18.2	20.0	17.8	18.2
500	22.1	19.2	21.2	25.6	22.0	16.4	17.6	19.7	17.1	17.7
1,000	19.2	16.3	18.4	22.6	19.1	12.8	14.9	18.7	13.2	14.9
2,000	14.1	9.8	12.2	16.9	13.2	5.5	10.3	14.4	8.2	9.6
3,000	7.9	3.1	5.5	9.4	6.5	−1.1	4.5	8.1	3.3	3.7
4,000	.9	−2.2	−2.0	2.5	−0.2	−3.8	−0.8	1.0	−1.7	−1.3
5,000	......	......	−9.4	−3.4	(−6.5)	......	−6.6	......	−7.9	(−7.1)
WINTER.										
396	−4.4	−7.4	−3.4	−1.6	−4.2	−11.2	−5.2	−7.3	−11.4	−8.8
500	−5.1	−8.0	−3.8	−1.0	−4.5	−11.3	−4.5	−7.7	−12.0	−8.9
1,000	−3.8	−9.2	−4.6	2.8	−3.7	−9.7	−2.6	−5.8	−12.4	−7.6
2,000	−4.3	−8.7	−5.7	1.9	−4.2	−10.7	−1.8	−4.1	−9.4	−6.5
3,000	−8.6	−12.7	−10.0	−3.7	−8.8	−14.8	−5.9	−7.3	−12.8	−10.2
4,000	−12.7	−16.6	−14.8	−9.8	−13.5	−19.4	−11.6	−11.2	−17.7	−15.0
5,000	......	......	......	−15.3	(−19.1)	−27.1	−17.8	......	−22.8	(−21.3)

An examination of these two tables shows that both in summer and in winter temperatures at and near the surface are lower in anticyclones than in cyclones, more decidedly so at Drexel than at Mount Weather. At higher levels there is little difference in the values at Mount Weather, and that slight difference is in favor of the "cold cyclone" theory; at Drexel the anticyclone still continues colder than the cyclone, but the difference is not as large as at the surface. In other words, the lapse ratè in anticyclones is smaller than in cyclones, with the result that in the higher levels the values in the two pressure systems are very nearly equal. Whether or not the relation continues at still greater altitudes in this country is a matter yet to be determined by intensive studies of additional sounding balloon observations.

In Europe, as has already been stated, the entire troposphere, except at and near the earth's surface in winter, is considerably colder during low than during high barometric pressure. What is the reason for these differences in the two continents? Surely we can hardly assume that different physical processes are in operation. Is not the reason rather to be sought in the relative effects of *all* the different factors that influence temperature distribution in the free air? I believe this can be shown as follows: The climate of western Europe is essentially marine in character. As such its temperatures are subject to relatively small fluctuations due to the importation of air from adjacent localities under the influence of winds having successively a northerly and a southerly component. The proximity of the Gulf Stream tends further to a spreading out of the latitudinal isotherms, thus adding to the moderating influences of the ocean. The result is that the effects of radiation, pressure, and vertical circulation are so much greater than those due to northerly or southerly winds as to produce what are actually observed, viz, lower temperatures in cyclones than in anticyclones.

The United States, on the other hand, i. e., those portions in which observations have been made, has a typically continental climate, and its temperatures are alternately affected by strong winds from a very cold northerly region and by almost equally strong winds from a very warm southerly region. The fluctuations are large, so large indeed that they tend to mask the effects of the other factors already referred to. That these latter are operating, however, is perhaps indicated by the fact that there is less difference in the temperatures at the upper levels than at the earth's surface; more particularly is this true at Mount Weather, which lies to the south of most pronounced anticyclonic and cyclonic activity; moreover, its proximity to the Atlantic gives it to some extent a marine climate, so far as easterly and southerly winds are concerned.

Another probable contributing cause to the temperature differences in the two continents is the fact that pressure systems in Europe move only about two-thirds as rapidly as do those in the United States. In Europe, therefore, the heating and cooling effects of radiation, vertical circulation, etc., are more pronounced, since they have greater opportunity for development.

A further inspection of Tables 1 and 2 raises the question as to whether it is not more logical to classify the temperatures with respect to the character of the pressure change, falling or rising, rather than to consider the cyclone or the anticyclone as a unit in itself. Thus, it will be observed that the temperatures in quadrants 1 and 4 of cyclones agree closely with those in quadrants 2 and 3 of anticyclones, and vice versa; in other words, that falling pressures, accompanied by southerly winds, have high temperatures; and rising pressures, accompanied by northerly winds, have low temperatures. To illustrate this, the values in Tables 1 and 2 have been regrouped in Table 3.

TABLE 3.—*Mean summer and winter free air temperatures, °C, over falling and rising air pressure, as observed at Mount Weather, Va., and Drexel, Nebr.*

Altitude above sea level (meters).	Summer.		Winter.	
	Falling pressure.	Rising pressure.	Falling pressure.	Rising pressure.
MOUNT WEATHER, VA.				
526	20.9	19.8	−0.3	1.0
1,000	17.8	16.6	0.0	−3.8
2,000	12.0	11.1	−1.6	−6.2
3,000	6.6	5.6	−6.4	−10.6
4,000	(0.5)	(0.2)	−12.0	−15.6
5,000		(−6.1)	(−17.2)	(−22.5)
DREXEL, NEBR.				
396	21.8	18.9	−4.6	−8.4
500	21.2	18.5	−4.6	−8.8
1,000	18.8	15.2	−2.4	−9.0
2,000	13.9	8.9	−2.1	−8.6
3,000	7.5	2.7	−6.4	−12.6
4,000	0.9	−2.4	−11.3	−17.1
5,000	(−4.9)	(−9.2)	(−17.1)	(−23.8)

That the relations shown in this table persist at all altitudes in the troposphere is well shown in figure 33, page 304, Mount Weather Bulletin, vol. 4, part 4. (See also "Introductory Meteorology," fig. 31, p. 47.) In the stratosphere the reverse relations obtain. Both Table 3 and the figure referred to indicate very clearly that, in this country at least, free-air temperature distribution is controlled to a greater extent by the horizontal wind circulation than by purely dynamic agencies within the high or low pressure systems themselves.

In a statistical study of the data obtained at Mount Weather and Drexel, Mr. Wm. S. Cloud, of the Weather Bureau, has computed, among others, the following correlation coefficients:

P_0, barometric pressure at surface.
P_3, barometric pressure at 3 kilometers.
T_0, temperature at surface.
T_3, temperature at 3 kilometers.
S_0, south component in wind at surface.
S_3, south component in wind at 3 kilometers.

	P_0	P_3	T_0	T_3	S_0	S_3
DREXEL.						
P_0			−0.51	−0.40		
P_3				.66		
T_0	−0.51				0.37	
T_3	−.40	0.66				0.40
S_0			.37			
S_3				.40		
MOUNT WEATHER.						
P_0			−0.16	0.13		
P_3				.54		
T_0	−0.16				0.43	
T_3	.13	0.54				
S_0			.43			

These values are based on about 200 observations. They show a definite relationship between the wind direction and temperature at the surface and at 3 km., whereas no such relationship is indicated in Mr. Dines' values for Europe. Moreover, the coefficients for P_0 and T_0 and for P_0 and T_3 at Drexel are opposite in sign to those for Europe, the annual values being −0.51 and −0.40, respectively. In winter they are −0.76 and −0.44.

No such connection appears in the annual means for Mount Weather, but in winter the coefficient between P_0 and T_0 is −0.41. These figures confirm the conclusions already given, viz., that in the United States, particularly in the interior portions, wind direction exerts a greater influence on the air temperatures than does the sea level pressure.

THE ORIGIN OF ANTICYCLONES AND DEPRESSIONS.

By Lieut. JOHN LOGIE.

[Abstracted from Proceedings Royal Society, Edinburgh, 1918, vol. 39, pp. 56-77.][1]

The essential feature of this theory is "that the chief cause of depressions and anticyclones is to be sought in the phenomenon of *radiation;* * * * that cyclones are caused by *cooling*, and anticyclones by *heating* of the air."

That temperature changes lead in turn to pressure changes is, of course, well known; hence, much of the argument in this paper is new only in form. It is also known that clouds modify the effects of insolation in the manner claimed.

The paper is well worth reading for it deals, in the language of thermodynamics, with a contributing factor (and in our opinion only a factor) in the production of cyclones and anticyclones; a problem full of difficulties, and whose solution is urgently needed.—*W. J. H.*

[1] cf. abstract, Sci. Abs., Aug. 31, 1919, p. 361.

GENERAL MOVEMENTS OF THE ATMOSPHERE.

(Discussion.)

In a recent paper[1] H. H. Hildebrandsson has presented the results of an exhaustive study of all available information on the subject of free air wind conditions. This information is based on observations of cloud and volcanic dust movement and on those with kites, pilot and sounding balloons. From the study are drawn certain conclusions, sweeping in character, which appear to be well founded, providing we can accept the data on which they are based as representative of all conditions. They are not representative, however, and the conclusions, at any rate some of them, are therefore not final. Particularly is this true of the conclusion No. 7, which reads: " * * * a direct upper current from the Equator to the poles does not exist, nor a lower current in the opposite direction from the poles to the Equator."

Most unfortunately neither upper clouds nor free balloons can be observed as a rule during conditions in which a southerly component in the upper winds is to be expected because of the existence of low clouds and generally stormy weather. That is to say, when a cyclone is approaching or is passing to the north of a station, upper winds are strong and have a decided southerly component. This condition is found when observations can be made with a cyclone in that position, as is well shown, for example, in figures 41 and 43 of Cave's "The Structure of the Atmosphere in Clear Weather." But in most cases such observations can not be made in the eastern half of a cyclone because of low clouds. The same thing is true of northeasterly and easterly surface winds under the influence of a cyclone approaching from the southwest with an anticyclone to the north or northwest, as shown in figure 47 and discussed on pages 6 and 78 of Cave's work. See also, in this connection, "Rules" 1, 2, and 4 in "The turning of the winds with altitude," MONTHLY WEATHER REVIEW, January, 1918, p. 21. Under such conditions kites can not be flown owing to the existence of a calm stratum between the surface easterly and the upper southwesterly wind, nor can balloons or upper clouds be observed, because of rainy weather or at least dense cloudiness in the lower layers. It follows, then, that undue weight is given to the observations made in the western half of cyclones where a northerly component in the upper winds is to be expected and is usually observed. Yet we find that even when the greater weight is given to observations in the western half of cyclones, still the resultant wind is almost exactly westerly. What would happen if representative observations could be obtained in all parts of cylcones and anticyclones? Most certainly we should find a resultant westerly wind with a small southerly component, probably so small that it would be shown only by the mean of a very large number of observations—observations which unfortunately can not be made, at least with present methods, for the reasons already given.

Practically no free air observations have been made at sea in middle latitudes, the one region where the planetary circulation should find greatest opportunity for unrestricted development. Conditions here can be judged only from the movements of cyclones. These as a rule travel eastnortheastward, and it is generally recognized that on the average they follow the direction of the upper winds. Unless we consider conditions in all parts of the temperate zones, we can draw no final conclusions.

From theroretical considerations it is certainly to be supposed that the prevailing westerlies have in the mean a slight southerly component. As is well known the latitudinal pressure variation at intermediate altitudes, i. e., 5 to 15 kilometers consists of a decrease from the tropics toward the polar regions. The corresponding temperature change is very small, with the result that the air density also decreases poleward. Under ideal conditions the resulting wind would be exactly parallel with the isobars, i. e., west to east. But conditions are never ideal in any part of the atmosphere. At the surface, where friction and other retarding effects are most in evidence, the departure from a gradient wind is exceedingly large. At the higher levels these effects, which include friction, turbulence and viscosity, disappear to a considerable extent, but most assuredly not altogether. If they are still present (and it must be admitted that they are) then the winds must necessarily make a small angle with the iosbars, i. e., the prevailing westerlies at those levels have a slight southerly component.

How does this air return equatorward? In all probability practically all of it does so in the lower 5 kilometers. Here we find a laditudinal variation in pressure and temperature such that the air density decreases from north to south, a condition that favors a slight northerly component on the average in the winds at these levels. The actual transfer is accomplished for the most part in the movements of anticyclones from north to south, especially over the continents. In a relatively short time as much air can be carried southward in this way as is carried northward at higher altitudes in a much longer time, owing to the greater density in the former than in the

[1] Results of some empiric researches as to the general movements of the atmosphere Translation by W. W. Reed. MONTHLY WEATHER REVIEW, June, 1919, 47, pp. 374-389.