NOTES ON THE APPLICATION OF UPPER-AIR OBSERVATIONS TO WEATHER FORECASTING.

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The wind during the month of April, 1912, at Mount Weather was favorable for kite flying. On 24 days heights of a mile or more above sea level were attained, and on 12 of the days the altitude reached exceeded 2 miles above sea level. On the 25th a height of 3.4 miles above sea level was reached.

A very considerable mass of detail as regards the temperature, relative humidity, wind direction, and velocity have been thus obtained, much of which stands in more or less definite relation to the weather types on the individual dates; there were some dates, however, when the relation between the observed conditions in the free air above Mount Weather and on the surface, as shown by the daily weather map, was not clearly apparent, as, for example, the three-day period of high northwest winds that began on the 3d and continued until the 5th. At the beginning of the period, the wind, both as to direction and speed, was clearly justified by the surface isobars, but on the middle day of the period there was observed at an altitude of about 2.5 miles (4 km.) a northwest wind of 73 miles per hour (33 meters per second), blowing directly across the central region of an extensive area of high barometric pressure, almost at right angles to the surface isobars, when, according to the belief generally held, the air in that portion of an anticyclone should be engaged in a descending motion.

Another three-day period of high winds set in on the 8th, when the maximum wind velocity of the month, 84 miles per hour (35.8 meters per second), was registered at an altitude of 8,947 feet (2,727 meters).

On the second day, at an altitude of 13,957 feet (4,255 meters), a velocity of 74 miles per hour (33 meters per second) and on the third day, at an altitude of 13,517 feet (4,120 meters), a velocity of 65 miles per hour (29 meters per second) from the west-northwest was registered, respectively. Except on the third day the wind direction aloft agreed fairly well with the surface isobars, but on that day Mount Weather, as before, was in the central portion of a region of high pressure, where strong horizontal winds are not expected. On the 4th day, at an altitude of 16,404 feet (5,000 meters), a west-northwest wind of 62 miles per hour (27.7 meters per second) was observed, but at a lower altitude the wind was west-southwest, and at the surface it was south-southeast. This fact seems to indicate that the change in the direction of the wind from a northerly to a southerly quarter begins at the surface and gradually works aloft. A change from northerly or westerly to southerly winds is usually a good prognostic of rain and falling weather. In this case rain occurred two days after the change, but the coming of the rain was also indicated on the daily weather map.

The relation between the temperature aloft and at the surface during April did not seem to be very close. On seven days during the month relatively high temperatures, which might be considered roughly as the crests of warm waves, appeared at levels closely approximating 5,900 feet above sea level (1,800 meters). The average temperature at that level for the seven days was 9.8° C.; the corresponding average for the surface was 12.7° C., a difference of 2.9° C. in 1,274 meters above Mount Weather, or a decrease of 0.23° C. per 100 meters of altitude. In two of the cases there was an inversion of temperature between the surface and the level of 1,800 meters, but in three other cases the air column temperatures were very nearly isothermal, the average decrease being less than a tenth of a degree C. for 100 meters of altitude. The warming that accompanies cyclones which pass near Mount Weather seems to be mostly confined to the layers between 1 and 2 kilometers above sea level, although at times the atmosphere possesses a relatively high temperature up to the 4-kilometer level (13,123 feet). On April 29, 1912, the kites were able to pass through the fog which enveloped the mountain, the latter on that date being in the front of a well-marked barometric depression. The depth of the fog was rather definitely fixed by the high temperature and low humidity encountered as the kite emerged from the fog at an altitude of 1,264 meters (4,174 feet) above the mountain.

It seems probable that the heating effect frequently observed between the 1 and 2 kilometer levels on the front of cyclones may be due to reflection and absorption of solar radiation at the upper surface of the clouds which in these latitudes almost invariably accompany cyclones. On the other hand the general warming of the atmosphere up to the 4 kilometer level is probably the result of transportation of warmer air from lower latitudes. Of course, both causes may be operative in one and the same cyclone. The lowering of temperature, due to a screen of cloud or fog has been observed on Mount Weather when the latter is in full sunshine and the valley stations about 300 meters below are under cover of a fog blanket. This condition obtained on February 19, 1912, and persisted for 12 hours. The mean lowering of temperature in the eastern valley was 3.06° C. (5.5° F.), western valley 3.22° C. (5.8° F., below that of Mount Weather for the corresponding time. These amounts evidently do not accurately represent the difference in temperature between the upper and lower surfaces, respectively, of a cloud layer.

The kite flights on the 12th and 15th are particularly interesting, in view of the fact that a thunderstorm apparently developed on each of the dates while the kite meteorograph was in the air. On the 12th there was very little horizontal wind across the mountain and no evidence of ascending currents, either in the behavior of the kites, or the form of clouds present; the latter were of the alto-cumulus type, which gradually became dense and merged into a continuous cloud sheet. A cumulo-nimbus cloud was not seen until the thunderstorm had been in progress for at least half an hour. The discharge of static electricity which came down the kite line was frequent and heavy. The surface wind was only a few hundred meters deep, and it was only by reeling in rapidly that the kites were elevated into a vigorous south-southwest wind, which at the top of the flight had become a west wind. Evidently this strong horizontal wind was

no hindrance to the formation of a thunderstorm. Although the head kite reached an altitude of 4,300 meters above sea level, it did not reach the cloud level prevailing at that time. The clouds, however, continued to form at levels which rapidly approached the earth's surface, as is usually the case when rain begins to fall from a high sheet cloud.

On the 15th there was an inversion of temperature between about 850 and 1,100 meters above sea level, which had practically disappeared by the time of descent. In both flights the air was cooler in the descent than in the ascent in the upper one and a half kilometers only, and the decrease in temperature with altitude in both flights at times exceeded the adiabatic rate for dry air. It was also observed that the rate of decrease during the time that elapsed between the ascent and the descent of the kites remained constant at only a few levels, increasing at some and decreasing at others, and that the altitude of the unstable part of the column was generally higher on the descent than in the ascent.

On the whole the predictive value of the upper air observations during April was not great. The idea suggested in these "notes" that barometric depressions follow the direction of the upper currents signally failed of confirmation on April 29, when a depression central over the lower Ohio Valley moved almost due eastward and diminished greatly in intensity, notwithstanding the prevalence of strong southwest winds above Mount Weather.