FREE-AIR SUMMARY

By L. T. SAMUELS

In Table 1 the temperature departures for the month are inappreciable except for the highest levels, where a marked tendency toward plus departures occurs at all stations. Relative humidity departures were mostly small and those of vapor pressure were likewise of no special significance, the latter being in general of the same sign as those for temperature.

In Table 2 the resultant winds for Ellendale exhibit the most pronounced departures from normal. At this station there was a decidedly greater south component together with a higher resultant velocity than normally, particularly in the higher levels.

An exceptionally striking example of a very deep and strong ascending air current occured at Ellendale on the 12th when the kite carrying the meteorograph became detached from the kite wire and immediately rose from an altitude of 1,750 meters to 4,900 meters above ground. The kite and instrument, together weighing approximately 18 pounds, rose as a free body throughout this 3-kilometer air column at the rate of 6.5 meters per second. The descent was at the rate of 4 meters per second. If we assume the effect of gravity alone and no descending current acting upon the falling kite, it is evident that the rate of the ascending current was approximately 10.5 meters per second. The meteorogram reveals a saturated condition throughout this air column and a temperature inversion at its top. The following is taken from the report of the official in charge at Ellendale:

A most unusual and exceedingly interesting action of the kites followed the breakaway on the 12th. The kites were being held at 2,200 meters awaiting the outcome of a thunderstorm cloud which had developed to the north and was spreading out toward the east and southeast. It appeared at first that our kites would be only in the extreme western edge of the rain area; however, the cloud built up toward the west and enveloped the kites more than was expected. When it became apparent that we could not wholly escape the storm, we started to reel in. Three kites were flying, two above the clouds and at a high angle. The record shows the head kite was at an altitude of approximately 1,600 meters at this time. We had reeled in for seven minutes under a fluctuating pull, which reached 350 pounds when the break occurred. During the interval of reeling in the surface wind had veered sharply to N. from SSE., the wind aloft remaining unchanged. At 4:49 p. m. the break, or rather the two breaks, came in quick succession. The upper section of the kite wire, between the second and third kites, was evidently struck by a mild lightning discharge, for it was found blackened and distempered later. This weakened it so that a break occurred at about 1,000 meters releasing the two lead kites in a westerly wind. The lower kite now being free from the others, shifted into the north wind. The shift took place so abruptly that with the sudden release from the other kites slack was thrown in the wire, forming a kink near the reel where the second break occurred when the wire again became taut. This last kite, trailing over 600 meters of wire, then moved off toward the south and southwest and finally caught on a telegraph wire about 2 miles to the southwest of the station. From this mooring the wire lay across a high tension line carrying 13,200 volts. When we reached the place long sparks were shooting up the kite wire whenever it touched two of the high-voltage wires. The kite wire was soon burned through and the kite came to the ground. This kite and wire were then recovered and taken back to the station.

Upon our return to town a telephone call had come in from the east that a kite was about 15 miles ENE. of the station. We made a trip out after it the same evening over exceedingly muddy and rough roads, made so by the heavy rain which fell east of the station during the thunderstorm. This kite, the first secondary, with most of the remaining wire, was recovered the same evening. Darkness soon prevented further search for the lead kite that evening. It was recovered the next day about 4 miles *west* of where the other secondary was picked up.

The meteorograph record shows a most unusual action of the head kite immediately following the breakaway. The upper section of the kite wire after being struck by the mild discharge broke at about 1,000 meters. It is not definitely known, as the kites were above the clouds, but conditions point toward the fact that the lead kite was at this time separated from the secondary, the break occurring at the swivel splice. This break was also apparently caused by weakened wire from the lightning discharge. The record shows that immediately after the break the instrument kite was actually sucked upward through the air and within a few minutes had reached an altitude of over 4,900 meters. This is by far the most amazing phenomenon I have ever encountered in connection with kite flying. Tremendous convection currents must have prevailed to cause such an ascent, for so long a period and through so much space, of an 18-pound kite and instrument. The record itself is unquestionable, both the pressure and temperature traces being quite true to form. The extreme height reached by the free kite was considerably more than twice that possible from the amount of wire out during the flight.

(Signed) L. A. WARREN, *Meteorologist.*

The data of this flight are given in the following table:

Time p. m.	Altitude (m) M. S. L.	Temperature	$\frac{\Delta t}{100\ m.}$	Relative humidity	Vapor pressure	Wind	
						Direction	Velocity
		°C.			mb.		m. p. s.
3:23	444 (surface)	22.4		67	18.16	SSE	5.8
	500	21.9		68	17.88	SSE	6.0
	750	19.3		75	16.80	SSE	6.9
3:33	783	18.8	1.06	76	16.50	SSE	7.1
	1,000	16.4		81	15.11	S	6.9
4:10	1,157	14.7	1.10	84	14.05	SSW	6.8
	1,250	14.2		89	14.42	SSW	7.7
4:14	1,296	13.9	0.58	92	14.62	SSW	8.1
	1,500	13.0		77	11.53	SSW	8.7
4:22	1,845	11.6	0.42	65	8.88	SW	9.7
	2,000	10.4		87	10.97	WSW	11.0
4:28	2,043	10.1	0.76	93	11.49	WSW	11.3
4:44	2,199	9.2	0.58	93	10.83	W	11.1
	2,500	7.9		93	9.90	W	
	3,000	5.9		94	8.72	W	
	3,500	3.8		95	7.62	WSW	
	4,000	1.7		96	6.62	WSW	
	4,500	−0.4		96	5.67	WSW	
4:54	4,908	−2.1	0.42	97	4.99	WSW	
	5,000	−1.5		97	5.24	WSW	
4:55	5,279	0.4	−0.67	97	6.10	WSW	
4:56	5,331	0.3	0.19	97	6.05	WSW	

It will be noted that the lapse rate from the ground to 1,157 meters (M. S. L.) exceeded the adiabatic for dry air while that *within* the cloud through which the breakaway kite was carried upward equaled the adiabatic rate for saturated air at the existing temperatures and pressures. It is evident that the convection in this case was extremely pronounced throughout an unusually deep layer, and although the lapse rates were sufficient to induce convection yet they were not greatly in excess of the respective adiabatic rates. This, however, should be expected from the fact that the observations represent conditions *within* the ascending column, whereas the lapse rates existing just previous to the vertical movement of the air in this region were probably even greater than those observed. While only a trace of rain fell from this storm at Ellendale it will be seen from Mr. Warren's report that *heavy* rain fell just east of the station.

Altitude (m.) M. S. L.	26th			27th		
	Temperature	Wind		Temperature	Wind	
		Direction	Velocity		Direction	Velocity
	°C.		m. p. s.	°C.		m. p. s.
141 surface	19.8	N	4.5	19.5	SSE	8.0
250	18.8	NNE	12.7	18.7	SSE	8.3
500	19.3	NE	13.6	16.9	S	9.1
750	17.6	NE	13.9	16.1	S	11.7
1,000	15.8	NNE	14.2	15.6	SSE	14.5
1,250	16.6	NNE	16.3	14.7	SSE	16.5
1,500	17.8	NNE	17.6	13.8	SSE	18.2
2,000	16.3	NNE	16.8	12.9	S	18.4
2,500	13.4	NE	15.4	12.7	SSW	19.2
2,723	12.1	NE	14.8	11.6	SSW	19.5

In connection with the tropical hurricane which reached the Louisiana coast on the 26th, the free-air

temperatures of the 26th and 27th over Groesbeck are a prominent feature. On the 26th this station was under the influence of the western quadrant of this disturbance, while on the 27th the center had passed just to the west of Groesbeck. Accordingly, the winds at Groesbeck on the two dates were from practically opposite directions. It is of special interest that the free-air temperatures were appreciably lower on the 27th when the winds were southerly than on the 26th when they were northerly. Wind velocities were strong on both dates.

At Broken Arrow on the morning of the 27th an ESE. wind of 21 meters per second prevailed at 3,000 meters above ground. Although the disturbance had almost disappeared so far as *surface* winds and pressures indicated, yet steep temperature and pressure gradients evidently persisted at this elevation.

Also in connection with this storm the afternoon pilot-balloon observation at Groesbeck on the 25th, when the hurricane was approaching the Louisiana coast, revealed steady increasing northeasterly winds to nearly 6,500 meters, by which time the balloon was carried beyond the range of vision. Ci. St. clouds, however, at a higher elevation were moving from the south. This is significant in view of the path of the hurricane and also because clouds of the same type at Broken Arrow, some 300 miles to the north, were simultaneously moving from the north-northwest.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1926*

TEMPERATURE (° C.)

Altitude, m. s. l. (meters)	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		*Washington, D. C. (7 meters)
	Mean	Departure from 9-year mean	Mean	Departure from 6-year mean	Mean	Departure from 9-year mean	Mean	Departure from 3-year mean	Mean	Departure from 9-year mean	Mean
Surface	27.7	+0.7	27.2	+1.1	19.3	−1.1	27.0	0.0	24.2	+0.4	25.5
250	27.5	+0.6	26.8	+1.1			26.0	−0.1	24.0	+0.4	24.8
500	25.7	+0.2	24.5	+1.3	19.0	−1.2	24.0	−0.3	22.4	+0.9	23.8
750	24.3	0.0	22.6	+1.1	18.0	−1.3	22.5	−0.7	21.0	+1.2	22.7
1,000	23.0	0.0	21.0	+1.1	17.2	−1.1	21.2	−0.9	19.4	+1.2	21.5
1,250	21.5	0.0	19.6	+1.2	16.3	−0.8	20.2	−0.6	18.1	+1.4	19.9
1,500	20.1	+0.2	18.2	+1.3	15.4	−0.3	19.2	−0.2	16.5	+1.2	18.4
2,000	17.2	+0.8	15.6	+1.6	13.2	+0.4	16.7	+0.2	13.8	+1.3	15.7
2,500	14.4	+1.4	12.9	+2.0	10.5	+0.6	14.3	+0.6	11.0	+1.1	12.6
3,000	11.3	+1.5	10.1	+2.1	7.5	+0.5	12.1	+1.0	7.8	+0.7	9.8
3,500	8.6	+2.2	7.6	+2.6	4.3	+0.2	9.7	+1.1	5.9	+1.5	6.7
4,000	5.8	+2.4	5.0	+3.3	1.2	0.0	8.4	+2.4	3.9	+2.0	3.1
4,500	2.8	+2.6	2.8	+3.7	−1.5	+0.4			2.5	+2.7	
5,000			1.0	+3.7	−2.6	+1.7					

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1926*—Continued

RELATIVE HUMIDITY (%)

Altitude, m. s. l. (meters)	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		*Washington, D. C. (7 meters)
	Mean	Departure from 9-year mean	Mean	Departure from 6-year mean	Mean	Departure from 9-year mean	Mean	Departure from 8-year mean	Mean	Departure from 9-year mean	Mean
Surface	65	0	73	+5	72	+7	74	+1	73	+7	79
250	65	0	73	+5			76	+2	73	+7	77
500	65	+2	74	+3	71	+7	78	+3	72	+6	76
750	65	+4	75	+3	66	+6	76	+6	72	+5	72
1,000	63	+3	74	+1	62	+4	74	+10	74	+6	69
1,250	61	+1	74	+1	60	+3	67	+5	73	+5	69
1,500	59	−1	71	−1	57	0	62	+1	73	+6	69
2,000	59	−3	61	−7	51	−4	60	0	69	+6	72
2,500	54	−8	59	−8	51	−3	56	−2	65	+7	76
3,000	57	−4	58	−9	53	0	49	−6	62	+9	68
3,500	55	−5	54	−13	55	+4	37	−11	57	+8	67
4,000	53	−7	52	−16	57	+6	13	−25	55	+5	70
4,500	53	−6	53	−14	58	+8			67	+15	
5,000			44	−14	59	+11					

VAPOR PRESSURE (*mb.*)

Surface	23.79	+0.99	25.89	+3.21	15.91	+0.83	25.99	+0.62	21.66	+2.34	25.76
250	23.62	+0.99	25.47	+3.13			25.27	+0.69	21.48	+2.37	24.42
500	21.34	+1.04	22.79	+2.80	15.34	+0.63	23.03	+0.73	19.16	+2.27	22.96
750	19.48	+1.19	20.67	+2.39	13.32	+0.25	20.59	+1.24	17.60	+2.14	20.37
1,000	17.50	+0.83	18.59	+1.89	11.80	−0.01	18.42	+1.69	16.49	+2.21	18.13
1,250	15.51	+0.31	16.91	+1.76	10.81	+0.08	15.57	+0.62	14.97	+1.96	16.50
1,500	13.63	−0.16	14.93	+1.43	9.65	−0.09	13.39	−0.25	13.60	+1.94	15.07
2,000	11.27	−0.17	10.85	+0.34	7.46	−0.39	11.27	0.00	10.88	+1.76	13.28
2,500	8.53	−0.62	8.73	+0.20	6.16	−0.21	9.13	−0.12	8.45	+1.56	11.28
3,000	7.45	+0.24	7.02	+0.07	5.20	−0.03	7.10	−0.39	7.48	+2.26	8.28
3,500	6.88	+1.26	5.44	−0.18	4.25	+0.03	5.12	−0.65	5.94	+1.97	6.52
4,000	6.46	+2.04	4.29	−0.36	3.50	+0.02	3.61	−0.51	5.42	+2.02	5.13
4,500	6.06	+2.74	3.75	−0.20	2.73	−0.10			5.97	+3.26	
5,000			2.69	−0.20	2.30	0.00					

* Naval air station.

TABLE 2.—*Free-air resultant winds (m. p. s.) during August, 1926*

Altitude, m. s. l. (meters)	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)	
	Mean		9-year mean		Mean		6-year mean		Mean		9-year mean		Mean		8-year mean		Mean		9-year mean		Mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 7° W.	2.5	S. 2° W.	3.4	S. 70° W.	2.4	N. 72° W.	0.2	S. 56° E.	1.6	S. 23° W.	0.8	S. 13° W.	3.2	S. 15° W.	3.0	S. 5° E.	0.9	S. 55 W.	1.2	N. 79° W.	0.5
250	S. 11° W.	2.6	S. 2° W.	3.6	S. 71° W.	2.6	N. 83° W.	0.4					S. 10° W.	4.2	S. 16° W.	4.1	S. 31° W.	1.7	S. 58° W.	1.5	N. 67° W.	1.5
500	S. 18° W.	3.9	S. 12° W.	5.2	S. 70° W.	4.2	N. 74° W.	0.7	S. 45° E.	2.1	S. 18° W.	1.3	S. 19° W.	5.5	S. 22° W.	2.4	S. 45° W.	2.4	S. 63° W.	3.2	N. 61° W.	3.6
750	S. 22° W.	3.7	S. 19° W.	5.7	S. 70° W.	4.6	N. 73° W.	1.0	S. 20° E.	4.4	S. 26° W.	2.6	S. 23° W.	6.1	S. 21° W.	6.0	S. 54° W.	3.0	S. 72° W.	4.2	N. 60° W.	5.0
1,000	S. 28° W.	3.4	S. 27° W.	6.0	S. 75° W.	4.9	N. 73° W.	1.0	S. 6° E.	2.8	S. 40° W.	2.6	S. 22° W.	6.3	S. 20° W.	5.9	S. 59° W.	3.2	S. 77° W.	5.1	N. 66° W.	4.9
1,250	S. 31° W.	3.3	S. 33° W.	5.6	S. 78° W.	5.3	N. 79° W.	1.5	S. 20° W.	2.7	S. 50° W.	3.0	S. 21° W.	5.6	S. 20° W.	5.4	S. 74° W.	2.9	S. 82° W.	5.7		
1,500	S. 38° W.	3.4	S. 40° W.	5.5	S. 76° W.	6.5	N. 83° W.	2.3	S. 35° W.	3.0	S. 61° W.	3.6	S. 19° W.	4.9	S. 16° W.	4.8	S. 89° W.	4.3	S. 87° W.	6.5	N. 83° W.	5.1
2,000	S. 45° W.	2.8	S. 45° W.	5.0	S. 75° W.	8.9	N. 81° W.	3.2	S. 58° W.	4.6	S. 75° W.	4.8	S. 26° W.	3.7	S. 9° W.	4.0	N. 80° W.	5.6	S. 89° W.	7.5	N. 80° W.	8.0
2,500	S. 76° W.	2.6	S. 50° W.	5.0	S. 69° W.	9.3	N. 81° W.	3.9	S. 73° W.	7.5	S. 86° W.	8.6	S. 22° W.	4.0	S. 10° W.	4.0	N. 81° W.	6.4	N. 86° W.	8.8	N. 78° W.	8.9
3,000	S. 47° W.	1.2	S. 48° W.	5.4	S. 76° W.	10.3	N. 85° W.	5.3	S. 74° W.	10.8	W.	8.7	S. 34° W.	3.3	S. 15° W.	3.9	N. 69° W.	8.3	N. 84° W.	10.7	N. 78° W.	10.2
3,500	N. 72° W.	5.3	S. 45° W.	6.7	S. 83° W.	12.6	S. 88° W.	8.2	S. 72° W.	12.5	N. 85° W.	11.3	S. 59° W.	3.5	S. 16° W.	4.8	N. 64° W.	14.6	N. 84° W.	11.4	N. 77° W.	12.6
4,000	N. 23° W.	13.0	S. 51° W.	7.7	S. 65° W.	11.1	S. 88° W.	9.2	S. 69° W.	13.9	N. 83° W.	11.7	S. 22° W.	13.0	S. 7° W.	4.6	N. 56° W.	15.2	N. 84° W.	12.8	N. 88° W.	11.2
4,500	N. 23° W.	13.0	S. 58° W.	7.1	W.	11.0	N. 87° W.	11.1	S. 74° W.	16.2	N. 84° W.	12.2					N. 65° W.	22.0	N. 80° W.	13.2	N. 81° W.	10.1
5,000					W.	11.0	S. 76° W.	14.5													N. 89° W.	9.9