AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By L. P. HARRISON

Beginning with January 1937, the monthly tables of aerological data obtained from airplane weather observations are extended to include three meteorological elements not previously presented in this REVIEW. In addition to mean free-air temperatures and relative humidities, with their departures from "normal", there are now given mean free-air specific humidities, barometric pressures, and equivalent potential temperatures.

Because of the falling off in the numbers of observations at higher levels, the monthly mean free-air temperatures, relative humidities, and barometric pressures are computed by a procedure equivalent to the method of differences. Monthly mean specific humidities and equivalent potential temperatures are computed by this same method only when the number of observations available at the surface is less than 15. That is, the arithmetic mean of the surface data for the month is first obtained, and the monthly means for the respective free-air standard levels are derived by successively applying to the former mean the mean differences between the available observational data for adjacent standard levels. When the number of observations is 15 or more at the surface, the "mean" specific humidities and equivalent potential temperatures are obtained directly from the monthly mean temperatures, relative humidities, and barometric pressures (as found in the manner just described) for the corresponding levels by the following procedure:

The saturation vapor pressure corresponding to the monthly mean temperature is multiplied by the monthly mean relative humidity, expressed decimally, and the result is regarded as the "monthly mean vapor pressure." With the latter and the mean barometric pressure as arguments, there is found by reference to an adiabatic chart the corresponding specific humidity, which then is regarded as the monthly mean of that element. By subtraction of the former of the two preceding arguments from the latter, there the partial pressure of dry air is computed. Using this as one argument and the monthly mean temperature as the other, the corresponding "partial potential temperature" is determined by reference to the adiabats on an adiabatic chart and is regarded as the mean for the month. Finally, by reference to a Rossby diagram, with the value last mentioned and the specific humidity as arguments, the corresponding equivalent potential temperature is found and considered as the appropriate monthly mean.

A slight error is inherent in this method, because of the use of specific humidity (grams of water vapor per kilogram of moist air) instead of mixing ratio (grams of water vapor per kilogram of dry air) which is one of the arguments on the Rossby diagram. Furthermore, the socalled monthly mean specific humidities and equivalent potential temperatures found in the manner just described may differ by slight amounts from the means of these elements that would be found by the method of differences. It may be mentioned that daily values of specific humidity and equivalent potential temperature are obtained by the same procedure as just outlined for monthly values, except that daily values of temperature, relative humidity, and barometric pressure are used as the basic arguments.

"Departures from normal" are given for temperature and relative humidity only. "Normals", beginning with the data for this month, are computed by taking the arithmetic mean of the monthly means for the calendar month in question during the past and current years of observations, except when the number of observations in any given month is less than 15, in which case the data therefor are left out of consideration. "Normals" prior to this time were computed by the method of differences, taking all observations into consideration. Thus in the past, the weight of each month's data in determining the "normal" was dependent upon the number of observations available during that month at the level in question; now the weight of each month's data is unity except when the number of observations is less than 15, when the weight becomes zero. "Normals" computed by the two methods under consideration may differ from one another by as much as 2° C. in temperature and 5 percent in relative humidity when observations are few in number.

It will be noted that many of the "normals" are based on only 3 years of observations. "Departures from normal" in such cases must be regarded as having little weight in comparison with departures from normals based on much more extended periods of record. Conclusions derived from such "normals" must be used with caution.

The mean surface temperatures for January (see chart I) were generally above normal in the eastern third of the country, including the west Gulf coast. The mean temperatures in the remainder of the country were generally below normal at the surface. The largest positive departures at the surface were largely concentrated in the eastern two-thirds of the area first mentioned and ranged from about +4° C. to +8° C. The largest negative departures at the surface were largely concentrated over the Western Plateau region, especially in the northern and southwestern portions thereof, and ranged from about −5° C. to −12° C.

The mean free-air temperatures for the month up to 5 kilometers above sea level (see table 1) showed essentially the same characteristics as were in evidence at the surface. Marked positive departures of from +3° C. to nearly +6° C. predominated along the northeastern Atlantic and Gulf coastal regions of the country, while slightly more pronounced departures of the opposite sign occurred in the northwestern and southwestern sections of the country (note Billings, Mont., and San Diego, Claif., respectively).

Table 3 shows the monthly mean barometric pressures and equivalent potential temperatures. Over the country as a whole, the lowest pressures prevailed in the north-central portion at all elevations up to 5 kilometers above sea level, with a center near Fargo, N. Dak. The highest pressures prevailed along the Atlantic coast, with one oenter over the northeast in the stratum up to nearly v.5 kilometer, and with another more pronounced center cver the extreme southeast (Miami, Fla.) that had a lertical extent from 1 to more than 5 kilometers above sea level. The monthly mean isobars in the lower 2 kilometers over the northeast coastal region showed a pronounced anticyclonic curvature and ran roughly parallel to the coast, thus giving further evidence of the westward extension of the Atlantic HIGH in that area. The trend of the isobars showed conditions favorable for a drift of warm, moist air from the Gulf of Mexico and from the southwestern part of the country toward the Gulf of St. Lawrence, and also for a drift of cold, dryer air from the northwestern part of the country toward the southeast, recurving to the northeast near the central portion. The trend of the isobars also indicated a situation conducive to a strong drift of cold air from the north and northwest along the Pacific coast.

Table 2 shows the monthly mean free-air relative humidities and specific humidities. With the exception of the stratum near the ground in the northwest, the relative humidities in the western third of the country were generally above normal in a marked degree, with the most pronounced positive departures (+17 to +23 percent) occurring at San Diego, Calif., from about 1 to 3 kilometers above sea level. The region characterized by this regime of excessive relative humidity coincided very closely with that previously noted as having had the most markedly deficient temperatures in the country during the month. From comparison with the data for surrounding stations, the relative humidities at Salt Lake City, Utah, appeared strikingly in excess of normal, especially at elevations from 2.5 to 5 kilometers above sea level. Slight negative departures from normal relative humidity generally prevailed in the central portion of the country, except in the extreme north at the higher elevations where the opposite was true, and in the extreme south at all elevations where rather large positive departures were in evidence (note San Antonio, Tex., +7 to +15 percent from 1.5 to 5 kilometers). In the lower strata, the southeastern section of the country as far north as Washington, D. C., was characterized by relative humidities moderately in excess of normal, especially near the northeast Gulf coast where the greatest departures occurred. Otherwise, the eastern third of the country appeared to be subject to preponderantly subnormal relative humidities, most notably in the northeast section at moderate elevations. This statement may require qualification and be open to question, however, inasmuch as many aerological observations were missed at stations in the area under consideration, and the days on which they were missed were generally days with low ceilings and perhaps precipitation; the statement, moreover, is not consistent with the occurrence of precipitation during the month appreciably in excess of normal for that area. On the other hand, the dominance of the Atlantic HIGH during the month may have caused somewhat more than the usual proportion of subsiding dry air from upper elevations over the Atlantic to flow along the coastal region (*cf.* discussion of mean barometric pressures).

In general, data on mean humidity may be regarded as open to question when the number of observations during a month falls appreciably below about five-sixths of the number of days in the month (the inconsistent values for Maxwell Field, Montgomery, Ala., at 4 and 5 kilometers, based on 14 or less observations, are an illustration).

Table 4 shows the free-air resultant winds based on pilot balloon observations made near 5 a. m. (75th meridian time) during the month of January. In general, the disposition of the resultant winds bears out the statements already made on the basis of the mean pressure distribution during the month. Along the south Pacific coast region the resultant winds were somewhat in excess of normal velocity and nearly normal in direction. This condition was most pronounced near Oakland Calif., where at the levels from 2.5 to 4 kilometers the monthly resultant velocities exceeded the normals by 5.6 to 12.2 meters per second. Near the State of Washington the resultant winds were generally oriented from about 180° to 45° clockwise with respect to normal, i. e., they were directed more from the north than from the south and west as usually is the case, but with slightly deficient velocities.

In the Rocky Mountain Plateau region the resultant winds were near normal in direction but slightly subnormal in velocity in the northeast portion and somewhat supernormal in the central and southern portions, especially at Albuquerque, N. Mex., at 3 and 4 kilometers above sea level where the departures were +4.3 to +7.2 m. p. s.

As to the Mississippi Valley, in the southern portion the resultant directions were oriented from about 45° to 90° counterclockwise from normal (i. e., more from the southerly quadrant than usual), while toward the northward the counterclockwise orientations became less pronounced until they were substantially zero in the extreme north. Departures from normal velocity in this region were generally inconsequential, except in the southeast near the Gulf of Mexico where positive departures from about +3 to +6 m. p. s. prevailed in the lower kilometer. At Key West, Fla., the resultant directions were normal up to 1.5 kilometers, but from 2 to 3 kilometers the resultant winds were oriented from 67° to 141° counterclockwise with respect to normal (i. e., more from the east than south and west), while the velocities were in excess of normal by +5.2 m. p. s. at 2 kilometers, dropping to about normal at 3 kilometers.

In the northeast, the resultant directions were approximately normal, except in the very lowest stratum of nearly a kilometer where they were oriented from 45° to 70° clockwise from normal at several stations. Resultant velocities were moderately below normal. Consideration of the individual wind data for the northeast coastal region discloses the fact that there was a somewhat more than normal occurrence of easterly winds during the month at least in the stratum from 0.5 to 1 kilometer above sea level or slightly higher, in conformity with the circulation to be expected along the coast under the influence of the extraordinarily predominant Atlantic HIGH.

At Sault Ste. Marie, Mich., up to 2 kilometers above sea level, the resultant winds were oriented from about 30° to 180° counterclockwise with respect to normal and had velocities moderately in excess of the usual values.

Table 5, which is included herein for the first time, shows the maximum wind velocities for the month, together with the dates of occurrence and directions from which observed, for the three strata extending from zero to 2,500 meters, 2,500 to 5,000 meters and above 5,000 meters (mean sea level), respectively. These data are shown for nine different sections of the country. The area included in each section is indicated in the footnotes below the table. The particular station at which the maximum velocity occurred in each section is also given. It will be noted that the maximum velocity for the lower layer was 43.8 m. p. s. from the southwest at Knoxville, Tenn.; while for the intermediate layer it was 54.0 m. p. s. from the north northwest at Oakland, Calif.; and for the layer above 5,000 meters, 65.0 m. p. s. from the west southwest at Rock Springs, Wyo.

With respect to monthly mean specific humidities and equivalent potential temperatures, detailed discussion will be omitted in the absence of comparative data; however, it may be remarked that the outline of the general circulation over the country inferred above from the barometric and wind data is generally confirmed by the distribution of these elements if we regard them as approximately conservative and consider that the monthly mean trajectories of the air from various sources must therefore be marked out by the lines of constant value of the elements in question, especially the equivalent potential temperature.

The meteorological phenomena during the month, which caused the abnormal conditions summarized above, were distinctly unusual in many respects. The North Pacific HIGH extended much farther north and was more strongly developed than ordinarily is the case in January; under this influence, the flow of cold P_p air southward along the Pacific coast was considerably in excess of normal, and numerous offshoots of the North Pacific HIGH moved slowly inland across the western coastal region. In addition, shallow outbreaks of cold P_c air occurred farther westward than usual over the Pacific Northwest States and adjoining areas; while very extensive high pressure systems, formed from relatively cold and shallow P_c air overlain by quite cold P_p or N_{pp} air, frequently moved down over the Western and North Central parts of the country as far south as southern Texas and neighboring regions. These conditions gave rise to deficient precipitation in the Northwest and parts of the Southwest, as well as to severe freezes throughout the far West with damage to agricultural interests that was especially great in California.

The frequent high pressures which were prevalent in the neighborhood of the Southeastern Plateau region probably contributed to the flow of moist N_{pp} air, from the oceanic area near the extreme south of the California coast northeastward to the Great Basin, with the occurrence of slightly above-normal precipitation over the latter area and central California.

In contrast to the usual drift of the cold P_c and P_p air masses toward the east, their drift during January after having reached their greatest southern extent was generally northeastward with pronounced recurvature. As these air masses spread out farther to the east, cyclonic waves frequently developed along their southern and southeastern peripheries and moved northeast along the region contiguous to and especially to the east of the lower Mississippi and Ohio Rivers.

The Atlantic HIGH was displaced much farther to the west, and was more intensely developed, than normally, during a considerable portion of the month. This was undoubtedly a contributory factor to the abnormal recurvature of the cold air masses and the frequent formation of cyclonic waves just referred to, because warm moist air from the Gulf of Mexico was impelled, to an extraordinary degree, to push northward against the wedges of cold air, and produced the almost unprecedented heavy precipitation and warm weather which were experienced in the eastern half of the country. In the central Mississippi and Ohio River Valleys the precipitation for the month reached remarkable totals of from 200 to 400 percent of the normal, with the consequent development of disastrous floods in that region.

TABLE 1.—*Mean free-air temperatures (t), in °C. obtained by airplanes during January 1937. (Dep. represents departure from "normal" temperature)*

Stations	Altitude (meters) m. s. l.																			
	Surface			500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Number of obs.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.
Barksdale Field [1] (Shreveport), La. (52 m)	16	9.8		9.8		10.2		8.2		7.0		4.9		2.8		−2.2			
Billings, Mont. [2] (1,089 m)	30	−16.2	−6.3					−14.4	−7.6	−15.2	−7.9	−15.6	−6.4	−17.4	−5.6	−22.5	−4.7	−29.4	−4.6
Boston, Mass.[1] (5 m)	19	1.3	+1.7	0.7	+2.6	−0.7	+2.6	−0.1	+3.6	−1.1	+3.7	−2.3	+4.3	−4.1	+4.8	−9.4	+4.7		
Cheyenne, Wyo.[2] (1,873 m)	31	−12.3	−5.3							−11.2	−5.4	−10.4	−5.0	−11.7	−4.2	−17.7	−3.8	−24.3	−3.4
El Paso, Tex.[2] (1,194 m)	31	1.6						5.0		3.2		1.2		−1.0		−5.4		−10.9	
Fargo, N. Dak.[2] (274 m)	30	−22.3	−1.3	−21.0	−1.5	−16.7	−1.4	−15.0	−2.1	−14.8	−2.2	−16.1	−2.3	−18.0	−2.3	−22.6	−1.7	−29.3	−1.5
Kelly Field (San Antonio), Tex.[1] (206 m)	18	8.3	+1.3	11.0	+0.7	10.8	0.0	10.4	0.0	9.7	+0.6	8.0	+0.9	5.6	+1.2	−1.3	+0.2	−8.8	−0.2
Lakehurst, N. J.[3] (39 m)	17	2.2		0.9		−0.1		1.3		0.7		−0.2		−2.1		−8.0			
Maxwell Field (Montgomery), Ala.[1] (52 m)	14	15.8		14.6		13.6		11.0		9.5		8.0		6.0		0.9		−5.1	
Miami, Fla.[2] (4 m)	30	21.0		20.5		16.3		14.3		12.9		11.0		9.0		3.3		−2.7	
Mitchel Field (Hempstead, L. I.), N. Y.[1] (29 m)	18	0.9	+3.4	0.6	+3.6	0.4	+4.5	0.8	+5.1	0.6	+5.9	−0.6	+5.8	−2.6	+5.8	−6.7	+6.7	−14.2	+5.6
Murfreesboro, Tenn.[2] (174 m)	29	8.2	+5.4	7.6	+4.7	8.1	+5.0	7.1	+4.2	5.7	+3.8	3.8	+3.8	1.7	+3.9	−3.9	+3.3	−9.7	+3.5
Norfolk, Va.[3] (10 m)	5	10.6		10.4		8.9		6.1		5.7		4.9		2.4		−3.5		−9.3	
Oakland, Calif.[3] (2 m)	30	3.3		3.5		0.9		−1.1		−2.9		−4.7		−7.0		−12.4		−18.6	
Oklahoma City, Okla.[2] (391 m)	27	−1.0	−1.0	−0.8	−1.4	2.0	−1.7	3.0	−0.8	1.6	−0.6	−0.1	−0.3	−2.1	+0.5	−7.6	+1.0	−14.6	+0.8
Omaha, Nebr.[2] (300 m)	31	−14.7	−6.5	−14.0	−6.9	−10.9	−6.7	−7.6	−5.1	−7.8	−4.5	−9.4	−4.0	−11.7	−3.7	−17.6	−3.6	−24.4	−3.8
Pensacola, Fla.[3] (13 m)	23	18.0	+6.7	16.8	+5.5	15.3	+5.3	12.6	+3.7	10.3	+3.6	9.5	+4.1	7.2	+4.7	1.7	+4.5	−3.8	+5.0
St. Thomas, V. I.[3] (8 m)	26	23.4		21.4		18.6		15.8		13.6		11.7		9.5		4.2		−1.8	
Salt Lake City, Utah [2] (1,288 m)	31	−11.2						−8.0		−8.8		−10.4		−12.4		−16.8		−23.3	
San Diego, Calif.[3] (10 m)	31	5.5	−5.4	5.8	−5.6	2.7	−7.1	−0.2	−6.8	−1.6	−6.9	−2.6	−5.0	−4.7	−5.6	−9.9	−4.6	−16.1	−3.9
Sault St. Marie, Mich.[2] (221 m)	29	−9.8		−8.7		−10.6		−11.5		−11.7		−12.3		−14.1		−18.8		−24.7	
Scott Field (Belleville), Ill.[1] (135 m)	13	−5.9		−3.5		−0.5		−1.2		−3.2		−4.9		−6.4		−9.5		−15.3	
Seattle, Wash.[3] (10 m)	9	−0.3		−3.5		−5.7		−7.2		−9.6		−11.9		−14.9		−22.1		−30.8	
Selfridge Field (Mount Clemens), Mich.[1] (177 m)	26	−4.0		−3.6		−3.6		−3.0		−3.7		−5.1		−6.7		−11.7		−16.9	
Spokane, Wash.[2] (596 m)	29	−13.3				−11.9		−11.9		−12.0		−13.2		−15.2		−20.3		−25.9	
Washington, D. C.[3] (13 m)	22	5.9	+6.5	5.0	+6.0	4.4	+6.3	3.4	+6.2	2.8	+6.6	1.5	+6.1	−0.8	+5.9	−5.4	+5.0	−11.4	+4.6
Wright Field (Dayton), Ohio [1] (244 m)	15	−0.4	+2.8	−1.4	+2.1	−1.1	+2.7	−1.8	+2.0	−3.3	+1.5	−4.9	+1.8	−6.8	+1.9	−10.9	+2.5	−16.5	+3.2

Observations taken about 4 a. *m.*, 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

[1] Army.

[2] Weather Bureau.

[3] Navy.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month (years of record are given in parenthesis following the number of observations): Billings, 91 (3); Boston, 92 (5); Cheyenne, 92 (3); Fargo, 90 (3); Kelly Field, 72 (3); Mitchel Field, 56 (3); Murfreesboro, 88 (3); Oklahoma City, 82 (3); Omaha, 179 (6); Pensacola, 178 (9); San Diego, 213 (9); Scott Field, 52 (3); Washington, 175 (12); Wright Field, 60 (3).

TABLE 2.—*Mean free-air relative humidities (R. H.), in percent, and specific humidities (q), in grams/kilogram, obtained by airplanes during January 1937. (Dep. represents departure from "normal" relative humidity)*

Stations	Altitude (meters) m. s. l.																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
			R. H.			R. H.			R. H.			R. H.			R. H.			R. H.			R. H.			R. H.			R. H.	
	Number of obs.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.	q	Mean	Dep.
Barksdale Field, La	16	6.3	84	----	5.8	73	----	4.3	50	----	4.1	52	----	3.5	44	----	3.3	46	----	2.9	44	----	1.9	36	----	----	----	----
Billings, Mont	30	0.8	67	+3	----	----	----	----	----	----	0.9	63	+6	1.0	65	+9	1.0	66	+8	1.0	70	+8	0.7	69	+4	0.4	67	+1
Boston, Mass	19	2.9	71	−1	2.9	71	−2	2.7	67	−4	2.3	51	−12	1.9	44	−14	1.7	40	−15	1.6	39	−15	1.2	40	−13	----	----	----
Cheyenne, Wyo	31	1.1	58	−2	----	----	----	----	----	----	----	----	----	1.2	57	−2	1.2	55	0	1.1	53	−1	0.8	53	+1	0.6	54	+3
El Paso, Tex	31	2.4	48	----	----	----	----	----	----	----	2.7	43	----	2.6	43	----	2.4	43	----	2.1	41	----	1.3	31	----	0.9	29	----
Fargo, N. Dak	30	0.5	71	−8	0.6	70	−6	0.8	67	−4	0.9	61	−5	0.9	58	−5	0.9	57	−2	0.8	58	0	0.7	58	+3	0.3	56	+3
Kelly Field, Tex	18	6.1	89	+5	5.9	68	+2	5.7	63	+4	5.3	57	+7	5.1	55	+10	4.3	48	+10	3.5	44	+8	2.6	47	+13	1.7	47	+15
Lakehurst, N. J	17	2.9	65	----	2.7	64	----	2.4	58	----	2.3	44	----	2.2	40	----	2.2	42	----	1.9	39	----	1.6	42	----	----	----	----
Maxwell Field, Ala	14	9.3	79	----	8.4	71	----	7.2	63	----	6.3	63	----	5.0	53	----	3.6	40	----	2.7	34	----	1.4	22	----	0.9	20	----
Miami, Fla	30	13.1	85	----	12.9	82	----	10.5	82	----	8.3	70	----	6.3	55	----	5.0	46	----	3.8	38	----	2.5	32	----	1.4	26	----
Mitchel Field, N. Y	18	3.1	78	+4	3.0	76	+4	2.6	60	−5	2.1	44	−13	2.0	41	−13	1.9	39	−12	1.9	42	−9	1.3	35	−13	0.9	37	−12
Murfreesboro, Tenn	29	5.9	89	+6	5.9	86	+6	6.0	81	+6	5.0	67	+2	4.1	57	0	3.5	51	−2	3.0	46	−4	2.0	43	−2	1.3	42	−3
Norfolk, Va	5	7.3	84	----	7.4	79	----	6.3	70	----	5.2	65	----	4.2	56	----	3.0	41	----	2.9	41	----	2.4	50	----	1.9	52	----
Oakland, Calif	30	3.7	77	----	3.7	73	----	3.3	72	----	2.9	69	----	2.4	59	----	1.8	51	----	1.5	46	----	1.0	43	----	0.7	42	----
Oklahoma City, Okla	27	3.0	83	+6	3.0	79	+5	2.9	59	0	2.6	45	−4	2.1	40	−4	1.9	37	−4	1.7	33	−5	1.1	33	−4	0.7	33	−4
Omaha, Nebr	31	0.9	78	−3	0.9	74	−4	1.3	68	0	1.5	58	−1	1.4	51	−2	1.3	51	−1	1.1	48	−3	0.8	47	−2	0.4	45	−1
Pensacola, Fla	23	11.4	89	+7	10.4	82	+7	8.7	72	+3	8.2	76	+14	7.4	74	+14	5.5	56	+7	4.5	50	0	2.8	41	−2	2.0	38	0
St. Thomas, V. I	26	14.9	84	----	15.2	91	----	13.0	88	----	11.5	87	----	9.7	80	----	6.6	58	----	4.9	47	----	2.7	33	----	1.5	26	----
Salt Lake City, Utah	31	1.6	70	----	----	----	----	----	----	----	2.0	70	----	1.9	70	----	1.8	71	----	1.6	73	----	1.2	73	----	0.8	72	----
San Diego, Calif	31	4.5	80	+9	4.5	74	+12	3.8	74	+20	3.2	72	+20	2.8	66	+23	2.4	57	+16	2.0	52	+17	1.2	45	+11	0.6	40	+4
Sault Ste. Marie, Mich	29	1.5	84	----	1.8	86	----	1.6	83	----	1.4	74	----	1.2	64	----	1.1	55	----	1.0	53	----	0.8	55	----	0.6	56	----
Scott Field, Ill	13	2.0	76	----	2.3	68	----	2.4	54	----	2.0	46	----	1.8	47	----	1.7	46	----	1.5	43	----	1.1	36	----	0.9	34	----
Seattle, Wash	9	2.7	72	----	2.3	73	----	2.1	75	----	2.0	73	----	1.7	71	----	1.5	70	----	1.3	69	----	0.8	68	----	0.1	66	----
Selfridge Field, Mich	25	2.2	76	----	2.3	78	----	2.1	64	----	1.9	51	----	1.7	47	----	1.6	44	----	1.3	39	----	1.0	37	----	0.7	37	----
Spokane, Wash	29	1.2	78	----	----	----	----	1.3	77	----	1.4	77	----	1.4	73	----	1.3	72	----	1.2	72	----	0.8	68	----	0.6	66	----
Washington, D. C	22	4.2	74	+5	4.1	72	+10	4.0	68	+10	3.9	67	+13	3.4	57	+8	3.1	54	+7	2.6	51	+9	1.5	37	−1	0.9	30	−10
Wright Field, Ohio	15	3.1	84	+3	2.9	82	+3	2.6	66	−5	2.5	61	−2	2.1	56	−1	1.9	52	−4	1.5	43	−9	0.9	34	−14	0.5	32	−12

TABLE 3.—*Mean free-air barometric pressures* (P), *in mb, and equivalent potential temperatures* (Θ_E), *in* °A, *obtained by airplanes during January 1937*

Stations	Altitude (meters) m. s. l.																		
	Surface			500		1,000		1,500		2,000		2,500		3,000		4,000		5,000	
	Number of observations	P	Θ_E	P	Θ_E	P	Θ_E	P	Θ_E	P	Θ_E	P	Θ_E	P	Θ_E	P	Θ_E	P	Θ_E
Barksdale Field, La	16	1,014	299	961	302	905	304	851	307	802	309	754	312	708	314	625	316	----	----
Billings, Mont	30	889	268	----	----	----	----	842	274	788	279	738	284	690	288	604	292	526	294
Boston, Mass	19	1,025	280	964	285	906	287	851	293	800	296	751	299	705	302	621	306	----	----
Cheyenne, Wyo	31	803	281	----	----	----	----	----	----	790	284	740	290	694	294	607	298	530	300
El Paso, Tex	31	880	292	----	----	----	----	847	300	797	303	748	306	704	308	620	311	547	315
Fargo, N. Dak	30	986	253	956	257	895	267	838	274	785	280	735	294	688	286	600	292	523	295
Kelly Field, Tex	18	995	298	960	304	904	308	852	312	802	316	755	318	710	318	628	319	553	320
Lakehurst, N. J	17	1,025	281	968	284	909	288	854	294	803	298	754	303	709	305	624	309	----	----
Maxwell Field, Ala	14	1,014	313	962	314	907	316	854	316	805	316	757	316	713	316	630	318	557	320
Miami, Fla	30	1,020	329	964	334	910	328	857	325	809	323	762	323	718	323	636	323	561	324
Mitchel Field, N. Y	18	1,026	280	969	285	910	289	854	293	803	297	754	301	708	305	623	309	549	311
Murfreesboro, Tenn	29	1,000	298	962	300	905	306	852	308	802	310	754	311	709	313	626	315	552	317
Norfolk, Va	5	1,020	302	962	308	905	308	851	308	802	310	753	311	708	313	624	317	550	320
Oakland, Calif	30	1,019	285	958	291	900	292	846	294	794	296	746	297	700	300	615	303	540	306
Oklahoma City, Okla	27	972	282	959	284	901	292	846	298	796	300	747	303	702	306	619	308	544	310
Omaha, Nebr	31	984	262	959	265	897	274	840	284	788	288	738	292	692	294	607	298	530	300
Pensacola, Fla	23	1,019	321	963	322	908	322	855	323	805	324	758	323	713	323	630	323	556	326
St. Thomas, V. I	26	1,016	337	960	341	906	338	854	336	805	334	758	328	714	327	632	326	558	326
Salt Lake City, Utah	31	868	277	----	----	----	----	845	284	792	288	743	292	697	294	610	299	534	302
San Diego, Calif	31	1,017	290	958	295	900	295	845	296	794	298	745	302	700	304	616	307	541	309
Sault Ste. Marie, Mich	29	993	268	958	273	898	275	840	279	787	283	736	288	690	291	603	297	527	301
Scott Field, Ill	13	1,008	272	962	279	902	287	847	291	795	294	746	297	700	300	615	307	540	311
Seattle, Wash	9	1,019	279	959	279	900	282	845	285	792	287	742	289	696	291	609	292	533	291
Selfridge Field, Mich	26	1,001	275	961	279	903	283	847	289	796	293	747	296	701	299	615	304	540	309
Spokane, Wash	29	947	267	----	----	899	273	843	278	790	284	740	288	693	291	606	294	530	299
Washington, D. C	22	1,023	289	962	293	905	297	851	301	800	304	752	307	706	309	622	312	547	315
Wright Field, Ohio	15	993	281	961	283	904	287	849	291	797	294	748	297	702	300	617	304	541	307

TABLE 4.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during January 1937*

[Wind from N=360°, E=90°, etc.]

Altitude (m) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (153 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Murfreesboro, Tenn. (180 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	322	1.7	358	1.0	250	2.7	284	2.0	264	4.5	237	1.6	21	0.2	249	1.9	301	1.7	43	1.4	98	4.2	78	0.3	243	0.9
500	-----	-----	94	1.0	-----	-----	305	4.6	-----	-----	239	4.4	197	3.3	245	2.5	285	2.6	83	2.6	110	10.0	224	0.2	186	4.3
1,000	-----	-----	122	1.9	-----	-----	292	5.8	-----	-----	256	9.7	238	7.9	261	4.4	283	5.7	328	0.6	112	8.9	195	1.6	202	8.5
1,500	-----	-----	259	6.9	248	6.3	297	10.7	-----	-----	260	11.8	246	9.3	263	10.8	281	7.5	245	3.4	124	6.8	258	3.0	242	7.7
2,000	260	3.9	259	9.4	284	6.1	278	11.8	261	6.5	267	15.2	-----	-----	266	11.6	279	8.9	249	6.0	117	6.5	263	3.2	252	8.5
2,500	254	7.5	256	9.7	281	8.1	285	11.6	257	10.9	266	15.1	-----	-----	267	12.7	282	12.1	239	8.8	116	5.6	324	4.3	257	12.3
3,000	254	11.6	-----	-----	285	8.5	273	12.6	258	11.6	268	16.4	-----	-----	256	15.6	267	13.3	242	12.0	115	2.8	346	5.4	260	14.0
4,000	258	19.0	-----	-----	280	10.7	-----	-----	253	11.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5,000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Altitude (m) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii[1] (68m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	345	2.4	95	1.5	19	0.7	307	1.2	-----	-----	82	1.9	312	1.8	163	2.3	35	0.7	209	1.0	38	0.9	61	1.3	12	1.2
500	6	3.4	334	1.9	129	2.2	276	2.0	-----	-----	153	6.3	281	2.5	-----	-----	313	1.1	216	3.5	60	1.7	-----	-----	338	1.8
1,000	314	2.1	333	3.8	197	3.9	277	6.3	-----	-----	193	7.7	268	3.7	-----	-----	297	2.6	233	6.5	47	0.7	97	2.6	294	4.3
1,500	276	5.6	326	5.8	231	7.8	271	9.3	-----	-----	201	8.0	257	8.4	171	4.0	294	3.5	258	10.2	15	1.5	95	2.2	259	7.8
2,000	260	8.9	331	7.6	230	10.2	262	12.0	-----	-----	204	9.1	247	10.1	197	4.3	288	5.4	267	14.0	356	2.1	353	2.6	271	8.4
2,500	269	10.8	348	10.4	232	10.4	261	12.3	-----	-----	206	10.0	256	11.4	224	4.3	287	8.2	-----	-----	9	2.3	337	2.8	255	12.9
3,000	270	10.4	345	16.8	-----	-----	252	10.3	-----	-----	-----	-----	252	15.3	255	6.3	292	9.6	-----	-----	32	2.7	311	3.2	-----	-----
4,000	283	14.2	360	17.9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	285	10.2	-----	-----	-----	-----	-----	-----	-----	-----
5,000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[1] Navy stations.

TABLE 5.—*Maximum free air wind velocities (M. P. S.) for different sections of the United States, based on pilot-balloon observations during January 1937*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station
Northeast[1]	41.5	WSW	1,320	9	Kylertown, Pa.	39.0	W	2,920	12	Burlington, Vt.	33.1	W	7,020	27	Albany, N. Y.
East Central[2]	43.8	SW	1,470	18	Knoxville, Tenn.	45.0	WSW	3,240	3	Greensboro, N. C.	31.0	WSW	5,250	25	Knoxville, Tenn.
Southeast[3]	33.2	WSW	2,500	3	Atlanta, Ga.	34.4	W	2,740	3	Atlanta, Ga.	24.8	SW	6,060	23	Charleston, S. C.
North Central[4]	38.0	WSW	1,730	4	Detroit, Mich.	50.5	W	3,890	9	Detroit, Mich.	52.8	WSW	5,330	10	Detroit, Mich.
Central[5]	39.0	WNW	1,720	31	Chicago, Ill.	45.9	SW	5,000	17	Wichita, Kans.	46.0	SW	5,020	17	Wichita, Kans.
South Central[6]	34.0	WSW	2,220	24	Dallas, Tex.	46.2	W	4,630	2	Amarillo, Tex.	44.6	WNW	6,790	15	Amarillo, Tex.
Northwest[7]	28.0	W	1,510	3	Billings, Mont.	43.6	N	3,820	19	Medford, Oreg.	59.0	N	8,030	7	Portland, Oreg.
West Central[8]	37.4	W	2,290	3	Cheyenne, Wyo.	54.0	NNW	3,690	17	Oakland, Calif.	65.0	WSW	9,960	26	Rock Springs, Wyo.
Southwest[9]	28.0	SW	2,100	1	Winslow, Ariz.	50.0	SSW	3,984	7	Albuquerque, N. Mex.	53.2	W	8,600	2	Winslow, Ariz.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

LATE REPORTS

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during December 1936*

TEMPERATURE (° C.)

Stations	Altitude (meters) m. s. l.																		
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		Number of observations
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Coco Solo, Canal Zone,[3] (15 m)	24.7	------	22.1	------	19.1	------	16.3	------	14.3	------	12.2	------	9.8	------	5.6	------	0.5	------	28
Pearl Harbor, Territory of Hawaii[3] (6 m)	21.6	−1.4	19.4	−0.9	15.5	−1.1	12.5	−1.4	10.5	−1.5	8.8	−1.5	6.8	−1.3	0.9	−1.5	------	------	31
RELATIVE HUMIDITY (PERCENT)																			
Coco Solo, Canal Zone	88	------	90	------	87	------	80	------	70	------	59	------	52	------	40	------	20	------	------
Pearl Harbor, Territory of Hawaii	78	+1	78	0	83	+2	78	+3	64	0	47	−4	36	−6	20	−13	------	------	------

[3] Navy.

Observations taken about 4 a. m., 75th meridian time, except by Navy Stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month- (Years of record are given in parenthesis following the number of observations.) Pearl Harbor, 139 (8).

LATE REPORT

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during November 1936*

TEMPERATURE (° C.)

Stations	Altitude (meters) m. s. l.																		
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		Number of observations
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Coco Solo, Canal Zone[3]	25.3	------	23.0	------	20.7	------	18.4	------	16.1	------	13.8	------	12.2	------	7.8	------	2.9	------	25
RELATIVE HUMIDITY (PERCENT)																			
Coco Solo, Canal Zone	90	------	90	------	88	------	85	------	84	------	77	------	72	------	61	------	59	------	------

[3] Navy.

RIVERS AND FLOODS

[River and Flood Division, W. J. MOXOM, temporarily in charge]

By BENNETT SWENSON

Unprecedented floods occurred during January 1937 in the Ohio River Valley. Complete reports of estimated flood losses are not yet available, but it is safe to assume that they were the largest of record. At the close of the month the Ohio River flood crest had not reached the Mississippi River at Cairo, Ill.

A report on the January 1937 floods will be made in the February issue of the REVIEW.

ESTIMATED FLOOD LOSSES DURING THE YEAR 1936

The estimated flood losses during the year 1936 are presented in the table below. The losses suffered during the disastrous floods of March and April comprise by far the greater part of the losses for the entire year.

Because of the widespread area over which the floods of March and April occurred and because of their severity, it has been possible only to obtain a very rough estimate of the losses incurred.

The loss due to suspension of business, including the wages lost to employees, was undoubtedly great during these floods but only in a few cases has it been possible even to give an approximation. Wherever such an approximation is available it has been included in the totals.

The amount of damage to land by gullying or other severe erosion or by deposit of silt, sand, gravel, rocks, or other debris, too, was of great magnitude. However, it is rather difficult to distinguish between that caused by the floods in the rivers or that caused by rainfall. Also it is not known what the effect will be of the great amount of sand which was spread over the farm land. For these reasons it was not considered advisable to include these figures with the losses.

From the data available the total losses incurred during the floods of March and April exceeded $270,000,000. This sum is slightly less than the estimates of the losses of the Mississippi River flood of 1927 which extended over a period of 6 months.

The splendid cooperation of the Bureau of Public Roads and the Extension Service of the United States Department of Agriculture in collecting information on damages