

AEROLOGICAL OBSERVATIONS FOR THE YEAR 1938

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

By B. FRANCIS DASHIELL

One of the most important advances in the aerological work of the Weather Bureau during 1938 was the development and increase in the use of radiosonde equipment. At the close of the year such observations were being conducted at six stations by the Weather Bureau; one by the Navy. These, as well as all airplane stations, are listed in table 1. This table includes annual mean free-air barometric pressures, temperatures, and relative humidities for standard levels up to 5 kilometers. A total of 4,621 airplane observations was made in the United States at the stations listed in table 1, and 62 percent reached 5 kilometers. Of the 945 radiosonde observations made since midsummer 20 percent reached an altitude of 20 kilometers.

Pilot-balloon observations of wind direction and velocity were being made from 2 to 4 times daily at 86 stations, including 4 in Alaska and 1 in San Juan, P. R., at the close of the year. This was an increase of 9 stations over the year 1937. As a safety measure helium gas was substituted for hydrogen at a number of places. At 15 stations having good visibility, new 100-gram-balloon observations were inaugurated. The ascensional rate of these balloons was determined after a long series of two-theodolite observations made at Washington. Since the 100-gram balloons reach higher altitudes than the 30-gram type in the same time, this accounts for many outstanding altitudes and wind speeds recorded on the monthly tables.

A series of observations with sounding balloons carrying recording meteorographs was conducted at Omaha, Nebr., in July. These flights were checked for the rate of ascent and wind directions and velocities by means of two theodolites, and a maximum altitude of 29 kilometers was attained.

Through the cooperation of the Works Progress Administration a program of assembling and reducing to punch cards all Weather Bureau pilot-balloon data and the summarization of airway surface records was inaugurated at New Orleans, La. It will be possible, in the future, quickly and accurately to summarize any of these aerological data for any period of time at any place, and thus make available to the needs of aviation much new material concerning surface conditions and upper-air winds.

The lowest mean free-air temperatures ($^{\circ}\text{C}.$) for the year were recorded at the surface at Fargo, N. Dak., and over Sault Ste. Marie, Mich., at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers. Maximum annual mean temperatures occurred at San Diego, Calif., at the surface, and 0.5 and 1 kilometer; over El Paso, Tex., at 1.5, 2, 2.5, and 3 kilometers; and over Pensacola, Fla., at 4 and 5 kilometers. For the country as a whole, January and February were the coldest months of 1938, but, in the South, above 2.5 kilometers, December became the coldest month.

Annual mean barometric pressure was lowest over Fargo, N. Dak., and Sault Ste. Marie, Mich.; particularly over the latter above 2 kilometers. At these places the lowest annual mean pressures occurred in December at 0.5, 1, 4, and 5 kilometers, and in January at 1.5, 2, 2.5, and 3 kilometers. High pressures prevailed over Pensacola, Fla., at all levels. Mean relative humidity was

highest over Pensacola, Fla., at the surface; over San Diego, Calif., at 0.5 kilometer; over Sault Ste. Marie, Mich., at all other levels up to 4 kilometers; and over Billings, Mont., at 5 kilometers.

Above 5 kilometers all observations were obtained by radiosonde. But, since these observations are for a period of 5 months only, no annual means have been computed. Therefore, they are not included in table 1. However, monthly means indicate that the lowest temperatures prevailed over Fargo, N. Dak., and Sault Ste. Marie, Mich., upward to approximately 11 kilometers; over Omaha, Nebr., for the next 4 kilometers; and then over Nashville, Tenn., and Oklahoma City, Okla., at 15, 16, and 17 kilometers.

Individual low temperatures recorded by radiosonde in the higher levels during 1938 were: $-66.3^{\circ}\text{C}.$ and $-72.0^{\circ}\text{C}.$, at Fargo, N. Dak. (December); $-70.7^{\circ}\text{C}.$, at Omaha, Nebr. (December); $-76.8^{\circ}\text{C}.$, at Oklahoma City, Okla. (December); $-73.7^{\circ}\text{C}.$, at Washington, D. C. (August); $-79.5^{\circ}\text{C}.$ and $-80.0^{\circ}\text{C}.$ (July), and $-89.8^{\circ}\text{C}.$ and $-80.0^{\circ}\text{C}.$ (November), all over Oklahoma City, Okla.; and $-78.0^{\circ}\text{C}.$ and $-78.9^{\circ}\text{C}.$, over Washington, D. C. (November); at 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20 kilometers, respectively.

Radiosonde observations were made at Fairbanks, Alaska, during the winter months of January, February, and March, in connection with investigations of polar air masses. They showed individual low temperatures of $-55.8^{\circ}\text{C}.$, $-56.5^{\circ}\text{C}.$, $-58.0^{\circ}\text{C}.$, $-58.2^{\circ}\text{C}.$, $-59.2^{\circ}\text{C}.$, and $-52.3^{\circ}\text{C}.$, at 10, 11, 12, 13, 14, and 15 kilometers, respectively.

Resultant wind directions and velocities were computed at 25 selected stations during each month of 1938. These were based on 5 a. m. (75th meridian time) observations at all standard levels up to and including 5 kilometers. At these stations the resultant winds departed in various amounts throughout the year from their normals. Large departures in direction were noted over Medford, Oreg., Key West, Fla., Pensacola, Fla., Sault Ste. Marie, Mich., and Oakland, Calif. The annual average departures from normal for the combined levels showed average differences of 38.2° , 35.5° , 34.5° , 30.3° , and 27.7° , respectively. More nearly normal resultant directions were noted at Boston, Mass.; Cheyenne, Wyo.; St. Louis, Mo.; Chicago, Ill.; and Washington, D. C. The annual average differences between the actual wind directions and their normals were: 11.2° , 11.3° , 11.5° , 12.3° , and 12.8° , respectively.

The resultant-wind velocities for the year were slightly in excess of normal for the country as a whole at all levels. This was particularly noticeable for the months of January, March, May, August, November, and December. Velocities were somewhat less than normal in February, June, July, September, and October, and especially so during September.

Table 2 gives the maximum wind velocities reported in 1938. High velocities occurred over all areas with a number of records established at certain stations. The maximum velocity of 90 meters per second, recorded over Winslow, Ariz., at 12 kilometers on the 14th of November, was a new record for the United States.

TABLE 1.—Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by airplanes and radiosonde during 1938

Stations and elevations in meters above sea level	Altitude (meters) m. s. l.																											
	Surface			500			1,000			1,500			2,000			2,500			3,000			4,000			5,000			
	Number of obs.	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H			
Airplanes																												
Billings, Mont. (1,090 m.)	355	891	6.3	65							846	8.3	54	798	5.8	53	750	2.5	55	705	-1.0	57	621	-7.5	58	545	-14.4	57
Cheyenne, Wyo. (1,873 m.)	353	811	4.3	70										799	6.5	61	751	5.1	55	707	2.0	53	623	-5.2	55	548	-12.6	56
Chicago, Ill. (187 m.)	362	994	8.4	81	957	9.3	72	901	7.8	69	846	6.0	66	797	4.0	62	749	1.6	58	704	-1.0	55	620	-6.7	51	545	-12.8	48
Coco Solo, C. Z. ¹ (15 m.)	317	1,009	24.8	89	955	23.1	86	902	20.3	85	851	17.6	81	802	15.2	75	756	13.2	65	712	10.6	59	631	5.2	57	558	-0.3	52
El Paso, Tex. (1,193 m.)	354	882	13.2	49							851	15.5	41	802	13.0	41	755	9.8	43	711	6.3	44	628	-0.7	46	553	-7.5	45
Lakehurst, N. J. ¹ (39 m.)	276	1,014	8.5	83	958	10.2	63	902	7.5	60	846	5.2	60	798	2.8	56	750	0.4	51	704	-2.4	48	619	-8.6	45			
Norfolk, Va. ¹ (10 m.)	296	1,019	12.9	84	962	13.5	65	906	11.1	60	853	8.9	58	803	6.7	56	755	4.5	52	705	2.1	48	626	-3.6	43	551	-10.0	40
Pearl Harbor, T. H. ¹ (6 m.)	265	1,015	21.9	82	959	21.1	76	905	18.1	80	852	15.6	77	804	13.8	66	757	12.7	50	713	10.9	39	632	6.6	29	559	-1.4	27
Pensacola, Fla. ¹ (13 m.)	323	1,015	16.2	88	962	17.3	64	907	15.1	64	855	12.7	59	805	10.4	53	757	8.2	46	713	5.8	40	630	0.4	35	556	-5.5	32
St. Thomas, V. I. ¹ (8 m.)	359	1,016	26.0	74	961	21.8	84	907	18.4	85	855	15.6	81	806	13.4	74	759	11.8	60	715	9.5	51	633	4.1	43	560	-1.4	38
Salt Lake City, Utah (1,288 m.)	365	872	7.7	67							850	10.4	54	800	8.2	51	752	5.0	53	708	1.6	55	624	-4.9	58	549	-11.8	58
San Diego, Calif. ¹ (10 m.)	346	1,015	13.6	84	958	14.0	78	903	14.9	60	851	13.4	51	801	11.0	46	754	8.4	43	709	5.5	41	627	-0.8	38	553	-8.0	37
Seattle, Wash. ¹ (10 m.) ²	224	1,017	12.0	72	959	10.0	70	903	8.6	62	850	6.4	56	799	3.9	52	751	1.2	47	706	-1.5	42						
Spokane, Wash. (597 m.)	365	946	6.6	77				901	8.9	62	848	6.9	59	798	3.9	59	750	0.7	60	704	-2.5	60	620	-8.8	58	544	-15.2	56
Radiosonde																												
Farro, N. Dak. (274 m.) ²	334	982	1.1	81	955	3.4	74	898	3.6	66	844	2.3	64	793	0.5	61	745	-1.8	60	699	-4.4	58	615	-10.0	56	539	-16.1	55
Nashville, Tenn. (180 m.) ²	332	997	11.8	81	960	13.2	71	904	11.4	69	851	9.1	65	801	6.9	61	753	4.5	58	708	1.9	53	625	-3.6	48	550	-9.9	46
Oakland, Calif. (2 m.) ²	333	1,017	10.8	84	958	11.6	72	903	12.2	58	850	10.2	62	800	7.7	48	752	5.0	45	708	2.1	43	624	-4.2	42	549	-10.7	41
Oklahoma City, Okla. (391 m.) ²	328	971	11.7	74	958	13.3	62	903	13.6	59	851	12.1	55	801	9.7	51	754	6.9	50	709	3.9	48	626	-2.4	47	551	-8.9	44
Omaha, Neb. (300 m.) ²	331	980	7.5	79	957	8.8	70	901	9.0	62	848	7.5	58	798	5.2	55	750	2.7	53	705	-0.2	62	621	-6.5	51	546	-13.2	50
Sault Ste. Marie, Mich. (221 m.) ²	319	989	1.6	86	956	2.1	80	898	0.9	76	844	-0.8	72	792	-2.7	68	743	-4.7	66	698	-6.8	63	612	-12.0	58	537	-18.0	56
Washington, D. C. ¹ (13 m.) ²	339	1,018	10.7	82	960	10.8	69	904	8.9	66	850	6.7	66	800	4.6	64	752	2.4	59	707	0.0	56	622	-5.5	51	548	-11.6	47

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 Navy.
² Yearly means based on 11 months. Month of December 1938 not included due to insufficient number of observations.

³ Yearly means based on 11 months. Airplane flights ended June 30, 1938, and radio sonde flights started latter part of July, but not sufficient number of observations to compute a mean for that month.
⁴ Radiosonde flights started in June 1938.

TABLE 2.—Maximum free-air wind velocities (meters per second), for different sections of the United States based on pilot balloon observations during the year 1938

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	Month	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Month	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Month	Station
Northeast ¹	50.1	SSW	1,240	24	Jan.	Cleveland, Ohio	52.1	NNW	2,950	28	Feb.	Kylertown, Pa.	50.2	NW	9,520	28	Mar.	Cleveland, Ohio.
East Central ¹	55.8	WNW	2,500	14	Nov.	Washington, D. C.	69.1	WNW	2,620	14	Nov.	Washington, D. C.	53.2	W	5,140	28	Dec.	Nashville, Tenn.
Southeast ²	38.2	WSW	2,080	25	Jan.	Jacksonville, Fla.	47.5	SW	3,540	9	Dec.	Charleston, S. C.	48.8	WSW	6,150	25	Nov.	Atlanta, Ga.
North Central ⁴	49.1	W	820	14	Nov.	Detroit, Mich.	57.6	WSW	4,800	13	May	Huron, S. Dak.	62.0	SW	8,570	3	Nov.	Fargo, N. Dak.
Central ⁵	43.0	SSE	2,080	12	Nov.	Chicago, Ill.	50.0	NW	4,950	18	Dec.	Springfield, Ill.	76.8	W	9,000	12	Dec.	Wichita, Kans.
South Central ⁶	49.6	SW	1,930	28	Jan.	Oklahoma City, Okla.	74.6	NNW	4,590	25	Jan.	Abilene, Tex.	68.0	WSW	9,810	23	Dec.	Oklahoma City, Okla.
Northwest ⁷	46.2	SSW	2,300	5	Feb.	Medford, Oreg.	69.8	SSW	2,660	11	Aug.	Havre, Mont.	59.2	NE	9,380	8	Oct.	Billings, Mont.
West Central ⁸	63.3	S	2,470	19	June	Modena, Utah	58.0	S	2,500	19	June	Modena, Utah	78.0	SW	7,960	17	Oct.	Denver, Colo.
Southwest ⁹	47.8	W	1,940	19	Mar.	Havre, Mont.	70.0	WSW	4,700	4	Mar.	Albuquerque, N. Mex.	90.0	WSW	12,020	14	Nov.	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.