

DEGREE-DAY NORMALS OVER THE UNITED STATES

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[Weather Bureau, Lincoln, Nebr., February 1937]

Because of the increased interest in degree-days, and the increased understanding of them as heating units by the general public, it has become more and more desirable during recent years to prepare normals by which to compare not only different winters in one place, but also the severity of a certain winter, or perhaps the normal winter, at two or more different places. This paper presents normal numbers of degree-days per month and per heating season for 158 first-order Weather Bureau stations over the United States. The normals are presented with the knowledge that there are some weaknesses in the method of calculation, but with the assurance that whatever error may be present is such that it will not materially detract from the value of the data in comparisons.

The number of degree-days is defined to be the difference between the mean temperature and 65°, applicable only when the mean temperature is below 65°, as a negative number of degree-days has no meaning. It is considered that for every degree that the mean temperature drops below 65°, a unit amount of heat must be used to keep a building at the optimum temperature. A day with the mean temperature of 64° will add one degree-day to the month's total; whereas a day with a mean temperature of 50° will require 15 units of heat and therefore will add 15 degree-days. Summing up the number of units for the individual days over a specified period, the total for a month, season, or any desired period is obtained.

A comparative table of the normal number of degree-days is of value because it is a very good measure of the severity of winters at various places. The mean annual temperature at two places is obviously not a good measure, for one may be comparatively mild throughout the year and the other have a hot summer and a cold winter, yet their mean annual temperatures may be nearly the same. For example, San Francisco, Calif., and Wichita, Kans., have annual mean temperatures of 56.1°, but the annual number of degree-days for San Francisco is 3,244, while that for Wichita is 4,558, which indicates a difference in winter severity of 1,314 degree-days, or over 40 percent.

Also, judging the winter severity at a station by its January mean temperature or by the mean winter (December, January, and February) temperature may lead to some erroneous conclusions due to the fact that at some stations the length of the winter may be of greater importance than its coldness. The normal seasonal degree-days take into consideration both the length and the coldness of the heating period.

Table 1 gives the monthly and annual normal numbers of degree-days at 158 cities in the United States. They are computed from tables given in *Normals of Daily Temperature for the United States*, by Charles F. Marvin and P. C. Day.¹ Whenever the mean temperature of every day during the month was less than 64.6°, the following equation was used in computation:

$$\text{Number of degree-days} = (65 - T)N$$

where T is the mean monthly temperature and N the number of days in the month. During a month when the mean temperature of any day exceeded 64.5° it was obvious that error would come in, and so for these months

the degree-days were computed by individual days and totaled to find the monthly amount.

This method of calculation will not give quite the same results as a long time average of degree-days. At many stations the mean range of temperature is large, and when the mean temperature approaches the limiting value of 65° the heating units, as computed from averages, will be too few. This is readily illustrated by two days having mean temperatures of 60° and 70°, respectively. Taken individually they will contribute five degree-days, but if averaged first they will contribute none.

In an attempt to determine the magnitude of this error, the records of Lincoln, Nebr., were used and the degree-days for 50 years (July 1886-June 1936, inclusive) were computed by days, totaled, and averaged. It was found that the actual average was 6,113 degree-days as compared to the normal of 6,053 obtained by the previously used method, which indicates a discrepancy of less than 1 percent.

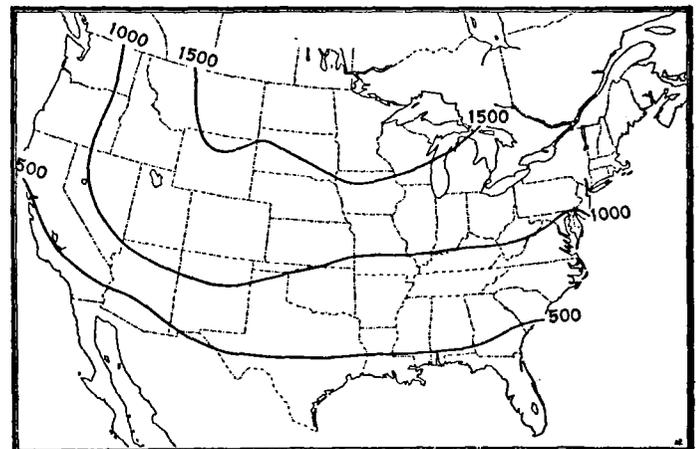


FIGURE 1.—Average number of degree-days for January.

The periods of years used in computing the two values were not identical, because the normal temperatures had been adjusted to cover a longer time; also a number of years of record had been added since the normal temperature had been computed. This may be the reason why the error is not as great as had been expected. However, since the error could scarcely appear at any time except from May through October at this station (other monthly means were far below 65°), the values for these months alone were taken and it was found that the actual average was 181 degree-days greater than the computed normal. This still remains less than 3 percent of the normal seasonal total, and since for all stations it would be of the same sign and quite small, it probably would not differ greatly from station to station and so would not greatly affect the usefulness of the normals in comparisons.

Figure 1 shows the January normal number of degree-days over the United States. The lines on this map follow closely the lines of January's actual mean temperature (not sea-level temperature, as is frequently published), which is as would be expected.

Figure 2 shows the annual normal number of degree-days, and considerable difference from the annual mean

¹ Normals of Daily Temperatures for the United States, MONTHLY WEATHER REVIEW SUPPLEMENT No. 25, Charles F. Marvin and P. C. Day.

temperature map is apparent. This difference is more easily shown by quoting individual cases. San Francisco and Wichita have already been mentioned. Portland, Oreg., and Concordia, Kans., have identical mean annual temperatures, but have a difference of 960 degree-days

Rock, Ark., have nearly equal mean temperatures, but their annual degree-days number 1,472 and 2,863, respectively, which show one to be 94 percent more severe than the other.

That January, the coldest month, cannot be taken as a test of the severity of the entire winter is seen by comparing the two degree-day maps. However, here again, individual examples are still more impressive. Columbia, Mo., and Salt Lake City, Utah, have identical January temperatures and degree-day normals, but their annual number of degree-days differs by 612. Charleston, S. C., and San Francisco, Calif., have equal January normals, but the annual totals of their degree-days differ by 88 percent. Finally Seattle, Wash., and Fort Smith, Ark., have equal January temperatures, but their annual numbers of degree-days differ by 1,995; conversely, the annual totals of degree-days at Seattle, Wash., and Topeka, Kans., are nearly the same, but their January amounts are 790 and 1,159, respectively.

It is evident that neither January mean temperatures nor the annual mean temperatures give a true indication of the comparative severity of the cold season at various places. The mean winter temperature, which generally means December, January, and February, does not take into consideration the varying length of the heating season at various places. Normals of degree-days combine the entire winter into one quantity which is easily mapped and which results in easy comparison of stations, and therefore appears to be more practicable than any other known method of comparing the severity of winters.

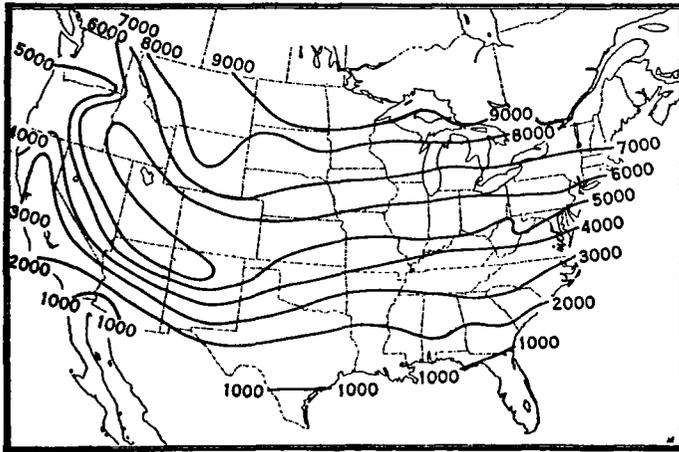


FIGURE 2.—Average annual number of degree-days.

in their annual total, which would be equivalent to 3 months averaging 10 degrees colder. Santa Fe, N. Mex., Erie, Pa., and Dubuque, Iowa, have nearly equal annual mean temperatures but have a range in number of annual degree-days of nearly 700. Los Angeles, Calif., and Little

TABLE I.—Average number of degree-days

Stations	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Abilene, Tex.	645	498	264	36	---	---	---	---	---	39	345	589	2,416
Albany, N. Y.	1,299	1,145	1,001	546	177	1	---	---	69	400	771	1,132	6,541
Alpena, Mich.	1,423	1,316	1,224	792	450	138	2	34	222	555	918	1,246	8,320
Amarillo, Tex.	921	753	561	276	49	---	---	---	---	228	585	868	4,239
Atlanta, Ga.	664	552	403	120	---	---	---	---	---	80	387	629	2,865
Atlantic City, N. J.	1,008	879	818	516	214	8	---	---	10	251	582	887	5,173
Augusta, Ga.	558	423	279	45	---	---	---	---	---	40	315	524	2,184
Baker, Oreg.	1,243	1,008	849	594	412	192	12	27	270	570	870	1,169	7,216
Baltimore, Md.	967	829	704	342	47	---	---	---	2	211	561	862	4,525
Binghamton, N. Y.	1,268	1,148	1,004	688	236	18	---	---	113	465	789	1,141	6,770
Birmingham, Ala.	617	476	298	58	---	---	---	---	---	51	333	577	2,410
Bismarck, N. Dak.	1,773	1,532	1,265	687	326	56	---	5	207	623	1,095	1,559	9,127
Block Island, R. I.	1,054	969	918	630	378	95	---	---	56	313	612	899	5,924
Boise, Idaho	1,091	846	691	438	245	30	---	---	102	431	720	1,020	5,614
Boston, Mass.	1,150	1,014	911	558	245	13	---	---	61	353	690	1,008	6,003
Brownsville, Tex.	161	68	---	---	---	---	---	---	---	4	118	---	851
Buffalo, N. Y.	1,252	1,140	1,051	666	323	41	---	---	81	406	768	1,091	6,818
Burlington, Vt.	1,432	1,277	1,113	651	264	21	---	---	140	490	861	1,259	7,508
Calro, Ill.	933	742	552	207	3	---	---	---	---	147	531	843	3,958
Charles City, Iowa	1,590	1,341	1,063	558	223	12	---	---	124	508	960	1,383	7,762
Charleston, S. C.	468	353	236	37	---	---	---	---	---	8	207	412	1,721
Charlotte, N. C.	738	591	453	156	---	---	---	---	---	111	432	682	3,168
Chattanooga, Tenn.	738	585	428	141	---	---	---	---	---	106	438	673	3,169
Cheyenne, Wyo.	1,224	1,056	989	723	456	138	---	13	240	626	906	1,132	7,503
Chicago, Ill.	1,237	1,063	890	519	202	3	---	---	17	307	714	1,085	6,027
Cincinnati, Ohio	1,076	902	747	378	71	---	---	---	10	288	675	980	5,127
Cleveland, Ohio	1,194	1,053	942	564	220	6	---	---	47	353	723	1,048	6,150
Columbia, Mo.	1,110	932	694	303	48	---	---	---	5	260	651	986	4,989
Columbia, S. C.	589	470	304	63	---	---	---	---	---	54	330	552	2,362
Columbus, Ohio	1,128	960	803	414	93	---	---	---	15	304	693	1,011	5,421
Concord, N. H.	1,345	1,182	1,060	648	332	68	---	---	4	171	474	819	7,287
Concordia, Kans.	1,197	986	744	345	71	---	---	---	6	282	706	1,063	5,402
Corpus Christi, Tex.	279	185	22	---	---	---	---	---	---	---	41	217	744
Davenport, Iowa	1,339	1,123	896	453	117	---	---	---	27	350	780	1,175	6,260
Dayton, Ohio	1,100	941	760	402	87	---	---	---	15	310	690	1,004	5,309
Denver, Colo.	1,091	904	797	537	273	18	---	---	78	428	756	1,014	5,894
Des Moines, Iowa	1,392	1,156	902	447	117	---	---	---	28	360	798	1,209	6,409
Detroit, Mich.	1,259	1,112	980	564	217	4	---	---	58	388	771	1,107	6,480
Dodge City, Kans.	1,116	890	688	342	65	---	---	---	3	276	672	1,004	5,058
Dubuque, Iowa	1,423	1,198	961	492	148	---	---	---	53	406	840	1,249	6,770
Duluth, Minn.	1,770	1,501	1,280	840	549	234	32	74	297	648	1,050	1,522	9,797
Eastport, Maine	1,383	1,218	1,119	780	536	297	143	133	276	542	849	1,200	8,476
Elkins, W. Va.	1,073	935	775	486	180	3	---	---	71	394	741	1,001	5,659
El Paso, Tex.	620	448	285	59	---	---	---	---	---	72	309	623	2,476
Erie, Pa.	1,184	1,067	976	597	254	13	---	---	55	360	708	1,026	6,240
Escanaba, Mich.	1,538	1,389	1,265	813	477	130	---	29	237	689	957	1,321	8,745
Eureka, Calif.	561	498	518	453	403	321	294	279	273	353	417	521	4,801
Evansville, Ind.	976	804	592	249	16	---	---	---	---	174	552	865	4,228
Fort Smith, Ark.	790	622	384	97	---	---	---	---	---	89	420	710	3,112
Fort Worth, Tex.	606	468	226	25	---	---	---	---	---	24	285	542	2,178
Fresno, Calif.	583	389	310	144	7	---	---	---	---	53	324	583	2,393
Galveston, Tex.	347	244	82	---	---	---	---	---	---	64	267	1,004	---
Grand Haven, Mich.	1,262	1,142	1,032	639	326	51	---	---	122	443	795	1,107	6,919
Grand Junction, Col.	1,271	899	663	378	123	---	---	---	31	378	771	1,162	5,676
Grand Rapids, Mich.	1,256	1,156	980	540	217	4	---	---	78	428	798	1,132	6,589
Green Bay, Wis.	1,528	1,333	1,128	654	313	35	---	---	139	512	930	1,324	7,896

TABLE I.—Average number of degree-days—Continued

Stations	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Greenville, S. C.	768	608	468	192	8					148	462	707	3,359
Hannibal, Mo.	1,175	988	744	348	63				9	279	687	1,038	6,331
Harrisburg, Pa.	1,116	974	809	423	102				23	316	666	1,001	5,430
Hatteras, N. C.	555	493	403	156	1					27	261	462	2,358
Havre, Mont.	1,615	1,439	1,175	639	360	94		22	258	636	1,014	1,383	8,635
Helena, Mont.	1,389	1,176	1,011	645	415	174	8	21	252	623	954	1,265	7,933
Houghton, Mich.	1,559	1,436	1,308	819	480	150	3	42	243	598	990	1,339	8,967
Houston, Tex.	381	258	86							122	329		1,143
Huron, S. Dak.	1,065	1,420	1,119	597	267	18			112	536	1,005	1,435	8,174
Independence, Calif.	831	638	512	297	72				7	232	534	797	3,920
Indianapolis, Ind.	1,135	949	775	387	77				12	288	681	1,017	5,321
Ithaca, N. Y.	1,262	1,134	1,032	600	232	12			102	431	792	1,116	6,713
Jacksonville, Fla.	298	196	76							88	270		928
Kalispell, Mont.	1,383	1,168	995	642	422	219	33	69	345	666	978	1,243	8,163
Kansas City, Mo.	1,141	946	691	396	43				226	639	1,008	1,008	6,002
Keokuk, Iowa	1,243	1,028	809	381	59				10	298	717	1,097	5,642
Knoxville, Tenn.	812	647	505	210	8					160	513	766	3,621
La Crosse, Wis.	1,616	1,282	1,038	534	177	1			87	456	894	1,324	7,309
Lander, Wyo.	1,448	1,190	1,011	678	428	135		18	279	666	1,041	1,383	8,277
Lansing, Mich.	1,321	1,179	1,017	582	251	15			107	456	825	1,172	6,925
Lewiston, Idaho	1,008	784	608	363	170	9			83	418	708	908	5,059
Lexington, Ky.	995	829	660	321	46				2	236	606	905	4,600
Lincoln, Nebr.	1,308	1,089	852	405	107				21	335	777	1,159	6,053
Little Rock, Ark.	732	563	372	92						72	387	645	2,863
Los Angeles, Calif.	322	266	232	168	87	3				11	123	260	1,472
Louisville, Ky.	949	778	608	258	16					178	549	849	4,185
Lynchburg, Va.	852	692	549	231	9				1	202	534	790	3,860
Macon, Ga.	564	440	257	51						53	324	542	2,231
Madison, Wis.	1,497	1,285	1,066	588	229	7			85	456	894	1,308	7,415
Marquette, Mich.	1,510	1,304	1,246	816	496	183	12	37	225	597	951	1,314	8,721
Memphis, Tenn.	747	590	394	98						76	399	663	2,957
Meridian, Miss.	558	431	245	41						56	324	536	2,191
Milwaukee, Wis.	1,376	1,182	1,020	636	338	52			80	431	831	1,206	7,152
Minneapolis, Minn.	1,621	1,375	1,097	558	226	9			113	499	978	1,407	7,883
Mobile, Ala.	418	288	164	11						3	192	397	1,473
Modena, Utah	1,187	952	831	570	356	62			150	527	858	1,144	6,637
Montgomery, Ala.	1,521	1,277	1,023	24						24	276	484	1,927
Moorhead, Minn.	1,897	1,593	1,311	732	307	34		7	69	636	1,137	1,658	9,516
Nantucket, Mass.	1,045	960	914	648	394	120			204	335	618	905	6,006
Nashville, Tenn.	818	655	490	180	3					130	480	744	3,500
New Haven, Conn.	1,141	1,008	905	534	220	10			55	347	690	1,008	5,918
New Orleans, La.	335	216	71							104	291	401	1,017
New York, N. Y.	1,057	944	846	468	139				12	270	624	930	5,290
Norfolk, Va.	766	624	521	246	19					89	408	679	3,342
Northfield, Vt.	1,544	1,361	1,197	741	378	111		53	267	604	966	1,383	8,605
North Head, Wash.	710	616	614	525	437	306		229	255	375	504	648	5,461
North Platte, Nebr.	1,305	1,075	880	492	195	4			97	474	852	1,187	6,561
Oklahoma City, Okla.	887	711	465	156	3					120	486	797	3,625
Omaha, Nebr.	1,336	1,106	888	414	91				16	332	795	1,197	6,154
Oswego, N. Y.	1,274	1,151	1,048	642	304	34			113	428	783	1,116	6,893
Palestine, Tex.	621	386	183	12						17	234	468	1,821
Parkersburg, W. Va.	1,008	862	688	348	55				10	276	636	924	4,807
Pensacola, Fla.	388	274	146	6						144	341	411	1,299
Philadelphia, Pa.	1,004	871	750	387	77				3	223	579	890	4,784
Phoenix, Ariz.	428	277	133	4						160	403	603	1,405
Pierre, S. Dak.	1,519	1,299	1,038	546	217	3			62	471	942	1,339	7,436
Pittsburgh, Pa.	1,063	916	787	414	91				15	288	654	955	5,183
Pocatello, Idaho	1,249	1,011	866	570	347	88			144	515	849	1,156	6,785
Port Huron, Mich.	1,324	1,184	1,073	660	304	38			102	450	825	1,159	7,119
Portland, Maine	1,321	1,154	1,029	660	363	79			162	468	810	1,159	7,210
Portland, Oreg.	794	641	561	396	251	80			100	335	546	738	4,442
Pueblo, Colo.	1,088	899	725	447	180	2			47	403	768	1,038	5,697
Raleigh, N. C.	741	610	459	168	1					98	420	682	3,179
Rapid City, S. Dak.	1,333	1,165	1,004	621	341	49			140	512	873	1,181	7,219
Red Bluff, Calif.	595	437	353	180	15					51	336	586	2,553
Richmond, Va.	840	711	552	252	15					167	501	781	3,819
Rochester, N. Y.	1,252	1,131	1,029	603	245	13			81	418	789	1,107	6,668
Roseburg, Oreg.	738	605	555	420	279	76			67	344	573	719	4,376
Sacramento, Calif.	595	417	332	58						73	342	583	2,400
Saginaw, Mich.	1,342	1,207	1,038	603	251	9			100	456	828	1,172	7,006
St. Louis, Mo.	1,051	846	648	267	15					191	588	933	4,539
St. Paul, Minn.	1,624	1,378	1,113	682	220	7			113	508	975	1,426	7,946
Salt Lake City, Utah	1,110	874	722	462	236	12			54	388	717	1,026	5,601
San Antonio, Tex.	394	269	70							138	350	501	1,221
San Diego, Calif.	332	277	257	195	130	36				42	159	279	1,707
Sandusky, Ohio	1,200	1,053	927	534	180				27	332	717	1,048	6,018
San Francisco, Calif.	408	358	335	300	254	195		183	123	140	261	425	3,244
San Luis Obispo, Calif.	415	333	319	276	211	87		7	14	99	231	372	2,364
Santa Fe, N. Mex.	1,122	893	784	549	288	30			122	463	783	1,063	6,087
Sault Ste. Marie, Mich.	1,603	1,467	1,345	828	496	192		37	90	285	632	990	9,345
Savannah, Ga.	422	308	186	15						7	195	391	1,624
Scranton, Pa.	1,190	1,056	908	507	174	1			74	406	735	1,063	6,114
Seattle, Wash.	790	669	623	468	326	180			207	422	582	722	5,107
Shreveport, La.	558	395	298	16						24	270	493	1,964
Sioux City, Iowa	1,463	1,232	1,001	516	142				68	437	804	1,299	7,052
Spokane, Wash.	1,162	944	784	498	294	72			174	518	795	1,071	6,312
Springfield, Ill.	1,194	994	769	369	71				7	285	684	1,032	5,405
Springfield, Mo.	976	834	614	270	41				2	211	579	893	4,420
Tacoma, Wash.	812	683	645	489	338	189		68	74	231	460	612	5,347
Tampa, Fla.	143	87	4							4	121	211	369
Toledo, Ohio	1,215	1,066	921	522	174				41	360	738	1,073	6,100
Topeka, Kans.	1,159	952	694	309	49				3	248	666	1,023	5,103
Valentine, Nebr.	1,429	1,221	1,014	579	273	19			88	437	912	1,252	7,274
Wicksburg, Miss.	521	370	202	19						22	252	465	1,861
Walla Walla, Wash.	1,001	781	586	357	167	9			58	356	666	914	4,895
Washington, D. C.	980	832	694	351	61				3	236	594	880	4,631
Wichita, Kans.	1,045	867	617	258	34					199	606	942	4,558
Williston, N. Dak.	1,817	1,593	1,305	690	341	75			16	252	670	1,134	1,587
Wilmington, N. C.	574	479	363	94						31	270	493	2,304
Winnemucca, Nev.	1,128	882	775	549	344	76			175	518	798	1,085	6,330
Yankton, S. Dak.	1,479	1,235	986	513	174				53	431	891	1,308	7,070
Yuma, Ariz.	329	179	38								89	304	939