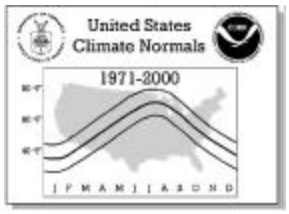

United States Climate Normals, 1971-2000
Degree Day Computation Methodology

National Climatic Data Center/NESDIS/NOAA
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The 1971-2000 degree day normals are computed using a new methodology. Previously, degree days were computed using the Thom rational conversion formulae (Thom 1954, 1966). The Thom method allows a monthly degree day total to be estimated from input average temperature means and standard deviations.

For the 1971-2000 normals, degree day totals were computed in *two* distinct ways. For stations that are not first-order National Weather Service locations, the rational conversion formulae developed by Thom (1954, 1966) was *modified* by using inputs of daily spline-fit (rather than monthly) means and standard deviations of average temperature. This modification improved consistency of the estimated degree day totals by eliminating month-by-month 'steps' in the inputs. For first-order stations, where daily data sets are largely devoid of missing values, monthly degree day totals were derived directly from daily values.

Computation of First-Order Monthly Degree Day Totals:

Based on comments from the climate research community and energy groups, monthly degree day totals were derived directly from daily average temperature values for first-order sites for the 1971-2000 period. Appendix A lists the first-order stations subjected to direct computation. These stations are also identified with an asterisk '*' in the HDD/CDD section of the monthly normals (CLIM81) PDF publication.

The computation of first-order monthly degree day totals began with the computation of average daily temperatures for the 1971-2000 period (with a precision of 0.5 degree Fahrenheit). Daily HDD/CDD (base 65) values were then computed with a precision of 0.5. The summation of these daily degree day values yielded 360 monthly totals for the 1971-2000 period. From the respective 30 monthly totals for a given month, the preliminary monthly degree day normal was computed using a simple average.

Monthly average temperature normals were computed based on a sequential record adjusted for inhomogeneities (due to changes in station locations, instrumentation, time of observation, surrounding environment, observing practice, sensor drift, *etc*). Such adjustments yielded a time series and normals representative of the observing practices as of the end of the normals period (*i.e.*, December 2000), since these are the conditions under which future observations will likely be compared. This adjustment was not accounted for in the preliminary monthly degree day normals, so they were subsequently adjusted for compatibility with the monthly average temperatures.

Daily normals of temperature, degree days, and precipitation were interpolating based upon the monthly normals. Each element was interpolated independently using a cubic spline fit function (Greville, 1967). To eliminate discontinuities between December 31 and January 1, the spline interpolation was performed on a series of 24 monthly values (included a repetition of values for the six months preceding and following the twelve monthly values). The resultant smooth curve of daily values for an element averaged or totaled up to the respective monthly normal.

Given the independent computation of each element, adjustments were performed on the daily data to remove spurious inflection points caused by rounding and to ensure adherence to functional relationships among the elements. Adjustments were based upon achieving climatologically reasonable inflection points, daily consistency between elements, monthly consistency between daily and monthly values by element, and close adherence of temperature and degree day values to the formula $T - 65 + H - C = 0$, where T = mean temperature, H = heating degree days, and C = cooling degree days. The preliminary degree day normals were adjusted in the context of these consistency checks to arrive at the final degree day normal for a given month.

In limited cases, preliminary degree day normals, when spline fit, resulted in daily values of 1 that were separated from the major rise and fall of non-zero daily degree day values over the course of a heating/cooling degree day season. These spurious daily degree day values are indicated with a '-99' (or an asterisk in non-digital printouts). Their presence assures consistency between the monthly total and the sum of the daily total (when values are considered equal to 1).

An example of the computation of first-order monthly degree day normals is shown in Table 1. The monthly average temperature values for both Buffalo, New York and Erie, Pennsylvania were adjusted for inhomogeneities, with an average adjustment of +0.1 and +1.0 degrees Fahrenheit, respectively. With positive average temperature adjustments, the expected adjustments to the preliminary monthly degree day normals would be downward for HDD and upward for CDD. This is the case here, as the preliminary HDD annual total of 6697 is adjusted downward by a modest 5 degree days to 6692 at Buffalo, while the preliminary CDD annual total of 539 is adjusted upward just 9 degree days to 548. With a larger average temperature adjustment at Erie, the adjustments to the preliminary degree days are more pronounced, from 6402 downward to 6243 for HDD and from 571 upward to 620 for CDD.

In evaluating the degree day adjustments on a month-by-month basis, it should be noted that the magnitude of the average temperature adjustment generally, but not strictly, correlates to the magnitude of the degree day adjustment. The variability is due to the constraint of assuring daily consistency between elements as well as day-to-day consistency within elements in the daily normals.

The computation of degree days for first-order stations for the 1971-2000 normals brings together the benefits of direct computation of values (versus estimation) with the need for degree day totals that are consistent with the homogeneity-adjusted monthly

temperatures. As data sets are refined and improved, there is an expectation that homogeneity adjustments will be performed on the daily data itself, eliminating the two-step process inherent in the present methodology.

Table 1. Degree Day Computations for Buffalo, NY and Erie, PA.

Normals Computations, 1971-2000							Normals Computations, 1971-2000						
BUFFALO NIAGARA INTL AP	New York			COOP: 301012			ERIE INTERNATIONAL AP	Pennsylvania			COOP: 362682		
				Heating Degree Days							Heating Degree Days		
Month	UnrndMean	AdjustMean	MeanDiff	Computed	Adjustment	Official	Month	UnrndMean	AdjustMean	MeanDiff	Computed	Adjustment	Official
01	24.4	24.5	-0.1	1257	-1	1256	01	26.1	26.9	0.8	1207	-11	1196
02	25.8	25.9	-0.1	1108	2	1110	02	27.2	28.2	1.0	1069	-23	1046
03	34.2	34.3	-0.1	954	7	961	03	35.4	36.5	1.1	919	-19	900
04	45.3	45.3	0.0	595	-1	594	04	45.6	46.8	1.2	585	-18	567
05	57.2	57.0	0.2	268	0	268	05	56.8	58.1	1.3	285	-25	260
06	66.1	65.8	0.3	66	-1	65	06	66.0	67.4	1.4	75	-17	58
07	71.1	70.8	0.3	9	-1	8	07	70.8	72.1	1.3	13	-9	4
08	69.4	69.1	0.3	22	-1	21	08	69.8	70.9	1.1	18	-3	15
09	61.7	61.5	0.2	150	-1	149	09	63.0	64.0	1.0	123	-7	116
10	50.9	50.7	0.2	440	2	442	10	52.4	53.3	0.9	397	-11	386
11	40.4	40.2	0.2	739	-2	737	11	42.2	42.9	0.7	686	-7	679
12	29.9	29.8	0.1	1089	-8	1081	12	32.0	32.7	0.7	1025	-9	1016
Annual			0.1	6697	-0.4	6692	Annual			1.0	6402	-13.3	6243
				Cooling Degree Days							Cooling Degree Days		
Month	UnrndMean	AdjustMean	MeanDiff	Computed	Adjustment	Official	Month	UnrndMean	AdjustMean	MeanDiff	Computed	Adjustment	Official
01	24.4	24.5	-0.1	0	0	0	01	26.1	26.9	0.8	0	0	0
02	25.8	25.9	-0.1	0	0	0	02	27.2	28.2	1.0	0	0	0
03	34.2	34.3	-0.1	0	0	0	03	35.4	36.5	1.1	1	0	1
04	45.3	45.3	0.0	3	1	4	04	45.6	46.8	1.2	5	0	5
05	57.2	57.0	0.2	27	1	28	05	56.8	58.1	1.3	31	-1	30
06	66.1	65.8	0.3	100	1	101	06	66.0	67.4	1.4	106	9	115
07	71.1	70.8	0.3	199	4	203	07	70.8	72.1	1.3	194	14	208
08	69.4	69.1	0.3	156	2	158	08	69.8	70.9	1.1	165	18	183
09	61.7	61.5	0.2	50	0	50	09	63.0	64.0	1.0	63	8	71
10	50.9	50.7	0.2	4	0	4	10	52.4	53.3	0.9	6	1	7
11	40.4	40.2	0.2	0	0	0	11	42.2	42.9	0.7	0	0	0
12	29.9	29.8	0.1	0	0	0	12	32.0	32.7	0.7	0	0	0
Annual			0.1	539	0.8	548	Annual			1.0	571	4.1	620

References:

Greville, T.N.E., 1967: "Spline functions, interpolation, and numerical quadrature," Mathematical Methods for Digital Computers, Vol. II, A. Ralston and H.S. Wilf (eds.), pp.156-168, Wiley, New York.

Thom, H.C.S., 1954: "The rational relationship between heating degree days and temperature," Monthly Weather Review, Vol. 82, pp. 1-6.

Thom, H.C.S., 1966: "Normal degree days above any base by the universal truncation coefficient," Monthly Weather Review, Vol. 94, pp. 461-465.

Appendix A. Stations with Directly Computed Monthly Degree Day Totals

(COOP ID/ WBAN ID/ Name / State Abbreviation)

010831	13876	BIRMINGHAM INTL AP	AL	154954	93821	LOUISVILLE STANDIFORD AP	KY
014064	03856	HUNTSVILLE INTL AP	AL	156110	03816	PADUCAH BARKLEY RGNL AP	KY
015478	13894	MOBILE RGNL AP	AL	160549	13970	BATON ROUGE RYAN AP	LA
015550	13895	MONTGOMERY DANNELLY AP	AL	165078	03937	LAKE CHARLES AP	LA
023010	03103	FLAGSTAFF PULLIAM AP	AZ	166660	12916	NEW ORLEANS INTL AP	LA
026481	23183	PHOENIX SKY HRBR INTL AP	AZ	168440	13957	SHREVEPORT AP	LA
028820	23160	TUCSON INTL AP	AZ	171175	14607	CARIBOU MUNICIPAL AP	ME
029439	23194	WINSLOW AP	AZ	176905	14764	PORTLAND INTL AP	ME
032574	13964	FORT SMITH RGNL AP	AR	180465	93721	BALTIMORE-WASHINGTON AP	MD
034248	13963	LITTLE ROCK ADAMS AP	AR	190736	14753	BLUE HILL OBS MILTON	MA
040442	23155	BAKERSFIELD KERN CO AP	CA	190770	14739	BOSTON LOGAN INTL AP	MA
040822	23157	BISHOP AP	CA	200164	94849	ALPENA COLLINS AP	MI
043257	93193	FRESNO YOSEMITE INTL	CA	202103	94847	DETROIT METRO AP	MI
045085	23129	LONG BEACH AP	CA	202846	14826	FLINT BISHOP INTL AP	MI
045114	23174	LOS ANGELES INTL AP	CA	203333	94860	GRAND RAPIDS INTL AP	MI
045115	93134	LOS ANGELES DOWNTOWN USC	CA	203936	94814	HOUGHTON LAKE ROSCOMMON	MI
047740	23188	SAN DIEGO LINDBERGH AP	CA	204641	14836	LANSING CAPITAL CITY AP	MI
047769	23234	SAN FRANCISCO INTL AP	CA	205712	14840	MUSKEGON COUNTY AP	MI
047946	23273	SANTA MARIA AP	CA	207366	14847	SAULT STE MARIE AP	MI
048558	23237	STOCKTON AP	CA	212248	14913	DULUTH INTL AP	MN
050130	23061	ALAMOSA BERGMAN FIELD	CO	214026	14918	INTL FALLS AP	MN
051778	93037	COLORADO SPRINGS MNPL AP	CO	215435	14922	MINNEAPOLIS INTL AP	MN
053488	23066	GRAND JUNCTION WALKER AP	CO	217294	14926	ST CLOUD MUNICIPAL AP	MN
056740	93058	PUEBLO AP	CO	224472	03940	JACKSON THOMPSON AP	MS
060806	94702	BRIDGEPORT SIKORSKY AP	CT	225776	13865	MERIDIAN KEY AP	MS
063456	14740	HARTFORD BRADLEY INTL AP	CT	229003	93862	TUPELO RGNL AP	MS
079595	13781	WILMINGTON NEW CASTLE AP	DE	231791	03945	COLUMBIA RGNL AP	MO
082158	12834	DAYTONA BEACH INTL AP	FL	237455	13994	ST LOUIS INTL AP	MO
083186	12835	FORT MYERS (PAGE AP)	FL	237976	13995	SPRINGFIELD REG AP	MO
083326	12816	GAINESVILLE RGNL AP	FL	240807	24033	BILLINGS INTL AP	MT
084358	13889	JACKSONVILLE INTL AP	FL	243558	94008	GLASGOW INTL AP	MT
084570	12836	KEY WEST INTL AP	FL	243751	24143	GREAT FALLS INTL AP	MT
085663	12839	MIAMI INTL AP	FL	243996	94012	HAVRE CITY CO AP	MT
086997	13899	PENSACOLA RGNL AP	FL	244055	24144	HELENA AP	MT
088758	93805	TALLAHASSEE MUNICIPAL AP	FL	244558	24146	KALISPELL GLACIER PK AP	MT
088788	12842	TAMPA INTL AP	FL	245745	24153	MISSOULA INTL AP	MT
089525	12844	WEST PALM BEACH INTL AP	FL	253395	14935	GRAND ISLAND CTR NE AP	NE
090435	13873	ATHENS BEN EPPS AP	GA	254795	14939	LINCOLN AP	NE
090451	13874	ATLANTA HARTSFIELD AP	GA	255995	14941	NORFOLK AP	NE
090495	03820	AUGUSTA BUSH FIELD AP	GA	256065	24023	NORTH PLATTE RGNL AP	NE
092166	93842	COLUMBUS METRO AP	GA	256255	14942	OMAHA EPPLEY AP	NE
095443	03813	MACON MIDDLE GA RGNL AP	GA	257665	24028	SCOTTSBLUFF AP	NE
097847	03822	SAVANNAH MUNICIPAL AP	GA	258760	24032	VALENTINE MILLER AP	NE
101022	24131	BOISE AIR TERMINAL	ID	262631	23154	ELY	NV
105241	24149	LEWISTON AP	ID	264436	23169	LAS VEGAS AP	NV
107211	24156	POCATELLO RGNL AP	ID	266779	23185	RENO CANNON INTL AP	NV
111549	94846	CHICAGO OHARE INTL AP	IL	269171	24128	WINNEMUCCA MUNICIPAL AP	NV
115751	14923	MOLINE QUAD CITY AP	IL	271683	14745	CONCORD MUNICIPAL AP	NH
116711	14842	PEORIA GTR PEORIA AP	IL	280311	93730	ATLANTIC CITY AP	NJ
117382	94822	ROCKFORD AP	IL	286026	14734	NEWARK INTL AP	NJ
118179	93822	SPRINGFIELD CAPITAL AP	IL	290234	23050	ALBUQUERQUE INTL AP	NM
122738	93817	EVANSVILLE INTL AP	IN	300042	14735	ALBANY INTL AP	NY
123037	14827	FORT WAYNE BAER AP	IN	300687	04725	BINGHAMTON BROOME CO AP	NY
124259	93819	INDIANAPOLIS INTL AP	IN	301012	14733	BUFFALO NIAGARA INTL	NY
128187	14848	SOUTH BEND RGNL AP	IN	305801	94728	NEW YORK CITY CENTRAL PK	NY
132203	14933	DES MOINES AP	IA	305803	94789	NEW YORK JFK INTL AP	NY
132367	94908	DUBUQUE AP	IA	305811	14732	NEW YORK LA GUARDIA AP	NY
137708	14943	SIOUX CITY AP	IA	307167	14768	ROCHESTER MONROE CO AP	NY
138706	94910	WATERLOO MUNICIPAL AP	IA	308383	14771	SYRACUSE HANCOCK INTL AP	NY
141767	13984	CONCORDIA BLOSSER AP	KS	310300	03812	ASHEVILLE RGNL AP	NC
142164	13985	DODGE CITY RGNL AP	KS	311458	93729	CAPE HATTERAS NWS BLDG	NC
143153	23065	GOODLAND RENNER AP	KS	311690	13881	CHARLOTTE DGLAS INTL AP	NC
148167	13996	TOPEKA BILLARD MNCPL AP	KS	313630	13723	GREENSBORO RGNL AP	NC
148830	03928	WICHITA MID-CONTINENT AP	KS	317069	13722	RALEIGH DURHAM AP	NC
151855	93814	CINCINNATI COVINGTON AP	KY	319457	13748	WILMINGTON NEW HANVR AP	NC
154746	93820	LEXINGTON BLUE GRASS AP	KY	320819	24011	BISMARCK MUNICIPAL AP	ND

322859	14914	FARGO HECTOR AP	ND	411136	12919	BROWNSVILLE AP	TX
323616	14916	GRAND FORKS INTL AP	ND	412015	12924	CORPUS CHRISTI INTL AP	TX
329425	94014	WILLISTON SLOULIN AP	ND	412244	13960	DALLAS LOVE AP	TX
330058	14895	AKRON CANTON AP	OH	412360	22010	DEL RIO INTL AP	TX
331657	14820	CLEVELAND HOPKNS INTL AP	OH	412797	23044	EL PASO INTL AP	TX
331786	14821	COLUMBUS INTL AP	OH	414300	12960	HOUSTON BUSH INTL AP	TX
332075	93815	DAYTON INTL AP	OH	415411	23042	LUBBOCK RGNL AP	TX
334865	14891	MANSFIELD LAHM AP	OH	415890	23023	MIDLAND INTL AP	TX
338357	94830	TOLEDO EXPRESS AP	OH	417174	12917	PORT ARTHUR AP BEAUMONT	TX
339406	14852	YOUNGSTOWN MUNICIPAL AP	OH	417943	23034	SAN ANGELO MATHIS AP	TX
346661	13967	OKLAHOMA CITY AP	OK	417945	12921	SAN ANTONIO INTL AP	TX
348992	13968	TULSA INTL AP	OK	419364	12912	VICTORIA RGNL AP	TX
350328	94224	ASTORIA CLATSOP CO AP	OR	419419	13959	WACO RGNL AP	TX
352709	24221	EUGENE MAHLON SWEET AP	OR	419729	13966	WICHITA FALLS SHEPPRD AP	TX
355429	24225	MEDFORD AP	OR	427598	24127	SALT LAKE CITY INTL AP	UT
356546	24155	PENDLETON MUNICIPAL AP	OR	431081	14742	BURLINGTON INTL AP	VT
356751	24229	PORTLAND INTL AP	OR	445120	13733	LYNCHBURG MUNICIPAL AP	VA
357500	24232	SALEM MCNARY AP	OR	446139	13737	NORFOLK INTL AP	VA
360106	14737	ALLENTOWN LEHIGH VLY AP	PA	447201	13740	RICHMOND BYRD INTL AP	VA
362682	14860	ERIE AP	PA	447285	13741	ROANOKE WOODRUM AP	VA
366889	13739	PHILADELPHIA INTL AP	PA	448903	93738	WASHINGTON DULLES INTL	VA
366993	94823	PITTSBURGH INTL AP	PA	448906	13743	WASHINGTON REAGAN NTL AP	VA
369705	14777	WILKES BRE SCTN AP AVOCA	PA	456114	24227	OLYMPIA AP	WA
369728	14778	WILLIAMSPORT LYCOMING AP	PA	456858	94240	QUILLAYUTE AP	WA
376698	14765	PROVIDENCE GREEN AP	RI	457473	24233	SEATTLE TACOMA AP	WA
381544	13880	CHARLESTON INTL AP	SC	457938	24157	SPOKANE AP	WA
381939	13883	COLUMBIA METRO AP	SC	459465	24243	YAKIMA MUNICIPAL AP	WA
383747	03870	GRNVL SPART AP GREER	SC	460582	03872	BECKLEY AP	WV
390020	14929	ABERDEEN RGNL AP	SD	461570	13866	CHARLESTON YEAGER AP	WV
394127	14936	HURON AP	SD	462718	13729	ELKINS AP	WV
396937	24090	RAPID CITY RGNL AP	SD	464393	03860	HUNTINGTON TRI STATE	WV
397667	14944	SIOUX FALLS AP	SD	473269	14898	GREEN BAY STRBL INTL AP	WI
401094	13877	BRISTOL TRI CITY AP	TN	474370	14920	LA CROSSE MUNICIPAL AP	WI
401656	13882	CHATTANOOGA AP	TN	474961	14837	MADISON DANE CO AP	WI
404950	13891	KNOXVILLE AP	TN	475479	14839	MILWAUKEE MITCHELL AP	WI
405954	13893	MEMPHIS INTL AP	TN	481570	24089	CASPER NATRONA CO AP	WY
406402	13897	NASHVILLE INTL AP	TN	481675	24018	CHEYENNE MUNICIPAL AP	WY
406750	03841	OAK RIDGE ATDD	TN	485390	24021	LANDER AP	WY
410016	13962	ABILENE MUNICIPAL AP	TX	488155	24029	SHERIDAN AP	WY
410211	23047	AMARILLO INTL AP	TX				
410428	13958	AUSTIN CITY (CAMP MABRY)	TX				