NOAA'S 1981–2010 U.S. CLIMATE NORMALS

An Overview

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The latest 30-year U.S. Climate Normals, available from the National Climatic Data Center, were calculated for over 9,800 weather stations and include several new products and methodological enhancements.

Climate normals are typically defined as 30-yr averages of meteorological conditions, such as air temperature, precipitation, etc. They are arguably the most fundamental attributes of the climate of a given locale. In fact, the terms *normal* and *climatology* are often used interchangeably. As a measure of central tendency, climate normals characterize the background state about which anomalous conditions and even extremes are allowed to operate. They can be used to determine what crops to plant, what clothes to pack for an extended trip, the rates a power company can charge its customers, where and when to schedule an outdoor wedding, and countless other applications.

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In the United States, the term *normals* is also commonly used in a broader sense to refer to a full suite of products issued by the National Oceanic and Atmospheric Administration (NOAA) that describes climatological conditions with 30-yr averages and other statistics (e.g., standard deviations). The new 1981–2010 set of NOAA's climate normals are described herein and replace the 1971–2000 normals that were released in the early 2000s. The overarching goals of NOAA's 1981–2010 U.S. Climate Normals are sixfold:

- to produce high-quality climate normals for as many U.S. stations as possible, including estimates for short-record stations;
- to compute the climate normals in a manner that is representative of the 1981–2010 time period, including stations with incomplete observing records;
- to compute the climate normals such that they reflect the station locations and their observing practices at the end of 2010;
- to add new products to meet user needs as identified via user engagement during the development process;
- to develop new statistical techniques as needed to meet the goals listed above; and

- to provide initial access to the new climate normals in a timely fashion (i.e., in 2011).

The new normals include three major product lines, each of which was produced separately: temperature-related, precipitation-related, and hourly normals. This paper provides a general overview of the temperature-related and precipitation-related products, which contain climate statistics at the daily, monthly, seasonal, and annual time scales. The hourly normals are described by Applequist et al. (2012) in an article in this edition of *BAMS*. Readers interested in additional methodological details about the daily and monthly normals should consult the documentation available from the NOAA Normals website (www.ncdc.noaa.gov/oa/climate/normals/usnormals.html).

HISTORY OF NOAA'S CLIMATE NORMALS. NOAA's National Climatic Data Center (NCDC) has a responsibility to fulfill the mandate of Congress ". . . to establish and record the climatic conditions of the United States." This responsibility stems from a provision of the Organic Act of 1 October 1890, which established the Weather Bureau as a civilian agency (15 U.S.C. 311). Furthermore, the Federal Records Act of 1950 (Public Law 754) established NOAA's NCDC as the official archive for weather records. In contrast with many nonofficial computations of climatological means from a myriad of sources, NCDC is the *official* source for calculations of U.S. normals. This official status is in keeping with NCDC's monitoring reporting responsibilities.

The mandate to describe the climate was combined with guidelines established through international agreement. From its inception in 1950, the United Nations' World Meteorological Organization (WMO) has recognized the need for standardizing the computation of climatological statistics and their international exchange, promoting the worldwide use of technical standards and uniform publication of these data. The end of a decade has been set by the WMO as the desirable term for a 30-yr period from which to calculate climatic conditions (WMO 1983, 1984, 1989).

Every 30 years, climatological *standard normals* are computed as part of an international effort led by the WMO. Standard normals for three periods (1901–30, 1931–60, and 1961–90) have been distributed by the WMO and its predecessor (the International Meteorological Organization) to the member nations (Heim 1997). The next WMO-mandated normals will cover the 1991–2020 period.

Starting with the 1921–50 period, NOAA (and its predecessors) computed decennial 30-yr climate normals for selected temperature and precipitation elements for a large number of U.S. climate and weather stations (Heim 1996; Owen and Whitehurst 2002). The normals from 1931 to 1960 to present are in NCDC's archives. The 1921–50 normals, which were the first normals set prepared according to WMO standards, are available from NCDC on microfiche only. The number of stations included in NOAA's climate normals has increased dramatically over the years (see Table 1). Currently, climate normals are computed for stations in the United States (including Alaska and Hawaii) as well as U.S. territories, commonwealths, compact of free association nations, and one Canadian station that is part of the U.S. Climate Reference Network's comparative data exchange initiative with Environment Canada (see Fig. 1).

PRODUCTS INCLUDED IN THE 1981–2010 CLIMATE NORMALS. NCDC released numerous climate normals products on 1 July 2011. These include station-based temperature, precipitation, snowfall, and snow depth normals at the daily, monthly, seasonal, and annual time scales. Also included are heating and cooling degree days; number of days per month above/below certain temperature thresholds and above certain precipitation/snowfall/snow depth thresholds; and precipitation, snowfall, and snow depth probabilities and percentiles (see Table 2). Since NOAA reports normals in imperial

Table 1. Number of temperature and precipitation stations, by normals period. This includes various estimates for short-record stations over the years.

Normals period	Temperature stations	Precipitation stations
1921–50	388	388
1931–60	3,656	3,656
1941–70	3,145	4,928
1951–80	3,349	5,506
1961–90	4,775	6,662
1971–2000	5,556	7,926
1981–2010	7,501	9,307

units (degrees Fahrenheit and inches), this convention is used in this manuscript as well. Precipitation normals are calculated for about 9,300 stations. Snowfall normals are available for about 6,400 of these stations, of which about 5,300 also have snow depth normals. Temperature-related normals were computed for about 7,500 stations. The greater number of stations with precipitation normals versus temperature normals is primarily due to the fact that around one-third of all stations in the U.S. Cooperative Observer Network do not report temperature. Accounting for precipitation-only and temperature-only normals stations, over 9,800 stations are included in the new normals. The following subsections provide brief overviews of the temperature-related and precipitation-related normals.

Temperature-related normals. The key underlying variables used to compute all temperature-related normals are daily observations of maximum temperature (Tmax) and minimum temperature (Tmin). As is customary, "mean temperature" (Tavg) is defined as the average of Tmax and Tmin for the day, and the diurnal temperature range (DTR) is the difference between Tmax and Tmin. Daily, monthly, seasonal, and annual normals are available for these four variables, as are standard deviations at the daily and monthly scale. Heating degree days (HDDs) and cooling degree days (CDDs) are temperature-based metrics of heating and cooling demand, respectively, derived from Tavg data. Normals of HDDs and CDDs were calculated at the daily, monthly, seasonal, and annual time scales. In addition, frequencies of threshold exceedance are included for both Tmax and Tmin at the monthly, seasonal, and annual time scales (see Table 3 for the list of temperature thresholds used). Examples include the mean number of days in July on which the daily maximum temperature reaches or exceeds 90°F and the mean number of days in winter with a daily minimum temperature of 32°F or below.

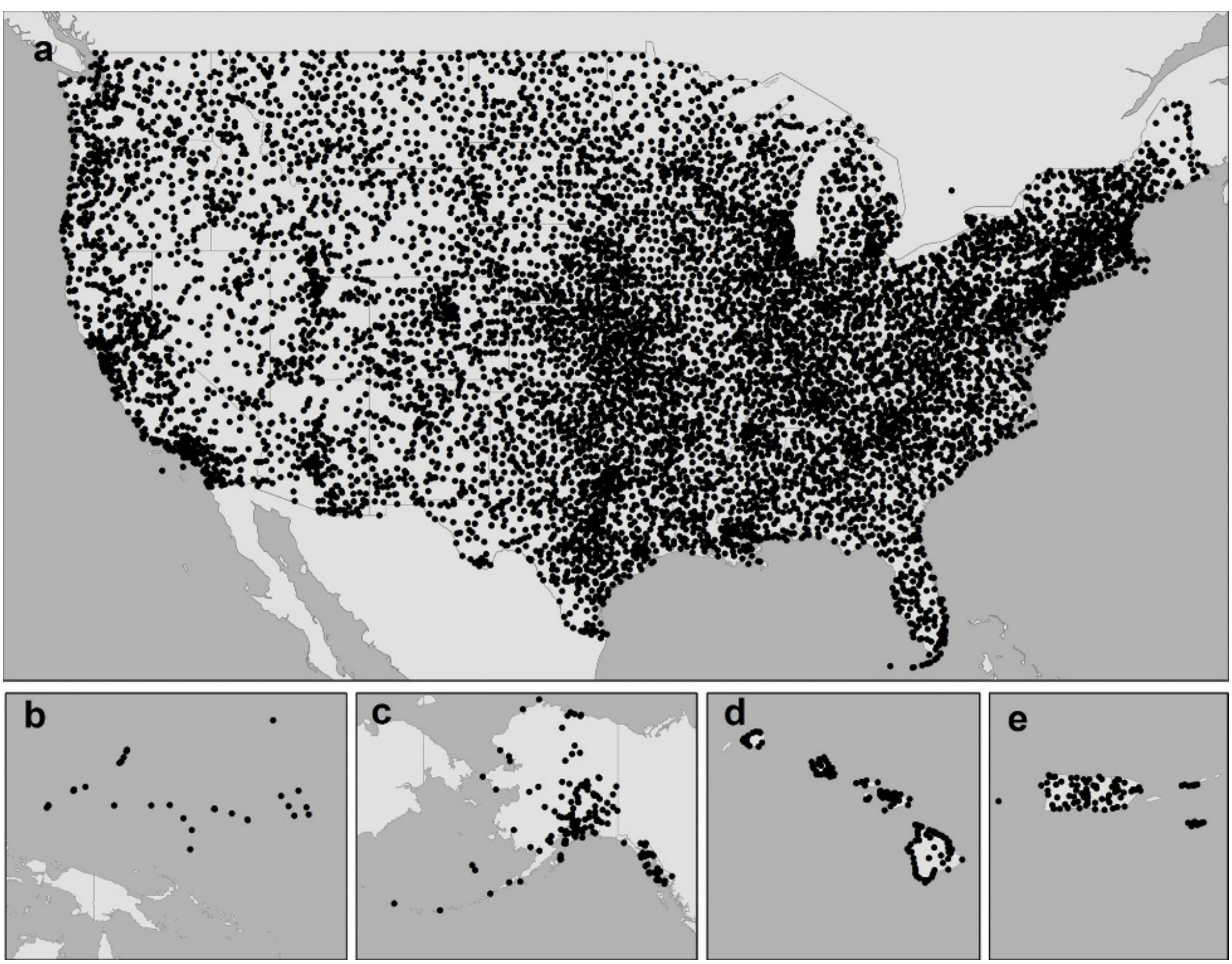

Fig. 1. Locations of the ~9,800 normals stations in (a) the continental United States and Canada, (b) the Pacific Ocean, (c) Alaska, (d) Hawaii, and (e) the Caribbean Sea.

Precipitation-related climate normals. Normals of precipitation, snowfall, and snow depth are all based on daily observations. Precipitation refers to rainfall plus snow water equivalent. Averages of precipitation and snowfall totals are computed at the monthly, seasonal, and annual time scales. Daily averages of precipitation and snowfall are not provided explicitly since the daily distributions of these variables tend to be strongly positively skewed with a mode of zero. Instead, month-to-date and year-to-date (January–December) precipitation and snowfall normals are provided. Frequencies of threshold exceedance are provided at the daily, monthly, seasonal, and annual time scales. All frequencies of threshold exceedance (including temperature frequencies) are scaled if necessary to account for missing values. The daily frequencies are expressed as probabilities. In fact, the daily probabilities for amounts above the lowest threshold (Table 3) are equivalent to the probability of occurrence for measurable amounts. For example, the probability of precipitation ≥ 0.01 in. represents the probability of measurable precipitation. Monthly, seasonal, and annual frequencies are reported as average number of days above the threshold value (analogous to the temperature frequencies). In addition, the 25th, 50th, and 75th percentiles are provided in two ways. For each month of the year, they are expressed as percentiles of monthly precipitation and snowfall totals. On the daily time scale they are calculated from nonzero daily precipitation, snowfall, and snow depth values.

METHODOLOGICAL OVERVIEW. The underlying values used to compute the 1981–2010 normals come from the Global Historical Climatology Network–Daily (GHCN-Daily) dataset (Menne et al. 2012). As its name suggests, this dataset contains daily observations for many atmospheric variables worldwide and is the most comprehensive set of daily climate data for the United States. The data values have undergone extensive quality assurance (QA) as described by Durre et al. (2010). A majority of the stations included in the 1981–2010 climate normals record their daily observations at

Table 2. NOAA's 1981–2010 Climate Normals suite of products (by time scale). Check marks indicate the availability of climate normals for a particular variable and time scale. The asterisks denote that daily precipitation/snowfall normals are reported as month-to-date and year-to-date normals in lieu of explicit daily averages.

Category	Parameter	Daily	Monthly	Seasonal	Annual
Averages	Maximum temperature	✓	✓	✓	✓
	Minimum temperature	✓	✓	✓	✓
	Mean temperature	✓	✓	✓	✓
	Diurnal temperature range	✓	✓	✓	✓
	Heating degree days	✓	✓	✓	✓
	Cooling degree days	✓	✓	✓	✓
	Precipitation (liquid equivalent)	*	✓	✓	✓
	Snowfall	*	✓	✓	✓
Standard deviations	Maximum temperature	✓	✓		
	Minimum temperature	✓	✓		
	Mean temperature	✓	✓		
	Diurnal temperature range	✓	✓		
Frequencies of threshold exceedance	Maximum temperature		✓	✓	✓
	Minimum temperature		✓	✓	✓
	Precipitation (liquid equivalent)	✓	✓	✓	✓
	Snowfall	✓	✓	✓	✓
	Snow depth	✓	✓	✓	✓
Percentiles	Precipitation (liquid equivalent)	✓	✓		
	Snowfall	✓	✓		
	Snow depth	✓			

or near 7 a.m. local time, with smaller percentages of stations observing in the late afternoon or around midnight. Each station is assigned the same identifier used in the GHCN-Daily dataset; corresponding metadata, such as latitude, longitude, station name, and so on, are taken directly from the GHCN-Daily station inventory. Note that the GHCN-Daily station IDs (e.g., USW00023174 for Los Angeles International Airport) are based on the National Weather Service's (NWS's) Cooperative Observer Program (COOP) and/or Weather Bureau–Army–Navy (WBAN) identifiers, not the airport codes (e.g., LAX) that are commonly used for airports.

The QA checks applied to GHCN-Daily flag a portion of the daily observations as erroneous. These erroneous data values are treated as "missing values" in the computation of climate normals. Durre et al. (2010) estimate that the false positive rate is on the order of 1%–2%. However, this effect is unlikely to have any appreciable impact on the climate normals due to the nature of long-term averaging. All 1981–2010 climate normal values are accompanied by a completeness flag, which is an indication of how many nonmissing and unflagged values (i.e., "good" values) are used in the calculation. In general, a station must have at least 10 "sufficiently complete" months for each month of the year for normals to be computed (although estimated normals are computed for some shorter records as described below). The completeness criteria are loosely based on the guidelines provided by the World Meteorological Organization (WMO 1989, 2007). All reported climate normals are representative of the local observation time (of day) for the station and are rounded to a fixed precision (e.g., HDD/CDD normals are rounded to whole degrees Fahrenheit). The remainder of this section highlights the most notable methodological enhancements and additions in the 1981–2010 Climate Normals compared to previous installments of this product line.

Higher-quality monthly data. The 1971–2000 temperature normals were computed from monthly temperatures that were adjusted for inhomogeneities using the methods described by Peterson and Easterling (1994) and Easterling and Peterson (1995). Building on this previous work, the monthly temperature data (Tmax and Tmin) used to compute the 1981–2010 normals are first calculated from GHCN-Daily and subsequently undergo robust QA (Menne et al. 2009) and homogenization using the pairwise comparison technique described by Menne and Williams (2009). Further, by statistical design, all temperature-related normals across all time scales (including the daily time scale) reflect the QA and homogenization applied to the monthly Tmax and Tmin data. For example, our statistical procedures ensure that the mean of the 31 daily Tmin normals in January average to the relevant monthly January Tmin normal, which in effect passes through monthly QA and adjustments down to the daily time scale. For precipitation, snowfall, and snow depth, we rely fully on the comprehensive set of QA procedures that are part of GHCN-Daily (Durre et al. 2010), since QA at the monthly time scale tends to be less effective for these variables. In addition, no effort was made either to identify or to remove inhomogeneities in the precipitation-related variables since no technique had been developed that was suitable for a station network as large and diverse as that used here.

Table 3. Thresholds used in exceedance frequencies, by variable.

Variable	Thresholds
Tmax (°F)	≥ 40, 50, 60, 70, 80, 90, 100 ≤ 32
Tmin (°F)	≤ 0, 10, 20, 32, 40, 50, 60, 70
Precipitation (in.)	≥ 0.01, 0.1, 0.5, 1
Snowfall (in.)	≥ 0.1, 1, 3, 5, 10
Snow depth (in.)	≥ 1, 3, 5, 10

Daily climate normals based on daily data. In the 1971–2000 climate normals, all daily normals were calculated using a cubic spline fit through the monthly normals. In other words, no daily data were explicitly utilized to refine the shape of the annual cycle. In contrast, the 1981–2010 Climate Normals make extensive use of daily observations from GHCN-Daily. This allows for a more precise representation of intraseasonal temperature signals using harmonic analysis and facilitates the inclusion of additional precipitation-related parameters such as daily percentiles, month-to-date and year-to-date normals, and daily probabilities

Direct computation of heating and cooling degree days. Previous installments of NOAA's climate normals have computed HDD/CDD normals using a parametric method described by Thom (1954, 1966). In the 1971–2000 Climate Normals, monthly degree-day normals were calculated directly from daily data for a small fraction of the stations (first-order stations), and the daily degree-day normals for these stations were calculated as the cubic spline fit through the monthly normals. A modification of the "Thom method" was used for all other stations. The 1981–2010 HDD/CDD normals were computed more directly using a 15-day windowing approach that exploits both the improved daily temperature normals and the distribution of daily observations in the window about these normals. Further, all monthly degree-day normals are calculated as the sums of the corresponding daily degree-day normals.

Quasi normals for short-record stations. For active short-record stations that fail the 10-yr completeness criterion described above but do have at least two years of sufficiently complete months for each month of the year, so-called "quasi normals," or estimated normals, are provided. Included in the active short-record stations are not only NWS sites but also stations in the U.S. Climate Reference Network, a national network operational since 2001 that was designed explicitly to measure long-term (e.g., 50–100 years or longer) climate variability and change. Average monthly temperature and precipitation normals are estimated using linear combinations of the normals from neighboring longer-record stations closely following the "pseudonormals" methodology outlined by Sun and Peterson (2005, 2006). Other statistics that are in some way dependent on these average monthly values are also available for the short-record stations. Quasi normals are computed for all temperature-related variables except standard deviations as well as for month-to-date, year-to-date, monthly, seasonal, and annual precipitation averages. Quasi normals are not provided for snowfall or snow depth parameters.

Table 4. Monthly and annual normals of Tmax (°F), Tmin (°F), precipitation (in.), and snowfall (in.) for select U.S. cities. In the column headings, "Var" stands for variable, the single letters represent the 12 months from January through December, and "Ann" stands for annual. The expression "Prcp" refers to liquid-equivalent precipitation. For display purposes, trace amounts of average precipitation and snowfall totals are rounded to zero.

Station	Var	J	F	M	A	M	J	J	A	S	O	N	D	Ann
New York, NY LaGuardia AP	Tmax	39.3	42.2	49.8	60.9	71.2	80.5	85.3	83.7	76.3	65.2	54.7	44.3	**62.9**
	Tmin	26.6	28.5	34.6	44.4	53.9	63.8	69.5	68.9	61.9	51.0	41.8	32.1	**48.2**
	Prcp	3.17	2.76	3.97	4.00	3.79	3.94	4.50	4.12	3.73	3.78	3.41	3.56	**44.73**
	Snow	7.4	9.1	4.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	5.2	**26.9**
Los Angeles, CA Intl AP	Tmax	64.6	64.3	64.4	66.4	68.1	70.6	73.8	74.9	74.6	72.5	68.9	64.6	**69.0**
	Tmin	48.8	50.0	51.7	53.8	57.3	60.5	63.7	64.3	63.2	59.3	53.2	48.7	**56.2**
	Prcp	2.71	3.25	1.85	0.70	0.22	0.08	0.03	0.05	0.21	0.56	1.11	2.05	**12.82**
	Snow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Washington, DC Natl Arboretum	Tmax	44.3	48.0	56.4	67.5	76.7	85.6	89.6	88.3	81.1	69.9	59.3	48.2	**68.0**
	Tmin	26.7	28.8	36.0	45.3	55.1	64.7	69.6	67.7	59.4	47.0	38.3	30.1	**47.5**
	Prcp	3.09	2.90	3.72	3.51	4.28	4.08	4.32	3.41	3.76	3.79	3.47	3.20	**43.53**
	Snow	4.6	3.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	**10.6**
Houston, TX Bush Intl AP	Tmax	62.9	66.3	73.0	79.6	86.3	91.4	93.7	94.5	89.7	82.0	72.5	64.3	**79.7**
	Tmin	43.2	46.5	52.5	59.4	67.6	73.3	75.1	74.8	69.8	60.9	52.1	44.6	**60.0**
	Prcp	3.38	3.20	3.41	3.31	5.09	5.93	3.79	3.76	4.12	5.70	4.34	3.74	**49.77**
	Snow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.1**
Boulder, CO	Tmax	46.9	48.3	56.0	63.3	72.2	81.6	87.7	85.3	77.7	65.8	53.7	45.3	**65.4**
	Tmin	22.2	23.1	29.2	35.6	43.5	51.3	57.3	56.1	48.0	37.8	28.5	21.3	**37.9**
	Prcp	0.76	0.82	2.19	2.87	2.80	2.20	1.79	1.84	1.68	1.55	1.24	0.94	**20.68**
	Snow	10.7	12.4	17.7	11.7	0.8	0.0	0.0	0.0	1.0	5.6	14.2	14.2	**88.3**
Fairbanks, AK Intl AP	Tmax	1.1	10.0	25.4	44.5	61.0	71.6	72.7	65.9	54.6	31.9	10.9	4.8	**38.0**
	Tmin	−16.9	−12.7	−2.5	20.6	37.8	49.3	52.3	46.4	35.1	16.5	−5.7	−12.9	**17.4**
	Prcp	0.58	0.42	0.25	0.31	0.60	1.37	2.16	1.88	1.10	0.83	0.67	0.64	**10.81**
	Snow	10.3	8.1	4.9	2.9	0.9	0.0	0.0	0.0	1.8	10.8	13.2	12.1	**65.0**

RESULTS. NOAA's 1981–2010 Climate Normals, like previous installments, showcase the broad array of climatological regimes present across the United States, not only within the conterminous United States but also across the full array of station locations shown in Fig. 1. Table 4 shows the monthly and annual normals of Tmax, Tmin, precipitation (prcp), and snowfall for 12 stations across the United States, including stations in Alaska and Hawaii. The January Tmin normal is −6.6°F in International Falls, Minnesota, and −16.9°F in Fairbanks, Alaska, whereas the January Tmin normals in Miami, Florida, and Honolulu, Hawaii, are 59.9°F and 66.3°F, respectively. July Tmax normals vary to a lesser degree across the United States, with values of 72.7°F in Fairbanks, 73.8°F in Los Angeles, California, 81.6°F in State College, Pennsylvania, and 93.7°F in Houston, Texas. Annual precipitation normals across the United States vary from less than 5 in. to well over 200 in. at some Pacific island stations. Los Angeles, Fairbanks, Honolulu, and Spokane, Washington, each receive less than 20 in. of precipitation per year on average, whereas the annual precipitation normal is nearly 45, 50, and 62 in. in New York, Houston, and Miami, respectively. Annual snowfall normals vary from zero in much of the southern tier of the United States to well over 200 in. in some areas. It is not uncommon for relatively dry stations such as Boulder and Fairbanks to have annual snowfall normals in excess of 50 in.

Figure 2 shows the spatial patterns of Tavg and precipitation normals over the conterminous United States. Annual Tavg normals follow a generally north–south pattern due to latitudinal variations in solar radiation (Fig. 2a), with some deviation primarily in the western part of the country in highland regions. The warmest Tavg normals are found in Florida and the desert Southwest, whereas the coldest normals are present in parts of the Rockies and near the Canadian border. Annual precipitation displays a typical east–west gradient with drier conditions in the West and substantially wetter conditions in the

Table 4. Continued.

Station	Var	J	F	M	A	M	J	J	A	S	O	N	D	Ann
State College, PA	Tmax	34.2	37.5	46.4	59.8	69.7	77.9	81.6	80.2	72.3	61.2	49.8	38.1	**59.2**
	Tmin	20.2	21.7	28.2	39.3	49.3	58.7	62.6	61.0	53.1	42.1	33.9	24.8	**41.3**
	Prcp	2.74	2.53	3.40	3.20	3.46	4.11	3.52	3.84	3.57	3.03	3.34	2.88	**39.62**
	Snow	12.5	11.0	10.3	1.4	0.0	0.0	0.0	0.0	0.0	0.3	2.3	7.8	**45.6**
Miami, FL Intl AP	Tmax	76.4	78.1	80.3	83.2	87.0	89.5	90.9	91.0	89.3	86.2	81.7	77.9	**84.3**
	Tmin	59.9	62.3	64.9	68.3	72.9	76.0	77.3	77.4	76.5	73.5	68.1	63.0	**70.1**
	Prcp	1.62	2.25	3.00	3.14	5.34	9.67	6.50	8.88	9.86	6.33	3.27	2.04	**61.90**
	Snow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Spokane, WA Intl AP	Tmax	34.4	39.6	48.9	57.2	66.4	73.8	83.3	82.9	72.9	58.0	41.6	32.2	**57.7**
	Tmin	24.7	26.4	31.6	36.8	43.8	50.4	56.3	55.8	47.4	37.2	29.8	22.5	**38.6**
	Prcp	1.79	1.33	1.61	1.28	1.62	1.25	0.64	0.59	0.67	1.18	2.30	2.30	**16.56**
	Snow	11.4	6.8	3.5	1.0	0.1	0.0	0.0	0.0	0.0	0.1	7.4	14.6	**44.9**
St. Louis, MO Lambert AP	Tmax	39.9	45.0	55.9	67.4	76.3	85.1	89.1	87.9	80.2	68.5	55.5	42.5	**66.2**
	Tmin	23.7	27.6	36.6	47.2	57.2	66.8	71.0	69.4	60.6	49.0	38.1	26.9	**47.9**
	Prcp	2.40	3.24	3.32	3.69	4.72	4.28	4.11	2.99	3.13	3.33	3.91	2.84	**40.96**
	Snow	5.6	4.3	2.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4.4	**17.7**
Honolulu, HI WSFO AP 703	Tmax	80.1	80.2	81.2	82.7	84.6	87.0	87.9	88.7	88.6	86.7	83.9	81.2	**84.4**
	Tmin	66.3	66.1	67.7	69.4	70.9	73.4	74.5	75.1	74.4	73.4	71.4	68.3	**70.9**
	Prcp	2.31	1.99	2.02	0.63	0.62	0.26	0.51	0.56	0.70	1.84	2.42	3.24	**17.10**
	Snow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
International Falls, MN AP	Tmax	15.4	22.0	34.7	51.5	64.8	73.2	77.8	75.9	65.4	51.1	33.7	19.0	**48.8**
	Tmin	−6.6	−1.3	12.5	27.1	38.7	48.4	52.6	50.7	41.8	31.0	17.4	0.4	**26.2**
	Prcp	0.62	0.57	0.95	1.53	2.86	3.92	3.70	2.81	2.99	2.08	1.38	0.81	**24.22**
	Snow	15.0	10.8	7.6	6.4	0.2	0.0	0.0	0.0	0.1	2.2	13.7	15.0	**71.0**

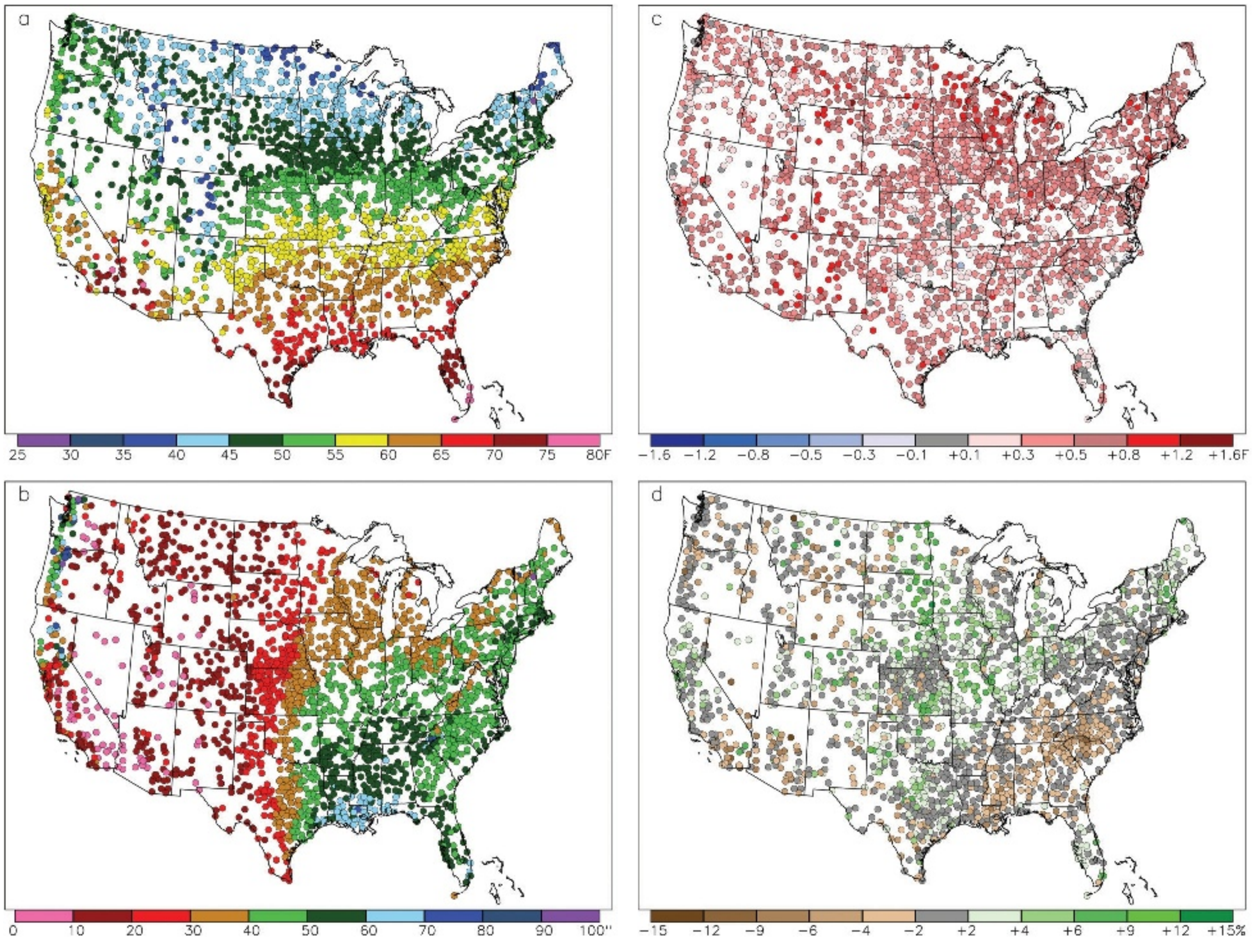

Fig. 2. (a) Annual Tavg (°F) normals for 1981–2010. (b) Annual precipitation (in.) normals for 1981–2010. (c) Difference between the new Tavg normals for the 1981–2010 period and comparable averages for the 1971–2000 period. (d) Percent difference between the new precipitation normals for 1981–2010 and comparable averages for the 1971–2000 period. Only stations with at least 25 years of complete monthly data in both time periods are plotted.

Table 5. Monthly and annual normals for Chicago Midway AP 3 SW. Abbreviations are as in Table 4. For display purposes, average numbers of days less than 0.5 are rounded to zero. Precipitation and snowfall percentiles refer to percentiles of monthly totals.

Variable	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Tmax	31.5	35.8	46.8	59.2	70.2	79.9	84.2	82.1	75.3	62.8	48.6	35.3	**59.4**
Tavg	24.8	28.7	38.8	50.4	60.9	71.0	75.9	74.1	66.4	54.2	41.5	29.0	**51.4**
Tmin	18.2	21.7	30.9	41.7	51.6	62.1	67.5	66.2	57.5	45.7	34.5	22.7	**43.5**
DTR	13.3	14.0	15.9	17.5	18.6	17.8	16.7	15.9	17.8	17.1	14.1	12.6	**16.0**
Precipitation	2.06	1.94	2.72	3.64	4.13	4.06	4.01	3.99	3.31	3.24	3.42	2.57	**39.09**
Snowfall	11.5	9.1	5.4	1.0	0.0	0.0	0.0	0.0	0.0	0.1	1.3	8.7	**37.1**
HDD	1,245	1,015	812	448	188	31	1	4	77	349	704	1,116	**5,989**
CDD	0	0	1	12	61	210	338	288	119	16	0	0	**1,045**
Days on which Tmax ≥ 90°F	0	0	0	0	0.6	3.1	6.3	3.8	1.2	0	0	0	**15.1**
Days on which Tmax ≥ 70°F	0	0.1	1.5	5.5	15.2	25.8	30.2	29.9	21.2	7.8	1.0	0	**138.2**
Days on which Tmax ≥ 50°F	1.4	2.9	10.6	23.5	30.5	30.0	31.0	31.0	30.0	28.1	13.1	2.9	**235.0**

East, with the notable exception of very wet conditions in the maritime climate zones along the West Coast (Fig. 2b). The driest stations are concentrated in the Southwest and Intermountain West, while the wettest stations are along the central Gulf Coast and in areas associated with orographically enhanced precipitation such as the Pacific Northwest and Mount Washington, New Hampshire.

To illustrate the breadth and utility of the products in NOAA's 1981–2010 U.S. Climate Normals, Table 5 shows a multitude of monthly and annual normals for Chicago Midway AP 3 SW. Annual normals of HDD and CDD (base 65°F) are 5,989 and 1,045, respectively, suggesting almost 6 times more weather-based demand (not accounting for fuel mix and other factors) for heating in colder months than for cooling in warmer months. Tmax reaches or exceeds 90°F, an average of 15.1 days per year, with 6.3 days on average in July alone. Individuals considering a move to Chicago can expect over 80% of winter nights to dip below freezing,

Table 5. Continued.

Variable	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Days on which Tmin ≤ 50°F	31.0	28.0	30.1	25.8	14.6	1.3	0	0.2	5.0	21.8	28.2	30.8	**216.8**
Days on which Tmin ≤ 32°F	27.1	23.2	17.2	3.3	0.1	0	0	0	0	1.1	12.0	24.3	**108.3**
Days on which Tmin ≤ 0°F	3.0	1.1	0	0	0	0	0	0	0	0	0	1.1	**5.2**
Precipitation: 25th percentile	1.15	1.03	1.61	2.11	2.49	2.76	2.07	2.26	1.58	1.94	1.89	1.48	–
Precipitation: 75th percentile	2.95	2.61	3.55	4.69	5.56	4.89	4.54	5.64	4.61	3.66	5.24	3.13	–
Days on which Precipitation ≥ 0.01 in.	10.7	8.8	11.2	11.1	11.4	10.3	9.9	9.0	8.2	10.2	11.2	11.1	**123.1**
Days on which Precipitation ≥ 0.1 in.	5.0	4.5	6.1	7.1	7.6	6.5	6.5	6.3	5.3	6.1	6.2	5.3	**72.5**
Days on which Precipitation ≥ 0.5 in.	1.2	1.1	1.7	2.5	2.8	2.7	2.8	2.7	2.1	2.2	2.2	1.4	**25.4**
Days on which Precipitation ≥ 1 in.	0.2	0.2	0.3	0.9	1.0	1.3	1.0	1.3	0.7	0.8	0.8	0.5	**9.0**
Snowfall: 25th percentile	4.8	3.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.6	–
Snowfall: 75th percentile	15.9	14.1	8.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0	2.5	14.9	–
Days on which snowfall ≥ 0.1 in.	8.1	5.5	3.8	0.7	0.0	0.0	0.0	0.0	0.0	0.1	1.8	6.7	**26.7**
Days on which snowfall ≥ 1 in.	3.7	2.8	1.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.6	**11.4**
Days on which snowfall ≥ 3 in.	1.0	0.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	**3.2**
Days on which snowfall ≥ 5 in.	0.4	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	**1.3**
Days on which snowfall ≥ 10 in.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.1**
Days on which snow depth ≥ 1 in.	18.9	12.9	4.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.9	10.5	**48.3**
Days on which snow depth ≥ 3"	11.4	8.2	2.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.0	**27.2**
Days on which snow depth ≥ 5 in.	6.4	5.4	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	**16.0**
Days on which snow depth ≥ 10 in.	1.2	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	**3.0**

and about 5 days when the temperature falls to 0°F or below. Precipitation (liquid equivalent) totals of 0.01 in. or more occur on average about a third of the time, fairly well distributed across the year. Chicagoans on average experience 9 days per year in which 1 in. or more precipitation falls, and an annual precipitation normal of 39.09 in. July rainfall averages 4.01 in., but nearby farmers can expect less than 2.07 in. in July about a quarter of the time. Midway receives an inch or more of snowfall an average of 11.4 days per year, and 37.1 in. on an annual basis. Residents should expect there to be at least 1 in. of snow on the ground for 48.3 days during the cold season.

Given observed climate change, there is growing interest in the degree to which climate normals change from one reporting period to another. Thirty-year climate normals (or changes from one period to another) are far from ideal metrics of climate change since both sampling and natural variability can lead to shorter-term shifts that are opposite in sign to the station's long-term trend (Easterling and Wehner 2009; Arguez and Vose 2011). Nonetheless, there are compelling reasons to consider changes from one climate normals period to another, given the widespread use of climate normals in both near-term and longer-term planning decisions across a multitude of climate applications and economic sectors. We calculate the differences between the 1981–2010 climate normals and the 1971–2000 period by computing comparable values for 1971–2000 using the aforementioned methodology and dataset used to compute the 1981–2010 Climate Normals, instead of comparing the new normals to the 1971–2000 Climate Normals published by NCDC in the early 2000s. This ensures that calculated differences between the two periods are not impacted by the substantial enhancements to the procedures described above, and instead reflect to the extent possible actual changes in the underlying climate signals. Figure 2c clearly demonstrates that on an "apples to apples" basis, virtually all stations in the conterminous United States were warmer in the 2001–10 period versus the 1970s, resulting in an average 0.5°F increase between climate normal periods. Much of this effect is due to considerably milder winter nights in the northern Great Plains and Midwest (not shown). The 1981–2010 period was wetter than the 1971–2000 period for much of the Great Plains and Midwest, and parts of New England and California, whereas drier conditions were reported in the Southeast and localized areas in the West (Fig. 2d).

CONCLUDING REMARKS. NOAA's 1981–2010 Climate Normals represent the latest decadal installment of 30-yr averages (and other relevant statistics) of meteorological variables for the United States. This new suite of products was developed after considerable engagement of user groups (including a large contingent from the energy industry), providing valuable input that guided the product development phase of this effort. The 1981–2010 Climate Normals can be accessed via file transfer protocol (FTP) here: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html. This access source is recommended for users experienced in handling large scientific datasets. Users interested in normals for one or a few stations can acquire them by contacting NCDC's User Engagement and Services Branch. The new normals are also available via the Climate Data Online (CDO) feature on NCDC's website. In addition, users can contact their local NWS office for information about climate normals in their area.

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