NOAA's 1981-2010 U.S. Climate Normals: An Overview

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1. Introduction

The National Oceanic and Atmospheric Administration (NOAA) released the 1981-2010 U.S. Climate Normals in July 2011, representing the latest decadal installment of this long-standing product line (Heim 1996, Heim 1997, Owen and Whitehurst 2002). Climatic averages (and other statistics) of temperature, precipitation, snowfall, and numerous derived quantities were calculated for ~9,800 stations operated by the United States National Weather Service (NWS). They include estimated normals, or 'quasi-normals,' for approximately 2000 active short-record stations. The 1981-2010 installment features several new products and methodological enhancements: (1) state-of-the-art temperature homogenization at the monthly scale, (2) extensive utilization of quality-controlled daily climate data, (3) new statistical approaches for calculating daily temperature normals and heating and cooling degree days, (4) a comprehensive suite of precipitation, snowfall, and snow depth statistics, and (5) hourly normals of numerous variables for 262 first order stations. Here, we provide a general overview of this new climate normals suite.

2. Background

Climate normals are typically defined as 30-year 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 basic 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.

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) every decade that describe climatological conditions with 30-year 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.

3. The New Normals

The over-arching goals of NOAA's 1981-2010 U.S. Climate Normals project are six-fold:

- produce high-quality climate normals for as many U.S. stations as possible – including estimates for short-record stations
- compute the climate normals in a manner that is representative of the 1981-2010 time period – including stations whose observing records are incomplete
- compute the climate normals such that they reflect the station locations and their observing practices at the end of 2010
- add new climate normal products to meet user needs as identified via robust user engagement
- develop new statistical techniques as needed to meet the goals listed above
- provide initial access to the new climate normals in a timely fashion (i.e. in 2011)

NOAA's National Climatic Data Center (NCDC) released the new normals on July 1, 2011. The suite of products included in the normals are shown in Table 1. Temperature-related normals were provided for about 7,500 stations. Precipitation-related normals were computed 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.

The underlying values used to compute the 1981-2010 Normals come from the Global Historical Climatology Network - Daily (GHCN-D) dataset (Menne et al., submitted). 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). 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.

a. Higher-quality monthly temperature data

The monthly temperature data used to compute the 1971-2000 normals 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 used to compute the 1981-2010 normals are first calculated from GHCN-D, and subsequently undergo robust QA (Menne et al. 2009) and homogenize ation using the pairwise comparison technique described by Menne and Williams (2009). Further, by statistical design, all temperature-related normals across all timescales (including the daily timescale) reflect the QA and homogenization applied to the monthly Tmax and Tmin data.

Table 1. Products (by timescale) in the 1981-2010 Climate Normals. Check marks indicate the availability of climate normals for a particular variable and timescale. 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	✓			

b. 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 temperature 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-D. This allows for a more precise representation of intra-seasonal temperature signals and facilitates the inclusion of additional precipitation-related parameters such as daily percentiles, month-to-date and year-to-date normals, and daily probabilities.

c. Direct computation of degree days

Previous installments of NOAA's climate normals have computed heating and cooling degree day (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 as well as the distributional properties of the high-quality daily temperature data in GHCN-D. Further, all monthly degree day normals are calculated as the sums of the corresponding daily degree day normals.

d. Quasi-normals for short-record stations

For active short-record stations that have 2-9 years of sufficiently complete months for each month of the year, so-called "quasi-normals", or estimated normals, are provided. This includes stations in the U.S. Climate Reference Network, a national network operational since 2001 that was designed explicitly to measure long-tern (e.g., 50 to 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). 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.

e. Hourly Normals

The 1981-2010 U.S. Climate Normals include a suite of descriptive statistics based on hourly observations from 262 first order stations in NCDC's Integrated Surface Database (ISD), ISD-Lite (Smith et al. 2011). The hourly normals were created primarily as a response to requests from the energy industry, which is expected to make significant use of these products to plan for changing load demands. For each hour and day of the year, statistics of temperature, dew point, mean sea level pressure, wind, clouds, heat index, wind chill, and heating and cooling degree hours are provided as 30-year averages, frequencies of occurrence, and percentiles. As the data used here have not undergone the same rigorous quality control, bias adjustments, and homogenization of that used for the daily and longer timescales, we encourage use of these products for examination of the diurnal changes of a particular variable, or day to day changes of values at a particular hour.

4. Concluding Remarks

NOAA's 1981-2010 Climate Normals represent the latest decadal installment of 30-year 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. This user engagement approach

is consistent with the principles of the proposed "The Climate Service" in NOAA.

The 1981-2010 Climate Normals can be accessed via file transfer protocol (FTP) here: http://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 will also be made available via the Climate Data Online (CDO) feature on NCDC's website. In addition, many users obtain climate normals for stations in their area from their local NWS office.

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