9B.3   **ON IMPROVING NOAA'S CLIMATE NORMALS:**
AN INTRODUCTION TO 'OPTIMAL NORMALS' OF TEMPERATURE

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1. INTRODUCTION

NOAA's National Climatic Data Center (NCDC) is responsible for producing official Climate Normals of numerous climatological variables, including maximum, minimum, and mean monthly temperatures. A Climate Normal is traditionally defined as a simple average over three decades, i.e. a 30-year average produced once every 10 years. NOAA's official Climate Normals were last produced for the 1971-2000 period.

Climate Normals are calculated retrospectively, but utilized prospectively. However, mounting evidence suggests that global climate statistics are non-stationary, calling into question the predictive skill of traditional climate normals. To complicate matters, NOAA's official Climate Normals are only released every 10 years, a frequency which is problematic for many users given the rapid rate of warming since the mid-1970s. For instance, an energy regulator setting utility rates in 2009 may be reliant upon official Climate Normals that were released almost a decade ago, which in most instances are too cool for today's climate.

There is a clear need to compute new Climate Normals that (1) are representative of the current state of the climate at the time they are reported and/or (2) explicitly accommodate the prospect of a changing climate. NCDC scientists are currently developing a new suite of experimental products called 'Optimal Normals' that attempt to address these two issues. The various techniques include simply updating the 30-year Climate Normals annually, as well as more rigorous techniques involving time series filtering theory, the estimation of optimal empirical weights, and the use of downscaled climate model projections for improved estimates of current and future Climate Normals. Here, we describe the first anticipated wave (to be released in 2009) of Optimal Normals of monthly maximum, minimum, and mean temperature: Annual Updates, OCN, and Hinge Fit.

2. COOP TEMPERATURE DATA

The data used in this study are obtained from the COOP Network, and have undergone extensive quality control (QC). The QC includes various bias adjustments, including an adjustment for time of observation bias. In addition, time series homogenization is accomplished by using pairwise comparisons to detect undocumented changepoints.

For more information on the QC analysis, see Menne et al. (2008) and Menne and Williams (2008). Please note that this QC analysis was not applied to previous installments of NOAA's official Climate Normals; therefore, comparisons should be made with care.

3. ANNUAL UPDATES

The simplest Optimal Normal is the Annual Update. It simply entails updating the 30-year Climate Normals using the most recent available 30-year period, which is currently the 1978-2007 period. To illustrate the need to provide Annual Updates, the difference between the 1978-2007 Normals and the 1971-2000 Normals were computed. Please note that the 1971-2000 Normals differ from NOAA's official 1971-2000 Climate Normals because of the additional QC analysis applied. A simple bootstrap test was used, with 1,000 simulations, to check for significant differences between the two-era averages. In essence, the key issue is how the 2001-2007 values compare to the 1971-1977 values, as earlier years cycle off the 30-year average with each new year's worth of data.

Figure 1 shows the difference between the 1978-2007 Normal and the 1971-2000 Normal for January minimum temperature (top) and July maximum temperature (bottom) for the contiguous United States. For clarity, only stations free from missing values and/or flags are shown. January minimum temperatures have been up to 2°C warmer throughout the U.S. except for Florida, with significant deviations concentrated in the Midwest and Great Plains. July maximum temperatures have been significantly warmer (up to 1.5°C) in the West.

4. OCN

The OCN method was developed at NOAA's Climate Prediction Center to improve initial conditions for short-term model forecasts (Huang et al. 1996). Essentially, these so-called "Optimal Climate Normals" are computed by determining an alternative averaging interval (N years) to the standard 30-year average. Huang et al. (1996) argue that fixed 10- and 15-year averages should be used for monthly temperature and precipitation, respectively. Livezey et al. (2007) contend that the appropriate N for OCN should be station-specific based on various factors, namely the residual lag-1 (g) autocorrelation and the linear trend (β). We follow the latter approach.

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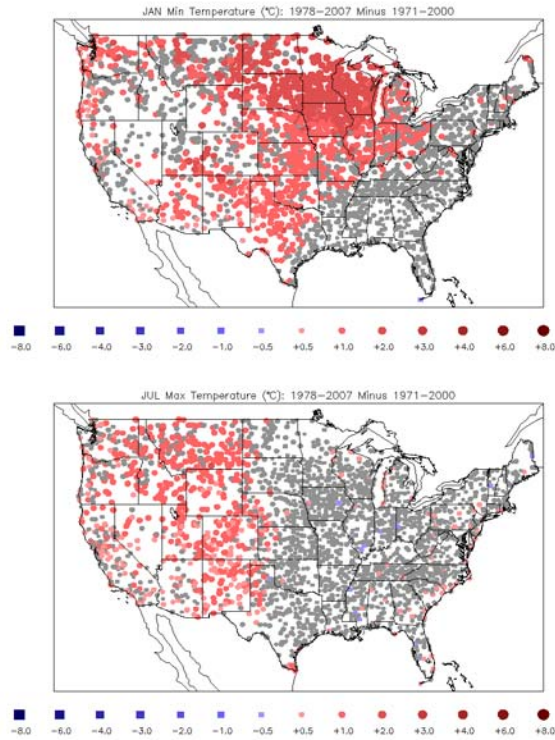
Figure 1. The 1978-2007 averages versus the 1971-2000 averages for January minimum temperature (top) and July maximum temperature (bottom). Gray symbols indicate stations that failed a two-tailed t-means test at 90% confidence.

The parameters g and β are computed using the 1940-2007 period. Figure 2 shows the value of N for January minimum temperature (top) and July maximum temperature (bottom). For January minimum temperatures, N is less than ~15 for much of the western two-thirds of the nation, whereas averaging periods for the extreme Southeast are very large (up to the 68-year period of record). The correlation between N and β is -0.78, quantifying the intuitive notion that strong linear trends require shorter averaging periods. For July maximum temperatures, there is much less spatial correlation present, although there is a tendency for smaller N in the West, consistent with the changes seen in Figure 1. Here, the correlation between N and β is a more modest -0.35.
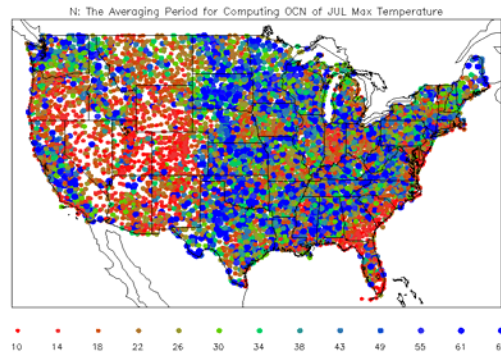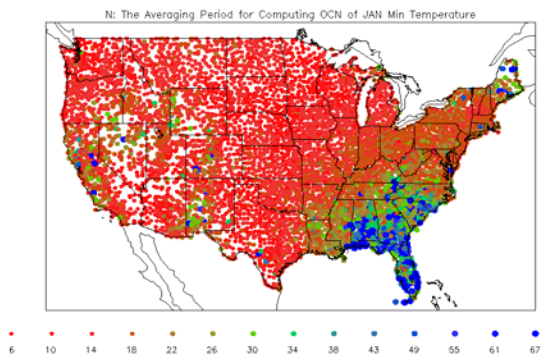

Figure 2. The parameter N from OCN analysis of January minimum temperature (top) and July maximum temperature (bottom).

The OCN are computed using an N-year average at each station. Using data through 2007, this implies an average over the period from 2008-N to 2007. NOAA/NCDC will update these values each year. Thus, the value of N for each station can change from year to year as additional data become available.

5. HINGE FIT

The Hinge Fit method, described in Livezey et al. (2007), uses a linear best fit line to define normal. The hinge point is set to 1975. Prior to 1975, the Hinge Fit is constrained to be a constant value, and after 1975, the Hinge Fit is a straight line with constant slope. Livezey et al. (2007) argue that the Hinge Fit is representative of the underlying base climate, given well-documented global changes (i.e., warming).

As with OCN, the 1940-2007 period was used for computing the 2007 Hinge Fit values. The 2007 Hinge Fit for January minimum temperature is warmer (by up to +6°C) than the 1971-2000 average for virtually every grid point in the United States (Fig. 3, top). Peak anomalies are found in the northern parts of the Midwest and Great Plains. For July maximum temperature, the Hinge Fit is generally warmer than 1971-2000 in the West, with smaller anomalies found elsewhere (Fig. 3, bottom).
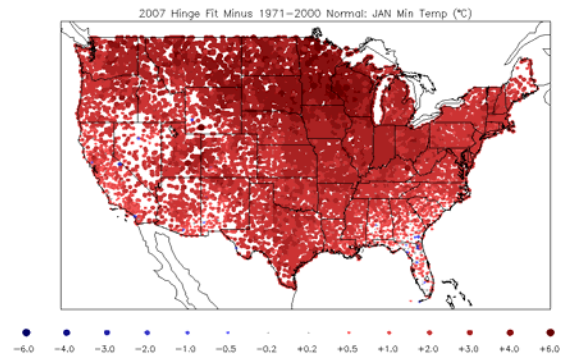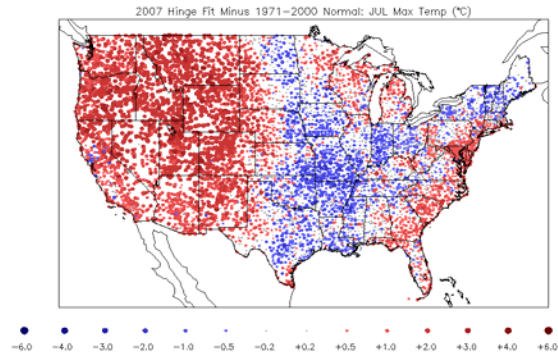
Figure 3. The 2007 Hinge Fit values versus the 1971-2000 averages for January minimum temperature (top) and July maximum temperature (bottom).

6. DISCUSSION

The results presented here all suggest that the current NOAA 1971-2000 Climate Normals are unlikely to be adequate indicators of either the current state of the climate or future climate conditions. The suite of experimental products known as Optimal Normals is an attempt to rectify this problem, and an explicit acknowledgment of the limitations of the traditional 30-year average Climate Normals.

The first wave of Optimal Normals will be available in 2009 for monthly maximum, minimum, and mean temperature for the COOP Network. NCDC plans to update these experimental Climate Normals once per year as new data values become available. In additional, a second wave of Optimal Normals are currently in the development phase, and should be available prior to the 2011 release of NOAA's official 30-year Climate Normals for the 1981-2010 period. This will include advanced statistical techniques, as well as the use of climate model projections to anticipate what Climate Normals may be in the future.

Future steps include applying significance testing to the OCN and Hinge Fit results. In addition, once all experimental products are operational, rigorous comparisons between the different Optimal Normals methods will commence. These comparative studies will guide future considerations, such as the possibility of a future official product release to complement the decadally-reported official NOAA Climate Normals.

7. REFERENCES

Huang, J., van den Dool, H. M., and A. G. Barnston, 1996: Long-Lead Seasonal Temperature Prediction Using Optimal Climate Normals. *J. Clim.*, **9**, 809-817.

Livezey, R. E., Vinnikov, K. Y., Timofeyeva, M. M., Tinker, R., and H. M. van den Dool, 2007: Estimation and Extrapolation of Climate Normals and Climate Trends. *J. Appl. Meteor. and Clim.*, **46**, 1759-1776.

Menne, M. J., and C. N. Williams, Jr., 2008: Homogenization of Temperature Series via Pairwise Comparisons. *J. Clim.*, in press.

Menne, M. J., Williams, Jr., C. N., and R. S. Vose, 2008: The United States Historical Climatology Network Monthly Temperature Data – Version 2. *Bull. Amer. Meteor. Soc.*, in press.