An operational near-real-time global temperature index

Robert G. Quayle, Thomas C. Peterson, Alan N. Basist, and Catherine S. Godfrey
National Climatic Data Center (NCDC), NOAA/NESDIS, Asheville N.C.

Abstract. To capture the global land surface temperature signal in a timely way, a blend of traditional long-term in situ climatic data sets, combined with real time Global Telecommunications System monthly CLIMAT summaries is employed. For the global sea surface, long-term ship data climatologies are combined with a blend of ship, buoy, and satellite data to provide the greatest possible coverage over the oceans. The result is a global century-scale surface temperature index that closely parallels other widely published global surface temperature measurements and can be updated monthly a week or two after the end of a month.

Introduction

It seems paradoxical that we need near-real-time data for a system that responds as slowly as climate, but recent paleoclimatic evidence and the recent warmth of the globe suggest that this paradigm is not always justified. Moreover, as nations struggle to develop effective environmental policies, the observed data become a critical part of these ongoing discussions and the meteorological infrastructure of the globe is also geared to real-time operation. Therefore, both the need for, and the capability for, delivering near-real-time climatic analyses are quite real. In fact, timely climatic information (provided when there is a maximum of interest) may be the best way to provide reliable information to the greatest number of people.

Surface Land Temperatures

Surface land air temperature (LAT) climatology (at instrument shelter height) is derived from the Global Historical Climatology Network version 2 data set (GHCN, Peterson and Vose 1997). GHCN v.2 includes previously unavailable Colonial Era data that fill in data sparse times and places (Peterson and Griffiths 1997). All data are processed via the Climate Analysis System developed at NCDC. The update system subjects the most recent data to a rigorous quality control (Peterson et al. 1998a). Its unique duplicate preservation scheme preserves the integrity of the input data streams (Peterson and Vose 1997). The First-Difference area averaging technique thrives on these duplicates and maximizes the global data available for analysis (Peterson et al. 1998b). Homogeneity adjustment procedures developed over several years assures objective, reproducibly homogeneous time series (Peterson and Easterling 1994, Easterling and Peterson 1995, Peterson et al. 1998c). Data volume varies from several hundred stations per year to several thousand (Peterson and Vose, 1997). For 1997, over 14,000 individual station monthly records are used in the analysis to produce 5x5 degree grid box data that are summarized into hemispheric and global averages.

Paper number 1998GL900297.

Sea Surface Temperatures

The Global Ocean Surface Temperature Atlas (GOSTA, Bottomley et al. 1990), provides over a century of global-scale 5x5 degree grid box in situ Sea Surface Temperature (SST) means by year through 1996. This application uses the U. K. Meteorological Office SST version called UKMO HSST, in the form of anomalies with respect to a 1961-90 averaging period (Folland et al. 1993). For near-real-time updates, the most timely and geographically complete data available are the National Centers for Environmental Prediction - Optimum Interpolation (NCEP OI) blended satellite, ship, and buoy SST data set (Reynolds and Smith 1994), also in monthly 5x5 degree grid box format, available for all years since 1982. NCDC produces global averages and the accompanying anomaly series from both data sets. To produce a long time series (beginning in 1880) with maximum contemporary coverage, these two SST data sets are combined. To fuse the two time series, a simple linear regression is performed for global monthly (and annual) mean anomalies for the years 1982-1997, using NCEP OI SST with respect to 1982-1997 as the dependent variable and UKMO HSST with respect to 1961-90 as the independent variable. A plot of the annual means is shown in Figure 1. The fit is very good, with r = 0.93, considering the areas covered are somewhat different, with ship data available primarily along shipping lanes, and blended NCEP OI data being virtually global because of the satellite data. The relationship between global mean annual modeled NCEP OI SST anomalies (SST_{OI}) and UKMO HSST anomalies (SST_{UK}) is described via the regression equation:

(1) $SST_{OI} = 0.80\ SST_{UK} - 0.15$, where anomalies are in deg. C.

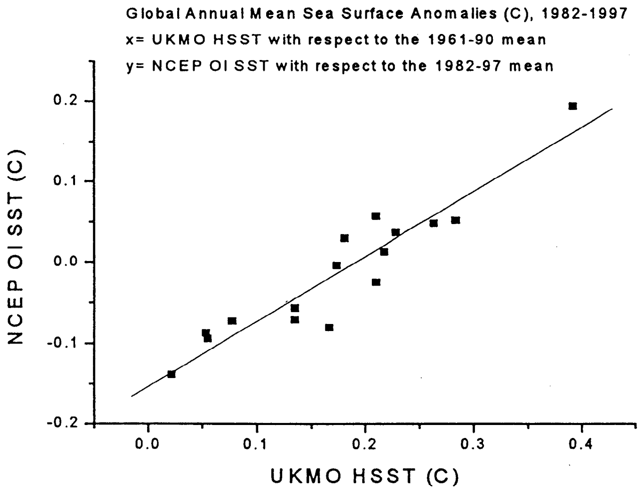

Fig. 1. A simple least-squares linear regression of global mean annual SST anomalies, 1982-1997: x = UKMO HSST wrt 1961-90 and y = NCEP OI SST wrt 1982-97. The correlation coefficient is 0.93.

The offset, -.15, adjusts the averaging period for the modeled NCEP OI SST anomaly to 1961-90, while the .8 factor reflects the reduced trend of NCEP OI SST compared to the UKMO data. A similar relationship exists for each month. Using the monthly equations, UKMO HSST data are converted to modeled NCEP OI SST anomalies (from 1961-90 means) for each month from 1880 thru 1981. The NCEP OI SST data are appended to this record, and are updated shortly after the end of each data month. For plotting purposes, the data are then adjusted to anomalies from a 1880-1997 averaging period. Figure 2 is a plot of these data from 1950 to 1997 (upper) and 1880 to 1997 (lower). On a globally averaged basis, the NCEP OI data are somewhat cooler than the UKMO HSST data because of differences between the NCEP and UKMO sea ice - SST conversions, and under-correction of satellite SST in areas of sparse ship and buoy data, primarily the southern hemisphere mid-latitudes. The former problem is being addressed by international standardization, while NCEP is researching ways to correct the latter (Reynolds, personal communication, 1998). The results of these studies will be used to guide possible future enhancements to this index.

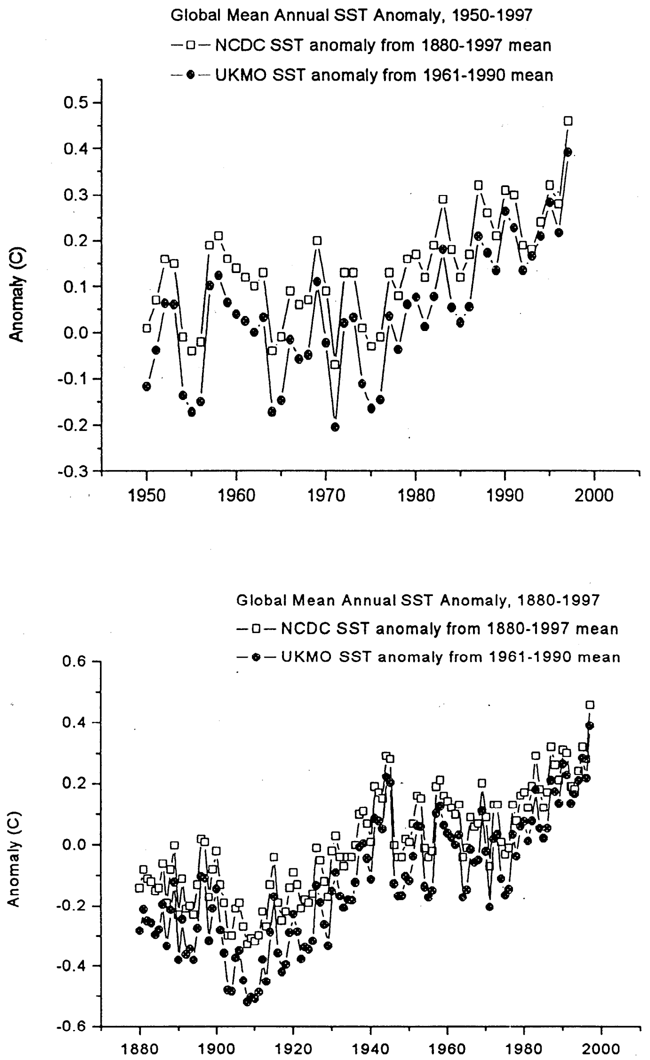

Fig 2. The NCDC (Modeled NCEP OI, wrt 1880-1997) and UKMO (wrt 1961-90) global sea surface temperature anomaly series, 1950-1997 (upper, for detail), and 1880-1997 (lower, for long term perspective).

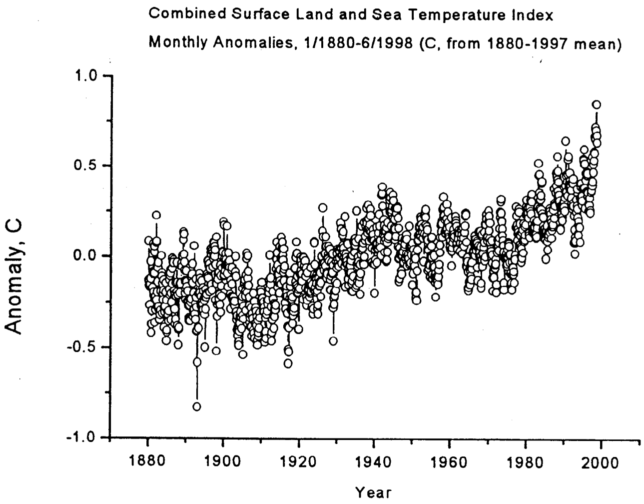

Fig. 3. The January 1880 to June 1997 NCDC combined land plus ocean surface monthly temperature anomaly index series wrt 1880-1997.

The Global Index

NCDC now has readily updatable global Surface Land Air Temperature (LAT) and global SST anomalies through the latest month of complete SST and CLIMAT data (World Meteorological Organization encoded data transmitted over the Global Telecommunications System, 2 to 10 days after the end of a data month). Note that the LAT data set is essentially independent from the SSTs, and LATs are summarized independently from SSTs. To combine these data into a simple index, the LAT is weighted with a coefficient of 0.3 (since about 30% of the surface of the Earth is land) and the SST with 0.7 (as the globe is about 70% ocean). The result is shown in Figure 3. It is called an index (as it is a combination of air and sea temperatures, and ignores ice-covered sea). When the new index is compared to similar data developed at the NASA Goddard Institute for Space Studies (www.giss.nasa.gov, documented in Hansen and Lebedeff 1987;

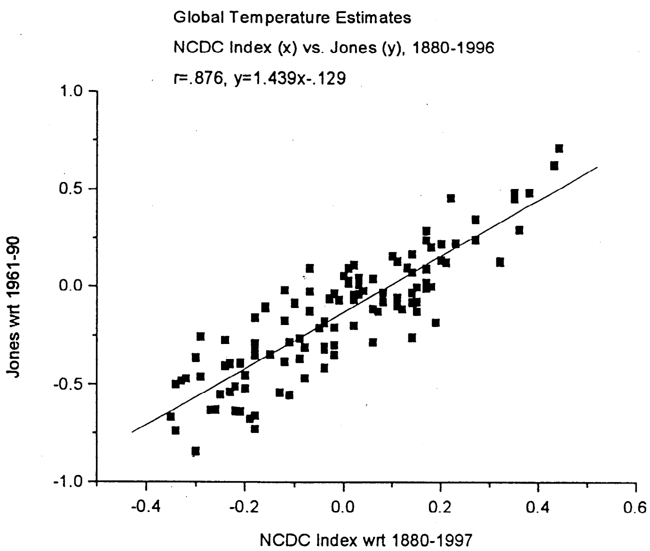

Fig. 4. A simple least-squares linear regression of global mean annual surface temperature anomalies (deg. C), 1880 to 1996: x = NCDC index wrt 1880-1997; y = Jones wrt 1961-90. The correlation coefficient is 0.87.

Reynolds and Smith 1994; Smith et al. 1996), the match is very good (r=0.95) for the period for which Hansen has a land-ocean product (1950 to the present, also using NCEP OI SST). The match (r= 0.87) with the current global benchmark surface data set (Jones 1994 with updates, Figure 4) for the period 1880-1996 is also relatively good, particularly for a near-real time index.

In summary, we believe we have combined the three best data sets in the world for their respective specialties: UKMO HSST for long-term SST; NCEP OI SST for recent decades; and the GHCN for global land surface temperatures. While not sophisticated, the technique is robust and the results, predictably, compare favorably with other widely used analyses.

References

Bottomley, M., C. K. Folland, J. Hsiung, R. E. Newell, D. E. Parker, *Global Ocean Surface Temperature Atlas "GOSTA"*, Bracknell [England] U.K.: Meteorological Office; [Cambridge]: Massachusetts Institute of Technology, 1990. (337pp) Also see: http://www.meto.govt.uk/sec5/CR_div/climate_index/hadley mohsst.html

Easterling, D. R. and T. C. Peterson, A new method for detecting and adjusting for undocumented discontinuities in climatological time series. *Int. J. Climatol. 15* (4), 369-377, 1995.

Folland, C. K., R. W. Reynolds, M. Gordon, and D. E. Parker, A study of six operational sea surface temperature analyses. *J. Climate 6* (1), 96-113, 1993.

Hansen, J., and S. Lebedeff, Global trends of measured surface air temperature. *J. Geophys. Res. 92* (D11), 13,345-13,372, 1987. Updated at ww.giss.nasa.gov.

Hansen, J., R. Ruedy, M. Sato, and R. Reynolds, Global surface air temperature in 1995: Return to pre-Pinatubo level. *Geophys. Res. Lett 23* (13), 1665-1668, 1996.

Jones, P. D., Hemispheric surface air temperature variations: A reanalysis and update to 1993. *J. Climate 7* (11), 1794-1802, 1994.

Peterson, T. C. and D. R. Easterling, Creation of homogeneous composite climatological reference series. *Int. J. Climatol. 14* (6), 671-679, 1994.

Peterson, T. C. and R. S. Vose, An overview of the Global Historical Climatology Network temperature data base. *Bull. Amer. Meteor. Soc. 78* (12), 2837-2849, 1997.

Peterson, T. C. and J. F. Griffiths, Historical African data. *Bull. Amer. Meteor. Soc. 78* (12), 2869-2871, 1997.

Peterson, T. C., R. S. Vose, R. Schmoyer, and V. Razuvaëv, Quality control of monthly temperature data: The GHCN experience. *Int. J. Climatol.*, (in press), 1998a.

Peterson, T. C., T. R. Karl, P. F. Jamason, R. Knight, and D. R. Easterling, The First Difference Method: Maximizing Station Density for the Calculation of Long-term Global Temperature Change. *J. Geophys. Res. (Atm.)*, (in press), 1998b.

Peterson, T. C., D. R. Easterling, T. R. Karl, P. Ya. Groisman, N. Nicholls, N. Plummer, S. Torok, I. Auer, R. Boehm, D. Gullett, L. Vincent, R. Heino, H. Tuomenvirta, O. Mestre, T. Szentimre, J. Salinger, E. Førland, I. Hanssen-Bauer, H. Alexandersson, P. Jones, D. Parker, Homogeneity adjustments of in situ atmospheric climate data: A review. *Int. J. Climatol.*, (in press), 1998c.

Reynolds, R. W. and T. M. Smith, Improved global sea surface temperature analyses using optimum interpolation. *J. Climate 7* (6), 929-948, 1994.

Smith, T. M., R. W. Reynolds, R .E. Livezey, and D. C. Stokes, Reconstruction of historical sea surface temperature using empirical orthogonal functions. *J. Climate 9* (6), 1403-1420, 1996.

National Climatic Data Center, 151 Patton Ave., Asheville, NC 28801-5001; rquayle@ncdc.noaa.gov; tpeterso@ncdc.noaa.gov; abasist@ncdc.noaa.gov; cgodfrey@ncdc.noaa.gov.

(Received September 21, 1998; revised December 3, 1998; accepted December 9, 1998.)