In Situ and Satellite Sea Surface Temperature (SST) Observations and Analyses

Huai-Min Zhang[1], Richard W. Reynolds[2], Viva F. Banzon[1], and Boyin Huang[1]
[1]NOAA National Climatic Data Center, Asheville, NC
[2]Cooperative Institute for Climate and Satellites, Asheville, NC

Project Summary

The purpose of this project is:

- To monitor and report the performance of the global ocean SST observing system in terms of a Government Performance and Results Act (GPRA) Performance Measure, for an optimum integration of the in-situ and satellite observation systems for climate scale Sea Surface Temperature (SST; Figure 1).
- To improve the climate-scale SST analyses produced at NOAA for climate research and monitoring as well as applications to societal benefits. These datasets are the foundation products for generating NOAA's climate monitoring reports that are produced monthly or as needed (Figure 2; http://lwf.ncdc.noaa.gov/sotc/global/).

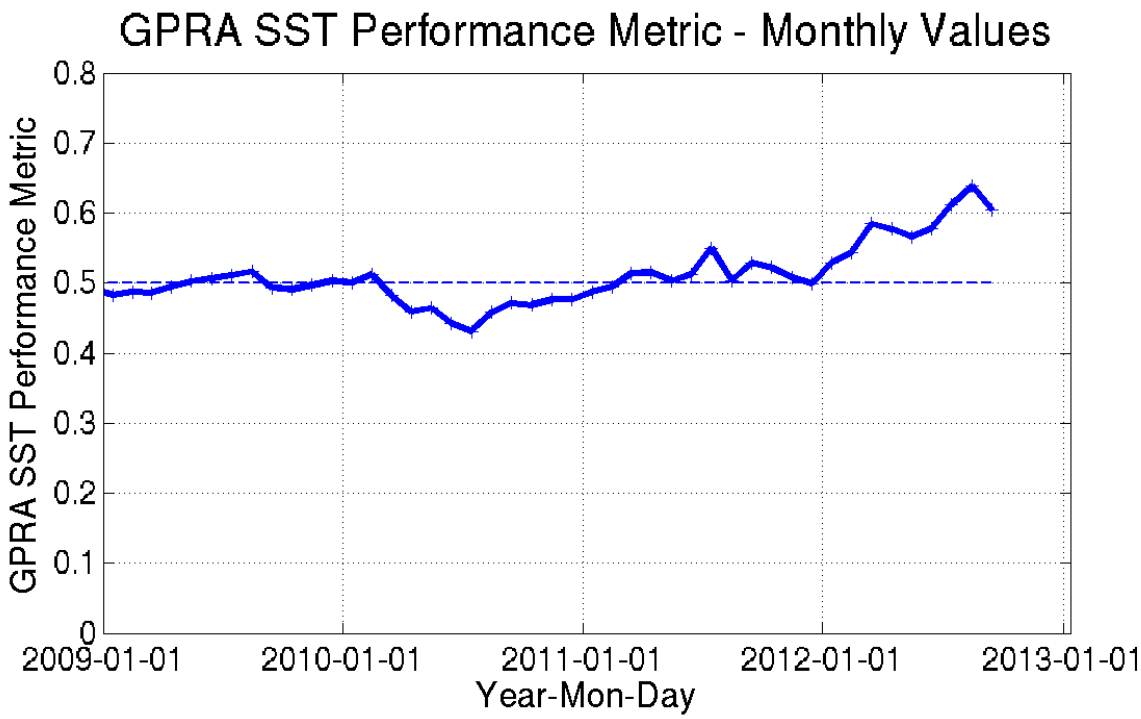

Figure 1: The GPRA Performance Measure versus time. The dashed line is the target.

This project supports the NOAA's Next Generation Strategy Plan (NGSP) goal of "Climate Adaptation & Mitigation" through sufficient climate observation and analysis. This project directly serves the following Climate Observation Division's Program Deliverables: 1) To identify climate variability through surface marine observations including SST and sea surface winds; and 2) To identify changes in forcing functions through the air-sea exchange processes.

The SST analyses/data are available via
http://www.ncdc.noaa.gov/oa/climate/research/sst/oi-daily-information.php
http://www.ncdc.noaa.gov/ersst

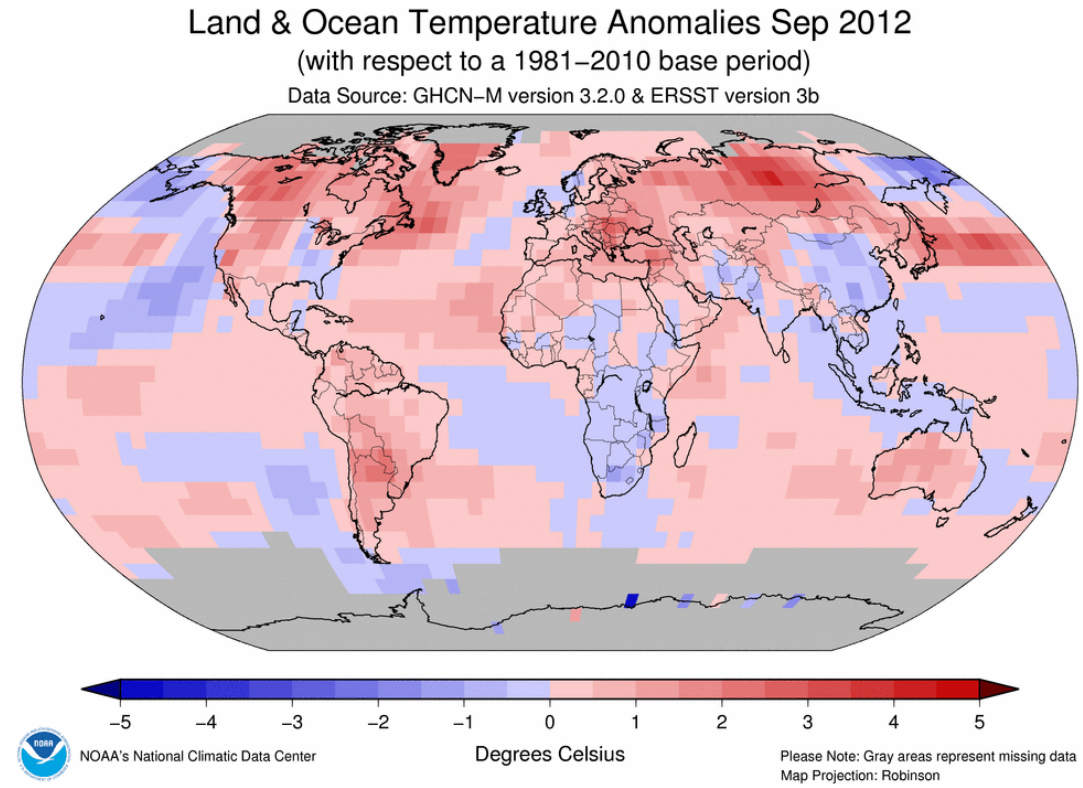

Figure 2: The SST observations and products are the foundation products for generating NOAA's climate monitoring reports that are produced monthly or as needed, as shown in this figure as an example (http://lwf.ncdc.noaa.gov/sotc/global/).

<u>Project Principles:</u> *The modern day Global Ocean Observing System (GOOS) consists of multiple platforms and instruments [both on-ground (in-situ) and remote sensing (e.g. satellites)]*. Each of these observations contributes to the understanding and assessment of climate change signals complementarily. On the other hand, individual instrument observations have limitations in coverage (in both time and space) and limitations on accuracy (e.g. Zhang et al 2004). To maximize benefits and integrally use all the available observations, it is necessary to blend them together to produce higher resolution and higher accuracy products, as well as to serve information extraction in the big-data era (Zhang et al 2006; Reynolds et al 2007).

Data blending results in reductions in uncertainties in the blended products. There are typically three types of errors in observations and blended products: 1) random error; 2) sampling error; and 3) bias error. The bias error is the systematic difference between one instrument (or a set of instruments, e.g., in-situ observations) and another (e.g., remote sensing/satellite observations). The combined error for all terms should be reduced to a required accuracy for meaningful climate change diagnostics. In the satellite era, satellite observations provide dense data coverage, thus in-situ data play a minor role in the reduction of random and sampling errors and

in increasing resolutions in blended products. However, in-situ observations provide the "ground-truth", and thus play an essential role in correcting the systematic biases of indirect measurements (e.g., remote sensing/satellite observations that are calibrated to in-situ observations, e.g. Zhang et al 2009).

An objectively determined Performance Measure is formulated for the integrated SST observing system. One of the important goals of the Sustained Ocean Observing System for Climate is to improve the SST accuracy over the global ocean for climate change monitoring and assessment. Because of the denser spatial coverage of satellite data, in situ data tends to be overwhelmed by satellite data. Thus, the most important role of the in situ data in the analysis is to correct large-scale satellite biases. Simulations with different buoy densities have shown the need for at least two buoys on a 10° spatial grid to reduce a satellite bias of 2°C to not exceed 0.5°C (minimum requirement; citations in Zhang et al 2009). Using this criterion, regions can be identified where additional buoys are needed, and a metric has been designed to measure the adequacy of the present observing system as a GPRA performance measure.

The work presented here follows the Global Climate Observing System (GCOS) Ten Climate Monitoring Principles. The PIs have been engaged with various WCRP working groups, including the Group for High Resolution Surface Temperature (GHRSST) and WCRP Surface Flux Analysis Working Group.

NOAA has combined the in-situ and satellite SST observations into gridded SST products. The NOAA's Optimum Interpolation (OI) SST analysis products (often also referred to as Reynolds SST Analyses; Reynolds et al 1994, 2002, 2007) are among the most utilized SST products (more than 3000 citations). They are widely used for many purposes including hurricane and other weather and ocean forecasting, fisheries (through better location of isotherms and the fish that follow them) and for climate prediction and analysis.

In this project, we continue to improve the SST analyses produced at NOAA for climate research and monitoring as well as applications to societal benefits (Banzon & Reynolds, 2011; Reynolds & Chelton, 2011), and to monitor and report the performance of the global ocean SST observing system in terms of a Government Performance and Results Act (GPRA) Performance Measure, for an optimum integration of the in-situ and satellite observation systems for climate scale SST.

References:

Banzon, V. and R.W. Reynolds, 2011: "Nighttime only SST fields", *XII GHRSST Science Team Meeting*, 29 June 29 – 1 July 2011, Edinburgh, Scotland.

Reynolds, R.W., T.M. Smith, 1994: Improved Global Sea Surface Temperature Analyses Using Optimum Interpolation. *J. Climate*, **7** (no. 6), DOI: 10.1175/1520-0442(1994)007.

Reynolds, R.W., N.A. Rayner, T.M. Smith, D.C. Stokes, and W. Wang, 2002: An Improved In Situ and Satellite SST Analysis for Climate. *J. Climate*, **15** (no. 13), 1609-1625.

Reynolds, R. W., T. M. Smith, C. Liu, D. B. Chelton, K. S. Casey and M. G. Schlax, 2007: Daily High-Resolution-Blended Analyses for Sea Surface Temperature. *J. Climate*, 20, 5473-5496, DOI: 10.1175/2007JCLI1824.1

Reynolds, R.W., and D.B. Chelton, 2012: Objective Determination of Feature Resolution in Two Sea Surface Temperature Analyses. (to be submitted to J. Climate)

Zhang, H.-M., R.W. Reynolds, T.M. Smith, 2004: Bias statistics of the AVHRR sea surface temperature. *Geophys. Res. Letts*., **31** (No. 1), L01307 10.1029/2003GL018804.

Zhang, H.-M., R.W. Reynolds, and T.M. Smith, 2006: Adequacy of the In Situ Observing System in the Satellite Era for Climate SST. *J. Atmos. Oceanic Tech*., **23** (1), 107-120.

Zhang, H.-M., R.W. Reynolds, R. Lumpkin, R. Molinari, K. Arzayus, M. Johnson, T.M. Smith, 2009: An Integrated Global Ocean Observing System for Sea Surface Temperature Using Satellites and In situ Data: Research-to-Operations, *Bull. Amer. Meteorol. Soc.*, **90** (No. 1), 31-38, DOI: 10.1175/2008BAMS2577.1