Ocean Data Management at NCDC

From Ingest to Archive, Blended Products and Data Services

Huai-Min Zhang[1], Richard W. Reynolds[2], Rich Baldwin[1], and Eric Freeman[3]
[1]NOAA National Climatic Data Center, Asheville, NC
[2]Cooperative Institute for Climate and Satellites, Asheville, NC
[3]STG, Inc, Contractor at NCDC, Asheville, NC

Table of Contents

1. Project Summary 1
2. Scientific and Observing System Accomplishments 3
   2.1. Outreach and Education 6
3. Publications and Reports 7
   3.1. Publications by Principal Investigators 7
   3.2. Other Relevant Publications 8

1. Project Summary

The goal of this project is to ensure that the surface marine observations, most of which are funded and managed by NOAA, are officially archived at the NOAA archive and served to the public. This is important to avoid any potential for permanent data loss or loss of NOAA/OCO investment (Figure 1). This project further carries through an End-to-End process (Figure 2), including ingestion of observing system data, data quality control, production of gridded and blended data sets, and provision of direct data services to the user communities, including scientific research, marine ecosystems (e.g. NOAA's World Coral Reef Watch), renewable energy industries (offshore energy), marine transportation (e.g. ship routing services), and outreach and education among many others.

The overall objectives of this project are:

1) to ingest the world's surface marine observations into the NOAA archive;
2) to quality control the data for various applications;
3) to produce blended products for optimal use of all the observations; and
4) to improve services for a wide variety of user communities.

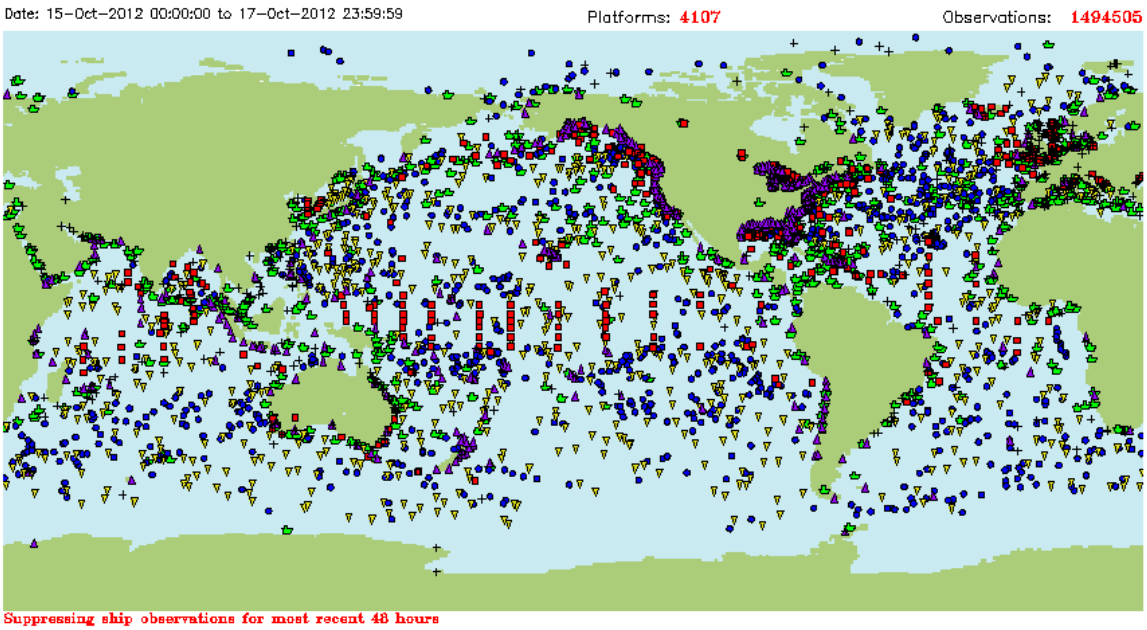

Figure 1: NCDC serves as NOAA's official archive of weather and climate data. This project is to ensure that the marine surface observations managed by NOAA OCO (this figure, from COD's Observing System Monitoring Center: http://osmc.noaa.gov/Monitor/OSMC/OSMC.html), and others such as the international VOSClim (below for details), are in the NOAA Archive and serviced to the public online.

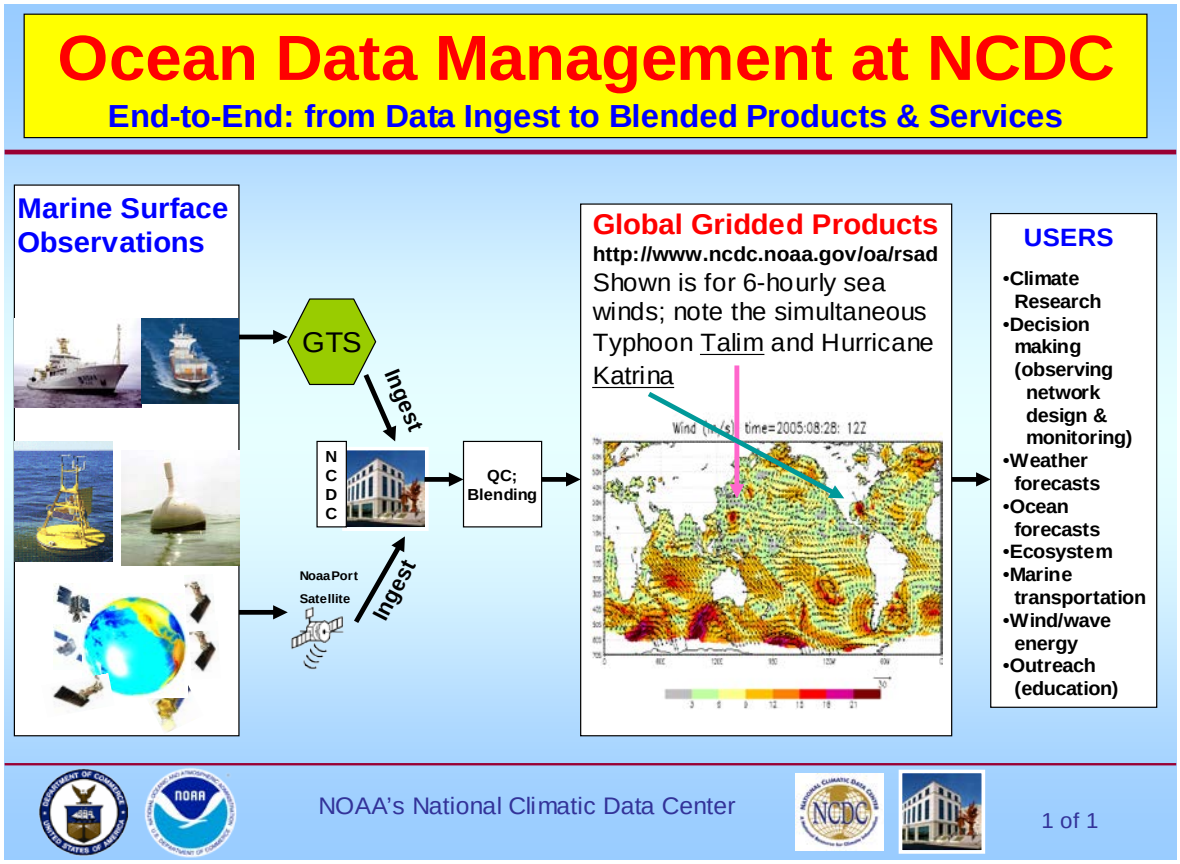

Figure 2: Conceptual diagram of the project's End-to-End data process, from ingest to archive, quality control and products development and services for societal benefits.

2. Scientific and Observing System Accomplishments

Accomplishment Highlights: 1) Surface marine observations are ingested and archived in near-real-time via the GTS stream (including the observations supported by NOAA/OCO). 2) Data are serviced to the public online. 3) Blended products for research and societal benefits are generated, maintained, and improved. 4) Duties of ICOADS are being transitioned from NOAA/ESRL to NOAA/NCDC; tasks are resource and labor intensive and will require additional funding to fully implement in FY13.

Our data and products are directly available online and in near real time (http://www.ncdc.noaa.gov/oa/rsad/air-sea/index.html and links therein for ICOADS and VOSClim). The user-friendly interfaces and formats have continued to extend the benefits to the society, such as applications in marine ecosystem (e.g., the near-real-time use in NOAA's world Coral Reef Watch), marine transportation safety and efficiency (e.g. ship routing), and offshore renewable energy services, among others.

The Blended Seawinds are updated daily. ICOADS dataset is updated monthly. Our data management is done according to NOAA/NCDC archive requirements. Our data and products are not linked to the National Environmental Policy Act (NEPA) and other NOAA Environmental Statutes (e.g. Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), Essential Fish Habitat (EFH), and the National Marine Sanctuaries Act (NMSA).

Specific Deliverables:

- ***Surface Marine observational Data Archive and Service: ICOADS***
  - Completed an upgrade to database load process that improves performance by 400%. Completed the transition from NCDC-IMMA format to the full IMMA format for usability of data to wider communities.

  - *Transition of duties from NOAA/ESRL to NOAA/NCDC:* Early in FY12, programmatic changes within NOAA resulted in NCDC taking responsibility and providing overall leadership for the ICOADS project in continuing close cooperation with ESRL, NCAR, and national and international partners. During the remainder of FY12, ICOADS partners began drafting transition plans to outline steps and resources needed to fully transition operations from ESRL to NCDC. Some major tasks identified for transition include operational production of an improved Near-Real-Time (NRT) product and also development of the next full ICOADS delayed mode release (e.g. 2.6.0). Both tasks are resource and labor intensive and will require funding to fully implement in FY13.

  - *Data are available online (e.g. Figure 3 below):*
    http://www7.ncdc.noaa.gov/CDO/CDOMarineSelect.jsp
    http://has.ncdc.noaa.gov/pls/plhas/has.dsselect
    ftp://ftp.ncdc.noaa.gov/pub/data/icoads2.5/

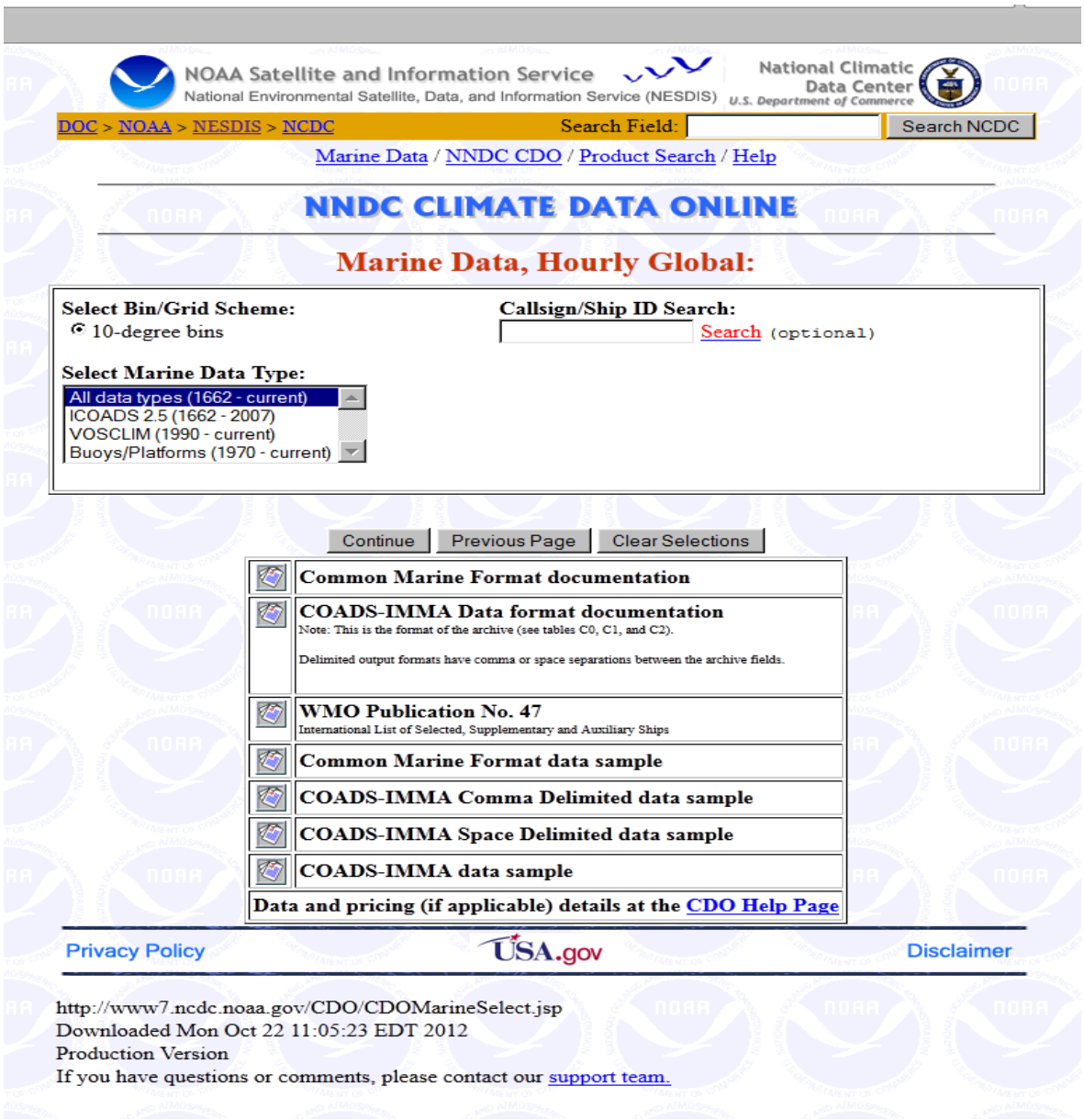

Figure 3: The Surface Marine Observations, including those funded by NOAA, are archived and serviced to the public online with web-based interactive tools.

- ***VOSClim - Increased data volume of archive and service; continued VOSClim webpage maintenance updating monthly statistics and data access, and service with the Global Collection Center (GCC):***
  NCDC continues to serve as the Data Acquisition Center (DAC) for this fleet. VOSClim ships aim to provide a high-quality subset of marine meteorological data, with extensive associated metadata, to be available in both real-time and delayed mode to support global climate studies.

  Program information and data are available online:
  http://www.ncdc.noaa.gov/oa/climate/vosclim/vosclim.html

- ***New versions and operational production and service of the blended 0.25°, 6-hourly sea winds, including the near-real-time version:***
  The importance for integrated use of the observing systems and production of air-sea interface products has been stipulated in the previous section (Project Summary). Our blended sea winds have been used by a wide variety of communities, including climate research, decision making & planning, wave hindcasting & forecasting, ecosystems, marine resource management, marine transportation (ship routing), wind/wave energy harvesting, and outreach & education.

  One major observational satellite, the NASA AMSR-E, stopped functioning in early October 2011. On the other hand, data from new and other satellites, including DMSP F17, started available. New versions of satellite retrieval of sea winds from older satellites have also become available. In FY12, we revised our processing processes by incorporating in new data for improved coverage, and production and services were continued. We have also completed part of the assessment and the process for Research-to-Operation transition of this product.

- ***Integrated use of observations by in-situ and satellite platforms for model forecast evaluations:***
  Recently, a WCRP Report, titled "Action Plan for WCRP Research Activities on Surface Flux" (WCRP Series Report No. 01/2012; http://www.wcrp-climate.org/documents/woap_fluxes_report_01_2012.pdf), strongly endorsed the Surface Flux Analysis (SURFA) project and approach. Project SURFA is an initiative of the World Climate Research Programme (WCRP), with the ultimate objective to institutionalize the evaluation of near real-time NWP fluxes and related fields with high quality reference data (over both land and ocean). When successfully demonstrated, the SURFA principle and infrastructure will also be utilized to evaluate climate models and satellite observations with the most accurate direct in-situ observations available. An example of the integrated use of the CPO/COD/OCO-funded in-situ and satellite observations is show in the figure below.

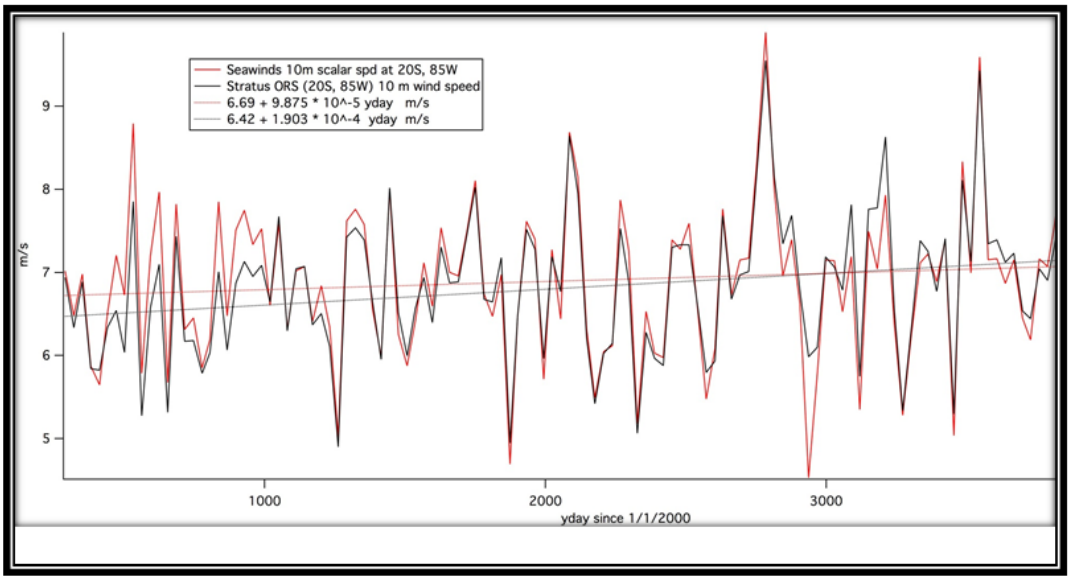

Figure 4: An example of cross-validation of sea surface winds observed by the Stratus Buoy and NCDC's Blended Sea Winds. (Courtesy: Dr. Robert Weller, Woods Hole Oceanographic Institution.)

Additionally, we continued the collaboration with the world Forecast Centers. We completed additional data analysis based on feedback from reviewers. A revised manuscript has been re-submitted to the journal Weather and Forecasting published by the American Meteorological Society (Peng et al 2012; Figure 5 below). We will use these analysis results to improve our products.

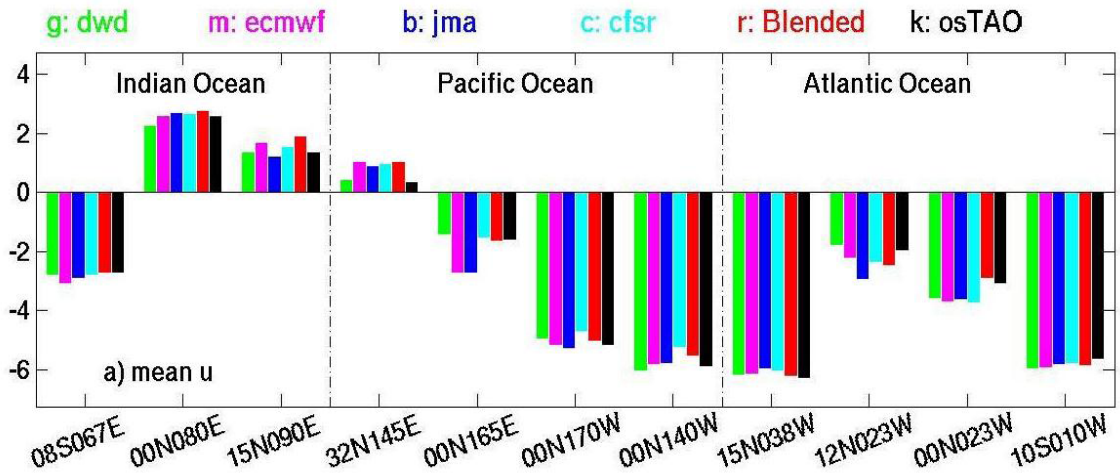

Figure 5: An example of the integrated use of observations from in-situ and satellite platforms for model forecast evaluations. Show are the mean zonal surface winds by OceanSITEs buoys, blended satellites, and forecasts from major international forecast centers: Green for German Weather Service DWD; Magenta for the European's ECMWF; blue for the Japanese Meteorological Agency (JMA); cyan for NOAA/NCEP's Climate Forecast System Reanalysis (CFSR); red for the NOAA/NCDC Blended Seawinds, and black for the OeanSITES buoys winds.

2.1. Outreach and Education

Dr. Richard W. Reynolds serves on the WCRP's Ocean Observation Panel of Climate (OOPC) and the Group for High Resolution Surface Temperature (GHRSST) Science Team. Members of both groups consist of well-known national and international scientists. Dr. Reynolds is a well-respected and published scientist as noted at: http://in-cites.com/papers/RichardReynolds.html. Dr. Huai-Min Zhang has taken the lead publishing papers on the requirements for integrated in-situ and satellite observations. Dr. Zhang is serving in the AMS Scientific and Technical Action Commission's Committee on Air-Sea Interaction, as well as the WCRP working groups of SEAFLUX and SURFA. Eric Freeman serves in the JCOMM Expert Team on Marine Climatology (ETMC).

We had also continued to engage private sectors, government agencies and policy makers to promote data use for societal benefits. The user-friendly web interfaces and data formats have continued to extend the products' benefit to the society, such as new applications in marine transportation safety and efficiency (e.g. near-real-time use in NOAA's world Coral Reef Watch, and Ship Routing services: Delta Western, Inc - Alaska's Petroleum Distributor; International Routing Services S.A.; Cornell Sailing Ltd; see the Outreach and Education section for more details). A partial list of our user communities includes not only climate research but also for direct societal benefits:

- For offshore renewable energy research & assessment: the Renewable Energy Systems Americas Inc, the UK Atmos Consulting Ltd, the Italy CESI RICERCA, the Univ of Maine, the UK Cranfield Univ, the Scotland Environmental Res. Inst, the Philippines Dept. Energy, the Demark DHI Port & Offshore Technologies, the UK 4C Offshore Limited, the Portugal wind projects evaluations, for domestic energy planning in Texas, MAETEC Renewable Energy (http://www.maetecengineering.com/), etc.
- Global Infrastructure Services Consultancy (http://www.cardno.com).
- Applications in ecosystem: the Inter-American Tropical Tuna Commission's research on spawning & recruitment by wind regimes, the South Africa Council for Scientific and Industrial Research's physical-biological processes study, and the near-real-time coral reef stress monitoring by the NOAA Coral Reef Watch (Figure 1), Examine sea wind data as a potential predictor of squid distributions (awinter@fisheries.gov.fk).
- Environmental applications: the oil/mineral slicks monitoring/modeling and the Environmental Resources Management Inc.
- Services to forecasting: marine weather forecasting by the Aerospace & Marine International.
- Construction engineering applications: the UK Scott Wilson Group plc and the McDonough Associates Inc (Chicago).
- Education: the Starpath School of Vavigation, the Univ Washington, among many other international schools for Maters and Ph.D researches.

3. Publications and Reports

3.1. Publications by Principal Investigators

- **Published**

Brohan, P., Allan, R., **Freeman, E**., Wheeler, D., Wilkinson, C., and Williamson, F., 2012: Constraining the temperature history of the past millennium using early instrumental observations, *Clim. Past Discuss*., **8**, 1653-1685, doi:10.5194/cpd-8-1653-2012

Martin, M., P. Dash, A. Ignatov, **V. Banzon**, H. Beggs, B. Brasnett, J.-F. Cayula, J. Cummings, C. Donlon, C. Gentemann, R. Grumbine, S. Ishizaki, E. Maturi, **R. W. Reynolds**, J. Roberts-Jones, Group for High Resolution Sea Surface temperature (GHRSST) analysis fields inter-comparisons. Part 1: A GHRSST multi-product ensemble (GMPE), *Deep Sea Research Part II: Topical Studies in Oceanography*, 2012, ISSN 0967-0645, 10.1016/j.dsr2.2012.04.013

Dash, P., A. Ignatov, M. Martin, C. Donlon, B. Brasnett, **R. W. Reynolds, V. Banzon**, H. Beggs, J.-F. Cayula, Y. Chao, R. Grumbine, E. Maturi, A. Harris, J. Mittaz, J. Sapper, T. M. Chin, J. Vazquez-Cuervo, E. M. Armstrong, C. Gentemann, J. Cummings, J.-F. Piollé, E. Autret, J. Roberts-Jones, S. Ishizaki, J. L. Høyer, D. Poulter, Group for High Resolution Sea Surface Temperature (GHRSST) analysis fields inter-comparisons-Part 2: Near real time web-based level 4 SST Quality Monitor (L4-SQUAM), *Deep Sea Research Part II: Topical Studies in Oceanography*, 2012, ISSN 0967-0645, 10.1016/j.dsr2.2012.04.002

Vose, R.S., D. Arndt, V. **F. Banzon**, D. R. Easterling, B. Gleason, B. Huang, E. Kearns, J. H. Lawrimore, M. Menne, T. C.Peterson, **R. W. Reynolds**, T. M. Smith, C. N. Williams Jr., D. Wuertz. 2012. "NOAA's Merged Land-Ocean Surface Temperature Analysis". Bulletin of the American Meteorological Society. doi: http://dx.doi.org/10.1175/BAMS-D-11-00241.1

- **In revision**

Banzon, V. F. and **R.W. Reynolds**, 2012: Use of WindSat to extend a microwave-based daily optimum interpolation sea surface temperature time series. (submitted to *J. Climate*)

Peng, G., H.-M. Zhang, H.P. Frank, J.-R. Bidlot, M. Higaki, S**. Stevens, and W.R. Hankins**, 2012: Evaluation of remotely-sensed and model surface wind forecast and reanalysis products with OceanSITES buoy measurements. *Weather and Forecasting* (re-submitted).

Reynolds, R.W., D. B. Chelton, J. Roberts-Jones, M. J. Martin, D. Menemenlis, and C. J. Merchant, 2012: Objective Determination Of Feature Resolution in Two Sea Surface Temperature Analyses. (to be submitted to *J. Climate*)

3.2. Other Relevant Publications

The datasets have been used by many research projects including student theses. Over last year, known *added* users are over 40. Near-real-time applications include:

- NOAA Coral Reef Watch: http://coralreefwatch.noaa.gov/satellite/doldrums_v2/index.html
- International Routing Services, S.A.
- For more other applications, please see Section 2.1 under "Outreach and Education".

References:

Curry, J.A., A. Bentamy, M. A. Bourassa, D. Bourras, E. F. Bradley, M. Brunke, S. Castro, S. H. Chou, C. A. Clayson, W. J. Emery, L. Eymard, C. W. Fairall, M. Kubota, B. Lin, W. Perrie, R. A. Reeder, I. A. Renfrew, W. B. Rossow, J. Schulz, S. R. Smith, P. J. Webster, G. A. Wick and X. Zeng, 2004: SEAFLUX, *Bull.Ameri. Meteorol. Soc.*, **85** (No. 3), 409–424.

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

WMO/TD-No. 1036/WCRP-112 (2000), Final Report of the Joint WCRP/SCOR Working Group on Air-Sea Fluxes (SCOR Working Group 110): Intercomparison and Validation of Ocean-Atmosphere Energy Flux Fields, 303pp+xvi.

Woodruff, S., 2010: Archival of data other than in IMMT format: The International Maritime Meteorological Archive (IMMA) Format. In Second Session of the JCOMM Expert Team on Marine Climatology (ETMC), Geneva, Switzerland, 26-27 March 2007, JCOMM Meeting Report No. 50, 68-101 [ref. JCOMM 2007]. Report updated in 2010 (http://icoads.noaa.gov/e-doc/imma/R2.5-imma_short.pdf).

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.Ameri. Meteorol. Soc., 90 (No. 1), DOI:10.1175/2008BAMS2577.1