Ocean Data Management at NCDC

From Ingest to Archive, Blended Products and Data Services

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1. Project Summary

This project carries through an End-to-End process, from data ingest from the observing systems, to data quality control, gridded and blended data production, and to direct data services to the user communities, including scientific researches, marine ecosystems (e.g. NOAA's World Coral Reef Watch), renewable energy industries, marine transportation (e.g. ship routing services), outreach and education, among many others (detailed later at the Outreach and Education section). The data include those from ICOADS, VOSClim as well as satellite sea surface winds. This project directly supports the NOAA's mission: "To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs." This is accomplished by fulfilling NCDC's mission: "To provide stewardship and access to the Nation's resource of global climate and weather related data and information, and assess and monitor climate variation and change."

NCDC plays an active and important role in the national and international climate change monitoring and assessment programs (e.g., IPCC and USGCRP). Climate change monitoring and assessment require meteorological and marine data over both land and ocean. Changes of environmental variables at and near the marine surface are important since they occur over approximately 70% of the Earth's surface and contain important climate change signals. Due to the drastic property differences between water and air (e.g., density and heat capacity), huge amount of water, energy, momentum and gases (e.g., carbon dioxide) are constantly exchanged at the turbulent air-sea interface. These exchanges regulate the weather in the short term and the climate change in long term. Thus, NCDC has been actively archiving, serving and utilizing the world's surface marine data, and it will need to continue to do so.

Modern day Global Ocean Observing System (GOOS) consists of multiple platforms and instruments (both in-situ and remote sensing). Each of these observations contributes to the understanding and assessment of climate change signals. However, 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 for the needs of both researches and societal applications (e.g. Zhang et al 2006; Reynolds et al 2007). For example, research on global water and energy budgets and numerical weather and ocean forecasts demand increasingly higher resolution forcing data (better than daily and 50 km; e.g., WMO/TD-No. 1036, 2000; Curry et al. 2004). The recent international Global Earth Observation System of Systems (GEOSS) and Global Climate Observing System (GCOS) also called for optimal combinations of the above platforms for integrated global observing system and service (reviewed in Zhang et al 2009).

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", 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).

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. Highlighted accomplishments are described in the next section.

2. Scientific and Observing System Accomplishments

Accomplishment Highlights: This project directly serves the COD's Program Deliverables in: 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. Our data and products are directly available online and in near real time (http://www.ncdc.noaa.gov/oa/rsad/air-sea/index.html). The user-friendly interfaces and formats have continued to extend the benefits 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).

Specific Deliverables:

- ***ICOADS - Increased data volume of archive and service; online data (complete archive) for years from 1662; Improved GIS services and capabilities:*** NCDC continued to ingest, archive, quality control and serve the ICOADS Release 2.5 data

(Woodruff et al 2010) as well as additional global marine observations currently not included in the latest official ICOADS release:
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/).
Preparations are underway to produce the next major ICOADS delayed mode release, Release 2.6.0, tentatively scheduled for availability in late 2012. Available global surface marine data for the entire period of record (1662-present) are available through Climate Data Online (http://www.ncdc.noaa.gov/cdo-web/search/), with the addition of a GIS dynamic map interface to aid in data discovery and access (http://gis.ncdc.noaa.gov/map/marine/). The improved interface provides search for nearly 1.5 million unique ships, access to ICOADS, VOSClim, buoys/platforms, and preliminary ICOADS/marine observations. Access improvements will continue to be gained with the addition of batch order functionality moving the order size limit to 15GB per request. Over the reporting period nearly 17,000 orders were processed representing approximately 340GB of data. Online data volume is given below:

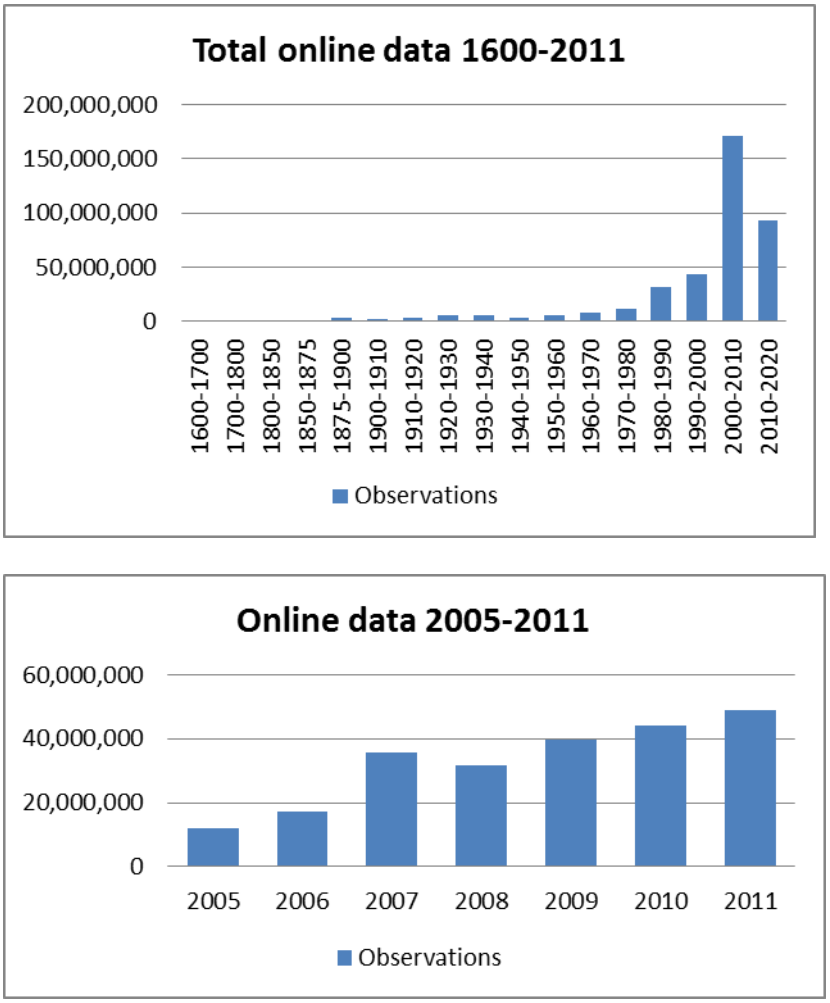

Figure 1. Total available online data (excluding Dec 2011).

- ***VOSClim - Increased data volume of archive and service; continued VOSClim webpage maintenance updating monthly statistics and data access, and service with the Global Collecting Center (GCC):*** We have achieved and exceeded the above deliverables. We had done a total revision of the VOSClim webpage, including a new logo and a more streamlined look (http://www.ncdc.noaa.gov/oa/climate/vosclim/vosclim.html). VOSClim is no longer a project, but has been formally adopted as a new class of observing ships within WMO/IOC JCOMM's Voluntary Observing Ships' Scheme. 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.

- ***Operational production and service of the blended global 0.25° and 6-hourly sea winds, together with the Near-Real-Time version; Engaged user community to expand societal benefits. A new version iss added.*** We had completed all of the above tasks. Both the near-real-time (NRT) version and the delayed mode research quality version had been operationally produced, and updated when there were changes in the observing systems. The observations from the NASA EOS AMSR-E had ended in early October 2011. In response, the NRT processing procedure had been changed in the new version, utilizing the newly available observations from the DMSP F16 and F17. This resulted in a better spatial coverage in this version.

  The user community continued to grow in the last year. Serving the near-real-time users (e.g., the NOAA's world Coral Reef Watch, the shipping routine services) was a challenging task last year, due to the PI's rotational assignments under a NOAA leadership development. He worked extended hours and during the weekends to bring the products up to date and to minimize the impact to the users.

- ***Improve the web and data archive and services for SURFA, and serve to the community:***

  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 (e.g. from the OceanSITES). In FY11, we continued to work with the international communities and world NWP Forecast Centers to expand the data collection and service, including participations from ECMWF, German, France and Japan. The data server had been revamped, resulting in better and faster data services.

In collaboration with the world Forecast Centers, we started data analysis utilizing this data repository. A paper has been submitted to the journal Weather and Forecasting published by the American Meteorological Society. The paper (Peng et al 2012) evaluated the NWP model performances as well as satellite-based products, against the in-situ observations (e.g. Fig. 2). The results revealed potential areas for future model and satellite product improvements.

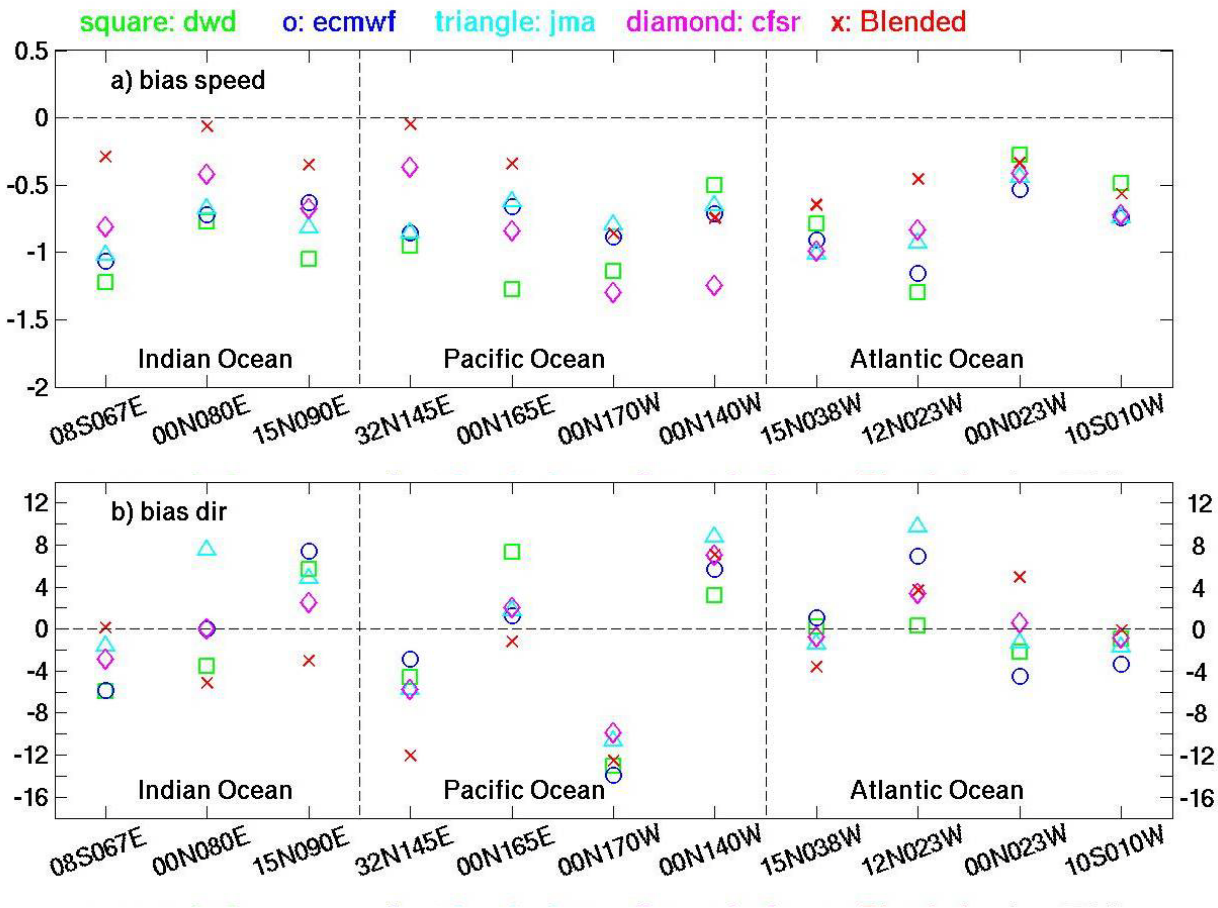

Figure 2. Statistical biases against selected OceanSITE buoy observations for various NWP forecasts and a blended satellite product. a) Wind speed; and b) Wind direction.

2.1. Outreach and Education

During this year, the PI (Dr. Zhang) completed a NOAA leadership development program, including rotational assignments at: 1) the USDA Forest Service's *Eastern Forest Environmental Threat Assessment Center* (*EFETAC, as co-Director*); 2) the NOAA Satellite Operation Facility (NSOF); and 3) the NOAA Budget Office. At EFETAC, the PI had promoted climate service applications to the forest service as well as bridging between NOAA and DOI/USGS (the Landscape Conservation Cooperatives/LCC, DOI's Climate Science Centers/CSC, etc).

Eric Freeman began working on a new student project with Commack High School in New York. The student will study the 120+ year record of Setauket, NY and use ICOADS data from nearby Long Island Sound for land-ocean temperature comparisons.

We had also continued to engage private sectors, government agencies and policy makers to promote data use for societal benefits. Additionally, 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.

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

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

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, E. M. Armstrong, C. Gentemann, J. Cummings, J. P. Piolle, E. Autret, J. Roberts-Jones, S. Ishizaki, J. Hoyer, and D. Poulter, 2012: Group for High resolution

SST (GHRSST): Analysis Fields Inter-Comparisons, Part 2: Near real time web-based Level-4 SST Quality Monitor (L4-SQAM). *Deep Sea Research II* (Special Issue on Satellite Oceanography and Climate) (submitted).

Fairall, C. W., H.-M. Zhang, G. Peng, S. Stevens, A. Brown, and D. Majewski, 2011: Surface Flux Analysis (SURFA) – Update on recent activities. *The 27th Session of the WCRP-JSC/CAS Working Group on Numerical Experimentation (WGNE)*, 17 – 21 October 2011, Boulder, CO, USA.

Huang, B., E. Freeman, J. Lawrimore, Chunying Liu, R. W. Reynolds, and D. Wuertz, 2012: Climate variabilities in merged land-ocean surface temperature (MLOST). *J. Climate*, (submitted).

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, 2012: Group for High resolution SST (GHRSST): Analysis Fields Inter-Comparisons, Part 1: A GHRSST Multi-Product Ensemble (GMPE). *Deep Sea Research II* (Special Issue on Satellite Oceanography and Climate) (submitted).

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* (submitted).

Peng, G., H.-M. Zhang, H.P. Frank, J. Bidlot, M. Higaki, and W. Hankins, 2011: A comparison of various Equatorial Pacific surface wind products, *Proc. IGARSS 2011*, 2049 – 2052, 24 – 29 July, 2011, Vancouver, Canada.

Reynolds, R.W., and D.B. Chelton, 2011: Objective Determination of Feature Resolution in an SST Analysis. *XII GHRSST Science Team Meeting*, Edinburgh, Scotland, 29 June 29 – 1 July 2011.

Wilkinson, C., S. Woodruff, P. Brohan, S. Claesson, E. Freeman, F. Koek, S. Lubker, C. Marzin, D. Wheeler, 2011: RECovery of Logbooks And International Marine Data: The RECLAIM Project. *Int'l J. Climatol.*, **31**, 968-979 (DOI: 10.1002/joc.2102).

Woodruff, S., S. Worley, S. Lubker, Z. Ji, E. Freeman, D. Berry, P. Brohan, E. Kent, R.W. Reynolds, S. Smith, C. Wilkinson, 2011: ICOADS Release 2.5: Extensions and Enhancements to the Surface Marine Meteorological Archive. *Int'l J. Climatol.*, **31**, 951-967, (DOI: 10.1002/joc.2103).

3.2. Other Relevant Publications

Shi, L., G. Peng, J. Bates, 2011: Deriving surface temperature and humidity from long-term HIRS observation in high latitudes. *J. Atmos. Oceanic. Tech.*, **29**, 3 – 13.

Near-real-time applications:

- 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".

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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.

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