U.S. Research Vessel Surface Meteorology Data Assembly Center

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1. Project Summary

The central activity of the U.S. Research Vessel Surface Meteorology Data Assembly Center (DAC) at the Florida State University (FSU) is the implementation of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (http://samos.coaps.fsu.edu/). The SAMOS initiative focuses on improving the quality of and access to surface marine meteorological and oceanographic data collected in situ by automated instrumentation on research vessels. In FY2013, 1 New Zealand-, 2 Australia-, and 28 United States-operated research vessels routinely transmitted daily emails containing one-minute averaged meteorology and surface oceanographic data to the DAC. Broadband satellite communication facilitates this daily transfer at ~0000 UTC. A preliminary version of the data is available via web services within five minutes of receipt. The preliminary data are placed in a common data format, are augmented with vessel- and instrument-specific metadata (e.g., instrument height, type, units), and undergo automated quality control (QC). Visual inspection and further scientific QC result in intermediate and research-quality products that are nominally distributed with a 10-day delay from the original data collection date. All data and metadata are version controlled and tracked using structured query language (SQL) databases. These data are distributed free of charge and proprietary holds via http://www.coaps.fsu.edu/RVSMDC/html/data.shtml, and long-term archival occurs at the U.S. National Oceanographic Data Center (NODC).

The DAC activities focus primarily on **NOAA Climate Mission** and **Technology and Mission Support** goals by providing high-quality weather and near-surface ocean data to validate

complementary satellite observations; global analyses of the ocean-atmosphere exchange of heat, moisture, and momentum; and computer model-derived analyses of climate, weather, and ocean parameters. The data distributed by the DAC address the **Office of Climate Observation program deliverables** related to **sea surface temperature**, **surface currents** (via the wind), and **air-sea exchanges of heat, momentum, and fresh water**.

Research vessels, being mobile observing platforms, are an essential component of the global ocean observing system. They are equipped with computerized data systems that continuously record navigational (ship position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near-surface ocean (sea temperature and salinity) parameters while a vessel is underway. Research vessels travel to remote, hard-to-observe ocean locations far from the shipping lanes sampled by merchant vessels. Research vessels provide essential observations between the fixed locations of surface moorings and support side-by-side comparison to mooring data when moorings are deployed or serviced.

The DAC provides data that quantify the physical and thermodynamic processes governing the interaction between the ocean and atmosphere, key to our understanding of how marine weather systems evolve, how these systems impact the ocean, and how the oceans impact the weather. On longer time scales, understanding the interaction between the ocean and atmosphere is necessary to assess our changing global climate system. The DAC provides high-quality marine meteorological and surface ocean measurements to the research and operational community so that they can identify and model the interactions between the ocean and atmosphere. Benefits include improved weather and climate models and forecasts that provide the public and private sector with the tools to make decisions affecting agricultural productivity, the energy use, and daily life.

Our user community includes scientists developing algorithms to retrieve marine observations from space, those working to define the range of air-sea exchanges in extreme environments (e.g., the Southern Ocean), and atmospheric and ocean modelers seeking to verify model analyses and forecasts. For many applications, our users require observations in the extremes of the marine environment (e.g., very high or low winds) and need frequent sampling in space and/or time to identify local marine features (e.g., weather and ocean fronts). The research vessels providing observations to the DAC meet these needs and the DAC quality evaluation ensures the users receive fully documented observations to complete their analyses.

2. Scientific and Observing System Accomplishments

Over the past year, we have concentrated on evaluating data quality (from collection to archival) for previously recruited vessels, distributing data to a widening user community, and working more closely with OMAO and the NOAA research vessel fleet. We also continued active participation in the international marine climate community.

Deliverables for FY2013 included the following:

1. Continue daily monitoring and automated quality control of data received from all vessels contributing to the SAMOS DAC.

2. Continue routine research-quality evaluation of meteorological data for all NOAA vessels contributing to the SAMOS DAC.
3. Distribute all quality-controlled SAMOS observations via web, ftp, and THREDDS services and ensure routine archival at NODC.
4. Develop and test new automated quality-control methods.
5. Engage OMAO to augment instrumental metadata for all recruited NOAA vessels.
6. Engage new user communities.
7. Continue liaison activities with U.S. and international (limited) government agencies, archives, climate programs, and the marine community

By making progress on these deliverables, described in the following sections, the SAMOS DAC continues to provide a high-quality, well-documented, surface underway dataset for use by a diverse community. In the past year, SAMOS data have been used to validate ocean model estimates of the freshwater inflow to the Gulf of Mexico under flood conditions (Androulidakis and Kourafalou 2013) and to examine the influence of the Mississippi River freshwater plume on a surface oil patch in the Gulf of Mexico. Both works address NOAA's goal for **sustainable management of marine ecosystems** and the former also addresses the goal for **risks to coastlines and coastal infrastructure**. Li et al. (2013) used SAMOS data to validate numerical weather prediction model and satellite estimates of winds in the Southern Ocean, improving the community understanding of the wind-driven Antarctic Circumpolar Current, key to upwelling and the general ocean circulation in the region. These are a few tangible examples of the impact that the SAMOS initiative has on addressing NOAA's societal challenges. Since SAMOS data are frequently used to validate satellite or model products and to develop new satellite retrieval algorithms, and these products are subsequently used for a range of research applications, it is difficult to directly track all the specific challenges that are addressed by FSU's COD-funded efforts to provide a high-quality research vessel data product. Overall, our efforts target the **program deliverables related to sea surface temperature, surface currents (via wind observations), and the air-sea exchanges of heat, momentum, and freshwater.**

2.1. Data quality control (Deliverables 1 and 2)

A comparison of ship days of data received by the SAMOS DAC in FY2012 and FY2013 is presented in Table 1. The total number of vessels routinely transmitting meteorology and surface oceanographic data to the SAMOS DAC has remained stable in the past year; however, four vessels ceased data submission (*Ka'Imimoana, McAurthur II, Oceanus, T.G. Thompson*) and five (*Endeavor, Fairweather, Falkor, Rainier, Thomas Jefferson*) were either recruited or had their data transmissions restored. Close collaboration between the SAMOS DAC and NOAA OMAO (see below) resulted in the receipt of additional data from NOAA vessels in FY13

Automated quality processing is completed on every dataset received from recruited vessels (Table 1). The automated processing continues to be a smooth operation; each dataset is versioned and tracked via an SQL database. In FY2013, we evaluated 4890 days of underway meteorological and near-surface ocean (SST and salinity) data (a 3.5% decrease from FY2012). The reduction of 180 ship days of data received and processed by the SAMOS DAC in FY2013 versus FY2012 is likely the result of overall reductions in ship operating days across the research vessel community. These data span the global ocean, extending into poorly sampled regions of

the Indian, South Atlantic, and Southern oceans (Fig. 1). The extent of these data from the tropics to the polar latitudes, along with many reports on the continental shelf, provide observations from the wide range of environmental conditions required by our users to meet objectives in satellite, air-sea exchange, and physical oceanographic studies.

Table 1: Ships transmitting observations to SAMOS DAC during FY 2012 and FY 2013. Eight vessels recruited with funds from NSF's Ocean Instrumentation and Technical Services program and one recruited via a contract with the Schmidt Ocean Institute are shown for completeness. Operators include NOAA, the Bermuda Institution of Ocean Sciences (BIOS), the Woods Hole Oceanographic Institution (WHOI), Australia and New Zealand via the Integrated Marine Observing System (IMOS), the U.S. Coast Guard (USCG), the U. S. Antarctic Program (USAP), the Scripps Institution of Oceanography (SIO), the Schmidt Ocean Institute (SOI), the University of Hawaii (UH), the University of Rhode Island (URI), the University of Washington (UW), and Oregon State University (OSU).

		Number of ship days with data	
Vessel	Operator	1/10/2011–30/9/2012	1/10/2012–30/9/2013
Atlantic Explorer[1,3]	BIOS	200	156
Atlantis[2]	WHOI	332	169
Aurora Australis[1]	IMOS/Australia	213	157
Bell M. Shimada	NOAA	148	177
Endeavor[1,3]	URI	--	9
Fairweather	NOAA	--	11
Falkor[4]	SOI	--	20
Gordon Gunter	NOAA	196	157
Healy[2]	USCG	188	83
Henry B. Bigelow	NOAA	175	155
Hi'ialakai	NOAA	153	77
Ka'imimoana	NOAA	166	--
Kilo Moana[1,3]	UH	214	78
Knorr[2]	WHOI	339	247
Lawrence M. Gould[2]	NSF/USAP	256	259
McArthur II	NOAA	5	--
Melville[1,3]	SIO	234	275
Nancy Foster	NOAA	135	143
Nathaniel Palmer[2]	NSF/USAP	315	345
New Horizon[1,3]	SIO	10	318
Oceanus[5]	WHOI/OSU	48	--
Okeanos Explorer	NOAA	115	126
Oregon II	NOAA	151	185
Oscar Dyson	NOAA	200	224
Oscar Elton Sette	NOAA	183	127
Pisces	NOAA	160	207
Rainier	NOAA	--	117
Roger Revelle[1,3]	SIO	357	308
Ronald Brown	NOAA	126	134
R. G. Sproul[1,3]	SIO	16	108
Southern Surveyor[1]	IMOS/Australia	170	157
Tangaroa[1]	IMOS/New Zealand	232	195
Thomas Jefferson	NOAA	--	166
T. G. Thompson[1,3]	UW	33	--
		5070	4890

[1]No research-quality visual QC completed.
[2]Visual QC discontinued at the end of 2012 as a result of NOAA budget reductions.
[3]NSF funding supported recruitment (part of UNOLS Rolling Deck to Repository program).
[4]*Falkor* recruited to SAMOS via contract with the Schmidt Ocean Institute. Leveraging COD-funded SAMOS infrastructure at FSU.
[5]*Oceanus* moved from WHOI to OSU at the start of 2012. This interrupted the data flow to SAMOS.

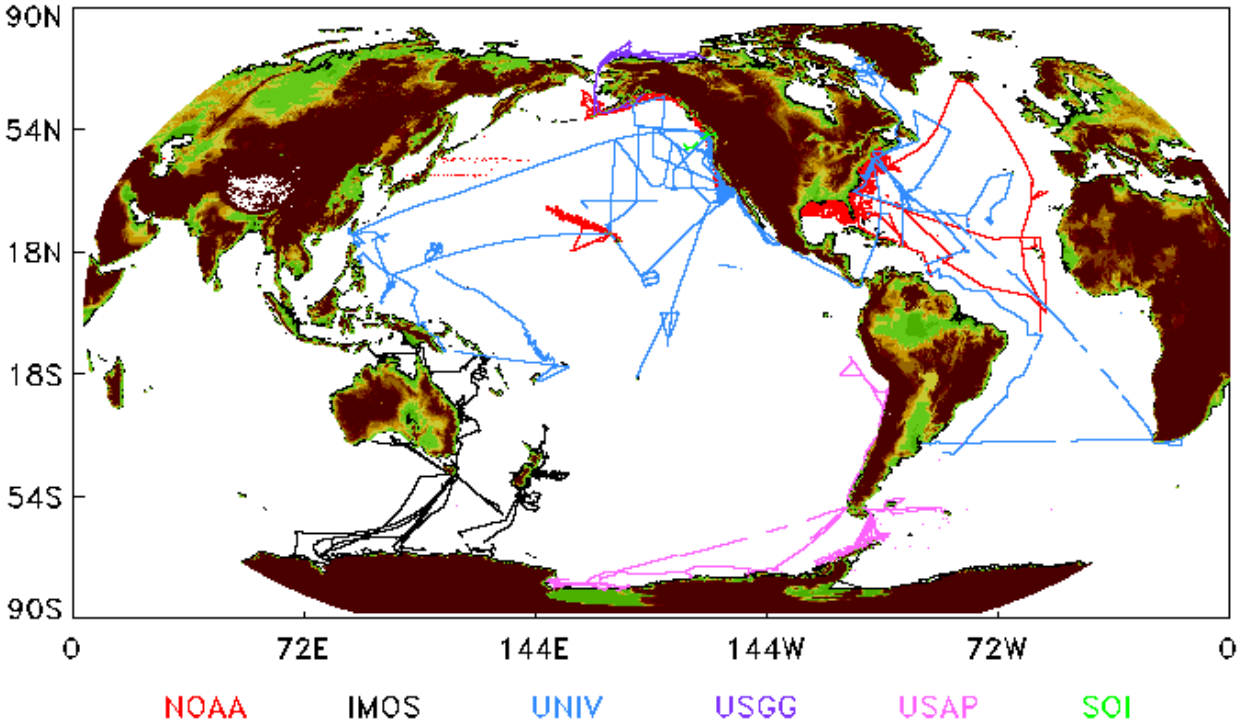

Figure 1: Cruise tracks showing data provided to the SAMOS DAC for FY2013. Data are color coded by the primary data providers. All university-operated vessels are shown in blue.

Our lead analyst, Jeremy Rolph, continues to conduct daily (not 24/7) visual inspections of all observations. This inspection, a quick-look, does not allow for adding/altering quality control flags on the data, but ensures the data received from the vessel are free of major sensor failures or other problems that would require notification of the vessel at sea. These at-sea notifications are highly desired by the vessel operators and onboard technicians and are the core benefit to the vessel operator. Prompt problem notification results in a quick resolution of sampling issues and adds value to the public investment in expensive shipboard observing systems.

Over the past year, Kristen Briggs completed visual QC for many of the recruited vessels (the exceptions are noted in Table 1). Visual QC allows the analyst to review, add, or modify data quality flags on the merged files. Visual quality control is manpower intensive and continued funding reductions from NOAA resulted in the loss of this capability for all non-NOAA vessels at the end of CY2012. The loss of visual QC for 5 vessels (Table 1) affected 1103 ship days of data, including data from the *L. M. Gould*, the *Nathaniel Palmer*, and the *Healy*, which primarily are located in the Southern and Arctic oceans. The reduction in the quality assessment of these high-value observations may adversely affect research applications in these extreme environments. We note that the Australians conduct visual QC for IMOS vessels. We are unable to leverage our NSF funding to provide additional visual QC for the non-NOAA vessels.

We again produced an annual report (Briggs et al. 2013) that summarizes the data quality for all vessels contributing data for the calendar year 2012. The report has been distributed to all operators of SAMOS vessels and posted to the SAMOS web site.

2.2. Data distribution and archival (Deliverable 3)

All near real-time (preliminary, 5-min delay from receipt) and delayed-mode (intermediate or research, 10-day delay from receipt) data are available via web (http://samos.coaps.fsu.edu/, under "Data Access"), ftp (samos.coaps.fsu.edu, anonymous access, cd /samos_pub/data/), and THREDDS (http://coaps.fsu.edu/thredds.php) services. The most recent data can be identified by selecting "preliminary" data at http://samos.coaps.fsu.edu/html/data_availability.php. Available data vary depending on which ships are transmitting data on a given day. We routinely test our web services and respond rapidly to failures of the system. Although we do not have a documented data management plan, the SAMOS web site includes our mission statement, data policy, and acknowledgements under the "About" tab on the SAMOS home page. The web site also provides access to recruitment materials for vessels, a subscription service for operators to access monthly data reports, desired SAMOS parameters and accuracy requirements, relevant literature and publications, best practice guides, and training materials.

SAMOS data are not presently provided to the Global Telecommunication System. As part of our work with JCOMM (see below) we are collaborating with the managers of the U.S. Voluntary Observing Ship scheme at the National Data Buoy Center (NDBC) to assess the quality of data records transmitted via the GTS from the same vessels that contribute to SAMOS. The majority of the U.S. research vessels contributing to SAMOS provide irregular 1-, 3-, or 6-hourly reports to the GTS via other National Weather Service- (NWS) supported programs (e.g., AMVER SEAS). Preliminary results reveal that the SAMOS data can be used to trouble-shoot the GTS data feeds from the NWS programs. The collaboration with NDBC personnel has also allowed SAMOS to receive updated instrumental metadata for several NOAA-operated RVs. The PI notes that our major user community continues not to require SAMOS data to be delivered via GTS. Our current web, ftp, and THREDDS systems meet their needs.

SAMOS data are archived at the U.S. National Oceanographic Data Center on a monthly schedule. To ensure integrity, each archival set includes files that contain the original, preliminary, and research-quality data and metadata (e.g., file naming and format descriptions); a file manifest; and a message-digest algorithm 5 (MD5) checksum for each file. NODC makes the archival sets available online via two types of Dissemination Information Packages: the public may download either individual files in the archival set—each file has a unique URL—or the entire archival set in one "tarball" file. Users may find all the SAMOS data by searching for SAMOS under "Contributing projects" on the Open Archive System at http://www.nodc.noaa.gov/Archive/Search. A check on 10 October 2013 located 1220 monthly SAMOS ship archive sets at NODC. Periodically, the PI downloads SAMOS data from NODC to ensure system integrity.

2.3. Developing new automated quality control (Deliverable 4)

Progress on this deliverable was limited in FY2013. We completed a prototype code to update our land-sea test for platform position to use the one-minute (vs. two-minute) gridded topography dataset available from the National Geophysical Data Center. Implementation of this code should occur in late CY2013 and will reduce the number of ship positions that are incorrectly flagged as being over land by our present land-sea code. Other developments were

delayed by the loss of a primary programmer at the start of 2013 and the 4-month search for a suitable replacement. Continued funding reductions and shifting priorities will likely result in limited, if any, new quality-control procedural developments in the coming years.

2.4. Interaction with OMAO (Deliverable 5)

Over the past year, the DAC has continued to communicate with the Office of Marine and Aviation Operations (OMAO) at NOAA. We now provide daily data delivery and data quality status reports to OMAO headquarters in Silver Spring via a real-time JSON web service. OMAO harvests the information from the web service and displays it at OMAO for their management team. Two face-to-face meetings, one at the annual UNOLS RV technicians meeting in Palisades, NY (Feb 2013) and the other at the NOAA Rolling Deck to Repository meeting in Silver Spring, MD (June 2013), provided an opportunity to improve the lines of communication with OMAO. These meetings allowed the PI and the DAC technical staff to begin working with OMAO's programming team to develop new methods to extract instrumental metadata from the data acquisition system used by the NOAA fleet. We have obtained a copy of this software and are working to install it in our instruments lab at FSU. This will allow our data quality analysts to have a better understanding of the tools being used by the marine technicians on NOAA vessels and should improve fleetwide communication on SAMOS problems. In June, we also encouraged OMAO to approach COD to discuss the science user requirements of the NOAA RVs for climate applications. There is a growing interest in OMAO to ensure that their vessels are routinely providing all possibly underway observations on all cruises, regardless of the core science mission of the cruise. Through our ongoing dialog and data exchange, the DAC is providing a service to OMAO that improves the quality of the data collected by NOAA vessels. Our communications, in part, resulted in an increase of 93 ship days of data from the NOAA fleet reaching the national archives in FY2013 (Table 1). In a time of generally reduced sea days for the U.S. research fleet, increasing the quantity of high-quality marine observations reaching the national archives adds value to the public investment in NOAA's research fleet. Ongoing interactions between the DAC and OMAO also address **Technology and Mission Support** goals in NOAA's strategic plan**.**

2.5. Engage new user communities (Deliverable 6)

DAC personnel and colleagues in the marine climate community continue to spread the message about the SAMOS initiative and the value of high-quality underway observations from RVs. In the past year this engagement was primarily through presentations at national and international meetings. The PI presented on SAMOS at the Fall AGU meeting in San Francisco, CA (Dec. 2012), the NSF Rolling Deck to Repository Advisory meeting in Palisades, NY (Dec. 2012), the UNOLS Research Vessel Technical Enhancement Committee meeting in Palisades, NY (Feb. 2013), and the 7th Session of the JCOMM Ship Observation Team in Victoria, Canada (Apr. 2013; funded by COD). Colleagues at the NSF Rolling Deck to Repository program presented SAMOS activities to the international community at the European Geophysical Union meeting in Vienna, Austria (Apr. 2013) and at the International Conference on Marine Data and Information Systems in Lucca, Italy (Sep. 2013). The continued engagement with the research and operational community through meetings has increased the visibility of the SAMOS initiative and we are receiving more requests for our observations. In addition to the three known

publications using SAMOS data by authors outside of FSU, we also know the data are being used to validate shortwave and longwave radiation fluxes in NRL models (J. May, personal communication, 2013), to estimate CO_2 fluxes in the western Arctic (C. Hauri, personal communication, 2013), and to determine ambient conditions during aerosol measurements on CLIVAR cruises (W. Landing, personal communication, 2013).

2.6. Liaison activities (Deliverable 7)

The SAMOS project continues to exemplify strong data stewardship practices for underway data from research vessels and maintains an active partnership with the Australian IMOS project, the UNOLS Rolling Deck to Repository (R2R) program, and the NOAA R2R initiative. The PI routinely receives requests from other marine data programs to share the lessons learned from SAMOS. Just over a decade past the first Workshop on High-Resolution Marine Meteorology held in Tallahassee, FL, on 3-5 March 2003 (funded by NOAA COD), the SAMOS project has become a model for the management of underway surface atmospheric and oceanographic data.

The SAMOS DAC serves as the project office for the entire SAMOS initiative. In this capacity, DAC personnel facilitate U.S. and international collaborations on topics such as data accuracy, data acquisition and exchange, training activities, and data archival. The PI performs an active role in the international marine climate community, serving on two JCOMM task teams (Marine Climate Data System, Instrument Systems). In April 2013, the PI was invited to and participated as a U.S. representative at the 7th Session of the JCOMM Ship Observation Team in Victoria, Canada. This meeting provided an opportunity to connect with the U.S. VOS program and resulted in a follow-up, face-to-face meeting in May 2013 between the PI and NDBC personnel responsible for coordinating the VOS program for the NWS.

3. Outreach and Education

Through COD funding, we continue to train the next generation of marine and data scientists. Aaron Paget completed his Ph.D in 2013 for which he investigated how white capping can be estimated from satellite data. This project ties into better estimates of mid- to high-latitude winds and fluxes. Although we are not examining the following, the white capping work is also very important for ocean color observations (it is the limiting factor at high wind speeds) and estimating surface fluxes of CO_2, so the work supports the larger NOAA climate goals related to **sustainable management of marine ecosystems.**

The PI also mentored a high school student as part of the summer 2013 Young Scholars Program at FSU. Although not working directly with the SAMOS observations, our student examined biases in forecasts of tropical storm and hurricane strength at landfall along the U.S. coastline in 2004 and 2005. This preliminary investigation provided insight into sources of errors in the forecasts and directly addresses NOAA's climate challenge for **risks to coastlines and coastal infrastructure**. COD funding to the PI allows him the flexibility to participate as a mentor in this summer research experience for high school students.

4. Publications and Reports

4.1. Publications by Principal Investigators

4.1.1. Published

Zheng, Y., **M. A. Bourassa**, and P. J. Hughes, 2013: Influences of Sea Surface Temperature Gradients and Surface Roughness Changes on the Motion of Surface Oil: A Simple Idealized Study, *J. Appl. Meteor. Clim*., **52**, 1561 - 1575. DOI: 10.1175/JAMC-D-12-0211.1

4.1.2. In Press

Gilford, D., **S. R. Smith**, M. Griffin, and A. Arguez, 2013: Southeastern US daily temperature ranges associated with the El Nino–Southern Oscillation. *J. Applied Meteor. Climatol.*, in press.

4.1.3. Proceedings from conferences

Fairall, C. W., **M. A. Bourassa**, M. F. Cronin, **S. R. Smith**, R. A. Weller, G. Wick, S. Woodruff, L. Yu, H-M Zhang, 2012: Observations to Quantify Air-Sea Fluxes and Their Role in Global Variability and Predictability. *Proceedings of the Integrated Ocean Observing System (IOOS) Summit Workshop*. Herndon, VA, 13 November 2012.

4.1.4. Data Reports

Briggs, K., **S. R. Smith**, J. J. Rolph, 2013: 2012 SAMOS Data Quality Report. COAPS, Tallahassee, FL, USA, 172 pp. [Available from Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, Florida, 32306-2840, USA].

4.2. Other Relevant Publications

Androulidakis, Y. S., and V. H. Kourafalou, 2013: On the processes that influence the transport and fate of Mississippi waters under flooding outflow conditions. *Ocean Dynamics*, **62(2-3)**, 143-164.

Kourafalou, V. H., and Y. S. Androulidakis, 2013: Influence of Mississippi induced circulation on the Deepwater Horizon Oil Spill transport. *J. Geophys. Res.*, **118**, 1–20, doi:10.1002/jgrc.20272.

Li, M., J. Liu, Z. Wang, H. Wang, Z. Zhang, L. Zhang, Q. Yang, 2013: Assessment of Sea Surface Wind from NWP Reanalyses and Satellites in the Southern Ocean. *J. Atmos. Oceanic Technol.*, **30**, 1842–1853. doi: http://dx.doi.org/10.1175/JTECH-D-12-00240.1