

U.S. Research Vessel Surface Meteorology Data Assembly Center

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Project Summary

The central activity of the U.S. Research Vessel Surface Meteorology Data Assembly Center (DAC) is the continued development 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 and ships of opportunity. The DAC activities focus primarily on NOAA Strategic Plan Goals 2 and 3 by providing high quality weather and near surface ocean data for use in validating satellite products, global air-sea flux analyses, and model fields. Research vessels are mobile observing platforms that are an essential component of the global ocean observing system. These vessels travel to remote and hard to observe ocean locations that are far from normal shipping lanes.

The rationale for this activity centers on the desire to understand the physical and thermodynamic interaction between the ocean and atmosphere. This interaction is key to our understanding of how marine weather systems evolve, how they 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 role of the DAC is providing the high quality marine meteorological and surface ocean measurements to the research and operational community so that they can address these ocean-atmospheric interactions. High quality observations are essential to our scientific understanding of the ocean-atmosphere interactions.

The DAC was established at the Florida State University specifically to coordinate the collection, quality evaluation, distribution, and future archival of SAMOS data. SAMOS are typically a computerized data logging system that continuously records navigation (ship's position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near ocean surface (sea temperature and salinity) parameters while a vessel is at sea. Measurements are recorded at high-temporal sampling rates (typically 1 minute or less). The DAC collaborated with the Woods Hole Oceanographic Institution (WHOI) to design a ship-to-shore-to-user data pathway for U.S. research vessel SAMOS data. In the past, the data flowed from ship to shore only in a delayed-mode with a 3 month to 2-year lag between collection and availability to the user community. The new data pathway supports automated data transmission from each ship to the DAC on a daily basis. A "preliminary" version of the SAMOS data are available on-line within 5 minutes of receipt by the DAC. The preliminary data undergo common formatting, metadata enhancement, and automated quality control. Visual inspection and further scientific quality control result in a "research" quality SAMOS product that are distributed with a delay of 10 days from the original data collection date. All quality-evaluated research vessel data from the SAMOS initiative and past DAC programs are freely available to the user community (<http://www.coaps.fsu.edu/RVSMDC/html/data.shtml>), and we continue to work with several

world data center archives (e.g., National Oceanographic Data Center, National Center for Atmospheric Research) to ensure long term stewardship of these data.

Accomplishments

Over the past year, our efforts have focused on the continued development of the SAMOS Initiative. In collaboration with partners at NOAA's Office of Marine and Aviation Operations (OMAO), Raytheon Polar Services (RPS), and the United States Coast Guard (USCG), the number of vessels participating in SAMOS has increased from 2 to 12. Data from all 12 vessels are routinely pushed through our automated data quality evaluation (DQE). In mid-2007, our research quality processing (including visual DQE) became operational. Many upgrades have been made to both our public access web site and our internal data base tools. Throughout the year, DAC personnel have been actively promoting the SAMOS Initiative through meetings and working groups, including the International Marine Technicians Symposium (17-19 October 2006) and the Fourth Session of the WMO/IOC JCOMM¹ Ship Observation Team in Geneva, Switzerland (16-21 April 2007). We continue to actively recruit new vessels to participate in the SAMOS initiative.

Deliverables for FY 2007 included:

1. Continue routine quality evaluation of meteorological data for 2 SAMOS vessels contributing to the DAC (and 2 delayed mode NOAA vessels, if necessary)
2. Recruit additional research vessels to the SAMOS initiative (focus will be on NOAA and UNOLS vessels)
3. Improve and enhance metadata collection from participating research vessels
4. Develop new data quality evaluation techniques
5. Create and distribute turbulent air-sea fluxes for vessels contributing to SAMOS
 - Subtask1: Compare SAMOS fluxes with available NWP products
6. Continue liaison activities with U.S. and international government agencies, archives, climate programs
 - Subtask1: Establish data exchange with GOSUD
 - Subtask2: Implement data exchange with NODC and NCAR archives
7. Expand user options on the SAMOS web site to ease user access to observations and metadata

The following accomplishments address the deliverables. Also noted are impediments to achieving the deliverables.

Vessel recruitment [Deliverable 2]

Recruitment of additional vessels to participate in the SAMOS Initiative was very successful during the reporting period. Ten new vessels were recruited (Table 1) in the past year. These vessels now routinely contribute SAMOS observations when they are at sea. Collaboration with NOAA OMAO resulted in eight new recruitments. OMAO developed a SAMOS data transmission applet as part of the version 4.0 release of their scientific computing system (SCS).

¹ World Meteorological Organization/Intergovernmental Oceanographic Commission Joint Technical Commission for Oceanography and Marine Meteorology

As the new SCS was installed in the fleet, the NOAA vessels began transmitting data to the DAC. In addition, Co-PI Smith attended the annual UNOLS RVTEC meeting and INMARTECH in October 2006 and had good conversations with several additional vessel operators. Most expressed interest in participating in SAMOS, but initiating new data transfers is still difficult in these times of tight operational budgets for research vessels.

Table 1: Ships transmitting observations to SAMOS DAC during FY 2006 and FY 2007.

Vessel	Operator	Number of ship days with data	
		1/10/2005 – 30/9/2006	1/10/2006 – 30/9/2007
<i>Atlantis</i>	WHOI	192	291
<i>Gordon Gunter</i>	NOAA		4
<i>Healy</i>	USCG		62
<i>Henry Bigelow</i>	NOAA		70
<i>Hi'Ialakai</i>	NOAA		107
<i>Ka'Imimoana</i>	NOAA		61
<i>Knorr</i>	WHOI	276	252
<i>Lawrence Gould</i>	NSF/Raytheon		32
<i>Miller Freeman</i>	NOAA		190
<i>Nancy Foster</i>	NOAA		122
<i>Oscar Dyson</i>	NOAA		170
<i>Ronald Brown</i>	NOAA		149
		468	1510

Daily SAMOS data processing [Deliverables 1, 2, and 3]

Preliminary processing of SAMOS observations received via daily email messages from participating research vessels is now an operational activity at the DAC. During FY 2007, 1510 days of shipboard meteorology data were processed for the 12 recruited vessels (see Table 1). Preliminary processing (Figure 1) starts once the data file arrives at the DAC as an attachment to an email. Each email attachment is unpacked, the data provided are verified that they conform to the format and parameters expected for the individual vessel, and finally the data are blended with vessel specific metadata and are converted to a common netCDF format. The data for each day are then passed through an automated quality evaluation program and data quality statistics are calculated prior to the file being posted for users on the SAMOS web and ftp sites. The entire process from arrival at the DAC to distribution of the preliminary data files is fully automated. Preliminary files appear on the data distribution site within 5 minutes of their arrival at the DAC (typically shortly after 0000 UTC).

A comparison of the spatial distribution of data received, processed, and on-line for 2006 and the start of 2007 is shown in Figure 2. Prior to 2007, the only two ships providing data were the *Knorr* and *Atlantis*. A rapid increase in vessels participating in SAMOS began in early 2007, leading to the present 12 recruited vessels (Table 1).

Each individual data file has been augmented with extensive metadata that is stored in a ship profile database. In addition, the shipboard database uses a strict version control to track individual data files received from their original email attachment to the final files released to the public (Figure 1). Individual data quality statistics are stored in the ship database and these can

be accessed through the data availability link on the SAMOS web site (http://samos.coaps.fsu.edu/html/data_availability.php). A sample of data quality graphics for the *Knorr* is provided in Figure 3.

Delayed-mode SAMOS processing [Deliverables 1 and 4]

Due to data logging problems on the ship or communication dropouts, some data arrive several days after they were collected. Often the data are noted to be missing by the analyst at the DAC and arrive after the analyst notifies the vessel technician at sea. In addition, data for a single day may be fragmented and may arrive in multiple files attached to a single email. As a result, the DAC developed a method to merge multiple files for a single observing day into a combined, delayed-mode data file. This merged file undergoes additional automated and visual data quality evaluation and is then released as a “research-quality” SAMOS data file for the particular observation day (Figure 1).

The process to merge multiple files for a single observing day and the visual data quality evaluation are now operational. The merge program is designed to eliminate duplicate records from the files being merged. Duplicates are eliminated based on a series of rules that take into account the automated quality control applied to the preliminary data files. The merge process is fully automated and the merged files are tracked within the file-tracking database. Currently the merge occurs 10 calendar days after the observation day (when the preliminary data should arrive at the DAC). Using the database, the analyst can easily reference the original file pieces that were merged to create a single data file for each observation day. Once merged, a summary of the data quality flags on the new file is produced and stored in the database.

Each day, the data quality analyst at COAPS reviews the latest merged files and conducts a visual quality evaluation. The visual analysis is accomplished using SVIDAT, a graphical user interface developed by COAPS programmers. SVIDAT allows the analyst to review, add, or modify data quality flags on the merged files. Once the analyst is satisfied with the data quality, the file is saved and posted automatically to the SAMOS ftp and web sites. This process also updates all necessary tracking information in the ship database and creates the copies of the original, preliminary, and research quality files for delivery to the national archive centers.

Delayed-mode evaluation of NOAA ship data [Deliverable 1]

We have received delayed-mode data from the *Ronald Brown* for the period February – December 2006. These data have been converted to our internal netCDF format and are awaiting quality control. For the *Ka’Imimoana*, we have received data for the period September 2004 – August 2007. The data for September 2004 – December 2005 have completed visual quality inspection and their data quality report is being written. Data from January – September 2006 have been converted to our format and are awaiting visual quality control. The remaining *Ka’Imimoana* data are awaiting conversion and quality evaluation. We note that in 2007 both the *Ronald Brown* and *Ka’Imimoana* were recruited to the SAMOS initiative and will no longer be providing delayed-mode data to the DAC. The outstanding delayed-mode data for the *Ronald Brown* and *Ka’Imimoana* will be evaluated and released by mid-2008. Future data for these vessels are being processed as part of the SAMOS initiative.

Metadata enhancement [Deliverable 3]

The SAMOS DAC continues to work to improve access to the metadata (e.g., instrument heights, sensor locations, averaging methods, etc.) necessary for scientific application of these observations. This continues to be a struggle. It is easier to get the SAMOS data from recruited vessels, but some critical metadata is lacking. We have had several telephone and in-person conversations to improve the situation. Recently, Mr. Smith has been asked to serve on the Data Management Best Practices Subcommittee of the UNOLS council. The committee will be reviewing data management practices (including metadata) for the UNOLS fleet. Finally, at the request of several vessel operators, the DAC has developed a web interface that will allow vessels participating in SAMOS to upload their metadata. The interface is in beta testing.

Liaison activities [Deliverable 6]

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 ranging from data accuracy, data acquisition and exchange, training activities, and data archival.

Foremost of these activities was participation by Mr. Smith at the International Marine Technicians Symposium (17-19 October 2006) at WHOI. The symposium provided an opportunity to introduce the activities of and plans for the SAMOS initiative to the international research vessel community. Throughout the week, Mr. Smith participated in dialogs with ship operators as part of the SAMOS vessel recruitment effort. Mr. Smith also visited one of the NOAA OMAO vessels in port at WHOI and received a demonstration of the NOAA OMAO SAMOS data applet in SCS 4.0. This meeting led directly to the recruitment of many of the NOAA vessels in 2007. The symposium was also the venue where the "A Guide to Making Climate Quality Meteorological and Flux Measurements at Sea" was first released to the technician and operator community. This guide was co-authored by Frank Bradley (CSIRO) and Chris Fairall (NOAA/ESRL) and was a collaborative effort between the WCRP Working Group on Surface Fluxes and the SAMOS initiative. Several scientists participating in SAMOS activities contributed to the guide.

Mr. Smith also was invited to participate at the Fourth Session of the WMO/IOC JCOMM Ship Observation Team meeting in Geneva, Switzerland (16-21 April 2007). The SOT is responsible for overall coordination of the Voluntary Observing Ship (VOS) program and the meeting brought together VOS participants from many countries. Participants included several countries that are working towards full automation of their standard VOS meteorological reports. Mr. Smith presented the activities of the SAMOS initiative and had productive discussions with the VOS automation community. They were keenly interested in the SAMOS approach to data quality evaluation and long-term access to observations for future climate research.

A dialog with Steve Rutz from NODC and Steve Worley at NCAR established guidelines for pushing SAMOS data to these data archive centers (subtask 2). Initial plans for the first submission to the archives in mid-2007 were pushed back by delays related to making the delayed-mode SAMOS processing operational. The SAMOS DAC started delayed mode processing on 1 September 2007 and we are working towards our first archival submission at the end of 2007.

Public access to observations and metadata [Deliverable 7]

A web presence for SAMOS is accessible at: <http://samos.coaps.fsu.edu/>. The pages provide information on the SAMOS initiative as a whole, provides links to relevant literature, and access to past SAMOS workshops. Through these pages, the DAC provides access to the preliminary quality controlled data for all 12 ships currently recruited to the SAMOS initiative. A metadata portal allows users to access ship- and parameter-specific metadata along with digital photos and schematics of participating vessels. Both the metadata portal and data access are user searchable. Criteria include searches by vessel and the observation dates. The web site also provides access to desired SAMOS parameters, accuracy requirements, and training materials.

The data distribution system is under constant development. New in the reporting period is the “Data Availability” link under “Data Access”. This new page provides the user with more options to select desired data than the older “Data Download” page. Through “Data Availability” users can select one or more ships and a time range to determine whether observations are available. The data are displayed graphically by day and each day is color-coded according to the overall quality of the days observations. The user can then select to download data of one or more ships and has the option of selecting only good quality or all available data. Drill down capacity allows the user to select a single day and ship from the graphic to display detailed data quality graphics (similar to Figure 3). A new metadata interface is being developed and will be launched in 2008. These new tools will be added to the web site for users when testing is complete.

Deliverables 5 and 6 (subtask 1) pushed forward to FY 2008

The rapid increase in ships participating in SAMOS, the need to shift our priorities to get our delayed-mode processing operational, and staffing turnover limited activity on these two deliverables.

Figures And Images

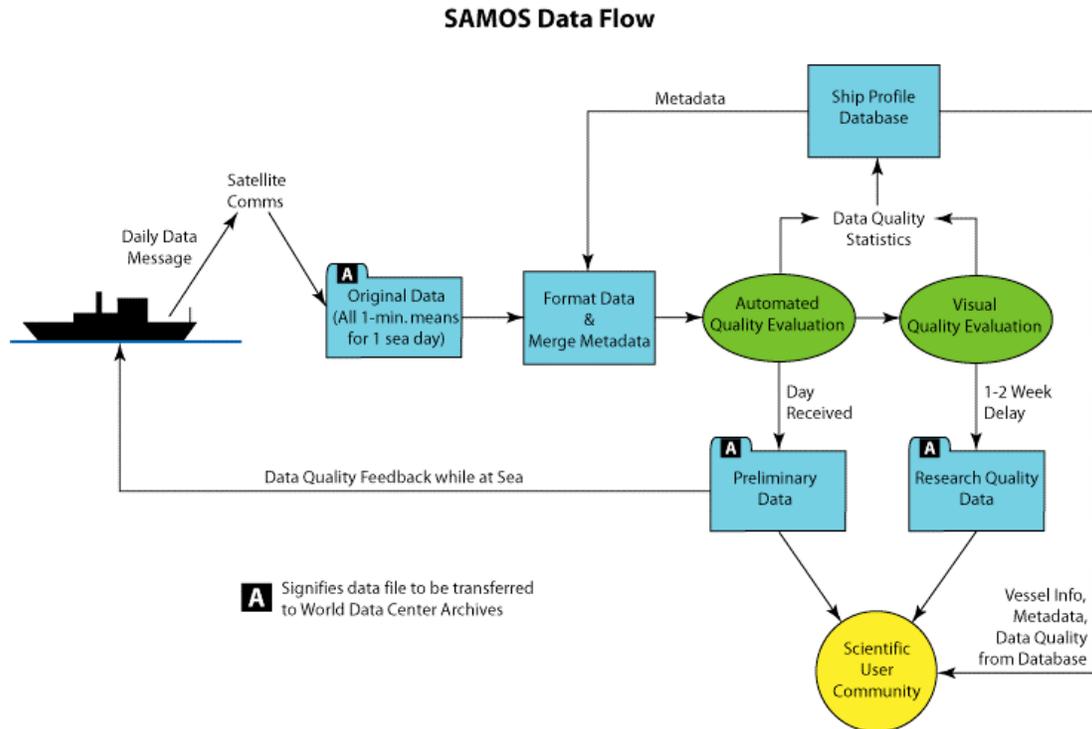


Figure 1. Operational data flow between research vessels at sea and the SAMOS DAC. Data transfers take advantage of 24/7 broadband satellite communications. Real-time data quality feedback to vessels at sea and their home institutions have proven successful to reduce the amount of poor quality data caused by sensor failures.

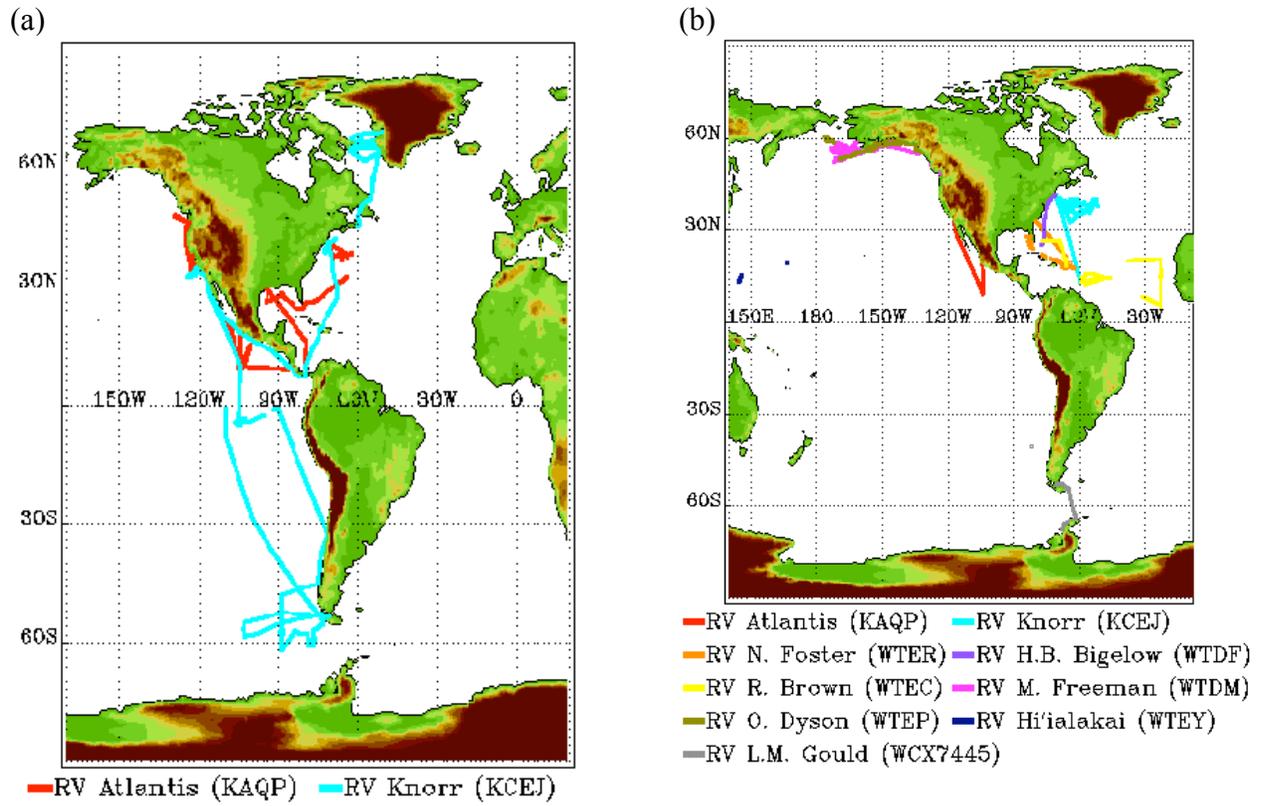
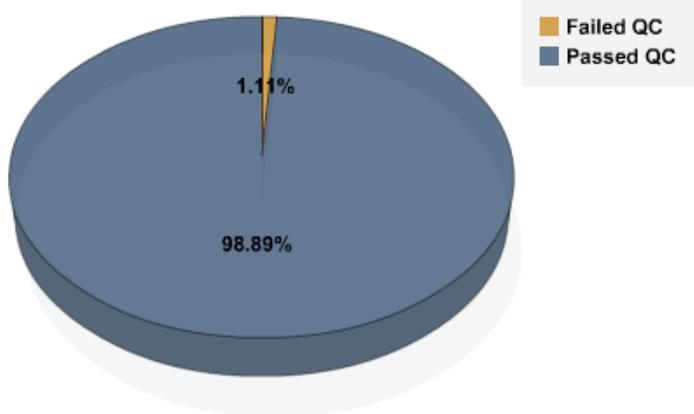
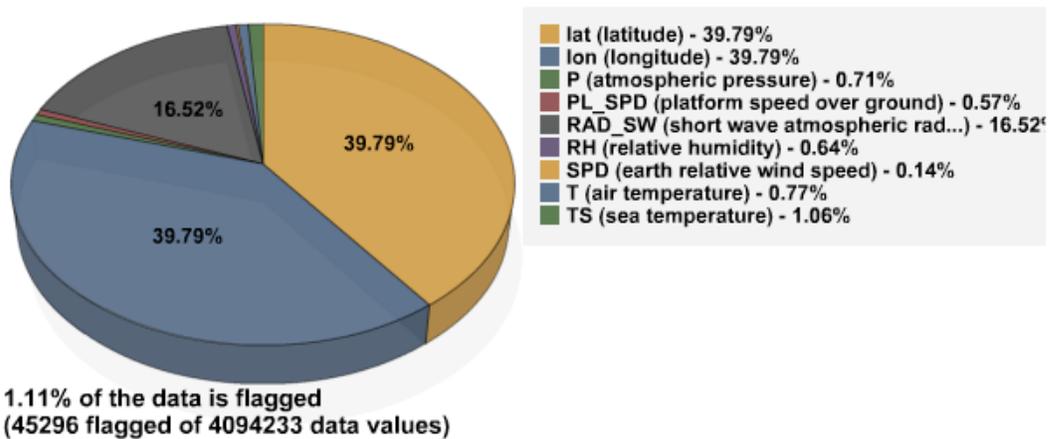


Figure 2: Cruise tracks comparing SAMOS data coverage for 2006 (January 1, 2006 – December 31, 2006) and the first half of 2007 (January 1, 2007 – May 21, 2007). An additional 3 vessels began reporting to SAMOS after May 2007 (not shown).

(a)



(b)



(c)

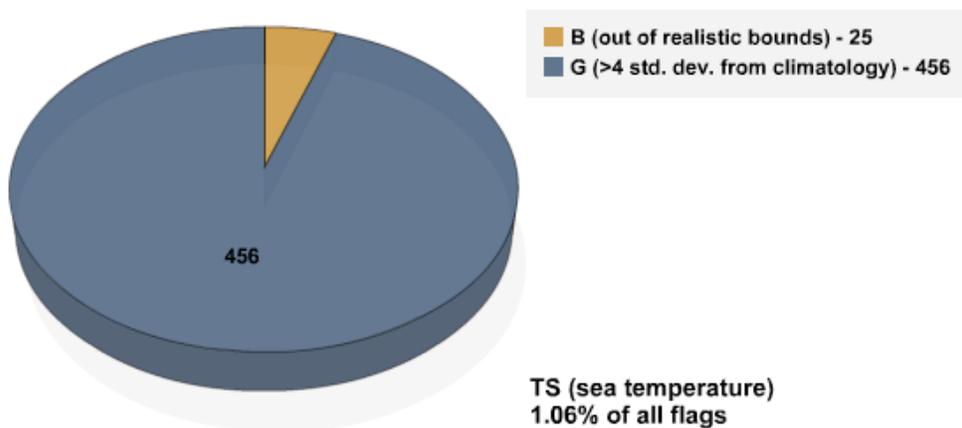


Figure 3: Data quality statistics for SAMOS observations received from the RV *Knorr* for the period 1 July 2006 – 30 June 2007. (a) Total percentage of data that passed or failed preliminary QC. (b) Breakdown by measured parameter of 1.11% of data that failed QC tests. (c) Flags applied to sea temperature (1.06% of the 45,296 values that failed QC tests).

Publications and Reports

Refereed

Smith, S. R., 2006: A Partnership between Shipboard Oceanic and Atmospheric Data Programs. *EOS, Trans Amer. Geophys. Union*, **87**, 463, 466.

Technical reports

Smith, S. R., 2007: Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative. Report for 4th session of the JCOMM Ship Observation Team meeting, 16-21 April 2007, Geneva, Switzerland, 2 pp.

Smith, S. R., R. Keeley, and T. Delcroix, 2006: Report of the 1st Joint GOSUD/SAMOS Workshop. UCAR Joint Office for Science Support, Boulder, CO, USA, 63 pp. [Available from COAPS, The Florida State University, Tallahassee, FL 32306-2840].

Conference proceedings/presentations

Bourassa, M. A., and S. R. Smith, 2007: Improving air-sea flux estimation with a new wave-dependant parameterization and high-quality research vessel observations. *ONR Progress Review – Southeast Region*, Tallahassee, FL, USA, 1-3 May 2007.

Smith, S. R., J. Rolph, and M. A. Bourassa, 2007: Progress of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative Data Assembly Center. *Climate Observation Division 5th Annual System Review*, NOAA, Silver Spring, MD, USA, 5-7 June 2007.

Smith, S. R., 2007: The SAMOS Initiative. 4th session of the JCOMM Ship Observation Team, Geneva, Switzerland, 16-21 April 2007, CDROM.

Josey, S. A. (presented by S. R. Smith), 2006: Evaluation of Air-Sea Fluxes. 2nd CLIVAR Global Synthesis and Observation Panel meeting, La Jolla, CA, USA, 8 and 9 December 2006.

Smith, S. R., 2006: The SAMOS data assembly center. *International Marine Technicians Symposium*, Woods Hole, MA, USA, 17-19 October 2006.

Smith, S. R., F. Bradley, and C. Fairall, 2006: A guide to making climate quality meteorological and flux measurements at sea. *International Marine Technicians Symposium*, Woods Hole, MA, USA, 17-19 October 2006.