Research Vessel Observations:
A Modern Data Record for Marine Climatology

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Introduction

Since 2005, the shipboard automated meteorological and oceanographic system (SAMOS) initiative has been collecting, evaluating, and preserving navigational, meteorological, and oceanographic observations from research vessels (RVs).

SAMOS' core mission supports marine climatology by

- creating quality estimates of the air-sea heat, moisture, momentum, and radiation fluxes;
- improving our understanding of the biases and uncertainties in meteorological parameters and fluxes;
- benchmarking new satellite and model products; and
- providing high-quality data to support modeling activities (e.g., reanalysis) and global climate programs.

The SAMOS data assembly center (DAC) focuses on U.S.-operated RVs.

- In 2009, a new partnership with the Rolling Deck to Repository (R2R) project in the U.S. provided an opportunity to recruit ~15 additional RVs to the initiative.
- Similar national efforts outside the U.S. may be leveraged to expand access to SAMOS data.

The DAC collaborates with the U.S. National Oceanographic Data Center (NODC) and ICOADS to ensure SAMOS data are preserved.

Recently, the operational weather and oceanographic community has requested SAMOS data be provided on the Global Telecommunications System.

What Is a SAMOS?

- It is a continuously recording, computerized data logger connected to navigational, meteorological, and near-surface ocean sensors.
- The desired interval between sequential observations is equal to or less than one minute.
- The SAMOS initiative does not specify or provide sensors used to collect data. Different systems currently exist on RVs (Fig. 1).
- SAMOS sensors differ (typically) from those provided by National Meteorological Services (for Voluntary Observing Ship Scheme).

Figure 1: Meteorological instrumentation on the (left) *Ronald Brown*, (top right) *Okeanos Explorer*, and (bottom right) *Knorr*. Photos credits: R. Wanninkhof, D. Wolfe, and B. Walden.

Data Acquisition

The SAMOS data assembly center (DAC) conducts routine quality evaluation for participating vessels and actively recruits new vessels.

Current Ships:

In 2010, 26 RVs routinely provided data to the DAC (Fig. 4).

Recruiting Efforts:

- Aquiring additional U.S. university operated vessels through partnership with the R2R
- Adding remaining NOAA vessels

Data Volume:

A typical vessel reports 20 parameters in each 1-minute report (navigation, meteorology, and thermosalinograph).

- In CY2010, over 6.1 million individual 1-minute data reports were collected by SAMOS vessels.

SAMOS Data Flow:

Protocol includes daily transmission of SAMOS data from a vessel at sea to the DAC (Fig. 2).

- File transmission occurs by e-mail attachments.
  - Files contain all 1-minute averages sampled during one day at sea.
  - Daily transfers occur just past 0000 UTC.
  - E-mail generation and transmission scripts are developed by each vessel operator.
- Data arriving at DAC undergo common formatting, metadata augmentation, and both automated and visual data quality evaluation.
- Visual inspection upon arrival allows at-sea notification (by e-mail) to quickly resolve problems.

Provision to Marine Climate Archives:

- ***US National Oceanographic Data Center***
  - All original, preliminary, intermediate, and research quality data are archived (Fig. 2).
  - Archive includes key metadata and documentation.
  - Protocol provides for monthly input to archive.
  - All files are cataloged and verified with MD5 checksums
- ***ICOADS***
  - One-minute SAMOS data will be reduced to hourly samples.
  - Code developed for WOCE submission to ICOADS v2.5 will be modified to allow automated submission as part of NODC protocol.
  - Planned submissions will be made in IMMA format.
  - Implementation is expected in summer 2011.

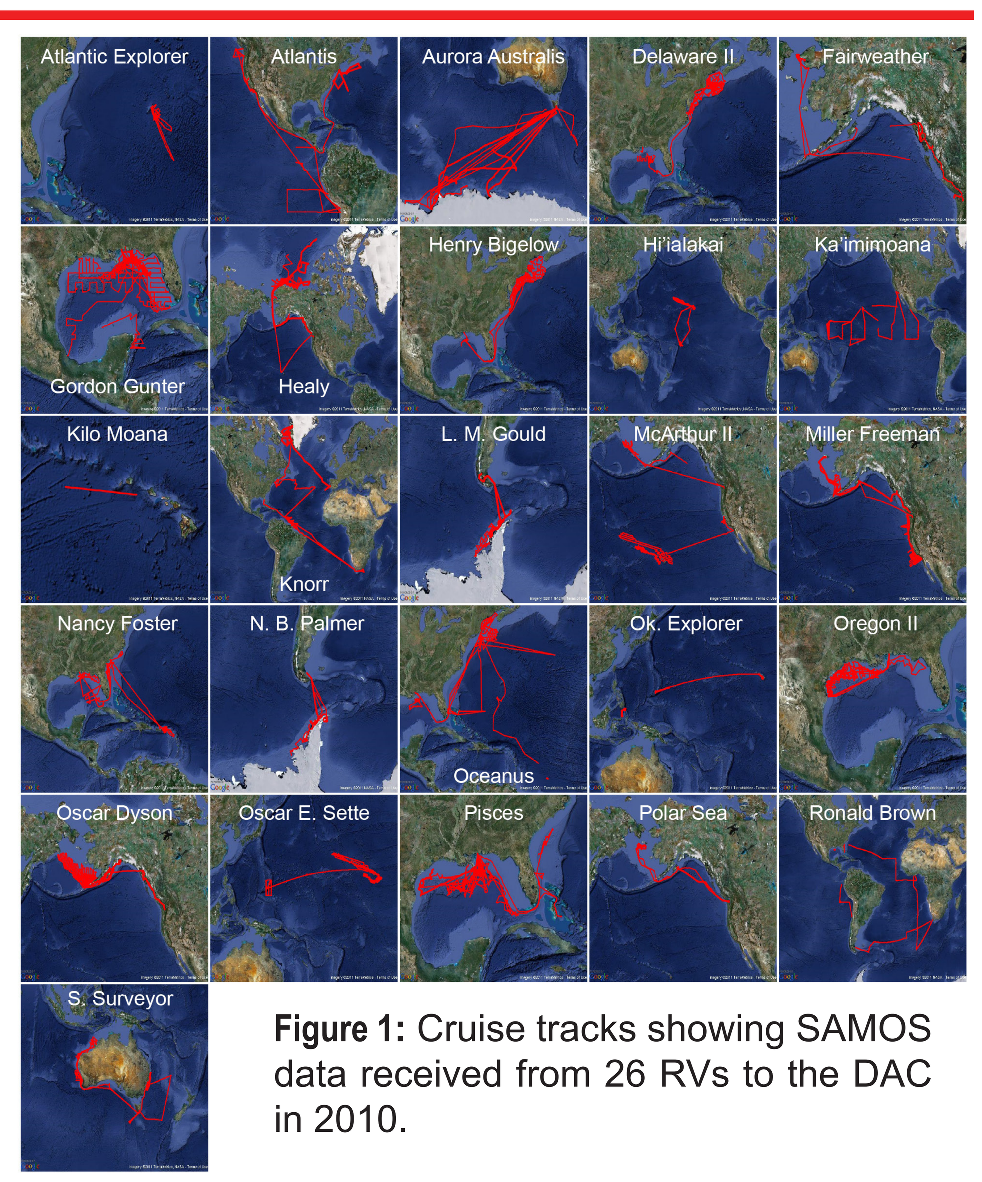

Figure 1: Cruise tracks showing SAMOS data received from 26 RVs to the DAC in 2010.

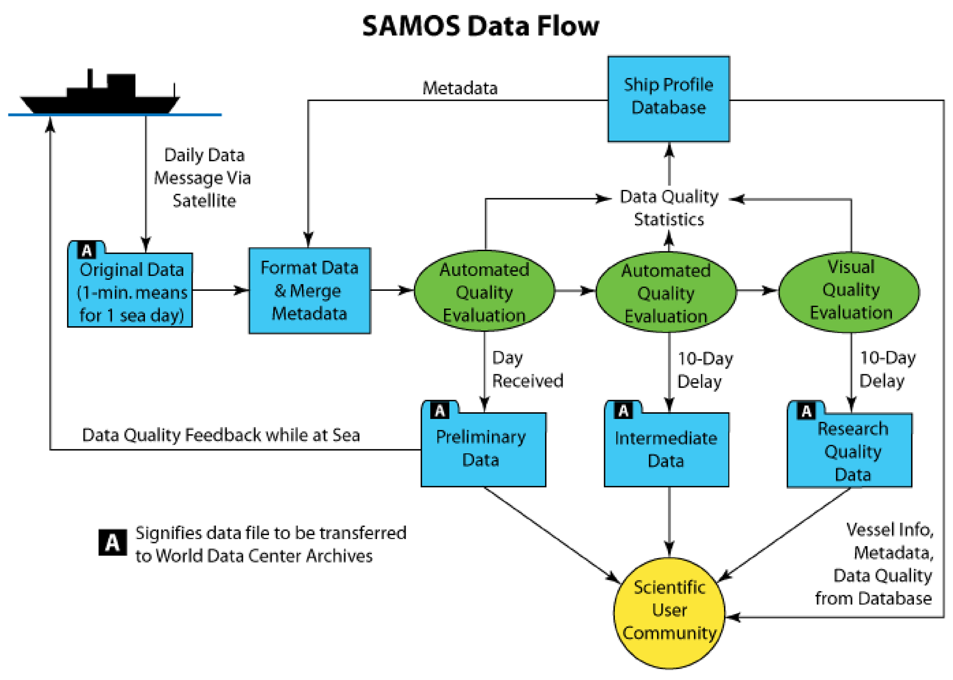

Figure 2: Ship-to-shore flow of SAMOS observations.

Data Distribution:

http://samos.coaps.fsu.edu/
http://coaps.fsu.edu/thredds.php
ftp://www.coaps.fsu.edu/samos_pub/data

Applications

SAMOS on RVs provide data to meet a wide range of user needs.

Air-Sea Interaction:

- High-frequency SAMOS sampling allows accurate estimation of bulk turbulent fluxes.
- SAMOS provide direct radiation fluxes (Fig. 5).
- Fluxes and parameters from which they are derived are used to evaluate gridded flux products (Fig. 4).
- Variability is assessed at different spatial and temporal scales to determine uncertainty in air-sea heat and freshwater fluxes (especially in poorly sampled Southern Ocean).

Satellite Studies:

- Data are available from a wide range of ocean conditions, frequently in remote oceans.
- SAMOS provide validation of observations from existing (e.g., scatterometers; Fig. 6) and future satellites (e.g., Aquarius, SMOS).
- SAMOS support development of retrieval algorithms (Fig. 3; See poster by Scott and Bourassa) and multi-product comparisons of satellite-based, air-sea flux estimates (Fig. 4).
- New users seek additional shortwave (Fig. 5), longwave, and photosynthetic radiation to benchmark satellite products.

Ocean Process Studies:

- Temperature and salinity data provide means to precisely locate surface oceanic fronts.
- RV data are successfully used to identify the barrier layer of the western tropical Pacific warm pool, the north wall of the Gulf Stream, and the Polar Front in the Drake Passage.

Product and Model Evaluation:

Lack of assimilation of SAMOS observations into operational models makes these data valuable for independent evaluation.

- Validating Numerical Weather Prediction (NWP) model output (Fig. 4)
- Verifying marine forecasts
- Developing metrics for ocean model performance

Understanding Errors:

- Developing temporal/spatial matching schemes (See poster by May et al.)
- Quantifying impact of air flow distortion (by vessel) on wind speed, flux, and air temperature measurements
- Determining bias in air temperature due to solar heating of ship

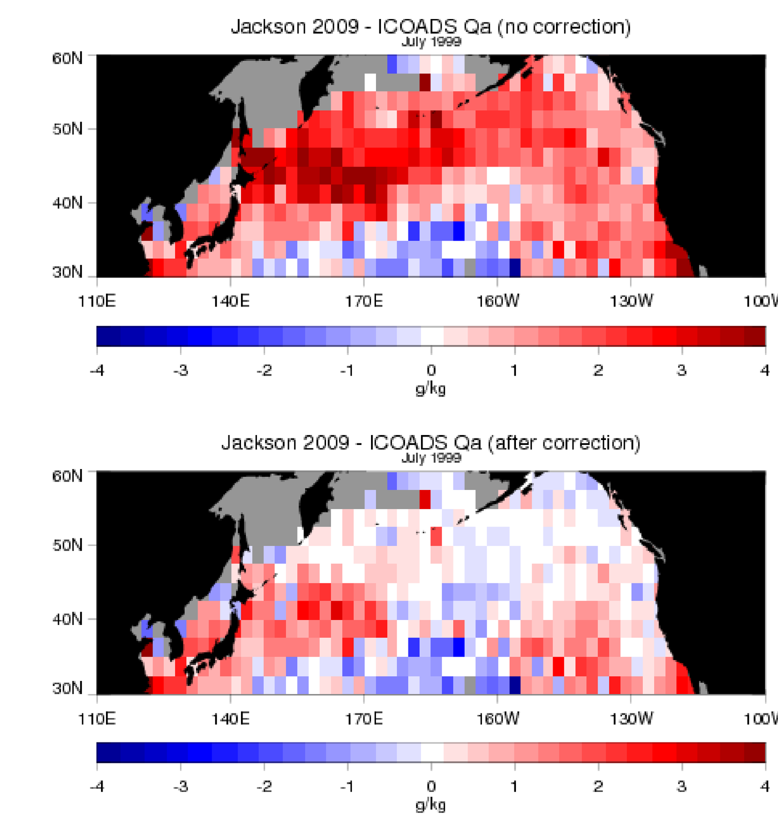

Fig. 3. The inclusion of underway data allows specific regional biases in satellite retrievals of near-surface humidity to be determined (a) and applied (b). (Courtesy D. Jackson)

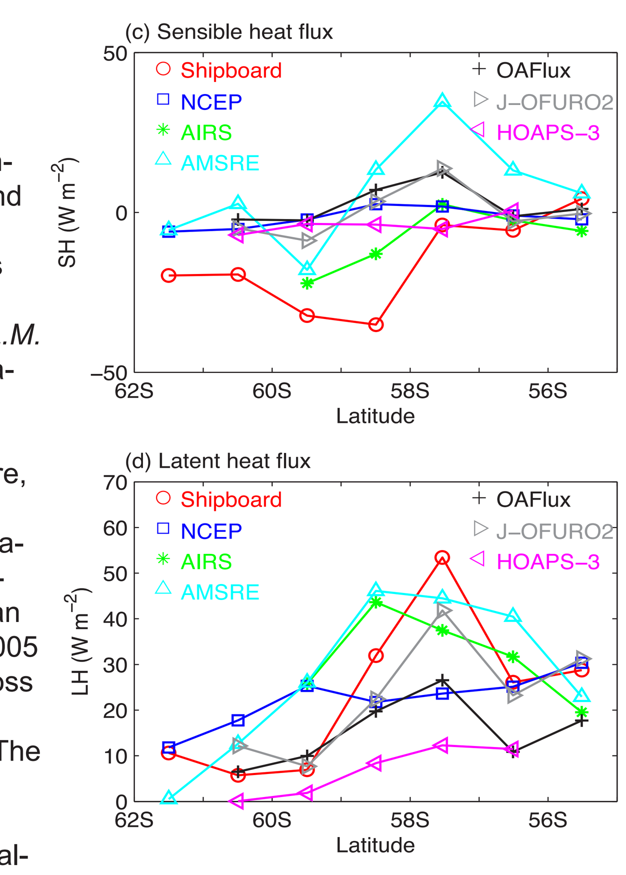

Fig. 4. Sensible (a) and latent (b) heat fluxes computed from R/V *L.M. Gould* measurements (red) of air temperature, SST and surface relative humidity during an October 2005 cruise across the Drake Passage. The shipboard fluxes are used to evaluate those computed from NCEP (blue), OAFlux (black), HOAPS3 (purple), J-OFURO (gray), AIRS satellite retrievals (green) of Ta, RH with SST, and AIRS Ta and RH with AMSRE microwave radiometer SST (cyan) measured from the Aqua satellite (courtesy J. Sprintall).

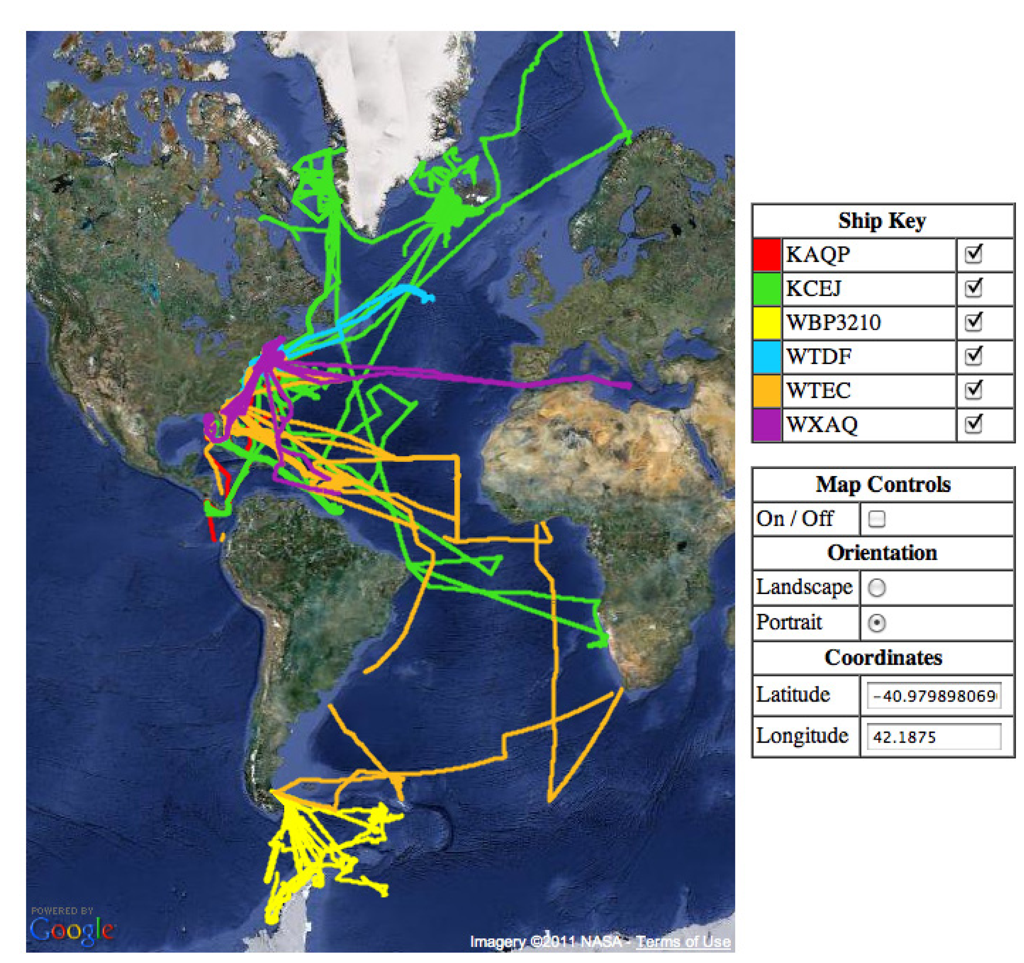

Figure 5: Coverage of shortwave (solar incoming) radiation provided to the SAMOS DAC from 2005-2010. The DAC continues to encourage the deployment of SW, LW, and PAR sensors.

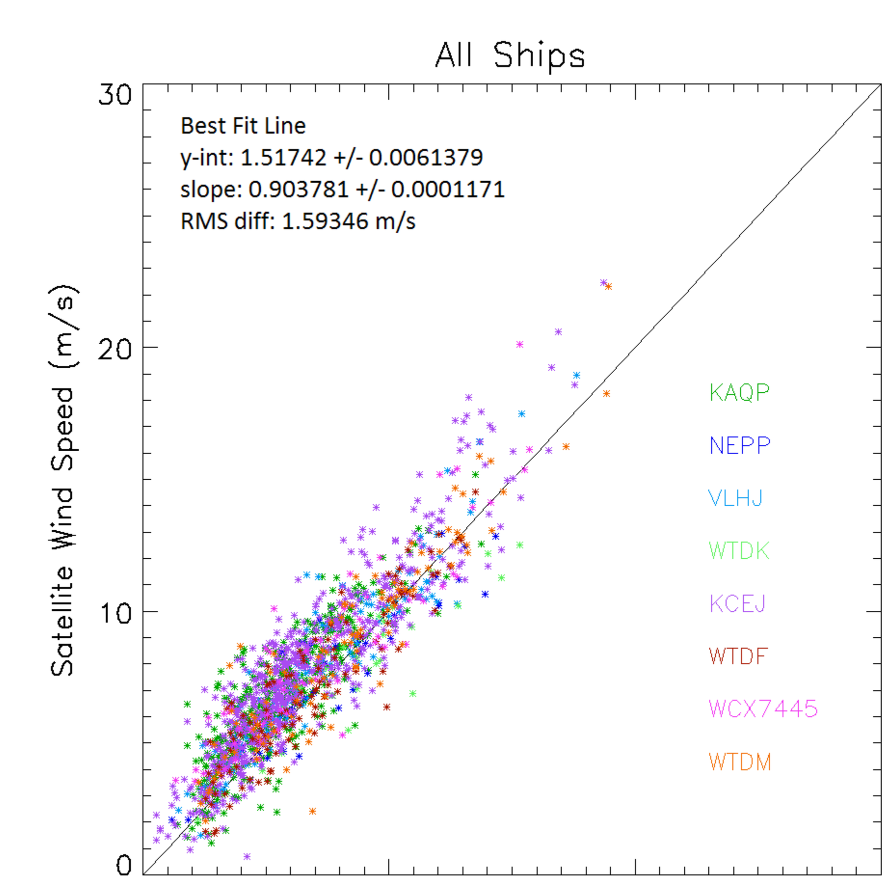

Figure 6: Collocated SeaWinds-measured wind speeds versus adjusted SAMOS 10-meter equivalent wind speeds. Each of these collocations have less than a 5 ms^{-1} wind speed difference and less than a 45° difference in wind direction.

Historical Data Rescue

A wealth of automated underway meteorological data exist for RVs.

- A preliminary catalog includes ~30 vessels from 6 countries.
- All data are at least hourly; many are 1-minute or higher frequency.
- Some records may already exist in climate archives.
- Additional RV data are known to exist.

Vessel(s)	Source	Start year	End year
Maurice Ewing	LDEO, Columbia University	1999	2005
Marcus Langseth	LDEO, Columbia University	2008	2009
Revelle, Melville	Scripps Institution of Oceanography	~1997	Present
Southern Surveyor	CSIRO	1990	Present
Franklin	CSIRO	1985	2002
Aurora Australis	Australian Antarctic Data Centre	1987	Present
L'Astrolabe	Australian Antarctic Data Centre		
Natsushima	JAMSTEC	1987	2010
Kaiyo	JAMSTEC	1991	2010
Yokosuka	JAMSTEC	2001	2010
Marai	JAMSTEC	1998	2010
Kairei	JAMSTEC	2001	2010
Ryofu-Maru Keifu-Maru Kofu-Maru Seifu Maru Chofu Maru	Japan Meteorological Agency	1997	2010
CCGS Shammok CCGS Wilfred Templeman CCGS Alfred Needler CCGS Teleost CCGS Pareizeau CCGS Hudosn CSS Dawson MV Gadus Atlantica	Northwest Atlantic Fisheries Centre, Canada	1985	Present
RRS Discovery RRS James Cook RRS Charles Darwin (retired) RV Prince Madog RRS James Clark Ross	British Oceanographic Data Center	~2006	Present

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