

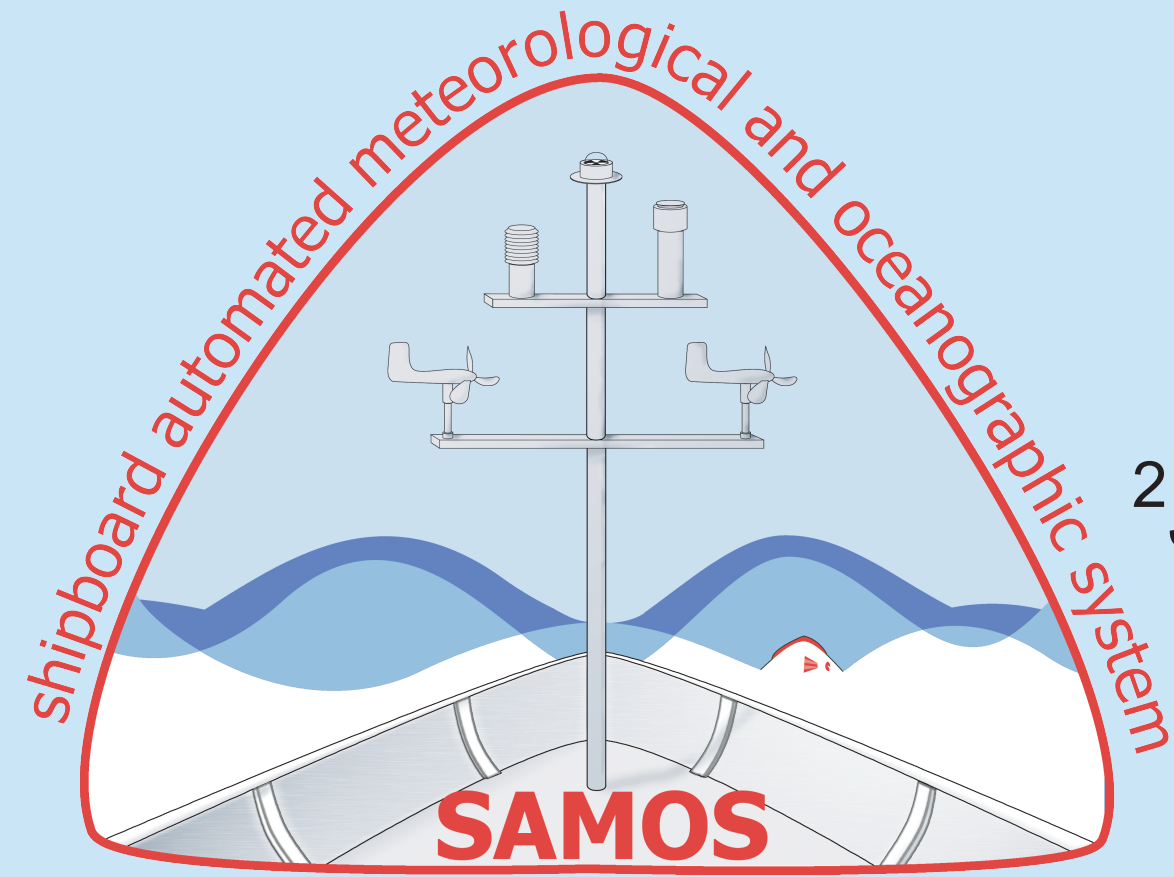
Shipboard Automated Meteorological and Oceanographic System Initiative

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Objectives

The shipboard automated meteorological and oceanographic system (SAMOS) initiative aims to improve the quality of meteorological and near-surface oceanographic observations collected in-situ on research vessels (R/Vs) and select volunteer observing ships (VOS). Scientific objectives of SAMOS include:

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

To achieve the science objective, the SAMOS initiative seeks to:

- ◆ improve access to quality assured SAMOS data for scientific and operational users by providing free and open access to data and metadata
- ◆ expand availability of SAMOS observations collected in remote ocean regions (e.g., Southern Ocean)
- ◆ improve the accuracy and calibration of SAMOS measurements
- ◆ provide standards for data and metadata collected on SAMOS equipped vessels
- ◆ ensure routine archival of SAMOS data at world data centers
- ◆ develop documentation and training materials for use by data collectors and the user community
- ◆ support comparison studies between in-situ platforms (e.g., R/Vs, VOS, buoys)
- ◆ develop partnerships within the international marine community

What is a SAMOS?

SAMOS have been deployed on research vessels (Fig. 1a) for several decades and are now being deployed on VOS (Fig. 1b). The typical SAMOS is a continuously recording, computerized data logger connected to sensors that record navigation, meteorological, and near-surface ocean parameters while the vessel is at sea. To achieve the science objectives of the SAMOS initiative, the desired interval between sequential observations is one minute. Parameters of interest are listed in Table 1.

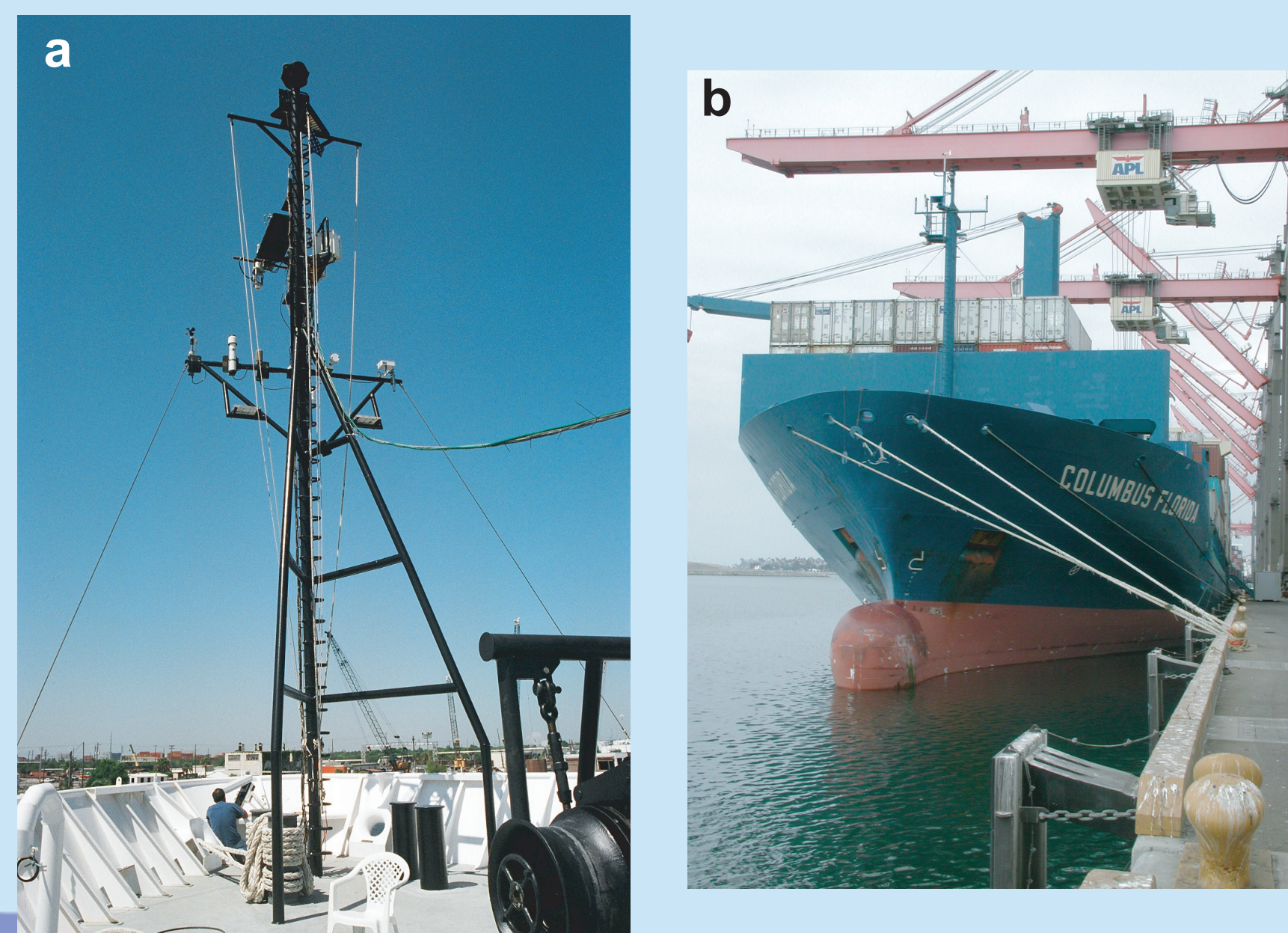


Figure 1: Bow masts with meteorological instrumentation on (a) R/V Ronald H. Brown and (b) VOS Columbus Florida. Photo credits: (a) Rik Wanninkhof, (b) David Hosom.

Data Stewardship

Data stewardship activities are essential to improve access to and integrity of high-quality SAMOS measurements. Through a newly formed data assembly center (DAC) on the campus of the Florida State University (FSU), the SAMOS initiative is focusing on

- ◆ setting standards for parameters to be routinely observed (Table 1), essential metadata, and uniform averaging methods
- ◆ establishing a protocol for data transport (ship-to-DAC-to-users)
- ◆ providing scientific data quality evaluation
- ◆ distributing SAMOS data from participating vessels in a free and open manner
- ◆ preserving the integrity of the SAMOS observations through archival at world data centers

Overall, SAMOS data stewardship activities are consistent with the GCOS climate monitoring principles. [Available at www.wmo.ch/web/gcos/Second_Adequacy_Report.pdf]

Primary data	Secondary data (desired if available)
• Observation time (UTC)	• Ship speed over water ³
• Latitude	• Vessel pitch, roll, and heave
• Longitude	• Photosynthetically Active Radiation (PAR)
• Ship course over ground	• Ultraviolet radiation
• Ship speed over ground	• Total Radiation
• Ship heading	• Visibility ⁴
• Ship-relative wind direction ¹	• Ceiling ⁴
• Ship-relative wind speed ¹	• Salinity
• Earth-relative (true) wind direction	• Conductivity
• Earth-relative (true) wind speed	• Radiometric Sea Surface Temperature
• Atmospheric pressure	• Swell & wind wave heights and directions ⁴
• Air temperature	• Weather, cloud cover, and cloud height ⁴
• Atmospheric moisture ²	
• Precipitation	
• Shortwave radiation	
• Longwave radiation	
• Sea temperature	

¹As measured by anemometer
²One or more measurements of wet-bulb temperature, dewpoint temperature, relative humidity, and/or specific humidity
³Fore-aft and along beam components
⁴If available from automated sensors

2005 Pilot Project

- ◆ A partnership between the Scripps Institution of Oceanography (SIO), Woods Hole Oceanographic Institution (WHOI), and FSU
- ◆ Developing data protocol for daily transmission of SAMOS observations from a vessel at sea to the DAC (Fig. 2).
 - File transmission via email attachments
 - Files contain all 1-min. averages sampled during one day at sea
 - Using SAMOS version 1 data exchange format
 - Daily transmission to occur just past 0000 UTC
- ◆ Initial vessels: R/V *Melville* and R/V *Oceanus*
- ◆ SIO, WHOI developing shipboard transmission scripts
- ◆ DAC developing near-real time data ingestion and scientific data quality evaluation (DQE)

Data Quality Evaluation

Based on FSU experience with delayed mode R/V meteorology data from World Ocean Circulation Experiment

- ◆ Daily data from ships automatically combined with metadata from database
- ◆ Files pass through two automated quality evaluation programs
- ◆ The subsequent files will be distributed to users as preliminary data (available within 1 day of receipt at DAC)
- ◆ Visual DQE will follow to produce research quality data (allowing ample time to receive delayed data)

Metadata

Metadata are essential to the scientific application of SAMOS data. The SAMOS DAC has developed a ship profile metadata database for all participating vessels. The database will be queried throughout the DQE. Plans also call for on-line user access to metadata database.

- ◆ A prototype SAMOS metadata specification is complete and will be used for the pilot project
- ◆ Standard will include:
 - vessel contacts, identification, dimensions, images and plans
 - instrument positions, make, model, calibration dates, exposure photos
 - Data precision, sampling rate, averaging methods
 - File history, version tracking, data quality statistics
- ◆ Still to be resolved is how to complete routine updates of vessel metadata (under consideration by pilot project)

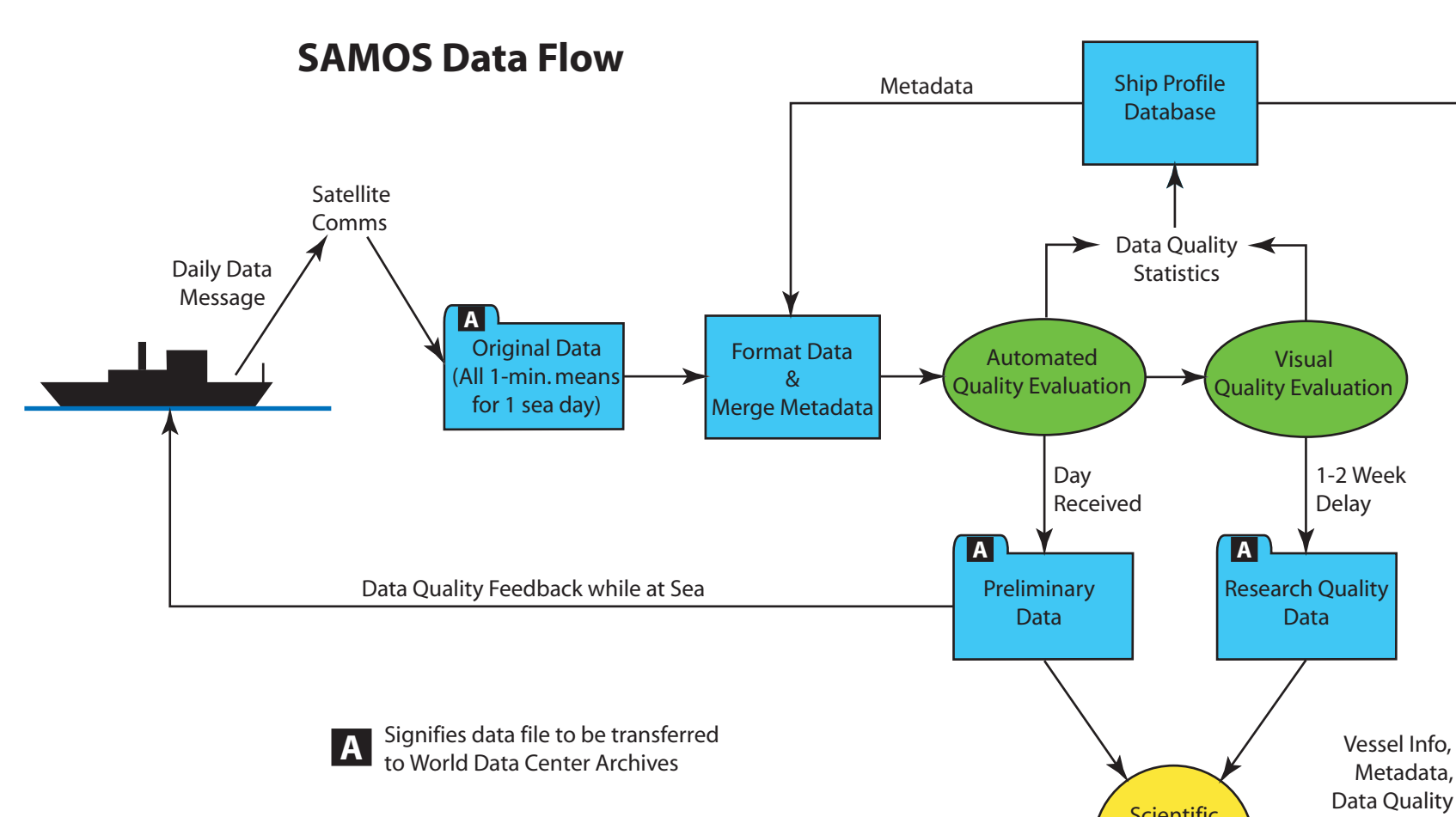
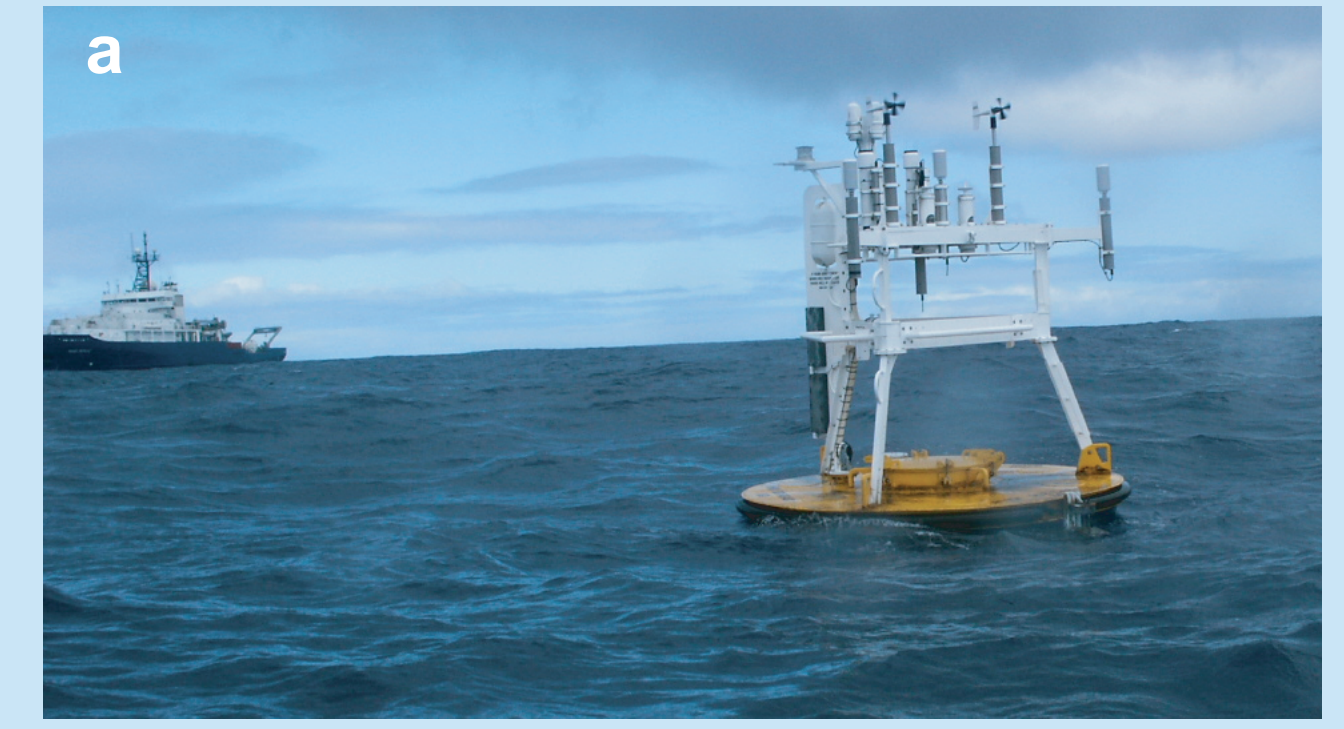


Figure 2: Schematic showing SAMOS data flow as planned for the 2005 pilot project.

Improving Data Accuracy

The SAMOS initiative seeks to improve the accuracy of marine meteorological and near-surface ocean parameters by

- ◆ working with the scientific community to establish data accuracy standards for the parameters listed in Table 1
- ◆ developing a roving standard instrument system for shipboard evaluation of R/V SAMOS installations
- ◆ conducting air flow modeling of vessels
- ◆ providing guidelines for sensor calibration and deployment
- ◆ promoting routine comparison studies between SAMOS equipped ships, buoys, and flux reference stations (Fig. 3a)



Roving Flux Standard and Shipboard SAMOS Evaluation

NOAA's Environmental Technology Laboratory (ETL) and WHOI have been collaborating on a project to evaluate and improve SAMOS observations from R/Vs in the U.S. fleet. Funding was sought from NOAA (ETL) and NSF (WHOI) to build a roving standard and deploy it on cruises of opportunity on NOAA, NSF, and U.S. Coast Guard R/V's. To date, only startup funds for ETL's contribution have been received.

- ◆ Additional funds for ETL to construct a new roving standard have been requested, but not yet approved.
- ◆ ETL made two cruises (2003:R/V *Roger Revelle* [SIO]; 2004:R/V *Ronald H. Brown* [NOAA]) associated with WHOI deployments to the Stratocumulus flux reference buoy (20°S, 85°W). The existing ETL flux system (high quality data but not intended as a standard) was used (Fig. 3b).
- ◆ The 2003 *Revelle* cruise was a test case for the concept and a number of instrument issues were found. Due to short notice for the exercise and shipping delays in freshly calibrated ship sensors, the principal lesson learned was that planning needs to start months in advance for meaningful onboard comparisons.
- ◆ In 2004, comparison on the *Ronald H. Brown* looked very good, except for anemometer placement.



Figure 3: (a) R/V *Roger Revelle* and WHOI flux reference buoy. (b) ETL direct flux sensors. Photo credit: Chris Fairall.

In an example of multi-platform comparison, ETL and PMEL are comparing measurements from the ETL flux shipboard system and the TAO buoys on the 95° and 110°W lines (based on 9 cruises between 1999 and 2003).

Training Activities

Discussions at the first two SAMOS (formerly High Resolution Marine Meteorology) workshops revealed a need for additional training materials that would target marine technicians and users of SAMOS observations. Technicians noted that they rarely received adequate training on marine meteorological observation methods and they welcomed access to better training materials. The technicians also felt that receiving additional scientific rationale for marine meteorological observations would encourage the technicians to spend more of their busy shipboard schedule on SAMOS data acquisition. To address these issues, the SAMOS initiative is

- ◆ developing a handbook focusing on the best procedures and practices for marine meteorological measurements. Plans include
 - a dynamic, on-line handbook that is easily expanded and updated
 - drill down capacity will keep the top level simple, allowing users to search for more technical details, as desired.
 - a wide range of topics: sensor exposure, calibration, and accuracy; metadata standards; measurement error; algorithms (true wind calculation, moisture conversions, bulk flux methods); sensor comparison methods; flow and heat distortion
 - technical contacts/experts for both data observers and users
 - free and open access to all handbook information
 - ◆ considering hosting training workshops or summer schools for marine technicians
 - ◆ encouraging funding agencies to support human capital development through training and education.
- Training activities are being spearheaded by NOAA ETL, the SAMOS DAC, and members of the WCRP Working Group on Surface Fluxes (WGSF).

International Participation

The SAMOS initiative currently is focused on U.S. research vessels; however, expansion to include international vessels is desirable.

- ◆ Necessary to achieve SAMOS science goals and develop a sustained global network of high-quality SAMOS observations.
- ◆ A future focus on the polar oceans is one goal of SAMOS, and the International Polar Year provides an opportunity to include high latitude vessels from many countries.
- ◆ Securing funding for international vessel involvement is primary limitation.
- ◆ International vessel operators, scientists, and data users interested in the SAMOS initiative should contact: smith@coaps.fsu.edu



Figure 4: U.S. Coast Guard Icebreaker. Photo courtesy of Philip McGillivray.

Partnerships

Partnerships are essential to the success of the SAMOS initiative. The initiative thanks those who have already contributed and continues to seek new expertise and resources.

- ◆ **User Community:** Provides scientific input to establish sampling methods and accuracy targets. SAMOS will continue to engage a wide user community to develop products for both research and operations.
- ◆ **UNOLS:** Several vessel operators participating in the pilot project. Additional members have provided critical feedback on data exchange methods, metadata standards, etc.
- ◆ **VOSclim Program:** Participants continue to provide expertise to create the SAMOS metadata specification.
- ◆ **GOSUD:** Opened dialog in 2004. GOSUD provided input on data and metadata standards. Discussions focus on potential data exchange where the SAMOS DAC will provide quality evaluation of meteorological data collected by GOSUD and the GOSUD data center will evaluate the near-surface ocean data collected by SAMOS.
- ◆ **WCRP WGSF:** Interested in SAMOS goal to improve marine meteorological observations. SAMOS initiative will provide critical data for benchmarking air-sea flux products. WGSF contributing to marine handbook.
- ◆ **Others:** Constructive feedback has been provided by members of JCOMM, SOT, and the international research vessel community. The SAMOS initiative welcomes ongoing collaboration with the NOAA Office of Climate Observation (OCO) and the U.S. National Science Foundation (NSF).

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