Underway Data Management via the SAMOS Initiative

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SAMOS
Shipboard Automated Meteorological and Oceanographic System

http://samos.coaps.fsu.edu

A Greek Man and Island

- Philosopher and Mathematician
  - Pythagoras of SAMOS➔

- Vacation spot in Greece⬇

Photo Credit: delboy85.tripod.com/ greeceandherislands/id9.html

Photo Credit: http://en.wikipedia.org/wiki/Pythagoras

A Data Stewardship Initiative

- **Focus**: To improve the quality of meteorological and near-surface oceanographic observations collected in-situ on research vessels (R/Vs)

- **Science Goals**:
  - 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, process studies, and global climate programs

An Instrument System

- Automated data logging system
  - Sampling interval of 1 minute or less
  - Continuous recording
  - Typically mounted on bow or on mast over wheel house

Courtesy: B. Walden, WHOI

- Typical observations:
  - **Navigation:** position, heading, course and speed over ground
  - **Meteorology:** true wind vector, air temperature, moisture, pressure
  - **Oceanography:** sea temperature, salinity, conductivity, fluorescence

- Additional capability:
  - Pitch, roll, heave, ship-relative winds, precipitation, multiple radiation components, visibility, ceiling height, swell and waves
  - Some direct flux measurements

History of the SAMOS Initiative

- Developed as an outcome of the World Ocean Circulation Experiment
  - COAPS hosted the WOCE meteorological data center
- Project conceived during workshop on high-resolution marine meteorology in 2003.
- SAMOS data center first funded by NOAA in 2004
- RVs *Knorr* and *Atlantis* first recruited vessels in 2005
- In 2009, became an active partner in the U.S. Rolling Deck to Repository (R2R) program.
- RV *Falkor* recruited in 2013 as first externally contracted vessel.

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SAMOS Overview

- **32 recruited vessels in 2014**
  - NOAA (17)
  - US Coast Guard (1)
  - NSF Polar Program (2)
  - Woods Hole Oceanographic Institution (2)
  - Bermuda Institute of Ocean Science (1)
  - Scripps Institution of Oceanography (4)
  - University of Hawaii (1)
  - University of Washington (1)
  - Schmidt Ocean Institute (1)
  - Australian Antarctic Division (1)
  - NIWA - New Zealand (1)
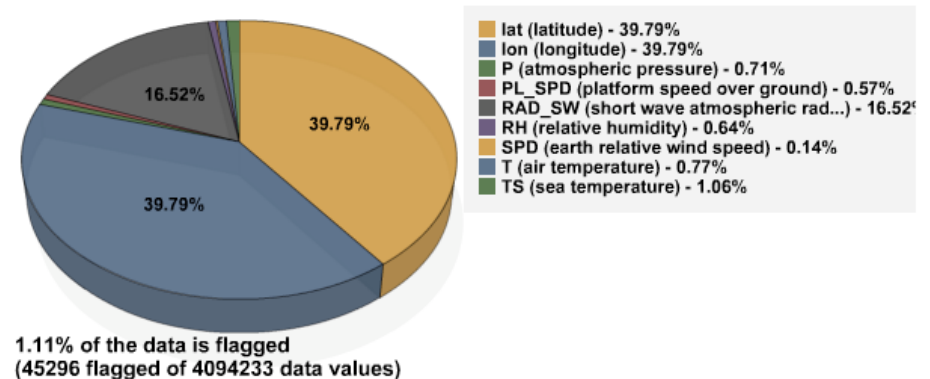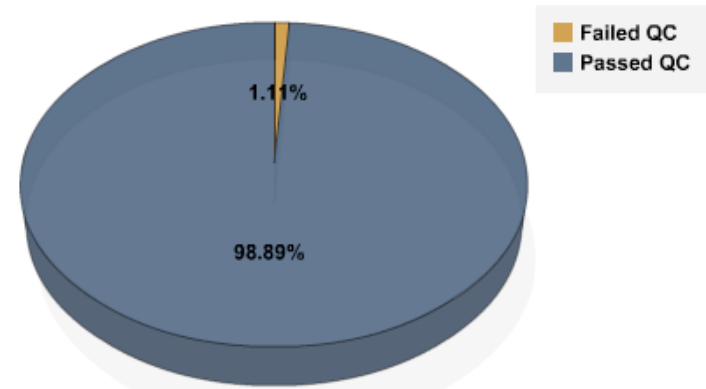
Cruise maps for each vessel in 2013
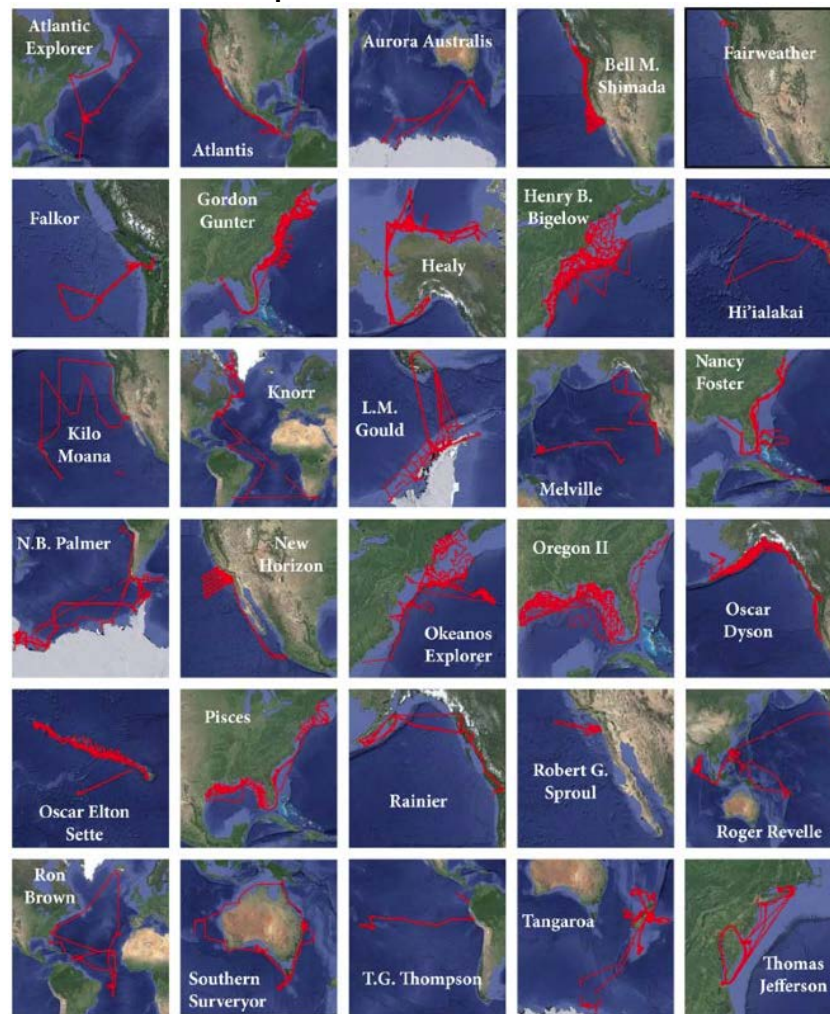
Flow of SAMOS Observations

- Ship to Shore
  - Data transmitted as once daily email attachment via 24/7 broadband satellite communication.
  - One-minute sampling interval
  - Data for previous day sent near as possible to 0000 UTC.
  - All vessels using key:value pair CSV SAMOS 1.0 format
- Detailed metadata is collected for all vessels.

SAMOS Data Flow

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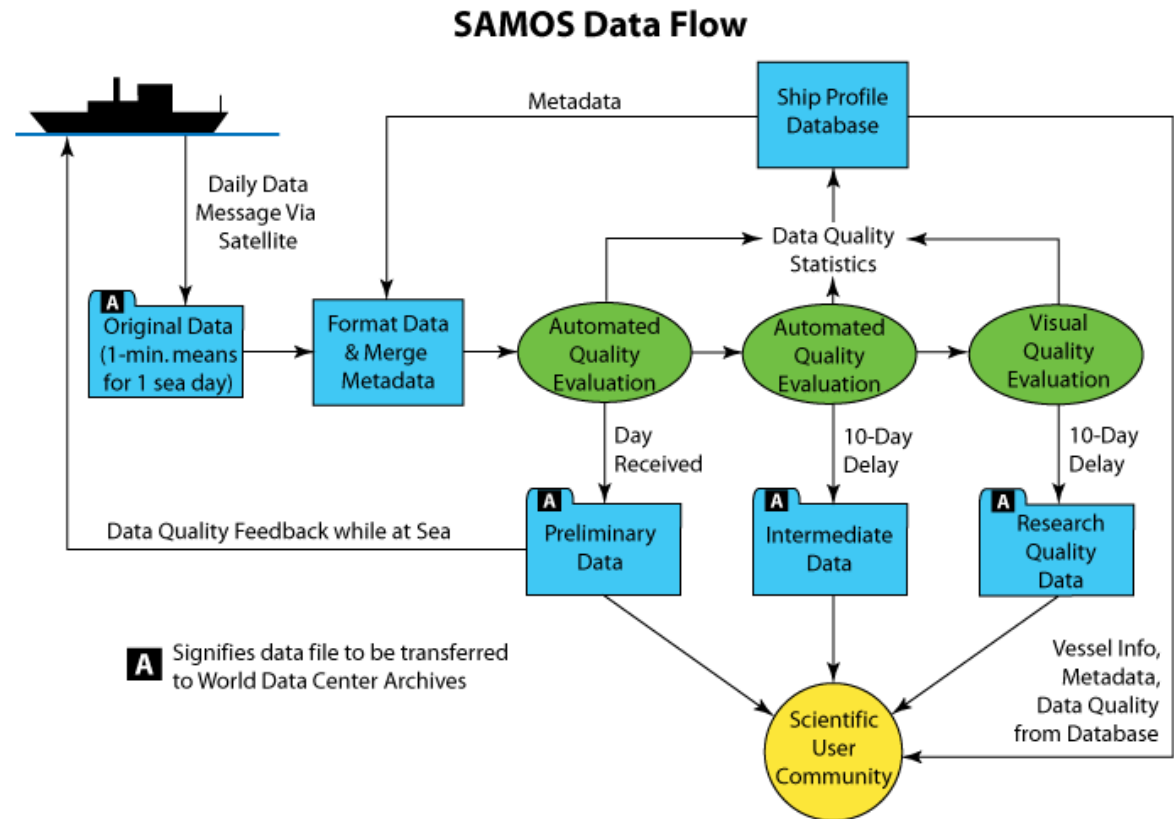
SAMOS Data Processing (1)

- Automated processing
  - Combines metadata with data received from vessel
  - Conducts preliminary quality evaluation
- Analyst visually monitors data from each vessel (not 24/7)
  - Vessel operators notified when problems are discovered
- Intermediate processing combines all observations for a single calendar day
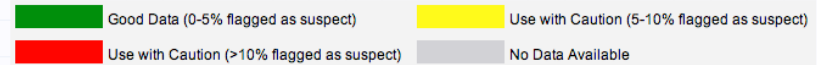- Research quality products developed with additional visual quality evaluation

Failed QC
Passed QC

1.11%

98.89%

lat (latitude) - 39.79%
lon (longitude) - 39.79%
P (atmospheric pressure) - 0.71%
PL_SPD (platform speed over ground) - 0.57%
RAD_SW (short wave atmospheric rad...) - 16.52%
RH (relative humidity) - 0.64%
SPD (earth relative wind speed) - 0.14%
T (air temperature) - 0.77%
TS (sea temperature) - 1.06%

16.52%   39.79%

39.79%

1.11% of the data is flagged
(45296 flagged of 4094233 data values)

SAMOS Data Processing (2)

- Data distribution
  - http://samos.coaps.fsu.edu/
  - Also available via FTP and THREDDS services
  - Direct access to metadata for all participating vessels
  - Graphical tools allow users to search for available data and quality information

- Archival occurs at US NODC
  - Monthly transfers to archive
  - Hourly subset in preparation for release 3.0 of International Comprehensive Ocean-Atmosphere Data Set

http://samos.coaps.fsu.edu

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Benefits for Vessel Operators

- Routine data quality evaluation by experienced marine meteorologists
    - At sea notification of data problems
    - Near real-time distribution of science observations
    - Long-term archival of data
- Metadata tracking (and inclusion into all data files)
- Educational opportunities for technicians
- Data quality subscription service
- Decision support for vessels wishing to improve their sensor suites and/or instrument exposure

Sensor Exposure Recommendations

Monthly Data Quality Reports
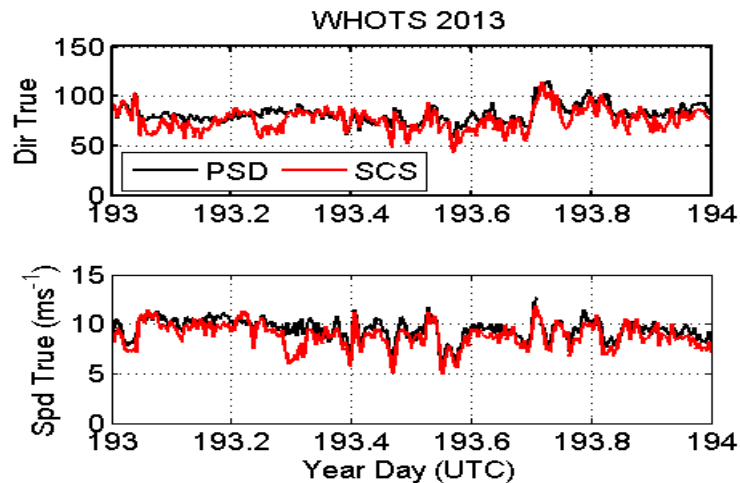
Quality Control Summary For KAQP 10/2010

Variable	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	10/10	10/11	10/12	10/13	10/14	10/15	10/16
Air Temperature	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Air Temperature 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Air Temperature 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Atmospheric Pressure	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟥	🟢	🟢
Atmospheric Pressure 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atmospheric Pressure 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	🟥	🟥	🟢	🟥	🟥	🟥	🟥	🟥	🟥	🟢	🟢	🟢	🟢	🟢	🔺	🟥
Earth Relative Wind Direction	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🔺	🔺	🟢	🟢	🟥	🟢	🟢
Earth Relative Wind Direction 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Earth Relative Wind Direction 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🔺	🟢	🟢
Earth Relative Wind Speed	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟥	🟢	🟢
Earth Relative Wind Speed 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🔺	🟢	🟢
Earth Relative Wind Speed 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Latitude	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Longitude	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Course	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Heading	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Relative Wind Direction	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platform Relative Wind Direction 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Relative Wind Direction 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Relative Wind Speed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platform Relative Wind Speed 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Relative Wind Speed 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Platform Speed Over Ground	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Precipitation Accumulation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precipitation Accumulation 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Precipitation Accumulation 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟥	🟥
Rain Rate	🔺	🟢	🔺	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔺	🔺
Rain Rate 2	🔺	🟢	🟢	🟢	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔺
Rain Rate 3	🔺	🟢	🔺	🔺	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔺	🔺
Relative Humidity	🟢	🟢	🟥	🟥	🟢	🟥	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Relative Humidity 2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Relative Humidity 3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Salinity	🟥	🟥	🟢	🟥	🟥	🟥	🟥	🟥	🟥	🟢	🟢	🟢	🟢	🟢	🔺	🟥
Sea Temperature	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔺	🟢
Short Wave Atmospheric Radiation	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Time	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢

🟢 = 0-5% flagged | 🔺 = 5-10% flagged | 🟥 = >10% flagged

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Improving Data Accuracy

- NOAA ESRL/PSD (C. Fairall lead) developed a portable seagoing air-sea flux standard (PSAFS)

  - PSAFS measures direct fluxes, mean meteorology, radiation and precipitation
 - PSAFS is deployed on R/Vs to evaluate vessel's SAMOS measurements

WHOTS 2013

Ship (SCS) and PSAFS (PSD) True Wind comparison

SST (seasnake)

ESRL radiometers
ESRL dynamic pressure port and sensor
Ship dynamic pressure port

Educational Initiatives

- "Guide to making climate quality meteorological and flux measurements at sea".
    - F. Bradley (CSIRO), C. Fairall (NOAA) lead authors
    - **Purpose**:To provide practical guidance to persons responsible for installing and maintaining meteorological instrumentation on ships
    - http://samos.coaps.fsu.edu/html/docs/NOAA-TM_OAR_PSD-311.pdf

- Created a professional development short course on marine meteorology for sea-going technicians
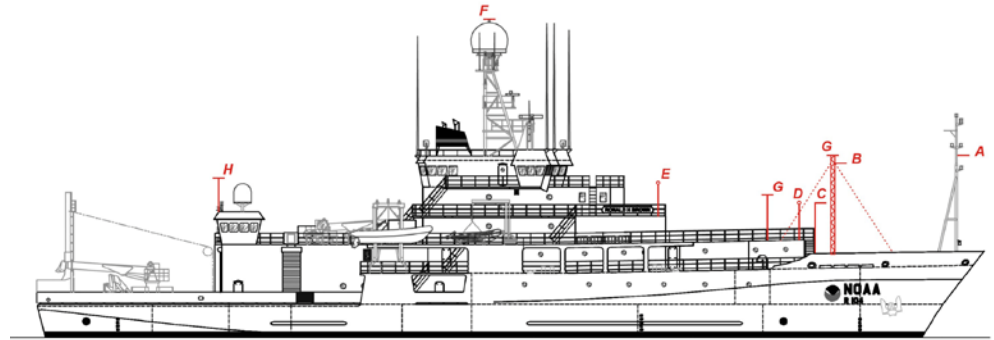
- Three sessions will be presented at INMARTECH
    - Sensor location and exposure
    - Adjusting observations for ship motion and sensor height
    - Quality assurance and control

- Also visit our demonstration table for insight into recommended sensors and to "ask a meteorologist" burning questions.
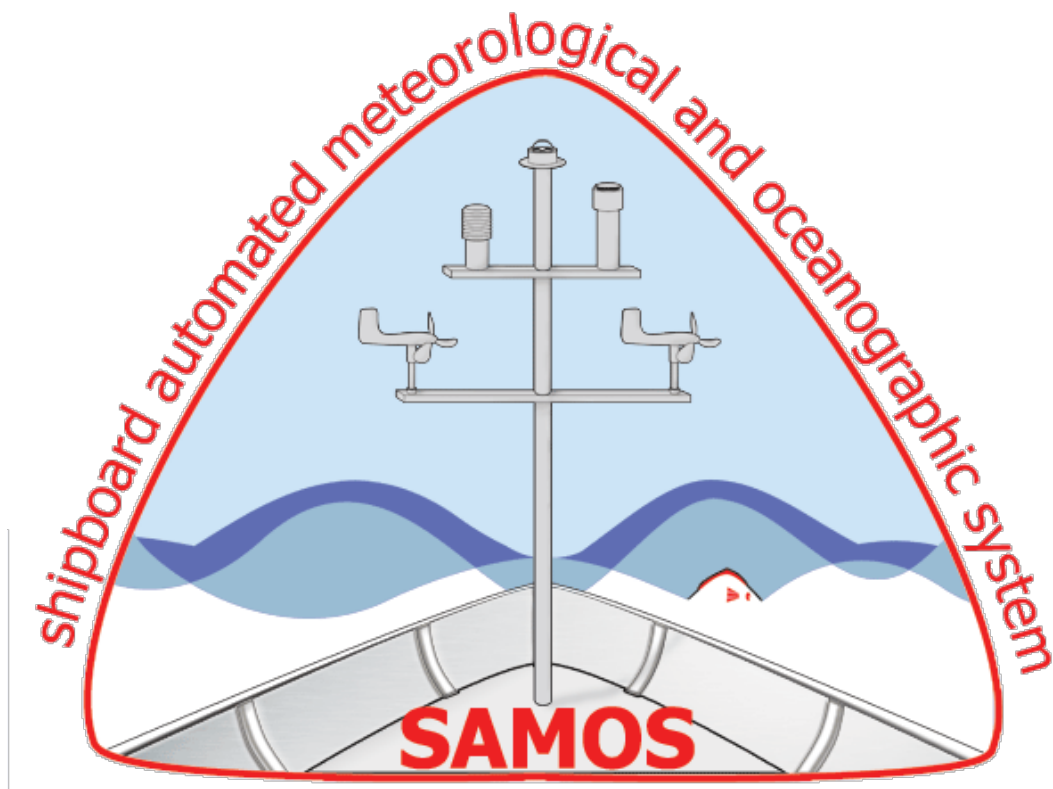
Why We Care

- SAMOS data uses:

  - Validating model analyses, air-sea flux fields, and satellite products

  - Satellite retrieval algorithm development
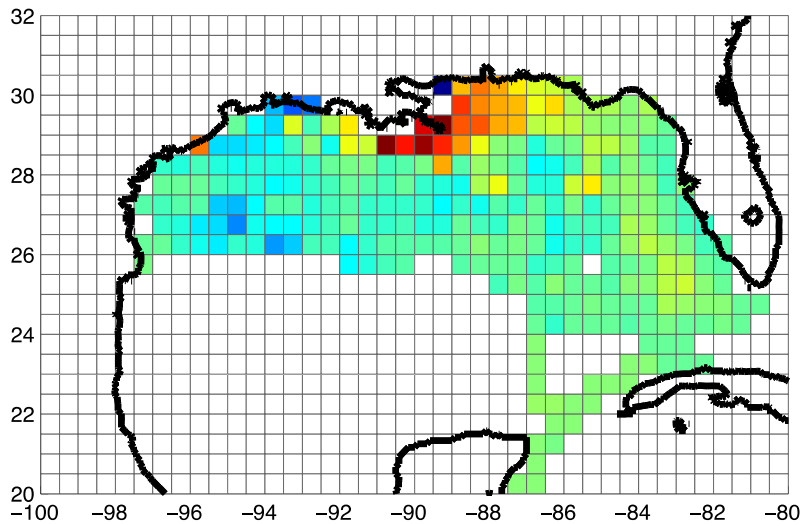
Adapted from Smith, Bourassa, and Jackson, *Sea Technology*, June 2012

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Questions?

SAMOS is base funded by NOAA's Office of Climate Observation and the U. S. National Science Foundation's Oceanographic Instrumentation and Technical Services Program (grant #0917685). Starting in 2013, the Schmidt Ocean Institute (SOI) provided contract funding to recruit the *RV Falkor* to the SAMOS initiative.

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More Scientific Applications

- Satellite product validation

  - SAMOS wind observations co-located with winds from scatterometers

  - SAMOS provides necessary auxiliary parameters (air and sea temperature, pressure, humidity) and instrumental metadata (sensor height) to adjust observations to standard 10-m equivalent neutral wind.

  - Satellite wind speed is generally higher than ship winds, especially at higher wind speeds.
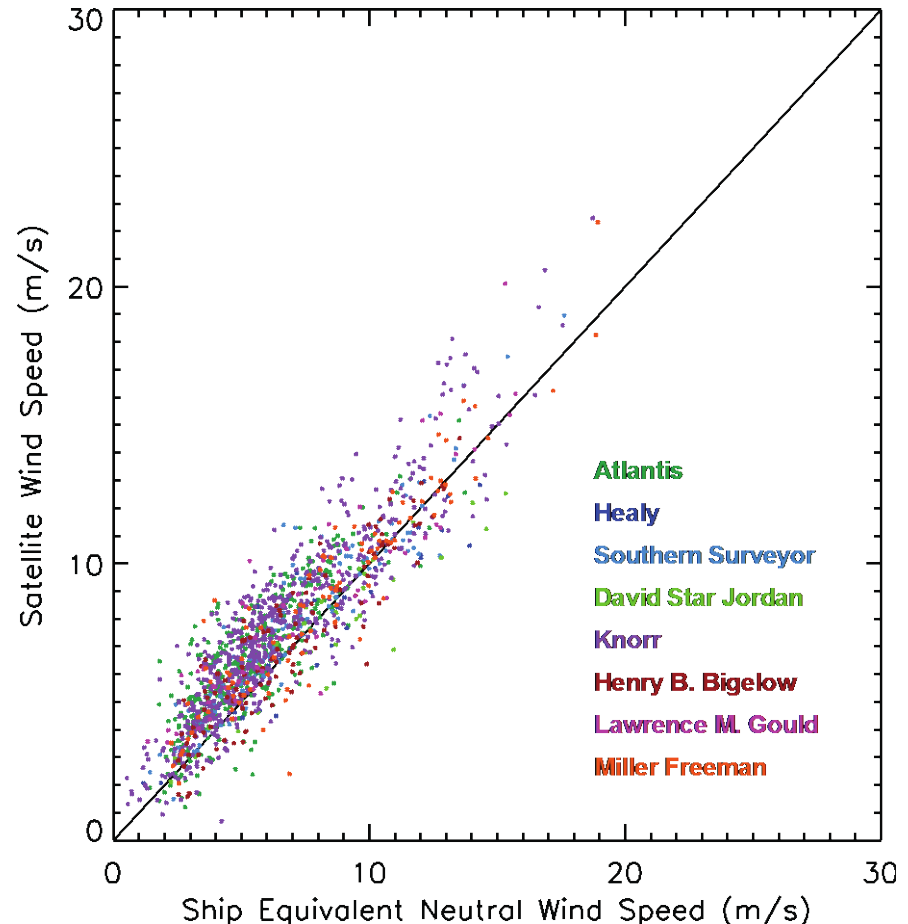
Value for Science Applications

Strengths

- High quality observations – routinely evaluated

- 1-min sampling frequency
  - Finer collocations possible

- Collected in remote oceans – away from shipping lanes

- Frequently co-located with other shipboard measurements (ADCP, multibeam, etc.)

Limitations

- Spatial/temporal coverage limited

- Repeat transects are rare

- Thermosalinograph observations rarely bottle calibrated