Sea Surface Salinity: Observations in the Global Ocean from Ships of Opportunity

The French SSS Observation Service

http://www.legos.obs-mip.fr/observations/sss/

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1. Rationale

- Sea Surface Salinity (SSS) is an essential variable of the global observing system for climate [1], and is valuable to enhance understanding of the global water cycles [2, and references therein]
- SSS is mainly affected by changes in Evaporation minus Precipitation (E-P) and by changes in the surface circulation [e.g., 3].
- In situ SSS is necessary to provide the ground truth for new SMOS [4] and Aquarius [5] satellite-derived observations

2. Objectives

Collect, validate, archive and distribute in situ SSS measurements collected by Voluntary Observing Ships (VOS):

- In real time for operational oceanography (CORIOLIS/MERCATOR/GODAE)
- In delayed time for research purposes:
  - Description and understanding of climate variability
  - Evaluation of climate models' skills
  - Calibration of paleoclimate timeseries
  - Calibration and validation of the new satellite missions

3. The monitoring system

Instruments and platforms at sea. The SSS measurements are based on SBE-21 thermosalinographs (TSG) onboard merchant ships (Fig. 1) operated from Brest, France, and Nouméa, New Caledonia. On average, each selected ship provides one to three sections per season along a regular track (Fig. 2).

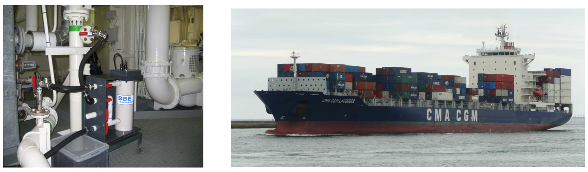

Figure 1.An example of TSG installation onboard a merchant ship

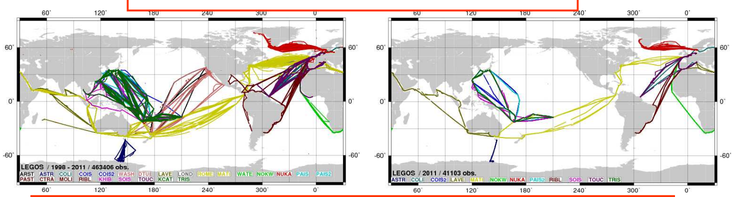

Figure 2. Spatial distribution of real time SSS collected from 1998 to 2011 and in 2011, so far.

Data acquisition. Most of the TSG measurements are collected every 15 s, and a 5 mn median filter is applied to reduce small scale signal and/or noise. The 5 mn resolution data are recorded in memory, and later on validated with the help of water samples (one/day on average) and/or collocated ARGO measurements: these are the **Delayed Mode Data**. Every hour, a 5 mn median value is transmitted via email by Inmarsat C to the LEGOS laboratory in Toulouse (with GPS position and time): these are the **Real Time Data**.

Real time monitoring. The real time SSS data (Fig. 3) are used to remotely check the onboard instruments (and contact the ship in case of problem), by comparing them to climatological ranges.

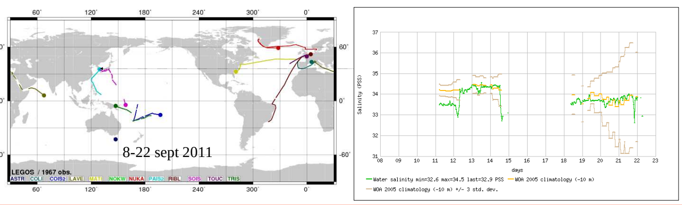

Figure 3. Examples of (left) spatial distribution of the real time SSS data collected during 15 days, and (right) comparison of SSS with climatological mean and standard deviation.

4. Data validation

Real time SSS data. The quality control is done automatically when data are received at LEGOS. Data are checked for realistic ship name, date, location, ship speed, and climatic limits based on the World Ocean Atlas (WOA, 2005). Alert messages are automatically sent to designated operators in case of dubious measurements and processing codes are attributed based on the tests.

Delayed mode SSS data. High-resolution SSS data are visually processed with a specially-designed software to check for internal consistency, climatic limits, geographic positions. Simultaneous bucket samples, collocated ARGO measurements and/or CTD measurements, pre/post calibration of the sensors, and remarks from scientific users are further considered to flag and correct the data.

5. A new gridded SSS dataset for the tropical Pacific

The French SSS observation service is the main contributor to the global set of in situ SSS data. Combining these TSG data with other available sources, a new gridded dataset has been produced for the tropical Pacific over the 1950-2009 period, following these steps:

- Validation of available in situ Sea Surface (0-10 m) Salinity data, following [6].
- Removal of duplicates and outliers based on multiple standard deviations
- Median averaging within grid elements of 1° lat x 1° long. x 5 days
- OI analysis, using decorrelation scales of 1 month, 1600 km in longitude, 275 km in latitude [6]

The resulting product is a gridded field of SSS and associated errors (1° lat. x 1° long. x 1 month) [7].

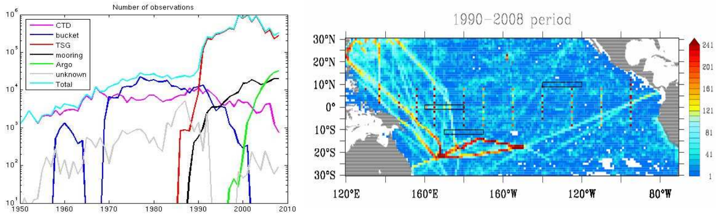

Figure 4. (left) Yearly distribution of SSS observations collected from different instruments (colour codes) and (right) spatial distribution for the 1990-2008 period

6. Observed versus CMIP3 modelled SSS

Mean SSS = 1950-2008 for the observations, 1950-1999 for the models.
Seasonal variability = 1st EOF on monthly mean climatology.
ENSO-variability = regression onto observed or modelled NINO3.4 SST

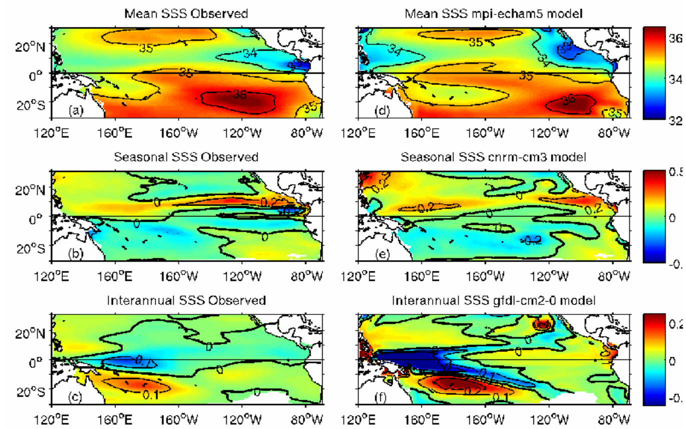

Figure 5. Spatial distribution of the (top panels) mean SSS, (middle panels) seasonal variability in SSS, and (bottom panels) ENSO-related variability in SSS. The left panels are from observations, and the right panels from the 'best' (see Figure 6) model at each time scale. Adapted from [8].

Seasonal variability **ENSO-related variability**

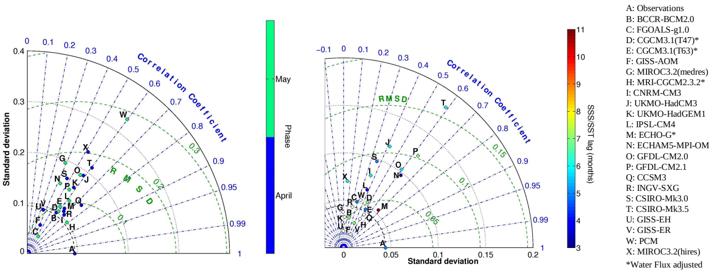

Figure 6. **Taylor diagrams** displaying the main statistics between the spatial distributions of observed (letter A) and modelled (letters B to X) patterns of SSS variability, for the (left panel) seasonal and (right panel) ENSO-related variability. The color bars represent the month of maximum SSS in the ITCZ in the left panel, and the lag in months between the 1st interannual EOF for SST and SSS time functions in the right panel, with SST leading.Adapted from [8].

7. Summary

- SSS is a key variable to improve our understanding of the global water cycle and climate variability, benchmark model performances.
- In situ SSS allows to evaluate the quality of the new satellite-derived observations [9, 10].
- Our SSS product and its associated error field is available to the research community [8].
- There is still work to be done to improve the ability of coupled climate models to reproduce the mean, the seasonal and ENSO modes for SSS in the tropical Pacific.
- Preliminary results suggest the different skill scores among models result in large part from the different simulations of fresh water flux (not shown here).

References

[1] Global Climate Oberving System, 2004.
[2] Schmitt, Oceanogr., 2008.
[3] Bonjean and Lagerloef, JGR, 2002.
[4] Kerr et al., IEEE, 2001
[5] Koblinsky et al., Radio Science, 2003
[6] Delcroix et al., DSR, 2005.
[7] Cravatte et al., Clim. Dyn, 2009.
[8] Delcroix et al., DSR, 2011.
[9] Gaillard et al., poster in this session.
[10] Boutin et al., poster in this session.