The French contribution to the Voluntary Observing Ships network of Sea Surface Salinity

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

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1. Rationale

- Sea Surface Salinity (SSS) is an essential climate variable *[1]* that reflects the global water cycle *[2]*.
- SSS is mainly affected by changes in Evaporation minus Precipitation (E-P) and by changes in the surface circulation *[3]*.
- In situ SSS is necessary to provide the ground truth for satellite-derived observations *[4]* and models *[5]*.

2. Objectives

The **French SSS Observation Service** (SSS-OS) aims to collect, validate, archive and distribute in situ SSS measurements made from 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
  - Calibration of paleoclimate timeseries
  - Evaluation of climate models' skills
  - Calibration and validation of the new satellite missions

3. Acquisition 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.*

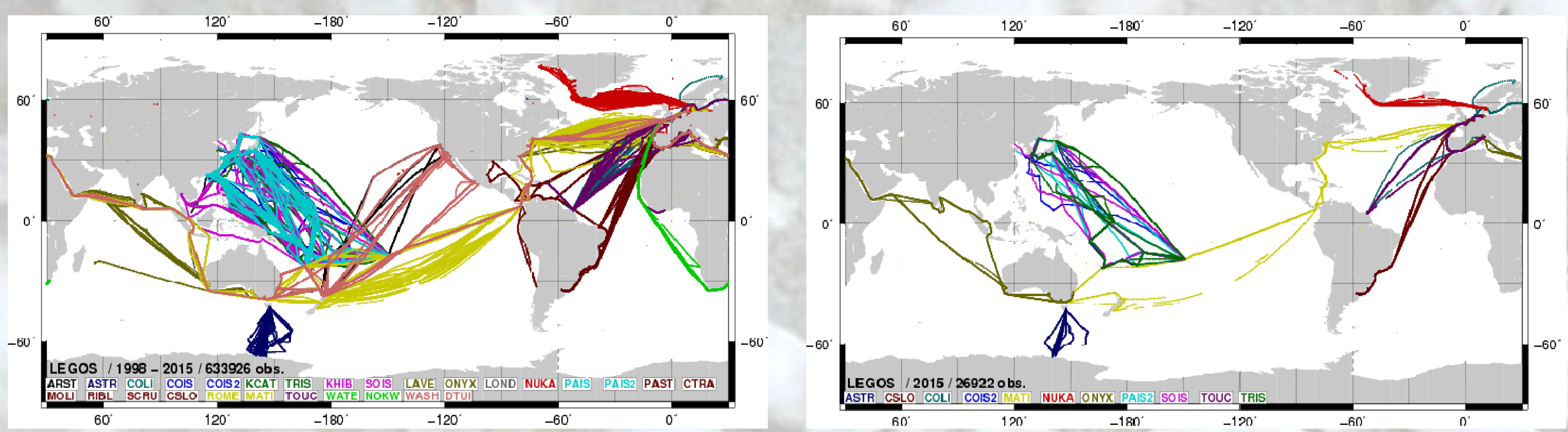

Figure 2. *Spatial distribution of real time SSS collected from 1998 to 2015, and in 2015.*

Data acquisition. TSG measurements are collected every 15 s, and a 5-min median filter is applied to reduce small scale signal and/or noise. The 5-min resolution data are recorded in a laptop, and later on validated and corrected with the help of external data: these are the **Delayed Mode Data**. Every 2 hour, a 5 min median value is transmitted (with GPS position and time) through an Inmarsat email to the LEGOS laboratory in Toulouse: these are the **Real Time Data**.

Real time monitoring. The real time TSG 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 and independent observations. TSGs have been recently equipped with flow-meters to better diagnose problems in real time.

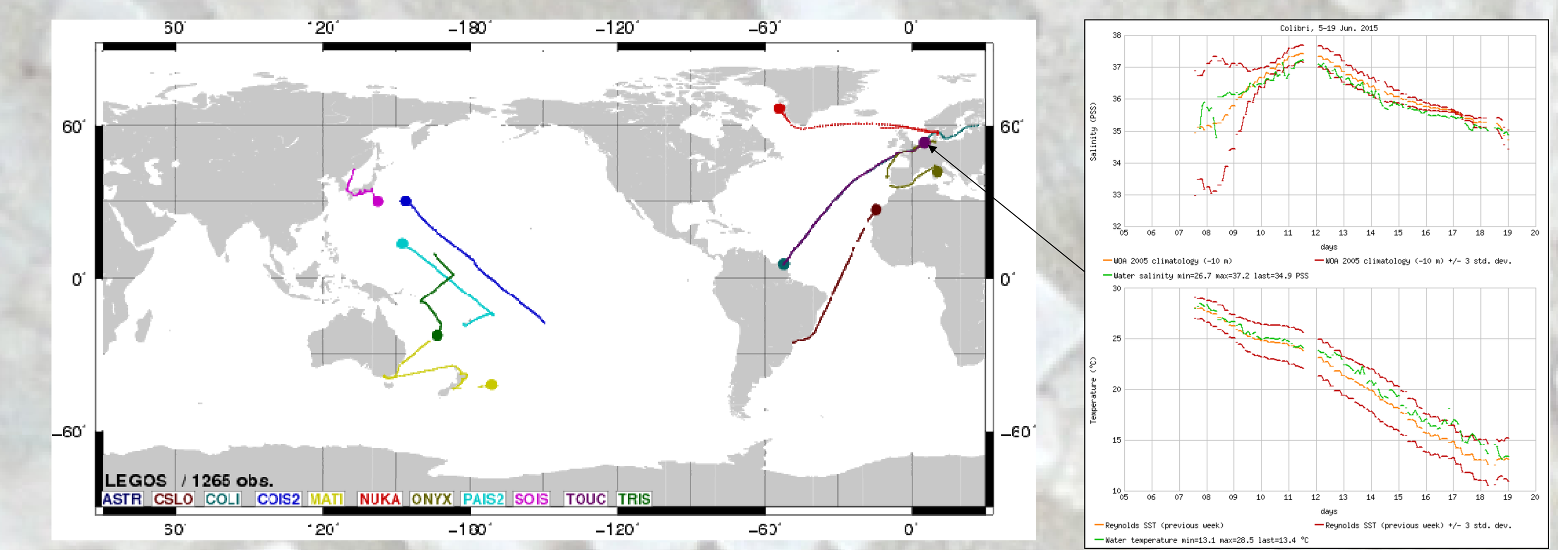

Figure 3. *Example of spatial distribution of real time SSS collected during 15 days, comparison of TSG salinity with WOA climatology and comparison of TSG temperature with Reynolds product.*

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, flow, and climatic limits based on the World Ocean Atlas. Processing codes are attributed to the measurements based on the tests. Alert messages are automatically sent to designated operators in case measurements have not been received for more than 2 days, or are dubious. Statistics on the number of received messages and sent alerts are monthly updated and used as quality indicators.

Delayed mode SSS data. High-resolution SSS data are visually processed with a dedicated software called TSGQC (*Fig. 4*) that we developed under Matlab©, freely available on the internet. The processing is done in two steps:

1- Quality Control flags are attributed based on recorded ship trajectory, comparison with SSS and SST annual or seasonal climatology, potential failure of the acquisition system observed onboard or previously experienced. Overall, *Good* and *Probably Good* data, which are recommended for research, represent around 80% of collected data (*Fig. 5*).

2- Corrections are applied based on comparison with daily water samples collected on board, and near surface data from Argo floats collocated with the ship trajectory. Corrections are generally positive to compensate for negative drifts of TSG measurements due to biofouling and abrupt shifts after harbor calls due to dirt of pieces of shell intrusion in the conductivity cell (*Fig. 6*). Errors are computed based on the number and dispersion of the external data taken into account for correction. They are generally lower than 0.1 pss and rarely exceed 0.2 pss (*Fig. 6*).

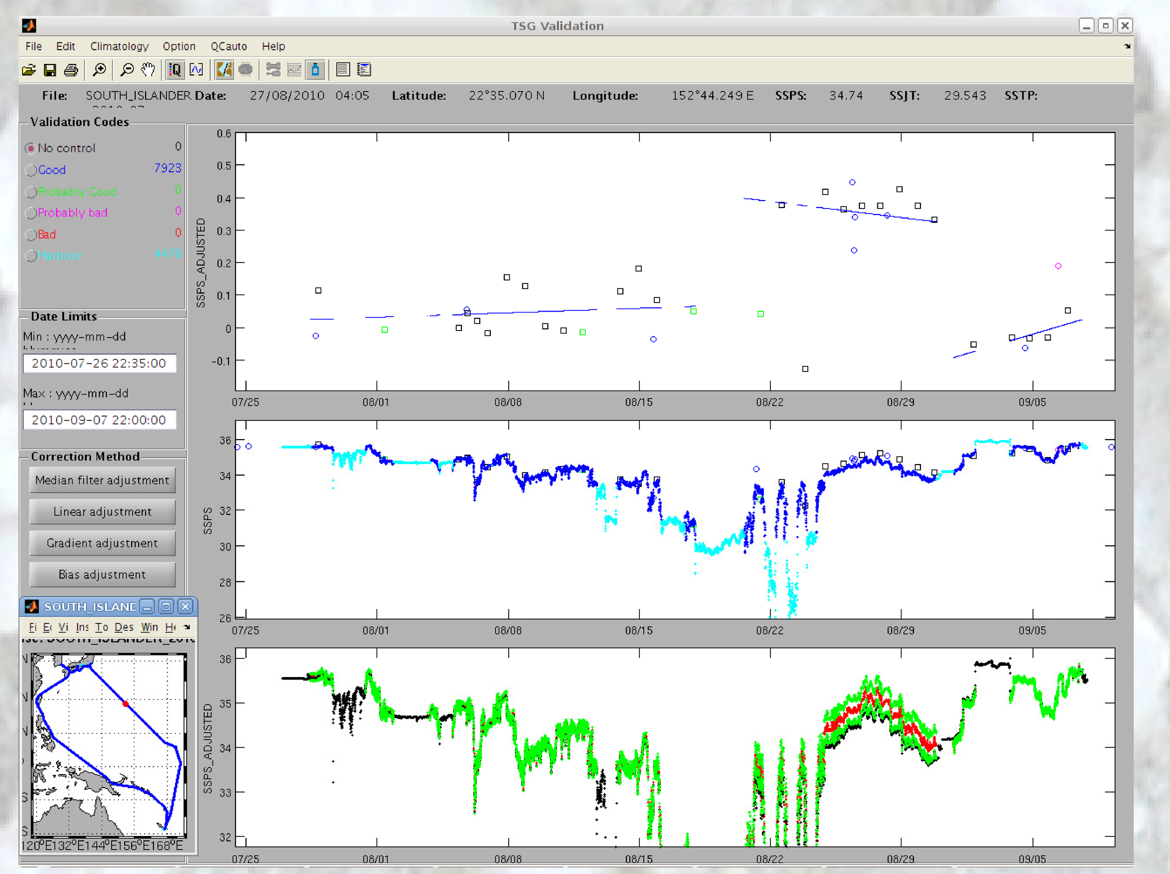

Figure 4. *Data processing with TSGQC. Upper panel: correction applied to TSG data (blue lines) based on observed differences with external data (squares: water samples, circles: Argo floats). Middle panel: TSG time series (blue: good data, light blue: harbor call). Lower panel: raw (black) and adjusted (red + green for error range) TSG time series.*

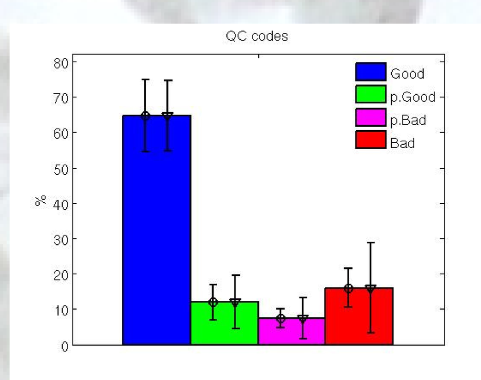

Figure 5. *Mean distribution of Quality Control flags attributed to SSS data in delayed time. Error bars: standard deviation among years (circles) and ships (triangles).*

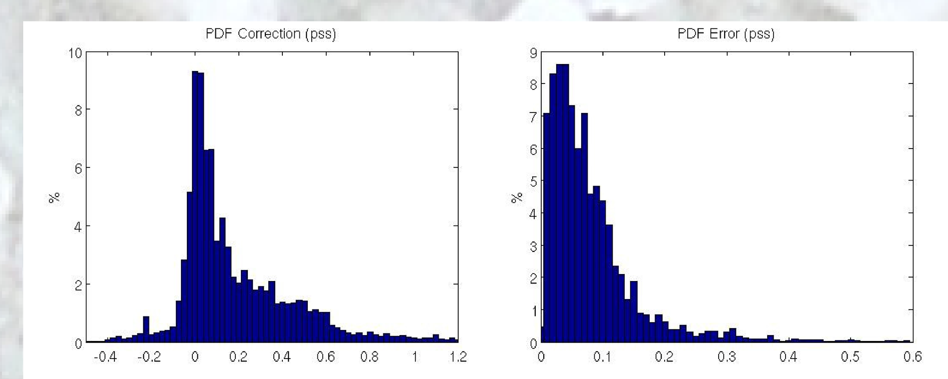

Figure 6. *Distribution of corrections applied in delayed time to TSG SSS data and errors attributed.*

5. Data products and distribution

Real time data feed the Coriolis operational oceanography database, updated daily, from which they can be extracted through a graphical web interface (www.coriolis.eu.org).

After about one year, delayed time data are available from the SSS-OS website through a graphical web interface that allows selection for multiple ships and for a given longitude, latitude and time range. Gridded products combining SSS-OS data with other sources of SSS data are also available for the Atlantic (30°S-50°N, 1970-2014) and the tropical Pacific (30°S-30°N, 1950-2009, currently being updated to 2014).

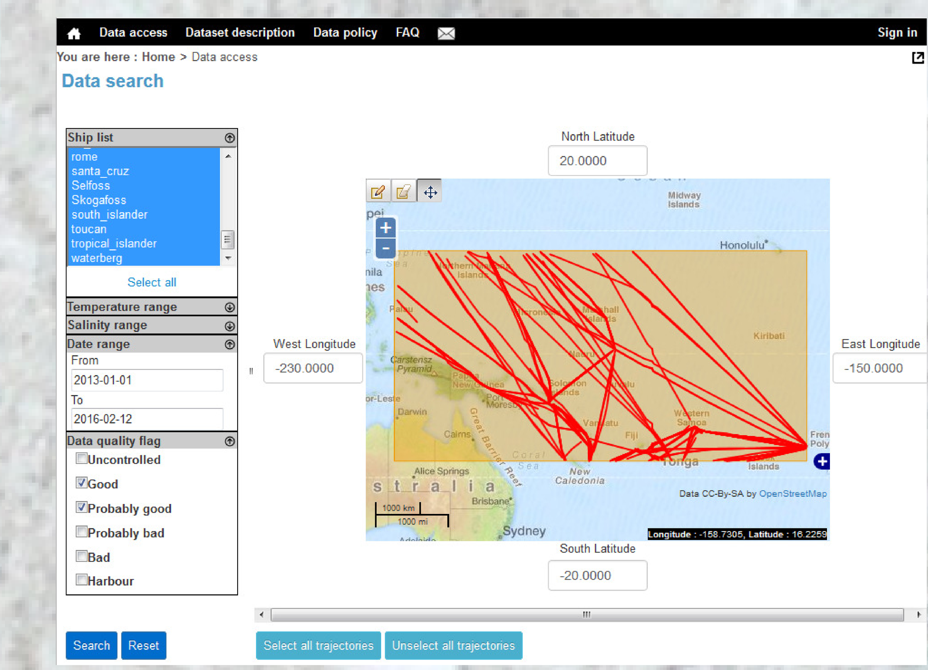

Figure 7. *The new SSS-OS graphical web interface for delayed time TSG data.*

6. Scientific outcome

Our TSG network provides long term SSS data with high horizontal resolution along frequently repeated lines. These data have been used in numerous publications, from mesoscale and regional to global climate change studies. Some recent examples are illustrated below.

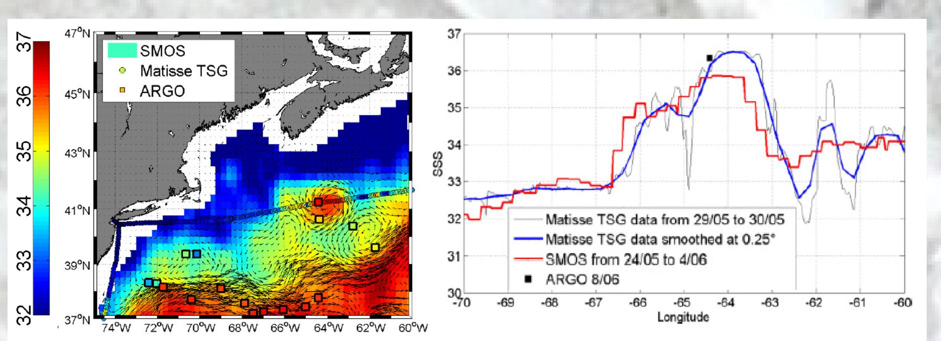

Figure 8. *Validation of SMOS data across a salty eddy detached from the Gulf Stream. Adapted from [6].*

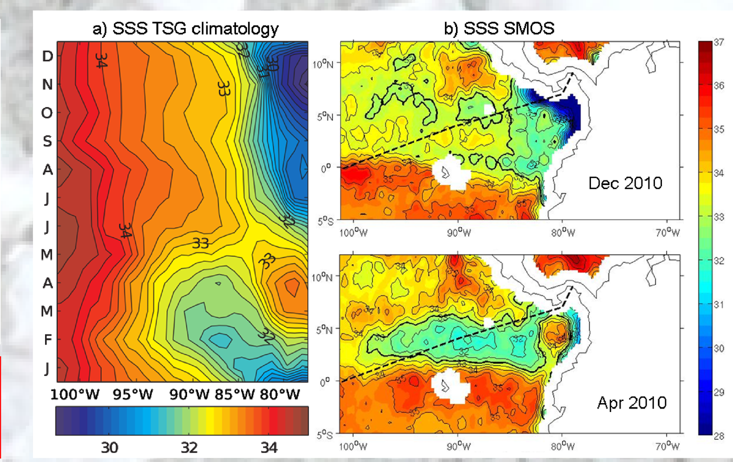

Figure 9. *Seasonal cycle of the eastern Pacific fresh pool along a TSG line, compared with monthly SMOS maps. Adapted from [4].*

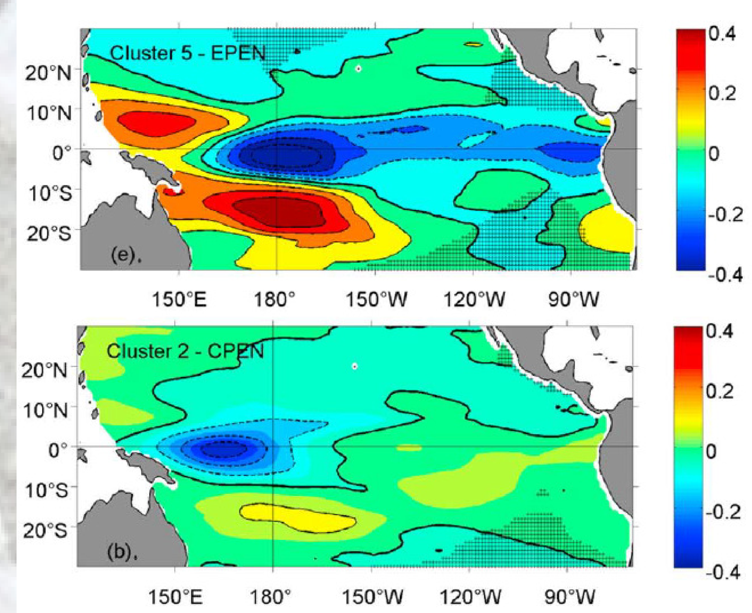

Figure 10. *Interannual SSS anomalies associated with El Niño events of the Eastern Pacific (top) and Central Pacific (bottom) types. Adapted from [7].*

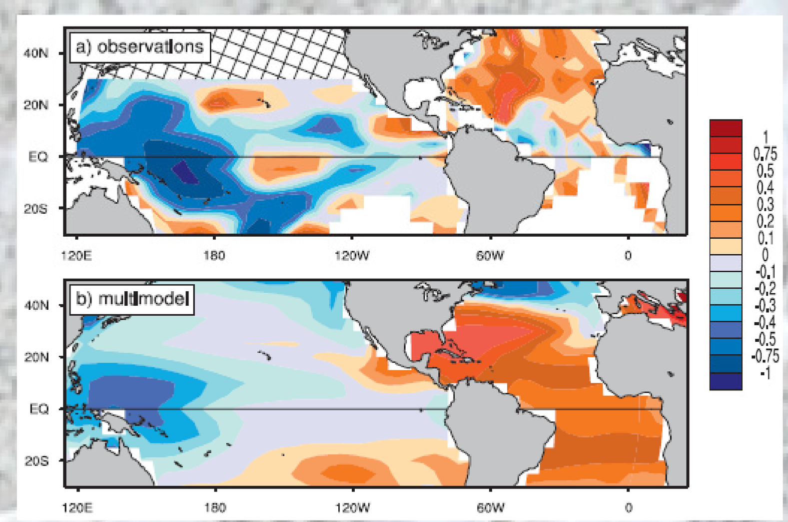

Figure 11. *Observed SSS trends (1970-2002) and multimodel SSS changes between the end of the XXI^st^ and XX^th^ centuries, in pss/century. Adapted from [8].*

References

[1] Global Climate Obering System, 2004
[2] Schmitt, Oceanogr., 2008
[3] Bonjean and Lagerloef, JGR, 2002
[4] Alory et al., JGR, 2012
[5] Delcroix et al., DSR, 2011
[6] Reul et al., GRL, 2014
[7] Singh et al., JGR, 2011
[8] Terray et al., JC, 2012

This poster is based on the paper: Alory et al., 2015, The French contribution to the Voluntary Observing Ships network of Sea Surface Salinity. *Deep Sea Research Part I*, *105*, 1-18, doi:10.1016/j.dsr.2015.08.005.

Background picture: salt crystals on the deck of a voluntary observing ship (© G. Alory)