Towards long-term (2002-present) reconstruction of Sea Surface Salinity in the Bay of Bengal based on AMSR-E and L-band Radiometer data

M. MONTERO[*], N. REUL[*], C. DE BOYER-MONTEGUT[*], J. VIALARD[+], J. TOURNADRE[*]
(marie.montero@ifremer.fr)
[*]LOPS (IFREMER/CNRS/IRD/UBO), Brest, France [+]LOCEAN-IPSL (IRD/Sorbonne Universités/CNRS/MNHN), Paris, France

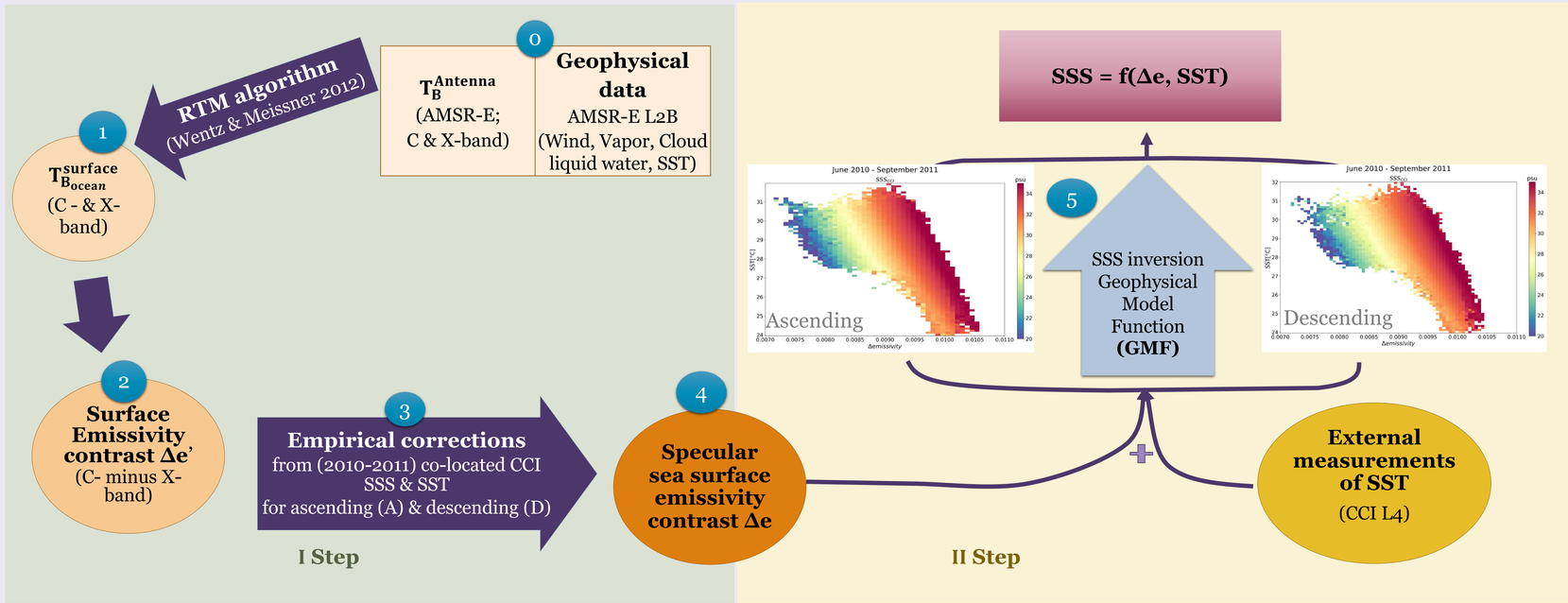
Abstract

This study is based on the study of the Sea Surface Salinity (SSS) retrieval from the microwave ocean radiometer measurements of AMSR-E (May 2002 – September 2011) across the plume of the Amazon River (Reul et al. 2009). The ability of X-minus C-band brightness temperature (T_B) to track SSS changes was demonstrated in highly contrasted SSS and warm Sea Surface Temperature (SST) regions.
We are focusing on the Bay of Bengal (BoB: Latitude [5 25] and Longitude [77 100]), which is under the monsoon influence and exhibits highly contrasted and variable SSS, fulfilling the condition of high Sea Surface Temperature (SST). Knowing that C-band T_B sensitivity to SSS is at least 10 times weaker than in the L-band (SMOS or Aquarius), we use the common period between AMSR-E and SMOS/Aquarius (Jan 2010 – September 2011) to remove the effect of other geophysical variables such as SST, surface wind, and atmospheric effects, using an empirical approach.
Our goal is to create an SSS database over 20 years (2002 - now) and to use it to explore the physical processes that drive SSS inter-annual variability in regions where it is strong, such as near major river estuaries or along the west coast of India.

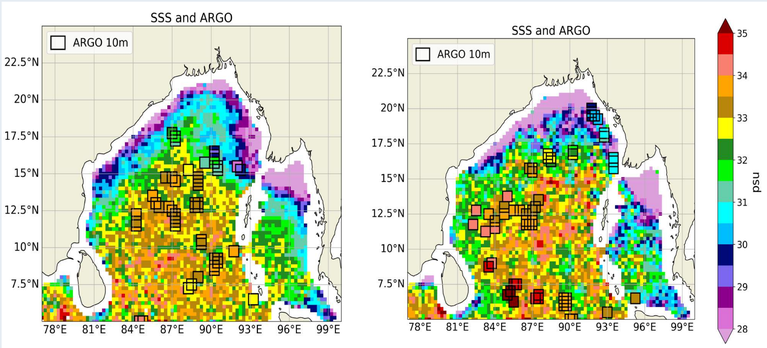
Data

- AMSRE: L2A (T_B at C and X band) from National Snow & Ice Center (https://nsidc.org) and L2B ocean products from Remote Sensing Systems (REMSS) including wind speed (WS), sea surface temperature (SST),water vapor (WV) and cloud liquid water content (CLWC) (https://www.remss.com/)
- Ancillary data
  - ESA's Climate Change Initiative (CCI) L4 SSS v3.21 and SST v2.1 time series over the BoB from January 2010 to end 2020 (merged SSS data from SMOS, Aquarius-SAC/D and SMAP)
- In situ ARGO profiler float data, 10m depth salinity, proxy of SSS

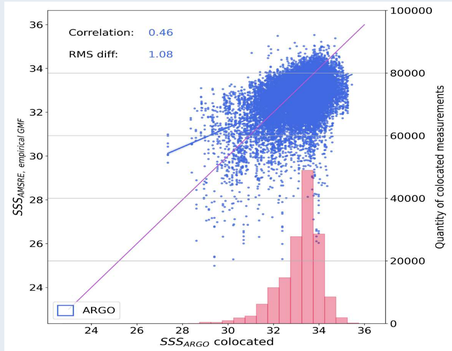
AMSR-E SSS retrieval algorithm



Examples: Monthly SSS regional mapping



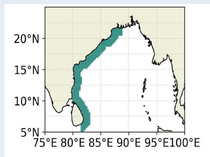
AMSR-E reconstructed SSS (background color) and the co-located 10m ARGO SSS for (left) November 2006 and (right) September 2009. We can see a correct reconstruction for some months but also a high underestimation in the center of the BoB and along the east coast of India.



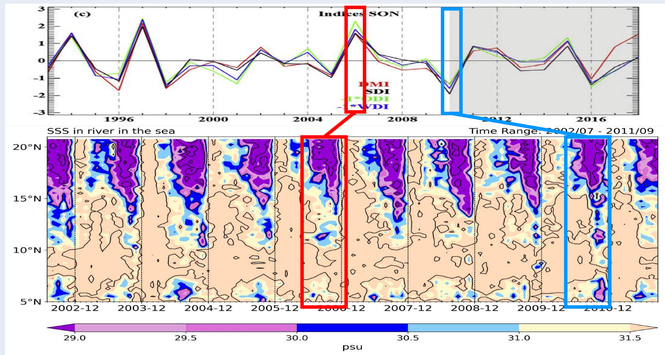
Scatterplot of the AMSR-E monthly reconstructed SSS (y-axis) and co-located monthly ARGO 10 m SSS, from 07-2002 to 09-2011. The histogram of co-located ARGO measurements is shown in red.

Application Example: Interannual Variability of the "River in the sea"

The influence of the **Indian Ocean Dipole** (IOD) on AMSR-E SSS along the East coast of India is consistent with *Akhil et al. (2014)* for the years 2006 and 2010:
Observing "the River in the sea" along the East Indian Coast



- Years with **negative IOD (2010)** → extended river in the sea southward
- Years with **positive IOD (2006)** → limited southward freshwater extension along the coast



Top: After Akhil et al. 2020 Time series of the four IOD indices used in this study over 1993–2018 period in September-October-November.
Bottom: Hovmöller Diagram of the river in the sea along the green domain shown on the left, between 07-2002 and 09-2011. One can observe the expected impact of high (red) or low(blue) IOD on SSS (Akhil et al. 2014's model) via the positive or negative Dipole Mode Index (DMI) or Sea-High Dipole Index (SDI).

Brief conclusion

- Some problems still exist concerning the reconstructed AMSR-E's SSS, mostly in the center of the BoB where the signal-to-noise ratio is very low and along the east coast of India, where a permanent underestimation is observed.
- We discovered recently that significant differences between ascending and descending passes require specific algorithms to be developed.
  - SST diurnal cycle is not responsible for these differences (foundation CCI SST or AMSR-E SST provides similar results).
  - Diurnal cycles in the wind speed can be a source for the differences.
  - Different land-sea transition effects are observed in the T_B in ascending and descending passes, and also impacts the SSS reconstruction.

Ongoing

- Paper Montero et al. (IEEE TGRS) in preparation
- Further studies of the impact from ascending or descending traces
- Neural Network SSS inversion method is under development, including more additional input parameters for the reconstruction (distance to the coast, latitude, longitude, …)
- The impact of the runoff from Ganga-Brahmaputra and Irrawaddy on SSS close to the estuaries and in the Bay is under investigation.

References

- Reul, N. et al. (2009). Demonstration of ocean surface salinity microwave measurements from space using AMSR-E data over the Amazon plume. Geophysical Research Letters (GRL) (0094-8276) (American Geophysical Union), 2009-07 , Vol. 36 , P. 1-5. 36. 10.1029/2009GL038860.
- Meissner, T. and Wentz, F.,J., "The Emissivity of the Ocean Surface Between 6 and 90 GHz Over a Large Range of Wind Speeds and Earth Incidence Angles," in IEEE Transactions on Geoscience and Remote Sensing, vol. 50, no. 8, pp. 3004-3026, Aug. 2012, doi: 10.1109/TGRS.2011.2179662.
- Akhil, V. P., et al. (2014), A modeling study of the processes of surface salinity seasonal cycle in the Bay of Bengal, J. Geophys. Res. Oceans,119, 3926–3947, doi:10.1002/2013JC009632.
- Chaitanya, AVS et al (2014). Salinity Measurements Collected by Fishermen Reveal a "River in the Sea" Flowing Along the Eastern Coast of India. Bulletin of the American Meteorological Society. 95. 10.1175/BAMS-D-12-00243.1.