Ongoing Validation of Ocean Surface Salinity Measurements from SMOS

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1. WHY WE NEED MORE SEA SURFACE SALINITY (SSS) DATA?

SSS and sea surface temperature (SST) have important implications for ocean circulation and air-sea interactions. Whilst many *in situ* data are assimilated in operational models along with measurements of SST from space, limited data on SSS result in models tending to relax surface salinity to climatologies. Satellite measurements of SSS could significantly improve the performance of ocean circulation and climate models.

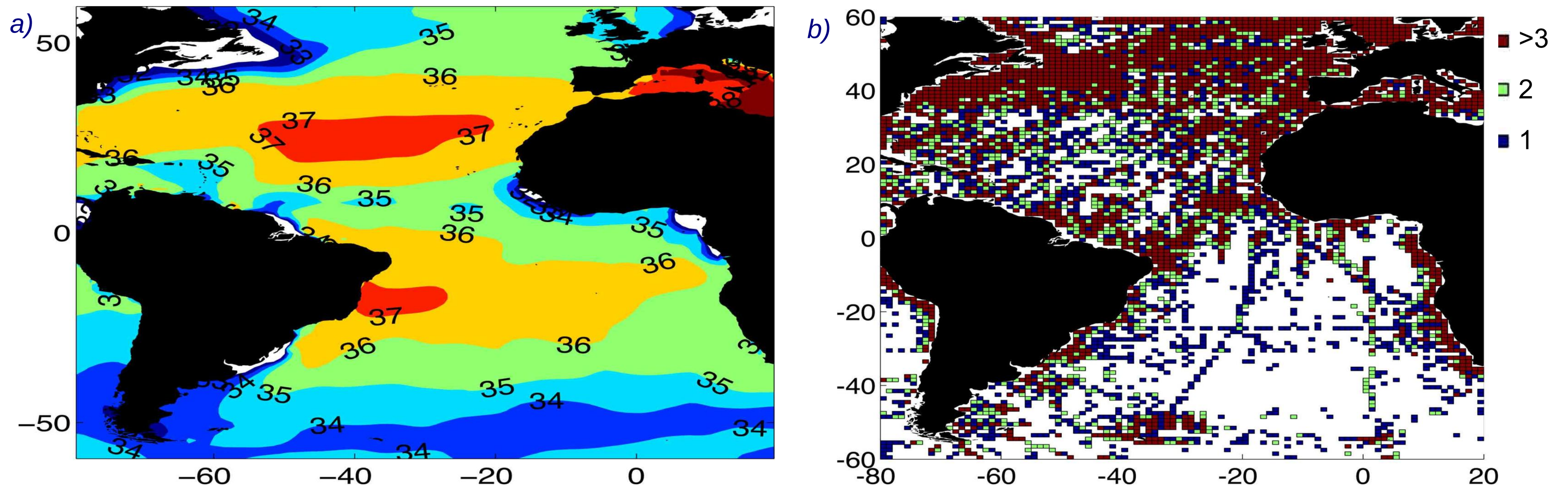

Figure 1: a) Interpolated SSS values from World Ocean Atlas 2005 (Antonov et al., 2006) for October based on 1° grid and b) the number of observations in each grid cell illustrating how climatological products can give a misleading impression about the SSS data available.

2. MEASUREMENTS OF SSS FROM SPACE

2 separate missions are designed to measure SSS from space:

1. **ESA Soil Moisture and Ocean Salinity (SMOS)**
   Launched November 2009, resolution 35-50 km across ~700 km swath (Fig. 2).
2. **US/Argentine Aquarius mission (launch 2010)**

Expected accuracy:
- 1 psu on single pass
- 0.1 psu averaged over 10-30 days and 1-2 degree grids (GODAE).

First order validation focuses on large SSS signatures (e.g. meridional gradient of SSS and freshwater plumes from large rivers) and whether these are detectable in single-pass images.

Examples of the *in situ* data types for validation are given in Boxes 3 and 4.

Figure 2: Artists impression of SMOS (ESA - AOES Medialab).

3. SSS VARIABILITY FROM *IN SITU* OBSERVATIONS I

During January and February 2010 the research ship RRS *Discovery* crossed the North Atlantic from Bahamas to Portugal. Continuous measurements of SSS (and SST) were made and have been averaged into one degree grid cells. Figure 3 shows these averaged values of SSS and compares them with values obtained from using Argo floats in the same periods.

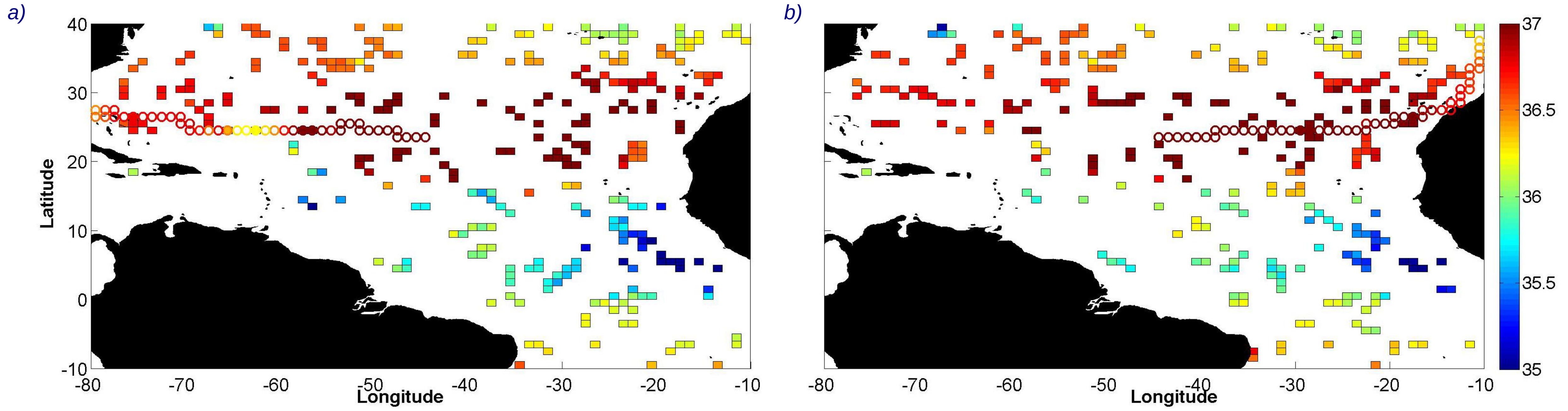

Figure 3: 1° x1° grid cells showing monthly averaged SSS from RRS Discovery (unfilled circles) and near surface salinity (depth <10 m) from Argo floats (filled squares) for North Atlantic study region for a) January and b) February 2010.

4. SSS VARIABILITY FROM *IN SITU* OBSERVATIONS II

Early work has focused on quantifying the inter-annual/-monthly variability of SSS in Atlantic Ocean using Argo and PIRATA data. An example of the agreement between these two sources is shown in Figure 4. Despite local variability, the meridional gradients of SSS are clearly visible in both data sources. These large-scale SSS signatures will serve for the initial validation of satellite SSS measurements.

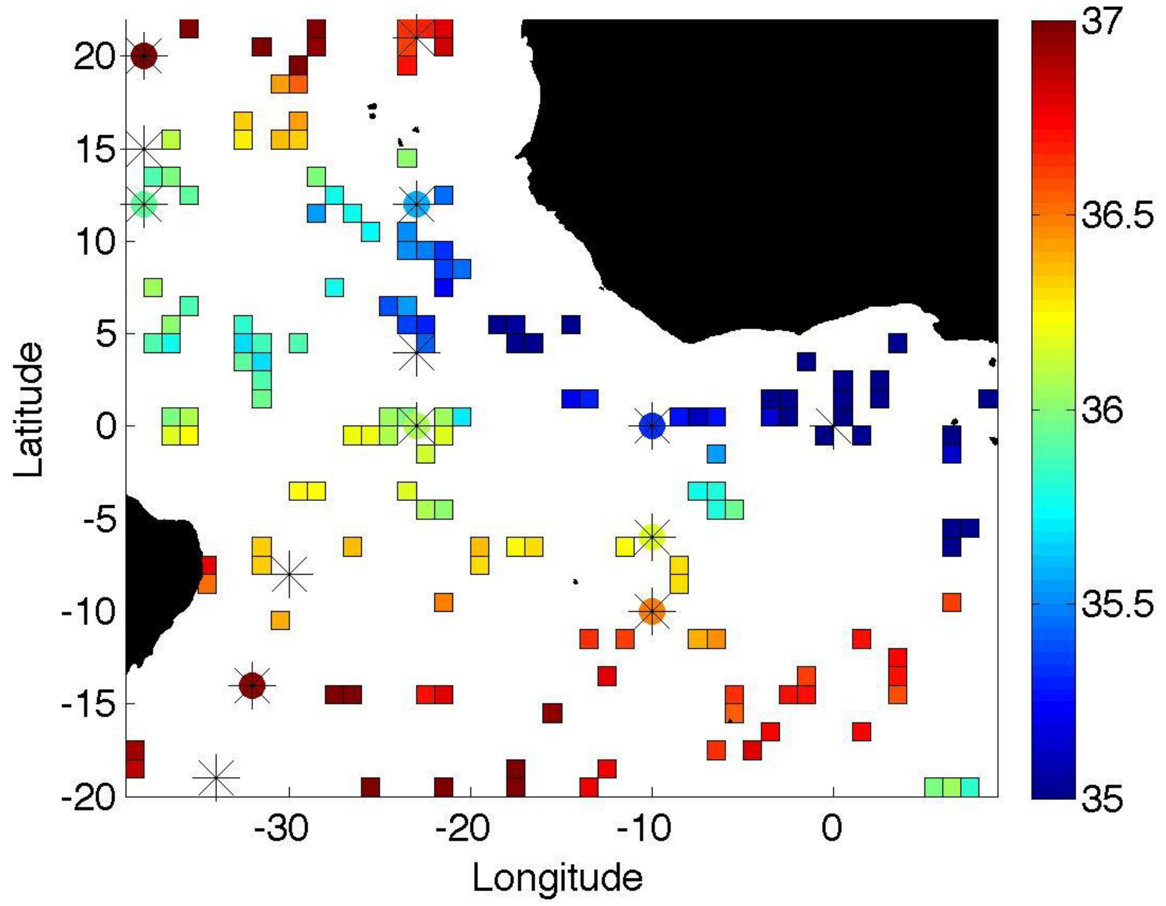

Figure 4: Monthly composite for February 2010 of PIRATA monthly averaged salinity values (shows locations of all moorings and filled circles indicate salinity at 1 m depth). Filled squares show 1°x1° gridded Argo measurements of near surface salinity (depth <10 m) for the same month.*

5. OCEAN MODEL OUTPUT

Another important comparison is between SMOS values of SSS with output from ocean (forecast) models. In preparation for SMOS validation, and for direct comparison with the *in situ* data described in Boxes 3 and 4, output from the UK Met Office FOAM model have been transformed to one degree grid cells and then the values averaged for January and February 2010 (Fig. 5).

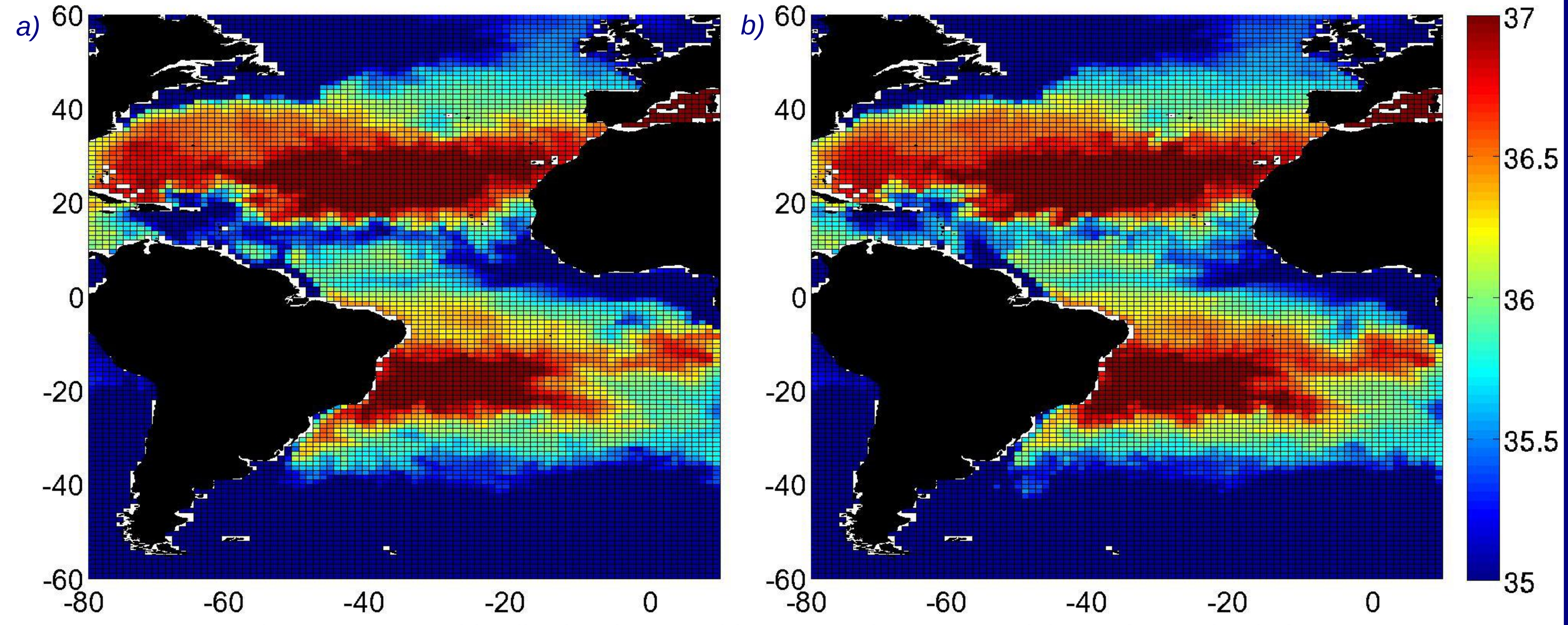

Figure 5: 1°x1° grid cells showing monthly averaged FOAM model SSS from Atlantic for a) January 2010 and b) February 2010.

6. SSS, E-P AND PRECIPITATION

A linear relationship between E-P (evaporation minus precipitation) and SSS has long been hypothesized (Fig. 6). A plot of monthly averaged rainfall and SSS (at 1 m depth) from the PIRATA array is shown in Figure 7, suggesting a possible high degree of correlation on monthly scales.

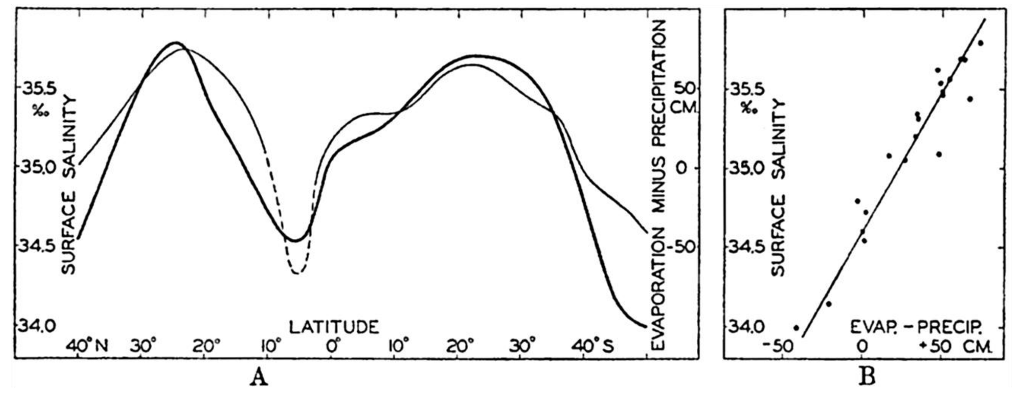

Figure 6: (A) Average values for all oceans of surface salinity and evaporation minus precipitation, plotted against latitude. (B) Regression of SSS against evaporation minus precipitation (Wüst, 1936).

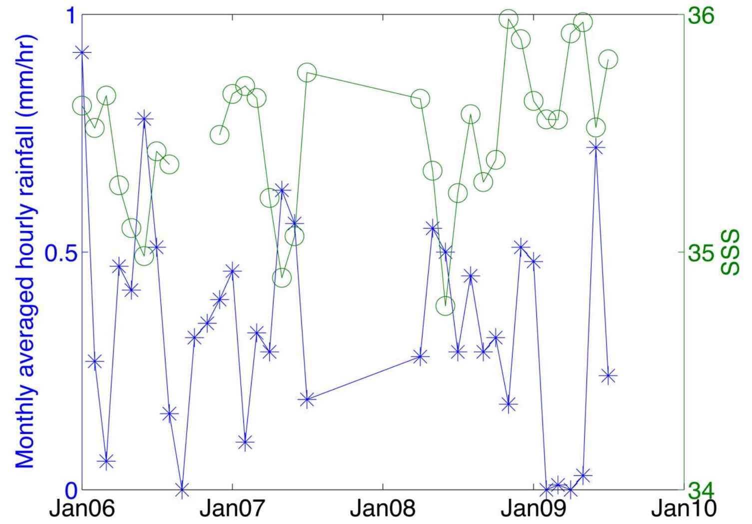

Figure 7: Monthly averaged rainfall rate (mm hr^{-1}) and sea surface salinity (SSS) between January 2006 and July 2009 for PIRATA mooring located at 38°W, 4°N.

7. SMOS DATA

Brightness temperature (Level 1c) data are now available from SMOS (Fig. 8) and the next stage is to combine these data with various other geophysical parameters to produce Level 2 SSS data products (Fig. 9).

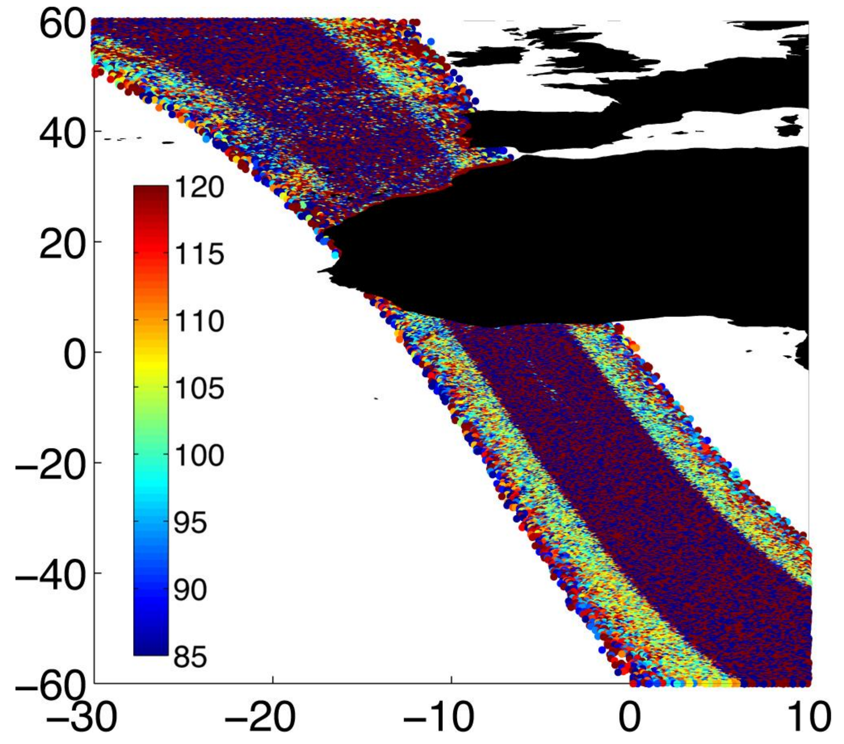

Figure 8: Example of SMOS brightness temperature data (extreme values removed) from 3rd March 2010.

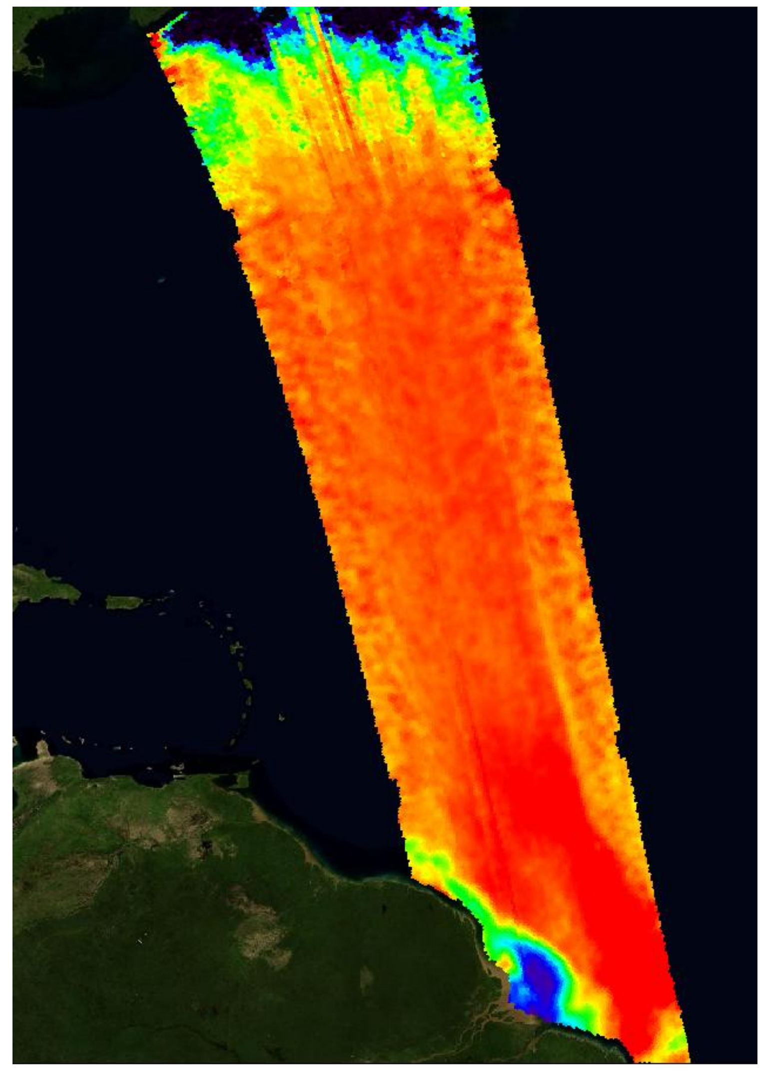

Figure 9: Preliminary example of SMOS (Level 2) SSS data.

8. FUTURE WORK

- Evaluate SSS variability and validation of "Level 2" SMOS data, can simple questions be answered for example:
  - *Are the meridional gradients of SSS represented in satellite SSS products?*
  - *Can the impact of the Amazon freshwater input be seen from space?*
- Development of "Level 3" satellite SSS gridded products
- Can we assimilate SMOS data in ocean forecast models?

9. References

Antonov, J. I., et al. (2006), Vol. 2: Salinity, 182 pp, NOAA, U.S. Department of Commerce, Silver Spring, Maryland, USA.

Wüst, G. (1936), Oberflächensalzgehalt, Verdunstung und Niederschlag auf dem Weltmeere, 347-359 cited in The Oceans, Their Physics, Chemistry and General Biology. New York: Prentice-Hall, 1942. (http://ark.cdlib.org/ark:/13030/kt167nb66r/).

10. Acknowledgements

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