### 1. Introduction

The ESA/SMOS satellite mission aims at estimating the Sea Surface Salinity (SSS) using L-band (1.4 GHz) radiometry with a spatial resolution at ground level of about 40 km and a global earth coverage in 3 days [1]. This is very promising because the sensitivity of L-band SSS is strong (on the order of 0.6 K/psu). It requires very well controlled stability of the antenna and very good corrections for geophysical effects other than SSS. Comparisons between in situ and retrieved SSS will be used to detect errors and biases in the retrieved SSS. However skin depth of L-band signal is 1 cm whereas in situ measurements are usually made at a few meters depth (typically 5 m to 10 m). In this paper, we investigate the order of magnitude of the vertical gradient of salinity in the upper 10 m. The goal is to define measurements depth suitable for Cal/Val phase, depending on the region, and to determine measurements that should be flagged or eliminated for Cal/Val exercise.

### 2. Data

As presented, there is no in situ measurement in the first cm. Hence, we use existing measurements and focus on vertical gradients between 5 m and 10 m. We focus on the Tropical Atlantic Ocean. We use three types of data:

- **The POLARSTERN** is a research vessel equipped with thermosalinograph (TSG) at 5 and 11 m below the surface. Surface measurements are repeated by 15 minutes (nearly 1 h). This vessel crosses the Atlantic Ocean twice a year, measuring temperature, conductivity, wind and rain rate. The used data are sampled from 1993 to 2000.

- **The ARAMIS project** [2] uses merchant ships along the AX11 route (35°N/20°W – 20°S/40°W). Twice a year, from 2002 to 2006, salinity and temperature are measured, every degree of latitude, by XCTD (Expendable Conductivity-Density and Temperature) from about 4 m depth, with a vertical resolution of 1 m.

- **The ARGO floats**, from CORIOLIS database are used from 01 January 2001 and 01 January 2007 [3]. We only keep the vertical profiles with at least 2 measurements of salinity in the first 10 meters of the ocean surface layer. Shallowest measurement is at best 2 or 5 meters.

### 3. Observed Vertical Salinity Gradients

For the POLARSTERN’s and ARAMIS’ data sets, we calculate the vertical gradient of salinity as the difference between measurements at 11m and measurement at 5m. The POLARSTERN’s data set contains more than 33 000 salinity gradients, and the ARAMIS’ one 124.

ARGO floats were selected in accordance with the valid flag determined by CORIOLIS [4]. We only kept good data and probably good data (quality factor between 0 and 2.5). Then, salinity gradients are calculated between the deepest and the shallowest measurement of salinity. We obtained more than 9 000 salinity gradients. An example of salinity gradients is shown in figure 2.

The spatial distribution of salinity gradients is similar for the three data sets. In most locations outside of Africa, the gradients are below 0.1 psi. Between 0 and 10° N, the gradients are greater than 0.1 units with most of them range from 0.1 to 0.5 psi. Gradients between 0.5 and 2 psi are mostly located near river mouths. Zones of high salinity gradients coincide with the position of ITCZ in this region.

Isolated high gradients outside this latitudinal band are due to the proximity of river mouths.

### 4. Rain Occurrence and Vertical Salinity Gradients

A first observation confirms that large gradients coincide with high rain rate.

In addition, thanks to the POLARSTERN vessel and its meteorological bow, we can verify that salinity gradients were, in a great majority, measured simultaneously to low wind speed and high SST (5m). It confirms the relation between salinity gradient’s position and ITTCZ’s position (not shown).

Even if a large majority of salinity gradients are below 0.1 psi, differences between rainy regions and the other is not negligible. Between 0 and 10°N, the mean of vertical salinity gradients in the whole region equals 0.014 psi and the standard deviation is 0.080 psi. The same calculation applied on 35°S and 35°N (except 0°-10°N) gives respectively -0.002 psi and 0.030 psi.

Differences between satellite SSS retrieved at 1 cm depth, 40km resolution and in situ SSS which is punctual is deeper. Drifter data increase the difficulty of the Cal/Val phase. However, if we consider an average on a large scale, the impact of salinity gradients is weak (the 5-10m gradient averages to 0.0002 psi between 30°S and 30°N). We have to be very careful when using in-situ data taken at a few meters depth below the surface to simulate SMOS data in tropical regions. In rainy regions, like 0-10°N, or near river mouths, using punctual data will bring a non negligible effect. The existence of gradients larger than 0.1 psi, between 5m and 10m depth, on the one side and with rain occurrence, on the other side, salinity gradients are expected to be more important in the 0-5m than in the 5-10m. Thence it is recommended to use rain history to flag in-situ measurements to be used for Cal/Val. We could have decide to reject measurements performed in rainy regions for SMOS Cal/Val. But it would be a non negligible effect. The existence of gradients larger than 0.1 psi, between 5m and 10m depth, on the one side and with rain occurrence, on the other side, salinity gradients are expected to be more important in the 0-5m than in the 5-10m. Thence it is recommended to use rain history to flag in-situ measurements to be used for Cal/Val. We could have decide to reject measurements performed in rainy regions for SMOS Cal/Val. But it would be a very challenging as these regions represent an important part of the ocean and fundamental places for the study of the climate. An improved solution is to deploy conductivity/temperature/drifters measuring at 50-55cm, 10cm in rain zones and not as often as possible. Data acquired in the first 10 cm are used.

### Discussion and Conclusion

Figure 2 shows the relation between salinity gradient’s position and ITTCZ’s position (not shown).