The Impact of Combining SMOS and ARGO Data on the SMOS Level 2 and 3 Products and Effect of the Vicinity of the Coast

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  • Performance at Level 2
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Introduction

At IGARSS’07, July 23rd-27th 2007

Using

- Ad-hoc geophysical parameters
- SMOS End-to-end Performance Simulator (SEPS)
- Level 2 Processor Simulator (L2PS)

“External Brightness Temperature Calibration”[*]

“External Salinity Calibration”[**]

Have been tested for an Academic Case, and succeeded allowing retrieving SSS gradients up to 1 psu/10° of latitude

Next Step:
Try a realistic scenario


[**] Talone et al., “Towards a Coherent Sea Surface Salinity Product from SMOS Radiometric Measurements and ARGO Buoys” Proceedings IGARSS 07, pp. 3959-3962
Objectives

• Simulate realistic situations

Ocean surface geophysical parameters generated using the Océan Parallélisé (OPA\(^*\)) model

SMOS-like brightness temperatures generated using SEPS (including instrument errors, calibration, image reconstruction...)

• Test the performance Level 2 and 3

30-day (1°x1°) and 10-day (2°x2°) products

• Assess the impact on the Coast Proximity Effect at Level 2 and 3

\(^*\) Mourre, B. et al., "Surface salinity response to forcing and parameter perturbations in a climatological simulation of the eastern North-Atlantic Ocean", Ocean Modelling
Introduction – Level 2 Retrieval Algorithm

SSS has been retrieved using the Level 2 Processor Simulator (L2PS), according to the minimization of the following cost function:

\[
\chi^2 = \frac{1}{N_{obs}} \sum_{n=1}^{N_{obs}} \left[ \frac{F_{n}^{meas} - F_{n}^{model}}{\sigma_{F_{n}}^2} \right]^2 + \frac{(SST - SST_{aux})^2}{\sigma_{SST}^2} + \frac{(U_{10} - U_{10aux})^2}{\sigma_{U_{10}}^2}
\]

where

\[
F = \begin{bmatrix} T_v \end{bmatrix} \quad \text{or} \quad F = \begin{bmatrix} T_h + T_v \end{bmatrix} = \begin{bmatrix} T_x + T_y \end{bmatrix}
\]

better to compute in the antenna frame, where the singularities due to the transformation from antenna to Earth frame are avoided.

Same models used in the forward model (SEPS) are used to compute \( F_{n}^{model} \).
Introduction – The External Calibrations

Using the auxiliary data as input to compute a brightness temperature image. The mean of the difference between the measured temperature and the modeled one is considered bias:

$$\Delta T_B = \langle T_B^{meas} (SSS_{orig}, SST_{orig}, U_{10orig}, \theta) \rangle - T_B^{mod} (SSS_{aux}, SST_{aux}, U_{10aux}, \theta)$$

The new brightness temperature is given by the subtraction between the measured brightness temperature and the bias: $$T_B^{corrected} = T_B^{meas} - \Delta T_B$$

Once the Sea Surface Salinity map is retrieved, to correct for the errors introduced by the forward models inaccuracies ($\varepsilon_r$, sea state dependence…), a Calibration Factor is calculated as in rain radar[*]:

$$CF = \frac{\langle SSS_{inst} \rangle}{\langle SSS_{retr} \rangle}$$

The CF has been calculated taking into account only the points observed more than 40 times (eliminating the noisiest points).

The final retrieved SSS is thus given by: $$SSS_{corr} = CF \cdot SSS_{retr}$$

Introduction – The External Calibrations

“True” Data → SEPS

Brightness Temperatures

Auxiliary Data → External Brightness Temperature Calibration

External Salinity Calibration

χ²

L2PS

Instant. Data

Sea Surface Salinity Maps
Three data-sets have been defined

- **Real Data** (SEPS forward models)
- **Auxiliary Data** (a priori information)
- **Instantaneous Data** (in situ data)

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**Real Data**
- SSS - OPA
- SST - OPA
- WS - ECMWF year 2000

**Auxiliary Data**
- SSS - Levitus
- SST - Levitus
- WS - NCEP-CORE year 2000

**Instantaneous Data**
- SSS – Argo(OPA) + VOS(OPA)
Simulation Settings

OPEN-OCEAN

\[ \text{latitude} \in (27W, 41W) \]
\[ \text{longitude} \in (9N, 27N) \]

From March 1\(^{st}\) to 31\(^{st}\), 2007 (SEPS-time)
64 overpasses
More than 1500 snapshots
\[ \sigma_{\text{SST}} = 0.81 \text{ K} \quad \sigma_{U10} = 1.6 \text{ m/s} \]

COASTAL

\[ \text{latitude} \in (5W, 20W) \]
\[ \text{longitude} \in (20N, 40N) \]

From March 1\(^{st}\) to 31\(^{st}\), 2007 (SEPS-time)
69 overpasses
More than 1700 snapshots
\[ \sigma_{\text{SST}} = 0.48 \text{ K} \quad \sigma_{U10} = 1.6 \text{ m/s} \]
Simulation Results - L2

OPEN OCEAN 63rd overpass – March 31st 7:47 GMT

**Only external brightness temperature calibration**

<table>
<thead>
<tr>
<th>Retrieved SSS</th>
<th>Original SSS</th>
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<tbody>
<tr>
<td><img src="image1" alt=" Retrieved SSS" /></td>
<td><img src="image2" alt=" Original SSS" /></td>
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<tr>
<td><img src="image3" alt=" Auxiliary SSS" /></td>
<td><img src="image4" alt=" Error in SSS" /></td>
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- mean error 0.203 psu
- std.dev 0.789 psu

**Both external brightness temperature and salinity calibration**

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<td><img src="image6" alt=" Original SSS" /></td>
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<tr>
<td><img src="image7" alt=" Auxiliary SSS" /></td>
<td><img src="image8" alt=" Error in SSS" /></td>
</tr>
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</table>

- mean error 0.003 psu
- std.dev 0.789 psu

Retrieved SSS

Auxiliary SSS

Error in SSS
Simulation Results - L2

COASTAL ZONE 19th overpass – March 9th 19:11 GMT

Only external brightness temperature calibration

Retrieved SSS  Original SSS

Auxiliary SSS  Error in SSS

no. of samples

error [psu]

mean error -0.30 psu std.dev 1.27 psu

Both external brightness temperature and salinity calibration

Retrieved SSS  Original SSS

Auxiliary SSS  Error in SSS

no. of samples

error [psu]

mean error -0.02 psu std.dev 1.28 psu
Simulation Results - L2

OPEN-OCEAN

COASTAL

Only external brightness temperature calibration

Both external brightness temperature and salinity calibration
Simulation Results – Open Ocean

10-day L3 (1st-10th of March) 2°x2°

Original SSS

Retrieved SSS

SSS Retrieval Error

Error statistics

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</table>

Error statistics:

- Mean error: -0.20 psu
- Std. dev: 0.26 psu

- Mean error: -0.16 psu
- Std. dev: 0.26 psu

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Simulation Results – Open Ocean

30-day L3 1°x1°

Original SSS
Retrieved SSS
SSS Retrieval Error
Error statistics

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<td>-30</td>
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</table>

Error [psu] statistics:
- Mean error: -0.16 psu
- Standard deviation: 0.16 psu

Mean error: -0.16 psu
Standard deviation: 0.16 psu
Simulation Results – Coastal

10-day L3 (1\textsuperscript{st}-10\textsuperscript{th} of March) 2°x2°

Original SSS

Retrieved SSS

SSS Retrieval Error

Error statistics

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<th>No. of samples</th>
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<td>Mean error -0.15 psu</td>
<td>Std.dev 0.33 psu</td>
</tr>
<tr>
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Simulation Results – Coastal

30-day L3 1°x1°

Original SSS

Retrieved SSS

SSS Retrieval Error

Error statistics

Latitude [°]

Longitude [°]

Latitude [°]

Longitude [°]

Latitude [°]

Longitude [°]

Latitude [°]

Longitude [°]

Error [psu]

No. of samples

Mean error -0.27 psu std.dev 0.30 psu

Mean error -0.20 psu std.dev 0.30 psu
The coast proximity effect at Level 2 – error r.m.s.
2D histogram error vs distance & number of observations

The error r.m.s. decreases just 5% (~0.15 psu over 3 psu) in the zone closer to the coast.
Simulation Results – Coast effect

The coast proximity effect at Level 2 – Mean Error
2D histogram error vs distance & number of observations

The mean error improves by 10% (~0.1 psu over 1 psu) when N > 30 observations
Simulation Results – Coast effect

The coast proximity effect at Level 3 – 10-days product

Performance improves only of a few % of psu (2-4%)

Only external brightness temperature calibration

Both external brightness temperature and salinity calibration
Simulation Results – Coast effect

The coast proximity effect at Level 3 – 30-days product

Performance improves only of a few % of psu (2-4%)
Conclusions

L2 Products:

- External Salinity Calibration remarkably reduces the retrieved SSS mean error, while std error remains constant.

- Coast proximity degrades the performance of the SSS retrieval (std error) by factor 1.5 – 2: large errors (> 1.5 - 2 psu) found up to 150 km from the coast.

- External Salinity Calibration slightly decreases the error induced by the coastal proximity: 10% for mean error and 5% for rms.

L3 Products:

- Mean error is reduced by 25% for 10-day products and 10% in 30-day ones.

- The impact of the External Salinity Calibration on the Coast Proximity effect is negligible (2-4 %)

- L3 mean error dominated by std error at L2

- L2→L3 averaging techniques not fully optimized: physical constraints not yet included, all pixels are considered so far….
Thank you very much for your attention!
error [psu]

no. of samples

mean error -0.16 std.dev 0.31

Tb

10 days Open-Ocean

no. of samples

mean error -0.20 std.dev 0.32

Tb + SSS
Error [psu]

No. of samples

Mean error -0.16
Std. dev 0.18

1 month Open-Ocean

Tb + SSS
error [psu]
no. of samples
mean error -0.16 std.dev 0.48

error [psu]
no. of samples
mean error -0.23 std.dev 0.48

Tb + SSS
10 days Coastal
Tb

no. of samples

mean error -0.20 std.dev 0.37

Tb + SSS

1 month Coastal