Generating SMOS Sea Surface Salinity maps with the help of Data Assimilation

Joaquim Ballabrerà, Nina Hoareau, Marta Umbert, Justino Martínez, and Antonio Turiel
Institut de Ciències del Mar (ICM), SMOS-BEC (Barcelona Expert Center, Spain)
Contact: joaquim@icm.csic.es

1. Introduction: The European Space Agency’s Soil Moisture and Ocean Salinity (SMOS) mission was launched on November 2009 and entered into operations phase in May 2010. SMOS provides global coverage of the Earth’s surface Ocean Salinity (OS) and Soil Moisture (SM) every 3 days with a spatial resolution of 40-50 km. Knowing the diverse problems in SMOS data (RFI, Land/Sea transition, ...) data assimilation is investigated here to study the possible improvement of Sea Surface Salinity (SSS) of SMOS, thanks to our ocean model used as an interpolator/extrapolator. All the study is focused on Macaronesian region, where both problems occur to retrieve SMOS data : RFI and Land/Sea transition effects. So this region is a real challenge to study the ability of using a simple data assimilation method (Nudging) to generate a Level 4 SSS maps from noisy Level 3 SMOS products.

2. Data: SMOS SSS (http://cp34-bec.cmima.csic.es/)

Advantages of Satellite data: - Global and systematic measure of SSS - Measure of first surface cm.
Problems of SMOS data: - RFI contamination - Land-sea transition
SMOS L3 binned product: 10 days maps spatial and temporal average, every 3 days with 1/6° resolution

3. Primitive Equation Model: OPA-NEMO

Basic characteristics of TARIFA03 configuration:
- Physical domains: Boundaries: 45°W-5°E, 15°N-44°N
  - First grid: 128 x 100 x 31
  - Spatial resolution: 1/6° x 1/6° x 50 m (at the equator)
  - Time step: 1800 s (48 time steps/day)
- Parameters:
  - Horizontal turbulent diffusivity: 300 m² s⁻¹
  - Horizontal turbulent viscosity: 1.2 x 10⁻⁷ m² s⁻¹
  - Deep vertical diffusion: 10⁻⁷ m² s⁻¹
  - Surface vertical diffusion: 10⁻⁷ m² s⁻¹
  - Vertical turbulent mixing: TKE model

4. Assimilation scheme: Nudging

\[
\frac{dx}{dt} = \text{Physics} + k (x^0 - x)
\]

- A Relaxation term is added into the equation of evolution of a prognostic variable (in our case SSS).
- The nudging term tends to reduce exponentially the distance between model and observations.

Nudging coefficient is \( k = 5.10^{-4} \)

5. Pre-process the data before assimilation?

- Given the low quality of the regional estimates of SMOS SSS, we fit the SMOS data onto the EOFs of the model SSS.
- Compare the impact of such pre-process, no correspondence appears between the zonal variability of the original binned data and the fitted one, not even in the centre of the domain, where the SMOS binned fields is supposed to have smallest error.

6. Results

- All data assimilation experiments drive the system with the same model of the SMOS original data (binned). Comparing to Argo, it is found that all the assimilation experiments produce salinity fields closer to the independent in-situ data than the original SMOS binned data.
- EXP2 (assimilation of the original SMOS data and with a nudging coefficient that is a function of space) provides the best result in term as: 1) SSS closest to the original SMOS data; while ii) significantly reducing the difference against the independent Argo SSS values.

7. Conclusion

- The results prove that Newtonian Relaxation has the potential to be used to generate Level 4 products of SMOS SSS. The simplicity of implementation, the robustness, and low cost, makes this technique well suited for its application in basin-wide or global numerical simulations.
- The resulting sea surface field has an improved geophysical coherence (not shown here) than the original binned data.

Acknowledgements
The SMOS-BEC is a joint initiative of CSIC and UPC mainly funded by the Spanish Ministry of Education and Science through the National Program on Space (ESP2007-65667-C04-01).