Towards the study of the impact of SMOS data on an ocean circulation model

Baptiste Mourre
Emilio García-Ladona
Joaquim Ballabrera
Antonio García Olivares
Jordi Font

Contribution to MIDAS-3 project nº ESP2004-00671

6th SMOS Workshop - DTU - 17 May 2006
Modelling Sea Surface Salinity (SSS) is not an easy task.

Influence of various processes: ocean advection, evaporation/precipitation, vertical mixing, …

+ Need for parametrizations: evaporation, vertical turbulent fluxes, …

Relaxation to climatological SSS to avoid model SSS drifts.

Many drawbacks in this approach:
- no physical justification
- surface control only
- prohibits salt budgets in the model
- need to rely on climatological sss

Other approach: SSS data assimilation. Limitation: lack of data.

SMOS observations will make it possible!
State of the art of SSS data assimilation:


- Importance of salinity correction in assimilation schemes…
  BUT very few experiments due to the scarcity of SSS data.

  Recom.: Every observation provided with its associated error estimate.
  Use of dynamic and multivariate assimilation schemes.

First impact studies in the Mercator operational system (SMOS WP3300, Tranchant & Testut 2005).

- Assimilation of SMOS L2 products => satisfactory improvement in the model.
  Level 2 products more appropriate than level 3 products.
  Weaker impact of Aquarius data (reasons still to be investigated, resolution ?).
Our objective = to pursue this direction:

- Investigate SSS model errors.

  Their nature/shape determines the proper way to assimilate SSS data in the model.
  
  *What influence in the vertical/horizontal? on other model variables?*
  *Stationary/evolving influence?, ...*

- Assess the impact of SMOS data when assimilated in an ocean model.

Work in progress! – first steps here:

- Configuration of the OPA model.
- Model SSS variability.
- Model sensitivity to the SSS relaxation term.
Study area: eastern North-Atlantic subtropical gyre

- SSS temp. variability ~ 0.1/0.2 PSU
- area of SMOS validation
- other teams working on the dynamics of this area with compilation of in-situ data
- coastal upwellings
OPA9.0 model (Océan Parallélisé)

- Regional configuration with open boundary conditions.

- Spatial resolution: 0.5º
  31 vertical levels (10-m resolution in the mixed layer)

- TKE scheme for vertical physics.

- Model initialization with Levitus climatology.
  Wind forcing, heat and freshwater fluxes from ECMWF model.

- SSS relaxation removed.

- Mensual climatology built from 5 years of simulations after a 10-year spin-up.
Influence of SSS relaxation

Context

Model

SSS

OPA model

Levitus climatology

Model and area

Conclusions
Influence of SSS relaxation

Context

Model and area

Conclusions
Mediterranean water

Introduced at east open boundary.
Towards data assimilation: correlation scales of model error?

First insights here: horizontal decorrelation scales for the SSS OPA/Levitus misfit.

SSS (OPA) – SSS (Levitus) [January] PSU

Autocorrelation SSS 20N

975 km
**Context**

**Model** and area

**Influence of SSS relaxation**

**Conclusions**

---

**SSS OPA/Levitus misfit**

**January**

**July**

- **decorrelation scale of SSS misfit (km)**

- **SMOS cell (200x200km)**

- **PSU**

- **Latitude (deg N)**

- **Longitude (deg W)**
SSS OPA/Levitus misfit: time evolution

SSS (PSU)

Levitus

OPA

SSS

Model and area

Influence of SSS relaxation

Conclusions

Context
Usual way to reduce the misfit: introduction of a relaxation term in the salinity equation.

Surface fresh water flux [Evaporation – Precipitation] (EMP) modified:

\[ EMP = EMP_0 + \gamma^{-1} \left( SSS_{\text{model}} - SSS_{\text{Levitus}} \right) SSS_{\text{model}} \]
Influence of SSS relaxation on model salinity

In surface, reduction of the difference to climatology.
Influence of SSS relaxation on model salinity

In surface, reduction of the difference to climatology.
Influence of SSS relaxation on model salinity

\( S_{\text{no relax}} - S_{\text{relax}} \) [annual mean]

In surface, reduction of the difference to climatology.
Influence of SSS relaxation on model salinity

$\text{SSS}_\text{no relax} - \text{SSS}_\text{relax}$ [annual mean]

In surface, reduction of the difference to climatology.
Influence of SSS relaxation on model temperature

**Context**

**Influence of SSS relaxation**

$SST_{\text{no relax}} - SST_{\text{relax}}$ [annual mean]

Weak differences in surface due to the SST relaxation.
Influence of SSS relaxation on model temperature

Weak differences in surface due to the SST relaxation.
Influence of SSS relaxation on model mixed layer depth

The SSS relaxation (modification of the EMP forcing) influences the model mixed layer depth (10 to 20% for the annual mean).
Modelling Sea Surface Salinity is a particularly tricky issue. Errors introduced from model deficiencies and atmospheric forcing.

Crude (unsatisfactory) way to control model SSS = relaxation to climatological values.

- Surface control only, without physical meaning.
- Influence on salinity in depth, on temperature and on the mixed layer depth by intrinsic adjustment of the model.

SMOS data will allow a more convenient data assimilation approach!

- Misfit OPA/Levitus: ~ +/- 0.3 PSU
- Zonal/Meridional decorrelation scales: 1500 / 750 km.
- Temporal decorrelation scales large (sign of misfit locally constant).

SMOS spatio-temporal sampling suitable to control these scales.