Toward variational assimilation of SARAL/Altika altimeter data in a North Atlantic circulation model at eddy-permitting resolution: assessment of a NEMO-based 4D-VAR system

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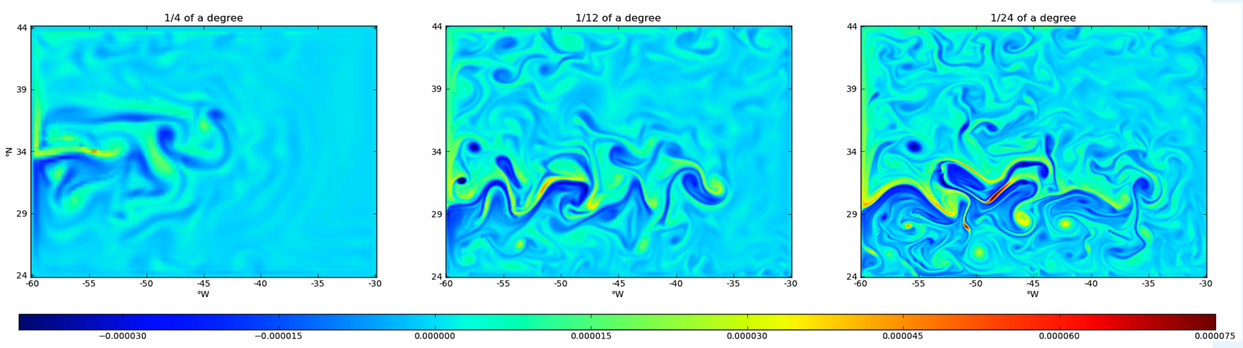
Context

In this project, the response of a variational data assimilation (DA) system based on NEMO and its linear tangent and adjoint model (NEMOTAM) is investigated using a 4DVAR algorithm into a North-Atlantic model at eddy-permitting resolution. The assimilated data consist of Jason-2 and SARAL/AltiKA dataset collected during the 2013-2014 period.

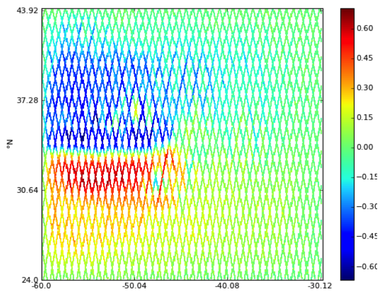
The main objective is to explore the robustness of the 4DVAR algorithm in the context of a realistic turbulent oceanic circulation at mid-latitude constrained by multi-satellite altimetry missions. This work relies on two previous studies.

First, a study with similar objectives was performed based on **academic double-gyre** turbulent model and synthetic SARAL/AltiKA data, using the same DA experimental framework. Its main goal was to investigate the impact of turbulence on variational DA methods performance. The comparison with this previous work will bring to light the methodological and physical issues encountered by variational DA algorithms in a realistic context at similar, eddy-permitting spatial resolution.

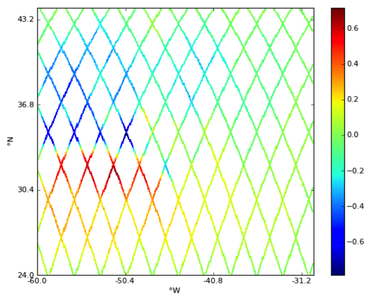


Examples of surface relative vorticity fields in SEABASS at different horizontal resolutions: from left to right 1/4 °, 1/12 ° and 1/100 °

We can notice that, thanks to NEMO-ASSIM (Bouttier et al (2012)), this academic configuration, called SEABASS (Sea Box for data ASSimilation), and will be promoted as the reference configuration for DA with NEMO.



Example of SARAL/AltiKA simulated altimeter SSH measurements in the double-gyre academic configuration



Example of Jason-1 simulated altimeter SSH measurements

Then, in the context of the OSTST and FP7 SANGOMA projects, an **ensemble DA experiment** based on the NEMO North Atlantic configuration at the 1/4 ° horizontal resolution (NATL025) and observational datasets has been realized (see [Candille et al., 2014] ; see also poster by Candille et al.). This work offers the opportunity to compare efficiency, pros and cons of both DA methods in the context of KA-band altimetric data, at spatial resolution commonly used today for research and operational applications.
Based on these studies, The present work aims at investigating:

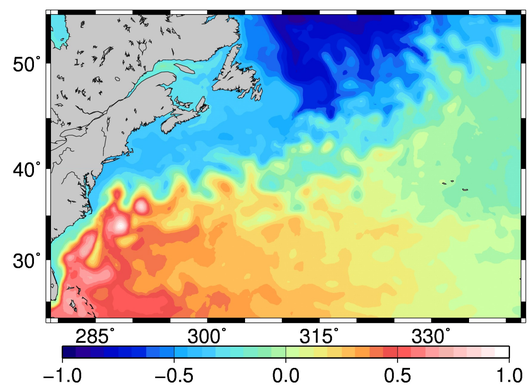
- The capability of the Incremental 4DVAR to cope with nonlinear ocean models in a realist context
- To explore the impact of various altimetric sampling (*e.g.* Jason-1 vs. SARAL/AltiKA) on incremental 4DVAR performances
- To compare pros and cons of different DA methods in a realist context (in terms of resolution and available datasets)

Experimental approach

Model The ocean model is based on the NEMO platform. More specifically, the regional configuration that we used is in the North-Atlantic region, at the eddy-permitting horizontal resolution of 1/4 °. The realistic model used for this experiment is the North Atlantic DRAKKAR configuration of NEMO version 3.4 (called NATL025).

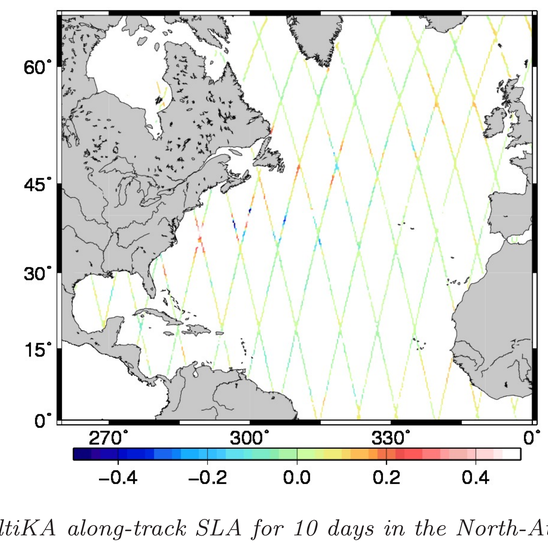
This model has a free surface formulation and the prognostic variables are the three-dimensional velocity fields and the thermohaline variables. The model domain covers the North Atlantic basin from 20 ° S to 80 ° N and from 98 ° W to 23 ° E. The horizontal resolution is 1/4 ° where the Rossby radius of deformation is about 50km. Lateral mixing of momentum and tracers is modelled with a biharmonic operator. Vertical mixing is modelled by the TKE turbulence closure scheme, and convection is parameterized with enhanced diffusivity and viscosity. The forcing fluxes are calculated through bulk formulations, using the ERA40 atmospheric forcing fields, which is considered as eddy-permitting in the mid-latitudes

Experimental approach (cont'd)



Snapshot of simulated NATL025 SSH (in m)

Data The SLA data we want to use in this experiment are Jason-2 and SARAL/AltiKA along-track products. They are taken from the period june 2013 - december 2013. On this period, we also use ARGO profiles (temperature and salinity variables, hereafter denoted T/S) provided by the UK-MetOffice.



SARAL/AltiKA along-track SLA for 10 days in the North-Atlantic region

For comparisons against observations and for assimilation process, the NEMO OBS module (see[Bouttier et al., 2012]) is used to compute the model-equivalent at observation time and location. Actually, NEMO OBS projects - by linear interpolations - the model outputs into the observation space at the exact observation time and location.

DA system The variational DA system we planned to use is the NEMOVAR framework. NEMO linear tangent and adjoint models (NEMOTAM, see [Vidard et al., 2014]) are used to compute the cost function gradient. **B** is parametrized according to [Weaver et al., 2005].

Objectives

There three main objectives in studying the results of that DA experiment.

First, we want to qualify and quantify the intrinsic performances of variational DA methods in such a realist context in terms of model and observation. To achieve this goal, we will compute many diagnostics based on the analyzed trajectory after DA experiment, such as RMSE, error power spectrum.

In comparing these results to those obtained on an academic double-gyre configuration and synthetic data, we will study the impact of realist ocean characteristics on variational DA methods (such as bathymetry, forcing, advanced vertical diffusion parametrization for example). This could be very useful to know the relevance of methodological studies regarding realist contexts.

Finally, thanks to Candille et al work, based on the same expeimental framework (except DA method), we will have the opportunity to compare pros and cons of both DA methods (SEEK with localization and Incremental 4DVAR) in a realist and present oceanic context (in terms of resolution and available data). This study is particularly relevant to help designing future DA systems for operational oceanography centers.

References

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