Impact of non-linearities on an incremental 4D-VAR data assimilation method in a high resolution numerical ocean model

Pierre-Antoine Bouttier[a], Eric Blayo[b], and Jacques Verron[c]

[a] *MEOM/LGGE, CNRS, France, Pierre-Antoine.bouttier@imag.fr,* [b]*MOISE/LJK, Université de Grenoble, France,* [c] *MEOM/LGGE, CNRS, France.*

A current stake for numerical ocean models is to adequately represent meso- and small-scale activity, in order to simulate its crucial role in the general ocean circulation and energy budget. It is therefore also a challenge for data assimilation (DA) methods to control these scales. However this small-scale activity is strongly linked to the nonlinear character of the flow, whereas DA methods are generally much less efficient in such contexts than in (almost) linear ones.

The purpose of this poster is to address this problem specifically, by exploring the behavior of an incremental 4D-VAR DA method in a non-linear ocean model, based on NEMO and NEMOVAR modeling frameworks. A series of experiments assimilating simulated altimeter data in an idealized Gulf Stream-like configuration of the NEMO model at increasing resolutions (which is a proxy for increasing nonlinearity) are analyzed.

We present in particular results characterizing scales and structures of the analysis error along the assimilation process, as well as tentative links with small scale activity. In order to study qualitatively and quantitatively the convergence of the algorithm and the structure of analysis and forecast errors, a wide spectrum of diagnostics has been employed: classical spatial and temporal RMSE, cost function characteristics, projection of error fields on model EOFs, characterization of the validity of the tangent linear hypothesis, etc.

In our experiments, it appears that the incremental 4DVAR algorithm is mainly sensitive to two factors: the length of the assimilation window and the number of inner loops during the minimization process. If both parameters are overestimated, increments produced by the DA algorithm are of excessive amplitude, which leads to the degradation of the validity of the linear tangent hypothesis. An optimally tuned eddy-permitting experiment, with two-month assimilation windows, is presented, which gives quite good results in terms of analysis and forecast error reduction.

Moreover we investigate some particular strategies for DA in such nonlinear contexts, with the aim of reducing the analysis and forecast errors. First we present the performance of quasi-static incremental 4DVAR for improving the algorithm convergence for long assimilation windows. Second we present preliminary experiments on observations filtering techniques based on model characteristics (*e.g.* EOF), to take into account the representativeness error in our DA process.