

SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Optimization of the OceanVar oceanographic data assimilation system for high-resolution applications
Computer Project Account:	spitstor
Start Year - End Year :	2015 - 2017
Principal Investigator(s)	Andrea Storto
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Other Researchers (Name/Affiliation):	Isabelle Mirouze Andrea Cipollone Raffaella Farina

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

The project aimed at optimizing the OceanVar variational ocean data assimilation scheme. We aim at improving the memory consumption and computational resources required by OceanVar and increasing its scalability focussing on the optimization of the horizontal operator that models horizontal background-error correlations. An improved version of the recursive filter operator that model horizontal correlations was implemented in global high-resolution (eddy-resolving) configuration. Such an improved operator takes advantage of a rigorous newly formulated mathematical framework, thanks to which we are able to avoid the use of extension zones in the west-east wrapping and inland ghost points to impose cyclic and land-sea lateral boundary conditions, respectively. Furthermore, the OceanVar 3DVAR scheme has been extended to a hybrid (ensemble/variational) 4DVAR formulation, and the ECMWF HPC resources were used to assess and enhance the computational performances of such a new and demanding scheme.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

Contrary to what was expected, we have been using local computing resources for testing the new filter formulation that led to the scientific publication of Mirouze and Storto (2016) (see below the reference). Furthermore, we used part of the resources allocated for the current year to test parallel performances of new extension of the OceanVar data assimilation system. Resources were under-used, due to the fact that they were enough only to run small tests and not full experiments.

Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

We found the Application procedure and progress reporting particularly user friendly and easy and quick to perform

Summary of results

(This section should comprise up to 10 pages and can be replaced by a short summary plus an existing scientific report on the project.)

A new formulation of the recursive filter has been set up and implemented in OceanVar, and successfully tested in a $\frac{1}{4}$ degree configuration of the global ocean data assimilation system used at CMCC. The scientific achievements are documented in details in the article reported below. Cyclic and land/sea boundary conditions have been reformulated analytically through the inclusion of a corrective term corresponding to the use of Neumann or Dirichlet boundary conditions. This strategy replaced the former strategy, where an extension zone with duplicated observations was used to impose cyclic conditions, and “ghost points” (i.e. inland extension of the computational domain close to shoreline) were used to handle the land/sea boundary conditions. The new strategy, implemented and tested in the $\frac{1}{4}$ degree global configuration of OceanVar, not only proves more accurate with respect to the previous one, but also improves the memory consumption and the computational time required by OceanVar.

We used the resources allocated for the third year to test parallel performances of new extension of the OceanVar data assimilation system, which now allow for a simplified four-dimensional hybrid formulation (ensemble/variational) of the variational data assimilation problem. Measuring performances appears crucial, as the new 4dvar scheme is about 20 times more expensive than the previous 3dvar scheme. In particular, as the system is hybrid MPI-OpenMP parallel, we tested different configurations of processes / threads. These tests were performed for a coarse resolution configuration (global 2x2 degrees of horizontal resolution, with 31 vertical levels) of the 4dvar data assimilation scheme. We found out that on cca, hyperthreading can save around 10% of wall-clock time for our hybrid parallelization, while further increase of threads is detrimental to the final computational time.

List of publications/reports from the project with complete references

Mirouze, I. and Storto, A. (2016), Handling boundaries with the one-dimensional first-order recursive filter. Q.J.R. Meteorol. Soc.. doi: 10.1002/qj.2840

Andrea Storto; Paolo Oddo; Andrea Cipollone; Isabelle Mirouze; Benedicte Lemieux-Dudon: Extending an oceanographic variational scheme to allow for affordable hybrid and four-dimensional data assimilation. Accepted. Ocean Modelling

Future plans

Submission of a project for the period 2018-onwards is under consideration