NEMO Long Term developments

CMCC White Paper

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In the process of defining the strategic long term evolution of NEMO, three main issues have been identified: Strategic, Scientific and Software Infrastructure.
The Strategic issues have the main objectives to improve and strengthen the impact and benefits of the NEMO consortium. This process involves developing further the role of the "consortium" approach and its goals together with a specific effort to address the evolution of ocean modeling and staying at the forefront of scientific research.
The Scientific issues concern the representation of missing ocean processes and environmental dynamics directly influencing the ocean. In addition a dedicated effort should be focused on the definition of on-line diagnostics that may represent a considerable added value.
The “Software Infrastructure” issue is mostly related to the interconnection between the NEMO package and the computational hardware.
In the following list details are provided for each of the above mentioned issues.

Strategic issues

In a community model several individuals are encouraged to participate in ongoing interaction designed around a common purpose. In general, a community model should grow organically from the needs of the members and will gradually take shape over time as the community grows. We suggest taking into considerations all the following issues in order to reinforce the Consortium and make NEMO more visible and used by a wider user community. The PRACE initiative is gaining momentum and we would like to see more applications of NEMO proportional to its role in the ocean modelling community.

1) ***Community configurations***
In order to gain a wider attention, NEMO should contain more up-to-date community configurations in addition to the historical reference configurations. Up to now only ORCA2 can be considered as a community configuration since it is used by a wide community. However it is of limited use with high-performance computing and other more challenging state-of-the-art configurations should be provided. This lack of community configurations will be necessary to make a better use of the PRACE resources. Specific regional configurations may also be given if maintained by interested consortium members.

The consortium should also consider the overarching issue of NEMO applications: should it be a global model that allows to resolve regional processes but not coastal dynamics that involve substantial code changes (for instance, to include unstructured grids, etc.)? How and where do we fix the resolution threshold? This depends very much on which community we want to target.

2) Coupling with other models

There is often the need to couple NEMO with other existing models. The coupling interface should be generalized. An alternative to the development of NEMO for very high-resolution coastal application might be to develop new tools (interfaces) in order to facilitate the coupling with different coastal models (finite elements, etc).

2.1) Climate modeling

The major requirement in this application will be to simplify the coupling with models of other components of the Earth system by developing a more generic interface. Now it exists for the atmospheric component and the biological model. We would like to support a fully flexible ocean component in order to facilitate the coupling with other modules of the Earth System.

2.2) Coastal applications

We use NEMO in the Adriatic and Ionian Seas with the horizontal resolution of 2km and 120 levels in order to provide short term forecasts and boundary conditions for coastal models. In the future these applications will require an improved application of boundary conditions in NEMO based on the BDY code and the extraction of NEMO points along the boundaries of the coastal model that may be unstructured. Furthermore, it may be necessary to apply the two-way coupling with high resolution NEMO along the coast by applying the AGRIF, or even a novel more general method for unstructured grids.

3) Training strategy

Dedicate more effort in the Training with specific fund-raising actions. This is seen as a way to increase as much as possible the number of NEMO users (and NEMO community configurations users).

4) Publication strategy

Define and support a consortium-wide publication strategy. There is already ongoing work in this direction but we suggest further and a more regular commitments.

5) Appropriate documentation and user support

There is the need to improve the current manual that is becoming rather cumbersome and less useful to users. It may be wise to launch a series of NEMO technical reports that contains the additions to the main code with more specific details. There may be more technical documents (also web pages) that contains how-to's to improve the user support that is rather weak at the moment.

Scientific issues

1) Data Assimilation
We envisage the application of novel observational operators and improved initialization techniques.

2) Forecasting
Forecasting systems will require sophisticated schemes for the generation of ensembles. New procedures for the perturbation of initial states, boundary conditions and model equations should be developed in the next years.

3) Wetting and drying scheme
For paleoclimate applications there is the need to start from the experience developed in the coastal applications in order to implement a way to have movable land-sea boundaries.

4) Overflows of dense waters
Coarse to eddy-resolving resolutions still present a weak representation of the overflows, with the result that deep waters and deep western boundary currents are poorly simulated. A better representation of characteristics and position of local water masses over the Greenland-Scotland ridge, for example, might highly impact the water masses and circulation in the Irminger and Labrador Seas and possibly the MOC. How to improve the oceanic overflow properties in NEMO should be further investigated. A new parameterization strategy should be pursued.

5) Closure of the fresh water budget for global applications
A typical problem of NEMO in global configurations is the strong impact of out of balance input fresh-water fluxes on sea-level. At the moment the problem is partially solved applying an ad-hoc and rough correction in order to close the budget. As the Earth's climate varies through natural and man-induced causes, there is a potential for redistribution of water on Earth, and acceleration of the global hydrological cycle. Even if the understanding of the global water cycle is maybe beyond the scope of NEMO we believe that a significant effort should be devoted to improve the way in which the problem is currently approached.

6) Ice shelf-ocean interaction
Developing NEMO skills in modeling the interaction between ice shelves and seawater will be a major step towards understanding what controls the pace of the current changes in Antarctic and Greenland outlet glaciers. Cavities under ice shelves should be incorporated into the ocean model. How to resolve the ice sheet/sea water interface should be investigated.

Software infrastructure

1) HPC evolution/Performance/Efficiency

We will constantly work on improving the performance of NEMO on supercomputers. Now we apply NEMO with configurations using thousands of cores and we have already started to test it with tens of thousands of cores. This is one of our major development lines and we will continuously improve the model's performance on different hardware configurations. NEMO should be maintained at the forefront of the computational technology available to the consortium members. A set of performance tests should be designed to demonstrate the model capabilities. Past experiences with different combinations of compilers/architectures should be collected in a public database for users and developers.