Preparing NEMO and EC-Earth models for very high-resolution production experiments

Miguel Castrillo (BSC), Dorotea Iovino (CMCC), Clement Bricaud (Mercator Ocean)

Recent studies have established that the typical atmospheric and oceanic resolutions used for the CMIP5 coordinated exercise (Coupled Model Intercomparison Project, phase 5), i.e., around 40km-150km globally, are limiting factors to correctly reproduce the climate mean state and variability. In the context of ocean forecasting like the Copernicus Marine Environment Monitoring Service (CMEMS, https://marine.copernicus.eu/), increasing resolution appears necessary to improve the quality of service and to satisfy the users' needs in the operational application.

Resolving scales below 100 kilometers, particularly submesoscale processes (1-50 km), is necessary to better represent the circulation in the open ocean and improve the large-scale representations.

Therefore, Ocean General Circulation Models (OGCM) have to evolve to resolve the global ocean flows at kilometric scale by exploiting massively parallel architectures and reducing I/O bottlenecks. In the framework of the ESiWACE project, unprecedented configurations with resolutions in the range of 1km-10km were developed for some of the more supported European climate models, like NEMO or EC-Earth.

In the EC-Earth case, the Barcelona Supercomputing Center (BSC) developed a coupled version of the EC-Earth 3 climate model at a groundbreaking horizontal resolution of about 15km in each climate system component. This very-high-resolution (VHR) configuration was used in the Glob15km project to run multi-decadal experiments that are currently being used in the STREAM project to identify the improvements in process representation with respect to coarser resolution model versions.

Within the ESiWACE2 project, new versions of the so-called demonstrators are being developed to allow operational climate predictions at more than one simulated year per day (SYPD) with production-mode configurations. In the case of EC-Earth, the most critical scalability problems have been tackled in the new EC-Earth 4, based on OpenIFS cycle 43r3 and NEMO 4, and the new Tco639-ORCA12 configuration uses a cubic octahedral grid in the atmosphere. In EC-Earth 4, both the atmospheric and the oceanic component output diagnostics through asynchronous XIOS servers, contributing to reduce the I/O overhead and improving scalability, which will be evaluated at one of the forthcoming pre-exascale EuroHPC systems.

In the NEMO context, a new global configuration (called ORCA36) has been developed with a 2-3 km resolution (1/36°). It is run with NEMO 4 OGCM and asynchronous XIOS servers. ORCA36 is forced by the high spatial resolution ECMWF IFS dataset at one-hour time frequency, which will improve ocean prediction, but will affect the time-to-solution. The use of a finer spatial resolution also implies that a smaller time step has to be used.

Running such a global high-resolution configuration will increase the computational needs, the size of model inputs and outputs and requires writing model outputs at a higher frequency. In order to reach a good time-to-solution, in the framework of ESIWACE 2 project and also the IMMERSE H2020 project, new HPC features have been developed in the NEMO OGCM to improve its scalability and will be tested on ORCA36 configuration.