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Parallel optimization of IPSL climate model

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Earth system models used to understand climate change and its underlying mechanisms are becoming more and more complex : current climate models incorporate ocean, sea ice, land, vegetation components and possibly the carbon cycle, the atmospheric chemistry, and other processes as well. They are used for future climate projections (for example, by the IPCC – Intergovernmental Panel on Climate Change) and paleoclimate modelling (PMIP 3 intercomparison project). The present IPSL (Institut Pierre Simon Laplace) model couples four components of the Earth System : LMDZ for atmospheric dynamics and physics, NEMO for oceanic component (ORCA for ocean dynamics, LIM for sea-ice dynamics and thermodynamics), and ORCHIDEE as the land surface component. It can include a full carbon cycle component, as well as a model of the atmospheric chemistry and aerosols. The OASIS coupler is used to synchronize, interpolate and exchange fields between atmospheric and oceanic components.

High Performance Computing is needed to run these models. Their use to produce climate simulations is continuously becoming more computationally expensive, because the climate modelling community is progressively targeting both higher model resolutions and the study of new physical processes. IPSL works on the optimization of its coupled model, in particular to increase the resolution and to take advantage of the current and future high performance computing platforms.

The set up of high resolution configuration of IPSL climate model started at BSC-MareNostrum (IBM PowerPC CPUs). A test configuration allowed us to evaluate the performance but also the problems encountered when the resolution of each component is increased and the components are coupled together. The configuration was atmosphere-land surface LMDZOR 280x280x19 on 72 cores (MPI parallelization) coupled to ocean-sea ice NEMO 1/2 degree (511x722x31) on 20 cores (MPI parallelization). This kind of architecture imposes some constraints on our models and limits their performances : low memory available per node, scalar processors with low frequency calculation, moderate MPI scalability. Then, we worked at GENCI-CINES-Jade (SGI Xeon CPUs), on setting up a configuration at higher resolution: 1/4 degree ocean model (1442x1021x75) and 1/3 degree atmosphere model (768x768x39) using hybrid MPI-OpenMP parallelization for the atmospheric component since this kind of parallelization is the best way to use up resources available on massively parallel scalar architectures. This configuration has run on 2191 cores with MPI-OpenMP parallelization for LMDZ atmosphere (256 MPI processes x 8 OpenMP threads) , MPI parallelization for NEMO ocean (120 processes) and MPI pseudo-parallelization for OASIS coupler (23 processes). This configuration also lead us to reconsider memory scalability in LMDZ model as well as the model "Input-Output" (IO), especially in order to improve both flexibility and performance. IPSL is developing an IO library using an XML description file and based on an asynchronous way (server mode) to write out data from models to output files, currently used in NEMO reference version.