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Improving performance of effectively submesoscale resolving ocean simulations

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Ocean models constitute a fundamental component of any Earth system model. Our goal is to capture the effects of submesoscale eddies, which require a resolution below one kilometer. Global simulations over several decades for this resolution are not yet feasible even on state-of-the-art high-performance computers due to excessive runtimes.
In this presentation, we explore two strategies to enhance the performance of the ICON-O ocean model: super-resolution to reduce the required spatial resolution and parallel-in-time integration to accelerate numerical time stepping.

First, a super-resolution approach motivated by machine learning is applied to incorporate fine-scale information into coarse-scale solutions. To this end, a deep neural network is trained using pairs of high- and low-resolution simulation snapshots. Subsequently, the network is used to periodically correct a low-resolution solution towards a restriction of a high-resolution simulation. Our results demonstrate that this correction enables computations on coarser grids, achieving discretization errors that are significantly lower than what would be possible with an uncorrected coarse solution.

Second, we propose to use spectral deferred corrections (SDC), a time integration scheme that allows for higher order and larger time steps by iteratively applying a low order integrator. A parallel version of SDC has recently been proposed, facilitating an even more efficient use of the available resources. This is achieved through optimized parameters and small-scale parallelism across the method, i.e., in each iteration within one time step.

We present our approach of implementing the aforementioned ideas in the ICON-O code. Furthermore, we show recent results, which were performed on the JUWELS cluster at the Jülich Supercomputing Centre.

Primary author: Dr FREESE, Philip

Co-authors: Dr KADOW, Cristopher; Prof. RUPRECHT, Daniel; Dr LAPOLLI, Fabricio R.; Dr HOFFMANN, Lars; Dr WITTE, Maximilian; Dr KORN, Peter; Dr GÖTSCHEL, Sebastian; Dr LUNET, Thibaut; Dr LU, Yen-Sen

Presenter: Dr FREESE, Philip

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