



Gain of efficiency with a new time scheme in NEMO : Runge Kutta 3rd order

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As Ocean General Circulation Models (OGCMs) become more complex, their computational efficiency remains a crucial challenge for ocean simulations. By using smart numerical choices, however, it is possible to increase the time step of an OGCM for a fixed spatial resolution, thereby reducing the computational cost and improving efficiency. To do this we are revisiting the NEMO time-stepping scheme. Modified Leapfrog (MLF) has been used so far. We implement Runge Kutta 3rd order (RK3) from Wicker and Skamarock (2002) as an intermediate step toward a coupled space-time scheme. RK3 time stepping implemented in NEMO is a single step iterative method using a predictor-corrector like formulation. It uses three stages to integrate the model from time step n to $n+1$. During the first stage (from n to $n+\Delta t$) we build guesses of tracers and momentum using an euler time stepping : on the one hand tracers are estimated by integrating advection terms only, on the other hand momentum are estimated by integrating advection, pressure gradient and coriolis terms only. During the second stage (from n to $n+\frac{1}{2}\Delta t$) we use $n+\Delta t$ tracers and momentum fluxes from stage 1 to build tracers and momentum guesses at $n+\frac{1}{2}\Delta t$ using the same equations. The last stage integrates full equations from n to $n+1$ with $n+\frac{1}{2}\Delta t$ tracers and momentum flux guesses from stage 2. We integrate the barotropic mode from n to $n+1$ at the beginning of the time step and interpolating it linearly at $n+\Delta t$ and $n+\frac{1}{2}\Delta t$ as proposed in the accompanying paper by Lemarie et al. (2022). The new RK3 implementation is now ready to be validated in NEMO. It has been tested on most of NEMO's components : to dynamics, active tracers, sea ice, passive tracers, ice shelves, open boundaries and AGRIF zoom. Global simulations with sea ice and biogeochemistry at low resolution show that the model using RK3 is stable when doubling the time step and is almost twice as fast as MLF (80% speed up). Nevertheless, some work remains before considering RK3 as fully operational in NEMO.