Community for the numerical modeling of the global, regional and coastal ocean

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Mixed-precision sensitivity in Earth System Modelling

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The resolution of Earth System models may be substantially increased in the next decade with the emergence of exascale supercomputer architectures, provided that mathematical and algorithmic developments for these models of the atmosphere, ocean, sea-ice and biogeochemistry can adequately handle heterogeneous node architectures supporting different levels of numerical precision combined with complex memory hierarchies. This requires us to carefully test precision sensitivity in archetypal geophysical flow scenarios, review the algorithmic choices and their implementation, and build confidence in the revised or newly proposed methods when reconsidering the need of double-precision floating-point arithmetic as a default choice.

Single-precision arithmetic, for example, has been successfully applied to atmospheric models where 40% reductions of computational cost have been observed. Equally, the potential for reduction of numerical precision in ocean models has recently been explored (GMD 12, 3135–3148, 2019). Given that ocean models are, like atmospheric models, memory and communication bound, the use of single- or mixed-precision can be expected to deliver similar performance gains. For both atmosphere and ocean, there are however remaining questions regarding the impact on variables with long-timescale memory, the dependence on subtle differences in weak gradient scenarios of mixed-phase fluids, and more generally transport uncertainty, which would benefit from a systematic intercomparison of both algorithmic choices and their precision sensitivity.

Here we present preliminary results from running the NEMO model with single-precision arithmetic, focusing on its computational and forecast performance, with respect to the double-precision model. We focus on a double-gyre, mesoscale eddy-resolving test case and use this example to motivate discussions on how consistent test cases could be constructed to test different ocean model configurations. As the use of reduced precision will generate complex non-linear feedbacks in eddy-permitting ocean models, it will be essential to relate and compare changes due to a precision reduction to changes of conventional model parameters or different models entirely. This will allow us to put the model response into the context of the model's algorithmic uncertainty. We find that, in some cases, single-precision can deliver a greater than 2x speed-up with respect to double-precision.

Do you need an official invitation letter?

No

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