Stability constraints for oceanic numerical models: implications for the formulation of space-time discretizations

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Abstract

Thanks to advances in computational power, global climate models are now configured with increasingly higher horizontal/vertical resolution. The extension of the range of application of this type of model, originally developed for low-resolution large-scale configurations, raises some new challenges of numerical nature. Indeed, depending on the target application, the numerics must be adapted based on accuracy, stability and efficiency considerations. To help rationalizing the appropriate choices for a given horizontal/vertical resolution, we developed offline diagnostics to predict stability limits associated with internal gravity waves, advection, diffusion, Coriolis, and bottom drag. This suite of diagnostics is applied to a set of numerical simulations with several horizontal/vertical resolutions and different numerical models including the global NEMO ORCA 1/2°, 1/4° and 1/12°, and the regional North-East Atlantic 1/36° MARS3D and NEMO configurations. Based on those results, we review the stability and accuracy of existing numerical kernels in vogue in the ocean community for advective processes and the dynamics of internal waves. We emphasize the additional value of studying the numerical kernel of ocean models in the light of coupled space-time approaches (e.g.; Daru & Tenaud 2004) instead of studying the time schemes independently from spatial discretizations, as usually done (e.g.; Shchepetkin & McWilliams, 2005), to get a more accurate measure of the stability and numerical diffusion of a given model.