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Accurate adaptive ocean modelling using quadtrees

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Adaptive numerical modelling could provide orders of magnitude improvement to geophysical fluid flow simulations. Recently, much effort has thus been devoted to the extension of classical adaptive techniques – such as finite-elements – to oceanic flows. This has not been without difficulties due to a number of important physical properties of the oceanic system which makes it different from the engineering problems solved using existing adaptive techniques:

1. The importance of rotation on large-scale oceanic motion requires a numerical scheme with an accurate representation of geostrophic balance.

2. Long-term global energetic and tracer budgets are important. The numerical scheme thus requires good conservation properties.

3. Bathymetry/Coastlines need to be accurately represented.

We will present a new finite-volume technique based on a quadtree adaptive discretisation initially developed for incompressible flows in complex geometries [1,2]. Test cases demonstrate the accuracy of the technique for the representation of both geostrophic balance and bathymetry/coastlines. Good energy and tracer conservation properties are also obtained.

The scheme is an extension of the "approximate projection" method to the linear free-surface barotropic equation. We will show that despite being fully-collocated (A-grid), this scheme does not exhibit computational-mode instabilities even in complex, realistic cases.

The simplicity of the quadtree discretisation also makes the adaptive part of the scheme very efficient while preserving full flexibility.

[1] Gerris: a tree-based adaptive solver for the incompressible Euler equations in complex geometries. S. Popinet. *J. Comput. Phys.*, 190:572-600, 2003.

[2] The Gerris Flow Solver. S. Popinet. http://gfs.sf.net