Geosci. Model Dev. Discuss., 8, C1707–C1712, 2015
www.geosci-model-dev-discuss.net/8/C1707/2015/

Geoscientific Model Development Discussions
Open Access

GMDD
8, C1707–C1712, 2015

Interactive comment on "Adaptive wavelet simulation of global ocean dynamics" *by* N. K.-R. Kevlahan et al.

Anonymous Referee #1

Received and published: 13 August 2015

1 Overview

The authors uses the Euler-Poincaré theory to introduce a new Brinkman penalization for the rotating shallow water equations. An error analysis is performed in the linearized 1-D case and the choice of penalization parameters is discussed. A numerical model based on this new penalization and on an adaptive wavelet method is then used to simulation ocean currents with realistic coastlines and bathymetry.
The main input of the paper is the derivation of a penalized formulated that guarantees both mass and energy conservation. In addition this formulation does not modify (increase) the gravity wave speed in the solid region and so is not prone to stability issues to this respect. This formulation is valuable by itself and this paper could be accepted

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

for a GMD publication if the following comments are addressed in a revised version.

2 Major comments

- Derivation of the new volume penalization
  At several places in the paper, we don't know if the equations are written for flat or non flat bottom:
  - Page 5268, Line 17: h is used instead of η in the case of a non flat bottom.
  - The momentum equation of page 5273 is clearly not consistent with a non flat bottom (a bathymetry gradient is missing at the right hand side) (same at bottom of page 5275). It seems that the partial derivative of the Lagrangian density L (bottom of page 5272) does not take into account the varying bathymetry. States at rest should correspond to constant η and not constant h.
  - The bathymetry b is also missing in the expression of the total energy page 5276.
- Link between the penalization parameters α, ϵ.
  From the beginning, the authors state that these two coefficients are linked by $\epsilon = K/\alpha$, K being the permeability. This is mentioned as an important difference with Reckinger et al. (2012). However at several other places this statement seems to be alleviated. In order to remove confusion, it would be preferable not to assume any dependency between the two coefficients and to mention where needed the advantage (or not) to have these two coefficients linked.
- Error analysis and choice of penalization parameters

GMDD
8, C1707–C1712, 2015

- In order to make convergence comparison clear, it would be really nice to have the same analysis for the Reckinger et al. (2012) set of equations.
- For clarity, a summary of main convergence results along with main assumptions may be given at end of section 4.1. In addition, I am not sure that the (dimensional) scaling factor $\frac{c}{L}$ can be dropped from the convergence factor as it is done in the following sections. The error estimates assume that $\epsilon \ll L/c$ so that these numbers are not independent. It is essentially a question of clarity for readers. No doubt that is is clear in authors's mind. The confusion comes from the fact that the $\frac{c}{L}$ is dropped at the beginning of section 4.2 and is however required for the conclusions of section 4.3: error is $\mathcal{O}(\alpha)$ when a) $\epsilon \approx \Delta x/c$ (for stability) and b) $L \approx \Delta x$ for marginally resolved fronts (so that $\epsilon \approx L/c$). In this case the asymptotic expansion (26) is not valid but the hypergeometric function is bounded.

• Numerical 1-D experiments

- It may appear more natural to have section 4.3 before the numerical experiments of section 4.2. This would allow to understand and to comment the choices made in 4.2.
- Note that a number of important parameters are missing here: what are the values of L, H, Δt and of the Courant number ?
- The influence of the smoothing parameter Δ (or of the ratio Δ/L) is not discussed.

• Realistic experiments

- As a general comment, I appreciate the work done by the authors to apply their code to simulations with complex coastlines and bathymetry. In particular, the choice of the indicator function is well explained and makes sense. However, I have to say that, for a first experiment, I would have prefer to see

GMDD
8, C1707–C1712, 2015

the code in action on a much simpler application that still allows to evaluate the merits of the volume penalization technique and of the grid refinement features. Shallow water numerical experiments on a rotated grid (cf Adcroft (1998)) could have been a good application.

- Could the authors detailed their remark on mass conservation ? (lines 4-10 on page 5288)
- Concerning the figures illustrating section 5.3, a plot of a well-known region (e.g. Gulf Stream) would be of interest.

3 Minor comments

- The title of the paper is not really reflecting its main content. May be just adding "based on a new Brinkman volume penalization" would be sufficient.
- The introductory section should be a bit longer with an introduction to other ways of dealing with complex coastlines in ocean modeling (e.g. unstructured meshes, cut cells, other immersed boundary methods ...)
- Page 5277. Would it be possible to treat the velocity penalization term implicitly to remove the stability constraint ?
- Page 5286, lines 19-21. I agree with this remark. However in a 3D simulation, care would have to be taken in order to not remove bathymetry barriers important for the thermodynamic circulation.
- Page 5292, lines 19-24. Authors should recall here that the stability is constrained by the smallest grid size in the computational domain. All (fixed or adaptive) refinement methods that do not include local time stepping share this limitation.

4 Technical details

- Page 5269, Line 20 : $m = \phi(x)u \rightarrow m = \phi(x)hu$
- Page 5271, Line 1 : vector-invariant (?)
- Page 5276, Line 13: some explanations/reference for the reflexion coefficient R should be given
- Page 5276: Mention that H is the mean depth
- Page 5280, Line 9: $t = 1 \rightarrow t = 1/c$
- Page 5280: Mention I_0 as the modified Bessel function
- Page 5282, line 15: one) to remove
- Page 5283, line 16: Is it $t = 0.22$ or $t = 0.26$ (as written in Fig. 3 legend) ?
- Page 5284, line 5: Is it 6×10^{-5} or 7.7×10^{-5} (as written in Fig. 4 legend) ?
- Page 5284, line 6: Replace $K^{1/2}$ by $\epsilon^{1/2}$ (in agreement with the legend of Fig. 5) or write $K^{1/2} \sim \epsilon^{1/2}$
- Page 5284, line 7: Is it $K = \Delta x^2$ or $K = 4\Delta x^2$ (as written in Fig. 4 legend and on page 5282, line 20) ?
- Page 5285, line 10 "Recall that" $\rightarrow$ "Note that"
- Page 5287, wet points are here associated to b negative while they were associated to $b > 0$ in 3.1
- Starting from section 5, ϵ is replaced by η (which represents the free surface elevation before ...)

GMDD
8, C1707–C1712, 2015

References:
Adcroft A., 1998: How slippery are piecewise-constant coastlines in numerical ocean models?, *Tellus A*, 50(1), pp. 95-108.

Interactive comment on Geosci. Model Dev. Discuss., 8, 5265, 2015.

GMDD
8, C1707–C1712, 2015
Interactive Comment