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

Anonymous Referee #2

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This article presents a detailed analysis of a penalization technique to represent "vertical" coastlines in shallow-water models. The technique is then applied to an existing wavelet-adaptive finite-difference/finite-volume discretisation of the shallow-water equations and used to simulate tsunami and global oceanic barotropic circulation.

I found the manuscript clear and well-presented. The model derivation and error analysis are thorough and useful in practice. I have two major reservations however:

1) the issue of representation of coastlines (or complex boundaries) in ocean models (or more general PDE systems) discretised on fixed grids (i.e. non-boundary conforming grids) has been studied very extensively in the past. The authors do not give sufficient credit and context for their own contribution. The introduction should do a much better job of summarising this field, besides the few references already given for

penalization techniques. One could mention in particular these now "classic" (not to say "old") references:

Adcroft, A., Hill, C., Marshall, J., 1997. Representation of topography by shaved cells in a height coordinate ocean model. Monthly Weather Review 125 (9), 2293–2315.

Dupont, F., 2001. Comparison of numerical methods for modelling ocean circulation in basins with irregular coasts. Ph.D. thesis, McGill University, Montreal.

Almgren, A., Bell, J., Colella, P., Marthaler, T., 1997. A Cartesian grid projection method for the incompressible Euler equations in complex geometries. SIAM Journal on Scientific Computing 18 (5).

Popinet, S., & Rickard, G. (2007). A tree-based solver for adaptive ocean modelling. Ocean Modelling, 16(3), 224-249.

Berger, M., LeVeque, R., June 1991. A rotated difference scheme for Cartesian grids in complex geometries. In: AIAA 10th Computational Fluid Dynamics Conference. Honolulu, Hawaii, pp. 1–7.

but there are many other more recent works on this topic. I also note that both Dupont, 2001 and Popinet and Rickard, 2007 both present (semi)-analytical test cases of the accuracy of boundary representation which are more stringent than the practical examples used by the authors (as well as very relevant for the type of applications envisaged). Moreover better than first-order in space accuracy is obtained. This need at least to be mentioned in the introduction.

2) the need for "vertical" coastlines (i.e. "side walls") in ocean models is not obvious at all. As with most of earth's topography coastlines are usually not steep at all (aside from the very few areas where sheer cliffs fall into the deep ocean). In most cases assuming vertical coastlines is done to circumvent dealing with "wetting/drying" at coastlines. In itself wetting and drying is not a major theoretical difficulty for shallow-water models: fullly-nonlinear shallow-water models have been shown to be theoretically well-posed in

the limit where the water depth tends to zero. Indeed for applications such as tsunamis, the non-linear shallow-water system has been shown to describe very well the shoaling and flooding properties of long waves on coastlines. Assuming "side walls" for such applications (as is done here for the 2004 tsunami) will essentially mean giving up any results regarding the extent of flooding on the coastline, which is of course one of the main reason to do such tsunami simulations. This point needs to be discussed by the authors both in the introduction and for the tsunami example. Also, the authors need to credit previous adaptive simulations of tsunamis, such as:

Popinet, S. (2011). Quadtree-adaptive tsunami modelling. Ocean Dynamics, 61(9), 1261-1285.

and others.

Some minor comments follow:

line 15: "Smaller-scale features, such as vortices and jet meandering, are predominantly generated in the real ocean by baroclinic mechanisms which cannot be captured by a single-layer model."

I find this comment too general. On the scales the author consider (i.e. less than 1km) and close to coastlines (which is the point of the article), barotropic flows are often the main cause of vortices and jets.

line 10 p 5291: Giving clear indications of computational speed, both relative and absolute, is important since the point of adaptivity is computational efficiency. Besides the approximate runtimes already mentioned, it would be good to give the absolute speed of computation, for example using

number of (degrees of freedom/grid points) advanced / computation time / number of cores

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