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Geoscientific Model Development Discussions

Interactive comment on "Thetis coastal ocean model: discontinuous Galerkin discretization for the three-dimensional hydrostatic equations" *by* Tuomas Kärnä et al.

Anonymous Referee #1

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The manuscript is well written, and I would recommend it after the points below are addressed.

1. I appreciate the idea of reducing dissipation. However, I haven't found any special measures specifically devoted to that. The dissipation introduced through the Lax–Friedrichs flux is applied everywhere, which is approximately equivalent to saying that the Reynolds or Peclet numbers on the grid scale are about one. How dissipation related to this flux compares to the explicit dissipation introduced in the code? I think it could be a good message to community if the authors will manage to demonstrate that dissipation due to numerical fluxes in low-order DG code is not too strong. Common

wisdom in ocean modeling is that the horizontal viscosity is selected as Vh, where h is the grid scale and V about 1 cm/s. Can the authors propose an estimate of effective viscosity in their code?

2. Significant part of dissipation in coastal codes can be traced back to friction added to barotropic equation to stabilize the barotropic flow in wetting-drying regimes. I do not see this in the present model, and would recommend to comment on that in the manuscript. In two-stage procedure: I do not see that the first solve for the elevation is implicit (Eq. 46). Please clarify this place. Time step limitations: I find the discussion to be a bit superficial, the CFL limitations in 2D are not the same as in 1D, and it is net limitation of horizontal and vertical advection that matters.

3. Scalability: From Fig. 7 I can conclude that scaling efficiency is on the level of 50% already for 50 cores. The mesh used contains 5k vertices, giving 100 vertices per core. This level is very good, however it is achieved even with some finite-volume codes such as MPAS atmosphere (I do not have information on MPAS-ocean). The point is that with DG one expects more floating point operations on the local level, i. e. better scalability, which is not the case. Bad scalability of 2D solver is noteworthy and is against expectations. Is it PETSc on its own, or the assembly operations? How preconditioning is organized? Some critical analysis is needed. In recent finite-volume ocean linear scaling is maintained 300-400 vertices per core, and here I see that the DG case it is not any better! Of course it depends on interconnect, but I do not see the message I expected: that DG codes scale better than FV ones.

4. Finally, the performance. For me the numbers are really disappointing. First, I would like to see how it compares to previous efforts (SLIM, UTBEST or like). Is there any progress in computational efficiency of DG codes? Second, please compare the throughput of Thetis to the throughput of other unstructured-mesh codes (MPAS, FV-COM, SHCISM, FESOM). There are some published data. My very crude estimates give a factor from 20 to 100. I am not willing to use this as an argument against; on the contrary, I would like to propose to critically analyse the performance and try to answer

why DG codes are that slow and what are the promises. In most cases it is the writing into memory or taking data from memory that limits the performance. Is it the mere enhanced size of DoF in DG codes? I think it would be a very valuable addition. Then, there is a question on effective resolution. Does the much larger number of DoFs in DG leads to better effective resolution than say MPAS approach? I do realize that the last question deserves a separate study and is not in the scope of GMD, but once again, I am missing the perspective. On the practical level of using the codes a user would be interested in throughput. It can be reached (i) directly or (ii) through better scalability or (iii) through better effective resolution. Is there any hope that a combination of these would make the DG codes same practical as their FV counterparts?

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