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Interactive Comment

Interactive comment on "Non-orthogonal version of the arbitrary polygonal C-grid and a new diamond grid" *by* H. Weller

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Comment: The above calls for an analysis of the accuracy of the asymmetric and symmetric H operators in isolation. This would help interpreting the numerical results obtained for the whole shallow-water scheme, especially the differences observed when only the operator H differs between two experiments.

Reply: Excellent idea. I will do this.

Comment: Ideally one would also like to have some indications of the truncation error of both H for nearly-orthogonal quadrilateral meshes, for instance a planar mesh made of identical parallelograms. This would shed light on the role of the off-diagonal terms of H.

Reply: Great idea. I will do this too. As parallelograms tend towards rectangles, the symmetric H tends towards diagonal. It is on the orthogonal hexagonal/triangular meshes that the symmetric H is not diagonal. I will describe this also.

Comment: 3.2.1 The test flow (solid-body rotation) is solenoidal, it may be useful to do a similar convergence study (Fig. 5) with an irrotational flow, e.g. ulat = cos(φ), ulon = 0.

Reply: Good plan. I will do this.

Comment: It should be mentioned that the symmetric H does not become diagonal when used on an orthogonal triangular/hexagonal C-grid but does become diagonal when used with an orthogonal Cartesian C-grid.

Reply: Yes, this should be mentioned. I will do this

Comment: Is (14-15) Perot's reconstruction?

Reply: No, it is slightly more complicated than Perot's reconstruction. I have not compared this reconstruction and Perot's reconstruction but I think they have some of the same asymptotic properties. I would rather not go into this as I think it would add too much length.

Comment: Section 4 : I understand the linearized (unnumbered) equations are integrated over one time step using (21-22) and the eigenvalues μ of this operator are computed, stability being indicated by $|\mu| \leq 1$. It may be useful to express the same information in terms of log $|\mu|$ or log $|\mu|$/dt especially for $|\mu|$. In fact since the time stepping is slightly dissipative it would be nice to see directly the (real part of) eigenvalues of the linearized operator without the time integration (e.g. eigen-values of L where (du/dt, dh/dt) = L.(u, h)). Although in practice what matters is the stability of the whole spatial + temporal scheme it would be interesting to know whether L really has only eigenvalues on the left of the imaginary axis (despite the lack of energy conservation) or maybe a few have a slightly positive real part.

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Reply: I will number these equations. I would be very happy to plot log $|\mu|$/dt and to investigate the sensitivity to time step and to the number of iterations updating the Coriolis each time step thereby removing the dissipative nature of the time-stepping (as suggested by John Thuburn). However I am reluctant to calculate the eigenvalues of the linearised operator without the time integration as this would be significantly more work. I would not be able to use the numerical model to do this.

Comment: What happens to this linear stability analysis if the TRiSK perp is replaced by the consistent perp (Eq. 16) ?

Reply: I have tried replacing the TRiSK perp by a consistent perp in the shallow water model and it runs stably but gives much worse numerical results due to the lack of stationary geostrophic modes and lack of energy conservation. I would rather not go into this in this paper.

Comment: Section 6 : Since much of the discussion is about the relative merits of symmetric vs asymmetric H it would be useful to have a direct assessment of their accuracy, e.g. something similar to Fig. 5 with H instead of perp. Error patterns would be interesting as well since, as mentioned before, the symmetric and asymmetric H should yield very similar errors in the center of a cubed sphere face due to the mesh being nearly Cartesian and orthogonal there.

Reply: I will certainly do a convergence study of the 2 versions of H like figure 5 and add this to the paper. Error patterns would have to be displayed on edges (like fig 1) which can be hard to display clearly. I will do this but I would rather put it as supplementary material as it would add significant length.

Comment: Fig.8 - 'normalized energy change' : Please specify how energy change is normalized ? I would suggest normalizing by initial available energy, i.e. kinetic+potential minus the potential energy of the flow at rest with the same mass (averaged height) (see e.g. Ringler et al. (2011) Eqs 16-18) Same remark for enstrophy. Also is kinetic energy defined by (10) ? With a symmetric H the kinetic contribution to

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the conserved energy is Ue Ve (Thuburn & Cotter, 2012, eq. 2.27).

Reply: The normalisation is just the standard Williamson et al 1992 normalisation. I would rather stick with this as it has been so widely used. I will clarify the text. Yes, the KE is defined by 10. I will clarify. Yes, the KE contribution to an edge is UeVe. But in 10 I partition this KE into cells differently which makes no difference to the total. Again, I will clarify.

Comment: Lack of second-order convergence with the symmetric H on the HR grids seem consistent with its non-diagonal character. Conversely second-order convergence on the the cubed and diamond grids suggests a superconvergence of the symmetric and asymmetric H (formally first-order accurate only).

Reply: Also, the symmetric H is closer to diagonal on the grids of quadrilaterals. Yes, superconvergence is in effect.

Interactive comment on Geosci. Model Dev. Discuss., 6, 6035, 2013.