Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
https://doi.org/10.5194/gmd-2022-225-RC2, 2022

Comment on gmd-2022-225

Hilary Weller (Referee)

Referee comment on "A mixed finite element discretisation of the shallow water equations" by James Kent et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-225-RC2, 2022

Generally, a referee comment should be structured as follows: an initial paragraph or section evaluating the overall quality of the preprint ("general comments"), followed by a section addressing individual scientific questions/issues ("specific comments"), and by a compact listing of purely technical corrections at the very end ("technical corrections": typing errors, etc.).

General Comments

This paper clearly presents the shallow water model which uses some of the numerical methods that will be used in the next Met Office dynamical core. It is therefore an important model description paper. It brings together mixed-finite element modelling of the second-order wave equations, finite-volume modelling of transport and semi-implicit time stepping. The paper is concise and easy to follow, drawing on other published work where needed in order to define the model, although some clarifications are still needed. The results are clearly presented and, at this stage, nearly comprehensive.

Specific Comments

The motivation for this new model could be a lot stronger. Much of the motivation provided could have been written last century, for example the need for parallisation and the need to go beyond finite differences, finite volume and semi-Lagrangian. The motivation for mixed finite elements is easy and has already been written about. The motivation needs in involve massive parallelisation, wave dispersion, spectral elements and DG.

Section 4 needs to define the order of accuracy in space of the transport scheme. I think it must be limited to two because you do not define how you fit a polynomial using cell average values.

Figure 4 and the related discussion (lines 239-243) are weak. Figure 4 only really shows that your model works. It doesn't, as you say, show that the "results are comparable to other shallow water models" or demonstrate "the model's ability to correctly simulate flow over orography". I would plot errors rather than figure 4 (in comparison to STSWM) and convergence with resolution. It is also informative to show the vorticity after 50 days which is a good indicator of conservation, balance and a lack of spurious artefacts in the solution. Eg see:

Fig 11 of "A uniï¬□ed approach to energy conservation and potential vorticity dynamics for arbitrarily-structured C-grids", Journal of Computational Physics 229 (2010) 3065–3090
or fig 5 of
"Computational Modes and Grid Imprinting on Five Quasi-Uniform Spherical C-Grids", Weller, Thuburn and Cotter.

Technical Corrections

Try to make your writing more concise. For example, delete phrases like "and the interested reader is referred there for more information".

Please also see
Shaw, J., Weller, H., Methven, J. and Davies, T. (2017) Multidimensional method-of-lines transport for atmospheric flows over steep terrain using arbitrary meshes. Journal of Computational Physics, 344. pp. 86-107. ISSN 0021-9991
for a description of the creation of stencils and polynomials for this type of transport scheme.

In table 1, use scientific notation rather than exponents.