Motivation for the cubicFit transport scheme

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Stability

- The slanted cell method improves the numerical representation of hydrostatic balance over steep orography compared to terrain-following meshes but requires a new advection scheme that is stable (and accurate) — Counter argument: *but the spurious velocities are small on terrain-following meshes anyway, so why should we use slanted cells?* — Supervisors: lots of models have stability problems at steep terrain, e.g. in early 2000s Adrian Simmons found ECMWF model crashed with gravity waves excited by cliffs at Antarctic coast, UKMO New Dynamics crashes were frequently over the Andes or Himalayas

- Application of von Neumann stability analysis is unique to the best of my knowledge — Counter argument: *but it's not entirely effective, I'm still finding meshes and wind fields that satisfy the stability criteria but are actually unstable*

- The stability analysis technique could be applied to any equation in any domain — Counter argument: *perhaps, but this hasn't been done*

Computationally cheap

- Computationally cheap, just a vector dot product (unlike most swept-area schemes that require a matrix-vector multiply (Lashley, 2002; Skamarock and Menchaca, 2010; Thuburn et al., 2014)) — Counter argument: *but have we traded accuracy for computational efficiency and was it really worth it?*

- Supervisors: Small amount of work per time-step will mean multi-tracer efficiency

- Small stencil permits lots of parallelisation — Counter argument: *surely true of any scheme with a Courant number* ≤ 1

Multidimensionality

- Not susceptible to splitting errors (unlike models such as CAM-FV, UKMO Dynamo) — Counter argument: *but (Chen et al.) shows that splitting errors are negligible for all but the steepest of terrain, so does it really matter, especially given the gains in computational efficiency by using a dimensionally-split transport scheme?* — Supervisors: dimension splitting has very similar cost to cubicFit

- No special treatment for the corners of cubed-sphere panels (unlike Counter argument: *citation, check weller2017*) or for hexagonal geometry (unlike Counter argument: *citation, gassmann?*) — Counter argument: *that's nice, but if the special treatments are effective, then does it matter?*

- Multidimensional in arbitrary dimensions. We use the scheme on an x–z plane but no special treatment would be needed for 3D multidimensional — Counter argument: *many other schemes would generalise to 3D multidimensional, too, but is there any motivation for doing so?*

Arbitrary meshes

- Suitable for arbitrary meshes including terrain-following meshes, cut cells, cubed-spheres and hexagonal icosahedra — Counter argument: *but real models choose their grid upfront and choose a suitable transport scheme to go with it, do they really need this flexibility?* — Supervisors: *Existing* models don't need this flexibility

- Suitable for steep slopes — Counter argument: *is this really a problem? e.g. ECMWF say they have no problem with steep slopes*

Miscellaneous

- Second-order accurate on distorted meshes (really?) unlike (Skamarock and Gassmann, 2011) — Counter argument: *only demonstrated properly in 1D, in 2D sometimes the scheme diverges, it doesn't even converge!*

- Eulerian schemes are less restrictive than semi-Lagrangian schemes for small-scale rotational flow because non-simply connected domains are permitted (Lauritzen et al., 2011) — Counter argument: *other Eulerian schemes already exist*

- Eulerian schemes allow choice in timestepping, e.g. optimized Runge–Kutta schemes could allow Courant numbers > 1 (as mentioned by John Thuburn) — Counter argument: *true for any Eulerian scheme* — Supervisors: Yes but there are very few Eulerian schemes out there

- Possibility of super-convergence — Counter argument: *only been achieved in 1D, not in 2D/3D*

- Standard limiters could be applied — Counter argument: *hasn't been done, true of many schemes*

- Conservative (unlike UKMO EndGame which suffers from eternal fountain of moisture) — Counter argument: *so are all other finite volume transport schemes*

References

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