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Asymptotic limit analysis for compatible numerics in numerical weather prediction

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The compatible finite element approach has recently been proposed as a discretisation method for numerical weather prediction. It is currently being developed for the UK Met Office Gung Ho dynamical core, i.e. the atmosphere model's fluid dynamics component. This approach allows the use of pseudo-uniform grids on the sphere and thus avoids the parallel computing issues associated with the longitude-latitude grid. It is also quite general, allowing for adaptive mesh refinement and higher-order discretisations.
We examine the compatible finite element method by means of an asymptotic limit analysis for the dry Euler equations. For this purpose, we first choose an asymptotic limit of certain parameters of the model, leading to a simplified set of equations. A sequence of numerical solutions from the parent model following this limit is then taken and compared with the solution from its simplified version. This way, the quality of the numerical discretisation in the parent model can be tested.
In particular, the methodology is applied to the hydrostatic simplification, using the model domain's length to height ratio as the limiting parameter. To do so, a hydrostatic switch is introduced in the compatible finite element implementation provided by Gusto, a dynamical core library based on the automated finite element toolkit Firedrake. The resulting numerical framework is then used to verify the parent model's expected behaviour in the asymptotic limit.