Geometric cell alignment on geodesic grids

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The error of many numerical schemes is usually related to the geometry of the discretization cell, and the solution of PDEs on the sphere often suffers from numerical grid imprinting. On geodesic grids, the geometric alignment theory [1] helps to explain grid related patterns when usual finite volume methods are used in the discretization of operators such as the divergence, curl and laplacian. This is done relating geometric properties of the cell to the convergence order of the methods. An aligned cell on a plane has opposite edges parallel and with the same length. On the sphere, this definition is extended using appropriate projection operators. The alignment of cells favours the cancellation of lower order error terms of numerical schemes, being a desirable cell property. To locally capture the cell alignment distribution on the sphere, an alignment index has been defined. The index reveals which cells are not well aligned (these are generally a minority in icosahedral based geodesic grids). This index provides a way to define hybrid schemes, combining different methods, according to the alignment property of the cell. An application of this idea is in vector reconstructions [2]. On staggered geodesic C grids, Perot's method [3] is a first order low cost method. However, it has second order accuracy on aligned cells. The combination of Perot's method on aligned cells, with a more expensive higher order reconstruction method on ill aligned cells, results in a low cost second order method. We will show results of a hybrid semi-Lagrangian transport scheme, employing this vector reconstruction method.

References

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