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Discretization of nonlinear terms on the hexagonal C-grid

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The talk discusses the generalized Coriolis and friction terms from two perspectives: (i) within the linearized discretized momentum equations on an equilateral grid, and (ii) as nonlinear terms on a distorted mesh.

The discrete linearized momentum equations are formulated using a trivariate coordinate system. The tendencies of the different forcing terms for each wind component must be linear dependent. This constraint determines unique discretizations for each term. The linearized vorticity flux term around a zonal mean current requires only the four rhombus PVs next to an edge. This is a novelty and differs significantly from known methods. The vector Laplacian must be formulated with the vorticity on vertices defined as the average of three rhombus vorticities.

A modified generalized Coriolis term is defined on the deformed mesh. The baroclinic wave test on the sphere does not reveal any sign of a non-linear Hollingsworth instability, even though it is demonstrated that the Lamb form and the advective form of momentum advection are not equivalent.

Physical constraints determine the shape of the stress tensor. These are invariance to the addition of solid body rotation and a resulting positive definite dissipation rate. An appropriate stress tensor formulation does not deliver a Laplacian momentum diffusion in the linear case. On the deformed mesh, the entries of this stress tensor are obtained by a least squares reconstruction of wind gradients. This approach avoids spurious deformations diagnosed for constant flow in the vicinity of pentagon cells.

It is impossible for both terms to meet all physical requirements and the additional numerical linear dependency constraint.