New dissipation mechanisms for the spectral element dynamical core in the Community Atmosphere Model (CAM)

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1 Abstract:

We introduce new resolution-aware dissipation mechanisms for CAM-SE (CAM with the spectral element dycore from HOMME) and evaluate their performance for a set of problems with locally refined grids. CAM-SE uses unstructured quadrilateral meshes with hyperviscosity for horizontal dissipation. The hyperviscosity operator requires a resolution-dependent coefficient. For variable-resolution grids, it imposes a challenge to define the coefficient. To address this issue, we propose a coefficient tied to local element length scales. This is further improved with a tensor-based hyperviscosity operator which allows scaling with respect to both length scales in distorted elements.

We evaluate these dissipation mechanisms using the Williamson et al. shallow-water test cases. The best results are obtained with the tensor hyperviscosity, where we show that the presence of mesh refinement has no impact on the large scale solution. At the same time, finer features of the flow in the locally refined region are resolved, while only minimal noise in the mesh transition region is present.

We also utilize the tensor hyperviscosity for topography smoothing. Since in climate models topography is represented by highly distorted data, it is common to apply a model-dependent, mesh-dependent smoothing to the field to avoid excessive noise. We demonstrate that in case of variable-resolution grids, the tensor-based hyperviscosity leads to a high quality, resolution-aware smoothing operator for the topography field.