Evaluating 2D and 3D Adaptive Mesh Refinement (AMR) Techniques with Moisture Processes

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The paper evaluates a cubed-sphere adaptive mesh refinement (AMR) technique that can dynamically adapt its grid resolution to atmospheric features of interest, such as strong vortices or rainfall patterns. The grid resolutions can thereby range from hundreds of kilometers to just a few kilometers in a single simulation. The paper reviews the design of the high-order, finite-volume, multi-block AMR framework which can solve both the 2D shallow water and 3D nonhydrostatic equation sets on the sphere. The framework is built upon the AMR library Chombo which has been designed at the Lawrence Berkeley National Laboratory. The 'cubed sphere' grid serves as the base computational grid for the atmospheric AMR applications.

Idealized 2D and 3D test cases are used to illustrate the variable- and high-resolution characteristics of the dynamically adaptive atmospheric model. Both the 2D and 3D configurations include simplified physical parameterization suites. The moisture interactions provide nonlinear forcing effects which challenge the AMR technique and the scale dependencies in the moist atmospheric model. The dynamical core test cases include a 2D moist barotropic wave and tropical cyclone, as well as selected examples from the Dynamical Core Model Intercomparison Project (DCMIP) and a 3D colliding-modons test case. The results suggest that AMR dynamical cores have the potential to serve as the basis for future-generation weather and climate models. They allow the flow-dependent generation of high-resolution domains while limiting the overall computational workload.

References:

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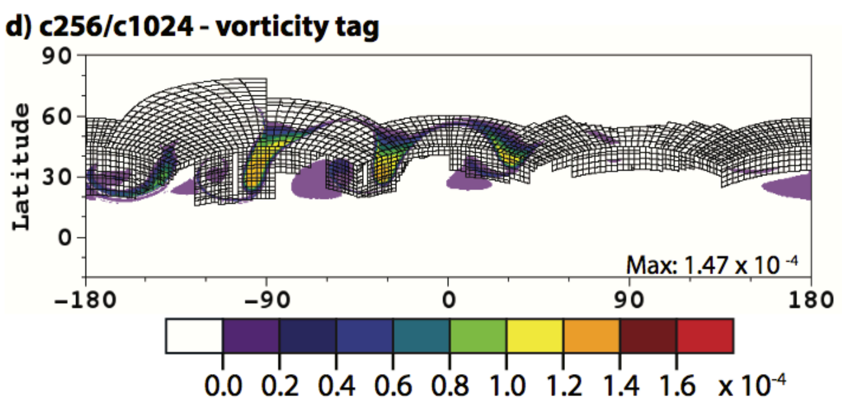

Figure: AMR model in the moist shallow water configuration: Cloud water mixing ratio (colored) after six simulation days with the moist barotropic wave test case. Relative vorticity is used to guide the refinement regions.