A massively-parallel framework for finite-volume simulation of global atmospheric dynamics

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A computational environment is being developed that aims at integrating --- within a single mathematical/numerical framework --- PDE's of global atmospheric dynamics. The paper reports an essential step towards this goal. It presents massively-parallel non-oscillatory forward-in-time finite-volume integrators for hydrostatic PDE's on the sphere, cast in the anholonomic geospherical framework. Spatial discretization employs bespoke unstructured meshes built about the vertices of the reduced Gaussian grid employed in the ECMWF's Integrated Forecast System (IFS). Such arrangement allows using a domain decomposition identical to IFS and opens avenues to the future high fidelity comparisons with IFS' solutions of primitive equations. Furthermore, it allows for model hybridization where selected elements can be directly exchanged between the two models, without interpolation.

The reported development operates on flexible dual meshes with an efficient parallel edge-based data structure and a non-staggered arrangement of flow dependent variables. The paper will discuss aspects of implementation on shared/distributed memory machines with MPI and OpenMP parallelization, in the context of efficiency and portability on supercomputing architectures. Selected canonical benchmarks of global shallow-water flows are used to validate the approach.