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An overlapping additive Schwarz preconditioner for the cubed-sphere

Spectral element formulations of the atmospheric 2-D shallow-water equations and 3-D primitive equations on the cubed-sphere are described. The equations are written in generalized curvilinear coordinates using contravariant/covariant components and the metric tensor. A semi-implicit time discretization results in a Helmholtz problem for the pressure. The Laplacian operator is approximated by the L_2 pseudo- Laplacian arising in the $P_N/P_N - 2$ spectral element formulation of the incompressible Stoke's problem. The two-level overlapping Schwarz preconditioner of Fischer and Tufo (1998), based on the fast diagonalization method (FDM) and scalable coarse grid solver, is extended to generalized curvilinear coordinates. To obtain a separable operator for the linear finite-element tensor-product approximation within each spectral element, the minimum of the inverse metric tensor and the maximum of its determinant are employed. Convergence rates and parallel CPU timings are compared against a block-Jacobi preconditioner.