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Compact spatial differencing for the spherical shallow water equations

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One of the main problems arised in the standard spectral transform algorithm as it is applied to the global modeling studies, is the rapid increase of computational cost, especially at very high resolutions. There have been many attempts to construct alternative solution techniques able to achieve high accuracy with significantly less computational cost than the spectral transform method. The compact finite difference schemes have been found as simple and powerful ways of reaching the objectives of high accuracy and low computational cost. Compared with the traditional explicit finite difference schemes, compact schemes with the same order have shown to be significantly more accurate with the added benefit of using smaller stencil sizes.

In this paper the fourth-order compact finite difference scheme is implemented to spatial differencing of the spherical shallow water equations (SWE). The divergence, height, and vorticity formulation of the SWE is employed to carry out the calculations. For time stepping of the SWE in time a three level semi-implicit scheme and for spatial differencing, the fourth-order compact and the conventional second-order centered finite difference methods are used. The SWE are solved on a doubly periodic longitude-latitude grid system. The grid points in this system are arranged such that no grid points are at the poles and has the advantage of avoiding singularity at the poles which enables the periodic boundary conditions to be imposed in both longitude and latitude directions.

To measure the validity and accuracy of the solution, the standard test sets proposed by Williamson *et al.* (1992) and the test case presented by Galewsky *et al.* (2004) are used. Furthermore, issues such as accuracy, stability, dissipation, and computational cost are addressed.