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Combined compact spatial differencing for the f-plane shallow water equations

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The compact finite difference schemes, introduced as far back as the 1930s, have been found as simple, yet powerful ways of reaching the objectives of high accuracy and low computational cost. Compared with the traditional explicit finite difference schemes of the same order, compact schemes have proved to be significantly more accurate with the added benefit of using smaller stencil sizes, which can be essential when treating non-periodic boundary conditions.

This paper is devoted to implementation of the eighth-order combined compact finite difference scheme to (potential) vorticity, height and divergence formulation of the f-plane shallow water equations in a doubly-periodic geometry. For the time stepping of the equations the semi-implicit method and for the spatial differencing the eighth-order combined compact formulation is used. In addition, the details of the computational procedure and related issues such as stability, dissipation, computational cost and accuracy are addressed.

Furthermore, to investigate the accuracy and other issues, the spatial differencing of the shallow water equations is carried out by the second-order centered, fourth-order compact and sixth-order super compact differencing methods. The results are also compared with those obtained by the pseudo-spectral method.