A Curvilinear Incompressible Navier-Stokes Solver for Coastal Hydrodynamics Applications

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In near-shore hydrodynamics, higher resolution is usually required for the surface wave modelling. In the present work compact finite difference schemes are employed for the numerical solution of the incompressible Navier-Stokes equations for a curvilinear coordinates system. A staggered grid discretization is introduced for the orthogonal computational domain in the curvilinear coordinates plane. This requires that the continuity equation is discretized at the cell centers, while the u-momentum and v-momentum equations are discretized at the midpoints of the vertical and horizontal edges of the cells, respectively. The incompressibility constraint is enforced for each time-step iteratively either by local pressure correction or by a Poisson equation based, global pressure correction method. Local pressure correction is carried out on cell by cell basis using a local, second-order-accurate discrete analog of the continuity equation. The global pressure correction is based on the numerical solution of a Poisson-type equation which is discretized to second or fourth order accuracy. In both cases, the updated pressure is used to recompute the velocities in order to satisfy the incompressibility constraint. Results exhibit very good agreement with other experimental and numerical calculations for a variety of domains and grid configurations. Refining the grid resolution for both the second and fourth order accurate discretization schemes leads to grid independent results for all the examined cases. The resulting overall numerical solver will be employed for the simulation of free surface waves and the study of their near shore behaviour.