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NUMERICAL SIMULATION OF 3D FREE SURFACE FLOWS IN TIME DEPENDENT CURVILINEAR COORDINATES

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The study of the fluid motion in three dimensional form on domains characterised by complex geometries which vary in time can be carried out by using boundary conforming curvilinear coordinate systems and by expressing the governing equations in contravariant formulation [1-3]. A transformation of the irregular, time varying physical domain into a regular, fixed computational domain is performed by using time dependent curvilinear coordinate systems.

In order to realise a three dimensional numerical model which is able to simulate the discontinuities in the solution related to the wave breaking on domains that reproduce the complex geometries of the coastal regions, we propose an integral contravariant form of the Navier-Stokes equations, devoid of the Christoffel symbols, in a time dependent curvilinear coordinate system.

The resulting motion equations are numerically solved, on a time dependent curvilinear coordinate system, by a finite volume shock capturing scheme, which uses an approximate HLL-type Riemann solver [4]. The advancing in time of the numerical solution is carried out by a second order accurate Strong Stability Preserving Runge-Kutta (SSPRK) fractional-step method in which, at every stage of the Runge-Kutta method, a predictor velocity field is obtained by the shock-capturing scheme and a corrector velocity field is added to the previous one, in order to produce a non-hydrostatic divergence-free velocity field and to update the water depth. The corrector velocity field is obtained by solving a Poisson equation, expressed in integral contravariant form. This equation is solved through a multigrid method which uses a four-colour Zebra Gauss-Seidel line-by-line method as smoother.

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