A Scalable Unstructured Finite Volume Code for the 3 Dimensional Shallow Water Equations

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Many shallow flow models employ orthogonal rectilinear or curvilinear coordinates in order to resolve lateral boundaries. However, this approach lacks flexibility in modelling domains, such as coastlines, with irregular geometry. Therefore, the model presented here is based on a discretisation applicable to unstructured grids. Since mass conservation was considered an important property a finite volume technique was employed.

In any attempt to solve a three dimensional problem, the scaling behaviour of the work involved is an important consideration. By careful limitation of the implicit terms in the discretisation, a model which scales with the same power law as a two dimensional model has been produced. In order to accomplish this, the advection and coriolis terms are discretised using Eulerian-Lagrangian techniques. Straightforward Eulerian-Lagrangian methods involving projections along straight lines can result in anomalies at boundaries and artificial mixing in stratified flow. To avoid this, a streamline tracking algorithm originally developed for traditional structured applications[2] has been generalised to the unstructured case and forms the basis of the Eulerian-Lagrangian components.

Previous work elsewhere resulted in a model which is applicable on a restricted class of unstructured grids [1]. By changing the location of the pressure storage points and adopting pressure gradient algorithms originally developed for the 2-dimensional case [3], a system has been developed which will accept a much broader class of grids. A non-linear semi-implicit decomposition of the pressure gradient term is applied which results in a free surface problem which is positive definite.

The authors believe that the approach presented here constitutes a basis for the modelling of shallow water flow in complex geometries which has advantages over many existing methods. The current capabilities of the model will be demonstrated using the example of Kelvin wave propagation in a complex basin.

References

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