Computational Methods for Large Scale Environmental Flows

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A number of research activities has been pursued in the area of numerical modelling of environmental flows, aimed at proposing fully multidimensional, stable, accurate and efficient computational methods. The mathematical properties of the proposed methods have been investigated, especially regarding stability, good conditioning of the involved algebraic problems and computational efficiency of the resulting algorithms. Various applications of the new methods obtained to large scale simulation problems have been carried out and are planned for the future, in collaboration with research centers such as the Environmental Fluid Dynamics Laboratory (Stanford University, Stanford, USA), the United States Geological Survey (Denver, USA), the Bundesanstalt für Wasserbau und Aussenstelle Küste (Hamburg, Germany) and the German Weather Forecasting Service (Offenbach, Germany). In particular, hydrodynamical models on structured and unstructured meshes have been developed for free surface, hydrostatic and non-hydrostatic flows in estuaries and coastal seas (see [3, 4, 5]). The inclusion of non-hydrostatic pressure has been shown in [5] to be beneficial in high resolution simulations of harbours for structured grid models. A fully non-hydrostatic model on unstructured meshes presented in [4] has given a considerable gain in accuracy and efficiency of high resolution simulations, allowing for direct simulation of large scale tidal flows and smaller scale features such as recirculation zones and short waves on the same computational grid. A semi-implicit, semi-lagrangian mesoscale nonhydrostatic model has also been developed in [2], whose aim is an accurate and efficient simulation of flows over complex orography. This model has been tested in simulation of waves in the lee of isolated mountains, breaking gravity waves and valley winds. Other research areas have been the study of mass conservative schemes for the Saint Venant equations of open channel flow (see [7]) and the development of robust and accurate schemes for transport of passive and reactive solutes in large scale simulations (see [6]).

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