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An adaptive mesh adjoint model and its applications in tidal/coastal flows

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Significant advances in ocean modelling can be achieved through the introduction of mesh adaptivity (or mesh optimisation). This can be used to simultaneously resolve both small and large scale ocean flows whilst smoothly varying resolution and conforming to complex coastlines and bathymetry. The purpose of this study is to introduce four-dimensional variational data assimilation (4-D Var) techniques into an advanced adaptive mesh ocean model in order to improve its predictive ability. To achieve this objective, a novel adjoint model has been developed based on a 3-D advanced adaptive non-hydrostatic finite element model (Imperial College Ocean Model). The novel adjoint (inverse) model has the ability to: (1) use different adaptive meshes and numerical methods in the forward and adjoint models; (2) reduce both the computer memory requirement and CPU time, as well as to accelerate the inversion with a hierarchy of finer meshes; (3) choose an adaptive discretisation scheme to reduce numerical dispersion errors in the forward and adjoint calculations.

The adjoint model is verified in 2-D/3-D tidal/coastal flows and is further applied to the inversion of open boundary conditions. Open boundary conditions are recovered by assimilating observations into the model. In this study, special attention is paid to: (1) the feasibility and advantages of using adaptive meshes in the forward and adjoint models, and subsequently computational efficiency, addressed by comparing the inversion results for both static and adaptive meshes; (2) the robustness of the adjoint

model, considered by assimilating sparse and noisy observations into the model; and (3) the potential of a hierarchy of finer meshes in the inversion, tested by increasing the resolution of adaptive meshes during each inversion iteration.