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Unstructured meshes and anisotropic adaptivity in ocean modelling: numerical issues and recent applications to ocean circulation, density overflows and deep convection in realistic domains

M. Piggott (1), C. Pain (1), G. Gorman (1), D. Marshall (2), C. Cotter (1), F. Fang (1), P. Power (1), L. Bricheno (1), M. Wells (1), C. Bain (3)

(1) Department of Earth Science and Engineering, Imperial College London, UK (m.d.piggott@imperial.ac.uk; http://amcg.ese.ic.ac.uk); (2) Department of Meteorology, University of Reading, UK; (3) School of Earth and Environment, University of Leeds, UK.

The use of finite elements, unstructured meshes and anisotropic adaptivity in three-dimensions offers many advantages for numerical ocean modelling. In particular any interaction between a range of spatial and temporal scales and the formation and evolution of localised features in a priori unknown locations can benefit hugely from this approach. This is because the model can automatically allocate computational resources in an optimal and dynamic manner as dictated by solution fields or estimates of model error. In addition, an accurate and efficient representation of complex geometries is straightforward with this approach, as are the use of realistic boundary conditions, and the preferential treatment of regions of socio-economic or scientific importance.

There are many issues that need to be addressed before the full power of these new modelling techniques can be fully exploited. In this presentation, we will discuss the design of error measures and appropriate criteria for mesh adaptivity, the use of highly anisotropic resolution dictated by solution dynamics, and the stable and accurate representation of hydrostatic and geostrophic balance on arbitrary irregular meshes. Current work on the application of these new techniques to complex oceanographic problems will also be presented. These include wind driven circulation and tidal modelling in realistic domains, overflows in the Denmark Strait region, and open ocean deep convection.