A revolution in numerical model design: towards the second generation of geophysical fluid flow models

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The last decade has been witnessing an increased interest into the development of ocean models using unstructured meshes. The latter offer many attractive features such as the ability to conform to complex coastlines and bathymetry but they also allow for the mesh resolution to vary in space and time. Numerical ocean models based on these techniques have the potential to simultaneously resolve both small and large scale processes. While much effort has been devoted towards ocean modeling, numerical methods based on such unstructured meshes are believed to be very promising for all kinds of geophysical and environmental fluid flows. Hence, the range of capabilities of such models is admittedly huge. Unfortunately, a step-by-step conversion from existing structured-mesh models to unstructured-mesh models is extremely unlikely to occur due to intrinsic algorithmic differences. Therefore, the second-generation models must be built starting from zero. In spite of this original approach in the field of geophysical fluid dynamics, the point of no return has probably been reached in terms of models development. Yet, many challenges still lie ahead and should be addressed within the next decade. A few examples of these concepts are shown and include the propagation of slow Rossby waves in the Gulf of Mexico, barotropic and baroclinic instabilities, barotropic tidal flow, flow in the Great Barrier Reef and a few idealized test cases in spherical geometry.