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Multiresolution ocean modelling

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Unstructured meshes introduce a multiresolution aspect in ocean modeling. Their resolution can be adjusted to practical needs according to the observed eddy activity, the Rossby radius of deformation, or the interest in small-scale dynamics in a particular area. Although the utility of unstructured meshes is well recognized in coastal ocean modeling, global ocean models used in climate studies are predominantly formulated on structured meshes. Several recent model development efforts such as FESOM at the Alfred Wegener Institute, ICON at the Max-Planck Institute for Meteorology (both Germany) and MPAS-Ocean at the Los Alamos National Laboratory (USA) propose fully functional ocean circulation models working on unstructured meshes. During long time such models were considered to be more computationally expensive than their structured-grid counterparts. The advances in computer technology and numerical methods lead to the fact that over recent years these models become similarly computationally efficient, showing a comparable throughput and offering an excellent scalability on massively parallel machines. The three models above are also used as ocean components of respective climate models.
We discuss the discretizations used, with a particular focus on numerical modes of these discretizations and measures needed to suppress them. Based on FESOM,we illustrate the througput and scalability on different meshes, and give practical examples from global simulations with a regional focus showing the benefits of unstructured meshes. We conclude with the statement that ocean models formulated on unstructured meshes are mature enough to be used in climate studies.

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