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Toward the multi-purpose, unstructured mesh, finite element, marine model SLIM

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The intrinsic flexibility of unstructured meshes is compelling for numerical marine modeling. Unstructured meshes are naturally used with a few methods, the most promising of which is probably the finite element method for the enhanced flexibility in the type of interpolation and the richness of the underlying mathematical framework. The multi-purpose finite element marine model SLIM (Second-generation Louvain-la-Neuve Ice-ocean Model) is currently employed to simulate a large number of two-dimensional and three-dimensional flows on the shelf, basin and global scales. The two-dimensional version of SLIM exists in two versions, which are based on the continuous and discontinuous Galerkin methods, respectively. The continuous version of SLIM2d has been enhanced to solve the shallow-water equations in spherical geometry independently of any coordinate system and without any singularity due to the presence of the poles. The discontinuous version of SLIM2d has been improved to simulate shallow-water flows with high-order basis functions, which are much more computationally efficient. The three-dimensional barotropic version of SLIM has been validated and preliminary results of the model, including a baroclinic component, are presented. SLIM3d resorts to a mode splitting between the external and internal modes, yet uses a unique time step with a semi-implicit treatment of the inertia-gravity waves. This method ensures strict tracer conservation and consistency. The three-dimensional mesh moves in the vertical to accommodate the free-surface motions or any other criterion. A finite element sea-ice model is also under development and should be coupled to the global ocean model in the near future. Results from applications in two and three dimensions are presented. We also outline the future directions of research.