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Modelling the oscillations of the thermocline in a lake by means of a fully consistent and conservative 3D finite-element model with a vertically adaptive mesh

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Vertical discretisation is crucial in the modelling of lake thermocline oscillations. For finite element methods, a simple way to increase the resolution close to the oscillating thermocline is to use vertical adaptive coordinates. With an Arbitrary Lagrangian-Eulerian (ALE) formulation, the mesh can be adapted to increase the resolution in regions with strong shear or stratification.
In such an application, consistency and conservativity must be strictly enforced.

SLIM 3D, a discontinuous-Galerkin finite element model for shallow-water flows (www.climate.be/slim, e.g. Kärnä et al., 2013, Delandmeter et al., 2015), was designed to be strictly consistent and conservative in its discrete formulation. In this context, special care must be paid to the coupling of the external and internal modes of the model and the moving mesh algorithm. In this framework, the mesh can be adapted arbitrarily in the vertical direction. Two moving mesh algorithms were implemented: the first one computes an a-priori optimal mesh; the second one diffuses vertically the mesh (Burchard et al., 2004, Hofmeister et al., 2010). The criteria used to define the optimal mesh and the diffusion function are related to a suitable measure of shear and stratification.

We will present in detail the design of the model and how the consistency and conservativity is obtained. Then we will apply it to both idealised benchmarks and the wind-forced thermocline oscillations in Lake Tanganyika (Naithani et al. 2002).

References

Tuomas Kärnä, Vincent Legat and Eric Deleersnijder. A baroclinic discontinuous Galerkin finite element model for coastal flows, Ocean Modelling, 61:1-20, 2013.
Philippe Delandmeter, Stephen E Lewis, Jonathan Lambrechts, Eric Deleersnijder, Vincent Legat and Eric Wolanski. The transport and fate of riverine fine sediment exported to a semi-open system. Estuarine, Coastal and Shelf Science, 167:336–346, 2015.
Hans Burchard and Jean-Marie Beckers. Non-uniform adaptive vertical grids in one-dimensional numerical ocean models. Ocean Modelling, 6:51–81, 2004.
Richard Hofmeister, Hans Burchard and Jean-Marie Beckers. Non-uniform adaptive vertical grids for 3d numerical ocean models. Ocean Modelling, 33:70–86, 2010.
Jaya Naithani, Eric Deleersnijder and Pierre-Denis Plisnier. Origin of intraseasonal variability in Lake Tanganyika. Geophysical Research Letters, 29(23), doi:10.1029/2002GL015843, 2002.