# SLIM1D and SLIM2D

SLIM2D is used in shallow-water environments where wind and tides are sufficient to keep the water column rather well mixed. It solves the depth-averaged shallow water equations for the surface elevation and the horizontal velocity. When the horizontal flow is mainly unidirectional such as for a well-mixed river, the shallow water equations can be averaged over the section leading to the 1D section-averaged shallow-water equations. SLIM1D consists of linear river segments where variable river width and cross-section are taken into account. River segments can be joined to model a river network with accurate computation of bifurcation by the means of a Riemann solver.

SLIM solves the model equations on an unstructured mesh with the Discontinuous Galerkin finite element method. This approach provides an optimal degree of flexibility both geometrically and functionally as it can accurately represent complex topographies and also model solutions with sharp gradients. Unlike more standard numerical methods, such as finite volumes, it introduces a minimal amount of numerical dissipation and thus preserves small-scale flow features such as recirculation eddies. The model equations can be forced by wind, tides, river discharges and large-scale currents from a global ocean model.

Most coastal areas are significantly influenced by tides. When approaching the coast, the tidal signal tends to amplify, especially in funnel-shaped embayments where the tidal range may reach considerable magnitudes. Combined with the fact that many estuaries and embayments also feature gradually sloping bathymetry, the total area submerged under water may vary significantly during the tidal cycle. To tackle this issues, SLIM2D is equipped with a wetting-drying algorithm that allows it to handle dry areas. The algorithm is based on an implicit time-stepping that combines computational efficiency with local mass conservation. The video below shows the water transport in the Columbia River estuary as modeled by SLIM2D. Dry tidal flats are clearly visible at low tide.

## To learn more…

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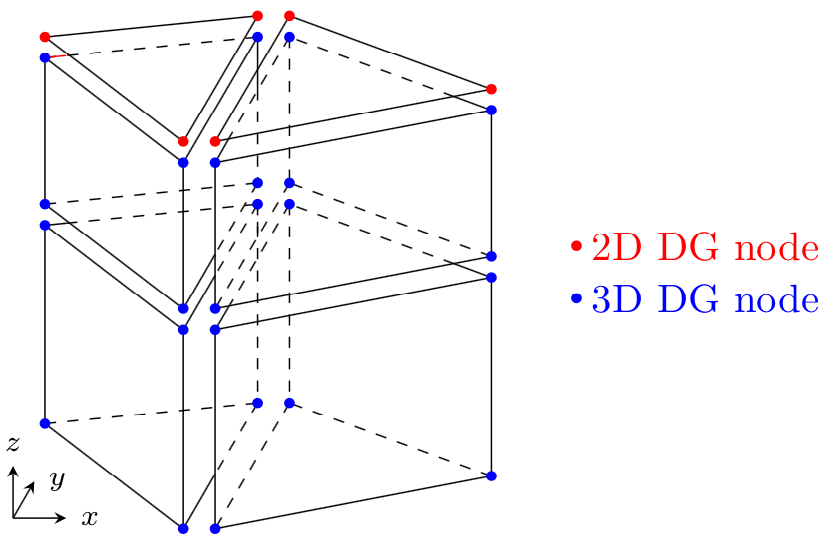
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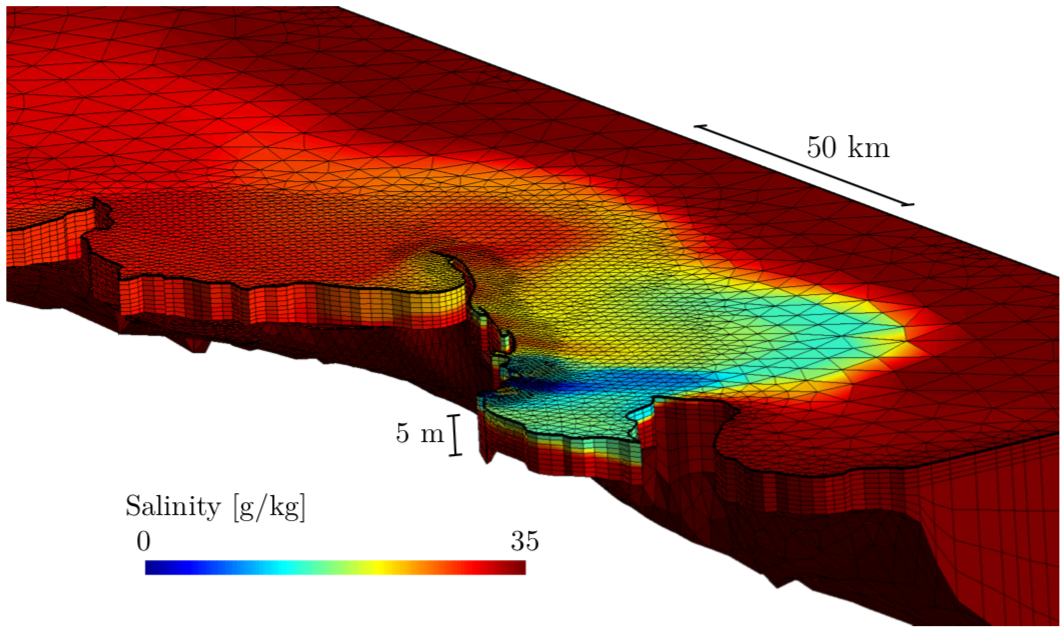
# SLIM3D

SLIM3D solves the three-dimensional hydrostatic equations under the Boussinesq approximation. The model variables are the 3D velocity, the surface elevation, the salinity and the temperature. The density is obtained by means of an equation of state. SLIM3D uses a mesh composed of triangular prismatic elements that are formed by extruding the 2D unstructured mesh in the vertical direction. The model equations are solved by means of the Discontinuous Galerkin finite element method.



Sketch of the 3D mesh obtained by vertically extruding a 2D triangular mesh. All variables are piecewise linear and discontinuous between elements.

One key aspect in any 3D ocean model is the coupling between the external and internal modes. SLIM3D uses a mode-splitting formulation in which the fast propagating gravity waves are solved in an external 2D mode. That mode can either be discretised explicitly with a small time step or implicitly with a larger time step.



3D mesh used to simulate the sediment plume dynamics of the Burdekine River (Australia). The bathymetry being quite shallow and smooth, sigma layers are sufficient to provide an accurate solution.

In the vertical, SLIM3D allows a combination of z and sigma layers. For rather shallow environments with mild bathymetry gradients, sigma coordinates can be used over the entire water column. For deeper areas with sharp bathymetry gradients, sigma layers are generally used only near the surface while z layers are used in the rest of the domain. The number of z layers can be adapted to better approximate bathymetry gradients.

The accuracy of the mode coupling has been tested on a baroclinic test case described in Ilicak et al. (2012). The domain is a periodic (along the 500km-long boundaries) and closed (along the 160km-long boundaries) channel with a bathymetry of 1000m (exaggerated on the video). The large bottom drag coefficient and asymmetric initial condition trigger baroclinic instabilities in the channel. The 4km mesh resolution is similar to one of typical mesoscale eddy permitting models. SLIM3D is able to reproduce the development of baroclinic eddies, as illustrated by the evolution of the predicted temperature.

## To learn more…

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