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Multi-Scales Approximations of Thin Flows for Curved Topography

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ABSTRACT

Most of geophysical thin flows take place in complex topography: avalanches, landslides, debris flows, etc. There is a strong link between the flow path and the geometry of the basal topography.

The terminology "shallow flow" is here used to characterize thin flows on curved surfaces. It is customary for this type of flows; to use the incompressible Naviers-Stokes equations to asymptotically derive reduced models for the evolution of the depth integrated speed and the thickness of the flow. Reduced model are mainly hyperbolic and finite volume method are often used for their numerical approximation. Approximations strategies are generally structured as follow:

- Construction of a global coordinate system associated with the assumption that the surface description is given analytically;
- Reduction of the model relatively to the global coordinate system;
- Approximation of the surface by a finite number of elements;
- Approximation of the reduced model using the discrete surface.

In the context of real applications, it is presumptuous to expect an analytical formulation of the surface. From the data provided by geographic information system (GIS), we casually extract a discrete description of the surfaces that drives thin flow. Therefore, it is more practical to use the discrete description as the starting point of the resolution strategy. This is the angle of approach that we will consider in the following. Then we will locally define two mesh scales: the element scale and the cell scale. The discrete mapping and the reduced model are defined at the element scale and the average values that evolve in time are defined at the cell scale [1,2].

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