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On the necessity of non-hydrostatic pressure models for free surface flow over complex topography

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There is a wide range of geophysical flows, such as flow in open channels and rivers, tsunami and flood modeling, that can be mathematically represented by the non-linear shallow water 1D equations involving hydrostatic pressure assumptions as an approximation of the Navier Stokes equations. In this context, special attention must be paid to bottom source terms integration and numerical corrections when dealing with wet/dry fronts or strong slopes in order to obtain physically-based solutions (Murillo and García-Navarro, 2010) in complex and realistic cases with irregular topography. However, although these numerical corrections have been developed in recent years achieving not only more robust models but also more accurate results, they still might find a limit when dealing with specific scenarios where vertical information or disspersive effects become crucial. This work presents a 1D shallow water model that introduces vertical information by means of a non-hydrostatic pressure correction when necessary. In particular, the pressure correction method (Hirsch, 2007) is applied to a 1D finite volume scheme for a rectification of the velocity field in free surface scenarios. It is solved by means of an implicit scheme, whereas the depth-integrated shallow water equations are solved using an explicit scheme. It is worth highlighting that it preserves all the advantages and numerical fixes aforementioned for the pure shallow water system. Computations with and without non-hydrostatic corrections are compared for the same cases to test the validity of the conventional hydrostatic pressure assumption at some scenarios involving complex topography.

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[2] C. Hirsch, Numerical Computation of Internal and External flows: The fundamentals of Computational Fluid Dynamics, Butterworth-Heinemann, 2007.