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A fully well-balanced scheme for shallow-water equations with Coriolis force

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When we derive numerical schemes for hyperbolic system of PDE with source terms, it is now well-known that a special care must be given to the discretization of the source terms in order to avoid large errors in the simulations. It lead in the last decades to the derivation of a lot of well-balanced scheme that are able to preserve some or all the steady solutions. For instance, for the standard shallow-water equations with topography, several fully-well-balanced schemes, that are able to preserve all the steady states, have been proposed, for instance in [2]. When taking into account the Coriolis force du to the Earth rotation, the numerical scheme presented in [1] is able to preserve the geostrophic equilibrium. However, there is no fully well-balanced scheme for this system.

The main focus of this work is therefore to derive a fully well-balanced scheme for the 1D shallow-water equations with both topography and the Coriolis force. In order to do this, we suggest to consider a relevant approximate Riemann solver that is build on a suitable discretization of the source terms and of the steady states. The resulting Godunov-type scheme preserves both the water height positivity and all the steady states.

In order to improve the precision, we also propose a second-order extension that keeps the good properties of the first-order scheme. Due to the complex structure of the steady states, the classical MUSCL method needs to be slightly modified.

Finally, some numerical experiments will show the relevance and the accuracy of both first-order and second-order scheme.

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