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# Numerical comparison between simplified mathematical models for rock-ice avalanches

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Rock-ice avalanches correspond to three-phase mixtures composed of a liquid and of particles of rock and ice. The presence of ice inside the mixture plays a key role in the mobility of rock-ice avalanches, since the heat produced by basal friction and particle collisions induces its transformation into water. Due to this continuous supply of liquid to the mixture, rock-ice avalanches can threaten populations living in cold mountainous areas. Thus, for a good hazard assessment and management, there is the need to construct mathematical models able to predict the flow of rock-ice avalanches. In the literature, there exist only few models that deal with this type of mass flows (Pudasaini & Krautblatter 2014, Bartelt et al. 2018, Sansone et al. 2021). As proposed in Sansone et al. (2021), a framework of different simplified rock-ice avalanche models can be derived by starting from a complete three-phase approach and by imposing two specific assumptions, namely the isokinetic and incompressibility hypotheses. In this way, five classes of simplified approaches can be detected, and these mathematical models are characterized by different levels of approximations of the physics of rock-ice avalanches.

In this work, we provide some numerical solutions for the depth-integrated one-dimensional versions of all the simplified mathematical models detected in Sansone et al. (2021). These numerical solutions are constructed using three different numerical schemes that distinguish themselves from the way the numerical fluxes are evaluated. While one of the three chosen numerical methods evaluates the numerical fluxes without considering the eigenstructure of the systems of equations, the other two schemes take partially or entirely account of the eigenstructure of the equation systems. Due to the possible loss of hyperbolicity detectable in some simplified models, we consider as test cases the problems of the small perturbations of the flow depth and of the concentrations.

The first result of the analysis computed corresponds to the comparison between the numerical solutions derived from the three numerical schemes for each class of models. In this way, the responses of the different numerical methods to each equation system can be investigated. The second result consists in comparing numerically the different classes of simplified models detected by Sansone et al. (2021), thus allowing us to quantify the effects of the assumptions of each class of models on the flow dynamics.

**References:**


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