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Simulating the propagation of wet snow avalanches: challenges and perspectives

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Recent winters saw a striking increase in wet snow avalanche activity. Compared to dry avalanches, wet snow avalanches present uniquely distinctive features such as slower velocities, larger depths, unusual trajectories and deposit shapes, and a paste-like rheology that can result in large shear and normal stresses. In addition, the behavior of wet avalanches may strongly vary depending on the actual snow liquid water content. Complex transitions between dry (cold) and wet (hot) behaviors have also been observed during the propagation of single avalanche events. Current numerical models of avalanche dynamics are challenged when it comes to capturing the full spectrum of these different regimes, and the transitions in between. In this contribution, we critically review the various rheological models that have been proposed in the literature to simulate dry and wet snow avalanches in the frame of depth-averaged shallow-flow approaches. On this basis, a simplified parametric rheological law is proposed, with the objective of representing both dry-like and wet-like behaviors and allowing for smooth transitions between them. The law is implemented in a robust 2D shallow-flow simulation code, and systematic sensitivity studies are performed on synthetic and real topographies. Simulation outcomes are analysed in terms of propagation dynamics and deposition patterns, and the ability of the model to capture both dry and wet regimes is discussed. Lastly, a specific calibration methodology is proposed to infer the relevant mechanical parameters from documented avalanche events.