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A bed pressure correction for depth-averaged granular flow models to ensure the physical threshold of motion

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Depth-averaged models, such as the Savage-Hutter model with Coulomb or Pouliquen friction laws, are usually considered to simulate aerial and submarine avalanches. In particular, submarine avalanches can be the source of a tsunami. These models are presented in local coordinates over the topography or a reference bottom. We show in this work that classical models do not in some cases preserve the physical threshold of motion. On the one hand, the simulated granular mass can start to flow even if the slope angle of its free surface is lower than the repose angle of the granular material involved. On the other hand, the granular mass can stay at rest being the slope angle of the free surface higher than the repose angle of the material. Several numerical tests are presented to illustrate these problems related to classical depth averaged models. In this work we also propose an initial correction which ensures that the model preserves, up to the second order, the physical threshold of motion defined by the repose angle of the material. Several numerical tests are presented, by comparing also with experimental data to illustrate the effect of the proposed correction.