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1D simulation of avalanches. A non-oscillatory central difference (NOC) scheme applied on the extended NIS rheology.

A. S. Moe (1), J. M. N. T. Gray (2) and X. Cui (2)

(1) International Centre for Geohazards, Norway, (2) School of Mathematics, University of Manchester, UK

A new tool for simulating dense snow avalanches and other gravity-driven mass flows is presented. The physical basis is an extended version of the Norem–Irgens–Schieldrop (NIS) rheology. The NIS rheology renders a granular behaviour with viscous, visco-elastic and visco-plastic effects, internal dry friction and a slip velocity at the base. A dispersive pressure that increases with shear rate in the flowing material and a shear rate dependent viscosity, cause the dominant friction type to change gradually from dry friction at low shear rates to viscous friction in rapidly sheared material, corresponding well to observed avalanche behaviour.

A depth-averaged, unit width set of equations for motion and mass balance are developed based on the NIS rheology, and on the assumption that the flow profile is similar to that of a steady-state gravity-driven shear flow on an infinite incline. The equation system is conservative, and is solved on a non-staggered Eulerian grid along the avalanche centre curve. A non-oscillatory central difference (NOC) scheme is used, which is of higher order accuracy and shock-capturing. The total variation diminishing (TVD) property ensures numerical stability.

An investigation of the characteristics of the equation system reveals that not all parameter combinations yield a physically sound model. A gravity driven flow with a free surface is a hyperbolic problem, and parameter combinations that have been used in earlier work with NIS rheology are shown to cause loss of hyperbolicity for certain sub-domains in the velocity - flow height-plane. Furthermore, attention is given to a potential problem with a singularity in the equation of motion as flow height diminishes. These possible pitfalls are avoided with certain guidelines for the parameter

ranges.

The simulation model has been tested on a series of known avalanches from Ryggfonn, the full scale test site of the Norwegian Geotechnical Institute (NGI).