Geophysical Research Abstracts
Vol. 20, EGU2018-19800, 2018
EGU General Assembly 2018

Granular flows in inclined channels

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Study of granular flows down inclined channels is essential in understanding the dynamics of natural grain flows like landslides and snow avalanches (e.g. Delannay et al., 2017). As a stepping stone, we consider a monodisperse dry granular material owing down a rough inclined channel with downslope contracting sidewalls: theoretically and numerically. Utilising the depth-averaged shallow granular theory (Savage & Hutter, 1989) together with an empirical (Pouliquen, 1999; Pouliquen & Forterre, 2002), but discrete particle simulations validated constitutive friction law (Weinhart et al., 2012; Thornton et al., 2012), an extended novel one-dimensional (depth- and width-averaged) granular hydraulic theory will be presented. Different ow states are predicted by this novel one-dimensional theory. Flow regimes with distinct ow states are determined as a function of upstream channel Froude number, F, and channel width ratio at the exit, Bc. The latter being the ratio of the channel's exit width and upstream channel width. For steady flows, besides describing the subcritical ow state (F < 1), the one-dimensional model also predicts two other steady states for a range of upstream prescribed supercritical ow conditions (F > 1) and channel openings (Bc). The two other states are flows with weak oblique shocks (smooth when width-averaged) and flows with a steady jump in the contraction region. Both, super- and subcritical ow states are verified by numerically solving the closed depth-averaged two-dimensional shallow granular model using an open-source continuum solver hpGEM (Pesch et al., 2007). Despite the strong inhomogeneities in the linear contraction region, we will show that the one- and two-dimensional solutions (averaged across the channel) incomparably match well.

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