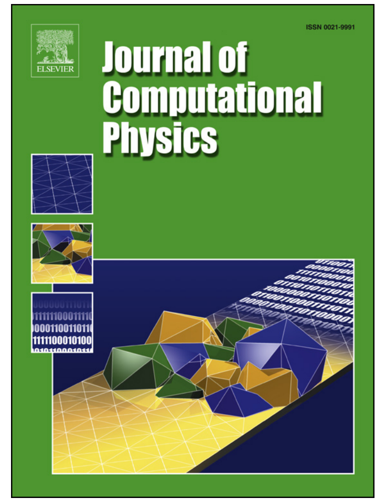
Accepted Manuscript



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PII: S0021-9991(17)30882-3
DOI: https://doi.org/10.1016/j.jcp.2017.11.038
Reference: YJCPH 7743

To appear in: *Journal of Computational Physics*

Received date: 15 May 2017
Revised date: 21 November 2017
Accepted date: 24 November 2017

2D granular flows with the $\mu(I)$ rheology and side walls friction: a well-balanced multilayer discretization

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Abstract

We present here numerical modelling of granular flows with the $\mu(I)$ rheology in confined channels. The contribution is twofold: (i) a model to approximate the Navier-Stokes equations with the $\mu(I)$ rheology through an asymptotic analysis; under the hypothesis of a one-dimensional flow, this model takes into account side walls friction; (ii) a multilayer discretization following Fernández-Nieto *et al.* (*J. Fluid Mech.*, vol. 798, 2016, pp. 643-681). In this new numerical scheme, we propose an appropriate treatment of the rheological terms through a hydrostatic reconstruction which allows this scheme to be well-balanced and therefore to deal with dry areas. Based on academic tests, we first evaluate the influence of the width of the channel on the normal profiles of the downslope velocity thanks to the multilayer approach that is intrinsically able to describe changes from Bagnold to S-shaped (and vice versa) velocity profiles. We also check the well-balanced property of the proposed numerical scheme. We show that approximating side walls friction using single-layer models may lead to strong errors. Secondly, we compare the numerical results with experimental data on granular collapses. We show that the proposed scheme allows us to qualitatively reproduce the deposit in the case of a rigid bed (i. e. dry area) and that the error made by replacing the dry area by a small layer of material may be large if this layer is not thin enough. The proposed model is also able to reproduce the time evolution of the free surface and of the flow/no-flow interface. In addition, it reproduces the effect of erosion for granular flows over initially static material lying on the bed. This is possible when using a variable friction coefficient $\mu(I)$ but not with a constant friction coefficient.

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