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Geoscientific Model Development Discussions

Interactive comment on "faSavageHutterFOAM 1.0: Depth-integrated simulation of dense snow avalanches on natural terrain with OpenFOAM" *by* Matthias Rauter et al.

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The authors present an implementation of a model for rapid mass movements similar to the established Savage-Hutter model in the open-source continuum fluid dynamics software OpenFOAM. From the concept such an approach is somewhere between using highly developed specific models (which are mostly not free and not open source) and developing an own code from the scratch. My own 2015 paper already cited was a first approach in this direction, and the promising results of the recent manuscript illustrate that such concept could indeed become an interesting alternative in the future. The biggest part of the implementation has already been published very

recently in the paper in Comp. Fluids. What is new here is the application to real topographies and the implementation of particle entrainment for snow avalanches. I feel that these new components indeed merit a publication in GMD. The paper is well written in my opinion, and I enjoyed reading it. Unfortunately I did not find enough time to get as deep into the theory as the first reviewer did and can provide only a few suggestions where the presentation could be improved.

Dear Prof. Hergarten,

thank you very much for your quick review and your interesting suggestions. This paper is indeed a summary of open questions from referees of the last paper. Especially (1) application to natural terrain, (2) comparison to an existing software and (3) interaction with GIS was requested by the referees of Rauter and Tukovic (2018) for future publications.

(i) As a principal problem, it was impossible to me to understand the brief review of the theory without the much longer paper in Comp. Fluids. However, I do not know whether there is a way to get around this problem, but maybe the authors can think about it.

(ii) In the beginning I got stuck at the way how the fundamental equations (Eqs. 1-3) have been extended by particle entrainment, in particular why only the first equation is affected. I think it is correct this way using the momentum-flux version of the shallow water equations, but maybe a bit more explanation on this might help.

We are aware of the fact that the theory is hard to understand for readers which are used to the classic surface aligned coordinate system. We think the biggest problem is that people think in surface aligned coordinates and it usually takes a while to get used to the new concept of projections and the usage of Cartesian coordinates. To solve this issue, we propose to add an explanation of surface projections in the appendix (see appended document).

(iii) How does the "non-physical" parameter u_0 affect the results, in particular the question how close the avalanche comes to rest?

The parameter u_0 has no relevant effect, as long as $|\overline{u}| \gg u_0$. At $|\overline{u}| = 100\, u_0$, the regularisation reduces the effective friction to 99%, at $|\overline{u}| = 10\, u_0$ to 91%, etc. This allows stopping in zones where only part of the possible shear stress is mobilized. We are using $u_0 = 10^{-7}\mathrm{m/s}$ in the simulations. Therefore, there shouldn't be any relevant effect on the dynamic behaviour at $|\overline{u}| > 10^{-5}\mathrm{m/s}$. Indeed, $10^{-5}\mathrm{m/s}$ is the velocity we observe in the deposition zone. This velocity matches the solver tolerance, and can thus be ignored. We will add this to the revised manuscript.

(iv) As a detail of the implementation, I did not get how the regularisation of Eq. 12 similar to Eq. 9 works. I hope that these suggestions help in improving the accessibility of the paper for those readers who are not so familiar with the theory.

The regularisation works by reformulating the explicitly calculated entrainment rate to an implicit entrainment rate, depending on h_{msc},

$$\frac{\dot{q}}{\rho} = \frac{\dot{q}}{\rho} \frac{h_{\mathrm{msc}}}{h_{\mathrm{msc}} + h_0}.$$

The term $\frac{\dot{q}}{\rho} \frac{1}{h_{\mathrm{msc}} + h_0}$ is calculated (similar to $\mu\, p_{\mathrm{b}}\, \frac{1}{|\overline{\mathbf{u}}| + u_0}$) following the entrainment model, a small value for h_0 and an estimation for h_{msc}. This way, the entrainment rate is reduced for $h_{\mathrm{msc}} \to 0$ and undershoots are prevented. Note that this works only when solving the equation implicitly. We will add this to the revised manuscript.

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2018-67/gmd-2018-67-AC2-supplement.pdf

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