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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Snow avalanche friction relation based on extended kinetic theory" *by* M. Rauter et al.

Anonymous Referee #1

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The authors present an avalanche model parameter study comparing the more traditional Voellmy model approach to a model (friction relation) based on a theory for granular shear flows. The paper can be divided more or less in two parts. To obtain the "new" friction relations, they derive a depth-averaged model, which is presented in the first part of the paper. Derivations follows the granular shear flows model by Vescovi (2014). Ibn the First part, they present also some parameter studies using material parameters, which might be relevant for small quartz particles. In the second part of the paper, the authors provide a cross-comparison of their friction relation with the commonly used Voellmy-model. To this end, the authors study two observed avalanche events for which velocity and field data are available. The paper is reasonably well written and the topic can be interest for readers of NHESS. Therefore, the paper might be worth to be published. Some language checking should be done. However, there

are several ambiguities in the presented in the paper, which should be addresses by the authors before publishing. General comments: The other present a friction relation for snow avalanches which they base on what they call extended kinetic theory. Similar approaches have been present previously, e.g., by Körner who also suggested a height dependency on the Voellmy \xi parameter (Körner, H. J. Modelle zur Berechnung der Bergsturz- und Lawinenbewegung, Interpraevent 1980, 1980, 2, 15-55.). The work would be worthwhile to be cited. The author argue to present a "new" friction relationship for snow avalanches, however, their first parameter study in the first part of the paper is probably only relevant for small quartz particles. Although some interesting features are presented, the authors lack to discuss the limitations/restrictions of their model in respect to snow particles/clouds, which constitute avalanches. I have doubts that, e.g., Eq (7) combined with Eq (9) (which suggests, e.g. an singularity) gives reasonable results for snow clouds. Similar reservations hold also for the other parameters in the kinetic model part of the paper. These limitations need to be discuss. On the other hand, in the second part of the paper the user restrict themselves again to more or less "traditional models" with a constant density; abandon the avenue the kinetic theory could give to include varying densities in the flow. It is also not clear to me, if the author include the factor 2/5 originating from the velocity profile is also include in the balance equations or only in the friction relation. The comparison in the second part as such is interesting, and the methods seems to be legitimate to compare simulation results with observations. However, here it puts the questions, if parameter sets for avalanches with different return periods (RGF probably 1-2 years whereas the VdlS event was probably in the order of 30 years) should be combined. Finally, the title draws the attention to a new friction relation for snow avalanches, however coming to the discussion at the end, the authors only focus on the second part of the paper, the model comparison with the observations. Here the other should also discuss limitations and perspectives of their proposed friction relation. Some specific comments: page 2 line 26 x is the curvilinear coordinate: Eq (1) and eq (2) are by no means written in curvilinear coordinates: you are using local Cartesian here.

page 3 line 13 Constitutive relations in the framework of three-dimensional continuum mechanics: Here, you only present your relations in respect to simple shear not for a fully three-dimensional framework, see also line 18.

Eq (6) is this correct for simple shear (coefficient 3/2???). page 8 line 7 This form of constitutive relation is difficult to implement in an operational simulation tool: Why ????

Figure 8 \nu 1 ??????? What do you mean with the text in the figure, something missing ??? Figuure 10 caption The error bars show the high fluctuation of velocity of grains which agrees to the assumptions of the kinetic theory: Why ??????? First of all, errorbars represents the error/uncertainty in the measurements.

page 13 line 18 This leads to a lower friction for larger flow heights and therefore larger avalanches. This behavior is in line with observations: Which ones????? Per contra, how do you explain, for example, observations by Wagner, P. Kalibrierung des Modells für das Ermitteln der Auslauflänge von kleinen und mittleren Lawinen Institut für Alpine Naturgefahren (IAN), BOKU-Universität für Bodenkultur, Institut für Alpine Naturgefahren (IAN), BOKU-Universität für Bodenkultur, 2016"

page 15 line 1 The affected area near the deposition area. The deposition area cannot be analyzed directly because the dynamic model does not simulate the deposition process explicitly.: I'm not sure if I get what do you mean here. Do the simulations not show the final height etc. at the end?????

Figure 12 a and b. Without any information of at least the rough profile of the path are the figure little meaningful.

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