Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2018-120-AC1, 2018

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Dome instability at Merapi volcano identified by drone photogrammetry and numerical modeling" *by* Herlan Darmawan et al.

Herlan Darmawan et al.

herlan@gfz-potsdam.de

Received and published: 8 August 2018

SC: The submitted manuscript provides a useful integrated study of drone-based geomorphological analysis and thermal infrared data collection to assess the stability of the dome of Merapi volcano. Water percolation within the dome is taken into consideration as trigger of dome collapses. The effort to provide a Factor of Safety is commendable. Although pyroclastic flow modelling is only a small portion of the research work illustrated here, to prevent this paper from being misleading, the authors should acknowledge the fact that there is still a lot of work to do before it is really possible to predict the mobility of pyroclastic flows.

Response: Thank you very much for the comments. We agree to the points that the modelling is only a small portion of the work, and that there is still a lot of work to do before PDC can be predicted, and that especially the modelling technique used is limited. Therefore we are more careful with the interpretation of our result and inserted a critical discussion.

SC: I have a few important comments: 1) There is the need to mention the actual basal friction that the authors have chosen when running Titan2D: Coulomb, Voellmy or Pouliquen-Forterre, for example. If this is not done, it would be impossible to fully characterize the simulations.

Response: comment accepted. Titan2D uses the Coulomb friction to simulate geophysical mass flow over natural terrain. We have now added this information in the revised version.

2) Please recognize in the text that Titan2D, as the name confirms, is a two-dimensional model whose results are adapted to a three-dimensional subsurface only later on by the software package.

Response: Accepted. We added the 2-D limitation in the introduction and in the method sections, where we describe the application and basic theory of Titan2D.

3) It is also very important to disclose that, in Titan2D, the flows never stop and the computer operator has to introduce an arbitrary criterion to decide when the flows cease their motion and a deposit is formed [Ogburn and Calder, 2017]. The lack of acknowledgment of this shortcoming generates the false notion that the pyroclastic flow mechanics is understood.

Response: comment accepted, it is true that Titan2D will not technically stop in the end of simulation. This we clarified in the revised version. As we note, the velocity of the flow will exponentially decrease to $\sim$0 m/s when the computation reached maximum time simulation (Charbonnier and Gertisser, 2009). In order to obtain more realistic rock avalanche model, we set validated coulomb friction angle and changed the maximum simulation time from 20 minutes to 1 hour, being aware that the accurate timing must not misinterpreted with true timing. We have added this clarification in the revised version.

4) The main problem with Titan2D is that it ignores completely the granular nature of pyroclastic flows. This is in contrast to the fact that block-and-ash flows are well documented worldwide to be dense granular flows of angular rock fragments [Nairn and Self, 1978; Saucedo et al., 2002]. It is therefore important to inform the readers that an effort is undertaken to understand how rock fragments dissipate energy when interacting among themselves and the subsurface within travelling flows [e.g., Cagnoli and Piersanti, 2015 and 2017]. Since the grain size strongly affects the mobility, it is important to state clearly the grain size of the simulated flows.

Response: We appreciate this comment. Titan2D software not completely ignores the granular nature of pyroclastic flows/debris avalanches. The flows are assumed to be incompressible continuum and the interaction between grains-grains and grains-basal surface is solved by Mohr-Coulomb law (see Patra et al., 2005). To discuss the limitations of the models and efforts of studying rock fragments in granular flows, we inserted the suggested references (Cagnoli and Piersanti, 2015 and 2017). We better clarify the momentum effects due to grain size interaction. We added further details of the basic theory of Titan2D in the methods section and more thoroughly discuss the limitation in the revised version.

5) My previous comments boil down to two questions. Considering that, block-and-ash flows are controlled by gravity and topography, do you really need Titan2D to know: A) that dome collapses discharge their rock debris down the deep and narrow valley which the horseshoe-shaped crater morphed into and B) that deposits form at the base of the volcanic cone where a dramatic change of the slope angle occurs?

Response: We appreciate this comment. Yes, it is necessary to define source collapse

mechanism in Titan2D. Titan2D is able to model several collapse scenarios such as a single collapse, multiple collapses, a gravitational collapse, or a fountain collapse that produce radial debris avalanches. In our model, we define that the mechanism of the source collapse is a single block collapse which triggered by hydrothermal alteration and neglect gas overpressure. Therefore, we chose a single gravitational collapse scenario (flux model) and set initial velocity of 0 m/s (no gas overpressure) and volume of 500.000 m3 (volume of delineated block). The deposit and the flow mechanism of Titan2D simulation are controlled by coulomb friction. In order to obtain realistic model where the flow is controlled by topography and different slope, we applied material map, which integrated with DEM. We defined variation of coulomb friction based on slope variation. In order to clarify the mechanism of source collapse and the debris flow, we added detail description of parameters that control the source collapse and the variation of coulomb friction angles in the revised version.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2018-120, 2018.