Comment on Synthetic benchmarking of concentrated pyroclastic current models

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Introduction

Gueugneau et al. (2021) present the results of a benchmarking initiative built to evaluate four models commonly used to assess concentrated PC hazard: SHALTOP, TITAN2D, VolcFlow, and IMEX_SfloW2D. The benchmark focuses on the simulation of channelized flows with similar source conditions over five different synthetic channel geometries: (1) a flat incline plane, (2) a channel with a sharp 45° bend, (3) a straight channel with a break-in-slope, (4) a straight channel with an obstacle, and (5) a straight channel with a constriction. In this paper they concluded that TITAN2D when the Voellmy-Salm rheology was chosen had significant discrepancies in flow simulation outputs compared to the ones obtained with the other three models. However, upon closely examining their model input files, we find that the input flux calculation for the volume desired is high. We explain and provide the solution below. With the help of this study, we were also able to find a minor bug in our code in the treatment of one of the lesser source terms and have fixed it for the future use.

Calculation of flow volume for flux source option

To compare all the models, different volumetric fluxes are set as fixed source conditions in their benchmarks which generates flows with different initial volume fluxes ($F$) for different activation time period $t_1 = \{100, 66, 33\}$ seconds. A total volume of $V = 10^6$ is selected. Flux initiates from a circular spot with a 25-m radius set at the center of the valley (center of the domain for the inclined plane) and at 500 m from the domain top boundary (to avoid back flow issues).

TITAN2D treats the time dependence of flux source as that required to create the default pile shape of paraboloid volume. All flux necessary for the input can therefore be found using following formulation.

\[
V = \int_0^{t_1} \frac{\pi r^2}{2} F \left(1 - \frac{t}{t_1}\right) dt
\]

Substituting the values of $t_1$ in Eq. (2) gives values of $F = \{20.372, 30.867, 61.733\} m/s$ instead of $F = \{45, 68, 145\} m/s$ used for the published study.

The likely source of confusion is the way TITAN2D reports volume of flow. Firstly, TITAN2D reports a full volume of the flow to standard output (usually screen or batch output for remote jobs) and then a more comprehensive and detailed “output.summary” file which reports on:

- outflow volume = volume that left the boundaries of simulation
- eroded volume = volume that was eroded this iteration
- deposited volume = volume that is currently deposited
Fig. 1 First 4 figures are taken from Gueugneau et al. (2021). Last figure shows the TITAN2D output on Bend DEM with the corrected flux values. The change in the flux values affects the output significantly and with the correct flux values, the simulation outcomes are in the range of other software.

Fig. 2 First 3 figures are taken from Gueugneau et al. (2021). Last figure shows the TITAN2D output on Constriction DEM with the corrected flux values. TITAN2D is able to simulate on Constriction DEM with the flux as calculated here outputs as shown above.
realvolume = “actual” volume within boundaries

Of these when all inputs for discharge plane and domain are defined and the terrain files define the flow domain boundaries the “realvolume” correctly reports the flow volume. In the case where artificial terrains are made using a fake GIS representation as in the test cases here and a discharge plane is undefined these calculations of volume may be inconsistent.

**Bug in the source code of TITAN2D**

While investigating the discrepancies for the outputs of this study, we found a small bug in the implementation of the turbulent part of the friction using \( \xi \). This was resulting in the momentum to be very slightly higher (1–2\%) higher than it should have been.

**Simulation outputs with corrected flux**

Using Eq. (2), we calculated the correct flux that needs to be given as the input parameter for TITAN2D. We used that flux values to run the simulation on the same DEMs. Figures 1, 2 and 3 show original and corrected simulations. Output of the simulations shows that TITAN2D’s performance is in the same range as the other software tools tested.

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**References**

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