Implementation of material maps into the Titan2D simulation tool

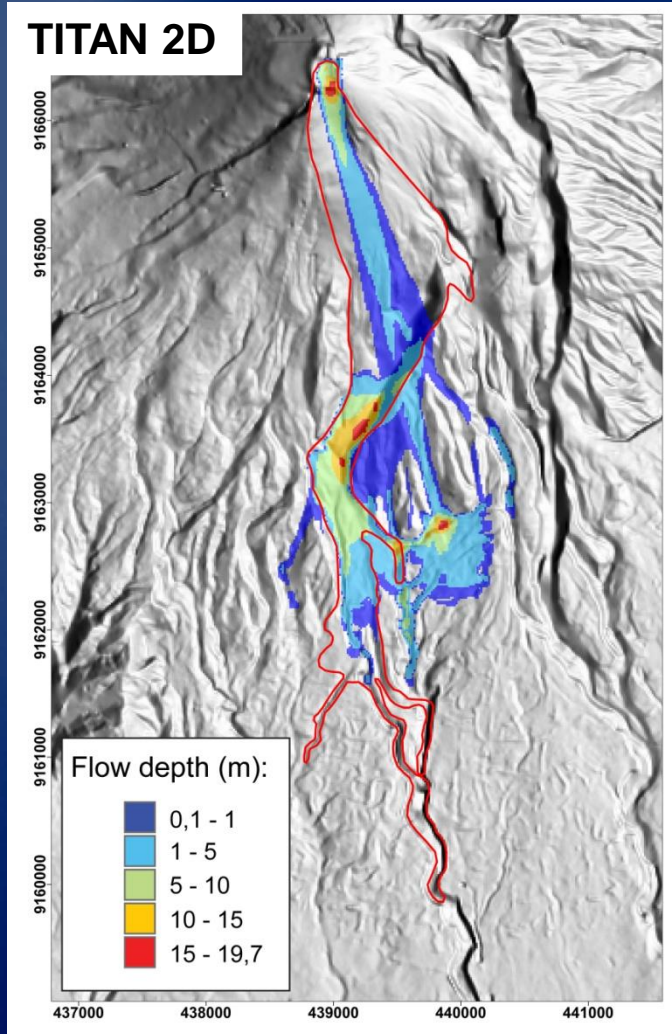**Sylvain Charbonnier**

Vhub working meeting
Bogota, Colombia
November 24-26, 2013

Motivation

Basal friction angle: 16.7 °

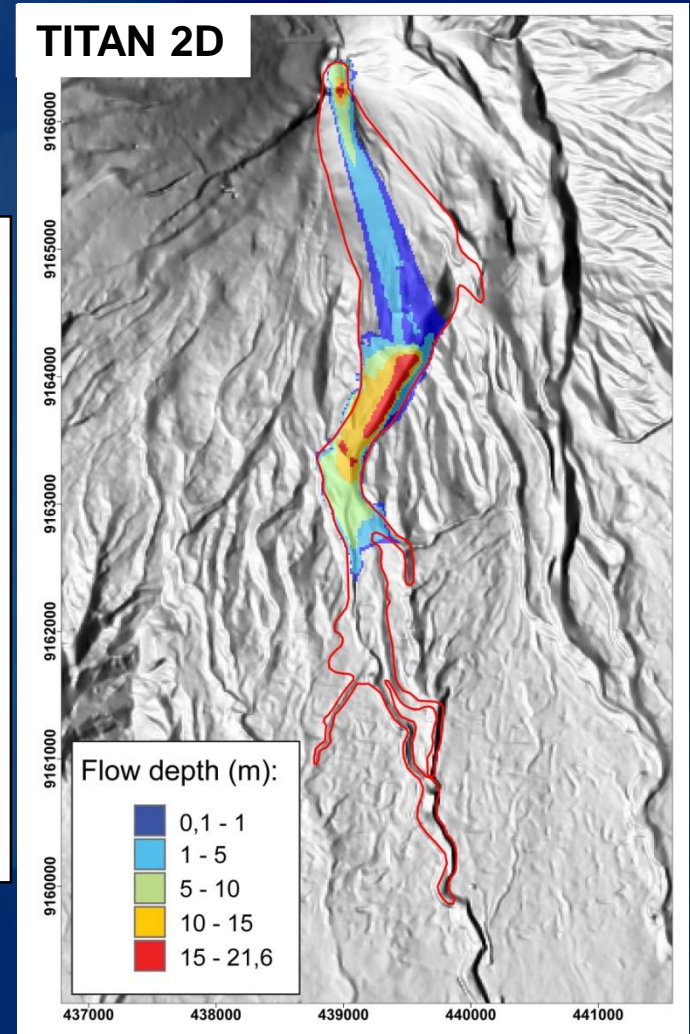Flow coverage match: **18.2%**

None of the simulations using a single basal friction is capable of reproducing the path and extent of the 2006 BAF events at Merapi volcano

Basal friction angle: 20 °

Flow coverage match: **32%**

Motivation

- Pouliquen (1999) pointed out that laws involving a constant friction parameter are restricted to granular flows that move over smooth inclined planes or flows on a steeply inclined rough plane. They proposed an empirical basal friction coefficient $\mu = \tan\varphi$ as a function of the mean velocity u and the thickness h of the flow:

$$\mu = \tan\phi_1 + (\tan\phi_2 - \tan\phi_1)\exp\left(-\gamma\frac{\sqrt{gh}}{u}\right)$$

- Other authors using the Manning or Chezy coefficients for hydraulic models to simulate debris flows → pseudo-variable bed friction according to flow depth and width, channel slope, and bed roughness…

- Our simulations of the 2006 BAFs at Merapi volcano show that using a varying bed friction angle based on decreasing local slope and increasing channel confinement better reproduce the paths, runout distances, areas covered and deposited volumes of the actual events (Charbonnier and Gertisser, 2012)…

Motivation

| Surface material	Coefficient of friction	Friction angle
Glacial ice/snow	0.037-0.50	2-26°
Alluvial deposits	0.10-0.20	6-11°
Vegetation	0.21-0.5	12-37°
Glaciofluvial deposits	0.15-0.30	9-17°
Bedrock	0.38-0.95	21-44°

From Stinton et al., 2004

Based on a data compilation of different bed friction values used in the literature, Stinton et al. (2004) assigned a range of friction coefficients to different types of bed roughness for the simulation of the Little Tahoma Peak avalanches → better match velocity, deposit morphology and run out of the actual avalanches…

Implementation in Titan2D

## 1. Material map based on bed roughness

In this case, the material map consists of a number of polygons in raster format, with each polygon representing a region, such as bedrock, forest, or an area underlain by glaciofluvial deposits, where the bed friction angle is assumed to be constant…. should be the same size and resolution as the GRASS DEM…
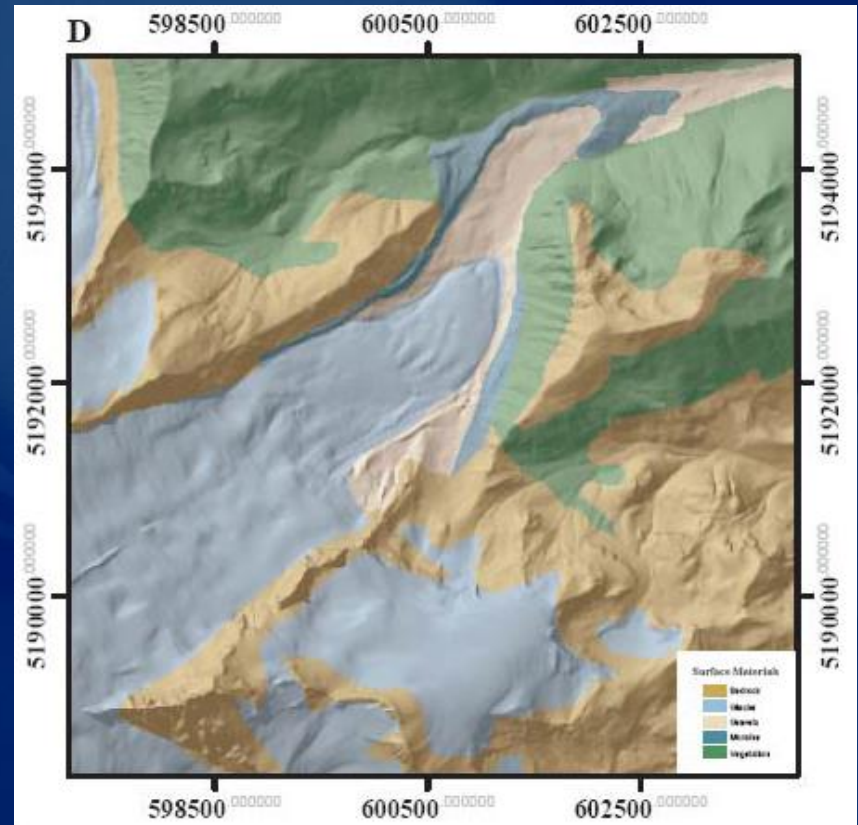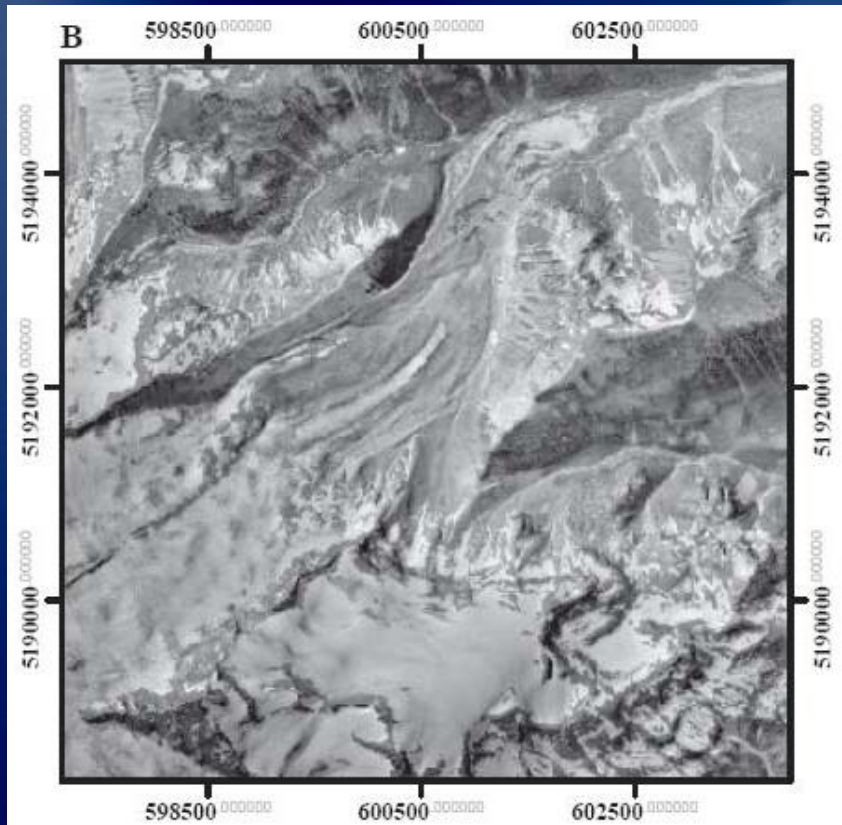
From Stinton et al., 2004
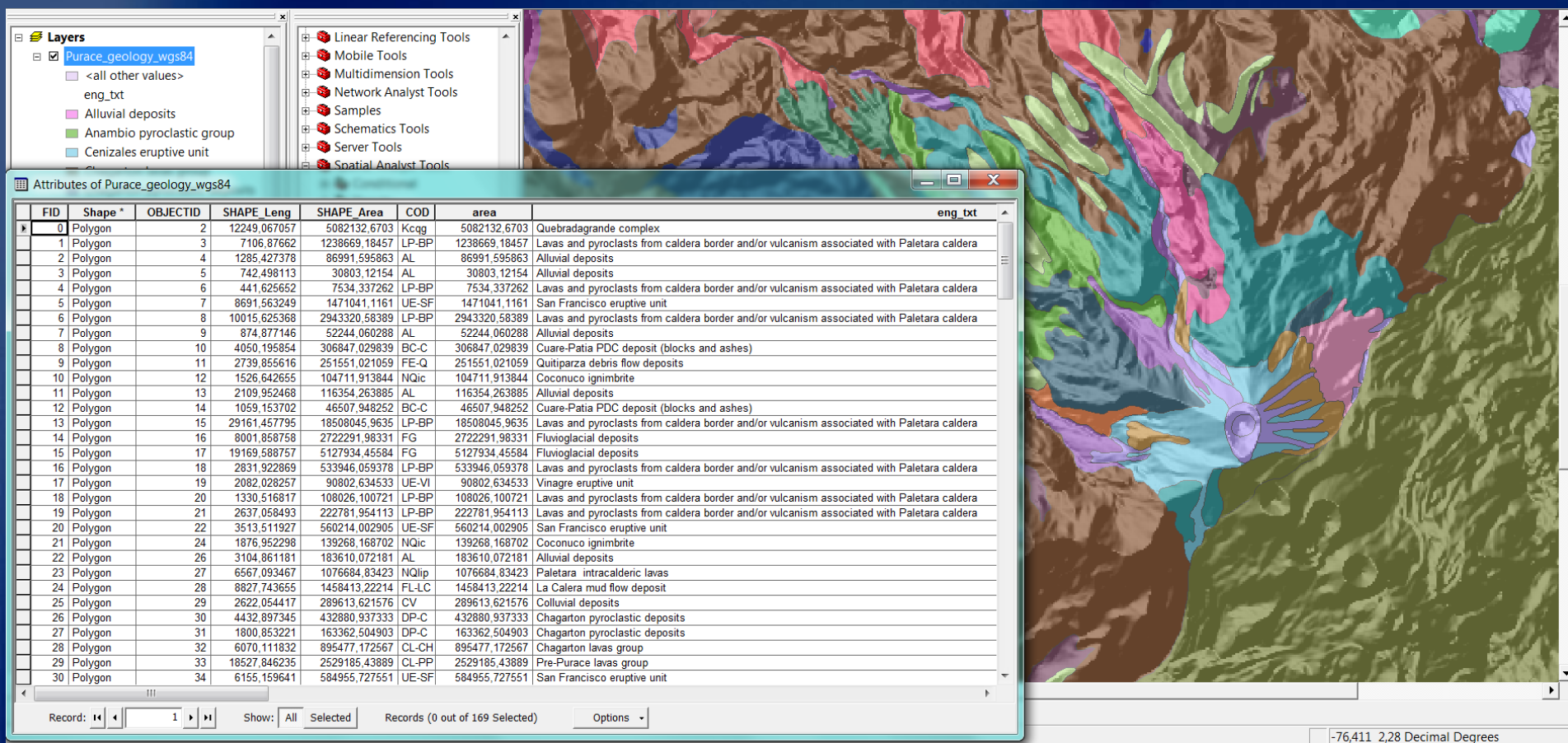
Implementation in Titan2D

2. Material map based on local slope and channel confinement
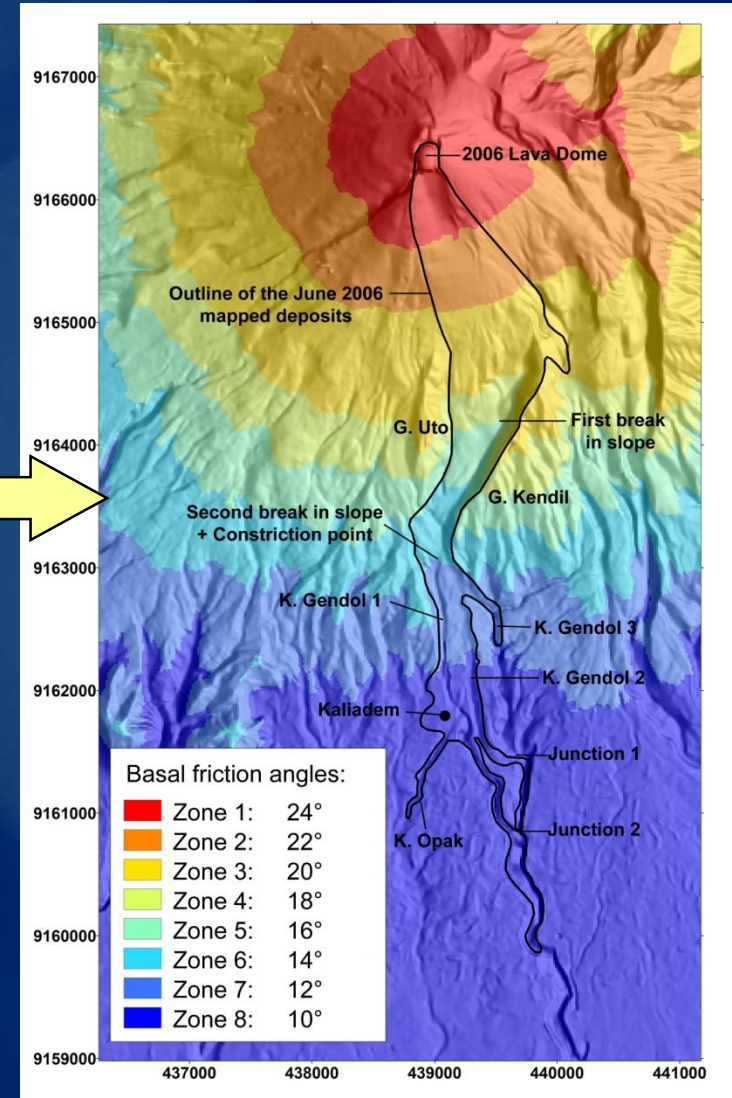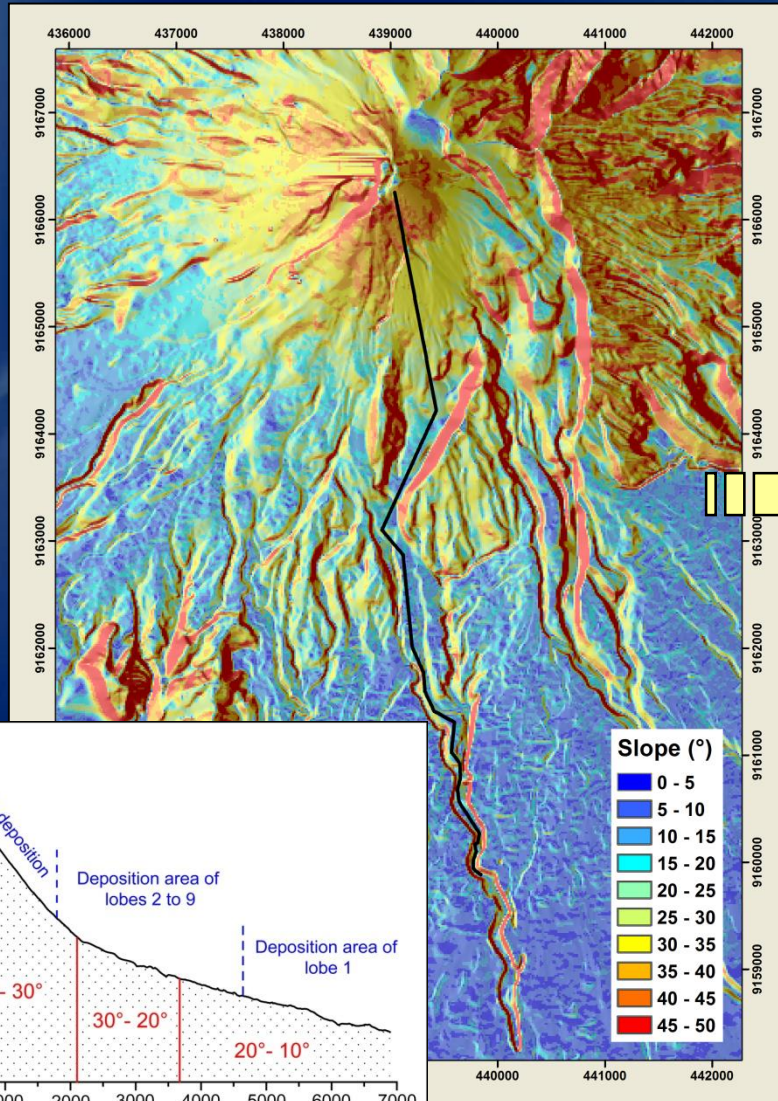
Charbonnier and Gertisser (2012)
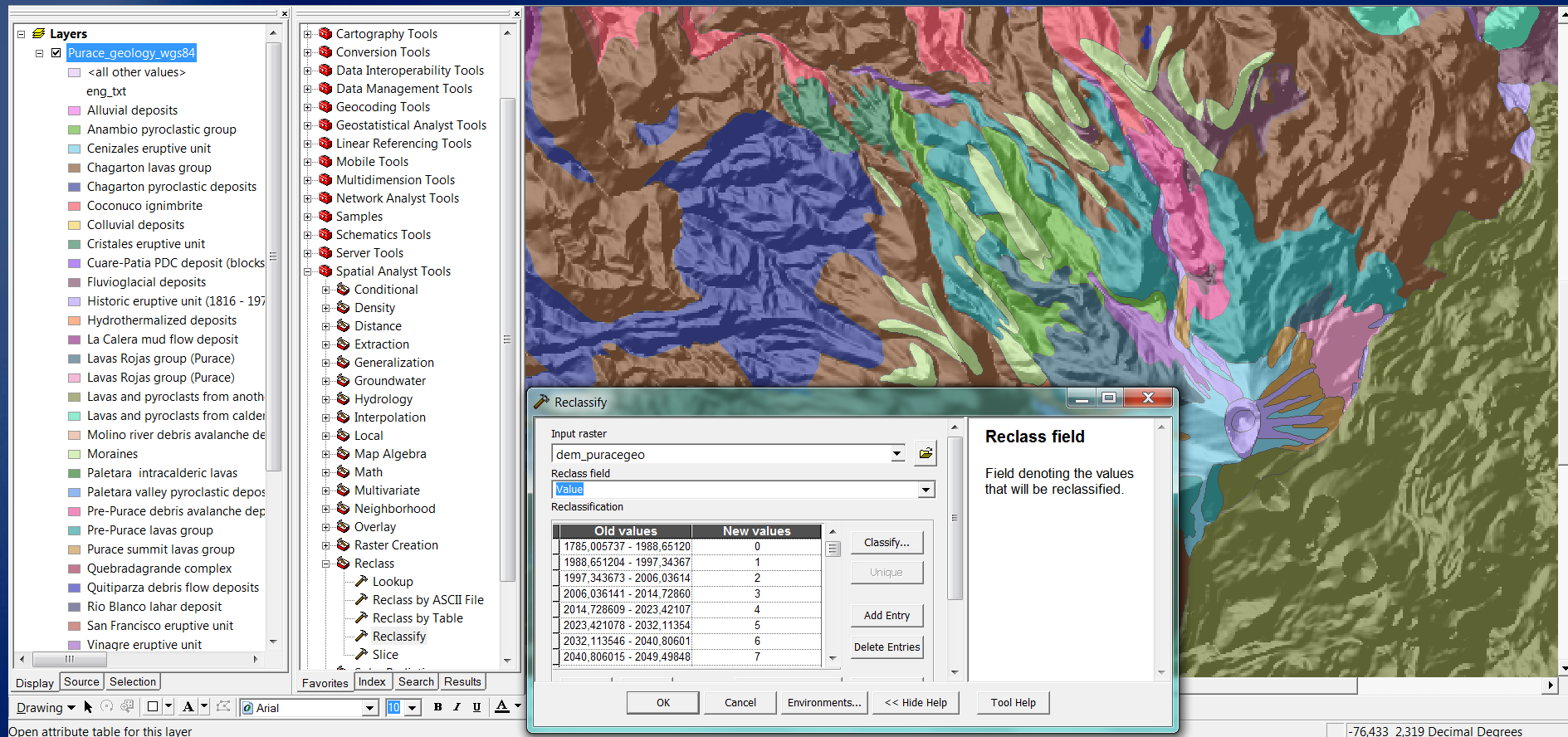
Implementation in Titan2D

- Creation of the material map using spatial analyst toolbox in ArcGIS:

- First convert the appropriate shapefile (polygons) into a raster map using the same spatial resolution as the DEM…
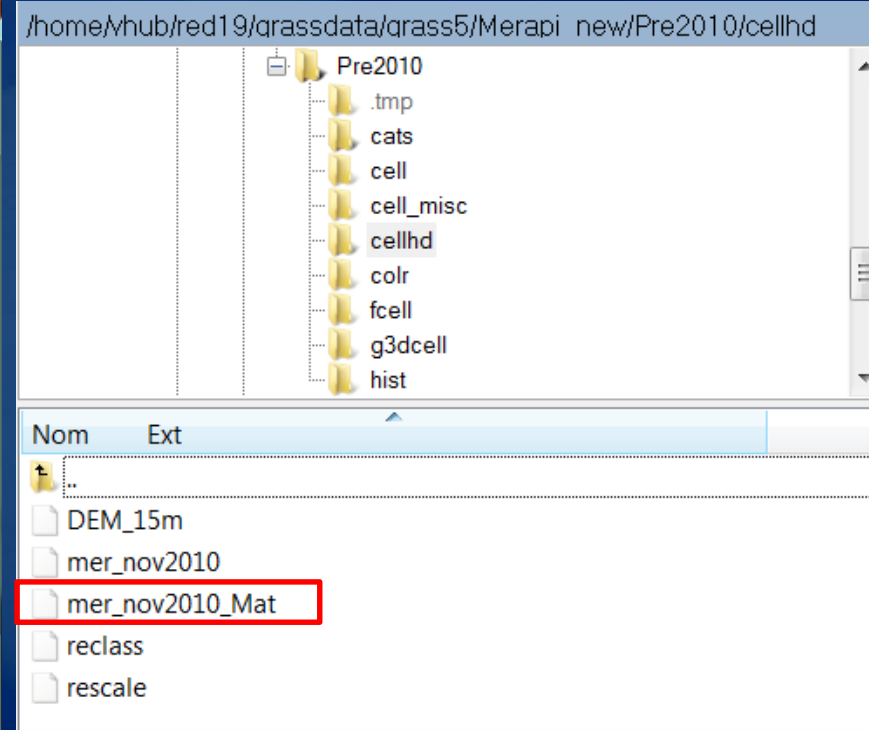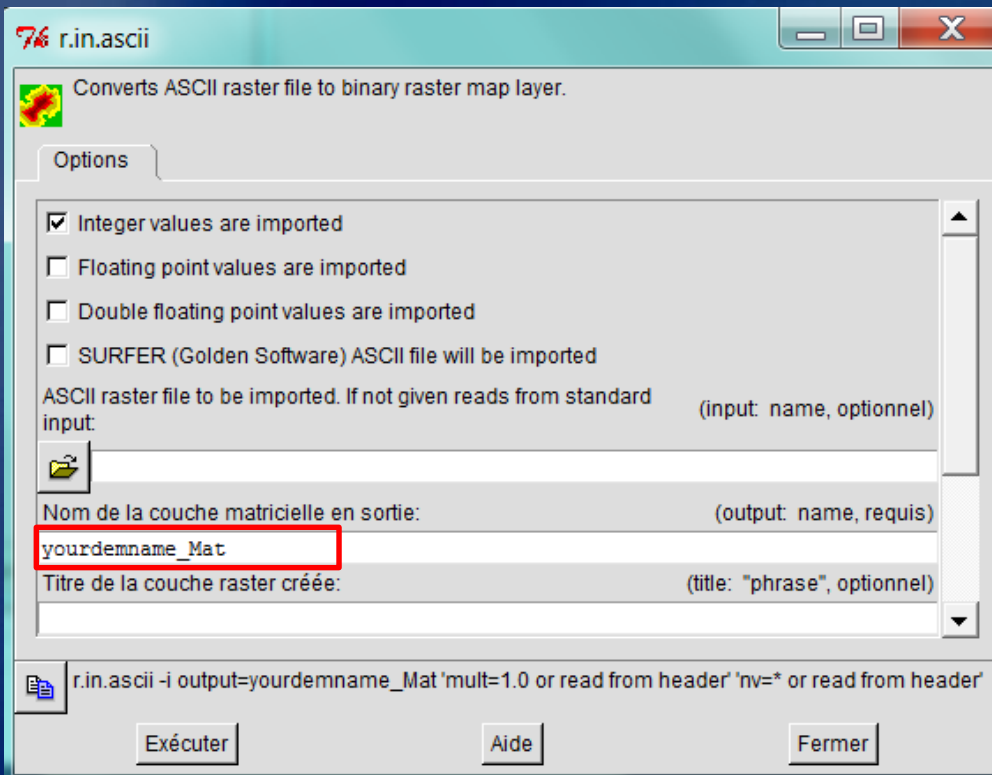
Implementation in Titan2D

- Creation of the material map using spatial analyst toolbox in ArcGIS:

- Then use the spatial analyst toolbox to reclassify the raster map using integer values (1 to x) that correspond to the zones of constant bed friction values… then save it as an ascii grid to be imported into GRASS GIS…
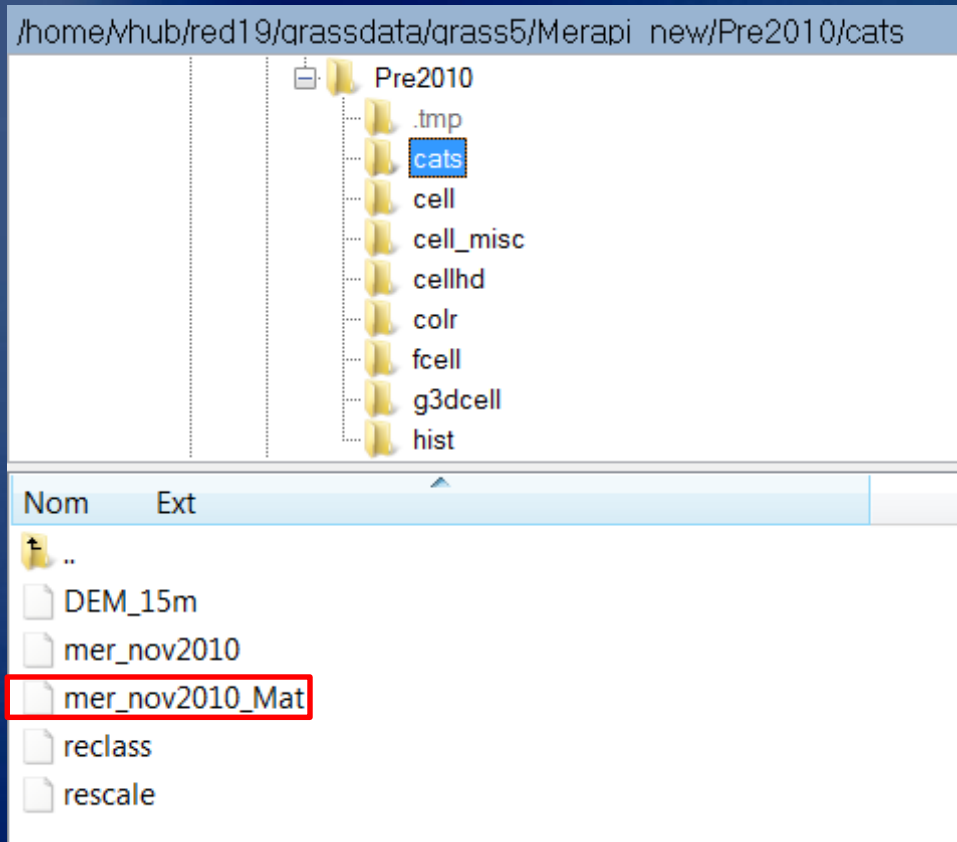
Implementation in Titan2D

- Import the material map (yourdemname_Mat) into GRASS GIS directory:

→ Make sure that after you imported the ascii file into your grass directory, you have a new file named 'yourdemname_Mat ' in the various GRASS GIS folders…

Implementation in Titan2D

- Edit the categories file (in the 'cats' folder) from the GRASS GIS directory:

→ Make sure you copy the same number of zones of constant friction angles as those you created in ArcGIS and assign the correct number + material name to each of them!

```
# 255 categories

0.00 0.00 0.00 0.00
```

```
# 8 categories
FrictionMaterial

0.00 0.00 0.00 0.00
0:MaterialA
1:MaterialA
2:MaterialB
3:MaterialC
4:MaterialD
5:MaterialE
6:MaterialF
7:MaterialG
8:MaterialH
```
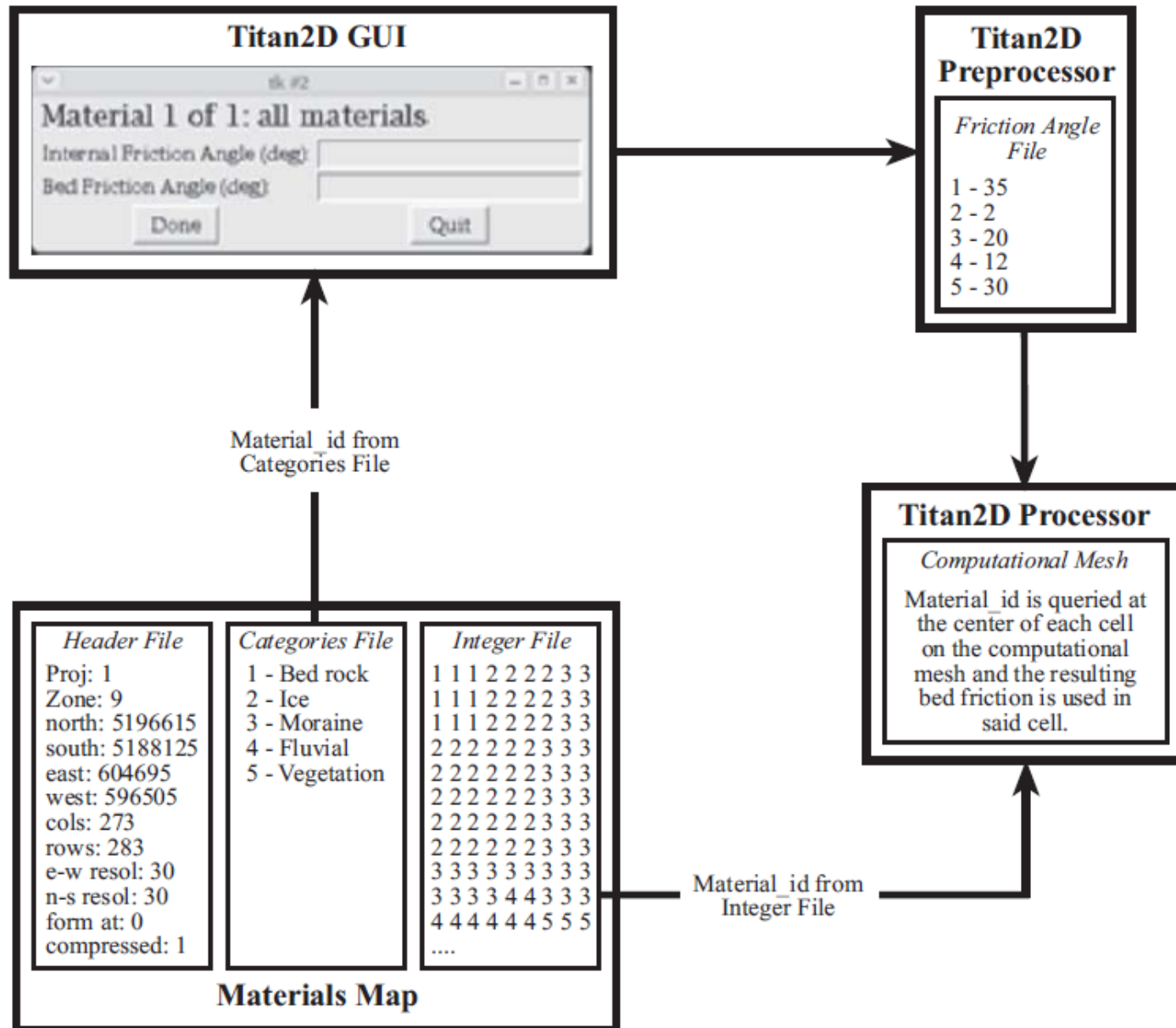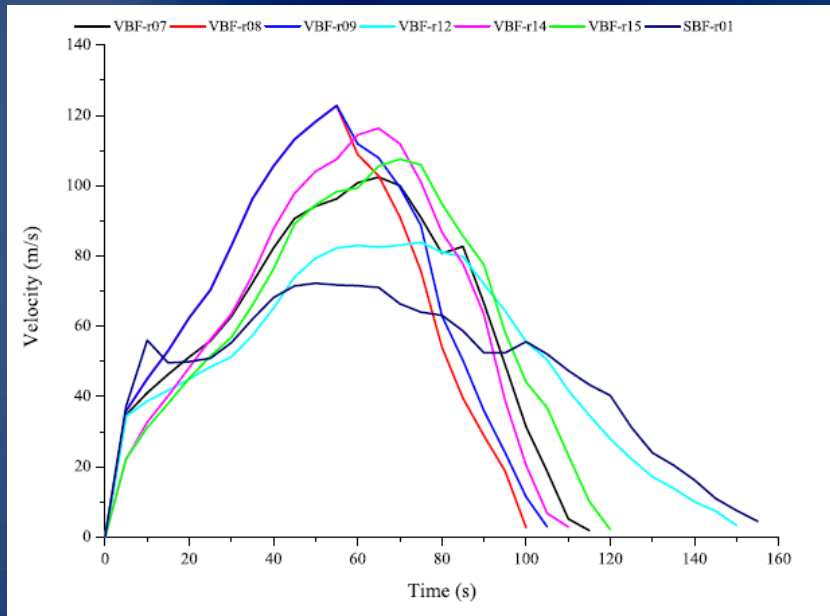
Implementation in Titan2D on Vhub

- When running a new simulation on Vhub, just enter the GRASS GIS information on the 'GIS' tab as usual and select 'True' in the 'Material Map' tab… you should get a new option to enter various friction angles for each zones you created in the material map!!

Implementation in Titan2D
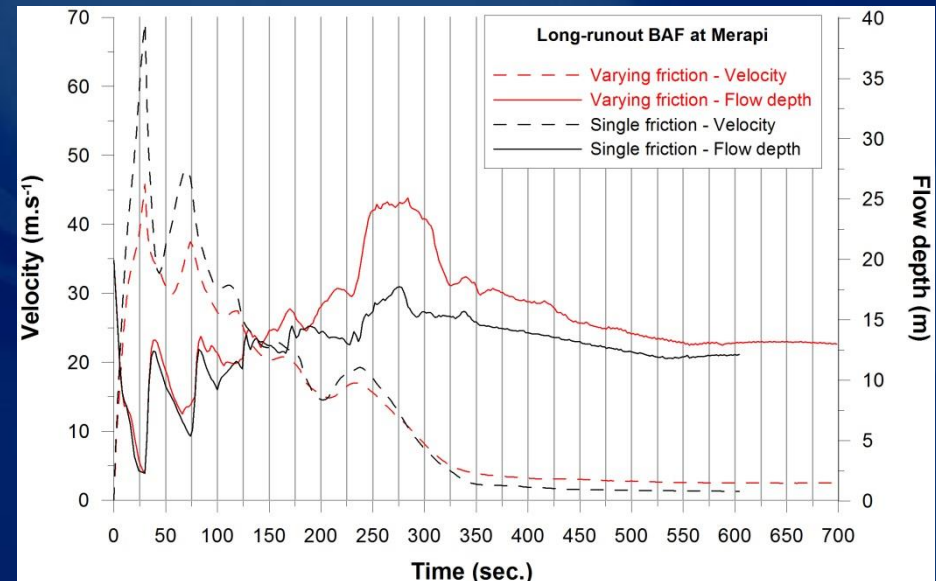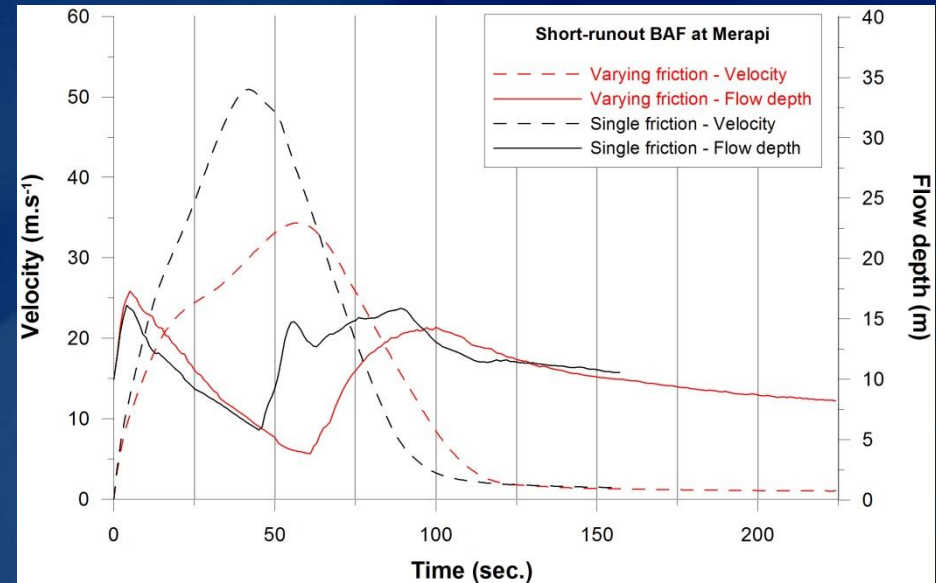
Effects on flow parameters

- ## Based on bed roughness:

From Stinton et al., 2004

- ## Based on local slope and confinement:

From Charbonnier et al. (2012)

- Variation in max. velocities, depths and total runout (duration) of the simulated flows

- Variation in the waxing (flow acceleration) and waning (flow deceleration) stages between simulations
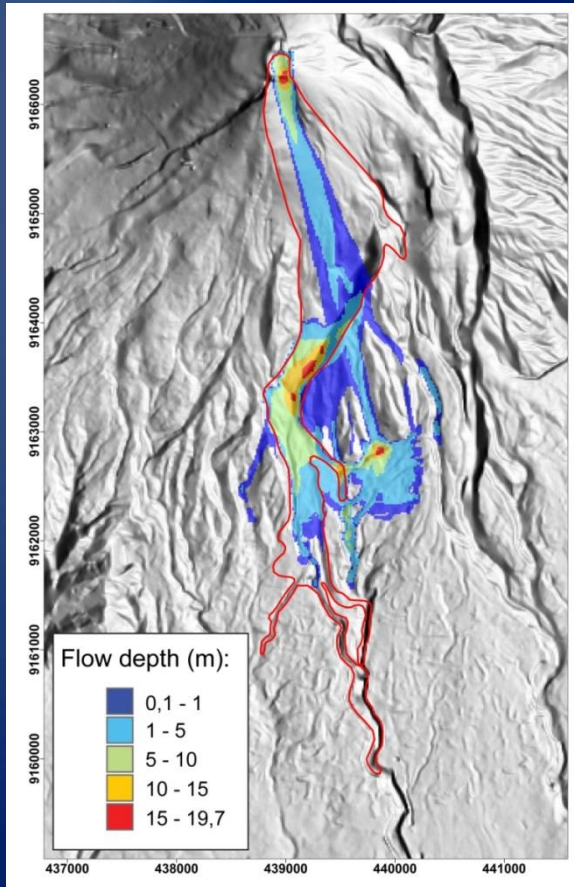
Effects on flow behavior

Single friction angle: 16.7°

Single friction angle: 20°
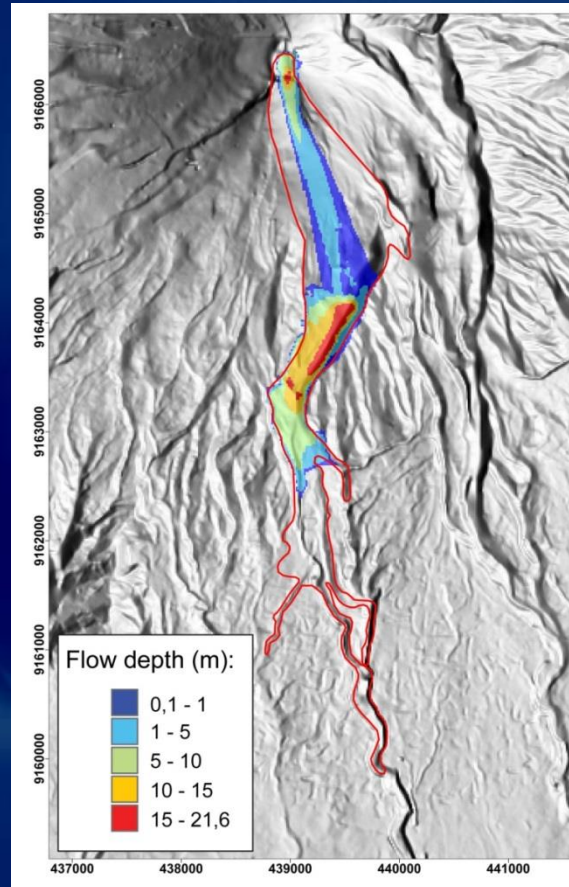
Varying friction angle: 24-10°

Flow coverage match: **18.2%**

Flow coverage match: **32%**
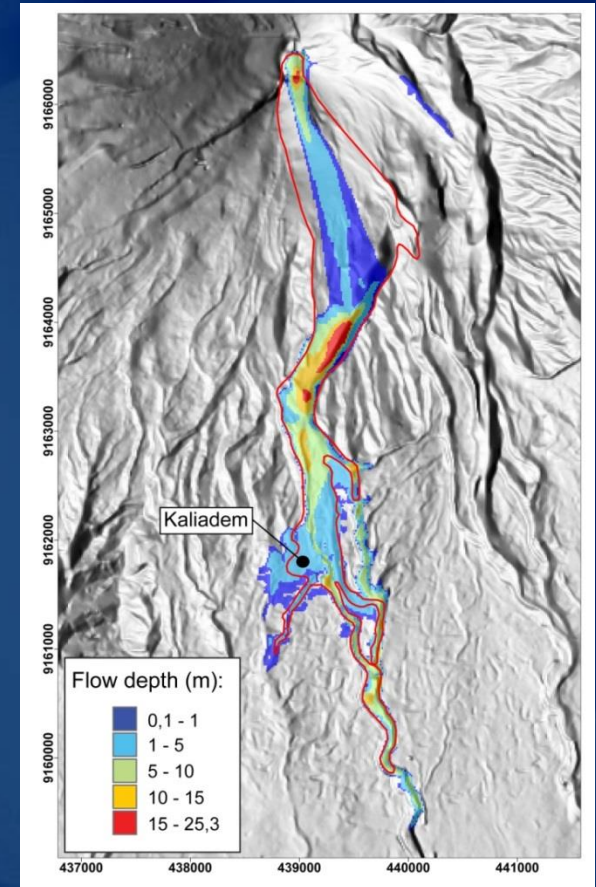
Flow coverage match: **72.3%**

Using a single bed friction angle, simulated flows either spilled over the ~200-m-high Kendil hill or covered only half of the area calculated for the actual event…

Questions?