

Debris Flow event on Osorno volcano, Chile, during summer 2017: New interpretations for chain processes in the Southern Andes.

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1. Reviewer 1: Abstract

The abstract is comprehensive and appropriate for the paper.

*I suggest to remove the word "Finally" at the end of the abstract.

A: We removed "Finally"

Introduction

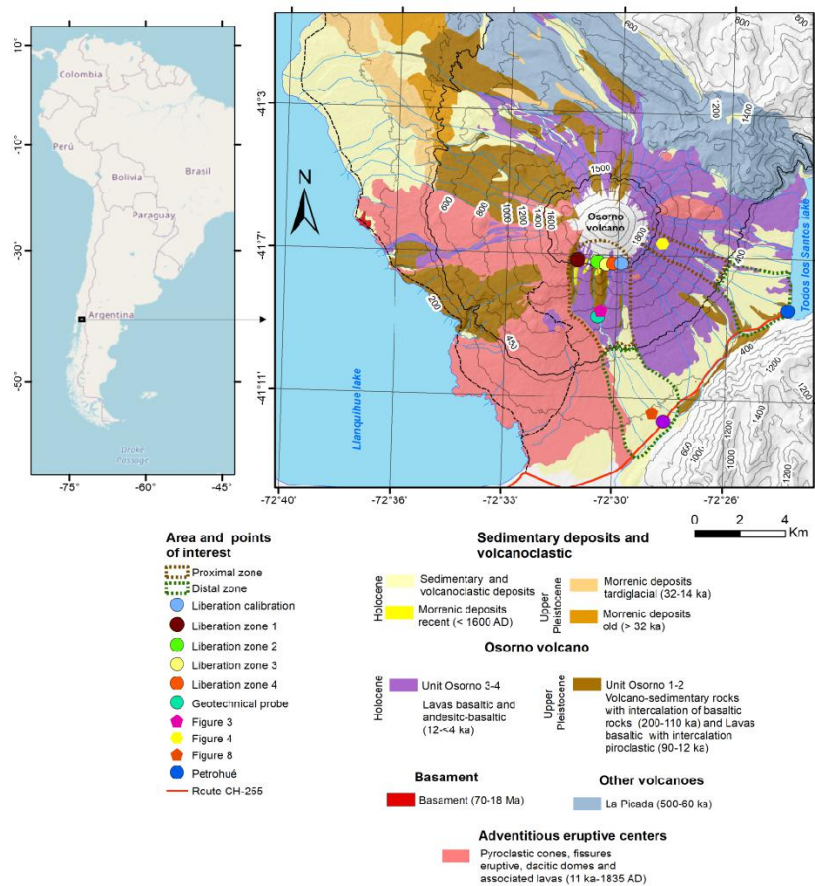
I think the description of the volcanic flow-type landslides in the Andes is very interesting. Probably mentions of the numerical modeling of debris flows in the scientific literature should be included.

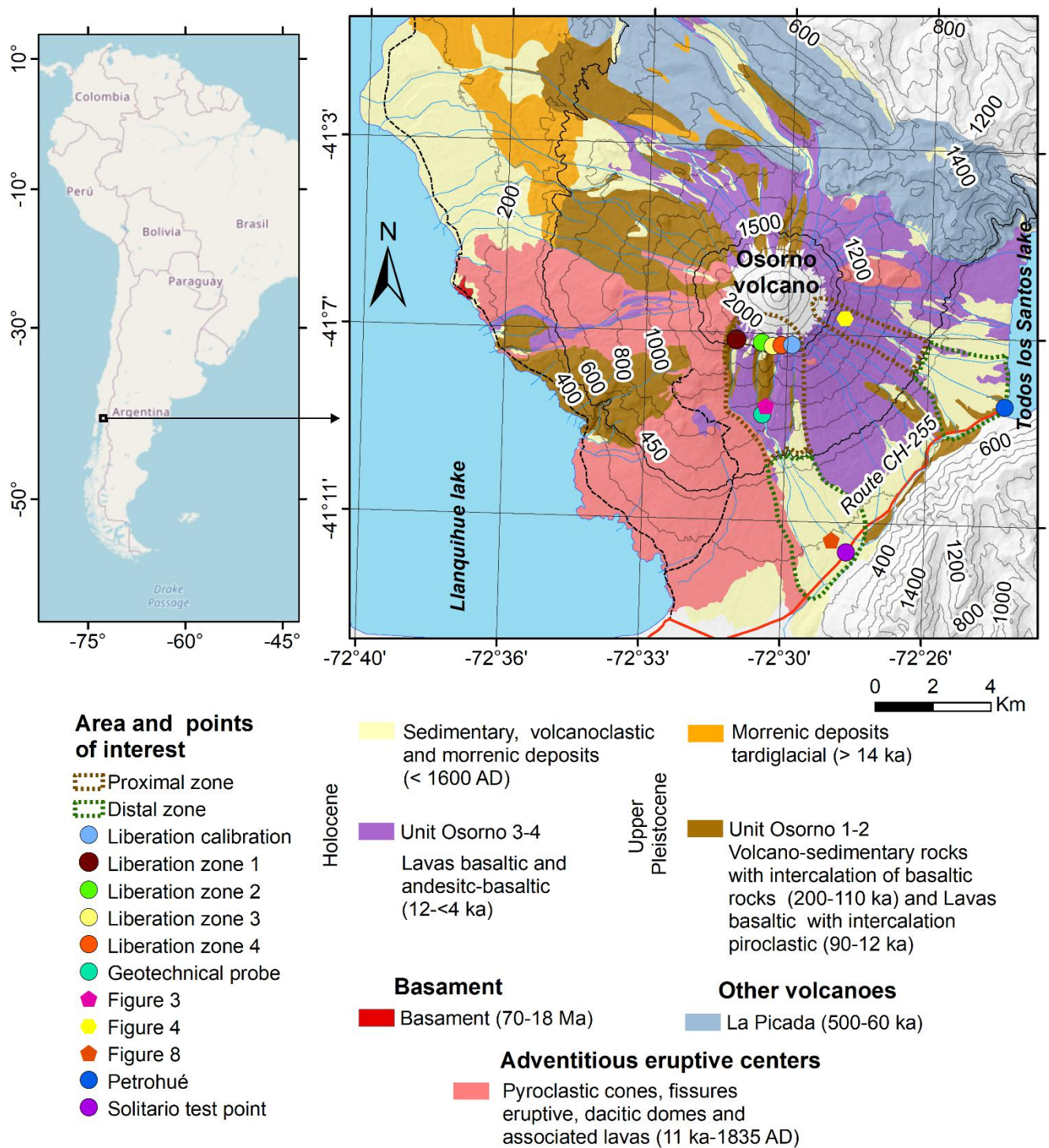
2. Reviewer 1: Line 38. "Nevertheless, debris flows in volcanic zones have not been evaluated in detail". I think this phrase is too risky. You can only say that it requires more investigation or not many research studies have been carried out...

A: We modified "Nevertheless, debris flows in volcanic zones have not been evaluated in detail... " to "Nevertheless, debris flows in volcanic zones have not many research studies have been carried out". Thanks by your accotation.

3. Reviewer 1: Figure 1. It is difficult to read the text of the figure. Maybe the font size is too small or probably it is solved easily increasing the size of the figure.

A: We change figure 1 with an improved figure with higher resolution.





4. Reviewer 1: Line 114. I suggest to mention Figure 2 better (in the text).

A: Now we added

“We implement a methodological approach based on comprehensive numerical modelling constrained by field data and laboratory analysis”

5. Reviewer 1: "Different soil deposits allowed understood the mobilization features, checking if it corresponds to a non-Newtonian flow." I suggest to rewrite this sentence.

A: Now we rewrite the sentence from

Different soil deposits allowed understood the mobilization features, checking if it corresponds to a non-Newtonian flow.

to:

Moreover, debris flow deposits identified in the field allowed understanding the rheology of these events (non-Newtonian flows).

6. Reviewer 1: "Liberation zones close to the Volcano summit, were physical weathering of the lava flow deposits exposed by pluvial erosion was assessed in the field." And to check (and correct) this one. "in the follow numerical model."

A: We modified the following text:

"Liberation zones close to the Volcano summit, were physical weathering of the lava flow deposits exposed by pluvial erosion was assessed in the field." to "We evaluated debris flow initiation zones close to the Volcano summit and the physical weathering of rock/soil."

"Scarps with potential rockfalls of unstable blocks were identified, measured, and georeferenced to stablish these zones in the follow numerical model." to "Scarps with potential rockfalls of unstable blocks were identified, measured, and georeferenced. We established these scarps as initiation debris flow zones in the following numerical model."

7. Reviewer 1: "The estimated values of the cohesion and internal friction angle was integrated into a database to be used during the back analysis phase" ...were integrated

A: Corrected

8. Reviewer 1: Line 153. The first time you mention "SERNAGEOMIN" you should specify what it is.

A: We change the sentence from

The back-analysis considered a final height of 1.5 m in route CH255, according to reports of SERNAGEOMIN.

To

The back-analysis considered a final height of 1.5 m in route CH255, according to reports of National Geological and Mining Survey (SERNAGEOMIN in Spanish).

9. Reviewer 1: Line 160. "If we take the η correspond to the fluid viscosity with isotropic stress distribution." Please rewrite it clearer.

A: Corrected, thanks by your detailed comment.

10. Reviewer 1: "Table 2 Model parameters used in r.avaflow." A space is missing. Correct the word "used." Why is there an asterisk (*) in the internal friction angle?

A: Now we added a space and replaced "usd" by "used"

11. Reviewer 1: Line 168. "parameters presenting serious discrepancies were..." What do you mean serious discrepancies? Is it discrepancies between the simulations and the real event? Or measurements?

A: We modified "In a first approach, parameters presenting serious discrepancies were restricted to the range proposed by Pudasaini (2012) for the simulation of debris flows." to "We selected model parameters to the range proposed by Pudasaini (2012) for the simulation of debris flows. We compared height flow with the calibration point (route CH-255), discarding unreasonable simulations."

12. Reviewer 1: Line 170. Do you consider a 30-m spatial resolution is appropriate for the modeling? Now, I think that if the reason for the selection of the spatial resolution is the availability or considerable computing efforts it should be stated in the paper. Line 184. "Surface representation" Good, partially answering my previous questions.

A: Now, we added an additional statement. We modified from "The SRTM and ASTER-GDEM models were used separately, with a spatial resolution of 30 meters" to "The SRTM and ASTER-GDEM models were used separately, with a spatial resolution of 30 meters due to data availability limitations."

13. Reviewer 1: Line 205. "These which favours a faster movement, increasing lateral erosion according to field results" Please rewrite if it can be clearer.

A: We modify from "These which favours a faster movement, increasing lateral erosion according to field results [Shu et al., 2018]." to "Lower unit weight favours faster flow processes increasing lateral erosion [Shu et al., 2018] and concordant with lateral erosion observed."

14. Reviewer 1: Figure 4 is referenced before Figure 3.

A: We inverted the figures to be coherent within the text

15.Reviewer 1: Line 233. "allowed understood" Probably misspelled.

A: We modified "Different initial water content into the simulations and DEMs differences allowed understood the uncertainty of the main initial input." to "Different initial water content into the simulations and DEMs differences delimited the uncertainty of the main initial input."

16.Reviewer 1: Line 234. "(¡Error! No se encuentra el origen de la referencia)"

A: Removed

17.Reviewer 1: Figure 5. "Volumen" Volume.

A: We corrected "Volumen" to "Volume" in figure 5 and 7.

18.Reviewer 1: Figure 6. "Escarp". "Error backanalysis". Scarp. And Reviewer 2: Figure 6: It would be useful to report the boundaries of the real debris flow for comparison with the simulations.

A: We corrected figure 6. Thanks for your detailed observation and corrections.

19.Reviewer 1: I think the results presented are relevant to the scientific community. I wonder if the authors consider that figures including more modeling results were not so relevant. In my opinion, since different scenarios, projections and zones were modeled, more maps of the debris flows would be interesting. Probably to include it (I suppose the journal have this option) as supplementary material if the authors justify that they were not so relevant for the paper.

A: We select the simulations that had relevant scientific information in the supplementary material in the original submission. If the reviewer needs additional information, we will add them.

20.Reviewer 1: I'm not sure if it was specified how the error calculation was done.

A: We modified from "Hence, we calibrate the flow runout taking control points of the height of the flow measured on the main road minutes after the event. We also assessed the quality of the simulations using possible release volumes based on field evidence." to "Hence, we calibrate the flow runout taking control points of the height of the flow measured on the main road minutes after the event. The percentual error was calculated using the height simulated with the measured height in "El Solitario pass" (Figure 1). A percentual difference was used between the simulated value and the measured height divided by the measured height. We also assessed the quality of the simulations using possible release volumes based on field evidence."

21.Reviewer 1: "DEM SRTM (...) DEM ASTER concentrated a larger part of the material towards the north". Not clear for me.

A: We modified "DEM SRTM produced a variation in the flow to the south, increasing the impact in Route CH-255; in contrast, DEM ASTER concentrated a larger part of the material towards the north" to "Simulations using DEM SRTM produced a variation of the flow to the south, increasing the impact in Route CH-255. These results had differences with the simulations using DEM ASTER, which showed the flow towards the north."

22.Reviewer 1: I consider many figures (e.g. 5-7) should be referenced better if divided to Figure 7a, b, c...

A: Figures 5 and 7 represent different phases of our contribution, so merge in just one could be confusing. We tried to merge figures 5 and 7 into just one, becoming too confusing to interpret. We request that these figures will be considered independent pictures in the final manuscript.

23.Reviewer 1: Lines 315-320. It is good for my previous comment about the DEM resolutions.

A: We agree with the previous comment of the reviewer. The zone has not Lidar data available or DEM with very high spatial resolution. Therefore, we discussed the results of two surface products available.

24.Reviewer 1: "Finally, water-rich mass flows are distinguished by material type, water content, the presence of excess pore pressure, or liquefaction at the source (Calhoun & Clague, 2018)." This phrase is repeated in lines 337 and 349. Then, both paragraphs have the same contents. Probably you were supposed to remove one of them.

A: Our apologies, we removed the second paragraphs. Thank you for the detailed comment.

25.Reviewer 1: Not clear about "best modelled scenario" and "worse scenario for...".

A: We modified "On the other hand, the area affected by the removal is greater with SRTM, for which we propose that the best modelled scenario represents at the same time the worst scenario for the resident population in the study area." to "Moreover, the debris flows area is greater using the DEM SRTM in comparison to DEM ASTER. The analysis using two DEMs allows evaluating the debris flow susceptibility of the population in the study area."

26.Reviewer 1: I suggest to shorten the first three paragraphs of the conclusions. A summary may be acceptably but I consider it is not necessary to present results to conclude about them (at least taking so many long phrases). The last conclusion is very accurate.

A: We modified the conclusions to avoid repeat results and previous information.