

Review of “Measurements and modeling of snow albedo at Alerce Glacier, Argentina: effects of volcanic ash, snow grain size and cloudiness” by Gelman et al

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General Comments:

The manuscript presents punctual albedo measurements over snow surfaces on different parts of a small glacier in the Northern Patagonian Andes in two consecutive years, together with measurements of physical parameters which could mostly explain the measured albedo variations (like grain size and form and particulate matter content). Then the authors try to reproduce the measured albedos, using a model, which is improved to account for partly cloudy conditions (which were present at least at one of the field days). In a last step the possible influence of the ash content, caused by eruptions of nearby volcanoes, on the total glacier surface mass balance is estimated using a simplified energy balance/mass balance model.

To my point of view the study is original and novel and fits well into the scope of the journal. I think that the significance of the study could be significantly increased by adding some additional data and analysis, which should not be too difficult to obtain and which would allow to better interpret the presented field data and model results:

1) Measured surface mass data at stakes: I think that the surface mass balance data measured at stakes were somehow used to interpret the sample obtained from the snow pits (section 3.1, Figure 2) but the detailed data are not indicated. Also in section 2.4 it is stated: “The model was calibrated by surface mass balance measurements performed on a seasonal to annual basis through the year 2016 over Alerce glacier”. I would like to know more details about this calibration process. How well could the model reproduce the observed melt and accumulation of snow? Which α_{firn} values fitted best to the observations? The time series of measured surface mass balance could also be helpful for quantifying the impact of the volcanic eruptions on the glacier’s surface mass balance.

2) I am surprised by the big influence of α_{firn} on the modeled surface mass balance of the glacier. In a “normal” year I would expect to have no firn in the ablation area and the firn of the accumulation area being buried by snow most of the year. How did you initialize the model (regarding presence of snow, firn, ice). Was 2016 a typical year? Probably not since autumn 2016 was exceptionally dry in the region. I would propose to run the model with a few years of “typical” meteorologic data (mean value of several years) and standard firn albedo for model initialization and then start to study the influence of different firn albedos. I think it should be much lower on average.

3) Since the albedo measurements are very punctual in time and space, and, as you are repeating in the text several times that particulate matter concentration is very variable in time and space, it would be great to get an idea about the significance of your punctual albedo measurements by analyzing for example optical reflectance in satellite images. Images obtained at dates near to your field campaigns could be used for calibration. By this means you could also easily go back until the 2011 Cordon Caulle eruption. Would be great to see how the reflectance of the glacier changed from summer 2011 to 2012. Or from summer 2015 to 2016.

Technical Comments:

Your abstract is 350 words which is too long (instructions from the journal's web page copied below). Try to reduce! For example you have three introducing sentences. One should be enough!

Research articles report substantial and original scientific results within the journal's scope. Generally, these are expected to be within 12 journal pages, have appropriate figures and/or tables, a maximum of 80 references, and an abstract of 150–250 words.

Detailed Comments:

Page2

Line 26: Patagonian Andes or Wet Andes instead of Southern Andes ? (to be more precise).

Line 27: you mean net shortwave ? Albedo is not influencing the oncoming shortwave radiation. I would say summer, since in spring glaciers are mostly snow covered and exhibit high albedos

Line 29 – until Page3 Line72: in this section you discuss the influence of light-absorbing impurities on snow albedo. You mention particulate matter, mineral dust, volcanic ash and black carbon). Are all particulate matter light-absorbing impurities? Are mineral dust, volcanic ash and black carbon both particulate matter and light-absorbing impurities? Perhaps order these definitions in an introducing sentence and avoid synonyms (particulate matter = light-absorbing impurities?)

Line 31: produced → producing

Line 32: “the growth of snow grains is accelerated” explain when and why.

Line 38: “as well as several positive feedbacks” which one?

Line 42: do not understand the sentence. What is a particle metric distribution?

Line 45: explain broadband albedo

Line 50: what is “online coupling”?

Page3

Lines 67-68: do not understand the sentence starting with “For example ...” Reformulate!

Page4

Line94: I think the mass balance model is not mentioned in Ruiz et al 2017

Page5:

Line124: ... “with a” ... → ... with one ...

Line126: How much W/m^2 is 0.1mv?

Page6

Line 166: “High-resolution pictures” ... Would be great if you could show them in the supplementary material

Page7

Line173/174 “are described in detail in section 3.2” → (Section 3.2)

Line 180: for → of

Page8

Line 221&228 I could not open the links indicated for the weather stations! Please indicate distance from glacier and elevation for both stations!

Page9

Line 251/252: on the base of what is this interpretation?

Page10

Line 262: Abl2-2016 → Abl1-2016?

Line 264: “These sites ...” which one? Abl3 and Abl4 ? In Abl2 and Abl5 PM content also seems to be quite high!

Line 268: “ firn layer from 2015 winter” – how do you know?

Line 290/291: “low seasonal humidity” – do you mean variations?

Page11

Line 328: “it was dated as winter snow from 2014” – how?

Page12:

Line 349: “a single measurement” - what does that mean? One voltage reading? How stable is the voltage in time?

Line 259: SNOW RADIUS!!!

Table1:

Why are there two values for the measured albedo in Abl4?

Why do you present the measured albedo in different lines? Should be always next to the modelled W.Aver?

Last column:

could you describe in the methods how you obtain these sensitivities? Are they really always symmetric? I do not understand the uncertainty associated to the concentration of BC? Why is it sometimes 100micrograms/kg and sometimes 20mg/kg.

These numbers have many zeros! Could you better indicate the percentual sensitivity and mark the most important contributor?

Page14.

Line 399: non-additive → non-linear?

Page 15

Line414/415: revise sentence starting with: “Volcanic ash ...”

Line 419: what is a thin layer? Give number!

Page 16

Line442 Albedo and glacier mass balance **model:** up to now only modeled mass balance is analyzed

Line443 “... glacier wide **modeled** annual and winter ...”

Page 18

Line510: delete “PM over”

Line 519: delete “major”

Line 523/524: please propose how to take account for that

Page 19

Line525: “**We found that rapid changes ...**” this is only a problem for your specific set-up. If you are able to measure upwelling and downwelling radiation simultaneously, this is not a problem.

Line530: “... suggesting strategies ...” which strategies are you suggesting? Which were the most important uncertainty?

Line534/535: glacier-wide albedo change sensitivity : explain this sensitivities with words or indicate where it was defined.

Line536: how high concentration of volcanic ash do you need for this reduction in SMB?

Figure 1:

could you please show the outline of Alerce glacier in the map and contour of terrain elevation? Would also be nice to have another more zoom-out map to better see the glaciological context of Alerce Glacier.

Figure 2:

what meaning has a white column color?

What do you think: why did you not find the dark layer at 45cm in Acc4 in Acc5?

Figure 4:

what are the units of the Y-Axis?

Diffuse radiation should be less intense than the direct one!