

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2022-190

Anonymous Referee #1

Referee comment on "Combination of Ground Penetrating Radar and Frequency Domain Electromagnetic surveys for the characterization of the Calderone Glacier (Gran Sasso d'Italia, Italy)" by Mirko Pavoni et al., The Cryosphere Discuss.,
<https://doi.org/10.5194/tc-2022-190-RC1>, 2022

Review comments for "Induced Electromagnetic prospecting for the characterization of the European southernmost glacier: the Calderone Glacier, Apennines, Italy" by Pavoni et al. manuscript 2022-190 for TC

Summary:

This paper has clear motivations and objectives. It is refreshing to see multiple geophysical methods being used in a glaciated environment. However, there are some major comments which should be addressed before considered for publication.

Major comments:

- This paper would greatly benefit from including the results and a log from the borehole observations mentioned in Line xx. The authors repeatability refer to the validation of the geophysical methods by borehole observations yet do not include the borehole results in the study. There is no location on the base map in Figure 1 of the borehole location. The paper would be much more complete with the addition of this observation.
- It is commonly known that electromagnetic methods are highly non-unique. Why do the authors not constrain the FDEM inversion with the GPR depths (snow and ice) and a range of expected conductivities?
- What is the uncertainty in the pseudo 2D FDEM inversion? Are there areas where the uncertainty is larger, for example in the ice, or at depth? A cross-section showing the uncertainty range/standard deviation would be useful to enable reliable assessment of the 2D section.
- I would consider changing the title. The words "prospecting for the characterization" do not work well together and FDEM should be in the title as this is the more novel

technique used in this glaciated environment. I would suggest something along the lines of: "Characterisation of the Calderone Glacier, Apennines, Italy using GPR, FDEM and borehole observations".

- The main text needs to be proof read thoroughly.

Minor comments:

- Figure A3 in the appendix, should be in the main text the depth of investigation is important in understanding the limitations of the electromagnetic inversion results.
- In the inverted FDEM sections, can you explain in more detail what is going on under the ice? The values seem to be more conductive than if it was bedrock.

Specific comments:

L98-99: did you get any CMP gathers to estimate the velocity of the snow and ice layer?

L130: "dozens" should be changed to "tens"

L134-136: the last sentence in this paragraph doesn't make sense.

L194-196: Need to explain this sentence in more detail. What are the instrumental resolution limits?

L201-202: where did you measure the several meters of snow cover during the data acquisition? I would mark these locations on the base map in Figure 1. Was this by a snow pit?

I would change the use of the word "subsoil" to "subsurface" as you are not working in a soil environment.

L221-222 This sentence doesn't make sense.

L226: "exciting" ? Do you mean "existing"?

L237-8: The ice ends at "x=30m", where did it end before and what is this value relative to. The retreat of the glacier should be discussed in terms of "The ice mass has retreated xx m since 2015".

L247-8: this borehole observation should be added to this paper.

L255: where is this measurement, show on Figure 1.

L263-267: This last paragraph is important for the FDEM inversion. I would have this in the main text before the inversion results, including figure A3.

L269: The paper needs to back up this concluding sentence with the borehole observations and a more detailed map in Figure 1 of where the snow depth measurements were acquired.

L274-275: do you mean time-lapse geophysical surveys?

L292: Repetition of the drilling/borehole observations with no results detailed in the paper.

L294-297: this should be in the discussion.

Table 1: could be moved to the appendix.

Figure 2: Nice figure. what is the measured apparent conductivity used to create these depth ranges? Do you not have to input a conductivity to estimate the depth of each coil separation?

Table 2: This is just a personnel preference, however many recent papers using electromagnetic methods in a glaciological environment work in terms of resistivity, in ohm.m, the inverse of conductivity. It might be easier for your readers to follow and directly compare with other studies if you worked in terms of resistivity.

Figure 5: This is also another personnel preference, however most recent papers using electromagnetic methods in a glaciological environment have hot colours (like red and purple) representing high resistivity/low conductivity and cold colours (e.g. blue) representing low resistivity/high conductivity. Again, this might make it easier for your readers to follow and compare with other studies.

Figure 8 and 9: Consider having one figure for 8 and one for 9, merging A and B, with the GPR transparently overlaid on the conductivity plot.

Figure A3: Have this in the main text. Add a dotted line at the depth of investigation. To me it looks like you only have sensitivity to 20 m depth as the sensitivity curves come close together after 20 m?