The Cryosphere Discussions

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Reply on RC1

Mauricio Arboleda-Zapata et al.

Author comment on "Exploring the capabilities of electrical resistivity tomography to study subsea permafrost" by Mauricio Arboleda-Zapata et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-60-AC1, 2022

First of all, we appreciate this reviewer's comments. We agreed with most of his suggestions and will try to follow them in the best way to improve the quality of our manuscript. Here we add your comments (in italics) and our responses below (in roman).

Line 29: "layer (or body)" -> "layer or body". There are many spots throughout the paper where parentheses are unnecessary and are actually a bit distracting, as they disrupt the flow of the sentence. Revising throughout the paper will improve the flow and make your ideas easier to understand.

Following this recommendation, we will remove some parentheses to allow for a more fluid read.

Line 66: "the less conductive is the medium" -> "the more resistive the medium", since you've been using resistivity to describe the water and sediments throughout the paragraph.

We agree. For consistency, we will replace in the whole text the word conductivity by resistivity.

Line 86: The phrasing of this sentence makes it sound like Arboleda-Zapata et al. (2022) also looked at the IBPT. I think it makes more sense to omit "also around the IBPT" to avoid this confusion.

We agree with this comment, and we will rephrase the corresponding sentence.

Figure 1 caption, line 3: "read line" -> "red line"

We will fix this misspelling error.

Figure 1 (b) and (f): I would use a different color besides red to indicate historical coastlines (since you've already indicated the red lines show the ERT profiles). Maybe a black dashed line to agree with Figure 1e would be better.

We will follow this recommendation and change the color of the red line in Fig. 1b and f to black.

Line 159: I disagree – I don't find these plots particularly useful and would omit them in the final paper. Even with your interpretation of higher noise levels in levels 7 and 8 in the Bykovsky dataset, I think this is easier to see in Figure 1c than it is in 1d (and would argue that this is better described as variability than noise, because it may be caused by real features).

We agree with this suggestion and will remove the corresponding plots. Additionally, we will update the corresponding text and sentences.

Line 181: It would be nice to specify that these are features you might expect to see at your study sites. Maybe something like "Allowing for abrupt changes is important in permafrost environments where high structural variability is often found. At our sites, we could expect to see sharp boundaries due to…"

We partially agree with this comment. At our field sites, we could have a combination of different structures. This is why we still think that mentioning all processes and common structures from subsea permafrost environments is important to exemplify cases where a layer-based parameterization approach might be used. On the other hand, we will highlight that some of these structures might be present at our field site.

Line 202: So every mesh is different? How is the mesh structure determined? More explanation is needed here.

Following this comment, we will extend this in the text and add two references (Akça et al., 2010 and Arboleda-Zapata et al., 2020) where this strategy is further discussed. During inversion, each particle is a model drawn on a different mesh because the subsurface interfaces (in our case, obtained from the sum of arctangent functions) force the model to update the cell positions according to the new interfaces.

Line 232: "we not" -> "we do not"

We will update this.

Line 264: It's not clear to me what "considering five nodes for each interface" is referring to. Does this mean that each interface is parameterized by five depths along the survey line? Clarification would be helpful here.

Following this comment, we will clarify this parameterization strategy by extending section 4.1 and adding the arctan function. Additionally, Because we considered the same number

of nodes and interfaces for both of our case studies, to avoid repetition, we will add this information in section 4.1 instead of in each case study.

Line 284: This phrasing could be interpreted as a general observation that more resistive permafrost = deeper boundary. I think it's important to specify two things: 1) that this is specific to your model, not a general observation, and 2) that this is due to a model equivalence/non-uniqueness problem (which will also help to introduce the following section).

We agree with this suggestion and will reformulate this sentence.

Figure 2: It would be nice if you showed the smooth inversion here as well, as it would provide a nice comparison for the layer-based models. Same comment for Figure 7.

Comparing different inversion strategies is beyond the scope of this study. However, for completeness and as a reference base model, we will add the smooth inversion results (see figures 1 and 2 in the attached file) to an appendix but without analyzing or discussing them in detail. The interested reader is referred to Angelopoulos et al.(2019), where the Bykovsky data set was inverted using a smooth inversion approach, and the obtained results have been discussed in detail. Other studies that used smooth inversion approaches to delineate the IBPT position are listed in lines 53-54.

Line 318: "because" -> "and". This statement is more of an observation than an explanation. Same comment for line 526.

We agree with this comment and will reformulate this statement to illustrate how far we are from the input model.

Line 351: Here, you could explicitly state that the low sensitivity to permafrost resistivity causes the error in your 1D models and contributes to the uncertainty in your 2D models.

We agree with this comment and will add a corresponding statement.

Figures 4 and 9: This is mostly personal preference, but I would find the correlation matrices easier to read if they only showed the lower left portion and omitted duplicate cells. I also find it difficult to estimate the magnitude of the correlations using the color scale alone and suggest printing the numerical values on each cell in addition to the color.

We propose a compromise here. We will add the correlation values in one-half of the correlation matrix. However, we prefer to show the entire correlation matrices also to highlight this symmetric property of the matrices.

Line 487: "especially, for marine data," -> "especially for marine data"

We will fix this misspelling.

Line 499: You could also note that this highlights the importance of having an accurate estimate of data noise. Since the misfits for the model in Figure 7d were higher, this set of models could potentially be ruled out if they were found to exceed expected error levels.

Following this comment, we will also highlight this in the corresponding statement.

Line 533: "resistivity" -> "ice-bearing permafrost resistivity"

We agree and will add the missing part as suggested by this reviewer.

Line 615: It's great that the data are available. If possible, you could share your code as well so that others can easily reproduce and build on your work.

The data used for our Bykovsky example is already available. We will also upload the Drew Point data set to the Pangea repository. At some point, we want to share the code once it is better organized and adequately documented. We highlight that there are already several available implementations of PSO. For example, in python, you will find an implementation under https://pyswarms.readthedocs.io/en/latest/index.html. Additionally, all the mesh manipulation and the forward solver were done in the freely available Python library pyGIMLi https://www.pygimli.org/. Our implementation consists of adding the interfaces with the arctangent function while preserving minimum mesh quality requirements. A similar approach is also given by Akça et al.(2010).

Please also note the supplement to this comment:
https://tc.copernicus.org/preprints/tc-2022-60/tc-2022-60-AC1-supplement.pdf