Reply on RC1
Baptiste Dafflon et al.

Author comment on "A Distributed Temperature Profiling System for Vertically and Laterally Dense Acquisition of Soil and Snow Temperature" by Baptiste Dafflon et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-292-AC1, 2021

RC1: 'Comment on tc-2021-292', Anonymous Referee #1, 22 Oct 2021

The manuscript “A Distributed Temperature Profiling System for Vertically and Laterally Dense Acquisition of Soil and Snow Temperature” by Dafflon et al. is a technical description of high-density temperature measurement (Distributed Temperature Profiling; DTP) system of ground surface and subsurface. The newly developed DTP system has an unprecedented measurement capacity with low cost, high resolutions, easy data retrieval, and flexibility in the sensor configuration. The authors also perform numerical experiments to assess potential errors in practical scenarios of sensor installations. Finally, they demonstrated the performance of the new DTP system in two field case studies. I agree that there will be numerous applications using this densely obtained temperature, which will certainly lead to new understandings in various areas of environmental studies. This DTP system will be breakthrough instrumentation in environmental monitoring when it becomes readily available for the public. The overall quality of the study is excellent, but there is a space to improve the presentation of the contents. I have minor comments to improve readability and attention from the research communities.

Dear Reviewer,

Thank you for your comments regarding the quality of the manuscript and study. We very much appreciate your review suggestions, which greatly helped us to improve this manuscript.

The manuscript structure is not consistent with the chaptering. This paper would not fall into a traditional structure because it contains a section of numerical simulation and two field case studies. Although Sections 3.2, 3.3, and 3.4 are in the Results chapter, they have their introduction and methods before the result descriptions. If authors want to follow the conventional chaptering, they should be consistent. Or, they could re-organize the chapters and sections separately for each different component.

We agree this manuscript does not have a traditional structure, primarily because it includes a numerical study, and two field cases. We think that introducing the site and data for the field cases before the numerical study would not make the reading and understanding of the paper easier. Though we recognize there is no perfect solution for organizing the manuscript, we decided to follow recommendation of Reviewer RC2, who
suggest that we do not change the structure of the paper. We are inclined to modify the structure of the paper if the editor and reviewers all agree.

The Introduction explains various aspects of the importance and applications of DTP. However, I think this Introduction could be more concise in explaining former application in the dense measurement of temperature, and technical challenges in the previous studies that could be overcome in this study should be more focused on. Although the authors summarized shortcomings of an earlier prototype of the DTP system (Leger et al., 2019), the readers would like to know a summary of individual limitations and shortcomings of the previous attempts of DTP referred to in Introduction.

We improved the introduction by making it more concise. In particular, we reduced the discussion of former applications. Also, we provided more details on the limitations and shortcomings of Leger et al (2019).

The sentence of the research objective starting from L113 is tediously long, and I could not understand it smoothly. And this doesn't seem to match the content of this paper. “to improve our predictive understanding of ...” is also the objective of this study? I think this is suspended from the previous phrase “to design and develop,” but this sentence is confusing.

We agree this sentence is too long and confusing. We removed the second part of the sentence and improved the paragraph.

L146: “digital temperature sensors” It would be helpful to explain in more concrete wordings (e.g., semiconductor-based IC?) for readers who are only familiar with thermistors, RTDs, and thermocouples. Every sensor output could be digital. Provide a long-term trending of the sensor quality.

Thanks for the suggestion. We improved the description of the sensor accordingly to the reviewer’s comment. It can be noted that there is currently no assessment of the long-term trending at room temperature and under various operating conditions. Based on the manufacturer documentation, long-term stability was determined using accelerated operational life testing at a junction temperature of 150°C (with an unknown number of sensor). The range of observed differences between pre and post 1000 hours at 150°C was reported to be +-0.03 °C. This value corresponds to an unspecified lifetime at room temperature.

L172-3: This is beneficial information. Could you also provide the battery life with Bluetooth connectivity (always on / occasional on) if possible?

We clarified that Bluetooth is always on and provided the calculation of the battery life.

L260: soil and temperature à soil temperature?

Corrected. Thanks.

L264: frost-affected à frost-susceptible

We followed the reviewer’s suggestion.

L337: I was confused with “measured” and “true” temperatures. What were compared? The analytical solution with simulated temperature by your numerical model? Or “true” measured temperature in the field?? Hypothetically measured temperature?

We are comparing soil temperatures simulated with and without the numerical
representation of the probe characteristics We have now clarified this in the manuscript.

Figure 3: Please use the same term in (b) graph and caption. Phase shift vs. time delay in amplitude.; Please consistent use of a or alpha for diffusivity in Table 1 and Figure 3.

We agree there were some inconsistencies between the figure and the captions. We addressed all of them.

Section 3.3: This section describes the overall performance of the temperature and snow depth measurements, but snow depth estimation could be more focused. This study used a different algorithm using temperature gradient from previous studies with standard deviation differences. Why did you choose the new algorithm, and what was the performance compared to the previous algorithm? Figure 5b could be more explained to describe the result of snow thickness calculation and its reliability.

We improved the discussion of the snow depth estimation, and further discuss the difference with algorithms used in previous studies. In our study the use of the temperature gradient enabled better results than using the standard deviation difference. However, we recognize that the performance of various algorithms may be case dependent due to the variable dynamics (in diurnal cycle, temperature during snow melt, etc) occurring over time and across various regions (e.g., in Arctic vs in Colorado). Thus, we do not intend to claim our algorithm work better than others. We added a sentence clarifying that further evaluation and development of algorithms for snow depth estimation may benefits from testing them on a large range of conditions and sites.

Figure 5: Unit for Soil moisture missing; The abbreviations for the title of color bars on the right of the figure should be explained in the capture. The color pallet, especially for Gv (b), should not be cropped because the readers like to see how prominent the boundary of the Gv between in air and in the snow was.

We agree there were some inconsistencies between the figure and the captions. We addressed them. We decided to keep the color pallet cropped (and mentioning it in the caption) as it increases visibility of small-scale variations.

Section 3.4 also has the same structure and nature in describing the other case study.

We ensured Section 3.3 and 3.4 have the same structure.

What material was used for the DTP tubes in the two case studies, plastic or metal?

We used plastic for both field studies. We clarified this in the text.

Figure 6: Is the snow depth derived from the DTP system or from ultrasonic? Are there data gaps in +5cm temperature? If so, please describe the gaps too.

The snow depth in Figure 6 is from a sonic sensor (we now mention it in the caption). The temperature at +5cm is not visible on the figure after June 3 because it is getting overlapped by temperature data from deeper sensors shifted above the ground-surface (due to the upward movement of the probe). We clarified this in the caption.

4 Discussion: this chapter is mostly a summary of the previous chapters. Potential usages of dense temperature measurements enabled by the DTP system are repeatedly described here after the descriptions in 1 Introduction. They could be merged, at least for some portions.

We agree with the reviewer. We removed several sentences to avoid redundancies
between the introduction and the discussion.

*Instead, the discussion of the system’s advantages and limitations, which is currently performed only in the last several sentences. They could be sufficient, but if possible, please add discussion on pitfalls/difficulties in detecting temperature boundaries to decide freeze-thaw or snow-air interfaces.*

We added a sentence discussing potential difficulties and limitations that may be encountered when estimating snow thickness.