The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2018-272-RC2, 2019

The Cryosphere Discussions
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EGU

Interactive comment on "Mountain permafrost degradation documented through a network of permanent electrical resistivity tomography sites" *by* Coline Mollaret et al.

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Received and published: 7 May 2019

Review of "Long-term monitoring of mountain permafrost degradation using an electrical resistivity tomography network". This manuscript presents an interesting dataset by Mollaret et al. of long-tern electrical resistivity tomography for permafrost under the effect of climate change. The raw dataset itself is very impressive. The manuscript is however weak regarding the type of time-lapse inversion used (no use of time, which is in my opinion a drastic error, see discussion below) to produce the end results as well regarding the poor discussion of the underlying physics of electrical resistivity / temperature changes in this situation. These are the two main weaknesses of the

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Discussion paper

current manuscript, which should be however published but the current manuscript is half-baked.

1. First I think a better analysis of the underlying physics of electrical conductivity / temperature / water content relationships under freezing conditions is required. See for instance Duvillard P.A., A. Revil, A. Soueid Ahmed, Y. Qi, A. Coperey, and L. Ravanel, Three-dimensional electrical conductivity and induced polarization tomography of a rock glacier, Journal of Geophysical Research, 123, . https://doi.org/10.1029/2018JB015965, 2018. Anotehr paper ion this topic is in press in JGR-SE. There are effects associated with surface conduction for instance.

2. ERTM (i.e. monitoring) is only superior to ERT if the time is properly accounted for in the inversion e.g., through sequential inversion or real .5D+time (or 4D° inversion i.e.g., including reguilarization over time as it is done over space (see for instance Karaoulis M., A. Revil, D.D. Werkema, B. Minsley, W.F. Woodruff, and A. Kemna, Time-lapse 3D inversion of complex conductivity data using an active time constrained (ATC) approach, Geophysical Journal International, 187, 237–251, doi: 10.1111/j.1365-246X.2011.05156.x, 2011; Karaoulis M., A. Revil, D.D., Werkema, P. Tsourlos, and B.J. Minsley, IP4DI: A software for time-lapse 2D/3D DC-resistivity and induced polarization tomography, Computers & Geosciences, 54, 164-170, 2013.). Such a discussion is required, inverting time lapse dataset without the inclusion of time in the inversion can lead to serious errors due to noisy data and artefacts in the inversion process itself (do inversion at two different iteration at two different times will produced many spurious noamalies). The ATC approach can handle strong change in the data space so the argument “This is because our measurements are characterized by irregular time gaps and by strong spatial and temporal resistivity contrasts (active layer frozen/unfrozen)” is, in my opinion, incorrect.

3. Personally I never accepted that reciprocity is necessarily the best test for error quantification and outliers removal. But I am fine with that. In principle, real time lapse inversion with the ATC technique filters out the data that are not correlated over time.

4. RES2DINV and the L1 option is a very bad choice for inversion. The algorithm tends to produce step-like structrures when the number of iteration in the inversion process goes being 3. These are inversion artefacts. So this is bit sad that such an amazing dataset is inverted in a careless way. In addition, RES2DINV does not take into account the data covariance matrix. A big drawback when dealing with noisy data.

5. Section 4.1. what about induced polarization? Self-potential?

6. The approach for looking at time lapse change in resistivity is very dangerous because the resistivity data have not been inverted with appropriate time-lapse regularization techniques. The relevant literature on the subject is even not cited and it is has been shown in the literature that doing like this brings a lot of artefacts in the computed changes because of inversion artefacts.

7. Section 4.3 is far from our level of knowledge regarding the underlying physics of the relationship between resistivity and temperature, which is non-linear, see Duvoiillard et al. 2018 and Coperey et al. 2019 (both in JGR-SE).

A.Revil May 7th, 2019

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