The Cryosphere Discussions

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Comment on tc-2021-329

Anonymous Referee #4

Referee comment on "Long-term analysis of cryoseismic events and associated ground thermal stress in Adventdalen, Svalbard" by Rowan Romeyn et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-329-RC4, 2022

Romeyn et al. presents novel and long time series of data on seismic events in a permafrost environment. The data analysis clearly distinguishes two kinds of events, derived from mining activities and natural sources (cryoseisms). The results are very interesting and worth publishing in The Cryosphere. In terms of periglacial geomorphology, however, I would suggest several corrections and clarifications, mainly on the terminology and data interpretation.

Major comments

1. Thermal contraction cracking and frost cracking appear to be confused (e.g., in Section 4.2): Please distinguish between frost cracking (which occurs when ground is 'freezing' and by a mechanism similar to frost heaving) and thermal contraction cracking (which occurs when 'frozen' ground is subjected to rapid cooling. Frost cracking associated with segregated ice tends to produce horizontal cracks which can result in rock fragmentation with repeated freeze-thaw cycles over thousands of years. In contrast, thermal contraction cracking produces vertical cracks with spacing of several meters and may not contribute to rock fragmentation (regolith formation).

2. Add more detailed geomorphological information: Boulder-producing scarps ('rockwalls' are more popular) and solifluction lobes are regarded as major sources of summer events, but these landforms cannot be identified on the air photographs (Fig. 7b-d). Perhaps on-site photographs or 3D models show more clear features.

3. Natural seismic events apart from thermal contraction cracking: Solifluction lobes are considered one of the possible sources of seismic events both in Abstract and Conclusion, but how does solifluction (slow soil deformation) produce seismic events? Landslides (active-layer detachment slides) may also be a possible source of summer events? Note that observations at nearby sites within Adventdalen shows that seasonal frost heave is most active in September or October and thaw subsidence in June (Harris et al., 2011; Watanabe et al., 2012), which seems to coincide with some peaks of the summer seismic events.

Specific comments

Line 43: Polygonal arrangement is primary represented by 'troughs' between a pair of ridges. Separated by troughs, ridges do not show polygonal array.

Line 54: Solifluction results from frost 'heaving' and creep.

Line 57: 'asymmetrical trajectory of soil' rather than asymmetry between the heaving forces?

Line 111: 'indicating the presence of sand/ice wedges': If the polygons are small (e.g., <3 m in diameter), they could be produced by desiccation cracking or cryoturbation within the active layer and sand/ice-wedges may be absent.

Line 199: Lachenbruch (1962) first proposed the visco-elastic behavior of ice-wedge polygons, so it should be cited here.

Line 262 (also Table 1): Why tensile strength of polycrystalline ice is used? Strength may be larger in frozen soil and at lower temperature (e.g., 2-7 MPa: Haynes & Karalius, 1977) and even more in frozen bedrock.

Figure 4: Improve the complicated units of distance. The northing distance is given by 10^6 m, but the easting by 10^5 m. I suggest both axes are given by a clearer unit like km.

Line 318: 'lowest during summer': but still high at Location 9?

Line 321: Landslides (active-layer detachment slides) can be added as a trigger?

Line 330: Boulder-producing scarps (‘rockwalls’ are a more popular term) and solifluction lobes: See the major comment 2.

Line 348: See the major comment 1.

Line 366: ‘Thermal contraction cracking of segregated ice bodies’: I cannot understand why segregated ice body is required for cryoseisms.

Line 368: ‘most likely rockfalls’: How about solifluction or landslides? (see major comment 3)

Line 373 (Figure 10b): ‘modelled number of frost quakes’: Are they counted when thermal stress exceeds 1.0 MPa?

Line 382: ‘including the inherently stochastic nature of seismicity’: Spatial variability of thermal conditions may be the primary factor of the deviation, since the modelled frost quakes are derived from temperature data at only one location?

Line 386: ‘the periods 17-26 Feb 2010 and 7-16 Feb, 2012’: Note that thermal contraction cracking was very active at down-valley sites during these two periods (see Matsuoka et al., 2018: Fig. 12).

Line 418: How does solifluction produce seismic events? See major comment 3.

References

Harris C et al., 2011, Permafrost and Periglacial Processes, 22, 239–253.

Haynes FD and Karalius JA, 1977, Effect of temperature on the strength of frozen silt. CRREL Report 77-3.

Watababe T et al., 2012. Geografiska Annaler, Ser. A, 94, 445–457.