Review of manuscript "Improving Seasonally Frozen Ground Monitoring Using Soil Freezing Characteristic Curve in Permittivity-Temperature Space" by Salmabadi et al. (submitted to EGUsphere)

This manuscript describes a comprehensive evaluation of soil moisture and soil temperature measurements at various locations in Canada with the aim of improving the classification of soils according to their freezing state. To this end, the authors consistently reconstructed and uniformly evaluated the freezing characteristic curve at 87 Canadian locations. This enabled them to determine where in Canada the soil is frozen for how long and how long the corresponding freezing and thawing phases last.

Since the fundamental work of R.D. Miller and P.J.Williams & M.W. Smith in the 1970s and 1980s, the freezing processes of soils in relation to the phase change from liquid water to ice and the associated temperature and pressure changes have been relatively well understood. In the 1990s, several doctoral theses were written in Minnesota (E. Spaans), Zurich (D. Stadler), and Uppsala (M. Stähli), where the freezing characteristics of soils were measured—very similar to this work by Salmabadi—and then used in numerical models. Even back then, we had similar discussions to those we are having today: when exactly is soil "frozen"? And how relevant is this partially frozen state? I am very pleased that this topic is being addressed once again in this manuscript.

The methodology for the precise analysis of the freezing state based on the freezing characteristics is described in great detail and is easy to understand. I have hardly any questions or objections to this. Of course, one could perhaps be critical of the assumption in lines 144-145 that the total water content remains constant during the freezing process. We know that this is not the case, but that water is transported from lower soil layers to the freezing front. However, for the methodology used here, I do not think it is a major problem to accept this simplification. More decisive for me are the assumptions in section 2.5.1, a) that hourly values are ultimately aggregated to daily values and thus only determined on a daily basis whether the soil is frozen, partially frozen or unfrozen, and b) that the threshold values are set at p=0.1 and 0.9 respectively. This makes sense to me, but I would still be curious to know whether there is a sensitivity analysis for these assumptions and threshold values.

Now to the results. The various freezing curves measured at a total of 87 locations are pooled into four large regions. This is then used to make statements about how these large regions differ in terms of freezing and thawing. I find it relatively bold to make such broad regional statements based on such a small number of sensors, which also represent a very local scale and are unevenly distributed. Is it really justified to say that in the eastern boreal forest, soils typically freeze within a very small temperature range, while in the western boreal forest, freezing is more gradual?

This measured freezing behavior, which varies from location to location and from large region to large region, naturally has various causes, as explained in the discussion on line 365. It has a lot to do with soil properties, but also with the history (antecedent moisture content of the soil). However, when it comes to the question of "How many days per year is the soil frozen, partially frozen, or unfrozen?", two important factors come into play that are hardly discussed in the text: snow cover and air temperature. This aspect could be emphasized a little more in the manuscript. It would certainly be useful for the reader to learn more about the meteorological conditions and snow cover at the various measurement sites. Ultimately, the freezing curves are also influenced by these factors.

Overall, I really like the study. The investigation of the freezing characteristics at the various Canadian locations is very thorough and undoubtedly adds value. As far as I can tell, the manuscript is linguistically flawless and well illustrated. Thank you very much.

Minor issues:

Line 130: “are are available” (“are” twice, remove one of them)