Response to RC2: 'Comment on egusphere-2022-224', Anonymous Referee #2, 18 Nov 2022. https://doi.org/10.5194/egusphere-2022-224-RC2

Comment 1. In my opinion this manuscript communicates an interesting and potentially important observation that the spectral gradients of brightness temperatures can be used to detect the freezing / thawing of soil. I also think that the paper is well written.

Response to comment 1. Thank you very much, for your opinion and support. You and RC1 feedback gave me back the ground under my feet and the possibility of further work on the article.

Comment 2. Line 30: the authors say that the single frequency methods use viewing angle of about 40 degrees. At least in case of SMOS also multiangular data is available even though the authors mentioned in the introduction might not have used it.

Response to comment 2. Yes, we meant this possibility. But we chose the SMAP data. SMAP is the real aperture radiometer (Spencer et al, 2010). SMOS is the interferometric radiometer (Kerr et al, 2000). In addition, each brightness temperature in the range of viewing angles from 10 to 65 degrees is measured by SMOS at different azimuth angles (see Fig. 1). These two factors cause, that the SMOS brightness temperature to be measured with additional fluctuations, which are a source of additional random error with respect to the SMAP data. As you can see (Fig. 2, Fig. 3), such fluctuations in the brightness temperature of SMOS are almost twice as large as those of SMAP. That is why we chose SMAP data.

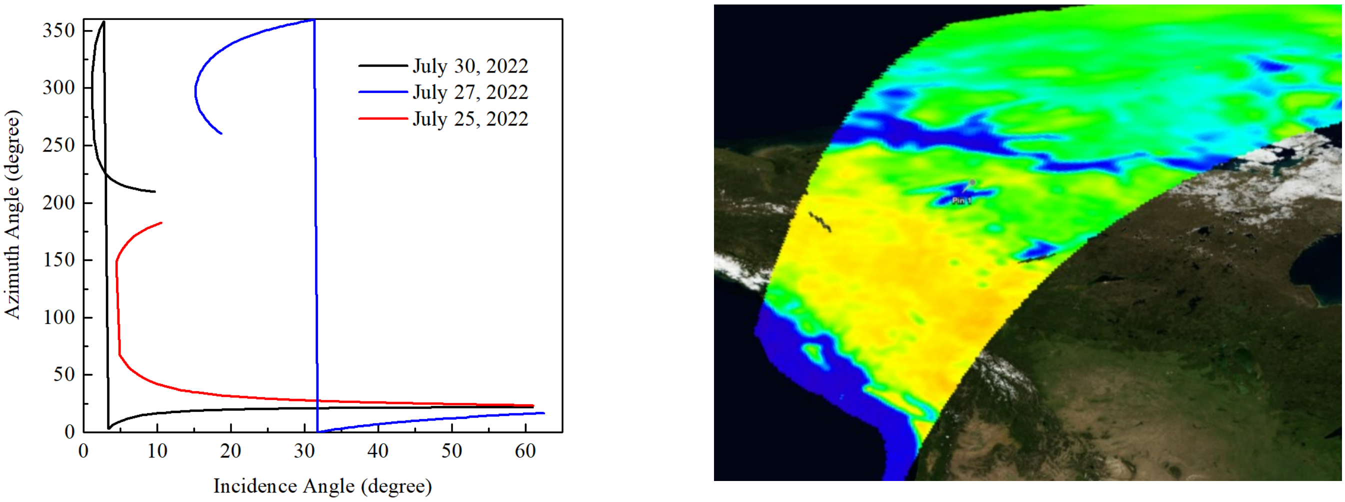

Fig. 1. Azimuth angle vs incidence angle at the central part of the Great Bear Lake

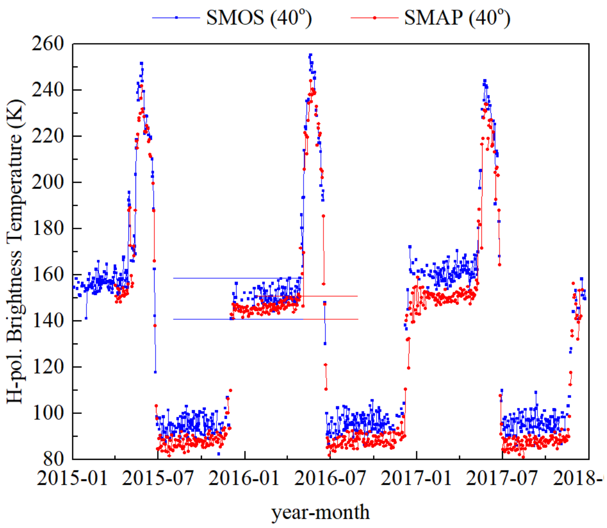

Fig. 2. Time series of brightness temperature (H-pol), measured by SMOS and SMAP at the viewing angle of approximately 40 degree over central part of the Great Bear lake.

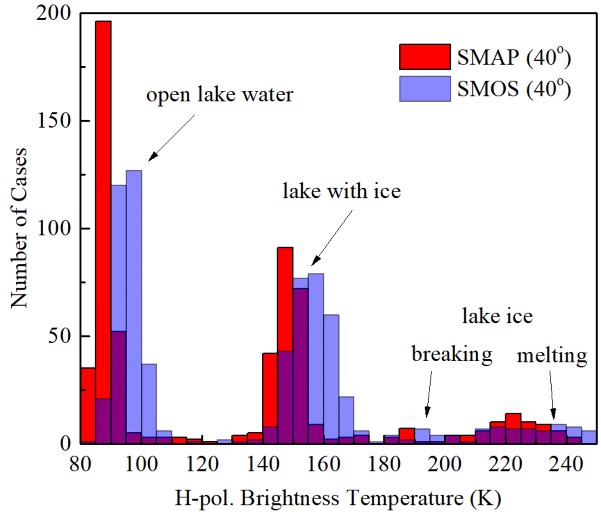

Fig. 3. Distribution of brightness temperature (H-pol) over central part of the Great Bear lake (based on data in Fig. 2).

References

Kerr Y. et al., "New radiometers: SMOS-a dual pol L-band 2D aperture synthesis radiometer," 2000 IEEE Aerospace Conference. Proceedings (Cat. No.00TH8484), 2000, pp. 119-128 vol.5, doi: 10.1109/AERO.2000.878481.

Spencer M. et al., "The Soil Moisture Active Passive (SMAP) mission L-Band radar/radiometer instrument," 2010 IEEE International Geoscience and Remote Sensing Symposium, 2010, pp. 3240-3243, doi: 10.1109/IGARSS.2010.5651760.

Comment 3. Lines 133-134, Fig. 1: the ovals mentioned in the text are practically invisible in Fig. 1 and their visibility must be improved.

Response to comment 3. The figures have been replaced. In the new version of the manuscript the selected areas are shown as rectangles with a dash line. In the new version of the manuscript word “ovals” was replaced to “rectangles” on

Line 134: “Several such regions are marked by rectangles with a dashed line in Fig. 1a, 1b (see the period 2015-2016).”

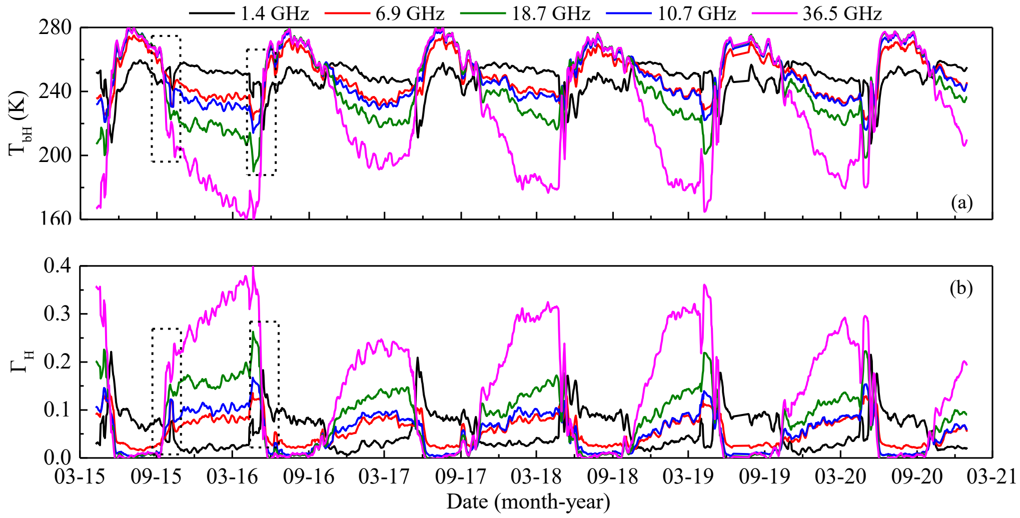

Fig. 4. (in manuscript Fig. 1.)

Comment 4. Fig. 2: the color of Ts0 and first gradient pair is very hard to distinguish. A different set of colors or line types should be applied.

Response to comment 4. In the new version of the manuscript, I changed the color of the Ts0 line to orange.

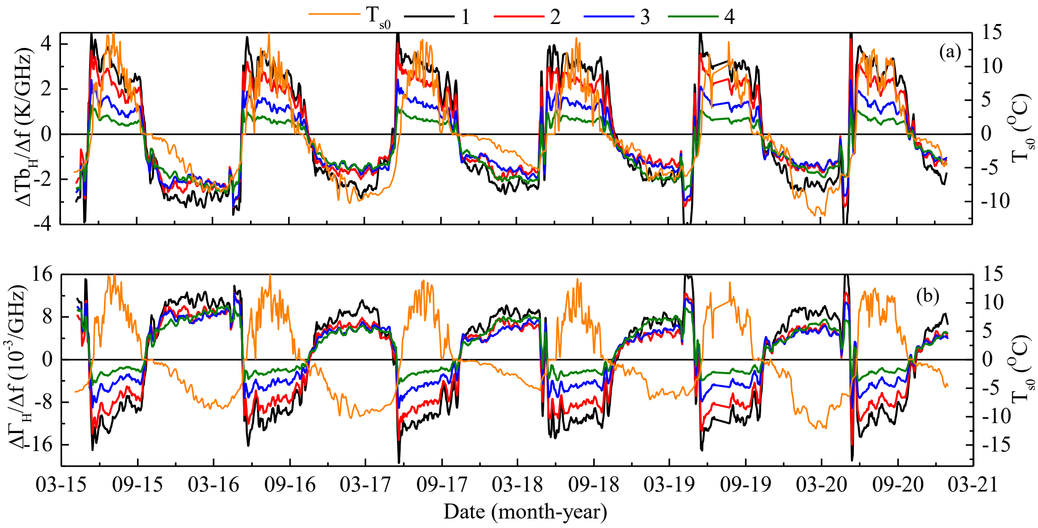

Fig 5. (in manuscript Fig. 2.)

Comment 5. Line 175: If the soil is dry the penetration depth at 1.4 GHz is couple of centimeters. Have the authors considered that the difference between using 6.9-1.4 GHz and 36.5-1.4 GHz could be related to this?

Response to comment 5. I didn't fully understand the question, but I'll try to answer. When the soil is dry, the thickness of emitting layer is greater than when the soil is wet. For wet soil, the emissivity in the L-band is mainly formed by the topsoil of 0-2 cm (Schmugge, 1980, Escorihuela et al, 2010). In the case of dry soil, the depth will increase slightly. By itself, the observation of the brightness temperature at horizontal polarization and a frequency of 1.4 GHz does not make it possible to unambiguously identify a thawed or frozen state (see Fig. 6 below). In this regard, we have proposed an approach that allows us to obtain a time series in Fig. 5 (in manuscript Fig. 2.) from the time series in Fig. 6 (below), which has a significantly greater unambiguity. From our point of view, namely the gradient of the spectral density brightness temperature or reflectivity demonstrates the difference in emissivity of the layers placed at different depths in inhomogeneous structure of the snow-vegetation-soil cover.

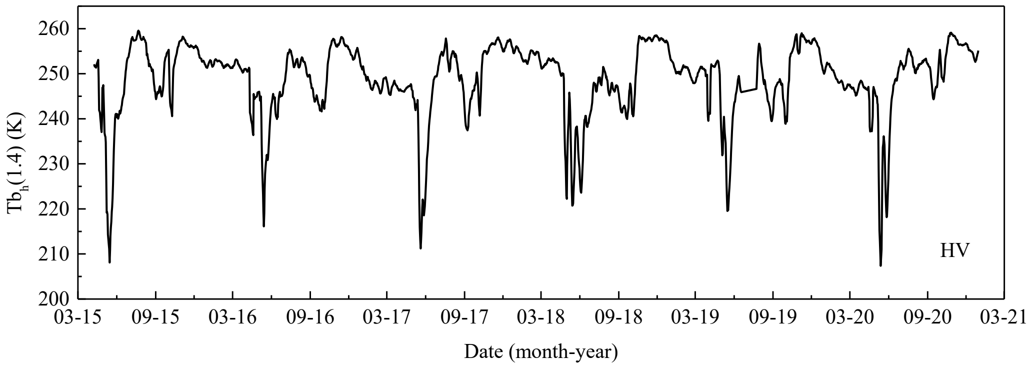

Fig. 6. Brightness temperature at H-pol (1.4GHz). HV test site.

References

Escorihuela M.J. et al. Effective soil moisture sampling depth of L-band radiometry: A case study. Remote Sensing of Environment, Elsevier, 2010, 114 (RSE-07569), pp.7. ff10.1016/j.rse.2009.12.011ff. ffird-00467991ff

Schmugge T. J. Effect of soil texture on the microwave emission from soils. 1980. NASA-TM-80632. 32 p. (https://ntrs.nasa.gov/citations/19800010256)