

Interactive comment on “Year-long, broad-band, microwave backscatter observations of an Alpine Meadow over the Tibetan Plateau with a ground-based scatterometer” by Jan G. Hofste et al.

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We, the authors would first like to also thank the second anonymous reviewer for taking the time to carefully read the manuscript and for providing comments on its contents and suggestions for its improvement. Please find below the replies of the authors to the comments given and, if applicable, proposed actions for the revision of the manuscript.

On behalf of all authors,

Jan Hofste.

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#Comment [1]: Line 17: As the system is measuring data from 1 to 10 GHz at four linear polarization combinations, it is strongly suggested to provide time-series data at L-band with all four polarizations, which will benefit the community a lot and future satellite missions operating at L-band, including the NASA-ISRO SAR (NISAR) mission [1] and the Terrestrial Water Resources Satellite (TWRS) [2]. Especially for the potential TWRS mission, it is aimed to measure the surface soil moisture and freeze/thaw state by the synergy use of active and passive observations at L-band. [1] Rosen, P. A., Kim, Y., Kumar, R., Misra, T., Bhan, R., & Sagi, V. R. (2017, May). Global persistent SAR sampling with the NASA-ISRO SAR (NISAR) mission. In 2017 IEEE Radar Conference (RadarConf) (pp. 0410-0414). IEEE. [2] Zhao, T., Shi, J., Lv, L., Xu, H., Chen, D., Cui, Q., ... & Zhao, K. (2020). Soil moisture experiment in the Luan River supporting new satellite mission opportunities. *Remote Sensing of Environment*, 240, 111680. **#Reply:** The bands we chose to show in the paper are: 2.5 – 3.0 GHz, from now on referred to as S'-band, 4.5 – 5.0 (C'-band), and 9.0 – 10.0 GHz (X'-band'). We chose to not show more than three bands to prevent the manuscript becoming too long. Instead of S', C', and X' we could have chosen 'L', 'C', and 'X' instead. As is explained in the document in section 5.1.2. the uncertainty of the absolute value of σ_0 will be largest for L-band where the antenna radiation patterns are widest. Although this is not a reason for discarding this data, the interesting dynamics are unaffected, the authors chose S' to prevent this uncertainty from becoming too large. This way, the values presented in the paper can easily be compared to other studies. However, since also the other reviewer asked for the L-band retrievals to be added in the manuscript we shall do so. The retrieved σ_0 for cross-polarization (X-pol) were also not added to the manuscript to prevent the manuscript becoming too long. In the revised manuscript, however, we shall add the X-pol timeseries of σ_0 and the X-pol results for the asphalt measurements. Finally, we shall add the Matlab code for calculating σ_0 from the raw data to the online dataset so that the reader can retrieve σ_0 -timeseries according to their own preferences. **#Action:** Add retrieved σ_0 timeseries for L-band to the manuscript in chapter 5. Also add retrieved σ_0 for the X-pol channels to sections

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5.1 (uncertainty in σ_0), 5.2.1 (backscattering of asphalt), and 5.2.3 (Time-series of σ_0 Maqu). In chapter 4 (derivation of σ_0) text will be added and/or modified so that the derivation of X-pol σ_0 is also described. Include Matlab code of σ_0 retrieval from raw data to online dataset.

#Comment [2]: Line 109: Is the Maqu site a permafrost or a seasonal frozen ground area? Have you confirmed that all the soil depths would be thawed during the summer? #Reply: The Maqu site is a seasonal frozen ground area. In the summer the soil at all depths is thawed eventually. Moreover, measurements of the soil temperature over investigated period showed no temperature below 0 °C at 70 cm depth and beyond. (line 109 – 110). This phenomena is also visible in the included soil moisture- and temperature dataset. We can add a more general overview of hydrometeorological conditions throughout the year in section 2.2 by adding a figure showing over time the soil moisture and -temperature, air temperature, precipitation and incident- and reflected short- and long wave irradiation (and albedo). #Action: Add figures in section 2.2 showing time-series measurements of volumetric soil moisture content, soil temperature, air temperature, precipitation, and incident- and reflected solar short- and longwave irradiation (and albedo).

#Comment [3]: Line 219: should it be m²/m²? #Reply: Indeed, the wrong units were placed. #Action: Change to m²/m².

#Comment [4]: Figure 8: Should the line in between be solid for the cyan lines (model simulations for HH)? Is that possible to include the S- and C-band also? How about the data at cross-polarizations? #Reply: The in-between cyan line, indicating the mean value of the empirical model, should indeed be solid. This will be adjusted. For the asphalt measurements we showed only the X-band data because only for that band we found multiple other studies [1] to compare our results to. The only other study on asphalt backscattering known to us (for bands within our measured 1 - 10 GHz range) is that of Baldi, 2014 [2], which then would only be one study to compare our results to. However, we realize now that the absence of (multiple) other studies to compare

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our results to is no valid reason not to simply show ours. We shall show our measured results for L-, S-, C-, and X-band for all four linear polarization combinations. #Action: Adjust the cyan line in figure 8. Add the measurement results for L-, S-, and C-band with all four linear polarization combinations. [1] Ulaby, F. and Dobson, M.: Handbook of Radar Scattering Statistics for Terrain, Artech House Inc., Norwood MA, USA, 1989. [2] Baldi, C.: The design, validation and analysis of surface based S-band and D-band polarimetric scatterometers, Thesis, 2014.

#Comment [5]: Figure 9-10: It is suggested to include data and results from all four typical bands (L/S/C/X) in this Section, which would attract more interests. #Reply: As mentioned in the answer to comment [1] analysis for L-band will be added here as well. #Action: Add analysis for L-band section 5.2.2.

#Comment [6]: Line 475: Are there any other observations to show it is snowfall, such as the camera, albedo etc.? It is better indicated of snow information in Figure 12. It is also suggested to indicate the date of soil freezing and thawing, as it seems to be the main target for this measurement as mentioned in the abstract. #Reply: Daily photographs of the site were not taken unfortunately. As indicated in reply [2] an overview of the hydrometeorological parameters and incident- and reflected short- and long wave irradiation (and albedo) will be added in section 2.2. Reviewer #1 suggested to give more examples of detailed time series time-series of σ_0 , like in Figure 13, for every season. Such a figure will be made for the January 2018 period, and in it the snowfall events shall be indicated. #Action: Add figures in section 2.2 showing time-series measurements of volumetric soil moisture content, soil temperature, air temperature, precipitation, and incident- and reflected solar short- and longwave irradiation (and albedo). Also add figure showing timeseries of σ_0 during winter at maximum temporal resolution (like Figure 13). Indicate snow events in this figure.

#Comment [7]: Line 501-505: I am not very convinced by your argument. Even the longer wavelength will penetrate deeper into soil, the S-band should also be sensitive to the top-layer soil as the major contribution comes from the top soil, in which

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larger water phase transition (liquid to ice) occurs. We have conducted a similar multi-frequency observation by microwave radiometry over a seasonal frozen ground. It is very interesting that brightness temperature and backscatter performed differently for the freezing-thawing process. Might be this is out of the scope of this data description paper; however, this is the value of presented measurements in this paper. #Reply: It is possible that the argument for explaining the differences in diurnal change of σ_0 for the different bands is indeed invalid. More analysis is necessary to find a satisfying explanation for the observed phenomena. As the reviewer suggests, this analysis is outside the scope of this data paper. #Action: Remove current explanation from manuscript and add sentence "In general the magnitude of the σ_0 - change . . ." to preceding paragraph.

#Comment [8]: Line 515-516: Is that possible to process σ_0 for cross-polarization also? It would be more interested to share with the community with the processed σ_0 for all the four polarizations and typical bands (L/S/C/X). #Reply: This comment is related to [1]. Yes, we shall process the cross-polarization data for already considered bands (S',C',X') and also for L-band. #Action: Add processed L-band data (co- and cross polarization) and cross polarization data for S', C', and X' to dataset.

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