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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.

Jan G. Hofste et al.

j.g.hofste@utwente.nl

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We, the authors would fist like to thank the first 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.

—-Completeness of dataset analysis/preparation and adequate presentation:—-

#Comment [1]: Why to confine the analysis/presentation to typical microwave bands? #Reply: The authors are not sure what the reviewer means by 'typical' microwave bands? 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'). I shall explain why we chose these: (1) Their respective wavelengths double each time approximately (see also reply [20]), thereby demonstrating, via the results, the wavelength-dependent scattering characteristics of the target. For example the effect of soil surface roughness and penetration depth of the soil and vegetation. (2) We chose no more than three bands for the analysis to prevent the manuscript becoming too long. (3) 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 sigma0 will be largest for L-band where the antenna radiation patterns are widest. Although this is not a reason to discard this data, the interesting dynamics are unaffected, the authors chose S' instead to prevent this uncertainty from becoming too large. This way, the values presented in the paper can easily be compared to other studies. We shall include the Matlab codes for processing the raw data in the dataset so that the readers can retrieve sigma0-timeseries according to their own preferences. #Action: Include Matlab codes for processing the raw data into sigma0-timeseries to online dataset.

#Comment [2]: What is about showing more broad-band/wide-band analyses? #Reply: The authors are not sure what the reviewer means by broad-band? The bandwidths S', C' and X' used in the manuscript follow from a consideration where fading uncertainty is weighed against the frequency resolution of target's scattering response (see section 4.3) and the change of the antenna radiation patterns over frequency (see Appendix C, lines 681 - 690). Calculating sigma0 for a broad bandwidth of, for example, 2 - 4 GHz would imply averaging out any frequency-dependent effects and would lead to an additional uncertainty of the beam's footprint.

#Comment [3]: Can we find characteristics of the observed media (alpine meadow) in non-typical/non-standard microwave bands? #Reply: We assume here that the reviewer refers to the frequencies outside the bands S', C', and X' as used in the manuscript. Microwave scattering and absorption are large determined by the dimensions of the scattering elements with respect to the wavelength. Changing the wavelength only slightly will not alter the response very much. Suppose that in addition to S', C', and X' we also pick L' which spans 1.4 – 1.6 GHz. As explained under comment [1] the corresponding wavelengths approximately double between these bands and it is therefore likely to observe different scattering behaviour between them. The response of a 5th band, say at 6.4 – 6.9 GHz will probably not show as large a difference as between C' and X'. However, these 'intermediate bands' are useful as additional observations and can be used, for example, to decrease the fading uncertainty in sigma0.

#Comment [4] : Why not adding at least L-band (if broad-band is not possible for some reasons)? #Reply: In reply [1] we explained why the response in L-band was not added into the manuscript. However, since the other reviewer also asked for L-band results we shall add these to the manuscript. #Action: Add retrieved L-band sigma0 to manuscript in chapter 5.

#Comment [5]: What about showing the variation in backscatter with viewing geometry (incidence: alpha & azimuth: Phi) also along time (similar to Figs. 9 & 10)? #Reply: Although this would have been very useful from an experimental perspective -different spatial footprints would provide stronger evidence for the observed temporal changes of the measured surface- this was not possible with the used scatterometer setup. The setup was not equipped with an automated motorized rotational stage.

#Comment [6]: Why not analysing and showing all polarizations in analysis and presentation? Reply: To prevent the manuscript from becoming long we chose not to add the cross-polarization (X-pol) results. The measured X-pol data are included in the dataset, along with the measured response of a polarizing reference target for calibration. However, since also the other reviewer asked for adding the X-pol data into the manuscript we shall do so. #Action: Add retrieved sigma0 for the X-pol channels to

chapter 5. Also in chapter 4 (derivation of sigma0) text will be added and/or modified so that the derivation of X-pol sigma0 is described.

#Comment [7]: What is the benefit of polarimetry in this data set? #Reply: The cross polarization channels could provide additional and complementary information on the target. Both for the vegetation and soil.

#Comment [8]: Why not showing at least cross-polarizations (e.g. in Fig. 13)? #Reply: See reply question [6].

#Comment [9]: Why soil temperature is mentioned as target variable? #Reply: The strength of the microwave (back)scattering from the soil is dependent on the roughness and dielectric contrast of the air-to-soil interface. The soil temperature is mentioned because it is one of the variables that effects the effective dielectric permittivity of the bare-soil-and-water mixture.

#Comment [10]: Why not showing more of the time series of the data set? #Reply: Considering the length of the manuscript we chose not to present more measured data. Also the guides for ESSD data papers state that "Articles in the data section may pertain to the planning, instrumentation, and execution of experiments or collection of data. Any interpretation of data is outside the scope of regular articles." However, given the general remark by the reviewer questioning whether the dataset coverage is adequately demonstrated we will add more sigma0 timeseries results, similar to the figure 13, to demonstrate the contents of the dataset. We shall show the response during the different seasons. #Action: Add more figures similar to figure 13 showing half-hourly sigma0 timeseries over consecutive days during all seasons.

#Comment [11]: Can we correlate to seasons? #Reply: In the first half of section 5.2.3, together with figure 12, a few general remarks are made considering the difference between the summer and winter period. So yes, we can correlate the scatterometer observations to the changing seasons. But, as explained with question [10] detailed analysis of the measured data is beyond the scope of an ESSD data paper.

#Comment [12]: Can we correlate to special (hydrological) events (e.g. drought)? #Reply: There were no long droughts during the timeseries considered (August 2017 – August 2018). However, there are periods during summer, for example in July, when there is little to no precipitation for 10 days or more during which the backscatter decreases in a different manner for S-, C- and X-band. This is due to the effects of vegetation. As mentioned under comment [10], we will a half-hourly sigma0 timeseries including such an event. #Action: Add a figure similar to figure 13 showing half-hourly sigma0 timeseries during a number of consecutive days in summer 2018 when there was no rain.

#Comment [13]: What are the exact ground conditions and their dynamics along the year? #Reply: Time series data of volumetric soil moisture content and soil temperatures (at depths 2.5, 5, 7.5, 10 cm, . . .) are included in the dataset. As are timeseries of precipitation. Besides these, the Maqu site also monitored the air temperature, and incident- and reflected solar short- and longwave irradiation were measured. To give the reader a better overview, graphs showing aforementioned hydrometeorological quantities will be added to chapter 2. #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 (also albedo).

#Comment [14]: Are there images how the site changes in phenology along the year (e.g. blooming or snowy or icy conditions)? #Reply: Apart from the measured incident- and reflected solar short- and longwave irradiation (which can be used to deduce snowfall) and the vegetation samples taken during two days in the 2018 summer no periodical images of the site were taken. There are however several photographs taken of the site at different seasons of the year. These photographs we will add to the manuscript. #Action: Add existing photographs of Maqu site that give the reader an indication of the changing phenology over the year.

#Comment [15]: Is it possible to add further in situ time series curves (e.g. precipitation,

vegetation conditions, solar irradiation : : :) to the figures to obtain a complete eco-hydrological picture of the alpine meadow? #Reply: See reply of comments [13] and [14]

#Comment [16]: Why not showing a temporal high-resolution freezing or thawing event with the hourly or half-hourly data? Just as a teaser for scientists to attract subsequent data usage. Reply: Figure 13 shows exactly this. Although detailed information is lost due to the small size of the figure. #Action: Increase size of figure 13.

—-Data preparation:—-

#Comment [17]: What about RFIs of the surrounding (area) and the hardware / measurement setup? #Reply: Any possible RFI signals, capable of reaching the receiver's final stage, were considered as part of the noise floor. This noise floor was determined by measuring the response with the antennas pointed skywards. In the retrieval of sigma0 this noise floor is subtracted from the target's signal. See section 5.1.1 Table 4 and Appendix D4.

#Comment [18]: Is the radiometric calibration accuracy reported in the manuscript? #Reply: Yes. See section 5.1.1, Table 4 (DeltaK) and Appendix D2.

#Comment [19]: How were cross-polarized backscatter (HV, VH) measurements (pre-)processed? #Reply: See reply on question [6].

#Comment [20]: Statement line 390: Is this correct? Does the wavelength double? #Reply: between the used bandwidths 5 – 4.5 GHz and 3 – 2.5 GHz it is true that the wavelengths are not exactly doubled, only approximately: (6.0 – 6.7 cm) and (10 – 12 cm) respectively. #Action: State that the wavelengths are approximately doubled.

#Comment [21]: Where is the asphalt zone? Can we sketch it in Fig. 2? #Reply: The backscatter measurements on asphalt were performed in the Netherlands earlier in 2017. The experimental setup and equipment used was the same as used at the Maqu site.

—-Graphical presentation:—-

#Comment [22]: Why are figures kept small throughout the document (e.g. Figs. 7, 12 & 13)? #Reply: The authors agree that the Figures are too small. #Action: Increase figure size to maximum allowed size.

#Comment [23]: Which figure shows all the seasonal and diurnal changes of the different polarimetric backscatters along the year? #Reply: Figure 12 shows the seasonal changes of the co-polarization backscattering channels for the whole August 2017 – August 2018 period. As mentioned with comment [10], figures will be added showing the diurnal changes of sigma0 (for co- and cross polarization) during 13 days for all seasons (like figure 13).

—-Citations:—-

#Comment [24]: Please add references to all equations not developed in the manuscript & to preceding research. #Reply: We shall add references to preceding research with those equations not developed in the manuscript. #Action: Add references to the equations not developed in the manuscript to preceding research.

—-Outlook:—-

#Comment [25]: Why the scatterometer data is not combined with the radiometer data (ELBARA-III) for an active-passive combined dataset (in the future)? This would be surely an even more unique dataset and fosters joint active-passive microwave research. #Reply: This manuscript specifically concerns the scatterometer system and the processing of its gathered dataset. The ELBARA-III dataset is made available elsewhere by Wen et al. [1]. The data paper accompanying this dataset is currently under review in Scientific Data. We will refer to this in the revised manuscript. [1] Wen, J. (Contributor), Zeng, Y. (Contributor), Zhao, H. (Contributor), Lv, S. (Contributor), van der Velde, R. (Contributor), Zheng, D. (Contributor), Wang, X. (Contributor), Wang, Z. (Contributor), Schwank, M. (Contributor), Yueh, S. (Contributor), Colliander, A. (Con-

tributor), Drusch, M. (Contributor), Mecklenburg, M. (Contributor), Su, B. (Creator) (16 Mar 2020). Multiyear in-situ L-band microwave radiometry of land surface processes on the Tibetan Plateau. DANS easy. 10.17026/dans-22u-gtqu

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