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Interactive comment on "Effects of decimetre-scale surface roughness on L-band Brightness Temperature of Sea Ice" *by* Maciej Miernecki et al.

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Dear Dr. Heygster,

I am very grateful for you time that you took to analyze the manuscript and provide the remarks. Following the reviewers suggestions I included additional subsections in the manuscript. Section 2 now contains the subsections dedicated to the analysis of the facet orientation angles: the slope and the facet azimuth direction. Section 3 is now supplemented with sensitivity analysis of the model. To put the results in the broader context we reflect on the implication on the SMOS sea ice thickness product, as well as on the planned CIMR mission. According to your suggestions we refrazed some of

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the sections to improve readability of the manuscript.

We took extra care to address all your remarks, nonetheless if some points require further attention we will gladly provide more exhaustive response.

Regarding your remarks to the manuscript.

The discussion of Fig. 6 and its use for interpretation of the experiments is incomplete:One of the interesting results of Fig. 6 is that between 4045angle, the h-pol TBs are practically insensitive to the roughness parameter s. This is important for L band satellite sensors observing only at such incidence angles like SMAP (in orbit since 2015) and the upcoming CIMR, and for the airborne observations at 45°(Figs. 9 and 10, Table 1): In the case when no influence of the roughness on the TB signal is expected (h-pol), the found correlation between observation and model is clearly higher, the RMSE, bias and the ubRMSE all are higher than at v-pol, where the model predicts a sensitivity to roughness. In Figs. 9(c) and 10(c), the h-pol 45angle cases, the modeled TBs show clearly less variability than the corresponding v-pol cases (Figs. 9(d) and 10(d)). Do you have an interpretation for this finding?

»>The comparison between the simulated and measured TB especially for the slide-looking antenna is not conclusive. First of all, we do not have the roughness information from the slide-looking footprint. We assume that the statistical distribution of facet geometries are the same as for the nadir one. Secondly, the assumption of the constant antenna gain over field of view is not adequate. The Geometrical roughness model describes the sub-footprint characteristics of the sea ice surface. Unfortunately, we do not have the measurements of the antenna gain functions when mounted on the aircraft. Thirdly, as indicated by the sensitivity the simulated TB is much more sensitive to the snow cover than to the surface roughness. However, due to the lack of independent snow measurements we resort to making assumptions about its thickness.

Fig. 6 and P12 L9-10 '..the horizontal and vertical polarization curves are brought together.' Correct only at incidence angles > 45°. At lower angles, the opposite is the case. Best, add to Fig. 6 the polarization difference curves near the bottom, potentially at an increased y scale.

»>The polarization difference is now added as a subplot the Figure 6.

Fig.6: Give x axis in degree, not in rd because in text you use deg. »>All angles are now given in degrees.

The current version of eq. (3) contains a product instead of a sum ('+' missing), and eq. (5) is incorrectly copied from Ulaby and Long, (2014), p443: replace $\hat{r}$ in nominator and in denominator by $\hat{n}$, and check order of factors. $\hat{r}$ in this equation does not make sense at all:$\hat{y}$ should be independent of $\hat{r}$!

»>Thank you for double checking the equation 3 (eq. 4 in the current version of the manuscript). It is a typo, the antenna looking direction $\hat{r}$ is looking downwards, therefore a "-" in the z axis is added.

Equation 5 after Ulaby and Long 2014 p443 , in the book the n_i denotes the "direction of propagation" , which in our case is the antenna look direction" $\hat{r}$. Probably my change of the notation contributed to confusion. In the manuscript the subscript "i" is reserved for the facet coordinates: n_i - facet normal, y_i and x_i coordinates on the facet's plane.

Units should be given in a consistent way throughout the whole manuscript. Here, the units m, cm and mm all occur, which is confusing and makes reading cumbersome. Have always a blank between number and units. »>Units: all the distance units are now converted to meters and all units are formatted with the siunitx package, (eg. 273K)

The references in the text are frequently odd: if part of a sentence, then it should read‘as found by Smith (1964)’, and if not, it should read like ‘...was formerly shown (Smith,1964)’. Might be incorrect use of LaTeX commands cite and citep. References with two authors are cited like (Ulaby and Long 2014), not like (Ulaby et al.2014). »>Citation formatting was corrected with more consistent use of "citep" and "citet" commands.

Abstract and main text should be in present tense, not past tense.Overall, I suggest accepting the paper after major revisions »> The paragraphs are re-written in present tense.

Other points Page 2 L(ines) 12-15:roughness explanation too short to be understandable without further reading. Some questions: ‘high pass filtering (cut off at 0.25m)’: high pass filtering occurs in frequency domain, but you give a length as cut off.

»> With reference to the spatial frequency in L7 i changed the frequency unit to mâĄż1

Give Fraunhofer criterion explicitly to make manuscript understandable without further reference. »>The Fraunhofer criterion is now explicitly stated

P5L11 the current version of MILLAS takes into account multiple reflections: if this is new, then describe it in more detail. »>An explanation about multiple reflections in MILLAS is added.

Fig. 2: indicate which columns are used for the three curves in Fig 3, e.g. by using the same colors as in Fig. 3. Fig. 3: give average values of slope, and give slope in deg instead of rad.Fig 4: indicate the values used for the three curves in

Fig 3, e.g. by corresponding colors. »>The color coding is introduced on figure 2, and subsequent. **P9L1: which is the direction of Phi_0: North? Flight direction?**

»> the coordinates system is defined such as $\Phi_0 = 0$, ie. so as $\hat{x}$ is parallel to the ground and on the plane including the nadir and side looking antenna directions.

P9L5: "local" coordinate system is an unhappy name, as all coordinate systems introduced are centered at the footprint center. Suggestion: we introduce a tilted coordinate system with the same origin, but the z-coordinate aligned .. with $\hat{n}_i$.

»> As suggested, we reformulated. Now we use 'tilted' instead of "local".

Eq. (9): define A, R. »>Eq9 Explanation added, A - facet area, R - distance 'antenna-facet'

Fig. 5: T_B H/V reads like a ratio, better call it e.g. T_B H,V. Explain ITS, CDF_alpha »>Fig 5 Notation changed $T_B H, V$ instead of H/V, explanation of ITS and CDF is now added to the title.

Regarding "Minor points" P(age) 1, L(ine) 11: take out incorrect blanks: 'on surface permittivity, second...'

»>P1L11 blanks taken out

P2L9: The incident wavelength reacts differently with individual components of the superimposed roughness: 1. Do you mean The incident radiation ? 2. Term superimposed roughness unclear. Do you mean roughness at different scales?

»> Rephrased, now: . . ."The incident radiation of a given wavelength reacts differently

with individual components of the superimposed roughness of many scales..."

P3L30: 30% RFI contamination: in time or in signal energy? »> 30% RFI contamination refers to the number of samples, this is now added to text.

P4L9: vertical, horizontal or both? »> This is unclear to me, as it refers to the Airborne Laser scanner description.

P4L16: define ALS »> the ALS abbreviation is now explained

P5L23 boned -> beyond, »>Now corrected

P5L33 Reference: do not give first names, check bibtex file »>Checked, and corrected

P8L9 "global" coordinate system in Cartesian basis (..)Cartesian coordinate system with the origin in the center of the sensor footprint

»>Changes as suggested

P12 end of L9: end→and

»> corrected

P13L3: height→high

»> corrected

P13L23: Figures 7,8,→Figures 7 and 8

»> corrected

P15L3: We want to determine the simulation setup that best reproduces....

»> corrected

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P16L8: I do not find 4.5 K in Table 1. Do you mean 4.6 K? »> Yes, corrected

P17L9: decrees→decreases

»> corrected

P17L10: decreased→decreases, increased→increases

»> corrected

P17L13: ..strongest for the roughest surface

»> corrected

P18L5: had→has

»> corrected

P18L7: inclusion of a crude snow...; A possible explanation. . .

»> corrected

P18L11: the microphysical snow and sea ice properties

»> corrected

P18L13: on request

»> corrected

Please also note the supplement to this comment:
https://www.the-cryosphere-discuss.net/tc-2019-110/tc-2019-110-AC2-supplement.pdf

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