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Hydrology and Earth System Sciences Discussions

Interactive comment on "Effective roughness modelling as a tool for soil moisture retrieval from C- and L-band SAR" *by* H. Lievens et al.

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Estimation of soil moisture from radar signal needs details about roughness parameters. This is generally complicated particularly if measurements are realized with one radar configuration. In this paper, authors propose an original approach considering effective roughness parameters and IEM model to estimate soil moisture without needed information about roughness. This could be useful particularly for one-configuration data. However, some aspects need further clarifications. They are indicated below:

1) Page 5003: Authors write: "Effective RMS heights are obtained by setting the correlation length to a certain fixed value. As an example, Fig. 3 shows a box plot of the obtained RMS heights for l=10 cm per study site according to the index in Table 1. This figure illustrates that seff is consistently larger at L-band (sites 12–15) than at Cband (sites 1–11), which may be attributed to a failure of the IEM in describing surface roughness as a scale-dependent phenomenon rather than to large in situ differences in roughness, since all fields were relatively smooth and tilled using similar machinery". It is important to note also, that IEM model shows generally good coherence with radar data in L band (Zribi et al., 1997 for example). In C band, we observe generally an over-estimation of simulation to real data. If we consider effective parameters, you will necessary decrease model level in C band and therefore decrease roughness value comparing to those of L band. This could be one reason of this difference that is particularly due to IEM validity.

Reply: This is a very valuable comment supporting the findings of the paper. It furthermore indicates that L-band may be recommended for soil moisture retrieval studies, since it allows a better coherence between modelling results and in situ measurements. We have added this comment in the text, referring to the work of Zribi et al., 1997.

2) Authors propose an explanation for difference between correlations in results illustrated in figure 1. However, there are two other reasons that could be added. The number of points is not the same, particularly for figure (c), and second, variation is difference between data with different incidence angles. In fact this could induce more or less roughness effect on radar signal. For example, we know that rows could induce high variation in low incidence angles.

Reply: With respect to this comment, it is worth mentioning that our intention was not to provide a thorough comparison of the correlations between the different SAR configurations. It should actually be pointed out that these correlations may not be directly compared in a quantitative fashion, e.g. due to the different number of study sites involved in the three data sets. In addition, we agree with the referee that the number of data points and acquisition specifications (e.g. incidence angle) may also be of influence. To make this clear, we rephrased this part, by adding the two proposed influences, and by stating that a direct comparison may not be justified. Finally, the number of data points has also been added to Fig 1, and the figure caption is adjusted accordingly.

3) Authors choose Lambert's law to describe normalisation to a reference incidence angle. This is perhaps valuable for a Gaussian surface (the minority of rough surfaces), but not necessary for the other surface types (particularly exponential), why authors choose to limit this relationship to Lamber's law.

Reply: The normalisation to a reference incidence angle is certainly not limited to Lambert's law. We are aware that there exist a large number of techniques for incidence angle normalisation, and that Lambert's law may not be the most appropriate one. We already pointed out in the text that this technique was originally developed for rough surfaces, and have added that it mainly applies to Gaussian surfaces. However, we still chose this technique because it is simple, does not require any parameter to be fitted, has proven to be value for a large number of terrains (Ulaby et al. 1982), and was already successfully applied in recent studies (e.g. van der Velde and Su, 2009). Nevertheless, application of different techniques opens a possibility to further improve the developed soil moisture retrieval approach. Therefore, we have indicated in the text that the normalisation is under no circumstances limited to the use of Lambert's law.

4) Authors select rms height equal to 1 and 2 cm for C and L band. Is it possible to select more precise parameters, based on IEM simulations?

Reply: We agree with the referee that the selection of the predefined roughness parameters could possibly be optimized. However, a few concerns can be made in this respect. First, there is only a significant possibility for optimization in Fig. 10. (f),

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corresponding to the selection of a predefined RMS height and calculation of effective correlation length for L-band HH. Second, it is yet hard to say whether the optimized setting would then be transferrable to other data sets. The latter is supported by the fact that there may not be enough data available for optimizing the selected RMS height for L-band HH. With more data, we would actually expect a similar pattern as observed for C-band HH and VV, which does not largely depend on the selected parameter value. Therefore, we currently prefer not to optimize the approach and not to formulate any firm conclusion upon the selection of specific values of the RMS height. To address this, we have modified the text, mentioning that optimisation might be possible, however, requires more data.

5) Page 5000: Authors write: "To minimise the effect of the wheat vegetation, only the first three and last two acquisitions are used in this study. During these acquisitions, the vegetation was characterised by a low volumetric plant water content (VWC<1.7 kgm-2 which is often reported as being the driving factor for direct canopy backscatter (e.g., Attema and Ulaby, 1978; Bindlish and Barros, 2001)." Authors use only IEM model, what about vegetation effect on radar signal, particularly for high incidence angles. In fact, VWC=1.7Kgm-2 is not very weak as level. It corresponds to probably more than 20cm for wheat height. Do authors try to validate this hypothesis?

Reply: We would like to stress that the VWC < 1.7 kgm-2 and high incidence angles are observed for acquisitions at L-band. Whereas such conditions would be unfortunate for soil moisture retrieval at C-band, the longer wavelength at L-band still enables an important sensitivity to surface soil moisture content. Furthermore, we investigated the importance of the wheat vegetation for soil moisture retrieval in Demmin in a second study, which in summary introduces a framework based on Water Cloud Modelling that allows for extending the present technique to the case that wheat vegetation is present. This work is currently under review for IEEE GRSL and the results of this study indicate that, during the first three and last two acquisitions, corrections for wheat vegetation are negligible, which justifies the application of a surface scattering model such as the IEM.

Finally, these results are corroborated by other studies, e.g. Dabrowska-Zielinska et al., 2007 observed only a slight attenuation of the backscatter in case of VWC < 2kgm-2. To address this concern, we have referred to the results of our study submitted to IEEE GRSL. Note that this second manuscript was not yet submitted, but in preparation, at the time of submitting this research paper.

6) What about roughness parameters for three data base. Authors illustrate results of correlation between moisture and radar signal. It could be important to discuss effect of roughness in the relationship between moisture and radar signal. Authors could add roughness interval (rms height, correlation length) in Table 1.

Reply: For the majority of the study fields, roughness parameters have actually been measured. However, roughness measurements are known to be problematic in many ways (see Lievens et al, 2009 for a study of their impact): roughness parameters largely depend upon the profile length (e.g. for this study, fields have been sampled with profilers of 1m up to 25m), parameters largely depend upon the processing (e.g. some profiles were not subjected to any processing, whereas others were processed extensively, e.g. 2nd order polynomial trend removal, etc...), and parameters depend upon instrument resolution, accuracy. Although we have considered showing the roughness parameter intervals for the fields that were sampled, we have decided not to do so, since parameters are not consistently measured across sites. Also, the basic idea of this work is that roughness measurements should not be trusted and can be replaced by effective values. To define our scope in terms of roughness conditions, it is clearly mentioned in the text that the application should be limited to smooth fields, associated with seedbed preparation or rotary tillage. This was the main criterion for the selection of the study fields. Since only fields with similar roughness conditions were selected, it is expected that the influence of the roughness on the relationship between soil moisture and backscatter is limited. Moreover, an analysis of this impact cannot be performed as it would require roughness measurements performed using exactly the same procedure across all fields.

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7) In conclusion, authors write: “As a consequence of these large differences, one should be cautious when applying a multi-frequency approach for the retrieval of surface parameters from SAR.” Change of roughness between L and C band is due to validity of IEM model and not to the use of multi-frequency data. So, if we consider other approach than IEM model, I don’t see why we can have a problem of roughness definition. Off course, the effect of roughness is not the same for L and C band.

Reply: We agree with the referee that this part of the conclusion was not correctly formulated. The objective was to question the use of a multi-frequency approach while using the IEM, not the use of multi-frequency approaches in general. This is corrected in the text by adding ‘the IEM in combination with...’

Ulaby, F. T., Moore, R. K., and Fung, A. K.: Microwave Remote Sensing: Active and Passive, vol. II, Artech House, Boston, MA, 1982. van der Velde, R. and Su, Z.: Dynamics in land-surface conditions on the Tibetan plateau observed by Advanced Synthetic Aperture Radar (ASAR), Hydrolog. Sci. J., 54, 1079–1093, 2009. K. Dabrowska-Zielinska, Y. Inoue, W. Kowalik, and M. Gruszczynska, Inferring the effect of plant and soil variables on C- and L-band SAR backscatter over agricultural fields, based on model analysis, Adv. Space Res., 39, 139âĂŤ148, 2007

Lievens, H., Vernieuwe, H., Álvarez-Mozos, J., De Baets, B., and Verhoest, N. E. C.: Error in SAR-derived soil moisture due to roughness parameterization: an analysis based on synthetical surface profiles, Sensors, 9, 1067–1093, 2009.

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