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Hydrology and Earth System Sciences Discussions

Interactive comment on "An inversion method based on multi-angular approaches for estimating bare soil surface parameters from RADARSAT-1" *by* M. R. Sahebi and J. Angles

Anonymous Referee #2

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General comments:

The paper is interesting but it must be improved considerably.

1) The paper presents an approach based on multi-angular SAR observations for the estimation of soil moisture and surface roughness. Several studies have been published in the past where multi-angular approaches are mentioned or explored. For instance:

-Fung, A.K.; Dawson, M.S.; Chen, K.S.; Hsu, A.Y.; Engman, E.T.; O’Neill, P.E.; Wang, J. A modified IEM model for scattering from soil surfaces with application to soil moisture sensing. In Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS’96), Lincoln, Nebrasca, USA, 1996; pp. 1297-1299. -Pasquariello, G.; Satalino, G.; Mattia, F.; Casarano, D.; Posa, F.; Souyris, J.C.; Le Toan, T. On the retrieval of soil moisture from SAR data over bare soils. In Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS’97), Singapore, 1997; pp. 1272-1274. -Baghdadi, N.; Gaulier, S.; King, C. Retrieving surface roughness and soil moisture from synthetic aperture radar (SAR) data using neural networks. Can. J. Remote Sensing, 2002, 28, 701-711. -Zribi, M.; Dechambre, M. A new empirical model to retrieve soil moisture and roughness from radar data. Remote Sens. Environ. 2002, 84, 42-52. -Sahebi, MR; Angles, J; Bonn, F. A comparison of multi-polarization and multi-angular approaches for estimating bare soil surface roughness from spaceborne radar data. Can. J. Remote Sensing, 2002, 28, 641-652. -Rahman, M.M.; Moran, M.S.; Thoma, D.P.; Bryant, R.; Sano, E.E.; Holifield Collins, C.D.; Skirvin, S.; Kershner, C.; Orr, B.J. A derivation of roughness correlation length for parameterizing radar backscatter models. Int. J. Remote Sens. 2007, 28, 3994-4012. -Rahman, M.M.; Moran, M.S.; Thoma, D.P.; Bryant, R.; Holifield Collins, C.D.; Jackson, T.; Orr, B.J.; Tischler, M. Mapping surface roughness and soil moisture using multi-angle radar imagery without ancillary data. Remote Sensing Environ. 2008, 112, 391-402.

In the manuscript a revision of those approaches is not provided. As a result, it is difficult to judge the merit of the technique presented and the contribution it makes, if any. It is therefore necessary to improve the description of the state-of-the art and to defend the interest of the manuscript.

2) The main limitation of multi-angular approaches is the difficulty of obtaining two (or more) scenes with different incidence angles and constant roughness and moisture conditions. This can seriously limit the operational use of these techniques. A critical discussion of this point is necessary in the text. It could be also interesting to assess (with numbers) the probability to obtain two scenes with different incidence angles

over an area in a short time. Such a study could be useful to objectively evaluate the applicability of the approach.

3) The structure and phrasing of the manuscript must be also improved, specially the introduction, the discussion and conclusions. The introduction is weak and its structure is unclear. The discussion of results is very speculative (see specific comments). The conclusions should be more concise and to the point.

Specific comments:

1. Introduction: - The structure should be improved. I suggest starting with the importance of soil moisture and roughness on hydrological applications (mentioned in the first paragraph of 209, but also in the conclusions!). Then, I would briefly explain the potential of remote sensing, and in particular SAR, for the estimation of those variables (now mentioned in the first paragraph of methodology). Next, I would mention the limitation of single configuration SAR observations and the problems related to surface roughness (for an excellent review on the topic please check: Verhoest et al., 2008; SENSORS 8, 4213-4248). Finally, I would explain in detail the multi-angular approach and present the objectives of the paper clearly.

- The objectives are not clearly presented.

2. Study site - The limitations of the roughness measuring instrument should be mentioned (again see Verhoest et al., 2008). It could be interesting to plot your field average roughness (rms height and l) parameters with their standard deviations. - On a previous paper (Sahebi et al 2002) the 18 November scene was also used along with an image acquired in the 12 November. It could be interesting to incorporate that image to this study also. Or at least it could be interesting to compare the results of this paper to those obtained on your previous paper.

3. Methodology - The first two paragraphs should be best placed in the introduction. - The last sentence of the second paragraph (page 212 lines 17-19) are not clear and

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should be rewritten.

3.1. Model descriptions - It should be explained in detail why you selected those models and not others. In the literature several analyses of those models have been published, with recommendations for their use. You should refer to those studies to justify the selection of the models. - It is not necessary to include the equations of the GOM and the OM, since they can be obtained from the literature. The MDM cannot be obtained from a journal paper, hence it deserves more explanations, specially on the observations used to modify the original Dubois model. - More recent versions of the OM have been published (the last in 2004). Those are supposed to correct deficiencies in the original model of 1992. You should use a more recent version of the model. - If the MDM is just an adaptation of the original Dubois model to your datasets, it is not useful at all for the scientific community. A theoretical model should be preferred to avoid site specific models. If the IEM is applicable to the roughness range of your data you should consider using it. - Maybe I’m wrong but it seems to me that in eq. 3, the term tanqe should be in the exponent.

4. Inversion method

- It is not clear to me how you could invert the GOM using only two different observations. If I understand your approach, you would have 3 unknowns (dielectric constant, rms height and l) and two equations. Please give some explanations.

5. Results and discussion - Estimated dielectric constant values are compared to measured dielectric constants. It must be taken into account that the dielectric constant is frequently dependent. Therefore, the dielectric constant measured with a Thetaprobe (that uses a frequency of 100 MHz) cannot be compared to that retrieved from RADARSAT (5 GHz). Both dielectric constants need to be converted first to soil moisture, using the method of Hallikainen or Dobson, or specific sensor calibrations for the case of the Thetaprobe. - The evaluation of results in soil moisture units will also be beneficial for their interpretation by the readers of HESS. Readers do not probably

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know by heart the moisture value corresponding to a dielectric constant error of 2.46. - In addition to comparing the performance of the different models, the discussion should also focus on the overall accuracy of the approach and its utility, i.e. is it useful from an applications point of view to obtain rms height estimates with an error of 1.12 cm? - Figures 3-8 should represent error bars with the standard deviation of measured moisture and roughness values. - Page 218, line7: The inaccuracy of the GOM is said to be somehow related to the correlation length. So far very little has been said on this parameter. It could be interesting to plot measured versus retrieved correlation length values. - Page 218, line 10: Very vague sentence, what ‘other studies’ are you referring to? Please give more details or add some references. - Page 218, line 15: This is very speculative. You should analyse the applicability of those models first. There are a number of papers where those models are evaluated. You can refer to them to support this statement. - Page 218, line 20: In this approach, the difference between the two incidence angles q1-q2 seems to be important. It seems that it will be easier to solve the equations when q1 and q2 are very different than when both are similar. This is something you could study with your scene from the 12 November. - Figure 9. In my opinion, in this case it could be said that the algorithm is not able to find a solution. - Page 219, lines 10-15: In the description of the ground measurements nothing has been said about the accuracy of measurements. At least the field average values and their standard deviation should be given to support your discussion. - Page 219, line 18: I would say the opposite. Field averaging would reduce errors, because speckle and other sources of variability would be averaged. - Page 219, line 21: This is something you could study in more detail. You could plot the average sigma0 values of fields depending on their look angle to the radar signal. You have also profiles in parallel and perpendicular to tillage. Therefore, you could simulate the sigma0 values that would be obtained with parallel profile data first and perpendicular data next and compare them. This kind of analyses could help you interpret your results more objectively.

5.2. Surface parameter mapping - Your retrieval method have been evaluated using

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field average data. It does not seem very correct to apply it pixel by pixel. Anyway, you cannot evaluate the accuracy of those pixel based estimations with ground data. The variability of surface roughness and moisture, speckle... could affect severely your estimations! Nothing is said about this. - In addition, rather than applying segmentation techniques I think it is more logical to perform the retrieval on a field scale and plot field scale roughness and moisture maps. - In my opinion, if you create those homogeneous areas using the original SAR image (any of both) you are creating areas with homogeneous backscatter. But this does not mean that those areas correspond to areas with homogeneous moisture or roughness. It seems more logical to make a segmentation for the moisture image (and obtain homogeneous moisture areas) and another segmentation for the roughness image (to obtain the areas where roughness is uniform). In any case, I think that the best thing you can do is to work at the field scale. - Page 220, line 13: ‘pixel maps are more accurate’. This sentence is not correct. What do you mean with accurate? Did you evaluate the accuracy of your maps? I don’t think that applying an inversion scheme evaluated on control fields to each pixel will lead to a more accurate map than working at the field scale. - The accuracy of the soil parameter maps you obtained is a very important issue. In fact, if those maps would be used on a hydrological model through a Data Assimilation scheme, it would be very important to know the accuracy of the predictions in order to assign realistic weights to your measurements. You should think on a method to evaluate the accuracy of your maps. For example, you could keep some ground measurements (using in the first part of the paper) for a validation and accuracy assessment of your maps. - The issue of speckle (page 220 line 24) is also important. Both filters, Lee and lowpass (I guess this last one corresponds to an average or Median filter), modify the pixel values, you should rewrite the text. The adaptive filters are more adequate for speckle reduction since the maintain bright pixels corresponding to coherent scatterers or other features. Any retrieval algorithm based on SAR data should be applied to speckle filtered images. In other words, you need to filter your images before applying any retrieval algorithm. This way, the influence of speckle on your results (already men-

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tioned in page 219 line 21) will be reduced. - You also mention that ‘the best filter should be chosen in each case. For this study, it was the low-pass filter.’ (page 221, lines 3-4). But you do not explain how you evaluated which filter was best. This is important.

6. Conclusions - The conclusions should be more specific and focus on the approach presented and the results obtained. - The last paragraph should be moved to the introduction. - Page 221 lines 20-21: ‘However, in this paper, we demonstrated that using the multi-angular approach, it is possible to decrease these types of errors and derive acceptable results for the overall watershed area.’ Maybe I missed something, but I don’t think you compared your results to any previous results, so it is not correct to conclude that with your approach it is possible to decrease errors. In addition, I don’t think you can say that you obtained acceptable results for the overall watershed, since no watershed scale application of your algorithm is presented in the paper. - Finally, I would like to mention that there are some publications where roughness parameters are related to Manning’s n and also some attempts to modify CN values using moisture estimates and models (for instance EUROSEM) that use rms height to calculate surface water storage and infiltration: -Engman E.T. (1986). Roughness coefficients for routing surface runoff. J. of Irrig. Drainage Eng., 112, 39–53. -Gilley J.E., Finkner S.C. (1991).Hydraulic roughness coefficients as affected by random roughness. Trans. ASAE, 34, 897–903. -Jacobs, J.M., Myers, D.A. and Whitfield, B.M. (2003). Improved rainfall/runoff estimates using remotely sensed soil moisture. Journal of the American Water Resources Association, 39(2), 313-124. -Morgan R.P.C., Quinton J.N., Smith R.E., Govers G., Poesen J.W.A., Auerswald K., Chisci G., Torri D. and Styczen M.E. (1998). The European Soil Erosion Model (EUROSEM): a dynamic approach for predicting sediment transport from fields and small catchments. Earth Surf. Processes and Landforms, 23, 527–544.

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