

pp_mes=measured backscattering coefficient at pp polarization (IEM simulation + noise) pp_sim=IEM simulations (Look Up Table) at pp polarization pp=hh, hv and vv
mv=soil moisture rms=rms surface height

Interactive
Comment

Normally, the minimum of the cost function Q (Qmin) gives the estimated values of mv and rms but with our wide range of rms (between 0.3 and 3.6 cm), several minima (Qmin1, Qmin2...) with close values were often found for the cost function (Qmin1≈Qmin2...). The minimum minimorum does not correspond always to optimum values of mv and rms.

The authors have added in the revised version the following sentences: The use of simple inversion technique based on simulated Look-Up Tables (IEM model), which minimizes a mean distance (cost function) between the simulated and the measured backscattering coefficients (HH, HV and VV polarizations) does not lead to estimate correctly the soil parameters. Indeed, several minima are sometimes found for the cost function with very close values. Thus, the minimum minimorum does not correspond always to optimum values of soil moisture and surface roughness.

Concerning the following comment “The paper could refer to such previous work and document how the approach of this paper differs from the other papers”, the authors have added in the revised version an analysis of previous works:

Inversion approaches using a priori information on soil parameters were developed to improve soil moisture retrieval from SAR data. Satalino et al. (2002) developed an algorithm to retrieve soil moisture content over smooth bare soils from ERS-SAR data (VV-23°). The method consists of inverting the IEM model for a restricted roughness range (rms between 0.6 and 1.6 cm), by using neural networks. Results indicate that only two soil moisture classes, i.e., dry and wet soils, can be retrieved using ERS data. It is mainly because a same measured radar backscattering coefficient corresponds to several combinations of soil moisture and surface roughness conditions. Mattia et al. (2006) also use a priori information on soil moisture through water balance model

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Interactive
Comment

and surface roughness by means of an empirical approach, to constrain the inversion of theoretical radar backscattering models. An accuracy of approximately 5% on retrieved soil moisture is obtained. A probabilistic inversion approach which uses the soil roughness uncertainty for retrieving bare surface soil moisture from SAR data was developed by Verhoest et al. (2007). Accuracy less than 0.06 cm³/cm³ was obtained for study cases with low surface roughness (rms surface height less than 1 cm).

Other minor comments:

Comment 1: doesn't sound good (soil parameters estimation): maybe rephrase to "Estimation of soil parameters over bare agricultural areas..."? Response 1: As suggested "Soil parameters estimation over bare agricultural areas ..." was changed in "Estimation of soil parameters over bare agricultural areas ..."

Comment 2: Page 2898 → Sometimes the volumetric moisture content is written as cm³/cm³ (e.g. line 16), in other places it gets no units (e.g. line 18), please make it consistent throughout the paper. Response 2: As suggested, the unit was added.

Comment 3: Page 2898 → Line 16: mention that surface roughness concerns the rms height. Response 3: As suggested we added "root mean square surface height lower or higher ..."

Comment 4: Page 2898 → Line 23: an RMSE Response 4: OK

Comment 5: Page 2900 → Line 2: IEM: also add Fung et al. (1992) Response 5: The reference of Fung et al. (1992) was added Fung, A.K., Li, Z., and Chen, K.S.: Backscattering from a randomly rough dielectric surface. IEEE Transactions on Geoscience and Remote Sensing, vol. 30, no 2, pp. 356-369, 1992.

Comment 6: Page 2901 → Line 10: IEM: also add Fung et al. (1992) Response 6: OK

Comment 7: Page 2902 → Equations 1 to 3: are these newly derived for this paper, or are they taken from Baghdadi et al.? If new, then please provide some statistics

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Interactive
Comment

with respect to their fit. Response 7: In Baghdadi et al. (2006b-2011) the expressions of Lopt2 for each polarization were given as a function of rms surface height and incidence angle. In this paper, these expressions were improved in using additional SAR datasets. As suggested, some statistics were added in the revised version: $^{\circ}\text{C}\text{S}\text{I}\text{A}\text{S}$ is in degree, Lopt and rms are in centimeters. The coefficient of determination R^2 is 0.98 for HH, and 0.96 for both HV and VV. A small difference between calibrated IEM simulations (using Lopt2, equation 1) and SAR data (less than 1dB) was observed, with a standard deviation better than 2dB. $^{\circ}\text{C}\text{S}$

Comment 8: Page 2904 – Lines 1-14: please give some information on the error that is expected Response 8: As mentioned in page 2904, the accuracy of roughness parameters should be better than $\pm 10\%$ for rms and between $\pm 10\%$ and $\pm 20\%$ for large and small correlation lengths, respectively (Baghdadi et al., 2012). For our dataset, the error on the rms surface height is about 0.09 cm for rms=0.9 cm (lower rms-value) and 0.4 cm for rms=4.0 cm (higher rms-value).

Comment 9: Page 2904 – Line 8: dependent (typo) Response 9: OK

Comment 10: Page 2904 – Line 19: Levenberg-Marquardt (not Marquart) (typo)
Response 10: OK

Comment 11: Page 2906 – Case 2: an overlap of 10% is found between both classes, not 5%. Is two classes sufficient, or wouldn't it be better to have had three classes (dry, intermediate and wet)? Response 11: OK for the overlap. Concerning the choice of two soil moisture classes and not of three classes (dry, intermediate and wet), of course the inversion result will be much better in using three soil moisture classes but that complicates the work of the expert who will have to choose for a given SAR acquisition (given date) the a priori knowledge on the soil moisture. The choice among our two classes of soil moisture (very wet soils or dry to wet soils) will be easier. Moreover, as this paper aims to test the contribution of polarimetric parameters on the soil moisture estimation and that Baghdadi et al. (2012) have shown that the alpha

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Interactive
Comment

angle allows to separate only two soil moisture classes (very wet soils with $mv > 0.30$ cm^3/cm^3 from the rest), the choice is thus doubly justified.

Comment 12: Page 2906 – Case 3: an overlap of 1 cm is found between both classes, not 0.5 cm. The smooth class includes roughness up to 2 cm: can this still be considered as smooth? On the contrary, the rough class includes roughnesses of 1 cm, which is quite smooth Response 12: OK for the overlap. As suggested, we changed the names of roughness classes. For soils with rms surface height lower than 2cm, “smooth soils” was changed in “smooth to moderate soils”. For soils with rms surface height higher than 2cm, “rough soils” was changed in “moderate to rough soils”

Comment 13: Page 2906 – Lines 24 and equation 4: bias is not equal to mean absolute error. Equation 4 now defines the bias. For the mean absolute error, one should take the absolute value of $Ei - Mi$. Response 13: We agree with you. Only Bias and RMSE were used.

Comment 14: Page 2908 – Line 3: please rephrase “slightly behind”: it is unclear what is exactly meant (underestimating?) Response 14: The sentence is changed in “The performance of the algorithm is slightly lower at incidence angle of 35°.”

Comment 15: Page 2908 – Line 6: an intermediate (typo) Response 15: OK

Comment 16: Page 2908 – Line 9: up till now, it is not clear how the a priori information is being fed to the neural network. Response 16: As suggested, we added clarifications. The following paragraph has been added in the revised version: “For each studied case (case 1 to case 4), only the sub-datasets corresponding to rms and mv values defined by the a priori knowledge are used in the training and the validation phases. For example, for the case 2, with a priori knowledge on mv, two neural networks were developed and validated in using the corresponding sub-datasets : sub-dataset_1 corresponding to data with $mv < 35\%$ and sub-dataset_2 corresponding to data with $mv > 25\%$. ”

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Interactive
Comment

Comment 17: Page 2909 – Lines 25 and 26: overestimation and underestimation (instead of resp. overestimate and underestimate) Response 17: OK

Comment 18: Page 2912 – Line 23: an RMSE Response 18: OK

Comment 19: Page 2913 – Line 1: an RMSE – Line 24: an NDVI Response 19: OK

Comment 20: Page 2916 – It is unclear to me why the last sentence (lines 19 to 21) is stated: although it is true, the link with the paper seems to lack. If this sentence is really needed in the conclusion, then please better frame it such that it fits the research that was presented. Response 20: The last sentences could be removed.

References: Fung, A. K., Z. Li, and K. S. Chen (1992), Backscattering from a randomly rough dielectric surface, *IEEE Transactions on Geoscience and Remote Sensing*, 30, 356–369.

Mattia, F., G. Satalino, L. Dente, and G. Pasquariello (2006), Using a priori information to improve soil moisture retrieval from ENVISAT ASAR AP data in semi-arid regions, *IEEE Transactions on Geoscience and Remote Sensing*, 44, 900–912.

Satalino, G., F. Mattia, M.W. J. Davidson, T. Le Toan, G. Pasquariello, and M. Borgeaud (2002), On current limits of soil moisture retrieval from ERS-SAR data, *IEEE Transactions on Geoscience and Remote Sensing*, 40, 2438–2447.

Verhoest, N. E. C., B. De Baets, F. Mattia, G. Satalino, C. Lucau, and P. Defourny (2007), A probabilistic approach to soil moisture retrieval from ERS synthetic aperture radar backscattering under soil roughness uncertainty, *Water Resources Research*, 43, W07435, doi:10.1029/2006WR005295.

These references were added and discussed in the paper.

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 9, 2897, 2012.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

