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Hydrology and Earth System Sciences Discussions

Interactive comment on "Soil moisture retrieval through a merging of multi-temporal L-band SAR data and hydrologic modelling" *by* F. Mattia et al.

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Answers to referee 2

We would like to thank the reviewer for his positive appraisal of our work and for his remarks, which will certainly contribute to improve the paper.

Our replies (i.e. [AR]) to the reviewer's remarks (i.e. [RC]) are listed next:

[RC] The authors provide a well written paper. It demonstrates the combined use of modelled soil moisture and multi-temporal L-band SAR data. Modeled data are used for deriving a priori information on soil moisture at coarse scale to be used in a retrieval algorithm, which transforms multi-temporal L-band SAR data to soil moisture.

General comments:

In the description of the L-band SAR data, information on the spatial resolution and the radiometric properties are missing. The latter are of interest for understanding the results of the sensitivity analysis in subsection 2.2

[AR] We agree with the reviewer's remark. The range and azimuth spatial resolution of the geocoded products is 2m and 4.5m, respectively. The pixels spacing is 2m x 2m and the radiometric accuracy is better than 2dB (Scheiber et al., 2007). This information has been included in Section 2.2 of the revised version of the paper.

[RC] The description of the retrieval algorithm refers to the sensitivity analysis and uses this to justify neglecting vegetation cover (p. 3485, line 28/p. 3486 line 1). It should be discussed, if this makes the presented approach site specific and therefore not repeatable for other test cases.

[AR] As stated in the manuscript, the algorithm applies to cereal fields. Therefore it is not site specific but rather crop specific. In this respect, it can be applied to other sites particularly those devoted to cereal cultivation, e.g. the algorithm has been already applied to a site in Southern Italy (Satalino et al., 2008). Of course, the validity of the adopted approximation is subject to further assessment through theoretical and experimental studies (on this point see the reply to 1st reviewer).

[RC] Also in the description of the retrieval algorithm an exponential autocorrelation function is assumed without justification (p. 3486/ line 13).

[AC] The assumption of an exponential autocorrelation function (ACF) stems from past studies (e.g. Mattia et al., 1997a; Mattia et al., 1997b, Mattia et al., 2003), which showed that the exponential shape is the most often observed in field measurements. Even in the case of roughness possessing multi-scale behaviour, the analysis of relatively short profiles shows that, at least close to the origin, their ACFs mostly decay with an exponential shape (Mattia et al., 1999). This point has been clarified in section 3. of the revised version of the paper.

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[RC] Admittedly, information on surface roughness used in an experimental assessment of the retrieval is given at the beginning of section 5. Maybe the authors could refer to this section when describing the retrieval algorithm in section 3.

[AR] We agree with the reviewer. In section 3 (pag. 3486, line 6), a reference to section 5 has been inserted.

[RC] Nevertheless, it is not clear, if in situ measurements of surface roughness have been made or if the used roughness information is based on model results or published data from other studies. A clarification would be highly appreciated.

[AR] The used roughness information is based on previous studies (e.g. Jackson et al, 1997; Davidson et al., 2003), which point to a range between 1.0cm and 1.5cm for the average value of the vertical roughness (i.e. s parameter) of sown fields. We agree that the value of 1cm adopted in the paper is an arbitrary choice and a slightly different value could have been selected. However, it should be noted that this is just an initial guess value with a limited influence on the final retrieved values. We have added this explanation in section 5 of the revised paper version.

[RC] A more thorough discussion of scale issues would be of interest, e.g. why and how does coarse resolution scale help to derive soil moisture from L-band SAR data at fine resolution.

[AR] The reason why (and how) a priori information on soil moisture content (mv) at coarse spatial scale can improve the retrieval of soil moisture maps at high resolution is simply because it is used as initial guess value for a constrained minimization technique. Under the assumption that the prior information on mv is reliable (i.e. well correlated with the observed values and affected by an rms error smaller than 7-8%), the minimization technique transforms a time series of L-band multi-temporal SAR images at high spatial resolution into multi-temporal soil moisture maps accurate within approximately 5% of rms error.

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[RC] Overall, the advantages of the proposed approach and its relation to other retrieval techniques should be discussed. Does the proposed retrieval algorithm have a potential in the context of operational and site independent soil moisture retrieval schemes?

[AR] The advantage of the proposed approach is that it can derive quite accurate multitemporal maps of soil moisture content over agricultural sites from L-band SAR data at single polarization. The drawback is that it requires not only prior guess values of soil moisture content at coarse scale but also updated information about crop maps (at least in terms of principal crops, e.g. broad leaves vs small stems). Therefore, it can be feasible to systematically retrieve soil moisture maps over agricultural sites, predominantly devoted to cereal cultivation, if different sources of remote sensing data are employed. For instance, a possible scenario to further validate the proposed approach could encompass PalSAR acquisitions in ScanSAR WB1 mode for soil moisture retrieval, C-band ASAR data for crop mapping and active/passive microwave systems at coarse resolution as a source of prior guess values of soil moisture content. A text summarising the above remarks has been included in the conclusions (i.e. section 6) of the revised paper.

Specific comments:

[RC] In section 2.2 there is only one subsection 2.2.1. If there is no subsection 2.2.2, the authors should maybe jointly describe the SAR data and present the sensitivity study in section 2.2.

[AR] We agree with the reviewer remark and we have accordingly modified the text in the revised version of the paper.

[RC] Figure 6: In the flow chart "Preprocessing" is shown as part of the implemented SAR retrieval algorithm. This is not mentioned in the text. Especially it is not clear, what kind of filtering has been applied and what was masked in the data and why.

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[AR] We agree with the reviewer. In the prepossessing step, a spatial mean filter over a window of 51 x 51 pixels has been applied. In addition, using the land use map reported in Fig. 1, the areas cultivated with winter rape, maize and sugar beet were masked. This information has been added on pag. 3495 of the revised paper version.

[RC] p.3483, line 1: Which bio-physical parameters relevant to the presented study have been obtained with the in situ measurements (even though the authors refer to a paper by Hajnsek et al. 2008, the bio-physical parameters used in the presented study should at least be listed)?

[AR] The biophysical parameters collected during the in situ measurements and relevant for the paper are the soil moisture content and the fresh wheat biomass. These measurements have been listed and illustrated in section 2.1.

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