Hydrol. Earth Syst. Sci. Discuss., 7, C2394–C2402, 2010
www.hydrol-earth-syst-sci-discuss.net/7/C2394/2010/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Cross-evaluation of modelled and remotely sensed surface soil moisture with in situ data in Southwestern France" *by* C. Albergel et al.

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Received and published: 21 September 2010

The authors thank the anonymous reviewer #2 for his review of the manuscript and for the fruitful comments. For an easier comprehension, general/specific comments of the referee are also reported (2.XX).

2.1 General comments (1) [The first aspect is related to the organization of the paper. In the manuscript a total of six soil moisture products were evaluated and compared (for ASCAT sensor and IFS model two products for each were considered), i.e. a large number of data. In my opinion, it should be clear to the reader the purpose of

the paper, i.e. the evaluation of different products against in-situ observations. In-situ data are assumed as benchmark ("truth"), notwithstanding the well-known problem related to their representativeness at the coarse spatial scale. Therefore, the comparison between ASCAT and SIM model might be removed. Otherwise, a more complete inter-comparison should be carried out (i.e. by comparing all the products among themselves). In this case it would be interesting to try to understand which product provides the more reliable soil moisture pattern (or, alternatively, the accuracy of each product) by using, for instance, the triple- collocation error method (e.g. Scipal et al., 2008; Dorigo et al., 2010). In this study, more than three soil moisture estimates are available for each point and, hence, also the reliability of the triple-collocation error method could be assessed.

Response to 2.1 [General Comments]

In response to the general comments [2.1] made by reviewer #2, the main purpose of the paper, i.e. evaluation of different soil moisture products (including model-derived products) against in situ observations will be enhanced in the introduction. In this study, regarding the good quality of the SIM analysis in terms of surface soil moisture and the need to develop new methods to complete the evaluation of remotely sensed ASCAT SSM, we propose to compare the latter to SIM. At this stage of the study, the objective of the paper is not to apply the triple collocation method. This method is able to provide error estimates of a set of three independent data sources, using an additive error model assuming e.g. a constant bias between each data set. Reviewer#2 mentions that more than three soil moisture estimates are available for each point making possible the use of the triple collocation method. However, an assumption of this method (among others) is that all the considered data sets are fully independent, which would lead to exclude the ECMWF products. Indeed, ASCAT and ECMWF_F6ui are not independent (the ASCAT product is assimilated in ECMWF_F6ui), IFS_ECMWF and ECMWF_F6ui share the same physic. Moreover, another assumption of this technique is that the different data sets observe the same physical phenomenon. Even though all three data sets represent SSM, they observe different soil layers and different dynamics and systematic errors may occur (Drush et al., 2005). Also, bias is not accounted for by the triple collocation technique. We tend to consider that investigating the use of the triple collocation method would be a study by itself, and that this issue has to be examined in a next stage. There is very much an expectation that we will make a triple collocation analysis between SIM, ASCAT and SMOS observations at a France scale. It will allow us to accurately determine error estimates and it will be very useful in a data assimilation framework to set observational errors. However, we think that the use of independent in situ observations is a prerequisite.

Drusch, M., Wood, E. F., and Gao, H.: Observation operators for the direct assimilation of TRMM microwave imager retrieved soil moisture, Geophy. Res. Lett., 32, L15403, doi:10.1029/2005GL023623, 2005.

2.2 General comments (2) [Moreover, a table where all the soil moisture products are reported should be needed. This table should include the type of the product (in-situ, hydrometeorological model, NWP model), the investigated layer depth, the period for which data are available, the spatial and temporal resolution, ... In fact, this table helps the reader to have a clear idea of the different data sets and models used in the study and of their differences. For instance, which are the main differences between the different models used? If I am not mistaken, the main differences between SIM model and the NWP models are not only related to the land surface scheme. In fact, for SIM model no data assimilation was performed but it uses also rainfall information from raingauges data across France (rainfall is the main driver of the soil moisture temporal pattern). The NWP models, usually, do not assimilate rainfall data and, hence, it is nice to see that these models provide a good agreement with in-situ observations; very few paper comparing NWP model output with soil moisture observations were published indeed (e.g. Balsamo et al., 2009).]

Response to 2.2 [General Comments]

We agree with reviewer#2. A table reporting all the different soil moisture products used in this study and their characteristics is required and will be added. SIM does not consider any data assimilation into the land surface model. However, SIM uses an atmospheric analysis (SAFRAN) based on numerous observations from more than 1000 meteorological stations and more than 3500 daily rain gauges. NWP models used in this study do not assimilate rainfall, but the information contained in meteorological observations of air temperature and air humidity close to the surface is used to analyse soil moisture. This analysis is more efficient in data-rich areas like southwestern France. The good performance of the NWP models to simulated soil moisture in this area will be emphasised.

2.3 [The ASCAT SSM product used in the study does not represent the latest version of this data set. As reported in very recent studies (Brocca et al., 2010a; 2010b; 2010c), the new version of the ASCAT SSM product provides more consistent soil moisture estimates. I suggest to use this new data set and to discuss the results considering the above mentioned studies which proved the good behaviour of the new ASCAT SSM product against in-situ and modeled soil moisture data for different sites across Europe.]

Response to 2.3

We agree with reviewer #2. However when this study was done, the above mentioned data set was not available. To be fully consistent, the ASCAT SSM product used in the first part of this study and evaluated against in situ data needs to be similar to the one used at ECMWF in the new analysis (f6ui) evaluated in the second part of the study. The near real time system of ECMWF is very time consuming and non-flexible in terms of re-processing. This implies that the analyses are not repeated for each re-processed data set of observations. However, this new ASCAT SSM data set is under study at CNRM and references to the above mentioned studies will be added in the discussion part of the next version of the manuscript.

2.4 [The analysis of the downscaled ASCAT SSM product has to be revised. I agree with Referee 1 that the significance of the correlation values computed with only 10 data points should be very low. Which are the average R values for the two data sets? I suggest, alternatively, to compare monthly or seasonal averaged values (that should be more robust) with in-situ observations taking the "original" and the downscaled ASCAT products into account. This analysis is easier to understand and clearer for the reader. However, the new ASCAT SSM product is already very good and I can't find an obvious added-value in the 1km product at this status. Basically, for hydrological applications, the 1km product is totally the same of the 25km one (only a linear rescaling).]

Response 2.4

We agree with reviewer #2, temporal evaluation of the ASCAT download product will be added in terms of bias and RMSE additionally to the spatial evaluation. If we consider this group of 10 stations (9 SMOSMANIA and SMOSREX), the following scores are obtain with the standard ASCAT product (averaged for all stations), bias = -0.078 and RMSE = 0.243. Considering the downscaled product, they are similar, bias = -0.071 and RMSE = 0.257. It will be added and discussed in the next version of the manuscript. A suggested by reviewers #1&#2 spatial correlations where further investigated, while from Figure 6 it is possible to appreciate that R values are greater for the downscaled ASCAT product than that of the ASCAT product, average R values are similar.

2.5 [The analysis of the two products of the IFS of ECMWF is not complete. As stated by the authors in the Conclusion section the contribution of the new data assimilation algorithm (SEKF against OI) should be separated from the contribution of ASCAT. As far as I know, the effect of the SEKF versus the OI method is much stronger than that related to the assimilation of the ASCAT SSM product (de Rosnay et al., 2010). Reading the paper, I could think that the improved performance of the IFS_F6ui SSM product against the operational one can be related to the assimilation of ASCAT. I well understand that these results are very recent and it is not easy to include all of them

in the manuscript. However, in my opinion, the analysis should be as much complete as possible and, hence, these very recent results on ECMWF product (and also those relative to ASCAT) should be added and discussed.]

Response 2.5

In this study, the ECMWF IFS used in operation in 2009 is evaluated against in situ data. The soil moisture analysis is based on observed screen-level parameters (T2m, RH2m) and the assimilation technique used is the optimal interpolation (OI). An advanced surface data assimilation system is also evaluated, based on a simplified extended Kalman filter (SEKF), screen-level parameters and ASCAT estimates. The differences between both analyses are the assimilation technique (OI and SEKF) and, for the latter, the use of ASCAT estimates. For the considered period and spatial resolution (T799, 23 km), only these products are available. Therefore if the added value of the new analysis and observations is demonstrated, the contribution of the new algorithm is not separated from the contribution of ASCAT estimates. In the conference proceeding/poster of de Rosnay et al. 2009, 2010, this issue not addressed in the same context as lower spatial resolution products (T255, 80 km) are used. It is found that the impact of using the SEKF instead of the OI method is much stronger than that related to the assimilation of the ASCAT SSM product. This result will be added in the discussion part of the next version of the paper.

de Rosnay P., Drusch M., Balsamo G., Beljaars A., Isaksen L., Vasiljevic D., Albergel C., Scipal K.,: Advances in land data assimilation at ECMWF, proceeding of the ECMWF/GLASS Workshop on Land Surface, Reading, UK, 8pp, 9-12 November 2009

de Rosnay P., J. Muñoz Sabater, G. Balsamo, M. Drusch, K. Scipal, C. Albergel, D. Vasiljevic, A. Beljaars, L. Isaksen ESA Living Planet Symposium, Bergen, Norway, 28 June - 2 July 2010, poster: "Use of satellite data for soil moisture analysis at ECMWF"

2.6 [P4302, L24: Why only the descending passes are used? With the new version of the ASCAT SSM product both passes provide nearly the same results (Brocca et al.,2010a).]

Response 2.6

Following the findings of Albergel et al, 2009, only the morning (descending) passes were considered. Prior to this study, both ascending and descending passes were analysed, together and separately and we found that the use of the descending passes presents better scores.

Albergel, C., Rüdiger, C., Carrer, D., Calvet, J.-C., Fritz, N., Naeimi, V., Bartalis, Z., and Hasenauer, S.: An evaluation of ASCAT surface soil moisture products with in-situ observations in southwestern France. Hydrol. Earth Syst. Sci., 13, 115-124, 2009. www.hydrol-earth-syst-sci.net/13/115/2009/

2.7 [P4304, L20: What does this sentence mean: "because of the lack of usable satellite measurements"? Please specify better.]

Response 2.7

In this particular mountainous area, part of the Pyrenees, no ASCAT SSM are available on the WARP-5 12,5 km regular grid. This was also found by Albergel et al., 2009 with orbital data.

2.8 [P4305, L4: I suggest to display all the performance indices (BIAS, RMSE) in a consistent way, i.e. considering either in relative term (between 0 and 1, as the saturation degree) or in volumetric terms (m3m-3). Moreover, concerning the evaluation of the SSM ASCAT products against in-situ data, the latter should have been rescaled between 0 and 1. How was the normalization performed? Are the maximum and minimum values of in-situ observations or the residual and saturation soil moisture values considered? Please specify.]

Response 2.8

As reported in section 2.4 (Data preparation), in situ data are normalized using the minimum and maximum values of each individual times series (i.e. for each stations) considering the whole 2007-2008 period.

2.9 [P4306, L8-10: Figure 5 should be more commented or removed.]

Response 2.9

In response to reviewers #1&#2, the discussion will be expanded and a link will be made between Figs 3, 4 and 5. Figure 4 illustrates the comparison between ASCAT and SIM SSM. Over this two year period, it is possible to appreciate the seasonal cycle of SSM, i.e. with dry (summer) and wet (winter) seasons for both SSM data sets and for all the considered stations. Finally, this representation of the seasonal cycle is completed by Fig. 5, presenting the probability density function of the three SSM data sets (in situ, ASCAT, SIM) over the LHS station. A bi-modal shape, characteristic of long SSM time series, is observed for the three data sets. It is caused by the accumulation of high SSM values in wet conditions (e.g. winter and springtime) and of low SSM values in dry conditions (e.g. summertime and the autumn) illustrated by Figs. 3 and 4. Fig. 5 completes Figs. 3 and 4 by presenting the probability density function of the three SSM data sets (in situ, ASCAT, SIM) over the LHS station. A bi-modal shape, characteristic of long SSM time series, is observed for the three data sets. Similar bi-modal pdfs are observed for the other stations (not shown).

2.10 [Figure 2: I suggest to change this figure with a more detailed framework of the study area including, for instance, the digital elevation model or the land use/soil types map (along with the location of the SMOSMANIA and SMOSREX stations).]

Response 2.10

In response to reviewers #1&#2, a new figure will replace Fig. 2, with a more detailed framework of the studied area (digital elevation model, SMOSMANIA and SMOSREX stations).

2.11 [Figure 3-4: These two figures are very hard to read. Likely, only an example for two or three representative stations should be better (as in Figure 7).]

Response 2.11

We agree with reviewer #2, however, having this information for all stations permits to highlight the variability of SSM time-series at different stations. The quality of Figs 3-4 will be improved as much as possible.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 4291, 2010.