# Response to Referee #1:

The Fundamental Climate Data Record (FCDR) of F08, F11 and F13 SSM/I satellites is used by the authors to retrieve surface soil moisture over the Tibetan Plateau from 1987 to 2008. In situ soil moisture observations were collected over a 2.5 year period and, in this study, they are used to validate the satellite product. The trends derived from the satellite product are described. The paper is well written and deserves to be published.

However, a number of clarifications have to be made. In particular, the assessment of the SSM/I retrieval is based on monthly values and is not completely convincing. The representation of the day-to-day variability should be assessed. The trend analysis is not complete. The quality of some Figures needs to be improved.

Authors' response:
We would like to thank the reviewer for carefully reading our manuscript and making useful suggestions for improving the quality of our manuscript. The text below provides our response to the comments/suggestions made by the reviewer.

Particular comments:
- P. 6631, L. 20: is "<" 1.4 GHz appropriate to designate low frequencies ?

Authors' response:
Actually, what we were trying to say is that L-band is the preferred frequency for retrieving soil moisture. The text will be modified to read,

"Data sets collected by microwave instruments operating at L-band (~1.4 GHz) have been proven to be superior for retrieving top soil moisture over a wide range of vegetated conditions (Jackson and Schmugge 1989)."

- P. 6633, L. 19: "these change" ?

Authors' response:
Change has been replaced by changes.

- P. 6634, L. 4: "i.e." or "e.g." ?

Authors' response:
i.e. has been changed to e.g.

- P. 6638, Eqs. (3-4): Pellarin et al. (2003, 2006) have derived similar functions at other frequencies at the global scale. Are Eqs. (3-4) valid at a global scale (i.e. was the same training database as in Pellarin used ?) or are they only valid over the Tibetan Plateau? In Pellarin et al. (2006), the hourly rain rate is used at C-band and X-band. Why is this quantity not used in this study ?

Authors' response:
For this study the same training data set was used as in Pellarin et al. (2003,2006). As such Eqs (3-4) should be valid at a global scale and not only for the Tibetan Plateau. The rain rate was not used in the relationships because only a marginal improvement was obtained. Upon that, using the rain rate as additional input variable would add an extra source of uncertainty to the atmospheric correction. An explanation for this could be that the effects of specific humidity and rain rate are correlated to each other, and that the specific humidity also holds information on the rain rate.

- P. 6638, L. 12: what do you mean by "Taeq is equivalent to Tad and Tau" ? It should be made clear that Taeq is not equal to Tad, nor to Tau. Please write the relationship between Tad or Tau and Taeq.

Authors' response:

We would like to thank the referee for his comment. Indeed, the $T_a^{eq}$ is not equivalent to $T_a^{\downarrow}$ nor $T_a^{\uparrow}$. $T_a^{\downarrow}$ is computed using $T_{a(fr)}^{\downarrow} = T_a^{eq}\left(1 - e^{-\tau_{a(fr)} \sec\theta}\right)$, whereby fr indicates the frequency dependence. This will be corrected in the revised manuscript

- P. 6639, L. 18-19: A constant emissivity at 37 GHz ? This is very hard to believe. Since you use a monthly climatology of this quantity, you do not (completely) use this hypothesis. Please clarify.

Authors' response:
The wordings in this paragraph are indeed not very well chosen here. We did not use a constant emissivity at 37 GHz. We intend to clarify that the emissivity at the vertical polarization, 37 GHz and incidence angle > 50 degrees has a limited sensitivity to changes in land surface conditions. This has been previously shown in, for instance, Owe and Van de Griend (IJRS 2001), and is nowadays used for the LPRM model (Owe et al. JGR 2008).

This reasoning is used for this study to justify the use of the monthly climatology of the emissivity from a readily available data set. The text will be modified to better describe this.

- P. 6639, L. 25: "To filters out" ?

Authors' response:
'filters' has been changed to 'filter'

- P. 6640, L. 12: "the in total" ?'

Authors' response:
'the' has been removed

- P. 6640, L. 13: "soil moisutre" ?

Authors' response:
'moisutre' has been changed to 'moisture'

- P. 6640, L. 17: "obvered" ?

Authors' response:
'obvered' has been corrected to 'observed'

- P. 6641, L. 11-13: at which time scale is this comparison made ? (daily ? monthly ?)

Authors' response:
The comparison is made for individual retrievals. To clarify this, the text has been modified to read:

'A comparison with in situ measurements collected in the Naqu river basin is presented to further evaluate the accuracy of the individual soil moisture retrievals.'

- P. 6642, L. 6-8: please define the MAE, RMSE, and SEE scores.

Authors' response:
Mathematical expressions for the error statistics will be provided in the revised manuscript.

- P. 6642, L. 12: I would not use the RMSE score here as this score is influenced by the bias. The bias between a large scale soil moisture product and very local in situ observations is not informative. The local observation in units of m3/m3 may vary a lot from one plot to another. What is needed is the correlation coefficient and the standard deviation of differences. Moreover, assessing the day-to-day variability is crucial. From this point of view, calculating a correlation coefficient using absolute values such as in Fig. 6 is not very useful. This relationship is

dominated by the annual cycle. Using scaled anomalies associated to a gliding window (e.g. as in recent Albergel et al. papers) is a way to properly assess the day-to-day variability.

Authors' response:
We agree with the referee that the RMSE is influenced by the bias, the bias between point measurements and large scale soil moisture products is not informative, and that absolute correlation coefficient is influenced by the annual cycle. We have, therefore, computed also the error statistics used in Albergel et al. (JHM 2013). This includes the anomaly correlation coefficient, the normalized standard deviation (SDV) and centered unbiased RMSE (E) as suggested by the referee.

The statistics we obtain are as follows:

| | | |
|---|---|---|
| $r$ | correlation coefficient | 0.80 |
| $r_{anom}$ | anomaly $r$ | 0.39 |
| SDV | norm. standard dev. | 1.028 |
| E | centered unbiased RMSE | 0.599 |

These error statistics are comparable to the values reported in Albergel et al. (JHM 2013). The SVD of 1.028 is somewhat better than the reported values, whereas the $r_{ano}$ obtained here is in the lower part of the range of values given in Albergel. The SVD in combination with the $r$ of 0.80 result in an E value of 0.599, which makes the performance of the SSM/I retrievals for the Naqu sites among the best as compared to the soil moisture products evaluated by Albergel.

- P. 6642, L. 25: a comparison at the monthly scale permits assessing the seasonal cycle, which is rather trivial. Have you tried to assess the correlation at a daily time scale?

- P. 6643, L. 17 ("the SSM/I data product is skillful"): again, at a monthly scale, this is rather trivial.

Authors' response:
We have not yet tried to compare the individual retrievals with the 3 hourly GLDAS top 0-0.1 m soil moisture simulations merely for practical reasons. In the revised manuscript we will show the daily analysis.

- P. 6644, Sect. 5.2: It would be nice to see a long time series of monthly Tb values. For example over the area presenting the largest trend. Are trends in surface soil moisture seen by the NOAH model ?

Authors' response:
A complete series of monthly SSM/I will be shown in the revised manuscript for the area with the largest trends. Surface soil moisture trends simulated by GLDAS-Noah at $0.25^{o}$ resolution are, however, not very meaningful because for various episodes different sets of the atmospheric forcings have been used (see ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/GLDAS_V1/README.GLDAS.pdf p5).

- P. 6646, L. 15-22: are such trends in soil freezing/thawing seen by the NOAH model?

Authors' response:
We have not looked at the soil freezing/thawing simulated by Noah for two reasons. First, the Noah results available via GLDAS provide only the total soil moisture and not the liquid and frozen soil moisture components separately. Secondly, freeze/thaw simulations depend on the surface and soil temperature simulations. These are highly biased for the Tibetan Plateau (see Reichle et al. 2010, Van der Velde et al. HESS 2009) because of the parameterizations used for the top boundary condition (or surface temperature), soil heat transfer and freeze-thaw transitions. These parameterizations are considerably different for the Tibetan Plateau than for other parts of the world. Therefore, we would expect that such comparison would not be very meaningful.

- P. 6647, L. 1: What is the explanation for the decrease in ETpot ? A decrease in wind speed ?

Authors' response:

In the recent literature, there are two hypotheses being discussed. The first is the decrease in wind speed which has been observed across the Plateau. The second is the decrease in incoming solar radiation because of an increase in cloud coverage.