Response to Referee #3:

The authors adapted existing retrieval algorithms to estimate topsoil moisture over Tibetan Plateau using harmonized 1987-2008 L1 SSM/I data set. The retrieved soil moisture was then compared with in situ measurements from 5 stations in _10x10 km2 area, and with model soil moisture from GLDAS-Noah to show good agreements. The data were further analysed to provide evidence for positive monthly and annual trends during the 21.5 years and positive dependency on elevation. The paper is generally well-written with sufficient details and documents publishable results. However the following points warrant clarifications,

Authors' response:
We would like to thank the reviewer for carefully reading our manuscript. The text below provides a point by point to the comments/suggestions made by the reviewer.

1. While an alternative retrieval algorithm for SSM/I is welcomed, its introduction is not properly motivated when there is an existing (and previously tested) implementation by Jackson et al. (2002). How does the proposed method be better, or is the choice made largely for practical reasons?

Authors' response:
The objective of this study is not to introduce an alternative algorithm for retrieving soil moisture. However, for long term soil moisture mapping over a poorly gauged region parameterizations are needed that are readily available and remove the atmosphere effects. Therefore, components of various algorithms were selected for the algorithm used in the present study. This is clarified in the introduction around P6633L7-11 as follows,

"Hence, the applied algorithm has similarities with the Land Parameter Retrieval Model described in Owe et al. (2008) and the inversion approach used in Jackson et al. (2002). The advantage of the algorithm formulated here is that the effects of the atmosphere are explicitly accounted for."

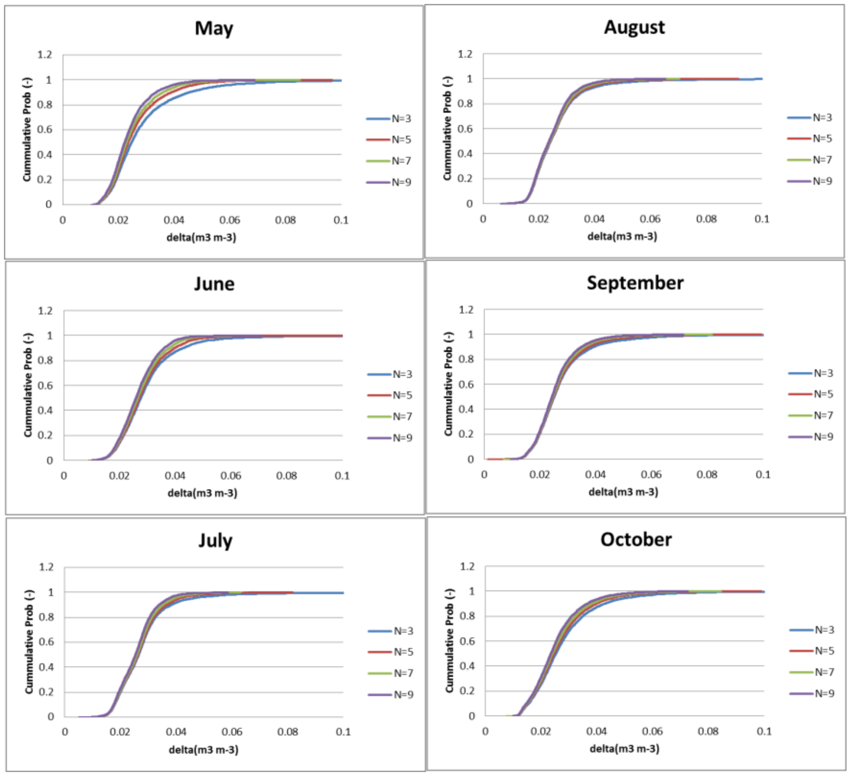
2. The shallow sampling depth at this higher frequency is susceptible to rapid changes to rainfall forcing and surface heating. Despite the fast dynamics, it is agreeable that longer trend is likely to be long-lived. However the threshold of 5 valid retrievals for estimating monthly means appears to be very low, leading to large sampling uncertainty for the sample means – please justify. What are the typical sample sizes for the estimation?

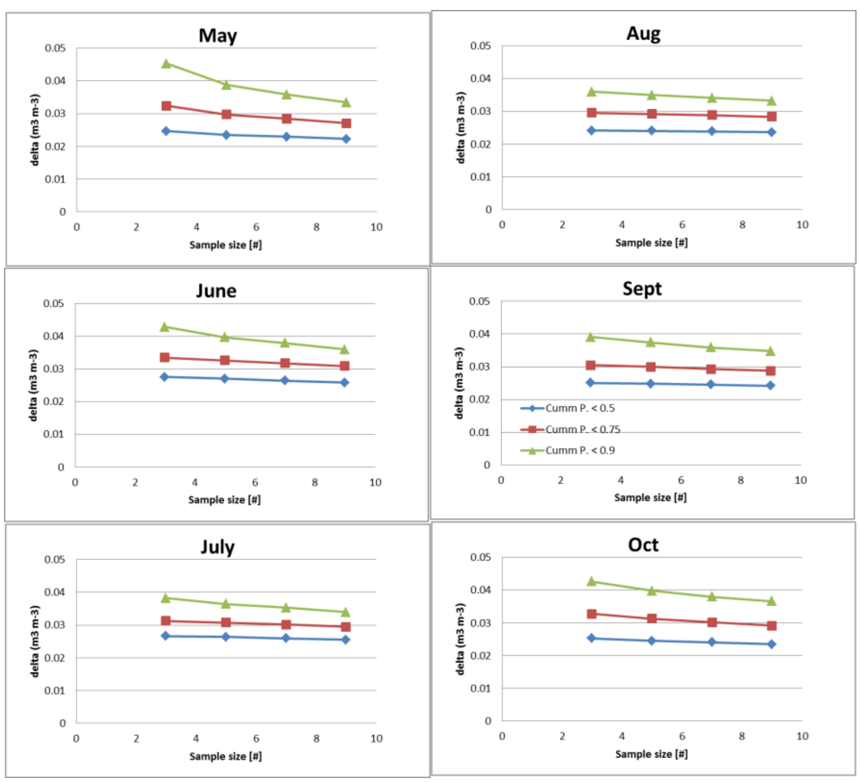
Authors' response:
The threshold of 5 valid retrievals is selected here because this sample size is frequently used in the literature (often without justification), for instance Albergel et al. (JHM 2013). However, the uncertainty caused by the sample size can be calculated using tabulated critical values for an assumed distribution, the sample size and the estimated standard deviation (stdev).

Because the stdev of a set of samples and the number of size may be correlated, we have taken as an estimate the stdev for each month averaged over the 21 years. The uncertainty associated with sample size is determined using this monthly averaged stdev, the number of samples of the specific calculated monthly mean soil moisture and a two-tail critical value of a normal distribution with which the uncertainty is determined with 90% confidence. This analysis is performed for threshold values of 3, 5, 7 and 9 retrievals.

The results are shown below as cumulative distribution functions and in figure on the following page where the uncertainty (delta) with which the mean with 90% confidence is plotted against the sample size (3, 5, 7, and 9) for cumulative probabilities of < 0.5, <0.75 and < 0.9. Both types of plots show that the sensitivity to the sample size is larger for May, June and October, which can be explained by the fact that for those months a smaller number of valid retrievals are available.

The largest decrease in the uncertainty due to sample size is, therefore, noted for the month May. However, an increase in the sample size from 5 to 9 retrievals results in a reduction of only 0.0013 m^3 m^{-3} for 50%, 0.0026 m^3 m^{-3} for 75% and 0.0053 m^3 m^{-3} for 90% of the data points in the month May. The impact of the sample size will be even small for the other months.





3. The discussion of VOD climatology is unclear. Figure 4 does not provide a clear picture of time evolution of VOD across the months and hard for readers to associate a similar seasonal dependence for soil moisture explained in the text. Perhaps the authors can present differencing maps, namely VOD_june – VOD_may, VOD_july – VOD_may, etc, or time series plots at selected locations.

Authors' response:
Thank you for the suggestion. We will create difference maps for Figure 4.

4. Please clarify the time scales (daily or monthly) at which comparisons with in-situ were made (Figures 5 and 6).

Authors' response:
Figures 5 and 6 both show the individual soil moisture retrievals. This will be clarified in the text.

5. Are all in-situ stations co-located within the same SSM/I satellite footprint?

Authors' response:
Indeed, all in-situ stations are located within the same SSM/I footprint. The text will be updated accordingly.

6. The treatment of DEM data with nearest-neighbour resampling does not make sense – DEM is understood to be in 1x1km2 resolution, while the footprint size is many times larger at 69x43km2. Spatial averaging or Hamming window sampling would seem more appropriate.

Authors' response:
Thank you for this remark. Indeed the nearest neighbor resampling does not make sense, but actually the DEM was resampled using an averaging technique. This will be corrected in the manuscript.

7. It is difficult to reconcile the labelling of the average of 6-month (May-October) data as the "annual value". Perhaps a better term should be used to avoid misunderstanding.

Authors' response:
We agree that a six month average should not be labeled as 'annual'. We renamed it as 'warm season'

8. Please clarify and justify the time window used to define the monthly or annual means and standard deviation in Eq. 6. Is the time window 21.5 years? If yes, then it is unclear to me the nature of the anomaly studied here because N has the same frequency information as Theta-bar. If no, what is the sensitivity of the results to different choices of window sizes?

Authors' response:
The time window is indeed 21.5 years. Then, the theta-bar is indeed confusing because we refer here to the monthly mean or warm season mean depending on the type of anomaly. The μ is in this case the 21.5 years average of either the respective monthly mean or the warm season mean. This information will be included in the revised manuscript.

9. Is equal-weighted linear regression used in the analysis of trend-elevation dependency in Figure 10? If yes, since the spread is variable at different elevation height, should weighted regression be used here? What is the sensitivity of the slope to the elevation binsize? What are the standard errors of the estimated slope?

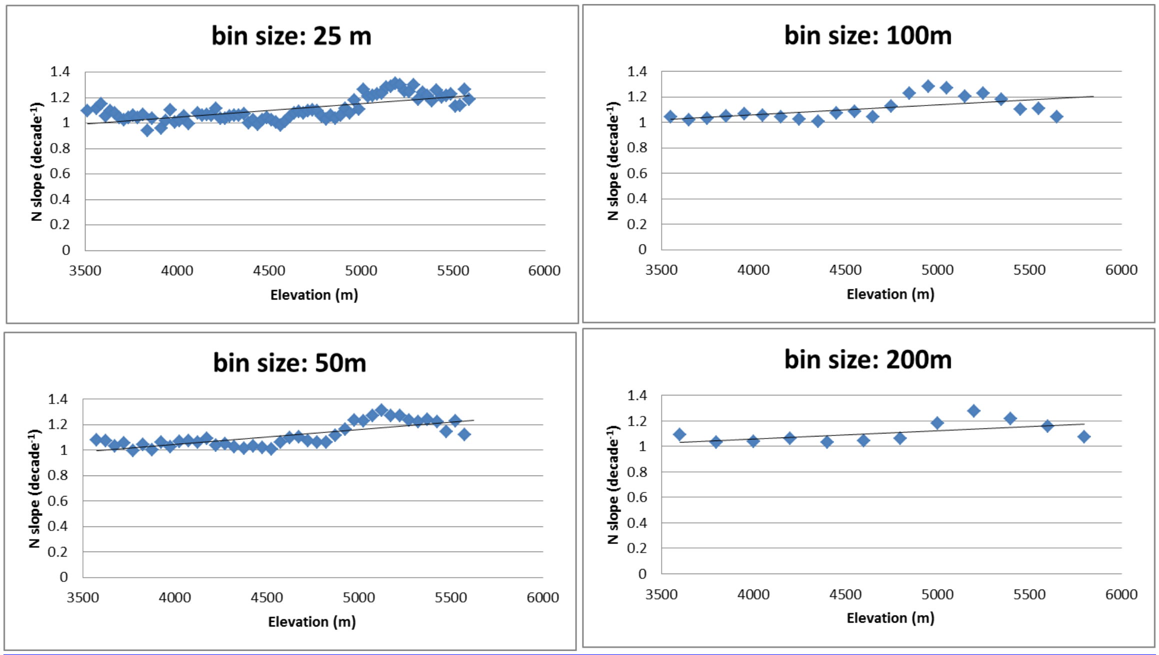
Authors' response:
We have used for Figure 10 an equally-weighted linear regression and now for this comment we have also perform an weighted linear regression based on the spread in the anomaly within an elevation bin as the referee suggestion. In addition to investigate the sensitivity of the slope for the bin size, this analysis has been performed for bin sizes of 25, 50 100 and 200m. The results in terms of the slope and standard error of

the estimated coefficients are shown in the table below for the weighted and uniform (equally-weighted) linear regression

bin size	Warm season				May			
	weight		uniform		weight		uniform	
[m]	slope	SE	slope	SE	slope	SE	slope	SE
25	0.000114	1.25E-05	0.000107	1.24E-05	0.000128	1.31E-05	0.000122	1.30E-05
50	0.000104	1.58E-05	9.65E-05	1.56E-05	0.000103	1.52E-05	0.0001	1.49E-05
100	6.63E-05	2.21E-05	6.16E-05	2.13E-05	7.81E-05	2.02E-05	7.61E-05	1.93E-05
200	6.76E-05	3.06E-05	6.46E-05	2.95E-05	8.27E-05	2.74E-05	7.89E-05	2.64E-05
bin size	June				July			
	weight		uniform		weight		uniform	
[m]	slope	SE	slope	SE	slope	SE	slope	SE
25	4.23E-05	1.13E-05	3.36E-05	1.06E-05	-1.65E-05	9.51E-06	-1.55E-05	9.26E-06
50	3.73E-05	1.03E-05	3.35E-05	1.00E-05	1.77E-05	1.04E-05	1.10E-05	1.00E-05
100	2.51E-05	1.24E-05	2.18E-05	1.19E-05	1.83E-05	1.17E-05	1.40E-05	1.15E-05
200	2.45E-05	1.38E-05	2.26E-05	1.32E-05	1.62E-05	1.47E-05	1.22E-05	1.43E-05
bin size	August				September			
	weight		uniform		weight		uniform	
[m]	slope	SE	slope	SE	slope	SE	slope	SE
25	4.21E-05	1.17E-05	3.85E-05	1.17E-05	6.66E-05	9.58E-06	6.44E-05	9.56E-06
50	3.41E-05	1.07E-05	3.23E-05	1.04E-05	5.43E-05	9.71E-06	5.35E-05	9.85E-06
100	3.09E-05	1.30E-05	2.90E-05	1.26E-05	3.66E-05	1.25E-05	3.67E-05	1.23E-05
200	3.16E-05	1.85E-05	2.95E-05	1.78E-05	3.50E-05	1.53E-05	3.38E-05	1.50E-05
bin size	October							
	weight		uniform					
[m]	slope	SE	slope	SE				
25	0.000115	1.56E-05	0.000118	1.44E-05				
50	9.86E-05	1.15E-05	9.77E-05	1.21E-05				
100	8.84E-05	1.26E-05	8.54E-05	1.26E-05				
200	6.43E-05	1.91E-05	5.85E-05	1.96E-05				

It is observed that the slope can vary significantly as function of the bin size and that the standard error of the slope range from 10% up to 200%. The relatively large range in slopes is noted because the relationship of the *N* trend with elevation is not linear. To illustrate this further, the relationship of the *N* trend with elevation is plotted for the warm season averages for the bin sizes 25, 50, 100 and 200 m. The four different plots show the same pattern. A slow and steady increase in the *N* trend up to an inflection point that is for the warm season averages around 4650 m. The selected bin sizes do affect noise observed in the relationship, which is one of the reasons for the observed variability in the statistics shown in the table above.

In summary the choice of the bin size is a trade-off between losing information and reducing the noise in the observed relationship. A visual comparison on the plots below suggests that a bin size of 100 m is a good compromise. For the revised manuscript a bin size of 100 m will be selected.



10. Table 1. What time zone is the satellite overpass times quoted?

Authors’ response:
The time zone of the Ascending Equatorial Crossing time is UTC. This is added to the table.

11. Figure 1. Include lat/lon labels to both the figure and its inset, so that the spatial relation between the figure and the inset is clear.

Authors’ response:
Thank you for the suggestion. The lat/lon labels will be added to the figure as well as inset.