

***Interactive comment on* “Influence of cracking clays on satellite observed and model simulated soil moisture” by Y. Y. Liu et al.**

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Author response to referee comments #1, 2 and two short comments

First of all, I would like to thank Wade Crow, Rogier van der Velde and the other two anonymous referees for their comments, which have provided valuable suggestions to improve this manuscript. Below I offer a response to their comments.

AUTHOR RESPONSE TO ANONYMOUS REFEREE #1

COMMENT 1) The specific comments P907: the words in title “satellite observed” should be changed to “satellite estimated”.

RESPONSE): Will do.

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COMMENT 2) P908L2TOL21: Abstract is not well organized, it is more similar to an introduction, which is, identification of research topics, and then provided scheme for solving problems, no any qualitative results in the abstract.

RESPONSE): Will revise the abstract accordingly. After reading all four referee and short comments, we plan to add one plot showing the time series of AMSR-E estimated and CLM simulated soil moisture over vertisols in the introduction. In this plot, we can clearly see the divergence between AMSR-E and CLM soil moisture starts from the end of rainy season, increases through the dry season, and reaches the highest at the start of next rainy season. Thus in the revised manuscript, we aim at answering two questions: (1) why AMSR-E soil moisture over vertisols during dry seasons is drier than surrounding non-clay soils and (2) why the difference between CLM and AMSR-E increases through the dry period and reaches the highest at the early of next rainy season. In the abstract of revised manuscript, we will put the answers to these two questions more explicitly.

COMMENT 3) P909L25L28: The authors claim to validate AMSER-E soil moisture by using CLM simulating results, this is not recommended, because both results are from numerical computation, it can be validated inter-crossly.

RESPONSE): We will rephrase this in the revised manuscript, using “compare AMSR-E and CLM soil moisture over vertisols” instead of “validate AMSR-E soil moisture against CLM simulations”.

COMMENT 4) P910L23TOP9117L14: The literatures in this paragraph not sufficient, some are not listed, such as “Retrieval of soil moisture and vegetation water content using SSM/I data over a corn and soybean region. Journal of Hydrometeorology, 6 (6), 854–863, 2005”, “Determination of land surface temperature and soil moisture from Tropical Rainfall Measuring Mission/Microwave Imager remote sensing data. Journal of Geophysics Research, 108(D2), 4038, doi: 10.1029/2002JD002176, 2003”.

RESPONSE): Will add in the revised manuscript.

COMMENT 5) P913L20TOP914L8: The AMSR-E estimated soil moisture is high than CLM simulated low, one reason need to be discussed, the top soil is usually much drier than the deeper soil for vertisols, especially in dry season.

RESPONSE): If we got this point correctly, the referee means that the soil layer depth of CLM is deeper than the penetration depth of AMSR-E C-band in dry season. The top soil layer of CLM represents the top-most 1.8 centimeters, while the penetration depth of AMSR-E C-band represents the top few centimeters, with increasing penetration depth as moisture decreases. In the dry season, the surface soil moisture of vertisols can be very dry and thus the AMSR-E C-band penetration depth is expected to be comparable with the soil layer depth of CLM.

COMMENT 6) P913L19TOP917L26: The discussion and conclusion are a little confused in these two parts. The discussion should give description and results of your research and other ones, and the reasons why they are same or different, while the conclusion is the presentation of the results.

RESPONSE): Will revise accordingly. As mentioned in response to comment 2, we will define two questions to be answered in the revised manuscript. After excluding all other possible answers in the results section, we will discuss how cracks over vertisols lead to the underestimated AMSR-E soil moisture and overestimated CLM soil moisture in more detail in the discussion section. The influences of not taking into account cracks on other simulated hydrological components are also discussed. In the conclusion, the results of this study are summarized and suggestions for future studies are put forward.

AUTHOR RESPONSE TO SHORT COMMENTS BY WADE CROW

COMMENT 1) One other potential explanation for Figure 1 might be land cover/land use issues - particularly as they relate to seasonal management of agricultural areas. That is, could the overly dry vertisol areas in Figure 1c be related to some type of large-scale land management practices (tillage?) which impacts surface roughness and/or vegetation coverage? Seems unlikely, but some brief discussion of land use in

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this regions (and its potential role in the seasonal contrasts seen in Figure 1) would strengthen the paper.

RESPONSE): Will add a brief discussion of land use over the vertisol regions with low AMSR-E soil moisture in comparison with surrounding non-clay soils. We read more literature and found that these vertisol regions are treeless and mainly covered by Mitchell grasses. Almost the entire region is dedicated to cattle grazing. Thus there is no large-scale land management practices (e.g., tillage) carried out over these regions and the land cover/land use issue seems not the cause for the low AMSR-E soil moisture.

COMMENT 2) Also – the topography of the vertisol areas should be described (in a manner analogous to the treatment of vegetation in Figure 3). Even under low-biomass, topography presents soil moisture retrieval problems. Could those problems be playing a role here?

RESPONSE): Will add one figure showing the elevation of the vertisol regions in the revision. In general, the elevation values within vertisol regions are rather similar and no obvious relief is observed, therefore topography within the vertisol regions plays little role in the anomalous behaviors of AMSR-E θ during dry seasons.

COMMENT 3) First two paragraph of Section 5. The connection between surface roughness and cracking made here raises the question of whether vertisol surface correction is just another manifestation of “surface roughness” and can be accommodated using a slightly larger roughness parameter in existing surface soil moisture retrievals (or whether the physical of the retrieval model itself has to be modified). I understand that the current paper is trying to avoid describing potential retrieval solutions to this problem – but the discussion of roughness presented here almost begs the question. How does this discussion of roughness tie into the cracking problem and does it point to a possible solution?

RESPONSE): In the revision, we run the AMSR-E retrieval algorithm to investigate

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the influences of surface roughness and soil porosity on the AMSR-E retrievals (both soil moisture and vegetation optical depth), that is, changing surface roughness or soil porosity while keep everything else the same. The results show that increasing surface roughness or soil porosity can increase the values of retrieved soil moisture. The difference is that increasing surface roughness will decrease the values of vegetation optical depth and increasing soil porosity will not change the vegetation optical depth. Thus we compare the time series of AMSR-E vegetation optical depth and AVHRR NDVI over two vertisol regions (region A and B). Within region A, AMSR-E vegetation optical depth agrees with NDVI very well, which means that AMSR-E vegetation optical depth is reasonably estimated and the low AMSR-E soil moisture is most likely attributed to the change in soil porosity. Within region B, during dry period, AMSR-E vegetation optical depth increases while NDVI decreases. It seems that AMSR-E vegetation optical depth is overestimated and thus the increases in surface roughness seems playing a more important role than the changes in soil porosity. In the absence of any in situ measurements over these vertisol regions, we can not perform any quantitative analysis to identify the individual contribution from soil porosity and surface roughness. Thus more in situ measurements of soil properties (e.g., soil moisture, soil porosity and fractions of clay and sand) which can represent different stages of cracks development over vertisols need to be collected for the further analysis.

COMMENT 4) Third paragraph of Section 5. Here the discussion switches quickly between the non-captured efforts of cracking on microwave retrieval to the non-captured effects of cracking on land surface modeling (without warning the reader). I would think about making this transition clear and – in general - being careful with the discussion surrounding surface cracking effects on land model soil evaporation calculations – since it seem to partially undermine the key argument made in Figures 1 and 2 (i.e., if the land model is not physical is these cases, how can it be used to make the case that the retrievals are non-physical?).

RESPONSE): After reading all four referee and short comments, we decide to add one

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plot showing the time series of AMSR-E estimated and CLM simulated soil moisture over vertisols in the introduction. In this plot, we can clearly see the divergence between AMSR-E and CLM soil moisture starts from the end of rainy season, increases through the dry season, and reaches the highest at the start of next rainy season. Thus in the revised manuscript, we aim at answering two questions: (1) why AMSR-E soil moisture over vertisols during dry seasons is drier than surrounding non-clay soils and (2) why the difference between CLM and AMSR-E increases through the dry period and reaches the highest at the early of next rainy season. Accordingly, the discussion section consists of two parts which respectively focus on the two aforementioned questions.

COMMENT 5) Figure 6 is interesting but seems misplaced towards the end of the paper. It seems more like a motivator for the analysis that should be presented at the front of the paper (it describes the potential importance of accurately capturing soil evaporation in vertisol regions but uses a completely different approach than the rest of the paper). Consider moving to earlier in the analysis.

RESPONSE): After reading all four referee and short comments, we decide to remove this figure while keeping the text: “Evans and McCabe (2010) found that regional climate model simulated surface temperature over vertisols in summer, during which vertisols regularly dry out and crack, is higher than the observations by more than 2 K, which are most likely due to poor representation of the cracking clay soils”.

COMMENT 6) Section 6 – “This study illustrates that the effect of soil cracking is one reason why it is unlikely that we can derive estimates of soil moisture content of the top few cm of soil with good absolute accuracy. . . . This need not be a major obstacle for successful uses of satellite passive microwave soil moisture for many purposes however.” For clarity, the authors should give a brief explanation of why they believe good absolute accuracy is not necessary for retrievals to be of value (for “many purpose”). I agree with the point - but one more sentence of clarification is needed to support this statement.

RESPONSE): We will add one example that successfully utilizes the changes in soil moisture values rather than the absolute soil moisture in the hydrological study. “For example, Crow et al. (2009) demonstrated how to improve satellite-based rainfall estimates utilizing the changes in satellite-based soil moisture retrievals over the contiguous United States. ”

AUTHOR RESPONSE TO ANONYMOUS REFEREE #2

Here we would like to put our responses to the referee’s comments on ‘Abstract’ to the end.

COMMENT 1) Introduction

1) Line 26 pp 908 - line 1 pp 909: There are only references referring to passive microwave retrieval of soil moisture. Please include also references referring to active microwave retrieval and soil moisture estimation by land surface models.

RESPONSE to 1): Will add more references from the aspects of active microwave estimated and land surface model simulated soil moisture.

2) Line 1-6 pp 909: The comparison of remote sensed soil moisture with other products helps to understand the satellite sensitivity to soil moisture and not the processes causing the soil moisture variability. At least, this is not what is presented in Wagner et al. 2003.

RESPONSE to 2): Will rephrase this sentence.

3) Line 21-22 pp 909: The authors should be more consistent in presenting the aim of this study in the whole article. The aim written here is a bit different from what it is written at the end of the introduction and in other parts of the article.

RESPONSE to 3): Will revise accordingly.

4) In my opinion it is not a good idea to present Figure 1 in the introduction, as the description of the data used for this figure is given only in the following paragraphs. I

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suggest to present it in the results.

RESPONSE to 4): After reading all four referee and short comments, we decide to add one plot showing the time series of AMSR-E estimated and CLM simulated soil moisture over vertisols in the introduction. In this plot, we can clearly see the divergence between AMSR-E and CLM soil moisture starts from the end of rainy season, increases through the dry season, and reaches the highest at the start of next rainy season. Thus in the revised manuscript, we aim at answering two questions: (1) why AMSR-E soil moisture over vertisols during dry seasons is drier than surrounding non-clay soils and (2) why the difference between CLM and AMSR-E increases through the dry period and reaches the highest at the early of next rainy season. In this way, readers will know what exact questions this study will try to answer after reading the introduction.

5) The black lines surrounding the vertisols areas in Figure 1, as well as in the other figures, are not very clear. I suggest to include in the article also a soil map, to help the reader to identify the vertisols location.

RESPONSE to 5): Will add one figure showing the spatial distribution of vertisols over mainland Australia.

COMMENT 2) Data and methods

1) The title should be changed in “Data”, as the methods are presented in chapter 3.

RESPONSE to 1): Will do it.

2) Line 21 pp 910: The authors refer to local time for AMSR-E ascending and descending acquisitions. It should be clarified to which location they are referring.

RESPONSE to 2): Will change “local time” to “equatorial local crossing time”.

3) Line 22 pp 911: As far as I know, it has been not demonstrated yet that AMSR-E VUA-NASA soil moisture retrieval represents the top 1.5 cm soil layer. Anyway the depth sensitivity depends on the soil moisture itself (i.e. wet or dry conditions) and on

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the soil texture. It would be better to mention some references, if known, about the depth of the soil moisture retrieved from passive microwave (C-band), as the same depth is taken in to account in the CLM model.

RESPONSE to 3): Change the “top 1.5 cm” to “top a few centimeters dependent on moisture conditions”; add one reference: “For example, the penetration depth of AMSR-E C-band is about 1 cm for the soil moisture of 0.2 m³ m⁻³, and 2 cm when the soil moisture is 0.1 m³ m⁻³ (Kuria et al., 2007).”.

Kuria, D. N., Koike, T., Lu, H., Tsutsui, H., and Graf, T.: Field-Supported Verification and Improvement of a Passive Microwave Surface Emission Model for Rough, Bare, and Wet Soil Surfaces by Incorporating Shadowing Effects, *IEEE T. Geosci. Remote*, 45, 1207-1216, doi: 10.1109/ TGRS.2007.894552, 2007.

COMMENT 3) Methods

1) In my opinion, in this chapter the authors should mentioned that the effect of some factors on AMSR-E soil moisture retrieval is investigated in order to support the hypothesis (about the sensitivity to soil cracks), but the hypothesis itself is not directly proved to be true. Excluding all the other possible factors leads the authors to the conclusion that the only factor affecting the anomalous soil moisture trend over dry vertisols are the soil cracks.

2) As the method consists of proving that all the possible factors affecting the AMSR-E soil moisture retrieval, except the soil cracks, over dry vertisols are not the cause of the observed anomalous behaviour, the authors should be careful to check all the affecting factors. Topography and land cover are important factor affecting the soil moisture, which in my opinion should be taken into account in the analysis.

RESPONSE): Will add a brief discussion of land use over the vertisol regions with low AMSR-E soil moisture in comparison with surrounding non-clay soils. We read more literature and found that these vertisol regions are treeless and mainly covered by

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Mitchell grasses. Almost the entire region is dedicated to cattle grazing. Thus there is no large-scale land management practices (e.g., tillage) carried out over these regions and the land cover issue seems not the cause for the low AMSR-E soil moisture.

Also, we will add one figure showing the elevation of the vertisol regions in the revision. In general, the elevation values within vertisol regions are rather similar and no obvious relief is observed, therefore topography within the vertisol regions plays little role in the anomalous behaviors of AMSR-E θ during dry seasons.

COMMENT 4) Results

1) I agree with the authors that a lower NDVI over vertisols with respect to the surrounding areas is an index of a lower vegetation density and therefore of a lower vegetation effect on the soil moisture retrieval. However it is also an indicator of a different vegetation cover over the two areas. I think the authors should add some comments about this point.

RESPONSE): After reading some literature, we found that vegetation over vertisols is mainly Mitchell grass and over surrounding non-clay areas includes hummock grass, woodland and shrubland. During dry periods, the density of vegetation is low over both vertisols and surrounding areas. Thus the impacts of vegetation on AMSR-E θ are minimal over vertisols and non-clay soils in close vicinity.

COMMENT 5) Discussion

1) In my opinion, this chapter looks in several points as an introduction, description of previous studies to support this. Moreover, further qualitative analyses are introduced. Instead, the discussion should further comment the presented results and link them with previous studies.

RESPONSE to 1): After reading all referee and short comments on the discussion section, we decide to add one part showing how the changes in surface roughness and soil porosity affect the AMSR-E retrievals (both soil moisture and vegetation optical

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depth) using VUA-NASA algorithm. This is also linked to several previous studies.

2) Line 22 pp 914: it would be very important to quantify how much the retrieved soil moisture is underestimated, when the increased soil porosity is not considered, and then compare this effect with the AMSR-E soil moisture product error due to LPRM model error propagation, which is estimated to be about 6%.

RESPONSE to 2): In the absence of in situ measurements over vertisol regions over mainland Australia, we are not able to quantify how much the retrieved soil moisture is underestimated. We can only qualitatively show the retrievals are underestimated. In the current figure, the difference between retrieved and actual soil moisture is indeed less than 6%. In the revised manuscript, we will add two parts in the current figure showing that further cracks (i.e., further increases in soil porosity) or further drying will lead to the difference higher than 6% or even invalid soil moisture.

3) Figure 6 is interesting but also confusing. Unexpectedly, a different model and additional data, not mentioned before, are used to show a new result, which is certainly interesting, but only partially support your study (a different model has been used and a different parameter, than soil moisture, is shown to be affected by craking clay soils). The figure needs more detailed description and explanation. Therefore I suggested to remove it or to move it.

RESPONSE to 3): Will remove the figure while keeping the text part.

COMMENT 6) Conclusions

1) I agree with comment number 6 of W. Crow.

RESPONSE to 1): We will add one example that successfully utilizes the changes in soil moisture values rather than the absolute soil moisture in the hydrological study. “For example, Crow et al. (2009) demonstrated how to improve satellite-based rainfall estimates utilizing the changes in satellite-based soil moisture retrievals over the contiguous United States.

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2) Line 18 pp 917: it is not clear how the differences between CLM and AMSR-E soil moisture can indicate the period of crack formation. Only two monthly averages were shown in the article, therefore it is not possible to conclude that CLM and AMSR-E soil moisture always agree over vertisols, except when there are soil cracks. Is it really possible to conclude that when the two products disagree over vertisol area, then soil cracks are present?

RESPONSE to 2): We decide to add one plot showing the time series of AMSR-E estimated and CLM simulated soil moisture over vertisols in the introduction. In this plot, we can clearly see the divergence between AMSR-E and CLM soil moisture starts from the end of rainy season, increases through the dry season, and reaches the highest at the start of next rainy season. In the revised manuscript, we aim at answering two questions: (1) why AMSR-E soil moisture over vertisols during dry seasons is drier than surrounding non-clay soils and (2) why the difference between CLM and AMSR-E increases through the dry period and reaches the highest at the early of next rainy season. In comparison with the current manuscript, we will put more efforts in answering the second question and show the difference between AMSR-E and CLM soil moisture might indicate the formation, development and resealing of cracks.

COMMENT 7) Abstract

1) Line 6-7: In the second sentence the authors state that both land surface models and passive microwave retrieval algorithms are not able to take into account of the effects of soil cracks for soil moisture estimation. However in the following sentence the authors state that to investigate the soil crack effect, the remote sensed and model soil moisture are compared. This is quite tricky. I mean, how can the authors evaluate the soil crack effect on soil moisture estimates if there is not an accurate soil moisture information as reference? Actually this sentence is misleading, because the aim of the article is achieved by excluding the effect of other factors on remote sensed soil moisture of vertisols and concluding that the unrealistic behaviour during dry season is due to soil cracks.

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RESPONSE to 1): Good point. In the absence of in situ measurements, we can not really quantitatively investigate the soil crack effect. We will do a major revision on the abstract to make it more logical.

2) In the abstract should be specified that AMSR-E VUA-NASA soil moisture products are used, as there also other AMSR-E soil moisture products available for the scientific community.

RESPONSE to 2): Will add this in the revised abstract.

3) Line 12-14: A part from the analyses and results described in the previous sentence (line 10-12), no further analysis were carried out on the retrieval model. The conclusion about the effect of soil porosity and surface roughness on soil moisture retrieval is just a consequence of the analysis described in line 10-12 and not the result of further analyses.

RESPONSE to 3): In the revision, we perform more analysis on the retrieval model, particularly showing the impacts of surface roughness and soil porosity on the retrievals. The abstract will be revised according to the new analysis.

4) Line 16: “Analyses show. . .” No analyses were carried out over the CLM model, but just qualitative considerations.

RESPONSE to 4): Will remove the ‘Analyses’.

AUTHOR RESPONSE TO SHORT COMMENTS BY Rogier van der Velde

COMMENT 1) P. 908 L23-25. Some references would be in place here.

RESPONSE): Will do it.

COMMENT 2) P. 909 L6-9. The authors refer here to the validation of soil moisture retrievals against the simulated soil moisture, but is not it the best way to validation retrievals against measurements. Please rephrase the text a bit.

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RESPONSE): Will rephrase it into something like: “we compare the soil moisture estimates from AMSR-E retrievals and CLM simulations” rather than validating one against another one.

COMMENT 3) P909 L10-13. I don't know of any study that looked at the for a specific soil type. Retrievals over peat soils could, for example, be having complete different characteristics. Maybe it is better to put into a broader context.

RESPONSE): Actually, it can be seen from the Figure 1 of the current manuscript that AMSR-E and CLM soil moisture estimates over non-clay soils are reasonably agree with each other, but the difference is very obvious over vertisols during dry periods. This is one main reason why we only focus on vertisols. In the revised manuscript, we will add one figure showing the spatial distribution of vertisols over mainland Australia. The total area of vertisols over Australia is more than half a million square kilometers, so the (in)accurate soil moisture estimates over vertisols in Australia may have considerable impacts on the hydrological cycle study.

COMMENT 4) P909 L201-203. It is not clear what the authors mean with “soil moisture dynamics in vertisol” is the temporal or spatial or the dynamics in the vertical direction.

RESPONSE): We remove this in the revised manuscript.

COMMENT 5) P909-910 –L11. This portion of the text is a bit vague, but could easily be more quantitative by showing retrieved and simulated sm time series. Also the percentage clay for the areas in Australia could be informative.

P910 L12-16. In this part and P909 L21-23 both explain what the authors are going to do in the text. I think it would be nicer to merge them into one. Further, there is no method applied to circumvent the soil moisture underestimation due to cracking soils and the potential impacts of cracking soils on hydrological components are not shown; only vaguely discussed.

RESPONSE): We really appreciate these two comments. Will add one figure showing

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the spatial distribution of vertisols over mainland Australia. We decide to add one plot showing the time series of AMSR-E estimated and CLM simulated soil moisture over vertisols in the introduction. In this plot, we can clearly see the divergence between AMSR-E and CLM soil moisture starts from the end of rainy season, increases through the dry season, and reaches the highest at the start of next rainy season. In the revised manuscript, we aim at answering two questions: (1) why AMSR-E soil moisture over vertisols during dry seasons is drier than surrounding non-clay soils and (2) why the difference between CLM and AMSR-E increases through the dry period and reaches the highest at the early of next rainy season.

COMMENT 6) P912 L18-19. What do the authors mean here by the “convert to volumetric soil moisture”? How?

RESPONSE): The unit of CLM soil moisture is kg m^{-2} . Given the soil layer depth is 1.8 cm, the CLM soil moisture was converted to volumetric soil moisture for direct comparison with AMSR-E θ retrievals.

COMMENT 7) P912 L20 – P914 L914. The authors discuss, here, how soil texture, vegetation and rainfall influence the soil moisture retrievals. - This is, in general, an interesting discussion but I am missing the real quantitative measures. For example, a constant soil texture is used, but what was the value of the fixed texture and how much are the change in soil moisture relative to the change in soil texture. - Also the discussion about the NDVI and optical depth relationship, sm and rainfall correlation could better visualized by the showing time series with the data. For me that is much more convincing. - An important variable affecting the retrieved soil moisture is surface temperature, but is missing in the analysis. As I remember correctly VUA product is derived using a linear relationship between the V-polarized 37 GHz TB. The clay cracks could also be responsible for a change in 37GHz emissivity and as such causing the low soil moisture retrievals. Maybe the authors could comment also on this issue.

RESPONSE): When we tested the impacts of soil texture on the low AMSR-E soil

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moisture over vertisols during dry period, we run a few experiments, e.g., considering all soil as clay, sand or something in between. All these experiments show the same results: AMSR-E soil moisture over vertisols during dry period are always lower than surrounding non-clay soils. In the revised manuscript, we add a few sentences on this, but the issue ‘how much are the change in soil moisture relative to the change in soil texture’ is out of the scope of this study.

We will add one plot showing time series of NDVI and optical depth over two large vertisol regions. One plot showing time series of AMSR-E and CLM soil moisture over vertisols will be also added in the revised manuscript.

We run the VUA-NASA algorithm model to test the influences of 37 GHz Tb on soil moisture retrievals. As mentioned in your comments, as clay cracks develop the surface roughness and soil porosity increase and consequently the emissivity increases, which might lead to higher 37 GHz Tb and overestimated surface temperature. In the VUA-NASA algorithm, higher surface temperature actually leads to higher soil moisture retrievals. This means that the 37 GHz is not the cause for the low AMSR-E soil moisture over vertisols during dry periods.

COMMENT 8) P914 L10-12. The conclusion that cracks in the clays are causing the underestimation of the soil moisture retrievals because other explanations can not be found is a bit an weak argument. The authors should find more quantitative prove of the cracks in clays maybe through photo’s. Then the shrinking and swelling of the clays should also be observable in the difference between the AMSR-E and CLM soil moisture.

RESPONSE): We found some more literature which evidences the existence of cracks during dry periods over the regions with low AMSR-E soil moisture. In addition, we add one plot showing time series of AMSR-E and CLM in the revised manuscript. In this plot, we can clearly see the divergence between AMSR-E and CLM soil moisture starts from the end of rainy season, increases through the dry season, and reaches

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the highest at the start of next rainy season.

COMMENT 9) P914 L12-18. Figure 5 is a nice illustration, but based on what source were availed to create this figure. Then where do the numbers for the soil moisture and soil porosity come from?

RESPONSE): In the revised manuscript, we will modify this figure and describe the data source explicitly. The soil porosity (0.45) and fraction of clay/sand (40%/31%) are taken from FAO soil property, which are typical values for vertisols over mainland Australia. T_s (300 K) is the average surface temperature over one vertisol region in north Australia on 1 October 2004. The Wang-Schmugge model is utilized to link these variables (also including actual soil moisture and soil porosity) to the mixed dielectric constant. We will revise the figure in the way which we can see how different soil porosity and actual soil moisture affect the AMSR-E retrievals.

COMMENT 10) P915 L7-L9. How should the surface roughness change?

RESPONSE): We run the VUA-NASA algorithm model and show the influences of surface roughness on the AMSR-E retrievals in the revised manuscript. From previous studies, the surface roughness get higher as soil dries. In our new figure, we also show that increasing surface roughness can lead to higher values of soil moisture retrievals.

COMMENT 11) P915 L12-17. What will be the minimum soil moisture content for your vertisols? And how do these soil moisture values relate to the minimum soil moisture contents retrieved.

RESPONSE): For the time being, we do not have in situ measurements over vertisols over mainland Australia. More in situ measurements over vertisols representing different stages of cracks development need to be collected in the future study. In this current paper, we can only qualitatively show how cracks of vertisols lead to underestimated AMSR-E and overestimated CLM soil moisture.

COMMENT 12) P917 L16-20. Why do the authors not show in the manuscript how

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difference between CLM and AMSR changes over time?

RESPONSE): As mentioned above, we will add one plot showing time series of AMSR-E and CLM in the revised manuscript.

I hope our responses help to clarify aspects of this manuscript and once again thank the referees for their thoughtful comments.

Yi Y Liu, 30 April 2010

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 907, 2010.

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