Response to the First Interactive Comment on “Estimation of surface soil moisture and roughness from multi-angular ASAR imagery in the Watershed Allied Telemetry Experimental Research (WATER)” by S. G. Wang et al.

Dear Anonymous Referee #1:

First of all, we greatly appreciate your careful work and very useful suggestions. We will try to take advantage of your advice for improving the manuscript. For an easier comprehension, your comments are also reported. We respond below in blue to your comments item-by-item.

Referee #1: In abstract, please write out AIEM

Response: Thanks for your suggestion and the word ‘AIEM’ has been written out in the abstract section in the revised manuscript.

Referee #1: P. 3366, l.10: replace ‘connects’ with ‘relates’

Response: The word ‘connects’ has been replaced by ‘relates’ in the revised manuscript.

Referee #1: P. 3366, l.12: replace ‘form’ with ‘scheme’

Response: The word ‘form’ has been replaced by ‘scheme’ in the revised manuscript.

Referee #1: P. 3367, l.8: turn sentence with plural (radar systems)

Response: Thanks for your suggestion and this sentence has been turned with plural in the revised manuscript.

Referee #1: P. 3368, l.26: put '…surface roughness is an essential input…'

Response: This sentence has been modified with '…surface roughness is an essential input…' in the revised manuscript.

Referee #1: P. 3370, l.8: replace When with After, put were instead of are

Response: The word 'When' has been replaced by 'After', the word 'are' has been replaced by 'were' in the revised manuscript.

Referee #1: P. 3372, l.22: put '… such as ASAR makes this possible.'

Response: This sentence has been modified with '… such as ASAR makes this possible.' in the revised manuscript.

Referee #1: P. 3372, l.26: put 'During the first step'

Response: Thanks for your suggestion, perhaps, it is in line 25. The word 'During' has been added into this sentence in the revised manuscript.

Referee #1: P. 3373, l.1: put 'During the second step'

Response: The word 'During' has been added into this sentence in the revised manuscript.

Referee #1: P. 3375, l.10: please put actual incidence angle values here (18.4 and 43.9)

Response: Yes, the actual incidence angel values have been added into this sentence in the revised manuscript.

Referee #1: P. 3375, l.14: what do the authors mean by ‘topography is flat’? How flat? Would it be possible to comment here on the implications of more heterogeneous topography on soil moisture retrieval? This is obviously important for a more world-wide application…

Response: Here, it means the terrain of this study area is fairly flat, since it locates in Zhangye oasis. On the contrary, if the terrain is rugged, such as high relief mountainous areas, topography may mask the signal variation in SAR caused by soil moisture, surface roughness and vegetation. Besides, it also affects the quality of image calibration and registration. As we were known, good quality calibration and registration are required for the use of SAR in the estimation of soil water content, especially for the multi-angular imagery method we proposed. Precise image-to-image co-registration is needed to obtain the backscatter difference for every SAR pixels in the domain of study area at different incidence angles. Thus, in this case study, both variations of incidence angle and SAR signals caused by topography are very small and can be neglected.

For more heterogeneous or high relief areas, although considerable efforts have been achieved in the field of geocoding and radiometric correction for SAR images (e.g., A. Loew and W. Mauser. "Generation of geometrically and radiometrically terrain corrected SAR image products," Remote Sensing of Environment, vol. 106, pp. P. 337-349, 2007), it is recognized that to precisely rectify the image distortions (i.e., layover, foreshortening and shadowing) is still a problem, and the variation of local incidence angle is complicated, both of them limit the usage of SAR observations to mountainous areas Therefore, to use these images to retrieve soil moisture by multi-angular method is still an critical issue need to be further addressed, indeed for quantitative analysis.

Referee #1: P. 3376, l.5: replace ‘these two’ with ‘both’

Response: Thanks for your suggestion and the words ‘these two’ have been replaced by ‘both’ in the revised manuscript.

Referee #1: P. 3376, l.5: comment: would HH polarisation not result in an attenuation of vegetation effects? Maybe the authors could comment here on what could be expected with a HV or VH polarization for example

Response: The reason why the HH polarization observations were selected in this investigation is the AIEM model we used is a single scattering version, that is to say, it not includes multi-scattering components. By doing simulations, the cross-polarization component seems too small and not correct compared to lots of literatures and textbooks have been published, such as Ulaby et al., 1982, 1986; Fung, 1994, etc.. Thus, co-polarization mode in HH was employed.

As for the vegetation effect, both co-polarization and cross-polarization observations would definitely impacted by the presence of canopy towards soil moisture retrieval. The variables affecting the scattering process could be attributed to radar parameters, such as frequency, polarization and incidence angle, and target parameters, such as vegetation properties and underlying soil contributions. Hence to consider the vegetation effect sufficiently should taking plant cover categories, plant density, plant height, pattern and plant dielectric properties, etc. into account. Whatever co-polarization or cross-polarization observations were deployed, complex dependence of sigma naught on the above system and target variables makes it difficult at this stage to render a detailed description on HV or VH observations. However, general remarks can be made is the presence of vegetation layer would lead to more de-polarization phenomenon and the plant morphology plays a key role in the scattering phase and magnitude of cross-polarization component.

Referee #1: P. 3376, l.10: remove ‘better’

Response: Thanks for your suggestion and the word ‘better’ has been removed in the revised manuscript.

Referee #1: P. 3376, l.13: put ‘denotes’ instead of ‘means’

Response: The word ‘means’ has been replaced by ‘denotes’ in the revised manuscript.

Referee #1: P. 3376, l.14-15: write ‘…a coefficient of determination equal to…’

Response: This sentence has been modified with ‘…a coefficient of determination equal to...’ in the revised manuscript.

Referee #1: P. 3377, l.10: remove ‘was’

Response: Thanks for your suggestion and the word ‘was’ has been removed in the revised manuscript.

Referee #1: P. 3377, l.11: put ‘before’ instead of ‘ago’

Response: The word ‘ago’ has been replaced by ‘before’ in the revised manuscript.

Referee #1: P. 3377, l.12: put ‘considerably high’ instead of ‘very strong’

Response: Thanks for your suggestion and the words ‘very strong’ has been replaced by ‘considerably high’ in the revised manuscript.

Referee #1: P. 3377, l.21: put ‘…manifesting that the soil moisture is slightly

underestimated.'

Response: This sentence has been modified with '…manifesting that the soil moisture is slightly underestimated.'

Referee #1: P. 3377, l.24: put 'shown' instead of 'indicated'

Response: The word 'indicated' has been replaced by 'shown' in the revised manuscript.

Referee #1: P. 3377, l.25: put '…due to the fact that'

Response: Thanks for your suggestion and this sentence has been modified with '…due to the fact that...'

Referee #1: P. 3378, l.11: insert 'these are' between 'but not'

Response: This sentence has been modified with '…but these are not...'

Referee #1: P. 3378, l.11: write 'A sampling…did take place at site E.'

Response: Thanks for your suggestion and this sentence has been modified with 'A sampling…did take place at site E.'

Referee #1: P. 3378, l.13: put 'from the literature'

Response: Thanks for your suggestion and this sentence has been modified with '…from the literature…'

Referee #1: P. 3378, l.18: remove 'both'

Response: The word ‘both’ has been removed in the revised manuscript.

Referee #1: P. 3378, l.26: put ‘verified’ instead of testified’

Response: The word ‘testified’ has been replaced by ‘verified’ in the revised manuscript.

Referee #1: P. 3379, l.20: put’…, it could still result in some uncertainties.’

Response: Thanks for your suggestion and this sentence has been modified with ‘…, it could still result in some uncertainties.’

Referee #1: P. 3380, l.6: put ‘seeking’

Response: The word ‘seek’ has been replaced by ‘seeking’ in the revised manuscript.

Referee #1: P. 3380, l.8: put ‘The investigation presented in this paper’

Response: This sentence has been modified with ‘The investigation presented in this paper...’

Referee #1: P. 3380, l.14: put ‘reliable’ instead of ‘feasible’

Response: The word ‘feasible’ has been replaced by ‘reliable’ in the revised manuscript.

Referee #1: P. 3380, l.18: remove the second ‘the’

Response: Thanks for your suggestion and the second ‘the’ has been removed in the revised manuscript.

Referee #1: P. 3380, l.18-19: do the authors mean ‘the presence of remaining vegetation effects’, given that they corrected for these?

Response: Yes, we agree with the referee and this sentence has been modified with ‘…the presence of remaining vegetation effects…’

Referee #1: P. 3380, l.24: put ‘instead’ of instead of ‘in place’

Response: The words ‘in place’ has been replaced by ‘instead’ in the revised manuscript.

Referee #1: P. 3381, l.1: put ‘area’ instead of ‘aspect

Response: Thanks for your suggestion and the word ‘aspect’ has been replaced by ‘area’ in the revised manuscript.

Response to the Second Interactive Comment on "Estimation of surface soil moisture and roughness from multi-angular ASAR imagery in the Watershed Allied Telemetry Experimental Research (WATER)" by S. G. Wang et al.

Dear Anonymous Referee #2:

First of all, we greatly appreciate your critical comments and constructive suggestions. We have tried our best to revise our manuscript according to the valuable suggestions. For an easier comprehension, your comments are also reported. We respond below in blue to your comments item-by-item.

General Comments:

Referee #2: … However, if I am not mistaken, in the paper the authors simply applied a methodology already proposed by Zribe and Dechambre (2002) together with Baghdadi et al. (2006a; 2006b) to field and satellite data collected during the WATER experiment. Therefore, no new methodology was developed by the authors, as it can be supposed reading the abstract and the purposes of the paper. I have not understood if the novelty of this paper is in the determination of equation (11). If so, it should be better highlighted in the corresponding section.

Response: In this manuscript, we used two empirical/semi-empirical relationships alike those ones proposed by Zribe and Dechambre (2002) together with Baghdadi et al. (2006b) to acquire surface roughness. However, we do not think this is just a simple application. What we contribute in this manuscript is that we propose a two-step retrieval scheme to derive soil moisture based on the physical model AIEM, not only over the course of the deduction of Eq.11, but also for the inversion of soil moisture. This is new.

As we were known, using multi-angular observations could be a promising way to acquire roughness information and Zribe and Dechambre (2002) has developed an empirical relationship. The first difference in our investigation compared to the above report is, as described in P.3376, L.5-7, the AIEM model was used to obtain Eq.11 and the domains of the roughness parameters were expanded during the simulations and calculation. At this stage, the obtained roughness could be more comparable to natural surface situation and is more reliable. In the revised manuscript, we have restated this point by adding a sentence in P.3380, L.12 (conclusion section) in front of 'An evaluation…River Basin' to highlight this aspect. In addition, the other difference from Zribe and Dechambre (2002) and Baghdadi et al. (2006a; 2006b) is that we used an iterative algorithm based on the AIEM during the inversion step as described in P. 3373, L.1-6, this could be more promising than empirical means to obtain soil moisture. The above two points are our main concerns.

In order to better emphasis our new contribution of the proposed two-step retrieval scheme, other modifications have been made in abstract section (P.3366, L.9) by adding '…by using a two-step retrieval scheme…' after '…ASAR images'. Secondly, in P.3370, L.5, we modified this sentence with '…The strategy is a two-step retrieval scheme which consisting of semi-empirical….'. And finally, in conclusions (section 4), we also modified the first sentence in the second paragraph (P.3380, L.8) with 'This investigation presented in the paper proposed a two-step retrieval strategy to estimate surface roughness and soil moisture…' in the revised manuscript.

Referee #2: The presentation of the results in terms of soil moisture retrieval is very short. For instance, why was the validation performed for only sites D and E if measurements were conducted at five sites (A-E)? The comparison was made for each measurement point. How many soil moisture measurements were carried out? Which is the spatial resolution of ASAR images?

Response: As we have declared at the end of the section 2.3 (P.3373, L.24-26), the problem of land salinization in experimental sites A, B and C is severe. As the following picture shows (Fig.1 in next page in this response), not only saline-alkali solutes are inside soil columns, but for most areas in these three sites, there is a shell layer with several centimeters thickness composed by saline-alkali materials onto soil surfaces. Thus, it is desirable to know whether SAR pulse can really detect soils information since the radar signals would be greatly impacted by this salt layer. At present, we did not accomplish a proper dielectric constant model and find out the feedbacks of SAR signals for this kind of salinity soil. Hence in this manuscript, we did not perform the roughness and soil moisture estimation and subsequent comparison for sites A, B and C but only at sites D and E although in situ measurements were conducted in all of the five sites. For this point, the sentence in section 3.2 (P.3377, L.14) has been modified with 'SAR penetration capacity is very sensitive to the imaginary part of dielectric constant, which is mainly influenced by the soil sanility. Therefore, due to strong salinization in most areas of the study site (Fig. 7), especially at sites A, B, and C, roughness and soil moisture estimation were not performed at these sites. In addition, in situ roughness measurements were not conducted at sites D and E due to vegetation obstacles so that we just use in situ soil moisture measurements at site D and E for validation. As shown in Fig.8, soil moisture estimates without eliminating vegetation effect are also used for comparison…'. We think by adding these words can help readers know why soil moisture validation were performed only for sites D and E.

Fig. 1 Soil salinity in the experimental sites

As the nested sampling strategy shows in the discussion manuscript (P.3391, Fig.2), at each experiment site, 49 soil moisture measurements were performed.

Forty five measurements were involved in the soil moisture validation for each ES and the other 4 were discarded. The reason is the quantities of these 4 soil moisture sampling are obviously irrational, which probably caused by improper sampling implementation. To clarify this point, in P.3377, L.17, we added a sentence 'For each ES, 45 points of in situ measurements were used to validate the estimates from SAR imagery…' before 'The results showed that for site D,….' in the revised manuscript.

The original resolution of ASAR APP product we acquired is 15m × 15m, after image-to-image co-registration based on the ETM+ image, the resolution of the imagery

used in the estimation of roughness and soil moisture is 30m × 30m. In the revised manuscript, we have added a sentence at P.3375, L.16, which is 'After image processes, the resolution of the imagery used for the estimation of roughness and soil moisture is 30 m × 30 m.' before 'Figure 3 illustrates the subsets….'.

Referee #2: By reading section 3.1, it seems that surface roughness measurements are not needed because the standard deviation and the correlation length of surface roughness can be obtained only by the knowledge of the difference in backscattering coefficient of two images acquired with different incidence angle. Are in situ surface roughness measurements used for the calibration of equation (13)?

Response: The in situ measurements of surface roughness were not involved in the calibration of Eq. 13. The parameters used to form this equation were referenced from Baghdadi et al. (2006b) since this investigation includes lots of SAR and in situ observations to obtain the statistical coefficients. Álvarez-Mozos et al. (2008) also reported that the calibration is promising. Thus, as described in P.3376, L.19-27, we used those coefficients provided by Baghdadi et al. (2006b) dependent on the configuration of acquisition SAR imagery (i.e., incidence angle, polarization, and frequency).

Besides, our original motivation is to evaluate the calibration since acquiring of the effective correlation length would be helpful to reduce one unknown surface parameter and derive soil moisture subsequently. Another purpose to carry the roughness filed measurements is to collect necessary data for developing microwave transfer model and validating soil moisture and roughness estimates. However, our field campaigns did not collect sufficient observations (including SAR data and in situ measurements) to further evaluate the validity of those coefficients summarized by Baghdadi et al. (2006b). Hence, it is also one of our next aims to better estimating soil moisture in future researches conducted in the Heihe River Basin.

Referee #2: Moreover, why is the vegetation effect corrected only using parameter values

taken from literature? I suppose that these parameters have a strong influence on the retrieved soil moisture therefore, why an attempt to calibrate these parameters was not carried out by using as benchmark the in situ observed soil moisture values?

Response: We agree with the referee, vegetation parameters are very significant for the correction. Actually, we attempted to observe the behaviors of canopy layer to the backscattering coefficients in experiments designs. Unfortunately, due to limited recourses, necessary in situ measurements of plant properties and underlying soils were obtained insufficient. Thus, we used the parameters values firstly referenced from literatures and then calibrated manually. That's why we summarized in the error analysis part (section 3.3, P.3378, L.8-16) that dedicated measurements of vegetation parameters are indeed desired. It is anticipate that the estimation accuracy of soil moisture can be improved by carrying more sophisticated vegetation measurements in our future field experiments in this river basin.

For revision, the paragraph begins at P.3374, L.26 in section 2.4 has been modified with 'As for the parameters used in the water cloud model, vegetation water content was measured only at site E on 18 June 2008, which was the closest date when radar images for the same experimental area were collected. Unfortunately, due to necessary measurements were not obtained sufficiently, the *vwc* at site D was inferred based on the local growing status. Constants A and b used in the water cloud model are not measurable parameters. Their values were first derived with a reference to Bindlish and Barros (2001) and then calibrated manually by fitting the observed and calculated backscattering coefficients. Parameters used for vegetation effects correction are shown in Table 3.' in the revised manuscript.

Referee #2: Another important drawback of the paper is related to the total absence of a comparison of the obtained results with those previously published in the scientific literature. If SAR images should be used to retrieve soil moisture operationally, a better assessment of their performance over different regions and by using different algorithms should be clearly assessed. In fact, the accuracy obtained in this study (RMSE<0.06

cm^3cm^{-3}) could be not sufficient for many applications.

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Response: We agree with the referee, many literatures reported that the RMSE of soil moisture estimation is around 0.04 cm^3cm^{-3}, or even smaller. Actually, one of our motivations is to explore and evaluate an operational methodology to estimate soil moisture since the main advantage of this two-step retrieval scheme is based solely on SAR imagery. As you have mentioned, it's just a case study which need to be broaden the application and may not be a so called operational method up to now, but it's really our goal. Thereby, we will evaluate this method for more landscapes over different regions in further.

As described in section 3.4 (P.3378, L.18-P.3379, L.26), we were quite aware that the errors of the estimation can be attributed to the presence of vegetation, the empirical deduction of surface roughness, the difference in sensing depths between SAR and TDR probe measurements, and the impact of the saline-alkali soils on SAR signals. As we have responded above and analyzed in section 3.3 and 3.4 in the manuscript, correction of vegetation effect is critical but we did not perform vegetation parameters calibration owing to lack of sufficient canopy measurements. We also would like to assess the difference of perceivable depth between SAR observation and TDR probe detection, since this point may be an important error source in arid region. Moreover, developing a proper dielectric model and evaluating the feedbacks of SAR signals for saline soils in this study area is an interesting issue and still going on. We suppose if all these issues can be well addressed, the accuracy can be improved.

For revision, firstly, we have replaced the word 'operational' by 'effective' and modified this sentence in P.3370, L.2 with 'The objective of this paper is to develop and evaluate an effective method that explores surface roughness based…'. Second, in P.3380, L.8, the sentence here has been modified with 'The investigation presented in this paper proposed a promising two-step retrieval scheme to estimate surface roughness and soil moisture without auxiliary information…'. And, for the sentence in last paragraph (P.3381, L.1), it has been modified with 'Potential future works in this area should expend the

applications of the proposed method over other study regions. Besides, some state-of-the-art tools can be dependent…' in the revised manuscript.

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Specific Comments/ Technical Corrections:

Referee #2: P3366, L9-14: The sentence is not clear at this point because the terminology is not yet been defined (roughness slope, roughness parameters). Please modify the sentence.

Response: Thanks for your suggestion and we have modified those sentences in P.3366, L.8-14 with '…This study aims to directly obtain surface roughness parameters (standard deviation of surface height σ and correlation length *cl*) along with soil moisture from multi-angular ASAR images by using a two-step retrieval scheme. The method firstly used a semi-empirical relationship that connects the roughness slope, Zs ($Zs=\sigma^2 / cl$) and the difference in backscattering coefficient ($\Delta\sigma$) from ASAR data in different incidence angles, in combination with an optimal calibration scheme consisting of σ and *cl*, to estimate the physical model-dependent roughness parameters (σ and *cl*). The deduced roughness was then used…' in the revised manuscript.

Referee #2: P3367, L2-4: I disagree with the authors about the fact that coarse resolution satellite sensor can not be employed at the catchment scale. Several contributions using these type of information for rainfall-runoff model calibration (Parajka et al., 2006, 2009), for the assessment of the reliability of modeled soil moisture (Sinclair and Pegram, 2010) and to improve runoff prediction (Crow et al., 2005; Brocca et al., 2010) were already published in the scientific literature.

Response: Thanks for the provision of additional references, we have read these papers and got some new ideas. For the revision, this point has been modified with '…It is well

known that space-borne passive systems possess the advantage of high revisit capacity but deficient in coarse spatial resolution. On the contrary, SAR sensors have the capability to provide…' in the revised manuscript.

Referee #2: P3368, L5-9: The expressions of the two linear relations can be also removed from the Introduction section.

Response: These two expressions have been deleted in the revised manuscript.

Referee #2: P3371, L10: "... and more applicable..." to modify with "... and applicable...".

Response: Thanks for your suggestion and this sentence has been modified with "... and applicable...".

Referee #2: P3371, L12: In equation (7) the symbol Fpq is not defined.

Response: The symbol Fpq denotes the complementary field coefficient and we have added this definition in the revised manuscript.

Referee #2: P3372, L15-18: The sentence is not clear and should be revised.

Response: This sentence has been modified with '…Soil texture and land surface correlation function type can be measured in field and assumed as a priori information. Thereby, the remained three unknown surface parameters are soil moisture *mv*, standard deviation of surface height σ and correlation length *cl*…' in the revised manuscript.

Referee #2: P3375, L12: What does it mean "after calibration". Please specify if different filters or different size were used.

Response: Here, ‘calibration’ means radiometric calibration, the purpose of this process is to convert the DN value from amplitude to backscattering coefficient, and to rectify the radiometric errors caused by the difference of observations between near and far range beams. The sentence in P.3375, L.12 has been modified with ‘After radiometric calibration,…’ in the revised manuscript.

How to do noise filter depends on the speckles on the imagery. For this purpose, we have tested different combinations of filters and sizes, eventually, we chose the enhanced Lee filter with 5 × 5 window size. The criterias for the selection of filters and sizes are by sight check and comparing the statistical mean, range and standard deviation of the backscatter coefficients. The bigger window size is, the smoother image we obtained. Smaller window size could keep details and edges on the image while it often can not reduce speckles effectively. Different filters also lead to different process results, by inspection of the processed images and comparing the statistical indexes, we thought enhanced Lee filter with 5 × 5 window size was more fit for acquired images.

Referee #2: P3376, L1: "..., it was found..." By who? Please add a reference.

Response: The reference Zribe and Dechambre (2002) has been added here in the revised manuscript.

Referee #2: P3376, L6-8: Again, it was found by who? Does it refer to in situ measurements carried out in this study?

Response: Yes, it refers to in situ measurements carried out in sites A, B and C in this study. The sentence in P.3376, L.8-10 has been modified with’…0.2 cm^3cm^{-3}. From the analysis of in situ roughness measurements (Table 2), the correlation function type is found to be fit for the exponential one.’ in the revised manuscript.

Referee #2: P3376, L21: The relationship provided by Baghdadi et al. (2006b) was

obtained from simulated data or from in situ observations? Please specify. How this relationship behaves considering in situ observation of surface roughness conducted in this study?

Response: The calibration presented by Baghdadi et al. (2006b) was based on a large experimental database consisting of SAR images and in situ measurements (soil moisture and roughness), and it is a extension of Baghdadi et al. (2002, 2004).
(N. Baghdadi, C. King, A. Chanzy and J.P. Wigneron "An empirical calibration of the integral equation model based on SAR data, soil moisture and surface roughness measurement over bare soils," International Journal of Remote Sensing, vol. 23, no. 20, pp. 4325-4340, 2002;
N. Baghdadi, I. Gherboudj, M. Zribi, M. Sahebi, C. King and F. Bonn. "Semi-empirical calibration of the IEM backscattering model using radar images and moisture and roughness field measurements," International Journal of Remote Sensing, vol. 20, no. 18, pp. 3593-3623, 2004.).

In the revised manuscript, we have modified the sentences in P.3376, L.19-20 with 'Additionally, on the basis of various SAR instrumental configurations and abundant in situ measurements, Baghdadi et al. (2006b) has deduced the calibrated correlation length form SAR images and found a statistical relationship between σ and cl, which is…'.

Since in situ roughness measurements have been carried only in sites A, B, and C and roughness estimation were performed in sites D and E, we did not compare the roughness behaviors.

Referee #2: P3377, L9-10: Please add a land use map to visualize the pattern of vegetated areas.

Response: Thanks for your suggestion and we have added a land use map (Figure 7) to visualize the pattern of vegetated areas in the revised manuscript.

Referee #2: P3378, L22: Please specify the characteristics of the TDR probes used in the study. It is quite strange to have portable TDR measurements for a layer depth of only 5 cm.

Response: The TDRs used in the field campaigns are Steven TDR and Delta TDR. The former one is composed of POGO portable soil sensor, Steven Hydraprobe, and PDA. The latter one includes a HH2 portable datalogger and a Theta Probe (type: ML2). The length of the probes of both two sensors are about 5 cm, thus the detection depth we described here is also around 5 cm.

Referee #2: P3379, L1-7: I have not understood if the coefficients in equation (12) were taken from Baghdadi et al. (2006b) or from in situ measurements performed in this study.

Response: The coefficients used in Eq. 12 were referenced from Baghdadi et al. (2006b). Because the above research obtained a parameterization of the calibration parameter for SAR sensors in C band with HH and VV polarizations at different incidence angles, and this calibration enabled a good generation of effective correlation length. Thus, we chose proper values of those coefficients dependent on the configuration of acquired images provided by Baghdadi et al. (2006b) as described in section 3.1 (P. 3376, L. 23-26).

Here, we have modified the sentences in P.3379, L.4-7 with '…In spite of the fact that a large quantity of images and corresponding in situ measurements were involved in the deduction of the coefficients used in Eq. (12) presented by Baghdadi et al. (2006b), it is conceivable that this empirical relationship could contribute more or less errors when it is deployed in our study environment.' in the revised manuscript.

Referee #2: P3379, L23: Results are reported only for sites D and E whereas strong salinization is present only on sites A, B and C, for which no result is shown.

Response: The strong salinization is a quite severe problem for land use in this area, and the farmers living there are really suffering from it. During the field works, they asked us whether it can be mended or not. We think this question is hard to answer. For soil moisture retrieval, as we have responded above, the salinization issue is complicated and need to be well addressed. Now, we are developing the dielectric model and evaluating the impacts of saline soils and salt-alkali layer on the SAR signals. If we could obtain proper algorithms, it is anticipated that we could properly estimate the roughness and soil moisture for the soils in sites A, B and C. However, it is not available at present. Besides, by doing these explorations, it can also be helpful to soil maintenance that would be more benefit for social activities and human beings.