Dear reviewer and editor,

Thanks for your positive comments and very useful recommendations to improve our manuscript. We have carefully modified the manuscript based on your suggestions and made response one by one. The main modifications consist of

1 Section 5 discussion was added putting our results in the big picture of literature.

2 Fig 1 and Fig 6 were revised according to your suggestions.

3 The confusion matrix of table 1 and table 2 were added.

4 Fig 3 was further clarified.

The Dai et al paper used the MODIS fractional snow cover product, in situ observations, and airborne observation data to evaluate the accuracy of snow cover and snow depth derived from passive microwave remote sensing data and to analyze the possible causes of uncertainties, such as cold desert, soil temperature, atmospheric correction, spatial resolution and topography and snow characteristics. The analyses are well-organized, the results are quite specific, which can provide a reference for the use of passive microwave remote sensing retrieving snow cover and snow depth, especially in some complex land surface region, such as Tibetan Plateau. Despite of its significance, several issues still need to be resolved before a publication to The Cryosphere. The paper needs thorough English edits and I only catch a few below, and some qualitative discussions are also needed.

Thank you very much for your reviewing our manuscript. We appreciated it that you gave a positive comments and very useful suggestions to improve our manuscript. We made a modification according to your suggestions and comments. The point-by-point revisions are as follows:

Below are some general comments:

Introduction:

The first paragraph needs to rewrite. ‘The Qinghai-Tibetan plateau (QTP) is considered the third pole of the world; its snow cover is an indicator of global climate change (Kang et al., 2010; Wu et al., 2003; Wang et al., 2015), and snow cover variation impacts the near ground air temperature and precipitation in Eurasia and across the Northern Hemisphere (Zhang et al, 2004; Lü et al., 2008; You et al.,2011).’ This part should be more focused on the topic of study and does not need to include everything that does not link to the topic of snow cover change in QTP.

RE：The Qinghai-Tibetan plateau (QTP) is considered the third pole of the world; its snow cover is an indicator of global climate change (Kang et al., 2010; Wu et al., 2003; Wang et al., 2015), and snow cover variation impacts the near ground air temperature and precipitation in Eurasia and across the Northern Hemisphere (Zhang et al, 2004; Lü et al., 2008; You et al.,2011).' was revised to

"The Qinghai-Tibetan plateau (QTP) is considered the third pole of the world and the Asian water tower (Kang et al., 2010; Wu et al., 2003; Wang et al., 2015; Immerzeel et al., 2010; Xu et al., 2008). Snow cover over it plays a significant role in the climate change and hydrological circle."

P2L17 remove should be replaced by eliminate.

RE：It was revised.

P3L1-4 the part is makes no sense for the topic of this paper, should be removed.

RE：This part was removed according to your suggestion.

P3L24 mainly should be replaced by primarily.

RE：It was revised.

2. Data

2.1 MODIS snow cover fraction

Snow cover fraction (SCF)-----Fractional snow cover (FSC)

Which products version was used in your manuscript?

RE：Fractional snow cover is the name of the product, but snow cover fraction is better to describe the content. In the text, MOD10A1 and MYD10A are of fractional snow cover products.

"The Terra/Aqua MODIS Level 3, 500m daily snow cover products (MOD10A1 and MYD10A1) were obtained from the National Snow and Ice Data Center (NSIDC) from 1 January, 2003 to 31 December, 2014 (Hall et al., 2006). The snow cover fraction (SCF) product derived from MODIS is generated" was revised to "The Terra/Aqua MODIS Level 3, 500m daily fractional snow cover products (MOD10A1 and MYD10A1) were obtained from the National Snow and Ice Data Center (NSIDC) from 1 January, 2003 to 31 December, 2014 (Hall et al., 2006). These products derived from MODIS were generated".

2.3 Meteorological station observations of snow depth

How the snow water equivalents were measured by meteorological station?

RE：Thanks for your remind.

" On the fifth, tenth, fifteenth, twentieth, twenty-fifth and the last day of a month (nearly every five days), snow water equivalents were measured using snow tube with a cross-sectional area of 100 cm^2 at the same time of snow depth measurement. And the record is also the mean value of three individual measurements. " was added to the end of this paragraph.

P6L19 18 and 36GHz, please keep the consistency of expression. Use K and Ka band or 18 and 36GHz all through the paper.

RE：Thanks for your suggestion. 18 and 36 GHz were used all through the paper.

2.4 Field experiments

Three observation routes were presented in figure 1, but in the following comparisons, you didn't compare the results of the observations in red and green line, why?

RE：There was rare snow during these two investigation periods, passive microwave remote sensing seldom underestimate the snow cover over QTP.

Please refer to the beginning of section 3.2.2: "Observations from December of 2013 and May of 2014 indicated sparse snow along the observation route, a result also shown by AMSR2."

P7L18 Why was the total portion of all possibilities not 1? Please check the data.

RE：The total portion of all possibilities did equal to 1. Maybe the expression is not so clearly.

"grids with TBD more than 20 K showed 4.9 % snow-free area, 82.9 % snow area, and 12.2 % uncertainty area, including 6.1 % high possibility of snow cover area and 6.1 % high possibility of snow-free area." was revised to

"grids with TBD more than 20 K showed 4.9 % snow-free area, 82.9 % snow area, and 12.2 % uncertainty area. The uncertainty areas included 6.1 % high possibility of snow cover area and 6.1 % high possibility of snow-free area."

When compared with MODIS snow cover fraction in figure 3, what is the relationship between the left and right figures? Please describe them clearly.

RE：The probability in figure 3 left was the ratio of frequency of a certain group of SCF and the frequency of all SCF with cloud fraction less than 10 %.

1: Left figures described the spatial distribution of probabilities of SCF >10 % when TBDs were more than 20 K (figure 3 a), between 15 and 20 K (figure 3 b), between 10 and 15 K (figure 3 c), between 5 and 10 K (figure 3 d), and less than 5 K (figure 3 e). Right figures were the statistic results of different probabilities for all group of SCF all over the QTP. The first group with horizontal axis labeled by "> 10%" is the statistic result of the right figure. The red bar means the number of pixels with probability of "SCF >10%" between 0 and 0.1 all over the QTP, the yellow bar for between 0.1 and 0.5, the light blue bar for between 0.5 and 0.8, and the dark blue bar for more than 0.8. The other groups which labeled by ">30%", ">50%", ">70%", and ">90%" presented the same meaning corresponding their SCF range as "SCF >10%", but their spatial distribution were not presented in figures.

2: "The frequencies of each SCF with cloud fraction less than 10 % for each TBD group from 2003 to 2007 were computed, which we called TBD-SCF table. Based on the TBD-SCF table, the probability was calculated. The results are described in the TBD-SCF table, which is the basis for determining the likelihood of snow cover for each AMSR-E grid given a TBD. The flowchart for building the TBD-SCF table is provided in Fig. 2." was revised to

"The frequencies of each SCF with cloud fraction less than 10 % for each TBD group from 2003 to 2007 were computed, which we called TBD-SCF table. Based on the TBD-SCF table, the probability was calculated, which was the ratio of frequency of a certain group of SCF and the frequency of all SCF with cloud fraction less than 10 %. The flowchart for building the TBD-SCF table is provided in Fig. 2."

3: "The frequency histograms of SCF > 10 %, 30 %, 50 %, 70 %, and 90 % were calculated according to the TBD-SCF table (Fig. 3), and the spatial distribution of the frequency of SCF > 10 % corresponding to each TBD group is presented in Fig. 3." was revised to

"The probabilities of all SCF groups to all TBD groups were depicted in figure 3. Left figures described the spatial distribution of probabilities of SCF >10 % when TBDs were more than 20 K (figure 3 a), between 15 and 20 K (figure 3 b), between 10 and 15 K (figure 3 c), between 5 and 10 K (figure 3 d), and less than 5 K (figure 3 e). Right figures were the statistic results of different probabilities for all group of SCF all over the QTP. The first groups with horizontal axis labeled by "> 10%" were the statistic result of the right figures. The red bar means the number of pixels with probability of "SCF >10%" between 0 and 0.1 all over the QTP, the yellow bar for between 0.1 and 0.5, the light blue bar for between 0.5 and 0.8, and the dark blue bar for more than 0.8. The other groups which labeled by ">30%", ">50%", ">70%", and ">90%" presented the same meaning corresponding their SCF range as "SCF >10%", but their spatial distribution were not presented in figures."

3. Evaluation methods and results

Your results involved AMSR2, but nothing results about AMSR2 appeared in 3.2.1.

RE：AMSR-E stopped in 2011, and AMSR2 started in 2012. The AMSR2 brightness temperatures from November, 2013 to March, 2014 were used to derive the snow depth in the field experiment areas, and the derived snow depths were compared with the field observations.

P7L18 "12.2 % uncertainty area, including 6.1 % high possibility of snow cover area and 6.1 % high possibility of snowfree area." Very confused.

RE：The total portion of all possibilities did equal to 1. Maybe the expression is not so clearly.

"grids with TBD more than 20 K showed 4.9 % snow-free area, 82.9 % snow area, and 12.2 % uncertainty area, including 6.1 % high possibility of snow cover area and 6.1 % high possibility of snow-free area." was revised to

"grids with TBD more than 20 K showed 4.9 % snow-free area, 82.9 % snow area, and 12.2 % uncertainty area. The uncertainty included 6.1 % high possibility of snow cover area and 6.1 % high possibility of snow-free area."

P8L13 snow depth is low---snow depth is shallow.

RE：It was revised.

P8L18 …with shallow snow---because of shallow snow.

RE："Areas with shallow snow" means that in these areas snow is shallow. If it is changed to because of, the meaning is also changed

P9L2-3 ’Snow cover conditions were derived from AMSR-E or AMSR2 at grids that contained meteorological stations and were compared with observations.’ Please rewrite.

RE：This sentence was revised to “Snow depths were derived from AMSR-E at grids that meteorological stations located on, and then were compared with station records.”

P9L4 ‘points’. I think here ‘samples’ should be better.

RE：”points” is changed to “grids”

Table 1 & 2. Please use confusion matrix to introduce how the accuracy values calculate.

RE：Thanks for your suggestion. We added the confusion matrix in the paper. In the text, we had explained how to calculate the overestimate, underestimate, omission and commission. Following is the confusion matrix of the comparison of table 1 and table 2:

Table 1 confusion matrix

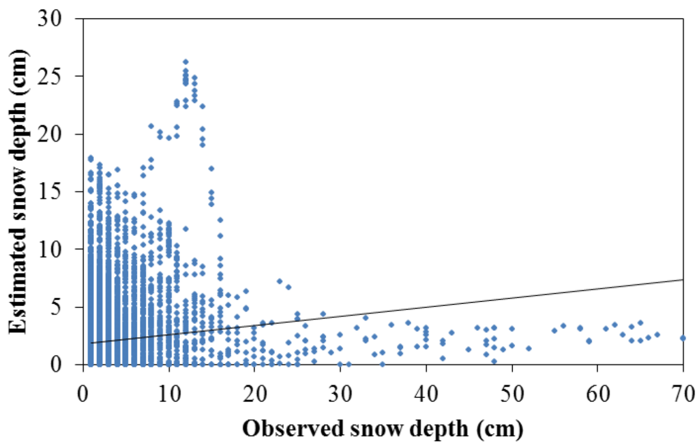
Confusion matrix	Snow(MODIS)	No snow(MODIS)	Snow(station)	No snow(station)
Snow(PM)	1367354	1749417	5139	27543
No snow(PM)	1232973	4597783	3656	144368

Table 2 confusion matrix

Confusion matrix	Original		After correction	
	Snow(MODIS)	No snow(MODIS)	Snow(MODIS)	No snow(MODIS)
Snow(PM)	1367354	1749417	1023344	901632
No snow(PM)	1232973	4597783	1586860	5441964

Please add the trend line and correlation coefficient in fig. 6a.

RE：Thanks for your suggestion. Fig. 6a was changed to



“The results showed that AMSR-E overestimates snow depths across the QTP” was revised to “The results showed that the correlation coefficient between them was 0.124, and AMSR-E overestimates snow depths across the QTP”

3.2.2 Comparison with field observations

When the estimated snow depth was compared with the observation along the observation route, do you consider the snow cover fraction as in Binggou watershed?

RE：At the first paragraph of this section, we added “According to MODIS fractional snow cover products, snow cover fraction of the pixels that these points located in ranged from 0.5 to 0.9 when the observations showed snow. If the snow cover fraction is considered in the comparison, the bias is 1.77cm, RMSE is 5.66 cm.”

P10L4 ‘Compared with these snow depth.’ Please replace the snow depth to samples.

RE：It was revised.

P10L6 ‘deep’ --- ‘thick or heavy’

RE：It was revised to thick.

P10L18 ‘Snow depth in a PM grid is reflected in the dense sample and snow cover fraction across the QTP.’ What is your meaning?

RE：This sentence was revised to “Evaluation of PM snow depth over QTP requires dense sampling in a whole pixel.”

4. Sources of error

4.1 Cold desert

How do you know where is the cold desert？what is your base?

RE：The cold desert can be identified by polarization difference. When the polarization difference is more than 18K, it can be regarded as cold desert, based on Grody and Basist (1996).

“Based on the classification criterion of Grody and Basist (1996), cold desert presented large polarization. There are large areas of cold desert on the middle and Northwest part of QTP, which also showed scattering” was added to the start of section 4.1.

“Take the Tuotuohe station (Id:56004) for example; this station is located in a desert area, during the winter, sand scatters the microwave signal and presents weak scattering features.” was revised to “Take the Tuotuohe station (Id:56004, Latitude: 34.22N, Longitude: 92.43E,

Fig. 1) which located on these areas (Fig. 1), for example; during the winter, ground scatters the microwave signal and presents weak scattering features."

P11L1 'Take the Tuotuohe station for example'---'Take the Tuotuohe station as a example'. What are the locations of Nyalam station (Id: 55655) in Section 3.2.1, Batang station (Id: 56247) in section 4.2, Tuotuohe station (Id:56004) in section 4.1, please label them on the fig. 1.

RE：Thanks for your remind. We added the longitude and latitude of these two stations, and presented the location in figure 1.

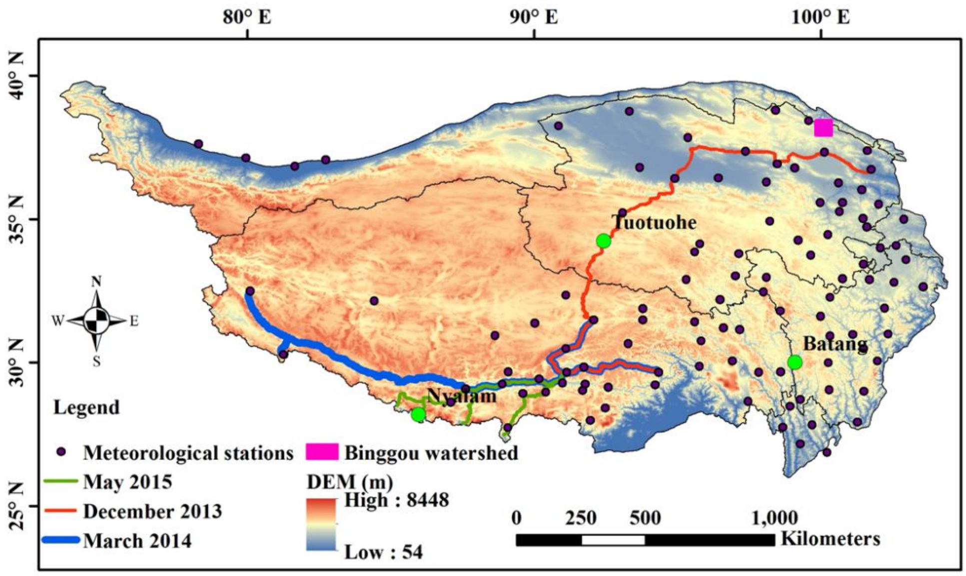


Fig. 8a. You mentioned the 'significant', you have to do the F test, and also add the test value to fig. 8a.

RE：Thanks for your suggestion. The R^2 showed there was a strong relationship between TB36V and TBD. According to your suggestion, we also did F test, and found their relationship presented significant correlation at the confidence level of 0.95.

In the first paragraph of section 4.2, "TB36V is sensitive to topsoil temperature (Holmes et al., 2009; Zeng et al., 2015). Statistical analysis between TBD (K) and TB36V at 109 stations showed that TBD has a significant negative correlation with TB36V (Fig. 8 a)" was revised to "TB36V is sensitive to topsoil temperature (Holmes et al., 2009; Zeng et al., 2015). Statistical analysis between TBD (K) and TB36V at 109 stations showed that TBD has a significant negative correlation with TB36V (Fig. 8 a) at the confidence level of 0.95"

P11L14 'Therefore, the ground temperature is the main reason cause the change in TBD'.

RE：“The ground temperature is the main contributor to the increase in TBD.” was revised to “the ground temperature is also a main reason causing large TBD.”

P11L25 ...is key to improving the...---is key to improve the...

RE：It was corrected.

5 Conclusions

You need separate your conclusions into two parts, a discussion section and conclusions section, to put your results in the big picture of literature, how your results differ from, similar as, or extent in certain degree of the current literature. You also need to include a paragraph on the possible explanations to the observed change, difference, or extension.

RE：Thanks for your suggestions. We added section 5 discussions, and made some modification in section 6 conclusion. In the section 1 and section 4, we also made some revisions to make analysis clearer.

1 “5 Discussions

Although satellite-based passive microwave brightness temperature data have been used to monitor global and regional snow depth since the 1980s, there were still some uncertainties on the snow depth retrieval algorithm in the QTP. Based on existing research on the evaluation of PM products, forest and grain size were the main causes resulting in the low accuracy of PM algorithm. In the forest regions, snow depth was usually underestimated by PM, and many methods had been developed to overcome it (Forest et al., 1997; Vander et al., 2015; Pullianen et al., 1999; Che et al., 2016). In the QTP, forest mainly distribute in the south region with rare snow, therefore, it cannot influence the estimation of snow depth.

Large grain size of snow can scatter much more irradiance than small one; therefore, fresh snow cover with small grain size tends to be underestimated, while snow cover with large grain size (e.g. depth hoar) tends to be overestimated due to its strong scattering. In order to solve this problem, the grain size growth model was developed by Kelly et al. (2003), and the a priori snow characteristics was used in the snow depth retrieval in northwest and northeast of China (Dai et al., 2012; Che et al, 2016). The Globsnow snow product used the assimilation method to optimize grain size, voiding the measurement of grain size (Pullianen, 2006). For the QTP, most areas were characterized by shallow snow or instant snow. Fresh snow melted out in few days resulting in weak scattering which is difficult to be detected by PM, therefore, snow cover was underestimated in these areas. However, due to the complex topography, snow accumulated in cold and shady areas can survive for a long time and its grain size increased with the metamorphism and form the depth hoar, resulting in strong scattering and then causing the overestimation. Therefore, because of the lack of efficient grain size data in the QTP, the accuracy of estimated snow depth was certainly influenced.

However, in this study, we found that except for the problem of forest and grain size, there were other some special problems for QTP which were the large areas of cold desert and frozen soil, and the patchy snow cover. In the section 4, we analysed the overestimation in the cold desert and frozen soil areas. There were some studies presenting the scattering features of cold desert and frozen soil, they were all of weak scatters, and the TBD at vertical polarization caused by desert and frozen soil were less than 10 K and 2 K, respectively (Grody and Basist, 1996). The criterion has been used to remove the other scatters in the global algorithm, and it works in most regions. But in the QTP there are still large areas presenting overestimation after using this criterion (Fig. 4) .

Some research reported that the overestimation came from the atmosphere (Savoie et al., 2009), but based on the analysis in this study, the atmosphere correction decreased the commission errors and improved the general accuracy, but sacrificed the omission errors. This study also showed that the TBD was mainly controlled by soil temperature. It has a strong negative correlation with brightness temperature at 36 GHz for vertical polarization which is the most sensitive to ground surface temperature. Brightness temperature at 36 GHz is much more sensitive to the land surface temperature than 18 GHz. With the surface temperature declines, the brightness temperature at 36 GHz decreases quickly. But the brightness temperature at 18 GHz keep stable, because it is influence by temperature at deeper layer of soil. Therefore, brightness temperature at 36GHz is lower than that of 18GHz, and the difference between them increases with the decrease of temperature of surface soil. Moreover, because of the freeze/thaw cycle of surface soil, the frozen soil becomes incompact and dry. The fine-scale soil and sand particles are scatters which also weaken the brightness temperature at 36GHz (England, 1976). In the northwest of the QTP, the surface temperature is very low and the polarization difference larger than 30 K which is the characteristics of desert. Therefore, we inferred that the combined action of frozen soil and desert resulted in large TBD, and then caused the serious overestimation,

Furthermore, patchy distribution of snow cover in the QTP was another cause for uncertainty of PM with coarse resolution. For the high latitude regions, snow is of large-area phenomenon, PM works well to detect snow cover except the mountainous areas with complex topography. But for the QTP which is characterized by low latitude and high altitude, not only in the mountainous areas snow cover distributes in inhomogeneity, but also on the plain areas. The patchy distribution does not only bring problem to the derivation of snow depth from PM, but also to the evaluation of the snow depth in a PM pixel. In this study, we used the MODIS snow cover to evaluate the accuracy of snow cover, and used station point data, sampling in lines and intense sampling data to assess the accuracy of snow depth. And we found that it is not so reasonable to use station observations to evaluate the accuracy of PM snow depth because of weak representation of many stations, and the general accuracy cannot depict the accuracy of PM snow depth in the QTP, neither can the simple overestimation. Therefore, it is necessary to develop a retrieval algorithm for improving the spatial resolution of snow depth."

was added before conclusions.

2

In section 6:

"Although satellite-based passive microwave brightness temperature data have been used to monitor global and local snow depth since the 1980s, the accuracy of snow cover and snow depth across the QTP derived from passive microwave remote sensing was still largely unknown. There are no prior studies that provided a detailed evaluation on the products of PM across the QTP, resulting in difficulties for users in selecting appropriate products. In this study, snow cover fractions derived from MODIS, meteorological station snow depth, in situ snow depth, and airborne snow depth were combined to evaluate the ability of AMSR-E to identify snow cover and snow depth and to analyse the sources of error. "

was revised to

"This study presented the accuracy of snow depth product derived from AMSR-E by comparing with MODIS snow cover fraction and in situ data, and analyzed the potential causes resulting the uncertainties of the product."

3: "However, there are uncertainties with these snow depth products. The NASA snow water equivalent product derived from Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E) generally tends to underestimate snow depth in North America (Tedesco and Narvekar, 2010), but overestimate in China (Dai et al., 2012; Che et al., 2016). Over the QTP, the snow cover was also overestimated by the existing snow products (Frei et al., 2012; Armstrong and Brodzik, 2002). Liquid water within snowpack masks volume scatter, and large grain sizes may contribute more to spectral gradient than snow depth. It is difficult to accurately correct for these snow characteristics at large scale to improve the modelling accuracy of brightness temperature. Some research uses a priori snow characteristics, assimilates snow depth observed at stations, or builds a local empirical relationship between snow depth observations and spectral gradients to improve the snow depth retrieval accuracy in some regions (Dai et al., 2012; Che et al., 2016, 2008; Pullianen, 2006). However, uncertainties still exist for the QTP, which is caused by the coarse spatial resolution of passive microwave remote sensing and the patchy distribution of snow cover. Across the QTP, meteorological stations are rare and mainly distributed in the valley with low elevation. Snow depth observed at these stations does not represent the snow status of the grid they are located on, and so it is unclear if data assimilation and an empirical equation will work to improve snow depth accuracy. It has also been reported that snow cover across the QTP is overestimated by PM algorithms compared to IMS snow cover products, caused by a thinner atmosphere (Savoie et al., 2009). At present, there is no definitive evaluation of the source of uncertainties or of the accuracy of snow depth products across the QTP, although there has been some comparison to meteorological station observation data (Yang et al., 2015)."

was revised to

P3L10-P4L10"However, there are uncertainties with these snow depth products, and some assessments had been performed on them. The NASA snow water equivalent product derived from Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E) generally tends to underestimate snow depth in North America (Tedesco and Narvekar, 2010) when compared with World Meteorological Organization (WMO) and Snow Data Assimilation System (SNODAS), but overestimate in Northwest and Northeast of China (Dai et al., 2012; Che et al., 2016) when compared with Meteorological station and field work observations. These authors pointed out that the errors primarily came from the grain size spatio-temporal variability and forest cover. It was because of grain size that mass investigation of snow characteristics were performed to obtain the a priori information of snow characteristics in Northwest and northeast China to improve the simulation of brightness temperature and retrieval accuracy of snow depth. And some research assimilated snow depth observed at stations, or built a local empirical relationship between snow depth observations and spectral gradients to improve the snow depth retrieval accuracy in some regions (Dai et al., 2012; Che et al., 2016, 2008; Pullianen, 2006). In order to reduce the influence of forest, forest transimissivites at different frequencies were absorbed in the algorithm, or the special equations were built between snow depth and TBD at different types of forest, to estimate snow depth more accurately at forest areas (Che et al., 2016, Pullianen, 2006). However, uncertainties still exist for the snow depth over QTP except grain size and forest, which is caused by the patchy distribution of snow cover. Based on existing research, the snow cover over the QTP was also overestimated compared with the optical snow extent products (Frei et al., 2012; Armstrong and Brodzik, 2002). Across the QTP, meteorological stations are rare and primarily distributed in the valley with low elevation. Snow depth observed at these stations does not represent the snow status of the grid they are located on, and so it is unclear if data assimilation and an empirical equation will work to improve snow depth accuracy. It has also been reported that snow cover across the QTP is overestimated by PM algorithms compared to IMS snow cover products, which was caused by the large elevation with a thinner atmosphere (Savoie et al., 2009). Compared with meteorological station observation, AMSR-E SWE also presented overestimation (Yang et al., 2015). But, Smith and Bookhagen (2016) thought Tibet lacks an extensive and reliable ground-weather station network, therefore, they did not rely on in-situ data, but focused on the factors reducing the reliability of SWE estimates from satellite-based PM data by comparing different satellite sensors. They found that satellite look angle and elevation showed very low influence on SWE variability. Thus, it seemed that general overestimation was undoubted for the QTP, but at present, there is no definitive answer to what are the causes and where do the overestimates occur over the QTP.”

4:” Therefore, snow depth derived from AMSR-E showed low consistency with that from stations over QTP. Because of the complex terrain, meteorological stations, mainly distributed in the valley with small snow and no continuing accumulation period, and have no obvious tendency of increase or decrease, may not present the snow status of a PM pixel. The “Former Soviet Union Hydrological Surveys” (FSUHS) presented highest station density (approximately one transect per 100 km gridcell) and is primarily composed of non-complex terrain with maximum elevation differences of <500m. When compared with these station observations, PM presented high correlation with in situ data, although underestimated the snow depth in the Former Soviet Union (Armstrong and Brodzik, 2002). Therefore, it is the complex terrain and special distribution of snow cover that make the meteorological station observation lack of their meaning on evaluation of snow depth.” Was added to the end of section 3.2.1.

5：” According to the comparison in section 4, PM remote sensing overestimated the snow cover extent in some areas and omitted snow cover in the shallow snow areas. Here, we discuss potential reasons for the misclassification” was revised to

“Although both existing research and this study reported the overestimation phenomenon over the QTP, the causes were still in suspense. Besides, this study found there was also serious omission problem in the shallow snow areas, and difference of snow depth between the estimation and in situ data. Therefore, we discuss potential reasons for the misclassification and bias in this section.”

6:” Furthermore, frozen soil is also a scatter; the TBD is influenced by frozen soil, and increases with the increase of ice content. Based on experiments, the TBD of frozen soil with high ice content could reach up to over 10 K (Jin et al., 2017)” were added in the section 4.2.

7: The added the references

“Derksen, C., Walker, A. and Goodison, B.: Evaluation of passive microwave snow water

equivalent retrievals across the boreal forest/tundra transition of western Canada. Remote Sens Environ, 96(3-4): 315-327, 2005.

Smith, T. and Bookhagen, B.: Assessing uncertainty and sensor biases in passive microwave data across High Mountain Asia. Remote Sensing of Environment, 181: 174-185, 2016.

Armstrong, R.L., Brodzik, M.J.: Hemispheric-scale comparison and evaluation of passive-microwave snow algorithms. Ann Glaciol., 34: 38-44, 2002.

Vander Jagt, B.J., Durand, M.T., Margulis, S.A., Kim, E.J., Molotch, N.P.: On the characterization of vegetation transmissivity using LAI for application in passive microwave remote sensing of snowpack. Remote Sens Environ, 156: 310-321, 2015.

Pulliainen, J.T., Grandell, J., Hallikainen, M.T.: HUT snow emission model and its applicability to snow water equivalent retrieval. Ieee T Geosci Remote, 37(3): 1378-1390, 1999.

Langlois, A., A. Royer, F. Dupont, A. Roy, Goita K. and Picard G.: Improved Corrections of Forest Effects on Passive Microwave Satellite Remote Sensing of Snow Over Boreal and Subarctic Regions. Ieee T Geosci Remote, 49(10): 3824-3837, 2011.

Foster, J. L., Chang A. T. C. and Hall D. K.: Comparison of snow mass estimates from prototype passive microwave snow algorithm, a revised algorithm and a snow depth climatology. Remote Sens Environ, 62(2): 132-142, 1997.

Goita, K., Walker A. E. and Goodison B. E.: Algorithm development for the estimation of snow water equivalent in the boreal forest using passive microwave data. Int J Remote Sens,, 24(5): 1097-1102, 2003.

England, A.W.: Relative influence upon microwave emissivity of fine-scale stratigraphy, internal scattering, and dielectric properties. Pure Appl Geophys, 114(2): 287-299, 1976”

were also added to the end of references.

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