Dear reviewer and editor,

Thanks for your comments and very useful recommendations to improve our manuscript. We have carefully revised them based on your suggestions and made responses one by one.

Snow cover is one of most important factors affected the land-atmosphere interaction and water budget on the Qinghai-Tibetan Plateau. And snow depth estimated from passive microwave remote sensing has been reported with uncertainties and the source of them has been discussed for many years. This paper utilized multi-source data including MODIS snow cover data, station measurements and snow course data, to evaluate the snow depth derived from AMSR-E and AMSR2 based on a spectral gradient algorithm. Many factors have impacts on the discrimination of snow from snow-free ground, and the linear relationship between the brightness temperature difference and snow depth. This is an interesting work. The impacts factors affected snow depth retrieval algorithm have been discussed thoroughly in this work. But the authors still need to consider the following questions. General comments/suggestions:

1. The threshold of MODIS snow fraction >10% is too small to definite snow covered surface. I suggest snow fraction should use a larger value. Since passive microwave remote sensing cannot detect snow when the grid is covered with 10% snow fraction.

Re: Thanks for your suggestion. We calculated the overestimation, underestimation, commission and omission when the MODIS fractional snow cover more than 30% and 50% was defined to be snow cover, and the descriptions were also added in the section 3.1.

" If pixels with SCF >0.3 is assumed to be snow pixel, the overestimation, underestimation, commission and omission errors are 72.2%, 0.9%, 17.5% and 9.9%, respectively. If SCF > 0.5 is the threshold between snow and no snow, they are 83.2%, 0.4 %, 19.5% and 7.2%, respectively. The overestimation and commission errors increase with the increase of the threshold, and the underestimation and omission errors decrease. " was added in the section 3.1 P8 L5-9.

And we explained the Fig.3 which contained the information of different SCF thresholds:

"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 (Fig.3 a), between 15 and 20 K (Fig.3 b), between 10 and 15 K (Fig. 3 c), between 5 and 10 K (Fig.3 d), and less than 5 K (Fig. 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."P8 L9-16

2. My another question is on the explanation of soil temperature effect on snow depth algorithm. The authors should justify the explanation on this. The reason might be difficultly discriminate dry snow from frozen soil. The soil temperature could be contributed to discriminate dry snow from frozen soil. There are similar scattering existing between dry snow and frozen soil. While the soil temperature is different between them as the authors stated in this work. The soil temperature might be higher when the surface is covered with snow.

Re: Thanks for your remind. We added the explanation in the section 5 Discussions:

"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 keeps 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." Was added in the section 5.

3. Section 2.1, "The relationship equation is SCF = 0.06 + 1.21 * NDSI". This equation is confusing given that for MOD10A1 in C5 and C6 and MYD10A1 in C6, SCF =-0.01 + (1.45 * NDSI6) and for MYD10A1 in C5, SCF =-0.64 + (1.91 * NDSI7). Please check it again and reference it to published papers. In which collection the NASA MODIS standard snow cover products were collected should be clearly stated as well because of some differences among different collections.

References: V. V. Salomonson and I. Appel, "Development of the Aqua MODIS NDSI fractional snow cover algorithm and validation results," in IEEE Transactions on Geoscience and Remote Sensing, vol. 44, no. 7, pp. 1747-1756, July 2006.

G. A. Riggs and D. K. Hall, "MODIS Snow Products Collection 6 User Guide," 2015.

Re: Thanks for your correction. We used the collection 5 data, and modified the description based on Salomonson and Appel (2006).

"The relationship equation is SCF = 0.06 + 1.21 * NDSI7, and it was developed over three different snow covered regions" was revised to

"The relationship equation is SCF = a+ b* NDSI, and the coefficients "a" and "b" and NDSI vary with sensors. Coefficients "a" and "b" are -0.01 and 1.45 for MODA1, and -0.64 and 1.91 for MYDA1, respectively. NDSI is the function of band 4 and band 6 for Terra (MODA1), and of band 4 and band 7 for Aqua (MYDA1) (Salomonson and Appel, 2006)."

4. Details of the snow identification algorithm is suggested to be more specific, such as the criteria of dry snow determination, how the "offset" value was determined in the equation "snow depth (cm) = 0.7*(TB18H-TB36H-5)+offset". The thresholding snow identification algorithm used in this paper was referenced to Che et al.(2008), in which threshold values were separately determined using SMMR and SMM/I data. In addition, AMSR-E and AMSR2 employed a same suite of thresholds in this paper. Given different design characteristics and other factors causing bias among sensors, it should be explained why this threshold-based method was applied consistently across sensors before inter-calibration.

Re: Thanks for your suggestion.

1 "In order to avoid the influence of liquid water, the descending orbit data was used and when the brightness temperature at 36GHz for vertical polarization was more than 265 K, the snowpack was set as wet" was added in section 2 P5l23-24.

2 "where, offset was monthly data which was used to decrease the influence of snow characteristics growth. They are -4.18, -3.58, -0.29, 2.15, 3.31 and 3.8 for Oct, Nov, Dec, Jan, Feb, Mar and Apr, respectively" was added after these criterion.

3 "These criterions were developed based on SSM/I (Grody and Basist, 1996). Based on the inter-sensor comparison between SSM/I and AMSR-E in Dai and Che (2010), and between AMSR-E and AMSR2 in Du et al., (2014), the brightness temperature from these sensors are close to each other. Therefore, in this study, these criterions were also applied for AMSR-E and AMSR2" was added in the end of section 2.2.

We also added corresponding references

Du, J., Kimball, J., Shi, J., Jones, L., Wu, S., Sun, R., and Yang, H.: Inter-Calibration of Satellite Passive Microwave Land Observations from AMSR-E and AMSR2 Using Overlapping FY3B-MWRI Sensor Measurements. Remote Sens., 6(9): 8594-8616, 2014.

Dai, L.Y., Che, T. : Cross-platform calibration of SMMR, SSM/I and AMSR-E passive microwave brightness temperature. P Soc Photo-Opt Ins, 7841, 2010.

5. As far as I know, both commission error and overestimation error in snow mapping are related with false snow detection on snow-free ground. Equations are needed to clarify how commission, omission, overestimation and underestimation errors were calculated in this paper.

Re: Thanks for your suggestion.

Given the bellowing table,

	Estimated snow	Estimated no snow
Observed snow	a	b
Observed no snow	c	d

the general accuracy, overestimation error, underestimation error, commission error and omission error are calculated based on the following equations:

General accuracy=(a+d)/(a+b+c+d)

Overestimation error=c/(a+c)

Underestimation error=b/(b+d)

Commission error= d/(c+d)

Omission error=b/(a+b)

We added a confusion matrix in the table 1 and table 2.

Table 1 Errors in derived snow cover from AMSR-E based on MODIS snow cover fraction and meteorological stations (a), and corresponding confusion matrix (b).

(a)

	Overall accuracy	Commission	Omission	Overestimation	Underestimation
MODIS snow cover fraction	66.7 %	27.6 %	47.4 %	56.1 %	21.1 %
Meteorological stations	82.7 %	16.0 %	41.6 %	84.3 %	2.5 %

(b)

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 Errors in snow cover derived from AMSR-E data and atmosphere corrected AMSR-E data over the QTP, based on MODIS snow cover fraction (a), and corresponding confusion matrix (b)

(a)

	Overall accuracy	Commission	Omission	Overestimation	Underestimation
Original	66.7 %	27.6 %	47.4 %	56.1 %	21.1 %
After atmosphere correction	72.2 %	14.2 %	60.8 %	46.8 %	22.6 %

(b)

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

6. Was wet snow excluded from ground observations before the evaluation of AMSR-E/AMSR2 snow depth? The capability of detecting snow depth from passive microwave data is limited by liquidwater content in snow cover. Also, it is better to discuss the effect of forest cover on evaluation of snow depth retrieval algorithm.

Re: During the observation of March 2014, the wetness of snowpack was observed only on March 23 and 24 using snowfolk. On March 23, the wetness of the observation pits was 1-2%. On March 24, it was 0.1-0.5%. In this study, the brightness temperature of cold overpass time was used to derive snow depth. Therefore, we regarded them as dry snow. On March 23, the snow could not be identified by PMW due to the fresh snow.

Forest is a general problem for PMW to derive snow depth. In the QTP, forest mainly distributes in the southeast areas. Based on your suggestion, we compared the forest cover fraction and the distribution of errors, and found that the omission errors distributed in the southeast areas (Fig. 4b) which is also the main forest areas. Therefore, in the section 5 Discussion, we added the description:

"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 southeast region with rare snow, therefore, it is not the dominant factor in the QTP. However, in the Fig 4 b, the northeast region with omission errors was the main forest areas. In this area, snowfall is a rare event, and volume scattering signal is weak, plus the forest cover, it is difficult for PMW to detect snow."

Minor comments/suggestions:

1. I suggested that it would be better that "Passive microwave (PM)" used in this manuscript replaced with "PMW". Since "PM" also is the abbreviation of Post Meridiem, meaning after midday.

Re: Thanks, it was revised through the paper including Fig. 2.

2. Page5 Line 25, there is a typoappeared on "Cold desert: TB19V-TB18V >=18 (K) . . .".

Re: Thanks, it was corrected.

3. In Fig. 1., please check if several selected meteorological stations on top left are out of the range of the Tibetan Plateau.

Re: Thanks, it was corrected. We removed the two stations on the top left.

4. As for the title of Fig. 4 and Fig. 8, there are some sub-figures in the sequence of alphabets. But these alphabets are supposed to be ahead of sub-titles.

Re: Thanks, it was modified.

5. In Fig. 7, the value of X-axis is missed.

Re: Thanks, we added the x axis lable.

6. In Fig. 8, it's better use the density plot i.e. scatter points in different color varying with point

density, to see whether most points are gathering around the 1:1 line.

Re: Fig. 8 is used to present the relationship between TB36v and TBD (K). The x-axis is TB36v (K), and y-axis is TBD (K), so there is no 1:1 line. From this figure, we can see that there is obvious negative relationship between TBD(K) and TB36v (K). In order to clarify its significance, we did an F test, and found the relationship is significant at the confidence level of 0.95.

7. In Fig. 9.,the geo-location of Binggou watershed would be more understandable with frame ticks and latitude/longitude labels.

Re: Thanks, we added the longitude and latitude.