Response to Reviewer #1

Comments to the Author:

This paper generated long-term daily gap-free snow cover products in the Tibetan Plateau over the past two decades by optimally integrating spectral, spatiotemporal, and environmental information within a Hidden Markov Radom Field model. From the report of this paper, the accuracy of the new snow cover products was greatly improved during the snow transitional period and over complex terrains as well as sunny slopes. As a spatiotemporally continuous and high-quality snow cover product is essential for cryospheric science, the produced long time-series daily snow cover product could be a significant dataset for understanding climate change and the water cycle over the Tibetan Plateau. The paper is scientifically sounding. Despite its significance, several issues still need to be resolved before a publication to ESSD. The introduction about the GPU-accelerated model, and why you chose this sample area to illustrate the snow cover percentage obtained from your daily snow cover products and MODIS 8-day composite products could be sufficiently explained. Besides, the total accuracy, omission error, and commission error of your new snow cover products should be compared and discussed with the accuracy reported by other studies. In addition, some figures need to be revised.

Response: We truly appreciate the constructive suggestions and comments. We have revised our manuscript to our best effort. In this revision, we have refitted the empirical relationship between snow fraction and NDSI, and reprocessed the input data for HMRF modeling. We have regenerated a more rigorous daily gap-free snow cover dataset. In addition, we have added longer time series and terrain-corrected Landsat images for validation, including Landsat-5 TM, Landsat-7 ETM+, and Landsat-8 OLI images. The new accuracy assessment demonstrates the effect and potential applications of our new daily snow cover dataset.

Comment 1:

L40, which rivers are there, please given specific examples.

Response: We have modified the sentence to "…the runoff of numerous rivers such as the Yangtze and Yellow rivers (Immerzeel et al., 2010)" (now in Line 40-41).

Comment 2:

L75, the abbreviation of HMRF is already defined on L66 and does not need to be defined again.

Response: We have removed the redundant definition (now in Line 76).

Comment 3:

L91, the numbers here appear to be inserted as formulas.

Response: We have modified the number format (now in Line 92).

Comment 4:

L91-95, the importance of the Tibetan Plateau as a water tower in Asia and the importance of snow in it should be highlighted.

Response: As suggested, we have added the following sentences in Line 95-99:

Seasonal snow cover on the TP has a great potential to influence the hydrological cycle and heat wave frequency in northern China (Wu et al., 2012). In addition, seasonal snow accumulation on the TP is an important part of surface water accumulation in southwestern China and surrounding countries. Several major rivers in China and surrounding Asian countries, such as the Yangtze, Yellow, Mekong, Salween, Brahmaputra, Ganges, and Indus Rivers, all originate from the TP.

Reference:

Wu, Z., Jiang, Z., Li, J., Zhong, S. and Wang, L.: Possible association of the western Tibetan plateau snow cover with the decadal to interdecadal variations of northern China heatwave frequency, Climate Dynamics, 39(9–10),2393–2402, 2012.

Comment 5:

Figure 1, change the frame color of the sample area, as its color is very close to the color of the stations.

Response: As suggested, we have modified our figure 1 as following:

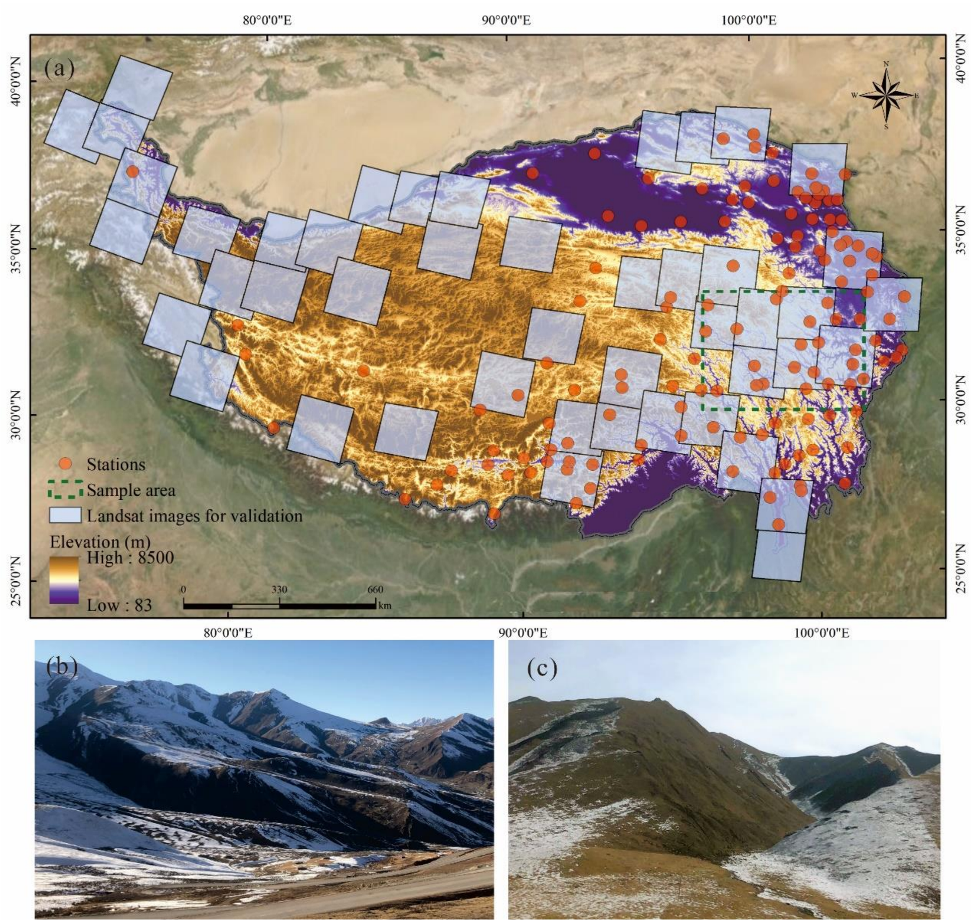


Figure 1: Topography, meteorological stations, and survey photos of the TP. (a) Surface elevation and distribution of meteorological stations in the TP. Landsat series data utilized for

validation and sample area are also shown. (b) and (c) in situ photos from field survey in the TP.

Comment 6:

In Figure 3, some text overlaps with the frame, please check and revise.

Response: As suggested, we have corrected the text in Figure 3.

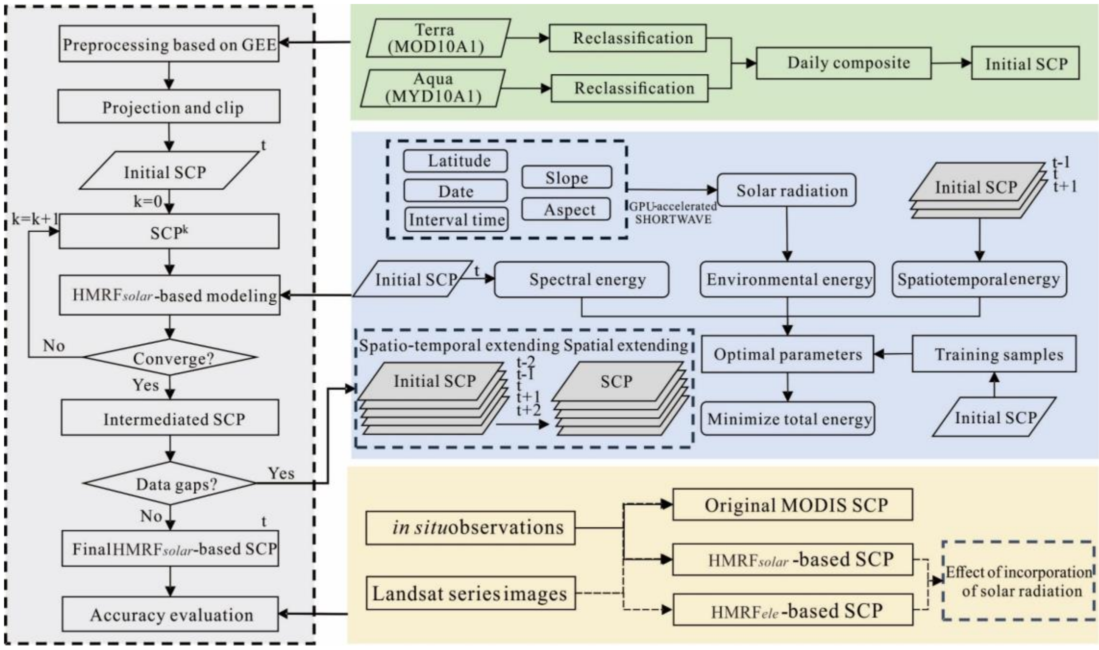


Figure 3: Overall flowchart of the HMRF_{solar}-based framework. (SCP stands for snow cover products)

Comment 7:

L192, change "snow product is" to "snow products are".

Response: we have changed the text as suggested.

Comment 8:

Line 222, the authors stated that they used a GPU-accelerated model. It is suggested to provide more detailed information about the GPU configuration.

Response: We have provided more detailed information about the GPU configuration in Line 237-239:

A general-purpose desktop computer was used to test the parallel computational efficiency. The computer has an Intel Core™ i7-10700 CPU (16 cores and max clock rate is at 2.90 GHz), an NVIDIA GeForce RTX 2070 SUPER Card with 2560 cores and 16240 MB global memory, and Windows 11 Ultimate 64-bit Operation System.

Comment 9:

L255-290, can the authors compare the overall accuracy, omission error, and commission error of new snow cover products with the accuracy reported by other studies?

Response: In this revision, we have compared the overall accuracy, omission error, and commission error of new snow cover products with the accuracy reported by previous studies on Line 414-417:

Compared with in situ observations, the overall accuracy of snow cover products on the TP reported by other studies is in the range of 90.74%-96.6%, and the omission error is greater than the commission error (Yu et al., 2016; Qiu et al., 2017; Xu et al., 2017; Zheng and Cao, 2019). The overall accuracy of our new snow products is 98.29% in comparison with in situ observations, and the new product has a considerable improvement in omission error.

References:

Qiu, Y., Zhang, H., Chu, d., and Xuecheng, Z.: Cloud removing algorithm for the daily cloud free MODIS-based snow cover product over the Tibetan Plateau, Journal of Glaciology and Geocryology, 39(3), 515-526, doi: 10.7522/j.issn.1000-0240.2017.0058, 2017.

Xu, W. F., Ma, H. Q., Wu, D. H., and Yuan, W. P.: Assessment of the daily cloud-free MODIS snow-cover product for monitoring the snow-cover phenology over the Qinghai-Tibetan Plateau, Remote Sensing, 9, ARTN 585， doi: 10.3390/rs9060585, 2017.

Yu, J., Zhang, G., Yao, T., Xie, H., Zhang, H., Ke, C., and Yao, R.: Developing daily cloud-free snow composite products from MODIS Terra–Aqua and IMS for the Tibetan Plateau, IEEE Transactions on Geoscience and Remote Sensing, 54, 2171-2180, doi: 10.1109/tgrs.2015.2496950, 2016.

Zheng, Z. and Cao, G.: Snow cover dataset based on multi-source remote sensing products blended with 1km spatial resolution on the Qinghai-Tibet Plateau (1995-2018), National Tibetan Plateau Data Center, doi: 10.11888/Snow.tpdc.270102, 2019.

Comment 10:

L291, please add the definition of "snow season".

Response: The definition of "snow season" has been added in Line 317-318:

To explore the details of snow cover variation, we define the snow season from September of previous year to August of the following year, for example, the time range of the 2002 snow season is 2002.9.1-2003.8.31 (Chen et al., 2018b).

Reference:

Chen, X., Long, D., Hong, Y., Hao, X., and Hou, A.: Climatology of snow phenology over the Tibetan plateau for the period 2001-2014 using multisource data, International Journal of Climatology, 38, 2718-2729, doi: 10.1002/joc.5455, 2018b.

Comment 11:

L295-296, it is suggested to use the threshold of 90% of overall accuracy to summarize the status of monthly accuracy.

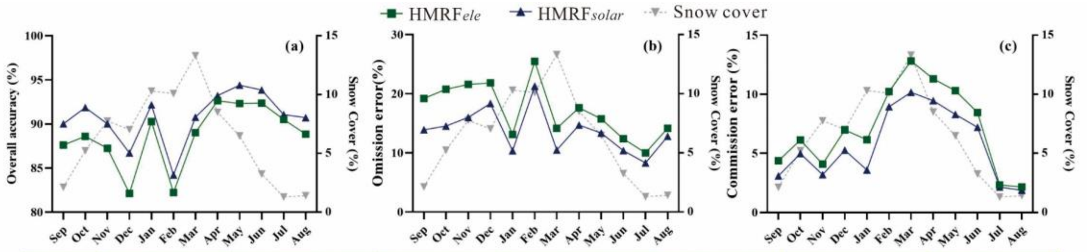
Response: In this revision, we have used the threshold of 90% of overall accuracy to summarize the monthly accuracy in Line 321-324:

Except November, December, and February, the OAs of the new snow products were more than 90% in all months. The accuracy was relatively low during snow *transitional period (November, December, and February to April), whereas the accuracy was higher in snow stable period.*

Comment 12:

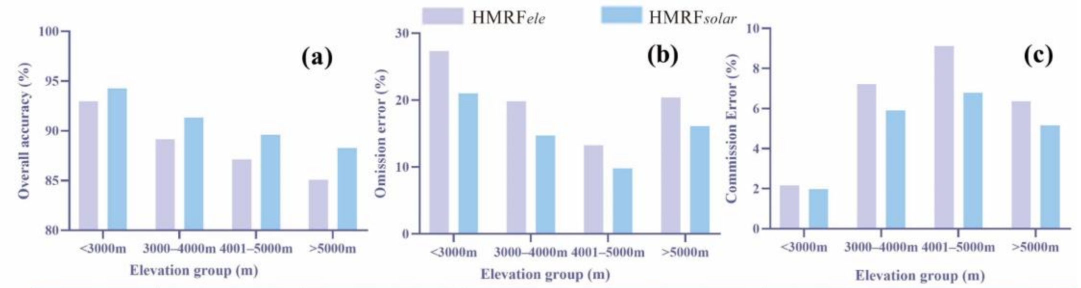
In figure 4, figure 5, figure 6, and figure 7, you should provide the improvements of OA, OE, and CE of your new snow products.

Response: We have added the improvements of OA, OE, and CE of the new snow products in figure 4, figure 5, figure 6, and figure 7.



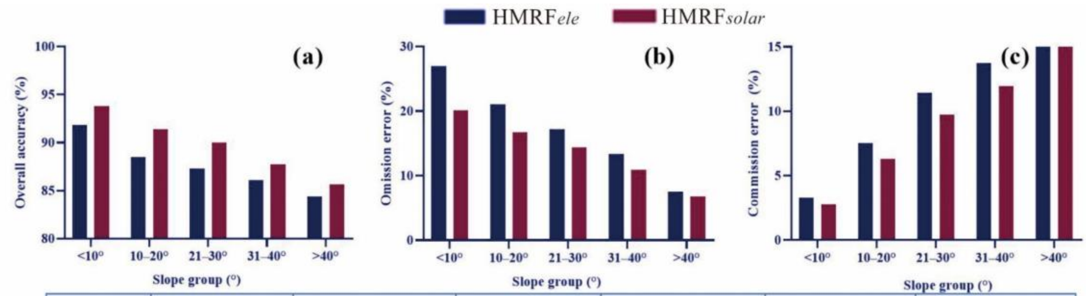
Month	OA-HMRF*ele*	OA-HMRF*solar*	OE-HMRF*ele*	OE-HMRF*solar*	CE-HMRF*ele*	CE-HMRF*solar*	Snow cover
Sep	87.62%	90.02% (+2.40%)	19.21%	13.92% (-5.29%)	4.37%	3.09% (-1.28%)	5.23%
Oct	88.61%	91.87% (+3.26%)	20.76%	14.53% (-6.23%)	6.13%	4.98% (-1.15%)	7.75%
Nov	87.26%	90.03% (+1.91%)	21.59%	16.01% (-5.58%)	4.09%	3.19% (-0.90%)	7.03%
Dec	82.14%	86.72% (+4.58%)	21.84%	18.37% (-3.47%)	6.98%	5.27% (-1.71%)	10.30%
Jan	90.29%	92.17% (+1.88%)	13.11%	10.36% (-2.75%)	6.15%	3.59% (-2.56%)	10.10%
Feb	82.24%	84.22% (+1.98%)	25.49%	21.29% (-4.20%)	10.23%	8.94% (-1.29%)	13.32%
Mar	89.03%	90.78% (+1.75%)	14.17%	10.49% (-3.68%)	12.82%	10.17% (-2.65%)	8.51%
Apr	92.64%	93.22% (+0.70%)	17.64%	14.72% (-2.92%)	11.31%	9.46% (-1.85%)	6.49%
May	92.32%	94.40% (+2.08%)	15.76%	13.36% (-2.40%)	10.31%	8.29% (-2.02%)	3.25%
Jun	92.37%	93.86% (+1.22%)	12.38%	10.39% (-1.99%)	8.46%	7.21% (-1.25%)	1.30%
Jul	90.53%	91.07% (+2.69%)	10.01%	8.31% (-1.70%)	2.33%	2.14% (-0.19%)	1.42%
Aug	88.86%	90.73% (+1.87%)	14.15%	12.82% (-1.33%)	2.16%	1.88% (-0.28%)	2.13%

Figure 4: Temporal variations in OA (a), OE (b), and CE (c) of HMRF_{ele}- and HMRF_{solar}-based snow products from 2002–2021.



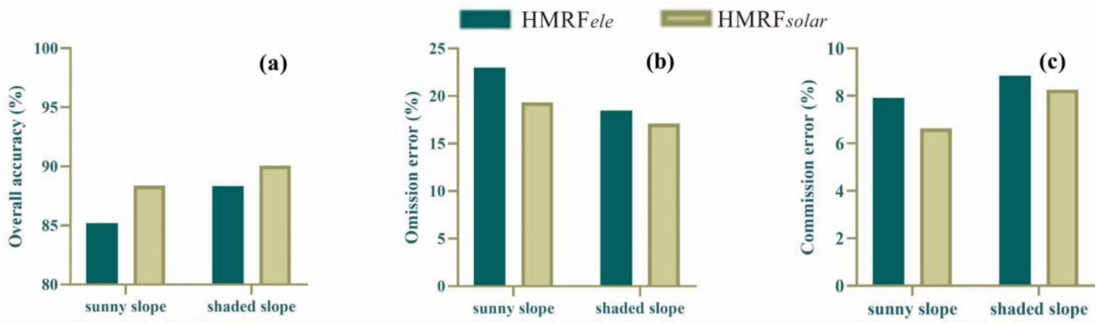
Elevation (m)	OA-HMRF*ele*	OA-HMRF*solar*	OE-HMRF*ele*	OE-HMRF*solar*	CE-HMRF*ele*	CE-HMRF*solar*
<3000m	92.96%	94.26% (+1.30%)	27.31%	20.98% (-6.33%)	2.16%	1.98% (-0.18%)
3000–4000m	89.15%	91.33% (+2.18%)	19.84%	14.69% (-5.15%)	7.23%	5.91% (-1.32%)
4001–5000m	87.12%	89.60% (+2.48%)	13.24%	9.77% (-3.47%)	9.12%	6.79% (-2.33%)
>5000m	85.09%	88.25% (+3.16%)	20.37%	16.12% (-4.25%)	6.36%	5.16% (-1.20%)

Figure 5: Effect of elevation on OA (a), OE (b), and CE (c) of HMRF_{ele}- and HMRF_{solar}-based snow products from 2002–2021.



Slope (°)	OA-HMRF*ele*	OA-HMRF*solar*	OE-HMRF*ele*	OE-HMRF*solar*	CE-HMRF*ele*	CE-HMRF*solar*
<10°	91.84%	93.78% (+1.94%)	26.94%	20.11% (-6.83%)	3.31%	2.75% (-0.56%)
10-20°	88.52%	91.42% (+2.90%)	21.06%	16.74% (-4.32%)	7.54%	6.31% (-1.23%)
21-30°	87.32%	90.03% (+2.71%)	17.23%	14.36% (-2.87%)	11.42%	9.73% (-1.69%)
31-40°	86.07%	87.76% (+1.69%)	13.35%	10.91% (-2.44%)	13.72%	11.97% (-1.75%)
>40°	84.39%	85.62% (+1.23%)	7.54%	6.73% (-0.81%)	17.97%	15.77% (-2.20%)

Figure 6: Effect of slope on OA (a), OE (b), and CE (c) of HMRF_{ele}- and HMRF_{solar}-based snow products from 2002–2021.



Aspect	OA-HMRF*ele*	OA-HMRF*solar*	OE-HMRF*ele*	OE-HMRF*solar*	CE-HMRF*ele*	CE-HMRF*solar*
Sunny slope	85.21%	88.37% (+3.16%)	22.96%	19.33% (-3.63%)	7.91%	6.63% (-1.28%)
Shaded slope	88.32%	90.07% (+1.75%)	18.47%	17.10% (-1.37%)	8.85%	8.26% (-0.59%)

Figure 7: Effect of aspect on OA (a), OE (b), and CE (c) of HMRF_{ele}- and HMRF_{solar}-based snow products from 2002–2021.

Comment 13:

Figure 7, change "91.14a" to "91.14".

Response: "91.14a" has been changed to "91.14" in figure 7.

Comment 14:

L375, explain why you chose this sample area to illustrate the snow cover percentage obtained from your daily snow cover products and MODIS 8-day composite products?

Response: We chose this sample area because it covers more mountainous areas and has seasonal snow for mutiple years, which makes it a perfect site to detect snow accumulation and melting. We have added more detials in Line 421-423.