Dear Reviewers:

We would like to sincerely thank the reviewer for the thoughtful comments and suggestions. All comments and suggestions have been considered carefully and well addressed. For clarity, the referees' comments are listed in black italics, and our responses and changes in the manuscript are shown in blue. We also mention where we made necessary changes in the revised manuscript by indicating page and line numbers in our responses. Please see our responses to your comments and suggestions below.

Response to Reviewer #1

Reliable downwelling shortwave radiation (DSR) estimation over the Tibetan Plateau (TP) is still a challenging scientific issue. This manuscript developed an improved parameterization scheme to obtain all-sky DSR based on satellite data and meteorological forcing data. The topic of the paper is interesting and it's a good fit for the scope of ACP. The whole paper is well organized with clear logic and robust results. The description of the method is clear. Numbers of work are integrated into this paper, and abundant discussions are presented as well. However, there are still some rooms for the improvement.

Author Response: Thank you very much for your positive comments. All comments were helpful for improving our manuscript. We carefully revised the manuscript and made the following point-by-point revisions according to your suggestions.

Major concerns:

1. *The spatial resolution of DSR estimated in this paper is 1 km. The spatial resolution of DSR products for comparison is coarser than 10 km. While the scale of the stations normally represents a scale of about less than 1 km. The authors should give some explanation about their scale mismatch problem.*

Author Response: Thank you for your suggestion. The scale mismatch problem is an important and difficult problem to solve in the quantitative remote sensing and atmospheric research fields. Some uncertainties can be induced due to the representativeness errors of point-scale measurements. The insufficient spatial representation of point-scale observations can be partly compensated by lowering their temporal resolution (Hakuba et al., 2013; Huang et al., 2016a; Huang et al.,

2016b). Therefore, the DSR estimation results were also validated at ten-day and monthly timescales to minimize this effect. Relevant statements have been described in Section 4.1 (P12, L262-L266) and Section 4.2 (P15, L332-L335).

'Representativeness errors of point-scale measurements can affect the validation results of instantaneous DSR estimations to some extent. The insufficient spatial representation of point-scale observations can be partly compensated by lowering their temporal resolution (Hakuba et al., 2013; Huang et al., 2016b). Therefore, the DSR estimation results were also validated at ten-day and monthly timescales.' (P12, L262-L266)

'In addition, it is noted that the accuracies of all datasets have been appreciably improved with increasing timescale. This is because the 3D radiative transfer effects and complexity of clouds can be significantly reduced and the spatial representativeness of ground-based measurements can be significantly enhanced through temporal averaging (Huang et al., 2016b; Huang et al., 2016a).' (P15, L332-L335)

If we have enough in situ data within a grid scale of 10 km or 25 km, an average or weighted average of the observations can be directly used to reduce some errors caused by scale mismatch. However, for well-known reasons, it is very difficult to carry out such measurements over the TP with its harsh environment and climate conditions.

The references are as follows:

Hakuba, M. Z., Folini, D., Sanchez-Lorenzo, A., and Wild, M.: Spatial representativeness of ground-based solar radiation measurements, Journal of Geophysical Research: Atmospheres, 118, 8585-8597, 10.1002/jgrd.50673, 2013.

Huang, G., Li, X., Ma, M., Li, H., and Huang, C.: High resolution surface radiation products for studies of regional energy, hydrologic and ecological processes over Heihe river basin, northwest China, Agric. For. Meteorol, 230-231, 67-78, 10.1016/j.agrformet.2016.04.007, 2016a.

Huang, G., Li, X., Huang, C., Liu, S., Ma, Y., and Chen, H.: Representativeness errors of point-scale ground-based solar radiation measurements in the validation of remote sensing products, Remote Sensing of Environment, 181, 198-206, 10.1016/j.rse.2016.04.001, 2016b.

2. *As far as I know, three atmospheric conditions (clear-sky, completely*

cloud-covered and partially cloud-covered) were distinguished based on cloud fraction data in previous study. In this paper, the author used MOD06 cloud product to distinguish cloud sky and clear sky conditions. Will this cause some uncertainties?

Author Response: Thank you for this comment. Since the cloud fraction is calculated from the 1-km resolution cloud product within a 5-km retrieval region, the spatial resolution of the cloud fraction data is 5 km. For the MODIS cloud fraction data, the 5-km geolocation is copied directly from the center MOD06 cloud product pixel in each 5-km area. Therefore, distinguishing different sky conditions is actually based on a 1-km cloud product. We use the cloud phase to distinguish clear sky and cloudy sky conditions. The spatial resolution of cloud phase data is 1 km. The probability of mixing pixels (i.e., partially cloud-covered) is relatively small at the 1-km spatial scale. Unlike land surface parameters, the spatial heterogeneity of atmospheric parameters is much smaller.

3. *The derived DSR was compared with current widely used DSR products in this paper. That's convincing. To our best knowledge, Letu et al. (2022) generated surface radiation products under all-sky conditions from the Himawari-8/AHI Next-Generation Geostationary Satellite. If the derived DSR can be compared with the latest DSR product, this paper may be more appealing. The reference is as follows,*

   Letu et al., A New Benchmark for Surface Radiation Products over the East Asia–Pacific Region Retrieved from the Himawari-8/AHI Next-Generation Geostationary Satellite, Bulletin of the American Meteorological Society, 103, E873-E888, 10.1175/bams-d-20-0148.1, 2022

Author Response: Thank you for your suggestion. The DSR product generated by Letu et al. (2022) (short for "H-8_EAP") is based on the Himawari-8/AHI satellite at a 10-min temporal scale and 5-km spatial scale over the East Asia-Pacific. The earliest time covered by this product was 2016. At present, the latest in situ data in this study are from 2016. In addition, the Himawari-8 satellite cannot observe the western part of the TP. The spatial range of the product cannot cover the entire TP. Therefore, six stations (BJ, QOMS, SETORS, NAMORS, NLGS and NLTS) in 2016 are selected to compare our product with H-8_EAP. The corresponding content in Table 4 has been updated in the revised manuscript. The RMSEs of H-8_EAP at three temporal scales

are 197.89, 140.67 and 125.70 W m^{-2}, respectively. The MBs of H-8_EAP at three temporal scales are -52.47, -57.07 and -62.74 W m^{-2}, respectively. The estimates of this study show smaller RMSEs (140.54, 82.67 and 71.48 W m^{-2}) and lower absolute value MBs (23.64, 21.54 and 14.97 W m^{-2}). Relevant statements have been updated in the revised manuscript. (P14, L306-L312; P15, L323-L331).

'In addition, Letu et al. (2022) produced a high-resolution (5 km, 10 min) DSR dataset (short for "H-8_EAP" in our study) under all-sky conditions from 2016 to 2020 in the East Asia–Pacific region based on the next-generation geostationary satellite Himawari-8/AHI, which was also selected for comparison. At present, the latest in situ data in this study are in 2016, and the Himawari-8 satellite cannot observe the western part of the TP. Therefore, six stations (BJ, QOMS, SETORS, NAMORS, NLGS and NLTS) in 2016 are selected for comparison with the H-8_EAP DSR dataset.' (P14, L306-L312)

'As summarized in Table 4, the RMSE range of these DSR products is approximately 150~230 W m^{-2} at the instantaneous scale. At the ten-day scale, the RMSE range is approximately 80~150 W m^{-2}. At the monthly scale, the RMSE range is approximately 70~130 W m^{-2}. The MB range of these DSR products is -120 ~ -20 W m^{-2} at three temporal scales. These large spans of RMSE and MB indicate that the current DSR products still have great uncertainties over the TP. The RMSE ranges of this study at three temporal scales are 132~152, 70~82 and 61~71 W m^{-2}. The MB range of this study is 3 ~ 24 W m^{-2} at three temporal scales. The estimates of this study show a smaller RMSE, lower absolute value MB and comparable R values at the corresponding spatial and temporal scales. This means that the derived DSR based on the proposed method performs better than other DSR products over the TP.' (P15, L323-L331)

Table 4. Comparison with existing DSR products on different timescales in terms of accuracy.

Product name	Instantaneous timescale			Ten-day timescale			Monthly timescale			Spatial resolution
	RMSE (W m^{-2})	MB (W m^{-2})	R	RMSE (W m^{-2})	MB (W m^{-2})	R	RMSE (W m^{-2})	MB (W m^{-2})	R	
MCD18A1	233.47	-76.43	0.60	147.04	-74.60	0.72	130.24	-74.17	0.74	1 km
This study	152.13	5.23	0.72	77.24	7.35	0.82	63.79	7.25	0.84	
H-8_EAP	197.89	-52.47	0.66	140.67	-57.07	0.67	125.70	-62.74	0.73	5 km
This study	140.54	23.64	0.77	82.67	21.54	0.78	71.48	14.97	0.81	
ERA5	165.67	-20.59	0.65	88.06	-21.44	0.82	74.19	-21.06	0.86	25 km

This study	135.11	15.67	0.77	75.01	15.24	0.83	67.12	15.75	0.83	100 km
CERES_SYN_1h	146.64	-46.70	0.75	84.27	-47.93	0.86	73.25	-47.53	0.89	
CERES_SYN_3h	160.50	-78.30	0.74	107.13	-79.48	0.85	98.67	-79.06	0.88	
GEWEX_SRB	194.45	-118.56	0.68	143.68	-119.71	0.80	135.54	-119.21	0.83	
This study	132.84	2.79	0.77	70.84	2.18	0.84	61.33	2.70	0.85	

Minor issues:

1. *Figure 1: the caption is too brief. The same problems exist in other figures. Please check and modify.*

Author Response: Thank you for your suggestion. The legend of the color map indicates the elevation above mean sea level in meters. We have improved the corresponding figure captions in the revised manuscript.

2. *Page 4, L116: The references cited here are too old. Are there any updated references on relevant studies?*

Author Response: Thank you for this comment. The references have been updated in the revised manuscript (P4, L116).

'However, since optical remote sensing is greatly affected by clouds, it is still a big challenge to estimate DSR efficiently and accurately under all-sky conditions (Li et al., 1995; Li et al., 1997; Huang et al., 2019; Zhong et al., 2019; Letu et al., 2020).'

3. *L 46: "It plays a decisive role" => "It plays an important role"*

Author Response: It has been corrected. (P2, L46)

4. *L 55: "and other major rivers in Asia originate from the TP" => "and most major rivers in Asia originate from the TP"*

Author Response: It has been corrected. (P2, L55)

5. *L 57: "an important research object of global and regional energy" => "an important research object for global and regional energy"*

Author Response: It has been corrected. (P2, L57)