General Remarks.

The parameterizations used to calculate DLR are pretty outdated, as stated in the introduction and other places in this study. One question is that the empirical parameterizations, for example those used in this study, are strongly dependent on locations and time and thus might be suitable for specific locations and seasons but not for others. As the authors stated in introduction 'Understanding of complex spatiotemporal variation of DLR and its implication is essential for improving weather prediction, climate simulation as well as water cycling modeling'. The empirical parameterizations are apparently not able to obtain complex spatial-temporal variations of radiation flux. Actually, an accurate radiation transfer model would be a better choice to calculate radiation flux. Cloud optical properties, especially cloud optical depth is critical to modulate radiation flux, which unfortunately has not taken into account in this study. Also, a simple way is used to calculate cloud fraction (equation 1) in the manuscript, so it is necessary to evaluate the calculated values with the observed ones at the meteorological site over TP.

Reply: We greatly appreciate the reviewer's opinions on our submission. We revised the manuscript according to these comments and suggestions.

Yes, not only DLR but also any radiation flux can be calculated from an accurate radiative transfer model if information about atmospheric radiatively active compositions is well known, but unfortunately, our knowledge of these radiatively active compositions are very limited under many circumstances. Regarding DLR estimation in specific, information about cloud amount, type, phase, height is more or less related to DLR, let it alone remarkable effects of water vapor content and its profile under clear sky condition on DLR. Much progress has been made on DLR derivation from satellite measurements, however, satellite remote sensing DLR products are still not free of large uncertainty (Zhou et al., 2007; Ahn et al., 2018), especially in the regions of elevated or complex terrain. As pointed out by the reviewer, the empirical parameterizations have limitation, but their advantages are also apparent. The method is simple but effective in the estimation of DLR, especially in regions with the parameterizations locally adjusted by high quality DLR measurements. Moreover, meteorological variables used for the DLR estimation are available across the world. These apparent advantages make this method is still widely used by the community and contribute to our understanding of the energy budget of the Earth's system (Wang et al., 2013).

Cloud optical depth is a key factor affecting DLR. COD is generally derived from satellite measurements, however, it should be noted that large uncertainty is still associated with satellite COD retrievals in the regions of elevated and complex terrain. The advantage of the DLR parameterization lies in that it adopt surface meteorological observations as the major inputs. Therefore, it is not common to adopt COD in the DLR parameterizations since COD data are generally not available.

Human cloud observation every 3 or 6 hours are available in meteorological stations before 2013, however, this observation protocol is stopped afterwards. Therefore, human cloud observations are very limited to collocate with our cloud derivations from 1-minute DSR measurements that prevents our attempt to compare cloud cover from human observations and our estimations.

Zhou, Y., Kratz, D. P., Wilber, A. C., Gupta, S. K., & Cess, R. D., An improved algorithm for retrieving surface downwelling longwave radiation from satellite measurements. J. Geophys. Res., 112(D15), 2007.

Ahn, S. H. , Lee, K. T. , Rim, S. H. , Zo, I. S. , & Kim, B. Y., Surface downward longwave radiation retrieval algorithm for GEO-KOMPSAT-2A/AMI. Asia-Pacific J. Atmos. Sci., 54(2), 237-251, 2018.

Wang, K., and Dickinson, R. E.: Global atmospheric downward longwave radiation at the surface from ground-based observations, satellite retrievals, and re-analyses, Rev. Geophys., 51, 150-185, 10.1002/rog.20009, 2013

Minor comments:

1. The references cited in introduction are pretty outdated. Are there any updated references on such kind of studies?

Reply: we appreciate reviewer’s comment here, in the revised version, we update some references in the introduction.

2. Line 185-186: it is better to give an equation on how to calculate DSR.

Reply:

$$DSR_{dir} = 1S_0\tau_r\tau_W\tau_o\tau_a\tau_g$$

where τ_r, τ_w, τ_o, τ_a and τ_g are transmittances due to Rayleigh scattering, water vapor absorption, ozone absorption, aerosol extinction and absorption by uniformly mixed gases O_2 and CO_2, respectively. Diffuse radiation is estimated as the sum of the Rayleigh scattered, the aerosol-scattered and the multiple reflected irradiance.

3. Line 189-192: how to deal with aerosol (concentrations, vertical profile, scattering and absorption, etc.) in your calculations? Some details are better provided.

Reply: DSR_{cal} calculation needs the aerosol parameters as follows: Angstrom exponent (α), the Angstrom turbidity (β), single-scattering albedo (ω). For α, and β in NC and AL, the data are from the monthly average of in-situ Cimel photometer measurements. The data in NQ are adopted the same value in AL because both site are at similar high altitude. For ω, we use the average value of 0.90 retrieved from CIE-318 observation in Lhasa (91.13, 29.67, 3663m). Aerosol vertical profile is not considered.

4. Line 193-194: ‘The terrain reflection is estimated according to Dozier and Frew (1990)’, again please give some descriptions on how to estimate surface albedo.

Reply: We deleted the terrain reflection component since our measurements were made under conditions with no surrounding mountains around sites.

5. Line 197-199: give some description on why use these values as surface albedo, are they from surface measurements?

Reply: Yes, these values are from the surface measurements.

For NQ and AL, the surface albedo value are 0.25 and 0.22, which are derived from the reference (Liang et al., 2012)

Liang H., Zhang R., Liu J., Sun Z., and Cheng X., Estimation of Hourly Solar Radiation at the Surface under Cloudless Conditions on the Tibetan Plateau Using a Simple Radiation Model, Adv. Atmos. Sci., 29(4), 675-689, 2012.

Albedo at NC is 0.183 derived from the reference (Zhao et al., 2011).

Zhao X., Peng B., Qin N., Wang W. (2011), Characteristics of Energy Transfer and

Micrometeorology in Surface Layer in Different Areas of Tibetan Plateau in Summer (in Chinese), Plateau and mountain Meteorology Research,31(1), 6-11, 2011.

6. Line 200: why scaled DSR to 1400 W m^{-2}, DSR is net downward shortwave radiation, rather than total solar radiation.

Reply: DSR means downward shortwave radiation, not net downward shortwave radiation. We just adopted 1400 W m^{-2} according to Duchon and O’malley (1998) and Long and Ackerman (2000). It only favors for a clear presentation of the normalized and observation DSR together in the same figure.

7. In addition, the paper would be greatly enhanced with additional proof reading to improve the quality of the written English.

Reply: The manuscript has been extensively revised according to reviewers’ comments and suggestions. We tried our best through additional proof readings to eliminate grammar errors.