Geophysical Research Abstracts
Vol. 21, EGU2019-5591, 2019
EGU General Assembly 2019

Three-dimensional radiative transfer modeling of the terrain-reflected radiation in high altitude mountains

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As a result of the high albedo of snow or ice and the rugged surface, high altitude mountains get more reflection between the slopes, which increases the incoming radiation at the ground surface. Because of the absence of measurements in snow-covered high mountains, the accurate surface solar radiation (SSR) in this area is not easy to derive. A large-scale remote sensing data and image simulation framework (LESS), which is a ray-tracing based three-dimensional (3-D) radiative transfer model, was used in this study to have an accurate simulation of SSR in a mountainous area in the Tibetan Plateau. The direct and diffuse fluxes without topographic effect were simulated with MODTRAN5 for clear sky, used as the input for the LESS simulation. The simulation result indicates that the radiation increases in mountainous area, even if there is no snow cover. The increased energy origins from two parts: direct and diffuse radiation and terrain-reflected radiation. The anomalies of the direct and diffuse flux with reference to a horizontal surface is related to the slope and aspect distribution, and varies in a day. The terrain-reflected radiation is positively correlated with the surface albedo, and it can be as large as 360 W/m^2 in the area covered with snow. The domain daily energy increase because of the terrain reflection is generally less than $40W/m^2$, which is around 8% of downward SSR on a flat surface. Three terrain configuration factors using in simplified approaches were evaluated by the ray tracing simulation. Only one terrain configuration factor has very similar result with the LESS in domain-averaged (12km*12km) terrain-reflected flux, the other two factors both underestimate the radiation. However, the simulation with terrain configuration factor cannot derive a reliable result on local position.