Mapping downward shortwave radiation using MODIS atmospheric products

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Introduction

The complex terrain and the distribution of solar energy on the Qinghai-Tibet Plateau have significant influences on the Asian monsoon and the global climate changes. However, the atrocious geographical and natural conditions make it quite difficult for the observations. A new improved parameterized model for estimating downward shortwave radiation was proposed by incorporating MODIS atmospheric products with DEM.

Data and study area

The study area is a part of the Qinghai-Tibet Plateau within the territory of China, extending from 26º00′ 12″ N to 39º46′ 50″ N and from 73º18′ 52″ E to 104º46′ 59″ E, covering an area of 2.5724×10^6 km2 (Fig. 1). All of the atmospheric and land parameters are readily available from MODIS products (Table 1).

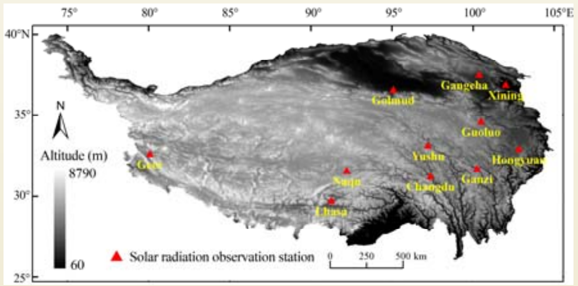

Fig. 1 Location of study area and global solar radiation observation stations

Table 1 MODIS atmospheric products used in calculating downward solar radiation

Parameter	Product	Spatial resolution(km)
Sensor zenith/azimuth	MOD03/MYD03	1
Total water vapor	MOD05/MYD05	1
Cloud optical thickness	MOD06/MYD06	1
Total atmospheric ozone	MOD07	5
Surface albedo	MCD43B3	1

Methodology

Under cloudy skies, the atmosphere is treated as a combination of a cloud layer and a clear layer from the cloud bottom downwards.

1. Direct solar irradiance for clear sky

   $I_{dir} = I_0 T_{clear} E_0 \sin h_{\alpha\beta}$

2. Diffuse solar irradiance for clear sky

   $I_{dif} = (I_R + I_A + I_n)$

3. Global solar irradiance for cloudy sky

   $I_G = (I_{dir} + I_{dif}) T_{cloud}$

4. Downward daily solar radiation

$$W_{\alpha\beta} = \sum_{i=1}^{n} \left(\int_{\omega sr}^{\omega ss} I_G dt \times f(dem) \right)$$

Model validation

The model was validated using observations from 11 stations within the Qinghai-Tibet Plateau (Fig. 1). Model validation was made by mean bias error (MBE) and correlation ocefficient(R^2). The results are represented in Fig.2 and Table 2.

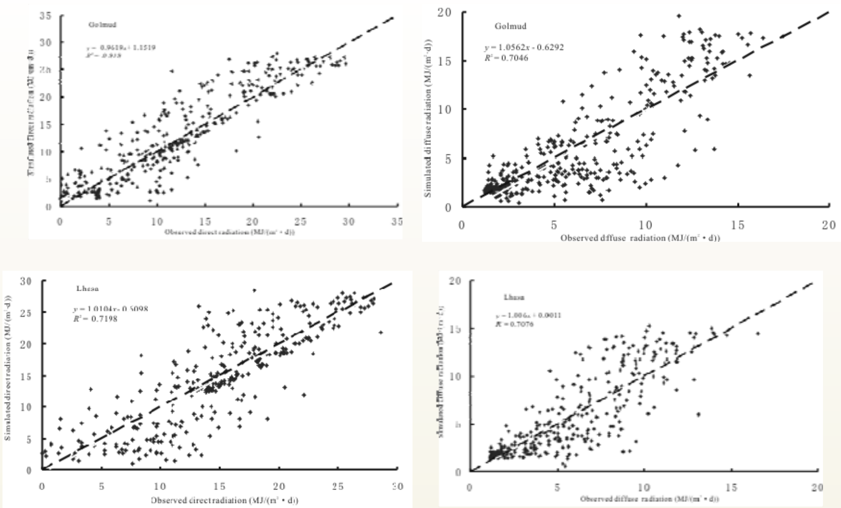

Fig. 2 Comparison of simulated and observed daily solar radiation at Golmud and Lhasa in 2007 (the dash line represents the 1:1 regression)

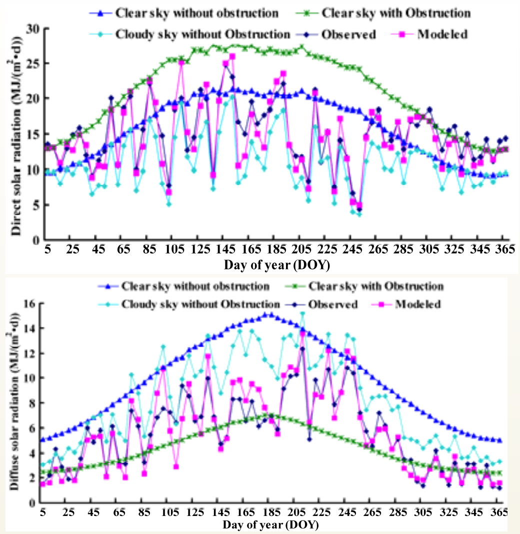

Fig. 3 Daily solar radiation under different conditions at Lhasa station

Table 2 Accuracy assessment of global solar radiation simulation

	Golmud	Lhasa	Geer	Naqu	Gangcha	Xining	Guoluo	Hongyuan	Ganzi	Yushu	Changdu
MBE	2.25	–2.05	–4.76	–0.97	–1.31	13.98	4.05	2.08	–3.54	–14.25	–0.77
R^2*	0.86	0.77	0.85	0.74	0.75	0.83	0.67	0.72	0.71	0.77	0.71
R^2**	0.95	0.96	0.97	0.88	0.91	0.95	0.79	0.85	0.91	0.97	0.92

*Notes: MBE represents daily mean bias error; * represents correlation coefficient of daily data; ** represents correlation coefficient of average data during 10-day period*

Cloud attenuation effects

A sensitivity study was carried out to observe the relationship between downward solar radiation, the terrain and cloud(Fig.3). The results show that both of them may play an important role in the transmittance of solar radiation under different weather conditions.

Discussion

-The model can be extrapolated to other areas without local calibration as the inputs were solely from satellite data and the attenuation factors of downward shortwave radiation were clearly represented.

- The errors caused by the aerosol can be neglected in the Qinghai-Tibet Plateau with a relatively low aerosol load.

-The use of new generation of meteorological satellites (with the spatial resolution ranges from 1 km to 10 km and temporal resolution ranges from 30 minutes to 12 hours) data holds great promise for the accurate estimation of surface solar radiation from remotely sensed imagery.

References

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