Estimation of Terrestrial Latent Heat Flux Based on Chinese GaoFen-1 Remote Sensing Data

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Abstract

Accurate estimation of terrestrial latent heat flux (LE) at high spatial resolution is of great vital importance for energy balance and water resource management, especially for agricultural production at field scale. However, there are relatively few LE products based on Chinese GaoFen-1 (GF-1) remote sensing data. In this study, we used GF-1 satellite data with a 16 m spatial resolution over the part regions of Ethiopia, Laos and Pakistan, and generated the LE products using Modified Satellite-based Priestley-Taylor model. LE products based on GF-1 data were aggregated to a 1 km spatial resolution to be validated by Global LAnd Surface Satellite (GLASS) LE products with the same spatial resolution as reference values. The validation results demonstrated that the 16 m GF and 1 km GLASS LE products of the three countries all presented good spatial consistency, and the coefficient of determination of LE estimates based on GF-1 data against GLASS LE products were all greater than 0.6, indicating that the accuracy of LE products based on GF-1 data was high. LE estimation based on GF-1 data is of great significance for energy balance and water resource precision management.

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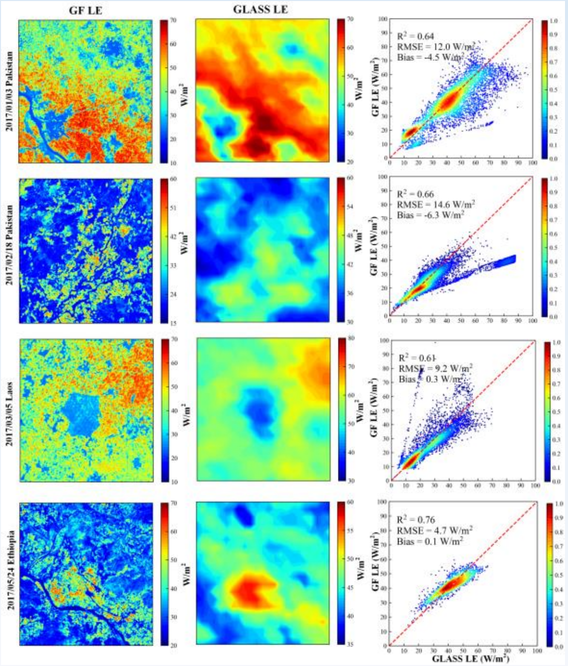
Introduction

Terrestrial latent heat flux (LE), which refers to the heat flux transferred from the land surface to the atmosphere through soil evaporation, vegetation transpiration and interception, is an essential component for characterizing the global and regional hydrological budget, energy redistribution and carbon cycles. Accurate estimation of LE at high spatial resolution is of great vital importance for energy balance and water resource management, especially for agricultural production at field scale. However, there are relatively few LE products based on Chinese GaoFen-1 (GF-1) data.

Results



The validation results show that the 16 m GF and 1 km GLASS LE products of the three countries all presented good spatial consistency, and the coefficient of determination of LE estimates based on GF-1 data against GLASS LE products were all greater than 0.6, indicating that the accuracy of LE products based on GF-1 data was high.

Data

Study area:

The part regions of Ethiopia, Laos and Pakistan

Satellite data:

The 16 m Chinese GF-1 remote sensing data

Modern Era Retrospective Analysis for Research and Applications-2 (MERRA-2) Meteorological data:

Air temperature (T_a), the ATI derived by the diurnal air temperature range (DT), the net radiation (R_n)

LE product:

1 km Global LAnd Surface Satellite (GLASS) LE product

Conclusions

The 16 m GF and 1 km GLASS LE products of the three countries all presented good spatial consistency. Validated by GLASS LE product, the accuracy of LE products based on GF-1 data was high. LE estimation based on GF-1 data is of great significance for energy balance and water resource precision management.

Acknowledgments

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Methods

GF-1 LE product was generated based on a Modified Satellite Priestley - Taylor (MS–PT) algorithm proposed by Yao et al. [1] The terrestrial LE consists of the unsaturated soil evaporation (LE_s), the canopy transpiration (LE_c), the canopy interception evaporation (LE_{ic}), and the saturated wet soil surface evaporation (LE_{ws}). The MS–PT algorithm can be given by:

$$LE = LE_s + LE_c + LE_{ic} + LE_{ws},$$

$$LE_s = (1 - f_{wet}) f_{sm} \alpha \frac{\Delta}{\Delta + \gamma} (R_{ns} - G),$$

$$LE_c = (1 - f_{wet}) f_v f_T \alpha \frac{\Delta}{\Delta + \gamma} R_{nv},$$

$$LE_{ic} = f_{wet} \alpha \frac{\Delta}{\Delta + \gamma} R_{nv}, \ LE_{ws} = f_{wet} \alpha \frac{\Delta}{\Delta + \gamma} (R_{ns} - G),$$

$$f_{sm} = ATI^k = \left(\frac{1}{DT}\right)^{DT/DT_{max}}, \ f_{wet} = f_{sm}{}^4,$$

$$f_v = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

where α is the Priestly-Taylor coefficient (1.26), γ is the psychrometric constant (0.066 kPa C^{-1}), Δ is the slope of saturation water vapor pressure versus temperature curve, f_{wet} is the relative surface wetness, f_{sm} is soil moisture constraint, f_T represents plant temperature constraint ($\exp(-(T_a - T_{opt})/T_{opt})^2)$), DT_{max} describes the maximum diurnal air temperature range (40 ℃), T_{opt} is an optimum temperature (25℃), R_{ns} is the surface net radiation to the soil ($R_{ns} = R_n(1 - f_v)$), G is soil heat flux ($\mu R_n(1 - f_v)$, $\mu = 0.18$), R_{nv} represents the surface net radiation to the vegetation ($R_{nv} = R_n f_v$), f_v is the vegetation cover fraction, and $NDVI_{min}$ and $NDVI_{max}$ are the minimum and maximum normalized difference vegetation index (NDVI), respectively.