Computers & Geosciences 105 (2017) 10–20

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

Reconstructing daily clear-sky land surface temperature for cloudy regions from MODIS data

Liang Sun[a,b,*], Zhongxin Chen[a], Feng Gao[b], Martha Anderson[b], Lisheng Song[c], Limin Wang[a], Bo Hu[d], Yun Yang[b]

[a] Key Laboratory of Agri-Informatics, Ministry of Agriculture, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China
[b] U. S. Department of Agriculture, Agricultural Research Service, Hydrology and Remote Sensing Laboratory, Beltsville, MD 20705, USA
[c] School of Geographical Sciences, Southwest University, Chongqing 400712, China
[d] Ningbo Meteorological Bureau, Ningbo 315012, China

ARTICLE INFO

Keywords:
MODIS
Land surface temperature
Reconstruction
Remotely Sensed DAily land Surface Temperature reconstruction (RSDAST) model
TVDI

ABSTRACT

Land surface temperature (LST) is a critical parameter in environmental studies and resource management. The MODIS LST data product has been widely used in various studies, such as drought monitoring, evapotranspiration mapping, soil moisture estimation and forest fire detection. However, cloud contamination affects thermal band observations and will lead to inconsistent LST results. In this study, we present a new Remotely Sensed DAily land Surface Temperature reconstruction (RSDAST) model that recovers clear sky LST for pixels covered by cloud using only clear-sky neighboring pixels from nearby dates. The reconstructed LST was validated using the original LST pixels. Model shows high accuracy for reconstructing one masked pixel with R^2 of 0.995, bias of −0.02 K and RMSE of 0.51 K. Extended spatial reconstruction results show a better accuracy for flat areas with R^2 of 0.72–0.89, bias of −0.02–0.21 K, and RMSE of 0.92–1.16 K, and for mountain areas with R^2 of 0.81–0.89, bias of −0.35−−1.52 K, and RMSE of 1.42–2.24 K. The reconstructed areas show spatial and temporal patterns that are consistent with the clear neighbor areas. In the reconstructed LST and NDVI triangle feature space which is controlled by soil moisture, LST values distributed reasonably and correspond well to the real soil moisture conditions. Our approach shows great potential for reconstructing clear sky LST under cloudy conditions and provides consistent daily LST which are critical for daily drought monitoring.

1. Introduction

Land surface temperature (LST), generally defined as the skin temperature of the Earth's surface, is an important factor in the study of environment, agriculture, hydrology and meteorology. LST reflects the processes of evapotranspiration (ET) (Anderson et al., 2012; Sun et al., 2013), surface energy balance (Bastiaanssen et al., 1998; Su, 2002), soil moisture change (Carlson et al., 1995) and climate change (Jin et al., 2005; Maimaitiyiming et al., 2014).

Land surface temperature can be retrieved using remotely sensed thermal infrared (TIR) data. Two widely used TIR instruments include the Advanced Very High Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectrometer (MODIS). Both are capable of observing the earth surface at least once per day at 1 km spatial resolution.

The MODIS instrument is a highly sensitive radiometer operating in 36 spectral bands ranging from 0.4 μm to 14.4 μm. MODIS is operating onboard Terra and Aqua. Terra was launched in December 1999 and Aqua in May 2002. A ± 55° scanning pattern at 705 km altitude achieves a 2330 km swath that provides global coverage every one to two days. Aqua has a 1:30 am/pm equator crossing time while Terra has a 10:30 am/pm equator crossing time. Thus, daytime MODIS thermal band imagery are available locally once in the morning from TERRA and once in the afternoon from AQUA. The MODIS team has developed and published more than 20 atmospheric, oceanic and land surface data products. The MODIS LST product is retrieved using the generalized split-window algorithm (Wan and Dozier, 1996) and the day/night algorithm (Wan, 1997). The reported error in LST is less than 1k, as validated over homogenous land surface patches (Wan et al., 2002). As a high quality data product, MODIS LST has been widely applied in many fields, especially drought monitoring. Many remote sensing drought monitoring indices are developed based on

* Corresponding author at: U. S. Department of Agriculture, Agricultural Research Service, Hydrology and Remote Sensing Laboratory, 10300 Baltimore Avenue, Beltsville, MD 20705, USA.
E-mail addresses: sunliang001@gmail.com, liang.sun@ars.usda.gov (L. Sun).

http://dx.doi.org/10.1016/j.cageo.2017.04.007
Received 12 December 2016; Accepted 24 April 2017
Available online 29 April 2017
0098-3004/