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Generating the 30-m land surface temperature product over continental China and USA from landsat 5/7/8 data

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ABSTRACT

Generating a long-time-series, high-spatial-resolution land surface temperature (LST) product has considerable applications in monitoring water stress, surface energy and water balance at the field scale. This paper proposes an operational method to generate 30-m LSTs from thermal infrared (TIR) observations of Landsat series. Two key issues were addressed in the proposed method: one involved determining the land surface emissivity (LSE) by developing different LSE retrieval methods for specific land cover types; the other involved choosing an optimal reanalysis atmospheric profile for implementing the atmospheric correction of TIR data. After LSE determination and atmospheric correction, LST was resolved by inverting the radiative transfer equation. In situ measured LST and LSE data were used to validate the proposed method. The validation results based on the measurements from 24 sites showed that the absolute average bias of the LSE data estimated from Landsat 5/7/8 was generally within 0.01, and the standard deviations were all less than 0.002. The average biases of the retrieved LST at SURFRAD sites were 1.11/1.54/1.63 K, whereas the RMSEs were 2.72/3.21/3.02 K for Landsat 5/7/8, respectively. The average biases (RMSEs) of the retrieved LST at the BSRN and Huailai sites were 0.08 K (3.69 K) and 0.90 K (3.42 K) for Landsat 7 and Landsat 8, respectively. Furthermore, the validation results at the SURFRAD sites show that the precision and uncertainty of the retrieved Landsat 5/7/8 LSTs were all better than those of the USGS LSTs. Finally, we produced monthly composited LST maps for the Chinese landmass and continental United States using the retrieved Landsat 5/7/8 LSTs. This study provides guidance on how to estimate large-scale LSTs from satellite sensors with only one TIR channel. We will massively produce global LSTs from Landsat series TIR data and release them to the public in the next stage.

1. Introduction

The land surface temperature (LST) plays an important role in the interactions and all energy exchanges between the atmosphere and land surface (Cheng et al., 2020; Coll et al., 2016; Li et al., 2013b; Meng and Cheng 2020; Wan and Dozier 1996). It is a key parameter in models of the surface radiation budget, energy balance, and water circulation on regional and global scales (Tang et al., 2017; Trigo et al., 2008; Yu et al., 2009). At present, LST can be obtained by ground measurement, remote sensing, and land surface modeling (Ouyang et al., 2018). Due to sparsely distributed ground measurement sites and inaccurate model simulations, it is almost impossible to effectively monitor LST with spatiotemporal continuity; remote sensing is an irreplaceable way to obtain LST at the global and regional scale (Xu and Cheng 2021).

Currently, LST is primarily estimated from passive microwave sensors and thermal infrared (TIR) sensors. Moreover, a few operational LST products with different spatial and temporal resolutions have been produced using various sensors, such as the spinning enhanced visible and infrared imager (SEVIRI) (Niclòs et al., 2011), moderate resolution imaging spectro-radiometer (MODIS) (Wan 2014), advanced spaceborne thermal emission and reflection radiometer (ASTER) (Gillespie et al., 1998), visible infrared imaging radiometer suite (VIIRS) (Yu et al., 2005), medium resolution spectral imager (MERSI) (Meng et al., 2017), and advanced microwave scanning radiometer (AMSR-E) (Zhang and

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