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# Radiance-based validation of land surface temperature products derived from Collection 6 MODIS thermal infrared data

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ABSTRACT

Land surface temperature (LST) is an important climate variable related to surface energy and water balance. The LST products retrieved from Terra-/Aqua-MODIS thermal infrared data have been widely used in climatological, hydrological, meteorological, and ecological applications. The newest collection (C6) MODIS LST products have been freely available for the user community since 2016. It is necessary to evaluate the accuracy of the C6 MODIS LST products prior to their application. In this study, the C6 MODIS LST products were validated using a radiance-based (R-based) method. We selected 38 validation sites worldwide over eight land cover types, i.e., in-land water, forest, shrubland, grassland, cropland, urban, snow, and bare soil surfaces. Except for the results for grassland sites during the daytime and night-time and the bare soil sites during the daytime, the C6 MODIS LST products are in good agreement with the R-based LST values, with bias and root mean square error (RMSE) values of less than 1 K for all sites during the daytime and night-time. Large LST discrepancies over grassland sites are caused by misclassification in the MODIS land cover type products, which can lead to large uncertainties in the determination of surface emissivity. We also compared the accuracies of the C5 and C6 MODIS LST products. Results indicate that there are no significant accuracy discrepancies between the C5 and C6 MODIS LST products for all sites, with the exception of bare soil sites. Compared with the C5 MODIS LST products, significant accuracy improvement in the C6 MODIS LST products over most bare soil sites can be found. The absolute bias values are reduced from approximately 1.4–3.0 K for C5 to approximately 0.3–0.8 K for C6, and the RMSE values from approximately 1.4–3.1 K for C5 to approximately 0.5–0.8 K for C6. However, further overestimation in the C6 MODIS LST products can be found over two bare soil sites due to the poor emissivity adjustment provided by the emissivity adjustment model incorporated into the C6 split window algorithm.

## 1. Introduction

Land surface temperature (LST) is an important parameter in surface energy and water balance (Weng, 2009; Sobrino and Jiménez-Muñoz, 2014; Duan et al., 2014a, 2014b). LST has been widely used in climatological, hydrological, meteorological, and ecological studies (Sandholt et al., 2002; Anderson et al., 2008; Weng and Fu, 2014; Leng et al., 2016; Duan et al., 2017a). Satellite-derived LST products from thermal infrared data are an important Earth System Data Record (ESDR) by NASA (Yu et al., 2008).

Validation and evaluation of satellite-derived LST products can facilitate their use for various applications and can improve the performance of the LST retrieval algorithm. Three different methods have been widely used to validate satellite-derived LST products: the temperature-based (T-based) method (Wan et al., 2002, 2004; Coll et al., 2005, 2009; Wang et al., 2008; Wang and Liang, 2009; Guillevic et al., 2012, 2014; Göttsche et al., 2013, 2016; Li et al., 2014; Xu et al., 2014), radiance-based (R-based) method (Wan and Li, 2008; Wan, 2008, 2014; Coll et al., 2009; Niclòs et al., 2011; Hulley and Hook, 2012; Gomis-Cebolla et al., 2018), and inter-comparison method (Guillevic et al., 2014; Frey et al., 2012; Trigo et al., 2008; Ermida et al., 2014; Duan et al., 2017b). These methods are complementary and provide different levels of information about the accuracy of the satellite-derived LST products. Detailed overviews of these three methods

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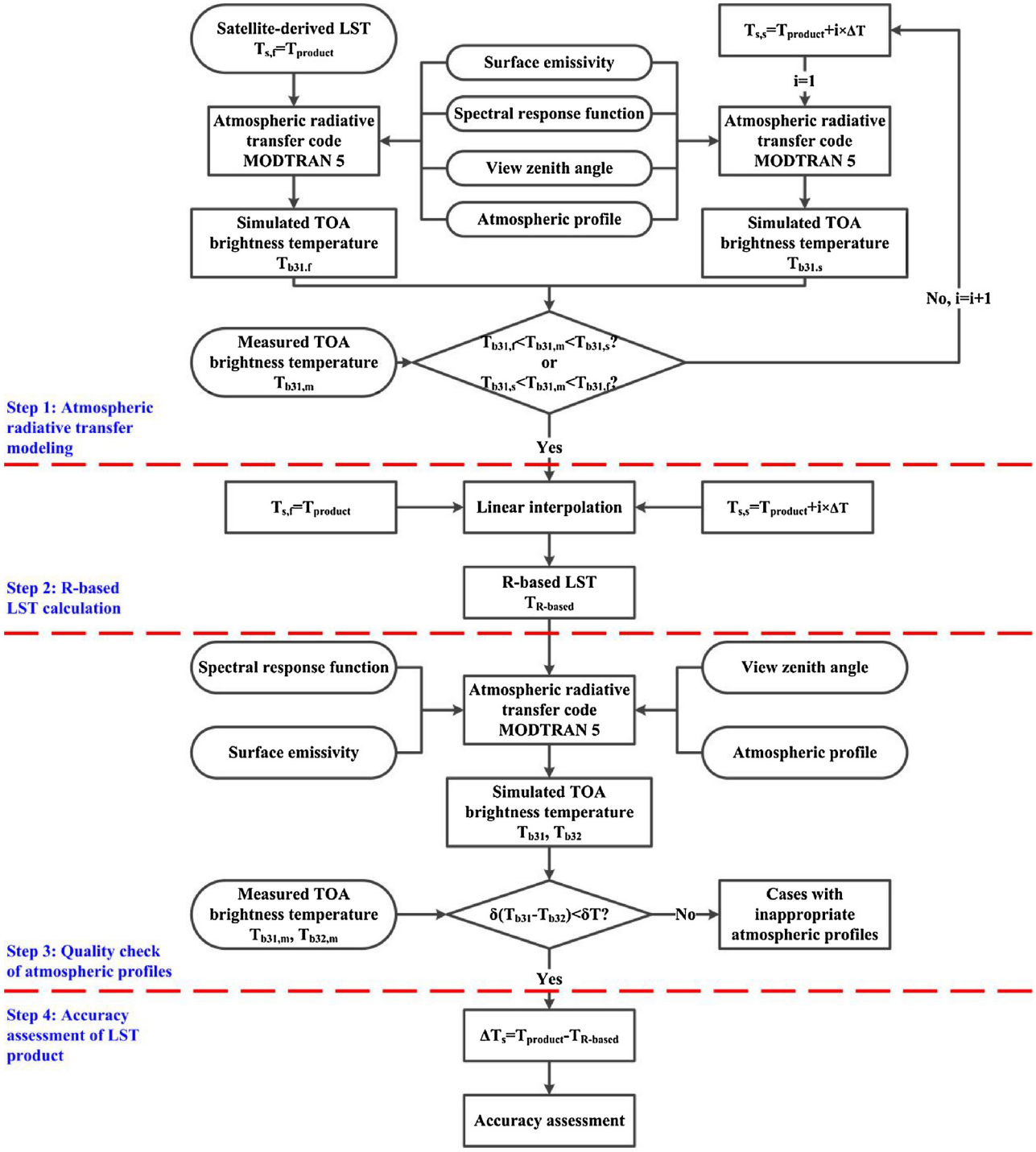


**Fig. 1.** Flowchart of the R-based LST validation method.

were provided by Li et al. (2013a) and Guillevic et al. (2014).

The R-based method developed by Wan and Li (2008) is an advanced LST validation method. This method does not rely on in situ LST measurements but requires atmospheric profiles concurrent with satellite overpass and surface emissivity measured in the field or estimated from land cover types (Li et al., 2013b). Therefore, the R-based method can potentially be applied to validate satellite-derived LST products during daytime and night-time periods at the global scale. The R-based method has been used for the validation of satellite-derived LST products at coarse spatial resolution, e.g., Terra-/Aqua-MODIS, Aqua-AIRS, and MSG-SEVIRI LST products (Wan, 2008, 2014; Wan and Li, 2008; Niclòs et al., 2011; Coll et al., 2009; Hulley and Hook, 2012; Gomis-Cebolla et al., 2018).

The objective of this study is to validate LST products derived from Collection 6 (C6) MODIS thermal infrared data using the R-based method. The newest C6 MODIS LST products have been freely available since 2016. Thirty-eight validation sites around the world were selected to evaluate the accuracy of the C6 MODIS LST products. These sites contain various land cover types: in-land water, forest, shrubland, grassland, cropland, urban, snow, and bare soil surfaces.

## 2. MODIS LST products

The generalized split window algorithm used for the generation of