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An improved method for separating soil and vegetation component temperatures based on diurnal temperature cycle model and spatial correlation

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ABSTRACT

This paper proposed an improved method for separating soil and vegetation component temperatures from one pixel land surface temperature (LST) using multi-pixel and multi-temporal data. The two main features of the method are (1) the use of a diurnal temperature cycle (DTC) model to describe component temperatures and (2) the application of a spatial weighting matrix to consider the spatial correlation of component temperatures. The proposed method was evaluated using an extensive simulated dataset with five component temperature types, three LST errors and 69 fractional vegetation cover (FVC) types, and field measurements with a high temporal frequency. Due to the time extendibility of DTC model, the possibility for retrieving component temperatures at any time was analyzed. Correspondingly, the schemes for selecting the best observations for four representative periods, i.e., 10:00–12:00, 09:00–18:00, 18:00–03:00 (on the next day) and 09:00–03:00, were determined. The validations showed satisfactory accuracies, and it was found that the errors were significantly influenced by the original LST retrieval error. In addition, the difference between the ideal temperature pattern from the DTC model and the actual temperature variation also affected the accuracy of the temporally extended component temperatures. Furthermore, sensitivity analyses indicated that the separation accuracy was independent of the uncertainty of the component emissivity but was influenced by FVC. Specifically, the retrieval accuracy was sensitive to the size and variation of FVC, and the latter had a more significant influence, but the result was less sensitive to the retrieval error and angular effect of FVC. Considering its accuracy, operability and robustness, the proposed method is effective for separating soil and vegetation component temperatures.

1. Introduction

Land surface temperature (LST) is a key parameter of land–atmosphere energy exchange and is widely used in agriculture, ecology, meteorology and global change studies (Li et al., 2013). Usually, satellite-derived LST is an area-averaged temperature of a single pixel. However, the pixel-averaged temperature cannot represent the actual temperatures of different components (e.g., soil and vegetation) for heterogeneous and non-isothermal pixels (Shi, 2011; Zhan et al., 2011). Some Earth system models, such as the classic two-source energy balance (TSEB) model used in an evapotranspiration study (Norman et al., 1995), use soil/vegetation component temperatures as input parameters. Therefore, component temperatures have a more physical meaning than LST and better meet the requirements of the models. On the other hand, the relative weights of different components with different temperatures are important for the directionality effect of LST

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