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Influence of adjacency effect on high-spatial-resolution thermal infrared imagery: Implication for radiative transfer simulation and land surface temperature retrieval

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ABSTRACT

The influence of adjacency effect on high-spatial-resolution satellite imagery in the visible and near infrared region has been studies since the 1980s. However, the adjacency effect is usually neglected in the thermal infrared (TIR) region. The conventional TIR radiative transfer equation (RTE) only takes into account radiance from target pixel and neglects radiance contribution from surrounding background pixels. In this study, two TIR RTEs taking into account the adjacency effect for uniform and non-uniform Lambertian surfaces were deduced based on the radiative transfer theory. In terms of the TIR RTEs, we analyze the dominating influence factors of the adjacency effect and quantify the magnitude of the adjacency effect in the TIR region using simulation and actual satellite data. Two different definitions of the adjacency effect are presented in this study: (1) the effect due to radiance from background pixels scattered into sensor's instantaneous field of view, and (2) the effect due to apparent thermal contrast between target and background pixels. The results show that atmospheric visibility, water vapor content, sensor spectral band, and background pixel land surface temperature (LST) have significant influence on the adjacency effect. For a specific simulation scene, the magnitude of the first definition of the adjacency effect is larger than 0.5 K when atmospheric visibility is lower than 23 km. This magnitude is as much as 2 K under haze weather conditions with atmospheric visibility of 5 km. The results indicate that the adjacency effect should be taken into account in the radiative transfer simulation. The magnitude of the second definition of the adjacency effect is less than 0.3 K, even at atmospheric visibility of 5 km. The results reveal that the accuracy of the TIR RTE for a uniform Lambertian surface is enough for the development of LST retrieval algorithm under relatively haze weather conditions. In situ LST measurements collected at the Hailar, Urad Front Banner, and Wuhai sites in China were used to validate the accuracies of the LST retrieved by the RTE-based single channel algorithm with/without adjacency effect correction. There are nearly no discrepancies between the LST retrieved with/without adjacency effect correction when aerosol optical depth (AOD) is low than 0.3. However, the RMSE of the differences between the retrieved LST and the in situ LST decreases from approximately 1.4 K for the LST retrieved without adjacency effect correction to approximately 0.6 K for the LST retrieved with adjacency effect correction when AOD is high than 0.3.

1. Introduction

Satellite sensors at the top of the atmosphere (TOA) receive radiation not only from target pixel, but also from surrounding background pixels. The phenomenon that radiation from surrounding background pixels scattered into sensor's instantaneous field of view (IFOV) is called adjacency effect (Burazerovic et al., 2013; Richter et al., 2006; Sei, 2007). This effect reduces apparent contrast between target and

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