The nonlinear three-band algorithm for retrieving land surface temperature from Himawari-8

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Introduction

The land surface temperature (LST) is a key parameter of the land-atmosphere interaction on various scales. Since satellite observations can provide LST data over wide area in homogeneous quality, LST retrieval algorithms have been proposed for various sensors. The Advanced Himawari Imager (AHI) onboard Himawari-8, a next-generation geostationary satellite, has three thermal infrared bands in the spectral range 10–12.5 μm, while previous satellites had two. The 10–12.5 μm range is suitable for retrieving LST since the atmospheric absorption is small in this range, and is mainly by water vapor. Another advantage of this range is that the land surface emissivity (LSE) does not differ much among various constituents of the land surface. The retrieval of the LST is sensitive to LSE estimation and water vapor estimation. (Li et al., 2013). Therefore, a retrieval algorithm that has high accuracy and high robustness against the uncertainties in input data is required. We present a new LST retrieval algorithm that makes the maximum use of AHI new window thermal infrared (TIR) bands.

Method

Previous studies (Atitar and Sobrino, 2009; Takeuchi et al., 2012) employed a nonlinear split-window algorithm (NSW), which considers the effect of the atmospheric attenuation by utilizing the differential adsorption of two adjacent TIR bands. In contrast, we have developed a nonlinear three-band algorithm (NTB) by utilizing a combination of AHI three TIR bands. The NTB is inspired from a three-band algorithm (TB) developed by Sun and Pinker (2003) which used two TIR and a near infrared band. The formula of the algorithm includes ten coefficients. The optimum values of these coefficients are derived using a statistical regression method from the simulated data, as obtained by a radiative-transfer model. The simulated data sets include the spectral response functions for the three AHI TIR bands, the seven satellite zenith angles (SZAs) from 0° to 60°, 215 radiosonde profiles, 6 LSTs for each profile, and 86 band LSEs. As a result, 109467 LST –($T_{10.4}$, $T_{11.2}$, $T_{12.4}$) relations were obtained in total for a fixed SZA value. After obtaining the coefficients in this way, we searched the best LST algorithm for five cases: three types of NSWs, one type of TB and one type of NTB.

Results

We checked the root-mean-square error (RMSE) in terms of the SZA, LST and precipitable water (PW) dependence by using dataset used to obtain coefficients. The result showed that the NTB can stably estimate the LST especially in hot and wet environments by comparison to the NSW. Moreover, we evaluated the sensitivities of five LST algorithms to the uncertainties in LSE, PW and noise equivalent delta-temperature (NEdT) by using the validation data independent of dataset used to obtain coefficients. Consequently, it was clarified that the NTB has the highest robustness against the uncertainties in LSEs and NEdTs of three TIR bands. The total estimation error of NTB is about two third of NSW for SZA smaller than 40°. Therefore, it is concluded that the NTB is more suitable for the LST retrieval from AHI than the NSW.

The NTB is combined with an appropriate cloud mask and a LSE products to retrieve LST (see Figure 1 for example). The spatial resolution of the AHI is about 2 km and the observation cycle is 10 minutes. Though the horizontal resolution is inferior to the products from polar-orbiting satellites, the high frequency

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observation explores new use of LST products. For example, the AHI can detect a difference in urban area such as commercial, industrial, and residential regions. Hence, it is expected that our Himawari-8 LST product is applicable to studies of thermal property in smaller scales (see Figure 2).

References

Z. Li *et al.*, *Remote Sens. Environ.*, vol. 131, pp. 14–37, 2013.
M. Atitar and J. A. Sobrino, *IEEE Geosci. Remote Sens. Lett.*, vol. 6, no. 1, pp. 122–126, 2009.
W. Takeuchi *et al.*, *Asian J. Geoinformatics*, vol. 12, no. 2, 2012.

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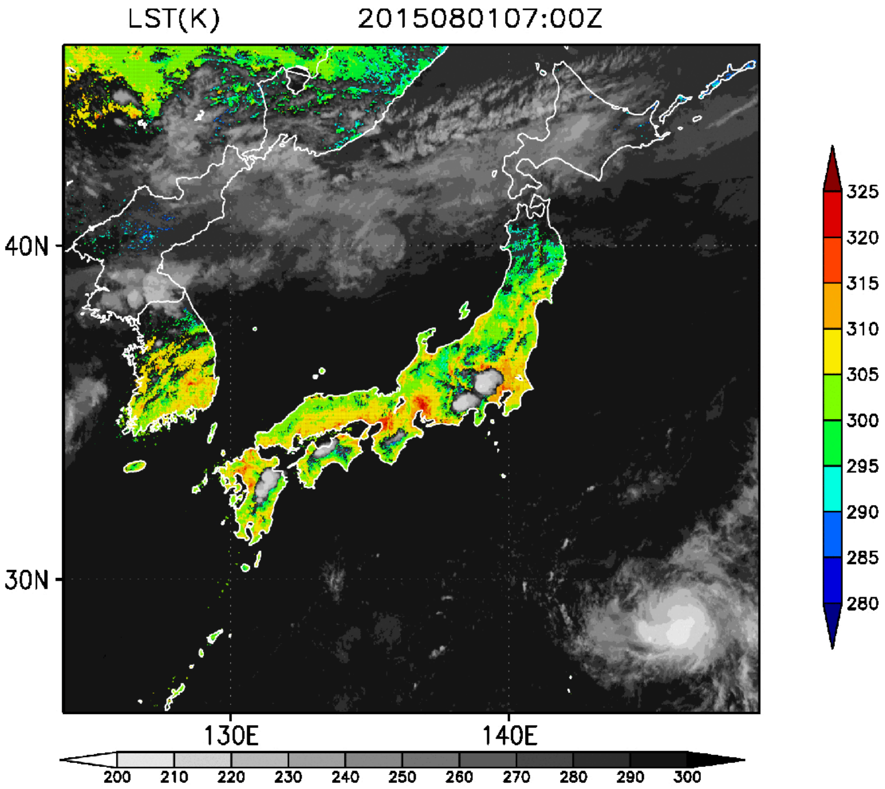

Figure 1. An example of the Himawari-8 LST product over Japan area on 01 August 2015 at 07:00 UTC.

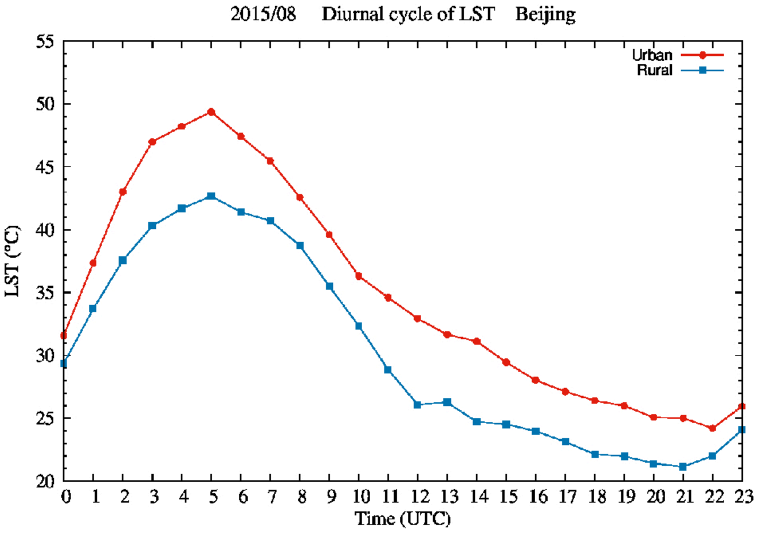

Figure 2. The Diurnal cycle of LST in Beijing urban and rural areas which was generated by composite processing for 31 days in August 2015. The temporal resolution was reduced to 1 hour.

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