Improvement of COMS Land Surface Temperature Retrieval Algorithm

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Abstract: Land surface temperature (LST) is a key environmental variable in a wide range of applications, such as weather, climate, hydrology, and ecology. However, LST is one of the most difficult surface variables to observe regularly due to the strong spatio-temporal variations. So, we have developed the LST retrieval algorithm from COMS (Communication, Ocean and Meteorological Satellite) data through the radiative transfer simulations under various atmospheric profiles (TIGR data), satellite zenith angle (SZA), spectral emissivity, and surface lapse rate conditions using MODTRAN 4. However, the LST retrieval algorithm has a tendency to overestimate and underestimate the LST for surface inversion and superadiabatic conditions, respectively. To minimize the overestimation and underestimation of LST, we also developed day/night LST algorithms separately based on the surface lapse rate (local time) and recalculated the final LST by using the weighted sum of day/night LST. The analysis results showed that the quality of weighted LST of day/night algorithms is greatly improved compared to that of LST estimated by original algorithm regardless of the surface lapse rate, spectral emissivity difference ($\Delta\varepsilon$) SZA, and atmospheric conditions. In general, the improvements are greatest when the surface lapse rate and $\Delta\varepsilon$ are negatively large (strong inversion conditions and less vegetated surface).

Key Words: Land surface temperature, COMS, MODTRAN 4, day/night algorithms.

1. Introduction

KMA (Korea Meteorological Administration) has been developing the COMS (Communication, Ocean and Meteorological Satellite) meteorological data processing system (CMDPS) for the successful operation and efficient use of the satellite data (e.g., KMA, 2008). The COMS is the first geostationary multipurpose satellite of Korea, which will be launched at the early of 2010. Various meteorological variables, such as clouds, aerosol, sea surface temperature and land surface temperature (LST) will be derived automatically by the CMDPS from the COMS level-1b data. LST is a key environmental variable in a wide range of applications, such as weather, climate, hydrology, and ecology (Prata and Cecchet, 1999). However, LST is one of the most difficult surface variables to observe regularly due to...
the strong spatio-temporal variations. At present, instruments on board satellites working in the thermal infrared are the only available operational systems capable of collecting cost-effective LST data at spatial and temporal resolutions appropriate to modeling applications (Becker and Li, 1995; Peres and DaCamara, 2004).

Theoretical possibility for the retrieval of LST using split-window method has been shown by Becker and Li (1990), and many others. Numerous works have been made to retrieve the LST from the satellite data, especially polar orbit satellite (NOAA/AVHRR, Terra/MODIS, Landsat/TM) (e.g., Price, 1984; Kerr et al., 1992; Ulivieri et al., 1994; Wan and Dozier, 1996; Han et al., 2004; Suh et al., 2008). However, operational retrieval of LST from the satellite data is very limited due to the poor accuracy of retrieved LST, particularly using geostationary satellite. The lower quality of retrieved LST is mainly caused by the combined effects of spatially and temporally varying emissivity and atmospheric conditions (Ulivieri et al., 1994; Jiang et al., 2006).

Recently, the various background data (e.g., land cover, vegetation index) and methods (vegetation coverage method; Valor and Caselles, 1996; Loveland et al., 2000) for the estimation of spectral emissivity are developed. And the quality of geostationary satellite (e.g., MSG/SEVIRI, MTSAT-1R) has been greatly improved recently. As a result, the quality of LST retrieved from geostationary satellite data, such as MSG/SEVIRI, has been significantly improved. As in the MODIS LST group, the LST over Africa and Europe retrieved operationally by the EUMETSAT LSA/SAF (Land Surface Analysis Science Application Facility) (Peres and DaCamara, 2004; Sobrino and Romagura, 2004). Hong et al. (2009) developed a split-window type LST algorithm by using MTSAT-1R data and evaluated the performance of LST algorithm using MODIS LST data. They showed that the LST over East Asia can be retrieved from MTSAT-1R data with the correlation coefficients and RMSE of about 0.82~0.99 and 1.5~4.28 K, respectively. However, the quality of retrieved LST is significantly better at nighttime than at the daytime and in vegetated areas rather than barren areas.

Basic information including spectral response functions and sub-satellite point of the COMS are released at the end of 2008. In this study, we developed LST retrieval algorithm using COMS data and evaluated the sensitivity of LST retrieval algorithm to the various impacting factors. And we developed 3-set (total, day and night LST algorithms) of split-window type LST retrieval algorithms to improve the quality of estimated LST from COMS data.

2. Radiative transfer model simulation

To develop a LST retrieve algorithm using a split-window method, ground match-up data are needed for the coefficients of regression equation. However, unlike the sea surface temperature, available match-up data over East Asia are severely limited in LST. So, we performed radiative transfer model simulations using MODTRAN 4 with various atmospheric and satellite viewing conditions. The main factors affecting the retrieved LST using split-window method are atmospheric profiles, spectral emissivity, satellite zenith angle and lapse rate at surface layer. The radiative transfer simulations are designed to include all the impacting factors (Table 1).

In order to consider the atmospheric effects, 441 TIGR databases were used within 60° of satellite zenith angle from the COMS position (see Fig. 1). LST has been subscribed to consider the strong