An estimation of surface reflectance for Advanced Himawari Imager (AHI) data using 6SV

Noh-hun Seong, Chang Suk Lee, Sungwon Choi, Minji Seo, Kyeong-Sang Lee and Kyung-Soo Han

Department of Spatial Information Engineering, Pukyong National University

Abstract: The surface reflectance is essential to retrieval various indicators related land properties such as vegetation index, albedo and etc. In this study, we estimated surface reflectance using Himawari-8 / Advanced Himawari Imager (AHI) channel data. In order to estimate surface reflectance from Top of Atmosphere (TOA) reflectance, the atmospheric correction is necessary because all of the TOA reflectance from optical sensor is affected by gas molecules and aerosol in the atmosphere. We used Second Simulation of a Satellite Signal in the Solar Spectrum Vector (6SV) Radiative Transfer Model (RTM) to correct atmospheric effect, and Look-Up Table (LUT) to shorten the calculation time. We verified through comparison Himawari-8 / AHI surface reflectance and Proba-V S1 products. As a result, bias and Root Mean Square Error (RMSE) are calculated about -0.02 and 0.05.

Key Words: surface reflectance, Himawari-8/AHI, 6SV

1. Introduction

TOA reflectance observed satellite sensor is altered by the interference of absorption by gasses and molecular that were called atmospheric effect. Atmospheric correction is essential pre-process to interpret information of remotely sensed images taken by satellite. The surface reflectance is used to produce related land properties such as albedo, vegetation index and etc. The atmospheric correction accuracy is affected for 2nd products using surface reflectance.

Many studies had shown atmospheric correction using various Radiative Transfer Model (RTM) (Hadjimitsis et al., 2002) such as the Moderated Resolution Atmospheric Transmission (MODTRAN) (Liang et al., 2001), Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART) (Ricchiazzi et al., 1998) and Simulation of the Satellite Signal in the Solar Spectrum (6S) (Vermote et al., 1997). In general, these RTMs have high accuracy but take a lot of time to computation. In order to compensate the defect, several studies used Look-Up Table (LUT) method (Vermote and Vermeulen, 1999; Liang et al., 2001; Nunes et al., 2008).

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† Corresponding Author: Kyung-Soo Han (kyung-soo.han@pknu.ac.kr)

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The sun-synchronous orbit satellite products have missing values in rainy season with many clouds. In this case, it can be solved using the geostationary orbit satellite products with high temporal resolution. In this study, we estimated Himawari-8 / Advanced Himawari Imager (AHI) surface reflectance using a LUT based on the 6S Vector (6SV) (Vermote et al., 2006). These surface reflectance products were verified through comparison with surface reflectance of Proba-V S1 channel data.

2. Data and Study area

We used TOA channel reflectance data of Himawari-8 / AHI. Himawari-8/AHI is a Japanese weather satellite operated by the Japan Meteorological Agency (JMA), it stared operational service on 7 July 2015. This satellite is geostationary orbit and located longitude 140.2°, provide 16 channel data every 10 minutes about full disk which covers almost of Asia and entire Australia (81.19°S - 81.19°N, 60° - 220°E). We performed atmospheric correction that used blue, red, NIR channel data of August 2015.

We used ancillary data as input parameter for atmospheric correction such as angular components (Solar Zenith Angle (SZA), Viewing Zenith Angle (VZA), Relative Azimuth Angle (RAA)), Aerosol Optical Depth (AOD), precipitable water, total column ozone content and cloud mask. One of the atmospheric composition, AOD utilized climatic data (Berthelot et al., 1984) to consider spatial change used by the EUMATSAT Satellite Application Facility on Land Surface Analysis (LSA SAF). In the case of the ozone and precipitable water, we used the median values corresponding to each of 0.48 gm cm⁻², 0.32 cm-atm because there are less impact for atmospheric correction factor than AOD (Lee et al., 2015). We calculated angular components by equation of Paltridge and Platt. R. (1976). Cloud mask was conducted by threshold method of Saunders and Kriebel (1988).

In this study, we used Proba-V S1 products as reference surface reflectance data. Proba-V is Sun-synchronous orbit satellite operated by European Space Agency (ESA). As daily synthesis data, S1 product was already corrected for its radiometric, geometric and atmospheric effects.

3. Method

In this study, we use 6SV RTM to correct atmospheric effect. This vector version of 6S called 6SV, is advanced RTM designed to simulate the reflection of solar radiation by a coupled atmosphere-surface system for a wide range of atmospheric, spectral and geometrical conditions (Vermote et al., 2006). It is a basic code for the calculation of LUT in the MODIS atmospheric correction algorithm. The 6SV calculated surface reflectance ($\rho_s$) based on following equation (1). 

$$\rho_{TOA}(\theta_s, \theta_v, \Phi) = T_g(\theta_s, \theta_v)[\rho_R + A + T(\theta_s)T(\theta_v)]\frac{\rho_i}{1-S\rho_i} \quad (1)$$

In equation (1), $\rho_{TOA}$ is TOA reflectance, $\theta_s$, $\theta_v$ and $\theta_i$ are angular components (SZA, VZA, RAA). $\rho_R$ corresponds to the intrinsic reflectance of the molecule + aerosol layer, $T(\theta_s)(T(\theta_v))$ to the total transmission of the atmosphere on the path between the sun and the surface (the surface and the sensor). S is the spherical albedo of the atmosphere that is normalized irradiance reflected by atmosphere when the isotropic light entered at the bottom of atmosphere. $T_i$ is total gaseous transmission for principal absorbing gases such as H2O, CO2, O2 and O3.

We pre-produced LUT to the computational efficiency and accuracy for 6SV RTM. We referred to ATBD of Geostationary Operational Environmental Satellite (GOES) -R / Advanced Baseline Imager (ABI) (Liang et al., 2010) similar Himawari -8 / AHI. Table 1 shows input parameters for 6SV calculation.