APPLICATION OF GEO SATELLITE OBSERVATION DATA FOR ATMOSPHERIC CORRECTION OF LEO SATELLITE IMAGE

Kwon-Ho Lee(1), Jong-Min Yeom (2)

[1] Gangneung-Wonju National University, 7 Jukheon-gil, Gangneung 25457, Korea
[2] Korea Aerospace Research Institute, Daejeon 34133, Korea

Email: kwonho.lee@gmail.com; yeomjm@kari.re.kr

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ABSTRACT: Understanding of atmospheric transfer process for atmospheric correction has been recognized as a major important issue of satellite image analysis. However, the optimal system to assess atmospheric parameter is still debated. This study proposes a possibly better method for atmospheric correction for low-earth orbit (LEO) satellite image. For estimating the characteristics of atmospheric transmission, gaseous absorption and particulate scattering have been estimated by using the geostationary orbit (GEO) satellite data with reanalysis data. The spectral aerosol optical properties from the 500 m resolution (1-hour interval) of the Geostationary Ocean Color Imager (GOCI) data and the 30 m spatial resolution of the Landsat 8 Operational Land Imager (OLI) provide a new opportunity to test the proposed algorithm. After the spatial and temporal collocations with the simple threshold tests, the atmospheric correction of OLI images from the case study showed that the averaged changes of reflectance at three visible R-G-B channels were red (10%), green (12%), blue (30%), respectively. Compared to these results with the other operational satellite products such as MODIS surface reflectance data, the mean relative error (MRE) is less than 10%. Combining the GEO and reanalysis data is more effective method for the atmospheric correction of LEO satellite.

1. INTRODUCTION

The optical imaging sensors onboard satellites having multi-spectral channels detect the radiation at a given wavelength region covered. During the past few decades, different types of satellite sensors have been operated. Recently, hyperspectral sensors have been operated with from aircrafts or satellite platforms. For these sensors, the measured radiation is subject to absorption and scattering by the atmosphere and the surface. In general, 0.2-2.5 μm spectral region is affected by absorbing gas constituents such as water vapor, O_3, NO_2, etc. The shorter wavelength region in the visible wavelengths is also affected by molecular and aerosol scattering. In order to study satellite remote sensing in a various research field, comprehensive removal of atmospheric absorption and scattering is required. Since the mid-1980s, atmospheric correction methods have been developed based on the sensor specified image processing and rigorous radiative transfer modeling. Basically, three different types of atmospheric correction method, which are the image-based empirical technique (i.e., Kruze et al. 1995), radiative transfer modeling approaches(i.e., Gao et al., 1993), and the hybrid approaches (i.e., Clark et al. 1995).

Atmospheric transmittances are dynamic physical parameters in satellite remote sensing requiresd the support of atmospheric constituents with high spatial and temporal resolutions. However, it is limited to meet this requirement with a single satellite sensor. For example, the Operational Land Imager (OLI) onboard the Landsat 8 satellite is able to monitor the variations in the spatial distribution of the earth surface with a 30-m spatial resolution. With the ability to provide timely observation such as the Geostationary Orbit (GEO) satellite meets the requirements for applying the atmospheric correction.

In this study, integration of GEO and LEO satellite data to generate atmospherically corrected images provided by the Landsat-8 OLI. Radiative transfer modelling coupled with surface-atmosphere are employed to test the suggested method. Also, atmospherically corrected reflectance has been tested with the typical operational surface reflectance products for the estimation of the retrieved results.

2. METHODOLOGY

The atmospheric correction of Landsat-8 OLI imagery is to estimate the atmospheric transmission, which is mainly determined by the absorbing gas and particulate scattering with the light path. Due to the inhomogeneous atmospheric constituents including water vapor, O_3, NO_2, and aerosols, estimating the atmospheric transmission in a traditional image-based algorithm is difficult. There exist satellite derived parameters estimated by LEO and GEO satellites observations for the atmospheric transmission calculations. Because integrating the different satellite data are time consuming, the Landsat-8 OLI imagery is corrected in two steps:

1. Landsat-8 OLI L1b reflectance and Himawari AHI derive aerosol data are temporally and spatially collocated for acquiring the clear sky pixels.

2. By assuming a spatially homogenous atmospheric constituents in a larger pixel of the satellite data, atmospheric transmission can be determined. These are then optimized pixel by the transmission correction with the initial inputs estimated from the step 1.

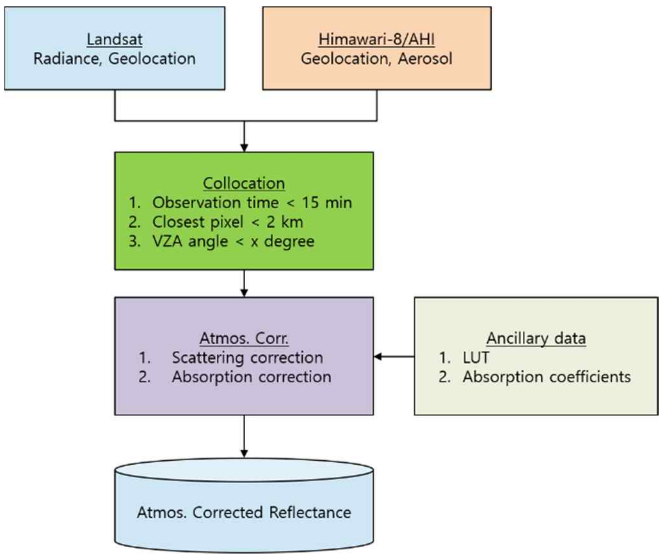

Figure 1. Flowchart of the atmospheric correction with fusion procedure.

The Landsat-8 OLI images used in this study were acquired covering the region of 25ºN-40Nº and 110ºE-130ºE. Geostationary satellite data were chosen by nearly the same time as the Landsat-8 overpassing time. Thus, it is reasonable to assure that the two images were acquired the same observation time. Based on this assumption, it is not necessary to measure/assume atmospheric parameters for Landsat-8 OLI, so atmospheric correction for the Landsat-8 OLI L1B images can be derived directly. The validation with match-ups in the MODIS L2 surface reflectance product or in-situ measurement data.

3. RESULT

Figure 2 shows an example of the differences in the atmospheric correction results of Landsat-8 OLI of the south-east of Korean peninsula acquired on May 2, 2016. These images are the RGB color composite of band 3/2/1. Without atmospheric correction in a left panel, a hazy appearance is shown due to the high concentration of absorbing constituents in the atmosphere (AOT_{500} = ~ 0.27, H_2O = 1.45cm). After the atmospheric correction in a right panel, hazy contributions to the satellite observed reflectance has been removed and clear RGB color composite images has been acquired.

Figure 3 shows histograms of the three Landsat-8 OLI bands (2/3/4) taken from a whole scene of Figure 2. The area is a mixture of vegetation (agricultural, forest, and mountain), urban areas. The form of histograms of the three bands appear different spectral behavior. After the atmospheric correction, peak shifting, little broadening, and reflectance reduction of the histograms are shown due to dependence of atmospheric correction. These changes are converted into increase of contrast between lowest and highest surface reflectance.

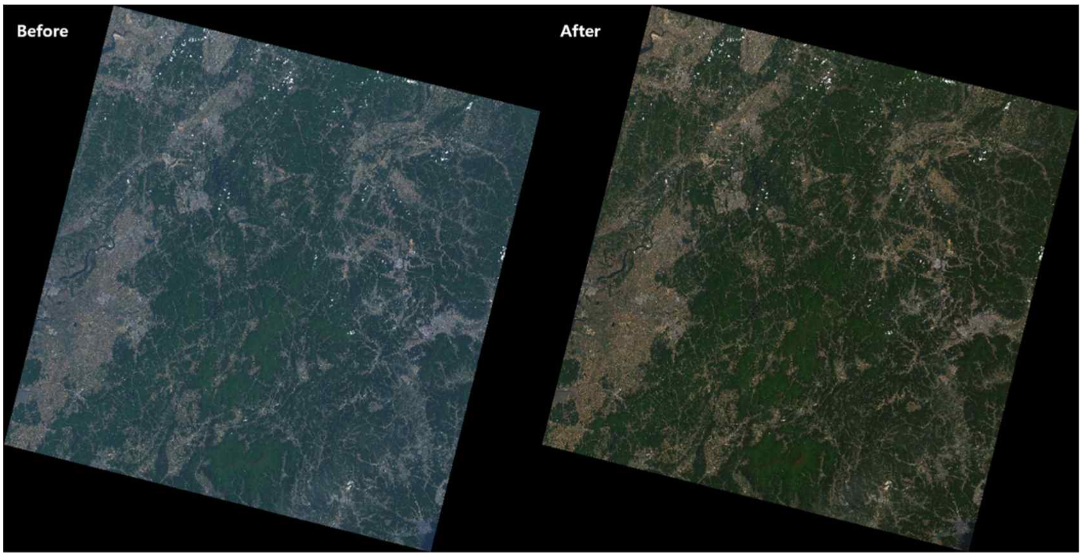

Figure 2. RGB color composite images produced from the top-of-atmosphere reflectance without atmospheric correction (left) and with atmospheric correction (right). Landsat-8 OLI L1b data acquired in South Korea on May 2, 2016.

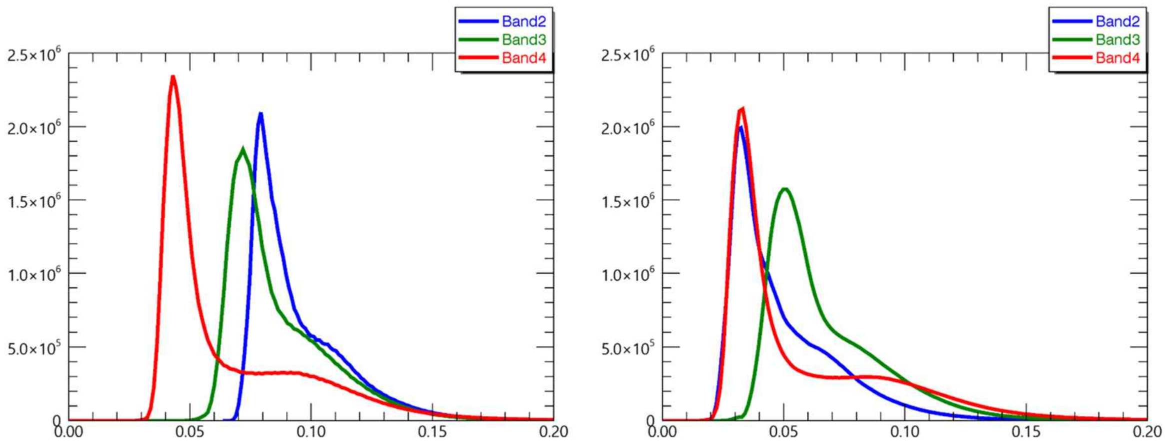

Figure 3. Histograms of the pixel reflectance values taken from the Figure 2.

4. SUMMARY

The atmospheric correction under the inhomogeneous variations of the atmospheric constituents using a single satellite sensor, such as the Lanbsat-8 OLI, has been limited by unknown atmospheric transmission information. This study estimated the atmospheric correction for Landsat-8 OLI data by using integration of the LEO and GEO satellite data products. Satellite derived atmospheric constituents were used to determine atmospheric transmission which is important parameter for the atmospheric correction. The results show that the atmospherically corrected Landsat-8 OLI images are enable to show the spatial details of local surfaces. Moreover, thanks to the derived high-resolution atmospheric constituent data leading to the reasonable atmospheric environmental parameters. These provide an opportunity to study the spatial and temporal variations in atmospheric transmission estimation, particularly for the high-resolution remote sensing image without in-situ measurements. However, imperfect atmospheric corrections can increase by using the uncertainty of each satellite products. Therefore, further research is required to address the uncertainty in the atmospheric corrections of various satellite sensors

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