THE APPLICATION OF THE TOMS AEROSOLS RETRIEVAL ALGORITHM TO GLI MEASUREMENTS

Hyun Jin Lee[1], Jae Hwan Kim[1], Hajime Fukushima[2], and Kyung-Ja Ha[1]

1 Department of Atmospheric Science, Pusan National University, Korea
2 School of High-Technology for Human Welfare, Tokai University, Japan
Corresponding author address: Hyun Jin Lee, Department of Atmospheric Science, Pusan National University, Pusan 609-735, Korea
(E-mail) hyunjin@pusan.ac.kr

ABSTRACT:

We have applied the TOMS aerosols retrieval algorithm to GLI measurements. TOMS has utilized the aerosol index, which is a measure of the change in spectral contrast due to the wavelength-dependent effects of aerosols. We have retrieved the GLI aerosol index, which is made by the pair of 380/400nm, 380/412nm, 380/460nm, and 412/460nm. We have found that the biomass burning aerosols represent the absorbing aerosols. In addition, the pair of 380/460nm has shown the best signal for detecting aerosols in Principal Component Analysis(PCA) and comparison of aerosol optical thickness from AERONET data. The theoretical aerosol index is also shown the best signal in the pair of 380/460nm.

KEY WORDS: TOMS AI, GLI, aerosols retrieval

1. INTRODUCTION

Tropospheric aerosols play important roles not only as an air pollutant but also as a controller of the global energy budget through direct and indirect radiative forcing. The satellite measurements are significant to detect the aerosols signal due to a global distribution of aerosols. However, the detection of tropospheric aerosols from satellite measurement is limited to the regions over land, because the surface reflectance of land is larger than aerosol reflectance in top of the atmosphere. It is well known that the UV bands have an advantage of aerosol retrieval due to the low surface reflectance and a weak effect of Bidirectional Reflectance Distribution Function (BRDF)(Torres et al., 2002). Total Ozone Mapping Spectrometer(TOMS) has utilized the aerosol index, which is a measure of the change in spectral contrast due to the wavelength-dependent effects of aerosols. The positive value in TOMS Aerosol index indicates the absorbing aerosols such as the biomass burning aerosols and dust aerosols. On the other hand, the negative value represents the non-absorbing aerosols such as sulfate and sea-salt particles. However, TOMS has the poor spatial resolution(50kmx50km in nadir).

In this study, we have applied the TOMS aerosol index to Global Imager(GLI) measurements, which has the UV channel, 380nm, with high resolution(1kmx1km). In order to validate the GLI aerosol index, we have used the Principal Component Analysis(PCA) and comparison of aerosol optical thickness from AERONET data.

2. DATA

The GLI instrument aboard the ADEOS-2 satellite has 36 channels ranging from the near-UV to the thermal-IR. GLI has several unique wavelength bands, including a channel in the near UV at 380nm. We have utilized the same orbital track data for neglecting BRDF during May 2003. We have taken an average 0.1°x0.1° due to the presence of noise in pixels. Table 1 shows the dataset in this study.

Table 1. Characteristics of dataset in this study.

Sensor	Application	Bands
GLI	Same orbital track data during May 2003	380nm, 400nm, 412nm, 460nm, 490nm, 680nm, 760nm, 860nm, 1130nm, 2100nm

3. METHODOLOGY

Herman et al.(1997) suggested TOMS AI which are a measure of the change in spectral contrast due to the wavelength-dependent effects of aerosols. As used this algorithm in GLI, the aerosol index is modified as

$$AI = -100\log\{[(I_{\lambda 1}/ I_{\lambda 2})]meas\} + 100\log\{[I_{\lambda 1}(A_{LER\lambda 1})/ I_{\lambda 2}(A_{LER\lambda 2})]calc \quad \text{(Eq.1)}$$

where $(I_{\lambda 1}/ I_{\lambda 2})meas$ are the measured backscattered radiance at two wavelength $(I_{\lambda 1} > I_{\lambda 2})$ and $(I_{\lambda 1}/ I_{\lambda 2})calc$

are the radiance calculated using a radiative transfer model for a pure Rayleigh atmosphere. A_{LER} is the wavelength dependent surface reflectance. In order to calculate the aerosol index, we have retrieved the background surface reflectance as function of wavelength using the minimum reflectance over study period, which represents pure surface reflectance. Based on the derived background surface reflectance, a pure Rayleigh atmosphere using Lookup table is calculated and the aerosol index is applied to GLI measurements in the presence of biomass burning aerosols over Korean peninsula. In order to examine the GLI aerosol index, theoretical aerosol index is simulated with the radiative transfer model, Rstar5b. In the model, we have composed the database of aerosol properties such as aerosol size distribution, refractive index, and aerosol height from AERONET sites, which are located in Beijing, Shirahama, Noto, Anmyon, and Gosan. Then the PCA, which determines which part of the multi-spectral signal is suitable to common image in all the channels (the pair bands in this study), has been performed for investigating the suitable pair of GLI aerosol index in detection of aerosol. In addition, we have compared the GLI aerosol index with the aerosol optical thickness from AERONET sites.

4. RESULTS

4.1 Surface reflectance

We have retrieved the background surface reflectance as a function of wavelength during May 2003(not shown). The background surface in each wavelength shows the different values. However, there are similar patterns, which show low values in vegetation area and high values in soil area. To validate, we have compared the average specific area(vegetation area, 128°E~130°E, 36°N~ 38°N) with previous study. The background surface reflectance of longer wavelength increases slightly and shows a peak at 1130nm. This pattern is consistent with Soufflet et al.(1997).

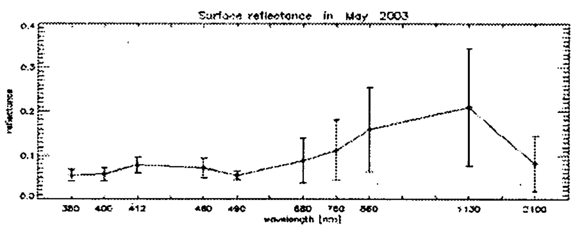

Figure 1. The derived surface reflectance.

4.2 GLI aerosol index

It is well known that dark area has an advantage to detect the aerosols due to the high contribution of surface reflectance in the top of the atmosphere(King et al., 1999). Therefore, we have selected the short wavelengths such as 380nm, 400nm, 412nm, 460nm, and 490nm, which show the low surface reflectance and thereby are selected to test the possible pair of aerosol index. However, we have not calculated the wavelength of 490nm, because the wavelength of 490nm in GLI is saturated at clouds and aerosols. Based on the theoretical aerosol index, this algorithm has been applied to GLI measurement on May 21, 2003, when it is covered with Russian biomass burning aerosols over Korea peninsula(Fig. 2). The aerosol index of the pair of 380/412nm and 412/460nm is not able to represent the presence of aerosols, because the wavelength of 412nm is saturated at aerosols and clouds. However, the GLI aerosol indexes indicate the absorbing aerosols and show the regional pattern of the aerosol optical thickness.

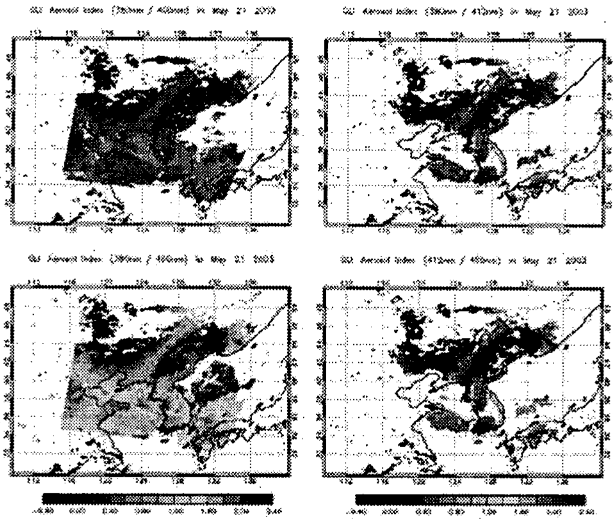

Figure 2. The GLI aerosol index of pair of 380/400nm, 380/412nm, 380/460nm, and 412/460nm.

4.3 Validation

4.3.1 The theoretical aerosol index

In order to examine the sensitivity of the GLI aerosol index, we have performed the aerosol index using radiative transfer model with the derived background surface reflectance in Fig. 1. Figure 3 shows the theoretical aerosol index using the pair of 380/400nm, 380/412nm, 380/460nm, and 412/460nm. The biomass burning aerosols indicate the absorbing aerosols, because of the positive values. This pattern is consistent with GLI aerosol index and Hsu et al.(1999). The theoretical aerosol index increase as the loading of aerosol is present. In addition, the aerosol index in the pair of 380/460nm is sensitive to the aerosol signal.

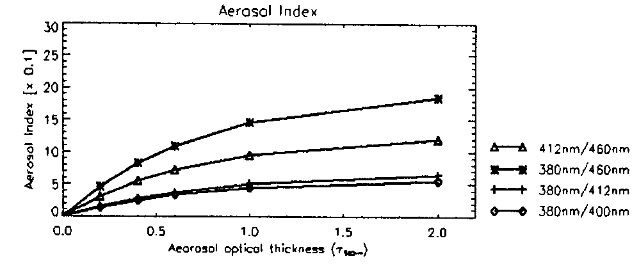

Figure 3. The theoretical aerosol index.

4.3.2 The Principal Component Analysis(PCA)

We have performed the PCA for investigating the suitable pair of GLI aerosol index in detection of aerosol (Fig. 4). PCA is the technique to determine the high contribution in Principal Common Image(PCI) to analyze the best pair of the aerosol index, even though the wavelength of 412nm is not able to be used due to saturation. The PCI contains a contribution from each pair, although the value of contribution in PCI is the positive and the negative. Figure 4 shows the contribution. In this figure, the pair of 380/460nm shows the highest, so we have concluded that the aerosol index of the pair of 380/460nm is the most sensitive to the detection of aerosol signal in the given GLI channel pair.

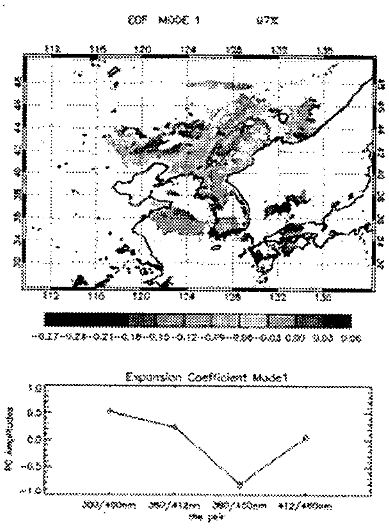

Figure 4. The Principal component image(upper) and principal component analysis(lower).

4.3.3 The comparison of AOT from AERONET sites

The aerosol index represents the presence of aerosols. Therefore, we have retrieved the GLI aerosol index during May 2003 and compared the GLI aerosol index with the aerosol optical thickness from AERONET sites. However, because the wavelength of 412nm is saturated at aerosols, we have excluded the analysis of GLI aerosol index in pair of the 380/412nm and 412/460nm. Therefore, we have compared the pair of 380/400nm and 380/460nm and found that the pair of 380/460nm is sensitive to the aerosol signal than that of 380/400nm(Fig. 5).

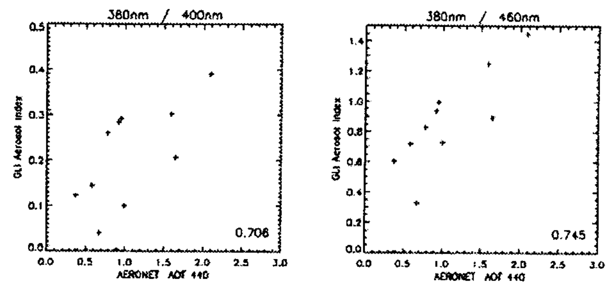

Figure 5. The correlation between AOT at 440nm derived from AERONET sites and aerosol index retrieved the pair of 380/400nm(left) and 380/460nm(right) from GLI measurements. The number means a correlation coefficient between AOT and aerosol index.

5. CONCLUSION

The detection of tropospheric aerosols from satellite measurement is limited to the regions over land, because the surface reflectance of land is larger than aerosol reflectance in top of the atmosphere. It is well known that the UV bands have the advantage of aerosol retrieval due to the low surface reflectance and a weak effect of BRDF. TOMS have utilized the aerosol index, which is composed of the two UV channels. However, TOMS has the poor spatial resolution. In this study, we have applied the TOMS aerosol index to Global Imager(GLI) measurements, which has the UV channel, 380nm, and high resolution(1kmx1km). We have found that the pair of 380/460nm has shown the best signal for detecting aerosols in the analysis using the PCA and with comparison to the aerosol optical thickness from AERONET data. The analysis of the theoretical aerosol index also shows that the pair of 380/460nm is the most sensitive among pairs.

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