Reflectance Band Ratios in Japan Using Satellite and Sky Observation Data

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Abstract: We observed the aerosol optical properties, such as the optical thickness (τ_A) and Ångström exponent α over Kanazawa area, Japan for the period of seven months from Oct. 2003 to April 2004. using the sky radiometer. The reflectance ratios between the visible and short wave infrared bands were computed for the classes of the vegetation, urban, and the others using several data sets of Terra/MODIS and the sky observation data. The computed band reflectance ratios were compared with those by Kaufman et al. (1997)[1] and us (2003)[2].

Key Words: *Aerosol, Optical Thickness, Atmospheric Correction*

1. INTRODUCTION

In the atmospheric correction of the remotely sensed earth image data we need the information on the aerosol optical parameters, such as the optical thickness τ_a, Ångström exponent α, and the type of size distribution. A method for estimating them from the satellite-measured data itself is highly desirable. It was found by Kaufman et al.(1977)[1] that there existed an empirical reflectance band ratio for a few land categories between the visible reflectance and middle IR reflectance as follows:

$r_{B1}/ r_{B7} = C_{1\,v}=0.50$ (vegetation) (1),
$r_{B3}/ r_{B7} = C_{3\,v}=0.25$ (vegetation) (2)
$r_{B1} / r_{B7} = C_{1u}=0.69$ (urban, and the other) (3),
$r_{B3} / r_{B7} = C_{3u}=0.42$ (urban, the other) (4),

where r_{B7}, r_{B1} and r_{B3} are the reflectance values in the band 7(2.15μm), band 1(0.645μm) and band 3(0.469μm) of Terra/MODIS. They obtained the reflectance band ratios using the ground and airborne measurement data in USA. Since the aerosol scattering effects are negligible in the band 7, we can obtain the surface reflectance in Band 7 by removing only molecular attenuation and water vapor absorption effects. The surface reflectance in band 1 and 3 can be easily found from the above reflectance band ratio. For given surface reflectance values for those classes, we can retrieve distributions of aerosol optical thickness in Bands 1 and 3 by using LUT(Look Up Tables) in which the theoretical radiances at the top of the atmosphere(TOA) are tabulated as a function of the surface reflectance and the aerosol optical

thickness for given bands and angles of the incident and reflection.
In our previous study[2], these reflectance ratios in Japan were found using the simultaneous sky measurement data and several image data sets of Terra/MODIS over Japan (May 06, 2002, April 07, April 16, May 09, and June 03 in 2003). as follows:

C_{1v}=0.554, C_{3v}=0.547	for vegetation	(5),
C_{1u}=0.580, C_{3u}=0.489	for urban	(6),
C_{1o}=0.503, C_{3o}=0.417	for others	(7),

We should note that there is a large discrepancy in the value of C_{3v} between USA and Japan. Seasonal variations in the reflectance ratio were studied in this paper.

2. COMPUTATION OF REFLECTANCE RATIO

We made sky observations using the sky radiometer (Prede: POM-01) at our study site which is localted on the campus of Kanazawa Institute of Technology for a period of 7 months from Oct. 2003 to April 2004. The aerosol optical parameters, namely, the optical thickness $\tau_a(500)$ at 0.5μm and Ångström exponent α. are deduced by Sky-radiation Pack Code Ver.4. For example, the scatter diagram of them is shown in the case of Oct. 2004 in Fig.1. From Fig.1 it is said that we have aerosol particles with small size ($0.8<\alpha<1.7$) when the aerosol optical thickness is small ($0.2<\tau_a(500)<0.4$). Whereas, we have those with large size (α=0.5) when τ_a(500 is larger than 0.4. During the observation period we found 5 data sets of MODIS in which the study site is included and is seen, namely, on Oct.09, Oct. 20, Oct.25, Oct 27, and Nov. 01, 2003. We computed the surface reflectance values for the area near the study site from the MODIS band 1 and 3 images by removing the atmospheric scattering effects using the deduced aerosol optical thickness and . Ångström exponent values. In the atmospheric correction we assumed Haze M model(coastal aerosol) with refracted index, m=1.33 and the mid-lattitude winter atmosphere model. Then, we classified the sub-image of MODIS near the study site into 5 classes, namely, vegetation, urban, cloud & snow, sea, and the others, by using the maximum likelihood method. The reflectance band ratio values for three classes of vegetation, urban and the others were computed using corresponding surface reflectance values in band 1, 3 and band7. The scatter diagrams for the vegetation were shown in Fig.2. The reflectance band ratios for three classes were by this study as follows:

C_{1v}=0.561, C_{3v}=0.475	for vegetation	(8),
C_{1u}=0.671, C_{3u}=0.525	for urban	(9),
C_{1o}=0.616, C_{3o}=0.487	for others	(10),

These reflectance ratios are different from those in the previous studies[1), 2)]. In this study the acquired dates of used data sets were in Oct. and Nov. 2003 and we assumed the mid-lattitude winter model, whereas they were in April to June 2003 and we assumed the mid-lattitude summer model in our previous study. It is difficult to say that the differences in reflectance band ratio between the current and previous studies is due to the seasonal changes without making sensitivity test on this matter in detail. We have not done it yet.

We retrieved the aerosol optical thickness values over land in Band 1 and 3 of MODIS data using pre-computed LUT of the theoretical radiance at TOP as a function of the reflectance for given angular conditions. The validation results of the retrieved aerosol optical thickness τ_a are shown in Fig.3, based on the new surface reflectance ratios found in this study.

3. CONCLUSIONS

We can conclude by this study as follows:

(1) We presented the surface reflectance ratios between the visible and infrared bands using both MODIS data sets and simultaneously observed sky data in the autumn.

(2) We found that the reflectance ratios for the autumn data are different from those for the spring-summer data. It is too early to say these differences due to the seasonal changes and we will continue to make further efforts on this subject.

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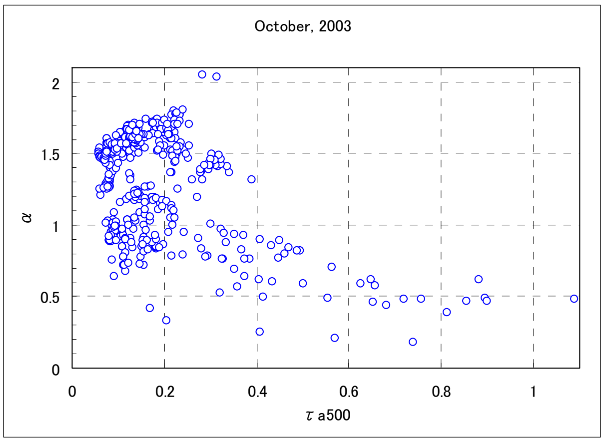
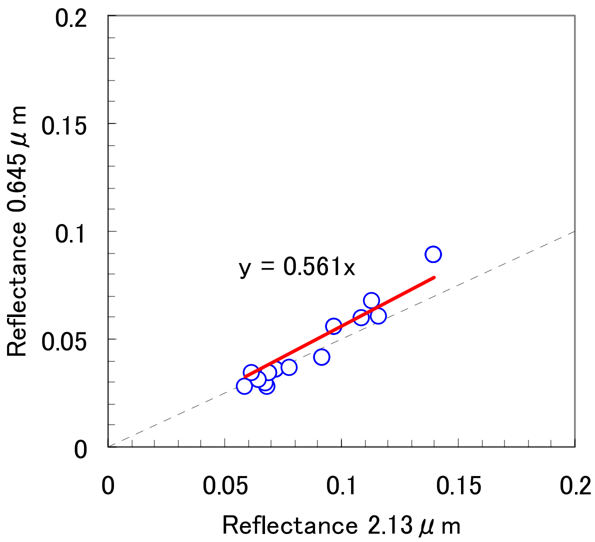
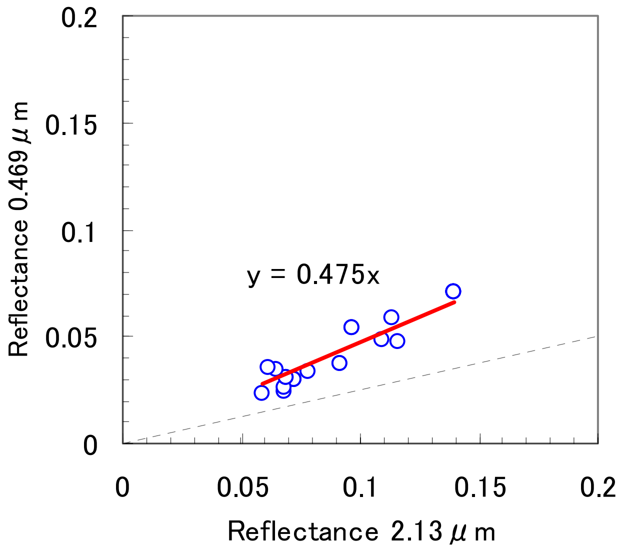


Fig.1. Scatter diagram of aerosol optical thickness τ_a(500nm) and Ångström exponent α.



(a) C_{1v}=0.561



(b) C_{3v}=0.475

Fig.2. Scatter diagrams and Reflectance band ratio. for vegetation

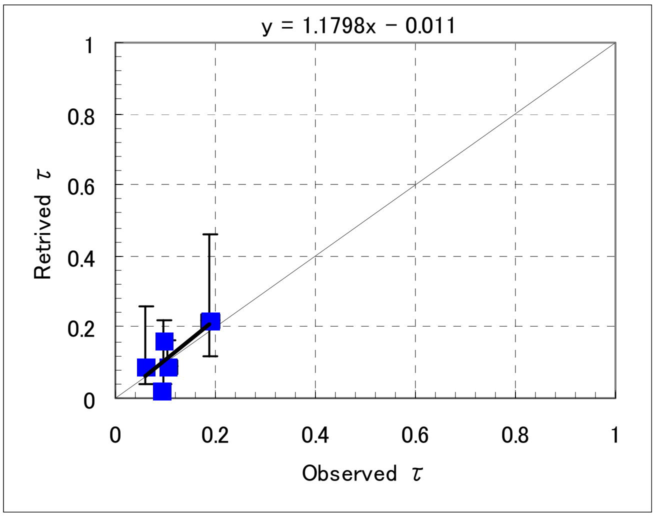


Fig.3. Observed and retrieved $\tau_a(500)$ using the autumn reflectance band.