THE VALIDATION OF AEROSOL OPTICAL THICKNESS RETRIED BY BAND CORRELATION METOD FROM MODIS IMAGE DATA

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ABSTRACT:

We retrieved the aerosol optical thickness τ_a over Japan from several data sets of Terra/ASTER and Landsat-7/ETM+ using the empirical band correlation method. This band correlation method for aerosol retrieval was originally proposed for MODIS data analysis by Kaufman et al.(1977)[1]. The empirical band correlation of surface reflectance for certain land categories in Japan between the visible and infrared bands were computed using several data sets of Terra/MODIS in 2002 and 2003, together with the observed sky radiometer data. The results of retrieved aerosol optical thickness τ_a were validated with the simultaneous sky observation data at our study site. We found a good agreement between the retrieved and observed values.

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 size distribution model. Since the sky observation time is not always synchronized with the time of satellite passing over, the method for retrieving the aerosol optical parameters from the satellite image data itself is highly desirable. The band correlation method is supposed to be useful for retrieving the aerosol optical parameters from satellite data itself. In the band correlation method the empirical surface reflectance ratios for certain land categories between the visible and infrared bands are critically important.

2. BAND REFLECTANCE RATIOS

Kaufman et al.(1977)[1] found that there existed empirical band ratios for a land category between the visible reflectance and middle IR reflectance as follows:

$$r_{B1}/ r_{B7} =C_{1v} \quad \text{(vegetation)} \quad (1)$$
$$r_{B1}/ r_{B7} = C_{1u} \quad \text{(urban)} \quad (2)$$
$$r_{B3}/ r_{B7} =C_{3v} \quad \text{(vegetation)} \quad (3)$$
$$r_{B3}/ r_{B7} =C_{3u} \quad \text{(urban)} \quad (4)$$

where r_{B7}, r_{B1} and r_{B3} are the reflectance values in the band 7(central wavelength:λ=2.16μm), band 1(λ=0.645 μm) and band 3(λ=0.469 μm) of Terra/MODIS. They obtained the reflectance ratios, C_{1v}=0.50, C_{3v}=0.25 for vegetation, C_{1u}=0.69, and C_{3u}=0.42 for urban from the analysis of the TM and airborne measurement data in USA. In this study, we compute these reflectance ratios in Japan 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). First of all we classified the MODIS image data into 5 classes, namely, vegetation, urban, cloud & snow, sea, and other, by using the maximum likelihood method. The band reflectance correlation does not hold for classes of cloud, snow, & sea and these classes are used for screening purpose. The classification map is shown in Fig.1. The reflectance values for three classes of vegetation, urban and other were obtained from Terra/MODIS image data by removing the atmospheric effects using the observed aerosol optical thickness values in Bands 1 and 3. Since the aerosol scattering effects are negligible in the band 7(λ=2.16μm), the surface reflectance in Band 7 was obtained by removing both molecular attenuation and water vapor absorption effects. We found the values of surface reflectance ratio for vegetation, urban and other classes in Bands 1 and 3, applicable in Japan, 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 other (7)

We should note a large discrepancy in the value of C_{3v} between USA and Japan. Seasonal and local variations in vegetation may explain this discrepancy. The scatter diagrams in band reflectance ratio for vegetation class are shown in Fig.2. For given reflectance ratios for these 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. Such examples in band 3 and band 1 are shown in Fig.3-(a) and -(b), respectively.

3. RETRIEVED RESULTS

We retrieved the aerosol optical thickness τ_A over the lands at λ=0.66μm from Terra/ASTER and Landsat-7/ETM+ data, using the band reflectance ratios given by eqns. (4)-(6) in section 2. The aerosol optical thickness map at λ=0.660 μm, retrieved from Terra/ASTER data, is shown in Fig.4 The aerosol optical thickness over the sea was estimated by assuming measured Ångström exponent α at our study site. From seen in Fig.4 we can notice a smooth transition between the sea and land. The validation results of the retrieved aerosol optical thickness τ_A from Terra/ASTER and Landsat/ETM+ image data are shown in Fig.4. Acquired dates of ASTER data sets are on April 02, 2002 and June 08, 2003, and that of ETM+ on April 15, 2001. As seen in Fig. 5, we can find an excellent agreement in τ_A between the estimation and observation.

4. CONCLUSIONS

The following conclusions were made by this study:

(1) We presented new band reflectance ratios for certain land classes between the visible and infrared bands using both MODIS data sets and simultaneously sky observation data.

(2) We confirmed that the band correlation method is a useful method for retrieving the aerosol parameters over lands.

(3) We obtained better results in the aerosol optical parameter retrieval over Japan using new band reflectance ratios than those using Kaufman's band reflectance ratios.

(4) Seasonal and regional variation in the band reflectance ratio should be studied further.

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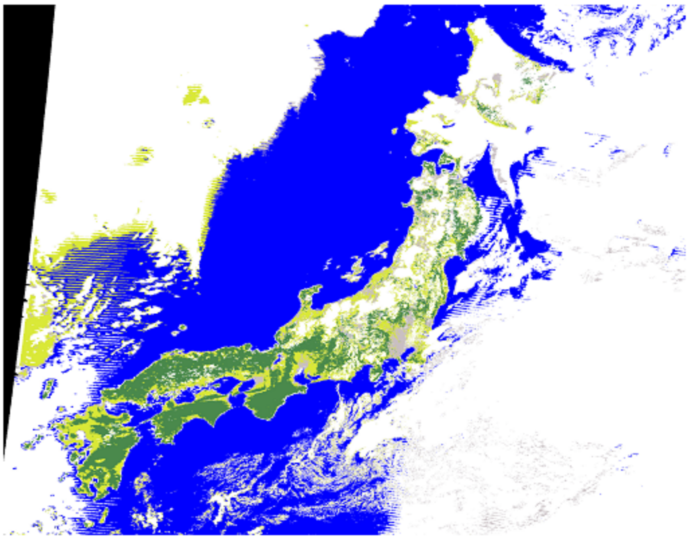


Fig.1. Classification results.

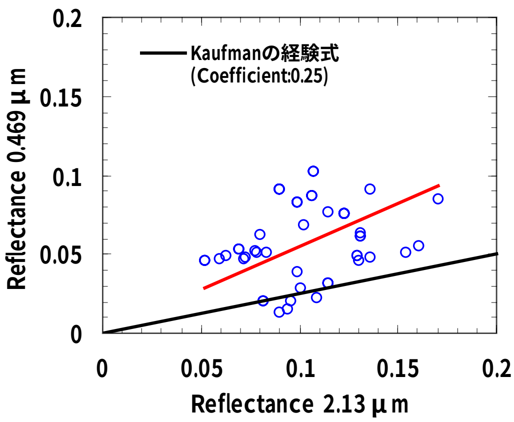


Fig. 2-(a). Band reflectance ratio at 0.469µm. C_{3v}=0.547.

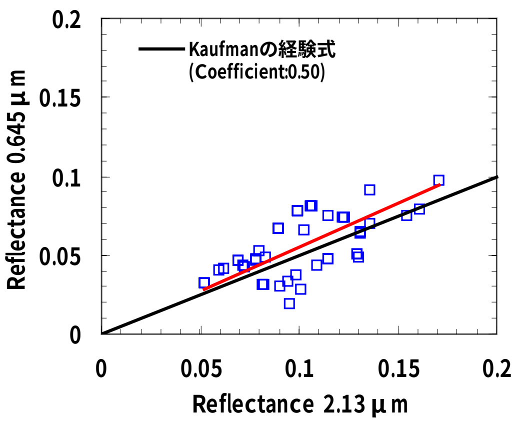
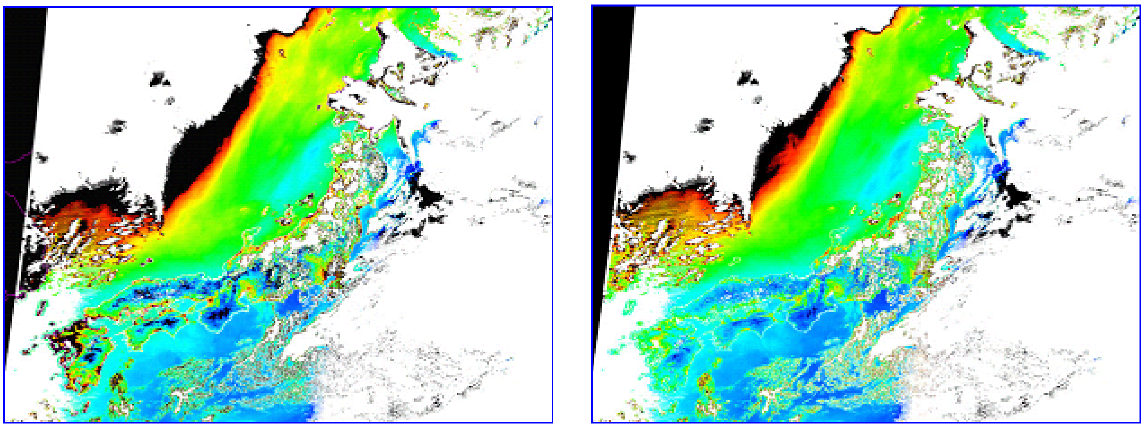


Fig. 2-(b). Band reflectance ratio at 0.645µm. C_{1v}=0.554.



(a) Retrieved t_A in Band 3(0.469μm) (b) Retrieved t_A in Band 1(0.645μm)

Fig.3. Retrieved t_A map near Japan, based on new reflectance ratios found in this study from MODIS data.

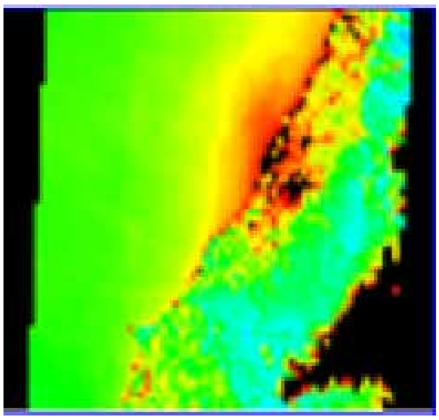


Fig.4. Retrieved τ_A map near Kanazawa city, Japan from ASTER data.

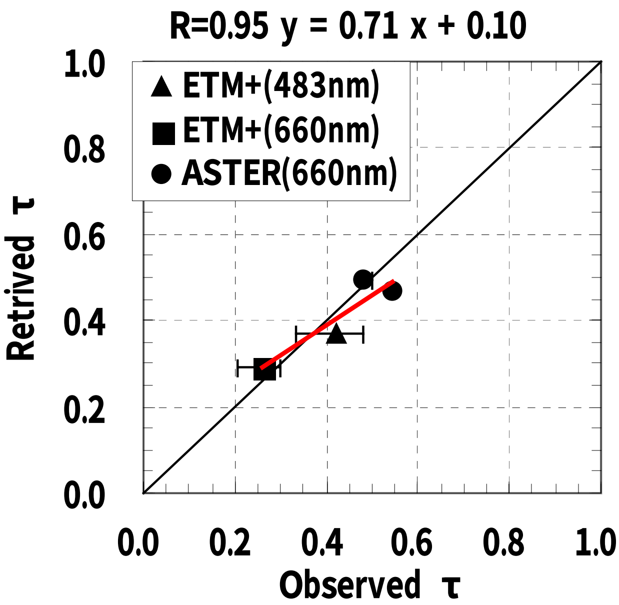


Fig.5. Validation of retrieved τ_A from ASTER and ETM+ data.