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Validation of Aerosol Optical Depth Retrieved from SPOT Satellite Images

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ABSTRACT: In this paper, the image-based retrieval algorithm of aerosol characteristics and surface reflectance is used to retrieve the AOD from SPOT images. The validation of retrieved AOD is made possible by using the AERONET data. Five SPOT satellite images are used to testify the algorithm. The results show that the RMSE of the retrieved AOD are 0.12 and 0.08 in XS1 and XS2 bands, although the largest error is 0.14 and some retrieved Junge ? parameter is abnormally larger than 4. Of course, more studies should be conducted to conclude the algorithm.,

1. INTRODUCTION

The importance of the aerosol is mainly due to the radiative forcing of climate by reflecting the sunlight back to space (Penner et al., 1992; Kiehl et al., 1993). Its uncertainty can also cause the uncertainty of the climate change model (Hansen and Lacis, 1990). It is also the main uncertainty for the atmospheric correction of remotely sensed data, which seems the only way that can supply the routine monitoring of the aerosol.

Retrieval of aerosol mainly relies on the use of dark targets (Kaufman et al. 1997). Due to the good correlation between visible reflectance (blue and red bands) and mid-IR reflectance (2.1 and 3.8μm), several priority based on the assumptions of this correlation has been chosen to monitor global aerosol distribution for EOS-MODIS radiometer. When there's no mid-IR channel, it seems aerosol can be only estimated from dense dark vegetation (DDV) targets (Kaufman and Sendra 1988), which are obtained by using the NDVI and low NIR reflectance. Since the necessity of the assumptions of the aerosol size distribution, single scattering albedo, and the refractive index, errors (~30%) exit in the retrieved aerosol optical depth (AOD) due to the aerosol effect on the NDVI.

Followed by the previous study (Liu and Vermote, 2000), the validation of the retrieved AOD from SPOT image is presented in this study.

2. ALGORITHM OF RETRIEVAL OF AEROSOL OPTICAL DEPTH

A image-based retrieval algorithm of aerosol characteristics and surface reflectances is used to retrieve the aerosol optical depth from SPOT images (Liu et al. 1996). The algorithm is briefly stated as following steps:

1. determine optical depth of Rayleigh scattering, O3, H2O and gas from LOWTRAN 7 (Kneizys et al. 1988), 5S (Tanre et al. 1990) or 6S (Vermote et al. 1997) code;
2. assume aerosol physical parameters include Junge size distribution (the initial ν is 3.0), refractive index (1.5322-0.01174i for continental model) and size range [001,10.];
3. determine the single scattering albedo, phase function and asymmetry factor by Mie theory;
4. generate satellite received radiance L=L(AOD) for given known reflectances of DDV in XS1 and XS2 bands;
5. determine AOD in XS1 and XS2 bands from determined digital counts of DDV from SPOT image using step 3;
6. determine Junge parameter ν by Angstrom formula;
7. check if the criterion = deviation of AOD(XS1) between two iterations smaller than an epsilon. If the answer is yes, AOD(XS3) is obtained by using the Angstrom formula with ν in step 6 and the procedure stops; if not, compute the new ν' and go to step 1. Maximum iteration number can be chosen to stop the iteration, if the criterion is not satisfied.

Figure 1 depicts the procedure of the algorithm of AOD retrieval from SPOT images.

3. DATA DESCRIPTIONS

Five SPOT images located at Chung-Li in northern Taiwan are selected in this paper (table 1). Scanning dates range from 1998/06 to 2000/09. The solar zenith angles are 20.6^o~42.5^o, and the viewing zenith angles are 3.6^o~30.4^o. The viewing direction is in back-scattering region if the relative azimuth is smaller than 90^o. There are three images scanned from back-scattering region.

The NCU_Taiwan station in AERONET (AErosol RObotic NETwork) (Holben et al., 1998) are used to testify the algorithm. Angstrom formula is used to interpolate the AOD in central wavelength of XS1 and XS2 bands from measurements in 440nm and 670nm.

4. ANALYSIS AND DISCUSSIONS

Figure 2 and figure 3 show the retrieved AODs compared with the measurements by sunphtometer in XS1 and XS2 band, respectively. The RMSEs of the retrieved AOD are 0.12 and 0.08 in XS1 and XS2 bands (table 2). The maximum errors in XS1 and XS2 bands are 0.14 and 0.13, respectively. Compared with the accuracy of retrieved surface reflectances (~0.02), the results are quite satisfactory. Nevertheless, some retrieved ?s, e.g. 1998/11/08, 1999/10/13, 1999/10/21, are abnormally larger than 4 which can be attributed to the error of assumption of the DDV reflectances (table 3).

5. CONCLUSIONS

The validation of retrieved AOD for SPOT images is studied in this paper. The image-based retrieval of aerosol characteristics and surface reflectance algorithm is used. Although the RMSE is relatively small, some retrieved Junge ? parameters are abnormally larger than 4 which may be due to the error of the assumption of the DDV reflectances. Of course, more studies should be conducted to conclude the algorithm.,

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Table 1. Solar and scanning geometries of SPOT images.

Date	θ_s*	θ_v**	ϕ***
1998/06/27	20.64	30.35	13.79
1998/11/08	42.49	13.09	119.83
1999/10/13	36.24	25.46	46.46
1999/10/21	37.04	3.57	124.74
2000/09/20	28.98	17.19	52.81

*: solar zenith angle; **viewing zenith angle; ***relative azimuth angle.

Table 2. Errors of retrieved AOD from SPOT images (table 1).

XS1			XS2		
Max	Min	RMSE	Max	Min	RMSE
0.14	0.02	0.12	0.13	0.01	0.08

Table 3. Comparisons of measured and retrieved Junge ? parameter. Measured Junge ? parameter is computed from all measurements (440nm, 670nm, 870nm, 1020nm) of sunphotometer. R2 is determinant coefficient modeled for Angstrom formula. Some retrieved ?s are larger than 4 which can be attributed to the error of assumption of the DDV reflectances.

Date	Measured		Retrieved
	Junge ?	R2	Junge ?
1998/06/27	3.66	0.99	3.53
1998/11/08	3.23	0.99	4.46
1999/10/13	3.02	0.89	6.88
1999/10/21	3.21	0.99	4.35
2000/09/20	3.40	0.99	3.15

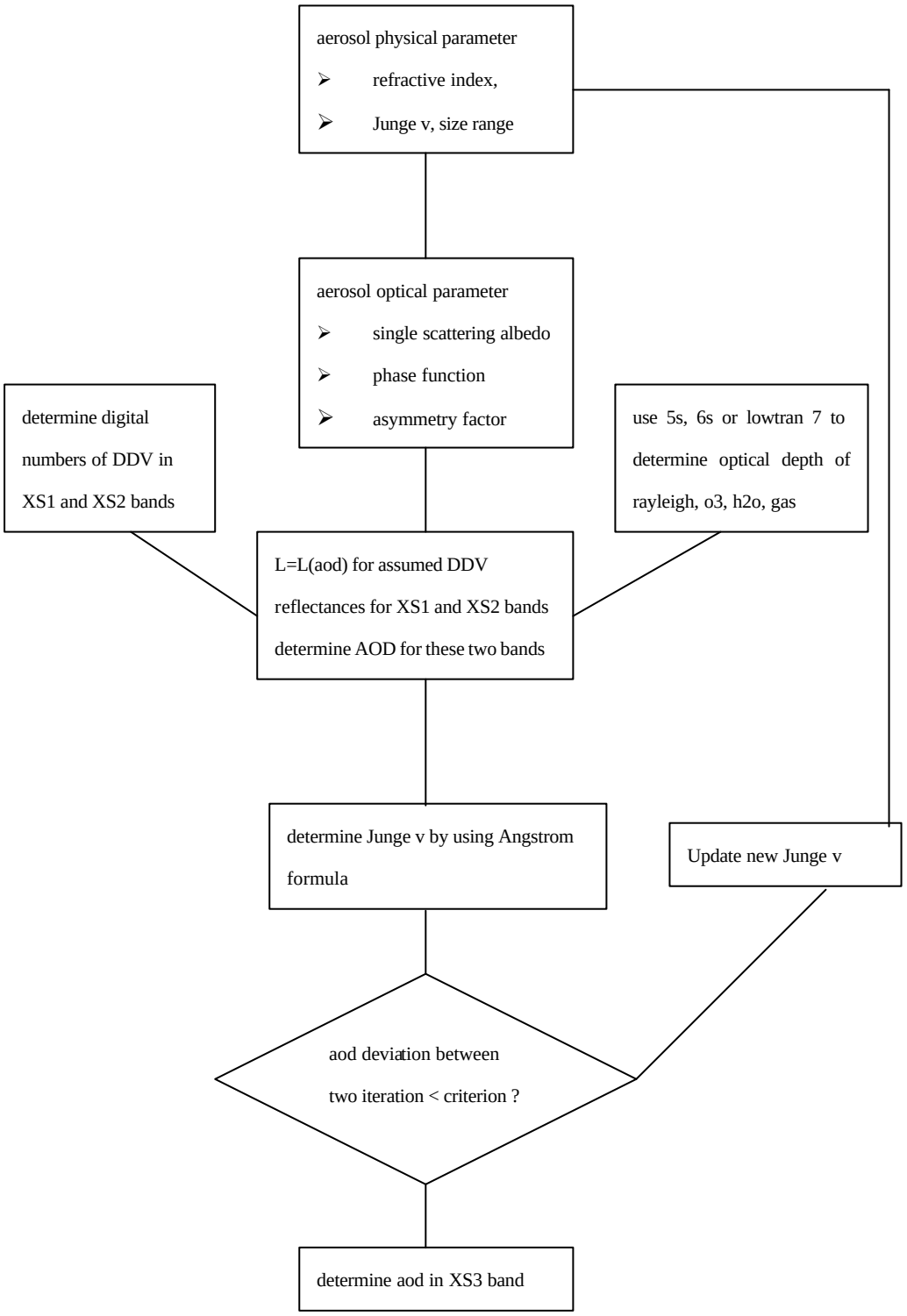

Figure 1. Algorithm of retrieval of aerosol optical depth from SPOT images

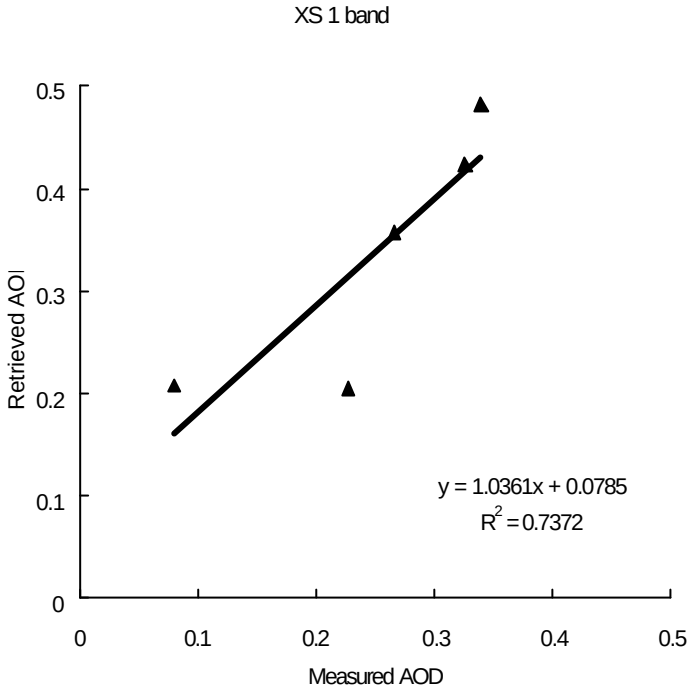

Figure 2. Retrieved aerosol optical depth compared with sunphotometer data in XS1 band.

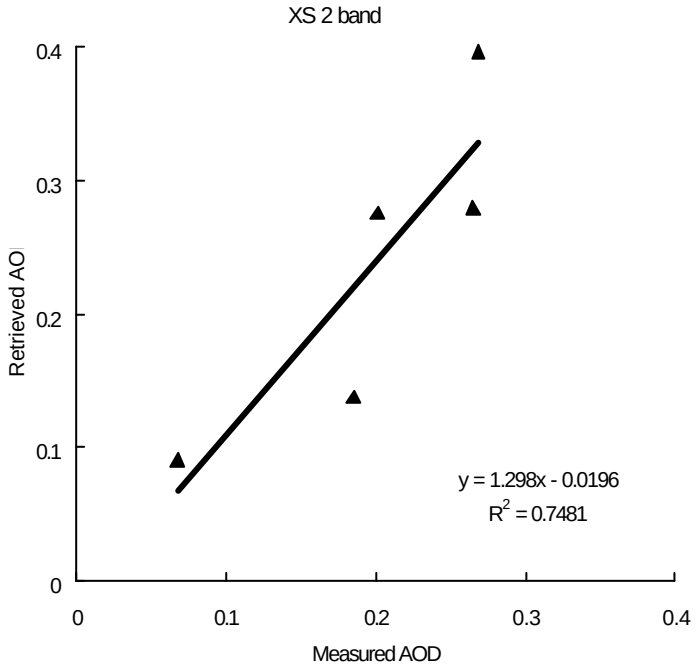

Figure 3. Same as figure 2, except in XS2 band.