Journal of the Korean Society of Remote Sensing, Vol. 14, No.3, 1998, pp.307~314

Aerosol Optical and Spectral Characteristics in Yellow Sand Events on April, 1998 in Seoul. Part I: Observation

Hye-Sook Park, Hyo-Sang Chung, Gyun-Myeong Bag, and Hong-Ju Yoon

Remote Sensing Research Laboratory, Meteorological Research Institute(METRI),

분광복사계와 일사계 관측에 의한 황사 및 에어러솔의 광학적 특성 연구

박혜숙 · 정효상 · 박균명 · 윤홍주

기상연구소 원격탐사연구실

Abstract

To examine the detectability of the yellow sand and/or aerosol from China crossing over the Yellow Sea within the range of OSMI wavelengths(400 – 900 nm), we have investigated the optical characteristics of aerosols in yellow sand events observed on April, 1998 in Seoul.

The spectral reflectance(%) and aerosol optical thickness in the range of Visible(VIS) and near Infrared (NIR) wavelengths were derived from the measurements of solar radiation using the GER-2600 spectroradiometer and sunphotometer during the April, 1998. The average spectral reflectance for the yellow sand events is over 40% and higher around 14:30 than 12:00 LST, but that for clear days is about 20% both at 12:00 and 14:30 LST in the range of 500-900 nm. The aerosol optical thickness at 501 nm varied from 0.25 on very clear day to 1.01 during a so-called "yellow-sand" episode and that for 673 nm varied from 0.14 to 0.92, respectively.

요 약

1999년에 발사 예정인 다목적 실용위성 1호(KOMPSAT-1)에 탑재되는 해색관측센서(OSMI: Ocean Scanning Multispectral Imager)로 관측될 자료를 이용하여 대기 황사 및 에어러솔의 탐지 가능성을 조사하기 위하여 황사 발생시의 에어러솔의 광학적 특성을 분석하였다. 본 연구에서는 '98년 4월 서울에서 관측된 황사현상 때의 대기 복사량을 지상에서 분광복사계를 이용하여 측정하였으며 이로부터 에어

러솔의 파장별 반사도(%)를 구하였고, 동일한 날에 대해 직달일사계로 관측한 일사량으로부터 에어러솔의 광학적 두께를 구하였다.

본 연구에서 처음으로 실시한 분광복사 관측 결과, 황사현상시 태양복사는 대기 중에 부유하는 황사입자에 의해 많이 산란 및 반사되는 것을 확인할 수 있었다. 황사현상일의 경우 관측된 평균 반사도는 500-900 nm 파장대에서 40% 이상으로 오후가 정오 무렵보다 더 높았고, 맑은 날에는 정오와 오후 모두 반사도가 평균 20% 정도였다. 파장별 반사도는 황사발생일의 대기 조건에 따라 달라지지만, 본 연구에서 분석된 사례일에 대해서는 500-900 nm 파장대에서 반사도가 40%에서 70%까지 증가하였다. 한편 501 nm에서 에어러솔의 광학적 두께는 맑은 날의 경우에는 0.25에서 황사현상일에는 1.01까지 증가하였고, 673 nm에서는 맑은 날의 경우 0.14에서 황사현상일에는 0.92까지 변하였다. 이와같이 황사발생시, 대기 에어러솔에 의한 반사도와 광학적 두께는 OSMI 파장대(400-900 nm)에서 매우 민감하게 반응함으로 OSMI 위성자료는 황사 및 에어러솔의 특성 파악 및 탐지에 매우 유용하다.

1. Introduction

A large amount of yellow sand and dust particles is uplifted in the NW Chinese Continent by frontal activities and transported to the Korean Peninsula, the Japan Islands, and the North Pacific Ocean crossing over the Yellow Sea in springtime(Takayama and Takashima, 1986). These transported yellow sand particles contribute significantly to the atmospheric turbidity over Korea in spring(March – May). We observed the yellow sand events three times in this season, 1998. Especially, the second event was severest and lasted very long time from 14 to 22 April. The visibility was below 6 km at that time. This phenomenon might be caused by the abnormal high and dry temperature due to the EL-NINO formed dry surface and produced much dust storms in China.

In order to examine the optical characteristics of aerosols during the yellow sand events, we carried out ground measurements of the solar radiation using the GER-2600 Spectroradiometer. In addition, we compared the aerosol optical thickness of the yellow sand days and clear days derived from in situ measurement using the sunphotometer in the METRI (Meteorological Research Institute). Aerosol optical characteristics in the yellow sand events had been observed in Japan by Tanaka et al.(1989), and Fouquart et al.(1987) had derived the optical thickness of the desert aerosol from the ground-based measurement by the single particle optical counters. Much studies have been carried out the optical thickness of desert yellow sand by the satellite data(Takayama and Takashima,1986; Kawata and Okumura,1996).

In this study, we present the preliminary results of the aerosol and/or yellow sand detectability using the Ocean Scanning Multispectral Imager(OSMI), which will be mounted on KOMPSAT-1 as the ocean color monitoring sensor with the range of 400-900 nm wavelength.

2. Data and Methods

We classify the clear days and yellow sand event days to compare the spectral and optical characteristics of the yellow sand from the ground-based measurements using the sunphotometer and spectroradiometer, respectively.

Solar radiation was measured at the roof of the Meteorological Research Institute(METRI: 37.57° N, 126.97° E) during the April using the GER-2600 instrument. The GER-2600 is a light weight, battery operated field portable spectroradiometer with full real-time data acquisition from 350 to 2500 nm with the 1.5 nm resolution from 350 to 1050 nm and 11.5 nm resolution in the range of 1050 to 2500 nm wavelength. Table 1 shows the specifications of the GER-2600 spectroradiometer. The merits of this instrument are high resolution, high speed and array-base measurement. This spectroradiometer measures the radiance, irradiance and reflectance/ transmittance, and the observed data are used for the environmental testing, vegetative stress analysis, forestry and crop analysis, marine life studies and ground truthing.

Table 1. The specifications of the GER-2600 spectroradiometer.

Model	Spectral Range(nm)	Band width Sampling	Detectors	Channels	Scan Time	Display	Weight Head (Approx.)
Ger-2600	350 - 2500	1.5 nm for 350-1050 nm/ 11.5 nm for 1050-2500 nm	Si/PbS	640	0.5 sec, Up	Real-Time	11 lbs/5.0 kg

In this measurement, we used the 20 m fiber optic cable with 23° Field of View. The GER-2600 spectroradiometer measures the atmospheric radiance and produces the spectral reflectance(%) of the target. In order to determine the reflectance of a target, two measurements are required ; the spectral response of a reference sample and that of the target material. The reflectance spectrum is then computed by dividing the spectral response of the target material by that of a reference sample. In our case, the reference is the white barium plate assuming perfect reflection and the target is the atmosphere. The atmospheric spectral radiance was observed by emission technique to exclude the water vapor effects. The one thing to pay attention is the position of the sun should be placed directly behind the viewer's back.

In addition, we compared the aerosol optical thickness derived from the solar incident radiation measured at METRI by the sunphotometer using the Langley method(Fr hlich and shaw, 1980). Spectral measurements were made with interference filters set on the rotating disk. In this study, we only selected and compared the values at 501 and 673 nm.

3. Results and Discussion

The solar radiance spectrum measured by the GER-2600 spectroradiometer is absorbed mainly by the H_2O, O_2, O_3 in the VIS and near IR wavelength range. The H_2O bands of importance are at 720 and 820 nm ; those of O_2 are 690 and 760 nm; those of O_3 are 450 and 770 nm(Iqbal, 1983; Liou, 1980). If we select the bands suitable to the detection of the yellow sand and/or aerosol, we must choose the wavelength except for the absorbing ranges by the atmospheric absorber. In our study, we found that the range of 670 - 676 nm is suitable for the aerosol detection., which is well verified from the distribution of absorption line strengths of gases by Park et al.(1987).

Figure 1 shows the spectral reflectance(%) in the clear days(March 31 and April 6) and yellow sand event days(April 16 and 20). The reflectance is closely connected with the particles of yellow sand and aerosol in the atmosphere. As shown in Fig.1, the reflectance around 12:00 LST is smaller than 14:30 LST and the reflectance of the yellow sand events was greater than the clear day. The reflectances for the clear days in the range of 500 - 900 nm are about 20%, but those for yellow sand events are over 40% both at 12:00 and 14:30 LST. It can be explained that the yellow sand and/or aerosol reflects the solar radiation with the 10 ~ 20% growth around 12:00 LST and over 20 ~ 40% increasing of reflectance around 14:30 LST between 500 ~ 900 nm wavelengths. We could confirm the yellow sand phenomenon around noon is severer on 20 than 16 April, and that in the afternoon is heavier on 16 than 20 April. These were also well coincide with the values of aerosol optical thickness in Fig. 2(a). The observations by GER-2600 spectroradiometer represents clearly the spectral characteristics of the yellow sand, even though the data must be validated.

Figure 2(a) shows the variation of the aerosol optical thickness and visibility during the observation period. The violet boxes show the value at 501 nm wavelength, while the green boxes correspond to value at 673 nm. The aerosol optical thickness is calculated only for very clear day to exclude the effect of cloud. Investigations of the aerosol optical properties have shown that the aerosol optical thickness at the wavelength of 501 nm is totally greater than that at 673 nm wavelength. It is found that 28 March, 14 – 19 April and 28 April have great aerosol optical thickness both at 501 and 673 nm and these days correspond to the period of yellow sand events. The yellow sand phenomena had observed three times in 1998(*i.e.* 28-29 March, 14-22 April and 28 April). The aerosol optical thickness varied slightly in the yellow sand events because the

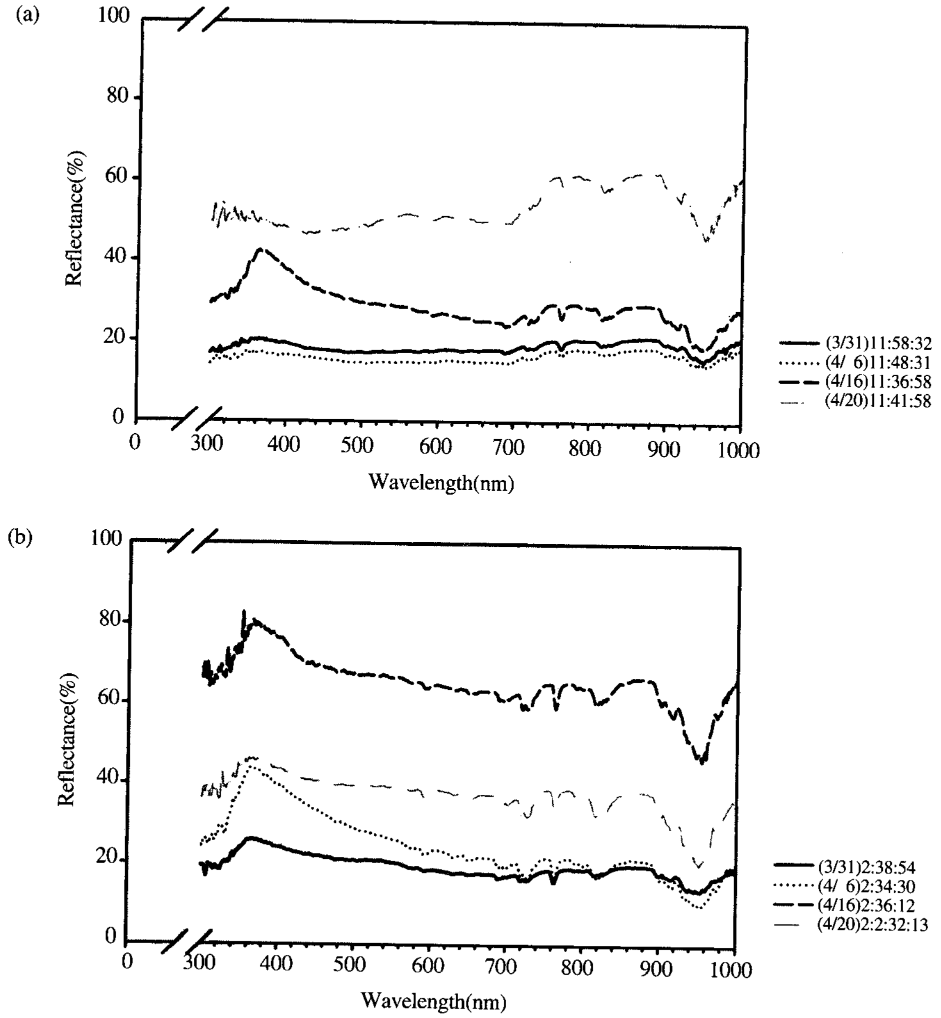

Fig. 1. The reflectance(%) in the spectrum band with the range of 300 - 900 nm. (a) and (b) are measured around 12:00 and 14:30 LST in METRI. The black and red lines represent the clear day, but the yellow and green lines indicate the yellow sand events on April 1998.

atmospheric circumstance was very different. The values in the yellow sand events reached from 0.61 to 1.01 at 501 nm wavelength, which are larger than the values of 0.47 - 0.92 at the wavelength of 673 nm. The mean aerosol optical thickness at 501 and 673 nm in the yellow sand events is 0.87 and 0.67, while those in the clear days are 0.36 and 0.22, respectively. For reference, the average aerosol optical thickness at 500 nm for springtime during 1977-1978 was 0.288 and the annual mean optical thickness was 0.202, which were measured by Cho(1980).

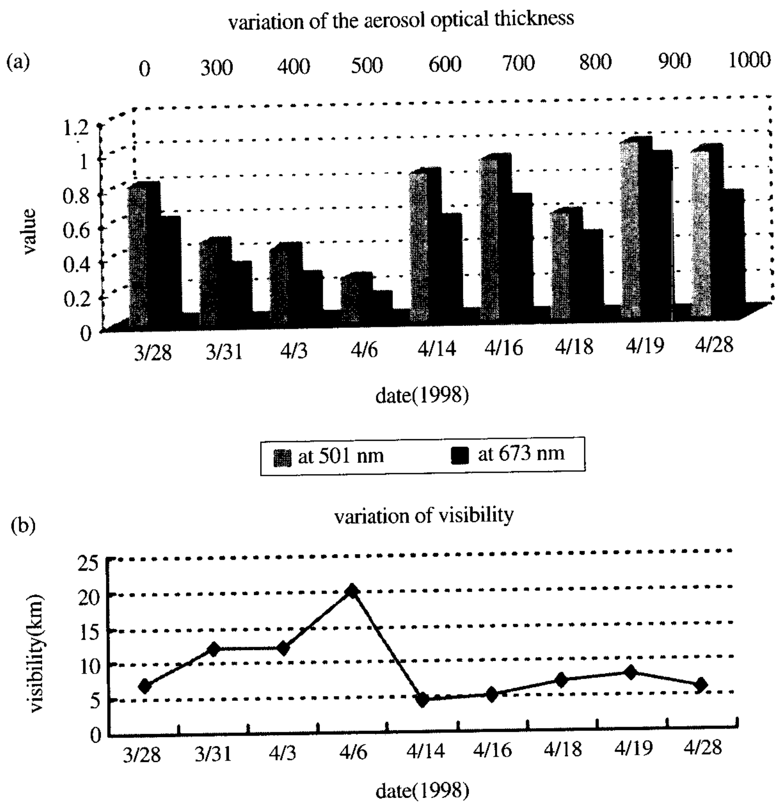

Fig. 2. a) is the aerosol optical thickness at 501 nm(violet box) and 673 nm(green box) derived from the data of the sunphotometer and b) is the variation of visibility observed in Seoul during the observation period.

The visibility as shown in Fig. 2(b) demonstrates the inverse relation to the aerosol optical thickness. The visibility decreases more as the yellow sand events become severer, because the particles of yellow sand pollute the atmosphere. The mean visibility in yellow sand events(28 March and 14-28 April) is 6 km, while that in the clear days(31 March and 3-6 April) is 15 km. However, the visibility is also greatly affected by the moist state of atmosphere.

4. Concluding remarks

We have analyzed the optical characteristics of aerosols in yellow sand events from the ground-based measurements of solar radiation to examine whether the data will be obtained from the OSMI can be used to yellow sand and/or aerosol detection or not. The observations show that the data within the range of OSMI wavelength (400-900 nm) are useful to the field of yellow sand and/or aerosol, because the optical properties of aerosols are very sensitive within these VIS and near IR wavelengths.

In the clear days, the mean spectral reflectance in the range of 500 – 900 nm is about 20% both around 12:00 and 14:30 LST. The mean aerosol optical thickness at 501 and 673 nm wavelength is 0.36 and 0.22, respectively and the average visibility is 15 km. Associated with the yellow sand events, it is found that the yellow sand and/or aerosols are responsible for large part of reflection and scattering of the solar radiation. The spectral reflectance in yellow sand events varies 40 to 70% according to the intensity of the yellow sand phenomena. The mean aerosol optical thickness at 501 and 673 nm wavelength is 0.87 and 0.67, respectively and the average visibility is 6 km.

However, the spectral reflectance and aerosol optical thickness in the low atmosphere are mainly affected by the variation of the water vapor. So, in the future study we will assimilate this observed radiation using the LOWTRAN 7 radiative transfer model and show the variation of aerosol optical thickness from the satellite data.

Acknowledgements

This study had been carried out with the financial support of Korea Institute of Geology, Mining and Materials(KIGAM).

References

Cho, H. K., 1980. On the size distribution atmospheric aerosol particles from spectral photometric measurements in Seoul., *J. Kor. Met. Soc.*, 16: 1-9

Fouquart, Y, B. Bonnel, M.Chaoui Roquai and R. Santer, 1987. Observation of Saharan Aerosols: Results of ECLATS Fields Experiment. Part I : Optical Thicknesses and Aerosol Size Distributions, *J. Climate and Appl. Meteo.*, 26: 28-37.

Fr hlich, C. and G. E. Show, 1980. New determination of Rayleigh scattering in the terrestrial atmosphere. App. Opt., 19: 1773-1775.

Iqbal, M., 1983. *An Introduction to Solar Radiation*, Academic Press, Toronto, Ontario, Canada, 390pp

Kawata, Y and T. Okumura, 1996. Estimation of aerosol optical thickness from satellite image data, *Remote sensing SIMPOSIUM:* 165-170.

Liou K. N., 1980. *An Introduction to Atmospheric Radiation*, Academic Press, INC. (LONDON) LTD, 392pp

Park, J. H., L. S. Rothman, c. P. Rinsland, H. M. Pickett, D. J. Richardson and J. S. Namkung, 1987. *Atlas of Absorption Lines From 0 to 17900 cm^{-1}*, NASA Reference Publication 1188, 196pp.

Tanaka M., M. Shiobara, T. Nakajima, M. Yamano and K. Arao, 1989. Aerosol optical characteristics in the Yellow Sand events observed in May, 1982 at Nagasaki-part I Observations, *J. Meteor. Soc., Japan*, 67(2): 267-278.

Takayama Y, and T. Takashima, 1986. Aerosol optical thickness of yellow sand over the Yellow Sea derived from NOAA satellite, *Atmospheric Environment*, Vol. 20: 631-638.