Optical thickness and transport of the aerosols associated with Asian duststorm over the deserts in northwestern China

By Kenji Kai *
Institute of Geoscience, University of Tsukuba, Tsukuba, 305 Japan

* (After April 1998) Corresponding author address: Kenji Kai, Unit of Environmental Informatics, Graduate School of Human Informatics, Nagoya University, Chikusa-ku, Nagoya 464-8601, Japan.
Phone & FAX: 81-52-789-4257. E-mail: kai@info.human.nagoya-u.ac.jp

Aerosols associated with Asian duststorms (Kosa) play an important role in cloud physics and radiative transfer processes in the atmosphere over eastern Asia. However, the geographical and temporal variability is so large that reliable climatological data of the aerosols associated with Kosa have not been obtained yet (Kai et al., 1988). The purpose of the present study is to investigate the seasonal variation of aerosol optical thickness over the arid area in northwestern China (Kai, 1997a).

As part of the Sino-Japanese Cooperational Program on the Atmosphere-Land Surface Processes Experiment in the Heihe River Basin (HEIFE), atmospheric turbidity measurements using multi-wavelength sunphotometers were carried out at oasis and desert stations from January 1991 to September 1992 (Mitsuta ed., 1994). The oasis station (100° 26'E, 38° 56'N; 1482.7m above mean sea level) is located in a Zhangye oasis (about 15km x 20km) in the Hexi Corridor of northwestern China. The desert station, about 60 km northwest of the Zhangye Oasis, is located at the southern border of the Badain-Jaran Desert (Kai et al., 1997b).

The aerosol optical thickness revealed a seasonal cycle with a spring maximum due to the frequent occurrence of duststorms in the Gobi Desert and its surrounding areas (Figure 2). The mean values of aerosol optical thickness at 500 nm were 0.254 over the oasis and 0.327 over the desert. The aerosol optical thickness over the desert was 1.28 times larger than that over the oasis. The wavelength dependence of the aerosol optical thickness is shown in Figure 3. The ratio of the aerosol optical thickness at 675 nm to that at 500 nm suggested a seasonal variation of the aerosol size distribution, with the size of aerosols being larger in winter than in summer (Figure 4).

The aerosol optical thicknesses at both the oasis and desert stations seem to be low, even though the stations were located in or near the Gobi Desert, i.e., a strong source of dust aerosols. To examine this point, the observed values in the dry regions of the world are reviewed. Table 1 lists the aerosol optical thickness at or near 500 nm at various places in the world. The values are classified into two categories, i.e., (a) values under the background or mean conditions, and (b) values under hazy conditions. According to the table, the atmospheric turbidity in background conditions over dry regions is somewhat lower than generally expected for background conditions, and that it sporadically becomes larger when duststorms occur.

Two reasons for the present results are pointed out. First, the Gobi desert is located in the interior of the Asian Continent, so that the water vapor is very low in the HEIFE region. This condition may prevent the growth of aerosols. Secondly, the desert region is usually dominated by a high pressure system, i.e., clean air descends from the free atmosphere by subsidence of the airmass.

References

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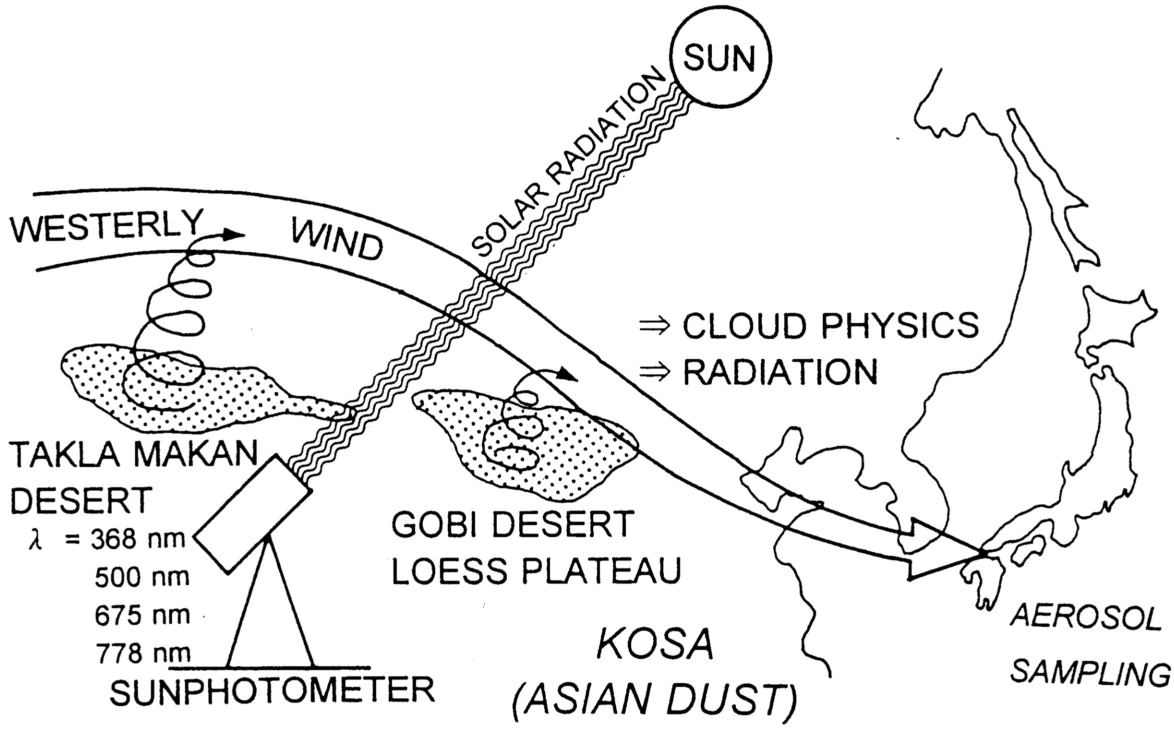

Fig. 1. Schematic illustration of Kosa (Asian duststorm) and the observation by sumphotometers.

Table 1. Aerosol optical thickness at or near 500 nm in various places.

Author	Place	Wavelength	Backgroudn or mean conditions	Hazy conditions	Remarks
Carson&Caverly (1977)	Cape Verde Is. Senegal	500	0.5	0.9–1.0	Saharan dust
Prospero *et al.* (1979)	western Atlantic the coast of Africa	500	0.1 0.3		Saharan dust
Levin *et al.* (1980)	Lebanon&Syria	500		1.5–3	Khamsinic conditions
Cerf (1980)	Volta, Niger	506	0.8		Saharan dust
Fouquart *et al.* (1987)	Niamey, Niger	550	0.2	1.5	Saharan dust
D'Almeida (1987)	Sahara	500	0.03	3.5	Saharan dust
Tanre *et al.* (1988)	Dakar, Senegal	500	0.4	2	Saharan dust
Shaw (1980)	Hawaiian Is., USA	500	0.015–0.020	0.18	Kosa
Tanaka *et al.* (1989)	Nagasaki, Japan	500	0.2	0.8	Kosa
Minoura & Arao (1991)	Nagoya, Japan	500	0.196	0.401	Kosa
Shi *et al.* (1994)	Pingchuan, Linze Hexi Cor., China	500	0.3–0.9		HEIFE, 10 days in Oct 1991
Shen & Wen (1994)	Desert st. Hexi Cor., China	500	0.279	0.548	HEIFE
Levizzani & Prodi (1988)	Mountain st. in north Italy	513.7	0.042–0.185	0.099–0.449	El Chichon dust
Elterman (1968)	Standard atmosphere	500	0.264 at the surface 0.118 at 1.5 km		
Present study	Oasis&desert st. Hexi Cor., China	500	0.246 (oasis) 0.313 (desert)		HEIFE

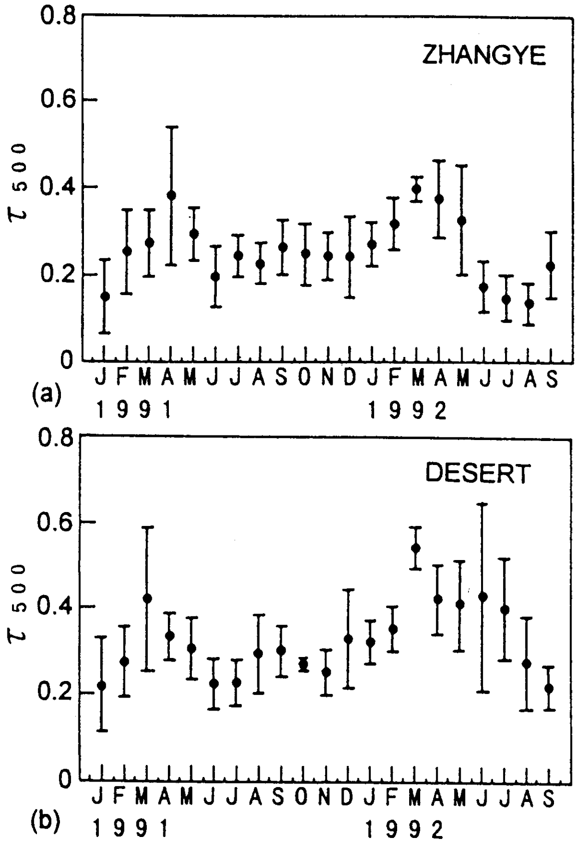

Fig. 2. Time variations of monthly values of τ_{500} over the oasis (a) and over the desert sites (b). The plotted circles are the monthly means, while the vertical bars indicate one standard deviation.

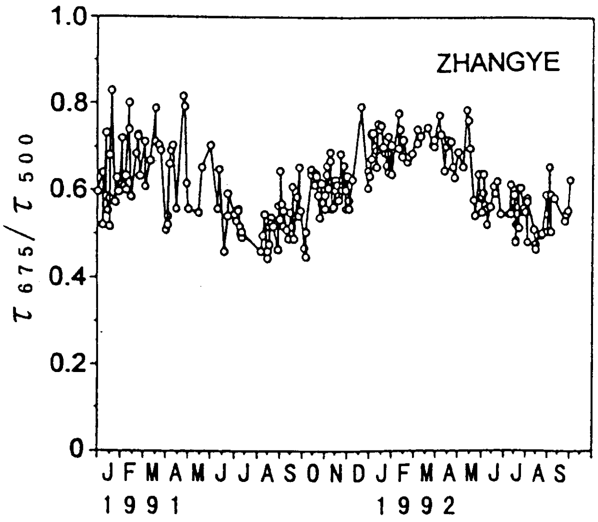

Fig. 4. Time variation of the ratio τ_{675}/τ_{500} at the oasis station.

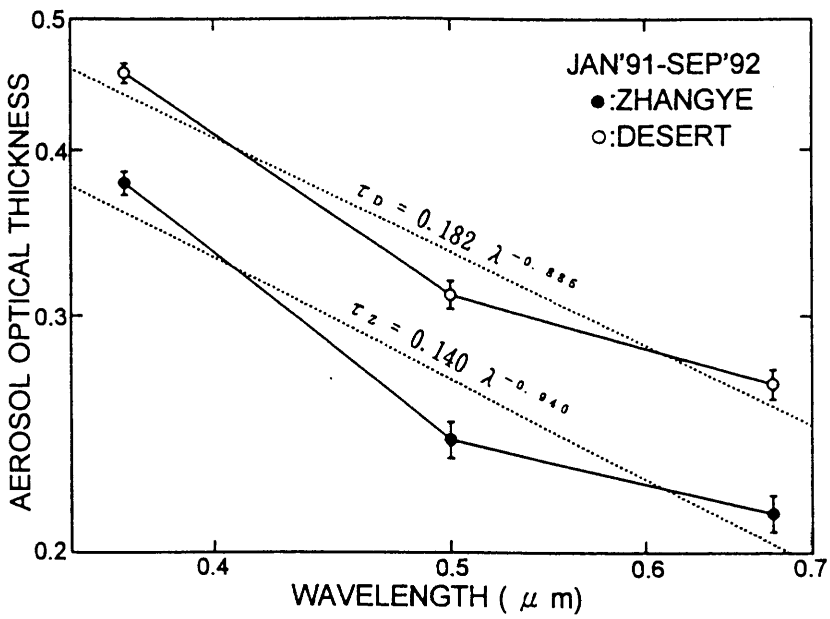

Fig. 3. Relationship between the aerosol optical thicknesses at the oasis station (solid circle) and desert station (open circle) and the wavelength (μm). The vertical bars indicate the mean error of the mean. The regression lines for both stations are shown in the figure.