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The Experts Meeting on Aerosols and their Climatic Effects, under the World Climate Research Program reviewed the status of the aerosol models in the Standard Radiation Atmospheres of the IAMAP Radiation Commission. One of the major areas for improving these aerosol models was identified as the need for a separate desert aerosol model. Several recommendations were made for developing such an aerosol model. A desert aerosol model based on these recommendations and other work will be discussed with emphasis on the optical and radiative properties and their variations with wind speed.

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OPTICAL AND RADIATIVE PROPERTIES OF A DESERT AEROSOL MODEL

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Introduction

One of the major sources of the natural atmospheric aerosols is wind-blown dust and sand. These predominantly originate from the arid and semi-arid regions which make up one-third of the earth's land area ~~(e.g. see Levin et al., 1980)~~. The aerosol models in the Standard Radiation Atmospheres (SRA) of the IAMAP Radiation Commission, do not include a model specifically representative of these regions. For this reason the Experts Meeting on Aerosols and their Climatic Effects (WMO 1983), under the World Climate Research Program, identified as one of the major areas for improving the SRA aerosol models, the need for a separate desert aerosol model. Several recommendations were made for developing such an aerosol model. This paper presents the optical and radiative properties of a desert aerosol model based on those recommendations. Two models are discussed representing the extremes of background conditions and a severe dust storm.

Physical Properties of the Desert Aerosols

The refractive index of the aerosols is based on the work of Volz (1973), Benjamin & Carlson (1980) and Patterson (1981), as discussed below. The real part of the refractive index follows Carlson & Benjamin (1980) for wavelengths, $\lambda \leq 2.5$ µm. For longer wavelengths Volz's (1973) measurements from the real part are used. The imaginary part of the refractive index is based on Benjamin and Carlson (1980) for $\lambda \leq 1.0$ µm, and is joined smoothly into an average of Volz's (1973) and Patterson's (1981) measurements for imaginary part, which are in good agreement with recent measurements (Fouquart, et al., 1984).

The size distribution is based on the review by Jaenicke (1983). The size distributions for the aerosol models are represented as the sum of 3 log-normal distributions:

$$\frac{dN(r)}{d \log r} = \sum_{i=1}^{3} \frac{N_i}{\sqrt{2\pi}\,\log \sigma_i} \exp - \frac{(\log r - \log R_i)^2}{2(\log \sigma_i)^2}$$

where $N(r)$ = particle concentration for particles with radius > r.
N_i = total number of particles in the i^{th} distribution
σ_i = geometric standard deviation
R_i = mode radius

The values of the parameters N_i, σ_i, and R_i are summarized in Table 1, following WMO, 1983 (their Table 4.1). The number density distribution for these models is shown in Figure 1 and the cross-sectional area distribution is shown in Figure 2. It will be noted that the two model size distributions differ significantly only for the larger aerosols.

Optical and Radiative Properties

The optical and radiative properties were derived from standard Mie scattering calculations. Figure 3 shows our results for the extinction, scattering and absorption coefficients for the Background Desert Aerosol Model and Figure 4 shows the corresponding results for the Desert Dust Storm Model. The extinction coefficients for the two models are shown in Figure 5. It will be noted that the Desert Dust Storm Aerosol Model extinction excedes the Background Model values by a factor of 40 in the visible and by 3 orders of magnitude in the far IR. This is due to the enhanced numbers of very large aerosols with severe wind conditions. The single scatter albedo (the ratio of scattering to total extinction) is shown in Figure 6, for the two models.

The asymmetry parameter, which characterizes the angular distribution of the scattered radiation is shown in Figure 7.

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TABLE 1 Parameters for Desert Aerosol Size Distribution

Size Distribution	i	N_i (cm^{-3})	σ_i	R_i (μm)
Background Desert Model	1	9.97×10^{2}	0.328	0.0010
	2	8.42×10^{2}	0.505	0.0218
	3	7.10×10^{-4}	0.277	6.24
Desert Dust Storm Model	1	7.26×10^{2}	0.247	0.0010
	2	1.14×10^{3}	0.770	0.0188
	3	1.78×10^{-1}	0.438	10.8

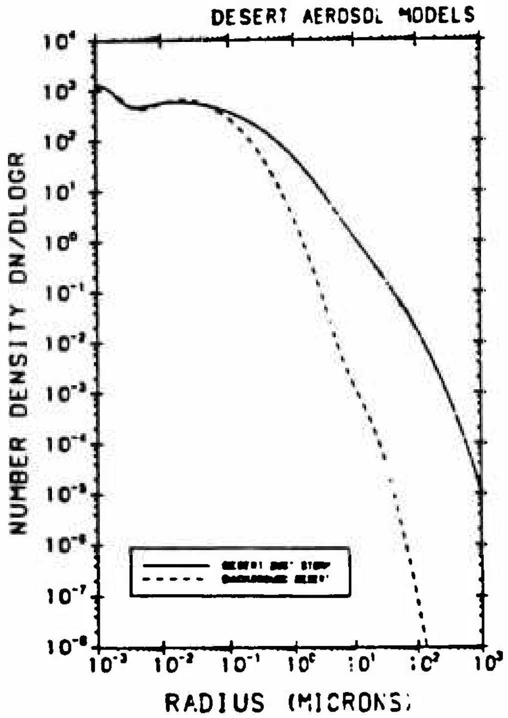

Figure 1. Number Density Distribution (particle/cm^3) for the Desert Aerosol Models.

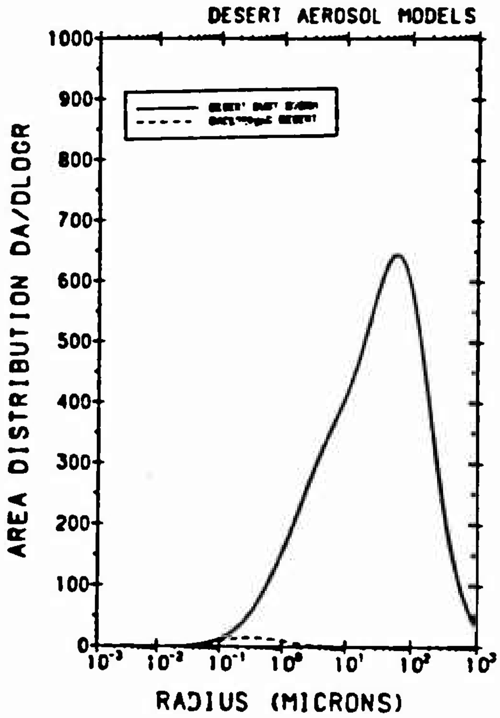

Figure 2. Area Distribution ($\mu m^2/cm^3$ for the Desert Aerosol Models.

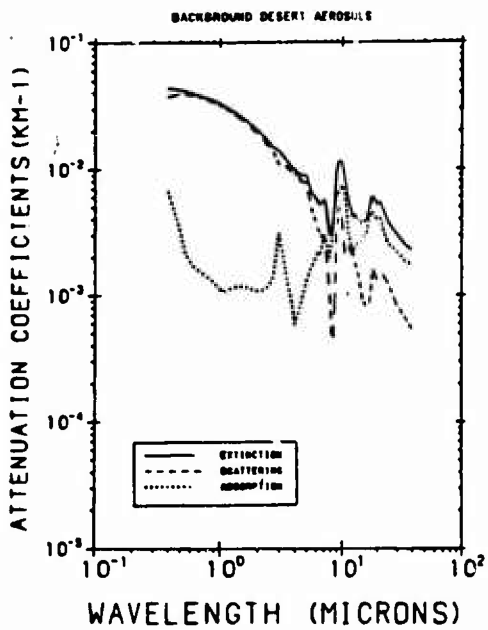

Figure 3. The Attenuation Coefficients for the Background Desert Aerosol Model as a Function of Wavelength.

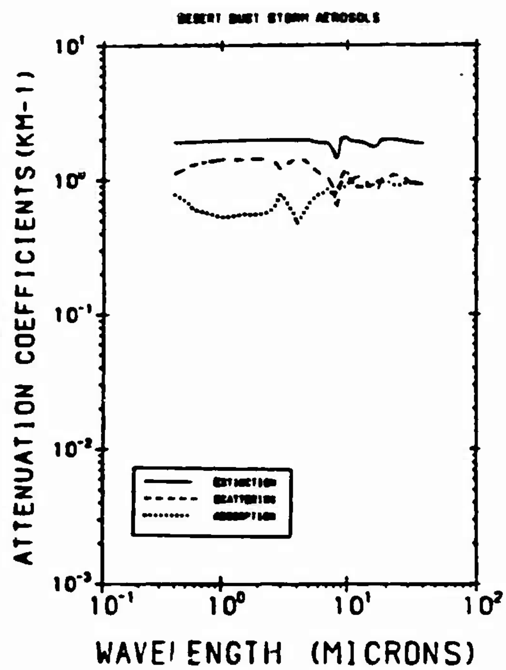

Figure 4. The Attenuation Coefficients for the Desert Dust Storm Aerosol Model as a Function of Wavelength.

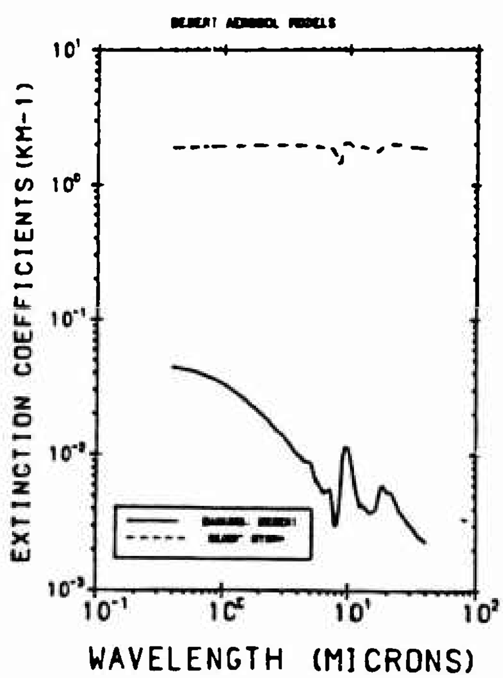

Figure 5. Comparison between the Extinction for the Background Desert and the Desert Dust Storm Aerosol Models.

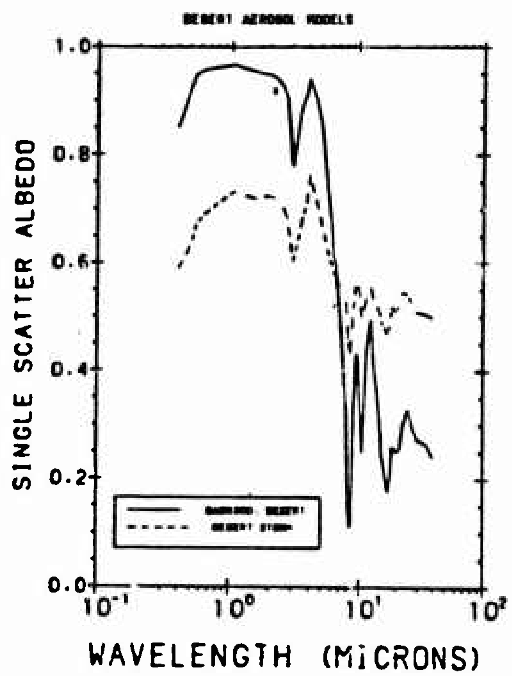

Figure 6. Comparison between the Albedo for Single Scattering for the Background Desert and the Desert Dust Storm Aerosol Models.

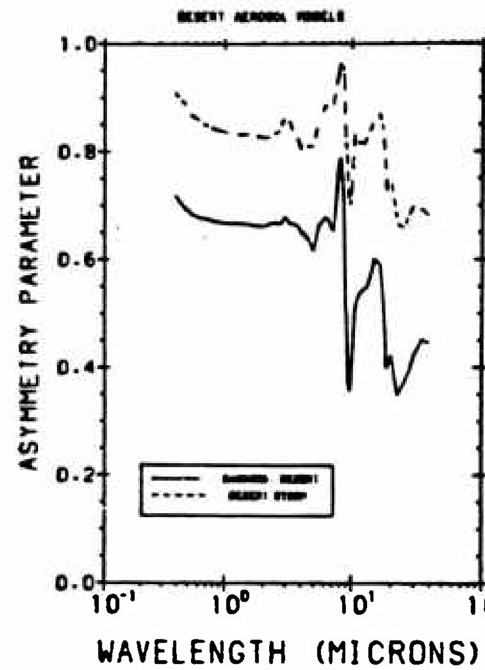

Figure 7. Comparison between the Asymmetry Parameter for the Background Desert and the Desert Dust Storm Aerosol Models.