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RECENT STUDIES OF THE OPTICAL PROPERTIES OF DUST AND CLOUD PARTICLES IN THE MARS ATMOSPHERE, AND THE INTERANNUAL FREQUENCY OF GLOBAL DUST STORMS

R. T. Clancy and S. W. Lee, LASP, Univ. of Colorado, Boulder, CO 80309, and D. O. Muhleman,Caltech, Pasadena, CA 91125

The results of research with two distinctly separate sets of observations yield new information on the optical properties of particulate scatterers in the Mars atmosphere, and on the interannual variability of the abundance of such scatterers in the Mars atmosphere. The first set of observations were taken by the IRTM (Infrared Thermal Mapper) instrument onboard the Viking orbiters, during the period 1976-1980. Several hundred emission-phase-function (EPF) sequences were obtained over the Viking mission, in which the IRTM visual brightness channel observed the same area of surface/ atmosphere as the spacecraft passed overhead. The 1-2% accuracy of calibration [1] and the phase-angle coverage that characterizes these data make them ideally suited to determining both the optical depths and optical properties of dust and cloud scatterers in the Mars atmosphere versus latitude, longitude, season ($L_S$), and surface elevation over the extended period of Viking observations. The range of seasons and locations for these observations are indicated in figure 1, in which the dust optical depth over regions from 19 separate EPF sequences are plotted versus $L_s$. [2] Mars cloud opacities are presented in figure 2. We have analyzed the EPF data with a multiple scattering radiative transfer code [3] to determine dust single scattering albedos which are distinctly higher (0.92 vs 0.86) than indicated by the Viking lander observations [4]. Although we find a single scattering phase function that is very consistent with that returned by the Viking lander observations, the scattering asymmetry parameter is 0.55 rather than the value of 0.79 reported by Pollack et al. [4]. These differences in the optical properties of atmospheric dust lead to very different radiative properties, and suggest much smaller particle sizes than previously considered (effective radius $\leq$0.4 μm vs 2.5 μm). Implications regarding dust heating of the atmosphere, dust settling times, opacity ratios between visible and infrared wavelengths, and the dust-corrected albedos of the Mars surface are considered.

The second set of observations regard ground-based observations of the 1.3-2.6 mm rotational transitions of CO in the Mars atmsophere. We have derived the low-to-mid latitude average of the atmospheric temperature profile (0-70 km altitude) from a number of such observations over the 1980- 1990 period [5]. A comparison of these microwave temperatures with those inferred from the Viking lander descent and orbiter IRTM observations (figure 3) indicates a distinct difference. The microwave temperatures are ~20 K cooler at all altitudes, and are consistent with radiative-convective equilibrium temperatures for the Mars atmosphere in the absence of significant dust heating [6]. Implications concerning the relative infrequence of global dust storms over the 1980-1990 period, the enhanced frequency of clouds expected with such colder atmospheric temperatures, and the accompanying changes in the atmospheric density profile are presented.



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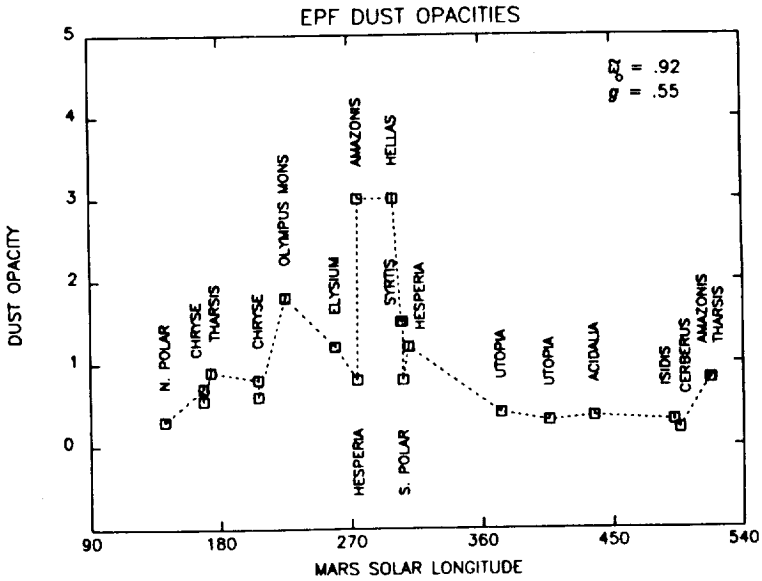


Figure 1. The dust extinction opacity (broadband solar) plotted versus solar longitude, as measured from Viking IRTM EPF data at various regions on Mars. The two global dust storms of 1976-1977 are apparent as $L_s$ near 200-300°.

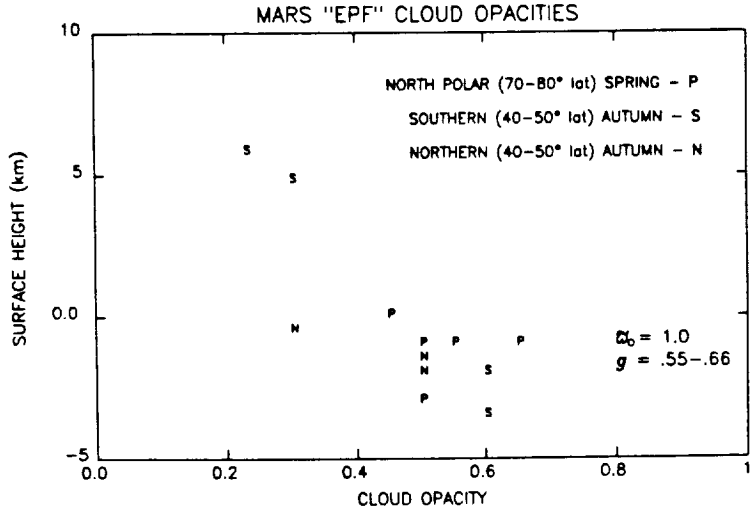


Figure 2. Extinction cloud opacities determined from the Viking IRTM EPF observations, plotted versus the surface elevation of the observed region. The various regions and seasons of these clouds are distinguished by different symbols.

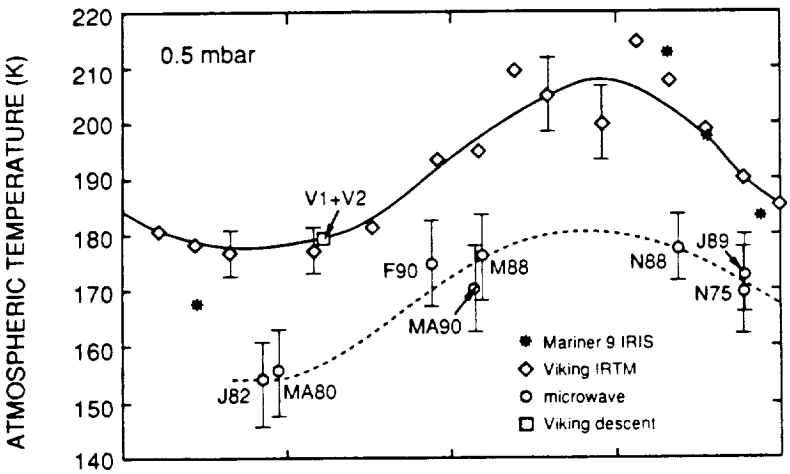


Figure 3. The low-to-mid latitude average temperature of the 0.5 mbar (~25 km) pressure level of the Mars atmosphere is plotted versus Mars season ($L_s$). The measurements connected by a solid line are obtained from Viking lander descents, Viking IRTM infrared temperatures, and Mariner 9 IRIS spectra; and correspond to high dust loading in the Mars atmosphere. The ground-based microwave measurements (circles) are connected by a smooth dashed line to indicate the seasonal dependence of atmospheric temperatures presumably related to low-dust loading in the Mars atmosphere. The month and year of the microwave measurements are indicated (M88=May, 1988).