OMEGA LIMB OBSERVATIONS OF THE MARTIAN DUST AND ATMOSPHERIC COMPOSITION.

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Introduction

The martian dust is one of the most difficult atmospheric components to model and observe. Indeed, a remote observer, to infer the dust optical thickness and properties, must discriminate photons scattered by aerosols among photons reflected by the martian surface. Various methods have been use to solve this problem. Here we present results obtained by looking at the Mars limb. Any light detected have been scattered by aerosols, although a fraction of the scattered light may have been reflected on the surface.

But limb observations do not only allow to more acrrurately disentangle surface and dust contributions to the martian reflectance. They also allow the observer to retrieve the vertical profile of the dust and aerosols (particle density as a function of altitude), while nadir observations are usually only sensitive to column integrated density. Moreover, when the dust slant optical thickness reaches saturation, the reflectance only depends on the single scattering albedo and the phase function of the particles. In these conditions, limb observations become powerful tool to constrain the particle optical properties. Finally, limb observations increase the sensitivity to minor gaseous species, and allows again to measure vertical distribution of some atmospheric constituents like water or oxygen.

The OMEGA spectro-imaging system aboard the Mars Express mission has observed during several limb sessions. OMEGA operates between 0.35 and 5.1 μm with a spectral resolution ranging from 7 to 20 nm. The vertical resolution of the limb observations varies from session to session between 2 and 9 kilometers. Various seasons, latitudes, and local time have been sampled.

Model

We use a two-stream radiative transfer code. The source function are calculated in plane parallel geometry (the solar zenith angle is never higher than 60 degrees). Then, the radiative transfer equation is integrated for spherical geometry. Gaseous opacity is calculated from a line-by-line radiative transfer code. For the particle optical properties we first assume a single scattering albedo and an asymmetry parameter extracted from the Ockert-Bell model (Ockert-Bell et al. (1999)). The dust vertical profile is inverted according the method proposed by Jaquin et al. (1986). Our code does not allow yet to include the thermal emission which starts to dominate the spectrum at wavelengths larger than ~ 4 μm.

To interpret the optical depth measured at a given altitude as a function of wavelength, we have designed a deconvolution tool. We take advantage of the optical thickness being the sum of the cross-section due to particles of all sizes, hence a convolution of the particle size distribution by the cross-section function. We have assumed a cross-section calculated from the Mie theory for the real and imaginary refractive index from Ockert-Bell et al. (1999). The deconvolution was stabilized and regularized using algorithm described in Craig and Brown (1986).

This allows us to recalculate the single scattering albedo and the asymmetry parameter as a function of wavelength and altitude and to iterate the inversion.

We will present the inverted dust vertical profiles. As shown in Figure 1, a wide variety of profiles have been retrieved some rather homogeneous, some exhibiting one or several detached haze layers. In Figure 2 we present one example of optical thickness as a function of altitude and wavelength. The dependence of the optical thickness with wavelength increases with altitude, showing the decrease of particle size with altitude.

References

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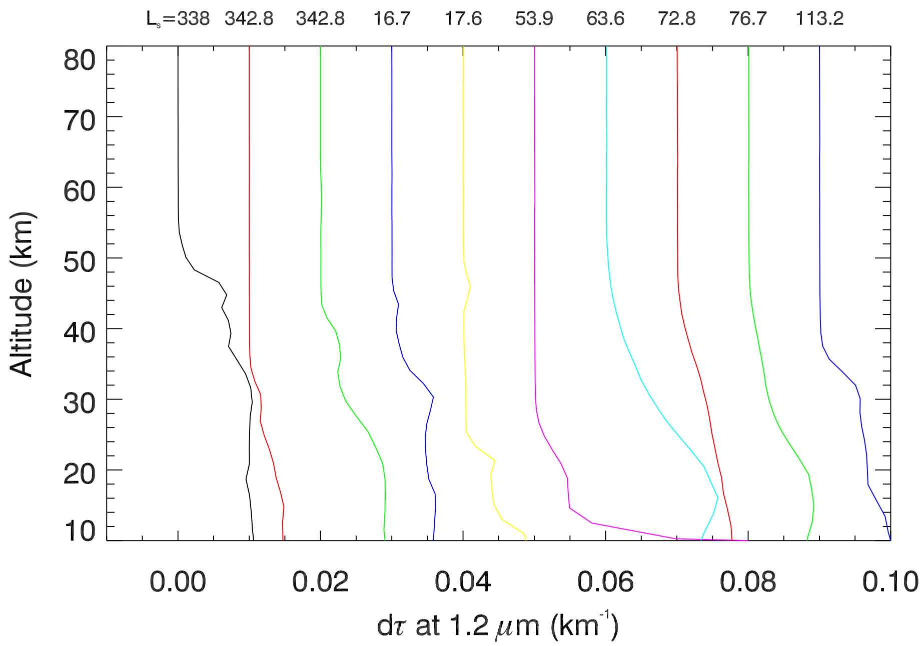

Figure 1: Figure 1 : Optical thickness as a function of altitude for different seasons and local time. The OMEGA data present a huge variability in terms of total optical thickness, the presence of detached layers some of which associated with water ice.

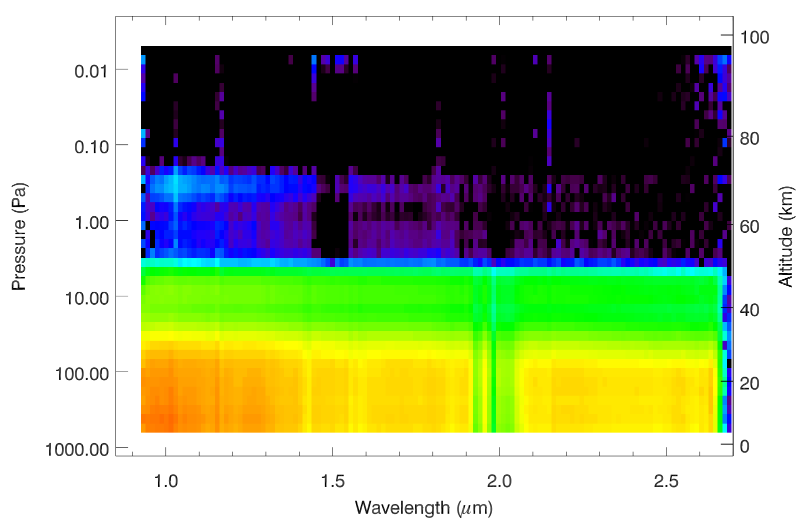

Figure 2: Figure 2: Optical thickness as a function of altitude and wavelengths for $L_s = 343\circ$. The detached layer at 60 km presents the spectral signature of water ice at 1.5 μm.