OMEGA SPOT POINTING OBSERVATIONS OF MARS AEROSOLS.

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Introduction

The characterization of martian aerosols is of key importance for the understanding of the dust cycle, the water cycle, and the heat balance in the atmosphere of Mars. Moreover, it is essential in order to correct remote sensing measurements for atmospheric effects, which is needed, e.g., for a reliable analysis of the underlying surface mineralogy. This motivates the retrieval of aerosol properties, in particular, the particle sizes, the refractive index, the optical depths, and the aerosol types, as well as their variation with local time, season and latitude.

The derivation of these parameters is an arduous task, due to the intrinsic difficulty in distinguishing between the surface and the atmosphere components. The investigation of nadir measurements of radiance limits the number of parameters that can be derived, and needs severe assumptions about the surface properties to be made. Limb measurements are not strongly affected by the surface properties and allow the evaluation of the dependence of the aerosol properties on altitude. However, the analysis is restricted to altitudes above 10-15 km (in relatively clear atmospheric conditions), since the atmosphere under limb viewing geometry becomes optically thick below. One satisfactory method is the examination of spot pointing observations, during which a certain surface area is observed with different observation geometries. As the dependence of the surface contribution on the viewing angles is different from that of the aerosols, these observations enable the separation of both components(see, e.g., [1, 2]).

Once the atmospheric contribution is isolated, the aerosol optical properties and optical depth can be derived. Furthermore, as the wavelength dependence of the extinction cross section for a certain aerosol type is a diagnostic for particle size, if the measurements are taken simultaneously over a wide spectral range, it is possible to infer the size distribution.

In this context, the OMEGA spectrometer, onboard Mars Express, represents an excellent oportunity to characterize Mars aerosols as it provides spot pointing sequences in the visible through the near infrared. We have used its reflectance measurements to derive martian aerosol size distribution and optical depths.

OMEGA spot pointing sequences

Since its launch in December 2003, OMEGA maps the diffused solar light and surface emission in 3 channels ranging from 0.38 to 5.1 μm with a S/N>100 and a spectral resolution of 0.004 to 0.02 μm. Its IFOV is 4.1 arcmin which translates into a 350 m resolution at periapsis. A more extended description of OMEGA capabilities can be found in [3].

Besides nadir and limb modes, OMEGA performs spot pointing sequences. In this mode, OMEGA points at the same area on the surface while it passes over it, providing reflectance as a function of phase and emission angles with an almost constant incidence angle. The observed surface and atmosphere do not vary substantially and thefefore their properties can be assumed fixed along the whole sequence.

We focus in this abstract on only one of the spot pointing sequences taken by OMEGA. Figure 1 shows the footprint and the coverage of incidence, emission, and phase angles of part of orbit 604. This particular

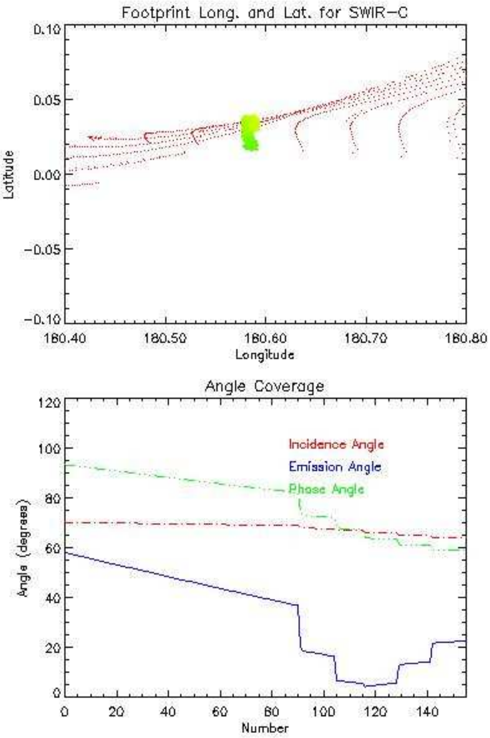

Figure 1: Upper panel: Latitude and longitude of OMEGA footprint during orbit 604. The colored asterisks are the selected measurements for the analysis. Lower panel: Observation geometry during the selected sequence of this orbit.

sequence was takenearly in the morning at L_s =58.8° over Lucus Planum (∼0°N,∼180°E), a bright and very uniform region. We have selected a latitude and longitude box of 0.02°×0.03°, which corresponds to an area on the surface smaller than $1\times2\,\mathrm{km}^2$. The acquisition time of the selected measurements was ∼30 minutes.

Modelling

In order to retrieve the aerosol parameters, we have simulated the reflectance at several wavelengths (free of gas and surface absorptions) for the different geometries within a sequence, and have compared them with OMEGA measurements. Our solution is the set of parameters which minimizes χ^2 both for each wavelength individually and for all of them simultaneously. Figure 2 shows the diagram of the modelling used here.

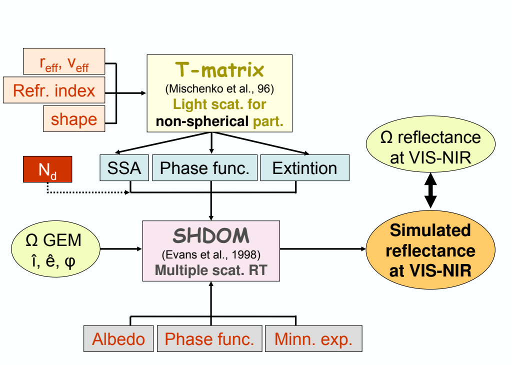

Figure 2: Diagram of the modelling.

We have calculated the reflectance with the multiple scattering atmospheric radiative transfer model SHDOM [4]. This code computes radiative transfer after supplying the properties of both the surface and the atmosphere.

Surface: We have chosen a Minnaert law together with a surface phase function (Henyey-Greenstein type) to model the surface BRDF. We have assumed the surface to be uniform along the latitude and longitude box selected for each spot pointing sequence. The unknowns for the surface component are the albedo (A_N), the Minnaert exponent (k), surface phase function assymetry (b) and backscattering (c)factors. All of them are a function of wavelength, and the Minnaert exponent also of phase angle. We have adopted the dependence of the albedo on wavelength derived in [5].

Aerosols: We have allowed two different types of aerosols: water ice and dust. For the ice, we have used the data compiled in [6]. For the dust, we have calculated single scattering albedos and phase functions as a function of wavelength with the T-matrix model [7], considering nonspherical particles (spheroids). The inputs of the model are the size distribution and the refractive index. We have used the refractive index derived in [8], including its dependence on wavelength. The free parameters for the dust component are therefore the effective radius (r_{eff}), the effective variance (v_{eff}), and the aerosol mass ammount.

Results and discussion

Figure 3 shows the best fit of the spot pointing sequence selected in Fig. 1 for six different wavelengths. The retrieved parameters are the following.

The surface could be modeled with a Minnaert law, using a Minnaert exponent of 0.9 for all wavelengths. adequate for moderate phase angles, as it is the case during this sequence. The surface albedo at 1 μm is 0.33, which is consistent with TES results [9]. The assymetry and the backscattering factors of the surface phase function are 0.05 and 1 respectively.

Our results also show that, during this sequence, the optical depths in the wavelenghts shown in Fig. 3 are around 1, with a maximum of 1.1 at 1 μm, and mainly originate from airborne dust. The effective radius of the particles is 1-1.25 μm. This value is slightly smaller than those derived with Viking, Pathfinder and MGS data. It agrees nevertheless with the typical size derived with TES Emission Phase Functions for Mars northern hemisphere during aphelion. The effective variance of the size distribution is ∼0.4. This relatively broad v_{eff} is likely to be due to a particle size vertical dependence, which cannot be resolved in this study.

The analysis that we have performed shows that spot pointing observations of reflectance are very useful in order to separate the surface contribution from that of the aerosols in the visible and near infrared. As the aerosol component can be isolated, they also provide reliable information about their size distribution.

The OMEGA spectrometer provides spot pointing observations on a regular basis over different latitudes. The upcoming analysis of this measurements will allow the derivation of the variability of Mars aerosol properties with location and season.

References

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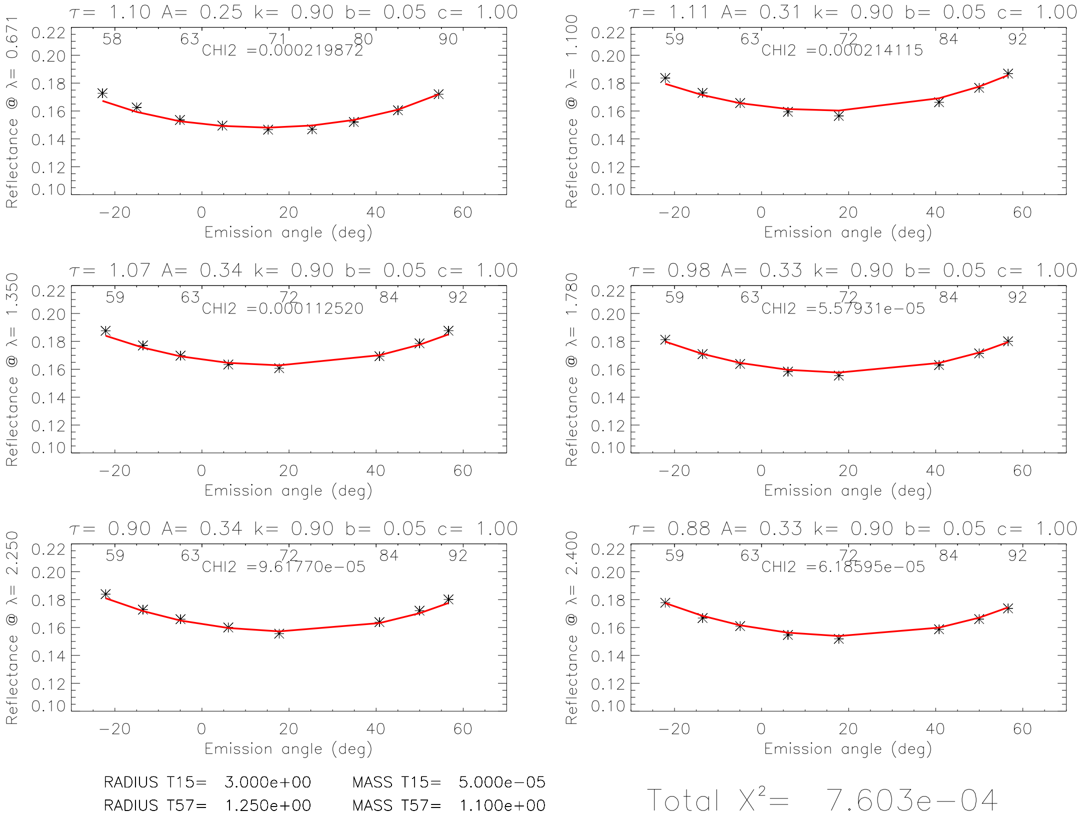

Figure 3: Best fit (solid line) for OMEGA measuremets (asterisks) taken around 180°E during orbit 604.