# Dust microphysical properties from OMEGA/MEX limb data.

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**Introduction:** Limb observations of planetary atmospheres are often used to achieve a more direct view of the vertical distribution of atmospheric structure and components. Limb observations of Mars in the VIS and NIR spectral ranges allowed detecting high-altitude clouds and haze layers whose vertical location would have been hardly retrievable from nadir views (e.g. [1],[2]). The dataset of OMEGA/MEX, although not optimized for such observations, contains a significant amount of limb views of Mars, which have not yet been studied at depth ([3]).
In limb observations, the OMEGA spectral range (0.35-5.1$\mu$m) is mostly sensitive to atmospheric scattering (by either dust or ices) which determines the overall spectral shape shortward of 4 $\mu$m, whereas the 4-5 $\mu$m range is dominated by thermal emission. Molecular emissions in non-LTE conditions by $O_2$, $CO_2$, and CO are also clearly detectable in their vertical extension. Vertical profiles of dust/ice properties, temperatures and trace gases are in principle retrievable from a limb spectral scan. However, this approach needs radiative transfer models suitable for spherical geometries, and an appropriate management of particulates scattering.

**OMEGA Data analysis:** In order to establish the potentiality of OMEGA limb data we selected few datasets at southern latitudes, extracting from them some spectral scans up to about 50 km of tangent altitude at a 2-3 km of vertical resolution. Two scans show the presence of a detached scatterer layer at about 45 km (Fig.1), and at least a twofold regime of scattering below it, deduced by the variations of slopes of the spectral continuum in several visible and near-infrared ranges. These variations have been studied in more detail by assuming that a compositionally uniform dust population is responsible of the scattering. Hence we retrieved the density ($n$) and the particles effective radius ($r_{eff}$) for each selected limb spectral scan.

**Retrieval method:** To perform the analysis we used the MITRA code, based on the multi-solver *LibRadtran* radiative transfer package ([4]) and already used to study planetary atmospheres ([5],[6],[7],[8]). It can be operated both as a forward model and as an inverse retrieval algorithm to study planetary atmospheres. The tool uses the MYSTIC Monte Carlo solver ([9]) to handle the spherical geometry in 1D. Full multiple scattering is treated with the Mie theory and either pure, mixed and coated spheres can be taken into account. The inversion algorithm, a constrained minimization technique based on the Gauss-Newton method ([10]), has been updated to deal with the computation of the jacobians for limb geometry observations.
Gases mixing ratios, temperature-pressure profiles and the a-priori dust properties have been taken from the Mars Climate Databes (MCD, [11], [12]). Gaseous cross sections have been computed from the HITRAN 2012 database ([13]) using the routines of the ARS radiative transfer code ([14]).

**Discussion and future work:** Our retrievals provide an overall regularly decreasing dust density with altitude up to about 40 km. Keeping the scatterers composition fixed, the variable spectral slopes is ascribed to a decreasing grain radius with altitude from 0.8 to 0.2 $\mu$m (effective radius). Above 40 km the presence of a detached layer is confirmed by a significant increase in both number density (~1.5 times) and grain radius by (~50%). It is worth stressing the importance of including multiple light scattering in the modelling, both within the radiative transfer source function and as additional diffuse illumination from the surface. These contributions appear essential for spectral modelling, but of course their inclusion in a Monte Carlo scheme is computationally demanding. Moreover, to take into account a diffuse surface contribution implies an evaluation of the surface scattering in the real illumination conditions. In our case, this has been done by searching in the OMEGA dataset for nadir-looking cubes covering the same region interested by the limb observation, and then applying the SAS method (described in [15]) and reflectance models to simulate a realistic surface albedo source.
Our approach aims to define and refine possible retrievals from OMEGA limb data in view of an extended application to the whole OMEGA dataset. Future applications will also involve trace gases' vertical profiles (e.g. $H_2O$, CO, $O_2$) by taking advantage of both absorption and emission features, and discrimination of scatterers microphysics and composition (e.g. dust

and water ice populations). Within the allowed coverage in latitude and solar longitude, the outputs of OMEGA limb scans may be placed in a climatological framework and significantly contribute to the understanding of Martian atmosphere. A fallout in the next future is also expected from the comprehensive application of multiple scattering to limb-viewing geometries of Mars, especially in the view of TGO limb and solar occultation measurements.

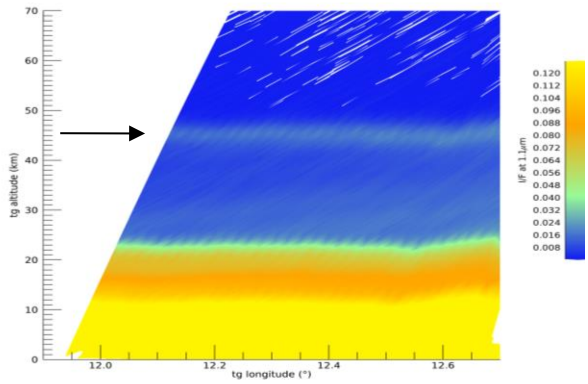


**Figure 1:** *Projected limb view from an OMEGA cube (at 1.1 μm wavelength) showing a detached layer around 45 km*.

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