

RETRIEVAL OF GAS AND AEROSOLS VERTICAL PROFILES BY MEANS OF LIMB OBSERVATIONS CONSIDERING MULTIPLE SCATTERING OF THE PFS/MEX AND NOMAD/EXOMARS INSTRUMENTS

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Introduction:

The Planetary Fourier Spectrometer (PFS) instrument on board Mars Express (MEx) is taking observations of the Mars atmosphere since 2004. Amongst all the observations, PFS observed the Mars atmosphere in limb geometry, and accumulated up to now nearly 3000 observations, with a total of nearly 25,000 individual spectra, during which radiances were measured at a spectral resolution of 2 cm^{-1} after applying Hamming apodization to the measured interferograms, in the wavenumber range 1750 to 8200 cm^{-1} (Formisano et al., 2005). These measurements show a good coverage of the planet in terms of latitude, longitude and Ls.

In this work, we present an algorithm used to invert the limb observations based on a Bayesian algorithm (Rodgers, 2000). We focus on the 3000 to 4400 cm^{-1} wavenumber region, where the PFS instrument radiometric calibration is well defined. The forward model, JACOSPAR, is a full radiative transfer code which accounts for multiple scattering of the Sun light by the atmospheric aerosols, in order to model the radiances with a high precision (Iwabuchi, 2006; Iwabuchi et al., 2009; Mahieux et al, 2016).

We intend to retrieve CO_2 , H_2O and CO vertical profiles for the gas species, and water ice and dust vertical profiles for the aerosol species, which all show clear absorption and/or scattering structure in the considered wavenumber region.

The method:

Forward model. JACOSPAR is a multiple scattering radiative transfer code that uses the backward-propagating Monte Carlo method, and the dependent sampling approach in order to reduce the computation time (Marchuk et al., 1980). It calculates the scattering for a given number of wavenumber values and interpolates the radiance for the other wavenumbers (Iwabuchi, 2006; Iwabuchi et al., 2009; Mahieux et al, 2016). JACOSPAR accounts for the instrumental field of view in its calculations.

JACOSPAR also computes precise analytical

Jacobians relative to the radiances with respect to the absorption and scattering extinction profiles. They are used to derive the Jacobians to volume mixing ratios (VMR) of the different variables, which are used in the Bayesian algorithm.

We compute the aerosols single scattering albedo, phase function and extinction coefficients using the Mie theory (Wiscombe, 1980), for altitude constant modified-gamma size distributions taken from Kleinbohl et al. (2009), using refractive index of dust and water ice from Wolf and Clancy (2003) and Warren (1984), respectively.

Bayesian algorithm. We implemented the Bayesian algorithm approach developed by Rodgers (2000) using the Gauss-Newton method. Based on an a-priori atmosphere obtained from the Mars Climate Database ver. 5.2 (MCD, Forget et al., 1999), we fit the logarithm of the different species VMR, assuming temperature and pressure conditions obtained from MCD for the latitude, longitude, time and Ls observation mean value.

Sensitivity study. We present a sensitivity study, conducted in different illumination geometries, to the different retrieved VMR profiles, which shows that the precision of the retrieved profiles is correlated with the distance of the MEx spacecraft to the impact point of the observations due to the relatively large field of view of PFS (1.52°), as well as with the vertical sampling (vertical distance between two consecutive impact points). We show that the sensitivity to CO_2 , H_2O and dust is reasonable, while is weaker for water ice and CO .

Results and discussion:

We searched for the best covariance values to the a-priori atmosphere in order to best fit the PFS measured spectra, and we obtained good fits for the fraction of the observations that have already been inverted.

The vertical profiles derived from a few observations will be presented and discussed in different illumination geometries, and compared to previous observations. We discuss variations of the different

VMR vertical profiles as a function of time, latitude and Ls within the retrieved uncertainties, and compare with profiles from models, such as MCD. In particular, we focus on water and dust vertical profiles.

Future applications:

The code is intended to be applied to the inversion of the NOMAD (Vandaele et al., 2015) on board ExoMars limb observations, that will be carried out from end of 2017. One of the channels of NOMAD, LNO, is a high resolution echelle grating spectrometer using the AOTF technology to select the wavenumber ranges to be measured, working in the infrared from 2.2 to 3.8 μm .

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