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Infrared solar occultation observations on Mars-Express: vertical distributions of water vapour and aerosol in the Martian atmosphere

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Abstract

The distribution of water vapour in the Martian atmosphere is monitored measured by several experiments in nadir, in the meantime direct measurements of H_2O vertical profiles are still in deficit. Solar occultation technique is one of the most sensitive methods for detection of minor constituents in planetary atmospheres and retrieval of their vertical distribution including spatial and temporal variations. An infrared AOTF spectrometer is a part of SPICAM experiment onboard Mars-Express mission [1]. It has solar occultation capability and operates in the range 1-1.7 μm with a spectral resolution of ~3.5 cm^{-1}. The FOV of the instrument when observing the Sun is 4.2 arc min that corresponds to vertical resolution better than 3.5 km, provided the distance to limb is less than 3000 km. During three Martian years (MY 27-29) about 550 successful infrared occultations have been carried out from January 2005 to August 2008, with L_s varying from 50 to 344. We report here a complete retrieval of solar occultation measurements of the Martian atmosphere performed in the IR range by SPICAM on Mars Express mission. For these orbits the atmospheric density from 1.43 μm CO_2 band, water vapor mixing ratio based on 1.38μm absorption and aerosol opacities were retrieved simultaneously.

Vertical profiles of aerosol extinction were obtained at 10 wavelengths (from 1 to 1.55 μm) in the altitude range from 10 to 60 km. The interpretation of these results in terms of Mie theory with assumed refractive indices of Martian dust and H_2O ice particles allows retrieving particle size distribution and number density.

A new (w.r.t. previously reported [2]) inversion algorithm has been developed for the retrieval of H_2O and CO_2 density. We solve the problem nonlinearly by using optimal estimation theory [3]. The direct model was calculated using HITRAN 2004 spectroscopic database [4] and Martian Climate Database v4.2 [5].

High-altitude clouds were detected at L_s=130°-160° in the range of 320°-50° of east longitude at 50-60 km with particles having r_{eff}=0.1-0.3 μm and at L_s=265˚-273˚ in the range of 200°-260° of east longitude at 70-75 km, prior to the beginning of the dust storm. The optical depth of these clouds is below 0.01.

Observations in summer of 2007 (MY28) allow to observe the evolution of the vertical distribution of dust during the global dust storm, which has started approximately at L_s=270° in the southern hemisphere.

During the dust storm larger amount of atmospheric water was observed in the southern hemisphere as compared with the northern latitudes at Ls 255-270 before the beginning of the dust storm. Obtained mixing ratio equals 100-200 ppm and H_2O profiles extend up to the altitudes of 50-60 km.

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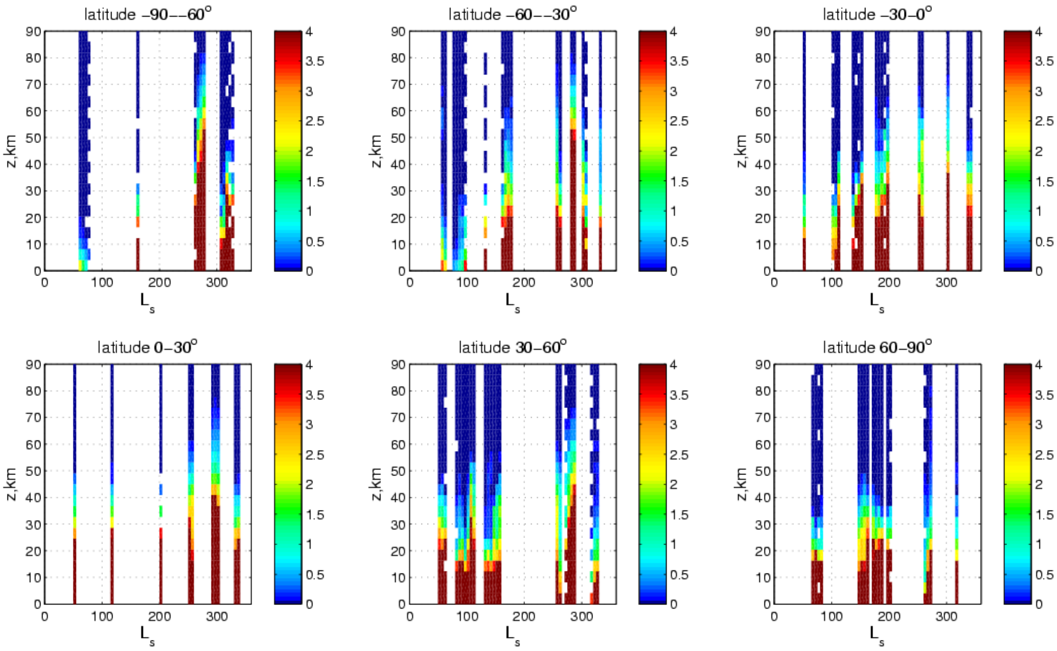

Figure 1. Aerosol vertical distribution in slant optical depth units versus a season for 6 ranges of latitudes and averaged for three Martian years. τ>4 (slant optical depth) is a detection limit of SPICAM IR during occultation observations.