New Dataset of Atmospheric Parameters Retrived by PFS-MEx

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Introduction
We used thermal-infrared spectra returned by the Mars Express Planetary Fourier Spectrometer (PFS-MEx) to retrieve atmospheric temperature profiles, surface temperatures, and single- and multi-spectral optical depths of dust and water ice. More than 2,000,000 spectra were processed to build this new atmospheric dataset, covering the full range of season, latitude, longitude, and local time. The data presented here span more than six Martian years (from M. 26, Ls = 25°, 10 January 2004 to M. 33, Ls = 79°, 6 December 2015). Atmospheric temperature and aerosol opacity are successfully retrieved in the polar regions, including the polar night. By exploiting PFS-MEx capability to perform observations at different local times (LT), this dataset allows investigation of the daily cycle of suspended dust and ice.

We present an overview of the seasonal and latitudinal dependence of atmospheric parameters during the relevant period, as well as an assessment of the interannual variability in the Martian climate. Local time variations of Martian aerosols are also presented, including dust and ice during a monsoon season and the global dust storm of M. 28, and daily variation of water ice opacity in the aphelion cloud belt. The general effect of suspended dust on atmospheric temperatures observed during the global dust storm of M. 28 is also presented. With unprecedented spatial and temporal coverage, and details revealed, this dataset offers unique challenges for the Martian global circulation models and, at the same time, for the PFS suite capability to be observed by MEx-TES.

PFS Dataset and Retrievals
Here we present the dataset of atmospheric parameters retrieved by PFS for more than 5 Myr. We used PFS data covering -33° > Ls > 215° (January 1999, 25°) to M. 33 (December 2015) to derive surface temperatures, vertical temperature profiles, and integrated dust and ice content in the Martian atmosphere. We collected data from all observed Martian years (panels A-C) in the southern hemisphere and the northern hemisphere in the early, middle, and late seasons, respectively, for each Martian year. We also retrieved the latitude of the seasonal cap and the latitude of the southern polar cap.

The retrieval algorithm (Giuranna et al., 2005; Wellerand et al., 2015) makes use of the optimal estimation method coupled with the Bayesian approach, and was optimized for the retrieval of dust and ice opacity during strong dust storms and in the aphelion cloud belt, respectively, as well as clear-sky and solar conditions in the polar regions. Used synthetic 100-°c100 spectra. The computation of synthetic spectra relies on the CO2/D2O water abundances employed in the AER code, which was specifically developed for the analysis of PFS spectra, and includes a full treatment of atmospheric multiple scattering and suspended particles.

The model is used for single-scattering quantities. METRAN 2012 is used as a spectroscopic database for the calculation of the gaseous absorption coefficients. Synthetic spectra are obtained by running the E&M code and then filtering the result with the PFS instrumental line shape (ILS). The retrieval algorithm (Giuranna et al., 2005; Wellerand et al., 2015) makes use of the optimal estimation method coupled with the Bayesian approach, and was optimized for the retrieval of dust and ice opacity during strong dust storms and in the aphelion cloud belt, respectively, as well as clear-sky and solar conditions in the polar regions. Used synthetic 100-°c100 spectra. The computation of synthetic spectra relies on the CO2/D2O water abundances employed in the AER code, which was specifically developed for the analysis of PFS spectra, and includes a full treatment of atmospheric multiple scattering and suspended particles.

Climatology of water ice clouds
The seasonal and latitudinal variation of water ice cloud optical depth as observed by PFS is shown in Fig. 2. Data collected from all observed Martian years were binned in 1° Ls × 1° latitude bins. In contrast to what reported by previous analyses of different datasets, the most prominent feature one can observe in the seasonal variation of the NH, rather than the ACB. Indeed, most of the frequent Martian clouds (on a zonally-averaged basis) are observed in the polar regions.

The polar clouds are observed all year long in both polar regions, although they show very different characteristics. The NH exhibits larger optical thicknesses and always extends to the surface, whereas the NH is an optically thinner winter ring that usually follows the climatological latitudes of the seasonal (water) ice cap edge. The NH shows peculiar features, observed here for the first time, with characteristic latitudinal and seasonal patterns that repeat very similarly every Martian year. Large optical depths (> 0.5) are always observed at latitudes > 80° N, from the summer solstice (Ls = 0°) until the winter solstice (Ls = 180°). From 270° to 360° Ls, the white polar NH region is observed with optically-thick water-ice clouds.

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Data Assimilation
The observed daily cycle of ice opacity shows a nearly symmetric behavior, which indicates that the minimum of opacity is observed. The mean daily cycle of ice opacity is observed at local dusk, when a mean value of 0.4 is observed, and then increases during the night to a value of 0.6. The ice opacity then decreases during the day, with a minimum of 0.4 observed at local noon, and increases again during the afternoon to a value of 0.6. This daily cycle is consistent with the expected value of 0.6 during solar noon, plus the observed increase of 0.2 to 0.4 during the afternoon.

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