OBSERVATIONS OF MARTIAN WATER VAPOR IN MY26-30 BY PFS/LW ON MARS EXPRESS. A. Pankine[1], [1]Space Science Institute (4750 Walnut Street, Suite 205, Boulder, CO 80301, apankine@spacescience.org)

Introduction: Seasonal variations in atmospheric water vapor abundances have been observed by multiple Mars orbiting spacecraft for several Martian years (MY) (e.g. [1], [2]). Observations by Thermal Emission Spectrometer (TES) onboard Mars Global Surveyor (MGS) [2] provided longest continuous almost global coverage of vapor changes in the Martian atmosphere during MY24-27. An uninterrupted observational record is important for establishing possible interannual variability. Several instruments currently in orbit around Mars provide continued observations of the atmospheric water vapor.

Spectra collected by Planetary Fourier Spectrometer (PFS) Long Wavelength Channel (LW) onboard Mars Express (MEX) spacecraft [3] are used to retrieve water vapor abundances over the same spectral range as TES and to extend the TES record of vapor variability to MY27-30. The PFS/LW retrievals are compared to contemporaneous retrievals from Compact Reconnaissance Imaging Spectrometer (CRISM) onboard Mars Reconnaissance Orbiter (MRO) spacecraft [4] and SPICAM IR spectrometer on Mars Express [5]. Seasonal changes in vapor abundances retrieved from the PFS/LW data are qualitatively consistent with the established seasonal cycle of water vapor; however comparison to other datasets reveals noticeable differences that could be due to differences in the retrieval processes or due to non-uniform vertical distribution of water vapor.

PFS/LW dataset: PFS/LW collects spectra in the range 250–1700 cm^{-1} (5.9–40 µm). Water vapor abundances are retrieved using multiple bands between 300-500 cm^{-1}. The retrieval algorithm is described in detail in [6]. Briefly, water vapor is assumed to be uniformly mixed below the condensation height and its spectral signature is modeled using line-by-line calculations. The CO_2 band centered on 665 cm^{-1} is used in a separate step to retrieve atmospheric temperature profile [7]. Surface emissivity and water column abundance are iterated until the best fit between the modeled and observed spectra is found.

Analysis of approximately one Martian year of PFS/LW water vapor observations (from Ls=330° in MY26 to 360° in MY27) was reported in [6]. The current analysis extends to Ls=180° in MY30 and includes data from orbits 10-9000. Since the initial analysis [6] the spectral calibration of the PFS data has been improved by calibration correction and refined calibration of laser diodes ([8], M. Giuranna, private communication). The retrievals presented here are from averages of 10 spectra along the ground track. Retrievals with estimated uncertainty exceeding 20 pr-µm or 20% were rejected.

Seasonal variability: Seasonal variability of the water vapor from combined retrievals for MY26-MY30 is shown in Figure 1. Retrievals were binned into 4°×5° latitude-Ls grid. Only the daytime retrievals are shown. Column abundances are color coded from 0 to 40 pr-µm. The annual evolution of water vapor in the Martian atmosphere observed by PFS/LW is qualitatively consistent with the seasonal cycle established by previous observations (e.g. [1], [2]).

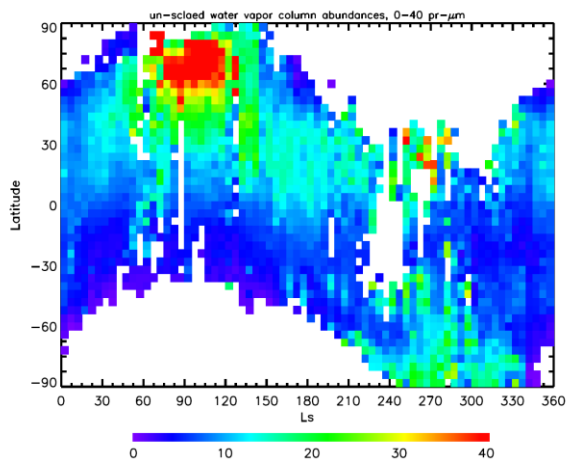

Figure 1. Seasonal cycle of water vapor from PFS/LW data for MY26-30.

Comparison to other datasets: Comparison of the new PFS/LW retrievals to the CRISM [4] and SPICAM [5] retrievals reveals noticeable differences. Figure 2 and Figure 3 compare seasonal cycle of water vapor observed in MY29 by PFS/LW and CRISM and SPICAM, respectively. Local times of observations differ for PFS/LW and CRISM observations, but are all for daytime observations. During northern spring and early summer (Ls=30-120°) in the northern mid and high latitudes PFS/LW vapor abundances are higher by ~20 pr-µm than CRISM and SPICAM abundances. Similar difference between PFS/LW and SPICAM abundances is observed in MY27 (not shown). Between Ls=120-150° PFS/LW abundances are lower by ~10-20 pr-µm. PFS/LW abundances are also lower by ~5-10 pr-µm than the CRISM abundances during southern summer season (Ls=240-330°) in the southern mid and high latitudes.

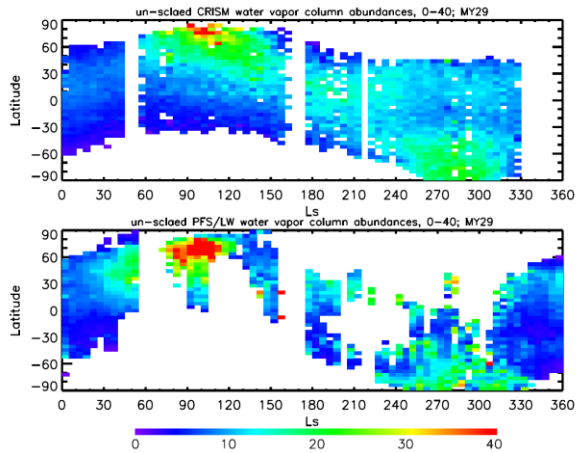

Figure 2. Comparison of CRISM (top) and PFS/LW (bottom) water vapor retrievals for MY29.

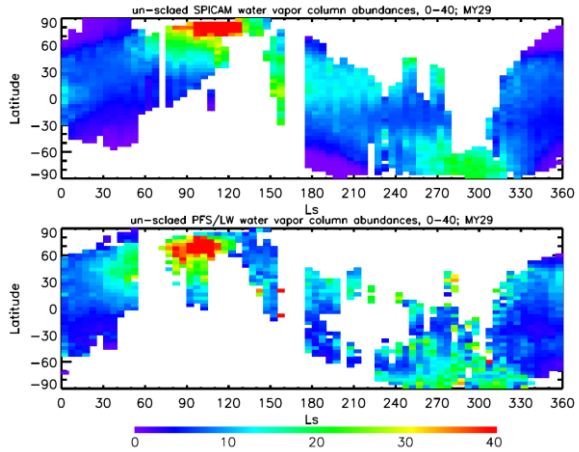

Figure 3. Comparison of SPICAM (top) and PFS/LW (bottom) water vapor retrievals for MY29.

The differences between PFS/LW, CRISM and SPICAM retrieval algorithms make it challenging to pin-point the exact reason for the observed difference in column abundances. There are differences in assumed surface pressures, atmospheric temperature profiles, local times of observations, longitudinal coverage and water vapor line broadening coefficients between the three retrieval algorithms – with all of these factors possibly contributing to the observed differences. For example, the three retrieval algorithms use different atmospheric temperature profiles: PFS/LW temperatures are those retrieved from the spectra, CRISM uses climatological values from TES data, and SPICAM – temperatures simulated by a Global Circulation Model. A several degrees difference between temperature profiles, especially in the lower atmosphere, can result in a difference of ~5-10 pr-µm for PFS/LW retrievals. Another reason for the observed differences between retrieved abundances could be non-uniform distribution of water vapor in the atmosphere. Retrievals from the CRSIM and SPICAM data are more sensitive to the vertical distribution of water vapor than the PFS/LW retrievals [9]. Consequently, higher PFS/LW abundances during northern spring and summer could be due to water vapor confined to the lower atmosphere.

References:

[1] Jakosky B. M. and Farmer C. B. (1982) *JGR, 87,* 2999–3019. [2] Smith M. D. (2008) *Annu. Rev. Earth Planet. Sci., 36,* 191-219. [3] Formisano V. et al. (2005) *Planet. Space Sci. 53*, 963–974. [4] Smith M. D. et al. (2009) *JGR, 114,* doi:10.1029/2008JE003288 [5] Trokhimovskiy A. et al. (2014) *Icarus*, in press [6] Fouchet T. et al. (2007) *Icarus, 190*, 32-49. [7] Grassi D. et al. (2005) *Planet. Space Sci. 53*, 1017–1034 [8] Giuranna M. (2005) *Planet. Space Sci. 53*, 993–1007. [9] Tschimmel M. et al. (2008) *Icarus, 195*, 557–575.