COLOCATED MEASUREMENTS OF CO WITH CRISM (MRO) AND PFS (MARS EXPRESS).

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Introduction

Carbon monoxide (CO) in the atmosphere of Mars is directly produced by photolysis of CO_2. As CO is a non-condensable species and has a lifetime relatively long, its abundance and its variation with season and location provide important clues about atmospheric transport dynamics [Nelli et al., 2007]. So far, the global picture of CO cycle has been investigated by Planetary Fourier Spectrometer (PFS) onboard Mars Express (MEX) [Sindoni et al., 2009] and Compact Reconnaissance Imaging Spectometer (CRISM) onboard Mars Reconnaissance Orbiter (MRO) [Smith et al., 2009].To better characterize the CO trends in the martian atmosphere, results from two different datasets were compared.

In this study, we will describe briefly both instruments. Two datasets have been selected:

- Measurements over 5 regions at low/mid latitudes
- Absolute colocated and simultaneous measurements

We will present here the analysis strategy and show preliminary results of the comparison.

CRISM dataset

CRISM/MRO is a hyperspectral imager with a spatial resolution of 15-19m/pixel and a spectral range of 362-3920 nm with a spectral sampling of 6.55 nm and a spectral resolution in the infrared ($\sim$ 2000 nm) of about 15 nm [Murchie et al., 2007].

CRISM has been collecting data since September 2006. Its main targets include carbon dioxide, water vapor and carbon monoxide. Retrievals performed using the near-infrared spectra obtained by CRISM are used to characterize the spatial and seasonal variation of the column-averaged mixing ration of CO. The data considered in this study were collected from all retrievals from Ls=113, MY28 to Ls=103, MY31.

Retrieval of CO by CRISM is performed using the 2.36 μm band (Smith et al., 2009). Although this band is weak, it is isolated from other atmospheric spectral

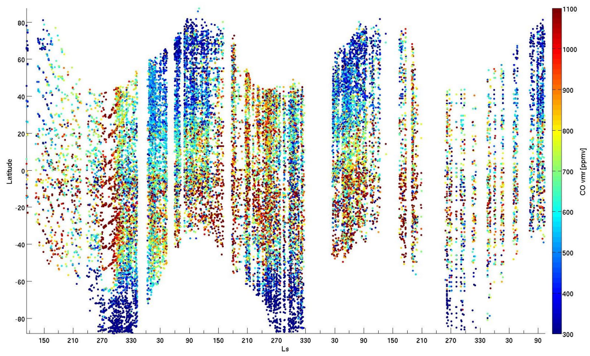

Figure 1: 33544 CRISM retrievals values. Latitude versus Solar Longitude

signatures and provides reliable retrievals. The CO retrievals from individual spectra are very noisy. CRISM CO results have therefore been heavily averaged and smoothed. For any single retrieval, uncertainty of 10% for surface pressure, 20% for water vapor and 40% for CO are estimated. The averaging of CO retrievals is done by taking all the retrievals within a box 30° in Ls and 10° in latitude, order the CO values from highest to lowest, discard the highest 30% and the lowest 30%, and then average the remaining central 40% for the final estimate. Finally, a total of 33544 CRISM retrieved values are available and are shown on Figure 1.

PFS dataset

PFS/MEX is a double-pendulum Michelson interferometer, working in two infrared channels [Formisano et al., 2005]. The Short Wavelength Channel (SWC) covers the range from 1.2 to 5.9 μm while the Long Wavelength Channel (LWC) covers the range from 4.9 to 45 μm. PFS's advantage is its relatively high spectral resolution ($\sim$ 1.3 cm^{-1} without apodization) over its wide spectral coverage.

As shown in Figures 2-3, CO can be studied with PFS data through the strong absorption bands around 4.7 μm , and a series of minor absorption lines around 2.36 μm [Sindoni et al., 2009]. PFS measurements in the

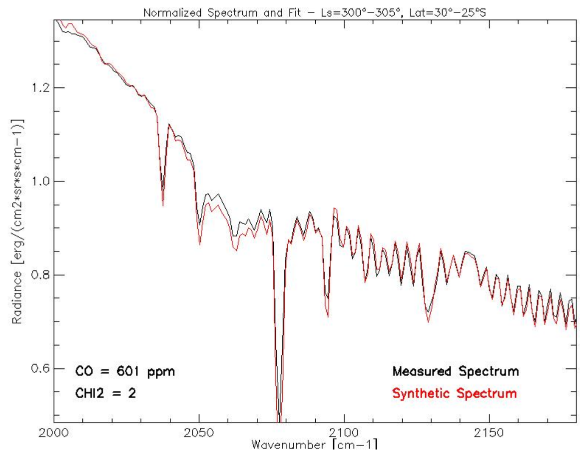

Figure 2: CO absorption bands in PFS spectrum around 4.7 μm [Sindoni et al., 2009]

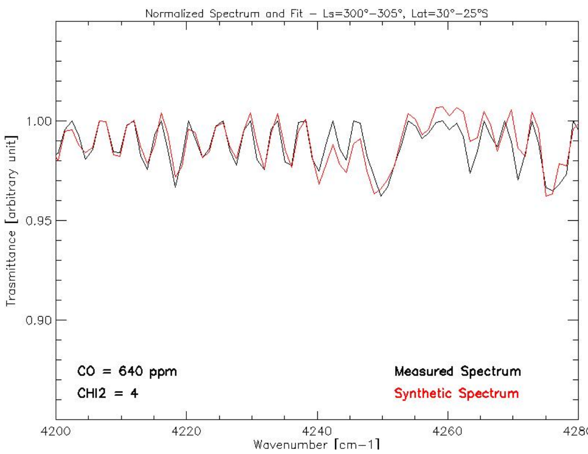

Figure 3: CO absorption bands in PFS spectrum around 2.36 μm [Sindoni et al., 2009]

4.7 μm band are more accurate than those done with the 2.36 μm one since the first shows stronger CO absorption features (high SNR) and has no instrumental effect. However, retrievals are more complex because both thermal radiation and solar reflection have to be taken into account. PFS observations have been performed from January 2004 (Ls=330° in MY 26). We selected PFS data for joint observations with CRISM spanning a period of almost 3 martian years (MY), from 06/11/2006 (Ls=131.41° in MY28) to 01/05/2012 (Ls=104.25° in MY31). During this period, 1178508 spectra were measured by PFS.

Comparison in 5 selected regions

We selected 5 boxes of latitude and longitude to start our comparison between the two datasets. We compared CO mixing ratio retrieved by PFS (4.7 μm band) and CRISM over the selected 5 regions shown in Figure 4: Terra Sabae (25S-30N 30-60E), Nili Fossae (8S-40N 60-90E), Arabia Terra (0-40N 0-45E), Tharsis (15S-30N 90-135W) and Elysium (0-40N 135-180E). They represent 244 co-located data in total.

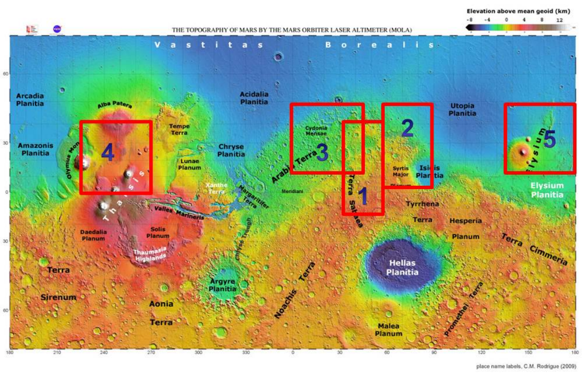

Figure 4: Selected regions on the Martian globe. The map comes from Mars Orbiter Laser Altimeter onboard the Mars Global Surveyor [Zuber et al., 1992]

Figure 5 shows the CO mixing ratio derived by PFS and CRISM over the selected 5 regions. The mean abundance retrieved by PFS is 663.9 ppm and the one by CRISM is 745.4 ppm. Both instruments measure clear seasonal variation of CO. Amplitudes of observed variations and mean values of CO mixing ratio are comparable in the two instruments (~10 % of difference).

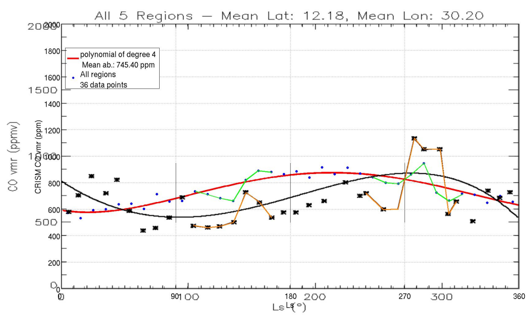

Figure 5: Averaged CO vmr values for the 5 regions binned together. The red curve represents a degree 4 polynomial function corresponding to the CRISM data while the black function corresponds to PFS observations.

Note that the retrieved seasonal cycle by PFS is shifted compared to the one obtained with CRISM. At the moment, the reason for this shift is still under discussion. Indeed, CRISM retrievals have high uncertainty

(∼40% from single CRISM measurement) but it is unlikely the reason for this discrepancy because more than 1000 CRISM retrievals are averaged in each region and this should reduce the error. For a non-condensable gas, one would expect a minimum during the local summer and a maximum during the winter, as observed by PFS, rather than in spring and autumn, respectively, as in the CRISM data. At low latitudes (mean latitude for all regions is $\sim 12°$) no huge amplitudes in these variations are expected. Indeed, the global mean shows reasonable variations (∼ 500 ppbv peak-peak). In order to constrain this discussion, we will retrieve CO mixing ratio by PFS 2.36 μm range with the same dataset. Despite this difference, there are clear features present in both datasets, at the same Ls. One example is the sudden increase of CO around 140-150 Ls and, most of all, the absolute maximum around 280-290 Ls with comparable width observed in the two data, from Ls∼260 to Ls∼300.

Co-located and simultaneous measurements

In order to compare CO abundances accurately, we looked for co-located and simultaneous measurements between PFS and CRISM. As already described, CRISM observations correspond to averages within boxes of 30° in Ls and 10° in latitude, whereas individual non-averaged PFS measurements were considered. Within these boxes, about 2000 common observations have been found. Figures 6 and 7 show the longitudinal, latitudinal, and seasonal distribution of the selected dataset for simultaneous observation between PFS and CRISM.

We will retrieve CO mixing ratio from PFS then compare the values with CRISM retrievals.

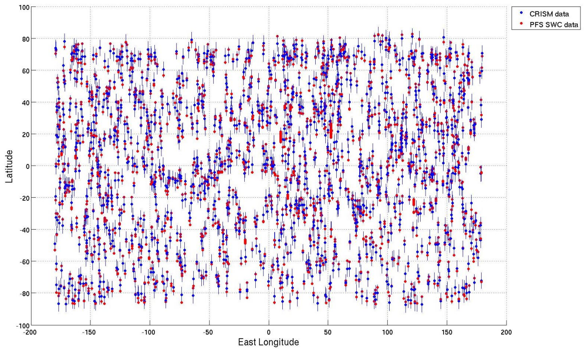

Figure 6: 1974 co-located and simultaneous retrievals of CRISM and PFS. Latitude versus East Longitude

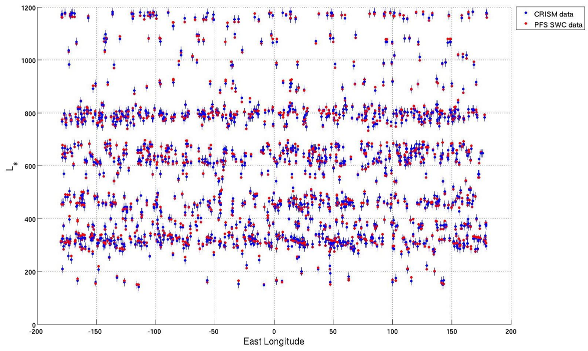

Figure 7: 1974 co-located and simultaneous retrievals of CRISM and PFS. Solar Longitude versus East Longitude