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High-resolution spectroscopy of Mars using IRTF/CSHELL: Variations of CH_4, CO at ~10 and 50 km, and O_2 airglow

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Abstract

Our long-term observations of methane are compared with the other ground-based and MSL data. Improved map of seasonal-latitudinal variations of CO in the lowest scale height will be coupled with observations of CO at ~50 km using its dayglow at 4.7 µm. An attempt to detect the O_2 nightglow at 1.27 µm at low latitudes resulted in its intensity of 10 ± 40 kR. Mean interannual variations of the O_2 dayglow are 20-30%.

1. Observations

Here we report some results of our mapping observations of Mars in the last four years using a long-slit high-resolution spectrograph CSHELL at NASA IRTF. It covers a range of 1.1 to 5.6 µm with resolving power of 4×10^4. The telescope with diameter of 3 m is at elevation of 4.2 km with mean overhead water of 2 pr. mm and pressure of 0.6 bar.

2. Methane

Our search for CH_4 in December 2009 and March 2010 that resulted in upper limits of 8 ppb [4, 5] was published prior to the MSL landing and beginning of the Curiosity operations in August 2012. Telluric methane exceeds that on Mars by a factor of $\sim10^4$ or more, and we improved a technique of extraction of the martian methane using spectra of the Moon observed almost simultaneously. Later both MSL in 2012 [9] and ground-based observations in January 2006, November 2009, and April 2010 [8] confirmed the lack of methane. CH_4 is ~10 ppb near Valles Marineris in our observations in February 2006 and less than 7.8 ppb in Villanueva et al. [8]. They chose an individual point in our plot and erroneously claimed significant disagreement. The published ground-based and MSL observations (Fig. 1) favor episodic ejection of methane of Mars, while the PFS and TES data show rather regular variations.

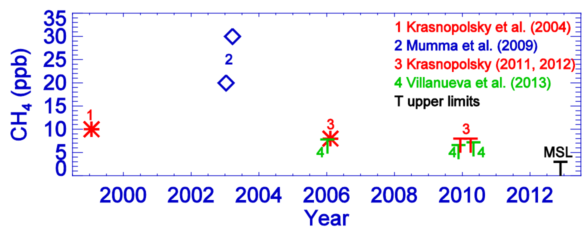

Fig. 1. Ground-based and MSL observations of CH_4

3. CO at 0-15 and 50 km

The discovery of seasonal variations of long-living species (N_2, Ar, O_2, CO, H_2 etc.) was made using observations of CO at L_S = 112° [2]. These variations are induced by condensation and sublimation of CO_2 in the polar regions. We continue those observations and use various lines of CO and CO_2 to measure the CO mixing ratio in the lowest scale height (Fig. 2).

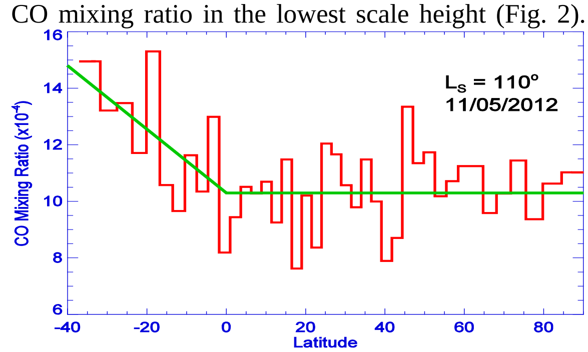

Fig. 2. Latitudinal variations of CO mixing ratio observed in May 2012.

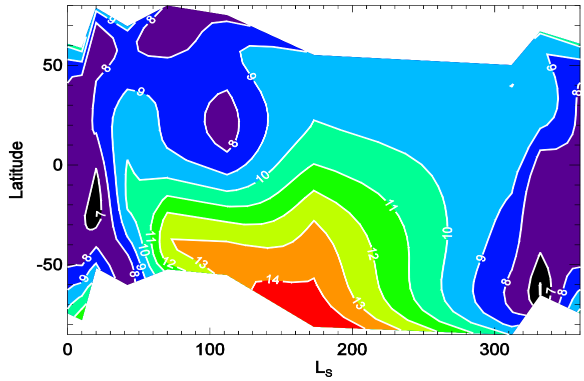

Fig. 3. Seasonal-latitudinal variations of CO (times 100 ppm)

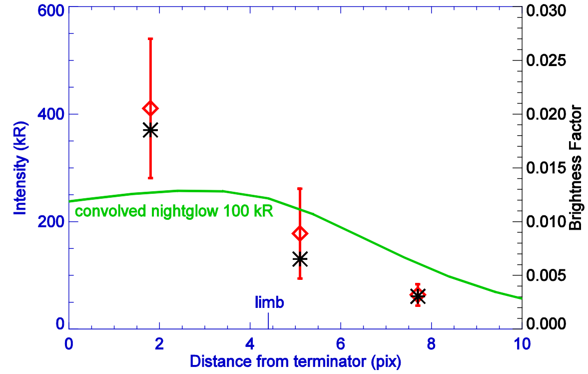

Fig. 5. Comparison of the observed airglow (red) and brightness factors with the calculated airglow results in its intensity of 10±40 kR.

Currently the collected data cover nine seasonal points on Mars, and a map of seasonal-latitudinal variations of the CO mixing ratio (Fig. 3) may be used to test GCMs.

Our observations near 4.7 μm (Fig. 4) reveal the CO (2-1) emission lines [1] that are excited by the solar radiation in the CO (2-0) band at 2.35 μm and quenched by CO_2. Our calculations show that the observed emissions reflect temperature and abundances of CO near 50 km. Therefore we will extract the CO mixing ratios both in the lower scale height and near 50 km to get a more detailed picture of the CO variations.

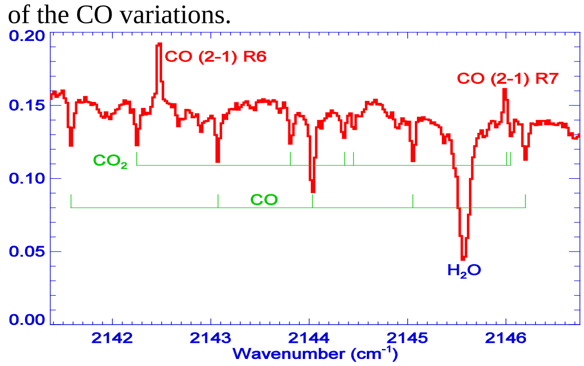

Fig. 4. CO emission lines observed near 4.7 μm.

4. O_2 night and dayglow at 1.27 μm

The discovery of the bright polar nightglow at 1.27 μm with a mean vertical brightness of 300 kR stimulated us to search for the O_2 nightglow at low latitudes. Our previous attempt was made in 2003 [3] at the nightside limb at 70°S and L_S = 173° and resulted in an emission of 2.2 MR, close to the observed polar nightglow. Recently we made thorough observations at three slit positions near the morningside limb, which rule out contamination from the dayside tail. The observed vertical intensity is 10 ± 40 kR (Fig. 5), that is, less than 50 kR with probability of 84%. Observed interannual variations of the O_2 dayglow are shown in Fig. 6.

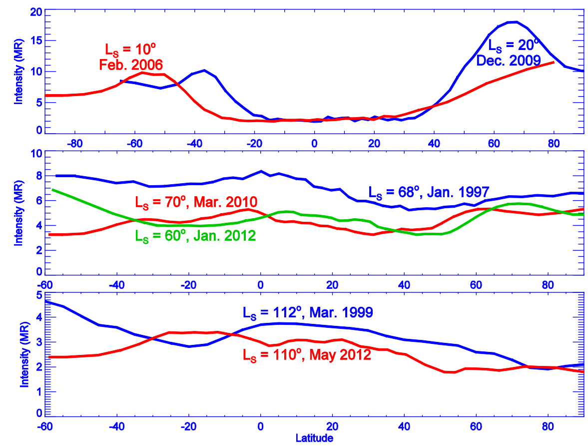

Fig. 6. Interannual variations of the O_2 dayglow.

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