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HDO/H_2O ratios at the northern summer on Mars observed by SUBARU/IRCS and MEX/PFS

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Abstract

We investigate Martian D/H ratio in water vapor at the northern summer by the joint observations between SUBARU/IRCS and MEX/PFS.

Although it is suggested that Mars has a drastic water cycle with the sublimation-condensation process, none of previous observations of water vapor could discriminate between the sublimation-condensation process and the atmospheric dynamics. Mapping of the isotopic fractionation, D/H ratio, in water vapor is a powerful tool to distinguish the different physical processes in the water cycle, because the lighter H_2O vapor preferentially sublimates compared to the heavier HDO vapor due to the difference in their vapor pressures.

Recent ground-based observations by IRTF/CSHELL showed that the HDO/H_2O ratio on Mars varies between about 2 to 8 (relatively to Standard Mean Ocean Water (SMOW); HDO/H_2O =3.11x10^{-4}) depending on location and local time at the northern spring (Villanueva et al., 2008; Novak et al., 2011). Novak et al. (2011) showed latitudinal gradients of HDO/H_2O ratio due to rich condensation of HDO vapor at high latitudes. We recently used SUBARU/IRCS to determine D/H ratios in water vapor. Owing to the wide spectral coverage of IRCS, we were able to observe H_2O and HDO features simultaneously. Our results showed similar latitudinal gradients as in Novak et al. (2011) for the same season, i.e., northern spring (Aoki et al. 2013). In addition, we carried out similar observations at the northern summer. The northern summer is expected to have a drastic water cycle, i.e., sublimation of the north polar cap, condensation of water-ice clouds to form the equatorial cloud belt, and possibly exchange of vapor from subsurface due to the raising surface temperature. Our ground-based observations are in the framework of the coordinated joint-observations with the Planetary Fourier Spectrometer (PFS) onboard Mars Express (MEX).

In order to detect the narrow lines of H_2O and HDO in the Martian atmosphere, spectroscopic observations with high-spectral resolution are indispensable. Only ground-based observations have capability to detect the Martian HDO because there are no space-borne instruments with such high spectral resolution at the moment. Here, we used high-dispersion echelle spectroscopy of IRCS (resolving power of 20,000) at SUBARU telescope (8.2m) in Maunakea observatory, Hawaii. The instrument can observe the following five spectral bands simultaneously; 2.94-3.01 μm, 3.01-3.18 μm, 3.28-3.36 μm, 3.49-3.57 μm, and 3.72-3.81 μm. The observed spectra exhibit strong lines of H_2O, HDO, CO_2(626), CO_2(627), CO_2(628), and CH_4. MEX/PFS measures the Martian radiation in the spectral range between 1.2 and 45 μm with a relatively high spectral resolution (~1.3 cm^{-1}). From the PFS data, we can retrieve H_2O abundance, temperature profile, surface temperature, water ice abundance.

The joint observations were performed on 13 April 2012 (Ls=96°). **Table 1** summarizes the observing conditions of SUBARU/IRCS. The slit (6.69" ×0.14") was put on the sub-observer longitudes along the North-South direction to investigate latitudinal distributions at the northern hemisphere. Meanwhile, PFS performed several observations orbiting around Mars. We selected observations in the +/- 3 days time slot wrt the IRCS observation date as shown in **Figure 1** (MEX orbit #10541-10567).

We retrieved HDO abundances from IRCS data using the absorption line at 2667 cm^{-1}. **Figure 2** shows the latitudinal distributions of HDO abundances. We found evidence of seasonal variation of HDO abundances and enhancement

at the northern summer around the north polar cap. Unfortunately, the abundances of H_2O could not be retrieved with IRCS data because of the high humidity during the observation (~70-80 % on the summit). We will retrieve the H_2O abundances from PFS measurements using 3845 cm^{-1} and/or 300 cm^{-1} bands, and compare them with the HDO abundances retrieved from IRCS data.

Figure and Table

Table 1: Observing conditions of SUBARU/IRCS.

Date(UT)	2012/13/April 6:17 - 10:49
***Ls* (°)**	96.2
Airmass	1.05 - 1.56
Slit direction	N-S direction
Observing areas (°)	40E - 80E 34W - 60W
Doppler shift (km/s)	+11
Mars diameter (“)	11

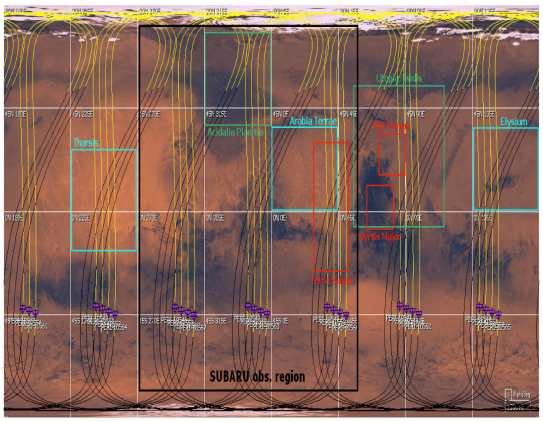

Figure 1: The tracks of PFS observations performed in 10-17, April 2012.

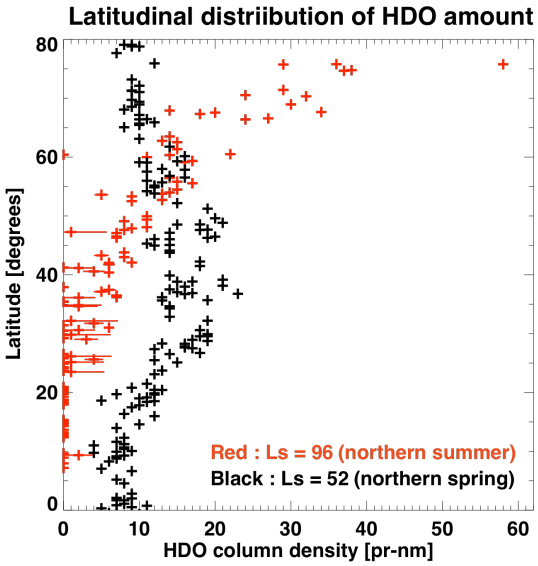

Figure 2: Latitudinal distributions of HDO abundances observed by SUBARU/IRCS at *Ls*=96° (red) and *Ls*=52° (black, from Aoki et al., 2013).

Acknowledgements

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