LATITUDINAL/DIURNAL MAPPING OF [HDO], [H_2O], AND THEIR RATIO ON MARS USING GROUND BASED HIGH-RESOLUTION SPECTROSCOPY. R.E. Novak[1], M.J. Mumma[2], and G. L. Villanueva[3], [1]Iona College, New Rochelle NY USA (rnovak@iona.edu), [2]NASA-Goddard Space Flight Center, Greenbelt MD USA (michael.j.mumma@nasa.gov), [3]NASA-Goddard Space Flight Center, Greenbelt MD USA (Geronimo.villanueva@nasa.gov).

Introduction: We report recent investigations of HDO and H_2O, on Mars for data taken on 3 April 2010 (L_s = 72.5°) and 21 January 2014 (L_s = 79.5°). The CSHELL spectrograph on the NASA-IRTF was used for our observations. The slit was positioned E-W on Mars centered at the sub-Earth point (Fig. 1A). Data at HDO and H_2O settings were taken over a four-hour period for each date. This is part of a larger study to obtain measurements of the seasonal and geographical variation of HDO, H_2O and their ratio, thereby obtaining better insights into the dynamics of Mars' atmosphere. We have previously presented latitudinal maps for several different seasonal dates [1-7]. We now present longitudinal/diurnal maps.

Our group has conducted an observing program to measure the [HDO]/[H_2O] ratio for different seasons and positions on Mars. DiSanti and Mumma [8] developed a technique for mapping HDO on Mars through its ν_1 fundamental band near 3.67 μm using CSHELL. Novak et al. [1] extended the approach significantly for HDO data acquired in January 1997. For data taken from 1997 to 2003, we compared our HDO data to H_2O results obtained from TES [9]. Since 2003, we have been using absorption lines near 3.33 μm (the $2\nu_2$ band) to determine H_2O abundances. With long slit spectrometers, we now map the two species using the same spectrometer-telescope combination, eliminating many sources of systematic error. Our observations have shown variations in the [HDO]/[H_2O] ratio [2,5,6].

Observations: A detailed description of our data acquisition and analysis routines was recently published [6]. Here, we present longitudinal/diurnal maps for [HDO] and [H_2O] values taken on 03 April 2010 (L_s = 72.5°) and 21 January 2014 (L_s = 79.5°). The slit was positioned E/W on Mars centered at the sub-Earth point (Fig. 1).

Maps for [HDO] versus longitude on these two dates are presented in Fig. 2A. For both dates, column densities in the 280°-300° W region are the lowest, but the densities are greater in both the Syrtis Major region and in the region west of Elysium Mons. Column densities from L_s = 72.5° (275°W and 340°W, Fig. 2B), are plotted versus local time. The densities at 275°W, accumulated over local times 09:00-13:00, are constant. On the other hand, column densities of HDO at 340°W increase between 06:30 and 09:00 LT. The elevation for this region is higher. This increase is interpreted as the vaporization of frost and water ice clouds after sunrise; the frost and water ice clouds are formed during the night and have a tendency to form over highland regions rather than lowlands [10], resulting in greater values and variation at 340°W. Likewise, the increased HDO column density near 240°W (Fig. 2A) is interpreted as the result of vaporization of clouds formed to the west of Elysium Mons.

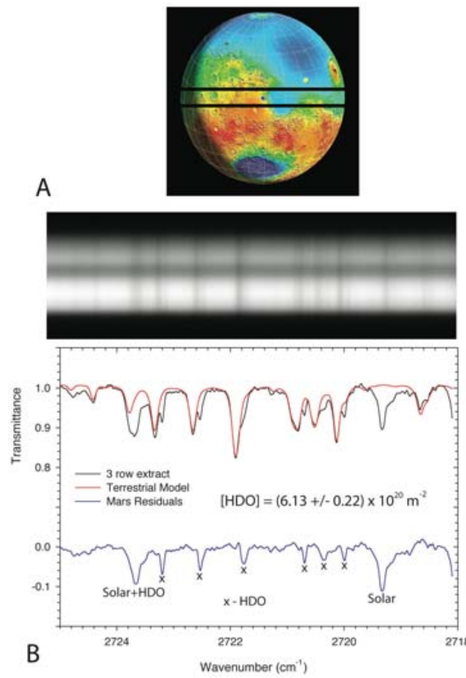

Figure 1: A. Position of the slit across Mars on 3 Apr 2010, 6:25 UT [12]. The sub-Earth position was centered within the spectrograph slit. **B**. Spectral-spatial image at HDO setting. Three-row extract is centered at 327°W, 14°N. The Martian HDO lines are red shifted with respect to the terrestrial lines. A terrestrial atmospheric model (red) is subtracted from the observed trace yielding the Martian absorption lines (bottom). The best-fit of this trace by Mars atmospheric models yields the column density of HDO.

Longitudinal maps of [HDO] and [H_2O] surrounding 14°N on 21 Jan 2010 are presented in Fig. 3 along with their ratio. The column densities of both species are greater in the highland region; likewise, the ratio between the two species is greater in this region. We

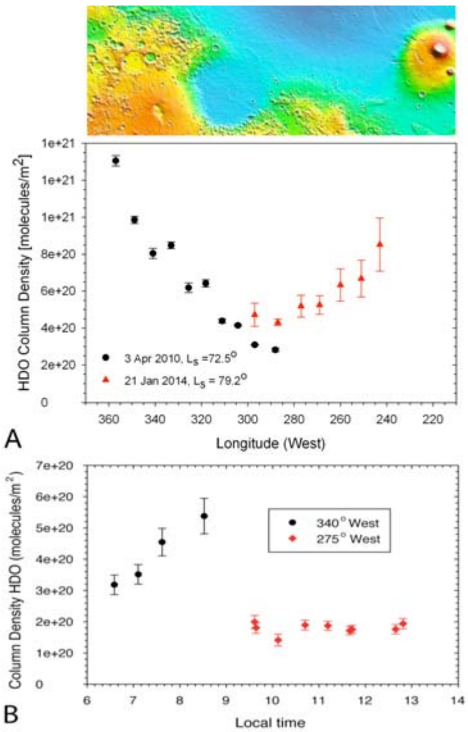

Figure 2: A. Retrieved HDO column for observations on 03 Apr 2010 (06:25 UT) and 21 Jan 2014 (13:42 UT). The cropped Mars-MOLA map indicates the location of the retrieve points. **B.** For observations on 03 Apr 2010, retrieved data points adjusted to local time are plotted.

interpret this as a result of water-ice formations that have a tendency to accumulate [HDO] rather than [H_2O]; when they vaporize, their ratio is thus higher.

Conclusion and Future Plans: We present longitudinal/diurnal maps of [HDO], [H_2O], and their ratio for L_s = 72.5° and L_s = 79.5° for different Martian years. Using updated analysis tools [6], we intend to further analyze recent data and reanalyze previously taken data. We plan to continue our observations during future Mars apparitions and to use ISHELL [11] which is currently being constructed at the NASA-IRTF. ISHELL is a cross-dispersed IR-spectrograph that can measure both HDO and H_2O bands simultaneously with a better sensitivity than CSHELL.

In addition to the observations described here, we plan to monitor water-ice clouds by taking CO_2 measurements at two different wavelengths (3.20 and 3.65 mm); path lengths at these wavelengths will be compared to altitude results from MOLA.

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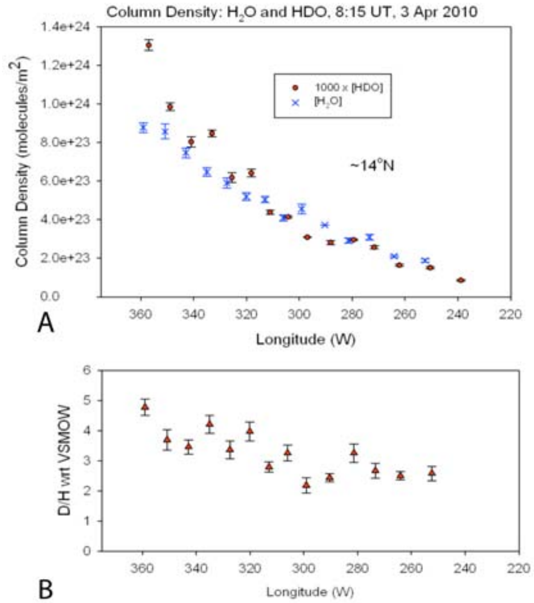

Figure 3: A. Column densities of HDO and H_2O at 8:15 UT, 3 April 2010. The slit was positioned E/W on Mars centered at 14°N. **B.** Using the values in Fig. 3A, the ratio between [HDO] and [H_2O] on Mars is compared to the Vienna Standard Ocean Mean Water (VSMOW) on Earth.

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