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Water vapor behavior in Jezero Crater. Leslie K. Tamppari¹, G. Martínez², J. A. Rodríguez-Manfredi³, M. de la Torre-Juárez¹, J. Polkko⁴, M. Hieta⁴, I. Jaakonaho⁴, M. Genzer⁴, A.-M. Harri⁴, H. Savijärvi⁴, T. Bertrand⁵, J. Holmes⁶, T. McConnochie⁷, F. Montmessin⁸, M. Smith⁹, M. Wolff⁷, E. Fischer¹⁰, P. Conrad¹¹, F. Gómez³, M.-P. Zorzano³, P. Patel¹², M. Lemmon⁷, E. W. Knutsen¹³, J. Pla-García³, and the MEDA Team, ¹Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109; leslie.tamppari@jpl.nasa.gov, ²Lunar and Planetary Institute, Houston, TX, ³Centro de Astrobiología (INTA-CSIC), Madrid, Spain, ⁴Finnish Meteorological Institute, Helsinki, Finland, ⁵LESIA, Observatoire de Paris, Meudon, France, ⁶Open University, Milton Keynes, UK, ⁷Space Science Institute, Boulder, CO, ⁸LATMOS, Guyancourt, France, ⁹NASA Goddard Space Flight Center, Greenbelt, MD, ¹⁰University of Michigan, Ann Arbor, MI, ¹¹Carnegie Institution of Science, Washington, D.C., ¹²University College London, UK, ¹³UiO, ITS, Norway

Introduction: To understand modern-day water vapor transport, we need to understand the global spatial and vertical distribution of vapor through time as well as temporary and long-term sources and sinks. The fleet of Mars orbital spacecraft, as well as some ground-based datasets, have provided an excellent record of vapor column abundances for several Mars years (e.g., [1]), some higher-altitude vertical profiles of vapor [2], and some insights into the diurnal changes in the column abundances (e.g., [3]). Datasets such as these have been used to constrain models and produce assimilation data sets [4-6].

The details of the water vapor vertical profile and vapor exchange with the subsurface, and how these change spatially and temporally, are less well understood. This information is needed to (i) determine the degree to which water vapor can buffer subsurface ice helping to preserve it, (ii) provide sufficient moisture for the formation of brines that could be astrobiologically important, or (iii) affect the extent of the vapor transport to annual or longer-term cold traps, and (iv) constrain models. Combinations of instrument's data [7] and solar occultation measurements [3] have been used to examine the vertical profile, finding that the lowest 5 km had a higher mixing ratio than above that, at least in some seasons. Several landed spacecraft, *Phoenix*, *Curiosity*, and *Perseverance* have collected near-surface relative humidity measurements [8-10] that have been used to understand the near-surface vapor amount and its variability, to constrain models that predict the vapor vertical profile, and to estimate subsurface conditions that would result in the observed diurnal change in vapor (e.g., [11]).

The newest of these relative humidity data sets, that of the *Perseverance* Mars Environmental Dynamics Analyzer (MEDA), is examined here. We focus on the first full year of these measurements, which extended from $L_s=40$ in Mars Year 36 (MY36; after [12]) to $L_s=40$ in MY37. We compare these near-surface values to column orbital measurements and evaluate the seasonal and regional differences, noting effects of

dust on vapor abundances. We examine the day-night variation as a function of season and examine the seasonal time periods for which the atmosphere can become saturated.

Methods: The *Perseverance* rover MEDA instrument [10] comprises multiple meteorological sensors including air temperature sensors, a pressure sensor, a relative humidity sensor (RHS), radiation and dust sensors, wind sensors, thermal radiation sensors, and an upward-looking camera. The sensors used in this work are the relative humidity, air temperature, and pressure sensors. Both the RHS and the air temperature sensors used are located on the rover mast at about 1.5 m above the Martian surface, whereas the pressure sensor is within the rover body with an inlet on the rover deck.

We also use orbital measurements of column water abundances taken from previous spacecraft for comparison to the MEDA RHS measurements taken in Jezero crater. We include the Viking Mars Atmospheric Water Detector (MAWD) data set [13], the Mars Global Surveyor Thermal Emission Spectrometer (MGS TES) data set [1], the Mars Reconnaissance Orbiter Compact-Resolution Infrared Spectrometer for Mars (MRO CRISM) data set [14], the ExoMars Trace Gas Orbiter NOMAD (TGO NOMAD) data set [3], and the Hope mission Emirates Mars InfraRed Spectrometer (EMIRS) data set [15].

Results:

Seasonal and diurnal behavior of near-surface humidity: Figure 1 shows the seasonal variability of orbital column abundances (taken near 1400 LT) as a function of L_s for MY13-36 along with maximum nighttime MEDA RHS data converted to equivalent column abundances (assuming a well-mixed atmosphere). Because the daytime temperatures are warm and the absolute abundance of water is low, daytime relative humidity is near 0% and is not measurable by MEDA. It is evident that there is a nighttime, near-surface depletion of water. Single column modeling has been done, indicating that the surface has ~25% porosity, allowing water to exchange

diurnally [16]. This depletion was estimated to be between $0.5 - 10 \text{ g/m}^2$ in [17], with the lower range most likely as modeling shows that only the bottom several hundred m to km participate in the exchange, not the entire column [e.g., 18].

The seasonal trend of varying water abundance is similar between the near-surface RHS and the column measurements, especially allowing for interannual variability. However, comparing the EMIRS data taken in MY36, coincident with the RHS data (Fig. 2), we see that the zonally averaged column values reach their peak abundances prior to the peak seen in Jezero crater. This was also seen in MCD modeling [22]. This may be due to a topographically-driven stationary wave that channels water differently at different longitudes over the season [e.g., 19].

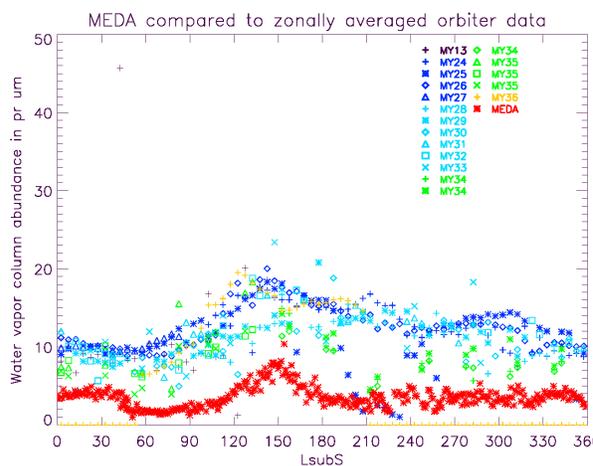


Figure 1. Zonally averaged column abundances of water vapor from orbiters compared to equivalent column abundances measured by MEDA, assuming a well-mixed column.

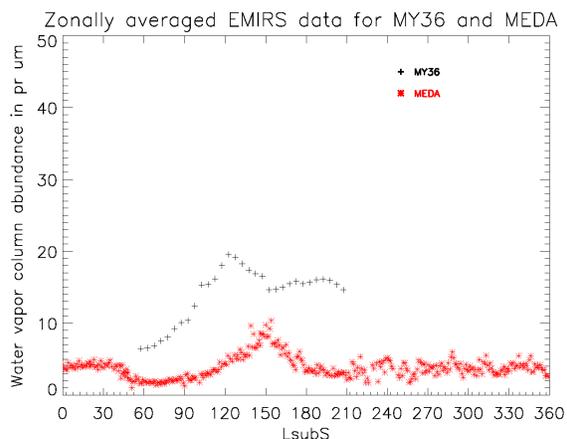


Figure 2. EMIRS column compared to MEDA.

Near-surface saturation conditions: Figure 3 shows the hourly averaged MEDA relative humidity

measurements in the 0400 LT hour. There are a number of sols in which the RH exceeds 100% near sol 550 ($L_s \sim 270$). A frost campaign was conducted, but no frost was seen [20], though fog could have formed briefly if the wind speed was small or if the rover had been over bedrock or a similarly low adsorption surface [21].

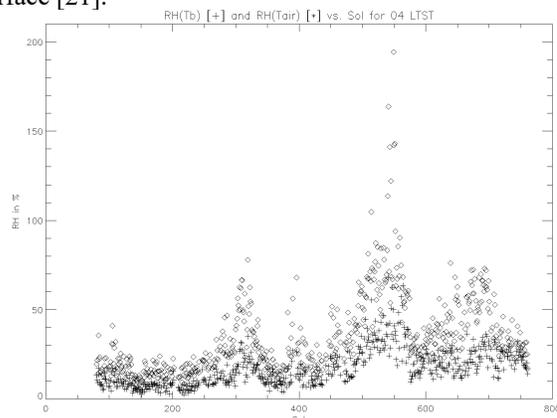


Figure 3. Hourly-averaged MEDA relative humidity values measured at 0400-0500 LT.

Summary: The MEDA RHS is providing high quality measurements and provides the third near-surface vapor abundance measurements on Mars to date. Longitudinal differences in the behavior of vapor are seen and diurnal activity (adsorption and perhaps frost or fog) are possible.

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