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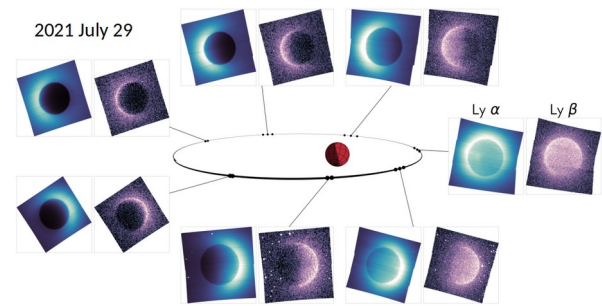
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**TEN YEARS OF UPPER ATMOSPHERE HYDROGEN MEASUREMENTS BY MAVEN/IUVS AND EMM/EMUS FOR UNDERSTANDING MARS WATER ESCAPE.** Mike Chaffin<sup>1</sup>, Justin Deighan<sup>1</sup>, Sonal Jain<sup>1</sup>, Greg Holsclaw<sup>1</sup>, Susarla Raghuram<sup>1,2</sup>, Hoor AlMazmi<sup>3</sup>, Krishnaprasad Chirakkil<sup>1,2</sup>, John Correia<sup>3</sup>, Scott England<sup>4</sup>, Frank Eparvier<sup>1</sup>, J. Scott Evans<sup>3</sup>, Matt Fillingim<sup>5</sup>, Rob Lillis<sup>5</sup>, Fatma Lootah<sup>6</sup>, Ed Thiemann<sup>1</sup>, Eric Quemerais<sup>7</sup>, Majd Mayyasi<sup>8</sup>, Nick Schneider<sup>1</sup>, Shannon Curry<sup>1</sup>, Hessa AlMatroushi<sup>6</sup>, <sup>1</sup>Laboratory for Atmospheric and Space Physics, CU Boulder (michael.chaffin@colorado.edu), <sup>2</sup>Khalifa University, <sup>3</sup>UAE Space Agency, <sup>4</sup>Virginia Polytechnic Institute and State University, <sup>5</sup>Space Sciences Laboratory, UC Berkeley, <sup>6</sup>Mohammed Bin Rashid Space Center, <sup>7</sup>LATMOS-IPSL, <sup>8</sup>Center for Space Physics, Boston University

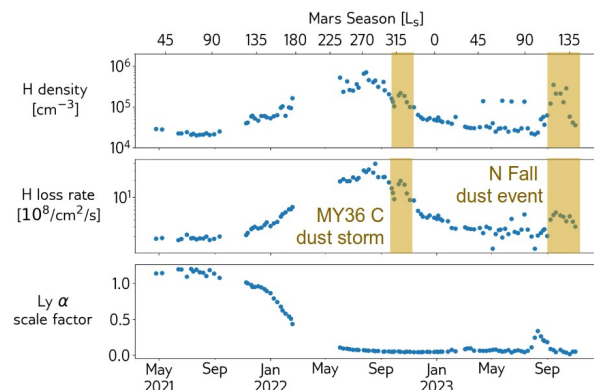
**Introduction:** Over its history, Mars has lost a large fraction of its initial water content to space as atomic hydrogen and oxygen. The hydrogen component of this loss can be diagnosed with measurements of sunlight scattered by hydrogen in the upper atmosphere at ultraviolet wavelengths of 102.6 nm (Lyman  $\beta$ ) and 121.6 nm (Lyman  $\alpha$ ). Since 2014, the MAVEN mission's Imaging Ultraviolet Spectrograph (MAVEN/IUVS) has been measuring Lyman  $\alpha$ ; The Emirates Mars Mission Emirates Ultraviolet Spectrometer (EMM/EMUS) added the capability to measure Lyman  $\beta$  beginning in 2021. Analysis of these measurements provides a decade-long record of H escape across multiple Mars years.

**Methods:** We employ a coupled density and radiative transfer model to perform simultaneous retrievals of hydrogen density and escape rate, as well as model scale factors accounting for absolute calibration discrepancies between the two instruments and the model. For time periods after the 2021 arrival of EMM, joint analysis of EMUS and IUVS data allow sensitive retrieval of the H density profile in the upper atmosphere due to the different observation geometry of the two spacecraft.

**Results:** We observe an increase in H density and escape rates in southern summer consistent with previous work, indicating that higher dust activity at this season carries water into the middle atmosphere where it can power escape to space. Comparing multiple Mars years allows assessment of interannual variability, including diagnosis of the differing response of the upper atmosphere system to multiple dust events, including several strong C-storm events and the planet-encircling dust event of 2018. While the IUVS record of H escape is more extensive, EMM's unique vantage point and access to wavelengths shorter than 110 nm eliminates several issues with IUVS data analysis resulting from limited coverage of the dayside and observation of a single hydrogen emission, enabling more robust determination of present-day water escape. We will discuss the implications of these two observatories for H loss measurements at the present epoch and their lessons for understanding the overall story of Mars desiccation.



**Figure 1:** Observations of Mars upper atmosphere hydrogen by EMM/EMUS. EMUS assembles images of the planet from multiple vantage points around Mars (red), in two UV wavelengths: Lyman  $\alpha$  (121.6 nm, blue), which is also observed by MAVEN/IUVS at lower altitudes, and Lyman  $\beta$  (102.6nm, purple). Comparison of these measurements with modeled intensities allows retrieval of geophysical information about hydrogen (and therefore water) escape at Mars.



**Figure 2:** H Escape parameters retrieved from EMM/EMUS observations from May 2021 onward. H loss peaks in southern summer (Ls  $\sim$  270), when seasonal dust activity boosts water into the middle atmosphere. Loss rates can also be perturbed by individual lower atmosphere dust events, as indicated by the brown boxes. Retrieval of a Lyman  $\alpha$  scale factor accounts for a known decline in instrument sensitivity with time and closely tracks independent estimates of this decline, indicating our retrieval is robust.