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Structural and compositional changes in the upper atmosphere related to the PEDE-2018a dust event on Mars as observed by MAVEN NGIMS

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Abstract

The onset of the planet encircling dust event (PEDE-2018a) started 30 May 2018 as observed by MRO/MARCI. After the onset of the event the upper atmosphere underwent structural, compositional, ionospheric, and temperature changes. The Mars Atmosphere and Volatiles EvolutioN (MAVEN) Neutral Gas and Ion Mass Spectrometer (NGIMS) had a good opportunity to observe the dramatic changes in the upper atmosphere including several wind scans from the onset and through the duration of the PEDE. At the onset of the dust even the atmosphere experienced an increase in the variability in the density and temperature profiles across all longitudes or latitudes. Additionally, the structure of the atmosphere exhibits significantly more turbulence after the onset of the dust event across all longitudes causing high variability in the altitude vs density as much as a factor of 5 -10 within a scale height. These significant structural features in the upper atmosphere made for dramatic variations not only the total density as measured by the navigation and accelerometer, but also in the specific neutral and ion compositions. Additionally, ion densities decreased over this period. We intend to map these structural and compositional changes as related to the dust event.

1. Introduction

Using MAVEN NGIMS to examine the upper atmospheric trends to find the changes in both the composition and the structures. Figure 1 shows how the composition changed right after the onset of the dust storm with the heating of the atmosphere and pluming of the CO_2 and Ar. Along with this expected pluming as observed during the previous 2007 PEDE storm (Heavens et al 2011). What had not been previously was how the O and He decreased after the onset of the storm. This decrease was proportionate to the strength of the storm and was irrespective of local solar time(lst). When comparing the ratio of the densities of each species for night (lst 19h – 24h & 0h– 4h), day (7h – 16h) and terminator (lst 4h -7h & 16h – 19h) the Ar and CO_2 increased substantially over altitudes from 150 – 300km. However, the O and He densities decreased by 20% - 50% during the dust storm.

Additionally, the upper atmosphere above 170km exhibited higher turbulence and wave activity throughout the storm. The wave and turbulent activity accounted for high variations in the densities in the upper atmosphere. Figure 2 is an example of the changes of the structure in the upper atmosphere. As a result the scale height and temperature computations have much higher variations and error. Figure 1 also shows how much more variation in the density at a constant altitude of 170km increased after the onset of the dust storm even compared with other night side observations (Ls 110 – 140).

2. Figures

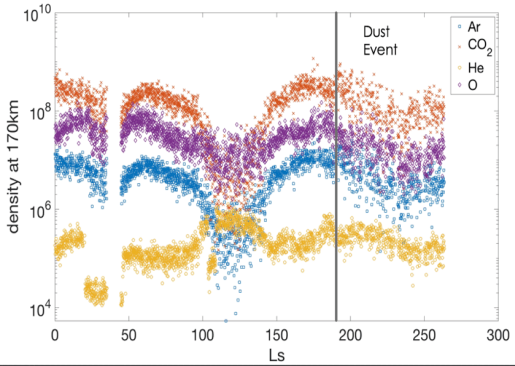

Fig 1: Log Density at 170km vs Ls (date/orbit). The peak of the dust storm, marked by the bold vertical line, occurs around June 6, 2018, this point indicates when the storm nearly encapsulated most of the surface.

Blue is the Ar trend, red is the CO2, purple is the O, and gold is the He. The Ar and CO2 heated immediately after the onset of the storm while the O and He cooled at the onset. These trends slowly normalized as the storm slowly decayed through mid October 2018.

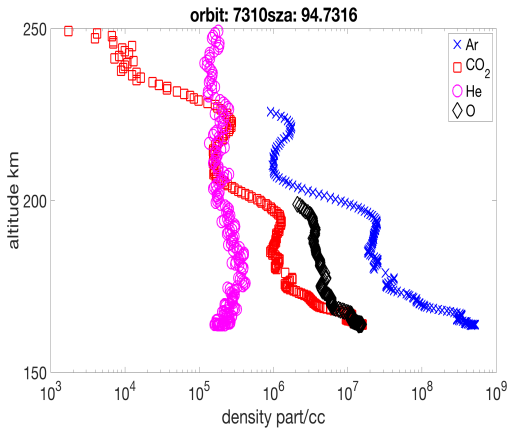

Fig 2: Vertical atmospheric profile of altitude vs log density. Red is Ar, black is O, blue is CO_2 and pink is He. The increase in structural changes makes the changes in scale height

3. Summary and Conclusions

The PEDE-18a dust event heated the overall upper atmosphere similarly to previously observed global dust events (Heavens et al 2011). With MAVEN NGIMS having the capacity to distinguish how the composition changed in the upper atmosphere indicating a cooling of the O and He in conjunction with the pluming of the CO_2 and Ar expands the picture of the atmospheric dynamics.

Acknowledgements

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References

[1] Heavens, N., G., McCleese, D., J., Richardson, M., I., et al.\ 2011, Journal of Geophysical Research (Planets), 116, E01010. 10.1029/2010JE003713