Mars' Atmospheric Escape: Exobase Altitude Variation

Noora Alsaeed, Bruce Jakosky, and Marek Slipski

Background

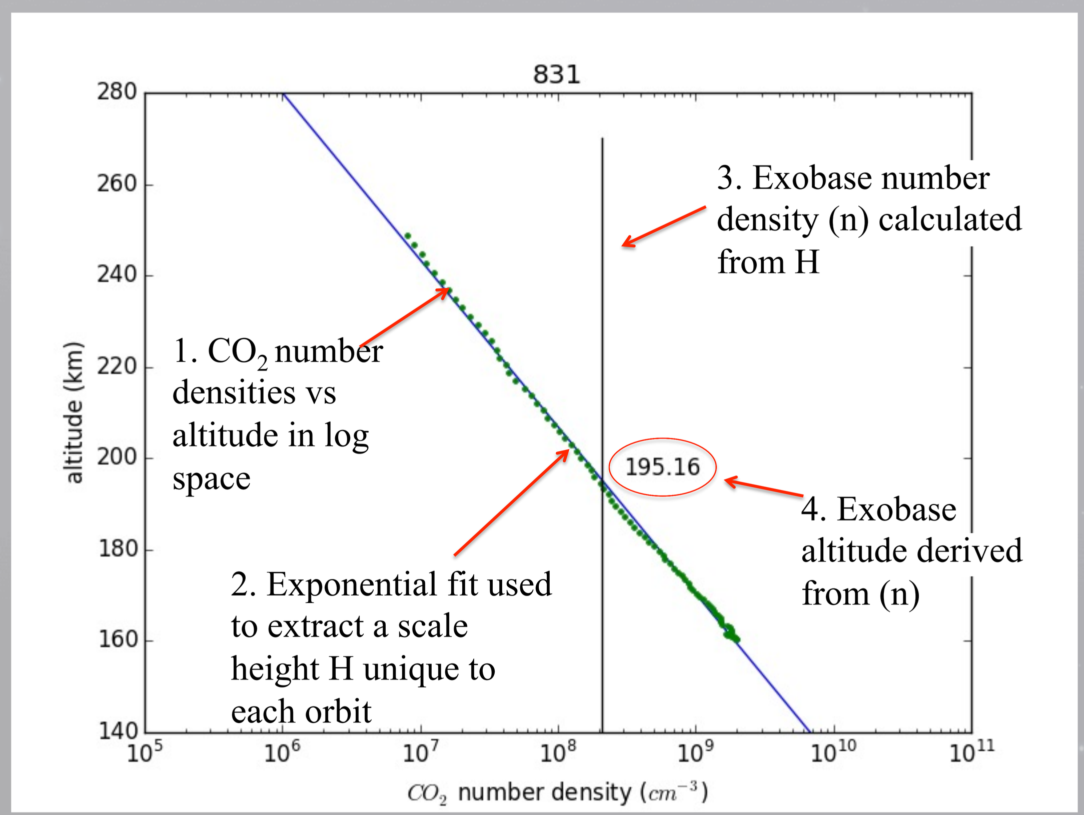
Evidence of past liquid water suggests that Mars' atmosphere must have been thicker. The thin atmosphere we see today is thus thought to be a result of atmospheric escape to space. To study this escape we focus on the exobase: the altitude above which molecules are free to escape to space if given enough energy. Using MAVEN data, we are able to link the atmospheric inputs and the structure of the atmosphere to see how this altitude varies with time.

Methodology

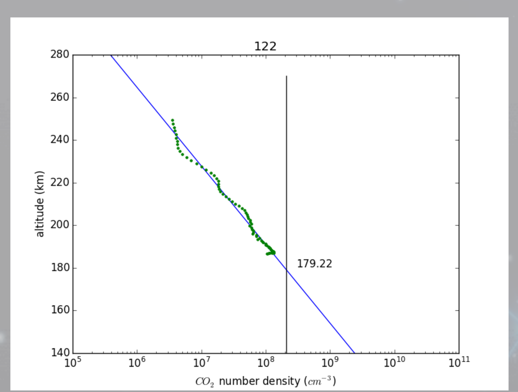
Data Used:

- Inbound CO_2 number densities from the Neutral Gas and Ion Mass Spectrometer (NGIMS) instrument on board MAVEN.
- Months of October, November 2014 and February to June 2015.
- Altitudes between 150 and 250 km

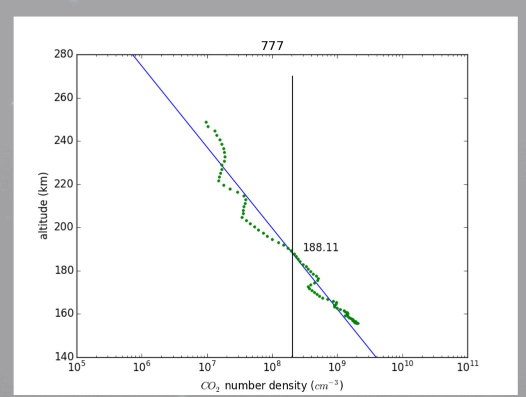
Analysis:



Issues Faced:



Relatively high minimum altitude in October and November, which decreases the amount of data we can fit and thus give less accurate results



Wave structure in several orbits makes it difficult to judge the accuracy of the fit

Extraction of Parameters

For each exobase altitude, we extracted the corresponding:

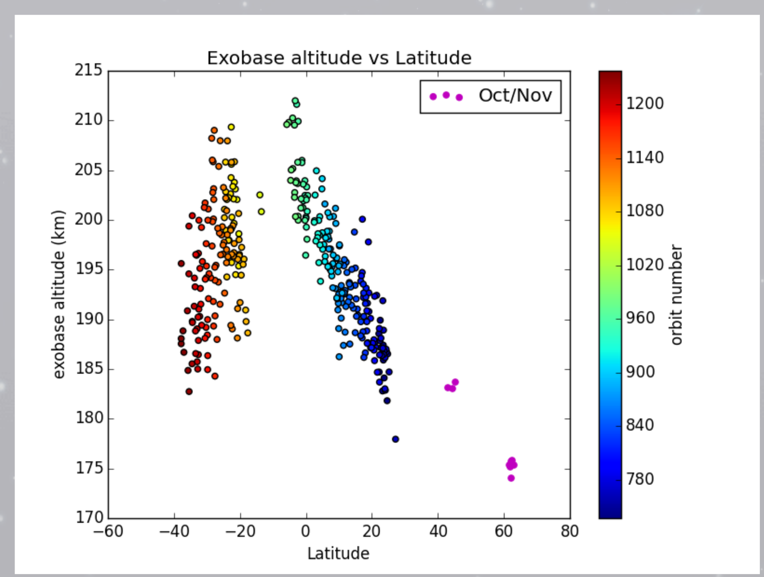
- Longitude and latitude
- Local time
- Solar zenith angle
- Season

The process is then repeated for all the orbits with data in the given time range

Exobase vs Parameters Plots

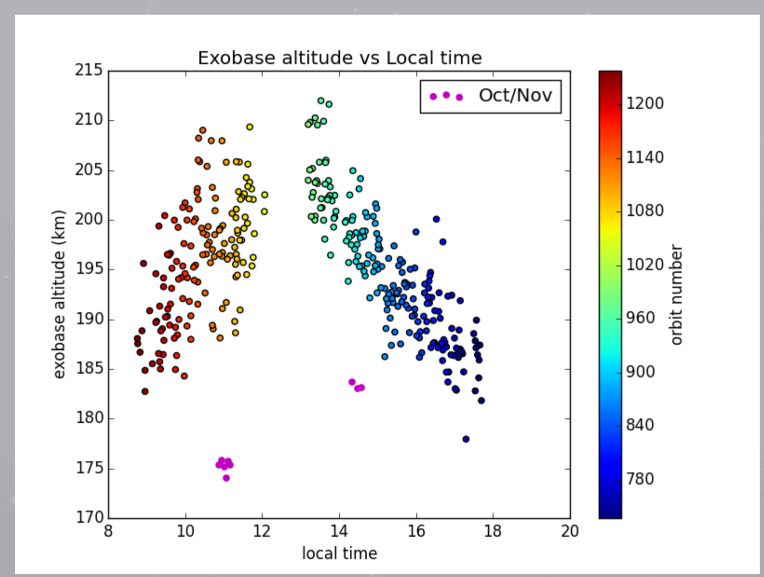
Exobase altitudes plotted against Mars' latitude:

Since we have limited coverage of latitude, the variation we see is not necessarily indicative of direct correlation between exobase altitude and latitude.



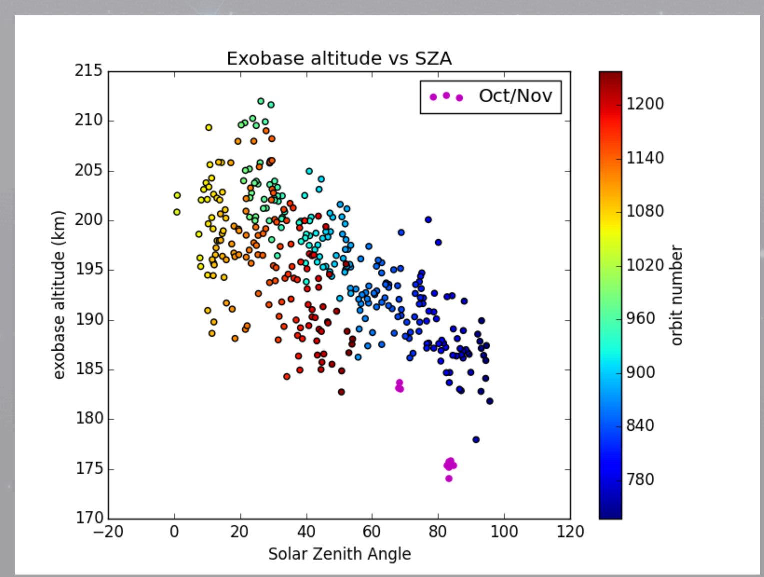
Exobase altitudes plotted against local time on Mars:

The peak we see around noon may be expected as we get more solar input in that time range

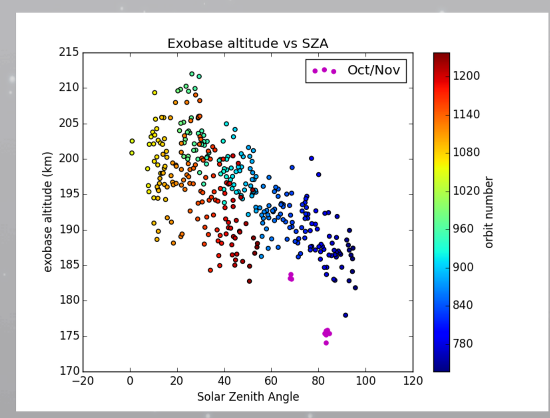


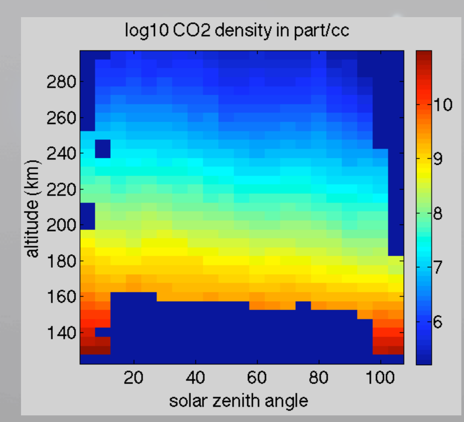
Exobase altitudes plotted against the solar zenith angle:

Here we can see resampling of solar zenith angle, and a general decrease towards 90° is to be expected as the incident heating decreases



Comparison with Similar Work





In Paul Mahaffy's work, we see a similar trend in CO_2 number densities versus solar zenith angle

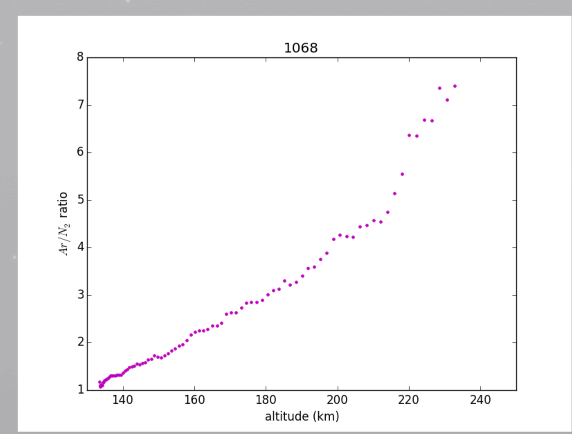
Conclusions

- In the plots we can see that the exobase varies with different parameters such as solar zenith angle, local time and latitude.
- Variation is convoluted by sampling of different periapse locations.
- Cannot make conclusions yet on what is causing this Variation

Future Work

- Further sampling of different periapse locations will help determine the driving factor(s) behind the variation in exobase altitudes.
- Finding the homopause altitude

The Nitrogen to Argon ratio was measured to be 1 near the surface by the curiosity rover. Since the atmosphere is well mixed below the homopause, we can see where N_2/Ar ratio reaches that value to get the homopause altitude



N2/Ar ratio vs Altitude

- Finding the isotope ratios
- Using the Rayleigh distillation formula to back out how much of the atmosphere was lost

$$R/R_o = f^{(\alpha-1)}$$

R = isotope ratio in remaining gas
R_o = initial isotope ratio
f = fraction of gas remaining
α = isotope fractionation factor, which depends on the exobase and homopause altitudes