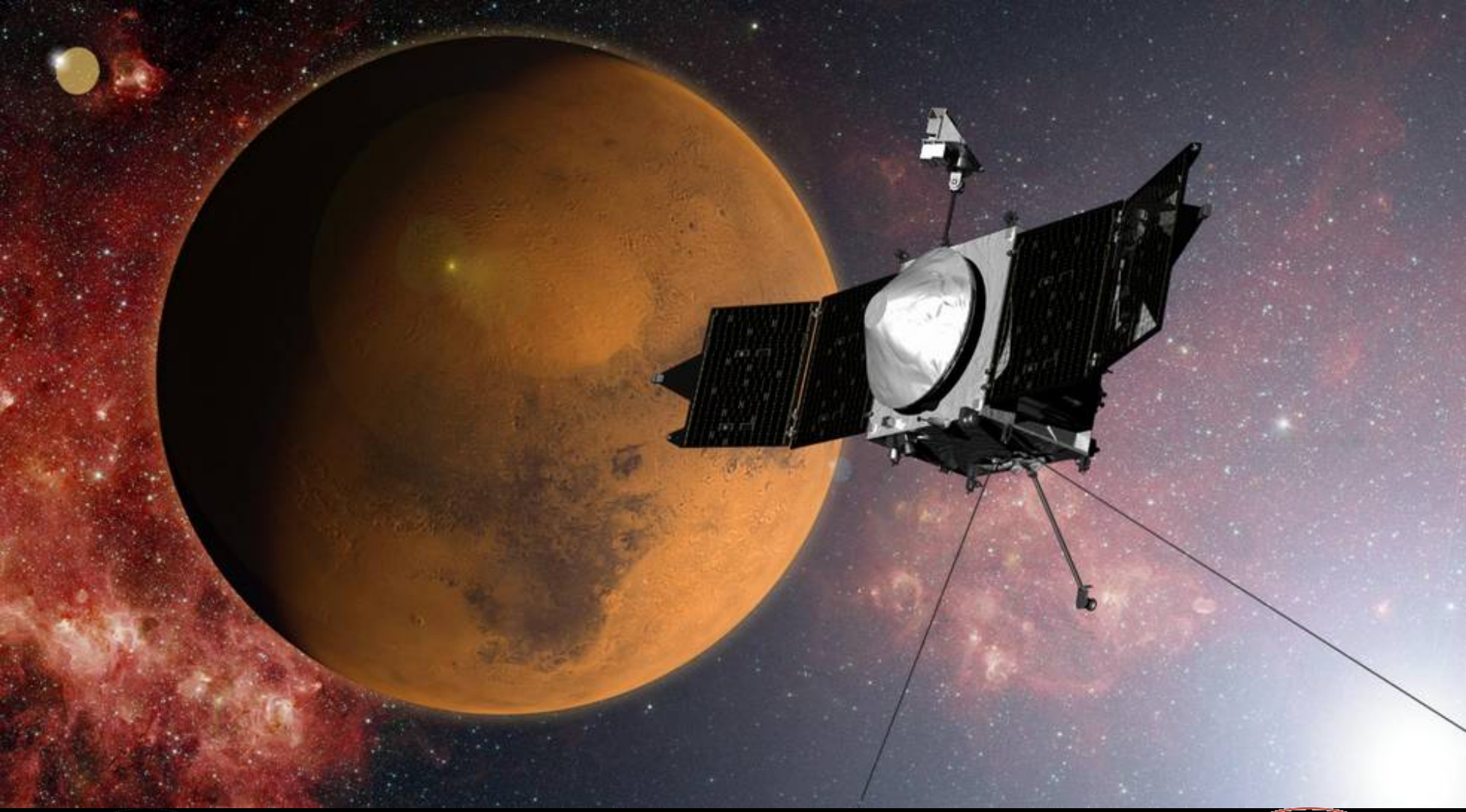
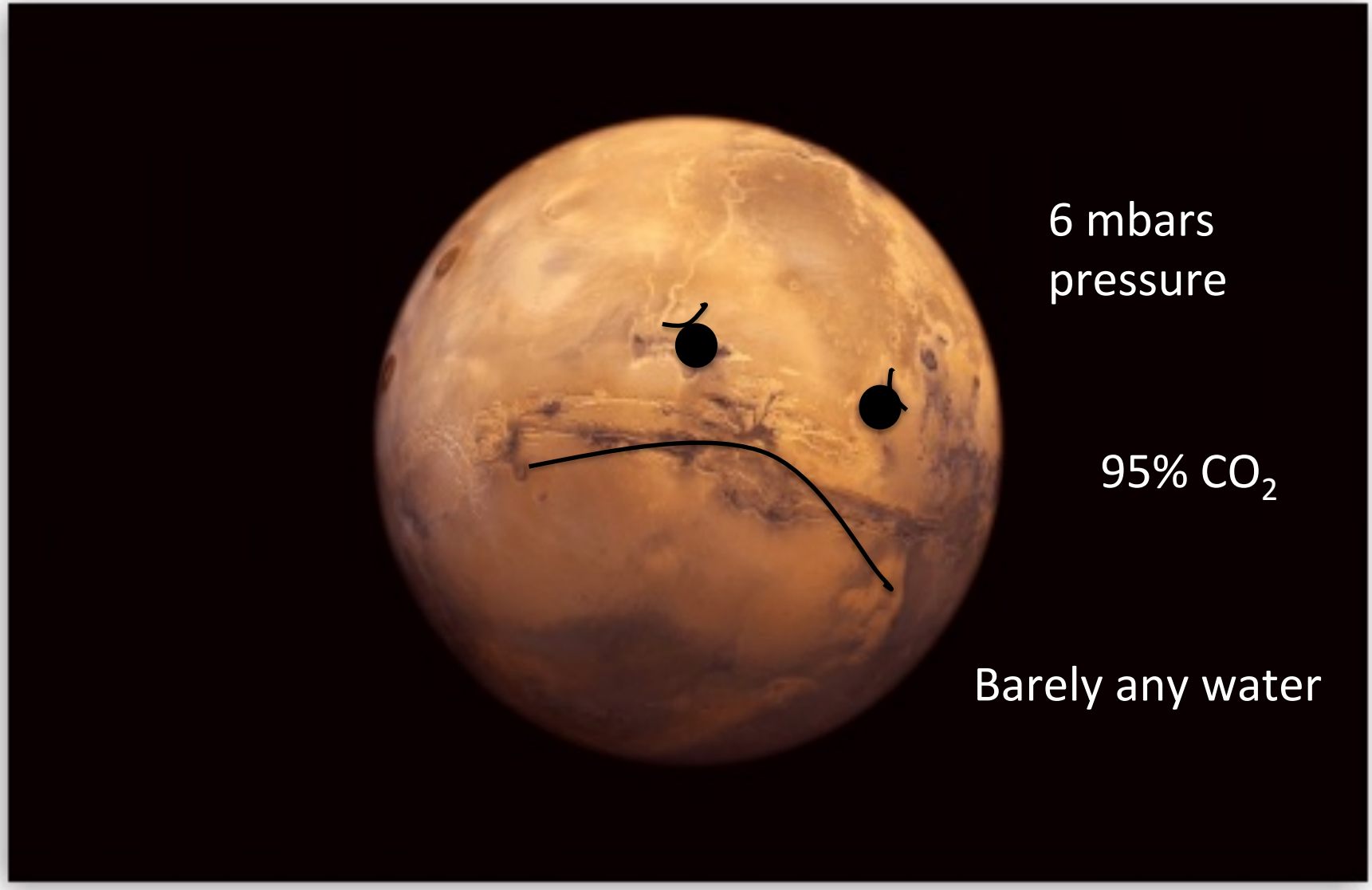


Studying Mars' Exobase

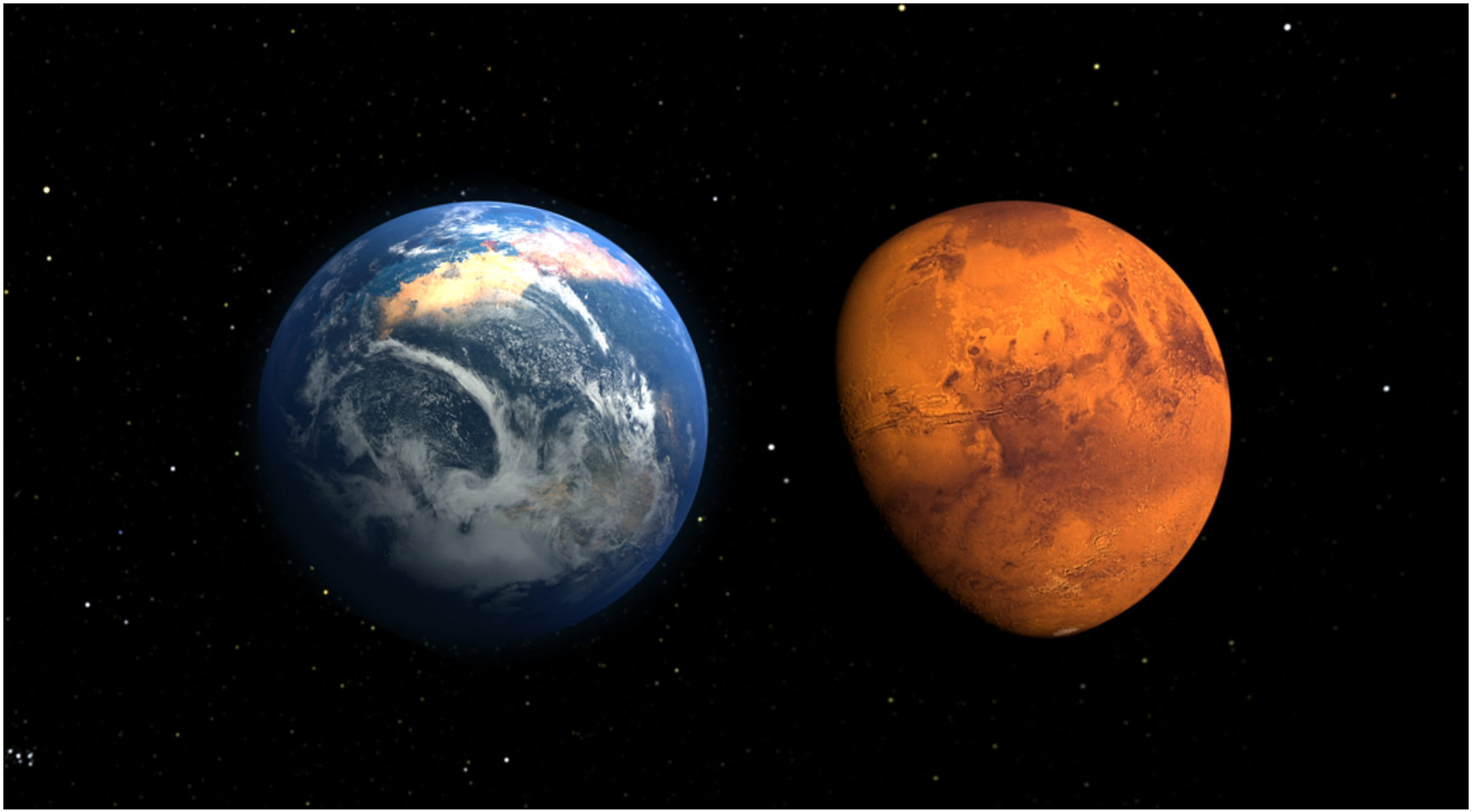
Noora Alsaeed

Bruce Jakosky, Marek Slipski

The Martian Atmosphere

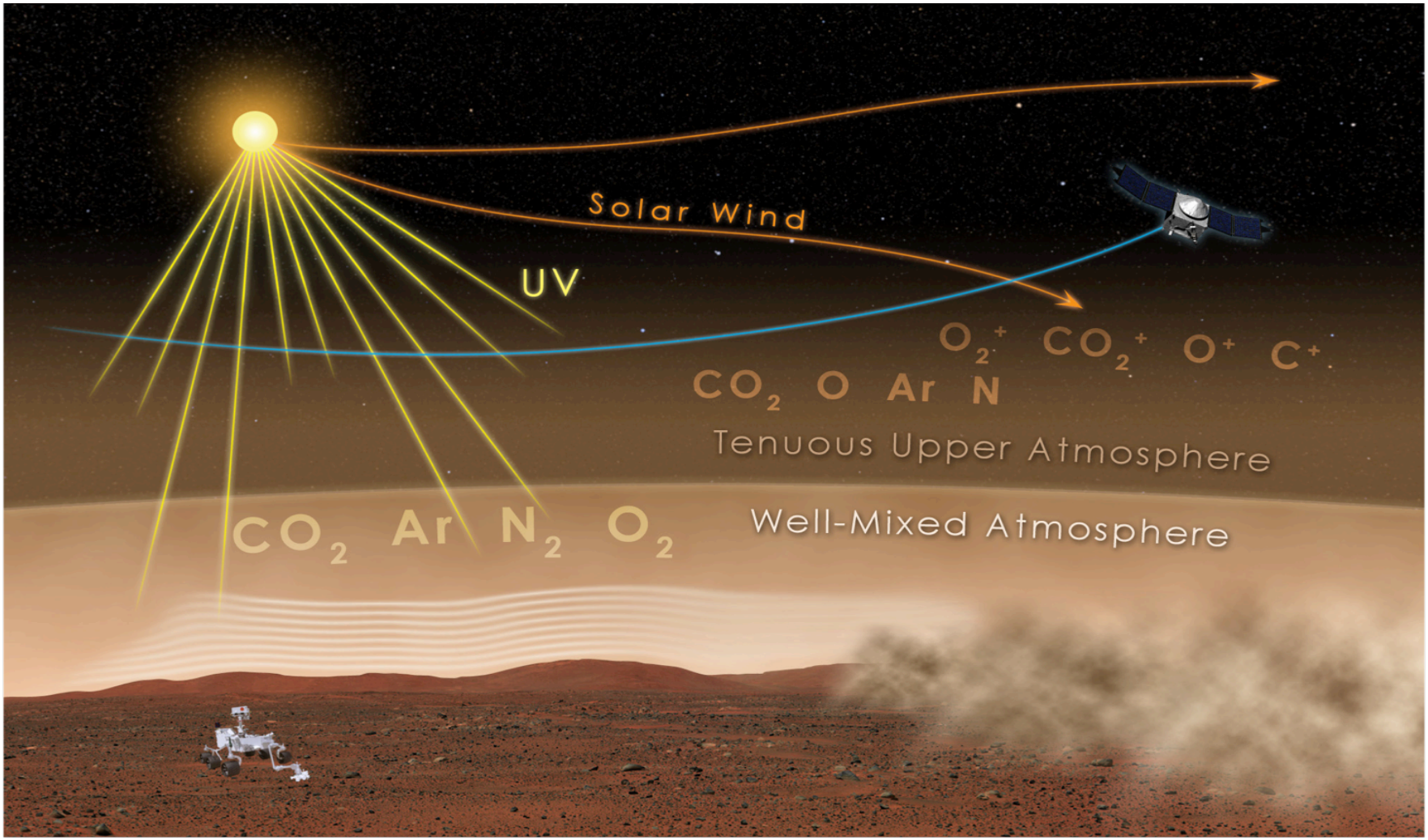


Early Mars Atmosphere Loss



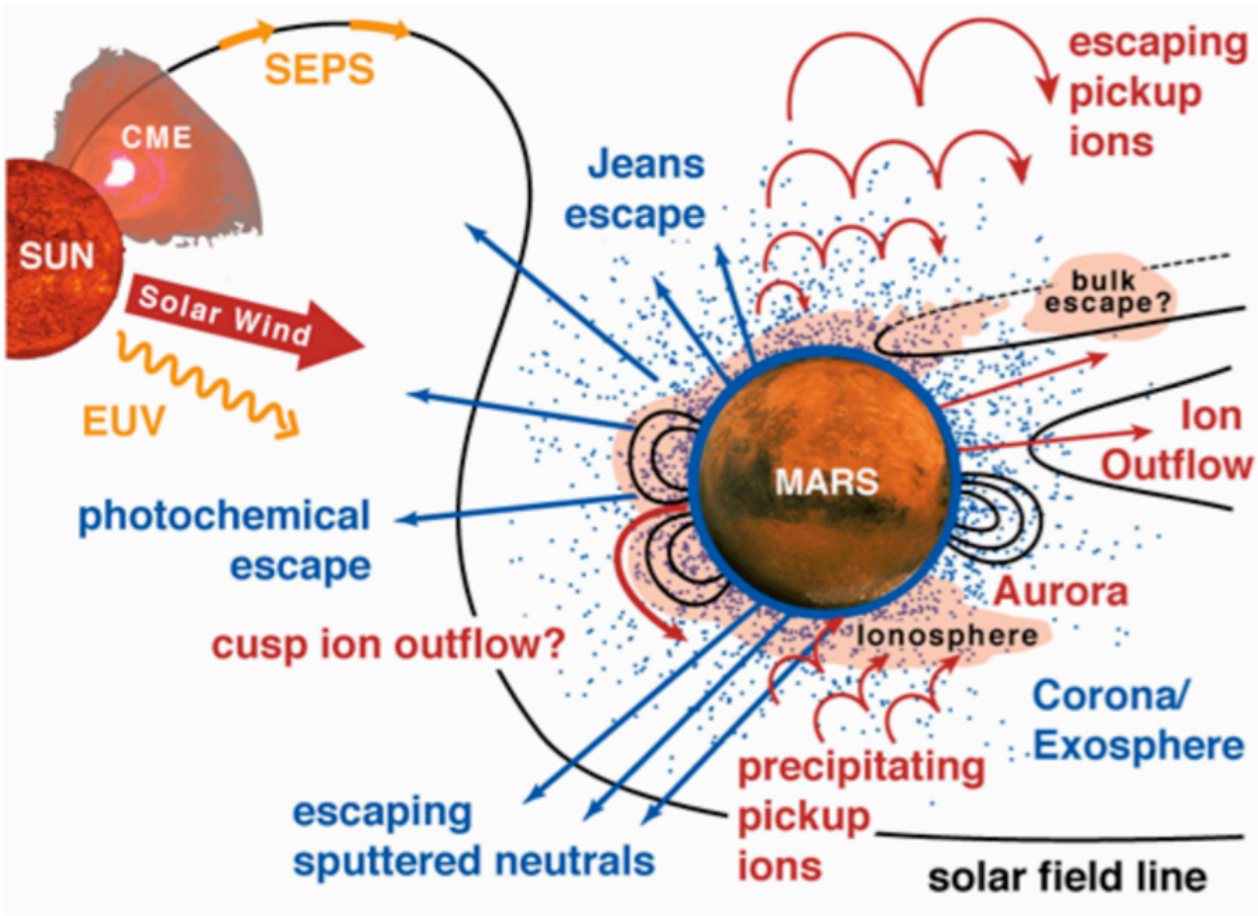
MAVEN

Mars Atmosphere and Volatile Evolution Mission



Solar Wind Strips the Atmosphere

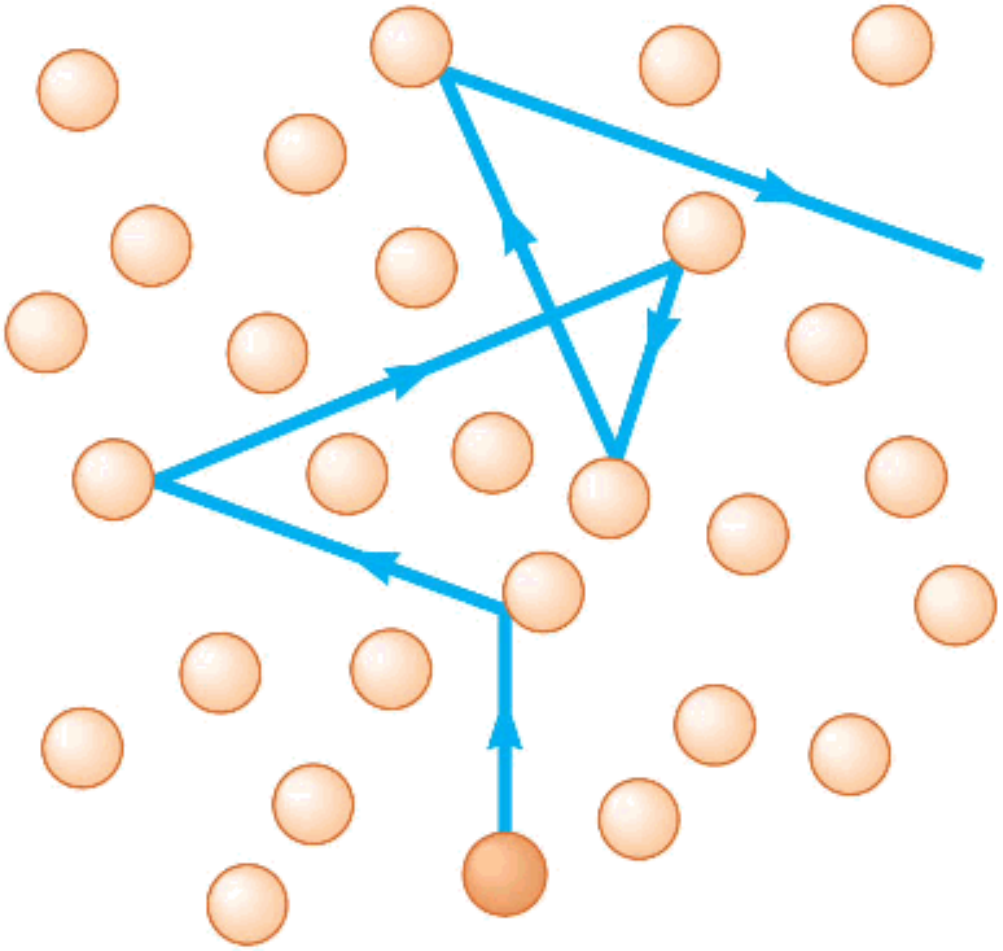
Atmospheric Escape



Significance of Studying the Exobase

- Altitude above which molecules are unlikely to collide with something before leaving the planet
- Knowing the exobase and how it varies will help determine escape rates

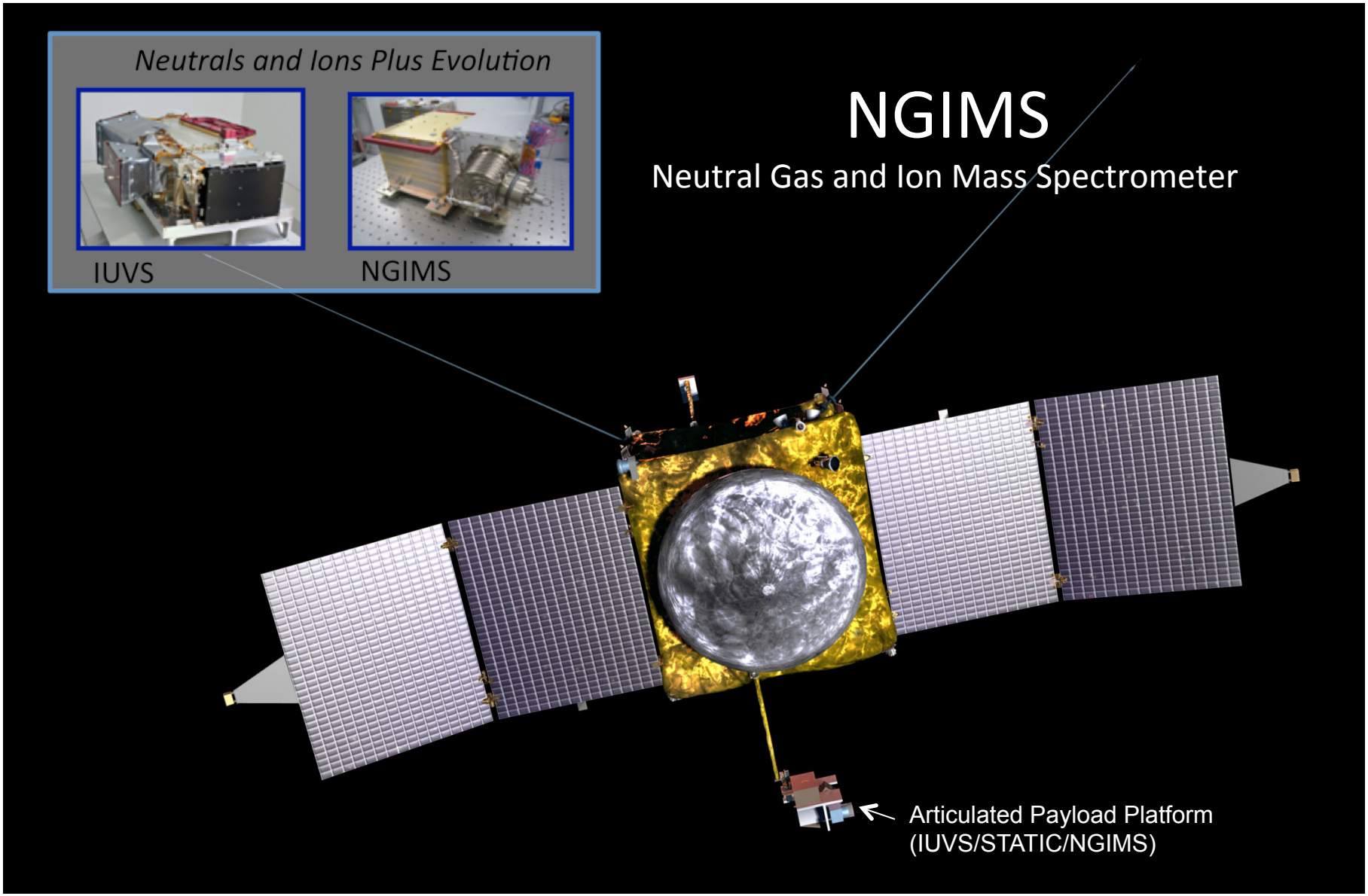
Formal Definition of Exobase



Analysis Overview

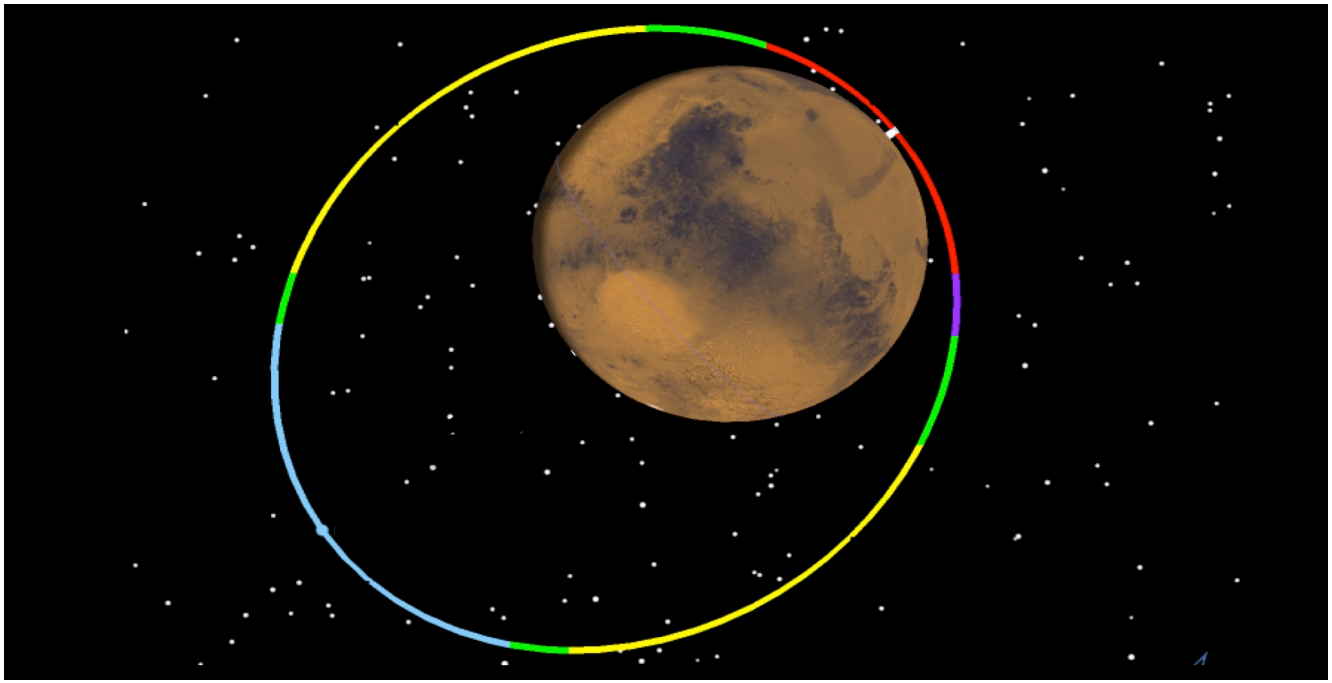
- Instrument and data used
- Calculations and computations
- Plots
- Results and Interpretation
- Future work

Instrument Used



Data Used

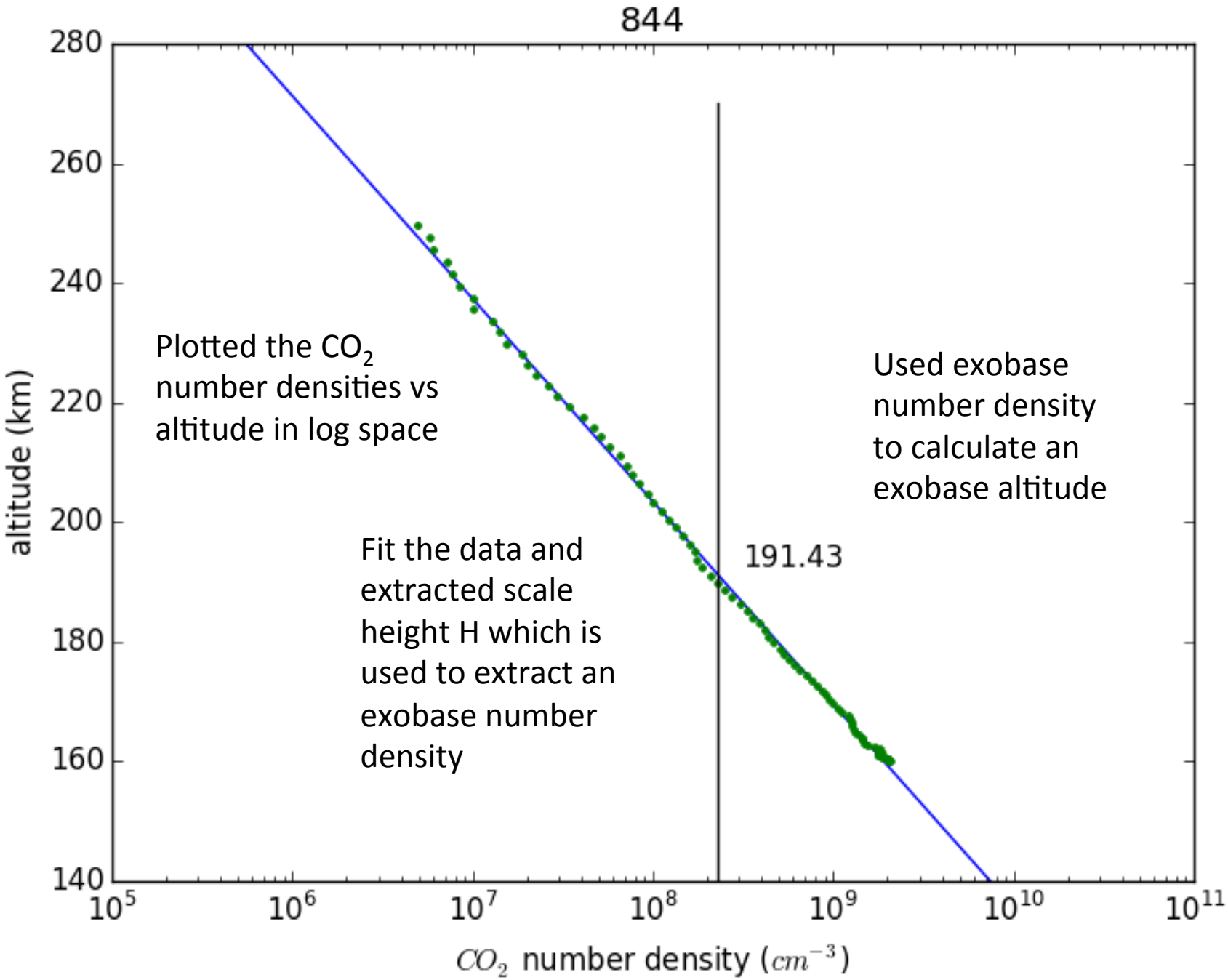
- Inbound CO_2 number densities
  - October, November, February – June
  - Altitudes between 150 km and 250 km

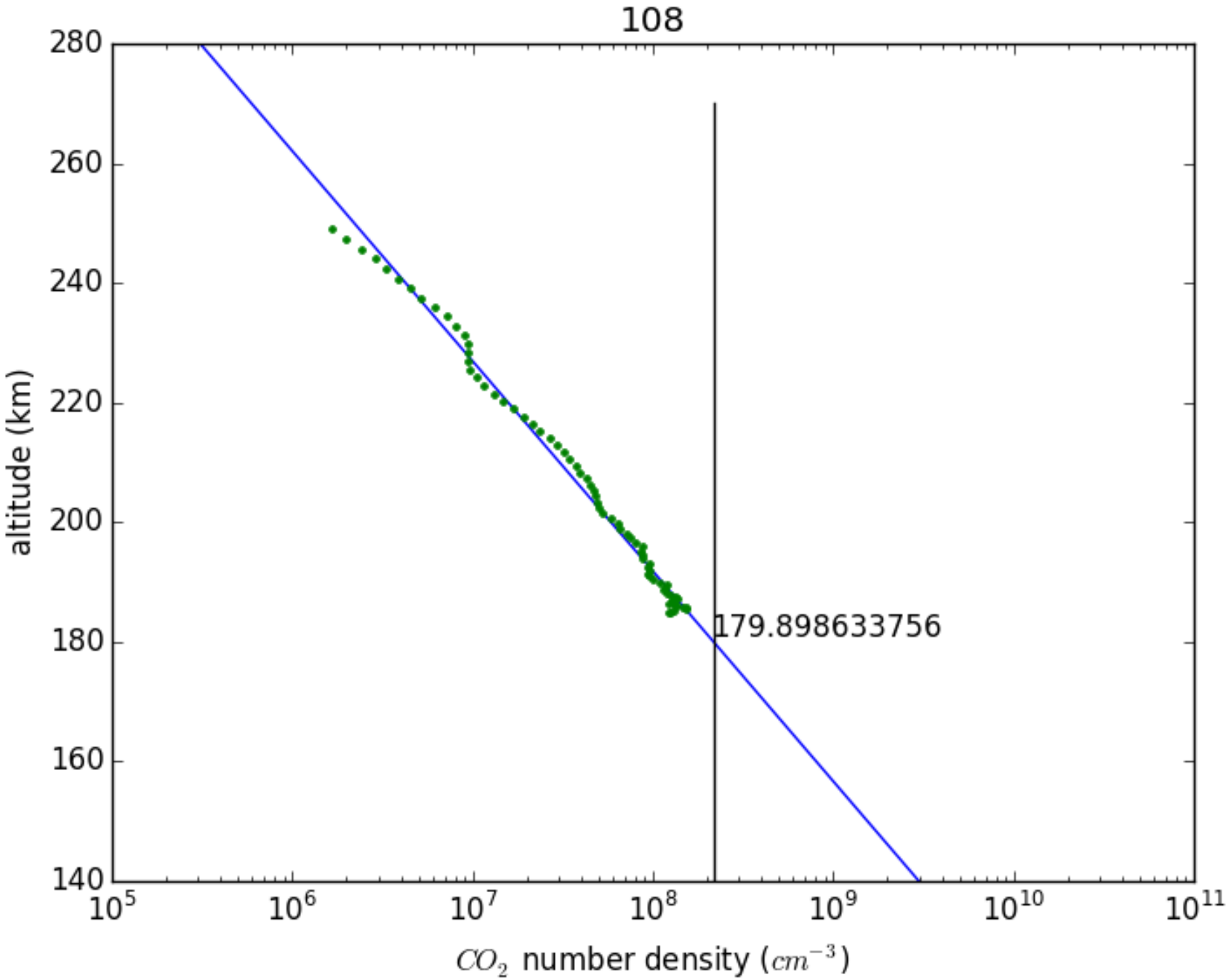


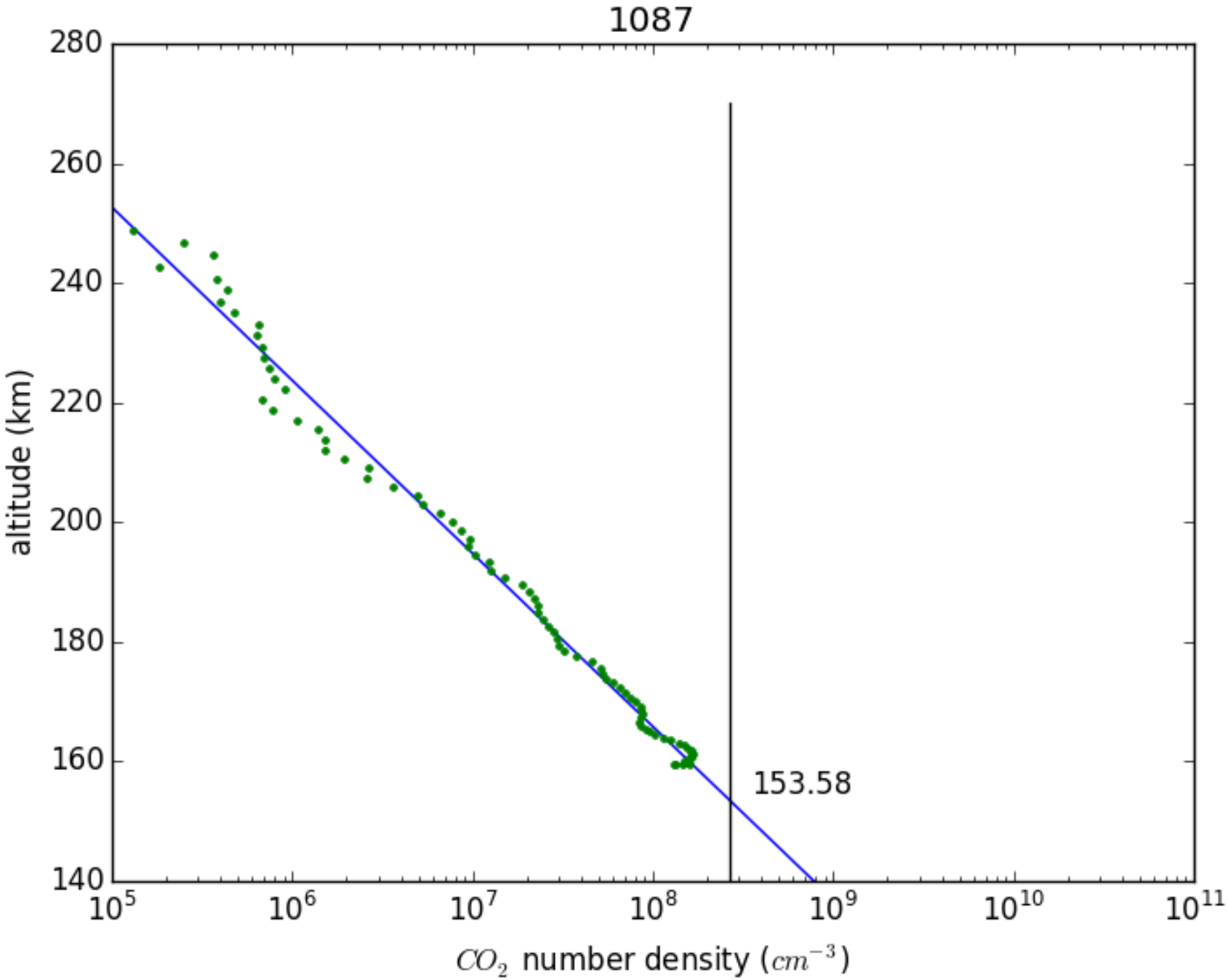
Analysis

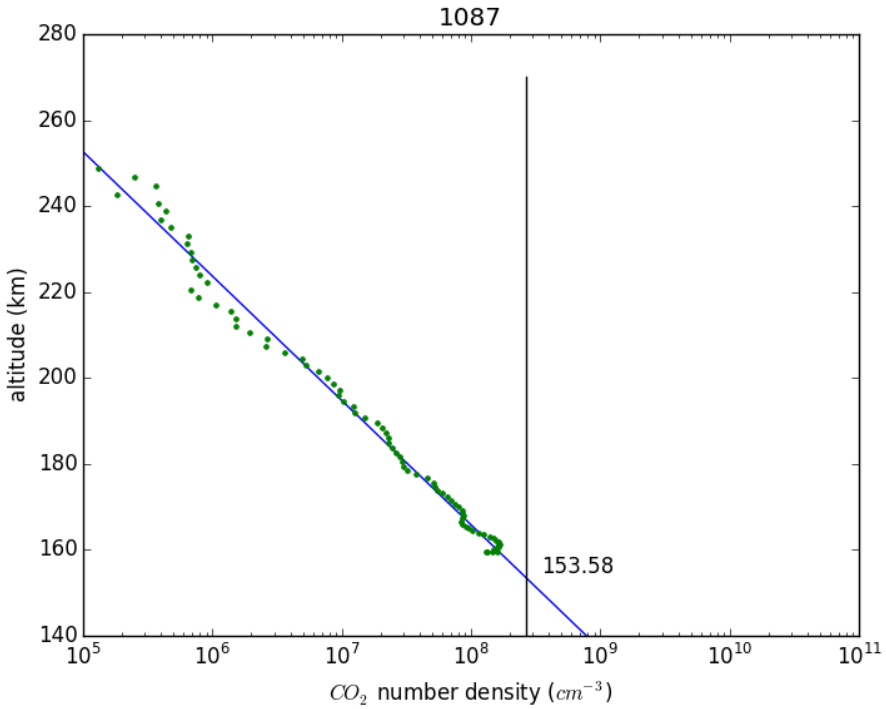
For each orbit:

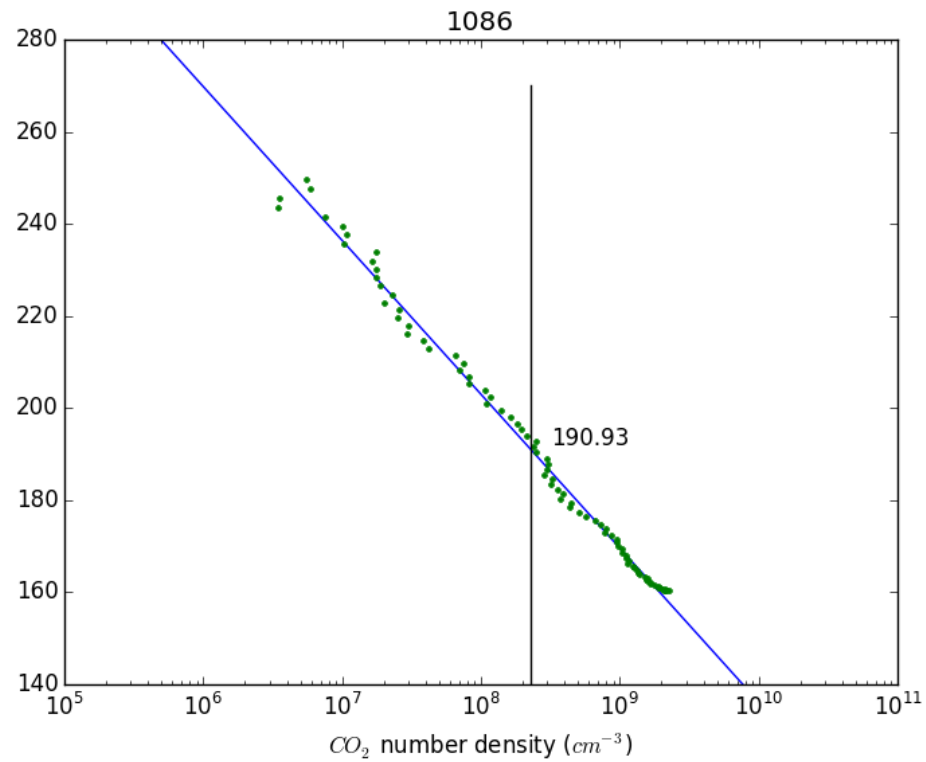
- Extracted scale height from fitting parameters
  - $H = kT/mg$
- Calculate exobase number density
  - $H = 1/n\sigma$
  - *σ is the collision cross section for CO_2*
- Calculate exobase altitude
  - $n(z) = n_o e^{-z/H}$


844
280
260
240
220
200
180
160
140
altitude (km)
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
CO_2 number density (cm^{-3})
191.43
Plotted the CO_2 number densities vs altitude in log space
Fit the data and extracted scale height H which is used to extract an exobase number density
Used exobase number density to calculate an exobase altitude


108
280
260
240
220
200
180
160
140
altitude (km)
179.898633756
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
CO_2 number density (cm^{-3})


1087
280
260
240
220
200
180
160
140
altitude (km)
153.58
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
CO_2 number density (cm^{-3})

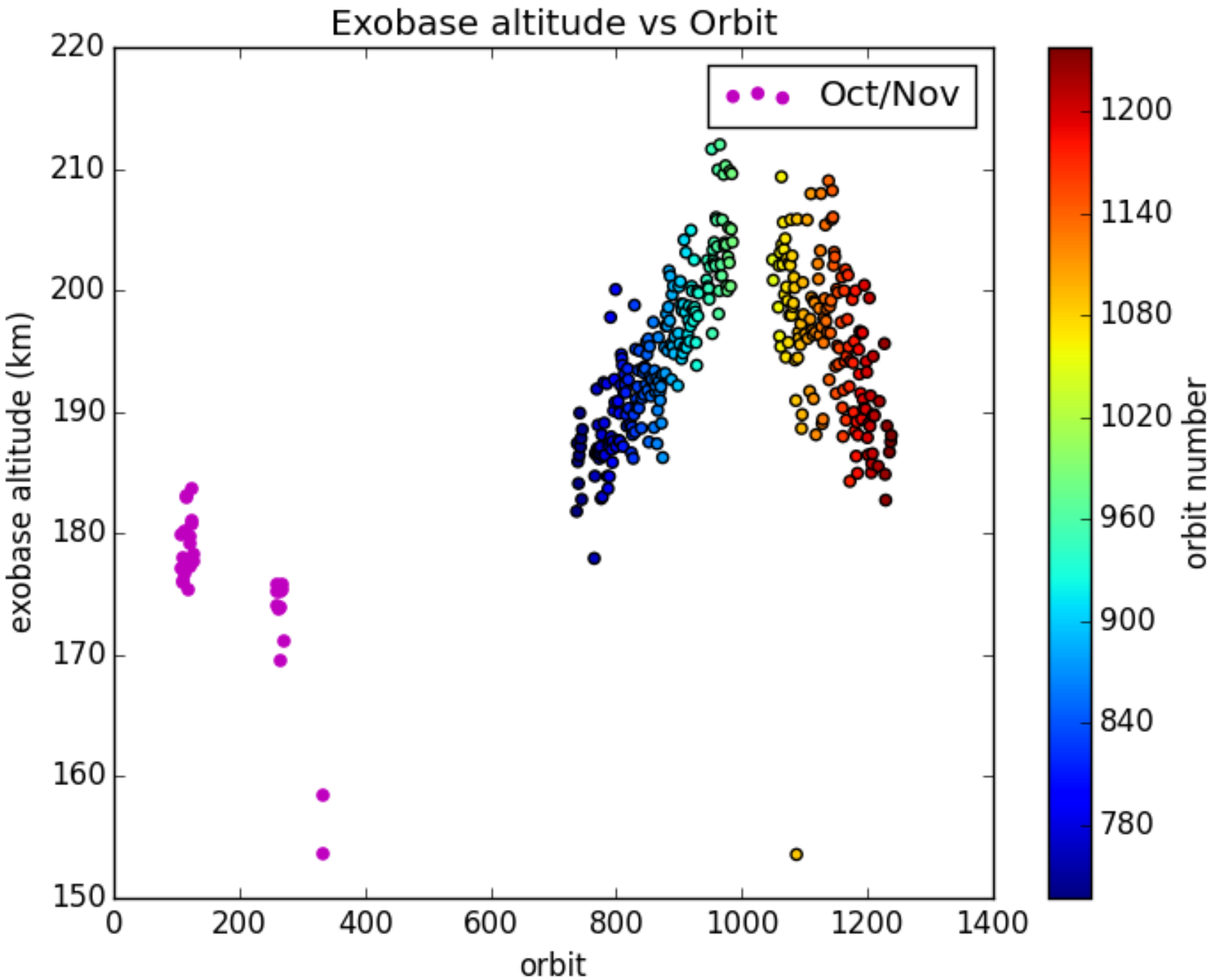

1087
altitude (km)
280
260
240
220
200
180
160
140
153.58
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
CO_2 number density (cm^{-3})


1086
280
260
240
220
200
180
160
140
190.93
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
CO_2 number density (cm^{-3})

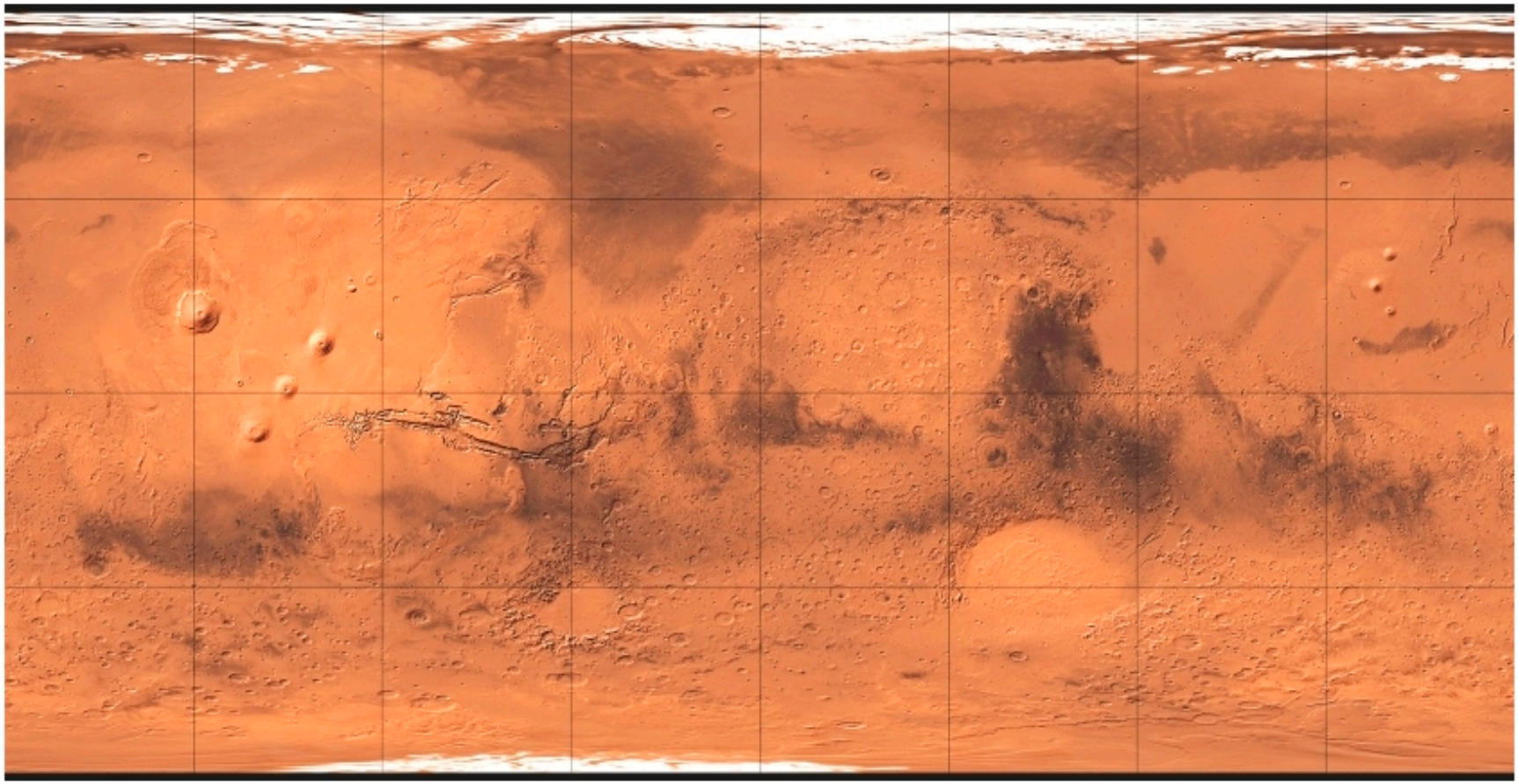
Creating the Exobase Plots

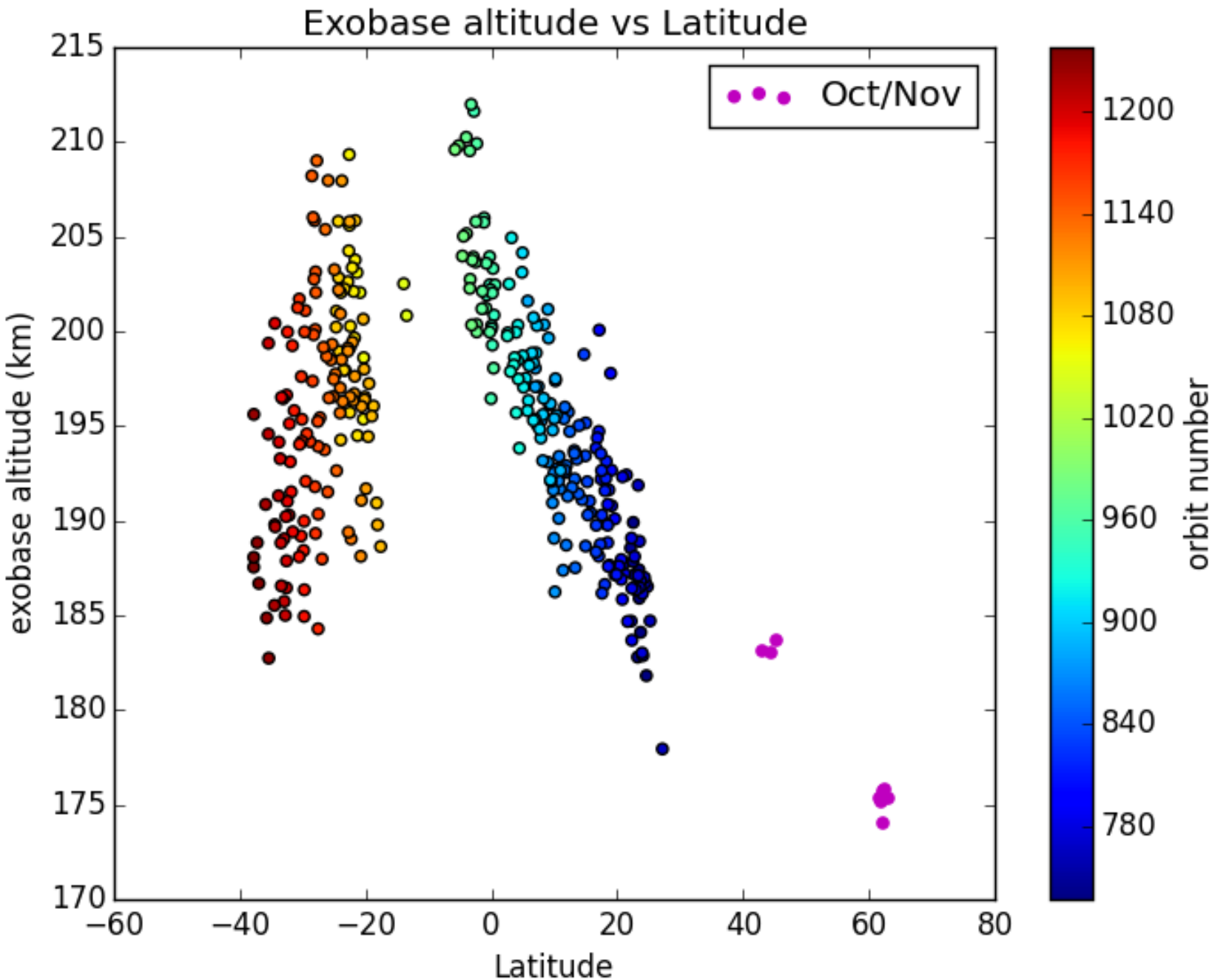
For each exobase altitude, extracted the corresponding:

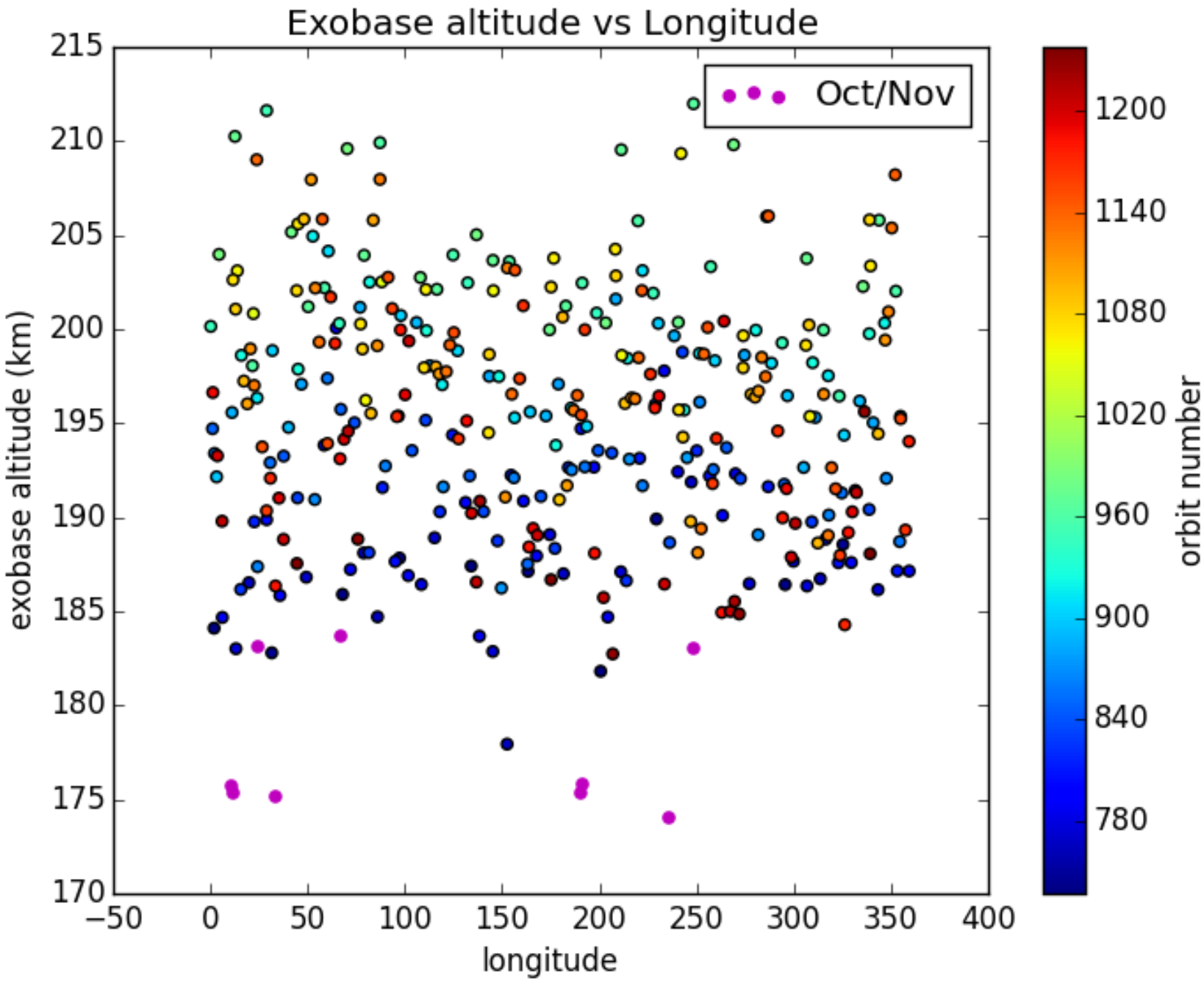
- Longitude and latitude
- Local time
- Solar zenith angle
- Season


Exobase altitude vs Orbit
Oct/Nov
exobase altitude (km)
orbit
orbit number
220
210
200
190
180
170
160
150
0
200
400
600
800
1000
1200
1400
1200
1140
1080
1020
960
900
840
780

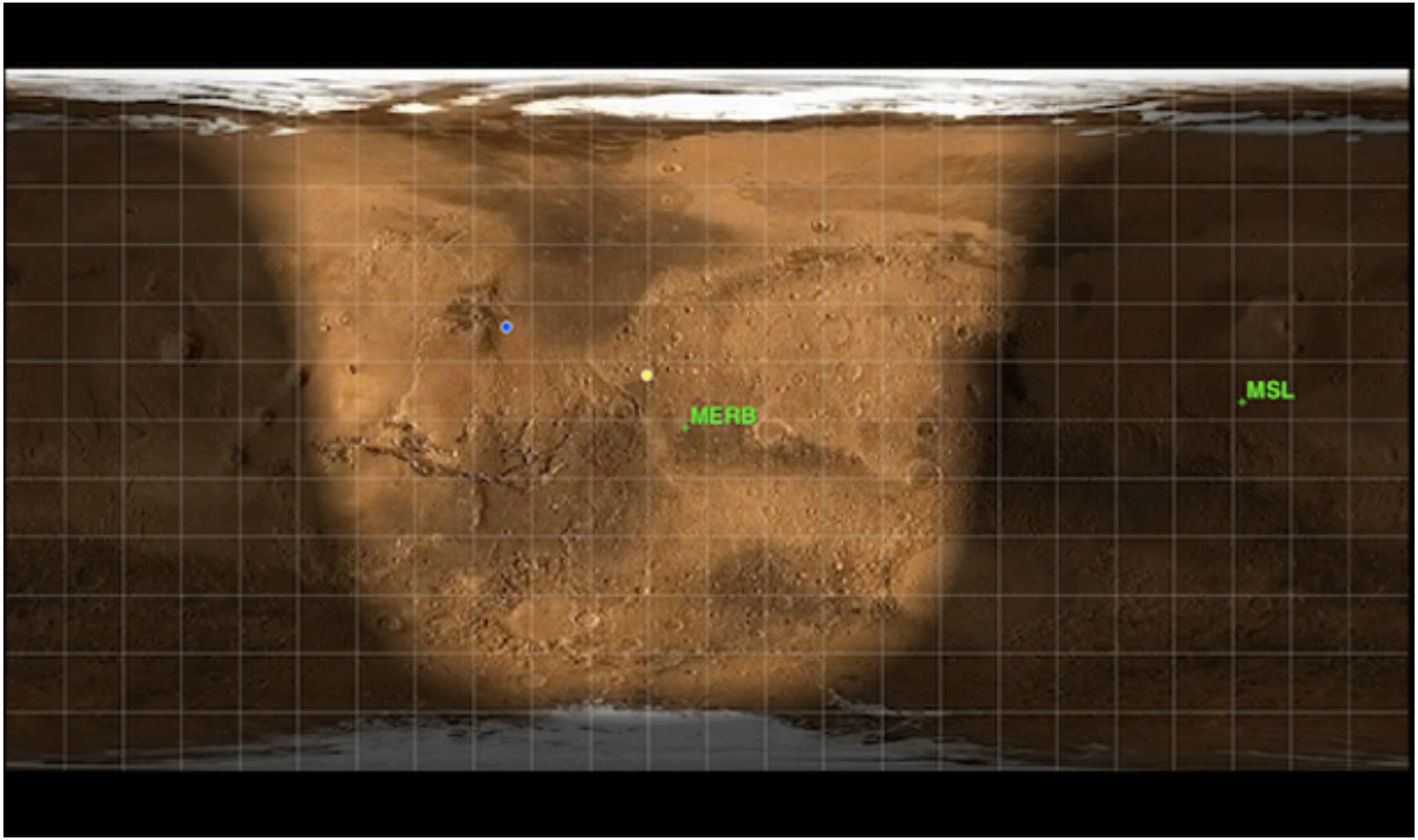
Longitude and Latitude

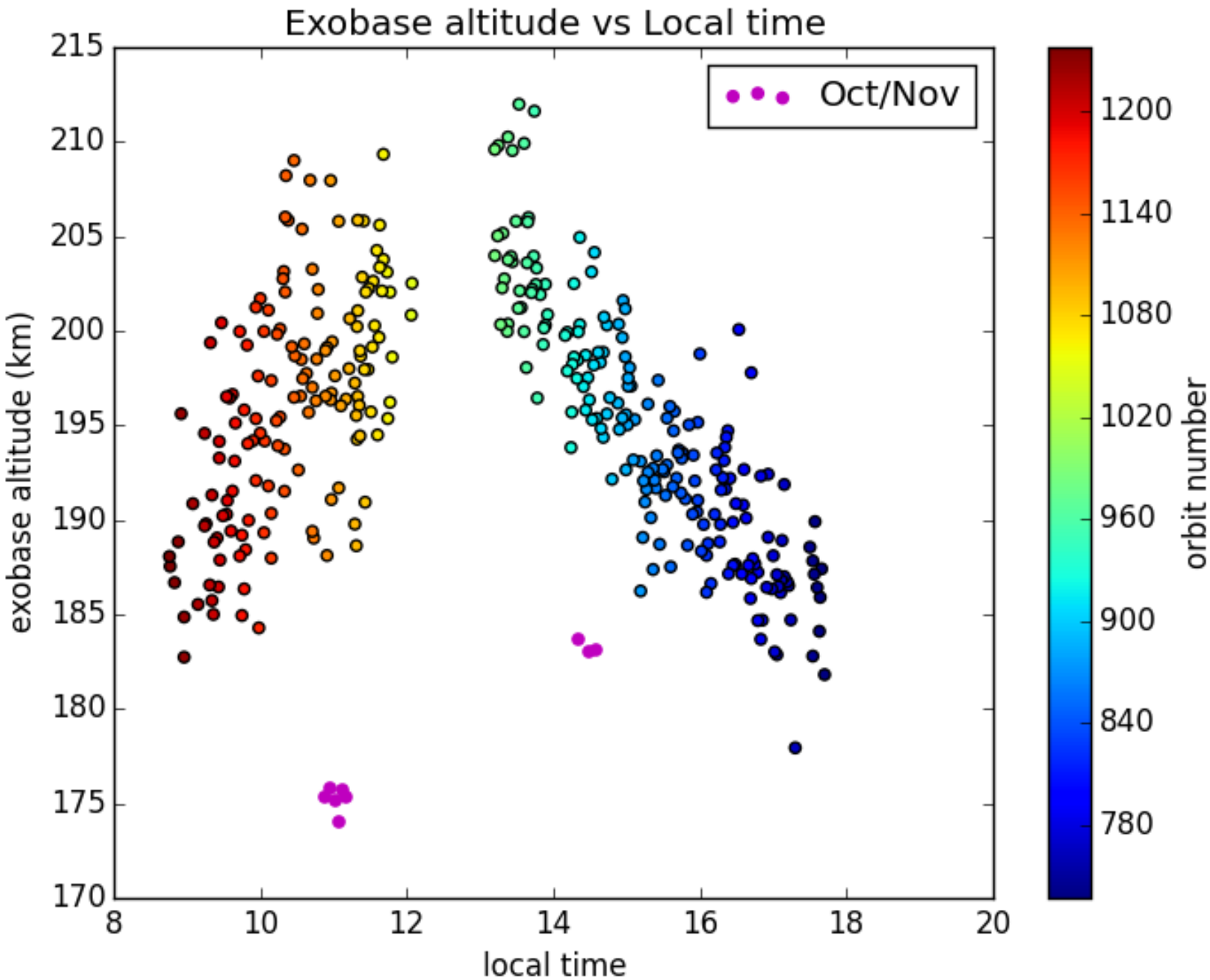



Exobase altitude vs Latitude
Oct/Nov
exobase altitude (km)
Latitude
orbit number
215
210
205
200
195
190
185
180
175
170
−60
−40
−20
0
20
40
60
80
1200
1140
1080
1020
960
900
840
780

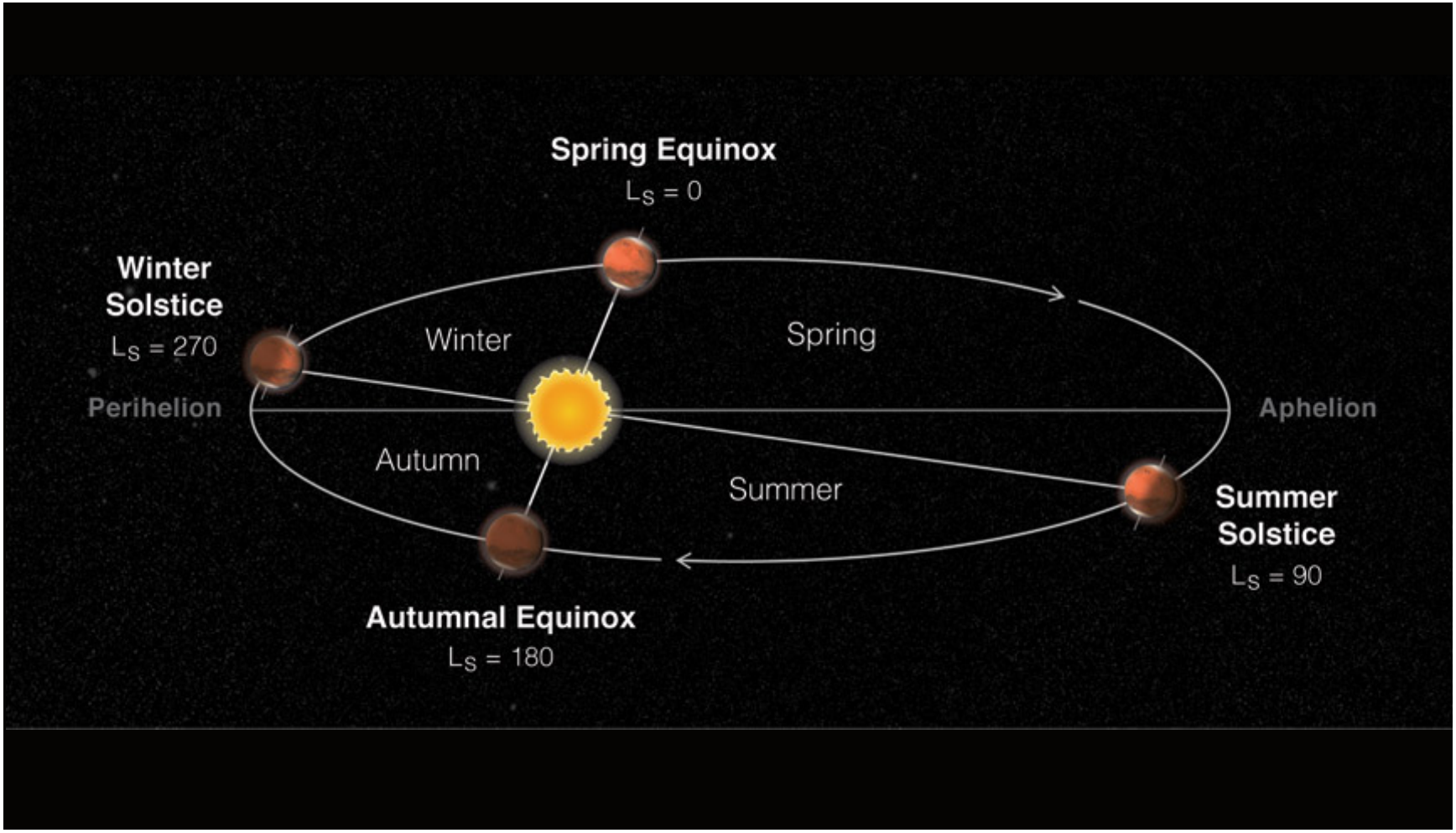

Exobase altitude vs Longitude
Oct/Nov
exobase altitude (km)
longitude
orbit number
215
210
205
200
195
190
185
180
175
170
−50
0
50
100
150
200
250
300
350
400
1200
1140
1080
1020
960
900
840
780

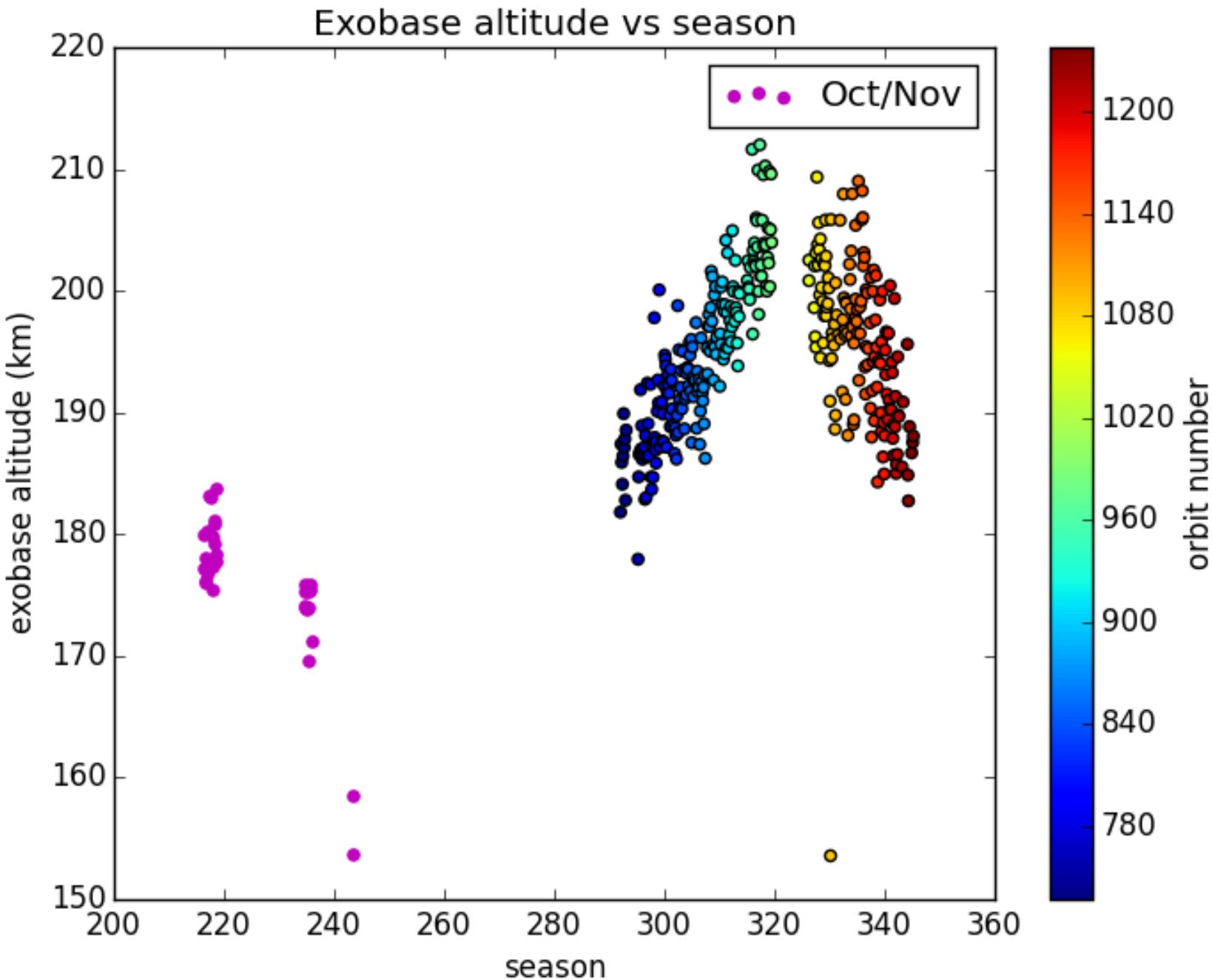
Local Time



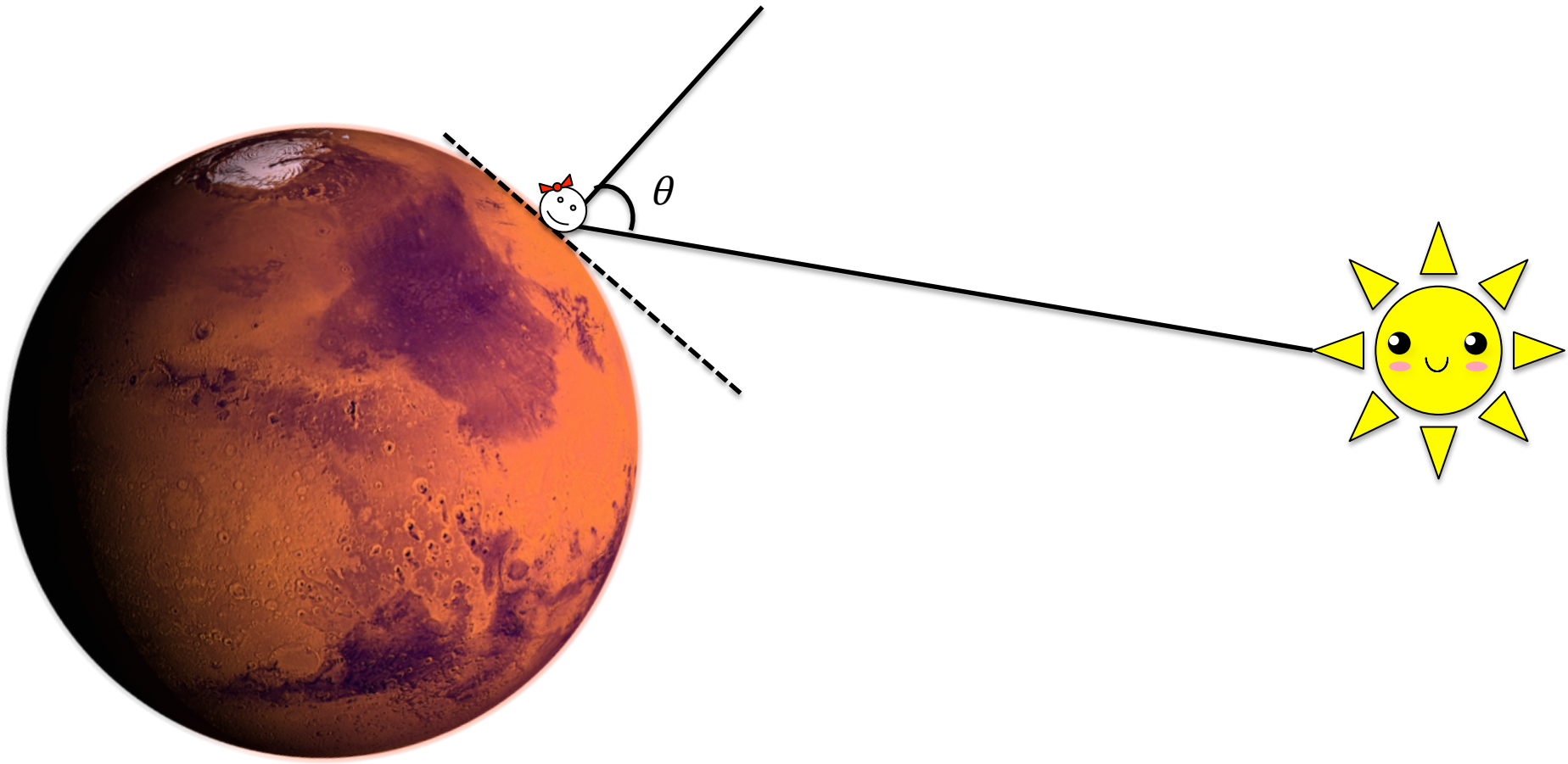

Exobase altitude vs Local time
Oct/Nov
exobase altitude (km)
local time
orbit number
215
210
205
200
195
190
185
180
175
170
8
10
12
14
16
18
20
1200
1140
1080
1020
960
900
840
780

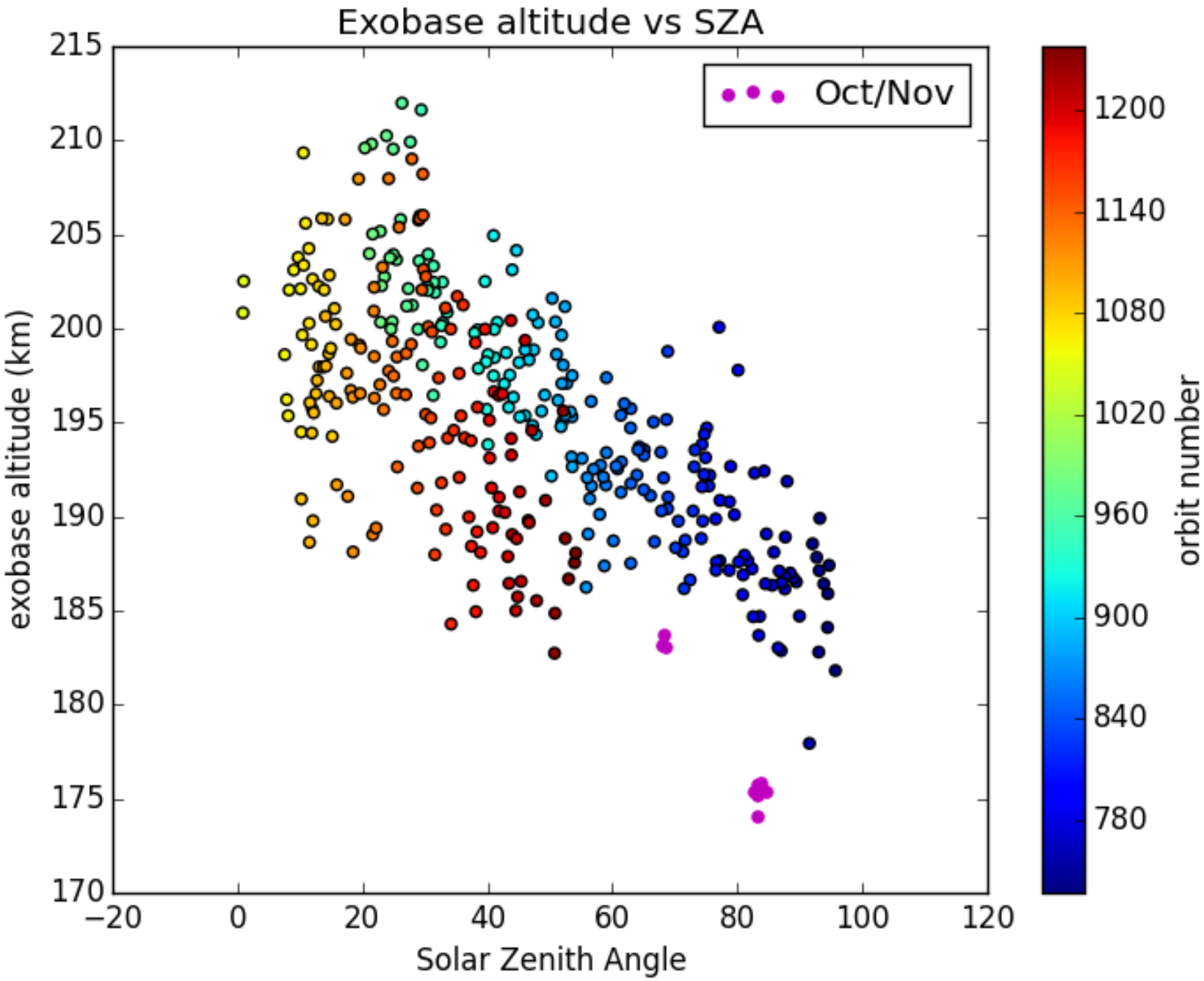
Season


Spring Equinox
Ls = 0
Winter Solstice
Ls = 270
Perihelion
Winter
Spring
Aphelion
Autumn
Summer
Summer Solstice
Ls = 90
Autumnal Equinox
Ls = 180

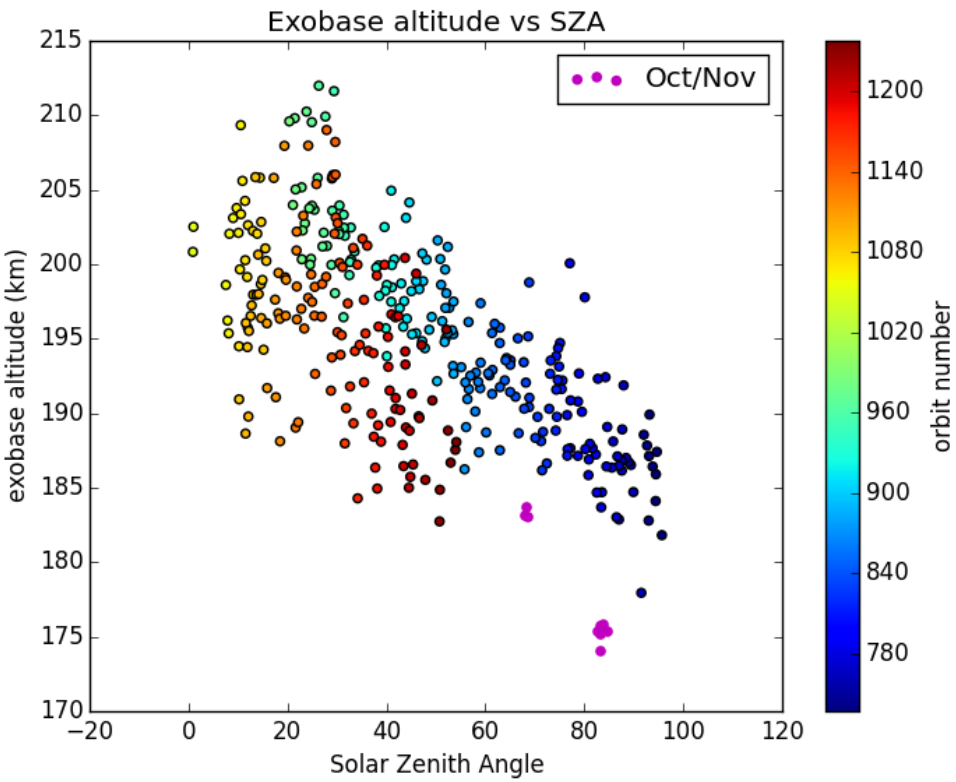

Exobase altitude vs season
Oct/Nov
exobase altitude (km)
season
orbit number
220
210
200
190
180
170
160
150
200
220
240
260
280
300
320
340
360
1200
1140
1080
1020
960
900
840
780

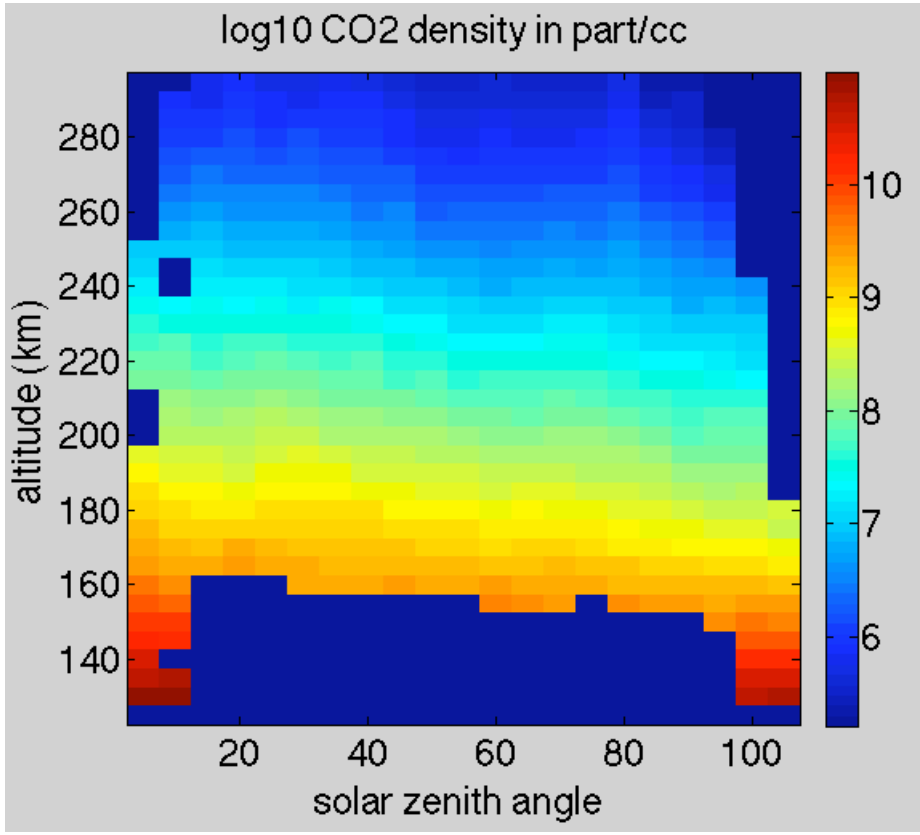
Solar Zenith Angle




Exobase altitude vs SZA
Oct/Nov
exobase altitude (km)
Solar Zenith Angle
orbit number
215
210
205
200
195
190
185
180
175
170
−20
0
20
40
60
80
100
120
1200
1140
1080
1020
960
900
840
780

Comparsion with Simiar work

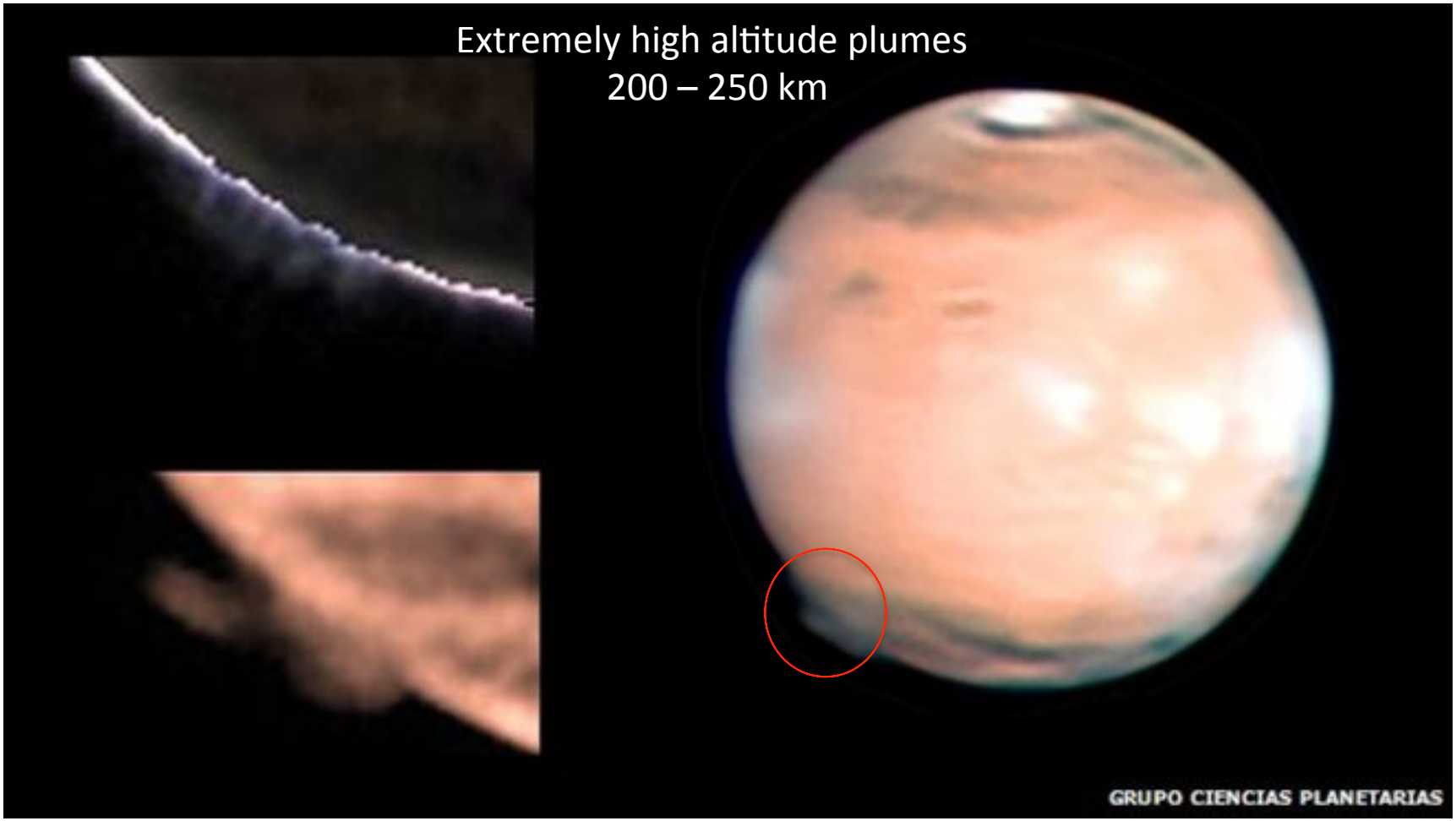




Future Work

- Further sampling of different periapse locations will help determine the driving factor(s) behind the variation in exobase altitudes.
- Finding the homopause altitude
- Finding the isotope ratios
- Using the Rayleigh distillation formula to back out how much of the atmosphere was lost

Solving Mysteries



Conclusions

- Calculated the exobase altitudes for the months of October, November, February to June and plotted them vs diff. parameters
- 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