

# Martian Crustal Field Modifications in the Dayside Ionosphere

Antonio Renzaglia, T.E. Cravens

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# Outline of Talk

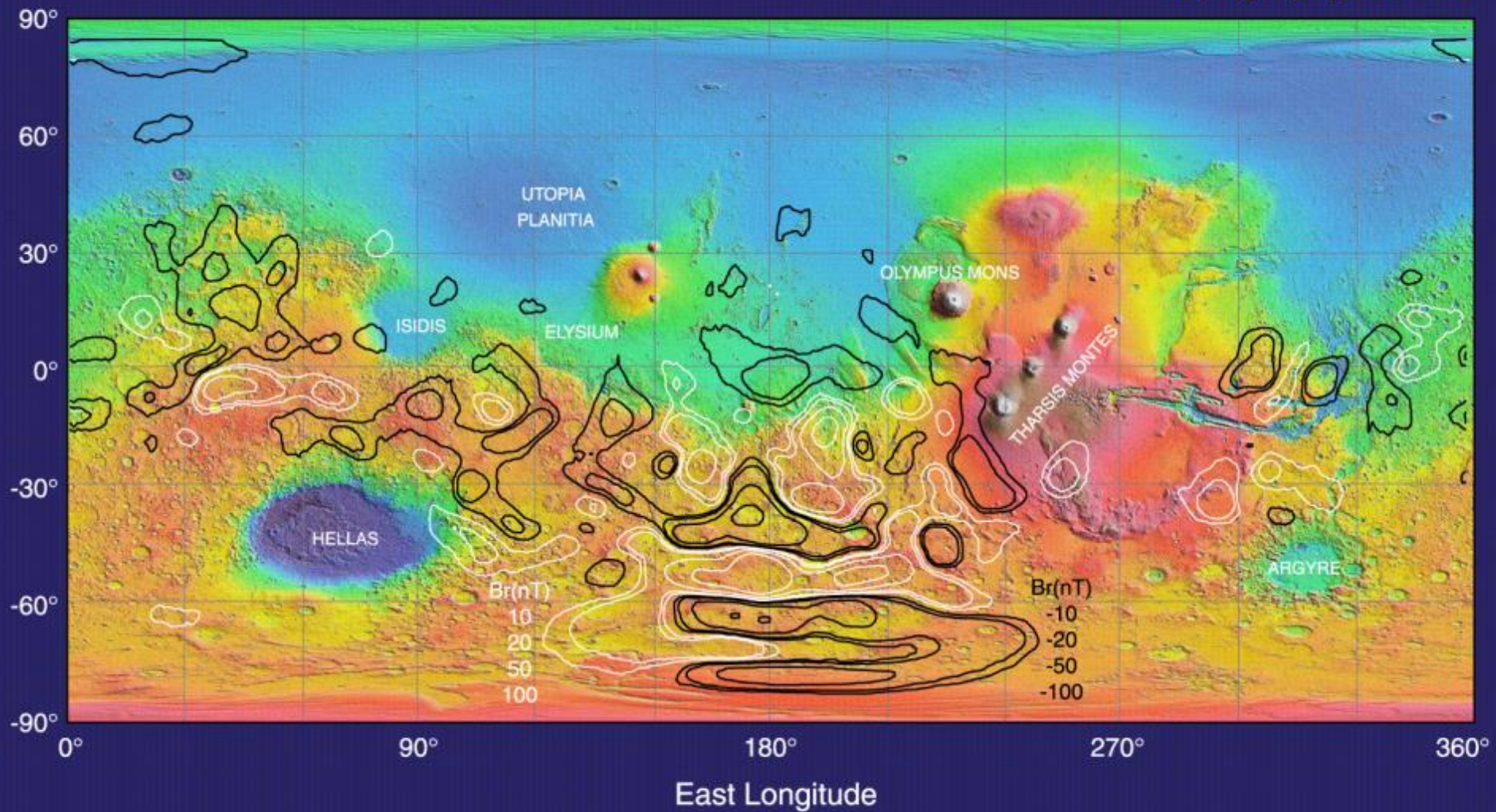
- Crustal Fields – What are they?
  - Global Map + model plots
- Solar Wind interactions with different planets
  - Production of induced fields at Mars
  - Current sheets
- Show how current sheets could modify crustal field values
- Show MAVEN orbit example

# Martian Crustal Fields

- Mars has no global magnetic field
  - No internal dynamo
- Strong, localized fields
  - Generated from rocks in the crust
  - 1000's of nT
- Open and closed fields
  - Open - extend up and interact with the solar wind – ion escape
  - Closed – reconnect with other fields – prevents ion escape

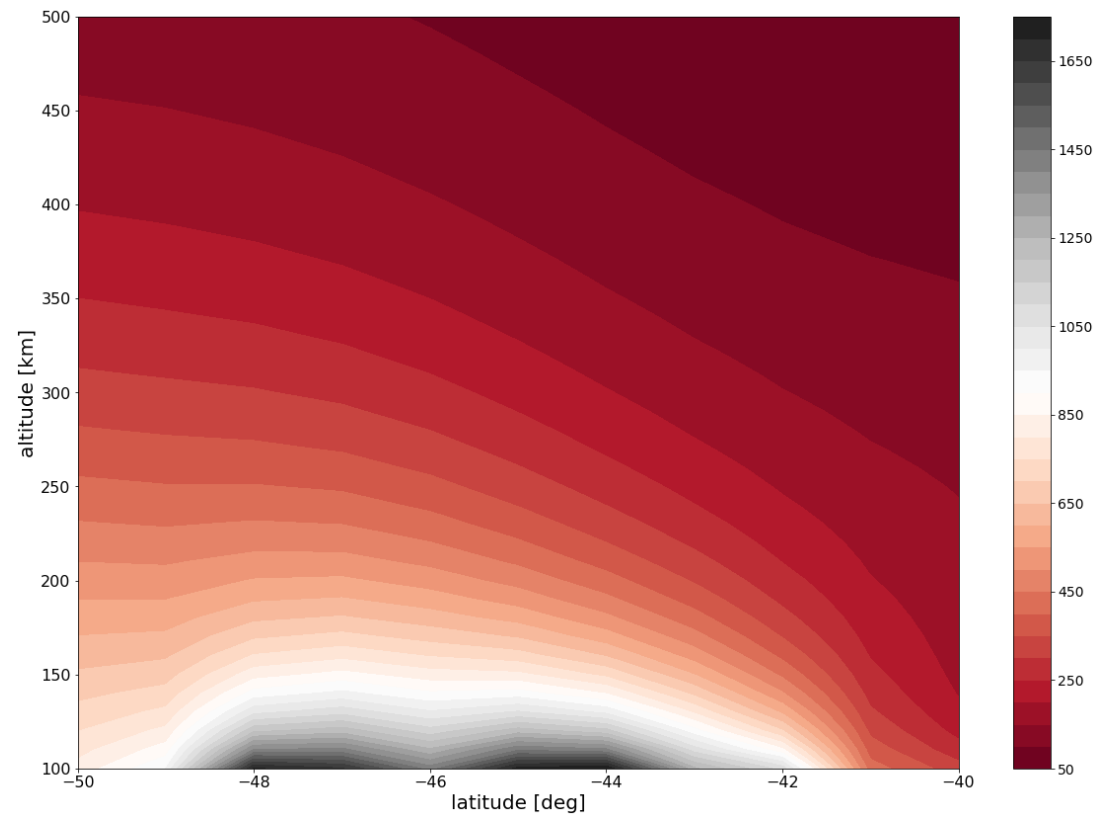
# Mars Global Surveyor

Mars Crustal Magnetism - MAG/ER  
Topography - MOLA

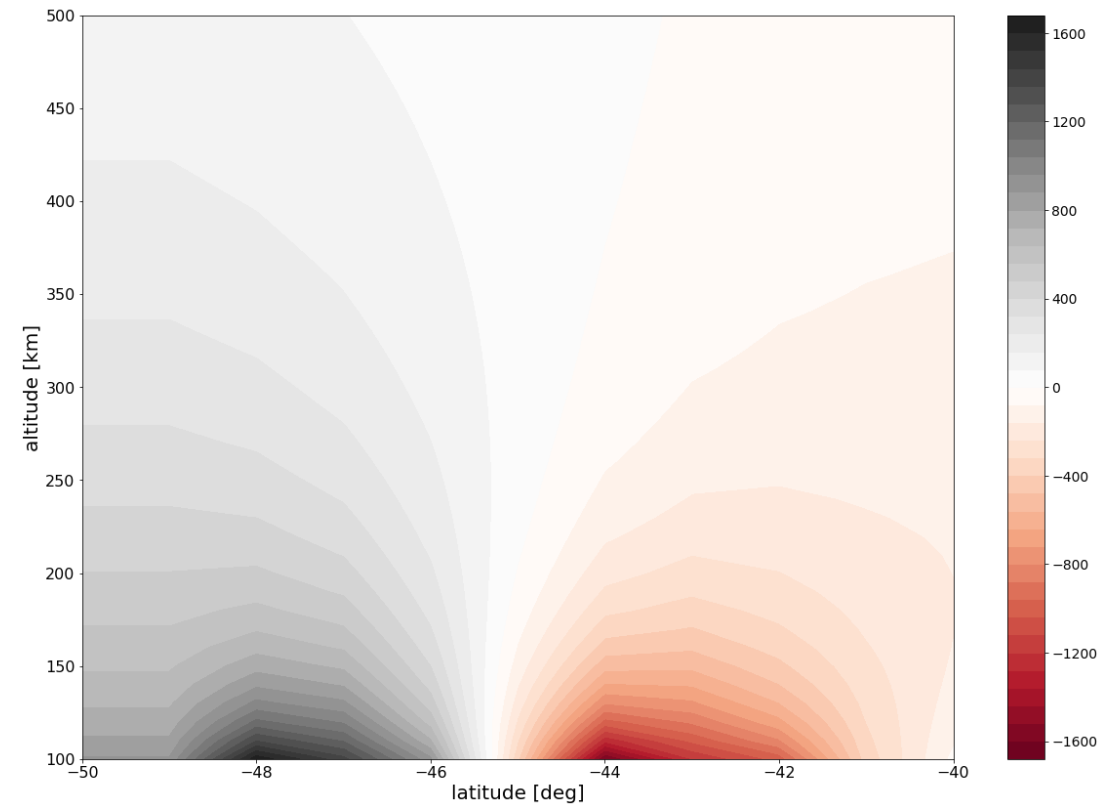


# Martian Crustal Fields – Purucker Model

lat vs alt @ lat=180 - contour plot of  $|B|$

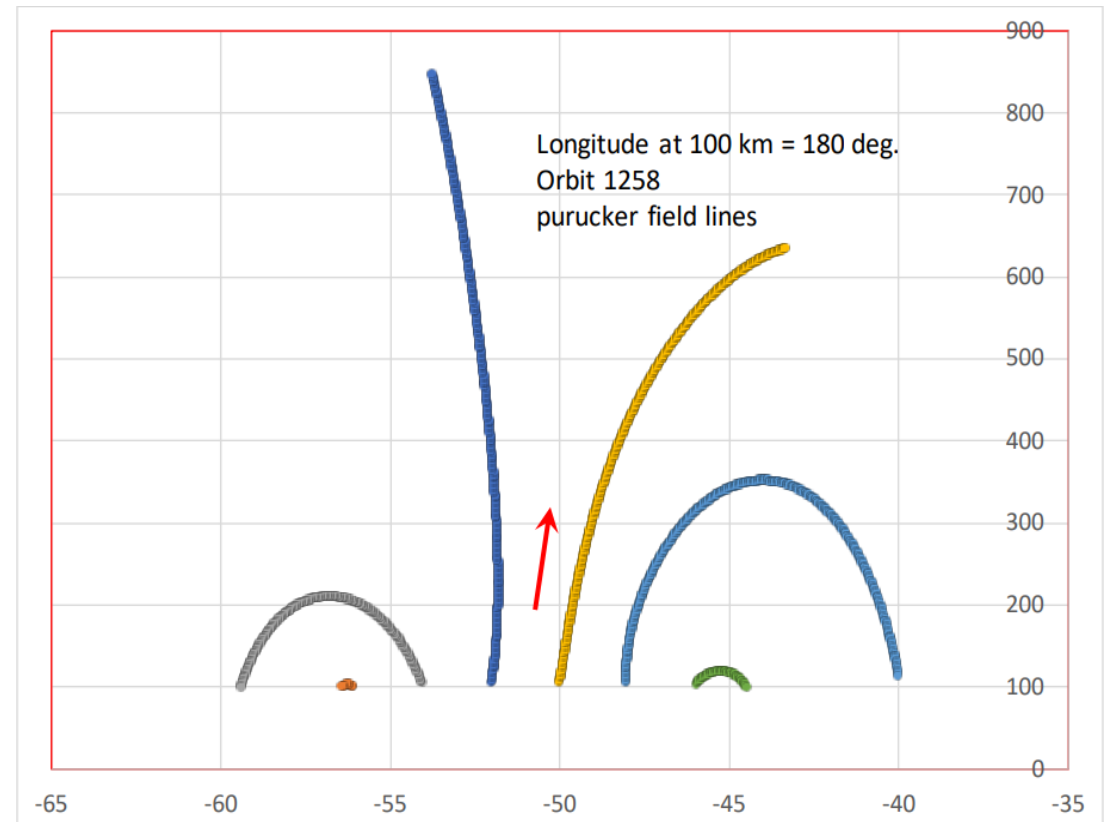
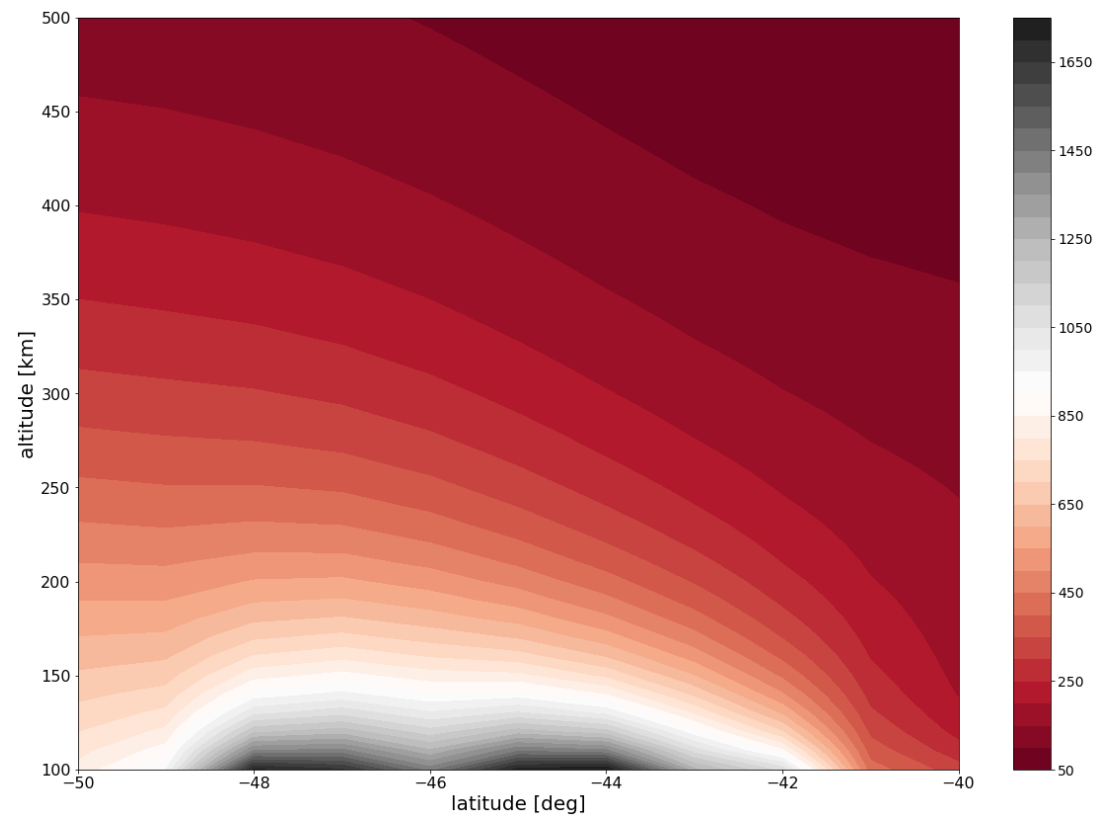


lat vs alt @ lat=180 - contour plot of  $B_r$



# Martian Crustal Fields – Purucker Model (ctd.)

lat vs alt @ lat=180 - contour plot of  $|B|$



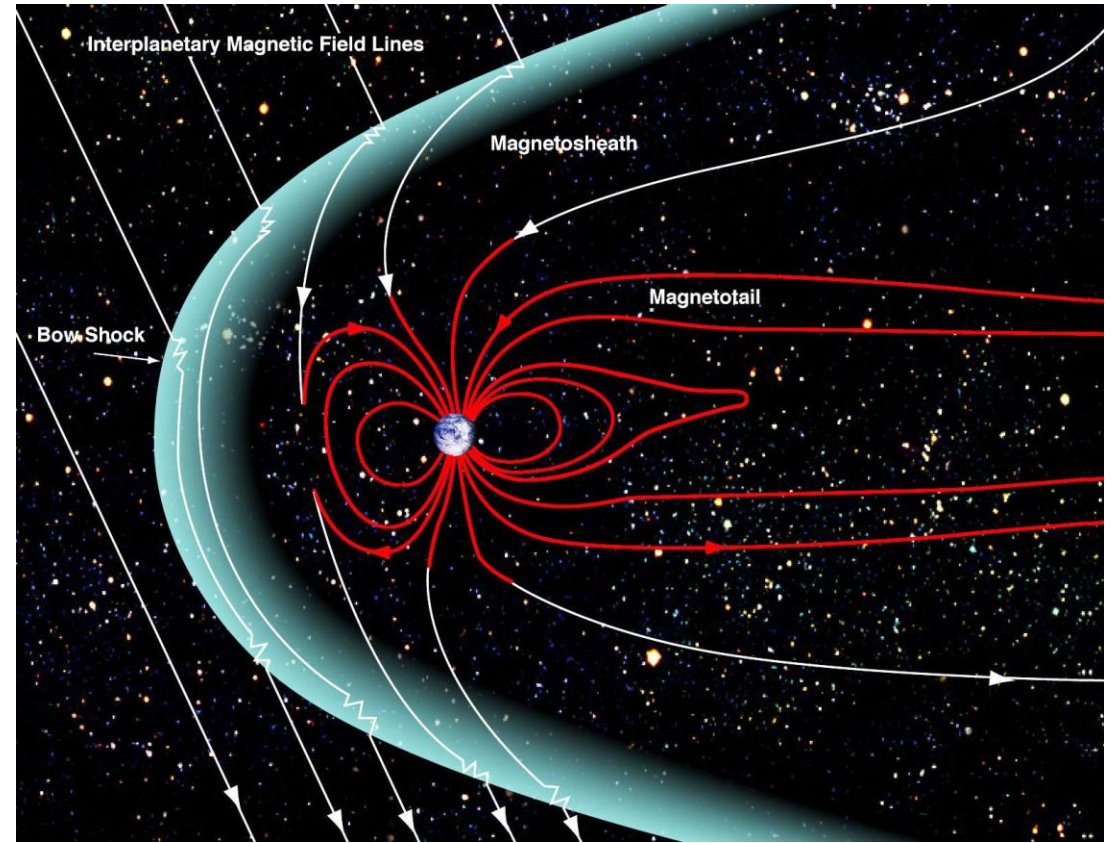
# Solar Wind Interactions with Planets

- Earth
- Venus
- Mars



# Solar Wind Interactions with Earth

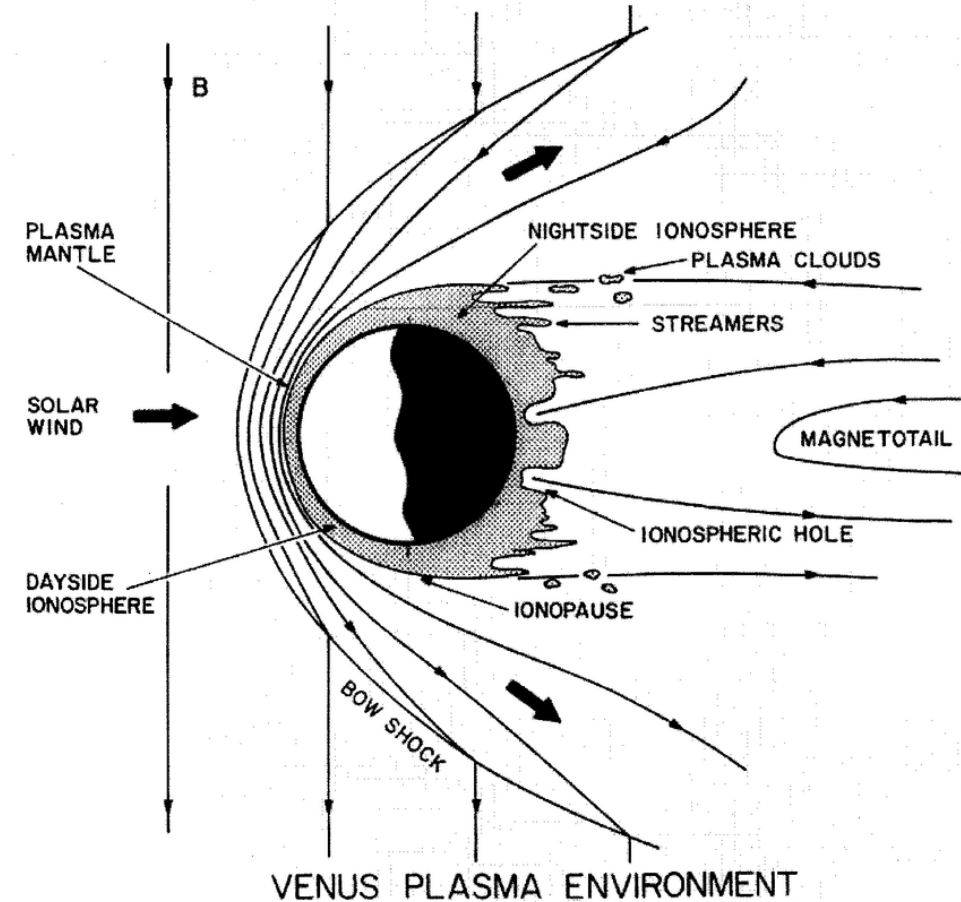
- Global magnetic field extends far beyond the ionosphere
- Solar wind and IMF get held further out away from the planet





# Solar Wind Interactions with Venus

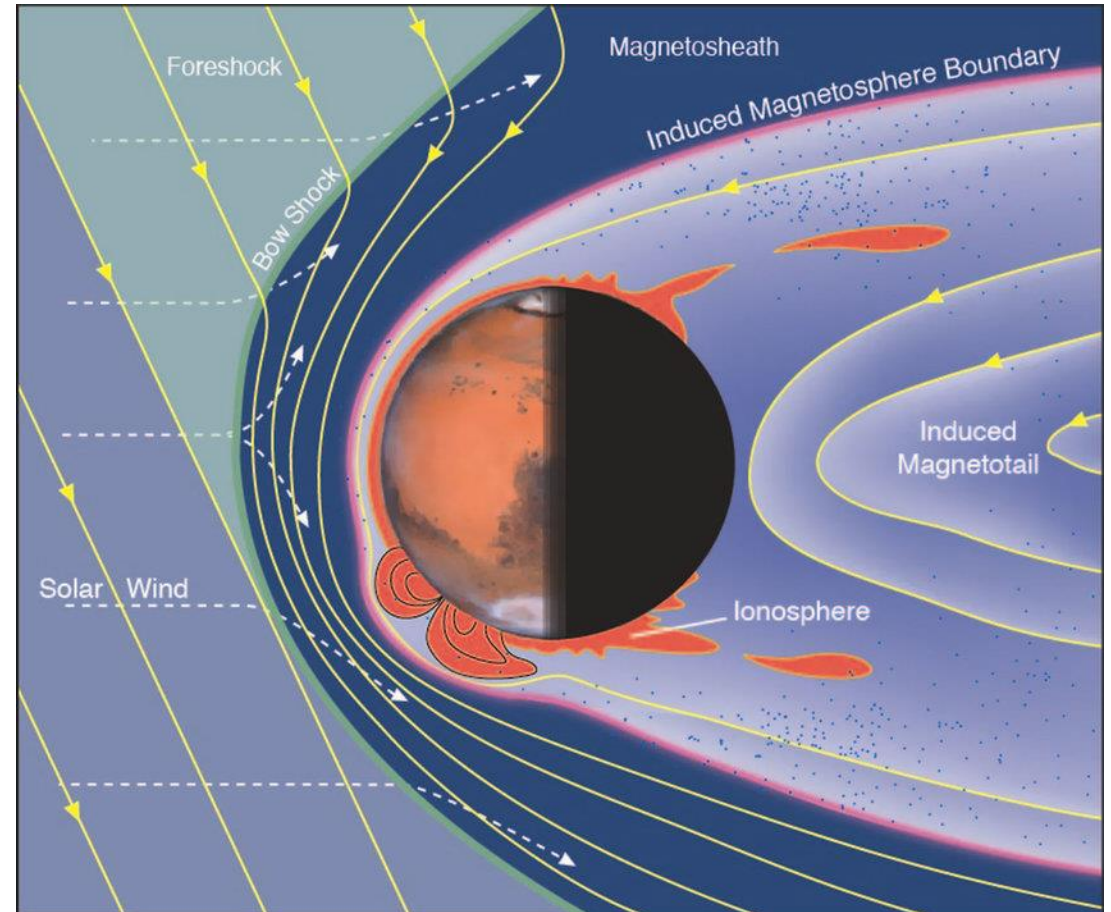
- No internal global field
- IMF piles up and drapes around the planet
- Solar wind and IMF can penetrate close to the ionosphere
- Produces an induced magnetic field in the ionosphere



Cravens, 1991

# Solar Wind Interactions with Mars

- Mars is a unique combination of these 2 types of interactions
- Crustal fields can provide similar protection as Earth-like interactions (on a much smaller scale)
- In areas with no (or weak) crustal fields, there are Venus-like interactions



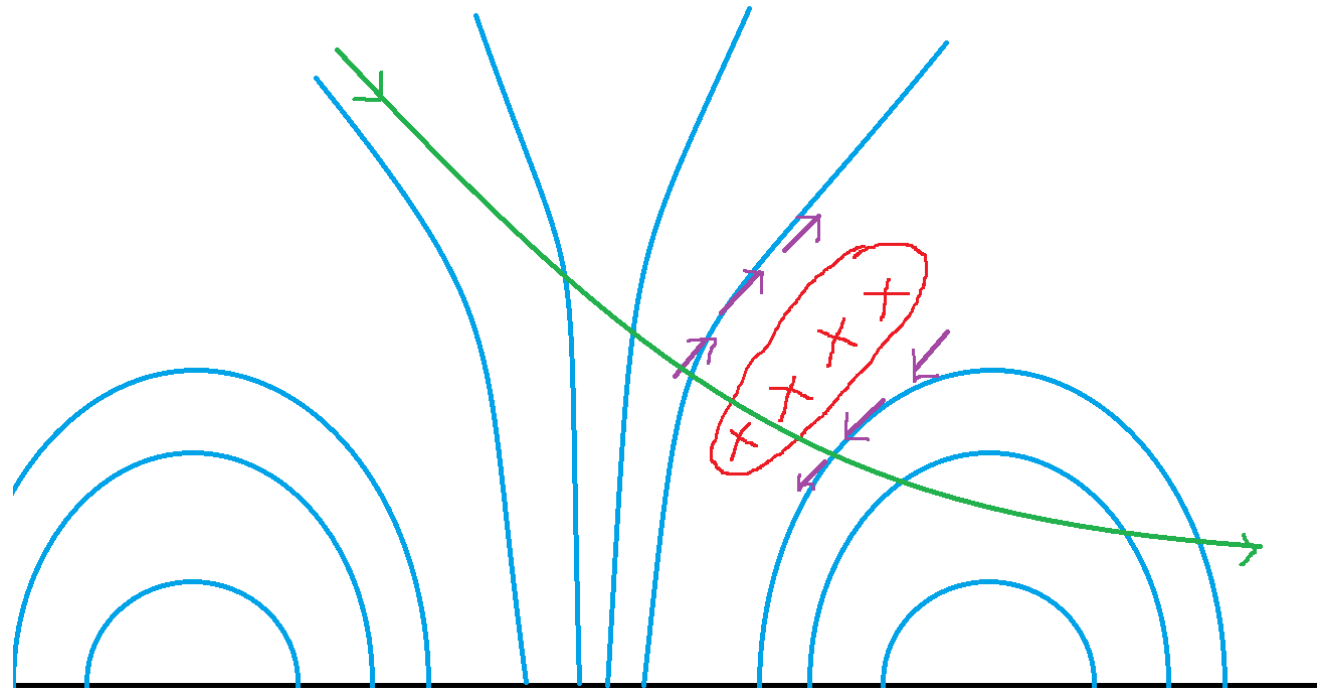
Lillis et al. 2015

# Induced-Crustal Field Interactions

- In regions where both induced and crustal fields exist close together, current sheets can be produced in between the two types of fields
  - These current sheets can then further alter the magnetic field structures in the area
- The fields can also go through magnetic recombination

# Current Sheets at Mars

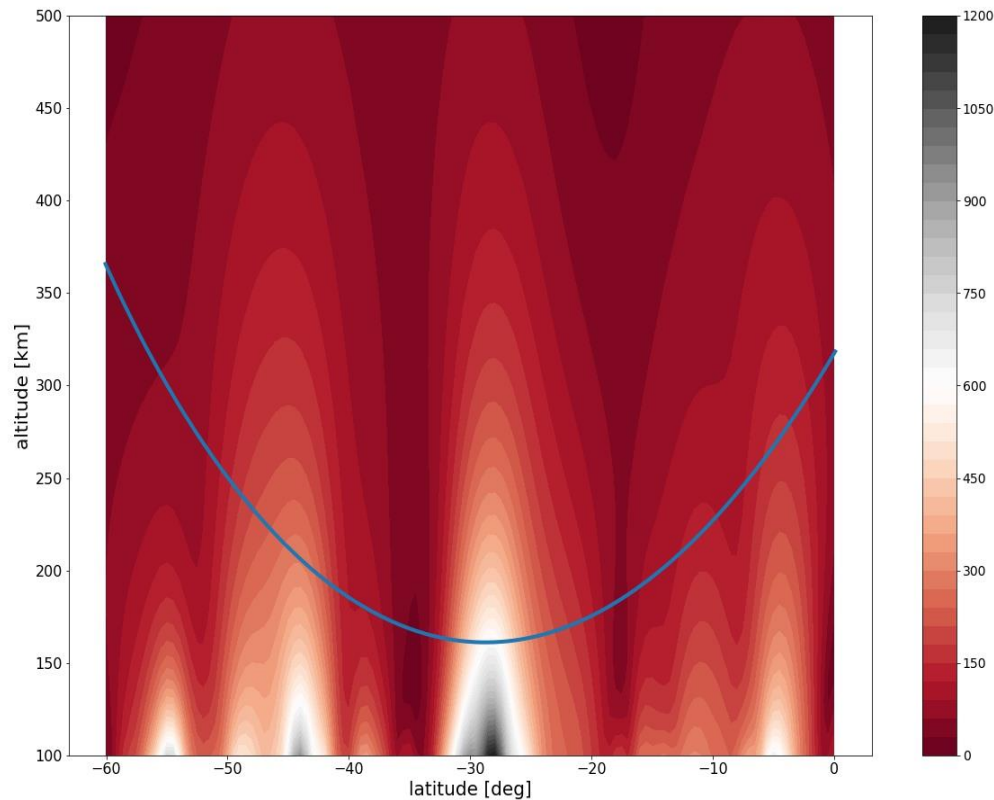
- Blue – Crustal Fields
- Red – Current sheet (into the page)
- Purple – Magnetic fields produced from the current sheet
- Green – Example spacecraft passing through the region



# Example of a Current Sheet

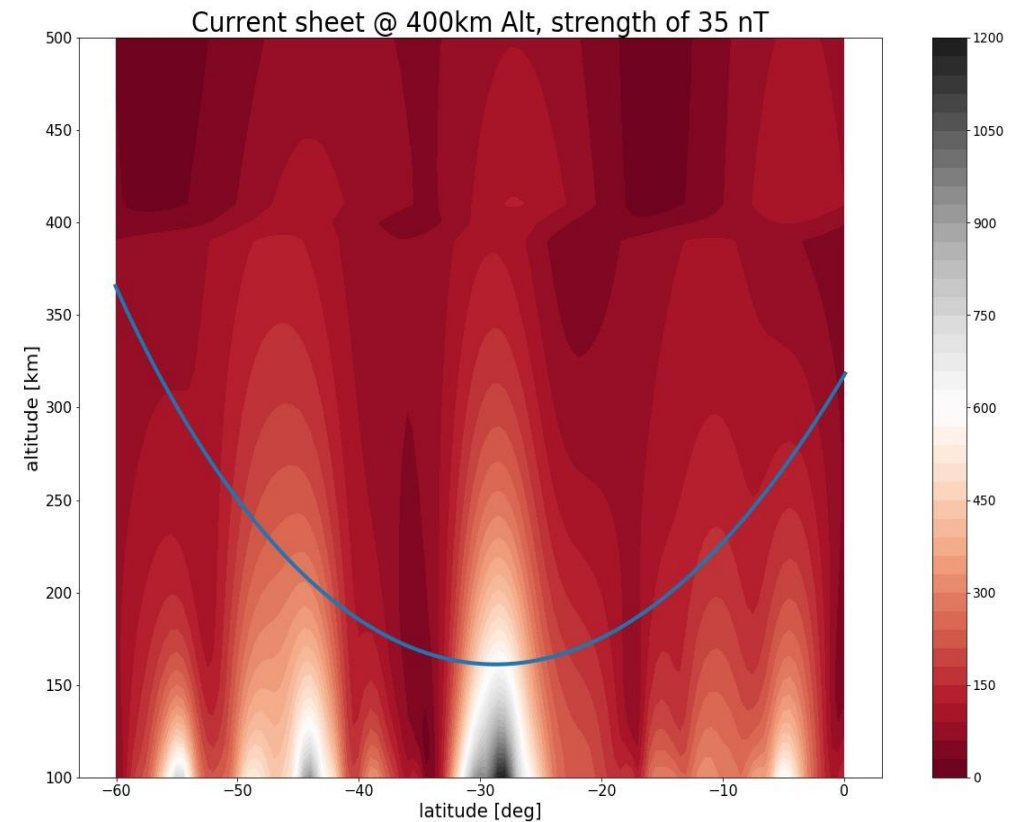
## No Current Sheet

lat vs alt @ long=190 - contour plot of  $|B|$



## Current Sheet

lat vs alt @ long=190 - contour plot of  $|B|$

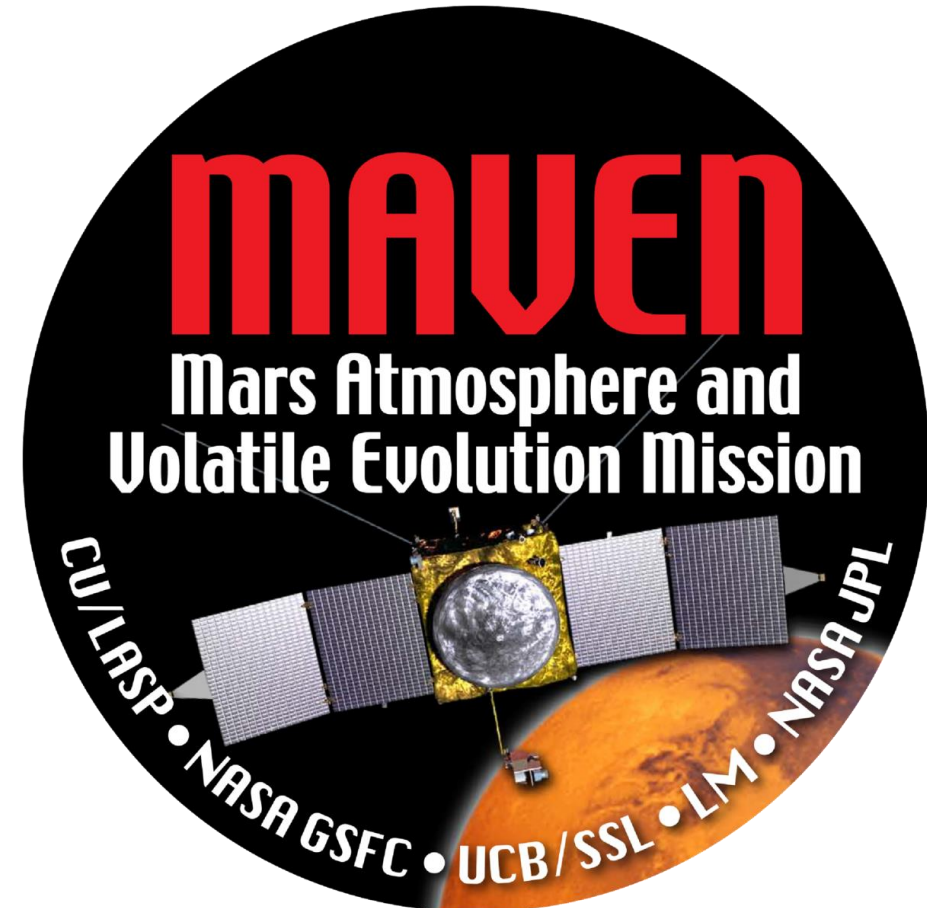


# How can we investigate current sheets?

- Data
  - Magnetic field data
    - Compare to models
  - Electron data
    - Density, temperature, pressure profiles

# MAVEN

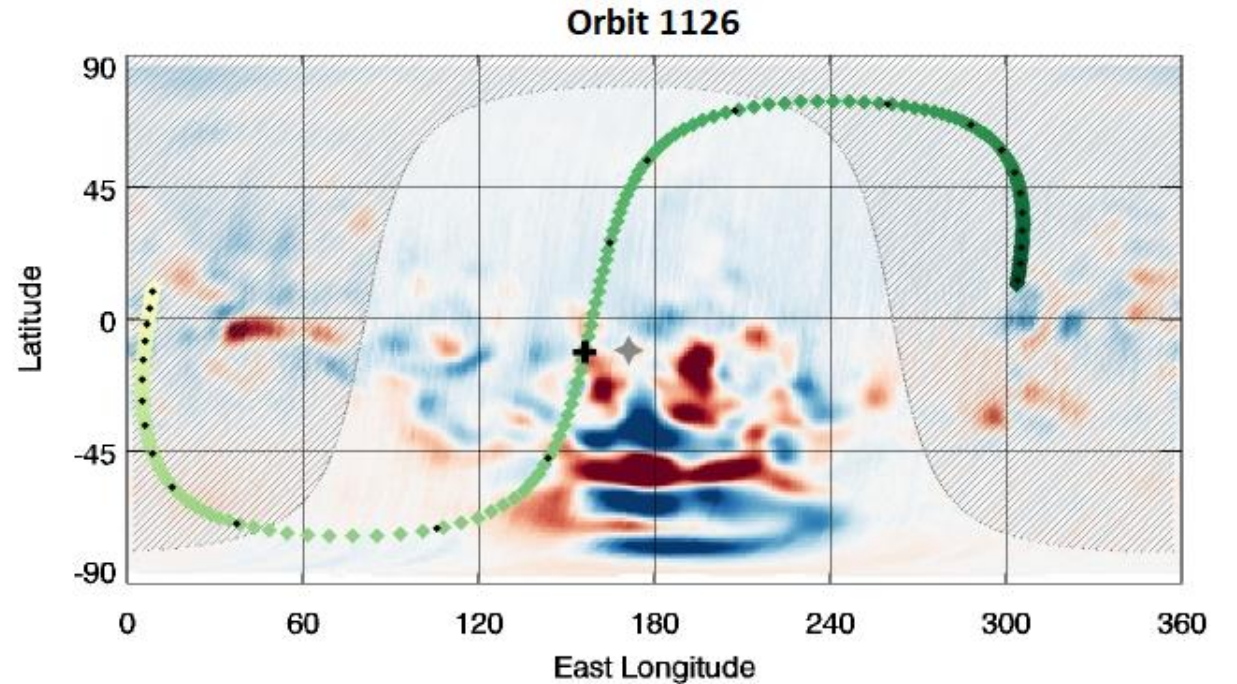
- Mars Atmospheric and Volatile Evolution explorer
- Orbiting since 2014
- Studying Mars' atmosphere
  - How Mars is losing its atmosphere
  - How this affected the planet long term





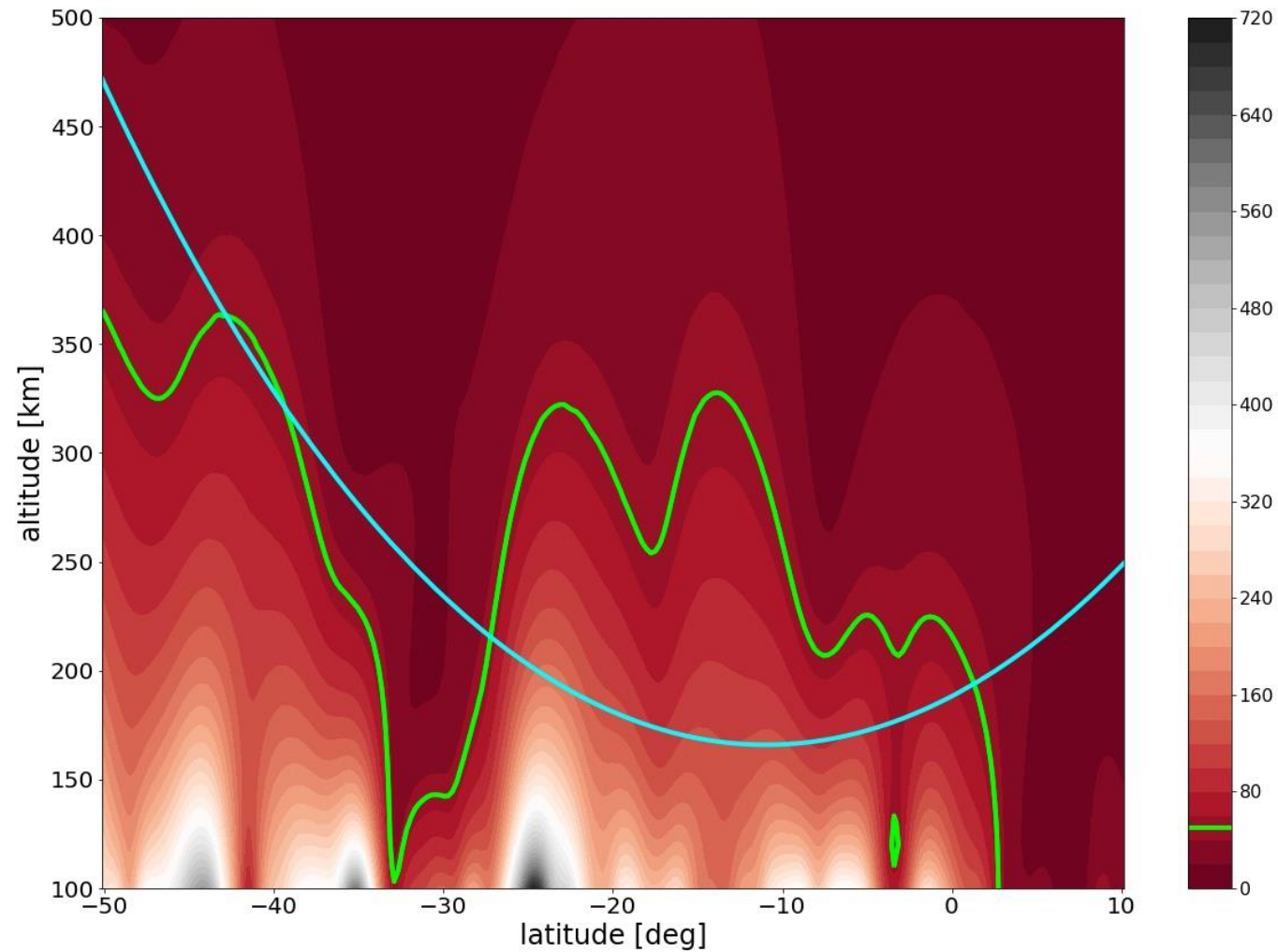
# MAVEN Orbit 1126

- 2015-04-29
- Periapsis info:
  - Altitude: 165.94 km
  - SZA:  $14.6^\circ$
  - Lat/Lon:  $-10.98^\circ$ ,  $156.29^\circ$
- Small to medium crustal field strength



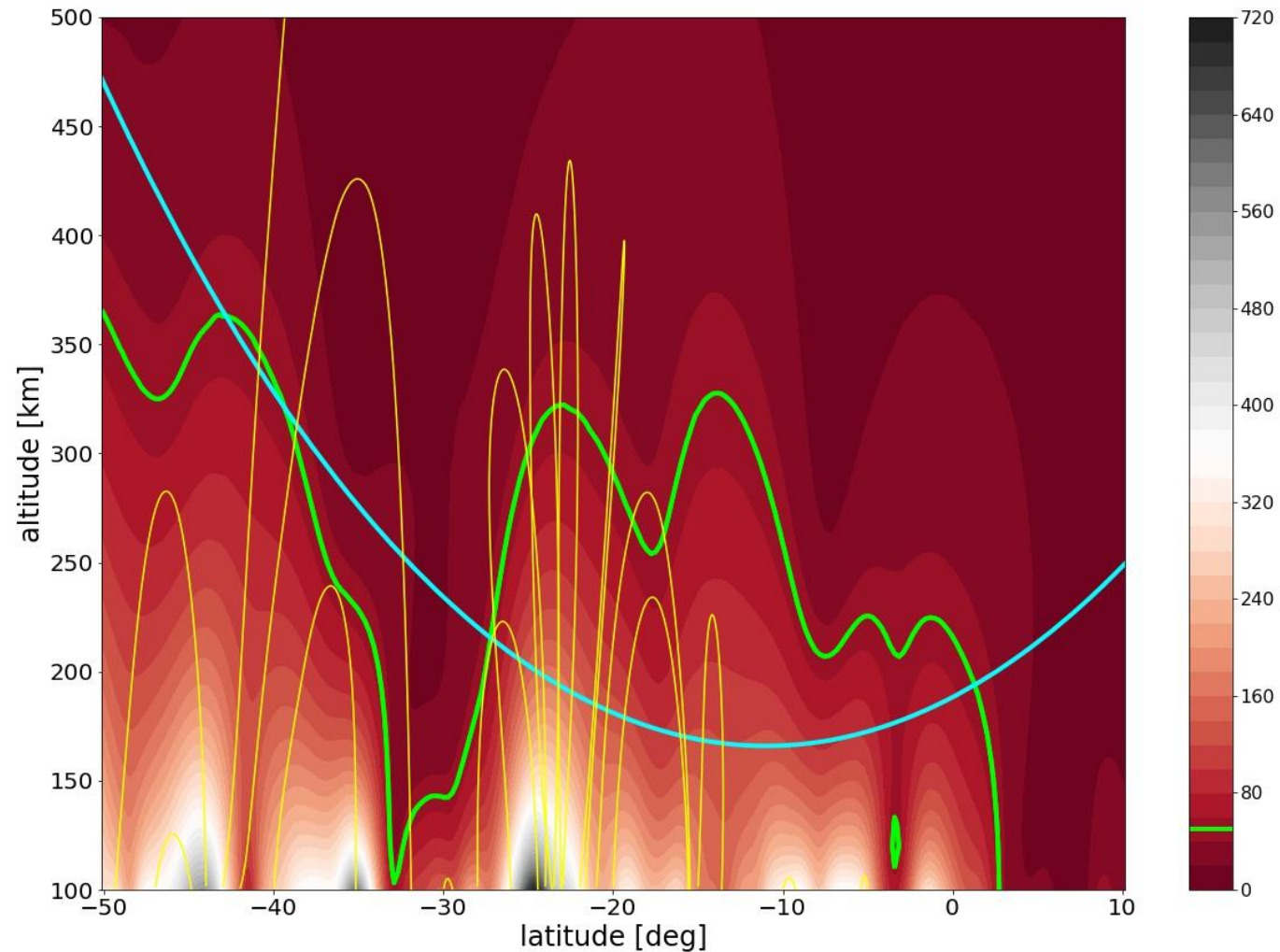
# Orbit 1126 - Purucker Crustal Model

Orbit 1126 - lat vs alt - contour plot of  $|B|$



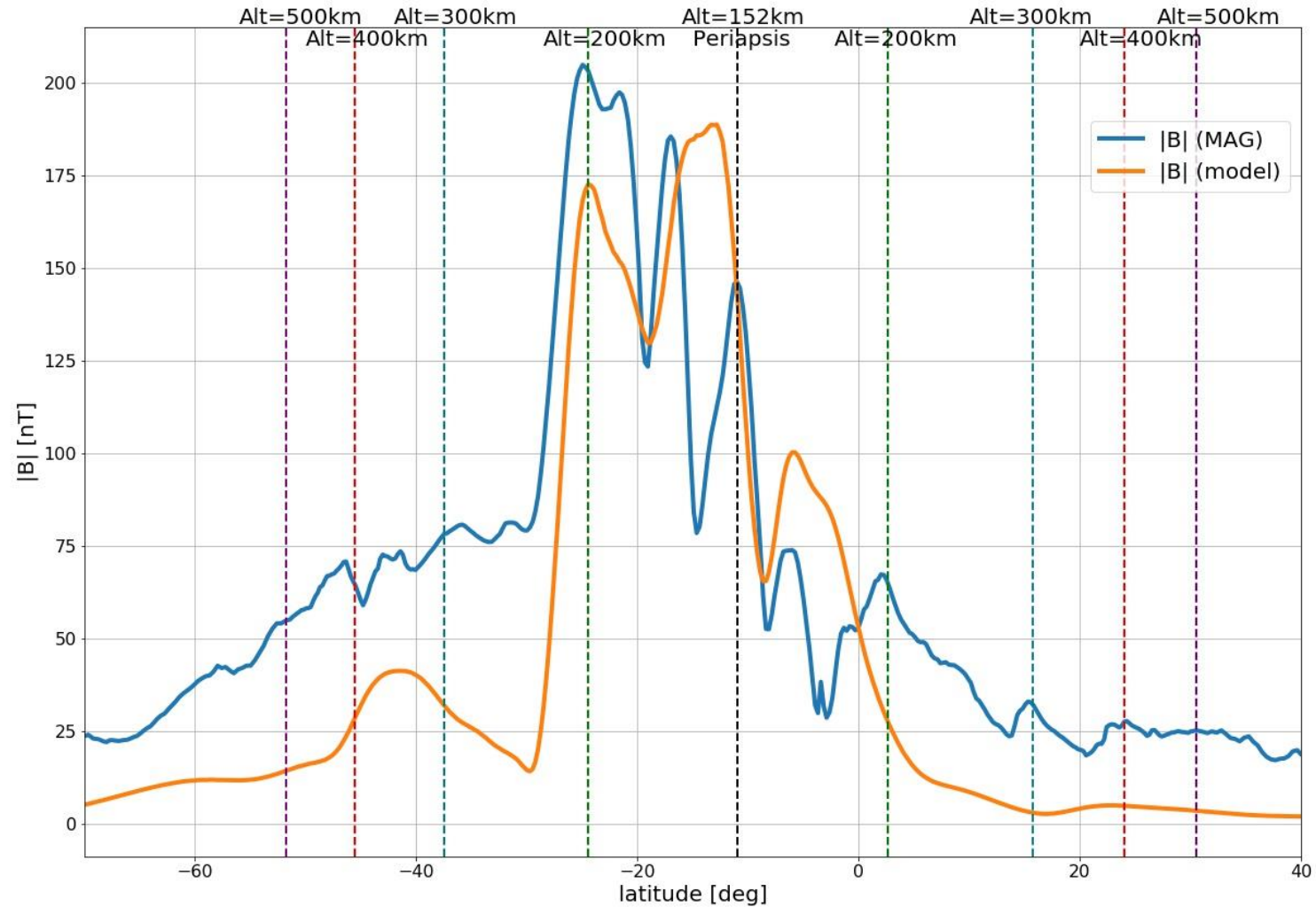
# Orbit 1126 - Purucker Crustal Model (ctd.)

Orbit 1126 - lat vs alt - contour plot of  $|B|$



# Orbit 1126 – MAG Data

lat vs  $|B|$  - Orbit 1126 (Dayside)



# Conclusions

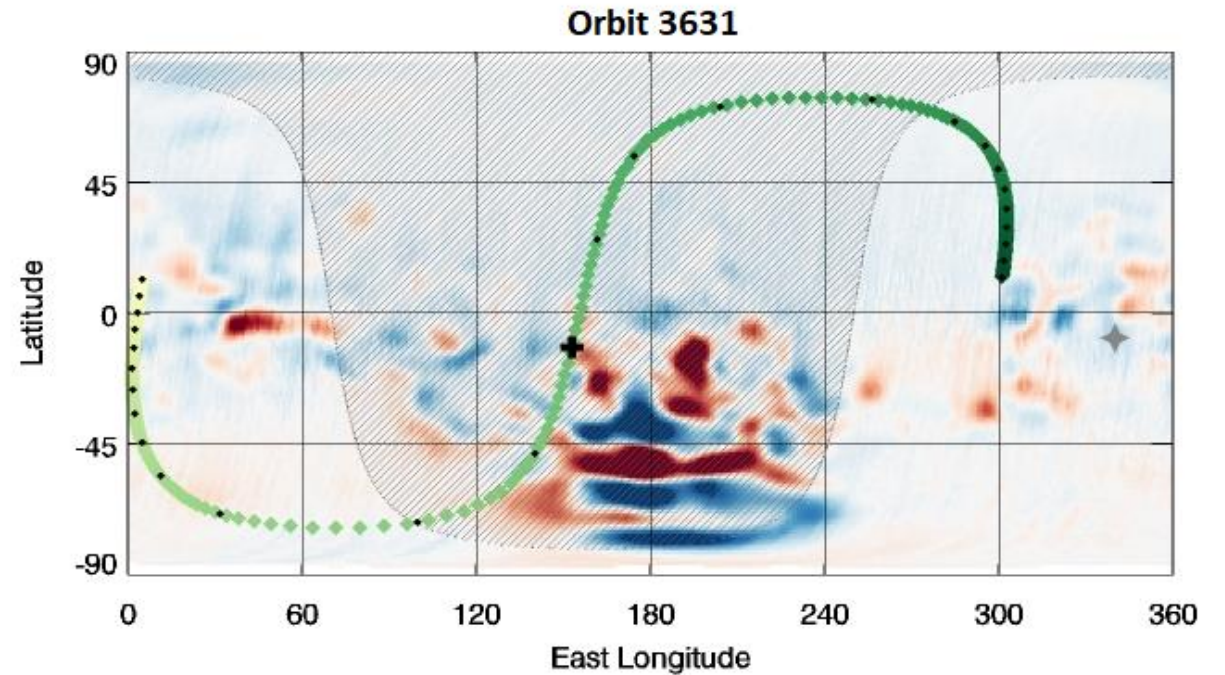
- Induced fields in the dayside ionosphere can give rise to current sheets
  - Influence the boundaries of the crustal fields
- Understanding the structure of crustal fields can help shed light on how Mars may be losing its atmosphere
  - In particular – oxygen and water

# Extra Slides



# MAVEN Orbit 3631

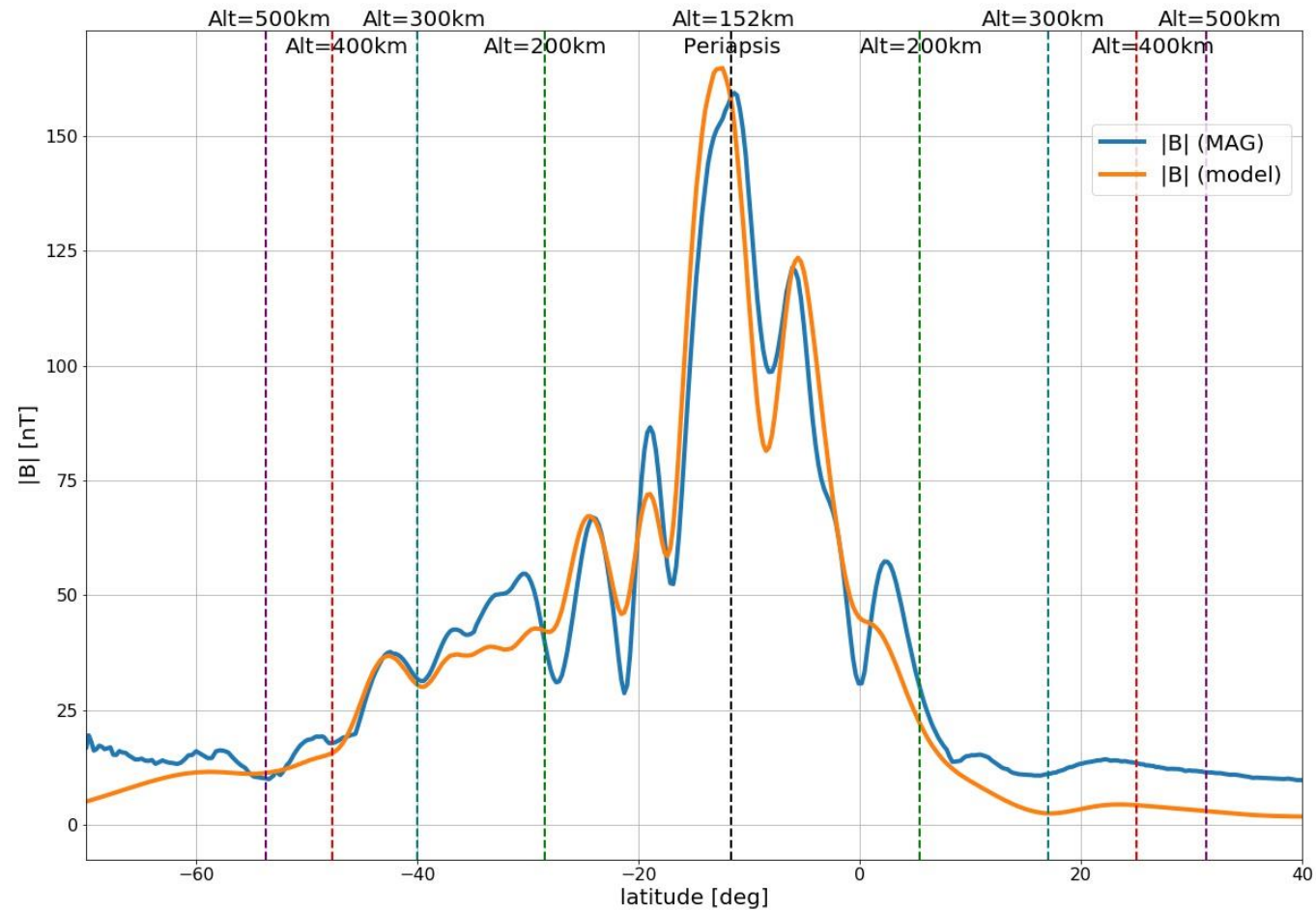
- 2016-08-09
- Periapsis info:
  - Altitude: 147.05 km
  - SZA: 158.61°
  - Lat/Lon: -11.63°, 152.93°





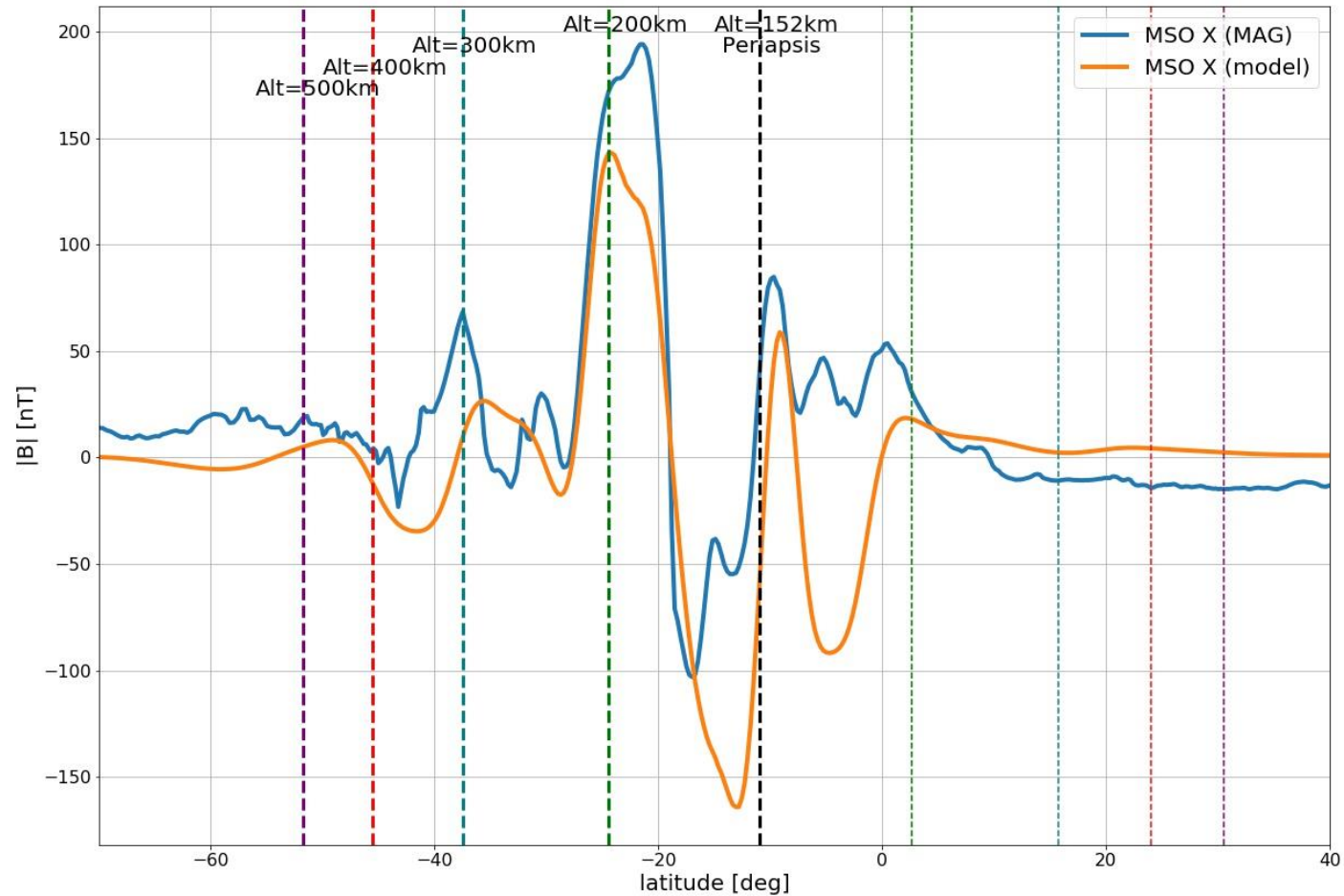
# Orbit 3631 – MAG data

lat vs  $|B|$  - Orbit 3631 (Nightside)



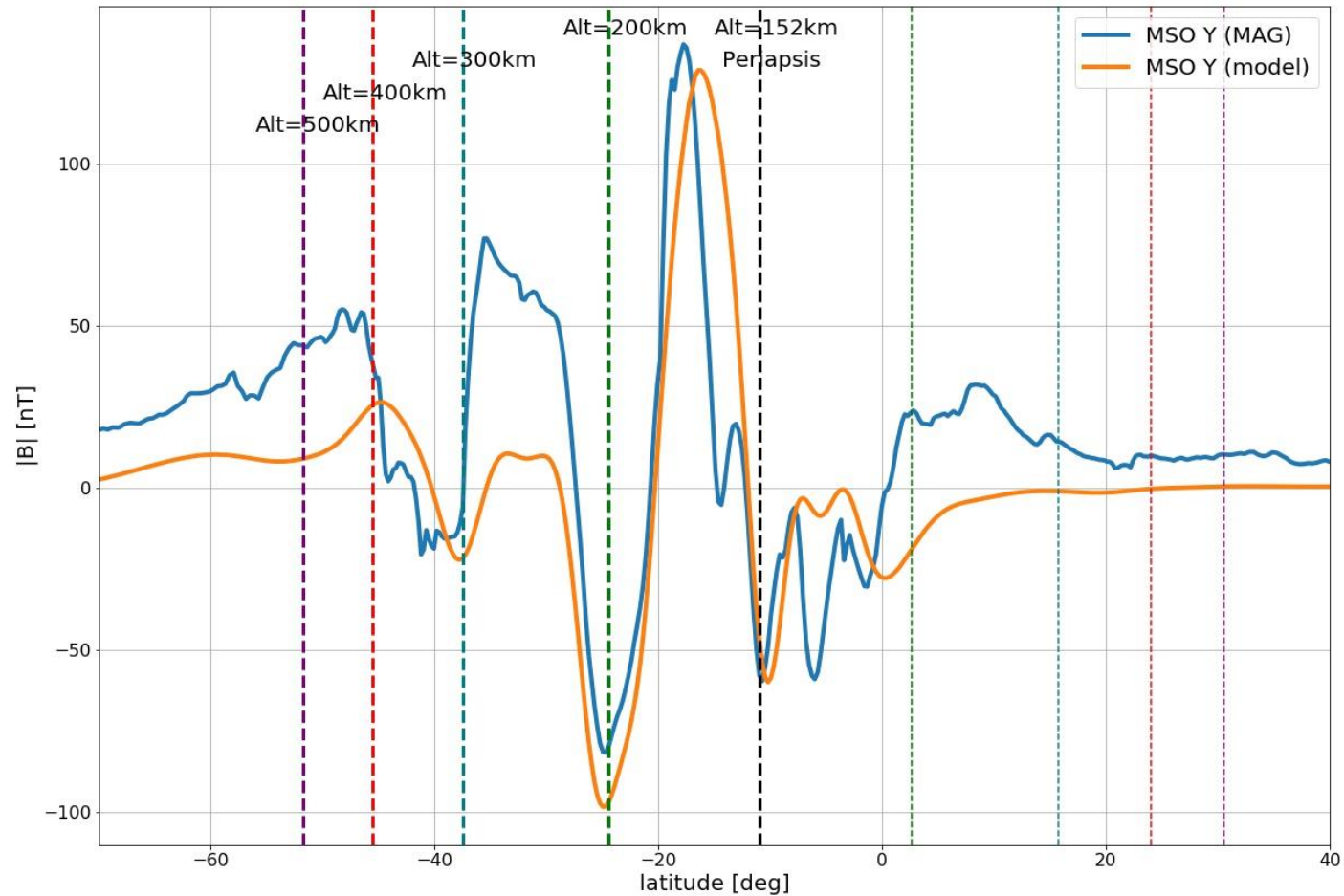
# Orbit 1126 – MAG Data (ctd.)

lat vs B<sub>x</sub> - Orbit 1126 (Dayside)



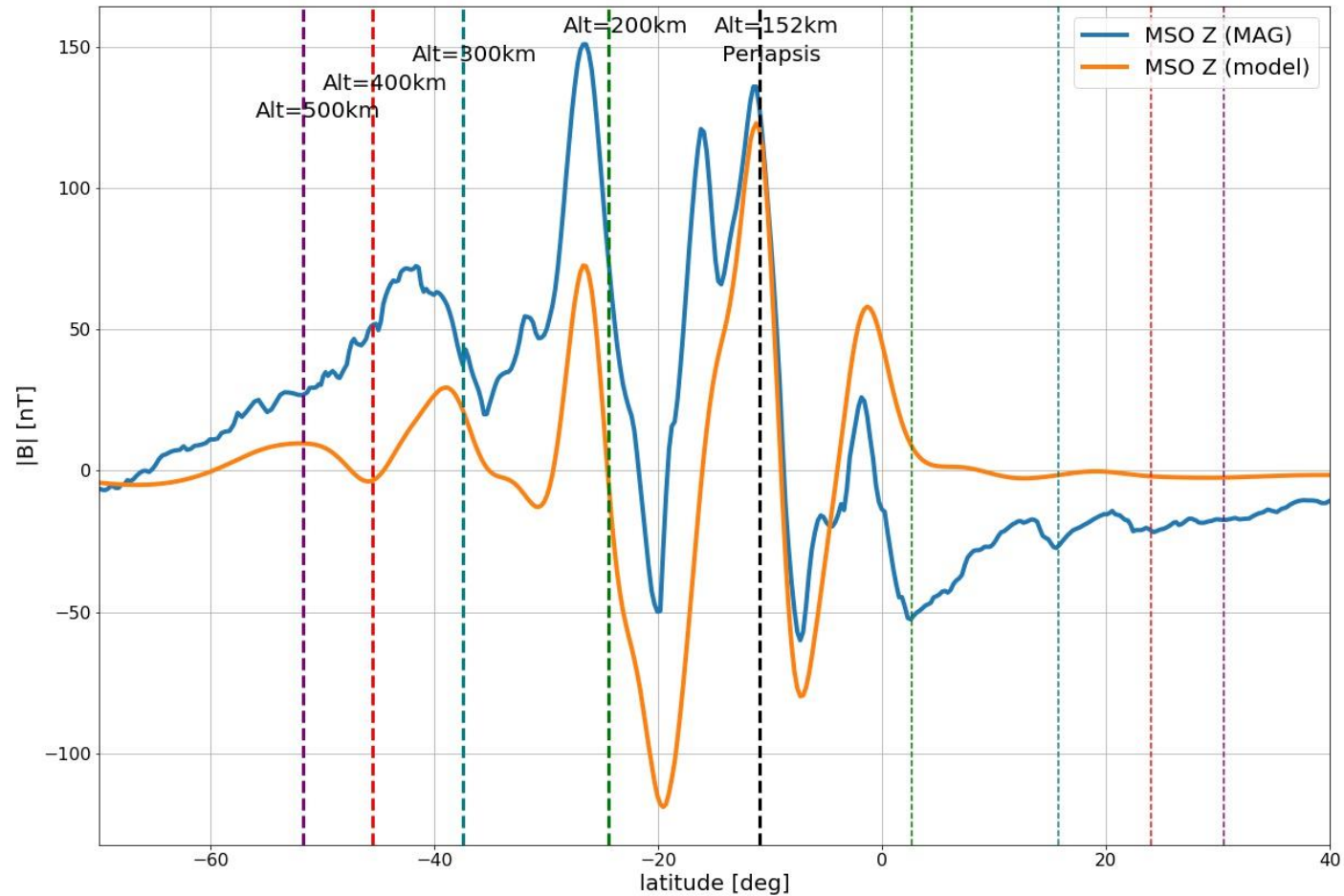
# Orbit 1126 – MAG Data (ctd.)

lat vs B<sub>y</sub> - Orbit 1126 (Dayside)



# Orbit 1126 – MAG Data (ctd.)

lat vs B<sub>z</sub> - Orbit 1126 (Dayside)



# MSO Coordinates Explained

- Centered on center of Mars
- X – points to center of the Sun
- Y – points antiparallel to Mars' orbital velocity
- Z – completes the coordinate system via right hand rule