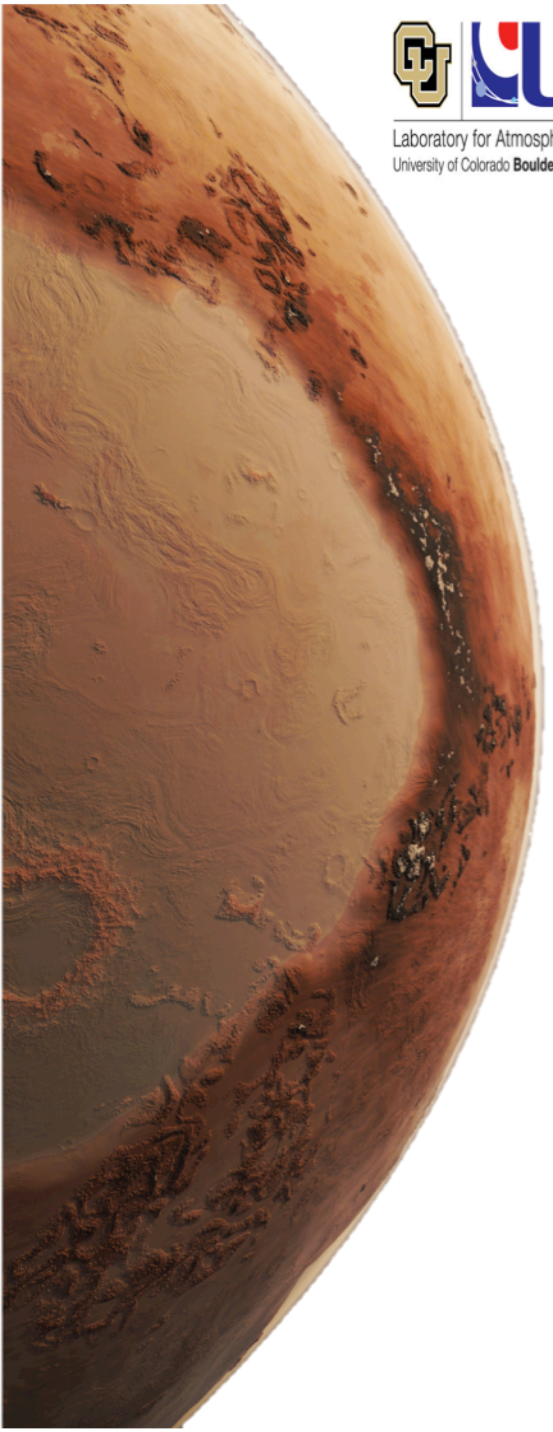
The magnetic field draping direction at Mars

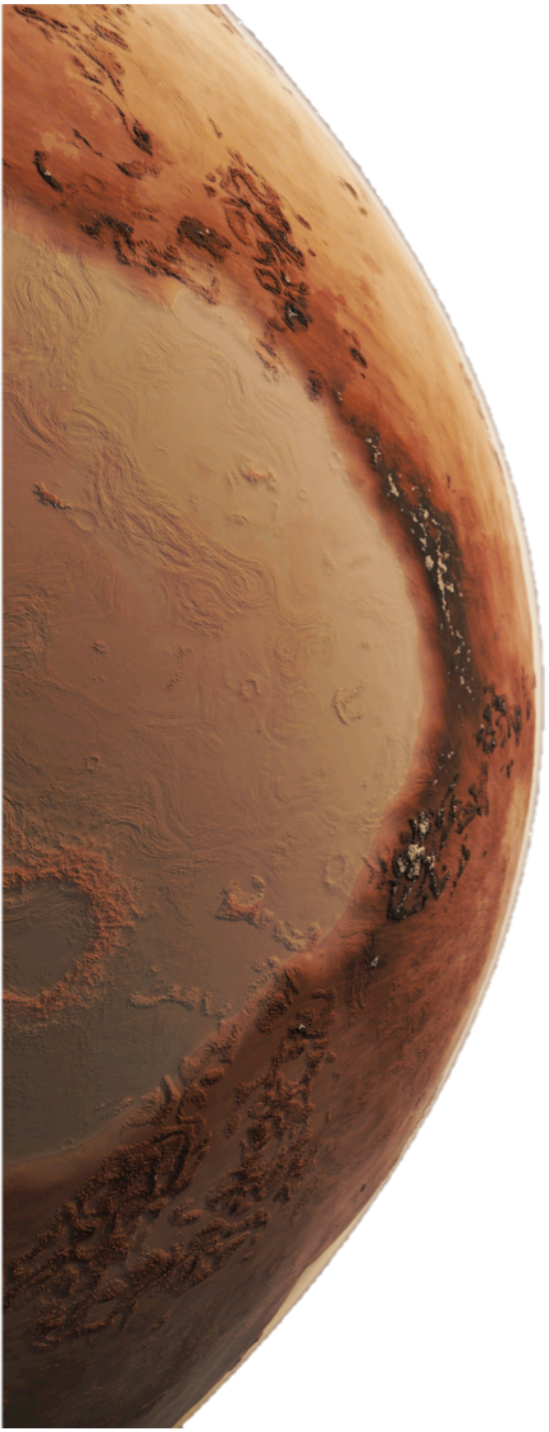
Fatmah Alkindi , Dr.David Brain,
Dr.Mikki Osterlooa

07/31/2015

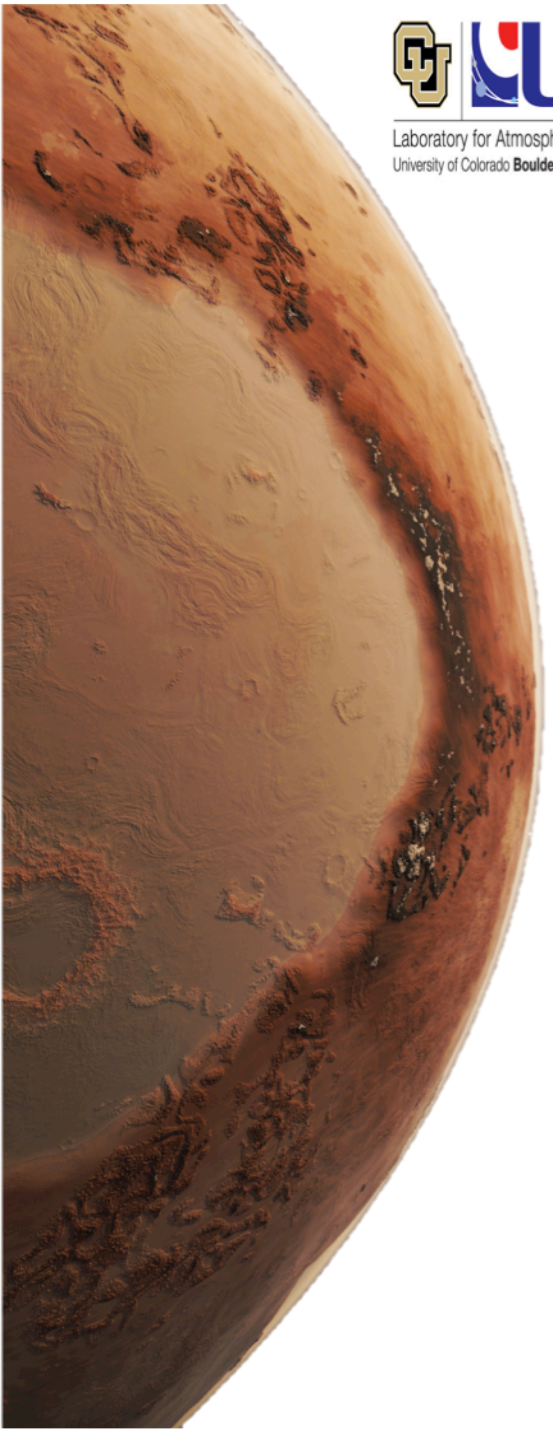


Outline

- Background about Mars' magnetic field
- Mars Global Surveyor spacecraft (MGS) analysis
- Mars Atmosphere and Volatile EvolutioN spacecraft (MAVEN) analysis
- Conclusion

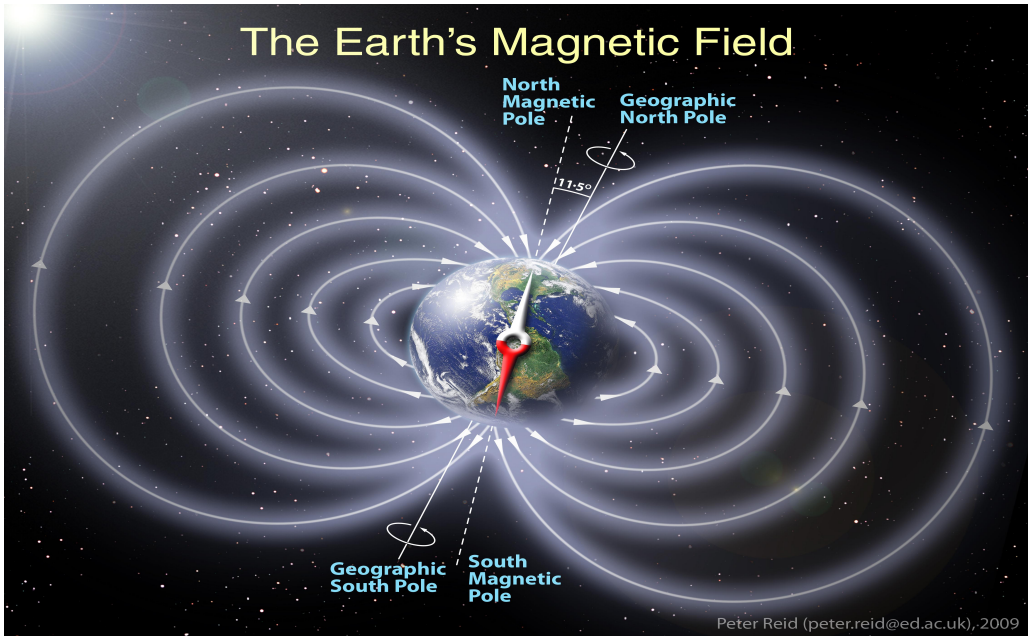


1. Background



Mars' magnetic field

- Mars has no inner dynamo to create a major global magnetic field.
- Since Mars is smaller than Earth, so lost its internal heat faster



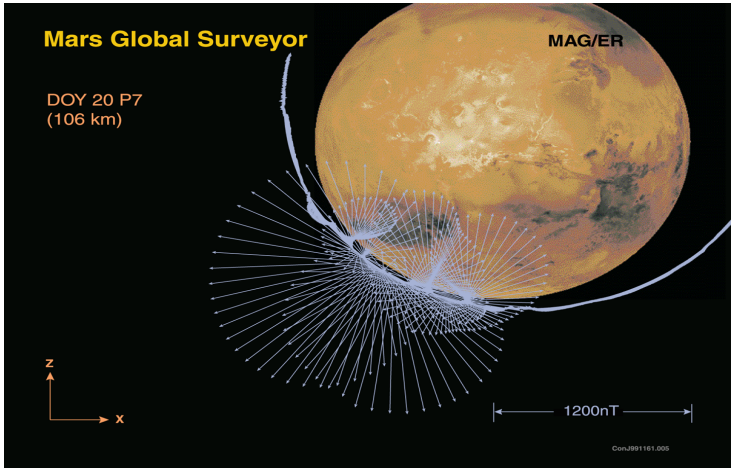
Mars' magnetic field

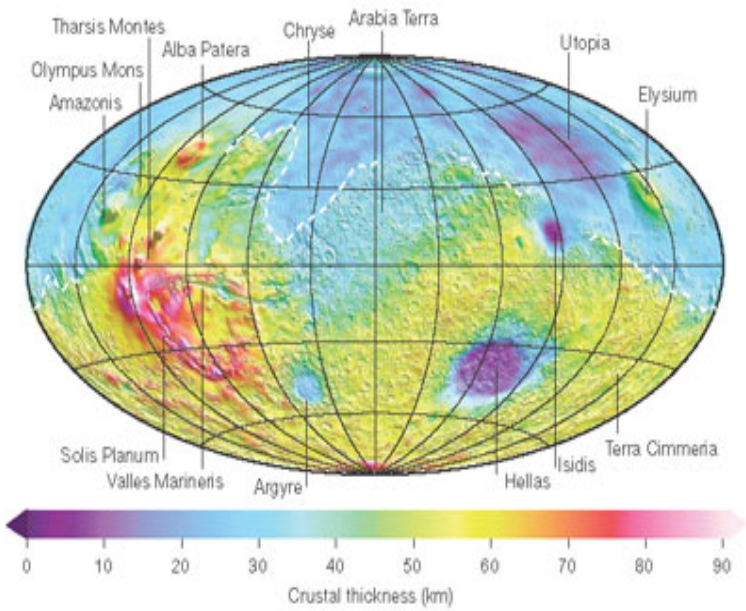
A strong magnetic fields coming from rocks in the crust

- First detected in 1997 (MGS)
- 10-20 times more magnetic than Earth rocks

Mars had a dynamo long ago

- The crustal magnetic fields are so strong that's the only explanation for how they got that way
- Dynamo shut off, leaving magnetized crust. Heating events (impact, volcanism) erased magnetization in many regions





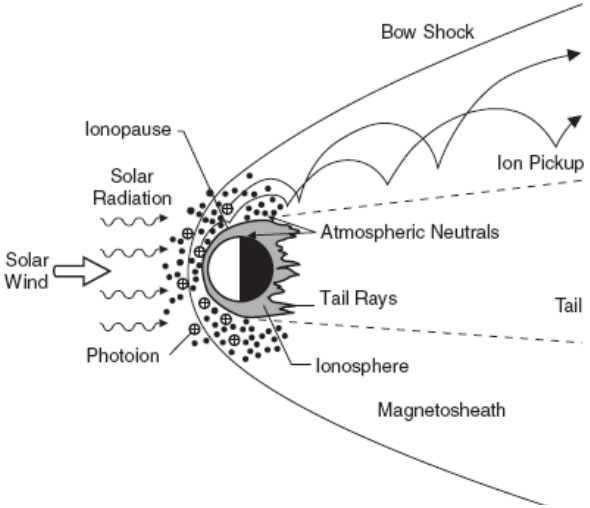
Induced Magnetosphere Formation

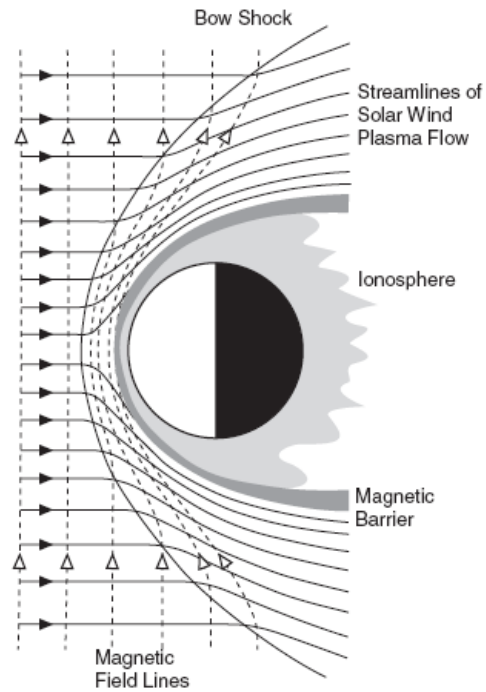
1. Sunlight ionizes neutral particles in the upper atmosphere

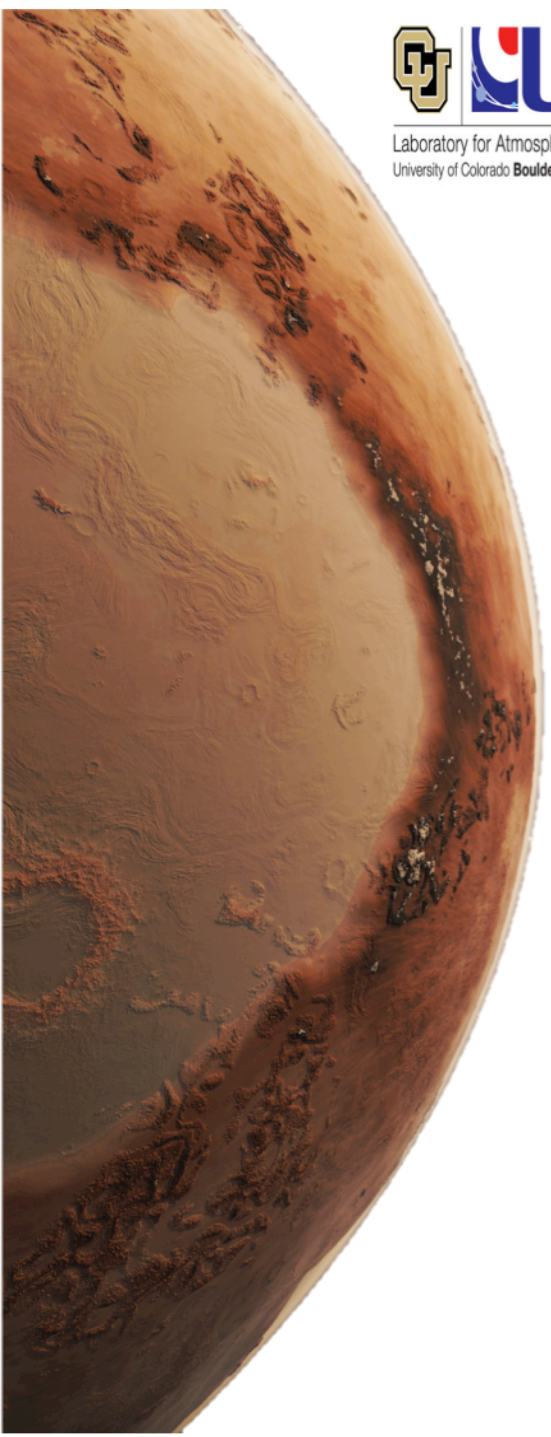
2. The solar wind magnetic field moving toward the ionosphere causes the ionospheric particles to move
   (Faraday's Law: changing magnetic field creates a current)

3. Ionospheric currents create a magnetic field
   (Ampere's Law: currents create magnetic fields)

4. Solar wind particle trajectories are bent by the magnetic field from the ionosphere
   (Lorentz Force)

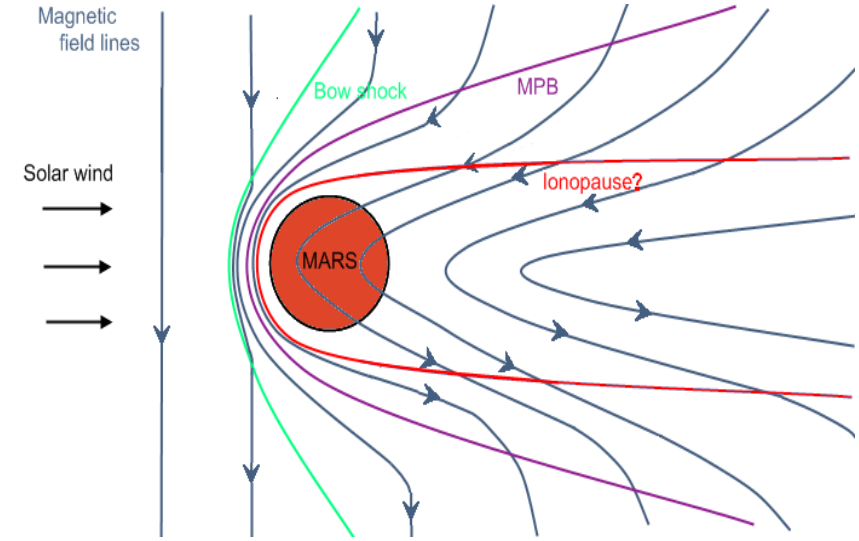


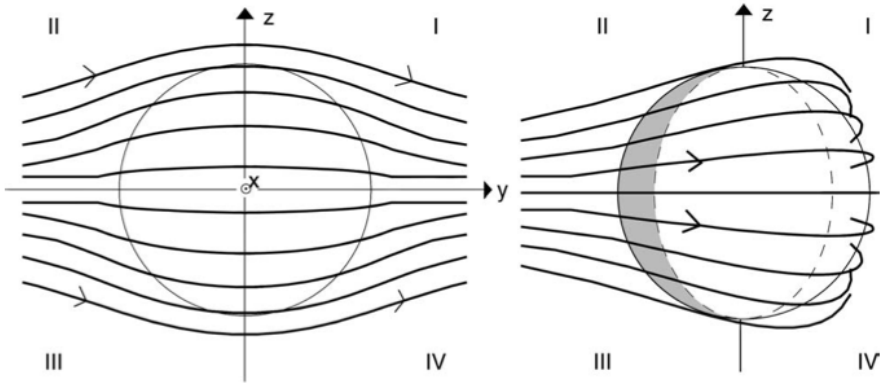




Why it drapes ?

- As magnetic field lines cannot pass through electrically conductive objects (such as Mars), they drape themselves around the planet.

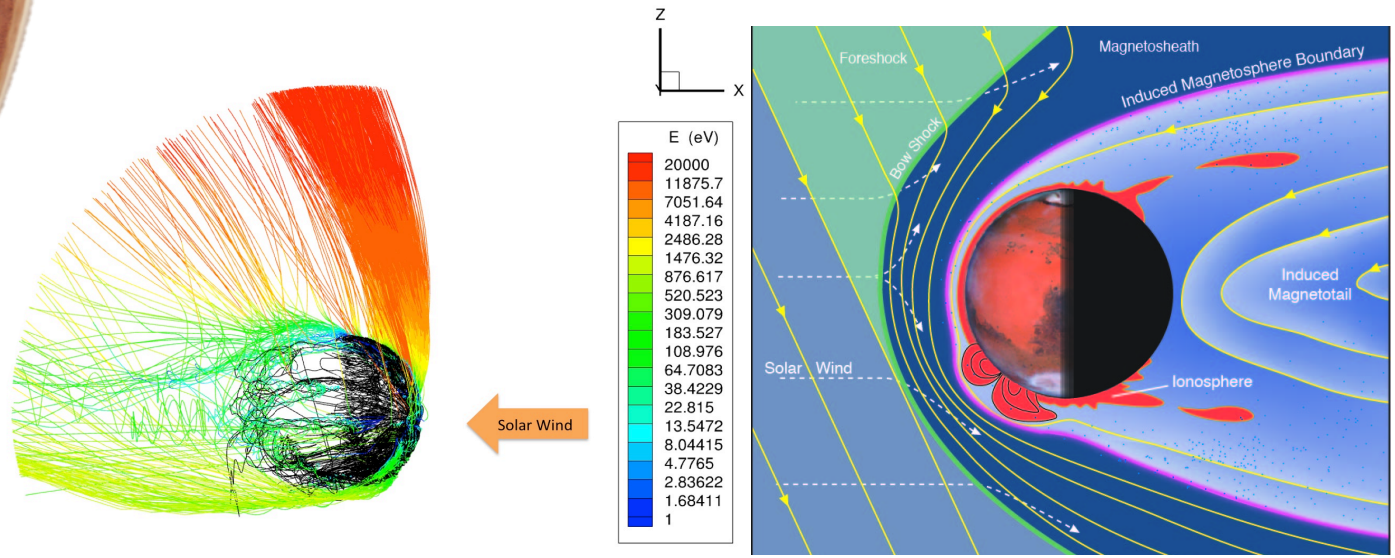


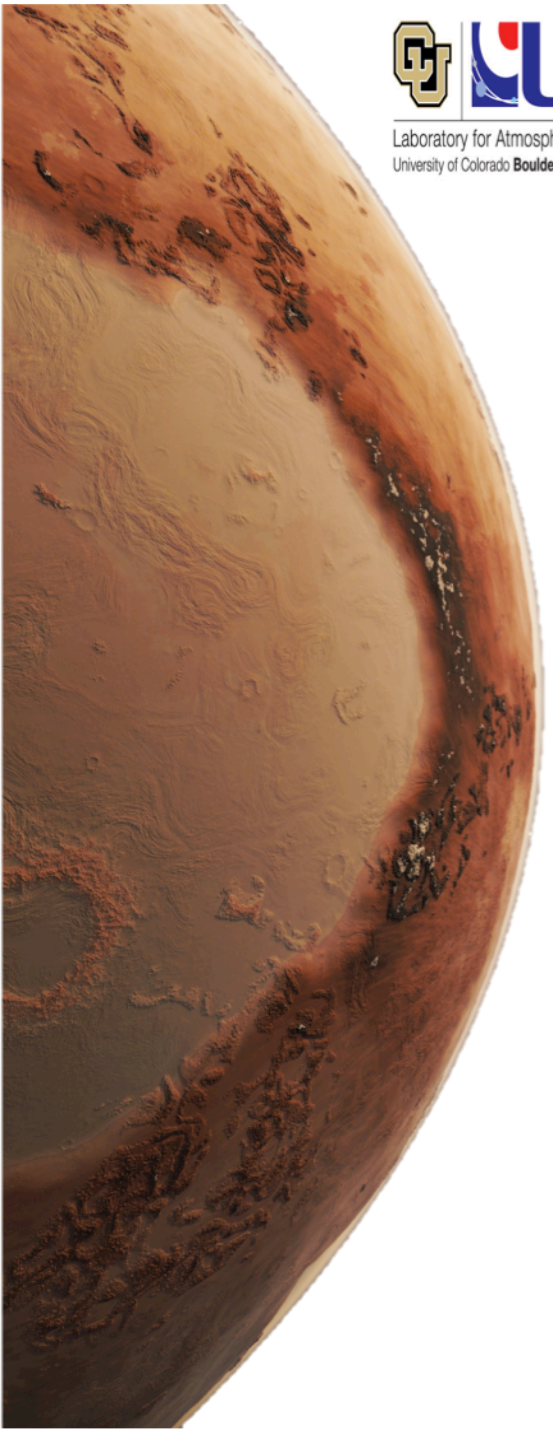


Why its important?

- Since the spacecraft are not always out in the undisturbed interplanetary magnetic field (IMF), we use the draping of the magnetic field direction as an indication to tell us about the direction of the IMF.

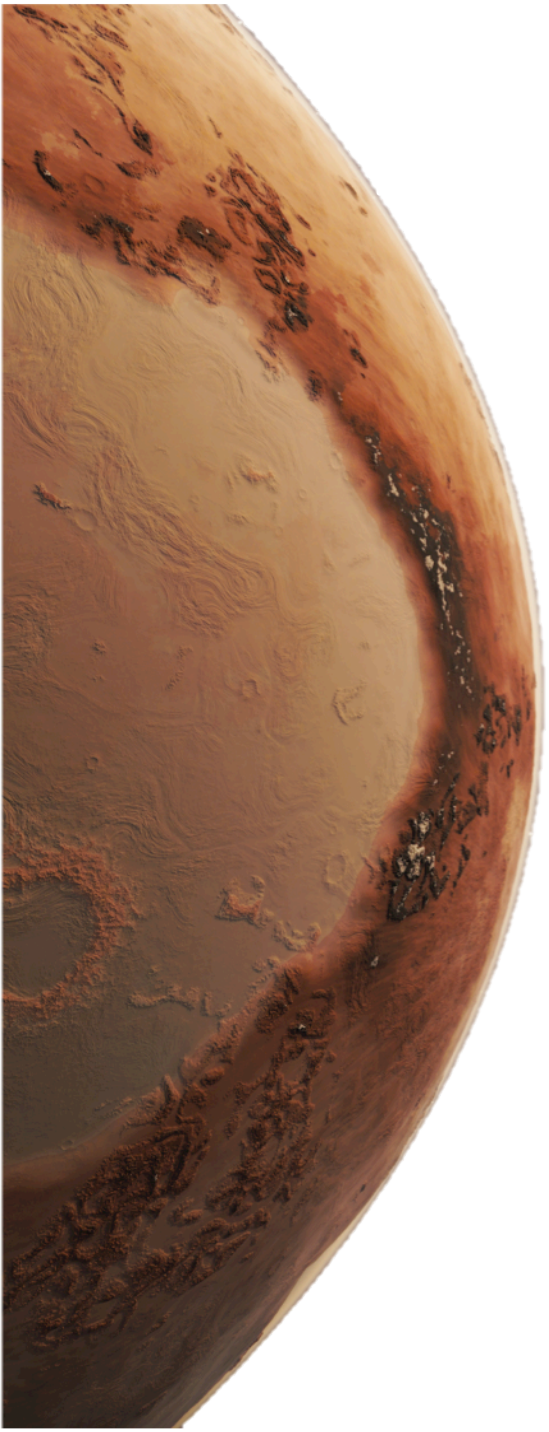
- The draping direction of the magnetic field can tell us about the direction in which planetary charged particles move or escape .





The project ?

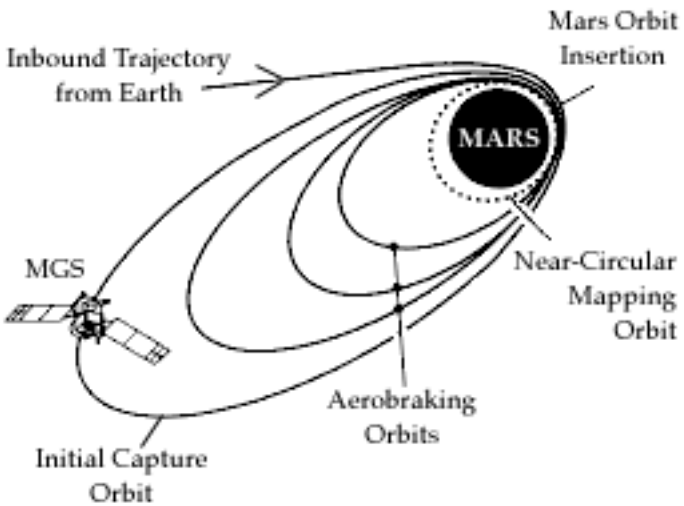
- Compute the draping direction of the magnetic field at mars, and use it as an indication to tell us about the direction of the interplanetary magnetic field (IMF).

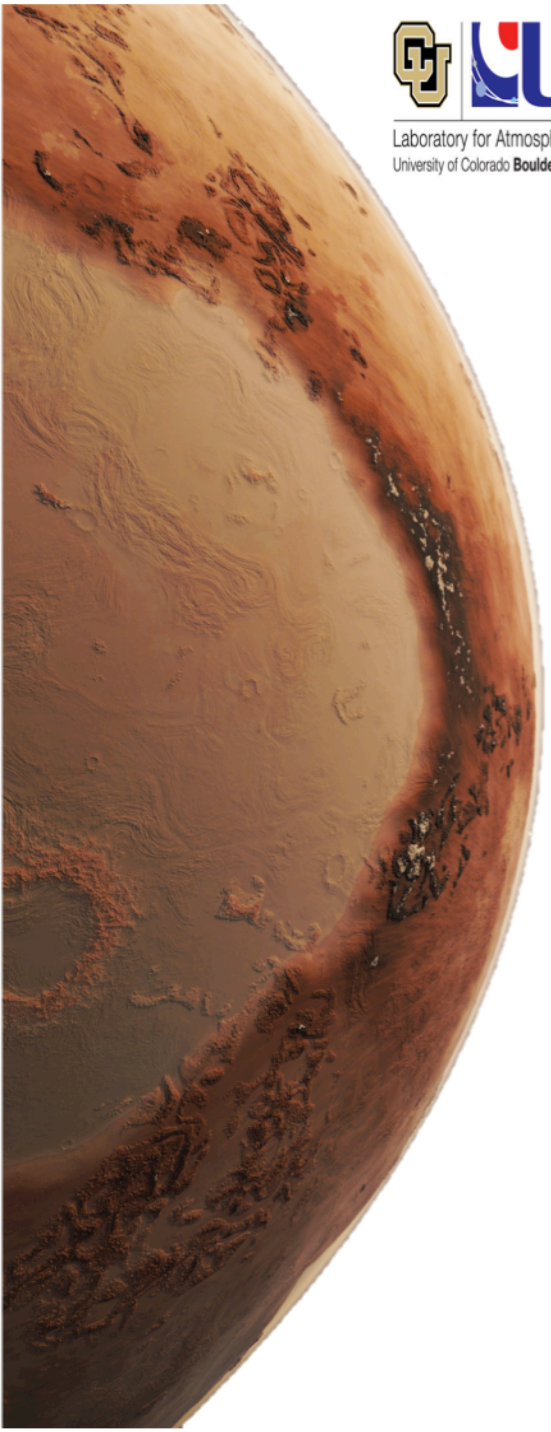


2. MGS Spacecraft analysis

MGS orbit

- Data from the magnetometer and electron reflectometer instruments (MAG/ER) on the Mars Global Surveyor spacecraft (MGS)
- The spacecraft was in a nearly circular orbit.





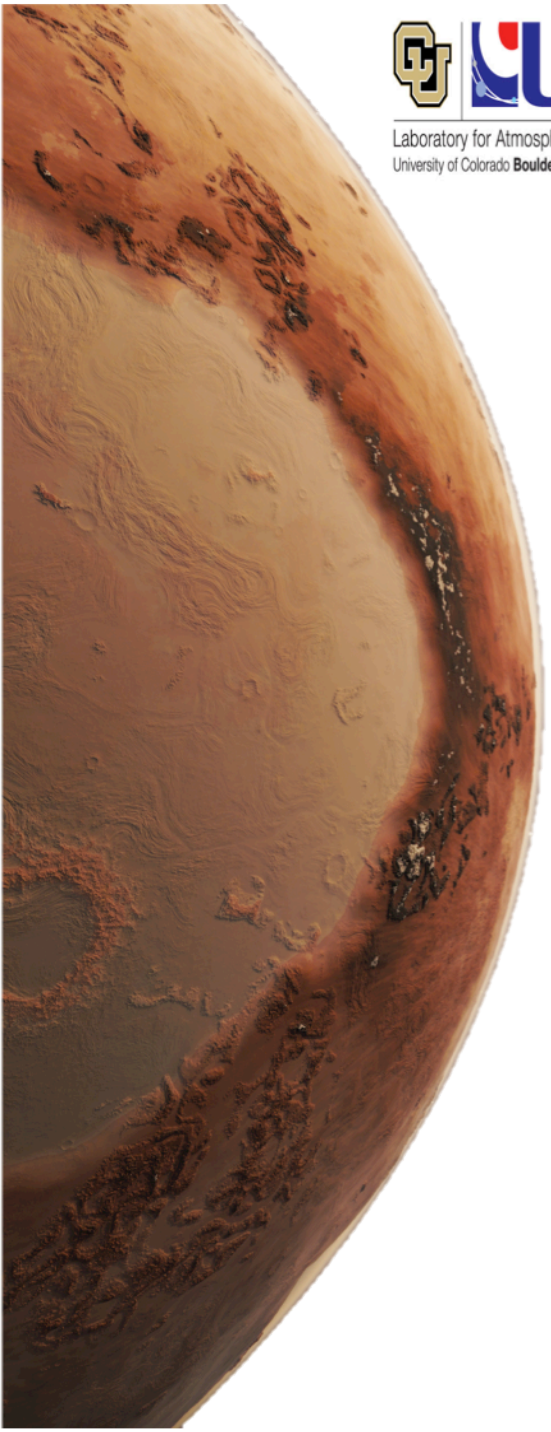
Approach

Once per orbit, look at the horizontal field and find out which way it points (Azimuth Angle) .

- Cartesian representations are used for the MAG data B_x, B_y, B_z
- For the horizontal field component, spherical coordinates computed B_N , B_E , B_R
- Azimuth angle

$$B_H = \sqrt{B_E^2 + B_N^2}$$

$$\theta = \tan^{-1}\left(\frac{B_N}{B_E}\right)$$



Flow of Analysis

- 1) Pick a location
  - 50°-60°N latitude, dayside
  - 50°-60°N solar latitude
- 2) Compute the draping direction
  - Geographic coordinates (PC)
  - Solar coordinate (SS)

(1) Geographic latitude, PC coordinate system(done!)

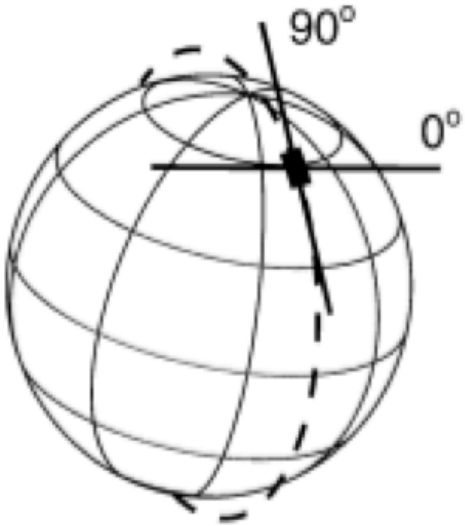
(2) Geographic latitude, SS coordinate system.

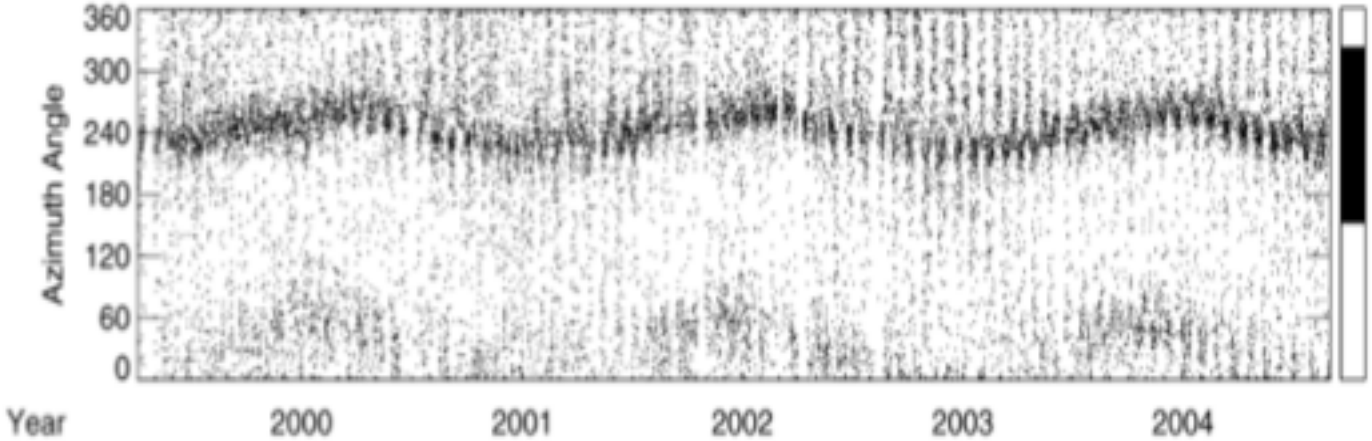
(3) Solar latitude, PC coordinate system.

(4) Solar latitude, SS coordinate system.

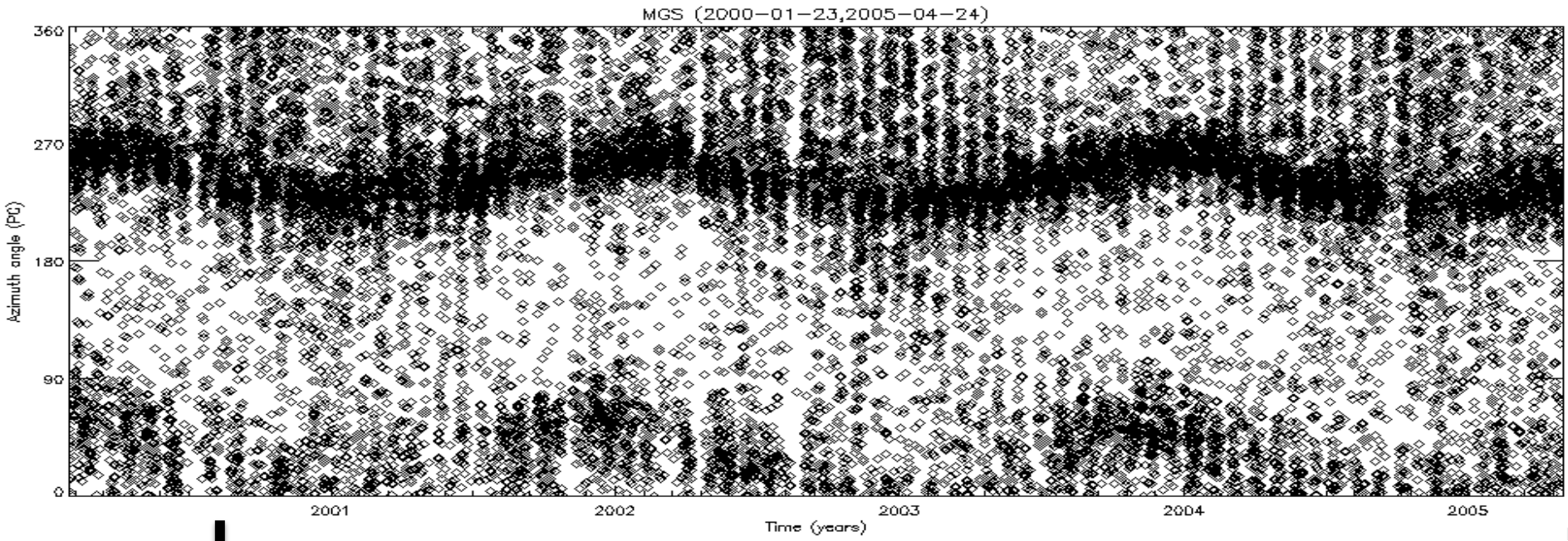
PC coordinate system

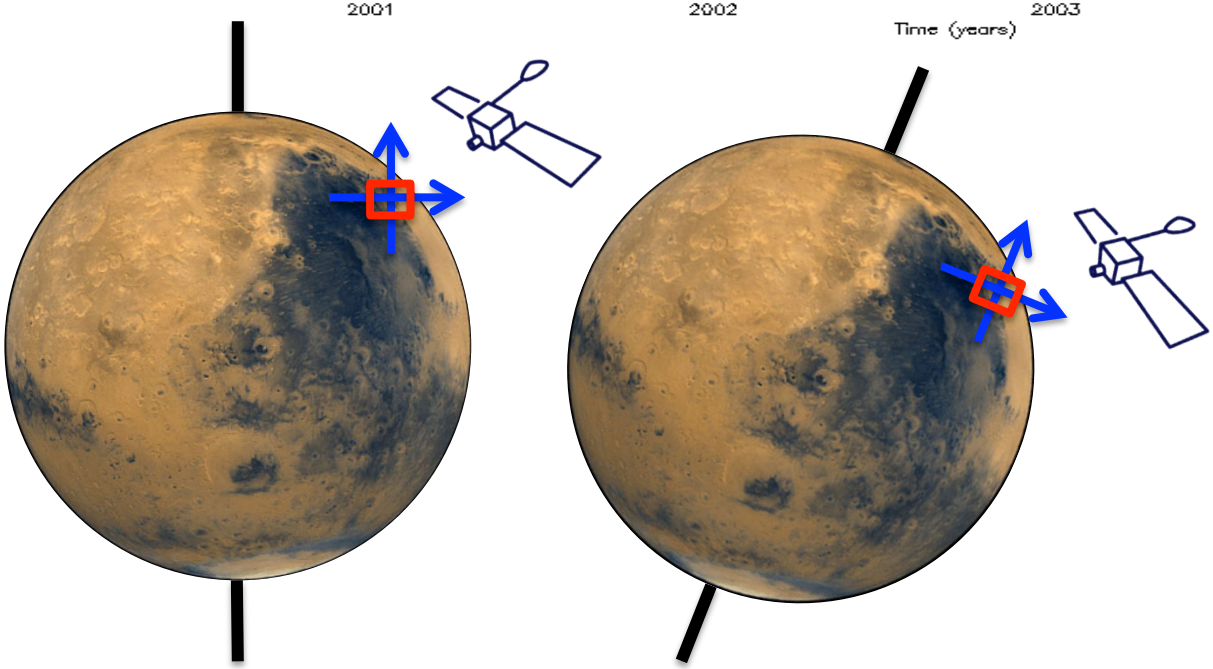
- Planetocentric (PC)
- Tied to the planet
- X axis is 0 °& points to Ea
- Y axis is 90°& points to no





Geographic latitude, PC coordinate system

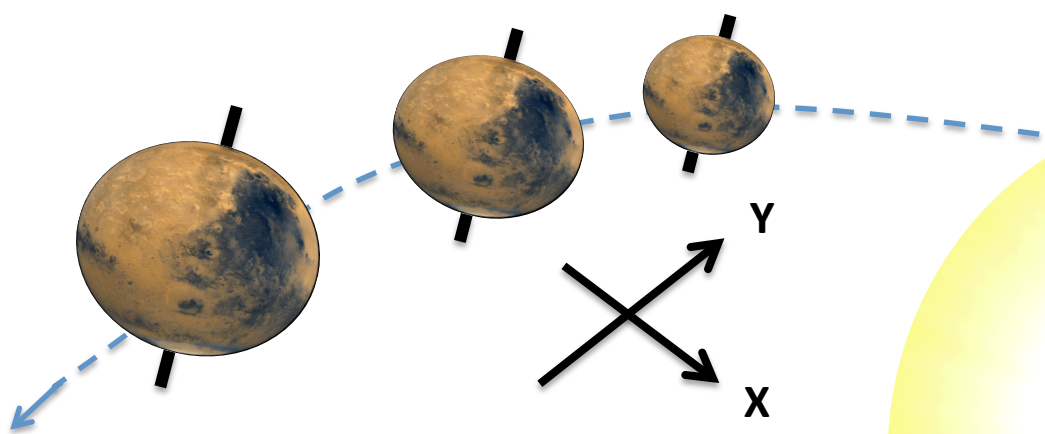




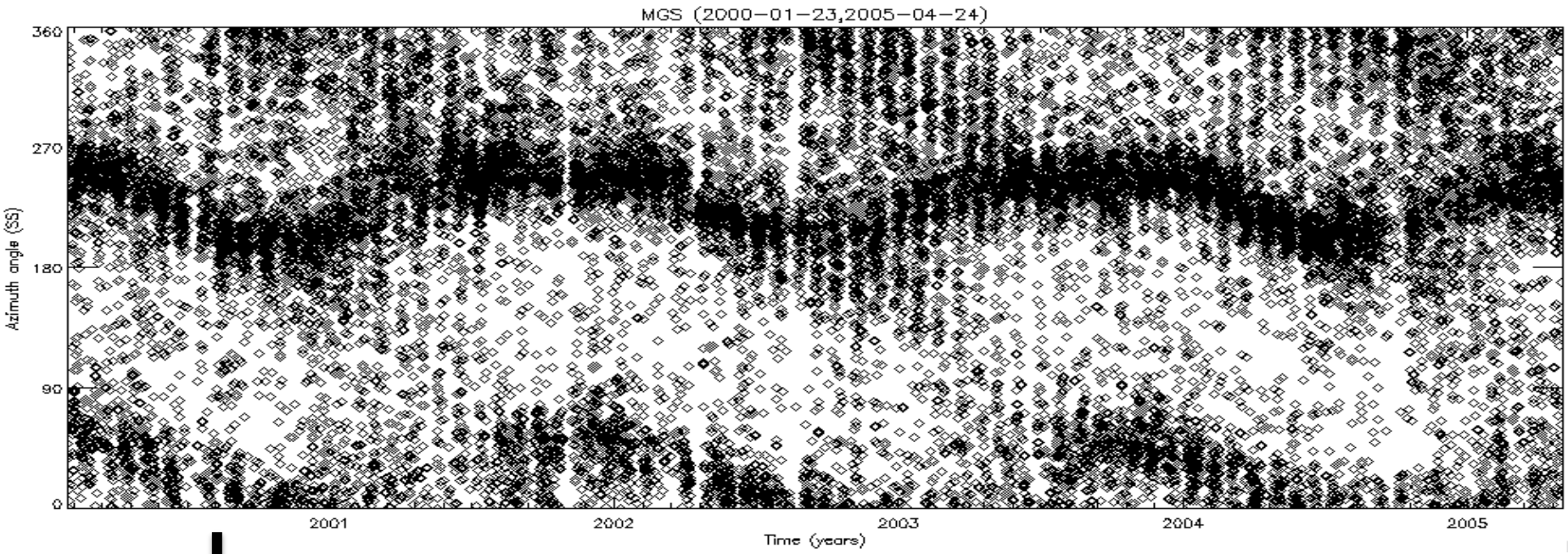
- The planetocentric coordinate system rotates with the planet as Mars rotate with respect to the sun.

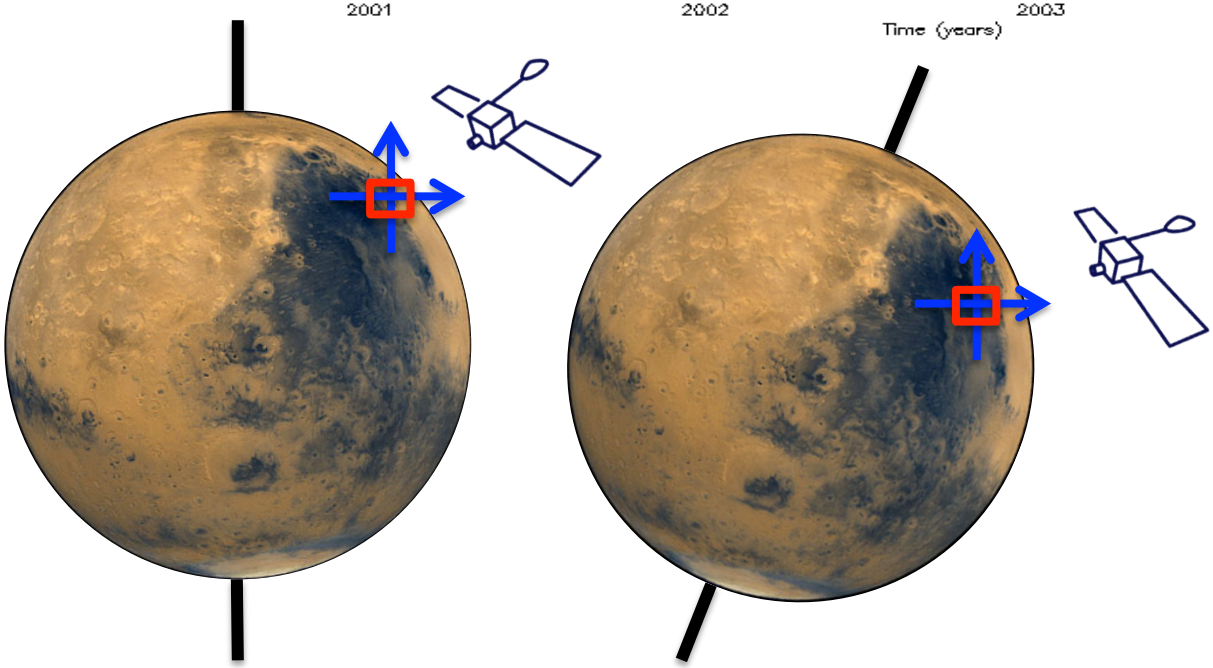
SS coordinate system

- Sun-State (SS) (same as MSO Mars-Sun-Orbit)
- Tied to the Sun
- X-axis positive toward the sun
- Y-axis points opposite to Mars' orbital angular velocity



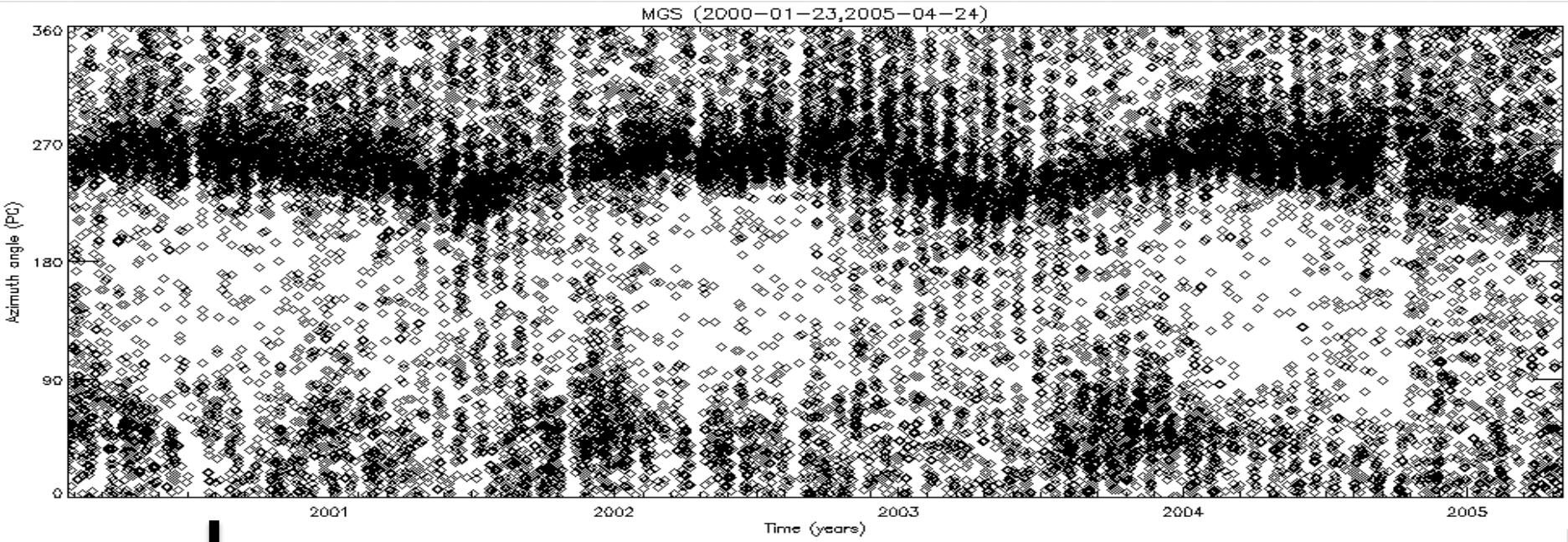
Geographic latitude, SS coordinate system

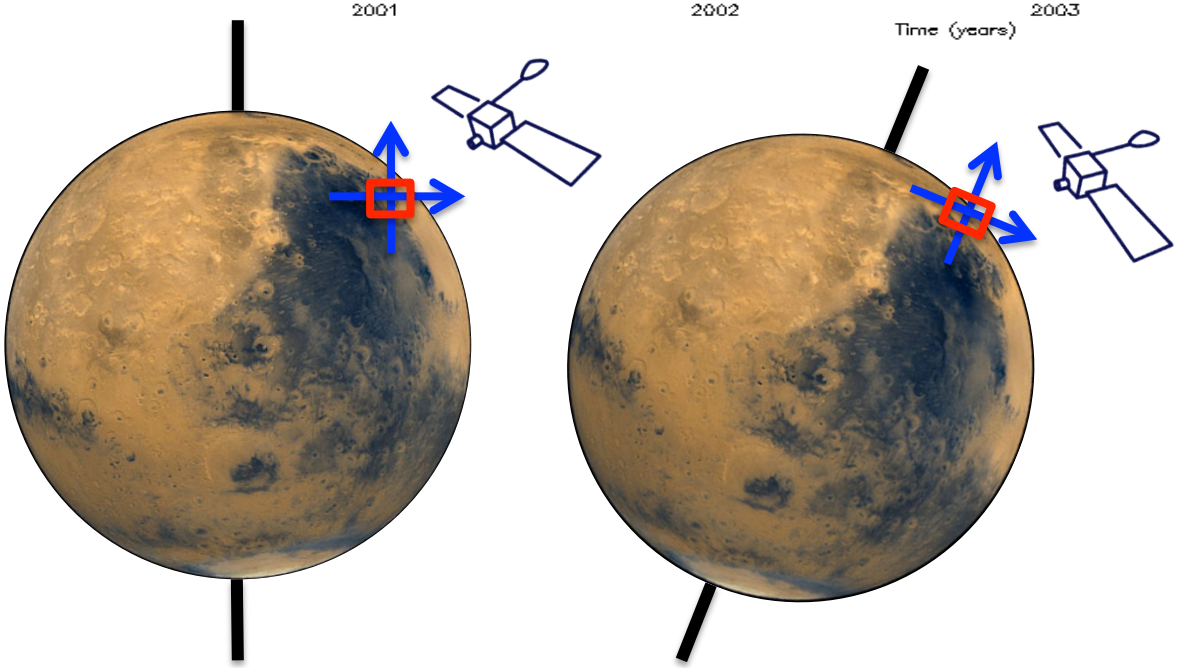




- Coordinate system didn't rotate, but Mars still 'wobbling' and with the geographic latitude, the region moved.

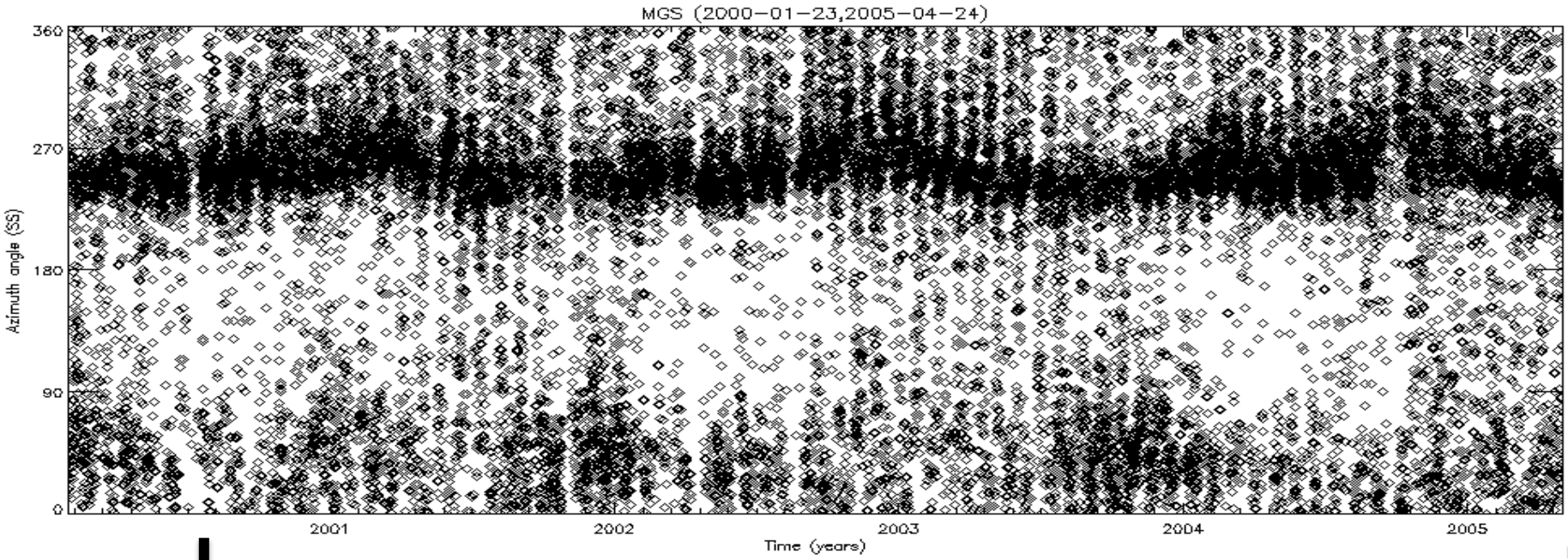
Solar latitude, PC coordinate system

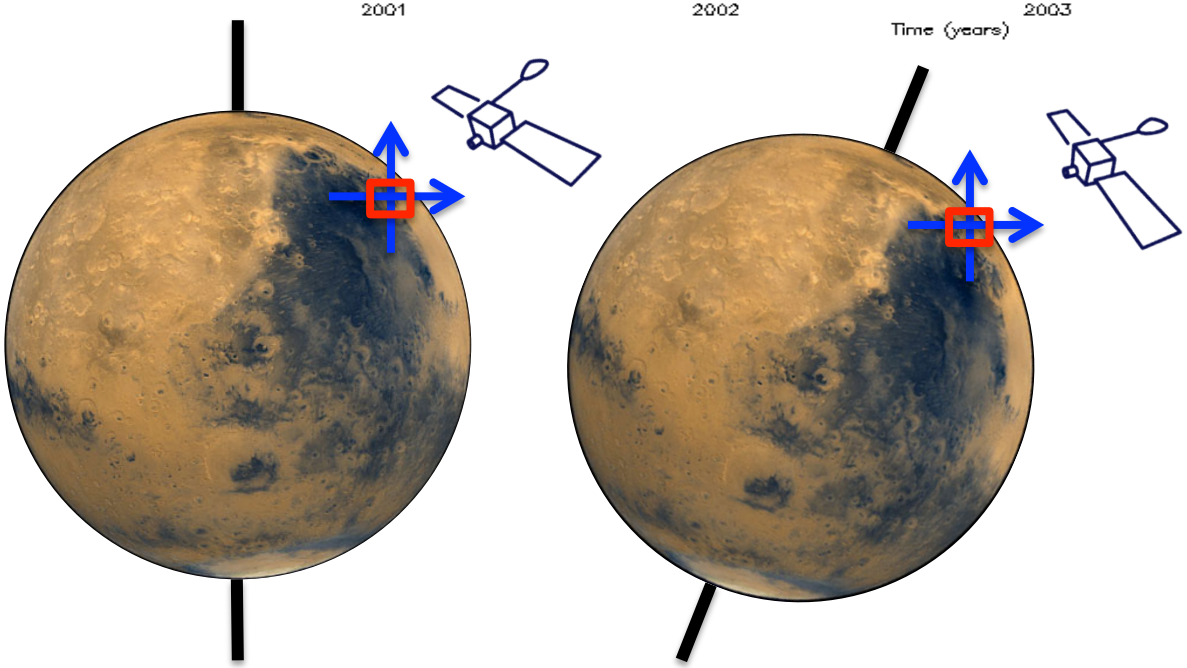




- The coordinate system still rotating with Mars wobbling, but with solar latitude, the region is more fixed.

Solar latitude, SS coordinate system

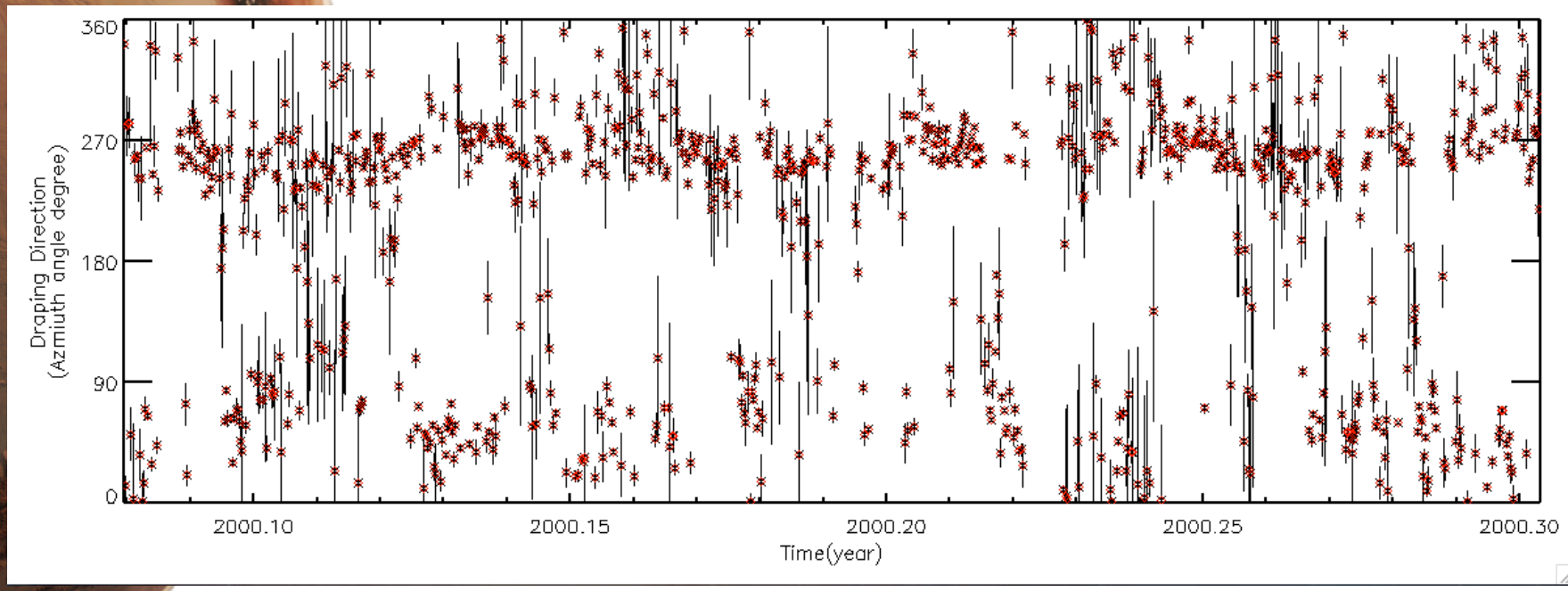




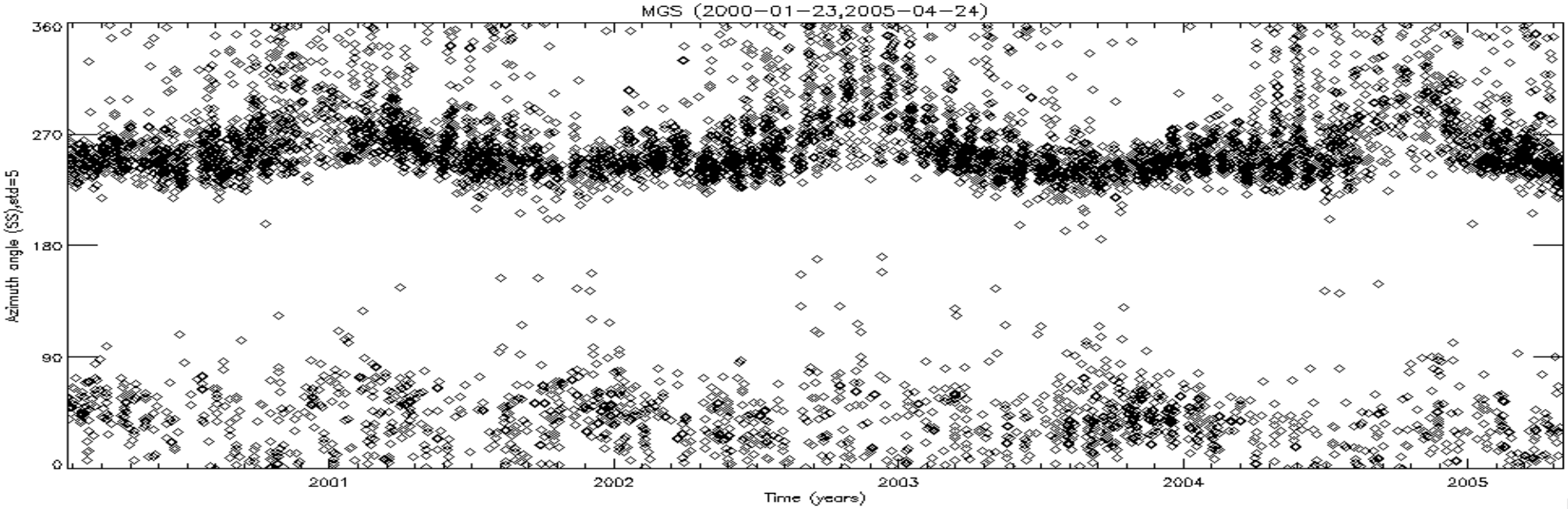
- Yay! Fixed coordinate system, fixed region.. Why the 'bouncing' then ?

Error bars

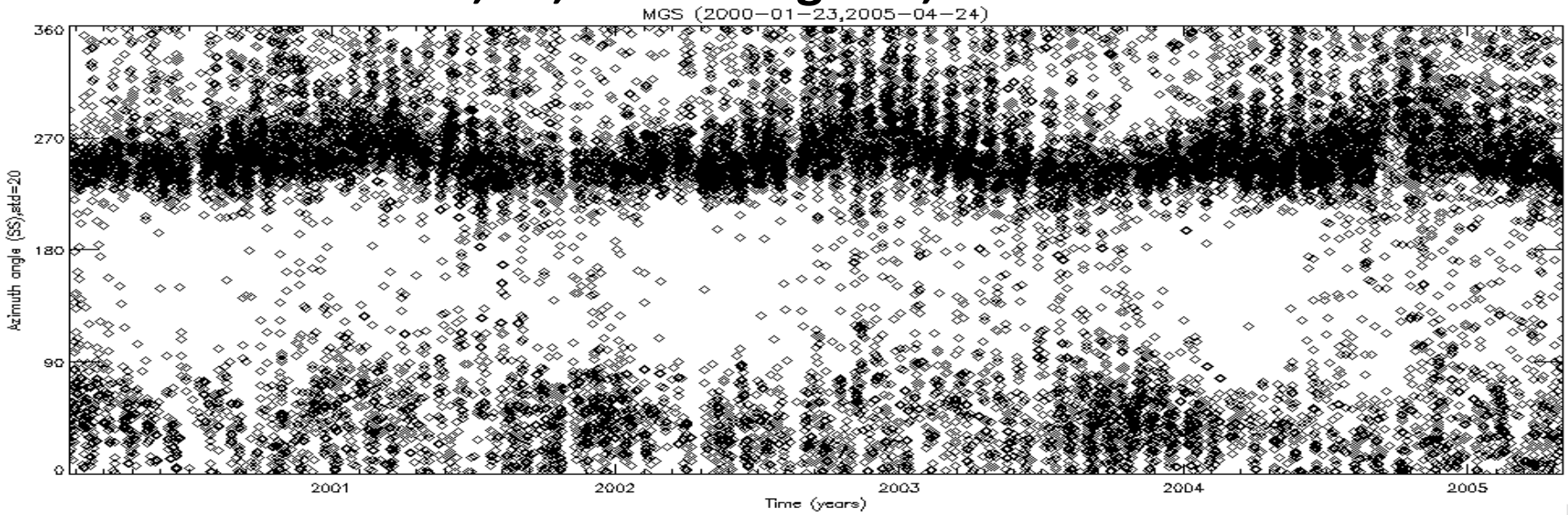
- show which orbits provide reliable estimates

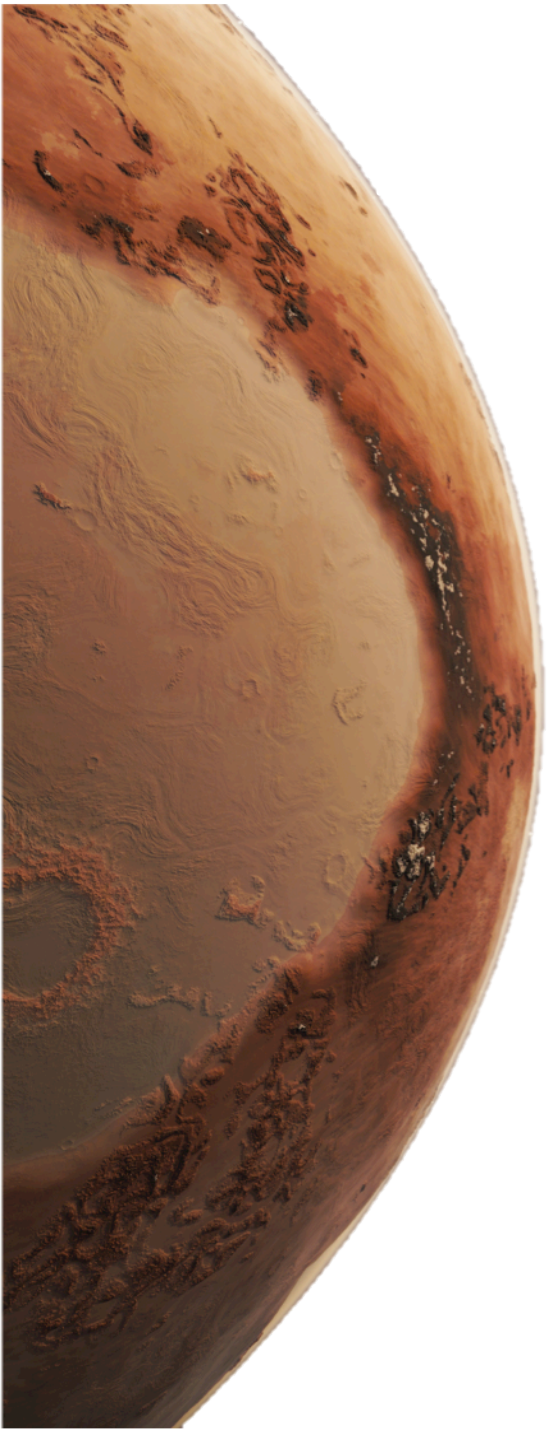


Solar latitude, SS, σ =5 degrees, data thrown = 71%



Solar latitude, SS, σ = 20 degrees, data thrown =26%

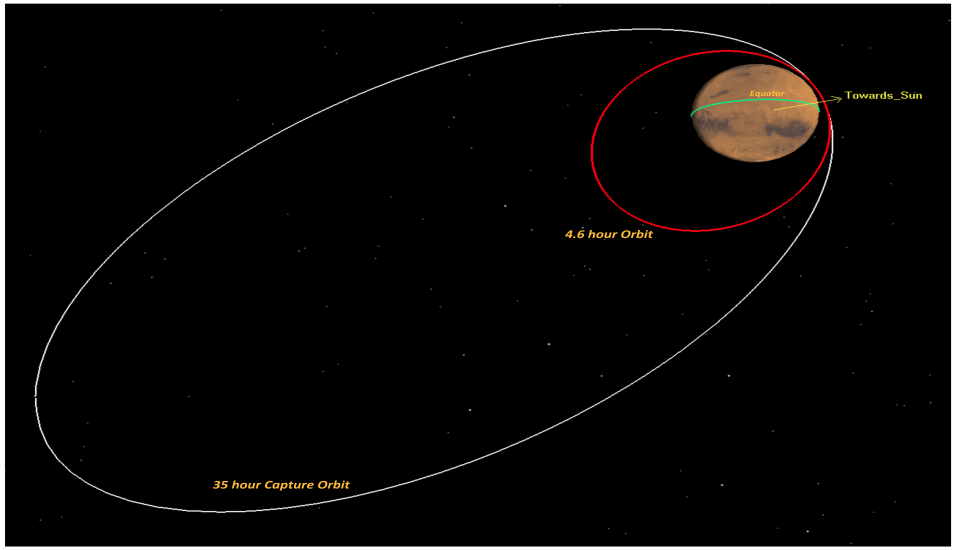




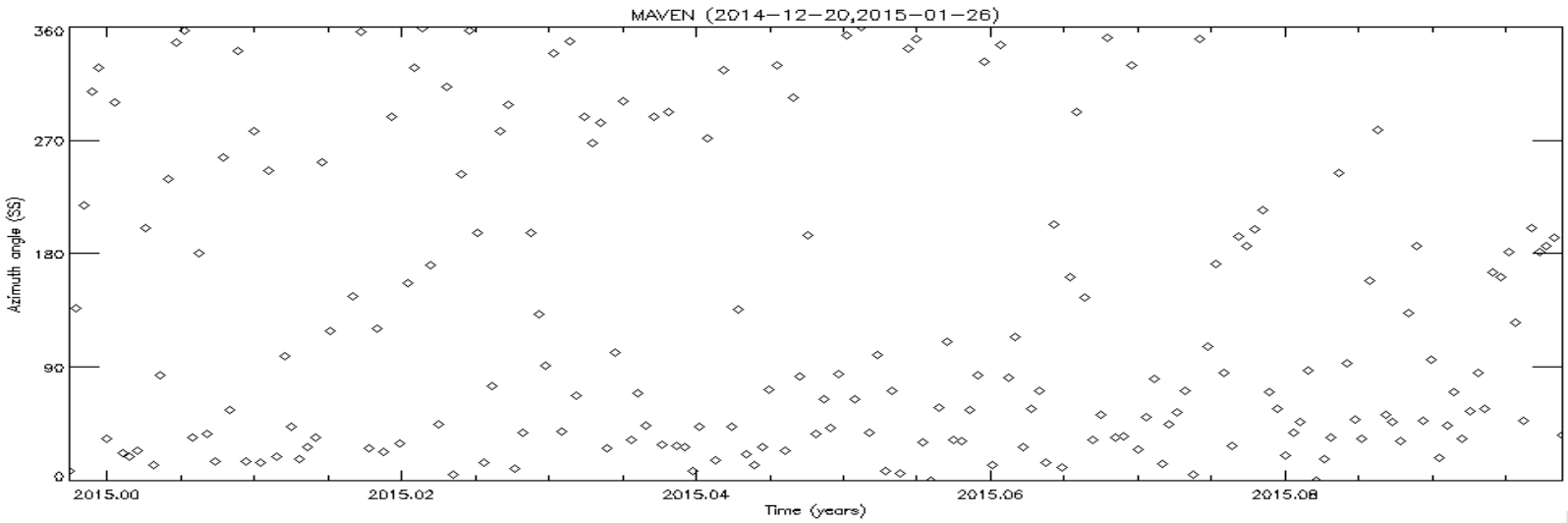
3. MAVEN spacecraft analysis

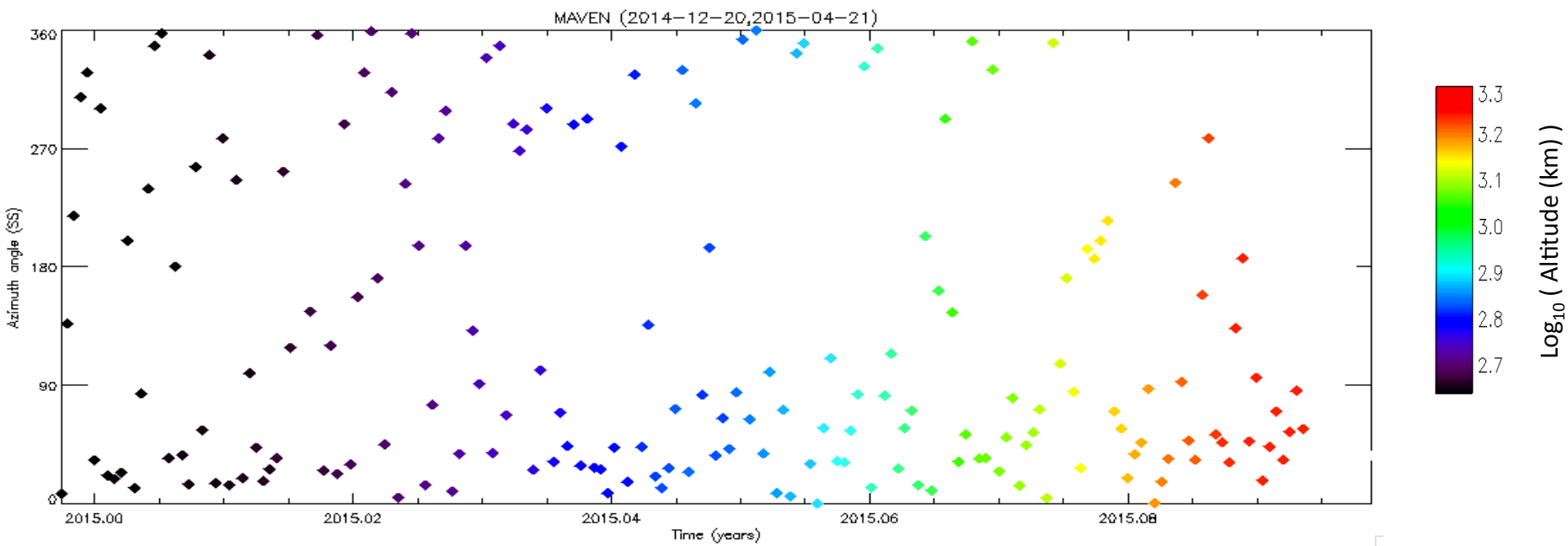
MAVEN orbit

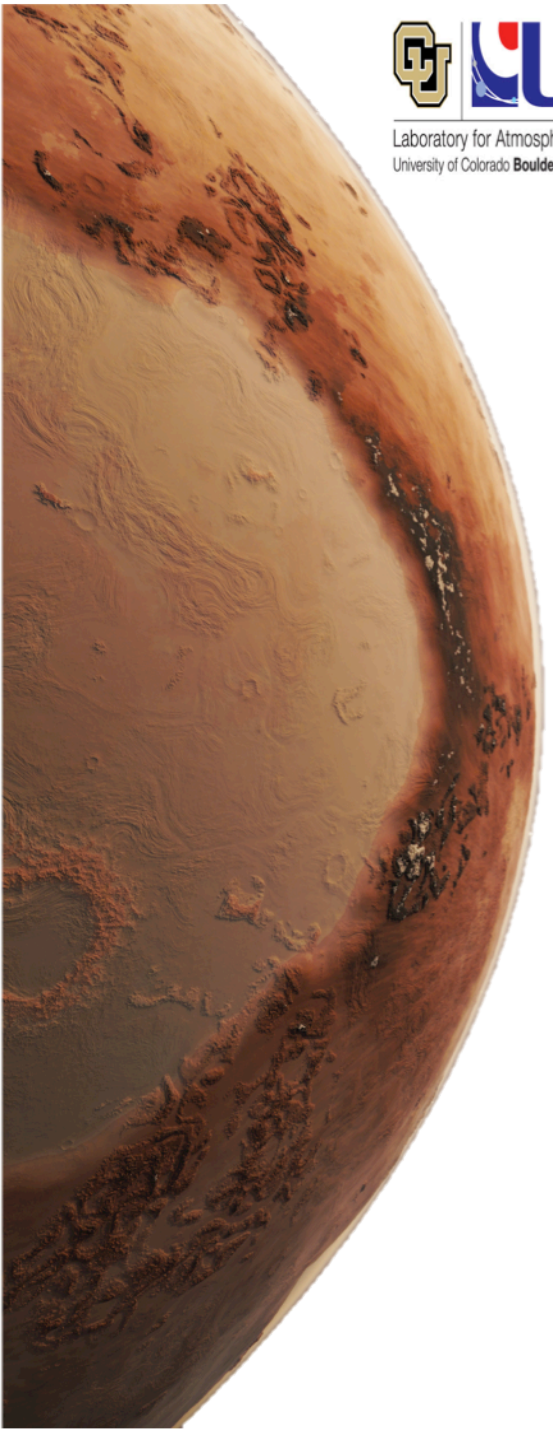
- Using data from the Magnetometer (MAG) on the Mars Atmosphere and Volatile EvolutioN spacecraft (MAVEN)
- Location of 50°-60°N solar latitude
- Solar coordinate (SS)



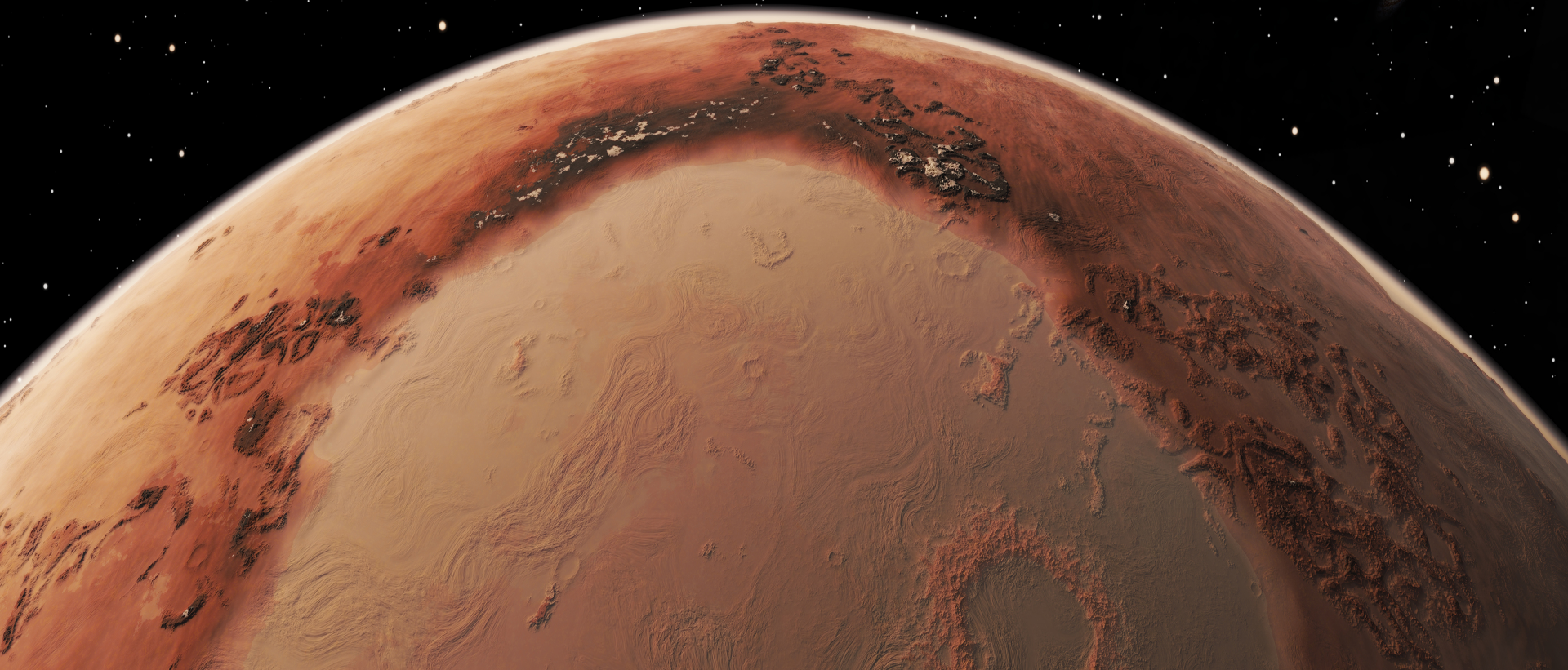
Draping direction







Conclusion

- Using a coordinate system tied to the Sun gives the best indication about the IMF direction.
- The error bars in draping direction for each orbit show which orbits provide reliable estimates.
- The draping direction changes with different altitude and different local time.

Thanks for listening
Any questions ?