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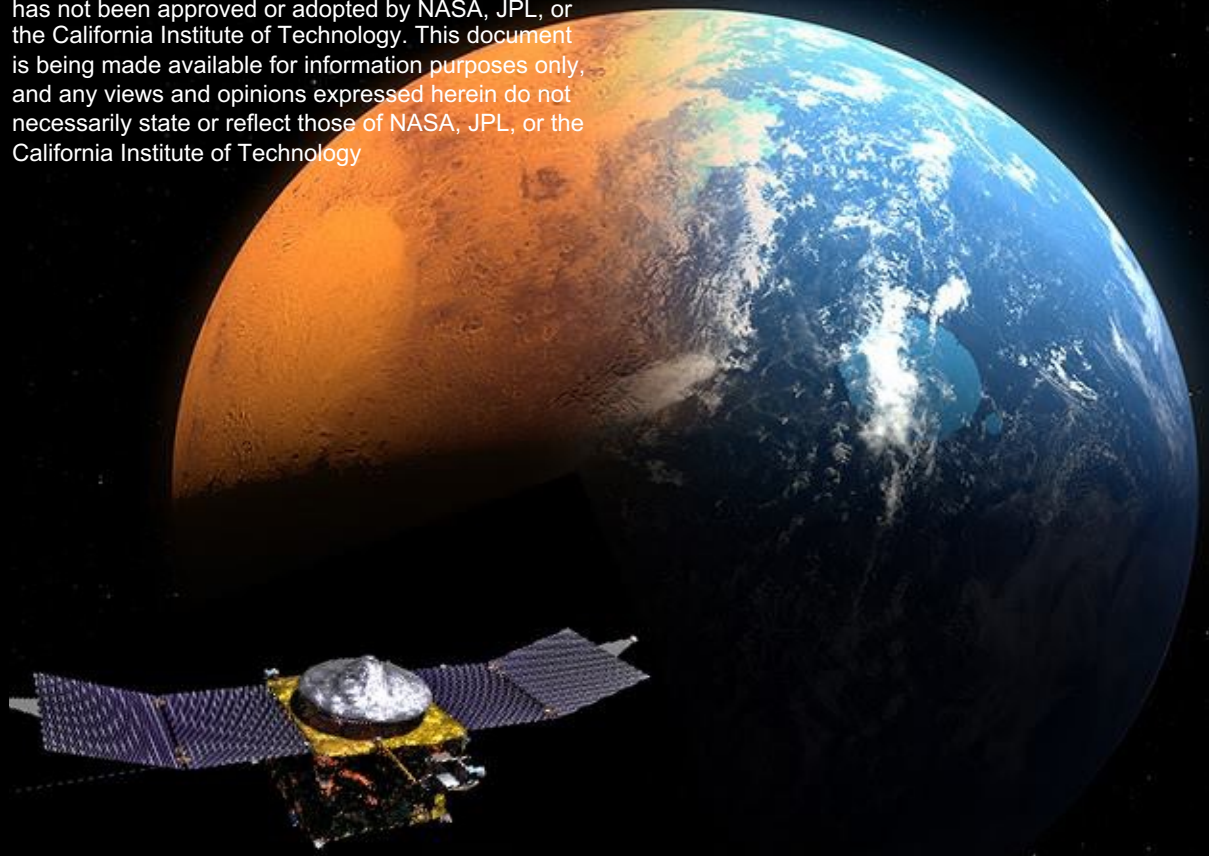


Mars Atmosphere and Volatile Evolution Mission (MAVEN) status

MEPAG VM14
February 2nd, 2022

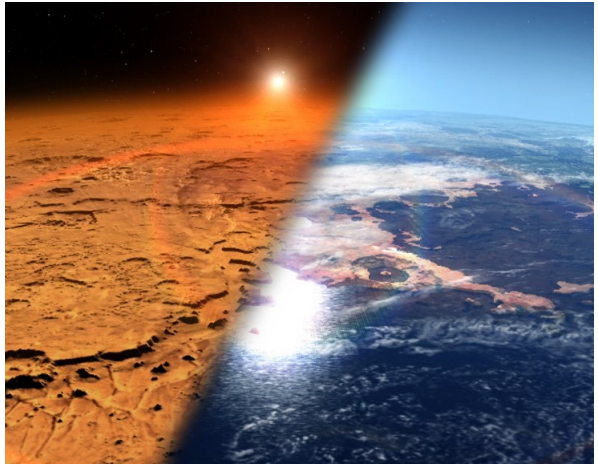
PI Overview
Dr. Shannon Curry

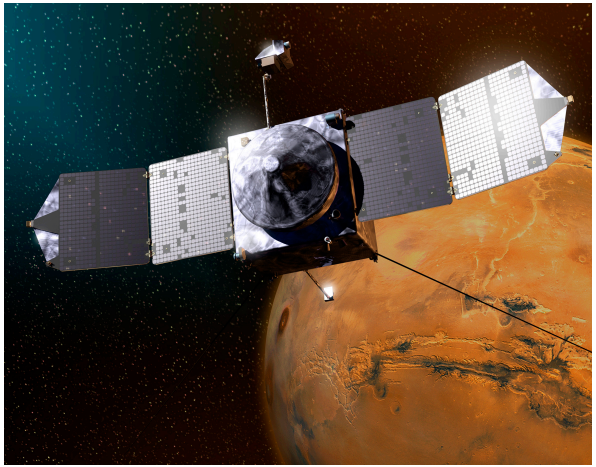
MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

What is MAVEN doing?

- *For water to be in stable liquid form on Mars' surface, a much higher atmospheric pressure would be required. MAVEN's primary goal is to understand atmospheric escape and evolution.*

- Currently, MAVEN is the best observer of atmospheric escape anywhere in the solar system
  - We have better understanding of atmospheric escape at Mars than at any other planet, **including Earth**
  - Consequently, Mars serves as a natural laboratory for understanding rocky planet atmospheres

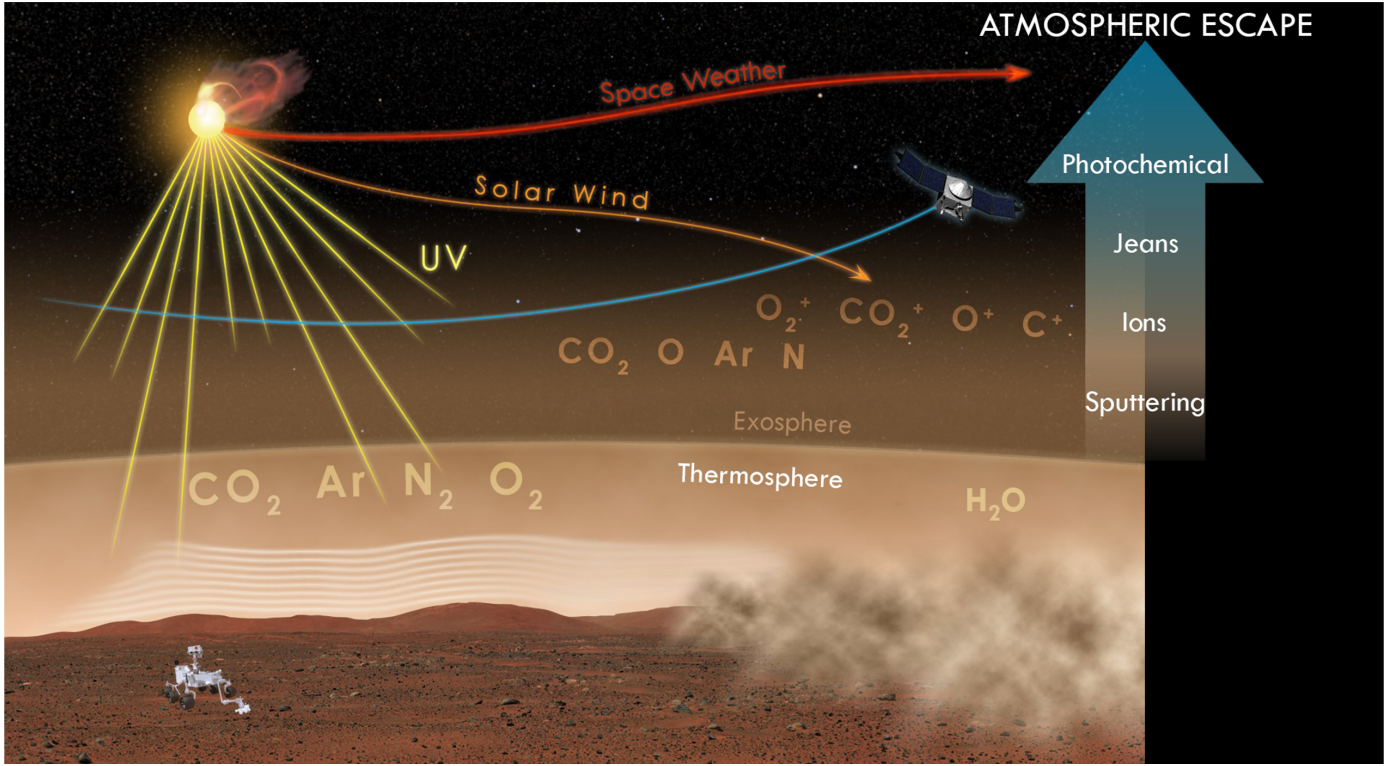




MAVEN observes drivers from above and below

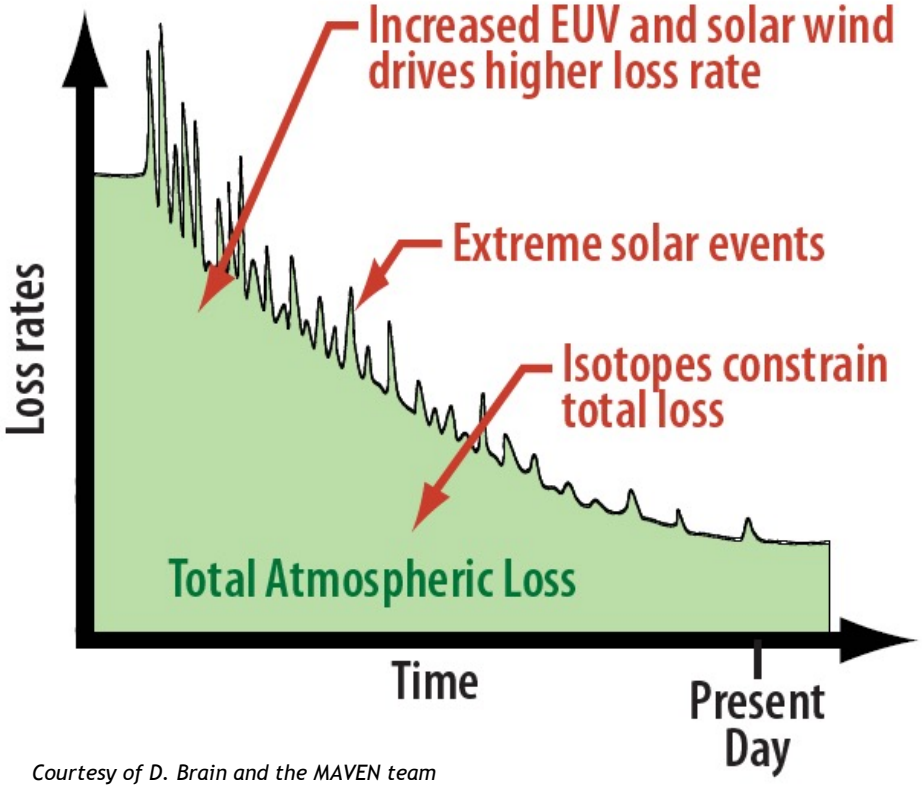
Drivers from below:
- Waves and tides
- Dust heating

Drivers from above:
- Solar radiation (UV)
- Solar Energetic Particle (SEP) radiation
- Solar wind
- IMF
- Extreme space weather / solar activity



Courtesy of S. Curry and the MAVEN team

So how much atmosphere has been lost at Mars?



Courtesy of D. Brain and the MAVEN team

An *extrapolation* back in time with current escape rates, scaled to extreme rates during a more active sun, suggests that our total escape rate would be responsible for the loss of a significant amount of water and / or atmosphere.

Assumptions:

- Increase in EUV and solar wind
- Increase in solar events (CMEs, CIRs)
- Early atmospheres are based on GCM models with increased EUV
- Post-bombardment
- Post-hydrodynamic

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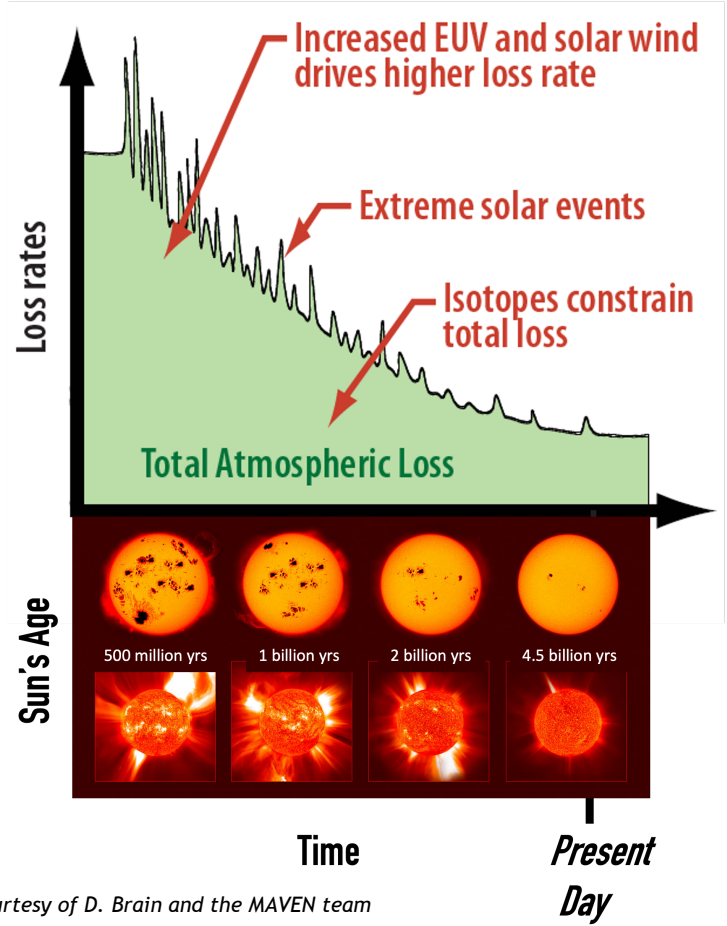

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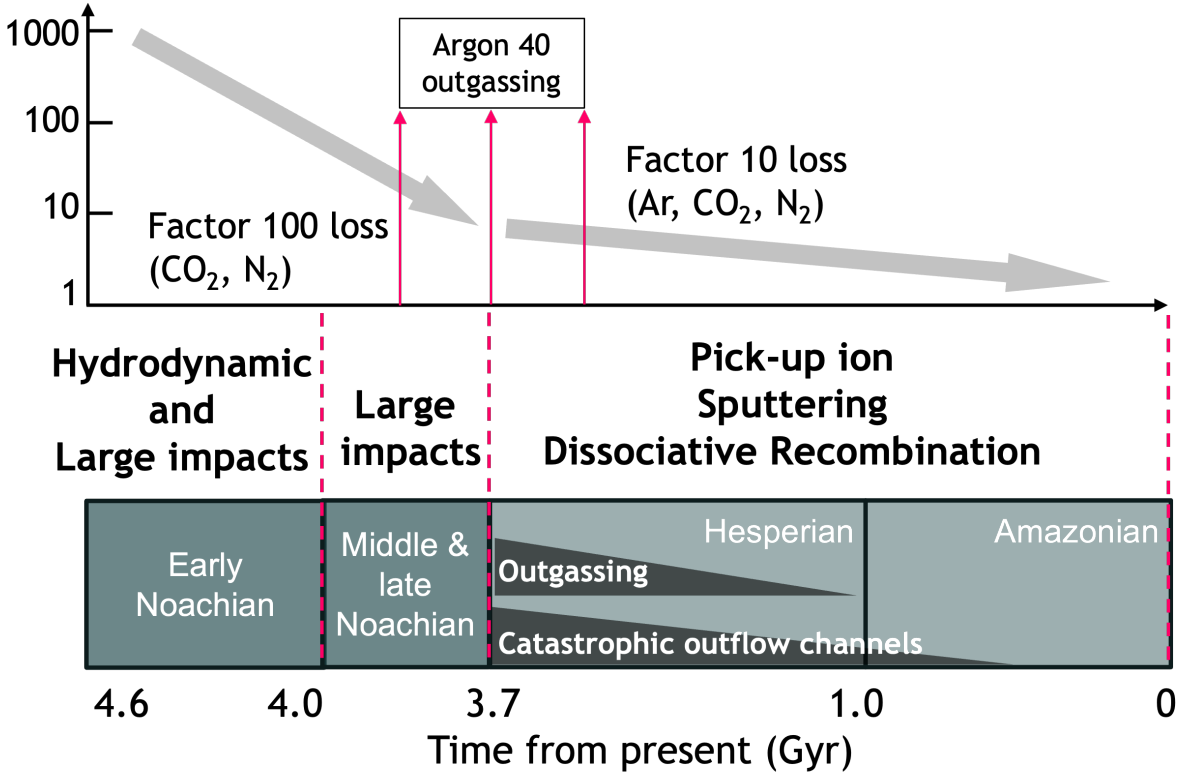


Using MAVEN measurements and extrapolating back in time, Mars has lost

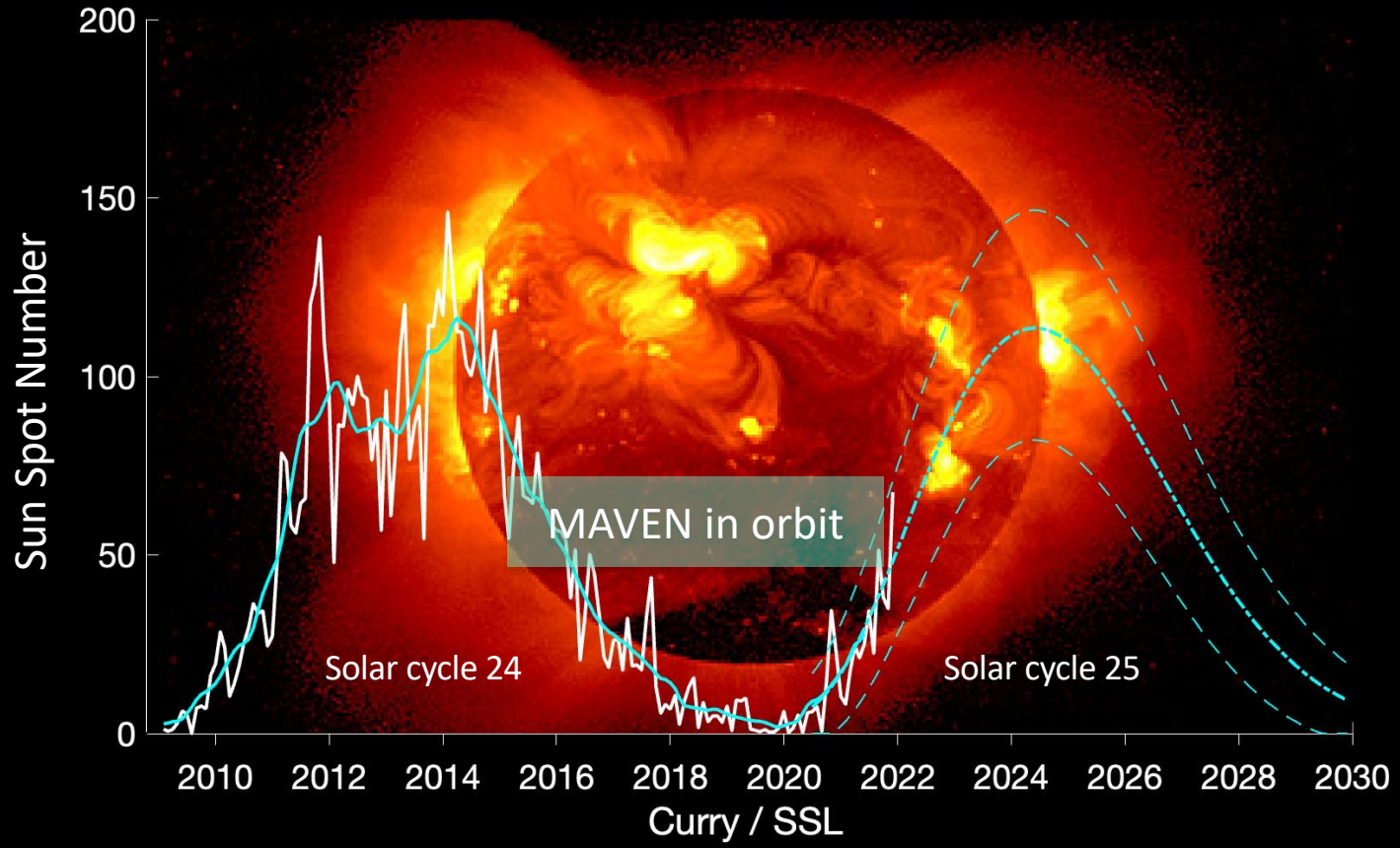
- **800 mbar of atmosphere**

  OR

- **23 meters of water**

Jakosky et al. [2018]
Chassefiere et al [2007]

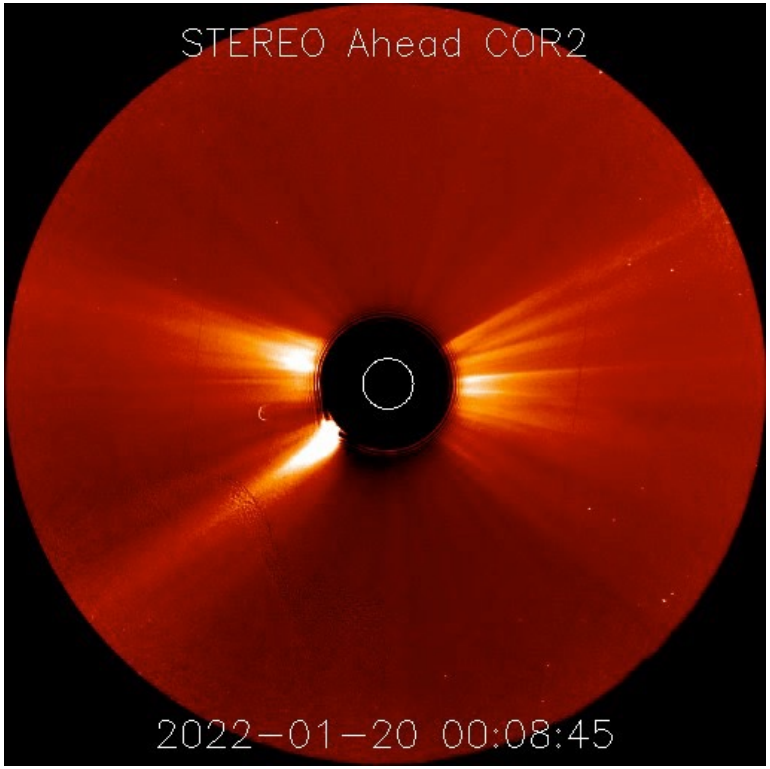
Solar cycle

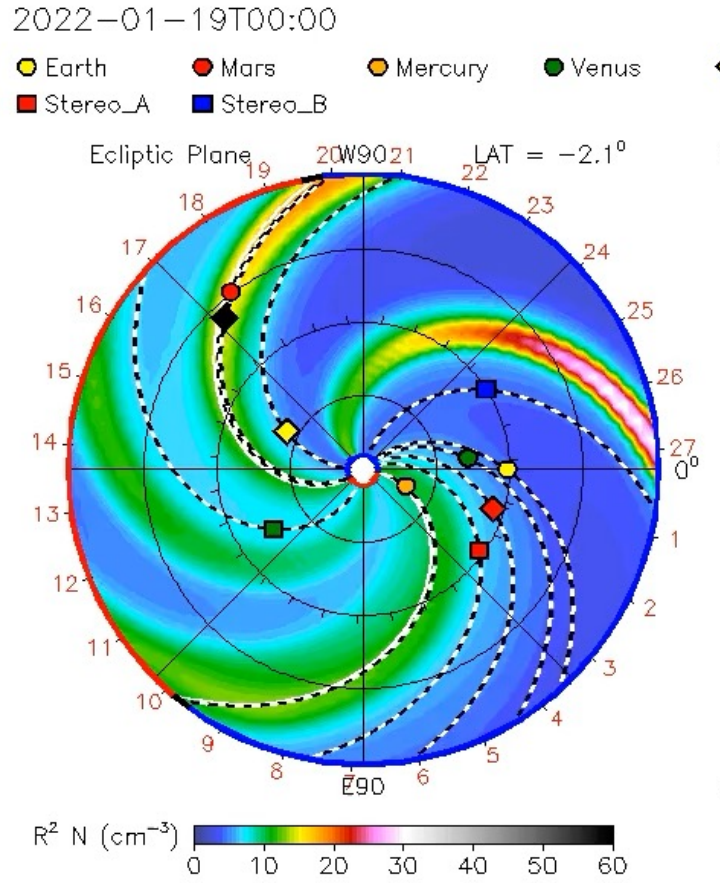


MAVEN is the only asset at Mars that can comprehensively observe the Sun

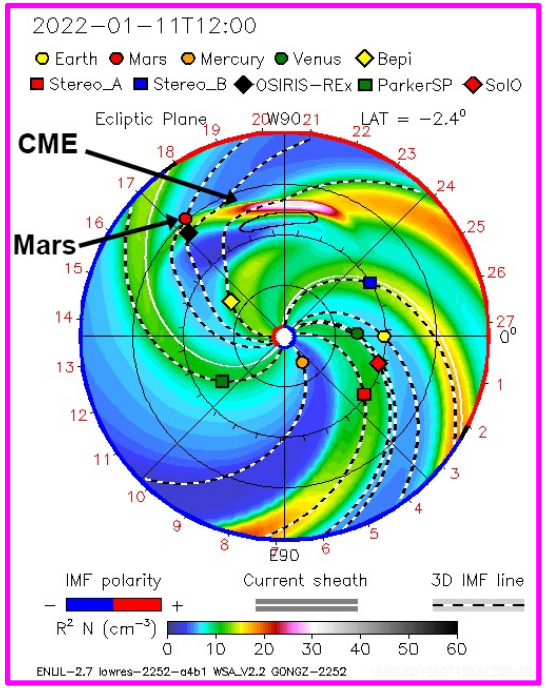
- The more sunspots, the more space weather events
- Scientifically, solar storms drive huge atmosphere escape
- Technically, solar storms can have serious implications for S/C and instrument health (e.g. degradation of solar arrays , Single Event Upsets, etc…)

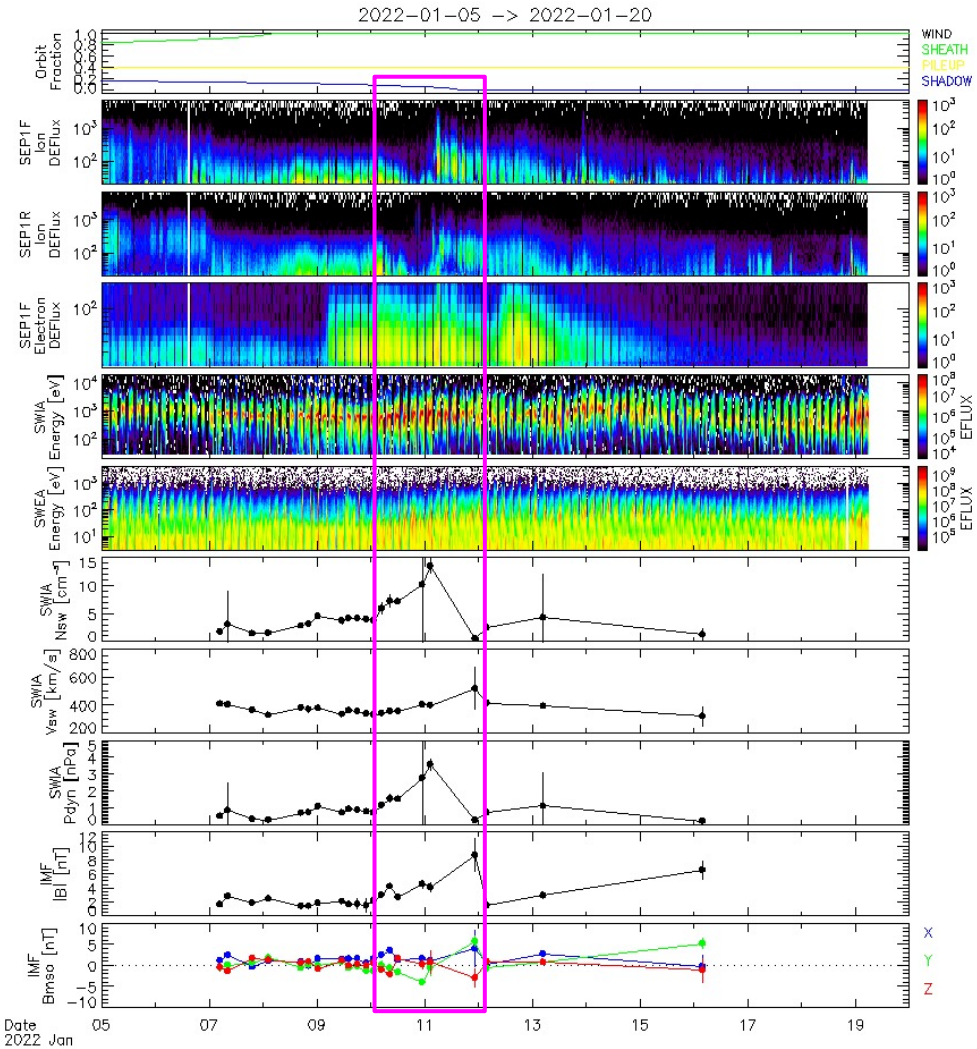
Space Weather





SEPs are likely associated with recent CME events that were predicted to impact Mars

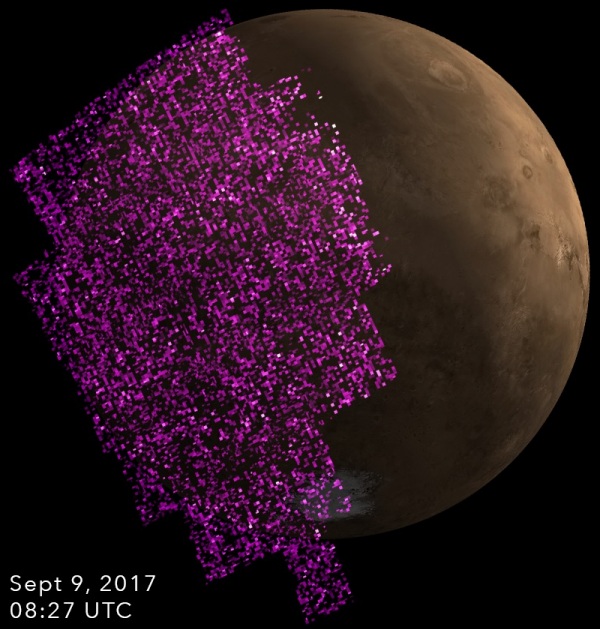




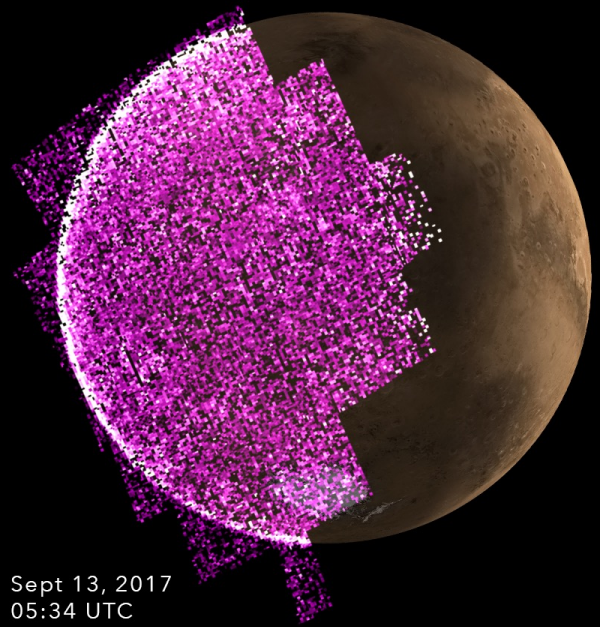
Courtesy of C. Lee and the MAVEN team

Solar Event of 10 Sept 2017: Solar Energetic Particles Produced Global Aurora

Before:



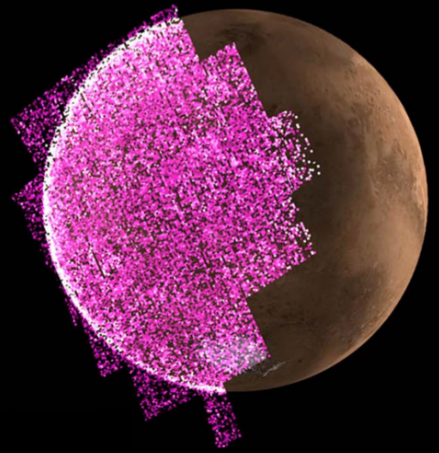
During:



(From Schneider et al., 2018)

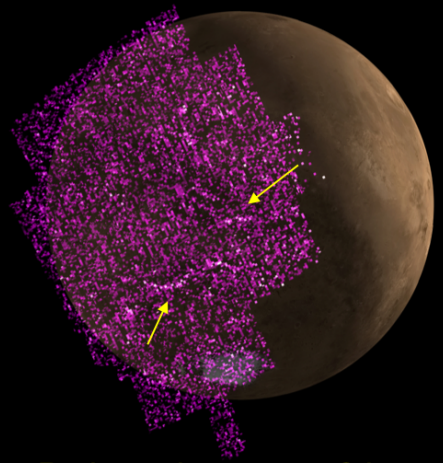
Space weather and Martian aurora

Diffuse Aurora



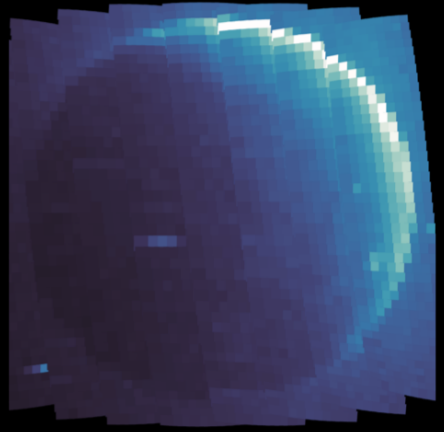
During strong space weather events, global aurora can engulf the planet, as in this image from September 2017

Discrete Aurora



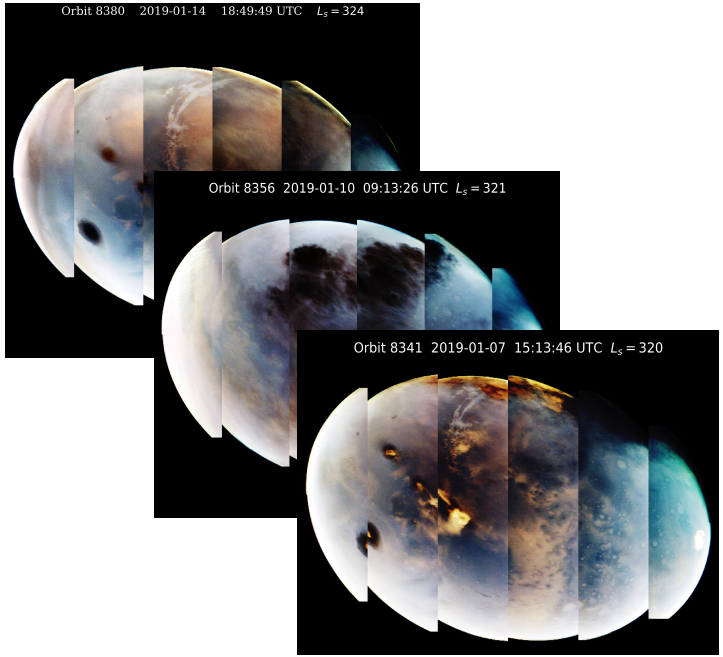
During solar storms, faint emissions (white arrows) cluster around remanent magnetic fields locked in regions of Mars' crust

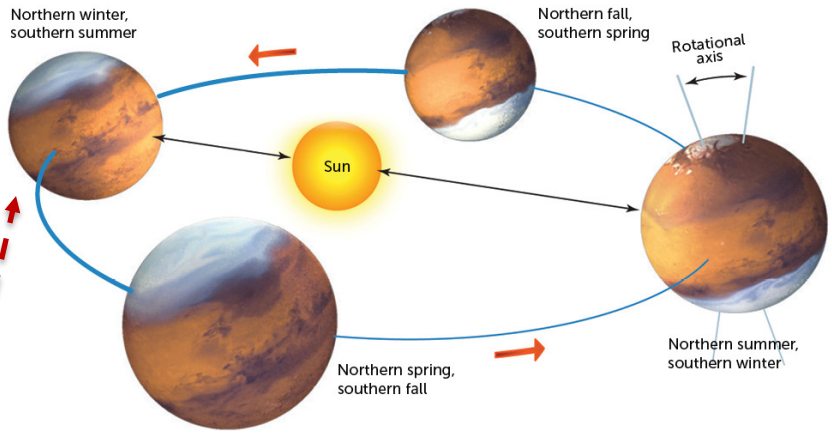
Proton Aurora



Solar wind protons penetrating Mar's atmosphere emit Lyman Alpha photons around the limb, adding to Mars' coronal glow

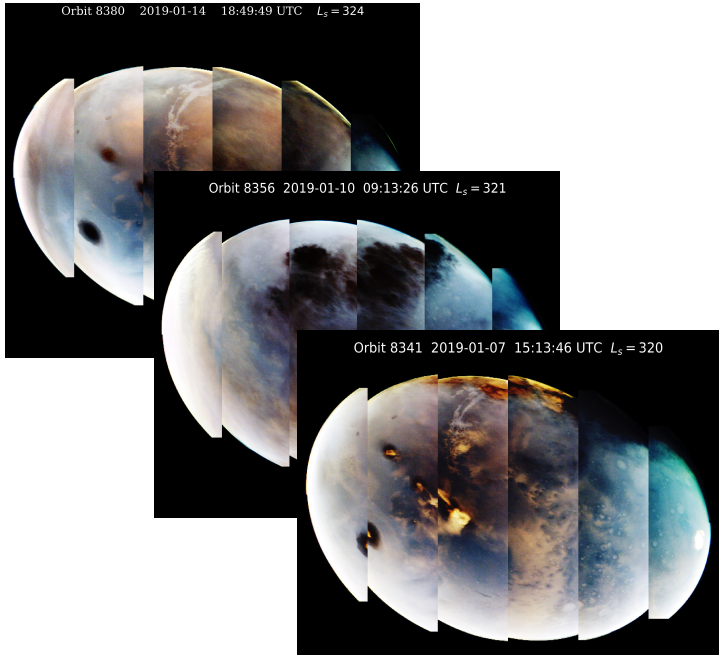
Dust and atmospheric erosion





- Dust season occurs at Mars' perihelion (or northern winter/southern summer
- Dust storms can be local or global and have a huge effect on our ground assets (e.g. solar panels)

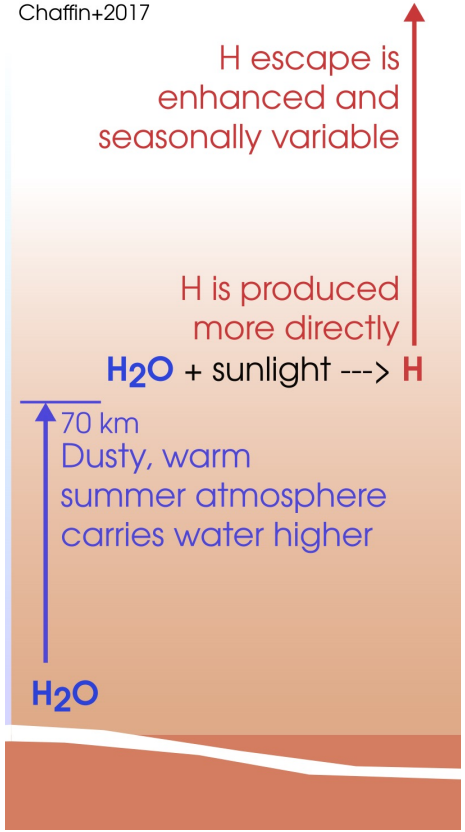
Dust and atmospheric erosion

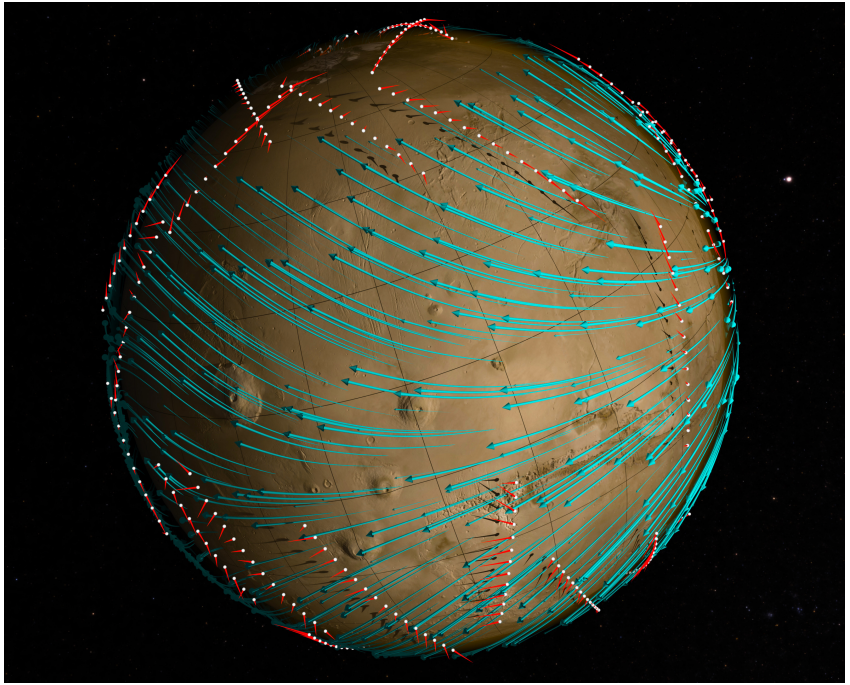


- MAVEN works with MRO and TGO to observe dust
- In 2018, MAVEN observed not just dust, but that dust storms remove water from the atmosphere at almost two time the rate of quiescent periods

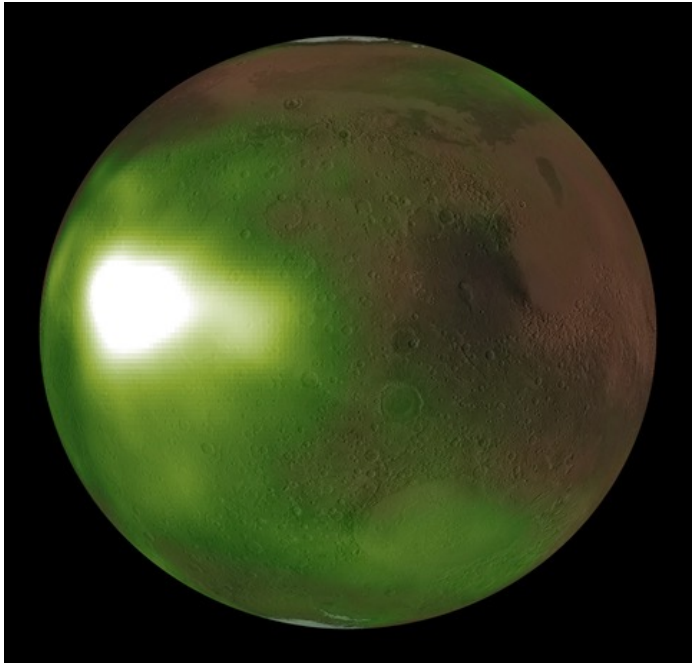
New Concept

Chaffin+2014
Clarke+2014
Chaffin+2017

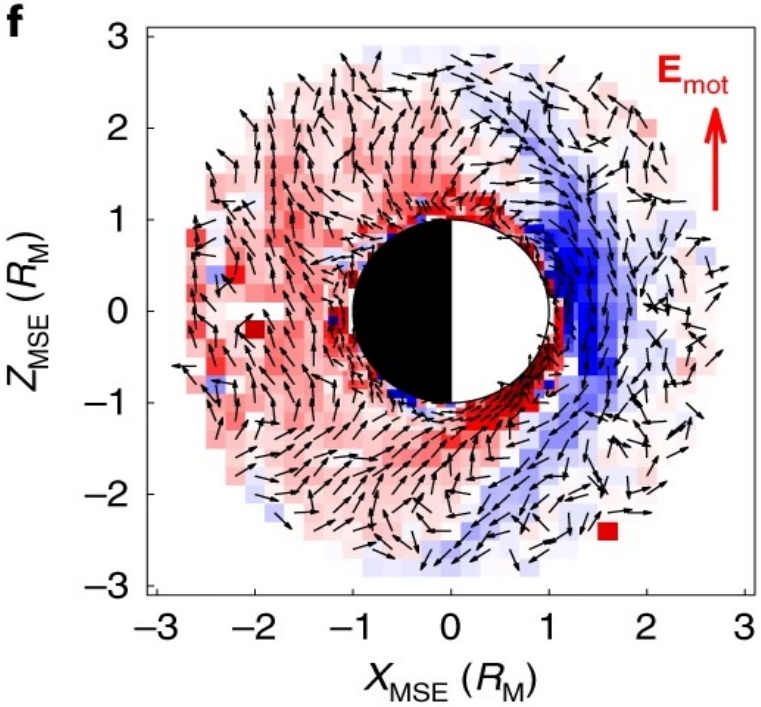


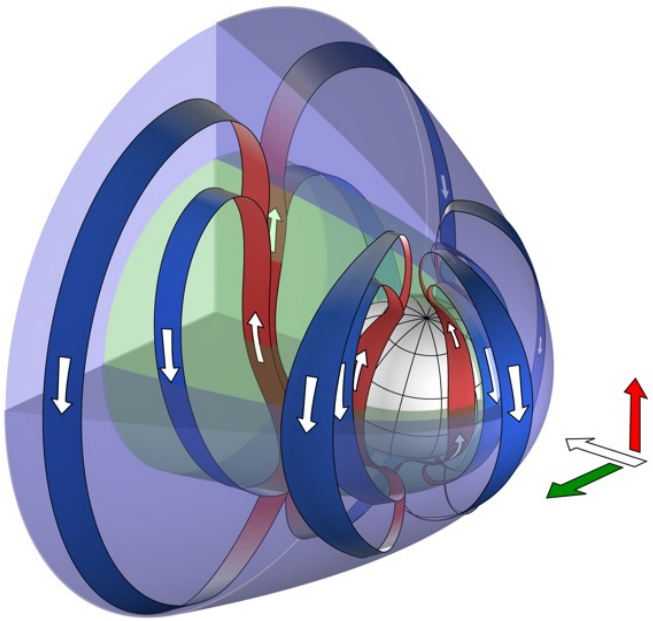


MAVEN NGIMS observations of thermospheric neutral winds (red) were the first to constrain wind circulation patterns (green) in the upper atmosphere of a planet other than Earth.



MAVEN IUVS observations of nitric oxide nightglow emission (false color). Localized peaks in intensity are repeatable and show downward winds cause chemical reactions that result in UV light.



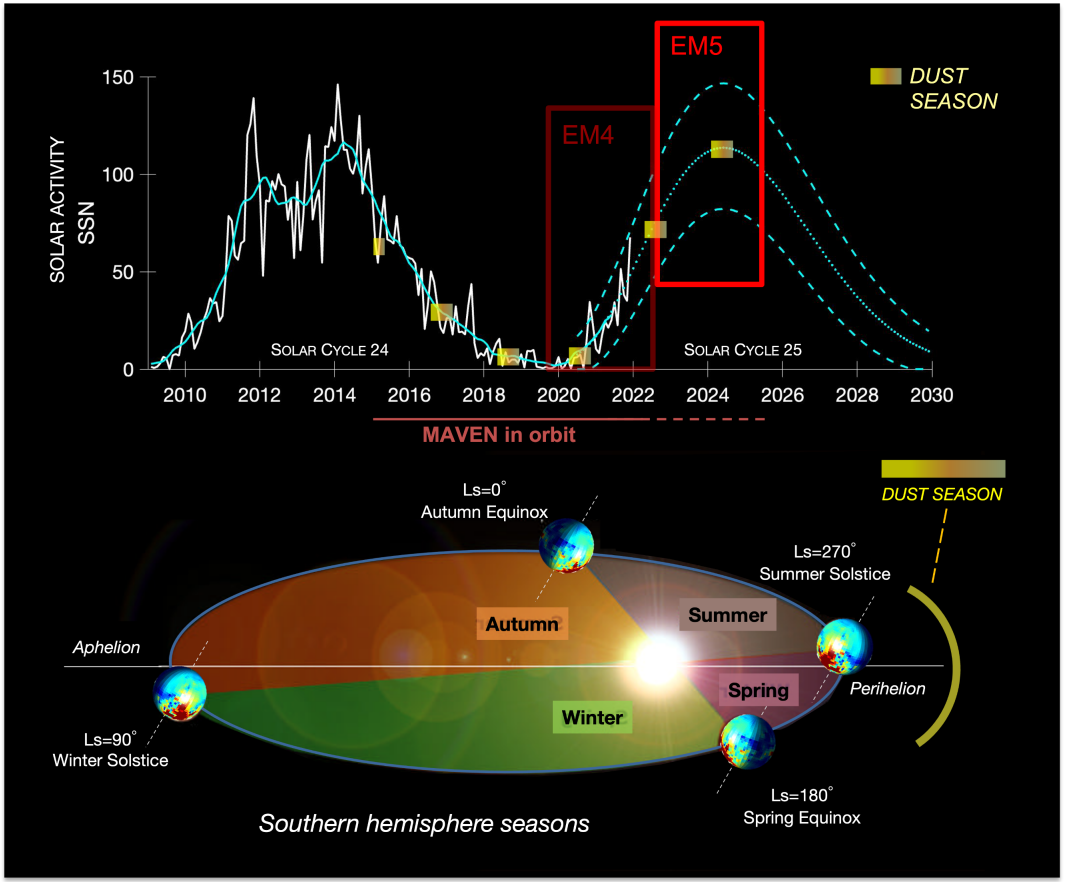


MAVEN MAG observations provide complete coverage of electric current strength and direction around Mars to produce the first map of the global magnetospheric current system at a planet without an intrinsic magnetic field like Earth (sun to the right).

Mission Project Status

Science

- Collaboration with the Moon 2 Mars (M2M) program
- Special issue on “Mars at solar minimum” in progress
- EM5 science will include solar maximum and two dust seasons
- MAVEN is delivering space weather alerts that notify key POC about potential solar transient events predicted to impact Mars
- MAVEN is also collaborating with other MEP assets to coordinate disseminating information about dust seasons



Mission Project Status

Overall

- ~7 years in orbit
- MAVEN currently in FY22 and EM-4 (1 Oct 2019 – 30 Sept 2022)
- SUBMITTED for the Planetary Mission Senior Review (PMSR) to cover FY23-FY25

Relay and ops continuing successfully

- MAVEN set a new solar system record for throughput during a single communications session at another planet during a relay session with the Perseverance rover. A total of 2.34 Gbits were transferred, well exceeding the prior record of 1.74 Gbits.
- Successful operations under COVID-19 restrictions and the Colorado wildfires
- We continue to conduct fuel management trade studies to enable operations through 2030
- Uncertainty over funding for FY22 and for subsequent years and impact on ops and science

Highlights/Collaborations

- Science is going extremely well; no significant issues being worked
- Ops and S/C teams have worked diligently to mitigate risks and issues
- Team working very well under COVID-19 ops restrictions
- High-visibility science results in Science and Nature
- Collaboration with the Moon 2 Mars (M2M) program
- Early onset of solar activity in Solar Cycle 25 and regional dust storms at Ls ~ 156

Issues/Concerns

- Aging DSN infrastructure and lack of sufficient resources/budget for SCAN (Space Communications and Navigation); deployment of tiger teams, stations going down for maintenance or unexpectedly, etc… not a sustainable path forward for the data volume coming from an increasing number of operational missions
- Funding levels for FY22 and beyond
- Future funding and opportunities for MAVEN science-team alumni; follow-on science and missions