

Mars Exploration Program Analysis Group (MEPAG)

chartered by NASA HQ to assist in planning the scientific exploration of Mars



Jeffrey R. Johnson, *MEPAG Chair*
Report to Planetary Science Subcommittee
September 30, 2016



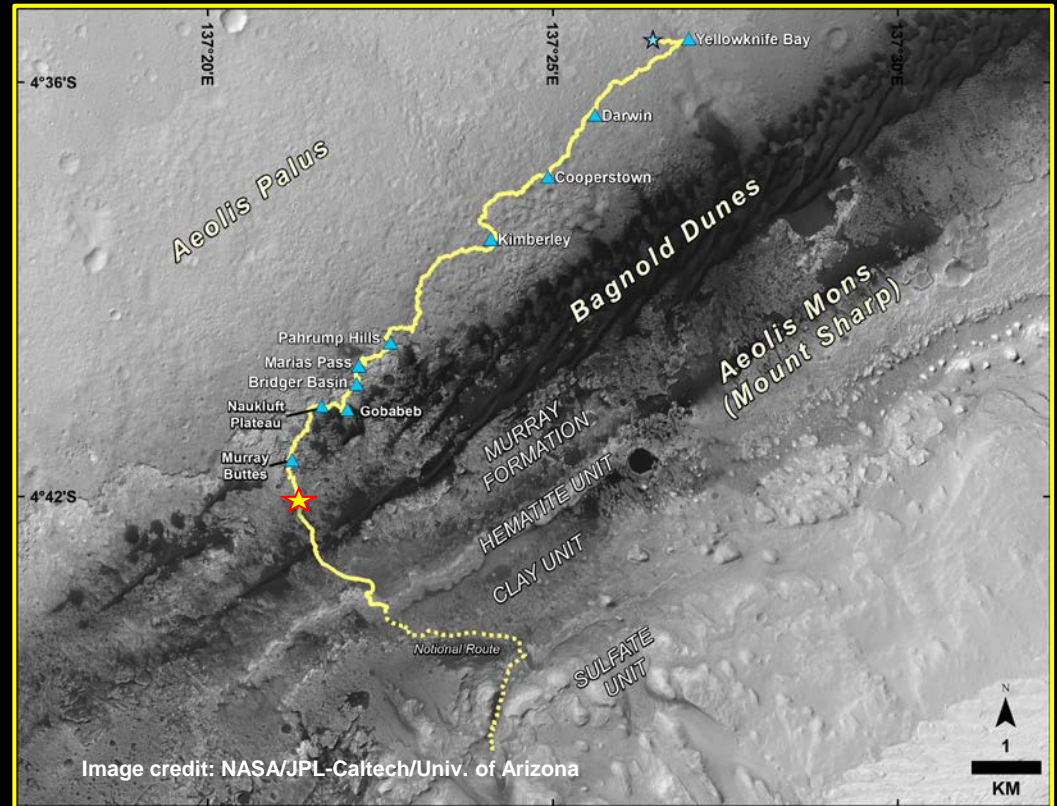
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Mission Status Highlights: *Curiosity* (@ Sol 1476)

- Completed four years on Mars in August
- > 14 km total traverse
- Traverse through the Murray Buttes is completed
- Driving south toward “Hematite Ridge”
- Intent to drill at several elevation intervals along the way



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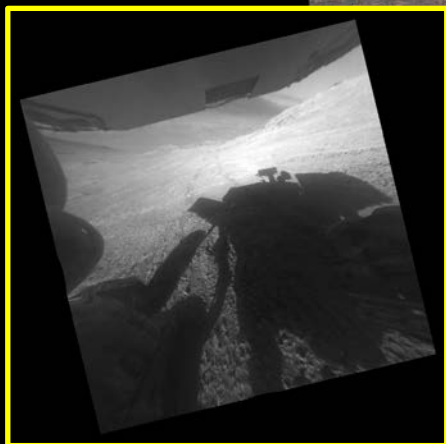


Mission Status Highlights: MER Opportunity (@ Sol 4510)

- Opportunity left Marathon Valley and is driving east and then south along Endeavour Crater rim
 - 50 nominal (90 sol) missions of exceptional performance on Mars!

"Sacagawea Panorama" in Marathon Valley Sols 4347-4375 (April-May 2016)

http://pancam.sese.asu.edu/4347B_P2445_1.html



<http://mars.nasa.gov/multimedia/images/?ImageID=7789>



<http://mars.nasa.gov/multimedia/images/?ImageID=7781>

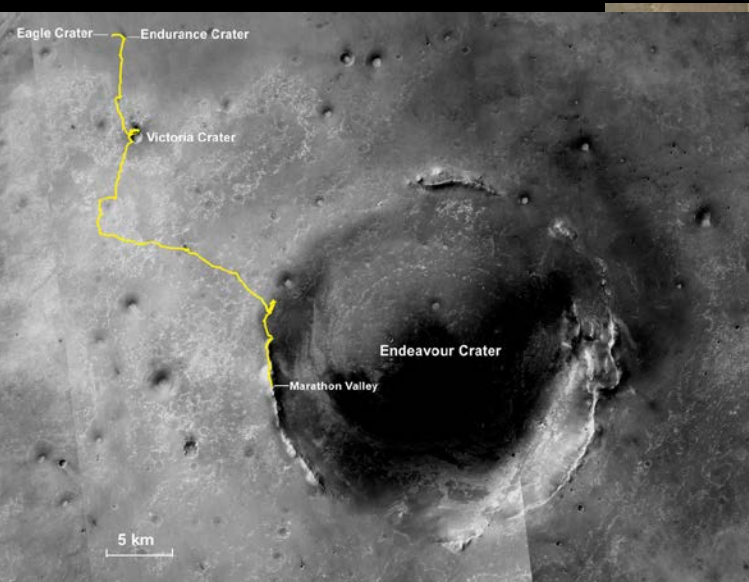
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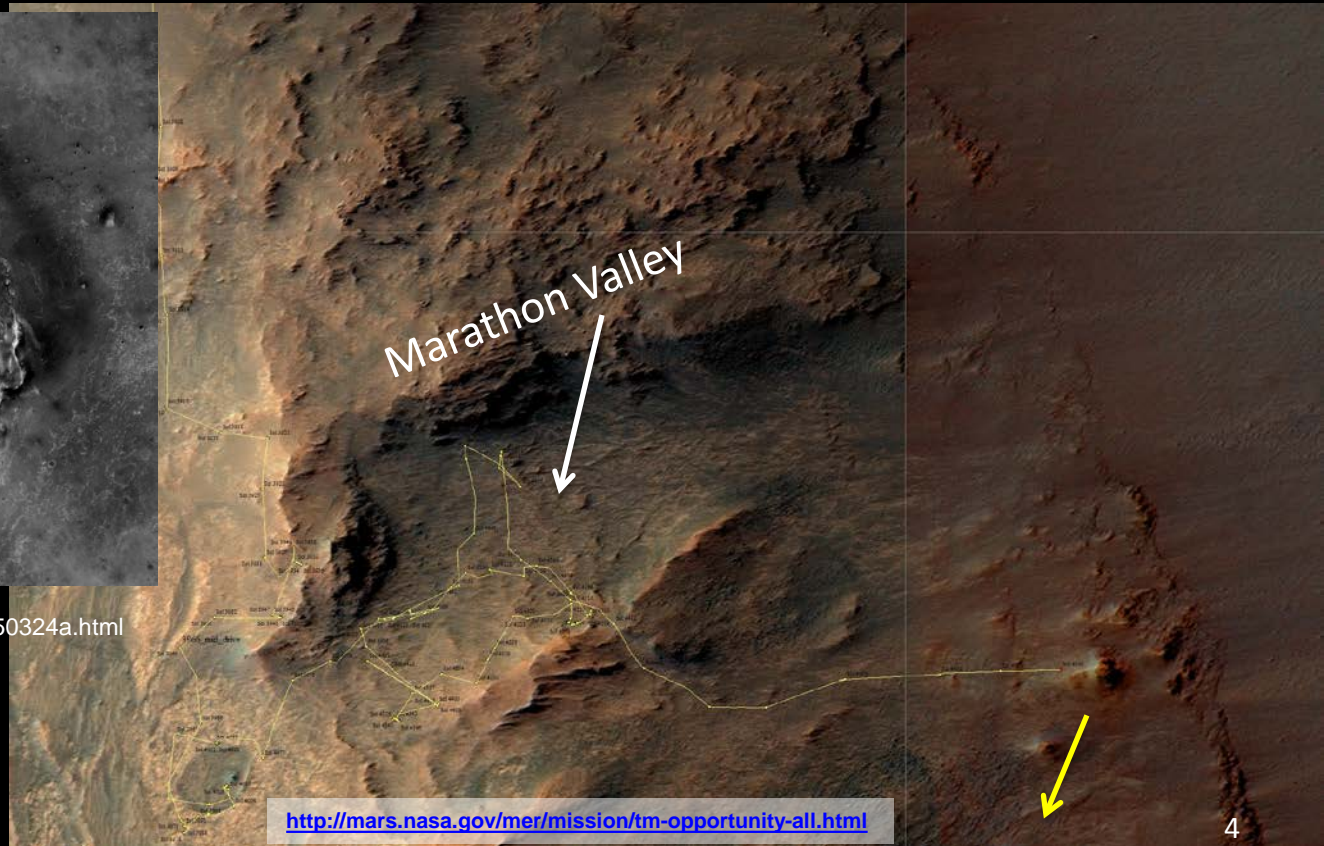


Mission Status Highlights: MER Opportunity (@ Sol 4510)

- Opportunity left Marathon Valley and is driving east and then south along Endeavour Crater rim
 - 43.5 km odometry



<http://mars.nasa.gov/mer/gallery/press/opportunity/20150324a.html>

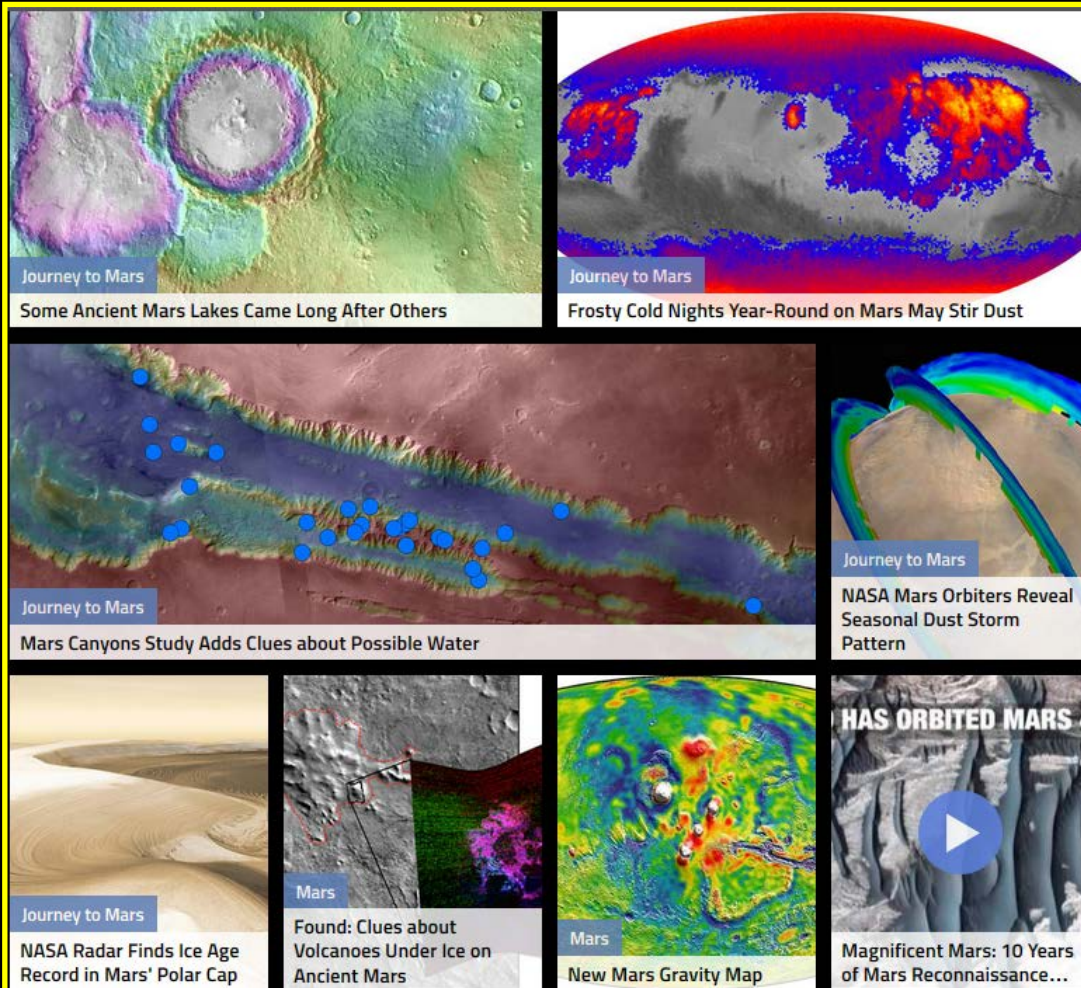


<http://mars.nasa.gov/mer/mission/tm-opportunity-all.html>



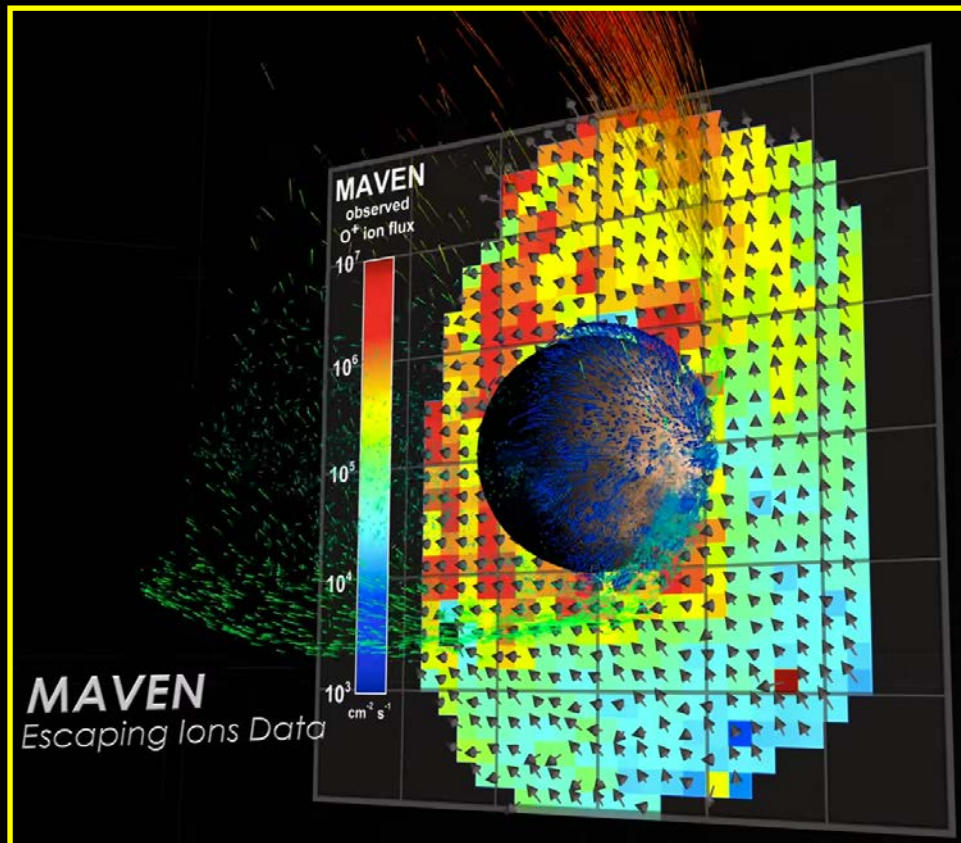
Mission Status Highlights: Mars Reconnaissance Orbiter (MRO), Odyssey (ODY)

- MRO celebrated 10 years of operations in March
- ODY approaching 15 years
 - October 24 anniversary
- Both orbiters are observing candidate sites (exploration zones) for humans on Mars
- Continuing to serve as data relays for rovers



Mission Status Highlights: Mars Atmosphere and Volatile Evolution (MAVEN)

- MAVEN began extended mission after completing 2nd year in orbital operations



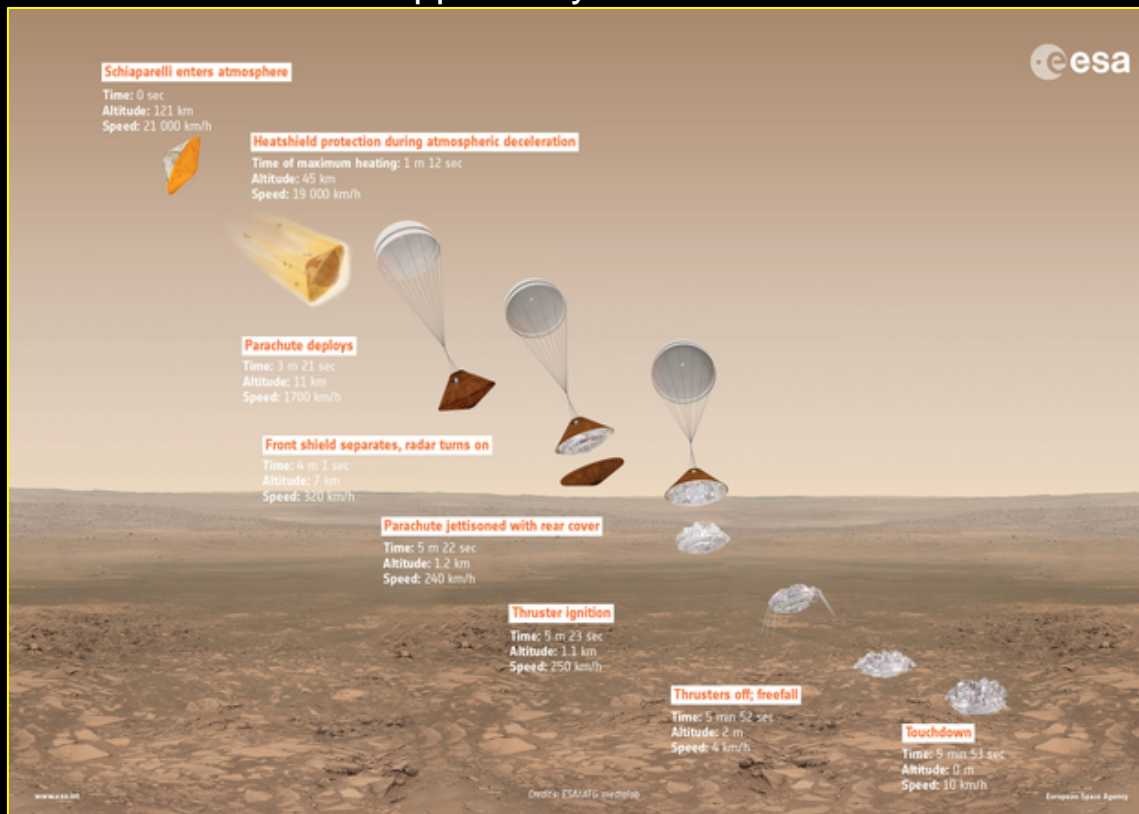
- A 3-D animation created by NASA's Scientific Visualization Studio using data from the MAVEN mission to Mars is the corporate winner of the inaugural Data Stories video contest sponsored by Science magazine
- The video explains how the solar wind is driving particles from the upper atmosphere of Mars into space, which may have caused the planet to dry out and cool over the eons

<http://lasp.colorado.edu/home/maven/2016/05/13/maven-data-used-for-award-winning-nasa-scientific-visualization-studio-video/>



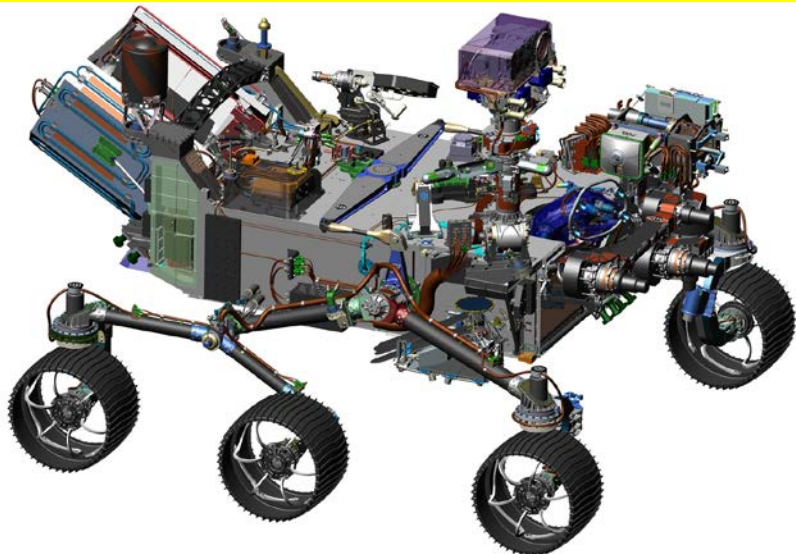
Mission Status Highlights: ESA

- Foreign collaborations with ESA Mars Express and ExoMars MOMA continuing
 - ExoMars Schiaparelli Entry/Descent/Landing (EDL) on October 19
 - NW of Opportunity in Meridiani Planum



Mission Status Highlights: Mars 2020, InSight

- 2020 Mars rover passed Key Decision Point (KDP) to enter Phase C in July
 - “the project is proceeding with final design and construction of the new systems, as well as the rest of the heritage elements for the mission.”
 - targeted to launch in summer of 2020 and arrive in February 2021
- New launch window opens May 5, 2018 for the InSight mission to study interior

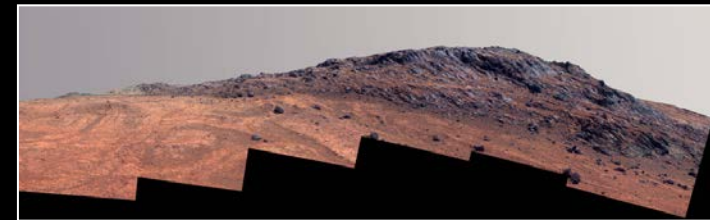




MEPAG Programmatics

- **New MEPAG Chair appointed in March:**
 - Jeff Johnson (JHU/APL)
 - Lisa Pratt transitions to MEPAG Executive Committee
- **Vacancies filled:**
 - Goals Committee
 - **Goal I <Life>** (Sarah Stewart Johnson, Georgetown University)
 - **Goal II <Climate>** (Robin Wordsworth, Harvard University)
 - **Goal IV <Human Exploration>** (Jacob Bleacher, Goddard Space Flight Center)
 - Search beginning for successor to V. Hamilton as Goals Chair
 - Executive Committee
 - Welcomed Scott Hubbard (Stanford University) as successor to the late Noel Hinners
 - Welcomed Ben Bussey (HEOMD, NASA HQ) as Ex Officio member
- **Mars Water In-Situ Resource Utilization Planning Study (M-WIP) released:**
 - Studied hypothetical water reserves and engineering/geological requirements to create viable production system, and implications for exploration
 - http://mepag.nasa.gov/reports/Mars_Water_ISRU_Study.pdf

Hinners Point, Marathon Valley
<http://photojournal.jpl.nasa.gov/catalog/PIA19820>





MEPAG Programmatics

- **MEPAG website updates:**

- Terms of Reference updated (from 2011)
 - <http://mepag.nasa.gov/about.cfm>
- “Top” discoveries list soon to be updated (from 2012)
 - <http://mepag.nasa.gov/topdiscoveries.cfm>
- Meeting #31 Summary posted (March, 2016)
 - http://mepag.nasa.gov/meeting/2016-03/MEPAG31_Summary_v2.pdf
- Survey of MEPAG newsletter effectiveness conducted
 - <http://mepag.nasa.gov/announcements.cfm>
 - Interest in more about non-US space agency plans/missions, and pointers towards “Mars in the news” items
 - Mars Project Office staff examining methods to obtain this information systematically

- **Activities**

- Assisted with R&A Review panel
- Participating Scientist white paper surveys (L. Prockter)
- Consulted on International Space Exploration Coordination Group white paper (B. Bussey)
- Our Red Planet (citizen science workshop) (A. Kaminski)

Top Discoveries of the Mars Exploration Program (as of 2012)

1. Ancient, Persistent Liquid Water
2. Complex Surface Geology
3. Modern Water
4. Recent Climate Change
5. Planetary Magnetism
6. Martian Climate and Weather
7. Modern Processes
8. Methane on Mars
9. Gravity and Figure
10. Mars Radiation Environment





Extended Missions

- All Planetary Science Division/Mars Exploration Program continuing missions were assessed this spring as part of the PSD Mission Senior Review. Recommended all 6 Mars Projects continue:
 - 5 Flight Projects: ODY, MER-B, MRO, MSL, MAVEN
 - 1 Support Flight Project: Mars Express/ASPERA-3 (Analyzer of Space Plasma and Energetic Atoms)

ODY 7th Extended Mission (2001)

MER-B 10th Extended Mission (2003)

MEX / ASPERA-3 (2003)

MRO 4th Extended Mission (2005)

MSL 2nd Extended Mission (2011)

MAVEN 2nd Extended Mission (2013)

- Projects were impressed with the range and depth of experience, including flight experience, of the panel members
- National Academy of Sciences (NAS) committee is also examining issues related to extended missions
 - V. Hamilton presentation at 2:30 pm today
- MEPAG is enthusiastic that the enormous value (science gained for the funds expended) of extended missions was recognized and that high-quality science will continue to be supported

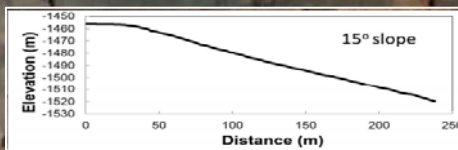
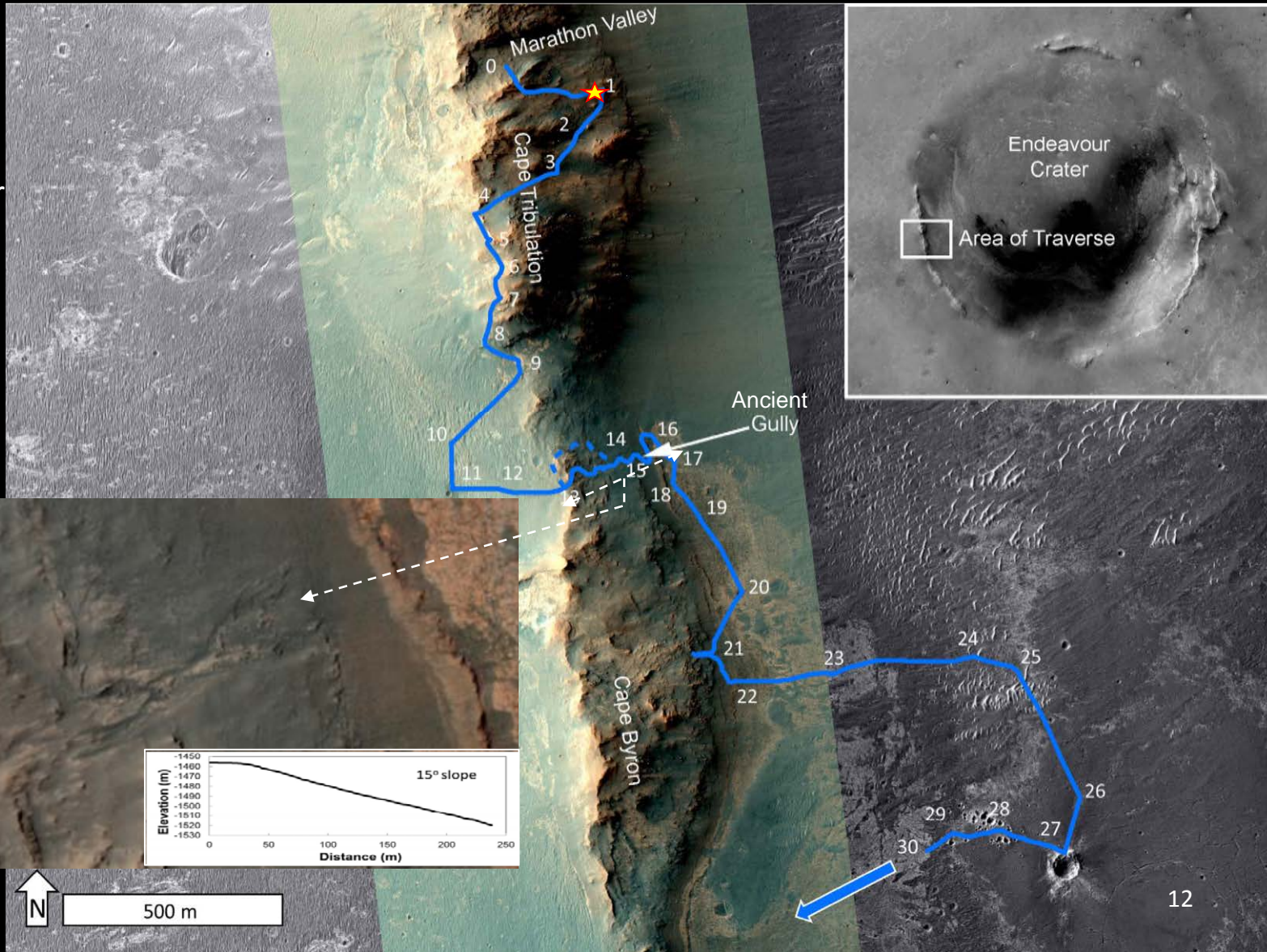
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MER Opportunity: Traverse Plan for Extended Mission

EM10 Science Targets

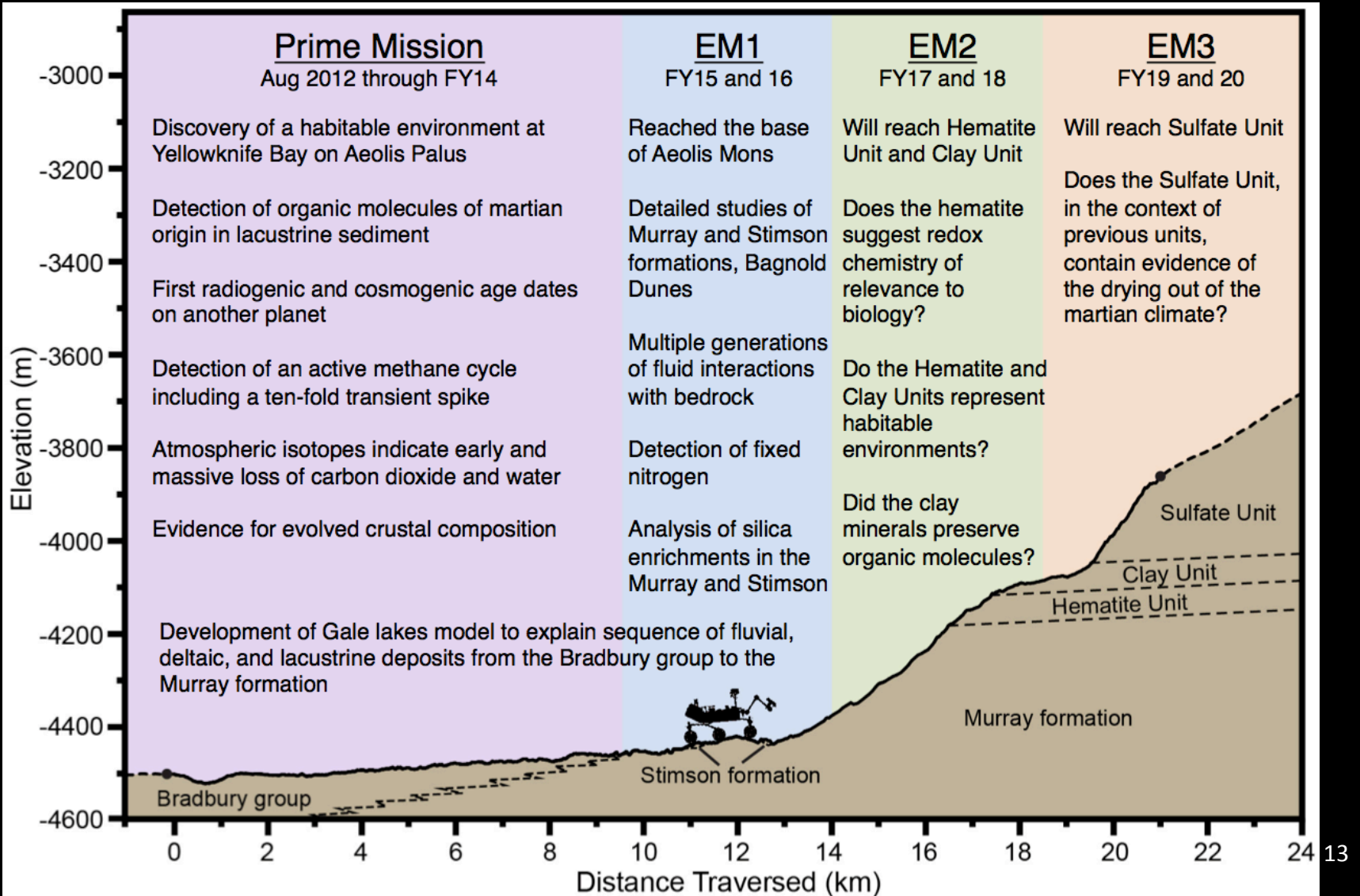
- Ancient bedrock older than Endeavour crater
- Sedimentary rocks inside the crater
- Fluid carved ancient gully



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MSL Curiosity at Aeolis Mons: Investigating a Habitable Planet in Transition

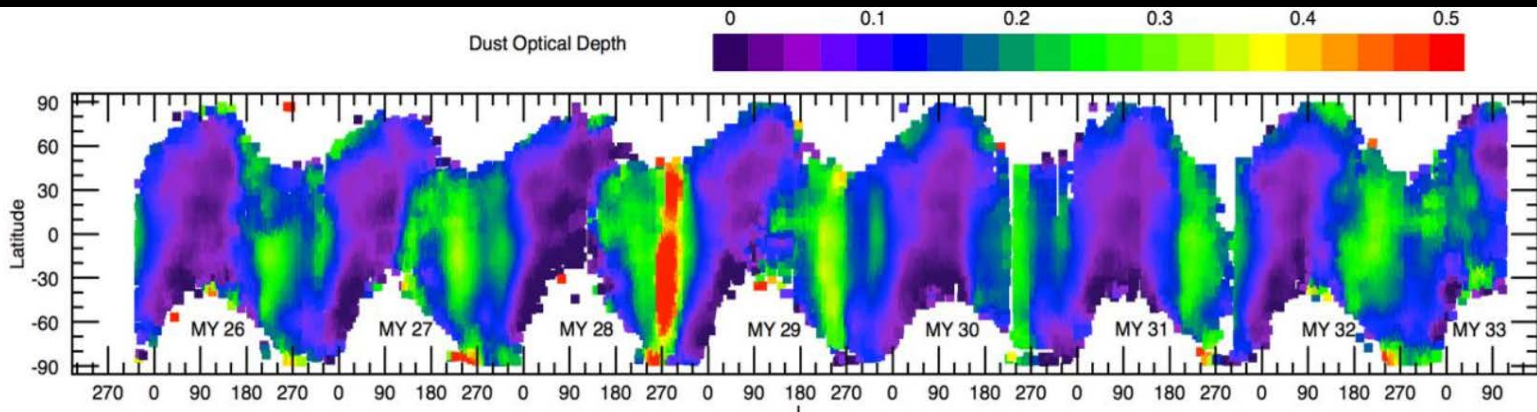


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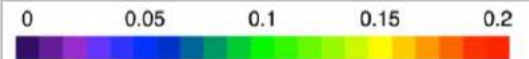


Mars Odyssey: Seeing Mars in a New Light

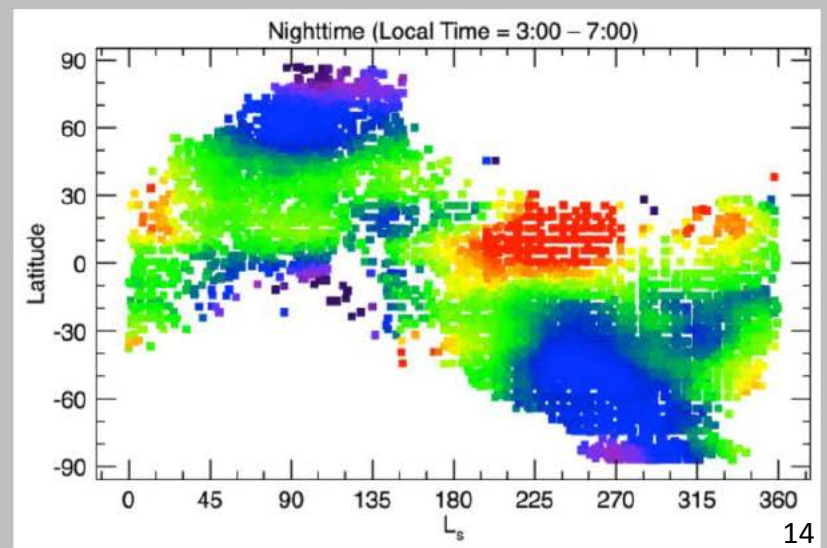
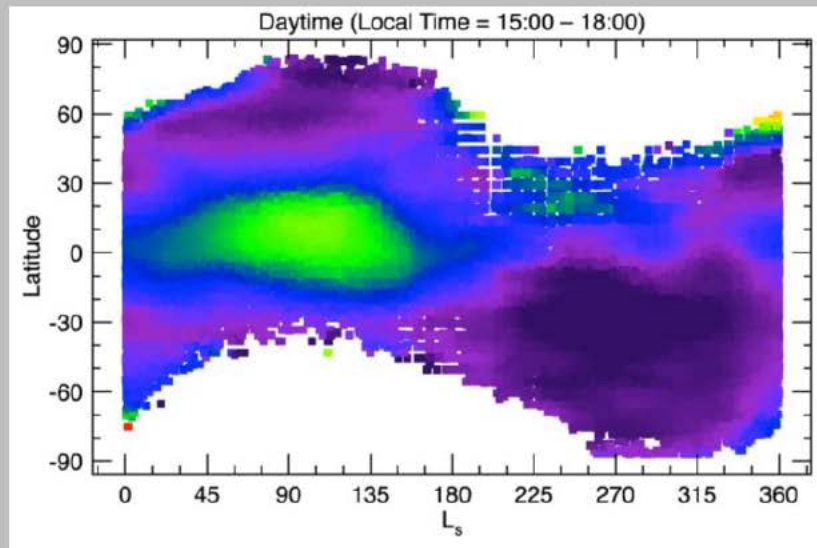


Inter-annual Variability of dust over a Mars Decade

Water Ice Cloud Opacity



Atmospheric and Surface Variations with Local Time



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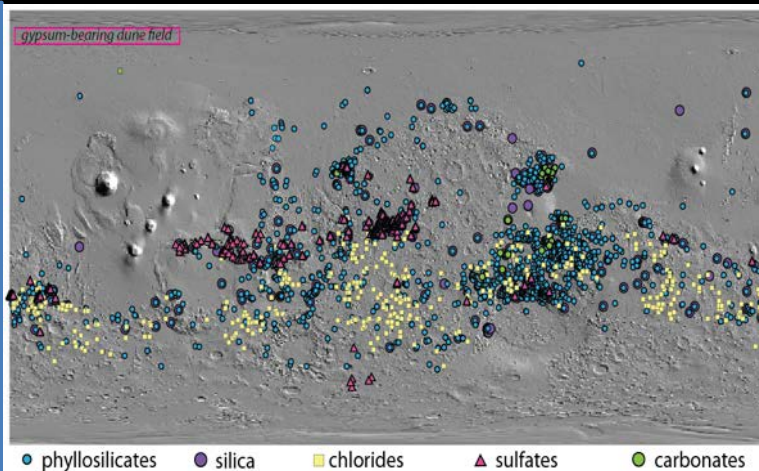


MRO 4th Extended Mission: Mars in Transition

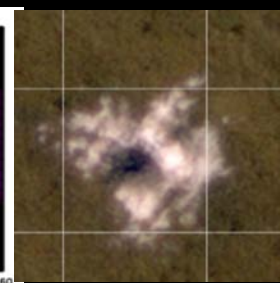
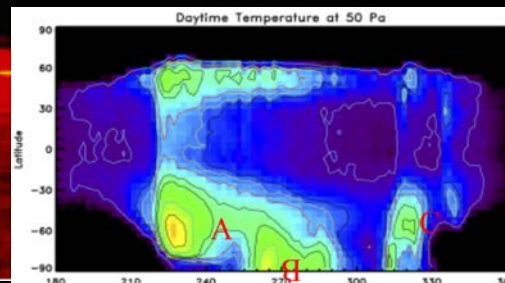
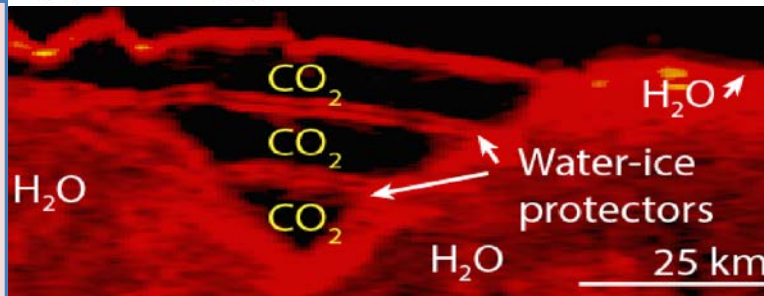
EM4: 16 Investigations addressing 4 Science Goals spanning all 3 Mars eras:

- *Ancient Mars*: Environmental Transitions and Habitability
- *Middle Mars*: Amazonian Ices, Volcanism, and Climate
- *Modern Dynamic Mars*: Surface Changes and Implications
- *Modern Dynamic Mars*: Atmospheric and Polar Processes

Ancient Mars



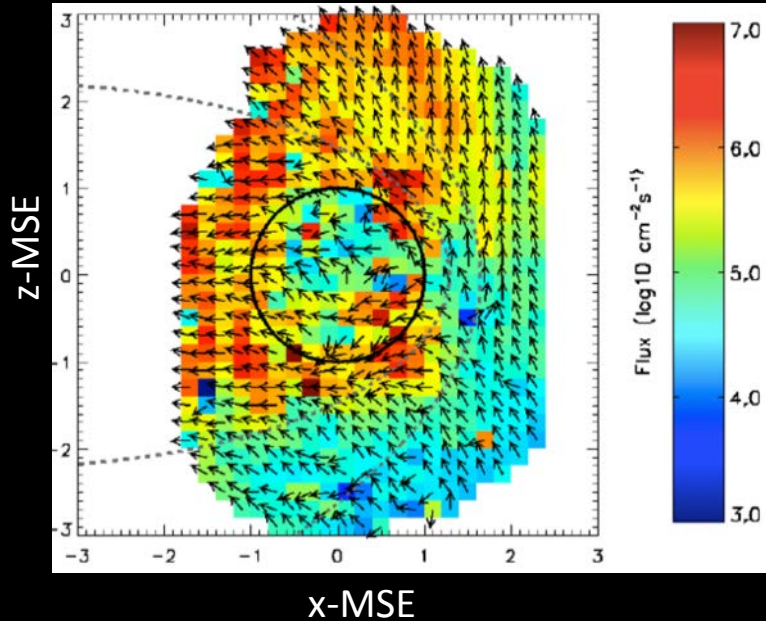
Middle Mars



Modern Mars: Atmos. & Surface



MAVEN: Quantifying Atmospheric Escape, Past and Present



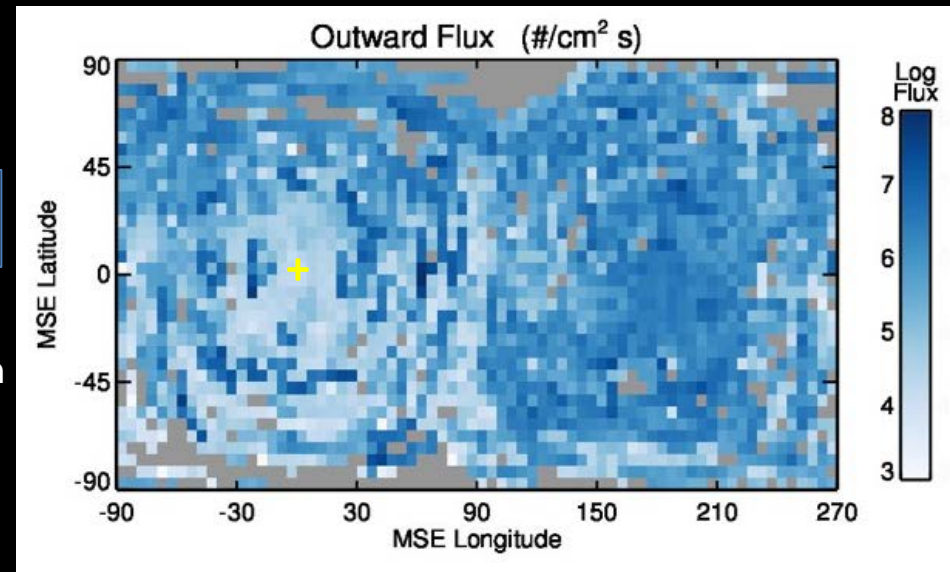
Ion density and flow direction projected onto X-Z plane in solar coordinates. Note polar plume and ion escape down the tail

New Observations in EM2

- Radio Occultations to map ionosphere and electron density peak
- Directly measure neutral winds
- High-spatial mapping of NO
- Observations of cold-ion outflow
- High-resolution mapping of ion out-flow near remanent magnetic fields

Goals

- Observe during a different phase of the solar cycle
- Characterize response to new solar events
- Quantify inter-annual variability
- Fill in the 3-D global coverage of space surrounding the planet



Map View: Escaping flux of ions mapped onto a sphere centered on Mars in solar coordinates



Looking Ahead

- Trace Gas Orbiter (TGO) and Schiaparelli Lander arrive at Mars October 19
- Next Mars Orbiter studies continue, but the *Objectives and Requirements Definition Team (ORDT)* has been deferred to early 2017
- Virtual MEPAG meeting on October 6 (half day)
 - 08:30-12:30 Pacific time; <http://mepag.nasa.gov/meetings.cfm?expand=m32>
- Face to Face MEPAG meeting in Feb/March/April 2017 (TBD)
- Participating in Panel on “Perspectives on the Future of Planetary Exploration”
 - 3rd International Workshop on Instrumentation for Planetary Missions October 24–27
- Formulation of new SAGs to start in the Fall. Possibilities include (but are not limited to):
 - Study possible roles of small satellites in Mars orbit for science and infrastructure
 - Study possible mission concepts for polar/ice science in anticipation of next Decadal Survey