

Mars Express highlights and status

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/on behalf of the Mars Express Team/*

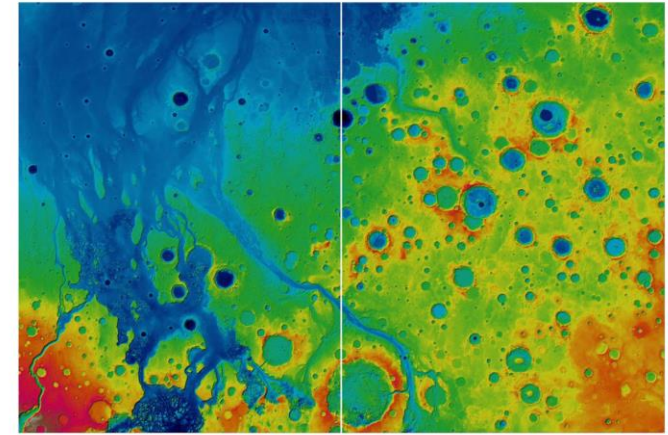
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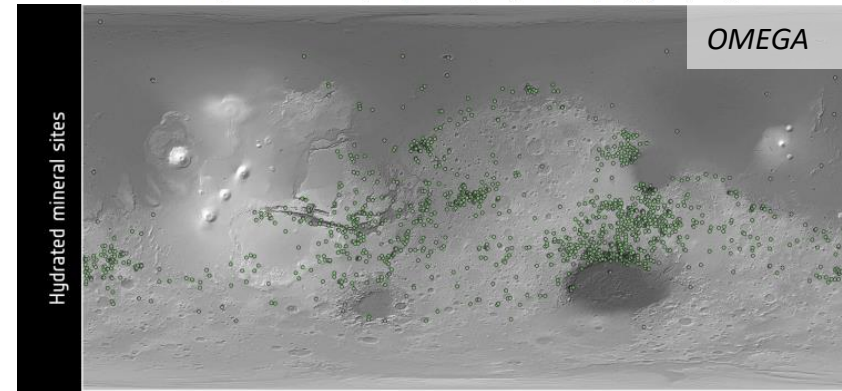
1. Geology, interior and history

- Discovery of a stable body of **liquid water under the south polar layered deposits**
- **Geology and composition of Jezero crater** and its vicinity
- Evidence of **a planet-wide ground water system**
- Map and catalogue of **chemical alteration features** with resolution of 200 m/px
- New **Digital Elevation Models**

HRSC Mars Chart MC11 (East and West)

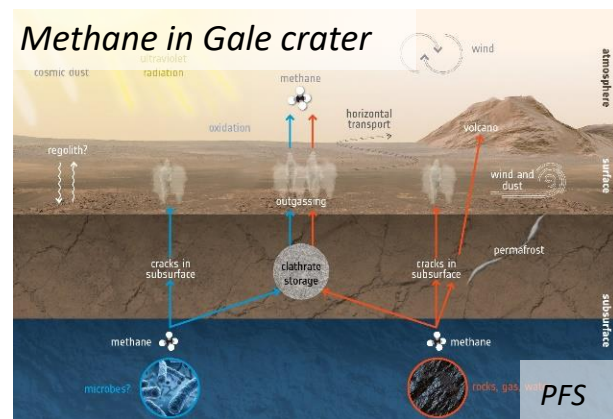
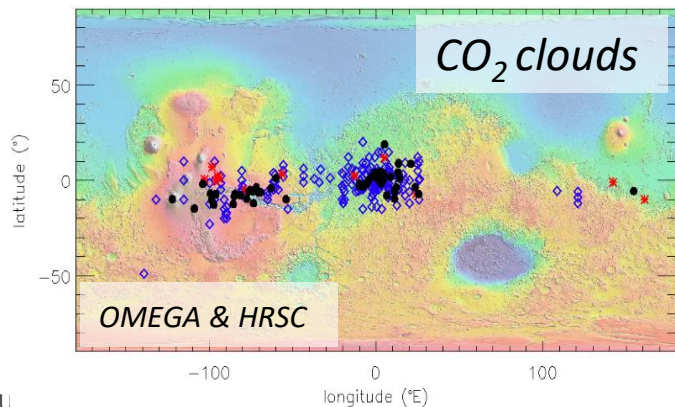
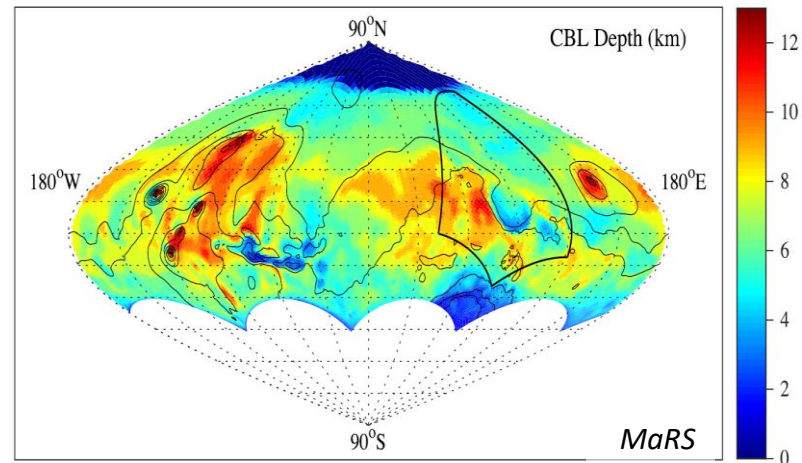


Deutsches Zentrum
DLR für Luft- und Raumfahrt e.V. 100 km 5000 1000 m HRSC multi-orbit DTM MC-11
HRSC multi-orbit DTMs for MC-11-E (Oxia Palus, East) and MC-11-W (Oxia Palus, West). Extent: 2663 km (E-W, at the equator), 1780 km (N-S), grid spacing 50 m.



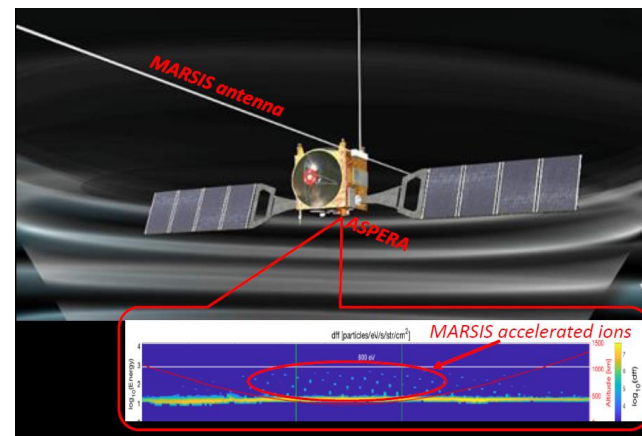
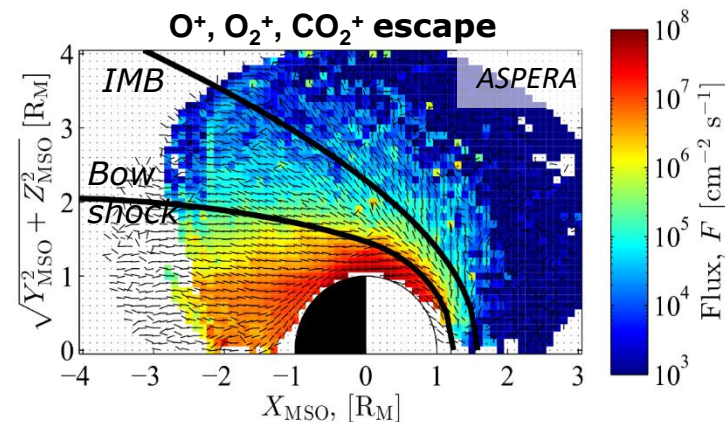
2. Meteorology and climate

- **Depth of the planetary boundary layer** from MEX radio-occultations
- **Methane:** enigma continues
- Longest record of **atmospheric ozone** (SPICAM)
- Monitoring of **CO₂ clouds**
- Long orographic cloud at Arsia Mons



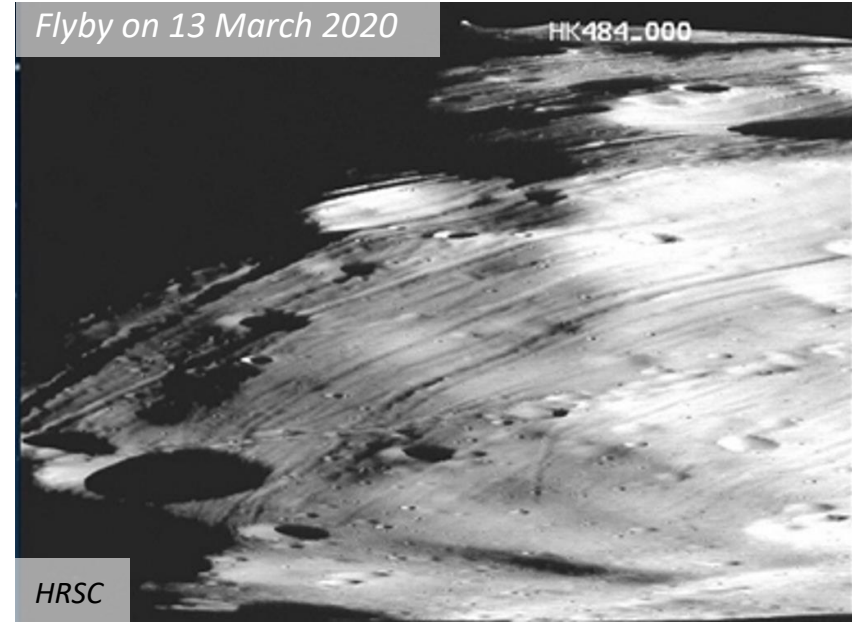
3. Aeronomy and plasma environment

- **Topology of the plasma boundaries** as function of the solar cycle, crustal magnetic field and dust loading
- Analysis of **interaction of Siding Spring comet with Mars plasmosphere** completed
- **Ion escape rate** dependence on EUV flux, solar wind density and velocity
- Atmospheric loss over the planet history <10 mbar → **Ion escape is NOT the main loss mechanism**
- First **active plasma sounding** at another planet



4. Phobos investigations

- In 2019 12 flybys of Phobos at <1000 km: augmenting the spatial and spectral coverage, constraining the age of Stickney crater and Phobos surface properties
- Almost all instruments operated during the recent flyby on March 13
- Working Group in support of MMX mission, lead by T. Duxbury, MEX IDS



➤ Spacecraft, operations and archiving are nominal

- **16 years of science operations**
- *Since April 2018 in "gyroless" AOCS mode*
- **MEOR conclusion:** *The spacecraft is in good health and ready to continue science mission till at least 2025*

➤ Mission extension

- *extension till the end of 2020 is approved*
- *extension till the end of 2022 is to be confirmed*
- *extension in 2023-2025 is requested*
- *SPC decision is expected in July 2020*

➤ Team and community

- ***MEX Team welcomes new ideas, suggestions, collaborations !***



**MEX objectives for
confirmation (2021-2022) and
extension (2023-2025) intervals**

Confirmation for 2021-2022

Geology and interior



- Augmenting surface stereo coverage to 89%
- Release of multi-orbit DEMs for several MC-30 quadrants
- Detailed regional spectral mapping coupled to in situ investigations
- High-resolution targeted sounding of the polar regions to characterize the most promising areas in the search for sub-glacial water reservoirs in collaboration with subsurface radar on the Chinese HX-1 orbiter
- Detailed investigations of landing sites for the current and future missions, as the most interesting locations from a geological viewpoint

Confirmation for 2021-2022

Meteorology and climate



- Continue monitoring of key meteorological parameters, including dust storms, to fill gaps in the coverage
- Campaigns of atmospheric observations from afar to get global snapshots of all meteorological parameters and/or their evolution with ~1 hour cadence (*a la* geostationary Earth satellites)
- Study of couplings between the lower and middle atmosphere and influence of dust in collaboration with TGO
- Extensive investigation of the temperature structure with high vertical resolution and improved coverage using dual-spacecraft MEX-TGO radio-occultations

Confirmation for 2021-2022

Ionosphere and aeronomy



- Augmenting the ionospheric coverage in latitude, longitude, season and local time
- Study of longitudinal variability and sounding of the ionosphere above crustal magnetic “anomalies”
- Study of the upper atmosphere during “wake up” from the solar minimum and revisiting the results obtained in the previous and rather unusual (very long period with very low activity) solar minimum in 2007-2009
- Response of the ionosphere to extreme events (CMEs)
- Influence of dust variations on the ionosphere

Confirmation for 2021-2022



Plasma and escape

- Continue monitoring of the plasma parameters and its dependence on solar EUV flux and solar wind conditions
- Monitoring of the plasma environment and escape processes through the 2nd solar minimum (2019) and first ever comparison to those in 2007-2009
- First active sounding of local plasma at another planet by ASPERA and MARSIS
- Support NASA's MAVEN that would hardly be in the solar wind after orbit lowering in 2019, by monitoring upstream solar wind parameters
- Dual spacecraft investigation of the plasma environment together with Chinese HX-1 orbiter

Confirmation for 2021-2022

Phobos and Deimos



- More than 20 Phobos flybys at a distance <1000 km are planned
- From global mapping to more detailed investigation of selected sites of high geological importance (e.g., crater Stickney, surface roughness analysis) in relation to future in situ investigations
- Continue supporting JAXA's MMX mission with available and new observations, including improvements to the global shape model, as well as team expertise.
- Continue multi-object imaging to improve the ephemerides of the Martian moons

Geology, interior and history

- *High-res stereo coverage to >95%*
- *image mosaics with up to 12 m/pixel resolution for the full equatorial range ($\pm 30^\circ$), both poles and most of the mid-latitude areas*
- *Multi-orbit DEMs (50 m/px)*
- *Completion of mineralogical mapping in collaboration with CRISM/MRO*
- ***High-res radar sounding of the polar layered deposits in collaboration with Chinese HX-1 mission***
- ***Support to in situ missions by continuously improving the local and regional context of topography (DEM), multispectral imaging, and geology in collaboration with CASSIS/ TGO***

Meteorology & climate

- *Continue monitoring atmospheric parameters, and their variations and filling gaps in the coverage, that is essential for climatology*
- *Study of couplings between the lower and middle atmosphere and dust impact on the atmospheric state using **coordinated MEX-TGO spectroscopic and radio-occultation observations***
- ***New "scan" pointing mode to study diurnal variations of atmospheric parameters over specific regions of interest (e.g., Tharsis, Hellas basin)***
- ***Coordinated PFS-SPICAM observations to constrain H₂O vertical distribution***

Aeronomy and plasma environment

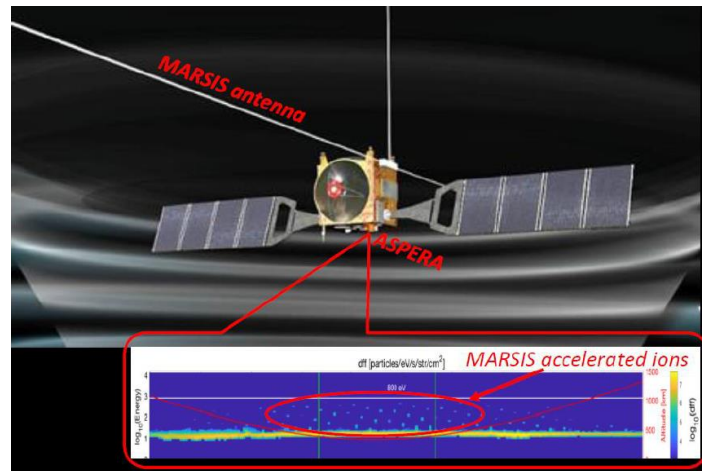
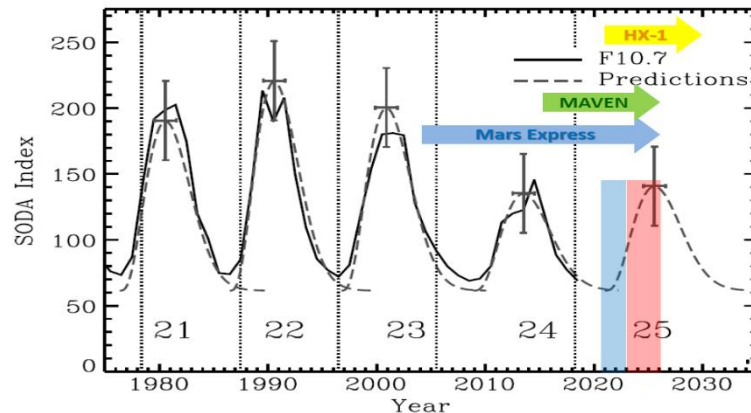
- ***Aeronomy, ionosphere and escape in the solar maximum #25 vs #24***
- *Continue monitoring ionospheric parameters, **benefiting from mutual MEX-TGO radio-occultations***
- *Coupling between the lower/middle and upper atmosphere in collaboration with TGO and MAVEN*
- ***Local plasma sounding by ASPERA during MARSIS operations***
- ***Continuous solar wind monitoring in support of NASA's MAVEN and Chinese HX-1 missions***

Phobos

- *More than 30 (tbc) Phobos flybys at a distance <1000 km*
- *Filling the coverage gaps*
- *Detailed investigation of selected sites of high geological importance (e.g., crater Stickney) in support of in situ MMX investigations.*
- *Search for reflected ions from Phobos*

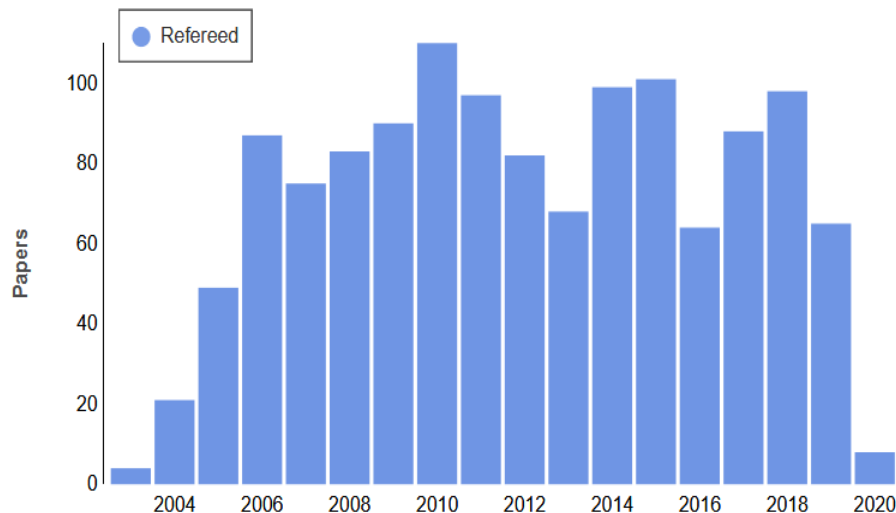
Novel investigations in aeronomy and plasma

- Solar cycle #25 and its comparison to the cycle #24
- Ionospheric sounding by MEX-TGO radio occultations
- Active sounding of the local plasma by ASPERA-MARSIS



Publication statistics

/status April 2020/



- ❑ >30 Tbytes of data archived including high level data products
- ❑ ~1300 papers
- ❑ ~55% are from ESA member states
- ❑ > 35000 total citations
- ❑ 148 theses

- *COSPAR-2018 awards to S. Barabash and J.-P. Bibring*
- *EGU-2018 award to Y. Langevin*
- *EGU-2019 award to J. Carter*
- *EGU-2020 David Bates medal to A. Sanchez-Lavega*

➤ **TGO** {MEX & TGO: two missions-one community}

- Successful implementation of the joint observation programme
- PS participate to partner's team meetings
- Discussions with the community (MAMO, EPSC)
- Analysis of the opportunities for joint observations (ESAC)

➤ **ExoMars rover**

- **A call for ideas !**



MAVEN

- going well: joint observations and data analysis
- ASPERA solar wind monitoring



China

- support in selection of landing sites for HX-1 mission in 2020
- collaboration by partner experiments

 **Japan**

support for JAXA MMX mission (WG led by T. Duxbury, MEX-IDS)

Thank you !