Discussion

Mars Express -Trace Gas Orbiter collaboration

Logistics

09:15-11:00 Meeting part1
11:00-11:30 Coffee
11:30-13:15 Meeting part2
13:30-14:30 Lunch at ESAC

13:30 Departure of Bus1 to Airport
14:30 Departure of Bus2 to Airport

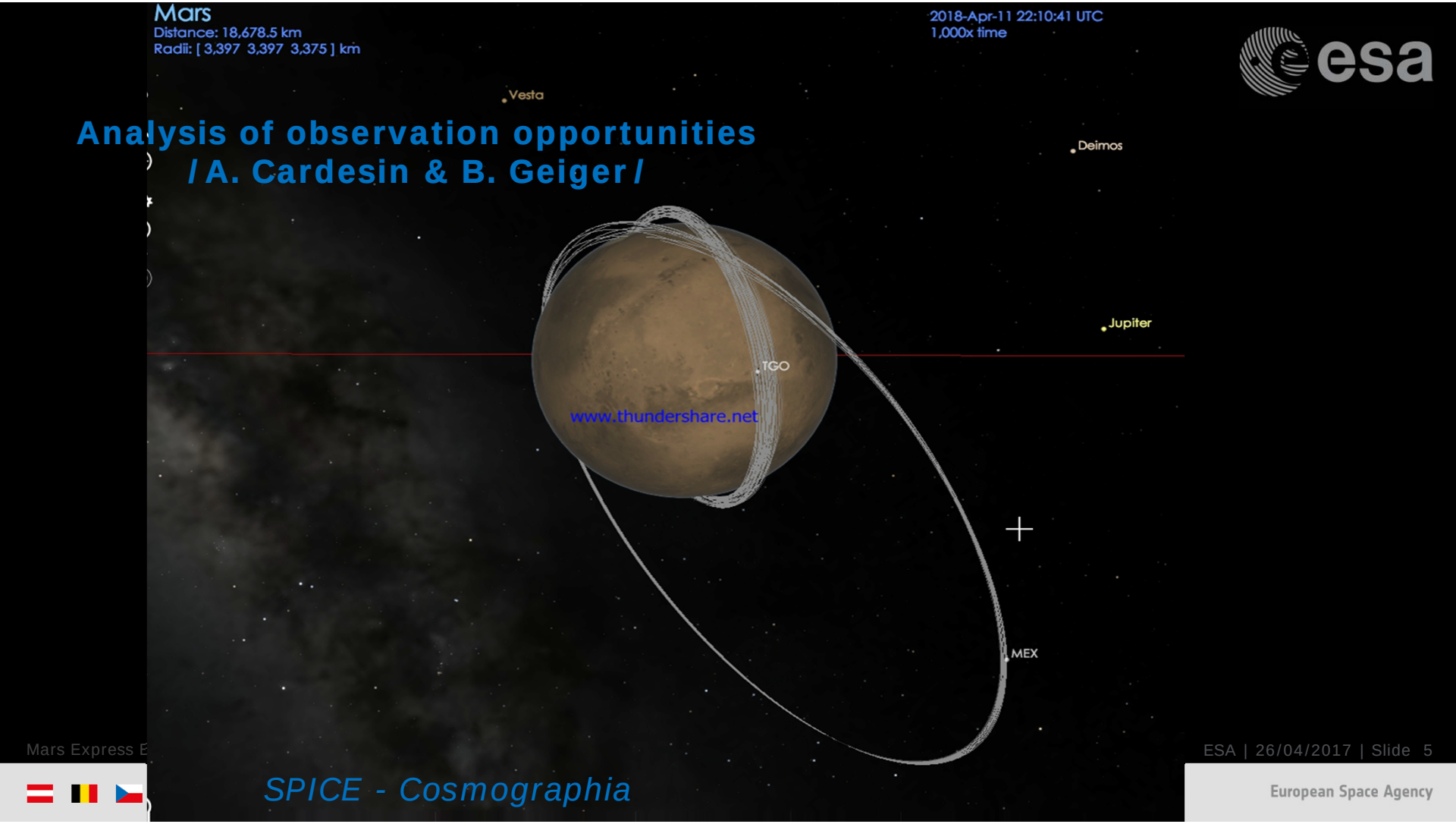
Agenda

1. D. Titov, H. Svedhem. Introduction (10 min)
2. A. Cardesin, B. Geiger. Analysis of joint observation opportunities (20 min)
3. Discussion (5-10 min/ presentation)
    - *Surface properties and geology*
    - *Lower atmosphere and meteorology*
    - *Upper atmosphere, aeronomy, plasma environment and escape*
    - *Instruments cross-calibration*
    - *Modelling and retrieval tools with multi-mission data*
    - *Comparison of radiative transfer codes*
    - *Collaboration with other missions (MAVEN, MSL, Isight, Exomars 2020, ...).*

Goals of the discussion

- Outline science areas and topics for the most efficient collaboration
- New ideas for collaborative science
- Identify operational requirements and opportunities for joint MEX and TGO observations
- Outline synergies in data analysis
- Identify needs for cross-calibrations of the instruments, algorithms and codes

Joint MEX-TGO collaboration plan



Analysis of observation opportunities

/ A. Cardesin & B. Geiger /

SPICE - Cosmographia

Surface properties and geology

- *HRSC and CASSIS*
- *MARSIS, MaRS (BSR) and FREND*
- *Targets for joint observations*

Lower atmosphere and meteorology

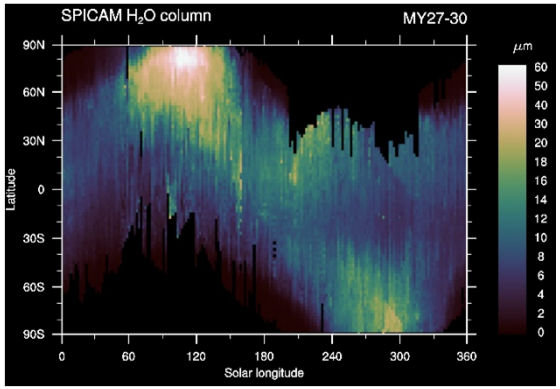
MEX-TGO climate synergies

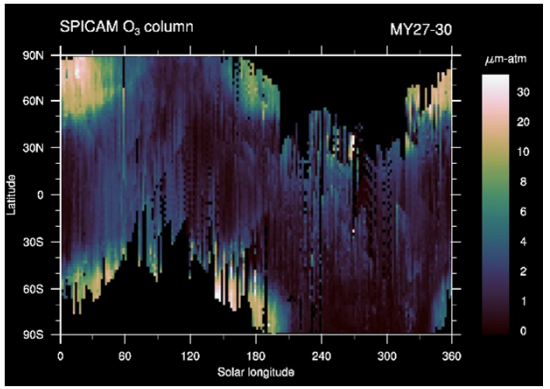
A. Määttänen

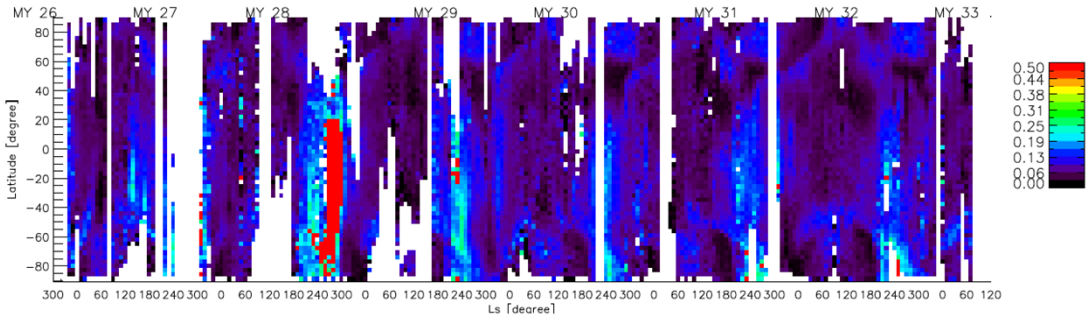
Mars Express IDS

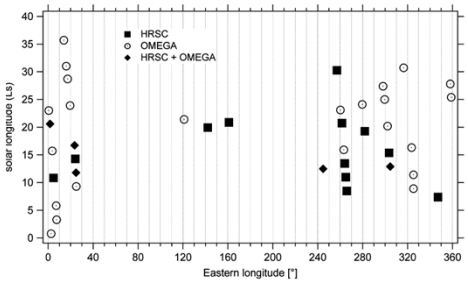
MEX Legacy

- Climatologies of:
  - Temperature
  - Dust
  - Water ice clouds
  - Water vapour
  - Ozone
  - Carbon monoxide
  - CO2 ice clouds
  - ….
- ADVANTAGE OF MEX: access to multiple local times (in contrast to MGS/TES, MRO/MCS...









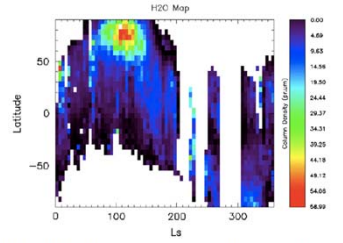


Fig. 8. Map of retrieved abundance of water vapour as a function of Solar Longitude (Ls) and Latitude as observed by PFS/SWC, from orbit 634 to orbit 6537, obtained using spectra averaged in 5° Ls × 5° Latitude bins.

MEX + TGO

- For climate studies long, continuous datasets are important:
  - Statistics
  - Interannual variability
- For climate studies good local time coverage is important:
  - Diurnal variations (examples: thermal tide, cloud formation, dust storm evolution)

- ☛TGO will complement the MEX climatologies
  - continuing the datasets of MEX
  - overlapping observations (intercomparison/cross-calibration possible?)
  - with a different LT coverage (complement the LT coverage)

- if TGO mission extends beyond MEX lifetime, it will also prolong the climatologies

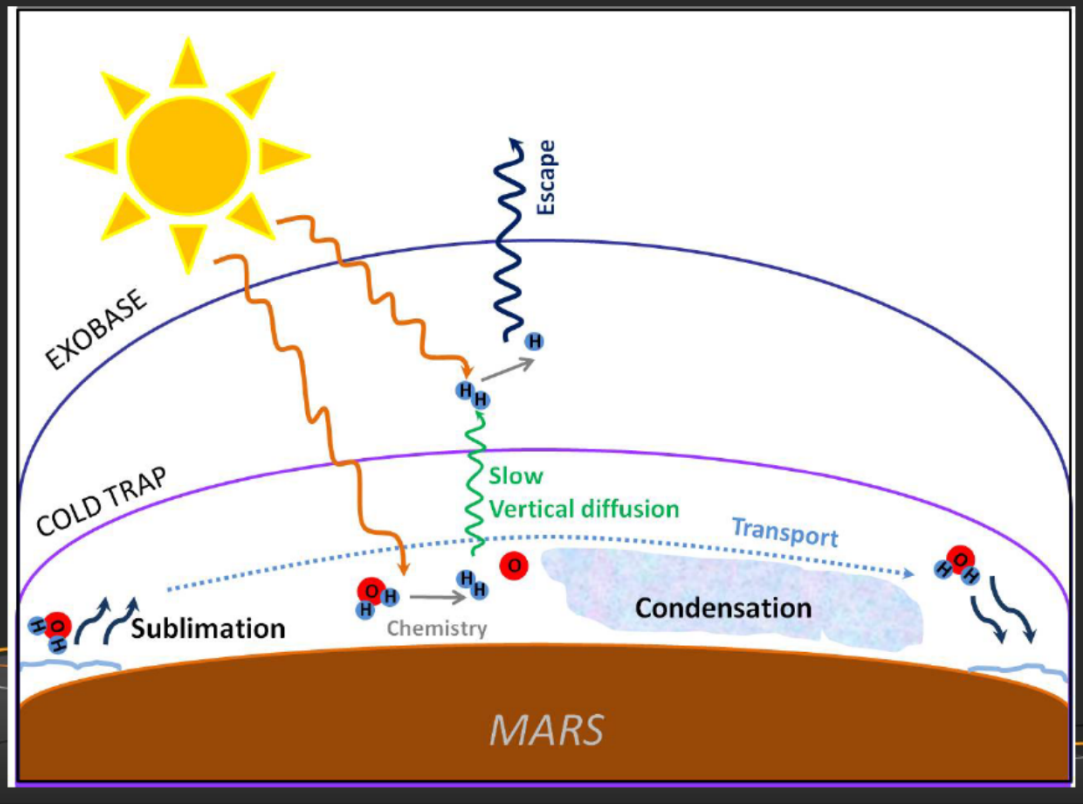
MEX + TGO + ground-based observations

- F. Forget pointed out at the last MEX SWT that MEX could be used in a novel way: full-disk viewing at apoapse
  - VMC is already doing this!
  - using the other instruments would allow for obtaining full-disk snapshots of climatological variables
  - sometimes better lighting conditions (when periapse in the night): increases the observation opportunities during the mission
  - confrontation with higher resolution observations (MEX+TGO)
  - confrontation with (possibly near-simultaneous) groud-based full-disk observations
  - would this be possible?

Upper atmosphere and escape

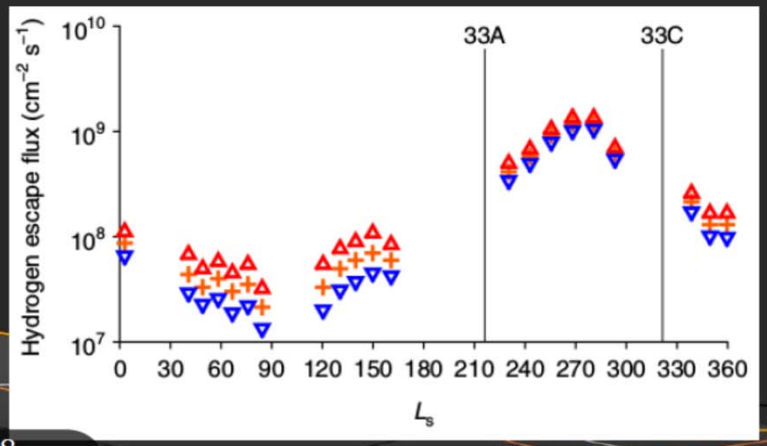
MEx+TGO+MAVEN: Water from surface to escape

- Classical picture of water escape



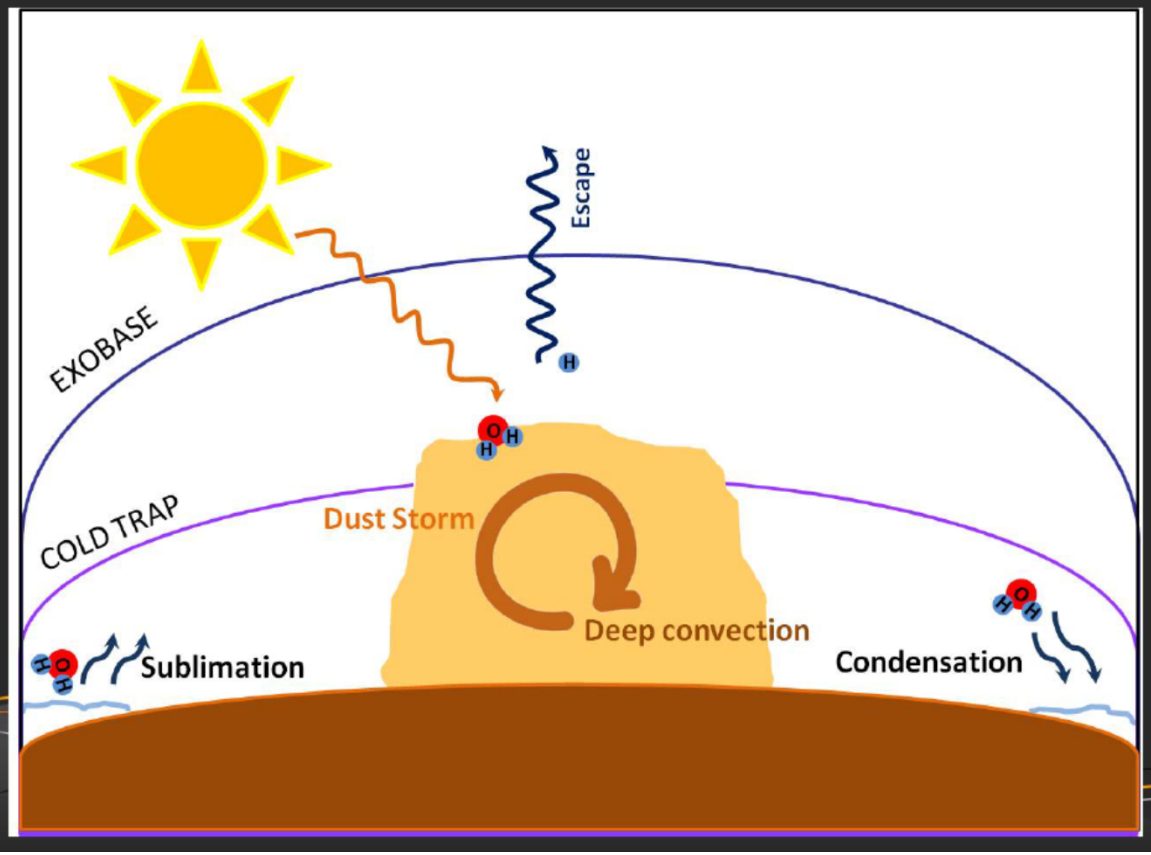
MEx+TGO+MAVEN: Water from surface to escape

- Classical picture of water escape
- Recent observations show things are more complicated:
  - Strong fast variability in H thermal escape, seasonal and/or dust storms
  - Supersaturated water vapour in the middle atmosphere
  - Water-derived ions



Heavens et al., 2018

MEx+TGO+MAVEN: Water from surface to escape



MEx+TGO+MAVEN: Water from surface to escape

- Classical picture of water escape
- Recent observations show things are more complicated:
  - Strong fast variability in H thermal escape, seasonal and/or dust storms
  - Supersaturated water vapour in the middle atmosphere
  - Water-derived ions
- Better characterization of links between lower atmosphere and H escape by combining:
  - MEx measurements of water and dust cycles (inc. profiles by SPICAM SO)
  - Regular TGO measurements of H2O (and HDO) profiles
  - MAVEN measurements of H escape and water ions

Radio Science on TGO vs MEX

- **Not yet an official topic on TGO**
  - **Earth Radio occultation measurements can be achieved at a fairly low cost and with a high value**

- **MEX → TGO mutual radio occultations**
  - **Better spatial and local time coverage**
  - **Independence on radio-occultation seasons**
  - **Higher S/N ratio**
  - **No distortions in the Earth atmosphere/ ionosphere and interplanetary medium**

Instruments cross-calibration

- *CASSIS - HRSC*
- *ACS & NOMAD - SPICAM*
- *ACS (TRVIM) - PFS*

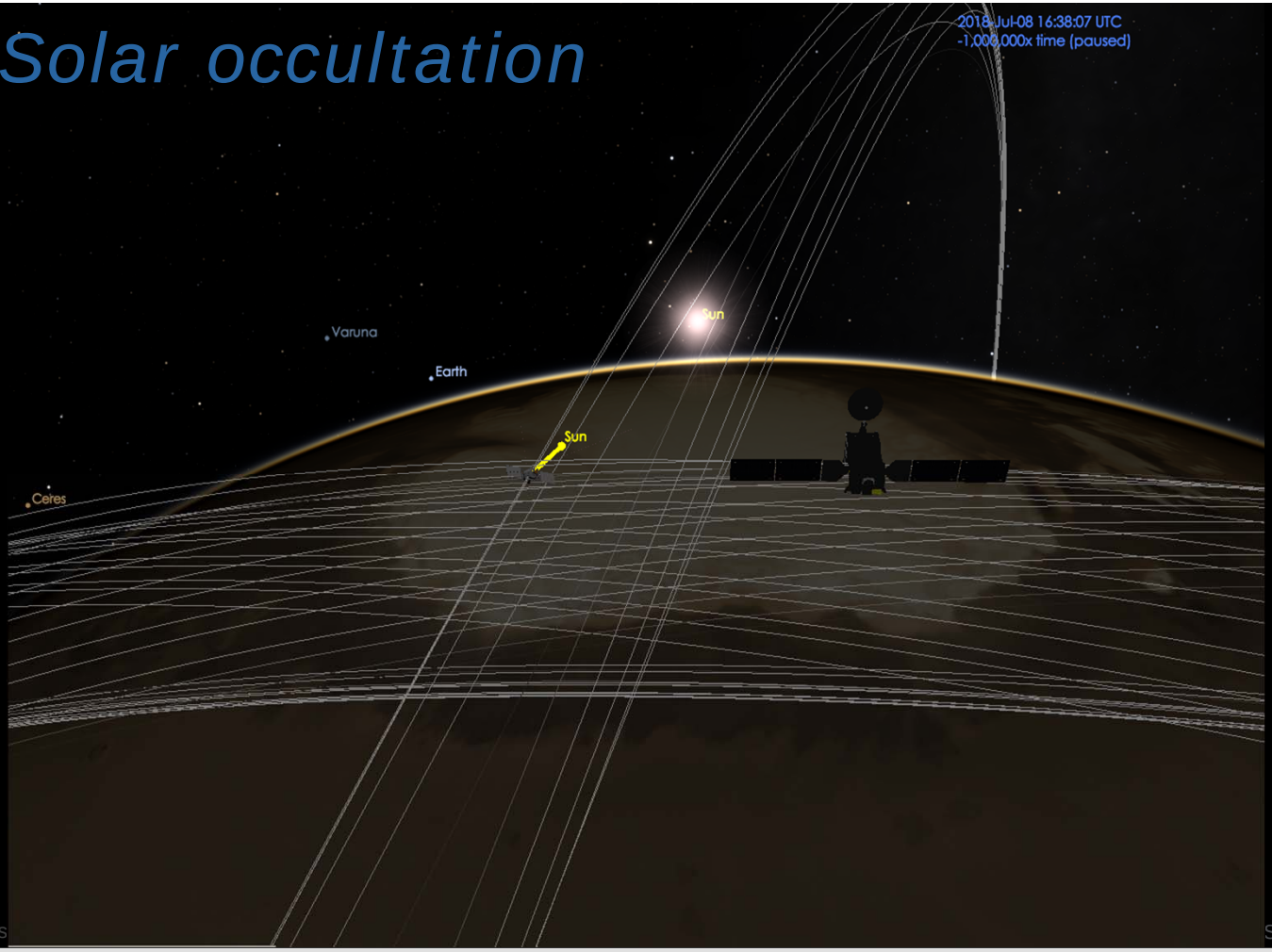
Comparison of radiative transfer codes and retrieval tools

Collaboration with other missions

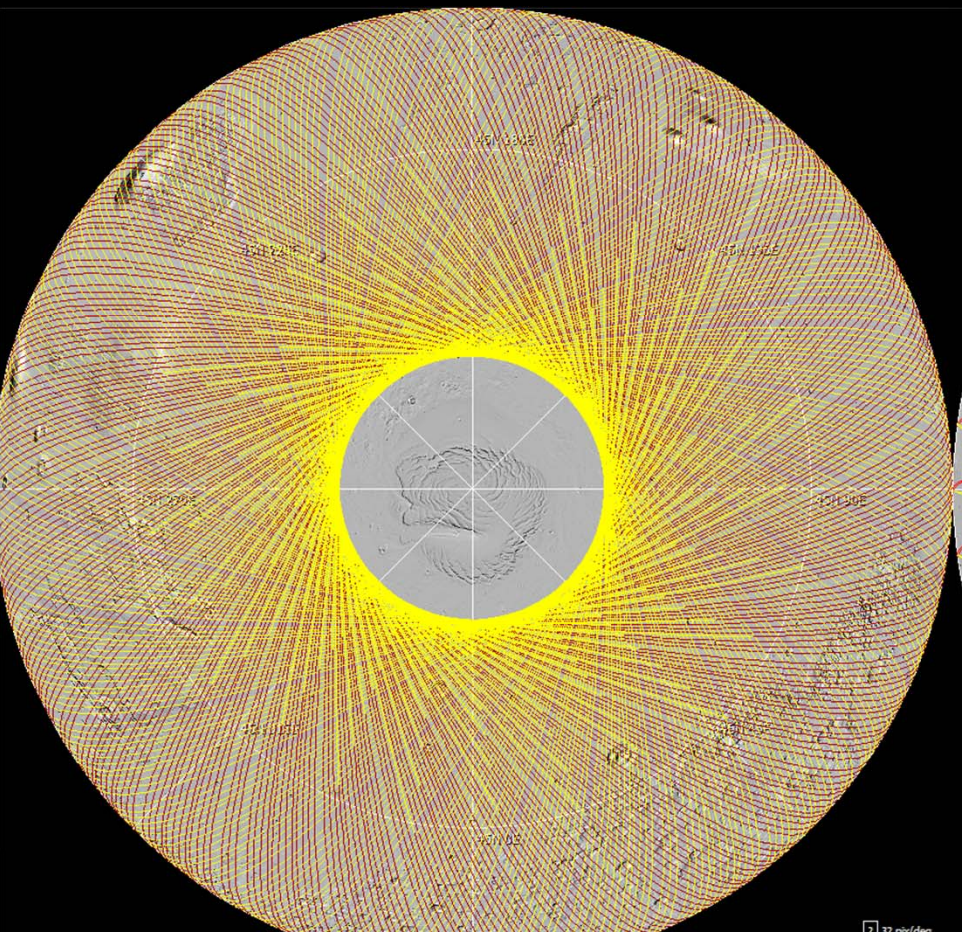
Additional slides

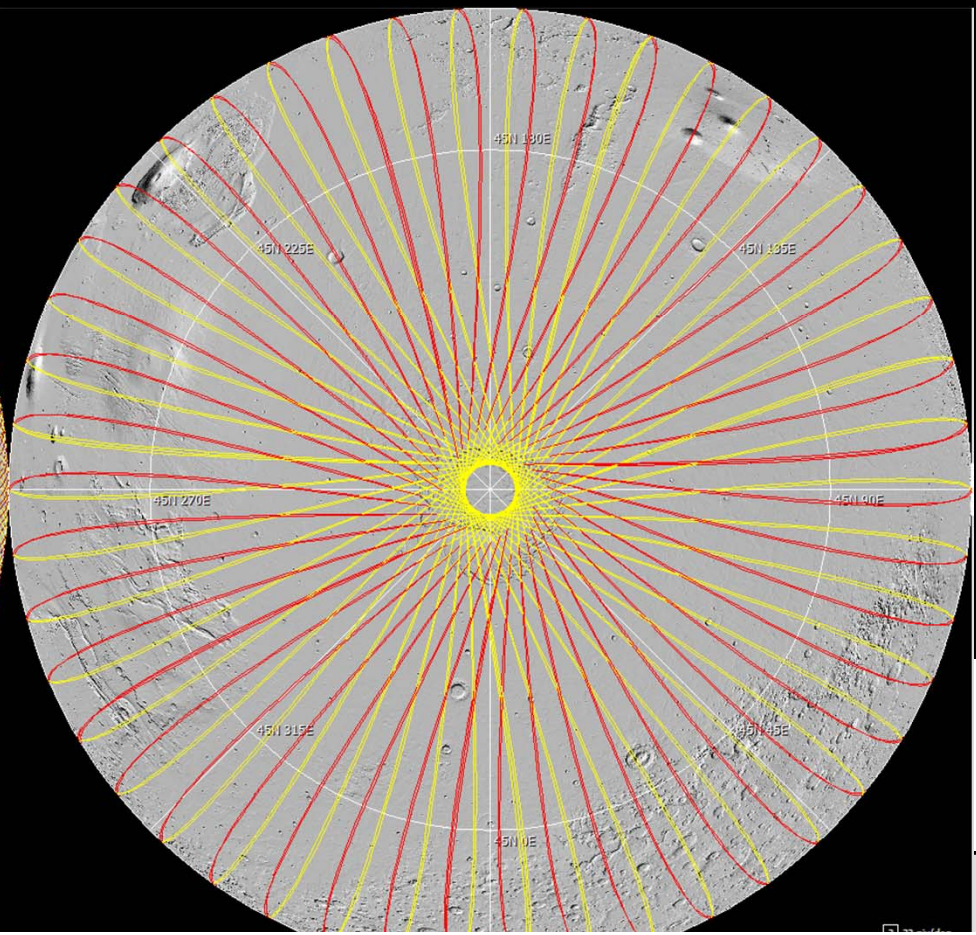
MEX – TGO collaboration

Solar occultation

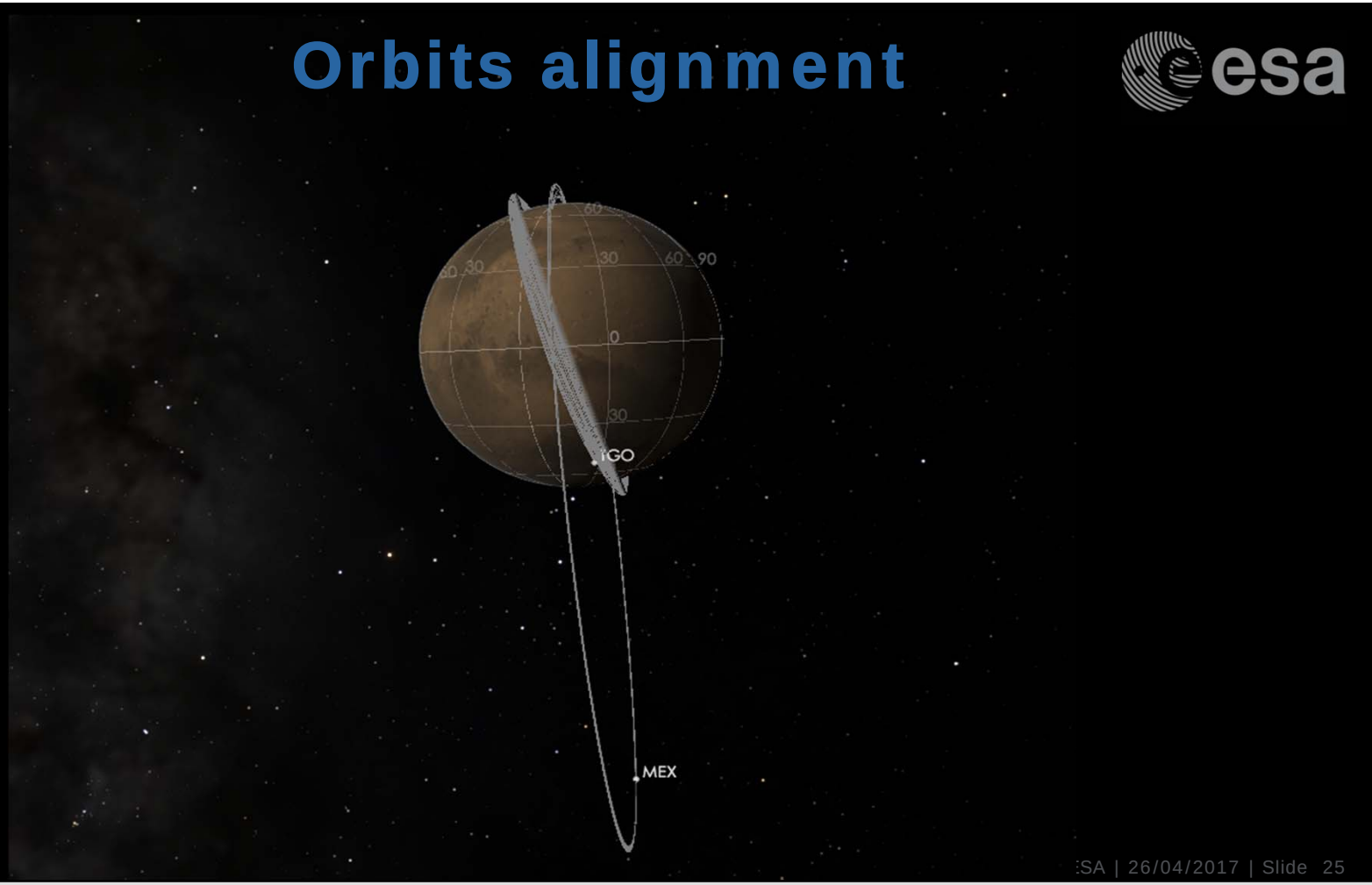


Nadir observation





Orbits alignment



Topics for the discussion

- climatological parameters (temperature, minor species, dust and ices)
- assimilation of MEX measurements in GCMs
- couplings between atmospheric layers:

  from the lower atmosphere to the exosphere
- dependence of escape on the state of the lower atmosphere

- surface: photometric properties and temporal variations
- sub-surface ice and its correlation with surface geology and mineralogy
- evolution of the polar caps and polar atmosphere

Implementation

- **Collaboration in data analysis**
  - *Early sharing and discussion of results*
  - *Cross comparison of retrieved climatological parameters*
  - *Joint use of TGO and MEX data in GCMs*
- **Collaboration at operations level**
  - *MEX support by providing data products*
  - *Analysis of joint observation opportunities*
  - *Joint Long-term activity plan (targets, campaigns)*
  - *Simultaneous and co-located observations*
  - *Filling gaps in the surface coverage*

Measures to foster MEX-TGO collaboration

- Exchange of Co-Is between TGO and MEX
- Selection of IDS and participating scientists on ExoMars
- “Gap analysis” in both topical and competence domains
- Implementation of operational synergies and collaboration at operational level
- Release of MEX high-level data products
- Conferences and data workshops