Investigating the Global Dust Storm in Mars Year 28 with Mars Express

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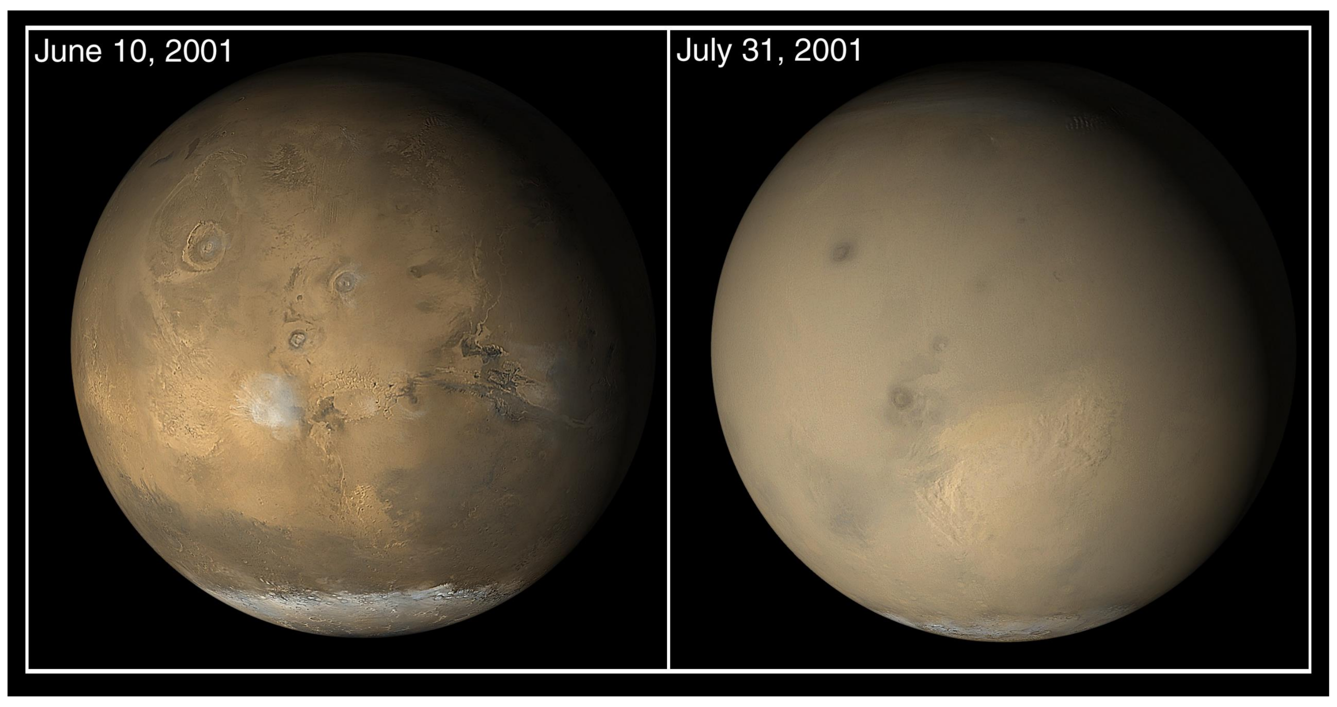
Introduction

Mars does not have a global magnetic field, and is exposed to the solar wind. This planetary induced magnetosphere forms several boundaries as the solar wind is deflected around Mars, including the bow shock and induced magnetospheric boundary (IMB).

During Mars' dust season, storms can grow and merge into global storms that cover the entire planet, lasting several months. These last occurred in 2018, 2007 and 2001. They have a profound impact on the Martian atmosphere, and we investigate if this effect can be seen further up into the plasma environment of Mars.

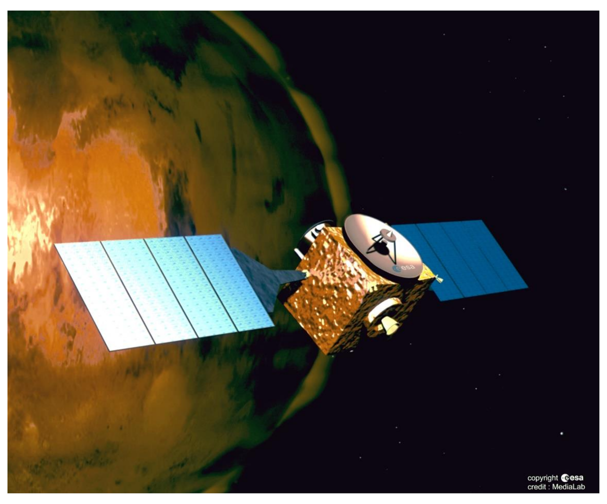


2001 global dust storm as observed by the Hubble Space Telescope. Image credit: NASA

Mars Express

European Space Agency mission

- 2003 – present
- ASPERA-3 Instrument: Analyser of Space Plasmas and EneRgetic Atoms
- Contains an electron spectrometer, two energetic atom sensors and an ion spectrometer

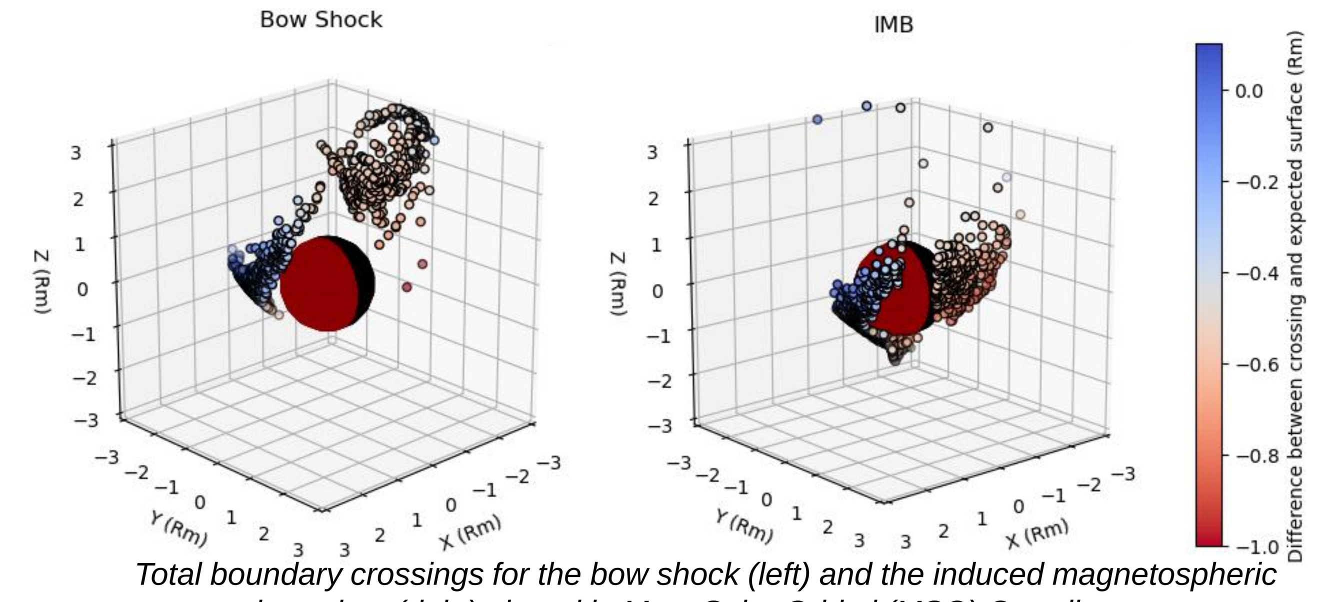


Artists impression of Mars Express. Image credit: ESA

Mars Year 28 Dust Storm

- Ls 256° – dust lifted 30 – 40 km (July 2007)
- Ls 275° – storm became global (mid-August)
- Ls 320° – normal surface conditions (mid-October)

Effects include atmospheric temperature increases[1] up to 40°K, increased photoelectron flux[2], CO_2 and H_2O concentrations at higher altitudes[1,2]. Ionisation levels increasing as dust and aerosols mix in the atmosphere[3].



Total boundary crossings for the bow shock (left) and the induced magnetospheric boundary (right) plotted in Mars Solar Orbital (MSO) Coordinates

Data Collection

Identify crossings of the bow shock and IMB from May – November 2007 using ASPERA-3 data. Identification done by eye for IMB crossings and using the Hall 2016 model[3] for bow shock crossings.

- 826 bow shock crossings (481 dayside, 345 nightside)
- 908 IMB crossings (663 dayside, 245 nightside)
- 6 IMB crossings misidentified as the bow shock by Hall 2016 model
- 195 bow shock crossings missed by the Hall 2016 model

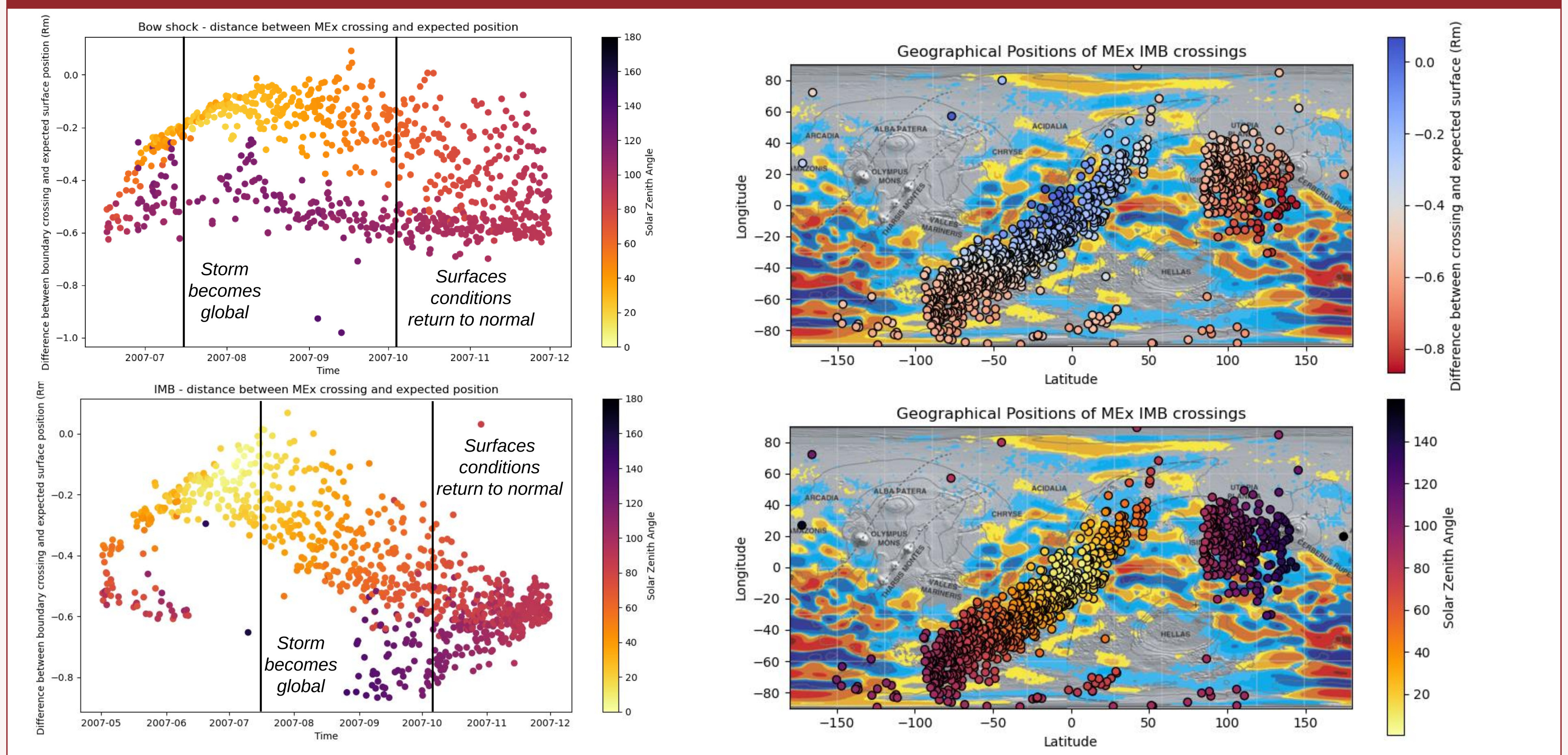
Boundary Modelling

Compared crossing positions to modelled surface position from 3D MHD models[4] provided by Wang *et al.*, 2020. Surface is represented by a generalised conic section, using parameters provided by Wang for the given solar wind conditions that were generated using ENLIL through the Community Coordinated Modeling Center.

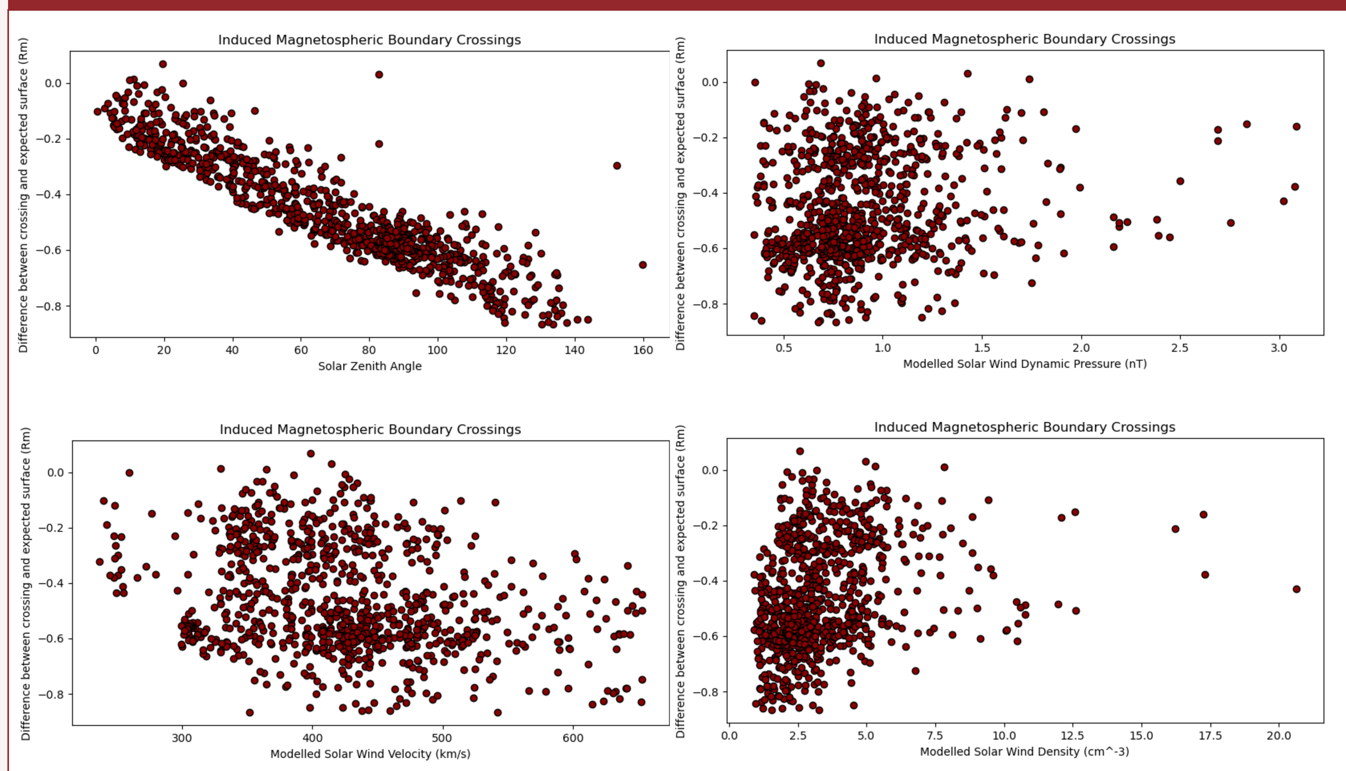
$$r = r_0 \left(\frac{1.0+\varepsilon}{1.0+\varepsilon\cos\theta}\right)^{\alpha_0+\alpha_1\cos[2(\phi-\omega)]+\alpha_2\cos\phi+\alpha_3\sin\phi}$$

Where r_0: subsolar stand-off distance, ε: eccentricity, α_0: degree of flaring, α_1: elongation degree, α_2: north-south asymmetry, ω: twisting angle, n: solar wind number density, V: solar wind velocity and P_d: solar wind dynamic pressure.

Results



Conclusions and Further Work



- Results show increased scattering as dust storm progresses
- Clear influence of the solar zenith angle
- Flaring of boundaries shows more uncertainty in position
- Continue work to compare to crustal magnetic field models
- Aim to disentangle the many influences on the system to leave a (possible) dust effect

References

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Paper in preparation

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