Investigating the 2007 global scale dust storm at Mars with ASPERA-3

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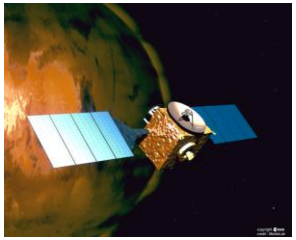
(1) Introduction

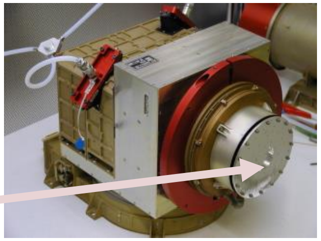
Mars' atmosphere is exposed to the solar wind due to the lack of a global magnetic field, allowing the contents of the atmosphere to be stripped away and lost into space.

Dust transportation plays an important role in the Martian climate system. As dust content increases, atmospheric and thermospheric heating increases which increases ionospheric densities causing expansion. Dust storms may merge and create a planet-wide dust event. The last two global scale storms occurred in 2007 and 2018 (Mars Years 28-29 and 34).

(2) Mars Express ASPERA-3 ELS



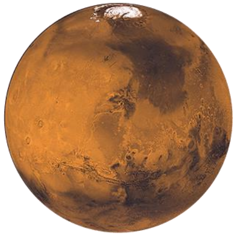
Mars Express artists impression (left) and ASPERA-3 instrument (right). Image credit: ESA



- Launched 2003, began science operations in 2004
- ASPERA-3: Analyser of Space Plasma and EneRgetic Atoms. Contains two energetic neutral atom sensors, an electron spectrometer (ELS) and an ion spectrometer[1]
- ELS is a top-hat electrostatic analyser covering electron energies 0.001 – 20 keV
- 4° x 360° intrinsic field of view divided into 16 sectors[1]

(3) 2007 Global Scale Dust Storm

- Dust lifted to 35 – 40 km altitudes in July (Ls = 256°)
- Dust storm became global in mid-August (Ls = 275°)
- Decay phase began late August (Ls = 285°)
- Normal conditions observed in mid-October (Ls = 320°)



Dust Storm Effects:

- Temperatures rose up to 240 °K at high latitudes, and increased by 40 °K in the Southern Hemisphere[2]
- North pole temperatures increased with a lower dust opacity[2]
- CO_2 particles dominate a larger altitude range due to heating from dust[2,3]
- Photoelectron flux enhanced[3]
- Ionisation due to dust and aerosols reaches higher in the atmosphere as mixing of dust aerosols increases[4]
- Enhancement of plasma density and increased peak altitude over magnetic field regions due to net upward motion[4]

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(4) Research Methods

- Look at electron energy and distribution against altitude of MEx
- Link to location on Mars below to identify if there is a difference due to geographical location
- Compare to conditions before and after the storm

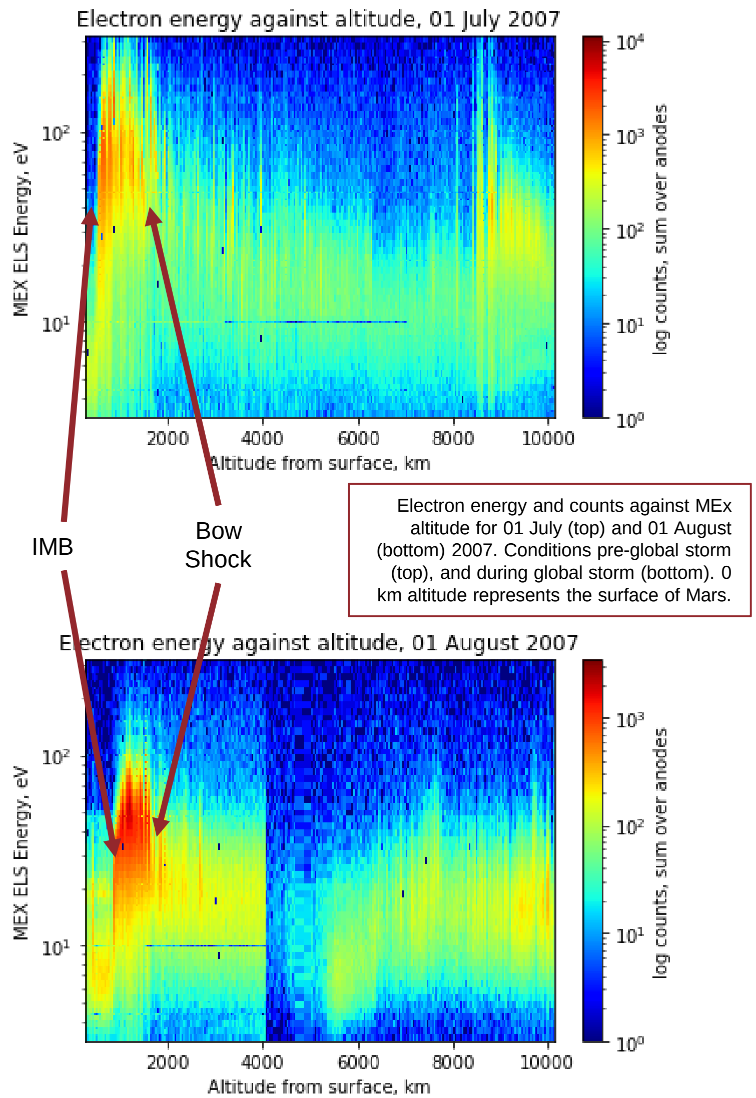
(5) Preliminary Results

Expectations:

- Signatures of photoelectrons to increase in altitude
- Boundaries (bow shock, photoelectron boundary, induced magnetospheric boundary (IMB)) increase in altitude
- Difference in northern and southern hemisphere

Initial observations:

- IMB and bow shock located further from the surface when the storm is global
- Density of electrons increases above ~1000 km in August with slightly lower energies



Electron energy and counts against MEx altitude for 01 July (top) and 01 August (bottom) 2007. Conditions pre-global storm (top), and during global storm (bottom). 0 km altitude represents the surface of Mars.

(6) Discussion

- Ionisation increases due to increased heating of particles in atmosphere and ionosphere
- Pressure on boundaries increases, pushing them further from the surface
- Increased ionisation may lead to increased atmospheric loss rates

Next Steps:

- Analyse data from July – October 2007
- Look at the position of MEx in relation to the surface
- Consider anode field of view and solar wind conditions

(7) Conclusion

- IMB and bow shock appear further from the surface during the storm (compared to models)
- Pressure on the boundaries increases as ionisation increases
- Other factors need to be considered to understand how the system is responding

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