Investigating the Martian atmosphere using the ExoMars 2016 lander

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Martian Dust Storms

I am studying the impact of atmospheric dust on the Martian climate.

Dust within the Martian atmosphere absorbs solar radiation and re-radiates at infrared wavelengths. This heats the surrounding atmosphere, which affects wind patterns and alters the planet's climate. Dust storms may also be also a hazard for spacecraft landing on Mars, and I am investigating the factors that affect the formation, growth and variability of these storms.

Gaining a greater understanding of the current Martian climate will facilitate more accurate predictions of atmospheric conditions, assisting in the planning of future missions.

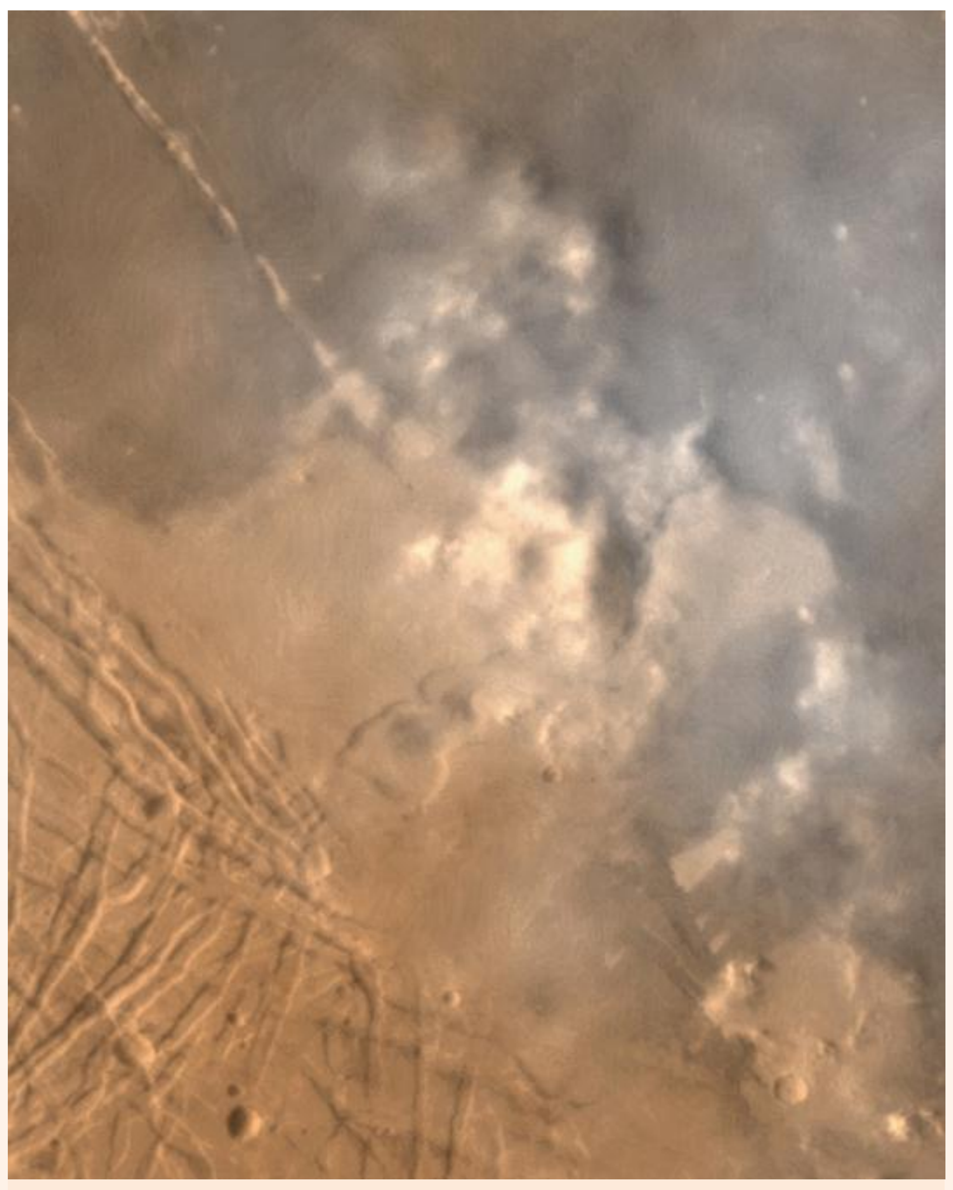

Figure 1
Dust storms imaged by the Mars Orbiter Camera (MOC) aboard Mars Global Surveyor (MGS).
Credit: NASA/JPL/Malin Space Science Systems

Atmospheric Modelling

Accurate modelling of the Martian atmosphere is essential for planning and completing future surface missions, and for appropriate analysis and interpretation of the returned data.

A Mars Global Circulation Model (MGCM) is a global, multi-level numerical model of the Martian atmosphere that can simulate physical processes ranging in scale from hundreds of kilometres to global scales. These models are used for conducting experiments that test climate and environmental hypotheses, and for predicting future climate patterns and events.

Processes in the model include surface dust lifting, transportation and sedimentation, allowing study of the growth, behaviour and decay of dust storms.

ESA ExoMars 2016

The ESA ExoMars 2016 mission will carry an Entry, Descent and Landing Demonstrator Module (EDM). EDM will land on Mars as the planet enters the annual dust storm season.[1]

Vertical profiles of the Martian atmosphere, such as temperature and wind speed, can be reconstructed using engineering data transmitted by the EDM during its descent and landing.[2] Incorporating these profiles into the MGCM will improve the model's accuracy.

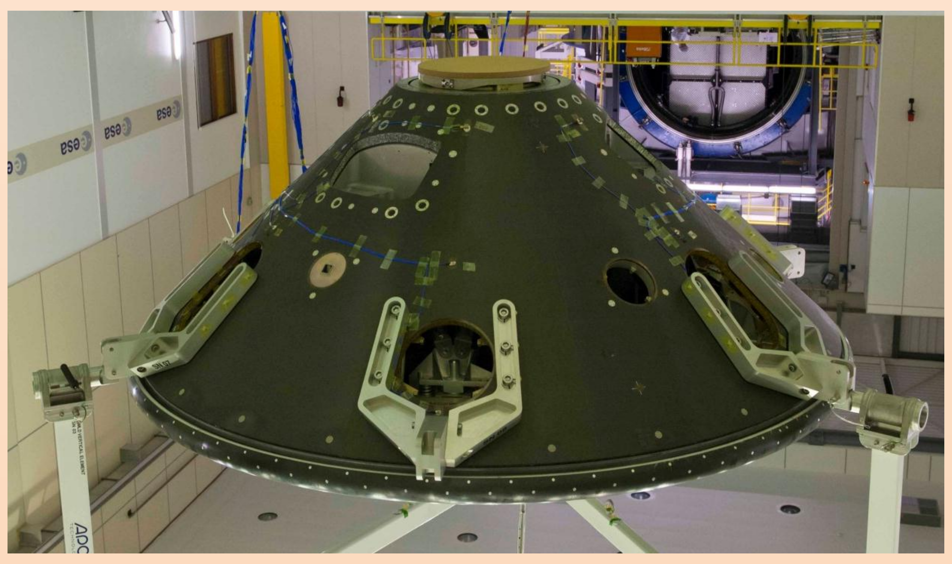

Figure 2
A structural model of the ESA ExoMars Entry, Descent and Landing Demonstrator Module during preparations for vibration testing.
Credit: ESA, Anneke Le Floc'h

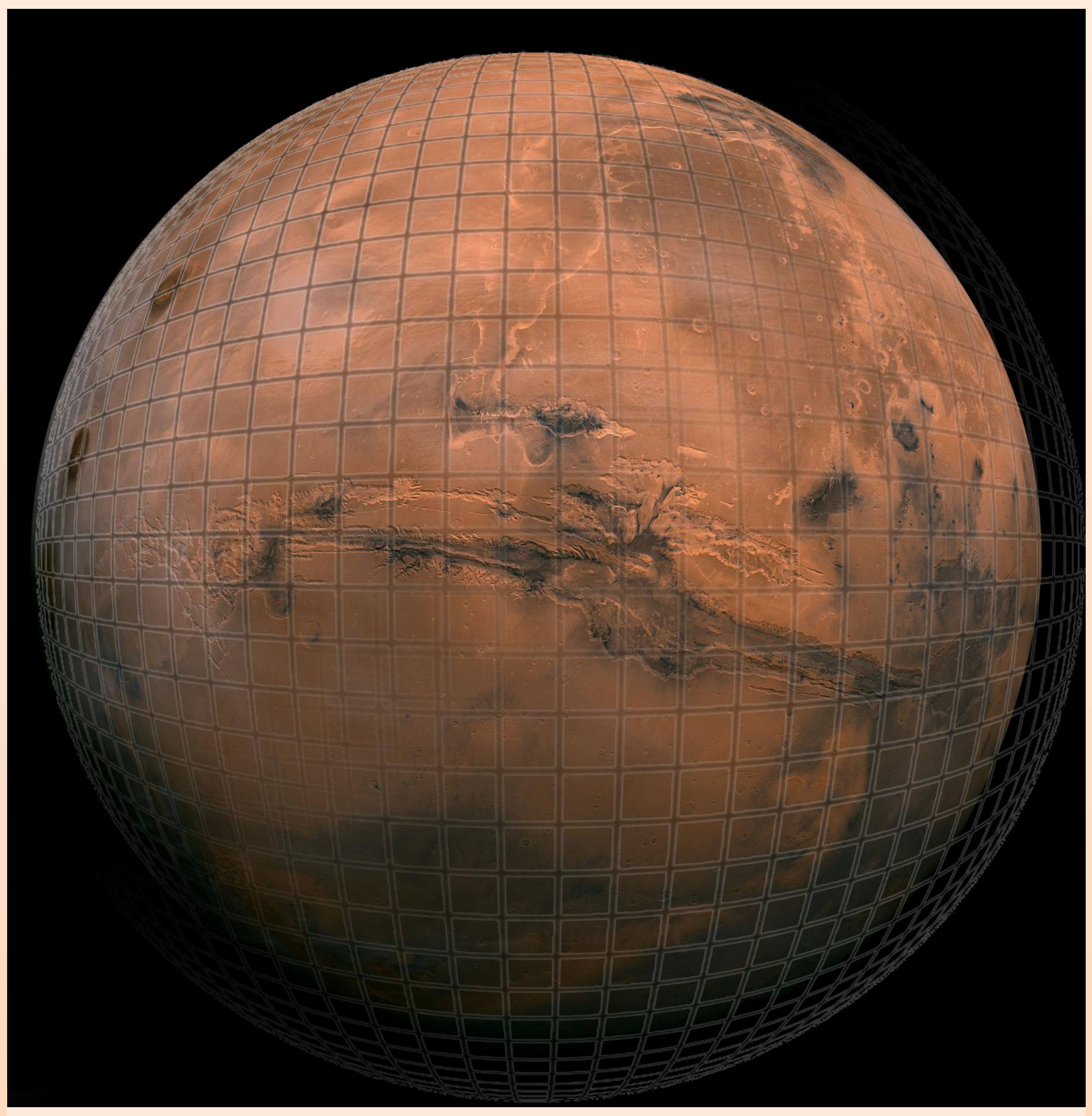

Figure 3
The MGCM divides the atmosphere into a grid of latitude by longitude by height. Sub-models operate within this grid to implement parameterisations of physical processes.
Base image: NASA/JPL-Caltech Viking mosaic

Modelling Surface Dust Lifting

I am using the MGCM to investigate the two mechanisms that lift dust from the surface of the planet: near surface wind stress and dust devils.

- Dust devils are small-scale atmospheric vortices, and are generally considered to give rise to the background haze of dust in the Martian atmosphere.
- Near surface winds are proposed as the driving force behind the formation and growth of dust storms. Dust lifting by near surface wind stress is simulated using the strength of the wind at the planet's surface, as calculated from large scale winds.

I am initially focusing on the dependence of dust lifting on near surface winds associated with small-scale features, with the goal of improving the model's representation of the dust lifting mechanism that drives storms.

Understanding the behaviour of Martian dust storms – and the related variability in atmospheric quantities such as temperature, density and wind speeds – is crucial for planning future missions to the planet's surface.

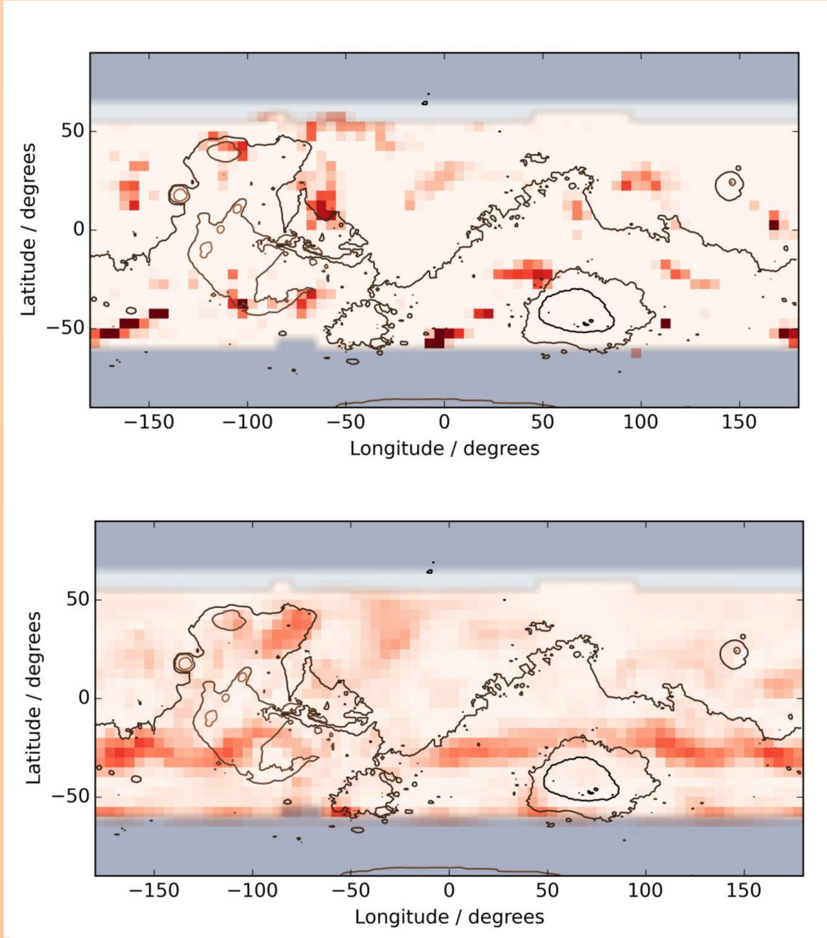

Figure 4
Total dust mass lifted (kg/m^2) by near surface wind stress (top) and dust devils (bottom) within one Martian month during the planet's Northern Hemisphere winter.
Darker red indicates a higher level of dust lifting at that grid-point. Grey regions identify the extent of seasonal polar ice caps.

References

[1] Forget et al. (2011). Fourth International Workshop on the Mars Atmosphere: Modeling and Observations, Paris.

[2] Ferri et al. (2012). 9th International Planetary Probe Workshop (IPPW9), 18 - 22 June 2012, Toulouse, France.

Martian Regional Dust Storms: Implications for Entry, Descent and Landing
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