The circulatory impact of dust from dust profile assimilation

Conference or Workshop Item

How to cite:

For guidance on citations see FAQs.

© The Authors

https://creativecommons.org/licenses/by-nc-nd/4.0/

Version: Poster

Link(s) to article on publisher’s website:
https://www.cosmos.esa.int/web/mars-science-workshop-2018/

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online’s data policy on reuse of materials please consult the policies page.
The circulatory impact of the vertical dust structure

Paul Streeter¹, Stephen Lewis¹, Manish Patel¹,², & James Holmes¹

¹School of Physical Sciences, The Open University, Milton Keynes MK7 6AA, UK, ²Space Science and Technology Department, STFC, RAL, UK (paul.streeter@open.ac.uk)

Dust Profile Assimilation

- Mineral dust is the key radiative forcer in the martian atmosphere.
- Data assimilation: LMD-UK MGCM + observations = best estimate of state (e.g. [1]).
- Vertical dust structure shown by MCS to be more complex than previously assumed [2].
- MCS dust profiles and columns are assimilated to examine impact on the circulation and transport (“3D”), and compared to a MCS column-only assimilation (“2D”) for MY 31.

Zonal Temperatures and Winds

**3D**

Major difference between assimilation cases is significantly warmer lower-middle atmosphere for the 3D case, due to greater dust representation above 10 km, and enhanced polar warming. Northern polar warming is also shifted higher, potentially heating the lower thermosphere.

In general, 3D case shows strengthened circulation, including as a strengthened southern polar jet; however, northern polar jet mostly unaffected, although strengthened at very high altitudes.

Asymmetry implies vertical dust distribution (i.e. more dust higher up) has most significant effect around “clear” season, when insolation is lower and more high-altitude dust layers are present.

Seasonal asymmetry also related to topography: elevated dust layers act to mitigate topographic asymmetry [3,4] by providing elevated heating source in northern hemisphere.

**3D-2D**

Above: zonal-mean temperatures and zonal winds for assimilated output from 3D assimilation (left) and the difference between 3D and 2D assimilation (right), averaged over ~15 solar longitude degrees for three periods in MY 31 using MCS data.

Top right: average dust mass mixing ratio over southern polar vortex for 3D and 2D assimilations.

Bottom right: mean meridional circulation for same periods as above zonal-mean plots.

**Ls**

- Better fit with observed dust exclusion over southern polar vortex [5], suggesting dynamical explanation.
- Mean meridional circulation (MMC) structure sees greatest difference around southern winter, with dramatically intensified Hadley cell. Suggests extra high-altitude dust mitigates topographic effects, as high dust loading can [6]. This has implications for long-term inter-hemisphere transport.

Transport

3D case sees some reduced surface eddy activity (Ferrel cells) due to greater lower-atmosphere static stability, which could impact eddy dust transport into polar regions. However, also see increased eddy activity at higher altitudes, due to increased thermal contrast at dust layer top.

Figures

- Detailed figures showing assimilated model (right) as combination of TES dust profiles and columns, assimilation cases is dramatically strengthened the N->S Hadley cell. Stronger Hadley cells overall.
- Reduced near-surface eddy activity; possible explanation for southern dust exclusion. TGO will offer a new dataset of dust profiles across a range of martian local times.

Summary

- Vertical dust structure has significant impact on temperature structure, global circulation, and transport.
- Circulatory impact of increased elevated dust presence appears greatest during lower-insolation times of year: mitigates effect of hemispheric topographic asymmetry and dramatically strengthen the N->S Hadley cell. Stronger Hadley cells overall.
- Reduced near-surface eddy activity; possible explanation for southern dust exclusion. TGO will offer a new dataset of dust profiles across a range of martian local times.

Acknowledgements

PMF acknowledges support from the UK Science and Technology Facilities Council under ST/012402/1 (STFC) and The Open University in the form of a PhD studentship. D.L., S.R., and J.H. acknowledge support as part of the project HERACLES (633127), funded by the European Commission’s Horizon 2020 programme. S.R. and J.H. also acknowledge the support of the UK Space Agency (STFC) under grant ST/R507606/1 (MSP). All authors are particularly grateful for discussions with David Kass and the MCS team (NASA JPL) and with Peter Read (Oxford) and Francois Forget and colleagues (LMD/CNRS Paris).

References