Asymmetric impacts on Mars’ polar vortices from the 2018 Global Dust Storm

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The 2018 Global Dust Storm had significant and asymmetrical impacts on the morphology and intensity of Mars’ two polar vortices. The southern vortex was substantially diminished while the northern vortex remained robust, but both were reduced in ellipticity. These vortex changes enhance transport into Mars’ southern (but not northern) polar region and modify longitudinal transport patterns.

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Background: ESA/DLR/FU Berlin
Polar vortices

- Common feature of planetary atmospheres
- Regions of cold, isolated air over winter pole circumscribed by powerful westerly wind jet
- Mars has characteristically elliptical vortices
Methods

OBSERVATIONS: Mars Climate Sounder (MRO/MCS) + Atmospheric Chemistry Suite (TGO/ACS)

MODEL: Mars Global Climate Model (MGCM)

DATA ASSIMILATION

2018 GLOBAL DUST STORM

- Mars Year (MY) 34
- Latitudinal extent: ~40 N to ~60 S
- Lasted several months
- Occurred at Mars equinox (transition from southern autumn/winter to southern spring/summer)
- Compared to MY 33, a “typical” year on Mars (no Global Dust Storm)

POTENTIAL VORTICITY (PV)

- Conserved dynamical/thermodynamic quantity
- Useful tracer for polar vortex location and intensity
- Greater value → more intense polar vortex
What?

North

• More symmetrical polar vortex shape; non-elliptical
• Reduced area
• Similar intensity
• Narrowed westerly jet

Why?

Clear

South

• More symmetrical polar vortex shape; non-elliptical
• Substantial local reduction in potential vorticity
• Significantly weakened winds

Why?
Why?

North

- Boosted meridional circulation...
- ...but limited diabatic (dust) heating

South

- High diabatic (dust heating) of the atmosphere
- Vortex already decaying (season)

Background: ESA/DLR/FU Berlin
What about shape?

- Plots of meridional wind deviation
- Reveals presence of stationary planetary waves: atmospheric waves with fixed position
- Stationary wave amplitude corresponds to decreased ellipticity of the polar vortices
- Topography anchors polar vortex morphology

Background: ESA/DLR/FU Berlin