Martian polar vortex dynamics and the 2018 Global Dust Storm

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Introduction

Mars’ winter atmosphere is characterized by a polar vortex of low temperatures around the winter pole, circumscribed by a strong westerly jet [e.g. 1]. These vortices are a key part of the atmospheric circulation and impact heavily on dust and volatile transport. They have a complex and asymmetrical (continuous relationship with atmospheric dust loading [2]; Regional and global dust events have been shown to cause rapid vortex displacement (ΔL) in the northern vortex, while the southern vortex appears more robust. This has implications for tracer transport through the zonal jets associated with the vortices [1]. A more coherent and low latitude zonal jet should provide a more effective barrier against tracers entering the polar regions. The 2018 Mars Global Dust Storm (GDS) was observed through its lifecycle by the Mars Climate Sounder (MCS) instrument aboard the Mars Reconnaissance Orbiter [1], using data assimilation [6] to integrate MCS retrievals [7] with the LMD Mars Global Atmospheric Climate Model (MGCM) [8] offers an opportunity to examine the effects of the GDS on the polar vortices.

Global dust storm effects

Fig. 1 shows the effect of the GDS on the potential vorticity (PV) and zonal wind speeds at the 300 K isentropic surface and for wind speeds between 20-30 km.

North Pole

Fig. 2: difference between zonally averaged PV (colours) and zonal wind speeds (contours) for MY 34 and MY 30 (MY 34 – MY 30), for the 300 K isentropic surface (PV) and for wind speeds between 20–30 km.

South Pole

Fig. 3: Potential vorticity at the 300 K isentropic surface (PV) and zonal wind speeds averaged between 20–30 km for MY 34 and MY 30, and the difference between them, for the north (left) and south (right) poles. Each circular line represents latitudes at 10 degree intervals, with the outermost circle being at 50 degrees. For the difference plots, dashed contour lines represent negative values.

Temporal variation

The GDS drastically accelerated the seasonal decay of the southern polar vortex; this was likely due to the enhanced diabatic heating from the high southern hemisphere dust loading destroying the equator-pole temperature gradient. The poleward shift in the highest westerly wind speeds at both poles suggests that equinoctial GDS events could allow greater tracer transport to high latitudes.

References


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