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Effects of the solstitial dust storms to the winter polar warmings in the Martian middle atmosphere

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The planet-encircling dust storms occurring around the northern winter solstice on Mars produce strong winter polar warmings in the middle atmosphere. Such features have been observed by the Viking spacecraft (so-called 1977b storm), and recently by the Mars Climate Sounder onboard the Mars Reconnaissance Orbiter in 2007 and 2009.

We have investigated the changes in the meridional circulation during the planet-encircling dust storms which produce such strong temperature inversions using a Martian general circulation model. It is shown that, in the simulation with the dust opacity τ=3 in visible wavelength, the tides, stationary planetary waves (SPW) with the zonal wavenumber s=1, and resolved small-scale gravity waves and eddies are significantly enhanced above the winter hemisphere. They caused vigorous poleward and downward transport, and, consequently, the adiabatic heating. The increase of the tidal forcing is mainly due to a stronger excitation in the summer hemisphere. Contribution of the SPW (s=1) increases during dust storms due to intensified generation in the lower atmosphere as well as due to more favorable vertical propagation. SPW (s=2) varies less with the dust load, dissipates lower, and contributes to the warming only below $\sim$0.1 mb. Transient planetary wave (s=1, period $\sim$5 sols) with a barotropic/baroclinic vertical structure provides up to 1/3 of the forcing by SPW (s=1).