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NUMERICAL SIMULATIONS OF DUST TRANSPORT INTO NORTHERN HIGH LATITUDES DURING A MARTIAN POLAR WARMING; J.R. Barnes and J.L. Hollingsworth, Department of Atmospheric Sciences, Oregon State University, Corvallis, OR 97331

A beta-plane tracer transport model has been developed and used to carry out numerical simulations of dust transport into northern high latitudes during a polar warming event. Such transport is potentially of considerable significance for the Martian climate system (1). The tracer model is identical, in essential aspects, to that developed by Garcia and Hartmann (2). The model represents tracer transport by the zonal-mean circulation and a single large-scale wave, with a simplified (severely spectrally truncated) latitudinal tracer distribution.

The flow for the tracer transport simulations has been generated using a beta-plane nonlinear dynamical model. Experiments with this model have demonstrated that a polar warming, with essential characteristics like those observed by the Viking IRTM during the 1977 winter solstice global dust storm (3), can be induced by the same basic mechanism responsible for sudden stratospheric warmings on Earth: anomalous amplification of the forcing of vertically propagating, planetary scale waves (4). As discussed by Barnes and Hollingsworth (1), the dynamics of such a polar warming (as well as one not produced by the forced planetary wave mechanism) imply poleward and downward transport of tracers into high latitudes. The so-called residual mean meridional circulation should constitute a good first approximation appropriate for the transport of tracers (5). Figure 1 shows the residual mean meridional velocity (at the center of the beta-plane channel, 60 degrees latitude) for a warming simulation with the nonlinear dynamical model. Very strong poleward flow (up to 7.5 m/s) is present throughout the warming above 20 km. There is weak equatorward flow below 20 km which develops after the peak warming occurs at about sol 10. In conjunction with this the residual mean vertical velocity is strongly downward (up to 5 cm/s) at high latitudes, at all levels, throughout the warming. This residual mean meridional circulation would be expected to produce significant poleward and downward transport of tracers (e.g., dust) which are initially confined largely equatorward of 60 degrees latitude. The extent of such transport might depend fairly strongly on the amounts of the tracer initially present at upper levels (above 20 km) at lower latitudes.

The numerical tracer simulations that have been carried out have been aimed at dust transport during a polar warming, given an initial zonal-mean distribution of dust that could have been produced by the zonally symmetric circulation in the very early stages of a global dust storm (6). The sensitivity of the dust transport to its initial vertical distribution has been examined, as well as the sensitivity to factors which influence the character of the polar warming, such as the zonal wind profile, the radiative damping, and the nature of the wave forcing. An attempt has been made to simulate dust deposition on the surface by incorporating a simple sedimentation term in the tracer transport model.

SIMULATIONS OF DUST TRANSPORT
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Figure 1: The residual mean meridional velocity at the center of the beta-plane channel (60 degrees north) for a wavenumber 1 polar warming simulation. The velocity is in m/s and the contour interval is 1 m/s; shaded regions represent equatorward flow. The vertical axis is height in km, and the horizontal is time in sols.