MESOSCALE SIMULATIONS OF POLAR CIRCULATIONS: LATE SPRING TO LATE SUMMER.

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Introduction: The OSU Mars MM5 computer model has been developed to study mesoscale atmospheric circulations on Mars. Development of the model and its validation against Viking and Pathfinder lander meteorology is described in [1]. Recently the model was used in a comprehensive high-resolution study of atmospheric circulations in the northern polar region during midsummer [2]. We will discuss results from this midsummer study along with select results from simulations performed in support of the proposed Mars Scout Phoenix mission that will land at high latitude in late spring (Ls~80).

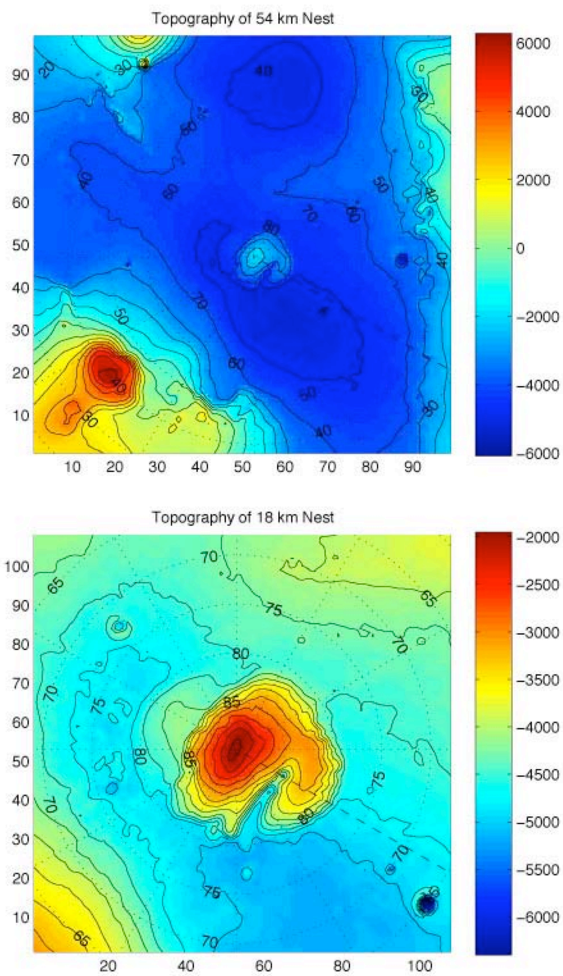

Figure 1. Topography of the nests used in the OSU Mars MM5. Axis numbering counts grid points in the domains. Contours intervals are 1000 m in the 54 km nest and 250 m in the 18 km nest.

Our simulations assume that the atmosphere is dry and we use hydrostatic dynamics; hydrostatic dynamics allows for long simulations (29 sols) and a good characterization of expected variability in the midsummer polar weather. The model uses a modified TES thermal inertia map, which yields a realistic simulation of the midsummer surface thermal environment in the high polar latitudes. The NASA Ames Mars GCM provides boundary and initial conditions for all simulations. There are two nested domains at spatial resolutions of 54 km and 18 km; the topography of these nests is shown in Fig. 1. These nests allow a high-resolution characterization of midsummer circulations in the northern polar region.

Zonal Mean Circulations: The zonal-mean circulation during midsummer immediately over the North Pole Residual Cap (NPRC) is characterized by near-surface easterlies and off-cap katabatic flow. The easterlies are relatively deep (~1.5 km) and fairly strong (~10 m/s), whereas the off-cap katabatic flow is relatively weak (~ 5 m/s) and shallow (~300 m). These flows are generally steady during the midsummer season and are suggestive in the context of the spiral troughs in the NPRC [3 and 4]. With a parameterized seasonal cap in the surface properties of the model for late spring conditions, the zonal mean circulation becomes quite vigorous.

Transient Circulations: Because of the higher resolutions used in these simulations, the use of modeling domains appropriate for polar studies and the realistic depiction of contrasts in the thermal environment near the NPRC, a great deal of transient eddy activity is seen to develop in each of our three midsummer simulations. During the midsummer study period between L_s=120 and L_s=150 there is a great deal of variability in the preferred locations of these eddies and in the physical processes that excite them.

At Ls=120 there is a dominant wavenumber one structure of transient circulations around the NPRC that exhibits retrograde motion (~5 sol period); this structure is often perturbed by flows associated with Chasma Boreale. By L_s=135 the atmosphere is in transition and we see the development of midlatitude transient circulations (forming on the northern slopes of Alba Patera and Tharsis) that transit the high latitudes to dissipate their energy on the NPRC. By L_s=150 the circulation is becoming winter-like and a polar jet has formed. Strong baroclinic storms are beginning to form along this jet and poleward fluxes of momentum and heat are becoming significant.

Using 20-sols of fully spun-up model output we have processed our data to produce mean diurnal cycles of the meteorological variables (*U*, *V*, *T* and *P*) at each location. From these data we have produced excursion quantities for the examination of transient circulations. Excursions from the mean diurnal cycle of surface pressure are useful for locating the centers of transient circulations with significant vorticity. As an example, for the L_s=120 case we show the 20-sol RMS amplitude of surface pressure excursions in the 18 km nest in Fig. 2. The 20-sol period is long enough to capture a couple "cycles" of natural variability in the circulation; thus, we believe that the general asymmetry and elevated activity associated with Chasma Boreale are representative of the transient activity at this date.

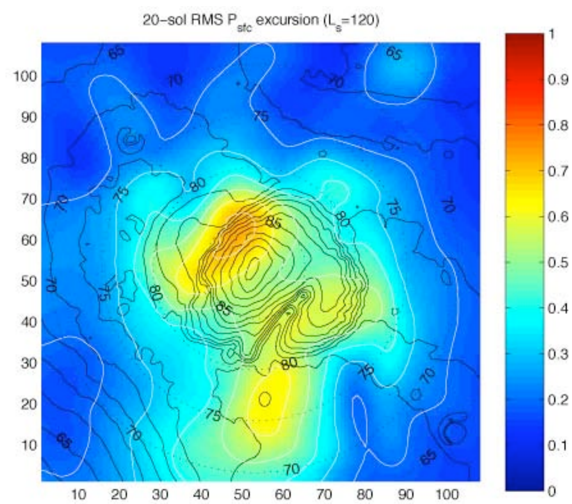

Figure 2. 20-sol RMS amplitudes of normalized surface pressure excursions for L_s=120. These data are from the 18 km nest. Axis numbering counts grid points in the domain.

Associated with the transient eddies at L_s=120 are strong winds (~15 m/s) that blow consistently and directly across the NPRC. These winds are very relevant in the water cycle of the NPRC during midsummer. Using mesoscale models to better understand the role of dynamics in the midsummer circulation may be very important in efforts to better describe the annual water cycle, especially the roles played by the NPRC and the regolith [5 and 6].

Additionally we have performed simulations to characterize the weather during the EDL phase of the proposed Mars Scout Phoenix mission. There is a great deal of transient eddy activity seen in these simulations that occurs along the transition from the edge of the cold seasonal cap to the much warmer surrounding terrain.

The polar atmosphere is filled with vigorous circulations from late spring through summertime. The changing dynamics during this period may be very important in the context of the annual water cycle; mesoscale modeling will be an important part of developing an improved understanding of these dynamics.

References: [1] Tyler, Jr. D. et al., (2002) *JGR, 107*; [2] Tyler, Jr. D. (2004) Ph.D. Dissertation, Oregon State University; [3] Howard A.D. (2000) *Icarus*, *144*, 267-288; [4] Herkenhoff K.D. and Plautt J.J. (2000), Icarus, *144*, 243-253; [5] Richardson M.I. and Wilson R.J. (2002) *JGR*, *107*; [6] Montmessin F. et al., (2004), *JGR*, *109*.