A MESOSCALE MODEL STUDY OF HIGH LATITUDE ATMOSPHERIC CIRCULATIONS AND TRANSIENT EDDIES IN THE NORTHERN POLAR SUMMERTIME.

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Introduction:

The Polar Regions of Mars are quite important to the present day climate and its evolution. Increasing our understanding of atmospheric dynamics in these regions requires an examination of atmospheric circulations on numerous scales, both spatial and temporal. During summertime in the northern Polar Regions a wide variety of atmospheric circulations can be observed; and, over a relatively short period dramatic changes can occur in the strength and location of these circulations. Mesoscale models are well suited for studying high latitude regions and the different types of circulations that occur there. When using a carefully constructed suite of longer simulations, a mesoscale model can be used to provide insight into the seasonal transitions of regional climates. At higher model resolutions (18 km) over the most poleward locations we can easily resolve the structure of katabatic flows on the residual ice cap and the prominent transient storms that move over and around the cap during the entire summertime period. Examining the high-resolution zonal-mean structure of the atmosphere provides a solid context from which to understand the meteorology of the northern polar summertime.

The OSU Mars MM5 [*Tyler et al.* (2002)] was reconfigured for this study. We have completed a comprehensive examination of circulations in the northern polar summertime [*Tyler and Barnes* (2005)]; this research was just taking shape at the time of the last Granada workshop.

In light of the upcoming exploration of high northern latitudes (NASA JPL/Phoenix) we were excited to be able to help the team by providing model results and analysis (meteorological characterization of the atmosphere during EDL and for the near-surface environment during the landed phase). Considering these Phoenix simulations this research becomes a characterization of circulations in the period spanning L_s=80 (Phoenix) to L_s=150 (including simulations at L_s=120 and L_s=135).

The Model:

For each of these simulations the mesoscale model was configured with a semi-global polar stereographic mother domain; this grid covers the northern hemisphere and extends to ~45° S, having a nominal resolution of 162 km. Two levels of two-way nesting were used to increase the resolution over the most poleward regions to 18 km. This highest resolution domain provides excellent resolution of latitudes poleward of 60° N. The topography for this domain, as configured for Phoenix simulations, is shown in Fig. 1. The dynamics of the model are hydrostatic, which reduces the computational overhead and allows for much longer simulations (29 sols total). The initial 9 sols of each simulation are discarded as spin-up for the model (spin-up does require the bulk of this period after initializing the model from coarse GCM output), leaving 20 sols of fully spun-up model output for analysis. An important strength of this method is that it allows for the construction of wind, temperature and surface pressure excursions (at each hour of the 20 sols) from the 20 sol mean hourly meteorological cycles.

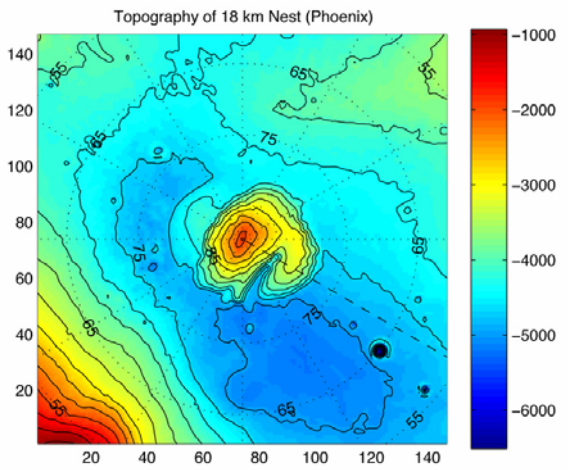

Figure 1. The topography of the 18 km nest for the Phoenix simulations is shown (147x147).

Descriptive Results of Simulations:

At the time that Phoenix will be landing on Mars (L_s=80), strong transient storms are expected to be prevalent in the region surrounding the receding seasonal cap. These storms reach fractional surface pressure excursions of ~2%, dynamically equivalent with strong terrestrial cyclones. These storms mostly follow high latitude storm tracks around the perimeter of the seasonal cap; they rarely have much effect on the weather equatorward of ~70° N. Their synoptic structure is typically wavenumber two with eastward propagation, although this structure is highly sensitive to the seasonal cap prescription and the atmospheric dust loading. Our best-fit simulation to observations of atmospheric and surface polar temperatures exhibits a zonal-mean polar jet of ~15 m/s at a height of ~10 km. Transient eddies appear to grow from weak perturbations in the polar jet and gain strength due to the sharp near-surface meridional temperature gradient. Additionally it seems that they gain strength from interaction with the katabatic flows off the cap topography. Chasma Boreale and Tharsis (due to its relative proximity) appear to be important influences in the birth, evolution and lifetime (and the statistical zonal asymmetry) of these storms.

By Ls=120 the seasonal cap has disappeared and only the cold residual ices remain. Transient storms still form along a weak polar jet, although the motion is retrograde and the synoptic structure is most typically wavenumber one. These storms are much weaker (~1% fractional surface pressure excursions); however, they have important significance in that they excite 10-15 m/s winds that blow directly and consistently across the residual cap. These winds, most likely, are an important dynamical influence in the water cycle of the residual cap, moving saturated air off the cap and supplying unsaturated air.

By L_s=135 the polar region is cooling towards fall and the structure of weak eddies traversing the edge of the seasonal cap has basically come to an end. At this time, however, much stronger cyclones (1-2%) are seen to form on the slopes of Tharsis. These storms can migrate great distances and actually reach the residual cap. These circulations are very suggestive of the large annular cloud structures observed in imagery from the Hubble Space Telescope and the Mars Orbital Camera [*Cantor et al.* (2002)] at this location and time of year. It is not obvious what dynamics are causing these storms to form; however, large-scale atmospheric circulations are undergoing fairly rapid seasonal transition at this time. It seems that a unique balance of conditions develops for a short period of time, and this balance provides the environment in which these storms can develop and thrive [*Tyler and Barnes* (2005)].

By L_s=150 the polar circulation has become very winter-like. Strong and deep eddies are beginning to form along the growing polar winter jet. These eddies typically have fractional surface pressure excursions of 2% and greater.

References:

Cantor et al., 2002, JGR, 107(E3); Tyler et al. 2002, JGR, 107(E4); Tyler and Barnes, 2005, JGR, 110, E06007.