SIMULATING THE LATE-SUMMER ATMOSPHERIC CIRCULATION OF THE MARTIAN NORTH POLE REGION.

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Introduction: Pictures taken from orbit over the north pole residual ice cap certainly suggest that atmospheric circulations have played an important role in the evolution of its present day appearance. One can hardly examine such images without envisioning a well-developed polar vortex. A more complete understanding of the late-summer atmospheric circulation for this region will help us understand the present day climatological stability of the residual cap. It is to this end that study the atmospheric circulation.

Our Model and Method: The computer model being used in this study is the Oregon State University Mars MM5 (OSU MMM5). Our model was developed by modifying the Penn State/NCAR MM5 so it could be used to simulate mesoscale circulations on Mars. For boundary and initial conditions the model uses output from the NASA Ames Mars GCM. The development of the model and the studies it has been used in are outlined in another abstract submitted for this workshop.

Methodology. Our approach to determining the circulation of the north-polar region is to first tune the model so it predicts surface and atmospheric temperatures that match data gathered during the Mars Global Surveyor (MGS) mission. With the MMM5 tuned to simulate the actual data we can then examine the simulated circulation with greater confidence in its accuracy. At this initial stage we are primarily concerned with simulating the temperature structure over the actual ice cap. Thus, the relevant data are 1) daytime and nighttime MGS/TES residual cap temperatures and 2) atmospheric temperature profiles from over the ice cap. The temperature profiles being used for this purpose are publicly available on the website of the MGS Radio Science (RS) team [1].

Tuning the MMM5 is a straightforward iterative process: 1) compare the zonal mean temperature profile of the model with that of data at 85.1° N, 2) adjust tunable parameters, 3) rerun the model and 4) compare the temperatures again. The global dust loading is a tunable parameter in both the GCM and the MMM5. In the MMM5 we additionally treat the deepest "soil" (ice) temperature as a tunable parameter. This approach was chosen because of the large subsurface heat flux values that are required in the polar heat balance during this season [2]. The deep "soil" (ice) temperatures of the residual cap in the model are initialized using annual average temperatures instead of diurnal averages (the MM5 uses diurnal average surface temperature by default to initialize the deepest soil temperature). Model initialization in the MMM5 is thus modified with a logical check to reset the deep "soil" (ice) temperature if the albedo is above a critical value. We are also setting the thermal inertia to an appropriate ice value dependent upon the albedo check. Presently we are using 175 K for the deep "soil" (ice) temperature and a thermal inertia of 900 J m^{-2} $s^{-1/2}$ K^{-1} for the ice locations.

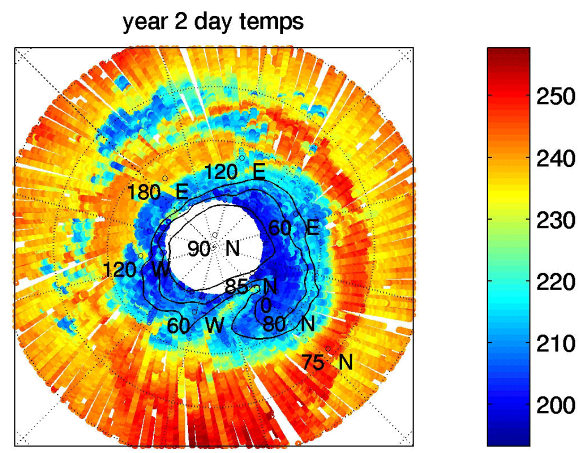

Figure 1: Daytime surface temperatures for the seasonal period ($130<L_s<140$). Temperature data is uniformly distributed across 1300-1400 hrs. Some contours from the MMM5 18 km nest topography are shown for reference.

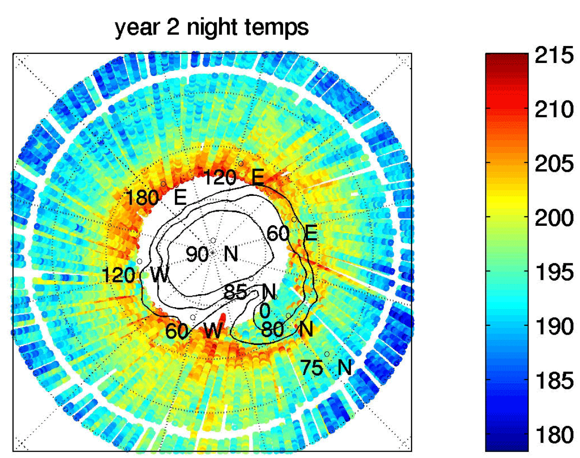

Figure 2: Nighttime surface temperatures for the seasonal period ($130<L_s<140$). Temperature data is uniformly distributed across 0300-0400 hrs. Some contours from the MMM5 18 km nest topography are shown for reference.

The Data: In Figs. 1 and 2 we show the respective daytime and nighttime TES surface temperatures that are being used to tune the MMM5 polar surface properties (thermal inertia and albedo). The local times of these data are approximately 1330 and 0330 hrs; the season is $130<L_s<140$. Daytime ice temperatures are fairly well represented in Fig. 1, but the nighttime temperature coverage in Fig. 2 is minimal.

For atmospheric temperatures we are using 99 RS profiles from this same seasonal period. These temperature profiles are tightly grouped around 85.1° N latitude. The mean time of the profiles is 0630 hrs and the L_s distribution is uniform over $130<L_s<140$.

Comparison With MMM5: Given the narrow latitude range of the RS temperature profiles, their uniform distribution in longitude, season and LST, it seems sufficient to use a simple average to form a zonal mean temperature profile. Locations of the RS profiles and the MMM5 data interpolations are shown in Fig. 3 over a map of the TES albedo that is presently being used in the model. The ice albedo values of this map are too low; presently we are considering ways to modify our datasets and maintain the resolution that is required to accurately resolve ice surfaces within the high-resolution topography of these simulations.

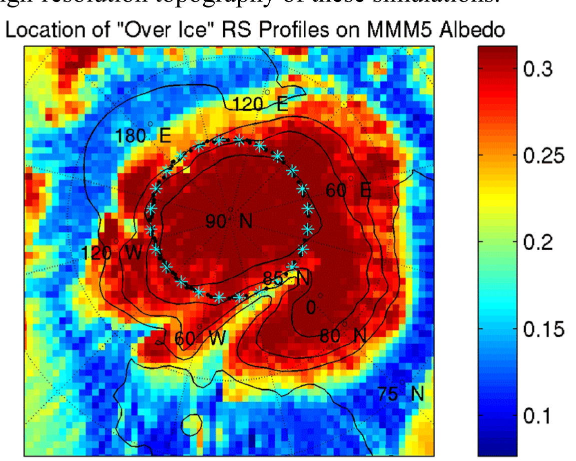

Figure 3: Locations of RS temperature profiles (black dots) and the MMM5 interpolations (cyan stars). The background map shows albedo and contours of the topography used in the 18 km polar nest.

To generate a zonal mean temperature profile for the MMM5 a simple average of model profiles was used. In Fig. 4 we show all of the RS and MMM5 profiles and the respective zonal means. The zonal means agree quite well throughout the bulk of the atmosphere although there is a much stronger near-surface inversion in the MMM5 zonal mean than there is in the RS data mean profile. Most of this inversion is aliasing of the model mean profile due to profiles that are over non-ice locations in the model.

Forward From Here: At this point we are still working to finalize our model configuration. We especially need to modify the albedo values and it will help greatly to have thermal inertia coverage to higher latitudes than we presently have. This work will move forward and we expect to have some interesting results to present in Granada.

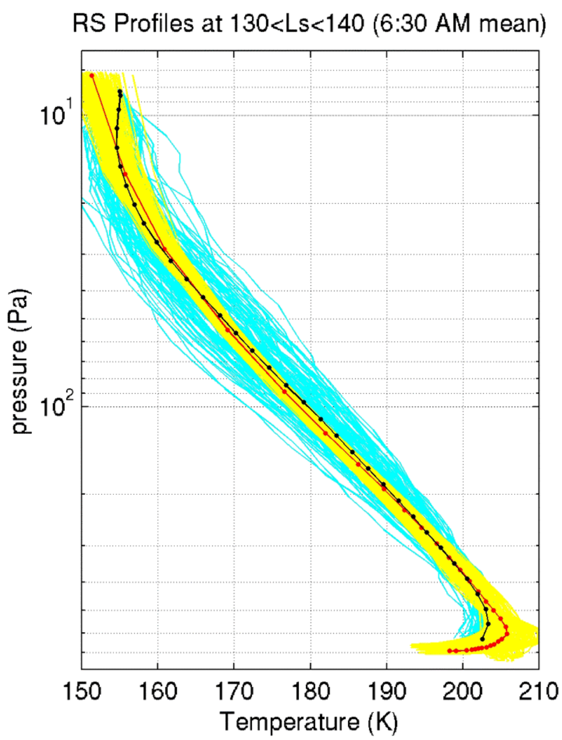

Figure 4: The 99 RS temperature profiles (cyan) and their average (black line/points) are shown along with 8 sols of MMM5 profiles (yellow) and their average (red line/points).

References:
[1] http://nova.stanford.edu/projects/mgs
[2] Paige and Ingersoll, Science, 228, 1160-1168.