ATMOSPHERIC MESOSCALE MODELING OF WATER AND CLOUDS IN NORTHERN SUMMER. D. Tyler\textsuperscript{1} and J. R. Barnes\textsuperscript{2}, \textsuperscript{1}College of Oceanic and Atmospheric Science, Oregon State University, 104 Ocean Admin. Bldg., Corvallis, OR, 97331-5503, dtyler@coas.oregonstate.edu, \textsuperscript{2}College of Oceanic and Atmospheric Science, Oregon State University, barnes@coas.oregonstate.edu.

Introduction: The North Polar Residual Cap and outlier ices (NPRC) are the most important source of atmospheric water in northern summer. GCMs are not typically run with sufficient resolution to resolve the NPRC or the mesoscale circulations caused by polar topography and the sharp gradients in ground temperature that exist at this season [1]. Carefully designed mesoscale modeling can be used to better simulate and understand the complexities of the sublimation and transport of water from the NPRC in summer [2].

Atmospheric dynamics play a very important role in the sublimation of ice, the formation of clouds, and the transport of water equatorward. Recent and long-standing problems regarding the water cycle and the climatology of the NPRC (the cloudiness in GCMs, the relative importance of regolith in the water cycle and the formation/evolution of spiral troughs) benefit from high-resolution mesoscale modeling.

Figure 1: Albedo data constructed using MARCI imagery (16 PPD), consistent with values for corresponding regions in the TES albedo data [3].

Performing mesoscale modeling requires high-resolution albedo and thermal inertia (ALB/TI) maps. For typical GCM grids, good lower-resolution ALB/TI maps are readily constructed from the TES data [3]. However, these data do not provide complete polar coverage and are quite “noisy” at native resolution in the highest latitudes; this creates a real challenge for mesoscale modeling.

For this work, we have developed a new ALB/TI data set. The red and blue channels of high-resolution MARCI imagery [4] are utilized. A composite image, spanning the period $105^\circ < L_s < 135^\circ$ [5], is used to construct an albedo field (red) and a mask (blue) for ice locations. For the most northern latitudes, the constructed albedo field is shown in Fig. 1. Albedo values are consistent with available data and our previous model tuning. For high northern latitudes, these new data replace older information in our global ALB/TI maps (a relationship between albedo and thermal inertia is presumed and utilized).

The Mesoscale Model: The Oregon State University Mars Mesoscale Model has previously been used for studies of the northern polar regions [1], [6]. An efficient water-ice cloud scheme [7] has been incorporated into the model, and results from preliminary water transport and cloud simulations were presented [8]. More recently, the prescription for dust in the model was improved; total column opacity (a function of latitude) is now prescribed at the zonal-mean surface pressure. This benefits polar modeling, since shallow dust layers are prescribed more realistically in complex terrains. For any cloud ice that falls out of the atmosphere, its mass is conserved in a surface reservoir of “snow/frost” (at locations not on the NPRC this ice always returns as vapor to the atmosphere at sunrise). Combining any “snow/frost” accumulation with the net sublimation of ice from the NPRC dome yields the surface ice budget.

The model is initialized with water vapor so the zonal-mean column abundances match TES observations at $L_s=120^\circ$. Our standard simulations run for 30 sols, where the final 20 sols are centered on the season of interest, $L_s=120^\circ$ for this work. We have run many test cases with up to two levels of two-way nesting over the NPRC (up to ~15 km resolution). Tuning and testing continue, and a third nest (~5 km) will soon be activated. The results presented at the conference will include this nest.

Developing Results: Column Water Abundance. Transient and quasistationary eddies are part of the summer circulation near the NPRC. These eddies excite asymmetries in the flow, producing considerable structure in atmospheric water at high latitudes. A typical example is shown in Fig. 2 below. Phoenix tends to be ~10 pr $\mu$m too dry in comparison to TES, as are the model zonal-mean abundances at this latitude. Longer simulations are being performed to see if this behavior persists in the
model. We have not yet experimented with a regolith source of water, although it is one mechanism that would improve agreement with TES vapor abundances in this high latitude (sharp meridional gradient) region just equatorward of the NPRC (60° < φ < 80° N).

Figure 2: Instantaneous column water abundances in the ~15 km nest after 12 sols (the nest is active for the final 4 sols). Phoenix is at the black asterisk and the axes are labeled in gridpoints.

Figure 3: Instantaneous column cloud ice abundances (same nest and time as in Fig. 2). Depths are in liquid water equivalent. Phoenix is at the white asterisk.

High Latitude Clouds. Thin clouds appear in the model at night and disappear by early morning. These clouds form at two distinct altitudes, very near the ground (below ~1 km) or much higher (~15-30 km), much like CRISM limb observations at L,=96° [9]. For the same time as Fig. 2 (Phoenix late afternoon) column ice abundances are shown in Fig. 3. We are exploring the sensitivity of the clouds to the dust prescription, as well as to the physical balance between the vertical mixing of water vapor and the sedimentation of cloud ice.

Ice Sublimation Fluxes. Our results exhibit far less cloudiness than is seen in some GCM simulations [10]. This may be largely due to the sizeable differences in area weighted sublimation fluxes. As reported earlier [8], the periphery of NPRC ices is where our modeling predicts the largest sublimation fluxes. Moreover, a sizeable region of the NPRC dome does not sublimate any ice at all. Due to sedimentation of cloud ice and the deposition of vapor as frost, this region is gaining ice mass. The ~15 km nest diurnal mean sublimation fluxes for the NPRC ices are shown in Fig. 4. The largest values, ~20 μm per day, are consistent with those in the Ames GCM ~10° of L, earlier [11]. However, if sublimation fluxes are summed over respective areas, the total flux of water in the GCM greatly exceeds that in the mesoscale model.

Figure 4: Mean diurnal ice sublimation fluxes in the 15 km nest for the final three sols of a 12 sol run.

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