SIMULATED WATER VAPOR TRANSPORT DURING MARTIAN NORTHERN SUMMER AND INTERPRETATION OF THE MGS TES OBSERVATIONS. A. A. Pankine[1], M. A. Mischna[1] and L. K. Tamppari[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, alexey.a.pankine@jpl.nasa.gov

Introduction: We simulate transport of the water vapor in the Martian polar summer atmosphere using a Mars version of the Planetary Weather Research and Forecasting model (planetWRF) [1] and compare the resultant spatial distributions to the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) observations of the water vapor column abundances [2, 3]. The goal is to explain the appearance and high degree of spatial and temporal variability of localized concentrations of water vapor (tentatively called plumes) observed in the vicinity of the Martian North Polar Residual Cap (NPRC) during summer (Figure 1). The water ice–made NPRC is exposed to the Martian atmosphere during summer and sublimation of the ice can be the source of the plumes. Large outliers of the main NPRC exist at latitudes of 75°N and also can contribute water to the atmosphere. Another potentially large source that can supply water to the atmosphere is the vapor released from the soil as the surface temperatures increase in summer. The multitude of the potentially important processes and limited understanding of each of them makes the whole problem of the polar water cycle a very complex one. Other groups focused on mesoscale aspects of the polar circulation and the details of the sublimation process [4]. In this study we are limiting the analysis to the atmospheric transport of the vapor released from prescribed surface sources.

Atmospheric Transport Modeling: The planetWRF is run with global resolution of 1.25° by 1.25°. After a 10 sol spin-up, the model is run for 60 sols (L_s~85-113°). The atmospheric transport of the vapor is simulated by releasing passive tracers from several prescribed locations within the northern polar region and then keeping track of their spatial distribution at different times. To simulate the diurnal cycle of a sublimating ice source we tie the emission rate of the tracers at the surface to the saturated pressure of the water vapor at the temperature of the surface. This is a crude approximation to ice sublimation due to natural convection under the assumption of the dry atmosphere. While in reality ice sublimation is likely dependant on surface roughness and winds, and relative humidity of the atmosphere, the approximation we are using captures the diurnal variability of the surface source.

Saturation of the vapor in the atmosphere and condensation on the ground are neglected in our approach using completely passive tracers. Saturation of the atmosphere may completely shut down vapor sources on the surface of the NPRC and also limit the amount of vapor in the upper parts of the atmosphere. Variation in intensity of the surface vapor sources is partially taken into account in our simulation by the inclusion of the diurnal cycle. The bulk of the vapor remains low in the atmosphere and thus its horizontal transport is weakly affected by neglected saturation with height. Lastly, during the time of simulations – L_s=85-113° - the ground temperatures in the polar region are high enough to prevent condensation even during the night. Hence we feel that our simulations should give a correct representation of vapor horizontal transport at least to first order. A more complex representation of the vapor sources and atmospheric sublimation/ground condensation are a subject of future work.

Several sites were chosen for the sources of tracers: a localized source at the edge of the NPRC, the interior portion of the NPRC, the outer edge of the NPRC and the outliers at 75°N.

Results: An example of MGS TES data and one of a preliminary result of the simulations are shown in Figures 1 and 2. The maps are centered on 90°N and extend southward to 60°N. The MGS TES map shows retrieved water vapor column abundances binned in 4° longitude by 2° latitude spatial bins (Figure 1). To create a complete map of the north polar region, 5° L_s worth of TES data is used [3]. The vapor abundances are shown in color according to the color scale from 0 (black) to 30 (blue) to 60 pr-µm (red). Black areas are the areas where there were no data or TES retrievals were not originally available. Note, that there are no retrievals over the NPRC (roughly inside the 80°N circle). The simulated data (Fig. 2) are shown on a polar map as a contour plot of instantaneous spatial distributions of column abundances using the same color scale as TES. The intensities of the simulated sources were scaled to match the abundances observed in the TES data. The fact that the plots of TES data show data averaged over 5° L_s along the spacecraft orbit and the plots of simulated data show instantaneous distributions can potentially be a source of error in interpreting the TES results. We plan to post-process the simulated data to make them more compatible with the TES plots.

Figure 2 shows simulated water vapor spatial distribution at L_s=96° for the surface source at the edge of the NPRC at 80°N, 270°E that was turned on at L_s=85°. The simulated spatial distribution has a number of similarities to that observed on the TES data map for the same time period (L_s=95-100°). For example, a large filament of vapor extending southward at longitude 210°E towards 180°E from the mass of water vapor encircling the NPRC may represent the vapor concentrations seen by TES in Figure 1 at 180°E. The simulation also shows that vapor abundances are lower between longitudes 330°E-30°E – something that is consistently observed in TES observations.

The simulation exemplified in Figure 2 also shows that most of the vapor is concentrated near the NPRC. The water vapor abundances seen in the simulation at the edge of the map near 60°N are lower than those seen in TES observations. This may point to a larger role of the regolith in supplying vapor to the polar region during summer.

This is a work in progress. Preliminary results indicate that variable large scale water vapor concentrations ('plumes') observed in TES data during summer near the edge of the NPRC may be the result of the atmospheric transport of water vapor sublimating off the NPRC. The spatial and temporal variability of these plumes reflects variability of circulation above the NPRC. However, the transport off of the NPRC appears to be weak enough to explain the observed general increase in the total atmospheric mass in the north polar region and northern hemisphere during summer. The regolith-released vapor may play a large role in supplying vapor to the atmosphere in summer. Our model is based on several important simplifications which may affect future results.

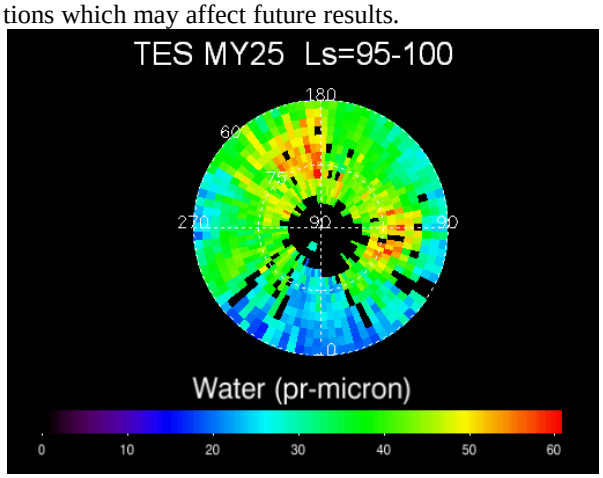

Figure 1. MGS TES water vapor column abundances in the Martian north polar region (from [3]).

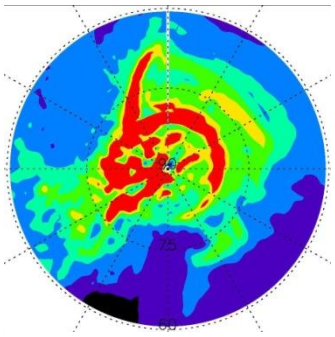

Figure 2. Simulation of water vapor column abundances for L_s=96°. The color scale shows water vapor abundances in pr-µm and is the same as in Figure 1.

References:

[1] Richardson M. I. et al. (2007) *JGR, 112,* E09001. [2] Smith M. D. (2002) *JGR, 107,* 5115. [3] Pankine A. A. et al. (2009) *Icarus, 204,* 87–102. [4] Tyler, D. and Barnes, J. R., (2005) *JGR, 110,* E06007.