SIMULATING THE MARTIAN WATER VAPOR CYCLE IN THE PAST AND PRESENT USING THE COMMUNITY ATMOSPHERE MODEL.

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Introduction: The Martian water vapor cycle is very interesting because water vapor is a much stronger greenhouse gas compared to CO_2, and is the leading candidate for the source of warming in the ancient climate. We use a modified version of the Community Atmosphere Model to simulate the water vapor cycle in the past and present. Here we present the results, including maps of water vapor column abundance and surface temperature of the ancient climate, assuming a thick, 500 mbar CO_2 atmosphere.

Model: We used the National Center for Atmospheric Research (NCAR) Community Atmosphere Model for our simulations. The typical resolution used is 2x2.5 degrees in latitude and longitude. Modifications to the model include adjusting the planetary parameters such as gravity and albedo to Martian values, changing the atmospheric composition, replacing the radiative transfer scheme, changing the calendar to cover a Martian year, and the addition of a carbon dioxide condensation scheme. Sources of water vapor in the model are prescribed water ice caps. Water is allowed to sublimate from the caps normally through the physics of the land model.

Results: To check the performance of the model, we compare model results to observations. Figure 1 shows a plot of the seasonal and latitudinal dependence of water vapor as observed by CRISM [1].

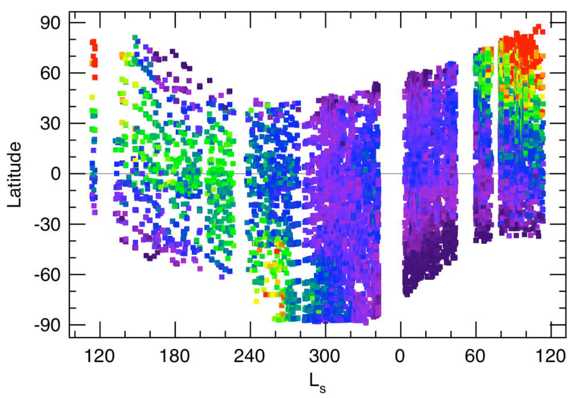

Figure 1. Retrieved water vapor column abundances as reported by Smith (2008) [1]. Red is a column abundance of 30 pr-µm or greater, green is about 15 pr-µm, and purple is less than 5 pr-µm. Maximum abundance in the northern summer is about 60 pr-µm.

The water vapor simulation results for the current climate are shown in figure 2.

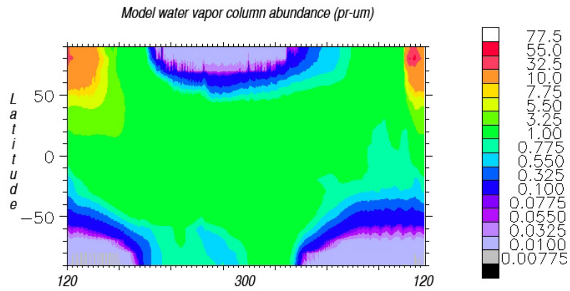

Figure 2. Zonally averaged model water vapor column abundances versus season. Maximum water vapor abundance in the northern summer is roughly 60 pr-µm. Southern values are significantly less than observations, at roughly 1 pr-µm.

Currently, the model produces water vapor column abundances that are close to observed values in the north, at around 60 pr-µm. Values in the south are significantly less, at roughly 1 pr-µm. The mid-latitude values between L_s=120 °-300° are also low compared to observations, however because the southern water vapor column abundances are also low, it is not clear if this is an issue with water vapor transport, or the sources.

To simulate the ancient climate, we assume a thick, 500 mbar CO_2 atmosphere. Initial surface conditions are the same as for the current climate, and the solar constant was reduced to 70% of the current value. Figures 3 and 4 show the zonally averaged water vapor column abundances and surface temperatures versus season.

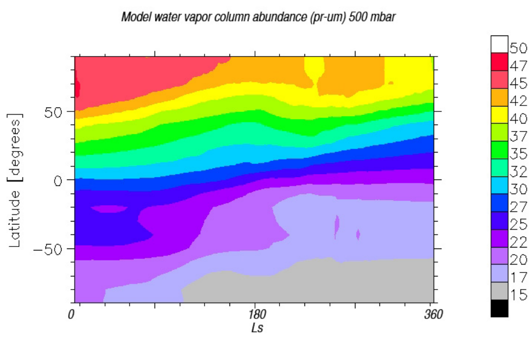

Figure 3. Zonally averaged model water vapor column abundances versus season for the ancient climate.

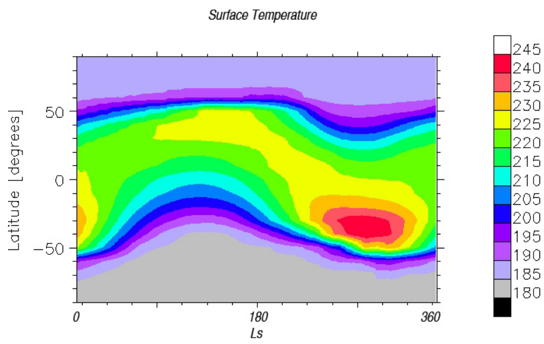

Figure 4. Zonally averaged model surface temperature versus season for the ancient climate. Peak surface temperature is roughly 240 K during southern summer.

The simulation results come from the fifth year of simulations. The water vapor column abundance plot suggests that model has not yet reached equilibrium, and that the simulation should be extended for some time until equilibrium is reached.

Over this same period, the peak surface temperature reached is roughly 240 K, about 30 degrees below the freezing temperature of water. Something of interest is that during the southern winter the temperature is roughly 180 K from the pole to 40 degrees south latitude. For these pressures, the condensation temperature is near 180 K, suggesting that in the ancient climate, the seasonal cap may have been much more extensive in the past.

References: [1] Smith, M.D. et al. (2008), *Third International Workshop On The Mars Atmosphere: Modeling and Observations*.