TIME DEPENDENT MODEL FOR WATER VAPOR DIFFUSION/ADSORPTION AND HEAT TRANSFER AT THE PHOENIX LANDING SITE. E. G. Rivera-Valentin[1] and V. F. Chevrier[1], [1]Arkansas Center for Space and Planetary Sciences (eriverav@uark.edu), University of Arkansas Fayetteville

Introduction: Phoenix has shown that there exists vapor pressure variations on a diurnal time scale, which are not predicted by the GCM [1]. Recorded vapor pressures by the TECP shows systematic variations by about 2 orders of magnitude (Fig. 1) [2]. Since the GCM model does not take into account atmospheric interactions with the regolith, we may infer that the shortcomings of this model in this polar region implies that such interactions are significant [2]. Possible processes that may account for such a coupling include adsorption onto regolith grains as well as hydration of perchlorate [2] or equilibrium with a liquid phase [3].

We investigate the effect of adsorption as a potential sink for water vapor [4,5]. We are creating an integrated numerical model that accounts for both heat and mass transfer of water vapor in the regolith, including the effect of adsorption [4]. Using this model, we can simulate the effect of adsorption on humidity and attempt to relate this to Phoenix observations.

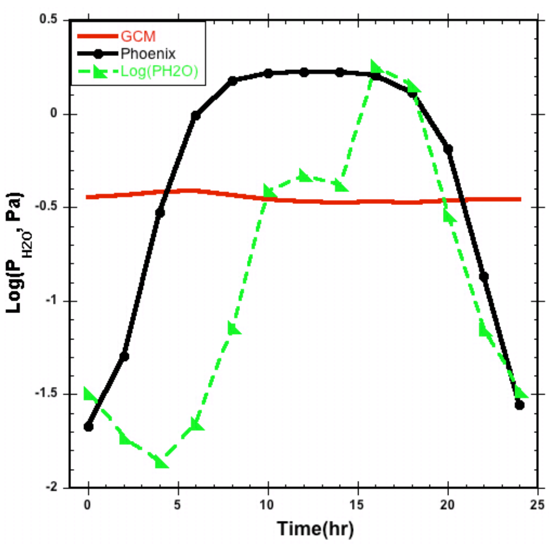

Fig. 1: Gausian fit to water vapor pressure at the Phoenix landing site [2], compared to the results from the GCM model and our preliminary results.

Methods: To model heat transfer, water vapor diffusion, and adsorption in the regolith, we use COMSOL Multiphysics. We specifically focus on the kinetics of the various processes and their variations with temperature. Most other models focus on longer timescales where adsorption can be averaged [6]. This though is based on the cyclicity of the adsorption process and the assumption that the process occurs instantaneously. However, recent studies have shown that slow adsorption kinetics can strongly affect the diffusion of water vapor [4]. Thus, the study of water behavior on short timescales requires the inclusion of the adsorption kinetics and a detailed study of the transient effects.

Heat Flux Model: We primarily use the equation set proposed by multiple authors to model the heat flux incident on the Martian surface [7]. We take into account the diffusion of the direct solar beam, the indirect solar illumination due to scattering, and thermal emission of the atmosphere.

Mass Transfer Model: The differential equation [4] for the transport of water vapor allowing for simultaneous diffusion and adsorption in the Martian regolith is:

$$\frac{\partial p}{\partial t}\left[1+\Psi\frac{\partial \theta}{\partial p}\right]=\frac{\partial D}{\partial z}\frac{\partial p}{\partial z}+D\frac{\partial^2 p}{\partial z^2} \quad (1)$$

where p is the partial pressure of water vapor, D is effective diffusion, z is a depth parameter, Ψ is a constant that corresponds to the thermodynamic part of the adsorption process and is defined as:

$$\Psi=\frac{RT_s\rho_{H20}\rho_{reg}A_s l}{M_{H2O}} \quad (2)$$

where R is the ideal gas constant, T_s is the temperature of the surface, ρ_{H20} is the density of water, ρ_{reg} is the density of the regolith, A_s is the specific surface area of the regolith, l is the thickness of the adsorbed water monolayer, and M_{H2O} is the molecular weight of water.

Results: At this moment, we have fully developed the heat flux model. We are in the process of integrating the heat flux and mass transfer models. Figure 1 shows our preliminary model results. The result shown is merely a simulation over 7 sols assuming warmest day conditions for every sol.

Conclusion: From Fig.1, we see that our model correlates well with evening humidity values, but does not with morning values. By simulating the mass transfer process at the Phoenix landing site, our model will help in understanding the observed vapor pressure variations. In addition, we will make a versatile model that will also include phase change and thus help determine if liquid water can form under present-day conditions.

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