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Effect of natural convection on the mass transfer coefficient from the Martian regolith

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To better study water on Mars, the Phoenix Mars Lander is scheduled to land in spring 2008 at the northern plains close to the north pole. In order to obtain a better insight into the water vapour transport and the local fluid motion near the lander, a three dimensional transient model of water vapour transport in the Martian regolith is being used. This model is based on Fick's law of diffusion corrected for porous media, including the Knudsen diffusion effects. The model includes near surface natural convection due to solar irradiation simulated on top of the Martian regolith. Furthermore, turbulence in the atmosphere is included using two different models, the $k-\varepsilon$ with production and dissipation for the turbulent buoyancy term and the SSG-Reynolds Stress model. The results of the numerical simulation of diffusion in the regolith for different natural convection cases on the surface are summarized by means of the Sherwood number. We define a special Sherwood number that is the ratio of the actual rate of diffusion obtained by simulation to a characteristic rate of diffusion with a linear profile. With the Sherwood number defined for a particular case, the water vapour flux from the regolith can be readily calculated given water vapour mass concentrations at two points, one inside the regolith and one at the near surface atmosphere, and the characteristic distance between these points. For example, two cases with different depths of regolith layer, the first one 10 cm and the other at 15 cm above an ice table were simulated. Atmospheric and regolith properties were determined based on the local conditions that are expected to be encountered by Phoenix during its surface operation. As a result, calculated Sherwood numbers for the two cases are $Sh_{10\mathrm{cm}} = 0.051$ and $Sh_{15\mathrm{cm}} = 0.033$ respectively. Lastly, simulations were also performed for a lab-

oratory experiment designed to ultimately validate the computational model.