Diurnal fluxes of water vapor in a sand sheet. K. E. Williams[1], T. N. Titus[1]. [1] U.S. Geological Survey Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86004, US.

Introduction and Background: Sand covers a significant portion of the Earth's surface, including the Grand Falls area of Coconino County, AZ. The vadose zone (unsaturated zone) in a soil is of particular interest because it is broadly applicable to desert soils, which are seldom saturated and usually dry. In the absence of strong geothermal heating, the near-surface soil temperature profile is expected to exhibit maximum variation (for a given diurnal period) at the surface, with the diurnal variations becoming successively damped with depth. The temperature at a given depth is the result of diffusive heat transport vertically within the soil column. Water vapor also is expected to be transported via diffusion through the soil column [1] for terrestrial and Martian soils [2]. We have selected a sand sheet within the Grand Falls Dune Field (GFDF), placed a meteorology station (temperature, relative humidity, wind speed, wind direction , pressure, insolation) and instrumented the sand with 5 different depths of temperature and relative humidity (TRH) sensors. The TRH sensors are located at depths of 1, 6, 12, 24, and 48 cm in order to capture diurnal temperature and humidity variations.

Model and Data: In general [1], the diffusive flux of water vapor is calculated as:

$$q_d = -D\frac{dC}{dx}, \qquad (1)$$

where q_d is the diffusive flux, D is the diffusion coefficient, C is the vapor mass concentration and x is distance. For a given material (sand), a gas-filled porosity f_a and tortuosity τ, we can rewrite (1) as:

$$q_d = \frac{f_a}{\tau}D\frac{(\rho_1 - \rho_2)}{x}, \qquad (2)$$

where ρ_1 and ρ_2 are the water vapor densities at two different points in the column [2]. Values of τ=1.5 and f_a=0.38 were chosen for sand [3], and D=0.22x10^{-4} for Earth air [4].

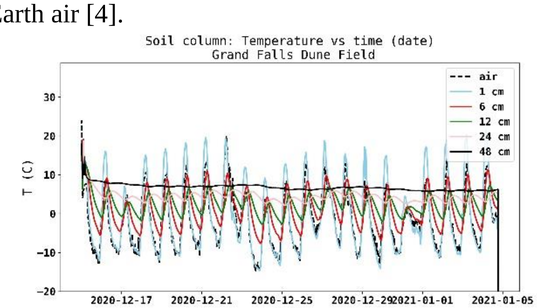

Figure 1. Temperatures for the atmosphere and all measured depths within the sand column.

Fig. 1 shows the temperature at the instrumented depths vs. time. The air temperature is very similar to the soil temperature at 1 cm depth, except the soil maximum diurnal temperature is higher. Fig. 2 shows the vapor density (within the sand pores) at the instrumented depths within the sand column, as well as the atmospheric water vapor density at ~ 1.5 m height. Diurnal variations are clearly visible, and the expected "dampening" at increasing depths are apparent as well. At 48 cm depth we see that the vapor density is essentially constant, although elevated.

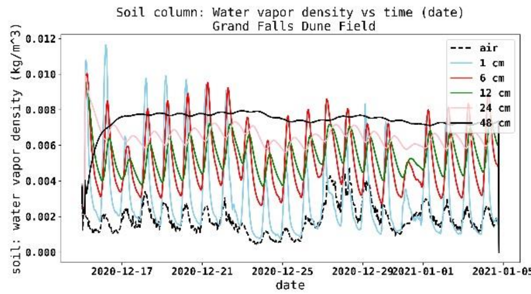

Figure 2. Water vapor density for the atmosphere and all measured depths within the sand column.

Results and conclusions: Calculations using Eq. 2 are shown in Figure 3. While some fluxes are positive (indicating net water vapor input to the soil), the majority of the fluxes are negative. Though diurnally varying, the negative fluxes indicate that the sand column is drying at this time of year at GFDF. The fluxes are expected to generally reverse by early summer with the onset of the monsoon.

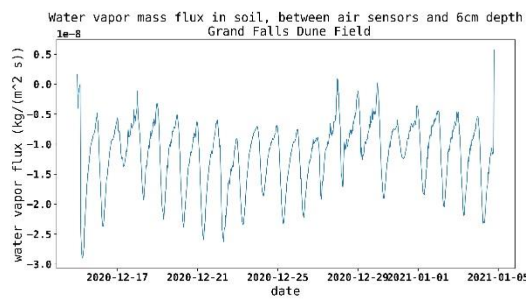

Figure 3. Water vapor mass flux between air sensors and the sand at 6 cm depth.

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