Slope Winds on Mars in relation to the Phoenix lander mission: Xiurong Sun[1] and Peter A. Taylor[1]; [1] Centre for Research in Earth and Space Science, York University, 4700 Keele St., Toronto, Ontario, Canada M3J 1P3.

Introduction: Measurements reported from the Phoenix mission by Taylor et al [1] suggest that slope winds may explain some of the observed features. A simple 1-D model of slope winds on Earth has been adapted to investigate this possibility.

Model details: The model is adapted from one developed for Earth applications[2]. It is a 1-dimensional (z), time dependent model of slope winds on an infinite uniform slope with or without any upper level flow. In the applications here the slope is 1 degree and Geostrophic wind is set to zero. A surface temperature cycle is imposed at the lower boundary and initial conditions have a specified initial temperature profile of a given lapse rate. The computations are initialised with zero wind and the model is run for a number of sols (10 in this case) in order to establish a regular diurnal cycle. We set the initial lapse rate to 2K/km (stable wrt the Mars DALR) and a surface temperature varying sinusoidally from 193K to 243K with the minimum at 0200 in Mars hours.Gravity is set to 3.72 ms^{-2} and the Coriolis parameter is 1.33 $x10^{-4}$ s^{-1}, corresponding to 70 degrees N on Mars. We take the surface roughness as 0.02 m and the model top is at 6 km. Our model uses a terrain-following coordinate system with the x-axis parallel to the downward slope and the y axis in the cross-slope direction. We take the x axis as west-east and the wind directions shown in the following figures so for straight downslope winds the direction is 270º.

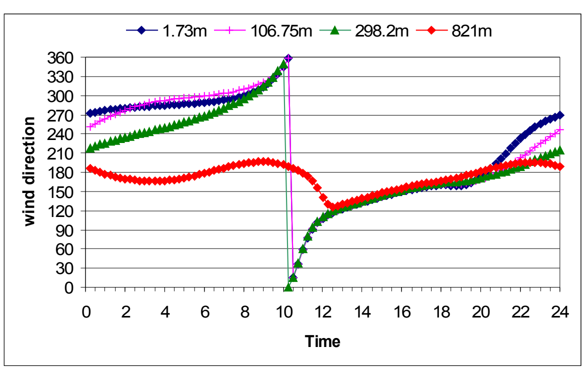

Figure 1 Wind directions at several heights after 10 sols. No upper level winds and wind speeds at 821m are minimal.

Results: After 10 sols we plot wind components atvarious times through the Martian day (taking 1 hour as 1/24 of a sol), Figure 1 shows wind directions at various heights while Figure 2 shows the two components of horizontal wind. Downslope winds (from 270 degrees in this simulation) at night are relatively shallow but can be strong despite the low slope. During the day the boundary-layer extends to heights of order 4 km and heating of the slope has induced strong up- and, through the action of Coriolis force, cross-slope winds.

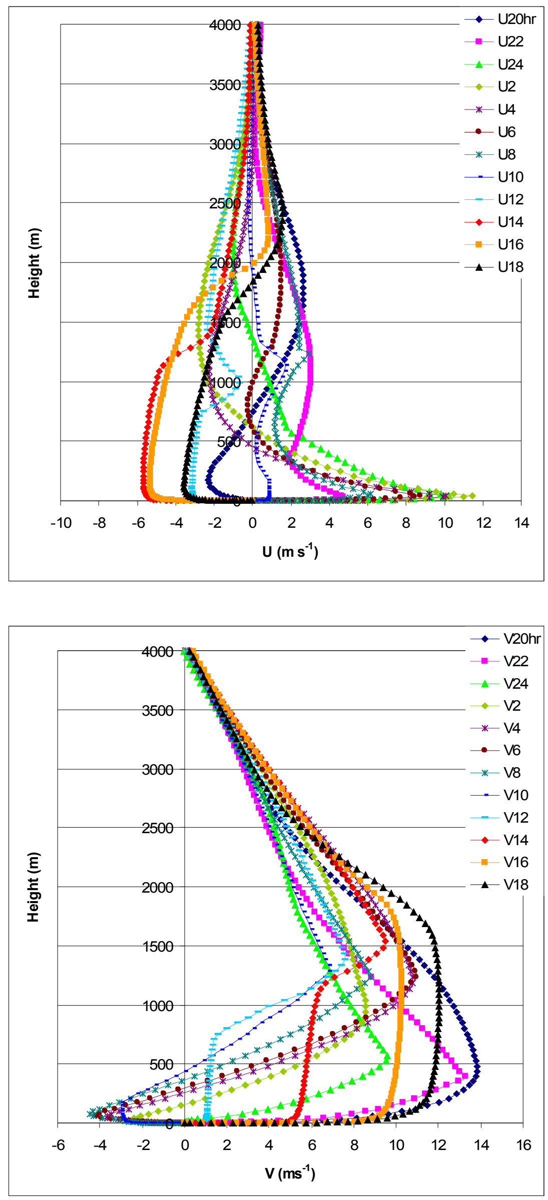

Figure 2 Diurnal cycle of U and V component winds on sol 10 of the simulation.

Another way to look at the wind data is via hodographs as shown in Figure 3. These clearly show the steady veering of the low level winds, very similar to the wind behaviour at the Phoenix lander site [1]. Wind speeds of 2-6 ms^{-1} are also very comparable to those observed by the Phoenix telltale at 2m.

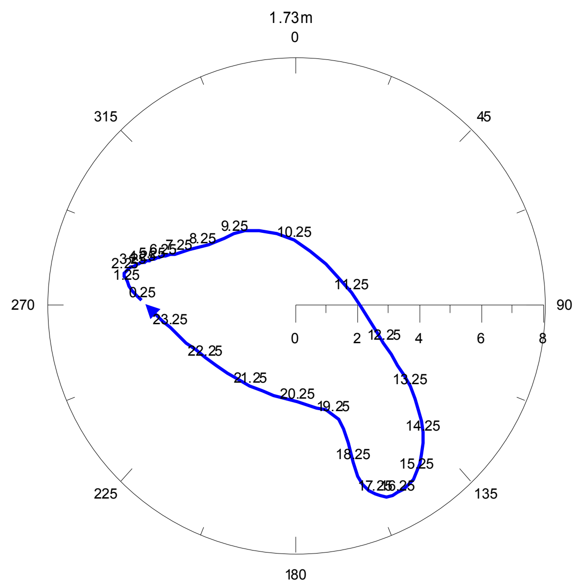

Figure 3 Wind "hodograph" at 1.73m above ground. on sol 10 of the simulation. Note that directions plotted here are those that the wind is coming from, so for a true hodograph rotate through 180 degrees.

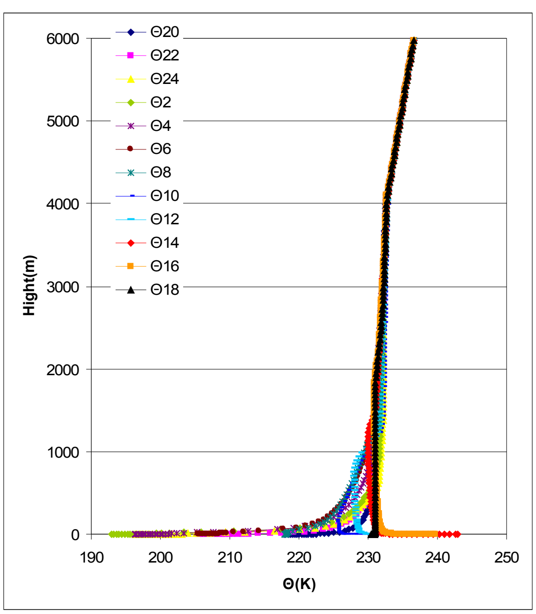

Figure 4 Temperature profiles on Sol 10 of the slope wind calculations.

Temperature profiles are shown in Figure 4 while surface heat fluxes are shown in Figure 5. The temperature profiles are well mixed up to 4km during the late afternoon, similar to results found by lidar backscatter measurements at the Phoenix lander site, while heat fluxes $\rho c_p \langle w\theta \rangle$ reach 7.4 Wm^{-2} in early afternoon, compatible with determinations being made from estimates of u_* and T_* from the Phoenix data.

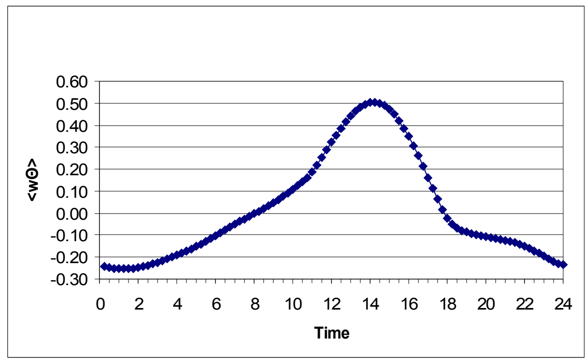

Figure 5 Surface heat fluxes on sol 10 of the slope wind simulation.

Conclusions: The local topography at the Phoenix Lander site (126W, 68N on Mars) is gentle but does show a general 1.4 degree slope upwards to the SE on scales of 10-20 km. Heimdall crater lies abour 20 km to the East of the lander site. While the terrain is certainly more complex than that in our simple model the overall wind flow and boundary-layer features are compatible and support the idea that slope winds can play an important role in the diurnal wind pattern.

References

[1] Taylor, P.A., Gunnlaugsson, H.P., Holstein-Rathlou, C., Lange C.F., Moores, J., Cook, C, Dickinson, C., Popovici, V., Seabrook, J, and Whiteway, J, 2008, Phoenix: Summer Weather in GreenValley (126W, 68N on Mars). Abstract for this workshop.

[2] Sun, X., Weng, W. and Taylor, P.A., 2008, Numerical Studies of Thermally Induced Slope Winds, Paper 12A, AMS 18th Symposium on Boundary Layers and Turbulence, Stockholm.