

THE MARTIAN SURFACE BOUNDARY LAYER: HEAT AND MOMENTUM FLUX RESULTS FROM MARS PATHFINDER. G.R. Wilson^{1,2}, S. Larsen³, J.R. Murphy^{2,4}, R.J. Sullivan⁵, J.T. Schofield⁶, D. Crisp⁶, R.M. Haberle², A. Seiff^{2,4}, J.A. Magalhães^{2,4}, J.R. Barnes⁷, ¹Arizona State University (gwilson@humbabe.arc.nasa.gov), ²NASA Ames Research Center, ³Risoe National Laboratory, ⁴San Jose State University Foundation, ⁵Cornell University, ⁶Jet Propulsion Laboratory, ⁷Oregon State University

The Mars Pathfinder Atmospheric Structure Instrument/Meteorological package (ASI/MET) is the most capable weather monitoring system ever sent to the surface of another planet. During the surface operations phase of the mission, the ASI/MET instrument, equipped with a directional wind sensor, three thermocouples at 0.25, 0.5, and 1.0 meter above the surface, and a pressure sensor, has returned more than 6.5 million individual weather measurements from the Carl Sagan Memorial Station. One of the prime objectives of the ASI/MET package is to characterize the surface boundary layer parameters, particularly the heat and momentum fluxes, scaling temperature and friction velocity, and estimate surface roughness. Other important boundary layer parameters, such as Richardson Number, Monin-Obukhov length, analysis of turbulence characteristics of wind and temperature, and atmospheric stability class can also be determined from these measurements. The latest results from this investigation will be presented.

During the Mars Pathfinder prime mission, the surface meteorological experiment collected weather measurements 51 times per sol at 0.25 Hz for 3 minutes. This data set comprised the most complete diurnal weather data set of the entire mission. In addition to these measurements, high rate (better than 1 Hz) boundary layer measurements were taken throughout the day for periods ranging from 15 minutes to 1 hour. In addition to these measurements, the Imager for Mars Pathfinder (IMP) monitored deflections of three windsocks mounted on the ASI/MET mast. These two distinct data sets can be combined to help constrain and calculate important boundary layer parameters such as the heat and momentum fluxes, surface roughness (z_0), friction velocity and scaling temperature, and ultimately, the bulk and flux Richardson Numbers, Monin-Obukhov length, and stability classes.

While the ASI/MET meteorological data set is a significant improvement over the Viking missions 20 years ago, it

falls short in constraining many key boundary layer parameters; one such parameter is surface temperature. It also lacks the phenomenal 4-year duration of the VL-1 lander meteorological observations. Nevertheless, the data set is rich in detailed knowledge of the structure of the near surface boundary layer.

During the extended mission, the ASI/MET instrument was operated continuously from between 0900 and 1500 local solar time at sampling rates between 0.25 to 1 Hz, and addition to this, over 1000 additional windsock images were returned. On 4 separate occasions, the ASI/MET was operated continuously for periods of 30+ hours, sampling the atmosphere every four seconds.

Surface heat flux can be calculated from this data set by extrapolating the ground surface temperature from the three mast thermocouples. Using boundary layer theory and relationships derived from terrestrial experiments we relate a bulk Richardson number to the more analytically powerful flux Richardson number. From this relationship the heat flux can be determined for a surface with a known z_0 .

Friction velocity can be calculated by using log profile and the Richardson number to correct for stability. From that, the relative drag coefficients as a function of wind direction (surface terrain) can be estimated.

In general Mar Pathfinder atmosphere-ground temperature differences are greater than those observed by VL-1 but the winds are lighter. Drag coefficients indicate that the surface is roughest in the direction of the rock garden and that surface roughness values vary between 1 and 5 cm. In addition, daytime unstable conditions tend to increase the friction velocity by approximately 20 percent.

This work would not be possible without the hard work and dedication of the engineers/technicians who made the ASI/MET instrument and the talented team of engineers and scientists who flew it to Mars and successfully operated it on the surface for 84 sols.