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Characteristics of the Martian Atmospheric Surface Layer; G.D.Clow (USGS, MS946, Menlo Park, CA 94025) and R.M.Haberle (NASA/Ames, Moffett Field, CA 94035)

We extend elements of various terrestrial boundary layer models to Mars in order to estimate sensible heat, latent heat, and momentum fluxes within the martian atmospheric surface ("constant flux") layer. The atmospheric surface layer consists of an interfacial sublayer (#1) immediately adjacent to the ground and an overlying fully turbulent surface sublayer (#2) where wind-shear production of turbulence dominates buoyancy production. Within the interfacial sublayer, sensible and latent heat are transported by non-steady molecular diffusion into small-scale eddies which intermittently burst through this zone. Both the thickness of the interfacial sublayer and the characteristics of the turbulent eddies penetrating through it, depend on whether airflow is aerodynamically smooth or aerodynamically rough, as determined by the Roughness Reynold's number. Within the overlying surface sublayer (#2), similarity theory can be used to express the mean vertical windspeed, temperature, and water vapor profiles in terms of a single parameter, the Monin-Obukhov stability parameter.

To estimate the molecular viscosity and thermal conductivity of a CO_2-H_2O gas mixture under martian conditions, parameterizations were developed using data from the TPRC Data Series [1] and the first-order Chapman-Cowling expressions; the required collision integrals were approximated using the Lenard-Jones (12,6) potential. Parameterizations for specific heat and binary diffusivity were also determined. The Prandtl and Schmidt numbers derived from these thermophysical properties are found to range 0.78 - 1.0 and 0.47 - 0.70, respectively, for Mars. Brutsaert's model for sensible and latent heat transport within the interfacial sublayer for both aerodynamically smooth and rough airflow has been experimentally tested under similar conditions [2], validating its application to martian conditions. For the surface sublayer (#2), we modify the definition of the Monin-Obukhov length to properly account for the buoyancy forces arising from water vapor gradients in the martian atmospheric boundary layer. This length scale is then utilized with similarity-theory turbulent-flux profiles with the same form as those used by Businger et al. [3] and others.

We find that under most martian conditions, the interfacial and surface sublayers offer roughly comparable resistance to sensible heat and water vapor transport and are thus both important in determining the associated fluxes. Airflow over surfaces similar to terrestrial polar snow (surface roughness length z_0 approx. 0.03 cm) is generally found to be aerodynamically smooth at low martian pressures (P<30 mb) but aerodynamically rough at high pressures (P>300 mb); airflow at the Viking Lander sites is aerodynamically transitional under current martian conditions. For aerodynamically smooth airflow, the thickness of the interfacial sublayer is found to be up to 100 times thicker for Mars than is typical for the Earth. At low pressures (P<30 mb) and high temperatures (T>250 K), buoyancy forces due to water vapor gradients can become so high on Mars that the surface sublayer (#2) essentially disappears (the Monin-Obukhov length becomes comparable to the thickness of the interfacial sublayer). At this point, the atmospheric boundary layer transitions to the "free convection" regime [4]. Free convection sensible and latent heat fluxes are smaller than those for the case when the surface sublayer (#2) is present. As expected, friction velocities u_* and the sensible and latent heat fluxes are found to be extremely sensitive to the Monin-Obukhov stability parameter for stable atmospheric conditions and mildly sensitive for unstable conditions.

The ability to predict heat losses across an interfacial boundary layer and to predict the shapes of the windspeed and temperature profiles in the atmospheric surface layer, should prove useful for estimating heat losses from engineering structures deployed on the martian surface and for improving our understanding of water vapor transfer rates from icy surfaces (such as the poles) to the atmosphere.

References: [1] Touloukian,Y.S. (1972) **Thermophysical Properties of Matter: The TPRC Data Series**, vol.3,6,11; [2] Brutsaert,W. (1975) **Water Resour. Res.**,11,543-550; [3] Businger et al.(1971) J.Atmos.Sci.,28,181-189; [4] Clow,G.D. and R.M.Haberle (1990) **Lunar and Planet. Sci. XXI**, in press.