MARS SURFACE BOUNDARY LAYER METEOROLOGY OBSERVATIONS FROM VIKING AND PATHFINDER.

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Introduction:

The structures of mean flow and turbulence of the atmospheric surface boundary layer have been extensively studied on Earth, and some- but less -on Mars, where only the Viking missions and the Pathfinder mission have delivered in-situ data

Basic Microclimate:

Largely the behaviour of surface layer turbulence and mean flow on Mars is found to obey the same scaling laws as on earth. The largest micrometeorological differences between the two atmospheres are associated with the low air density of the Martian atmosphere. Together with the virtual absence of water vapour, it reduces the importance of the atmospheric heat flux in the surface heat budget. This increases the temperature variation of the surface forcing the near-surface temperature gradient and thereby the diabatic heat flux to higher values than typical on the Earth, resulting in turn in deeper daytime boundary layers. As wind speed is much like that of the Earth, this larger diabatic heat flux is carried mostly by larger maximal values of T_*. These basic aspects of the Martian climate are illustrated as diurnal cycles of heat flux, stability and boundary layer heights, derived from parameters from Viking and Pathfinder landers.

Basic scaling laws:

The scaling laws have been validated, analysing the Martian surface layer data for the relations between power spectra of wind, pressure and temperature turbulence and the corresponding mean values of wind speed and temperature. Usual spectral formulations have been used based on the scaling laws ruling the Earth atmospheric surface boundary layer, whereby the Earth atmosphere is used as a standard for the Martian atmosphere. Examples of data analysis of both Viking and Pathfinder data are presented, and it is pointed out that the uncertainties in comparing Earth and Mars data to some extent is due to that the Earth regression formulas are rarely build to apply to the low measuring heights used on Mars (≈ 1 meter or less). The daytime velocity spectra scale with the boundary layer height, and through this relation these spectra are argued to constitute the only experimental validation of the generally large daytime boundary layer heights expected on Mars due to the high diabatic heat fluxes, mentioned above.

Effects of the higher viscosity:

The lower density of the Martian near surface atmosphere, yields a much higher kinematic viscosity here than on Earth. The higher kinematic viscosity yields a number of differences in characteristic parameters for Mars and Earth's atmosphere. The Kolmogorov scale is of the order of ten times larger than on Earth, meaning that very often there is no inertial subrange in the Martian turbulence data. Also the characteristic Reynolds number for the atmosphere is found to be much smaller than for Earth's atmosphere, actually about the geometric mean between the value for a boundary layer wind tunnels and the Earth atmosphere. In the principle, this should be important for the modelling efforts, although it is difficult to point to practical applications of this fact.

Additionally consequences of the larger kinematic viscosity are the increased "smoothness" of the Martian atmospheric flow, as described by the roughness Reynolds number. Also, the particle dynamics of Martian aerosols are influenced in that both the gravitational settling velocity and the Stokes number are influenced. The authors will try to summarise the parameters influenced and comment on the influence.

Conclusions:

From Viking and Pathfinder data the turbulent Martian atmospheric surface boundary layer is generally found to obey the same similarity formulations, as those pertaining to Earth, although the diurnal stability variations are quite strong compared to Earth desert conditions. Some of the Earth-model Mars-data inter-comparisons are quite crude, however, and when the kinematic viscosity becomes important, the Martian atmospheric surface layer shows some differences from its Earth counterpart. Also, it should be pointed out that the existing data shows that the interannual variability of the Martian climate is large enough to support continuing measuring programs.

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