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RELATIONSHIPS BETWEEN TOPOGRAPHIC ROUGHNESS AND AEOLIAN PROCESSES

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The interaction between winds and desert surfaces has important implications for sediment transport on Earth, Mars and Venus, and for understanding the relationships between radar backscatter and aerodynamic roughness as part of the NASA Shuttle Imaging Radar (SIR-C) Mission [1,2]. We report here results from measurements of boundary layer wind profiles and surface roughness at sites in Death Valley and discuss their implications. The sites included a flat to undulating gravel and sand reg, alluvial fans, and a playa.

Table 1. Estimates of average particle size composition of Death Valley Sites.

Site	Mean Particle Size Composition (% of surface covered)				
	Clay/silt	Sand	Gravel	Cobbles	Boulders
Stovepipe Wells Flats	1.3	42.5	45.0	11.5	
Kit Fox Fan		63.0	20.0	11.0	6.0
Golden Canyon Fan	25.0	23.0	28.3	17.0	6.7
Trail Canyon Fan			65.0	20.0	15.0
Confidence Mill Playa	100.0				

Boundary layer wind profiles were measured using cup anemometers at heights of 0.75, 1.25, 2.07, 3.44, 5.72, and 9.5 m, temperature sensors at 1.3 and 9.6 m, and wind vanes at 9.7 m and 1.5 m. More than 200 wind profiles were measured at each site. Data were sorted by direction and stability characteristics after calculation of the bulk Richardson number (Ri). Following corrections for atmospheric stability, z_o and u_* were estimated using least-squares methods. Aerodynamic rougheness (Table 2) increases from the smoothest Confidence Mill Playa, to the roughest site, Golden Canyon Fan. Differences in z_o for different wind directions suggest that local conditions may affect aerodynamic roughness.

Table 2: Arithmetic mean values of aerodynamic roughness (z_o)

Site Wind Direction	N-NE	SE-S	W-NW	NW-NNW
Stovepipe Wells		0.00026		0.00055
Kit Fox				
Mast 1	0.00107	0.00237		
Mast 2	0.00085	0.00078		
Golden Canyon				
Mast 1	0.00356	0.00360		0.00537
Mast 2	0.00110	0.00245		0.00113
Trail Canyon	0.00190	0.00182	0.00012	
Confidence Mill	0.00063	0.00018		

Micro-topographic measurements were made using a template and a laser-photo device. After the linear trend in the data due to overall surface slope was removed, the RMS height and correlation length were calculated from the unfiltered data (Table 3). Comparisons show that the RMS height derived from the laser data is ~ an order of magnitude less than that of the template data, suggesting that it is measuring particle roughness. Roughness (RMS height) increases in the same sense as that suggested by visual inspection of the surface. Both the template and site characterization data suggest that Golden Canyon Fan was the roughest site studied. Kit Fox Fan and Trail Canyon Fan differ only slightly from each other. The E-W roughness is less in all cases than the N-S values, probably as a result of the E-W orientation of the bar and swale topography at an oblique angle, a further index of the surface roughness is the geometric mean of the N-S and E-W RMS heights.

Table 3: RMS height (m) derived from template and laser profiles

	N-S	E-W	Mean
Stovepipe Wells			
Laser			0.0056
Kit Fox Fan			
Template	0.0615	0.0328	0.0420
Laser			0.0097
Golden Canyon Fan			
Template	0.0772	0.0394	0.0571
Laser			0.0150
Trail Canyon Fan			
Template	0.0660	0.0256	0.0364
Laser			0.0076
Confidence Mill			
Laser			0.0066

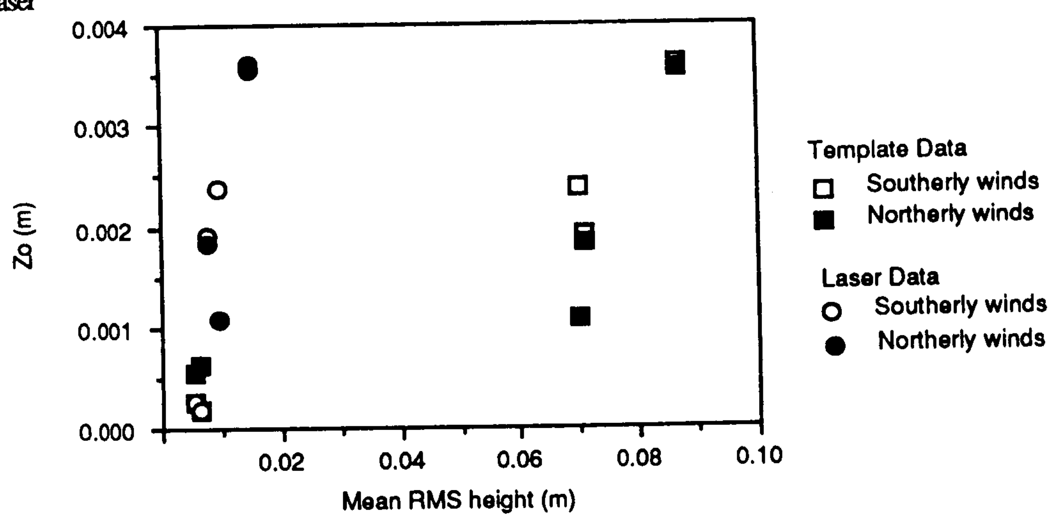

Figure 1: Relationships between geometric mean of RMS height for template transects and laser profiles and aerodynamic roughness estimates.

The aerodynamic roughness of a surface is a function of its microtopographic and particle roughness characteristics. At the alluvial fan sites studied, particle roughness is superimposed on the microtopography of the bars and swales developed on the fan surface. There is a good relationship between unfiltered RMS height and aerodynamic roughness, suggesting that the RMS height of the surface is a good index of its overall roughness. However, as the wind crosses the surface at an oblique angle to the terrain profiles, the geometric mean of the RMS height for both laser profiles gives better "3-D" characterization of the surface, which correlates well with aerodynamic roughness estimates (Fig.1). Data for the laser profiles at each site provide a measure of particle roughness. There is a similarly good correlation between mean RMS height for each site and aerodynamic roughness estimates.

REFERENCES CITED

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2. Greeley, R., Lancaster, N., Sullivan, R.J., Saunders, R.S., Theilig, E., Wall, S., Dobrovolskis, A., White, B.R., and Iversen, J.D.: A relationship between radar backscatter and aerodynamic roughness: preliminary results. Geophys. Res. Letters 15, 565-568 (1988).