N94-16747

DETECTING SURFACE ROUGHNESS EFFECTS ON THE ATMOSPHERIC BOUNDARY LAYER VIA AIRSAR DATA: A FIELD EXPERIMENT IN DEATH VALLEY, CALIFORNIA

Dan G. Blumberg and Ronald Greeley

Department of Geology, Arizona State University
Tempe, Arizona 85287-1404

1. *INTRODUCTION*

The part of the troposphere influenced by the surface of the earth is termed the atmospheric boundary layer (*Stull 1988*). Flow within this layer is influenced by the roughness of the surface; rougher surfaces induce more turbulence than smoother surfaces and, hence, higher atmospheric transfer rates across the surface. Roughness elements also shield erodible particles, thus decreasing the transport of windblown particles. Therefore, the aerodynamic roughness length (z_0) is an important parameter in aeolian and atmospheric boundary layer processes as it describes the aerodynamic properties of the underlying surface. z_0 is assumed to be independent of wind velocity or height, and dependent only on the surface topography (*Bagnold 1941; Greeley and Iversen 1985*). It is determined using *in situ* measurements of the wind speed distribution as a function of height. For dry, unvegetated soils the intensity of the radar backscatter (σ^0) is affected primarily by surface roughness at a scale comparable with the radar wavelength. Thus, both wind and radar respond to surface roughness variations on a scale of a few meters or less. Greeley et al. (*1991*) showed the existence of a correlation between z_0 and σ^0. This correlation was based on measurements over lava flows, alluvial fans, and playas in the southwest deserts of the United States. In this report we show that the two parameters behave similarly also when there are small changes over a relatively homogeneous surface.

2. *EXPERIMENTAL DETAILS*

A study was conducted during the Spring of 1991, in which the atmospheric boundary layer was assessed and compared with σ^0 values obtained from AIRSAR data. Five masts equipped with wind anemometers, wind vanes, and temperature sensors were deployed over an unvegetated alluvial fan on the eastern edge of the Stove Pipe Wells Dune Field in Death Valley, California. The alluvial fan lies at sea level below the Grapevine Mountains, and receives its deposits primarily from Mud Canyon. The predominant airflow in this area is NNW-SSE, across the fan.

Micrometeorologic data were collected for a period of 10 weeks and reduced following a procedure by White (*unpublished*) to derive the surface shear velocity, the Richardson number (*Stull 1988*), z_0 per wind profile, and a mean z_0 per data set. Each data set consisted of approximately 100 wind profiles for a given wind direction per site (Table 1). AIRSAR data were obtained at the site using bands C (5.6 cm), L (24 cm), and P (68 cm). The radar data were calibrated using POLCAL software (*vanZyl et al. 1990*), based on trihedral corner reflectors that were deployed prior to the imaging.

3. *RESULTS*

Mean σ^0 values were extracted for the location of each of the five masts (Table 2) (values did not need to be normalized for variations in incidence angles, as all incidence angles were between 45^o to 47^o). Figure 1 shows that σ^0 and z_0 change simultaneously and in the same direction for winds from the north-northwest, suggesting that they are responding to similar surficial changes. These variations are probably induced by roughness changes comparable with the radar wavelength. Surface roughness measurements were conducted using an electronic distance meter, a surface template, and a laser profiler. The surface roughness data are being analyzed to determine if the changes in surface roughness corroborate the radar and wind results. Winds from the south-southeast showed larger variations of z_0, suggesting that they are affected by the fluvial dissection found south of the study site.

4. *CONCLUSIONS*

Based on the north-northwesterly winds we conclude that z_0 and σ^0 have similar spatial patterns even when measured over a relatively homogeneous surface. L-band cross-polarized data correlate best with z_0 over a dry, unvegetated alluvial fan. Further work is required to determine the scales of roughness affecting these parameters.

Table 1. z_0 across the alluvial fan

Mast	Distance from northwest to southeast (m)	z_0 (m) southeasterly winds	z_0 (m) northwesterly winds
2	200	0.00608	0.00208
3	400	0.00055	0.00076
4	700	0.00806	0.00288
5	1000	0.00240	0.00310

Table 2. σ^0 variations across the alluvial fan

Mast	C-band (dB)			L-band (dB)			P-band (dB)		
	HH	HV	VV	HH	HV	VV	HH	HV	VV
1	-12.72	-20.97	-12.32	-21.92	-34.70	-20.06	-31.31	-47.01	-27.14
2	-14.29	-22.40	-12.77	-24.43	-36.94	-22.46	-34.27	-49.73	-30.78
3	-13.87	-22.52	-12.85	-25.34	-40.61	-22.96	-35.00	-50.65	-31.87
4	-13.16	-22.47	-13.00	-23.40	-37.39	-21.18	-32.74	-48.78	-29.67
5	-12.35	-21.71	-11.66	-22.36	-35.66	-20.48	-32.20	-49.01	-29.04

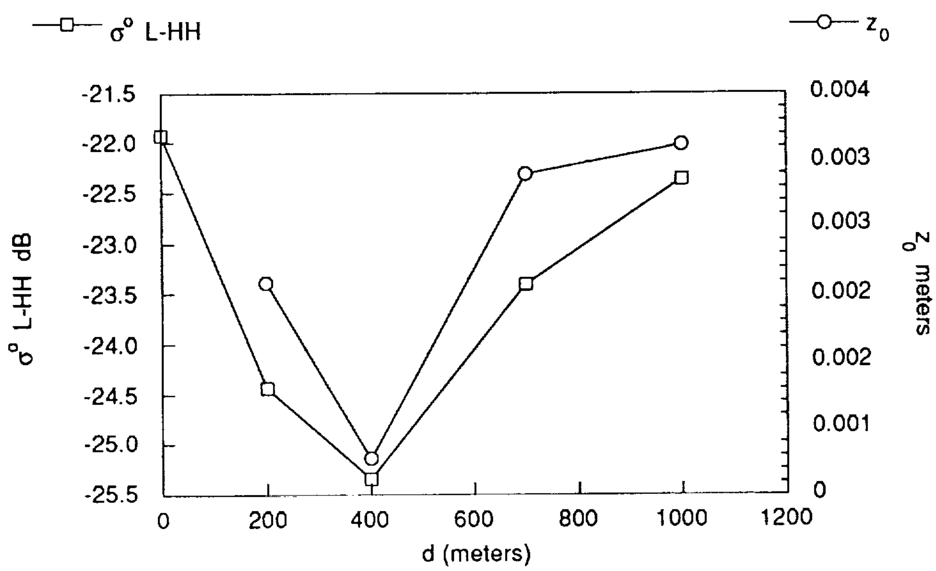

Figure 1: Mean radar backscatter in L-band (24 cm) , and z_0 values for northwesterly winds versus the locations of the masts across the alluvial fan. For the most northern station no z_0 value was determined due to instrument problems.

References

Bagnold R.A., 1941, *The Physics of Blown Sand and Desert Dunes*, Methuen, London, pp. 265.

Greeley R., and J.D. Iversen, 1985, *Wind as a Geological Process*, Cambridge, New York, pp. 333.

Greeley R., L. Gaddis, N. Lancaster, A. Dobrovolskis, J. Iversen, K. Rasmussen, S. Saunders, J. vanZyl, S.Wall, H. Zebker, and B. White, 1991, Assessment of Aerodynamic Roughness via Airborne Radar Observations, *Acta Mechanica*, Suppl. 2, pp. 77-88.

Stull R.B., 1988, *An Introduction to Boundary Layer Meteorology*, Kluwer Academic Publishers, Netherlands, pp. 666.

vanZyl J., C.F Burnette, H.A. Zebker, A. Freemean, and J. Holt, 1990, *POLCAL Users Manual*, JPL, D-7715, Pasadena, pp. 49.