FINAL ASSESSMENT OF 2018 WIND PROFILING DATA FROM THE PUNA OF ARGENTINA. J. R. Zimbelman[1], S. L. de Silva[2], M. G. Spagnuolo[3]. [1]CEPS/NASM, Smithsonian Institution, Washington, D.C. 20013-7012, zimbelmanj@si.edu, [2]CEOAS, Oregon State University, Corvallis, OR 97331, [3]IDEAB, UBA-CONICET, Buenos Aires, Argentina.

Introduction: Field work to determine the aerodynamic roughness height (z0) of gravel-covered megaripples was conducted in the Puna of Argentina [1] during November 19-23, 2018. Preliminary results from that work were reported at LPSC 50 [2]. Here we present new results from reprocessing the data after constraining it to times during which wind profiling is likely to be most useful.

Background: Wind profiling data can be used to constrain aerodynamic roughness height (z_0) if careful attention is paid to the many factors that can limit the usefulness of the wind data [3]. Early wind profiling data from the Puna suggested z_0 was in the range of 1 to 3 cm [4], but these results were hampered by us not being aware of the many recommendations made by Wieringa [3] prior to this earlier work. Wieringa makes the important point that a 'wind speed of zero is true in a purely algebraic sense only, since it implies extrapolation of (the Law of the Wall) below its limits of validity' [3, pg 325]. The 2018 trip obtained new data-logging anemometer results after paying careful attention to limitations associated with profiling data.

Methodology: Two portable towers ~2.3 m tall were used, each with five data-logging anemometers spaced logarithmically on the towers. Sampling sites and anemometer heights were selected following the recommendations of Wieringa [3]. Specifically, the lowest anemometer height was >20 times the estimated z_0 of the area, five recording anemometers were used now instead of the three used in the earlier work [4], towers were sited at a distance downwind of the nearest megaripple that was >15 times the megaripple height, the fetch upwind of the tower had consistent roughness elements for >100 m, and we avoided times near sunrise or sunset. Records were only used here for time intervals where the wind speed systematically increased with increasing height. A least-squares logarithmic fit was applied to the average wind speeds for each useful time interval. Fits should have a correlation coefficient (r^2) that was ≥0.90; this fit was used to calculate the height of zero wind speed (z_0).

Results: Intermittent issues arose with some of the anemometers during most data collection runs, perhaps associated with the high elevation of the Puna. Most likely the inconsistent problems were <u>not</u> caused by wind flow over megaripple topography since we were careful to locate the towers sufficiently downwind from the nearest megaripple.

Campo Piedra Pomez (CPP). No fits using five anemometers gave r^2 >0.90; excluding one anemometer did not improve the fits. A tower located downwind of a fetch of >200 m of flat gravel-covered plain (lacking megaripples) gave a z_0 of 1.3 cm, r^2 of 0.79, for a five-anemometer fit. Gravel size and packing is greater on a megaripple crest than it is between megaripples (Fig. 1).

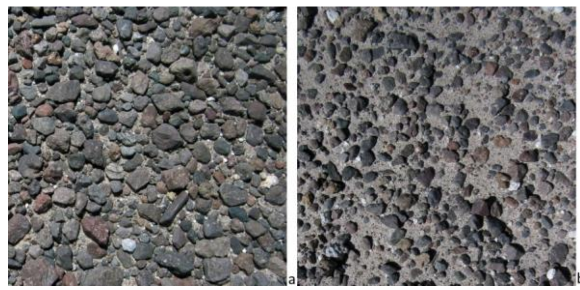

Figure 1. Gravel clasts near a megaripple crest (a) and between megaripples (b) at CPP. Both vertical views show areas 15 cm on a side. JRZ, 11-19-2018

CPP West. A five-anemometer fit was obtained during a 26-minute interval (Table 1), giving z_0 of 1.4 cm, r^2 of 0.95. The afternoon wind was parallel to the megaripple crests instead of being perpendicular to the crests. Aerodynamically this condition is analogous to that of the CPP flat gravel plain.

Lago Purulla. Incipient gravel megaripples were forming on wind-scuplted ignimbrite bedrock. Five-anemometer fits had r2 <0.72, but a four-anemometer fit gave z0 of 1.0 cm, r2 of 0.89.

Purulla. Intermittent anemometer discrepancies were particularly problematic at this location. One 7-minute interval gave a five-anemometer fit with r2 of 0.36, but the same interval gave a four-anemometer fit of z0 of 1.1 cm with r2 of 0.98 (Fig. 2).

Incahuasi. Wind direction was variable at this location (±45° of perpendicular to megaripple crests). In spite of the variable wind orientation, a 2.5-hour recording (Table 1) gave z0 of 4.5 cm, r2 of 0.95 (Fig. 3). Megaripples are similar to those at Purulla (Fig. 2).

Discussion: The CPP gravel plain (lacking megaripples) and the wind flow parallel to megaripple crests at CPP West both display comparable z_0 values of ~1 cm. This result suggests that the 1 cm z_0 value may reflect 'skimming flow' has occurred above the

Table 1. 5-anemometer average wind speeds.

CPP West		**11-20-18**	(26 min)
Anem	Ht (cm)	V_{ave} (m/s)	
5	200	10.38	
4	134	9.07	
3	90	8.11	
2	60	7.56	
1	40	7.07	

Incahuasi		**11-22-18**	(2hr 26min)
Anem	Ht (cm)	V_{ave} (m/s)	
5	200	1.66	
4	160	1.56	
3	127	1.39	
2	101	1.33	
1	80	1.28	

Figure 2. Oblique view of gravel-covered megaripples at Purulla. Bedforms are ~70 cm tall. JRZ, 11-21-2018.

Figure 3. Oblique view of gravel-covered megaripples at Incahuasi. Bedforms are ~60 cm tall. JRZ, 11-22-2018.

closely spaced gravel particles. Wieringa [3, p 327] says ‘skimming flow occurs when the surface is so closely covered with obstacles (at a relative distance ≤3 times the height of the obstacle) that flow in the interspaces between obstacles has a regime quite separate from the bulk flow above’. In this case the roughness height is less a result of the size of an individual particle than it is the cumulative effect of many closely spaced irregular gravel particles. Therefore, the 1 cm z_0 value represents a lower limit of aerodynamic roughness in a gravel-rich setting. As form flow associated with megaripple shape increases, z_0 begins to reflect the influence of the scale of the megaripples. Results from Incahuasi suggest that when form flow becomes important, z_0 can become 4.5 cm in the Puna megaripple fields. Wieringa’s words that the calculated height at which wind speed reaches zero holds only in a ‘purely algebraic sense’ means that z_0 values obtained from a logarithmic fit to wind profile data must be interpreted using considerable caution.

Conclusions: Puna gravels (consisting of both lithics and pumice) have z_0 of ~1 cm, likely representing skimming flow above the closely spaced gravel particles. The Puna megaripple fields have z_0 of up to ~4 cm as the roughness height transitions from that of the skimming flow over the gravels to a roughness height that includes the effect of the bedform size.

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