Aeolian Sand Sorting and Soil Moisture in Arid Namibian Fairy Circles

Supplementary Information

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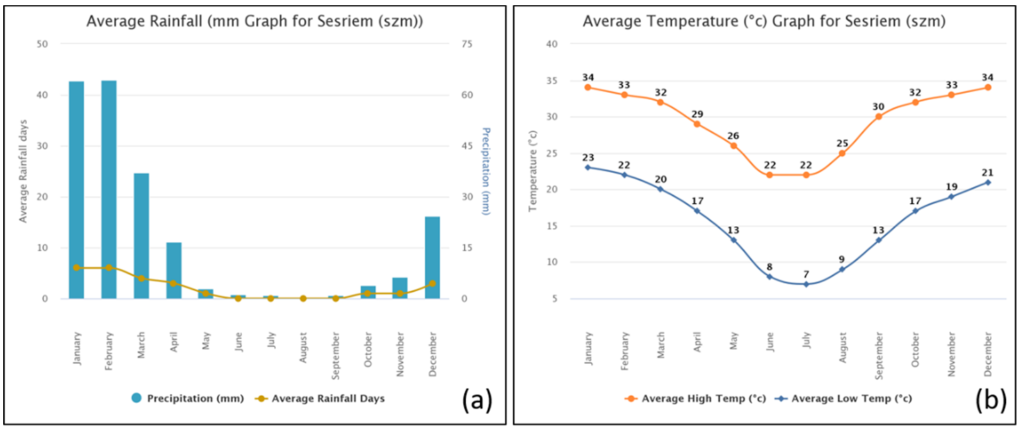
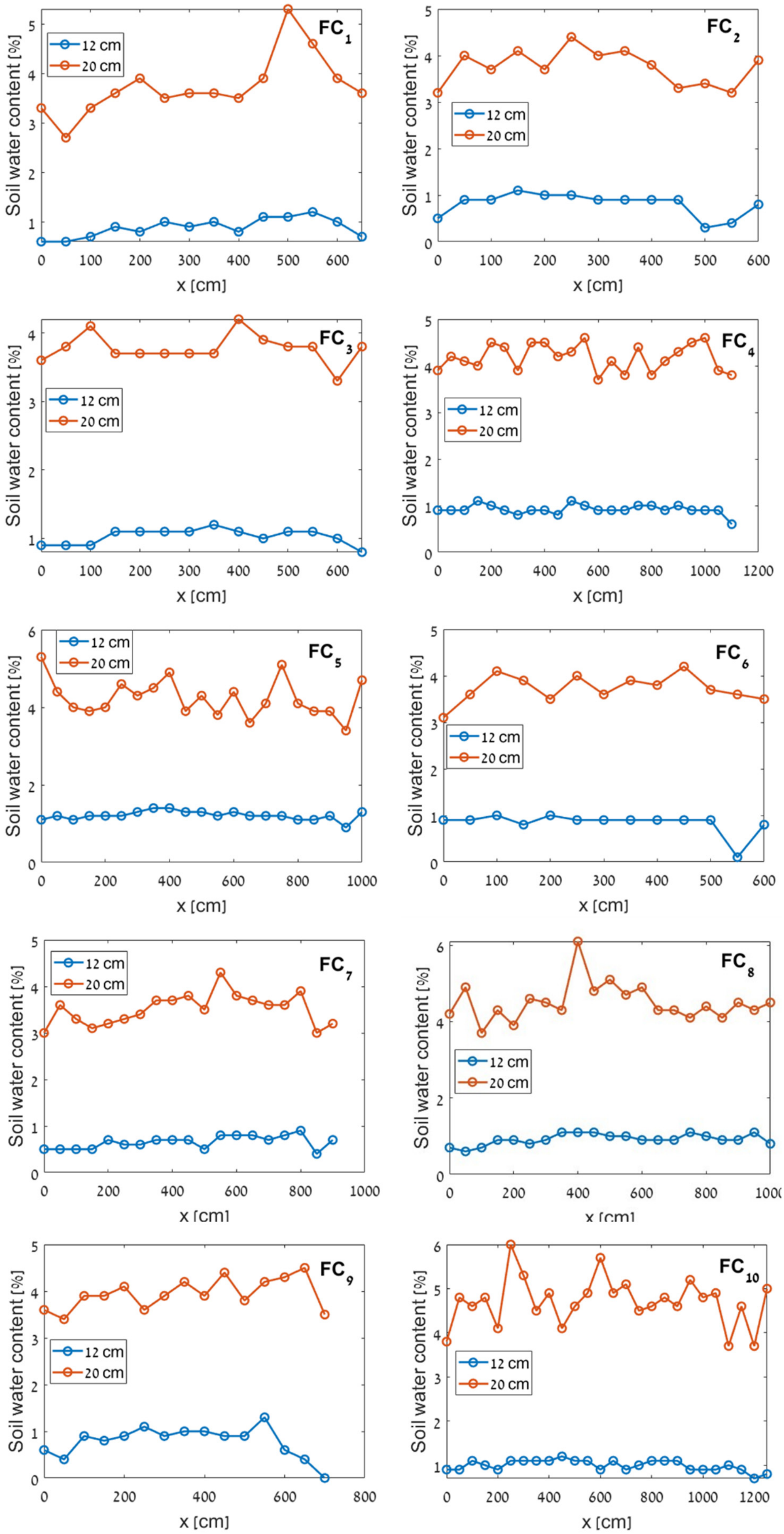


Figure S1. (a) Average rainfall by month and average number of rainy days in Sesriem. The rainy season is mainly between January and March. (b) Average high and low monthly temperature. The lowest average temperature is in July (7°C), the highest is in December and January (34°C). Source: https://www.worldweatheronline.com/v2/weather-averages.aspx?q=szm&custom_header=sesriem+airport+(szm)+weather%2C+namibia



FC_1
FC_2
FC_3
FC_4
FC_5
FC_6
FC_7
FC_8
FC_9
FC_{10}
12 cm
20 cm
Soil water content [%]
x [cm]

Figure S2. Cross-section SWC profiles at two depths (12 and 20 cm) for the 10 fairy circles in the study site.

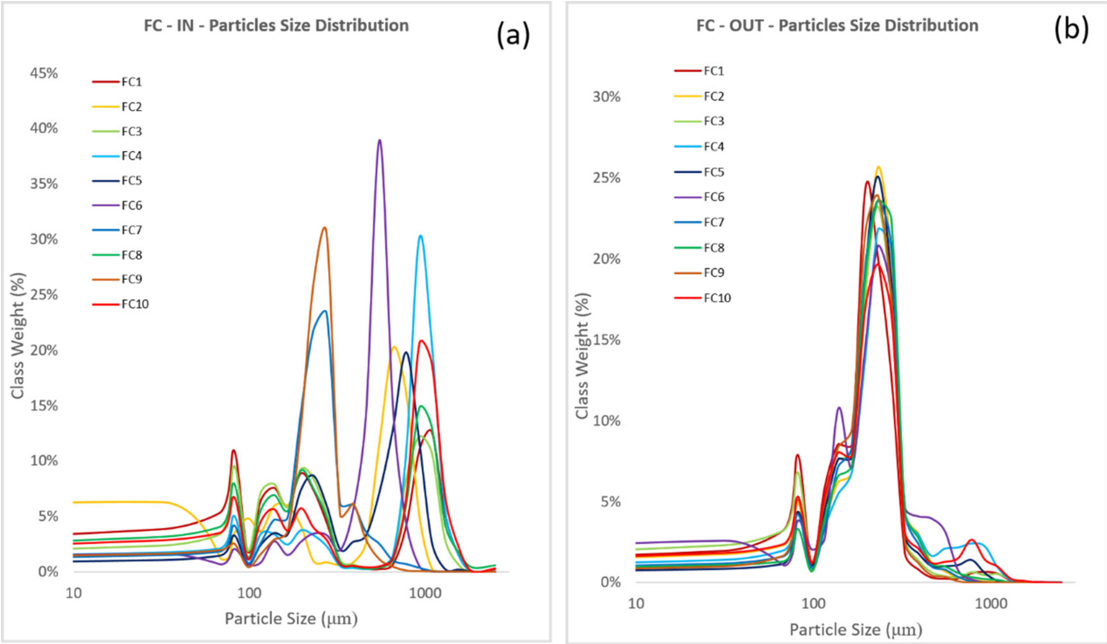


Figure S3. Grain size distribution curves of samples taken from inside the fairy circles (a) and from outside (b). Overall, the samples from the interior are much coarser than those from outside. See text in the main manuscript for more details and grain size statistics.

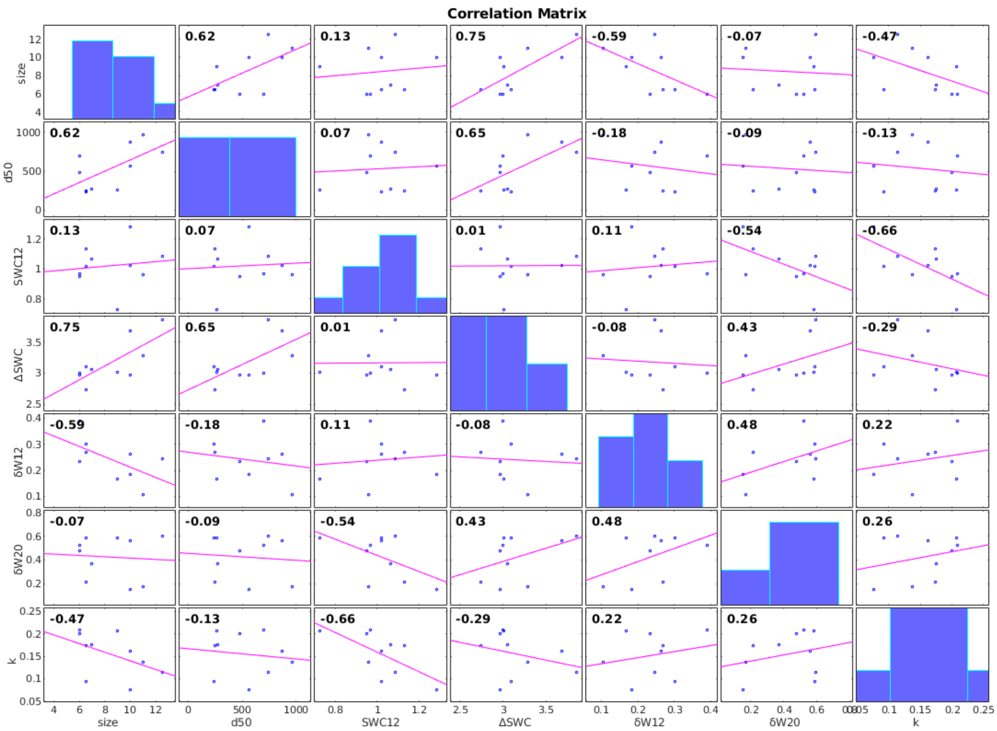


Figure S4. Correlation matrix, showing correlation plots between the following variables: diameter (size) of the fairy circle, median surface grain diameter (d50), soil water content at 12 cm depth (SWC12), estimate of vertical moisture gradient (ΔSWC = SWC12 - SWC20), lateral moisture gradients at 12cm and 20cm depth (δW12 and δW20) as well as the hydraulic conductivity, measured at the surface (k). Inset numbers are the values of Pearson's correlation coefficient R.

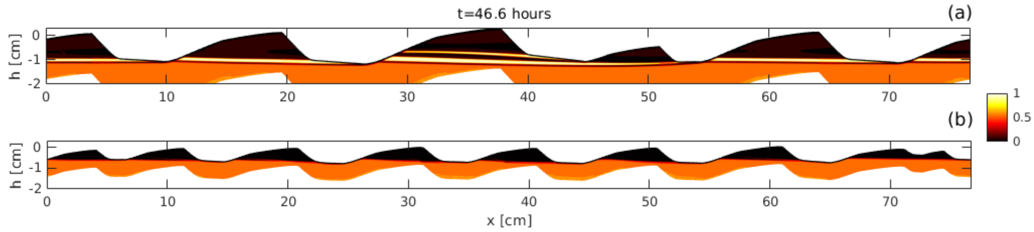


Figure S5. The difference between the two types of megaripples (smaller inside the fairy circle and larger outside) can be shown by preliminary numerical simulations (this is work is still in progress) of the model of Manukyan and Prigozhin, 2009 [1]. This mathematical model is one of a very few models that consider the sorting mechanism in the formation of sand ripples and the interaction of the bedform with the saltation cloud. In fine sand, the ripples can grow to their final size due to the erosion of grains from the crest by the wind. For a bidisperse grain size distribution of fine and coarse grains, the ripples grow larger, and a segregation of grains develops. The crest and the windward slope are covered by coarse grains, forming the armoring layer. In addition, the model can also simulate the inner laminated layer structure of sand ripples. The figure shows the effect of the degree of flux saturation on the formation of megaripples and seems to support the discussion in the main text (0.75 in panel a and 0.2 in panel b). For small saturation values, the ripples are smaller and the armoring layer is thin compared to the ripples developed for higher saturation flux, representing the conditions at the bare areas (all other parameters are the same in both simulations). The initial condition is random small perturbations for both simulations. The color bar shows the concentration of fine grains; the black color represents the armoring layer; and the y axis is the height in cm (the scale is the same for both panels).

Figure S6. *Asphodelus ramosus* ring in the Northern Negev, Israel (31.1016N, 34.8327E; 155 mm/year). The interior of the ring is covered by fine grains deposited by the wind.

Figure S7. The top 10 cm layer of the soil inside a fairy circle. The megaripple layer is predominantly composed of coarse grains (grayish), delineated by the white curve. Below this layer, the sand is predominantly composed of fine grains (reddish).

References

1. Manukyan, E.; Prigozhin, L. Formation of aeolian ripples and sand sorting. PRE 2009, 79, 031303. https://doi.org/10.1103/PhysRevE.79.031303.