Impact of grain size distribution and wind velocity on the armoring layer of aeolian megaripples

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Introduction

Aeolian ripples formation is influenced by various factors, including surface conditions, boundary layer forces, and dominant sand transport mechanisms. When the grain size distribution (GSD) is bimodal, taller structures, known as megaripples, emerge. The bimodal distribution facilitates the simultaneous operation of two transport mechanisms: saltation for fine grains and reptation for coarse grains. This leads to a spatial distribution of grain sizes within the bedform, with smaller grains accumulating at the base and larger grains at the crest, forming an armoring layer. studies indicate that the sorting mechanism is a fundamental factor in understanding the formation of megaripples and that the armoring layer plays a crucial role in aeolian sand transport, aeolian erosion, and development dynamics of megaripples.

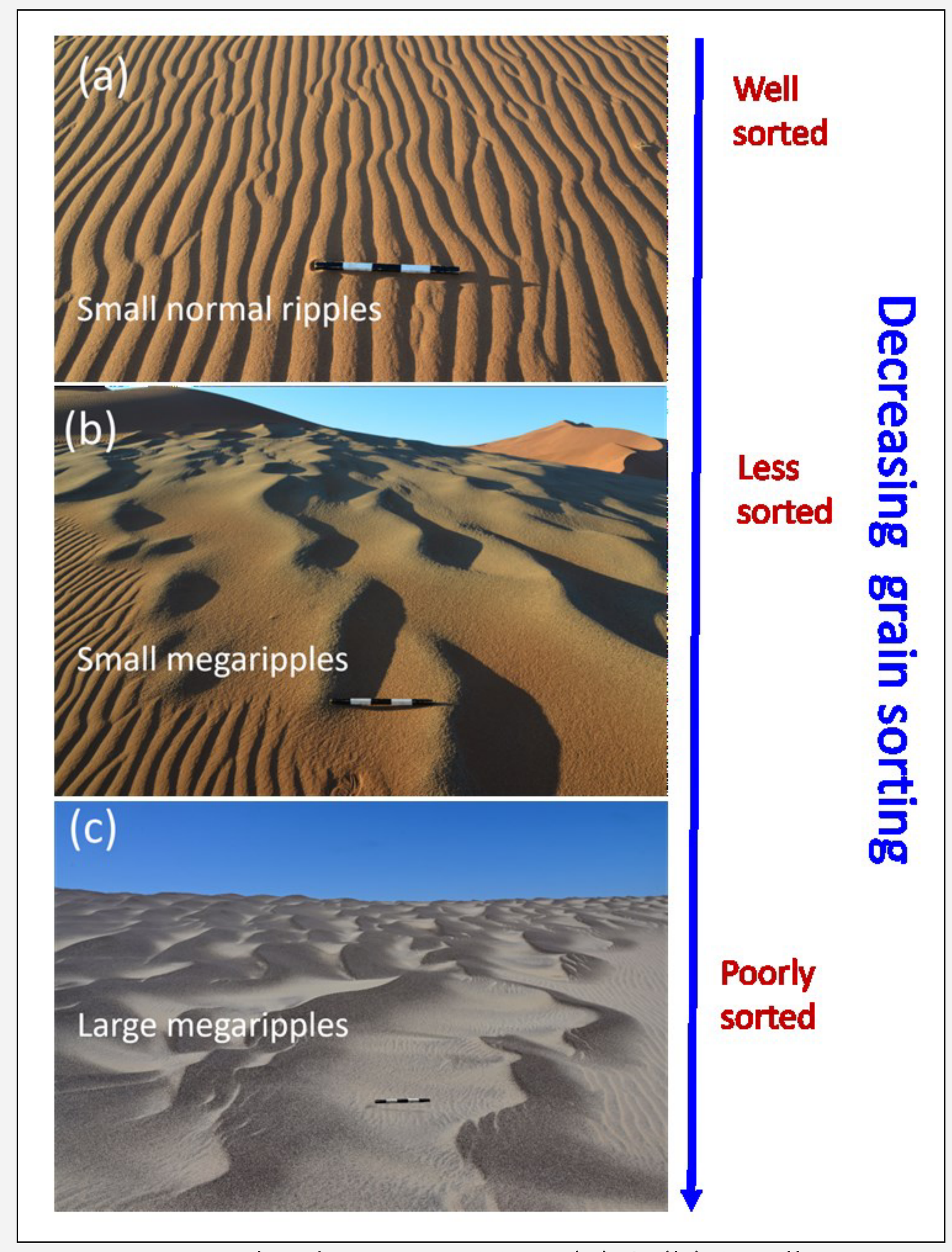
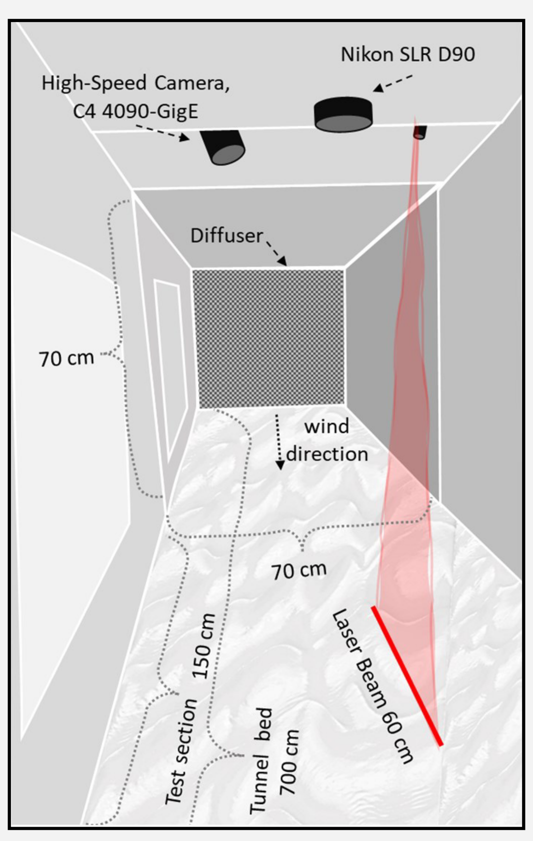


Fig1. Decreasing sorting leads to transition. (a) & (b) Small impact ripples and megaripples at Sossusvlei, Namibia. (c) Large megaripples near Torra Bay, Namibia

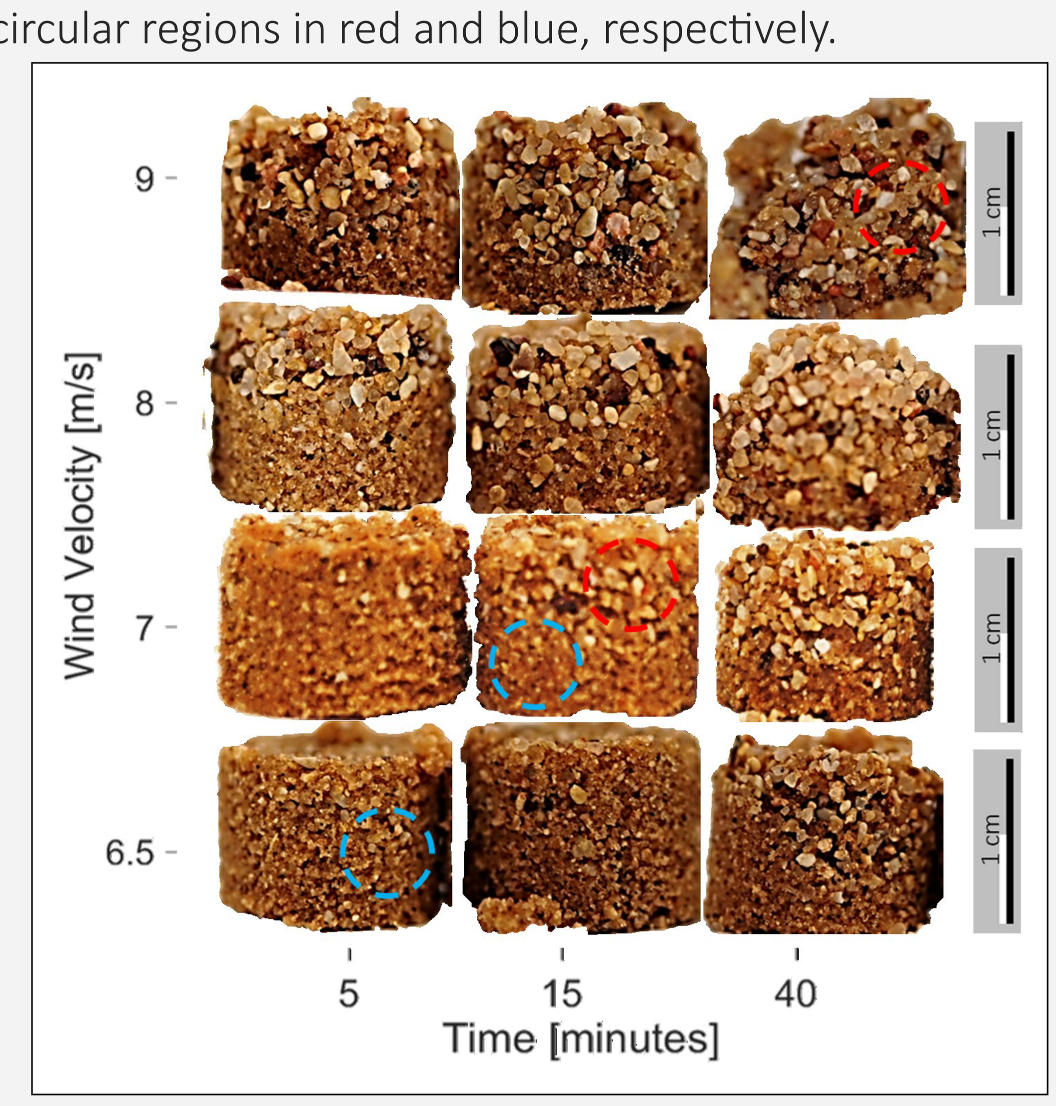
Methods



The experiment was conducted in the stationary boundary-layer tunnel at Ben Gurion University Aeolian Simulation Lab (Figure 2). Core extractions from the ripples crest and saltation samples were taken, alongside measuring wind velocity, documenting sand bed development, and analyzing surface morphology. The sand used in the experiment had a bimodal GSD similar to megaripple fields in Israel. Wind velocities covered the range from fluid threshold to ripple destruction. In addition core samples from natural megaripple fields were also analyzed.

Fig2. The set of the experiment in the BGU stationary wind tunnel.

Fig3. Armoring layer evolution over time under different wind velocities. The armoring layer comprises a distinct accumulation of coarse grains above finer grains, demonstrated in selected images by circular regions in red and blue, respectively.



Results & discussion

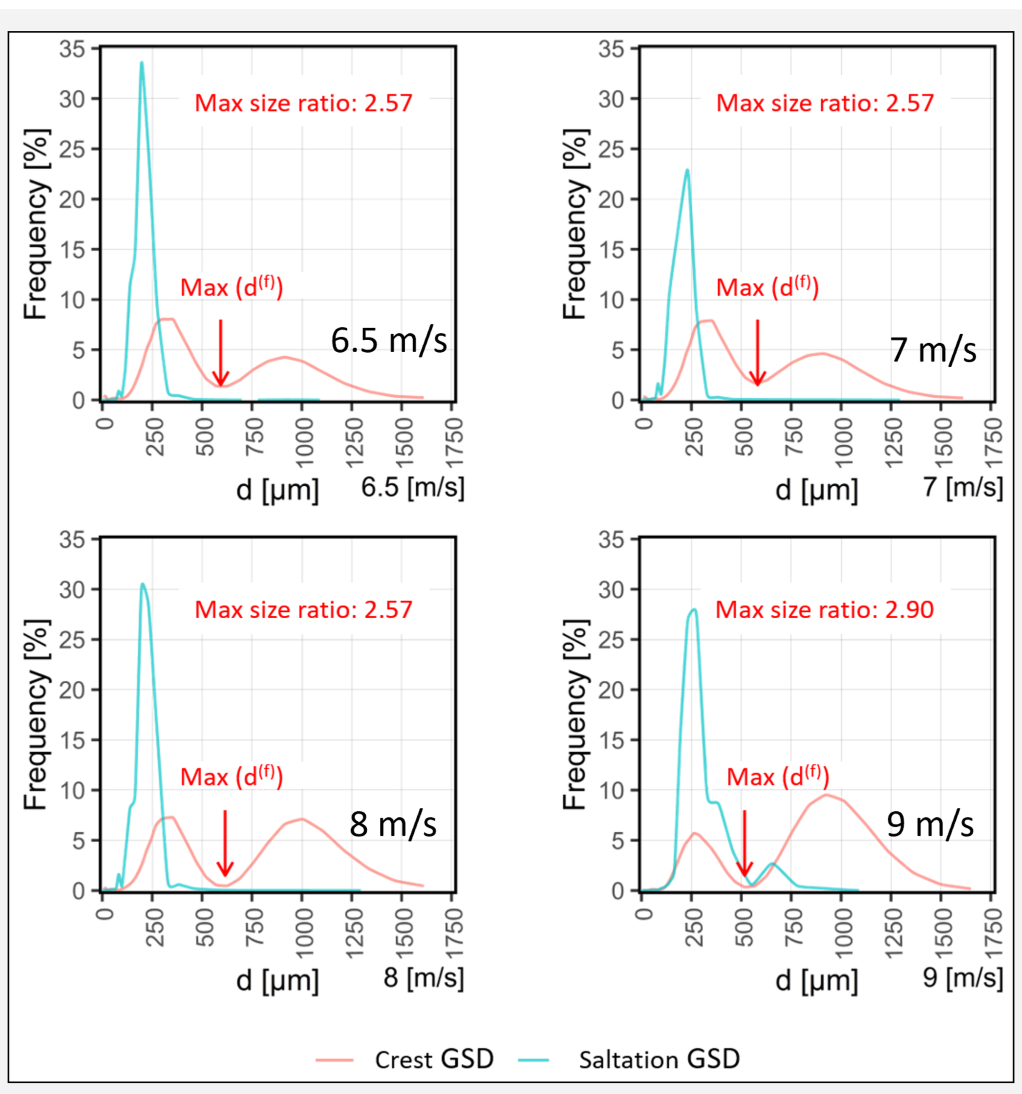


Fig4. GSDs of the crests cores and from the saltation traps for 40 minutes and for different wind velocities.

Figure 3 demonstrates the variations in segregation intensity under differing wind conditions. With increasing wind velocity, there is a shift in the composition of the ripple crest, characterized by a decrease in fine particles and an increase in coarse particles.

Notably, as illustrated in Figure 5, ripple height and armoring layer thickness seems to be correlated irrespective of wind velocity, affirming previous studies findings regarding the development and destruction mechanism of megaripples. Essentially, thicker armoring layers correspond to taller megaripples, suggesting a cumulative effect stemming from the deposition of coarse grains at the crest.

Figure 4 highlights that while coarser grains can saltate at high wind velocities, the maximum grain size typically driven by saltation is smaller than the minimum mode observed in the crest GSD ($max(d^f)$). The "max-size ratio", representing the ratio between the maximum diameter of the reptating grains and the saltating grains, ranged between 2.6 and 2.9. this aligns closely with the prediction of Tholen et al.,(2022) model, which anticipates a ratio of 2.75, despite the smaller dimensions of megaripples observed in the wind tunnel experiments compared to those found in the field.

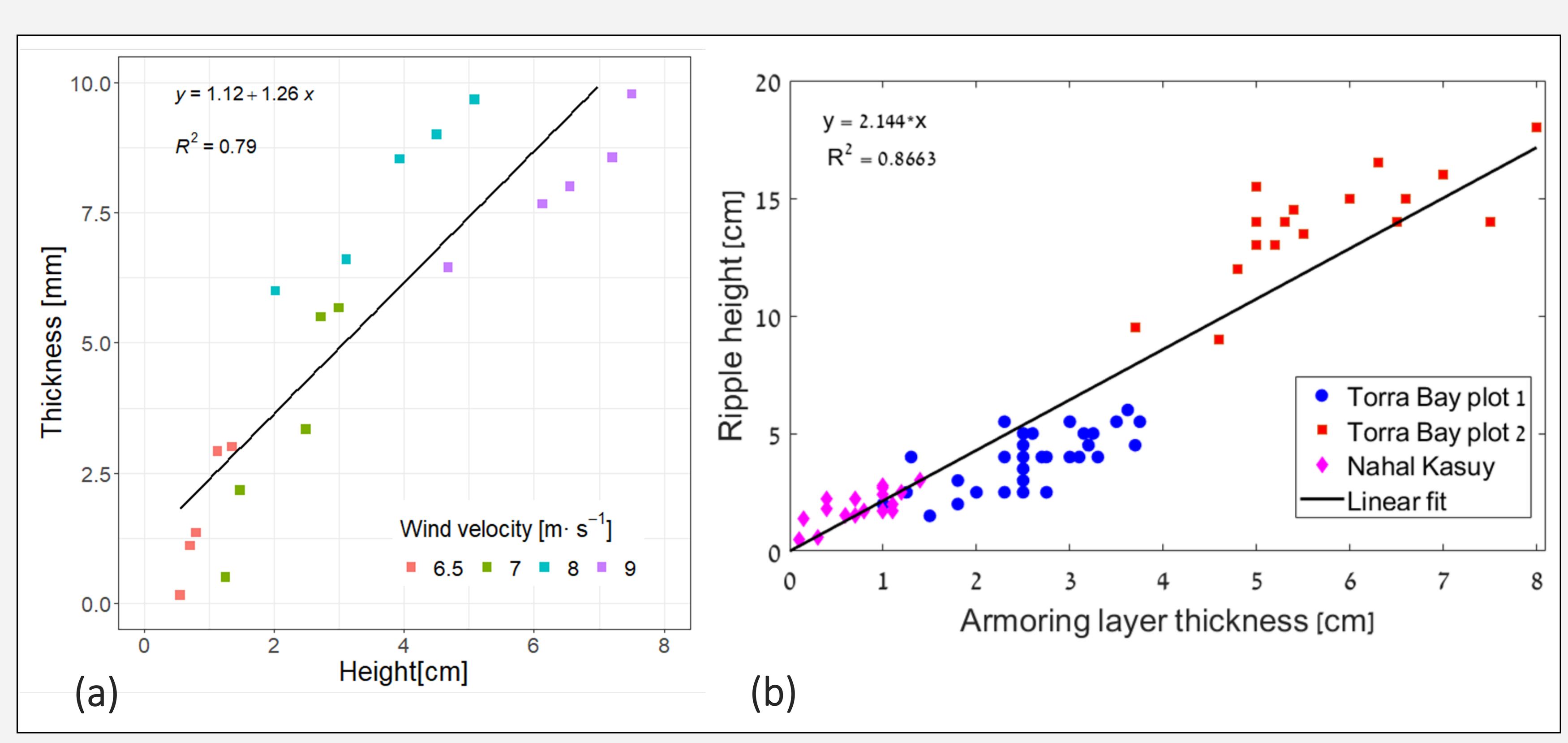


Fig5 Ripple height as a function of the armoring layer thickness (a) lab measurements (b) field campaigns (natural megaripple plots).