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Optimal array of sand fences from CFD simulations

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Sand fences are often employed to reduce wind velocity and prevent aeolian soil erosion in areas affected by sand encroachment and desertification. Erection of sand fences also provides a means to reduce rates of dust emission, which is largely a result of the impacts of wind-blown sand grains onto the soil and affects the climate of our planet. Several types of fence have been designed and their impact on sediment transport dynamics investigated since many years. However, the search for the optimal array of fences by means of field experiments alone is a challenging task given that field experiments are plagued with uncontrolled weather conditions and large time scales. To achieve maximal soil protection with the minimal amount of fence material, a quantitative understanding of the turbulent wind profile over the relief including the area to be protected as well as all erected fences is required.

Here we apply Computational Fluid Dynamics (CFD) to investigate the average turbulent airflow through an array of fences as a function of the spacing, porosity and height of the fences. In particular, we study the effect of these parameters on the fraction of soil area over which the basal average wind shear velocity drops below the threshold for sand transport in presence of the fences. A cost function is introduced, which encodes the information on the amount of material necessary to construct the fences for a given protected area. We show that, for typical sand-moving wind velocities, the optimal fence height that minimizes this cost function is around 50 cm, while fences of height around 1.25 m lead to maximal cost [1].

[1] Lima, I. A.; Araújo, A. D.; Parteli, E. J. R.; Andrade Jr., J. S.; Herrmann, H. J. Optimal array of sand fences. Scientific Reports 7, 45148 (2017)