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Characterization of windblown sand transport in open field conditions through wind-sand tunnel testing and computational simulation

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Aeolian sediment transport in desert and sandy coastal environments affects civil structures and infrastructures, such as pipelines, industrial facilities, towns, single buildings, farms, roads, and railways [1]. The wind flow interacts with surface-mounted obstacles of any kind inducing sand erosion, transport, and sedimentation around them. This can lead to detrimental effects such as the loss of functionality of the endangered structure or infrastructure, or even danger for users when structural failure is involved [2]. In order to cope with the effects above, the demand for the characterization of aeolian sand transport and the design of Sand Mitigation Measures (SMMs) has grown in the last decade and is expected to further increase in the next years [1]. The multiphase and multiscale nature of the aeolian flow ranging from the sand grain diameters to the obstacle characteristic lengths make the problem only tractable by means of physical experiments and computational simulations. On the one hand, in-situ full scale field tests are expensive, time-consuming, and subject to environmental setup conditions difficult to control. On the other hand, numerical models shall be carefully validated against physical experiments. Hence, experimental Wind-Sand Tunnel Tests (WSTTs) are often carried out.

In this study, windblown sand transport on flat ground is reproduced by means of WSTTs carried out in the wind tunnel L-1B of von Karman Institute for Fluid Dynamics. The aim of WSTTs is twofold. On one hand, they are intended to characterize the incoming sand flux in open field conditions. On the other hand, they allow to properly tune cheaper Wind-Sand Computational Simulations [3], so as to assess the performance of SMMs in full-scale. The wind tunnel setup implements a uniform 5-meter-long sand fetch as sand source. The wind speed boundary layer and sand flux saltation layer are characterized through 2D Particle Image Velocimetry (PIV) and Particle Tracking Velocimetry (PTV) techniques, respectively. Wind flow and sand transport state variables are assessed along the sand fetch by setting the wind speed equal to 1.3, 1.5, 2 times the threshold one, and by assessing the influence of a monoplane grid installed at the inlet of the wind tunnel testing sections. Results from WSTTs are critically discussed by investigating the effects induced by the sand fetch length, wind speed, and turbulence intensity on the sand transport.

Finally, a Eulerian multiphase computational fluid dynamics model is tuned in order to reproduce the obtained results.

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