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Evaluating the efficacy of multitemporal TLS and UAS surveys for quantifying wind erosion magnitudes of sand dune topography

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Wind erosion constitutes a prominent land degradation process in regions of Hungary characterized by low annual precipitation. In these areas, it poses significant challenges to agricultural productivity and adversely impacts soil and environmental quality. Presently, human activities exert a more pronounced influence on the endangered areas of Hungary in comparison to climate-related factors. It is noteworthy that the wind erodibility of Hungarian soils not only poses a soil conservation challenge but also gives rise to economic ramifications, such as nutrient loss, as well as environmental and human health concerns. Within agricultural landscapes, wind erosion contributes to the removal and transportation of the finest and biologically active soil fractions, rich in organic matter and nutrients.

High-resolution topographic surveys have become integral for assessing volumetric changes in sand dune mobility and mapping wind erosion. While Unmanned Aerial Systems (UAS) surveys have been extensively employed for erosion rates exceeding the decimeter scale, Terrestrial Laser Scanning (TLS) surveys have demonstrated efficiency in capturing more extensive negative erosional forms, even in a vertical orientation. To enhance the field of view, a mounting framework can be implemented to elevate the TLS. However, determining centimeter-scale material displacement in flat terrain conditions remains challenging and requires an increased number of scanning positions.

To identify optimal settings for surveying centimeter-scale wind erosion magnitudes, we conducted combined multi-temporal TLS and UAS surveys at the Westsik experimental site near Nyíregyháza during the spring of 2023. This site features dune topography with a height of 6 meters. Our investigations encompassed various UAS image acquisition modes, involving different flight altitudes and camera settings, utilizing a DJI Matrice M210 RTK v2 drone and a Zenmuse X7 24 mm lens. Additionally, we generated diverse point clouds through various scanning scenarios using a Trimble X7 TLS device. In the data processing phase, we explored multiple co-registration algorithms to address the challenge of larger Root Mean Square Error (RMSE) in Digital Terrain Models (DTMs) from UAS Structure from Motion (SfM) compared to the actual wind erosion rates.

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