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# A new turbulence-based model for sand transport

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Knowledge of the changing rate of sediment flux in space and time is essential for quantifying surface erosion and deposition in desert landscapes. While many aeolian studies have relied on time-averaged parameters such as wind velocity (U) and wind shear velocity (u*) to determine sediment flux, there is increasing evidence that high-frequency turbulence is an important driving force behind the entrainment and transport of sand. However, turbulence has yet to be incorporated into a functional sand transport model that can be used for predictive purposes.

In this study we present a new transport model (the 'turbulence model') that accounts for high-frequency variations in the horizontal (u) and vertical (w) components of wind flow. The turbulence model is fitted to wind velocity and sediment transport data from a field experiment undertaken in Namibia's Skeleton Coast National Park, and its performance at three temporal resolutions (10 Hz, 1 Hz, 1 min) is compared to two existing models that rely on time-averaged wind velocity data (Radok, 1977; Dong et al., 2003). The validity of the three models is analysed under a variety of saltation conditions, using a 2-hour (1 Hz measurement resolution) dataset from the Skeleton Coast and a 5-hour (1 min measurement resolution) dataset from the southwestern Kalahari Desert. The turbulence model is shown to outperform the Radok and Dong models when predicting total saltation count over the three experimental periods. For all temporal resolutions presented in this study (10 Hz–10 min), the turbulence model predicted total saltation count to within at least 0.34%, whereas the Radok and Dong models over- or underestimated total count by up to 5.50% and 20.53% respectively.

The strong performance of the turbulence model can be attributed to a lag in mass flux response built into its formulation, which can be adapted depending on the temporal resolution of investigation. This accounts for the inherent lag within the physical saltation system that has been reported in previous studies. Whilst the inclusion of both the u and w flow components is a key conceptual element of our new model, similar to recent field studies (e.g. Schönfeldt & von Löwis, 2003; Wiggs & Weaver, 2012; Chapman et al., 2013), we find that fluctuations in w are relatively unimportant for driving saltation, because wind-driven flux is more strongly associated with a positive u component. The best predictions of total sand transport are achieved using our turbulence model at a temporal resolution of 4 s in cases of partially developed saltation, and at a resolution of 1 min in cases of well-developed saltation. The proposed approach could prove to be significant for integrating turbulent transport processes into long-term, macro-scale landscape modelling of drylands

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