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Evaluation of Saltation Flux Impact Responders (Safires) for measuring instantaneous aeolian sand transport rates

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Abstract

The assessment of aeolian sand transport rates in the field on small temporal and spatial scales is of primary interest for the development and testing of more detailed models of sand movement by wind in general and of interactions between the flow field and the saltation layer in particular. One basic method of assessing detailed transport rates employs a responder that registers and counts the impacts of saltating grains hitting the probe through time. The Sensit and the Saltiphone are two examples of this type of instrument that have been used in various previous studies. This paper reports on laboratory calibrations and preliminary field tests of a new design of piëzo-electric impact responders capable of measuring saltation impacts at a frequency of 20 Hz, called 'Safires'.

Laboratory calibrations were performed with a vertical gravity flume generating known sand grain fluxes using regular sand and specific individual size-fractions. The fall velocities of grains as a function of their size and fall distance along the vertical tube were calculated using a numerical solution of the Basset-Boussinesq-Oseen equations. This enabled the determination of the momentum flux as a function of fall distance along the tube. Initial tests of 35 Safires involved investigation of three fundamental characteristics: correspondence between digital and analogue signals generated by the instrument, relative response as a function of azimuth angle around the probe (directional response), and linearity in response as a function of mass flux in the fall flume.

Calibrations of the instruments involved two approaches. The first is an investigation of direct correspondence between mass flux and signal response. The second involves determination of the minimum momentum threshold required for the instrument to register a grain impact. Using this lower limit and the known distribution of grain size and speed at different fall depths a prediction can be made as to the sand grain flux the Safire ought to measure, which is then compared with the signal response. The latter approach essentially determines the instrument's measuring efficiency.

These Safires were also deployed in the field as part of a larger experiment designed to investigate aeolian streamers. During this experiment sand traps were deployed along-side Safires on time scales of 10 minutes and this provided the opportunity to compare the instrument's recordings with traditional sand trap yields.

The advantages of the Safire are: 1) that they provide high-frequency measurements, 2) that they present a very minimal obstruction to the wind flow (no scour observed in the field), and 3) that they are of a (relatively) low-cost. However, the sensor shares the limitation inherent in all impact responder-type instruments, namely that measurements are based on grain momentum rather than mass alone and that results are therefore difficult to translate to traditional mass fluxes.