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Field calibration of aeolian sand transport models

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All aeolian sand transport models include one or more empirical calibration coefficients, based on either wind-tunnel measurements or field measurements from a specific environment, to obtain correspondence between measured and observed transport rates. When evaluated using field-based scenarios, it is common for the models to substantially over-predict transport rates compared to those measured. Many reasons have been offered to explain the disparity, including the impacts of a suite of environmental controls not considered in the models, such as sediment moisture content, surface slope, or vegetation. We posit that at least some of the error is attributable to the application of laboratory-derived constants to prototype environments. This position is based upon previous research demonstrating the distinct scaling constraints on wind tunnel boundary-layer conditions so that the laboratory studies cannot replicate, especially, the effects of larger-scale turbulent structures. Other effects stem from the use of environment specific calibrations where complicating factors are included but not explicitly described (e.g., local slope or moisture effects). To account for such effects, we recalibrated five transport equations using quality-controlled data obtained from three field experiments. These data include 5 data sets from Inch Spit, Ireland (described in Sherman et al., 1998), 13 data sets from Esposende, Portugal (described in Li et al., 2009), and 15 data sets from Jericoacoara, Brazil (described in Li et al., 2010). Samples in each case were obtained from a flat, dry sand surface (moisture content less than 2%) with a long, unobstructed fetch (60 – 200 m) with low gradients – conditions approaching the ideal. We used these data to recalibrate the Bagnold (1937), Kawamura (1951), Zingg (1953), Owen (1964), Hsu (1971), and Lettau and Lettau (1978) models. Each of these models has at least one empirical constant to scale physical relationships with observed transport rates. We use field measurements and samples to obtain observed values for transport rate, grain size, and shear velocity. Shear velocity estimates were obtained from the slope of log-linear velocity profiles using an apparent von Kármán parameter (κa) instead of the von Kármán constant ($\kappa = 0.40$), as described in Li et al. (2010). We used linear regression to relate model predictions with observations. Using their original empirical coefficients, all models yield comparable regression statistics with values of r2 of approximately 0.80, and $P < 0.001$. The robust regression results reflect the quality of the field data and support their use for this recalibration effort. We then manipulated the regression analyses to correct the slopes of least-squares lines to 1:1 and intercepts to zero. The new calibration coefficients, and their comparison to originals, are presented. We also present comparisons of model results using original and recalibrated coefficients and the von Kármán constant with predictions using the adjustable, apparent von Kármán parameter and the recalibrated coefficients.