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Desert dune growth and development: measurements of airflow and morphological change

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The early stages of dune development remain a poorly understood aspect of bedform evolution. Flow-form feedbacks, however, are recognised to be fundamental in driving bedform growth across different stages of dune development. Specifically, the growth of aeolian bedforms has been linked theoretically with the location of the maximum windspeed at a point upwind of the bedform crest. This upwind position of maximum velocity, combined with the relaxation length scale for sand transport (Lsat) allows sand deposition in the crestal region of dunes, a necessity for vertical growth of the dune body. To date, there has been only limited empirical evidence of this process on a small number of individual dunes.

We present field data from the Skeleton Coast dunefield in Namibia on the morphological change of a suite of bedforms over the full range of dune development stages (i.e. sand patch, protodune, dome and barchan dune). Our investigations include measurements at both high-energy event timescales and over a multi-annual period. For the event-scale periods, near-surface airflow measurements have been undertaken coincident with high frequency surface change allowing the coupling of flow dynamics and morphological change to the stage of dune development.

This paper will highlight the extent to which the crestal flow velocity patterns elucidate the distribution of erosion and deposition for the range bedform types. For example, the airflow over the protodune demonstrates the crest-upwind velocity shift coinciding with patterns of sediment deposition and vertical growth. Annual change of the established dunes (dome and barchan) reveals features maintaining their shape while migrating, while also increasing their overall sediment volume.

While flow-form measurements indicate the importance of airflow dynamics in driving dune growth as observed over the short term, multi-year change reveals shrinkage of both the sand patch and protodune at our study site. Such long term measurements therefore demonstrate the influence of external forcings, such as sediment supply. This suggests caution when applying models to interpret real world environmental examples.