Quantifying avalanche frequency, sediment budgets and crest-brink deformation processes on a barchan dune using terrestrial laser scanning

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Dune fields are synonymous with desert regions and the dunes within them are constantly moved and shaped by the wind, creating beautiful patterns through intricate feedback relationships between process and form. Our understanding of small-scale airflow and transport, along with large-scale links between overall dune field patterns and different climate drivers has improved over recent years, but questions as to how these elements actually form, grow and migrate are still unanswered. Using a novel methodological approach and applying state-of-the-art equipment we have started to address this gap by directly linking shape change on dune surfaces to aeolian sand transport and wind process dynamics. By increasing our understanding of the way in which dune surfaces change, we can improve our ability to predict and manage dune migration in dryland environments and apply this knowledge in understanding the potential for re-activation of 'relict' dune systems in response to climatic variation.

Aims and Objectives

The overall aim of this project was to investigate the development and migration of barchan dunes along the Skeleton Coast in Namibia in September 2014, through the collection of the first high resolution spatial (mm accuracy over 10s of m) and temporal (seconds to weeks) dune surface sedimentation data set using terrestrial laser scanning, complimented by co-located airflow measurements (Figure 1). The overall aim was accomplished through a number of specific objectives focused on a typical barchan dune:

1) Quantify event-based sedimentation and saltation pattern variations
2) Quantify spatial variations in airflow, turbulence and saltation
3) Identify the dynamic feedbacks operating between airflow, sand transport and sedimentation.

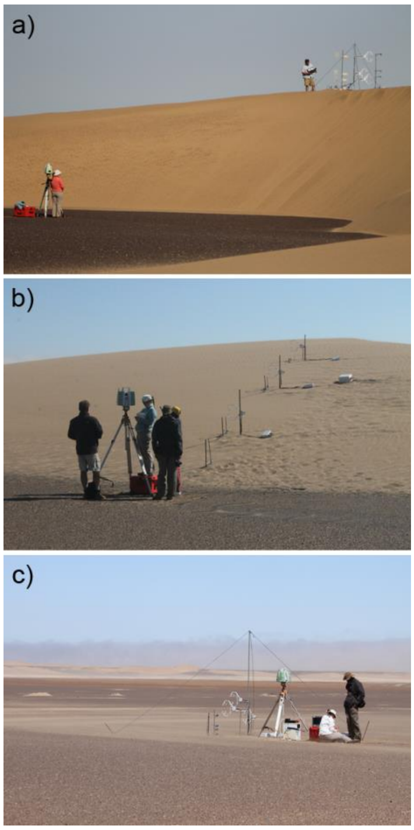

Figure 1: a) avalanche measurement, b) ripple migration and c) horn transport

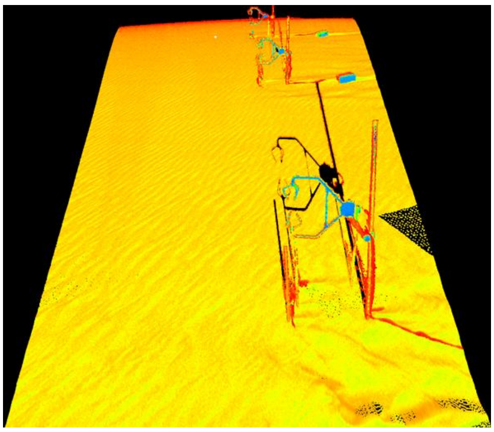

Figure 2: Raw point data during a single scan of the dune flank to measure ripple migration rates

Main Findings

We successfully measured surface deformations including ripple migration on the dune flanks (Figure 2), avalanches on the slipface and saltation exiting the horns of the barchan. During the measurement period, wind directions changed enabling us to link differences in avalanche patterns to reworking, where larger avalanches occur on the reworked surface but take longer to initiate. Avalanche erosion and deposition patterns also change with the wind intensity as well as the duration of the wind storm (Figure 3). Avalanches initiated within the grain fall zone and propagated depending on slope morphology.

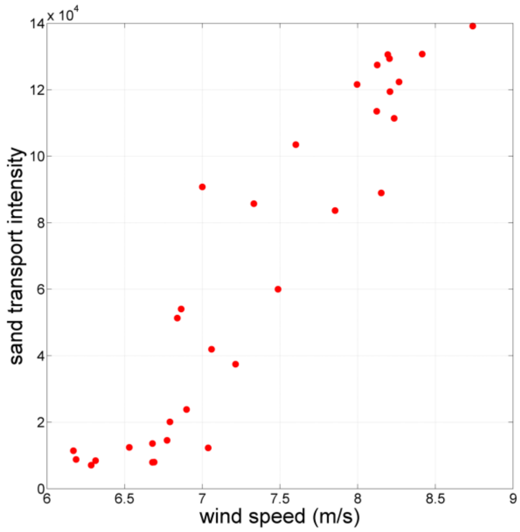

Figure 3: Mean wind speed and total saltation counts

Grant Value and Dissemination

The BSG grant enabled us to obtain further funding from National Geographic and expand the project to include a second field campaign (commencing in Sept. 2015). Preliminary findings will be presented at AGU 2015, and several publications are planned.