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Temperature and humidity measurements within desert barchan sand dunes, relation to dune aeolian mobility and microbial growth

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We present diurnal variations of temperature and humidity profiles below the surface of hyper-arid aeolian crescent-shaped "barchan" dunes in Qatar and Mauritania, measured using a thermal probe and a new ultra-sensitive capacitance instrument that we developed for this purpose. We also report long-term measurements from a probe sunk on the downwind avalanche face of a mobile Qatar barchan, recording temperature and humidity until it emerged on the upwind slope 15 months later. We interpret the data by modeling heat and moisture transfer at the surface in terms of measured net surface radiation, wind, and atmospheric conditions.

We demonstrate the presence of microbes on sand grains within these mobile dunes using microscopic observations, fluorescence counts, metagenomic sequencing, and C12/C13 isotope analysis of carbon dioxide sampled below the surface. By determining how water activity grows with moisture adsorbed on these sands, we delimit regions within the dune where our instruments recorded humidity conducive to microbial growth.

Finally, we compare the mobility of two adjacent Mauritania barchans having distinct surface grain size, shape, and depth humidity profiles. Armored by large grains on its surface, the smaller dune was more oblong. As a result, it lacked flow recirculation in its wake, trapped less aeolian sand downwind, and was much less mobile than its smaller size would suggest. This slower mobility led to greater humidity and cohesion at depth than the larger dune exposed to the same atmospheric and wind conditions.