NAMIB SAND SEA FIELD ANALOGUES TO THE LINEAR DUNES OF TITAN. J. Radebaugh1 R.D. Lorenz2, J.W. Barnes3, A.G. Hayes4, K.D. Arnold1 and C.K. Chandler1. 1Department of Geological Sciences, Brigham Young University, Provo, UT 84602 (janirad@byu.edu); 2Johns Hopkins Applied Physics Laboratory, Laurel, MD; 3University of Idaho, Moscow, ID; 4Cornell University, Ithaca, NY.

Introduction: Sand dunes in Earth’s large deserts are similar in size and relationship to substrate and topography to the tens of thousands of dunes seen on the surface of Titan by Cassini. Field studies of large dunes can thus inform our understanding of the evolution of similar dunes on Titan. A recent field study to the Namib Sand Sea yielded valuable results concerning the morphology, internal structure, and response to winds of a section of a typical dune in the sand sea.

Linear Dunes on Earth: A dominant landform in Earth’s large deserts, such as the northern Sahara, Saudi Arabia, Australia and Namibia, is the linear dune [1]. This duneform, named for the morphological characteristic of the length greatly exceeding the width, is typically found in broad locations such as shields, where sands can undergo transport and accumulation freely [2]. The great sizes of linear dunes, which range up to several km wide, up to 200 m in height, and can be several hundred kilometers long [3], pair with large collection areas to ensure great sediment volumes.

The Namib Sand Sea is a type location for this dune form, possessing linear dunes of a variety of sizes and morphologies across an extensive depositional basin located between the Atlantic Ocean and the eastern uplands. The sand is derived from the South African uplands via the Orange River on the sand sea’s southern margins and is then shepherded north by SSW winds and north-moving oceanic longshore drift [4]. Sand remains in the system because of seasonal easterly winds and a topographically rugged northern margin, which lead to low volumes of sediment transport north of the Kuiseb River [4]. It is these opposing winds that are thought to create and elongate the linear form, through down-axis sediment transport resulting from wind deflection in the lee of active crests [5]. The opposing, seasonal winds cause the crestlines of the Namib linear dunes to shift, create cuspatate morphologies and change slip face orientations [5, 6] (Fig. 1).

Linear Dunes on Titan: Linear dunes are also a dominant landform on Titan, covering close to 15% of the surface [7, 8, 9]. They are similar in size and radar character as seen by the Cassini spacecraft at 2.2 cm as sand dunes on Earth at 3 cm (Fig. 2). Cassini SAR images of dunes are lower in resolution than similar 3 cm SAR images of Earth’s dunes, so crestline details cannot be observed. However, it is clear that dune sands are absorbing to the SAR signal, and thus must be fine-grained and free of any rough or solidifying coverings. Near-IR and microwave images of Titan indicate the dune sands are carbon-bearing material from methane photochemistry that happens in the upper atmosphere [10, 11]. Because dune morphologies are similar to those in the Namib and other deserts, we infer the particles were, and possibly are, free to move and saltate in Titan’s dense winds and lower gravity [12, 13] (Fig. 2).

The Namib as a Field Analogue: The Namib Sand Sea can yield important insights into dune formation and evolution on Titan, where we have limited data. Much of that work thus far has been comparisons of dune morphologies, which have helped us determine...
wind directions, sand thickness variations and behavior around topographic obstacles [14, 11]. Large topographic obstacles in the Namib jut up above the dunes, leading to deflection of the wind and alteration of the trajectory of the linear dune forms out to several kilometers from the obstacle. This morphology can also be seen in the Belet Sand Sea on Titan, where interdunes are SAR-dark and thus sandy, and where dunes are deflected by SAR-bright, rough and elevated inselbergs [14]. Dunes on Titan are currently only accessible from a spacecraft orbiting at a significant distance from the body. The constraints on the images we can obtain are such that we cannot see details that may indicate if the dunes are undergoing active development. Furthermore, the formation and elongation of linear dunes on Earth is not well understood, or may vary across regions, and thus field studies of active dune systems such as those in the Namib will help us unravel linear dune histories on Titan and Earth.

**Namib Field Studies:** A reconnaissance research trip to the northern Namib Sand Sea in August 2013 included aerial overflight and ground-based morphological studies of dunes. In addition, Global Positioning System (GPS) and Ground Penetrating Radar (GPR) studies were done on a previously unstudied dune south of the Gobabeb Research Station. The aerial observations revealed highly variable morphologies of linear dunes across the sand sea, in particular in the height of dunes, morphology of crestlines, and amount of sand in the interdunes (Fig. 3).

**Application to Titan:** Further studies on our chosen location dune in the Namib Sand Sea using GPS and GPR, perhaps in a grid survey and at neighboring dunes, will provide an understanding of the current state and history of the northern Namib linear dunes. We will then combine this information with analysis of remote sensing data, similar to what is available from Cassini, to help us understand how these results can inform dune formation and evolution on Titan.

**References:**