Sensitivity of Automatic Determination of Sand Transport Direction and Rate to Dune Morphology in the Namib Sand Sea. S. P. Scheidt[1] and N. Lancaster[1]. [1]Desert Research Institute, 2215 Raggio Parkway, Reno, NV 89512, sscheidt77@gmail.com.

Introduction: Many morphologic dune groups make up the hyperarid Namib Sand Sea, a 120-200 km wide area situated on the Atlantic coast of southern Africa between Walvis Bay and Lüdertz (Figure 1). These dune groups include barchans [1,2,3,4], transverse, linear [5] and complex forms, and some of these dunes have been examined as terrestrial analogue for dunes on Mars and Titan [6,7,8]. Studies suggest that sand transport is taking place on Mars [9,10,11], but actively migrating dunes have not yet been identified on Mars [12,13]. Measuring dune migration and sand flux rates is important to understanding aeolian systems. A number of different approaches have been used in the field [e.g., 14,15,16], but the recent development of the Coregistration of Optically Sensed Images and Correlation (COSI-Corr) algorithm [17] has also afforded a unique remote sensing application for measuring dune migration rates in dune fields [18,19]. Necsoiu et al. [19] were able to use precisely orthorectified, coregistrated SPOT and ASTER satellite imagery to take advantage of the algorithm's ability to determine subpixel correlation between images from different dates, which was related to dune migration rate. These rates are slow compared to the rate of barchan dune sand flux measured in the Bodele region of Chad using COSI-Corr applied to ASTER satellite data [18]. Both studies produced meaningful estimates of dune celerity over time from satellite image data. Vermeesch et al. [18] chose to use simple barchan dune forms to test their techniques in order to avoid second order features of more complex dunes that might cause errors in the application of the correlation algorithm.

Approach: The viability of the COSI-Corr technique for dune studies is established, so our work seeks to test the algorithm's sensitivity to different dune types and evaluate the performance of alogorithm with respect to each. We use locations in the Namib Sand Sea where previous measurements of dune morphologic changes have been measured, including dune migration rates of barchan dunes [2,3] and changes in linear dunes (specifically the crest orientation) [5]. These areas include dunes near (1) Walvis Bay, (2) linear dunes just south of the Kuiseb River and (3) dune groups at the southern margin of the sand sea northeast of Lüderitz (Figure 1). Orthorectified ASTER data from different dates have been acquired that will allow us to study changes between seasons in the same year, as well as incremental and maximal changes between years 2000 and 2009.

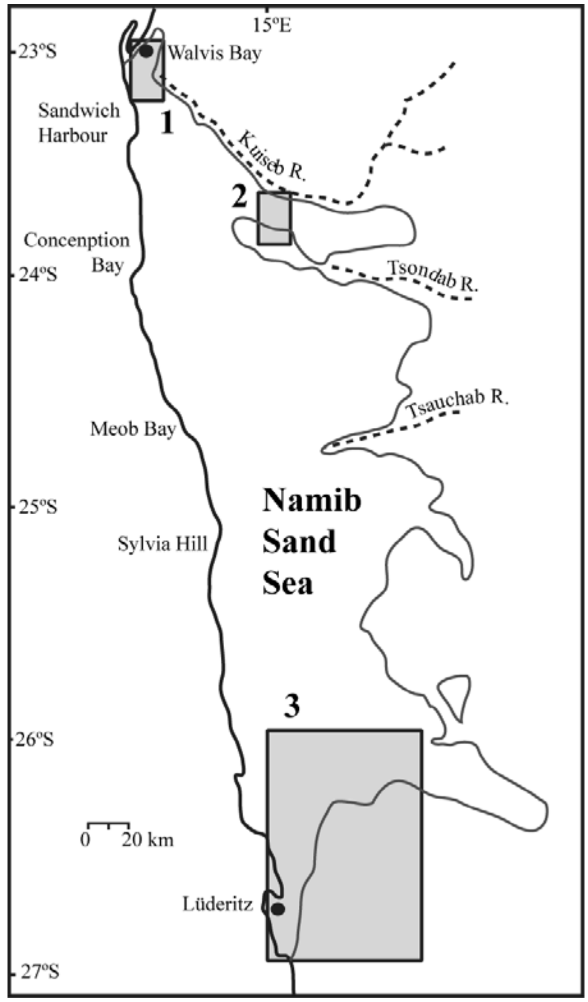

Figure 1. The study location map of the Namib Sand Sea. The numbered, shaded boxes (see text) above show the areas where we are experimenting with the measurement of dune migration and morphologic change using ASTER data and the COSI-Corr algorithm.

Results: A number of different algorithm parameters can be chosen when applying the COSI-Corr algoirthm to determine land surface change, where some of these parameters are set according to the expected magnitude of land surface change (e.g. dune displacement) [17]. For complex dunes and in dune fields with several different dune types, the same parameters are not ideal for each of these areas. Consequently, a variety of questions arise from the results. For example, the sediment transport direction appeared to be estimated correctly according to linear dune defects, but the correct magnitude of transport rate was uncertain. For closely spaced transverse dunes, the offset between 'before' and 'after' satellite imagery appeared to be less than 2 pixels, but the resulting sand transport vectors appeared to be overestimated. In the case of these transverse dunes, we suspect the algorithm (given the set of parameters chosen) determined the correlation between the wrong adjacent dune crests. In areas where transverse dunes are widely spaced, such as the Walvis Bay barchan dunes [2] (Figure 2) and barchan dunes at the southern margin of the Namib Sand Sea (Figure 3), the correct sand transport directions were estimated.

Future Work and Conclusions: Testing of the algorithm continues in order determine seasonal and year to year changes of Namib sand dunes, which will be compared to previously published dune migration rates. We expect the completion of this sensitivity analysis to be useful for future studies that apply COSI-Corr to Mars image data sets to make these types of aeolian measurements. For example, HiRISE data may be used to measure ripple migration rates. The sensitivity analysis should help establish for specific dune types: (1) the ideal time interval between images used in the algorithm, (2) ideal algorithm parameters to avoid errors and (3) the limitations that need to be considered when applying this technique to other aeolian systems on Earth, Mars and Titan.

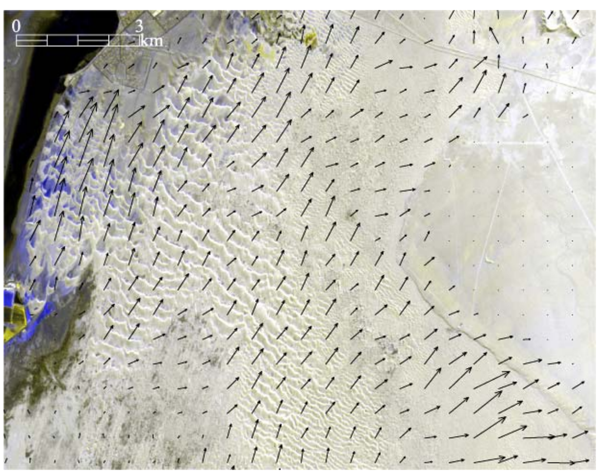

Figure 2: Cosi-Corr dune migration rate vectors are overlain on this color composite image, where both 'before' (May 2003) and 'after' (July 205) ASTER Band 3 are used. Areas of change show as color values here, where gray-scale generally indicates no change. 'Yellow' indicates higher reflectance from 2003 dune faces. 'Blue' indicates the 2005 dune faces. Blue areas on the left margin of the image indicate interdune changes in reflectance, but also indicate the highest rates of barchan dune movement. The direction of the vectors agree with the dune morphology, crest orientations and resultant wind directions for this area.

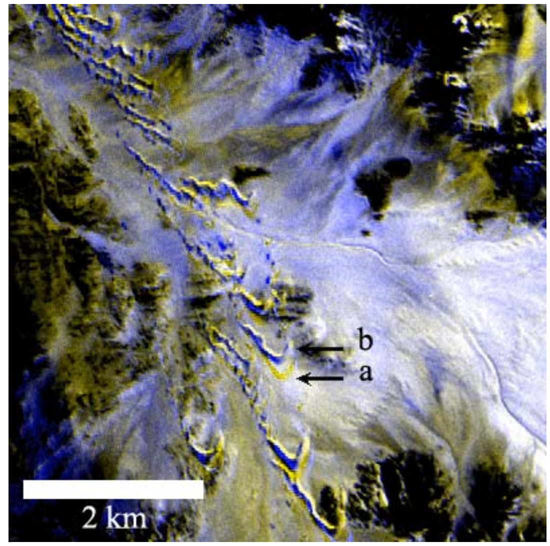

Figure 3. Barchan dunes migrate north-northwest in this area on the southern margin of the dune field. (a) 2003 barchan dune position (yellow). (b) 2005 barchan dune position (blue).

References: [1] Lancaster N. (1989), The Namib Sand Sea: Dune Forms, Processes, and Sediments, 200 pp. [2] Slatterly M.C. (1990), S. Afr. Geogr. J., 72, 5-10. [3] Endrödy-Younge S. (1982), Cimbebasia(A), 5, 257-271. [4] Bourke M.C. and Goudie A.S. (2009), Aeolian Res., 1, 45-54. [5] Bristow et al. (2007), Geology, 35(6), 555-558. [6] Breed C.S. (1977), Icarus, 30(2), 326-340. [7] Radebaugh J. et al. (2008), Planetary Dunes Workshop, Abstract #7034. [8] Wall S.D. et al. (2009), American Astronomical Society, DPS meeting #41, #21.07. [9] Bourke, M.C. et al. (2008) Geomorphology, 94, 247–255. [10] Bourke M.C. et al. (2008) Planetary Dunes Workshop, Abstract #7040. [11] Fenton L.K. (2006), GRL, 33, L20201. [12] Zimbelman, J.R. (2000) GRL, 27, 1069–1072. [13] Schatz V. et al. (2006) JGR, 111, doi:10.1029/2005JE002514. [14] Bristow C.S. and Lancaster N. (2004), Geomorphology, 59, 189-196. [15] Greeley R. et al. (1996), Sedimentology, 43, 41-52. [16] Baas A. (2004), Geomorphology, 59, 99-118. [17] Leprince et al. (2007), IEEE T. Geosci. Remote, 45, 1529-1558. [18] Vermeesch P. and Drake N. (2008), GRL, 35, L24404, doi:10.1029/2008 GL035921. [19] Necsoiu et al. (2009), Rem. Sens. Environ., 113, 2441-2447.