DETAILED MORPHOLOGY OF BARCHAN DUNE MOVEMENT FROM A SINGLE WIND EVENT USING UAV-ACQUIRED IMAGES. C. G. Tate[1], J. M. Moersch[1], R. C. Ewing[2], and C. B. McCarty[1]. [1]**Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA, ctate10@vols.utk.edu**, [2]Department of Geology and Geophysics, Texas A&M University, College Station, TX, USA.

Introduction: Barchan sand dunes are crescent shaped dunes that migrate with the wind due to erosion on the windward side of the dune and deposition on the leeward side. Barchan dunes form when the sand supply is less abundant than other dune fields [1] and exhibit an inverse relationship between slip face height and dune advance rate [2]. An area near the southwestern shore of the Salton Sea in southern California is a classic locality for barchan dunes within the United States and has been used for many sand dune studies and investigations [*e.g.*, 3, 4.]. Recent migration rates for the Salton Sea dunes have been calculated as values ranging from ~3-43 m yr^{-1} [4].

To date, morphological studies of the Salton Sea dunes have involved aerial photographs [*e.g.*, 3], aerial Light Detection and Ranging (LiDAR) [*e.g.*, 4, 5], and or terrestrial laser scanning (TLS) [*e.g.*, 4, 5]. Investigations using satellite images at similar locations have been performed as well [*e.g.*, 6]. However, new techniques making use of Unmanned Aerial Vehicles (UAVs) are becoming prevalent in all remote sensing applications due to the low cost and logistical ease of deployment and the high spatial resolution of the acquired data. This makes UAVs particularly useful for acquiring high spatial and high temporal resolution data or images for morphological change detection investigations [7, 8].

We have acquired such a data set over the Salton Sea dunes, with images taken before and after a short, but strong wind event. The closely-spaced times of acquisition of these data bracketing the strong wind event make this a unique data set, and the ease of deployment of the UAV very soon after the event made this possible. The repeatability of the over flight parameters was also paramount to ensure co-located data between the two data acquisition campaigns.

Data: Images were acquired during over flights of the dune field with a DJI Phantom 4 Pro UAV outfitted with a 20 megapixel, 1” CMOS, *f* / 2.8 camera. Flights were performed on March 3rd, 2017 and March 6th, 2017. Each flight was performed at an altitude of 60m, resulting in a ground sampling distance of 1.88 cm. Images were acquired with a front and side overlap of 80%, resulting in 1597 and 1563 geotagged images for the March 3rd and 6th flights, respectively, which covered an area of approximately 0.521 km^2.

Meteorological data (wind speeds and directions) during the event that took place on March 5th, 2017 were acquired from the weather stations nearest the study area (an example is shown in Figure 1).

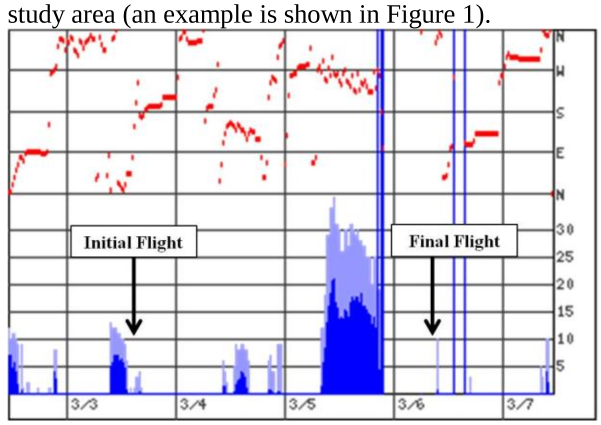

Figure 1. Wind directions and speeds (miles per hour) showing the wind event on 3/5/2017 from the N6BOC weather station at Salton City, CA. Approximate flight times are marked.

Methods: The images for each flight were processed with Pix4D software in order to produce orthophotomosaics and digital surface models (DSMs) of the study area for each flight day. Figure 2 shows the orhtophotomosaic produced from the data acquired on March 3rd, 2017.

Figure 2. Orthophotomosaic produced from images acquired on March 3rd, 2017.The major dunes are labeled with a corresponding letter used for discussion below.

While Pix4D products are georeferenced to a reasonable accuracy, the resulting DSMs must be precisely registered to each other in order to ensure minimal artifacts when performing change detection analysis. For this purpose, manual ground control points were selected on fixed outcrop features within the orthophotomosaics in order to warp the post-event orthophotomosaic to the pre-event orthophotomosaic. The resulting transform was also used to warp the final DSM in the same manner, with an RMS of 1.8868 pixel units. The resulting DSMs were then differenced from each other in order to identify areas of erosion and deposition and investigate morphological changes.

Results: Figure 3 shows the initial change detection results from differencing the DSMs produced in the processing step.

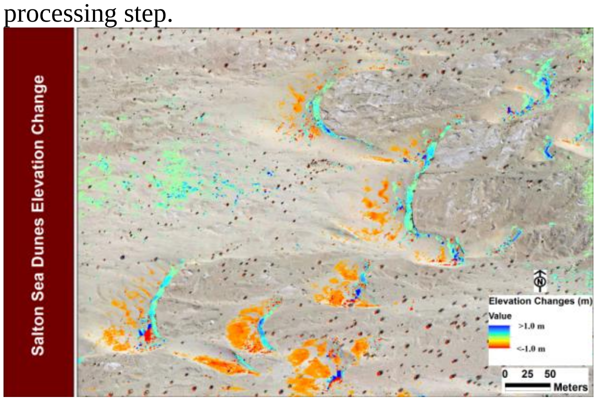

Figure 3. Elevation changes calculated from UAV data overlaid on the March 3^{rd} orthophotomosaic. Values within ±20 cm of 0 cm have been masked out due to uncertainties in the analysis. Red colors indicate erosion, while blue colors indicate deposition.

Investigation of the morphology of the dunes shows the expected pattern of erosion on the windward side and deposition on the leeward side of the dune. This is evidenced in Figure 3. This is also consistent with the wind pattern data showing winds primarily from the west during the March 5^{th} event (Figure 1). While the windward sides show primarily erosion due to the event on March 5^{th}, there are localized amounts of deposition on windward sides near the crest of the dunes. This is consistent with deposition on the downwind side of the crest due to flow expansion before separating at the brink.

The calculated average depth of erosion and deposition is 32 cm ± 20 cm and 30 cm ± 20 cm, respectively. Figure 4 shows an example of the extent of slip face movement for dune B before (red) and after (blue) the wind event.

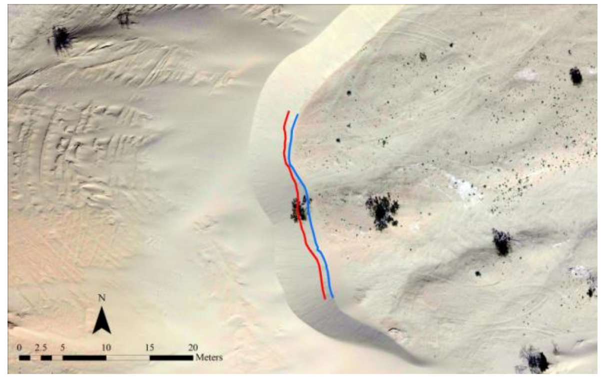

Figure 4. Slip face position extents as evidenced by data acquired on March 3rd (red) versus March 6th (blue) shown on dune B, overlaid on the March 6th orthophotomosaic.

The average amount of advancement observed during this single event on dunes B and C is ~0.85 m and ~0.71 m, respectively. Annual migration rates calculated from this advancement are ~87 m yr^{-1} to ~103 m yr^{-1}. As expected, these rates are much greater (approximately 2 to 3 times) than typical annual migration rates. This suggests that dune migration, at least in this field, is highly episodic, with long periods of little, gradual activity punctuated by very short bursts of high activity leading to the majority of dune movement. In conclusion, we have used UAV data to investigate morphological changes in the Salton Sea barchans due to a single wind event and observed a large amount of advancement in the dune slip face, accordingly.

References: [1] McKee E. D. (1979) A Study of Global Sand Seas. [2] Bagnold R. A., *et al.* (1941) *Progress in Physical Geography*, 18, 91-96. [3] Long J. T. and Sharp R. P. (1964) *Geological Society of America Bulletin*, 75, 149-156. [4] Pelletier J. D. (2013) *Journal of Geophysical Research: Earth Surface*, 118, 2406-2420. [5] Hoose M. P., *et al.* (2014) poster presented at Annual IMAGIN Conference, Mt. Pleasant, MI. [6] Necsoiu M., *et al.* (2009) *Remote Sensing of Environment*, 113, 2441-2447. [7] Clark A. (2017) *GeoResJ*, 13, 175-185. [8] Hugenholtz C. H., *et al.* (2012) *Earth-Science Reviews*, 111, 319-334.