The Albedo of Martian Dunes: Insights into Dune Migration and Wind Regimes K. A. Bennett[1], L. Fenton[2] and J. F. Bell III[1], [1]School of Earth and Space Exploration, Arizona State University (primary contact: Kristen.A.Bennett@asu.edu), [2]Carl Sagan Center at the SETI Institute.

Introduction: Aeolian activity is the primary geologic agent currently influencing the surface of Mars. Now that high resolution cameras have been orbiting Mars for decades, evidence of aeolian activity in the form of mobile dunes has been identified [1-3]. As it is not possible to take multiple high resolution images over many years at every dune field on Mars, we investigate whether albedo measurements of dune fields can yield information on dune activity and the local wind regime.

Background: The hypothesis that albedo could yield information on dune activity and the local wind regime has been previously proposed. Edgett *et al.* [4] hypothesized that transverse aeolian ridges had high albedos because they were immobile. This is because in active dunes, sand sized particles saltate, and once these particles impact the surface, they hit any dust that has settled on the top of the dune and cause the dust to be suspended. In this scenario, any dust that settles on top of sand dunes will be removed more efficiently by dunes with higher activity [5,6]. Therefore, dunes that are migrating more rapidly would have a lower albedo than dunes migrating slowly.

Alternatively, albedo and dune migration rate could be decoupled. Sullivan *et al.* [7] studied the El Dorado dunes at Gusev Crater using data from the Mars Exploration Rover, *Spirit*. They put forth the hypothesis that dust devils are responsible for clearing dust off dunes and keeping the albedo of dunes low, while strong, infrequent winds cause ripples and dune migration [7]. In this case, the albedo of a dune field would reflect the frequency of dust devils and wind gusts, and would not yield insight into migration rates.

In this study, we test the hypothesis that a dune's albedo can be related to its migration rate. If this is shown to be false, we test the hypothesis that dust is removed from the surface of a dune by dust devils.

Methods: We obtained multiple Context Camera [8] images over several dune fields and calculated the estimated lambert albedo of each dune field using the methods outlined in [9]. We observed the change in each dune's albedo over time. We compared the albedo of several dunes with known migration rates. When dust devil tracks are visible, we calculated the dust removal rate of the dust devils.

Results: Figure 1 shows how the albedo at four different dune fields changed over time. The blue circles are observations taken during the first half of the martian year, whereas the red squares are observations taken during the second half of the martian year. Generally, the albedos of dunes are lower in the beginning of the year and higher later in the year. This is likely because more dust storms typically occur in the second half of the martian year [10]. The dunes in Nili Patera and in a crater in Syrtis Major both exhibit this trend. The albedo increases during the dusty season, and then returns to a baseline albedo. At the dunes in Arabia Terra, the albedo decreases slowly after the dusty season. At the Bagnold dunes in Gale crater, the albedo record of the dunes is more random.

Dust devil tracks were observed only at the dunes in a crater in Syrtis Major (Figure 2). These dunes have not been observed to move [1]. We used the image in Figure 2a to calculate how quickly dust devils can remove dust from the surface of a dune. The dust storm in MY 28 began to decay around L_s = 310° [10]. The image in Figure 2 was taken at L_s = 325°. Depending on what albedo is considered to be dust-free, between 25-50% (Figure c and d, respectively) of the dune had been cleared of dust at this point. Using the more conservative 25% value, at this rate the dune would be dust-free by MY 29 L_s =10°. The next observation, taken at L_s = 57°, shows a low, likely dust-free, albedo. Therefore, the majority of the dust was cleared before L_s = 57°, which is consistent with our calculations.

Interpretations: The dunes in Nili Patera are among the fastest moving dunes thus far identified on Mars. Although the dunes in a crater in Syrtis Major have not been observed to move [1], the albedo trends are the same at both of these sites. At Nili Patera, this is likely due to saltation from strong winds whereas at Syrtis Major, this is likely due to dust removal by dust devils. This implies that there is not a simple correlation and albedo alone can not necessarily be used to estimate a dune's migration rate.

In Arabia Terra we observed a decrease in albedo after the dusty season, which is consistent with strong winds causing saltation and dust removal. However, it is likely that winds strong enough to saltate sand occur less frequently at this site than at Nili Patera since the decrease in albedo is slower. In Gale crater, the variations in albedo are more random, which could imply that dust fallout might not be as seasonally constrained here or that winds strong enough to saltate sand occur sporadically. These results imply that the variation in a dune's albedo with time could be used to describe the local wind regime. The rate of decrease of a dune's albedo could distinguish between consistent frequent winds, consistent less frequent winds, and sporadic winds.

While albedo might not be an accurate proxy for a dune's migration rate, if dust devil tracks are observed on a dune, this could imply that wind strong enough to saltate sand is rare in this area and that the dunes are migrating very slowly, if at all.

References: [1] Bridges, N. T. *et al.* (2012) *Geology*, 40, 31-34. [2] Silvestro, S. *et al.* (2010) *JGR*, 37. [3] Silvestro, S. *et al.* (2013) *Geology*, 41, 483-486. [4] Edgett, K. (1997) *Icarus*, 130, 96-114. [5] Bagnold, R. A. (1941) Methuen, London. [6] McEwan, I. K. *et al.* (1992) *Sedimentology*. 39, 6. [7] Sullivan *et al.* (2008) *JGR*, 113, E6. [8] Malin, M. C. *et al.* (2007) *JGR*, 112, E5. [9] Bell *et al.* (2013) *Mars*, 8, 1-14. [10] Wang, H. and M. I. Richardson (2013) *Icarus*.

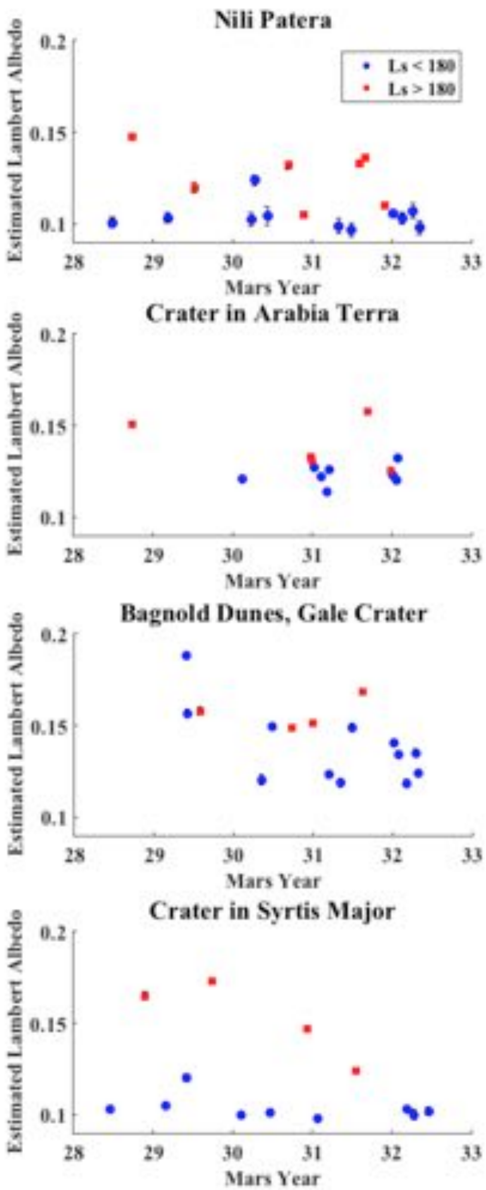

Figure 1: CTX-derived albedo of selected dunes with time. The blue circles are observations taken in the first half of the Mars year, red squares are from the second half. Generally, albedos from the second half are higher.

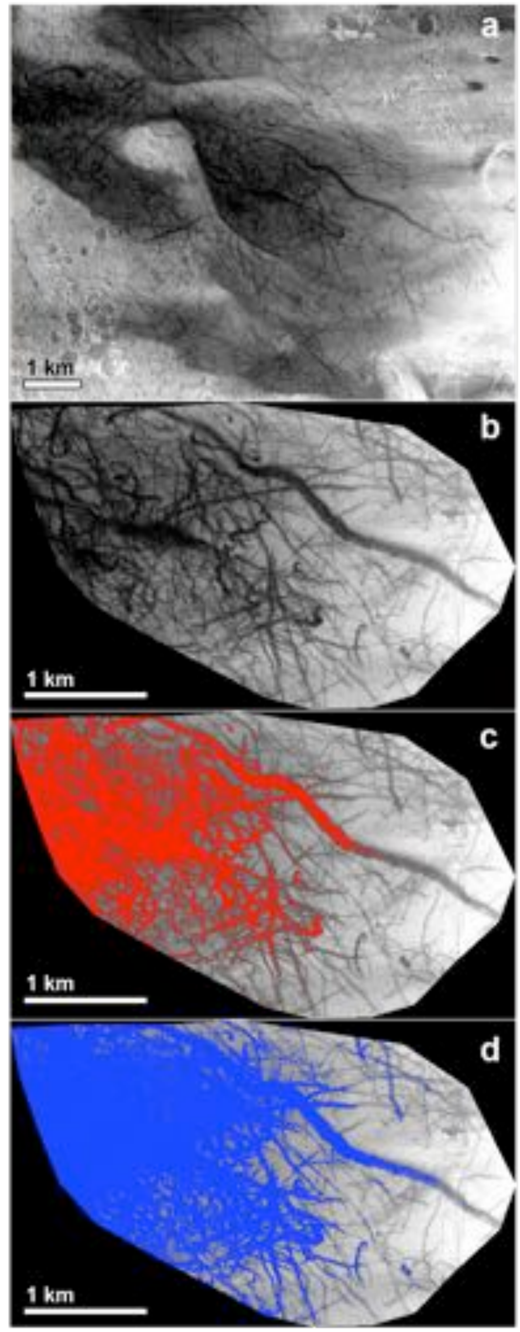

Figure 2: a) CTX image of dunes in a crater in Syrtis Major that show dust devil tracks. b) The region of interest. c), d) The red and blue pixels show that 25% or 50%, respectively, of the region of interest has been cleared of dust. c) assumes that only the areas with the lowest albedo are completely clear of dust. d) assumes that any location with a dust devil track is dust-free.