LOCAL, REGIONAL, AND GLOBAL ALBEDO VARIATIONS ON MARS FROM RECENT SPACE-BASED OBSERVATIONS: IMPLICATIONS FOR FUTURE HUMAN EXPLORERS.

J.F. Bell III[1] and D.F. Wellington[1], [1]Arizona State Univ., School of Earth & Space Exploration, Tempe AZ (Jim.Bell@asu.edu).

Introduction: The surface of Mars has gone through dramatic changes in albedo over the last ~40 years of modern space-based observations. These variations have been monitored and quantified by telescopic [*e.g.,* 1-3], orbital [*e.g.,* 4-10], and surface-based [*e.g.,* 11-12] observations spanning nearly 20 Mars years. Detailed characterization of the spatial and temporal variability of these changes has helped to elucidate the causes of seasonal and secular variations in the distribution of mobile surface materials (dust, sand) in the planet's current climate regime. These changes also provide important observational inputs for global and mesoscale climate models [*e.g.,* 13-15]. Here we summarize the recent historic record of surface changes on Mars, characterize the nature of these changes in terms of various hypothesized surface/atmospheric interaction processes, and qualitatively conjecture on the implications of these processes for future human explorers and eventual inhabitants of the Red Planet.

Observations: Much of the modern record of dust storm and albedo change activity on Mars comes from synoptic-scale global imaging studies based on data taken from the Viking Orbiter, Mars Global Surveyor (MGS) orbiter, Hubble Space Telescope (HST), and Mars Reconnaissance Orbiter (MRO) missions, as well as local-scale time series observations from long-lived surface platforms like the Mars Exploration Rovers (MERs) Spirit and Opportunity.

In this presentation we review the history of modern space-based observations of albedo changes and related atmospheric dust activity on Mars, but focus mostly on the substantial time history of the most recent global-scale images acquired from the MRO Mars Color Imager (MARCI) investigation [*e.g.,* 16]. MARCI is a wide-angle multi-spectral imager capable of acquiring almost daily coverage of large portions of the martian surface at up to 1 km/pixel near the centerline of each image swath. MARCI has been in orbit around Mars since 2006, providing nearly six Mars years of continuous surface and atmospheric observations. MARCI data build on the nearly five previous Mars years of global-scale imaging from the MGS Mars Orbiter Camera Wide Angle (MOC/WA) imager [*e.g., 9,*17], which operated from 1997 to 2006.

MARCI time-series observations (*e.g.,* Figure 1), like MOC/WA observations before them, show that, while many of the most significant changes in the surface albedo are the result of large dust storms, other regions experience seasonal darkening events that repeat with different degrees of regularity from one Mars year to the next [18]. Some of these are associated with local dust storm activity, while for others, frequent surface changes take place with no associated evidence for dust storms, suggesting action by seasonally-variable winds and/or small-scale storms/dust devils too small to resolve from orbit. Discrete areas of dramatic surface changes located across widely separated regions of Tharsis (including the slopes of some of the large volcanoes) and in portions of Solis Lacus and Syrtis Major are among the regions where surface changes have been observed without a direct association to specific detectable dust storm events [19].

Deposition following the annual southern summer dusty season (when insolation increases by up to ~40% relative to southern winter due to the relative high eccentricity of the Martian orbit) plays a significant role in maintaining the cyclic nature of these changes. These and other historical observations also show that major regional or global-scale dust storms produce unique changes that may require several Mars years to reverse.

Here we show regional time-lapse MARCI mosaics for much of the Martian surface that minimize surface obscuration by atmospheric dust and clouds while clearly showing the wide variety of seasonal patterns of surface changes on Mars.

Implications: Future human explorers, tourists, and eventually colonists will relatively quickly learn that Mars is not only a dusty place, but that the frequency of dust deposition and dust-clearing events is generally quite repeatable (and thus predictable [*e.g.,* 9]) from place to place during the Mars year. Thus, locations for semi-permanent or permanent stations or structures that could be most susceptible to contamination or mechanical fouling by typically micron-sized airfall dust particles might best be established in regions with the longest time history of consistently low surface albedo, if other environmental constraints on site selection are otherwise roughly equal. Examples of such regions, discussed here, include northern Syrtis Major, Sinus Sabaeus, and a number of other persistently low albedo northern mid-latitude regions.

A caveat to the above, however, might be that many of the lowest albedo locations on the planet are also sites of active or recently-active sand transport (not coincidentally, as saltation helps to keep a surface clean of dust). Thus, a balance between the need for dust mitigation/minimization and the potentially-erosive long-term effects of sandblasting will need to be struck by future Martian astronauts and, eventually, civil engineers.

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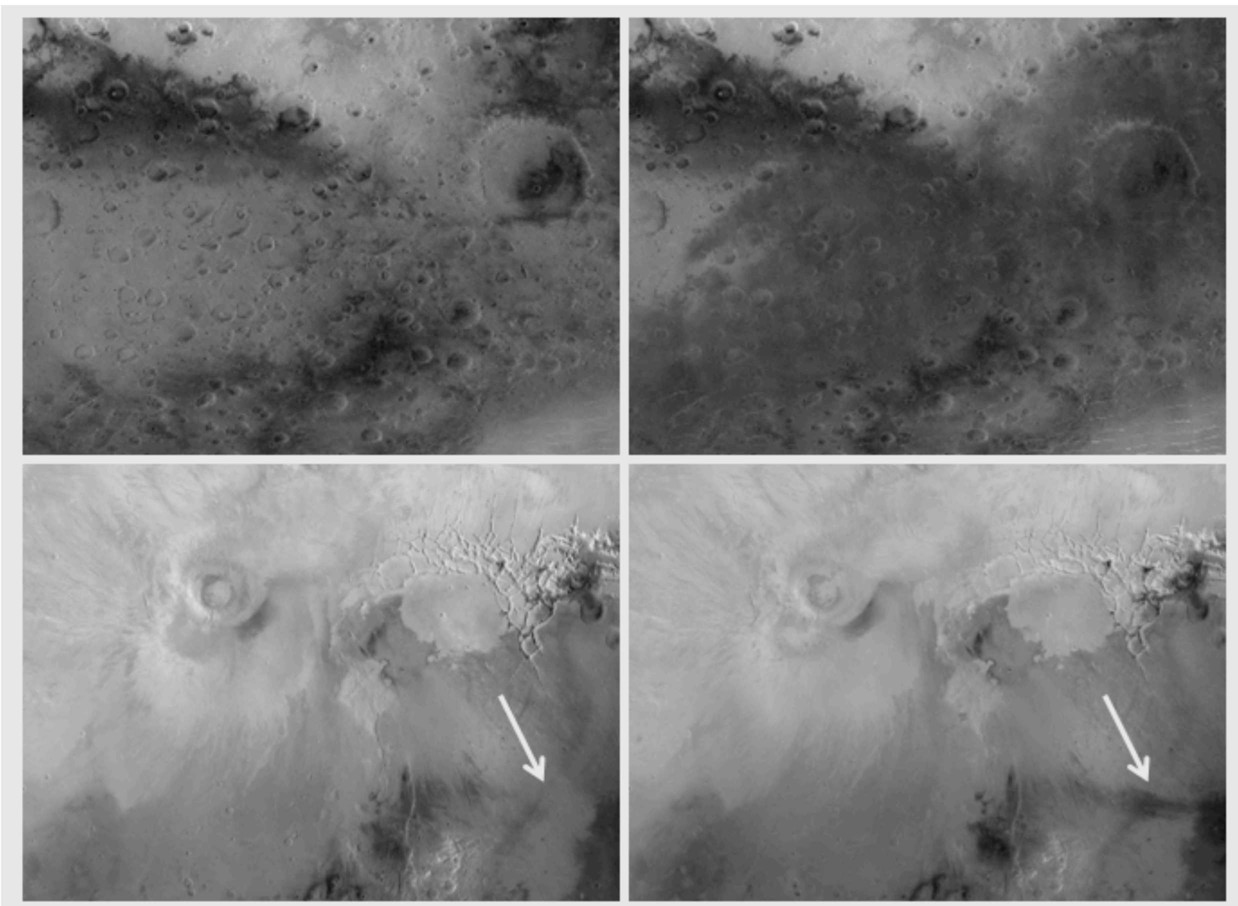

Figure 1. These four images are map-projected MRO/MARCI Band 5 (720 nm) mosaics showing before (left) and after (right) views of surface darkening (dust removal) on Mars. For scale, each image is approximately 2500 km across. TOP: Extensive darkening in Noachis and Sabaea Terrae following a large cross-equatorial storm in Mars Year 31. The 450-km crater just above center at right is Huygens. BOTTOM: Southern hemisphere low latitude mosaic including Arsia Mons and portions of Daedalia, Syria, Sinai, and Solis Plana. The dark streak in lower right (arrow) formed gradually over L_s = 200°-320° of Mars Year 29, with no obvious associated dust storm clouds.