Three-and-a-Half Mars Years of Surface Albedo Changes Observed by the Mars Reconnaissance Orbiter MARCI Investigation

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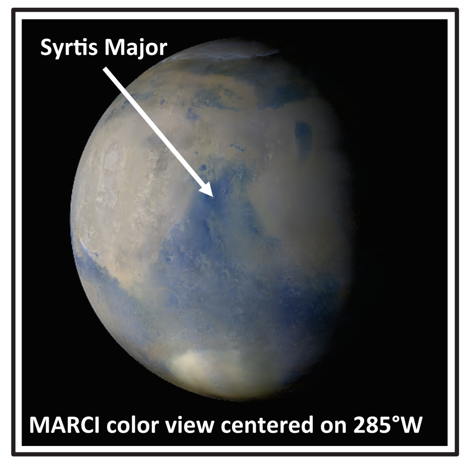

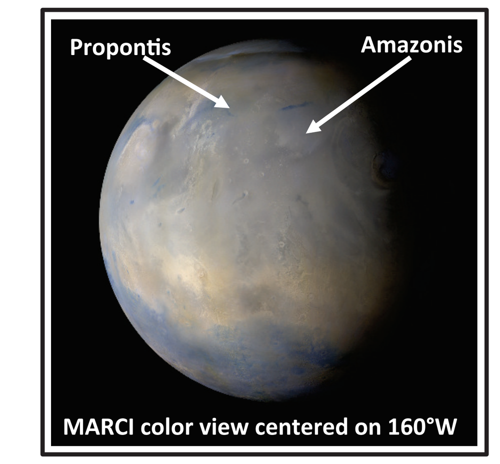

Introduction & Methods

- The Mars Color Imager (MARCI, Figure 1) is a wide-angle CCD camera aboard the Mars Reconnaissance Orbiter (MRO) [1].
- Five filters are in the visible to near-IR (Table 1), while the other two (not used in this study) are in the UV.
- MARCI's wide field-of-view and MRO's near-circular polar orbit has allowed MARCI to obtain almost 30,000 images that provide daily coverage of large portions of the planet since 2006, making it ideal for studying regional scale seasonal and interannual changes
- In this study, we focus on the nature and timing of surface changes caused by aeolian dust transport. These changes are the visible expression of otherwise unobserved near-surface atmospheric conditions.
- Raw MARCI images were I/F (radiance factor) calibrated, photometrically-corrected assuming a simple Lambert function, map-projected to a transverse equal-area cylindrical projection at a scale of ~1 km/px, and mosaicked into time-steps of 20° L_s by selecting the lowest albedo pixel in regions of overlap. Regions of high incidence or phase angle were excluded.

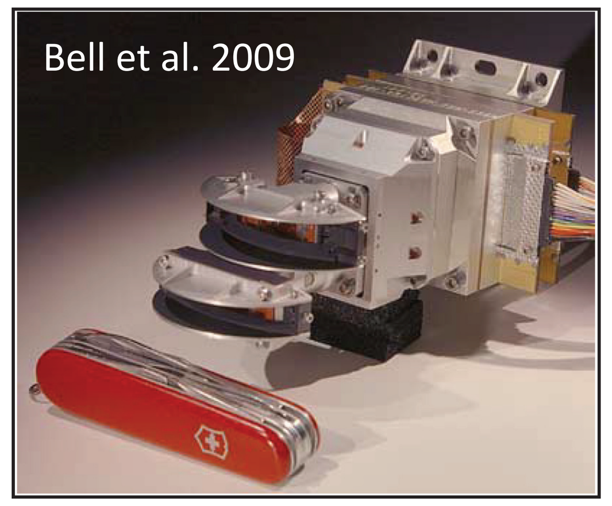

Figure 1: The MARCI instrument with Mike Malin's Swiss army knife in front for scale [1].

Band Number	λ_{eff} ± FWHM (nm)
1	437 ± 32
2	546 ± 40
3	604 ± 31
4	653 ± 42
5	718 ± 50

Table 1: MARCI visible and near-infrared band centers and full-width at half maximum [1].

MRO Timeline

Figure 2: A timeline comparing Earth dates with the Martian calendar suggested by Clancy et al. 2000 [2]. Image annotations give time in terms of Martian year and areocentric longitude (L_s), defined as the angle between Mars' current orbital position and the position of Mars on the northern hemisphere vernal equinox. Each Martian year begins with L_s=0, the northern vernal equinox. The arrival of the Curiosity rover on Mars placed additional bandwidth demands on MRO. (PSP = Primary Science Phase, begins when spacecraft is in science orbit and ready to collect data – November 2006 for MRO.)

References

[1] Bell, J. F., III, et al. (2009), Mars Reconnaissance Orbiter Mars Color Imager (MARCI): Instrument description, calibration, and performance, J. Geophys. Res., 114, E08S92, doi:10.1029/2008JE003315.

[2] Clancy, R. T., et al. (2000), An intercomparison of ground-based millimeter, MGS TES, and Viking atmospheric temperature measurements: Seasonal and interannual variability of temperatures and dust loading in the global Mars atmosphere, J. Geophys. Res., 105.E4, 9553-9571.

[3] Thomas, P. C., et al. (2003), Mesoscale linear streaks on Mars: environments of dust entrainment, Icarus, 162.2 (2003): 242-258.

Example Observations of Surface Albedo Changes

Classes of Surface Albedo Changes

Type	Seasonality	Examples
Seasonal cycles of dust deposition and removal over a timescale of months	Dust deposition concentrated around perihelion dust season, followed by gradual removal; modulated by the severity of the annual dust season	Syrtis Major (Fig. 3) and several low albedo features in Tharsis
Sudden changes (timescale of days or less) within a particular season followed by period of stasis	Changes frequently take place annually between Ls 180-360°, with little change the rest of the year, and display significant interannual variability	Mesoscale linear streaks in Amazonis (near 27°N, 158°W) (Fig. 4), streaks in Acidalia (33°N, 24°W), regions S and E of Sinus Sabaeus, portions of Nilosyrtis, Alcyonius, Hyblaeus
Secular change not occurring every year or not most years	Unknown	Brightening of Propontis (Fig. 5), minor darkening in Cerberus near 11°N, 201°W, westward expansion of S. Major west boundary

Table 2: A summary of observed surface albedo changes by periodicity.

Figures shown here are sets of MARCI band 5 mosaics (lowest albedo of overlapping images) of 20° L_s time-steps. See presenter for time-lapse animations covering many additional regions.

Seasonal Change In Syrtis Major

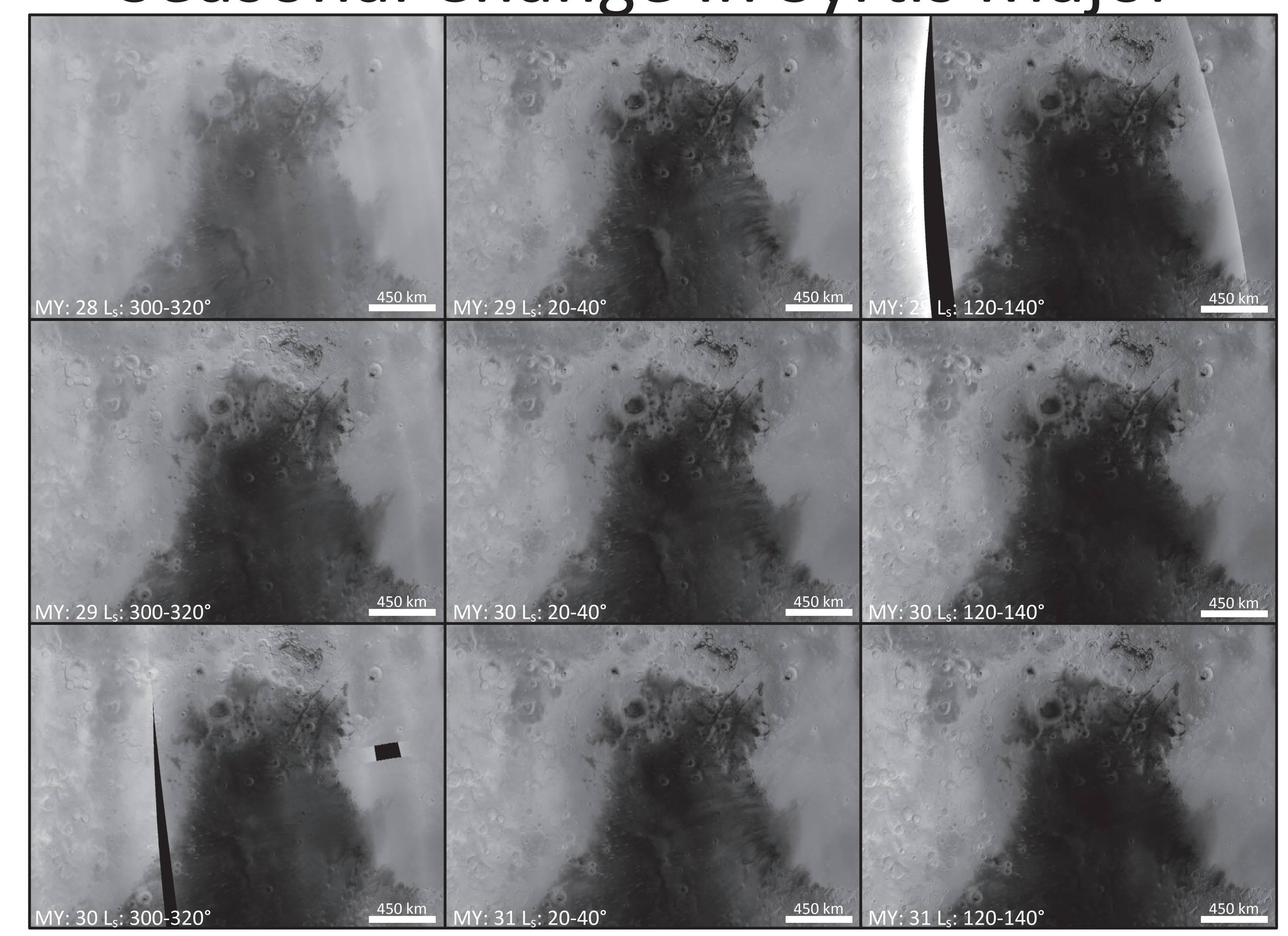

Figure 3: Seasonal dust deposition followed by gradual removal in Syrtis Major. Images within a row step through a seasonal cycle of dust deposition and removal and are separated by about 100° L_s or approximately 6-7 (Earth) months. Images within a column are separated by a Martian year. Map center is approximately 15°N, 290°W.

Annual Changes In Amazonis Mesoscale Linear Streaks

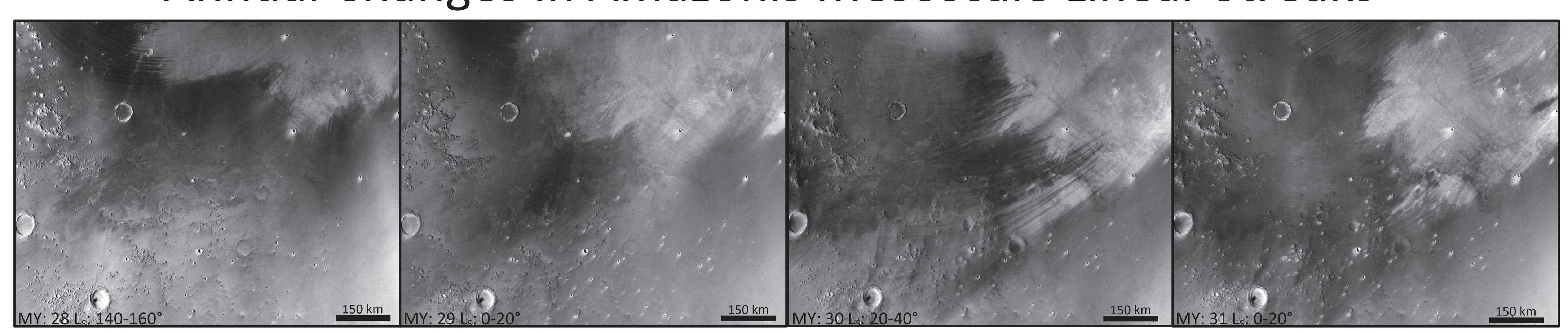

Figure 4: Mesoscale linear streaks appear as subparallel sets of dark curvilinear streaks extending up to several hundred kilometers in length. The streaks in northern Amazonis undergo major changes during the northern fall and winter (L_s 180-360°), but change little during the northern spring and summer seasons (L_s 0-180°), in agreement with previous observations (Thomas et al. 2003 [3]). As can be seen in the images above, there is substantial interannual variation in streak patterns (e.g., indistinct in early MY 29, very prominent in early MY 30), though in general the orientation of the streaks is NE-SW or E-W, curving to the north. The maps are centered near 27°N, 158°W.

Secular Brightening In Propontis

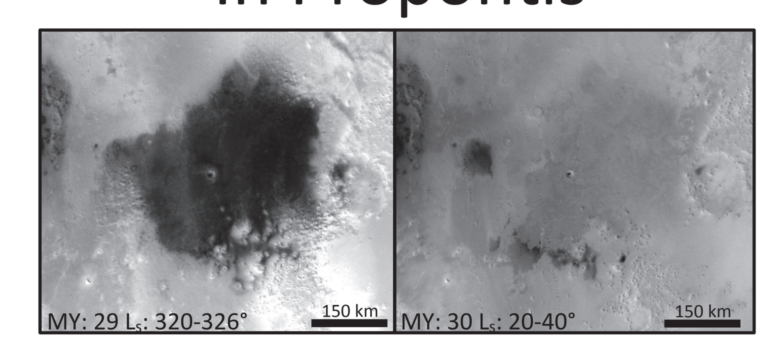

Figure 5: The low albedo feature known as Propontis underwent a substantial brightening at approximately L_s=326° of MY 29. MRO subsequently went into a major safe mode, so the next complete mosaic of the region occurs in the MY 30 L_s 20-40° time-step. The map center is approximately 37°N, 178°W.

Conclusions & Future Work

- MARCI observations of the surface of Mars since late 2006 reveal numerous changes in surface albedo features that can be categorized into at least three classes based on the timing and recurrence of the changes. These classes reflect seasonally changing atmospheric conditions or (for secular changes) unusual near-surface conditions.
- Further work will focus on obtaining higher temporal resolution information from individual (non-mosaicked) MARCI observations and quantifying the magnitude and extent of the surface variations.

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