TEMPORAL ANALYSIS OF ALL AVAILABLE HIGH-RESOLUTION MARS IMAGING PRODUCTS SINCE 1976

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ABSTRACT:

Starting from Viking Orbiter 1, launched in August 1975, several mainly NASA orbiters have been sent to Mars to accomplish the robotic tasks of imaging its surface. Initial analyses of these early images indicated a planet with similar characteristics to the Moon pitted with craters and large volcanic and tectonic features but dead from a geological perspective. Recently, scientific interest has shifted towards high-resolution imaging, which allows the identification of previously undiscovered geological phenomena and surface features as well as the examination of surface composition and geological history. The increasing frequency of Mars orbiters, carrying high-resolution cameras, allows the dynamic analysis of Martian surface, i.e. the analysis of the temporal evolution of certain areas that reveal natural processes that happen over time. The latter can be roughly classified into two major categories; processes that happen periodically each and every Martian season (e.g. seasonal flows in high latitude areas (McEwen et al., 2011) and events that do not follow some iterative pattern but are rather sporadic (e.g. new impact craters (Byrne et al., 2009)). Consequently, it is beneficial to conduct a twin temporal grouping of Mars imaging products, the first examining product distribution through time, so as to point out areas that favor the search for sporadic events, and the second product distribution per season, to identify areas favouring the search for periodic events.

It should be noted that a Martian day (i.e. a "sol") lasts roughly 24 hours, 39 minutes and 35 seconds and a Martian year approximately 668.6 sols (Allison, undated). Due to the fact that the orbit of Mars around the Sun is elliptical, the seasons of Mars are not of equal duration. The length of spring, summer, autumn and winter is approximately 193.3, 178.64, 142.7 and 153.95 sols, respectively. In order to able to capture this, it is common to count Martian time through areocentric longitude L_s, which is the relative seasonal advance of the Sun, counted in degrees. As a matter of fact, L_s range from 0° to 359°, while a value equal to 0°, 90°, 180° and 270° correspond to the Mars northern hemisphere vernal equinox, summer solstice, autumnal equinox, and winter solstice, respectively (Allison, undated). .While a globally accepted Martian calendar is not currently available, the vernal equinox of 11 April 1955 is usually adopted as the beginning of Mars Year 1 (MY1) (Clancy et al., 2000). This places 1st January 2014 at the end of spring of MY32 and Viking Orbiter launch at MY11.

Consequently, the currently available products are drawn from a period of ~20-21 Martian years. However, imaging over that time period was neither constant nor uniform. Instead, it demonstrated large episodics, the most important of which being a 9 Martian years gap between MY14 and MY23 that reduce the actual imaging range to ~11 Martian years. More specifically, the six orbiter missions that conducted extensive high-resolution mapping of Martian surface, are:

- NASA Viking Orbiter 1, launched in August 1975 which acquired images from the winter of MY11 until the summer of MY14
- NASA Viking Orbiter 2, launched in September 1975 which acquired images from the summer of MY12 until the summer of MY13
- NASA Mars Global Surveyor, launched in November 1996 which acquired images using Mars Orbiter Camera - Narrow Angle (MOC-NA) from the autumn of MY23 to the summer of MY28
- NASA Mars Odyssey, launched in April 2001 and acquiring images in the visible spectrum through Thermal Emission Imaging System (THEMIS-VIS) from the winter of MY25 onwards to the present-day
- ESA Mars Express, launched in June 2003 and acquiring images in the visible spectrum from the High Resolution Stereo Camera (HRSC) from the spring of MY26 onwards, and
- NASA Mars Reconnaissance Orbiter, launched in August 2005 and imaging with two different cameras (i.e. Context Camera (CTX) and High Resolution Imaging Science Experiment (HiRISE)) from the summer of MY28 onwards

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The above imaging cameras use pixel resolutions that vary from 25cm per pixel for HiRISE to several hundreds metres per pixel for some Viking Orbiter products. In order to impose some homogeneity in our analysis, all images with resolution coarser than 100m per pixel are ignored and the rest are grouped into two classes. The former, named "F"ine, consists of images with resolution finer than 20m per pixel and includes some THEMIS-VIS images, the majority of HRSC nadir and MOC-NA images and all CTX and HiRISE images. On the other hand, the latter, named "C"oarse, consists of the rest of the images with 20-100m resolution.

F and C images are further decomposed twice, using a different clustering criterion. More specifically, F images (C images) that were acquired at MY11 to MY14, MY23 to MY25, MY26 to MY28 and MY29 to MY 31 are grouped into sub-classes F11, F23, F26 and F29 (C11, C23, C26 and C29), respectively, while F images (C images) that were acquired during Martian spring, summer, autumn, winter are grouped into sub-classes F1, F2, F3 and F4 (C1, C2, C3 and C4), respectively.

We will present availability maps for each of the above 16 sub-class, i.e. 16 global Mars map, plotting the number of times each Martian region was imaged at the sub-class context. For example, a pixel with a value 2 at F3 map would correspond to an area that was mapped twice during autumn with resolution finer than 20m per pixel. The map raster size is 500mx500m using a sinusoidal projection. Moreover, since polar regions are of major interest 8 further availability maps are presented for "N"orth and "S"outh polar regions using the season-based decomposition and F image group (i.e. N1, N2, N3, N4, S1, S2, S3 and S4). In this case stereographic projection will be used and a 100mx100m raster. This allows us, within the Martian geological context, to assess the potential of change detection for each geographic region on the Martian surface. A similar analysis is planned for the Moon in future.

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References:

Allison, M. Technical notes on Mars Solar Time, www.giss.nasa.gov/tools/mars24/help/notes.html

Byrne, S., C. Dundas, M. Kennedy, M. Mellon, A. McEwen, S. Cull, I. Daubar, D. Shean, K. Seelos, S. Murchie, B. Cantor, R. Arvidson, K. Edgett, A. Reufer, N. Thomas, T. Harrison, L. Posiolova and F. Seelos, Distribution of mid-latitude ground ice on Mars from new impact craters, Science, Vol. 325, No. 5948, pp. 1674-1676, 2009

Clancy, R.T., B. J. Sandor, M. J. Wolff, P. R. Christensen, M. D. Smith, J. C. Pearl, B. J. Conrath and R. J. Wilson, 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, Journal of Geophysical Research: Planets, Vol. 105, No. E4, pp. 9553-9571, 2000

McEwen, A., L. Ojha, C. Dundas, S. Mattson, S. Byrne, J. Wray, S. Cull, S. Murchie, N. Thomas and V. Gulick, Seasonal Flows on Warm Martian Slopes, Science, Vol. 333, No. 6043, pp. 740-743, 2011