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Analysis of Martian coverage with high-resolution image mapping products

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Abstract

A meta-data analysis has been performed of high-resolution imagery that have been acquired over the last four decades from Mars. More specifically, image footprints downloaded from the PDS Geosciences Node Mars Orbital Data Explorer (ODE) [4] were used to group all Martian imagery based on Martian season that each image was acquired. This clustering allows us to examine whether seasonal Martian phenomena can be identified from imagery that depict the same area during the same season. Additionally, statistics about the high-resolution image coverage of specific Martian surface areas with increased recent importance (e.g. landing sites) are estimated. It should be noted that we have selected to discriminate high-resolution from low-resolution images through a twenty metres per pixel threshold.

1. Introduction

A Martian day (i.e. a "sol") lasts 24 hours, 39 minutes and 35 seconds and a Martian year approximately 668.6 sols or 686 (earth) days, 23 hours and 31 minutes [1]. Due to the elliptical orbit of Mars around the Sun, the seasons of Mars are not of equal duration. The length of spring, summer, autumn and winter is 193.3, 178.64, 142.7 and 153.95 sols, respectively [1]. In order to be able to deal with this, it is common to count Martian time through areocentric longitude Ls, which is the relative seasonal advance of the Sun, counted in degrees. Ls ranges 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 [1]. 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) [2]. This places 1st January 2014 at the end of spring of MY32 and Viking Orbiter launch at MY11. In the current analysis, all available image products acquired until the end of MY31 have been employed. In this period, six orbiter missions have conducted extensive high-resolution mapping of the Martian surface. More specifically, these were NASA's Viking Orbiter 1, Viking Orbiter 2, Mars Global Surveyor (through MOC-NA), Mars Odyssey (through THEMIS-VIS) and Mars Reconnaissance Orbiter (through CTX and HiRiSE) and ESA's Mars Express (through HRSC). The images from these cameras form the basis of our meta-data analysis.

2. Analysis Results

The overall spatial surface coverage that each camera has achieved demonstrates that the coverage of orbiter cameras can be classified into two categories, the first focusing on imaging specific Martian surface regions with very high-resolution (MOC-NA, HiRISE) whilst the second is focused on imaging the entire surface of Mars, at the expense of very high resolution (THEMIS-VIS, HRSC, CTX). From analysis of these three cameras, HRSC has achieved the most complete mapping of the Martian surface (91.94%), followed by CTX (82.62%) and THEMIS-VIS (61.06%). Overall, these statistics demonstrate that for a large part of the Martian surface area these 3 different imaging sources contain most of the images with resolution finer than 20m per pixel. MOC-NA, HiRISE and VO provide additional high-resolution imagery for regions of increased scientific interest. Their coverage is 5.38%, 1.39% and 0.18%, the latter taking into account only images with resolution finer than 20m/pixel.

Moreover, in Table 1, statistics of the coverage at different Martian seasons are reported. It is apparent that NH spring coverage is much more extensive than the coverage of any other season. This could only be partially explained by its longest duration, since summer's sparse coverage is not consistent with the fact that it is 20% longer than autumn and winter. Additionally, it appears that there is repeat coverage for the same season (i.e. at least three images with resolution finer than 20 metres per pixel) for 8.16%-28.9% of the Martian surface. Thus, it becomes apparent that a substantial area of Mars can be examined to analyse the characteristics of currently unknown seasonal phenomena [3], based on distinct and common features in images of the same corresponding area taken during the same season.

Table 1: Martian surface global coverage statistics for different (Martian) seasons. In parentheses is reported the surface percentage that was mapped more than 3 times during the same season.

Season	Coverage
Spring ($0° < Ls < 90°$)	81.97% (28.9%)
Summer ($90° < Ls < 180°$)	53.55% (8.16%)
Autumn ($180° < Ls < 270°$)	55.93% (8.51%)
Winter ($270° < Ls < 360°$)	57.8% (9.33%)

We have also found that a large area of the Martian surface remains un-covered for each season. This can be explained by the fact that, just like in Earth, the northern (southern) latitude (polar) zones of Mars are mostly at dark during the winter (or summer). Since we are currently dealing with images in the visible spectrum, this feature determines a pattern in which images are acquired according to the season. These conclusions are further demonstrated in Figure 1, which shows a global coverage map of Mars for NH summer ($90° < Ls < 180°$).

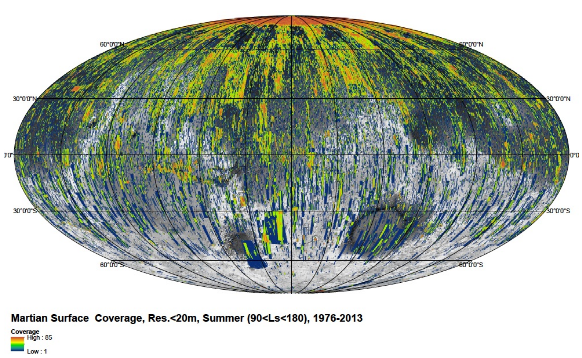

Figure 1: Martian surface coverage during north hemisphere summer ($90° < Ls < 180°$).

Finally, in Table 2, mean repeat coverage statistics for different areas with increased interest are reported. These are landing sites or candidate landing sites, which have been imaged repeatedly for both engineering and scientific purposes. The reported scores are the mean number of times that each site was mapped, estimated by segmenting the image into 100mX100m cells and aggregating all image footprints that overlap with each cell.Table 2 shows an extensive repeated coverage of such areas, which allows tracking temporal changes on the martian surface as well as potentially improving the mapping quality through super resolution [5].

Table 2: Mean repeated coverage statistics for specific Martian regions of interest.

Season	Mean Coverage (1m/pixel)	Mean Coverage (20m/pixel)
Gale Crater	12.16	93.55
Victoria Crater	11.19	63
Gusev Crater	12.9	83.03
Hypanis Vallis	0.33	14.96
Oxia Palus	0.12	7.35

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