A QUALITY CONSTRAINED THEMIS DAYTIME INFRARED GLOBAL MOSAIC

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OVERVIEW

The THEMIS daytime infrared global mosaic compiled by Hill et al. (2014) [1] has been re-evaluated on an image-by-image basis in order to replace poor quality images with the highest quality images available. The resulting quality constrained mosaic is complete from 90°N - 87.3°S and is the highest quality, highest resolution global map of Mars currently available.

BACKGROUND

The 2001 Mars Odyssey spacecraft entered orbit around Mars on October 24th, 2001 and is the longest-operating spacecraft in the history of Mars exploration. The Thermal Emission Imaging System (THEMIS) has been acquiring observations in both infrared and visible wavelengths since the beginning of science operations in February 2002.

During the first fourteen years of science operations, THEMIS has acquired over 200,000 infrared images of the surface, which includes 100% daytime coverage between 87.3°N - 87.3°S and approximately 95% nighttime coverage between 60N - 60S. In 2011, Edwards et al. [2,3] used data acquired during the first 7.5 years of the mission to create daytime and nighttime global mosaics of THEMIS infrared images, but were unable to achieve complete coverage in both mosaics due to the lack of quality data over some regions. In 2014, Hill et al. [1], used data from the first twelve years of the mission to complete the daytime global mosaic between 87.3°N - 87.3°S and significantly improve the coverage of the nighttime global mosaic. However, while assembling these mosaics, the emphasis was still on improving coverage. Poor quality images were still used, when necessary, to fill gaps in the mosaics and were subsequently left in place.

METHODS

Each quadrangle of the previously compiled THEMIS daytime infrared global mosaic, which is composed of THEMIS band 9 (12.57 µm) images, was visually reevaluated image-by-image. Images that reduced the quality of the overall mosaic (ex: significantly errors in their reconstructed geometry, noise due to low surface temperatures or atmospheric effects, etc) were removed and replaced by higher quality images. Images acquired using the Odyssey spacecraft's recently revived ROTO (Routine Off-nadir Targeted Observation) capability have been used to fill the gap in north polar coverage between 87.3°N – 90.0°N. Finally, the stretches used on the individual mosaic images were adjusted to better emphasize regional contrast differences, unlike the previous global mosaics that were optimized for local contrast differences.

RESULTS OF MOSAIC IMPROVEMENTS

This work has resulted in the development of an updated and quality constrained version of the THEMIS Day IR Global Mosaic, which has been designated version 13.0. This is highest resolution and highest quality global map of Mars currently available. As an example of the improvements made throughout the global mosaic, particularly the increased emphasis on regional contrast over local contrast, the improved Syrtis Major quadrangle mosaic is presented in Figure 1.

The improved THEMIS Day IR Global Mosaic has also allowed updated versions of two combination global mosaic products to be produced. An updated version of the "THEMIS Day IR with MOLA Color" global map, designated version 2.0, was produced by overlaying colorized surface elevation data from the Mars Orbiter Laser Altimeter [4] on the updated THEMIS Day IR Global Mosaic. Similarly, an updated version of the "THEMIS Day IR with Night IR Color" global map, designated version 2.0, was produced by overlaying a colorized version of the current THEMIS Night IR Global Mosaic (v14) on the THEMIS Day IR Global Mosaic.

All three of these improved global mosaics will be made available through the JMARS geospatial information system (http://jmars.asu.edu) developed by Arizona State University's Mars Space Flight Facility once the observations currently being acquired over the north pole have been incorporated into the mosaics.

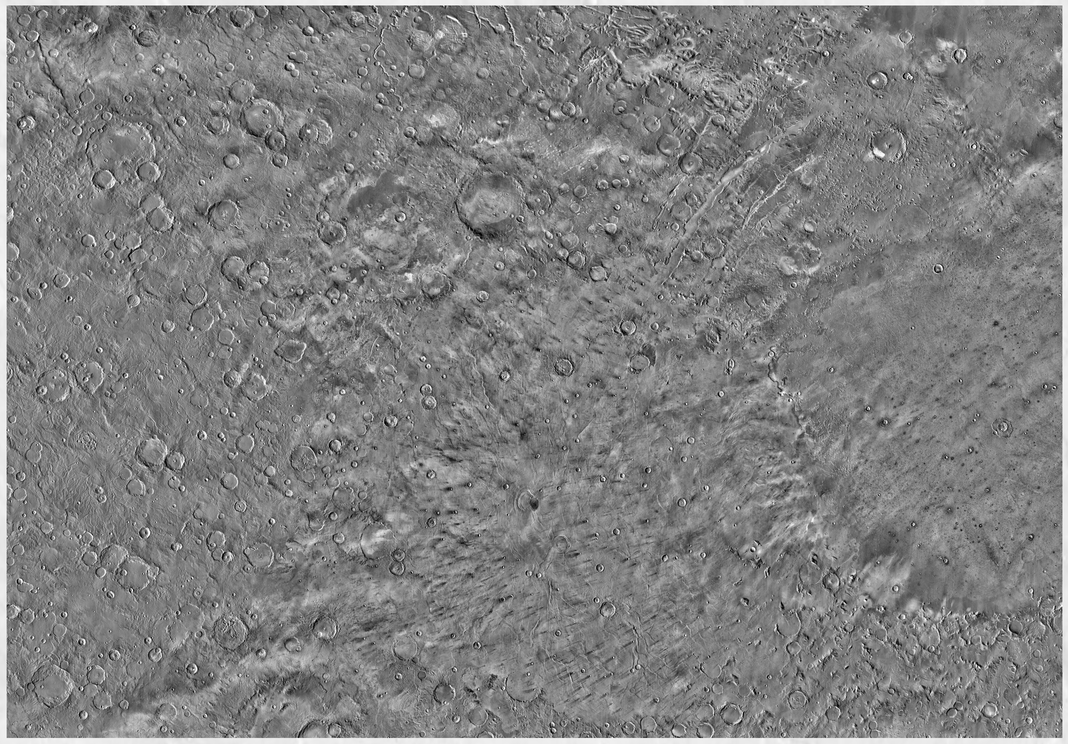

Figure 1: Improved Version of the Syrtis Major Quadrangle Mosaic — 250 km

FUTURE WORK

Work on a quality constrained version of the THEMIS nighttime global infrared mosaic has already begun, using the same methods that were used in the revision of the daytime global infrared mosaic. When completed, it will be released along with an updated version of the "THEMIS Daytime IR with Nighttime Temperature" global map through the JMARS geospatial information system (http://jmars.asu.edu) developed by Arizona State University's Mars Space Flight Facility . These products will also be published to the NASA Planetary Data System (PDS) as THEMIS special products. And in spring 2017, THEMIS will acquire images over the south pole mosaic gap using the same ROTO strategy used for the north pole gap.

References

[1] Hill et al. (2014) 8th International Conf. on Mars, Abstract #1141. [2] Edwards et al. (2011) JGR, 116,E10008. [3] Edwards et al. (2011) JGR, 116, E10005. [4] Smith et al. (2003) PDS.

MOSAIC QUALITY IMPROVEMENTS

Images with Poor Geometry Replaced

The previous THEMIS global mosaics, as well as this new quality-constrained mosaic, do not attempt to tie images to ground points. Instead, the individual images are placed according to geographic positions derived from reconstructed spacecraft position and pointing data. Although the image-to-image registration is rarely perfect, offsets are usually small relative to the 100 m/pixel resolution of the mosaic. However, in cases where the Hill et al. [1] daytime global mosaic contained images with large offsets (due to extrapolations over gaps in spacecraft position and pointing telemetry, etc), the images were removed and replaced by images with better geometry data. An example of a registration error is shown in Figure 2a and the correction is shown in Figure 2b.

Noisy Images Replaced

The Hill et al. [4] daytime global mosaic also contained numerous images with significant noise resulting from low surface temperatures, atmospheric effects, etc. These poor quality images were identified and replaced by higher-quality images, where possible. An example of a noisy image affecting mosaic quality is shown in Figure 2c and the correction is shown in Figure 2d.

Remaining Small Gaps Filled

Although the Hill et al. [4] daytime mosaic was described as 100% complete between 87.3°N - 87.3°S, a number of small gaps were subsequently identified by users. These gaps were the result of line dropouts in various images that were not completely filled in by overlap with adjoining images. The gaps were identified by reviewing the entire mosaic at full resolution and then filled with the highest-quality images available. An example of a line dropout image gap is shown in Figure 2e and the correction is shown in Figure 2f.

Polar Gaps Filled with ROTO Images

Due to a combination of the Odyssey spacecraft's orbital inclination and the THEMIS infrared field-of-view, the instrument is not able to observe poleward of 87.3° while in its nominal nadir-pointed attitude. In 2015 the Odyssey team resumed Routine Off-nadir Targeted Observations (ROTOs), which allow THEMIS to request up to ten roll-only ROTOs per month, which can be up to +/-11° from nadir. These ROTO observations allow THEMIS to observe between 87.3°-88.75° at both poles, which has allowed a significant portion of the existing gaps at both poles to be filled. Additional non-routine ROTOs were subsequently approved, which allow the entire north polar gap in the mosaic to be filled. A view of the north polar gap with overlaid colorized surface elevation data from the Mars Orbiter Laser Altimeter [4] is shown in Figure 3.

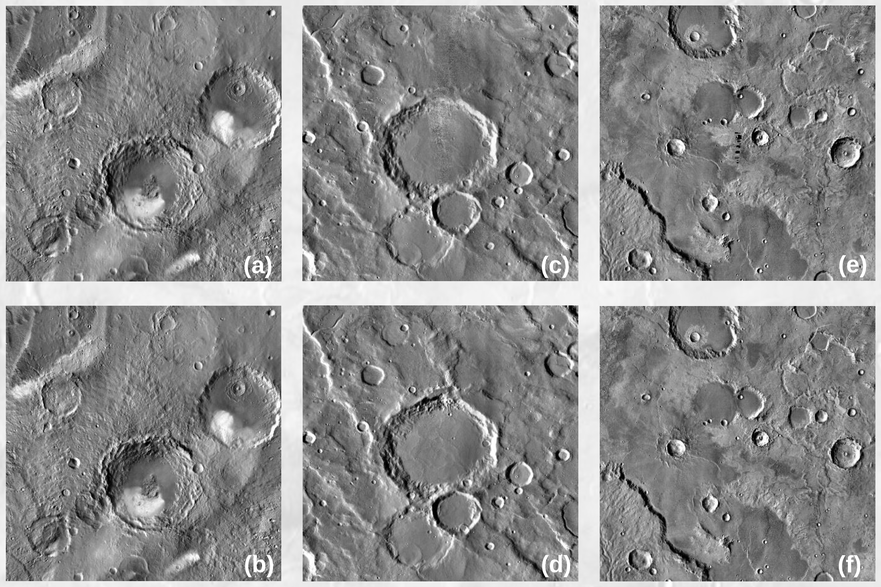

Figure 2: Examples of Mosaic Improvements — 50 km

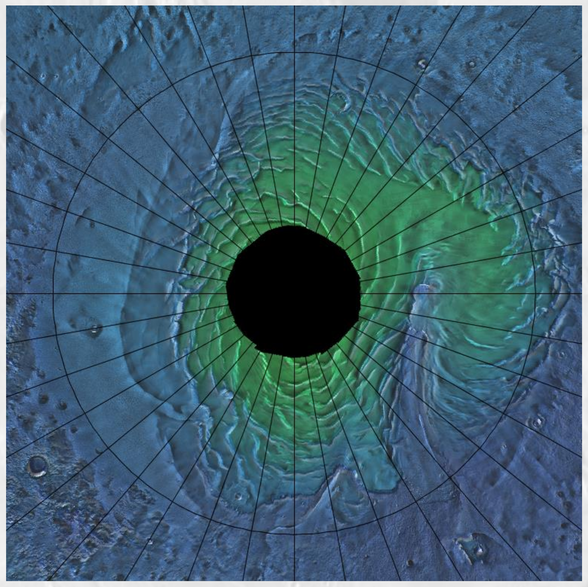

Figure 3: Current North Pole Mosaic Gap