TIME-DEPENDENT CALIBRATION OF MESSENGER'S WIDE-ANGLE CAMERA FOLLOWING A CONTAMINATION EVENT # 2489

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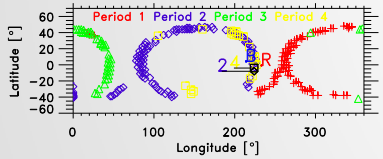
Abstract

A time-dependent correction function was developed to handle contamination of WAC imagery acquired during the first year of the orbital phase of the MESSENGER mission. This contamination correction function has been implemented in the Integrated Software for Imagers and Spectrometers (ISIS) [4] system, specifically in the *mdiscal* MESSENGER calibration application. Continued analysis has improved the time response of the correction to handle specific filters under-corrected by the initial fitting functions. The upgraded correction will be incorporated into the March 2014 PDS delivery.

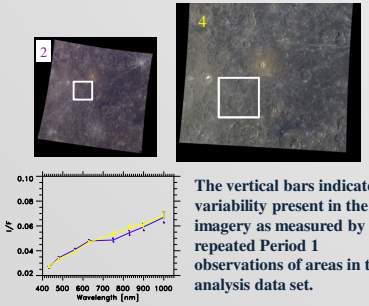
Correction Analysis

Analysis of orbital images taken by the wide-angle camera (WAC) of the Mercury Dual Imaging System (MDIS) on the MESSENGER spacecraft uncovered an unexpected and sudden decrease in responsivity that recovered over time. The change occurred on or about 24 May 2011, during the time the spacecraft experienced its first hot season.

To isolate the effects of the contamination, a restricted-photometric angle data set was extracted from the global color map imagery. The center locations for the images in the restricted set are shown below. The contamination event occurred between periods 1 and 2, with most of the effect dissipated by the end of period 4 (2012-02-15).



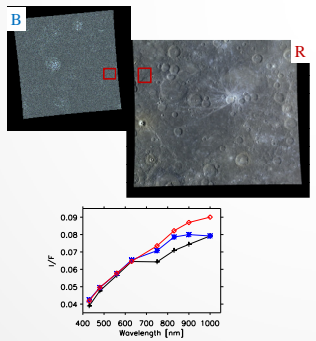
While no single location was imaged in all four event correction periods, a region near 220E and the equator was viewed in periods 2 and 4, specific examples before standard photometric correction being used for illustration. Independent checks on the derived corrections were provided by the out-of-set data indicated with R (acquired during Period 1) and B (acquired during Period 2). The uncorrected Period 2 and 4 images and spectra from the small area, with uniform signatures and no obvious cratering, in the white squares are shown below.



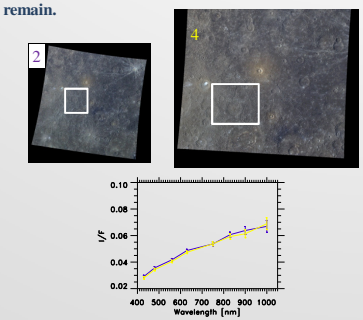
The vertical bars indicate variability present in the imagery as measured by repeated Period 1 observations of areas in the analysis data set.

First Correction

For the initial correction, all filters were assumed to have the same time constant, returning to their pre-event medians by the end of Period 4. The contamination effect was most pronounced when working with ratios of the filter responses to the response at 630nm, which showed the least contamination effect, so ratios to 630 nm were used to derive the contamination functions, with the 630 nm channel corrected separately. The most successful approach was to generate a linear interpolation between the pre-event median and a linear fit to short time-step medians of the event-contaminated data and fit an exponential to the interpolated transition function. Difficulty fitting the 1000 nm channel meant it was initially uncorrected. The spectra shown below for the photometrically-corrected Red and Blue images are taken from the adjacent areas indicated by the red rectangles, with the black line being the uncorrected spectrum from the Period 2 Blue image, the blue the initial correction, and the red line from the Period 1 Red image. Although most of the "kink" between 630 nm and 750 nm is removed, the 900 nm and 1000 nm channels are significantly undercorrected.

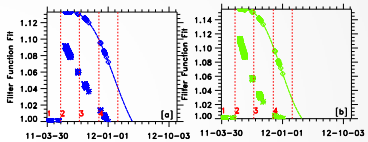


When applied to test eight-color images, this first correction removed most of the contamination in the blue-side filters (430-560 nm) for data acquired during period 2, but undercorrected the red-side filters (750-1000 nm). As seen below, while the first correction improves the agreement between the Period 2 and Period 4 images, significant differences remain.

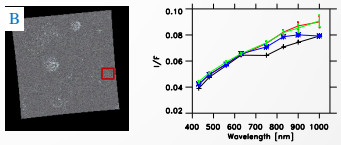


Second Correction

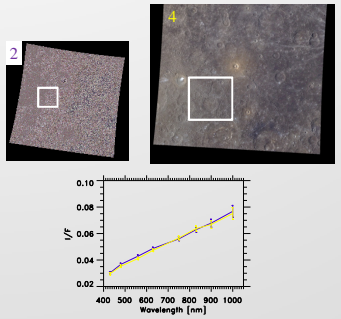
In the March 2013 PDS delivery, an empirical second correction was applied on top of the first correction for the data in the eight-color global map. However, analysis continued to provide an improved exponential correction that could be applied singly to all the event correction data and avoid the two-step process. To develop this second exponential correction, several deficiencies were addressed. On the blue side, examination of later data indicated the effects of the contamination persisted past the end of Period 4, so the time constants for those filters were increased. On the red side, the shape of the empirical corrections indicated a higher-powered exponential was required to fit the data. After iterative fitting, new corrections were developed, as shown below, for the [a] 430 nm and [b] 830 nm channels. The asterisks are the first correction, and the diamonds with the lines are the second. The 900 nm correction was found to be adequate to correct the 1000 nm channel.



The second corrections applied to the blue image are also shown below, with the resulting spectrum, indicated by a green line, now almost completely overlying the Period 1 Red spectrum.

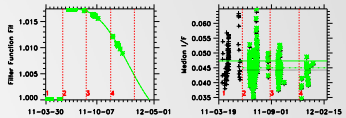


When applied to the Period 2 and Period 4 imagery, the resulting spectra almost completely overlie each other, indicating the temporal response is now more correctly determined. Also, the spectra have the smooth slope expected for areas with uniform signatures. In addition, the overall coloration of the two images is more similar than seen in either the uncorrected or the first-corrected imagery.



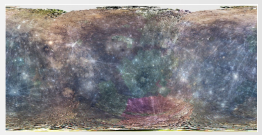
630 nm correction

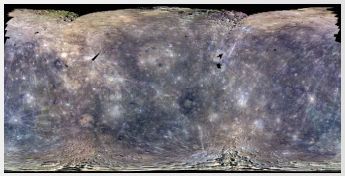
An exponential correction of the same order as that used for the other filters, with a slightly increased time constant, was applied at 630 nm separately (see the filter function in green below left). Although the corrections (below right, black crosses are uncorrected, green asterisks are corrected) did not return the post-event median (black dashed line) to pre-event medians (green solid line), this level of correction (green dashed line) provided the substantial agreement seen in the corrected spectra for the Blue, Red, and Periods 2 and 4 cases and is considered sufficient.



Global Maps

As a final check, the second correction was applied to the new M Combo photometrically corrected map (below top), with the overall results as shown (below bottom).





Conclusions

A time-dependent correction function has been developed and modified that substantially mitigates the effects of a contamination event that occurred during the first year of WAC imagery acquisition. The exponential characteristics of the corrections may yield clues as to the cause of the contamination. That analysis continues.

References

Hawkins S. E., III, et al. (2007), *Space Sci. Rev, 131*, 247–338.

Hawkins S. E., III, et al. (2009) *Proc. SPIE, 7441*, paper 74410Z.

Domingue D. L. et al. (2011) *Planet. Space. Sci., 59*, 1873–1887.

Anderson J. A. et al. (2004), *LPS 35*, 2039.