Information for Scientific Users of HiRISE Color Products

By Alfred McEwen and Eric Eliason, October 10, 2007

HiRISE PDS releases consist of a set of official products, and a set of 12 "Extra" products for each image. Below are examples for hypothetical HiRISE image PSP_005000_1000.

Official PDS products:

Experiment Data Records (EDRs) -- This is the raw data, usually in 28 channels for each image. Only users with specialized needs (such as producing topographic models from stereo pairs) will need to access these images. In addition, if there are concerns about whether or not an unusual color marking is an artifact, it is best to examine the EDRs. The color data is constructed from 6 CCDs out of 14 total: RED4, RED5, BG12, BG13, IR10, IR11.

Reduced Data Records (RDRs) -- These are radiometrically calibrated, geometrically mapped images with lossless JPEG2000 compression (file names end in .JP2). Lossless compression means that the data volume is reduced without sacrificing any information. The full HiRISE RDR information is contained in just two products:

PSP_005000_1000_RED.JP2 Grayscale mosaic of all RED-filter channels.
PSP_005000_1000_COLOR.JP2 IR, RED, BG 3-color product over center 20% of the RED swath width.
Additionally, each JP2 image also has a PDS label (companion .LBL file) providing useful information about the observation such as map projection and viewing information.

RDR Extras:

The official PDS products are enormous files, typically larger than 1 GB in size, and quite difficult to work with. So we also create a set of RDR "Extras" at reduced scale or with slightly "lossy" compression to produce smaller files that are much easier to display. "Lossy" compression eliminates some small-scale detail (such as random noise), which enables compression into smaller files that are easier to transfer, store, and manipulate.

First, there are 2 basic types and scales of Extra RDR products:

- those ending in .JP2 are JPEG2000 images at the full spatial scale.
- those ending in .jpg are JPEG products at reduced scale--called browse images.

Next, there are 2 geometries:

Those that include NOMAP in the file name are not map-projected, but the up to 10 RED CCD images or 2 sets of color CCD images are stitched together to show all of the data.

Those without NOMAP in the file name are map projected.

There are 6 map-projected Extra products:

PSP_005000_1000_RED.QLOOK.JP2 – same as official PDS RED (or grayscale) product except with lossy compression to reduce the file size.

PSP_005000_1000_RED.browse.jpg browse version (2048 pixels wide)

PSP_005000_1000_RED.abrowse.jpg browse version with title and scale bar

PSP_005000_1000_COLOR.QLOOK.JP2 – same as official PDS color product except with a contrast stretch applied to each color band and lossy compression.

PSP_005000_1000_COLOR.browse.jpg browse version (2048 pixels wide)

PSP_005000_1000_COLOR.abrowse.jpg browse version with labels and scale bar

There are 6 NOMAP products types:

PSP_005000_1000_RED.NOMAP.JP2 Up to 10 RED-filter CCD images stitched together

PSP_05000_1000_RED.NOMAP.browse.jpg browse version

PSP_005000_1000_IRB.NOMAP.JP2 3-color image consisting of IR, RED, and BG images. The IR and BG images have been warped to line up with the RED.NOMAP image

PSP_05000_1000_IRB.NOMAP.browse.jpg browse version

PSP_005000_1000_RGB.NOMAP.JP2 3-color image consisting of RED, BG, and synthetic blue images. The BG image has been warped to line up with the RED.NOMAP image. The BG (blue-green) bandpass primarily accepts green light. The synthetic blue image digital numbers (DNs) consist of the BG image DN multiplied by 2 minus 30% of the RED image DN for each pixel. This is not unique data, but provides a more appealing way to display the color variations present in just two bandpasses, RED and BG.

PSP_005000_1000_RGB.NOMAP.browse.jpg browse version

Note that the NOMAP products are in the geometry of our raw images. Since MRO flies north mostly on the dayside of Mars, most of these images have north down (actually ~7 degrees tilted from straight down), except near the North and South Poles where images have many possible orientations.

What do the colors in HiRISE images mean?

The PDS products are stretched differently from the products in the Extras directory. The PDS-product color is given the same minimum and maximum value, in calibrated units of reflectance (I/F), for each color bandpass. The result is that the colors are relatively bland, but they are also consistent from place to place on Mars. (The PDS label (.LBL file) provides the information for converting the DN value to I/F: I/F = DN*SCALING_FACTOR + OFFSET.) It isn't natural color, as seen by normal human eyes, because the IR, RED, and BG channels are displayed in red, green, and blue colors. For the Extras products, each color band is individually stretched to maximize contrast, so the colors are enhanced differently for each image based on the color and brightness of each scene. Scenes with dark shadows and bright sunlit slopes or with both bright and dark materials are stretched less, so the colors are less enhanced than is the case over bland scenes.

In spite of the variable level of color enhancement for the Extras products, we can make some generalizations to better understand what the stretched color images are showing. Dust (or indurated dust) is generally the reddest material present and looks reddish in the RGB color and yellow in the IRB color. Coarser-grained materials (sand and rocks) are generally bluer (or sometimes purplish in IRB color) but also relatively dark, except where coated by dust. Frost and ice are also relatively blue, but bright, and often concentrated at the poles or on pole-facing slopes. Some bedrock is also relatively bright and blue, but not as much as frost or ice, and it has distinctive morphologies. The IR and RED bandpasses are often highly correlated so the IR provides little new information, and the RGB color does a better job of showing the RED vs. blue-green color variations by moving these differences into the warmer colors. Also, one of the four channels of IR data has special problems and may be excluded from the RDR products or have anomalies, whereas the RGB color always covers the full color swath, unless some data was lost in transmission to Earth. The IR channels do provide unique information in some small but important areas on Mars, particularly when the mineral olivine or a diversity of minerals altered by water are present. The best way to understand what the colors indicate about composition is to compare them to mineral maps derived from the 18 m/pixel CRISM data (see http://crism.jhuapl.edu/). HiRISE color images enable extrapolation of the CRISM results to smaller spatial scales.

Another benefit of the color is that it helps resolve ambiguities in grayscale images. One region may be brighter or darker than another due to different materials on the surface or due to different slopes and angles of illumination, and it can be difficult to make this distinction by examining a grayscale image. With the color images this ambiguity is resolved because different materials have different colors. Stereo images provide an alternate means of resolving this ambiguity.

Radiometric calibration of the data into units of I/F (ratio of reflected intensity to incident intensity of sunlight in each color bandpass) is a work in progress. It is probably accurate to only about the 10% level, but we hope to improve this in the future. Atmospheric variability introduces a comparable or even larger uncertainty in the I/F of surface materials.

Artifacts to watch out for

The colors are not always perfectly coregistered. If you see parallel bands of intense colors near bright-dark edges, that is probably misregistration. But the actual color of

Mars can give this appearance as well, but with more muted colors, due to aeolian processes.

Another apparent artifact is the variable color of shadows. Shadows really do have different colors (as on Earth), but can get exaggerated by the automatic contrast stretches (lowest 0.1% of values are set to black and highest 0.01% are set to white, with linear scaling between these values; this is done independently in each color).

This automatic contrast stretching can also create unusual colors (actually more realistic colors) in non frost/ice materials when bright frost or ice is present, as these bright patches control the high values set to white.

Sometimes there are erroneous colors near the center of each set of CCDs, or near samples 1000 and 3000 in unbinned NOMAP images (samples 500 and 1500 in 2x2 binned images). This is due to special calibration problems in the center columns, where the data is split and read out into the two channels.

Some of the early HiRISE images include saturation due to the choice of Look-Up Table (LUT) for onboard conversion of the data from 14 to 8 bits per pixel. If the very brightest highlights have strange colors, this could be due to saturation.

Sometimes small spots, lines, or jagged patterns will be unusually bright in one of the colors. These are probably cosmic-ray hits.

Rectangular patterns with very bright colors are where data is missing from one or more color channels due to loss of data telemetry from MRO to the ground stations.

Images obscured by atmospheric dust or haze generally appear noisy. The original images are not noisy but they are bland, so the stretches applied to best see the surface features also enhance the noise. Condensate hazes can also create diffuse color variability that does not correspond to the distribution of surface materials, especially in the BG.

Two of the CCDs have special noise or DN dropouts due to poor performance of an electronic part when cold: CCDs IR10 and RED9. These bad data sometimes lead to poor contrast stretches and odd colors. One other CCD, BG13, has on very rare occasions (twice that we know of while imaging Mars) suffered from a malfunction that creates down-column smear. Due to these problems we have sometimes applied more pixel binning (4x4 rather than 2x2) to BG13 or IR10 than to BG12 or IR11, resulting in loss of color resolution over half of the color image. We process the images in a way that adds the RED-image detail to the IR and BG images, which are usually binned to a greater degree than RED4 and RED5, so the images have the best possible grayscale resolution in spite of lower color resolution.