

PROCESSING HIRISE IMAGES USING ISIS3. K.J. Becker¹, J.A. Anderson¹, S.C. Sides¹, E. A. Miller¹, E. M. Eliason², and L.P. Keszthelyi¹; ¹ U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001 (kbecker@usgs.gov); ²Lunar and Planetary Lab, U. Arizona, Tucson, AZ 85721-0063

Introduction: The Integrated Software for Imagers and Spectrometers Version 3 (ISIS3) [1] system is being used to process data from the High Resolution Imaging Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter (MRO). Image processing utilizes Planetary Data System (PDS) approved Experiment Data Record (EDR) files. EDRs are ingested into ISIS where they are radiometrically calibrated, geometrically projected and finally mosaicked into a single useful image. This abstract and accompanying poster describes the sequence of ISIS applications used to process HiRISE images. The ISIS system, available free to the science community, supports a variety of unix-based computer operating systems and can be downloaded from <http://isis.astrogeology.usgs.gov/>. Examples of images that have been fully processed can be viewed at <http://marsoweb.nas.nasa.gov/HiRISE/> and <http://hiroc.lpl.arizona.edu/>.

Data and Image Characteristics: Raw HiRISE image data is received from the MRO spacecraft at the NASA Deep Space Network (DSN) and transmitted via the Jet Propulsion Laboratory (JPL) to the University of Arizona (UA) HiRISE Operations Center (HiROC) facility for processing.

HiRISE has 14 CCD detectors, ten of which are monochrome red (RED0-RED9), two infrared (IR10, IR11) and two blue-green (BG12, BG13). Each CCD is split in half, called *channels*, for a maximum of 28 files per observation. For example, RED5_1 and RED5_0 represent the left and right (raw geometry) channels of the RED5 CCD, respectively. Each channel file is converted to a PDS-labeled EDR by the HiROC processing pipeline system. The HiRISE Software Interface Specification (SIS) document [2] describes the contents of the PDS files in detail.

Ingestion into ISIS: The *hi2isis* ISIS application converts HiRISE EDR channel files into ISIS file format. The ISIS file format consists of a Parameter Value Label (PVL) label and one or more data objects. The label contains keywords and values that describe the content of the file and the modes in which the instrument was commanded. A typical HiRISE channel file will initially have the image data object and five additional ancillary data objects that are used in HiRISE radiometric calibration processing. Additional PDS PVL keywords are propagated to the file that provide information required in subsequent processing steps.

Radiometric Calibration: Radiometric calibration is performed on each individual HiRISE channel file (EDR). HiRISE radiometric calibration is still work in progress, so it cannot yet be fully described. However, the basic procedure is to (1) remove the offset in the image data numbers (DN), (2) remove dark current, (3) correct for the time-varying component of offset and drift, (4) correct for column-to-column gain variations, and (5) convert the signal to I/F values.

hiclean is the application that corrects for offset, dark current and drift. The ancillary calibration data are used to compute corrections in both the sample (column) and line (row) directions. A useful tool for evaluating the effectiveness of *hiclean* is the *higlob* application which combines the image data and all the ancillary data into a single array. The output of *higlob* can be viewed using *qview*, the ISIS display application.

The output from *hiclean* is refined by the subtraction of what is referred to as the “B” matrix and then gain corrections are completed by multiplying by the “A” matrix. This process will be accomplished by the ISIS *hical* application, but it is still under development.

After *hical*, the channels are ready to be combined into CCD files using the *histitch* application. Minor residual calibration artifacts often produce an imbalance of signal between the “stitched” CCD channels. One effective method for cosmetically correcting the CCD images is to run *cubenorm* which removes residual vertical and horizontal artifacts.

Unprojected Products: The *hicdstitch* application can be used to create quick unprojected mosaics of the RED, IR or BG stitched images. *hicdstitch* accepts a list of HiRISE *histitched* images and creates a single band image that places each CCD image in the proper order according to the HiRISE focal plane assembly engineering specifications. The order of the CCD files in the input list has no effect on the order of its placement in the resulting image.

Please note that *hicdstitch* products often exceed 2 GB. While ISIS is designed to handle such file sizes, appropriate computer hardware is important for processing in a timely manner. Furthermore, *hicdstitch* will reject the input list if it contains any combination of RED, IR or BG images – they must all be of the same color. Finally, *hicdstitch* products are intended as “quicklook” products. Seams can often be seen

between CCDs and the products cannot be map projected.

Projecting HiRISE Images: Although it is possible to project individual CCD channels, it is recommended that *histitched* CCD images be projected. To project HiRISE images, they must be initialized with the appropriate SPICE kernels. These kernels are available from NAIF, but are also maintained and provided with the ISIS installation. The ISIS application *spiceinit* is executed on each CCD file. It performs a search of the SPICE kernels to determine if the time of image acquisition has proper coverage of planet, spacecraft and camera pointing ephemeris data. *spiceinit* then adds the SPICE information to the ISIS file. *cam2map* uses the SPICE information to project the image to a projection specified by the user.

Fig. 1 shows the processing sequence from ingestion of the EDR channels, calibration and, finally, projection to equirectangular map coordinates.

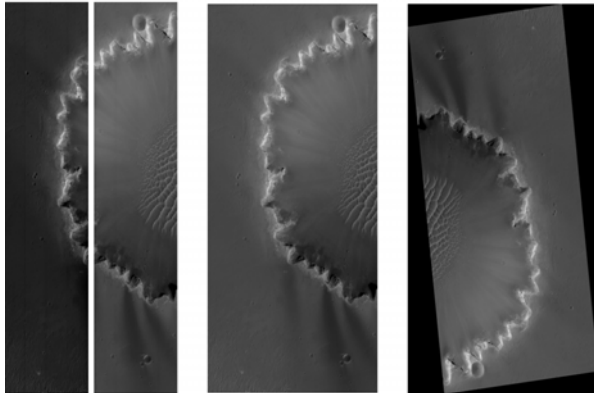


Figure 1: Portion of PSP_001612_1780 RED4 detector EDR channels, calibrated (*histitched* CCD) and the final projected image.

Creating Mosaics: The recommended approach to creating a mosaic is to use the *maptemplate* and *automos* applications.

maptemplate assists users in the creation of a map projection file, also in PVL format, that will be used by all the files from a given observation. This ensures that consistent projection parameters are applied to all files used in the final mosaic. *cam2map* is then run on each CCD file to produce consistent map projected products for each CCD.

automos creates a single mosaic from the set of projected images. The input to *automos* is a list of images produced by *cam2map*. Choose a name for the output mosaic and optionally specify the latitude and longitude ranges as desired. The result is a map projected image comprised of the input list of files geometrically placed into the proper location within the geometric latitude and longitudes specified.

Tone Matching: Parameters set for each detector can differ enough that adjacent detectors can have varying brightness. This becomes obvious when the mosaic is displayed (using *qview*) with abrupt changes of brightness at CCD boundaries. *equalizer* corrects this problem. You must select at least one image within the image list to hold its brightness such that all others will be adjusted to produce a tone matched mosaic. Files created by *equalizer* now become the input list into *automos*.

Color Products: Producing color products from HiRISE images is challenging due the very high resolution of the images which dramatically reveals any spacecraft jitter and errors in the SPICE. We developed a program called *slither* that addresses this problem. *slither* is a one-dimensional (cubic spline) transform that shifts images up, down, left or right while preserving whole lines. The amount of shift is provided in the form of a control net that is created by *hijitreg*, a HiRISE specific application, or *coreg*.

slither does have some unusual quirks. The recommended technique is to match the IR10 and BG12 to RED4 and IR11 and BG13 to RED5 *histitched* products. IR and BG images are typically offset by many lines and samples, which must be manually measured (in *qview*) and input into *hijitreg*. A “trick” is to hold the IR and BG images as the *match* file and the REDs as the *from* files and to select the appropriate chip size. After *hijitreg*, run *slither* on each IR and BG image using *direction=REVERSE*.

The final step before projecting with *cam2map* is to stack the registered IR-RED-BG sets into a single cube using *cubeit*. It is critical to specify the labels from the RED image as the one to propagate in *cubeit*. After projecting both sets, use *automos* to create the mosaic.

Conclusion: HiRISE is the most complicated planetary camera to date, and its processing is commensurately complex. Development for HiRISE processing software is ongoing and changes should be expected. We offer an on-line workshop for ISIS3 at <http://isis.astrogeology.usgs.gov/IsisWorkshop/>. We maintain support through a bulletin board system at <http://isis.astrogeology.usgs.gov/IsisSupport>. You can submit support questions by registering as a user or browse the large volume of content without having to register.

References: [1] Anderson, J.A., et al., Modernization of the Integrated Software for Imagers and Spectrometers (2004), *LPSC XXXV*, Abstract #2039. [2] E.M. Eliason, et al. (2006) *Software Interface Specification for HiRISE Experimental Data Record Products*, NASA/JPL, JPL Document Number D-32004.