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High resolution digital terrain models and orthorectified images of Mars from HiRISE and HiSCI

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Abstract

Stereo images acquired from the High Resolution Imaging Science Experiment (HiRISE) camera currently operating on the Mars Reconnaissance Orbiter are being used to generate high resolution Digital Terrain Models (DTMs) and orthorectified images [1]. Orthorectified images of repeat coverage over a given DTM can now be created, providing a powerful research tool for investigating active surface processes on Mars. New discoveries of surface changes on Mars have been made that would not have been possible without stereo images [e.g. 2]. The methods and products developed for HiRISE DTM and orthoimage processing will be leveraged for the planned High-resolution Stereo Color Imager (HiSCI) instrument to fly on the joint NASA-ESA ExoMars Trace Gas Orbiter (TGO) mission, planned to launch in 2016 [3]. The HiRISE team releases DTMs and orthoimages to the Planetary Data System (PDS) on nearly a monthly frequency [1]. A similar schedule for DTM/orthoimage production and public release is planned for HiSCI [3].

1. New orthoimages

A HiRISE DTM is derived from a geometric stereo pair, where two images are acquired on different orbits so that a sufficient convergence angle between the two images is formed (~10º-25º) [4]. This viewing geometry allows for the derivation of topographic heights based on accurate spacecraft pointing knowledge and x-parallax in the stereo pair.

HiRISE teams at the University of Arizona and the USGS employ a method using the Integrated Software for Imagers and Spectrometers (ISIS) [5] and SOCET Set (© BAE Systems, Inc.) for production of publicly released products. This method controls the images to the planetary surface accurately using Mars Orbiter Laser Altimeter (MOLA) data [6], and is described in detail in [7].

To orthorectify additional images that have been acquired over the same target, the images are imported into SOCET Set and controlled to the original stereo pair by using the network of tie and control points created for the terrain model. The other images to be orthorectified are not required to have similar photometric angles as is the original stereo pair. After controlling the other images to the source pair, they are orthorectified, exported to ISIS and post-processed to PDS formats (fig. 1).

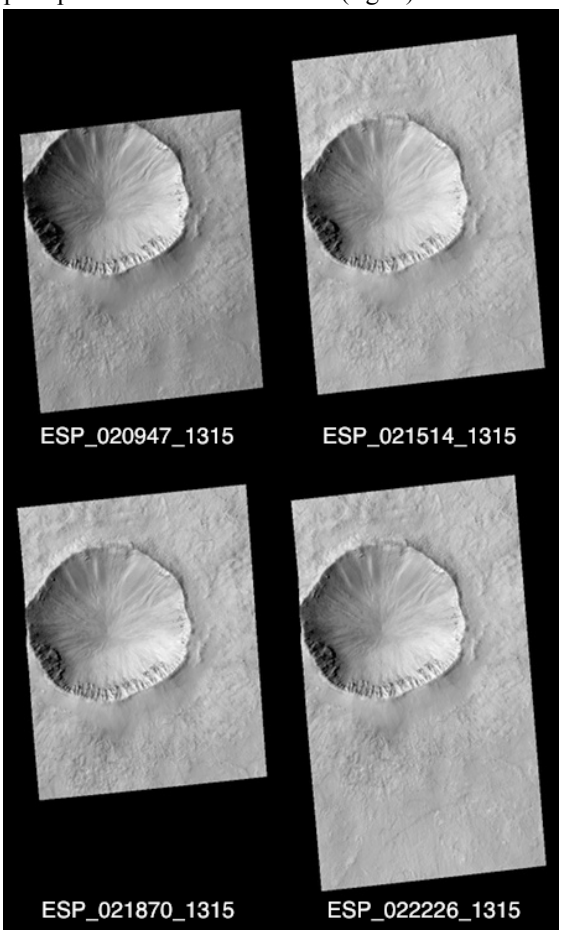

Figure 1: Series of HiRISE images orthorectified to the DTM created from PSP_014011_1315 and PSP_014288_1315 (not shown).

1.1 Color orthoimages

HiRISE images contain a three-band color swath across the center ~20% of the image composed of near-infrared (NIR), red and blue-green bands [4]. HiRISE color is imported into SOCET Set using the controlled support files of the corresponding monochromatic image data. The color is then orthorectified and exported to ISIS. PDS formatted

HiRISE color orthoimages are currently in development. HiSCI color will cover the full swath-width of 8.5 km and will have an additional NIR band [3].

1.2 Quality and precision

Horizontal resolution of HiRISE DTMs is typically either 1 or 2 m/post, depending on source image pixel scale (25 or 50 cm/px respectively). Since the stereo pair is controlled to the MOLA shots, the absolute horizontal accuracy is dependent on the coverage at each site, but can be expected to be in the range of 50-100m [8]. Vertical precision is estimated to be better than 25 cm, given a convergence angle of 20º and bin 1 (25 cm/pixel) source images [7,8]. Orthoimages are created in SOCET Set, by orthorectifying the source stereo pair to the derived terrain model. Orthoimages can be validated by comparing them to a shaded relief of the DTM generated with the same sun angles as the source image.

1.3 Production and release schedule

Post-processing on the ISIS files converts the DTM and orthoimages to the PDS standard file formats as described in the Software Interface Specification for HiRISE Reduced Data Record Products, version 1.2 [9]. DTM/ortho production is prioritized internally to the team, and final products are released to the public one year from creation. PDS releases are made monthly as they are available. It is anticipated that HiSCI DTM production and release will follow a similar schedule. HiRISE DTMs, orthoimages and ancillary files are available at http://hirise.lpl.arizona.edu/dtm.

2. Change detection

The most obvious use of a DTM is to gain a 3D perspective of the surface. Orientations of surface features and stratigraphic relationships can be better understood and interpreted with the addition of accurate elevation information. High resolution DTMs are also extremely useful for change detection studies. The advantage of orthoimages is the removal of topographic distortions that could otherwise be misinterpreted as changes in feature positions and shapes, although illumination differences remain. Many processes on Mars undergo changes that are only resolvable at the scale provided by HiRISE (<1m) and the planned HiSCI (~2m) instruments. Seasonal and other changes can be measured more accurately with orthorectified images. Orthorectified images can also be used in conjunction with the DTM to distinguish between albedo changes and topographic features.

4. Addressing continuing science goals with HiSCI stereo

The anticipated 20 times greater stereo coverage (by area) that HiSCI will provide compared to HiRISE [3] will be a crucial resource for studying active surface processes on Mars. It may be the only source of high-resolution new and repeat coverage by the time it flies, depending on the status of MRO-HiRISE. The stereo capability of HiSCI will the best way to address the stated goals of TGO-HiSCI including to quantify and map active surface processes (specifically regions thought to be sources of trace gases) and certification of new candidate landing sites [3].

5. Conclusion

It is becoming more and more apparent that the surface of Mars is an active place, changing on a much shorter time scale than previously thought [e.g. 10-12]. Stereo coverage is the key to discovering and studying current activity on the surface of Mars. High resolution DTMs and orthoimages provide the best way to quantify and measure surface changes. Color orthoimages from HiRISE and HiSCI will provide critical data for comparison with high resolution spectrometers such as the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [13].

The HiRISE team's experience with stereo production will be advantageous in developing new products from HiSCI data. Continued production of HiRISE DTMs, as well as the anticipated additional coverage from HiSCI will provide a critical resource for the study of Martian surface processes.

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