EPSC Abstracts
Vol. 12, EPSC2018-1096, 2018
European Planetary Science Congress 2018

HRSC at Mars: 15 years of research (and counting)

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Abstract

Since Mars Express entered orbit around Mars in December 2003, the High Resolution Stereo Camera (HRSC) experiment has taken a total of >40,000 images of Mars and its moons, Phobos and Deimos. Almost the entire surface has been imaged in color and stereo at a scale of 10-20 m/pixel, and large parts have been observed more than once, enabling multitemporal studies. More than 600 peer-reviewed papers have been published since 2004, and numerous public releases and exhibitions helped to disseminate HRSC results. The camera is still in excellent technical shape and continues to deliver high-quality data.

1. Introduction

The High Resolution Stereo Camera (HRSC) of ESA's Mars Express Mission is designed to simultaneously map the morphology, topography, structure and geologic context of the surface of Mars as well as atmospheric phenomena [1]. The HRSC directly addresses two of the main scientific goals of the Mars Express mission: (1) High-resolution three-dimensional photogeologic surface exploration and (2) the investigation of surface-atmosphere interactions over time; and significantly supports: (3) the study of atmospheric phenomena by multi-angle coverage and limb sounding as well as (4) multispectral mapping by providing high-resolution three-dimensional color context information. The unique multi-angle imaging technique of the HRSC supports its stereo capability by providing 3 to 5 stereo observations from each mapping orbit, making the photogrammetric processing very robust [2]. The stereoscopic imagery and derived products (Digital Elevation Models, slope maps) are especially useful to characterize landing sites and their geologic context [e.g., 3]. HRSC data products bridge the gap in scale between highest ground resolution images (HiRISE) and global-scale observations (e.g., MOLA, THEMIS-IR).

2. Observations

2.1 Surface studies

Mars has been shaped by endogenic and exogenic processes over its entire history, hence it displays a variety of surface features that is second only to Earth. The large areal coverage of HRSC (an individual image sequence is typically 10^4 km^2) at typical scales between ~15 m (panchromatic), 30-50 m (color), and 50-100 m (DEM) is ideal for studying landform assemblages and landscapes (e.g., Fig. 1) while still enabling the investigation of individual landforms such as a fault or a river valley. The simultaneous acquisition of color/textural *and topographic information* is particularly important in this context, as the study of the land surface in 3D analysis is essential in the verification or calibration of physical models, linking process and form (geomorphometry; e.g., [4]).

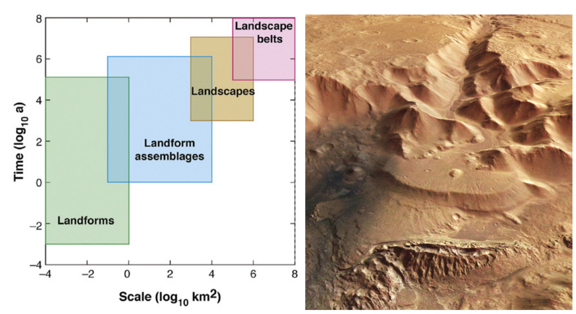

Figure 1: Surface characterization with HRSC. *(left)* Spatiotemporal hierarchy of landforms and landscapes (after [5]). The spatial resolution of HRSC makes it especially useful to analyze landform assemblages and landscapes, but also enables investigating the full range from large landforms to landscape belts. *(right)* Example of perspective view derived from HRSC color and stereo data, showing a landform assemblage in the Nephentes region (from background to foreground: valley, delta, possible fissure volcano).

An example for such studies is the investigation of Martian river channels and deltas, the dimensions of which could be quantified with HRSC DEM to model the formation timescales of deltaic deposits [6]. Another example is the 3D investigation of tectonic faults to constrain the strain, e.g., at rifts on Mars [7].

2.2 Phobos

Mars Express is currently the only spacecraft exploring Mars from an elliptical orbit. This allows regular, close flybys (<150 km) of Phobos. A prerequisite for such spectacular images (Fig. 2) is a very accurate knowledge of the orbital position of Phobos. Since 2003, measurements of the positions of the Martian moons in relation to the stars have repeatedly been obtained by examining images acquired by the Super Resolution Channel (SRC; [8]), which is part of the HRSC. Such astrometric measurements are used to continuously determine the positions of the Martian satellites and improve the ephemerides [9]. Stereo-photogrammetric methods were applied to derive a global digital terrain model (DTM) with 100 m/pixel resolution, enabling to re-determine to volume and improving the knowledge of the bulk density [10].

Figure 2: Phobos as seen by HRSC from a distance of approximately 115 kilometres.

2.3 Atmospheric investigations

HRSC regularly monitors clouds in the Martian atmosphere. The different viewing geometry between the individual channels enables determining the altitude and across-track velocity of clouds [11]. Numerous limb observations were obtained and provide a great potential to investigate the vertical layering of the atmosphere. Moreover, a close cooperation between HRSC and the MEX Interdisciplinary Scientists has recently been started to monitor the atmosphere from greater distances.

2.4 Combination with other data sets

HRSC DEM can be combined with other data to determine their three-dimensional extent. This is a perfect approach to study the stratigraphy of, e.g., alteration minerals. Such studies are part of HRSC's ongoing efforts to better characterize the Martian (paleo)environment [12].

3. Summary and Conclusions

HRSC is healthy and fully operational. Future observations will focus on improved 3D coverage of the Martian surface, Phobos imaging, and monitoring of atmospheric phenomena to initiate new science investigations.

Acknowledgements

We are grateful to the ESA teams at ESAC, ESTEC, and ESOC for 15 years of cooperation and support of HRSC's operations. The team spirit of all experiment teams on Mars Express helped to harmonize the observation requests and is highly appreciated. We also would like to thank the growing number of HRSC data users who found them helpful in their investigations.

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