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Evaluating the performance of CaSSIS elevation data for geomorphological and geological analyses

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Abstract

The Colour and Stereo Surface Imaging System (CaSSIS[1-4]) aboard ESA's Trace Gas Orbiter is enabling the acquisition of elevation data at ~20 m/pixel of the surface of Mars. Here we evaluate the performance of CaSSIS for geomorphological and geological studies by comparing with other elevation data used for such a purpose. These datasets are from the ConTeXt (CTX) and the High Resolution Imaging Science Experiment (HiRISE) cameras on NASA's Mars Reconnaissance Orbiter, whose elevation datasets are produced at 20-25 and 1-2 m/pixel, respectively. We find that CaSSIS elevation data have similar potential to those from CTX, yet CaSSIS will have better coverage and the addition of colour across the whole swath.

1. Technical details and methods

CaSSIS operates a pushframe image-capture system and performs in-track stereo by rotation of the telescope assembly in flight. Via this mechanism a stereo convergence angle of ~20° is obtained and the delay between subsequent images is on the order of 15-20s [1]. The CaSSIS elevation data shown here were produced by the team at the Astronomical Observatory of Padova (OAPD-INAF) from data acquired during the aerobraking phase of TGO in 20 November 2016. Two sets of framelets have been acquired from a mean distance of 520 km with a mean pixel scale of 6 m/px. At this time the orbit was highly elliptical and the spacecraft was rapidly changing altitude and speed across the scene causing unique challenges for the stereo reconstruction. Hence, the analysis of these elevation data should be considered as a minimum estimate of CaSSIS' performance. The production of the elevation data performed by 3DPD [5] includes: initial identification of tie-points using a SURF-type algorithm [6], production of an initial disparity map based on Delaunay triangulation, refined by a fast normalized cross correlation (NCC) [7], and an iterative sub-pixel refinement with a least square matching algorithm [8]. CTX and HiRISE elevation data of the same region were produced from bundle adjusted images using the Ames Stereo Pipeline [9]. They were vertically controlled to the HRSC elevation data H3210_0000da4 with 125 m horizontal resolution.

2. Initial Results

Fig. 1 shows the location of the three elevation datasets produced for this study. The horizontal resolution is 18, 25 and 2 meters for CTX, CaSSIS and HiRISE, respectively. The data are located over Noctis Labyrinthus to the west of Valles Marineris (6°1'10"S, 10°45'10"W). This area is characterised by steep escarpments with bedrock at the top and a talus slope below – a configuration characteristic of many zones with active slope processes on Mars (e.g. RSL [10], slope streaks [11], gullies [12]) – hence particularly suited to test the performance of CaSSIS.

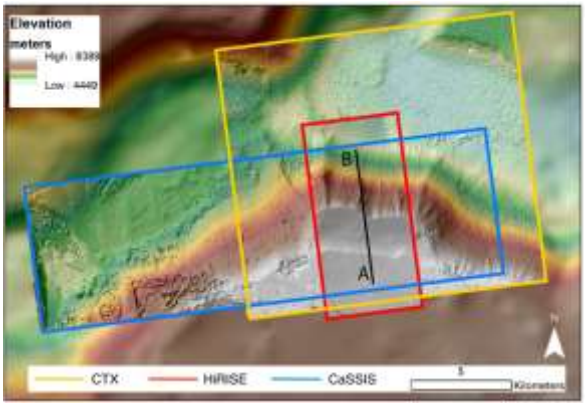

Figure 1: Map showing the footprints of the CaSSIS, HiRISE and CTX elevation data with shaded relief. Background elevation is from HRSC H3210_000. The black line marks the trace of the centre of the swath profile, spanning up to the edge of the HiRISE DTM footprint.

Fig. 2 shows the comparison between the three topographic swath profiles for CTX, CaSSIS and HiRISE. The sampling step along the profile has been chosen according to the horizontal resolution of the DTMs and the swath profiles have been collected across width of 3 km. Both values have been chosen in order to gather the maximum information in the overlapping area of the three datasets. The topographic information captured by the three datasets is consistent and comparable, despite the widely differing resolutions and noise.

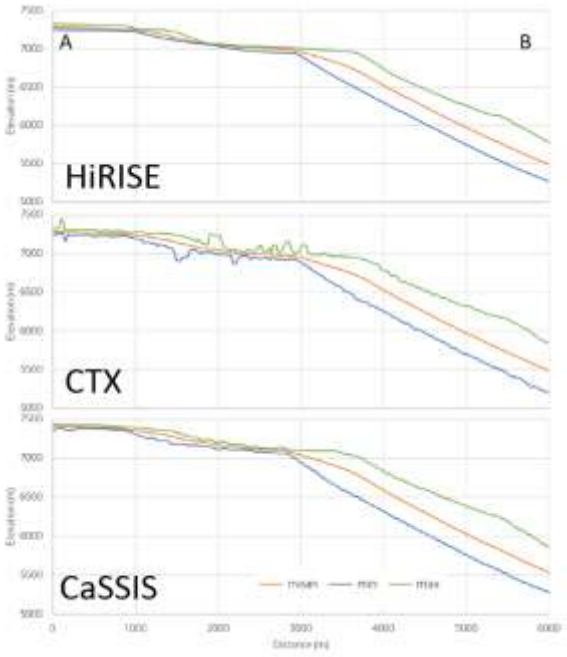

Figure 2: Topographic swath profiles derived from the HiRISE, CTX and CaSSIS elevation datasets along A-B in Fig.1. No vertical exaggeration.

3. Summary and outlook

Our initial analyses have revealed that CaSSIS elevation data have a similar potential to data derived from CTX stereo pairs. The main advantages of CaSSIS over stereo acquisitions of CTX/HiRISE are: (1) the ability to take near-instantaneous stereo images meaning elevation data can be taken over areas that often change between CTX/HIRISE images making stereo reconstruction difficult or impossible (dunes, seasonally frosted areas, polar caps), (2) more data-volume is specifically allocated to stereo acquisitions than is possible for CTX/HIRISE which obtain stereo data by using different orbits and (3) co-registered colour data can be made available across the whole swath width, which is particularly important when measuring active slope processes [13].

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