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Description of HRSC-AX images (Appendix B)

HRSC is a multisensor pushbroom instrument with 9 CCD line sensors mounted in parallel (Figure B1) that has been in orbit around Mars since January 2004 on ESA's *Mars Express spacecraft* (Gwinner et al., 2016). It simultaneously obtains high-resolution stereo, multicolor, and multiphase images. Digital photogrammetric techniques are used to reconstruct the topography on the basis of five stereo channels, which provide five different views of the ground.

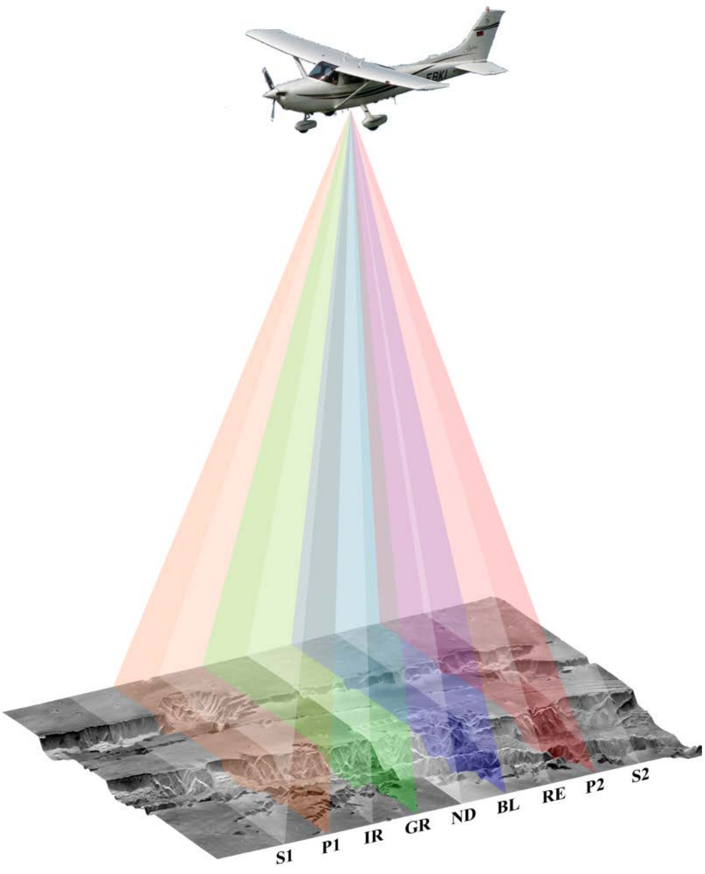

Figure B1. Operating principle of the airborne High-Resolution Stereo Camera (HRSC-AX), and viewing geometry of the individual Charge-Coupled Device (CCD) sensors. ND—nadir channel; S1, S2—stereo 1 and stereo 2; P1 and P2—photometry 1 and photometry 2; IR—

near-infrared channel; GR—green channel; BL—blue channel; RE—red channel. All nine line sensors have a crosstrack field of view of ± 6 °.

The four color channels (blue, green, red, and near-infrared; Figure B2) are used to make true orthophotos in color and false color. The particular value of HRSC is the stereo capability, which allows the systematic production of high-resolution DEMs with grid sizes between 50 and 100 m (Wewel et al. (2000); Scholten and Gwinner (2004); Scholten et al. (2005); Gwinner et al. (2005, 2010).

Since 1997 different airborne versions of HRSC have been developed, one of which (HRSC-AX) was used to acquire stereo color images over Svalbard. The principles of HRSC-AX data processing are described by Gwinner et al. (2006). Data on the camera orientation are reconstructed from a global positioning system inertial navigation system (GPS INS). HRSC-AX has been used in diverse technical and scientific applications (e.g. Gwinner et al. (1999); Gwinner et al. (2000)). The aerial survey covering the Brøgger peninsula took place on 17 July 2008 at around noon, acquiring data over most of the northern part of Brøggerhalvoya (Figure B3). A Dornier Do228 aircraft from the German Aerospace Center (DLR) was used for the survey, flying at an altitude of ~2,800 m. A comprehensive description of the initial results is given by Hauber et al. (2011a, 2011b).

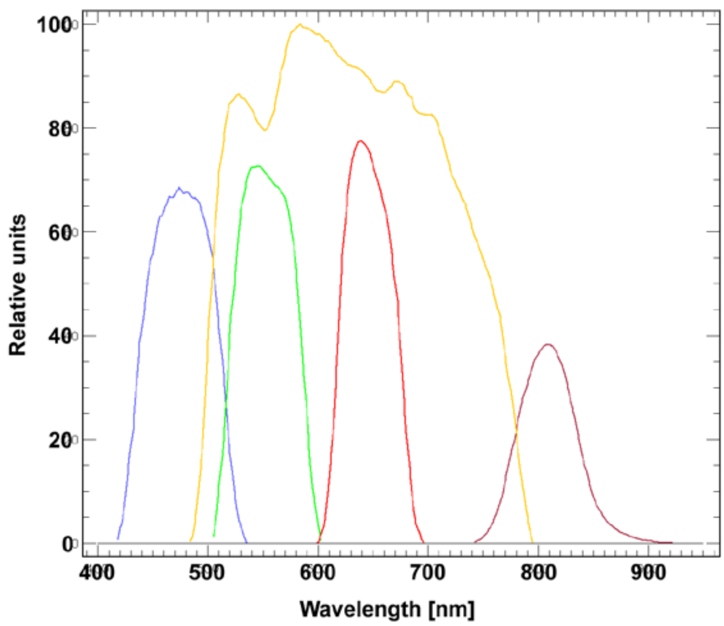

Figure B2. Spectral response of HRSC-AX panchromatic color filters.

Data processing from the raw images to the final data products, including digital photogrammetric processing, was performed with the VICAR (Video Image Communication and Retrieval; http://www.mipl.jpl.nasa.gov/external/vicar.html) software developed at the JPL (Jet Propulsion Laboratory, Pasadena, USA) and the DLR. We provide HRSC-AX data in the form of a digital elevation model (DEM) and as individual channels (panchromatic nadir channel, red, green, and blue color channels, and CIR false-color channels). The CIR (color-infrared) channels are computed by merging a false-color image (an RGB image where R, G, and B correspond to the original infrared, red, and green channels, respectively) with the nadir channel. Table B1 lists important key properties of the individual HRSC-AX image files. Metadata for HRSC-AX data are contained in "image labels", which we provide as two XML files (one for the panchromatic and (false) color images, and one for the DEM). The label entries consist of keyword-value pairs; essential keywords are defined below in Table B2. The elevations recorded in the DEM are ellipsoid heights, i.e. they are not computed with respect to a geoid but to a mathematically defined reference surface, which is a rotational ellipsoid with the equatorial A and B axes both having a radius of 6378.14 km and the polar C axis having a radius of 6356.75 km. This results in an offset of about 36.5 m with respect to geoid heights, i.e. sea Level in the HRSC-AX DEM is not at 0 m, but at ~36.5 m.

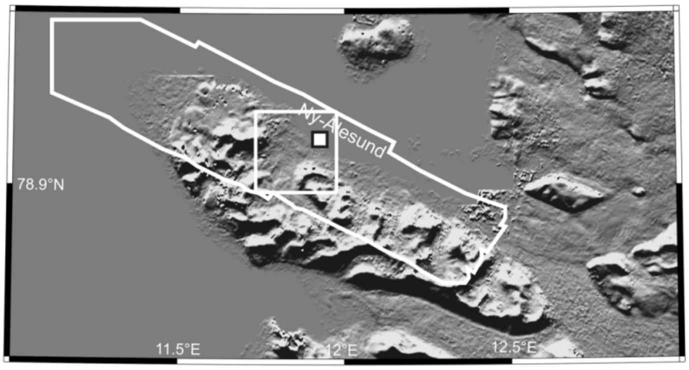

Figure B3. Context map of Brøgger peninsula, with the thick white outline showing the total coverage of the HRSC-AX survey and with the white square indicating the location of the image tile provided in this publication (base map: hillshade version of ASTER DEM).

Image name	Number of lines	Number of samples	Ground pixel size
430-8765_5.0x5.0km.pan	25,000	25,000	0.2 m
430-8765_5.0x5.0km.dsm	10,000	10,000	0.5 m
430-8765_5.0x5.0km.re	25,000	25,000	0.2 m
430-8765_5.0x5.0km.gr	25,000	25,000	0.2 m
430-8765_5.0x5.0km.bl	25,000	25,000	0.2 m
430-8765_5.0x5.0km.cir_re	25,000	25,000	0.2 m
430-8765_5.0x5.0km.cir_gr	25,000	25,000	0.2 m
430-8765_5.0x5.0km.cir_bl	25,000	25,000	0.2 m

Table B1. Image size and pixel size of individual HRSC-AX images.

Name	Definition	Dimension	Type	Label Group
File_Name	Name of the data file		string	
FORMAT	Image format (BYTE: 8 bit per pixel, HALF: 16 bit per pixel; REAL: 32 bit per pixel)		string	
TYPE	Type of data file		string	
ORG	Order of image file (BSQ = band sequential)		string	
NL	Number of lines		int	
NS	Number of samples		int	
NB	Number of bands		int	
TARGET_NAME	name of the target		string	MAP
A_AXIS_RADIUS	The a_axis_radius element provides the value of the semimajor axis of the ellipsoid that defines the approximate shape of a target body. 'A' is usually in the equatorial plane.	km	real	MAP
B_AXIS_RADIUS	The b_axis_radius element provides the value of the intermediate axis of the ellipsoid that defines the approximate shape of a target body. 'B' is usually in the equatorial plane.	km	real	MAP
C_AXIS_RADIUS	The c_axis_radius element provides the value of the c_axis of a solar system body. For tri-axial ellipsoidal objects, the c_axis is the semiminor axis of the ellipsoid which defines the approximate shape of the body.	km	real	MAP
BODY_LONG_AXIS_ LONGITUDE	The BODY_LONG_AXIS_LONGITUDE element represents the offset between the longest axis of the triaxial ellipsoid used to model a body and the prime meridian of the body. Its value is the sum of the offset added to the prime meridian. This term is the positi	deg	real	MAP
CARTESIAN_AZIMU TH	The cartesian_azimuth element provides the clockwise rotation, in degrees, of the line and sample coordinates with respect to the center of the pixel at the map projection origin (*i.e.* where line_projection_offset and sample_projection_offset are measured).	deg	real	MAP
CENTER_LATITUDE	The center_latitude element provides a reference latitude for certain map projections. In many projections, the center_latitude along with the center_longitude defines the point or tangency between the sphere of the	deg	real	MAP

Name	Definition	Dimension	Type	Label Group
	planet and the plane of the projection.			
CENTER_LONGITUDE	The center_longitude element provides a reference longitude for certain map projections. In many projections, the center_longitude along with the center_latitude defines the point or tangency between the sphere of the planet and the plane of the projection.	deg	real	MAP
COORDINATE_SYSTEM_NAME	Defines whether the CENTER_ LATITUDE is geocentric or geodetic.		string	MAP
LINE_PROJECTION_OFFSET	The line_projection_offset element provides the line offset value of the map projection origin position from the center of the pixel at line and sample position 1,1 (line and sample 1,1 is considered the upper left corner of the digital array).	pixel	real	MAP
SAMPLE_PROJECTION_OFFSET	The sample_projection_offset element provides the sample offset value of the map projection origin position from the center of the pixel line and sample 1,1 (line and sample 1,1 is considered the upper left corner of the digital array). Note that the posi	pixel	real	MAP
MAP_PROJECTION_TYPE	The map_projection_type element identifies the type of projection characteristic of a given map.		string	MAP
MAP_SCALE	The map_scale element identifies the scale of a given map. The scale is defined as the ratio of the actual distance between two points on the surface of the target body to the distance between the corresponding points on the map. The map_scale references	km $pixel^{-1}$	real	MAP
POSITIVE_LONGITUDE_DIRECTION	The positive_longitude_direction element identifies the direction of longitude (e.g. EAST, WEST) for a planet. The IAU definition for direction of positive longitude is adopted.		string	MAP
SPHERICAL_AZIMUTH	One of three Euler angles (the others are center_latitude and center_longitude) that define the pre-mapping orientation of the planetary sphere for any spherical projection.		real	MAP
DTM_RANGE	indicates at which minimum or		real	H

Name	Definition	Dimension	Type	Label Group
	maximum value the elevations in the DTM raster file have been cut-off		(2)	
DTM_A_AXIS_RADIUS	The DTM_A_AXIS_RADIUS element provides the value of the (+X) semi-axis length of the triaxial ellipsoid surface used as reference for DTM data.	km	real	DIGITAL_TERRAIN_MODEL
DTM_B_AXIS_RADIUS	The DTM_B_AXIS_RADIUS element provides the value of the (+Y) semi-axis length of the triaxial ellipsoid surface used as reference for DTM data.	km	real	DIGITAL_TERRAIN_MODEL
DTM_C_AXIS_RADIUS	The DTM_C_AXIS_RADIUS element provides the value of the (+Z) semi-axis length of the triaxial ellipsoid surface used as reference for DTM data.	km	real	DIGITAL_TERRAIN_MODEL
DTM_OFFSET	The DTM_OFFSET element provides the constant value by which a stored elevation value is shifted or displaced.	m	real	DIGITAL_TERRAIN_MODEL
DTM_SCALING_FACTOR	The DTM_SCALING_FACTOR element provides the constant value by which the stored elevation is multiplied		real	DIGITAL_TERRAIN_MODEL
DTM_DESC	The DTM_DESC provides a free form, unlimited length character string that describes the DTM data.			DIGITAL_TERRAIN_MODEL

Table B2. Description of metadata (keyword-value pairs) contained in the HRSC-AX image headers.

For detailed information read:

Boike, J., Juszak, I., Lange, S., Chadburn, S., Burke, E., Overduin, P. P., Roth, K., Ippisch, O., Bornemann, N., Stern, L., Gouttevin, I., Hauber, E., and Westermann, S.: A 20-year record (1998–2017) of permafrost, active layer, and meteorological conditions at a High Arctic permafrost research site (Bayelva, Spitsbergen): an opportunity to validate remote sensing data and land surface, snow, and permafrost models, Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2017-100, in review, 2017.