MAPPING OF CERES BY DAWN: NEW SPG AND SPC DTMS OF OCCATOR CRATER AND ITS INTERIOR CRYO-VOLCANISM-RELATED BRIGHT DEPOSITS. A. Neesemann[1], S. van Gasselt[2], R. Jaumann[1], J.C. Castillo-Rogez[3], C.A. Raymond[3], F. Postberg[1]. [1]Freie Universität Berlin, Institute of Geological Sciences, Planetary Sciences and Remote Sensing. Malteserstr. 74-100, 12249 Berlin, Germany (a.neesemann@fu-berlin.de), [2]National Chengchi University, Department of Land Economics, Geomatics Group, No 64, Sec 2, ZhiNan Rd., Wenshan District, Taipei 11605, Taiwan, [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

Introduction: After its successful 14 month mission at asteroid Vesta in 2011/2012, the Dawn spacecraft [1] headed for its next target, Ceres. During its 3.5 year lasting mission, the dwarfplanet was globally mapped by the onboard Framing Camera (FC) [2] from different polar science orbits/altitudes and locally from a highly elliptical orbit (Sec. Data and Methodology) until it ran out of hydrazine in late October 2018. With increasing coverage at higher resolution, the unique nature of the 92 km young [3] Occator crater and its contribution to our understanding of Ceres volatile-rich crust [4-7] quickly became evident. Its interior central cryovolcanic dome Cerealia Tholus (Fig. 1) but especially the corresponding bright carbonate [8-10] and ammonium chloride deposits [10] named Cerealia Facula (CF) and the thinner, more dispersed Vinalia Faculae (VF) - both, surface expressions of a deep brine reservoir under Occator [11] - understandably made it the target for future sample return missions studies [12-17]. Planning and preparation of such sample return missions requires the characterization of the potential landing site based on the most accurate topography and orthorectified image data. Therefore, our current work does not serve as an end in itself, but is a continuation of previous work [18,19] with the aim to provide the above mentioned required data products. It serves primarily to:

- Demonstrate capabilities of the freely available USGS Integrated Software for Imagers and Spectrometers[1] (ISIS) and the Ames Stereo Pipeline[2] (ASP) [20] of creating high quality image data products and stereophotogrammetric (SPG) and stereophotoclinometric (SPC) DTMs.
- Provide new high resolution DTMs and orthomosaics of Occator crater for future landing site studies and as a base for subsequent processing of even higher resolved XM2 (XMO7) data products
- Provide a detailed description, the code/scripts and supplementary data (Ground Control Point (GCP) networks, new camera angle (CK) and spacecraft position (SPK) kernels) used for the creation of mentioned data products for easy reproducibility
- Compare and evaluate SPG and SPC approaches (advantages/disadvantages) and acertain quality differences in terms of effective resolution

Data and Methodology: We used all nadir and offnadir (no limb observations) FC2 F1 clear filter images [2] acquired during DAWNs nominal and first extended (XM1) mission phase at median altitudes of 1485 km and 389 km. Additionally, we used those FC2 F1 images acquired during the second extended mission (XM2) at ground resolutions of ≥17 mpx^{-1}. This includes the polar High Altitude Mapping Orbit (HAMO/CSH), the Extended Juling Orbit (XMO2/CXJ) (~136 mpx^{-1}), the Low Altitude Mapping Orbit (LAMO/CSL) and Extended LAMO (XMO1/CXL) (~34 mpx^{-1}), and the highly elliptical Extended Mission Orbit (XMO7). In order to create precise DTMs and orthoimages, we established a advanced workflow that combines the strengths of ISIS and the ASP. The general processing steps include: 1. systematic noise/static warm pixel removal, 2. precise co-registration and bundle adjustment (correction of CK and SPK), 3. photometric correction using models and parameters established by [21,22], 4. creation of accurately registered ISIS level 3 map-projected data, 5. derivation of SPG and SPC DTMs, and 6. creation of ISIS level 4 FC2 orthomosaics and corresponding DTMs.

A major aspect and most time-consuming part of our work is the precise manual successive but joint registration of HAMO, LAMO, and XMO7 data. Automated image registration is indispensable when handling large datasets, but might lead to misregistration increasing with differences in resolution, illumination angles and observation geometries - which might be the reason for the observable 1-3 pixel horizontal offset between the global HAMO[3], LAMO[4], and several local LAMO[5] PDS F1 mosaics. Therefore, we only used the HAMO-based global orthomosaic and corresponding SPG DTM [23] as ground source for initial spiceingestion and co-registration.

Results: In total we created four DTMs. First, a regional HAMO-XMO2 SPG and SPC DTM at 136 mpx^{-1} between 184-296°E and 24°S-46°N. Subsequently, using the previously created SPC shapemodel as the new source for future spiceingestion, we created a local LAMO-XMO1 SPG and SPC DTM at 34 mpx^{-1} between 222.65°E-255.85°E and 11°S-28.5°N. Promising results, at the example of the 47 km Azacca and 110 km Ezinu crater, were presented in [18,19]. In the meantime, however, we further improved our approach i.a. by densifying the GCP networks for each individual image and thus minimizing CK and SPK uncertainties and reducing the stereo correlation and subpixel refinement kernel sizes.

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[3]https://sbnarchive.psi.edu/pds3/dawn/fc/DWNCHCFC2_2/
[4]https://sbnarchive.psi.edu/pds3/dawn/fc/DWNCLCFC2_2/
[5]https://sbnarchive.psi.edu/pds3/dawn/fc/DWNCLSPG_2/

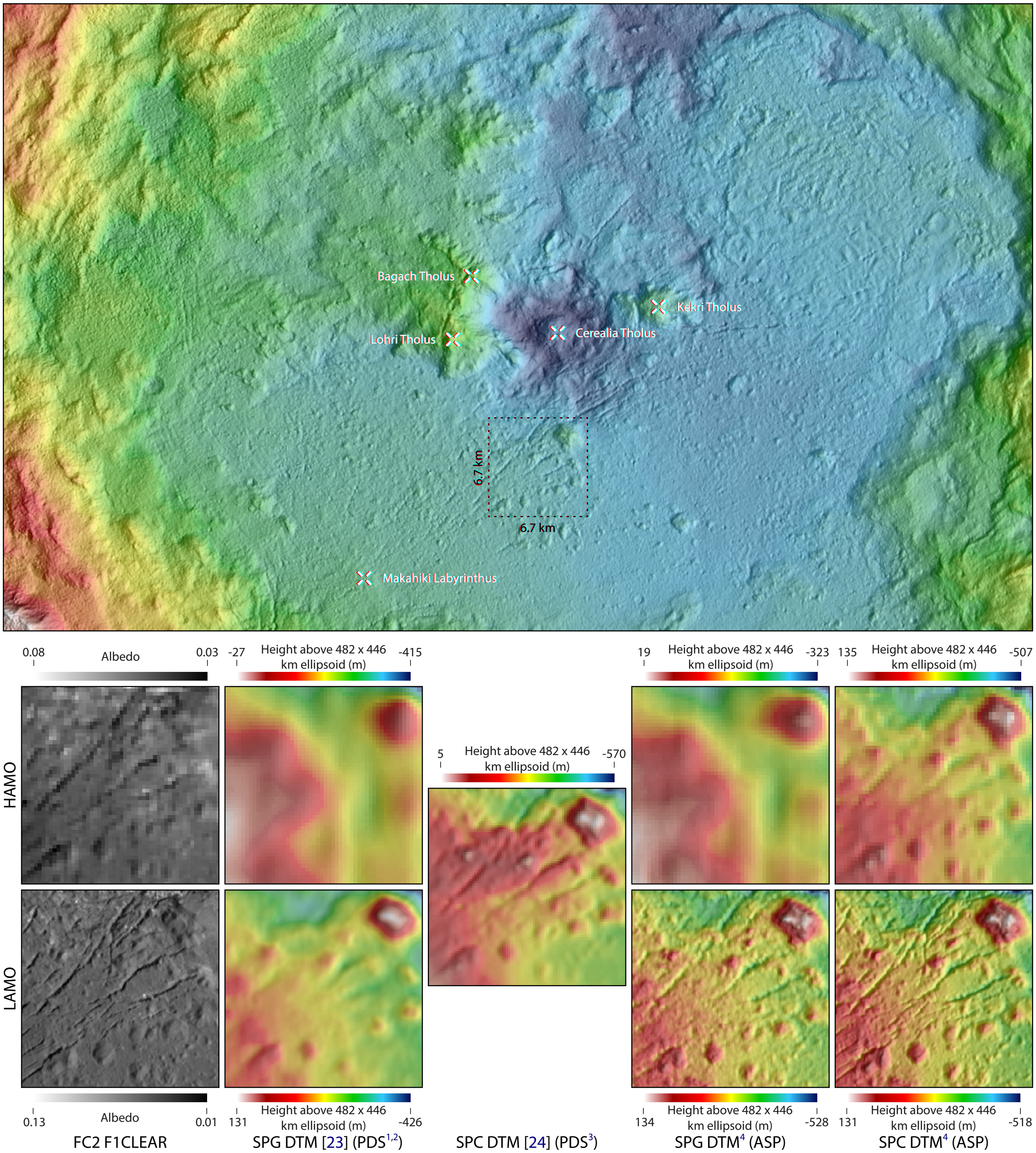

Fig. 1. Top: Extract of our LAMO-based ASP SPG DTM of the interior of Occator crater, centered at 19.76°N/239.27°E. **Bottom:** Detail views of a local region southwest of Cerealia Facula exhibiting the northeastern extension of faults that belong to Makahiki Labyrinthus as well as numerous mounds. We chose that region as it provides a good impression of the different level of detail between both, published HAMO and LAMO SPG and SPC DTMs and equivalents derived in our study. While SPG DTMs usually achieve an effective resolution of only 25 % of their original image data, the high mutlicoverage of data taken at varions phase angles allows for a much more precise reconstruction of the topography close to 100 %. [1]https://sbnarchive.psi.edu/pds3/dawn/fc/DWNCHSPG_2/, [2]https://sbnarchive.psi.edu/pds3/dawn/fc/DWNCLSPG_2/, [3]https://sbnarchive.psi.edu/pds3/dawn/fc/DWNCSPC_4_01/, [4]this study.

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