TOPOGRAPHIC DATA REDUCTION FOR THE VERITAS 2023 ICELAND FIELD CAMPAIGN. G. Cascioli1,2, E. Mazarico2, D. Nunes3, S. Smrekar1, A. Gülcher4, J. Whitten5 M. C. Raguso6, J. Head6, 1University of Maryland Baltimore County, 2NASA Goddard Space Flight Center, 3NASA Jet Propulsion Laboratory, 4California Institute of Technology, 5Smithsonian Institution, 6Brown University

Introduction: VERITAS is a NASA Discovery class mission set to launch in the 2029-2031 time frame. VERITAS, through its state-of-the-art instrumentation - composed of an InSAR, an emissivity mapper and a gravity science investigation [1,2,3,4]- will provide foundational datasets to understand the evolution and past and present geological and geophysical processes on Venus. In August 2023 members of the VERITAS science team performed a two weeks-long field campaign in Iceland with the goal of gathering data to characterize and calibrate VERITAS instruments [5, 6, 7, 8]. We report here on the amount and quality of the surface characterization dataset, discuss the data reduction strategy, and provide a first look at the final dataset that will be made publicly available to the scientific community.

Data Description: The purpose of this dataset is to compile a catalog of geometric surface properties (elevation, slope, roughness) of lava flows with different morphologies to help understand the radar-surface interaction and better interpret the global Venus SAR dataset that will be collected by VERITAS. We measured the surface topography of 41 distinct sites by means of three small portable terrestrial laser scanners (TLS). Each area -identified as a potential Venus volcanic flow analog- was measured in a 5x5 m square patch configuration. All patches were also imaged by an airborne multiband (L, S, and X-bands) SAR flown and operated by a DLR team (see [6] for more details). For better understanding surface roughness effects on radar backscatter, sub-radar-pixel digital elevation models (DEMs) are needed. For each patch 8-10 individual laser altimetric scans were collected with a millimetric resolution, leading to ~40-60 million measurement points per patch. The location of each TLS location has been measured through differential GPS allowing for cm-level positioning via PPP postprocessing. For additional detail on data acquisition see [7].

Data reduction and analysis: Individual scans for each terrain patch result in point clouds with partial coverage, depending on the scanner location with respect to surface characteristics (roughness, boulders, cracks). Localized low data density is minimized by combining and matching all the individual scans. The matching process is performed with the Leica Cyclone software leading to an average matching accuracy lower than 5 mm for the 41 measured patches. The lidar scanners have a field of view of 360° in azimuth and ±45° in elevation, and a maximum range of tens of meters. The total coverage of the matched 8-10 scans configurations extends beyond the target 5x5 m area of interest, and contains artifacts due to the movement of objects and people outside the patch ‘safe zone’. For processing, the matched point cloud is cropped into 6x6 m tiles to allow for some padding around the measured patch. While the native resolution of the scanner data is 1 mm, due to the point coordinates quantization we currently output a 1 cm DEM by gridding and averaging the point cloud dataset. For every patch we compute the slope and the roughness at the radar wavelengths (after detrending the DEM with a plane fit, using the methods described in [9]). The data are saved as TIF raster files, registered to the intrinsic TLS reference system. Using the recorded and postprocessed GPS information on the scanner locations we project the raster datasets into a geodetic reference frame consistent with SAR geocoded data products. (e.g., ISN2016 – EPSG 8088). This procedure is enabled by the knowledge of the location of at least 4 points both in the intrinsic TLS reference frame and in a global reference frame (WGS84, provided by the recorded GPS locations). The attached figures show an example of data acquisition and processing for a patch collected on the 2022 Fagradalsfjall volcanic field in the Reykjanes peninsula region. Figure 1 shows a typical moment in the data acquisition procedure. This photo highlights the topologic complexity of this specific flow characterized by elevated slopes at short wavelengths. Figure 2 shows the point cloud obtained by matching the output of all individual TLS scans. This highlights the large spatial coverage of the matched point cloud product, which encompasses a large area besides the 5x5 m patch of interest. Figure 3 represents the point cloud density in the 6x6 m tile which is used for processing. The locations of the TLS stations are clearly seen as the circular low-density regions, corresponding to the 45° shadow cone under each scanner. For this patch, 8 scans were collected in 4 distinct locations. Two scans in the same (x,y) location were collected at different heights, as evidenced by the concentric low-resolution cones. The density map of this patch is highly spatially variable because of the complexity of the surface topography. Different sites (e.g., composed predominantly by tephra) show much more uniform data density. Figures 4 and 5 show the derived 1-cm DEM, and the slope and roughness at X-band wavelength.

Conclusion: The VERITAS 2023 Iceland field campaign was successful in acquiring topographic data
that will yield high resolution georeferenced DEMs. The data were collected at 41 morphologically distinct sites in conjunction with airborne SAR images. These datasets will allow to precisely characterize the radar-surface interaction at a sub-pixel scale, information that is essential for testing the theoretical predictions of how the Venus environment will change the surface morphology and textures of Venus lava flows [10]. The raw and derived datasets will be made available to the wider scientific community.

Figure 1 — VERITAS PI and a team member set up the TLS for data collection. Pink rocks delineate the 5x5 m patch geometry.

Figure 2 — Point cloud prior to cropping of the area of interest. VERITAS team members can be identified by the yellow color of their safety vests. The 5x5 m area of interest is at the center of the image and can be recognized by the higher point cloud density.

Figure 5 — Roughness (left) and slope (right) computed at X-band wavelength (3.1 cm) on the 6x6 m patch.

Figure 3 – Data density for the selected patch. (6x6 m shown here)

Figure 4 – 1cm DEM of the selected patch (6x6 m shown here).

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