AN IMPROVED TOPOGRAPHIC MAP OF ALPHA REGIO FROM MAGELLAN ALTIMETER DATA. E. R. Pimentel[1,2], B. A. Campbell[1], and J. B. Garvin[3], [1]Smithsonian Institution, Center for Earth and Planetary Studies, Washington, DC 20013-7012, [2]California Institute of Technology, Pasadena, CA 91125, [3]NASA Goddard Space Flight Center, Greenbelt, MD 20771

Introduction: The Magellan Global Topographic Data Record (GTDR) for Venus contains kilometer-scale vertical artifacts in numerous tessera locales due to rugged topography at the few-km horizontal scale. Here we present improved topography for Alpha Regio based on a re-analysis of power-versus-delay records from the Magellan ARCDR information. We infer that vertical artifacts pervasive throughout the coverage of Alpha Regio are due to (1) the large cross-track footprint of the Magellan radar altimeter (ALT), and (2) the template-fitting procedure used to process the ALT echo profiles favorably fitting to echo returns from off-track, intra-tessera lava ponds.

Background: The Magellan altimeter collected echo records of 302 delay samples at horizontal spacing of 5-12 km along each orbit track. These data can be assembled to form a radargram much like those of Mars radar sounders (Fig. 1) [1].

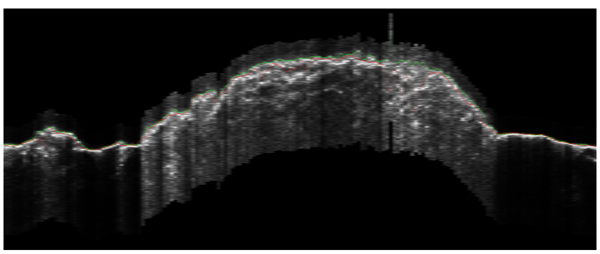

Fig. 1. A radargram for part of Magellan Track 600, created by placing 302-sample pulse records into a cross-sectional view as done for SHARAD or other radar sounders. Red and green dashes show the radius values derived from the two MGN-ALT algorithms.

Two algorithms were used to fit data collected by the Magellan ALT. One algorithm fits to the first bright echo returned after an ALT burst, and the other algorithm finds the echo that best matches a library of model templates of simulated responses from variably rough surfaces [2]. Over the smooth Venus lava plains, both algorithms locate the same echo in delay, and thus correspond to the same planetary radius value. Over Alpha Regio, the algorithms often yield different radius values at the same location, and the difference between these values can be over a kilometer in vertical distance.

The current GTDR of Venus was created using the model template algorithm. Black spots visible in the GTDR map over Alpha Regio appear in the altimetry profiles as systematic and drastic drops in elevation (Fig. 2). These drops often fall near or below the mean planetary radius for Venus (6051.0 km), and when comparing the location of these black spots to the same location in Magellan SAR images, there are no surface features that correspond to such drastic elevation differences.

Approach: We use large differences (>100 m) in the radius values generated by the first-reflection and model-template algorithms to flag locations for inspection within the altimetry profiles. For each profile, we determined the best radius value at a flagged location, taking into account the mean planetary radius at 6051.0 km and drastic or unreasonable changes in slope. We then imported the point cloud of revised radius values into ArcGIS and correlated it with Magellan SAR Left-Look images at 150 m/pixel resolution. Ford & Pettengill [2] report that the cross-track and along-track footprint dimensions of the ALT at the latitude of Alpha Regio are 16 km and 8 km, respectively. The time resolution of the altimetry data corresponds to a one-way vertical distance of 33.2 m.

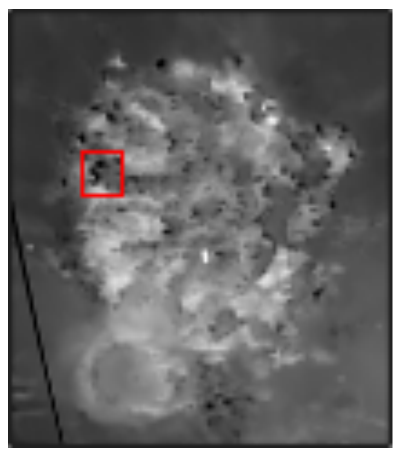

Fig. 2. Magellan GTDR map of Alpha Regio. Dark pixels within the tessera are km-scale vertical anomalies that affect geologic interpretation. Red box shows location of traces in Fig. 3.

Altimetry & SAR Observations: Intratessera ponds of varying size are ubiquitous throughout Alpha Regio and are characterized by smooth, flat surfaces compared to the surrounding tessera terrain. Figure 3 displays a SAR image with track 516, which bisects a lava pond, and track 517, which just barely crosses the southeastern margin of the same lava pond. Moving approximately north to south along track 517, the altimeter nadir point gets closer to the margin of the lava pond. The closing distance between Magellan and the margin of the pond spatially aligns with a drastic offset in elevation along Track 517 (Fig. 4). No features in the SAR image suggest that this drastic elevation change represents the real surface topography along track 517.

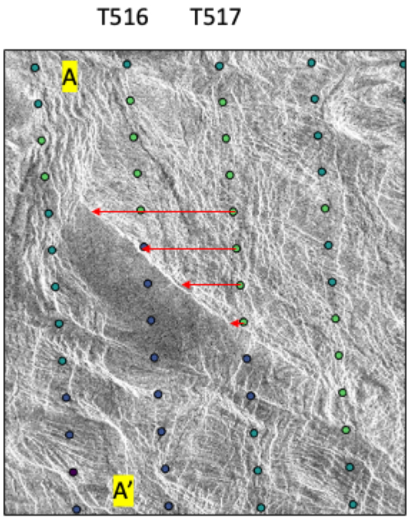

Fig. 3. Magellan ALT tracks on radar image for a region of Alpha Regio with a large, radar-dark, lava pond. Red arrows show footprints on Track 517 that detect the lake echoes (Fig. 4) at off-track distances up to ~30 km.

We propose that the bright echoes that represent the drastic elevation change in Track 517 are returns from the smooth surface of the off-track lava pond. As Magellan gets closer to the margin of the pond, the time delay of the return echoes decreases, and this is projected in the profile as an increase in elevation. Both algorithms, and thus the GTDR, are affected by this erroneous echo tracing. The profile of Track 517 displays a series of faint returns above the lava pond that appear consistent with features in the SAR images and with the adjacent along-track terrain. We interpret this faint signal to represent the true surface topography along Track 517.

This finding indicates that, in practice, off-nadir smooth regions can be detected at larger cross-track offsets than indicated by the beam dimensions at the cited fractional power level [2]. Partly due to the rugged, low-return nature of the topography at nadir, the template-fitting algorithm used to create the GTDR often tracks bright echoes from the smooth surface of off-track lava lakes. The farther off track the lava lake, the greater the time delay of the return echo, which presents itself in the altimeter profile as anomalously low elevation.

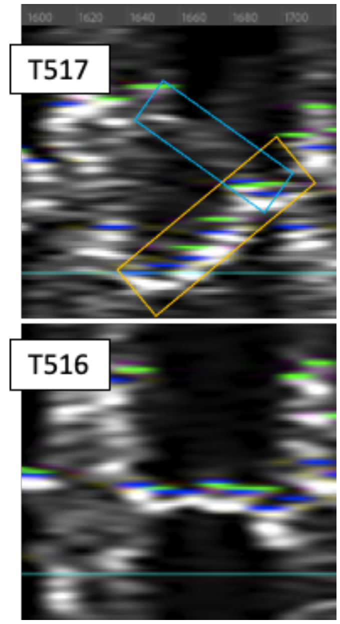

Fig. 4. Segments of two Magellan ALT tracks noted in Fig. 3 (A in Fig. 3 is at left, A’ at right). Lower box shows “flat” trace of the lava lake beneath the spacecraft, while upper box shows in gold the erroneous topography due to detection of that lake well off track. The correct surface echo is faintly visible in the blue box. Blue and green dashes indicate detections of the echo by the two MGN algorithms. Horizontal line corresponds to elevation of the Venus plains surrounding Alpha Regio.

Conclusions: We present revised planetary radius values that correct kilometer-scale vertical artifacts for improved topography across Alpha Regio. We infer that the vertical artifacts visible in the current GTDR coverage of Alpha Regio are most often due to smooth, off-track intra-tessera lava ponds. This interpretation suggests that detection of these off-nadir lake echoes can occur for larger cross-track distances than assumed for the nominal ALT footprint.

The method described here to revise radius values across Alpha Regio can be repeated for other tesserae. Improved topography across Alpha Regio can aid DAVINCI in landing site analysis, and improved altimetry over all the tesserae can aid VERITAS in thermal modeling and planning for interferometric topography data collection and processing.

References: [1] Campbell, B. A., and Whitten J. L. (2022), *GRL*, https://doi.org/10.1029/2021GL096446, [2] Ford, P. G. and Pettengill, G. H. (1992) *JGR, 97,* 13103–13114.