Stereo-Derived Topography from the Venus Magellan Dataset: an assessment of the quantitative scientific value of sub-km DEM products. A. L. Gleason[1], L. S. Glaze[2], R. R. Herrick[3], and J. B. Garvin[4]: [1]alynngleason@gmail.com, [2]NASA Goddard Space Flight Center (Code 698, Greenbelt, MD 20771; Lori.S.Glaze@nasa.gov), [3]Geophysical Institute, University of Alaska, Fairbanks (Fairbanks, AK 99775-7320, rherrick@gi.alaska.edu), NASA Goddard Space Flight Center (Code 600, Greenbelt, MD 20771; James.B.Garvin@nasa.gov)

Introduction: Numerous recent studies of Mars have clearly demonstrated that high resolution topographic measurements are vital for a detailed analysis of landform morphologies and for understanding surface processes. Similarly detailed topographic data are needed in order to better understand the many enigmatic surface processes of Venus [1]. Currently, there are only two sources of topography available for Venus. The first is nadir radar altimetry data acquired via the Magellan mission, and the second is derived using radar stereogrammetry techniques on the basis of Magellan SAR images [2] [3]. The nadir radar altimetry data, while valuable for synoptic examination of global topography and regional-scale features, is too coarse in both horizontal and vertical resolution (10-30 km horizontal and 80-100m vertical resolutions, [2]) for any quantitative analysis of surface processes and their histories. In recent studies, stereo methods have been successful in deriving high-resolution topography for impact craters [4] and steep-sided domes [5]. In these studies, the horizontal resolution was improved to 300-1000m, with a vertical precision of several 10's of meters. Due to the success of stereo methods in these cases, a study was recently undertaken to assess the utility of the sub-km scale DEMs in analyzing surface properties and processes for a wide range of different landforms on Venus. These features include: tesserae, coronae, paterae, lava flows, lava channels and mountain belts.

Methods: This study used stereo SAR images collected by the Magellan mission from the early 1990's. The horizontal resolution of this data is ~120m/pixel (resampled to 75m/pixel). For this study, the data were restricted to left-left look images, or a same-side geometry, in order to simplify the use of available radar-stereogrammetry methods. Under this constraint, ~26% of the surface has imagery available for reprocessing into DEMs and analysis. The software programs Magellan Stereo Toolkit (MST, [5]) and Stereo Matching Toolkit (SMT, [5]) were used for the stereo processing. The resulting DEMs have a horizontal resolution of 225-1000m/pixel. This is similar to the Mars Global Surveyor MOLA spatial resolution.

Results: In Figure 1a, a small tessera unit located at 26° N, 358° E is illustrated. Figure 1b displays the stereo-derived DEM, and Figure 1c displays the horizontal profile across the tessera unit. Overall, the background plains surrounding the tessera unit are very smooth and do not display a large amount of relief. The middle region of the tessera unit is distinguishable and is revealed to have ~100-200m of relief above the plains. However, the DEM does not distinguish finer details of the tessera unit: i.e. the heights and depths of internal fractures and faults. The outlying areas of the tessera unit are obscured, and it is not clear whether this is because the elevation difference between the edges of the unit are the same elevation as the plains or if this is due to errors in the stereo processing. Overall, the low relief of the feature is somewhat surprising, given the interpretation of regionally high topography generally associated with tessera units [6].

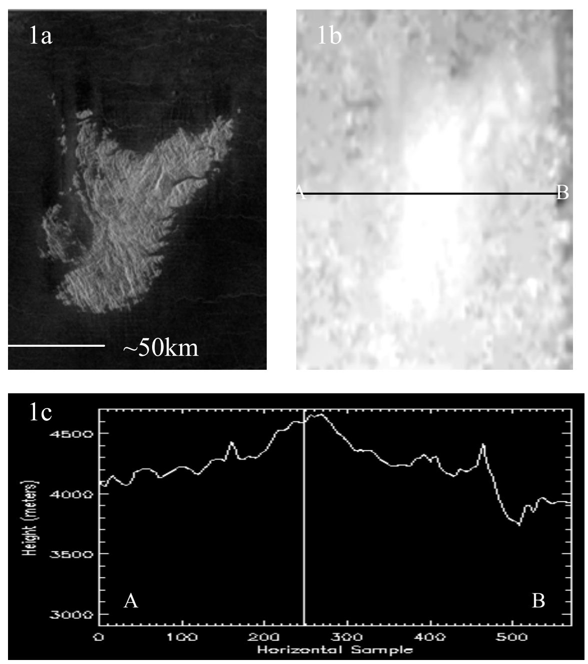

Figure 1a: orthorectified SAR image of the tessera unit located at 26° N, 358° E.

Figures 1b and 1c: DEM of the tessera unit above. The tessera unit is visibly elevated above the surrounding plains, but at most only ~100-200m. Anomalous spikes and dips located to either side of the tessera unit are attributed to errors in the DEM rather than true topographic features.

Another feature that was selected for study is a lava channel system, located at 12° S, 90° E. The Magellan SAR image of the study area is illustrated in Figure 2a, and the resulting DEM and profile in Figures 2b and 2c. From the SAR image it is noted that the surrounding plains are relatively flat and smooth, an assumption that is corroborated by the DEM. The DEM in Figure 2b does distinguish between the large "lava pool" and the surrounding terrain, however the smaller channels to the south are not clearly resolved. These smaller channels are more representative of other channels observed on the surface of Venus. Therefore, little new quantitative information can be gained using the stereo methods described here for small-scale features up to several hundred meters across.

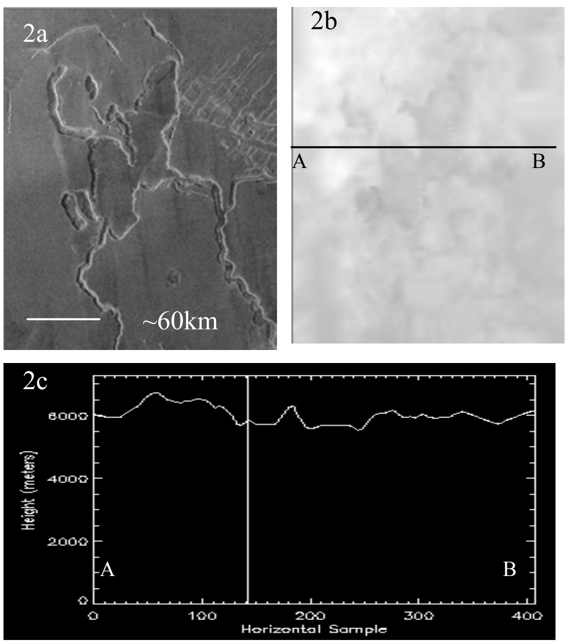

Figure 2a: channels located at 12° S, 90° E.

Figures 2b and 2c: DEM and horizontal profile of channels above. The "lava pool" is recessed ~1km below the surrounding plains. The smaller channels to the south are not clearly distinguishable in the DEM.

Discussion: This study was undertaken to determine whether or not reprocessing the Magellan stereo data for Venus on a large scale is feasible and to asses the quantitative quality of the DEM data products produced. Data with optimal stereo geometries accounts for ~26% of the Venusian surface, and even so, large gaps exist in the Magellan cycle 3 coverage. On the basis of these data limitations, analysis over large features and wide areas is difficult. While studies show that utilizing opposite side geometry coverage is possible for the Magellan data [5], automated matching methods do not perform well in these cases, making manual matching necessary. This stipulation limits the use of opposite side geometry coverage, and in many cases makes it impractical.

MST, which was specifically created for use with stereo pairs from the Magellan mission, was found to have several limitations in its use. Areas over 100 km on a side or more are difficult to process and the results often have large errors in the match points. This increases the amount of interpolation needed between points and decreases overall DEM resolution. In flat regions, such as those seen in Figures 1a and 2a, MST has difficulty finding match points using the automated matching algorithm. Because of this, the match points "drift" erroneously away from true match points, especially along the edges of the region. The software is further limited by hardware requirements, requiring outdated processors to run.

The DEM products generated in this study did produce relative height information useful for comparative studies. However, it failed to produce DEMs with sufficient detail to reliably distinguish any surface features such as faults, fractures, lineaments and levees that might be related to surface processes and formation. Furthermore, while the horizontal resolution of the DEMs were much improved over that of the available nadir radar altimetry data, the vertical resolutions of the two data sets are comparable. In order for the DEMs to be quantitatively useful for analysis of surface processes, the vertical precision must be improved by at least an order of magnitude.

Conclusions: While stereo derived topography is successful for relatively discrete, small to intermediate sized features such as impact craters and steep-sided domes, it is found to be lacking for larger landforms and wide areas of study. The topography results of this study were found to be qualitatively and comparatively useful. However, little new quantitative information was derived from these data products for the reasons stated above. Therefore, it is proposed that new, improved topography data (200-300m horizontal resolution, <10m vertical precision) from a future mission to Venus is needed before reasonable quantitative results can be inferred for surface processes and their histories.

References: [1] Crisp, D. et al. (2002) *ASP Conference Series*, 272. [2] Plaut, J.J. (1993) *Guide to Magellan Image Interpretation*, 19-31. [3] Plaut, J.J. *Guide to Magellan Image Interpretation*, 33-43. [4] Herrick, R.R. and Sharpton, V.L. (2000) *JGR*, 105, 20,245-20,262. [5] Gleason, A.L., (2008) MS thesis, University of Alaska Fairbanks. [6] Bindschadler and Head (1991) *JGR*, 96, 5889-5907.