ASESSMENT OF PUBLISHED VIKING ORBITER DEMS DERIVED FROM STEREO PHOTOGRAMMETRY USING MOLA DATA. J-P. Muller', J-R. Kim and J.G. Morley Department of Geomatic Engineering, University College London, Gower Street, London WC1E 6BT, UK Email: jpmuller@ge.ucl.ac.uk

Introduction: [1] described the exciting results which have been obtained from the initial set of mainly Northern hemispheric laser altimetry tracks from the MOLA instrument [2] known as the SPO-1 phase. More recently [3] has shown that the Mapping Phase of MGS was sufficient to allow for the creation of a 1/64^{tho} (≈4km) global terrain model. The MOC instrument has recently (May 7th to June 2nd 1999) produced an across-track global stereo coverage of Mars at IFoV around 250m. It is therefore opportune to compare the pre-existing Mars Digital Terrain Model (DTM) obtained by Wu and co-workers at USGS Flagstaff using stereo photogrammetry based on Viking Orbiter data [4], [5], [6] http://www-pdsimage.jpl.nasa.gov/jbcache/viking/vo_2007/docuemnts/vo1info.txt with elevations for those areas where MOLA data has so far been published in the public domain (SPO-1). In order to facilitate this comparison the two data-sets needed to be transformed into the same co-ordinate frame. It was decided on the basis of the results of the MOLA analysis to transform the USGS DTM. The USGS DTMs were transformed in a number of sequential steps. Firstly they were transformed onto the same ellipsoid as MOLA. Secondly they were transformed using the recently available transformation parameters to convert from the original global Ground Control Points' network derived by [7] to one derived using the positions of the Mars Pathfinder lander craft and re-processed global Viking Orbiter tracking data by DLR [8]. Thirdly, they were transformed to the same gravity model as MOLA using the GMM-1 [9]. Elevation values were compared assuming that there is no planimetric shift between the two data-sets. It should be noted that shifts of up to 10km have been observed (T. Duxbury, Per. Comm., 1999). However, as most of the area where the analysis was performed is very flat it is not believed that this shift will cause any global biases. Analysis of the elevation differences between the USGS DTM and MOLA tracks was performed for both the best available DTM of Mars created over Olympus Mons [4] and for the global DTM created for mapping the entire planet using stereo photogrammetry [6,10]. A GIS was used to perform the comparisons to select the nearest neighbouring point to the MOLA footprint from the USGS DTM grid. The results indicate that for 2,519,005 comparisons there appears to be an elevation difference of 1.79±1.38km globally. Possible explanations for these elevation differences are discussed. Visualisations of these differences were also produced using both colour-coded height difference MOLA tracks over the MDIM, USGS colour coded DTM and sideways profile plots over the MDIM as well as a histogram analysis of elevation differences. Finally an attempt was made to merge the MOLA elevations with the USGS DTM to produce a DTM. The overall agreement of this new DTM was better than 20m with the MOLA elevation values.

Method: The USGS DTM was transformed into the same co-ordinate reference frame as the MOLA data by:

1. Transformation of the data from sinusoidal to Plate Carrée (lat,lon) projection using the original Mars radius values (a=3,393.4km, b=3,375.73km)
2. Transformation to the same Mars radius values as MOLA (a=3,376.2km, b=3,376.189km)
3. Shift of the lat,lon, height values using the transformation computed by DLR and areocentric lat, lon, height values [8]
4. Datum shift using the NASA/GSFC GMM-1 gravity model used for MOLA [9]

Each MOLA profile was then ingested into the ARC/INFO GIS system and the nearest neighbour interpolation function employed to locate the closest USGS transformed DTM height value. Difference statistics in elevations were then computed, a variety of visualisations produced of these height differences using the GMT package from Hawii University (http://www.soest.hawaii.edu/wessel/gmt.html) and a new DTM created by merging MOLA and USGS.

Results: A local regional analysis was first performed using the best available DTM on Mars of Olympus Mons [4]. Only two profiles from SPO-1 intersected with this region shown here in Figure 1.

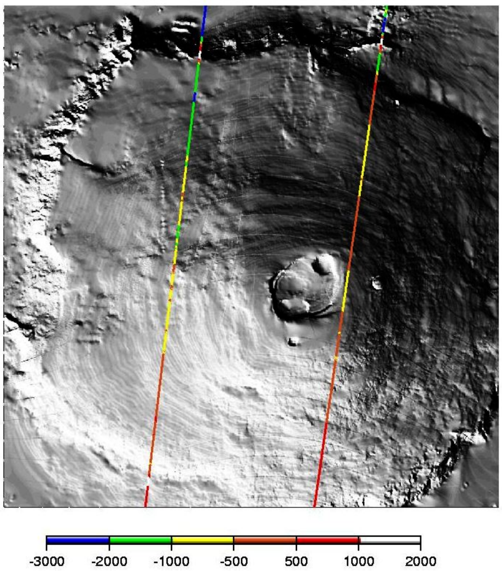

Figure 1. MOLA profiles on Olympus Mons DTM.

The left of these profiles is shown in Figure 2 which indicates good agreement between the MOLA and USGS DTM except on the Northern flank. This may be due to the local datum employed in this area.

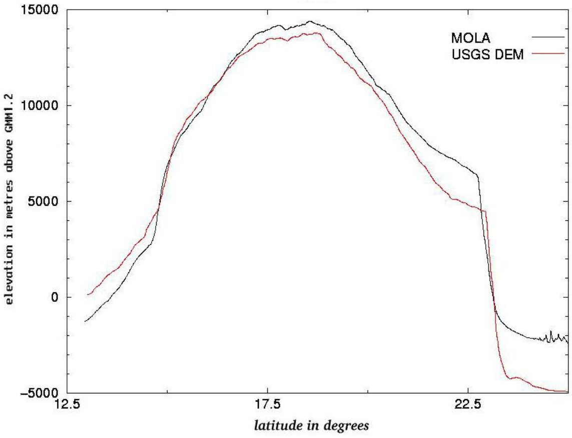

Figure 2. Comparison of USGS-MOLA profiles.

A comparison was then performed between all available MOLA data and the USGS DTM which is shown in Figure 3. It appears that the USGS heights are generally higher above 60ºN compared against the MOLA heights.

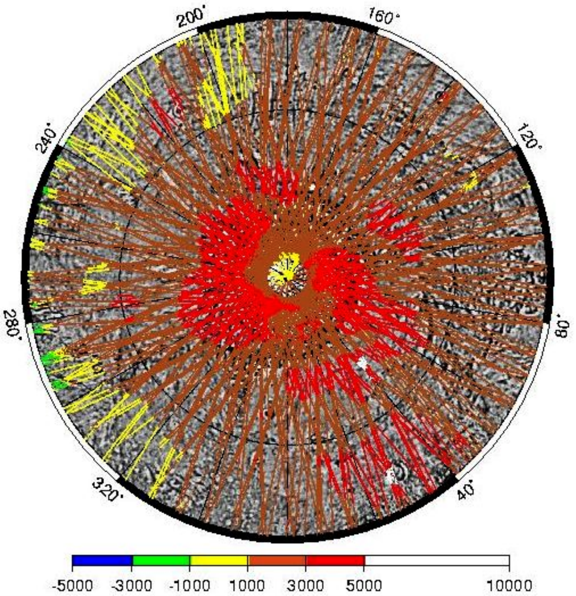

Figure 3. Height comparison of USGS and MOLA profiles superimposed on the MDIM.

A statistical comparison was also carried out between the USGS and MOLA heights and the histogram of elevation differences is shown in Figure 4. Notice the offset in values which is reflected in the overall difference of 1.79±1.38km. It is probable that much of this difference is due to the definition of the vertical datum in the USGS DTM which was based on the 6.1mb pressure level [7] and the inherent ±1km accuracy of these elevation values. A cross-over analysis of the MOLA tracks within 1km of each other indicates that MOLA data are consistent to within ±25m so it is clear that this elevation difference is primarily due to errors in the USGS DTM.

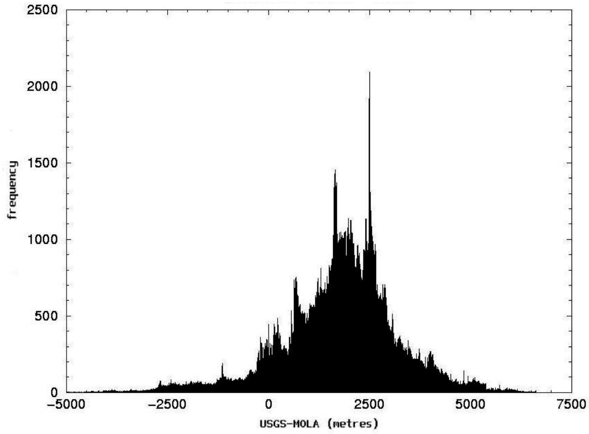

Figure 4. Histogram of USGS-MOLA differences.

Finally, the local USGS DTM height values were offset by the USGS-MOLA height differences were offset and a new DTM computed using Delauney triangulation. The resultant DTM for the Northern hemisphere is shown in Figure 5 data were used where the height differences have now been reduced down to ±20m. This DTM has more high spatial frequency detail than the SPO-1 MOLA data but should be comparable to the global DTM data-set from MOLA recently shown in [3].

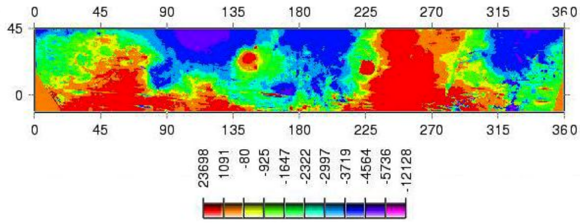

Figure 4. New Mars DTM based on USGS-MOLA height differences.

References: [1]Smith, D. E. *et al. Science* **279**, 1686-1692 (1998).[2]Zuber, M. T. *et al. J. Geophys. Res.* **97**, 7781-7798 (1992).[3]Smith, D. E. *et al. Science* **284**, 1495-1504 (1999).[4]Wu, S. S. C., Garcia, P. A., Jordan, R., Schafer, F. J. & Skiff, B. A. *Nature* **309**, 432-435 (1984).[5]Wu, S. S. C. & Howington, A.-E. 608-611 (NASA, 1986).[6]Wu, S. S. C., Jordan, R. & Schafer, F. J. 614-617 (US Geological Survey, Flagstaff, AZ, USA, 1986).[7]Wu, S. S. C. & Schafer, F. J. in *50th Annual Meeting of the American Society of Photogrammetry* 456-463 (American Society of Photogrammetry, Washington D.C., 11-16 March, 1984). [8]Zeitler, W. & Oberst, J. *J. Geophys. Res. - Planets* **104**, 8935-8940 (1999).[9]Smith, D. E. *et al. J. Geophys. Res.* **98**, 20,871-820,889 (1993).[10]Wu, S. S. C., Jordan, R. & Schafer, F. J. (US Geological Survey, Flagstaff, AZ, USA, 1989).

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