ERRORS IN VIKING LANDER ATMOSPHERIC PROFILES DISCOVERED USING MOLA TOPOGRAPHY. Paul Withers[1], R. D. Lorenz[1], and G. A. Neumann[2,3] [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA, [2]Earth, Atmospheric, and Planetary Sciences Department, Massachusetts Institute of Technology, MA 02139, [3]Laboratory for Terrestrial Physics, NASA Goddard Spaceflight Center, Greenbelt, MD 20771, USA (withers@lpl.arizona.edu).

Abstract's Abstract: Each Viking lander measured a topographic profile during entry. Comparing to MOLA, we find a vertical error of 1–2 km in the Viking trajectory. This introduces a systematic error of 10-20% in the Viking densities and pressures at a given altitude.

Introduction: During their descent through the martian atmosphere, the Viking landers experienced aerodynamic deceleration. Regular measurements of this deceleration were used with an initial entry state and knowledge of the martian gravitational field to reconstruct the spacecraft's trajectory to landing. They were then combined with knowledge of the spacecraft's aerodynamic characteristics to deduce a profile of atmospheric density, pressure, and temperature. Additional data sets, including radar altimetry measurements of altitude above the spatially-varying martian topography, were used to constrain the reconstructed trajectory and atmospheric structure profile.

The First Altimetric Profile on Mars as measured by Viking: A by-product of this analysis was a profile of planetary radius relative to the landing site as a function of distance from the landing site, where distance is measured along the spacecraft's trajectory. With detailed knowledge of martian topography provided by the laser altimeter (MOLA) aboard the Mars Global Surveyor spacecraft, the accuracy of this ancient altimetric profile, the very first every measured for Mars, can be tested. The Viking Lander 1 profile is published in Seiff (1993) and originally in the more obscure Seiff and Kirk (1977) [1,2]. Using the spacecraft trajectory, archived at the National Space Science Data Centre as dataset PSPA-00269, and the landing site coordinates (22.272 +/- 0.002N, 47.94 +/- 0.2W, Viking-era aerocentric coordinates) we converted distance along the trajectory into aerocentric latitude and longitude [3]. West aerocentric longitudes, when subtracted from 360 degrees, give east aerocentric longitudes. 0.2 degrees was then subtracted from the Viking-era east longitudes to convert them into MGS-era east longitudes [4]. We used these latitudes and longitudes in the MOLA 1/16 degree resolution planetary radius dataset to obtain corresponding MOLA values for planetary radius relative to the landing site as a function of distance from the Viking 1 landing site.

Comparison with MOLA data: Figure 1 shows the Viking Lander 1 profile, as scanned and manually digitized from figure 13 of Seiff (1993), and the corresponding MOLA profile [1]. No vertical offset has been applied. Many features in one profile can be seen at the same distance along the other profile. This suggests that the radar altimeter was working well during atmospheric entry. However, a vertical offset is present between the two profiles. The Viking 1 profile is 2.3 km too high at 640 km distance from the landing site. The spacecraft is at approximately 130 km altitude at this time. This offset decreases, approximately linearly, to 0.8 km at 140 km distance from the landing site. The spacecraft is at approximately 30 km altitude at this time. Since the spacecraft trajectory is referenced to the landing site, it is not surprising that the offset decreases as you approach the landing site.

Simple Method of Discovering Error: For skeptical readers, a quick and simple way of discovering the offset is to examine the MOLA 1 degree planetary radius dataset. No region 6 km above the Viking 1 landing site is closer than about 1000 km to the landing site, significantly further away than the 600 km or so inferred from Seiff's figure.

Implications for Viking Atmospheric Structure Results: A vertical error on the order of 2 km is present in the Viking Lander 1 entry and atmospheric structure reconstruction. Errors in latitude and longitude are small, on the order of tenths of a degree. For a scale height of 10 km, this corresponds to published densities and pressures at a given altitude being systematically incorrect by approximately 20%. Atmospheric temperatures are minimally affected. The boundary layer wind studies of Seiff (1993) are severely affected by this offset [1].

Improving the Viking Atmospheric Structure Results: A rederivation of the trajectory and atmospheric structure reconstructions for both Viking Landers is warranted. At a minimum, it should quantify the error present in the published results. In an ideal case, it would use the radar altimetry and newly available MOLA topography to greatly improve the accuracy of the reconstructed trajectory and atmospheric structure reconstructions.

Future Work: Only the Viking 1 altimeter profile is shown in Seiff (1993) [1]. We have not yet been able to acquire a copy of Seiff and Kirk (1977) which we hope may also contain the Viking 2 altimeter profile. We would like to repeat this work on the Viking 2 altimeter profile, if we can find it. Rederiving the Viking entry trajectories and atmospheric structure profiles with the additional constraint of MOLA topography will require a great deal of time spent in the JPL archives. We are unlikely to attempt it ourselves. There is also the possibility of evaluating the performance of the Viking radar altimeter, which has interesting engineering implications.

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References:

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Figure 1