ELEVATING VENUS OBSERVATIONS (OF THE SOLID PLANET) FROM ORBIT. M. S. Gilmore, Dept. of Earth and Environmental Sciences, Wesleyan University, 265 Church St. Middletown, CT, 06459, www.wesleyan.edu/planetary, mgilmore@wesleyan.edu

Introduction - the state of things: The Magellan orbiter (1989-1994) measured global synthetic aperture radar (SAR) and altimetry and gravity data revolutionized our understanding of the morphology and stratigraphy of Venus. Venus Express (2005-2014) carried two instruments, VIRTIS and VMC that exploited the atmospheric window ~1 micron to see the surface, yielding surface emissivity that can be related to composition. We can expect the next generation of Venus orbiters to include radar, gravity and emissivity instruments at improved spatial and spectral resolution and greater coverage. Here I explore some of the technology enhancements that would support such missions.

Improvements in radar: A logical next step for a Venus orbiter that includes one or all of the following: 1) SAR of improved spatial resolution (better than ~100 m/pixel), 2) altimetry of improved horizontal resolution (better than ~10 km/pixel), and 3) improved gravity model (at least degree and order 180). As outlined in the VEXAG Goal, Objectives, and Investigations for Venus Exploration document, these three datasets form the basis for improved interpretation of Venus geomorphology, stratigraphy, and lithospheric properties. Finer resolution imagery and altimetry can be obtained with stereo observations using SAR or with interferometric SAR (InSAR), the latter of which can be used for change detection that may be associated with current tectonic or volcanic activity. InSAR requires repeat-pass imaging where the spacecraft orbit is well known; a DEM is be necessary to control for topography in the interferogram. Another enhancement to the radar is polarimetry, which should be sensitive to surface properties including density, fines and composition.

In general, many of the instruments and technologies necessary to acquire these data are presently available. However, as outlined in the Venus Technology Plan, a major bottleneck for SAR data is the current inability to return such data volumes back to Earth. NASA Space Communication and Navigations (SCaN) Directorate is working on optical communications systems and infrastructure and has recently demonstrated optical communications from the Moon using LADEE [1]. Such demonstrations are essential to explore the effects of atmosphere, and ground receiving systems issues including pointing, vibrations and detectors and to enable the next generation of Venus orbiters.

Improvements in infrared observations: The VIRTIS instrument on VEx confirmed the ability to detect emission from the surface through the atmospheric window at 1 micron [2]. The atmospheric contributions to this signal must be removed and improved knowledge of the composition and physical state of the atmosphere will refine this correction. The surface emissivity is also a function of temperature, which on Venus correlates with topography. Errors over rough terrain are significant in Magellan topography and thus more precise altimetry is necessary to confidently interpret surface emission in VIRTIS or future datasets. The remaining signal contains information about surface composition and grain size [3]. In reflected light at room temperature, there is abundant data to show that the 1 micron reflectance, r, is related to Fe^{2+} content of constituent minerals [4], which constrains primary igneous mineralogy and/or weathering products at the surface. By Kirchoff's Law (r=1-e), we expect that emissivity, e, likewise tracks iron content.

Absolutely essential to the interpretation of the emissivity data are the laboratory spectra of rocks and minerals collected at Venus temperatures. This is the goal of the Planetary Emissivity Laboratory (PEL) [5] where over a decade of work is yielding some of the first measurements of the emissivity of materials and showing that they do not necessary behave as one would predict using room temperature spectra. Such laboratory spectra and future multispectral infrared imagers may provide revolutionary global maps of iron content.

A better understanding of the surface mineralogy also relies on experimental work on the weathering of Venus rocks in simulated present-day and ancient Venus atmospheres [e.g., 7]. This will be enabled by better knowledge of the composition of the lower atmosphere by probes and in situ missions, as well as investments into sustained weathering experiments in Venus chambers.

References: [1] Stevens et al. (2014) doi:10.1364/CLEO_SI.2014.SM4J.1 [2] Mueller et al. (2008), JGR, 113, E00B17. [3] Hashimoto and Sugita (2003) J. Geophys. Res., 108I, 5109. [4] Adams and Filice (1967) J. Geophys. Res., 72, 5705. [5] Maturilli et al. (2008) PSS 56, 420. [6] Helbert and Matrulli (2009) Earth Plan. Sci. Lett. 285, 347; Helbert et al. (2013) EPSL, 371-272, 252. [7] Aveline et al. (2011) Lunar Plan. Sci., 42, #2165.