**ATMOSPHERIC WINDOWS TO IMAGE THE SURFACE FROM BENEATH THE CLOUD DECK ON THE NIGHT SIDE OF VENUS.** J. J. Knicely and R. R. Herrick, Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320 (jknicely@alaska.edu).

**Introduction:** The study of the Venusian surface is an arduous task. Surface probes are short-lived due to the harsh surface conditions (~735 K and 92 bars) [e.g., 1, 2] and sulfuric acid [3], requiring other means for long-term or comprehensive study of the surface. Generally, that involves the use of orbiting satellites or ground-based telescopes. With Venus, we have the option of using balloons which can float beneath the cloud deck where conditions are similar to Earth surface conditions [4]. It is well understood which parts of the surface emissivity spectrum can be viewed from space on the Venus night side through atmospheric windows. Here, we evaluate whether more of the spectrum can be observed by placing the sensor below the cloud deck. Moroz [4] examined possible windows at 0.65, 0.85, and 1.02 microns through which emission from the surface on the night side of Venus could reach a sensor. This work expanded on [4] by modeling the surface emission of bands from 0.7 to 250 microns using a total extinction coefficient data set from [5]. The emission from the surface, its scattering and absorption, and the emission from the atmosphere were calculated from the surface to various heights beneath the cloud deck. We explored the effects of different sensor heights and surface emissivities, variation in surface elevation, and variations in the temperature profile on the possible atmospheric windows.

**Methods:** We defined a surface viewing atmospheric window as any wavelength at which 50% or more of the detected signal comes from the surface. We calculated the observed signal using the radiative transfer equation. Under Venus conditions, we generally expect mafic rocks (e.g., basalt) to have emissivities greater than 0.9, and more felsic rocks (e.g., granite) to be less than 0.9 [6, 7, 8]. Sensor height was varied in 10 km intervals from 10 to 100 km. Surface elevations were 0 and 11 km, with surface temperatures of 735 and 650 K, respectively. The temperature profile of [1] was used with 20 K added, and then with 20 K subtracted from both the surface and temperature at all altitudes to simulate changes in the temperature profile that may occur at different latitudes [9].

**Discussion:** The prospective windows are largely expanded versions of previously identified windows that have been exploited by satellites and ground-based observatories. Figure 1 illustrates the results for our nominal case, in which emissivity was unity, sensor altitude was 40 km, surface elevation was 0 km, surface temperature was 735 K, and the temperature profile was that from [1]. Under these conditions, surface viewing atmospheric windows occur at 0.758-0.867, 0.876-0.926, 0.940-0.942, 0.952, 0.958-1.033, 1.082-1.109, 1.136-1.142, and 1.171 microns. Sensor altitude and regional temperature variations had little effect on identified windows. If the assumed emissivity is reduced from 1.0 to 0.7, then the total bandwidth for which radiance from the surface exceeds the atmospheric radiance drops by 32.3%. Simulating a surface at 11 km elevation results in a 96.3% increase in total bandwidth and new windows centered at 1.27, 1.34, and 1.72 microns as compared to the nominal conditions. Any lander or balloon mission should make use of 1.0, 1.1, 1.14-1.19, and 1.27 micron windows as these provide a comprehensive ability to extract information about the surface from the night side. These windows have the potential to elucidate questions about the composition and redox state of the surface of Venus [8, 10], which have important implications for the evolution of the planet.

**References:** [1] Seiff et al. (1985) *Adv. Space Res*. Vol 5. [2] Crisp & Titov. (1997) *Venus II*. [3] Bezard & de Bergh. (2007) *Jrnl. Geop. Res*. Vol 112. [4] Moroz. (2002) *Planet. & Space Sci*. Vol 50. [5] Lebonnois et al. (2015) *Jrnl. Geop. Res.: Planets*. Vol 120. [6] Jensen. (2007) *Remote Sensing of the Environment*. [7] Lillesand et al. (2015) *Remote Sensing and Image Interpretation*. [8] Helbert et al. (2018) *LPSC XLIX* Abstract #1219. [9] Haus & Arnold. (2010) *Planet. & Space Sci*. Vol 58. [10] Dyar et al. (2017) *VEXAG XV* Abstract #8004.

**Acknowledgments:** Supported in part by the Alaska Space Grant Program. Comments from F. Meyer, L. Glaze, and G. Arney improved this work.

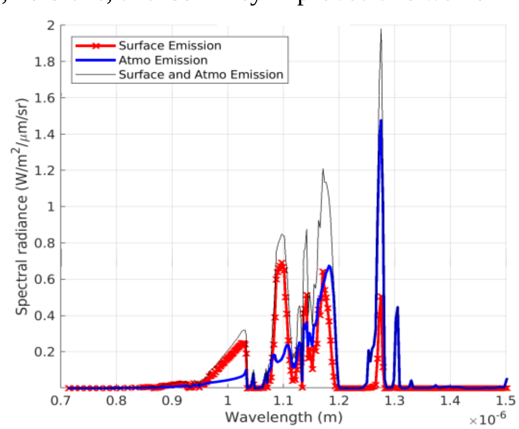


Figure 1. Surface vs Atmospheric emission for our nominal conditions. There is approximately 0.27 microns of total bandwidth.