OBSERVING VENUS WITH NASA'S HIGH-ALTITUDE BALLOON PROGRAM. E. F. Young[1], M. A. Bullock[2], M. F. Skrutskie[3], T. Kremic[4], [1]Affiliation Southwest Research Institute, 1050 Walnut St., Boulder, CO 80302 (efy@boulder.swri.edu; con@boulder.swri.edu), [2] Science and Technology Corp., 21 Enterprise Parkway, Suite 150 Hampton, VA 23666-6413 (mbullock75@gmail.com), [3] PO Box 400325, University of Virginia, Charlottesville, VA 22904-4325 (mfs4n@virginia.edu), [4] 21000 Brookpark Rd, Cleveland, OH 44135 (tibor.kremic@nasa.gov).

Introduction: NASA's Balloon Program Office (BPO) regularly flies payloads weighing several tons at altitudes of 33 - 38 km, above 99.3% - 99.6% of the Earth's atmosphere, respectively. Balloon-borne telescopes operating in the stratosphere have three distinct advantages over ground-based telescopes with respect to tracking daytime and nighttime clouds on Venus and obtaining spectral image cubes.

- The Fried parameter, r_0, is thought to be larger than 4 meters at float altitudes, compared to 10-15 cm at good terrestrial sites. Balloon-borne telescopes should have diffraction-limited performance as a result, even at visible and UV wavelengths where ground-based adaptive optics (AO) systems typically have poor Strehl ratios. As an example, a stratospheric 1-m aperture telescope has a Point Spread Function (PSF) width of 0.10" at λ=0.4 µm.
- Balloon-borne telescopes have access to most of the UV and IR spectrum (Figs.1,2), with sky backgrounds dominated by zodiacal light and sky emission lines [1].
- NASA has developed super-pressure balloons with nominal flight durations of ~100 days [2]. These platforms provide consecutive nights to help determine wave phenomena in Venus's atmosphere.

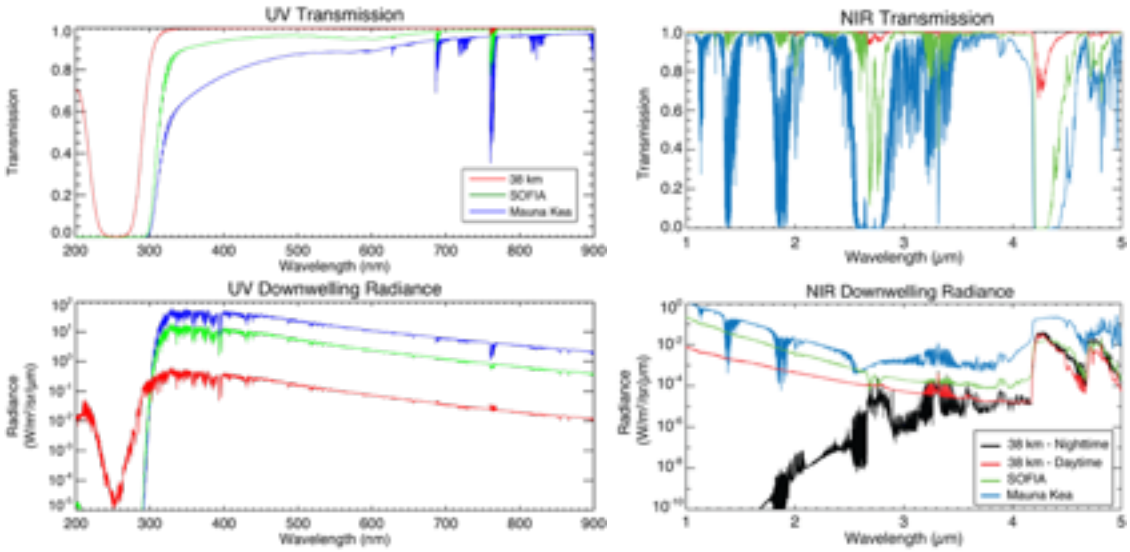

Figure 1. Stratospheric balloons have access to key parts of the UV and IR spectrum. The UV window at 200-240 nm can constrain the ratio of SO/SO_2 at the cloud tops. The IR spectrum has nearly complete access to the 1 - 5 µm range, including partial access through the terrestrial CO_2 band at 4.3 µm.

The Case for a Stratospheric Venus Observing Platform: A balloon-borne telescope dedicated to observing Venus during the 100-day period around inferior conjunction could provide an uninterrupted sequence of pole-to-pole images and spectra. Unlike previous space missions (Venus Express and Akatsuki), a balloon campaign could monitor cloud top features continuously for 2 days and middle/lower cloud deck features for 3-4 days. A one-meter aperture telescope could resolve 100-km cloud top features at 283 and 365 nm, over time spans of at least ten hours, sufficient to determine cloud motions at the 1 m/s level (rms). A stratospheric telescope has access to spectral ranges that are normally opaque to terrestrial observers. Some useful bands include 2.5 - 2.55 µm (diagnostic of cloud base altitudes, sensitive to SO_2), 200-240 nm (sensitive to SO and SO_2 features) and 4.3 µm (allows limb sounding).

References: [1] Chanover et al., 2016. "Findings Report: Gondola for High Altitude Planetary Science Science Instrument Definition Team", <http://tinyurl/ghaps-sidt-report>. [2] <https://www.csbf.nasa.gov/balloons.html>.