**VENUS CLOUD EXPLORER - UNDERSTANDING VENUS'S HABITABLE ZONE (VHZ) VIA A LONG-LIVED IN-SITU AERIAL OBSERVATORY.** K. H. Baines[1] J. Cutts[1], P. Byrne[2], L. Dorsky[1], J. O'Rourke[3], S. Seager[4], C. Wilson[5]. [1]Jet Propulsion Laboratory, California Institute of Technology, M/S/ 183-3024800 Oak Grove Dr., Pasadena, CA, 91109, USA; kevin.baines@jpl.nasa.gov; [2]Dept. of Earth and Planetary Science, Washington University, 1 Brookings Dr., St. Louis, MO, 63130, USA; [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA; [4]Dept of Physics, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA, 02139, USA; [5]Dept. of Physics, Oxford University, Oxford, UK.

**Introduction:** Venus is essential to our understanding of the evolution and habitability of Earth-size planets throughout the galaxy. The selection of the VERITAS, EnVision and DAVINCI+ missions by NASA and ESA in June 2021 is an important step in advancing the science. However, addressing the habitability of Venus's clouds in 52-62 km altitude range encompassing the putative Venus habitable zone (VHZ) spanning temperatures 20º ± 40º C requires an in-situ aerial platform that can operate throughout this environment for extended periods in order to capture the full complexity of our sister planet. In particular, to gain an understanding of Venus's intricate array of photochemical and thermodynamical processes within the VHZ, the vehicle must be able to sample the full inventory of gases and aerosols throughout the VHZ over all times-of-day and over a wide range of latitudes. In addition, to understand the rates of supply of surface-emitted materials (such as phosphorus and sulfur) into and out of the VHZ, vertical transport mechanisms such as convection, turbulence, and gravity and planetary waves must be well-characterized, as well as the vertical distribution and flux (precipitation) of aerosols. To gain increased understanding of the rate and power of surface activity responsible for the flux of surface materials into the atmosphere, relevant surface science observations should be conducted. These include investigations of seismic activity due to Venus quakes and volcanism, and mapping observations of remanent magnetism locked into surface materials to provide insight into ancient geologic processes that may have occurred if Venus had once had a significant magnetic field [1].

A balloon-borne aerial observatory appears to be the most cost-effective and practical means to conduct such a comprehensive set of investigations. To access the 10-km deep altitude range noted above, the observatory is able to adjust its altitude via a "balloon-within-a-balloon" concept, in which an inner super-pressure balloon acts as a helium reservoir to store and release the helium needed for the outer zero-pressure balloon to climb/descend and float at whatever VHZ altitude is desired. To explore all times-of-day, Venus's "global jetstream" prevalent at VHZ altitudes can be utilized to propel the observatory zonally East-to-West at 55-85 m/s, depending on altitude, to allow it to circumnavigate the planet and sample all times-of-day in 5.3 - 8.1 days. Over the planned 100-day mission, the gentler (~ 1-5 m/s) but much less predictable meridional winds then allow the vehicle to visit a wide range of latitudes, currently expected to be > 30 degrees from the initial near-equatorial latitude of deployment. During these travels, radio-tracking via orbiter(s) and the Deep Space Network and other ground-based radio telescopes, supported by an on-board IMU as well as pressure/temperature and 3-D relative-wind sensors, will provide information on sheers, turbulence, convection, and gravity and planetary waves. Detailed measurements of the chemical compositions of the gaseous atmosphere and its aerosols will be provided by a mass-spectrometer capable of measuring both the gases and the aerosols (the Aerosol-Sampling Instrument Package, ASIP [2] and by a Tunable Laser Spectrometer [3] targeted for specific chemicals of interest, such as $PH_3$. ASIP has incorporated within it a nephelometer/particle counter [4,5] that provides particle sizing and particle number-density information for assessing the relative abundance of the trace molecular species found inside the particles and to provide detailed particle number and volume densities over altitude for determination of precipitation rates. Utilizing a vaporizer operating at up to 600oC to vaporize the aerosols, ASIP provides a complete accurate inventory of all species mass-separated by 10 milli-Dalton from its neighbors, out to 300 Dalton, for both atmospheric gases and the aerosols. An array of light sensors measures the radiation both up and down providing a means to assess radiative balance and energy deposition as a function of altitude and time-of-day within the clouds. An array of sensitive pressure sensors act as infrasound microphones that detect and characterize Venus-quake-generated soundwaves, as recently been successfully achieved for the Earth (Siddharth). Finally, a magnetometer detects remanent magnetism from terrain being overflown by the observatory at ~ 20-km scales.

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