VENUS DISCOVERY-CLASS BALLOON MISSIONS: SCIENCE OBJECTIVES AND DESIRED LATITUDINAL AND LONGITUDINAL COVERAGE. K. H. Baines[1], S. K. Atreya[2], M. Bullock[3], D. Crisp[4], L. W. Esposito[5],D. Grinspoon[6], J. L. Hall[4], S. S. Limaye[1], P. R. Mahaffy[7], C. T. Russell[8], C. R. Webster[4], and K. Zahnle[9] [1]SSEC/University of Wisconsin-Madison, Madison, WI, blueskies4321@yahoo.com, [2] University of Michigan, Ann Arbor, MI, [3] Southwest Research Institute, Boulder, CO, [4] Jet Propulsion Laboratory/CalTech, Pasadena, CA, 91108, [5]LASP/University of Colorado, Boulder, CO, [6] Denver Museum of Nature and Science, Denver, CO, [7]NASA/GSFC, Greenbelt, MD, [8] University of California, Los Angeles, CA, [9] NASA/Ames Research Center, Moffett Field, CA

Following the trailblazing flights of the 1985 twin Soviet VEGA balloons, long-duration, globe-circling missions to fly in the skies of Venus have been proposed to NASA's Discovery and ESA's Cosmic Visions programs, and are a key element of the Venus Flagship mission promoted by the 2011 National Research Council (NRC) Solar System Decadal Survey and the 2009 NASA Venus Flagship Mission. Such relatively simple floating platform missions that use super-pressure balloons to maintain a near-constant altitude would effectively address fundamental science issues highlighted in a variety of high-level studies authorized by both NASA and the NRC in recent years, including the aformentioned NRC Decadal Survey, various NASA roadmaps, and recommendations of the Venus Exploration Analysis Group (VEXAG), including the latest Goals/Objectives/Investigations and Roadmap documents.

Session: This topic is intended for the session "Within the Atmosphere". The focus is on exploration targets within the relatively benign 54-57-km-altitude cloud region where temperatures and pressures are near Earth-surface conditions, and where relatively simple craft can produce outstandingly large advances in our understanding of Venus. The primary VEXAG Goals addressed are I.A (Venus formation and evolution), I.B (Processes that control climate, including super-rotaton and greenhouse-driven radiative balance), I.C (Venus clouds: Their makeup, and their roles in radiative balance, dynamics and climate), III.A (Water: Evolution and role in climate over the eons), and III.B (Coupled climate of atmosphere and surface over time).

Target: The target region is (1) vertically, the 54-57-km cloud region, the most convectively unstable region within the middle atmosphere, and thus a particularly sensitive locale for sampling meteorology and local dynamics (c.f. Figure 1), and (2), horizontally, (A) all times-of-day – to investigate day/night effects on meteorology, dynamics, and chemistry – and (B) over a wide range of latitudes, from near the equatior to the polar region, to investigate variations in the dynamical and chemical environments across all Venusian climatic zones.

Science Goal(s): Extensive (> 3 week) balloon missions flying in the middle clouds near the relatively benign 54-57-km altitude regime (~30C, ~0.5 bar), would uniquely address key questions of Venus's origin, evolution, and climate, by obtaining detailed contemporaneous in-situ measurements of (1) trace gases and cloud aerosols associated with Venus's radiative balance, its active photo- and thermo-chemistry, and dynamic meteorology and of (2) motions and local temperatures which characterize convective and wave processes that transport momentum and heat both vertically and horizontally, a key to understanding Venus' global super-rotation. Floating in Venus's rapid windstream, the balloon-borne science observatory could sample rare gases and trace chemicals and measure vertical and horizontal motions and microphysical and optical cloud aerosol properties within Venus's dynamic middle cloud layer. Tracked by an array of Earth-based telescopes and perhaps a carrier spacecraft that flies above the backside of the planet as viewed from Earth, all three components of winds - zonal, meridional, and vertical - could be measured with unprecedented precision over nearly all longitudes.

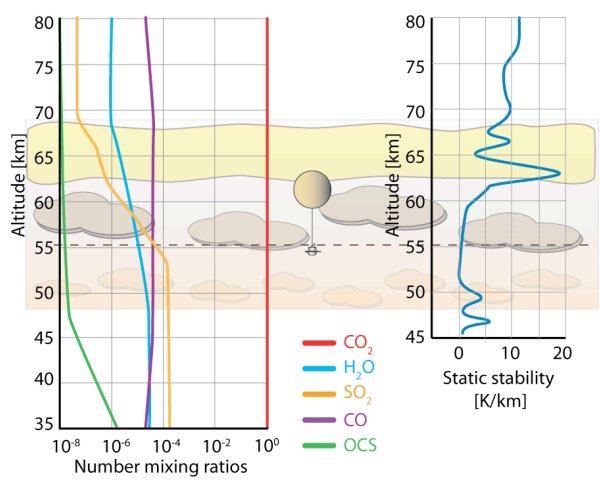

Figure 1. Drifting in Venus' high speed winds at the ~55-km level (~30°C, 0.5 bar) of low static stability (right), the Venus super-pressure balloon experiences variable clouds, reactive gases (left) and rich dynamics, all key to understanding Venus's super-rotation, radiative balance and global greenhouse-driven atmosphere.

Such globe-circling data acquired over all longitudes and times of day would provide unique data on the magnitude and phase of the thermal-tidally-driven wind, the cloud-level solar input, and solar-driven chemical processes. Although the route the balloon would take is somewhat uncertain due to the large uncertainty in meridional winds, the mission would likely explore a variety of distinctive dynamical-meteorological regimes within Venus's energetic atmosphere as it alternately flies in daytime and nighttime conditions and as it drifts poleward over several weeks from the convective temperate region through the wave-populated mid-latitudes to the exceedingly cloudy north polar vortex region. Indeed, sampling all three major latitudinal regimes is important to understand the roles that solar heating, meridionally transporting Hadley Cells, and latitudinally-varying planetary waves, photochemistry, and possibly lightning play in the generation of Venus's climate.

As well, the mission would test a variety of scenarios for the origin, formation, and evolution of Venus by sampling all the noble gases and their isotopes, especially the heaviest elements never before reliably measured, xenon and krypton. Altogether, a long-duration balloon mission would provide key information for comparative planetological studies of the terrestrial planets as it greatly enhanced our fundamental understanding of (1) the circulation of Venus, including the roles that solar thermal tides, cloud solar heating, and convective and meridional motions play in powering the planet's poorly-understood super-rotation, (2) the nature of Venus's sulfur cycle, key to Venus's current climate, and (3) how our neighboring world formed and evolved over the aeons to its present un-Earthlike state of extreme environmental conditions.