DEVELOPMENT OF VENUS BALLOON SEISMOLOGY MISSIONS THROUGH EARTH ANALOG EXPERIMENTS. S. Krishnamoorthy[1], A. Komjathy[1], J. A. Cutts[1], M. T. Pauken[1], R. F. Garcia[2], D. Mimoun[2], J. M. Jackson[3], S. Kedar[1], S. E. Smrekar[1] and J. L. Hall[1]

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Introduction: The study of a planet's seismic activity is central to the understanding of its internal structure. Seismological studies of the Earth led to the discovery of the layered structure of its interior, which in turn has led to great advances in the understanding of catastrophic events such as earthquakes and volcanic eruptions. Earth's planetary twin, Venus, has shown strong evidence of recent geological activity. Seismological studies can help us understand the evolution of these geological events and aid our quest to determine why Venus is so similar to Earth in certain aspects yet so different. However, extremely high temperature and pressure conditions on the surface of Venus present a significant technological challenge to performing long-duration seismic experiments. Therefore, despite visits from many spacecraft since Mariner 2 in 1962, the internal structure of Venus still remains a mystery.

Seismic experiments conducted from aerial platforms offer a unique opportunity to explore the internal structure of Venus without needing to land and survive on its surface for long durations. In particular, the dense atmosphere of Venus allows for balloons to be flown in the mid and upper atmospheric regions. These balloons may be used as vehicles for seismic experiments that can collect infrasound data as indication of seismic waves while floating in the prevailing winds. One possible way to detect and characterize quakes from a floating platform is to study the infrasonic signature produced by them in the atmosphere. Infrasonic waves are generated when seismic energy from ground motions are coupled into the atmosphere. The intensity of the infrasound depends heavily on the relative density of the atmosphere and the planet's crust. On Venus, where the atmospheric impedance is approximately 60 times that of Earth, the coupling of seismic energy into the atmosphere is expected to be commensurately greater.

However, the performance of seismic experiments from balloons comes with its own set of challenges – sulfuric acid in the Venusian atmosphere can degrade balloon material and the remote deployment of balloons on another planet is also a technological challenge. There also exist scientific challenges – the process of infrasound generation and propagation is complex, depending on many factors such as quake location, intensity, and prevailing atmospheric conditions, to name only a few. Therefore, sophisticated simulations and experiments are needed to develop a scientific mission that can inform us of the internal structure of Venus.

In order to achieve the aim of performing geophysical experiments from an atmospheric platform, JPL and its partners (ISAE-SUPAERO and California Institute of Technology) are in the process of developing technologies for detection of infrasonic waves generated by earthquakes from a balloon. The coupling of seismic energy into the atmosphere critically depends on the density differential between the surface of the planet and the atmosphere. Therefore, the successful demonstration of this technique on Earth would provide ample reason to expect success on Venus, where the atmospheric impedance is approximately 60 times that of Earth.

Presentation Content: In this presentation, we will share results from the first set of Earth-based balloon experiments performed in Pahrump, Nevada in June 2017. These tests involved the generation of artificial sources of known intensity using a seismic hammer and their detection using a complex network of sensors, including highly sensitive micro-barometers suspended from balloons, GPS receivers, geophones, microphones, and seismometers. This experiment was the first of its kind and was successful in detecting infrasonic waves from the earthquakes generated by the seismic hammer. We will present the first comprehensive analysis of the data obtained from these sensors and use these data to characterize the infrasound signal created by earthquakes. These data will also inform the design of future experiments, which will involve tropospheric and stratospheric flights above naturally occurring areas with high seismicity.