INVESTIGATING WAVES IN THE VENUS ATMOSPHERE VIA RADIO OCCULTATIONS BETWEEN ORBITING CUBESATS. P. Vergados[1], C. O. Ao[1], A. Komjathy[1], R. Preston[1], T. Navarro[2], G. Schubert[2], D. Atkinson[1], J. Cutts[1], S. Asmar[1], and J. Lazio[1]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA, 91109, [2]Department of Earth, Planetary, and Space Sciences, UCLA, Los Angeles CA, 90095

Objective: Modeling efforts suggest that mountain waves that succeed in reaching cloud levels could explain the observed Venusian bow-shaped structures [1], and gravity and planetary waves are associated with other dynamical features including Venus's double polar vortices and its super-rotating atmosphere [2]. This emphasizes the role of waves in driving Venus's dynamics, but there is a large window of uncertainty of the vertical temperature structure and wave activity of the planet. Our goal is to study the spatial-temporal coverage a constellation of small satellites (SmallSats) could provide via occultation soundings.

Introduction: Occultation sounding is a remote sensing technique that vertically scans a planetary atmosphere to retrieve its properties in a fine vertical resolution by measuring the amount of bending of propagating signals between occulting spacecrafts over a planet's limb. Radio occultations (RO) between an orbiting spacecraft around Venus and a ground-based antenna on Earth have been used to probe the vertical thermal structure and wave activity of Venus's atmosphere, with measurements conducted by the Pioneer Venus Orbiter (PVO), Magellan, Venus Express (VEX), and Akatsuki missions. The PVO and the Magellan missions revealed temperature inversion layers at different latitude regions on Venus [3] and small-scale temperature oscillations caused by vertically propagating gravity waves [4]. The VEX mission captured a double cyclonic vortex over Venus's south pole [5], whereas the Akatsuki mission observed a 10,000 km long inter-hemispheric bow-shaped structure aloft the cloud-top at ~65 km [6]. The only operating satellite orbiting Venus today is Akatsuki, but it provides vertical temperature profiles only when it occults behind Venus's limb as seen from Earth.

Methodology: Spacecraft crosslinks have already been demonstrated in the planetary context at Mars, with RO measurements of the Martian ionosphere via the Mars Reconnaissance Orbiter – Mars Odessey crosslinks [7], and an initial study at JPL found that SmallSats with a 6U form factor would be technically capable of conducting such measurements. RO crosslinks between two or more Venus-orbiting SmallSats would enable measurements with dramatically improved spatial and temporal coverage compared to previous missions, analogous to the use of RO observations now providing detailed sensing of the Earth's atmosphere via the use of Global Navigation Satellite System (GNSS) constellations. Denser atmospheric measurements at Venus might allow deeper insight into surface-atmosphere coupling through physical processes related to large- and small-scale wave perturbations in the Venusian atmosphere, including gravity, planetary and acoustic waves, and the polar vortices.

Preliminary Results: We modify JPL's advanced occultation simulator to Venus's planetary properties to estimate the locations of RO soundings acquired by a constellation of three SmallSats. Our preliminary results show that during seven Earth days' time period, we obtain more than 1,500 occultations with dense spatial coverage that sample 75-110 degrees East and 75-110 degrees West longitude regions from the South to the North pole of Venus. These are regions of high interest, because they coincide with Venus's bow-shaped structures. At latitudes greater than 80 degrees, in both hemispheres, we obtain a good spatial coverage at almost all longitudes. Such high latitude occultation soundings could be potentially beneficial to probe the vertical thermal structure and wave activity of the polar vortices. Further, the possibility of SmallSats flying in tandem in Venus orbits at low altitudes would allow for prolonged flying time within Venus's ionosphere, perhapse providing access to the greatly amplified waves that could be produced during seismic phenomena.

Conclusions: A constellation of three SmallSats could fill in the spatial-temporal gaps and complement observations from the Akatsuki satellite, and could also provide synergistic observations from future Venus balloon-borne platforms that cannot retrieve high resolution vertical profiles. RO measurements could also help improve state-of-the-art global circulation models (GCMs) of Venus, which are key components in understanding the circulation and dynamic properties of the Venusian atmosphere.

References:

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