Ground and Space-Based Microwave Remote Sensing of the Venus Atmosphere in Support of the Decade of Venus. A. B. Akins, T. M. Bocanegra-Bahamón, P. Vergados, C. O. Ao, S. W. Asmar, R. A. Preston, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena CA 91109, USA.
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Introduction: The recent selections of VERITAS, DAVINCI+, and EnVision have demonstrated multinational commitment to continued exploration of Venus over the coming decade. Microwave observations of the Venus atmosphere have the potential to augment the science return of these missions and to bridge important observational gaps. In this presentation, we discuss how new radio occultation experiments and ground-based microwave observations can improve our understanding of the Venus atmosphere during the Decade of Venus

Dual Band Radio Occultations: Signal absorption measurements during prior S- and X-Band occultation experiments at Venus have revealed the distribution of sub-cloud H_2SO_4 vapor as a function of altitude, latitude, and time, permitting insight into the mean meridional circulation patterns of the Venus atmosphere [1]. Dual X- and Ka-Band occultations can improve on these results through simultaneously retrieval of temperature profiles and H_2SO_4/SO_2 abundances, improving our understanding of the relationship between cloud-level chemical and dynamical cycles [2]. Both VERITAS and EnVision will fly with X- and Ka-Band telecommunication channels, permitting such an experiment for the first time at Venus.

The simultaneous sensitivity of X- and Ka-Band occultations to both SO_2 and H_2SO_4 aerosol creates a degeneracy that limits the accuracy of attempts to retrieve their respective vertical structures. This degeneracy may be limited, however, by coupling the retrieval process to a transport model of the Venus atmosphere [1, 3]. Through this process, retrieval errors within 50% can be obtained for SO_2 abundance, as shown in Figure 1. We will discuss progress in simulating these retrievals, analyzing their uncertainties, and their contribution to our understanding of Venus' cloud-level atmosphere

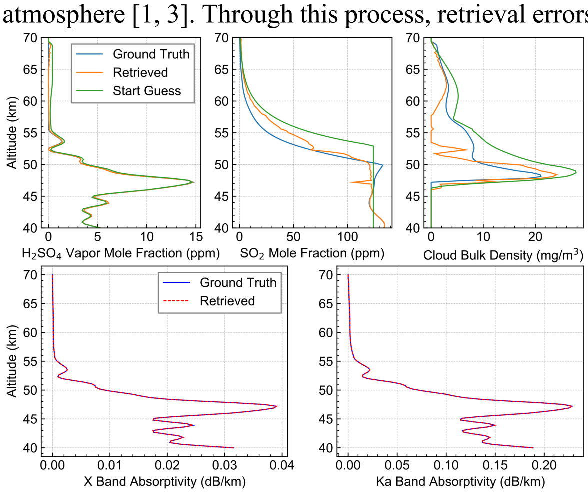

Fig. 1. Simulated retrievals of H_2SO_4 vapor, SO_2, and aerosol density from dual-band occultation absorptivity profiles.

VLA Observations: Ground-based microwave observations of Venus are sensitive to thermal emission from the deep atmosphere. Spatially resolved VLA observations of the Venus atmosphere were last obtained in 1996, and thermal structure retrievals obtained vertical resolution of 20 km [4]. VLA receiver upgrades since that time permit retrievals of temperature and composition of the deep atmosphere within 10 km resolution (see Fig. 2) and can potentially achieve high enough sensitivity to resolve weak thermal wave signatures in the lower atmosphere. We have recently obtained the first spatially-resolved observations of the Venus atmosphere since the VLA receiver upgrade. We will present resolved maps of deep atmosphere thermal emission derived from these observations (preliminary 3 cm map shown in Figure 2), and discuss the implications of these results for quantitative assessment of deep atmosphere dynamical processes.

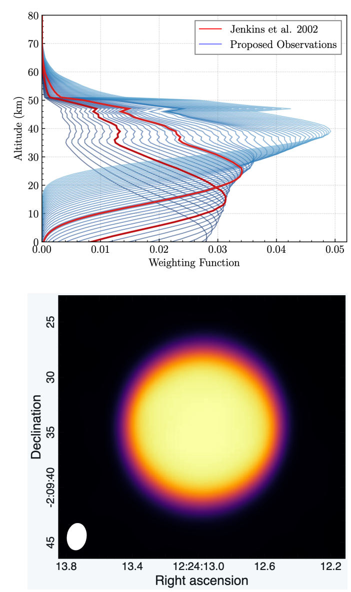

Fig. 2. (Top) Atmospheric weighting functions for VLA observations analyzed by Jenkins et al. [4] (in red) and for recent observations (in blue). (Bottom) Preliminary 3 cm map of Venus from VLA observations obtained in 2021.

References: [1] Oschlisniok, J., et al. (2021). *Icarus*, *362*, 114405. [2] Akins, A. B., & Steffes, P. G. (2020). *Icarus*, *351*, 113928. [3] Imamura, T., & Hashimoto, G. L. (1998). *JGR*, *103*, 31349. [4] Jenkins, J. M., et al. (2002). *Icarus*, 158, 312–328.