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Radio-holographic methods for inversion of radio occultation experiments of past Venus' spacecraft

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We present the results of the ongoing efforts to reprocess complex radio occultation signals of past NASA Venus' missions with radio-holographic methods [1, 2]. One of the advantages provided by using radio-holographic methods, over the traditional geometrical optics approach, is the higher (sub-Fresnel) vertical resolution obtained in the derived atmospheric profiles. On Venus, this has been previously shown by [3] which obtained temperature profiles with vertical resolutions of $\sim$150 m in height. The resolution of fine vertical structures are essential to investigate the role of local waves in the vertical transport of heat and mass, and the impact of these small-scale vertical motions in the global circulation of Venus' atmosphere. Additionally, radio-holographic techniques have been successfully used to address multi-path phenomena in radio occultation experiments of the Earth's atmosphere (*e.g.*, [4]). In the case of Venus, radio occultation signals can be severely distorted by multipath interference, especially in the cold collar region, resulting in errors up to $\sim$15 K in temperature [5].

We are initially focusing in the reprocessing of the multiple radio occultation sessions obtained by NASA's Pioneer Venus Orbiter (PVO) and Magellan spacecraft. PVO gathered fourteen years (1978-1991) of radio occultation data covering altitudes from 38-100 km, day and night side, for both hemispheres. Magellan datasets span from October 1991 to October 1994, covering altitudes from 39-90 km, day and night side of the northern hemisphere. By reprocessing these datasets using radio-holographic methods, we expect not only to derive more precise temperature profiles with higher vertical resolution, but also to enable the analysis of the temporal variation of the profiles with an extended coverage of spatial and solar illumination conditions (in combination with the results obtained by ESA's Venus Express and JAXA's Akatsuki orbiters).

In the reprocessing new ideas regarding Venus atmospheric composition are also being studied. Past and current models employed to process Venus radio occultation experiments make use of the hydrostatic balance assumption, where the atmosphere is assumed to be well-mixed with a constant molecular composition [6]. As pointed out by [6], in view of the measured vertical gradient in the abundance of Nitrogen below 64 km, the mean molecular weight will not be constant over the altitude range of the occultation profiles. [7] extended the altitude to 64 km over which the Nitrogen abundance has been measured with high accuracy, thereby confirming the gradient in the nitrogen mixing ratio based on MESSENGER neutron spectrometer observations, which was initially detected by [8]. As suggested by [9], it is possible that the absence of Nitrogen near the surface can render the lower atmosphere of Venus to be adiabatic rather than superadiabatic based on the VeGa 2 lander temperature profile. This condition has never been considered in the derivation of neutral atmospheric profiles from Venus radio occultation experiments, and would affect all calculations of altitude that involve the hydrostatic balance assumption and the adiabatic lapse rate [9].

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References

[1] Jensen, A. S., Lohmann, M. S., Benzon, H.-H., & Nielsen, A. S. Full spectrum inversion of radio occultation signals. Radio Science, 38 (3), 2003.

[2] Jensen, A. S., Lohmann, M. S., Nielsen, A. S., & Benzon, H.-H. Geometrical optics phase matching of radio occultation signals. Radio science, 39 (3), 2004.

[3] Imamura T., Miyamoto M., Ando H., Häusler B., Pätzold M., and others. Fine Vertical Structures at the Cloud Heights of Venus Revealed by Radio Holographic Analysis of Venus Express and Akatsuki Radio Occultation Data. Journal of Geophysical Research: Planets, 123: 2151-2161, 2018.

[4] Gorbunov, M. Canonical transform method for processing radio occultation data in the lower troposphere. Radio Science, 37 (5), 2002.

[5] Pätzold, M., Hausler, B., Bird, M., Tellmann, S., Mattei, R., Asmar, S., Dehant, V., Eidel, W., Imamura, T., Simpson, R., and others. The structure of venus middle atmosphere and ionosphere. Nature, 450 (7170), 657660, 2007.

[6] Limaye S. S., Grassi D., Mahieux A., Migliorini A., Tellmann S., and Titov D. Venus Atmospheric Thermal Structure and Radiative Balance. Space Science Reviews , 214, 2018.

[7] Peplowski, P., & Lawrence, D. Nitrogen Content of Venus Upper Atmosphere from the MESSENGER Neutron Spectrometer. In Lunar and Planetary Science Conference, vol. 47, (p. 1177), 2016.

[8] Oyama, V., Carle, G., Woeller, F., Pollack, J., Reynolds, R., & Craig, R. Pioneer Venus gas chromatography of the lower atmosphere of Venus. Journal of Geophysical Research: Space Physics, 85 (A13), 78917902, 1980.

[9] Lebonnois, S., & Schubert, G. The deep atmosphere of Venus and the possible role of density-driven separation of CO_2 and N_2. Nature Geoscience, 10 (7), 473, 2017.