Detailed temperature structure of the Venusian atmosphere revealed by radio holographic analysis of radio occultation data

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Radio occultation (RO) is one of the most important measurement techniques for studying planetary atmospheres. Radio occultation method relies on the measurement of the frequency shift of the received signal caused by the bending of radio waves in the radial gradient of the refractive index in the atmosphere. The relationship between the impact parameter and the bending angle is retrieved from the observed frequency shift, and this relationship yields the vertical profiles of the refractive index, from which the temperature profile is obtained. The geometrical optics (GO) method has long been used for the analysis of RO data. However, this method cannot disentangle multipath rays, which often occur in the temperature inversion region at high latitudes in the Venusian middle atmosphere. Furthermore, vertical resolution is limited by the size of the Fresnel zone (~1 km for a typical spacecraft-tangential point distance of 2 Venus radii and the wavelength of the radio wave of 3.6 cm).
Radio holographic methods have been proposed for processing of RO signals in multipath regions and obtaining atmospheric profiles with high resolution. One of them is the Full Spectrum Inversion (FSI), which was recently applied to GPS occultation data of the Earth’s atmosphere. By applying the FSI technique to ESA’s Venus Express RO data, we demonstrated the applicability of this technique to Venus’ atmosphere.
The new vertical temperature profiles obtained by FSI technique seem to well repro- duce the temperature structure in the multipath region and achieve high vertical resolution (~150 m). Thin, near-neutral layers were found in the high-resolution static stability pro- files in the high latitude. This feature can be attributed to generation of turbulent layers by breaking gravity waves. The static stability profile in the middle and high latitude tends to show sharp transition from neutral stratification below ~60 km to stable stratification above, suggesting that the convective layer and the overlying stable layer are adjacent to each other with a very thin transition region. Such a condition is favorable to convective generation of gravity waves.

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