Vertical profiles of temperature in the polar night regions of the Martian atmosphere observed by MGS radio occultation measurements using the FSI method

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Mars has a climate cold enough to cause condensation or supersaturation of carbon dioxide (CO_2), which is the major constituent in the Martian atmosphere. The condensation of the major constituent does not occur on Earth, and so the phenomenon is unique to Mars. In the polar night on Mars, CO_2 snows and accumulates on the surface, or CO_2 directly condenses on the surface, forming polar caps. CO_2 sublimates again from the polar caps after the polar night ends. The total amount of the Martian atmosphere changes by 20-30% when condensation and sublimation repeats in the polar night region. The study of the atmospheric CO_2 supersaturation and condensation needs the observations of high-precision temperature with high vertical resolution. We focused on radio occultation technique, which provides atmospheric thermal structure with high vertical resolution. Radio occultation measurements utilize the frequency variations of radio waves emitted from a spacecraft orbiting a planet toward a receiving station on Earth. The frequency variations of the radio waves depend on the vertical profiles of the atmospheric temperature and pressure of the planet. In the previous radio occultation measurements, frequency variations were analyzed using a method based on geometric optics (GO). Recently, Full Spectrum Inversion (FSI) method [Jensen et al., 2003; Tsuda et al., 2011], which realizes higher vertical resolution, was proposed instead of GO. Sakurai [2022] applied FSI to the frequency variations obtained in the radio occultation measurements conducted by the Mars Global Surveyor (MGS). This analysis enabled the derivation of vertical temperature profiles with a higher vertical resolution than those officially published by NASA.
In the present study, we improved a frequency analysis procedure and successfully reduced artificial noises appearing in the vertical profiles of temperature with the order of tens of meters, which was identified as a problem in Sakurai [2022]. We newly derived 33 temperature profiles located in the polar nights. We found neutral layers with a thickness of about a few hundred meters, which were not detected by GO. Those neutral layers could be attributed to the convection associated with CO_2 condensation [Caillé et al. 2022], the convection related to water ice clouds [Hinson et al., Icarus] and atmospheric gravity wave breaking [Sakurai, 2022; Fukuoka, 2023].

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