

## Observations of minor constituents in the Venusian atmosphere, CO and SO<sub>x</sub> using the millimeter/submillimeter-wave band radio telescopes, SPART/ALMA

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As exoplanets are being explored, there is an urgent theme to understand the atmospheric environment of habitable planets. In Venus, it is known that there is an unsolved absorption spectrum in the cloud region in the ultraviolet wavelength region. The temperature and pressure at this altitude are close to those at the troposphere of the Earth, and the spectrum is similar to that caused by bacteria, so that the possibility of absorption by organisms has been discussed. Atmospheric environment of the earth-type planet whose main component is CO<sub>2</sub> such as Venus and the past earth seems to be comparatively universal. Therefore, study how materials circulate via cloud heights in the Venusian atmosphere is also important in understanding how such circulations influence planetary habitability/organisms.

Against this background, we have observed the minor constituents of the Venusian atmosphere using the 10m single dish radio telescope, SPATR at the Nobeyama Radio Observatory of Japan, and ALMA interferometers. The millimeter/submillimeter-wave band high-resolution heterodyne spectroscopies allow us to address the molecular abundances at a higher altitude than the H<sub>2</sub>S<sub>4</sub> clouds layer on both dayside and nightside of Venus. Since 2011, SPART has been monitoring the rotational spectral lines of carbon monoxide (CO) in the 100 and 200 GHz bands. The mixing ratio of CO at an altitude of about 80 km observed during the time appeared to be anti-correlated with the intensity of solar UV in the 11-year solar cycle. These trends were compared with the abundance of SO<sub>2</sub> observed by Venus Express (VEX) and the albedo observed by VEX/Akatsuki satellite. In addition, the preliminary results obtained with ALMA show the latitude/longitude and altitudinal distributions of SO and SO<sub>2</sub> are anti-correlated. In this conference, a brief picture of the material circulations in the Venus middle atmosphere inferred from these results will be also discussed.

Keywords: planetary atmosphere, Solar system, Venus, terrestrial planet, millimeter/submillimeter-wave band telescope, heterodyne spectroscopy