南極昭和基地における中層大気微量分子のミリ波帯観測

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Millimeter-wave Bnad Observations of Minor Constituents in the Middle Atmosphere at Syowa Station

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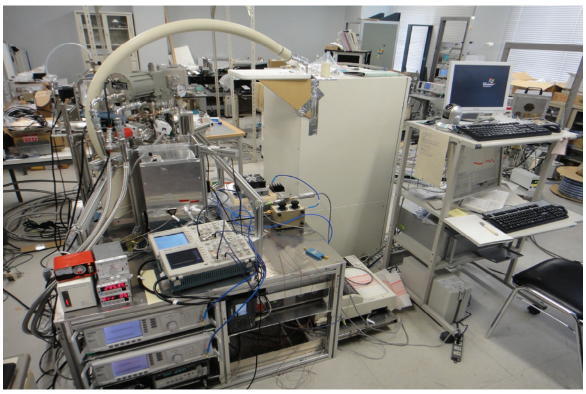
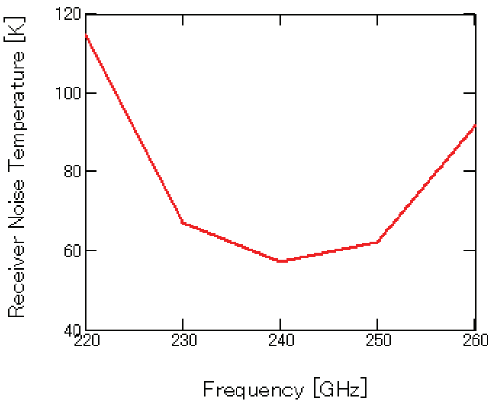
In order to study the chemical and dynamical effects of energetic particle precipitation (EPP) on minor constituents in the upper and middle atmosphere, we are planning to make a continuous monitoring of vertical profiles of NO_2, HO_2, and Ozone by using a millimeter-wave spectroscopic radiometer from Syowa station. We will continue the monitoring for 5 years since 2011 in order to cover the next solar maximum. Two different types of the EPP effects are expected to be observed from Syowa station. One is “direct” effect that energetic solar protons enter directly into the mesosphere and make in-situ ionization of nitrogen and oxygen molecules leading to enhancement of NOx /HOx and depletion of ozone caused by the NOx /HOx enhancement (e.g., Jackman et al. 2001, 2005). The other is “indirect” effect that NOx is enhanced in the thermosphere through ionization of N_2 by auroral electrons and then the enhanced NOx air flows downward to the mesosphere and the upper stratosphere with the descending polar vortex (e.g., Seppala et al. 2007).

Our remote sensing spectroscopy does not need a background source like the Sun; thus, we can proceed with long-term and continuous monitoring of minor constituents such as ozone and NOx species in the polar neutral middle atmosphere even during polar night. The millimeter-wave band radiometer is sensitive to the mesosphere up to ~70km, and thus, gives the most suitable observation methods from the ground to study the above phenomena. We chose 250GHz-band in which relatively stronger lines of these molecules exist. The NO_2 line intensity is extremely weak, ~ a few tens mK in antenna temperature but is expected to be enhanced by more than 100 times and a few tens times than normal intensity for direct and indirect effects, respectively. Based on our model calculation, our superconductive radiometer can detect such an enhancement enough by several hours or one-day integration. Thus, we started development a new 250GHz-band millimeter-wave spectroscopic radiometer in collaboration with the Space and Upper Atmospheric Science group of NIPR in 2008.

Recently we redesigned the quasi-optical system of the radiometer with GRAP 9 software, so that the expected performance in the characteristics of beam propagation was obtained. In addition we developed heterodyne the mixer detectors employing superconductor-insulator-superconductor (SIS) junctions at the clean room of the Advanced Technology Center of the National Astronomical Observatory of Japan. The receiver noise temperature is about 60 K. This quantum-limited sensitivity will allow us to observe the faint spectral lines of NOx species reliably at the site. Finally the radiometer system was tested by demonstrating the gas cell observations of N_2O lines at our laboratory. The completed system were already taken apart, and then loaded onto the Shirase. In this talk we will present the progress and current status.



The millimeter-wave band radiometer.



Performance of the 250 GHz band superconducting SIS mixer receiver newly developed for this mission.