Current status of the new multi-frequency millimeter-wave spectrometer installed at Showa Station and initial results of multi-line observations

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It is well-known that energetic particle precipitation (EPP) triggered by solar activity produces nitrogen oxides, which catalytically destroy ozone in the polar regions. We have been conducting steady measurements of millimeter-wave spectra of nitric oxide and ozone to monitor the temporal variation in the mesosphere and lower thermosphere above the Showa Station since 2012, in order to study the influences of the energetic particles on the atmospheric composition change. Simultaneous observations of several molecular species which are chemically and dynamically related with can provide useful information to understand the factors that cause temporal changes of atmospheric composition. However, due to the limitation of the instantaneous frequency bandwidth of the backend spectrometer, it is not possible to cover the line spectra of both molecules at the same time, so we had to switch the receiving frequency and observe nitric oxide and ozone alternately. To overcome this situation, we developed a new observing system for multi-frequency observations using a waveguide-type frequency multiplexer (Nakajima et al. 2020).

The new multi-frequency millimeter-wave spectrometer was installed at Showa Station by the 61st Antarctic Research Expedition, and the steady observation was started in November 2020. The new spectrometer enables simultaneous observations of NO, O_3, CO, and HO_2 spectral lines between 230 GHz and 250 GHz. In this spectrometer system, the radio waves are focused by a newly designed frequency-independent optical system using the quasi-optical approximation method (Gonzalez, 2016), and the signals in two frequency bands are extracted by two superconducting mixers cooled by a small power-saving refrigerator (Ulvac UR4K03) with a cooling power of 0.3W. Then, the signals of two frequency bands are recombined through the IF circuit into the 2 GHz band width of the final stage FFT processor to obtain the spectral signals of the multiple molecular species simultaneously.

In the presentation, we will explain the configuration of the new observation system in detail, and summarize the characteristics, problems, and issues of the actual system, and report the initial analysis results of the observation data acquired after November.

[References]
Nakajima et al., “Waveguide-Type Multiplexer for Multiline Observation of Atmospheric Molecules using Millimeter-Wave Spectroradiometer”, *J. Infrared Milli. Terahz Waves*, 41, 1530–1555, 2020.
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