Multi-frequency mm-wave spectrometer for atmospheric minor constituents at Syowa Station

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We have been carried out monitoring of nitric oxide and ozone in the stratosphere to lower-thermosphere above Syowa station since 2012 to study the influence of energetic particle precipitation on the atmospheric composition change. The previous observations, however, have alternated between nitric oxide and ozone because the instantaneous bandwidth of the spectrometer was too narrow to cover both spectral lines at the same time. To overcome such a situation, we developed new observation system for multi-frequency observation by using a waveguide-type frequency multiplexer (Nakajima et al 2020). The new system allows simultaneous observation of NO, O_3, CO, NO_2, and HO_2 spectral lines between 230 GH and 250 GHz, which will lead to a comprehensive understanding of actual physical-chemical processes by simultaneous measurements and making correlation analyses of spaciotemporal variations of those molecules having different chemical properties. After the laboratory evaluation, all the components of the new system were shipped to Syowa station with the 61th Japanese Antarctic Research Expedition (JARE).

As of the early October, the construction of the new observation system was completed and replaced the old one, after some experimental measurements of each part of the observing system since January, such as the 4K-cryogenic cooling system (Ulvac UR4K03), alignment of quasi-optical system adjusted by using a radio-beam linear scanner, and new IF circuit system which combines three separated frequency signals to a single output port connected to the backend FFT processor (RPG XFFTS) with a bandwidth of 2GHz. During the re-assembling of the observation system at Syowa Station, there were also several unexpected problems, such as the cold-stage temperature for the superconducting devices staying around 5.0K instead of expected 4.3K and inexplicable large losses of the superconducting bandpass filter. For the latter problem a backup room-temperature bandpass filter was used as a temporary solution, and we still try to find the solution to fix the problems. However, as a whole, the simultaneous observation data of ozone (O_3), carbon monoxide (CO) and nitric oxide (NO) were obtained, and it was confirmed that the initial planned performance was almost achieved. Now, the observational parameters are optimizing through the test observations. The latest performance including the attempt to detection of NO_2 and HO_2 and the future plan of steady operation will be reported in this presentation.

References

Nakajima, T., Haratani, K., Mizuno, A., Suzuki, K., Kojima, T., Uzawa, Y., Asayama, S., Watanabe, I., “Waveguide-Type Multiplexer for Multiline Observation of Atmospheric Molecules using Millimeter-Wave Spectroradiometer.” J Infrared Milli Terahz Waves (2020). https://doi.org/10.1007/s10762-020-00740-z