

R005-04

A 会場 : 11/26 PM2 (14:50-16:20)

15:35~15:50:00

時間差マルチビーム観測方式の開発とトロムソ Na ライダーへの実装

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Development of a time-delayed multi-beam observation method and its implementation to the Tromsø Na lidar

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In the polar mesosphere and lower thermosphere region, where part of the atmosphere is ionized, it is essential to measure the neutral atmosphere and the ionosphere simultaneously to understand the neutral-ion interactions. The Tromsø sodium (Na) lidar was developed in 2009 – 2010 by Nagoya University, Shinshu University, and RIKEN. In addition, University of Electro-Communications has been involved in its operation and development since 2015. This lidar system is equipped with a laser diode-pumped laser system, which has advantages in stability and lifetime. Another feature is that observations can be made simultaneously in five directions (vertical, east, west, north, and south) using split beams. This lidar is located at the European incoherent scatter (EISCAT) radar site in Tromsø (69.6° N, 19.2° E), so we are able to perform simultaneous observations of the neutral atmosphere and ionosphere by using the EISCAT radars and the Na lidar. The observation height range of the Na lidar depends on the distribution height range of the Na layer, which is normally from 80 to 110 km. On the other hand, recent observations have revealed low-density Na events at higher altitudes (above 110 km, up to 196 km). It is called thermospheric Na, and the extension of the observation range of Na lidars is expected by observing such thermospheric Na. However, the Inter-Pulse-Period (IPP) of Tromsø Na lidar is 1 ms, and thus the corresponding observation range is 0-150 km. Therefore, to observe the thermospheric Na layers, we have been working on an extension of the altitude range of the Tromsø Na lidar.

In this study, we have developed a time-delayed multi-beam method to improve the performance of Tromsø Na lidar. This method forms multiple beams by physically switching the transmission direction of each pulse without splitting the beam. Specifically, the beam is switched alternately between one vertical direction and the other four directions (east-west-south-north) every 1 ms. In this case, the IPP becomes 2 ms for each direction and the measurement range is extended to 0 – 300 km. In addition, the pulse energy of the vertical beam is 5 times higher than the current system. The power per unit time is 2.5 (= 5/2) times higher, and noise is reduced by decreasing the number of accumulations. Therefore, the signal-to-noise ratio can be improved. For the implementation of this method, two key techniques are needed. Those are (1) switching of the transmission direction of laser pulses at high speed and with high pointing accuracy, and (2) control of transmission of time-delayed pulses and multi-channel measurement.

For (1), we developed a 2-direction beam line switching system using a commercially available galvanometer scanner. When applying a galvanometer scanner, performance evaluation experiments were conducted because it was unclear whether it had enough beam switching accuracy. The experimental results showed that the switching beam position drifted approximately 130 μ rad (max.) due to motor heating and room temperature fluctuations. This drift is less than the required beam position accuracy (<200 μ rad), so in other words, the results showed a good performance. For (2), we developed an 8-channel (4+4) photon counting system that performs time-delayed measurements using an FPGA (Field-Programmable Gate Array). The time-delayed photon counting is synchronized with the operation of the 2-direction beam line switching system. We have confirmed that the system is operated as designed, based on the experiments.

In the presentation, we will introduce the developed system and experimental results on the system performance. Furthermore, we plan to implement the system at the Tromsø Na lidar in October 2025, so initial reports on the implementation will also be presented.