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Novel Real-time Observation of High-resolution Water Vapor Behavior for Detection of Precursors of Cumulonimbus Clouds and Investigation of Their Evolution: - Preliminary Results -

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We have initiated a new research project to analyze the behaviors of precipitable water vapor with high spatial and temporal resolutions using a dense global navigation satellite system (GNSS) network and next-generation microwave radiometers. Recently, line-shaped rainbands with extreme and hazardous characteristics have been occurring frequently in Japan, leading to disasters such as severe flooding and landslides. However, there is insufficient knowledge regarding the generation mechanism of cumulonimbus clouds within these rainbands. Our project has four research subobjectives: (1) to develop a novel microwave radiometer for use in millimeter-wave spectroscopy, enabling high-resolution and high-precision monitoring of water vapor behavior, and conduct field measurements using this radiometer for proof of concept; (2) to conduct high-resolution water vapor measurements using a dense network of low-cost GNSS receivers; (3) to conduct GNSS water vapor tomography for estimating precise temporal and spatial variations; and (4) to numerically predict weather precisely using dense-measurement water vapor datasets and fine GNSS tomography results. Our project is aimed at not only the advancement of mesoscale meteorology but also application to space geodetic techniques such as very long baseline interferometry (VLBI) and GNSS. Regarding the first subobjective, significant progress has been achieved in the development of a next-generation microwave radiometer utilizing millimeter-wave spectroscopy since 2018. To date, we have successfully engineered a new front-end module equipped with an orthomode transducer (OMT) and a wideband feed. The prototype of the complete receiver system has a wide bandwidth feed spanning from 16 to 58 GHz, facilitating the measurement of two frequency bands: 16-28 GHz (H_2O) and 50-58 GHz (O_2). We plan to integrate this system into a 40-meter-class dish telescope to assess its performance in detecting water vapor variability this summer. For the observation of GNSS precipitable water

vapor, we first installed a low-cost GNSS receiver and a commercial-based microwave radiometer at Kagoshima University in early November 2023 as a preliminary observation to understand the variability of water vapor in the southern Kyushu area. In addition to the precipitable water vapor information obtained from this observation, we plan to investigate the variability of water vapor in this area based on the information obtained from the GNSS Earth observation network (GEONET) system of the Geospatial Information Authority of Japan (GSI) and a commercial-based GNSS observation network. Our presentation will include preliminary results and an outlook on future developments. *This work received support through JSPS KAKENHI Grant Numbers JP21H04524 and 23H00221.*