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Numerical study on precipitable water vapor variation associated with heavy rainfall using a non-hydrostatic model

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The frequency of weather disasters caused by local heavy rainfall is increasing due to the global warming. For the mitigation of these disasters, it is important to monitor the variation of water vapor before the rainfall.

Global Navigation Satellite Systems (GNSS), that include GPS, are now widely used to perform precise positioning. In addition to this, the vertically accumulated water vapor amount, precipitable water vapor (PWV) can be estimated from GNSS observations. The Geospatial Information Authority of Japan is operating a nationwide GNSS network, called GPS Earth Observation Network System (GEONET), and PWV from GEONET can be estimated with a mean horizontal spacing of about 20 km. To improve the horizontal resolution of PWV, we have installed a dense GNSS receiver network with horizontal spacing of 1-2 km near the Uji campus of Kyoto University.

In parallel to dense GNSS observations, down-scale experiments using a non-hydrostatic regional model (JMANHM) with grid intervals of 2 km and 250 m were performed to investigate the PWV variation associated with a thunderstorm observed on 28 July 2011 and 14 August 2012 within the dense GNSS network.

In the 250 m forecast for the case on 14 August 2012, a rainband located south of Kyoto was roughly reproduced. In the model, small regions in which PWV values started to increase about 10 minutes before the rainfall were found. At the 850 hPa surface over these regions, vertical wind velocity and cloud water content became large in conjunction with the rapid increase of PWV. It is expected that the increase of pwv value was occured because low level moist air was lifted up by the upward wind. Similarly, increasing of PWV value before rainfall was observed by the GNSS receiver at the Uji campus. These results suggest that PWV variation could be predictive of heavy rainfall.

Keywords: heavy rainfall, GPS meteorology, non-hydrostatic model