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# Development of the GPS tomography of water vapor distribution in troposphere using neural network

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When the rain cloud bringing the damage of a heavy rain and the thunderstorm is developing, there is an apparent flow of the water vapor from the neighborhood. It is possible that the GPS can detect the flow and distribution of water vapor. Therefore, in this study, we develop a water vapor tomography from GPS and AMeDAS data using algorithm of residual minimization learning neural network (RMTNN). We carried out the numerical simulation to investigate the horizontal vertical resolution of the algorithm; the target area is E135- E137, N34-N36, Alt 0 km-10 km. We divided the area into 20 and 50 in horizontal and in 50 vertical, respectively. Therefore, the scale of a voxel is 0.1∗0.1∗0.2 km. We put 400 GPS sites in a total on the surface uniformly; the inter-GPS distance is 0.1. We used GPS satellites coordinates at 09:00 JST on Aug 13, 2012 for the simulation. We added 5% noise to data.

To investigate the horizontal resolution, we perform the numerical simulation to reconstruct the water vapor distribution which has uniformly decrease in exponentially with altitude and a gaussian enhancement in horizontal. The center of the Gaussian enhancement is fixed at E136, N35. We carried out simulation with changing peak values of the Gaussian enhancement; 30%, 20%, and 10% against the background water vapor density, and half?width values of the gaussian enhancement ; 0.5, 0.3, and 0.1. To investigate vertical resolution, we perform the numerical simulation to reconstruct the water vapor distribution which has uniformly decrease in exponentially with altitude and a gaussian signal in both horizontal and vertical. The center of the signal is E136, N35, Alt 2 km, with the peak value of 15(g/mˆ3), half-width value width of 0.3in horizontal and 0.6 km in vertical, respectively.

The results of the numerical simulation demonstrate the following capacities of the developed RMTNN algorithm; (1) for the horizontal resolution, water vapor disturbance with 30% peak value against the background level can be reconstructed by 6 GPS observation sites in a linear profile, disturbance with 20% peak value, 10 GPS observation sites and (2) for the vertical resolution, it is possible to reconstruct an inverted layer of the water vapor distribution with adequate points for restriction points. These facts show that the developed tomography algorithm on the tropospheric water vapor has the ability to reconstruct disturbance without any model dependence.

Keywords: GPS tomography, water vapor