Tsukuba dense network GPS observation campaign:Correction of phase center variation, and water vapor tomography.

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1.Introduction

To investigate water vapor variations with the order of a few - a few tenth km, dense net GPS campaign observations with 75 GPS receivers within 20km square area over Tsukuba city were carried out for 2.5 months in fall of 2000 and in summer of 2001.

By using IGS antenna phase center model and nulti-path stacking maps, antenna specific biases and error variations of PWV were reduced and elevation dependency of slant delay (SD) was removed.

Tomography methods were applied to this improved SD to derive 3-D water vapor structures. The results show the characteristic spatio-temporal variability of water vapor according to weather conditions.

2.Experiment description

The cut-off elevation of the GPS satellite was set to 0 degrees and the sampling interval was set to one second. All receivers logged data for 24 hour each day. One minute interval surface weather observation was done at 22 sites. A water vapor radiometer (Radiometric WVR 1100) observed precipitable water vapour in the direction of the GPS satellite at Meteorological Research Institute and Geographical Survey Institute. We performed three hourly radio sonde observation during the 2000 autumn campaign.

3. Correction by Phase Center Map of each station

For GPS analysis, we used version 2.6 of the GIPSY-OASIS II software package in point positioning mode (Zumberge et al., 1997) . To retrieve accurate slant delay for tomography input, it is necessary to remove the elevation dependency of postfit residual. We used IGS model for phase center variation model. In addition, we constructed phase center variation maps by stacking one-way postfit phase residuals over entire campaign period. Unit size of the stacking map was 2 degree elevation by 5 degree azimuth.

The result showed that the new phase center maps almost removed elevation angle dependency of postfit residual.

The improvement in the SD estimation had positive impact to estimation of GPS derived precipitable water vapor. It was agreed quite well with upper air sonde observation and water vapor radiometer observation, by R.M.S error of 2.0mm or less. Time mean of PWVs at 75 sites in the campaign area showed water vapor anomaly patterns due to height difference of GPS sites and climatic north-south gradient of water vapor.

4.Water vapor distribution estimated by the tomography method

In the tomography method, the atmosphere is divided into many cells. The observed slant water vapor is equal to the integration of the product of the slant path length and the water vapor density in each cell. This relation is used to construct observation equations. The observation equations were solved by least square method to derive three-dimensional distribution of water vapor.

During the observation period of Tsukuba dense network GPS observation in 2000 autumn, a small radar echo (a rainfall area) generated in the observation domain and moved northward. A water vapor distribution near this small rain area was estimated by the tomography method. It was possible to trace the northward movement of a water vapor anomaly consistent with the movement of the radar echo. The moving direction of the water vapor anomaly was the same as that of the observed horizontal wind. However, the radar echo intensity was so weak that the water vapor anomaly in the rainfall area was not necessarily large for reliable tomography estimation.

In future, we will apply the tomography method to thunderstorms observed in the 2001 summer campaign. We expect large differences of water vapor between the inner and outer regions of thunderstorms, which will be properly retrieved by the tomography method. We will also try to investigate water vapor anomalies in the dry weather conditions.