Tsukuba GPS Dense Network Observation: Analysis of slant water vapor by GPS, and comparison with Water Vapor Radiometer

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We executed Tsukuba GPS Dense Network Observation from October 14 to November 13, 2000. We retrieved integrated water vapor along GPS ray path (SWVgps) by using GPS retrieved Zenith Total Delays (ZTD) and pos-fit residuals. The comparison results with WVR observed SWV (SWVwvr) are described here.

1.Analysis procedure of SWV by using GPS data

The GPS receiver observes dual frequency career-phase. GIPSY/OASIS-II software package was used to estimate site coordinates and zenith mapped total delay (ZTD). ZTD consist of zenith hydrostatic delay (ZHD) and zenith wet delay (ZWD). In GIPSY analysis, ZHD was estimated as a height dependent constant value (ZHDapr). ZWD was modeled as a random walk variable, and estimated every 30 second. Niell's mapping function(NMF) was used to estimate ZTD from STD. ZHD can be calculated by using surface pressure. Then, GPS derived slant water vapor (SWVgps) was calculated as follows.

SWVgps=(STD-ZHD*NMFh+residual)*PI (1)

Here STD means slant total delay.

STD=ZWDest*NMFw+ZHDapr*NMFh (2)

PI is a conversion coefficient of SWV from slant wet delay, which estimated from surface temperature.

2. WVR data analysis

Water vapor radiometer (Radiometric WVR 1100) observed 23.8 and 31.4GHz dual frequency microwave brightness temperature at Meteorological Research Institute. We retrieve precipitable water vapor in the direction of the GPS satellite (SWVwvr0) by using Radiometric's algorithm. We did not use the data when retrieved liquid water content (LWC) exceeded 0.3kg/m**2, considering that rain or high humidity conditions existed. We constructed 40 minutes averaged time series of zenith mapped SWVs and calculated residuals. Over estimation was seen under 30 degree elevation. So we used only over 30 degree elevation data for PWVwvr retrieving. PWVwvr had a negative bias of 2.7mm against the radio sonde derived PWV. So, we adjusted the bias of SWVwvr as following.

SWVwvr = SWVwvr0+2.7*NMFw (3)

3. Comparison between SWVgps and SWVwvr

We did GPS analysis by the following eight methods from the view point of antenna phase center correction and gradient parameter estimation.

(1)Antenna phase center correction.
(P1)No correction (noPCV)
(P2)Correction by IGS model (PCVigs)
(P3)Stacking of postfit residual made from noPCV analysis(noPCV+MPS)
(P4)Stacking of postfit residual made from PCVigs analysis (PCVigs+MPS)
(2)Atmospheric model
(g1)Assumption of isotropic atmosphere (no Gradient)
(g2)With estimation of first order gradient (with Gradient)

We did eight kinds of GPS analysis by the combination of the above-mentioned procedures.

And, SWVgps and SWVwvr were compared in every the elevation two degrees. SWVgps from (P1)and(P3) had negative bias. The biases growing as elevation becomes low. On the other hands, absolute value of biases of SWVgps (P2) and (P4) were less than 2mm in all elevation. The results of (P4)+(G2) showed most small value of RMS in almost all elevation. But the difference was small. The results of (P4)+(G1) showed relatively large RMS values. Construction of correction map by stacking of postfit residual from without Gradient parameter estimation may result in inclusion of climatic information of water vapor into correction map. It means, climatic pattern will disappear from retrieved SWVgps. Averaged azimuth distributions of SWVgps support above mentioned idea.