The Impacts of GPS Precipitable Water Assimilation in the JMA Global 4D-VAR Data Assimilation System

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1. Introduction

The International GNSS Service (IGS) operates a global network of ground-based GPS stations continuously for GPS satellite tracking, and provides GPS observation data via its FTP server. These data allow global estimation of ground-based GPS precipitable water (PW) data. We assessed the accuracy of global GPS-PW data and the related impact on JMA's global four-dimensional variational data assimilation system.

2. Outline of GPS-PW calculation and comparison with radiosonde-derived PW data

We used GIPSY-OASIS II software (GIPSY, Jet Propulsion Laboratory/NASA, Webb and Zemberg, 1993) for zenith tropospheric delay (ZTD) retrieval with the final ephemerides of IGS. Furthermore, in order to retrieve GPS-PW data derived from ZTD information, temperature and surface pressure data at IGS stations are required. Data from operational global analysis were used for this purpose.

In order to evaluate the accuracy of GPS-PW data, we compared them with PW values derived from radiosonde observation data (sonde-PW). In this comparison, we selected stations where the horizontal distance and the vertical height difference between GPS and the radiosonde station were less than 30 km and 200 m, respectively. Figure 1 shows scatter plots of GPS-PW values against sonde-PW data. The result shows good precision for GPS-PW, as indicated by the close correspondence to sonde-PW data.

3. Impact of GPS-PW on JMA's global data assimilation

We carried out observation system experiments for GPS-PW with a low-resolution (TL319L60) global data assimilation and forecasting system from August 1 – August 31, 2010. The forecasts were executed from each 12 UTC initial for the test run (with GPS-PW) and a control run (without GPS-PW). GPS-PW data satisfying the following conditions from the 192 stations shown in Figure 2 were used:

- The GPS-PW range was between 1 mm and 90 mm.
- The elevation difference between the model surface and the actual surface was less than 300 m.
- The PW difference between the first-guess value and the GPS-PW value was less than 10 mm.

In consideration of observation error correlation, the GPS-PW data were thinned using 100-km grid boxes. Only GPS-PW data observed at the analysis time were used. The PW correction of the elevation difference between the model surface and the actual surface was applied. The method is described in Ishikawa (2010).

Figure 3 shows average differences in the analyzed PW data between the control and the test (with GPS-PW). In the test, PW values are higher around IGS stations in the tropics. Figure 4 shows the improvement rate (%) of the test against the control for RMSE in the geopotential height forecast at 500 hPa. The result shows the positive impact of the GPS-PW assimilation.

References

[1] Webb, F. H. and J. F. Zumberge, 1993: An introduction to the GIPSY/OASIS-II. JPL Publ., D-11088.

[2] Ishikawa, Y., 2010: Data Assimilation of GPS Precipitable Water Vapor into the JMA Mesoscale Numerical Weather Prediction Model. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell., 40, 01.13 – 01.14.

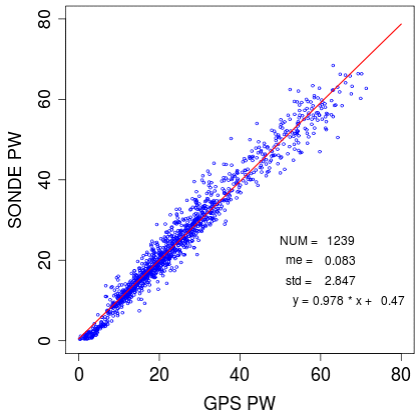

Figure 1: Scatter plots of GPS-PW data against sonde-PW values. The sampling period was from August 1 to August 31, 2010. The red line represents the linear regression derived from the scatter plots.

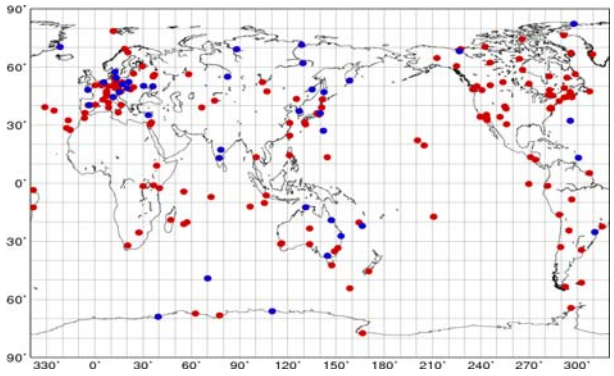

Figure 2: Location of IGS stations (192). The blue dots show the stations used for comparison with sonde-PW data.

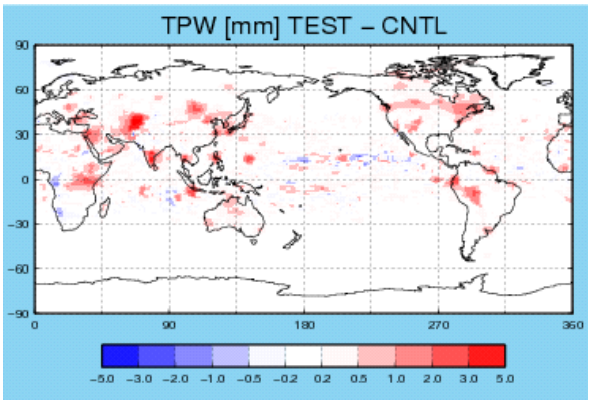

Figure 3: Average differences in analyzed values of PW between the control (without GPS-PW) and the test (with GPS-PW). The sampling period was from August 1 to August 31, 2010.

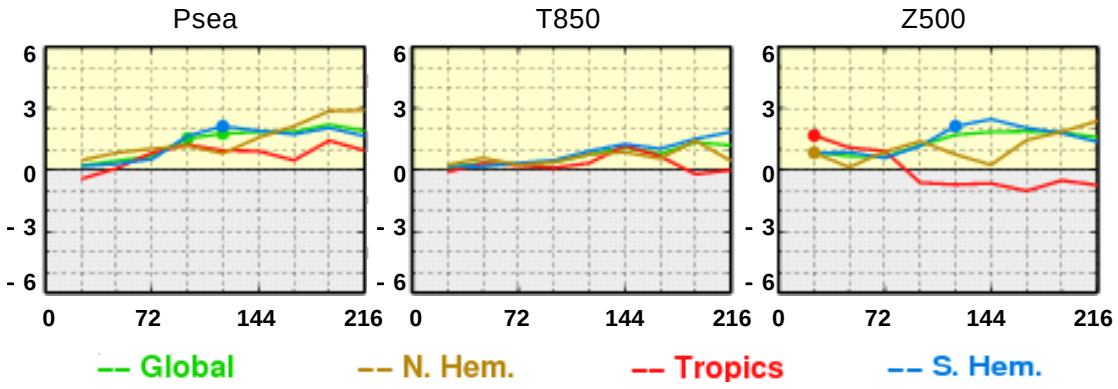

Figure 4: Improvement rate (%) in the RMSE of forecasting with GPS-PW against that without. The panels show surface pressure (left), T850 (middle) and Z500 (right). The horizontal axis represents the number of forecast hours. Lines appearing in the upper (yellow) area indicate a reduced RMSE. Dots on the score lines represent statistical significance.