Enhanced Use of Ground-based GNSS Data in JMA's Mesoscale Data Assimilation System

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1. Introduction

Based on atmospheric delays in GNSS (Global Navigation Satellite System) signals, it is possible to determine the absolute water vapor content of the atmosphere. Against this background, the Japan Meteorological Agency (JMA) uses precipitable water vapor (PWV) data from the Geospatial Information Authority of Japan's nationwide ground-based GEONET (the GNSS Earth Observation NETwork system, which has approximately 1,300 receivers located throughout Japan; Figure 1) for its mesoscale data assimilation system (see Ishikawa (2010) for details, including JMA's usage of ground-based GNSS data). Quality control for PWV data derived from ground-based GNSS data has been improved.

2. Availability of GNSS PWV data

JMA previously reported that PWV data derived from ground-based GNSS data in rainy conditions (referred to as rain data) had a negative bias against the first guess in mesoscale analysis. As a result, data from areas with approximately ≥ 1.5 mm/hour of rainfall were rejected in quality control and not used in mesoscale analysis. However, a review based on PWV data collected since 2015 indicated that rain data exhibit no bias in any season (Figure 2). As the mesoscale model has been improved, negative biases were reduced and rain data are now considered appropriate for use with the current mesoscale data assimilation system.

3. Impacts of rain data

Observation system experiments for data assimilation and forecast system usage with the addition of rain data (referred to here as TEST) were performed over the period from 18 June to 23 July 2018. Figure 3 shows the resulting lower dry bias and root mean square errors for forecasting of surface specific humidity. Figure 4 shows the equitable threat score (ETS) for three-hour cumulative precipitation forecasts, and indicates that rain data have a positive impact on high-intensity precipitation data within a six-hour forecasting range.

4. Summary

JMA's mesoscale data assimilation system previously rejected PWV data derived from ground-based GNSS data in rainy conditions due to negative biases against the first guess. However, such data are now considered appropriate based on a review using the latest mesoscale assimilation system. The data have positive impacts on forecasting of surface specific humidity and precipitation. Based on these impacts, PWV data in rainy conditions has been used in JMA's operational mesoscale data assimilation system since 26 March 2019.

References

Ishikawa, Y., 2010: Data assimilation of GPS precipitable water vapor into the JMA mesoscale numerical weather prediction model. CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling, **40**, 01.13 – 01.14.

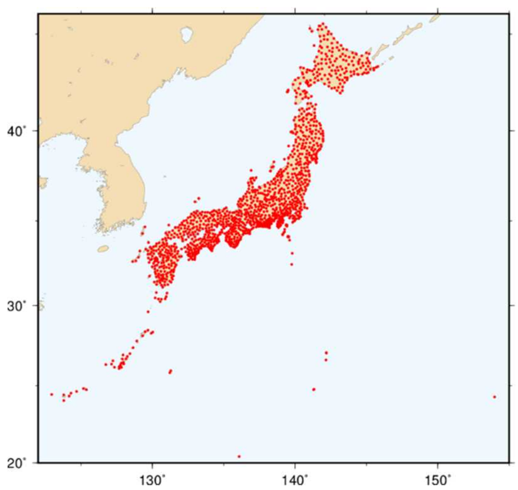

Figure 1. GEONET stations (red points)

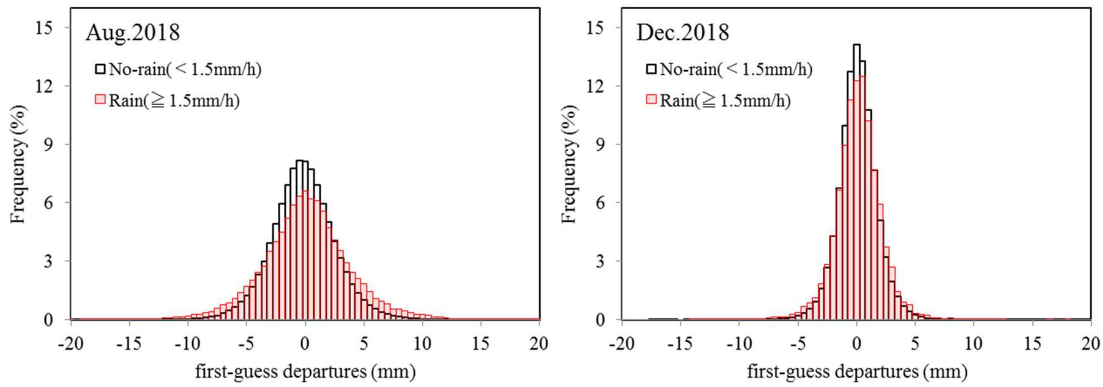

Figure 2. First-guess departures of ground-based GNSS precipitable water vapor for August (left) and December 2018 (right). Areas with ≥ 1.5 mm/hour of rainfall are shown in red, and those with < 1.5 mm/hour are shown in white.

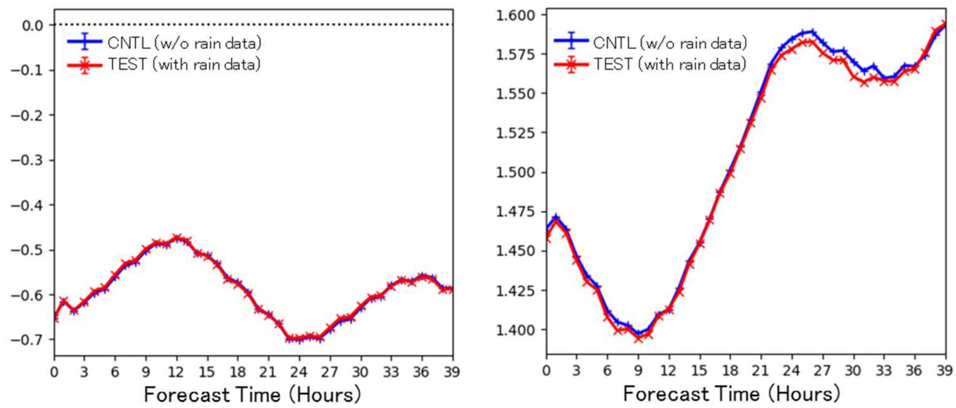

Figure 3. Mean errors (ME; left) and root mean square errors (RMSE; right) of surface specific humidity (unit: kg/kg) forecasts against observations in Japan as a function of forecast range (unit: hours) during the period from 18 June to 23 July 2018 for forecast experiments (blue lines: CNTL without rain data; red lines: TEST with rain data)

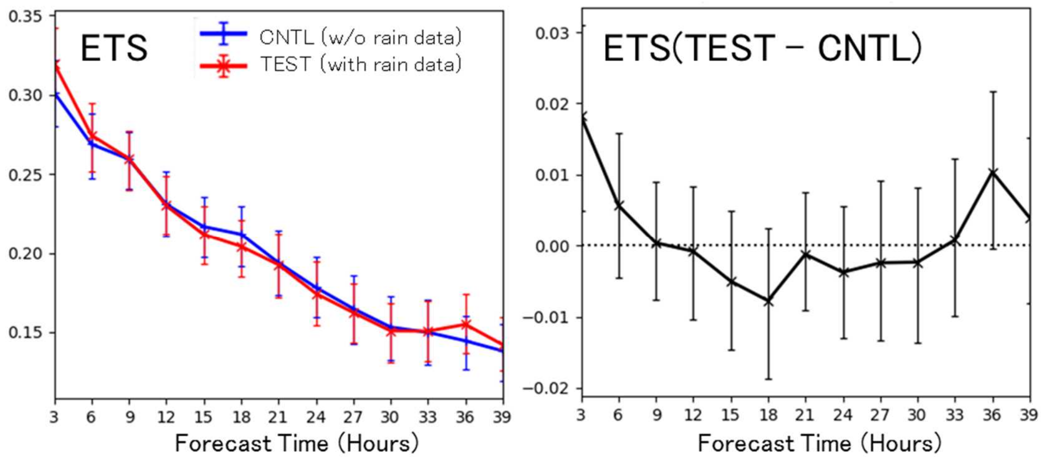

Figure 4. Equitable threat scores (ETS; left) for three-hour cumulative precipitation forecasts against Radar/Raingauge-Analyzed Precipitation during the period from 18 June 2018 to 23 July 2018 for forecast experiments (blue lines: CNTL without rain data; red lines: TEST with rain data). The figure on the right shows TEST - CNTL. Error bars represent 95% confidence intervals.