Operational Use of Ground-based Microwave Radiometer Data in JMA's Regional NWP Systems

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1. Introduction

The Japan Meteorological Agency (JMA) works on enhancing observation equipment to capture the inflow of lower-tropospheric water vapor that causes stationary linear mesoscale convective systems. One example of such equipment is the ground-based microwave radiometers (MWRs) adopted in western Japan for monitoring based on the brightness temperatures (TBs) of microwaves from water vapor and cloud liquid water. A related data processing method has also been developed for assimilation in JMA's regional numerical weather prediction (NWP) systems (Meso-Scale Model (MSM) and Local Forecast Model (LFM)), and its effects have been examined.

2. Precipitable water vapor determination

Toward the application of MWR data, precipitable water vapor (PWV) information based on TBs has been assimilated into NWP systems along with existing PWV data from other observations. As per Hogg et al. (1983), PWV values were retrieved from the TBs of two water vapor channels (23.84 and 27.84 GHz) for this purpose. Here, mesoscale analysis for MSM with uniform spatiotemporal quality and sufficient quantity were used to determine correlation coefficients between PWV and TB.

3. Quality control (QC)

Since low-quality data negatively affect NWP, QC incorporating rain checking for MWR was applied based on that for ground-based GNSS (Ishikawa, 2010), which also assimilates PWV. Via such checking, rain data are eliminated because MWR channels are influenced by raindrops. These are detected using MWR rain gauges and radar observations.

Post-QC quality of PWV data from MWRs was assessed, with results from the Hirado site shown in red in Figure 1. The bias of observation minus background statistics from June 1 to August 9 2023 fell from 3.2 to -0.45 mm, and the standard deviation also dropped from 12.78 to 1.89 mm. The quality of MWR data passing QC was equivalent to that of ground-based GNSS data used in JMA's NWP systems. Figure 2 shows PWV at the Hirado MWR site and at a ground-based GNSS station nearby.

4. NWP system effects and results

Numerical experiments were conducted to evaluate the effects of MWR data on NWP systems. The control experiment (CNTL) had the same configuration as the operational MSM as of March 2023, and those of the test experiment (TEST) were the same except for the assimilation of PWV derived from 13 MWR sites (Figure 1). The experiments covered the period from June to July 2023, with results showing improved rainfall distribution associated with stationary linear mesoscale convective systems. Figure 3 shows that distributions of three-hour TEST cumulative precipitation were closer to radar/raingauge-analyzed precipitation than those of CNTL. Thus, it can be considered that ongoing assimilation of MWR data supports appropriate modification of water vapor distribution.

In this way, NWP rainfall prediction was improved via assimilation of PWV from MWRs with QC incorporating rain data rejection. Accordingly, MWR data in MSM and LFM were adopted in March 2024.

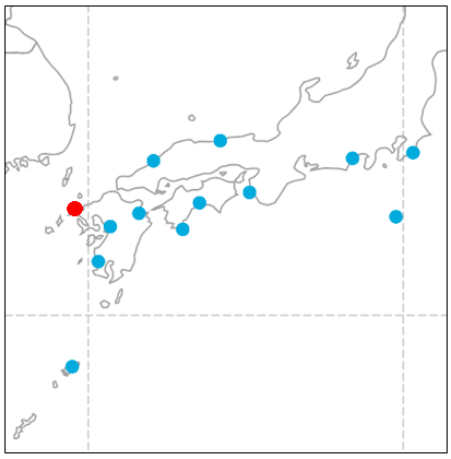

Figure 1: Distribution of MWR in experimentation. Red: Hirado site.

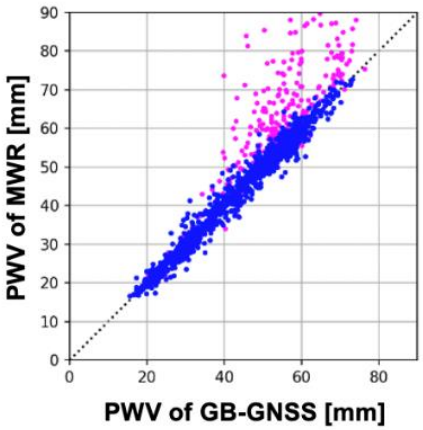

Figure 2: Relationship between MWR PWV [mm] (vertical) and GB-GNSS PWV [mm] (horizontal) at Hirado from June 1 to August 9, 2023. Blue and pink: QC-passed/rejected MWR data, respectively.

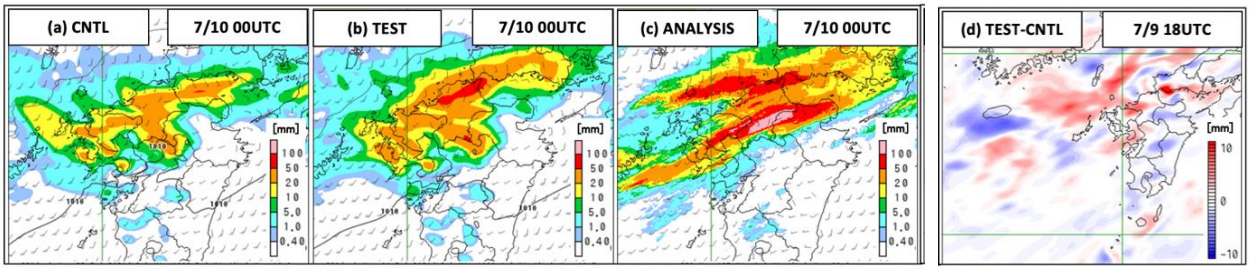

Figure 3: Three-hour cumulative precipitation [mm/3 hrs] at 00 UTC on July 10, 2023, for the Kyushu area of Japan. (a) TEST (6-hour forecast range); (b) CNTL (6-hour forecast range); (c) radar/raingauge-analyzed precipitation; (d) difference between initial conditions of PWV [mm] (TEST – CNTL) at 18 UTC on July 9, 2023. The map in (d) shows a larger area than the others.

References

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