Impact of Data Assimilation of Shipborne GNSS Data on Rainfall Forecast (Part 2)

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1. Introduction

Heavy rainfalls occur almost every year in Japan. Airflows that supply water vapor to heavy rainfalls originate from the Oceans around Japan. The accurate observation of water vapor over the Oceans is essential to increase the accuracy of rainfall forecast (fig. 1). In this study, precipitable water vapor (PWV, water vapor amount in column) observed by GNSS on vessels (shipborne GNSS) was assimilated using the Meso-NAPEX (Numerical Analysis and Prediction EXperiment system), which was implemented to the data assimilation system of the Meteorological Research Institute. A few cases in which data assimilation of shipborne GNSS data improved the rainfall forecasts were reported (Seko et al. 2019). In this report, the impacts caused by bias correction of shipborne GNSS PWV and by the number of observations are explained.

2. Shipborne GNSS data

The GNSS data that was observed by eight vessels (freighters) on the western side of Kyushu island were used in this study. GNSS PWV was retrieved using the procedure tried by Shoji et al. (2017). This area is located on the upstream side of the low-level inflow that supply water vapor to the rainfall systems over the Kyushu. The bias and standard deviation between the shipborne GNSS PWV and the mesoscale analysis (MA, 3 hourly and 5 km resolution) of Japan Meteorological Agency (JMA) are -0.56 mm and 2.56 mm, respectively (Shoji et al, 2019).

3. Specification of data assimilation method

The Meso-NAPEX is a quasi-operational data assimilation system which enables us to make data assimilation experiments. The horizontal resolution of the Meso-NAPEX is 5 km. The data assimilation window is 6 hours and the observation data are assimilated every hour. As the target event for this report, the rainfall system that passed through the northern Kyushu on 27-28th Aug. 2019 was adopted. This rainfall system caused the flooding and landslides there and killed 4 people.

We performed 7 experiments (table 1). In **CNTL**, the conventional data of JMA including the satellite data were assimilated by using the Meso-NAPEX. The PWV data of shipborne GNSS (**SGP**) were added to the conventional data in **SN**. Because of the bias between MA and SGP, the bias corrections were performed by adding +0.5 mm to SGP (**SC**) or by adding the values that were estimated with linear approximation (0.02728*SGP-0.4178) to SGP (**SL**). To increase the number of SGP data, the SGP obtained at -30 min and -15 min before the hour (00 min) were also assimilated in cases of **SN3**, **SC3** and **SL3**. In these cases, the SGP data at -30 min and -15 min before the hour were not used when the vessels were not moving.

4. Assimilation results of shipborne GNSS

The results of **CNTL**, **SC3** and **SL3** are shown in fig.

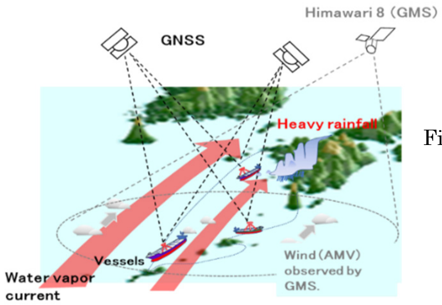

Fig. 1 Illustration of data assimilation experiments for shipborne GNSS observation.

2. The intense rainfall regions where 3-hour amounts exceeded 50 mm were observed over the northern Kyushu (indicated by a red circle in fig. 2a). Figure 2b shows the 3-hour rainfalls that were predicted in different experiments. The intense rainfalls were well reproduced in **SC3** and **SL3**, while they were not seen in the northern Kyushu in **CNTL**. In SL3, in the region extending to southwest from the northern Kyushu, the rainfall was too intense, compared with observations. This rainfall was caused by the larger PWV on the west of Kyushu (blue arrow).

The differences of PWV predicted in **CNTL** and **SC3**, **SL3** at the forecast times (FTs) from 1 to 3 hours are shown in fig. 2c. The regions with increased PWV (red regions) that were produced by the assimilation of SGP moved northeast (indicated by red arrows) and then it led to the intense rainfalls (thin black lines, 20 mm). As for the PWV-increased regions on the south of Kyushu (black arrows), they disappeared when the linear approximation was adopted (**SL3**).

The impact of the number of SGP data was shown by the extended forecasts at FTs from 3 to 9 hours (fig. 3). The intense rainfalls (indicated by red arrows) were reproduced only in **SN3**, **SC3** and **SL3** at FTs=3 and 6, though the rainfall extending to southwest were too intense in **SN3** and **SL3**, and the intense rainfalls were reproduced at FT=9 in all cases. This result suggests that the number of vessels that provide SGP data should be increased to improve the accuracy of rainfall forecasts.

Table 1. Data assimilation experiments of shipborne GNSS

Case	SGP	Bias correction	Time of assimilation
CNTL	No	-	-
SN	Yes	+0.0 mm	00 min
SC	Yes	+0.5 mm	00 min
SL	Yes	Linear approx.	00 min
SN3	Yes	+0.0 mm	-30, -15, 00 min
SC3	Yes	+0.5 mm	-30, -15, 00 min
SL3	Yes	Linear approx.	-30, -15, 00 min

5. Summary

The results of this report indicate that SGP data should be considered as useful for data assimilation and that the increase of the number of SGP observations improves the rainfall forecast. The further studies on

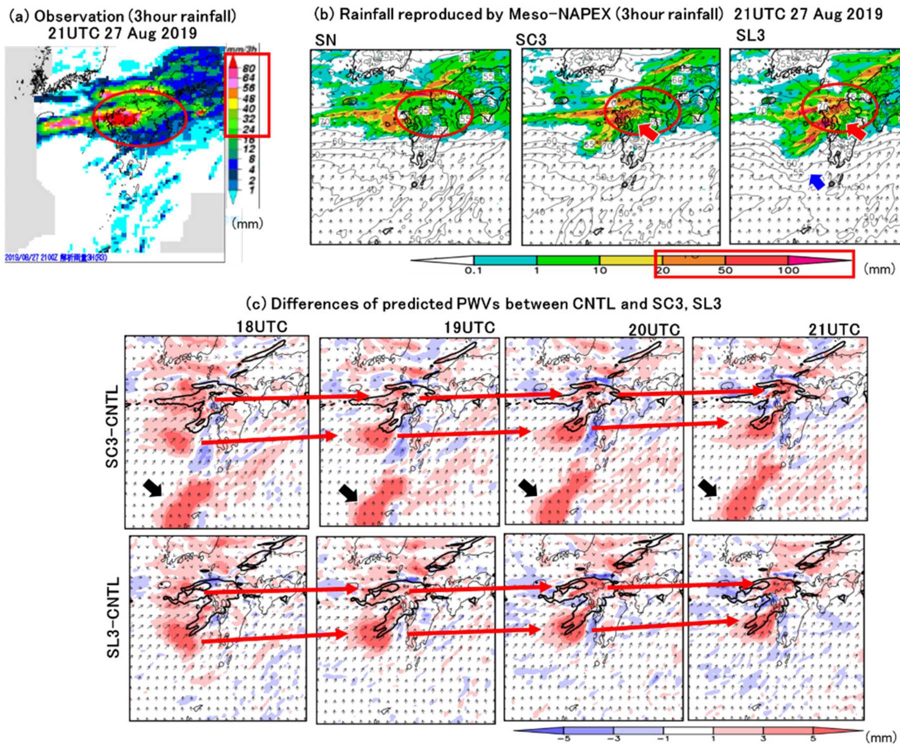

Fig. 2 (a) Observed 3-hour rainfall distribution at 21 UTC 27th Aug. 2019. (b) Rainfall distributions of 3-hour forecasts at 21UTC that were obtained in **CNTL**, **SC3**, and **SL3**. (c) Differences of the predicted PWV between **CNTL**, **SC3**, and **SL3**.

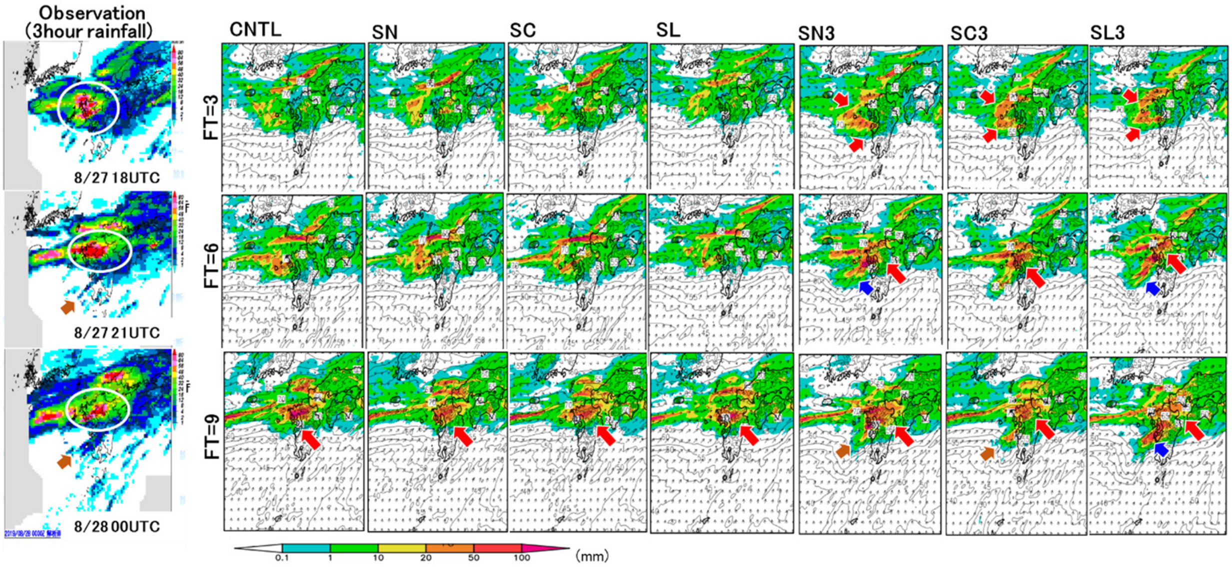

Fig. 3: 3-hour rainfall distributions of the extended forecasts, in which the start time of data assimilation was changed from 18UTC to 15UTC 27th Aug 2019.

the bias correction and of the synergy effect of wind data are desired.

Acknowledgments

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