P1.48 USE OF TMI AND SSM/I DATA IN THE JMA OPERATIONAL MESO ANALYSIS

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1. INTRODUCTION

The Japan Meteorological Agency has been operating a Meso-Scale Model (MSM) to be utilized for very short range rainfall forecast to mitigate natural disasters. For this purpose, it is essential to prepare accurate initial conditions. Therefore, the Meso-analysis with a 4D-VAR scheme (Meso 4D-VAR) has been operated since March 2002. Although the Meso 4D-VAR brought considerable improvement in the precipitation forecasts of MSM, it still does not have enough accuracy to predict heavy rainfall quantitatively. It needs not only to improve MSM and Meso 4D-Var but also to introduce new observations.

Introduction of satellite data into the Meso 4D-VAR is essential to improve the short range rainfall forecast in Japan. The reason is that Japan is surrounded by the ocean, where the atmospheric observations especially of water vapor, are quite few except for those from satellites. Therefore, JMA has been developed the satellite data assimilation system for the Meso 4D-VAR. With the system, observational system experiment (OSE) for both rain rates and total column precipitable water retrieved from Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI) and Special Sensor Microwave/Imager (SSM/I) is performed.

In this report, the description of the assimilation system and results from the OSE are presented.

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2. OPERATIONAL MSM AND MESO 4D-VAR

The MSM is a hydrostatic spectral model with a horizontal resolution of 10km and 40 vertical levels up to 10hPa. It covers Japan and its surrounding region with the extent of 3600km by 2880km. The domain is shown in Fig. 1.

For the data assimilation, Meso 4D-VAR with 3-hour assimilation windows has been used. The Meso 4D-VAR employs an incremental method to reduce the computational cost. The horizontal resolution of the inner-loop model is 20km. The forward model in the Meso 4D-VAR is the same as MSM except for the horizontal resolution. In the adjoint model, several physical processes are omitted. For the moist processes, large scale condensation and convective adjustment are implemented, but convective parameterization is not implemented. All observed data are assimilated with a temporal resolution of one hour. The observation data assimilated operationally are upper air sounding data, surface observational data, aircraft data, hourly wind profiler data, and Radar-AMeDAS precipitation (RA) data. RA is one hour precipitation data estimated from radars and calibrated with rain gauge data.

In the operation, 6-hour continuous data assimilation, which is realized by two sequential Meso 4D-VAR data assimilations, and 18 hours MSM forecast are performed every 6 hours. The process flow of the operations is shown in Fig. 2.

3. RAIN RATE AND TOTAL COLUMN PRECIPITABLE WATER RETRIEVAL

The assimilated data are rain rate (RR) and total column precipitable water (TCPW) data retrieved from TMI and SSM/I data. TMI and SSM/I are satellite-borne microwave imagers. Some NWP centers assimilate the brightness temperature of SSM/I directly into the NWP models with a radiative transfer model. Meanwhile, the retrieved RR and TCPW are used in this study to reduce the computational cost because the operational Meso 4D-Var should be executed within 20 minutes.

There are a number of studies to retrieve both RR and TCPW from TMI and SSM/I; e.g., Shibata(1994), Kummerow(1997). For this operation, the MSC method developed by Takeuchi and Kurino (1997) is employed. It is a simple statistical method and, therefore, the computational cost is very low. The method is available only over the ocean.

A sample of retrieved RR is shown in Fig.3. Though the correlation of RR with RA data is not so high (0.59), the rain band pattern shows good correspondence between RR and RA. RR is assimilated as the hourly rainfall data, whose observational error is set twice as large as the error of RA data.

In contrast to RR, TCPW showed a good correlation with the value calculated from upper air sounding data (0.98). The observation error of 5mm is used. TCPW data is thinned to one data in a 40km by 40km area.

RR and TCPW are complements to each other since TCPW is not obtained in rain area and RR is not obtained in rain free area. RR assimilation is not effective when the background rainfall rate is zero. Since TCPW data improve the water vapor fields before it forms precipitation, addition of TCPW data bring positive effect to RR assimilation.

4. OBSERVATIONAL SYSTEM EXPERIMENT AND RESULTS

4.1 A case study for rain rate assimilation

A case study of the RR assimilation for the analysis date of 18UTC 18 Jun. 2002 was performed. The assimilated RA data, TMI-RR and analyzed rain fields with and without TMI RR are shown in Fig. 4. With TMI RR, the analyzed rain band over the East China Sea was broadened and the pattern showed better correspondence with TMI RR than that without TMI RR.

4.2 A case study for rain rate and total column precipitable water assimilation

A result from a case study of both RR and TCPW assimilation is shown in Fig. 5. The analysis date is 00UTC 25 Aug. 2003. Without TCPW assimilation, a water vapor concentration area was analyzed over the East China Sea (Fig.5b). However TCPW observation did not show the concentration (Fig 5a). With TCPW assimilation, the concentration was not analyzed (Fig.5c) and showed good correspondence with the observation. MSM forecasts from these initial conditions were performed in this case. RA observation showed that torrential rain occurred at the northern part of Kyushu island after 18 hours (Fig 5a'). The case without TCPW assimilation, a convective system was developed over the East China Sea right after the forecast was started and it moved toward the southern part of Kyushu Island (Fig.5b'). With TCPW, it took much time to develop the convective system over there and to predict heavy rain at the northern part of the island (Fig.5c'). It showed good correspondence with RA observation while the intensity was much less.

4.3 Cyclic assimilation and forecast experiment

To estimate the total effect of the RR and TCPW, an OSE was performed for two weeks starting from 3 Jun. 2003. Considering the real time operation, TMI and SSM/I data received after the cut-off time was not used in the OSE. Meso Analysis was performed cyclically using those additional data. With the resultant initial conditions, 48 forecasts are performed and compared with operational forecasts, in which the satellite data are not assimilated.

The threat scores of weak (1mm/3hour) and moderate (10mm/3hour) rain over Japan are shown in Fig. 6. The both threat scores showed positive impact in the rainfall forecast after 12 hours forecast, while it showed almost neutral before 9 hours forecast. The result can be explained by that the water vapor field over ocean is improved with the additional data and it needs time to flow over Japan islands. In the operational Meso Analysis, RA data has been used and it adjusts rainfall field to RA observations. It makes it hard to identify the difference of the rain score in the first half of the forecast period.

The evaluations for 500hPa height and 850hPa temperature using upper air sounding data are shown in Fig. 7. Both data showed almost neutral or slight improvement. RR and TCPW assimilation does not directly affect dynamic variables such like winds and temperature. However, the modification of water vapor field changes the location where convection develops, and improves the dynamical field.

5. CONCLUSIONS

The OSE for both rain rate and total column precipitable water data from TMI and SSM/I were performed in this study. The assimilation of those data improved the rain and water vapor analysis. And it brought considerable improvement in both weak and moderate rainfall forecast after 12 hours. Moreover, the forecast of 500hPa height and 850hPa temperature was also improved. Undoubtedly, the introduction of those data brought positive effect in MSM forecast.

With the results, JMA decided to use the data in operational MA. It has started from 00UTC 15 Oct. 2003.

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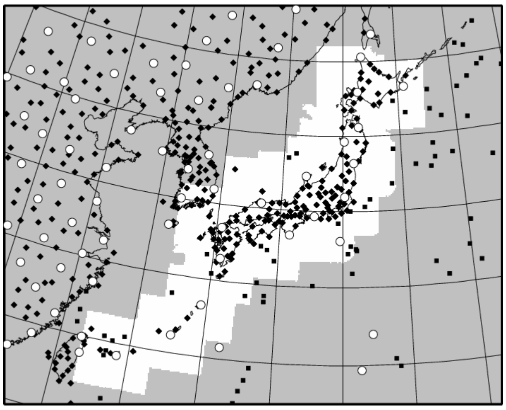

Fig. 1 Domain of MSM. Open circle shows upper air sounding sites, closed symbol shows surface observations, and shade shows out of the coverage of Radar-AMeDAS rainfall observation

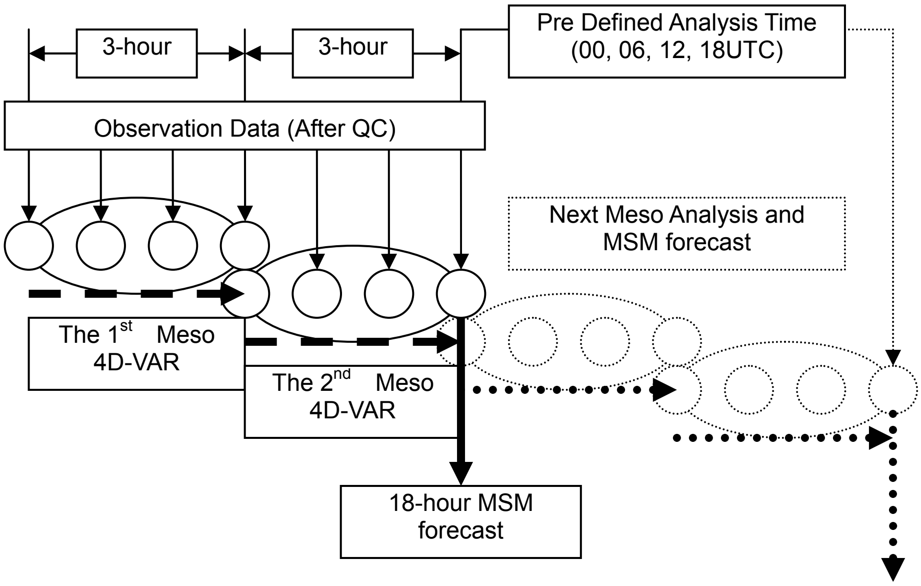

Fig.2 Process flow of JMA operational Meso Analysis and MSM forecast

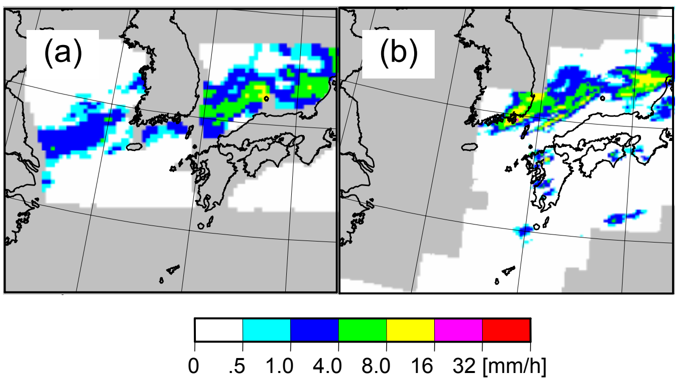

Figure 3. (a) Rain rate retrievd from TMI (1720UTC 18 Jun. 2001) and (b) corresponding Radar-AMeDAS rainfall data (1700UTC on the same day)

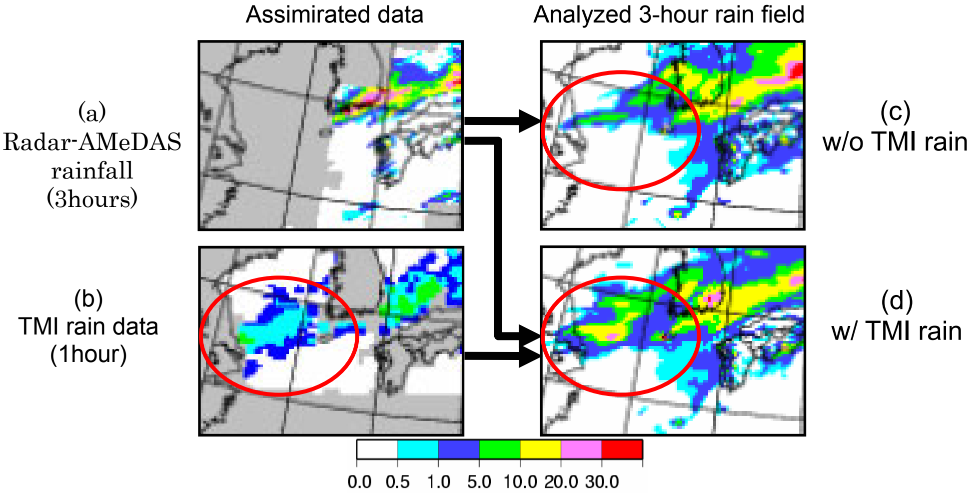

Figure 4. (a) 3-hour Radar-AMeDAS rainfall data, (b) RR data from TMI, (c) analyzed rain field without assimilating RR, (d) with RR assimilation.

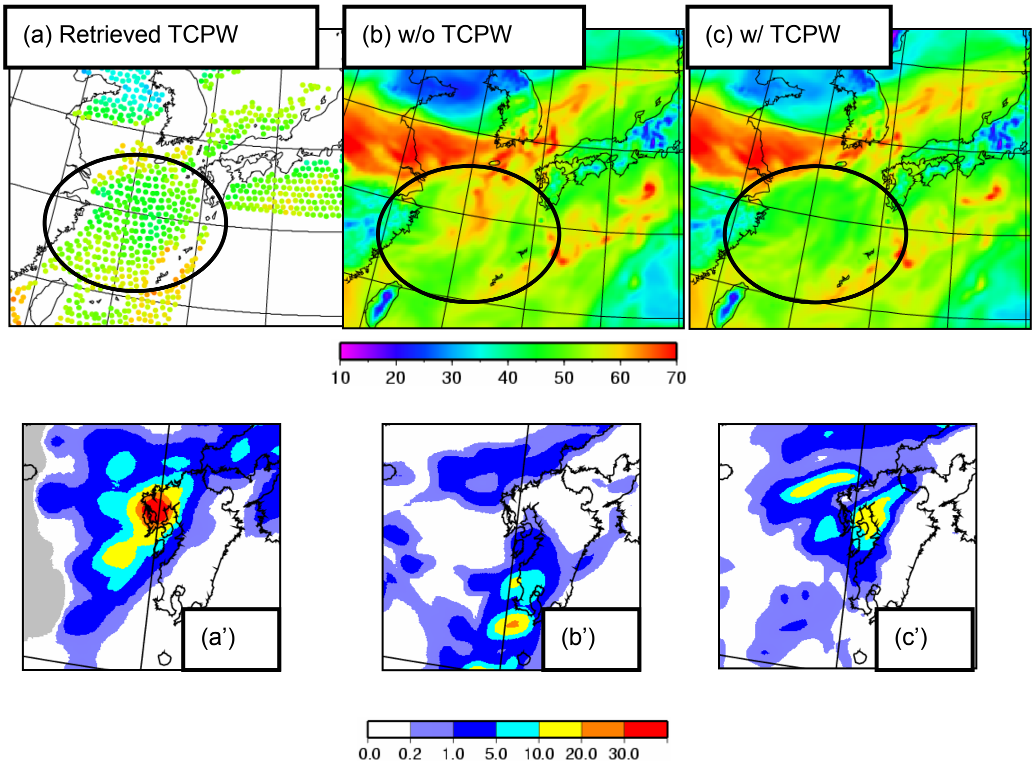

Fig.5 (a) Retrieved TCPW from TMI and SSM/I, (b) analyzed TCPW field without assimilating TCPW data, (c) with TCPW assimilation, (b') and (c') are 3-hour rain forecast after 18 hours from these initial conditions, and (a') is corresponding RA observation.

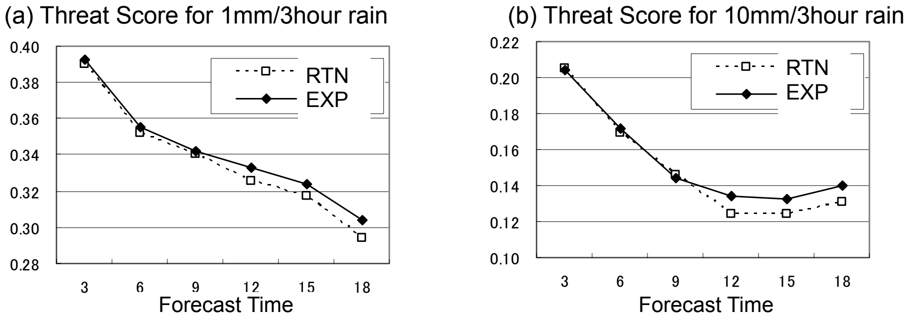

Fig. 6 The threat scores for weak (1mm/3hour) and moderate (10mm/3hour) rainfall forecasts

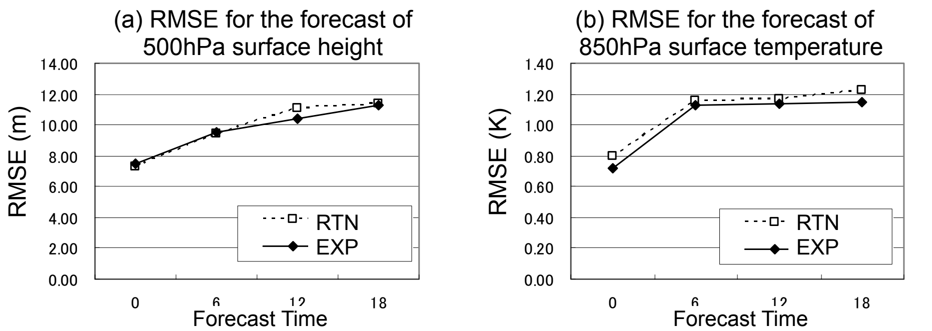

Fig. 7 RMSE of the routine (RTN) and experiment (EXP) forecast against upper air sounding data