Comparison of CRM and surface/radar observations

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1. Introduction

Quantitative evaluation is necessary on the prediction of winter meteorological conditions especially when snowfall happens for disasters related to avalanche and blizzard depend on the small-scale meteorological conditions. The snowfall is also important as water resources in the warm season.

The author and co-workers have compared winter precipitation distributions between radar observations and simulations using a cloud-resolving model (CRM). The simulation successfully reproduced the difference among the features of various winter precipitating cloud systems during the heavy snowfall in December 2005. Although the simulated precipitation variation in a coastline- perpendicular direction seemed quantitatively well reproduced in a level of 1500 m, a large discrepancy was found in the vertical profile of precipitation in levels below 1500 m. While radar-based snow water equivalent (SWE) increased with decreasing height, simulated SWE decreased with decreasing height below 1500 m. The excessive evaporation was suggested in the simulated atmosphere for the comparison with surface observation indicated the underestimation of precipitation and relative humidity. However, they used a fixed relation between precipitation intensity (R) , terminal fall velocity of snow particles (Vt), and equivalent radar reflectivity factor (Ze). The downward increase of Ze may be affected by the change of these relations in the real precipitation.

In this study, the author describes the results of a comparison of simulation data using a CRM and radar/surface observation data. A period during 12 to 18 February 2008 was selected as an analysis period. A continuous snowfall was observed associated with a developing low pressure system and the succeeding outbreak of a winter monsoon in the analysis period.

2. CRM simulations

Numerical simulation of snowfall for the analysis period was carried out at the Snow and Ice Research Center (SIRC), National Research Institute for Earth Science and Disaster Prevention (NIED) through the double nesting of JMANHM. The JMANHM is a non- hydrostatic mesoscale model for research and operational use developed at the Numerical Prediction Division (NPD) of the Japan Meteorological Agency (JMA) and the Meteorological Research Institute (MRI). Details of the JMANHM are described in Saito et al. (2006).

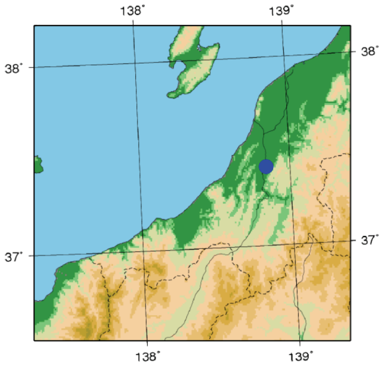

Fig. 1 Domain of the inner model. A solid blue dot indicates the place of this workshop.

Lambert Conformal projection and the terrain-following vertical coordinate system were used for both inner and outer models. The horizontal resolution of outer (inner) model was 10 km (1.2 km). The area of the inner model is shown in Fig. 1. An explicit 2-moment 3-ice bulk cloud microphysics scheme was used in both models. A convective parameterization scheme was not used in both models. The simulation was executed using operational Meso-Scale Model (MSM) forecast as initial and boundary conditions of the outer model. The 3-hour forecast and the succeeding forecast data of the outer model were used as the initial and boundary conditions of the inner model. Data of the inner model of 9 to 20 hour from the initial time of the MSM in 1-hour intervals were used for the analysis.

3. Observation data

The CRM simulation was compared with surface station data and radar observations. The data of SIRC observation field and 18 JMA stations (the Automated Meteorological Data Acquisition System: AMeDAS) were used as the surface station data. The lack of data was treated basically in accordance with the JMA guideline and was taken into consideration in the comparison with the simulation.

The simulated mixing ratio of snow (graupel) particles Qs (Qg) (g kg^{-1}) was compared with Ze (dBZ) observed by the XPOL radar (Iwanami et al., 1996) located at SIRC. The Qp was the sum of the mixing ratios of rain, snow and graupel. The Ze was on a Cartesian coordinate system in a horizontal (vertical) resolution of 1 km (500 m) converted from 12-elevation volume scan data in 10-minute intervals.

4. Comparison results

4.1 surface meteorological elements

A comparison of the simulation and surface observation of 19 stations (18 JMA stations and

SIRC) was made. Mean error (ME) and root mean square error (RMSE) of surface meteorological elements were calculated. The ME of temperature was between 0.5 K and 1K at many points except three coastal stations (ME ~ 0 K) and two inland stations (ME <0K). Many of the stations showed negative bias in simulated daily precipitation between -5 mm and 0 mm, except four stations located near or between mountains. No station showed ME of more than 1 mm in daily precipitation. The average values of 19 stations were:

	ME	RMSE
Temperature	0.43	1.41
Daily precipitation	-4.78	10.01

4.2 precipitation

The precipitation during the analysis period was manually divided into 14 cases using the Ze distributions in a level of 1500 m. Each case was classified to a specific type of mesoscale precipitating cloud system (Nakai et al. 2005).

Case 11 was a period of meso-beta scale vortices moving in west-east direction and accompanied by a significant change of wind direction in the Doppler velocity field after the passage (Fig. 2a). The prevailing snow particle type was rimed snowflakes and aggregates according to the observation at SIRC. Similar snowbands in the same west-east running direction were reproduced in the simulation although the time evolution of the cloud features was several hours earlier than observation. Figure 3a is a west-east vertical section of Qs and Qg averaged in the north-south direction over a box surrounding the snowband. The Qs was larger than Qg by one order of magnitude. It seems that the composition of the precipitation particles was well simulated.

Case 5 was a period of longitudinal snowband moving in a direction of west-northwest to east-southeast (Fig. 2b). Graupels dominated the precipitation particles according to the observation at SIRC. Longitudinal snowbands were reproduced although the running direction was slightly different. Figure 3b is a west-east vertical section of Qs and Qg averaged in the north-south direction over a box surrounding the snowband. The Qs was much larger than Qg. It is obviously different from observed characteristics of precipitation particles.

5. Summary

The results of numerical simulations were compared with surface station data and radar observations for the period of one week in the middle of February 2008. The simulation result is applicable to the point-to-point comparison although there are problems to be solved for the quantitative reproduction of meteorological variables. Heat, moisture and momentum transport in the surface boundary layer should be re-examined for the simulation of the station data. The quantitative validation on microphysical characteristics of each type of precipitating cloud systems is essential to the improved prediction and radar estimation of solid precipitation.

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References

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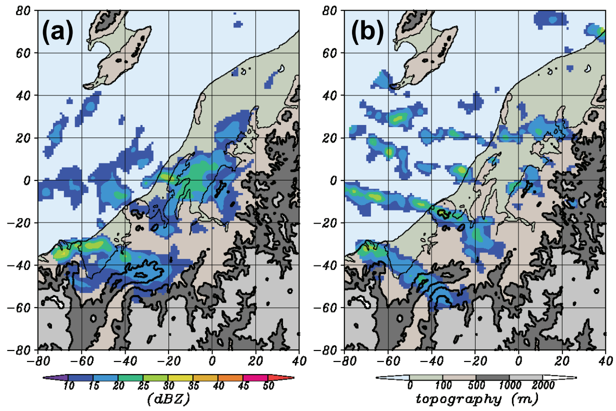

Fig. 2. Ze distribution in a level of 1500 m. Absscissa and ordinate are the distance from radar located at SIRC. (a) 1723 JST February 16, 2008, and (b) 0003 JST February 14, 2008.

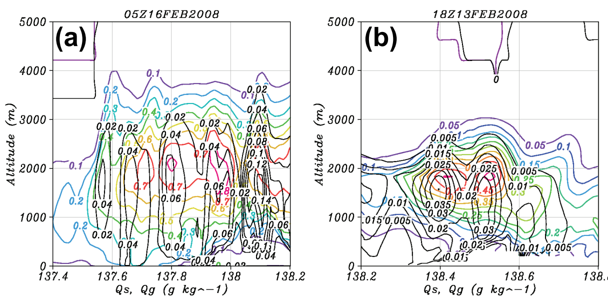

Fig. 3. West-east vertical sections of Qs and Qg averaged in the north-south direction over a box surrounding snowbands. (a) 05 JST February 16, 2008, and (b) 18 JST February 13, 2008.