NUMERICAL SIMULATION OF HEAVY SNOWFALL SYSTEMS OBSERVED ON THE SOUTHERN COASTAL AREA OF SEA OF JAPAN ON 16 JANUARY 2001

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1. INTRODUCTION

On 12-16 January 2001, a heavy snowfall was observed in Joetsu area, the western part of Niigata prefecture, Japan(in Fig. 1). The snow depth on the ground increased 1 m 40 cm deep during 5 days in Joetsu city. The snowfall was mainly induced by quasi-stationary band-shaped snowfall systems. They elongated east and west along the southern coast of sea of Japan. In this study, we tried to reproduce this snowfall system using a cloud resolving model, and investigated its structure and environmental field.

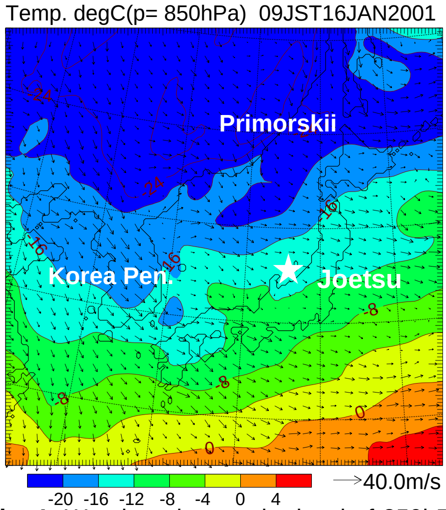

Fig. 1: Weather chart at the level of 850hPa on 09JST 16 January 2001. Contours and arrows denote temperature (deg C) and wind vector field respectively. Star mark presents the location of Joetsu city.

2. OBSERVATIONS

Fig. 1 shows the air temperature and wind fields at the level of 850hPa on 09JST 16 JAN. 2001. A continental strong cold air had flowed out over Sea of Japan. Two major cold air streams were seen. One is mainly north-westerly flow from Primorskii to the northern part of Japan, another is mainly westerly flow from Korea Pen. to the western part of Japan. Joetsu area is located down the former stream.

A remarkable snowband was observed in Joetsu area on 16 January by JMA Niigata operational radar. Fig. 2a shows a horizontal distribution of hourly precipitation intensity deduced from radar at 1400JST. This snowband was about 200km in length and about 50km in width and aligned in an east and west direction at coastal area. Fig. 2b shows a temporal variation of precipitation intensity along 138E in Fig.2a. This snowband was quasi-stationary during a whole day and caused 40cm snowfall in Joetsu city.

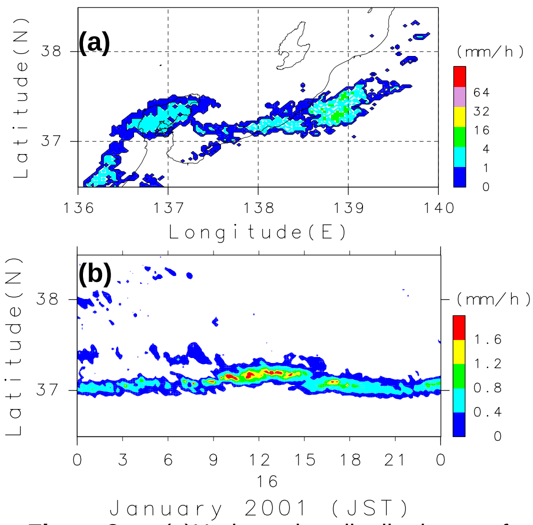

Fig. 2: (a)Horizontal distribution of precipitation intensity observed by the JMA Niigata operational radar at 1400JST 16 January 2001. (b)Time-latitude (along 138E in (a)) cross section of precipitation intensity.

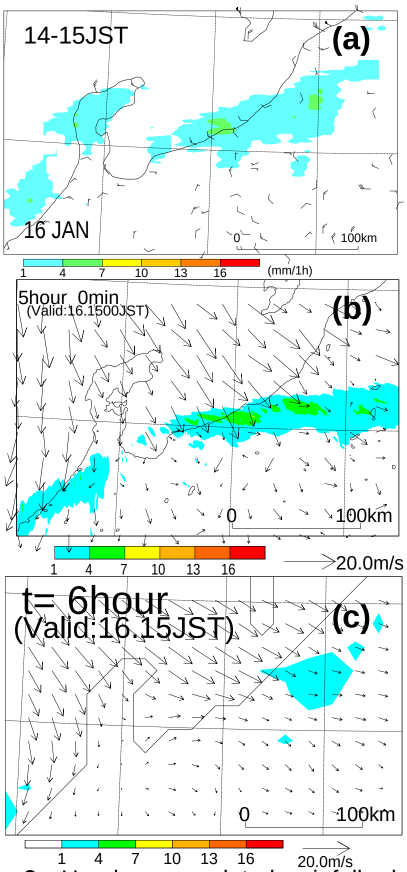

Fig. 3: Hourly-accumulated rainfall charts from 1400JST to 1500JST on 16 January 2001. (a) Observation, (b) 1km-NHM simulation, and (C) RSM simulation.

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3. NUMERICAL MODELS

The elastic version of the Meteorological Research Institute/Numerical Prediction Division,JMA unified nonhydrostatic model (MRI/NPD-NHM: Saito et al. ,2001) was used. The calculation domain has 300x300x38 horizontal and vertical grids. The cloud-physics in the model contains the cold rain scheme. The MRI-NHM with a 1-km horizontal grid(1km-NHM) is one-way nested within the forecast of the MRI-NHM with a 5-km grid(5km-NHM). The initial and boundary conditions for a 5km-NHM are provided from output produced by Regional Spectral Model(RSM), which is a hydrostatic model used operationally in the Japan Meteorological Agency. The 5km-NHM is one-way nested within the RSM forecast with the initial time 09JST 16 Jan.2001.

4. RESULTS

4.1 STRUCTURE OF SNOWBAND

Fig. 3 shows hourly-accumulated snowfall charts form 1400JST to 1500JST. The snowfall areas and intensity simulated by the 1km-NHM (Fig.3b) well corresponded with the observations(Fig. 3a), while the RSM with a 20-km grid simulated the intensity considerably weaker and the area broader(Fig. 3c).

Fig. 4 shows the horizontal distribution of snow mixing ratio simulated by the 1km-NHM between 1400JST on 16 January 2001 (4 hour forecast). The convective cells in the simulated snowfall system, which are about 10km in horizontal scale and about 4km in vertical scale, propagate east-southeastward at a speed of about $10 ms^{-1}$. The direction and speed of cell's motion roughly correspond with those of the wind in the system. They spread in a eastward direction.

4.2 ENVIONMENTAL FIELD OF SNOWBAND

Fig. 5 shows the horizontal distribution of vertical difference of equivalent potential temperature between about a 1.2km height and the surface. On the northern side of the snowfall system, a convectively unstable atmosphere is observed in the lower layers, accompanying with the environmental winds that veered to the northwest toward the surface.

Fig. 6 presents the horizontal distribution of potential temperature and wind field near the surface. In the coastal area of Toyama and Ishikawa prefectures, a cold air pool is observed. The convergence zone is formed by a cold air outflow and the warmer northwesterly wind. The snowband developed over this convergence zone.

This simulation shows that the snowfall system formed as a result of convectively unstable marine atmosphere in the lower layers from the northwest flowing into the coastal convergence region. The convective cells in the system were carried to the downwind side by the mean wind in the system, and developed by the inflow of convectively unstable atmosphere in the lower layer from the northern side of this system.

5. SUMMARY

By using the cloud resolving model nested in the operational regional model, observed features of the band-shaped heavy snowfall system was well reproduced. The system contained several convective cells with about a 10km length and about a 4km height. The inflow of convectively unstable marine atmosphere in the lower layers were significant for the formation and maintenance of these snowfall system

Reference

Saito, K., T. Kato, H. Eito and C. Muroi, 2001: Documentation of the Meteorological Research Institute/ Numerical Prediction Division Unified Nonhydrostatic Model. *Tec. Rep. MRI*, **42**, 133 pp.

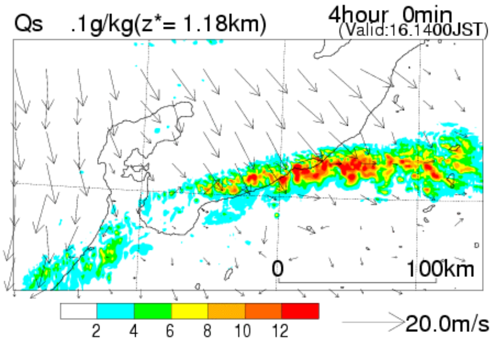

Fig. 4: Time series of 1km-NHM simulated snow mixing ratio (0.1g/kg) at z*=1.18km with surface horizontal wind vectors between 1400JST(4hour forecast) and 1450 JST (4hour 50min forecast) with 10 minutes.

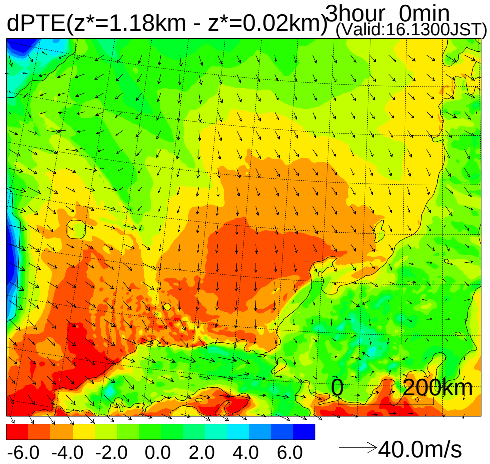

Fig. 5: 5km-NHM simulated horizontal distribution of vertical difference of equivalent potential temperature between about 1.2km height and surface on 1300JST 16 January 2001(3 hour forecast). White and black vector denote horizontal wind at about 1.2km height and surface, respectively.

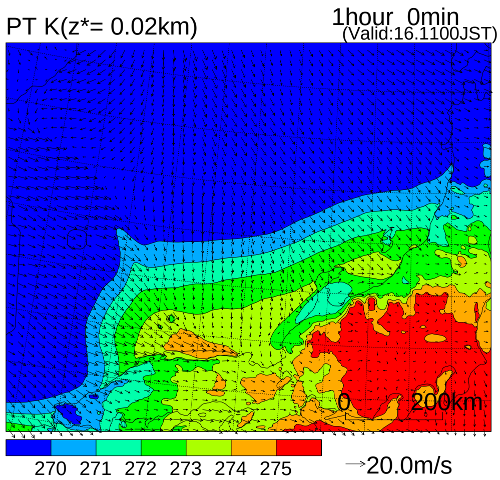

Fig. 6: 5km-NHM simulated horizontal distribution potential temperature at surface on 1100JST 16 January 2001 1 hour forecast). Vector denotes horizontal wind at surface.