PRELIMINARY COMPARISON OF AMSR-E OBSERVATION AND NUMERICAL SIMULATION WITH CLOUD RESOLVING MODEL FOR SOLID PRECIPITATION IN WINTER DURING THE WAKASA 2003

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1. INTRODUCTION

For improving the accuracy of passive microwave solid precipitation retrieval algorithm using the AMSR/AMSR-E, the feild campaign (WAKASA2003) was conducted in the Fukui area, Japan, from January 12 to February 5, 2003. During the WAKASA2003, many active convective snowfall clouds frequently formed over the Sea of Japan due to cold outbreak. On 28-29 January 2003, broad cloud bands extending southeastward from the base of the Korean Peninsula to the Fukui area formed, and developed under the influence of the upper cold low. In this paper, high-resolution numerical simulations of these cloud bands are performed using a CRM with 1 km horizontal resolution. The expected brightness temperatures simulated by microwave radiative transfer model (MRTM) with CRM-derived atmospheric conditions were compared with AMSR-E observations. Our purposes are to check and improve the cloud microphysics scheme of the CRM, and to supply useful information from the model-derived 3-D structures of precipitation for improving the accuracy of the AMSR-E precipitation retrieval algorithm.

2. OBSERVATIONS

Figure 1 shows the GMS-5 visible imagery at 13 JST on 29 January 2003. Several clouds were found over the Sea of Japan, as a consequence of heat and moisture supply to continental cold air mass. The remarkable cloud bands, where cumulus convections developed, were distributed over the Sea of Japan from the base of the Korean Peninsula to the Tohoku district of Japan. It is well known that these cloud bands form over the low-level convergence zone (Japan Sea Polar-air mass Convergence Zone; JPCZ) between two cold airflows with different property (Nagata et al., 1986; Nagata, 1991; Nagata, 1992). These cloud bands formed in the previous day (28 Jan.), and developed under the influence of upper cold low (Fig. 1).

In this time, there are observations of AMSR-E, which is a microwave radiometer aboard AQUA satellite. Figure 2 is the scattering index retrieved from 89 GHz britness temperature of AMSR-E. Colors varying from black to white correspond to increasing scattering. The areas with large scattering index, where a amount of snow and graupel perticles is large, were distributed over the Sea of Japan. These areas well corresponded to high radar reflectivity intensity areas observed by JMA operational radar(not shown).

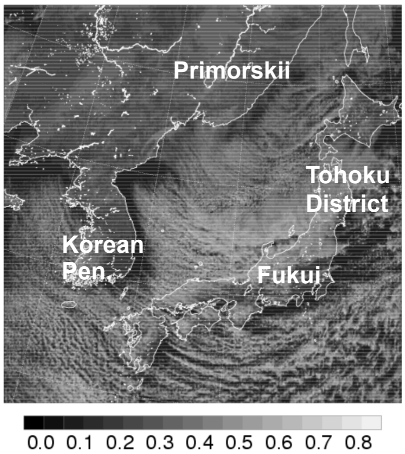

Fig. 1: GMS-5 visible imagery at 13 JST on 29 January 2003.

3. NUMERICAL MODELS

The CRM developed by Japan Meteorological Agency (JMA) is used in this study (JMA-NHM: Saito et al., 2001). The fully compressible equations with the conformal mapping are employed as the basic equations of the JMA-NHM. Primary physical processes such as cloud physics, atmospheric radiation and mixing in the planetary boundary layer are also included in the JMA-NHM. The bulk cloud microphysics scheme is employed in the JMA-NHM. This scheme predicts the mixing ratios of six water species (water vapor, cloud water, rain, cloud ice, snow and graupel) and the number concentrations of five condensed water species. The JMA-NHM has been transferred to the Earth Simulator (ES), which is the fastest supercomputer in the world. In the present study, the JMA-NHM has a horizontal grid size of 1km with 2000 x 2000 grid points. The vertical grid with a terrain-following coordinate contains 38 levels with a variable grid interval of 40 m near the surface and 1090 m at the top of the domain. The model top is 20.36 km. The time step interval is 5 seconds. The initial and boundary conditions for the JMA-NHM are provided from output produced by Regional Spectral Model (RSM). The RSM with a horizontal grid size of about 20km is a hydrostatic model used operationally in JMA. Radiative transfer calculations are performed with a 4 stream MRTM (Liu, 1998). It includes absorption and scattering by hydrometeors to calculate the expected microwave brightness temperatures corresponding to the atmospheric conditions simulated by the JMA-NHM.

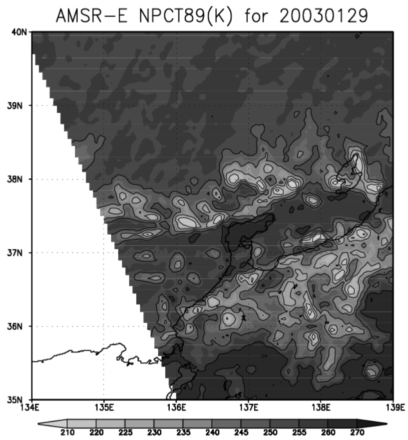

Fig. 2: Scattering index retrieved from 89 GHz brightness temperatures of AMSR-E at 13 JST on 29 January 2003.

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4. RESULTS

Figure 3 shows a horizontal distribution of vertically integrated total condensed water simulated by the JMA-NHM. The JMA-NHM successfully reproduced features of broad cloud bands. In particular, model-simulated cloud bands resembled observed one (Fig. 1) in shape and location. Detailed features of several cloud streets were also simulated around cloud bands. Figure 4 shows a horizontal distribution of scattering index calculated from 89 GHz brightness temperature simulated by JMA-NHM and MRTM. The spatial structures of the simulated scattering index almost agree with that of AMSR-E observation (Fig. 2). However, the contrast between high and low scattering in simulation is stronger than that in AMSR-E observation. The magnitude of scattering index in simulation is much larger than that in observation. These results indicate that the JMA-NHM overestimated the amount of solid water particles. It is presented in the horizontal distributions of vertically integrated values of each solid water particles that most of model-simulated precipitation particles were snow particles(not shown). The maximum value of total snow water is ~ 6 kg m^{-2}. This value was almost equivalent to that of total precipitable water. In comparison with aircraft observations for each parameters of snow, JMA-NHM-simulated number concentrations (~ 100 /l) and averaged diameters (~ 0.5 mm) are almost reasonable. However, an amount of simulated water contents (~ 1.0 gm^{-3}) is larger than that in observation (~ 0.5 gm^{-3}). These gaps in the amount of snow between observation and simulation indicate the necessity of tuning and improvement of the cloud microphysics process in the JMA-NHM.

The same experiment was also conducted on the case in the previous day (not shown). In this case, cloud bands, of which cloud top height was about 3 km, were in the moderate stage. On the comparison of AMSR-E observation and numerical simulation, almost similar aspects shown in the developed case were also found in this case. However, a better agreement about a degree of the scattering was obtained between the simulation and the observation This result indicates that defferences of dvnamic structures such as the intensity of updraft and the cloud top height also affect the amount of model-simulated solid precipitation particles.

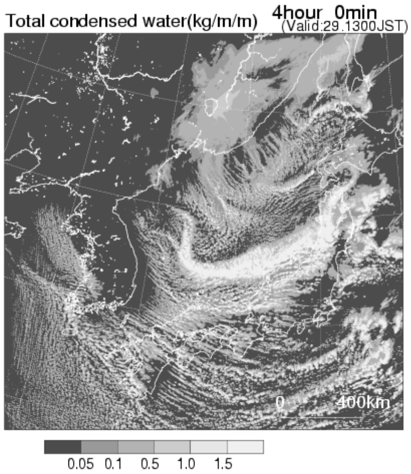

Fig. 3: Horizontal distribution of vertically integrated total condensed water simulated by the JMA-NHM (4 hour forecast).

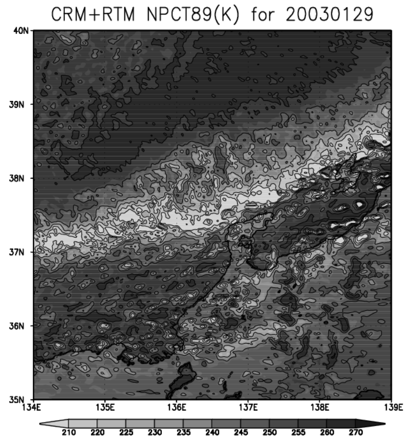

Fig. 4: Scattering index calculated from 89 GHz brightness temperatures simulated by MRTM with JMA-NHM -derived atmospheric conditions retrieved at 13 JST on 29 January 2003.

5. SUMMARY

A high-resolution wide-range numerical simulation of cloud bands observed on the Sea of Japan during the WAKASA2003 was performed using a CRM with 1km horizontal resolution and 2000 x 2000 km calculation domain. Cloud features observed by a meteorological satellite were well reproduced in CRM. Comparison of AMSR-E observation and simulation with CRM and MRTM suggests that CRM overestimates the amount of solid water particles, especially, snow particles. It is necessary to examine the process of cloud microphysics in the model and also to carry out the comparison with the other cases.

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