Characteristics of cloud microphysics in the JMA nonhydrostatic model on solid precipitation forecast

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1 Introduction

The Japan Meteorological Agency(JMA) has been operating a nonhydrostatic meso scale model (MSM) with the horizontal grid spacing of 5km. The main purpose of the operation is to provide information contributing to preventing natural disasters such as heavy rain and snow.

The JMA is also developing a model with the finer horizontal grid spacing of 2km to contribute to the aviation forecast and more detailed information for disaster prevention. We call the model LFM (Local Forecast Model). As a part of the development, the Numerical Prediction Division of the JMA has operated the LFM experimentally since July 2007. The computational domain of the experiment covers with $300 \times 300\text{km}^2$ area (red solid square in Figure 1). It includes a plain facing the Pacific Ocean where heavy snow events rarely occur. Through the experimental operation, we have found that the LFM is superior to the MSM in prediction of heavy rain. We are planning to extend the computational domain for next experiment. The Sea of Japan side of the Japan Islands, where heavy snowfall events often occur, is going to be included in the domain. Snowfall events will be important forecast objectives. We should understand characteristics of the LFM on solid precipitation through some case studies.

Purposes of this presentation are to investigate (i)how the LFM can represent snow cloud and fall compared to observation and the MSM, (ii)what differences of characteristics of water content between the LFM and the MSM are.

2 Forecast models

Both forecast models of the LFM and the MSM are based on JMA-NHM(Saito et al. 2006). The differences between the two models are their resolution and moist processes. The MSM uses cloud microphysics (Lin et al. 1983; Murakami 1990) together with Kain-Fritsch (KF) type cumulus convective parameterization because the horizontal grid spacing of 5km is too coarse to represent cumulus convection explicitly. On the other hand, the LFM with higher horizontal grid spacing of 2km uses only the cloud microphysics to represent convection explicitly.

3 Case study

A snowfall event occurred around the Sea of Japan side of Japan Islands on 9 January 2009. The daily amount of snowfall on 10 (15UTC 9 to 15UTC 10) January 2009 was recorded 67cm at Daisen(located at the altitude of 875m), and 32cm at Tottori (located at the altitude of 7.1m) observatory stations (Figure 1). The synoptic situation showed an upper trough and cold air were located over western side of the Japan Islands. The lower atmosphre was warm and moist. Thus, the atmosphere was potentially unstable over the region (Figure 2).

Figure 3 show accumulated precipitation of observation, the MSM and the LFM from 18-21UTC 9 January 2009. Both of the models can represent precipitation around the northeastern side of the surface convergence line, and a snowfall along the Chugoku Mountains well. But the models tend to precipitate snow more than observation on the Chugoku Mountains. Though precipitation represented by the two models is similar to the observation, the water content in the atmosphere differs between the two. Figure 4 shows forecasted vertically integrated snow at 21UTC 9 January 2009. The MSM forecasts the snow broadly. The distribution of the snow cloud is corresponding to the region where the level of neutral buoyancy is high. When cloud ice generated by the KF scheme is removed as a sensitive study, the amount of the snow cloud was reduced (not shown). This result suggests that the broad snow cloud was converted from cloud ice with the help of the KF scheme and the KF scheme is sensitive to the static stability of the mosit atmosphere. On the other hand, the LFM concentrates the snow cloud and cloud water around the northeastern side of the surface convergence line. The alignment of cloud clines and positive vertical velocity are perpendicular to the surface convergence line and parallel to the vertical wind shear vector (Figure 5). The convective patterns are qualitatively similar to eigen modes derived from linear theories (Asai 1970; Asai 1972). That suggests the LFM represents the snow cloud and the convection explicitly.

4 Summary and future plans

In the case study, both the MSM and the LFM can represent total precipitation well comparing with the observation. However, both of the models tend to be sensitive to the orography and to concentrate much snowfall on the mountain. The structure of the cloud differs between the two models. The main causes of the difference seem to the sensitivity of the KF scheme to the static stability of the moist atmosphere, and explicit/implicit expression of the convection. The convective pattern forecasted by the LFM is qualitatively consistent with eigen modes derived from the linear theories. In the future, we have to investigate more cases and verify statistically through the next experimental operation to identify whether these characteristics are general or not.

References

Asai, T., 1972: *J. Meteor. Soc. Japan.*, **50**, 525-532

Lin, Y.-L. et al., 1983: *J. Climate. Appl. Meteor.*, **22**, 1065-1092

Murakami, M., 1990: *J. Meteor. Soc. Japan.*, **68**, 107-128

Saito, K. et al., 2006: *Mon. Wea. Rev.*, **134**, 1266-1298

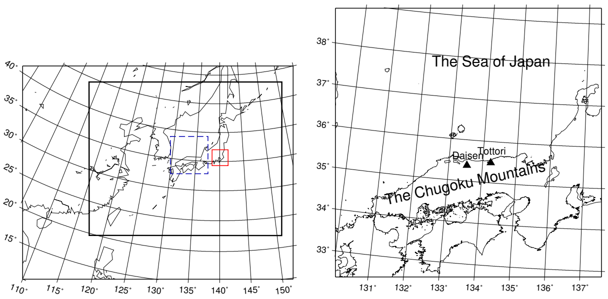

Figure 1: Left:computational domains of the MSM(thick solid square colored by black), the LFM for the experimental operation(thin solid square colored by red), and the LFM for this presentation(thin dashed line colored by blue). Right: detailed map of the computational domain for the LFM.

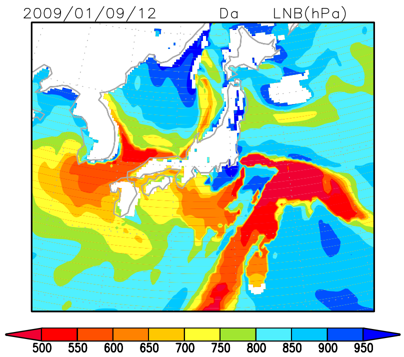

Figure 2: Level of neutral buoyancy (hPa, approximating potential level of cloud top) at 12UTC 9 January 2009

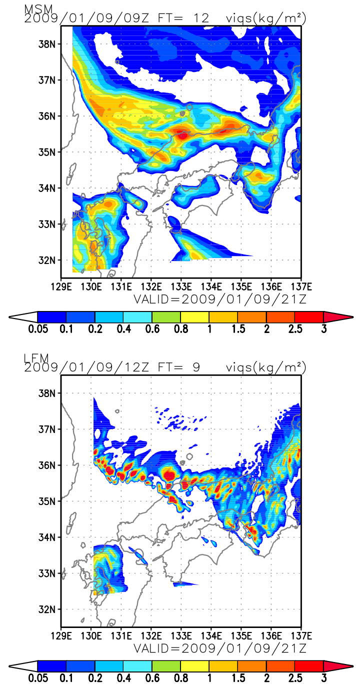

Figure 4: Vertically intergrated snow in the atmosphere at 21 UTC 9 January 2009. Top: the MSM. Bottom: the LFM

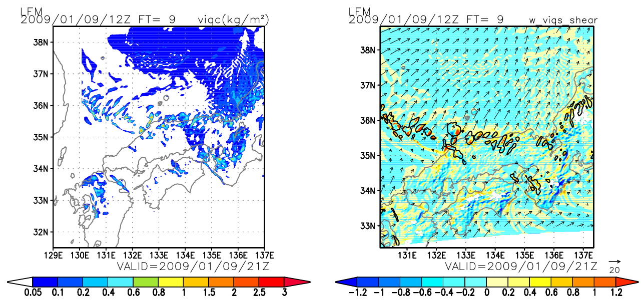

Figure 5: Left: Vertical integrated cloud water in the atmosphere, Right:Vertical velocity at the height of 1000m (m/s, shade) and difference of wind vector between the height of 3000m and 100m (m/s, vector) at 21UTC 9 January 2009.

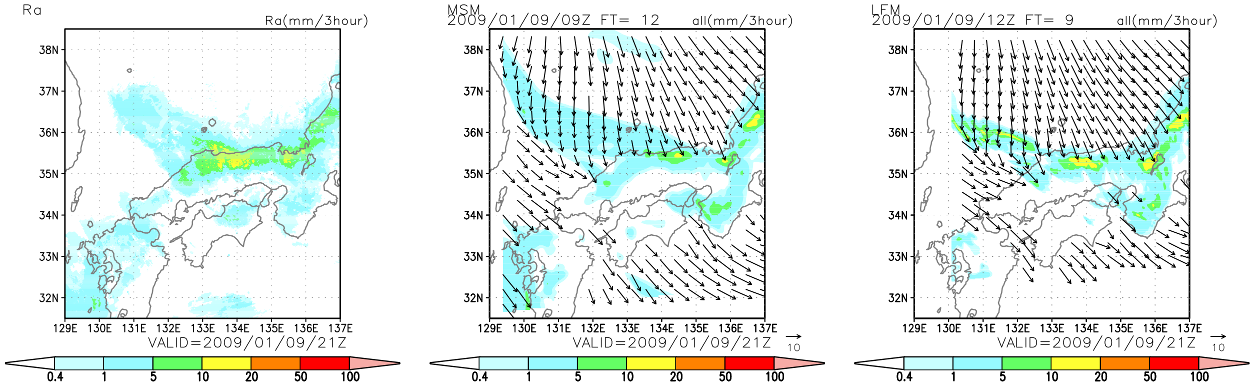

Figure 3: Accumulated precipitation from 18-21UTC on 09 March 2009. Left: Observation(derived from radar data corrected by rain gauge data). Center:the MSM. Right: the LFM