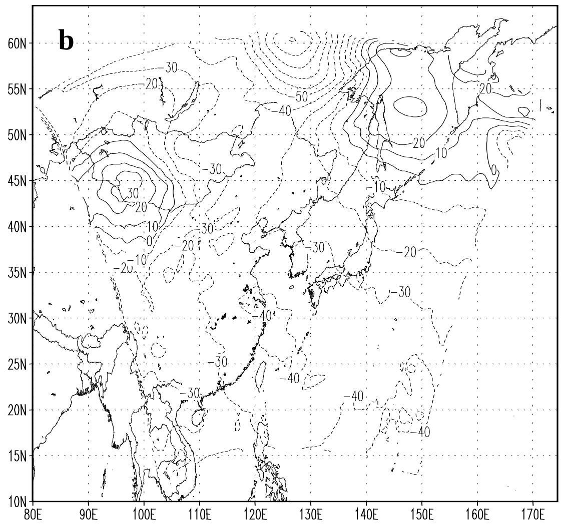
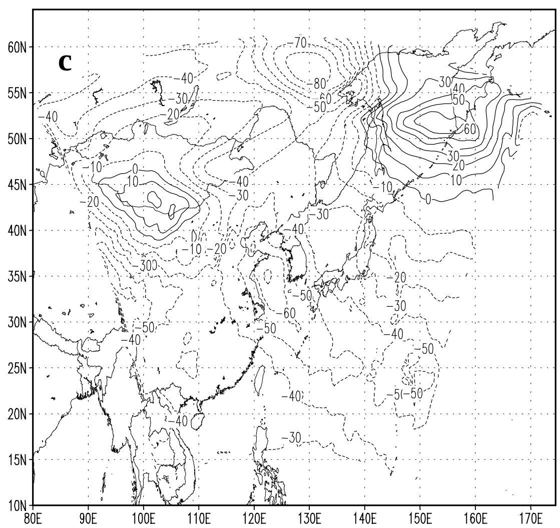
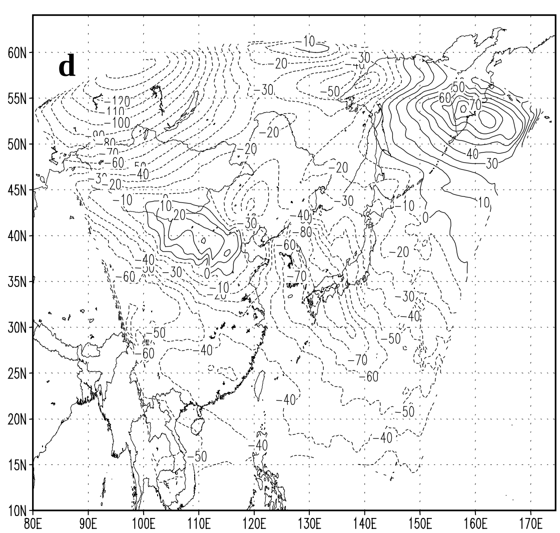
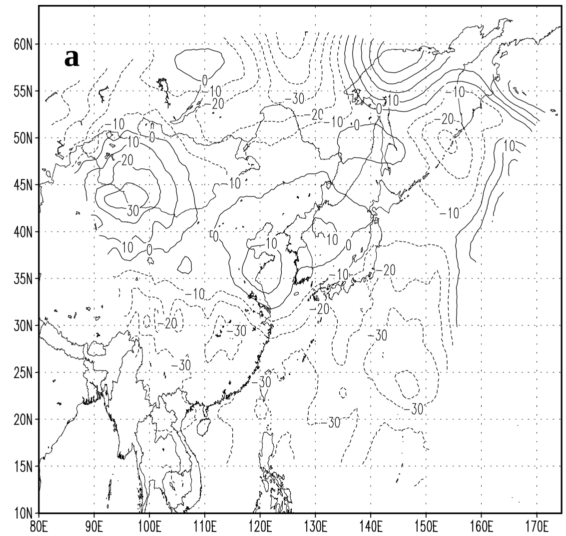
Fig. 4 The difference of geo-potential height at 500hPa for the (a) 12h, (b) 24h, (c) 36h, and (d) 48h forecast results of MM5 at KMA between using GDAPS forecast and GDAPS analysis as LBC.









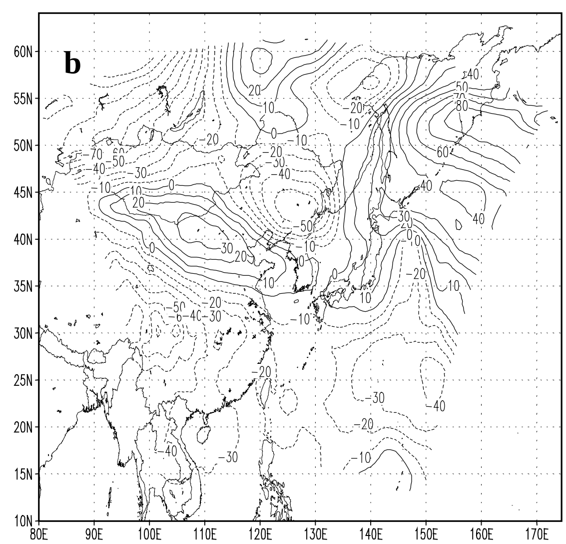


Figure 5. The difference of the geo-potential height at 500hPa for the (a) 24h and (b) 48h between GDPAS forecast and GDPAS analysis

limitation to regional numerical weather prediction., Bull. Amer. Meteor. Soc., 78, 2599-2617
Ronald, M. Errico, Tomislava Vukicevic, and Kelvin Raeder, 1993: Comparison of initial and LBC sensitivity for a limited-area model. , Tellus, 45A, 539-557
Vukicevic, T., and R.M. Errico, 1990: The number of artificial and physical factors upon predictability estimates using a complex limited-area model. Mon. Wea. Rev., 118, 1460-1482

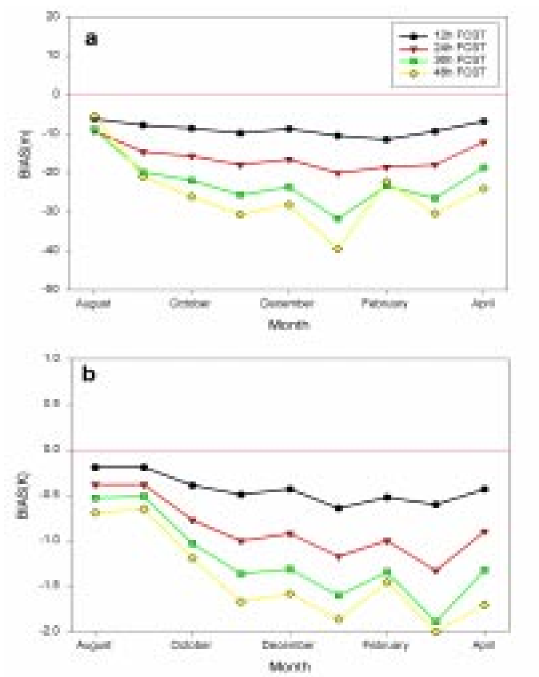


Figure 1. Mean monthly bias for 12, 24, 36, 48h forecasts of (a) 500hPa geo-potential height and (b) 850hPa temperature

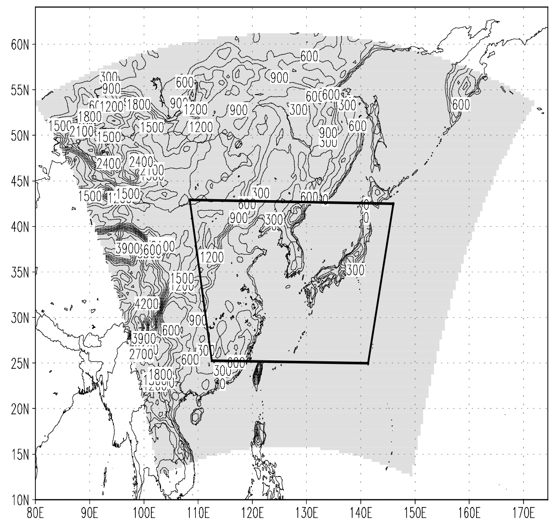


Figure 2. Domain used in MM5 at KMA and the area for verification.

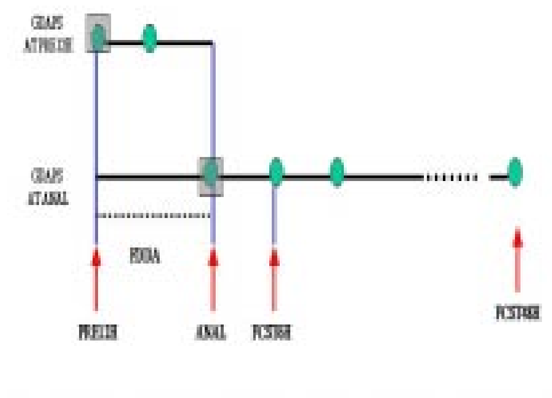
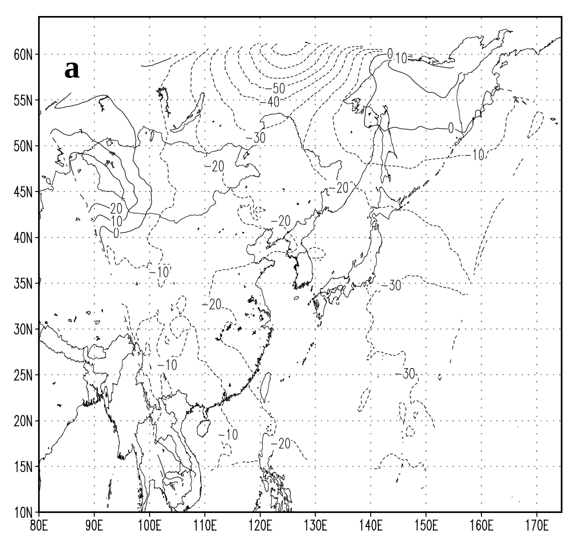


Figure 3. The initialization of MM5 at KMA



Baumhefner and Perkey(1982), the speed of this case is about double one.

The negative bias is reduced by 10, 30, 60gpm for 24, 36, 48 hour projection respectively in the 500hPa geo-potential field in the experiment extending the west boundary to the west by around 30 degree. However these still exists the negative bias, which imply that the spurious noises around the Tibetan plateau may not a major factor for the negative bias.

Replacing the relaxation boundary condition with the Perkey-Kreitzberg method which consists of linearly combining specified time-dependent tendencies at the boundaries and the first three grid points inside the boundaries (Baumheiner et al, 1982) make little differences. So this problem is almost independent of selecting the LBC formulation at least for this case.

The use of the FDDA can have both a positive and negative effect on the influence of LBC. The pre-forecast integration period will allow LBC errors to propagate closer to the domain center. (Thomas et al. 1997) In this case using the FDDA makes the negative bias deepened. For the 24, 36, 48h forecast, the difference of 20, 30, 60gpm respectively at the 500hPa geo-potential field for the Korean Peninsular from the control run is deteriorated.

Even if there is the negative bias in the initial field, that is less significant than in the LBC. A major portion of the initial difference is quickly dissipated, unless some other process of error growth compensates for this loss. (Errico,1987) So, the probability of that the bias seriously related with the initial field which is indirectly comes from GDAPS analysis is not considered here.

Through those above five experiments it could be thought that the negative bias comes from the LBC which GDAPS offers with some certainty.

4. Experiments to reduce the negative bias

The following three experiments were conducted to attempt to correct the bias in the current operational MM5 at KMA: the forecast (1) doubling of the update period of LBC from 6 to 12, (2) reduction of relaxation coefficients in the LBC.

The negative bias if reduced after 36 hours by 30gpm in the 1st experiment. The negative bias is reduced by 30,30,10 gpm for 24,36,48 hours projection respectively for the 500hPa geo-potential in the 2nd experiment.

However it is noted that the relaxation coefficient affect both on Newtonian term and diffusion term.

5. Discussion and Plan

In spite of advancement in numerical weather prediction (NWP), lateral boundary condition is still a limiting factor to predictability in a Limited-area models(LAMs)(Thomas et al., 1997). In this case, the systematic bias in the coarser–mesh model comes into the interior of the LAM. In addition, there is a great possibility the generation of spurious noises around the LBC in the west where Tibetan plateau is located.

Considering that the model is needed to be run operationally, it cannot be easily avoided to use the LBC which comes from GDAPS and to collocate the west LBC in the high terrain. Here, the pragmatic remedy for removing the systematic bias should be considered.

At first the method to remove the bias have to be tried. One is that a realistic structure of the pre-process for averting or modifying the systematic bias comes from GDAPS is to be built. Though there is still negative bias in the GDAPS analysis, it is much better to use it as LBC instead of GDAPS forecast only for the FDDA time when the data is able to be available. So the GDAPS analysis will be replaced for the current GDPAS forecast as the LBC during the nudging duration. After doing experiments run with this new preprocess structure, the results will be shown.

Secondly the adjustment of the LBC formulation can be thought. Thomas et al. (1997) said the use of appropriately engineered LBC algorithms can generally reduce the amplitude of the significant error mode propagation to accept levels. So, employing well-tested and effective LBC formulation for the situation will be considered after doing further experiments.

At then the more academic approach for this is to be done. Which variable and which level initiate and drives the bias is to be known. In addition the process of the negative bias affect the forecast should be clearly understand

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Systematic Bias in MM5 at KMA

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1. Motivation

A Regional Data Assimilation and Prediction System (RDAPS), based on the MM5V2 with hydrostatic dynamics, was implemented on SX-5 supercomputer at Korea Meteorological Administration in June 1999. The RDAPS has been regularly run twice a day for 48-h projection of mesoscale circulation with unit grid distance of 30-km over northeast Asia.

The verification has been performed for the last 9 months from August 1999 to April 2000. It is shown in Fig. 1 that the RDAPS has a negative bias in the geo-potential height and temperature.

Several experiments were designed to identify the source of negative bias, and to find out an appropriate corrective measures. Those experiments are mostly associated with the sensitivity of initial condition and lateral boundary condition (LBC) on the systematic bias, understanding that the LBC is provided from the global spectral model GDAPS(Global Data Assimilation and Prediction System). The physical process may attribute on the systematic bias in the RDAPS, which however is beyond the scope of current research

2. Configuration of the MM5 at KMA

As you can see in Fig. 2 the domain covers east of Asia and a lambert conformal mapping is used. The gird consists of 171X191 points oriented approximately east-west north-south, centered at 38N and 126E with a grid spacing of 30km. There are 24 pressure layers for objective analysis and 33 sigma layers for integration.

The first guess field for the initial conditions come from GDAPS analysis and interpolated to the MM5 grid. Lateral boundary values are specified as function of time the same spatially interpolated GDAPS forecast. A Four-dimensional data assimilation (FDDA) is performed. Those the process for initialization at KMA is shown in Fig. 3

Integration time step is a 50 seconds. The reason for using the smaller time step is cause by the operational run with great stability.

For the physical parameterization, the Reisner microphysics scheme is used on all domain, as is the cloud-radiation scheme and the Blakadar planetary boundary layer scheme. The Kain-Fritsch cumulus scheme is selected.

3. Source of the negative bias

A case period of 23-25 Nov. 1999 is selected for the experiment, as the negative bias in that period is worst in 9 months. The analyses used for the verification are those prepared from the MM5 system's initial condition.

For the control run, every other conditions are the same as the current operational model system, explained in the section 2, except no FDDA and 12 pressure layers instead of 24.

Four sensitive experiments are executed to identify the contributing factors for the negative bias; (1) with the non-hydrostatic dynamic process (2) with the analysis lateral boundary field (2) with the extended domain (3) with the sponge lateral boundary formulation (4) with the FDDA

The non-hydrostatic run instead of hydrostatic one decrease the negative bias which is, in the maximum, 120gpm for the 500hPa geo-potential height to the value below 20gpm. Here, the FDDA which may maximize the effect is used. This result is caused by the substantial reduction of the spurious noise especially over the Tibetan Plateau by using the local perturbation pressure instead of the large terms of the hydrostatic model in the pressure gradient force (Dudhia, 1993).

In Fig. 4, the difference of the geo-potential height at 500hPa for the 12, 24, 36, and 48 forecast results of MM5 at KMA between using GDAPS forecast and GDAPS analysis as LBC is shown. As you can see the difference of 30, 30, 60, 80 gpm respectively around the Korean peninsular is shown. It can be shown that the similar difference pattern in the whole domain with that of the LBCs gotten between from GDAPS forecast and GDAPS analysis, which is depicted in Fig. 5 only for 24, 48h. It is roughly assumed that the negative bias in the north-west boundary propagates inward at a rate of 15~20 degrees of latitude and 40 degrees of longitude per 12 hours. Comparison with the rate 20-30 degrees of longitude per day of