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# STUDY ON THE POSITIONING OF SOUNDING BALLOON DRIFTING ASSOCIATED WITH A PROCESS OF GALE AND TEMPERATURE DROP USING MM5

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## 1. INTRODUCTION

Initial data and boundary data of forecast variables should be given when we do limited area weather forecast with numerical models (Shen Tongli, et al., 2003). With the development of numerical forecast, the resolution of models has been higher and higher, which can reach over ten miles or even less (Liu Hongya, et al., 2005). Thus, it would directly affect the accuracy of numerical weather forecast if we had improved the quality of initial data and boundary data of forecast variables. In this respect, Wang Yueshan(2000) elaborated the importance of objective analysis when making the initial fields of model in detail; Liu Liping(1999), Huang Yanbin(2003), Tuo Ya(2003) added initial data that differ from each other to their initial fields of model, argued the simulation results in many ways, and some useful conclusions have been gained.

One of the ways to improve the quality of initial data and boundary data of forecast variables is adding data of radiosonde to the initial fields formed by NCEP Final Operational Global Analysis data. Affecting by upper air current, sounding balloon would drift apart from the station where the balloon was sent up during ascending, resulting in the floating distance of several tens of miles generally or even more than 100 miles (Liu Hongya, et al., 2005), which were head and shoulder above the resolution of numerical model. However, we ignored sounding drifting for a long time, which obviously increased errors of initial fields and then finally impacted simulation results and analysis. After temporal interpolation and spatial correction respectively by empirical formula and method of area weighting of triangle when assumed sounding balloons to be air particles, Zheng Liangjie (1989) concluded that position correction did not change the characters of any meteorology element fields except their values by using the triangle area weighing method and relating empirical formula after considering a balloon as a particle. Based on MM5(v3) model, Yang Yuhua (2005) compared height fields at 500hPa from 9 cases using the data with messages of sounding position from operation system MICAPS by CMA after year 2004, the results showing that the simulation capability of MM5 had been better. After calculating the actual positions of balloon at each pressure levels according to the theory of sounding, By taking the initial fields respectively assimilated with sounding data before and after position correction by 3D-VAR system into WRF model, Liu Hongya (2005) found that position correction could improve the accuracy of precipitation forecast and is also useful for better application of high-resolution numerical forecast models. But more cases were needed to verify.

The messages of sounding drifting used in the above experiments were formed by not observation but

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rather interpolation. In order to analyze the impact of height-depending sounding balloon drifting on mesoscale numerical forecast model and explore the values of sounding data，Ji Lei (2008) had improved the objective analysis system of MM5 using new sounding data with accurate position message at each pressure level. Through the simulations of a stratiform clouds precipitation, he concluded that the differences of initial fields caused by position correction become more obvious above 500hPa and is more sensitive to heavy precipitation weather system and besides; The distribution of precipitation and the center of heavy rain are obviously bettered; after the position correction, the scores are higher than schemes before the position correction and without sounding data, and as the resolution is rising, the position correction will better the high rainfall grads but not the low rainfall grads.

In this paper, in order to analyze the model results after adding new sounding data with accurate position message (Li Wei 2005,2008) at each pressure level during the mesoscale strong weather system, the process of a gale and temperature drop will be taken as an example, based on the objective analysis system of MM5 improved by Ji Lei (2008).

## 2. SYNOPSIS OF WEATHER SITUATION

At 00:00 on 16 Mar 2004 (UTC, the same hereinafter), cold air behind ladder trough from the region of Lake Baikal had arrived at Inner Mongolia at 500hPa. Northeast, North China and Yangtze-Huaihe River basin had been controlled by Northeast Cold Vortex in lower layers. Then, a gale and temperature drop had occurred in the North China. At 12:00 on 16, cold air from Northeast had strengthened and moved to the south, cold-core high in lower layers had been in the Hetao Area (fig 1).

At 18:00 on 16 Mar 2004, cold air from Northwest behind trough had strengthened further and had moved southeastward on a large-scale. the temperature in Northeast, North China and Northeast had dropped obviously when heavy cold-core high controlled. As shown in fig 2, isotherm of 15℃ at 1000hPa in Jiangsu and Anhui provinces had been pushed from north to south by the forefront of gale and the surface temperature in these areas had dropped almost 10℃ during six hours from 18:00 on 16 to 00:00 on 17.

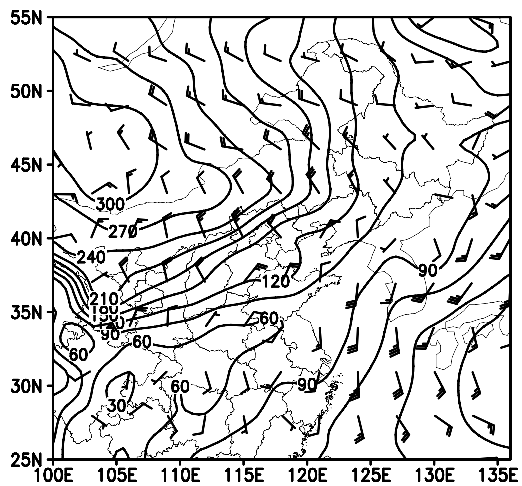


Fig.1 Geopotential height field and wind field at 1000hPa at 12:00 on 16 Mar 2004. Unit:gpm

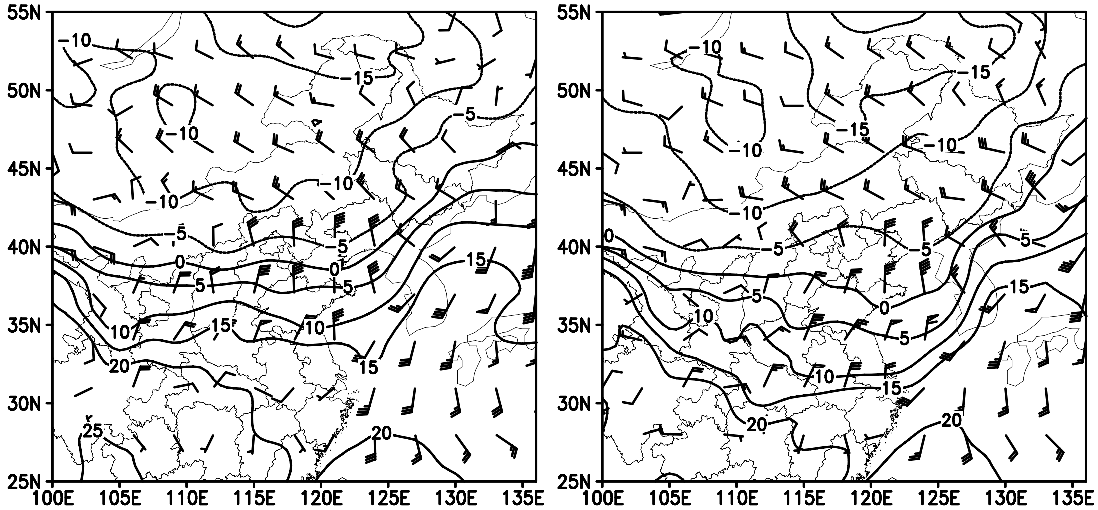


Fig.2 Temperature field and wind field at 1000hPa at 18:00 on 16 Mar(left) and at 00:00 on 17 Mar(right) 2004. Unit: ℃

Table 1 Physics schemes in MM5

| Integral time | | 16_12:00～17_12:00 Mar 2004 | | |
|---|---|---|---|---|
| Model center | | 36.0°N , 117.3°E | | |
| Nesting scheme | DIS | 36km | 12km | 4km |
| | NESTIX*NESTJX | 131*130 | 139*127 | 151*166 |
| | IMPHYS | Raisner | Raisner2 | Raisner2 |
| | ICUPA | Grell | none | none |
| | IBLTYP | MRF PBL | | |
| | IFRAD | Cloud-radiation scheme | | |
| | ISOIL | Noah Land-Surface Model | | |

## 3. NUMBERICAL EXPERIMENTS AND ANALYSIS

### 3.1 *Model Schemes*

The vertical direction of MM5 model has been divided into not equidistant 37 layers and the pressure of the top layer is 10hPa. Triple-nested grid program and Two-way nested program (Hou Ruiqin, 2006) without 4D-VAR system are used in our experiment. Schemes A, B and C respectively stand for the experiments of initial field without sounding data and with sounding data before and after position correction.

We have collected the sounding data at 00:00 and 12:00 UTC. The Physics schemes in MM5 are shown in table 1 in details.

### 3.2 *Impacts of* Initial F*ields after* P*ositioning*

The differences of initial temperature fields at different layers between schemes C and B after 12 hours of simulation (00:00 on 17 Mar 2004) have shown in fig 3 with the resolution of 36 km. As seen in fig 3, the difference of initial temperature field is up to 2.5℃ at 150hPa, while is 0.6℃ at 500hPa and only 0.15℃ at 800hPa. Therefore, the differences of temperature field are greater in upper layers than that in lower layers due to increase of floating distances during balloons ascending process.

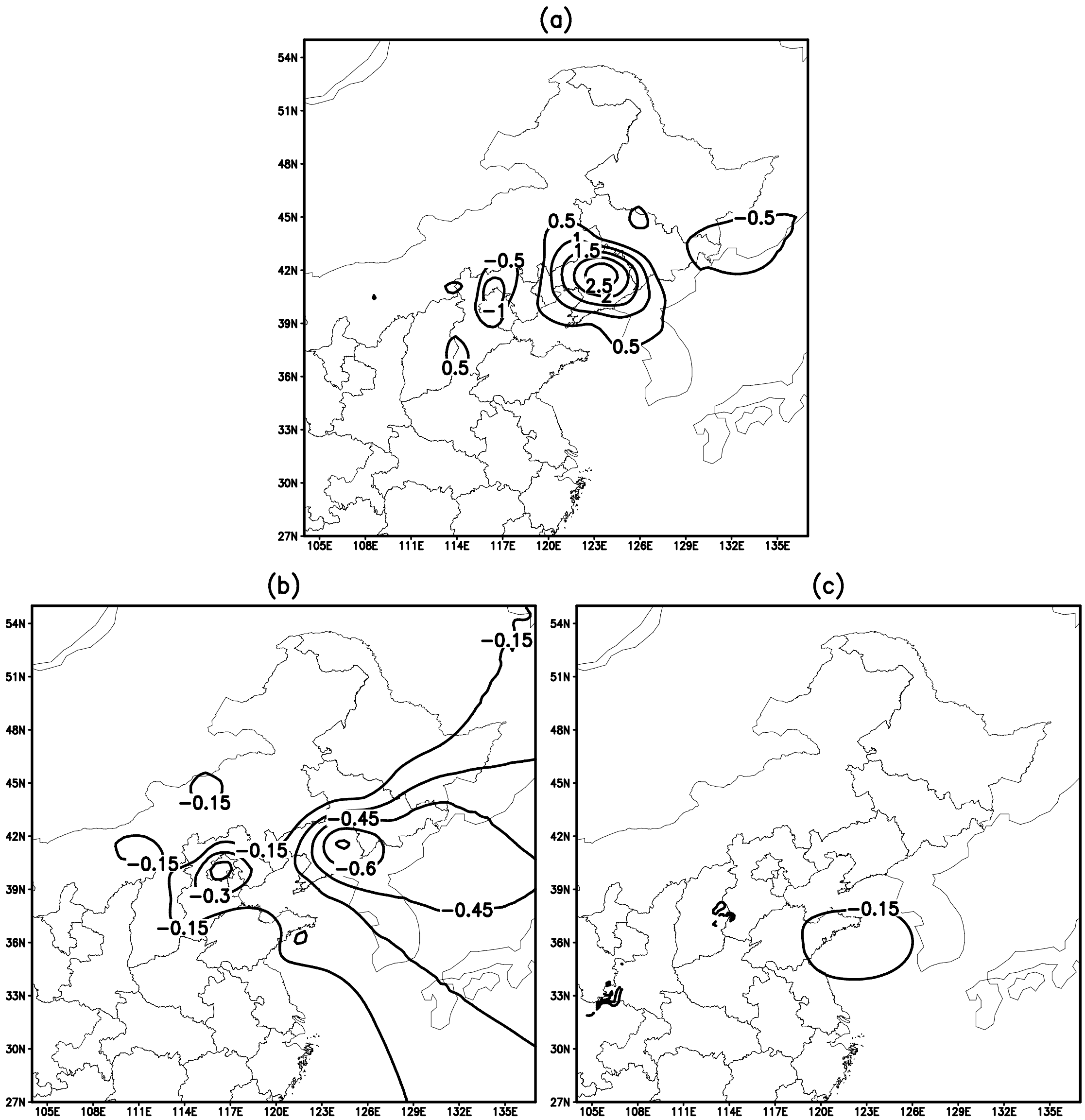


Fig 3 The differences of initial temperature field at 00:00 on 17 Mar 2004. Scheme C – B. unit: ℃
(a) 150hPa (b) 500hPa (c) 850hPa

Comparing fig 3b with fig 4, we can see that the differences of initial temperature field at 500hPa at 00:00 on 17 are greater than that at 12:00 on 17, while almost no difference at 850hPa at 12:00 on 17. Therefore, the differences of initial temperature field reduced at lower layers. By comparing the results with that on the accurate synoptic chart at 12:00 on 17 (not given) , we can see the reason is that the meteorological element fields below 500hPa are relatively steadier due to weaker lower layer winds, which resulting in shorter floating distances of sounding balloon.

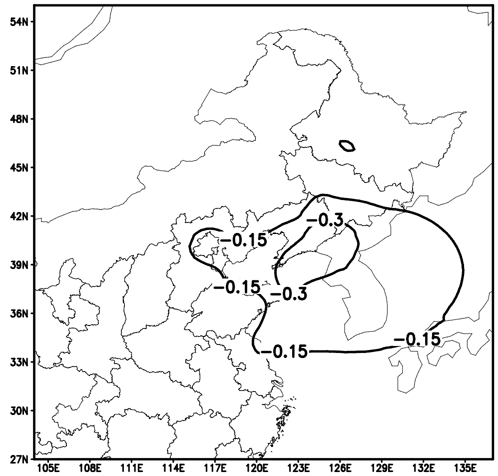

Fig 4　The differences of initial temperature field at 500hPa at 12:00 on 17 Mar 2004. Scheme C – B. unit:

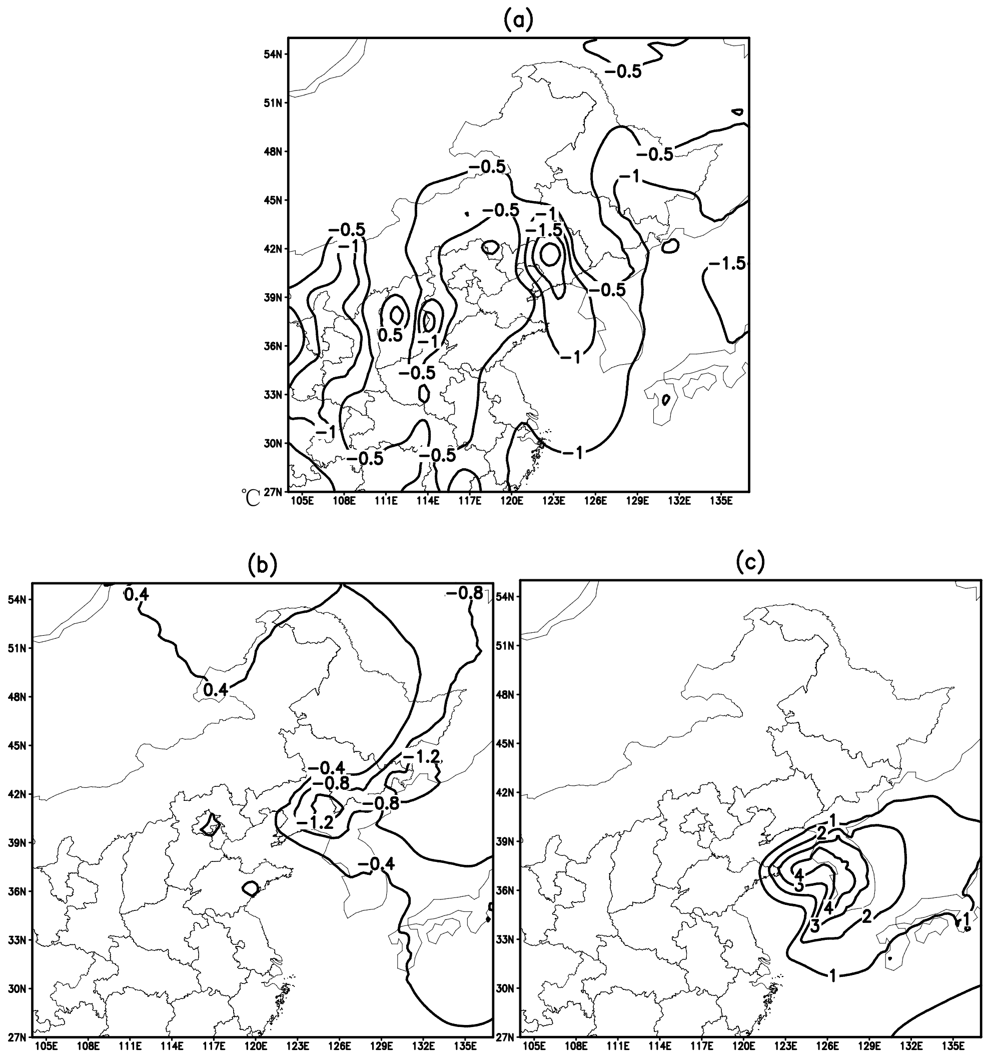


Fig 5　The differences of initial wind field at 00:00 on 17 Mar 2004. Scheme C – B. unit: m/s

(a) 150hPa　(b) 500hPa　(c) 850hPa

The differences of initial wind fields at different layers between schemes C and B at 00:00 on 17 Mar 2004 have shown in fig 5. The difference of initial wind field at 850hPa, which corresponds well with the winds center at lower layers is up to 4 m/s. That is due to the increasing of gale at lower layers while cold air from Northwest behind trough has strengthened. By comparison, the difference at 500hPa is smaller than that at 850hPa while the difference of wind speed is smaller at 500hPa than that at 850hPa. We can see from the differences of initial wind fields at each pressure layer (not given) at 12:00 between 16 Mar and 17 Mar that the differences are greater below 500hPa than that upon 500hPa. Therefore, the changes of initial wind fields are obvious when large wind shear appears, which surely have impacts on model results.

### 3.3 *Impacts of MM5 Results after Positioning*

The differences of temperature fields at 850hPa between each scheme and Observation respectively at 06:00 on 17 Mar 2004 have shown in fig 6(a～c) with the resolution of 9 km.

After 06:00 on 17 Mar 2004, North China was controlled by cold high gradually when Northeast Cold Vortex moved eastward. Cooling rate of the ground reduced and the wind center moved to the ocean by degrees. All three schemes have simulated the cooling process and 2℃ below the value of observation in the mass. The differences of temperature in some area from scheme A are greater than that from other schemes, which can reach -6℃ in northwest of Hubei province. The results of schemes B and C are closer to the observation, but still have -4℃ locally.

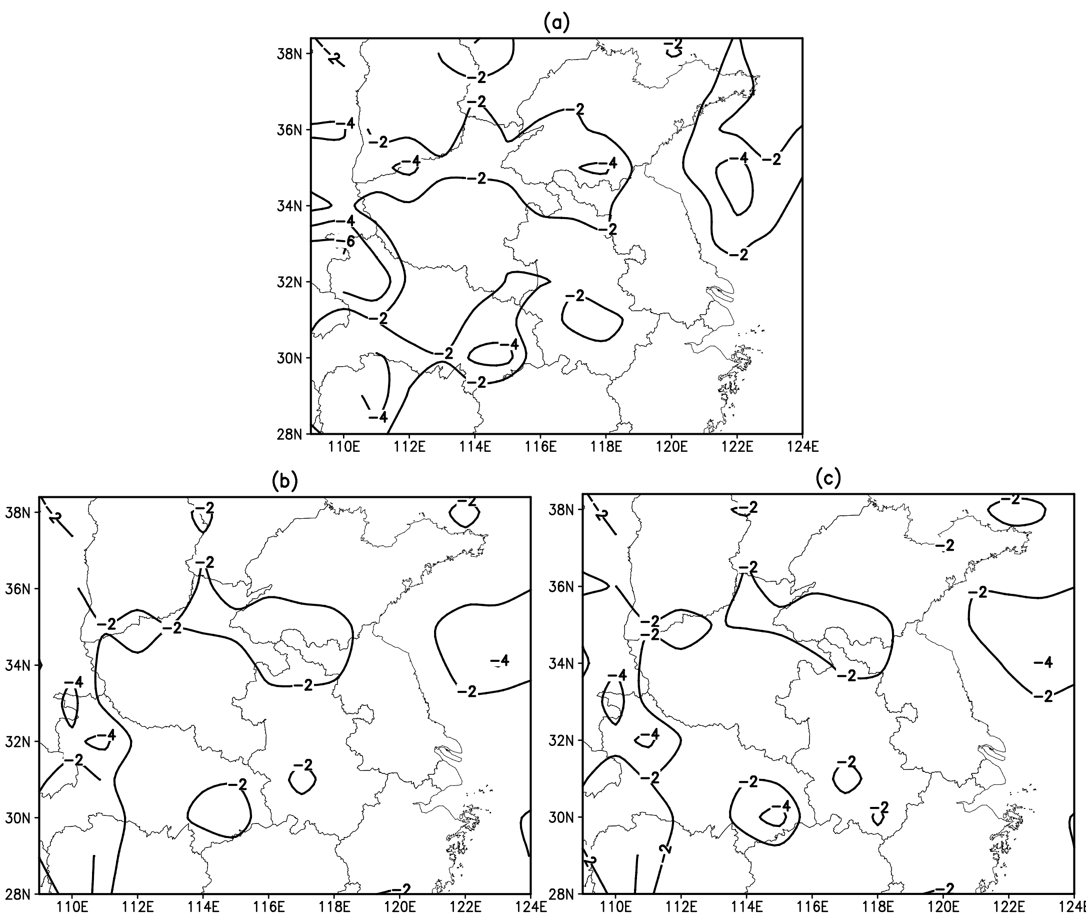


Fig 6 The differences of temperature field at 850hPa at 06:00 on 17 Mar 2004. unit: ℃

(a) Scheme A－Observation (b)Scheme B－Observation (c)Scheme C－Observation

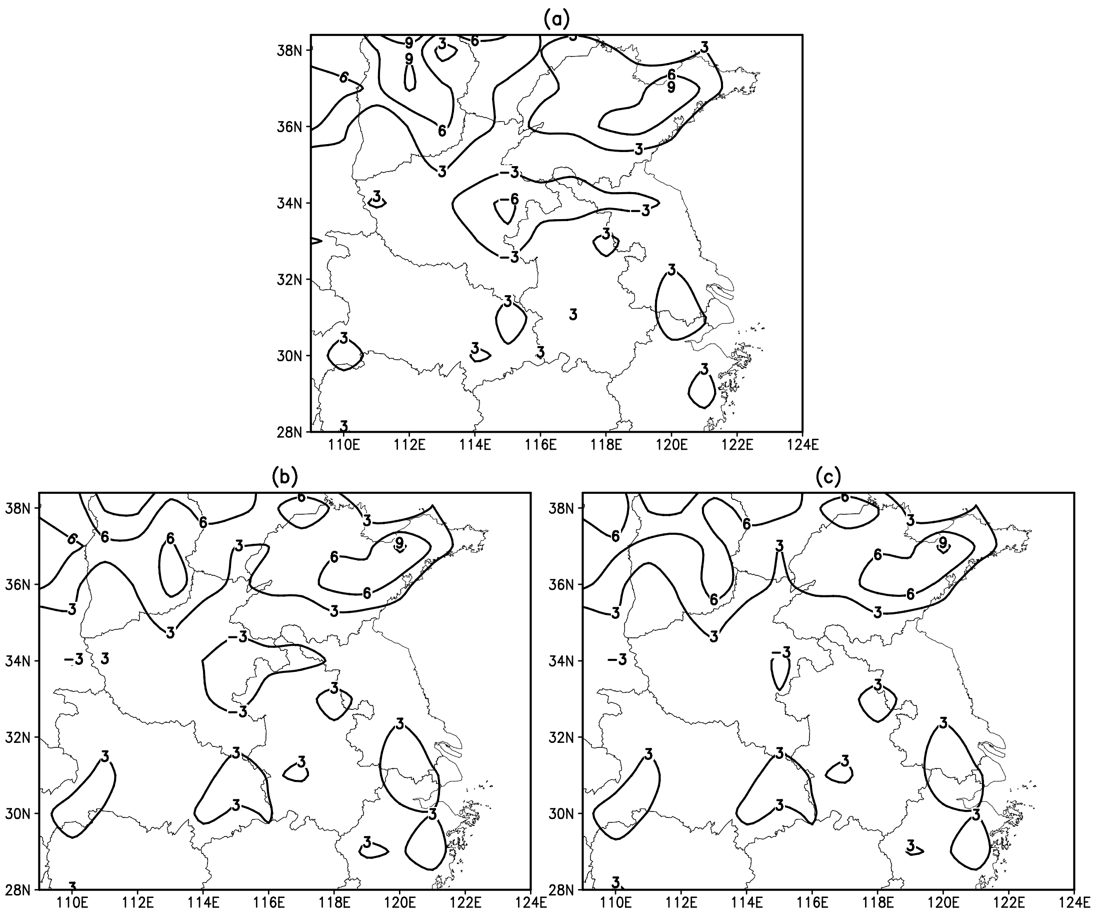


Fig 7 The differences of temperature field at surface at 12:00 on 17 Mar 2004. unit: ℃

(a) Scheme A－Observation (b)Scheme B－Observation (c)Scheme C－Observation

The differences of surface temperature fields between each scheme and Observation respectively at 12:00 on 17 Mar 2004 have shown in fig 7(a～c). From south to north, the differences increase from 3 to 6 degrees while 9 degrees at some regions. For the joints of Jiangsu, Anhui and Henan provinces, the differences are between -6～-3℃ in fig 7a which are greater not only in numerical values but also in sphere of influence than that in fig 7b and 7c. Considering the sphere of influence, results from fig 7c is in better agreement with observation.

### 3.4 *Analysis of The Process of Gale and Temperature Drop*

The forefront of gale had arrived at the north edge of Jiangsu and Anhui provinces at about 18:00 on 16 Mar 2004 and then moved southward fast to the south edge of these two provinces at about 00:00 on 17 which continued to move southeastward. Surface temperature dropped very fast in Jiangsu and Anhui provinces during that time periods. The differences of wind field at 1000hPa and surface temperature fields between scheme C and B at selected four times (19:00 and 21:00 on 16, 00:00 and 02:00 on 17 Mar 2004) have added up with the resolution of 4km which have shown in fig 8(a～d) respectively.

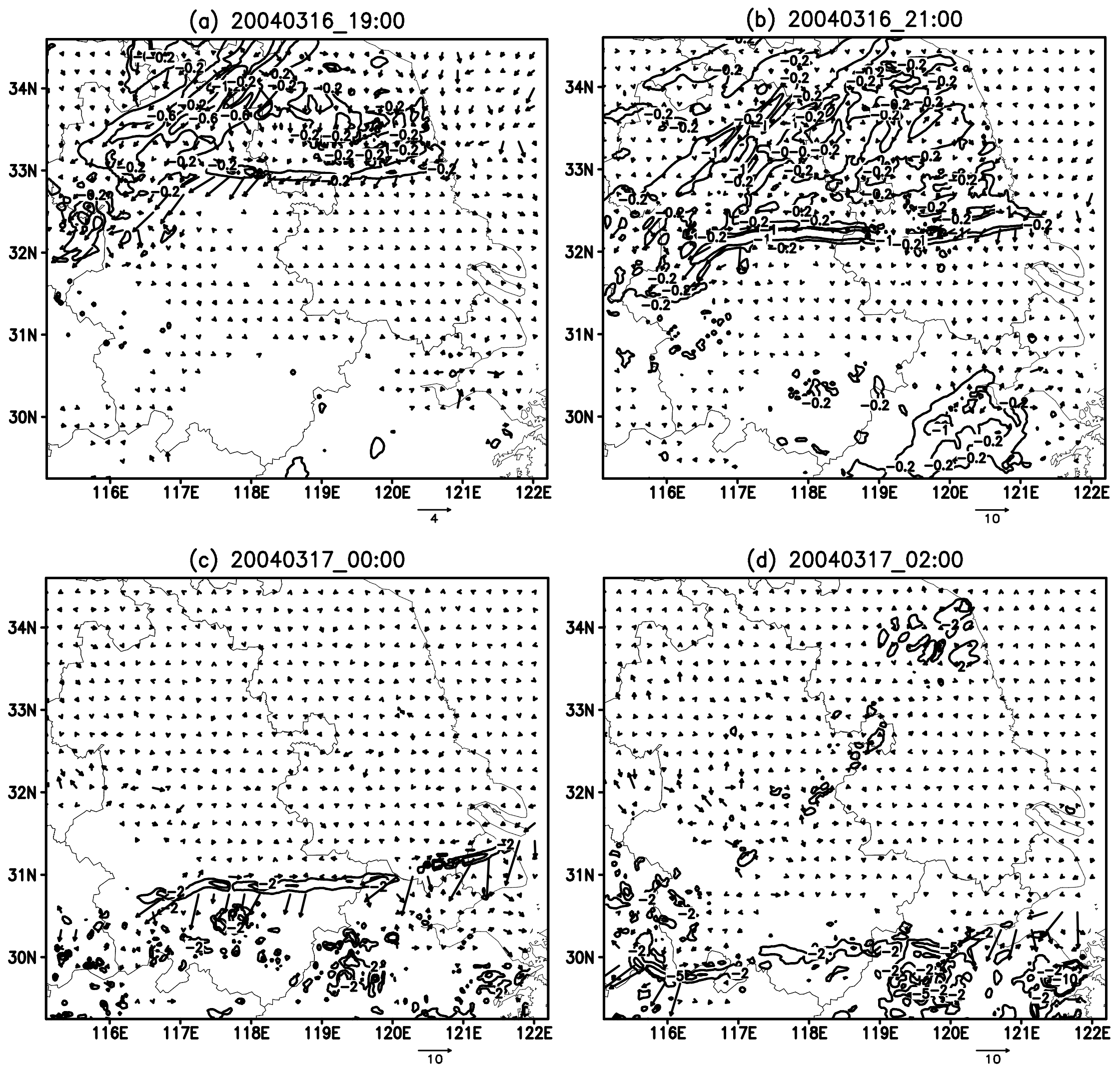


Fig 8 The differences of wind field at 1000hPa (unit: m/s) and temperature field at surface (unit:℃). Scheme C–B

The model results (fig 8) show that the difference of wind field at 1000hPa is up to 10m/s while the major component is north wind, which tallies with the observation that north wind is major near the ground during that time periods (fig 2). That is to say the model results increase the north wind near the ground after position correction. The places whose wind fields change obviously (from fig 8a and c) correspond to the forefront of gale (from fig 2) very well. The model can simulate the process of wind shear after position correction.

Fig 8 indicates that higher value of temperature variations correspond well with obvious changes of wind fields at the same location with position correction. Fig 8a shows that the variations of wind fields near 33°N is around 4m/s, corresponding to the maximum temperature field variation of -0.6℃. Fig 8b shows similar results near 32°N, with wind filed variation of 10m/s and corresponding temperature filed variation of reaching -1℃. Fig 8c and 8d also show obvious temperature variations of -2℃ and -5℃ at the location of relatively higher wind field variations. The results indicate that the wind shear has great impacts on surface temperature, with changes of temperature proportional to wind filed variations.

To sum up, the southward movements especially the locations of forefront of gale can be simulated closer to observation by scheme C, while the changes of temperature fields are consistent to the changes of wind fields. MM5 model can simulate the process of cooling more accurately after the position correction when the differences of temperature fields between scheme C and B are minus during southeastward movements of the cold air.

## 4. CONCLUSIONS

Based on the above discussion of the process of a gale and temperature drop, the results can be briefly summarized as follows:

1) It is necessary to improve MM5 initial fields using sounding balloon data for the strong mesoscale weather system. Generally, position correction results in relatively smaller variations of initial meteorological element fields for lower levels, but larger variations for higher levels. However, in case of strong atmospheric motion below the 500hPa level, the variations of the lower level initial meteorological element fields, especially wind fields, are obvious, even larger than that of the higher levels.

2) The position correction makes the results of MM5 more approaching to the observed data. Taking the process of gale and temperature drop as an instance, the accuracy of model results is enhanced in terms of reducing error values and corresponding sphere of influence.

3) After the position correction, the model can simulate the southward movement of the gale and temperature drop accurately, the simulated foreland of gale is corresponding well with the observed data and the variation of the temperature field is consistent with the variation of the velocity field very well.

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