A simplified Explicit Scheme of Phase-mixed Cloud Used in WRF model and precipitation experimentation

Yan Zhihui* Zhu Zhenghui
(National Meteorological Center, Beijing 100081)

1. Introduction

Based on WRF model (Version 1.3) system introduced in National Meteorological Center /CMA, a simplified explicit scheme of phase-mixed cloud (HL3) was introduced in the model successfully. The case study of precipitation prediction, with the initial fields and boundary conditions provided by the medium-range prediction system T213 run in the National Meteorological Center, were made for the scheme (HL3) and compared with the original simple ice explicit scheme (Ncloud3) in the model, and the diagnosis analysis on the horizontal and vertical distributions of cloud physical parameter such as cloud water and rain water were made for the two schemes, also.

2. The difference between two schemes

HL3 is a simplified version of explicit moisture scheme of phase-mixed cloud developed by Z. Hu and Q. Liu in CAMS/CMA, in which the moisture, cloud water, cloud ice, rain water, snow and graupel are considered as prognostic variables. Compared with Ncloud3 scheme, the main differences included: (1) the cloud was divided into cloud water and ice crystal according to the atmospheric temperature in Ncloud3; but in HL3, the cloud water is the only form. When the temperature is lower than $0\,^\circ\text{C}$, supercooled cloud water existed (no cloud ice). (2) Two processes, the nucleation and multiplication of ice crystal, are taken into account in HL3 scheme. In these two processes, the cloud water was transformed into snow crystal directly, and falling toward to the ground with terminal velocity.

3. Numerical experiments

The precipitation prediction experiment was made with initial fields at 0000UTC 10 October 2003. This is a heavy rainfall case occurred in east part of China. Fig.1 (a) is the observed 24-hour accumulated precipitation amount (mm) from 0000 UTC 10, October 2003 to 0000 UTC 11 October 2003. The blue shaded area showed the rainfall area over 10 mm. Fig.1 (b) and (c) are the corresponding 24-hour precipitation forecast by HL3 and Ncloud3 respectively. From Fig.1 we can see that the rainfall area predicted by two schemes was same completely, almost, but the distribution of heavy rain belt was different. Compare the rain belt over 50mm with Fig.1 (a), (b) and (c), we can see that although the heavy rain belt predicted by two schemes was deviated to the east from the observation area, the prediction for the sub-heavy rain belt near the Yangtse River is different obviously. Since the prediction of the precipitation intensity made by HL3 is stronger than that by Ncloud3 scheme, the prediction of this sub-heavy rain belt made by Ncloud3 scheme was pass over, but it was predicted correctly by HL3 scheme. For this single case, the prediction for precipitation made...
by HL3 was improved slightly.

In order to compare with Ncloud3 scheme, the result predicted by Lin scheme was used as reference. Fig.2 is the time cross-section of mean cloud water content for main precipitation area by three schemes (Ncloud3, HL3 and Lin scheme). Time interval is three hours. In the figure, the red line is the contour for cloud water content (unit: g/kg) predicted by HL3 scheme. Blue line and green line are the same results made by Ncloud3 and Lin scheme. From Fig.2 we can see that there were two maximum cloud water centers, one was located between 300hPa and 400hPa pressure levels, another was situated near the surface (lower than 900hPa pressure level). For the high level maximum cloud water center, the prediction of cloud water made by HL3 showed that the maximum value occurred later and lower than the other two schemes.

As to the low level maximum cloud water center, the prediction for cloud water content predicted by three schemes were completely same at first 6 hours, almost. The main difference occurred in 12 hours after initial time. The contour of 0.3 g/kg predicted by Ncloud3 lowered down under the 900hPa pressure level rapidly. The same line predicted by HL3 and Lin scheme just began to lower down slowly at same time and always kept above 900hPa pressure level for remaining time.

Fig.3 is the time cross-section of mean rainwater (or snow) for main precipitation area by three schemes (Ncloud3, HL3 and Lin scheme). The explanation for different curves is as same as Fig.2. From Fig.3 we can see that there were two maximum rainwater centers, also. At the beginning, the high level maximum center was located about 300hPa pressure level and later the position went down with time and then kept between 500hPa and 400hPa pressure level. The predictions made by three schemes were similar at first 9 hours. After 12 hours, maximum center predicted by Lin scheme kept at 600hPa pressure level stably, but the prediction made by Ncloud3 and HL3 schemes was still above 500hPa pressure level. The maximum value of rain water predicted by Lin scheme was about 0.055g/kg, but the corresponding values predicted by Ncloud3 and HL3 schemes were 0.16 g/kg and 0.10 g/kg, they were much higher than Lin scheme obviously. At the low level, the prediction made by Ncloud3 scheme showed that there was no obvious maximum rainwater center, but the same prediction made by HL3 and Lin schemes showed that the maximum rainwater center occurred below 900hPa pressure level. The maximum value appeared about 15 hours after initial time. The distribution of rainwater predicted by HL3 was better than that by Ncloud3. And the time for rainfall occurrence predicted by HL3 was more than two hours earlier than by Ncloud3 scheme. It was closer to the Lin scheme. But it was noted that the maximum value predicted by HL3 was stronger than that by Lin scheme obviously.

4. Summary

The preliminary results was shown that the precipitation forecast for rainfall area made by the simplified explicit scheme of phase-mixed cloud is correspond to that by simple ice explicit scheme, and has an improvement on the heavy rain belt, slightly. In addition, the predictions to the spatial and temporal distributions of cloud water and rainwater over main precipitation area are improvement somewhat, also. But the predictions for cloud water and rainwater made by HL3 scheme showed that the transformation from cloud water to rainwater and fall speed of rain drops was too fast. It will be improved in
the future.

Acknowledgement
This work is supported by the National Key Project of Meteorological Service Technology for Olympic Games.

Fig. 1 Comparison of precipitation prediction with two schemes
(a) Observed accumulated precipitation amount from 0000 UTC 10 October 2003 to 0000 UTC 11 October 2003
(b) 24-h accumulated precipitation amount prediction made by H3
(c) 24-h accumulated precipitation amount prediction made by NCloud3
Fig. 2. Comparison of mean cloud water for main precipitation

Fig. 3. Comparison of mean rain water (or snow) for main precipitation