A Real-time MM5/WRF Forecasting system in Taiwan

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1. Introduction

Ensemble forecast has been extensively used in operations, since early 1990's, at many forecast centers in the world. In recent years, there have been many studies discussing the performance of an ensemble rainfall forecast (e.g., Du et al. 1997; Ebert 2001; Zhang and Krishnamurti 1997).

In view of the need of mesoscale ensemble of precipitation forecasts, a group of researchers in Taiwan has, since 2000, jointly run an MM5 ensemble system in real time during each Mei-yu season. The system consists of six members, each run by a university or a government institute. The participants include the National Taiwan University (NTU), the National Central University (NCU), the National Taiwan Normal University (NTNU), the CWB, and the CAA. Verification of this ensemble system in terms of precipitation forecasts during the Mei-yu seasons of 2000, 2001, and 2002 was presented in Chien and Chou (2004). In the paper, the authors attempted to find the best physics combination of MM5 that is especially suitable for simulations in the Taiwan area during a Mei-yu season. Furthermore, several methods, in addition to the ensemble mean, were examined, in order to search for a better way to produce the ensemble rainfall prediction.

The preparation of running WRF was started after the summer of 2003. Since January 2004, we have started running WRF in real time for the Taiwan area. During the Mei-yu season (15 May to 20 June) of 2004, we set up a mesoscale ensemble forecasting system that included this WRF model and two MM5 members. The products of ensemble mean forecasts of rain and other meteorological fields, are generated and posted on a website:

http://pblap.atm.ncu.edu.tw/mefsea

In addition, the simulation results of each single member are shown and the comparisons between MM5 and WRF could be made. In this paper, comparisons between MM5 and WRF on the forecasts of a typhoon (Nida 2004) that passed the eastern coast of Taiwan from 17 to 20 May 2004, and a heavy rainfall event that occurred on 20 May 2004, are presented.

2. Configuration of MM5 and WRF simulations

The model configuration of the two MM5 members (MM5N and MM5C) includes two domains with 45 and 15 km horizontal grid spacing. The Grell cumulus parameterization scheme, the Mixed-phase microphysics scheme, and the MRF PBL scheme are used in the simulation. The only difference between these two members is on the initial and boundary conditions. The MM5N used the analyses and forecasts of the NCEP AVN model as input data, while the MM5C used those of the CWB global model (GFS). The WRF model has only one 45-km domain, with the physics including the Kain-Fritsch (new Eta) cumulus parameterization scheme, the NCEP 3-class simple ice microphysics scheme, and the MRF PBL scheme. Its initial and boundary conditions were obtained from the NCEP AVN model. The models ran twice a day at 0000 UTC and 1200 UTC, with forecast extended to 48 hours.

3. Case studies

Because the modeling system is still in its early establishing stage, we only provide two cases here for a preliminary examination. These two cases are both linked to an important event in Taiwan on 20 May 2004, the inauguration day of President Chen. The Central Weather Bureau of Taiwan issued a typhoon warning a few days before the inauguration day, when the typhoon Nida (2004) was still located over the ocean to the east of the Philippines. This made the preparation of inauguration ceremony more complicated and difficult. Fortunately, Nida (2004) made a big turn to the northeast on 18 May and did not make landfall on Taiwan. The weather on 20 May was, however, not good for outdoor events, either. A Mei-yu front was approaching Taiwan on that day, and it brought large rainfall on the northern Taiwan in the morning when the ceremony took place. Later, the mesoscale convection system (MCS) moved southward and resulted in heavy rainfall in the central and southern Taiwan.

The preliminary results show that both MM5N and WRF made good forecasts on the track of Nida (2004)[1]. Early on 15 and 16 May, the typhoon was heading toward the northwest; observations and model forecasts all suggested a high possibility of making landfall on Taiwan. At a critical time, 0000 UTC 17 May, however, both models predicted that the typhoon would make a right turn toward the northeast at approximately 0000 UTC 18 May. The forecast tracks were successfully similar to the observed tracks. The average errors on the track forecasts were listed in Table 1. Because there was no bogus of the typhoon's center during the data preparation of model runs, positions of the center in the initial condition had an average error of 38 km compared with the observation. The track difference between WRF and MM5N was small because they both used the same ICs and BCs. However, it is still seen that for model forecasts before 24 h MM5N appeared to have smaller errors, while for forecasts longer than 24 h WRF presented a better result.

In the morning of 20 May, a mesoscale convection system, which was located at the leading edge of a Mei-yu front, moved toward the northern Taiwan. It brought large rainfall in Taipei such that the inauguration ceremony was crowded with raincoats and umbrellas.

The MM5N and WRF both appeared to make good forecasts for the MCS. It is found that the timing of MCS was slightly better captured by WRF than MM5N. However, the simulated rainfall amount of WRF was not large enough compared with the observations. The reason for that is because we used the Kain-Fritsch scheme in WRF; it has a tendency of underforecasting rainfall that was associated with Mei-yu fronts in the Taiwan area. The predicted rainfall amounts of MM5N were more consistent with observations. Chien and Jou (2004) have shown that the Grell scheme could produce better rainfall forecasts than the Kain-Fritsch scheme for a Mei-yu season in Taiwan. Our case study here with MM5 and WRF shows a consistent result.

Table 1: The average forecast error (km) of typhoon track.

	0h	12h	24h	36h	48h
WRF	38	155	158	164	191
MM5N	38	130	158	190	231

[1] The forecasts of MM5C were not available during the events.

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