THE SENSITIVITY OF NESTING STRATEGY OF THE NCEP REGIONAL SPECTRAL MODEL

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1. Introduction

A review by Warner et al. (1997) had provided us with a comprehensive understanding of the lateral boundary problem in regional atmospheric models along with a tutorial guidance for the regional model users. The lateral boundary problem was quantitatively shown in the paper, and the guidance was provided regarding the useful time range of the regional model integration. It indicates that the larger the domain is, the longer the useful forecast range can be. For the continental domain, it has the longest useful range of 135 hr in the mid-latitude uncoupled meteorological regimes, and it has the shortest range of 22 hr in the mid-latitude winter weather regimes. The limitation, as mentioned in the Warner et al., indicates that regional model may not be suitable for use in a long-range integration because of the lateral boundary problem.

From our experimental experiences with the National Centers for Environmental Prediction (NCEP) Regional Spectral Model (RSM), as published in Juang and Kanamitsu (1994), Juang et al. (1997), Hong and Juang (1998), and others, it was recognized that the behaviors of the NCEP RSM are somewhat different from most other existing regional models, not only because it is a spectral model but also because it has an untraditional numerical treatment on nesting strategy.

This paper evaluates the performances of the NCEP RSM based on the sensitivities of different model domain sizes.

2. Experimental design

A winter case over the Great Lakes was selected for all the experiments in this study. The mature stage of the cyclogenesis over the Great Lake was about 1200 UTC 5 January 1997, thus the experimental period selected was from 1200 UTC 3 January to 1200 UTC 6 January 1997 with two days in advance to predict the mature stage of the cyclogenesis and one day for its further evolution. A month-long integration from the same initial condidions are done on big and small domains.

Three experiments named "R48big", "R48medium", and "R48small", are presented to examine the sensitivity of the model domain sizes with the same resolution of 48 km and the same base field from T126. The ratio of the domain size is 16:4:1 for big, medium, and small experiments, respectively.

3. Results

Figure 1 shows the RMSD of the mean-sea-level pressure for the experiments T126, R48big, R48medium, and R48small with respect to (a) analysis and (b) T126 forecasts in the period from initial time to 72 hr. In terms of RMSD on average (Fig. 1a), the experiment R48big has the best forecast while the experiment R48small is the closest to the experiment T126. The results from the R48big indicate that the perturbation generated and evolved in the NCEP RSM helped to provide the better forecast when compared to others. Also, the smaller the domain, the closer the RMSD is to the experiment T126. In Fig. 1(b) indicates that the larger the domain is, the larger the RMSD, in respect to the base field provided to the NCEP RSM. Therefore, it can be implied that proximity exists between the base field and the small domain, so, the "small domain" can be used for longer integration without any significant drift away from the base field, say T126 in this case. This was proven in a month-long integration (not shown).

Fig. 2 shows the 250 hPa isotach for the experiments R48big, and R48small after 48 hr integration. The magnitude of the jet in Fig. 2(a) from R48big is about 3 ms^{-1} larger than those of R48small in Figs. 2(b). In comparison of Figs. 2(a) and 2(b) (big domain and small domain) to Fig. 6 in Warner et al. (1997), the magnitudes

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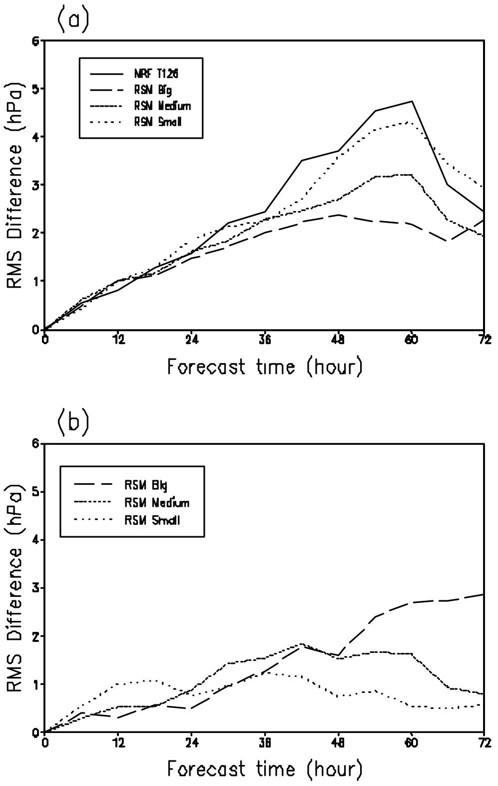

Fig. 1. Temporal evolutions of (a) the RMSD of mean sea level pressure with respect to analysis, and (b) the RMSD of mean sea level pressure with respect to the NCEP GSM T126.

of jet stream from the NCEP RSM results have less significant difference when compared to theirs. In both cases, again, the big domain is 16 times of the small domain. The wind speed differences are as large as 15 ms^{-1} and the gradients of the jet are significantly different between the small and big domains in Warner et al. (1997). In our results, however, there are only 3 ms^{-1} differences in the speed and no shape difference in the gradients of the jet. It implies that NCEP RSM is capable in generating about the same features among different sizes of model domain.

4. Concluding remarks

The elementary design of the NCEP RSM (Juang and Kanamitsu 1994 Juang et al. 1997),and Hong and Juang 1998) comprises variable decomposition with perturbation method, spectral computation, linear forcing in perturbation, relaxation along a narrow lateral boundary zone, and initial terrain blending along the lateral boundary.

Based on all experimental results and when compared with those results in Warner et al. (1997), The NCEP RSM demonstrates that it behaved different than the other regional models due to its domain nesting. There are two major findings here which are very different from what Warner et al. (1997) had. The first one is that it is not necessary to have a large domain in order to avoid the lateral boundary influence. The second one is that multi-nesting is not necessary in order to have a very fine resolution forecast over a small domain. The reasonable mesoscale features are generated over the entire domain due to the minimal area of relaxation along the lateral boundary.

A complete study about the issues on the model domain sizes, nesting strategy and resolution effects in the RSM is presented in Juang and Hong (2001).

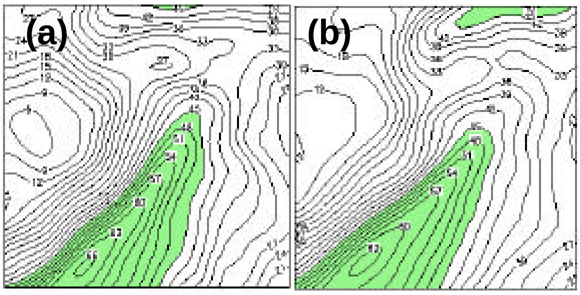

Fig. 2. 48-hr forecasted isotachs (ms^{-1}) on 250 hPa (with contour intervals of 3 ms^{-1}, values larger than 45 ms^{-1} are shaded) from (a) R48big and (b) R48small experiments.

5. Acknowledgements

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