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THE PHYSICAL PERTURBATION IMPLEMENTATION OF NCEP RSM FOR REGIONAL CLIMATE DOWNSCALING

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1. INTRODUCTION

The uniqueness of NCEP RSM (Juang and Kanamitsu 1994; Juang et al 1997) is its own perturbation for spectral computation. The definition of the perturbation is a difference between the fields obtained from RSM and its outer model or analysis, which is called a base field, on the same sigma surfaces. The difference on the same sigma surfaces is based on equation set in a mathematical concept. In this concept, the perturbation is a mathematical perturbation.

The same sigma surface between RSM and its base field is not at a same terrain height. In order to provide a consistent mass flux through the lateral boundary, the lateral boundary blending between two terrain heights is necessary for long-term integration (Hong and Juang 1998). But, in some cases, we found that it may not be efficient to control the mean mass with only lateral boundary terrain blending. A long-wave removing from the perturbation, as described in Juang et al 1997, may be efficient to remove long-wave bias or mean bias during integrations.

When the difference of the terrain becomes larger and larger due to difference resolution between RSM and its base field, removing the perturbation may remove the difference due to the difference of terrain heights significantly. Thus, the problem prompts to us; how to remove perturbation in physical way? This report is to present a method to construct a physical perturbation for removing the mean and possible long-waves.

2. THE METHOD

The original design of the RSM has a different grid system between RSM regional grid and the base field grid. Since base field grid is to provide not only the base field but also the gradients of base field, so the base-field grid is defined a way to be easy to do interpolation to regional grid as well as larger than the regional grid for computing gradients for lateral boundary of regional grid.

One of the direct methods to have a physical perturbation, instead of a mathematical perturbation, is to provide a base field at the same physical height as the regional model. The simple way to have this is to provide base field in the same horizontal resolution and the same terrain height as the regional model, then vertical interpolation is performed to have base field on the same sigma surface as the regional model.

The implementation of the physical perturbation can be described as following:

(1) All routines in the model having base field grid are modified to have the base field had the same horizontal resolution and the same sigma surface with the same terrain height as those in RSM. It requires not only horizontal interpolation but also vertical interpolation from outer models such as global model or analysis.

(2) All preprocessor routines to generate regional input will be prepared in the base field grid first as described in (1), then interpolation to regional grid. In this case, we can have zero perturbation at the beginning of the model integration because the first step of the base field provided to do difference is the same as the initial condition in the regional grid.

In these two steps, the model integration will generate physical perturbation from an initial zero value of the perturbation at the same physical heights between RSM field and its base field. Then we can remove any perturbation we want during integration. The perturbation removal in

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wave space acts as an extra spectral filter. The mean perturbation of all field is represented a total flux through lateral boundary. As a physical perturbation with nesting into the global for instance, the mean value, which is integrated along the lateral boundary, should be zero. Thus, the mean value in the perturbation is removed after every time step.

3. RESULTS

From the experiences, we know that the problem of mean mass happens in the cases of smaller domain with high terrain along the lateral boundary. Thus we selected two domains as shown in Fig. 1 over southwestern US and Mexico. Two is chosen to provide not a single evidence of this experiment. They have a 3-degree difference in longitudes. They, from reanalysis, show monthly mean of mean-sea-level pressure with boundary of the Pacific high and complicated patterns over terrains for August 1990.

Figure 2 shows the integration results of monthly mean as the same as Fig.1 but from the original design of NCEP RSM. Fig. 3 shows the same as Fig. 2 but from the current modified version of NCEP RSM, and Fig. 4 shows the same as Fig. 3 but with mean value removed. There are several results from these experiments.

Figure 2 shows the same pattern as Fig. 1 except vales are higher than analysis, nearly all over the domain. It is indicating a mean bias due to the lateral boundary nesting over these small domains. Fig. 3 shows the same results as Fig. 2, it implies we can obtain the same integration between original design and the modified design of the base field nesting. And the modified results show a better lateral boundary results than the original method, which has lateral boundary terrain blending.

After mean-bias correction, Fig. 4 shows the same values as the analysis in Fig. 1. It indicates the bias of the Figs 2 and 3 are all from the mean value. Fig. 5 shows an evolution of root-mean-square differences (RMSD) between each experiment and analysis. It indicates that the mean bias correction performs as the best result daily as compared to other experiments.

4. CONCLUSIONS

The vertical integration in base fields may introduce different vertical modes in the base field, however, the base field provides only the tendency and the results shown here is not indicating any problem. Thus we can conclude that an implementation on physical perturbation is a success.

The disadvantage of this method is to have extra vertical interpolation in base field. But the advantages of this modification are no needs of lateral boundary terrain blending and horizontal diffusion on pressure surfaces. And it should improve the nesting as shown in Juang and Hong 2001.

Only the mean bias correction is shown here, however, the physical perturbation can be used to remove some long waves which have already resolved very well by the base field. Nevertheless, how to determine the optimal waves to remove in different model domains should be investigated.

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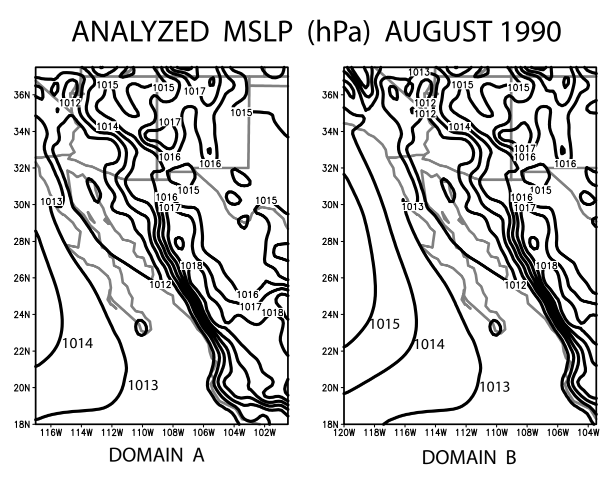

Fig. 1 Monthly-means of mean-sea-level pressure from analysis over two domains are shown for August 1990.

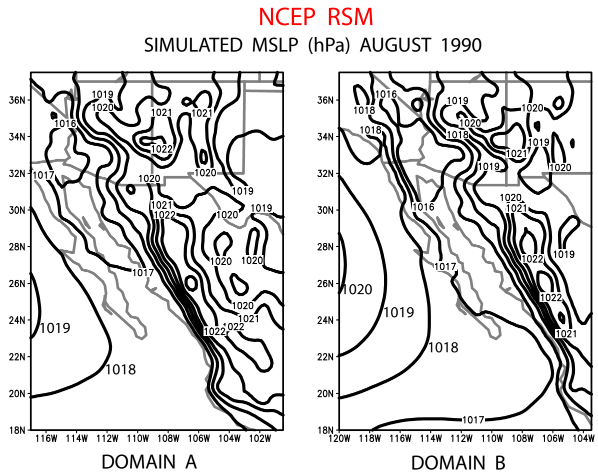

Fig. 2 The same as Fig. 1 except from original NCEP RSM without modification.

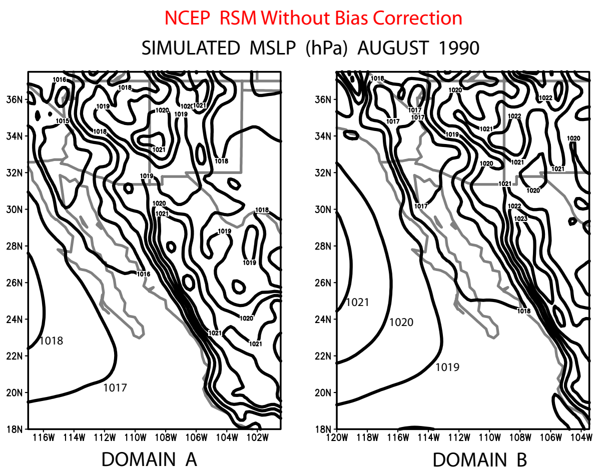

Fig. 3 The same as Fig. 2 except from the modified method presented in the text without mean bias correction.

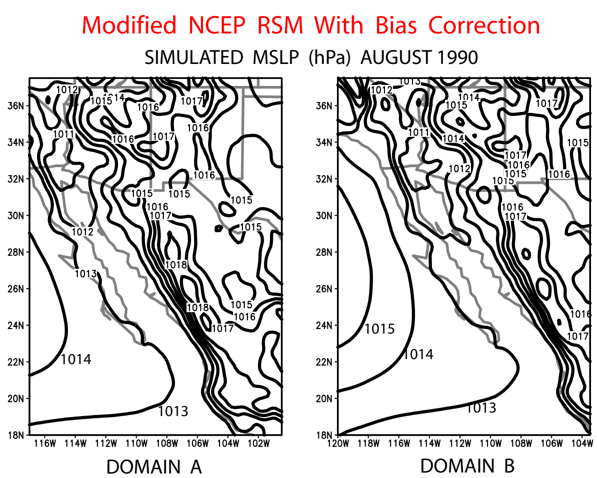

Fig. 4 The same as Fig. 3 except with mean-bias correction.

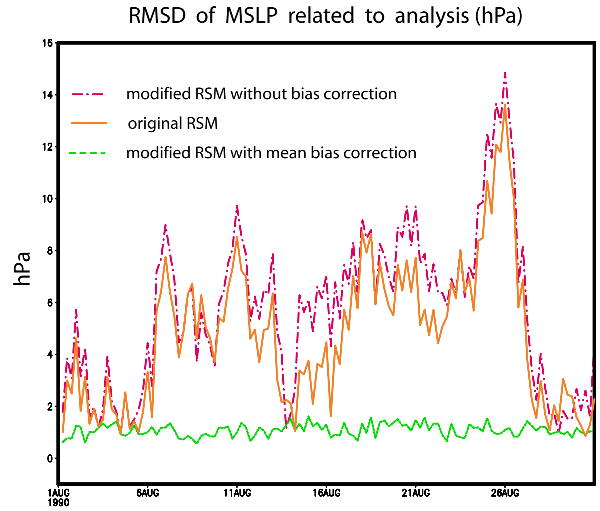

Fig. 5 Root-mean-square differences of mean-sea-level pressure for all experiments with respect to analysis.