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A COMPARISON OF THE OBSERVED AND FORECAST FREQUENCIES OF VARIOUS PRECIPITATION AMOUNTS IN THE 1986, 1987, AND 1988 VERSIONS OF THE NESTED GRID MODEL

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1. INTRODUCTION

During the fall of 1987, the National Meteorological Center (NMC) made several changes to the Nested Grid Model (NGM) (National Weather Service, 1985; 1986) which significantly affected the model's precipitation. In particular, a hemispheric temperature adjustment scheme was added to the model on October 22, 1987 (National Weather Service, 1987a) and the time step used in the calculation of physical processes was changed on December 10, 1987.

The hemispheric temperature adjustment scheme forced the average hemispheric temperature to remain constant throughout the forecast period at all sigma layers in the model. To accomplish this, the scheme simply added or subtracted heat from the model at each of the layers. Prior to the implementation of this adjustment process, the NGM tended to become cooler with increasing forecast projection (Jensenius, 1988). The addition of heat to the model, of course, lowered the relative humidities in the model and consequently reduced the overall precipitation.

The time step change was implemented to save computer time and was not expected to have any significant effects on the model's forecasts (National Weather Service, 1987b). Prior to the change, the physical processes in the model atmosphere over North America (including convective and non-convective precipitation) were calculated every 75 seconds. Since the change, the physical processes have been calculated at forecast intervals of 15 minutes. However, after implementation, Phillips et al. (1988) found that the longer time step increased the convective precipitation in the model and decreased the non-convective precipitation. The net result was that the longer time step reduced the combined total precipitation. Phillips et al. (op. cit.) concluded that the stabilizing effects of releasing the latent heat at higher layers through convective precipitation, rather than at lower levels through non-convective precipitation, reduced cyclogenesis in the model.

The combination of the hemispheric temperature adjustment and time step changes resulted in a decrease in the total precipitation produced by the NGM and a decrease in the number of forecast occurrences of precipitation in 6-h periods (Jensenius, 1988; 1989). In this Office Note, we attempt to determine how <u>each</u> change affected the precipitation in the NGM. To test the effects of each change, we have evaluated the statistical relationships between the observed and forecast occurrences of various amounts of precipitation in the NGM before, between, and after the two changes were made. The results are presented here.

2. METHOD

To evaluate how the two changes affected the NGM's precipitation, we examined the forecast frequencies of various amounts of precipitation in the NGM before either change was made (October 22, 1986 - December 9, 1986), after the hemispheric temperature correction was implemented but before the time step was changed (October 22, 1987 - December 9, 1987), and after both changes were implemented (October 22, 1988 - December 9, 1988). For comparison, we also tested the Limited-area Fine-mesh Model (LFM) (National Weather Service, 1978; Newell and Deaven, 1981) for the same periods and with matched samples. The model forecasts were interpolated to about 230 stations throughout the contiguous United States where precipitation observations were available. Only forecasts from 0000 UTC were evaluated. For each of the 6-h periods between 12 and 48 hours, we determined the observed and forecast relative frequencies of ≥ 0.01, ≥ 0.10, ≥ 0.25, ≥ 0.50, and ≥ 1.00 inches of precipitation. Note that the two 6-h periods between 0 and 12 hours were not used because of "spin up" problems in the NGM and because of the method used to calculate precipitation in the LFM during the first 12 hours of the forecast.

3. RESULTS

For each of the three 7-week verification periods, we combined the data for all stations and days and for the six 6-h forecast periods. This gave us a sample size of approximately 60,000 cases in each verification period. Fig. 1 shows the relationship between the observed and forecast relative frequencies of the various precipitation amounts for the three verification periods for the NGM. In this graph, we've plotted the forecast versus observed relative frequencies of ≥ 0.01, ≥ 0.10, ≥ 0.25, ≥ 0.50, and ≥ 1.00 inches of precipitation for each of the verification periods. Ideally, all points would fall on the dotted line where the forecast frequency matches the observed frequency. If a point is above and to the left of the dotted line, the model is underforecasting the event. Points plotted below and to the right of the dotted line indicate that the event is being overforecast. Of course, the highest observed or forecast frequency corresponds to the lowest precipitation amount category (≥ 0.01 inches) and vice versa. Clearly, there is a distinct change in the relationship between the observed and forecast relative frequency between 1986 and 1987 for the frequencies of ≥ 0.01, ≥ 0.10, and ≥ 0.25 inches of precipitation. The hemispheric temperature adjustment definitely appears to have "dried out" the NGM. Fig. 1 also indicates that there was little change in the relationship between observed and forecast relative frequency between the 1987 and 1988 verification periods for the same three amounts. Note that the NGM overforecast the frequency of ≥ 0.01 during all three verification periods.

To better understand the effects of the model changes on the relative frequencies of the larger amounts of precipitation, we plotted the same data on a log-log plot (Fig. 2). For the categories of ≥ 0.50 and ≥ 1.00 inches, Fig. 2 indicates that the relationship between the observed and forecast relative frequencies changed most between the 1987 and 1988 verification periods. Between 1987 and 1988, the time step change appears to have significantly reduced the forecast relative frequencies of the larger amounts of precipitation in the NGM. Note that the model underforecast the frequencies of ≥ 0.50 and ≥ 1.00 inches during all three of the verification periods.

For comparison, the LFM was evaluated on a matched sample of data. Note that the LFM was not changed during the 1986 - 1988 period. Fig. 3 is a linear plot of the observed and forecast relative frequencies for the LFM for the three verification periods. Although the observed relative frequency of ≥ 0.01 inches changed significantly between 1986 and 1987, the relationship between the observed and forecast frequencies changed only a little. Clearly, however, the LFM overforecasts the frequencies of ≥ 0.01, ≥ 0.10, and

≥ 0.25 inches of precipitation. Fig. 4 is a log-log plot of the same data. As anticipated, the results for the three verification periods are very similar.

4. SUMMARY

For the October 22 - December 9 period, the inclusion of the hemispheric temperature correction scheme appears to have reduced the NGM's forecast frequencies of ≥ 0.01, ≥ 0.10, and ≥ 0.25 inches of precipitation, but had a relatively small effect on the forecast frequencies of ≥ 0.50 and ≥ 1.00 inches of precipitation. In contrast, the change to the longer time step reduced the NGM's forecast frequencies of ≥ 0.50 and ≥ 1.00 inches of precipitation, but had little effect on the forecast frequencies of the smaller amounts.

Since the NGM overforecast the relative frequency of ≥ 0.01 inches of precipitation, the inclusion of the hemispheric temperature correction scheme has helped to reduce this overforecasting bias. Since the NGM tended to underforecast the relative frequencies of ≥ 0.50 and ≥ 1.00 inches of precipitation, the change to the longer time step made this underforecasting bias worse. Note, however, that synoptic-scale models should be expected to overforecast the frequencies of small amounts of precipitation and underforecast the frequencies of large amounts of precipitation when being verified with station data.

The results presented here are for all stations combined for the October 22 - December 9 period. Note that the precipitation that occurs during this period is generally non-convective. Because the ratio of convective to non-convective precipitation varies depending on the time of the year and location within the country, and because the changes made to the NGM (especially the change in the time step) are related to the type of precipitation (convective versus non-convective), the results should not be interpreted as being valid for all stations and seasons. However, the results do support the conclusions of Phillips et al. (1988).

5. ACKNOWLEDGMENTS

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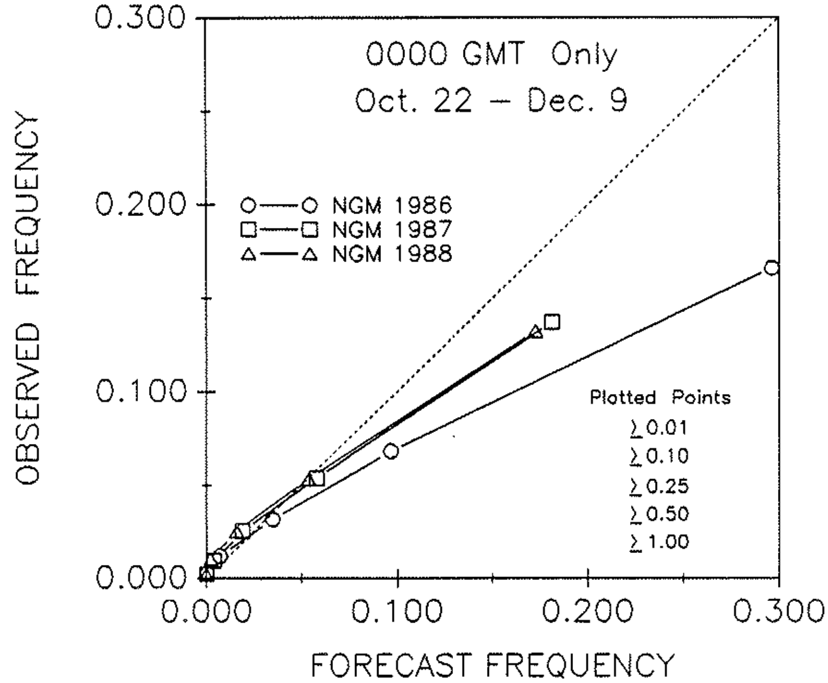

Figure 1. Observed versus NGM forecast relative frequencies of ≥ 0.01, ≥ 0.10, ≥ 0.25, ≥ 0.50, and ≥ 1.00 inches of precipitation for the 1986, 1987, and 1988 test periods.

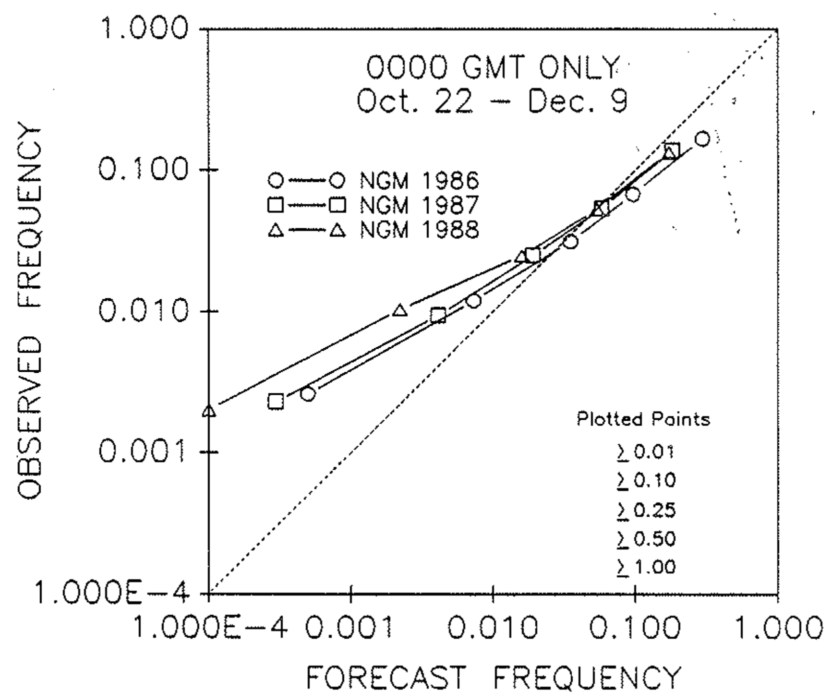

Figure 2. Same as Fig. 1 except that the data are plotted on a log-log scale.

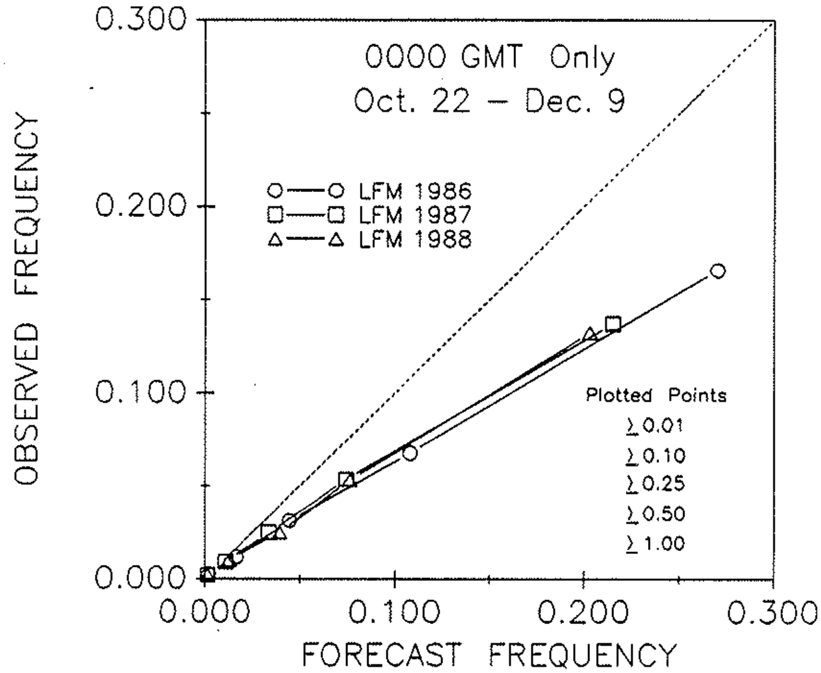

Figure 3. Observed versus LFM forecast relative frequencies of ≥ 0.01, ≥ 0.10, ≥ 0.25, ≥ 0.50, and ≥ 1.00 inches of precipitation for the 1986, 1987, and 1988 test periods.

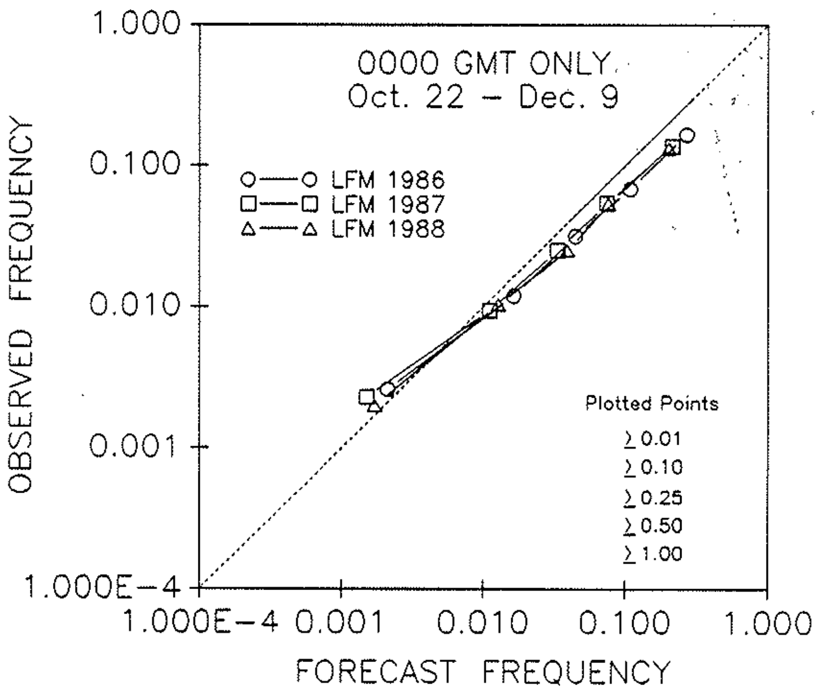

Figure 4. Same as Fig. 3 except that the data are plotted on a log-log scale.