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AN EVALUATION OF THE 10 YEARS OF SEASONAL CLIMATE OUTLOOKS ISSUED FOR WISCONSIN

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1. INTRODUCTION

Every day many decisions are made based on weather and climate predictions. For example, utility companies use forecasts of expected temperature to determine base rates for home heating and cooling costs. Farmers use climate forecasts to select crop varieties based on expected length of the growing season and to anticipate planting and harvesting dates. And tourism boards focus their advertising campaigns on activities complimentary to expected climatic conditions.

A tool that has the potential to be useful for any decision in which climate plays a role is the Long-Lead Seasonal Climate Outlooks issued by the Climate Prediction Center (CPC) branch of the National Weather Service. First issued in December 1994, the outlooks have been available for use by the public sector for just over ten years now.

CPC's outlooks are seasonal in that, on the third Thursday of each month, outlooks for temperature and precipitation are issued for 13 overlapping three-month seasons out to one year in advance (e.g., JFM, FMA, AMJ, …, JFM of the following year). These outlooks are issued for 126 outlook divisions (Fig. 1) across the U.S.

The outlooks themselves begin with the assumption that there is an equal likelihood (33.3% probability) that a given season's average temperature/total precipitation will fall into an above normal (AN), normal (N), or below normal (BN) category (AMS, 2001). Then, based on predictions of future climate from various tools (e.g., coupled oceanic-atmospheric general circulation models and statistical tools such as canonical correlation analysis (Hwang et al., 2001) and optimal climate normals (Huang et al., 1996)), CPC may assign a greater likelihood (a higher probability) that a given season's temperature/total precipitation will fall into one of three the categories (AN, N, BN). When predictions of future climate from the various tools provides conflicting predictions, CPC issues an "Equal Chances" outlook (33.3% probability of AN, N, BN seasonal average temperature/total precipitation). In either case, the sum of the three categories will always equal 100%.

Any prediction, especially a long-range prediction, is accompanied by some level of uncertainty. Therefore, potential users need to be aware of the extent of the uncertainty so they can base their decisions accordingly.

Now that the seasonal climate outlooks have been issued for a little more than ten years, we examined their accuracy for the three outlook divisions that encompass Wisconsin: division 14, division 25, and division 26 (Fig. 1). Three questions were addressed. First, are outlooks for a specific season(s) more accurate than others? Second, do shorter lead times yield more accurate outlooks than longer lead times? Third, do outlooks with increasing confidence levels translate into increased forecast skill?

2. MATERIALS & METHODS

A record of CPC's seasonal temperature and precipitation outlooks were obtained at http://www.cpc.ncep.noaa.gov/pacdir/NFORdir/HUGEdir2/cpcllft.dat and http://www.cpc.ncep.noaa.gov/pacdir/NFORdir/HUGEdir2/cpcllfp.dat, respectively. The

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corresponding observed values were obtained at http://www.cpc.ncep.noaa.gov/pacdir/NFORdir/webdat_t3 and http://www.cpc.ncep.noaa.gov/pacdir/NFORdir/webdat_p3, respectively. The season-specific threshold values used to assign both predicted and observed temperature and precipitation values into their respective AN, N, and BN categories were obtained at http://www.cpc.ncep.noaa.gov/pacdir/NFORdir/HUGEdir/llfct9501.

Once the data were entered into a spreadsheet, they were sorted by season, by lead time, and by magnitude of the probability anomaly (amount by which the forecast exceeds 33.3%). After sorting the data a protocol for statistical analysis was developed. Eleven categories (5 for AN outlooks, 5 for BN outlooks, and 1 for Equal Chance) were created based on the CPC-assigned probability anomaly (Table 1). The midpoint of each category is the expected probability of an above normal or below normal event. The number of AN or BN outlooks falling into a given category were tallied and multiplied by the midpoint of that category to get the expected number of observed AN or BN values. A chi-squared analysis was then performed for each category to compare the number of forecasted AN (BN) events to the number of observed AN (BN) events. A low p-value ($p < 0.05$) indicated disagreement between the forecast and the observed condition.

3. RESULTS & DISCUSSION

We examined the temperature and precipitation outlooks issued from December 1994 through October 2004 for Outlook Divisions 14 "Upper Michigan" (which includes northeastern Wisconsin), 25 "Northern Illinois" (which includes southern Wisconsin), and 26 "Northern Wisconsin." In all, we examined 4,368 outlooks each for temperature and precipitation (10 years of outlooks, 3 outlook divisions, and 13 outlooks issued per month).

3.1 *Outlooks by Season*

Examining the outlooks by season, we found that forecasts for above normal (AN) temperatures were more common in the winter and early spring seasons (DJF, JFM, and FMA) (Fig. 2). These were also the seasons in which CPC placed their highest confidence in their AN outlooks. Below normal temperature outlooks had a greater tendency to be issued during the late summer and fall seasons (JAS, ASO, and SON). During the spring and fall transitional seasons a high percentage of temperature outlooks were assigned to the "Equal Chances" (EC) category, including 97% of AMJ temperature outlooks being assigned EC.

Based on our chi-squared analysis, the P-values indicated that the best outlooks (i.e., those outlooks whose expected number was not significantly different than the observed number) were those for AN temperature during the winter seasons (DJF and JFM). Those also happened to be the outlooks that were assigned particularly high confidence levels (Fig. 3). For the MAM, JJA, and JAS seasons the expected number of AN outlooks were not significantly different than the observed number.

Precipitation outlooks by season showed a greater tendency toward AN outlooks in the fall and early winter seasons (SON and OND) (Fig. 4). BN precipitation outlooks were more common in the winter and early spring seasons (JFM, FMA, and MAM). A very high percentage ($\geq 84\%$) of precipitation outlooks issued for the spring through summer months were assigned EC.

Accuracy of precipitation outlooks showed no specific seasonal pattern, i.e., no particular season was more accurately forecast than another (Fig. 5). Additionally, the seasons in which the observed number of (AN or BN) outlooks were not significantly different than the expected number often had fewer than 15 outlooks to analyze, so it is difficult to assess their true accuracy.

3.2 *Outlooks by Leadtime*

Temperature outlooks examined as a function of leadtime showed that the lowest percentage of EC outlooks occurs with the shortest leadtime (0.5 months) and gradually increased with increasing leadtime (although the increase was quite modest) (Fig. 6). The percentages of outlooks in the AN and BN categories changed little with increasing leadtime.

High P-values for AN and BN outlooks show that the observed number of AN and BN outlooks was not significantly different than the expected number, indicating good accuracy when examined as a function of leadtime (Fig. 7). Although there are relatively few AN outlooks with higher confidence levels (0.400-0.499), these outlooks did have the highest P-values.

Precipitation outlooks showed a very definite trend, the lowest percentage of EC outlooks occurs with the shortest leadtime (0.5 months) and gradually increases with leadtime (Fig. 8).

P-values indicate that the observed number of AN and EC precipitation outlooks was not significantly different than their respective number of expected outlooks indicating good accuracy when examined as a function of leadtime (Fig. 9). However, when observed and expected numbers of EC are not significantly different, it simply means that precipitation was predictably random during those seasons. There were no leadtimes during which the observed number of BN outlooks were not significantly different than expected numbers, indicating poor accuracy by BN outlooks.

3.3 *Outlooks by Probability Anomaly*

Of the 4,368 temperature outlooks that we examined, approximately two-thirds (64.5%) were assigned EC. AN and BN temperature outlooks have been assigned 18.2% and 15.9% of the time, respectively (Fig. 10). The remaining 1.2% of the outlooks were actually assigned N.

Taken as whole, AN temperature outlooks with high confidence (0.500-0.599 probability anomalies) were the only outlooks that had significant P-values (Fig 11); i.e., their observed numbers were not significantly different than their expected numbers. It must be noted, however, that there were only a total of 21 outlooks that had probability anomalies of this magnitude.

Of the 4,368 precipitation outlooks that we examined, approximately five-sixths (84.3%) were assigned EC (Fig. 12). There were an equal number of AN and BN precipitation outlooks, 343 (7.9%) and 344 (7.9%), respectively. There were no N precipitation outlooks assigned.

Taken as whole, AN precipitation outlooks with high confidence (0.400-0.499 probability anomalies) were the only outlooks that had significant P-values (Fig 13); i.e., their observed numbers were not significantly different than their expected numbers. It must be noted, however, that there were only a total of 30 outlooks that had confidence levels of this magnitude.

4. SUMMARY AND CONCLUSIONS

The Climate Prediction Center has been issuing Long-Lead Seasonal Climate Outlooks for ten years. On the third Thursday of every month, temperature and precipitation outlooks are issued for consecutive 3-month seasons out to one year in advance (JFM, FMA, MAM, … , JFM of the following year). CPC assigns a certain percentage to the likelihood that seasonal temperature and precipitation will fall into one of three categories: above normal (AN), normal (N), and below normal (BN). The sum of those percentages always totals 100%. If CPC does not weight a given category more than another, then an “Equal Chances” (EC) outlook is assigned (i.e., a 33.3% probably that temperature/precipitation will fall into the AN, N, or BN categories).

For Wisconsin, outlooks calling for “Equal Chances” of AN, N, or BN were the general rule. Approximately 65% of all temperature outlooks and 84% of all precipitation outlooks were assigned EC.

As a function of season, AN temperature outlooks exhibited some skill in the winter and summer seasons, while BN outlooks exhibited little skill. During the seasons JAS through JFM, it was observed that EC outlooks were almost always issued, however, AN temperatures often occurred. This suggests that there were many missed opportunities to correctly predict AN temperatures during those seven consecutive seasons

As a function of leadtime, AN temperature outlooks exhibited some skill across all leadtimes, while BN temperature outlooks were just not very accurate. In terms of precipitation, AN and EC outlooks demonstrated good skill. However, “accurate” EC outlooks is an oxymoron, it basically says “I can accurately predict that precipitation will be random.”

When all temperature outlooks were combined and examined as a function of their probability anomaly, only AN temperature outlooks at the 0.500-0.599 probability anomaly have significant skill. Likewise, only AN precipitation outlooks at the 0.400-0.499 probability anomaly have significant skill.

5. REFERENCES

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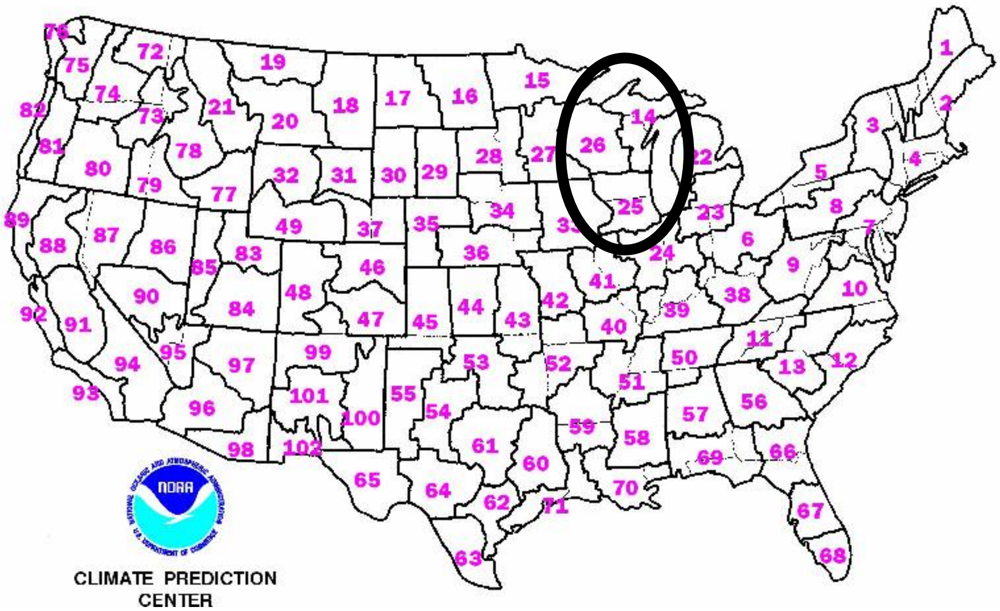

Fig 1. Outlook divisions for the contiguous U.S. for which CPC issues seasonal climate outlooks. The specific study area is shown in the oval.

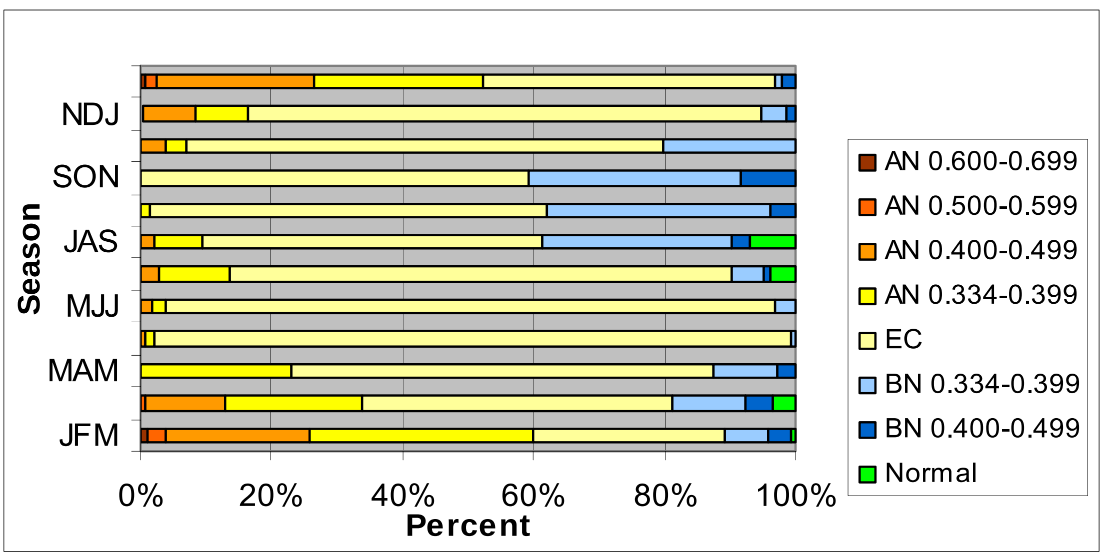

Fig. 2. Percentage of AN, N, BN, and EC temperature outlooks in each season.

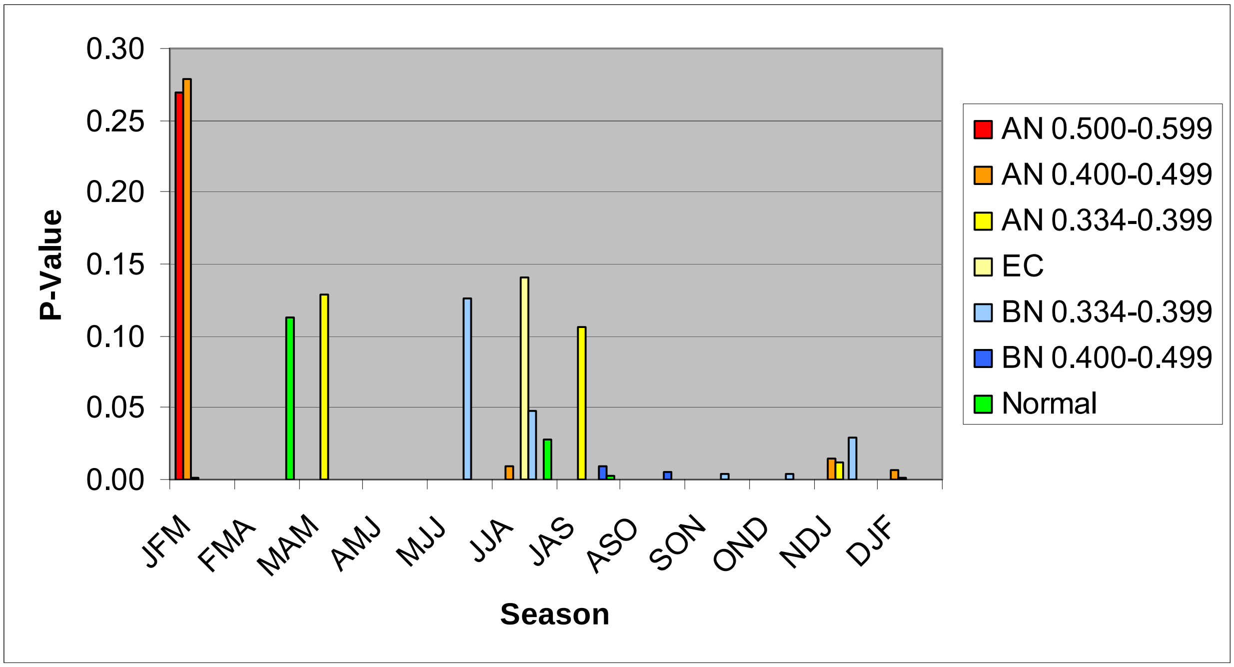

Fig. 3. P-values resulting from a chi-squared analysis of temperature outlooks by season.

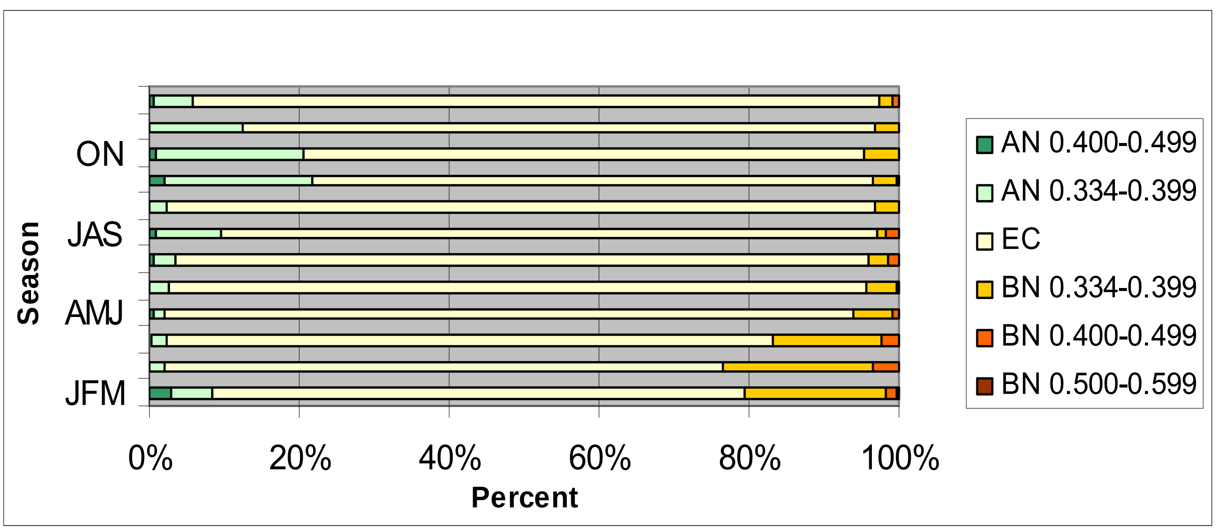

Fig. 4. Percentage of AN, N, BN, EC precipitation outlooks in each season.

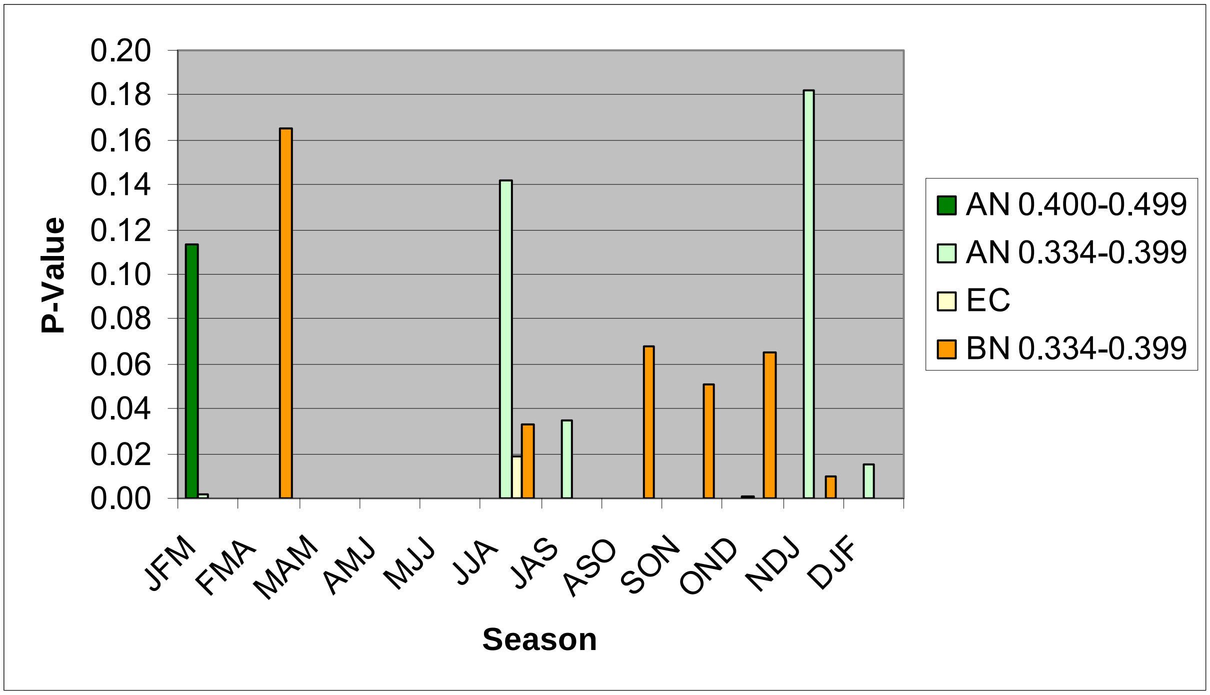

Fig. 5. P-values resulting from a chi-squared analysis of precipitation outlooks by season.

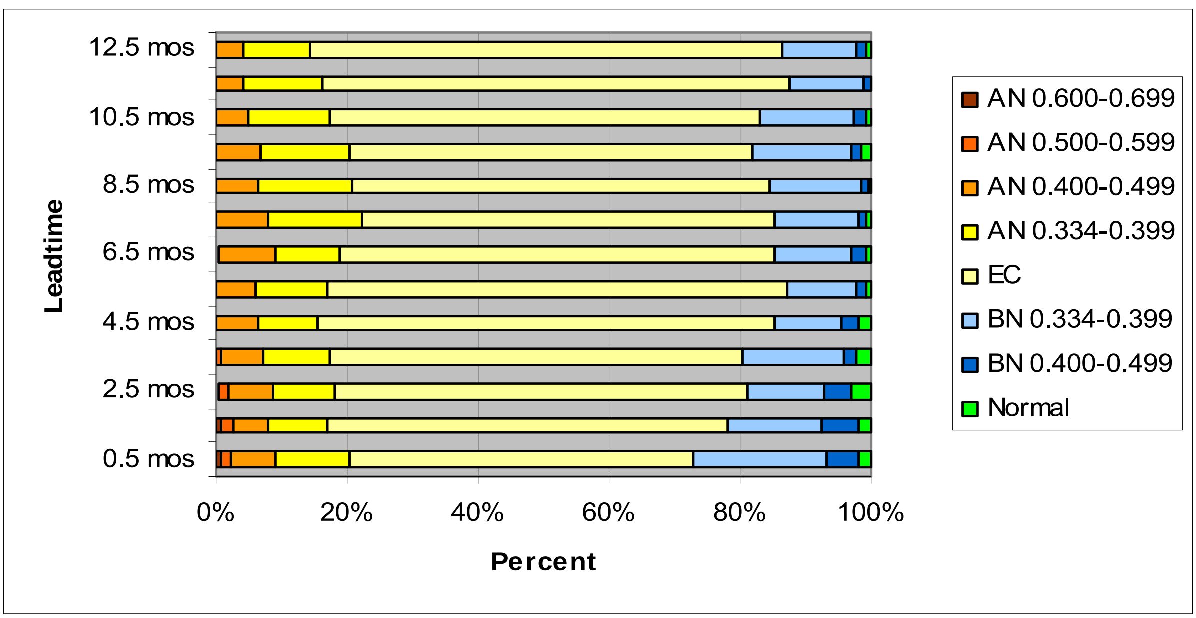

Fig. 6. Percentage of AN, N, BN, and EC temperature outlooks in each leadtime.

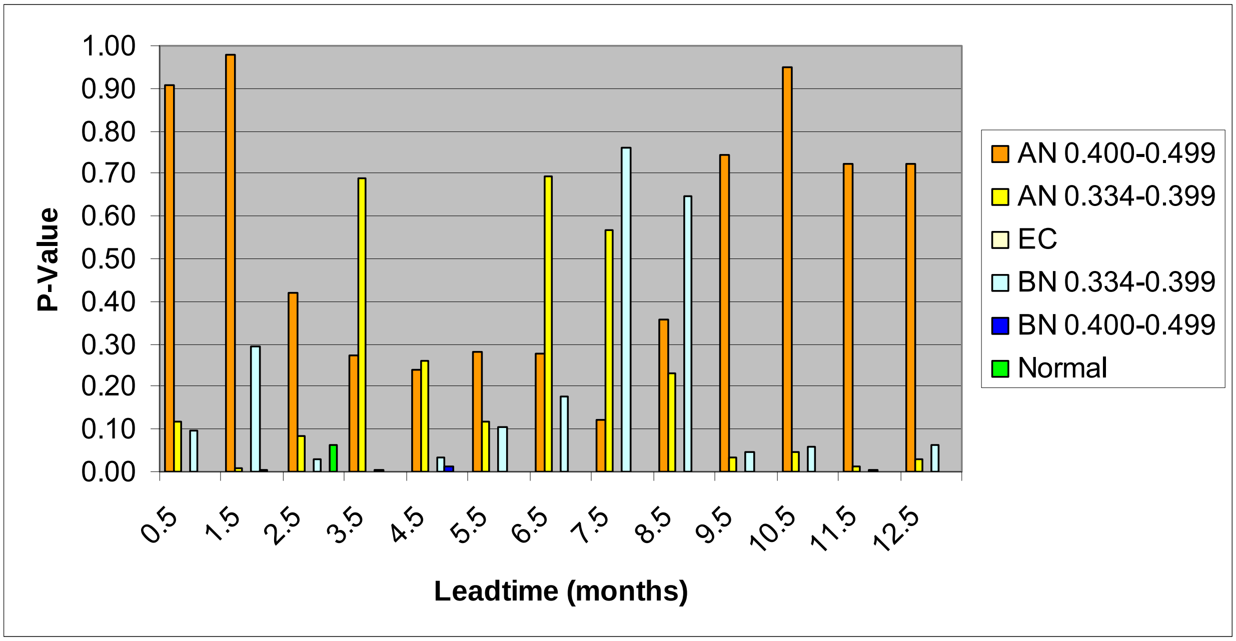

Fig. 7. P-values resulting from a chi-squared analysis of temperature outlooks by leadtime.

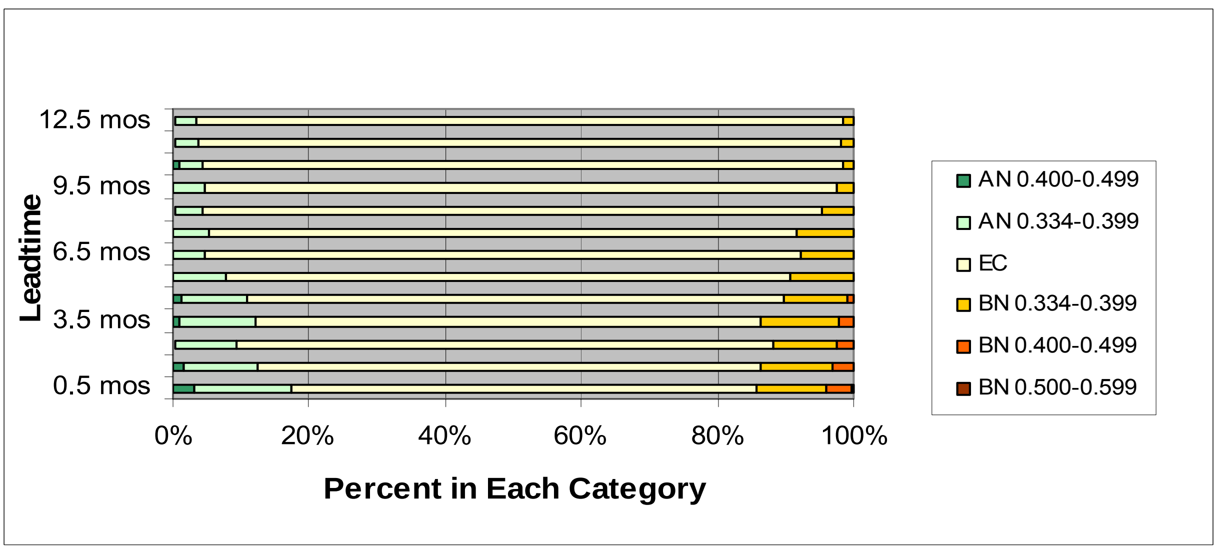

Fig. 8. Percentage of AN, N, BN, and EC precipitation outlooks in each leadtime.

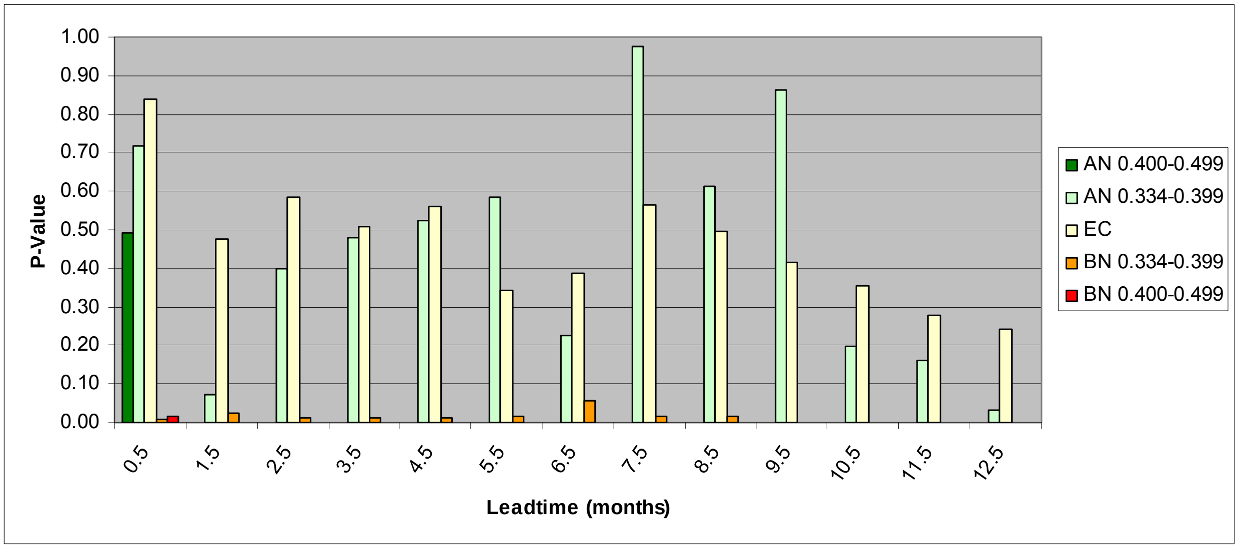

Fig. 9. P-values resulting from a chi-squared analysis of precipitation outlooks by leadtime.

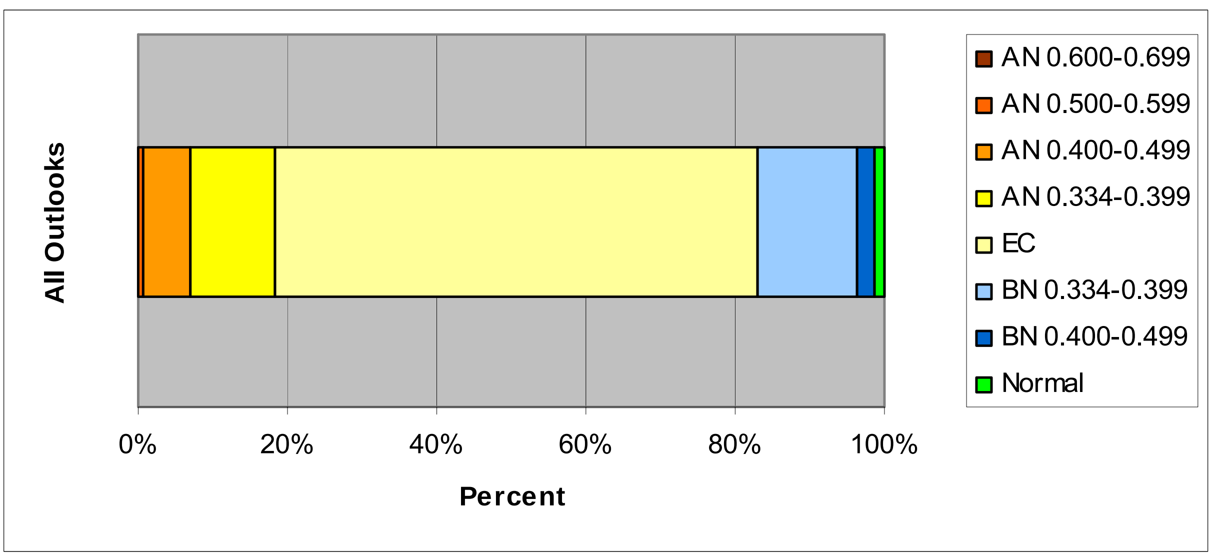

Fig. 10. Percentage of AN, N, BN, and EC temperature outlooks for the 4,368 outlooks issued in the study period.

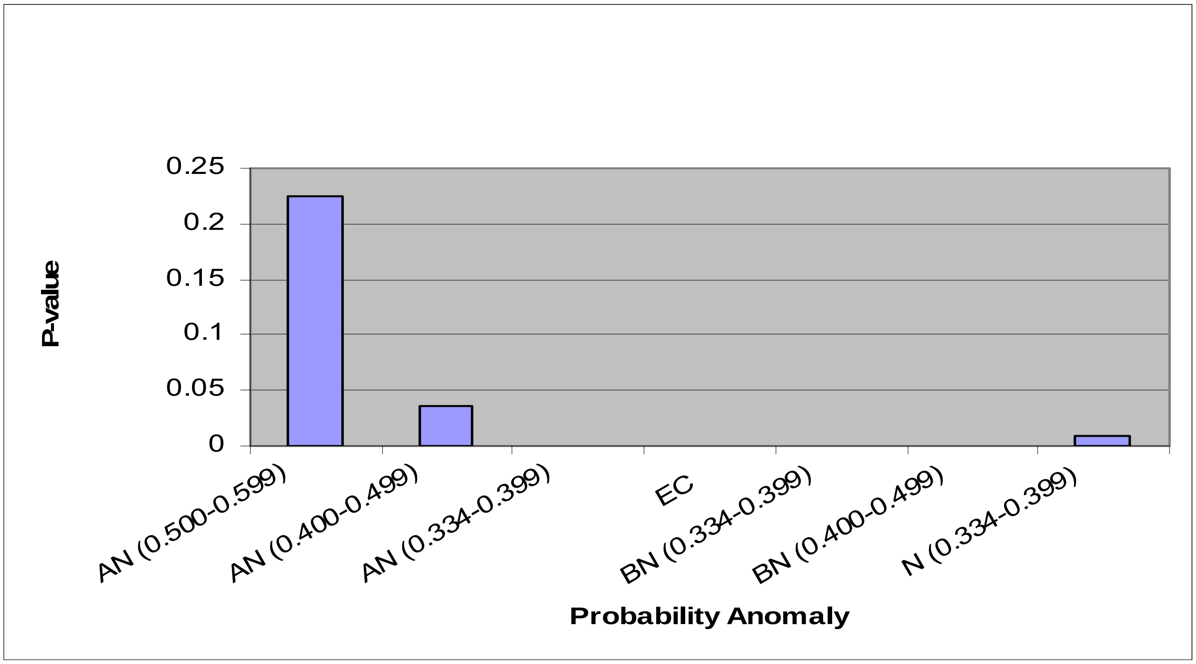

Fig. 11. P-values resulting from a chi-squared analysis of all temperature outlooks merged together.

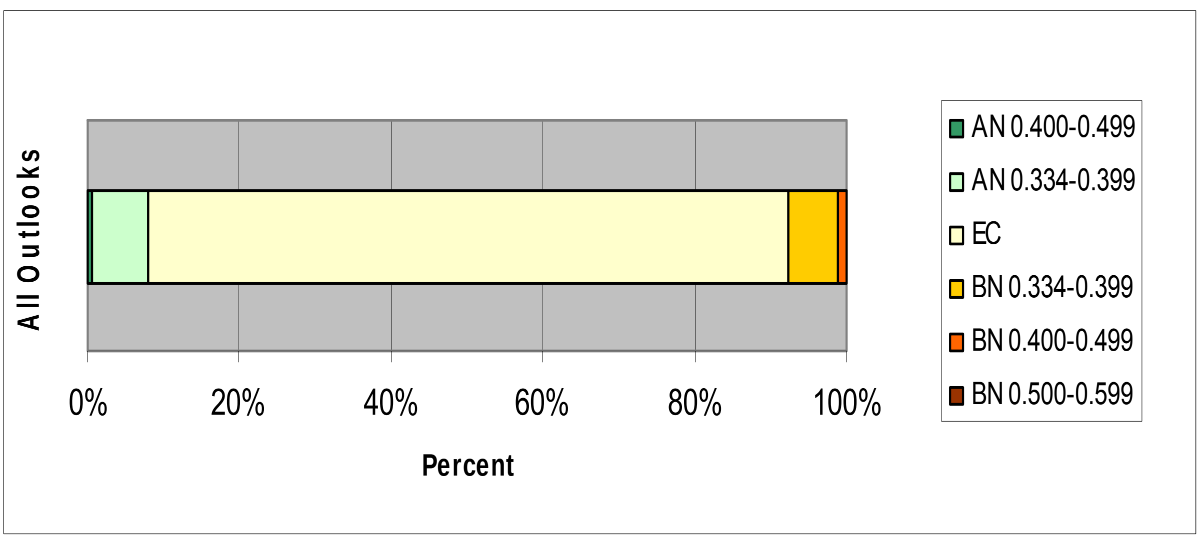

Fig. 12. Percentage of AN, N, BN, and EC precipitation outlooks for the 4,368 outlooks issued in the study period.

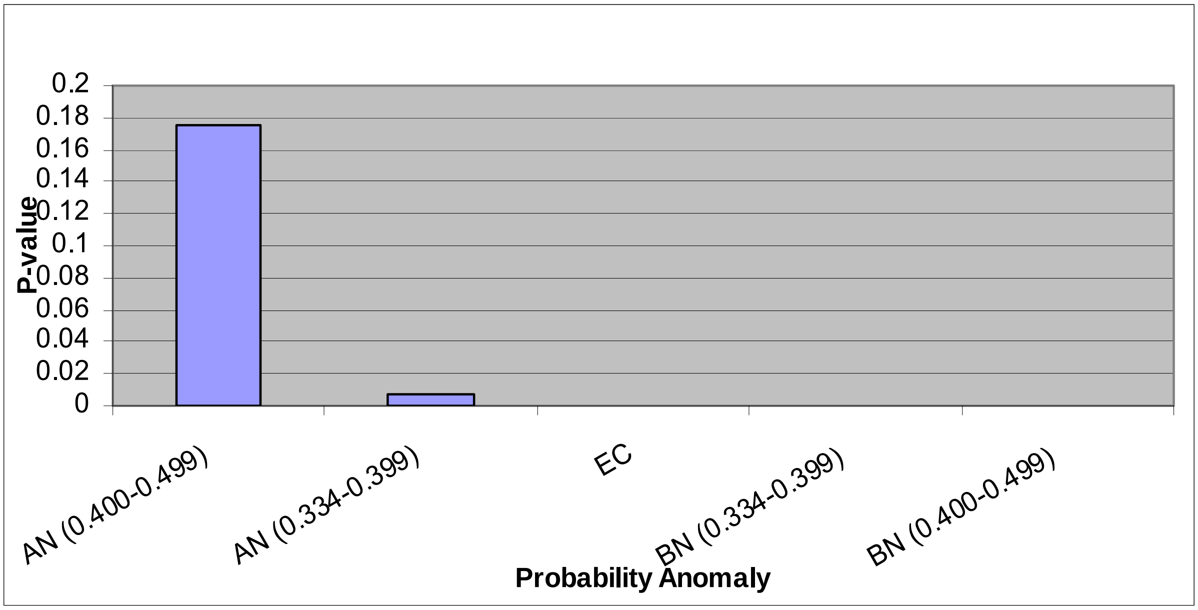

Fig. 11. P-values resulting from a chi-squared analysis of all precipitation outlooks merged together.

Probability Anomaly (% by which an Outlook exceeds 33.3%)	Outlook Probability	Midpoint
36.7% - 46.6% AN Outlook	70.0% – 79.9%	75.0%
26.7% - 36.6% AN Outlook	60.0% - 69.9%	65.0%
16.7% - 26.6% AN Outlook	50.0% - 59.9%	55.0%
6.7% - 16.6% AN Outlook	40.0% - 49.9%	45.0%
0.1% - 6.6% AN Outlook	33.4% - 39.9%	36.6%
Equal Chance Outlook	33.3%	33.3%
0.1% - 6.6% BN Outlook	33.4% - 39.9%	36.6%
6.7% - 16.6% BN Outlook	40.0% - 49.9%	45.0%
16.7% - 26.6% BN Outlook	50.0% - 59.9%	55.0%
26.7% - 36.6% BN Outlook	60.0% - 69.9%	65.0%
36.7% - 46.6% BN Outlook	70.0% – 79.9%	75.0%

Table 1. Categories used for the chi-squared analysis.