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USEFULNESS OF RECENT NOAA/CPC SEASONAL TEMPERATURE FORECASTS

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1. INTRODUCTION

Operational climate forecasts for 3-month average temperature are issued monthly by the NOAA Climate Prediction Center, for lead times from 0.5 to 12.5 months. Among these forecasts, the probability of exceedance forecasts present information on expected shifts in the probability distribution of average temperature relative to climatological distributions (Barnston et al., 2000). The forecasts appear to support a wide range of possible applications in agricultural and water resource management. However, adoption and use of the forecasts has been limited, partly due to a lack of user-oriented measures of forecast utility on a regional basis. As a step in this direction, the frequency and magnitude of forecast departures from climatological conditions have been summarized across all forecast divisions for the year 1997-2002. This measure is termed “usefulness” in the sense that forecasts for strong or persistent departures from climatological conditions are more likely to be perceived as useful by managers, while weak or non-forecasts may be ignored. A similar analysis on seasonal precipitation forecasts showed large variations in usefulness with region, ENSO state, and season (Schneider and Garbrecht, 2003.)

2. DEFINING USEFULNESS

A large percentage of the average temperature forecasts issued by NOAA/CPC offer no information beyond the climatological odds for average temperature (“Normal” conditions). These situations are indicated on the probability of exceedance forecasts by overlapping forecast and Normal curves, and on tercile forecast maps by white regions labeled “EC” (for “equal chances” for precipitation in each of the three terciles). These forecasts are essentially non-forecasts, situations where the forecasters lack confidence in their ability to reliably forecast departures from Normal odds. We are interested in knowing how often, and by how much, the average temperature forecasts predict departures from Normal conditions, since these are the forecasts that might prompt a change in practice from established operating procedures. Accordingly, we take the departure of the mean of the forecast distribution from the mean of the Normal distribution as the basis of this measure of usefulness. Since the mean value of 3-month average temperature varies widely with season and location, it is convenient to normalize the departure by dividing by the mean of the Normal distribution, and express it as a percentage:

$$D_N = \frac{F_\mu - N_\mu}{N_\mu} \times 100$$

where F_μ is the mean of the forecast distribution and N_μ is the mean of the Normal distribution. This allows us to conceptualize the departures as percentages of the mean, with positive numbers indicating an increase over Normal. It should be kept in mind that this method of normalization tends to emphasize departures in cool regions relative to warm regions.

Our measure of usefulness is then the frequency of precipitation forecasts issued with D_N greater than some defined threshold (here, ± 2.5%, 5%, and 7.5%). Simply put, larger and more frequent sizeable departures indicate a higher level of potential usefulness. These levels were arbitrarily chosen, but provide a general reference point. The threshold levels for the usefulness of temperature forecasts are half the size of the thresholds used for precipitation forecasts (Schneider and Garbrecht, 2003), because the variability in average temperature is usually much smaller than the variability in precipitation. Using the ratio of the standard deviation over the 30-year mean as an indicator of climatic variability, temperature variability is at least a factor of two smaller than the variability in 3-month total precipitation, and frequently as much as a factor of 10 smaller. This is illustrated in Figure 1, which plots the ratios of standard deviation to mean for both average temperature (T) and total precipitation (P) by 3-month period for three forecast divisions: FD15 in northern Minnesota, FD53 in central Oklahoma, and FD98 in southeastern Arizona.

3. RESULTS AT THE SHORTEST LEAD TIME

To illustrate the variability of usefulness with region and season, Figure 2 shows times series of forecast D_N versus normalized departures of actual 3-month mean temperature for the same 3 forecast divisions in Figure 1. The plots also include a matching time series of ENSO category (derived from data on the NOAA/NCEP/CPC web site), ranging from a +3 for strong El Niño conditions to –3 for strong La Niña conditions.

The first characteristic of interest in Figures 2a to 2c are the large differences in the range of variability in

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northern Minnesota compared to the other two regions. Normalized actual mean temperature departures were as large as +175% during the 3-month period of December-January-February in northern Minnesota, while the largest departures in southeastern Arizona or central Oklahoma were only +15%, and were usually less than ±5%. Generally, the climatological variability in winter temperatures (expressed as a percentage of normal) is significantly larger in the northern Great Plains than anywhere else in the contiguous United States. Some of this is an artifact of our normalization, but most of it is a reflection of a significant difference in variability, as illustrated in Figure 1. By contrast, the forecasts predicted departures of 28% at most for northern Minnesota, and just under 4% at best for the other two divisions.

The next point to note in Figures 2a to 2c is that the largest forecast departures were in the fall, winter, or spring of moderate to strong ENSO events. Warm episodes were forecast for northern Minnesota during the strong El Niño of 1997-1998, and for southeastern Arizona and central Oklahoma during the strong and moderate La Niñas of 1998-1999 and 1999-2000. Other modest departures have been forecast on the basis of trends alone (in particular for July-August-September 2001 – February-March-April 2002), or weak La Niña conditions in the Desert Southwest (Figure 2c).

Figure 3 summarizes the usefulness at the 2.5%, 5%, and 7.5% levels for the shortest forecast lead time (0.5 months) across the contiguous United States. Since the study period covers 1997 through 2002, there were 70 forecasts at this lead time for each forecast division. The percentage of these 70 forecasts with departures above the thresholds is indicated on the maps by forecast division. As with the precipitation forecasts, the potential usefulness of the temperature forecasts depends strongly on location. The highest levels of usefulness for the average temperature forecasts are in northern Maine, Vermont, and New Hampshire; from the western Great Lakes westward into the northern Rocky Mountains; southward through the central into the southern Rocky Mountains; in the southern Great Plains; and then from south Texas along the Gulf Coast into the extreme southern Appalachians and Carolinas. Of these regions, the northern Great Plains have the greatest potential usefulness.

4. DISCUSSION

Clearly, the forecasts under-predict the magnitude of actual average temperature departures, but to a lesser degree than the shortfalls of the precipitation forecasts. The usefulness of temperature forecasts are also markedly different in both magnitude and location of regional maxima than the usefulness of precipitation forecasts. Precipitation forecasts had usefulness magnitudes varying from more than 50% to less than 10% for departures larger than 5% of the mean. Average temperature forecasts have a usefulness of 20% at most, and most regions are in the 1-5% range, for departures larger than 2.5% of the mean. Precipitation usefulness is highest in the Desert Southwest, Texas and Florida, and to a lesser degree in the Pacific Northwest, Northern Rocky Mountains, and along the southern Atlantic coast. Temperature usefulness is highest in the northern Great Plains, and to a lesser degree across the western Great Lakes, Rocky Mountains, and Gulf Coast. To a large degree, these maxima in usefulness follow the seasonal maps of historical temperature impacts associated with ENSO, and reflect the important role the ENSO forecast plays in the creation of these seasonal forecasts. Unfortunately, that leaves the regions without strong or consistent ENSO impacts on average temperature with low levels of forecast usefulness: the Pacific Northwest, the northern Great Basin, and coastal California. In these regions, the average temperature forecasts have had very little to offer on departures from Normal conditions, even at the shortest lead times.

With the exception of the Desert Southwest, the majority of the larger forecast temperature departures were for the fall, winter, and spring seasons. Managers requiring forecasts of departures for the summer in the rest of the United States may not find much information offered in the CPC seasonal forecasts.

5. REFERENCES

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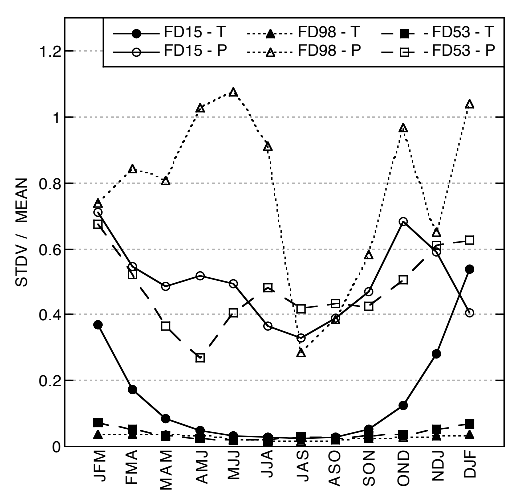
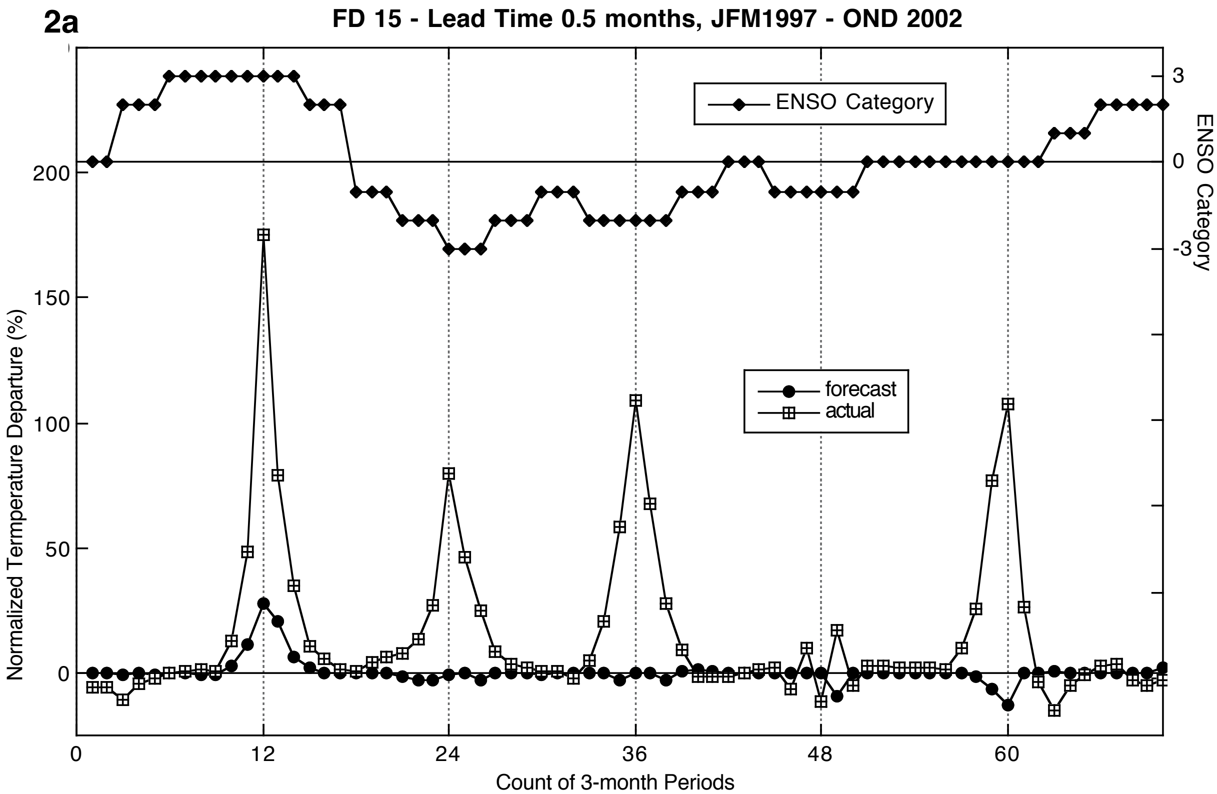
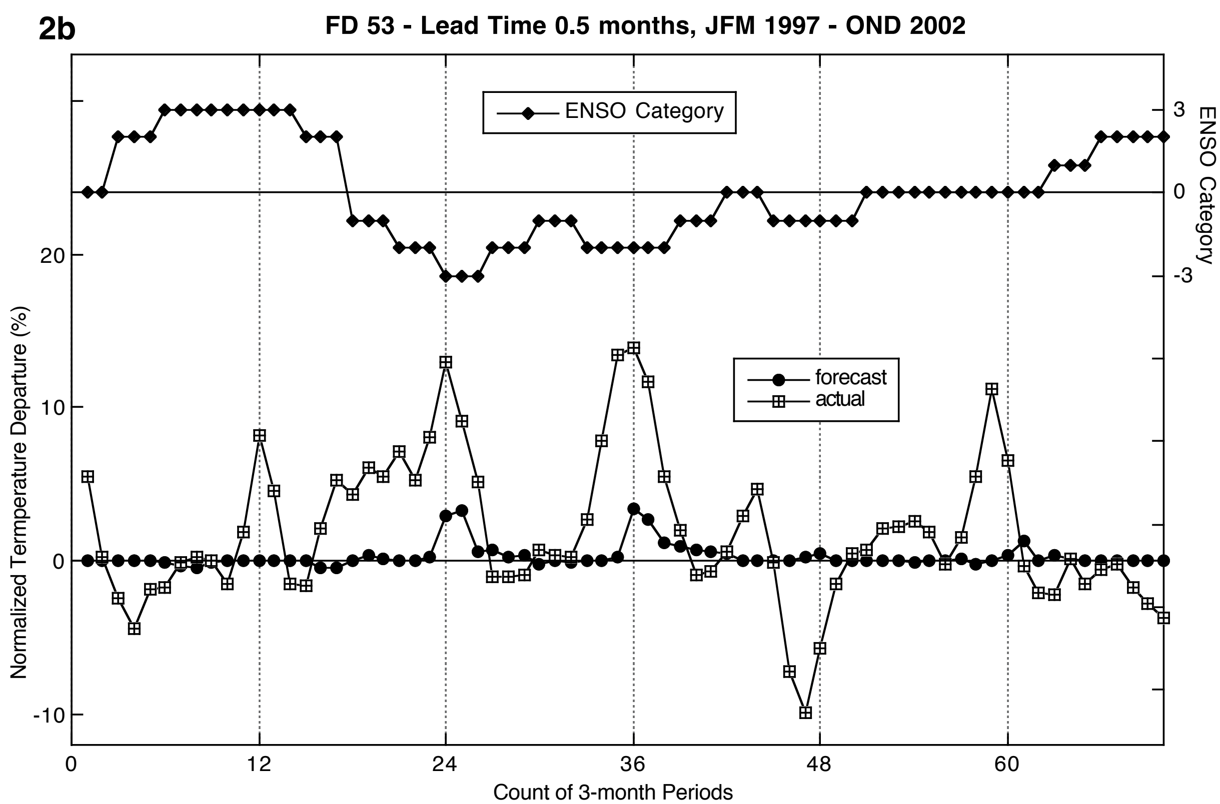


Figure 1. Ratios of standard deviation to 3-month mean values of average temperature and precipitation for 3 forecast divisions (15, 53, and 98).

2a


FD 15 - Lead Time 0.5 months, JFM1997 - OND 2002
ENSO Category
forecast
actual
Normalized Termperature Departure (%)
ENSO Category
Count of 3-month Periods
0
12
24
36
48
60
200
150
100
50
0
3
0
-3

2b


FD 53 - Lead Time 0.5 months, JFM 1997 - OND 2002
ENSO Category
forecast
actual
Normalized Termperature Departure (%)
ENSO Category
Count of 3-month Periods
0
12
24
36
48
60
20
10
0
-10
3
0
-3

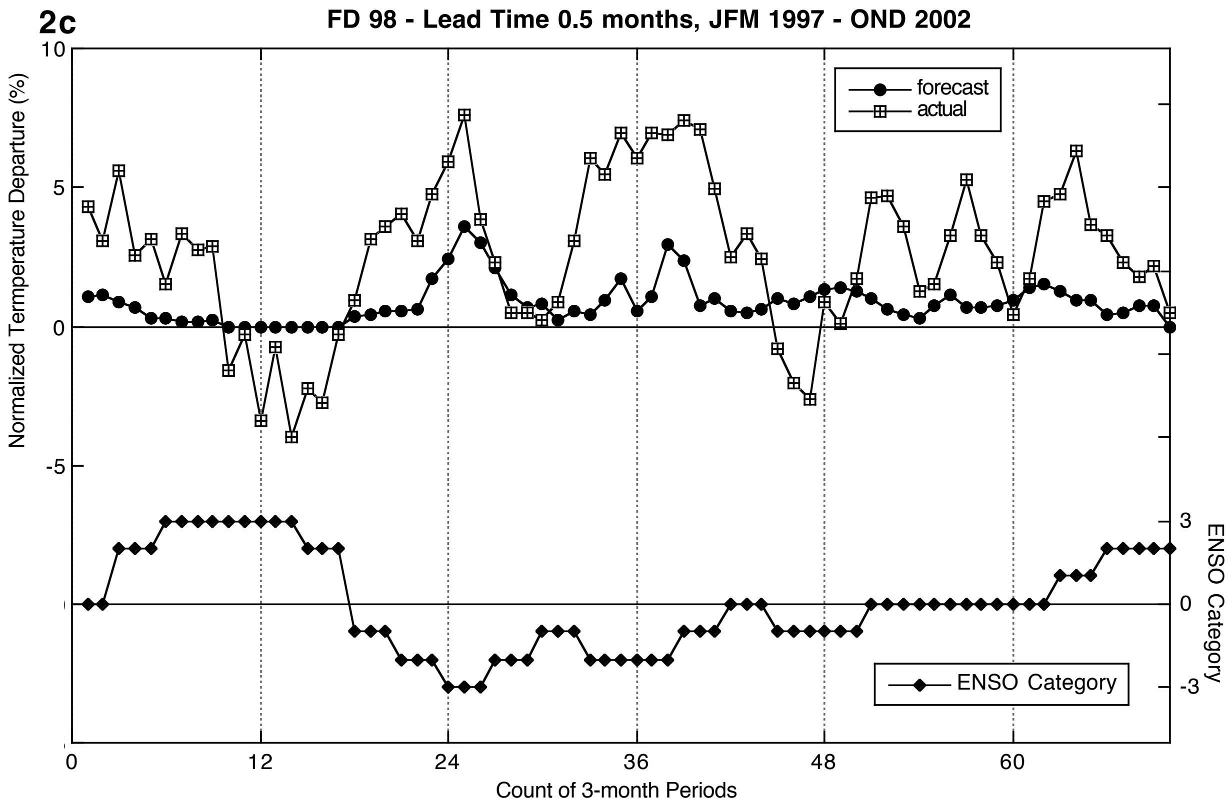
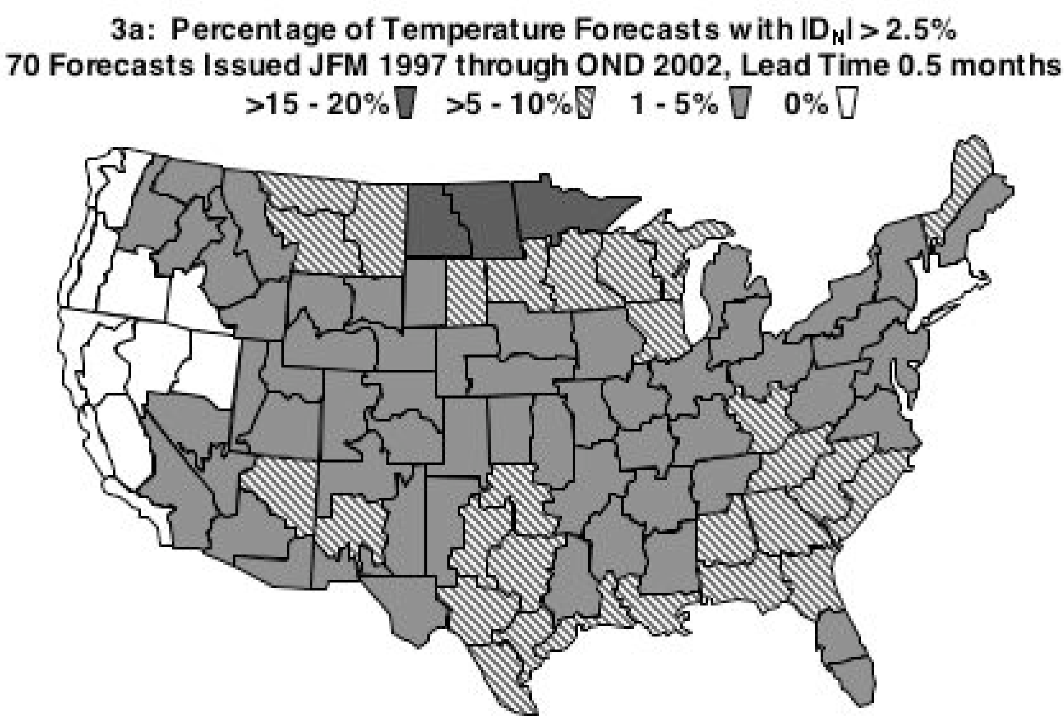


Figure 2. Time series of normalized average temperature forecasts, normalized actual average temperature, and ENSO category. Positive values of normalized temperature departure indicate warmer than average conditions. ENSO categories range from +3 for strong El Niño conditions, to –3 for strong La Niña conditions. Each values represents a 3-month period, and there are 70 overlapping periods in these time series.



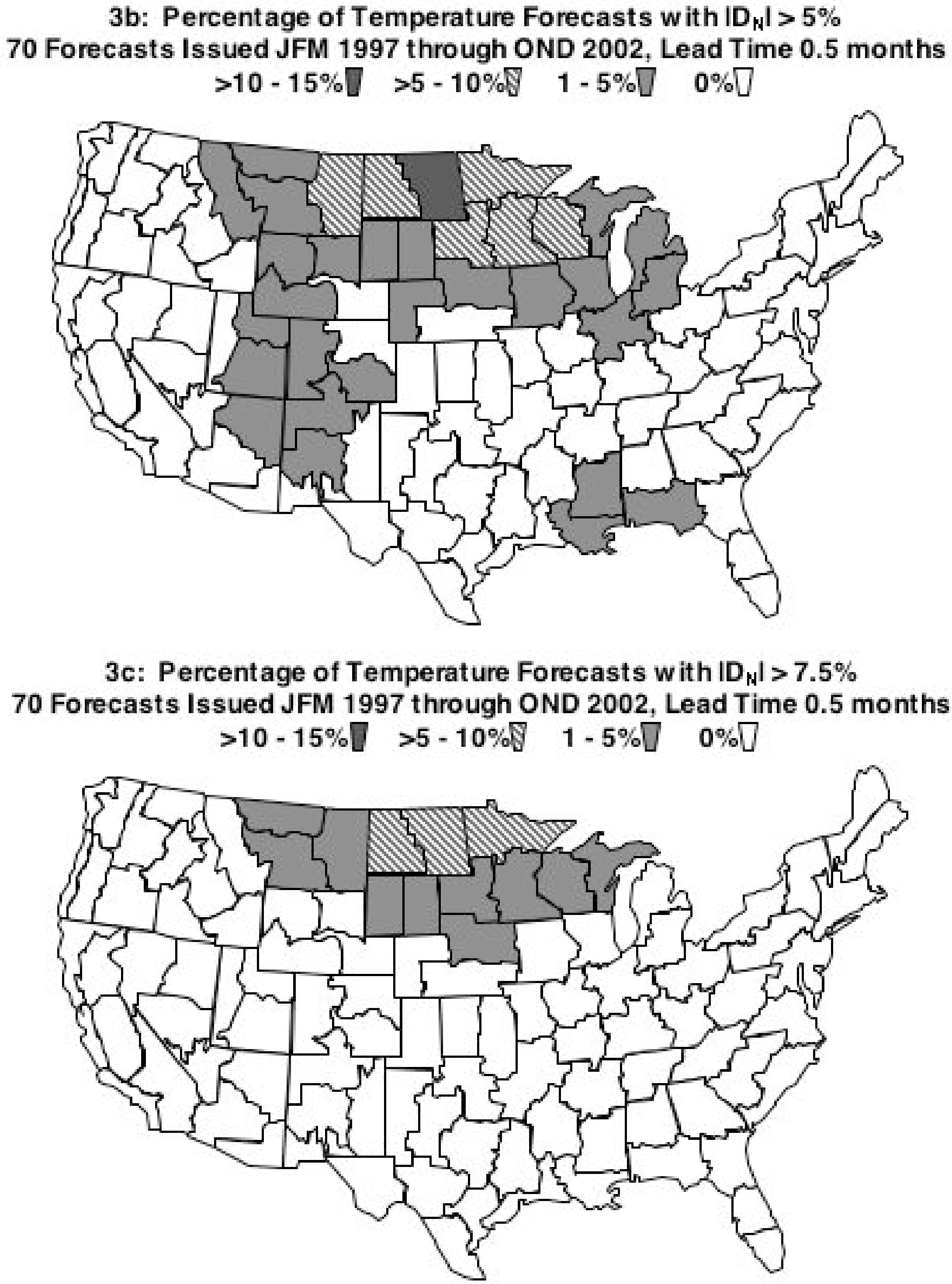


Figure 3. Maps of potential usefulness of the average temperature forecasts at three different thresholds, at the shortest lead time (0.5 months, or 2 weeks).