P2.22 **A METHOD FOR COMPUTING THE MONTHLY PALMER DROUGHT INDEX ON A WEEKLY BASIS: COMPARING DATA ESTIMATION TECHNIQUES**

Richard R. Heim Jr. *
NOAA / NESDIS / National Climatic Data Center, Asheville, North Carolina

1. INTRODUCTION

The Palmer Drought Index (PDI) was created by Wayne Palmer in the 1960s to address deficiencies in drought monitoring and analysis that had existed to that point (Palmer, 1965). Using precipitation and temperature to estimate moisture supply and demand within a two-layer soil model, it was the first comprehensive effort to assess the total moisture status of a region. Over the years the index has been applied across the U.S. and is used in other parts of the world (Heim, 2002). Palmer developed the index using monthly data, but he noted that it could be computed on a weekly or even daily basis instead of monthly.

The PDI traditionally has been computed by several agencies of the National Oceanic and Atmospheric Administration (NOAA) for operational drought monitoring and historical analysis, specifically the National Environmental Satellite, Data, and Information Service (NESDIS) and the National Weather Service (NWS). The NOAA/NESDIS/National Climatic Data Center (NCDC) computes the PDI on a monthly basis, while the NOAA/NWS/Climate Prediction Center (CPC) computes the PDI on a weekly basis. When used operationally, the monthly and weekly PDIs sometimes paint contrasting drought pictures (Fig. 1). This is due to the recursive autoregressive nature of the Palmer model equations (Heim, 2005).

The research presented in this paper is an outgrowth of an effort to resolve the differences between the weekly and monthly PDIs operationally created by NOAA. The key to this effort is to compute the monthly PDI for an operational month before the data for the full month are available, which requires estimating the month's total precipitation and temperature for those days from the current date through the end of the month. Current forecasting technology does not include predictions a month in advance for daily temperature and precipitation amount at the resolution needed to compute the PDI for this purpose. Therein lies the problem: on an operational basis, the weather for the remainder of the month is not known.

This paper compares three potential estimation methods for the unknown portion of the month. For each method, the monthly PDI was computed for a test month (July 2003) at several periods during the month. For a method to be successful, the July PDIs computed for the periods near the beginning of July should be reasonably close to the PD I values that existed at the end of June, and the July PDIs computed for the periods near the end of July should be reasonably close to the PDI values that are computed at the end of July with a full set of daily observations for July. In this way, the successful estimation method should represent a reasonable transition of the PDI values from the end of June to the end of July.

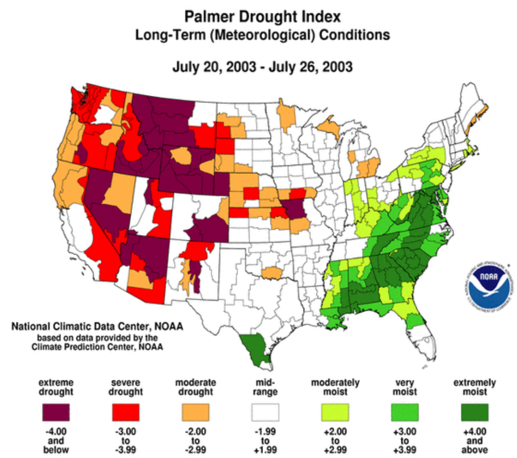

Fig. 1a. CPC weekly PDI for July 26, 2003.

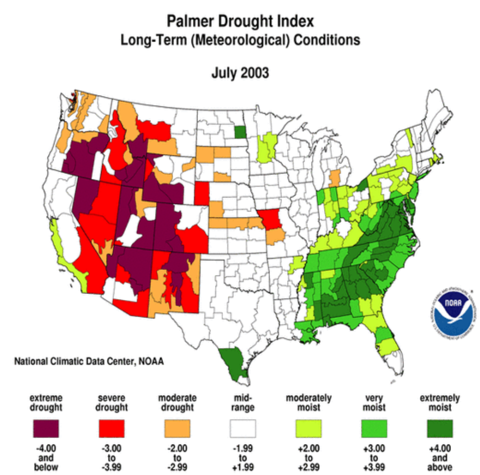

Fig 1b. NCDC monthly PDI for end of July 2003.

2. DATA

The U.S. climate division data base (Guttman and Quayle, 1996) was used in this analysis. This data base is used in drought monitoring because it is widely recognized as a spatially and temporally complete data base (Guttman and Quayle, 1996) which spans the last

* *Corresponding author address:* Richard R. Heim Jr., National Climatic Data Center, 151 Patton Avenue, Asheville, NC 28801-5001; e-mail: Richard.Heim@noaa.gov

century and which is updated operationally. It is comprised of monthly temperature and precipitation for the 344 climate divisions in the contiguous United States covering the period from 1895 to present. The Z Index, Palmer Drought Severity Index (PDSI), Palmer Hydrological Drought Index (PHDI), and CPC modification (Heddinghaus and Sabol, 1991; Heim, 2002) of the PDSI (called PDI but also referred to as PMDI) are computed for all climate divisions operationally and for the period of record. The PMDI was used in this study because it is the index that is best suited for operational applications.

The CPC computes divisional temperature and precipitation operationally on a daily basis and makes these data available in a moving 1000-day file. The daily data in the CPC 1000-day file formed the data source for the operational computation of estimates of monthly divisional temperature and precipitation.

3. PROCEDURE

Weekly PMDI values are computed by the CPC for weeks ending on Saturday. July 2003 was chosen for this analysis because the severity and expanse of drought peaked during the summer of 2003 and this month in particular had a wide representation of very wet and very dry conditions. July 2003 monthly temperature and precipitation values were computed for all 344 contiguous climate divisions for the four Saturdays in July and the end of the month (the ending dates for these periods were July 5, 12, 19, 26, and 31, for a total of five days) using three different methodologies. A total of 15 sets (five periods for each of three methodologies) of Palmer Index output (i.e., July 2003 monthly PMDI) were generated from the data. The three methodologies used to estimate monthly temperature and precipitation were suggested at a drought workshop (Second Annual Drought Monitor Forum and North America Drought Workshop, 25-27 April 2002, Asheville, North Carolina) and are:

i) the observed daily data from the CPC 1000-day file for the first of the month through day X were combined with 1971-2000 daily normals for day X+1 through the end of the month. The daily normals were estimated from the monthly divisional normals using a spline fit. This estimation methodology is referred to here as "NORMALS."

ii) the observed daily data from the CPC 1000-day file for the first of July through July X were combined with the observed data for June Y through June 30, where Y was chosen so that the data covered a moving 31-day window. This estimation methodology is referred to here as "WINDOW."

iii) the observed daily data from the CPC 1000-day file for the first of July through July X were multiplied by a factor, 31/X, so that the resulting monthly values represent the conditions that would result from the persistence of the observed anomalies to the end of the month. This estimation methodology is referred to here as "PERSISTENCE."

The 15 sets of July 2003 derived monthly PMDI values ("TEST") were compared to the PMDI values for June 2003 which were computed from monthly temperature and precipitation ("TRUTH"), to determine how well they represent a transition from June moisture (drought and wet spell) conditions to July moisture conditions. The 15 sets of July 2003 derived monthly PMDI values ("TEST") also were compared to the "final" July 2003 PMDI values computed for July 31 ("TRUTH") to determine how well the "weekly" July values represent a transition to the "final" July monthly moisture conditions. The comparison statistics include the mean and the variance of the absolute value of the differences between the "TEST" and "TRUTH" values for the 344 climate divisions, and the Pearson correlation coefficient of the "TEST" and "TRUTH" values for the 344 climate divisions. The mean and variance statistics measure the degree of closeness between the "TEST" and "TRUTH" values, while the correlation coefficient measures their spatial or geographic comparability. Since the correlation coefficient was used to give an indication of spatial comparability and not to make statistical inferences, data dependency issues were not examined.

4. RESULTS

The mean absolute differences, variance of the absolute differences, and correlation coefficients are summarized in Tables 1 and 2. As noted earlier, the successful estimation method should represent a reasonable transition of the PDI values from the end of June to the end of July. The end of June analysis is presented in Table 1, and the end of July analysis is presented in Table 2.

Table 1 indicates that the July "weekly" PMDI values using the "NORMALS" methodology have steadily greater departures from the June monthly PMDI values as the weeks progress. The "WINDOW" methodology does not have a consistent change from week to week. The "PERSISTENCE" methodology shows decreasing departures as the weeks progress, but the smallest departure is still greater than the greatest departure for the other two methodologies. For comparative purposes, the statistics for the CPC weekly PMDI are also shown ("WEEKLY"). The "WEEKLY" values were derived from four weeks (July 5, 12, 19, and 26). From Table 1, we see that the "NORMALS" estimation method gives results that represent the best transition from the drought and wet spell conditions of the previous month.

Table 2 shows that each of the three methodologies has decreasing departures for every week as the month progresses, with all three converging to the same value by the end of the month for each division. In every case, the weekly PMDI values from the "NORMALS" methodology are closest to the final July monthly values. The statistics for the CPC weekly PMDI are also shown for comparative purposes.

Fig. 2 shows the July 2003 weekly PMDI values computed by the three estimation techniques and computed operationally by CPC for three climate divisions: south central Iowa (IA08), northeast Kansas (KS03), and western Montana (MT01). The monthly

PMDI values for April, May, June, July, and August are also shown to provide a larger scale perspective of how the moisture conditions were changing through time. In all cases except one (July 19 for IA08), the "NORMALS" methodology produced weekly results that were closer to the temporal trend represented by the monthly PMDI values.

Table 1. Comparison of weekly estimates of July 2003 PMDI to the June 2003 monthly PMDI for the three estimation techniques, and also for the CPC weekly PMDI. The top number is the mean absolute difference in PMDI, the middle number is the variance of the absolute differences, and the bottom number is the Pearson product moment correlation coefficient.

Technique	July 5	July 12	July 19	July 26	July 31
NORMALS	.32 .106 .982	.56 .387 .944	.65 .406 .936	.75 .513 .922	.79 .522 .919
WINDOW	.87 .359 .954	.78 .481 .939	.68 .411 .935	.81 .547 .913	.79 .522 .919
PERSISTENCE	1.72 1.989 .822	1.32 1.312 .837	1.01 .789 .885	.88 .643 .905	.79 .522 .919
WEEKLY	1.07 .881 .879	1.19 1.011 .860	1.35 1.196 .848	1.47 1.289 .826	NA

Table 2. Comparison of weekly estimates of July 2003 PMDI to the July 31, 2003 PMDI estimate for the three estimation techniques, and also for the CPC weekly PMDI. The top number is the mean absolute difference in PMDI, the middle number is the variance of the absolute differences, and the bottom number is the Pearson product moment correlation coefficient.

Technique	July 5	July 12	July 19	July 26	July 31
NORMALS	.70 .365 .942	.51 .193 .974	.36 .104 .985	.16 .023 .997	0 0 1.0
WINDOW	1.13 .832 .890	.83 .475 .939	.62 .289 .955	.24 .062 .992	0 0 1.0
PERSISTENCE	1.38 1.680 .872	.82 .463 .952	.46 .165 .978	.20 .035 .996	0 0 1.0
WEEKLY	1.11 1.086 .859	.95 .832 .901	1.03 .914 .908	1.05 .812 .917	NA

Figs. 3 and 4 are a side-by-side comparison of the weekly PMDI computed by CPC and the pseudo-weekly PMDI computed by NCDC using the "NORMALS" methodology. The figures illustrate the differences in transition from the end of June 2003 moisture conditions to the end of July moisture conditions.

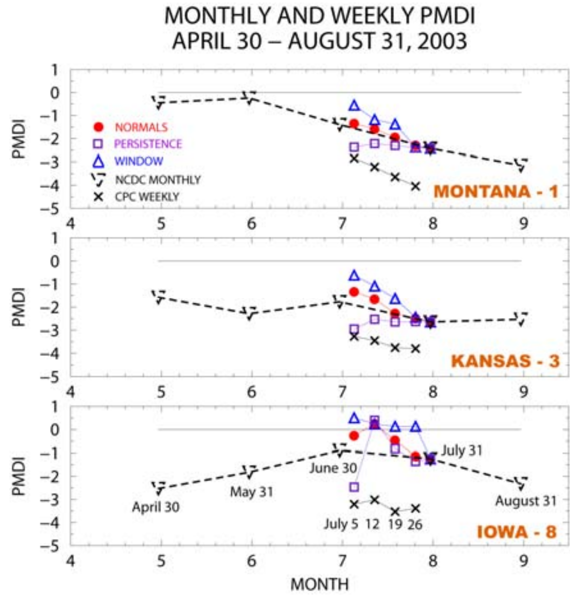

Fig. 2. The weekly PMDI values for July 5, 12, 19, 26, and 31 computed by the "NORMALS" (filled circle), "WINDOW" (up triangle), and "PERSISTENCE" (square) estimation methodologies and the "WEEKLY" (X) values computed by CPC for three climate divisions: western Montana (MT01), northeast Kansas (KS03), and south central Iowa (IA08). The monthly PMDI values (dashed down triangle) for April-August are plotted on the last day of each month.

5. CONCLUSIONS

The results of this analysis suggest that the "NORMALS" methodology produces results which are better than a persistence or moving window approach for estimating the Palmer Drought Index for a month before the month is over. To produce ideal results, the normals period should be identical to the calibration period used for the Palmer model. In this analysis, 1971-2000 normals were used for the "NORMALS" estimation while 1931-1990 was used for the Palmer calibration period. In spite of these differences in climatologies, the "NORMALS" methodology produced smaller "error estimates" and better correlations than the other two methods.

This study indicates that a monthly Palmer Drought Index computed on a weekly (or even daily) basis, using normal temperature and precipitation to estimate the weather for the rest of the month, is useful for monitoring drought on an operational basis.

6. REFERENCES

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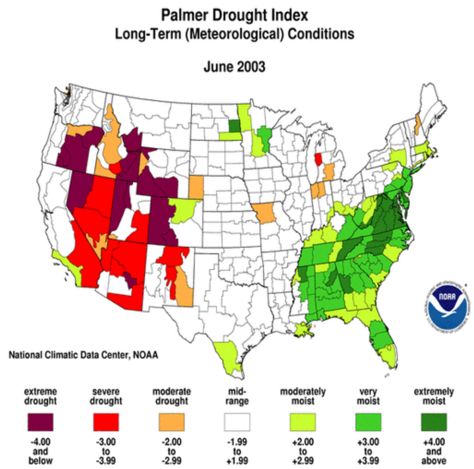

Fig. 3a. NCDC monthly PDI for end of June 2003.

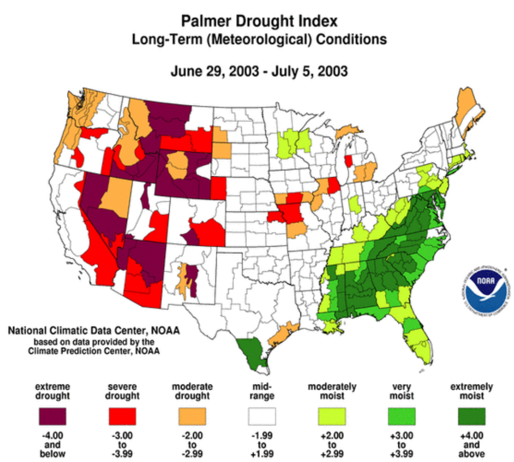

Fig. 3b. CPC weekly PDI for July 5, 2003.

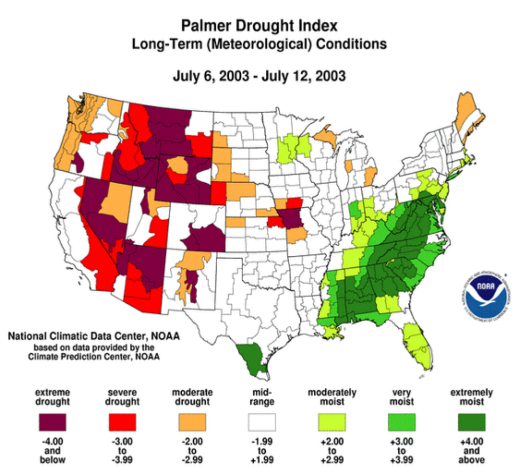

Fig. 3c. CPC weekly PDI for July 12, 2003.

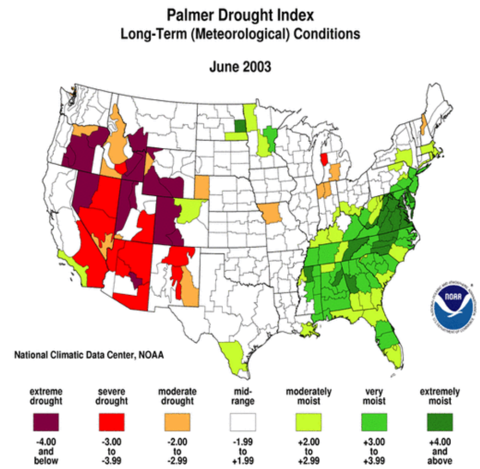

Fig. 4a. NCDC monthly PDI for end of June 2003.

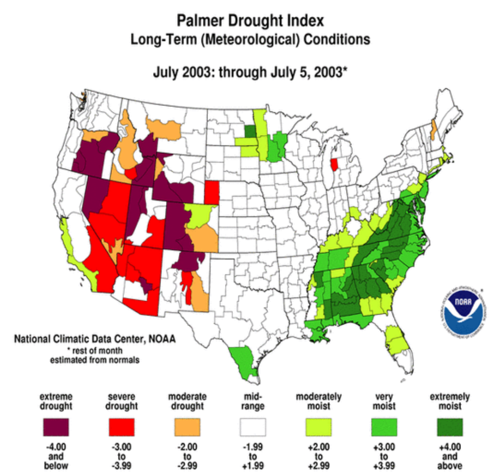

Fig. 4b. NCDC pseudo-weekly PDI for July 5, 2003.

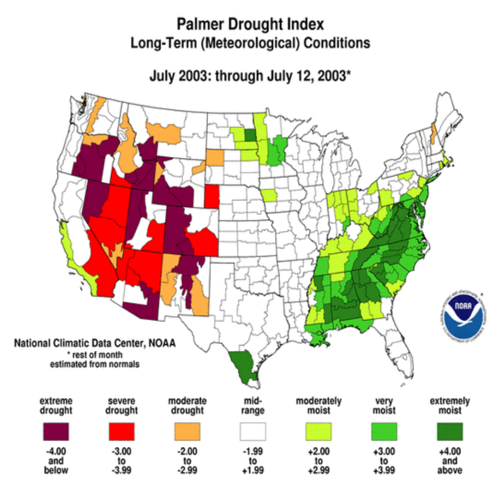

Fig. 4c. NCDC pseudo-weekly PDI for July 12, 2003.

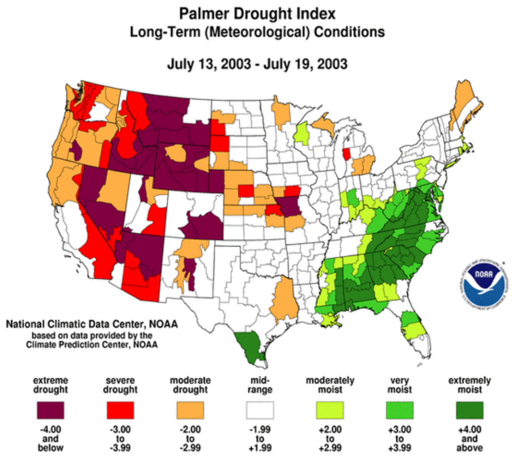

Fig. 3d. CPC weekly PDI for July 19, 2003.

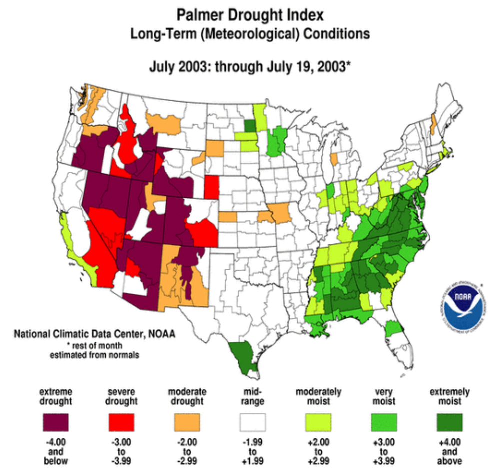

Fig. 4d. NCDC pseudo-weekly PDI for July 19, 2003.

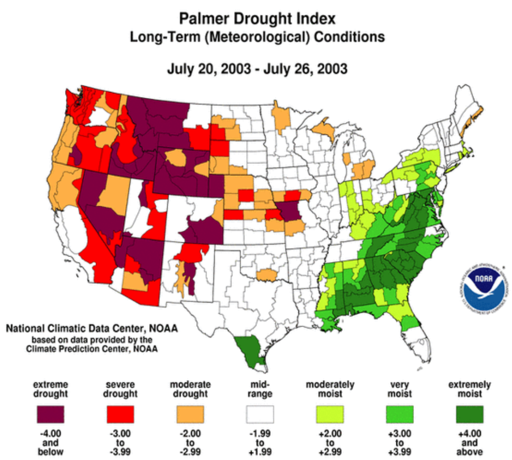

Fig. 3e. CPC weekly PDI for July 26, 2003.

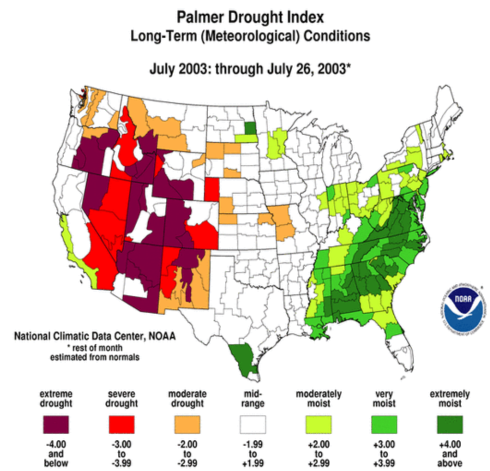

Fig. 4e. NCDC pseudo-weekly PDI for July 26, 2003.

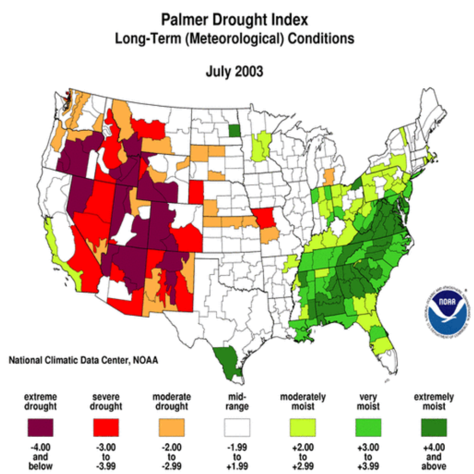

Fig. 3f. NCDC monthly PDI for end of July 2003.

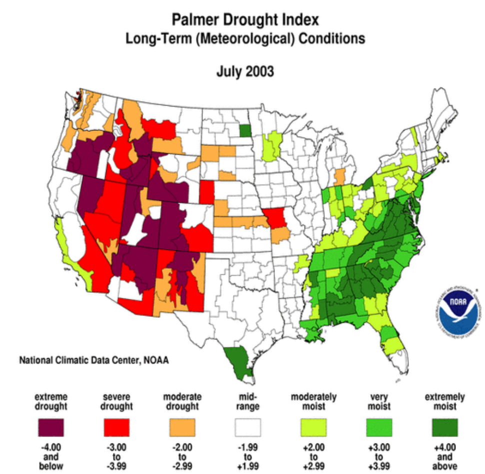

Fig. 4f. NCDC monthly PDI for end of July 2003.

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