P8.3

MIDWESTERN DROUGHT

Michael A. Palecki*
Midwestern Regional Climate Center, Illinois State Water Survey, Champaign, IL

1. INTRODUCTION

Summer drought in the Midwestern United States (MN/IA/MO to MI/OH/KY) has proven to be quite difficult to project even at short time intervals. For instance, spring 2000 outlooks predicted with a high degree of confidence there would be a major summer drought in the Midwest. This prediction, based on both persistence and dynamical modeling, proved to be incorrect, as above normal precipitation returned to the region in June 2000 (Sonka and Changnon 2001). Some climatological linkages have been made between Midwest drought and the status of the Southern Oscillation (Trenberth and Guillemot 1996), Pacific sea surface temperatures (Rajagopalan et al. 2000), and even solar and lunar forcings (Cook et al. 1997). However, most of these relationships have proven to be nonstationary (Rajagopalan et al. 2000) or too weak to provide skillful predictions of summer drought in the Midwest at lead times of one or two seasons.

Drought in the Midwest is often associated with and/or preceded by drought in other regions of the United States. Once drought is established by some forcing in the conterminous U.S., the area affected will tend to evolve spatially over time due to feedbacks with the atmospheric circulation and the continued evolution of extra-regional forcings. Therefore, it should be possible at times to look at the status of drought in other key regions during the prior winter in order to gain some insight into the future course of summer drought in the Midwest. This initial study utilized simple composites to first find external regions that appear to have an association with Midwest summer drought, and then reverse the process to see if drought status in these regions may be viewed as precursors.

2. ANALYSIS

Utilizing the U.S climate division data set, the precipitation totals for summer (JJA) in Illinois were ranked for the period 1896 to 2002 for use as a general indicator of dryness in the Midwest. Precipitation was used rather than a drought index in order to focus on the onset or intensification of drought as opposed to its local persistence. The five driest summers for Illinois were, in rank order, 1936, 1988, 1991, 1933, and 1930. The Palmer Drought Severity Index (PDSI), standardized precipitation anomalies, and standardized temperature anomalies for the 5 winters prior to these summers were composited (Figure 1). It is clear from these composites that drought exists during these winters in the Interior West, including eastern Washington and Oregon and most of Idaho. The largest precipitation anomalies are closer to Illinois in a region centered on Kansas. However, since the PDSI composite does not show a strong signal in Kansas, it appears that dryness is just getting started in this area. Interestingly, precipitation totals are higher than normal in Illinois prior to the summer drought, indicating a shift of the winter storm track from over the Great Plains to a Midwest axis. Finally, a huge dipolar pattern of temperature anomalies, cold in the west and warm in the east, helps to support the conclusion that an anomalous trough-ridge pattern is associated with these winters.

The two most promising winter indicators of summer dryness in Illinois are Idaho PDSI and Kansas standardized precipitation anomalies. To examine the evolution of the U.S. precipitation patterns leading to the dry Midwest summers, the ten years with the lowest Idaho winter PDSI and the ten years with the lowest Kansas winter precipitation totals were composited. In the case of extremely low winter PDSI years in Idaho (Figure 2), precipitation during winter is below normal in Kansas and above normal in Illinois, as would be expected from the Illinois summer-based composites (Figure 1). There is also a strong indication of dryness on the East Coast. Precipitation then continues to be below normal for the next 5 months in large portions of the Midwest, with summer dryness well explained in the June and July panels of Figure 2. Interestingly, in the case of low winter precipitation in Kansas (Figure 3), conditions for the next 2 months are usually wetter than normal in the Midwest. In the late spring, dry conditions form in the Mid-Atlantic region before becoming strongly established during summer in the Midwest.

Both sets of composites indicate plausible steps with regards to the establishment of Midwestern summer drought. The Idaho precursor has the advantage of being tied strongly to ENSO, while the Kansas precursor is much closer spatially and climatologically to the Midwest. A final set of composites was performed to examine the associations of not only the dry winter years in Idaho and Kansas but the ten wettest winter years in each location. As expected, the dry winters in Idaho (Figure 4, left) and Kansas (Figure 5, left) produced coherent composite pattern of dryness in the Midwest during the following summer, although the Kansas winter signal was much stronger. However, when comparing the wet winters to the following summer in the Midwest, the Idaho signal again favored a dry summer (Figure 4, right), while the Kansas precursor indicated a wet summer for the Midwest (Figure 5, right). The Idaho composite results can be explained by the nature of ENSO responses to some extent. Extreme winter dryness or winter wetness in the Interior Northwest is strongly related to the sign of ENSO mode, but the Midwest summer response to the ENSO modes is less than systematic. For instance, one of the strongest ENSO events in the 20th Century, in 1982-83, was followed by severe drought in the Midwest, while the Midwest floods of 1993 occurred during a moderate ENSO. On the other hand, the composites related to winter conditions in Kansas follow a classic model of mid-continent drought enhancement through land-atmosphere local feedbacks.

* *Corresponding author address:* Michael A. Palecki, Midwestern Regional Climate Center, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820-7495; e-mail: palecki@uiuc.edu.

3. CONCLUSIONS

An initial exploration of winter precursors to summer drought in the Midwest has yielded two candidates: Interior Northwest drought status as indicated by the PDSI, and standardized precipitation anomalies in Kansas. As is normal with composites, the relationships between extremes are much stronger than the relationships between the entire time series of the precursor and target variables. However, this pilot study indicates the possibility of improving the projection of summer drought conditions in the Midwest during some conditions. Contingency tables may be useful for estimating probabilistically the summer conditions during a subset of the years when winter conditions are in an extreme state, which are also some of the times when useful projections are most needed. These relationships will be explored in more detail.

4. ACKNOWLEDGMENTS

This work was supported by NOAA Cooperative Agreement NA17RJ1222. The views expressed in this document are those of the authors and do not necessarily reflect those of NOAA.

5. REFERENCE

Cook, E.R., D.M. Meko, and C.W. Stockton, 1997: A new assessment of possible solar and lunar forcing of the bidecadal drought rhythm in the western United States. *J Clim.*, **10**, 1343-1356.

Rajagopalan, B., E. Cook, U. Lall, and B.K. Ray, 2000: Spatiotemporal variability of ENSO and SST teleconnections to summer drought over the United States during the Twentieth Century. *J. Clim.*, **13**, 4244-4255.

Sonka, S.T., and S. A. Changnon, 2001: *Midwestern Impacts of the 2000 Drought Forecast*. Final Report, UCAR Award Number S01-31363. Ag Education & Consulting, Savoy, IL. 97 pp.

Trenberth, K.E., and C.J. Guillemot, 1996: Physical processes involved in the 1988 drought and 1993 floods in North America. *J. Clim.*, **9**, 1288-1298.

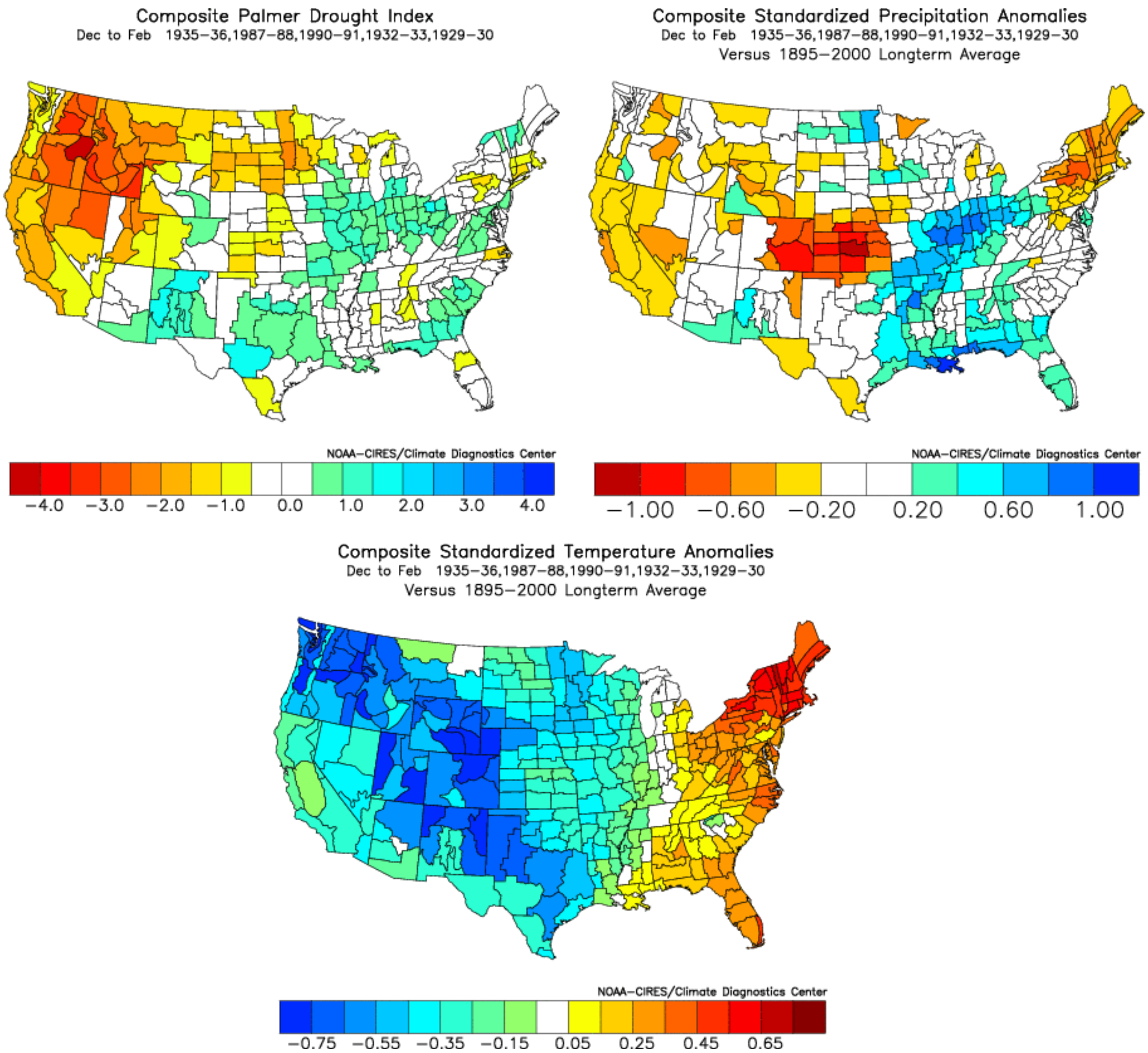

Figure 1. Composite PDSI, standardized precipitation, and standardized temperature conditions during the winter (DJF) prior to the 5 driest summers (JJA) in Illinois.

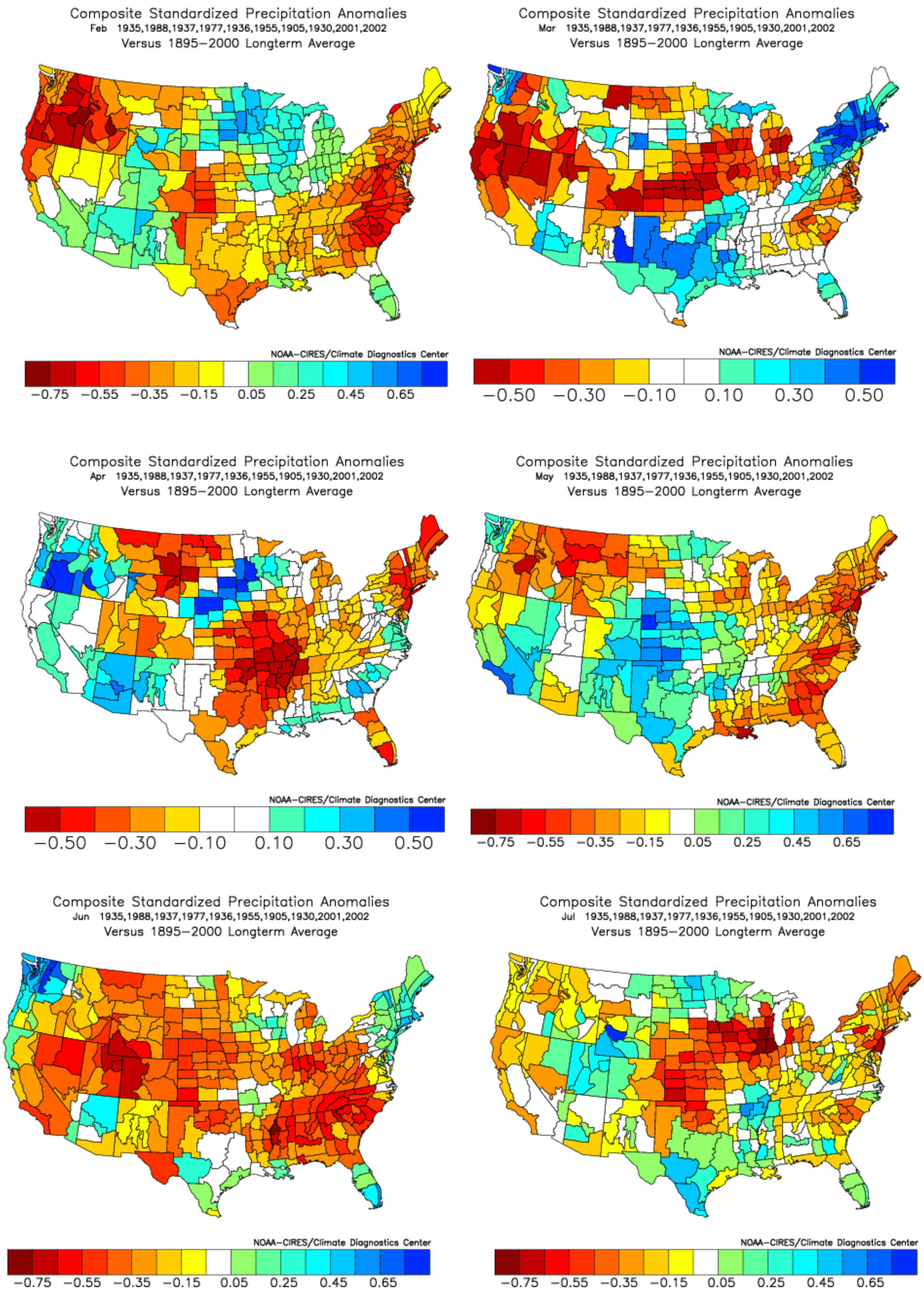

Figure 2. Monthly composites of standardized precipitation for the years with the 10 lowest winter PDSI in Idaho.

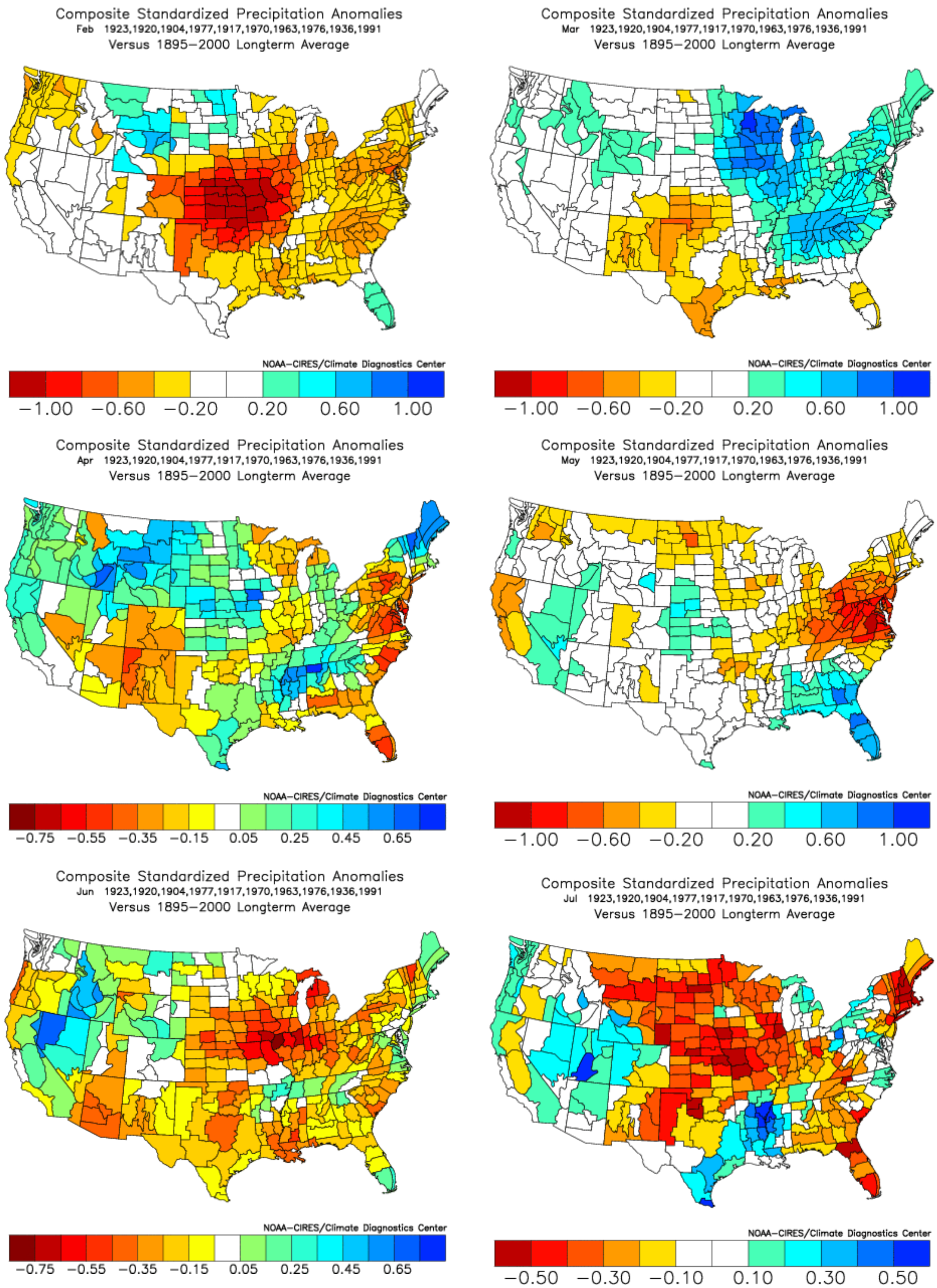

Figure 3. Monthly composites of standardized precipitation for the years with the 10 driest winters in Kansas.

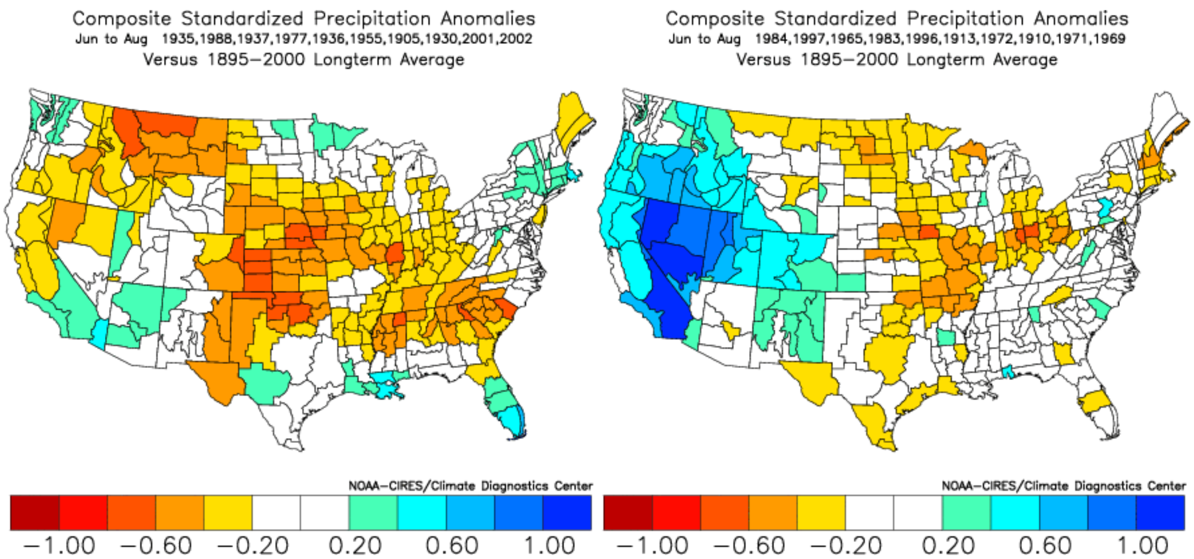

Figure 4. A comparison of the summer standardized precipitation anomalies following the ten winters with the lowest PDSI (left) and ten winters with the highest PDSI (right) in Idaho.

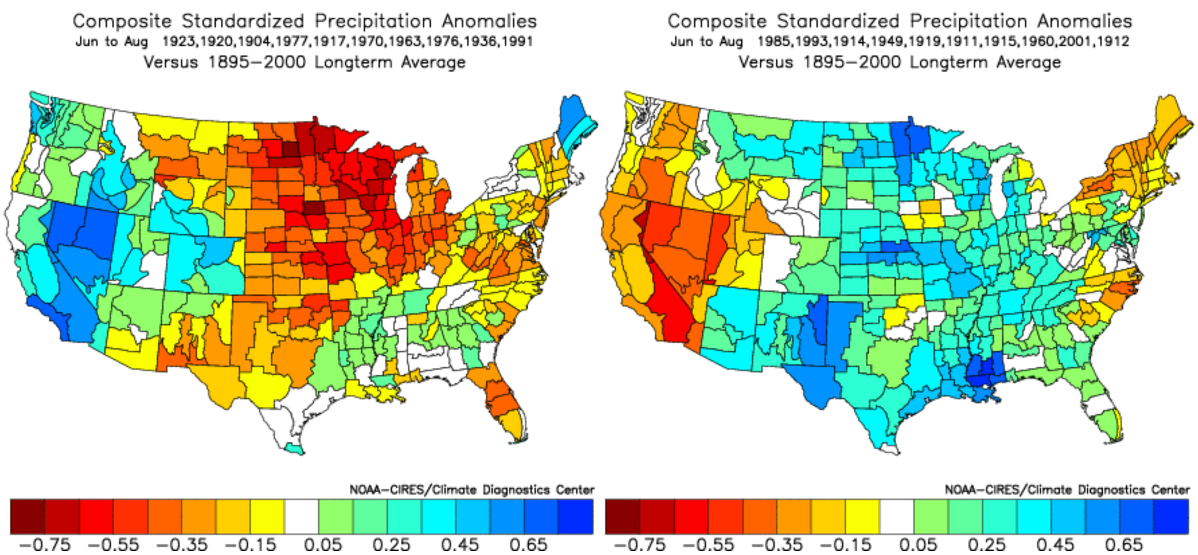

Figure 5. A comparison of the summer standardized precipitation anomalies following the ten winters with the least precipitation (left) and ten winters with the most precipitation (right) in Kansas.