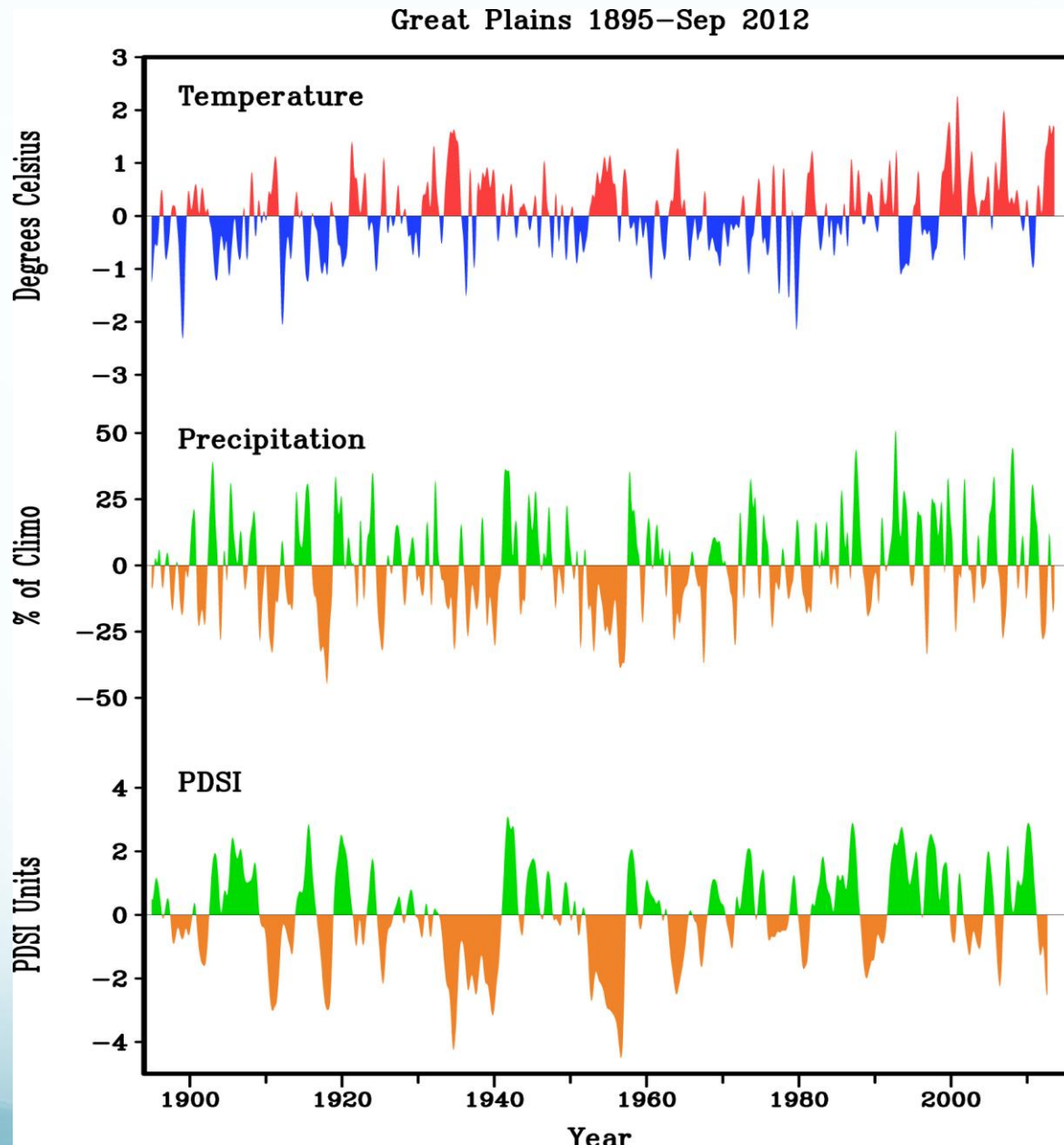


Is A Transition to Semi-Permanent Drought Imminent in the Great Plains?*

Martin Hoerling NOAA/ESRL

J.Eischeid, X. Quan, H. Diaz, R. Webb, R. Dole, D. Easterling
* in press, *J. Climate*

Observed Great Plains Climate Variations: 1895-2012



Assessment of the History of Great Plains Climate Variations

“The 1895–2009 linear precipitation trend is positive across most of the U.S. and trends exceed 10% per century across the southern plains and the Corn Belt.”

--- *McRoberts and Nielson-Gammon, J. Appl. Meteor. Climatol. 2011*

“During 1948-2009 there were no systematic changes in the annual and warm season mean daily and minimum central US temperature. However, May–October maximum TCUS has decreased [by 0.9C (62 yr)⁻¹] with the lowest value in 2009“

--- *Groisman, et al., J. Hydrometeor 2012*

“For some regions including central North America, droughts have become less frequent, less intense, or shorter in duration since about 1950. Conditions over the Great Plains and Midwest have been as bad, or worse, than the current [2011] drought numerous times in our instrumental record.”

--- *IPCC SREX 2012*

“It is likely that anthropogenic warming has increased drought impacts over North America in recent decades through increased water stresses associated with warmer conditions, but the magnitude of the effect is uncertain.”

---- *U.S. Climate Change Science Program, 2008.*

On the One Hand....

Projection of Imminent and Prolonged Extreme Great Plains Drought (PDSI; derived from 22 CMIP3 Models)

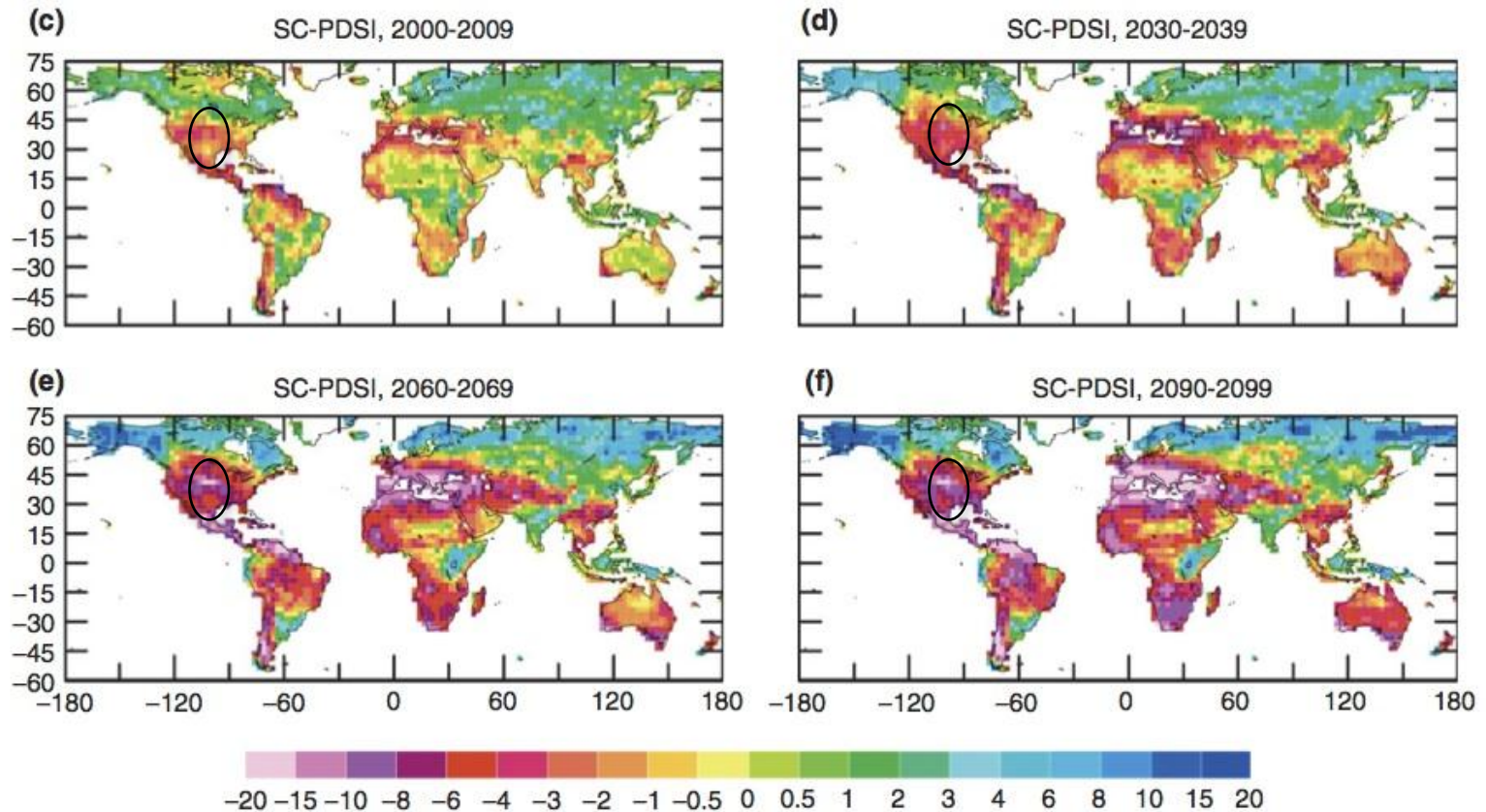
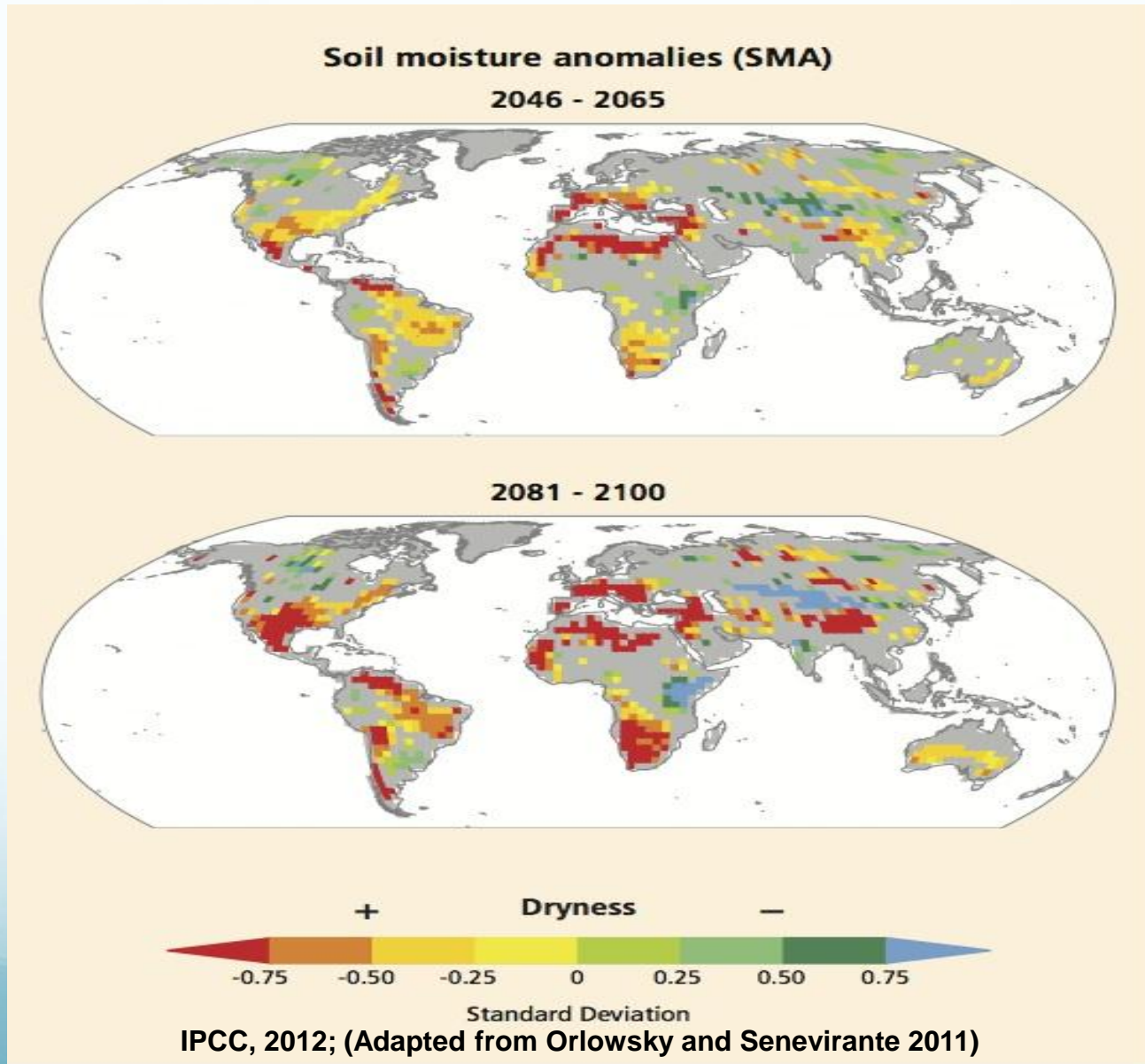


FIGURE 11 | Mean annual sc-PDSI_{pm} for years (a) 1950–1959, (b) 1975–1984, (c) 2000–2009, (d) 2030–2039, (e) 2060–2069, and (f) 2090–2099 calculated using the 22-model ensemble-mean surface air temperature, precipitation, humidity, net radiation, and wind speed used in the IPCC AR4 from the 20th century and SRES A1B 21st century simulations.¹²⁸ Red to pink areas are extremely dry (severe drought) conditions while blue colors indicate wet areas relative to the 1950–1979 mean.

(from Dai 2011)

On the Other Hand....

Projection of Only Modest Drying, Mostly late 21st Century (Soil Moisture; derived from 17 CMIP3 Models)



Uncertainties in Future Great Plains Drought

“Regions like the United States have avoided prolonged droughts during the last 50 years due to natural climate variations, but might see persistent droughts in the next 20-50 years”

--- *Dai, Wiley Interdisciplinary Reviews: Climate Change, 2011.*

“The [CMIP3] response to future PDSI increases is very robust and indicates that in many regions increased ET will lead to decreased soil moisture regardless of how mean precipitation changes”

--- *Wehner et al., J. Hydrometeor., 2011.*

“Although the predicted future changes in drought occurrence [based on CMIP3 soil moisture] are essentially monotonic increasing globally and in many regions, they are generally not statistically different from contemporary climate or natural variability for multiple decades”

---- *Sheffield and Wood, Clim. Dyn., 2008.*

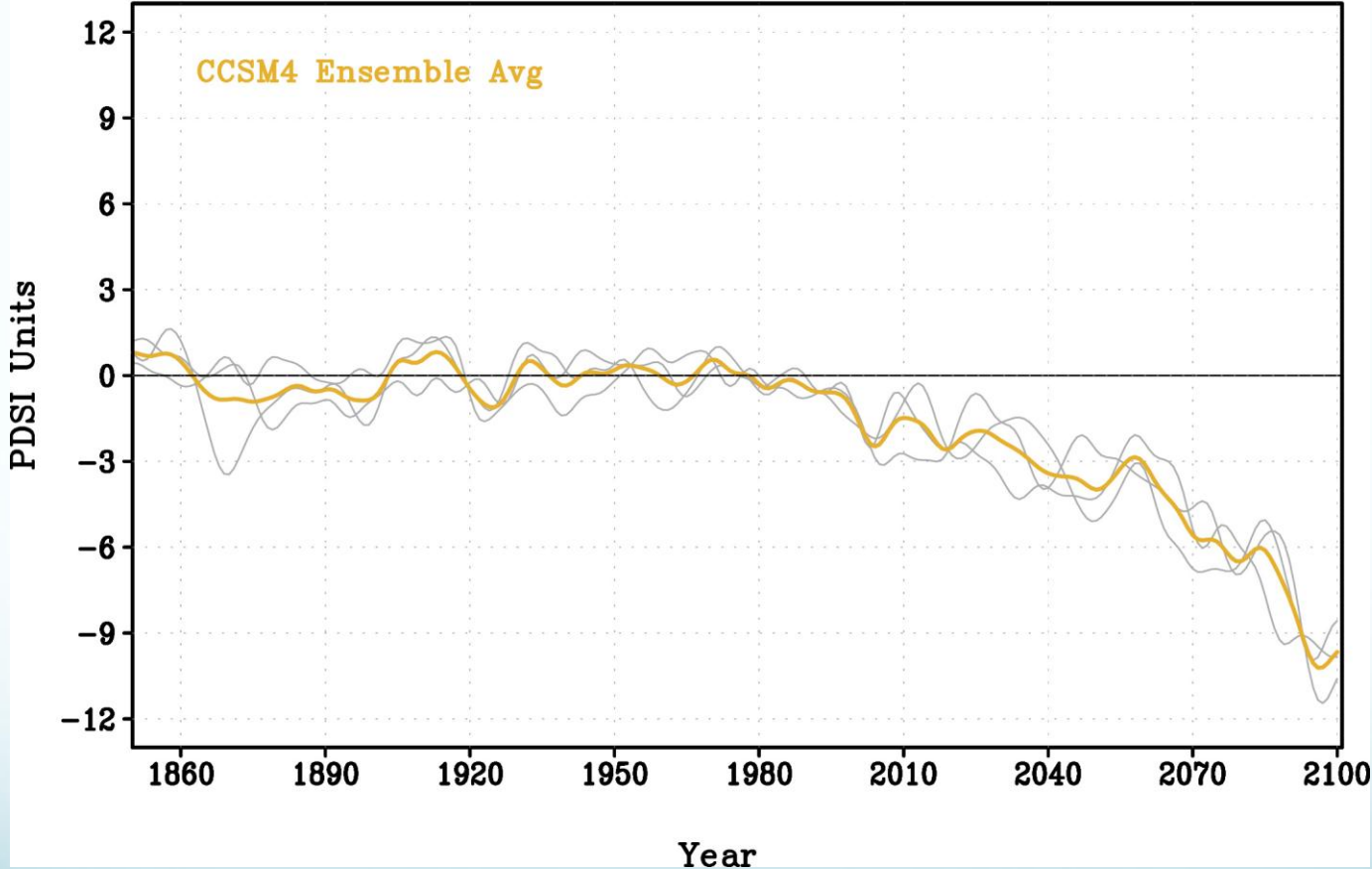
“ There is overall low confidence [in drought projections over much of the US Great Plains] because of insufficient agreement of projections of drought changes, dependent both on model and dryness index.

---- *IPCC SREX, 2012*

Parallel Diagnosis of Projected Changes in Drought Inferred From Soil Moisture & PDSI

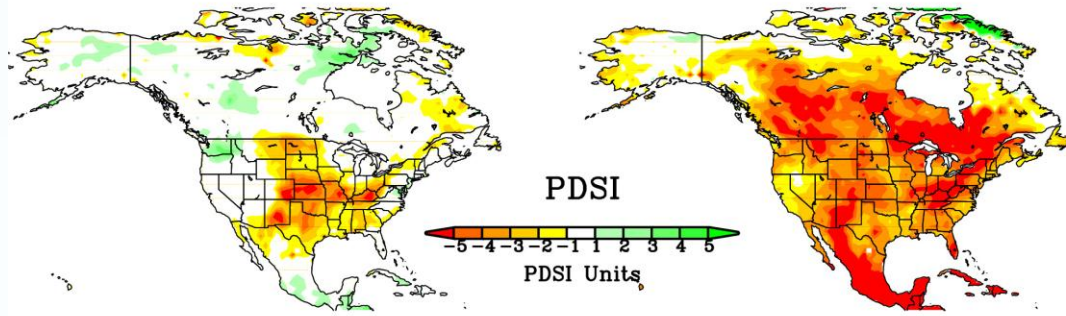
- Diagnose drought indices in a three-member ensemble of CCSM4 runs spanning 1850-2100.
- Calculate $PDSI_{sc}$ and calibration from monthly CCSM4 sfcT and Pcpn output during 1901-2000 for each of the three simulations separately.
- Calculate soil moisture from monthly CCSM4 column integrated moisture for 3 top layers of the land model (CLM4) having ~10cm depth.
- Monthly $PDSI_{sc}$ is obtained for the entire 1850-2100 period for each run using the respective set of parameters.
- Monthly soil moisture is obtained for the entire 1850-2100 period for each run, normalized to its standard deviation during 1901-2000.

Great Plains Annual PDSI: 1850–2100
1901–2000 Calibration Period



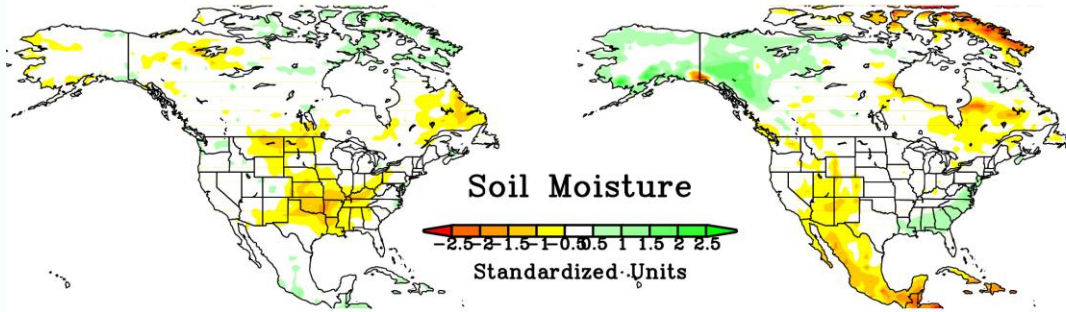
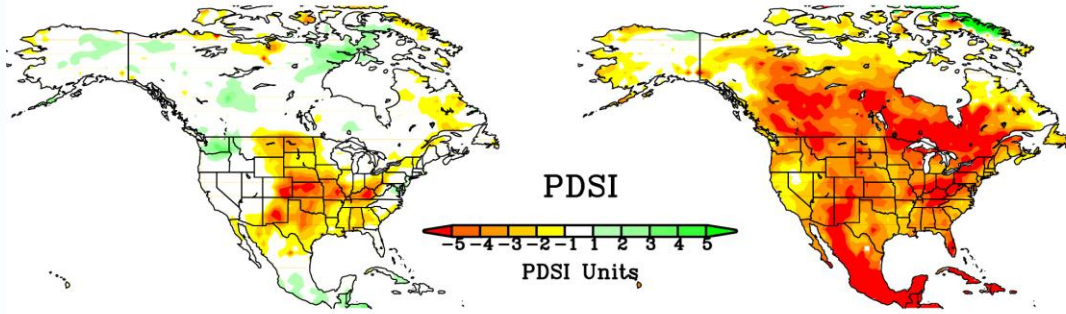
1865-1875

2045-2055



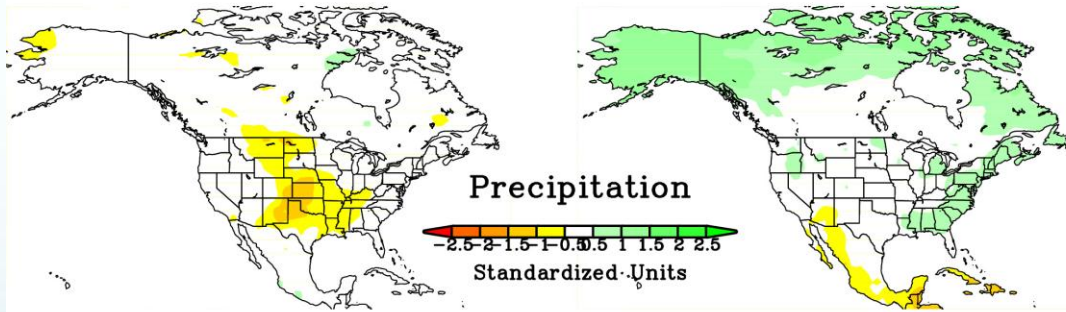
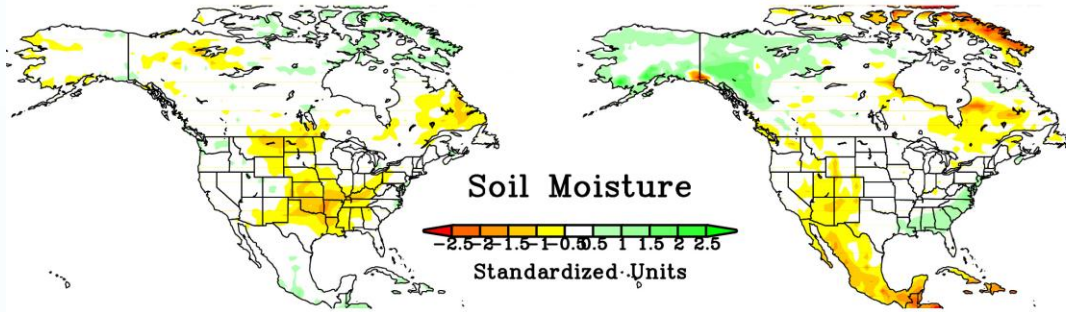
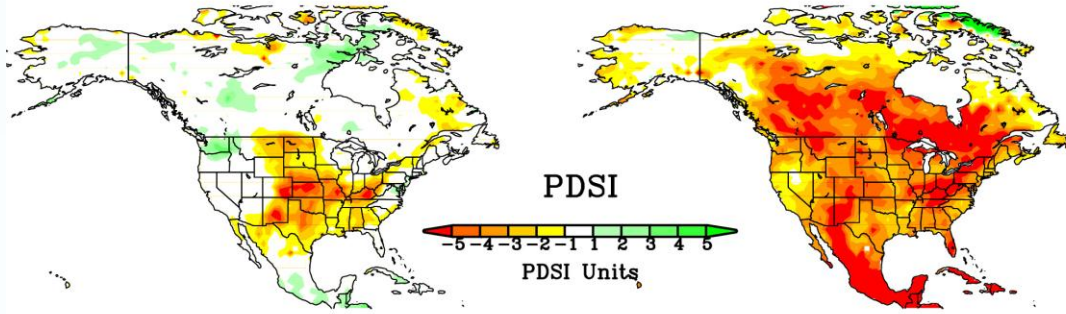
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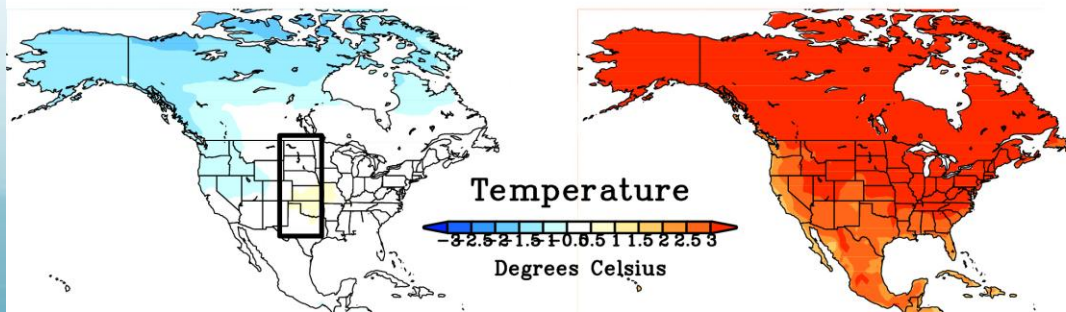
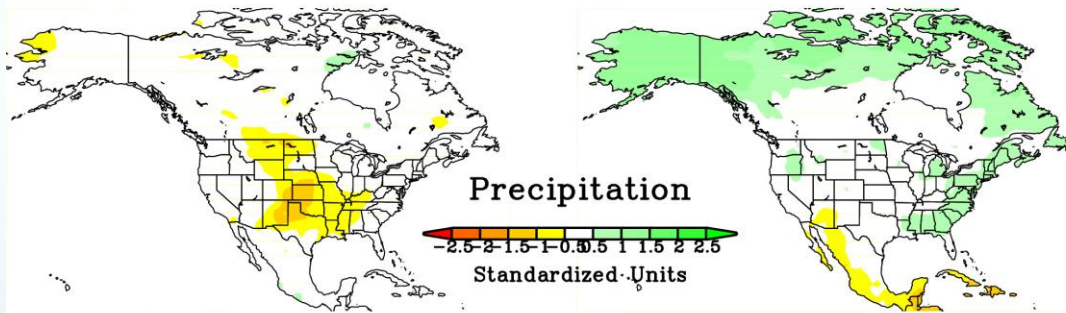
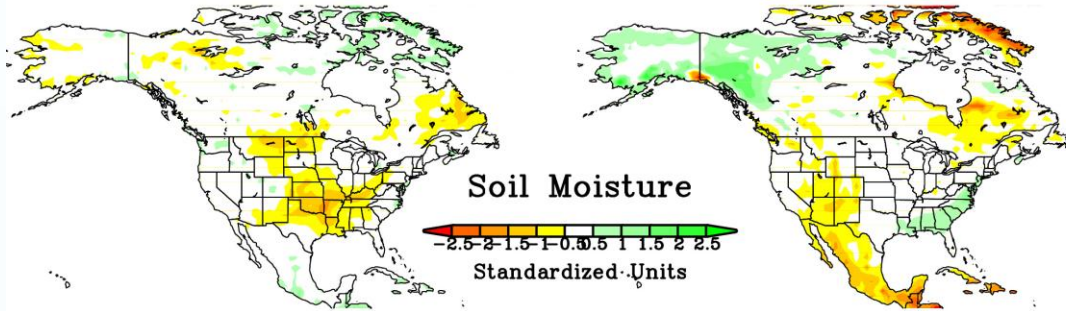
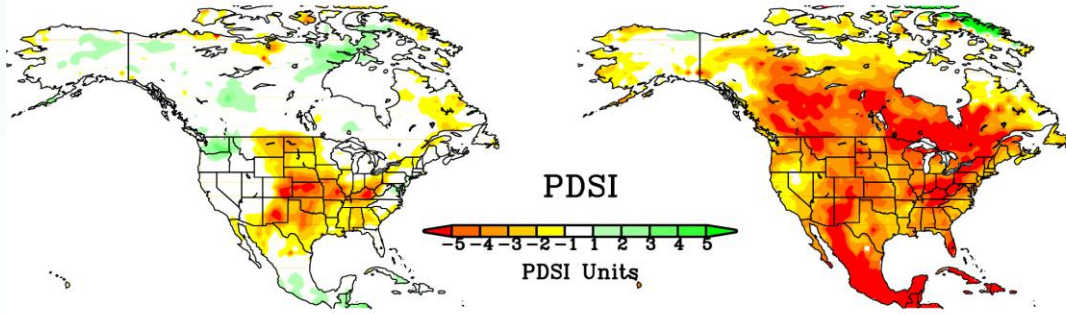
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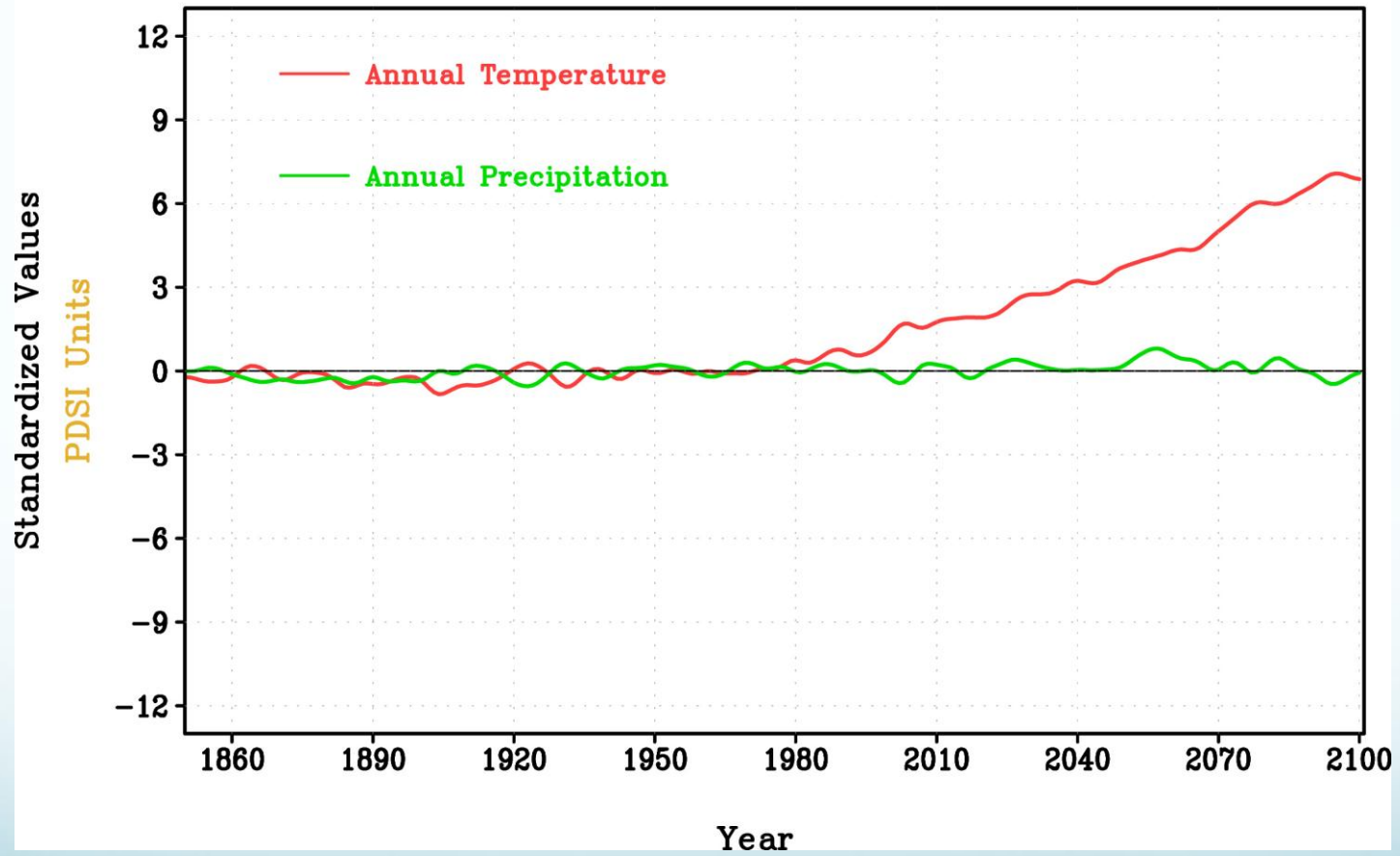


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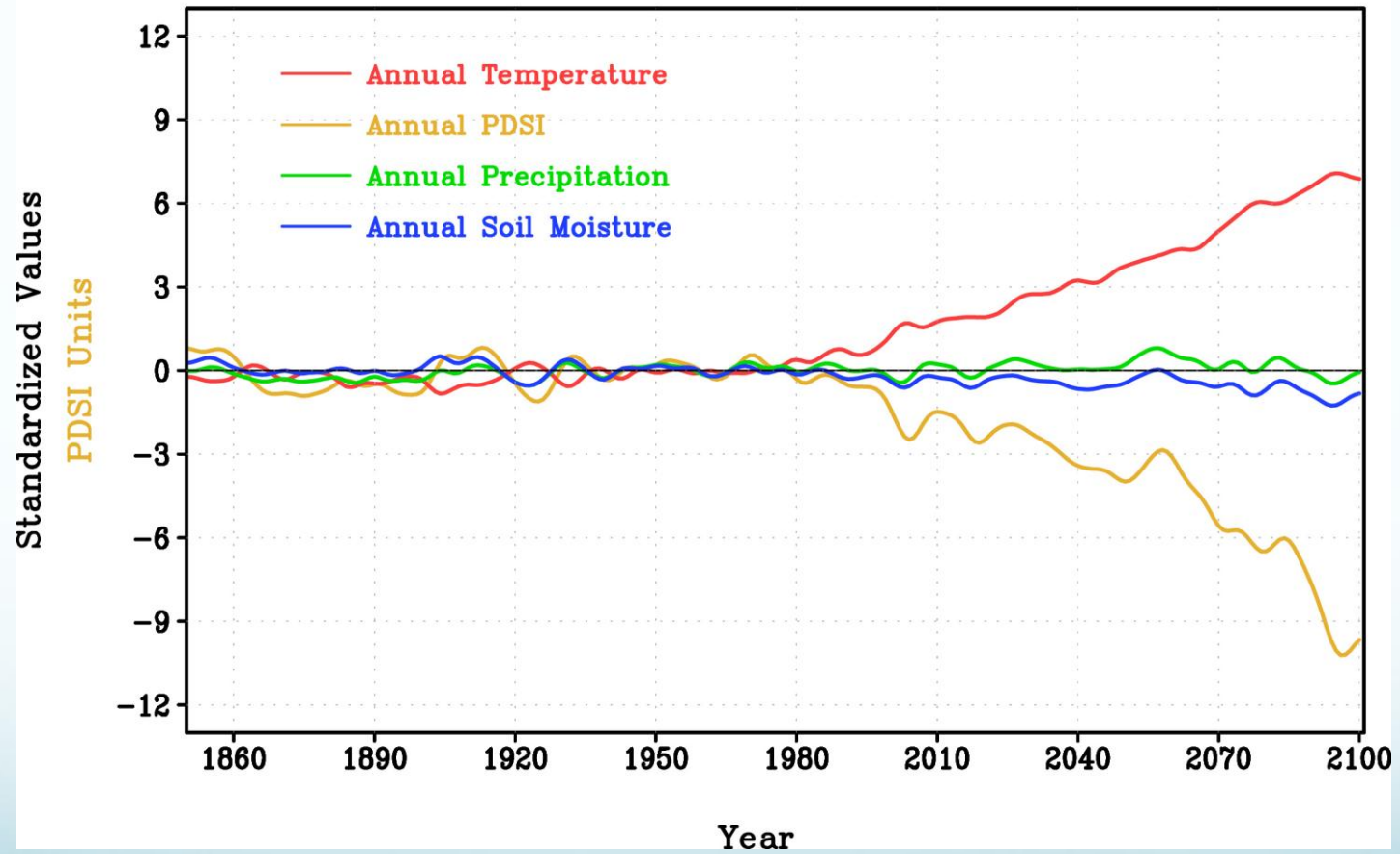
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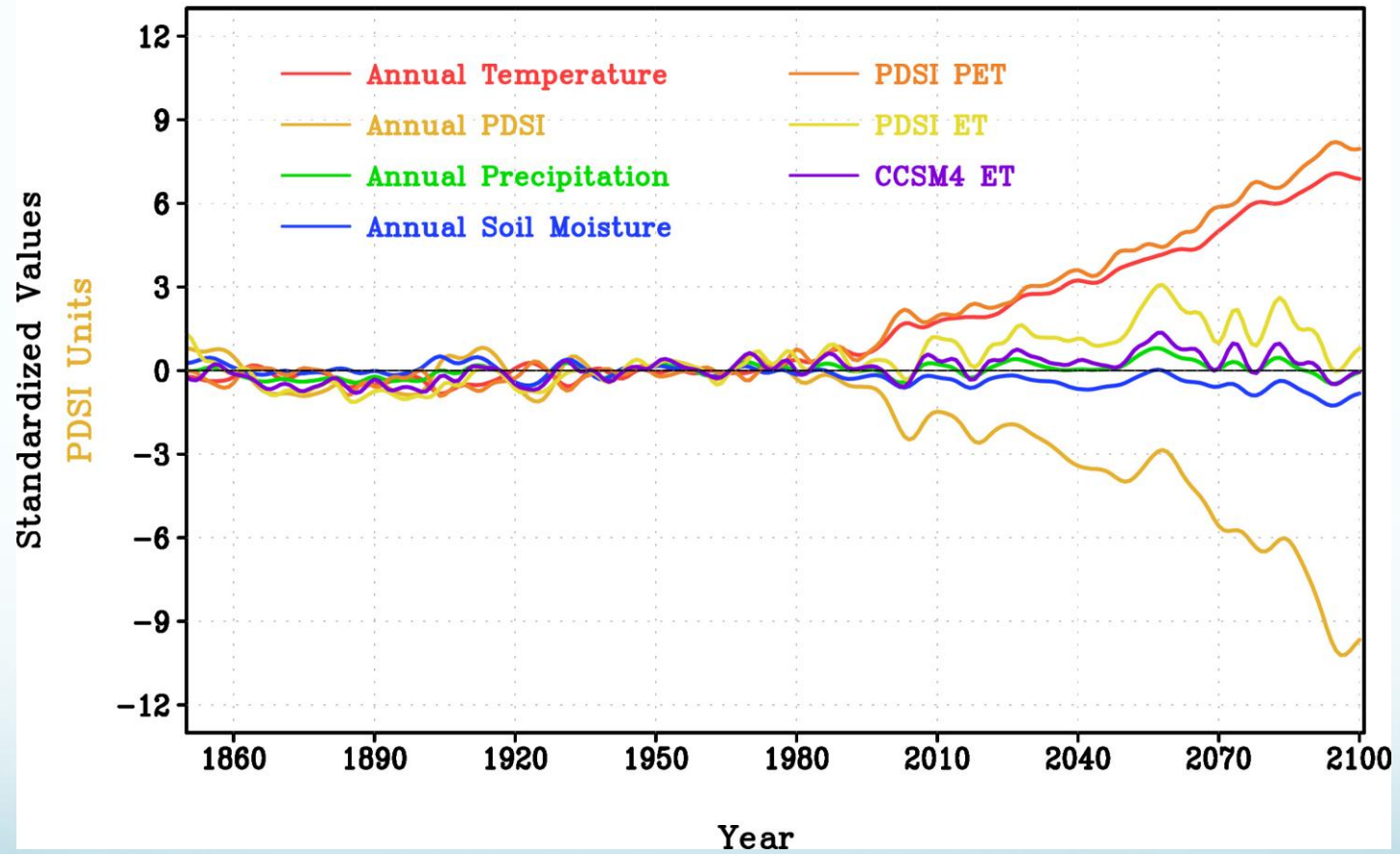
Great Plains 1901–2000 Reference Period



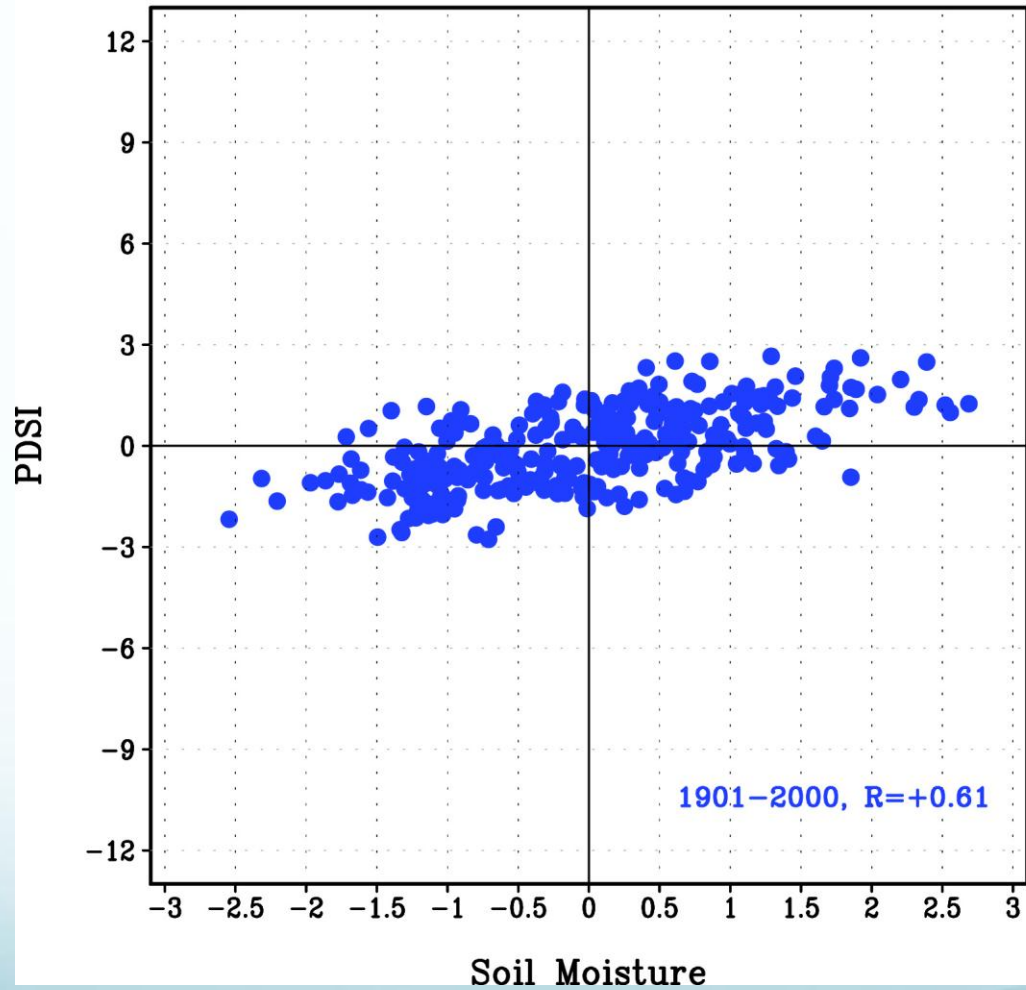
Great Plains 1901–2000 Reference Period



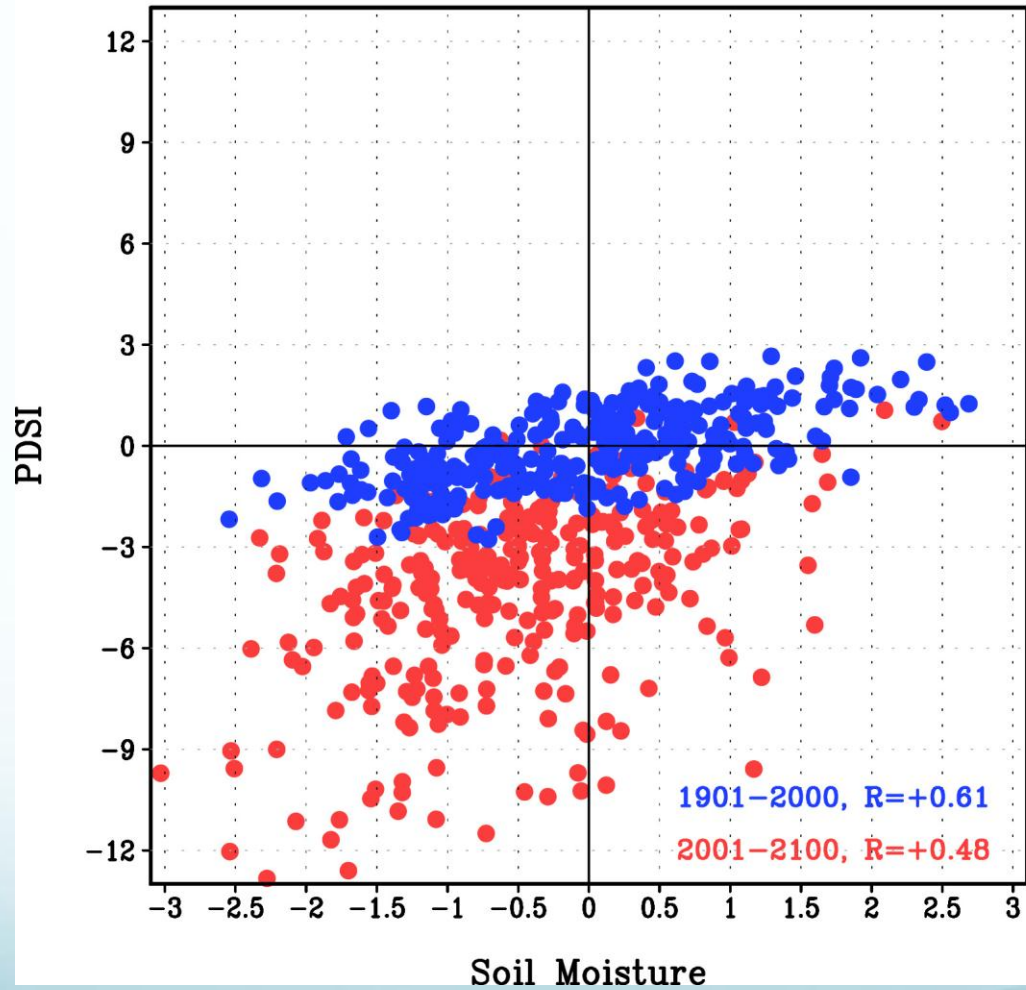
Great Plains 1901–2000 Reference Period



Great Plains-CCSM4
Annual Soil Moisture (10cm) vs. Annual PDSI
1901-2000 Reference Climatology



Great Plains-CCSM4
Annual Soil Moisture (10cm) vs. Annual PDSI
1901-2000 Reference Climatology



Summary & Implications of Key Findings

- * PDSI and soil moisture present very different views on how surface water balances may evolve over the Great Plains due to global warming.
- * Simplifying assumptions regarding temperature effects on water balances (especially ET) in Palmer's model compromise its suitability as drought indicator in a warming climate (see also Lockwood 1999; Dai 2011)

Summary & Implications of Key Findings

- Projections of chronic PDSI decline in the 21st Century are likely an exaggerated indicator for future Great Plains drought severity.
- Inferences of possible amplifying effects of temperature alone (separate from Pcpn effects) on drought severity inferred from analysis of Palmer's model should be viewed as unreliable.
- While the possibility of a Dust Bowl-like period in the near future for the Great Plains cannot be ruled out, such an occurrence will likely be related to sustained Pcpn deficits rather than local temperature effects of surface warming alone.