Providing Crop-Specific Flash Drought Information

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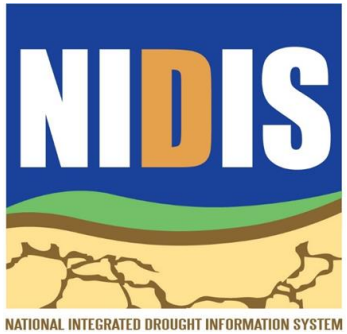
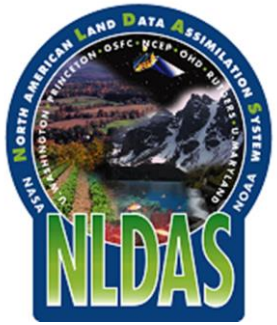
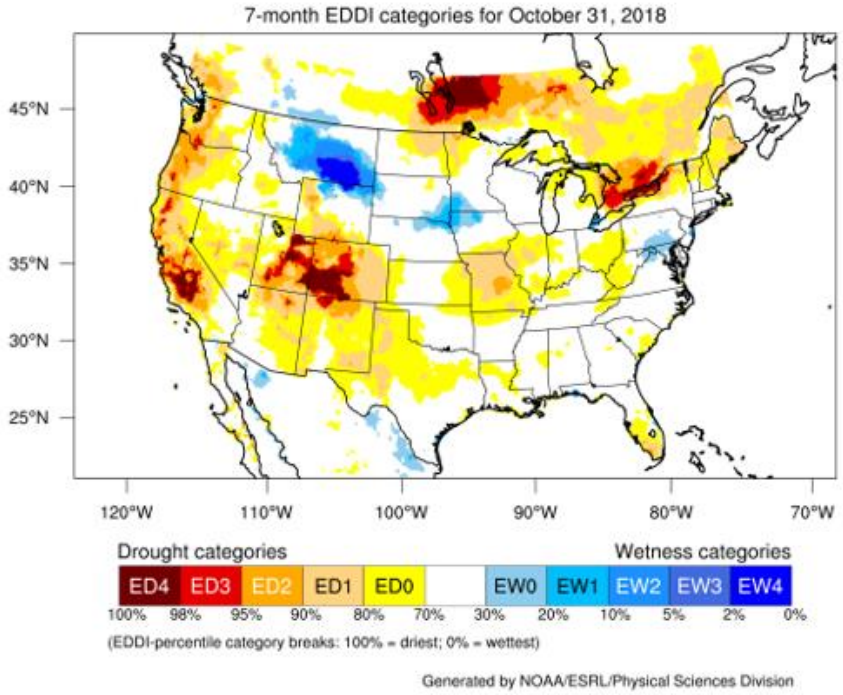




The Problem

- Even with all the indicators of drought at our disposal, we still don't have a great handle on how different drought ingredients impact certain crop types.



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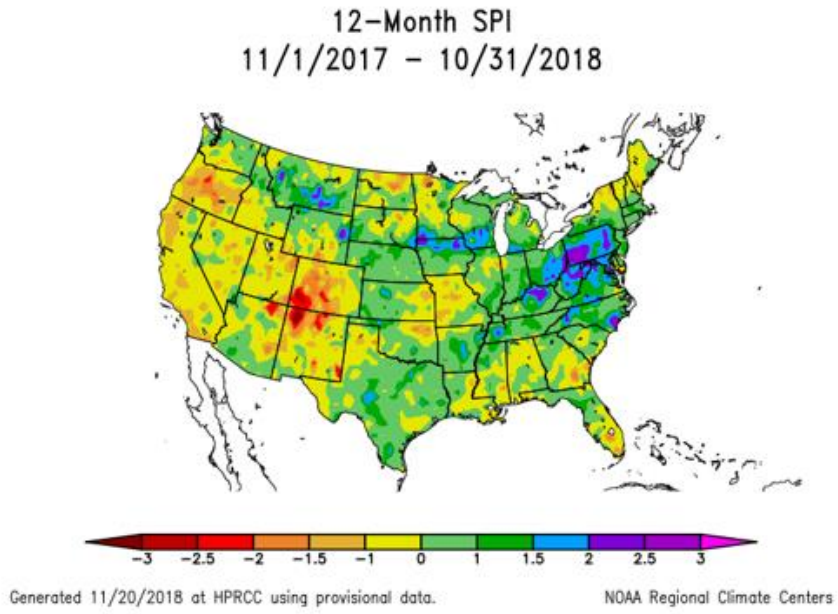

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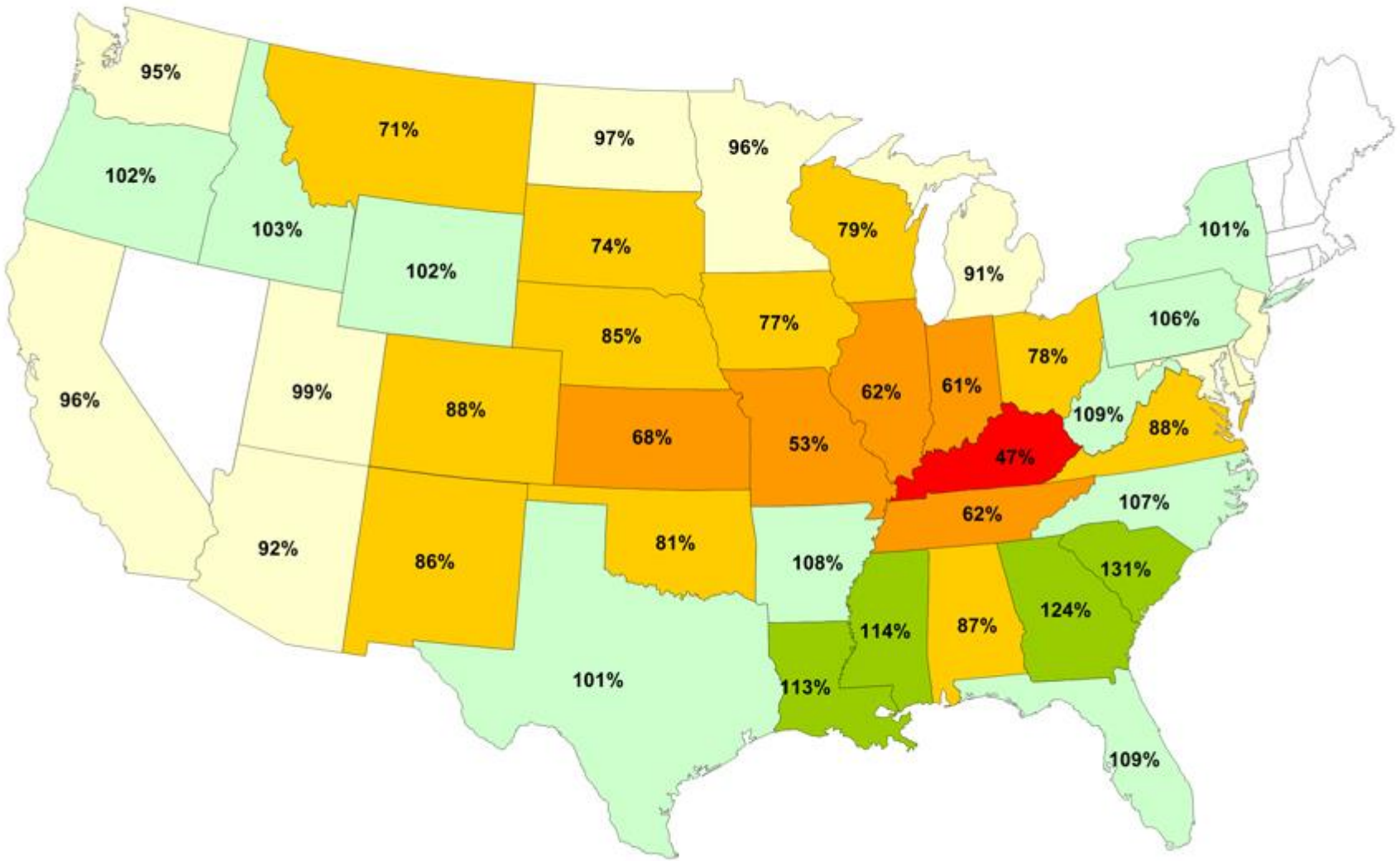
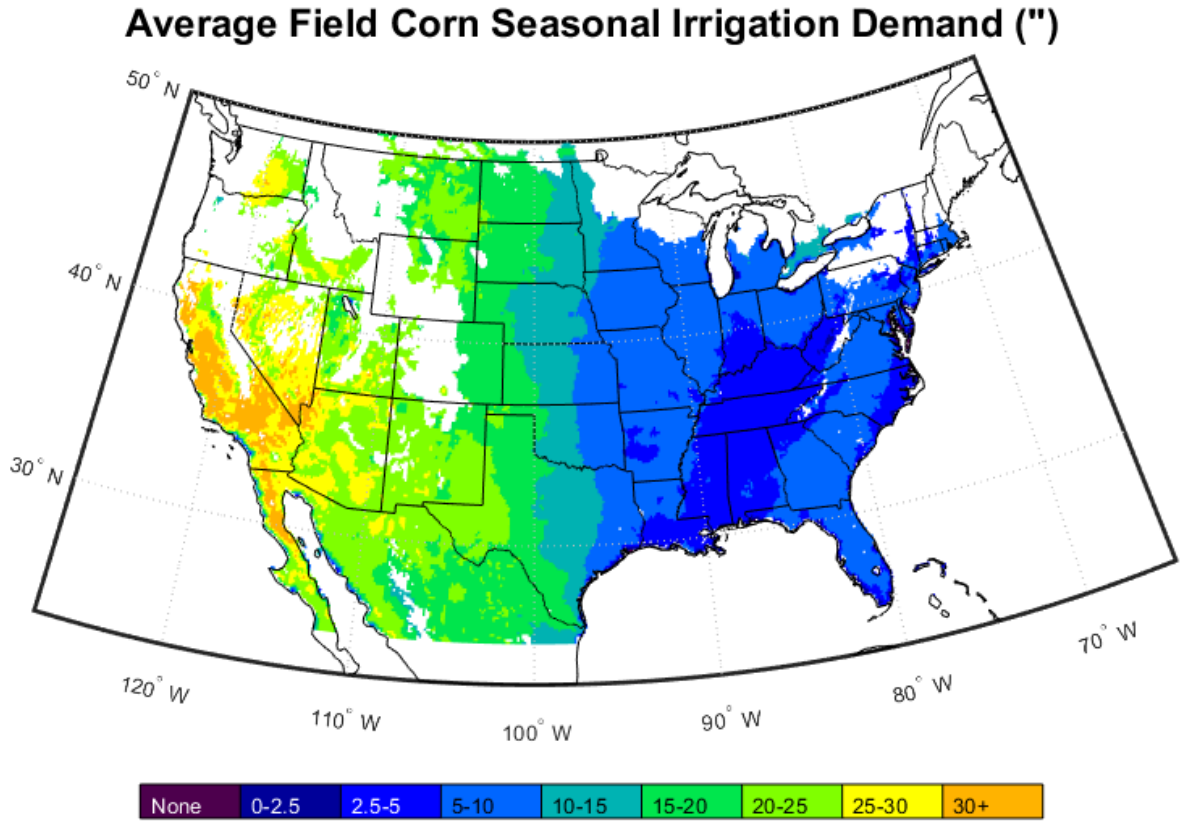
Figure 1. 2012 State Corn Yields as a Percent of Trend Yield.



- With 88 million acres of land dedicated to corn in 2012, an average loss of 40 bushels/acre = net loss of $15 billion at $4/bushel.
- In 2012, the price of corn hit an all time high, likely due to supply and demand. One producer's misfortune is another's gain

A Drought Index Tracking Irrigation Demand

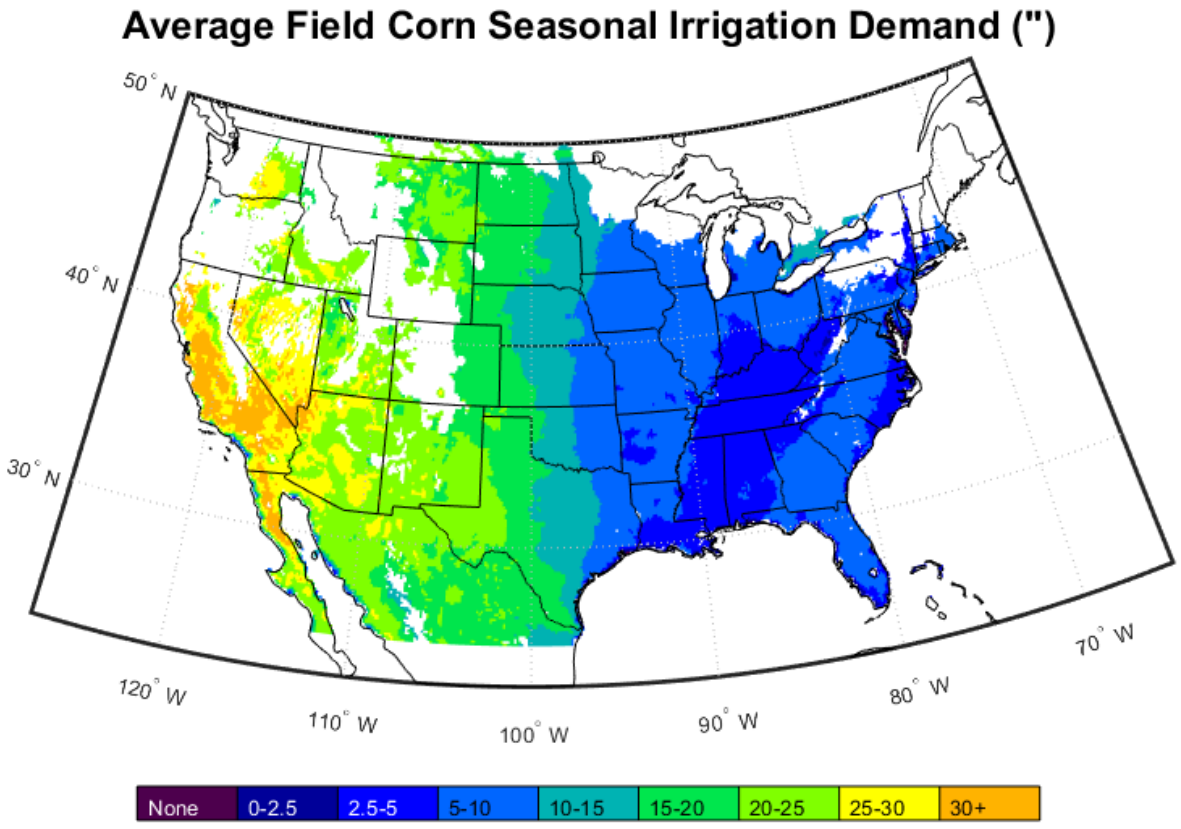
- Here we explore some results from an experimental drought monitoring product designed to compare crop-specific irrigation demand from year-to-year
- How much irrigation water would it take to grow crop X to completion without stress?
- This is an example using field corn ->



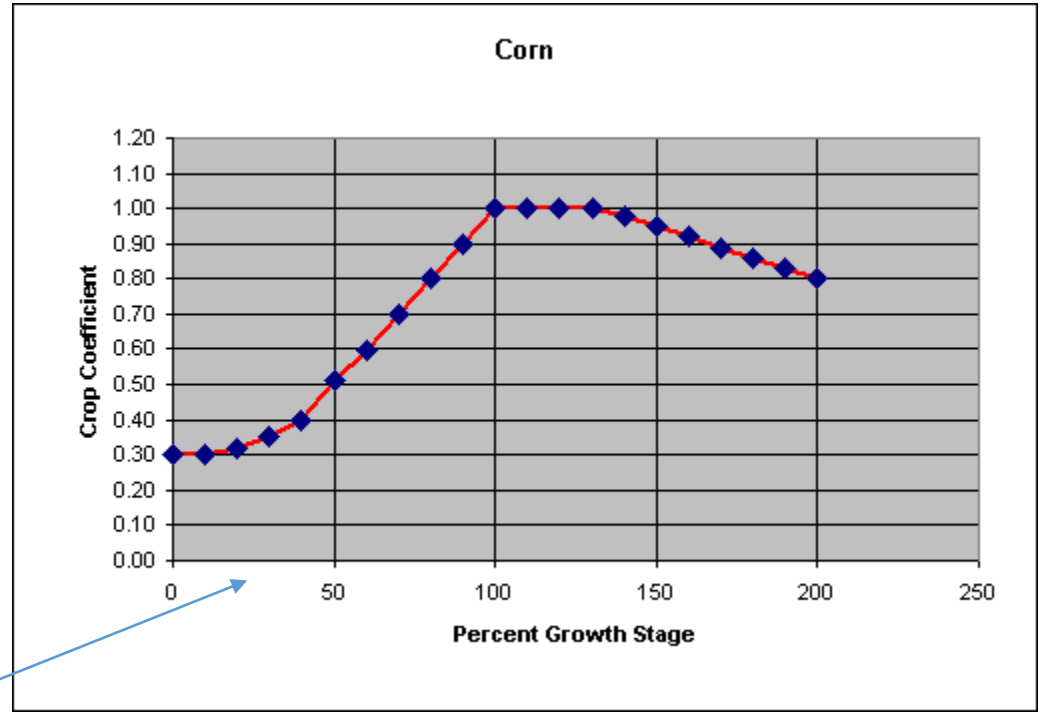
A Drought Index Tracking Irrigation Demand

How it Works:

1. A surface soil water balance model is used to determine how much irrigation is needed from year to year
2. The model is driven by NLDAS-2 Meteoroligc data (precipitation and potential ET)
3. Actual ET is determined by applying a crop coefficient to potential ET (based on crop type and growth stage)
4. Once soil moisture is sufficiently low, an irrigation event is created, which restores soil water balance, but ups the season's irrigation demand
5. Once the crop reaches maturity (based on growing degree days), it is "harvested," and the season "ends"



Crop coefficient example from source (Agrimet)



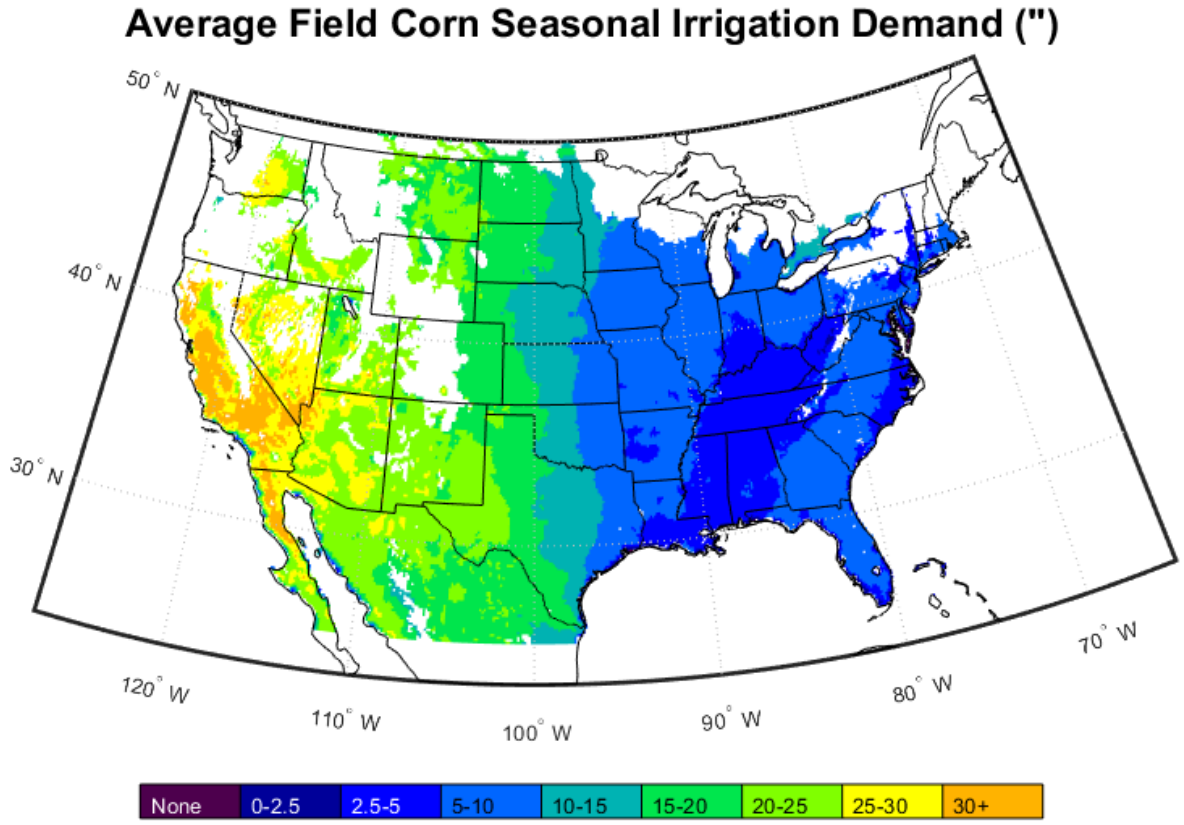
Crop coefficient is determined by its growth stage, which is calculated by Growing Degree Days since planting

Tracking Irrigation Demand

Crop Failures:

A crop is assumed to have an unlimited supply of irrigation water. That's not realistic, but for the purpose of this product, we want to showcase drought-related anomalies rather than simply calling the crop a failure

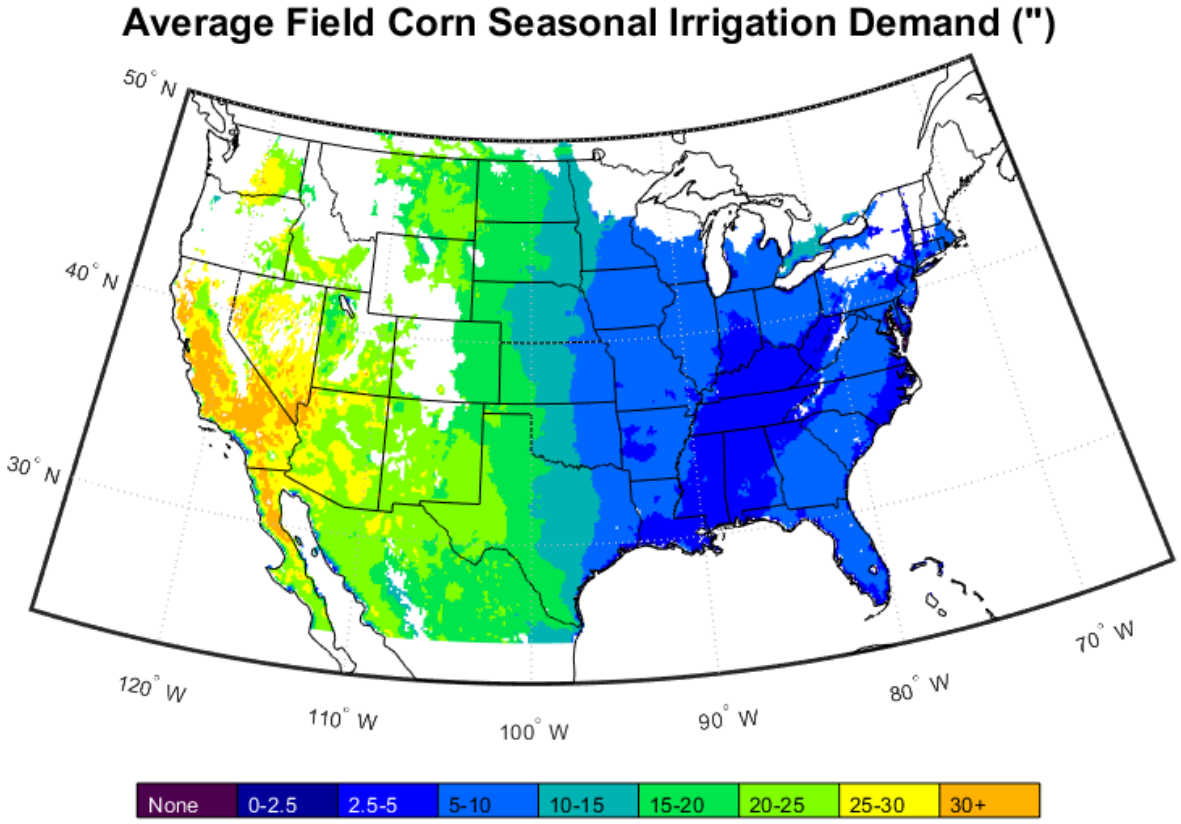
Freeze-related failures: a crop must be "replanted" so to speak on account of any hard freeze before July 1st. It is a failure if another hard freeze occurs post-July 1st prior to accumulating 2700 GDD



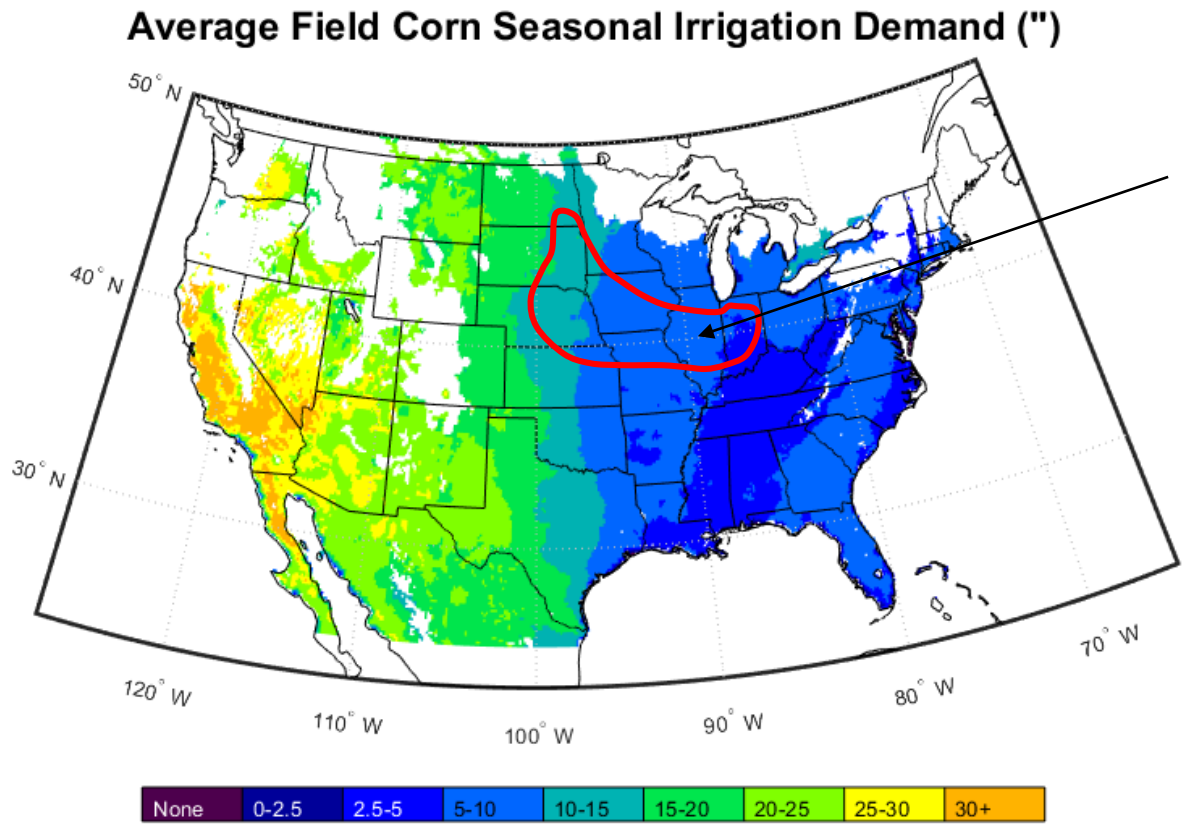
Tracking Irrigation Demand

Soil Specifics:

- Soil moisture is simulated for a flat, uniform, loam field
- Soil moisture profiles start the season 2/3^{rds} saturated
- New soil level ~ Old level + precip – ET, but losses to runoff or infiltration do occur based on soil profile saturation level and or precipitation intensity

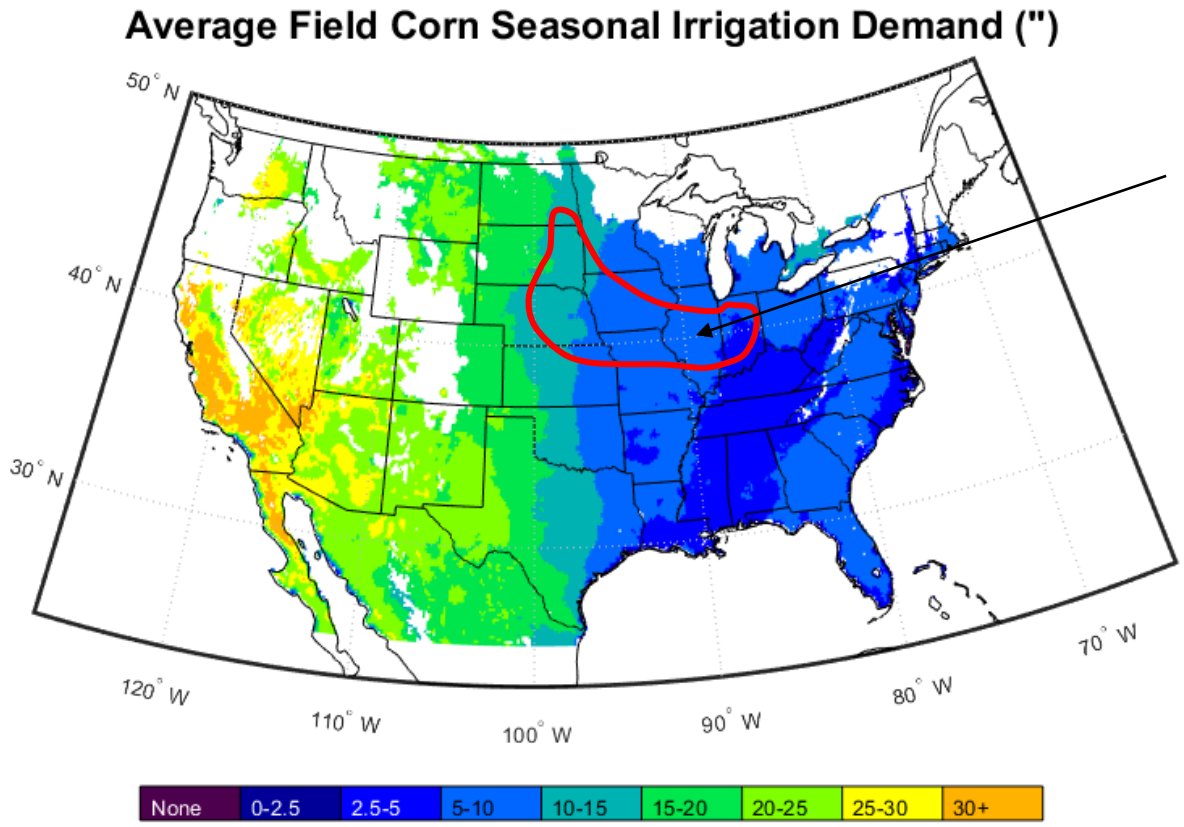


Tracking Irrigation Demand (some caveats)



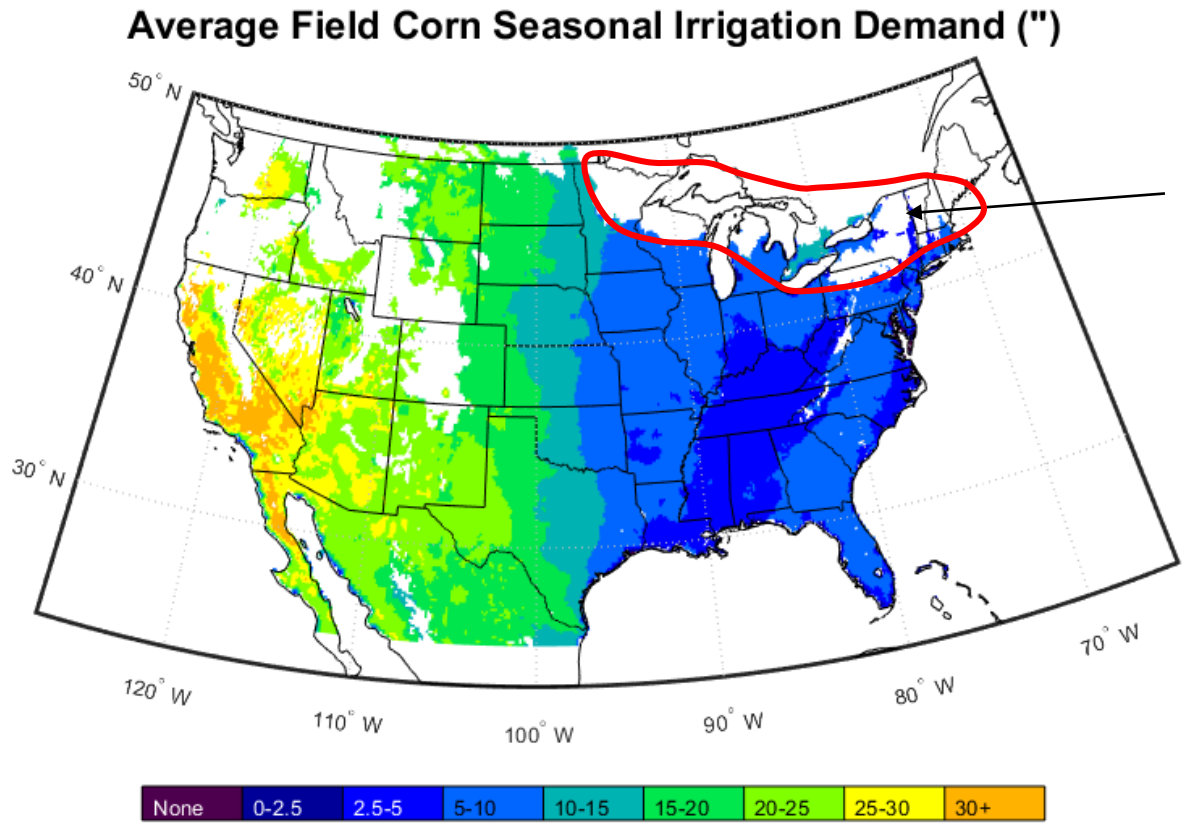
Most of the corn belt is actually dry land (no irrigation applied), but looking at theoretical irrigation demand can still help us assess the magnitude of a drought's impact on a crop

Tracking Irrigation Demand (some caveats)



We do offer zooms on this product for just the corn belt, and just the irrigated corn belt (more on that later)

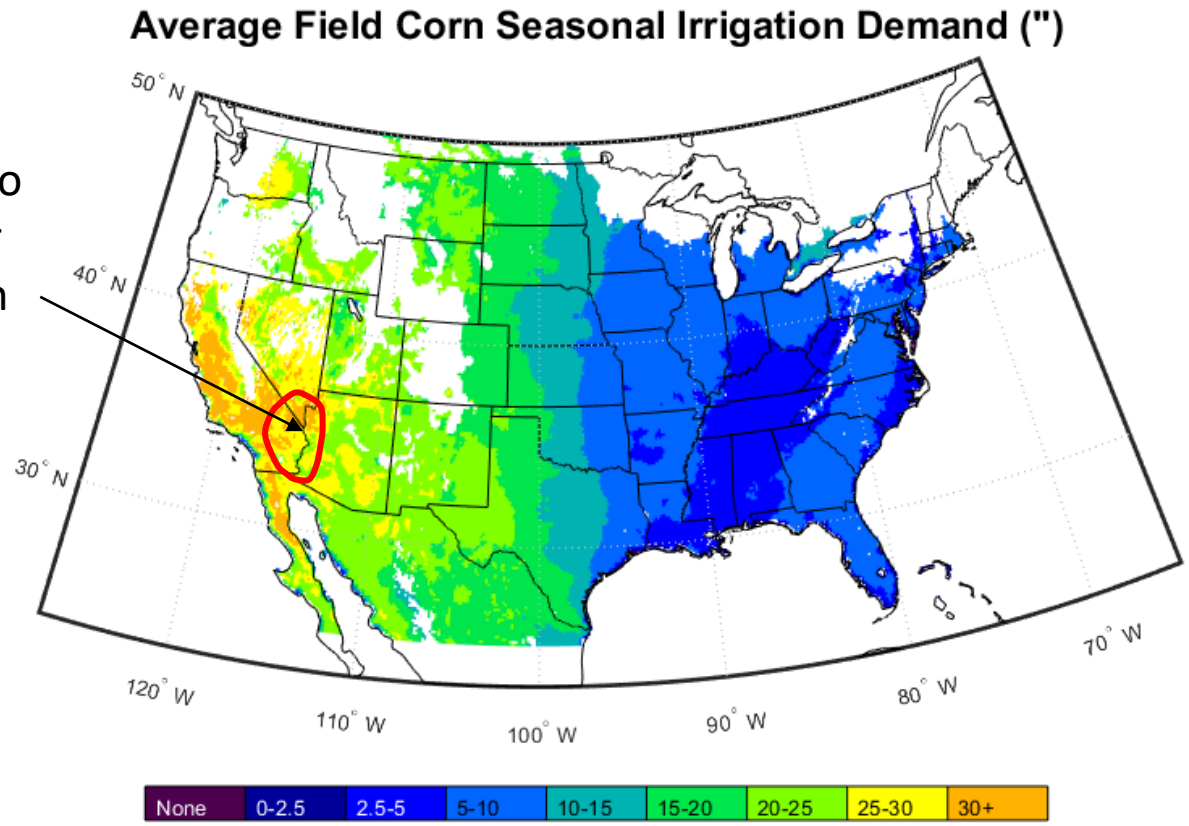
Tracking Irrigation Demand (some caveats)



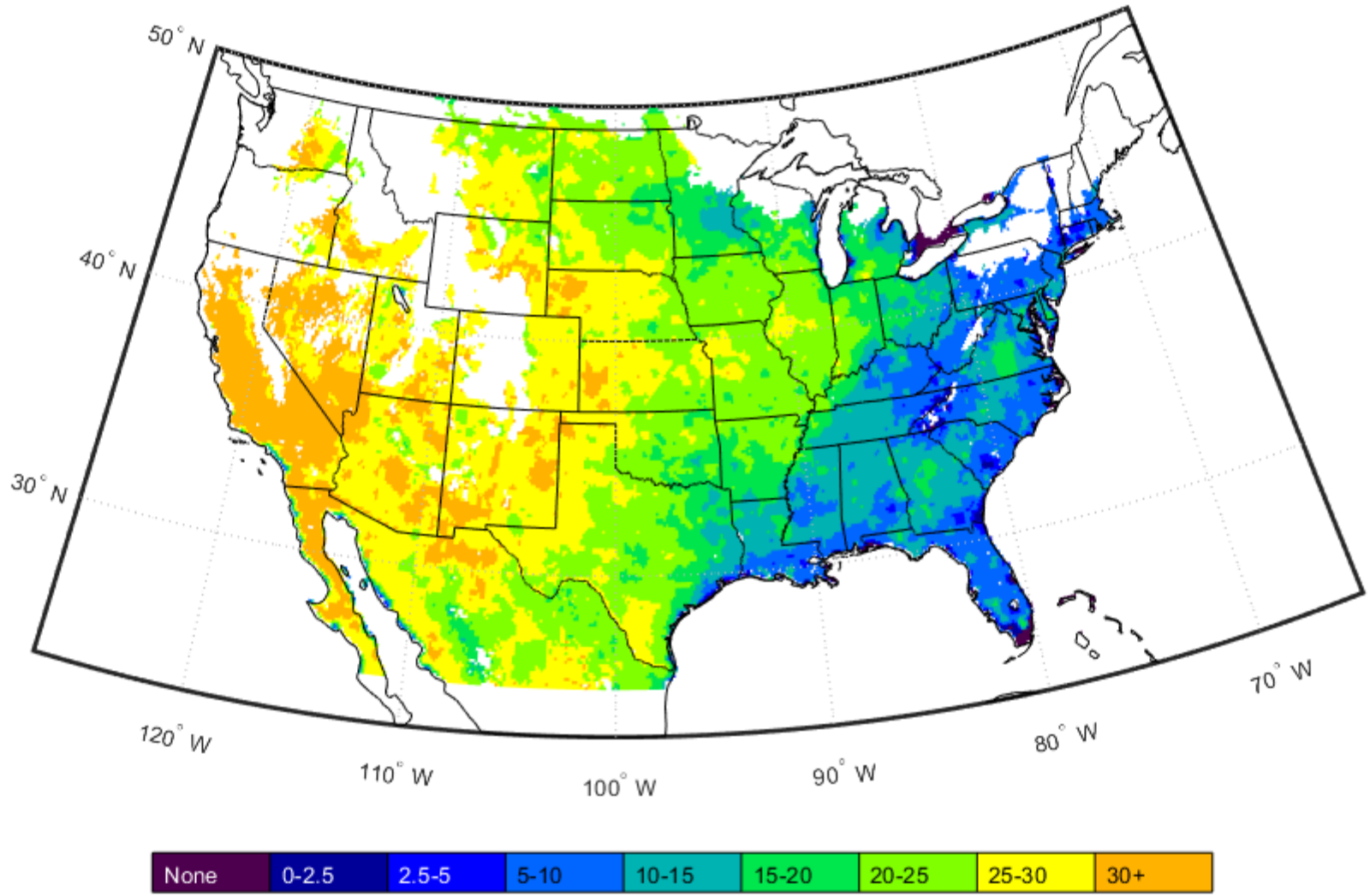
Some areas are whited out in this image due to the number of years in which fall freeze occurred before maturity. That doesn't absolutely mean you shouldn't grow corn here

Tracking Irrigation Demand (some caveats)

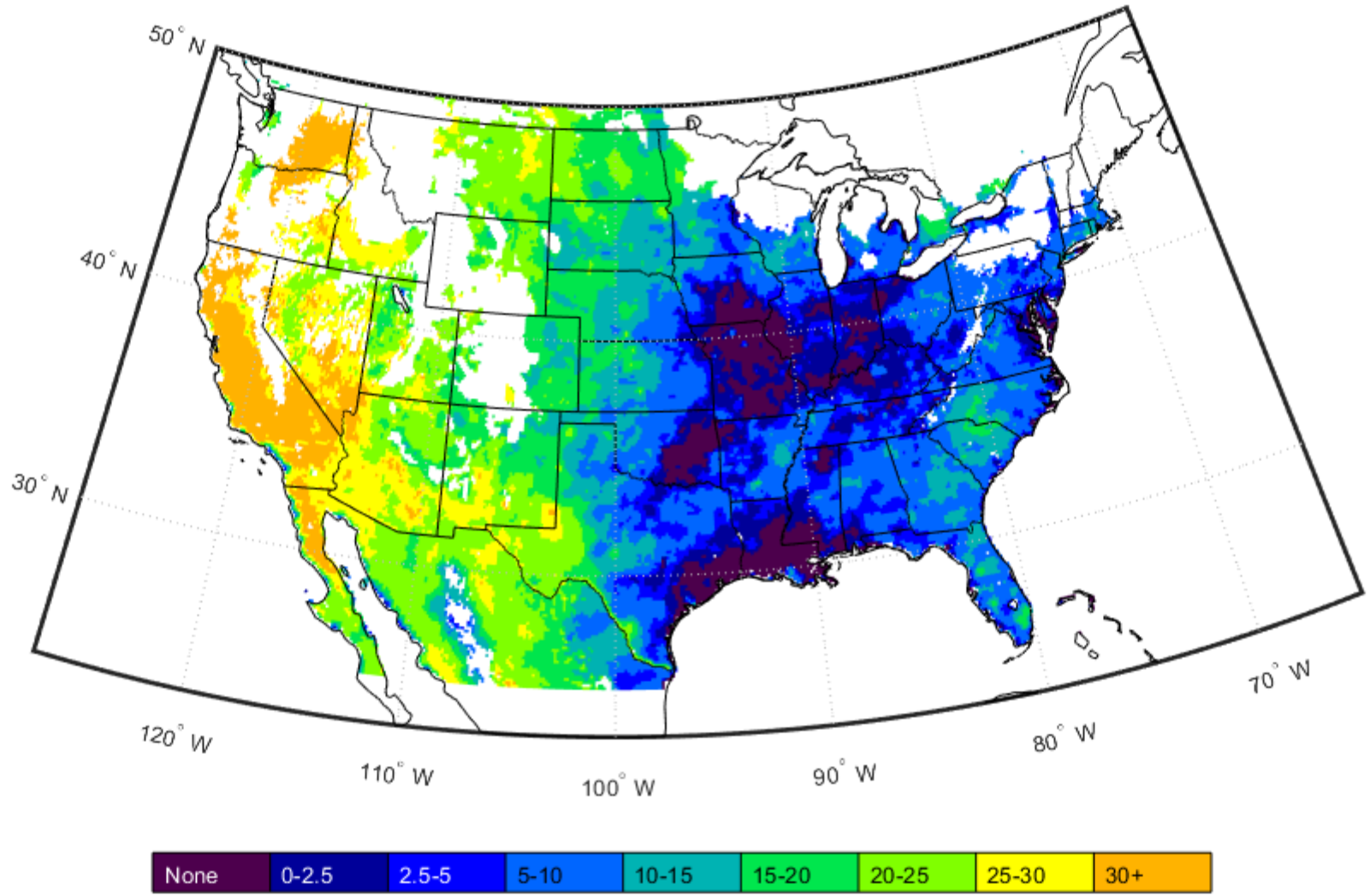
Environments with too high of heat stress for growth have not been masked

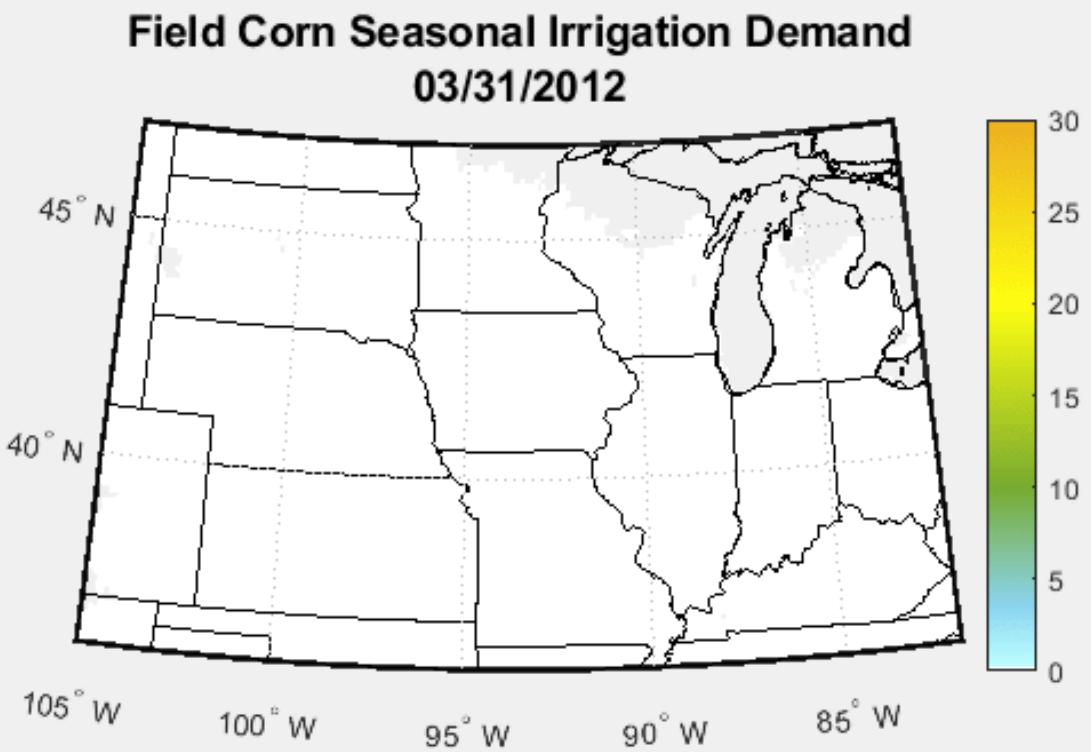


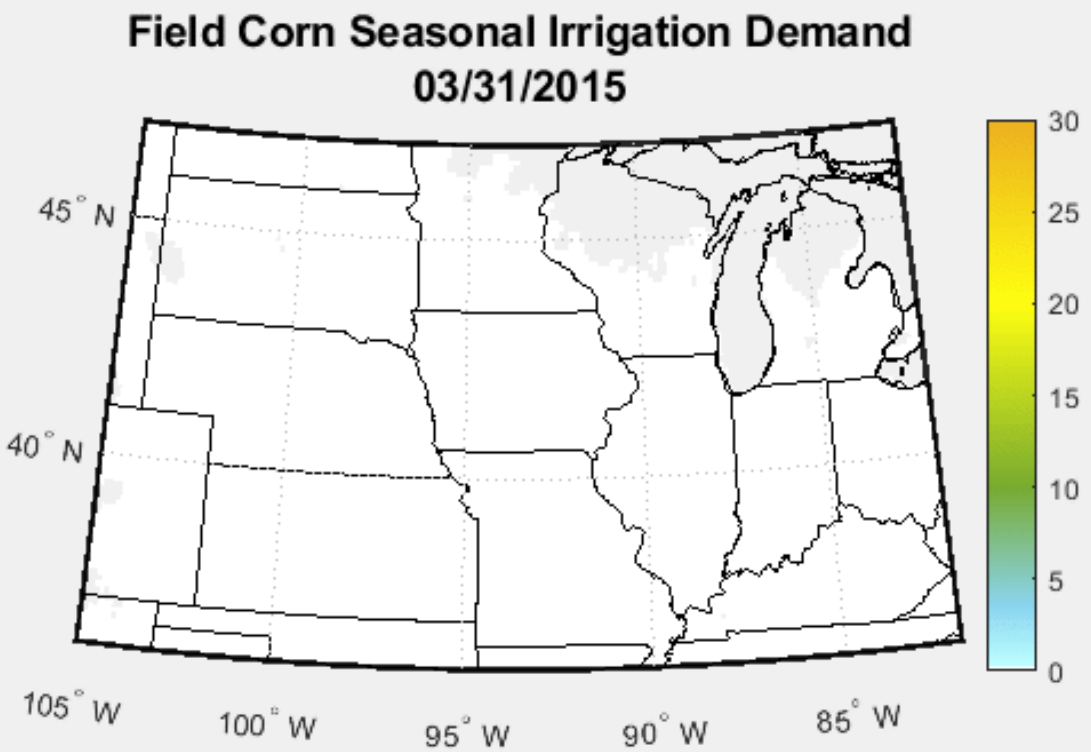
Field Corn Seasonal Irrigation Demand (inches)
October 31st, 2012



Field Corn Seasonal Irrigation Demand (inches)
October 31st, 2015

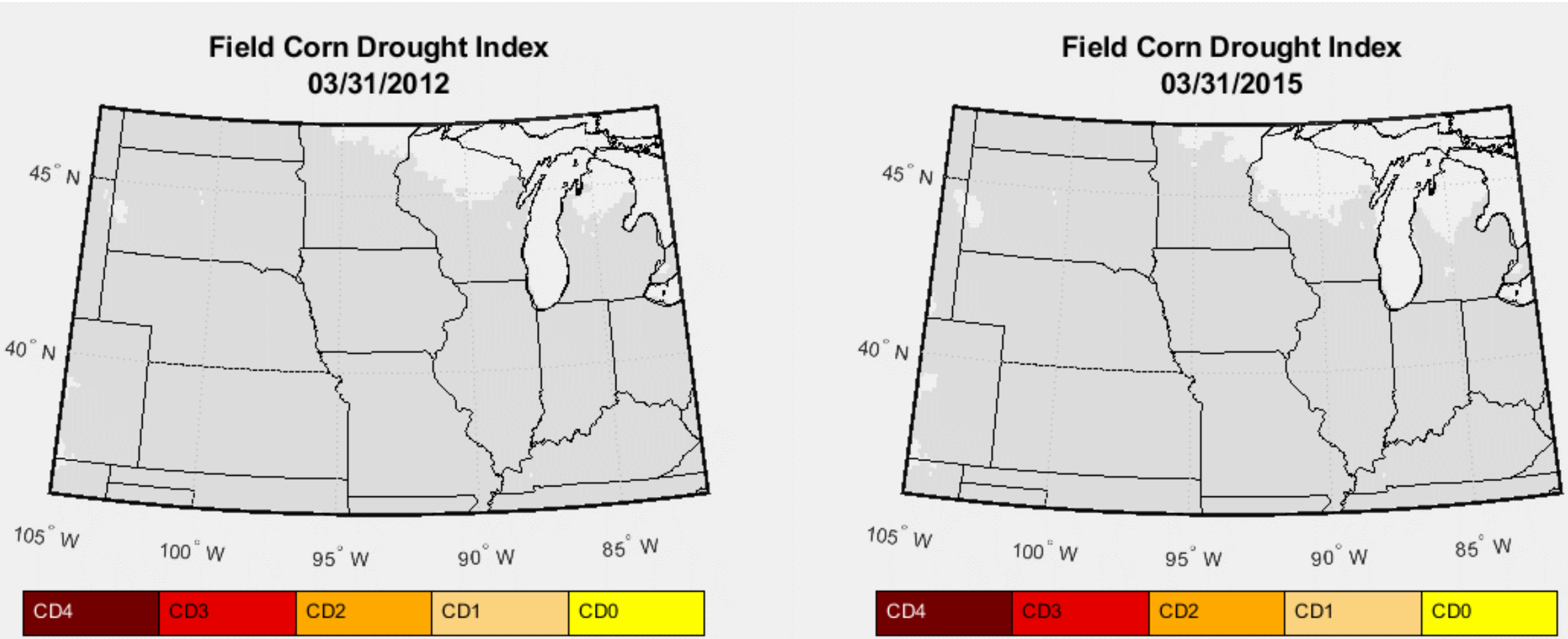



Field Corn Seasonal Irrigation Demand
03/31/2012
45° N
40° N
105° W
100° W
95° W
90° W
85° W
30
25
20
15
10
5
0


Field Corn Seasonal Irrigation Demand
03/31/2015
45° N
40° N
105° W
100° W
95° W
90° W
85° W
30
25
20
15
10
5
0

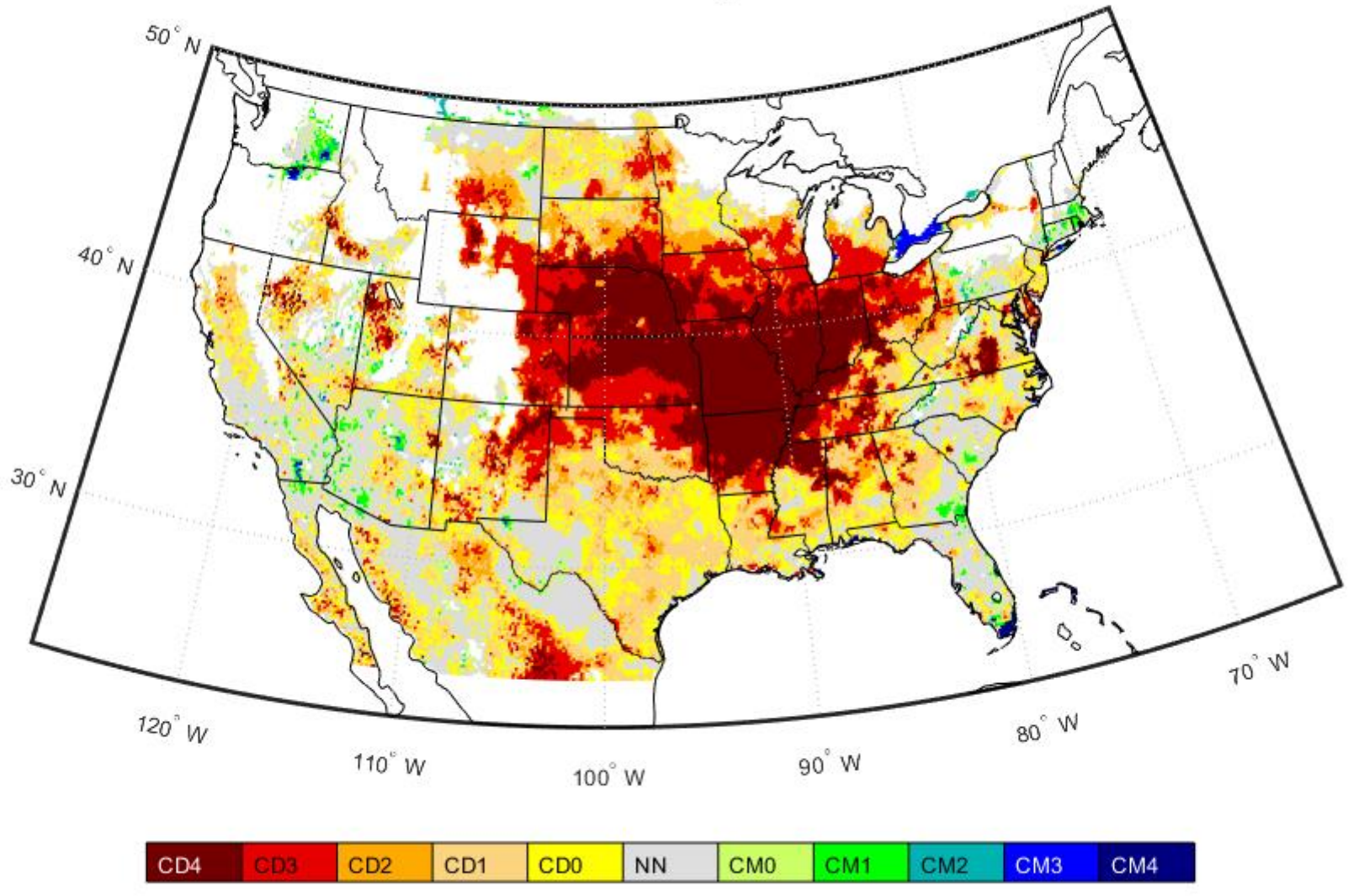
Creating a Drought Index

- The irrigation for each day of the growing season is compared to other years on the same calendar day
- The value is ranked as a percentile, this percentile is calculated as in Hobbins et al. 2016 for the Evaporative Demand Drought Index
- The aggregation period is not flexible. It is tracked once/year from plant date to harvest
- The US Drought Monitor is based on the following percentile groupings: D4 (0-2nd), D3 (3-5th), D2 (6-10th), D1, (11-20th), D0 (21-30th). For consistency's sake, our drought index is displayed the same way.

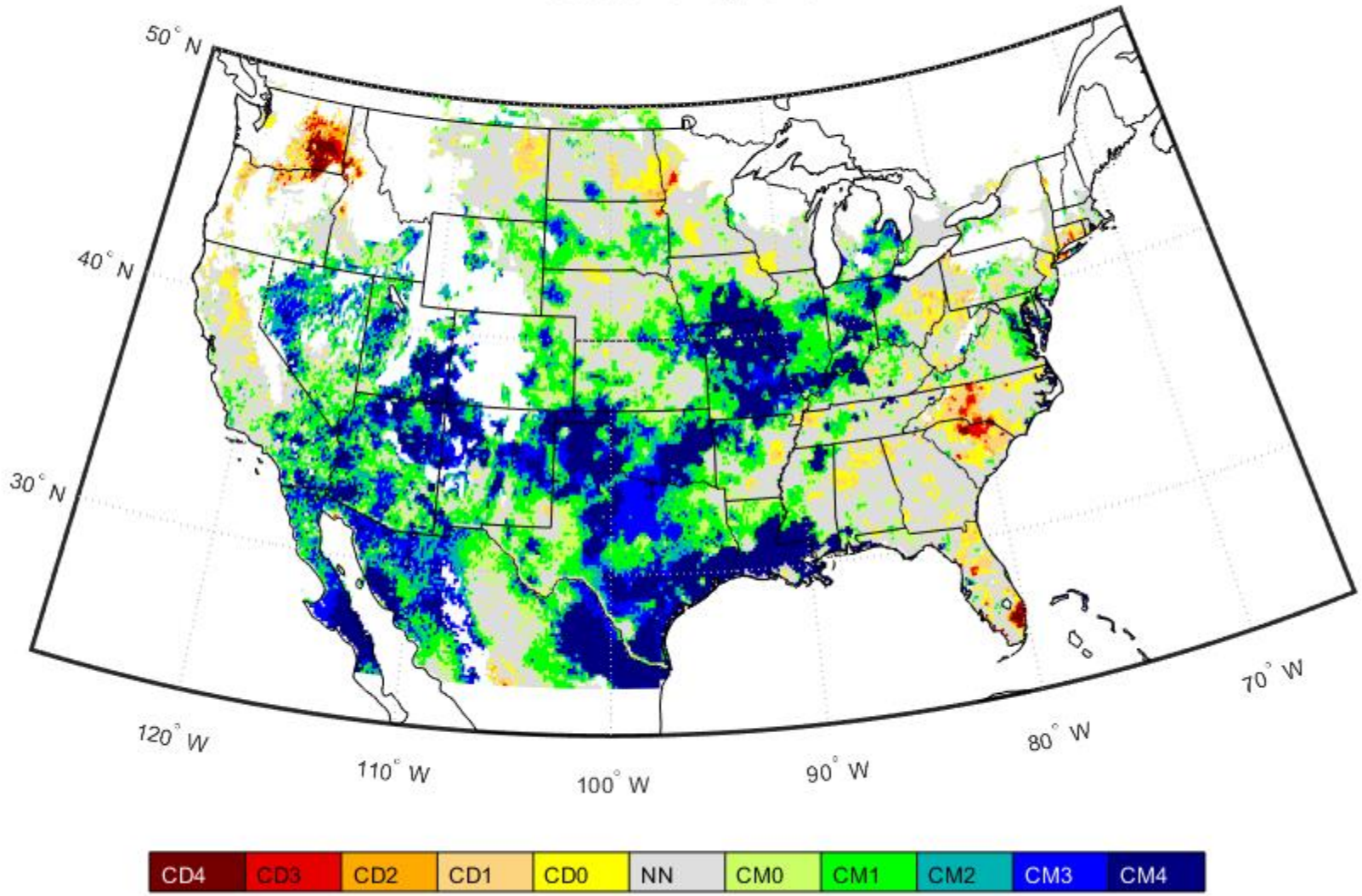

Field Corn Drought Index
03/31/2012
45° N
40° N
105° W
100° W
95° W
90° W
85° W
CD4
CD3
CD2
CD1
CD0

Field Corn Drought Index
03/31/2015
45° N
40° N
105° W
100° W
95° W
90° W
85° W
CD4
CD3
CD2
CD1
CD0

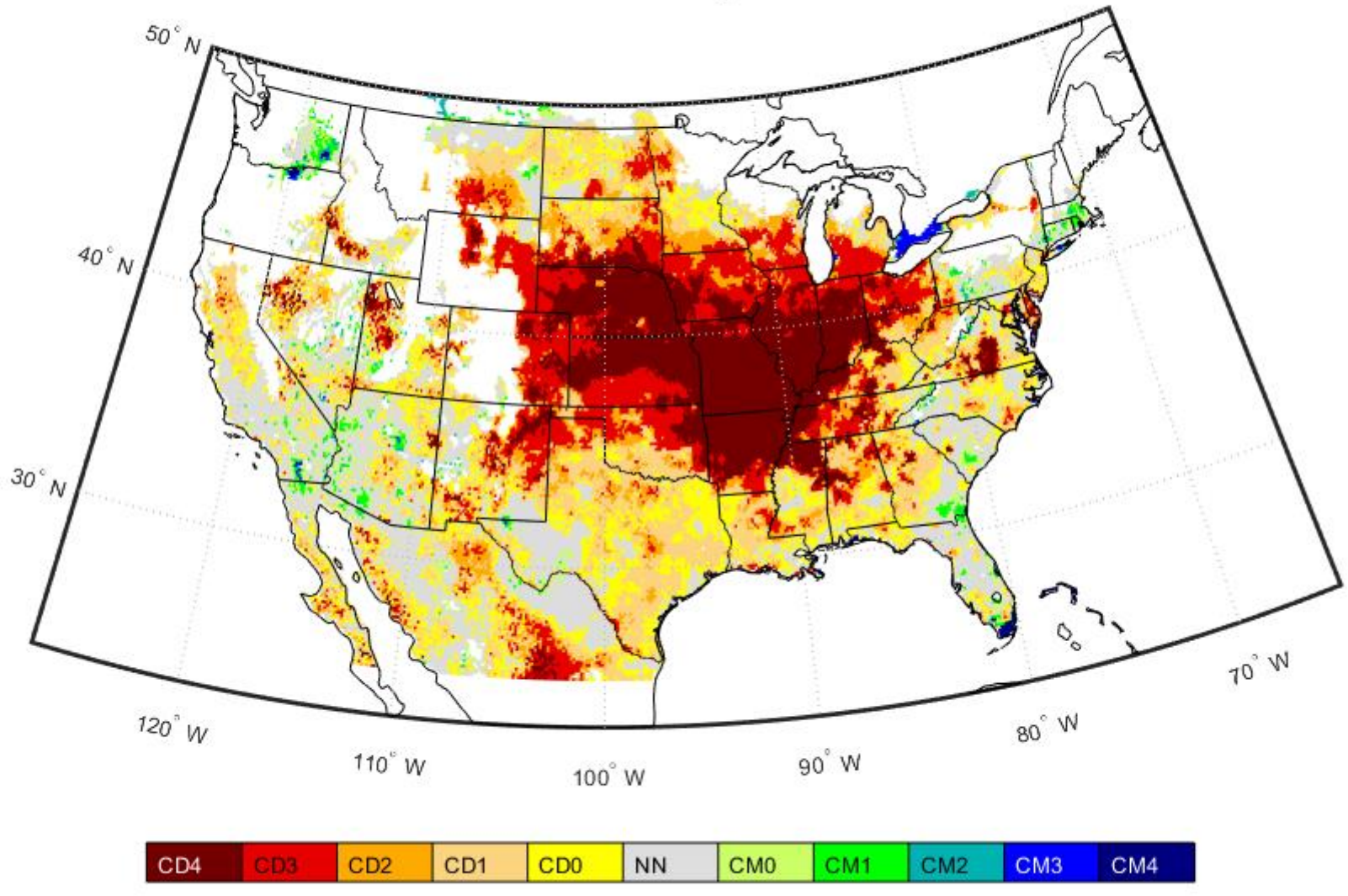
Field Corn Demand Drought Index
October 31st, 2012



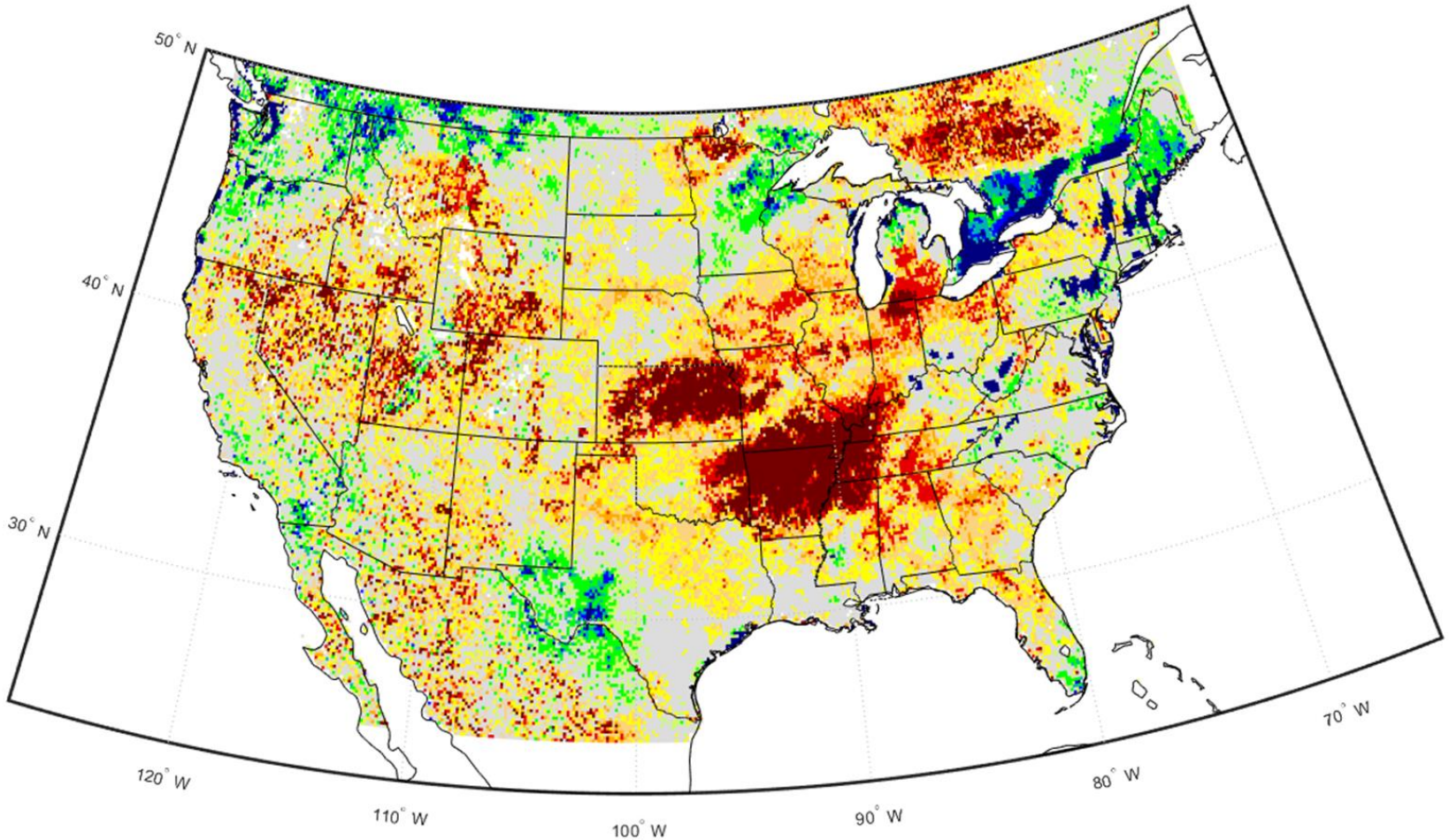
Field Corn Demand Drought Index
October 31st, 2015



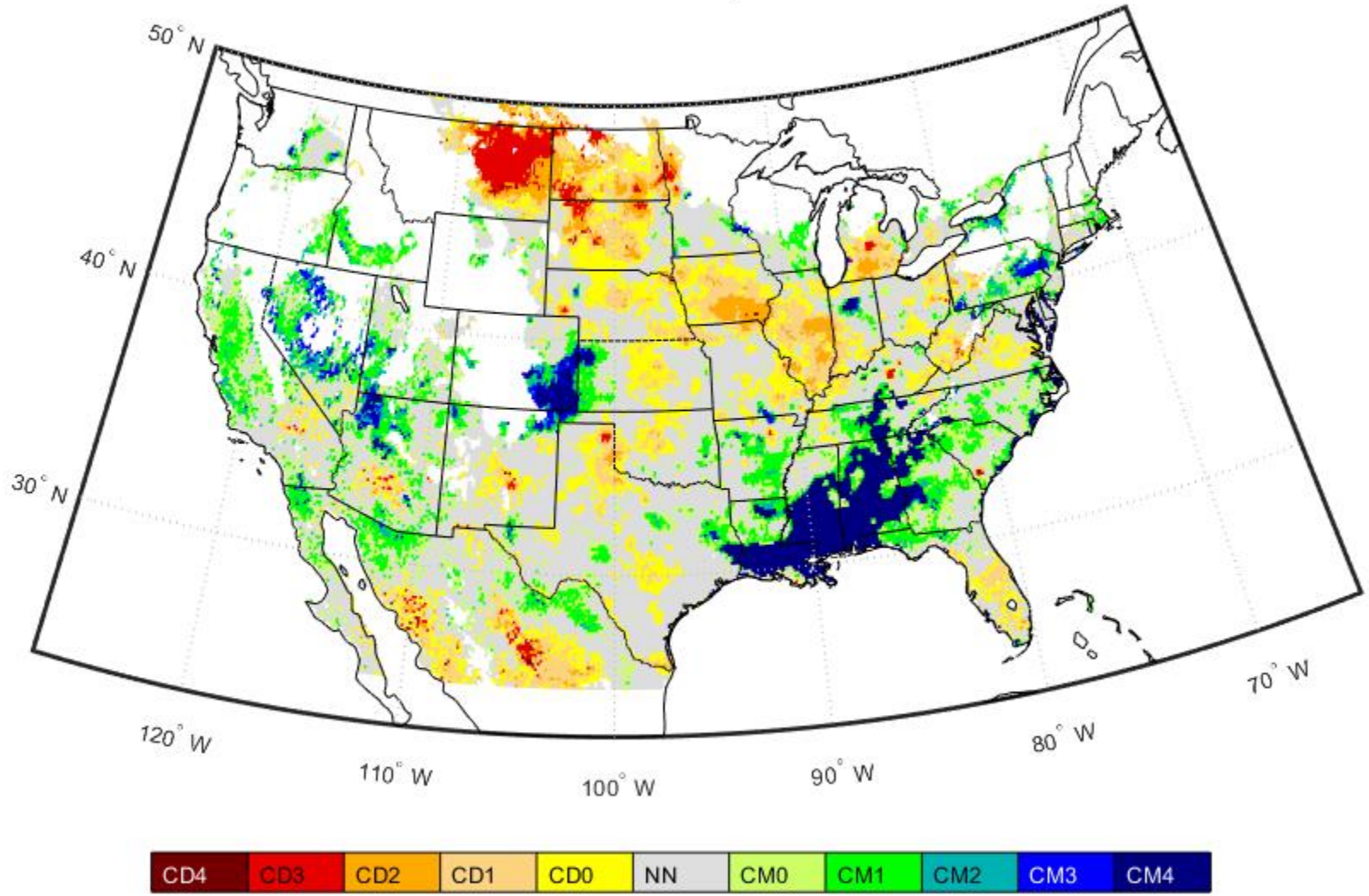
Field Corn Demand Drought Index
October 31st, 2012



Winter Wheat Drought Index
October 31st, 2012

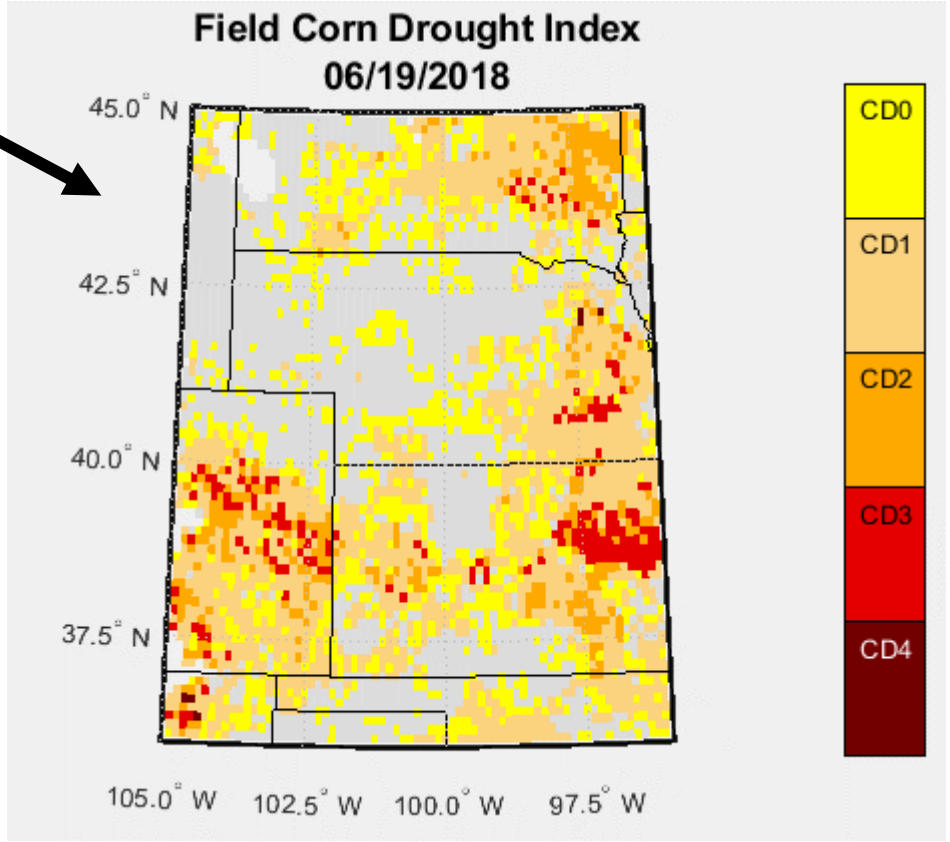


Field Corn Demand Drought Index
October 31st, 2017



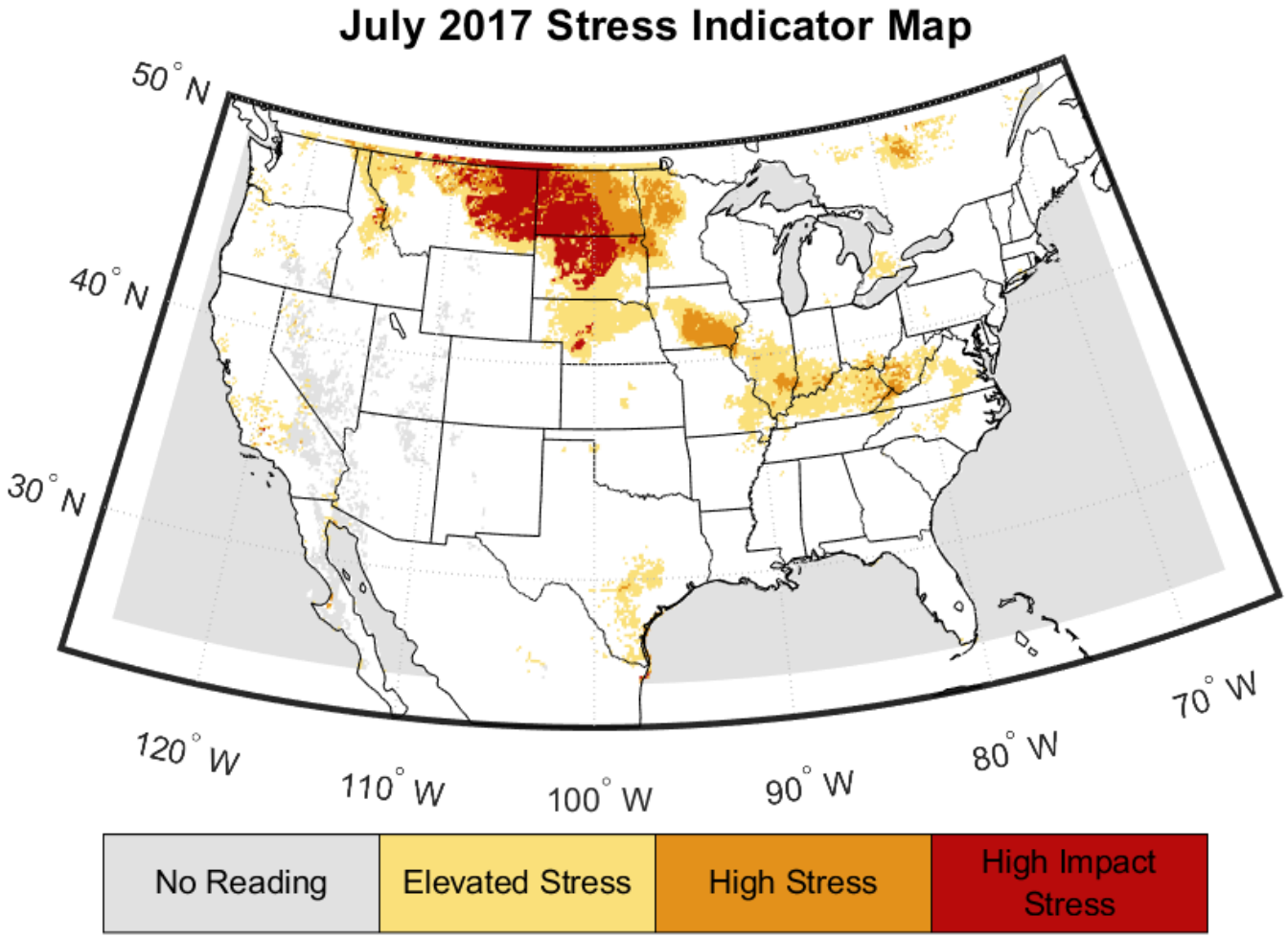
We’re D3 in Sioux Falls!

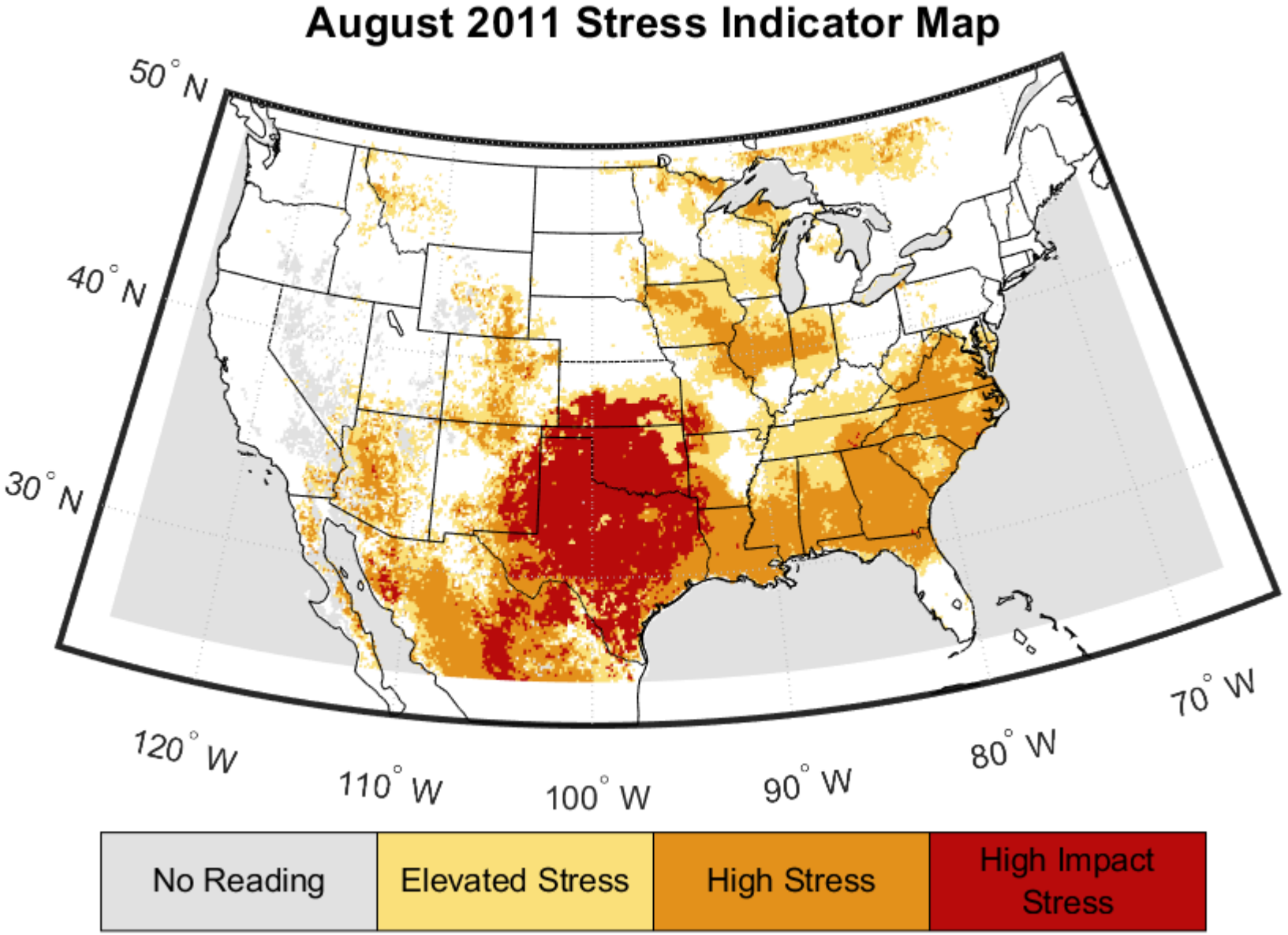
We’re D3 in Rocky Ford!



Also in the Hopper: High Impact Stress Detector

- Similar to ESI, uses potential and actual ET data. Highlights when the ratio between the two is askew
- Geared more towards tracking transitional zones between moisture and energy limited climes

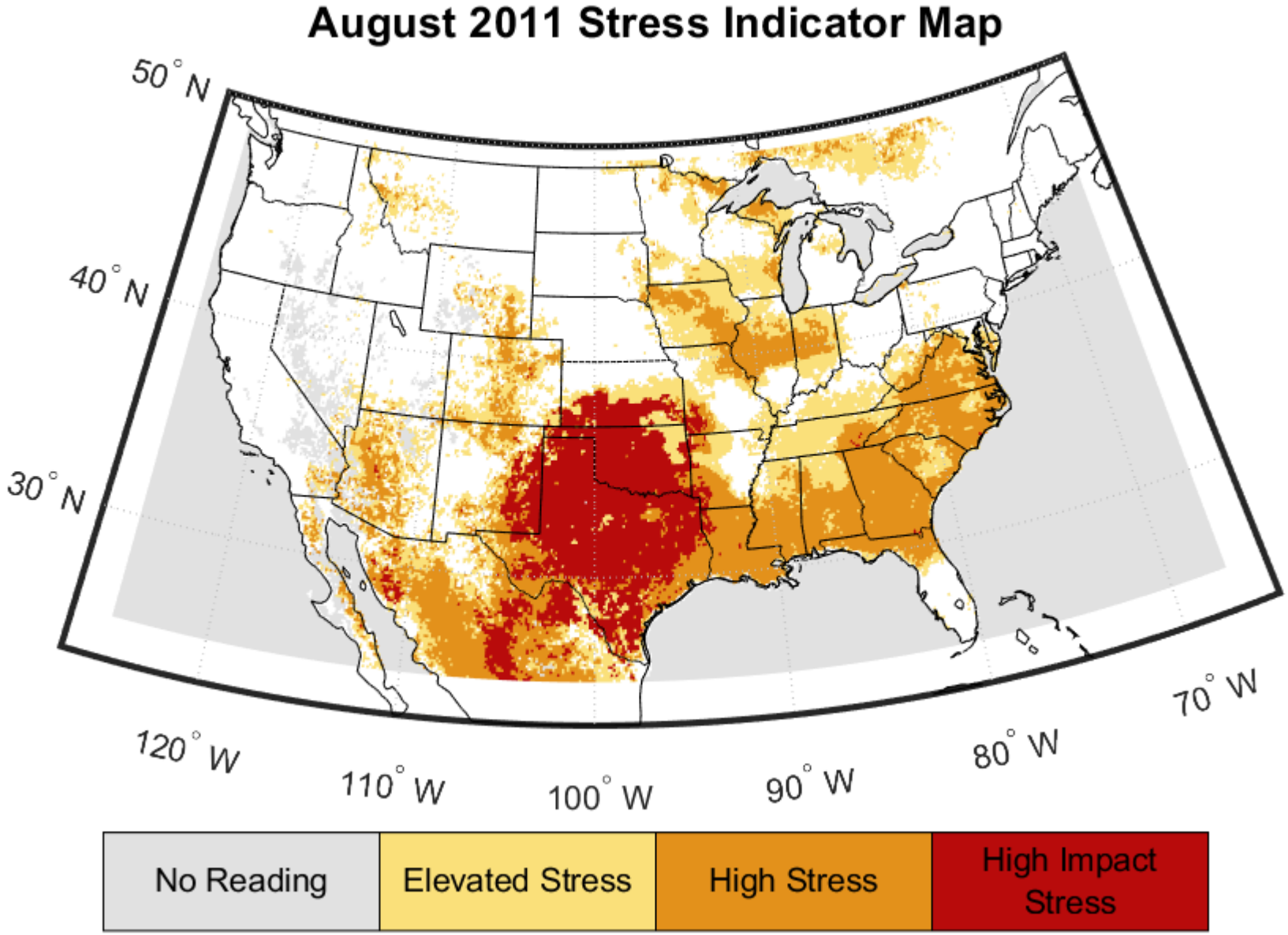




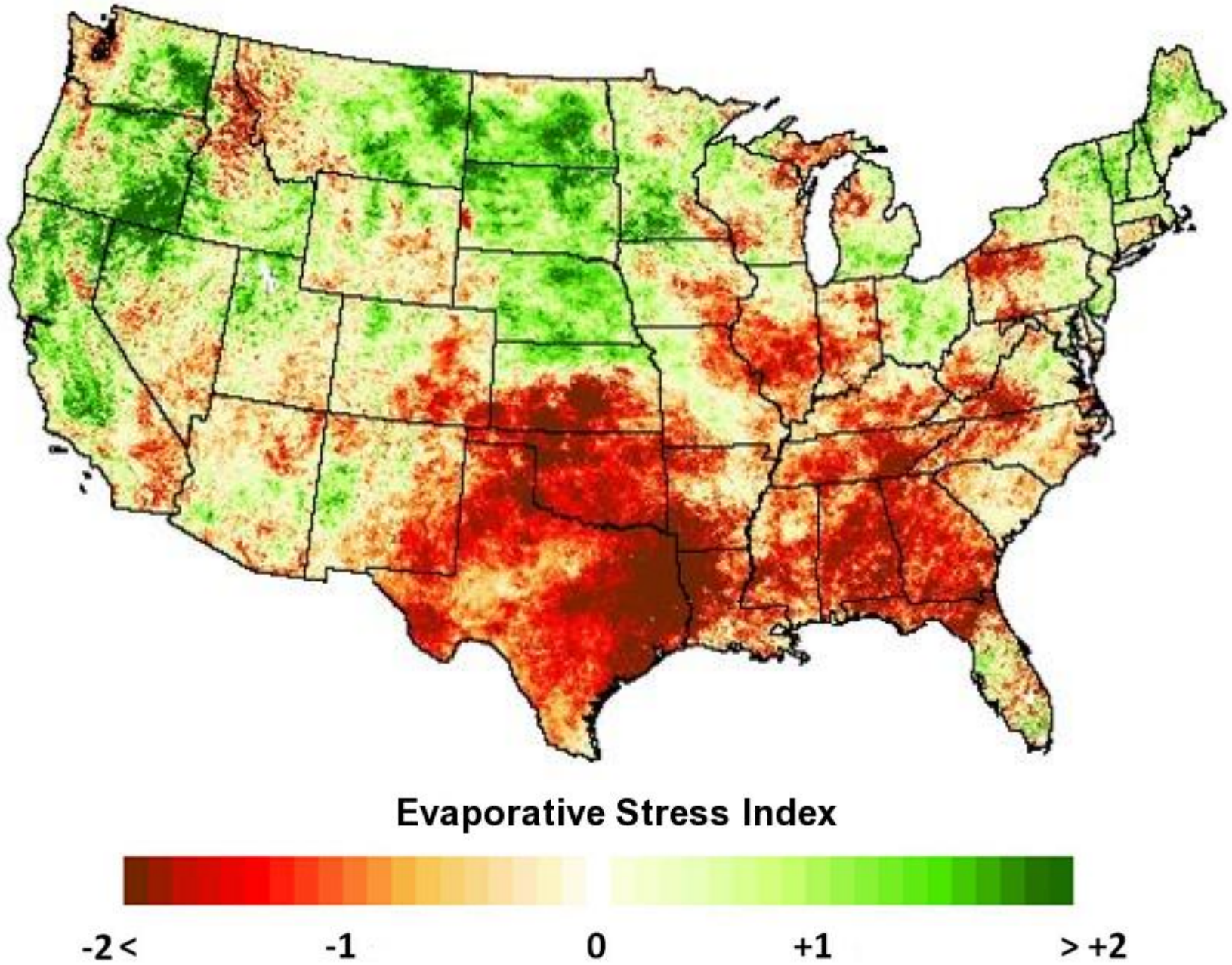
High Impact Stress?

1. 1.5” or greater deficit in monthly actual evapotranspiration
2. Monthly potential evapotranspiration > 6”
3. AET/PET ratio at least one sigma below normal

In other words: Demand is high in both an absolute and relative sense, and surface vegetation clearly suffering

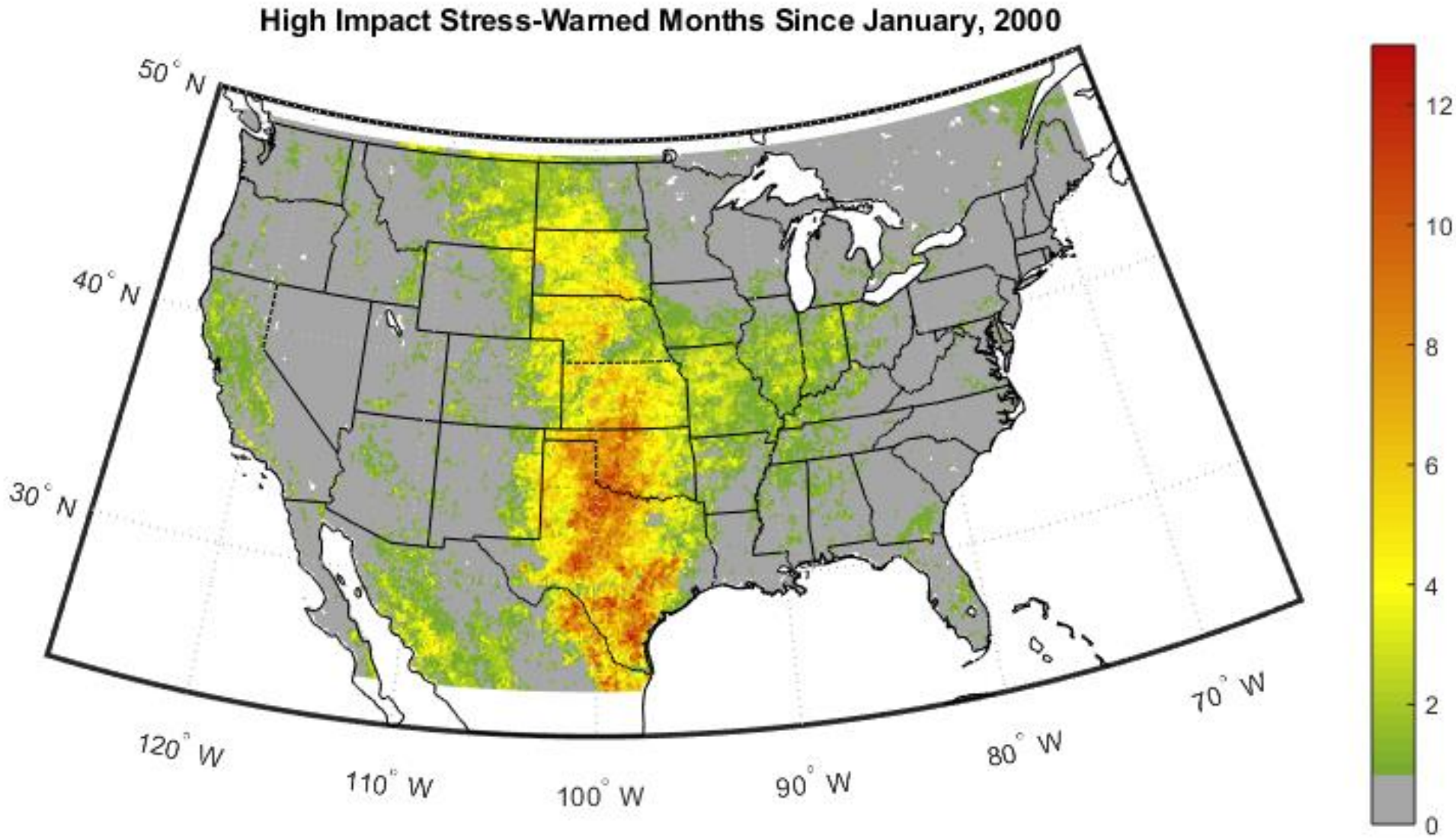


Qualifications for high stress are the same other than requiring a specific AET deficit



ESI
September
2nd, 2011

USDA


High Impact Stress-Warned Months Since January, 2000
50° N
40° N
30° N
120° W
110° W
100° W
90° W
80° W
70° W
12
10
8
6
4
2
0

Conclusions

- Parametrized irrigation varied widely from year-to-year, place-to-place, and by crop type (examples for corn and wheat above). For instance, irrigation over corn in western Missouri varied from 0 to over 20” (on par with central AZ average)
- Known droughts such as 2012 over the Midwest, and 2017 over the northern high plains were easily identified.
- Crop type impacts not just seasonal irrigation need, but also irrigation percentile, and therefore level of drought severity.
- Using this tool, we hope to help bridge the divide between appraising drought based on meteorological data and impacts (it probably can’t be used to tell a farmer how much to irrigate, but it can help put their complaints on a level playing field)

Future Work

- Compare model output to surface observations from Ag weather stations
- Expand model to include more crop types
- Build more sophistication into soil water balance model (ie parametrizing crop stress)
- Produce operationally