Climate Vulnerability in Montana's Agricultural Sector and Park County

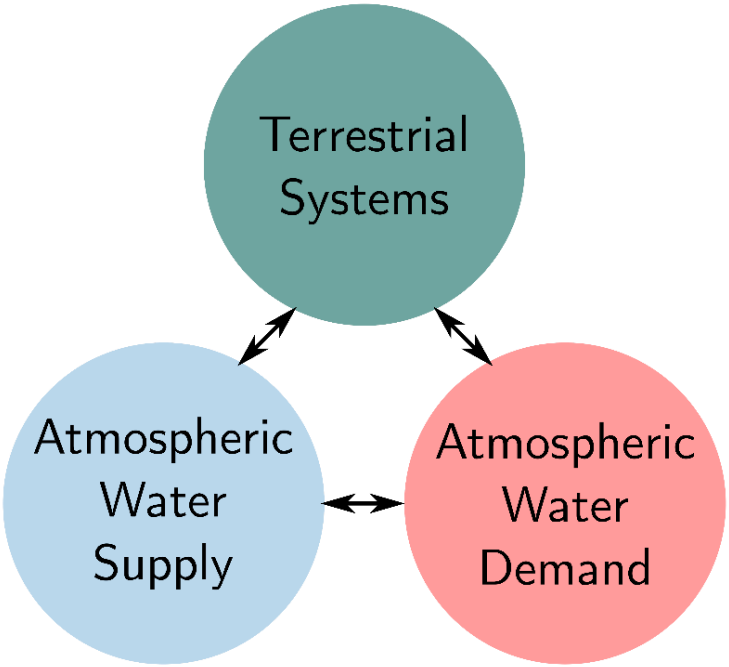
Marco P. Maneta

Geosciences Department, University of Montana
marco.maneta@umontana.edu

The Upper Yellowstone: Examiming the Confluence of Past Lessons and Future Needs
West Creek Ranch, September 4-7, 2018

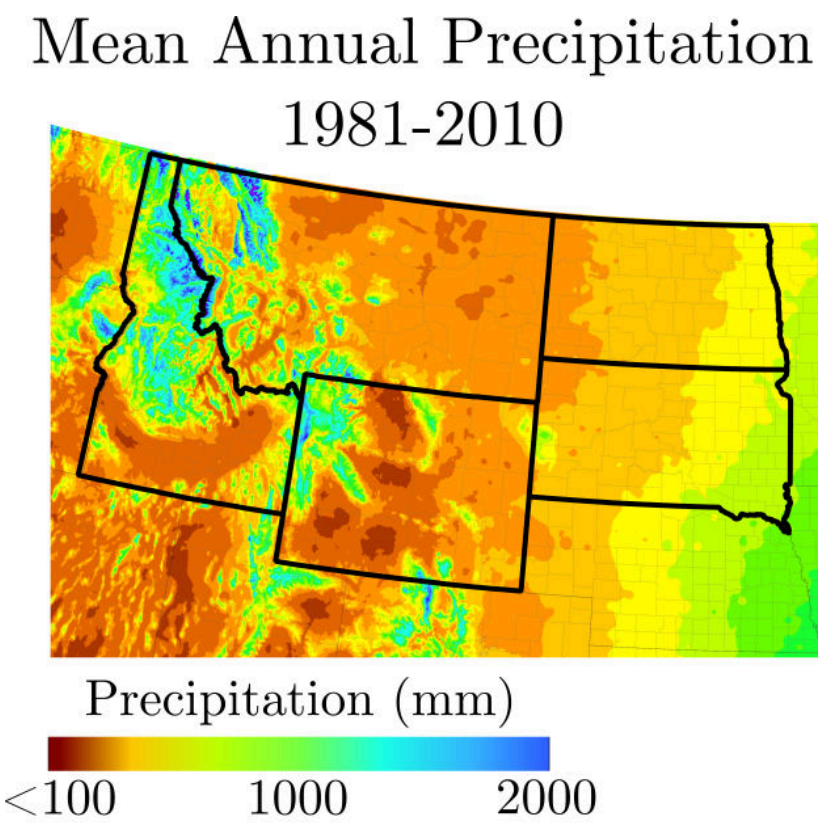
United States Department of Agriculture
National Institute of Food and Agriculture

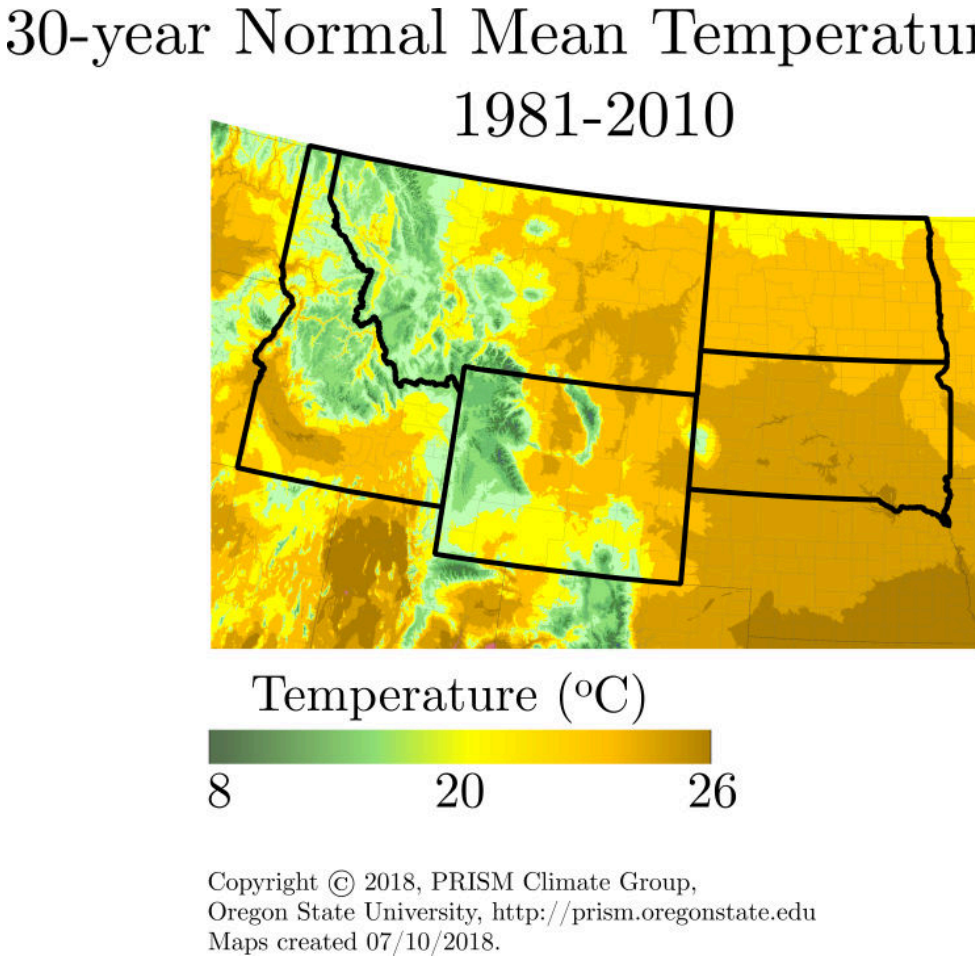
Coupled Climate-Terrestrial Systems



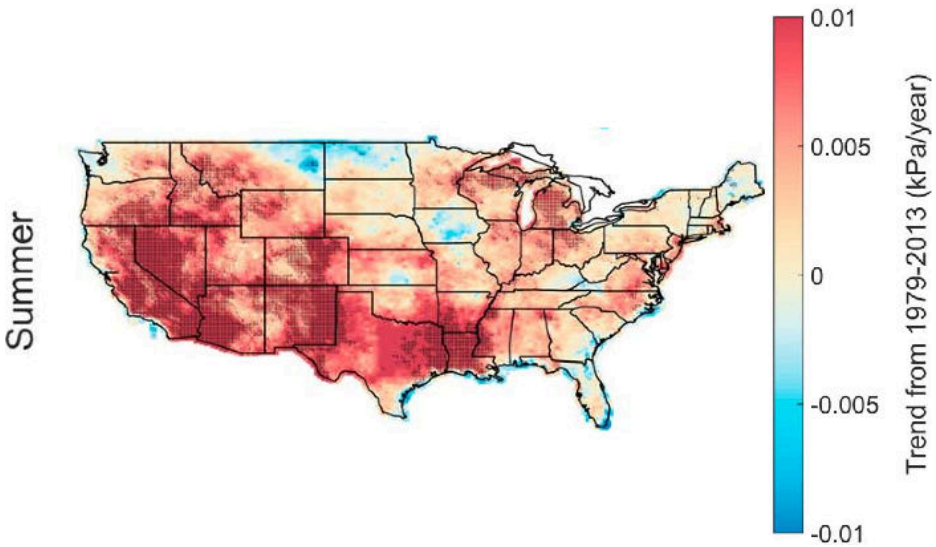
- Climate provides key physical constraints to regional water supply and demand
- Climatologic and ecological systems adjust to find equilibrium
- Water demand is a very local phenomenon, water is needed at a very specific place and time

Coupled Climate-Terrestrial Systems





Increasing atmospheric and soil aridity

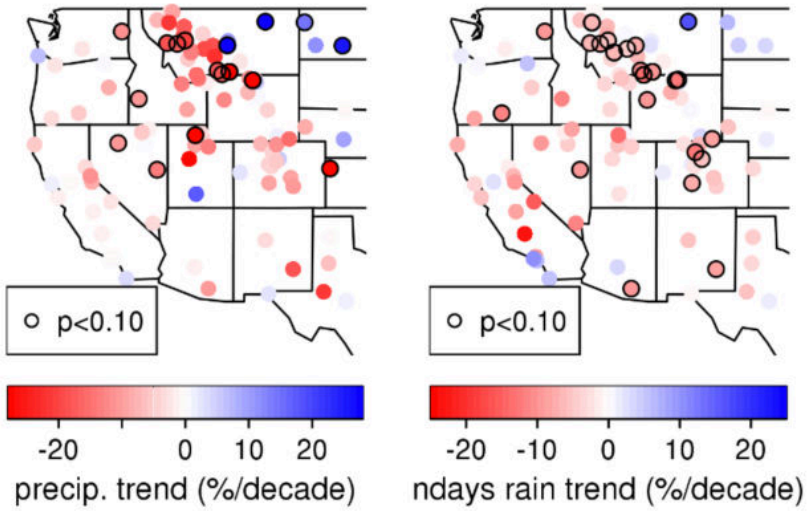


Vapor pressure deficit trends over summer months.
Ficklin et al., 2016. JGR.

- Vapor pressure deficit a direct measure of atmospheric water demand.
- Increasing across much of the US, particularly in the west.
- Decreasing in eastern Montana and North Dakota.

Increasing atmospheric and soil aridity

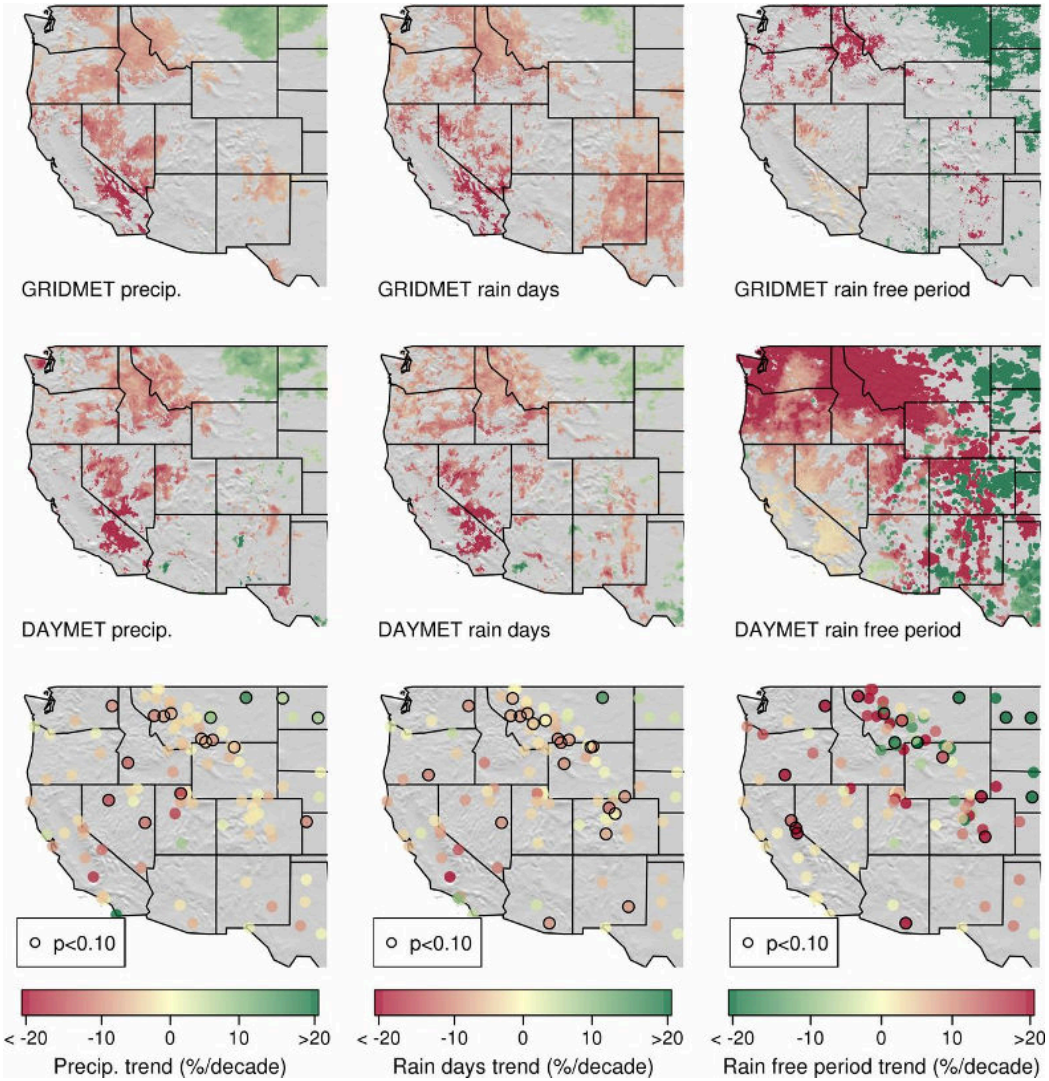
- Atmospheric water supply decreasing across much of the US west.
- # of rain days also decreasing.
- Increase in eastern Montana and North Dakota.



Precipitation trends over growing season.

Holden et al., 2018. PNAS.

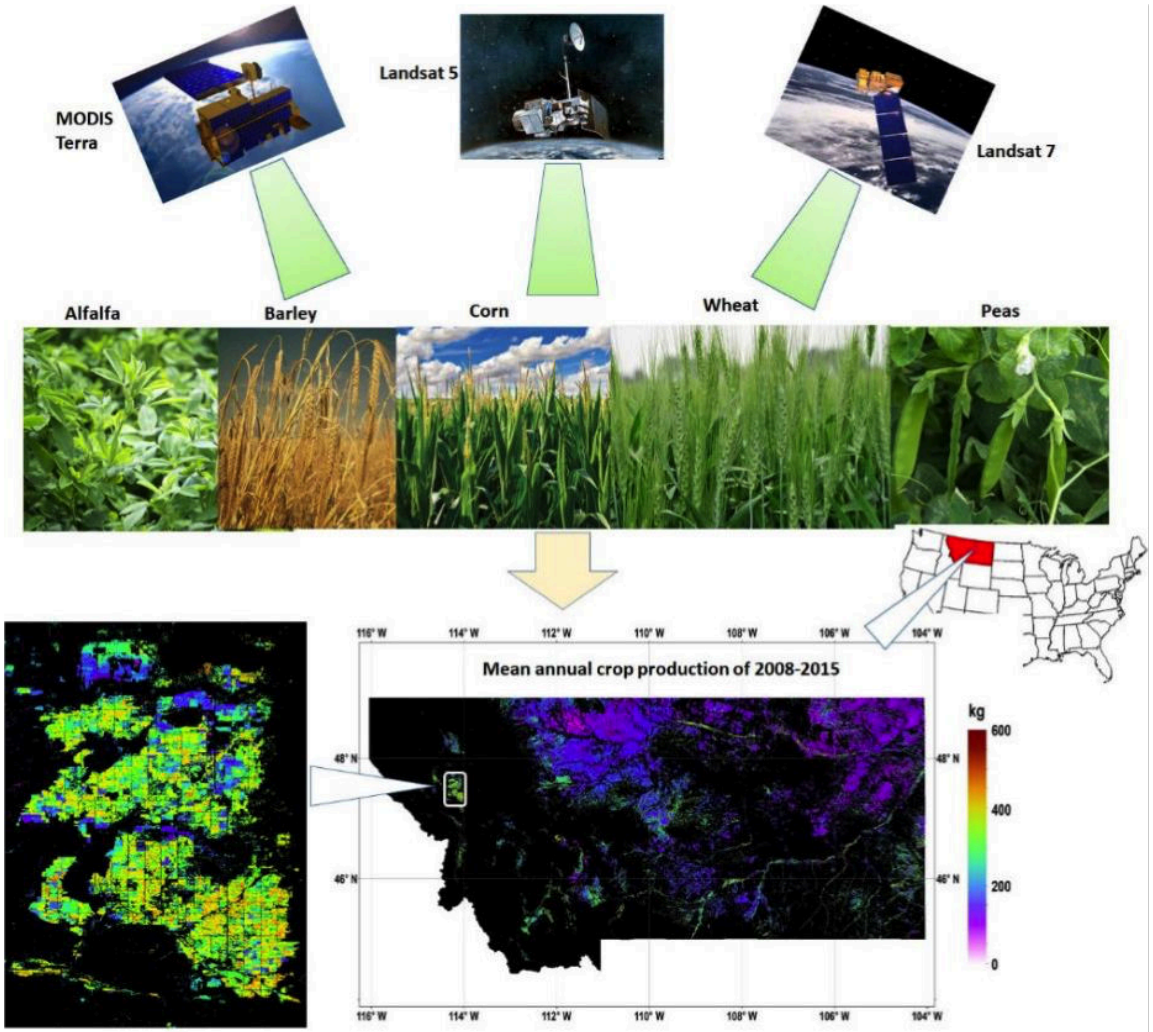
Declining precipitation during growing season



Holden et al., 2018. PNAS

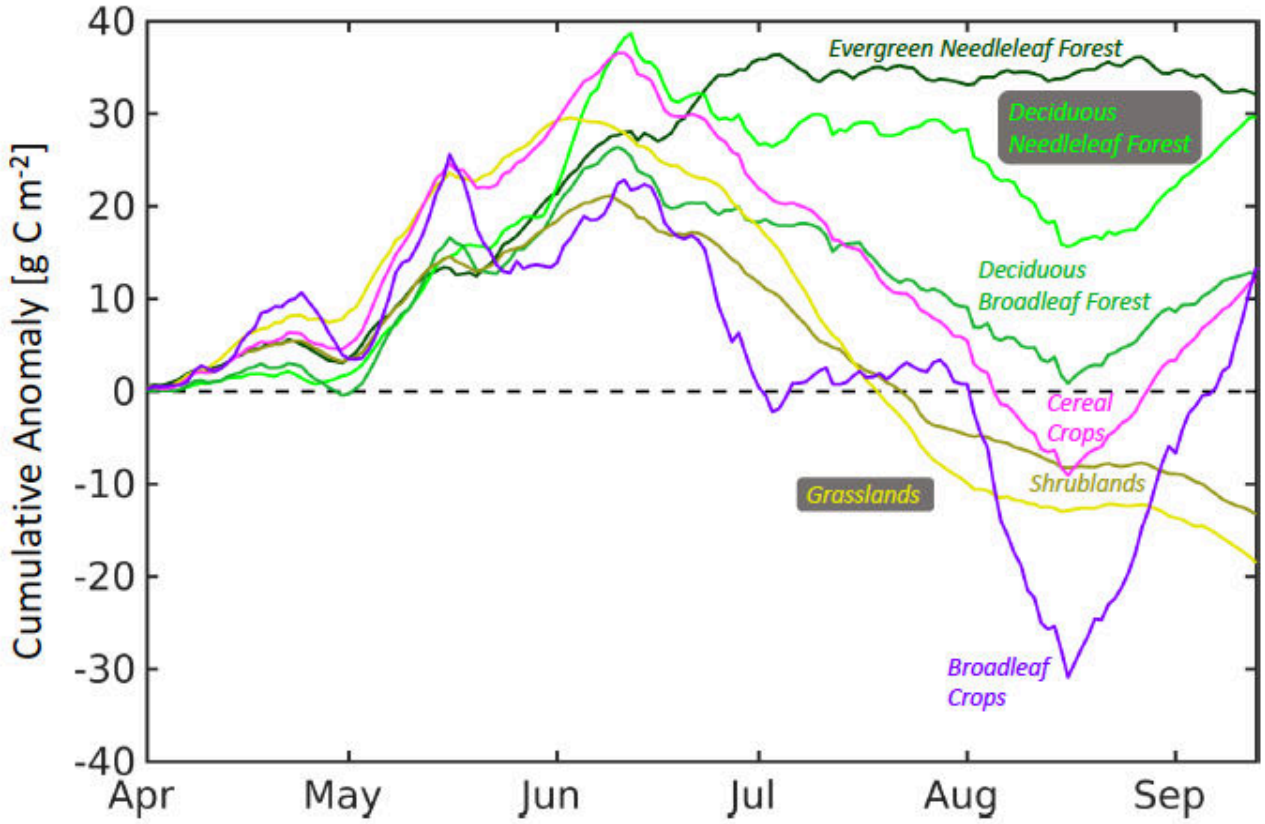
Trends in precipitation statistics from 1979 to 2016 from three different datasets

MODIS-LANDSAT imagery fusion - NDVI



Remote Sensing of productivity

Portrait of 2017 Northern Plains Flash Drought



Jones et al, NTSG

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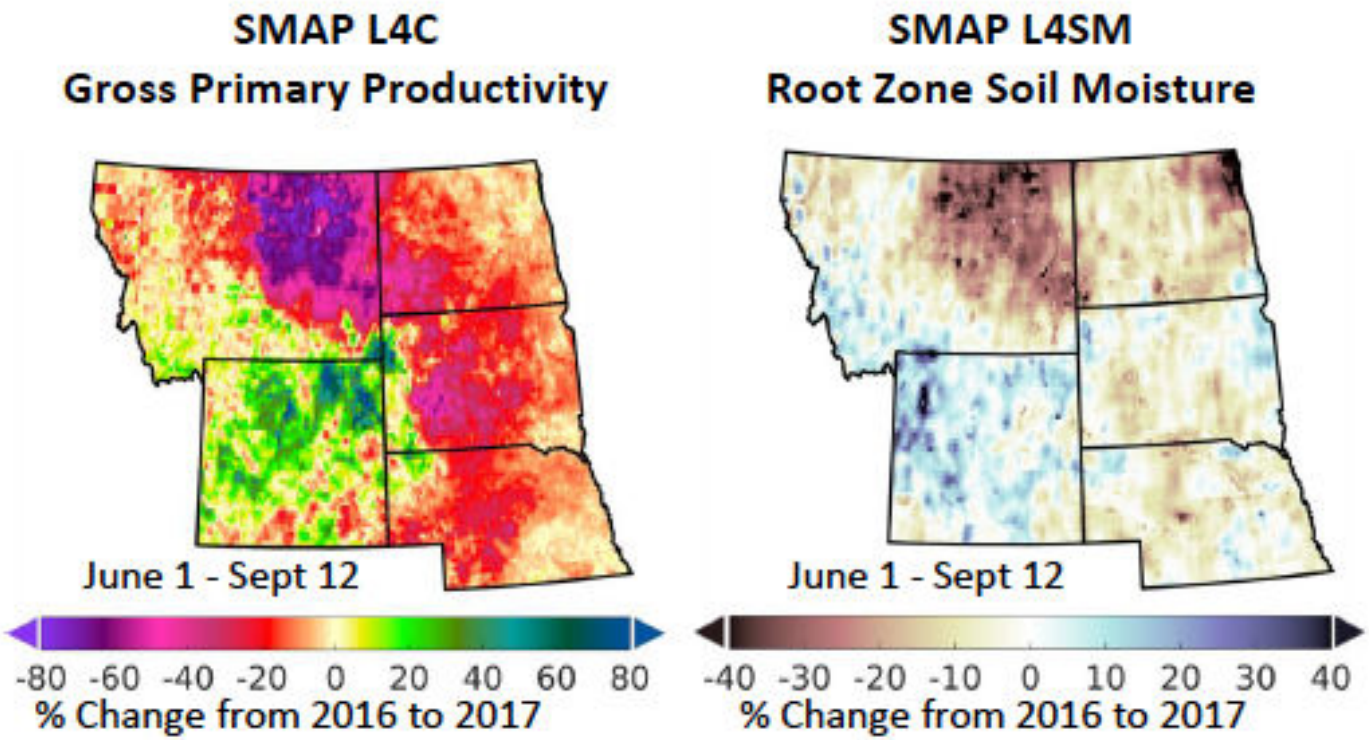
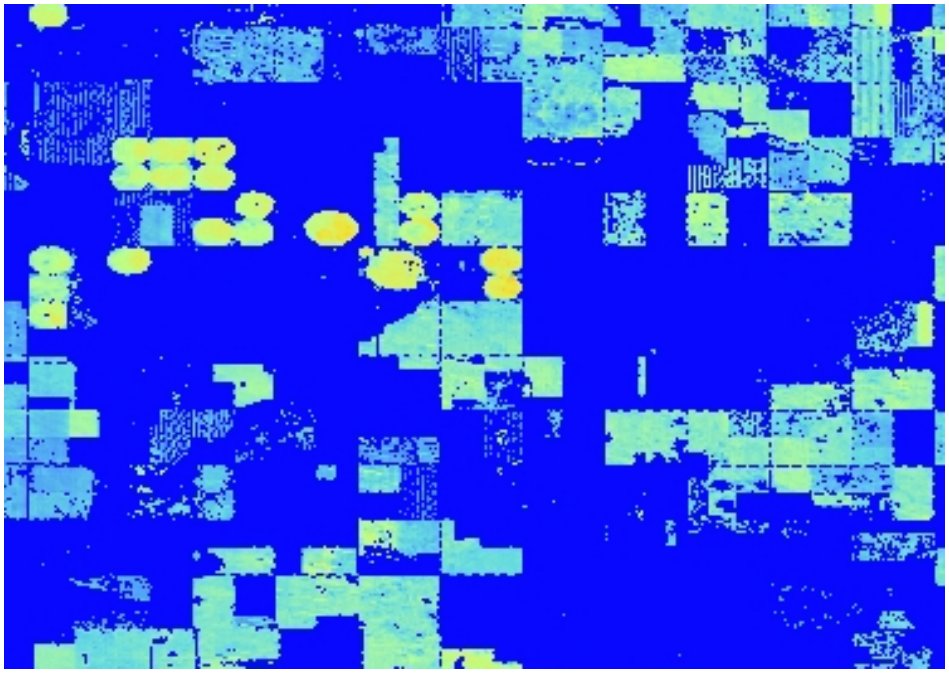


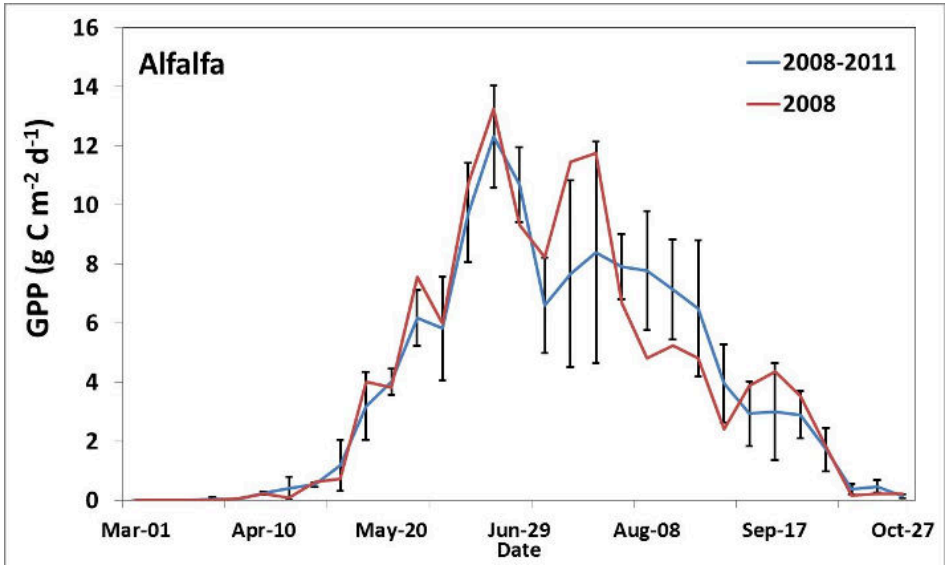
Jones et al, NTSG

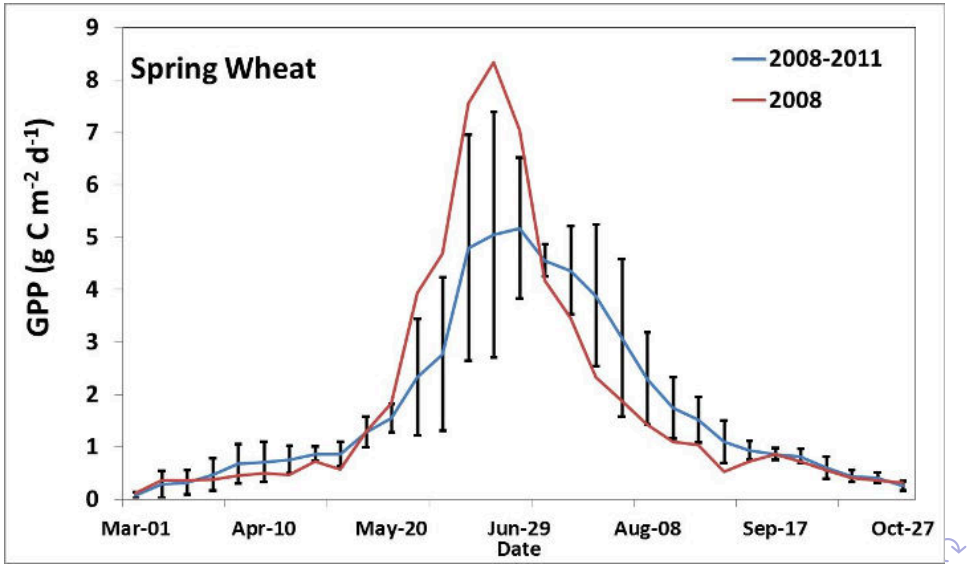
Remote Sensing of agricultural activity

Crop productivity

Field Scale crop productivity







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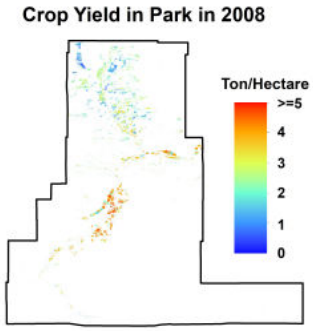
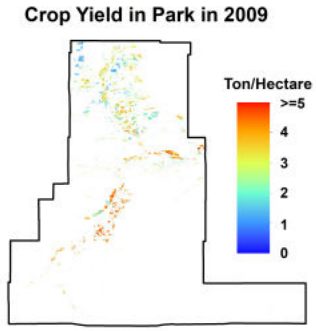
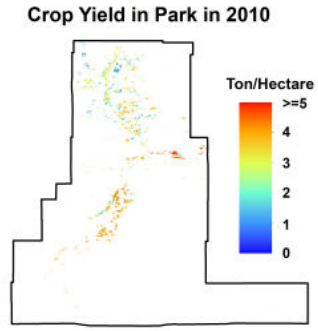
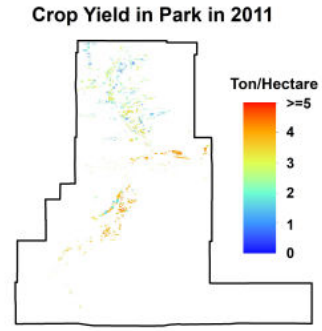
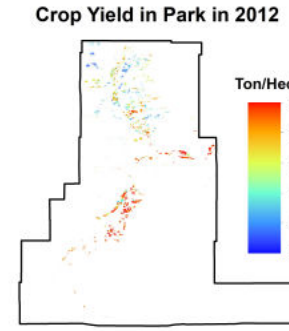
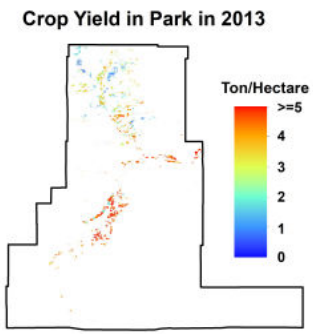


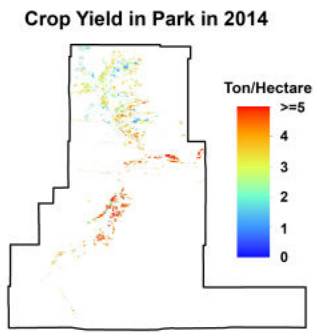


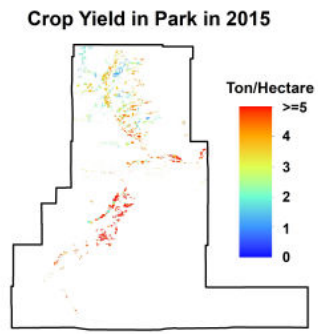


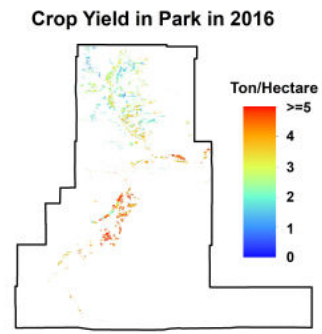


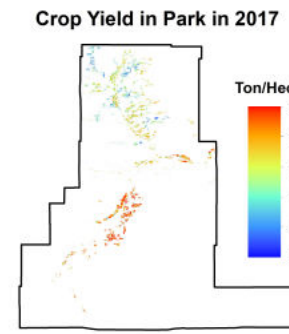






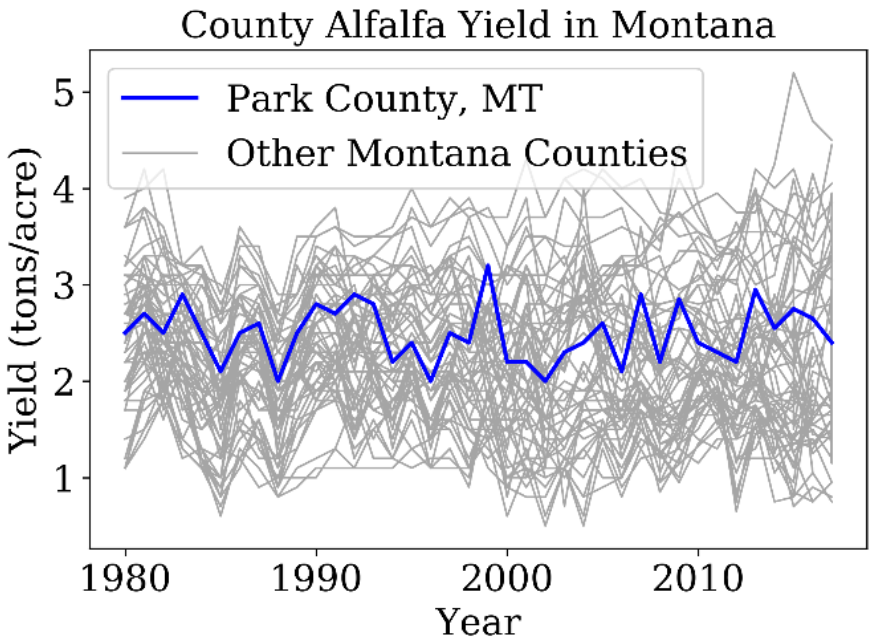


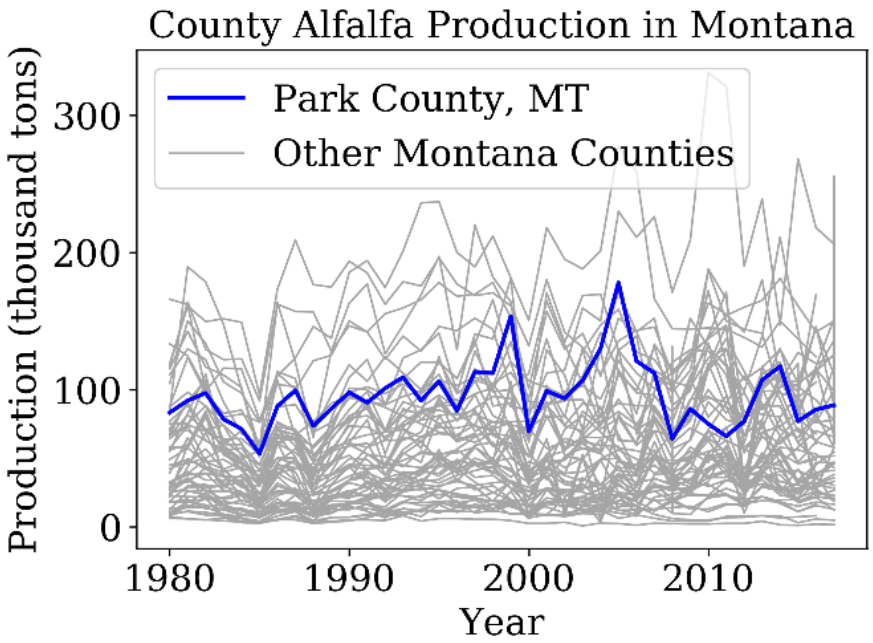




Crop productivity

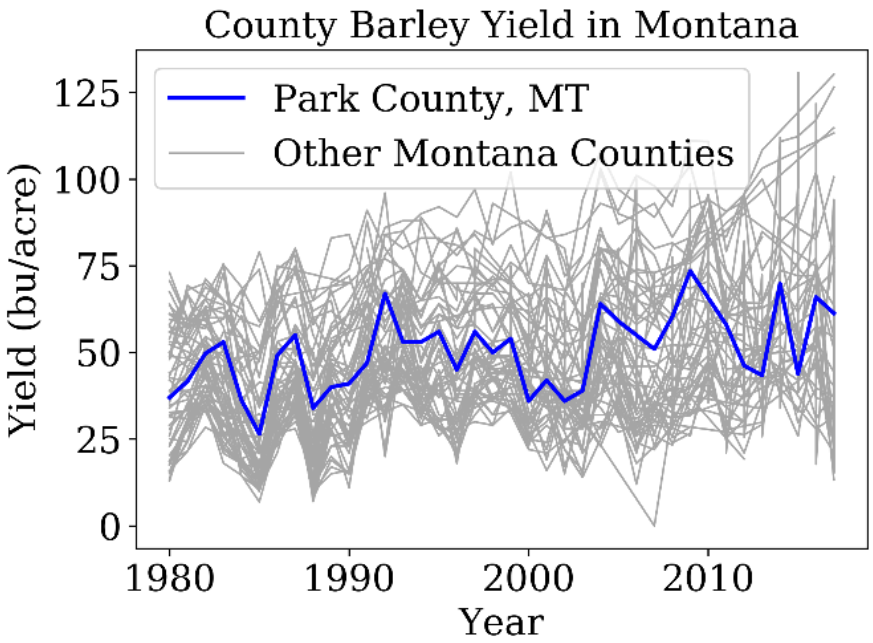
Alfalfa Hay

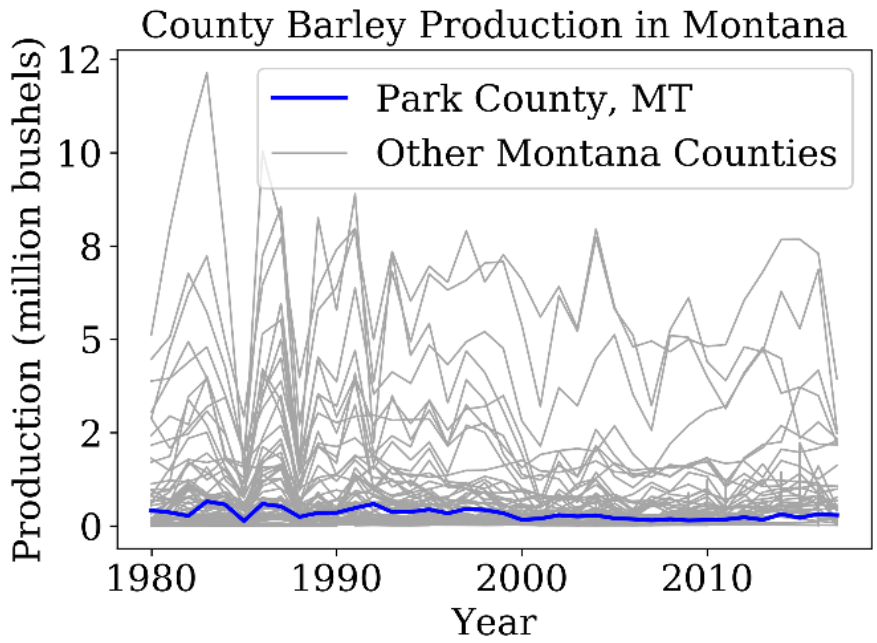




Crop productivity

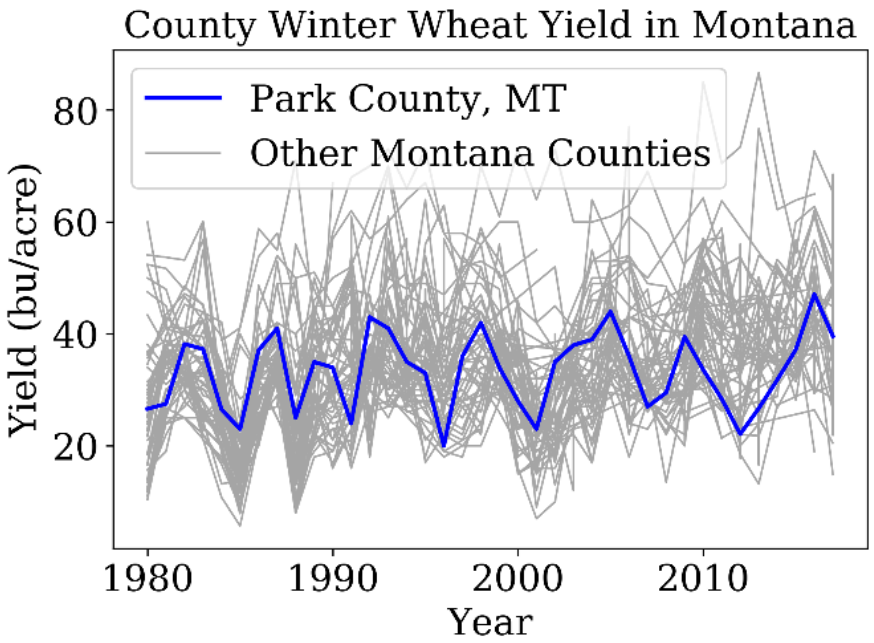
Barley

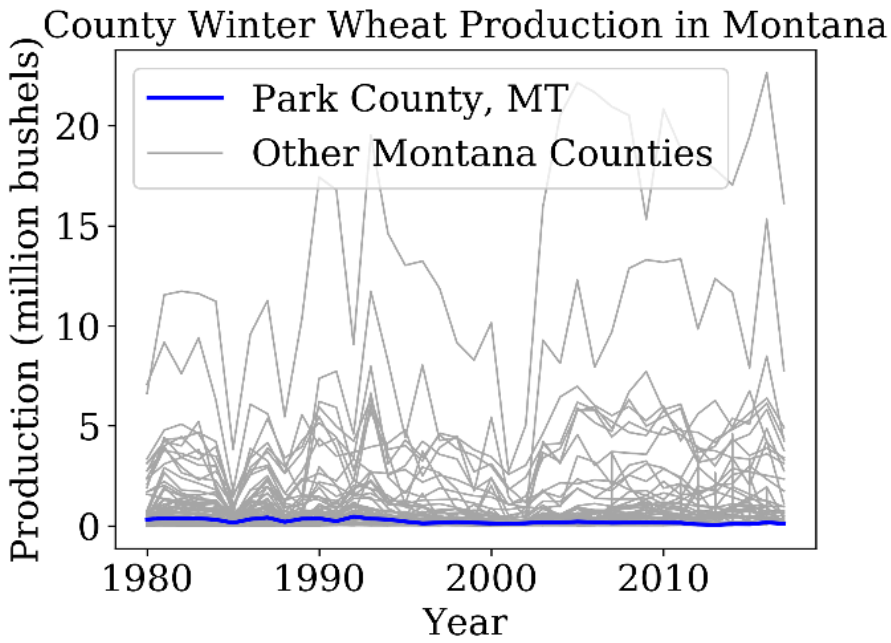




Crop productivity

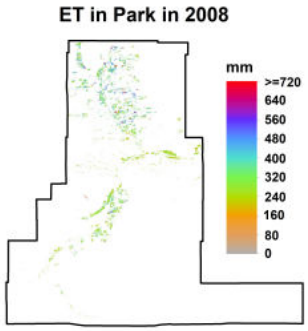
Winter Wheat

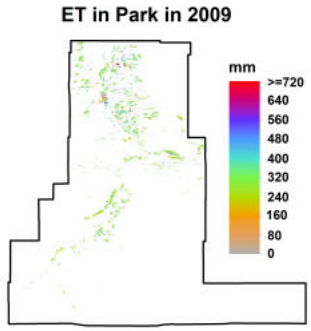


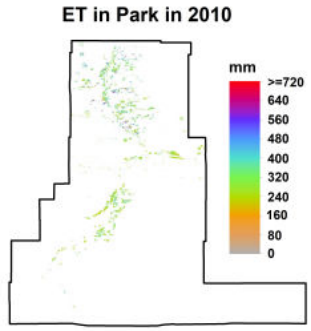


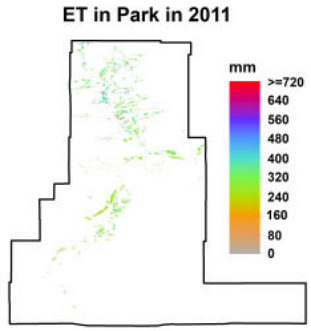
Remote Sensing of agricultural activity

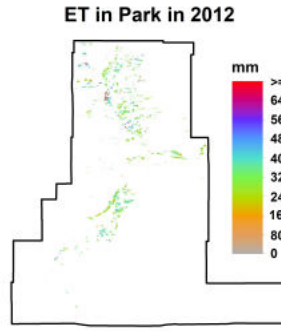
Crop water use

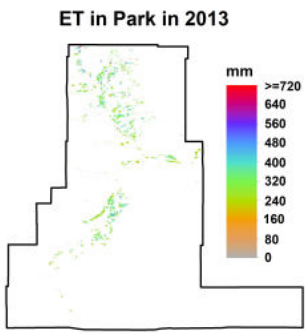


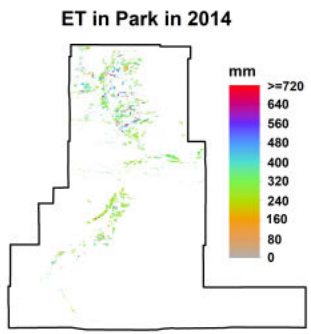


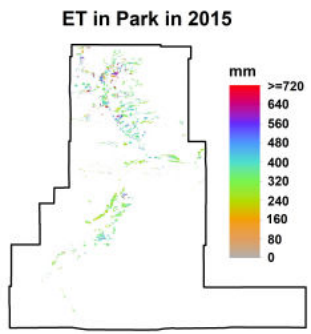


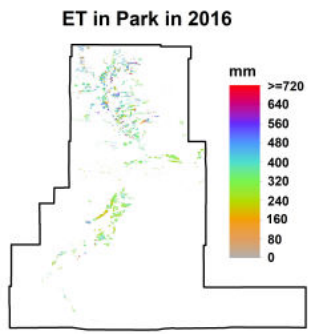


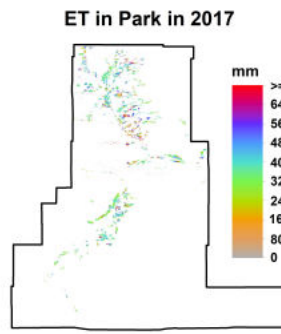






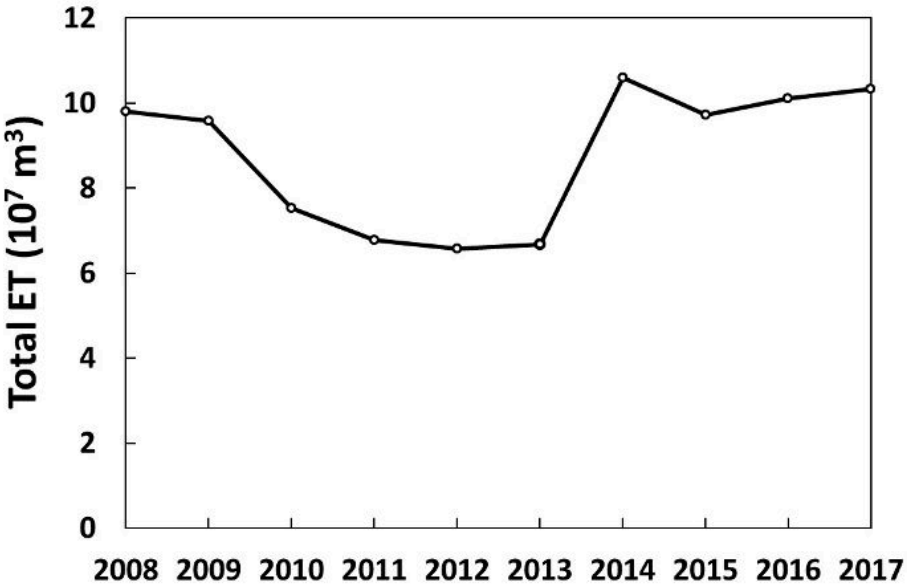


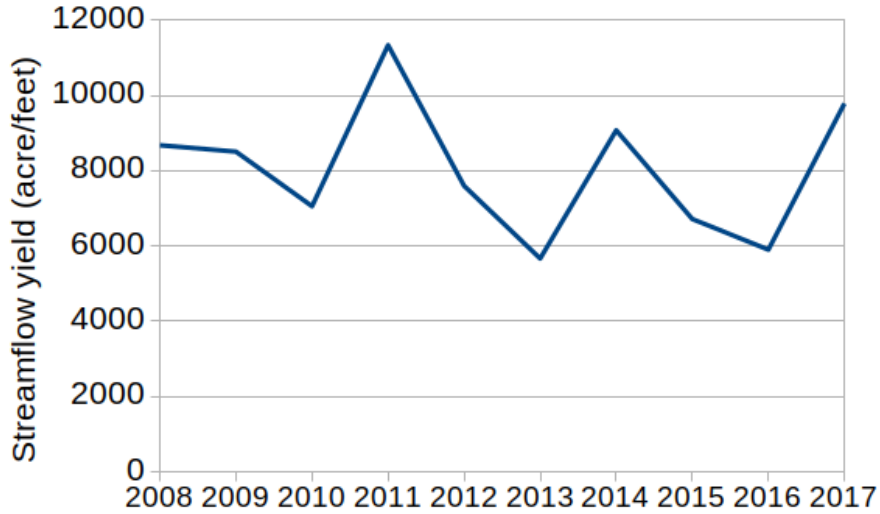




Agricultural activity

Agricultural efficiency

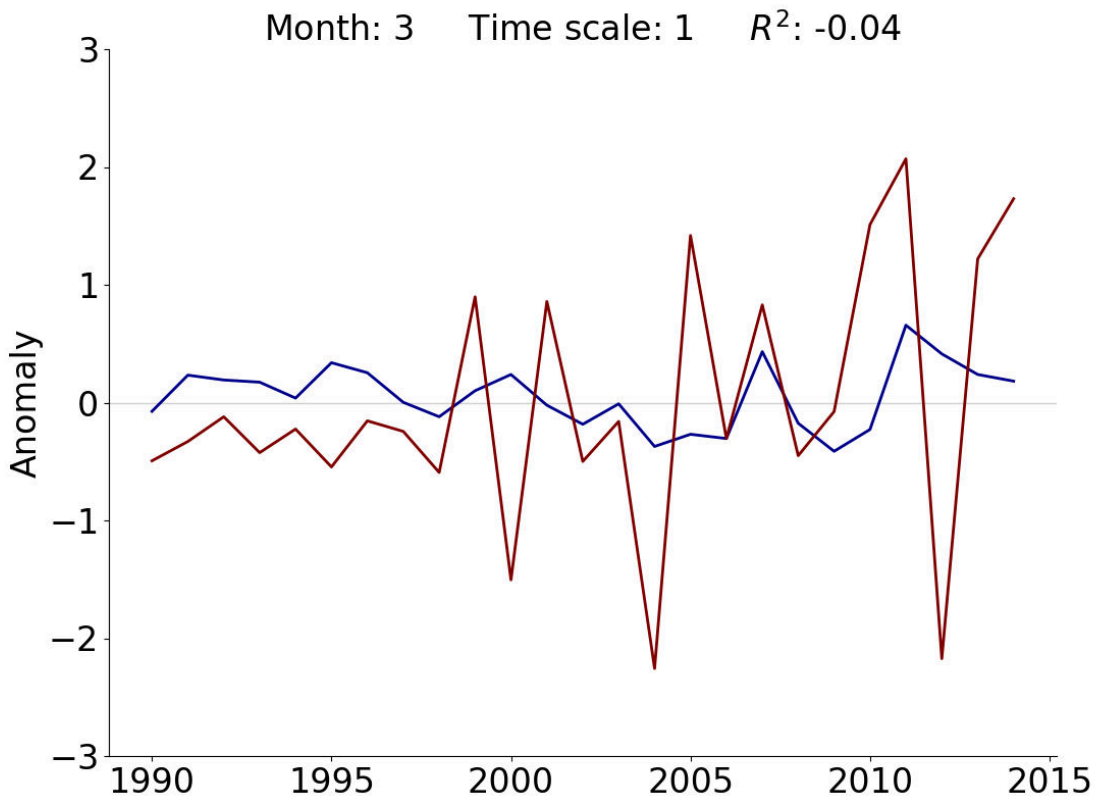




- Agricultural appropriation of total ET (natural + irrigation) between 89,000ac/ft and 56,700 ac/ft
- Average annual precipitation volume over cropland 122,000 ac/ft
- Average annual streamflow volume (8,000 acre/feet)

Production anomalies and drought

- How do precipitation and production anomalies correlate?
- Which month and at what time-scales do precipitation anomalies explain production the most?



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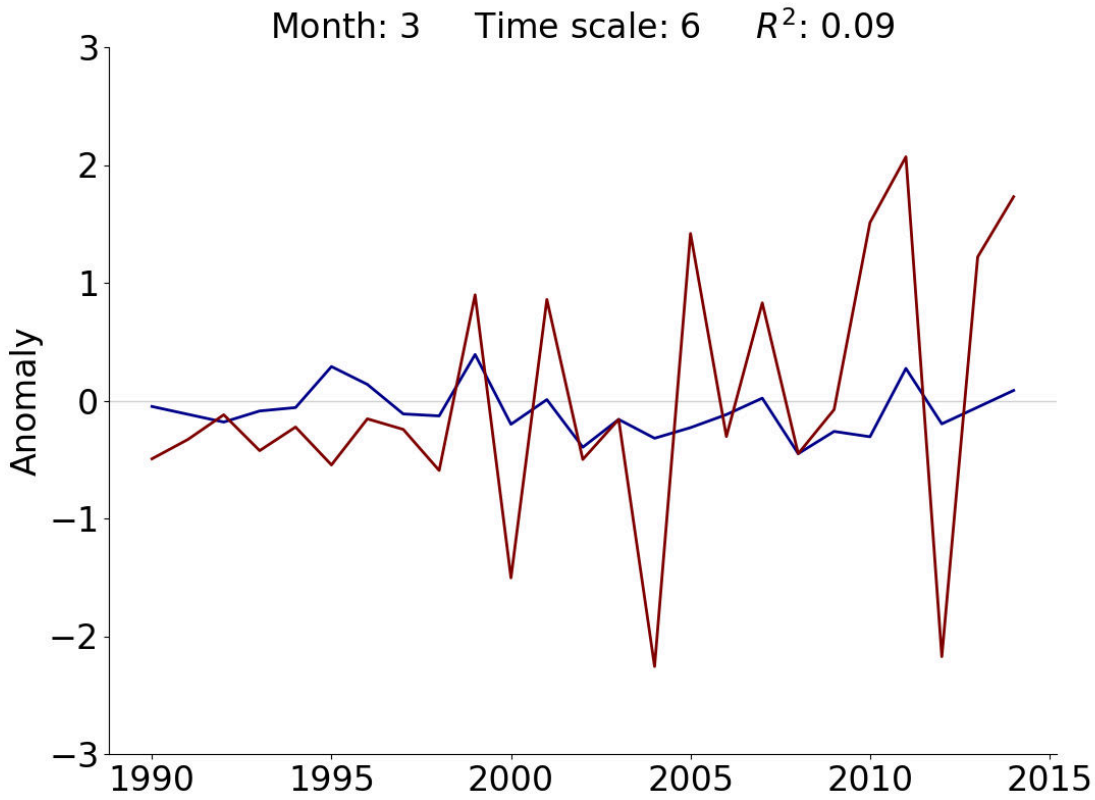

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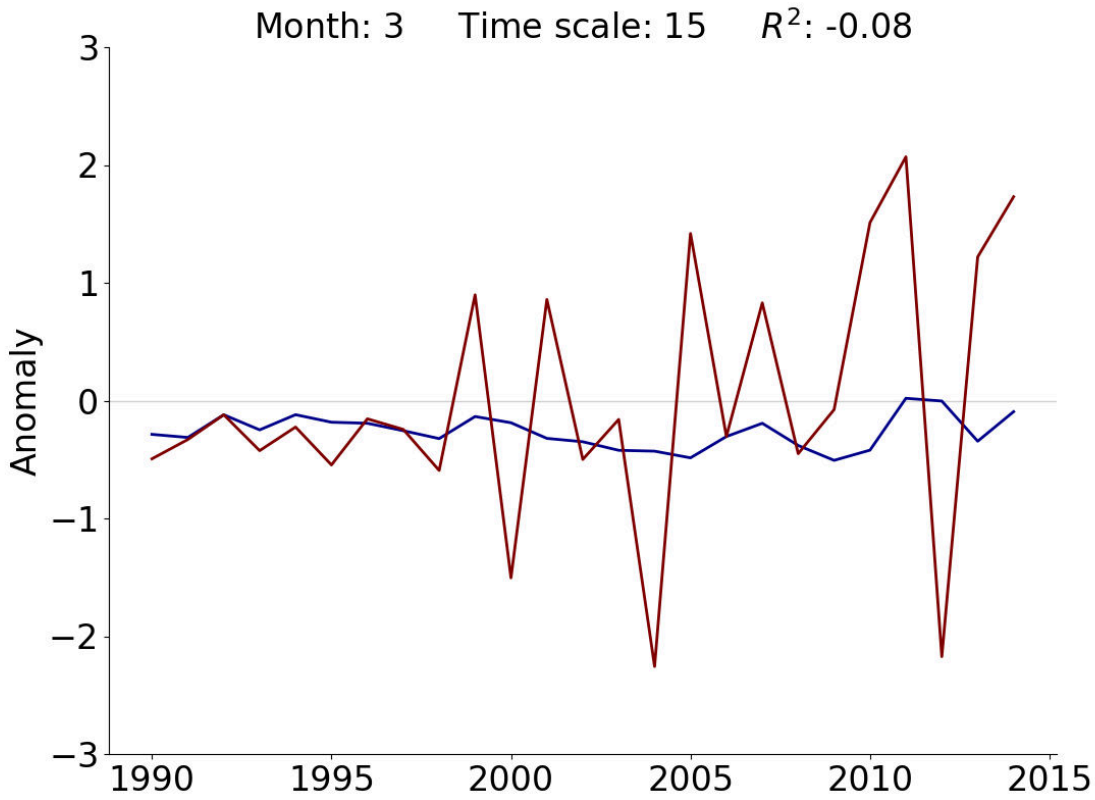

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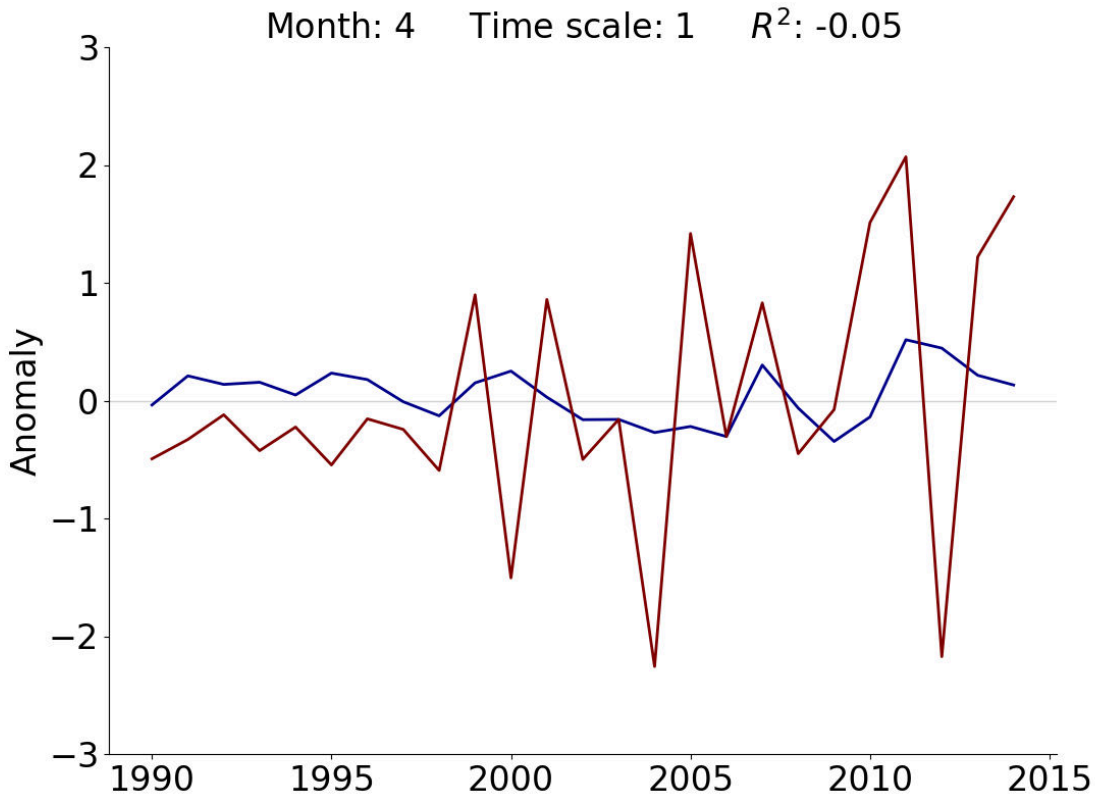

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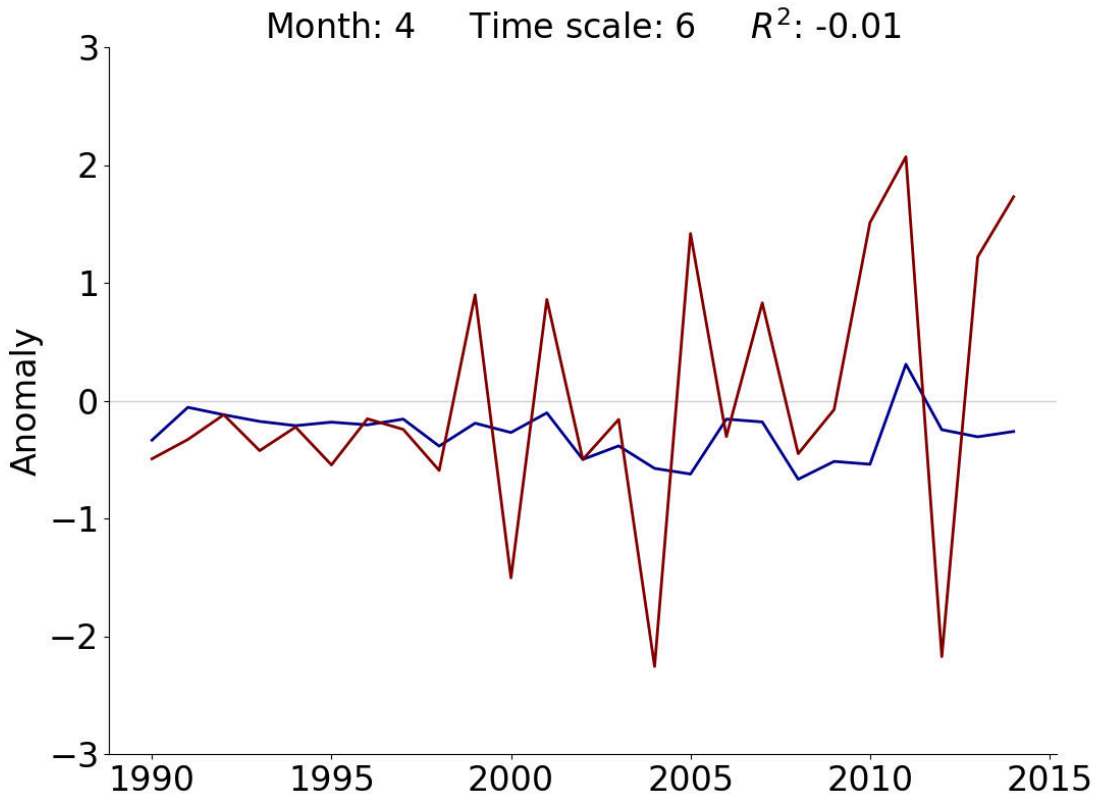

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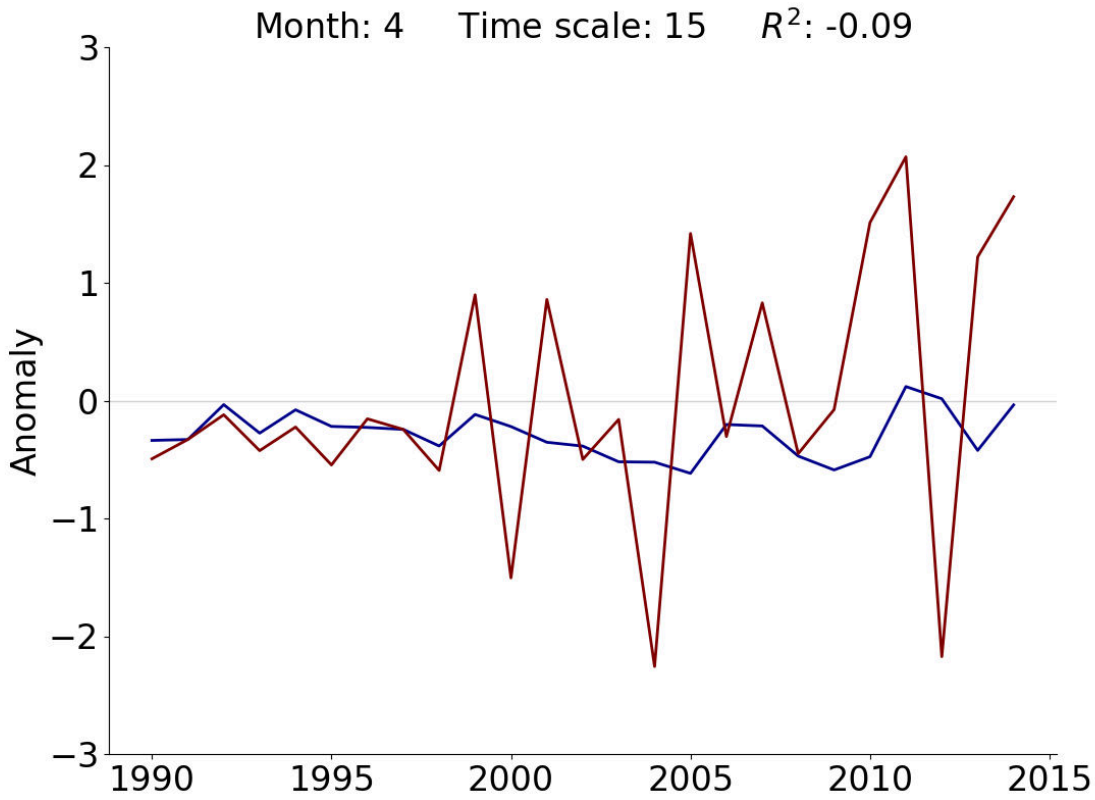

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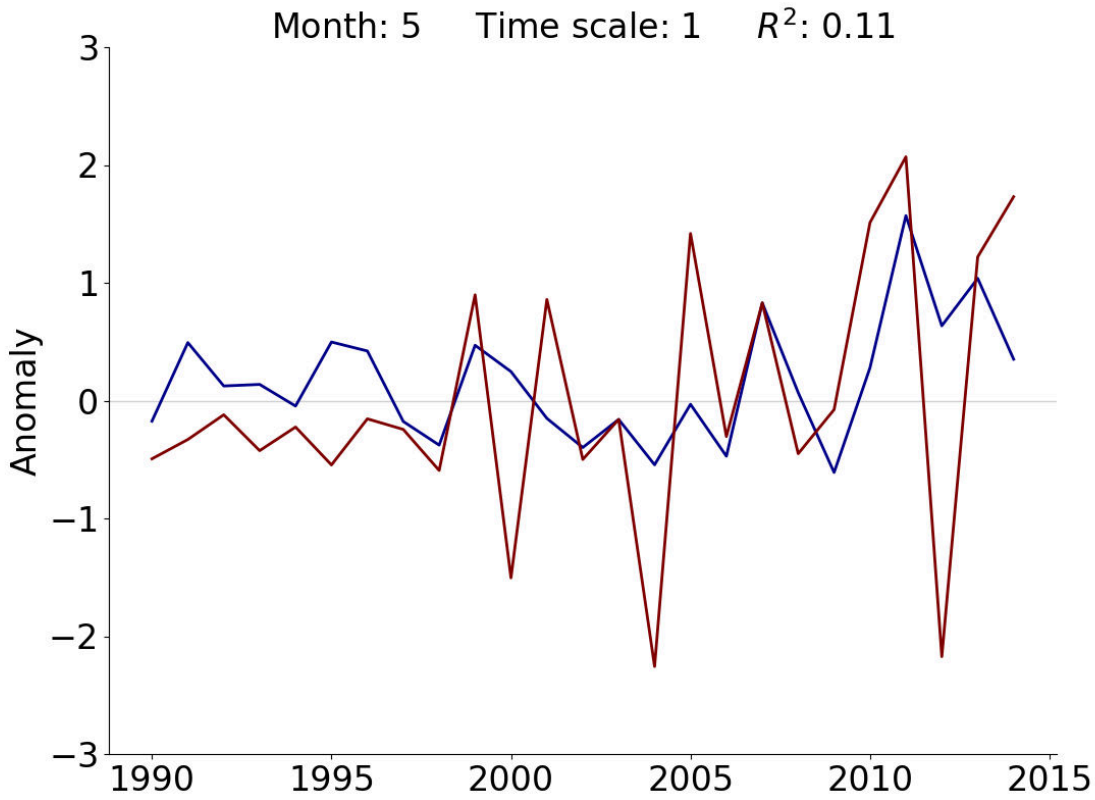

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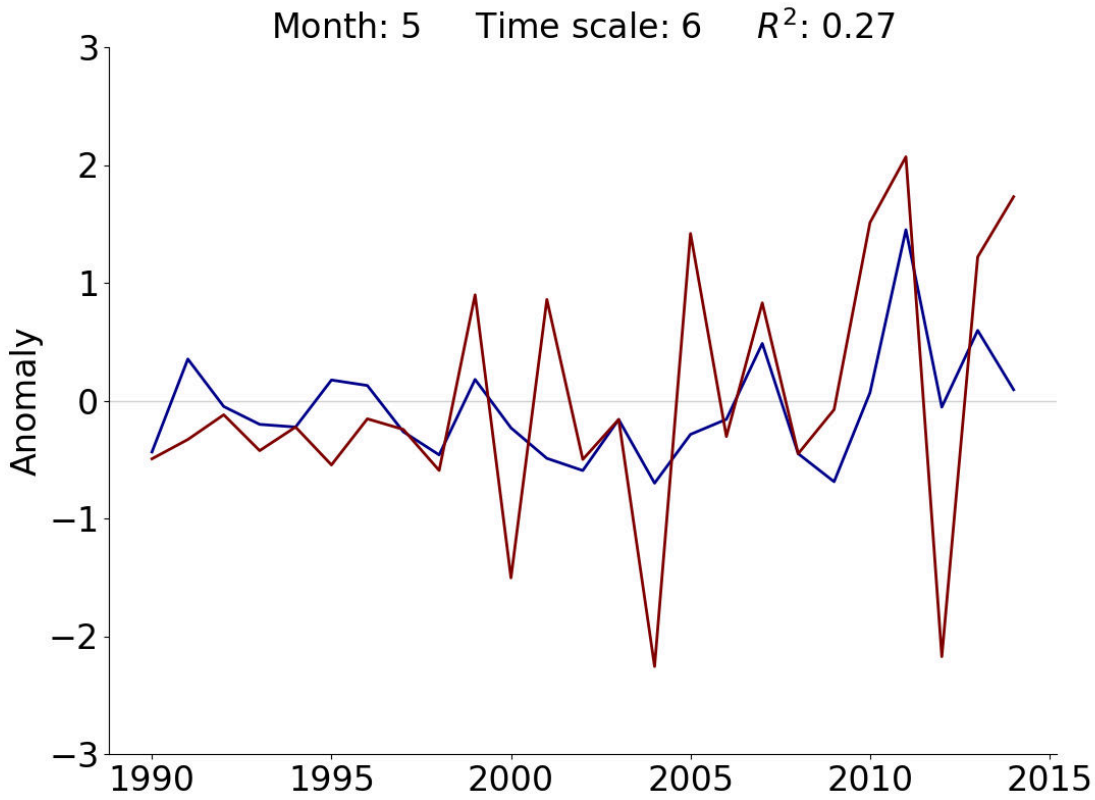

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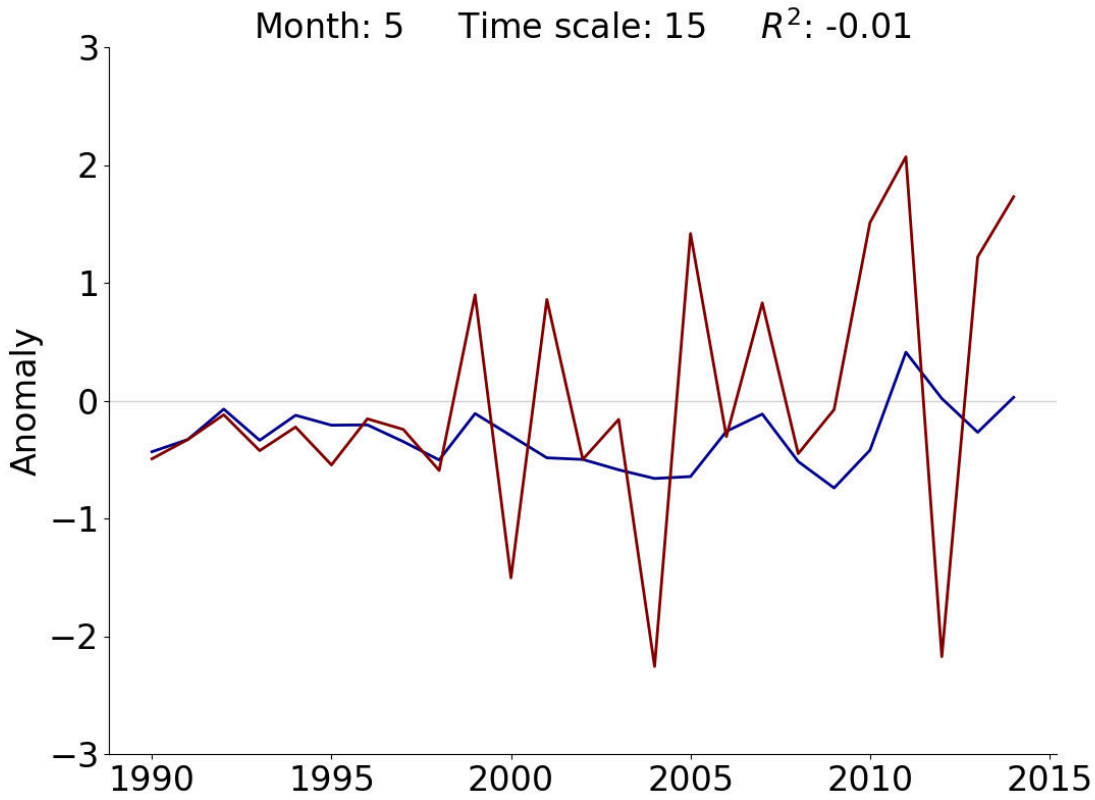

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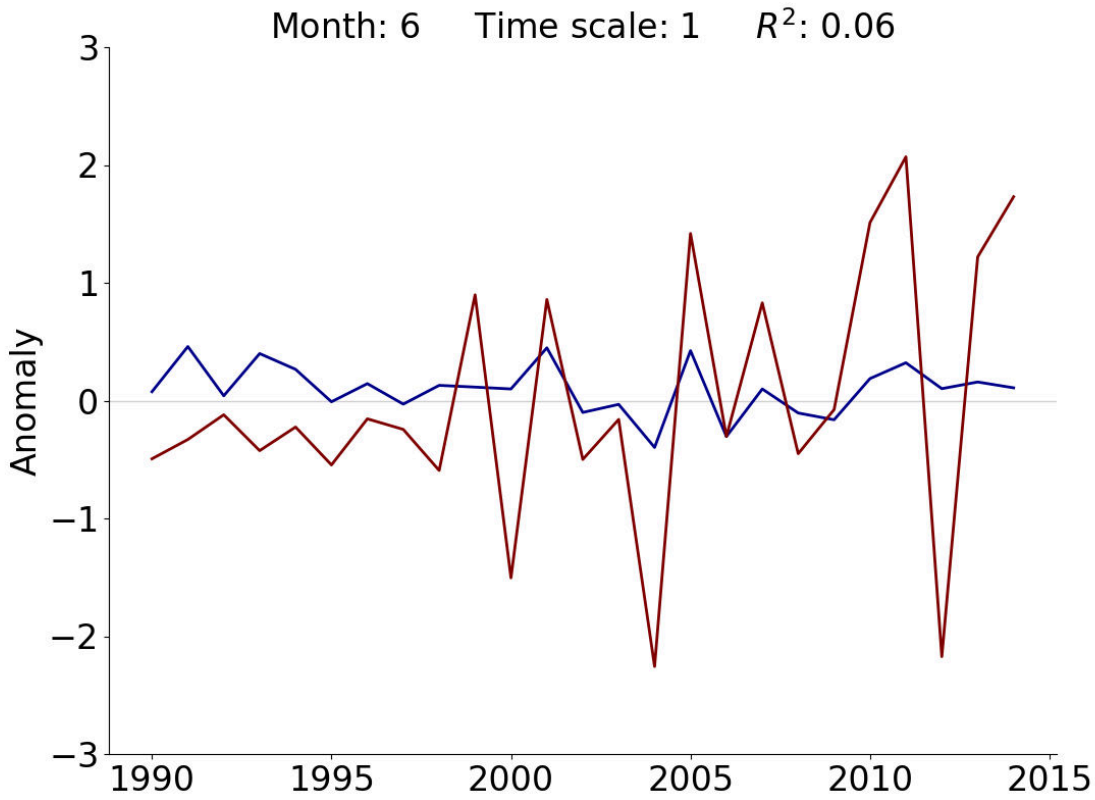

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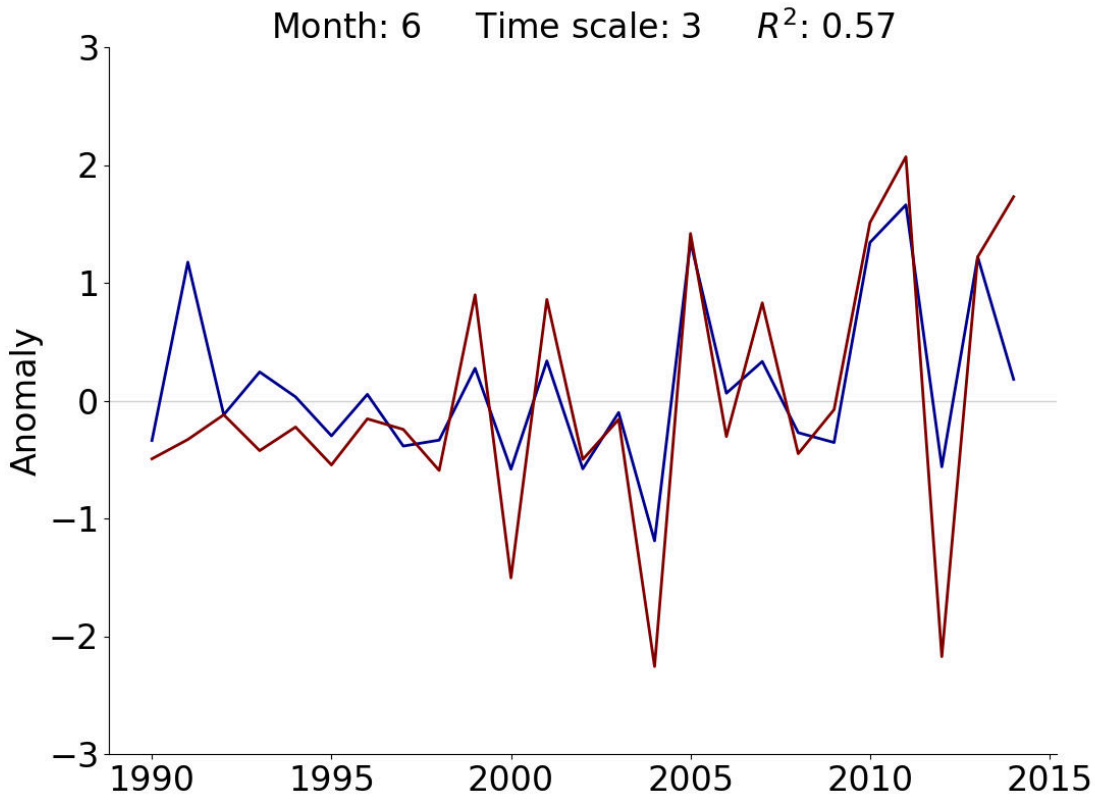

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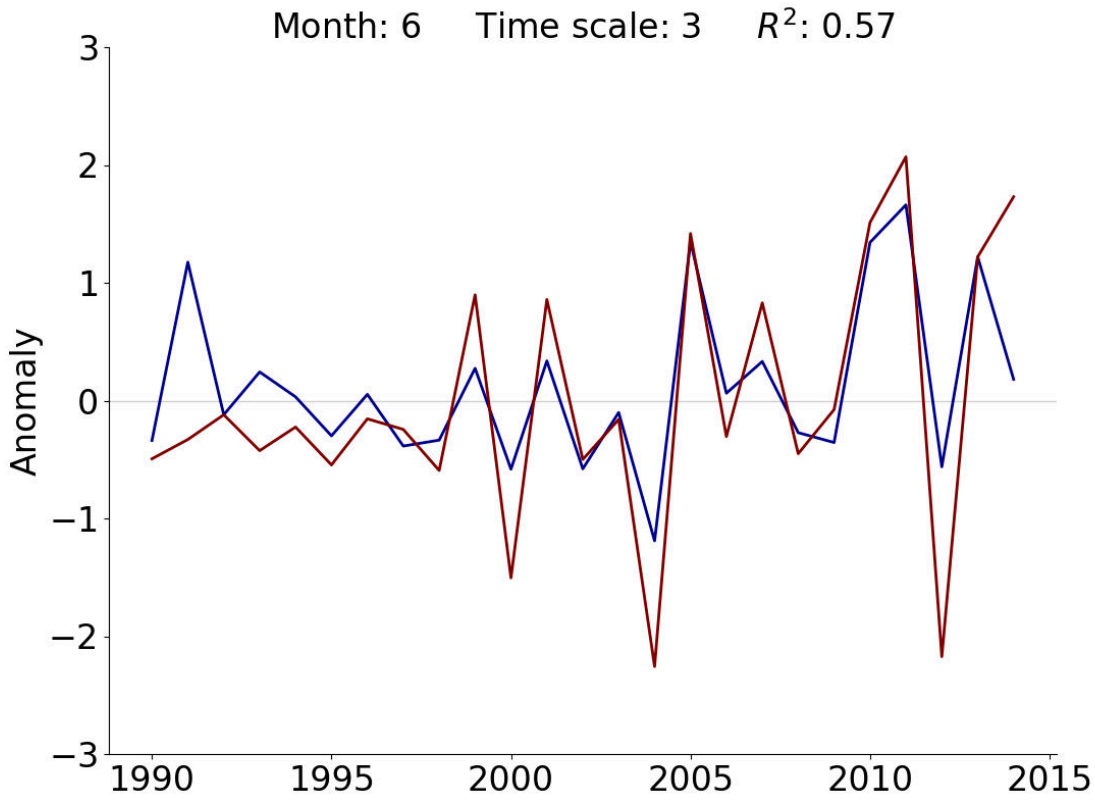

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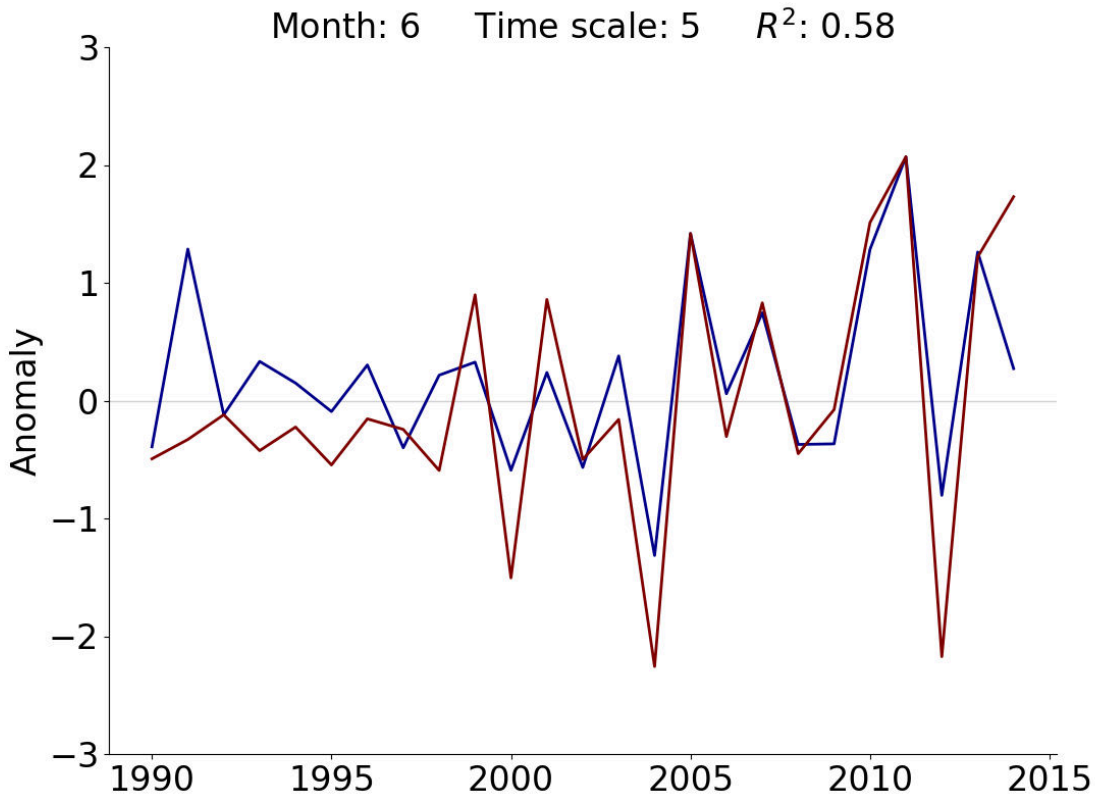

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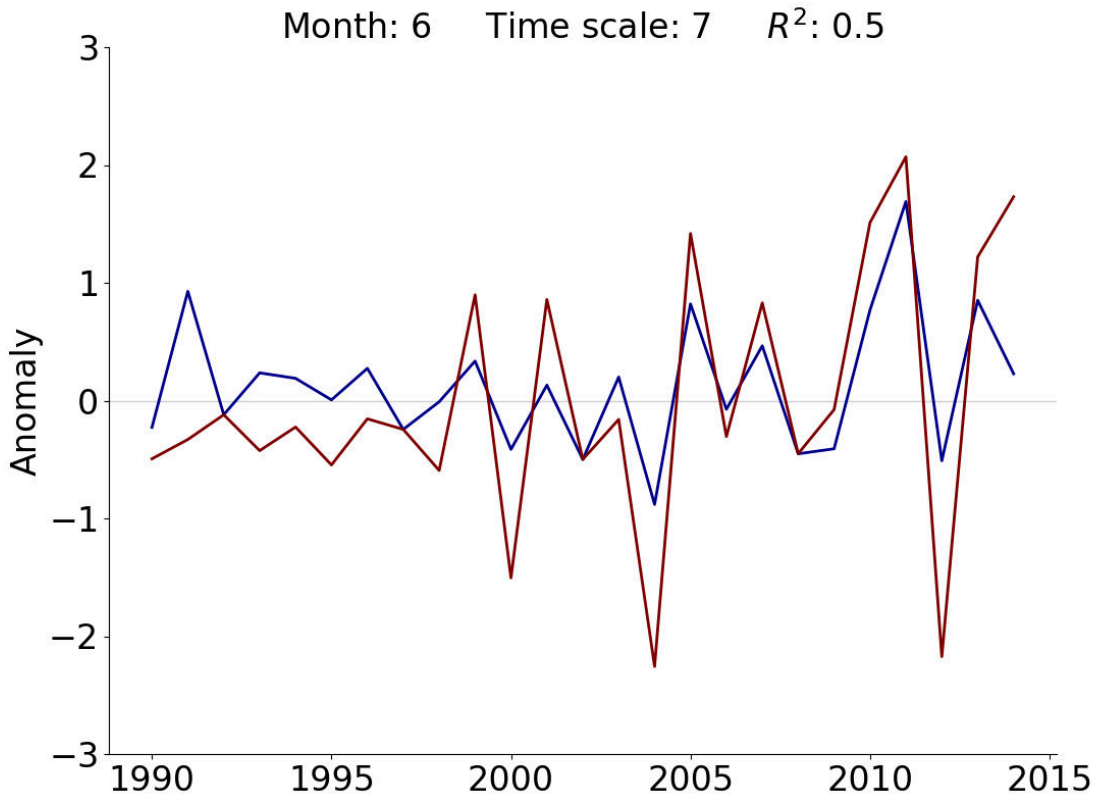

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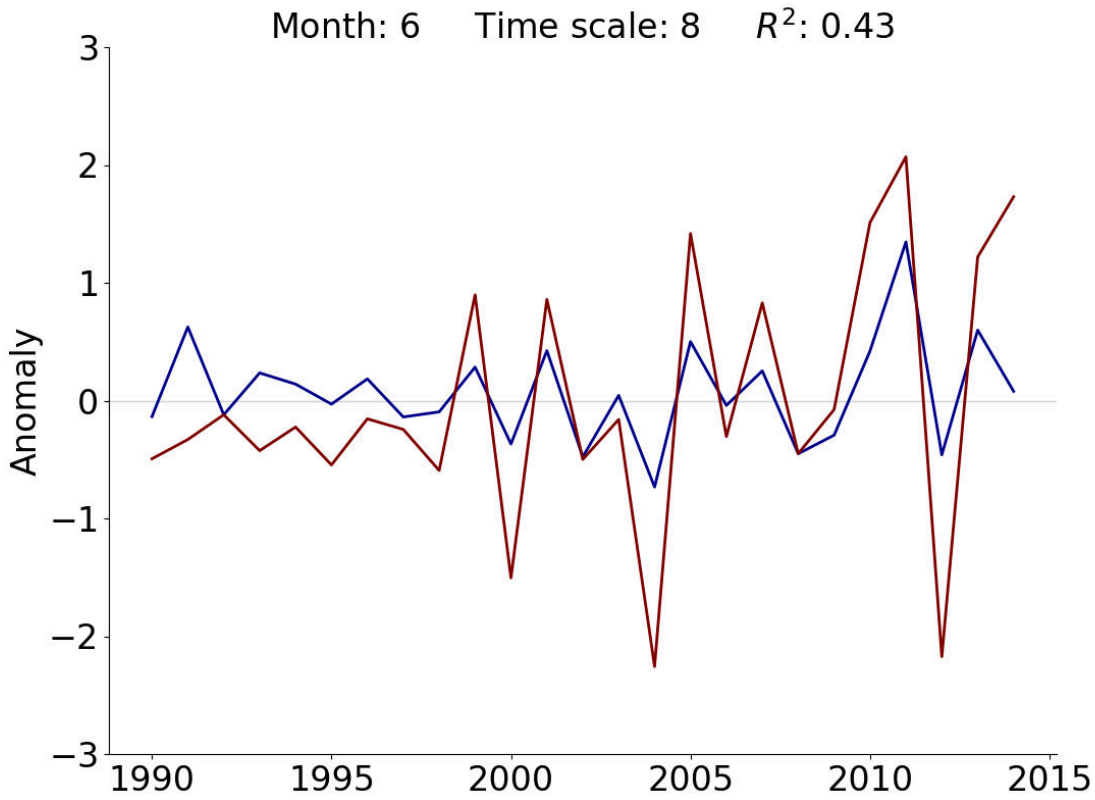

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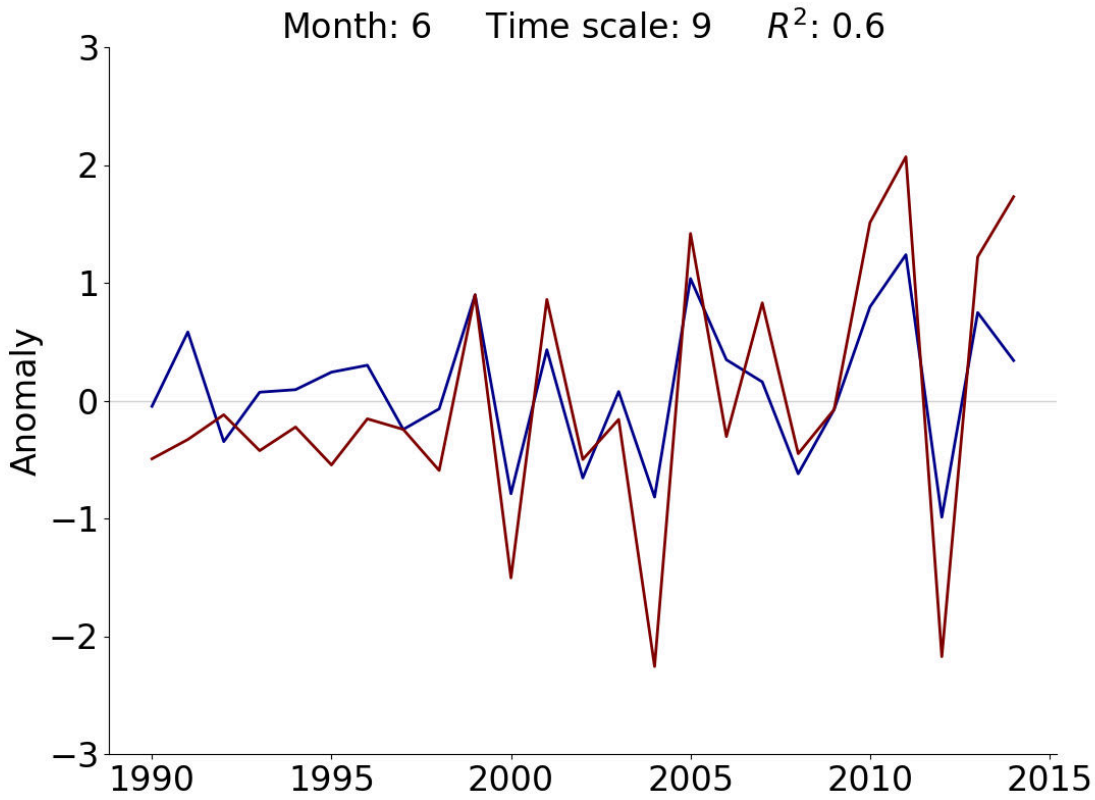

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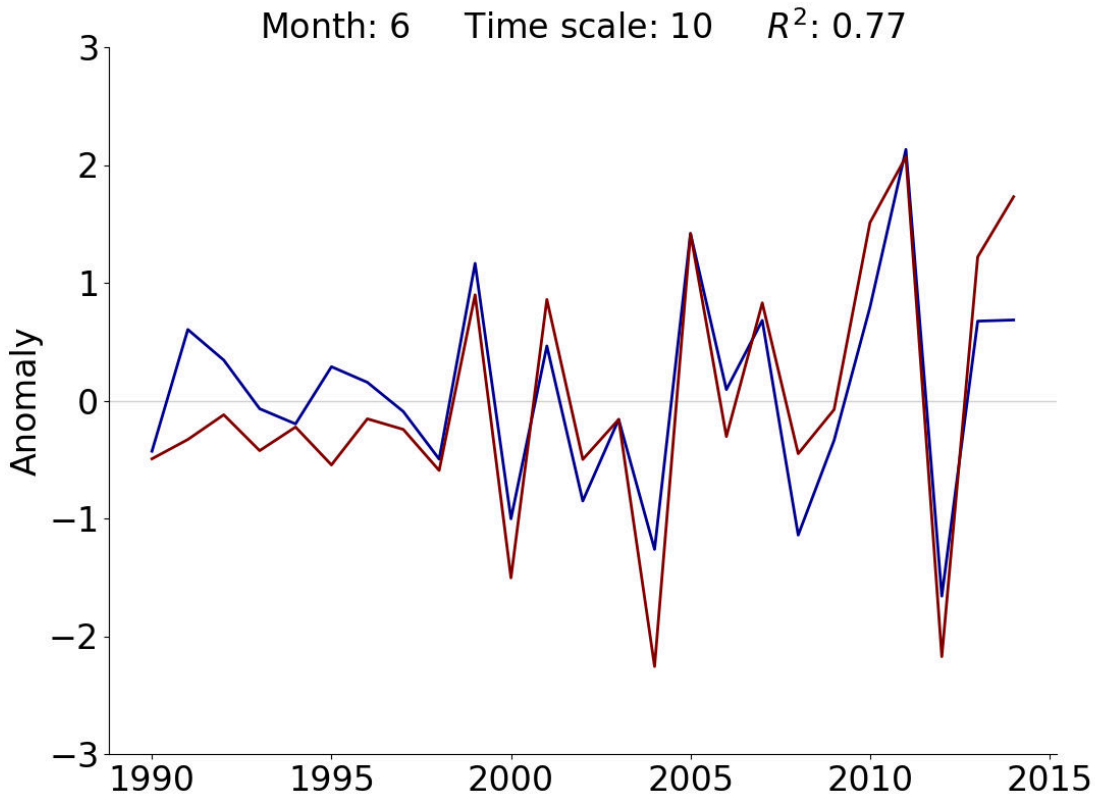

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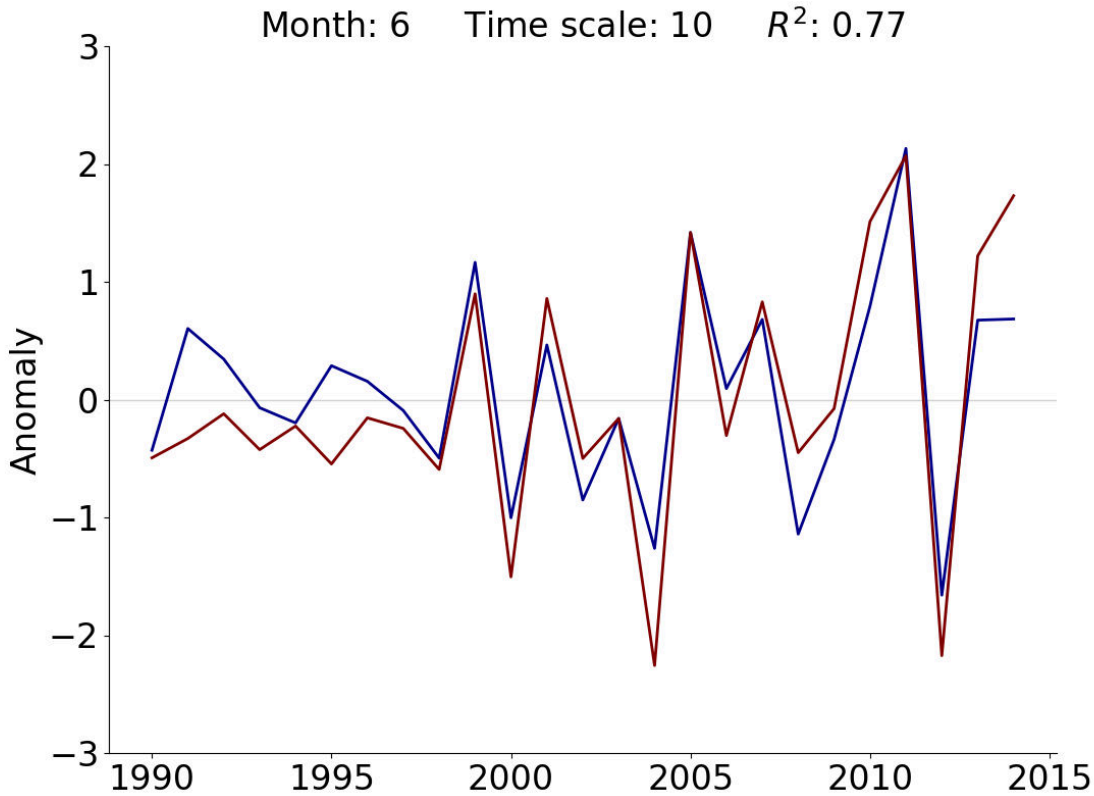
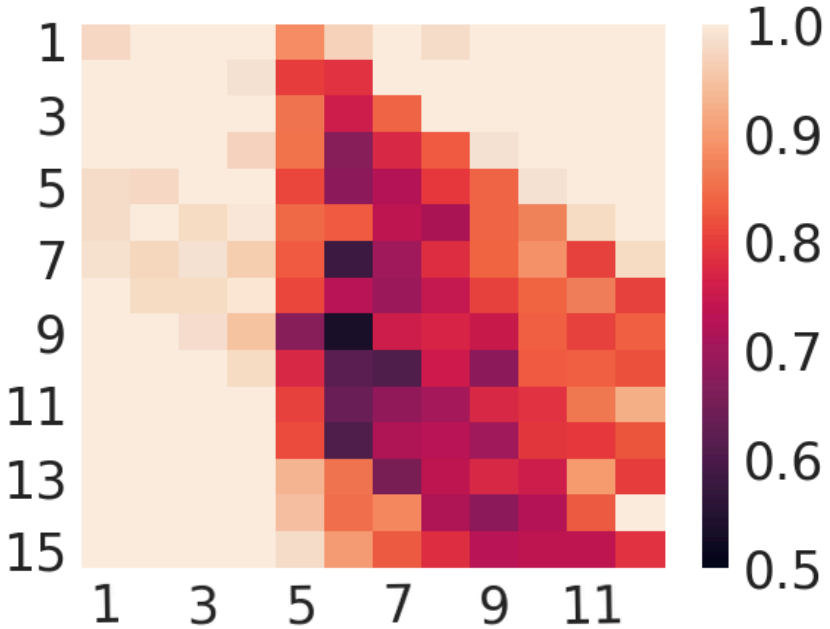


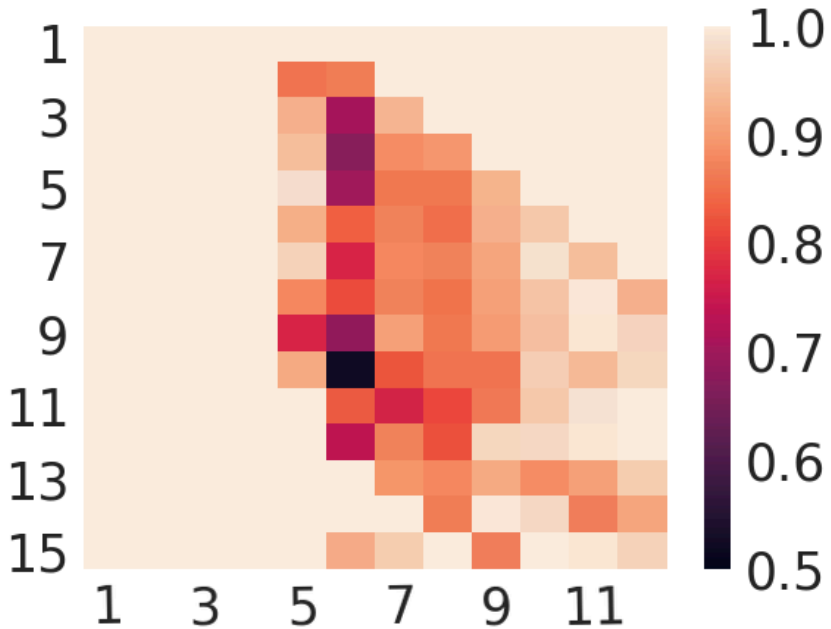
Sensitivity of Agricultural production to drought

Alfalfa at the county-scale

Powder River County, MT

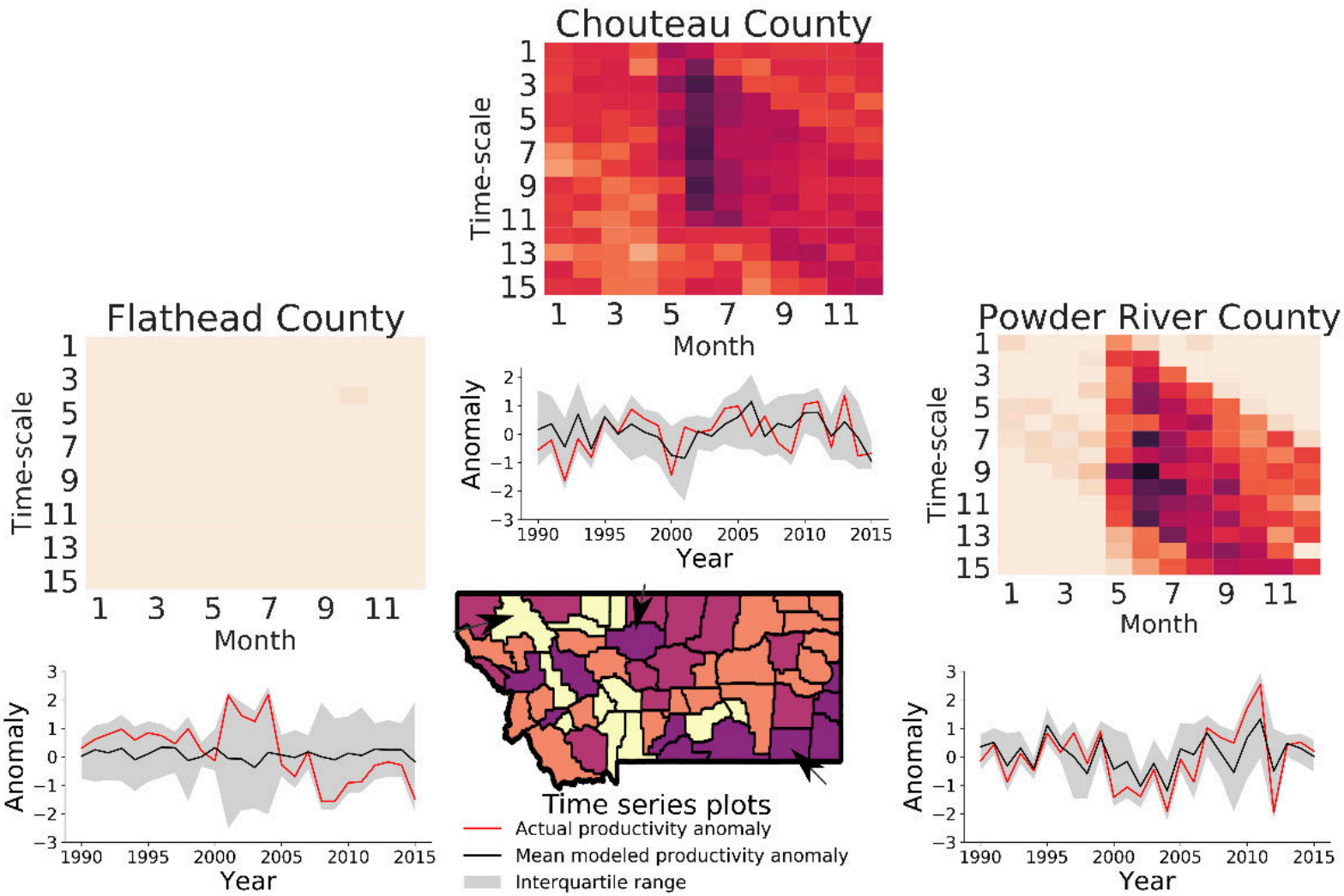


Wibaux County, MT



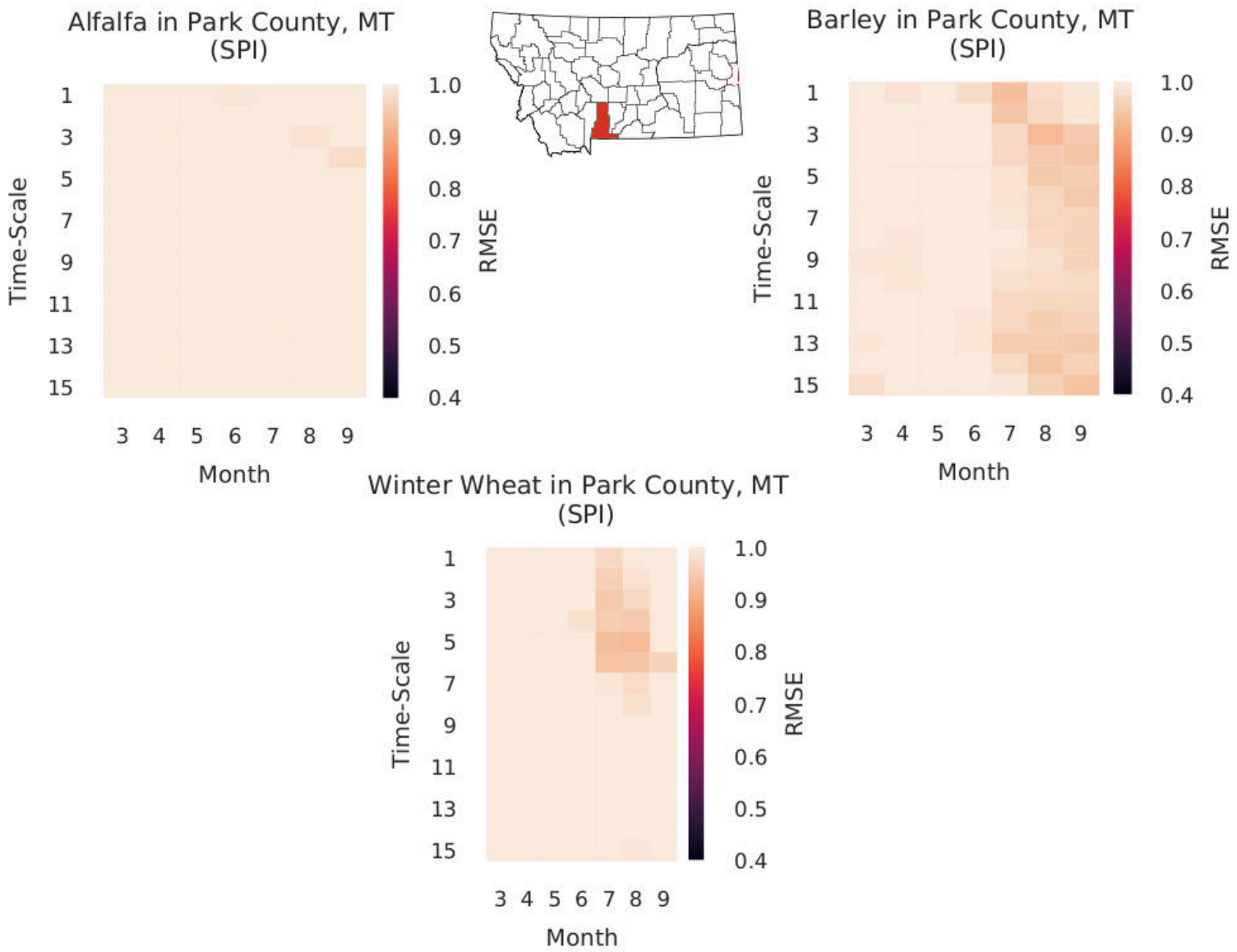
Sensitivity of Agricultural production to drought

County scale sensitivity alfalfa



Sensitivity of Agricultural production to drought

Park County



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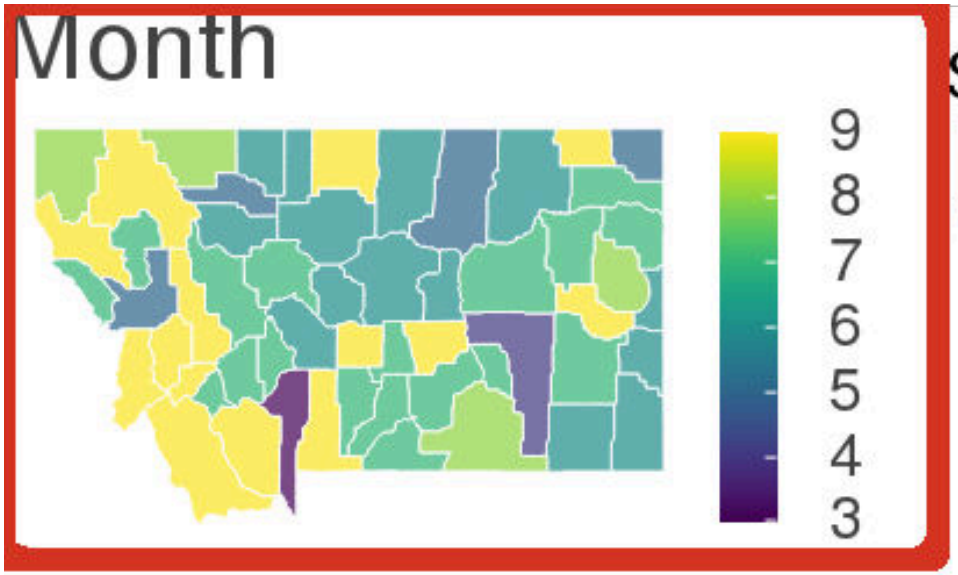

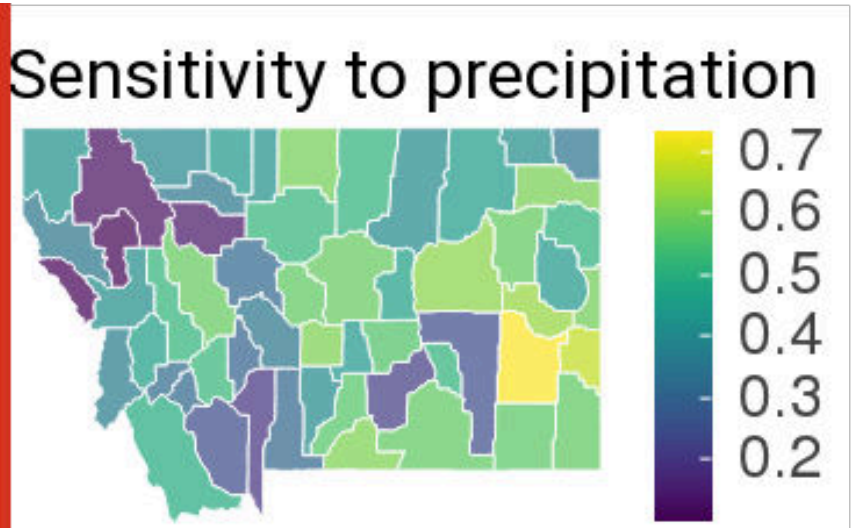

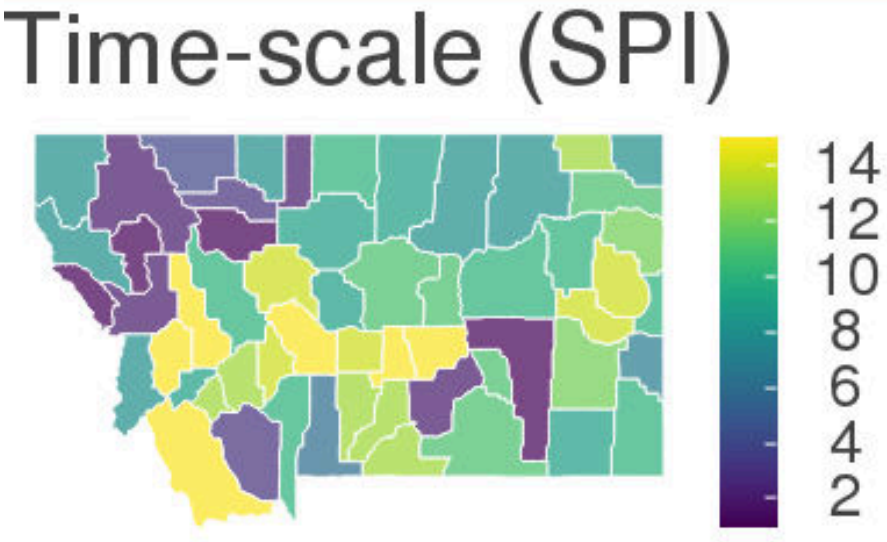

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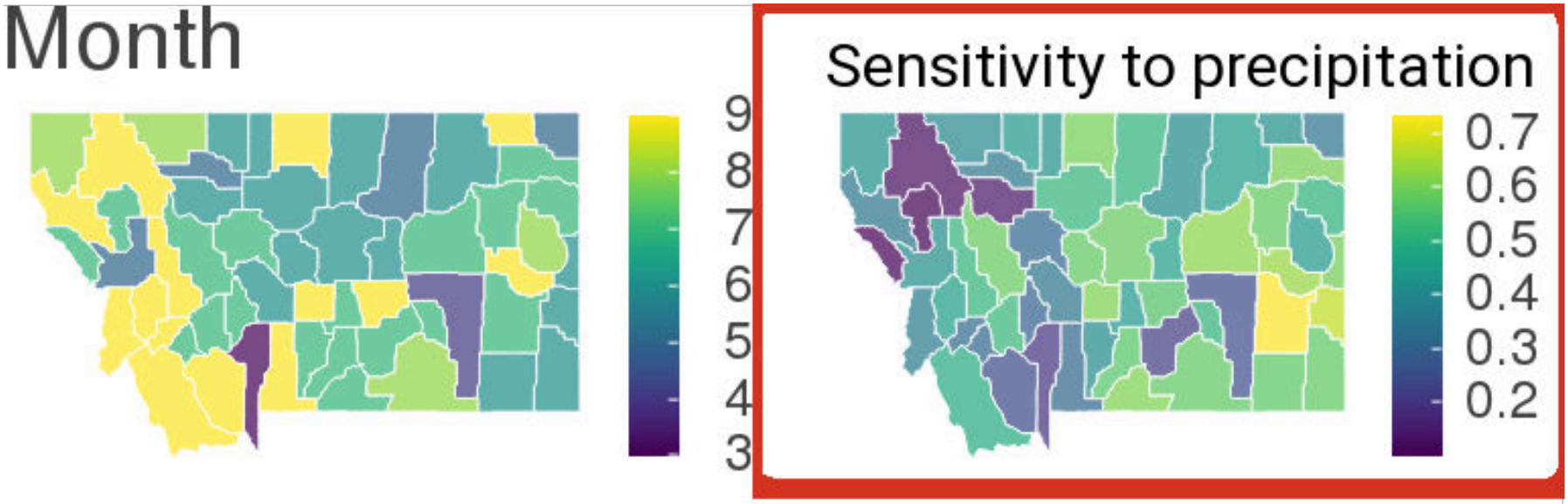

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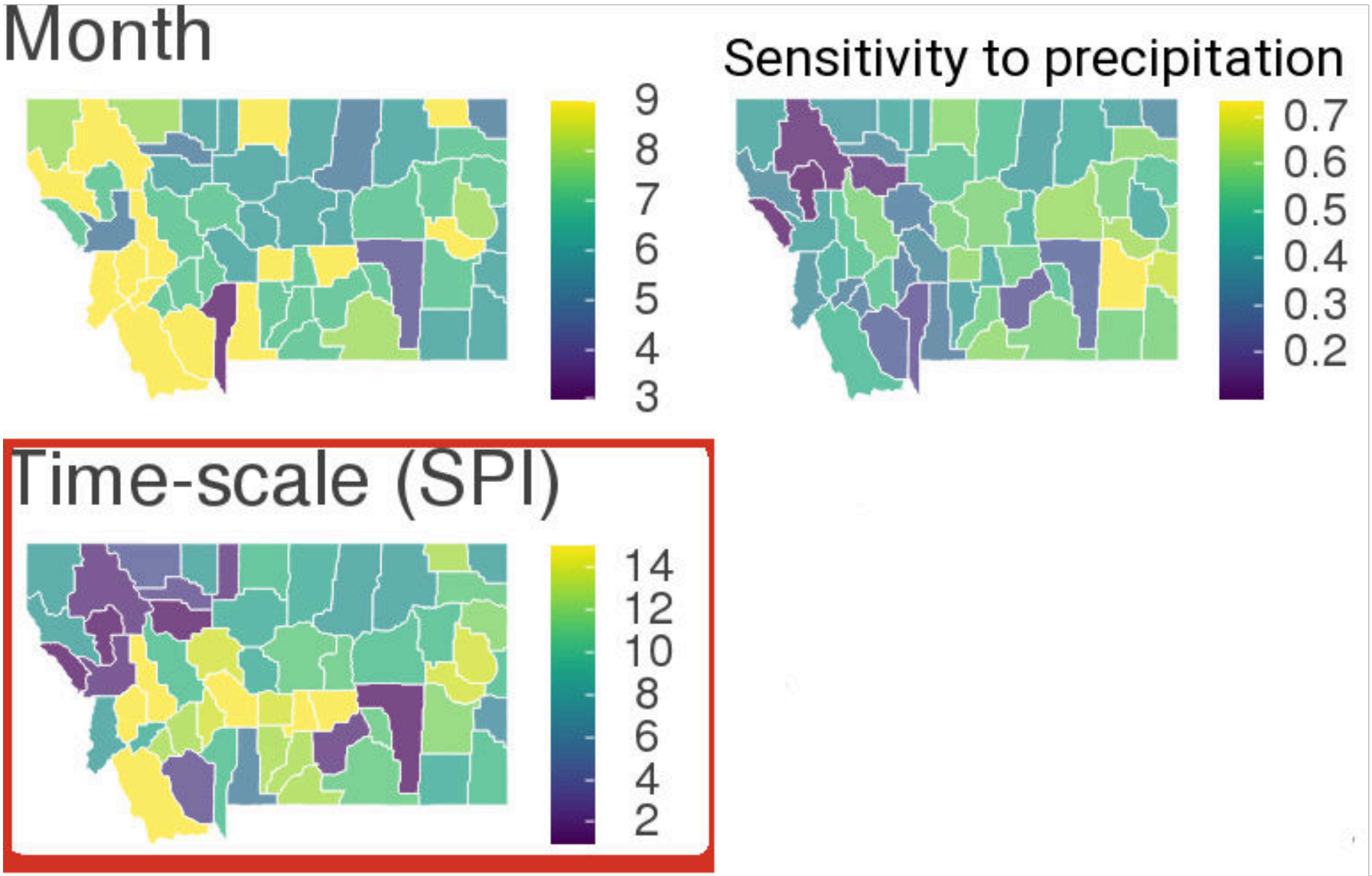

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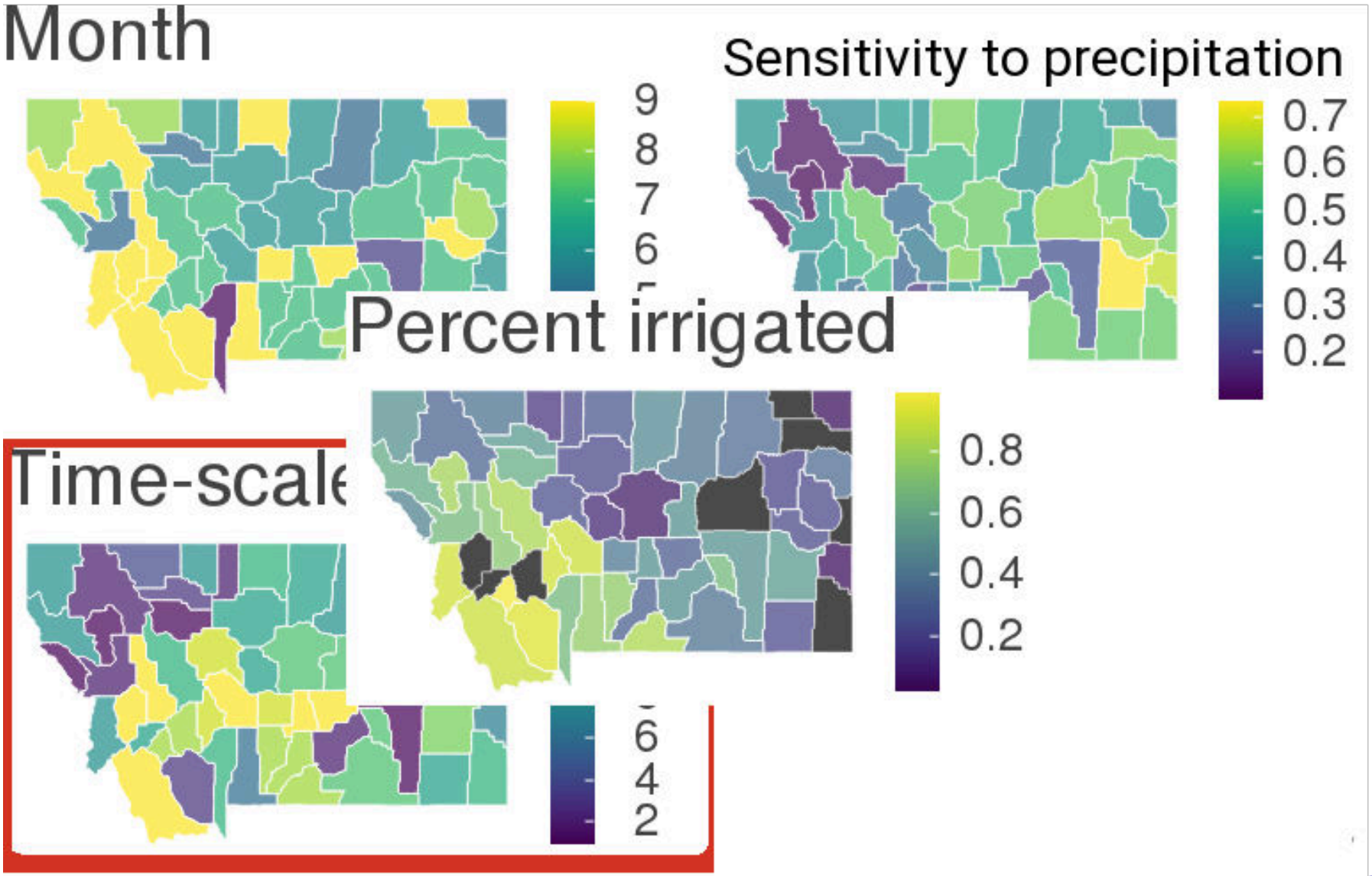

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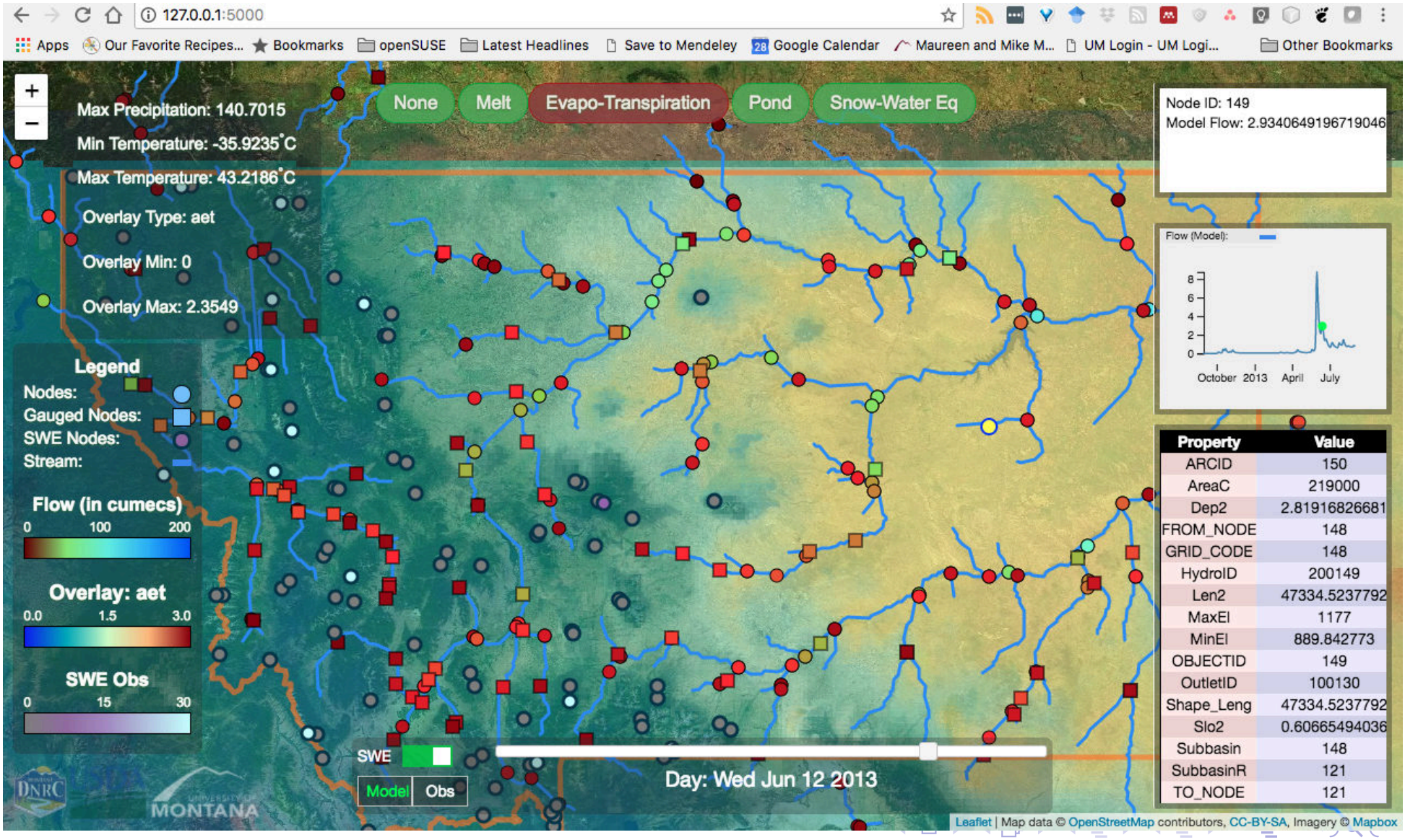
- Irrigation is prevalent, which detaches ag from climate/weather cycles.

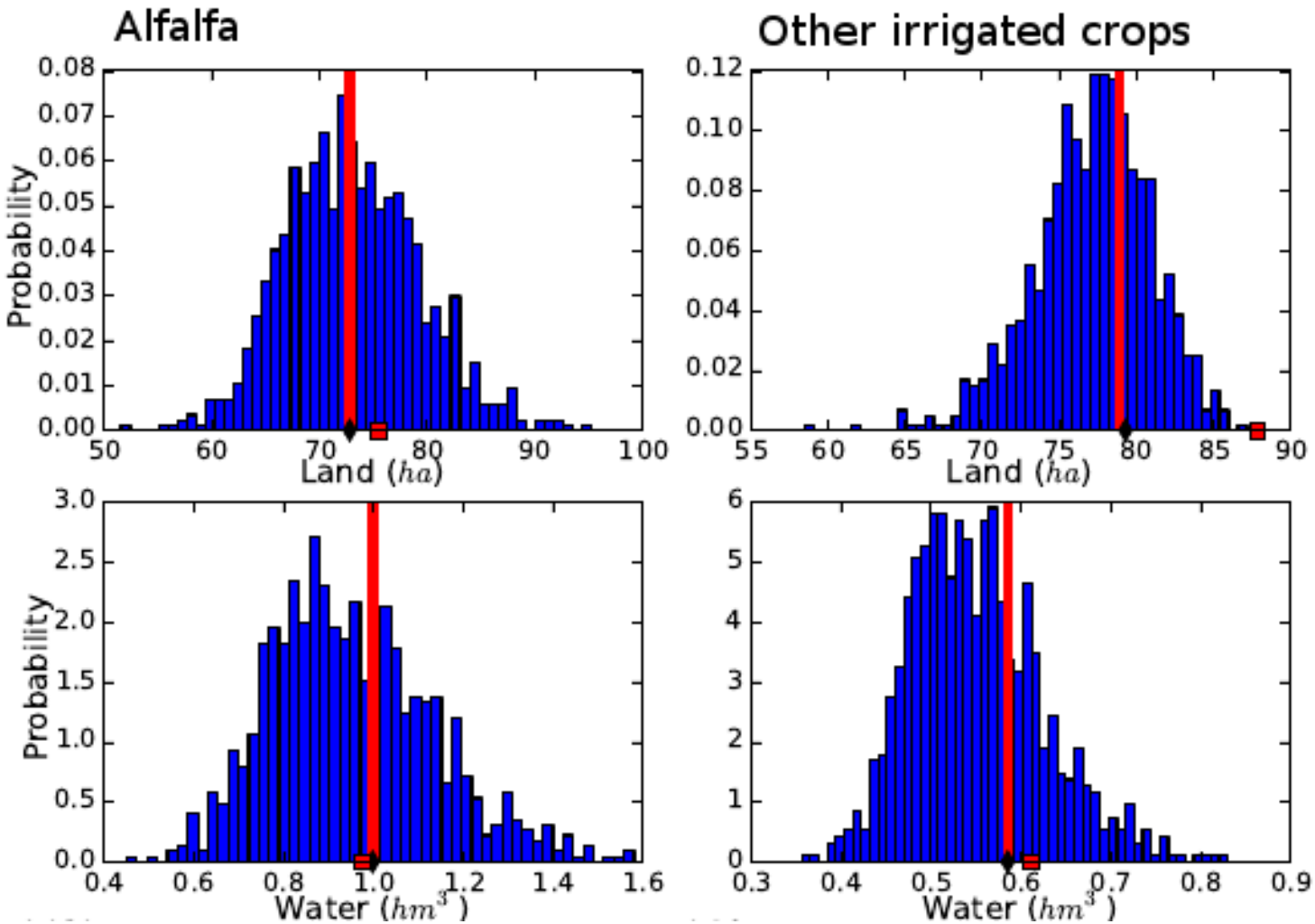
Thank You!

Water Use and Agricultural Productivity Simulator



Results

Reproduction of baseline observations



Results

Simulation of scenarios

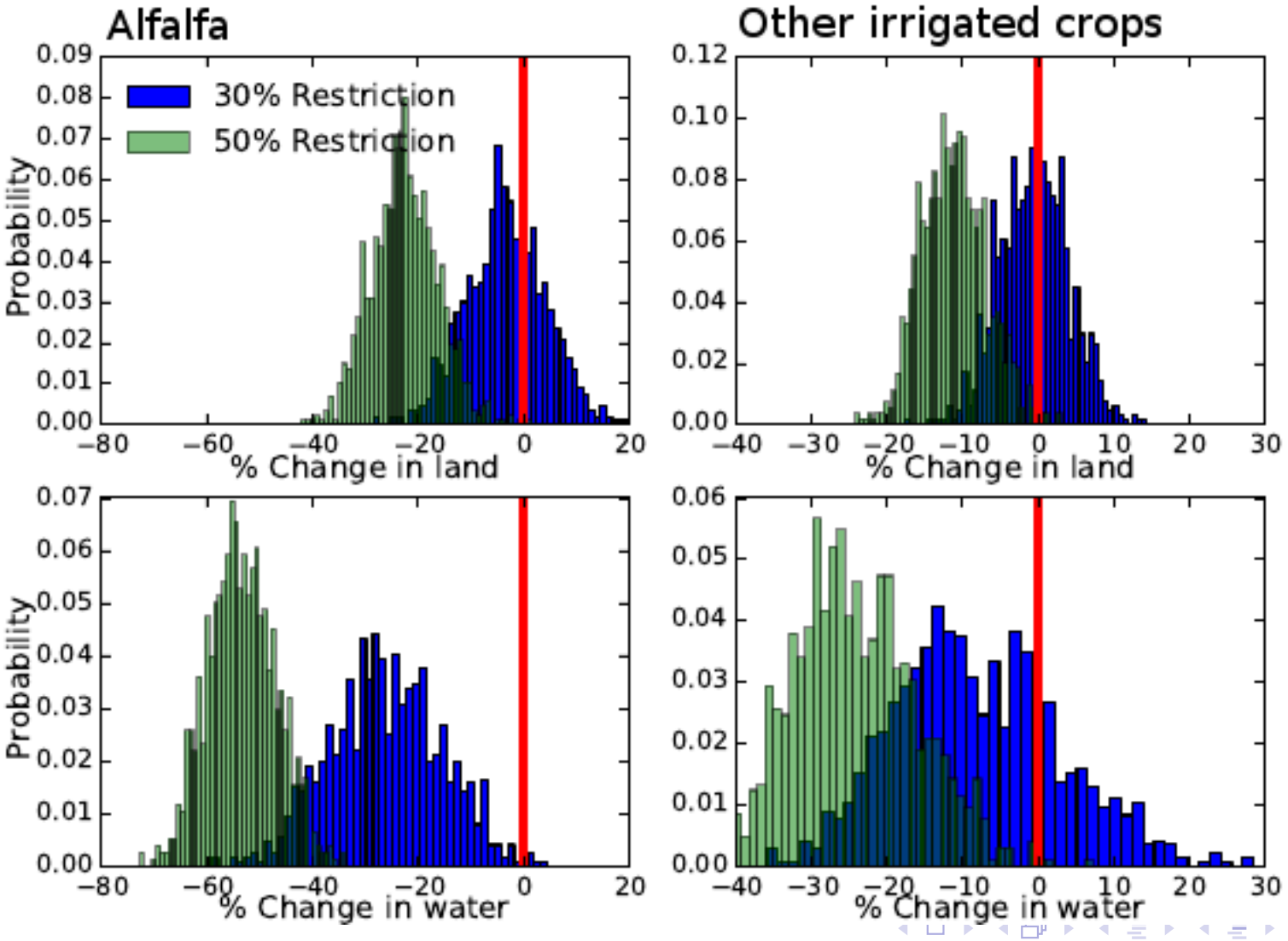
Test drive:

New water allocation rules that results in:

- Scenario 1: 30% reduction in water available
- Scenario 2: 50% reduction in water available

Results

Impact of a reduced access to water



Results

Summary of impacts

	Baseline	30% reduction	50% reduction
Water available	2300	1610	1150
Water used	2060	1610	1150
Shadow value	\$0.0	\$9.00	\$25.3
% loss net rev		-2.76	-11.3