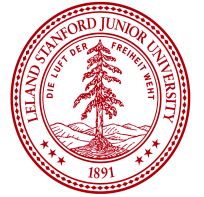


SCHOOL OF EARTH SCIENCES
ENVIRONMENTAL EARTH SYSTEM SCIENCE



High-Resolution Modeling of Extreme Precipitation in the United States

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Stanford University

MOTIVATION

- Extreme Events result in severe damage to natural and human systems
- Potential increase in frequency and intensity of extremes in a warmer climate
- Adaptation planning and mitigation Strategies
 - Near-term climate projections
 - Reduced vulnerability to extremes



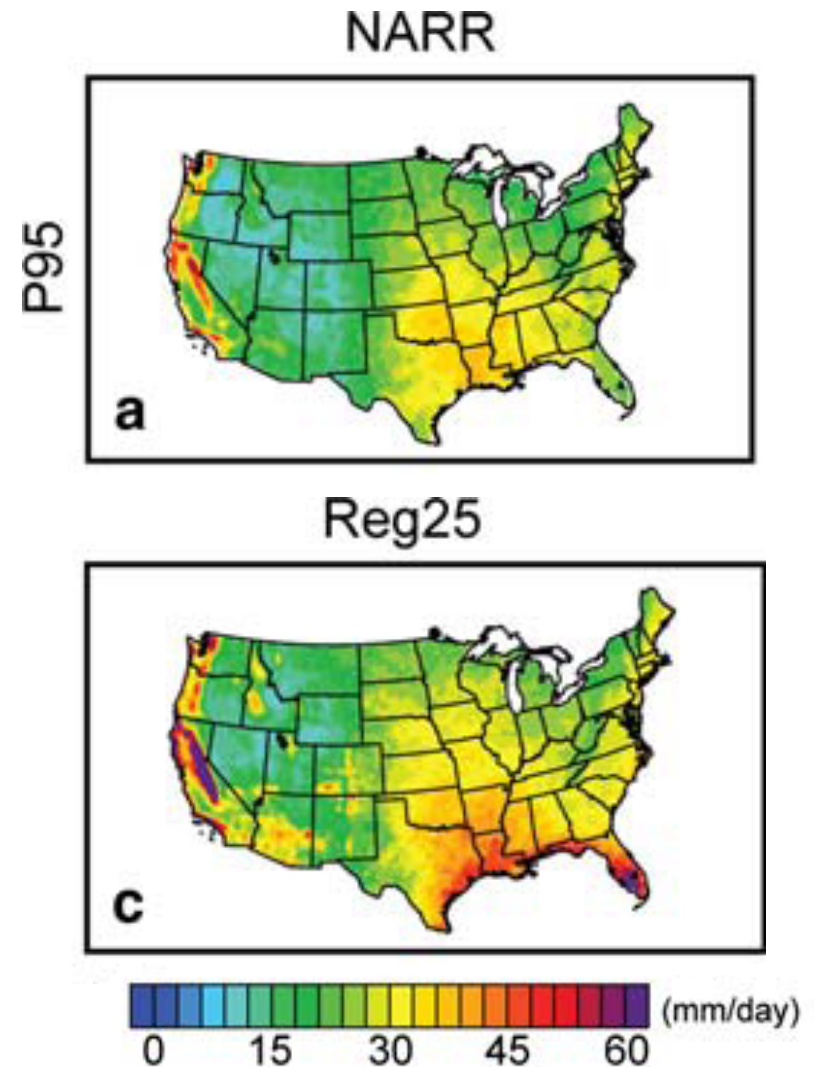
Texas Drought 2011



Mississippi River Flooding - 2011

Climate Model Experiments

- ICTP **RegCM3** at 25 km horizontal resolution nested in **CCSM3**
- 5-member physically uniform ensemble
- **A1B SRES emissions scenario** (IPCC 2000) for future radiative forcing
- Simulation period – **1950-2099**
- Baseline period – **1970-1999**
- Future decades for discussion – **2030-39** (near-term) and **2090-99**
- Statistical significance – Student's t-test with **p-value=0.05**

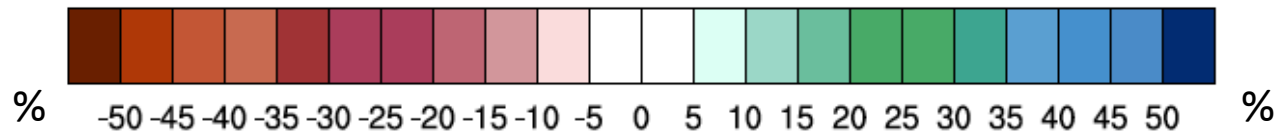
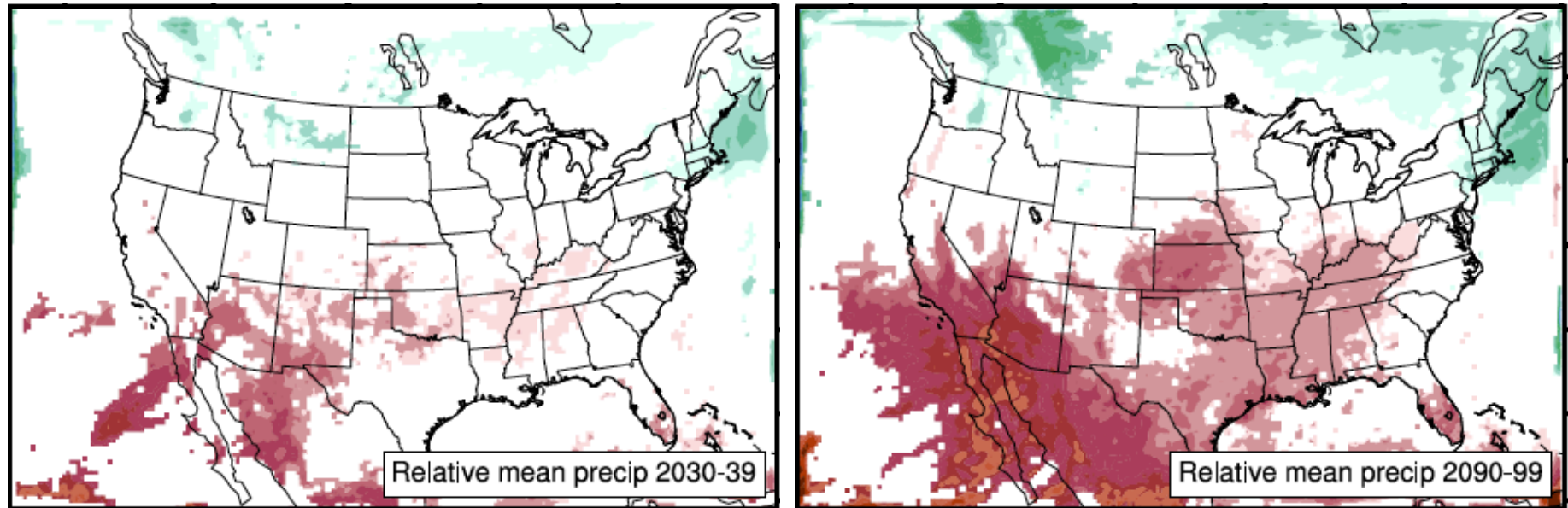


95th Percentile Precipitation –
Ref: Walker and Diffenbaugh (2009)

Change in Total Annual Precipitation

2030-39

2090-99



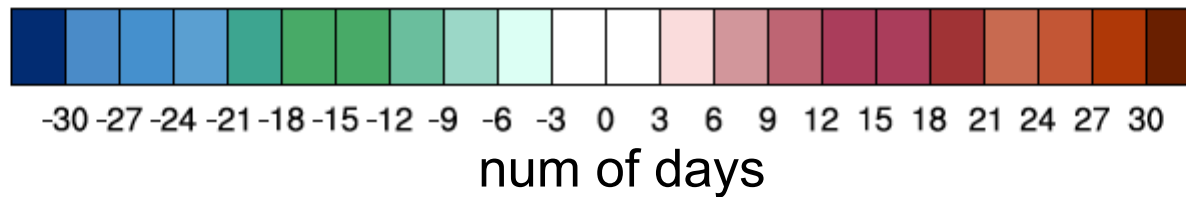
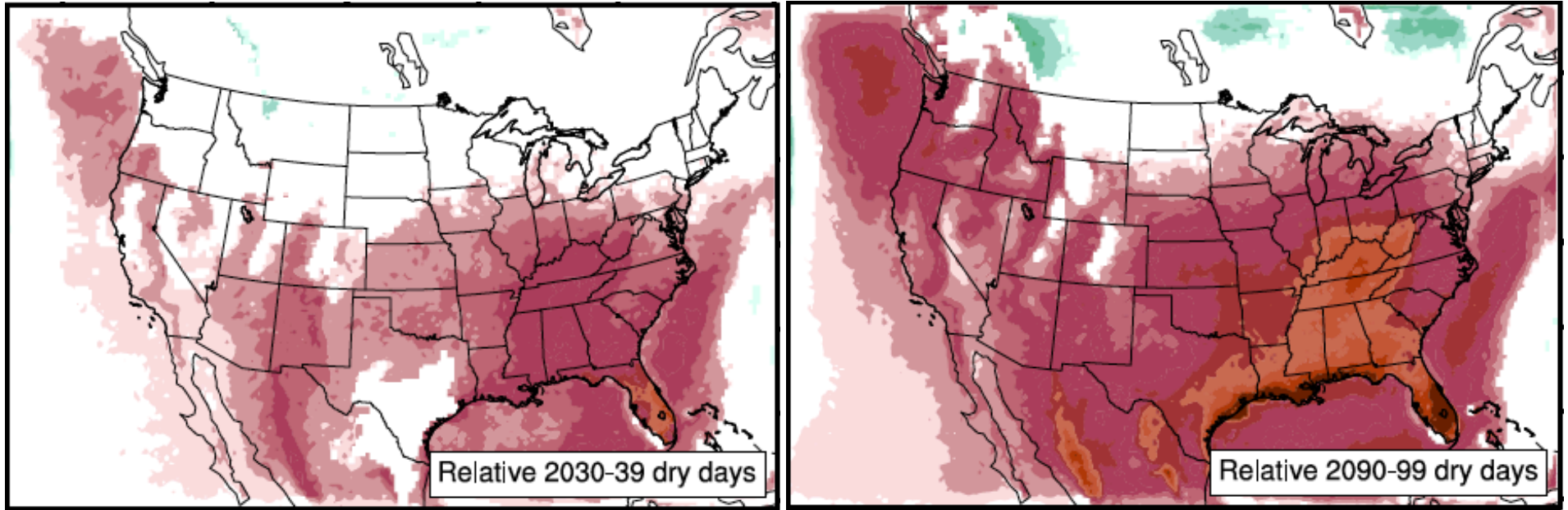
p-value < 0.05 level

Significant near term drying over parts of the Southwest and Mexico that intensifies and expands over most of the region by the end of the century

Annual Frequency of Dry Days (P < 1mm)

2030-39

2090-99



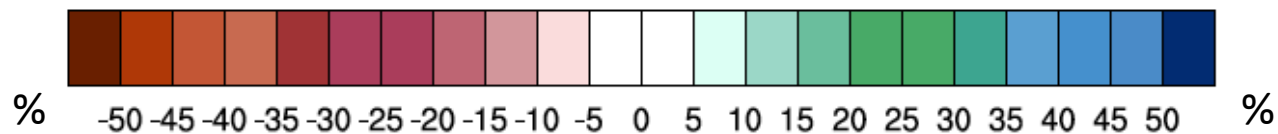
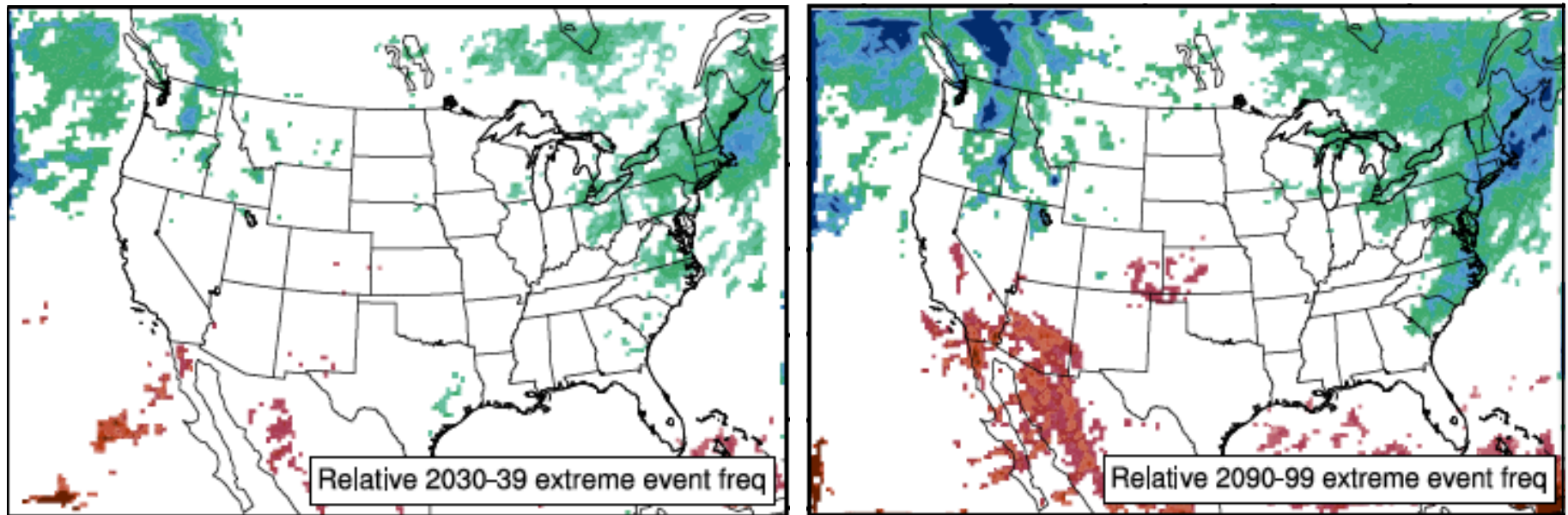
Substantial increases in frequency of dry days over the Southeast in the near-term and most parts of the U.S by 2090-99

Frequency of Annual Extreme Events

Definition of Extreme Event– Days with precipitation exceeding the 95th percentile in baseline

2030-39

2090-99



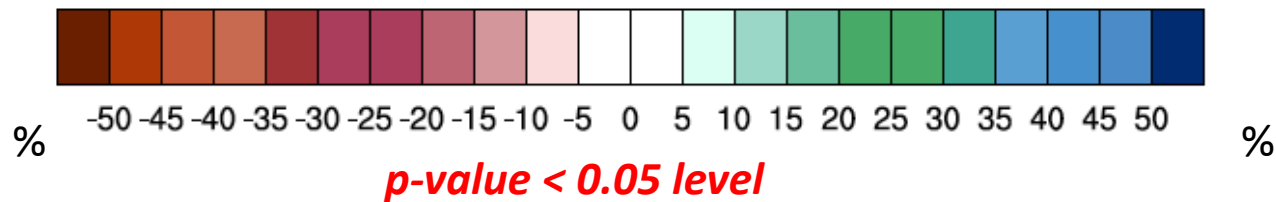
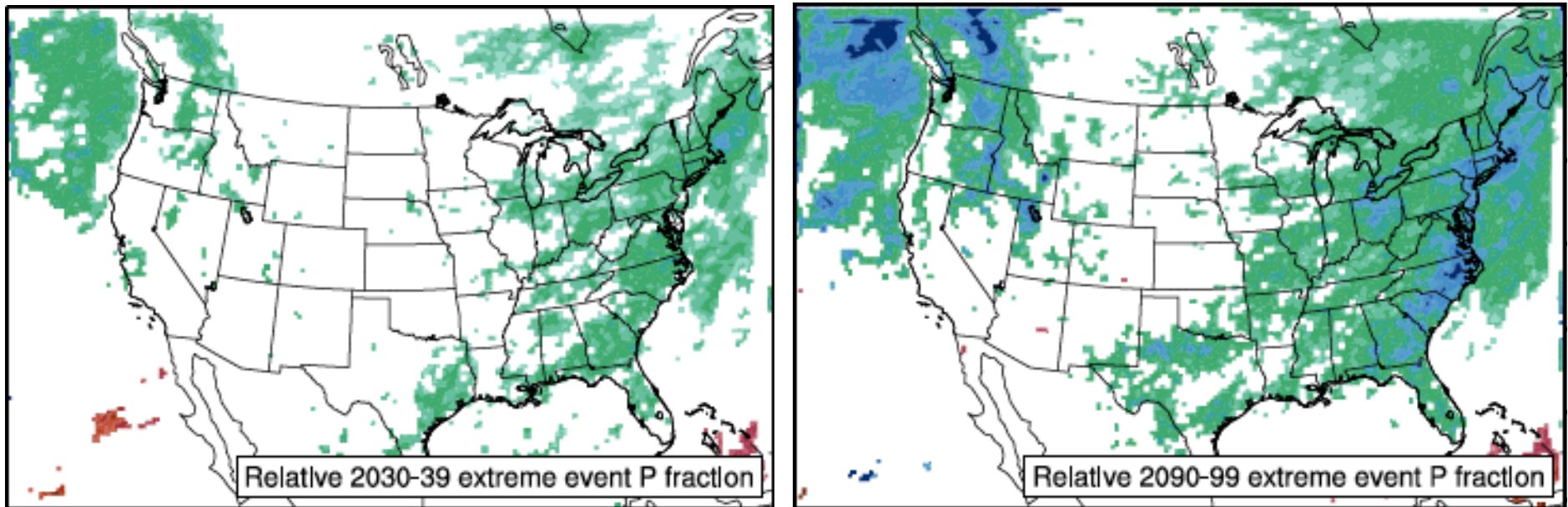
p-value < 0.05 level

Moderate increase of wet extremes in the near-term over the Northeast and parts of the Northwest and almost a 50 % change by the end of the century

Extreme Precipitation Fraction

2030-39

2090-99

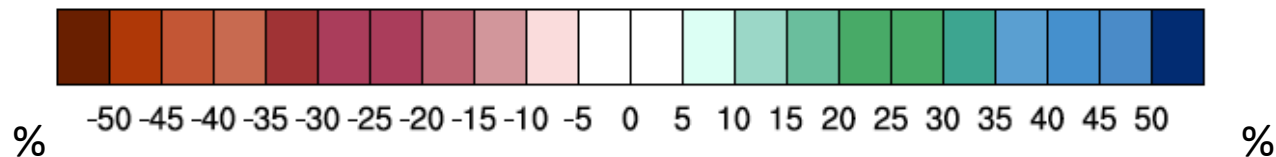
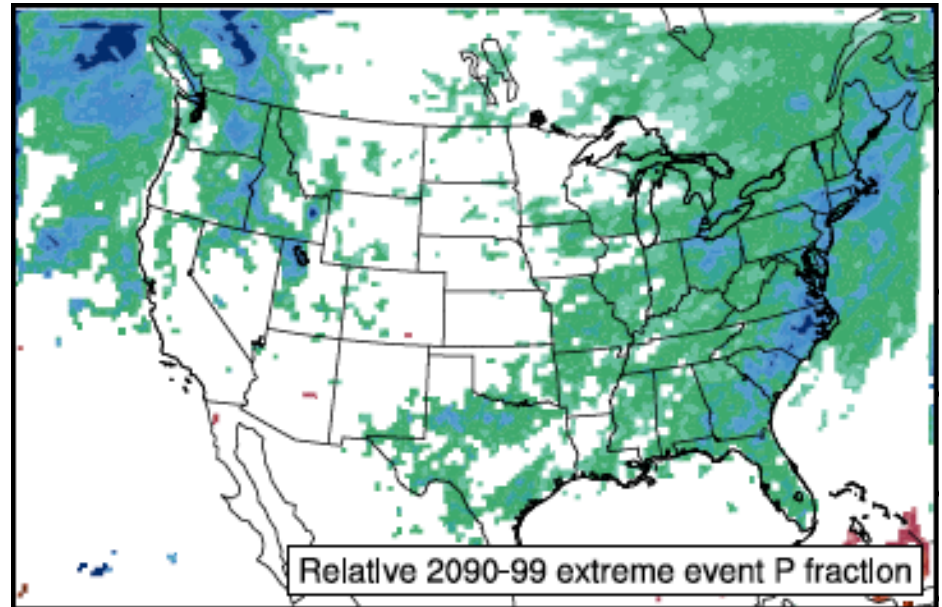
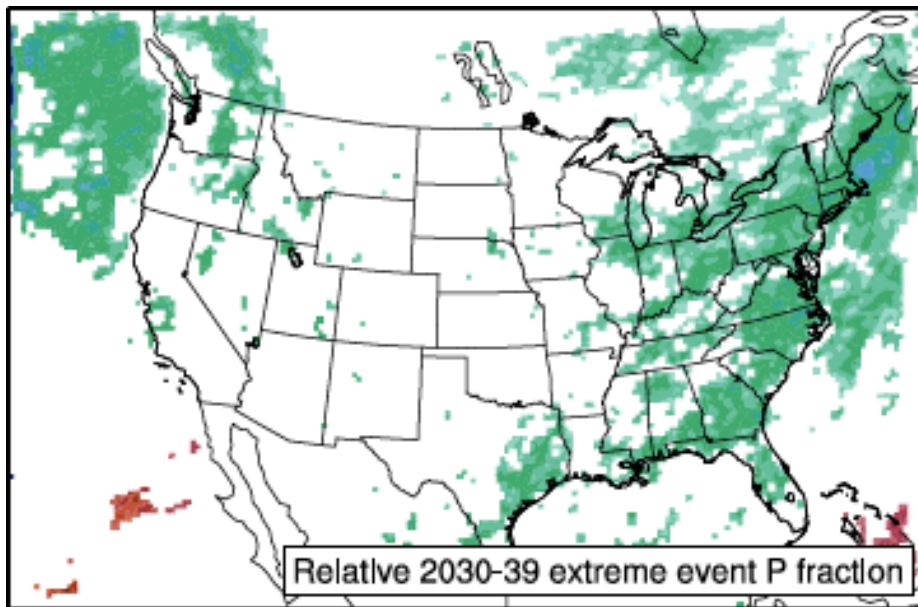


Increase of >20% in extreme precipitation fraction over the Eastern U.S, Midwest and parts of Northwest by 2030-39, intensifying over most regions by 2090-99

Extreme Precipitation Fraction

2030-39

2090-99

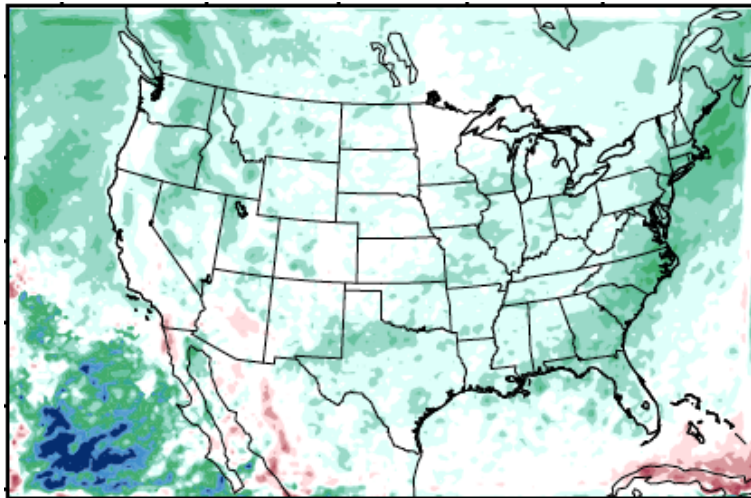


p-value < 0.05 level

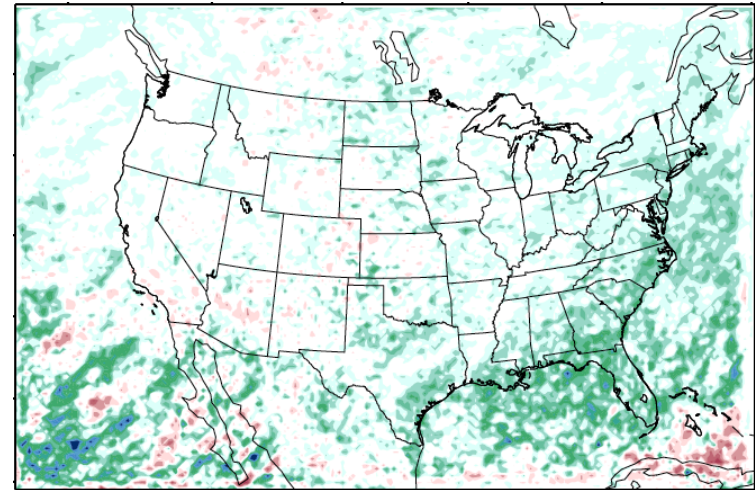
Fraction = f (Extreme Event Frequency, Extreme Precip Intensity, Total Rain Days/Dry Days, Average Precip Intensity)

Analyzing Precipitation Intensities (2090-99)

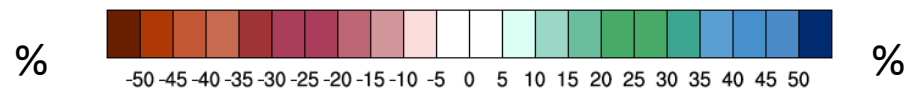
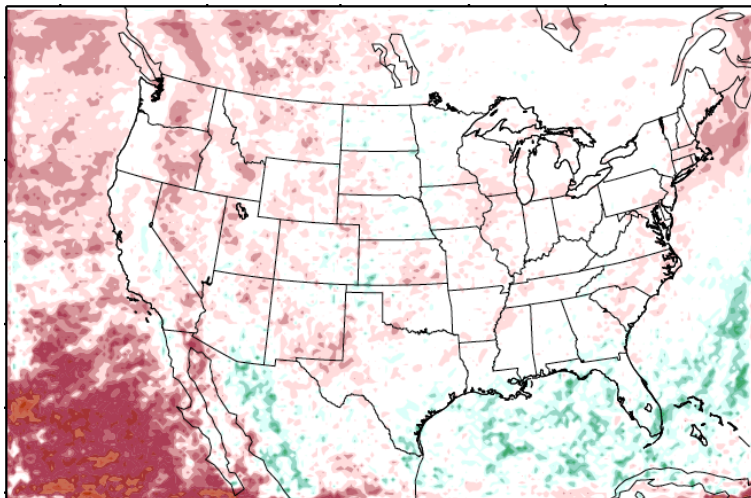
Total Precipitation Intensity



Extreme Precipitation Intensity

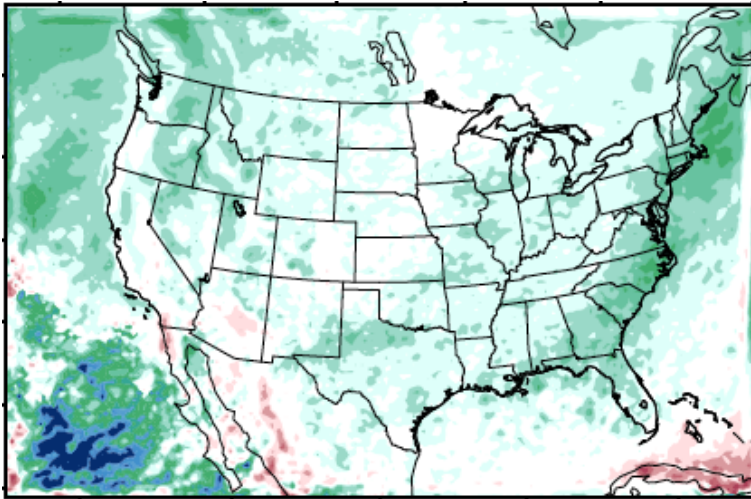


Ratio of Extreme to Average Precipitation Intensity

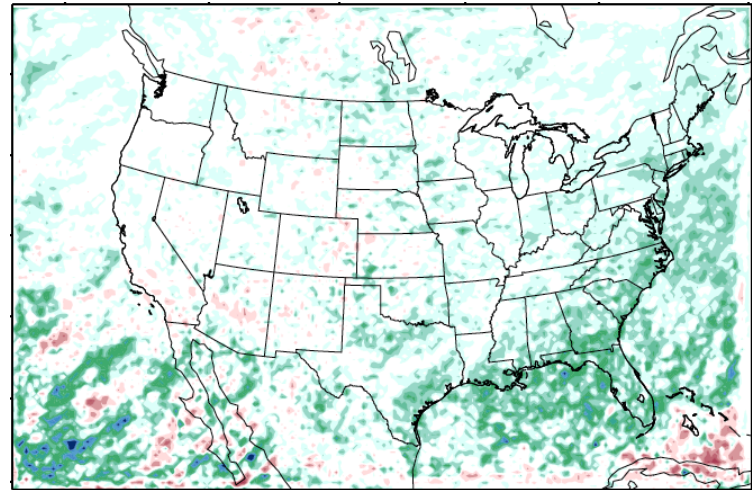


Analyzing Precipitation Intensities (2090-99)

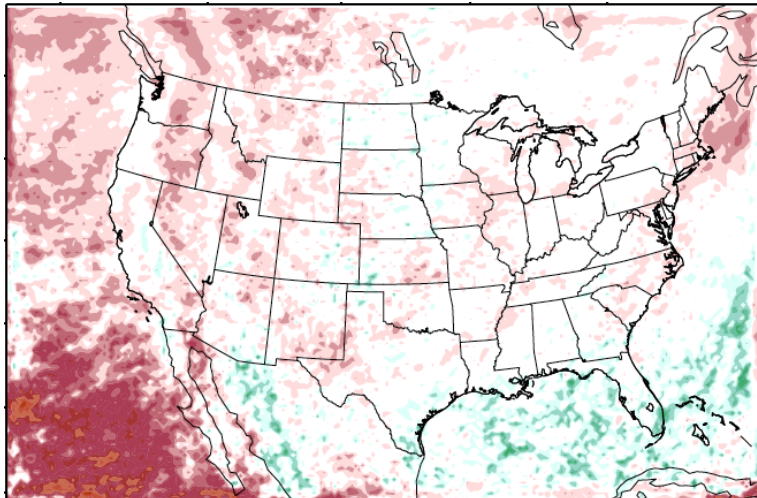
Total Precipitation Intensity



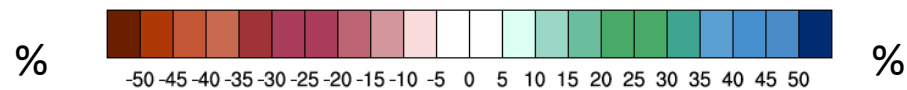
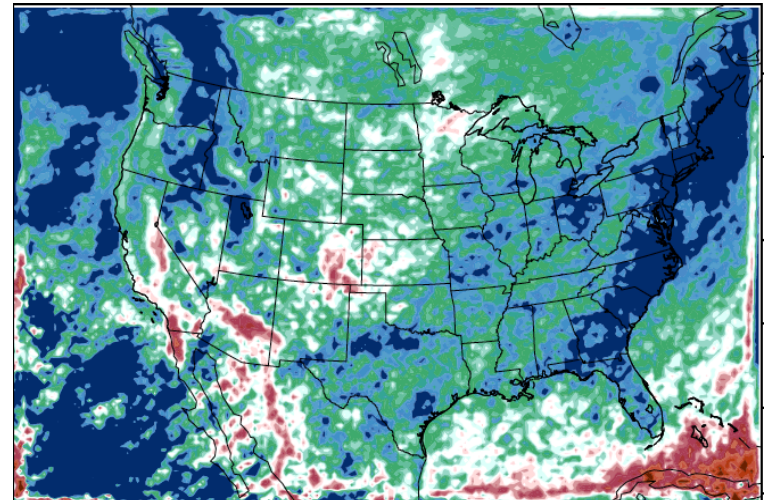
Extreme Precipitation Intensity



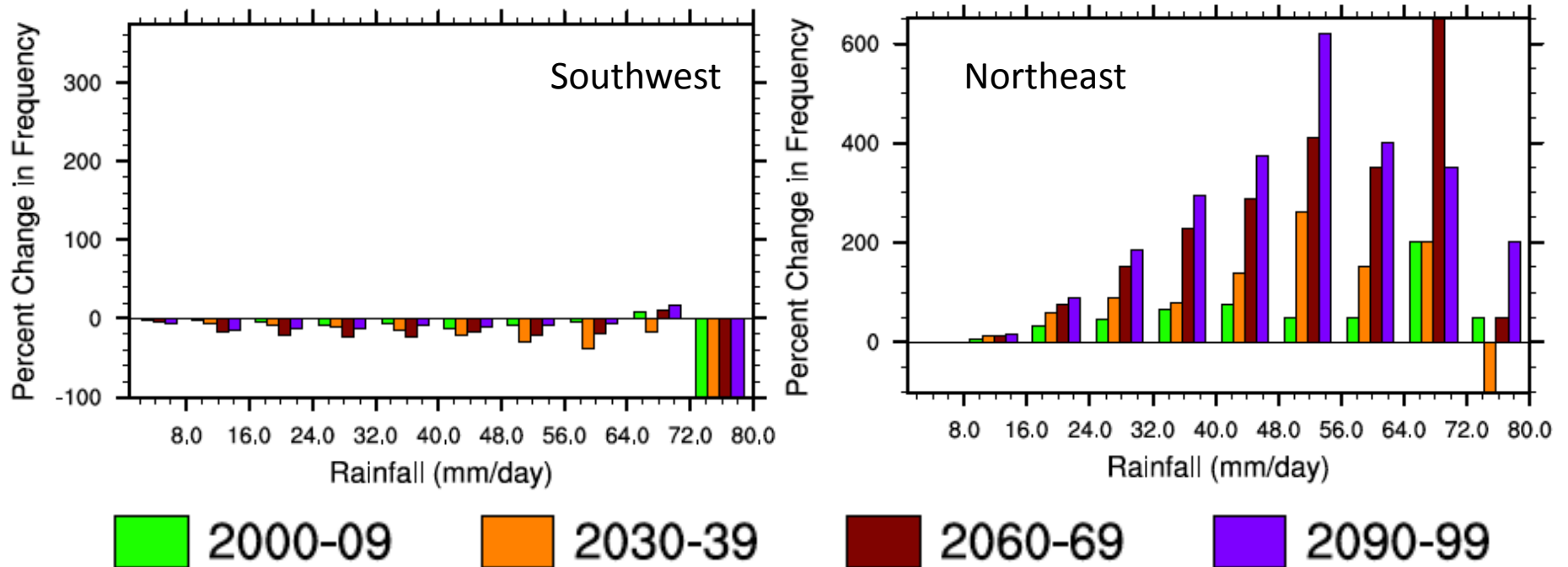
Ratio of Extreme to Average Precipitation Intensity



Non-Extreme Precipitation Intensity

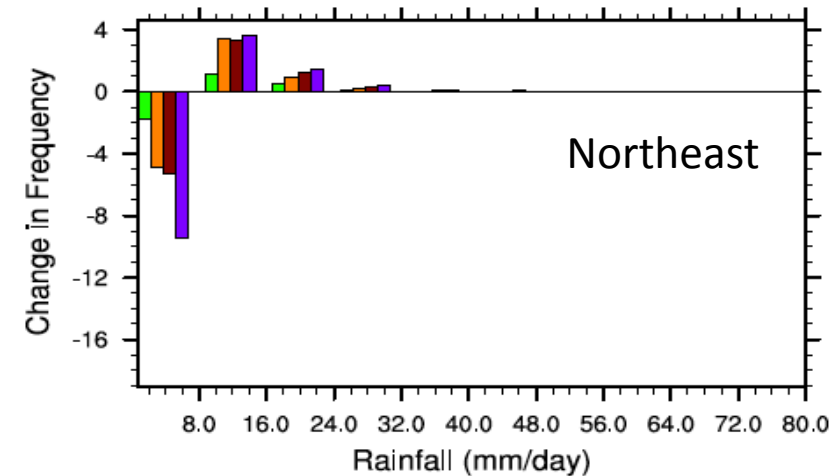
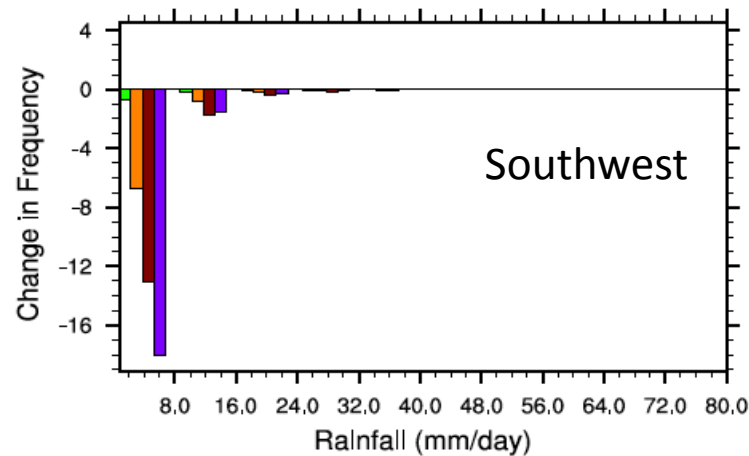
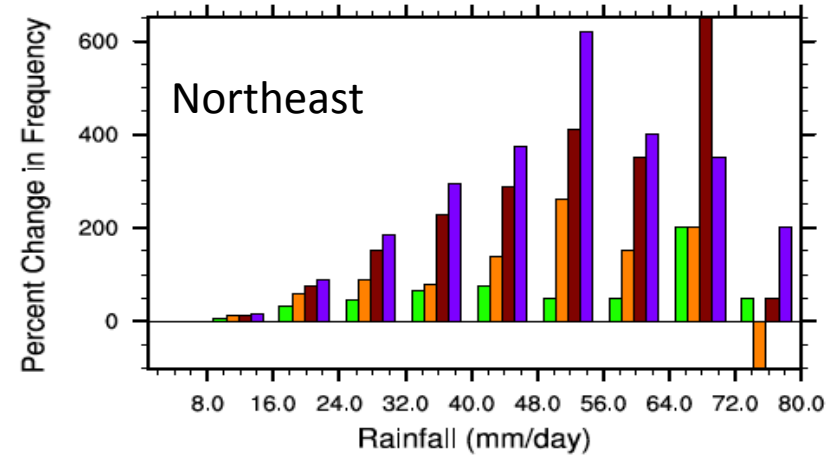
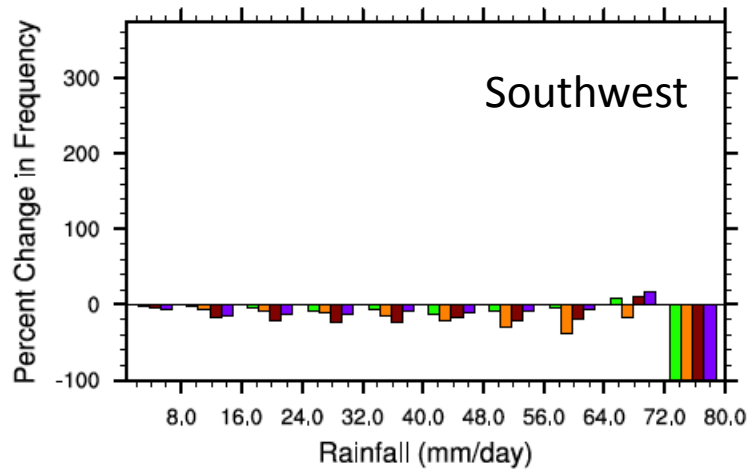


Changing Precipitation Distribution



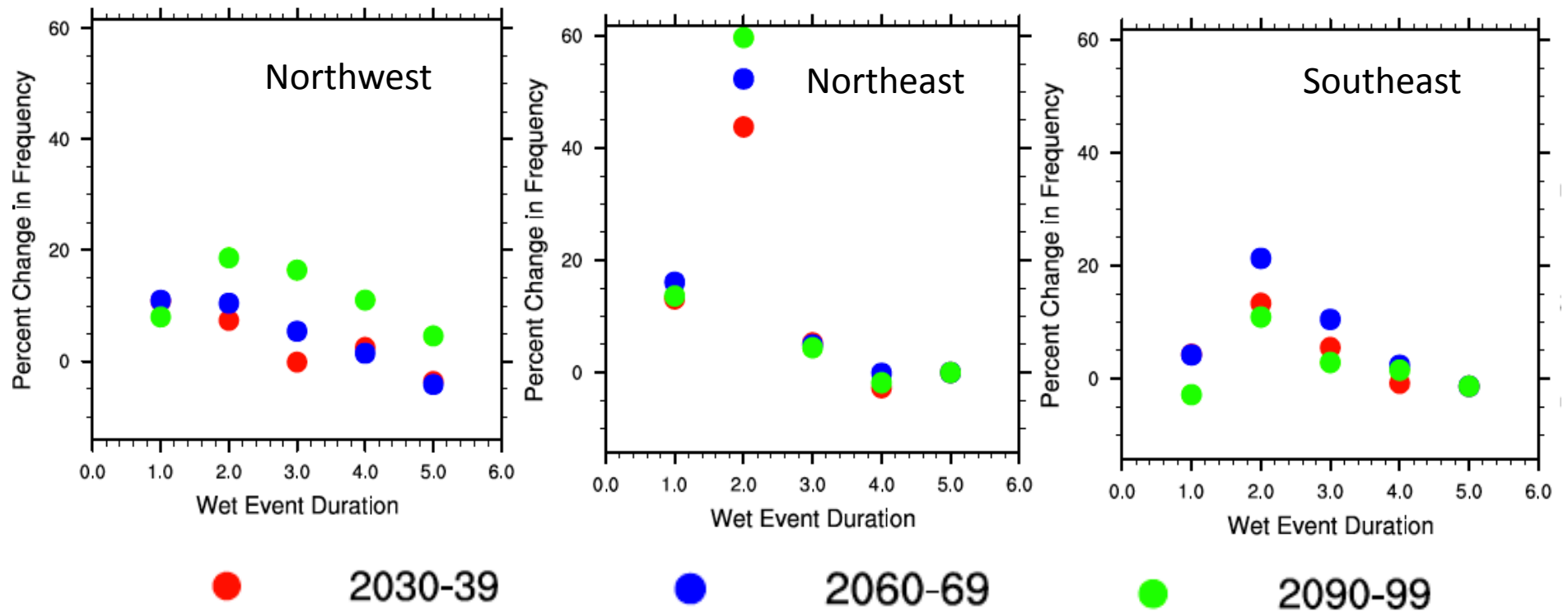
Decreases in low precipitation amounts but increase in precipitation >10 mm/day in Northeast in all future decades. Overall decreases in Southwest

Changing Precipitation Distribution



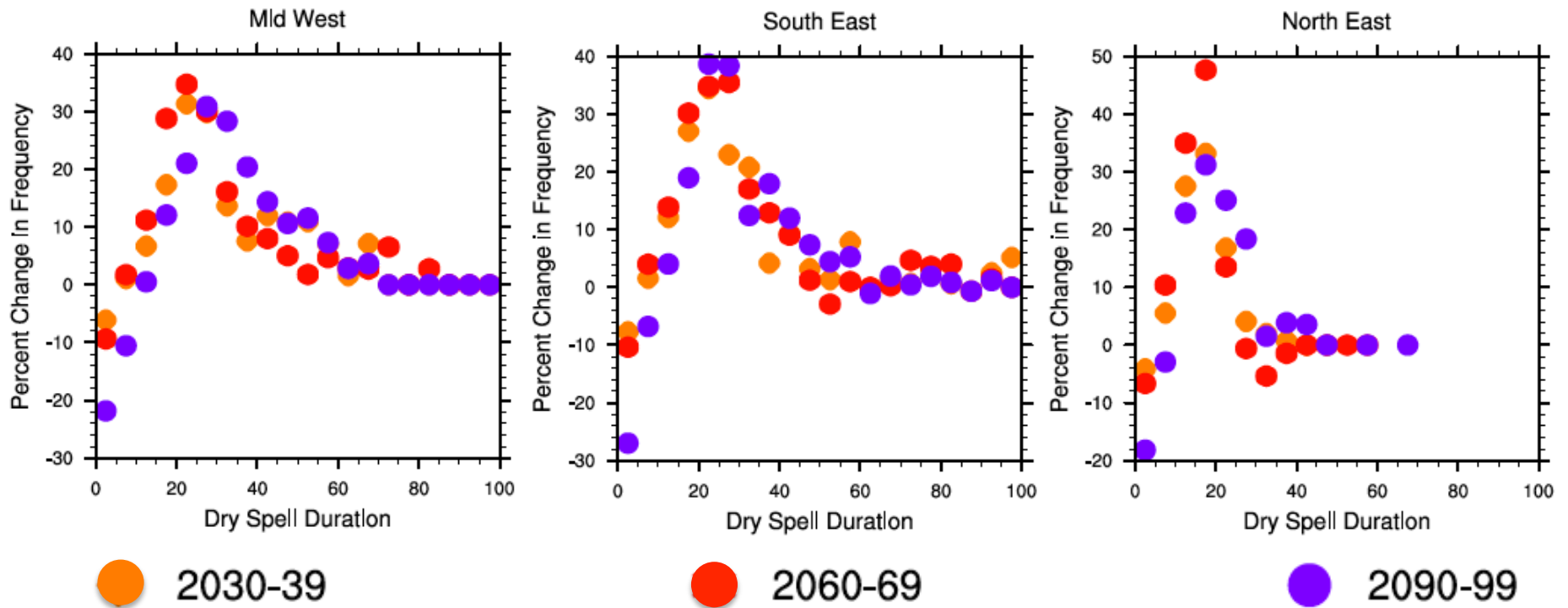
Decreases in low precipitation amounts but increase in precipitation >10 mm/day in North East in all future decades. Overall decreases in South West

Consecutive Wet Extreme Days



Increase in consecutive extreme events of longer duration in these regions in all future decades

Effect on Dry Spell Lengths

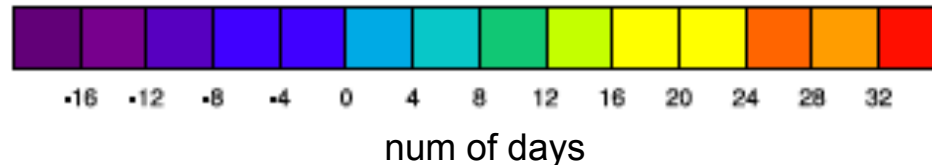
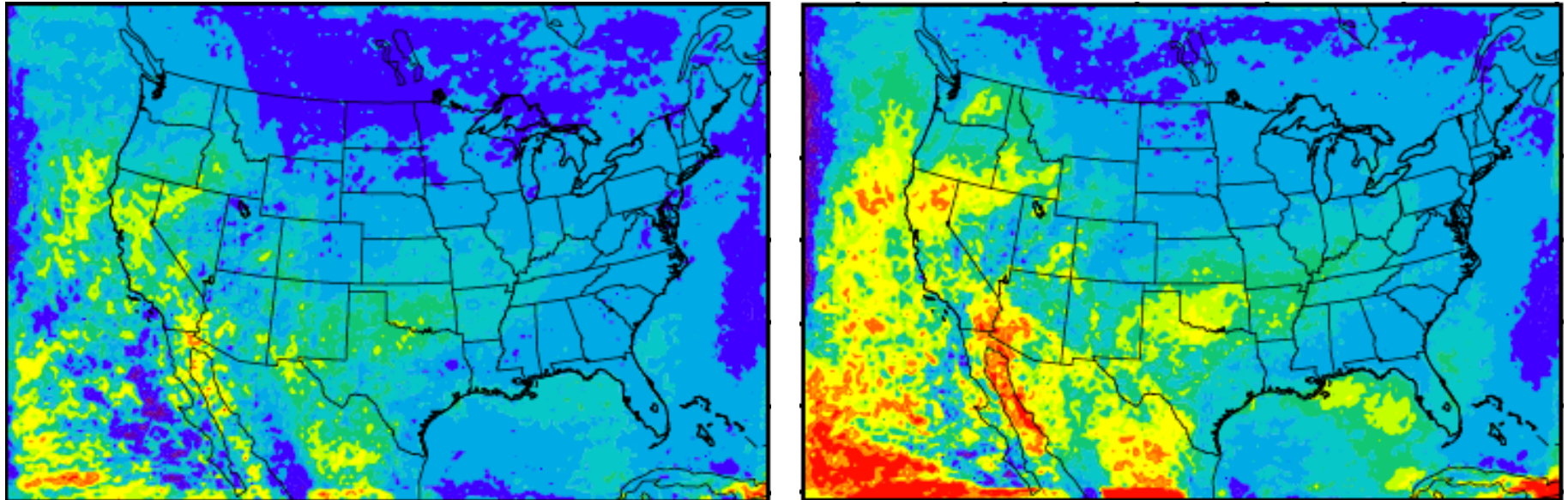


Consistent shift towards longer duration dry spells

Maximum Consecutive Dry Days

2030-39

2090-99



Increase in duration of maximum consecutive dry events over most of the U.S in the near term and all over the U.S by the last decade

Conclusions

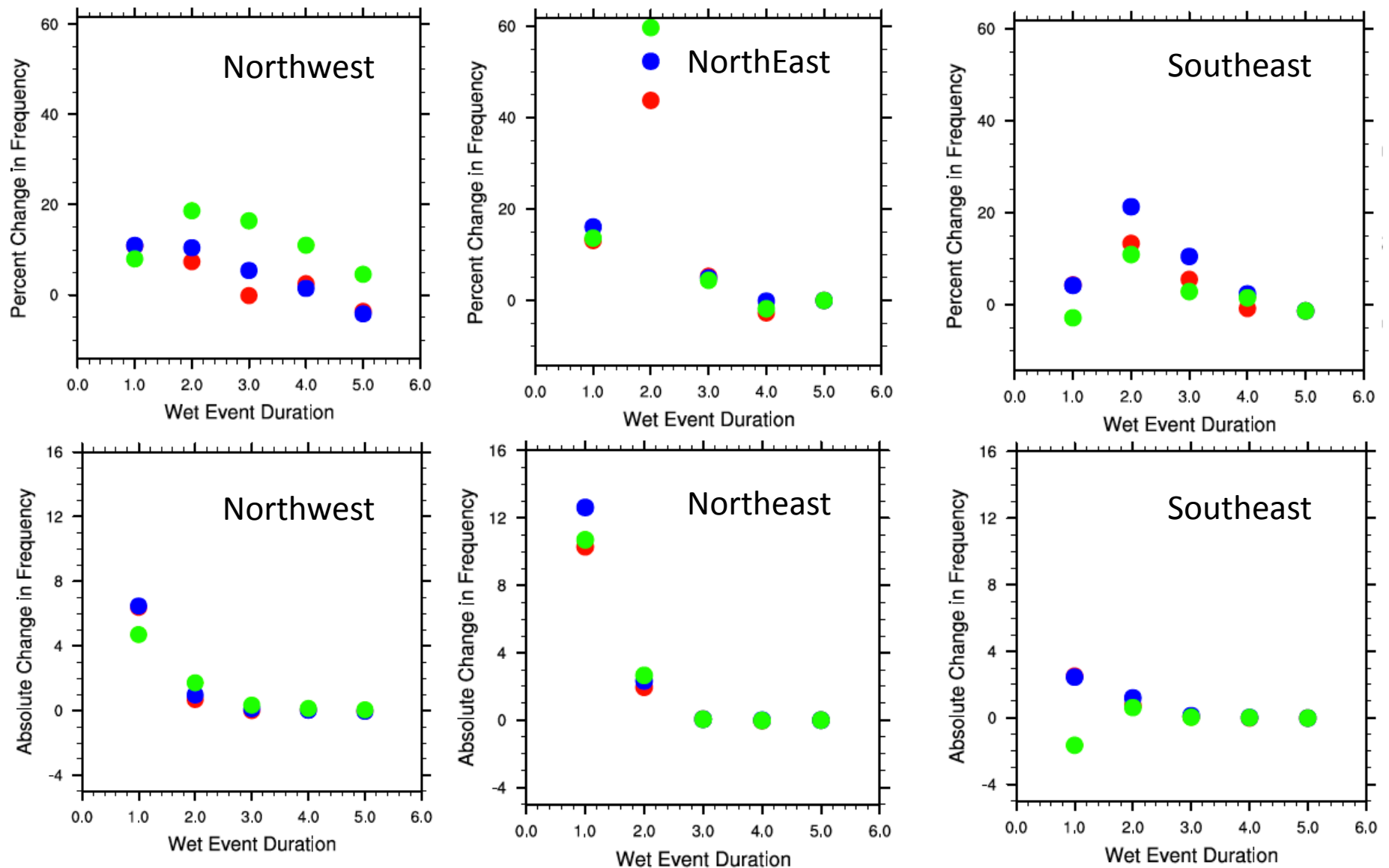
- Increase in the frequency of extreme events and their contribution to total precipitation
- Greater increases in average precipitation intensity relative to extreme precipitation intensity
- Shift towards greater precipitation from moderate to high events
- Consistent increases in the duration of wet and dry extreme events

Future Work -

- Validation of present climate extremes with these simulations and CMIP5 ensemble
- Analysis of atmospheric conditions and soil moisture fluxes around extreme event occurrences



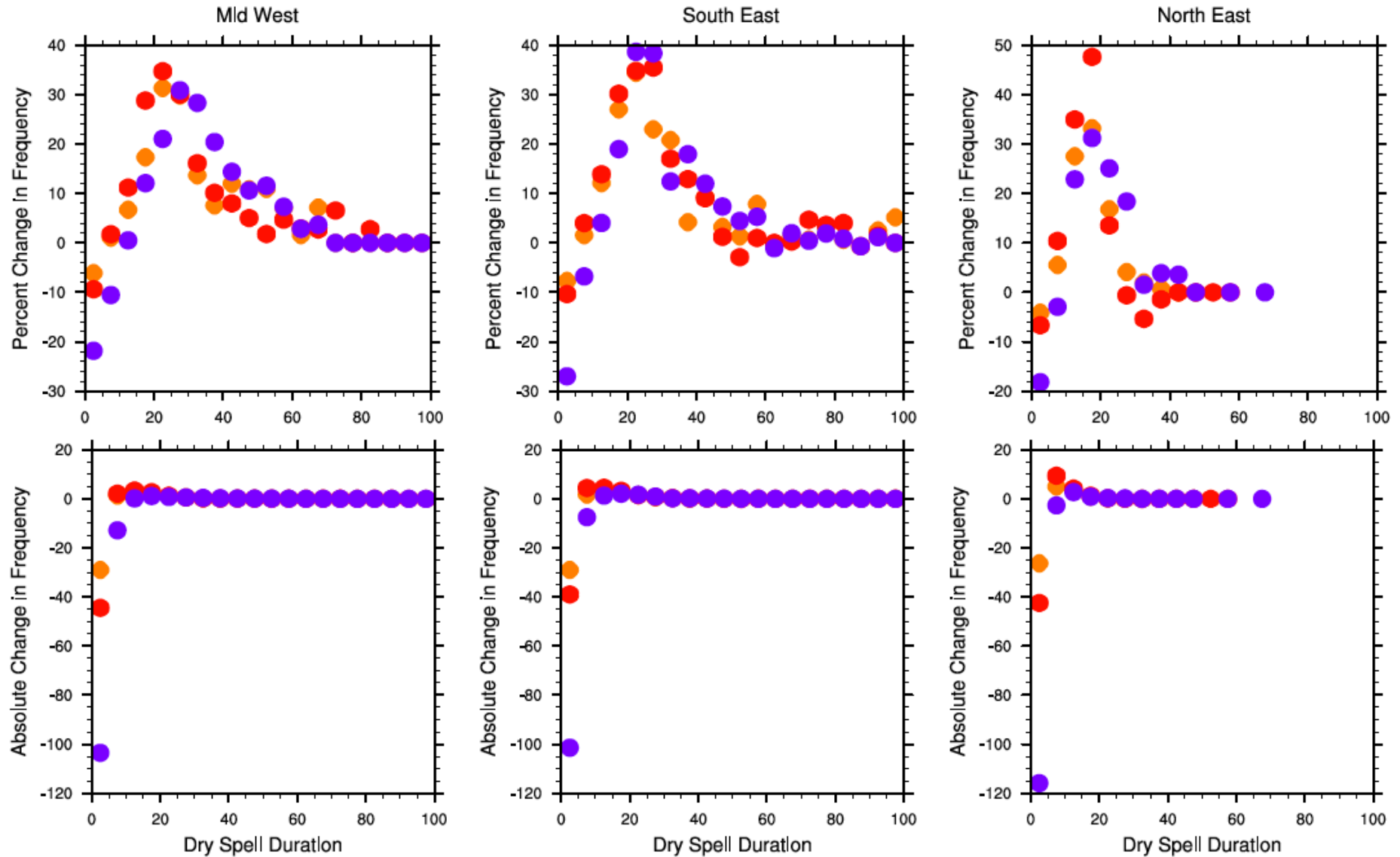
Consecutive Extreme Event Days



Shift towards consecutive extreme events of longer duration in both regions in all future decades

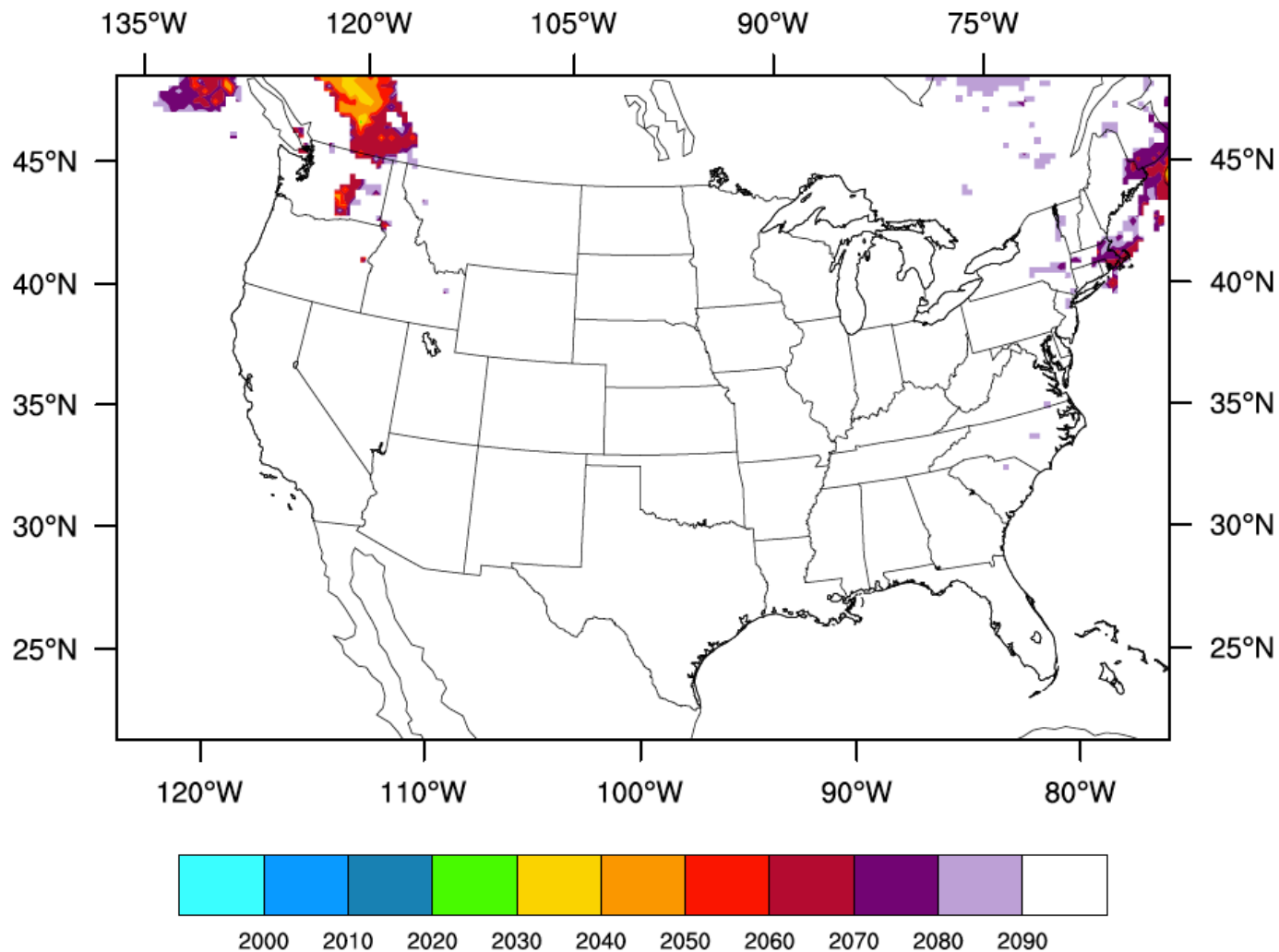


Effect on Dry Spell Lengths



Increase in total number of dry days and increased duration of dry spells

Time of Emergence of Extreme Event Days



Time of Emergence of Extreme Event Precipitation Fraction

