

# Projections of 21<sup>st</sup> Century Ventura County Climate

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*Division of Atmospheric Sciences, Desert Research Institute*



RESOURCES LEGACY FUND

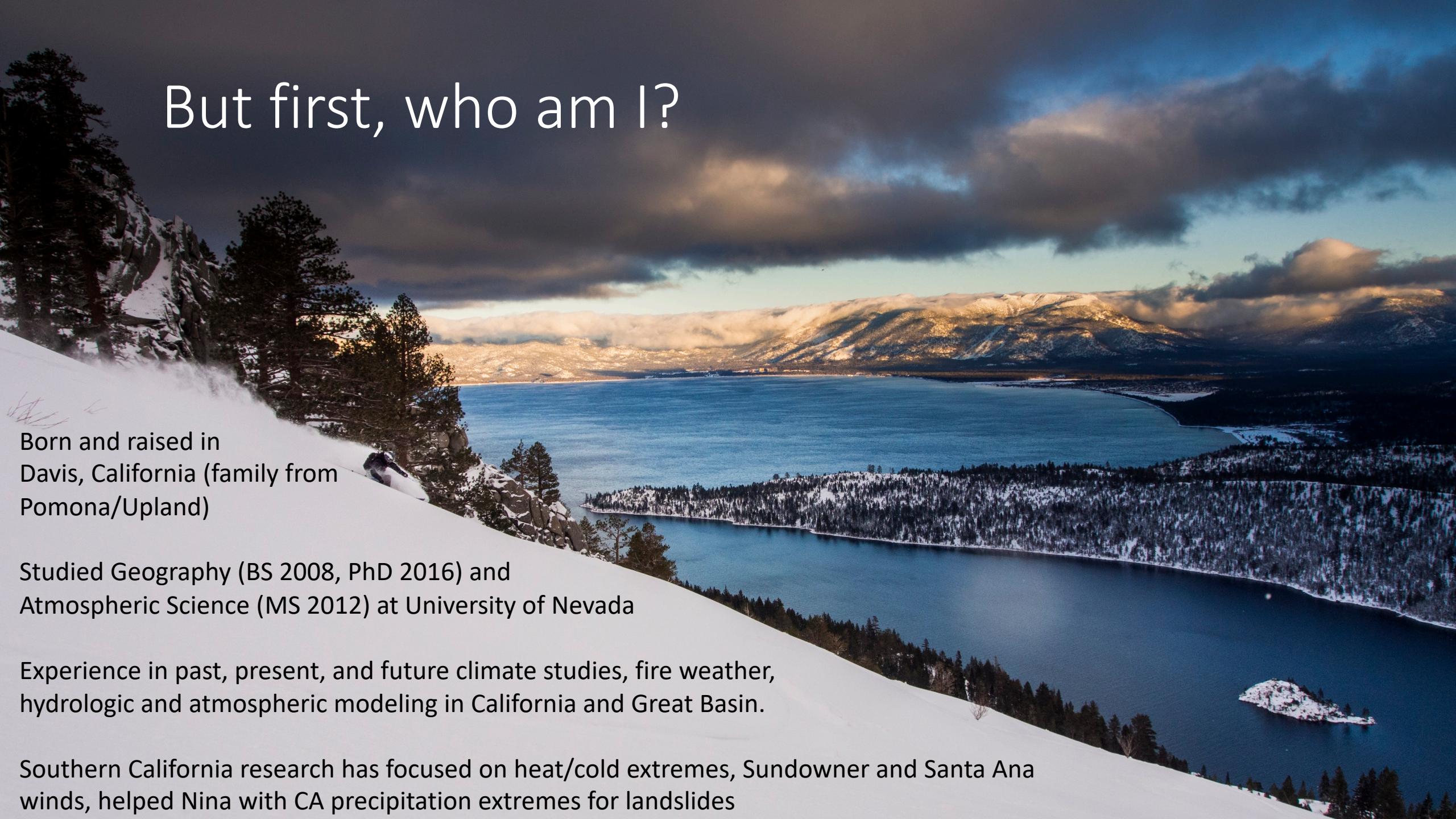
Creative Solutions. Lasting Results.



# Topics to cover

- Global Climate Modeling 101
- Downscaling of Climate Models
- Examples of Climate Projections
  - Precipitation
  - Temperature
- Specific Example
- Next Steps

# But first, who am I?



*Me*

Born and raised in  
Davis, California (family from  
Pomona/Upland)

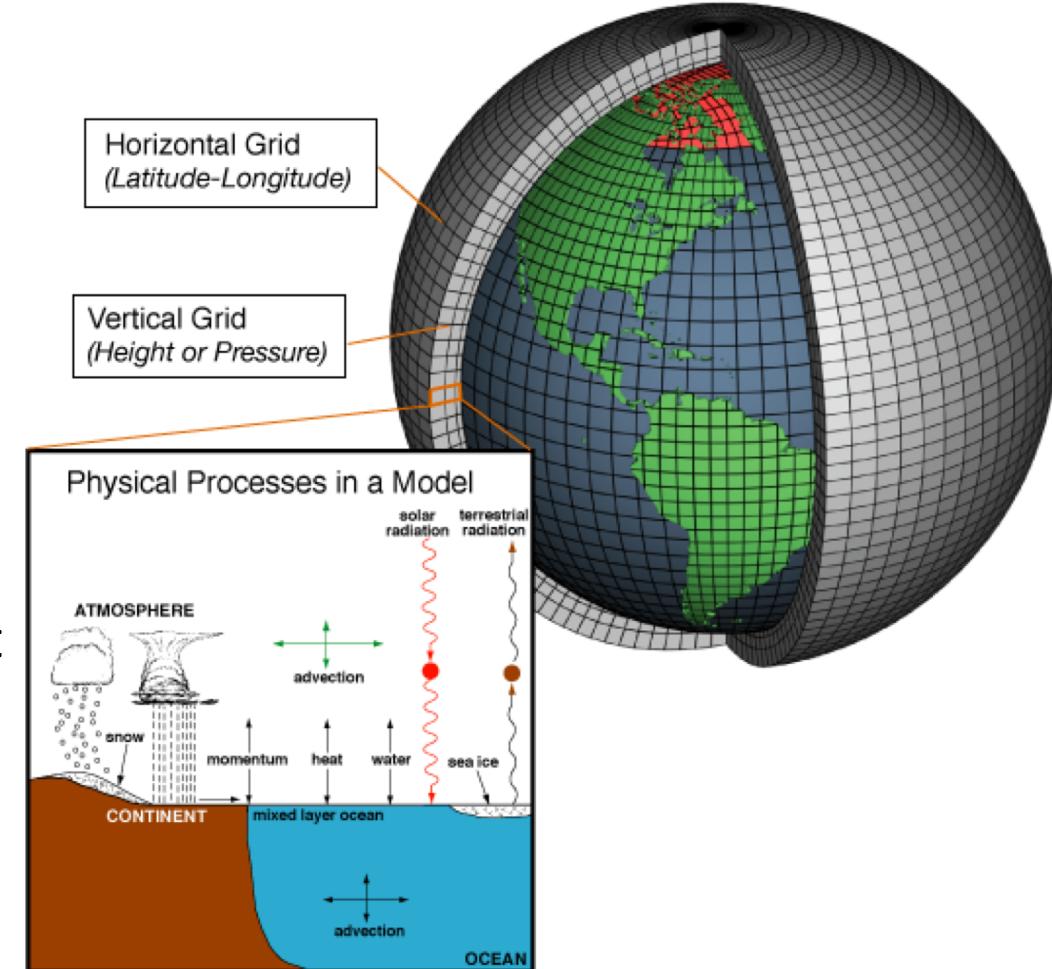
Studied Geography (BS 2008, PhD 2016) and  
Atmospheric Science (MS 2012) at University of Nevada

Experience in past, present, and future climate studies, fire weather,  
hydrologic and atmospheric modeling in California and Great Basin.

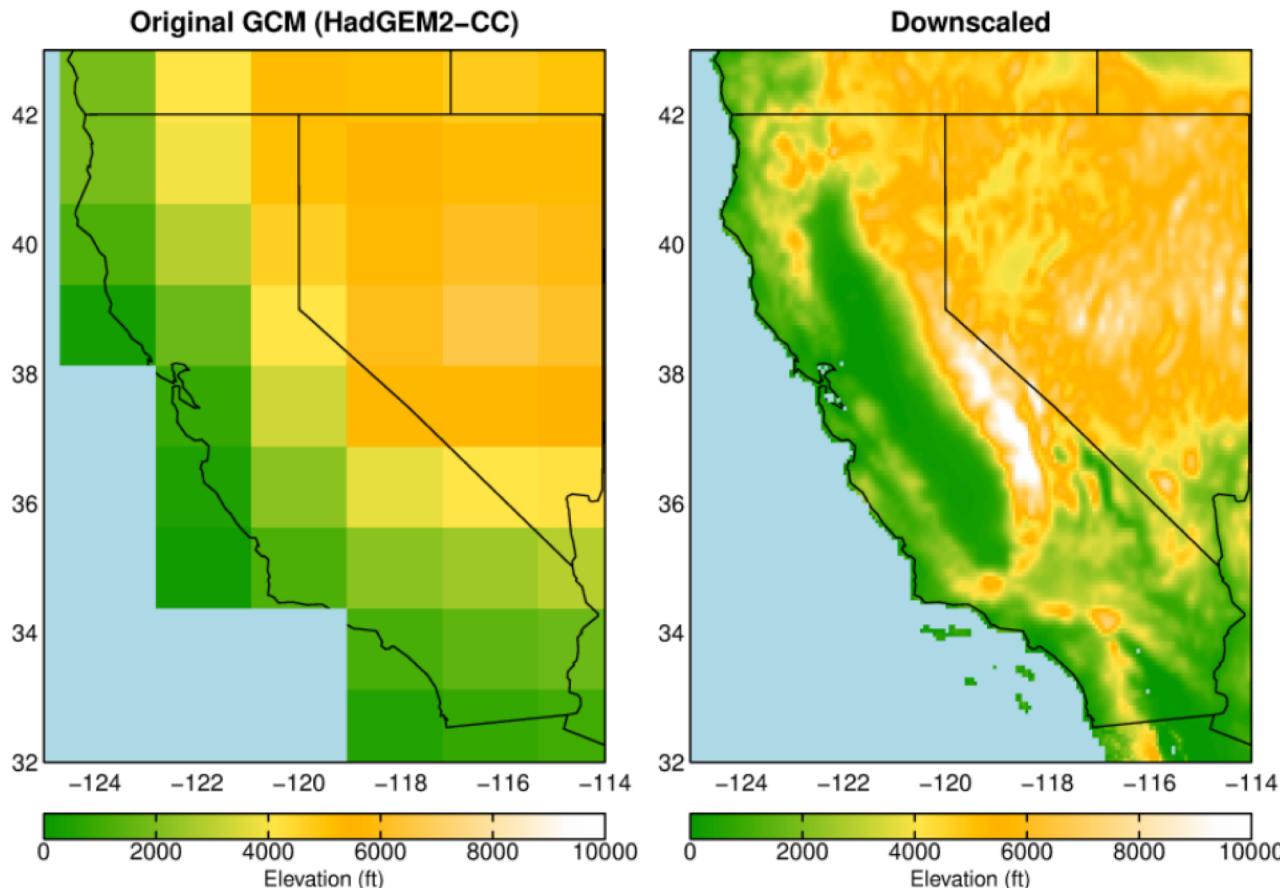
Southern California research has focused on heat/cold extremes, Sundowner and Santa Ana  
winds, helped Nina with CA precipitation extremes for landslides

# Global Climate Modeling 101

- Best tool to estimate responses of Earth System to perturbations in atmospheric composition (greenhouse gases)
- Key ‘spheres’ simulated and coupled
  - Ocean, atmosphere, land surface, sea-ice/glaciers
- Must get major modes of climate variability
  - Seasonal (almost got it)
  - ENSO (improving)
  - Global SSTs (present challenge)
  - MJO (emerging major challenge!)
- Due to computational constraints, models are still quite coarse in spatial resolution, can’t be used for local impact studies alone
  - Example: A single value of temperature/precipitation for Ventura County is NOT acceptable, right?
- Models vary in their computational representation of physical Earth System
  - (more or less) the same equations yield different results



# Downscaling: Making Global Model Output Usable For Impact Studies



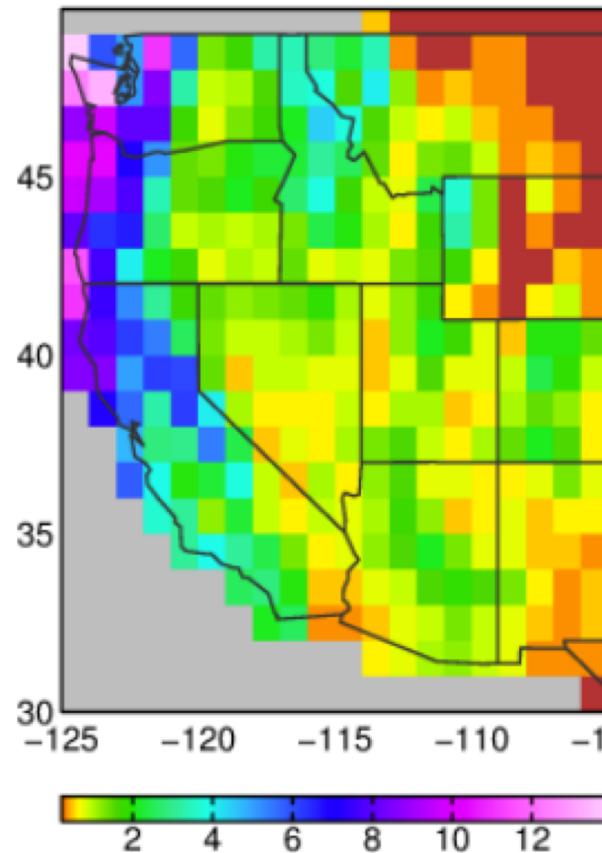
- Global climate models (GCMs) cannot resolve terrain, *note absence of major landforms*
  - Downscaling transforms coarse GCM into finer spatial scale
  - Dynamical (regional model with GCM boundary conditions, e.g., WRF, expensive)
  - Statistical (computationally efficient), uses observed historical relations between larger scale climate and local observations
  - **Employed here for Ventura**
  - Carries (bad) assumption of historical relation between local/regional observations continues into future
- GCMs also have systematic errors, signed biases
  - E.g., Precipitation 20% too low
  - Bias correction step uses historical observations to estimate corrections to historical model simulation, applies correction to future
- Both steps employed to create, ‘bias-corrected, spatially downscaled projections’

# Systematic Error (Bias in GCM) Removal: Historical December Precipitation Example

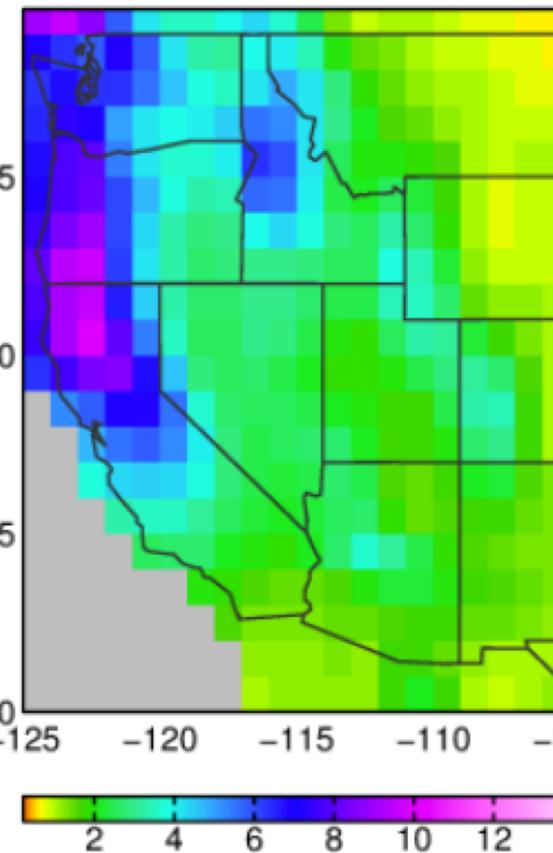
- Variability adjusted to match observations at varying frequencies but preserve GCM's climate change projection

Pierce et al. 2016

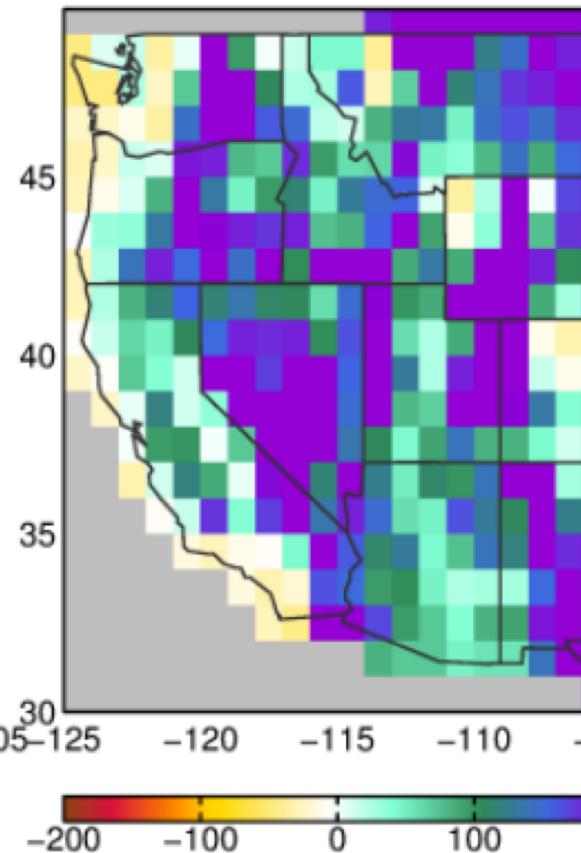
a) Observations (mm/day)



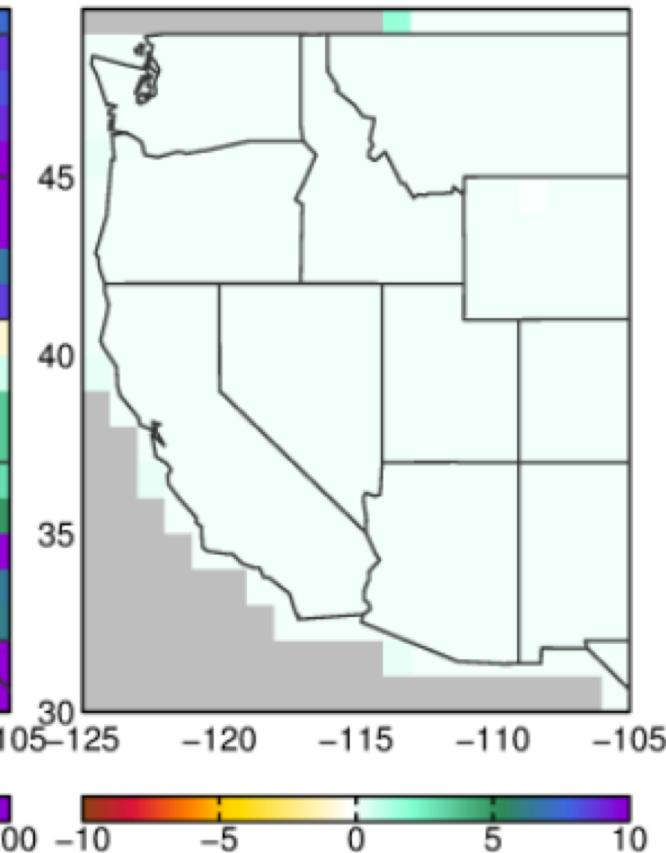
b) Model Orig (mm/day)



c) Model error (%)

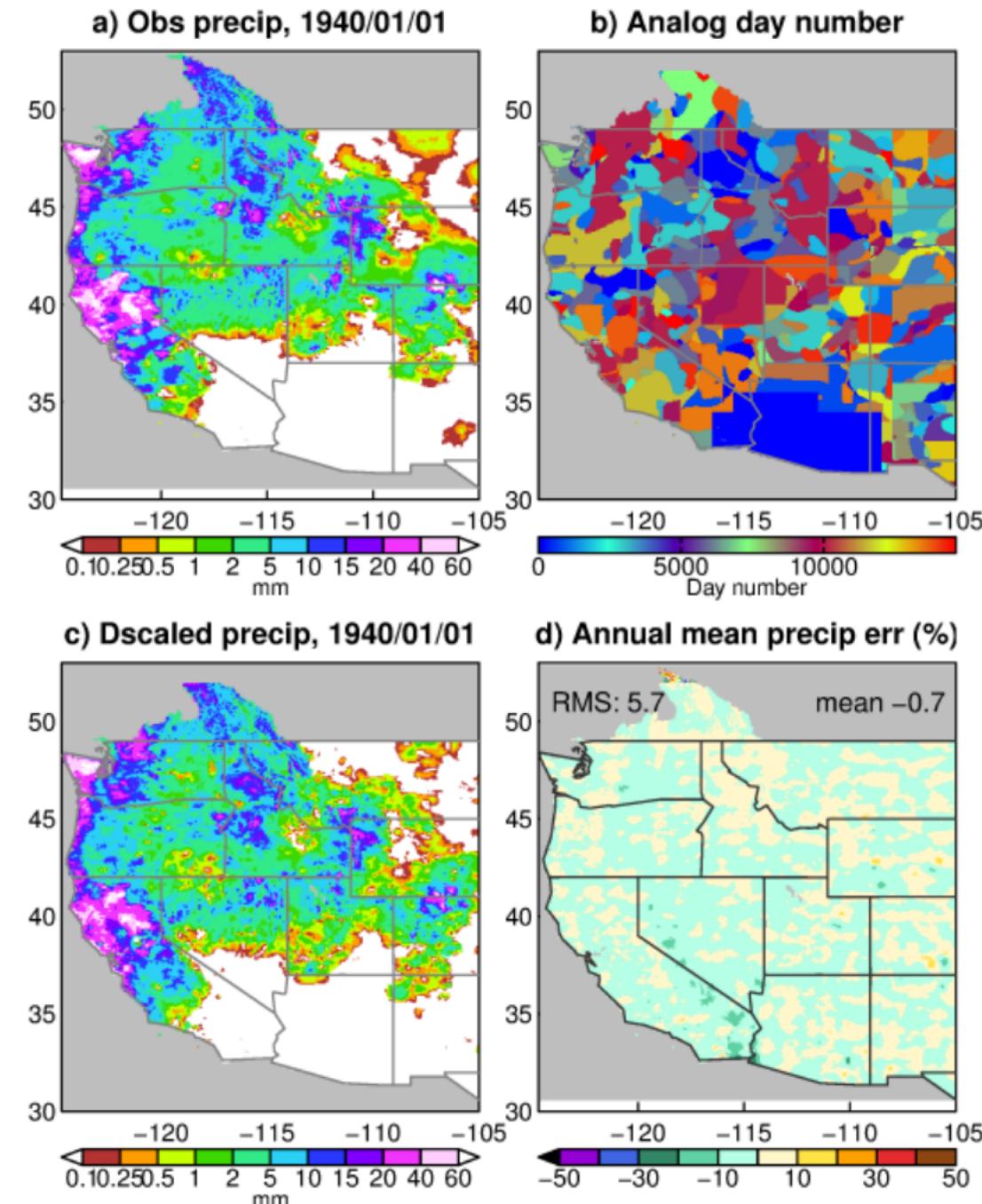


d) Error after BC (%)

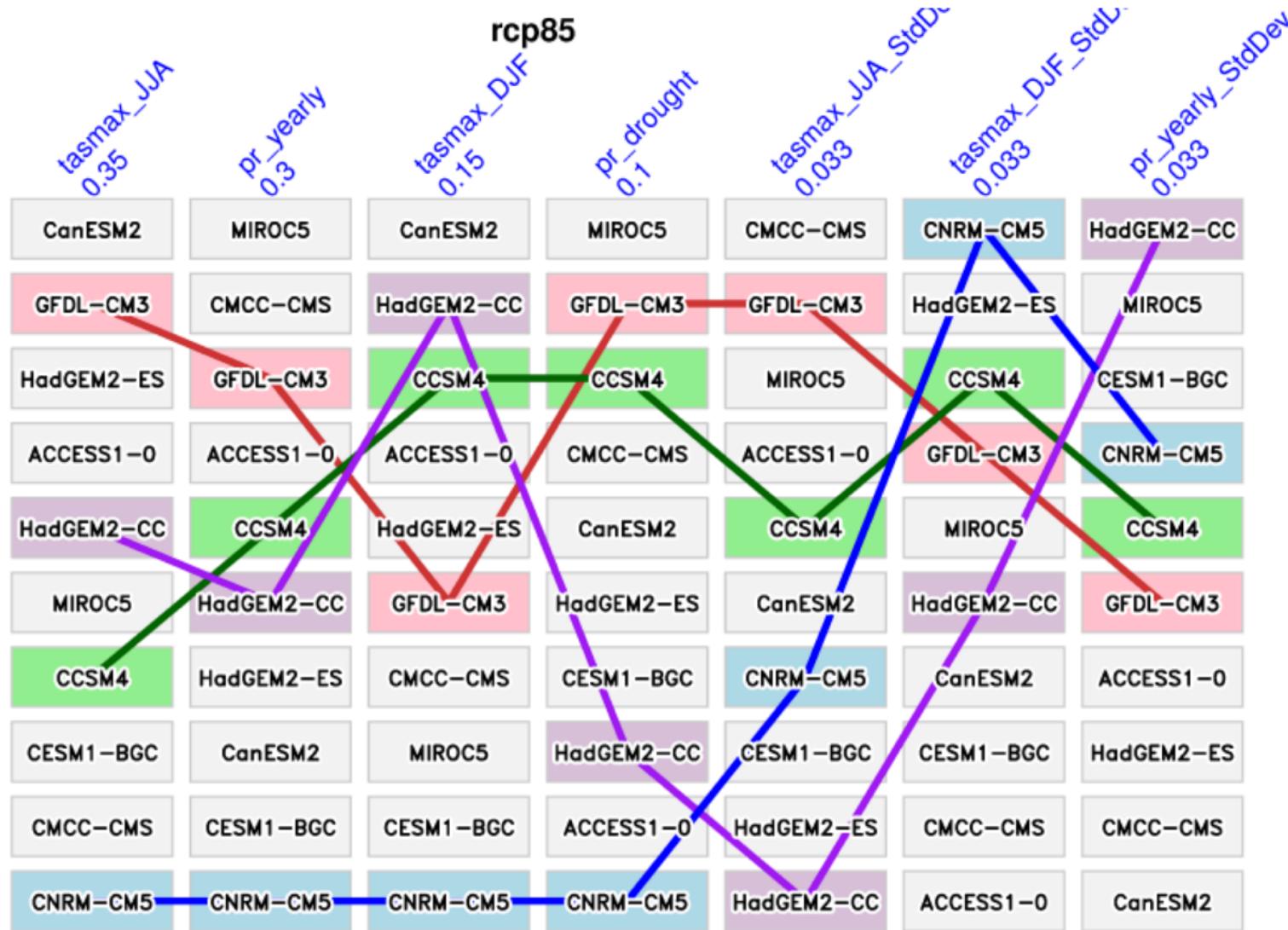


# LOCA: LOcally Constructed Analogs

- LOCA improves upon previous 'analog' downscaling methods, aims to preserve daily extremes and variability
- Analog techniques
  1. Identify historical days that are similar to GCM output
  2. Assume relationship between larger scale (regional) average temperature and local temperature at a station remains constant in time
  3. LOCA finds 30 observed days that best match a given model day in a  $1^{\circ}$  box around the station
  4. The best day of the 30 is scaled so the amplitude matches the model day



# Paring Down The Options: From 32 to 4



- Models were selected\* on the basis that they reasonably represented global and regional California climate
- Various metrics chosen, given weights
- Purpose is to reduce volume of GCM output to useable amount while keeping ‘best’ models

\*Selection process described by CA DWR Climate Change Technical Advisory Group 2015)

# Examples of Projections

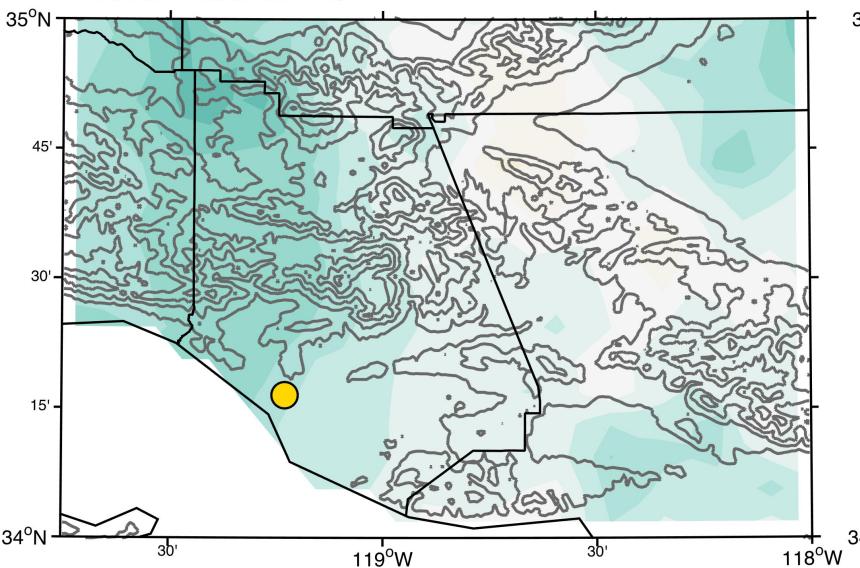
- Showing 4 best California models for RCP8.5 (business-as-usual emissions)
- Near-future (2020-2039); Mid-Century (2040-2069); Late-Century (2070-2069)
- Remark: *Late-Century projections may happen sooner than anticipated.*



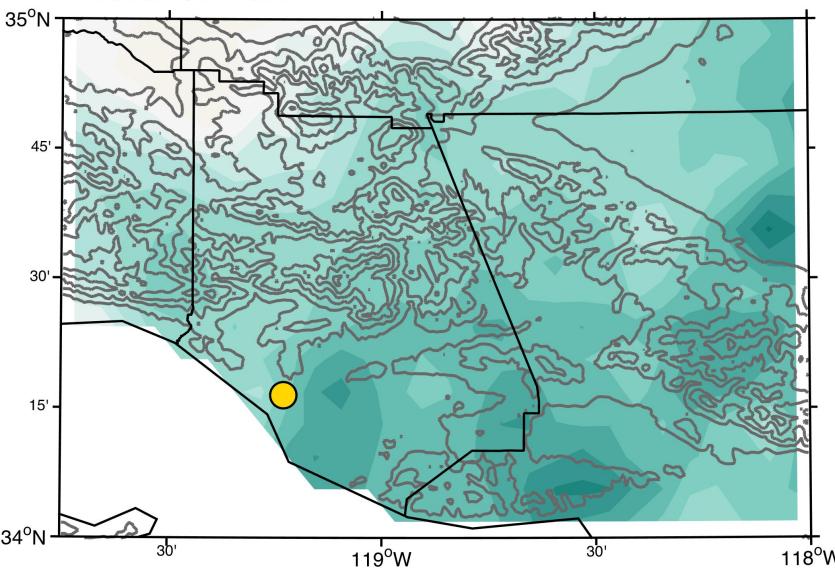
# Annual Precipitation

- Varies between models and time periods, most actually project an increase in annual average

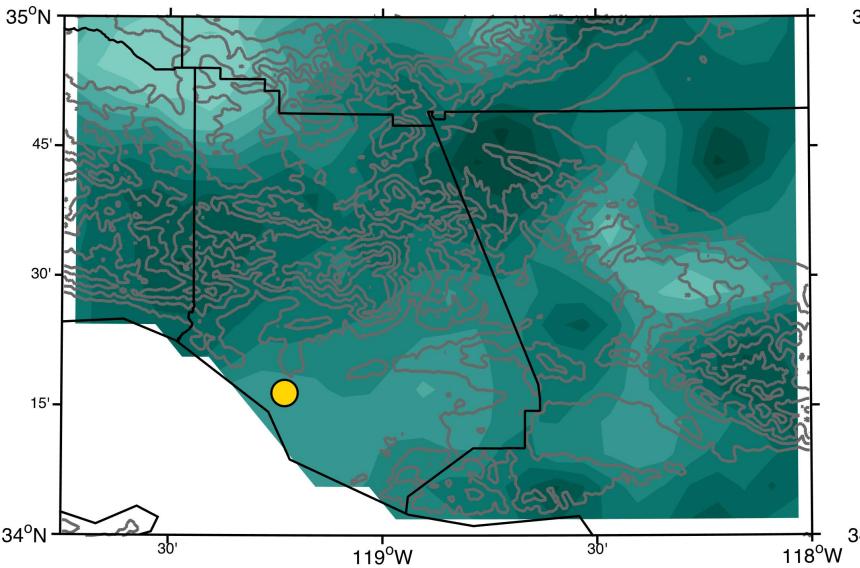
**Model: HadGEM2-ES**



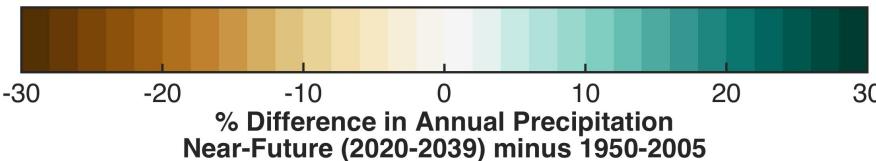
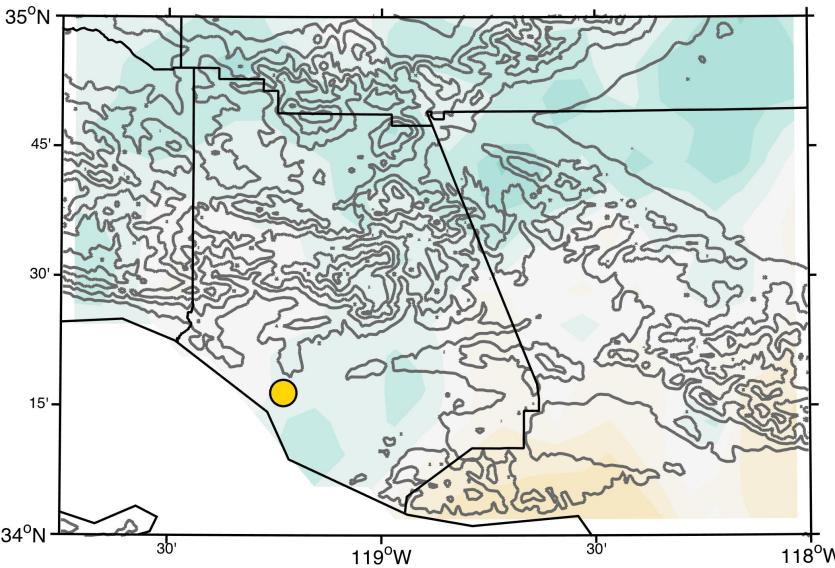
**Model: CanESM2**



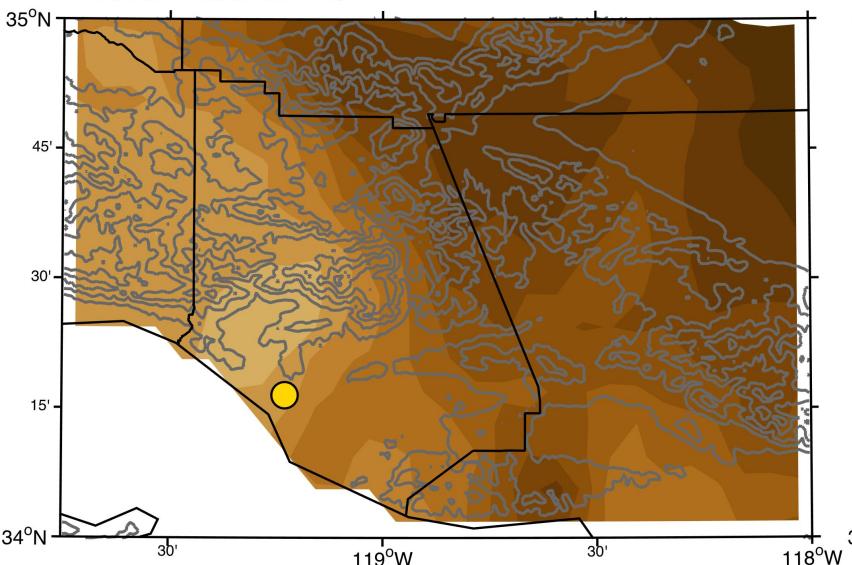
**Model: CNRM-CM5**



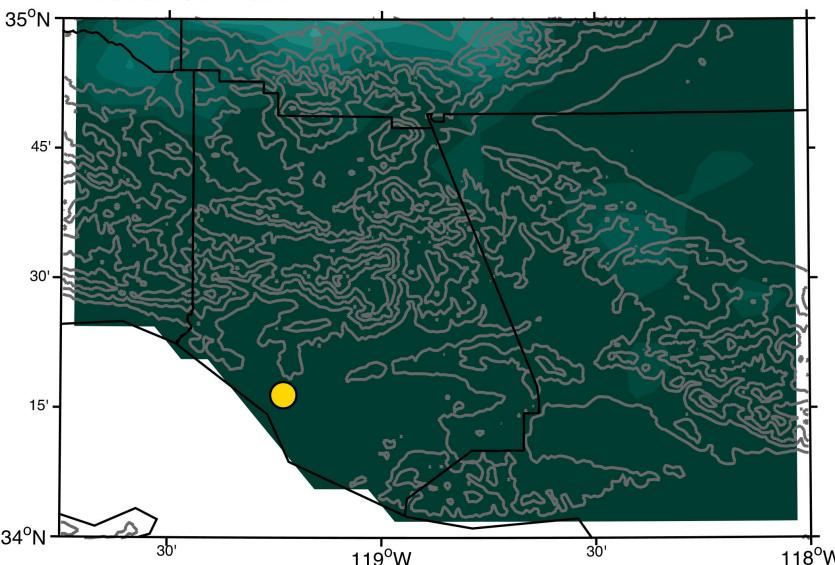
**Model: MIROC5**



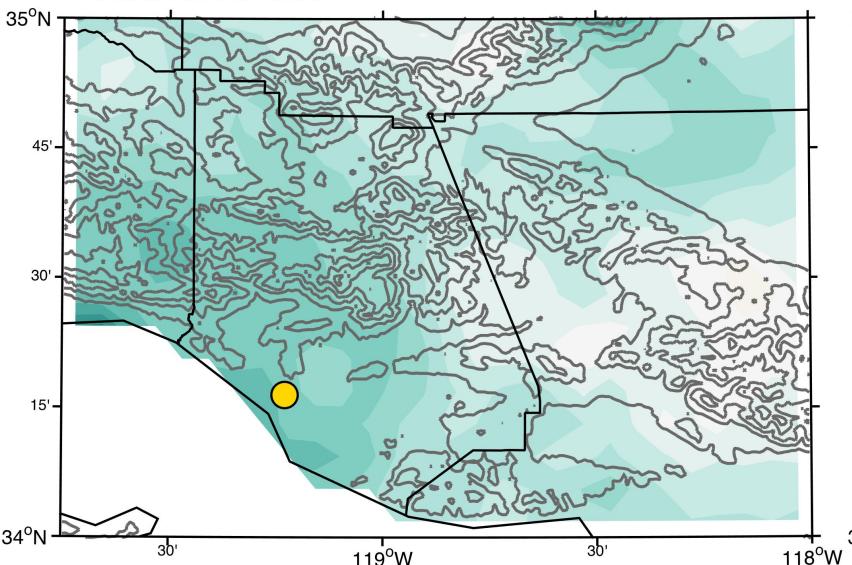
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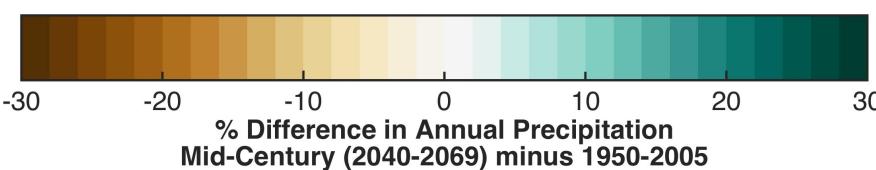
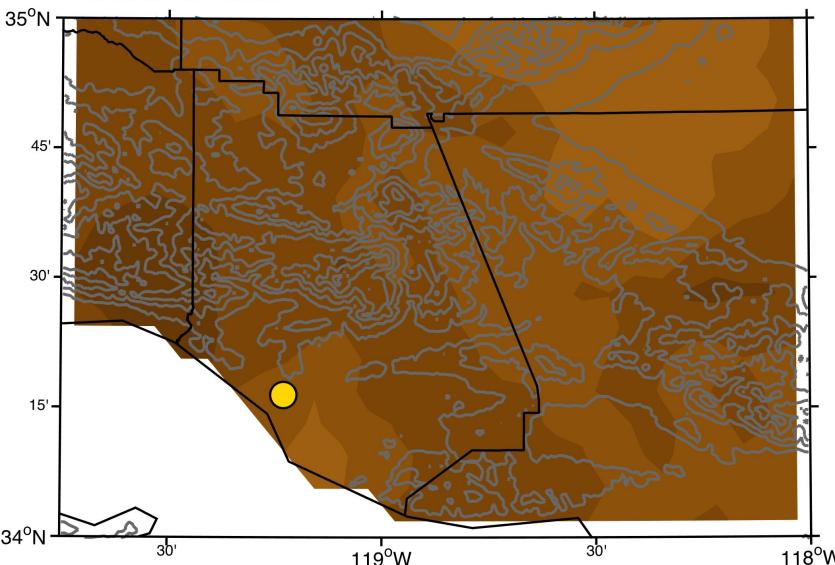
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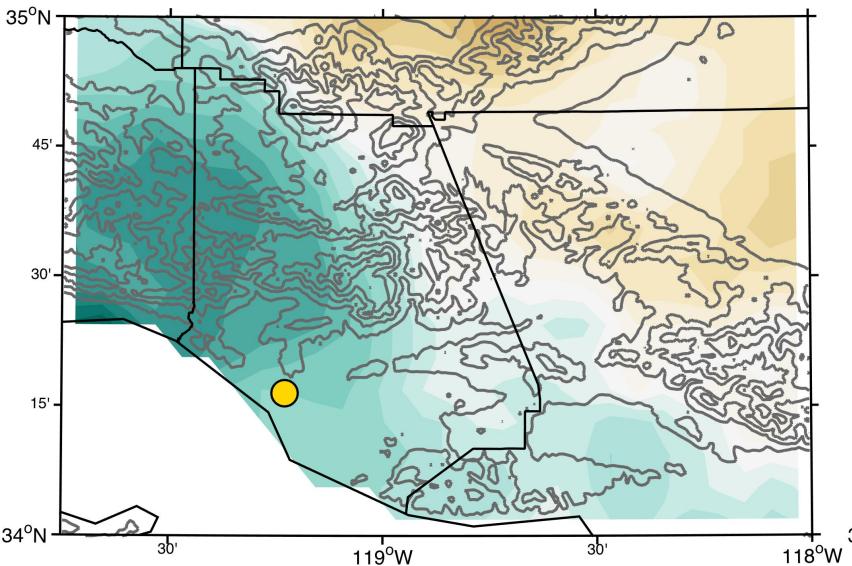
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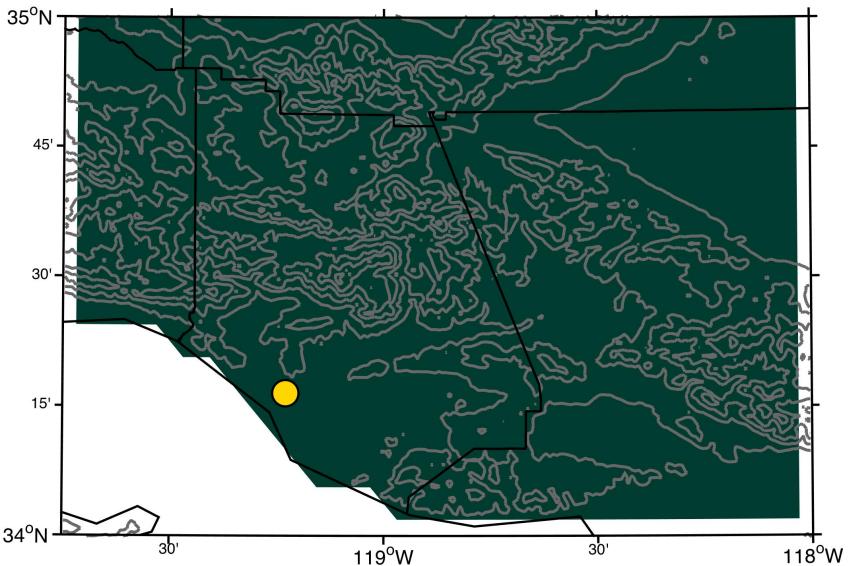
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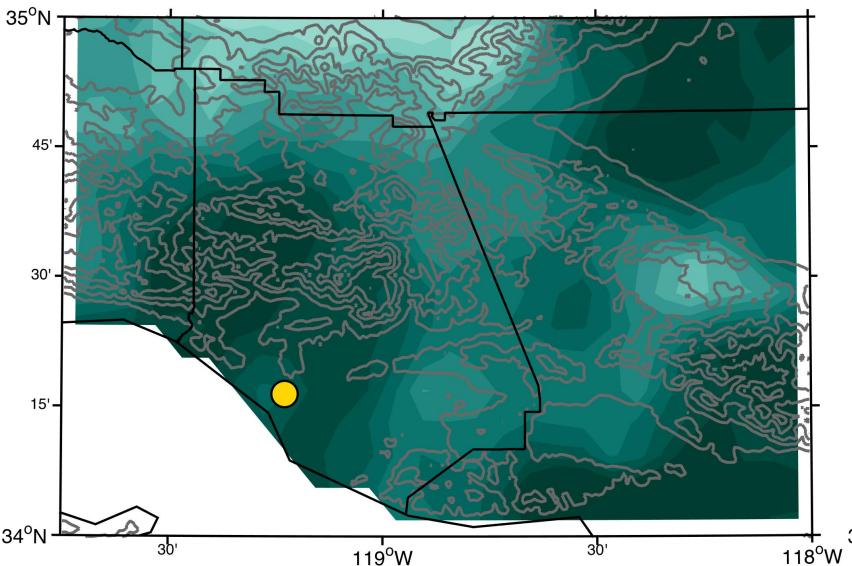
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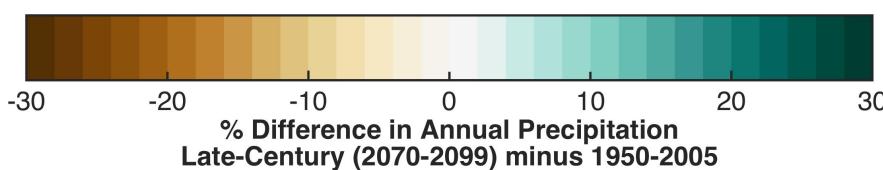
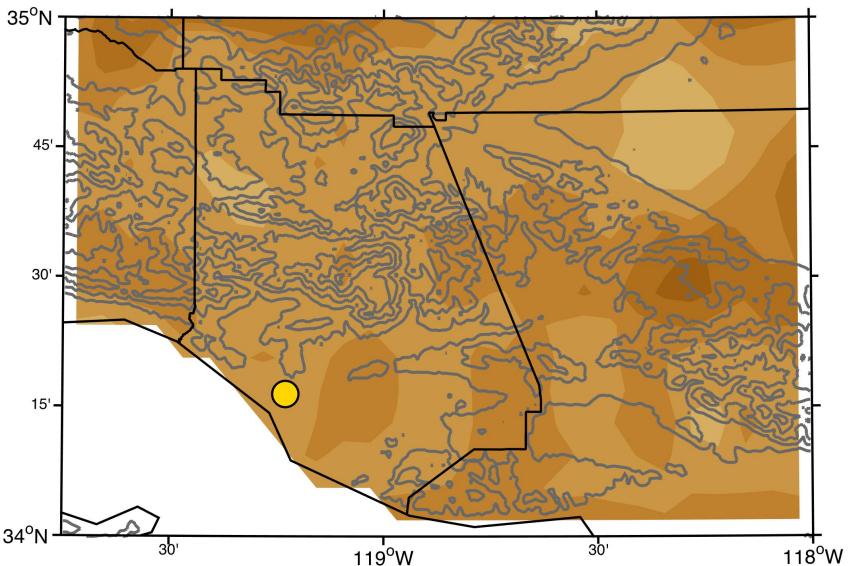
**Model: CanESM2**



**Model: CNRM-CM5**



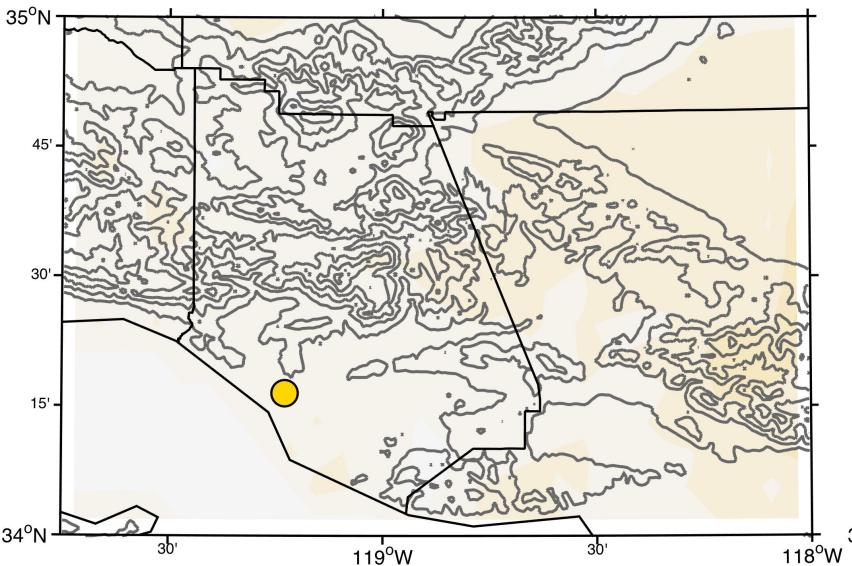
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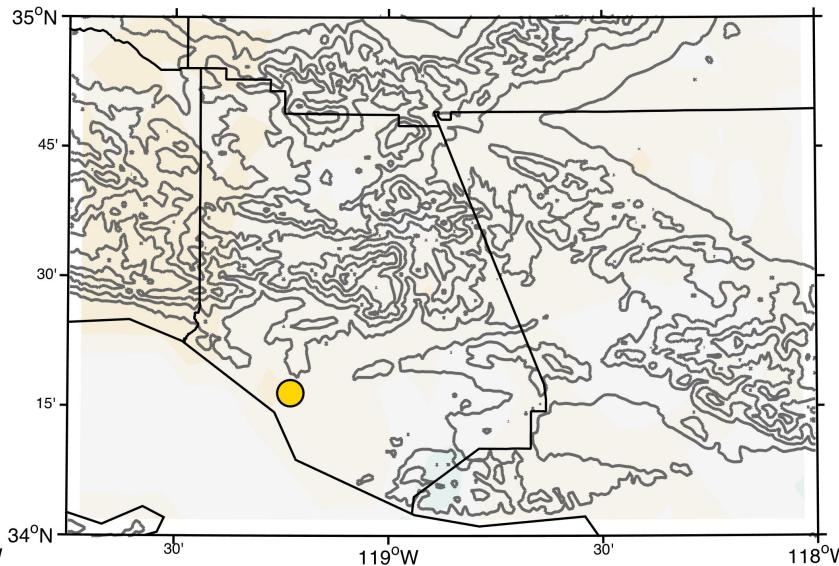
# Changes in Annual Average Number of Dry (Precip = 0) Days

- Polade et al (2014) *Nat. Sci. Rep.* identified dry day changes as a key way in which midlatitude climates will change under warming
- In dryland environments that depend on a few large storms (i.e., SoCal) more dry days = less opportunities for precipitation

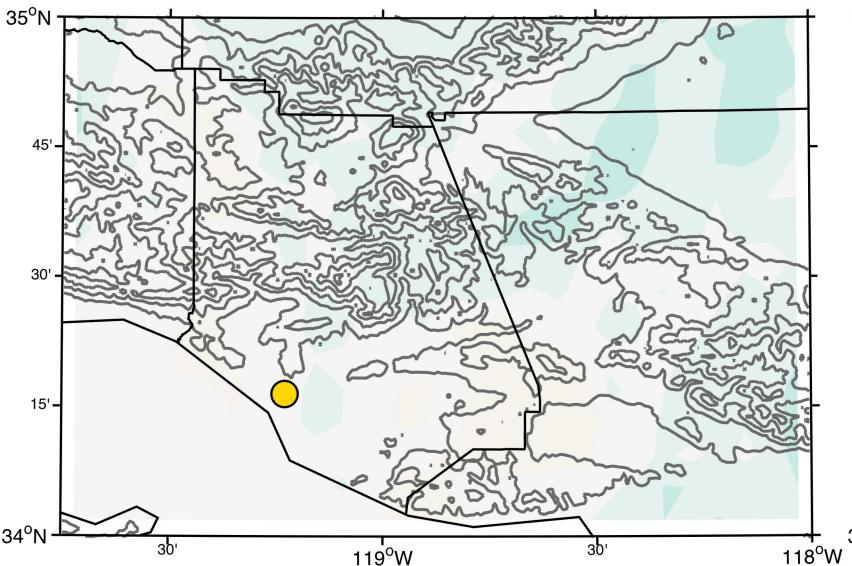
**Model: HadGEM2-ES**



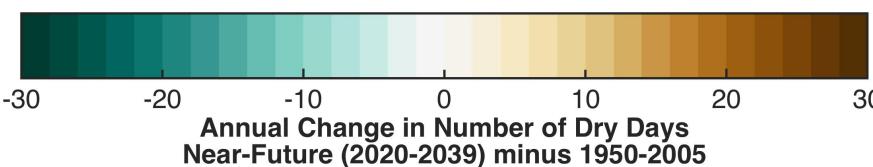
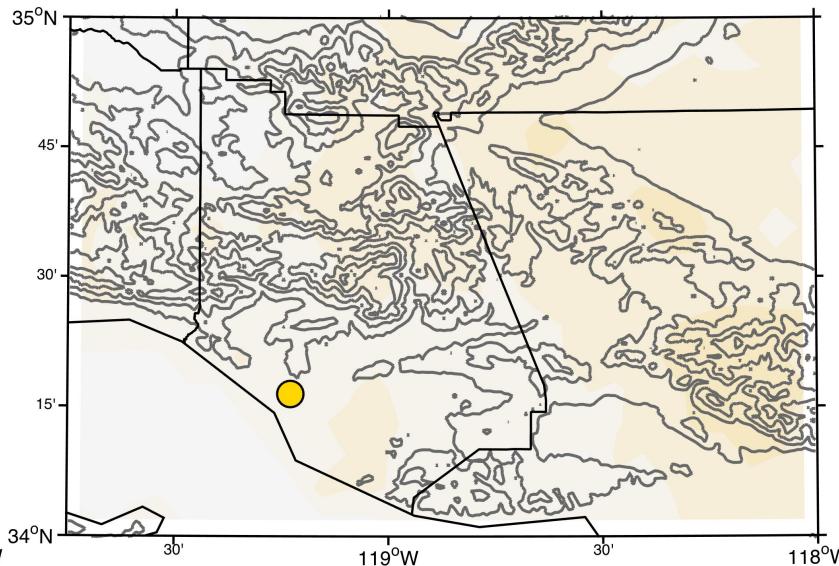
**Model: CanESM2**



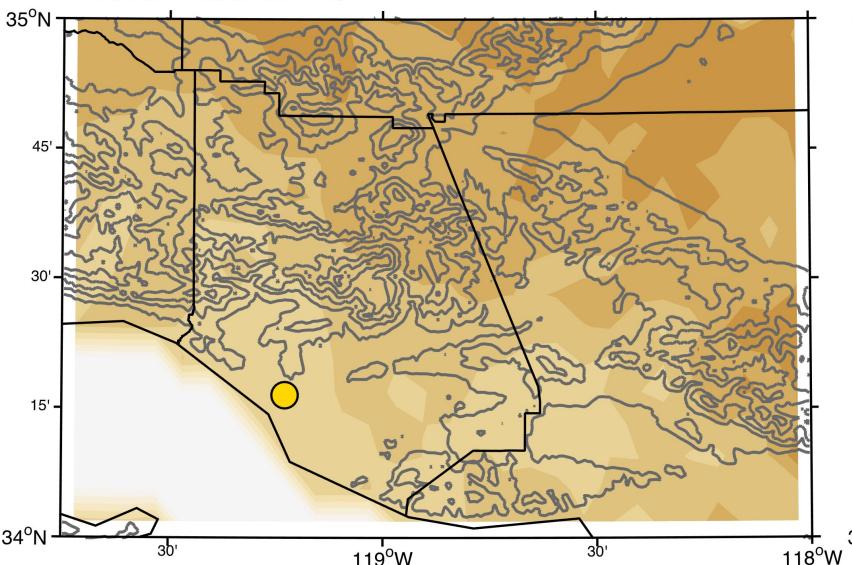
**Model: CNRM-CM5**



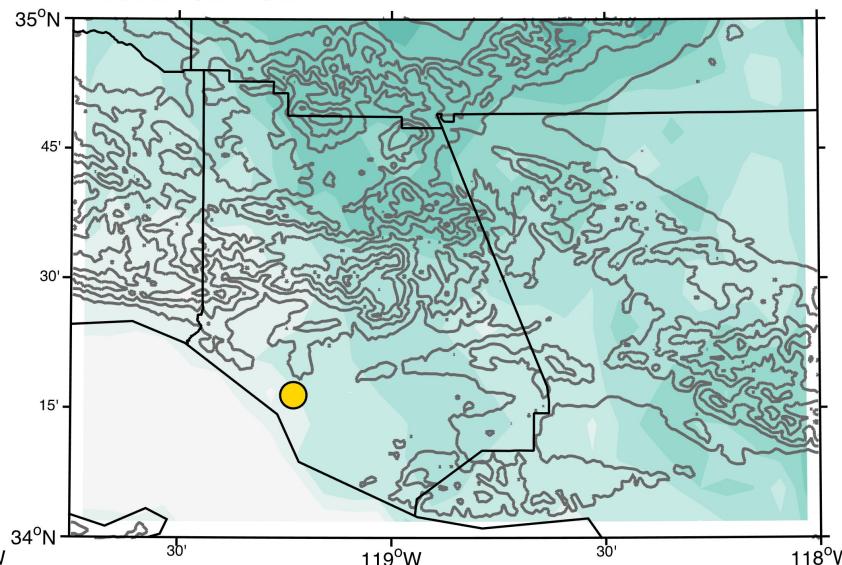
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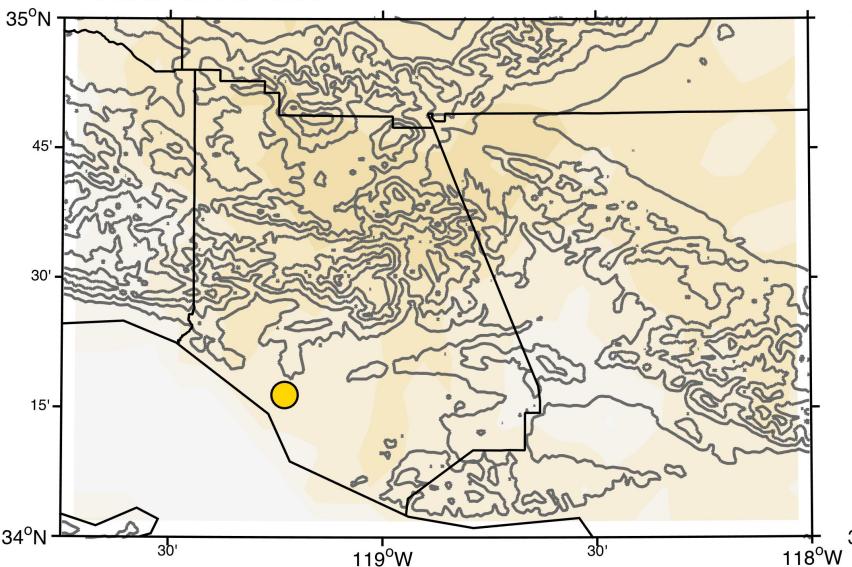
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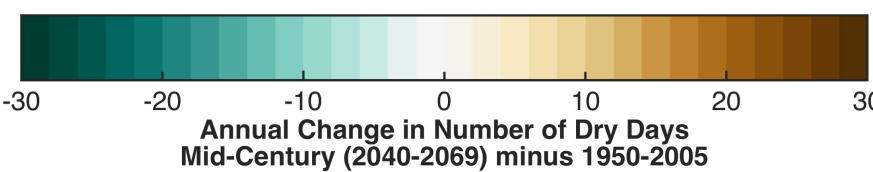
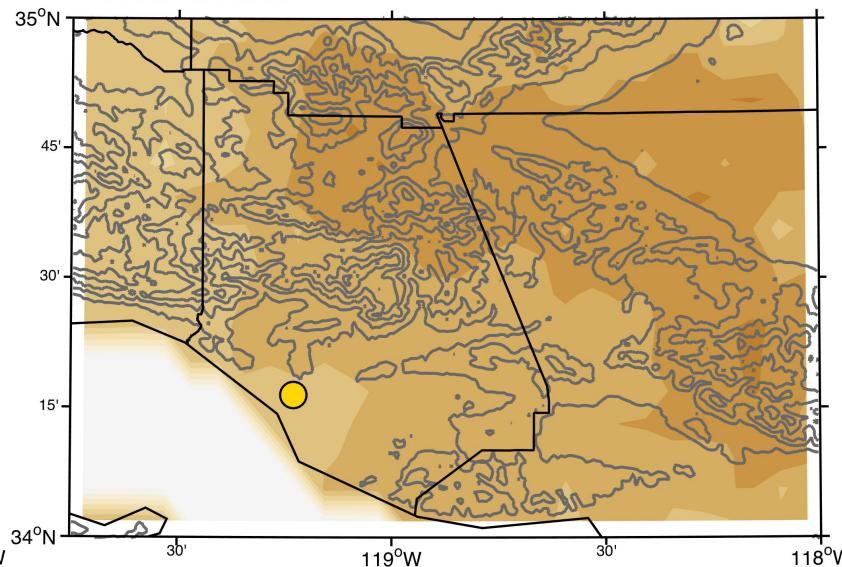
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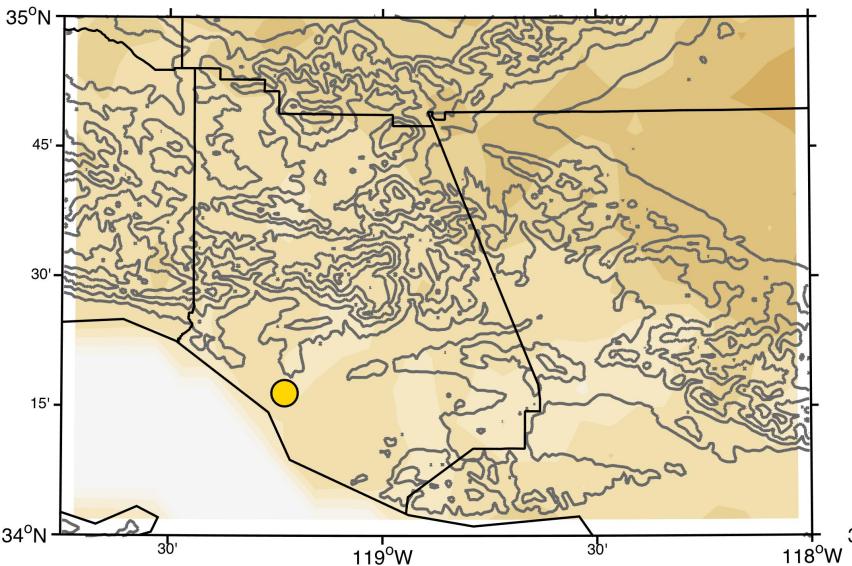
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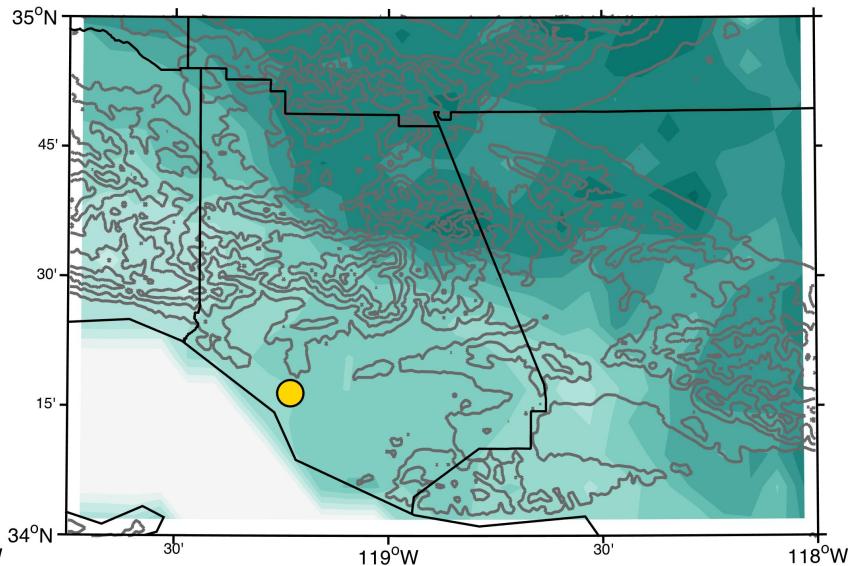
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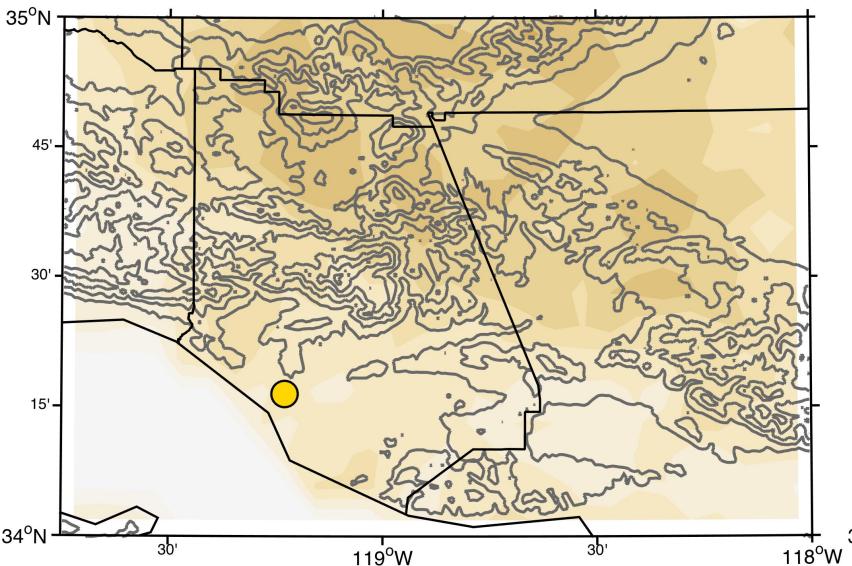
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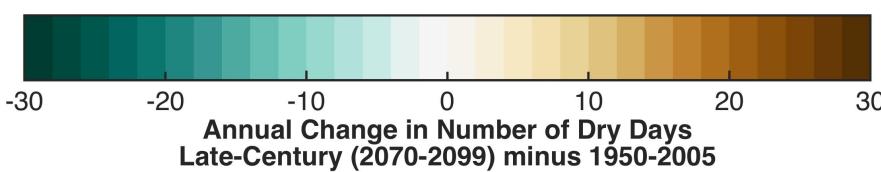
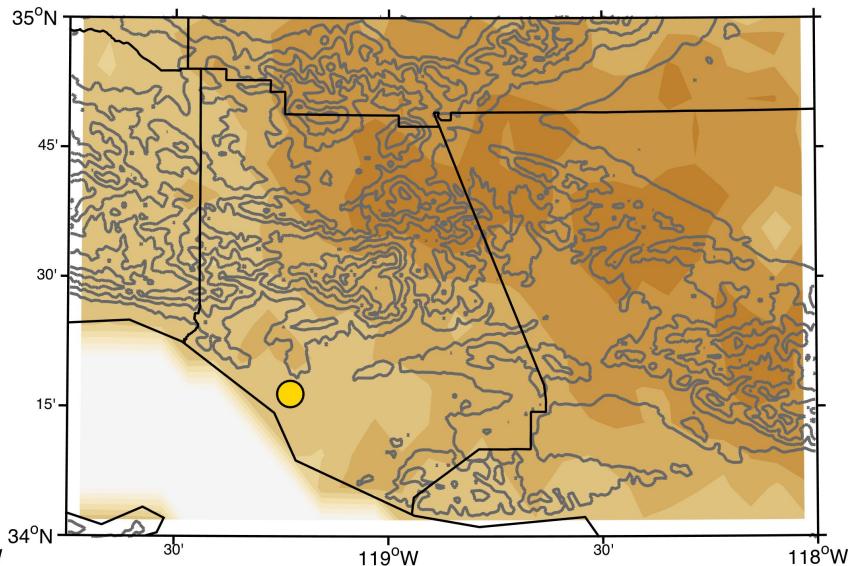
Model: CanESM2



Model: CNRM-CM5



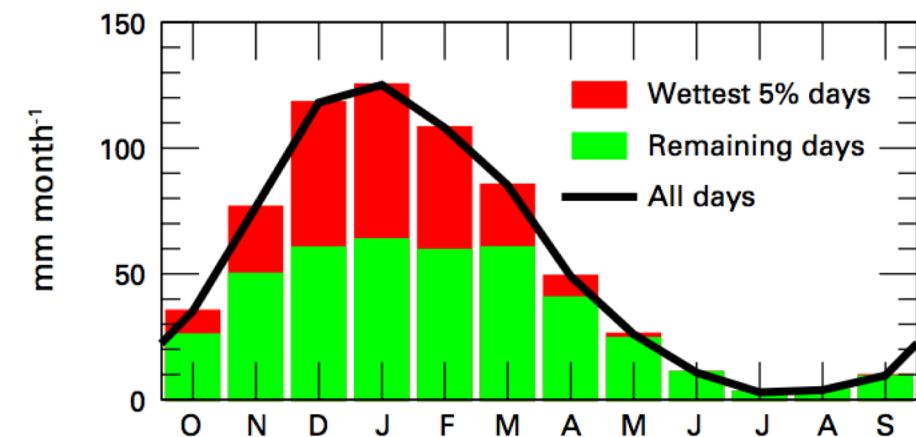
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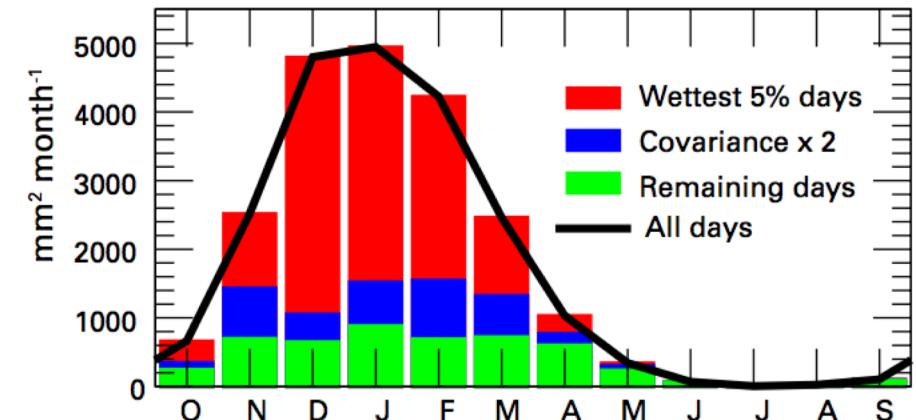
# Changes in Contribution of Wettest Days (Top 5%) to Annual Precipitation

- Dettinger (2016) SFEWS showed how interannual precipitation variability in CA is driven by wettest 5% of days (~80% of variance) →
- Increasing contribution is consistent with bigger storms and increased flooding likelihood

**A) Monthly Mean Contributions to Total Precipitation**

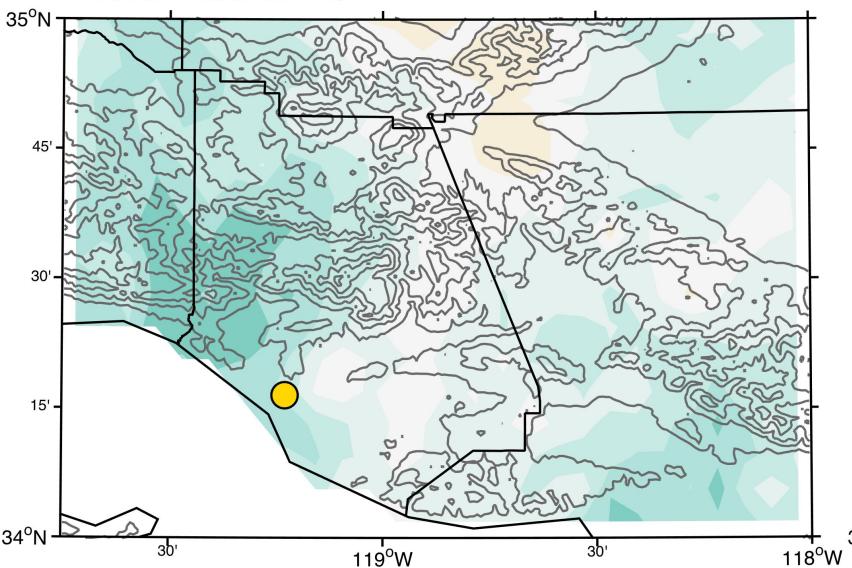


**B) Monthly Variance of Contributions to Total Precipitation**

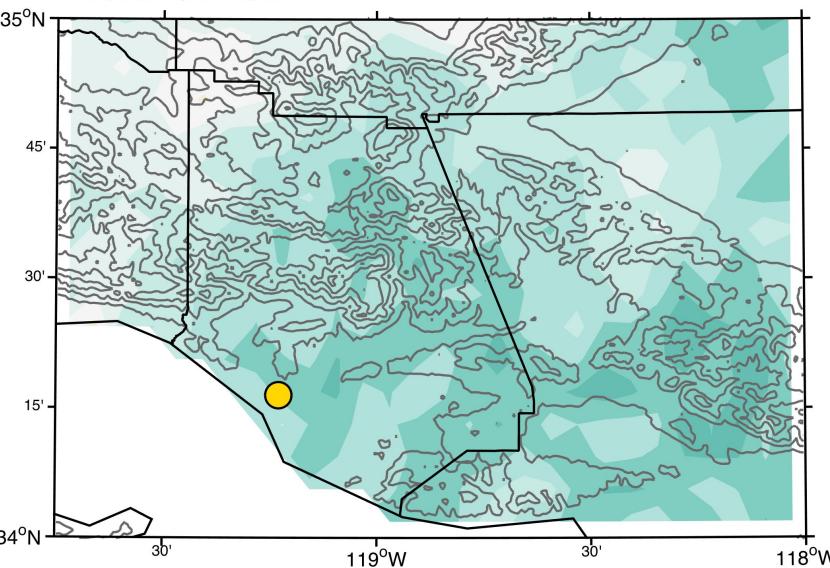


**Figure 4** Seasonality of monthly **(A)** means and **(B)** variances of Central Valley catchment's total precipitation and contributions from the wettest 5% of wet days and remaining days, water years 1916–2010

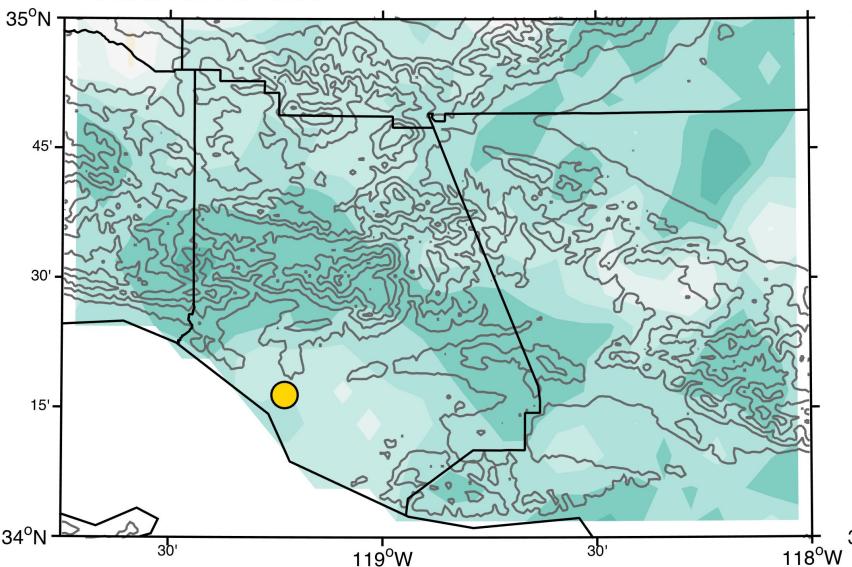
Model: HadGEM2-ES



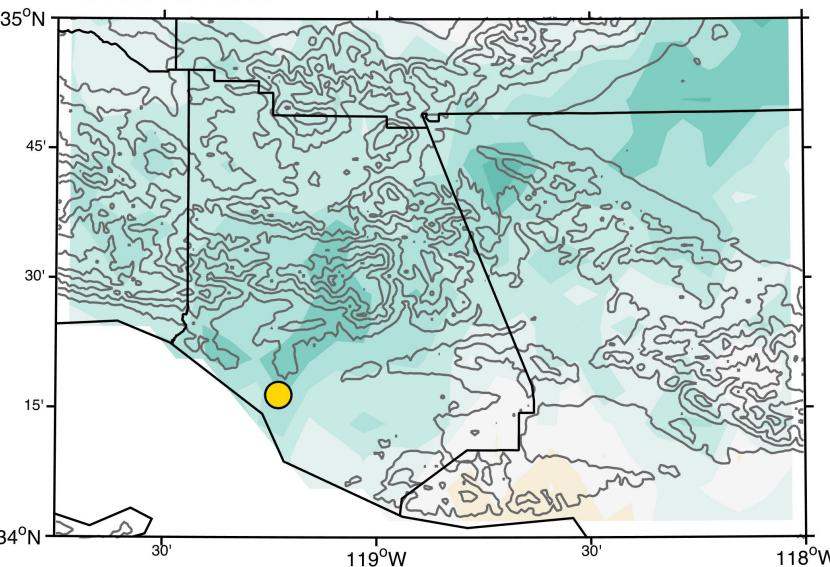
Model: CanESM2



Model: CNRM-CM5

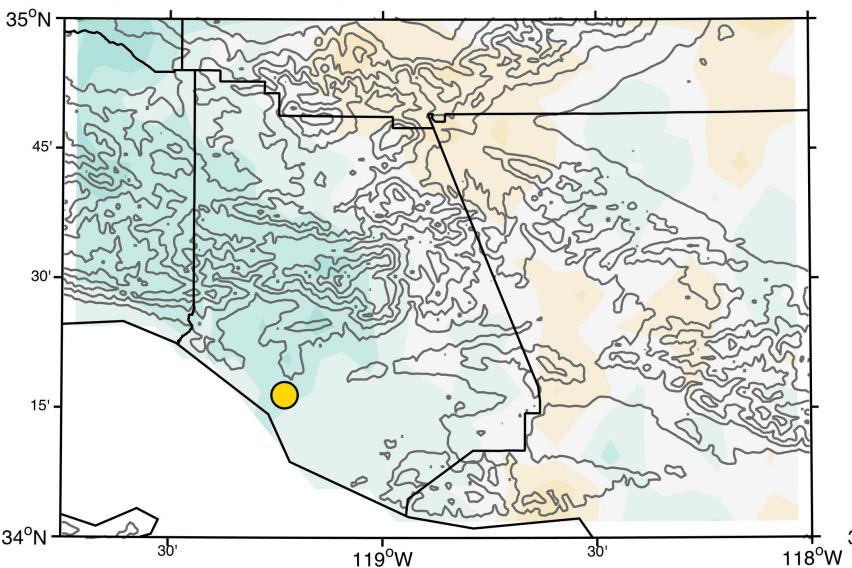


Model: MIROC5

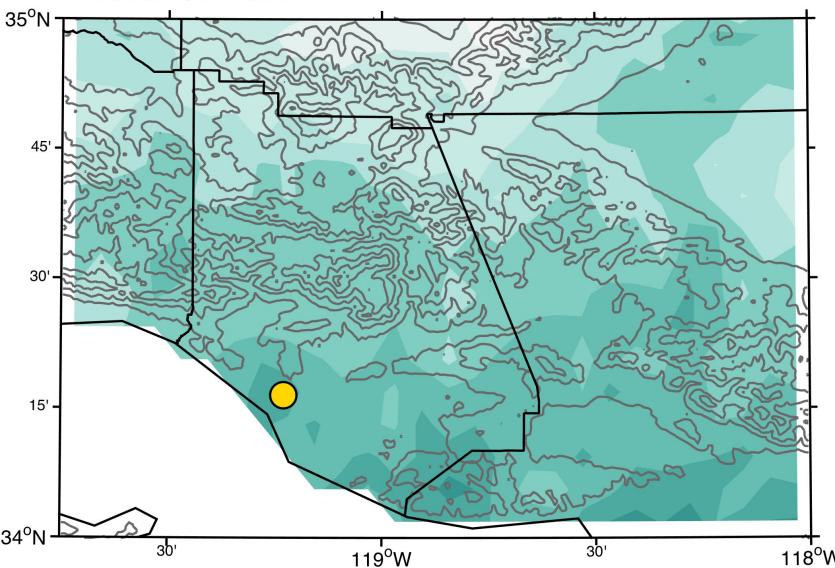


-30      -20      -10      0      10      20      30  
% Change in Contribution of Wettest 5% Days to Annual Precipitation  
Near-Future (2020-2039) minus 1950-2005

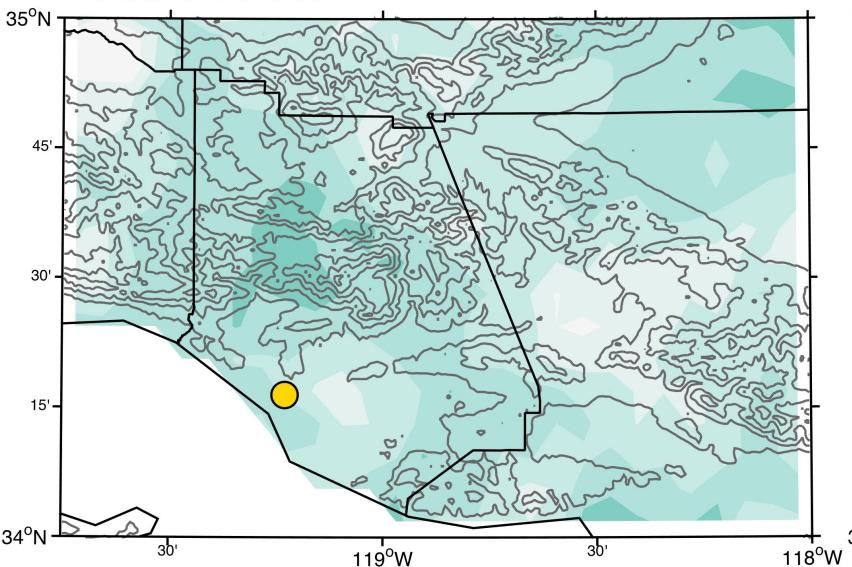
**Model: HadGEM2-ES**



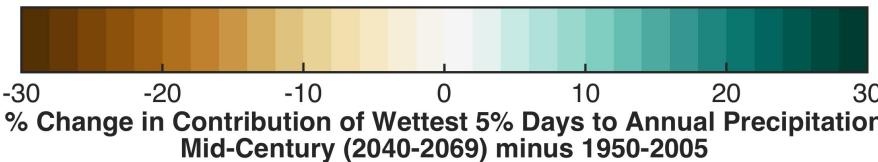
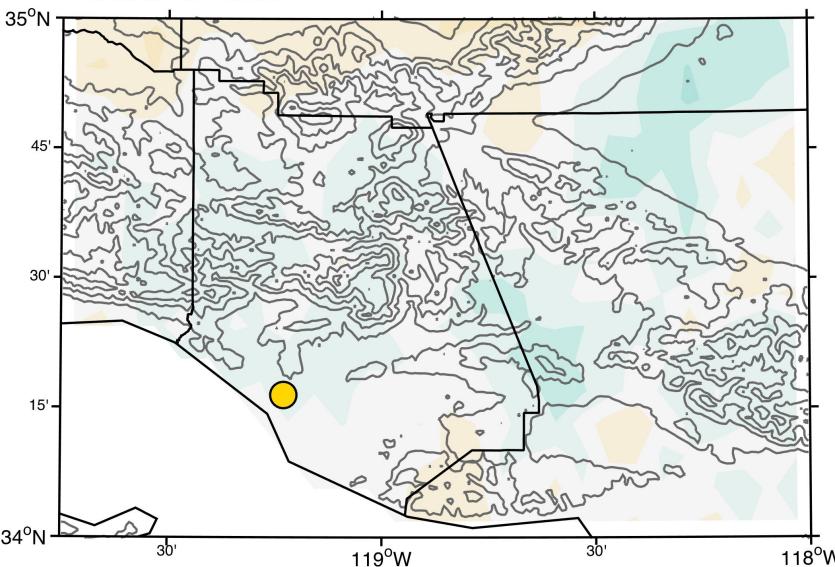
**Model: CanESM2**



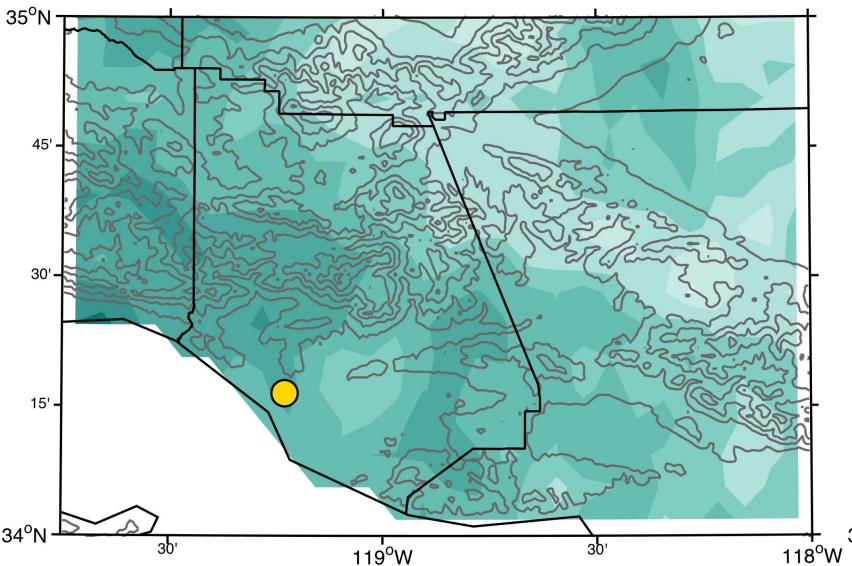
**Model: CNRM-CM5**



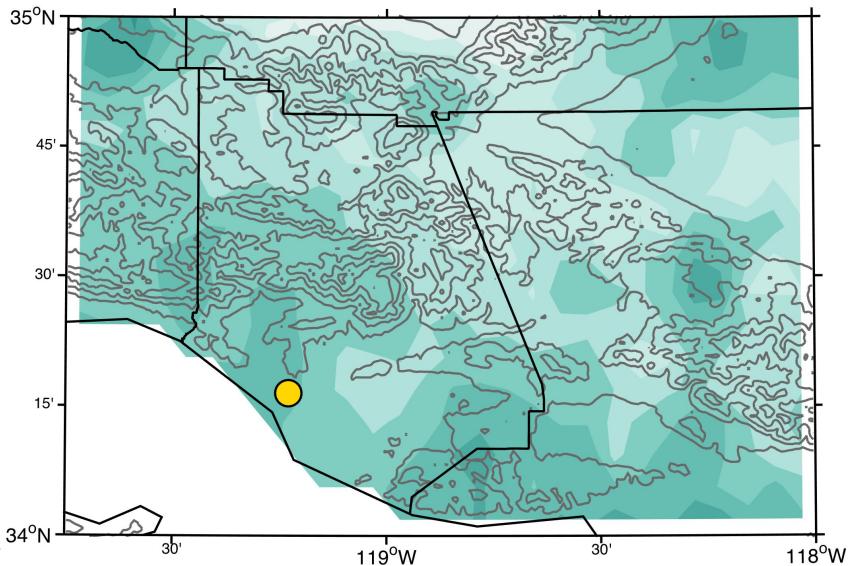
**Model: MIROC5**



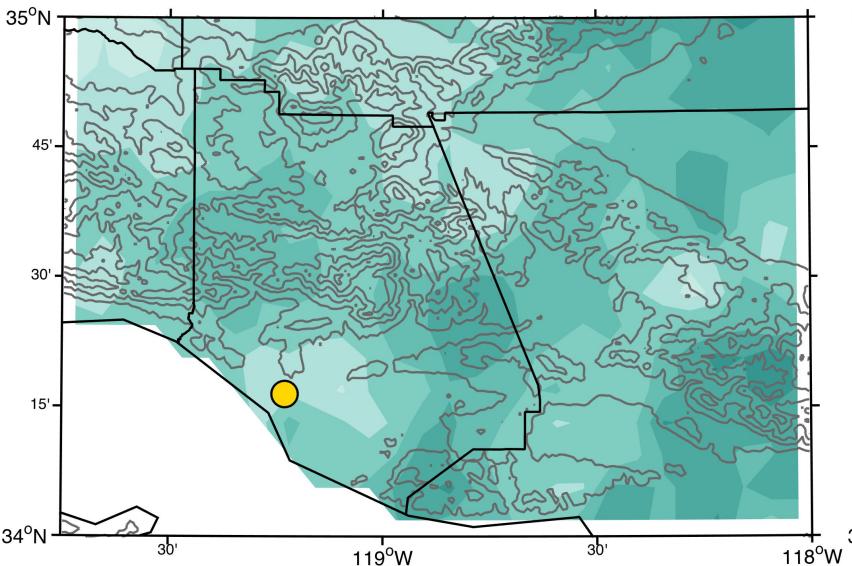
Model: HadGEM2-ES



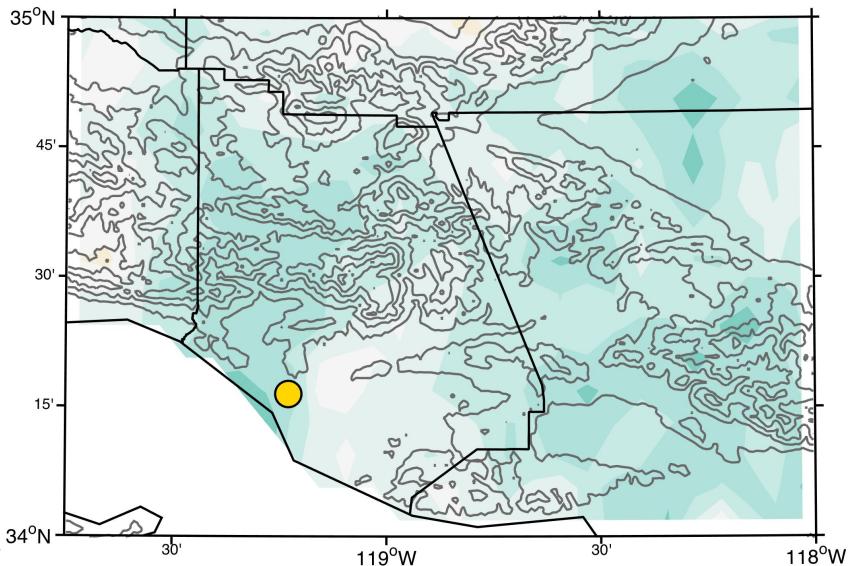
Model: CanESM2



Model: CNRM-CM5



Model: MIROC5

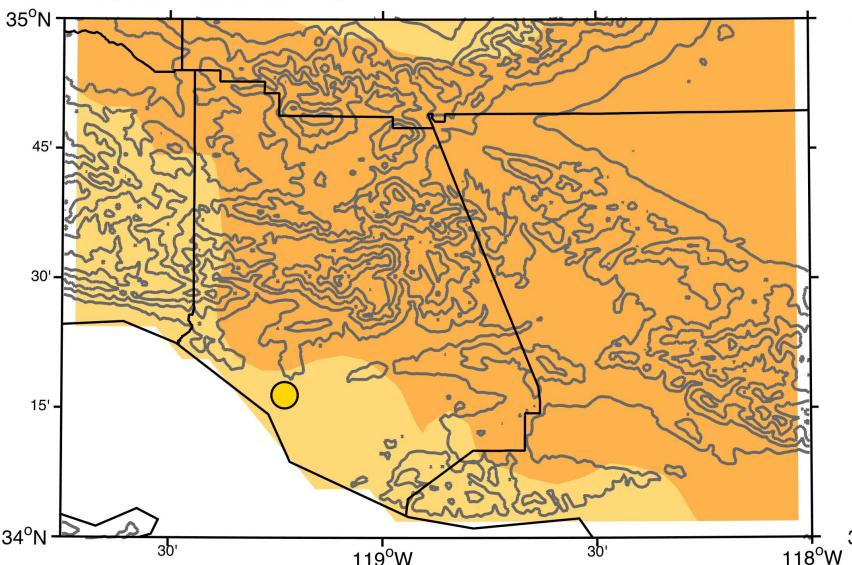


-30 -20 -10 0 10 20 30  
% Change in Contribution of Wettest 5% Days to Annual Precipitation  
Late-Century (2070-2099) minus 1950-2005

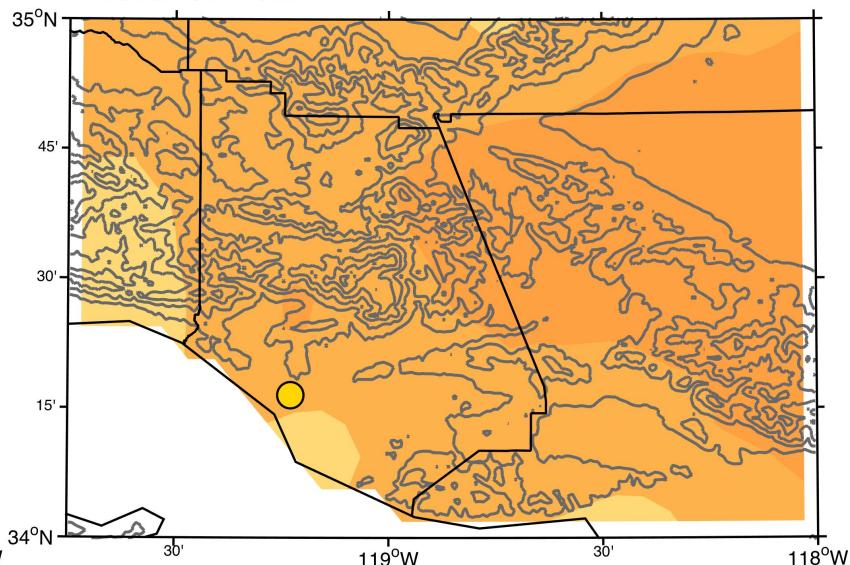
# Temperature Changes

- Whereas precipitation projections are varied/uncertain, temperature projections are much more consistent for both maximum and minimum temperature
- The ‘drier future’ concept is largely temperature-driven due to atmospheric water demand from higher temperatures

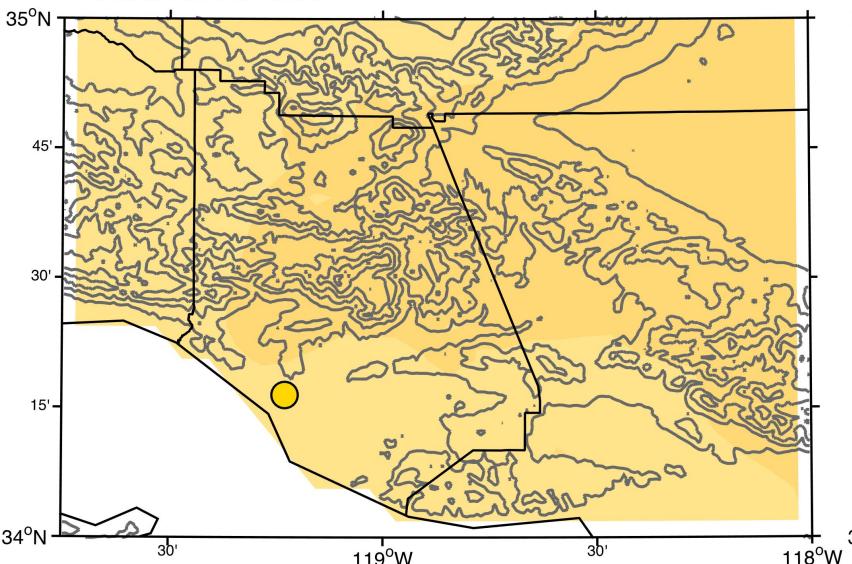
**Model: HadGEM2-ES**



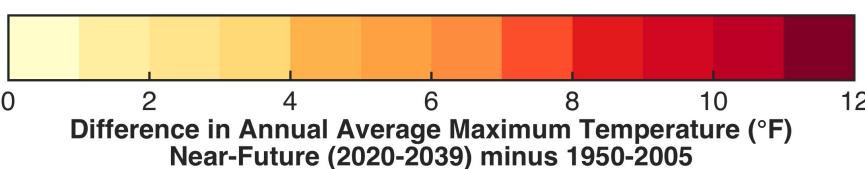
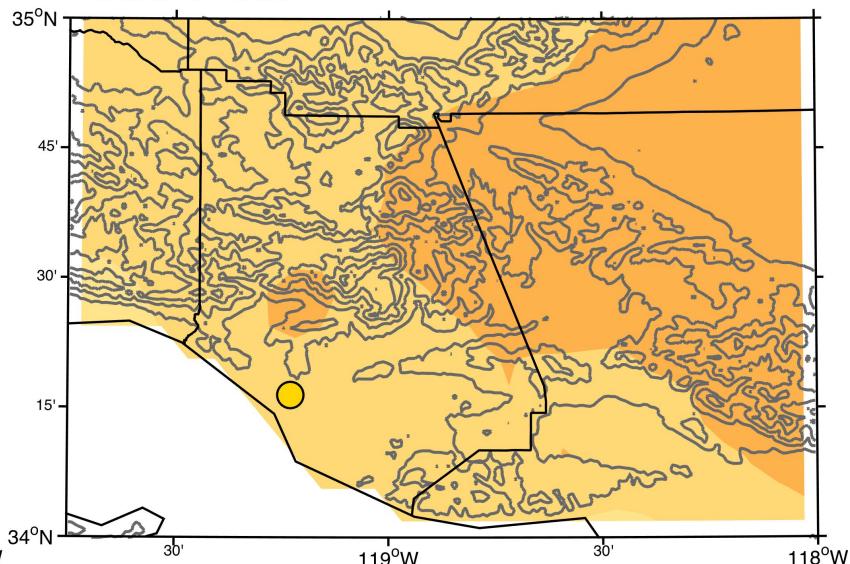
**Model: CanESM2**



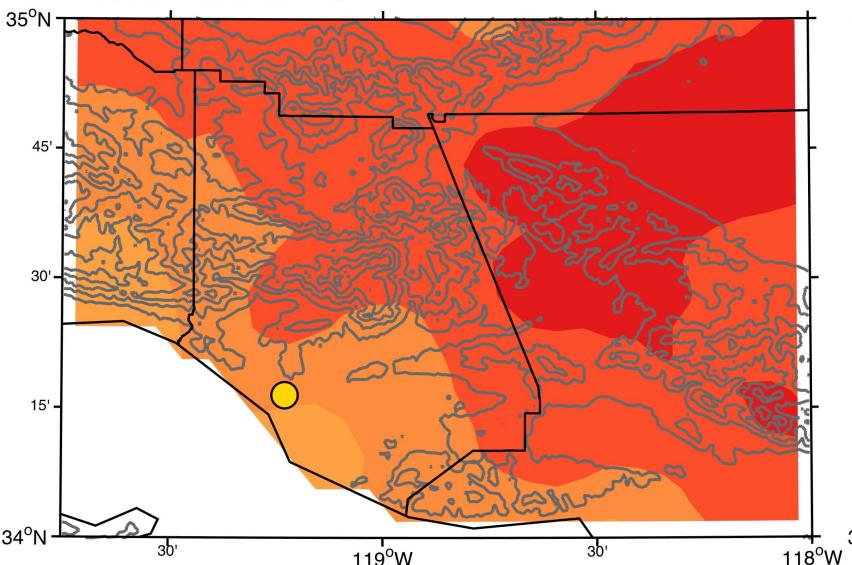
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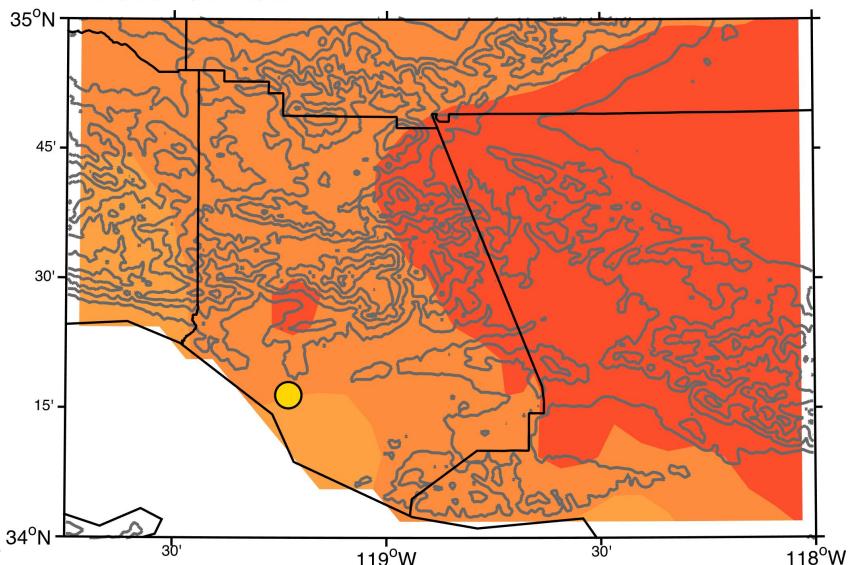
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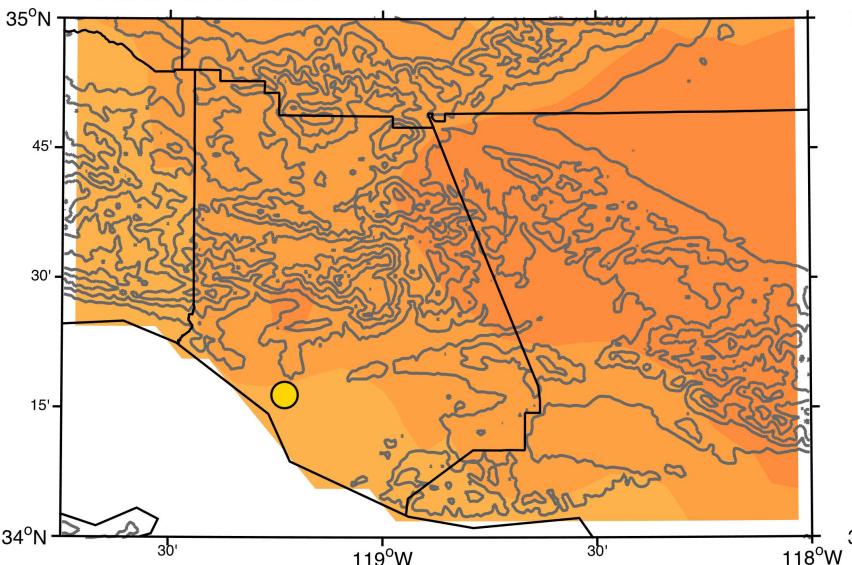
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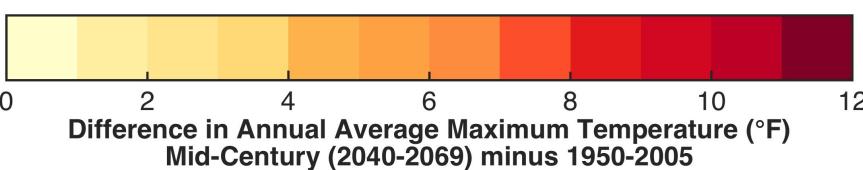
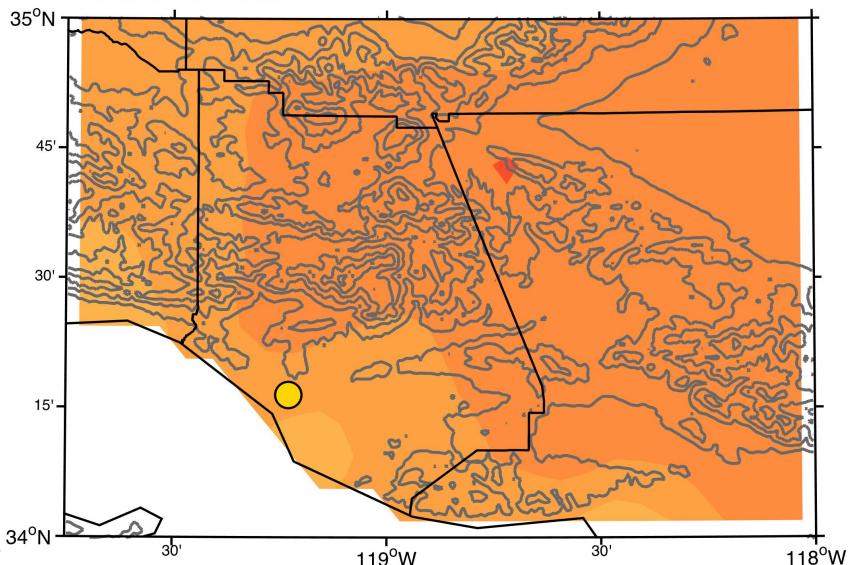
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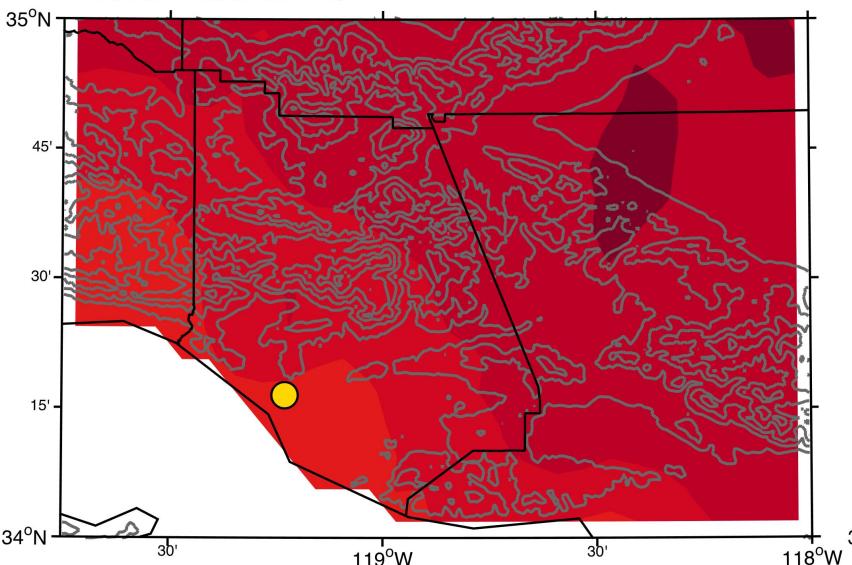
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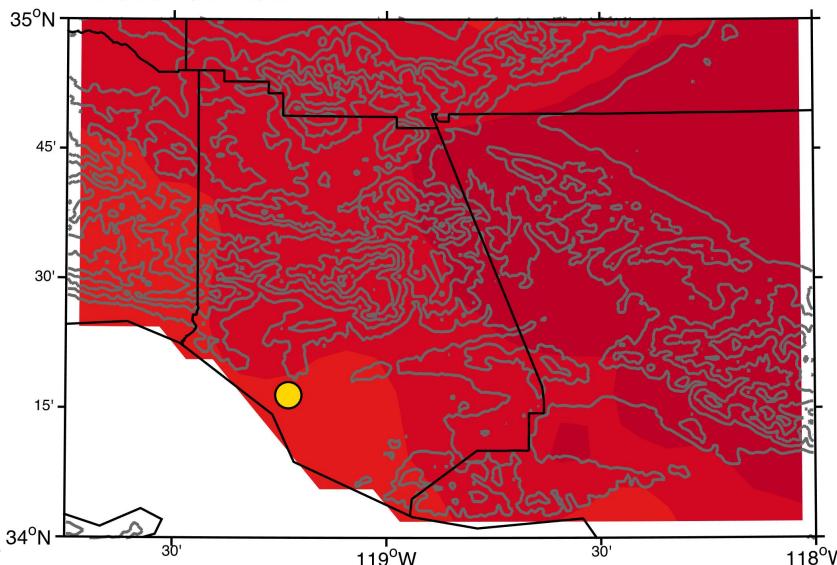
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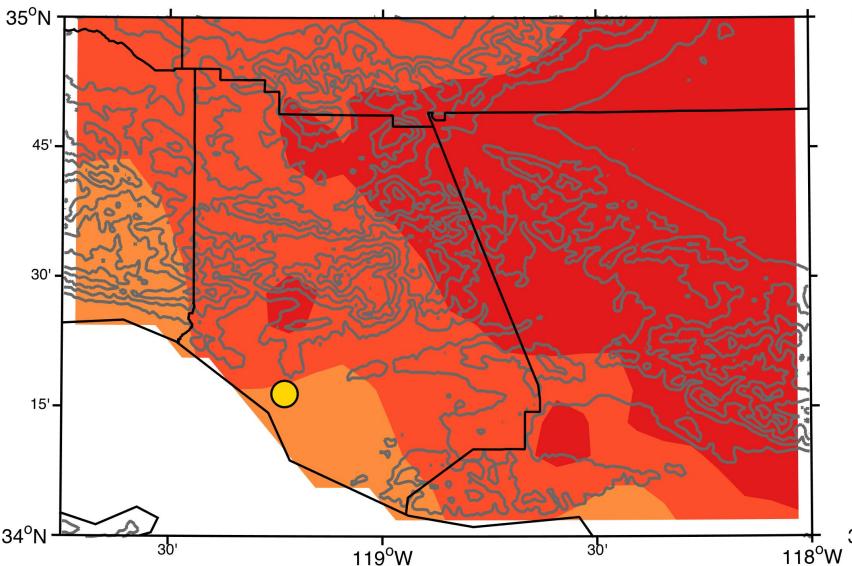
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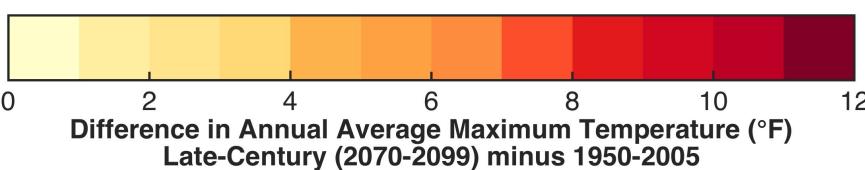
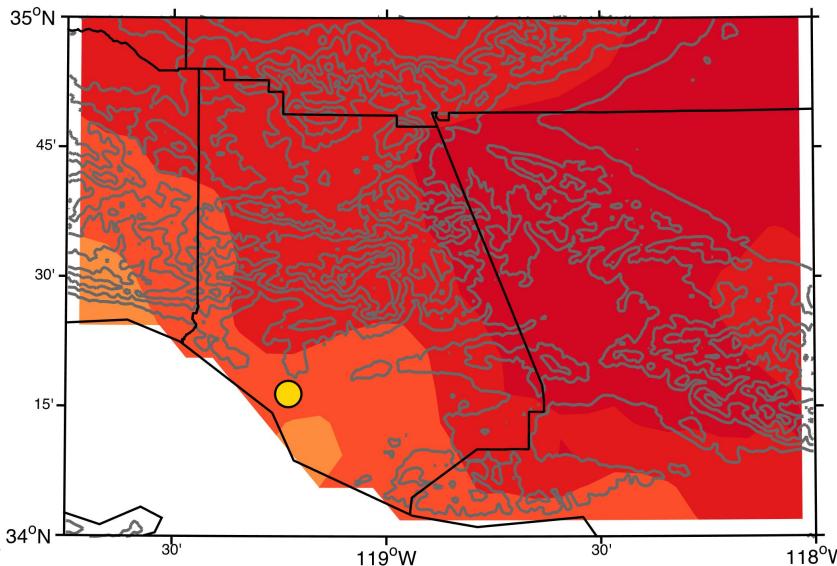
Model: CanESM2



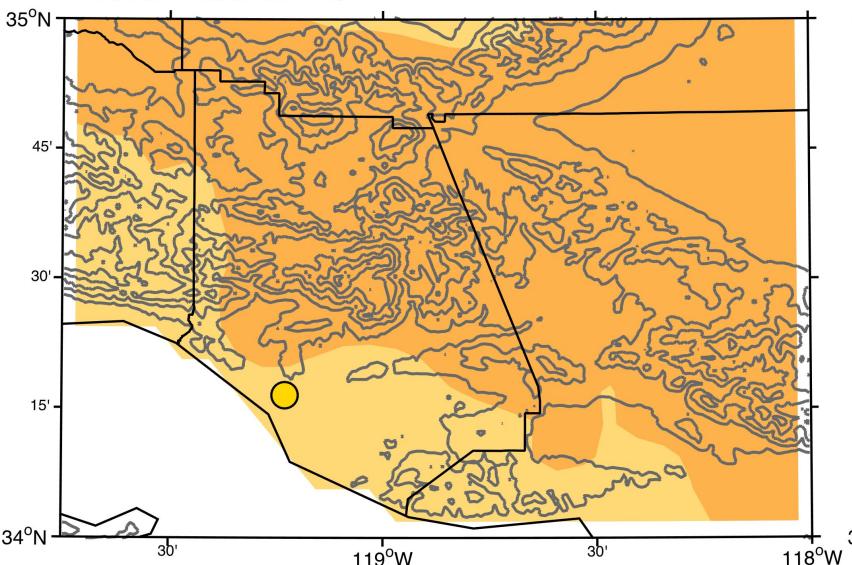
Model: CNRM-CM5



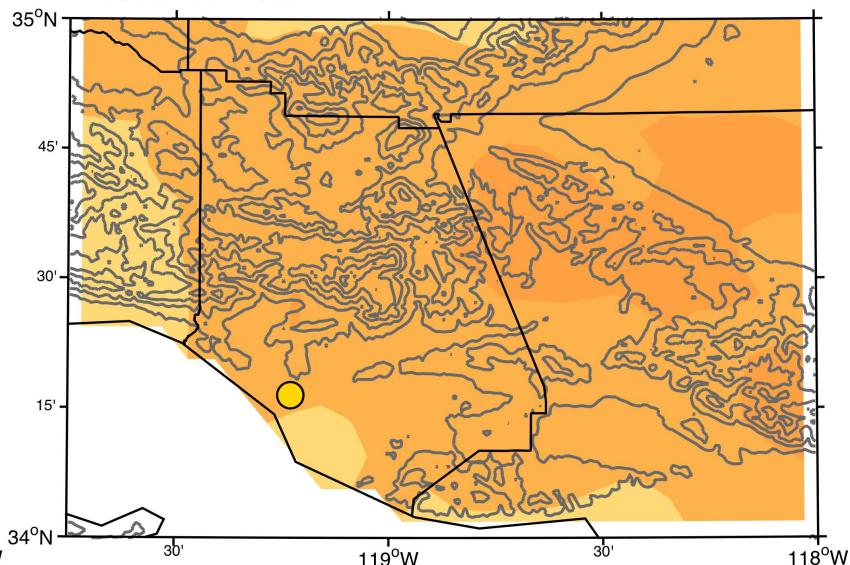
Model: MIROC5



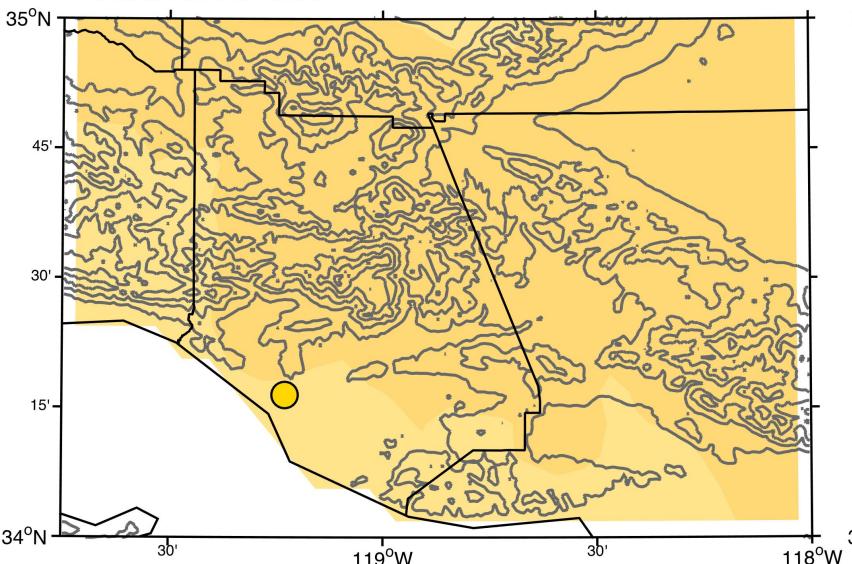
Model: HadGEM2-ES



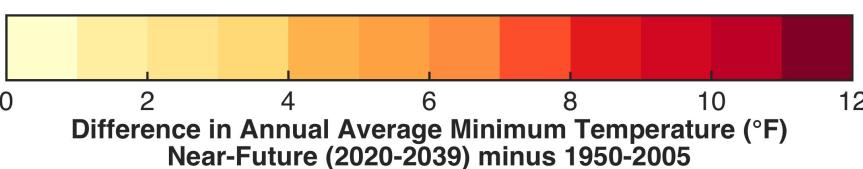
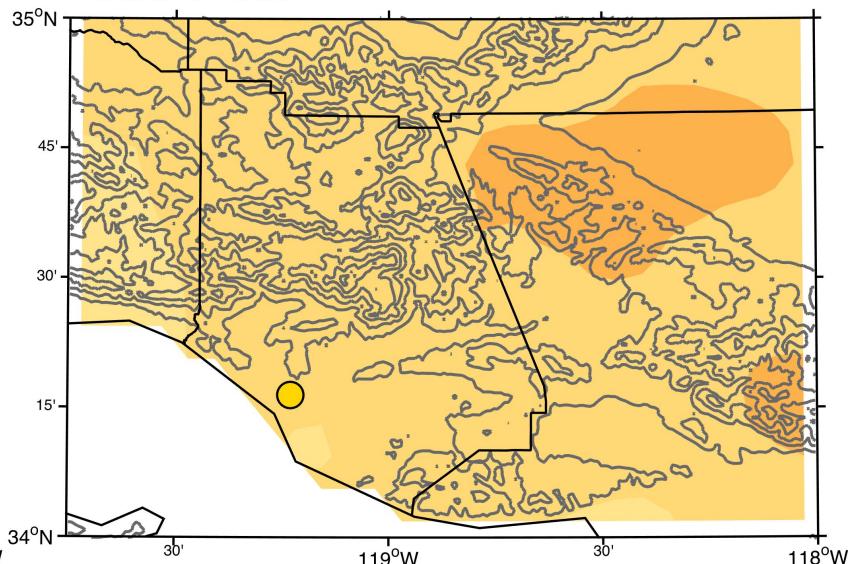
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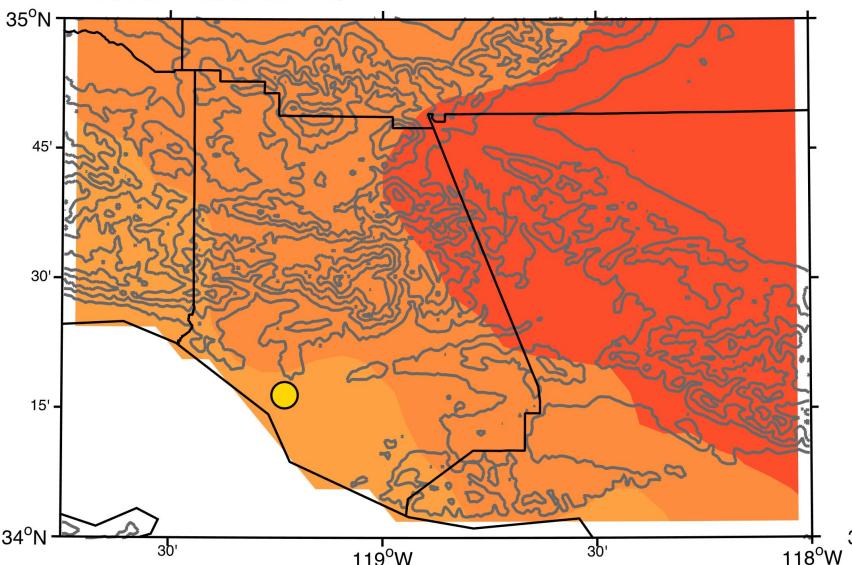
Model: CNRM-CM5



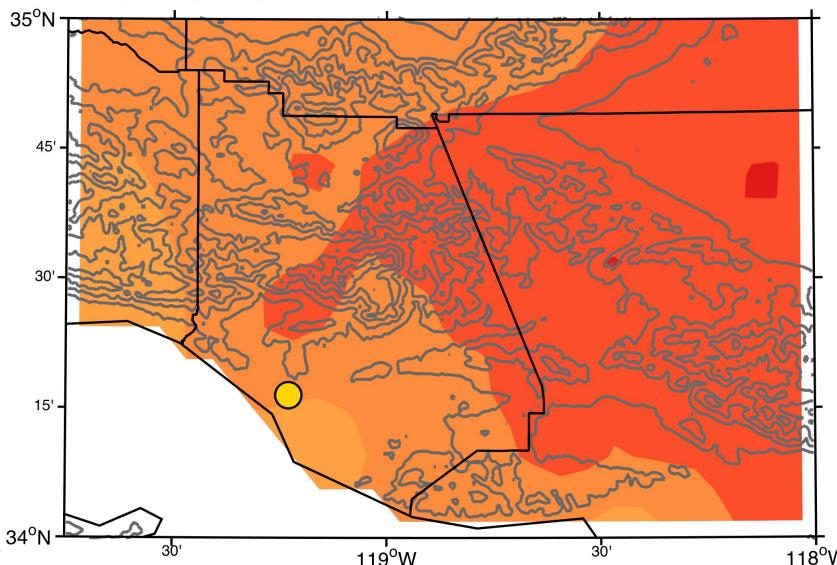
Model: MIROC5



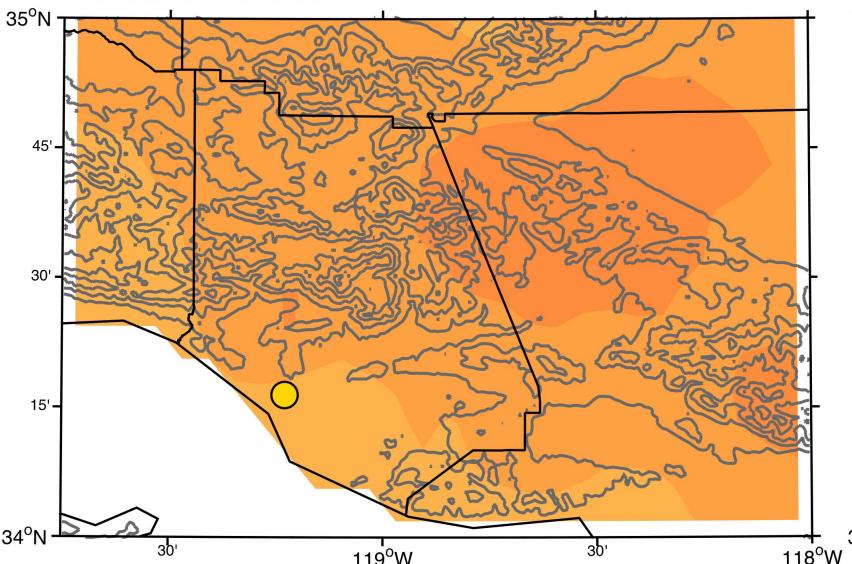
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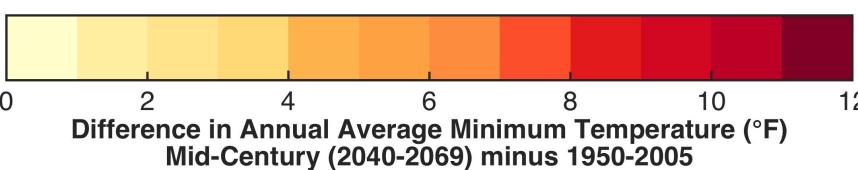
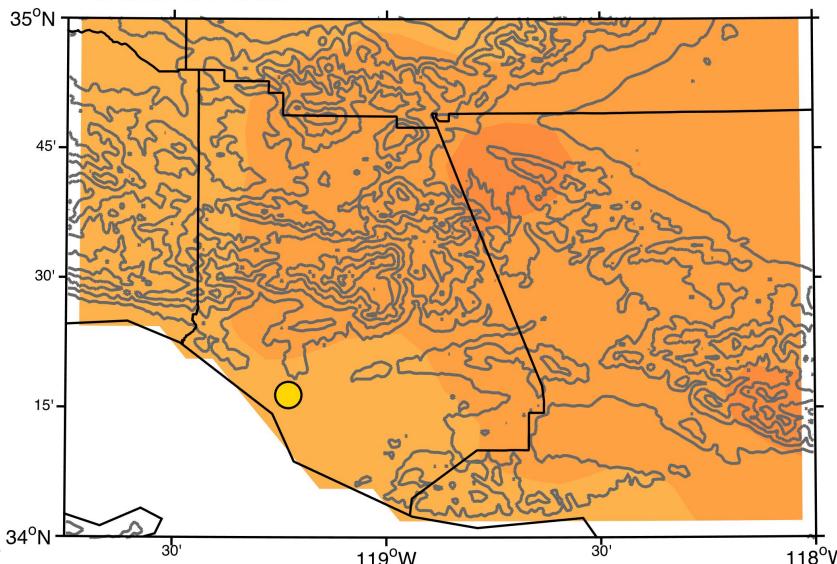
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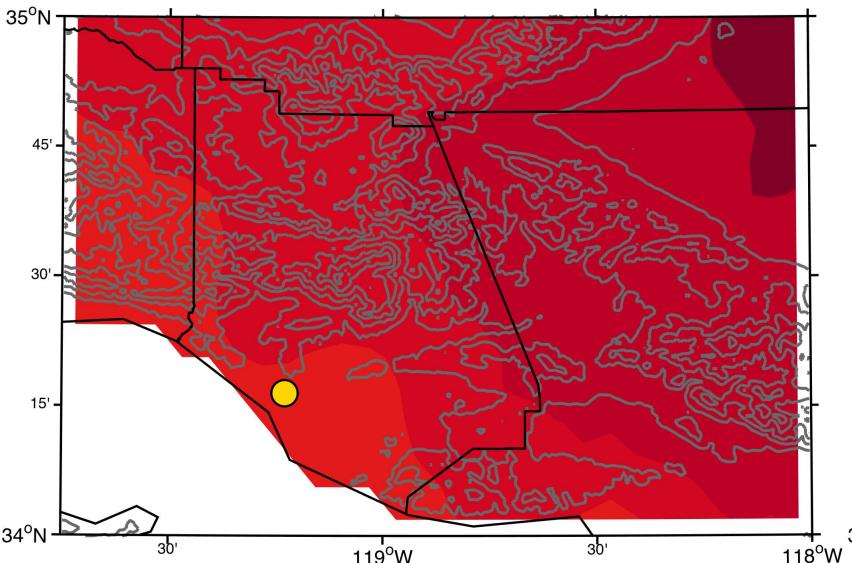
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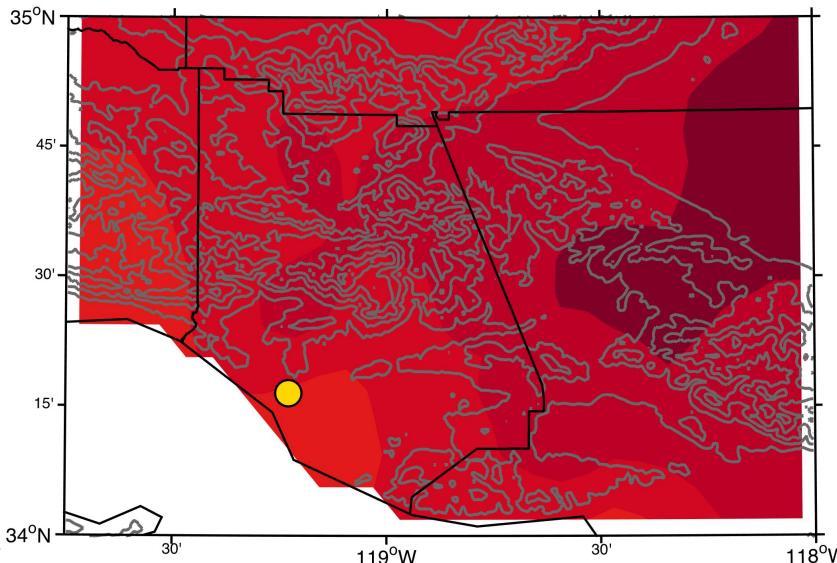
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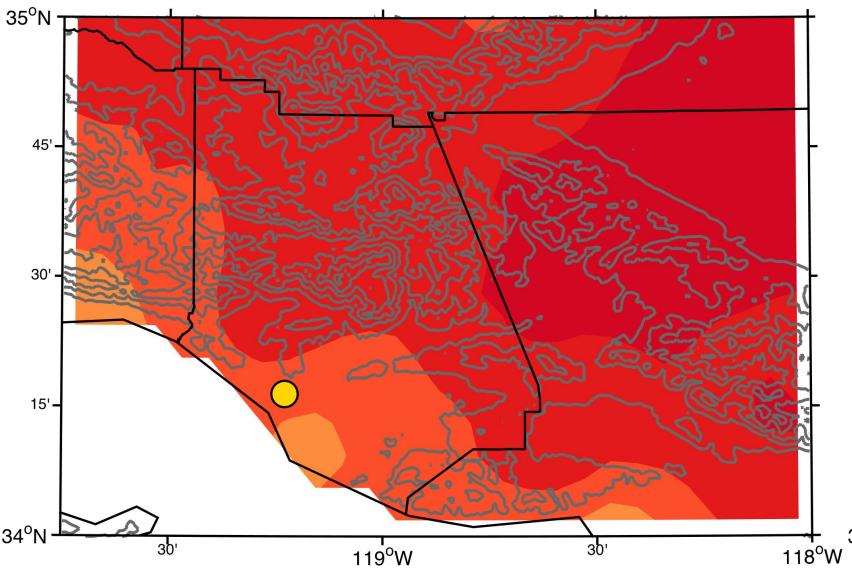
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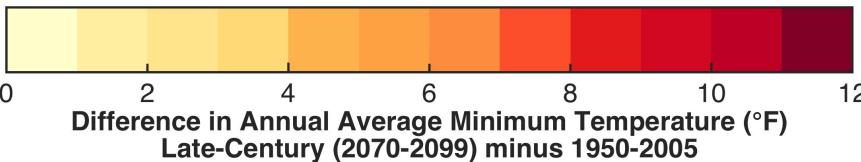
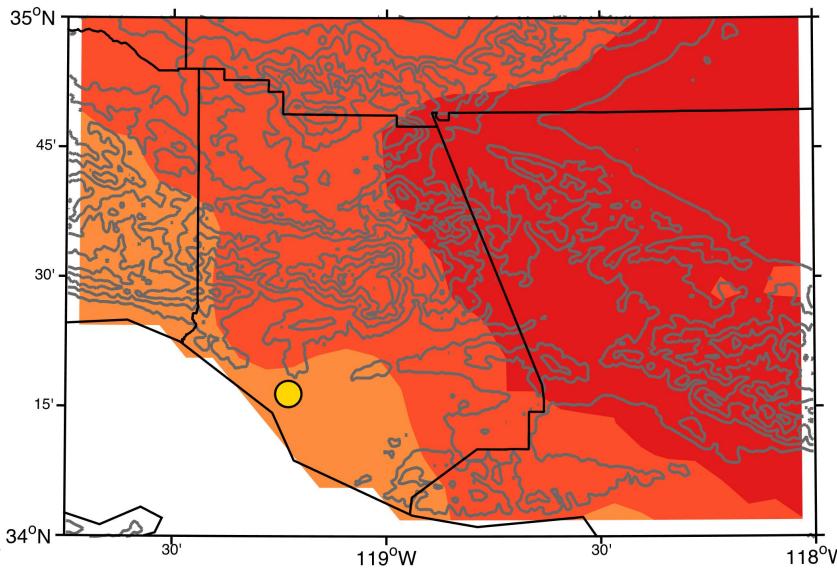
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Model: CNRM-CM5



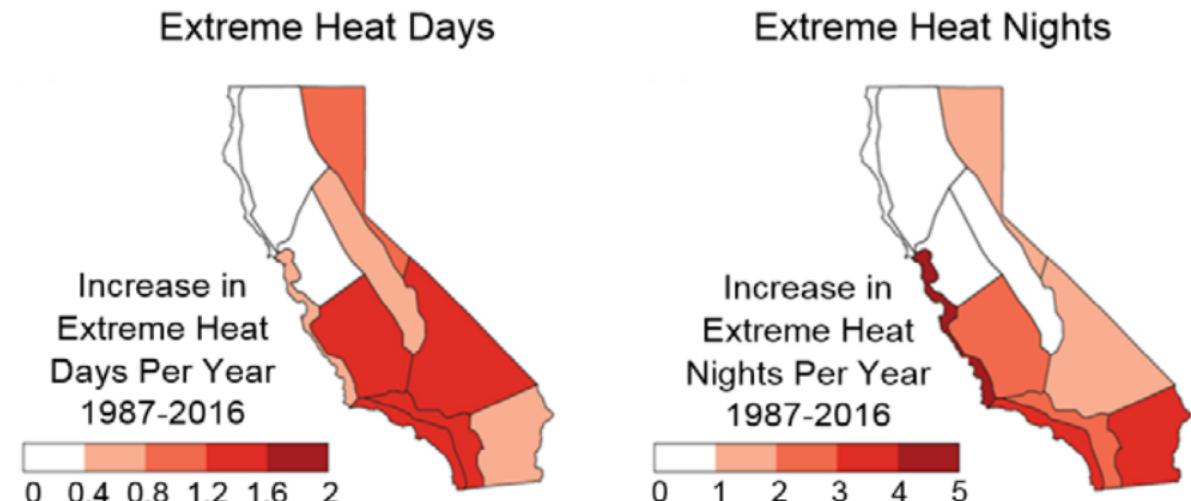
Model: MIROC5



# Changes in Temperature Extremes

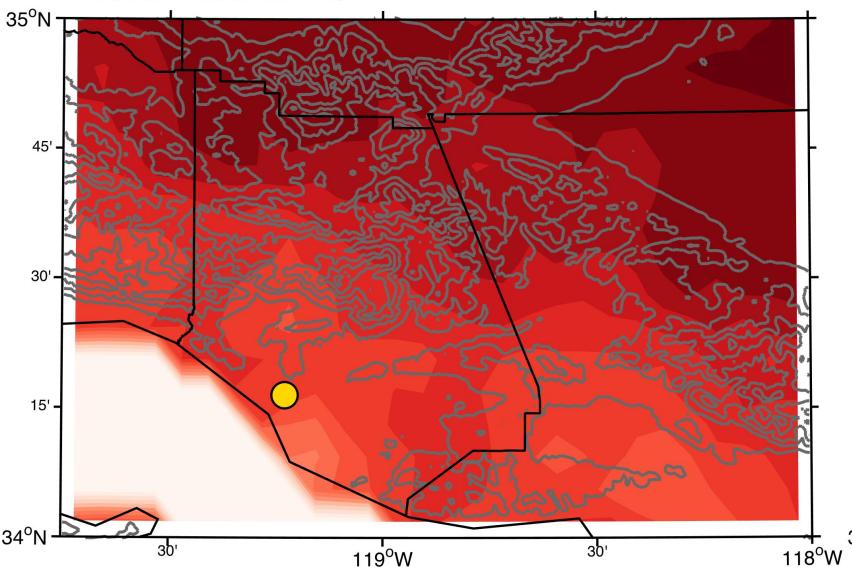
- Using definition as applied in California Climate Change Indicators Report, we look at top 2 percent of maximum and minimum temperatures
- Implications for public health, water and energy demand, and agriculture

**Figure 2. Regional trends in extreme heat days and nights**

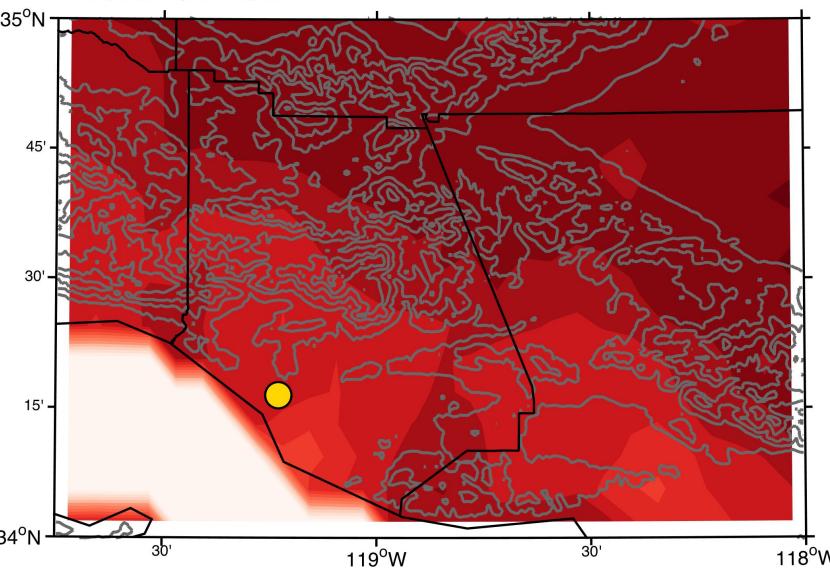


Hatchett (2018) ICCCal  
<https://oehha.ca.gov/climate-change/report/2018-report-indicators-climate-change-california>

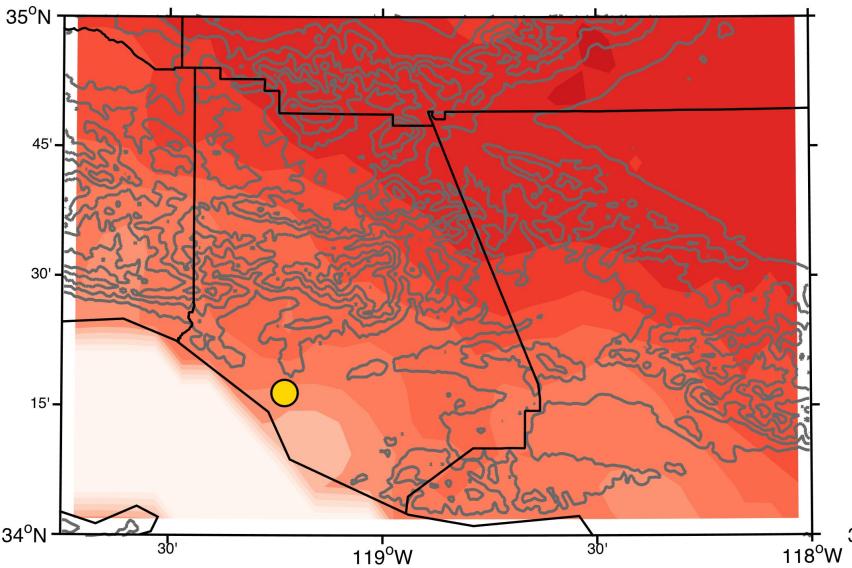
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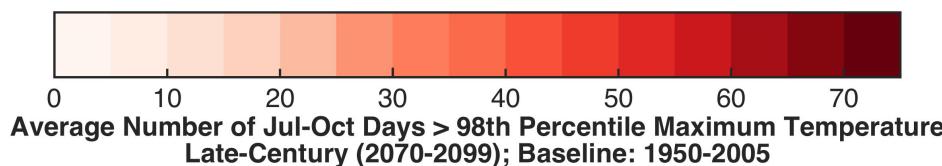
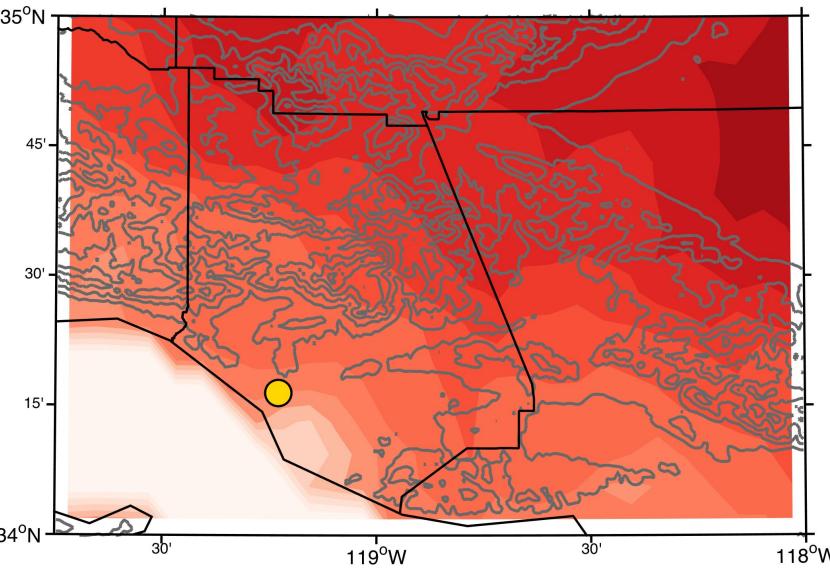
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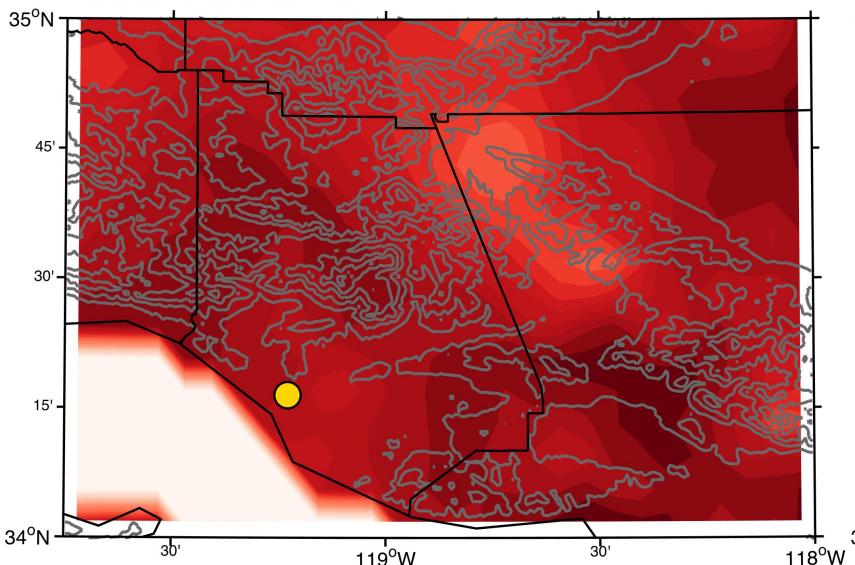
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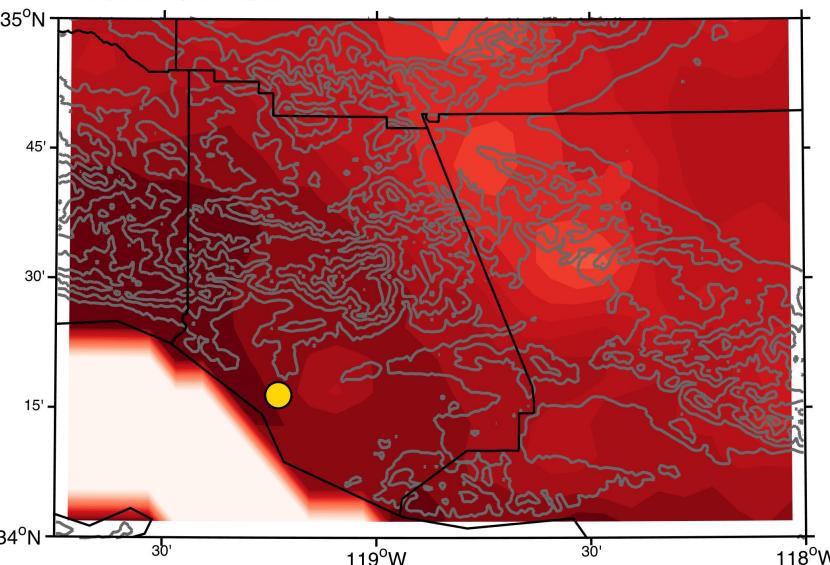
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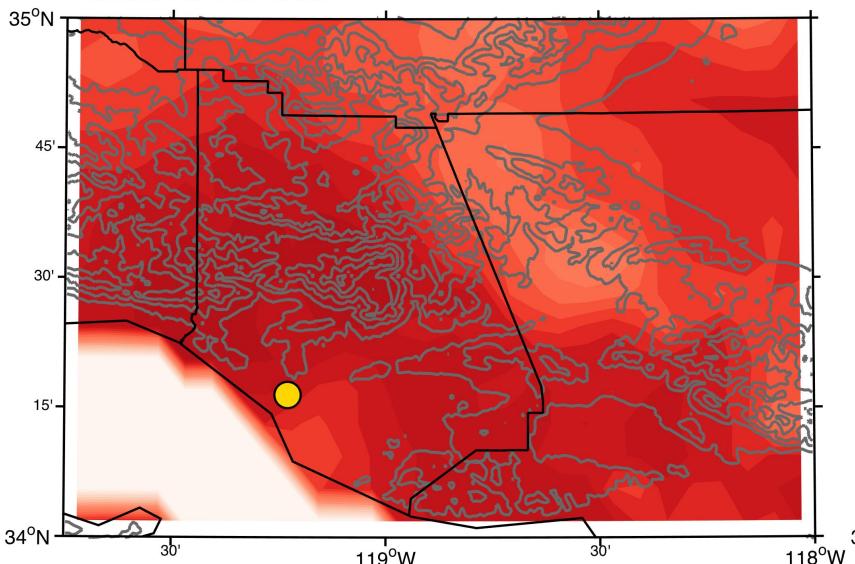
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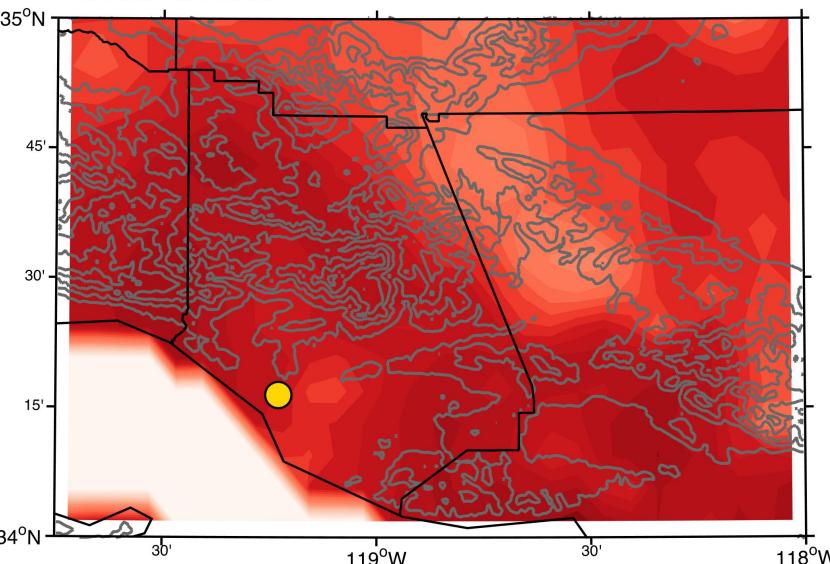
Model: CanESM2



Model: CNRM-CM5



Model: MIROC5

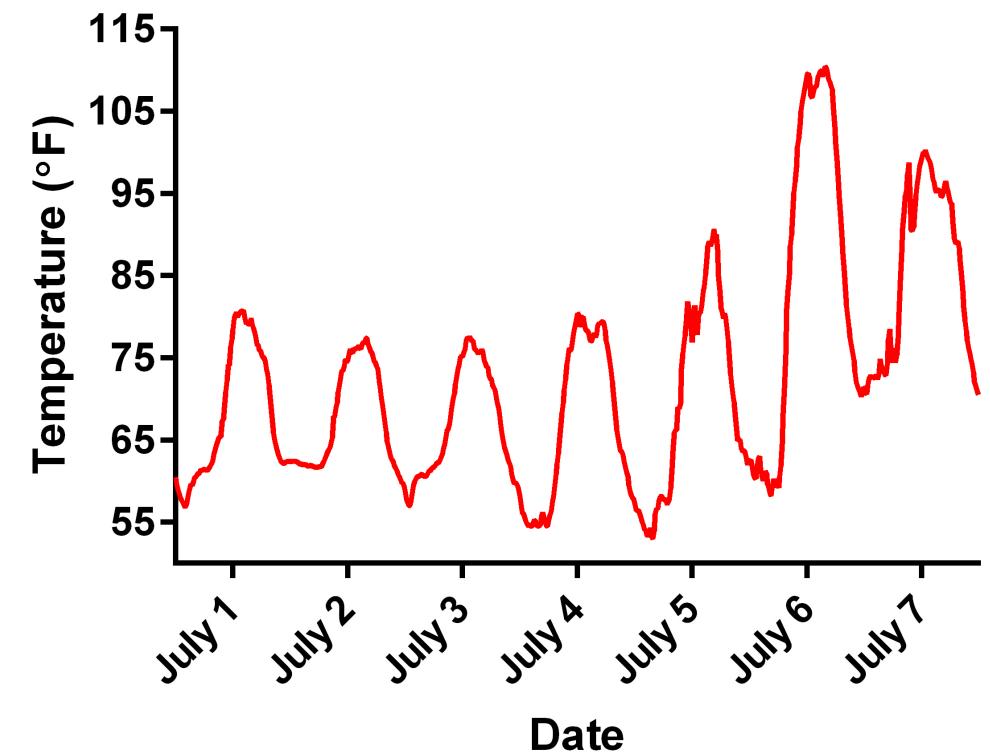


Average Number of Jul-Oct Days > 98th Percentile Minimum Temperature  
Late-Century (2070-2099); Baseline: 1950-2005

0 20 40 60 80 100

# Example of Specific Calculations: Avocados

- July 2018 heatwave caused significant damage to avocado and lemon crops
- Native oaks also affected

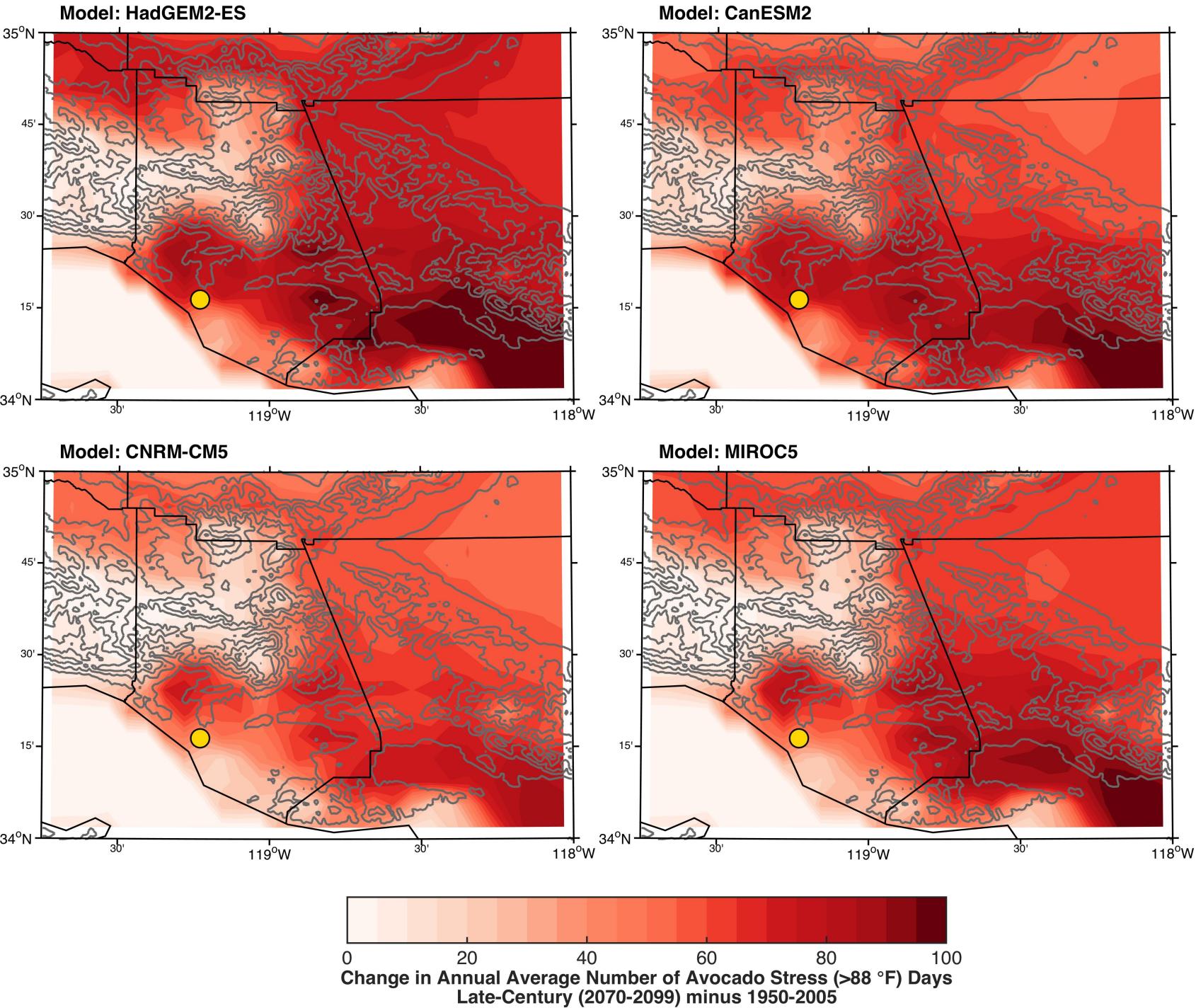


<https://www.californiaavocadogrowers.com/article/avocado-heat-damage-follow>



Stomatal Closure  
begins at 88°F  
and stresses  
plant

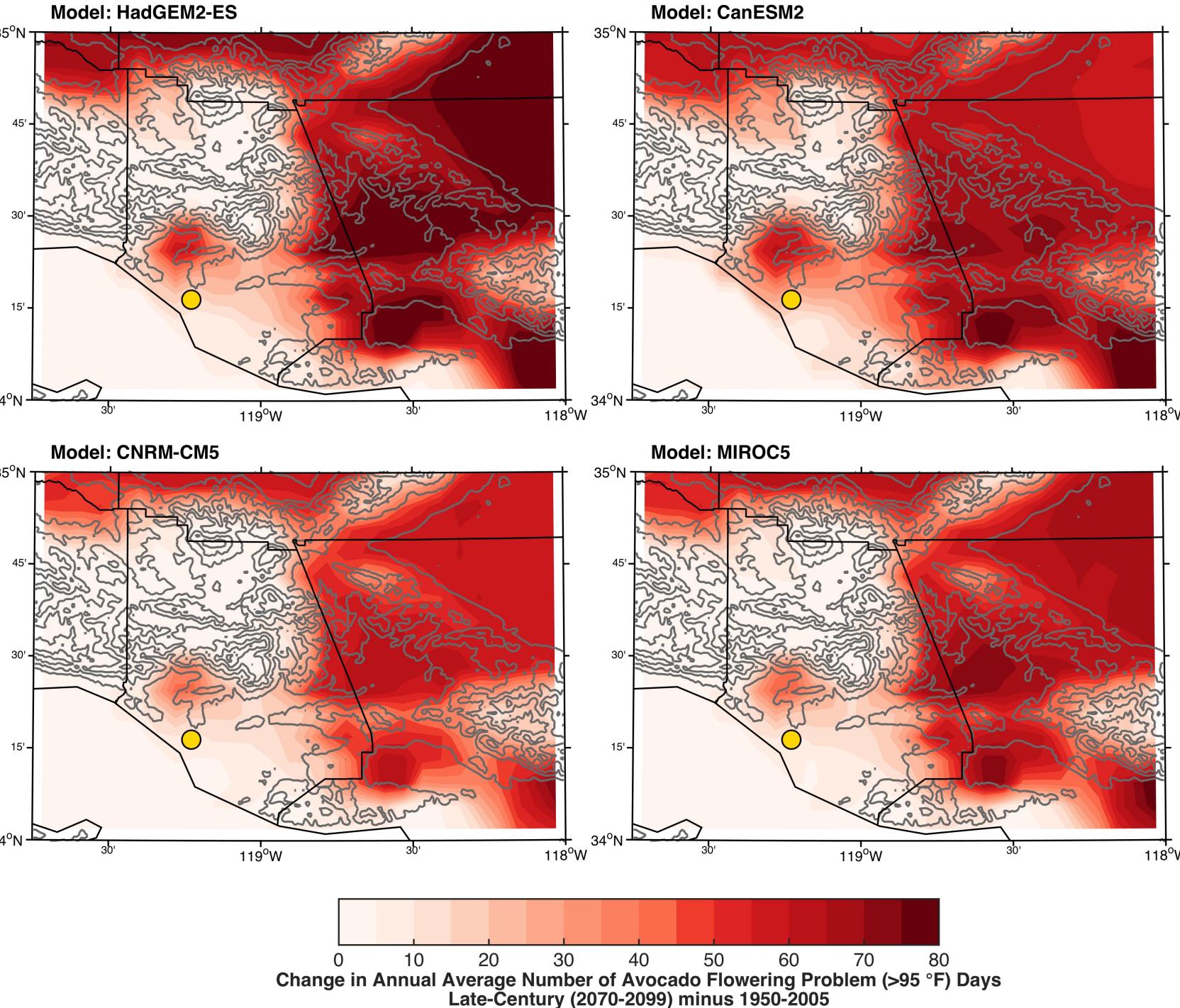
This a response  
to prevent loss  
of water and  
prevent  
embolisms  
(bubbles) in  
xylem



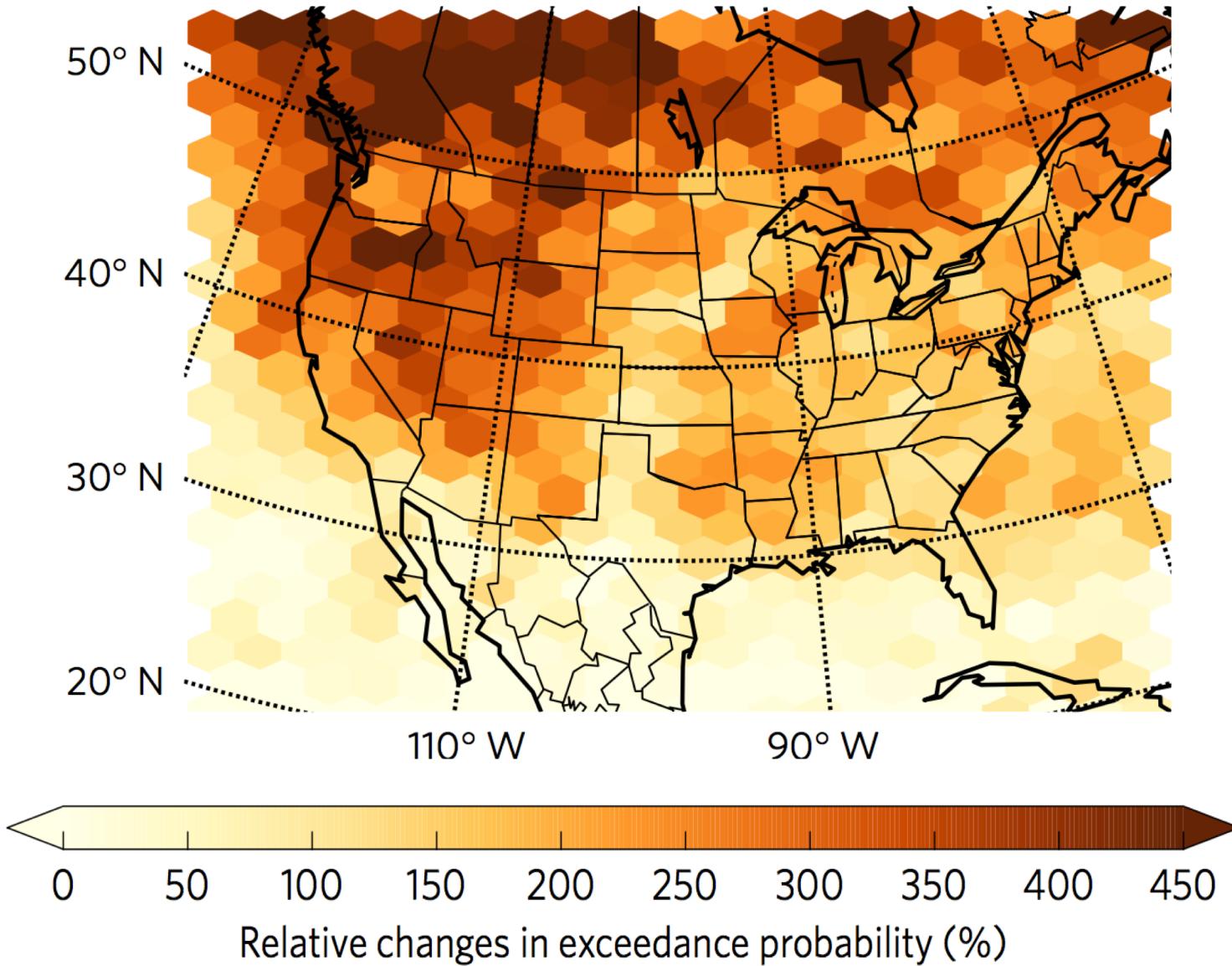
# Flowering problems in avocado occur at 95°F

What other crops are of thermal concern?  
Citrus, Strawberries, Celery, etc?

Native plants/restoration efforts?  
Ojai's oaks?



# Next Steps: Future Hourly Precipitation Extremes I



For Dec-Jan-Feb

Based on business-as-usual (RCP 8.5) scenario

~1.5-2x more likely to exceed top 0.05% of historic hourly precip. in warmer climate in S. CA

Pro: 4 km and hourly resolution good to explore at scales of interest

Con: Temperature perturbation experiment; does not resolve larger (global) circulation responses to warmer climate

# Next Steps: Future Hourly Precipitation Extremes II

Examine historical sub-daily precipitation data from stations in Ventura County's ALERT gauge network

Compare against Prein dataset

Examine spatial nature of changes in Prein (e.g., compare changes in mountains vs. lowlands)

Focus is on flooding, but also look at seasonal effects as well, as agricultural issues may arise (e.g., moldy strawberries, pests)



# Next Steps: More Stakeholder-driven Output!

- We are here to help respond to specific needs, help address concerns
  - If you can think of a calculation that would help, we can try it!\*
- Advise in prioritization process for IRWM plan
- Facilitate planning amidst model uncertainty
- You are welcome to provide input/insight/discussion anytime

# Concluding Remarks

- Temperatures will very likely increase
- Temperature extremes (by 20<sup>th</sup> century standards) will become more frequent
- Precipitation will likely become more variable on annual scales
- Increase in number of dry days and increase in annual precip contributed by biggest storms consistent with circulation changes expected in a warmer world
- *What are thresholds that you are concerned with?*
- *Would projections from more (i.e., 10 or 32) models be more useful/helpful?*

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[Nina.Oakley@dri.edu](mailto:Nina.Oakley@dri.edu)

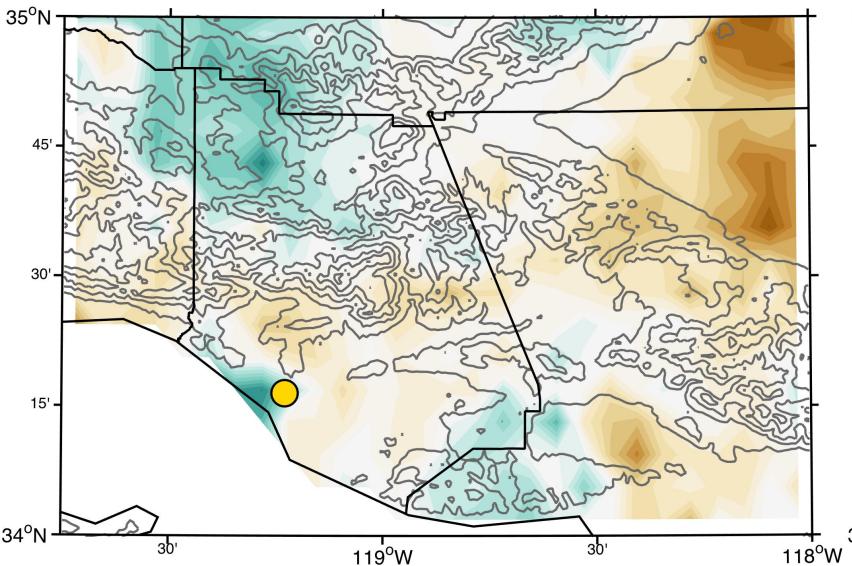


extras

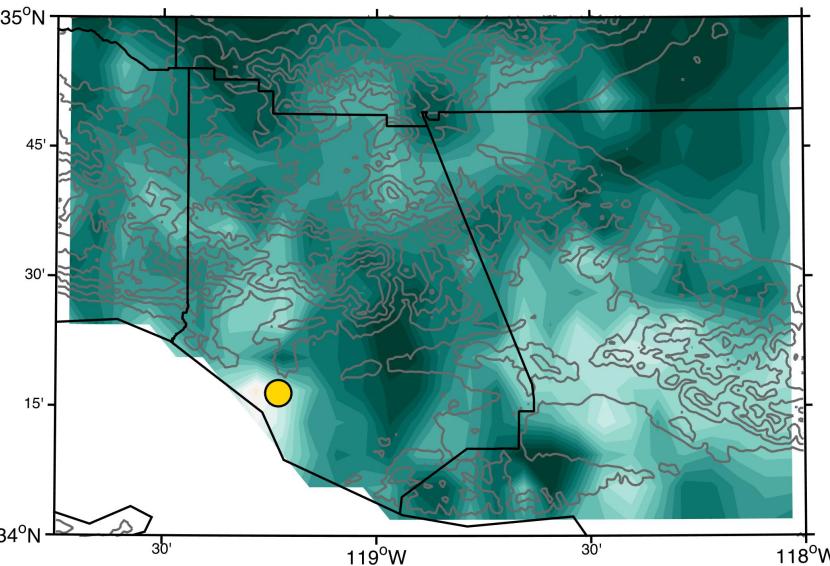
# Dry Season Length

- Implications for fire season length, irrigation
- Varied outcomes in projections

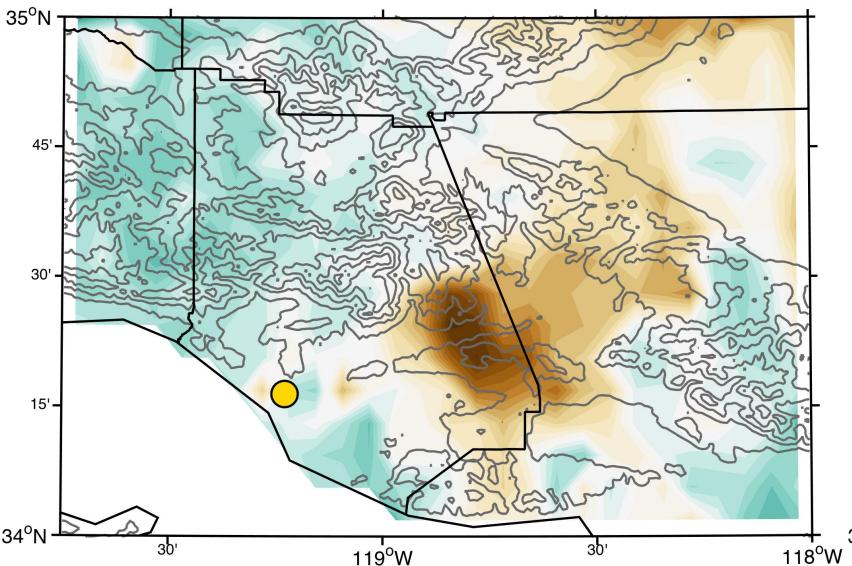
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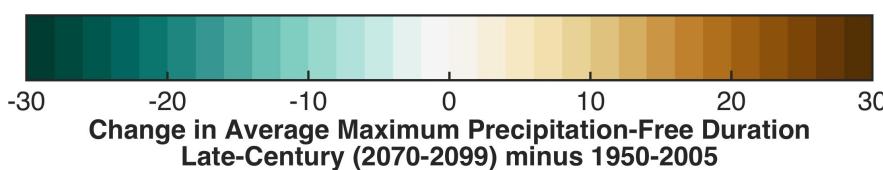
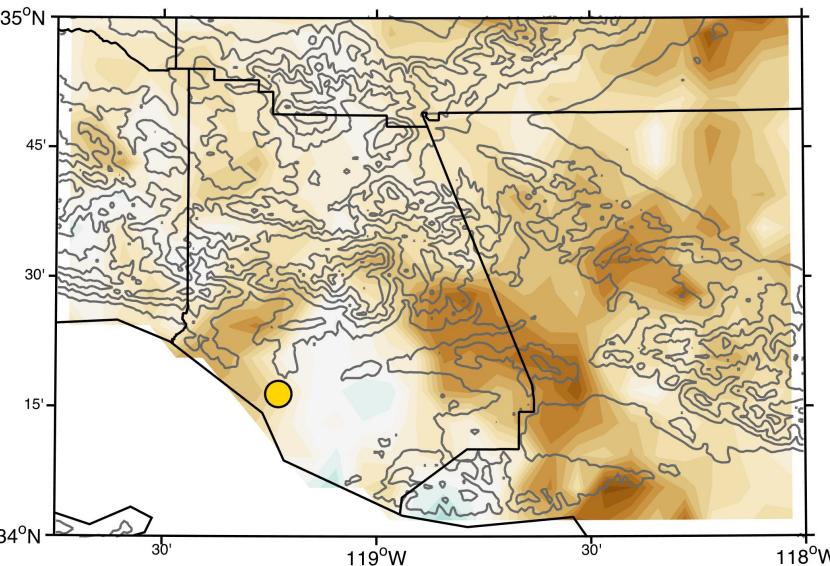
Model: CanESM2



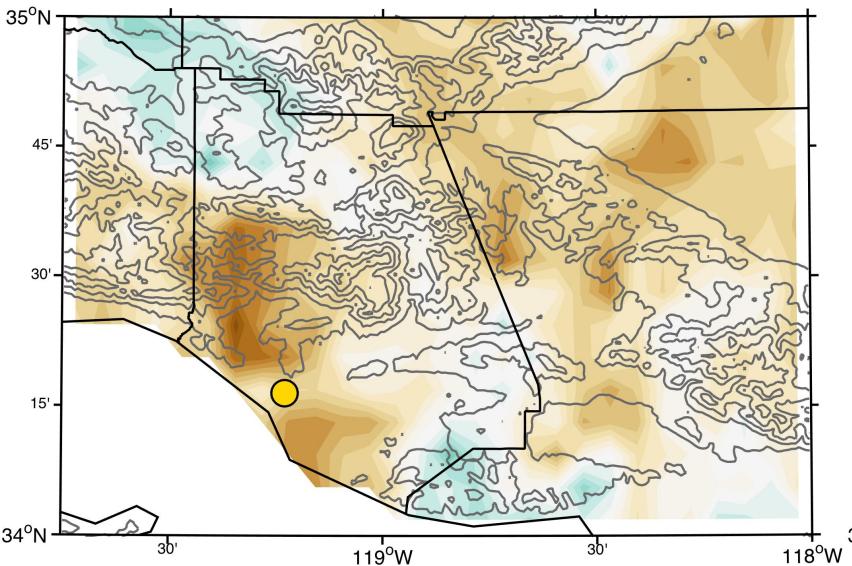
Model: CNRM-CM5



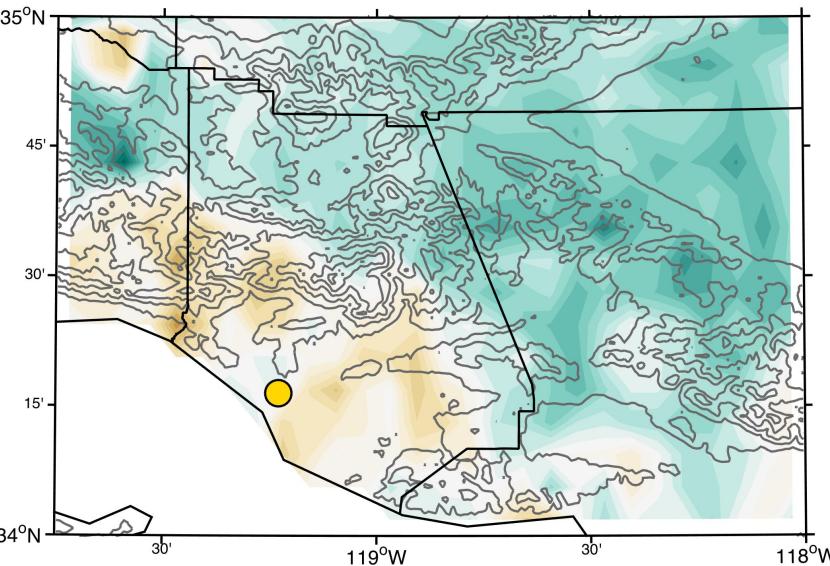
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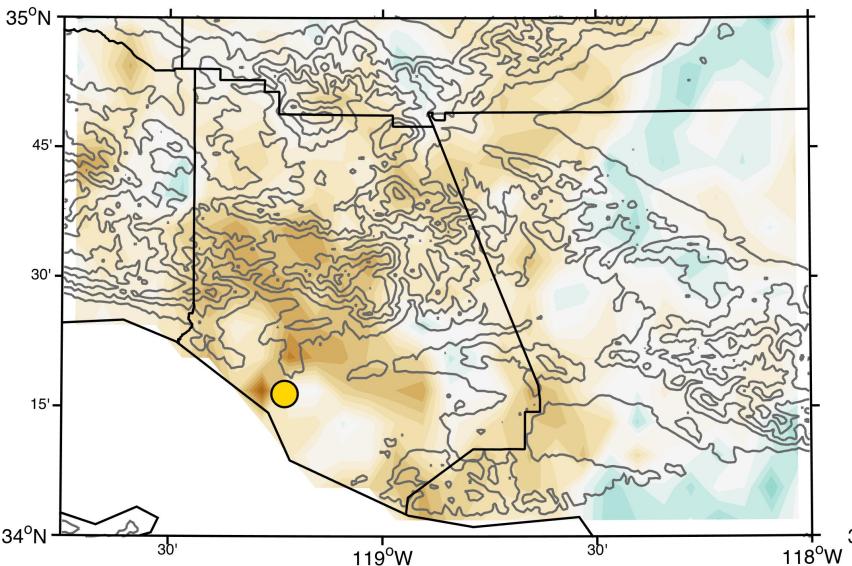
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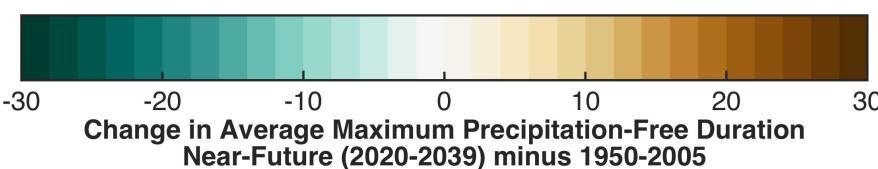
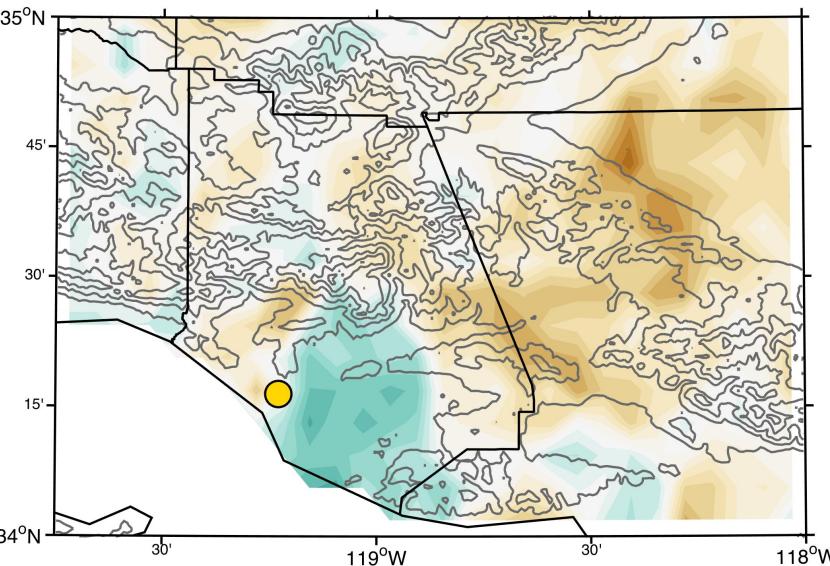
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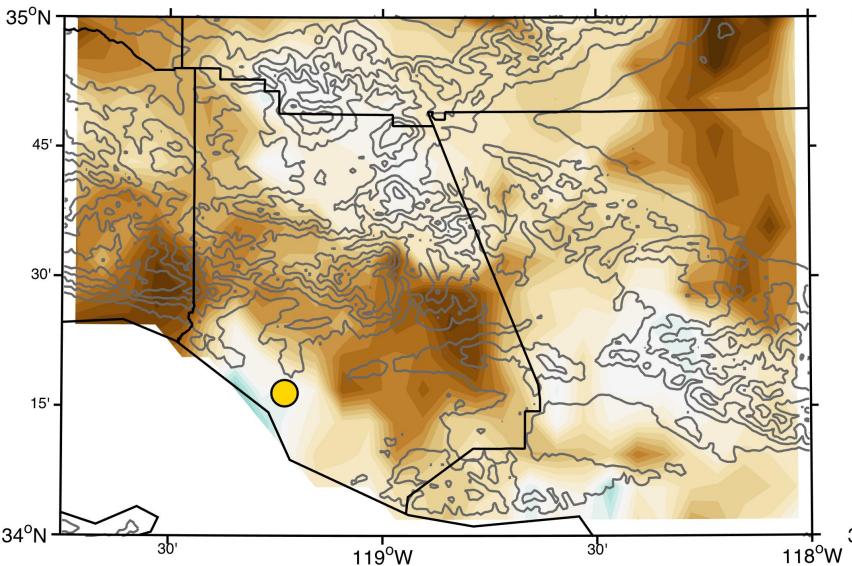
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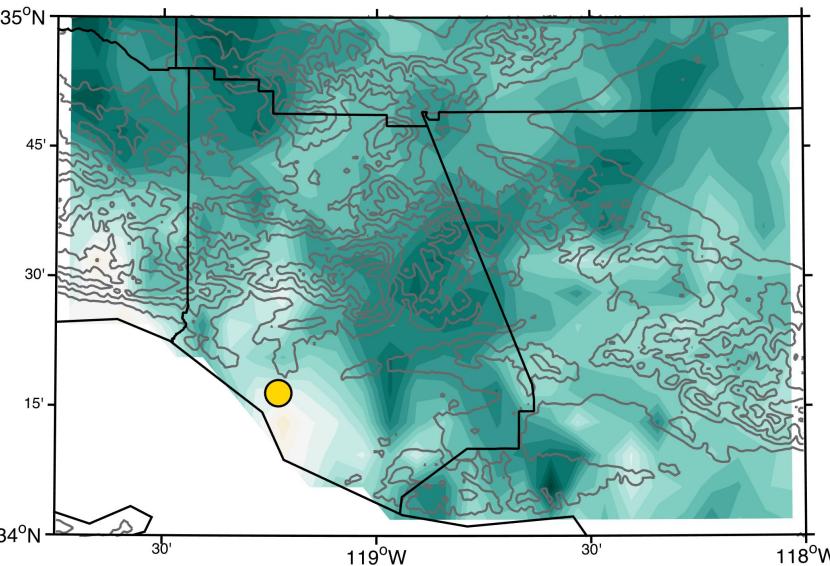
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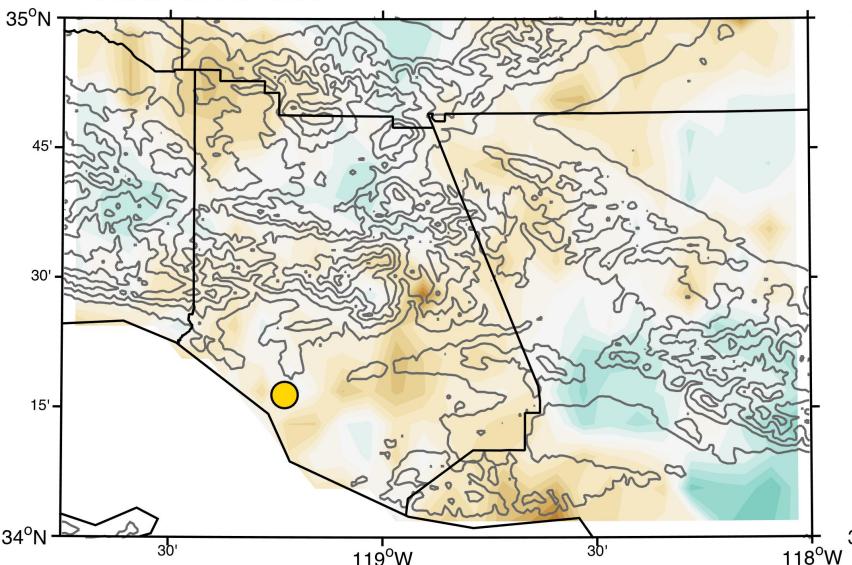
Model: HadGEM2-ES



Model: CanESM2



Model: CNRM-CM5



Model: MIROC5

