Climate Change Projections for Ventura County 2021-2040

Nina Oakley, Ph.D.

Benjamin Hatchett, Ph.D.

Desert Research Institute, Reno, Nevada

RESOURCES LEGACY FUND
Creative Solutions. Lasting Results.

CNAP
California-Nevada Climate Applications Program

DRI
Desert Research Institute

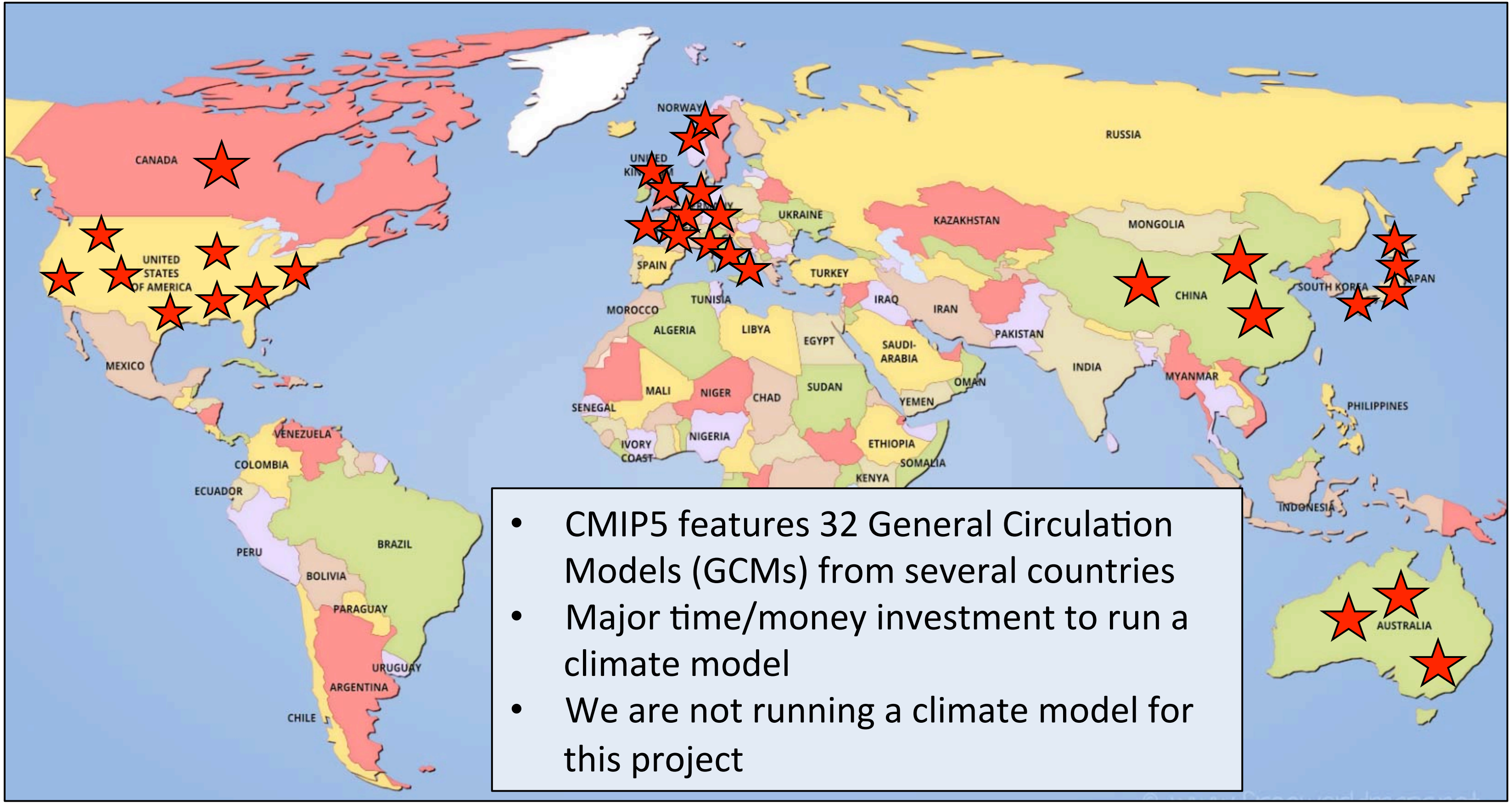
Follow-up to October 2018 Meeting

- Incorporated many requested analyses
    - Evapotranspiration
    - Likelihood/uncertainty across suite of models
    - Change in 85^{th} percentile precipitation days
    - Temperature, precipitation, ET_0 by season

- Developed draft report on climate change and potential impacts in Ventura County
    - Literature review where not possible to do analysis (e.g., wildfire)
    - Report currently under review by small groups
    - Formatted final version out early June!

- We are not producing a new dataset, providing analysis and interpretation of existing data

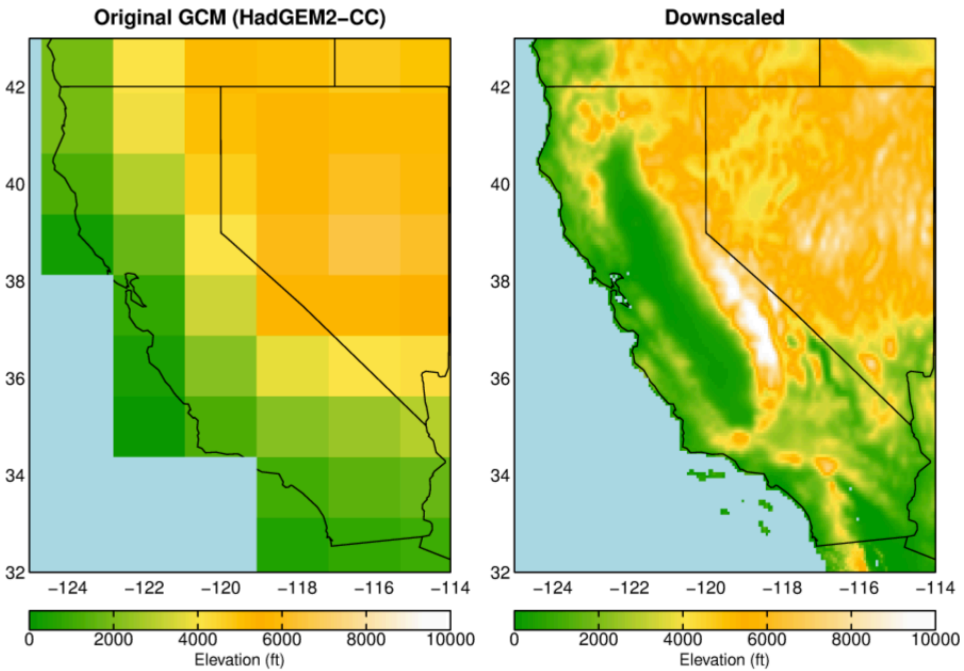
Recap: Using Downscaled Data From CMIP5 Models



- CMIP5 features 32 General Circulation Models (GCMs) from several countries
- Major time/money investment to run a climate model
- We are not running a climate model for this project

CMIP = Climate Model Intercomparison Project

Downscaling: Making Global Model Output Usable For Local Studies

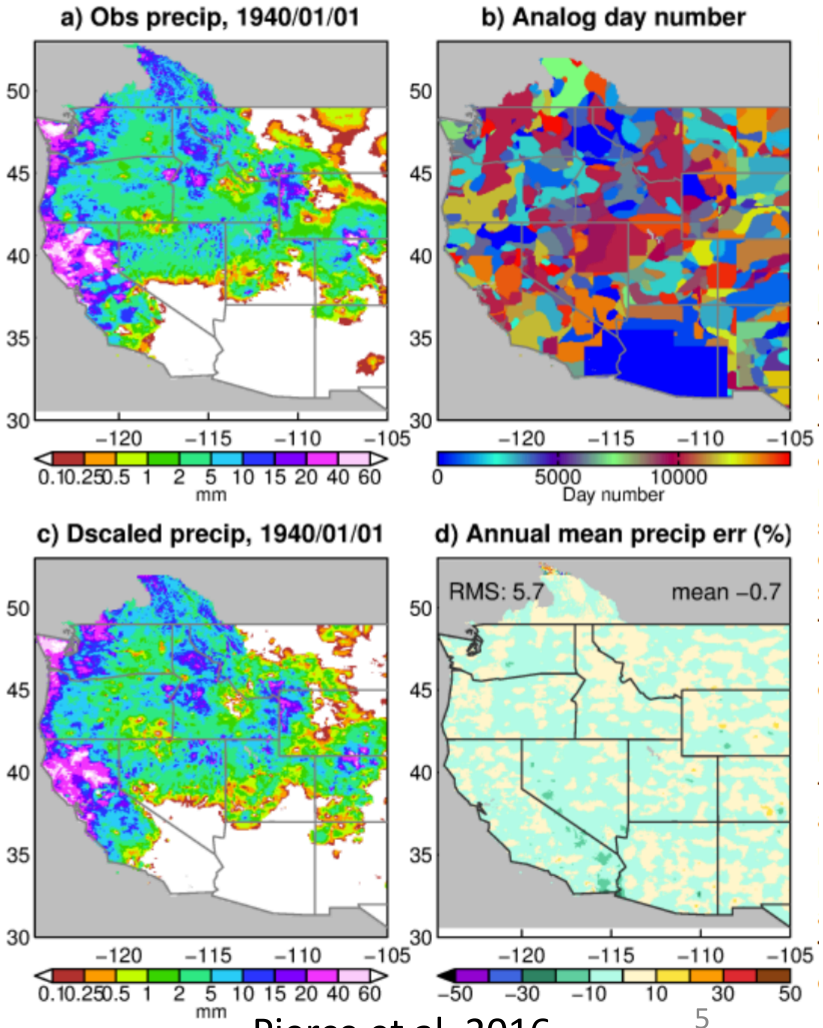


Pierce et al. 2016

- Global climate models (GCMs) cannot resolve terrain, downscaling transforms coarse GCM into finer spatial scale
- GCMs also have systematic errors, biases
  - E.g., Precipitation 20% too low
  - Bias correction step uses historical observations to estimate corrections
- LOCA (Locally Constructed Analogs) downscaling method used here
  - Produced by Pierce et al. XXX to support the California Climate Change Assessment
  - Done for all 32 CMIP5 models
  - Same source but distinct from datasets CA DWR has provided to water agencies to force hydro models

LOCA: **LO**cally **C**onstructed **A**nalogs

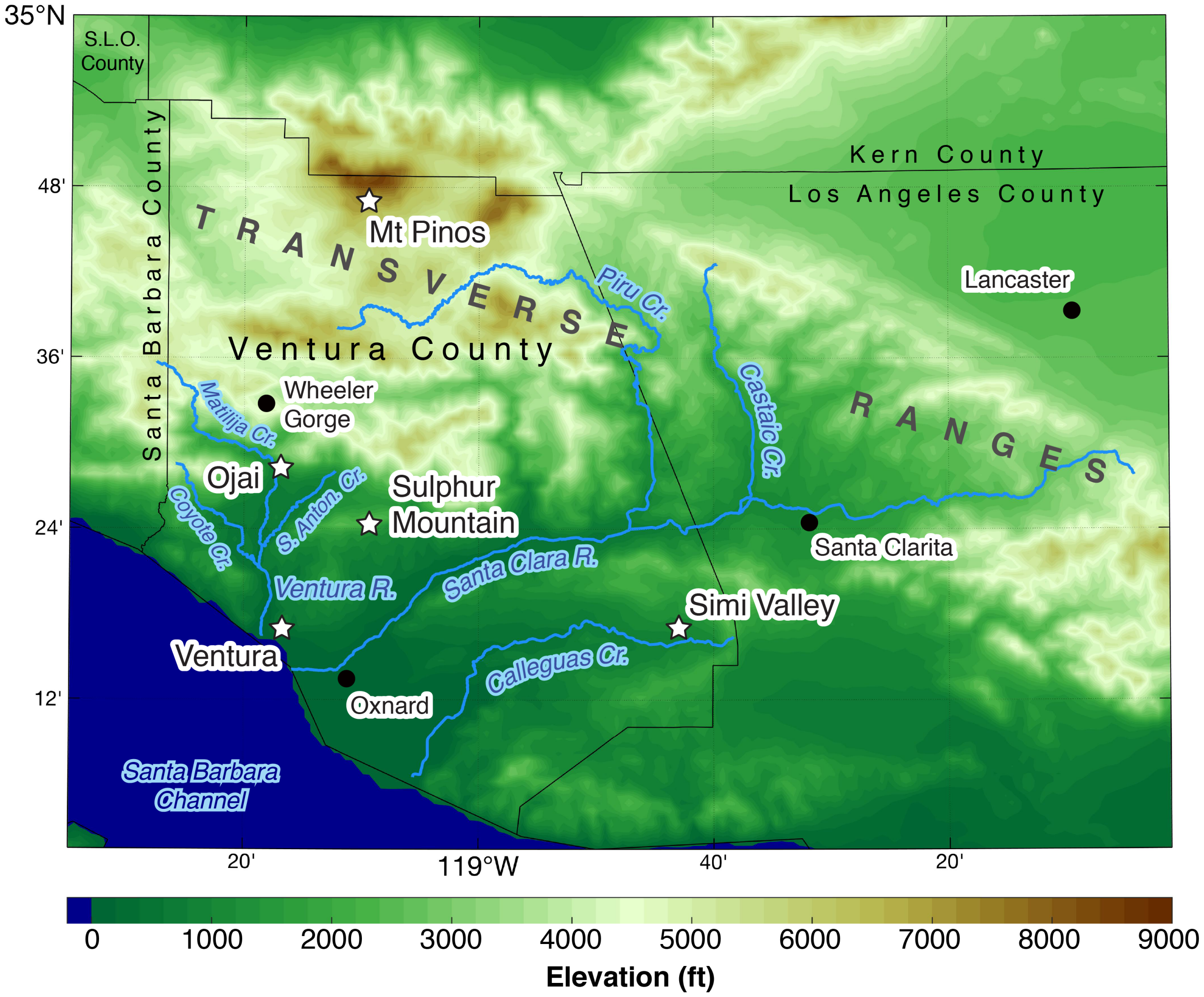
- LOCA improves upon previous 'analog' downscaling methods, aims to preserve daily extremes and variability
- Analog techniques
  1. Identify historical days that are similar to GCM output
  2. Assume relationship between larger scale (regional) average temperature and local temperature at a station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



Pierce et al. 2016

Study Area

- Starred locations: Used as analysis points
- Other marked locations referenced in report

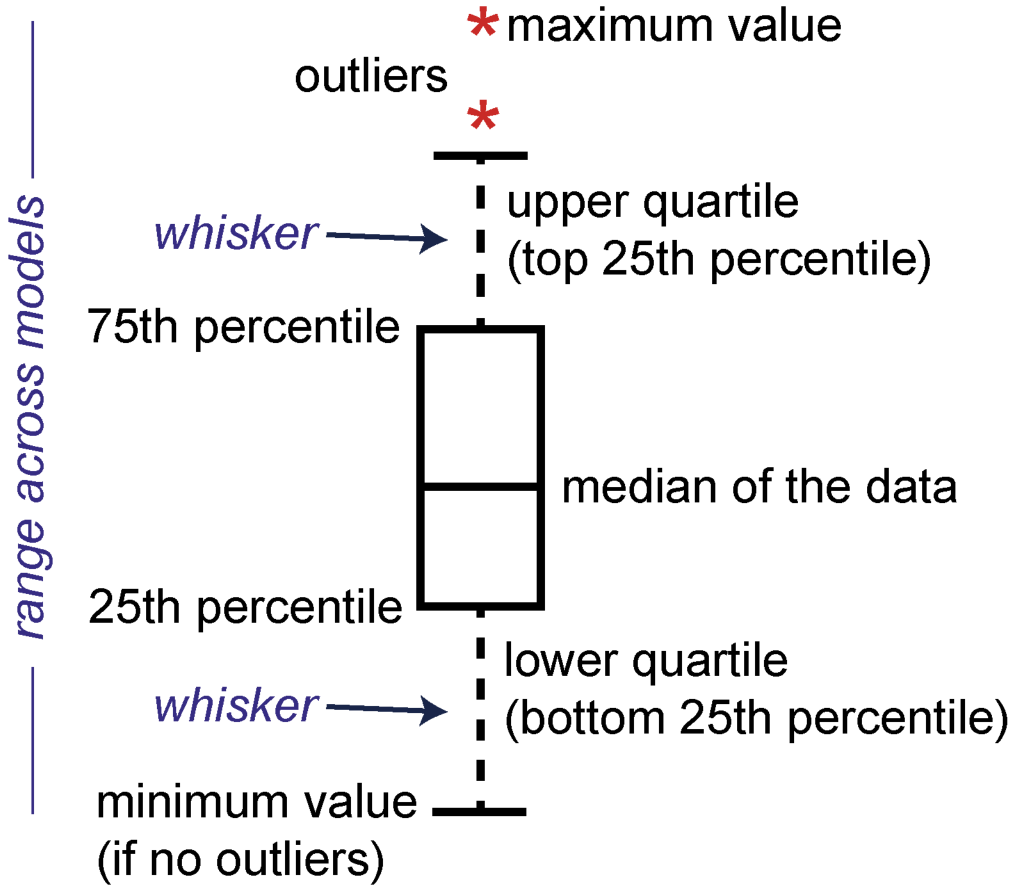


Interpreting Boxplots

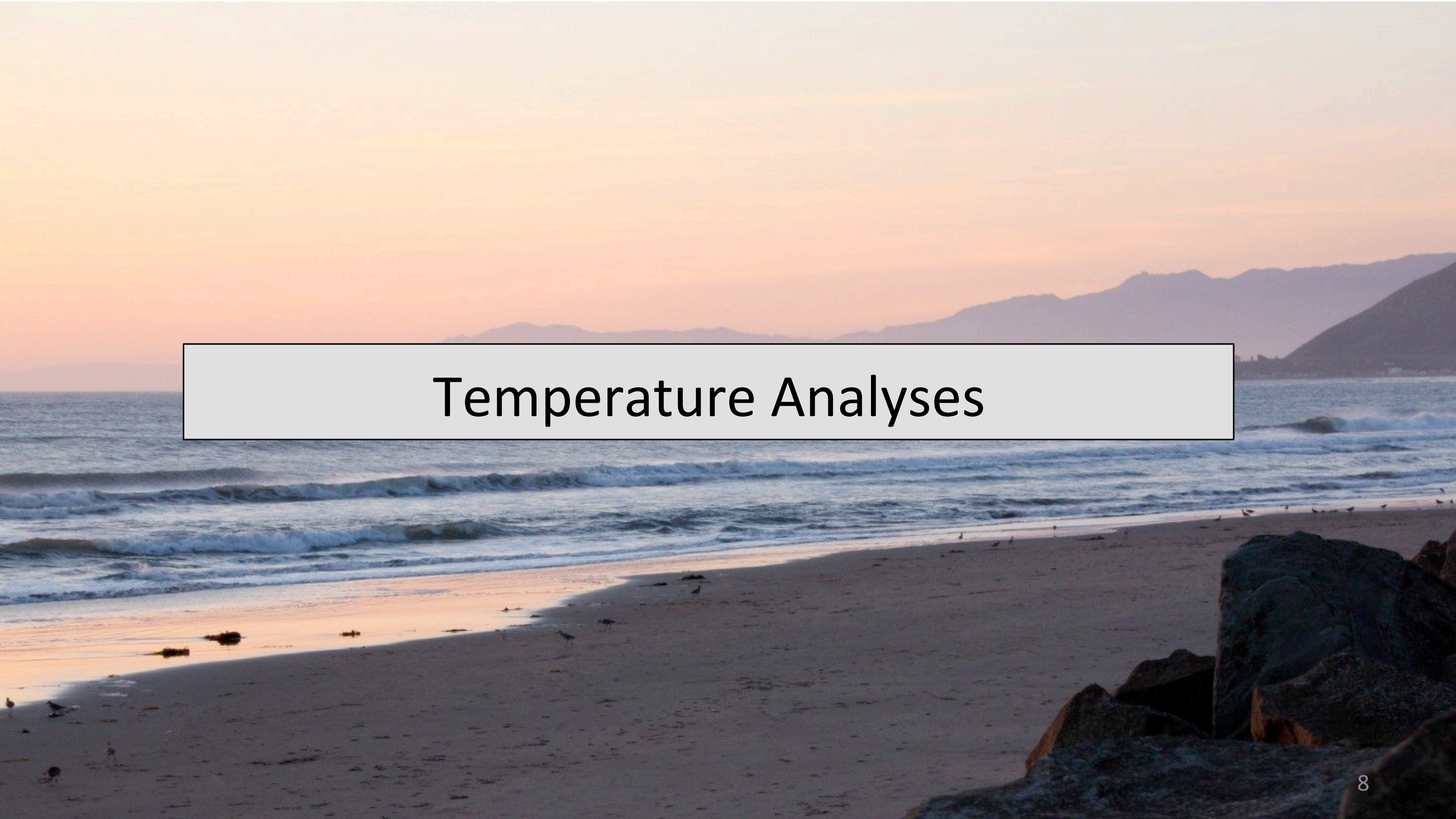
- Boxplots used to show model “spread” or uncertainty across the 32 CMIP5 models

- Boxplots created for five locations in county with distinct climate characteristics

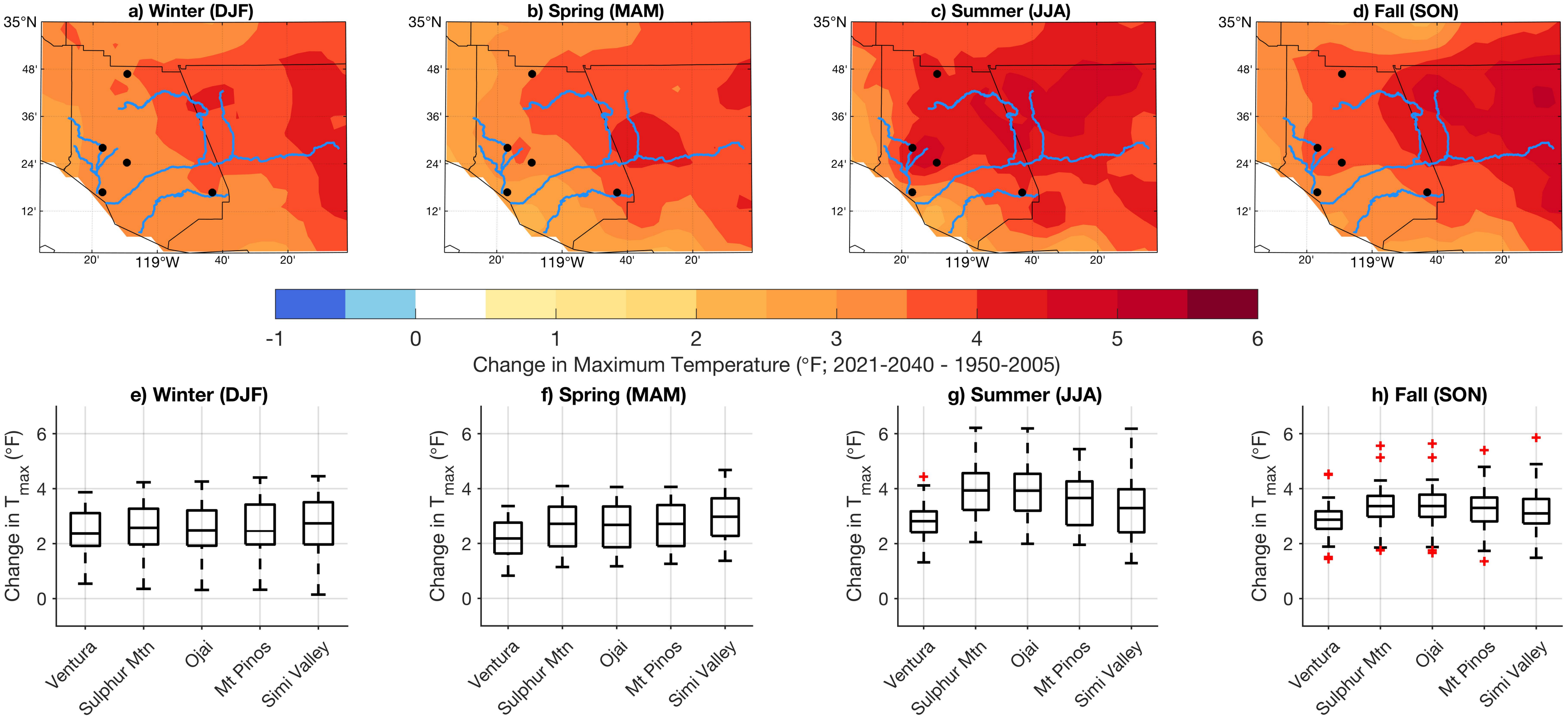
Interpreting a Box and Whisker Plot



Temperature Analyses

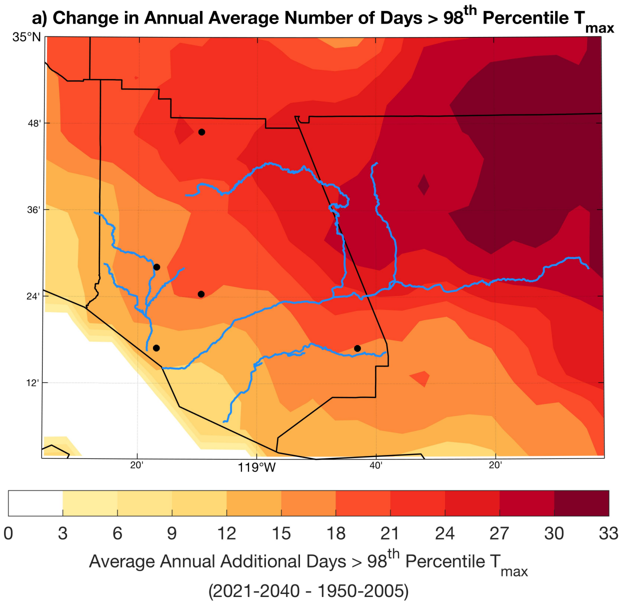


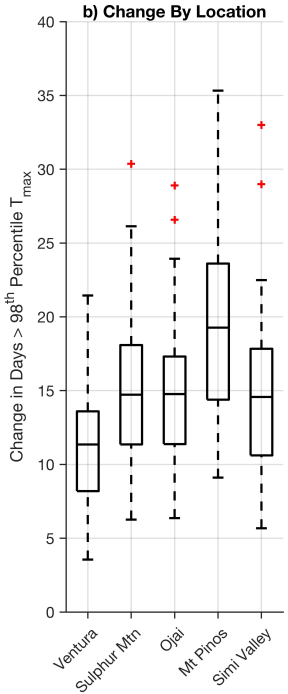
Maximum Temperature



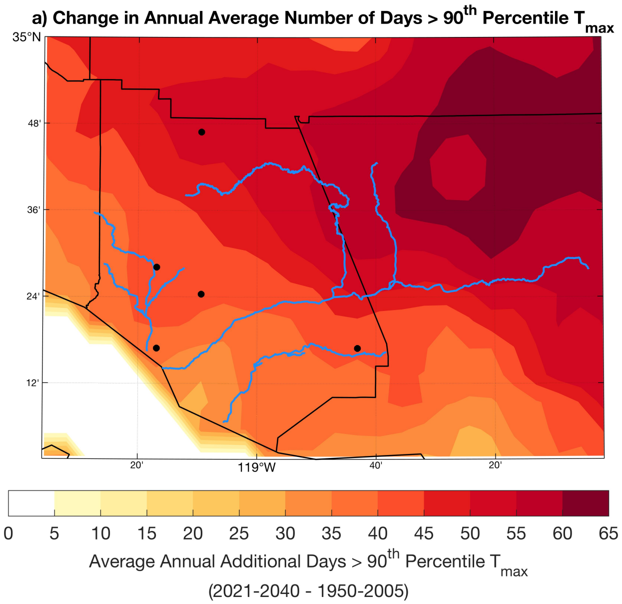
Maximum Temperature Extremes

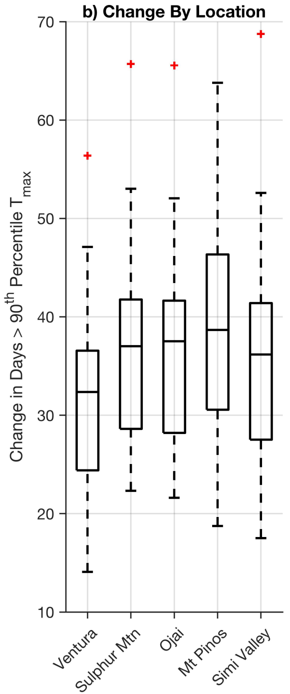
98th Percentile “Hottest Days”





90th Percentile “Hot Days”

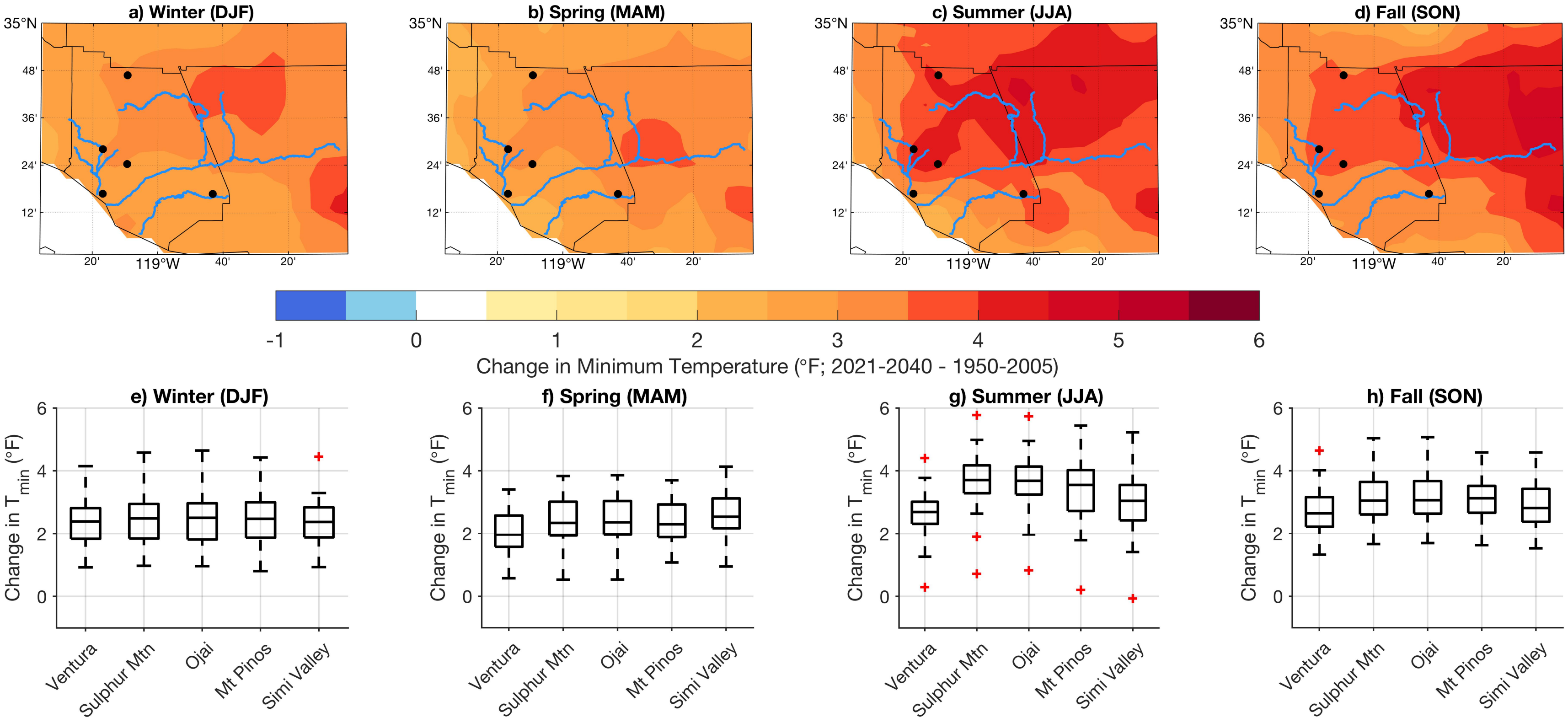




*Coastal regions may be underestimated if marine influence (fog) lessens

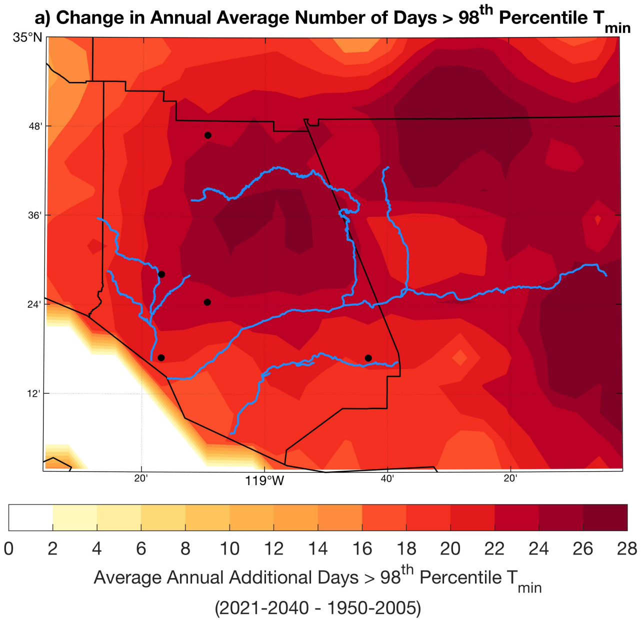
Similar patterns, but different magnitudes.

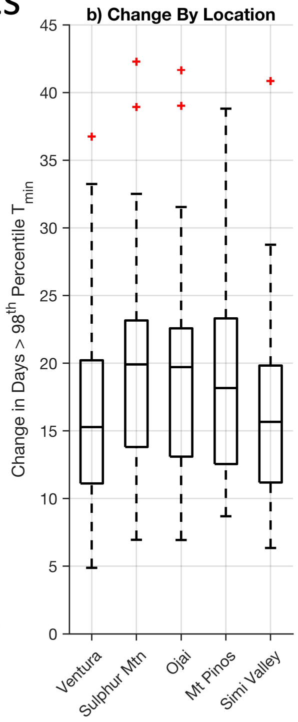
Minimum Temperature



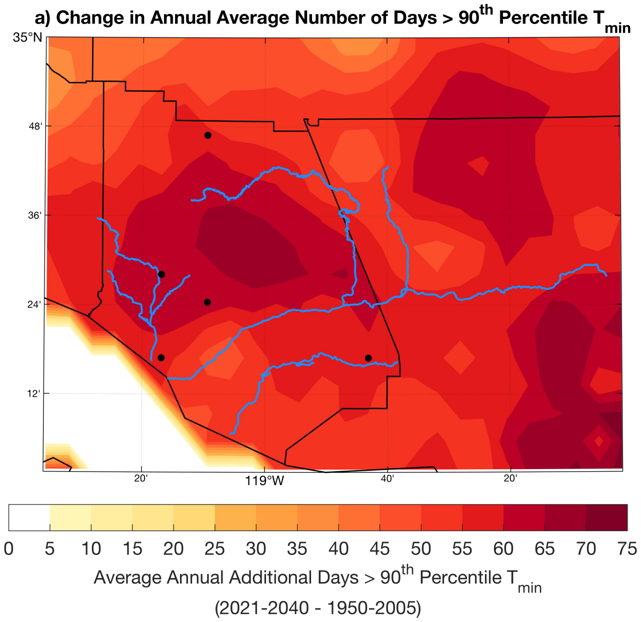
Minimum Temperature Extremes

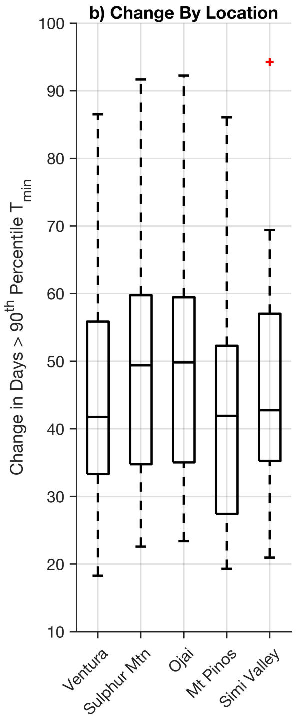
98^{th} Percentile "Warmest Nights"





90^{th} Percentile "Warm Nights"

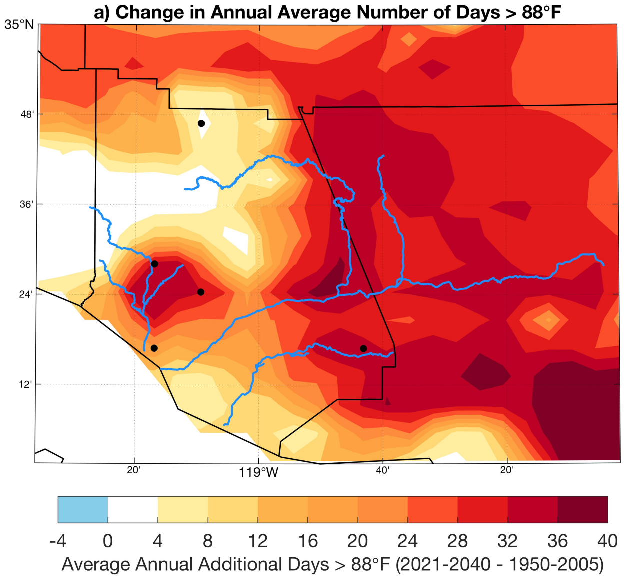


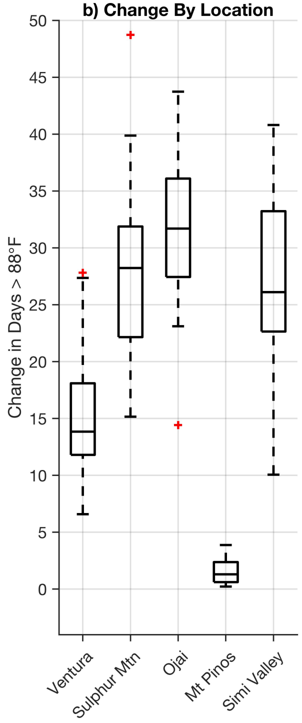


Similar patterns, but different magnitudes.

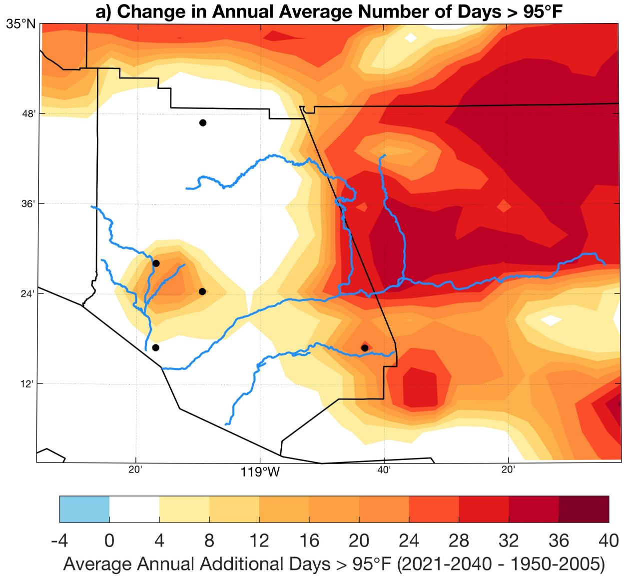
Temperature Threshold Examples

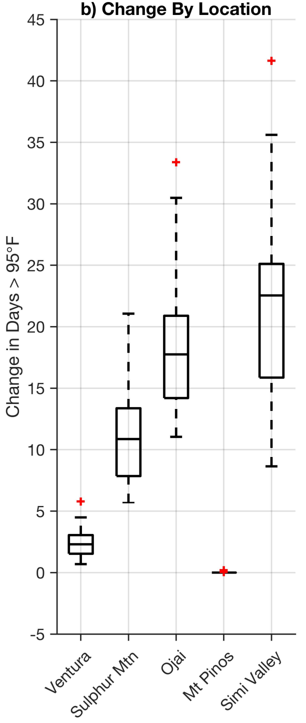
Stomatal Closure in Avocado Trees



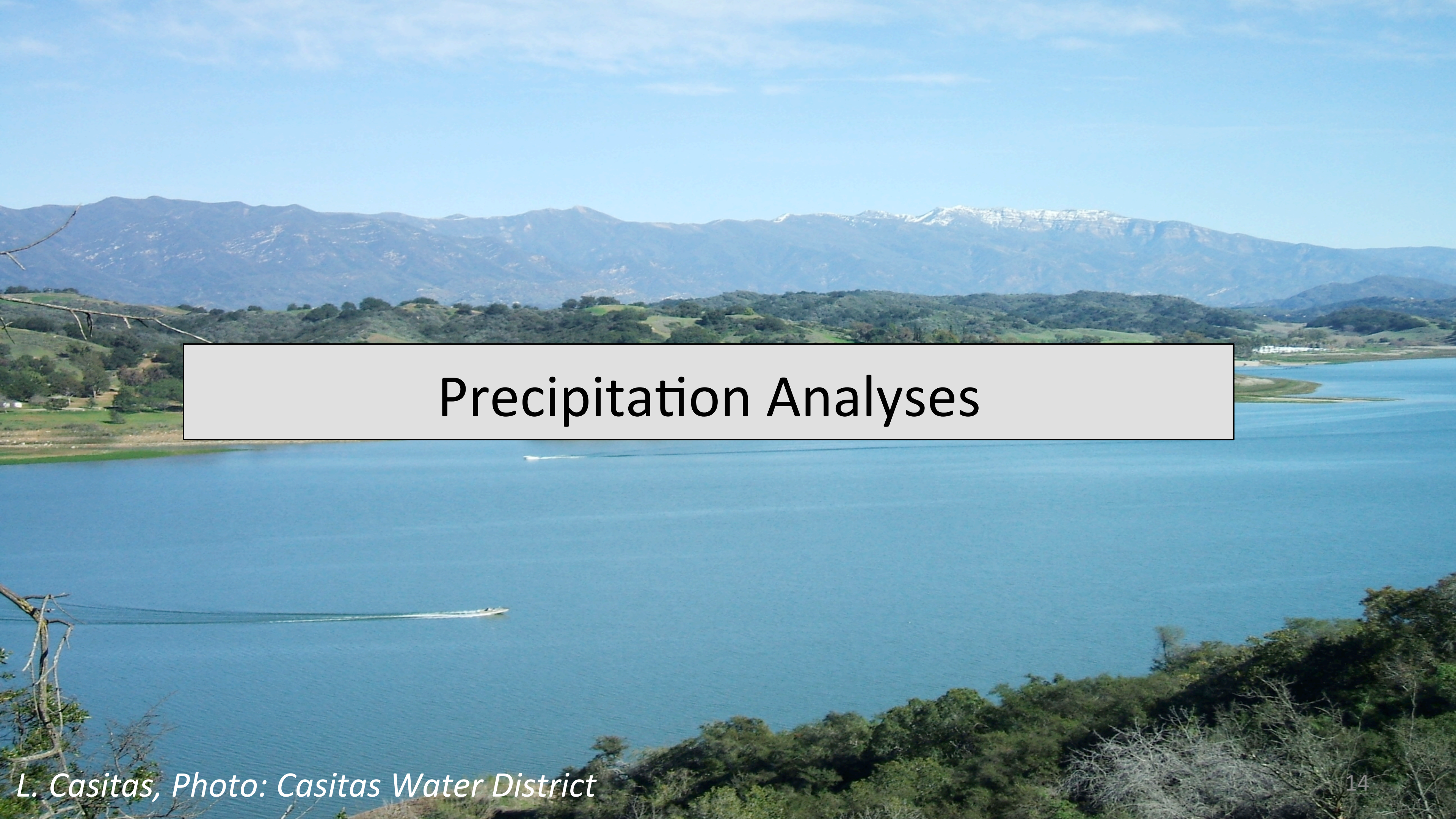


Avocado Flowers Damaged + CalOSHA High Heat Procedures





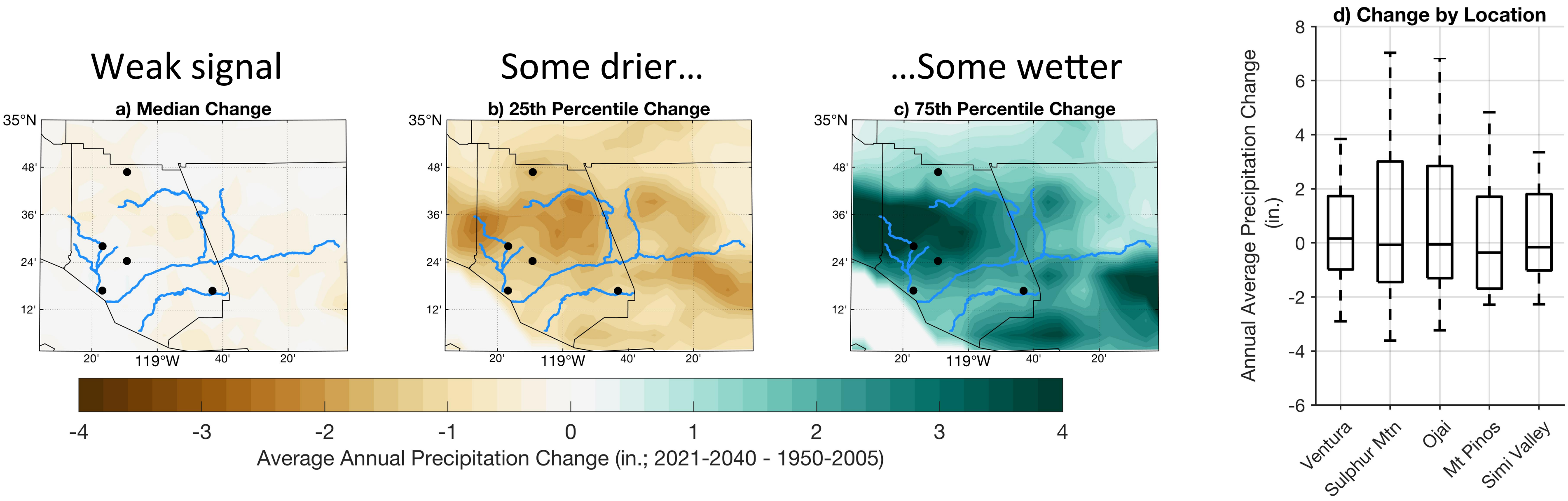
Precipitation Analyses



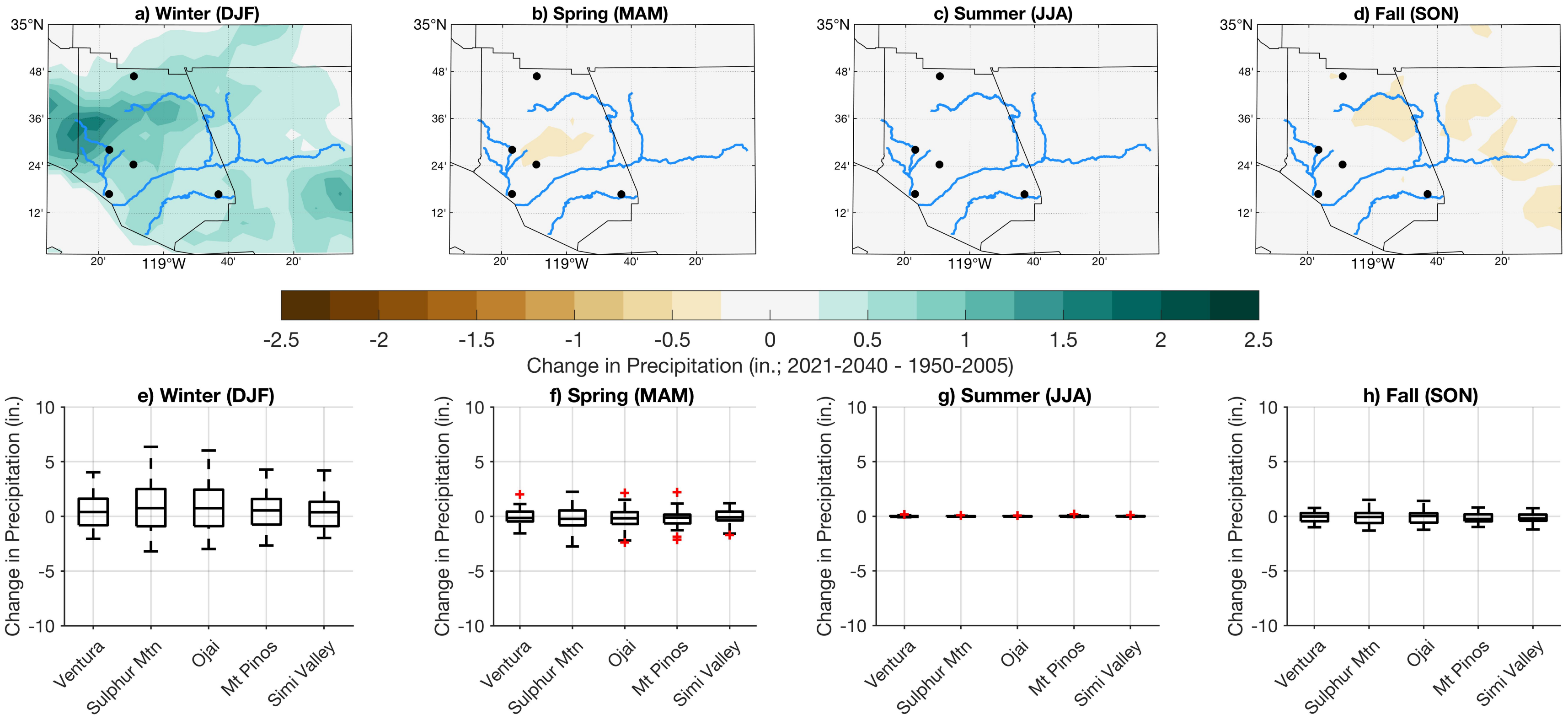
L. Casitas, Photo: Casitas Water District

Annually, Projected Precipitation Changes Are Mixed

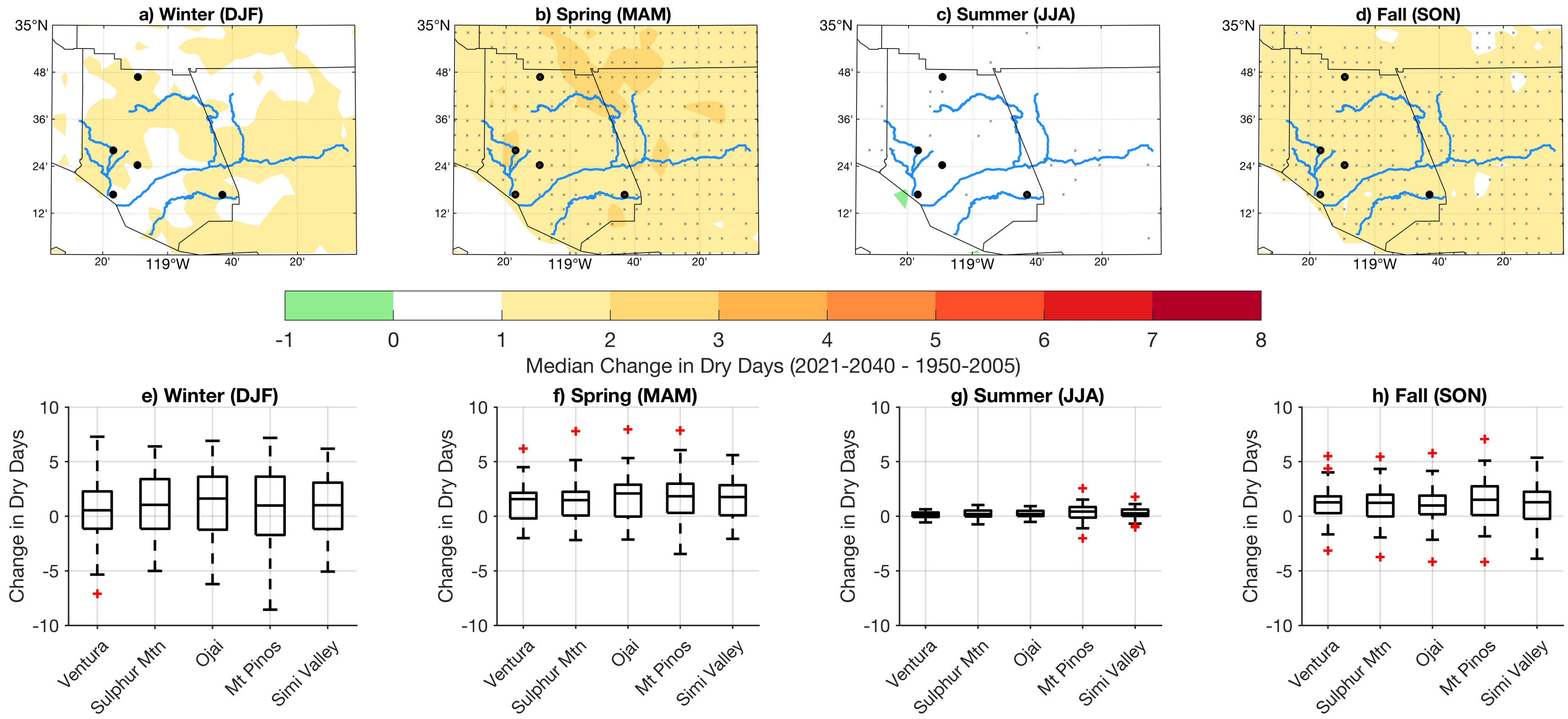
Weak signal | Some drier… | …Some wetter



Winter May Get Wetter

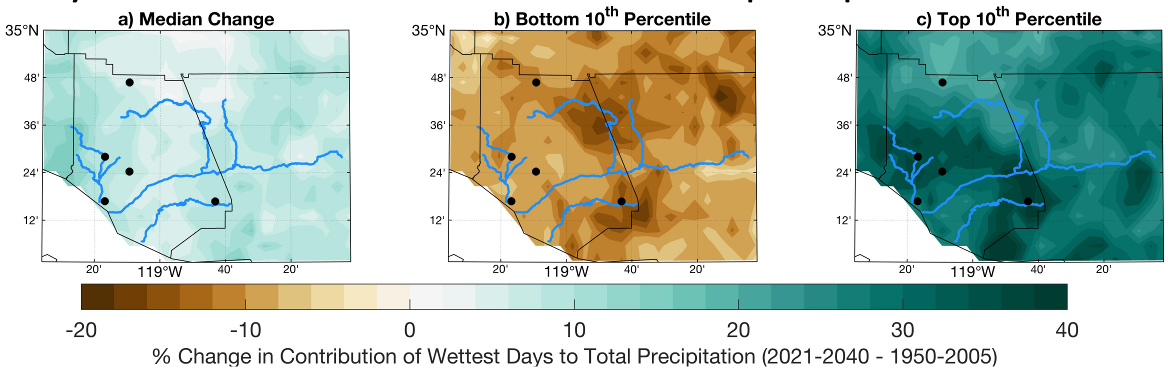


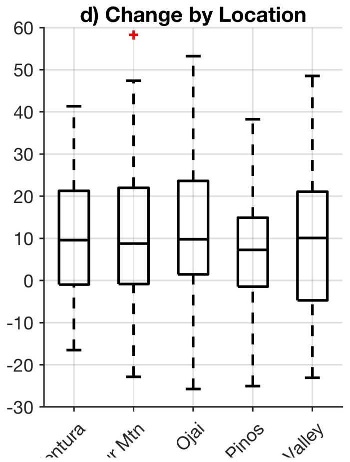
Shoulder Seasons Will Have More Dry Days (winter is mixed)



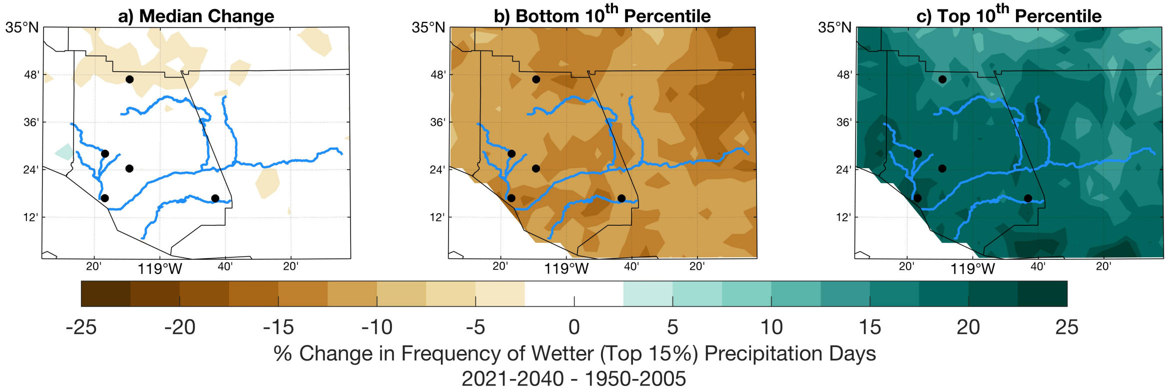
…Suggests Precipitation Intensification

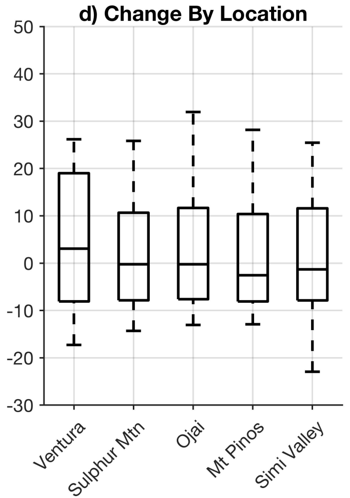
Wettest days contribute *more* to total annual precipitation



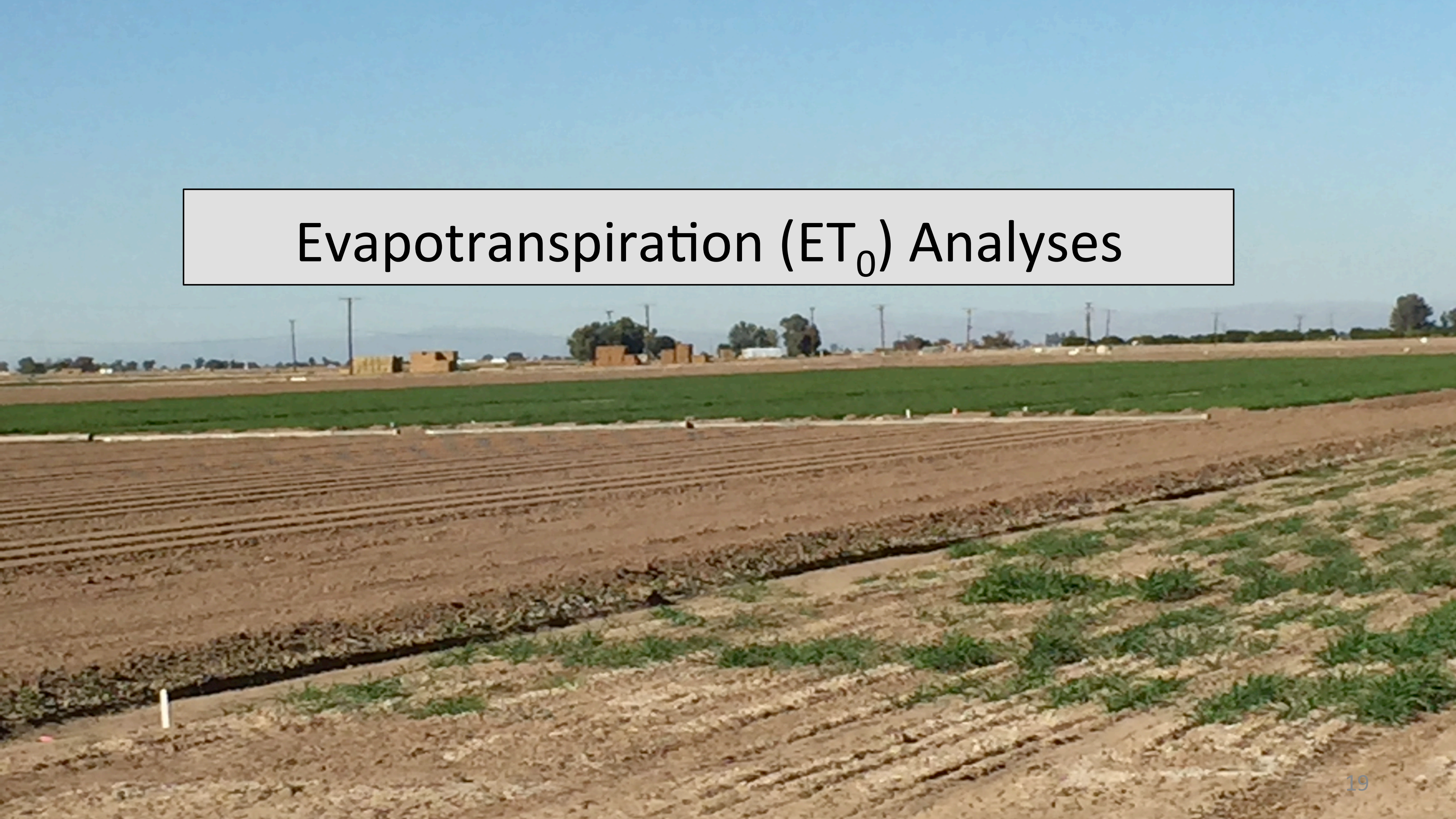


More frequent days exceeding 85th percentile daily precipitation





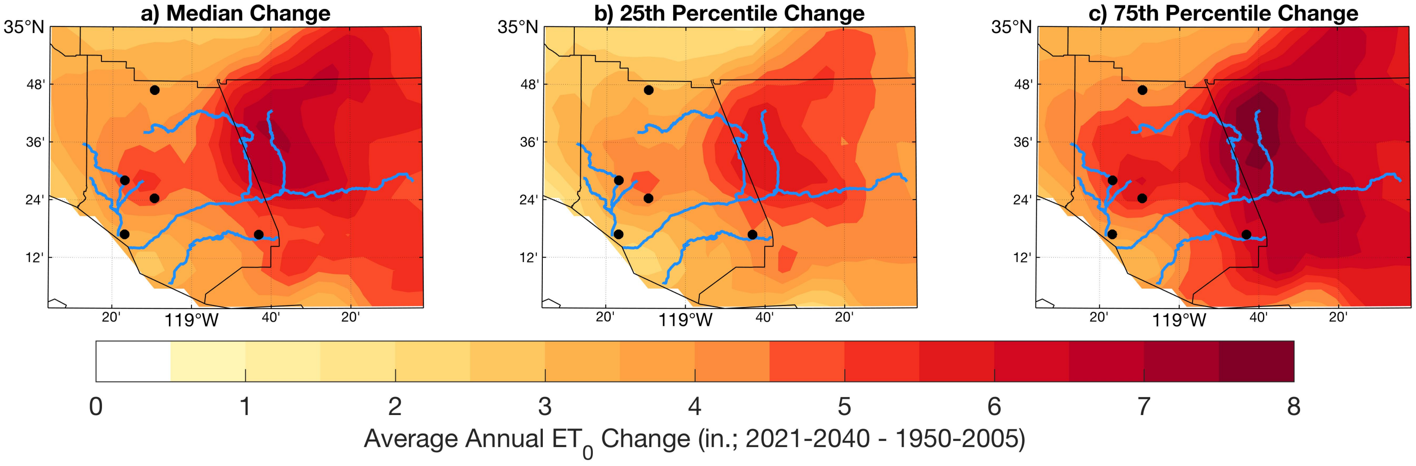
Evapotranspiration (ET_0) Analyses

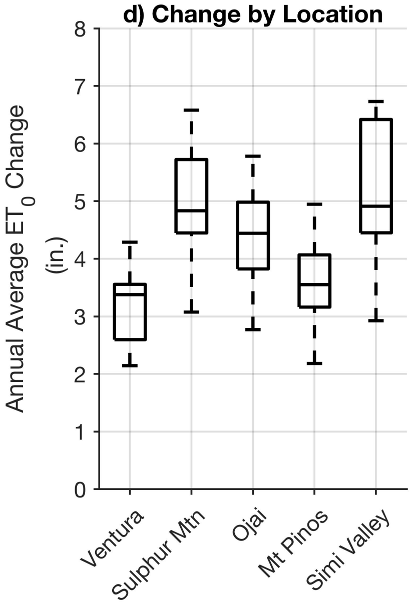


Annual Projected ET_0 Change

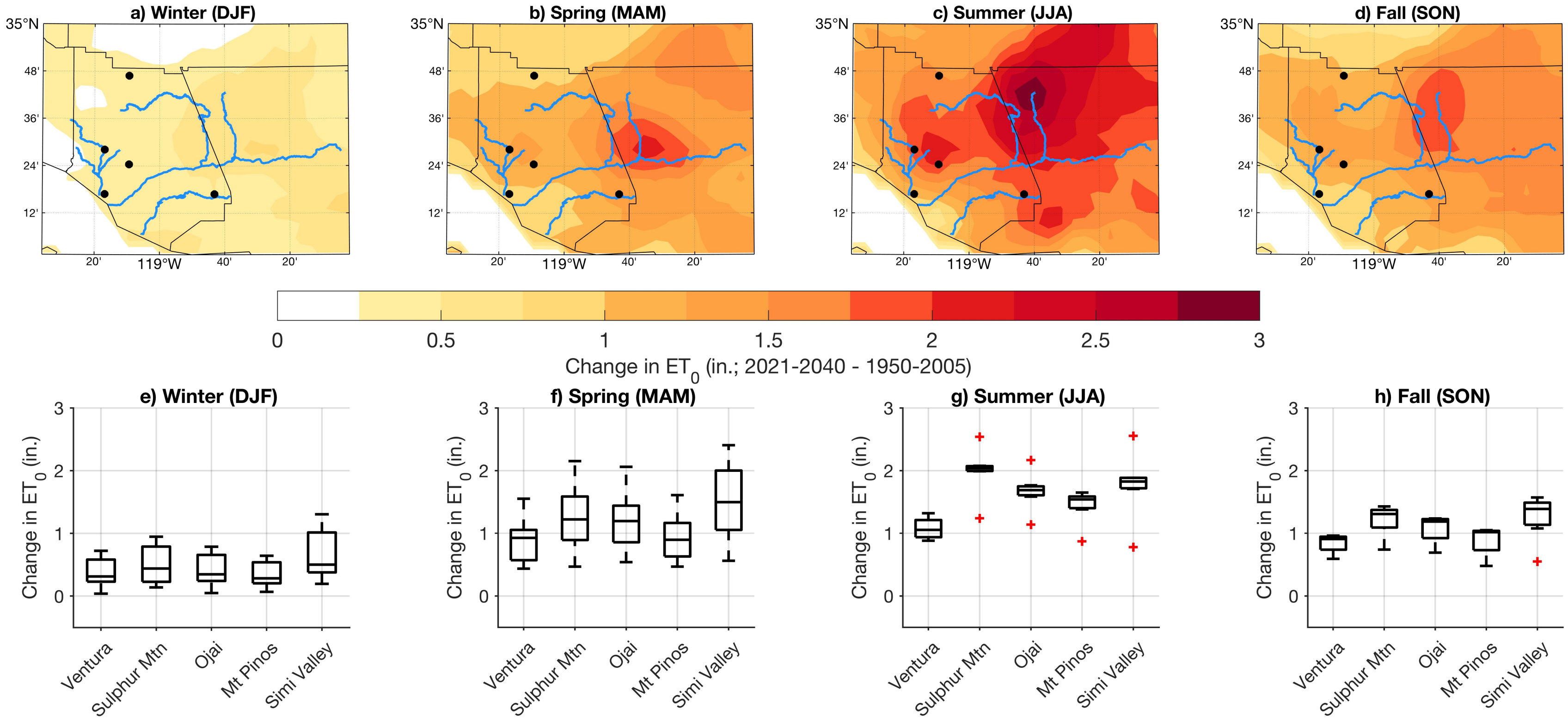
Lower estimate: 'less drought'

Higher estimate: 'more drought'

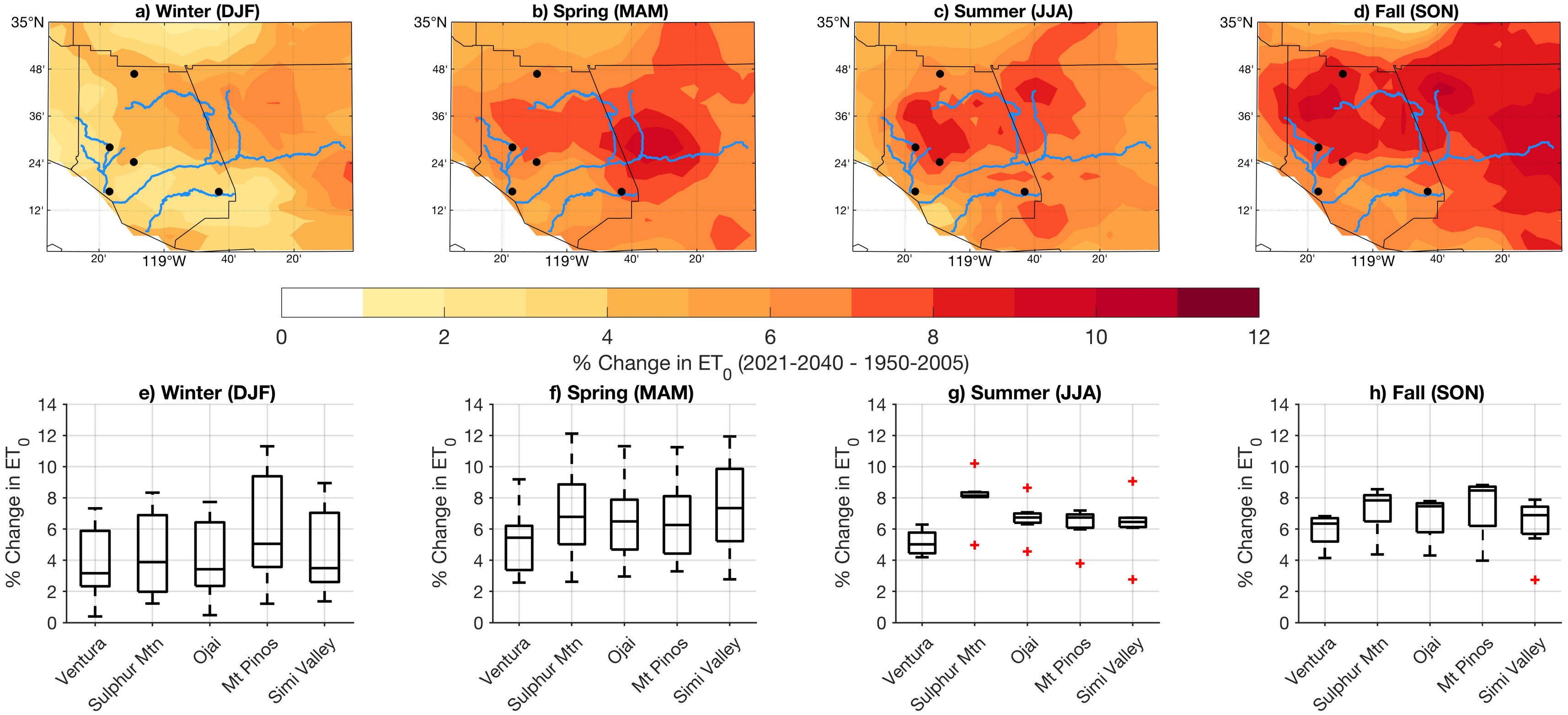




ET_0 Changes By Season



% ET_0 Changes By Season



Spring/fall have potential to have largest relative changes

Short Duration-High Intensity Precipitation Analyses

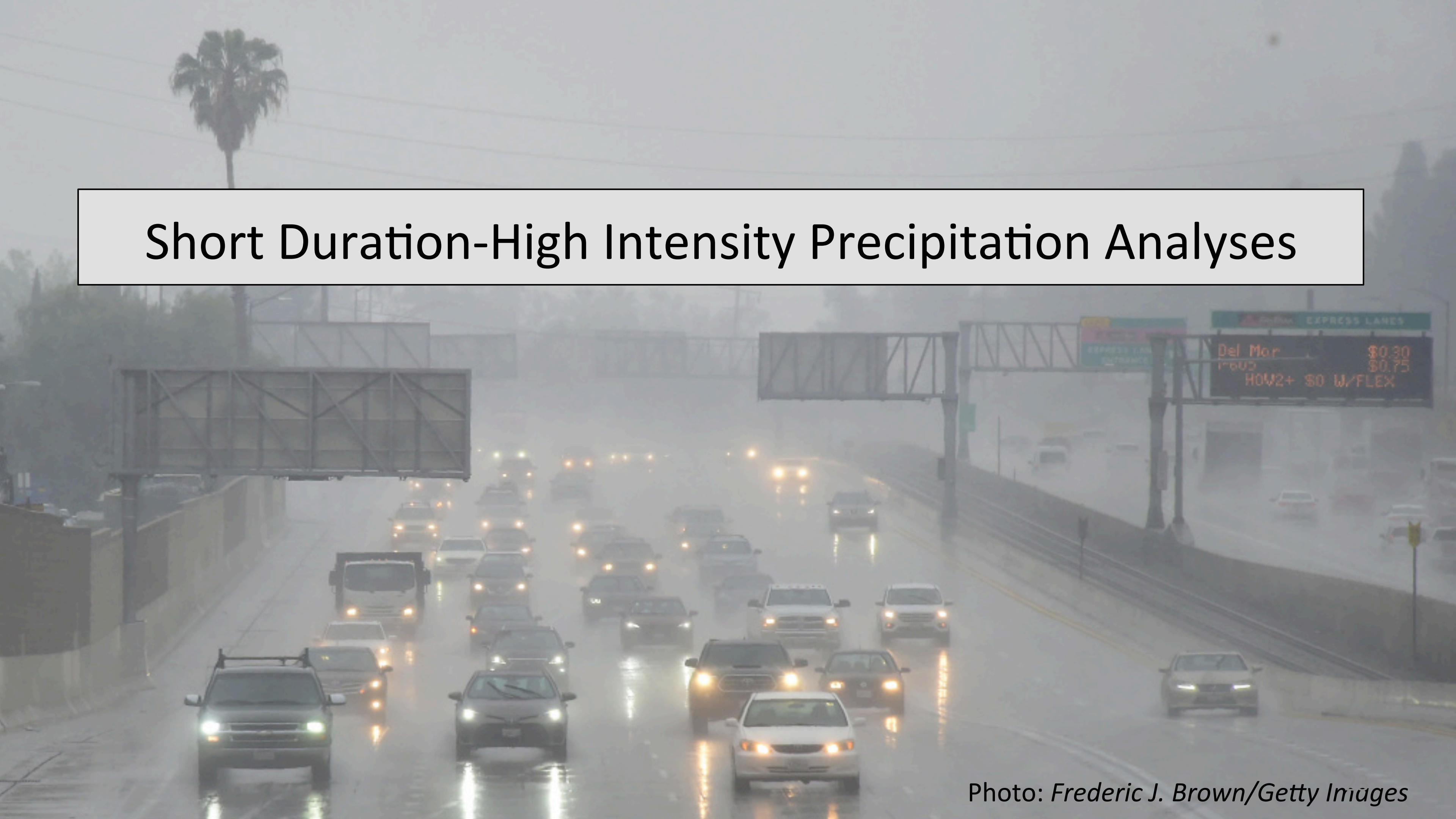


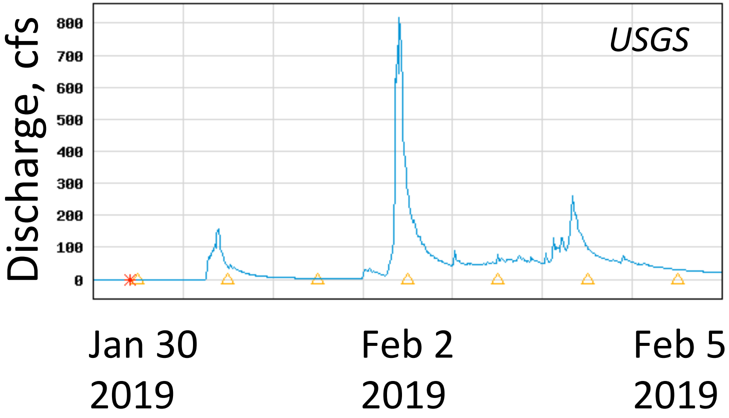
Photo: *Frederic J. Brown/Getty Images*

Why do we care about short-duration, high-intensity precipitation?

Post-fire debris flow in Camarillo Springs (Dec. 2014)
Photo: USGS

Shallow landslides in Ventura County
Photo: J. Godt, USGS

Mission C. Near Mission St.
Santa Barbara



May cause flash flooding; peaks in hydrograph have reservoir management implications

nature climate change
LETTERS
PUBLISHED ONLINE: 5 DECEMBER 2016 | DOI: 10.1038/NCLIMATE3168

The future intensification of hourly precipitation extremes

Andreas F. Prein*, Roy M. Rasmussen, Kyoko Ikeda, Changhai Liu, Martyn P. Clark and Greg J. Holland

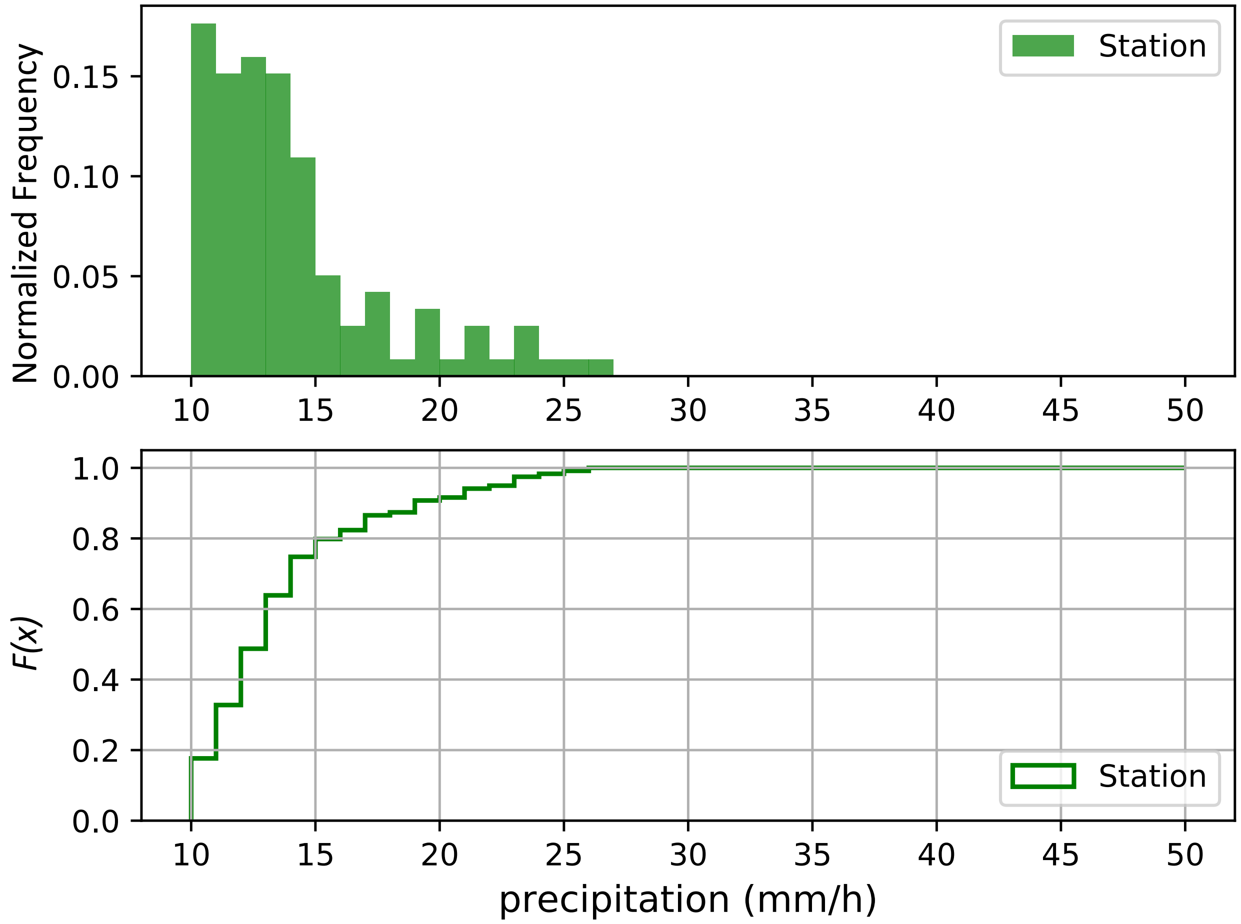
Not a projection, but an experiment

Process: Dynamically downscale (to 4 km) ERA-INTERIM for period 2000-2013 using WRF. A “control” simulation is run, then a “perturbed” pseudo-global warming simulation. Perturbation is the Representative Concentration Pathway (RCP 8.5) 95-year ensemble monthly mean climate change signal from 19 CMIP5 models.

Benefit: Demonstrates impact of thermodynamic changes associated with warming on hourly precipitation characteristics for the given historic period.

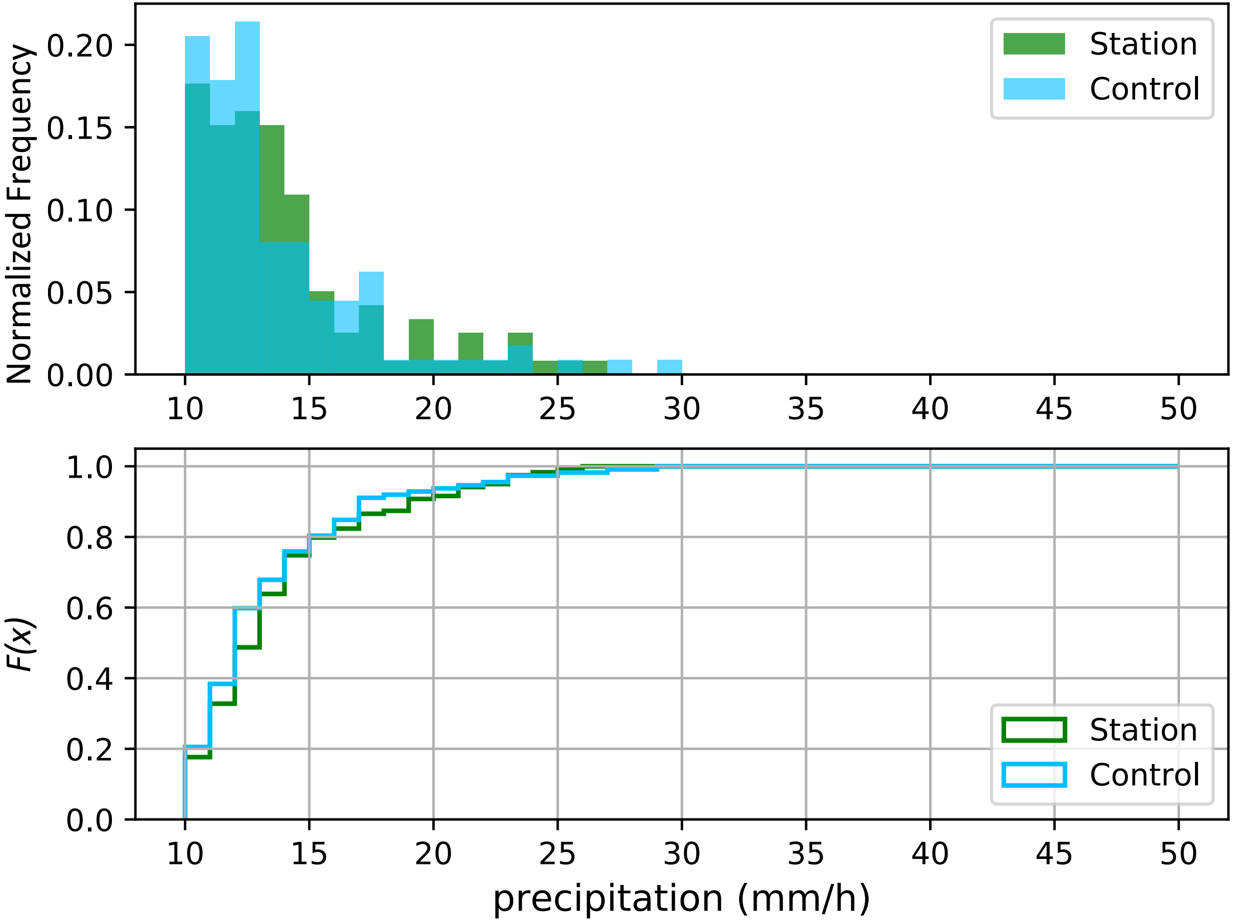
Limitation: Does not account for large-scale circulation changes that are likely to occur in a changing climate.

WheelerGorge Hourly Precip. Intensity 2000-2013



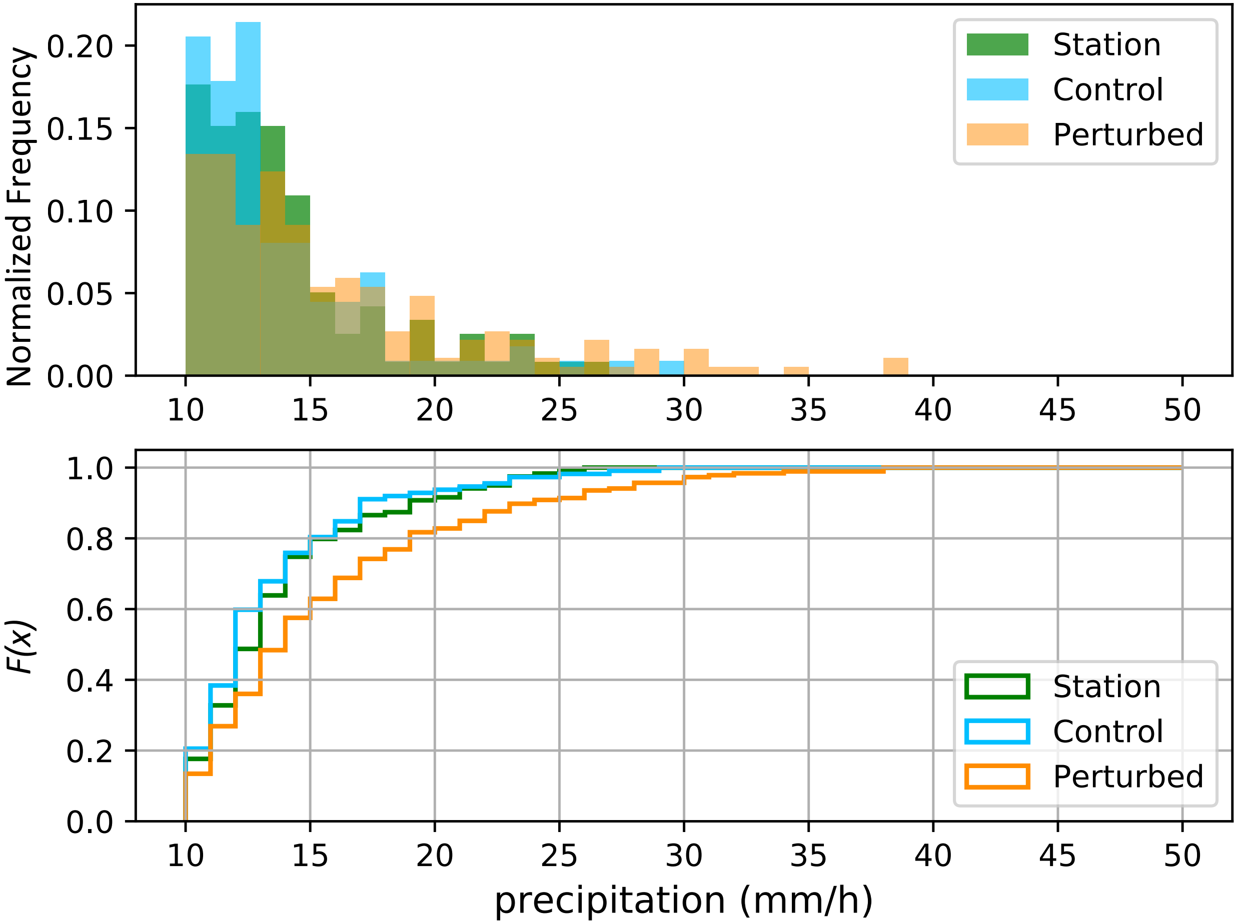
Station data courtesy VCWPD

WheelerGorge Hourly Precip. Intensity 2000-2013



Station data courtesy VCWPD

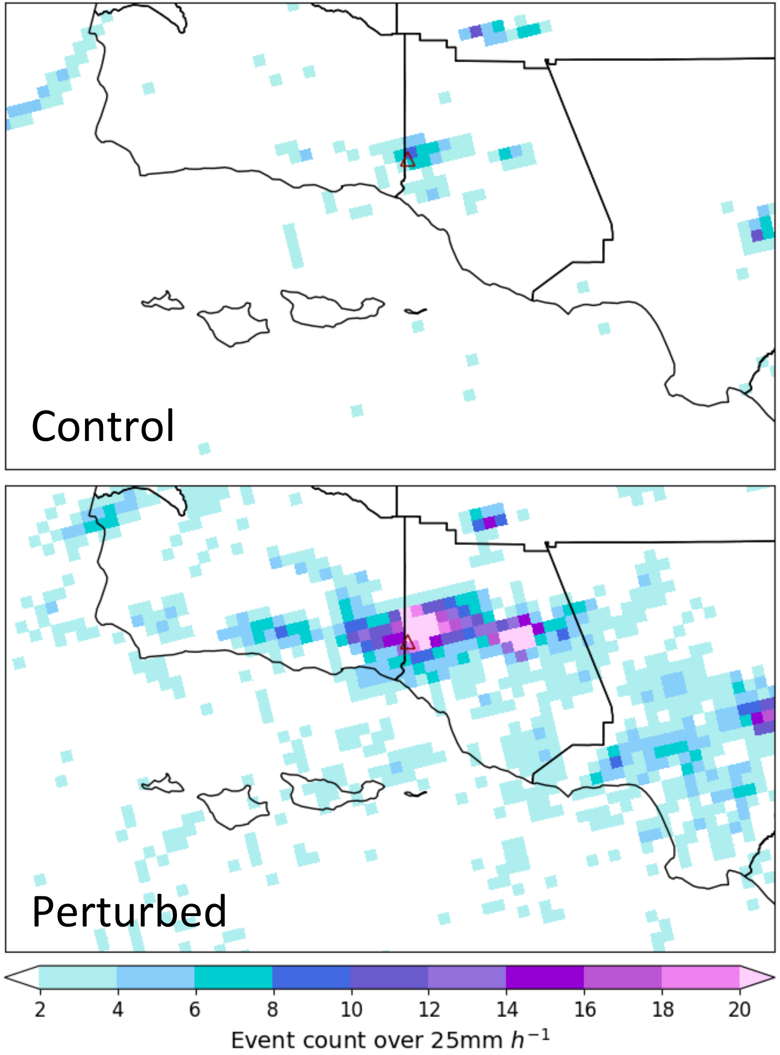
WheelerGorge Hourly Precip. Intensity 2000-2013

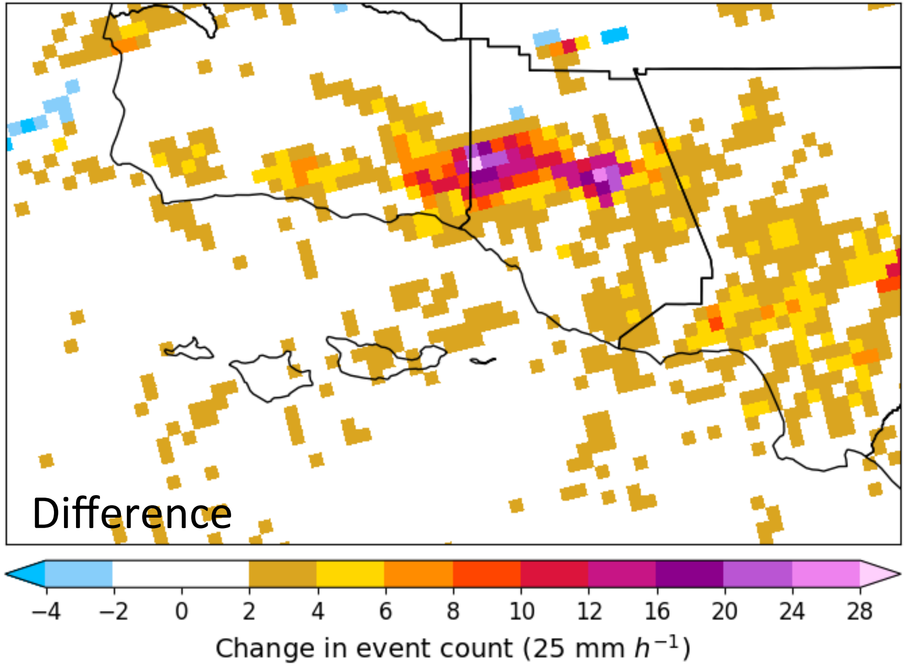


In pseudo global warming simulation (perturbed), distribution shifted towards more frequent events exceeding ~12 mm/h

Station data courtesy VCWPD

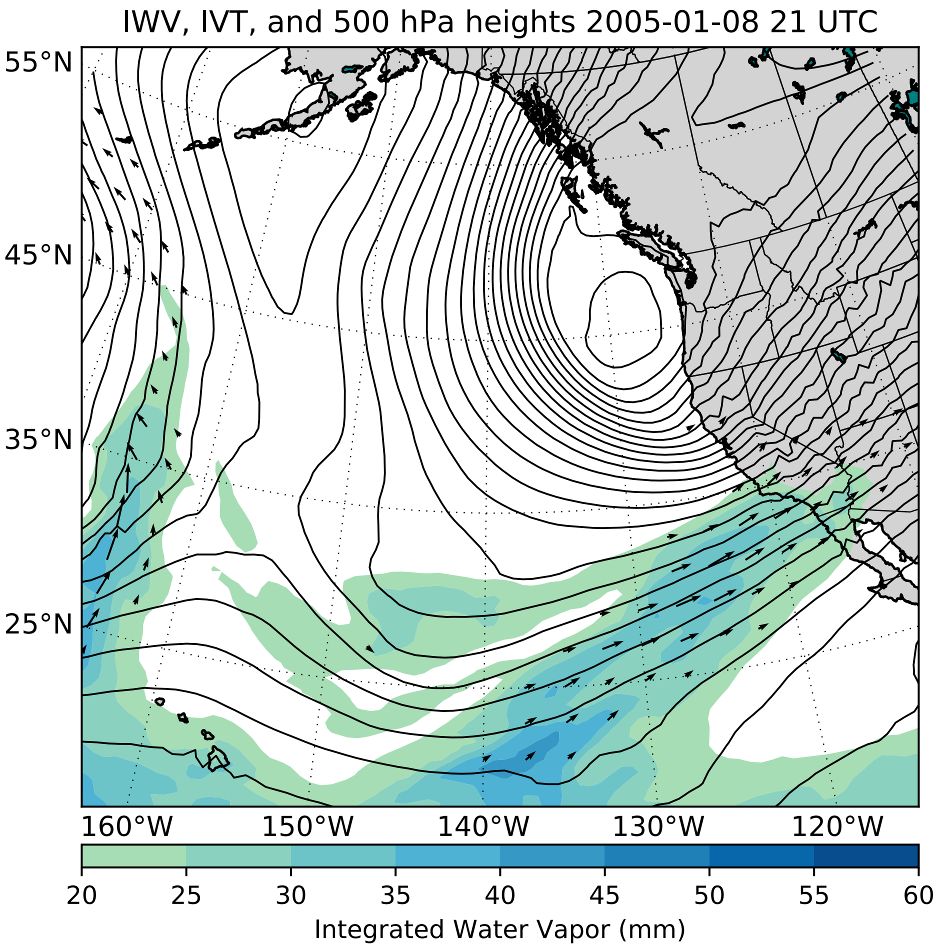
Change in total number of >25 mm h^{-1} events 2000-2013 period





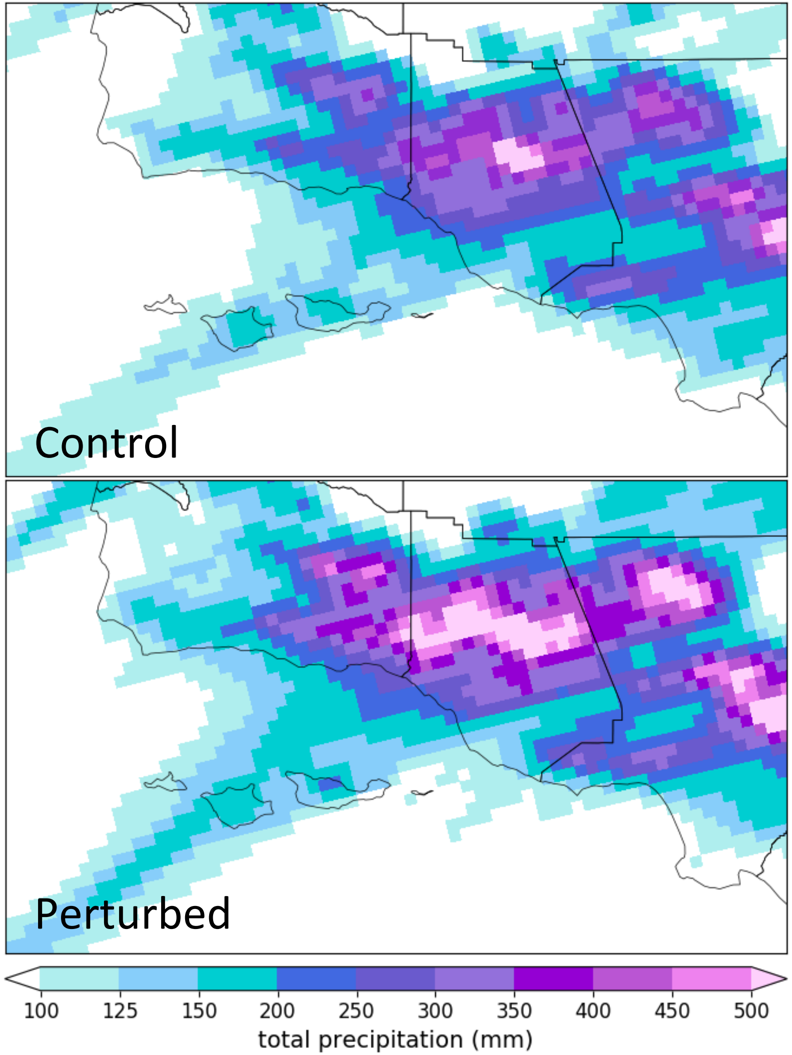
Roughly 2-3x more >25 mm h^{-1} events in high elevations of Ventura County in perturbed (warmed) simulation for the 2000-2013 period

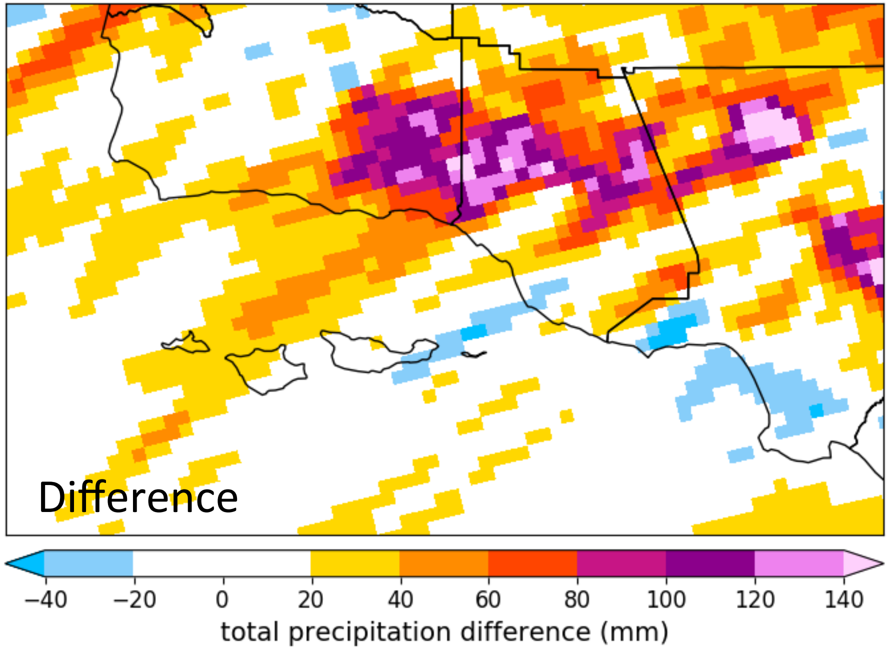
Storm Example: January 7-11 2005



Atmospheric river impacted southern CA, major flooding and damages, landslide at La Conchita killed 10, damaged or destroyed 36 homes

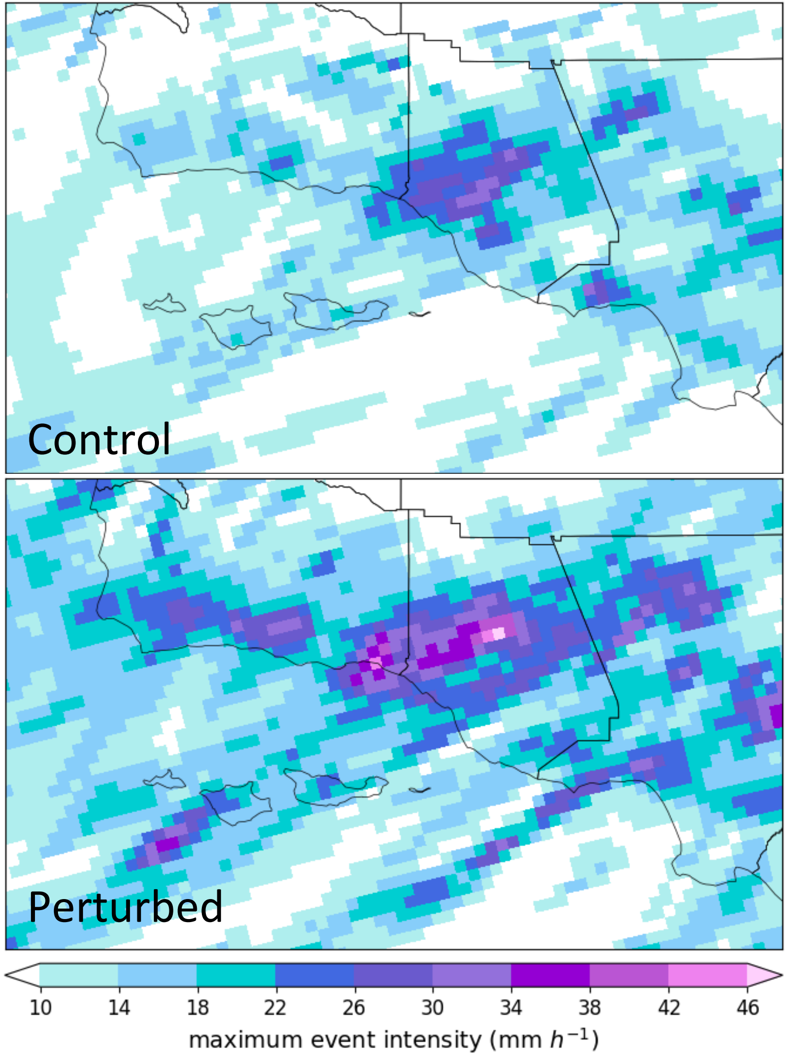
January 7-11 2005 Storm Event: Total Precipitation

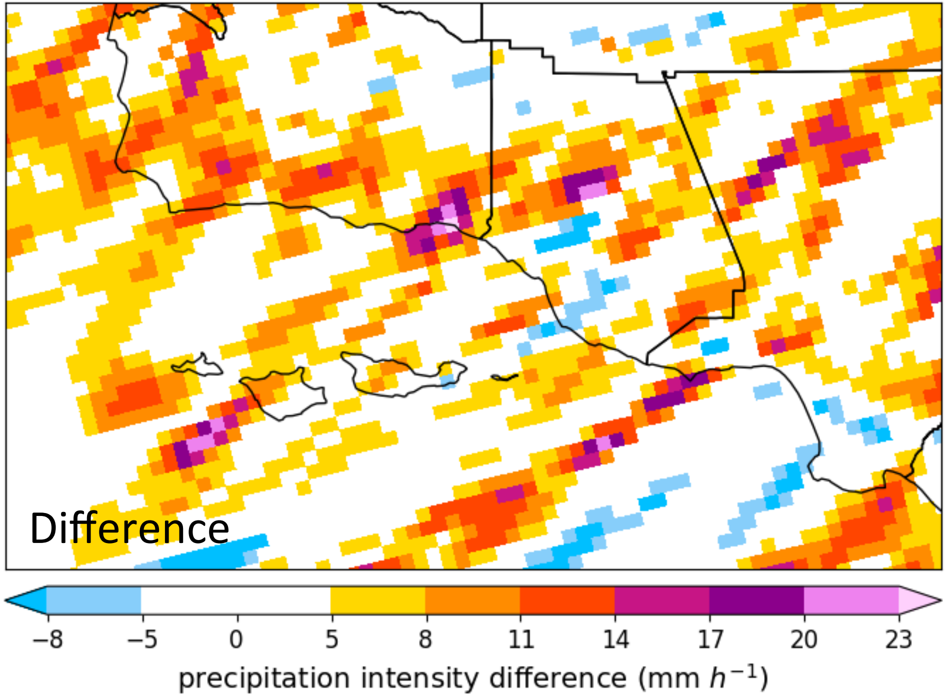




In highest elevations, storm total precipitation increases by more than 120 mm (~5 in) in perturbed scenario as compared to control

January 7-11 2005 Storm Event: Maximum Precipitation Intensity





In places with highest intensities in control, increase of 10-20 mm h^{-1} in perturbed

As Literature Review in Report

- **Drought:** Increased drought susceptibility due to increasing temperatures and ET_0 (e.g., Diffenbaugh et al. 2015). Uncertainty in drought types, frequency, magnitude, and duration in future climate.

- **Sierra Snowpack:** 64% decrease in April 1 snow water equivalent by late century (Reich et al. 2018)

- **Wildfire:** Potential increase in wildfire frequency due to spring/fall drying (Swain et al. 2018) , growing population in WUI (Radeloff et al. 2018), conversion from chaparral to grasses (Syphard et al. 2018). Uncertainty in changes in wildfire size (Hall et al. 2018)

- **Atmospheric Rivers (ARs):** Increased intensity and frequency (longer duration) of AR conditions in Southern California (Espinoza et al. 2018). Intensification of AR-related precipitation (Hall et al. 2018). Little change in average number ARs, but more inter-annual variability (Dettinger 2011)

Conclusions, Limitations, and Future Work

Conclusions from LOCA Analyses

- Good agreement across models that inland areas increase at least 3-5 °F, coastal areas 2-3 °F
- More days exceeding extreme/impactful temperature thresholds
- Increase in ET_0, especially in upper Santa Clara R. watershed during spring and fall (5-10% increase)
- Model disagreement on precipitation signal; any changes in annual/seasonal totals small (winter slight increase)
- Increased dry days, precipitation intensification at daily to sub-daily scales (from Prein data analysis)


Thomas Fire, Dec 2017

Impacts

- Increased water demand due to increased ET_0
- Fewer opportunities to capture rainfall, may need more effective capture/storage methods
- Potential for decreased streamflow, especially in upper Santa Clara
- Increased temperatures, water demand may impact what crops can be grown economically
- Heat impacts to human health, increased need for access to A/C; increased energy demand for cooling
- Temperature and precipitation distribution changes may affect native plants, restoration efforts
- Increased potential for flash flooding
- Increased wildfire frequency; increased drought risk
- *What comes to mind for you?*

See also: Hall et al. 2018 (CA 4th Climate Assessment)

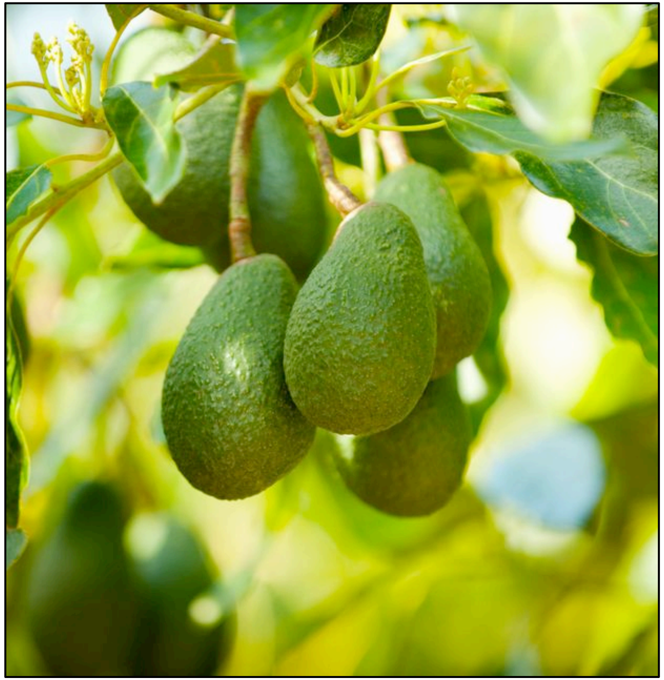
Limitations

- GCMs do not:
  - Accurately represent marine stratus (fog)
  - Resolve fine-scale atmospheric processes (e.g. convection) well
- Statistical downscaling does not capture fine-scale atmospheric processes, but is computationally efficient

There is uncertainty in climate model projections and downscaling methods. However, these are currently the best tools we have to support planning and decision-making in a changing climate.

Future Work

- **Storm sequencing:** Requires establishment of definitions/thresholds, hydrologic modeling
- **Impacts of temperature on water quality:** Need to establish thresholds to examine in model projections
- **Impacts on native plant species:** Need to establish thresholds to examine in model projections
- **Change in frequency of Article 21 years:** Establish what climate conditions necessary for excess water
- **Impacts to energy demand**
- **Drought characteristics**
- **Wildfire size, intensity, frequency**
- **2041-2070 period**



RESOURCES LEGACY FUND
Creative Solutions. Lasting Results.

CNAP
California-Nevada Climate Applications Program

DRI
Desert Research Institute

Thank you! Questions?

@WRCCclimate
@CnapRisa
@CW3E_Scripps

WRCC

Contact:
nina.oakley@dri.edu
benjamin.hatchett@dri.edu

References

Diffenbaugh, N. S., Swain, D. L., & Touma, D. (2015). Anthropogenic warming has increased drought risk in California. *Proceedings of the National Academy of Sciences*, *112*(13), 3931-3936.

Espinoza, V., Waliser, D. E., Guan, B., Lavers, D. A., & Ralph, F. M. (2018). Global Analysis of Climate Change Projection Effects on Atmospheric Rivers. *Geophysical Research Letters*, *45*(9), 4299-4308. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2017GL076968

Hall et al. (2018) California 4th Climate Assessment Statewide Summary Report http://www.climateassessment.ca.gov/state/docs/20180827-StatewideSummary.pdf

Pierce, D. W., Cayan D.R., Dehaan, L. (2016) Creating climate projections to support the 4th California Climate Assessment. http://loca.ucsd.edu/~pierce/IEPR_Clim_proj_using_LOCA_and_VIC_2016-06-13b.pdf

Prein, A. F., Rasmussen, R. M., Ikeda, K., Liu, C., Clark, M. P., & Holland, G. J. (2017). The future intensification of hourly precipitation extremes. *Nature Climate Change*, *7*(1), 48. https://www.nature.com/articles/nclimate3168

Radeloff, V. C., Helmers, D. P., Kramer, H. A., Mockrin, M. H., Alexandre, P. M., Bar-Massada, A., ... & Stewart, S. I. (2018). Rapid growth of the US wildland-urban interface raises wildfire risk. *Proceedings of the National Academy of Sciences*, *115*(13), 3314-3319. http://www.pnas.org/content/pnas/115/13/3314.full.pdf

Reich, KD, N Berg, DB Walton, M Schwartz, F Sun, X Huang, and A Hall, 2018: “Climate Change in the Sierra Nevada: California’s Water Future.” UCLA Center for Climate Science. https://www.ioes.ucla.edu/wp-content/uploads/UCLA-CCS-Climate-Change-Sierra-Nevada.pdf

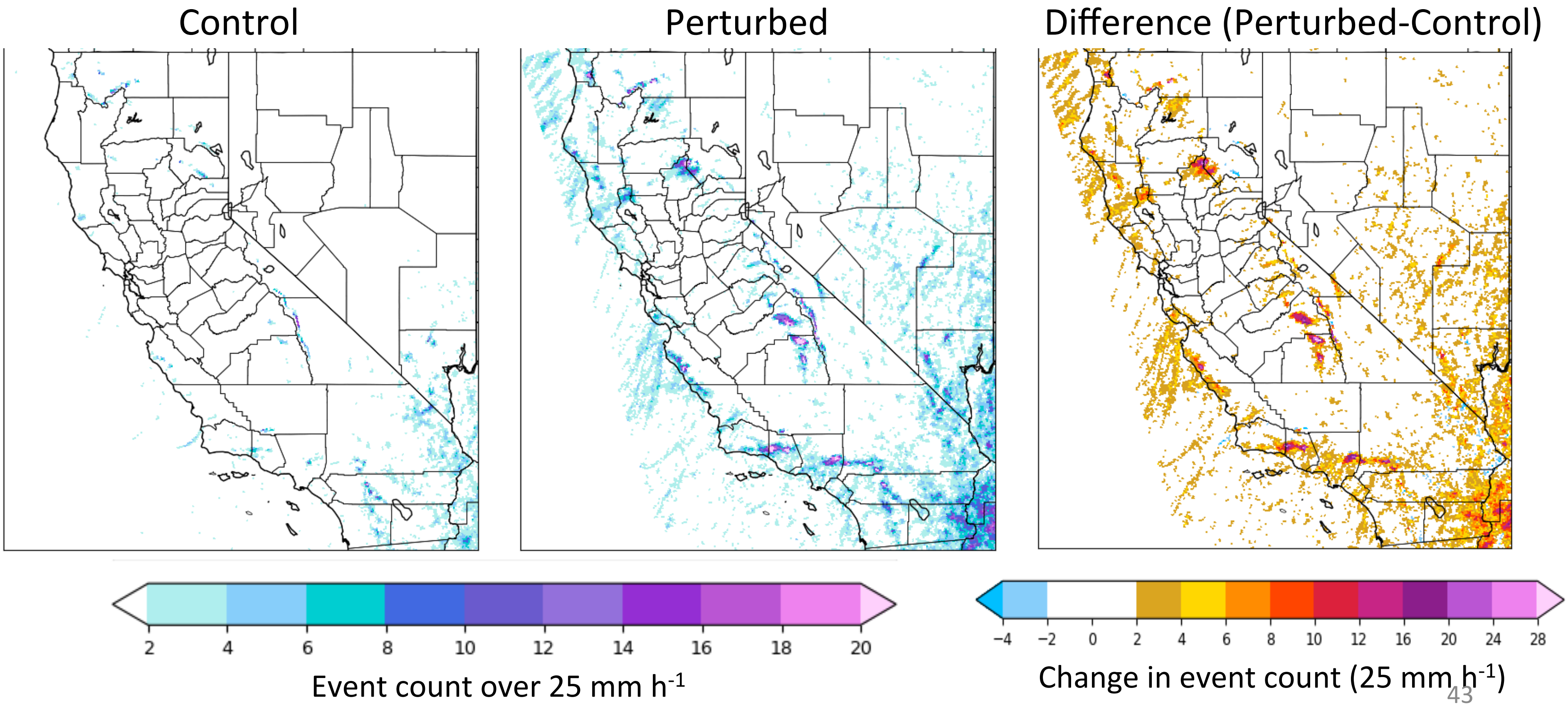
References

Swain, D. L., Langenbrunner, B., Neelin, J. D., & Hall, A. (2018). Increasing precipitation volatility in twenty-first-century California. *Nature Climate Change*, *8*(5), 427.

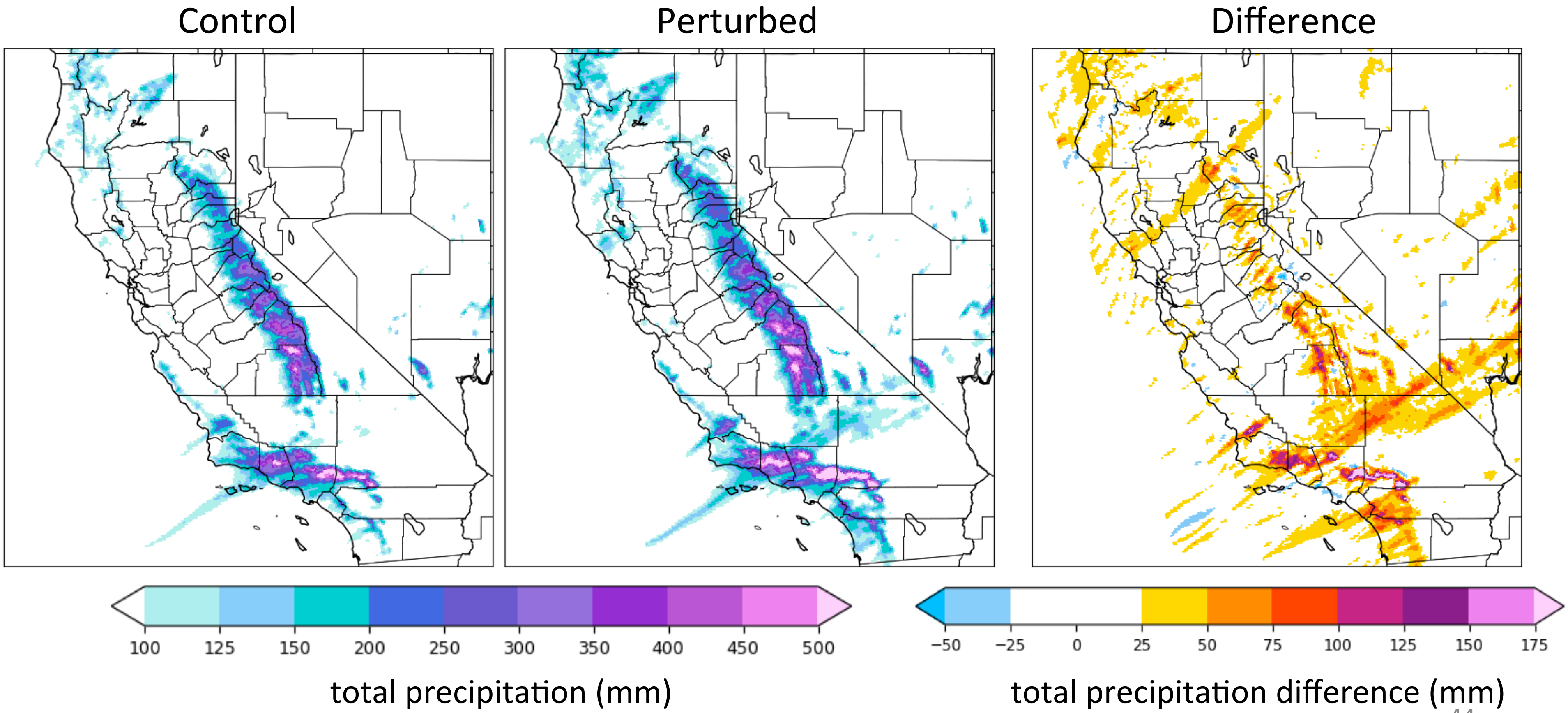
Syphard, A. D., Brennan, T. J., & Keeley, J. E. (2018). Chaparral landscape conversion in Southern California. In *Valuing Chaparral* (pp. 323-346). Springer, Cham.

Extra Slides

Change in total number of 25 mm h^{-1} events 2000-2013 period



January 7-11 2005 Storm Event: Total Precipitation



January 7-11 2005 Storm Event: Max Precipitation Intensity