Climate Change Projections for Ventura County
2021-2040

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Follow-up to October 2018 Meeting

• Incorporated many requested analyses
  • Evapotranspiration
  • Likelihood/uncertainty across suite of models
  • Change in 85th percentile precipitation days
  • Temperature, precipitation, ET₀ 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

- 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

Pierce et al. 2016
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° 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.
Temperature Analyses
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

Change in Minimum Temperature (°F; 2021-2040 - 1950-2005)

-1 0 1 2 3 4 5 6

a) Winter (DJF)  b) Spring (MAM)  c) Summer (JJA)  d) Fall (SON)

Change in T_{min} (°F)
Ventura Sulphur Mt. Ojai Mt. Pinos Simi Valley

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Minimum Temperature Extremes

**98th Percentile “Warmest Nights”**

**90th 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

Average Annual Precipitation Change (in.; 2021-2040 - 1950-2005)
Winter May Get Wetter

Change in Precipitation (in.; 2021-2040 - 1950-2005)

-2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5

a) Winter (DJF)  

b) Spring (MAM)  

c) Summer (JJA)  

d) Fall (SON)  

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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 (ET₀) Analyses
Annual Projected ET$_0$ Change

Lower estimate: ‘less drought’

Higher estimate: ‘more drought’
ET\textsubscript{0} Changes By Season

- a) Winter (DJF)
- b) Spring (MAM)
- c) Summer (JJA)
- d) Fall (SON)

Change in ET\textsubscript{0} (in.; 2021-2040 - 1950-2005)

- e) Winter (DJF)
- f) Spring (MAM)
- g) Summer (JJA)
- h) Fall (SON)
% $ET_0$ Changes By Season

Spring/fall have potential to have largest relative changes
Short Duration-High Intensity Precipitation Analyses
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*

Discharge, cfs

Mission C. Near Mission St.
Santa Barbara

May cause flash flooding; peaks in hydrograph have reservoir management implications
The future intensification of hourly precipitation extremes

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

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.
In pseudo global warming simulation (perturbed), distribution shifted towards more frequent events exceeding ~12 mm/h.
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
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.
In places with highest intensities in control, increase of 10-20 mm h\(^{-1}\) in perturbed
• **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 ET₀, 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)
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**
Thank you! Questions?

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WRCC


Extra Slides
Change in total number of 25 mm h\(^{-1}\) events
2000-2013 period

Control

Perturbed

Difference (Perturbed-Control)
January 7-11 2005 Storm Event: Total Precipitation

**Control**

**Perturbed**

**Difference**

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- Total precipitation (mm)
- Total precipitation difference (mm)

- 100 125 150 200 250 300 350 400 450 500
- -50 -25 0 25 50 75 100 125 150 175
January 7-11 2005 Storm Event: Max Precipitation Intensity

Control

Perturbed

Difference

maximum event intensity (mm h⁻¹)

intensity difference (mm h⁻¹)