

Cal-Adapt: Linking Climate Science with Practitioner Need

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Webinar
Berkeley, California
December 6, 2018

Cal-Adapt

Linking Climate Science with Practitioner Need

Developed by UC Berkeley's Geospatial Innovation Facility



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Cal-Adapt



Cutting-Edge Mapping Technology at UC Berkeley

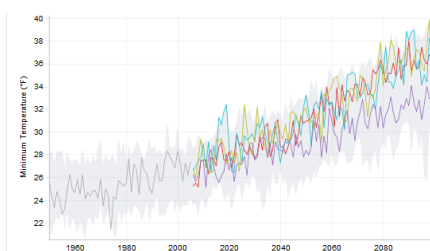
Today's Talk

- Introduce Cal-Adapt
- How can you use Cal-Adapt? Live Demo
- Impact on Climate Adaptation Practice and Policy
- Feedback and Future Directions:
 - Stakeholder engagement
 - What new datasets, features and tools would help support user needs?

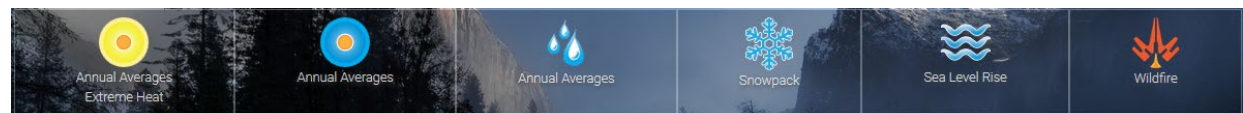
Cal-Adapt: A Tool for Energy Sector Resilience and Research

Cal-Adapt provides a scientific basis for exploring climate-related risks and resilience options for energy sector planning and adaptation.

- Convey local climate risks based on peer-reviewed science;
- Climate change projections presented in **easy-to-understand format** with plain English descriptions *and* scientific rigor;
- **Interactive maps and charts** provide a variety of approaches to explore different aspects of climate change;
- **Access to primary climate change data** for further analysis and research;
- Enable **development of custom tools** designed to manipulate climate change projections to support decision-making.



Cal-Adapt offers a variety of tools for exploring high-resolution projections of climate, including temperatures, precipitation, snowpack, sea level rise, and wildfire.



Cal-Adapt 1.0

Originally released to the public in 2011 to showcase the innovative climate change research produced by the scientific community in California, as documented in the 2009 California Climate Adaptation Strategy. Cal-Adapt 1.0 has been visited by over 160,000 visitors from all 50 states and over 190 countries.



Stakeholder Engagement

- User survey conducted by Energy Commission in 2014
- Contributors:
 - State, municipal, county, & regional public officials
 - Consultants: private and non-profit
 - Interest groups
 - Academics

cal-adapt

EXPLORING CALIFORNIA'S CLIMATE CHANGE RESEARCH

Video Tour
VIEW THE DIFFERENT TOOLS AND DATA AVAILABLE IN CAL-ADAPT

Explore Climate Tools
INTERACTIVE MAPS & CHARTS

About Cal-Adapt

WHAT'S NEW?

WHAT'S TO COME?

FAQS

Provides information not available elsewhere. The envy of other states.

Site developed by:
Geospatial Innovation Facility

Cal-Adapt is a product of the Public Interest Energy Research (PIER) program

Stakeholder Engagement

Spatial Information Needs

Users need help leveraging existing resources

Users want guidance on which layers to include in their local analysis

Cal-Adapt has the potential to fill an existing gap by helping users understand climate science

cal-adapt

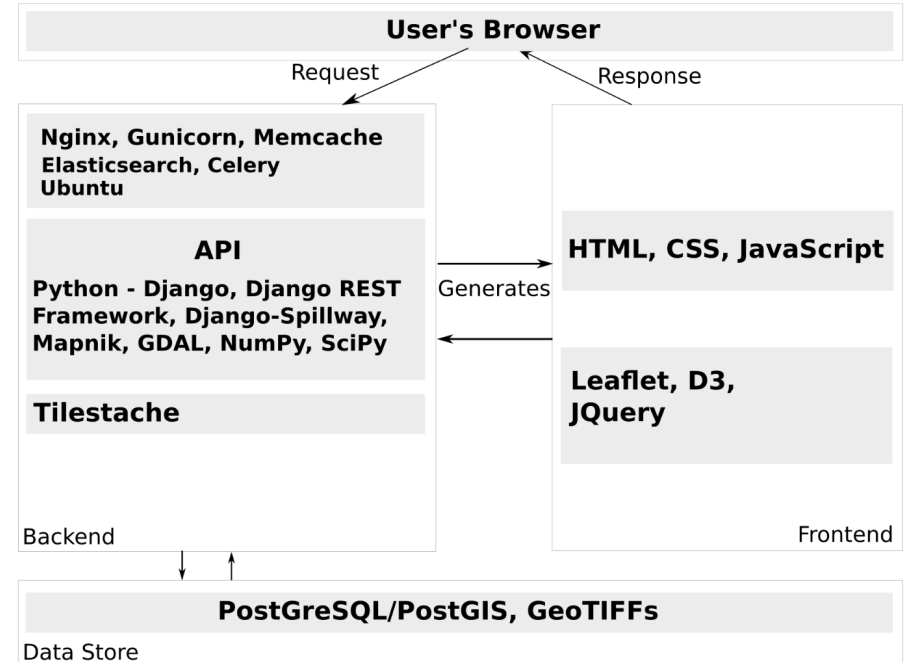
<http://cal-adapt.org>

Cal-Adapt 2.0

- Higher resolution, higher fidelity data including:
 - Temperature and precipitation at daily time steps from LOCA (Localized Climate Analogues) downscaled CMIP5 data, Scripps Institution of Oceanography (Pierce et al. 2018)
 - Sea Level Rise inundation (Delta as well as open coast and bay)
 - Observed historical data (daily temperature, precipitation)
 - Wildfire projections
 - VIC hydrological variables
 - Enhanced usability, including support for interpreting data and visualizations
 - Built with modern and powerful data visualization libraries (e.g. D3, Leaflet)
 - Public API* supports third-party tool development
- * Applications Programming Interface

Cal-Adapt API

- Open source architecture powered by Django, Django REST framework and Django-Spillway, an open source library developed at the GIF
- Dynamic temporal aggregation of time series data
- Spatial aggregation by counties, climate regions, watersheds, census tracts, legislative districts
- Allows other organizations to access climate data and build domain specific visualization and planning tools



Providing Scenarios Approved by State for Energy Sector Planning

- Recommended scenarios available via Cal-Adapt, which defaults to the four “priority” models chosen to represent a range of possible futures.
- These scenarios are the basis for California’s Fourth Climate Change Assessment.
- IOUs requested set of common standards, timeframes, and scenarios to rely on for planning.
- OPR’s forthcoming guidance to state agencies will rely on these scenarios, too.

CLIMATE MODELS			
<input checked="" type="checkbox"/>	HadGEM2-ES*	<input checked="" type="checkbox"/> Show/Hide	Warm/Dry
<input checked="" type="checkbox"/>	CNRM-CM5*	<input checked="" type="checkbox"/> Show/Hide	Cool/Wet
<input checked="" type="checkbox"/>	CanESM2*	<input checked="" type="checkbox"/> Show/Hide	Average
<input checked="" type="checkbox"/>	MIROC5*	<input checked="" type="checkbox"/> Show/Hide	Complement
<input type="checkbox"/>	ACCESS1-0	<input type="checkbox"/> Show/Hide	
<input type="checkbox"/>	CCSM4	<input type="checkbox"/> Show/Hide	
<input type="checkbox"/>	CESM1-BGC	<input type="checkbox"/> Show/Hide	
<input type="checkbox"/>	CMCC-CMS	<input type="checkbox"/> Show/Hide	
<input type="checkbox"/>	GFDL-CM3	<input type="checkbox"/> Show/Hide	
<input type="checkbox"/>	HadGEM2-CC	<input type="checkbox"/> Show/Hide	

Cal-Adapt.org

cal-adapt

TOOLS DATA RESOURCES BLOG ABOUT HELP

Exploring California's Climate Change Research

Cal-Adapt provides a view of how climate change might affect California. Find tools, data, and resources to conduct research, develop adaptation plans and build applications.



Annual Averages
Extreme Heat
Cooling Degree Days



Annual Averages
Heating Degree Days



Annual Averages



Snowpack



Sea Level Rise



Wildfire



Streamflow

Climate Tools

Explore projected changes in temperature, precipitation, snowpack and sea level rise in California over this century with our interactive climate data visualizations.

EXPLORE

Download Data

Download high resolution downscaled daily, annual and monthly climate projections for your project area in NetCDF or GeoTiff formats.

EXPLORE

Find Resources

Search State of California's Research Catalog, explore peer-reviewed publications, understand how to use climate projections.

EXPLORE

Cal-Adapt



Cal-Adapt 2.0 Demo

Cal-adapt.org

Cal-Adapt



Cal-Adapt Use Cases: Energy Sector

California Investor-Owned Utilities participating in the **U.S. Department of Energy's Resilience Partnership** used Cal-Adapt tools and data to support vulnerability assessments:

- **PG&E**: used Cal-Adapt's extreme heat tool to explore intensity and duration of projected mid-century heat waves
- **SoCalEdison**: used Cal-Adapt in conjunction with spatial overlays of infrastructure and as a basis for exploring uncertainty.
- **SDG&E**: used Cal-Adapt to support a comprehensive GIS-based vulnerability study.

More about DOE's Resilience Partnership here: <https://energy.gov/epa/partnership-energy-sector-climate-resilience>

Cal-Adapt Use Cases: Energy Sector

Moving beyond vulnerability assessments, California Investor-Owned Utilities participating have used Cal-Adapt to support **on-the-ground resilience efforts**:

- **SDG&E**: Used Cal-Adapt 2.0 to support climate-resilient design of a compressor station in Blythe, California, to investigate implications of climate re: SDG&E's Design Standards, and to explore climate dimensions of system hardening projects.
- **SoCalEdison (SCE)**: Data available on Cal-Adapt 2.0 improved analyses regarding projected climate (e.g., Mesa Substation Project in Monterey Park, California); plans to integrate climate projections into existing planning models.

Ultimately, General Rate Cases that incorporate climate adaptation actions are envisioned, relying on data available on Cal-Adapt.

Cal-Adapt Use Cases beyond the Energy Sector

As an easy-to-use, free and publicly available tool that aligns with data endorsed by the state for research and planning, Cal-Adapt has been adopted by resilience initiatives beyond the natural gas and electricity sectors for which it was primarily developed:

- The **California Department of Public Health** used climate risks portrayed by Cal-Adapt as the foundation of work to “Build Resistance Against Climate Effects” (BRACE) by preparing local and county-level public health departments for projected risks;
- The **California Government Operations Agency (GovOps)** leveraged Cal-Adapt’s publicly available **Applications Programming Interface (API)** to develop an automated tool supporting incorporation of adaptation into Sustainability Roadmaps;
- The **United States Forest Service (USFS)** has already used Cal-Adapt for planning at least one **fuel treatment** (Tatham Ridge Project) with future climate conditions in mind;
- OPR’s Adaptation Clearinghouse (a.k.a. **ICARP**, or Integrated Climate Adaptation and Resiliency Program), development of which was mandated by SB 246, **refers users to Cal-Adapt for exploration of local climate risks** through high resolution climate projections.

Cal-Adapt's Impact on Climate Adaptation Policy and Guidance in California

Cal-Adapt has already made a difference in adaptation and policy planning in California and has been explicitly recognized by California's legislature as a key recourse to support local hazard mitigation efforts:

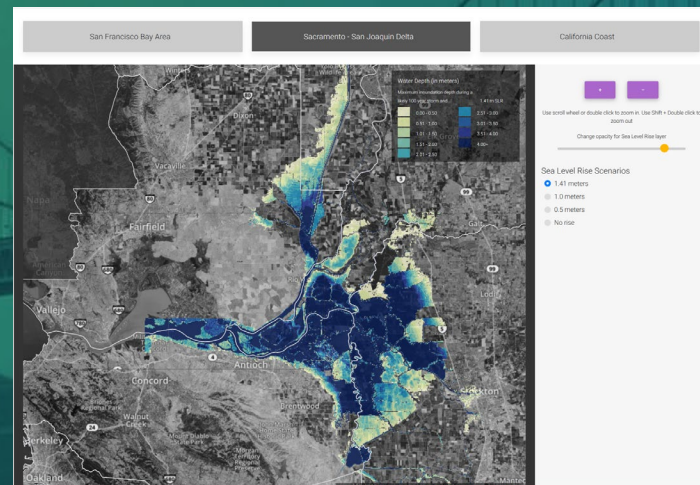
- Cal-Adapt is named as a resource by landmark legislation (SB 379) that requires the integration of climate-related risks into local hazard mitigation plans.
- General Planning Guidelines (2017 update) direct local governments to Cal-Adapt as resource to support assessment of climate -related vulnerabilities and development of adaptation policies.
- *Planning and Investing for a Resilient California* (January 2018) which provides adaptation guidance from the TAC established by OPR directs state agencies to Cal-Adapt as a source for peer- reviewed, state- sanctioned data depicting projected climate risks and for map overlays to facilitate planning and investment.
- In March 2017, the State Water Resources Control Board (SWRCB) approved a resolution (no. 2017- 0012) on "Comprehensive Response to Climate Change" directing staff to consult "the most current data available through Cal-Adapt."
- OPR's Adaptation Clearinghouse (the Integrated Climate Adaptation and Resiliency Program), development of which was mandated by SB 246, refers users to Cal-Adapt for exploration of local climate risks through high resolution climate projections.

Cal-Adapt 3.0

- **Integrate new research results**
 - From California's Fourth Climate Change Assessment and other key data
- **Improve data services and decision support**
 - Incorporate distributed cloud processing infrastructure for increased computational power
 - Batch processing that allows users to input a spreadsheet of points and extract results
 - Develop easier method to calculate temporal summaries, e.g. monthly averages
 - Improved data download options
- **Expand stakeholder outreach**
 - Quarterly short webinars planned to discuss specific tools and topics to improve beta-testing
 - Workshops and meetings with stakeholders
- **Develop new visualizations and tools**

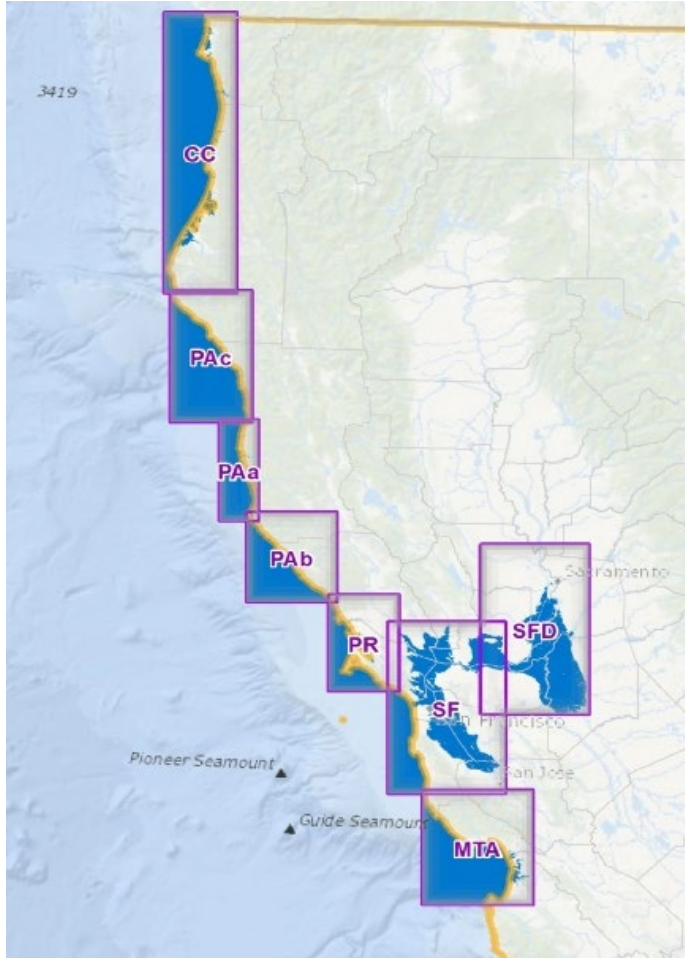
Enhanced Sea Level Rise Tool

- Enhanced **Sea Level Rise** tool is in the planning stages
- Partnering with **Climate Central** to compute and visualize flood risk and to effectively communicate sea level rise science
- Designed to allow users to view multiple datasets portraying SLR impacts
- Additional datasets include:
 - CoSMoS (USGS Coastal Storm Modeling System)
 - Updated CalFloD-3D (Radke)

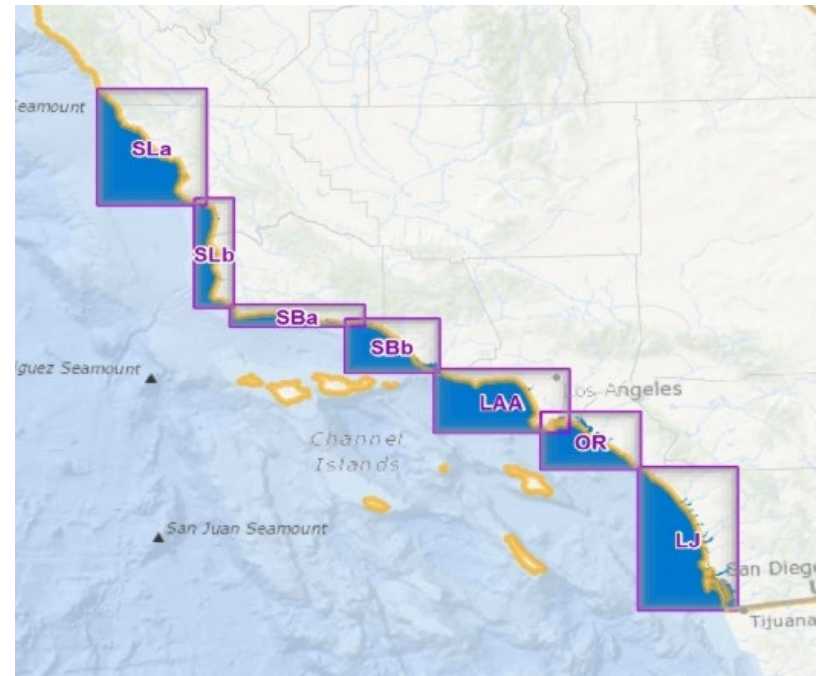


Coming Soon: 3Di-modeled Coastal Flooding (50 meter resolution)

Northern California



Southern California



Radke et al. 2018, Assessing Extreme Weather-Related Vulnerability and Identifying Resilience Options for California's Interdependent Transportation Fuel Sector

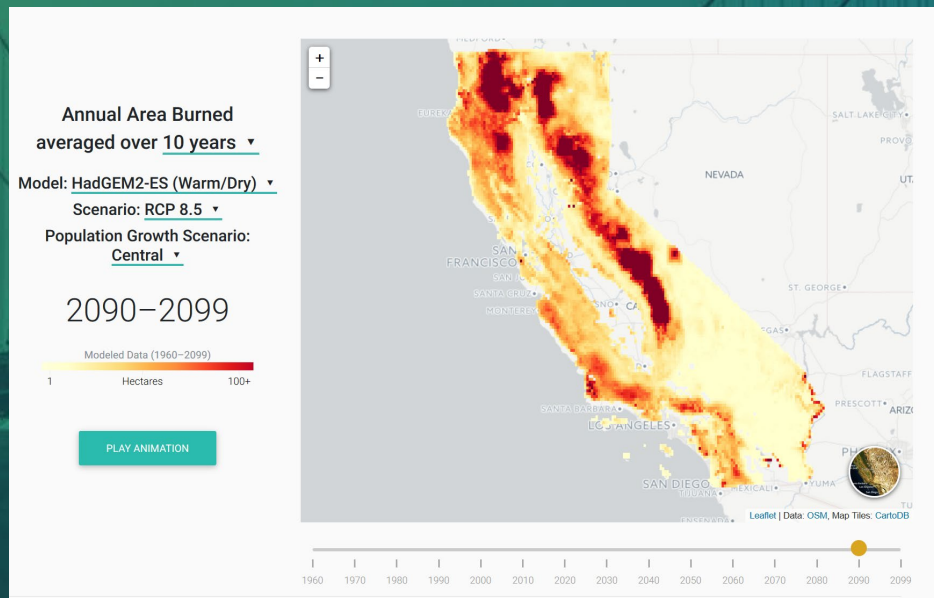
<http://keystone.gisc.berkeley.edu/>

Cal-Adapt

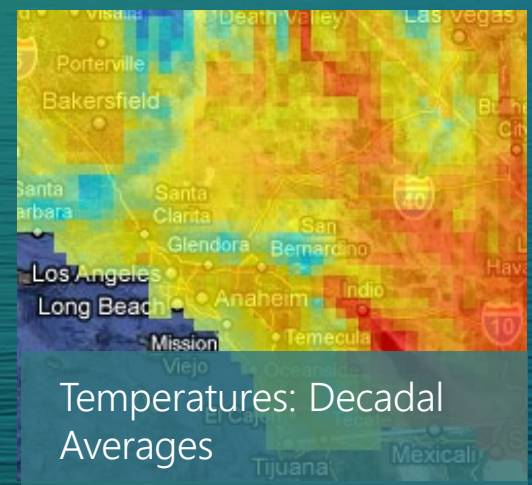
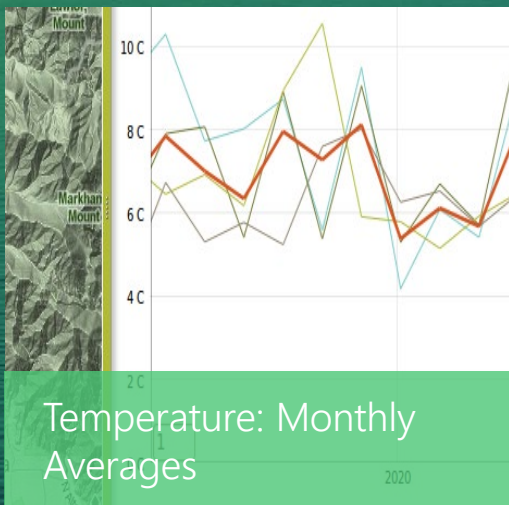
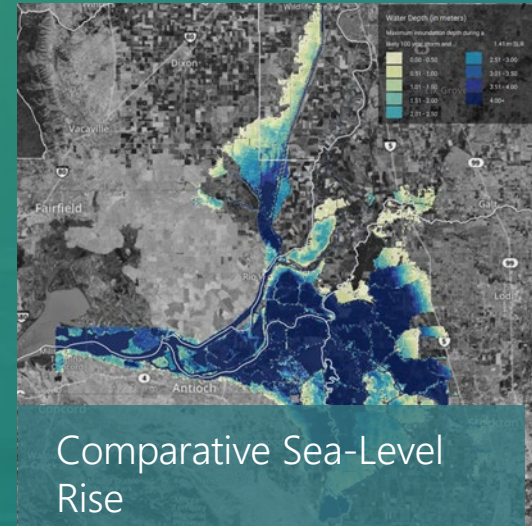
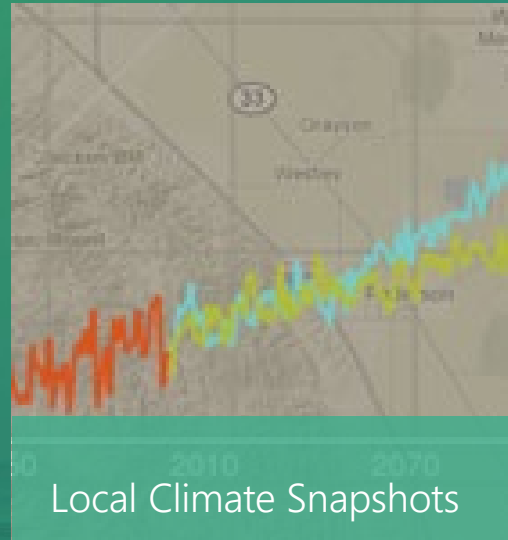
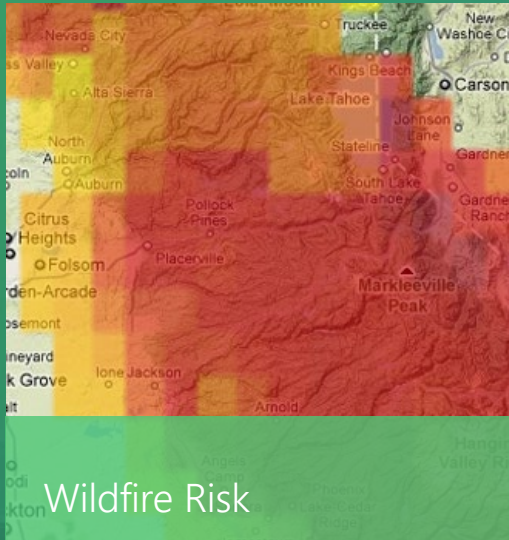


Enhanced Wildfire Tool

- Additional wildfire data layers from UC Merced will be included on Cal-Adapt when available:
 - Monthly time step
 - Emissions
- Develop visualization for exploring extreme wildfire years
- What additional features would make the wildfire tool more useful?
 - Monthly and/or seasonal averages in addition to annual averages?



Stakeholder Engagement is Critical!



What We're Working on Now: Extreme Precipitation

- How are extreme events changing over time?
 - Frequency of occurrence of extreme wet and extreme dry seasons
 - Frequency of occurrence of extreme precipitation events within a season
- How do you define extreme precipitation events?
 - Percentiles e.g. Extreme (98th %tile), Moderate (36th-67th %tile)
 - Return Interval (likelihood of an event with a specified intensity and duration, such as 10 year or 100 year Return Interval)
 - Amount of precipitation that falls within a specified duration (e.g. Maximum annual 5-day consecutive precipitation)
- Accounting for differences in extreme precipitation events in different areas of CA (?)

Hydrological Data: Variable Infiltration Capacity Model (VIC)

VIC is a hydrological model that is driven by daily maximum and minimum temperatures (projected and observed) to provide high-resolution (1/16° grid, ca. 3.6 miles by 3.6 miles) projections at daily time steps for a suite of hydrological parameters:

- Evapotranspiration (mm/day)
- Runoff (mm/day)
- Soil moisture (3 layers) (mm)
- SWE (snow water equivalent) mm
- Daily change in SWE (mm/day)
- Snowfall rate (mm/day)
- Rainfall rate (mm/day)
- Snow melt rate (mm/day)
- Dew rate (mm/day)
- Sensible heat (W/m^2)
- Latent heat flux (W/m^2)
- Potential evapotranspiration (PET) from vegetation (mm/day)
- Air temperature (2 m daily average) ($^{\circ}C$)
- Relative humidity (2 m above surface) (percent)
- Specific humidity (2 m above surface) (kg/kg)
- Albedo (surface reflectivity) (fraction)
- Shortwave down (W/m^2)
- Shortwave net (W/m^2)
- Longwave net (W/m^2)
- Sublimation net (mm/day)

VIC was developed by X. Liang (University of Washington) and others. Learn more about VIC at:

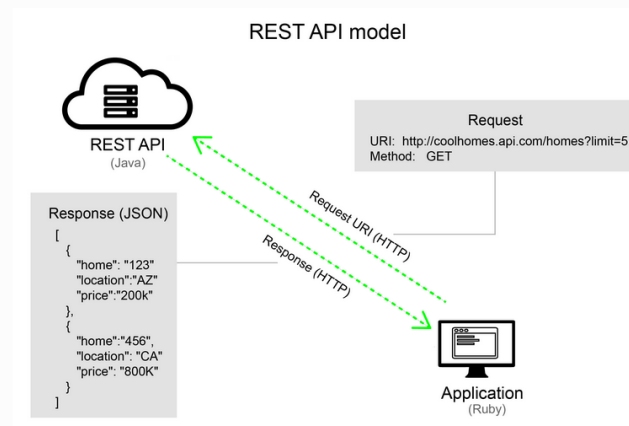
- <http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index-old.shtml>

Cal-Adapt API

Cal-Adapt API (Application Programming Interface) provides programmatic access to climate data hosted on Cal-Adapt. In general, an API is like a cog that allows two systems to interact with each other, e.g. a web browser on your computer and the Cal-Adapt server.

The Cal-Adapt API is built using [Django](#), [Django REST framework](#), and [Django-Spillway](#), an open source library developed at the GIF. The API follows an architectural style called REST (Representational State Transfer) which uses HTTP as the transport protocol for the message requests and responses.

What is a REST API?



A general model of a REST API (source)

The client (web browser, desktop GIS software, Python script, etc.) sends a request to the API server for data and the server sends a response back. The client and server can be based in any language, but HTTP is the protocol used to transport the message. This request-and-response

We Need Your Input!

- How does your organization **currently use climate data** in adaptation and resilience planning?
- What information do you need from Cal-Adapt to make climate projections **useful and actionable**?
 - What **data format** do you use (NetCDF, Geotiff, csv?)
 - What **software** do you use? GIS, AutoCAD, other?
- What additional **data layers** would be most useful?
- We need **your** help in identifying new visualizations, tools, or features that would help support energy sector climate adaptation and resilience!

Thank you

Questions? We welcome your feedback.

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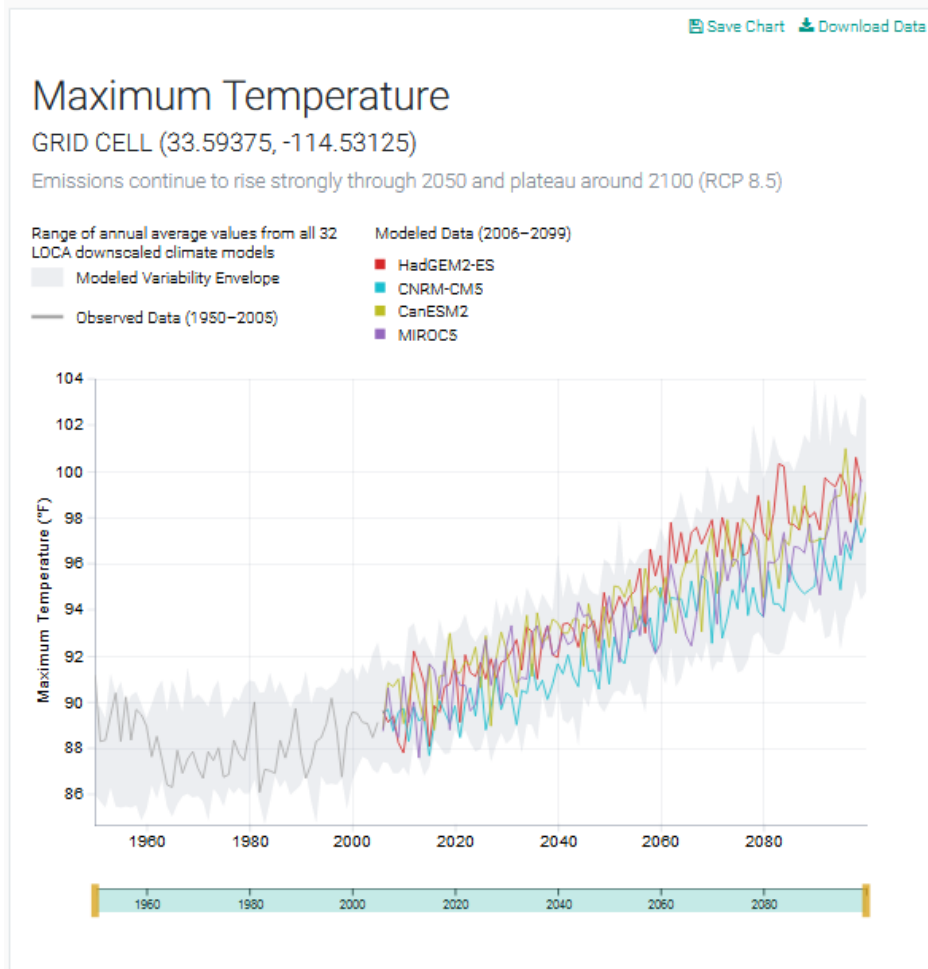
Twitter: @cal_adapt

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Backup Slides

Average Daily Maximum Temperatures in Blythe: Migrating Beyond Envelope of Historical Variability (*observed and modeled*)



SCENARIOS

RCP 4.5

Emissions peak around 2040, then decline

RCP 8.5

Emissions continue to rise strongly through 2050 and plateau around 2100

QUICK STATS

Annual Mean for 1961-1990

87.6°F

Annual Mean for 2070-2099

96.8°F

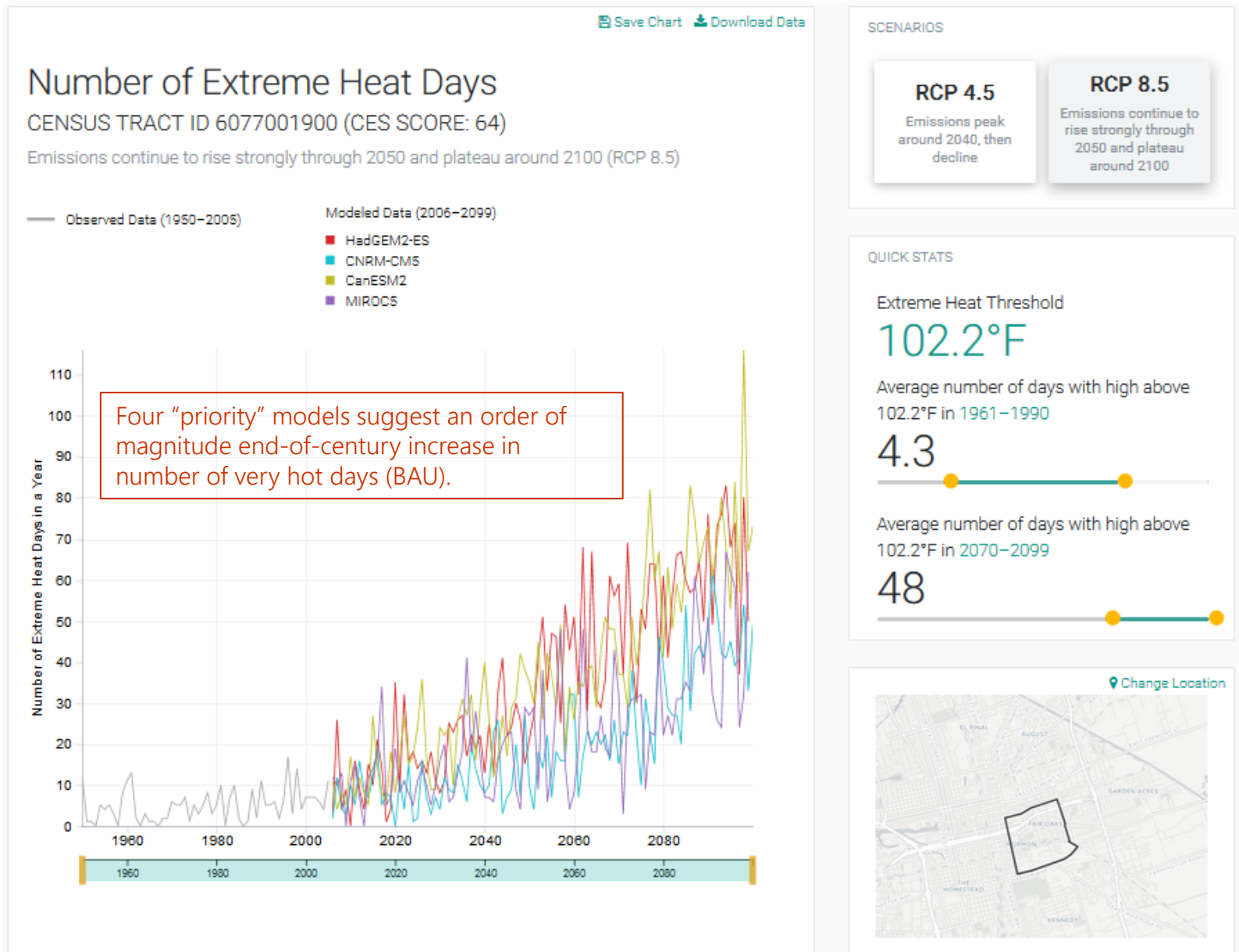
Change Location



Cal-Adapt



Projected annual number of extreme heat days in a Disadvantaged Community in Stockton



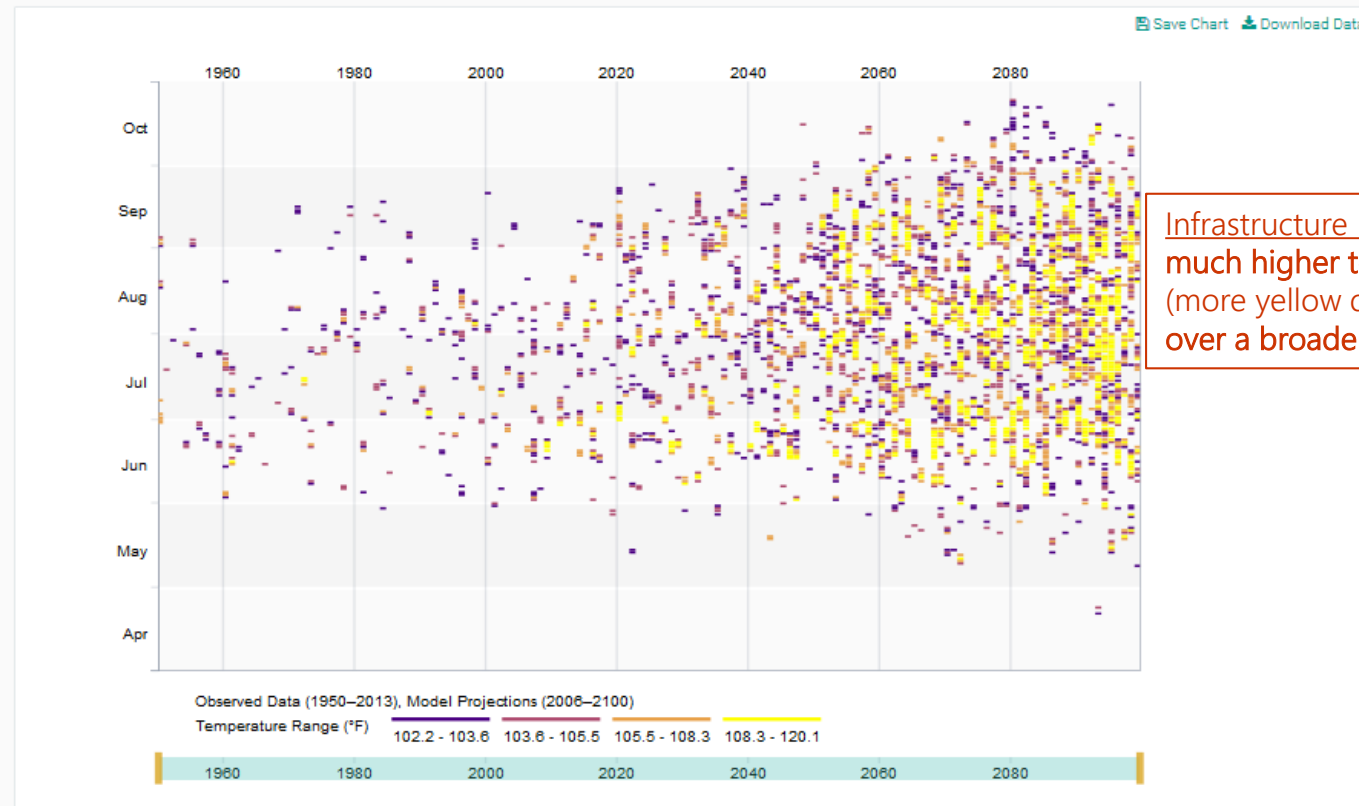
Timing, Magnitude of Stockton's Extreme Heat Migrating Beyond Historical Bounds

Timing of Extreme Heat Days

Days above 102.2°F derived from HadGEM2-ES model

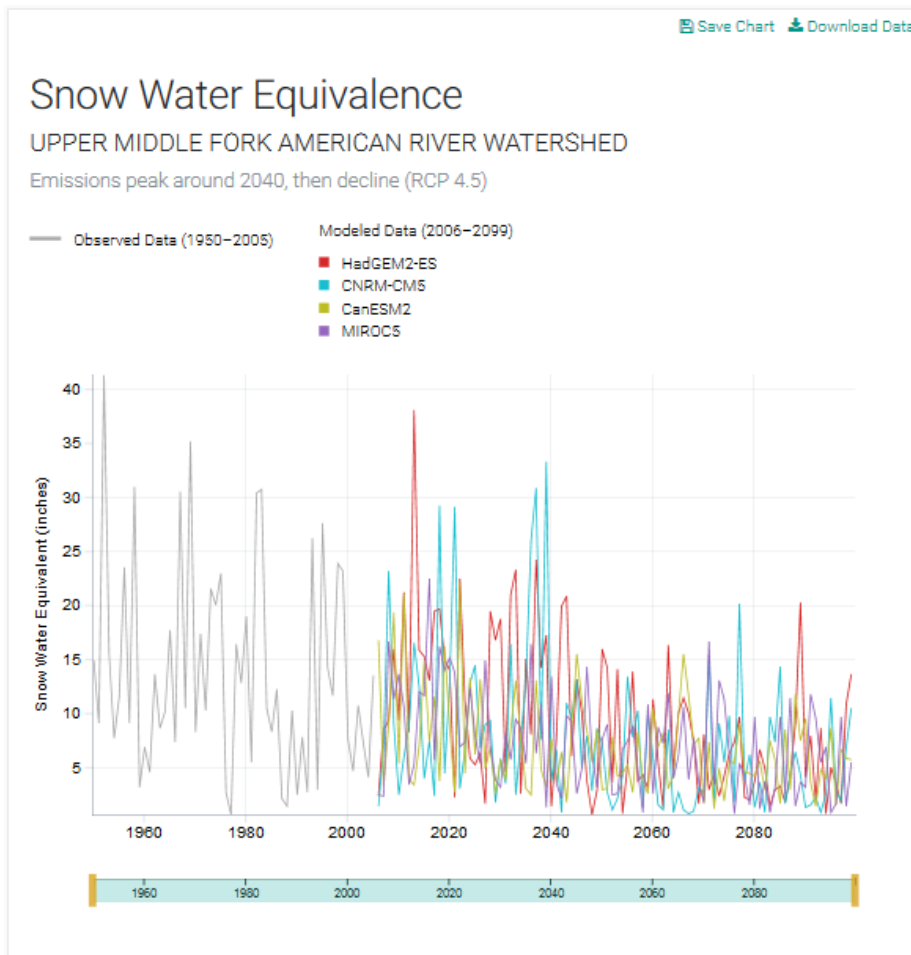
CENSUS TRACT ID 6077001900 (CES SCORE: 64)

Emissions continue to rise strongly through 2050 and plateau around 2100 (RCP 8.5)



Infrastructure planning: anticipate much higher temperature extremes (more yellow dots), which persist over a broader portion of the year.

Upper Middle Fork of American River: Substantial Decline in Mid-Century Snowpack



SCENARIOS

RCP 4.5
Emissions peak around 2040, then decline

RCP 8.5
Emissions continue to rise strongly through 2050 and plateau around 2100

MONTH

April

QUICK STATS

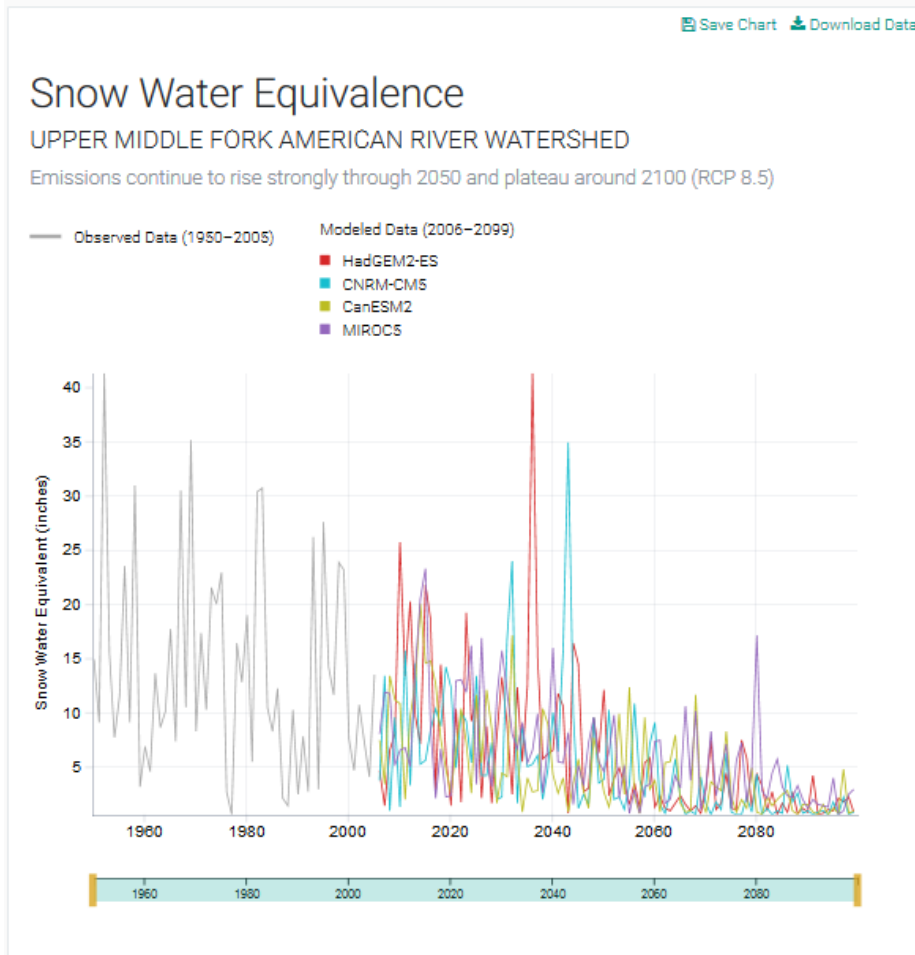
Annual Mean for 1961–1990
13.4"

Annual Mean for 2030–2049
8.8"

Change Location

Upper Middle Fork of American River Watershed: Four priority models suggest a 22% to 65% decline by the 2030–2049 timeframe (BAU scenario).

Upper Middle Fork of American River: Substantial Decline in End-of Century Snowpack



SCENARIOS

RCP 4.5

Emissions peak around 2040, then decline

RCP 8.5

Emissions continue to rise strongly through 2050 and plateau around 2100

MONTH

April

QUICK STATS

Annual Mean for 1961–1990

13.4"

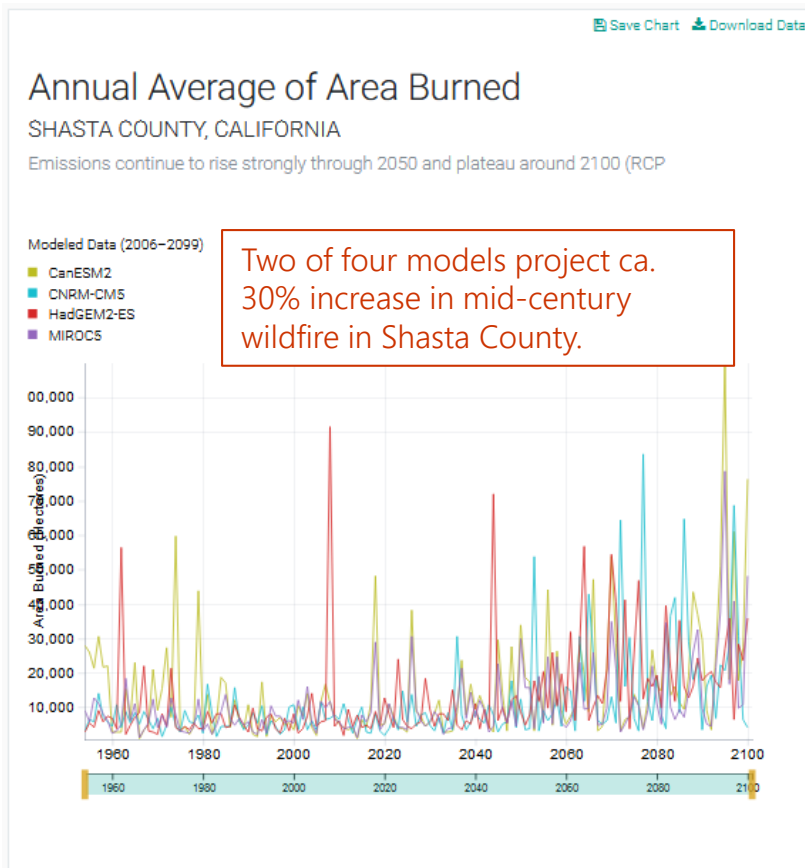
Annual Mean for 2070–2099

1.9"

Change Location

Upper Middle Fork of American River Watershed: Four priority models suggest 75% to 93% decline in April snowpack by end of century (BAU scenario).

Wildfire in Shasta County



SCENARIOS

RCP 4.5
Emissions peak around 2040, then decline

RCP 8.5
Emissions continue to rise strongly through 2050 and plateau around 2100

POPULATION SCENARIO

Central

QUICK STATS

Annual Mean for 1961–1990
8,243.6
Hectares

Annual Mean for 2030–2049
9,443.4
Hectares

Change Location

Use of wildfire projections in California's Fourth Climate Change Assessment supporting analysis in this region and other locations vulnerable to wildfire.