Cal-Adapt Energy Sector User Needs Assessment Workshop

Nancy Thomas
UC Berkeley's Geospatial Innovation Facility

Cal-Adapt and Climate Adaptation Clearinghouse Energy Sector User Needs Assessment Workshops

Sacramento, California

September 12, 2017

Cal-Adapt

Cal-Adapt

A Tool for Energy Sector Resilience and Research

Developed by UC Berkeley's Geospatial Innovation Facility

GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

Nancy Thomas, Executive Director
Shruti Mukhytar, Lead Developer
Brian Galey, Senior Developer
Eric Lehmer, Web Developer
Maggi Kelly, Faculty Advisor

Development Supported by the California Energy Commission

with oversight and guidance from:

Susan Wilhelm, Energy Generation Research Office (EGRO)
Guido Franco, Team Lead for Environmental Research, EGRO

Our **Technical Advisory Committees** (past and present)
Stockholm Environmental Institute (prototype)
Amy Luers, then of google.org, key early collaborator

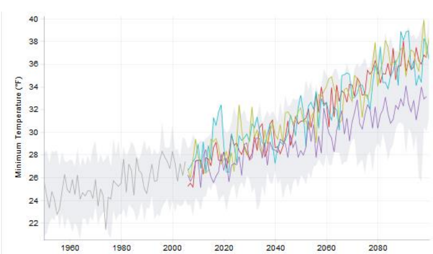
Agenda

9:30AM – 9:40AM	**Welcome and Introductions**
9:40AM – 10:10AM	**Cal-Adapt 2.0 Introduction and Demo**
10:10AM – 10:20AM	**Cal-Adapt Energy Sector User Examples** (Susan Wilhelm)
10:20AM – 10:30AM	**Audience Questions and Feedback**
10:30AM – 11:20AM	**Focus Groups** ▪ Climate Tools (Temperature, Precipitation, and Relative Humidity) ▪ Projected Wildfire Risks ▪ Snowpack, Streamflow, and other Hydrological Projections ▪ Cal-Adapt API
11:30AM – 11:45AM	**Report back**
11:45AM – 12:00PM	**Wrap up**

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

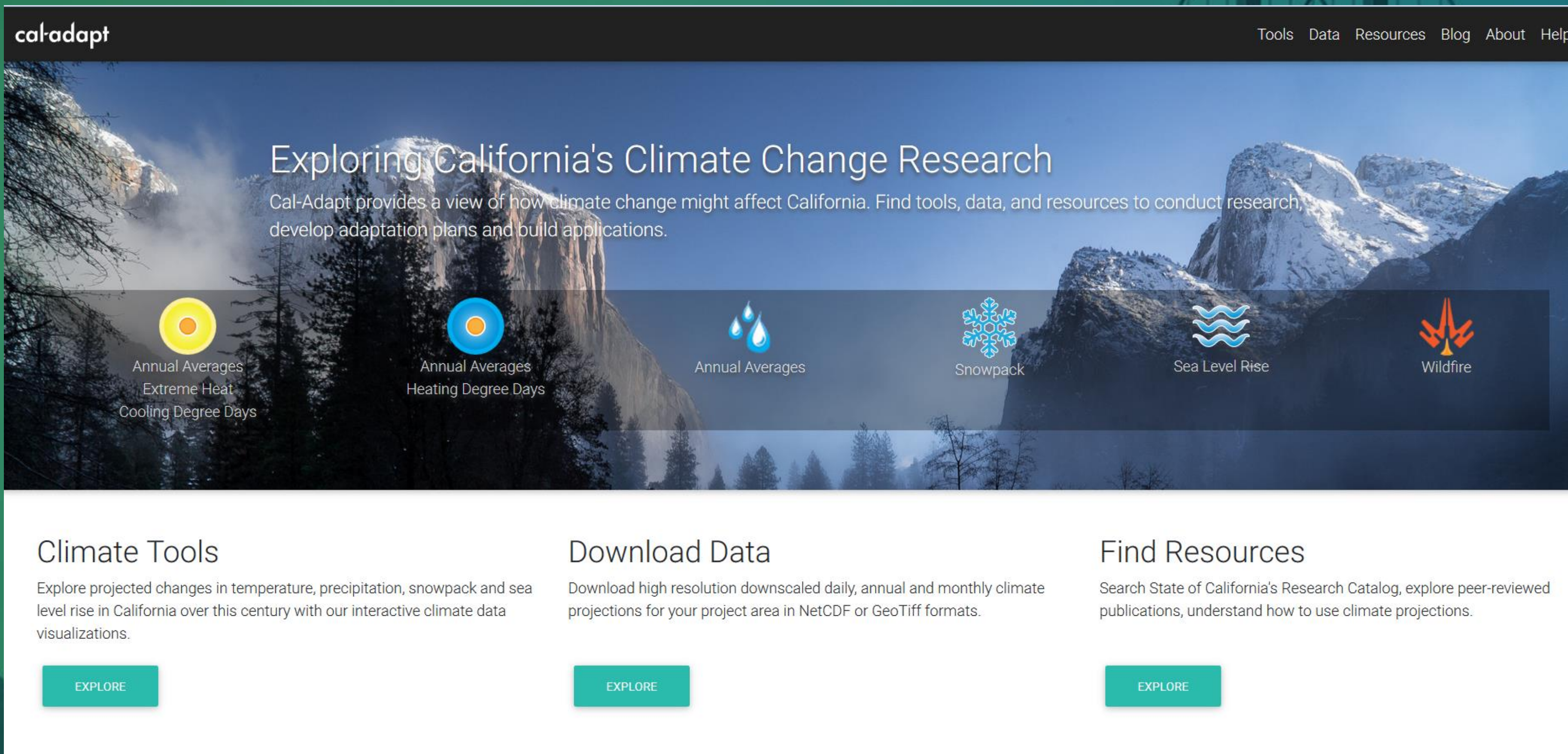
Cal-Adapt provides a scientific basis for exploring climate-related risks and resilience options for energy sector planning and adaptation.

- **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 2.0


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
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 2.0 Enhancements

- Higher resolution, higher fidelity data
  - Temperature and precipitation at daily time steps from LOCA (Localized Climate Analogues) downscaled CMIP5 data, Scripps Institution of Oceanography (Pierce et al. 2014)
    - 1/16 degree grid, (~ 6km x 6km)
    - LOCA is better able to capture *extreme temperatures* and *spatial distribution* of precipitation
  - inundation (Delta as well as open coast and bay)
  - observed historical data (daily temperature, precipitation)
  - wildfires

Cal-Adapt 2.0 Enhancements

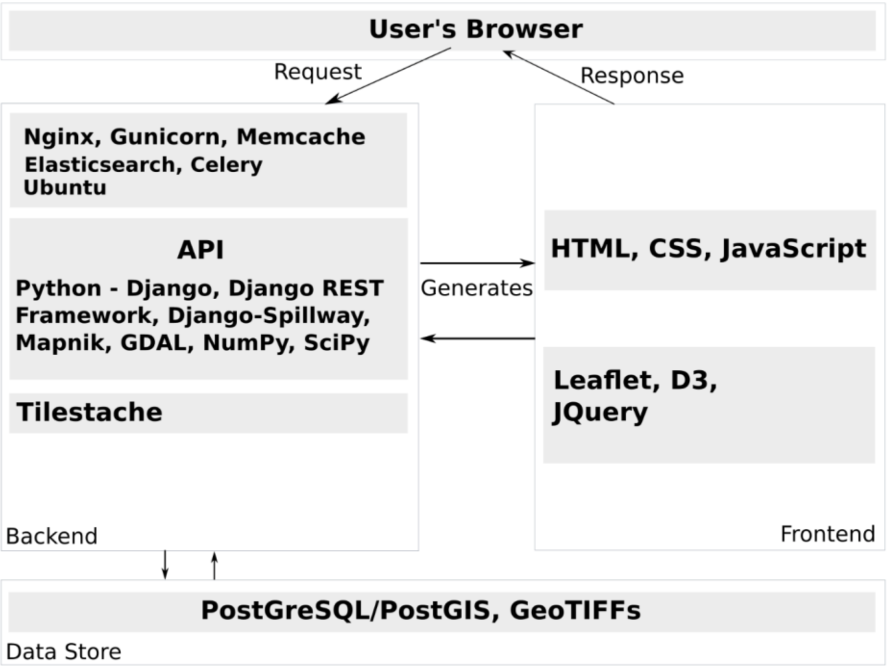
- Enhanced Data Visualizations
  - New boundary options: users can aggregate and view data by a number of different boundary options including counties, census tracts, watersheds, etc.
    - Users can also upload their own custom boundary file in a number of different formats (shapefile, GeoJson, kml, etc.)
  - Slider tools allow users to average values over user-specified time periods
  - Ability to print charts to image file to easily include in reports
  - Easy-to-understand text descriptions of visualization tools

Cal-Adapt 2.0 Enhancements

- Improved Access to Data
  - Save charts: users can download data visualizations directly to PNG files
  - CSV download: time series shown can be downloaded directly as csv files for use in many software programs
  - GeoTIFF: users can download data for selected variables for use in many geospatial applications
  - Primary NetCDF data: researchers can directly access NetCDF data for many data sets including:
    - all 32 CMIP5 models for 2 RCP scenarios (RCP4.5 and RCP8.5)
    - VIC modeled variables for all 10 CA models
  - Through Public API for custom tool development

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



How Does Cal-Adapt Support the Energy Sector?

Serve Data

- Common scenarios basis for 4th assessment research portfolio
- Scenarios aligned with recommendations for energy sector planning
- Enables cross-sector integration of results

Data Visualizations

- Support decision-making
- Communicate results of latest peer-reviewed scientific research
- Climate, hydrological, sea-level rise, snowpack, wildfire risk

Provide Resources & Outreach

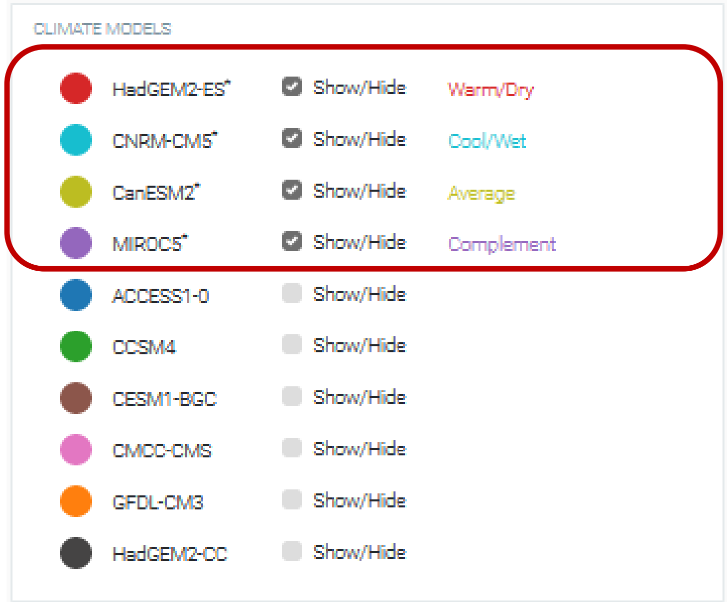
- Interface with resilience planning
- Webinars and training sessions

Develop Tools

- Build domain specific tools to support decision-making
- Focus on the energy sector

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 <u>forthcoming guidance to state agencies will rely on these scenarios</u>, too.



Cal-Adapt 2.0 Demo

Cal-adapt.org

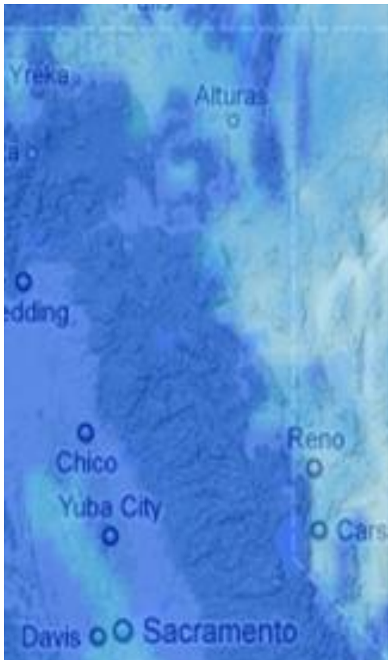
We Need Your Feedback!

Questions and Break-out Groups

User Feedback on Cal-Adapt 2.0

- Have you used Cal-Adapt?
- How have you used Cal-Adapt and what did you use it for?
- What do you like about Cal-Adapt?
- What would you suggest for improvement?
- We need your help in identifying new visualizations, tools, or features that would help support energy sector climate adaptation and resilience!

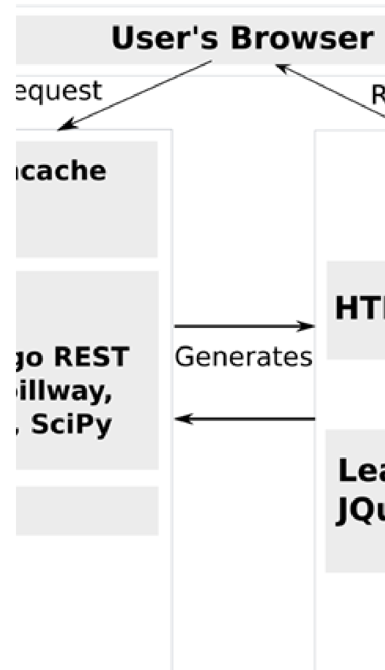
Focus Groups



Climate Tools (Temperature, Precipitation, and Relative Humidity)

Projected Wildfire Risks

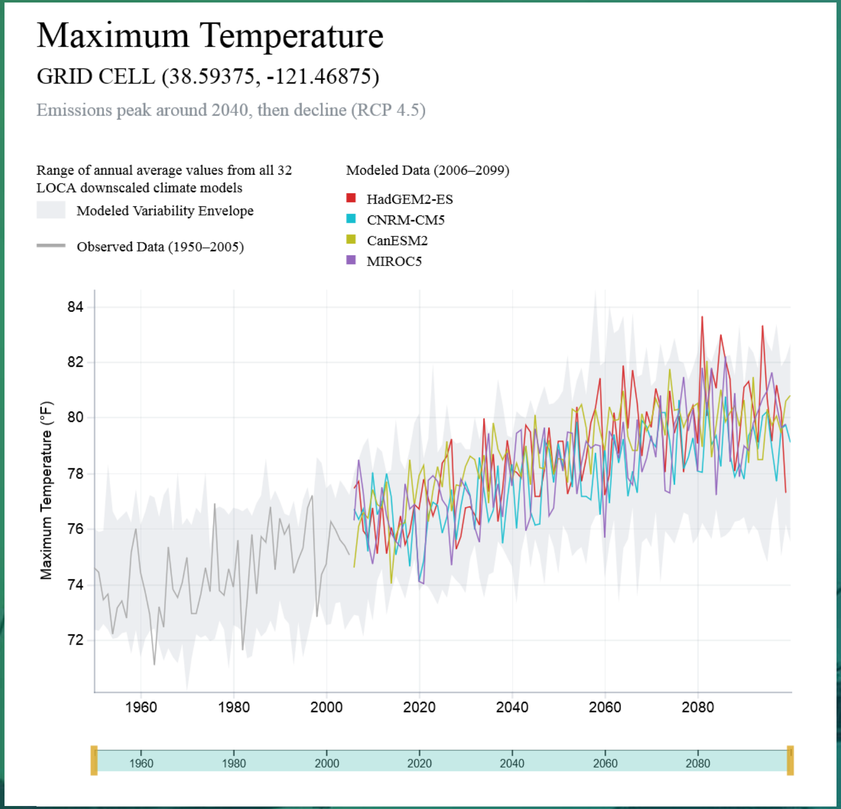
Snowpack, Streamflow, and other Hydrological Projections



Cal-Adapt API and Custom Tool Development

Climate Tools

Temperature, Precipitation, and Relative Humidity

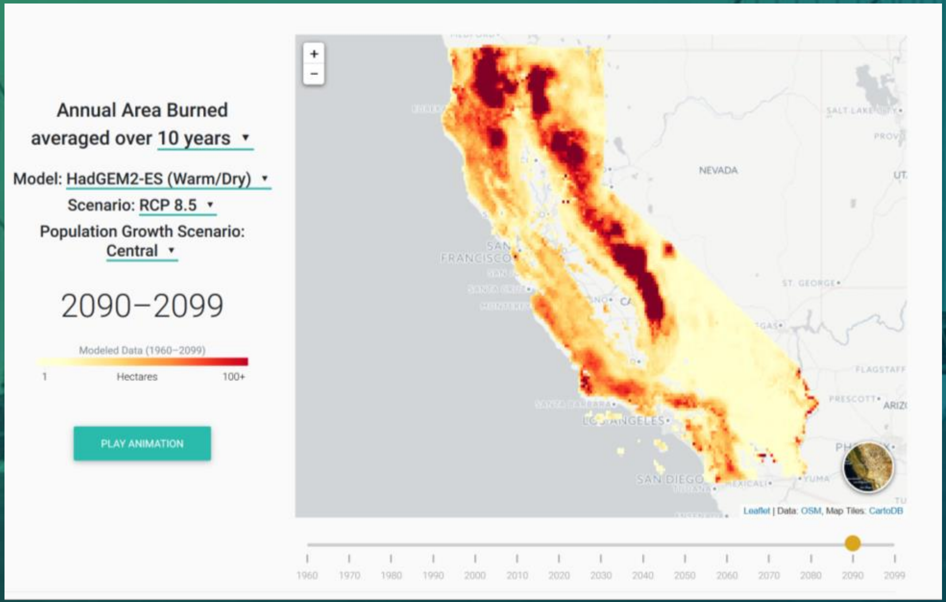


- What additional features would make the temperature and precipitation tools more useful?
  - Monthly and/or seasonal averages in addition to annual averages?
  - Additional stats: distribution as well as mean? Individual model results?
- What additional features would improve the usability of the extreme heat tool?
  - User-defined threshold?

Cal-Adapt

Projected Wildfire Risks

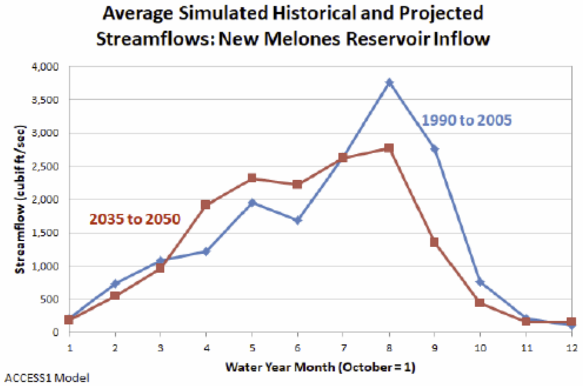
- What additional features would make the wildfire tool more useful?
  - Monthly and/or seasonal averages in addition to annual averages?
- Is it useful to look at multivariate charts? For example area burned vs. precipitation?
- New wildfire data layers will be included on Cal-Adapt when ready:
  - Fire severity
  - Emissions



Snowpack, Streamflow, and other Hydrological Projections

Streamflows: New Melones

- Hydrographs shift to higher flows in the winter and less in the summer
- Simulation of historical and projections using the Variable Infiltration Capacity (VIC) hydrological model. ACCESS1 global model downscaled with LOCA.
- Numerical values depend on the global model (e.g., ACCESS1) used.



DRAFT

Cal-Adapt API

Cal-Adapt API Docs

1.0

Search docs

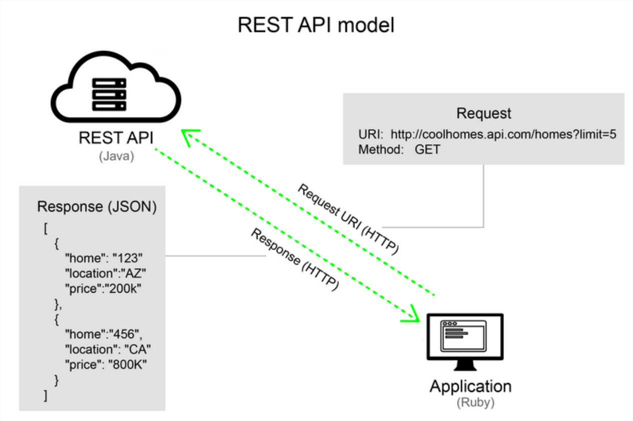
- Getting Started
- Data Catalog
- Working with Series
- Working with Raster Store
- Cookbook

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 uses HTTP as the transport protocol for the message requests and responses.

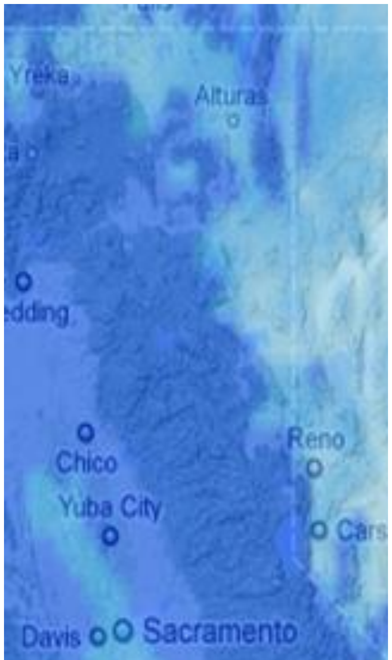
What is a REST API?



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

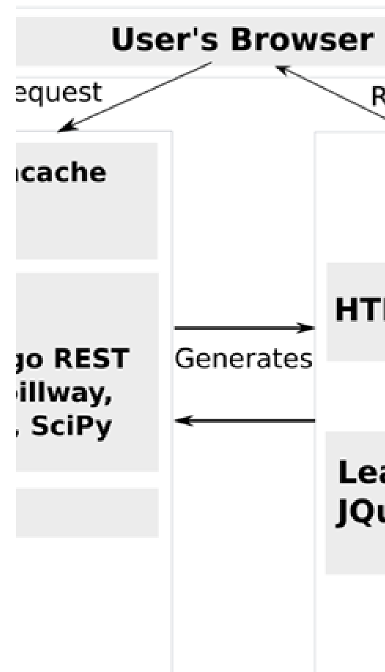
Focus Groups



Climate Tools (Temperature, Precipitation, and Relative Humidity)

Projected Wildfire Risks

Snowpack, Streamflow, and other Hydrological Projections



Cal-Adapt API and Custom Tool Development

Thank you

Questions? We welcome your feedback.

nethomas@berkeley.edu
support@cal-adapt.org

Twitter: @cal_adapt

Backup Slides

Four Slides re: Major Datasets

- LOCA: temperature, precipitation, relative humidity
- Hydrological data
  - VIC for a number of hydrological variables
  - Bias-corrected, routed stream flow at 11 locations in California
- Wildfire projections

- Gridded observed data: temperature, precipitation
- Sea Level Rise: inundation associated with various increments of SLR (0 to 1.4 m), as portrayed by high-resolution hydrological modeling
  - Cal-Adapt 2.0 also links users to Our Coast, Our Future, a publicly available interactive tool that presents results from USGS's Coastal Storm Modeling System (CoSMoS)
- Long Drought Scenarios

<u>LO</u>calized <u>C</u>limate <u>A</u>nalogues (LOCA): Temperature, Precipitation, Humidity Projections

LOCA provides high-resolution (1/16º grid, ca. 3.6 miles by 3.6 miles) projections at daily time steps for:

- Maximum temperature
- Minimum temperature
- Precipitation
- Relative humidity

LOCA was developed by David Pierce, Dan Cayan, and others at the University of California, Scripps Institution of Oceanography. Learn more about LOCA at:

- DW Pierce, DR Cayan, and BL Thrasher (2014). "Statistical Downscaling Using Localized Constructed Analogues (LOCA)." *Journal of Hydrometeorology*. http://journals.ametsoc.org/doi/abs/10.1175/JHM-D-14-0082.1
- http://loca.ucsd.edu/

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 (1/16º 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 (**s**now **w**ater **e**quivalent) 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) (ºC)
- 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

Hydrological Data: Stream Flows at 11 Locations

Stream flows at 11 locations were constructed by routing the projected run-off output from VIC (1950-2100, RCP4.5 and RCP8.5) and bias-correcting based on the Department of Water Resources' estimates of unimpaired flows through 2014. The 11 locations for which daily streamflow data are available are:

- Sacramento River near Red Bluff (*VIC name*: SAC_BEND_BRIDGE)
- Feather River near Oroville (*VIC name*: OROVILLE)
- Yuba River at Smartville (*VIC name*: SMARTVILLE)
- Bear River near Wheatland (*VIC name*: BEARCREEK)
- American River at Fair Oaks (*VIC name*: FOLSOM_INFLOW)
- Mokelumne River at Pardee Reservoir (*VIC name*: PRD-CAMANCHE)
- Calaveras at Jenny Lind (*VIC name*: NEW_HOGAN)
- Stanislaus River at New Melones Reservoir (*VIC name*: N_MELONES)
- Tuolomne River at Don Pedro Reservoir (*VIC name*: DPR_INFLOW)
- Merced River at Exchequer Reservoir (*VIC name*: LK_MCCLURE)
- San Joaquin River at Millerton Reservoir (*VIC name*: MILLERTON)

Bias-corrected stream flows were developed by David Pierce, Jordan Goodrich, and Dan Cayan at UCSD's Scripps Institution of Oceanography.

Wildfire Projections: Annual Average Area Burned

Parameters describing projected wildfires were developed for monthly time steps on a 1/16º grid for 1950-2100, RCP4.5 and RCP8.5, and four global climate models (CanESM2, CNRM-CM, HadGEM2-ES, and MIROC5). Population trajectories and land use/land cover were also considered.

For each scenario, 100 Monte Carlo simulations were developed.

- At this point, Cal-Adapt shows annualized average area burned.
- Other parameters (*high severity burned area, given a fire; emissions*) are forthcoming and may be visualized on Cal-Adapt.

Wildfire scenario projections were provided by Dr. LeRoy Westerling at the University of California Merced, using a statistical model based on historical data of climate, vegetation, population density, and fire history coupled with regionally downscaled LOCA climate projections.

Gridded Observed Data

Historical observed daily temperature and precipitation data from approximately 20,000 NOAA Cooperative Observer (COOP) stations form the basis of agridded dataset from 1950–2013 (daily time steps, 1/16º grid or ca. 3.6 miles by 3.6 miles).

- Maximum temperature
- Minimum temperature
- Precipitation

These data were developed by B. Livneh and colleagues. Details are described in:

- B Livneh, TJ Bohn, DW Pierce, F Munoz-Arriola, B Nijssen, R Vose, DR Cayan, and L Brekke (2015). "A spatially comprehensive, hydrometeorological data set for Mexico, the U.S., and Southern Canada 1950–2013." *Scientific Data* 2, Article no. 150042. https://www.nature.com/articles/sdata201542

Sea Level Rise and Inundation Associated with Extreme Storm Events

Inundation depths associated with various increments of sea level rise (SLR) ranging 0 to 1.41m and extreme storm events based on a high-resolution hydrodynamic model coupled with high-resolution earth surface models. Storm events approximate observed historical 100-year storms. Data represent the San Francisco Bay, the Sacramento-San Joaquin Delta, and the entire California coast. Shown on Cal-Adapt is:

- Maximum inundation depth

These data were developed by J. Radke and colleagues at the University of California, Berkeley. Details are described in:

- JD Radke, GS Biging, M Schmidt-Poolman, H Foster, E Roe, Y Ju, O. Hoes, T Beach, A Alruheil, L Meier, W Hsu, R Neuhausler, W Fourt (2017). *Assessment of Bay Area Natural Gas Pipeline Vulnerability to Climate Change*. California Energy Commission. Publication number: CEC-500-2017-008. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2017-008

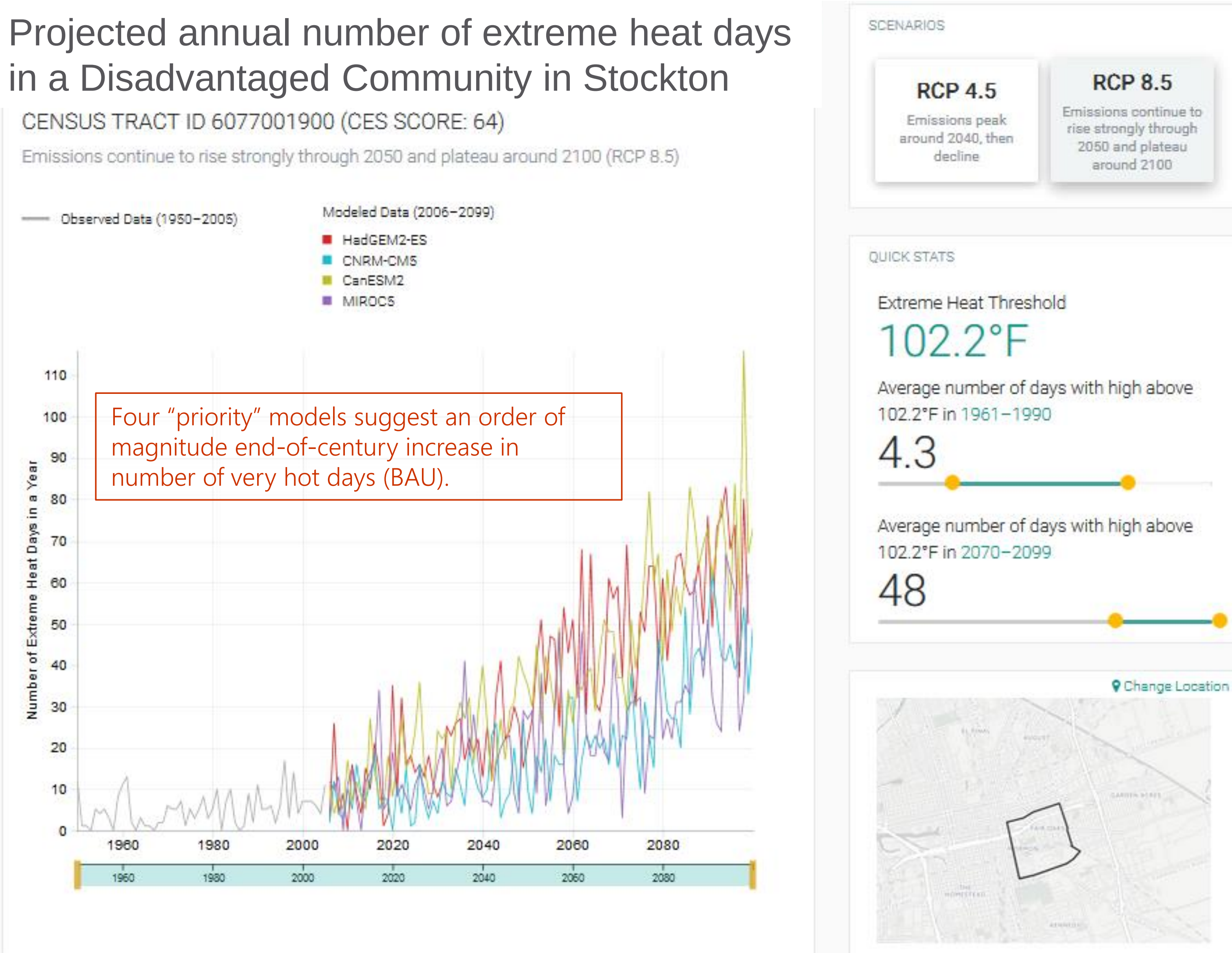
Long Drought Scenarios

Two scenarios portray long droughts to enable exploration of extended (20-year) drought conditions. Cal-Adapt provides data describing a 2051-2070 drought associated with the HadGEM2-ES LOCA downscaled projection for RCP8.5, as well as a nearer-term drought (2023-2042) created by adjusting the temperatures for the later century drought to cohere with an earlier time frame. Data comprise projections at daily time steps and 1/16º grid for:

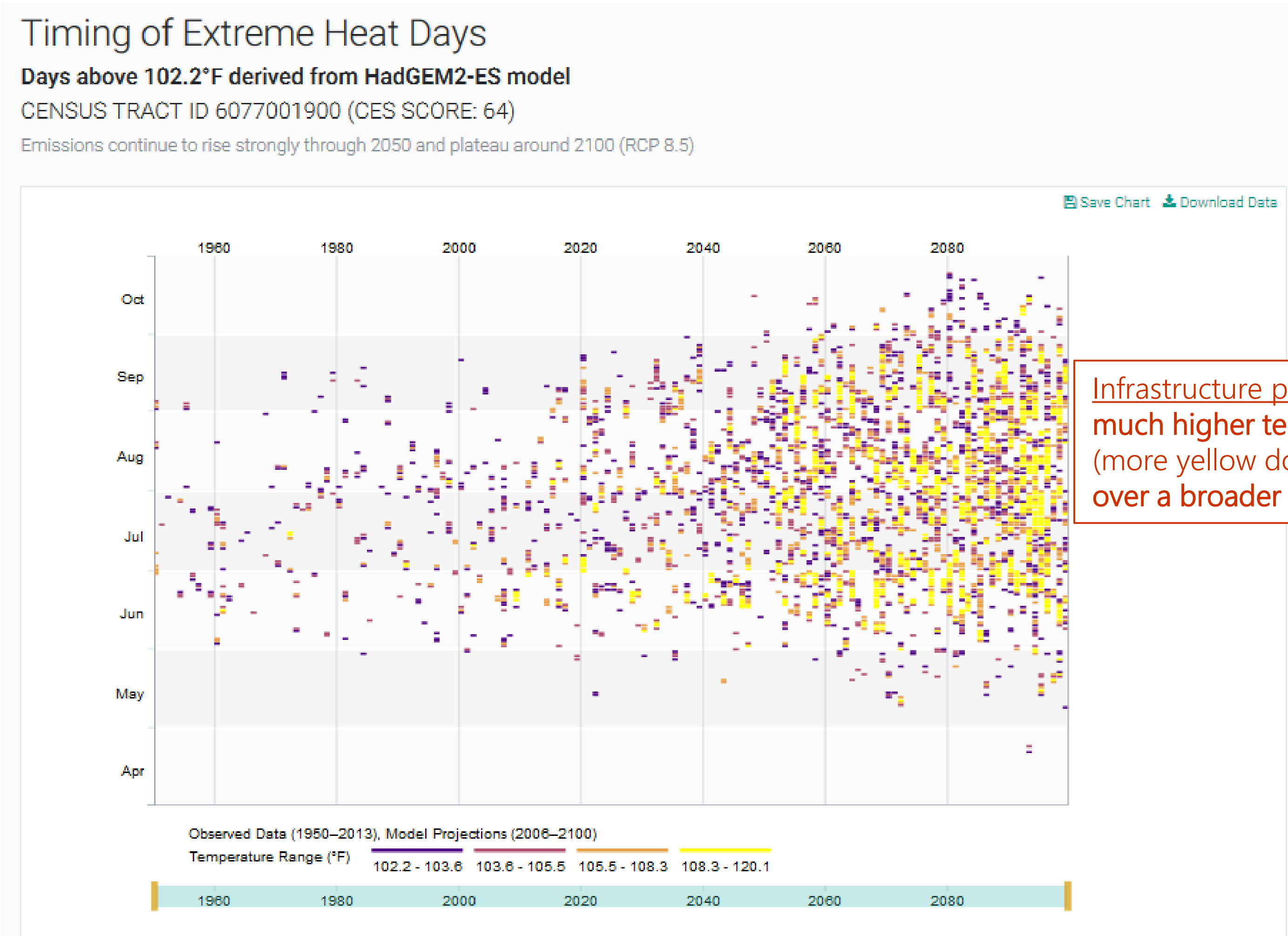
- Maximum temperature
- Minimum temperature
- Precipitation
- Select VIC parameters: evapotranspiration, base flow, runoff, soil moisture (3 layers)
- *… and all of these various for the 5 years prior to, and 4 years after, the long drought.*

These data were developed by D. Cayan, L. Dehaan, and colleagues at UCSD's Scripps Institution of Oceanography.

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

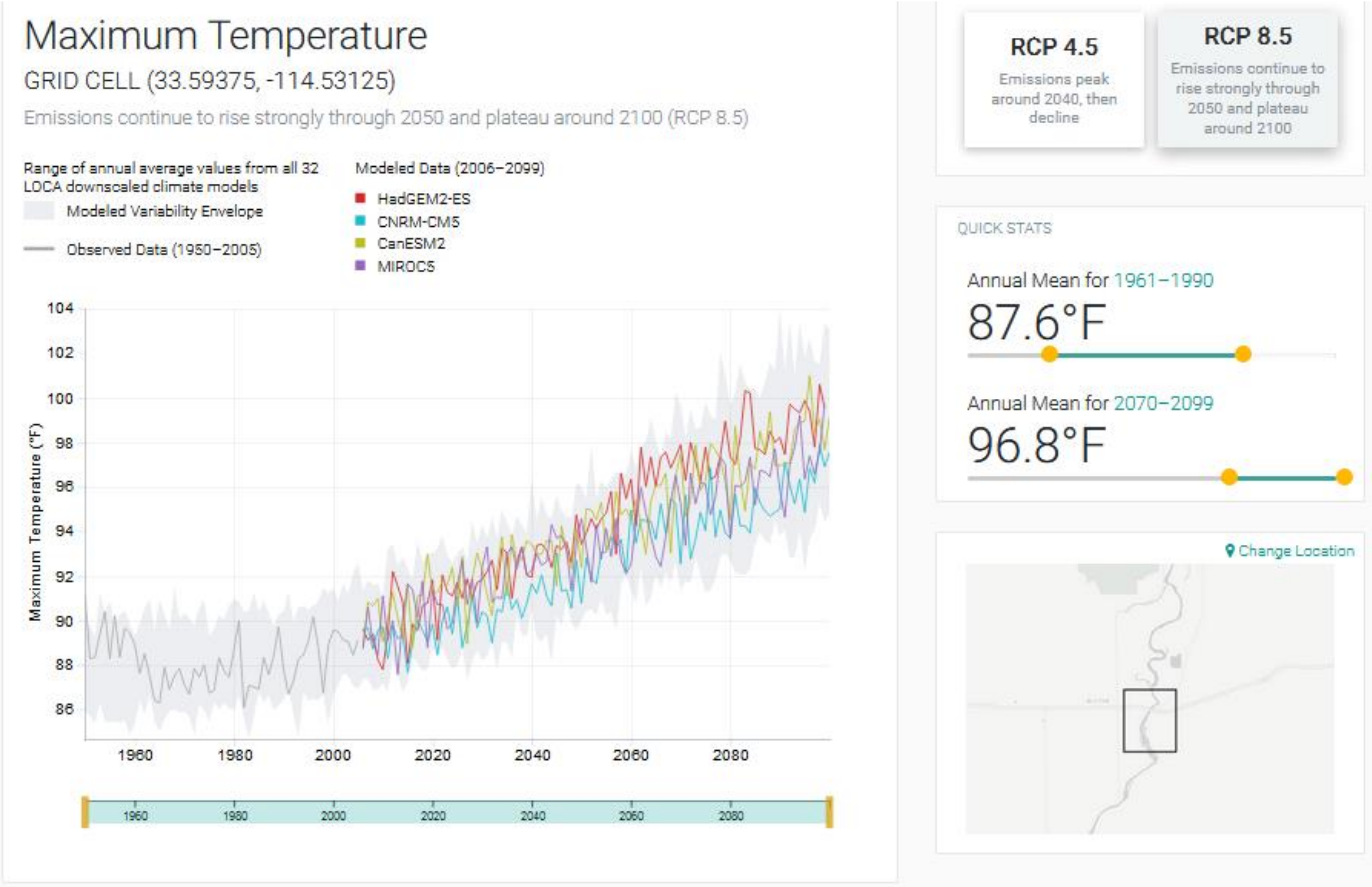


Timing, Magnitude of Stockton’s Extreme Heat Migrating Beyond Historical Bounds



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

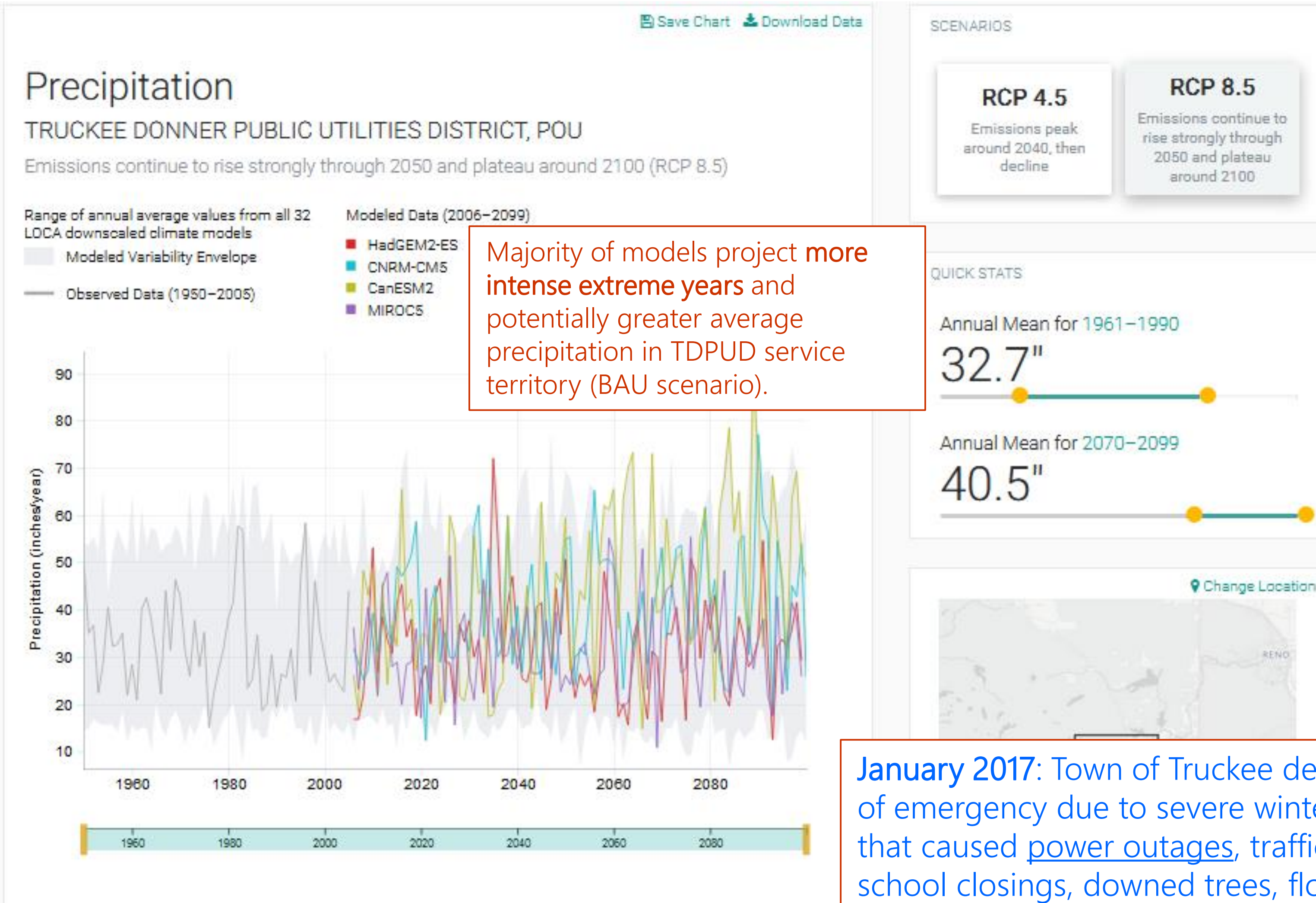
Average Daily Maximum Temperatures in Blythe: Migrating Beyond Envelope of Historical Variability (*observed and modeled*)



Cal-Adapt

http://beta.cal-adapt.org/tools/annual-averages/#climatevar=tasmax&scenario=rcp85&lat=33.59375&lng=-114.53125&boundary=locagrid&units=fahren

Projected Precipitation in Truckee Donner Public Utility District(TDPUD)

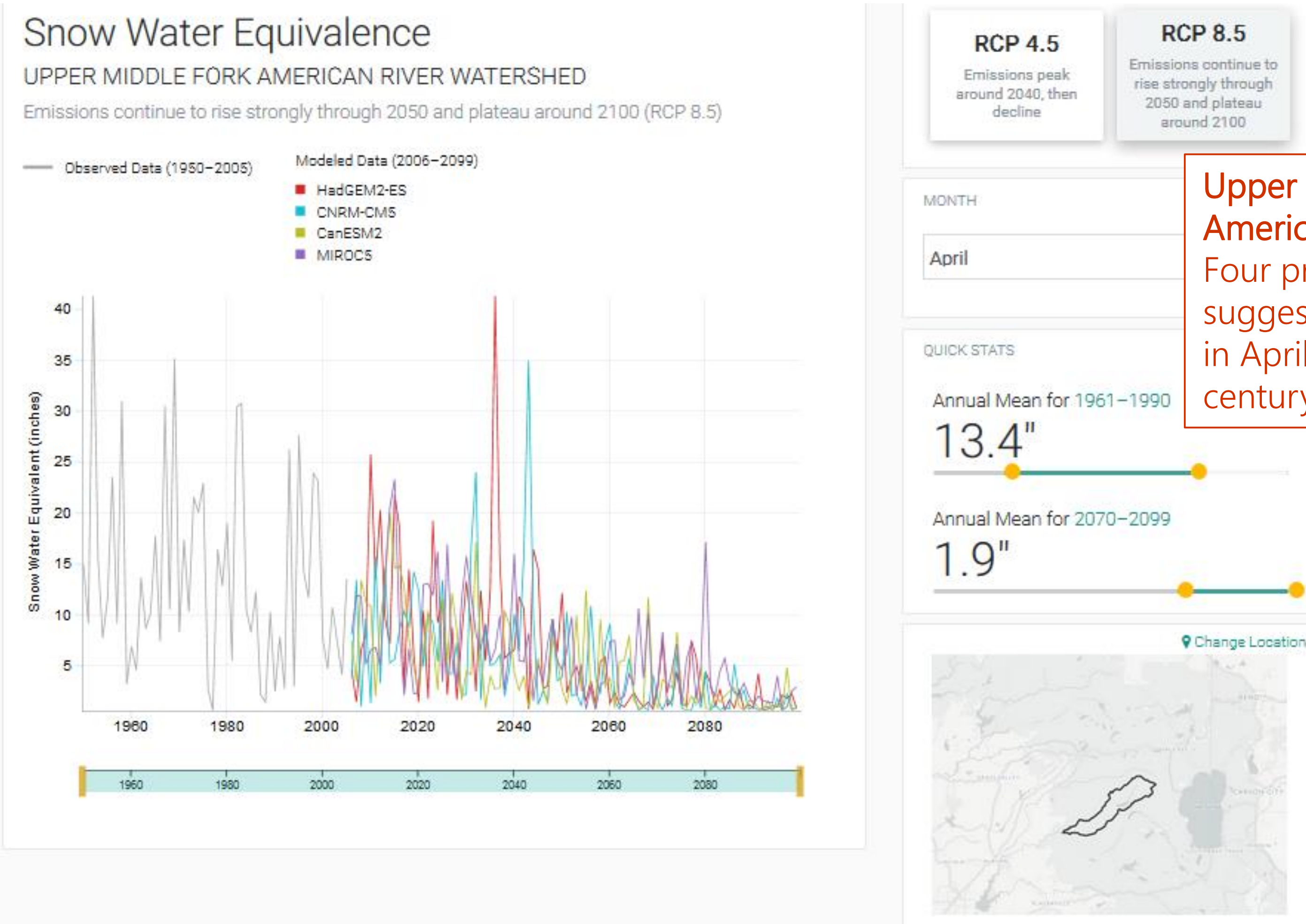


Majority of models project **more intense extreme years** and potentially greater average precipitation in TDPUD service territory (BAU scenario).

January 2017: Town of Truckee declared state of emergency due to severe winter storms that caused power outages, traffic delays, school closings, downed trees, flooding.

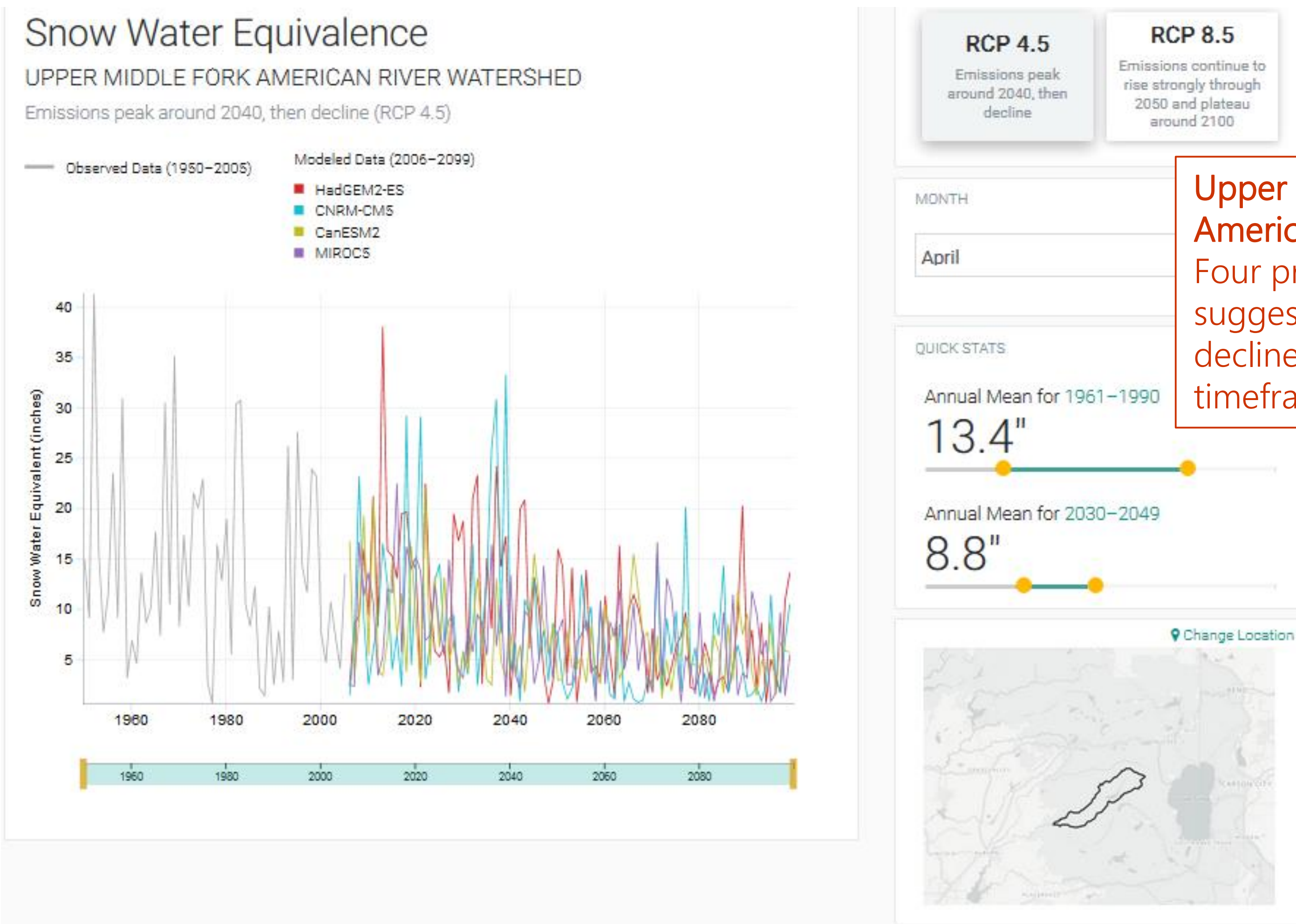
Cutting-Edge Mapping Technology at UC Berkeley

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



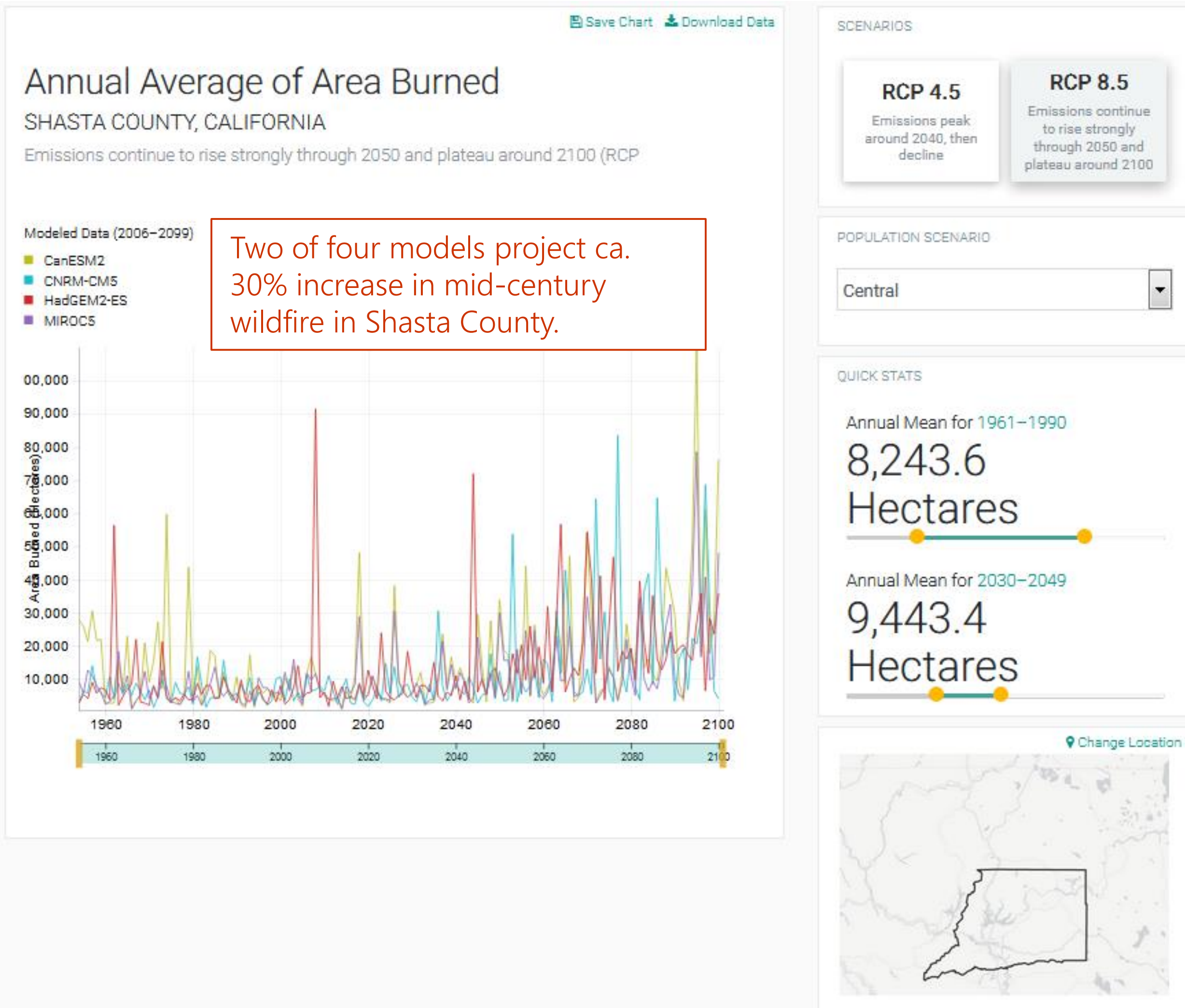
Upper Middle Fork of American River Watershed: Four priority models suggest 75% to 93% decline in April snowpack by end of century (BAU scenario).

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



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

Wildfire in Shasta County

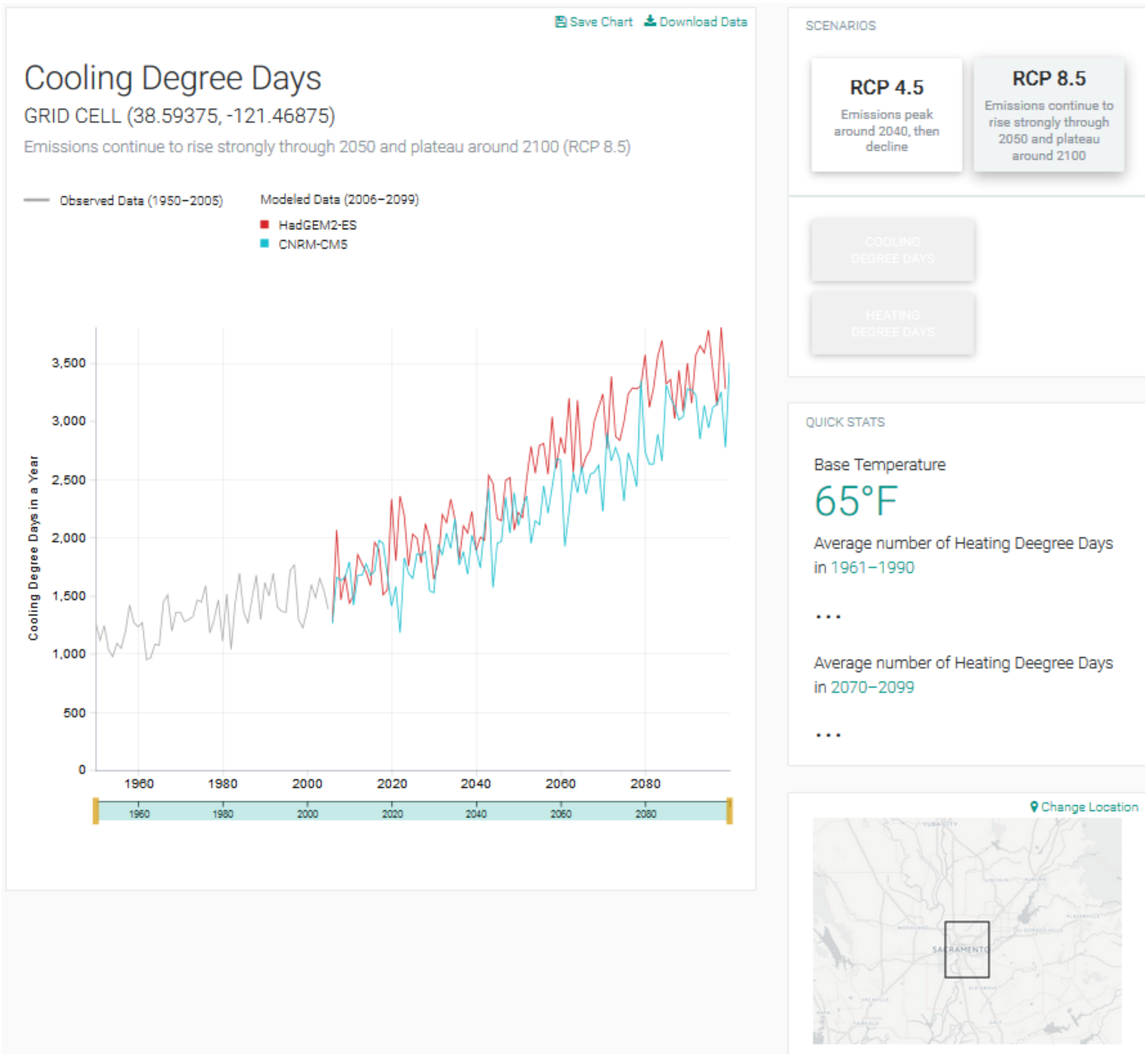


Two of four models project ca. 30% increase in mid-century wildfire in Shasta County.

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

Cal-Adapt

Heating Degree Days, Cooling Degree Days



A new tool enables calculation of heating degree days and cooling degree days– both used as proxies of demand for heating and cooling buildings– based on user-specified parameters.

This is important because we can no longer use historical climate as a legitimate proxy for future demand!

Cal-Adapt

Additional Data Available at: http://beta.cal-adapt.org/data/