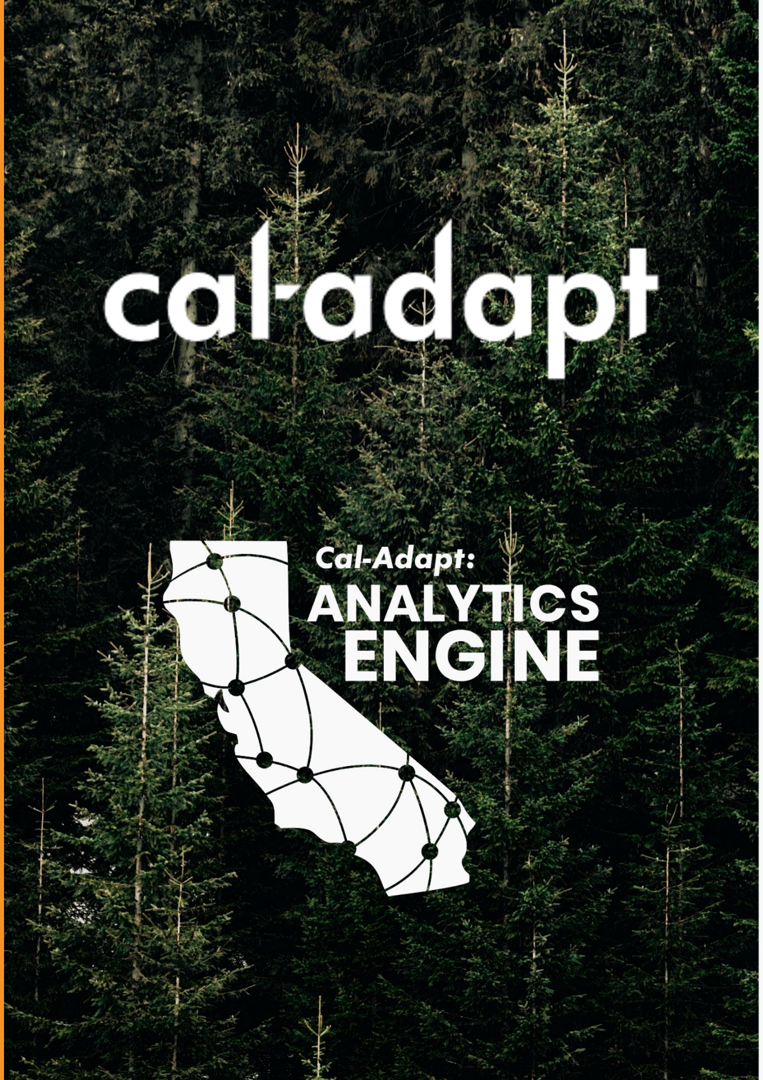

Actionable data & tools to enable climate-informed decision-making in California

A California Adaptation 2023 Session

Wednesday, August 2nd, 10:15-11:45 AM

Primary funding provided by the California Energy Commission

cal-adapt.org
analytics.cal-adapt.org

Speakers

Justine Bui

she/her

Spatial Informatics Group

Nancy Thomas

she/her

Geospatial Innovation Facility (UC Berkeley)

Nancy Freitas

she/her

Lawrence Berkeley National Lab | UC Berkeley

Owen Doherty

he/him

Eagle Rock Analytics

CAL-ADAPT

Problem Statement

- Data portraying climate change in California is difficult to access and take action upon
- Cal-Adapt offers free public access to trustworthy data and tools that support exploration of California’s climate change impacts on state infrastructure, communities, and natural resources

Problem Statement

- California has invested a lot in producing climate projections, but climate data can be difficult to access and utilize for many users
- The Analytics Engine will offer a cloud-based analytics platform to help transform the petabytes of data into useful and accessible data products

Goals for our Session

- Learn about the Cal-Adapt enterprise (Cal-Adapt website and Analytics Engine) and how it will be expanding with the Fifth Climate Assessment
- Understand how engagement and co-production has informed the development of the Analytics Engine

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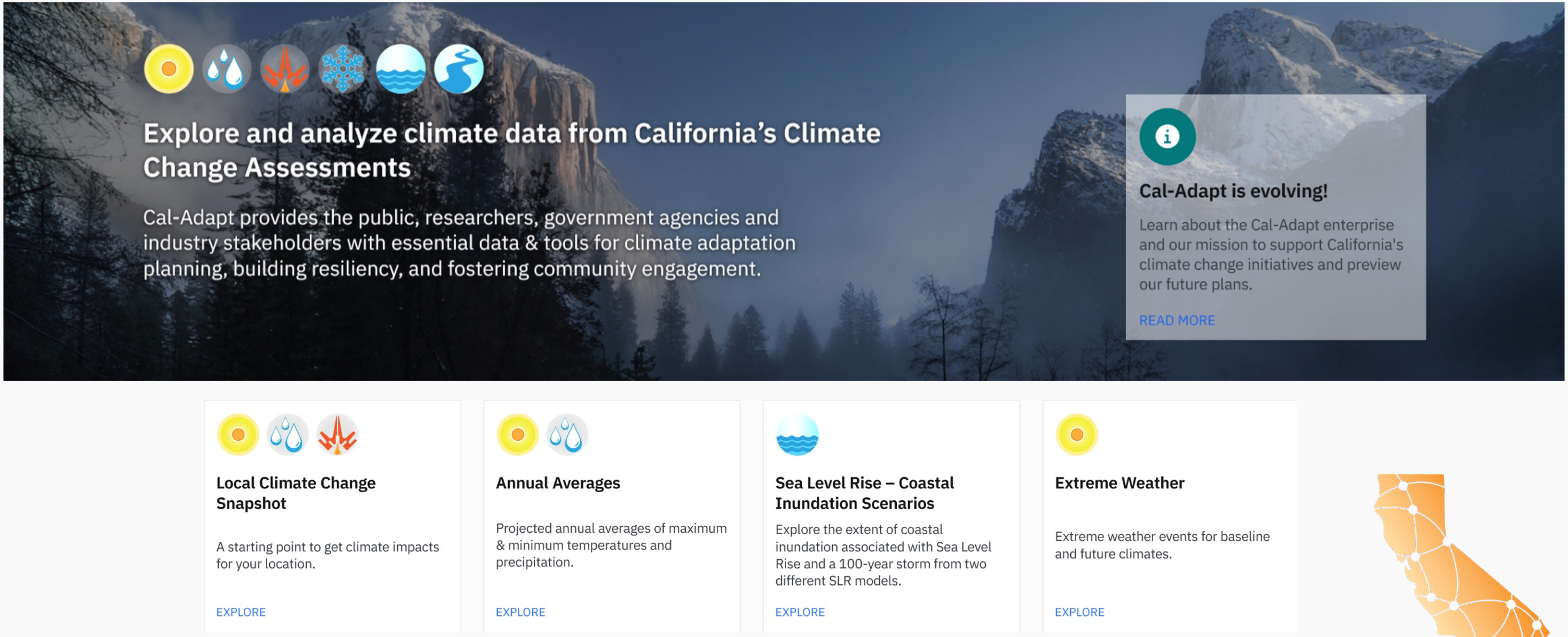
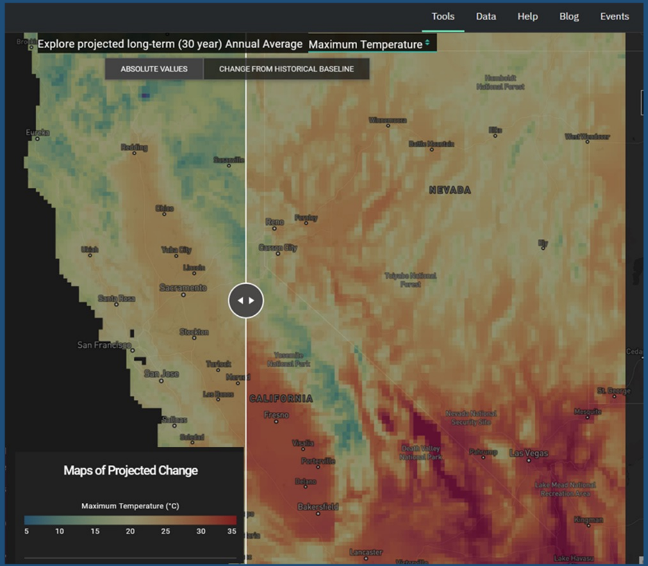
Cal-Adapt: ANALYTICS ENGINE

The Cal-Adapt Enterprise

Cal-Adapt.org





Our Mission

We make data portraying climate change in California more **accessible** and **actionable** for a broad audience, with an emphasis on energy sector stakeholders and local governments.

Cal-Adapt 2.0

Cal-Adapt provides a way to explore peer-reviewed climate change projections and scenarios approved by the State and used as the basis for the **California's Fourth Climate Change Assessment**

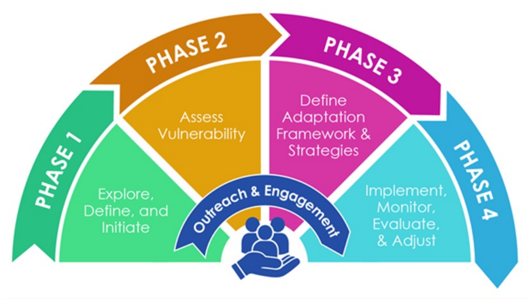
Cal-Adapt: ANALYTICS ENGINE

How is Cal-Adapt being used?

State Climate Resource

Cal-Adapt has been recognized by California's legislature as a key resource to support ***climate adaptation resiliency and planning*** and has helped California move forward by providing easy access to climate projections sanctioned by the state.

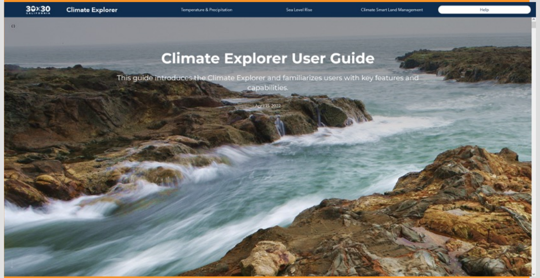
Adaptation Planning Guide (APG)



California Public Utilities Commission

The California Public Utilities Commission (CPUC) issued an **Order Instituting Rulemaking (R.18-04-019)** to integrate climate change adaptation matters in relevant CPUC proceedings.

CA Nature 30x30 Climate Explorer



Regional Planning

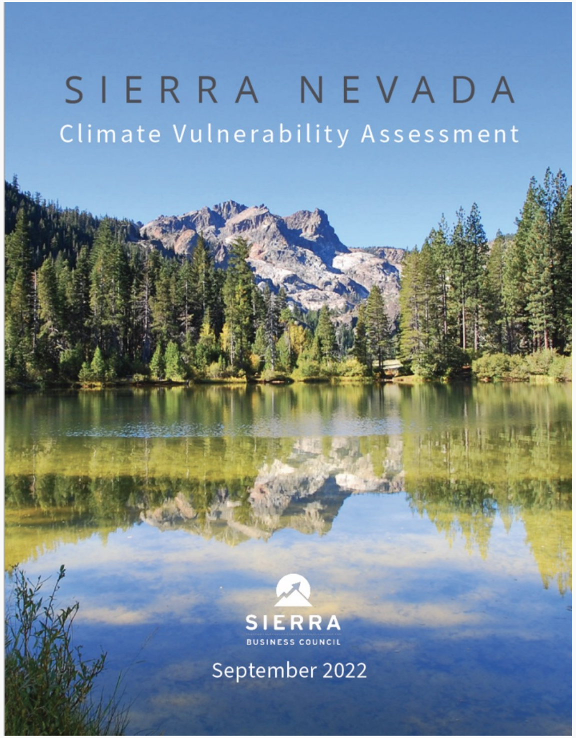
The Sierra Climate Adaptation and Mitigation Partnership (Sierra CAMP) used Cal-Adapt to help inform the "Sierra Nevada Climate Vulnerability Assessment," which is designed to help Sierra Nevada communities prepare for climate change.

SIERRA BUSINESS COUNCIL

SIERRA NEVADA CONSERVANCY

Sierra Institute for Community and Environment

CNAP California-Nevada Climate Applications Program A NOAA RISA team



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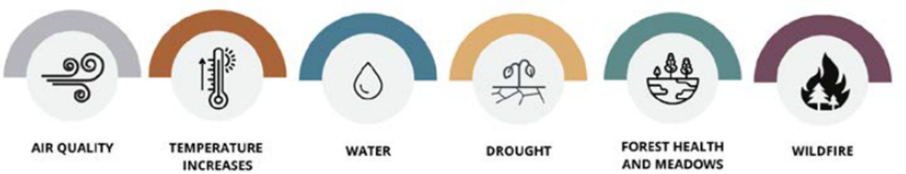
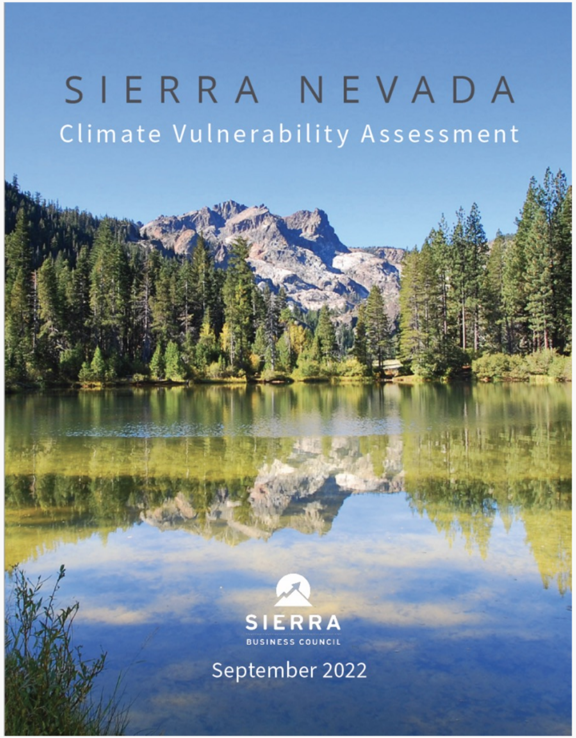




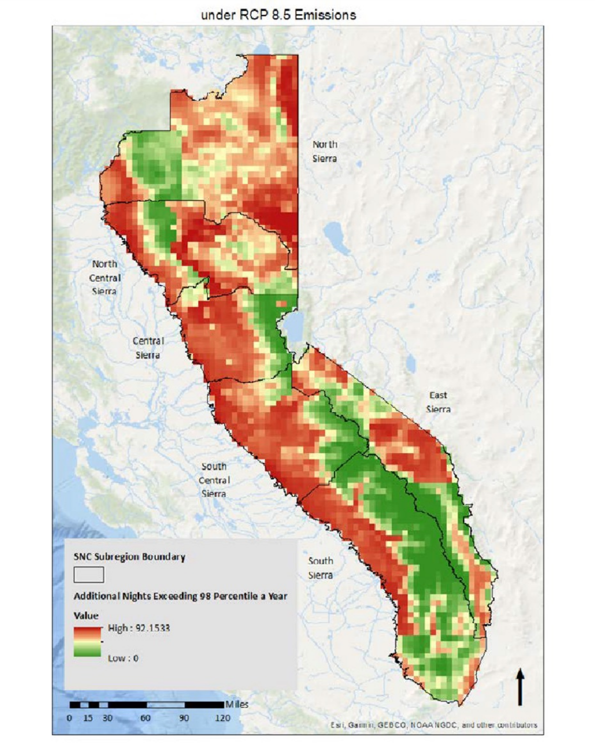
Sierra Nevada Climate Vulnerability Assessment

CHANGE IN NUMBER OF WARM NIGHTS A YEAR 2070-2099

Subregion	Change Across the Subregion *Subregions Include Diverse Topographic Changes*	Average Change Across the Subregion *Average Includes Diverse Topographic Changes*
North Sierra	Will increase 3–92 days a year	On average will increase 57 days a year
North Central Sierra	Will increase 1–92 days a year	On average will increase 58 days a year
Central Sierra	Will increase 1–91 days a year	On average will increase 56 days a year
East Sierra	Will increase 0–86 days a year	On average will increase 28 days a year
South Central Sierra	Will increase 1–89 days a year	On average will increase 58 days a year
South Sierra	Will increase 0–86 days a year	On average will increase 34 days a year

County	Average Increase in Days *Average Includes Diverse Topographic Changes*
Alpine	56.9
Amador	59.2
Butte	51.6
Calaveras	66.1
El Dorado	58.2
Fresno	31.7
Inyo	28.3
Kern	31.3
Lassen	62.8
Madera	44.5
Mariposa	56.3
Modoc	64.7
Mono	58.4
Nevada	58.5
Placer	51.8
Plumas	64.5
Shasta	36.3
Sierra	55.7
Tehama	54.5
Tulare	36.0
Tuolumne	55.3
Yuba	54.1

Tables coincide with the map on the previous page (data points are represented by grid colors). For example: as seen in the subregion table, higher elevations in the North Sierra Region will experience a minimal increase in the number of warm nights per year, whereas the lower elevations will experience a much higher increase in warm nights per year over the late-century time period. On average Alpine County will experience a 56.9-night increase.



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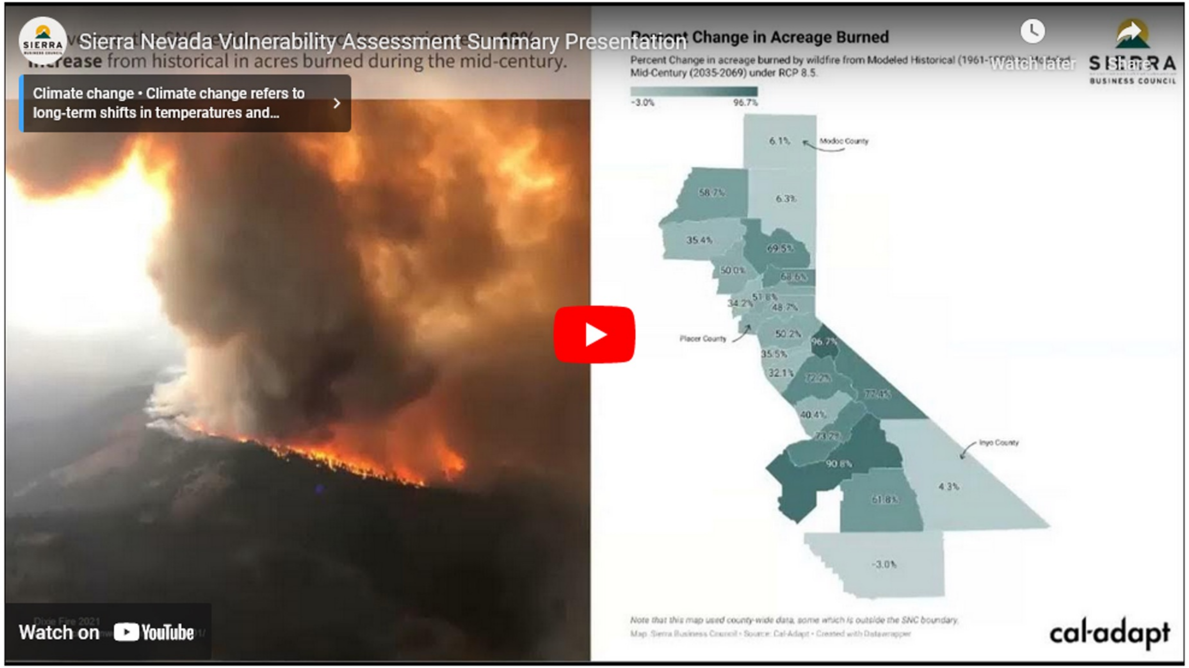
Sierra Nevada Climate Vulnerability Assessment

WATCH THE SUMMARY PRESENTATION



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Sierra Institute for Community and Environment

CNAP

Cal-Adapt is evolving!

How does the Analytics Engine differ from Cal-Adapt?

Cal-Adapt 2.0

- **Fourth Climate Change Assessment** data: CMIP5 downscaled climate data
  - Daily temporal resolution
  - ~6km spatial resolution
- Optimized for **fast interactive data visualization** on a web browser
- Hosted on Amazon Web Services using EBS (Elastic Block Store) data storage and Elastic Compute Cloud (EC2)

Analytics Engine

- **Fifth Climate Change Assessment** data: CMIP6 downscaled climate data
  - Sub-daily (~hourly) temporal resolution
  - ~3km spatial resolution
- Optimized for **big data computational analysis** using the power of the cloud
- Hosted on Amazon Web Services using S3 data storage and Pangeo stack

Expanded Cal-Adapt Enterprise

DATA

Projections

SIO/UCSD and UCLA are generating the next generation climate projections. (EPC-20-006)

Historical Products

Historical climate products. SIO/UCSD and UCLA (PIR-19-007)

Future Climate Research

5th Assessment and other future research work.

ACCESS

Cal-Adapt: Analytics Engine

Computing resources on top of climate data information for technical users. ERA, UCB, SIG, E3 (EPC-20-007)

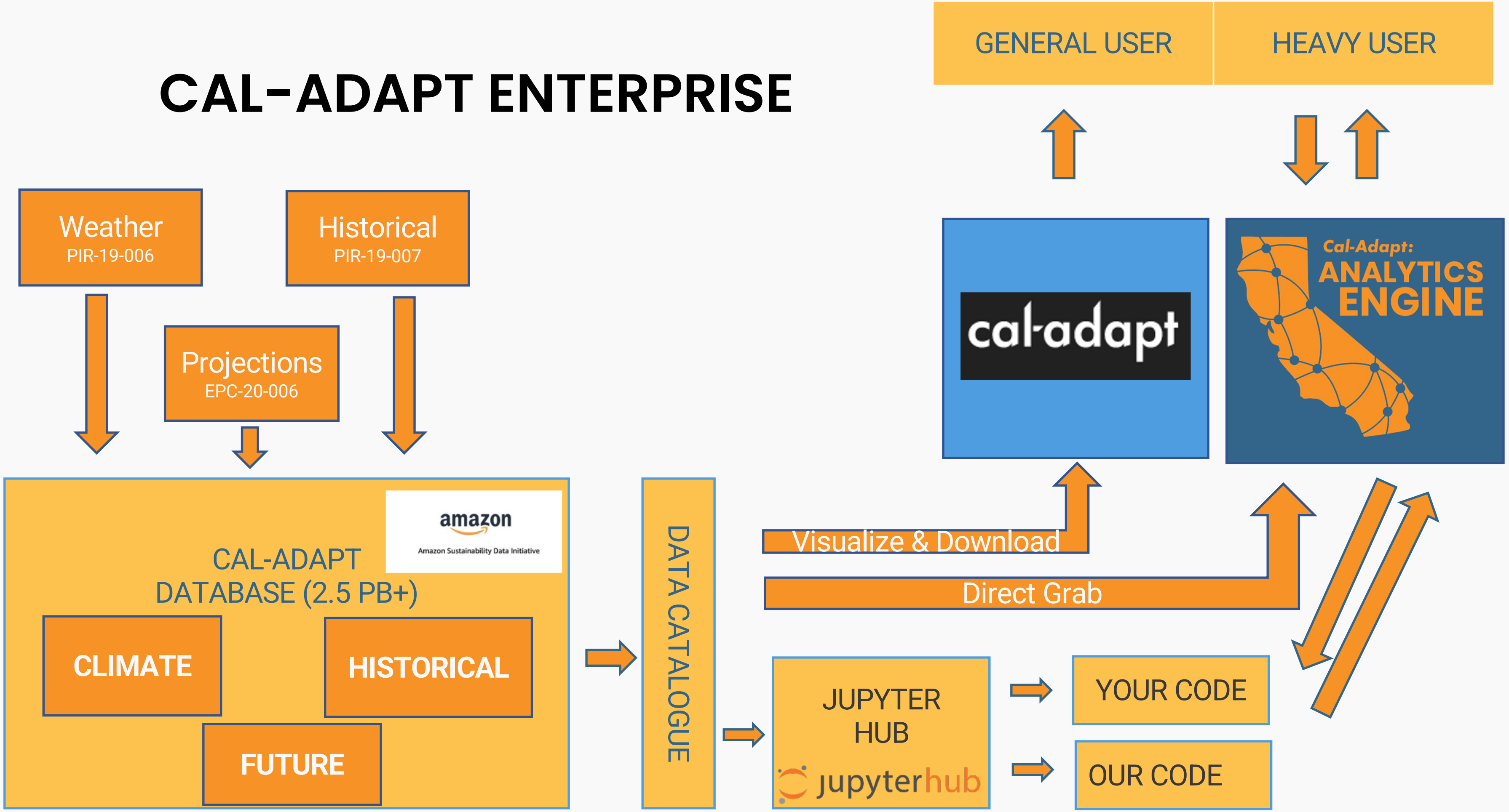
Historical Data Platform

Recent weather and past weather observations and information. ERA and LBNL (PIR-19-006)

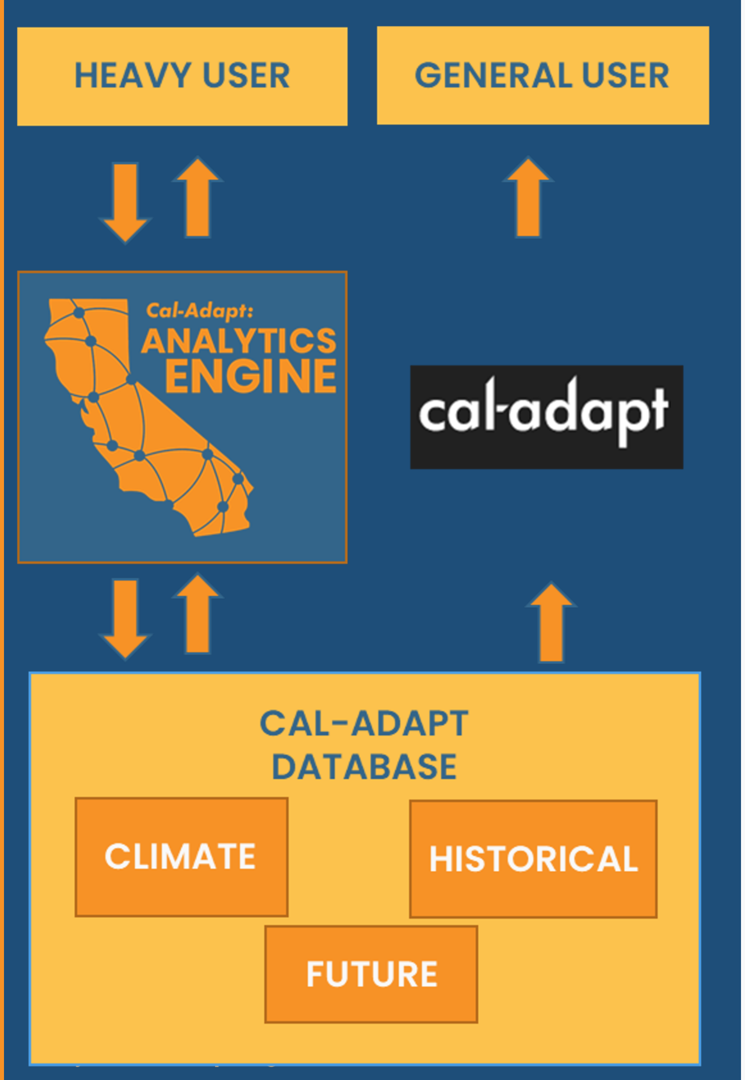
Cal-Adapt

Cal-Adapt.org has visualizations and download capacities. ERA/GIF (EPC-21-038)

CAL-ADAPT ENTERPRISE



What is being developed?



Cal-Adapt Web Application 3.0

We are building the next-generation web application to update a subset of climate tools with the latest Fifth Assessment climate data (EPC-21-038)

Key Upcoming Activities

User Needs Assessment

Listening sessions and working groups of key stakeholders to co-produce an updated Cal-Adapt web application that uses the next-generation Fifth Assessment climate data

Beta Data Download Tool

Incorporating Fifth Assessment climate (link) data access

- Daily data
- 3km across California
- 100+ datasets from various GCMs, ensembles, etc.

Tool Launch and Webinar

Full launch of the new Data Download tool to allow easy access to key Fifth Assessment climate variables

How Can You Get Involved?

- Join our co-production process!
- Become a beta tester for our new Data Download tool
- Let us know what data, tools, and guidance materials you need to make Cal-Adapt.org more useful

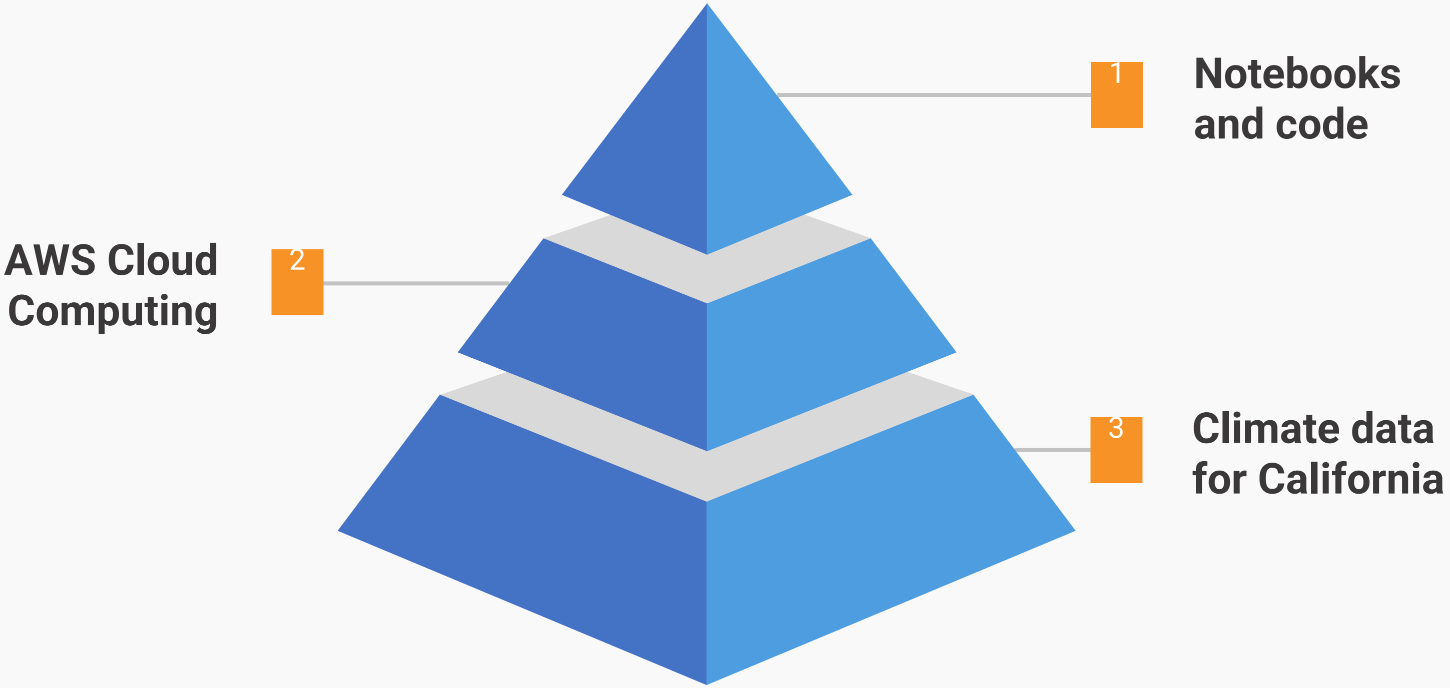
The Analytics Engine

Cal-Adapt: ANALYTICS ENGINE

What is the Analytics Engine?

analytics.cal-adapt.org/

How does the Analytics Engine work?



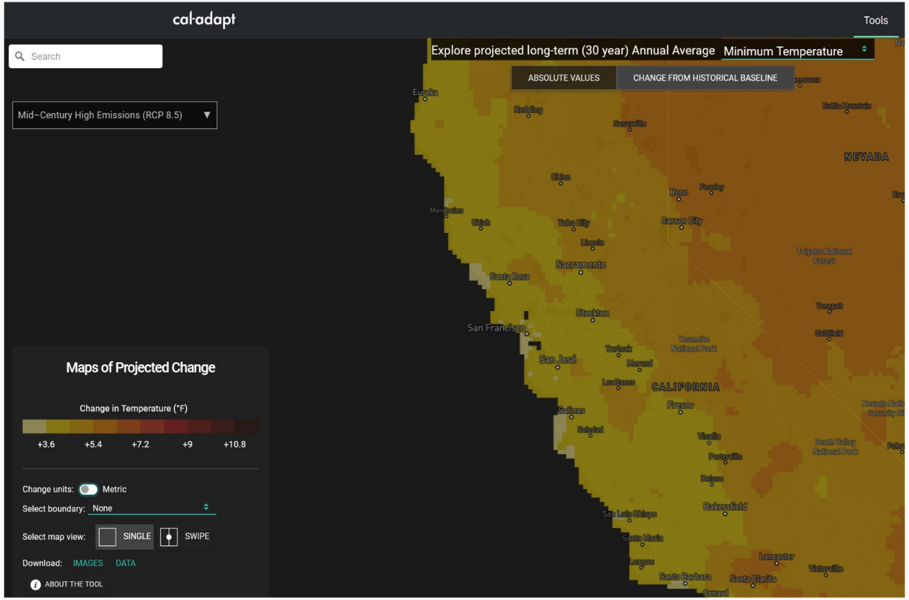
When to use Cal-Adapt vs. the Analytics Engine

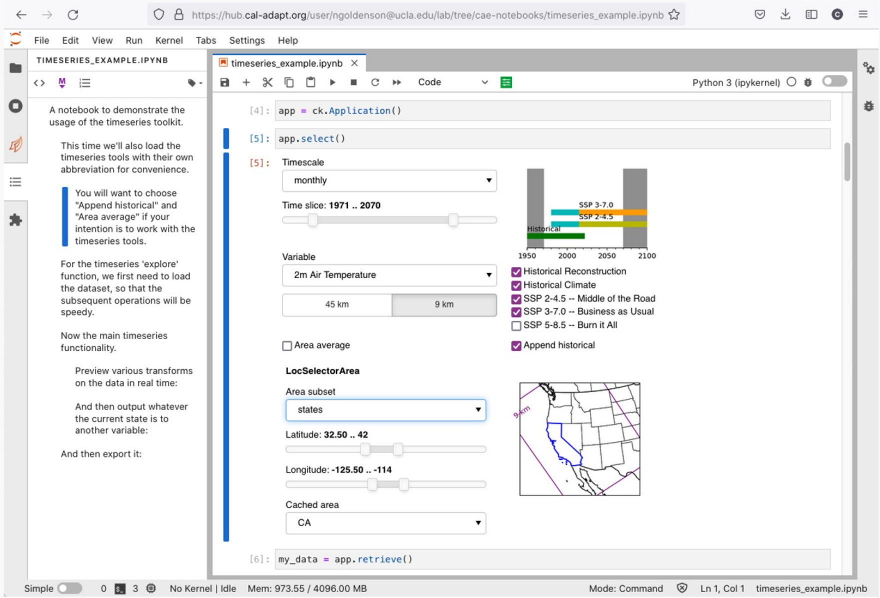
cal-adapt

- Interactive maps and tools
- CMIP5 data
- Daily + 6km resolution

Cal-Adapt: ANALYTICS ENGINE

- Detailed data analysis
- CMIP6 data
- Hourly + 3km resolution





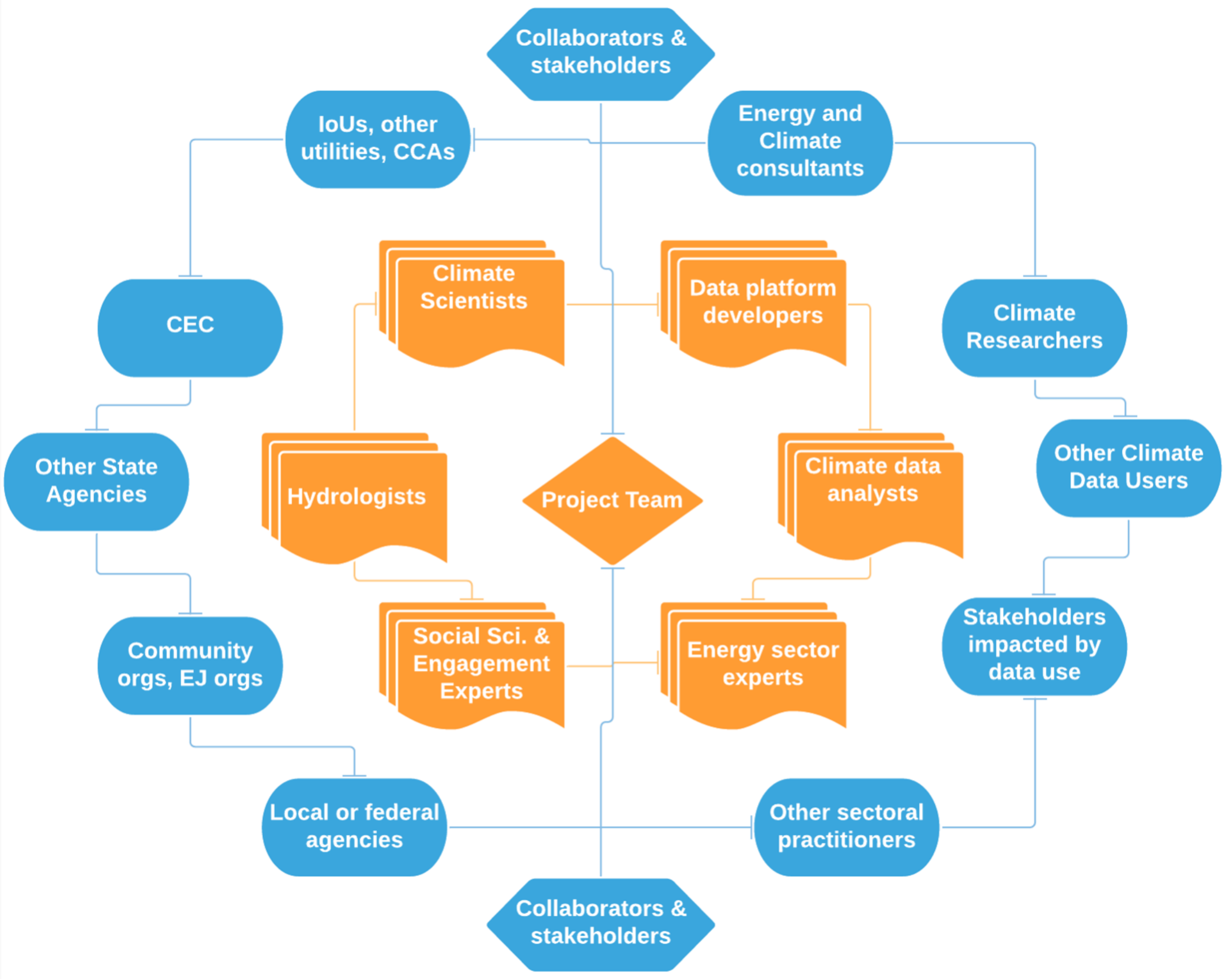
analytics.cal-adapt.org/

Cal-Adapt: ANALYTICS ENGINE

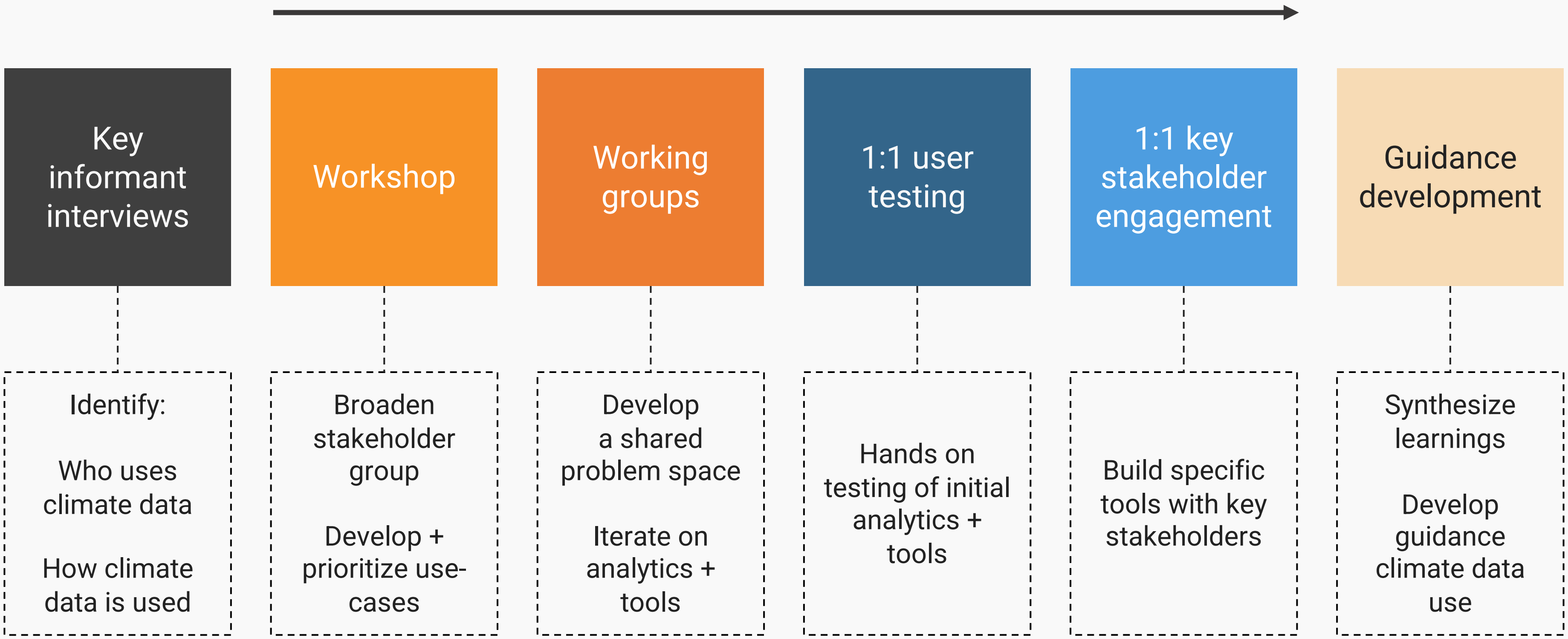
Engagement Process

A co-production approach

Co-create the data, analytics and platform with users, collaborators and stakeholders



Co-production process and activities



Stakeholder map + interviews

Users of climate information for climate adaptation include:

Policy Users, Academics / Researchers, Public Consumer & Learners, and Semi-Technical & Technical Users

Use-Cases

Initial priorities:

01	Threshold-based tools	Identify vulnerable assets, areas, and communities
02	Hourly time series	Input climate information into impact or management models
03	Distribution of extreme events	Understand timing and location of extreme events to connect with health impacts, agricultural yields, etc.

In development:

04	Wildfire planning	Inform long range prevention and management
05	Renewable energy planning	Incorporate climate data into solar, wind, and hydroelectric planning

Cross-cutting issues

01	Uncertainty of climate data	Understand climate model uncertainty and natural variability of the climate system
02	Credibility of climate data	Assess data credibility and learn which data to use to address a specific problem

Notebook development

Cal-Adapt Analytics Engine

WORKING GROUP 3 - June 23, 2022

Group discussion 2: Stakeholder feedback on the Threshold Tools notebook

Definitions refresher

Return period: estimates the average time between extreme events of a certain value. This is sometimes worded as a "1 in x years" event.

Return value: refers to a value or intensity (of temperature, precipitation, or another variable) that would be expected to be exceeded once every return period, or a 1-in-X year event. Effectively it is the inverse of the return period. Instead of wondering how often an extreme heat event will occur, we are instead considering what an extreme temperature event would look like once in any given time period.

Guiding questions

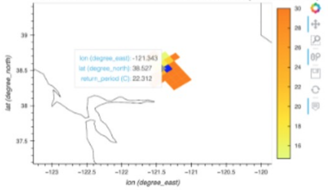
1. What specific **applications** would you use a 1-in-X year threshold event result for?
    a. What applications would you use a **return period** for, for a selected return value? [e.g. how frequently an extreme event of x-degrees temperature or x-inches rainfall could occur]

Calculate return period for a selected return value

Use-Case Example: A electric utility with existing electrical infrastructure in Sacramento wants to calculate the return period of a 45 degrees C temperature event that occurred historically (during the 1980-2010 time period) as a benchmark input for their reoccuring asset vulnerability assessment.

Visualize return period

```
threshold_tools.get_geospatial_plot(sacramento_1980_rp, data_variable='return_period', bar_max=30)
```



- What specific applications would use use this tool to address?
- How do you currently do these analyses at your agency?
- What variables, resolutions, temporal and spatial scales of data are required?
- What data platform features are required?
- How do you want to output the data?

Notebook development

Cal-Adapt Analytics Engine

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```

Cal-Adapt Analytics Engine

WORKING GROUP 3 - June 23, 2022

State Agency - Drainage design, sizing based on historical data. I will be interested about the overall distribution. Let's say what is the distribution of a 3-day 100-year duration event. It will be important for economic analysis. It is a back and forth exercise. I am trying to find a figure…

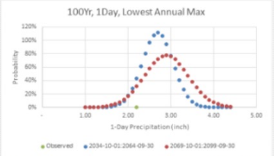


Figure 4: Normal probability distribution function of the 100-year return period 1-day extreme precipitation representative of 10 General Circulation Model with 2 Representative Concentration Pathways. The green dot represents the historical data, the blue dots represent the mid-century projection, and the red dots represent the late-century projection.

Table 3. 100-year return period event with a 1-day duration for the mid- and late-century precipitation projection and multiple probabilities ranging from 50% to 99% and their corresponding percentage change from historical data.

Historic Data (1960-10-01:1990-09-30): Precipitation = 2.20inch				
	Mid-Century (2034-10-01:2064-09-30)		Late-Century (2069-10-01:2099-09-30)	
Probability	Precipitation (inch)	Percentage Change from Historic	Precipitation (inch)	Percentage Change from Historic
50%	2.7	22%	2.9	32%
60%	2.8	27%	3.0	38%
70%	2.9	31%	3.2	44%
80%	3.0	36%	3.3	51%
90%	3.2	43%	3.6	62%
95%	3.3	49%	3.7	70%

IOU - We use these estimates mostly for asset-specific analyses. For example, if we know an asset class is sensitive to 110 degree heat, we can prioritize where we want to further study our system. It is also helpful to look at which regions change the most for this type of analysis.

Research Organization - Knowing the return period for a specific value is helpful, but it would also be helpful to know the return period for a specific variable for a particular duration. For example, how often would you expect to see temperature exceeding a threshold for 3 days? 5 days, etc.?

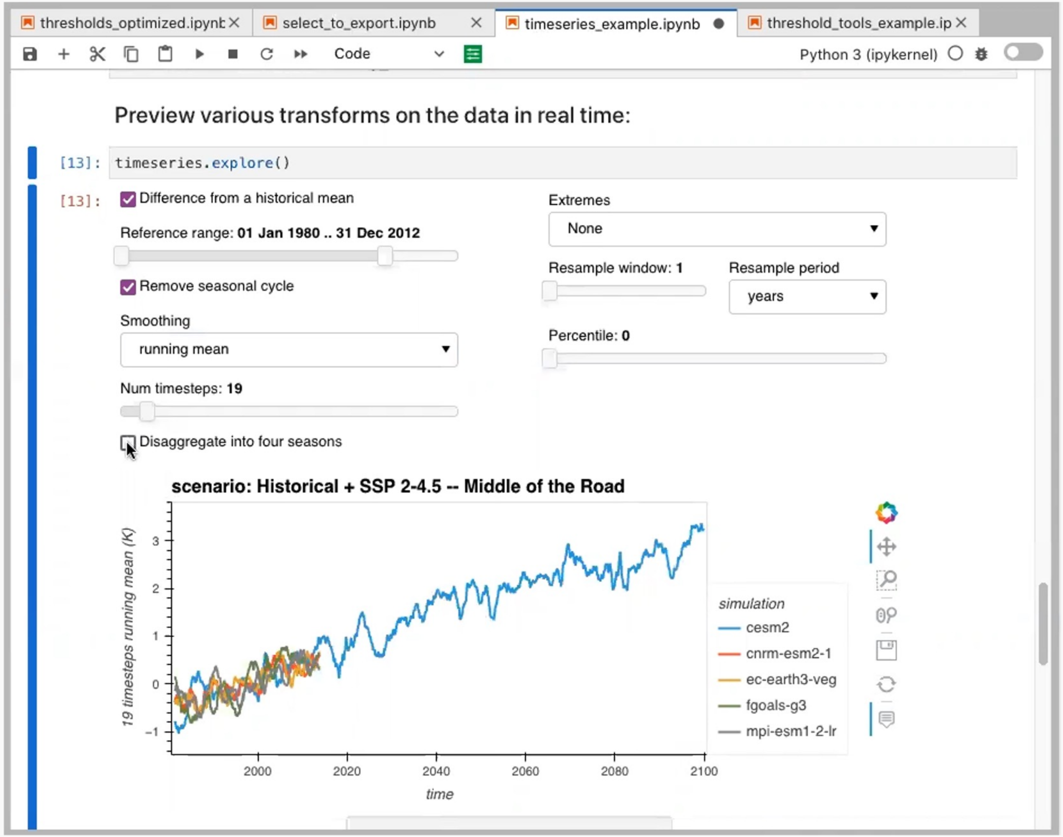
- I see a similar comment from SCE above. The ability to specify the temporal duration would be a valuable functionality.

State Agency - Not using this functionality at this time

IOU - For asset thresholds and building standards, understanding how often an asset will be exposed to a certain hazard or level of hazard is very helpful for system planning

Consultant - We would use it to convert to load or grid events for the purpose of reliability planning.

Notebook development



Systematic review of data

Lack of data

- Hourly data
- Granular spatial data
- Data on application-relevant metrics
- Translating climate data into impact metrics
- Cascading and compounding events

Accessing and working with available projections

- Downloading large data
- Computing power
- Cleaning and aggregating data

Appropriateness of approach for different contexts

- RCP 8.5 for all decisions? Median vs 90th percentile of models?
- Sampling variability?
- How to compute delta?
- To what extent do results differ if approaches change?

Current engagement

1:1 key stakeholder engagement

Current engagement

1:1 key stakeholder engagement

Develop guidance on best practices for using climate data

Cal-Adapt:
ANALYTICS
ENGINE

analytics.cal-adapt.org/

How You Can Benefit from the Analytics Engine

Analytics Engine Benefits

The Cal-Adapt Analytics Engine

1. Reputable, sanctioned climate data localized for California
2. Scientifically rigorous (but approachable) analytical tools
3. Computational resources to assess vulnerability and plan

Analytics Engine
Benefits

What data will be included?

Users Expect:

- Rigorous, scientifically sound
- Sanctioned
- Appropriate for California

We Require:

- Open, peer-reviewed and reproducible
- Rigorous metadata and documentation
- Consistent with state guidelines for climate data use

Analytics Engine
Benefits

Overview of data sources

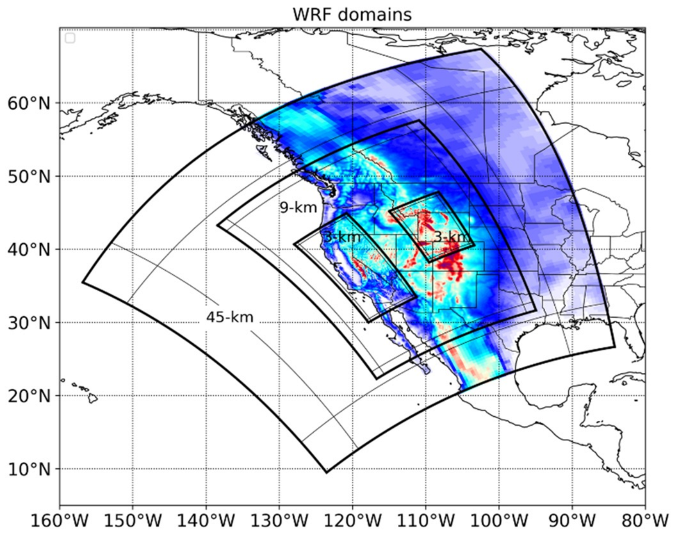
Foundational climate data for California’s Fifth Climate Assessment

- Localized climate projections
- Historical observations

Derived products:

- Wildfire projections
- Renewable energy potential
- Hydrological modeling

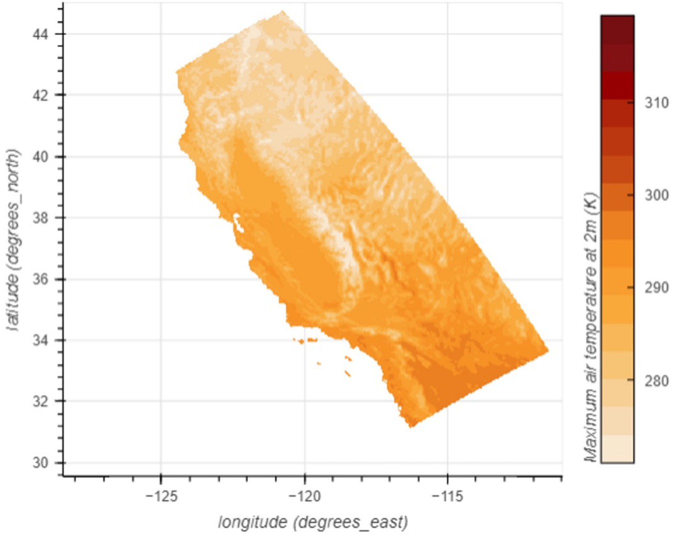
Downscaled Climate Projections: WRF



Source: Stefan Rahimi, UCLA

- Dynamically downscaled from **4** CMIP6 Global Climate Models using WRF model
- Shared Socioeconomic Pathways 2-4.5, 3-7.0, 5-8.5
- **Hourly,** daily, and monthly time resolution
- 3km, 9km, and 45km
- 20+ variables: air temperature, precipitation, wind speed, humidity, etc.

Downscaled Climate Projections: LOCA2



- Hybrid statistically downscaled from **64** CMIP6 Global Climate Models using LOCA approach
- Shared Socioeconomic Pathways 2-4.5, 3-7.0, 5-8.5
- Daily and monthly time resolution
- 3km
- 8 variables: air temperature, precipitation, wind, humidity, solar radiation

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WRF

Not bias corrected: can be used as-is to examine relative change but not absolute values

Suitable for applications that require **sub-daily observations** and focus on **extremes**

Compare across GCM and global emissions scenario

LOCA2

Bias corrected: absolute values can be used as direct inputs into models

However, sub-monthly extremes may be distorted by this approach

Can characterize within-model variability in addition to across GCM and emissions scenario

WRF

Not bias corrected: can be used as-is to examine relative change but not absolute values

Suitable for ... **su**... focus on **extremes**

Compare across GCM and global emissions scenario

LOCA2

Bias corrected: absolute values can be used as direct inputs into models

...er, sub-monthly extremes ...

Can characterize within-model variability in addition to across GCM and emissions scenario

Data selection depends on your question of interest

→ The Analytics Engine provides tools to help assess which model output is right for your application

Analytics Engine
Benefits

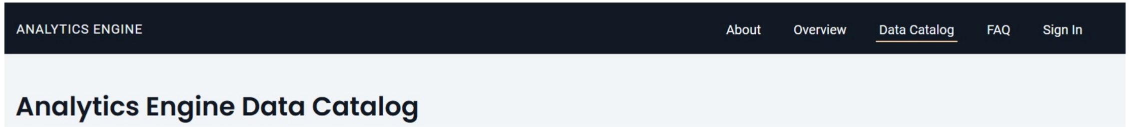
Challenges

1. Types of Downscaling
2. Bias Correction
3. How fine scale?
4. What time points?
5. Massive datasets
6. Difficult to use formats

Analytics Engine
Benefits

What’s In the Analytics Engine

1. Data Catalogue



2. Climate functions

3. Notebooks for analysi

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Analytics Engine Benefits

Data Catalogue

Current Analytics Engine Data Catalog

Datasets available to download and analyze through Cal-Adapt: Analytics Engine

wrf, prec, hourly

Downscaling Method	Institution	Source	Experiment	Variant	Frequency	Variable*	Resolution	Path
WRF	UCLA Center for Climate Science	CESM2	ssp245	r11i1p1f1	Hourly	prec	9-km (d02)	s3://cadcat/wrf/ucla/cesm2/ssp245/1hr/prec/d02/
WRF	UCLA Center for Climate Science	CESM2	ssp370	r11i1p1f1	Hourly	prec	45-km (d01)	s3://cadcat/wrf/ucla/cesm2/ssp370/1hr/prec/d01/
WRF	UCLA Center for Climate Science	CESM2	ssp370	r11i1p1f1	Hourly	prec	9-km (d02)	s3://cadcat/wrf/ucla/cesm2/ssp370/1hr/prec/d02/
WRF	UCLA Center for Climate Science	CESM2	ssp370	r11i1p1f1	Hourly	prec	3-km (d03)	s3://cadcat/wrf/ucla/cesm2/ssp370/1hr/prec/d03/
WRF	UCLA Center for Climate Science	CESM2	ssp585	r11i1p1f1	Hourly	prec	45-km (d01)	s3://cadcat/wrf/ucla/cesm2/ssp585/1hr/prec/d01/
WRF	UCLA Center for Climate Science	CESM2	ssp585	r11i1p1f1	Hourly	prec	9-km (d02)	s3://cadcat/wrf/ucla/cesm2/ssp585/1hr/prec/d02/
WRF	UCLA Center for Climate Science	CNRM-ESM2-1	historical	r1i1p1f2	Hourly	prec	45-km (d01)	s3://cadcat/wrf/ucla/cnrm-esm2-1/historical/1hr/prec/d01/
WRF	UCLA Center for Climate Science	CNRM-ESM2-1	historical	r1i1p1f2	Hourly	prec	9-km (d02)	s3://cadcat/wrf/ucla/cnrm-esm2-1/historical/1hr/prec/d02/
WRF	UCLA Center for Climate Science	CNRM-ESM2-1	historical	r1i1p1f2	Hourly	prec	3-km (d03)	s3://cadcat/wrf/ucla/cnrm-esm2-1/historical/1hr/prec/d03/
WRF	UCLA Center for Climate Science	CNRM-ESM2-1	ssp370	r1i1p1f2	Hourly	prec	45-km (d01)	s3://cadcat/wrf/ucla/cnrm-esm2-1/ssp370/1hr/prec/d01/

Items per page: 10 | 11–20 of 37 items | 2 of 4 pages

* See variable descriptions here

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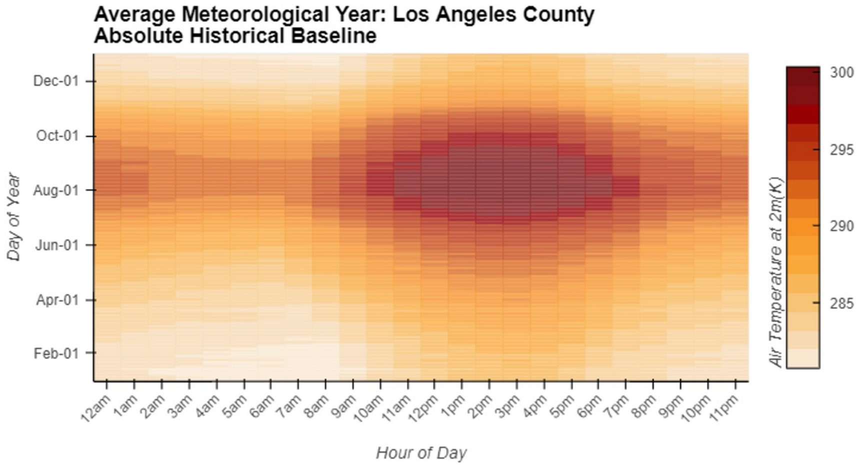
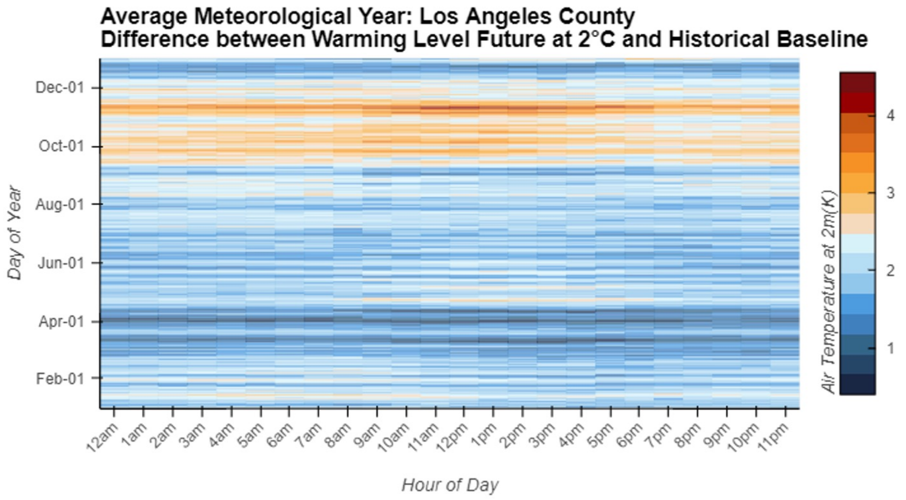
Analytics Engine
Benefits
Climate Functions

Prebuilt functions which can be called through the ClimakitAE library





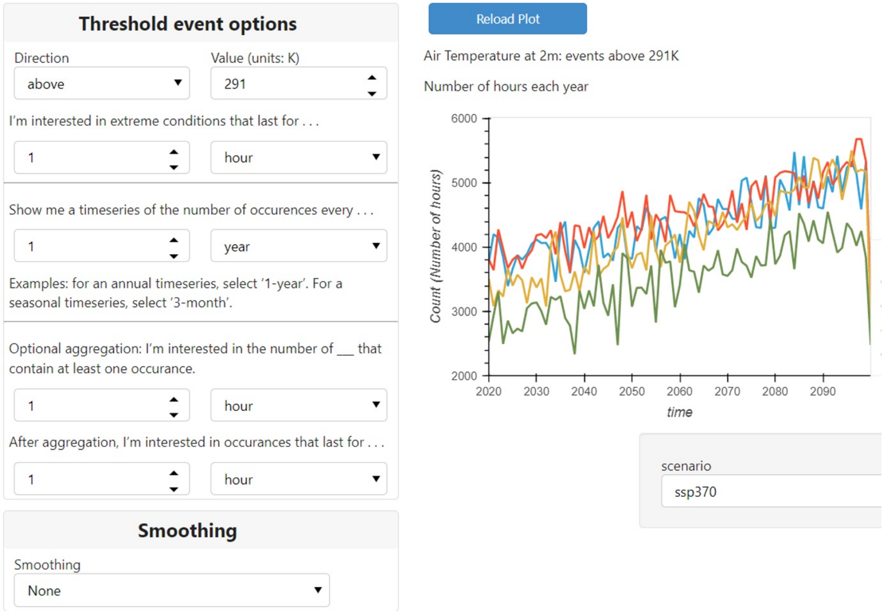
Analytics Engine Benefits

Jupyter Notebooks

- **Uncertainty tools:** understand sources of uncertainty in using climate data
- **Threshold tools:** explore extreme events
- **Warming levels:** apply global warming level framework to analyze regional responses

Coming soon

- **Typical meteorological years:** create time series of hourly annual data representing ‘typical’ conditions
- **Model selection tool:** evaluate model skill and select the right models for your study needs



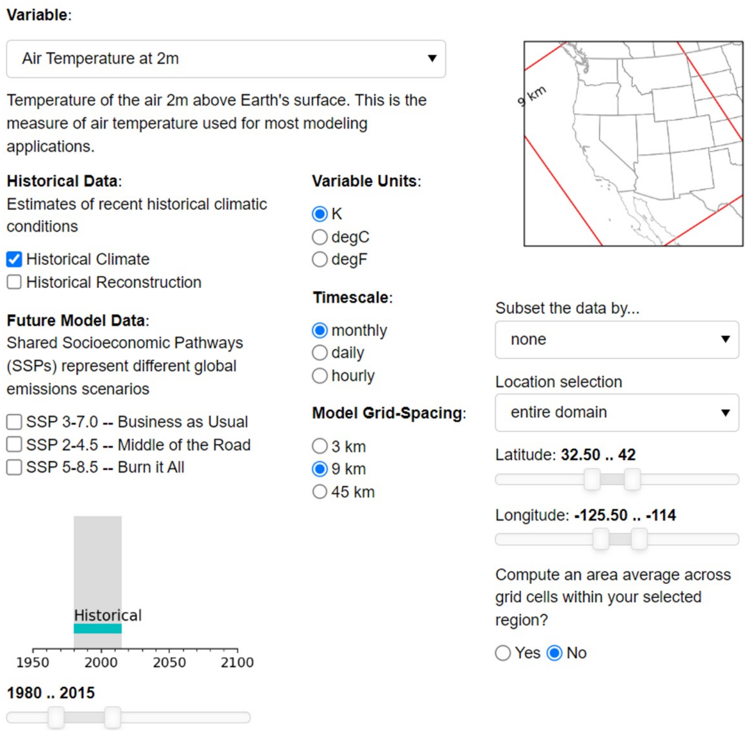
Cal-Adapt: ANALYTICS ENGINE

Getting Started with the Analytics Engine

analytics.cal-adapt.org/

Getting Started with the Analytics Engine

- **getting_started.ipynb:** Introduction to retrieving, visualizing, and exporting climate data using python and the Analytics Engine

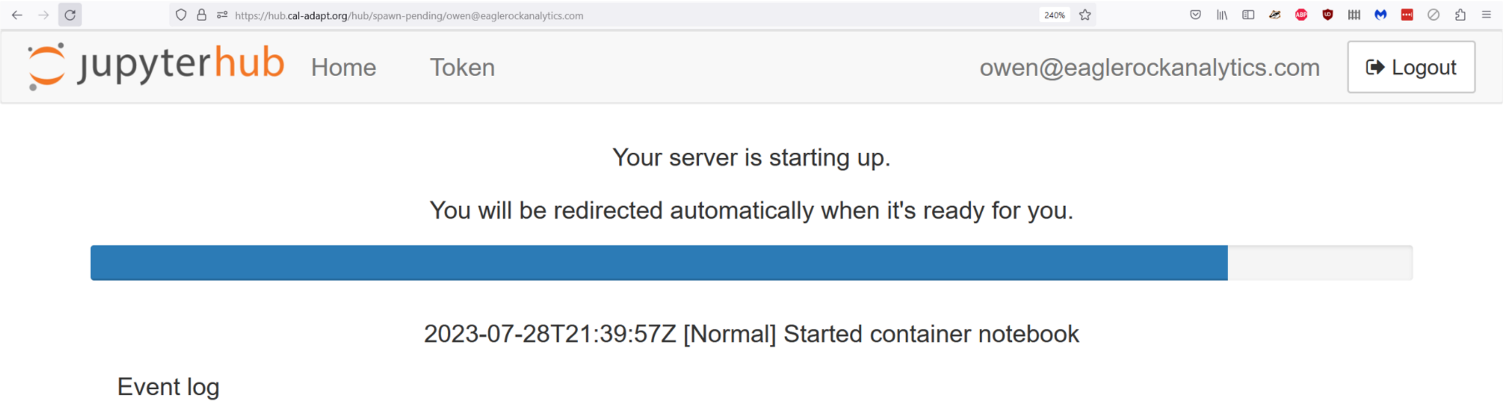


Getting Started with the Analytics Engine

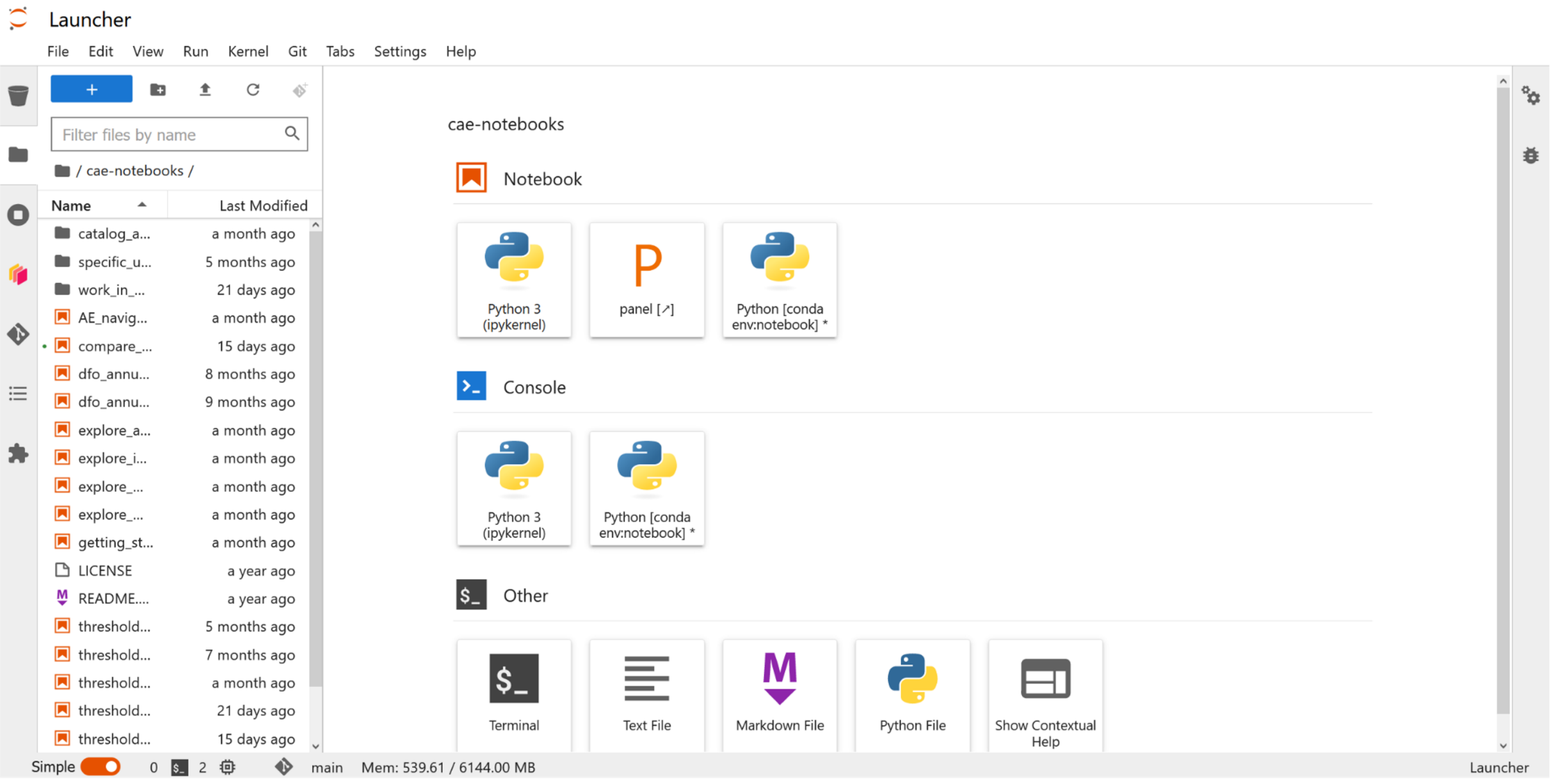
jupyterhub

Sign in with AWS Cognito

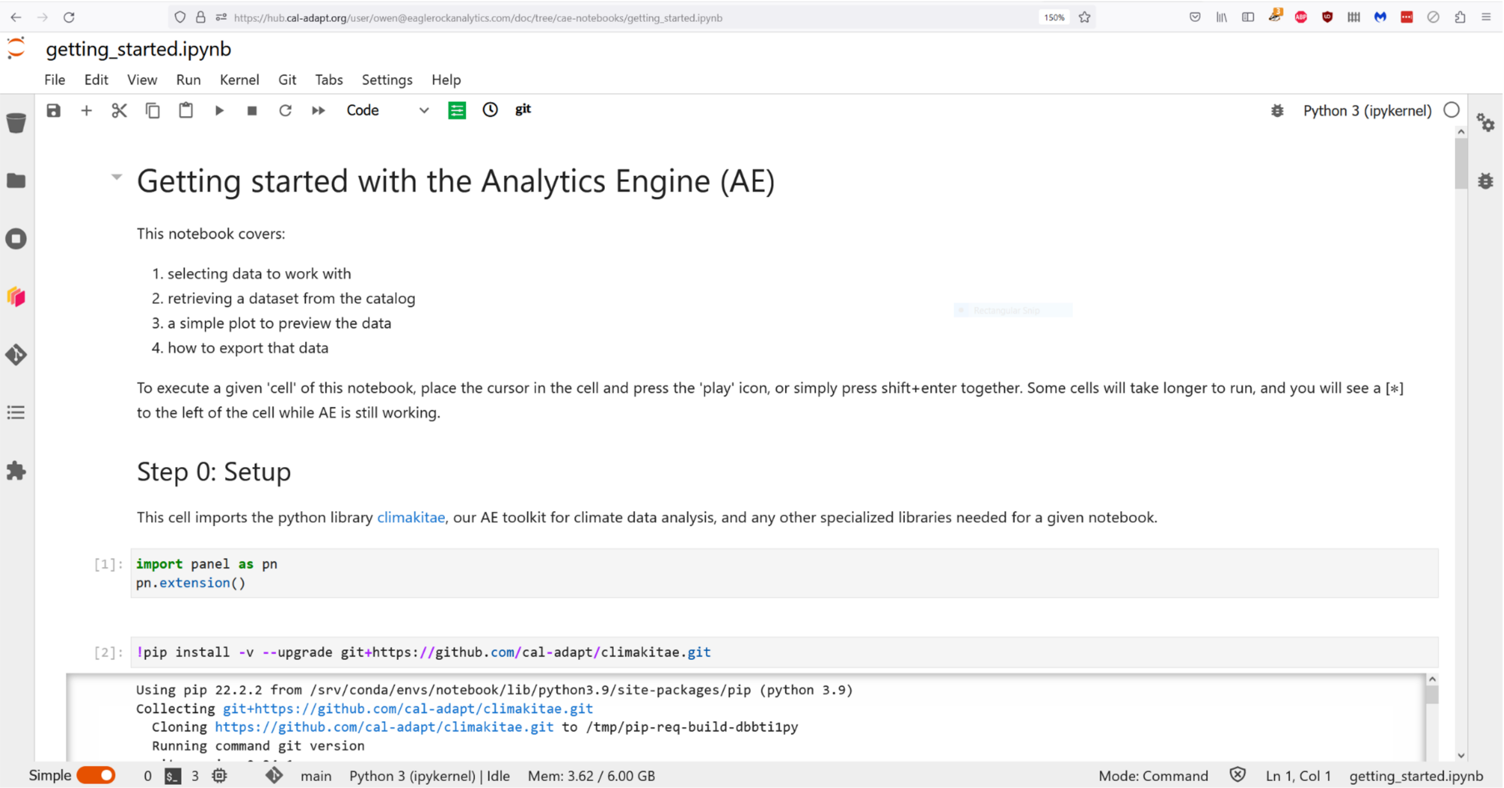
Getting Started with the Analytics Engine



Getting Started with the Analytics Engine



Getting Started with the Analytics Engine



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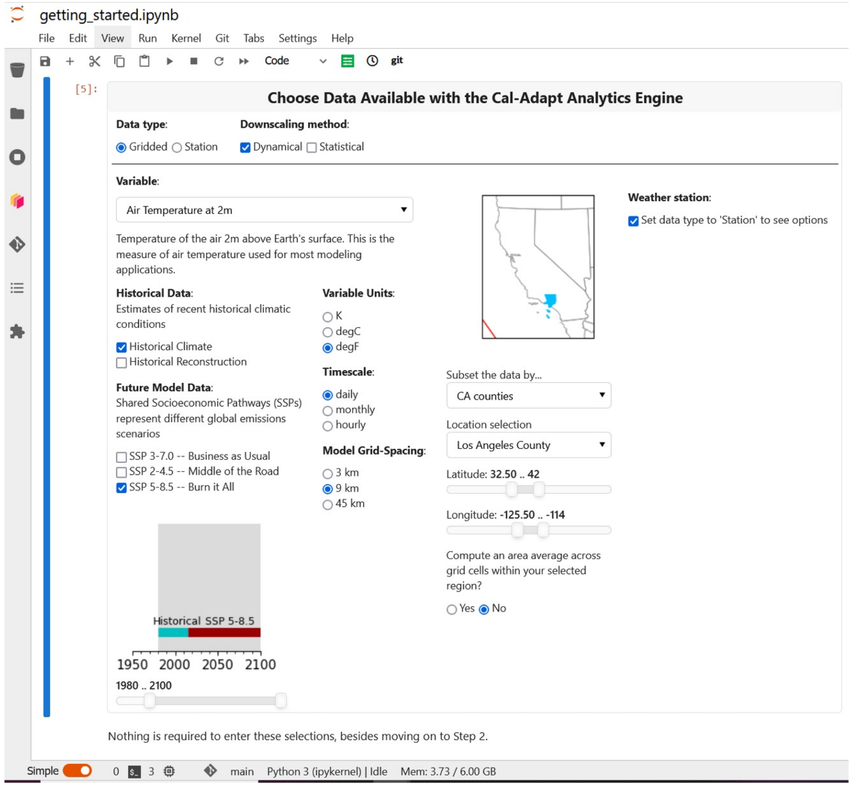
Getting Started with the Analytics Engine



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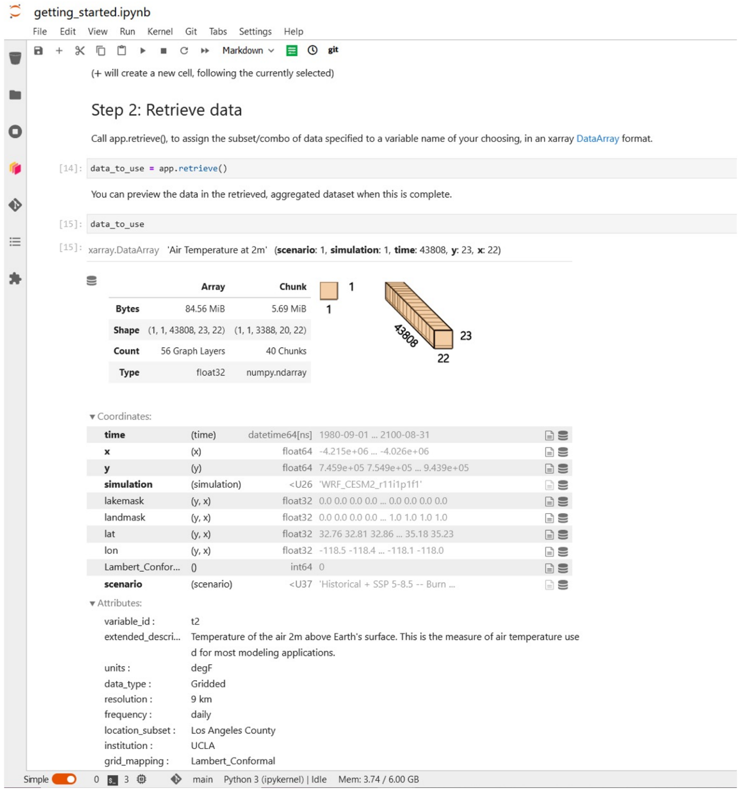
Getting Started with the Analytics Engine



getting_started.ipynb

File Edit View Run Kernel Git Tabs Settings Help

Markdown git

(+ will create a new cell, following the currently selected)

Step 2: Retrieve data

Call app.retrieve(), to assign the subset/combo of data specified to a variable name of your choosing, in an xarray DataArray format.

```
[14]: data_to_use = app.retrieve()
```

You can preview the data in the retrieved, aggregated dataset when this is complete.

```
[15]: data_to_use
```

[15]: xarray.DataArray 'Air Temperature at 2m' (**scenario**: 1, **simulation**: 1, **time**: 43808, **y**: 23, **x**: 22)

	Array	Chunk
Bytes	84.56 MiB	5.69 MiB
Shape	(1, 1, 43808, 23, 22)	(1, 1, 3388, 20, 22)
Count	56 Graph Layers	40 Chunks
Type	float32	numpy.ndarray

▾ Coordinates:

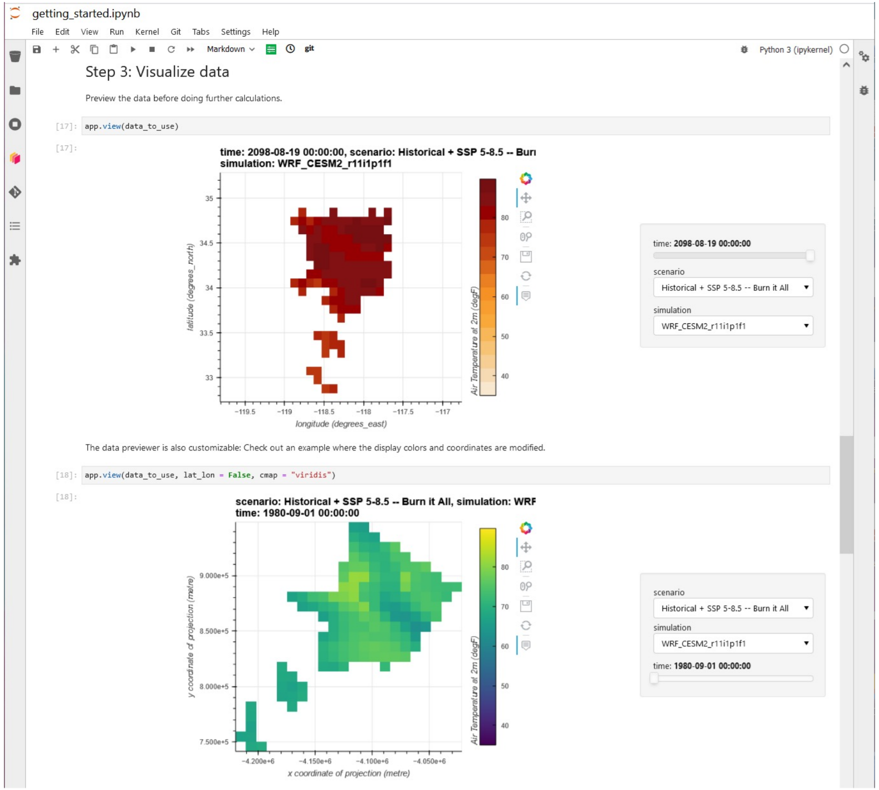
time	(time)	datetime64[ns]	1980-09-01 ... 2100-08-31
x	(x)	float64	-4.215e+06 ... -4.026e+06
y	(y)	float64	7.459e+05 7.549e+05 ... 9.439e+05
simulation	(simulation)	<U26	'WRF_CESM2_r11i1p1f1'
lakemask	(y, x)	float32	0.0 0.0 0.0 0.0 ... 0.0 0.0 0.0 0.0
landmask	(y, x)	float32	0.0 0.0 0.0 0.0 ... 1.0 1.0 1.0 1.0
lat	(y, x)	float32	32.76 32.81 32.86 ... 35.18 35.23
lon	(y, x)	float32	-118.5 -118.4 ... -118.1 -118.0
Lambert_Confor...	()	int64	0
scenario	(scenario)	<U37	'Historical + SSP 5-8.5 -- Burn ...

▾ Attributes:

variable_id :	t2
extended_descri...	Temperature of the air 2m above Earth's surface. This is the measure of air temperature used for most modeling applications.
units :	degF
data_type :	Gridded
resolution :	9 km
frequency :	daily
location_subset :	Los Angeles County
institution :	UCLA
grid_mapping :	Lambert_Conformal

Simple 0 3 main Python 3 (ipykernel) | Idle Mem: 3.74 / 6.00 GB

Getting Started with the Analytics Engine



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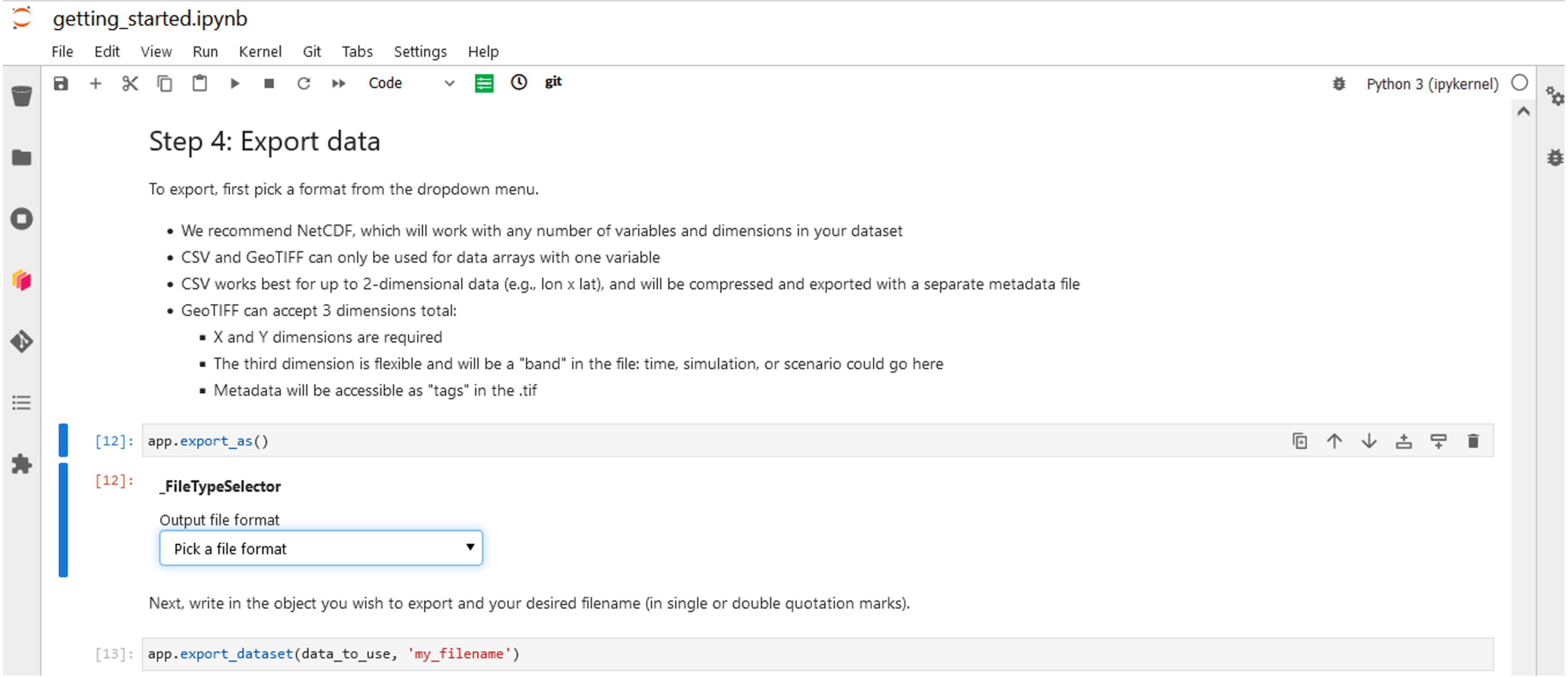
Getting Started with the Analytics Engine



Cal-Adapt: ANALYTICS ENGINE

What’s in Development?

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Analytics Engine Developments

Guidance and Help

- Convey appropriate use guidelines for climate data
- Help finding the subset of projections right for you

Analytics Engine Developments

More Data!

Coming soon:

- **Wildfire Projections**
- **Renewable Generation Profiles**
- **Three Hydrological Models**
- **Historical Weather Observations**
- **Potentially Additional Contributed Research Data**

New Tools and Capabilities

Coming soon

- **Typical meteorological years:** create time series of hourly annual data representing ‘typical’ conditions
- **Model selection tool:** evaluate model skill and select the right models for your study needs
- **Wildfire indices**: derived proxies of wildfire risk from climate model data

User Contributions

Co-Generation

- Capacity to benefit less resourced groups

First examples of Cogeneration:

- Department of Water Resources methods
- Derived data

Check out the Analytics Engine!

For the month of **August 2023** we're happy to extend temporary logins to non-energy stakeholders!

Please email analytics@cal-adapt.org with your request.

Let’s jump into a panel Q&A session with our speakers!

Q&A Session

Thank you for your time!

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Cal-Adapt: ANALYTICS ENGINE

Learn more by visiting our websites!

Cal-Adapt: cal-adapt.org

Analytics Engine: analytics.cal-adapt.org

Get in touch!

Cal-Adapt: support@cal-adapt.org

Analytics Engine: analytics@cal-adapt.org