California Energy Commission

Climate Data and Analysis Working Group

Energy-Related Environmental Research
Energy Research & Development Division

December 6, 2023

Overarching Purpose of C-DAWG

- **Bridge gaps** between climate researchers, energy stakeholders who need to use climate-related data, and CEC staff.
- Promote **knowledge exchange**.
- Elicit **input on key decisions** (e.g., related to analytical methodologies or scenario choices).
- Promote **deep coordination** within our portfolio.

Housekeeping

- Meetings are not recorded
- Welcome candid exchange
- Please “raise hand” to speak
- Please mute when not speaking

Today's Agenda

Topic	Time	Presenter
Welcome and Introductions	11:00 - 11:05	Martine Schmidt-Poolman, California Energy Commission (CEC)
General Use Projections Selection for California's Fifth Climate Change Assessment: Discussion of Process and Models	11:05 - 11:25	Julie Kalansky, Scripps Institution of Oceanography (SIO)
Presenting Hourly Sea Level Rise Projections	11:25 - 11:45	Dan Cayan (SIO)
Cal-Adapt: Providing Initial and Improved Access to New CMIP6 Data	11:45 - 12:05	Mark Koenig, Eagle Rock Analytics
Wrap-up	12:05	Susan Wilhelm (CEC)

General Use Projections

Discussion of Process & Models

General Use Projections 1-01

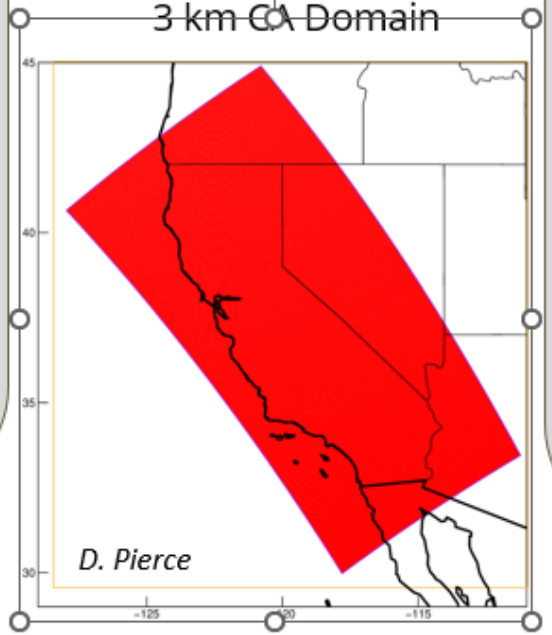
- What are General Use Projections?
  - A minimum subset of the 199 downscaled LOCA Hybrid GCM runs that can reasonably capture the range of future projections
- Why have General Use Projections?
  - Provide a starter-set of models for those less comfortable with large amounts of data
  - Allows the use of a uniform set of projections across different analyses to support coordination, comparisons and collaboration across jurisdictional and other types of boundaries
- Should I only use the General Use Projections?
  - No, it is always better to use the full set of runs if you are able
  - Using the General Use Projections is the minimum number of projections that should be used in any analysis

Large Set of CMIP6 Downscaled Climate

Dynamically Downscaled Data

- Downscaled with WRF
- SSP 370 only (medium warming)
- Hourly data for 37 variables
- Dynamically consistent
- Non-biased corrected
- 1980-2100
- 8 models
- ~1000 years of model data

GCMs selected based on historical representation skill *(Krantz et al., 2021)*



Statistically Downscaled Data

- Downscaled with LOCA2
- SSP 245, 370, & 585 (lo, med, hi)
- Daily data for 8 variables*
- Hourly temperature at select stations
- Biased corrected to observations
- 1950-2100
- 15 models, 199 runs
- ~10,000 years of model data

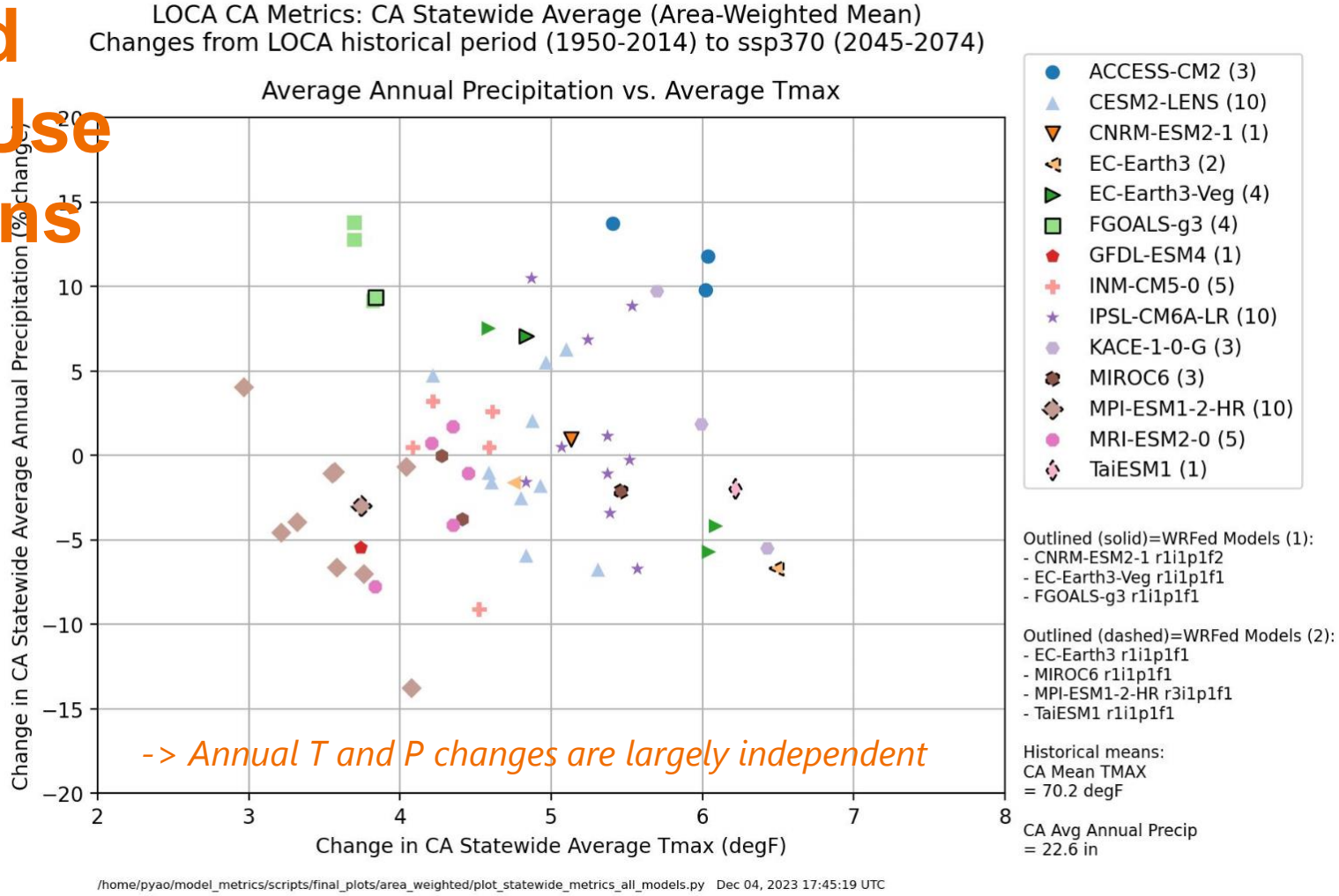
EPIC-20-006 Scenarios Project sponsored by CEC

***Variables:** Tmin, Tmax, precipitation, diurnal temperature range, RH min, RH max, surface downward shortwave, vector winds

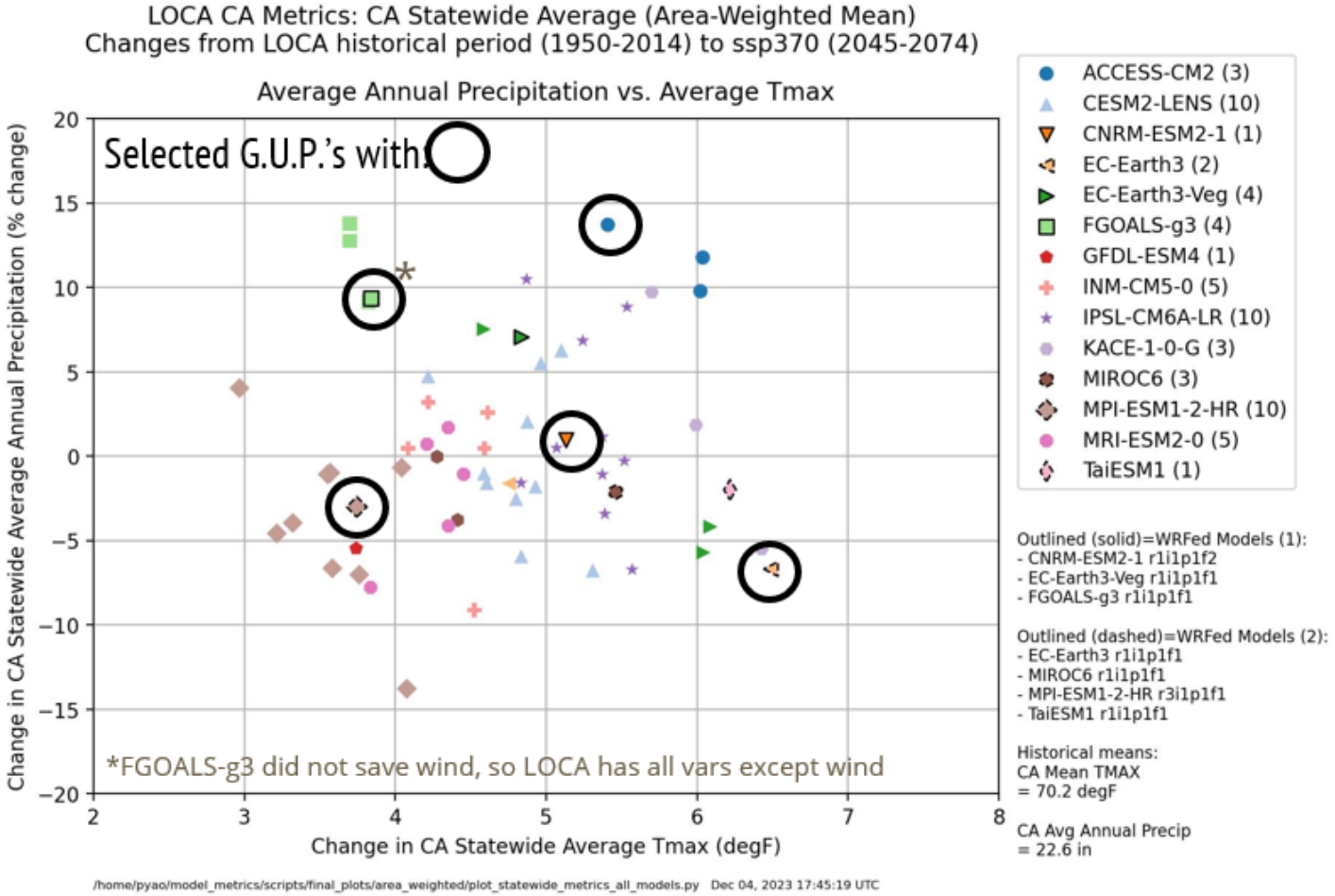
Considerations for Selection of General Use Projections

- Target SSP370 with a 2045-2074 mid-century period, which many users have identified as a high priority and is far enough in future to capture climate change signals.
- Favor including projections that have WRF data available
- Pare down metrics to a small number because too many uncorrelated metrics would reduce the ability of the metrics to usefully distinguish between models.
    - Metrics include temperature, precipitation and wind.
- Favor metrics that are simple variables; avoid those that are derivatives of several variables.
- Ensure the models selected capture the range of GCMs and ensemble members.
- Selection did not consider time series/sequences (special cases will cover, e.g., droughts)
- Exclude GCMs that have an unrealistically high climate sensitivity based on Tokarska et al., 2020 and Hausfather et al., 2022

Proposed General Use Projections



Proposed General U Projectior



Proposed
General L
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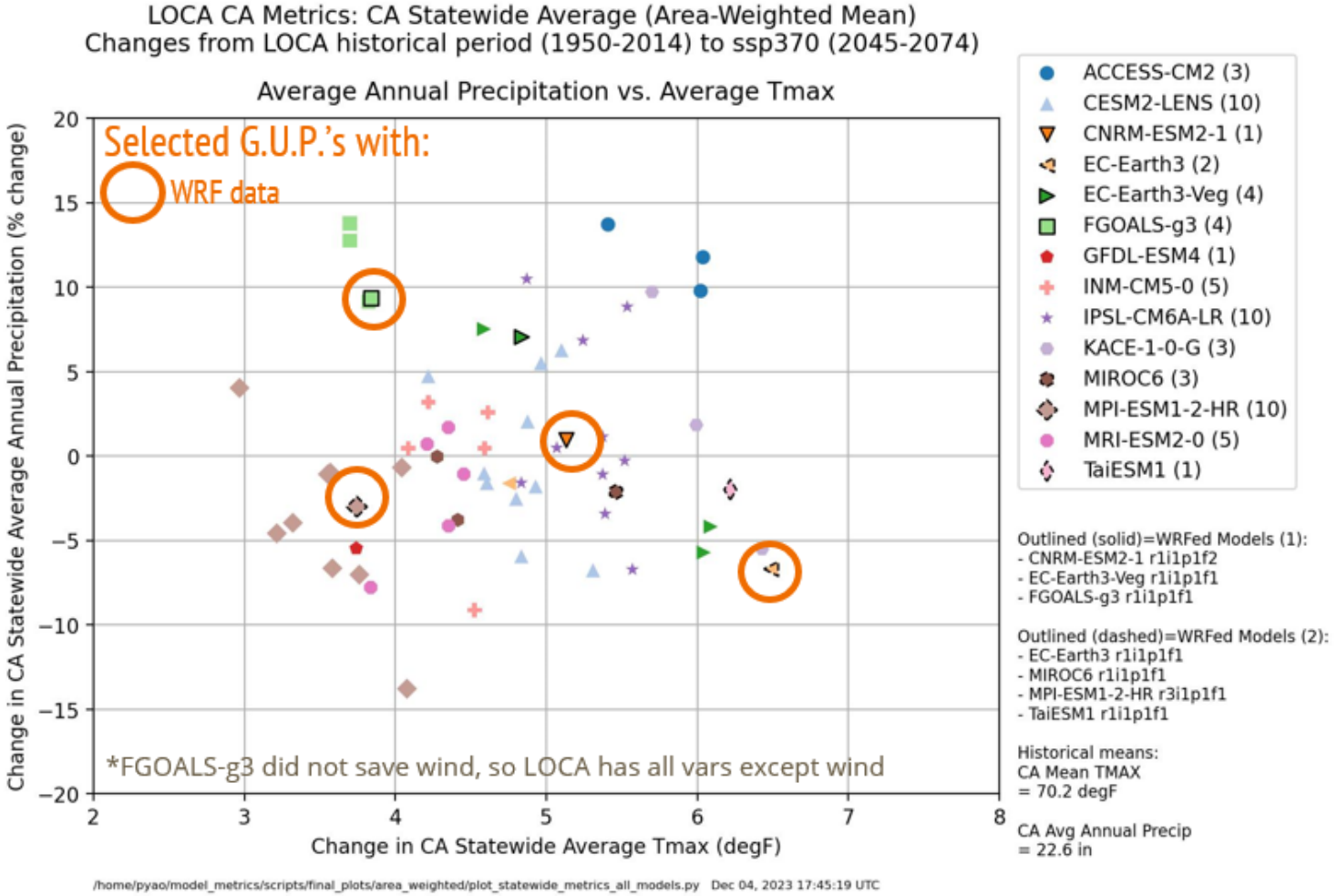

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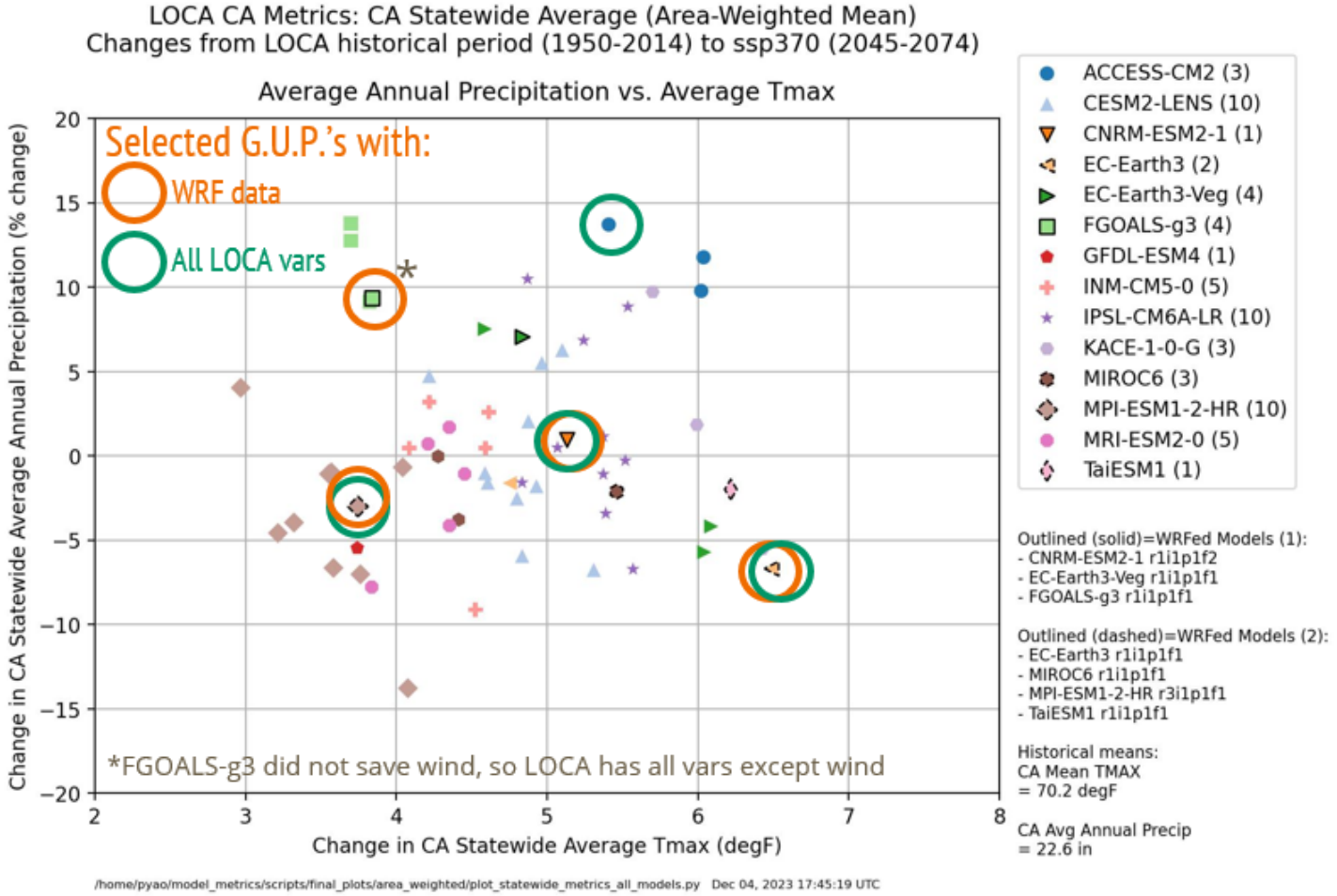
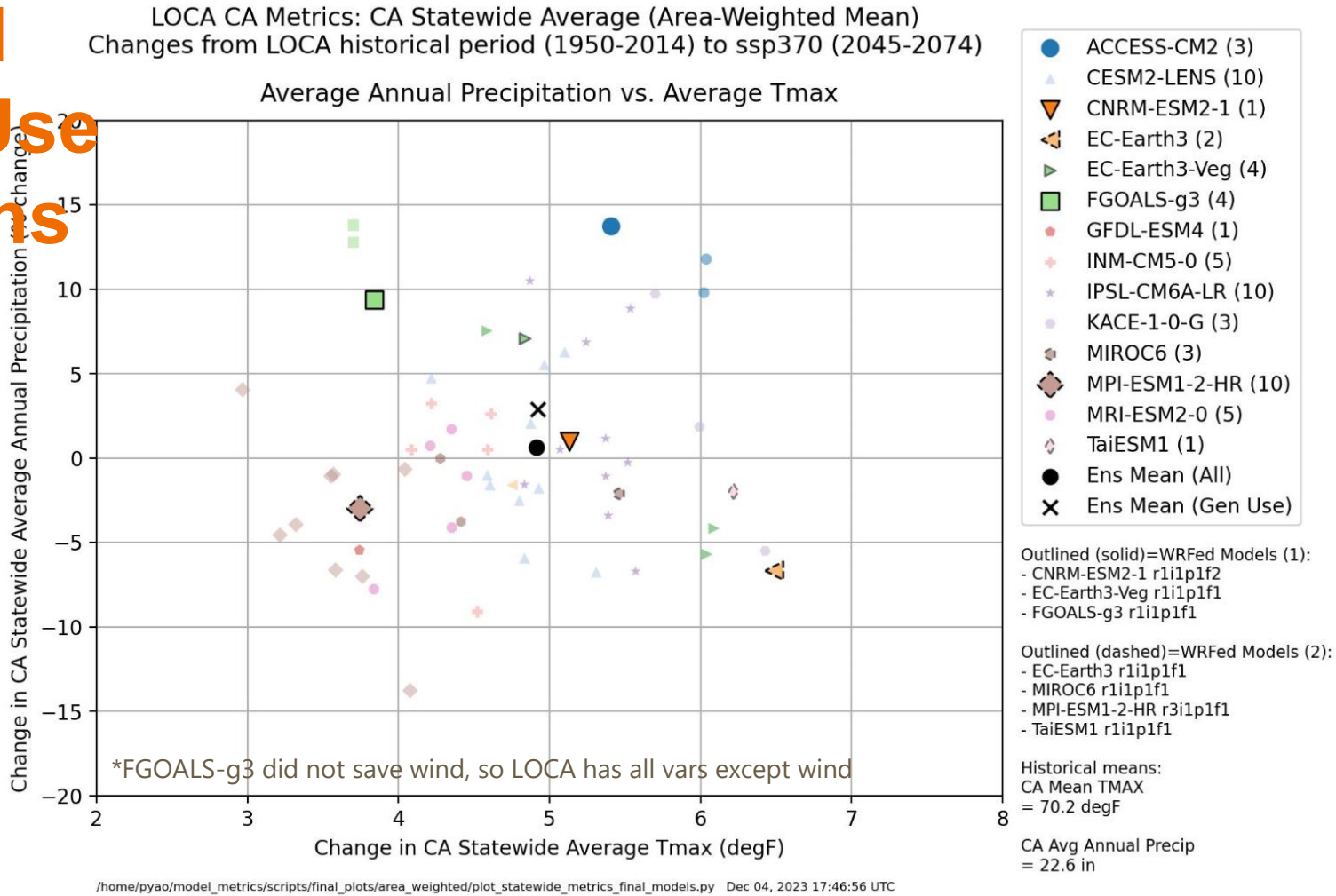
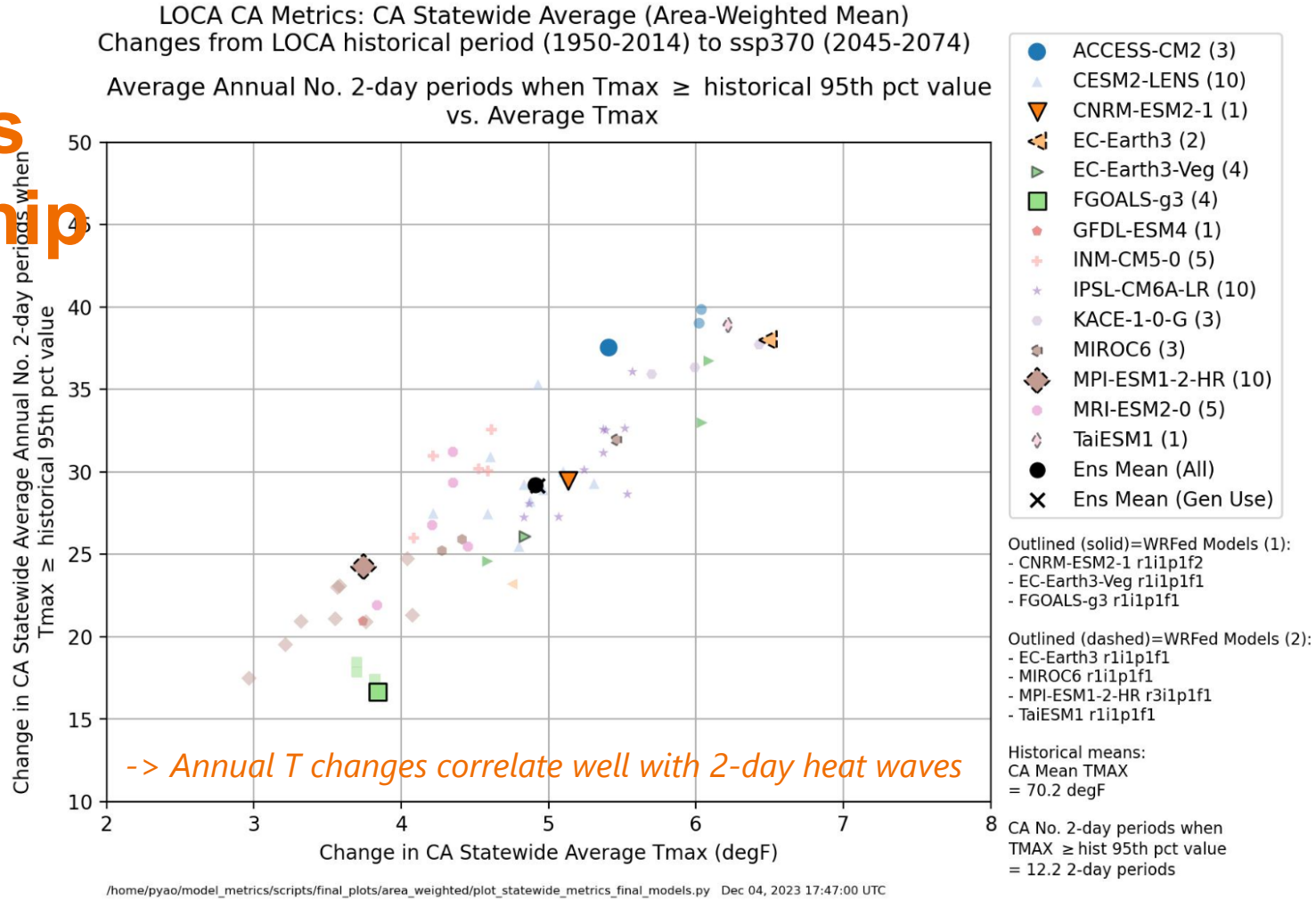


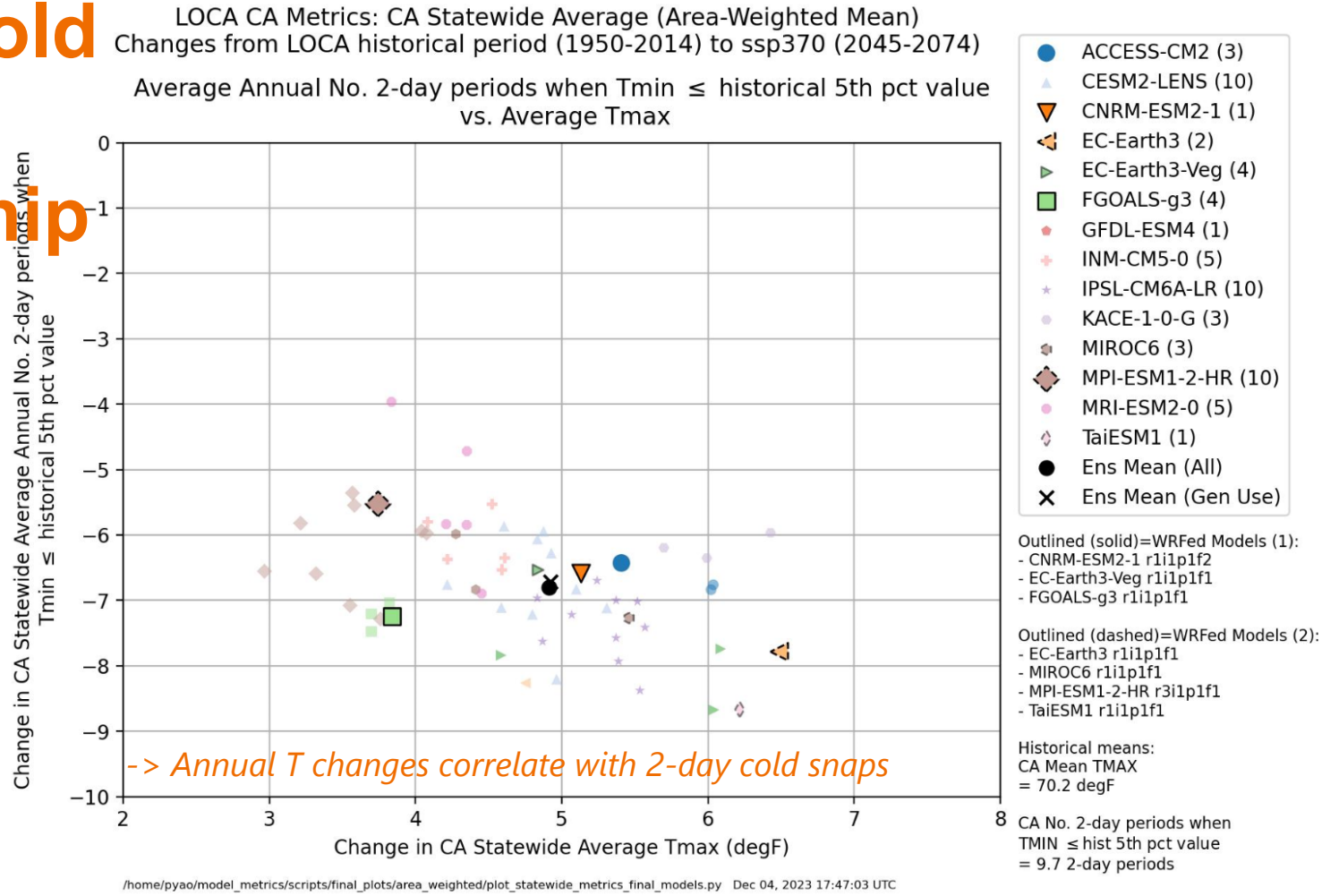
Proposed General Use Projections



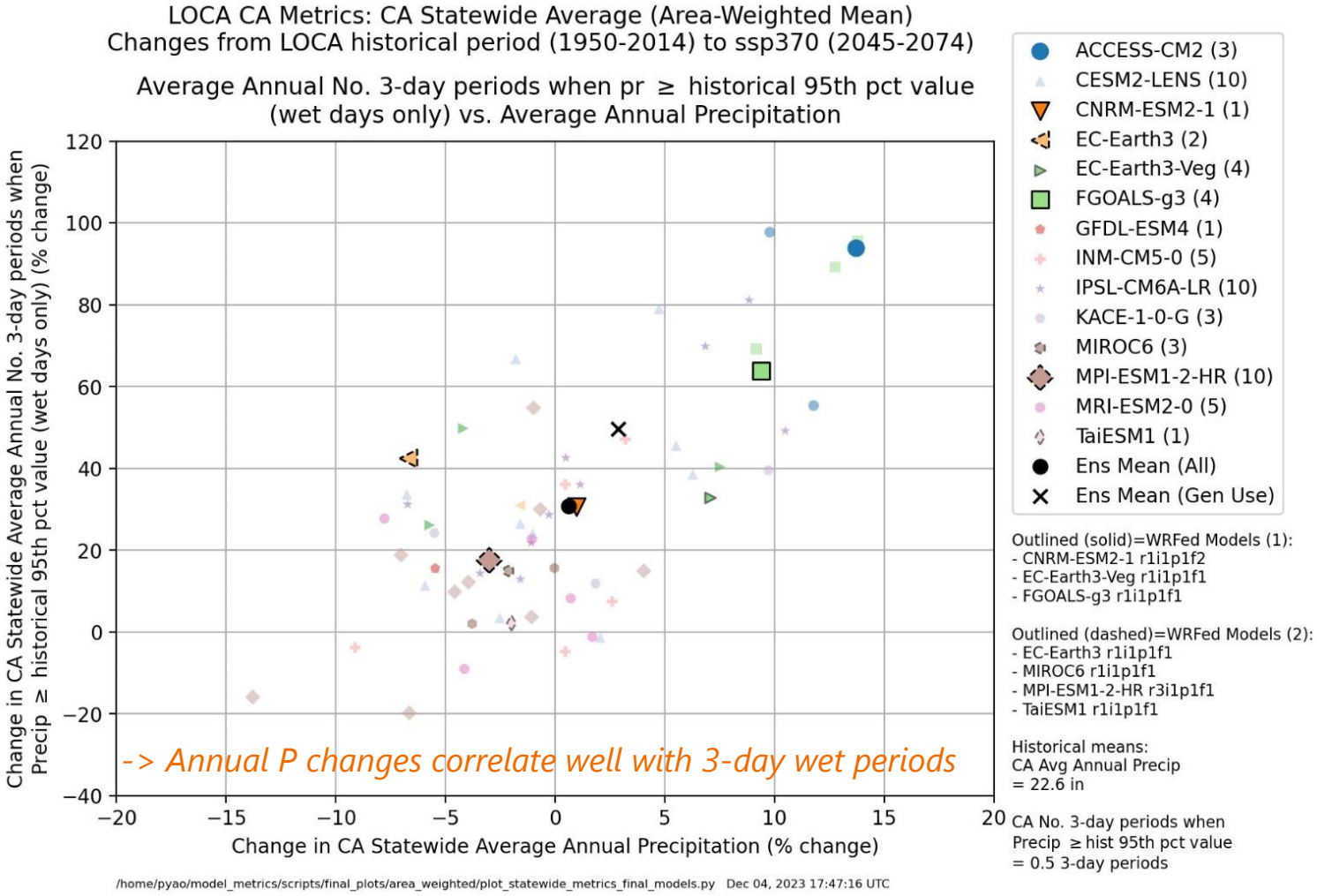
Tmax & Heatwaves Relationship



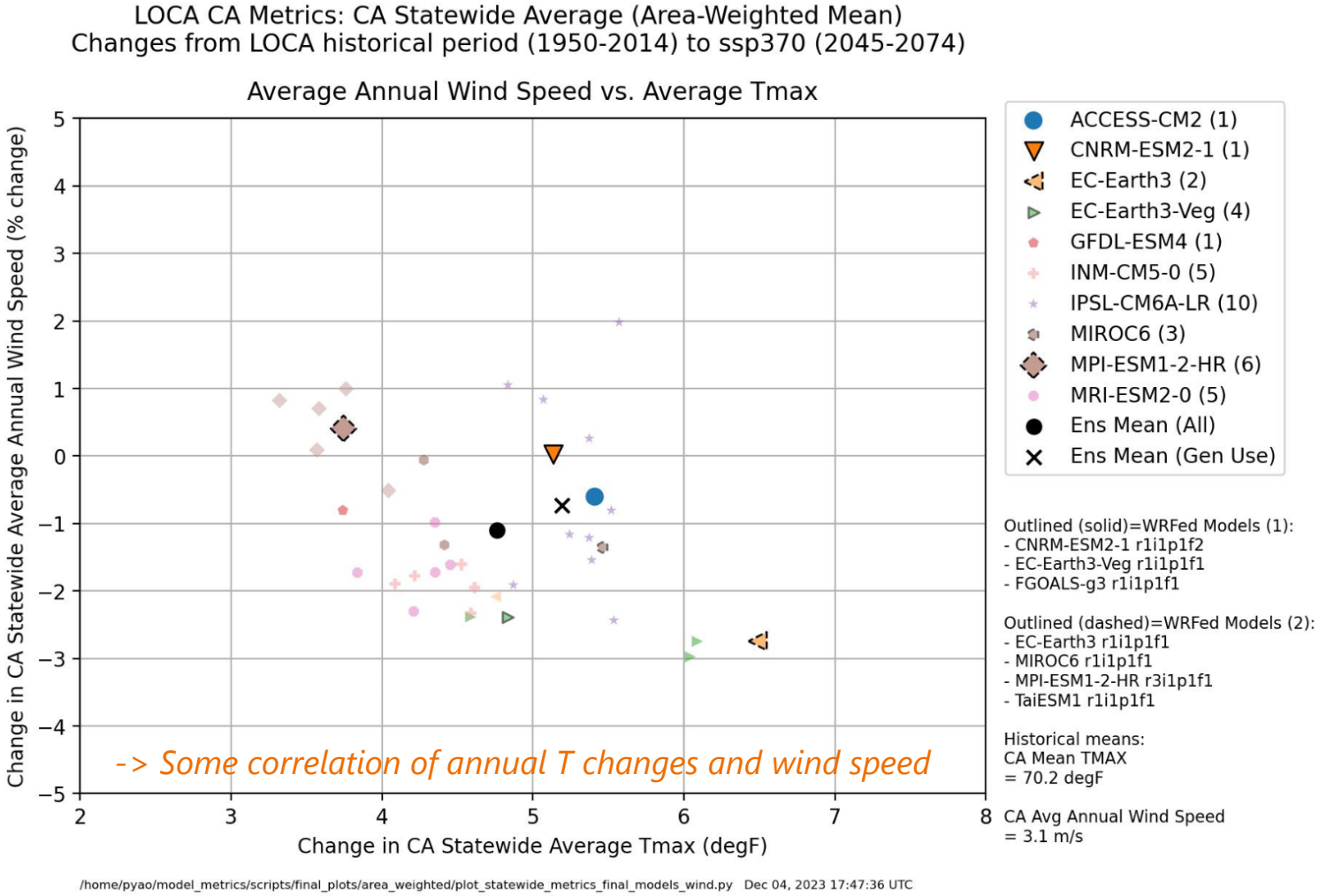
Tmax & Cold Snap Relationship



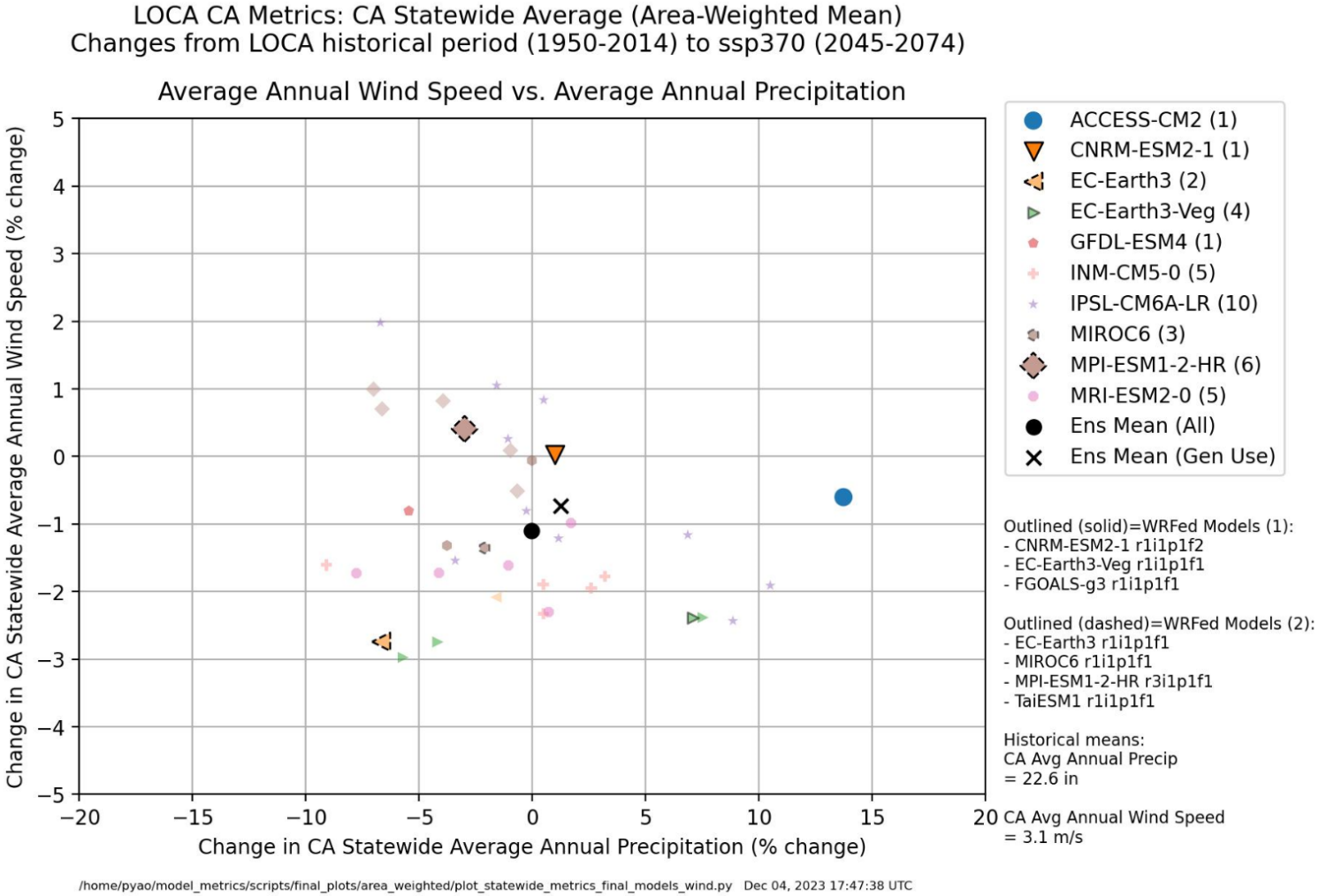
Precip & Wet Extremes (Flood)



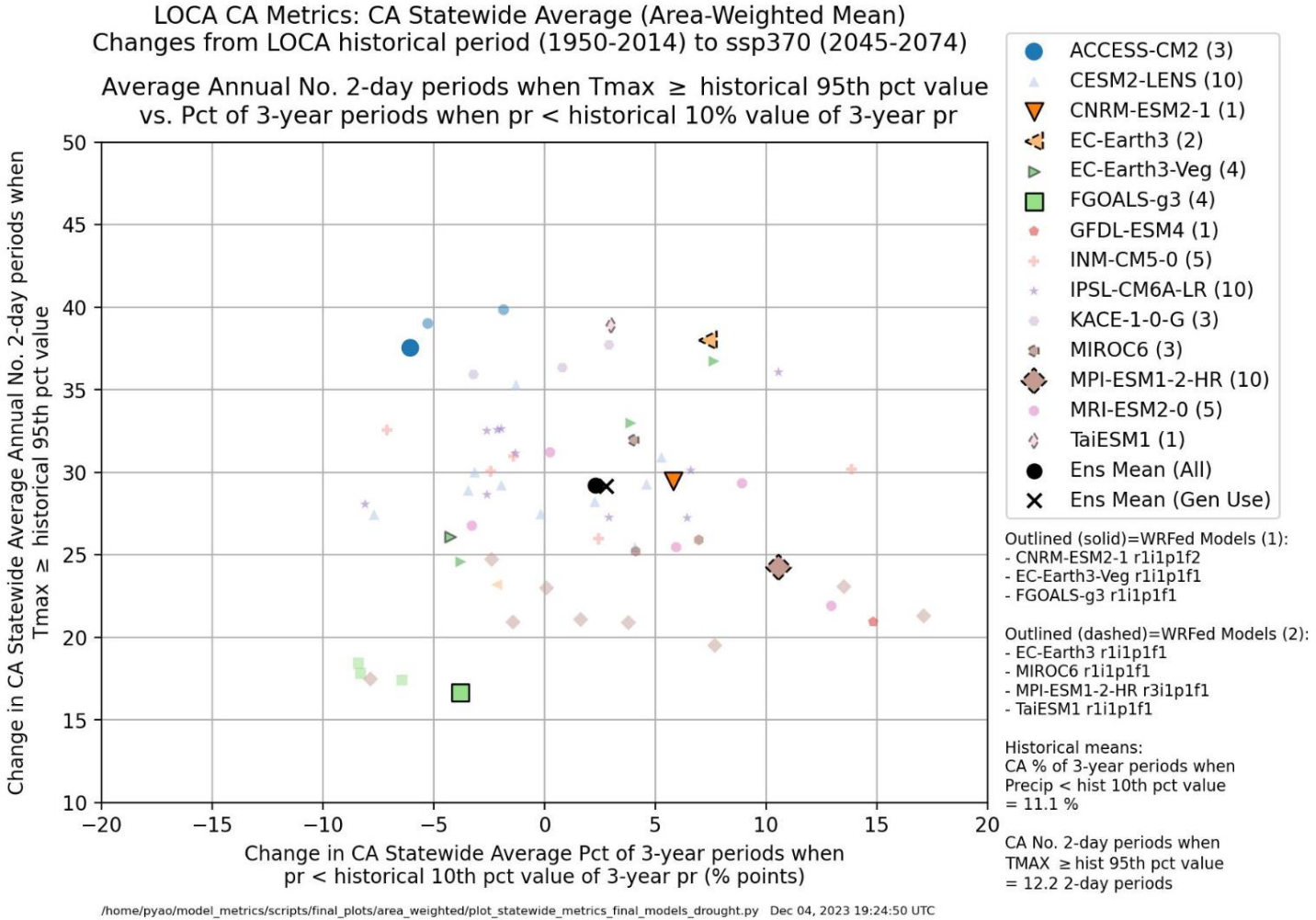
Temp & Wind Speed



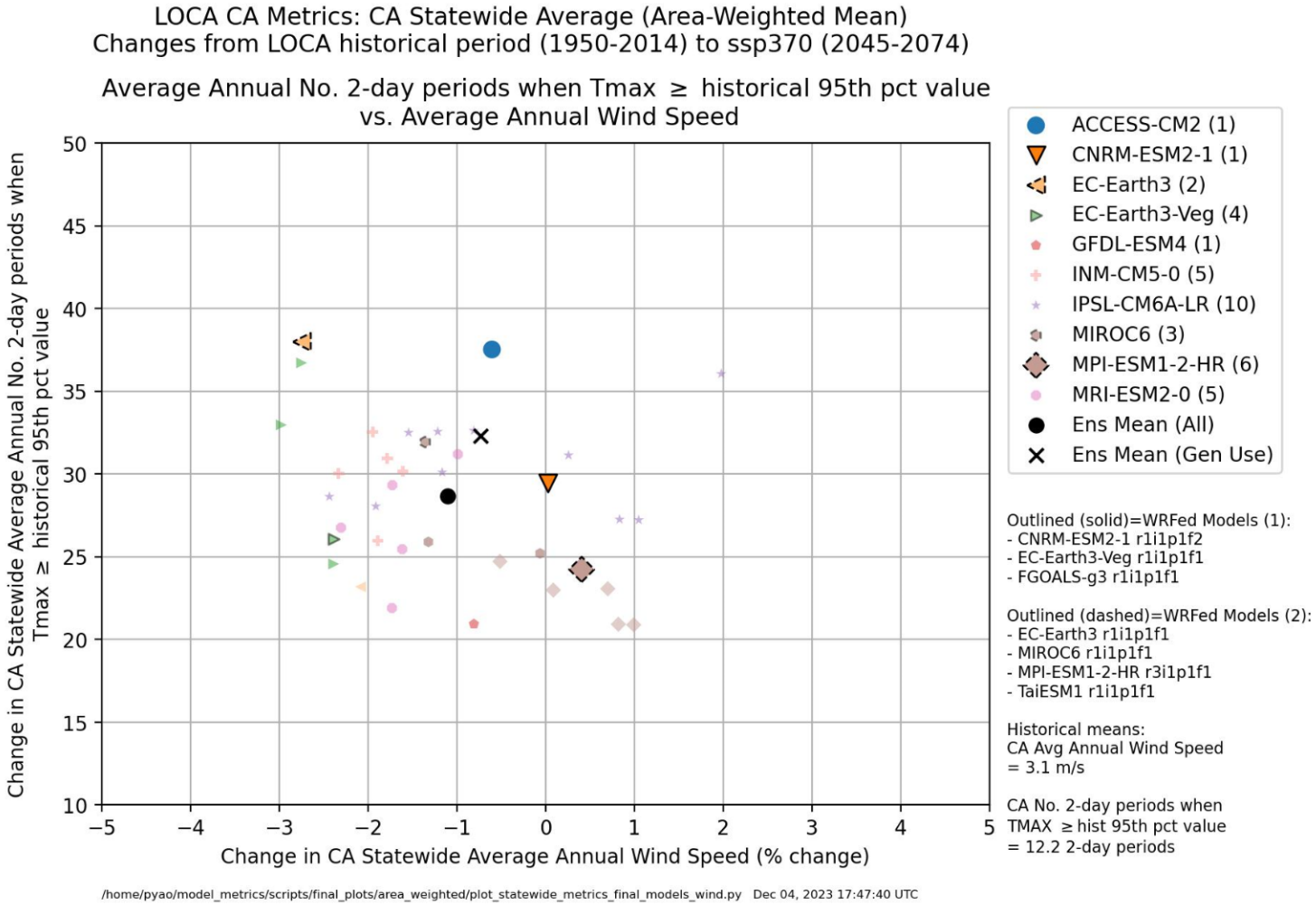
Precip & Wind


LOCA CA Metrics: CA Statewide Average (Area-Weighted Mean)
Changes from LOCA historical period (1950-2014) to ssp370 (2045-2074)
Average Annual Wind Speed vs. Average Annual Precipitation
Change in CA Statewide Average Annual Wind Speed (% change)
Change in CA Statewide Average Annual Precipitation (% change)
ACCESS-CM2 (1)
CNRM-ESM2-1 (1)
EC-Earth3 (2)
EC-Earth3-Veg (4)
GFDL-ESM4 (1)
INM-CM5-0 (5)
IPSL-CM6A-LR (10)
MIROC6 (3)
MPI-ESM1-2-HR (6)
MRI-ESM2-0 (5)
Ens Mean (All)
Ens Mean (Gen Use)
Outlined (solid)=WRFed Models (1):
- CNRM-ESM2-1 r1i1p1f2
- EC-Earth3-Veg r1i1p1f1
- FGOALS-g3 r1i1p1f1
Outlined (dashed)=WRFed Models (2):
- EC-Earth3 r1i1p1f1
- MIROC6 r1i1p1f1
- MPI-ESM1-2-HR r3i1p1f1
- TaiESM1 r1i1p1f1
Historical means:
CA Avg Annual Precip
= 22.6 in
CA Avg Annual Wind Speed
= 3.1 m/s
/home/pyao/model_metrics/scripts/final_plots/area_weighted/plot_statewide_metrics_final_models_wind.py Dec 04, 2023 17:47:38 UTC

Drought & Heatwaves



Wind Speed & Heatwaves



Limitations of General Use Projections

- General use projections are, by design, meant to be limited
- Models evaluated for a limited set of metrics, scales and scenarios
  - Mid-century, SSP370, all of CA, and largely for temperature and precipitation
- May not cover all user-relevant ranges
  - e.g. different time periods, SSP scenarios, locations, and/or variables
- Wherever possible, it is recommended to use a larger set of runs to analyse the range of plausible outcomes for specific applications
- For frequency of extreme events, especially the most extreme, a few GCM simulations may not capture the variability in extremes well
- Forthcoming Analytics Engine tools will help to more easily conduct preliminary analyses with larger datasets

Final Thoughts…

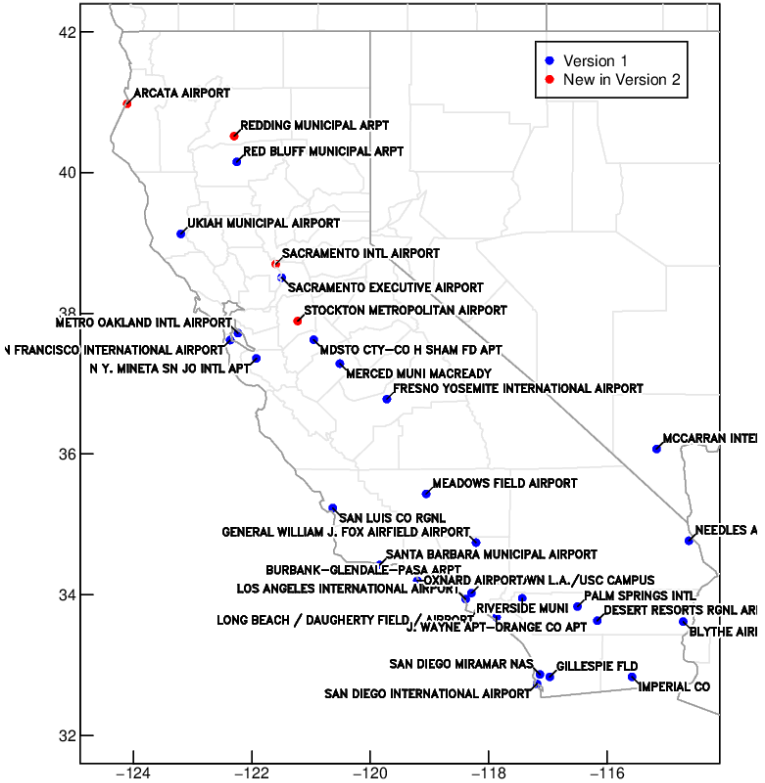
- The 5 selected G.U.P.'s capture the range of projected temperature and precipitation changes for SSP370, all of CA & mid-century; capture the wind except the quadrant of greatest decrease in wind
  - Access-CM2 r1i1p1f1
  - CNRM-ESM2-1 r1i1p1f2
  - EC-Earth3 r1i1p1f1
  - FGOALS-g3 r1i1p1f1
  - MPI-ESM1-2-HR r3ilp1f1
- Did not select on extremes, annual mean precipitation and temperature changes correlate with changes in extremes (heatwaves, cold snaps, floods, droughts)
- Changes in wind speed by GCM vary regionally (not shown)

LOCA2 Hourly Temperature Projections

for Individual CEC Requested Stations

Overview

- Projections of hourly surface temperatures from 1950-2100 at individual locations
  - Based on LOCA method* and existing LOCA2 gridded 3km downscaled CMIP6 daily Tmax and Tmin results
- 33 stations
  - 32 CA + Las Vegas station locations of importance requested by CEC demand forecast unit
- Includes all models from LOCA CA dataset
  - (15 GCMs with up to 10 ensemble members each, depending on SSP2-4.5, SSP3-7.0, or SSP5-8.5)
- Analog matching method
  - Better represents hourly variability compared to traditional climatological diurnal cycle approach



Map of the 33 stations, 4 new stations in this version labeled red

*Pierce and Cayan 2019 https://cirrus.ucsd.edu/~pierce/tmp/Hourly_data_interpolation_2019-05-23.pdf

LOCA2 Hourly Temperature Projections

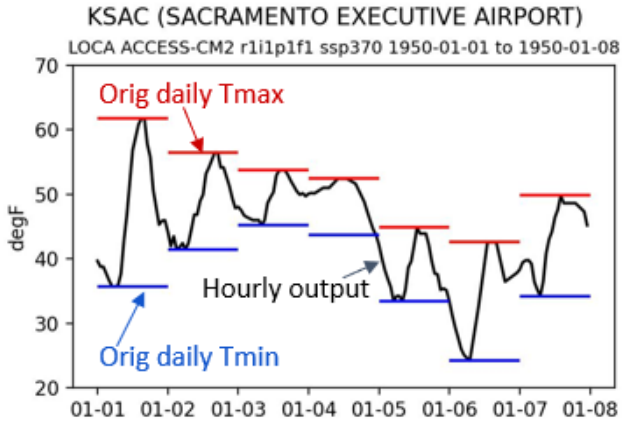
for Individual CEC Requested Stations (2)

What's new in Version 2

- Projections based on LOCA2 (CMIP6), featuring latest generation of available models, SSP scenarios, and ensemble members compared to Version 1 (CMIP5)
- 4 additional stations in northern California
- Longer period of record for most stations from HadISD, the historical hourly temperature training data provided by Eagle Rock Analytics
- Method improved to better represent difference between wet vs. dry days
- Method improved to ensure that hourly values more closely match the input LOCA Tmax and Tmin

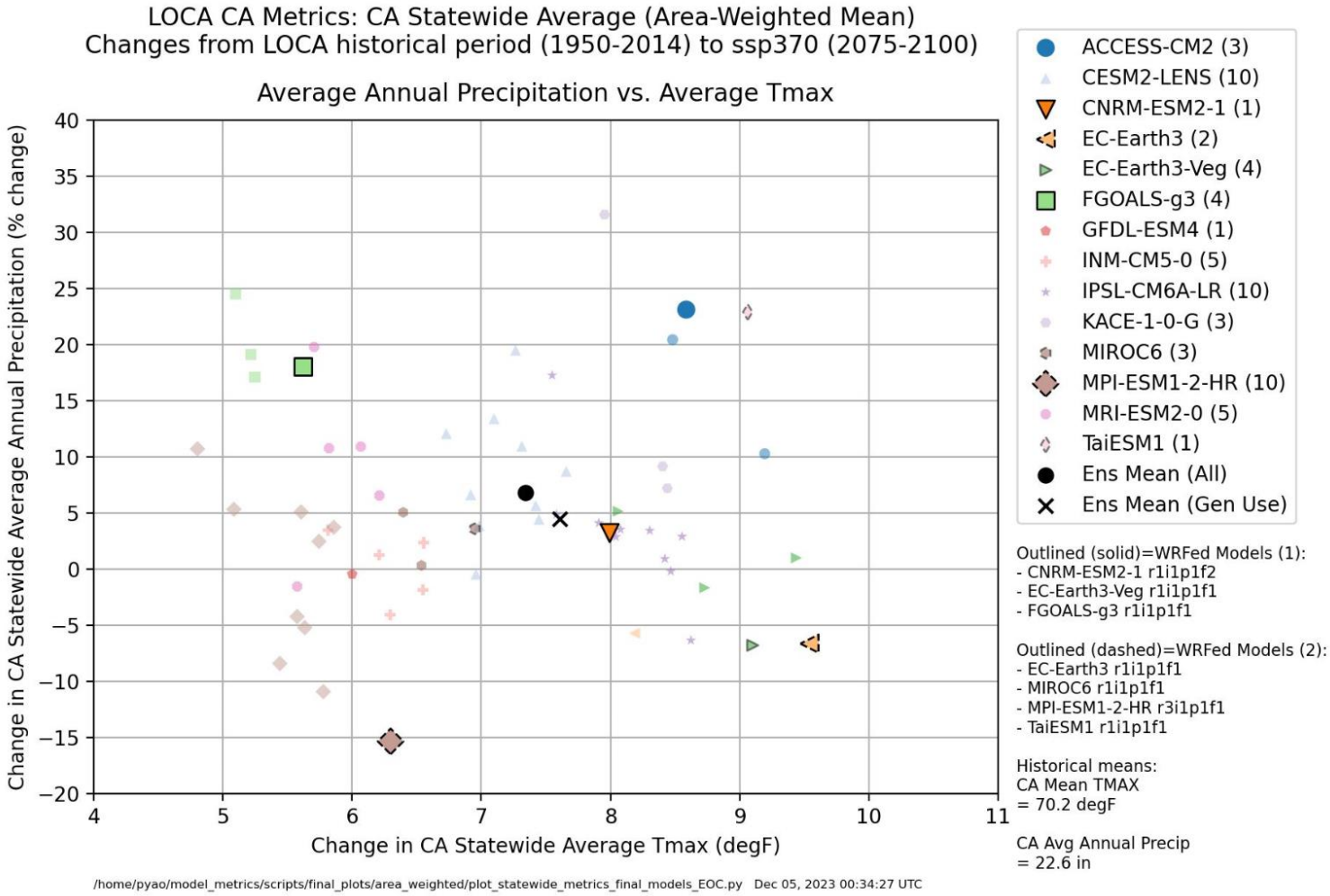
Projections are complete

- 129 total simulations for each of the 33 stations = 4,257 total
- Next steps are to finalize documentation and share data with the Analytics Engine team



Example timeseries plot at KSAC. Red/blue lines are the input daily LOCA Tmax and Tmin values, respectively. Black line is the hourly LOCA projection.

Appendix: Proposed General Use Projection (End of Century)



Sea Level Projections from CMIP6 climate and weather

EPC-20-006 Climate Scenarios Project *funded by CEC*

Sam Iacobellis, Julie Kalansky, David Pierce, Dan Cayan - Scripps Institution of Oceanography, UCSD

December, 2023

- Hourly sea level projections over the 21st century at sites along the California coastline and within the San Francisco Bay/Delta.
- Projections underpinned by sea level rise scenarios adopted by the California Sea Level Rise Guidance Update (Ocean Protection Council, *forthcoming*).
- The hourly projections augment the SLR Guidance *(forthcoming)* results with fine scale (hourly) detail. These projections could be used to explore plausible event-scale occurrences within the longer term trajectory of possible sea level futures.
- The hourly time sequences were developed from global earth system models used in the downscaled weather and climate projections and associated hydrologic modeled land surface hydrology over California.

Sea Level Projections at 13 California locations

Locations with >3 decades of hourly observations

Components of sea level height and Uncertainties

Hourly sea level height is estimated (Cayan et al 2008) as a combination of:

- long-term sea level rise

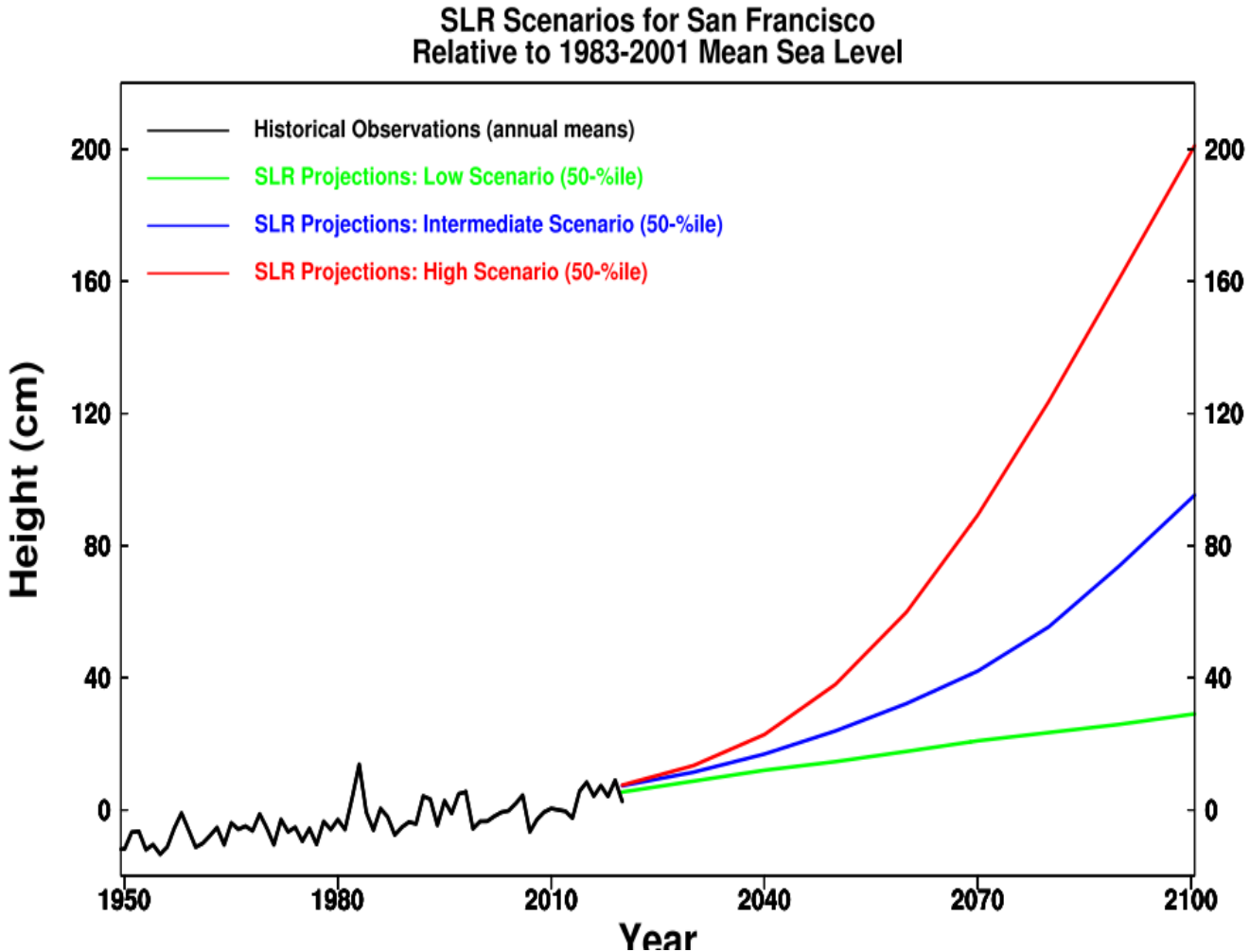
  uncertainties small in short term but grow large over 21st Century because of uncertain future warming and especially uncertain ice melt from Greenland and Antarctica. *Global SLR is greatest uncertainty in long term planning beyond mid-century.*

- meteorological and short period climate variability (HMET)

  natural variation of weather and short period (months to a few decades) climate persists and possibly grows slightly through 21st Century. Details of weather (e.g. winter storms) and climate events (e.g. El Nino) is impossible to know beyond near term—models provide a statistical envelope of possible outcomes but no precision on timing. Modeling attempts to capture extremes but linear approach is imperfect. *Unpredictable weather and short period climate are most serious sources of uncertainty within next few decades.*

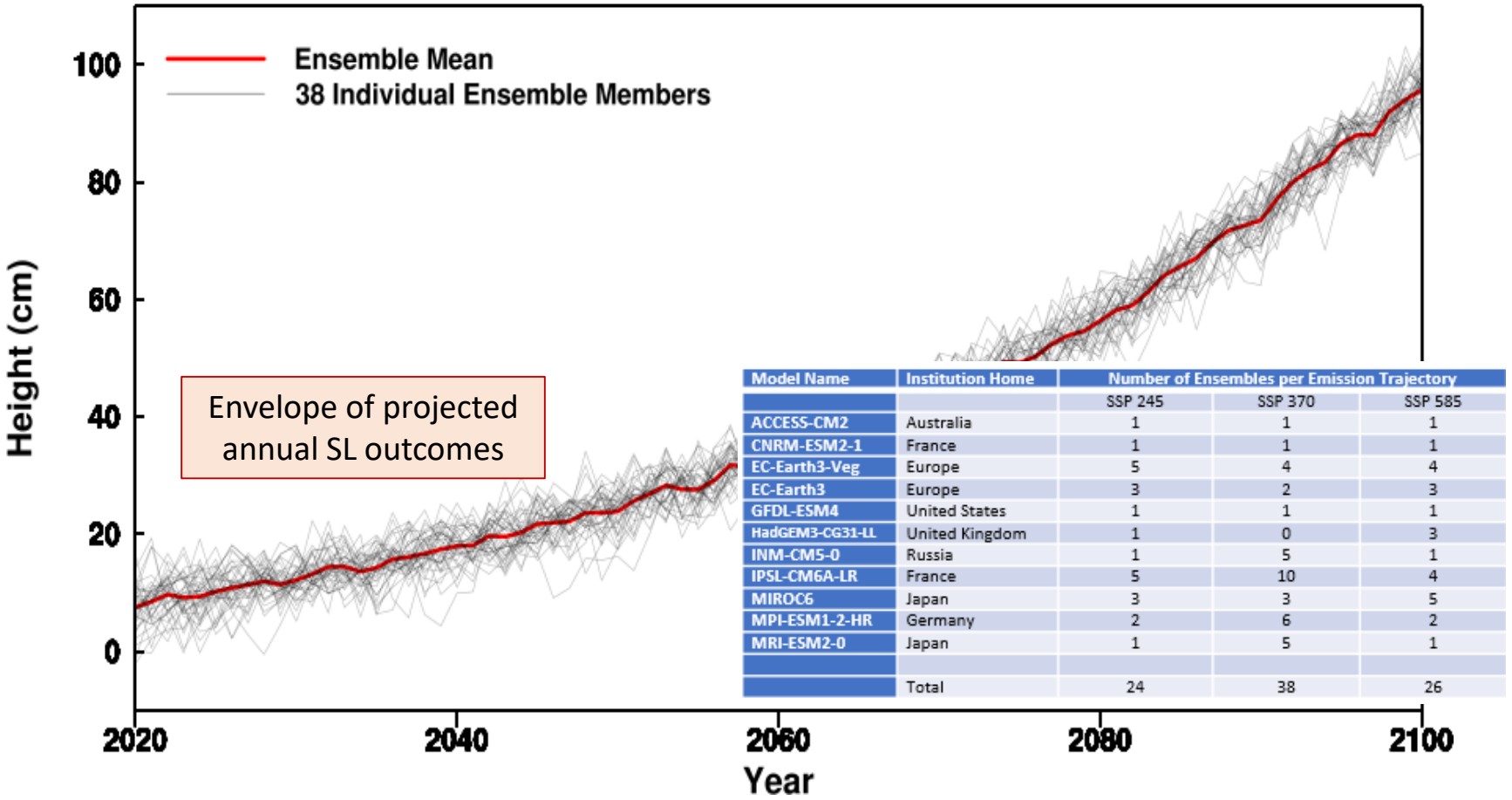
- astronomical tides

  high degree of certainty of major tidal constituents. Predictability informs cautionary measures during high tide windows (e.g. winter king tide events).



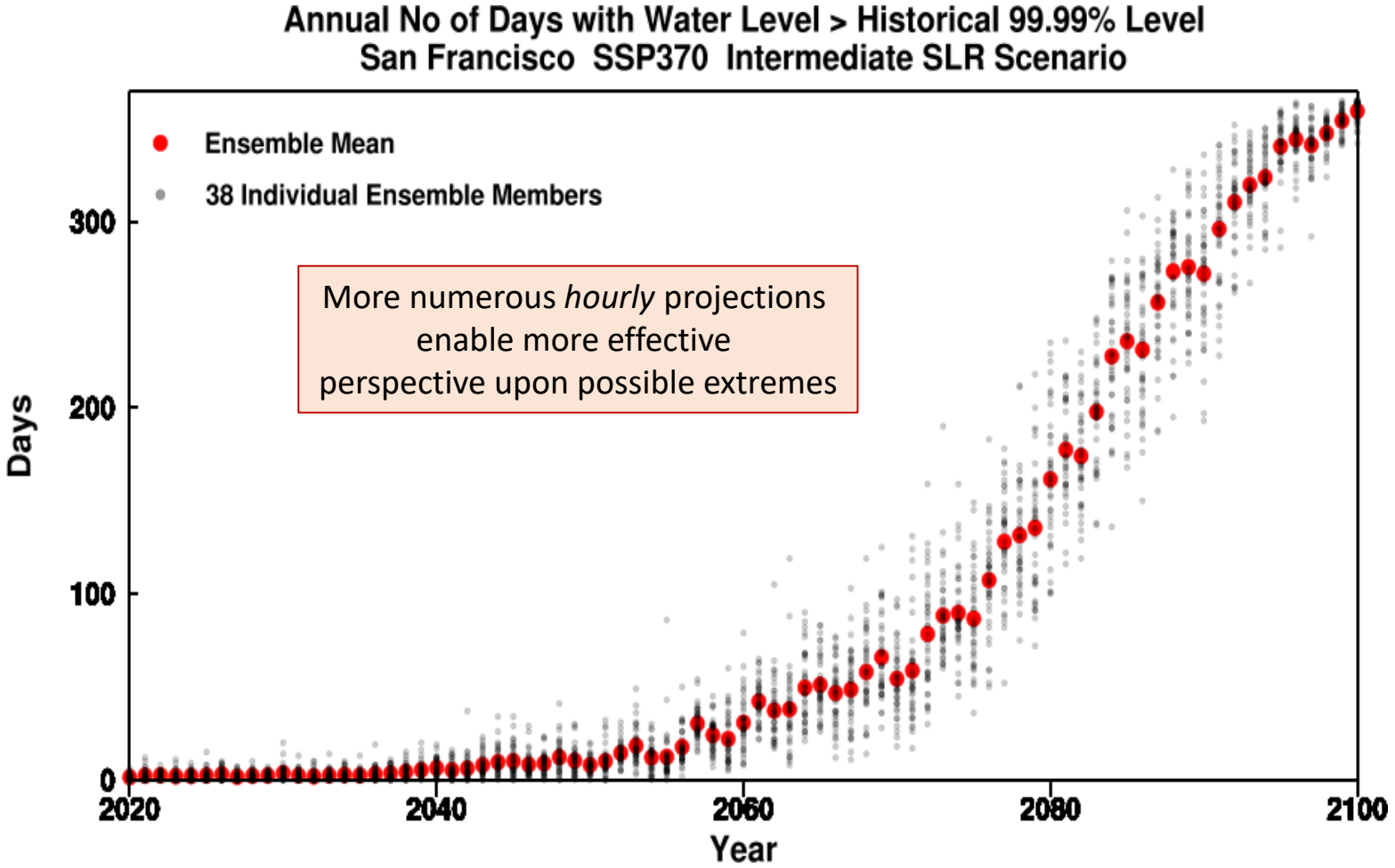
EPC-20-006 hourly projections follow a low, medium and high sea level rise scenarios adopted by the California Sea Level Rise Guidance Update, *forthcoming.*

Annual Water Level Height Relative to 1983-2001 MSL
San Francisco SSP370 Intermediate SLR Scenario



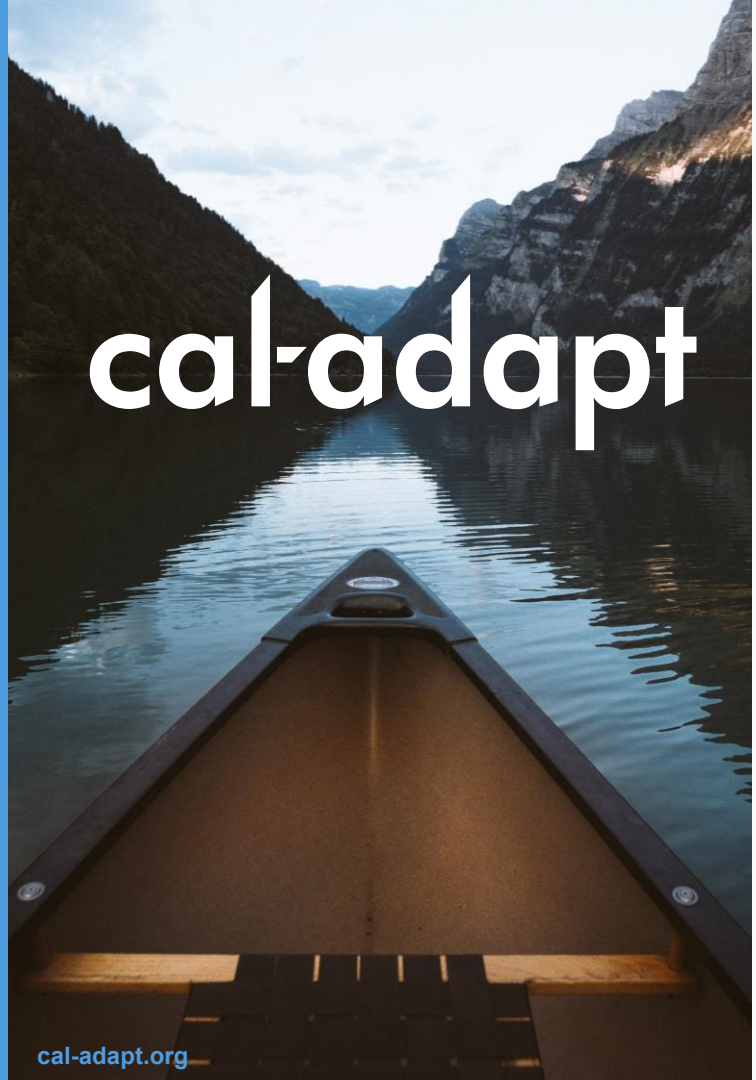
Envelope of projected annual SL outcomes

Model Name	Institution Home	Number of Ensembles per Emission Trajectory		
		SSP 245	SSP 370	SSP 585
ACCESS-CM2	Australia	1	1	1
CNRM-ESM2-1	France	1	1	1
EC-Earth3-Veg	Europe	5	4	4
EC-Earth3	Europe	3	2	3
GFDL-ESM4	United States	1	1	1
HadGEM3-CG31-LL	United Kingdom	1	0	3
INM-CM5-0	Russia	1	5	1
IPSL-CM6A-LR	France	5	10	4
MIROC6	Japan	3	3	5
MPI-ESM1-2-HR	Germany	2	6	2
MRI-ESM2-0	Japan	1	5	1
	Total	24	38	26


Annual No of Days with Water Level > Historical 99.99% Level
San Francisco SSP370 Intermediate SLR Scenario
Ensemble Mean
38 Individual Ensemble Members
More numerous *hourly* projections enable more effective perspective upon possible extremes
Days
0
100
200
300
2020
2040
2060
2080
2100
Year

Cal-Adapt

Providing initial and improved access to new CMIP6 data



Climate-Informed Energy Sector Adaptation Planning to Support a Climate Resilient Transition to Zero-Carbon via Cal-Adapt

Primary Funding Provided by

California Energy Commission – EPIC Program (EPC-21-038)

Managed by: Mithra Moezzi, Ph.D. (CEC)

EAGLE ROCK ANALYTICS

Owen Doherty, PhD
Principal Investigator
Eagle Rock Analytics

Mark Koenig
Project Manager
Eagle Rock Analytics

Partners

GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

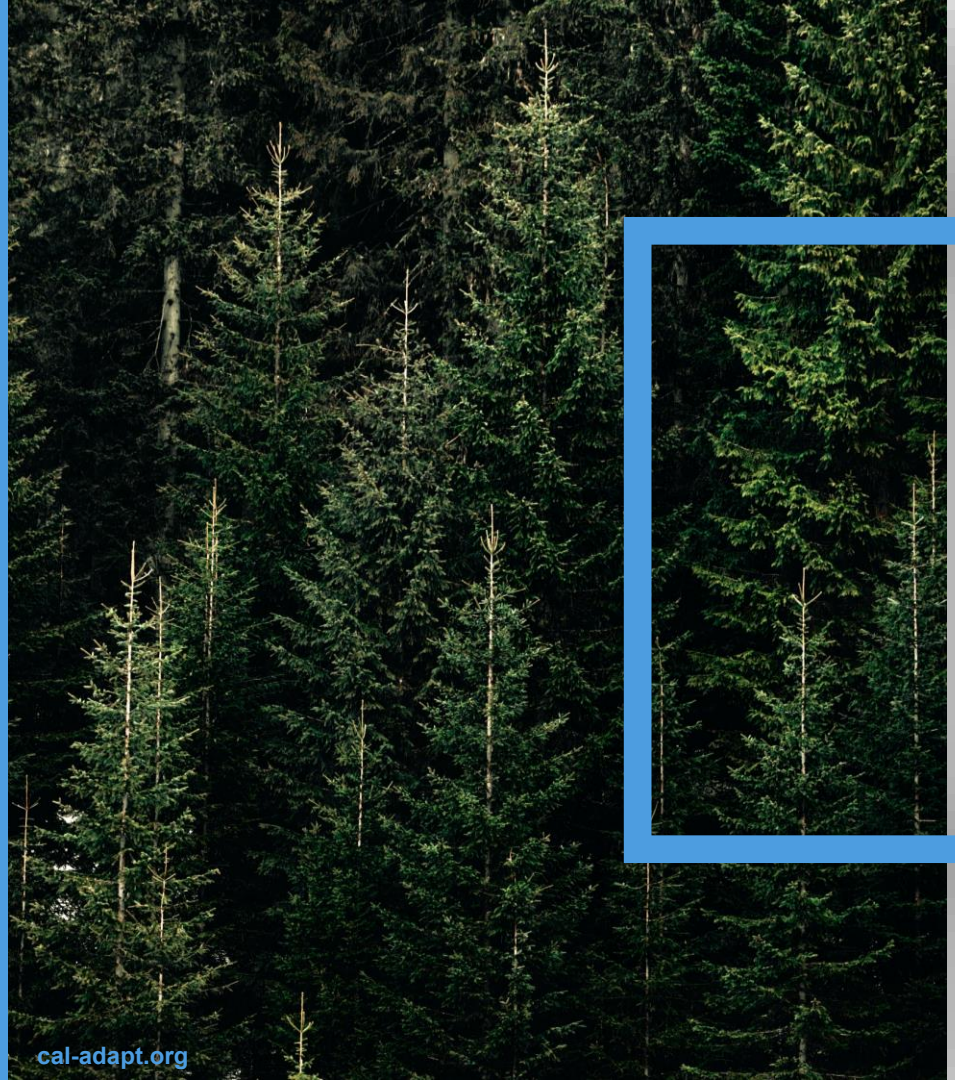
Berkeley
UNIVERSITY OF CALIFORNIA

Cal-Adapt Vision

Supporting the next generation of Cal-Adapt to bring massive amounts of new data, tools, and visualizations to energy sector users and beyond

Co-Production

- Working together
- Listening
- Acting upon information
- Iterative development
- Utilizing scientific best practices



History & Next Version

GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

1.0

2011 – Initial research with CMIP3 climate data

GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

2.0

2017 – CMIP5 data alongside interactive maps and tools

EAGLE ROCK ANALYTICS

3.0

2024 – CMIP6 data, tools, and an enterprise approach

Partners

GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

BERKELEY LAB
Bringing Science Solutions to the World

Major Phases

Cal-Adapt was developed to for climate change research produced in California.

- California Climate Adaptation Strategy

Continues to be improved with cutting edge data and responding to end user needs.

Overarching Enterprise

cal-adapt

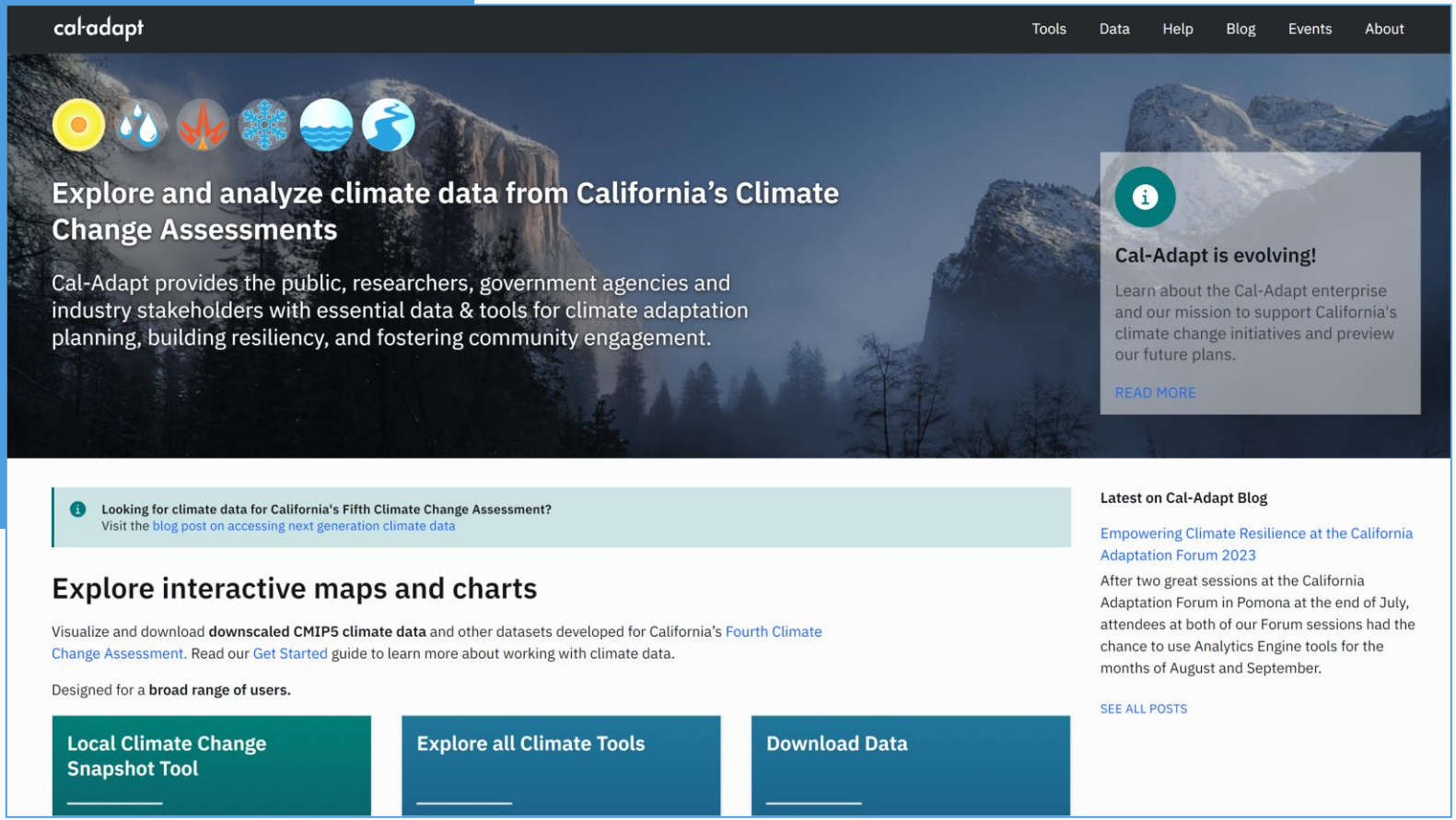
A central location for visibility into a variety of state-sponsored climate research

- Cal-Adapt.org
- Analytics Engine
- Research Grants
  - Projections Teams
  - Pyregence
  - Future work

Overarching Enterprise[2]

cal-adapt

- Cal-Adapt.org
  - Web access to data, visualizations, tools, education, and more.
- Analytics Engine
  - Provides cloud-compute analytics, data access, and robust technical support
- Research Grants
  - Central location to access information regarding other research grants


cal-adapt
Tools
Data
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Blog
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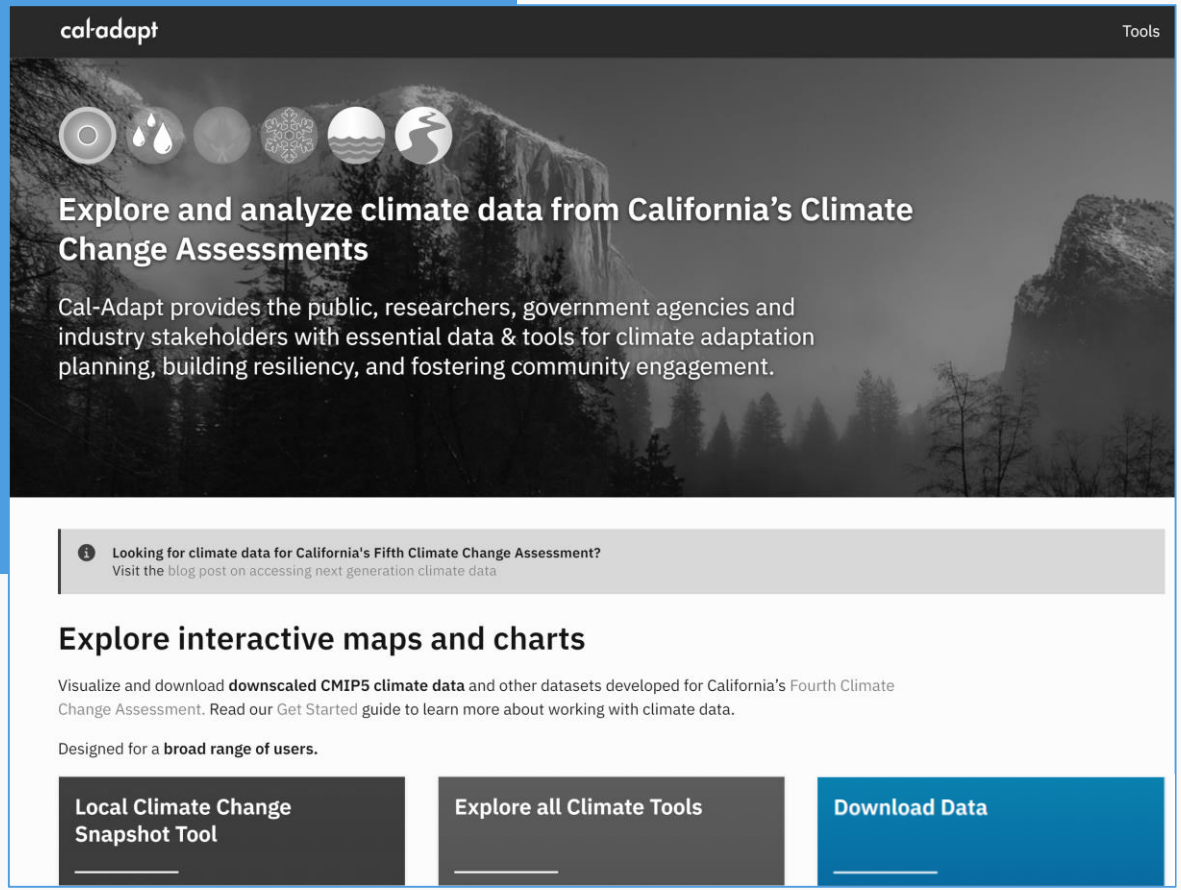
About
Explore and analyze climate data from California's Climate Change Assessments
Cal-Adapt provides the public, researchers, government agencies and industry stakeholders with essential data & tools for climate adaptation planning, building resiliency, and fostering community engagement.
Cal-Adapt is evolving!
Learn about the Cal-Adapt enterprise and our mission to support California's climate change initiatives and preview our future plans.
READ MORE
Looking for climate data for California's Fifth Climate Change Assessment?
Visit the blog post on accessing next generation climate data
Explore interactive maps and charts
Visualize and download downscaled CMIP5 climate data and other datasets developed for California's Fourth Climate Change Assessment. Read our Get Started guide to learn more about working with climate data.
Designed for a broad range of users.
Local Climate Change Snapshot Tool
Explore all Climate Tools
Download Data
Latest on Cal-Adapt Blog
Empowering Climate Resilience at the California Adaptation Forum 2023
After two great sessions at the California Adaptation Forum in Pomona at the end of July, attendees at both of our Forum sessions had the chance to use Analytics Engine tools for the months of August and September.
SEE ALL POSTS



Cal-Adapt 2.0 Features

(Current version)

Data Download

- Coupled Model Intercomparison Project (CMIP5 data) from 2009
- Used for the Fourth Climate Change Assessment
- Spatially resolved to a 6-km grid
- Temporally resolved to a daily measure
- ~30 Terabytes of data

Cal-Adapt 3.0

Features

(In development)

Data Download

- Coupled Model Intercomparison Project (CMIP6 data)
- Spatially resolved to a 3k-km grid
- Temporally resolved to a daily measure
- 2.5 petabytes of data

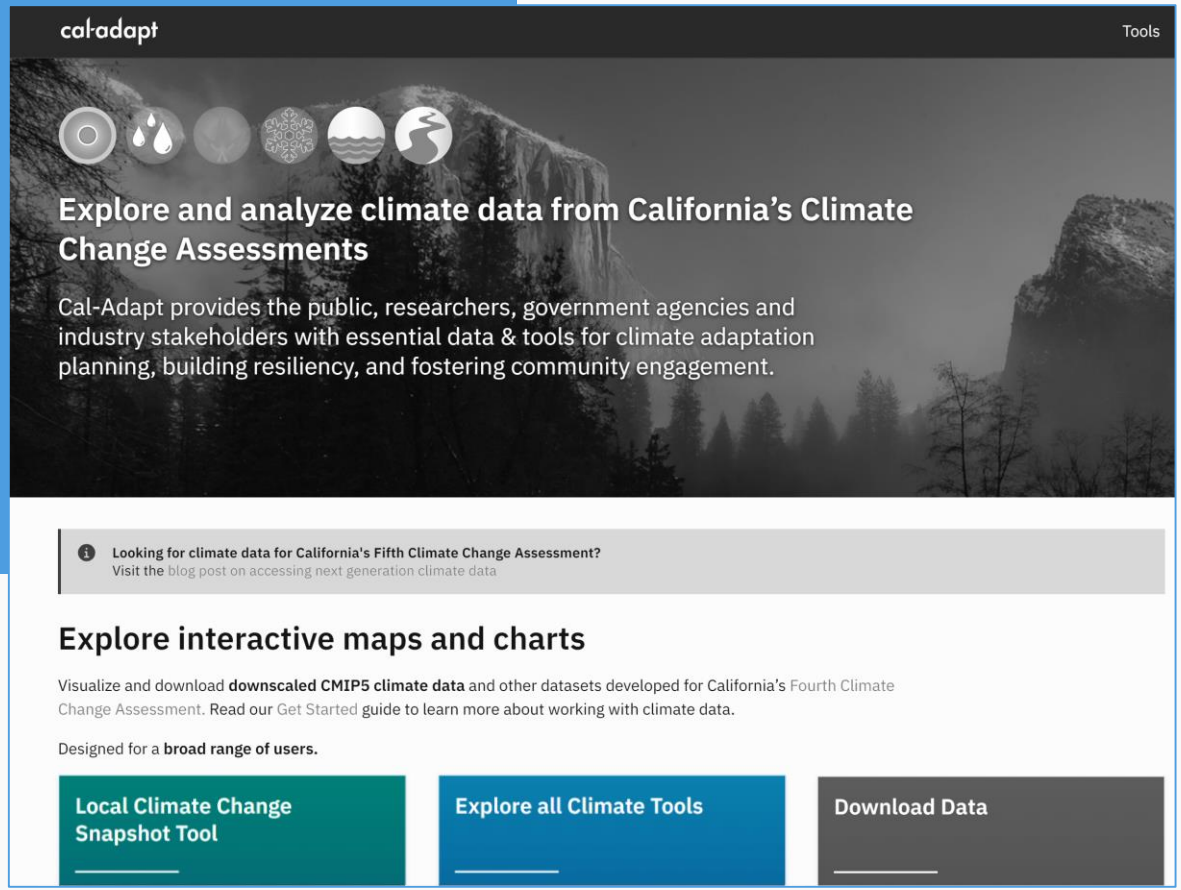
Cal-Adapt 3.0

Features

(In development)

Data Download

- Initial basic functions available Q1 2024
- Incremental improvements from there
- Feedback welcome

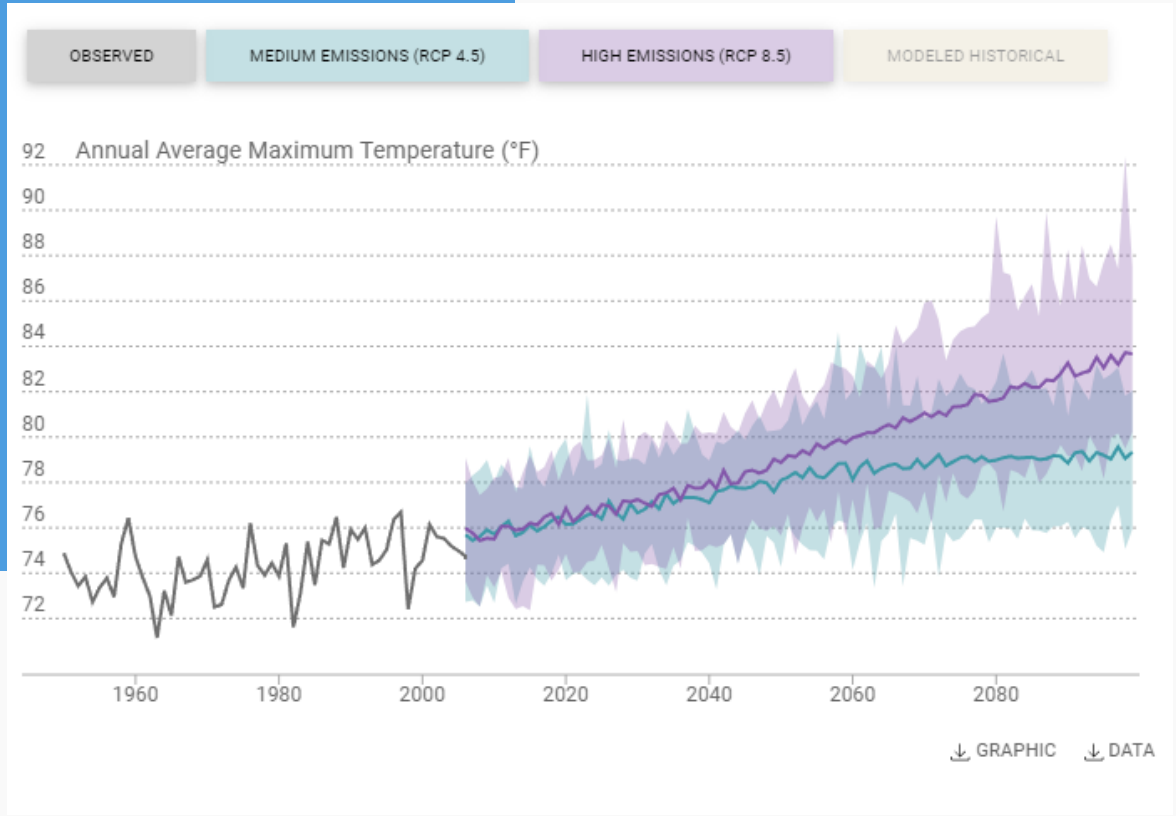


Cal-Adapt 2.0 Features

(Current version)

Climate Tools and Visualizations

- 14 tools ranging from temperature extremes, to wildfire, to sea level rise and more
- Built on CMIP5 data
- Useful for a variety of uses including local planners, policy makers, curious citizens, and more



Cal-Adapt 2.0 Features

(Current version)

Local Climate Change Snapshot

- Showcase possible futures
- Demonstrate past observations
- Export graphic and/or underlying data

Cal-Adapt 3.0 Features

(Development beginning Spring 2024)

Climate Tools and Visualizations

- Climate and wildfire projections
- Distribution of zero-carbon electricity generation
- Potentially more…

Upcoming Events

Winter/Spring 2024

- Workshop
  - Engagement with stakeholders to showcase existing functionality
- Summit
  - Relaunch the Cal-Adapt enterprise with a large audience
- One on One sessions (limited)
  - Deep dive into specific topics

Cal-Adapt Vision

Supporting the next generation of Cal-Adapt to bring massive amounts of new data, tools, and visualizations to energy sector users and beyond

Questions

Appendix

Graphics

- Photo by Tolu Olubode on Unsplash
- Photo by Thanos Pal on Unsplash
- Photo by Shane Rounce on Unsplash
- Photo by Jo Szczepanska on Unsplash
- Photo by AR on Unsplash
- Photo by AbsolutVision on Unsplash
- Photo by Daniil Silantev on Unsplash

References

- cal-adapt.org
- CMIP6
- Fourth Climate Change Assessment
- LOCA (Localized Constructed Analogs)

Thank you!

Goal

C-DAWG's goal is to promote sustained technical exchange and collaboration between climate science researchers, energy system researchers and technical experts, technology innovators, and state agency staff to facilitate high-impact research and knowledge transfer that directly supports energy sector resilience as California transitions to a 100% clean energy system.

https://www.energy.ca.gov/programs-and-topics/topics/research-and-development/climate-data-and-analysis-working-group-c-dawg

CONTACT

Climate Data and Analysis working Group

916-776-0824

cdawg@energy.ca.gov

SUBSCRIBE

Climate Data and Analysis Working Group (C-DAWG)

Email *

Email