

Future Hydroclimates from Physical and Statistical Models

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CWEMF Annual Meeting | April 2026



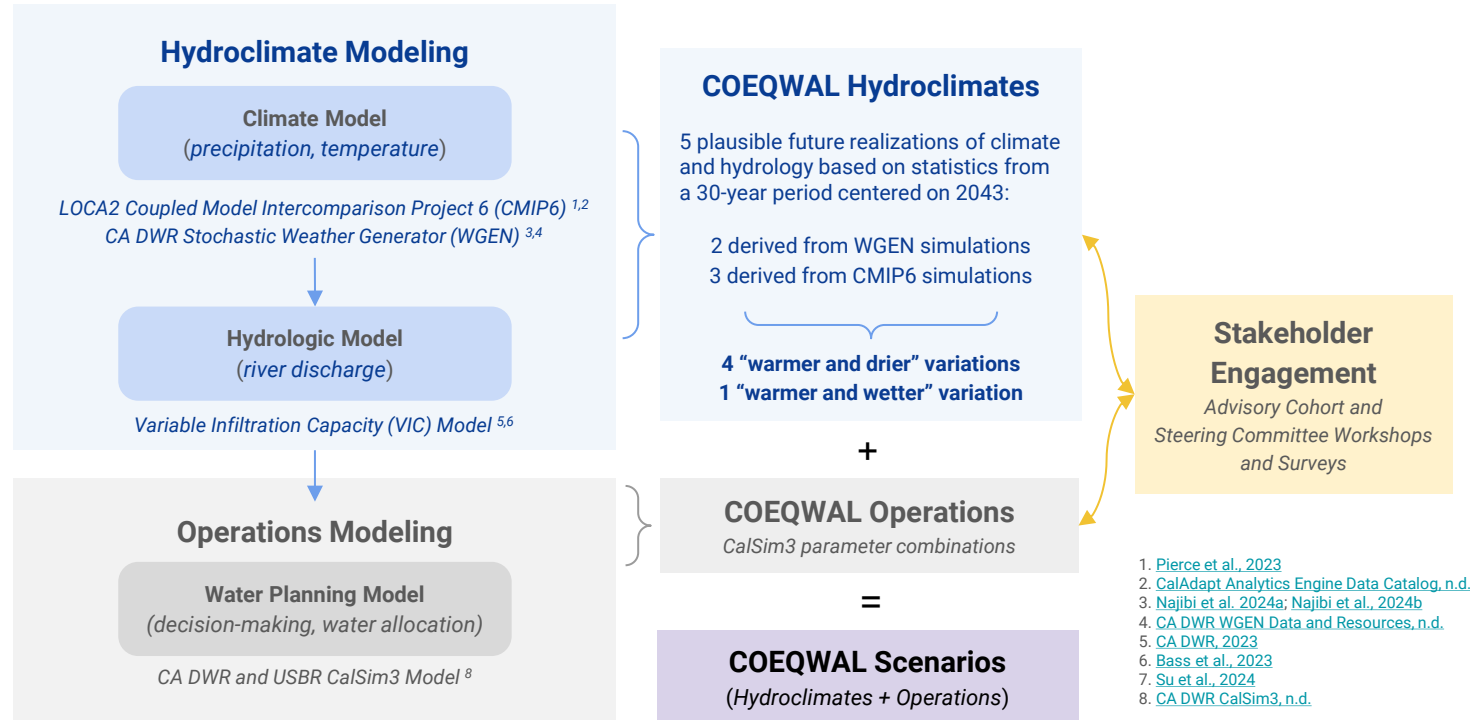
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- **COEQWAL Community Input**
- **Selected COEQWAL Hydroclimates**
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COEQWAL Hydroclimate Overview



Hydroclimate Datasets

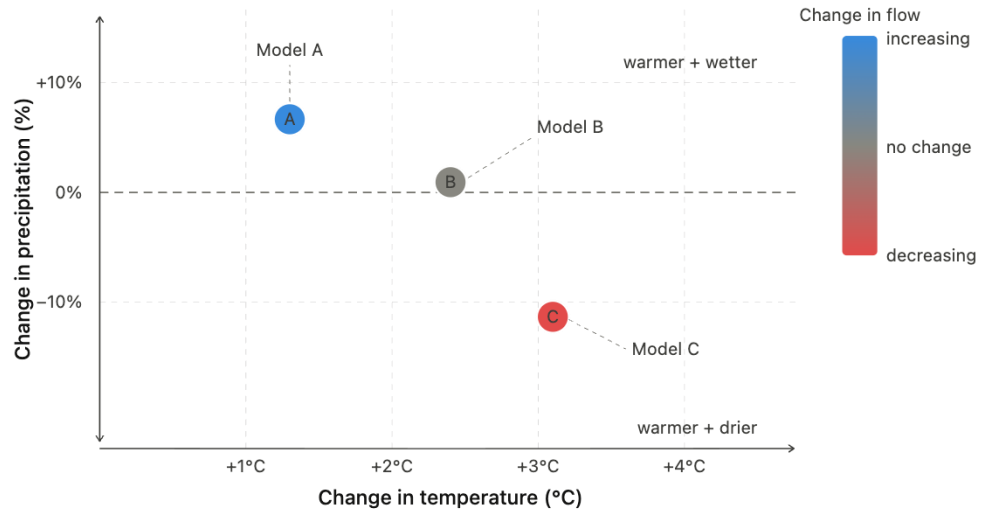
Hydroclimate	Baseline	Future	Climate Modeling	Hydrologic Modeling	Purpose	Sources
CMIP6-VIC (Physical)	1950-2014	SSP 3-7.0; <i>transient</i> climate projection 2015 - 2100	LOCA2-downscaled CMIP6; 3 km	VIC; <i>direct</i> climate forcing.	Generated for California's Fifth Climate Change Assessment	Bass et al., 2023 ; Su et al., 2024 ; CalAdapt, n.d. ; CA Governor's Office, n.d.
WGEN-VIC (Statistical)	1915-2021	Average +1.5°C , +1.7°C and +1.8°C; <i>adjusted stationary</i> baseline climate	CMIP6-informed WGEN perturbation simulations; 6 km reprojected to 3 km	VIC; <i>indirect</i> climate forcing.	Generated for CA DWR's 2023 SWP DCR	CA DWR, 2023 ; CA DWR, n.d.

Hydroclimate Evaluation Framework

We use a 3D response surface approach to identify and compare hydroclimate features across models as part of the COEQWAL hydroclimate selection process.

Each **point** represents a modeled future hydroclimate, positioned by its projected **change in temperature** (horizontal axis), **change in precipitation** (vertical axis), and resulting **change in streamflow** (color).

Change is estimated between a selected **comparison period**, and can be summarized over different **time windows and regions**.



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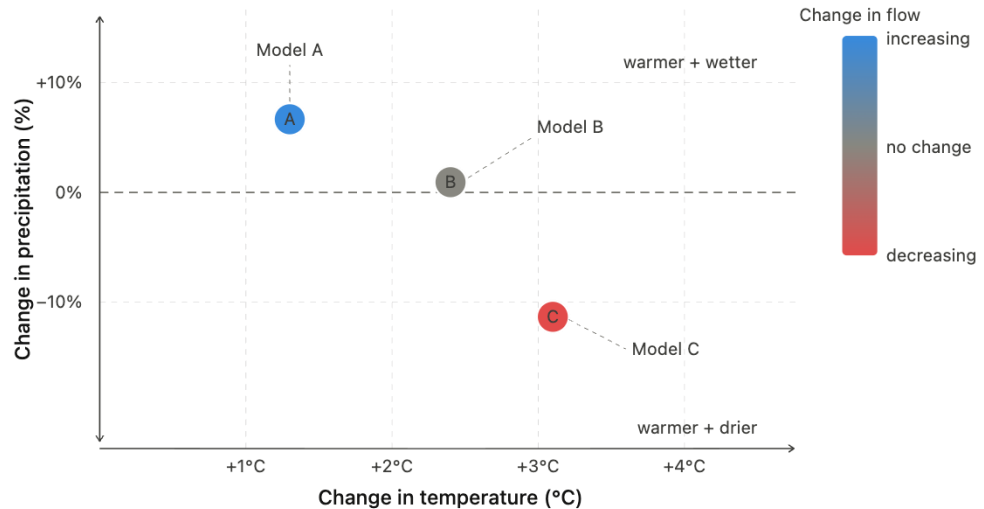
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Comparison Period:
2028-2057 vs. 1992-2021

Time Window:
Annual

Region:
Central Valley inflow basins

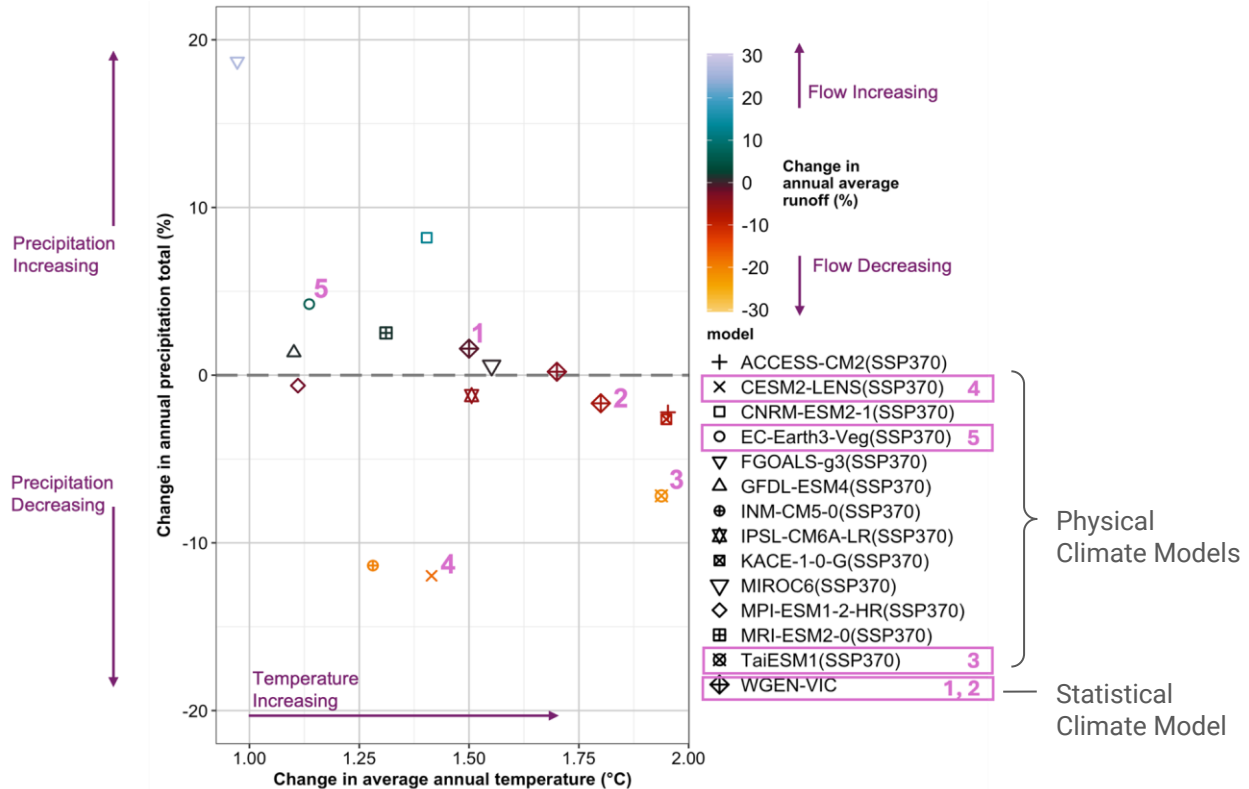


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Hydroclimate Evaluation Framework

Comparing flow outcomes across physical and statistical climate models (Mukhopadhyay et al., *in prep.**)

Dimension	WGEN-VIC (SWP DCR)	CMIP6 (SSP370)	Interpretation
Annual runoff (CV inflow)	Narrow range; minimal precipitation change and modest flow change	Wide spread in precipitation and runoff responses at comparable warming levels	CMIP6 captures a wider range of transient variability; WGEN reflects a narrower range of prescribed stationary perturbations
Spring runoff (CV inflow)	Minimal spring precipitation change; modest flow decline	Stronger spring drying and flow decline at comparable warming levels	Seasonal differences may reflect transient variability in CMIP6 and/or structural differences in how physical vs. statistical models represent seasonal climate.
Seasonal flow timing (SAC, SJR)	Weaker seasonal redistribution; similar in SAC and SJR	Stronger shift to more winter flow, less late spring/summer flow; more pronounced in Sac than SJR at comparable warming levels	Regional (north vs. south) differences more likely reflect structural differences in how physical vs. statistical models represent regional climate variability

* Comparable warming levels refers to comparisons using CMIP6-VIC SSP 370 data for the early-century period (2044 - 2062). This work also evaluates WGEN-SAC-SMA, CMIP6 (SSP585), and CMIP6-VIC at early-, mid-, and end-century horizons (vs. the 2043-centered period used in COEQWAL).

COEQWAL Community Input

Feedback from COEQWAL Advisory Cohort and Steering Committee via workshops and survey

Hydroclimate Feature	Preferences	Purpose in Hydroclimate Selection	Challenges
Comparison period	< 30 years, 30 years	Defines the baseline vs. future time windows over which change is estimated for the 3D framework	The distinction between model output resolution and comparison period was a source of confusion; from a modeling perspective, short period comparisons capture variability rather than long-term change
Time window	Annual, winter, spring	Defines the time window over which climate and flow change is aggregated for the 3D framework	Period of interest strongly tied to community affiliation (e.g., fisheries vs. water management)
Region	Central Valley, Sac, SJR, 8RI	Defines the spatial domain over which change is aggregated for the 3D framework	Differences in physical and statistical model representation at finer spatial scales are not well quantified and were difficult to communicate
Extremity	Moderate and extreme	Guides where in the 3D response surface hydroclimates are selected for subsequent COEQWAL CalSim3 modeling	Community preference was for fundamentally altered, hydrologically extreme future climate sequences; COEQWAL (via CalSim3) is limited to prescribing changes to a stationary historical baseline

Selected COEQWAL Hydroclimates

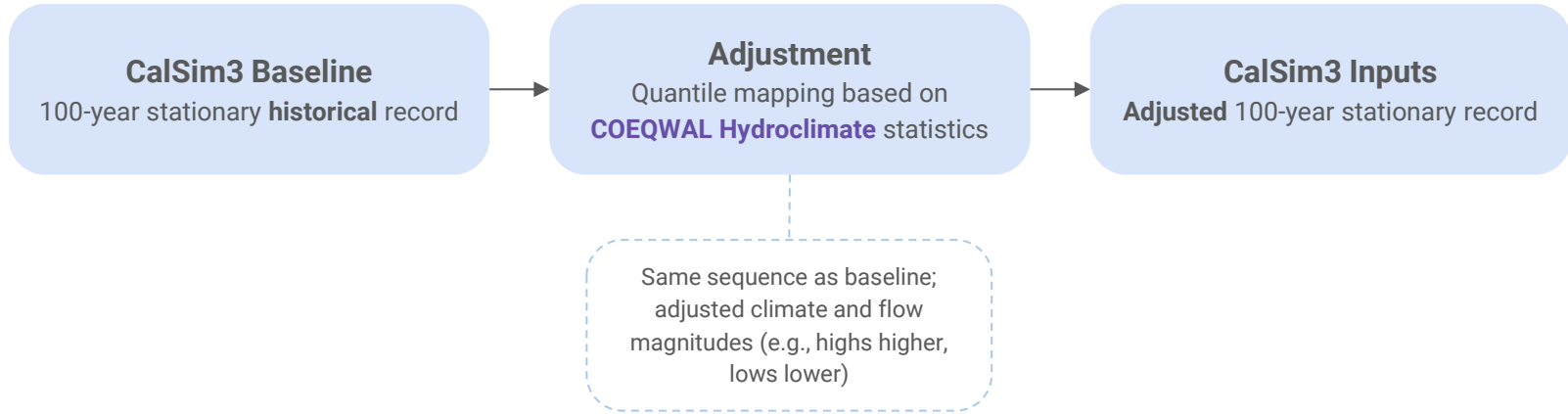
COEQWAL Hydroclimate	Climate Model Source	Temperature change	Precipitation change	Flow change	Level of concern
Warmer and Drier 1	DWR WGEN "50th Percentile Level of Concern" for 8RI April-July	+1.5°C	+1.5%	-1%	50th
Warmer and Drier 2	DWR WGEN "95th Percentile Level of Concern" for 8RI April-July	+1.8°C	-1.8%	-6.5%	95th
Warmer and Drier 3	LOCA2 CMIP6 TaiESM1 SSP370	+1.9°C	-7.2%	-21%	>99.99th
Warmer and Drier 4	LOCA2 CMIP6 CESM2-LENS SSP370	+1.4°C	-12%	-17.7%	>99.99th
Warmer and Wetter	LOCA2 CMIP6 EC-Earth3-Veg SSP370	+1.1°C	+4.2%	+6.7%	44th

Centered hydroclimate selection on WGEN-VIC, which is designed to interface directly with CalSim3.

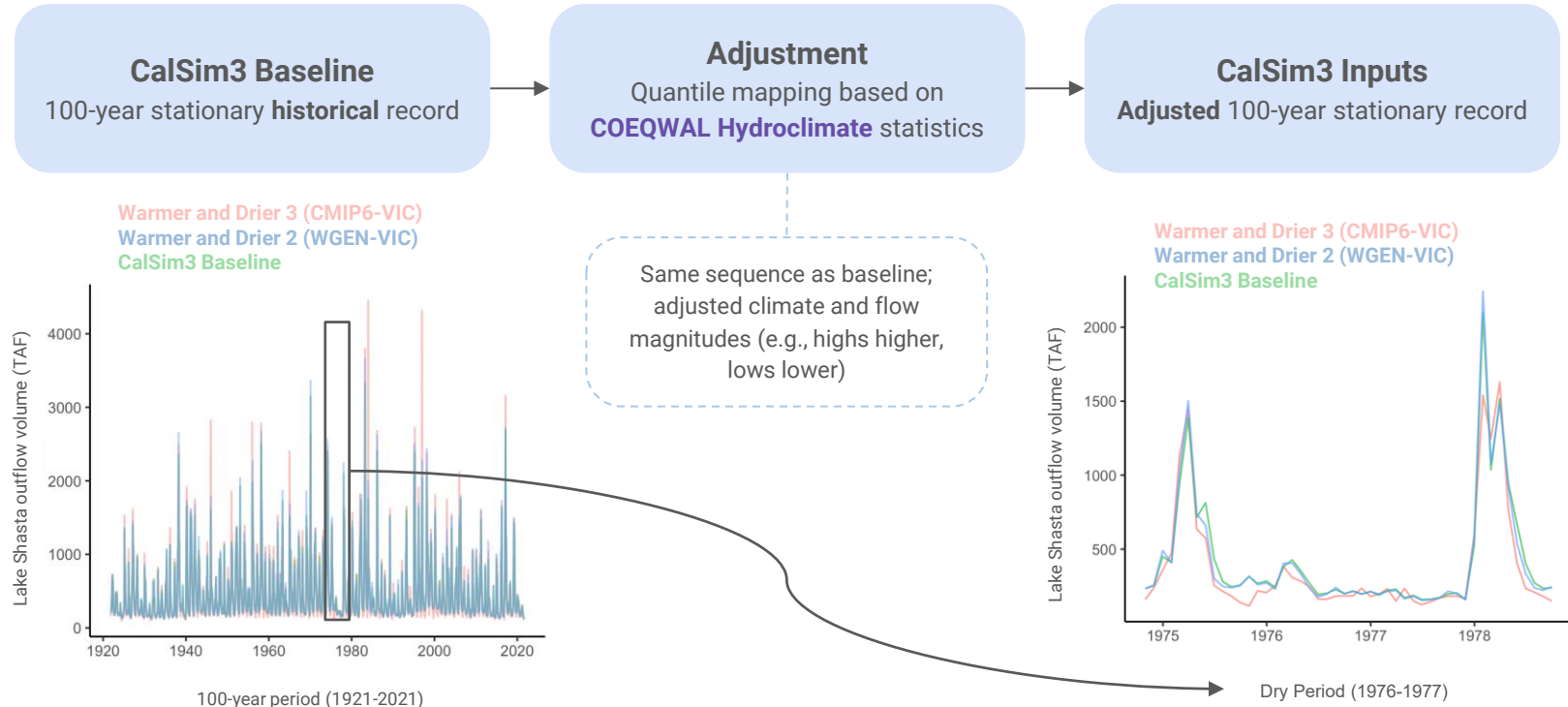
Additional CMIP6-VIC projections represent plausible conditions that deviate from WGEN-VIC in ways identified as salient by the community: **higher warming levels and relatively drier and/or wetter conditions**.

Hydroclimates do *not* represent an ordered sequence of increasing change along any one dimension (temperature, precipitation, flow), but can be related to DWR's flow-based "Levels of Concern".

From Hydroclimates to CalSim3 Inputs



From Hydroclimates to CalSim3 Inputs



Thank you!

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Climate Action Initiative

COEQWAL
COLLABORATORY FOR EQUITY IN WATER ALLOCATION

UC San Diego

 SCRIPPS INSTITUTION OF
OCEANOGRAPHY

Extra

Hydroclimate Evaluation (Additional)

(Mukhopadhyay et al., *in prep.**)

Comparison Period:

CMIP6: 30-year moving average medians at early (2044 - 2062), mid (2063 - 2083) and end (2084 - 2100) century relative to a 1950–2014 historical baseline average.

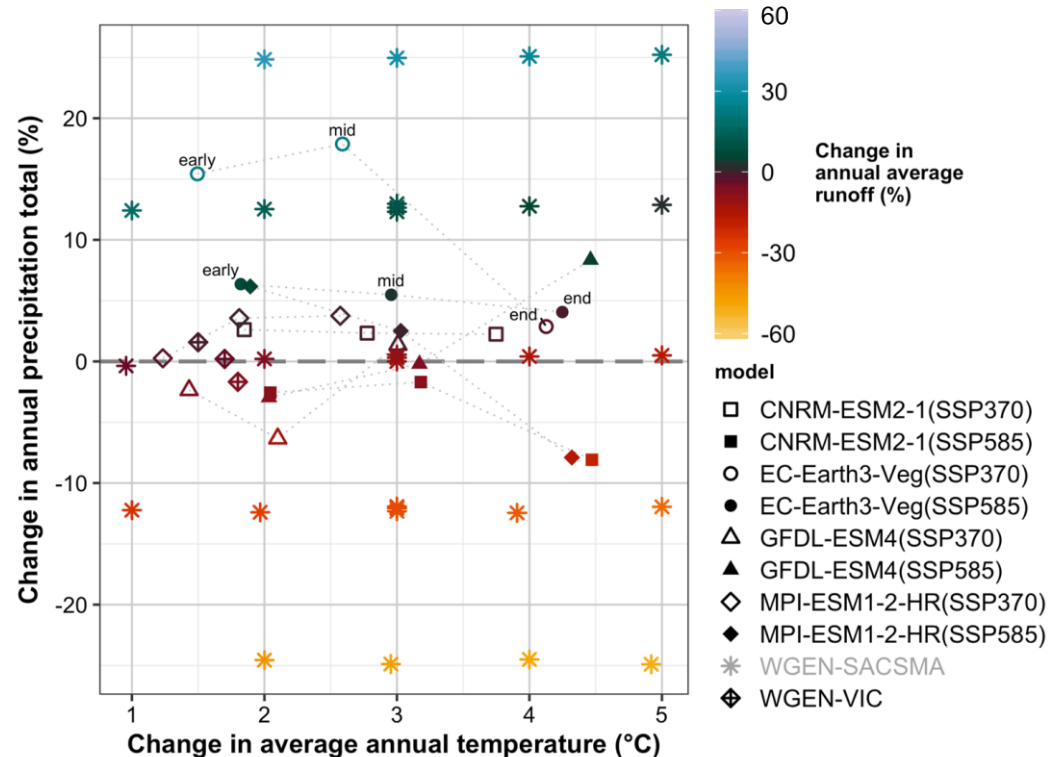
WGEN: average change between the 1915–2021 historical baseline and prescribed perturbations of the baseline record.

Time Window:

Annual

Region:

Central Valley inflow basins



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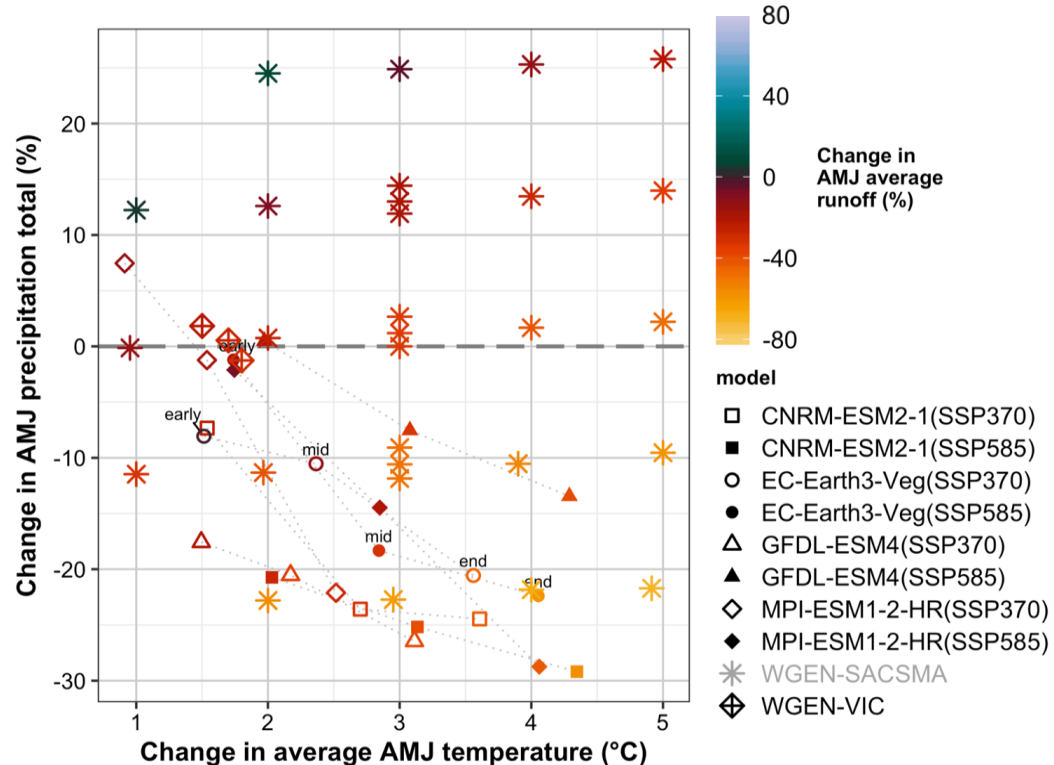
Time Window:

Spring: April, May, June (AMJ)



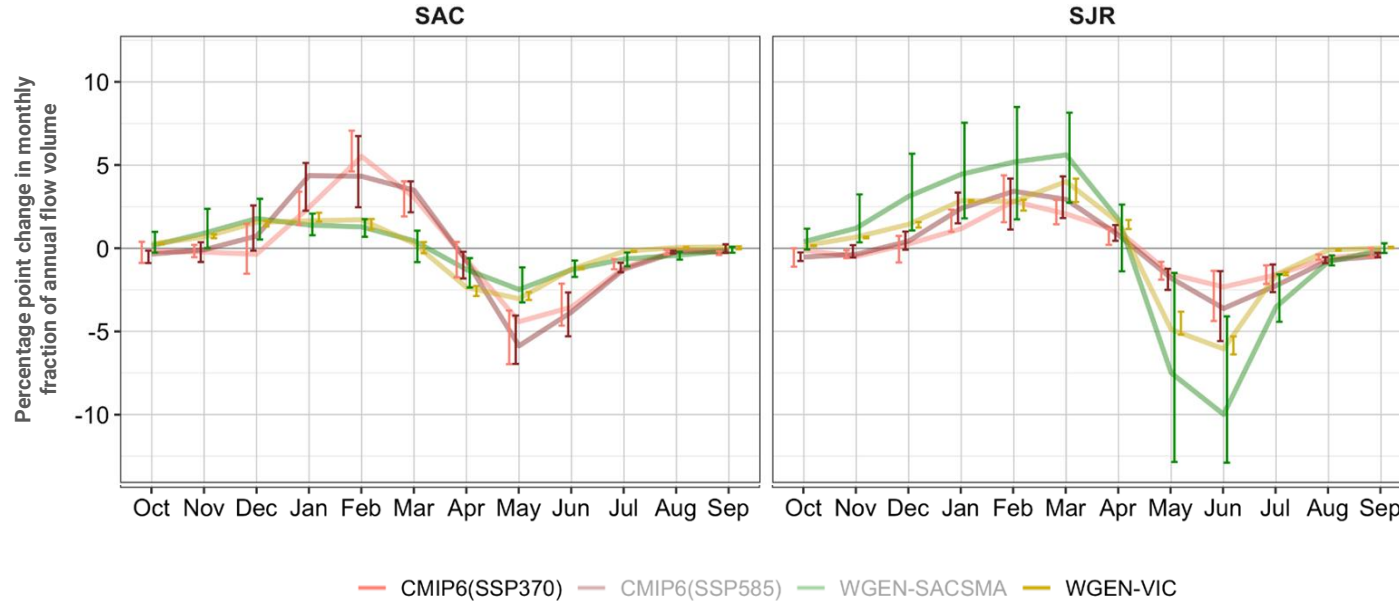
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Seasonal flow timing: Percentage point change in each month's share of annual flow volume, averaged across the four SAC and four SJR 8RI basins. **CMIP6-VIC** values reflect early-century (WY 2044–2062) 30-year moving average changes relative to a 1950–2014 baseline; **WGEN-VIC** values reflect average changes from prescribed perturbation levels relative to a 1915–2021 baseline. Bars show min-to-max range across models within each dataset.