A New Normal for Streamflow over Northern California: Less Moderates, More Extremes.

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Recent years extreme events that exceeded a billion dollars in economic damage.

EVENT	BEGIN DATE	END DATE	SUMMARY	ESTIMATED COST *(IN BILLIONS)*	DEATHS
California Flooding † *February 2017*	2017-02-08	2017-02-22	Heavy, persistent rainfall across northern and central California created substantial	$1.5 CI	5
West/Northeast/Southeast Drought † *2016*	2016-01-01	2016-12-31	California's 5-year drought persisted during 2016 while new areas of extreme drought developed in states across the Northeast and Southeast. The long-term impacts of the drought in California have	$3.6 CI	0
Western Drought † *2015*	2015-01-01	2015-12-31	Drought conditions were present across numerous western states (CA, NV, OR, WA, ID, MT, UT, AZ) with the most severe conditions continuing to plague California	$4.8 CI	0
Western Drought † *2014*	2014-01-01	2014-12-31	Historic drought conditions affected the majority of California for all of 2014 making it the worst drought on record for the state. Surrounding states and parts of	$4.2 CI	0
Western/Plains Drought/Heatwave † *Spring-Fall 2013*	2013-03-01	2013-11-30	The 2013 drought slowly dissipated from the historic levels of the 2012 drought, as conditions improved across many Midwestern and Plains states. However, moderate to extreme drought did remain	$11.3 CI	53
U.S. Drought/Heatwave † *2012*	2012-01-01	2012-12-31	The 2012 drought is the most extensive drought to affect the U.S. since the 1930s. Moderate to extreme drought conditions affected more than half the country for a	$33.0 CI	123

San Francisco Chronicle

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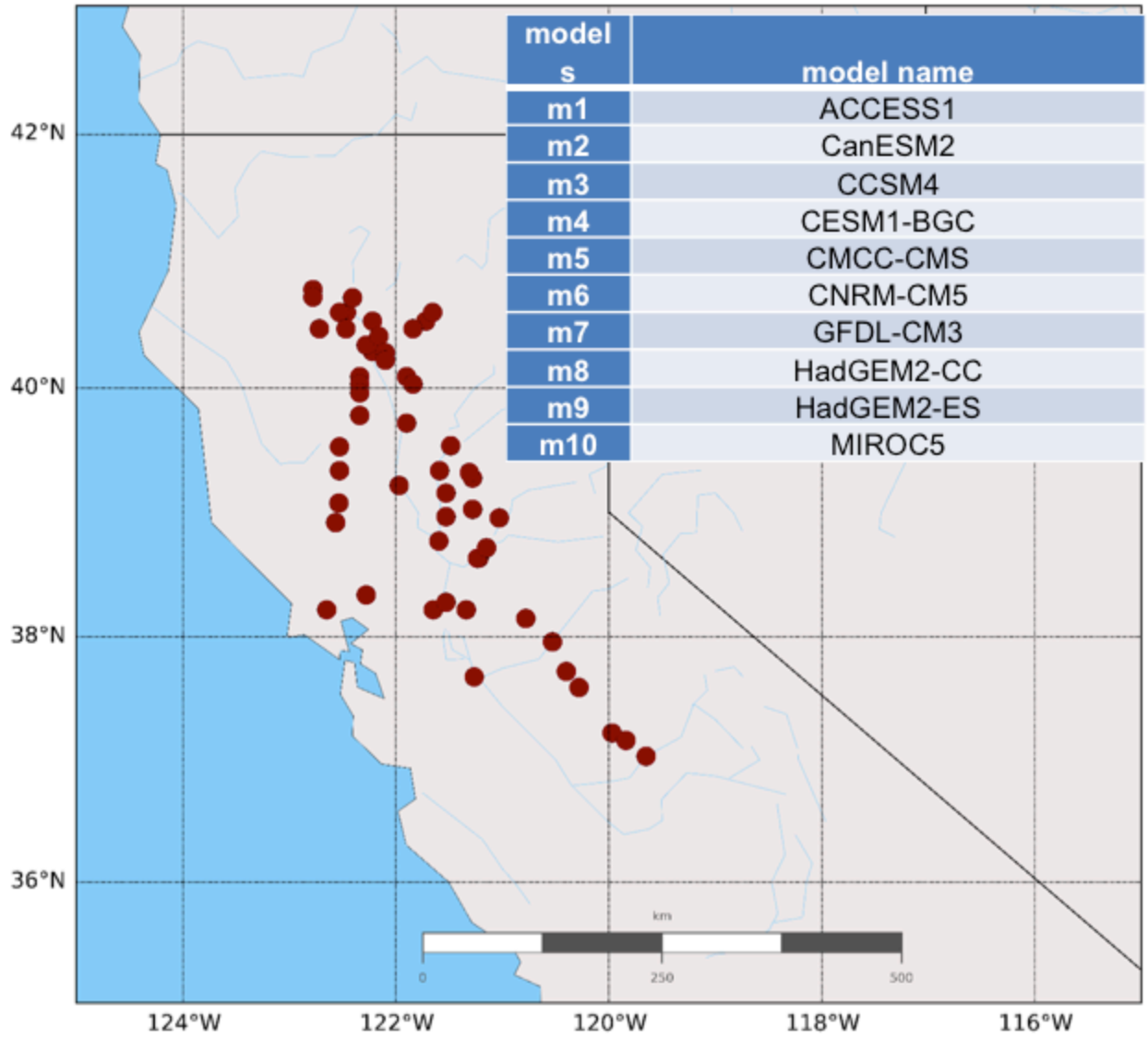
Objective

No

Yes

The direction of changes in river discharge due to climate change.

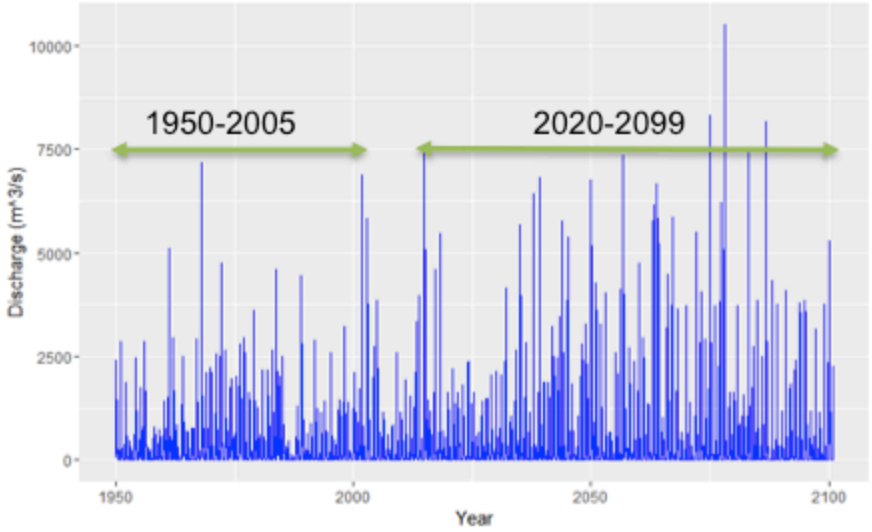
Data: Biased-corrected routed streamflow



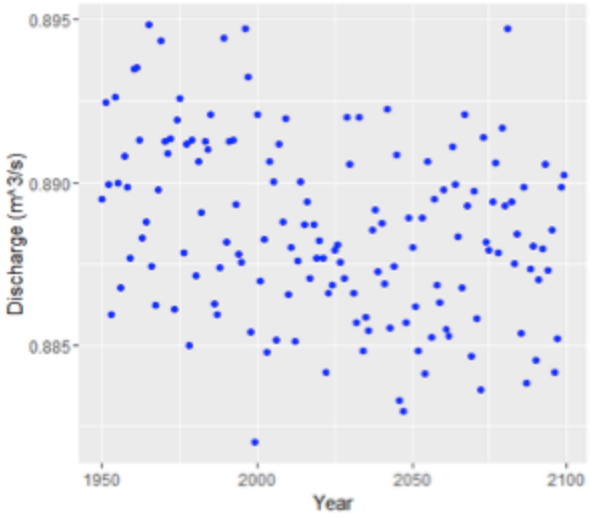
models	model name
m1	ACCESS1
m2	CanESM2
m3	CCSM4
m4	CESM1-BGC
m5	CMCC-CMS
m6	CNRM-CM5
m7	GFDL-CM3
m8	HadGEM2-CC
m9	HadGEM2-ES
m10	MIROC5

Based on California's Fourth Climate Change Assessment recommendations, ten CMIP5 GCMS with 2 scenarios (RCP4.5 and RCP8.5) are selected.

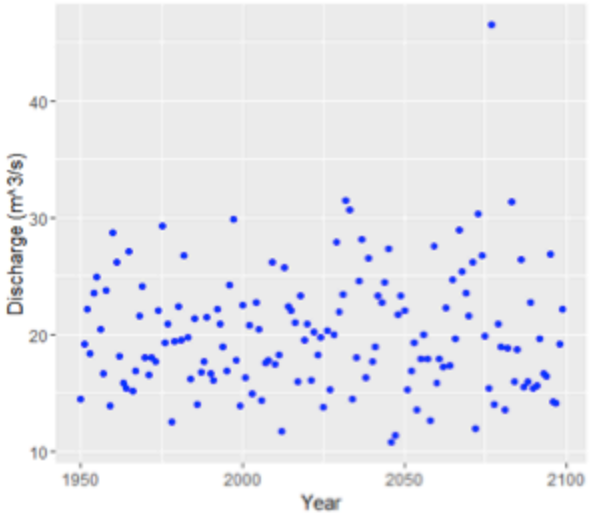
Methodology



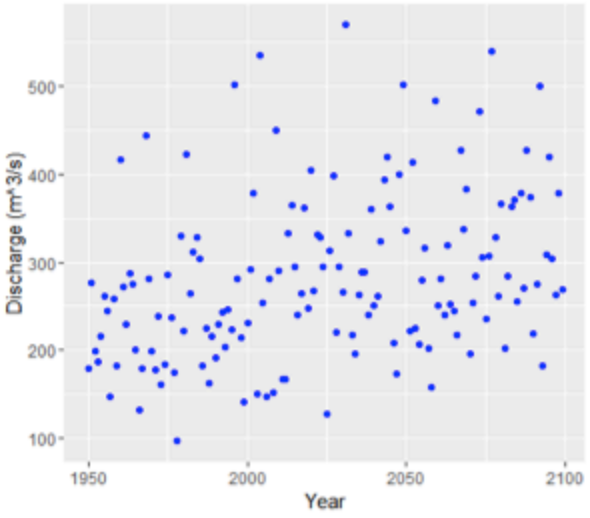
To investigate changes in the magnitude and direction of discharge, we computed annual time series for different discharge quintiles.



Q(min)

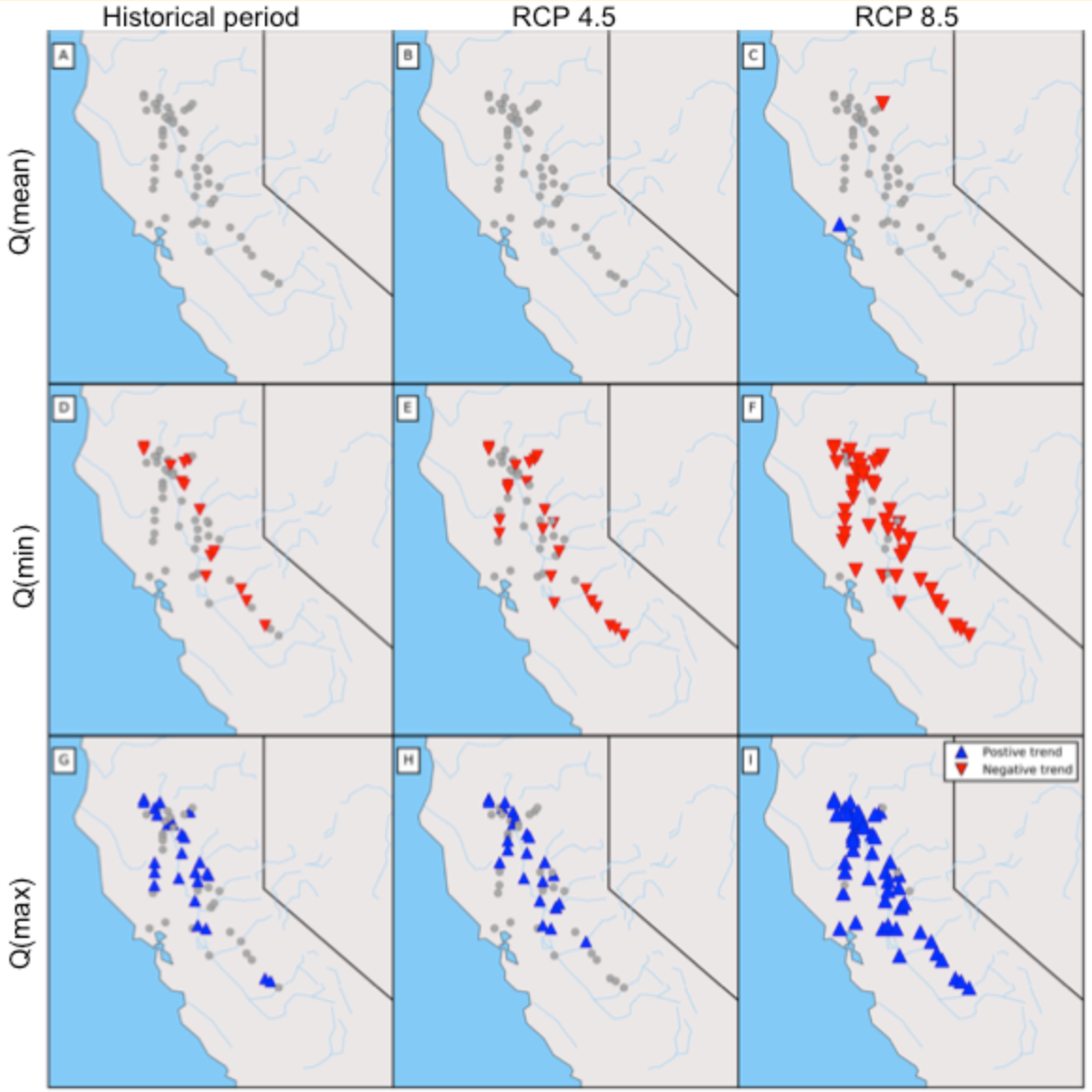


Q(mean)

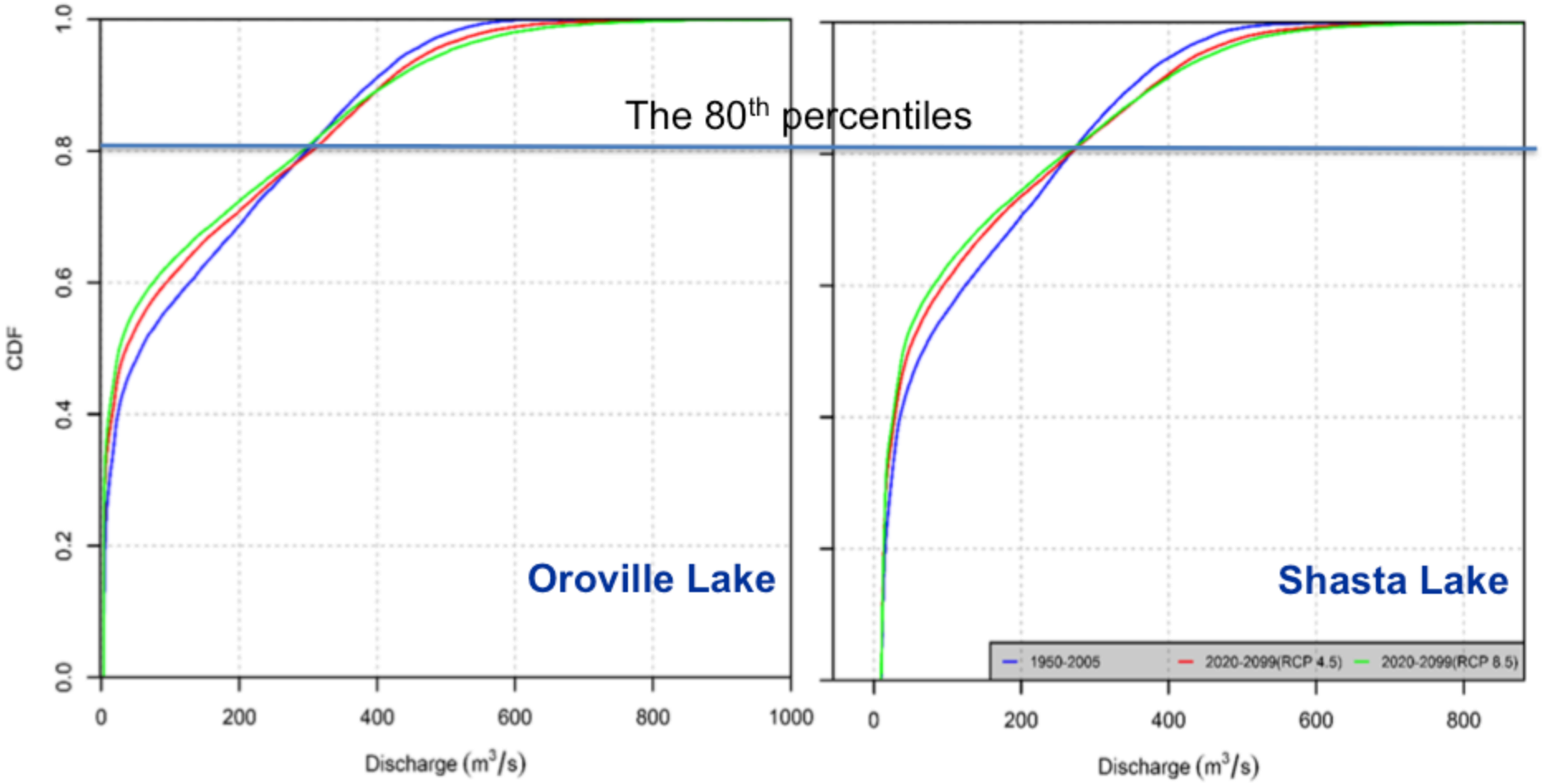


Q(max)

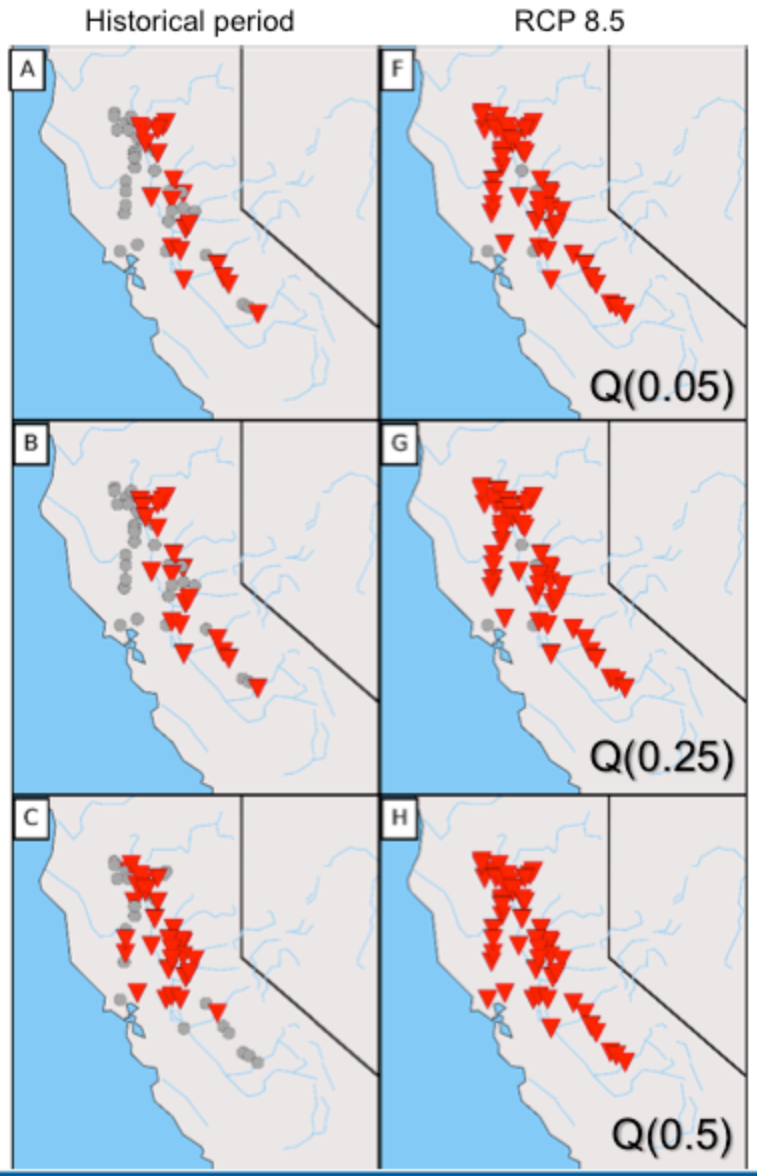
Discharge time series data are checked for the presence of monotonic changes over time by using Mann-Kendall test.

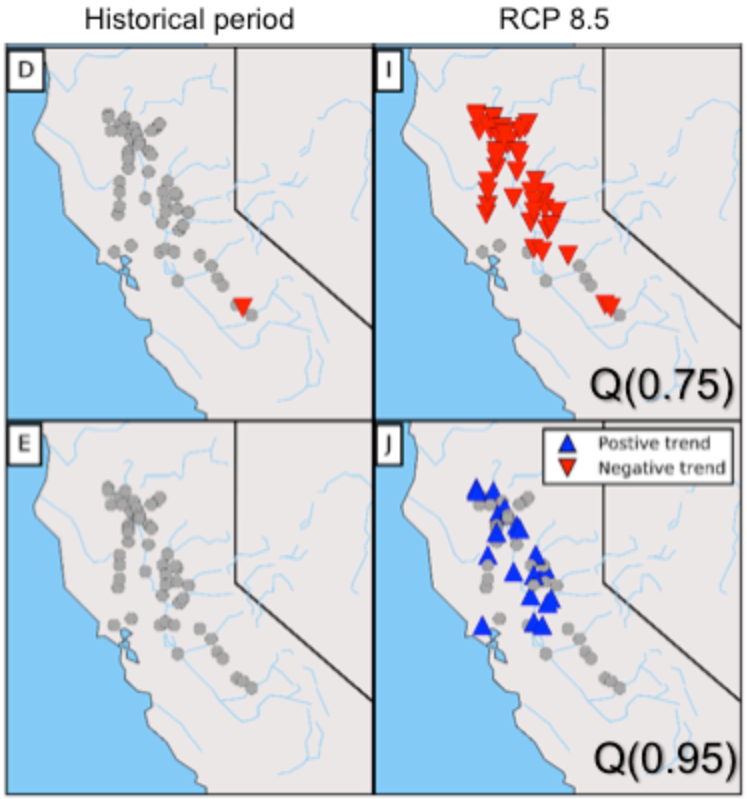


Empirical Cumulative Distribution Functions (ECDFs) of streamflow.

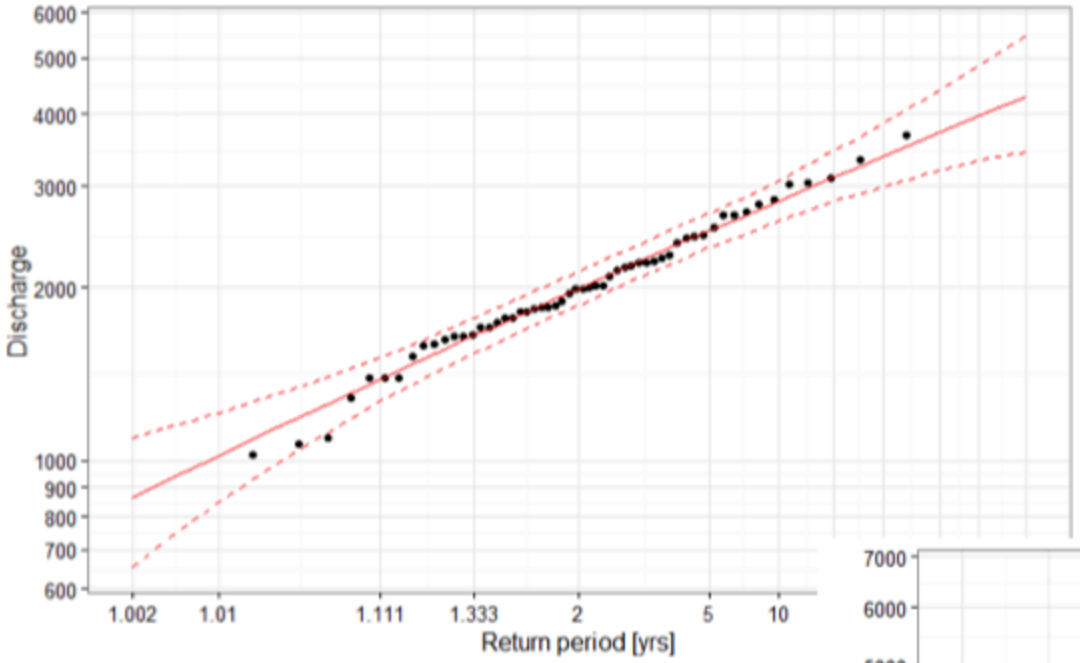


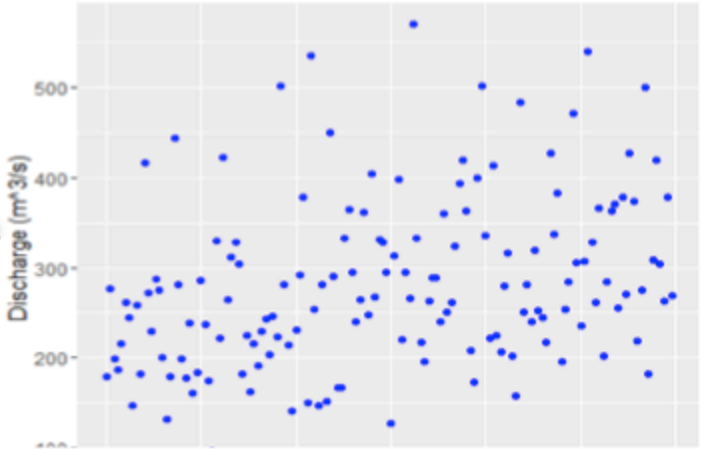
Current climate model simulations indicate an asymmetrical change in the tails of the streamflow distribution.





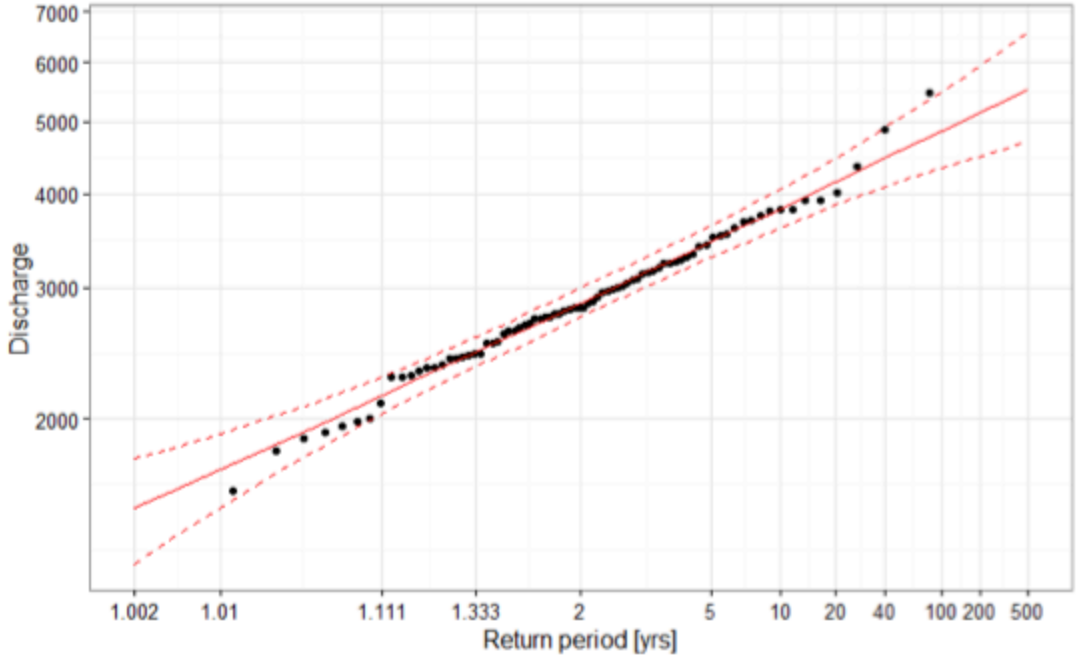
Flood Frequency Analysis



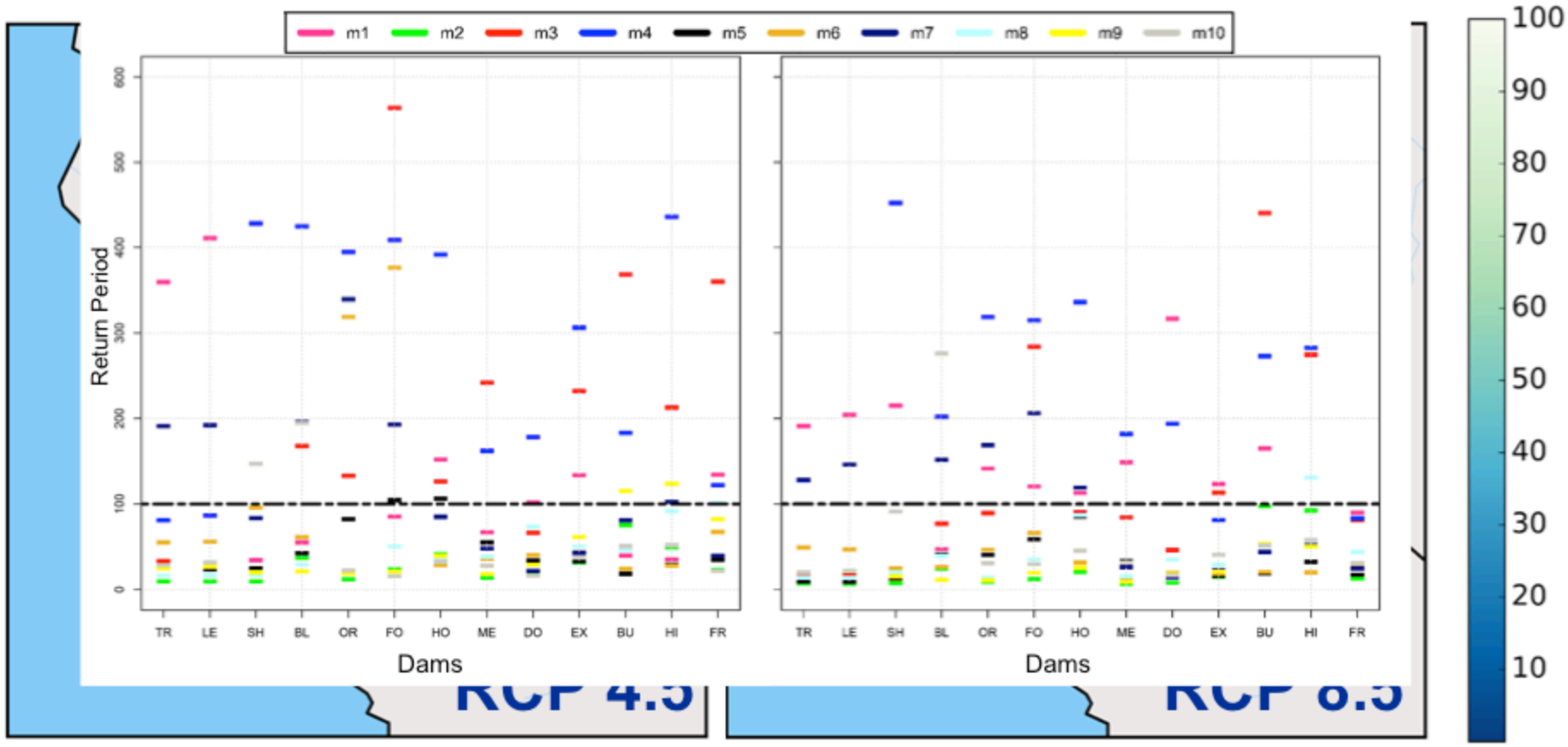


Bulletin 17B Method

Fit log-Pearson type 3 (LP3) distribution to annual maximum flood series by fitting Pearson type 3 (P3) distribution to logs of flood peaks using method of moments (MOM)



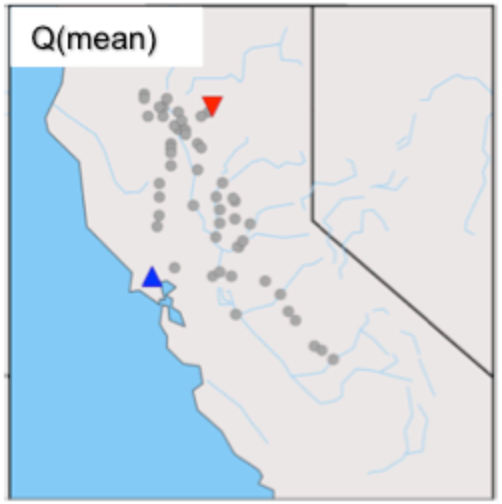
Return period in the future corresponding to a 100-year flood in the historical period.

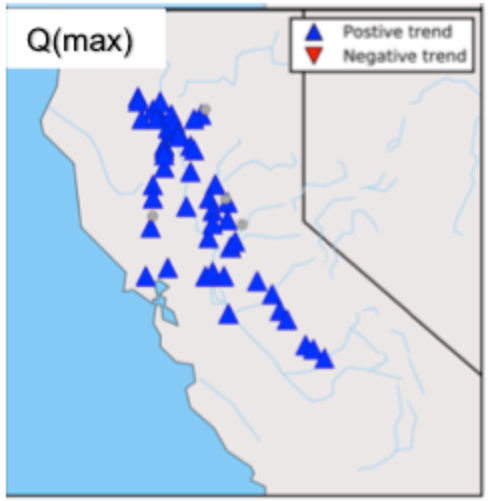


Maps showing the projected return period under RCP 4.5 (left panel) and RCP 8.5 (right panel) corresponding to a 100-year flood level in the historical period for 13 major dams over California.

Conclusion: A possible picture of future

Opposing trends in the two tails of the future streamflow simulations: lower low flows and higher high flows with no change in the overall mean of future flows relative to the historical baseline.





Thanks!

List of the reservoir

I1	Trinity Lake Inflow (calsim and wytypes)
I100	Lewiston Lake Inflow (calsim)
I4	Shasta Lake Inflow (calsim)
I42	Black Butte Lake Inflow (calsim)
I6	Lake Oroville Inflow (calsim)
I8	Folsom Lake Inflow (calsim)
I92	New Hogan Reservoir (calsim)
I10	New Melones Reservoir Inflow (calsim and wytypes)
I81	New Don Pedro Reservoir Inflow (calsim and wytypes)
I20	Lake McClure Inflow (calsim and wytypes)
I53	Eastman Lake Inflow (calsim)
I52	Hensley Lake Inflow (calsim)
I18	Millerton Lake Inflow (calsim and wytypes)