Watershed Modeling in CASCaDE: Projecting Hydrologic Changes and Management Challenges in California

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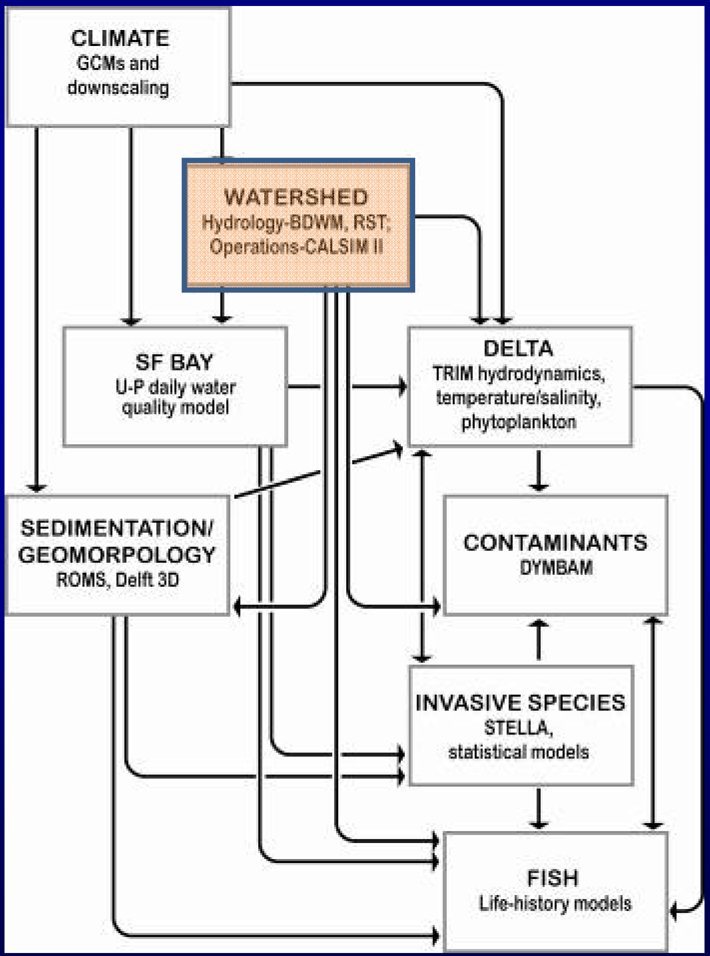
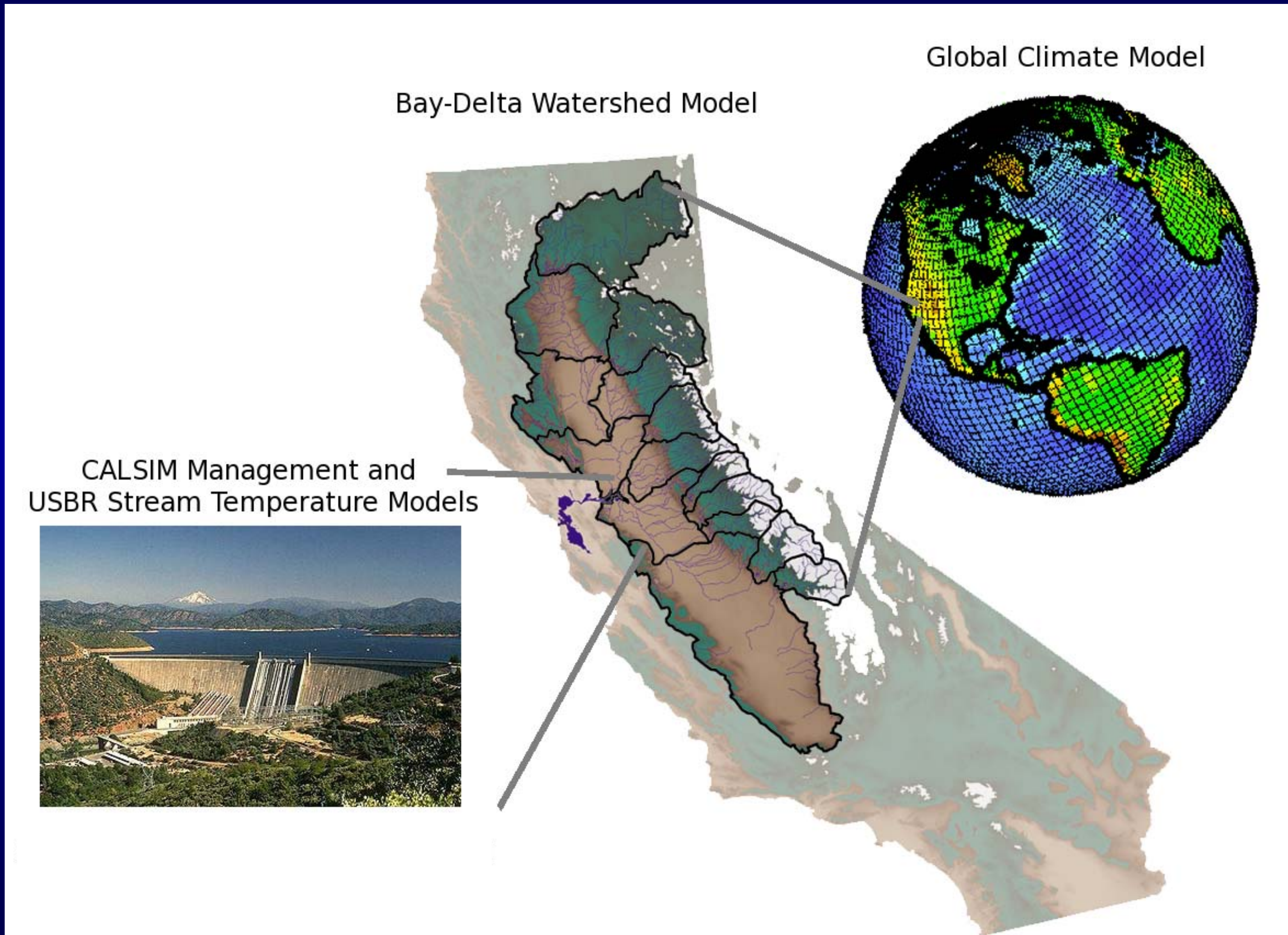
CASCaDE Project Structure



http://cascade.wr.usgs.gov

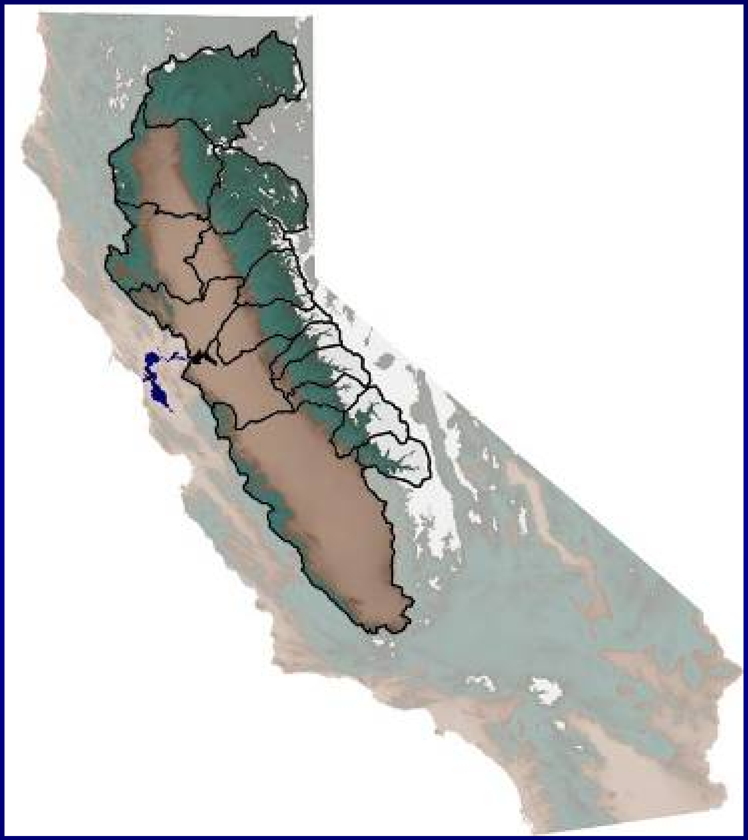
- Computational Assessments of Scenarios of Change for the Delta Ecosystem
- Mike Dettinger et al. have provided daily downscaled GCM output for four scenarios
- My task is to translate these into managed flows and stream temperatures at locations throughout the Bay-Delta watershed
- This entails a novel application of a hydrology model (BDWM) and CALSIM-II, a management optimization model.
- Following is an overview of the modeling approach and results for one of the four scenarios

Model Hierarchy for CASCaDE Watershed Modeling

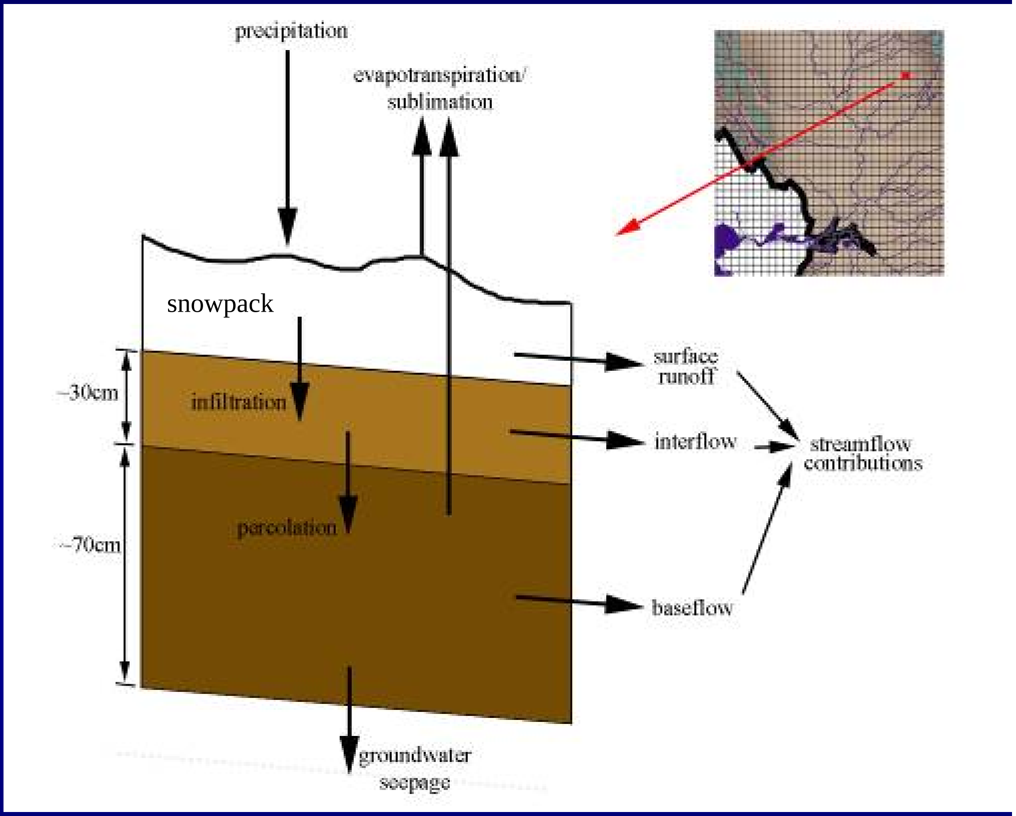


The Bay-Delta Watershed Model (BDWM) covers the entire watershed and simulates daily variability over climate-change time scales.

Model Domain and Routing Basins



Sample Grid Cell

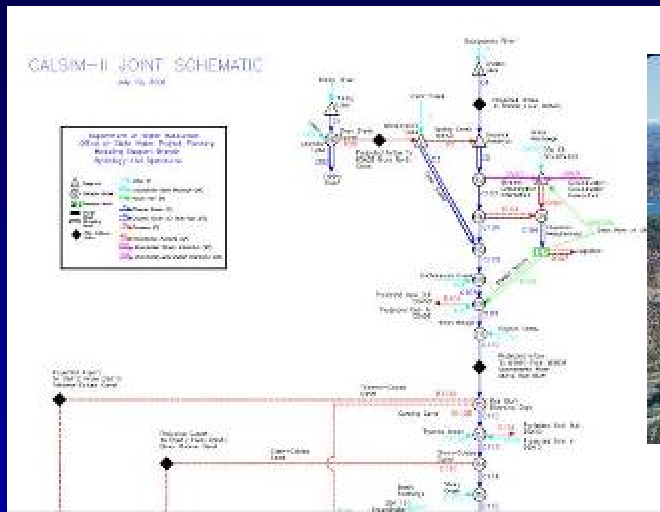


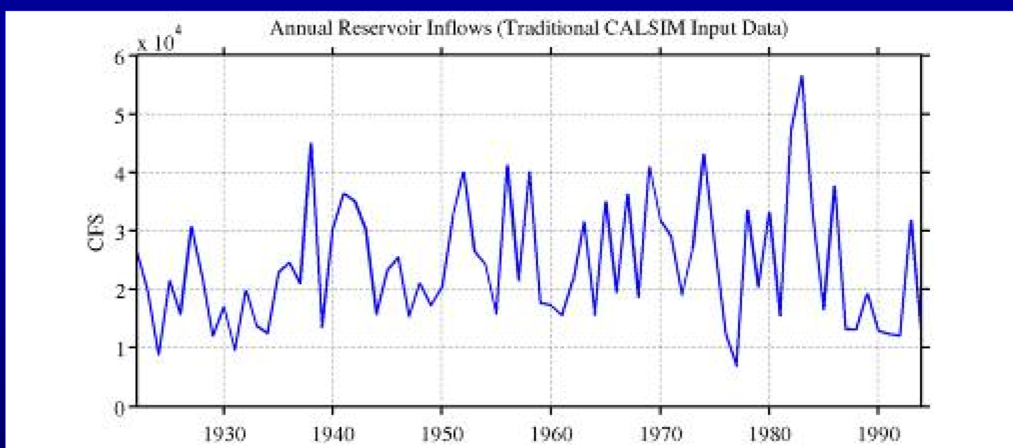
Features

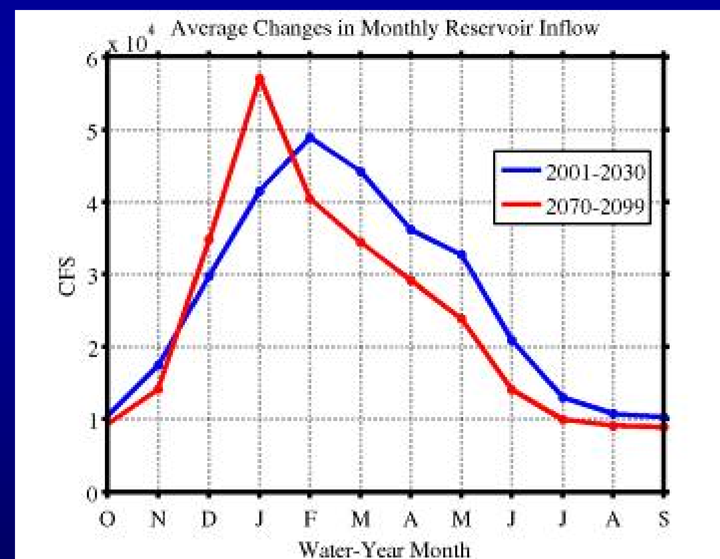
- 4 km resolution
- Daily time step
- Simulates snowpack, streamflow, etc.
- Routes streamflow to points of interest
- Capable of ensemble, multi-decade simulations

Model developed with Kosta Georgakakos, Hydrologic Research Center, Del Mar, CA

CALSIM-II is the CA Department of Resources’ freshwater management model.

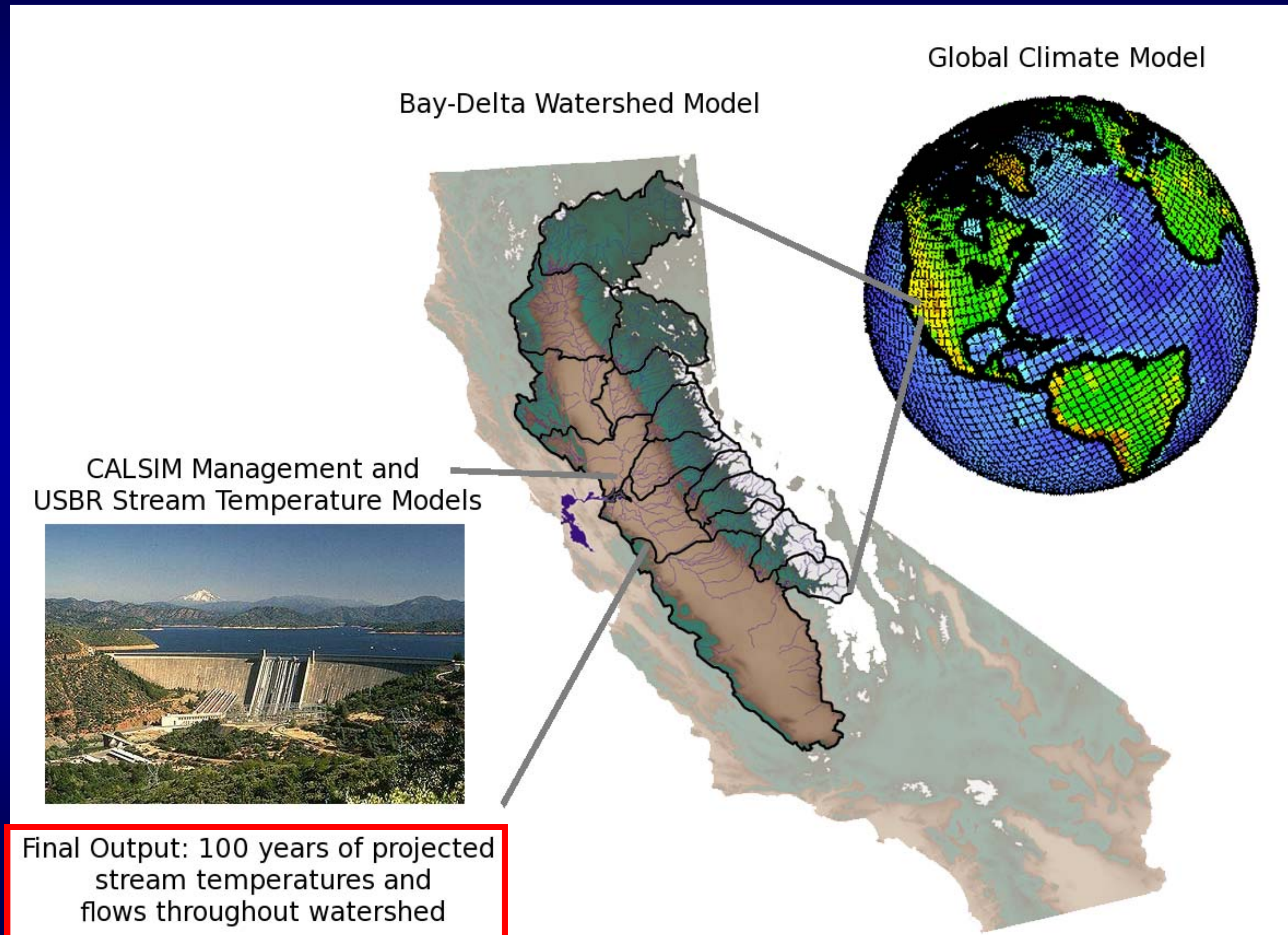


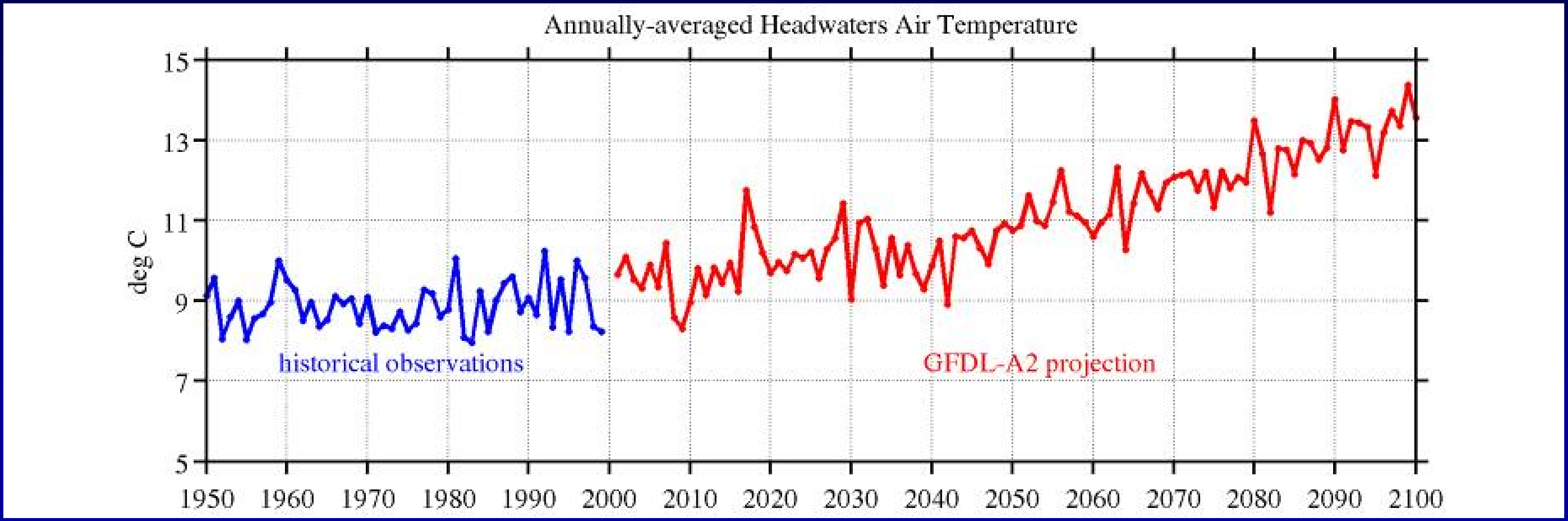


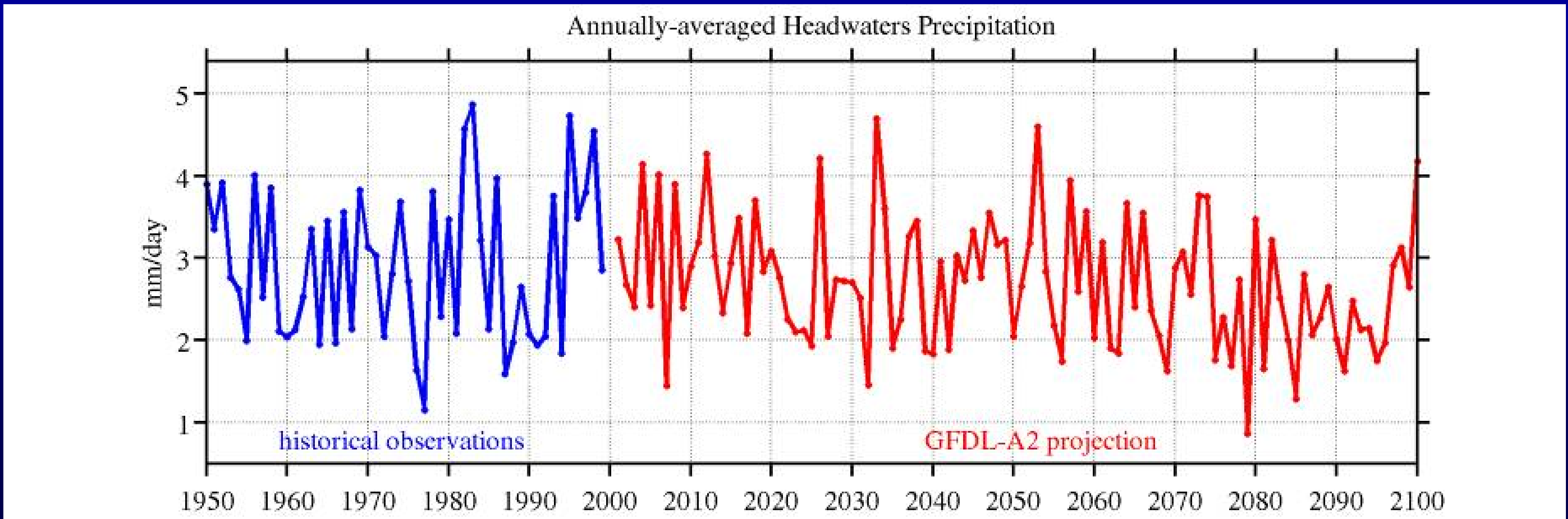


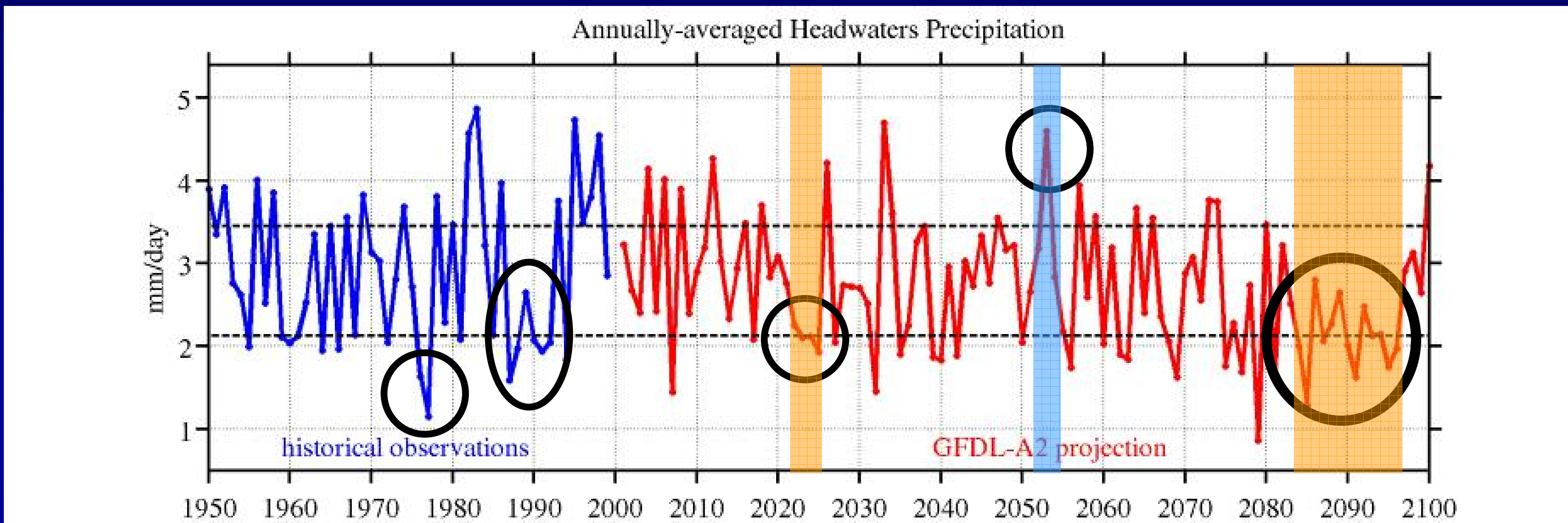
For this study, CALSIM-II was reconfigured to accept inflows *directly* from the BDWM hydrology model, allowing a representation of both projected long-term changes *and* projected interannual-to-interdecadal climate variability.

Model Hierarchy for CASCaDE Watershed Modeling



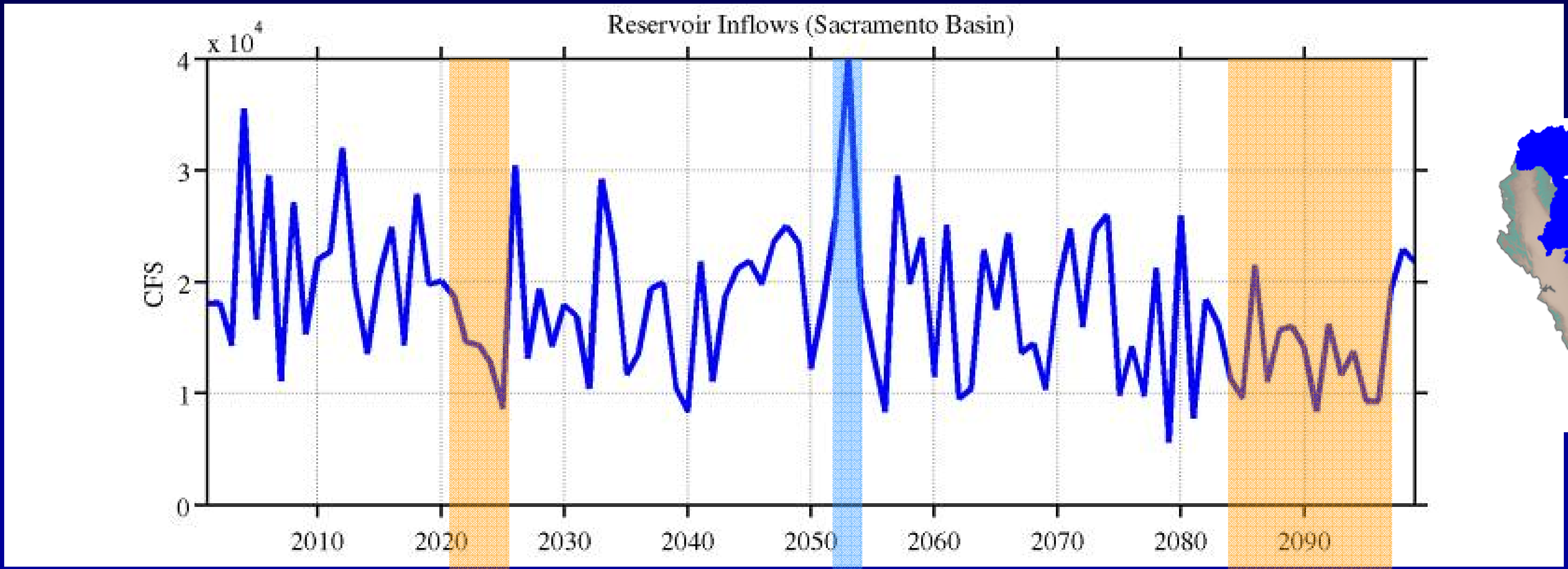

Annually-averaged Headwaters Air Temperature
deg C
15
13
11
9
7
5
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
historical observations
GFDL-A2 projection

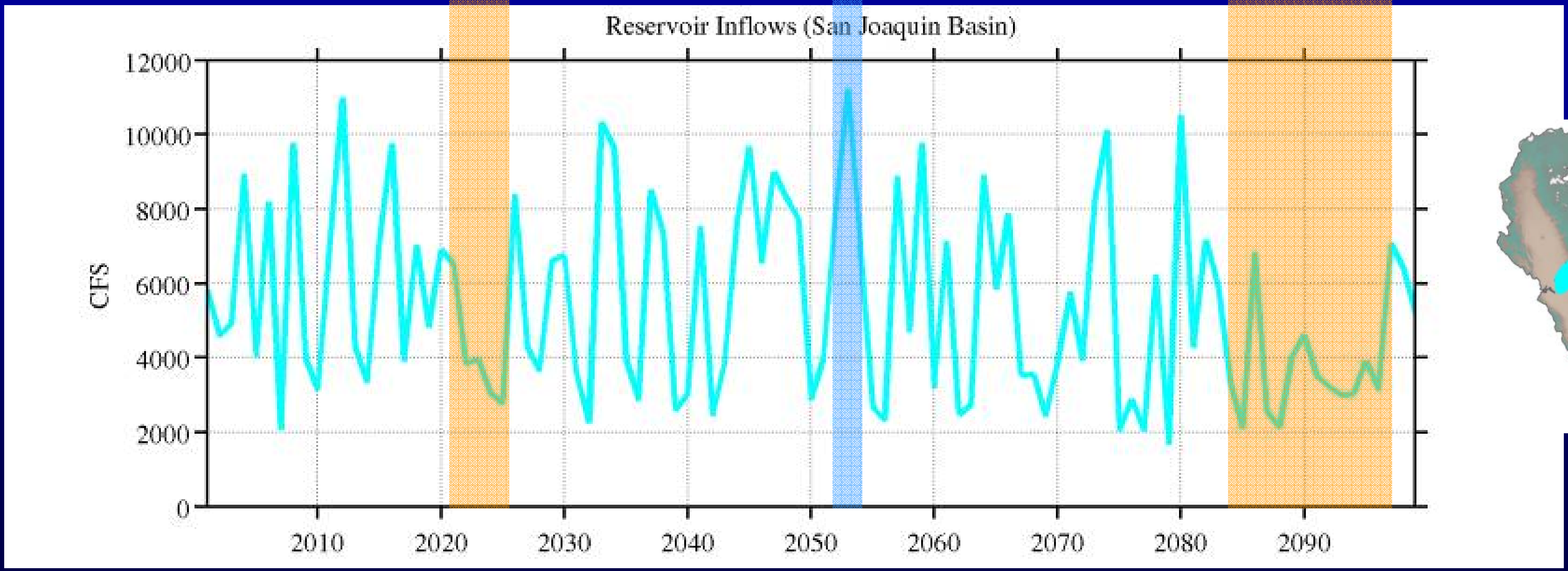

Annually-averaged Headwaters Precipitation
mm/day
5
4
3
2
1
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
historical observations
GFDL-A2 projection



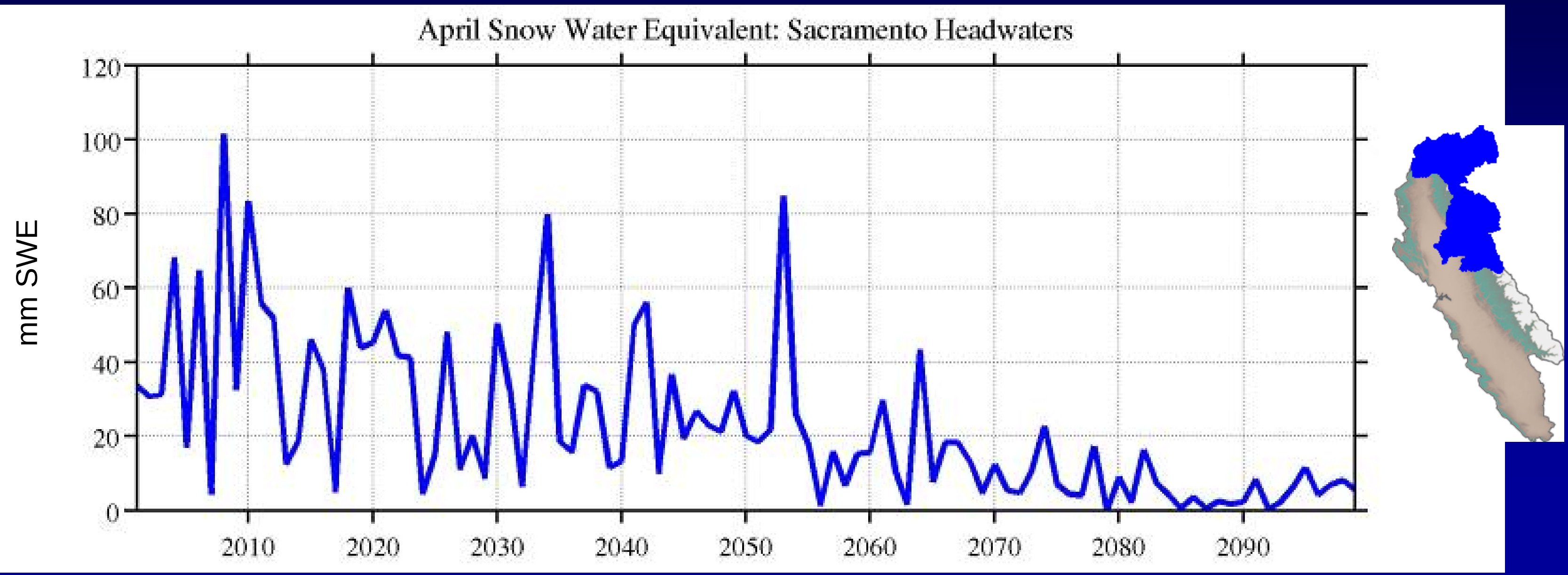
NOT A PREDICTION!

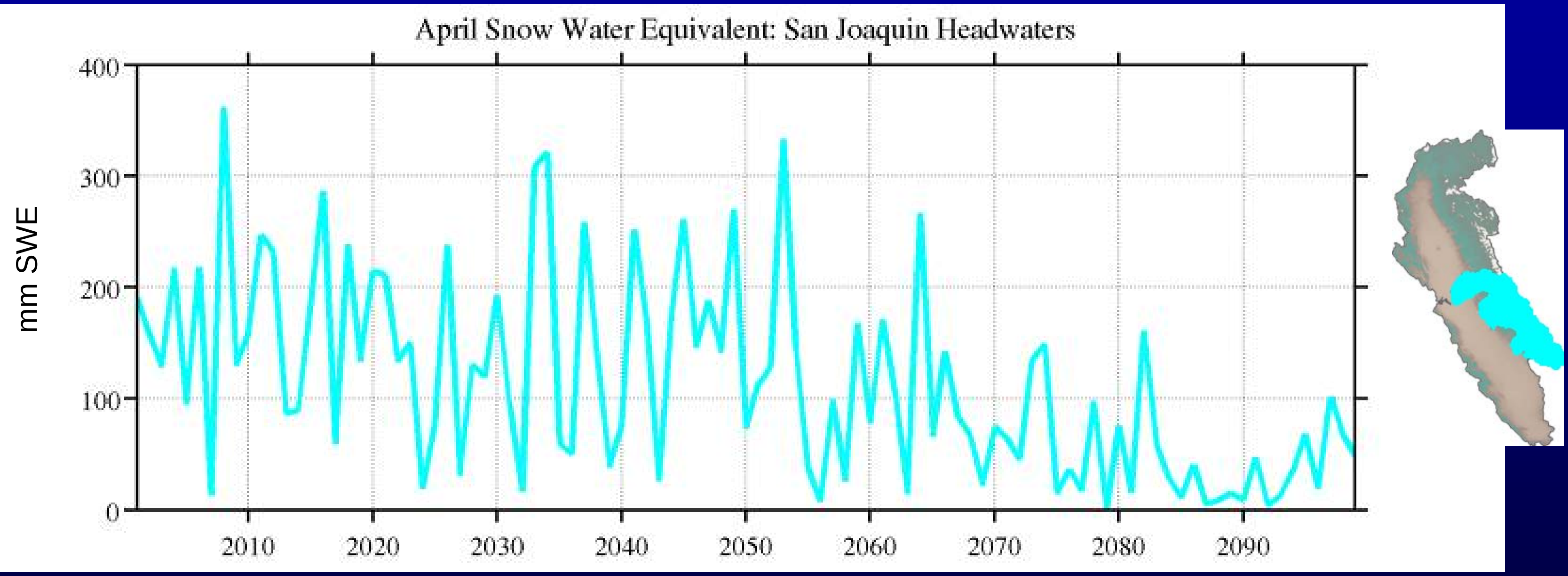
Interannual precipitation variability drives reservoir inflow variability.



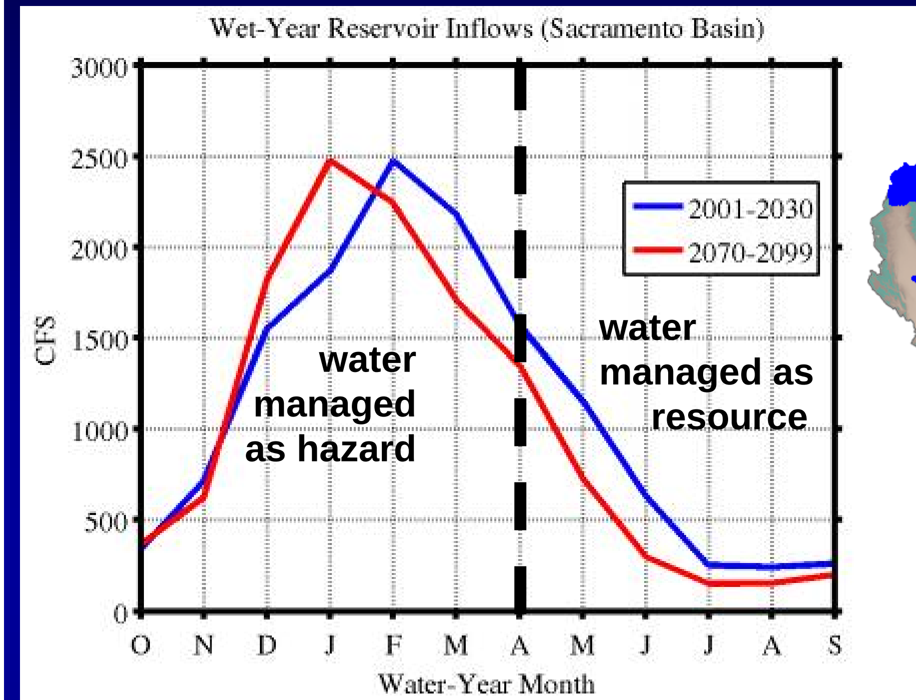


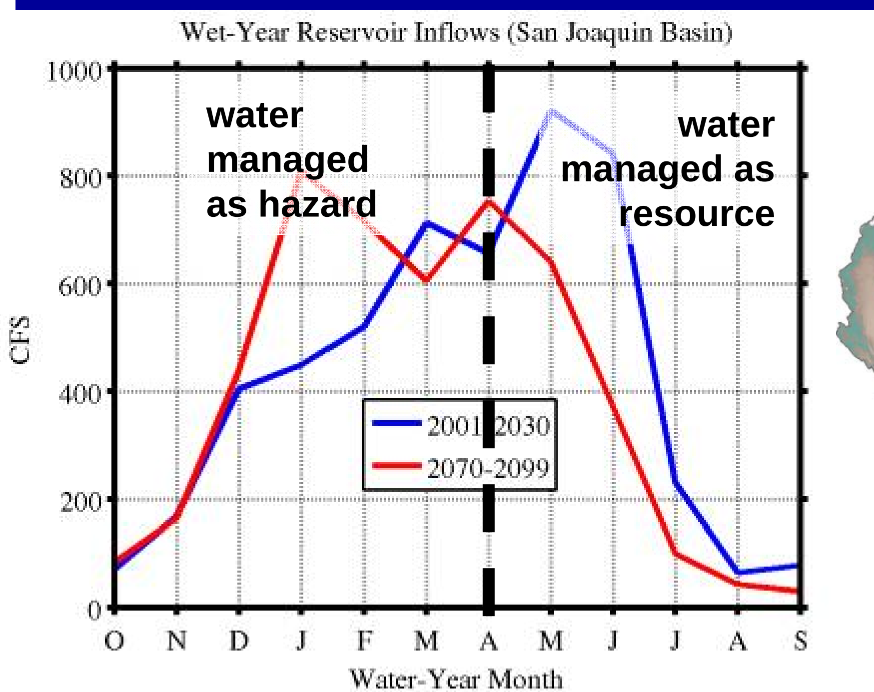
The long-term warming drives a decline of snowpacks.



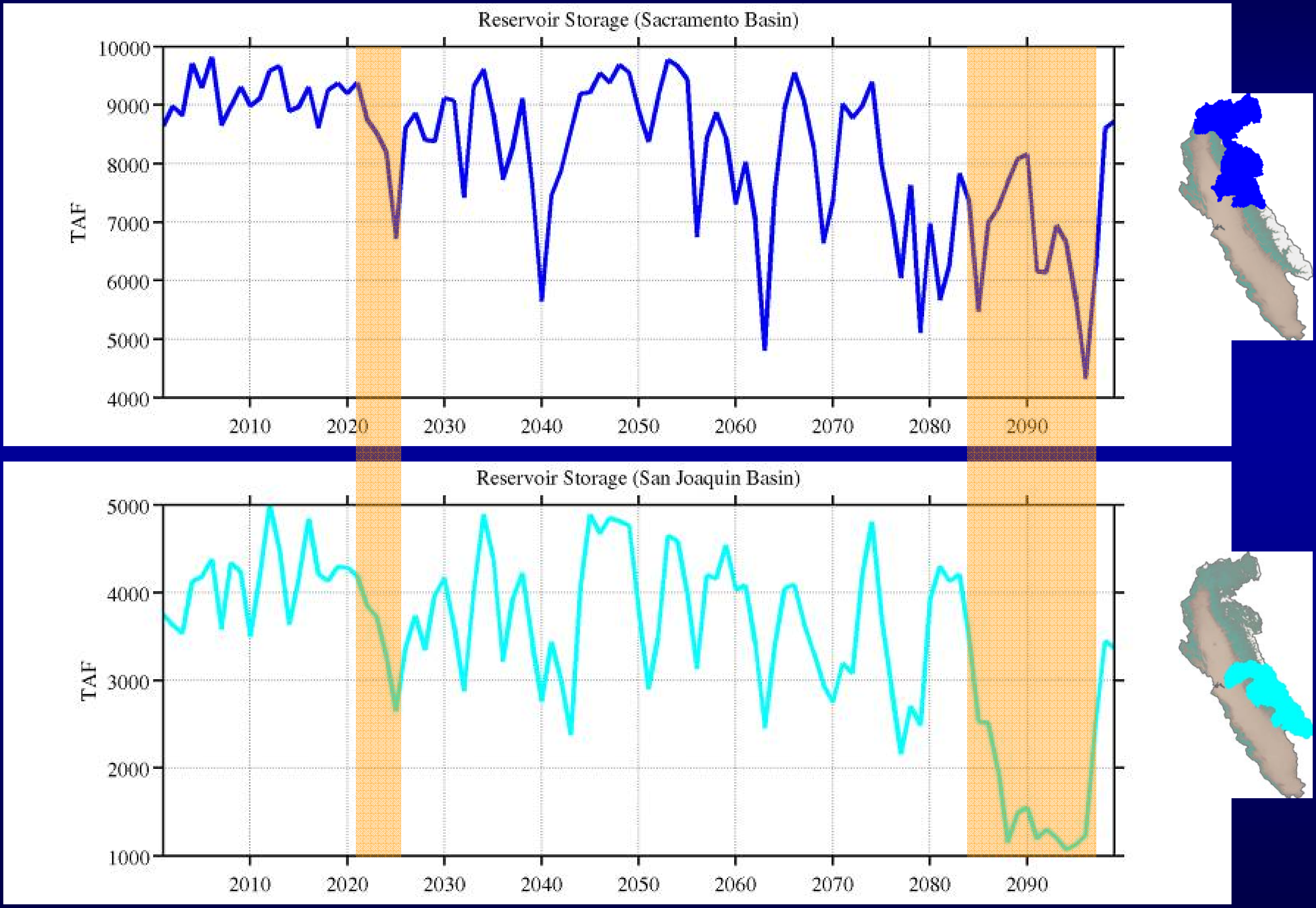


Reduces snowpack leads to earlier runoff, resulting in more water being managed as a hazard.

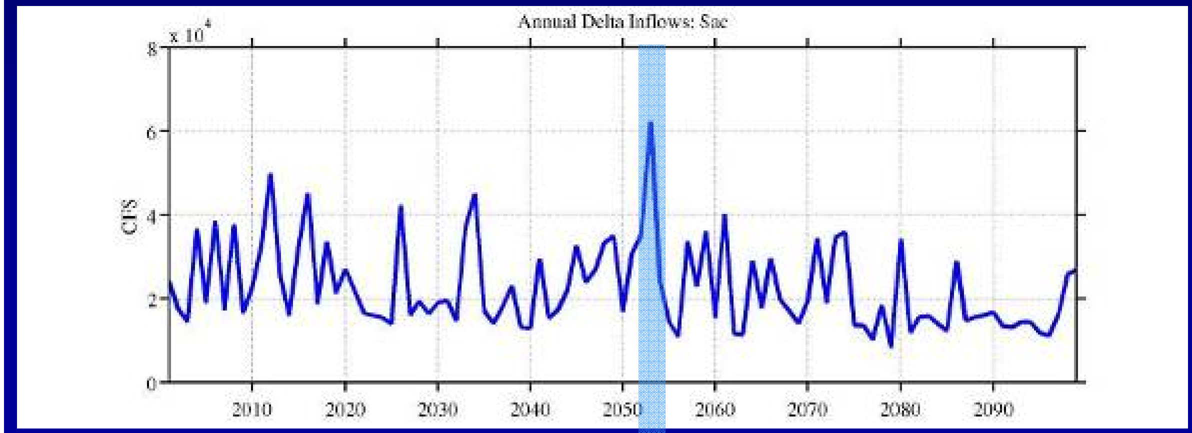


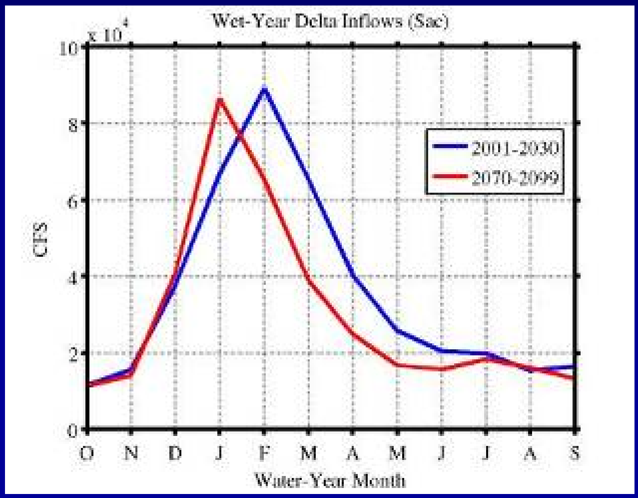


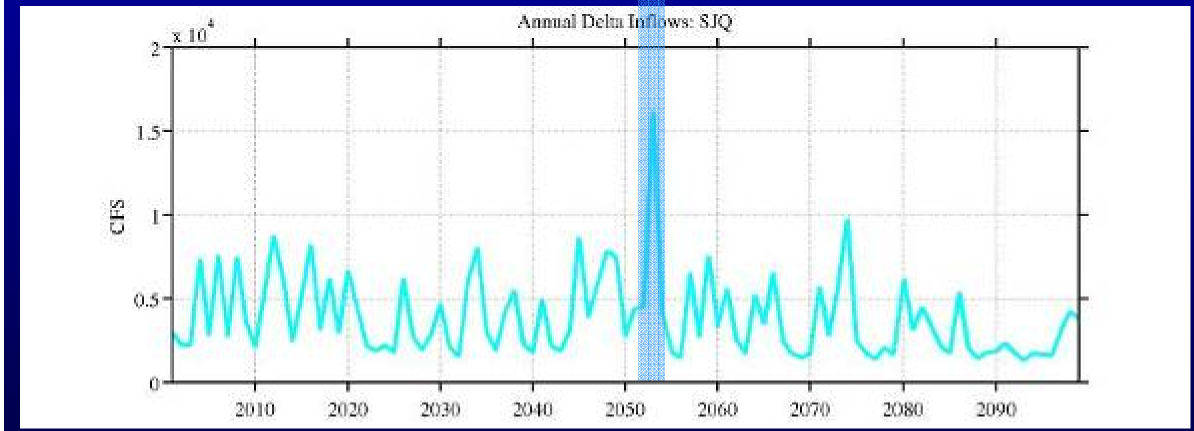
The combination of interannual inflow variability and within-year timing shifts results in emptier reservoirs.

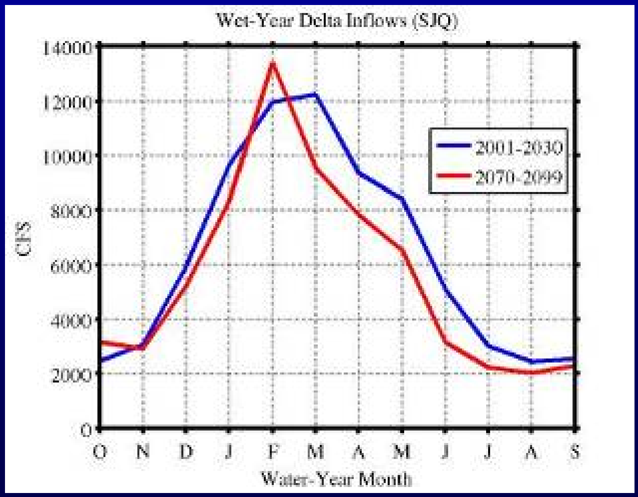


Ultimately, both the magnitude and timing of Delta inflow are affected.









Conclusions

- This approach allows the CALSIM-II operations model to be driven by 100 years of hydrology corresponding directly to the climate scenarios.

- Incorporating climate variability and change provides a dramatically different picture than climate change alone.

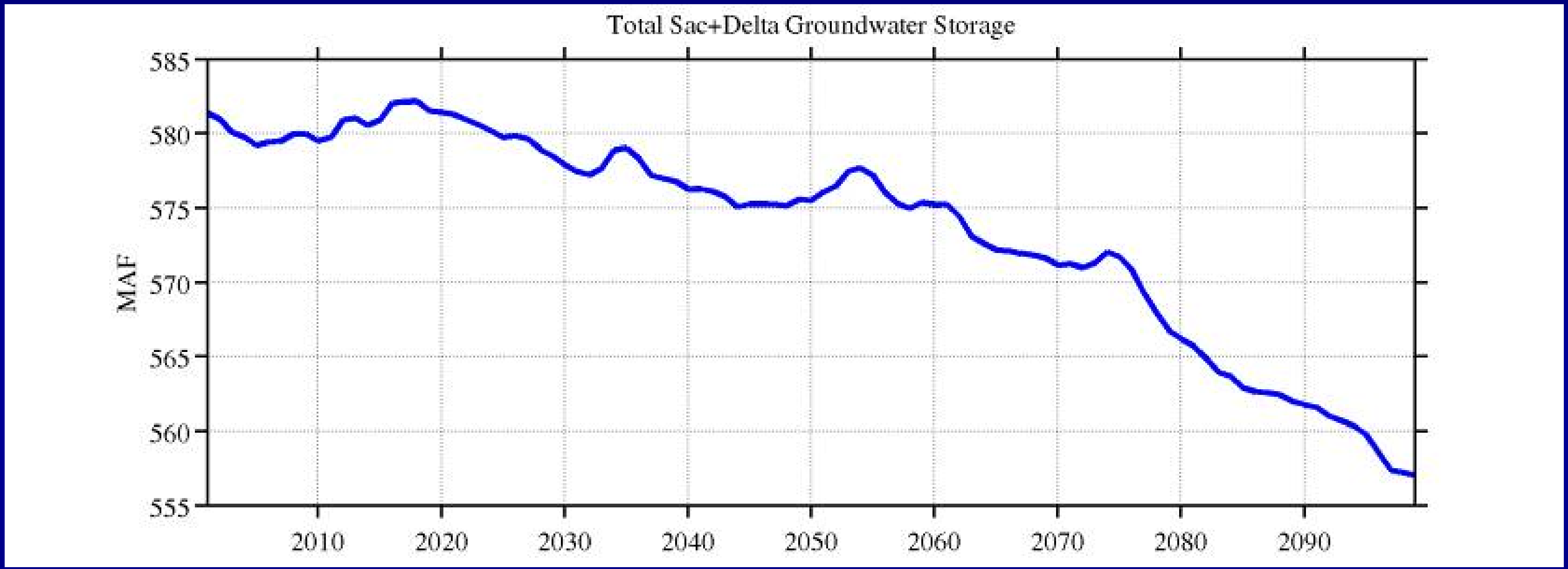
- Drought impacts on water supplies are amplified by the runoff timing shift associated with reduced snowpack.

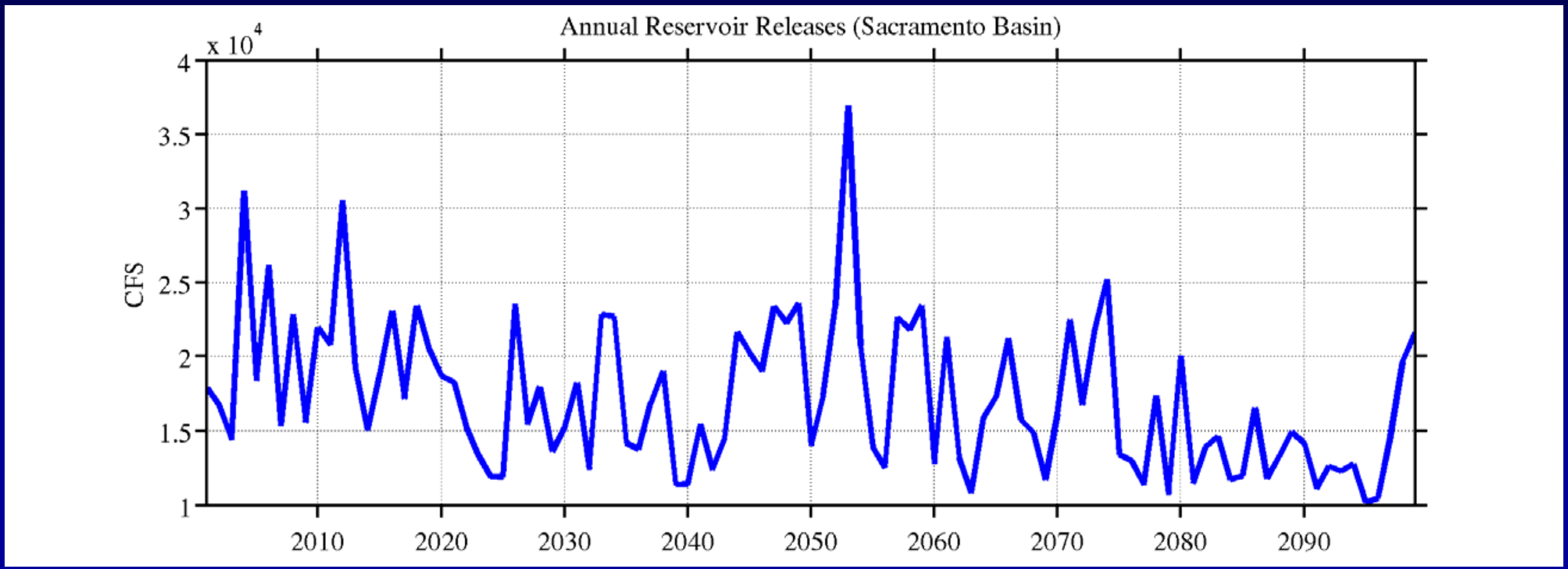
- Stream temperatures were not emphasized here but were also produced for each scenario using the USBR stream temperature model.

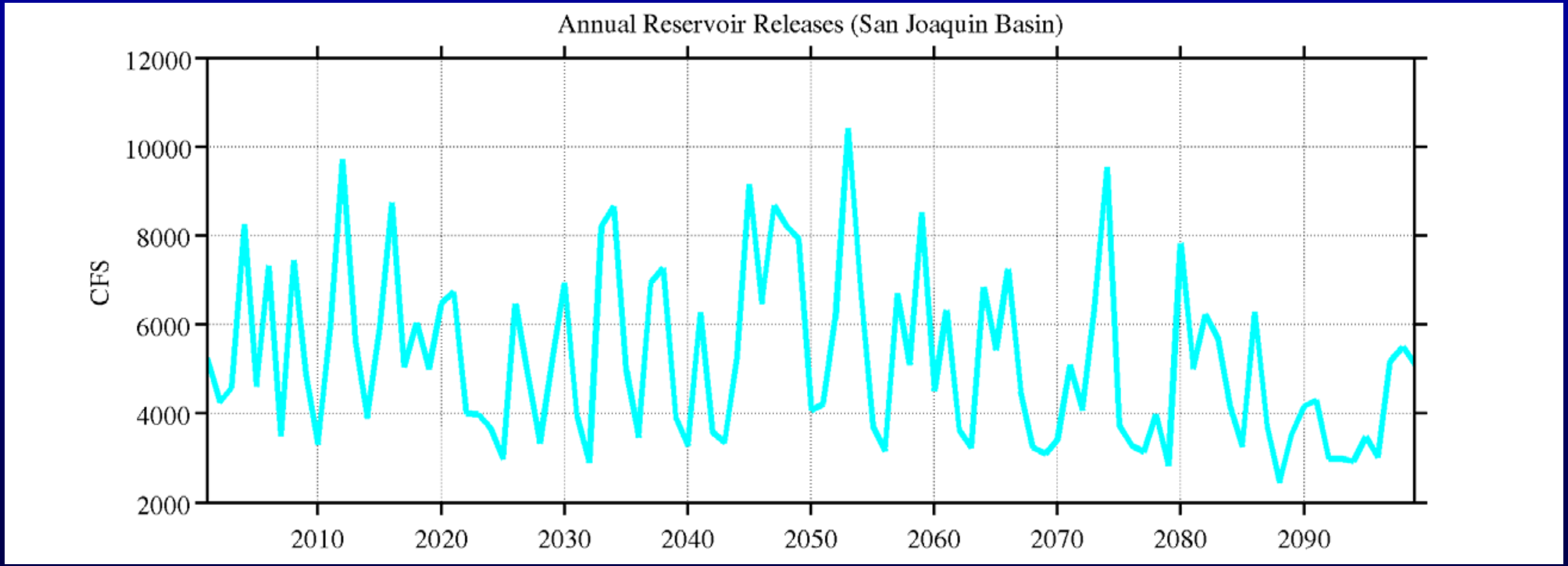
- All data are available at http://cascade.wr.usgs.gov

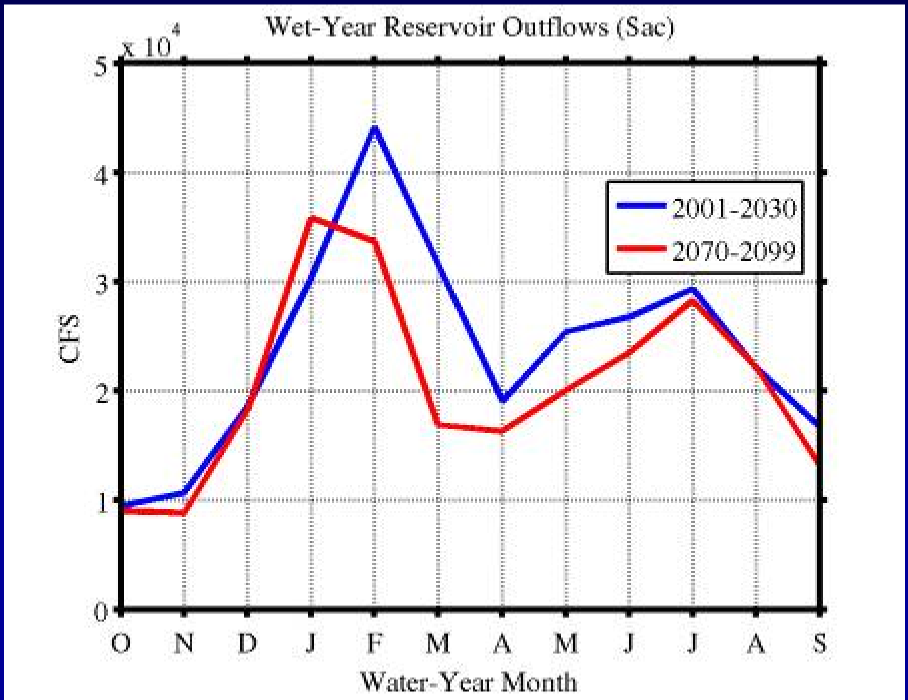
This work is funded by the CALFED Science Program through the USGS CASCaDE Project and the California Energy Commission's Public Interest Energy Research Program (PIER) through the California Climate Change Center at Scripps Institution of Oceanography.

Groundwater pumping at unsustainable rates masks flow reductions.

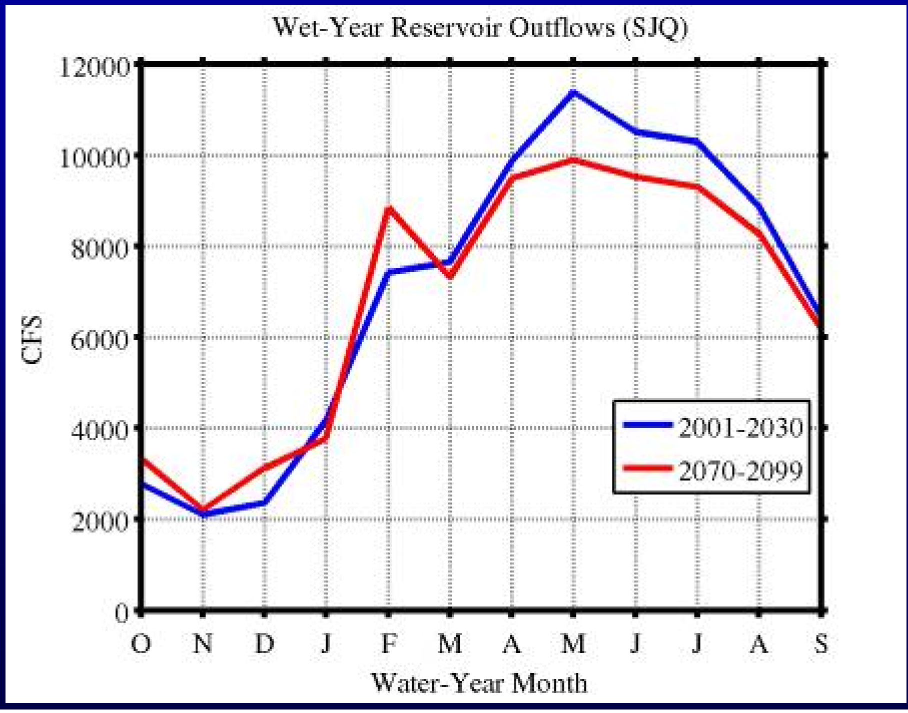



Annual Reservoir Releases (Sacramento Basin)
x 10^4
CFS
4
3.5
3
2.5
2
1.5
1
2010
2020
2030
2040
2050
2060
2070
2080
2090


Annual Reservoir Releases (San Joaquin Basin)
CFS
12000
10000
8000
6000
4000
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090



Wet-Year Reservoir Outflows (Sac)
x 10^4
CFS
2001-2030
2070-2099
0
1
2
3
4
5
O N D J F M A M J J A S
Water-Year Month



Wet-Year Reservoir Outflows (SJQ)
CFS
2001-2030
2070-2099
0
2000
4000
6000
8000
10000
12000
O N D J F M A M J J A S
Water-Year Month

CALSIM Output is used to drive USBR stream temperature model.