

CalSim 3 GW-DLL Calibration

CWEMF 2026

April 22, 2026

Presenters:

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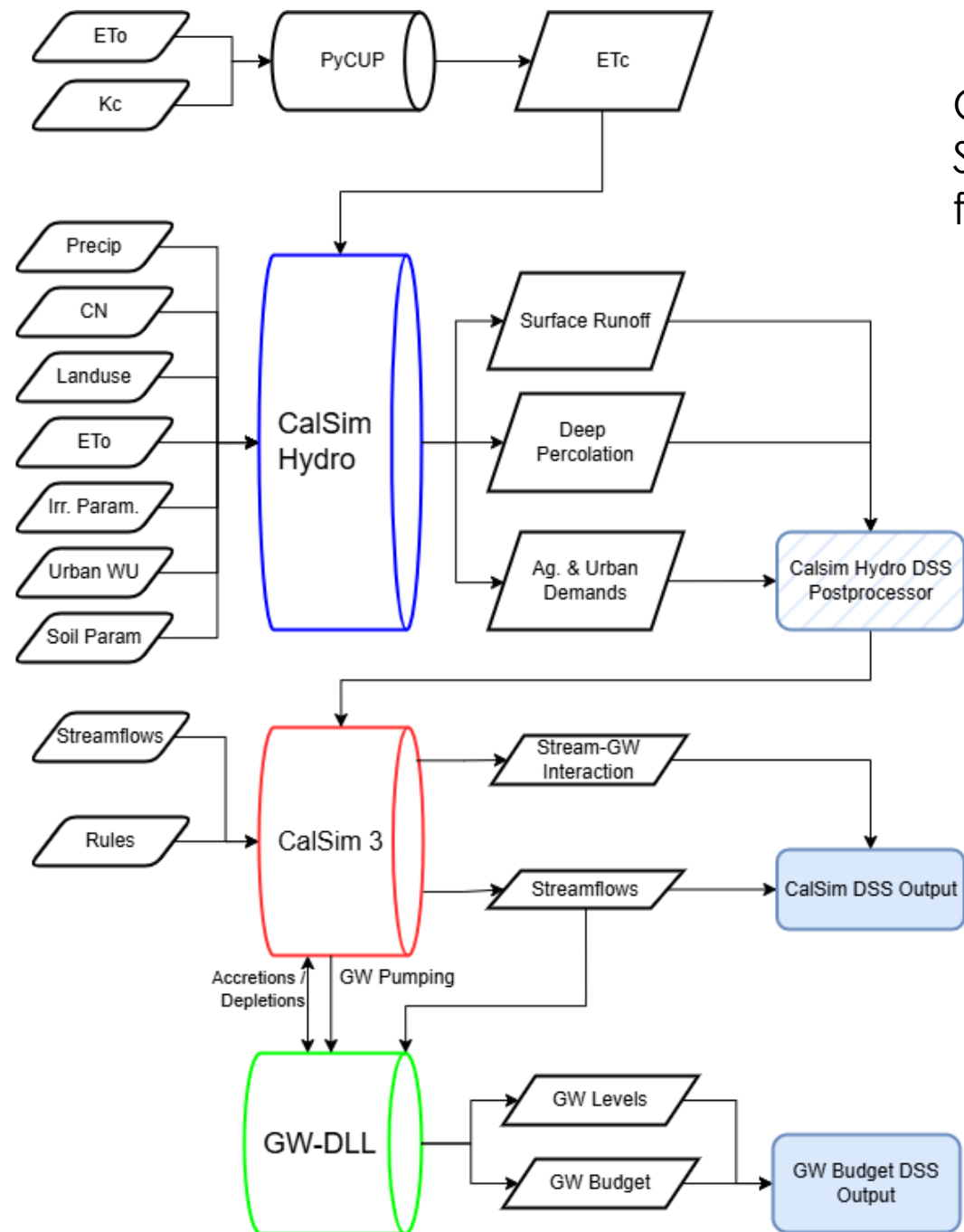


Background and Motivation



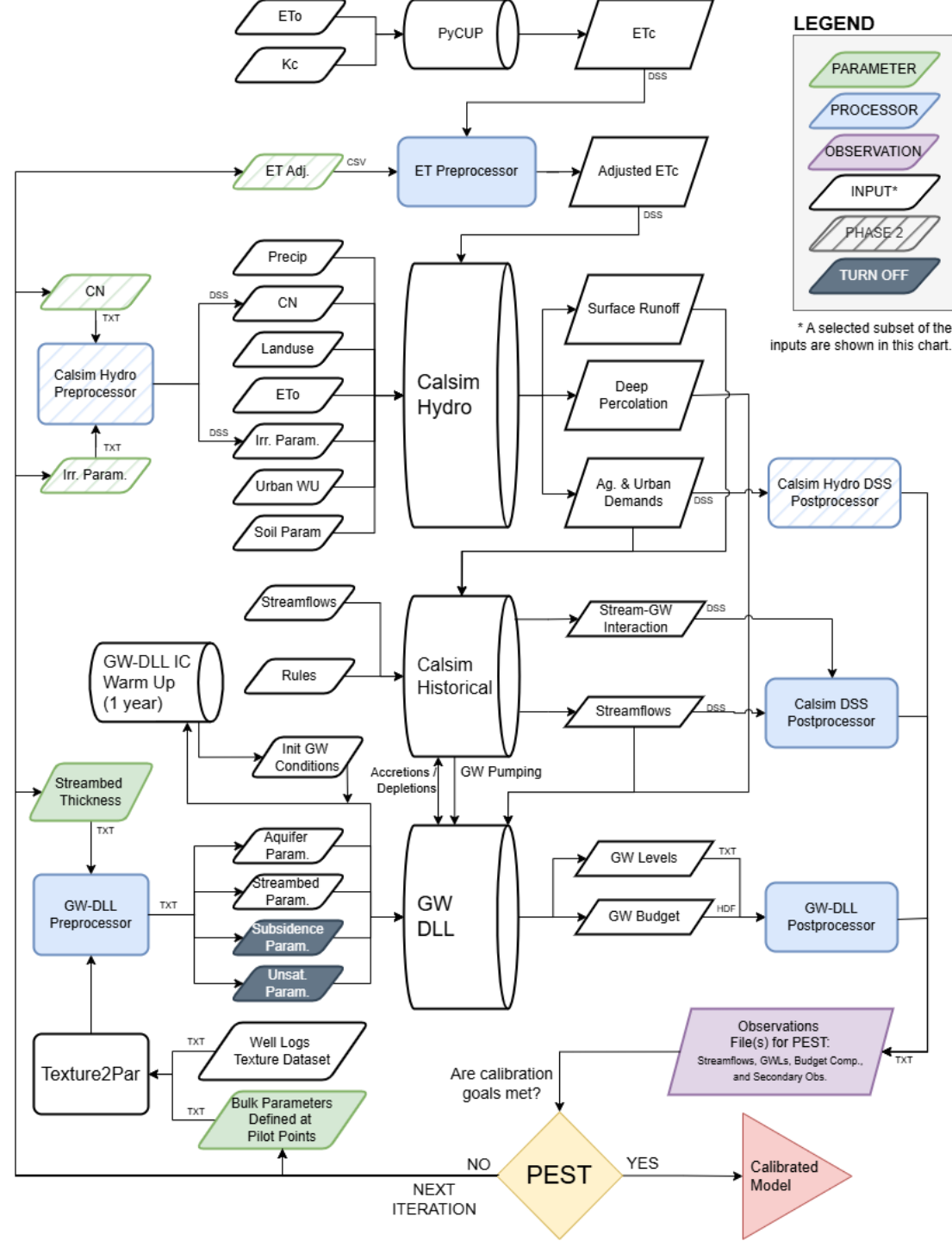
- Flows and reservoir conditions simulated by CalSim are directly influenced by the GW conditions simulated by GW-DLL
- DWR developed new GW-DLL for CalSim 3
- An integrated calibration of CalSim Hydro and the GW-DLL parameters was never performed for CalSim 3
- Challenges with modeling extreme climate change scenarios and validating streamflows in CalSim 3

CalSim 3 Workflow



CalSim receives the Stream-GW exchange from GW-DLL

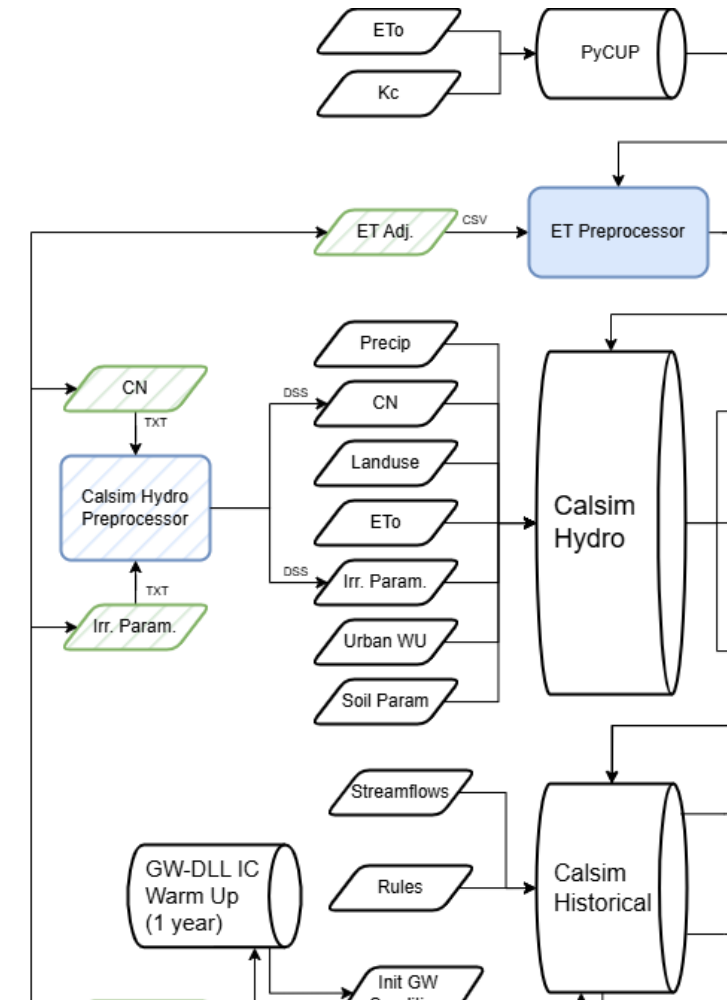
PEST Setup



Surface Water Parameters for calibration

1. Curve Numbers (CN)

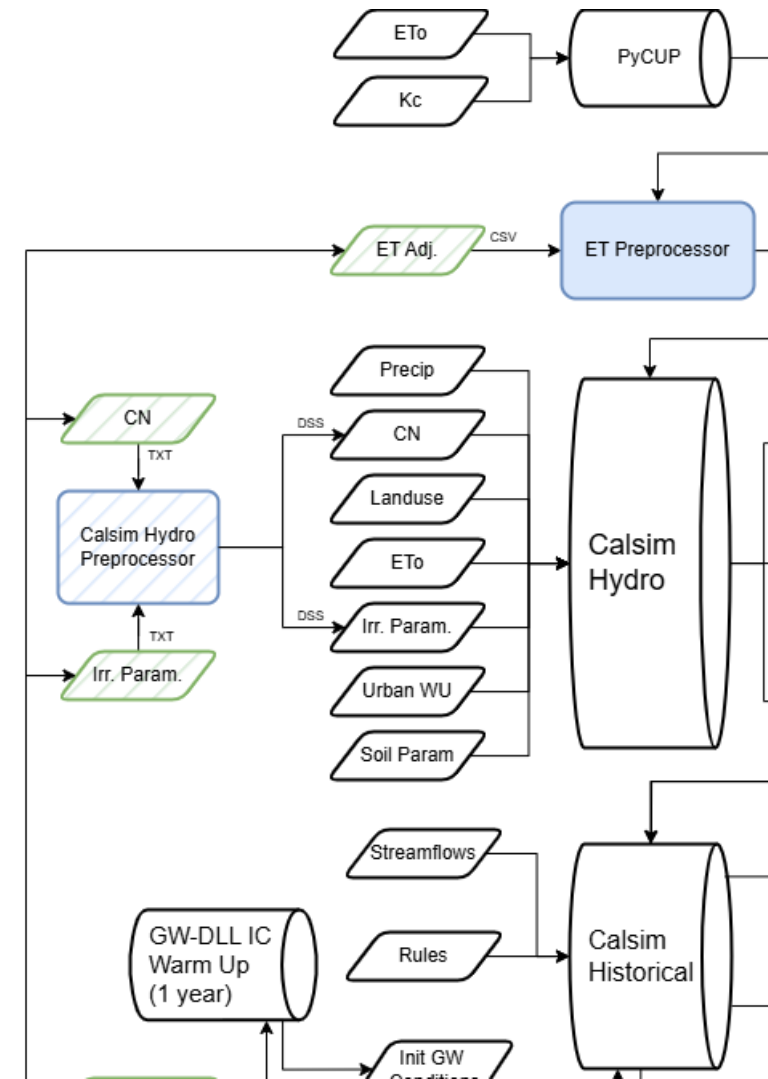
- In CalSim Hydro, Curve Numbers (CNs) are used to represent land-surface runoff response using the SCS Curve Number method
- Dimensionless parameters (30 to 95 range)
- Treated as adjustable parameters in calibration to:
 - Improve fit to observed streamflow
 - Maintain consistency with groundwater heads and water balance



Surface Water Parameters for calibration

2. ET Adjustment

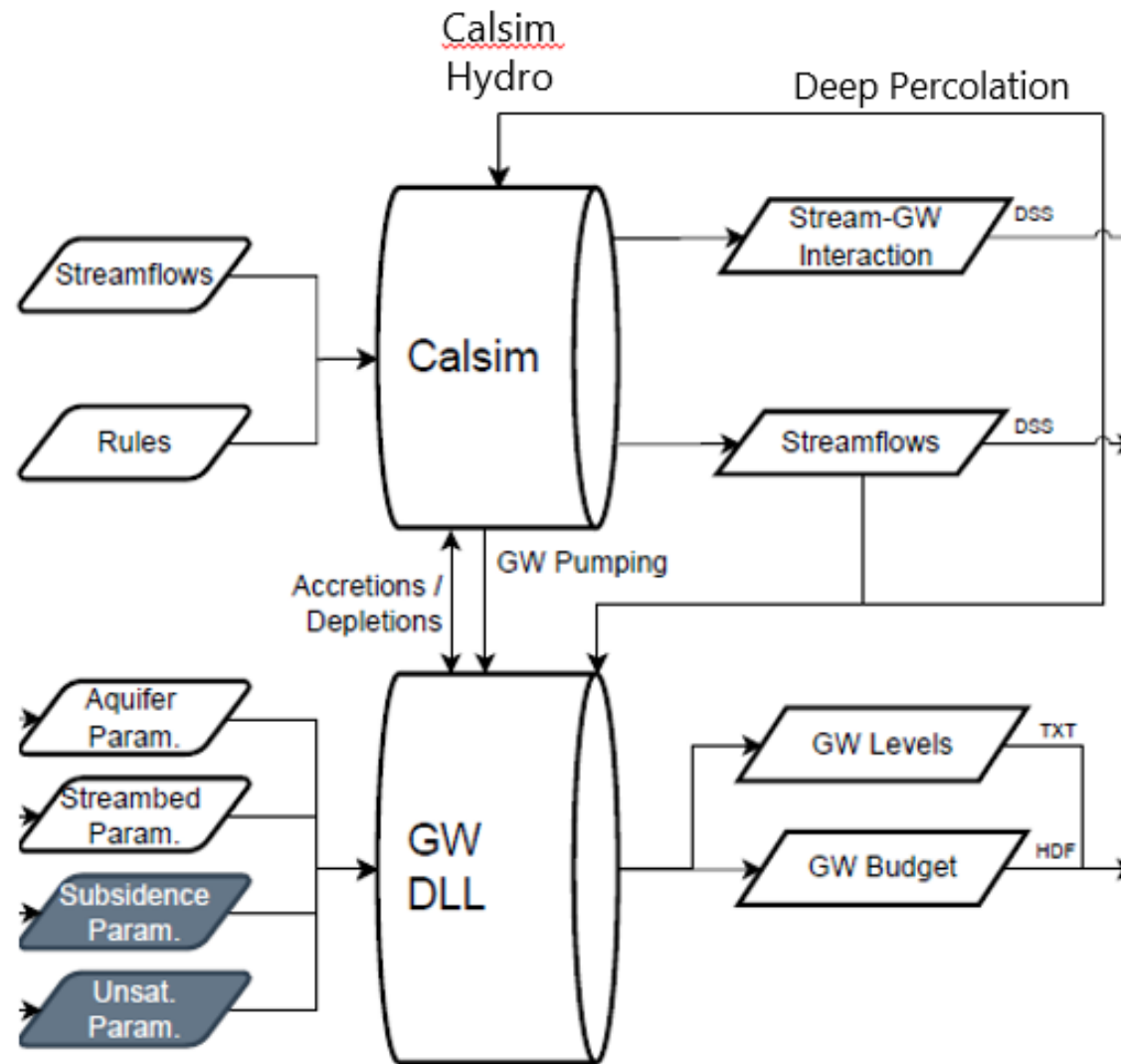
- Crop evapotranspiration (ET) is a major driver of consumptive water use and directly controls irrigation demand, soil moisture, and groundwater recharge
- The range of adjustments applied is -20% to +5%.
- An adjustment multiplier was used to calibrate crop ET outputs from PyCup to:
 - Represent local condition
 - Improve model fit and water balance
 - Impacts both surface and groundwater balance



Groundwater Parameters

3. GW-DLL Parameters

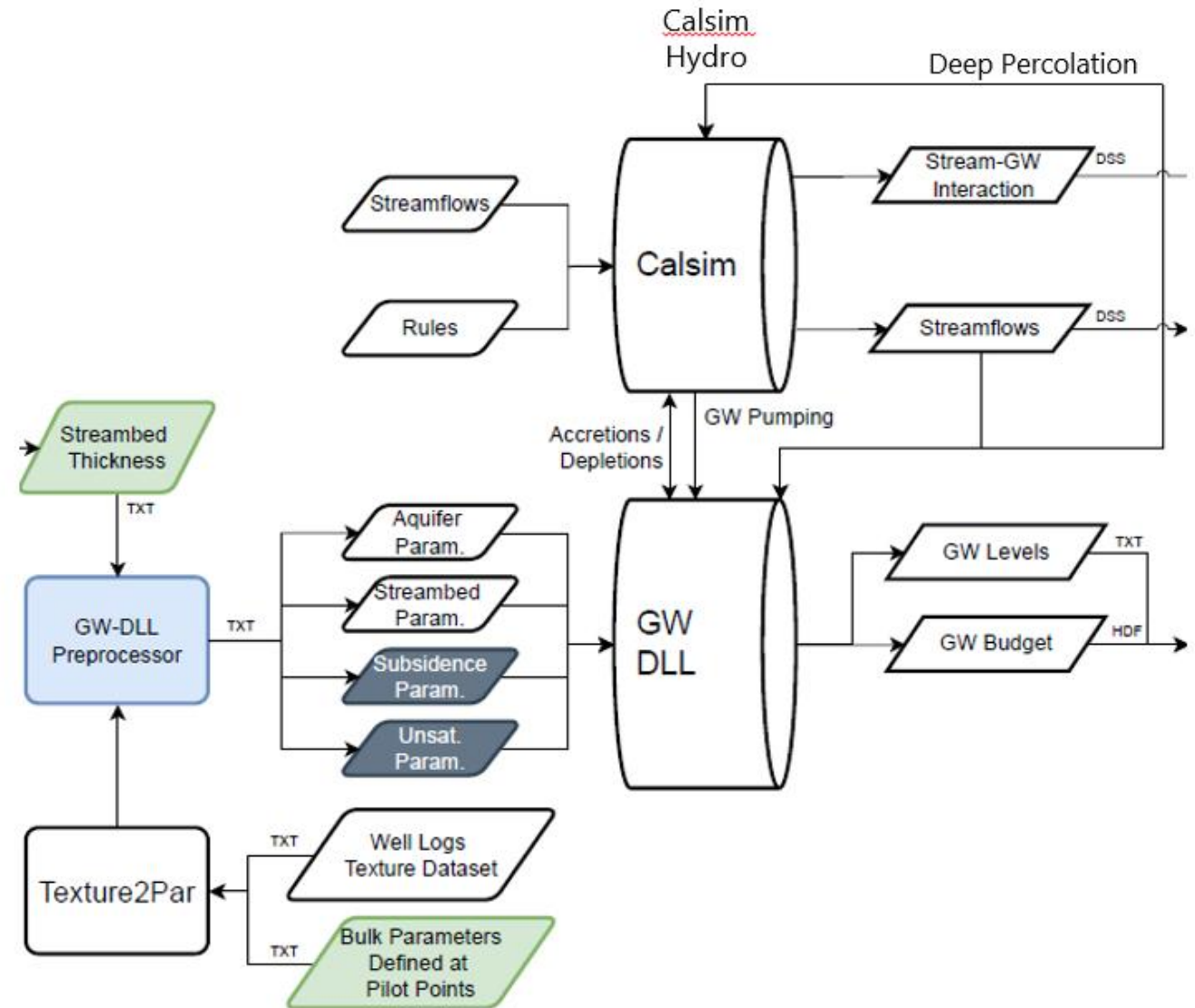
- Aquifer Hydraulic Parameters and Streambed Parameters are defined in GW-DLL input files by each node.



Texture2Par & Preprocessor

3. GW-DLL Parameters

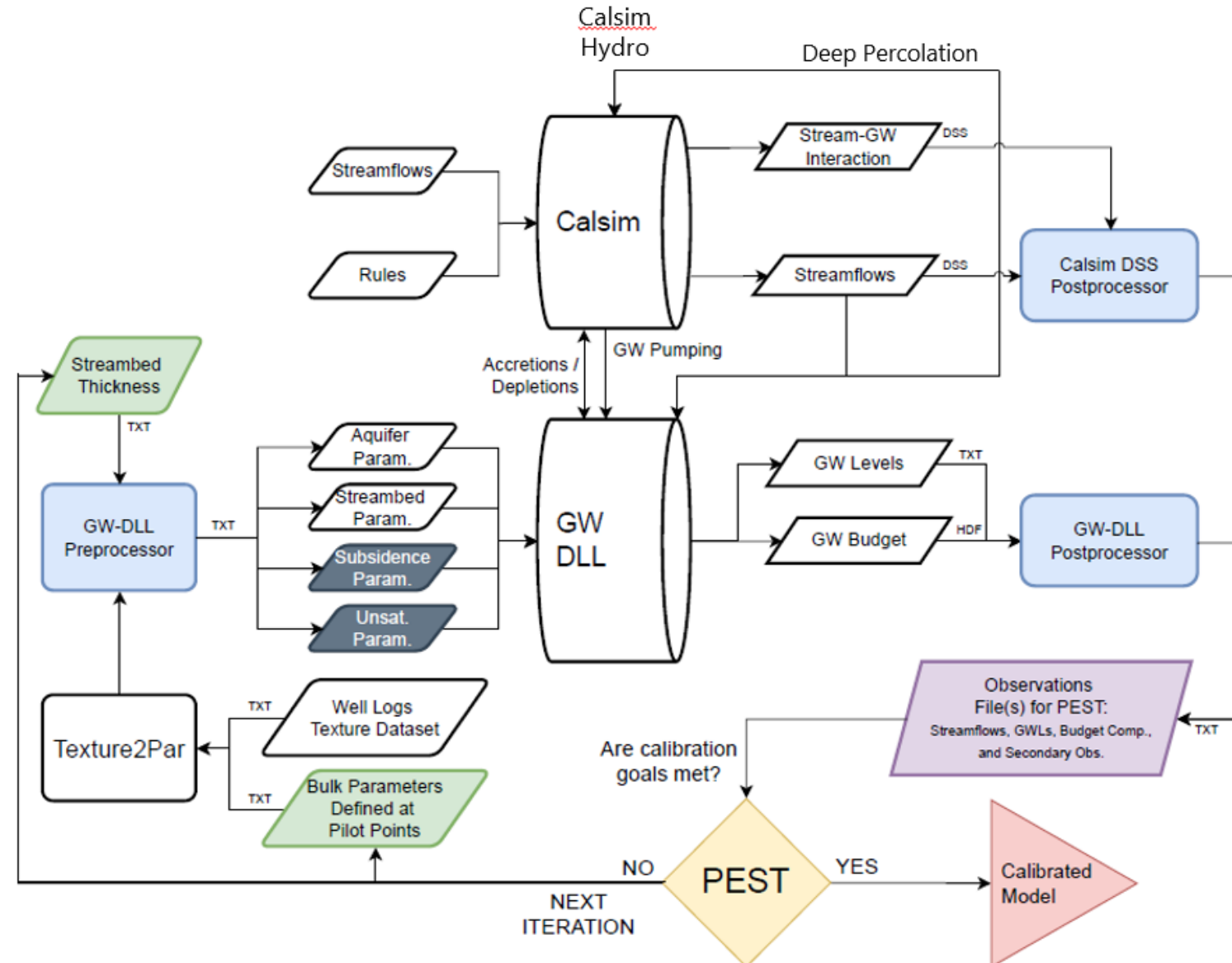
- Texture2Par enables the estimation of the aquifer parameters based on the borehole texture data and bulk parameters at Pilot Points.
- GW-DLL Preprocessor links streambed conductivity to Layer 1 Kv and the streambed thickness values to calculate conductance.



PEST++-IES

3. GW-DLL Parameters

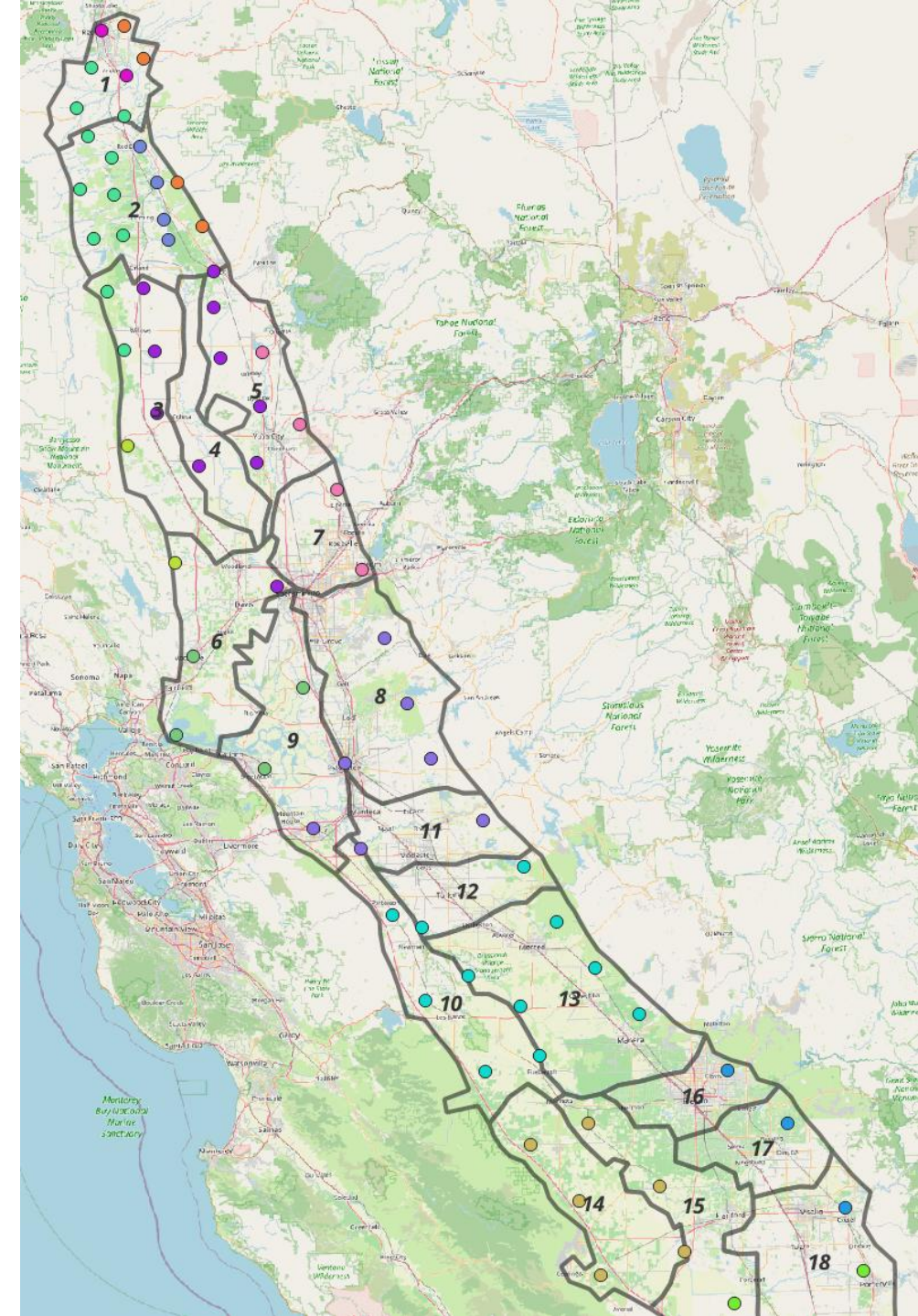
- Streambed thickness by each reach, and bulk parameters at each pilot point are defined as parameters in PEST++-IES.



Pilot Points

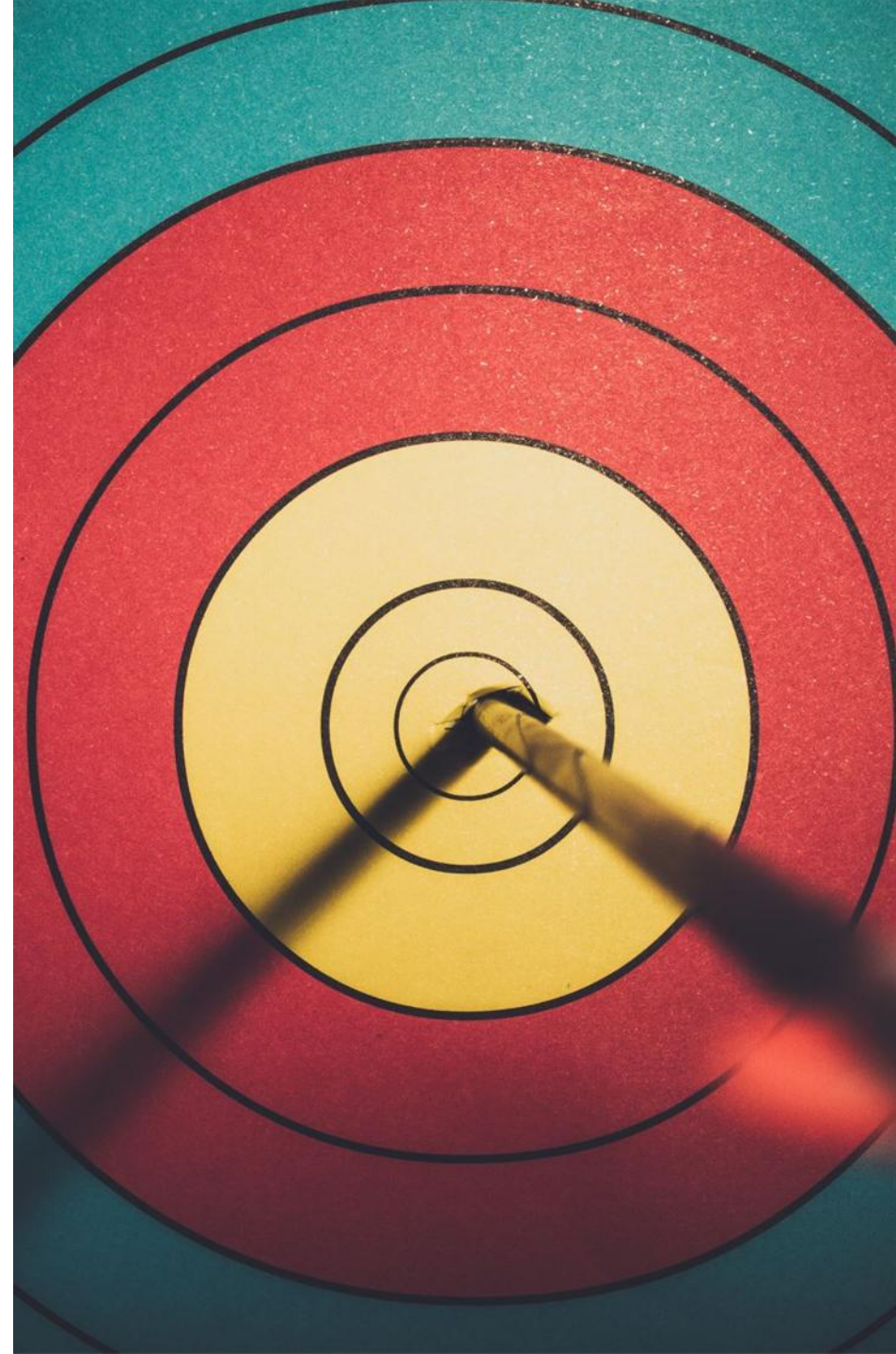
3. GW-DLL Parameters

- Started with 63 Pilot Points, all grouped together
- Gradually increased to 80 Pilot Points, 13 groups
- Most changes are in Northern Sacramento Valley



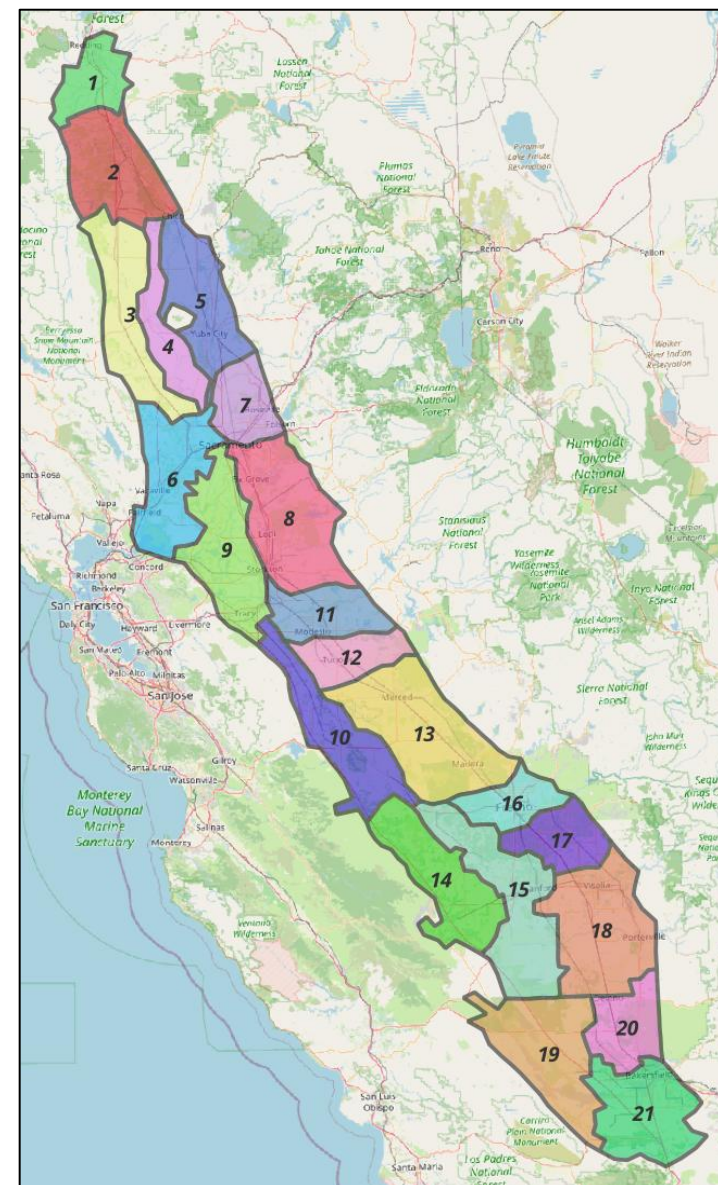
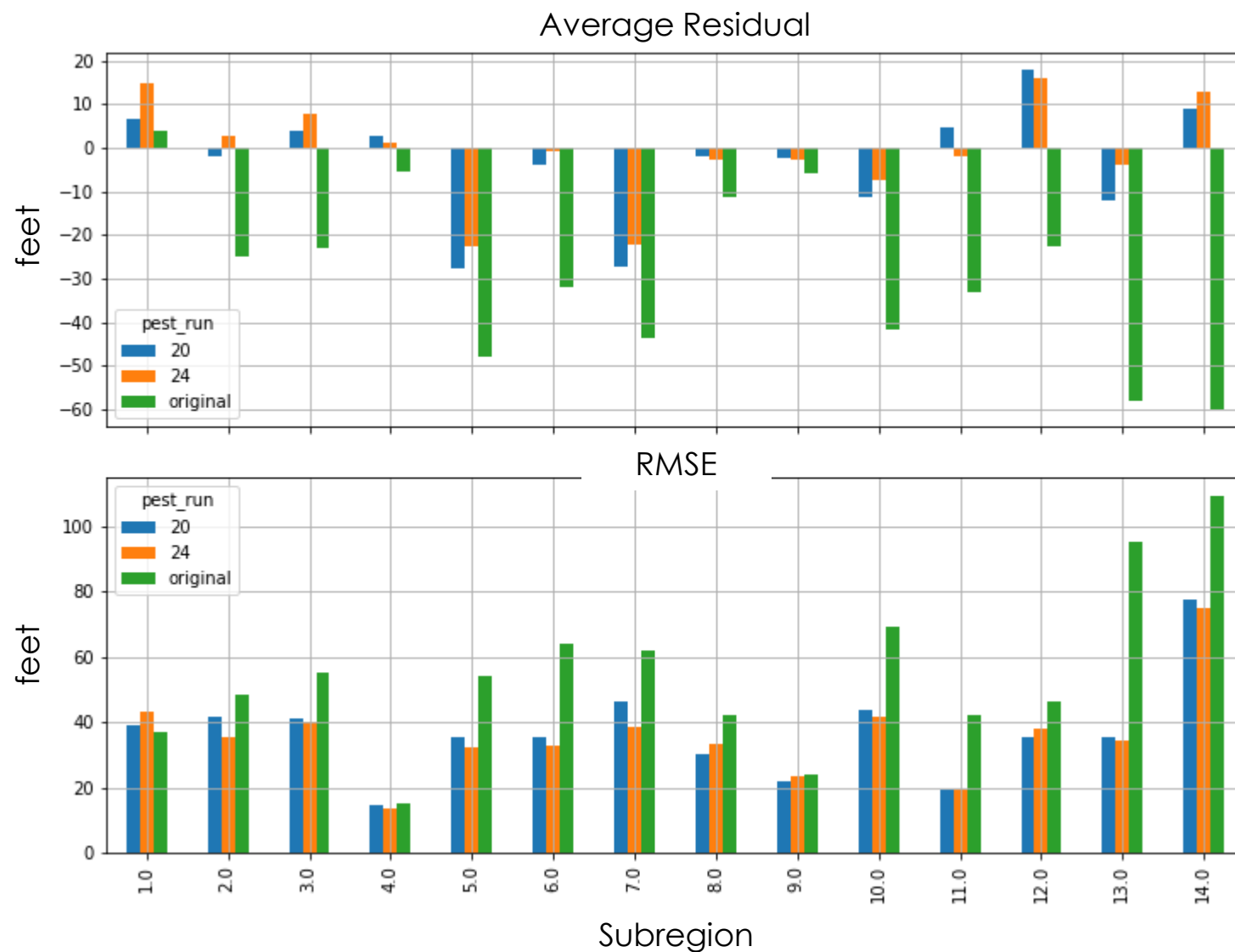
PEST Observations

- For calibration (non-zero weighted):
 - GW Heads:
 - 2,150 Locations
 - 108,900 Primary Obs.
 - 132,700 Secondary Obs.
 - Closure Terms: 15 Locations x 252 time steps
 - Streamflow errors: 38 Locations in addition to Closure Terms
- For tracking (zero weighted):
 - Channel Flows: 17 Locations
 - Stream Gain: 939 Stream Nodes
 - GW Storage Change, Pumping, Deep Percolation: 21 Subregions



WORK IN PROGRESS

Groundwater Level Calibration

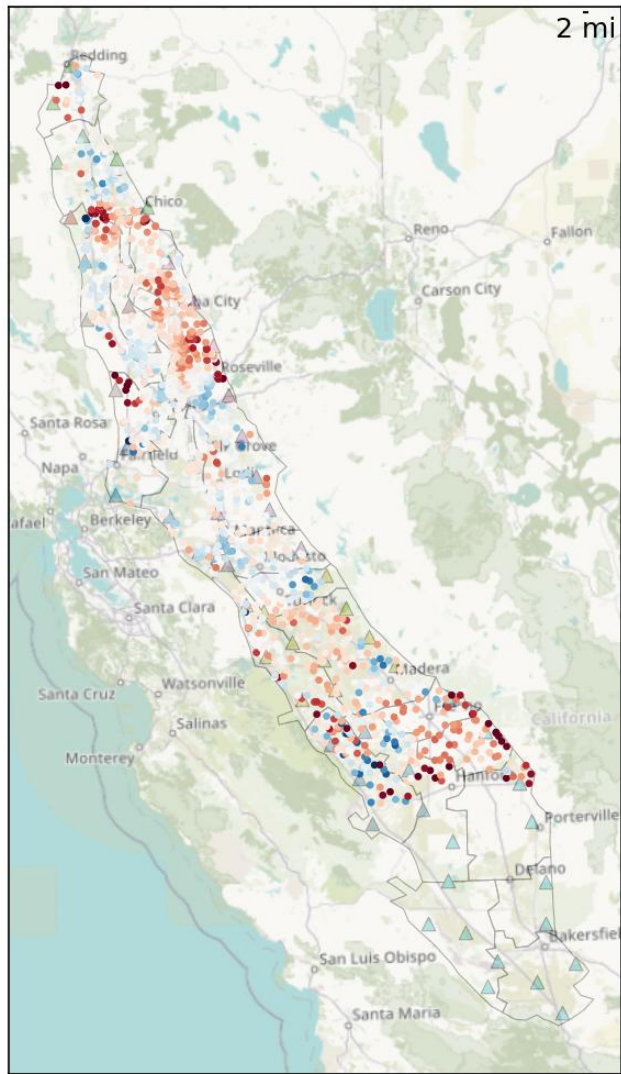


WORK IN PROGRESS

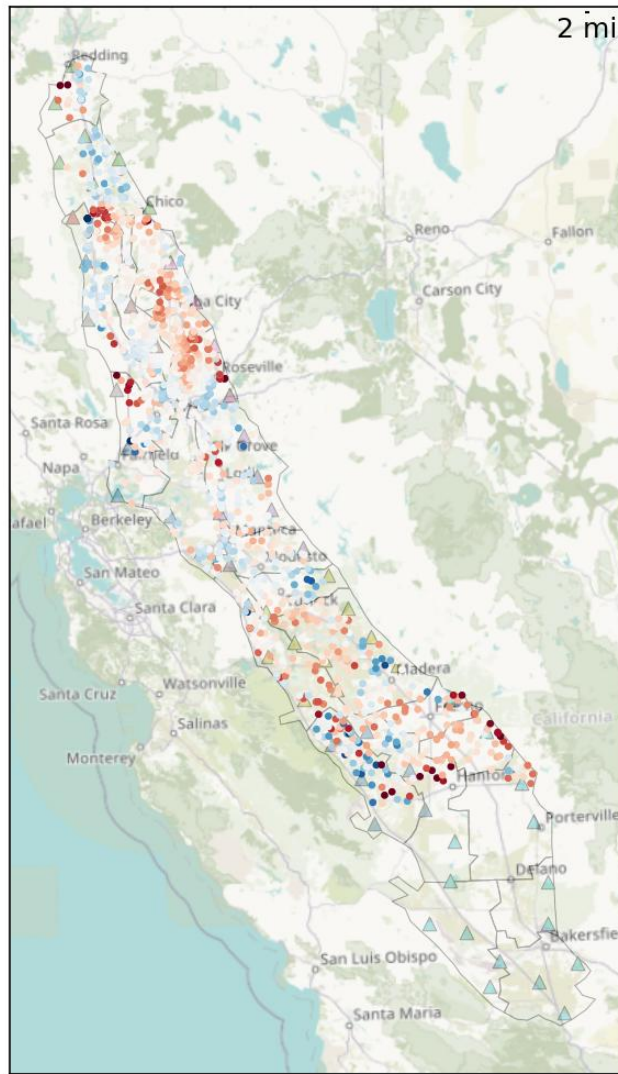
Groundwater Level Calibration

Average Residual

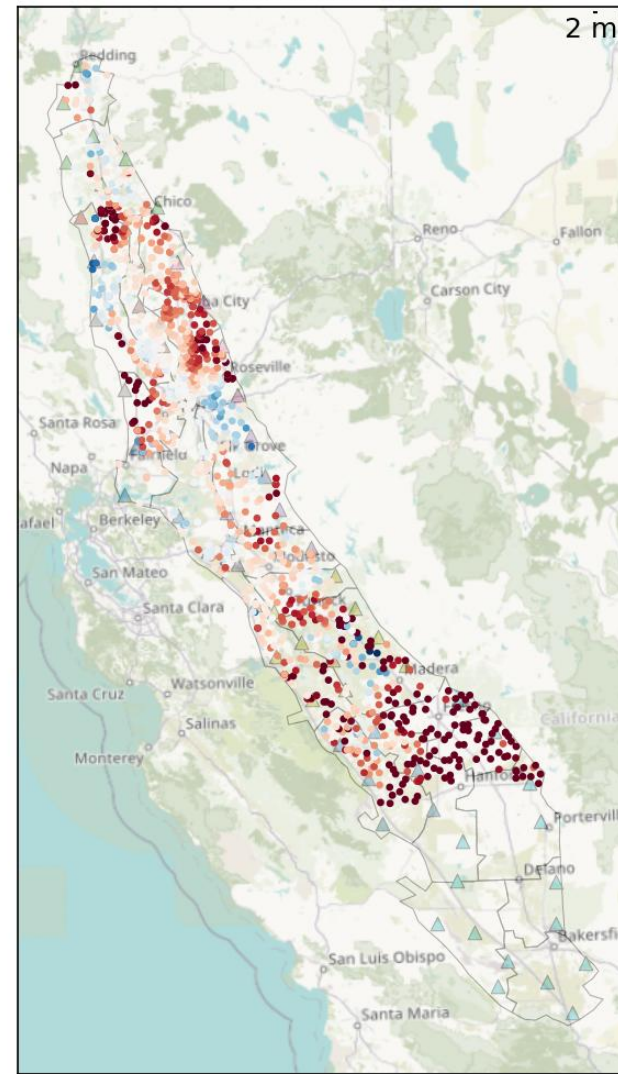
Run_20



Run_24



Run_original



Overestimation

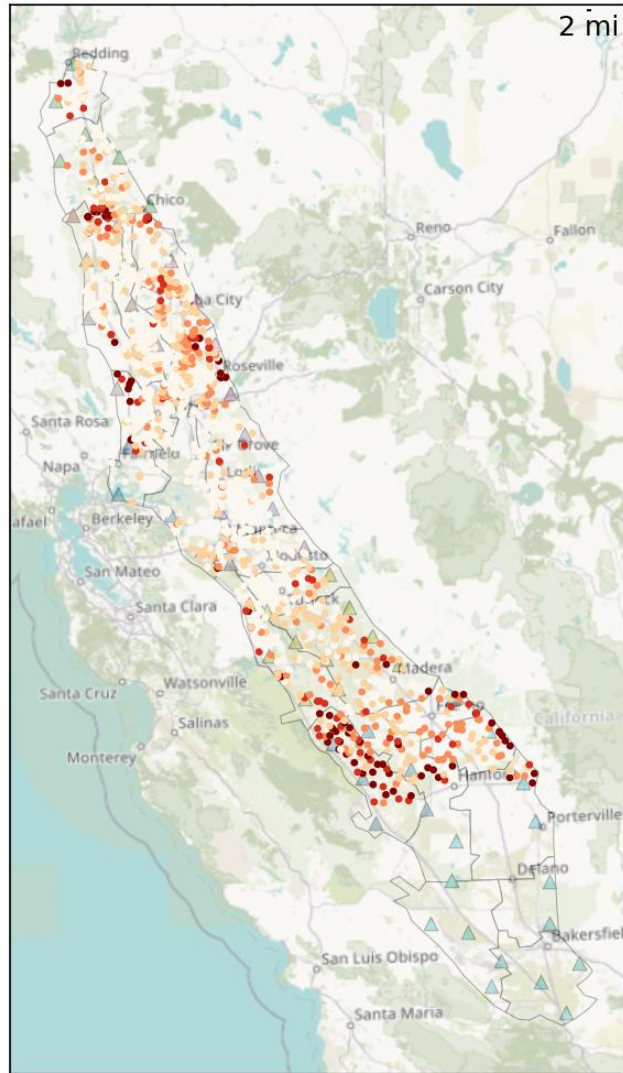
On Point 😎

Underestimation

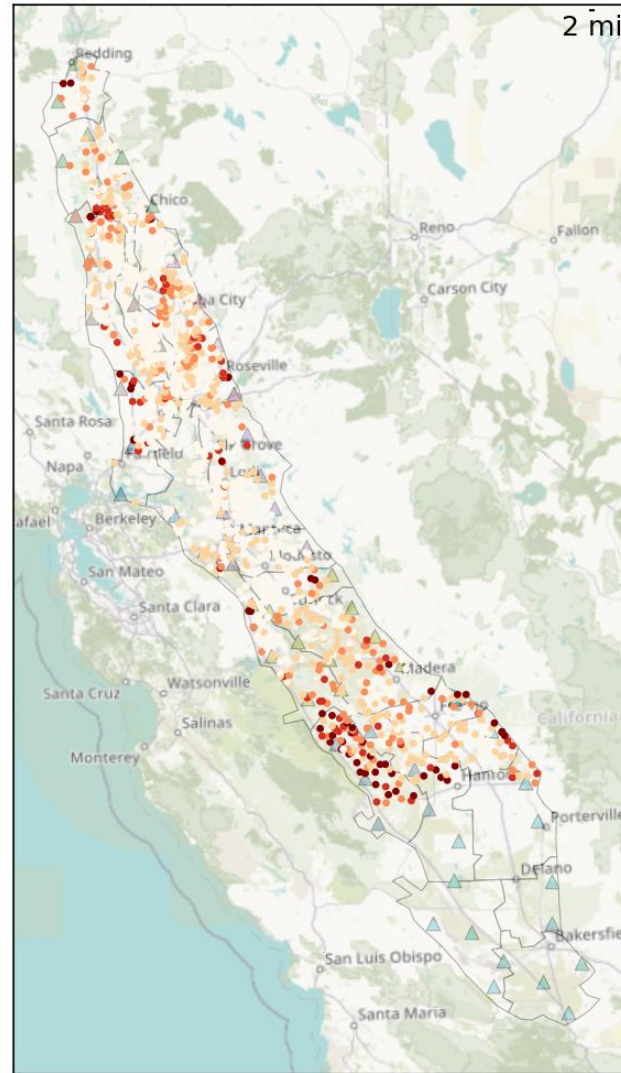
WORK IN PROGRESS

Groundwater Level Calibration RMSE

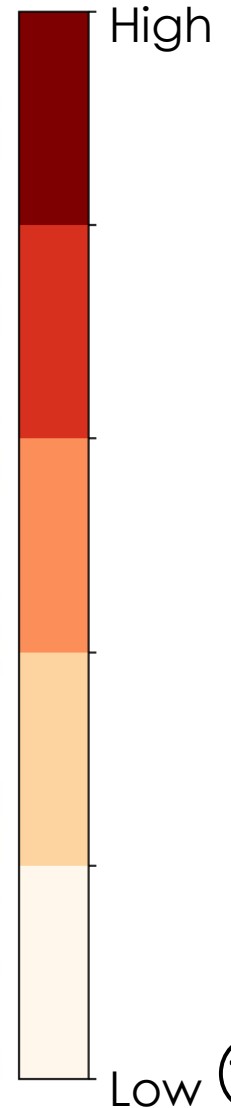
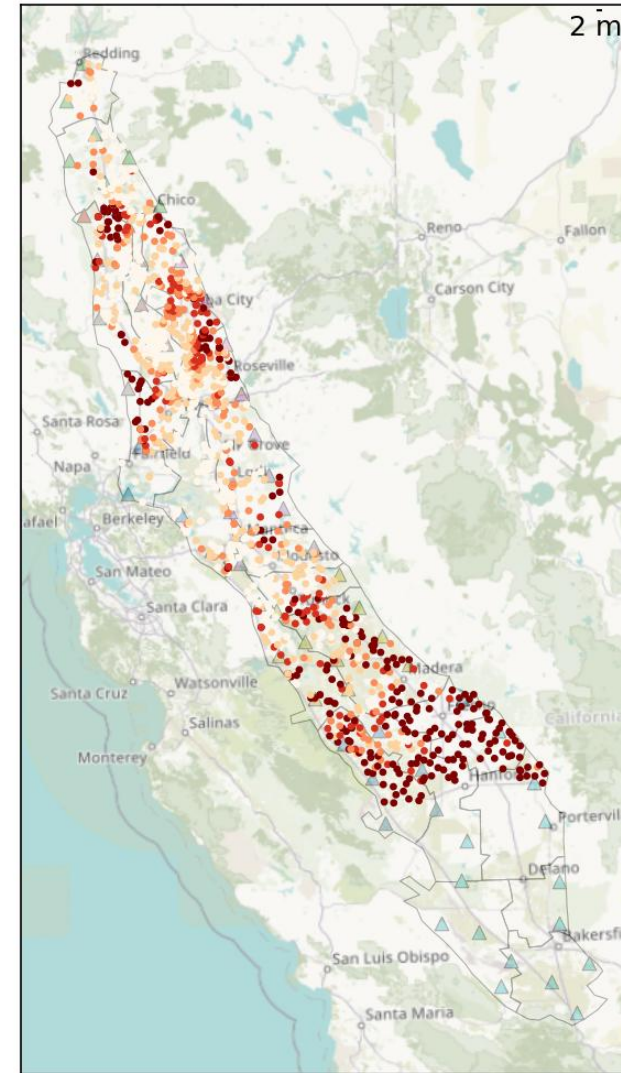
Run_20



Run_24



Run_original

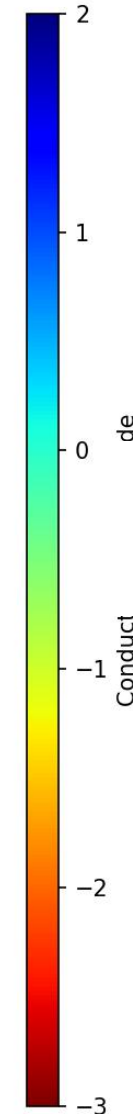
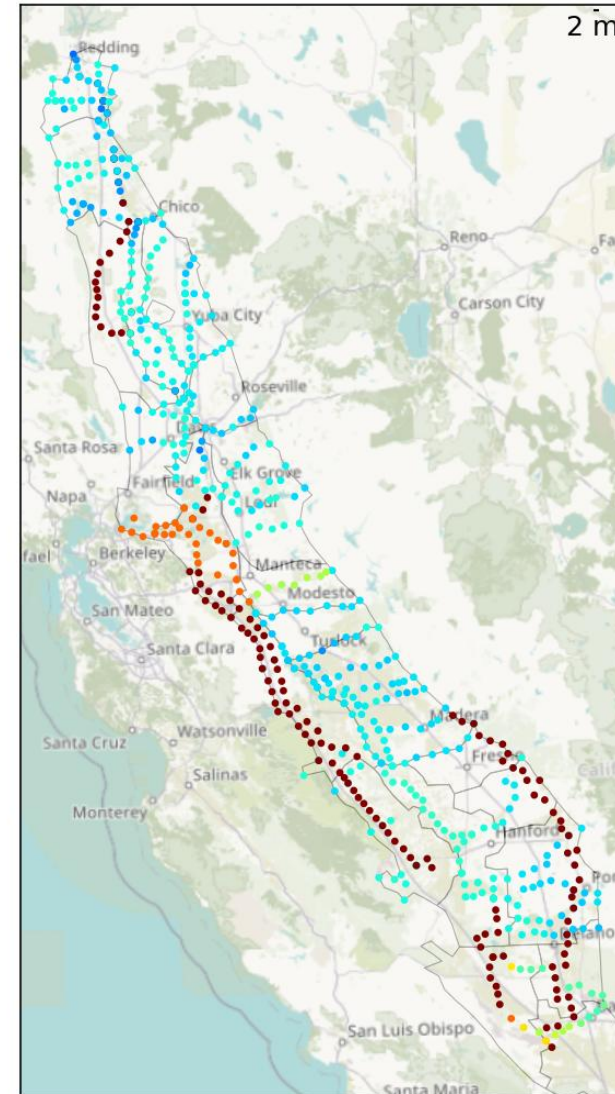
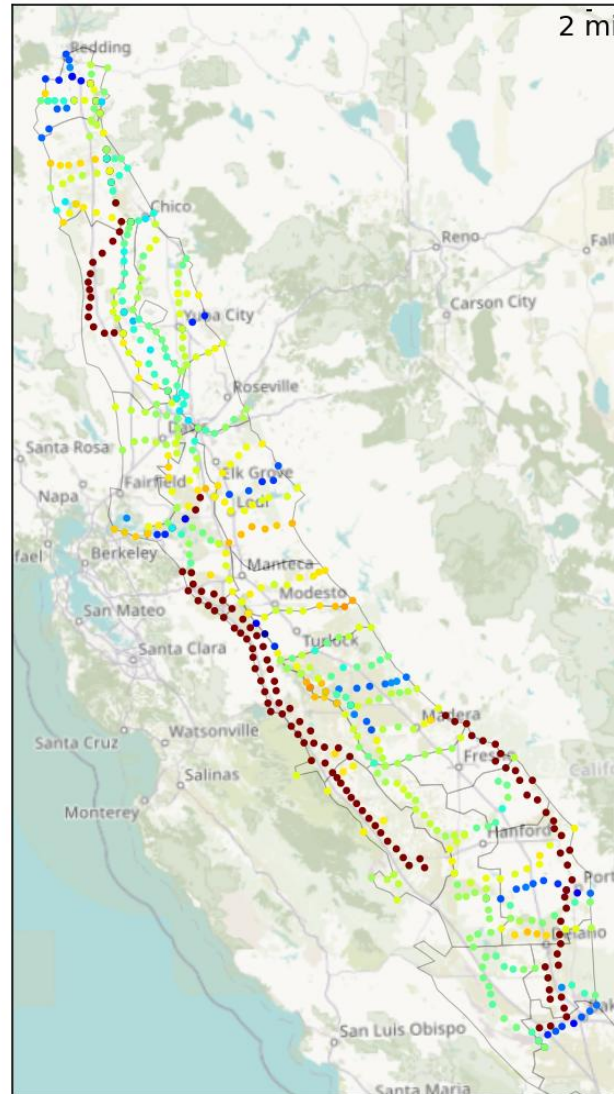


WORK IN PROGRESS

Streambed Conductance

Run 24

Original



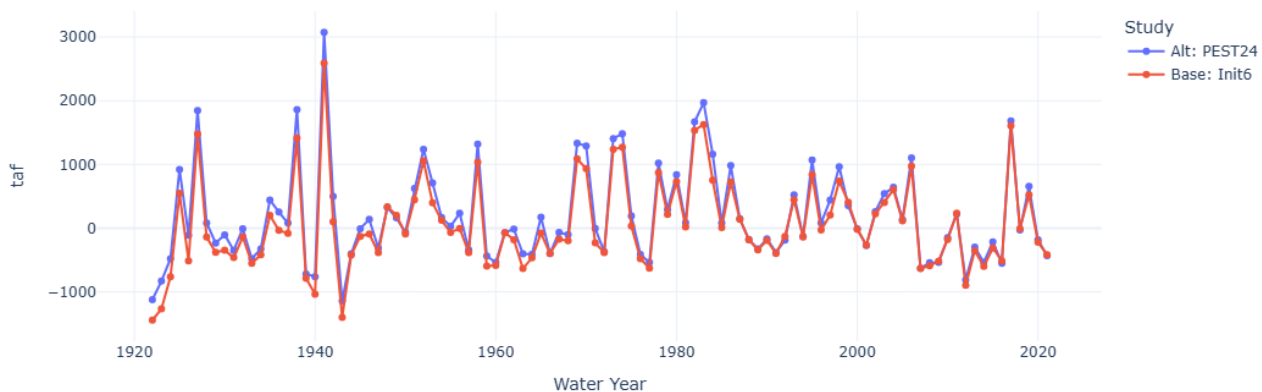
Log-scale
[1/day]

WORK IN PROGRESS

Closure Terms

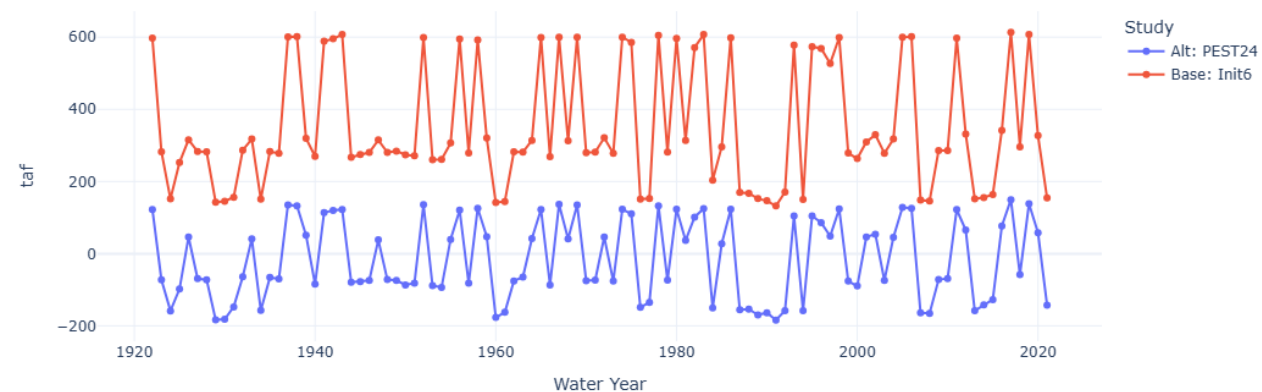
CT_SACBASIN Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



CT_SJRBASIN Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



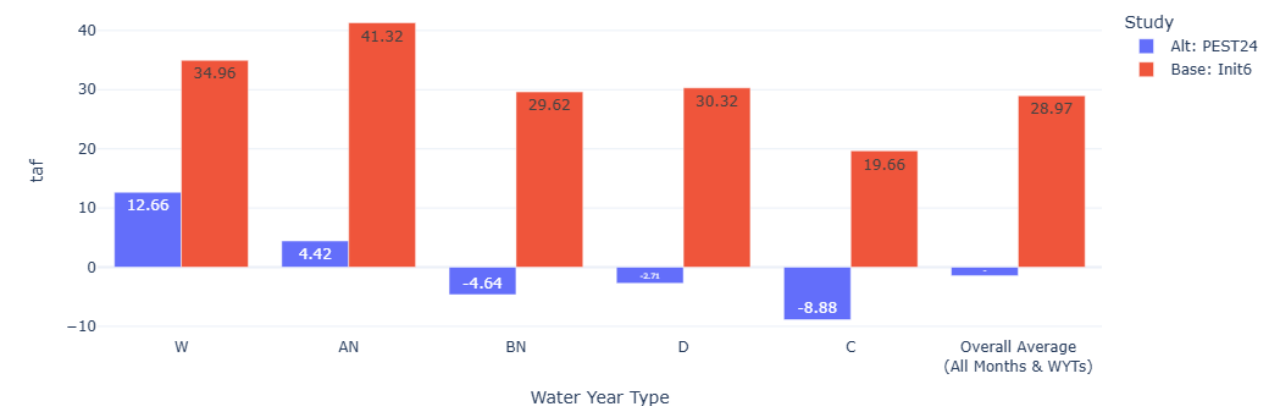
CT_SACBASIN Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021



CT_SJRBASIN San Joaquin Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

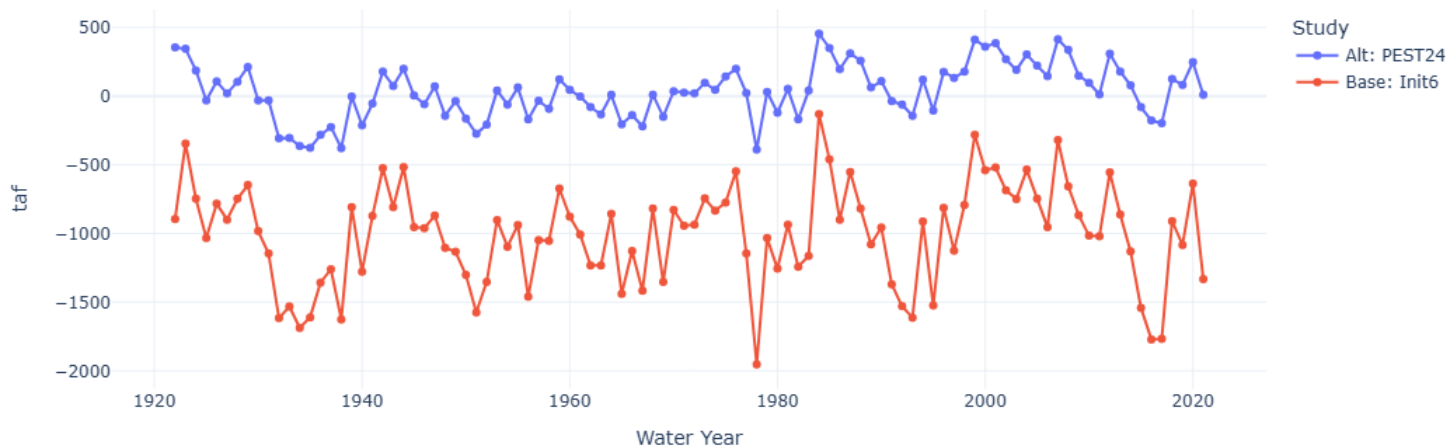


WORK IN PROGRESS

Total Stream Gain

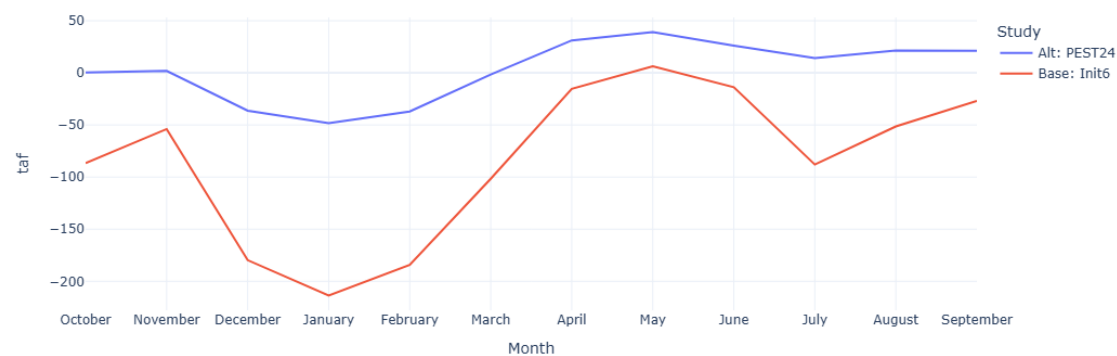
SG_Total Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



SG_Total Monthly Averages

Months: All, Water Year Types: All, Water Years: 1922-2021

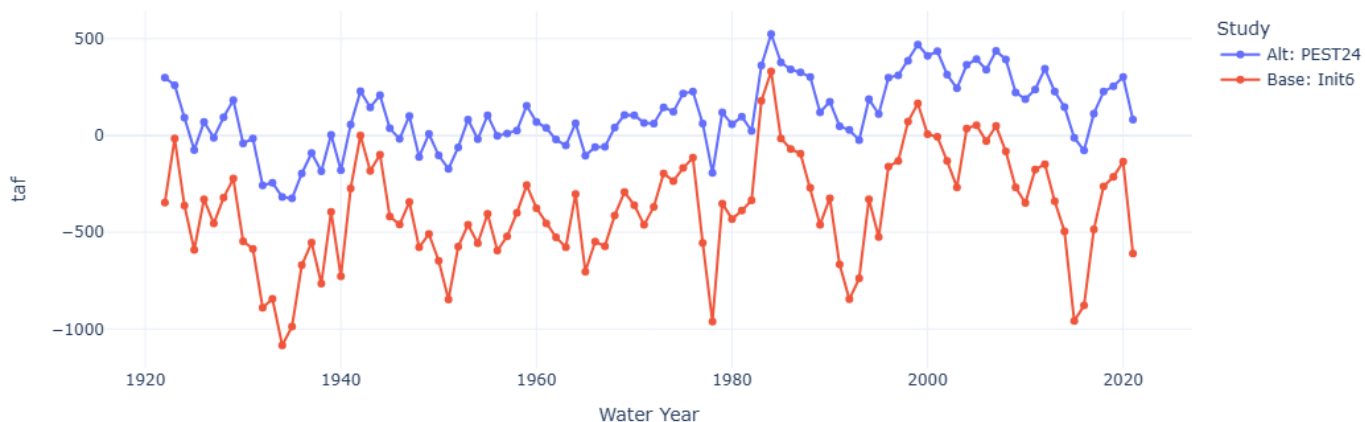


WORK IN PROGRESS

Sacramento Stream Gain

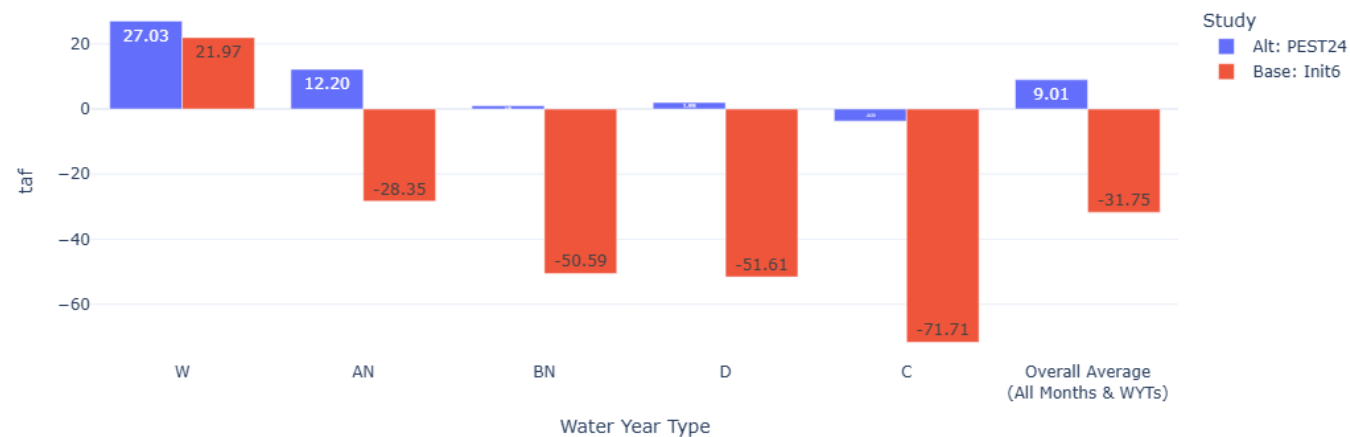
SG_SAC Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



SG_SAC Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

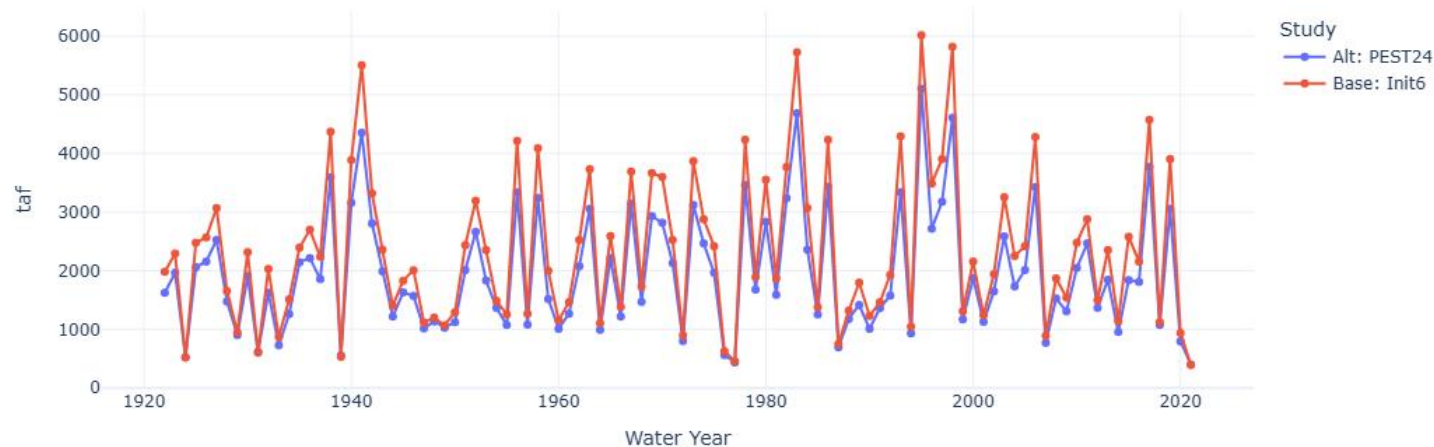


WORK IN PROGRESS

Sacramento Surface Runoff

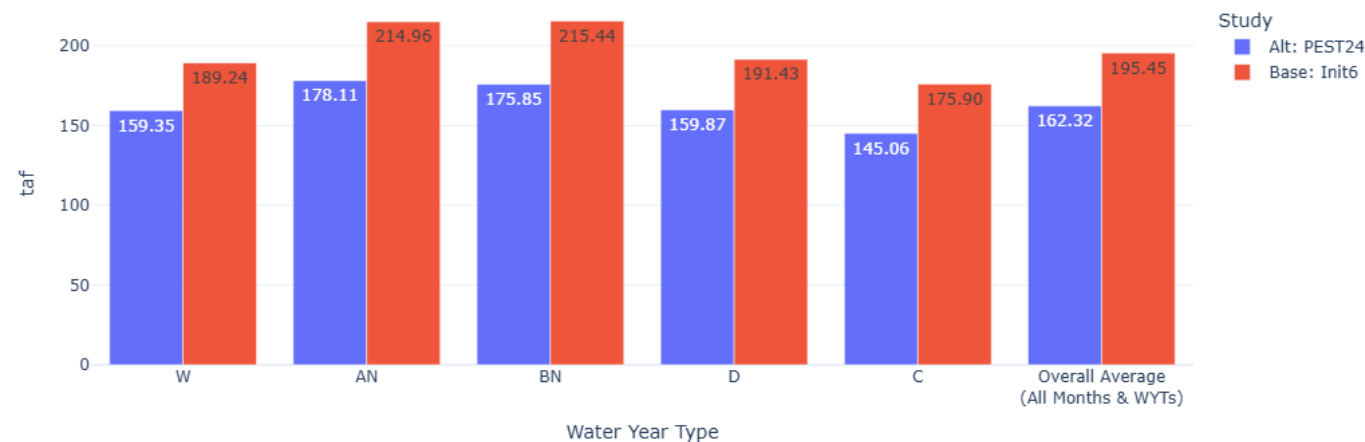
SR_SACBASIN Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



SR_SACBASIN Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

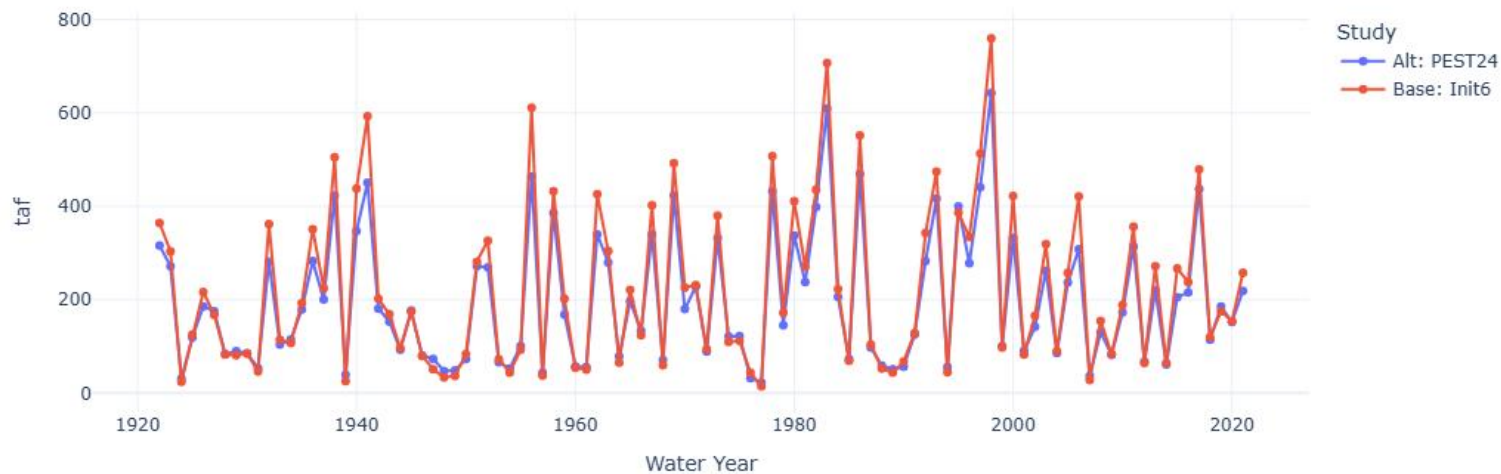


WORK IN PROGRESS

SJR Surface Runoff

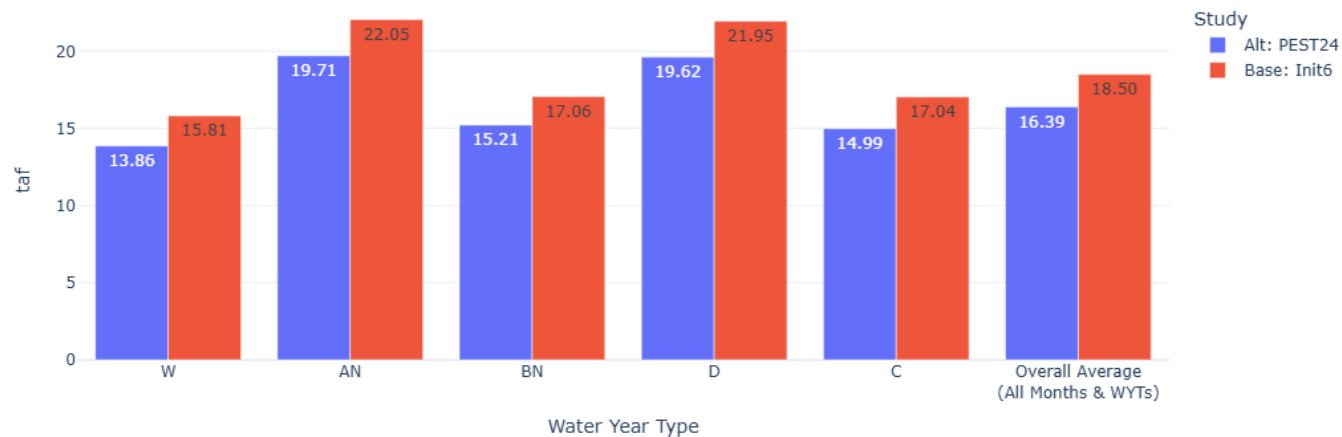
SR_SJRBASIN Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



SR_SJRBASIN San Joaquin Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

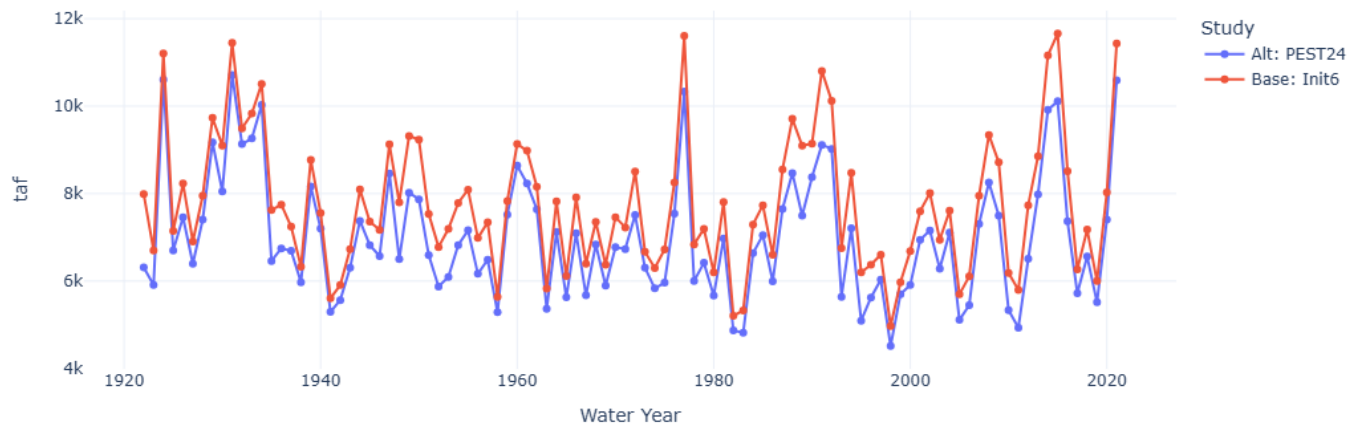


WORK IN PROGRESS

Groundwater Pumping

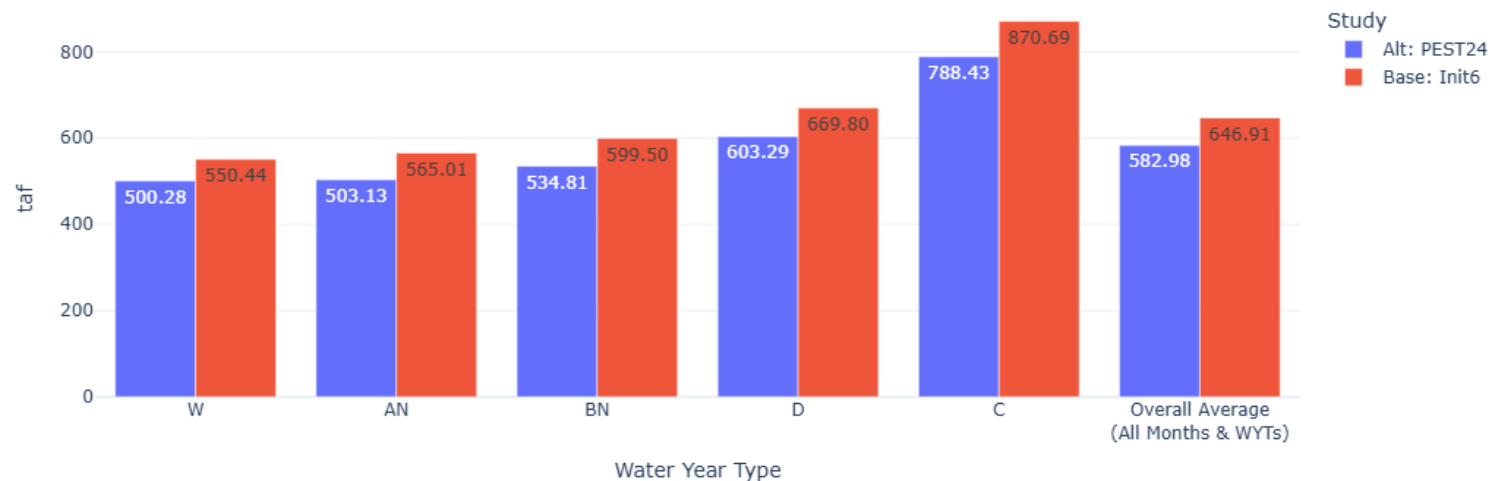
GP_TOTAL Annual Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



GP_TOTAL Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

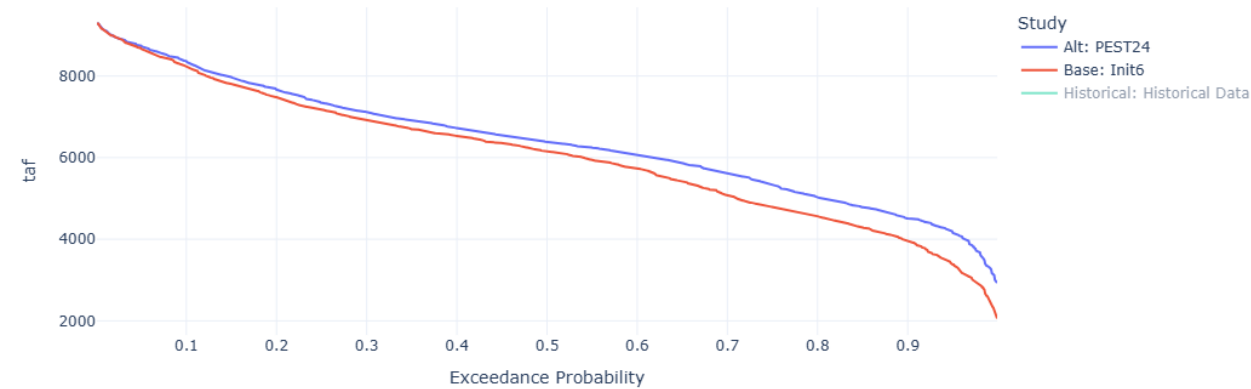


WORK IN PROGRESS

Planning Study Results – Key Metrics

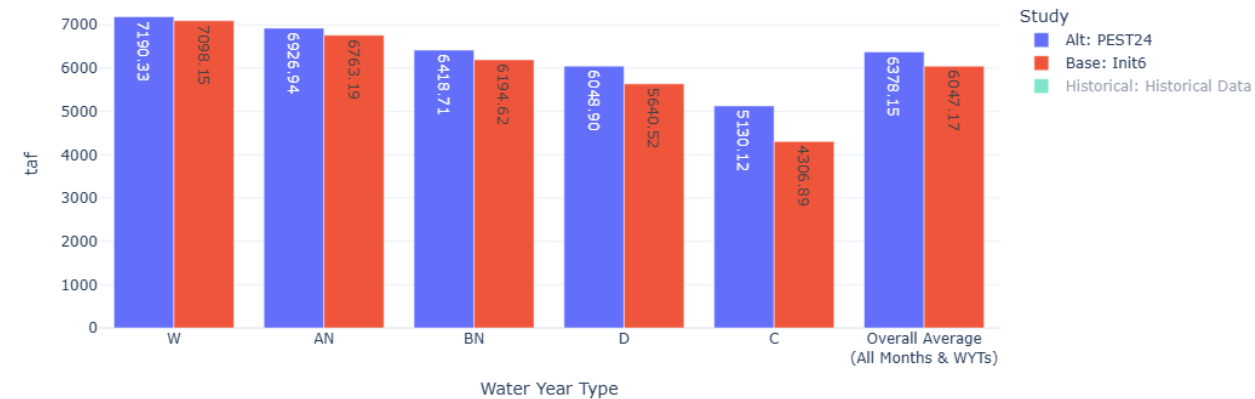
CVP STORAGE Monthly Exceedance

Months: All, Water Year Types: All, Water Years: 1922-2021



CVP STORAGE Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

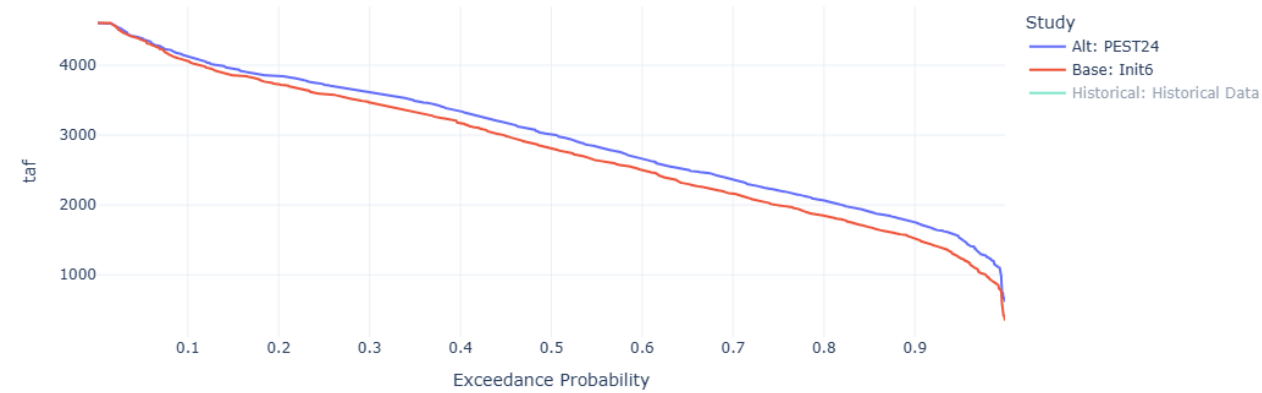


WORK IN PROGRESS

Planning Study Results – Key Metrics

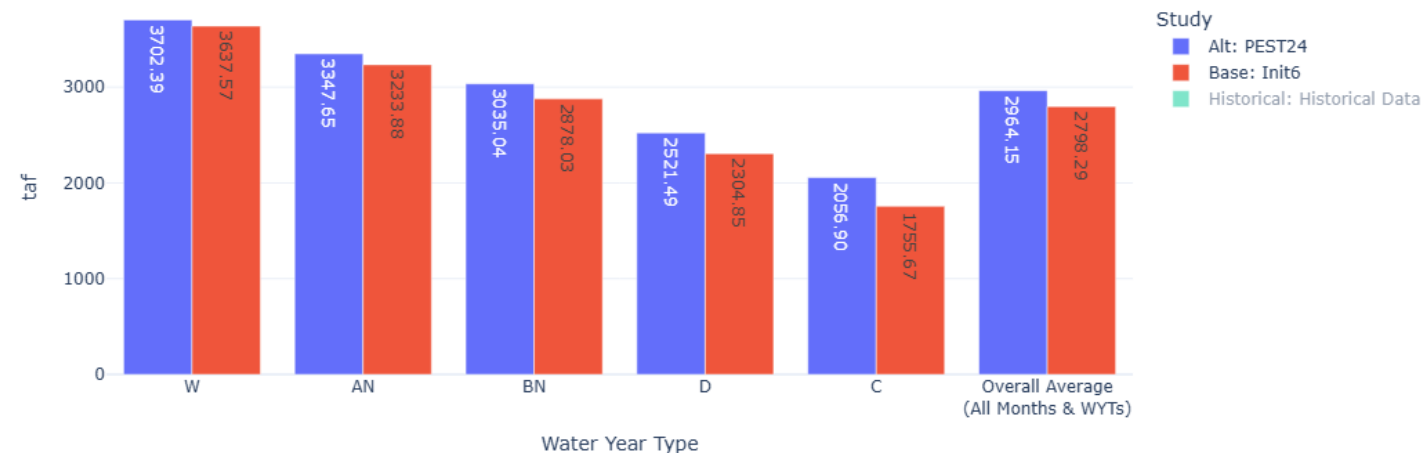
SWP STORAGE Monthly Exceedance

Months: All, Water Year Types: All, Water Years: 1922-2021



SWP STORAGE Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021

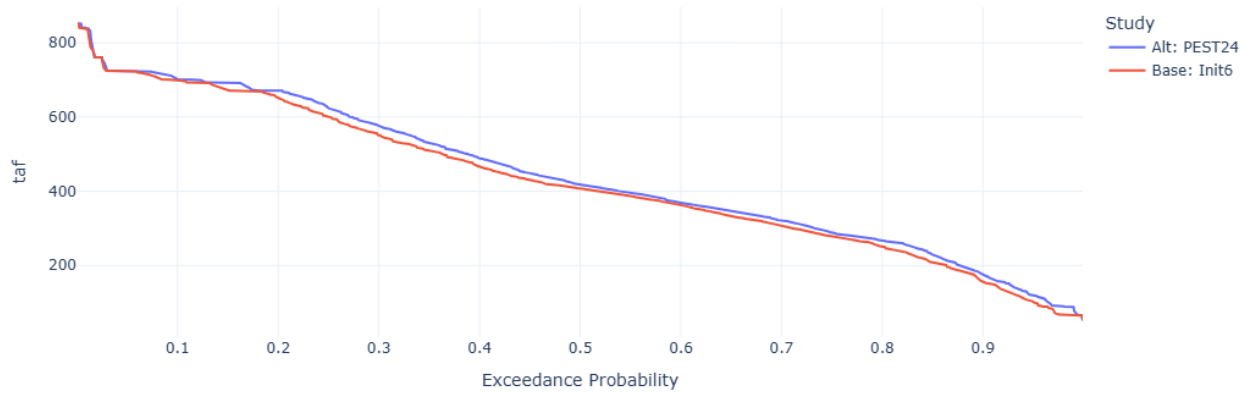


WORK IN PROGRESS

Planning Study Results – Key Metrics

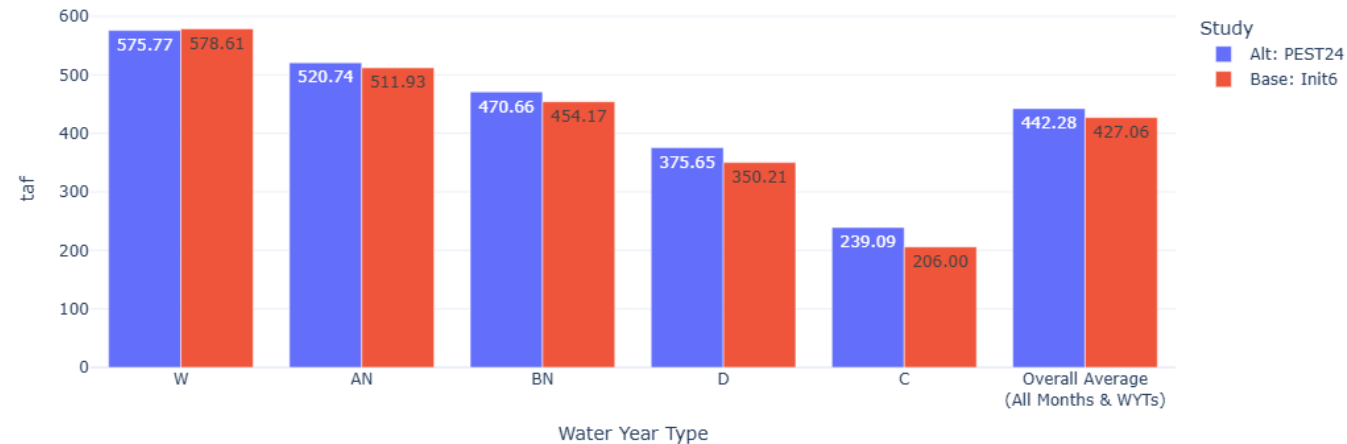
EXPORTACTUALTD Monthly Exceedance

Months: All, Water Year Types: All, Water Years: 1922-2021



EXPORTACTUALTD Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021



WORK IN PROGRESS

Planning Study Results – Key Metrics

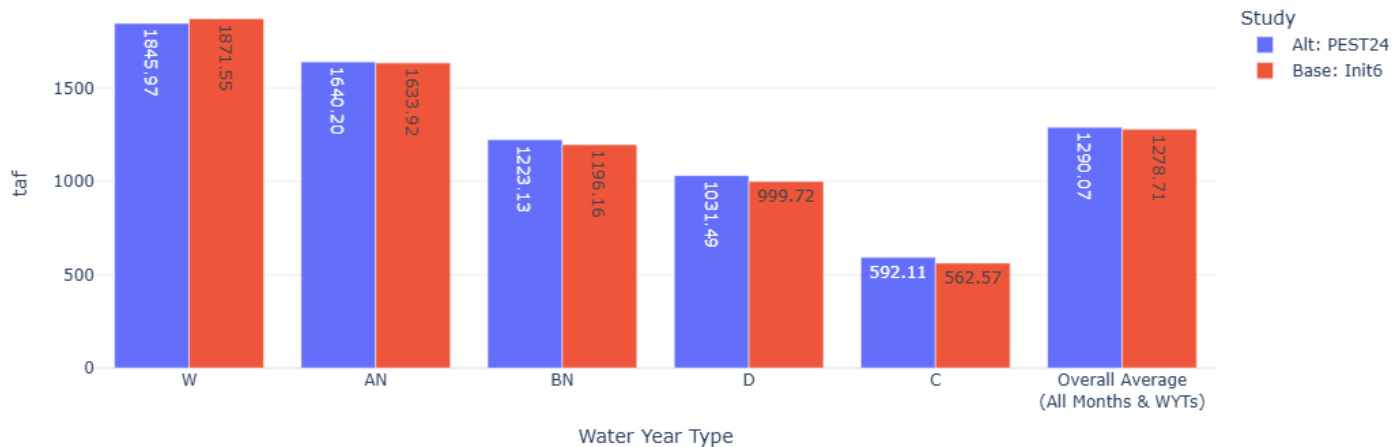
NDOI Monthly Averages

Months: All, Water Year Types: All, Water Years: 1922-2021



NDOI Sacramento Valley Index Average

Months: All, Water Year Types: All, Water Years: 1922-2021



Summary

- **Groundwater Levels:** Calibrated parameters significantly reduce groundwater-level errors across most of the model domain, with only a few localized areas showing residual discrepancies.
- **System Storage:** CVP and SWP storage performance improves relative to the non-calibrated model due to substantially reduced groundwater seepage losses.
- **Surface–Groundwater Interaction:** Improved representation of stream–groundwater exchange leads to more realistic system behavior and water balance.
- **Flows and Exports:** Streamflows and export volumes increase overall, reflecting reduced losses and improved surface water – groundwater budget consistency in the calibrated model.



Next Steps

- Continue refinements to local groundwater pilot point groupings based on PEST observations in certain problematic areas of the model domain
- Integrate CalSim Hydro 2 (developed by DWR) into the PEST setup
- Integrate further updates to the GW-DLL and recalibrate
- Test the calibrated parameters for extreme climate scenario runs

Thank You

Project Team



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Lauren Thatch



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Puneet Khataavkar



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Ali Taghavi
Reza Namvar

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Can Dogrul
Nazrul Islam