CalSim Rim Inflow Projection

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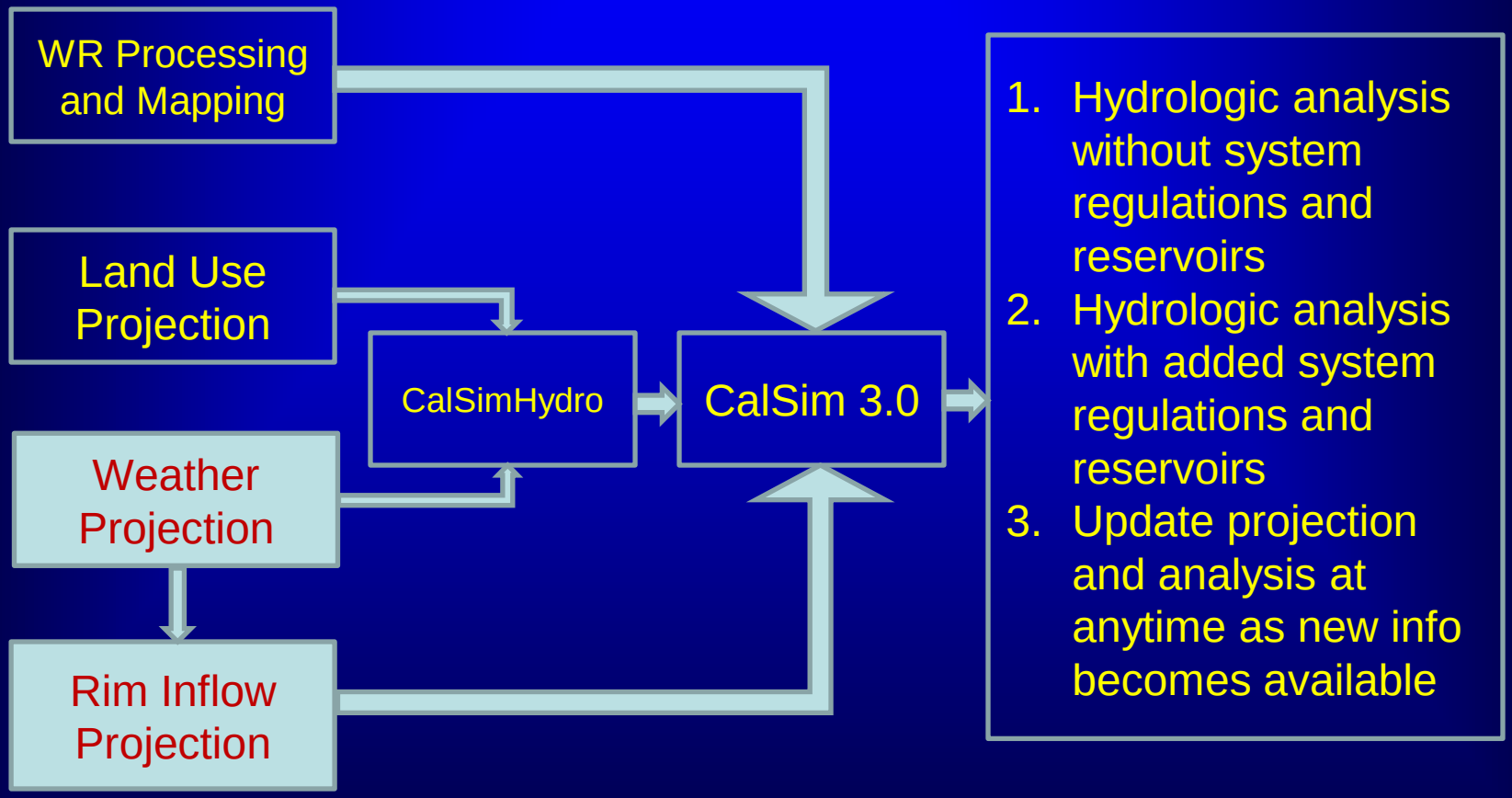
Incorporating Water Right Based Diversions Into CalSim 3.0 for real-time projection



Outline

- Introduction
- SWAT model development
- Rim Inflow projection
- From SWAT outputs to Calsim rim inflows: flow mapping

Introduction

- Precipitation-runoff models are modeling tools for predicting streamflow generation using climate data (e.g. VIC, WEEP, PRMS, BCM, and SWAT for the California Central Valley).

- SWAT models were developed as part of the Natural Flows project recently published ("Estimates of Natural and Unimpaired Flows for the Central Valley of California: Water Years 1922-2014 (DRAFT)", DWR, March 2016).

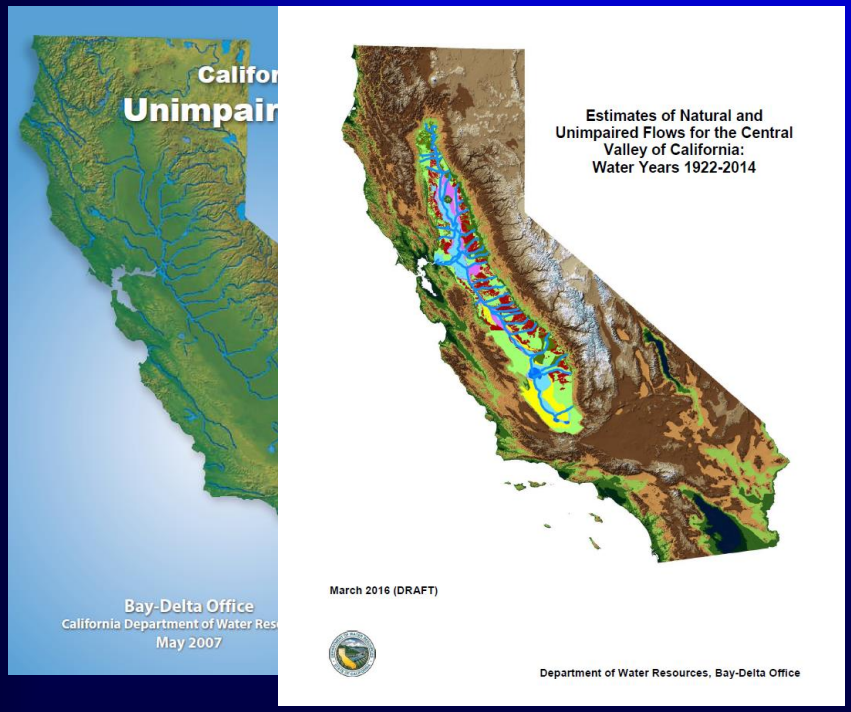
- These watershed models can also be applied in Calsim rim inflow projection.

Approach

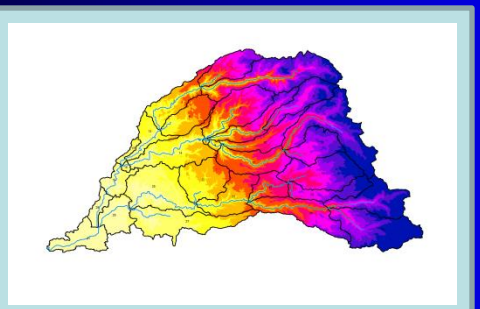
- Daily SWAT models were calibrated with observed/estimated unimpaired streamflow data.
- Up to date model update is possible by using PRISM daily weather data.
- For remain of a Water year projection, weather forecast or assumed weather pattern can be applied.
- Mapping from SWAT outlets to Calsim rim inflow locations

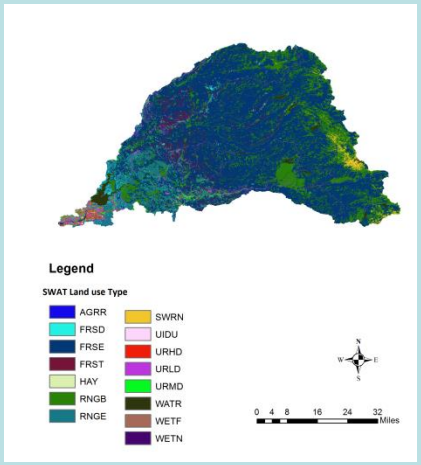
Central Valley Rim Watersheds with SWAT Models

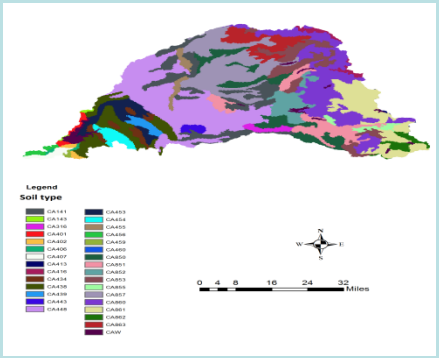
- Twenty three separate daily SWAT models for the whole Central Valley (Simulation period 1915-2014)
- Model calibration using observed/estimated unimpaired streamflow at watershed outlets.



SWAT Model set up







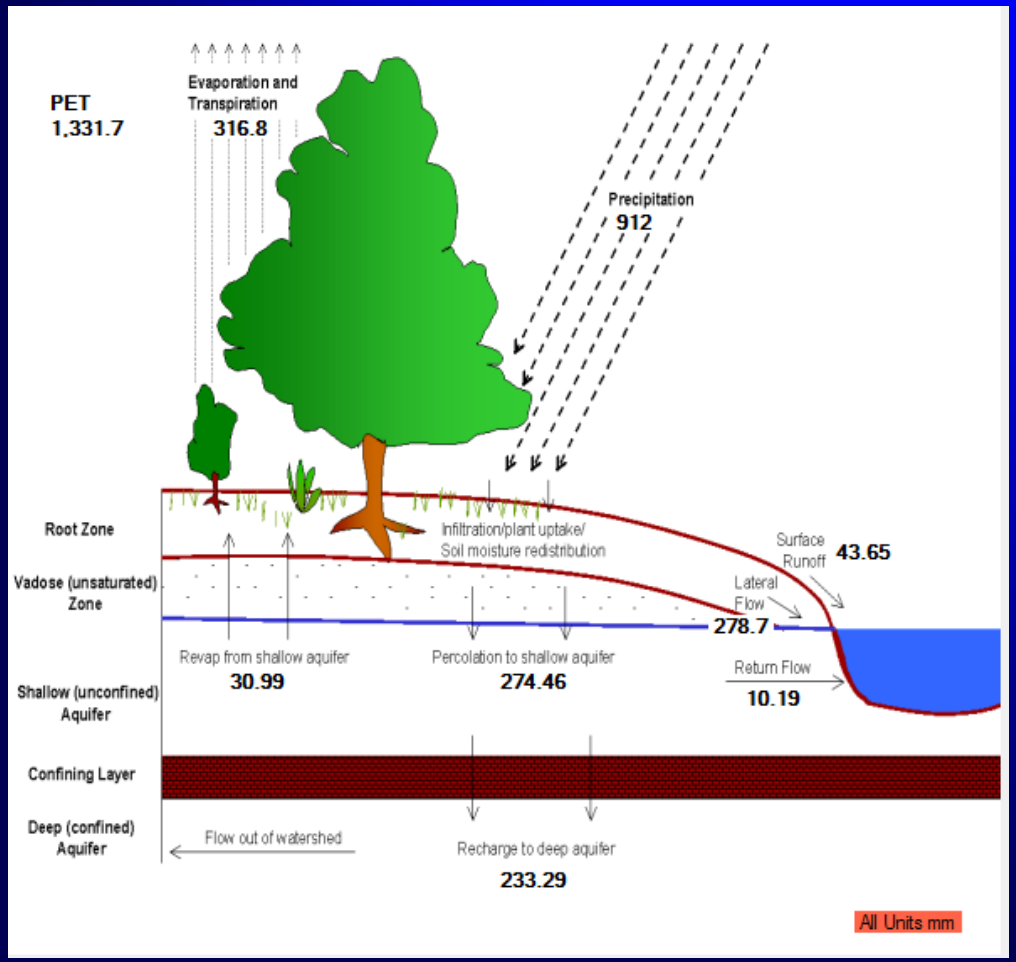
Daily Precip, Tmax, Tmin

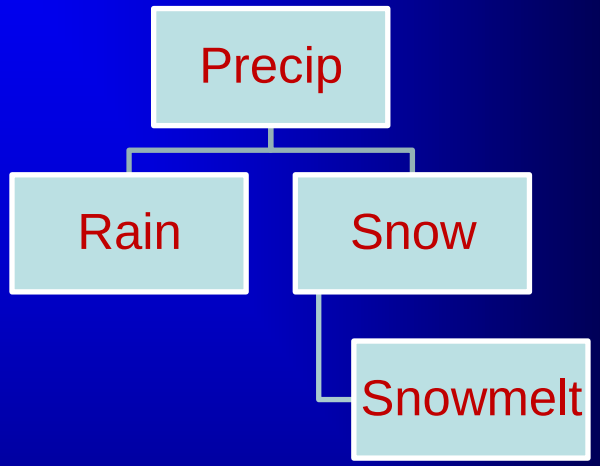
Topography, land use, and soil

SWAT

Streamflow

SWAT Model structure





Example SWAT hydrologic components, during Cottonwood Creek calibration process

Model performance

- Statistics Table, and plots

Table A-1. SWAT Calibration and Validation Statistics Summary: Sacramento River and Eastside Streams

Watershed	No. of Subbasins	No. of HRUs	Drainage Area (km^2)	Observed Data	R^2	Nash-Sutcliffe Efficiency
Sacramento River at Shasta	25	98	16,261	1922-2014	0.90	0.89
Feather River	64	99	9,335	1922-2014	0.90	0.90
Yuba River	39	122	3,174	1922-2014	0.85	0.84
American River	31	200	4,943	1922-2014	0.89	0.89
Bear River	19	46	752	1922-2014	0.84	0.84
Putah Creek	27	51	1,506	1922-2014	0.83	0.80
Cache Creek	25	45	2,440	1922-2014	0.79	0.72
Stony Creek	29	63	1,963	1922-2014	0.68	0.67
Thomes Creek	36	156	699	1921-1979	0.73	0.73
Elder Creek				1949-1979	0.70	0.69
Mill Creek	23	101	1,034	1931-2014	0.75	0.74
Deer Creek				1922-2014	0.76	0.67
Big Chico Creek				1931-1985	0.83	0.83
Cosumnes River	38	132	1,387	1921-2011	0.85	0.85
Mokelumne River	23	77	1,502	1921-2014	0.81	0.80
Calaveras River	25	117	933	1922-2014	0.86	0.85

Key:
HRU = hydrologic Response Unit
km^2 = square kilometer
R^2 = Coefficient of Determination

Graphic plots for SWAT calibration

Simulated vs. Observed monthly flows: Time series data, Scatter plot, and frequency curves.

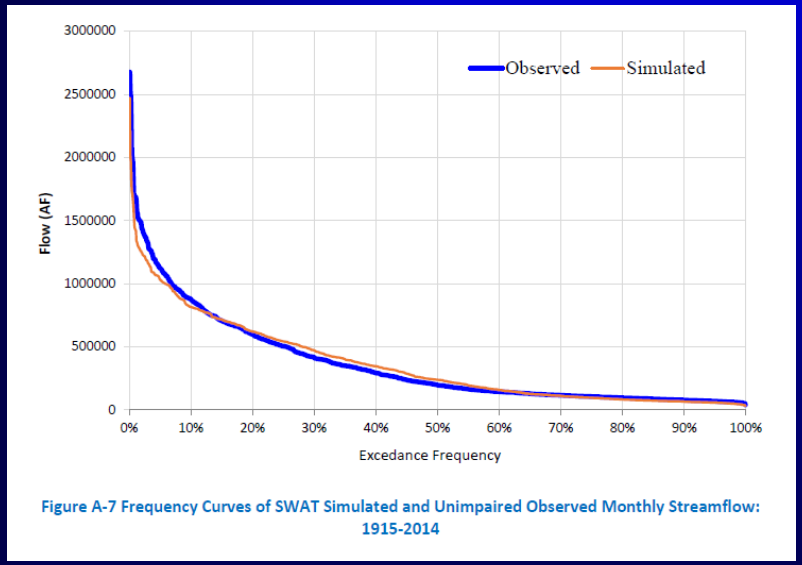


Figure A-7 Frequency Curves of SWAT Simulated and Unimpaired Observed Monthly Streamflow: 1915-2014

Feather River at Lake Oroville

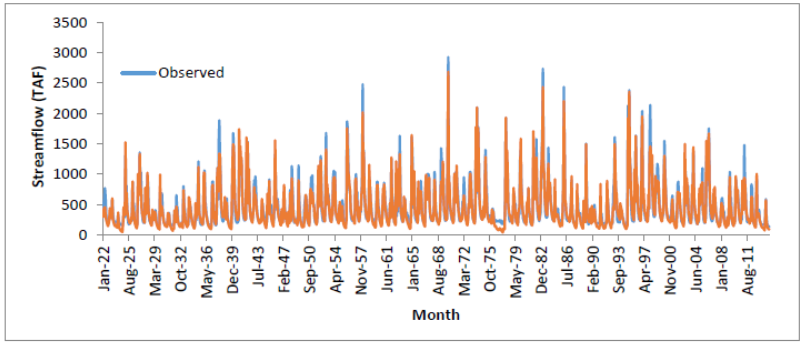


Figure A-5. SWAT Simulated and Unimpaired Observed Monthly Streamflow Sacramento River at Shasta: 1922-2014

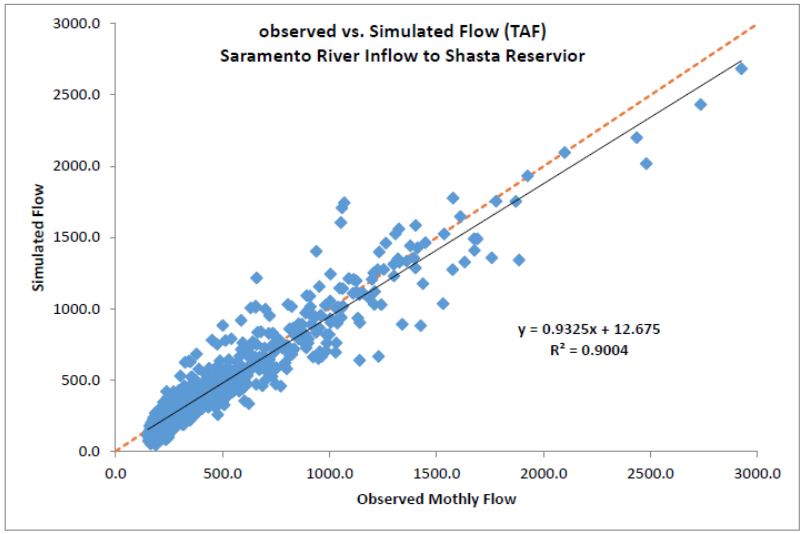


Figure A-6. Scatter Plot of SWAT Simulated and Unimpaired Observed Monthly Streamflow Sacramento River at Shasta: 1922-2014

Sacramento River at Shasta Reservoir

Steps in rim inflow projection

Update SWAT models
With PRISM daily Precip, Tmax and Tmin data

Each watershed has multiple sub-basins;

Weather data to be spatially averaged over sub-basins

SWAT model runs

Initial Soil moisture conditions are simulated using historical weather data;

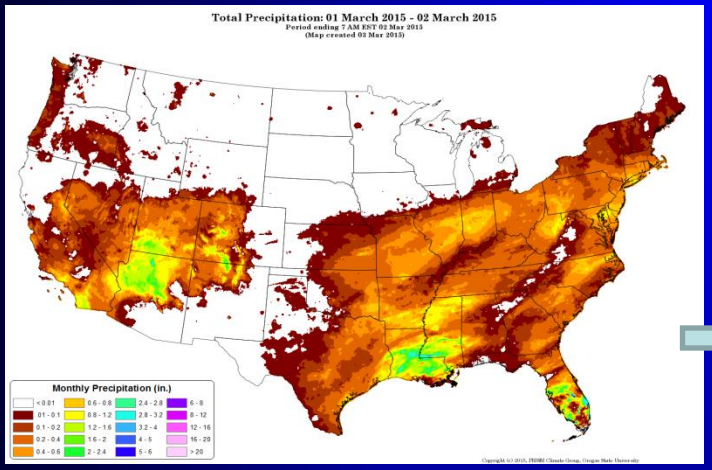
Future weather data by weather forecast or water year assumptions

Results

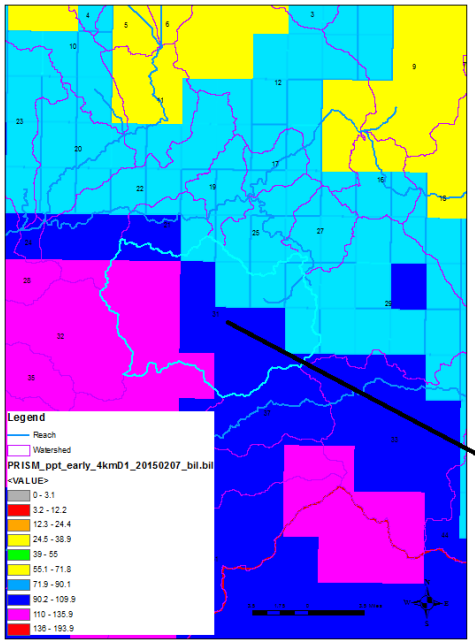
SWAT Simulated Streamflows

Flow mapping for Calsim rim inflow locations

Use of PRISM Daily climatic data



PRISM Climate Group, Oregon State University,
http://prism.oregonstate.edu



PRISM data:

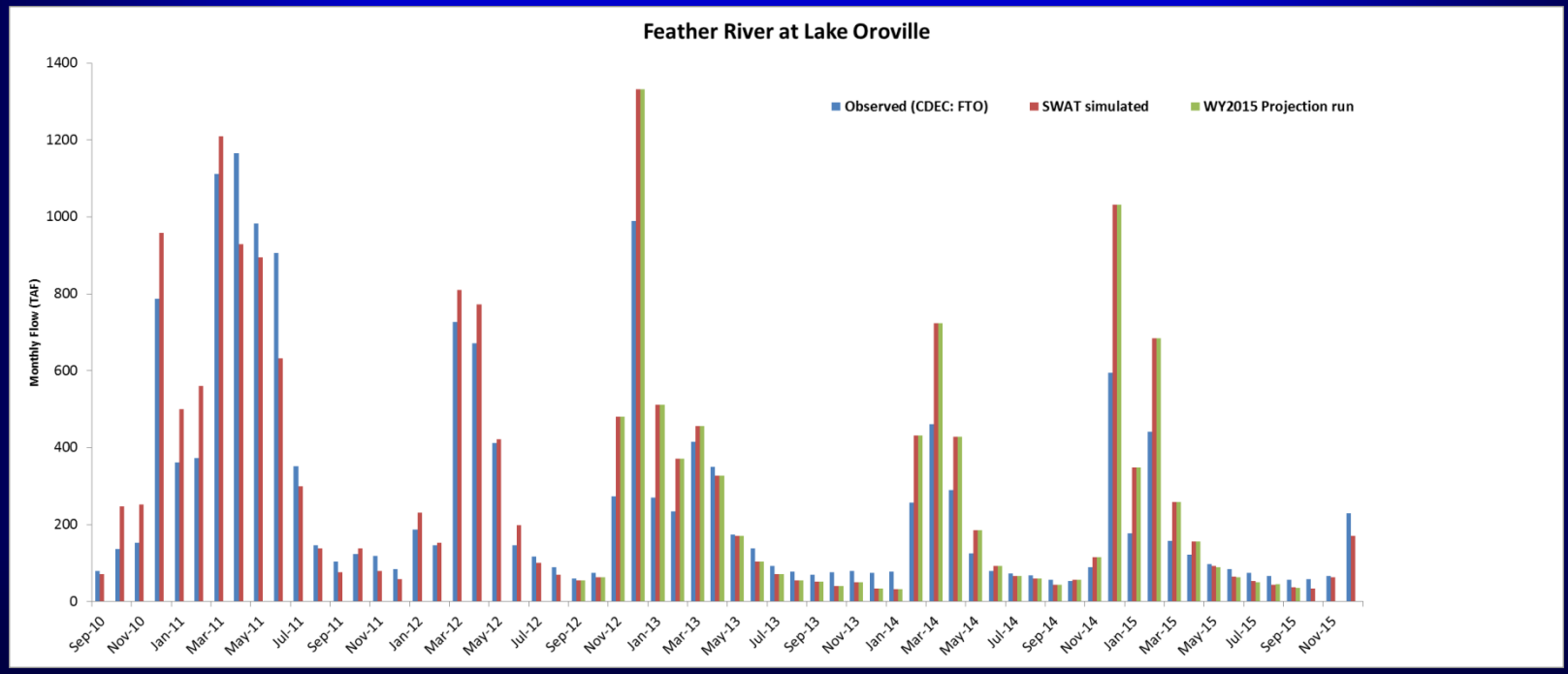
1, Daily PRISM Precip, Tmax, Tmin GIS map data extract;
2, Spatial averaging over subwatersheds;
3, Converted into SWAT format;

Feather River, sub basin #31
PRISM 02-07-2015 (mm/day)

2015	35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
2015	36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
2015	37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
2015	38	93.5	69.7	66.3	70.5	69.4	65.9	52.9	49.7	64.9	80.3	71.7	72.3	54.3	61.5	56.8	73.8	75.3	71.3	75.6	80.1	88.8	89.6	91.4	100.6	77.	65.9	81.7	105.7	86.6	51.7	100.
2015	39	1.3	0.7	1.4	1.1	1.1	1.2	2.1	1.7	2.3	1.3	2.1	2.3	2.5	2.6	2.0	2.3	2.4	2.7	1.9	1.2	1.1	2.3	1.8	2.5	1.7	2.5	2.4	4.3	2.8	2.4	2.
2015	40	41.4	33.0	35.7	35.6	37.0	35.1	31.4	32.5	36.6	39.7	37.7	40.7	30.9	35.5	34.6	43.6	43.5	41.5	43.2	43.0	50.4	50.1	45.3	59.1	48.6	39.0	51.8	62.3	55.5	36.1	62.
2015	41	10.4	3.7	3.7	4.2	3.1	3.1	6.7	8.2	5.9	4.6	4.1	5.1	7.2	7.9	8.4	6.2	5.3	8.1	4.1	3.3	3.5	5.0	6.6	6.3	4.6	8.6	5.7	8.7	7.4	9.8	6.
2015	42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
2015	43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.

Test case: WY2015 Projection performed on 5/1/2015

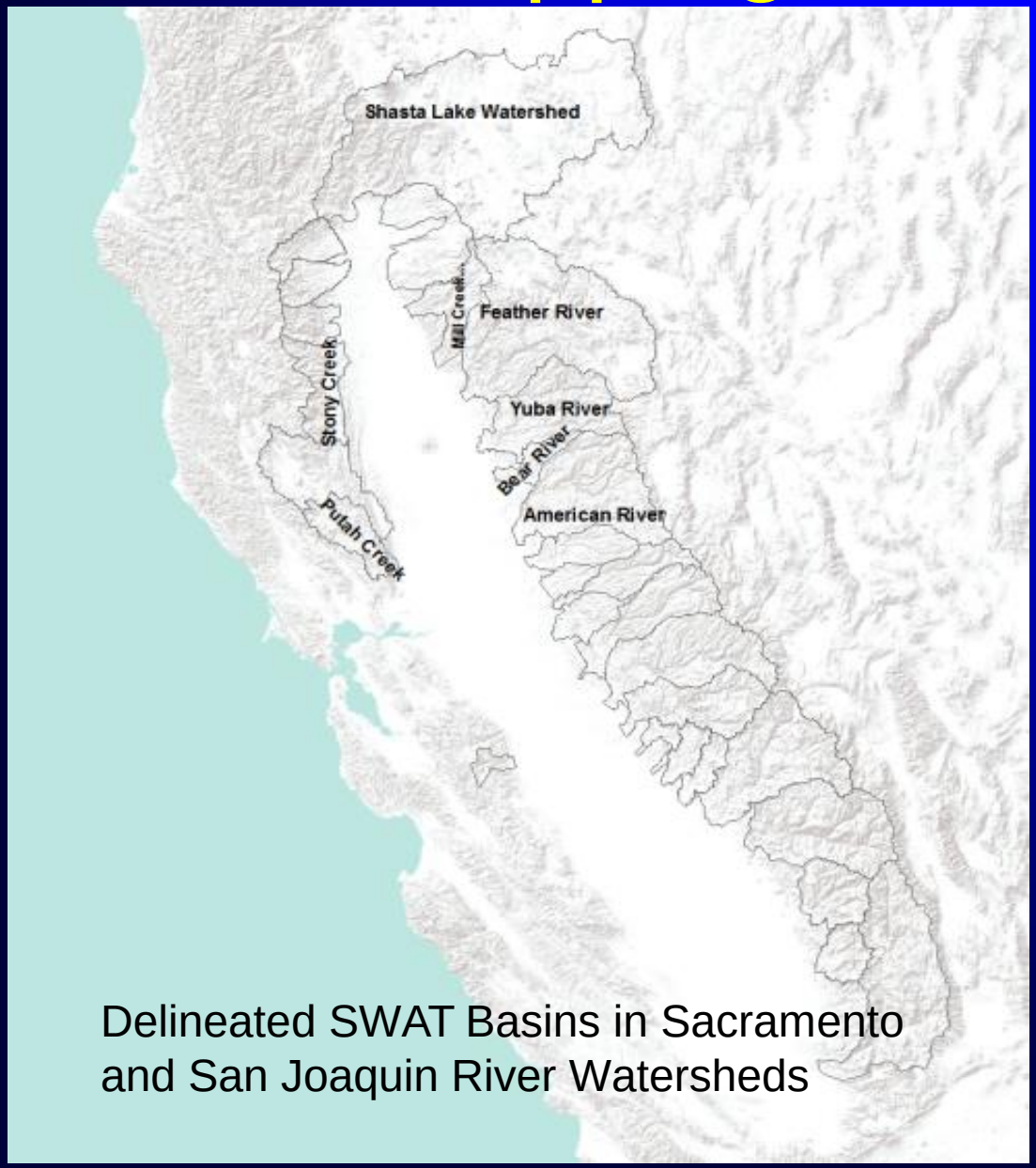
- Ten rim watersheds in Sacramento Valley
- SWAT updated to 4/30/2015;
- Projection assumption: no Precip for 5/1/2015~9/30/2015 and air temperature repeated WY2014.



Mapping from SWAT to CalSim 3.0

- CalSim 3.0 (after domain expansion) has delineated 107 watersheds in Sacramento River basin and the eastside streams of Delta
- Currently SWAT delineated 13 watersheds in Sac
- For time being, SWAT was run for 8 watersheds in 2015
- Mapping from 8 SWAT watersheds to 107 CalSim watersheds is necessary.

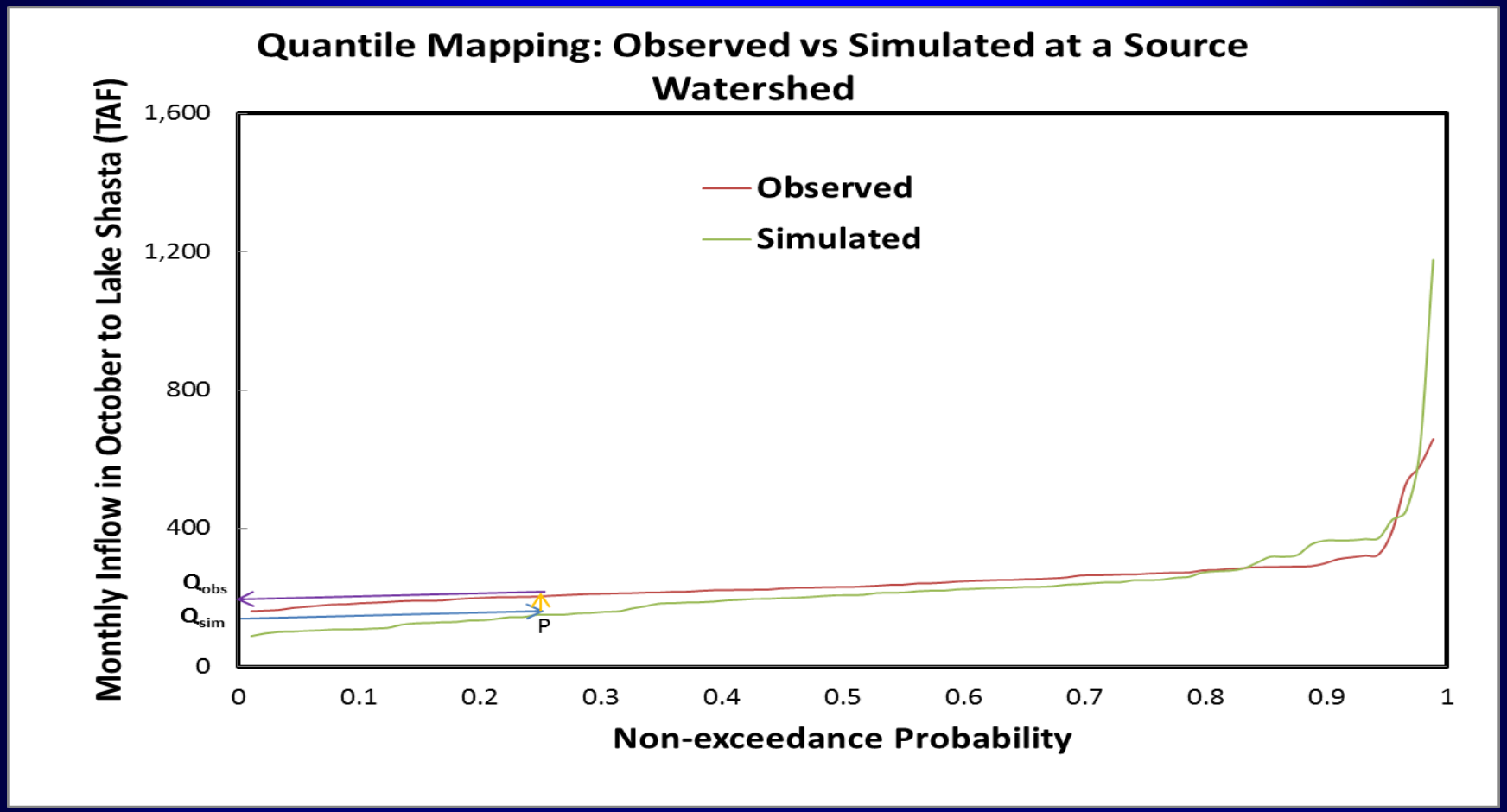
Flow Mapping: SWAT to CalSim



Delineated SWAT Basins in Sacramento and San Joaquin River Watersheds

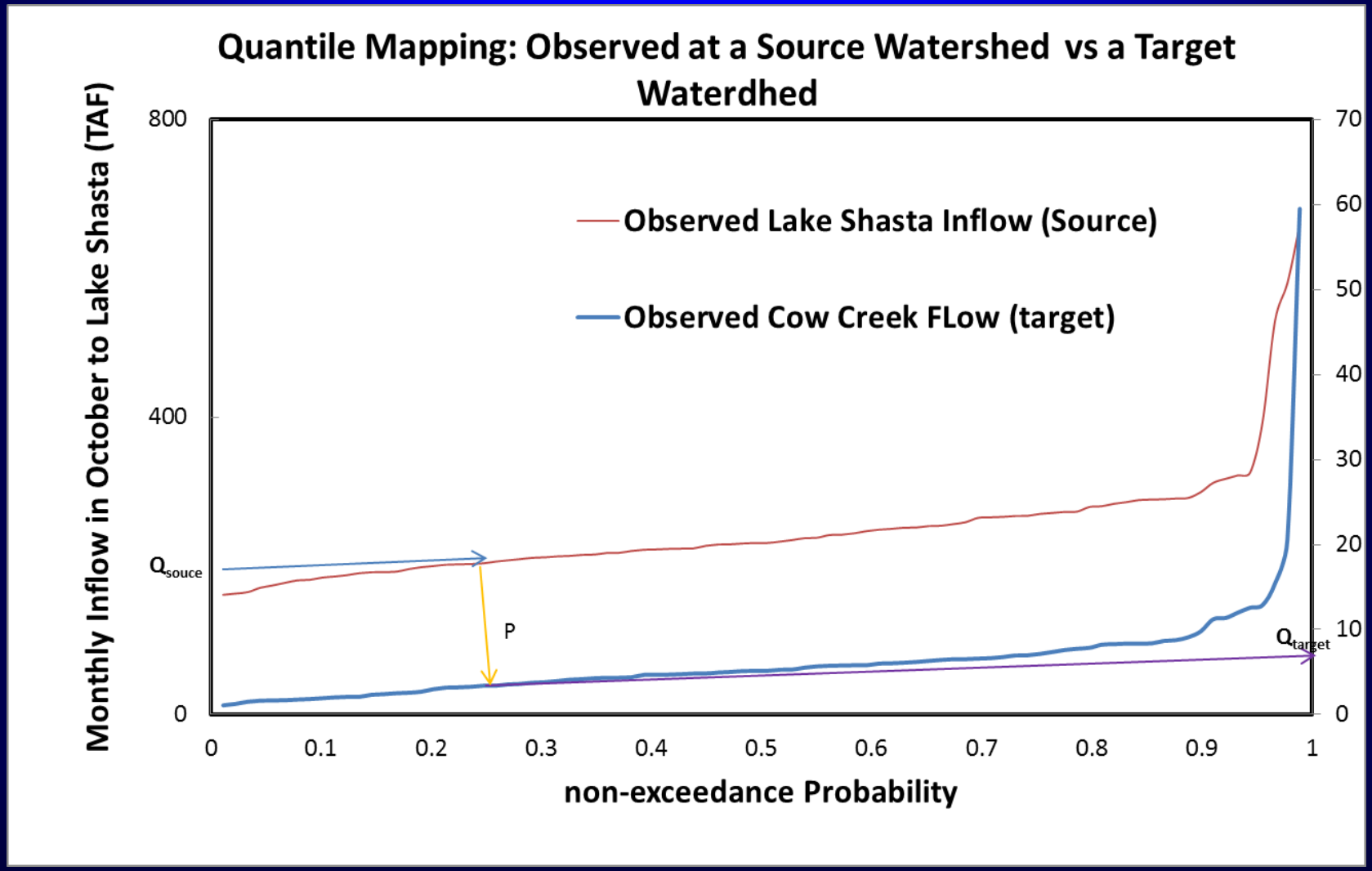
Delineated CalSim 3.0 Basins in Sacramento River Basin

Mapping Method: Double Quantile Mapping



1. Form Source and Target Watershed Pairs
2. First Quantile Mapping for Bias Correction of Simulated and Forecasted Rim Flows for a Source Watershed
3. Second Quantile Mapping for Rim Flow Forecasting for Target Watershed

Mapping Method: Double Quantile Mapping (2)



CalSim Rim Inflow Projection– Guobiao Huang (DWR) and Jianzhong (Jay) Wang (DWR)

SWAT (Soil Water Assessment Tool), a precipitation-runoff model, was used to simulate stream flows for most rim watersheds of the Central Valley. SWAT, which is a public domain, generic, semi-distributed hydrologic model developed by the U.S. Department of Agriculture, provides a tool for using observed precipitation and air temperature data to estimate runoff generation from a watershed. Twenty-three SWAT models were developed and calibrated to match available unimpaired observed streamflow data at different rim watershed outlets for the whole Central Valley. The SWAT model set up is based on existing land use conditions, land surface elevations, soils, and stream geomorphology. The calibrated daily time step SWAT models can be frequently updated with newly available daily precipitation and air temperature data (e.g. PRISM or DAYMET data). Therefore, from a known initial condition at a given time, future weather projection can be used as SWAT input to generate rim inflow projections for use in CalSim water rights simulations. Since SWAT models have not been fully calibrated for all CalSim rim inflow locations, flow mapping is applied to transfer streamflow projections information at SWAT model outlets to CalSim rim inflow locations.