CalSim 3 Historical Operations Study

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Credit: DWR Pixel. Photo of Lake Oroville from March 2025

Outline

➢ Motivation

➢ Previous Work

➢ Approach

➢ Timeline

➢ Key Messages

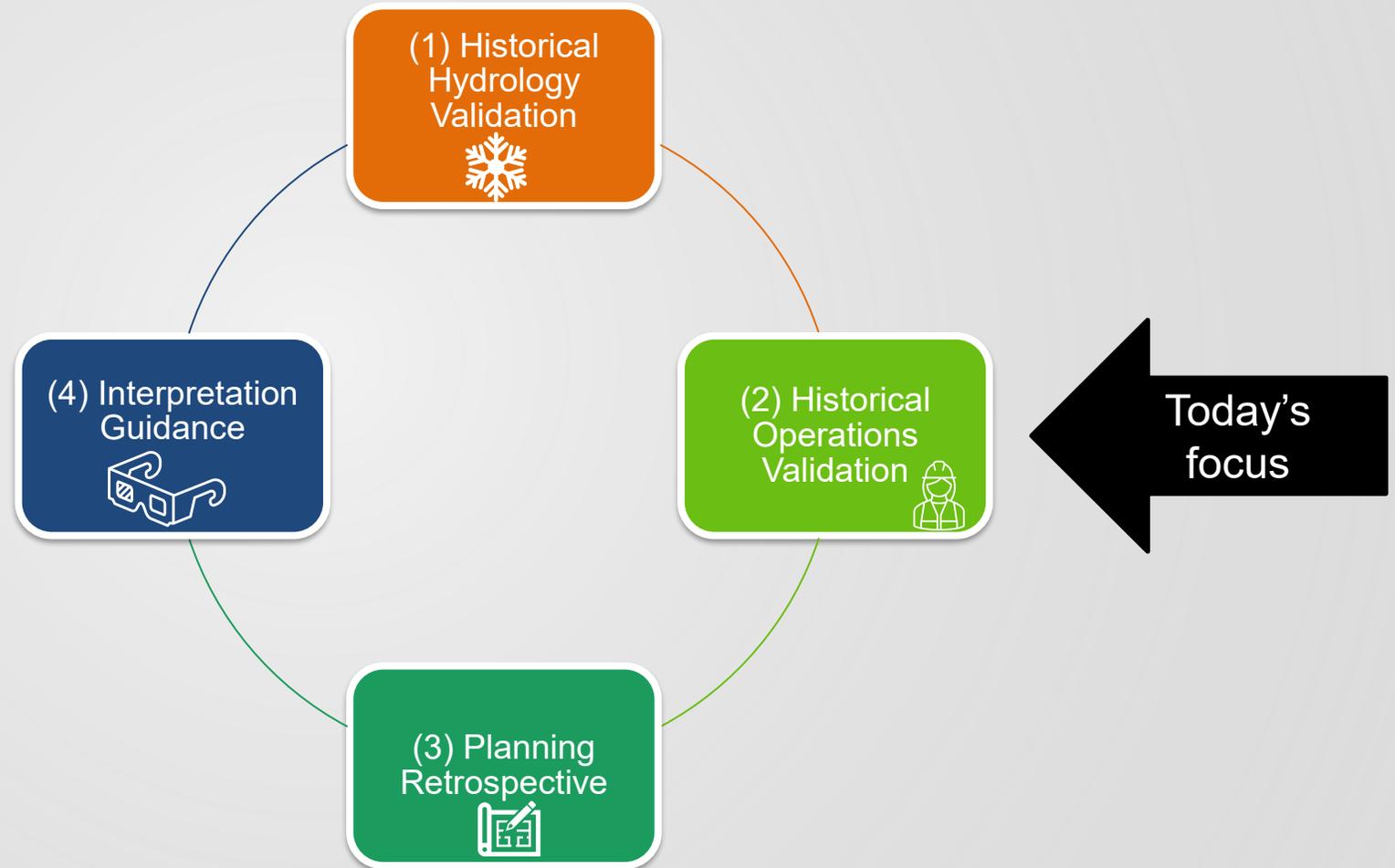CALIFORNIA DEPARTMENT OF
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Motivation

- Evaluate the ability of CalSim 3 to simulate the delivery capability of the CVP/SWP systems historically

- Build a robust validation framework

- Part of a series of three other whitepapers

The Big Picture of CalSim 3 Whitepapers

- Each of these analyses serve to demonstrate CalSim 3's:
  - Validity
  - Accuracy
  - Robust nature
- Purpose is to increasing transparency and public trust regarding CalSim 3's use.

(1) Historical Hydrology Validation

(2) Historical Operations Validation

(3) Planning Retrospective

(4) Interpretation Guidance

Today's focus

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Historical vs. Projected Level of Development in CalSim
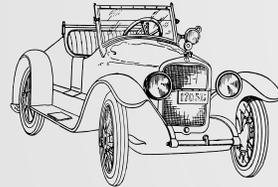

- The CalSim **planning** model uses hydrology from 1922-2021 (100 years) as input.

- The **typical** CalSim simulations (planning mode) use a **constant level of development (2020)** for facilities, land-use, water supply contacts, and regulatory requirements for the entire simulation period, not an evolving historical level of development.

- CalSim planning mode represents possible water operations for a given level of development using historically-based fluctuations in hydrologic conditions which is used for **comparative analysis**.

Previous Relevant Work

✓ **CalSim II** Historical SWP-CVP Operations Report (2003)

✓ Sacramento Water Allocation Model (**SacWAM**)

✓ California Food-Energy-Water System (**CALFEWS**)

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CalSim II Historical Operations (2003)

- Water Years 1975-1998

- Evaluated six-year drought of 1987-1992 and full period

- Results generally within -5% to 6% for South Deliveries and +-3% for Delta Outflow
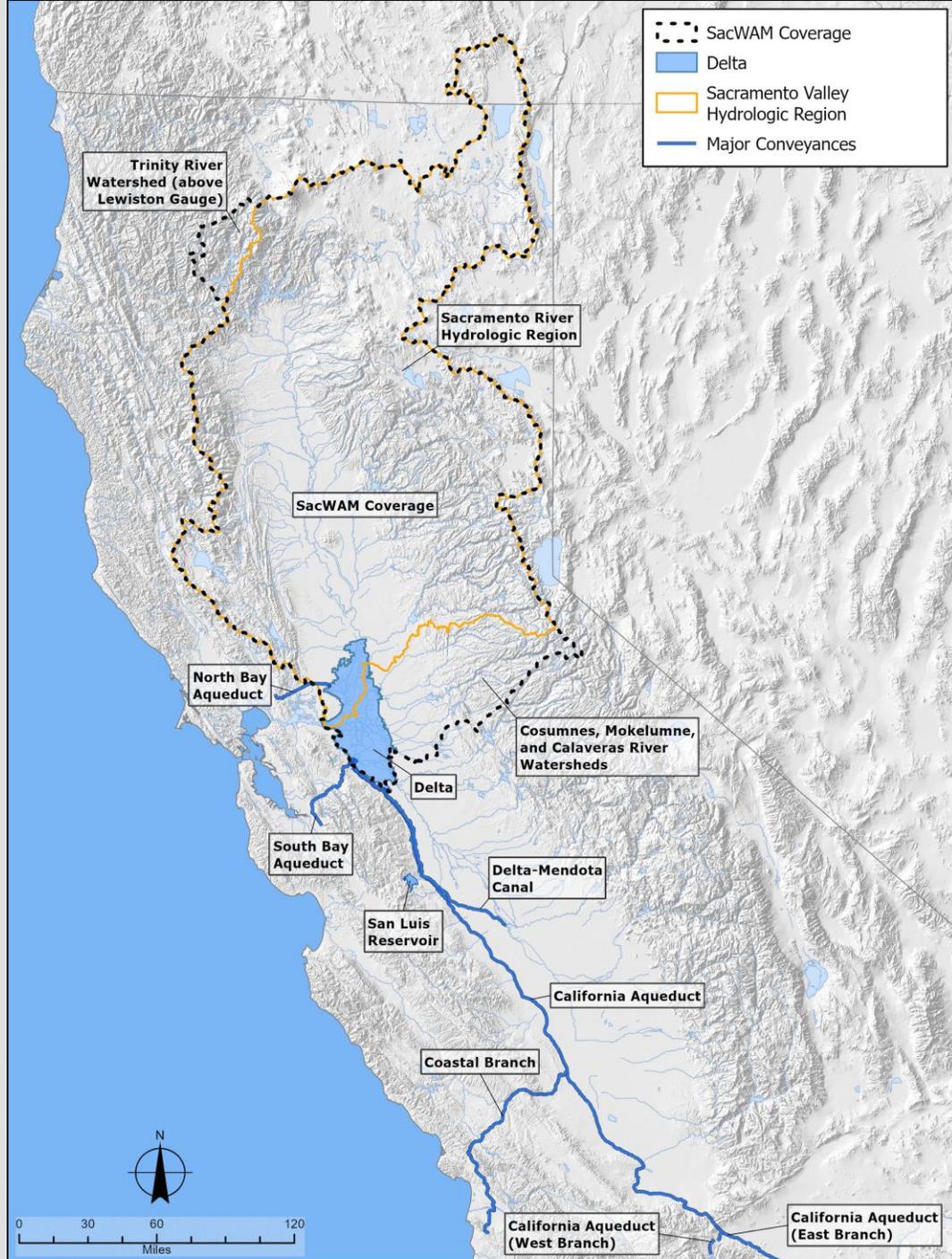
CalSim II Simulation of Historical SWP/CVP Operations

Technical Memorandum Report

November 2003

California Department of Water Resources Bay-Delta Office

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SacWAM

- Sacramento Water Allocation Model

- Based on the Water Evaluation And Planning (**WEAP**) software

- Hydrologic and system operations model to assess the potential effects of **revisions to instream flow and other requirements** in the Bay-Delta watershed

- **Many parallels with CalSim**

State Water Resources Control Board (September 2023). *Sacramento Water Allocation Model Model Version 2023.06.12 Documentation.* https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/sacwam/docs/sacwam-2023.06.12-doc.pdf

SacWAM Validation

- Compared **non-project streams** from **WY 1996-2015** and **CVP/SWP** influenced parameters from **WY 2010-2015**

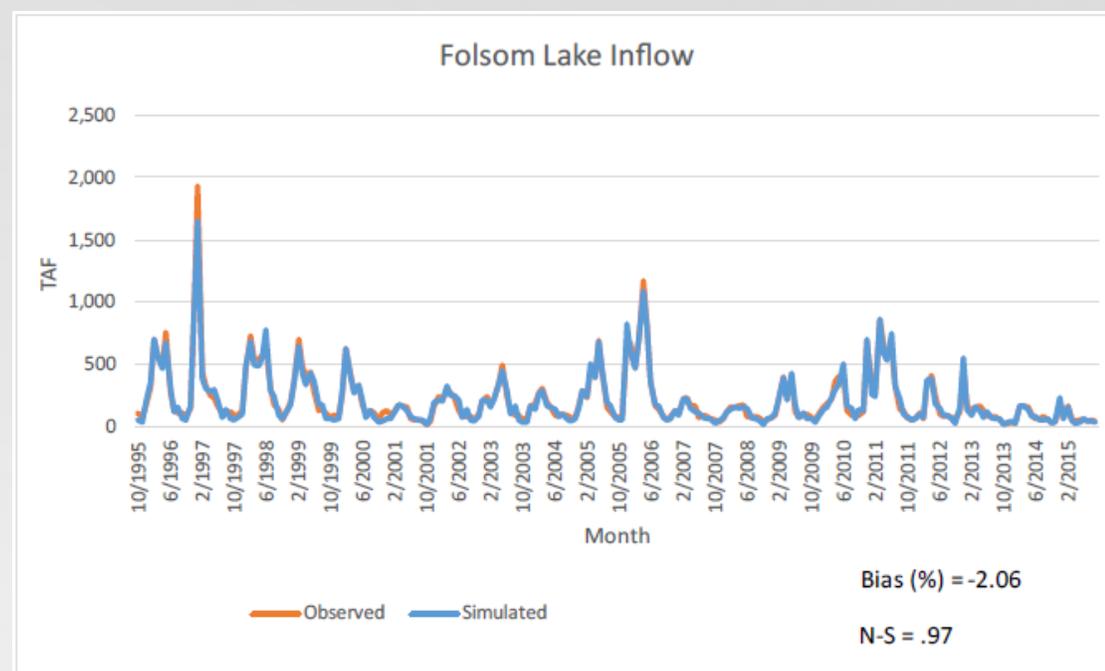- Evaluated **Percent Bias** and **Nash-Sutcliffe Efficiency (NSE)**

Figure A.8.11a. Folsom Lake Inflow, Monthly 1996 to 2015
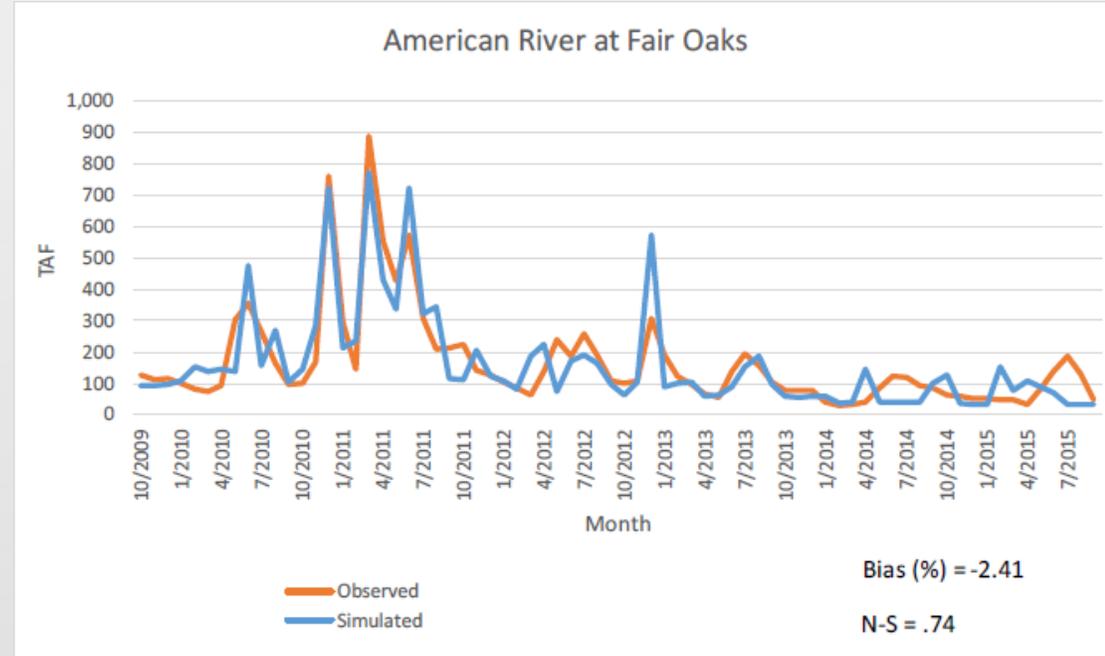
Figure A.7.6a. American River at Fair Oaks, Monthly 2010 to 2015

CALFEWS

- California Food-Energy-Water System

- Open-source model developed in **Python** and **Cython**

- **Rule-based** simulation

- Can be used to evaluate **water supply** and **financial risk** of Central Valley water users

Gupta, R. S., Steinschneider, S., & Reed, P. M. (2025). Exploring Water System Vulnerabilities in California's Central Valley Under the Late Renaissance Megadrought and Climate Change. *Earth's Future*, *13*(4), e2024EF005465. https://doi.org/10.1029/2024EF005465

CALFEWS Validation

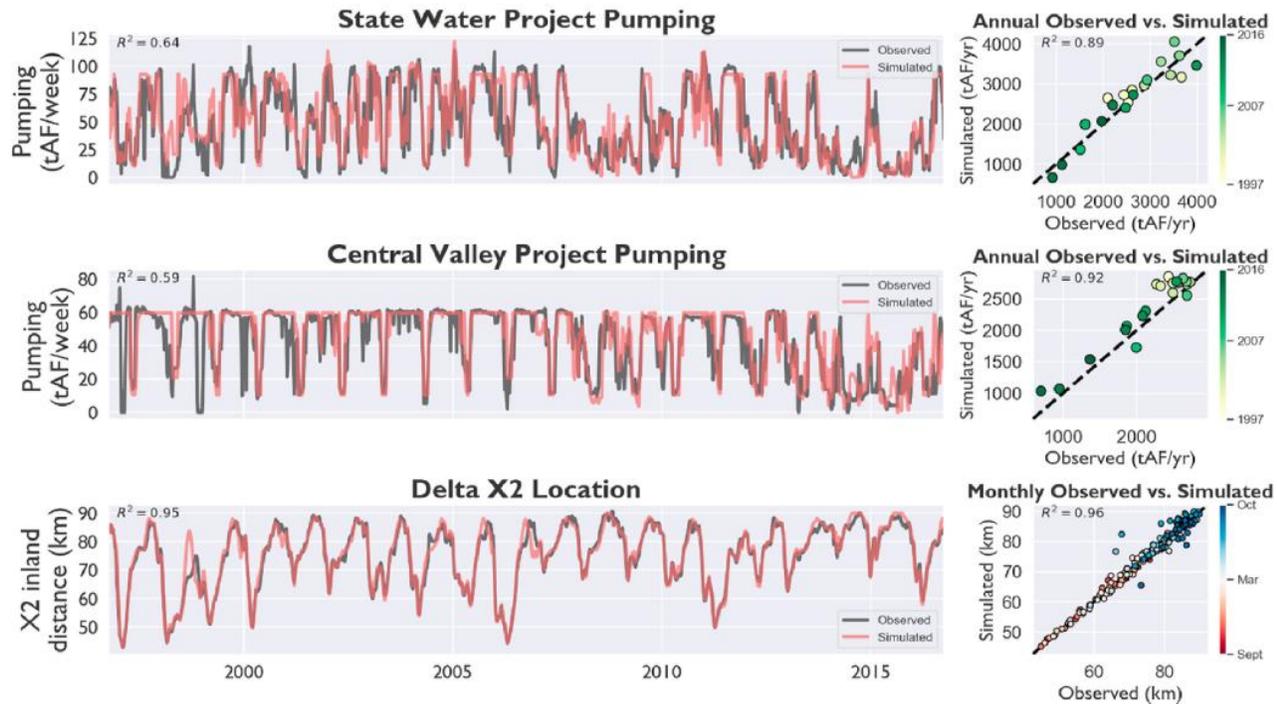Fig. 6. Correspondence between total weekly and annual observed and simulated pumping through SWP and CVP delta pumps, and weekly/monthly estimations of the delta X2 salinity, measuring distance inland from the Golden Gate Bridge to a point of 2 ppt salinity, October 1996–September 2016.

Zeff, H. B., Hamilton, A. L., Malek, K., Herman, J. D., Cohen, J. S., Medellin-Azuara, J., Reed, P. M., & Characklis, G. W. (2021). California's food-energy-water system: An open source simulation model of adaptive surface and groundwater management in the Central Valley. *Environmental Modelling & Software*, *141*, 105052. https://doi.org/10.1016/j.envsoft.2021.105052

- October 1996-September 2016 (20-year period)
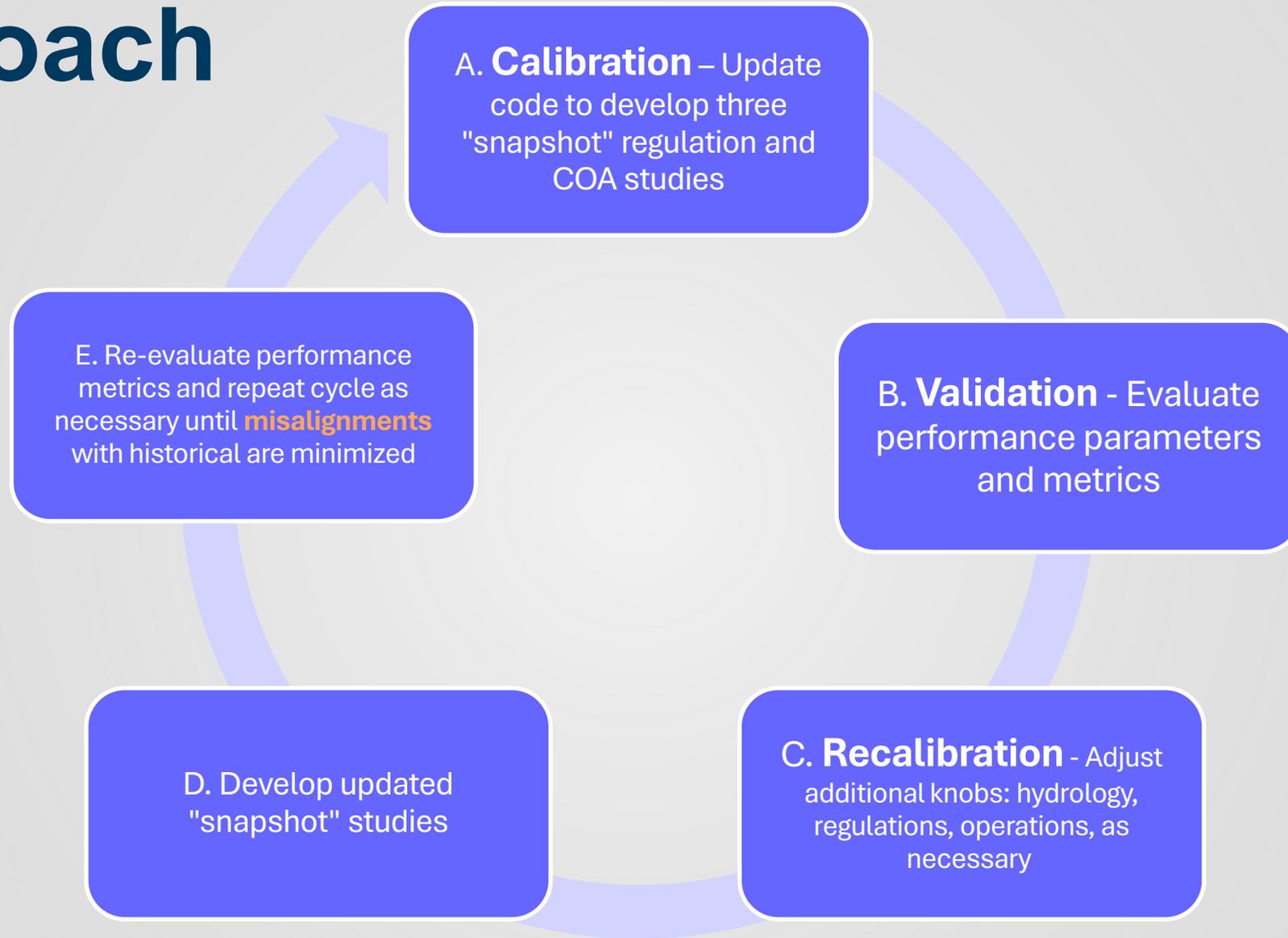- Timeseries plots
- **R-squared** with scatterplots

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Summary of Historical Validation Efforts

Component	CalSim II (2003)	SacWAM (2023)	CALFEWS (2021)	CalSim 3 (2025)
Platform	Water Resources Integrated Modeling System (**WRIMS**)	Water Evaluation And Planning (**WEAP**)	**Python** and Cython	**WRIMS2**
Solution Procedure	Simulation-optimization (priority driven)	Same as CalSim II	Rule-based simulation	Same as CalSim II
Developers	CA DWR, USBR, Consultants	State Water Resources Control Board, SEI	Academia (UNC Chapel Hill, Cornell University, UC Davis)	Same as CalSim II
Historical validation period	WY 1975-1998 (24-year period)	WY 1996-2015 (non-project) WY 2010-2015 (CVP/SWP)	WY 1997-2016 (20-year period)	WY 2000-2021 (22-year period)
Regulatory Environments Covered	D-1485, D-1641	D-1641 + 08-09 Biological Opinions	Same as SacWAM	D-1641 + 08-09 Biological Opinions + 2020 ROD and ITP
Validation Metrics	% Difference	• Percent Bias • NSE	R-squared	**Combination of all?**

How Will This Latest Effort Improve Upon the 2003 Work?

✓ **Dynamic simulation** of previously fixed parameters (Trinity imports, San Joaquin at Vernalis flow)

✓ More focus **beyond** just **SWP/CVP operations**

✓ **More regulatory eras evaluated** (D-1641, 08-09 Biological Opinions, 2020 Record of Decision (ROD) and Incidental Take Permit (ITP)

✓ Ability to capture and evaluate **extreme states of hydrology and operations** (2014-2015 drought, 2017 storms)

 ✓ Temporary Urgency Change Petition (TUCP) sensitivity

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Approach

A. **Calibration** – Update code to develop three "snapshot" regulation and COA studies

B. **Validation** - Evaluate performance parameters and metrics

C. **Recalibration** - Adjust additional knobs: hydrology, regulations, operations, as necessary

D. Develop updated "snapshot" studies

E. Re-evaluate performance metrics and repeat cycle as necessary until **misalignments** with historical are minimized

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A. Calibration

- Manual calibration
  - Initial Phase: Focus on **updating WRESL code** to transition between regulatory environments and COA sharing
  - Later Phases
    - Adjust knobs
      - Time-varying land-use
      - Update facilities, contracts, etc.

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A. Summary Assumptions Table

| Feature	Part 1: D-1641
Period of simulation	WY 2000-2007 (the hydrology calibration starts at 2000)
Hydrology	Time-varying land-use[1]
Regulatory Environment	**D-1641**
COA	1986
TUCPs	None

[1] – Work with Hydrology Development Group

Map labels:
- OREGON
- Legend: State Water Project (red), Central Valley Project (blue)
- Shasta Lake
- Lake Oroville
- Sacramento River Basin
- Sacramento Valley Inflow to Delta
- Sacramento
- Delta
- San Joaquin River Basin
- CVP SOD Deliveries
- San Francisco
- NDOI
- Delta-Mendota Canal
- NEVADA
- San Luis Reservoir
- San Luis Canal
- Tulare Basin
- SWP SOD Table A Deliveries
- California Aqueduct
- Santa Barbara
- Los Angeles
- ARIZONA
- San Diego
- MEXICO

Dogrul, Emin & Kadir, Tariq & Brush, Charles & Chung, Francis. (2016). Linking groundwater simulation and reservoir system analysis models: The case for California's Central Valley. Environmental Modelling and Software. 77. 168-182. 10.1016/j.envsoft.2015.12.006.

B. Validation - Performance Parameters

- North-of-Delta (NOD) and San Luis Storage
- **Sacramento Valley Inflow to Delta**
- River control points in each of the major rivers (Sac, American, Feather, San Joaquin)
- **Net Delta Outflow Index (NDOI)**
- **SWP South-of-Delta (SOD) Table A deliveries**
- **CVP SOD deliveries**
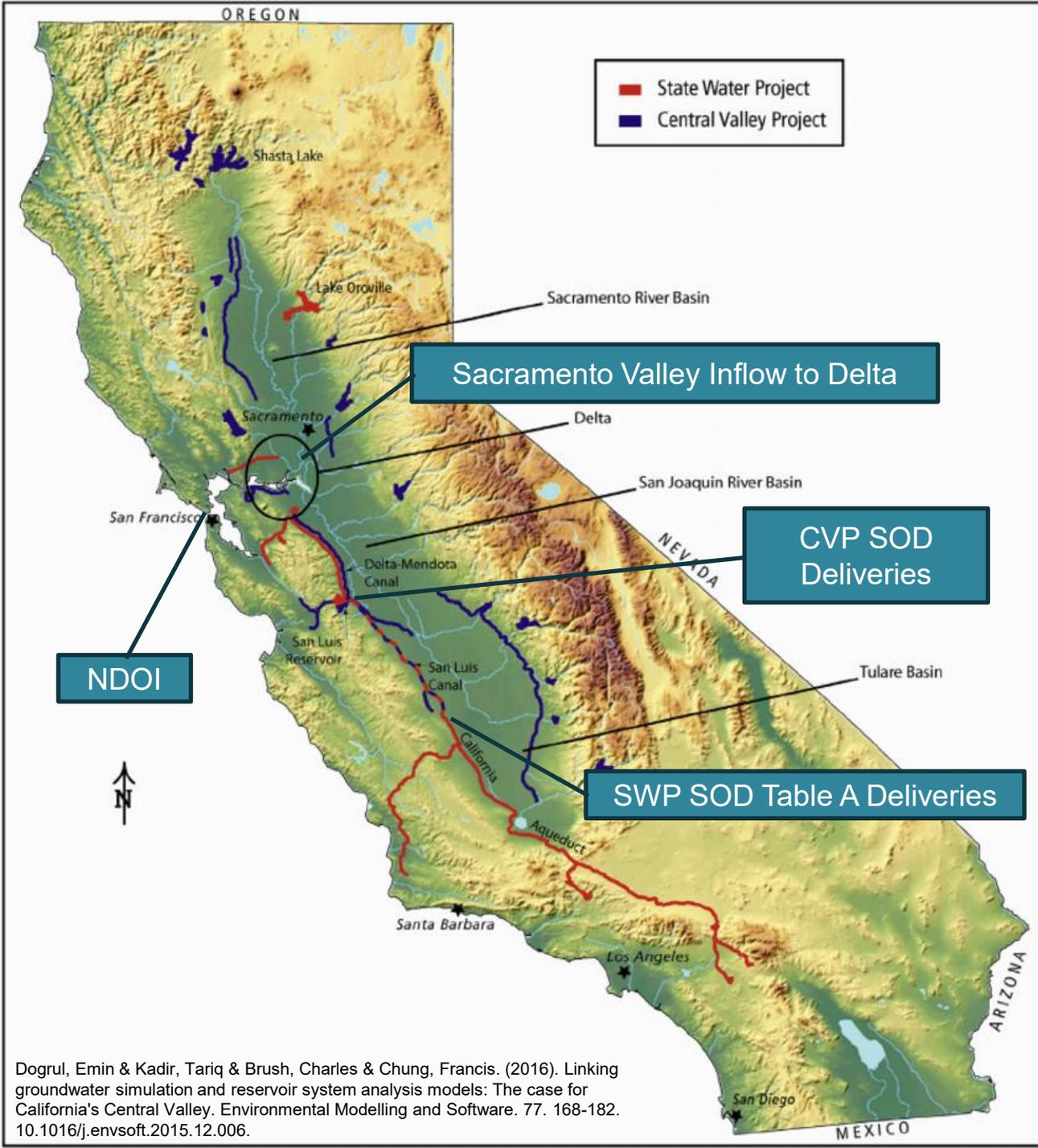
B. Validation - Performance Metrics

- **Keystone Metric: Annual Average of SWP Table A deliveries % difference <5%**[*]

- **R-Squared**

- Percent Bias

- Nash-Sutcliffe Efficiency

From CalSim II (2003) Report

Performance Parameter	Dry-period average 1987-1992				Long-term average			
	Simulated taf/yr	Historical taf/yr	Difference taf/yr	%	Simulated taf/yr	Historical taf/yr	Difference taf/yr	%
SWP south-of-Delta Table A deliveries	1,930	2,030	-100	-4.9	1,810	1,790	20	1.1
CVP south-of-Delta deliveries	2,230	2,320	-90	-3.9	2,650	2,490	160	6.4
Sacramento Valley inflow to the Delta	9,700	9,670	30	0.3	19,830	19,920	-90	-0.5
Net Delta Outflow Index	5,270	5,090	180	3.5	19,070	19,690	-620	-3.1

Image generated using ChatGPT

C. Recalibration - Knobs

- Time-varying land use
- Facilities
- SWP/CVP allocation logic
- Reservoir balancing
- Weights

Key Takeaways

- CalSim is normally run in **planning mode** with a fixed assumed demands, infrastructure, operations, and regulations for comparative analysis.

- This effort will develop a **historically-based CalSim 3** run focusing on the last ~20 years.

- This work faces different considerations compared to physically-based hydrologic models since CalSim is a **mass balance, linear-programming-based** model.

- **But this type of work has been done before!** It will just be more challenging due to the more detailed and extensive nature of CalSim 3 compared to the other models.

- This is a part of **three** other **whitepaper efforts.**

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Questions or Comments?

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🖥 https://water.ca.gov/library/modeling-and-analysis

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