

Delta and Central Valley Watershed Flows: Trends and Attribution 1922-2009

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Presentation at the California Water and Environmental
Modeling Forum

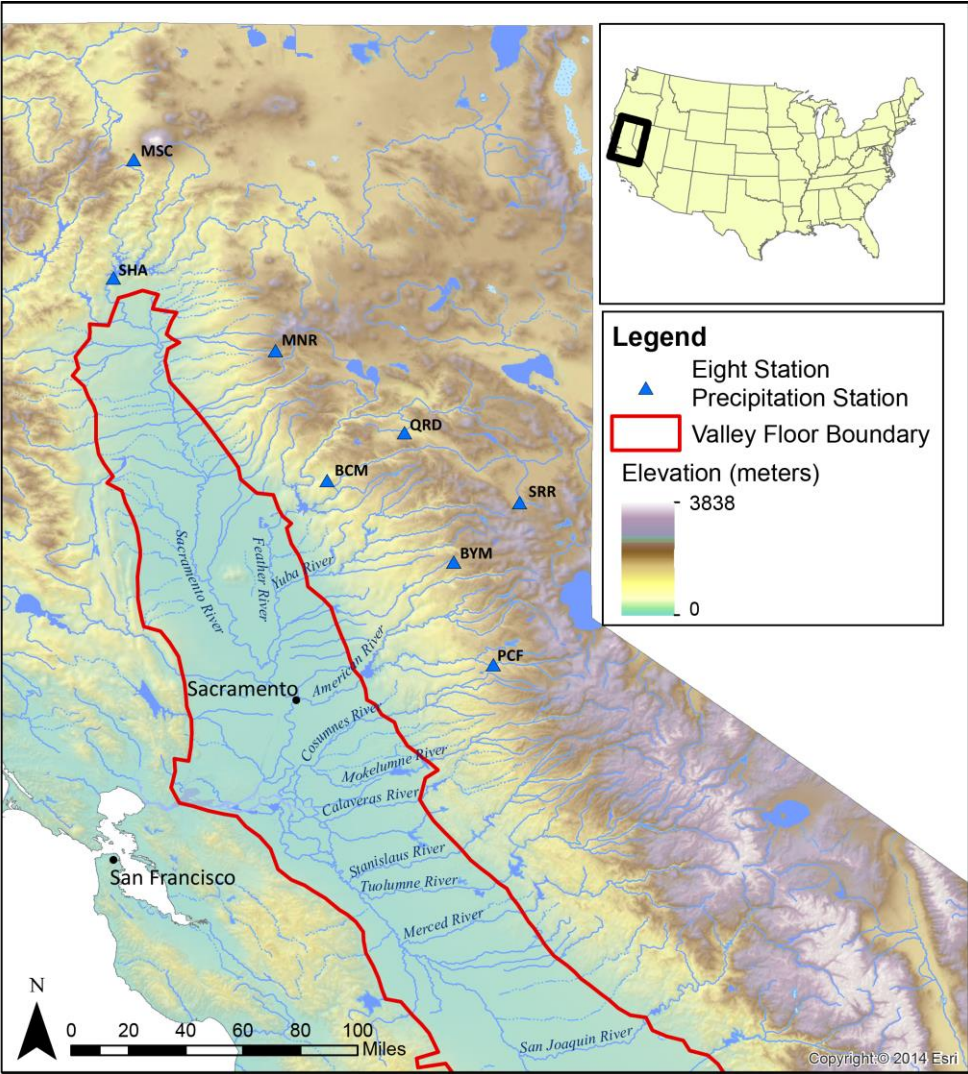
April 11, 2016



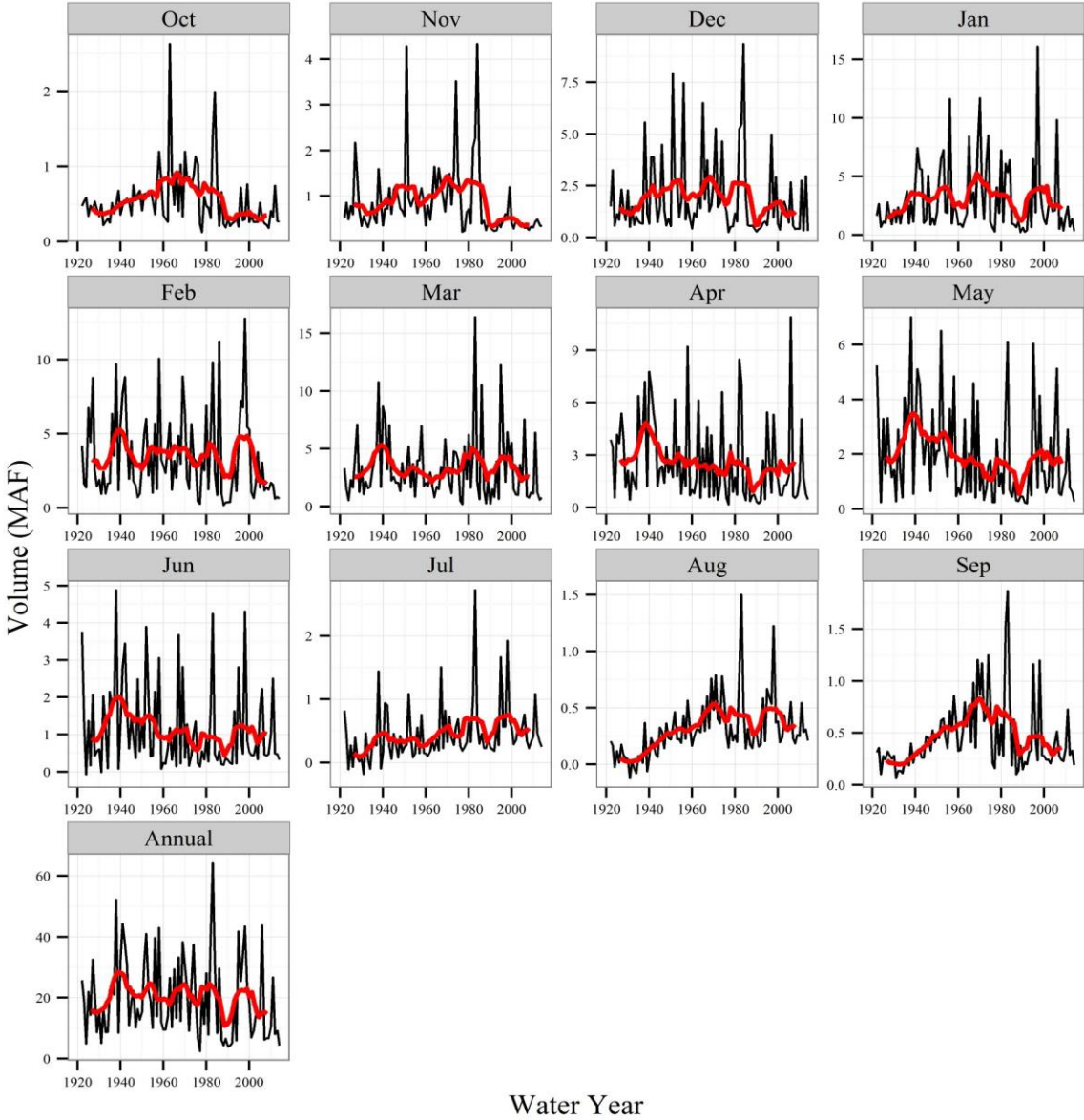
Presentation Overview

- Used observed data across the Central Valley and Delta to understand **how** flows have changed over water years 1922-2009
- The high inter-annual variability necessitates the use of formal statistical techniques to detect trends; specifically we used the Mann-Kendall test and Sen slope test to determine the significance of trends
- Explore trends over 1922-1967 (before and during major water construction), and over 1968-2009 (following construction)
- An understanding of **why** Delta outflows have changed, looking at upstream flows and other drivers

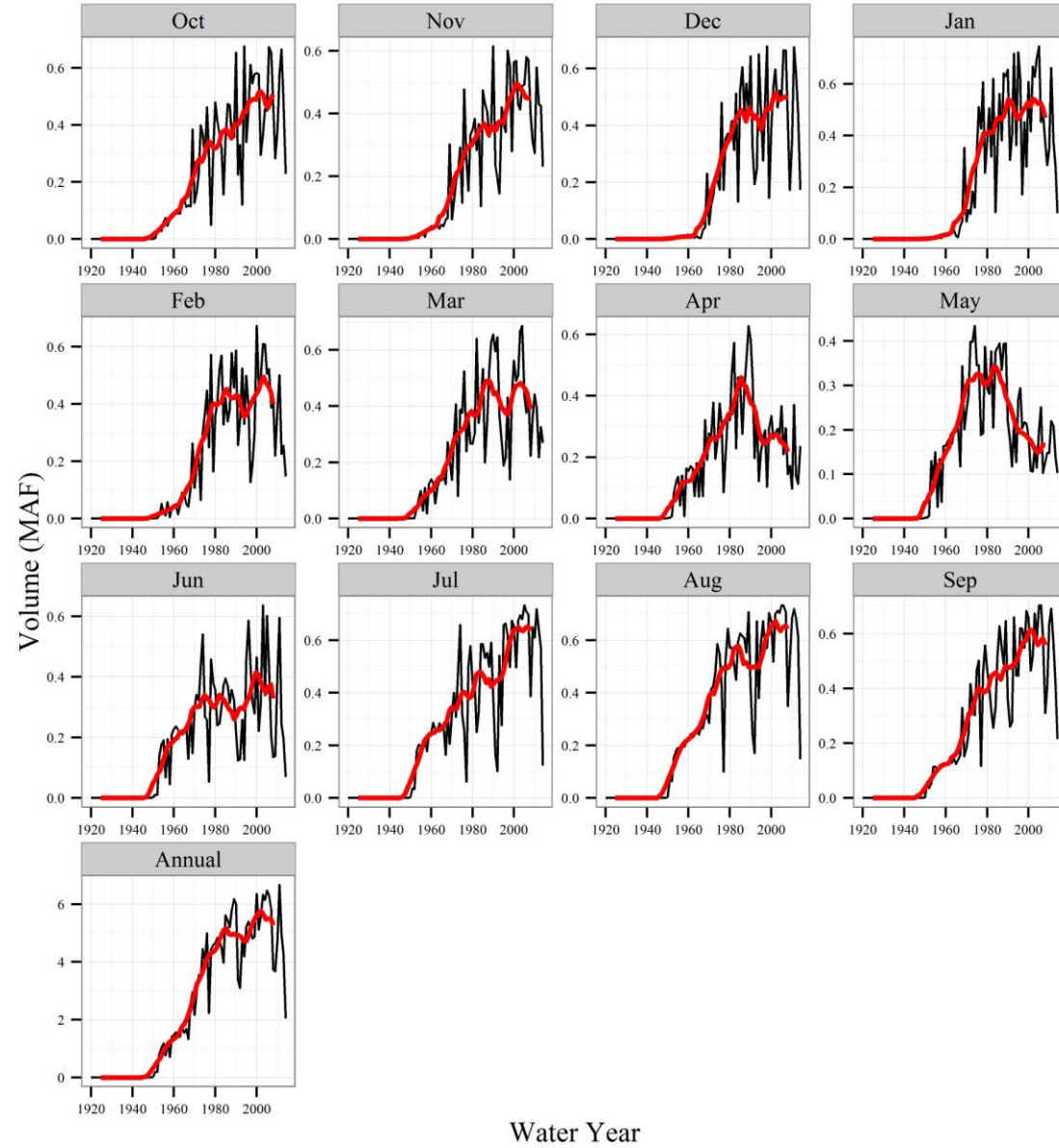
Central Valley Watersheds



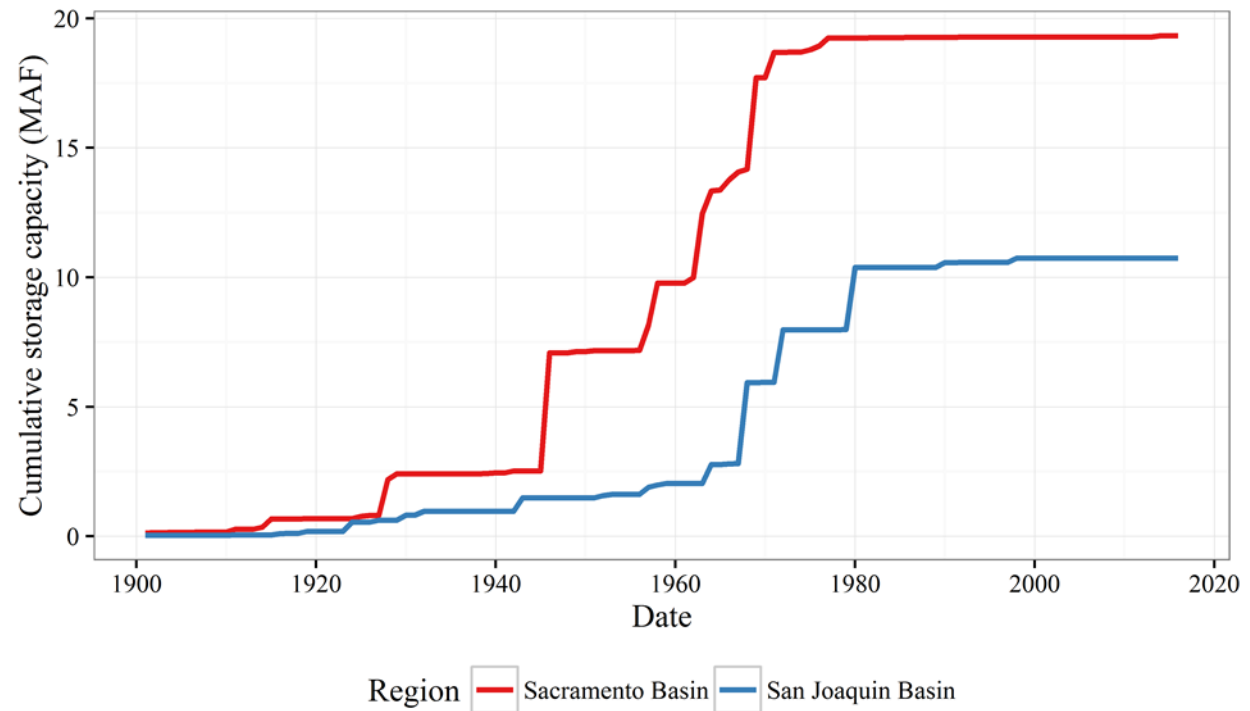
Net Delta Outflow (DAYFLOW)



Delta Exports (CVP + SWP + NBAQ + CCWD)

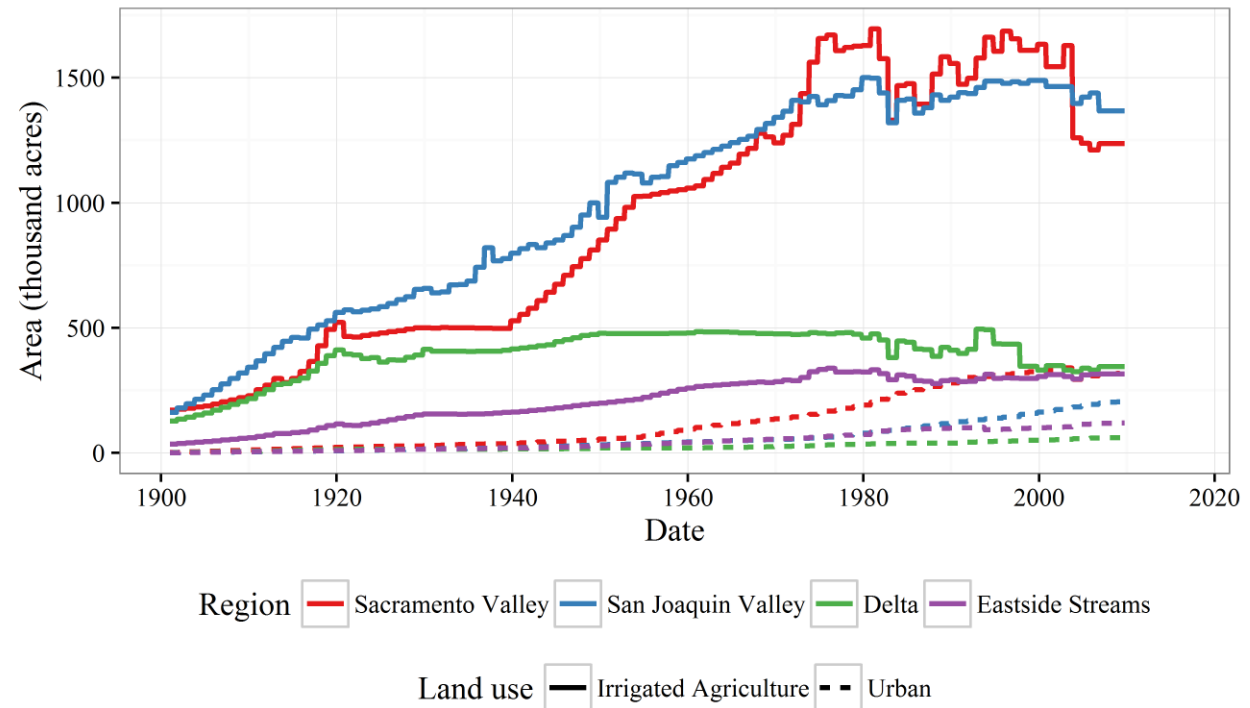


Other Drivers of Change (1) Reservoir Construction



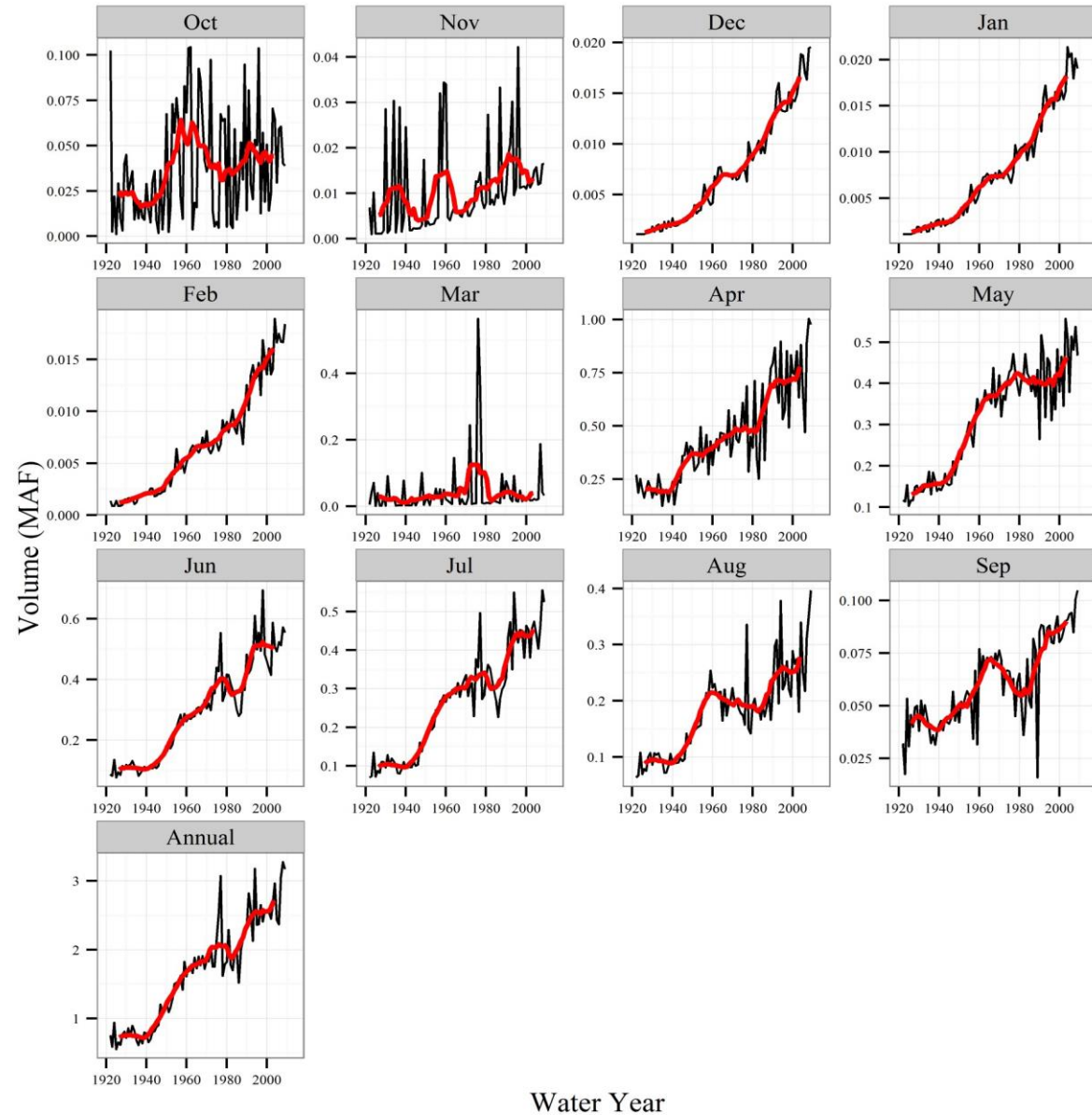
Data from Andy Draper, MWH Global.

Other Drivers of Change (2) Irrigated Agriculture and Urban Land



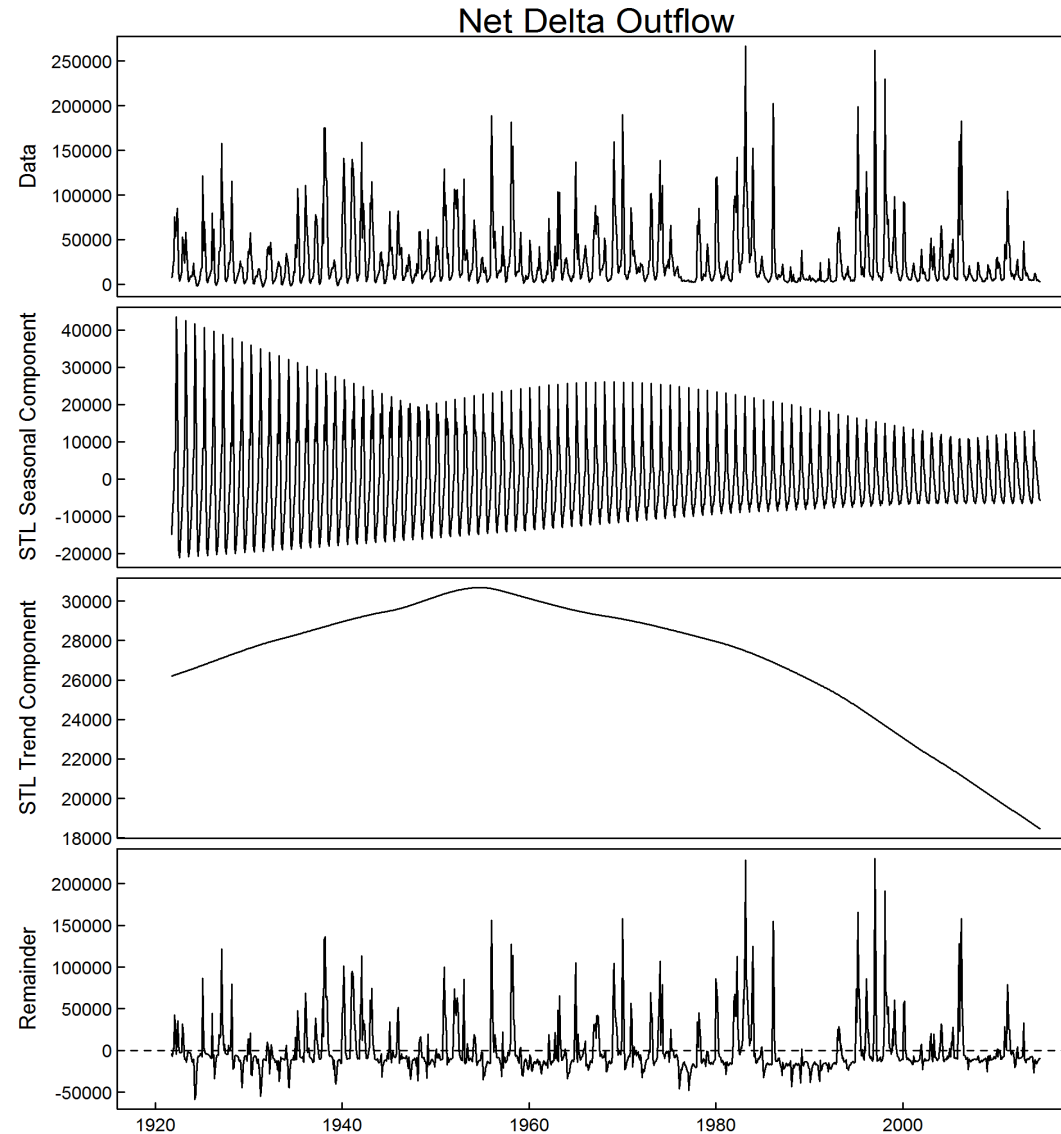
Data from Andy Draper, MWH Global.

Other Drivers of Change (3) Groundwater Pumping in the Sacramento Valley

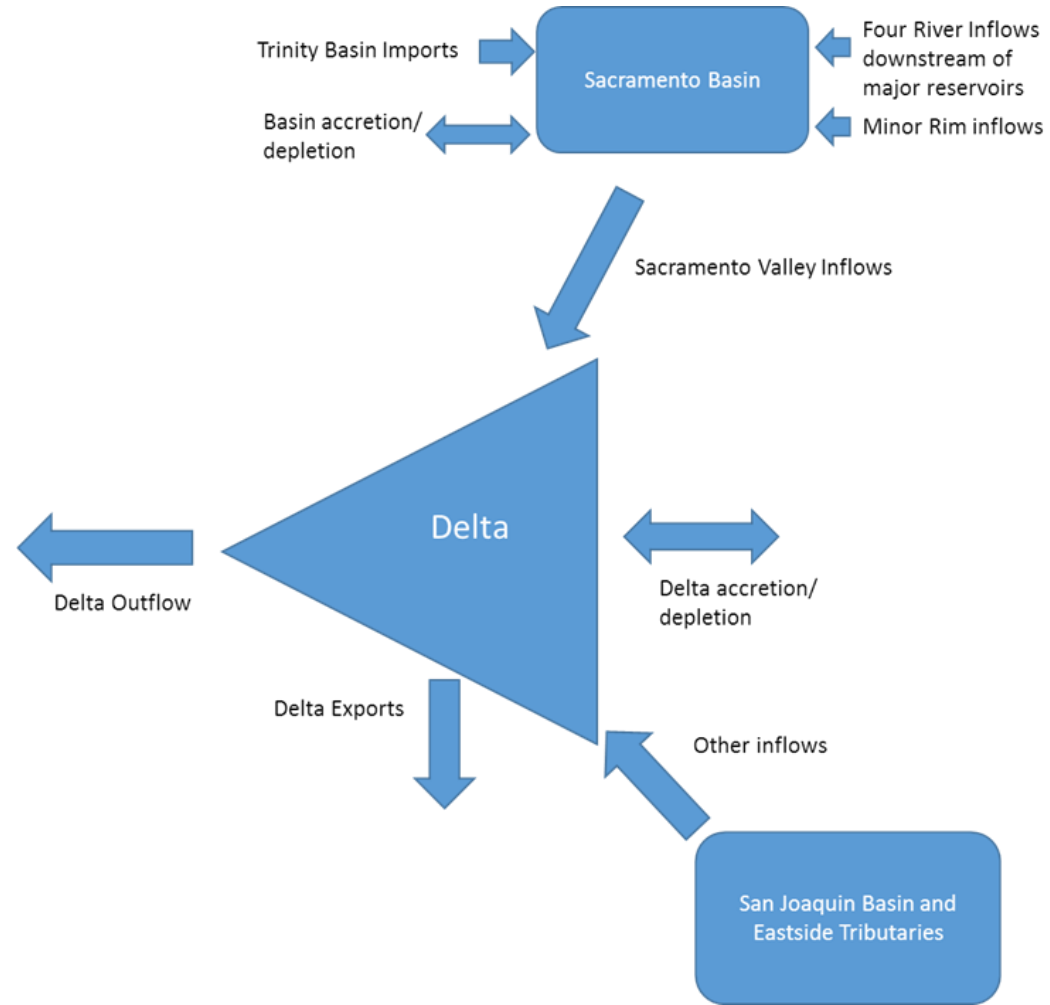


Data from C2VSIM historical run.

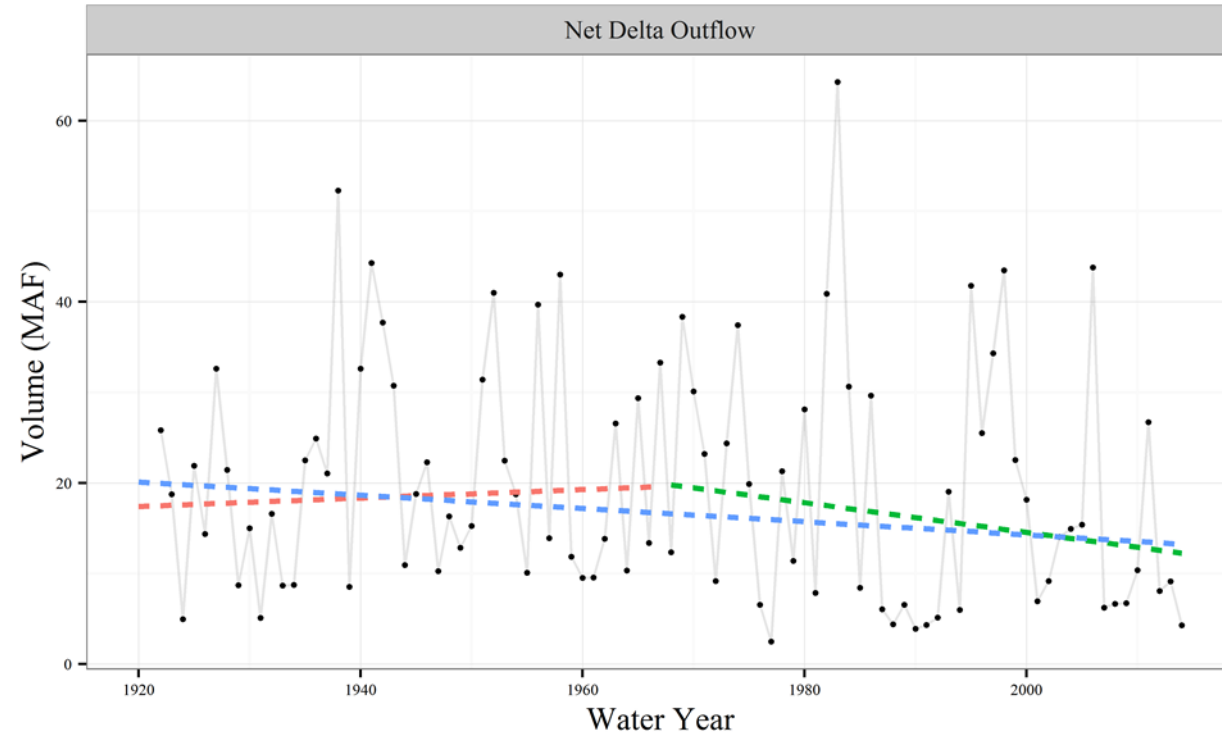
Net Delta Outflow: Seasonal Trend Decomposition Based on Loess (STL)



Simplified Flow Contributions to Net Delta Outflow

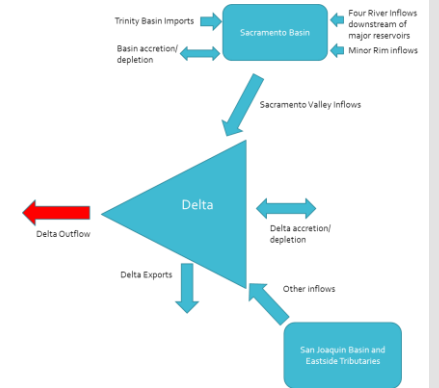


Trends in Annual Delta Outflows

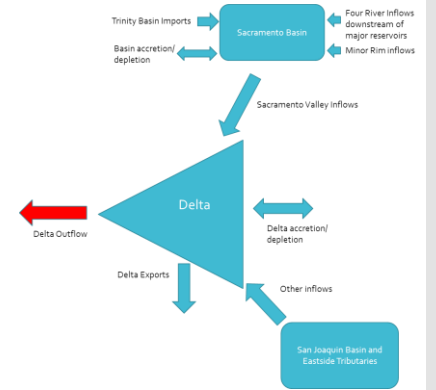
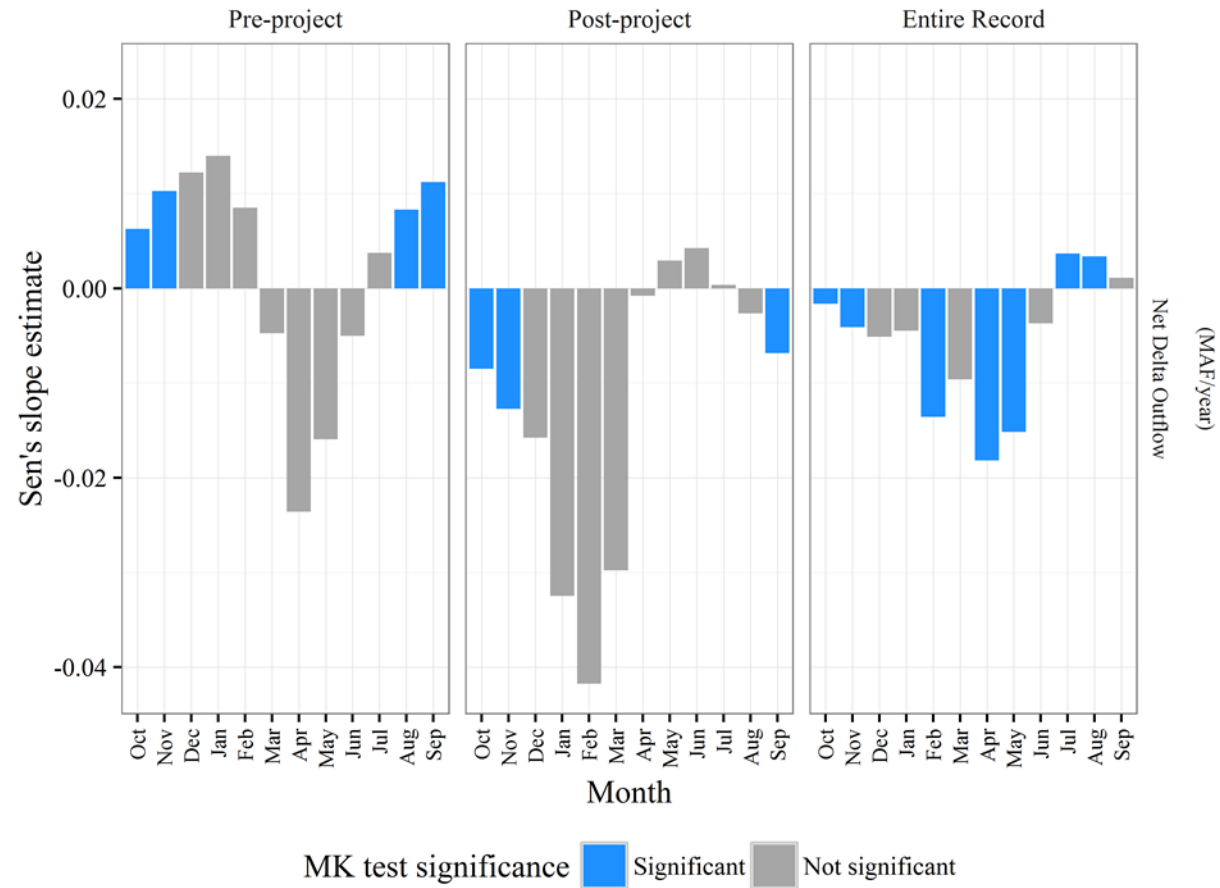


Period of trend evaluation — Pre-project — Post-project — Entire Record

MK Test Significance — Significant — Not significant

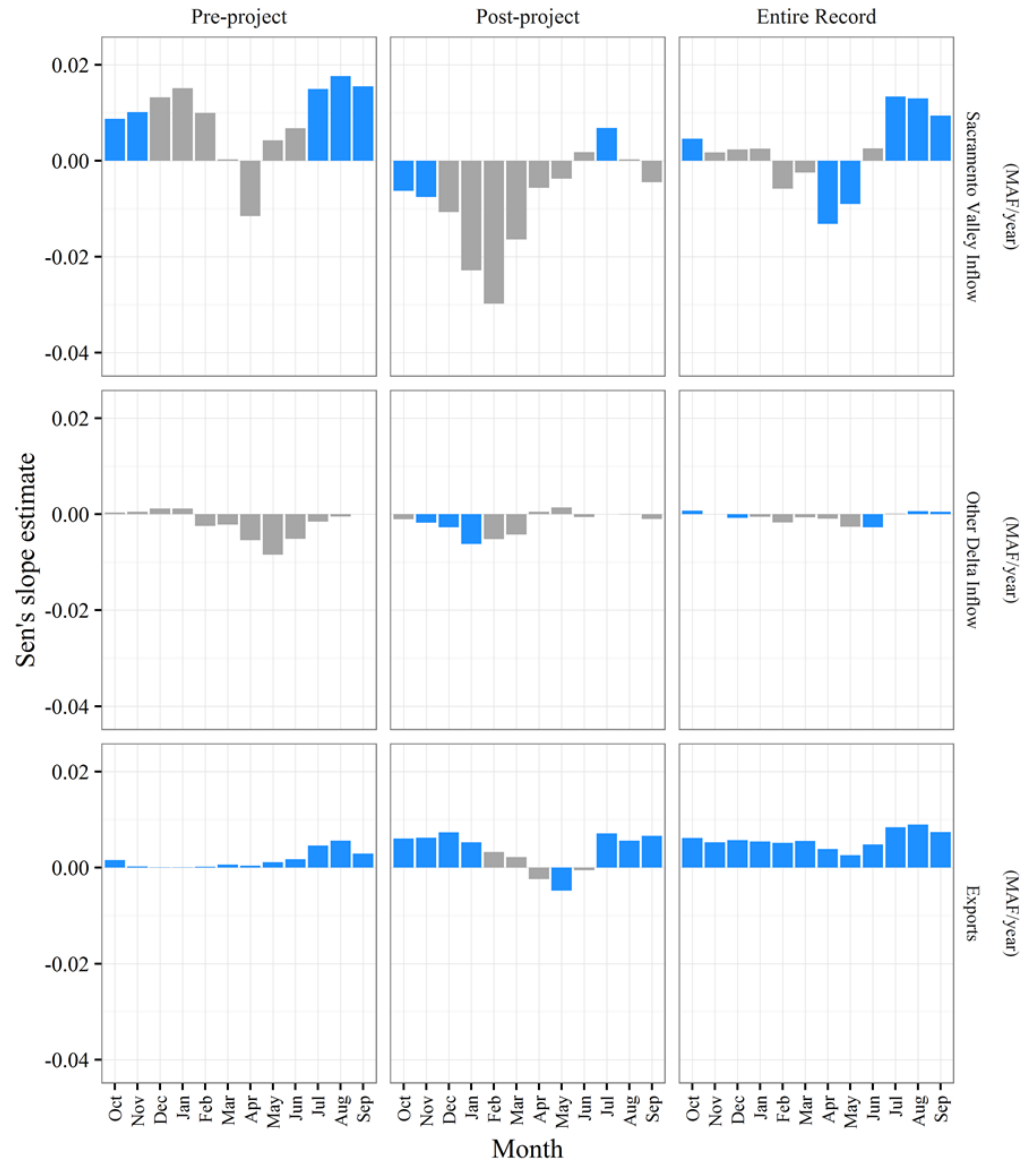


Trends in Monthly Delta Outflows

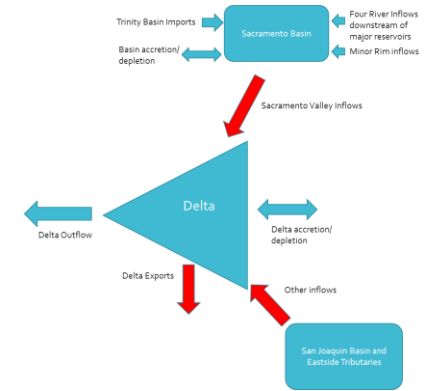


Pre-project: 1922-1967; Post-project: 1968-2009

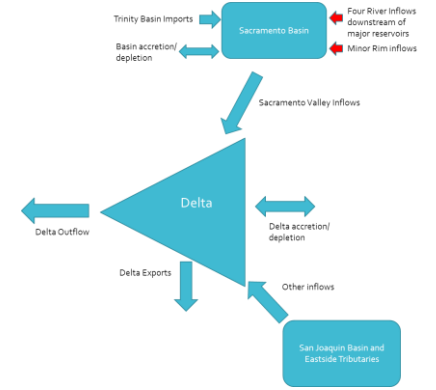
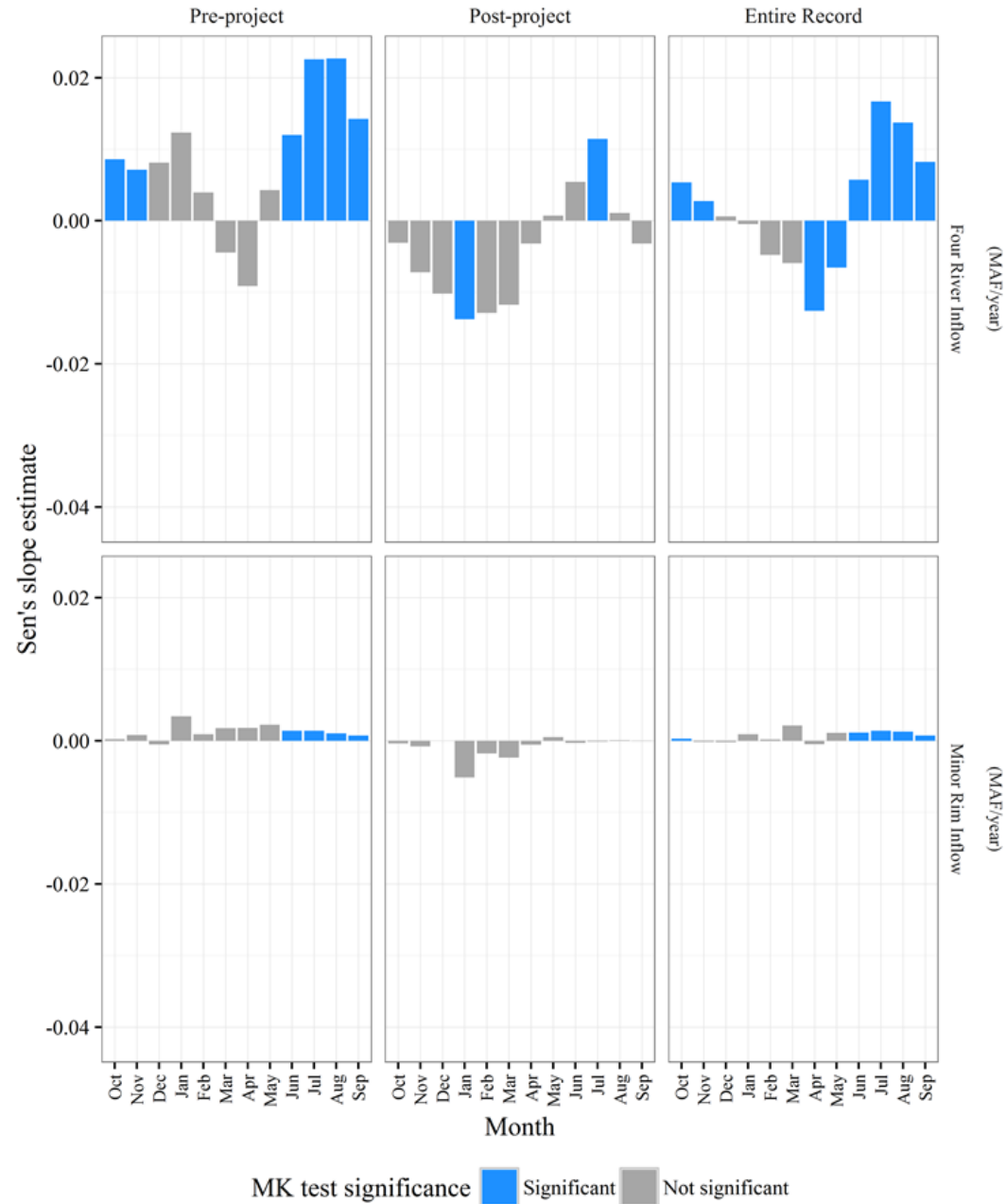
Trends in Monthly Delta Inflows



MK test significance ■ Significant ■ Not significant

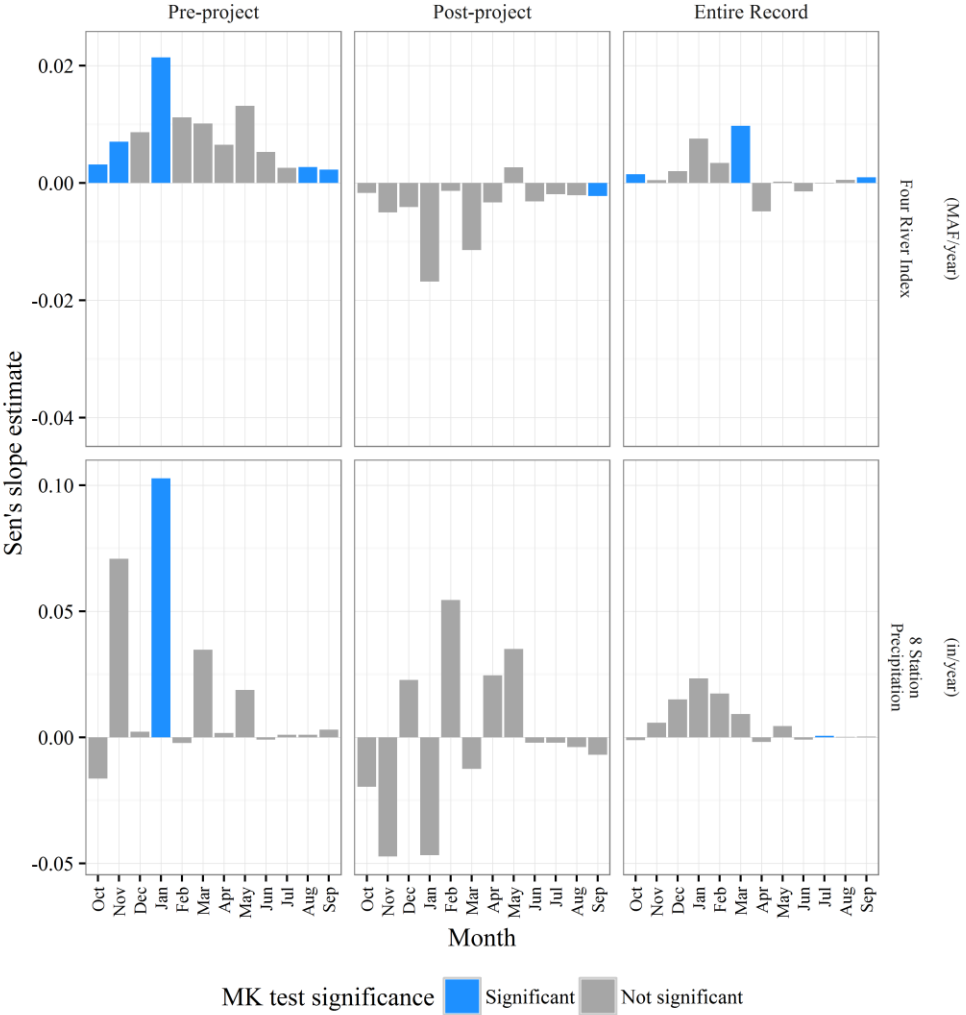


Trends in Sacramento Valley Inflows

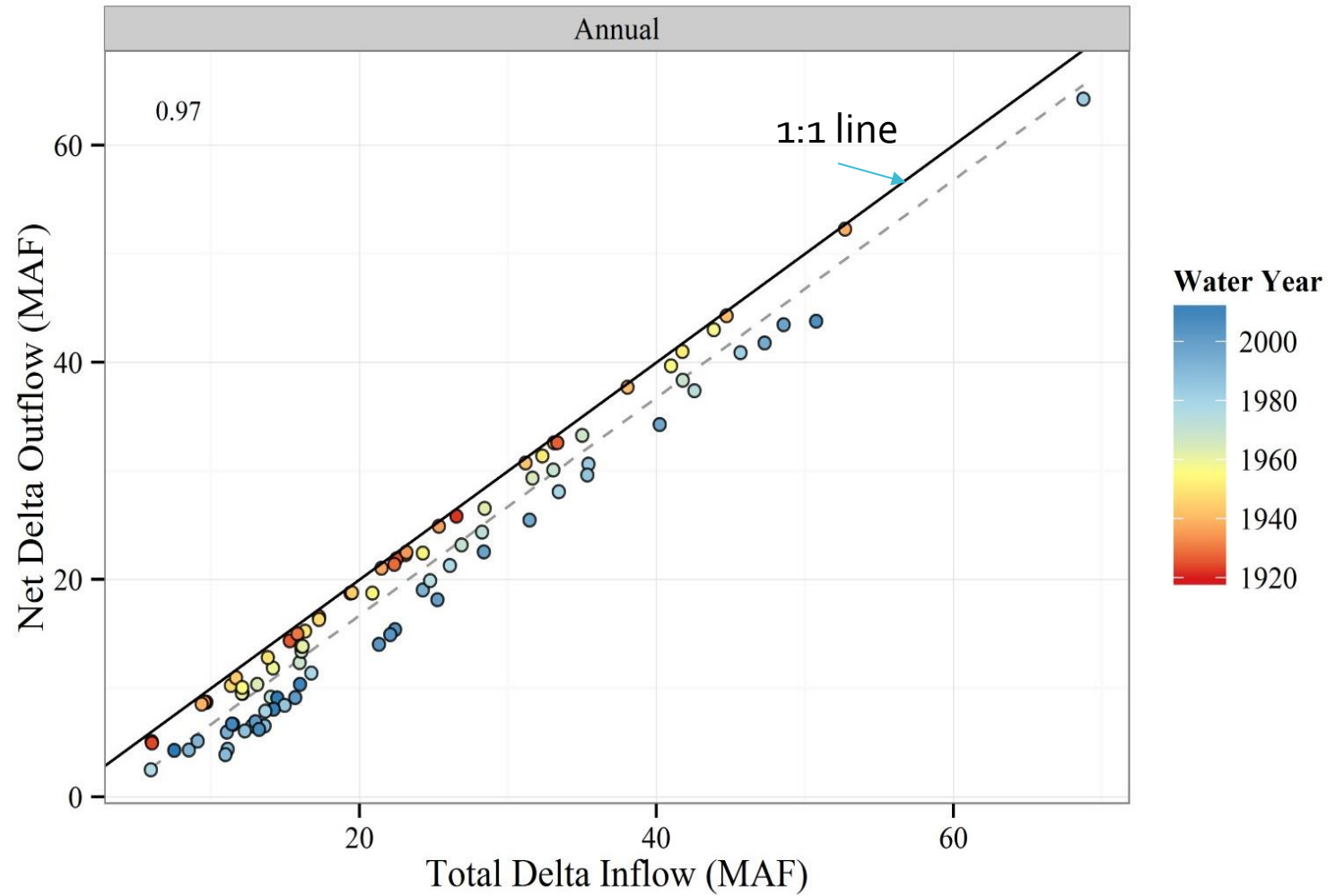


MK test significance ■ Significant ■ Not significant

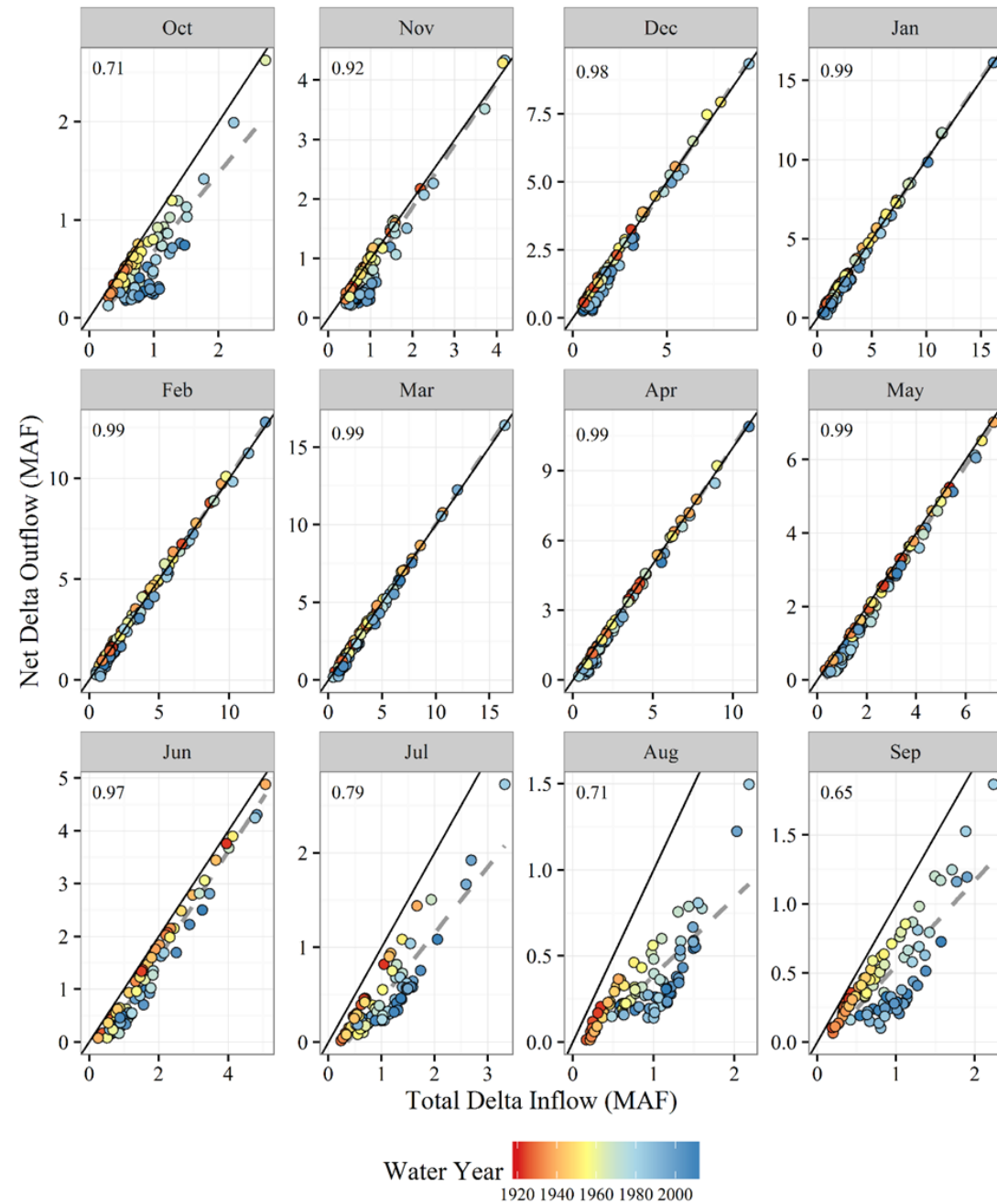
Underlying Climatic Drivers



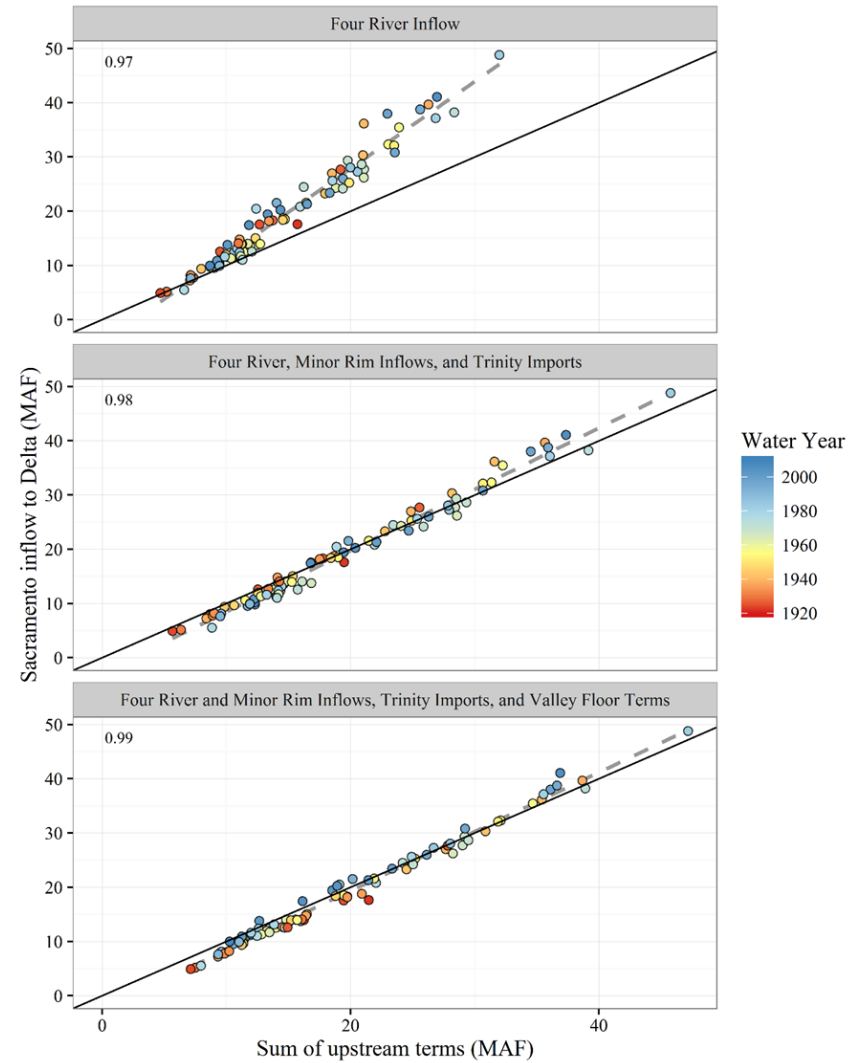
Annual Water Balance for the Delta Using Inflows and Outflows



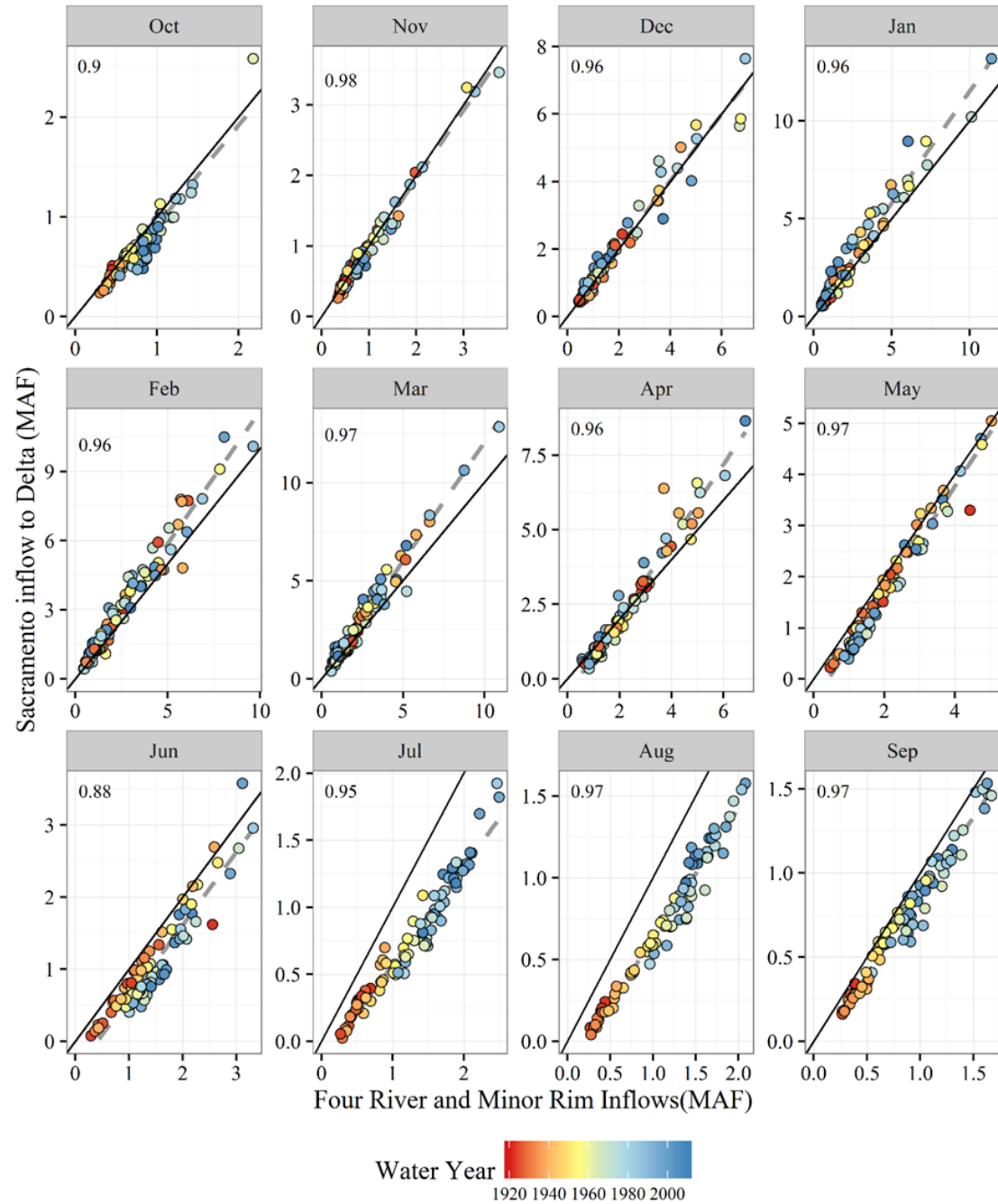
Monthly Water Balance for the Delta Considering Inflows and Outflow



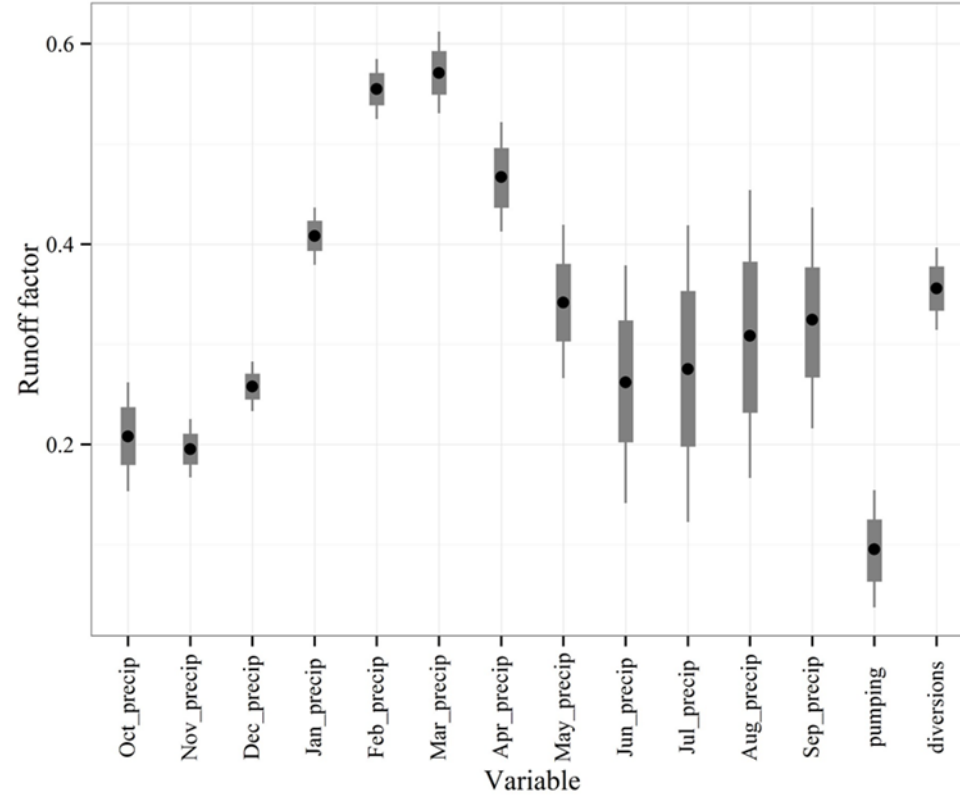
Water Balance for the Sacramento Valley Adding Flow Terms Incrementally



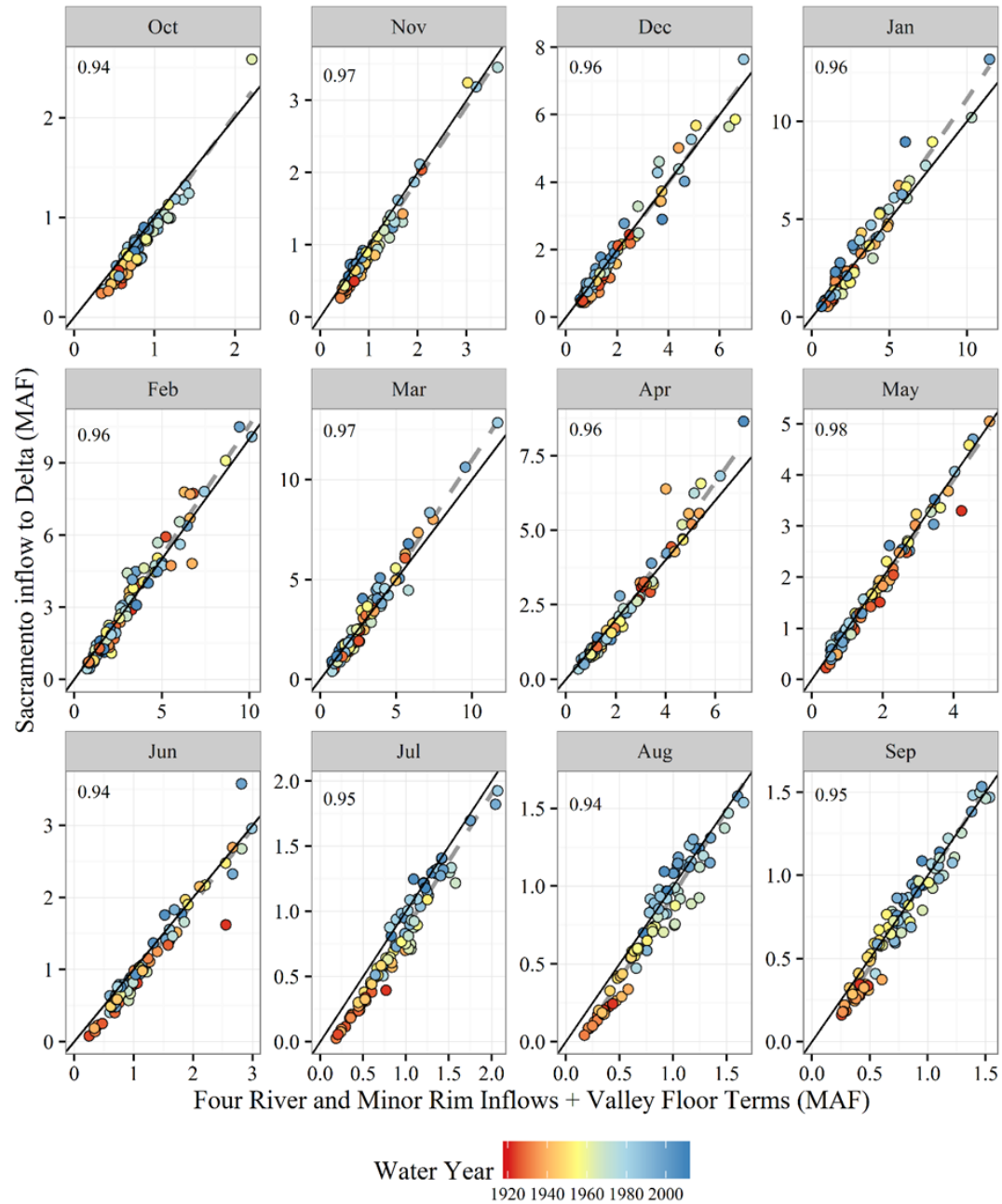
Water Balance with Four River Inflows and Minor Rim Inflows



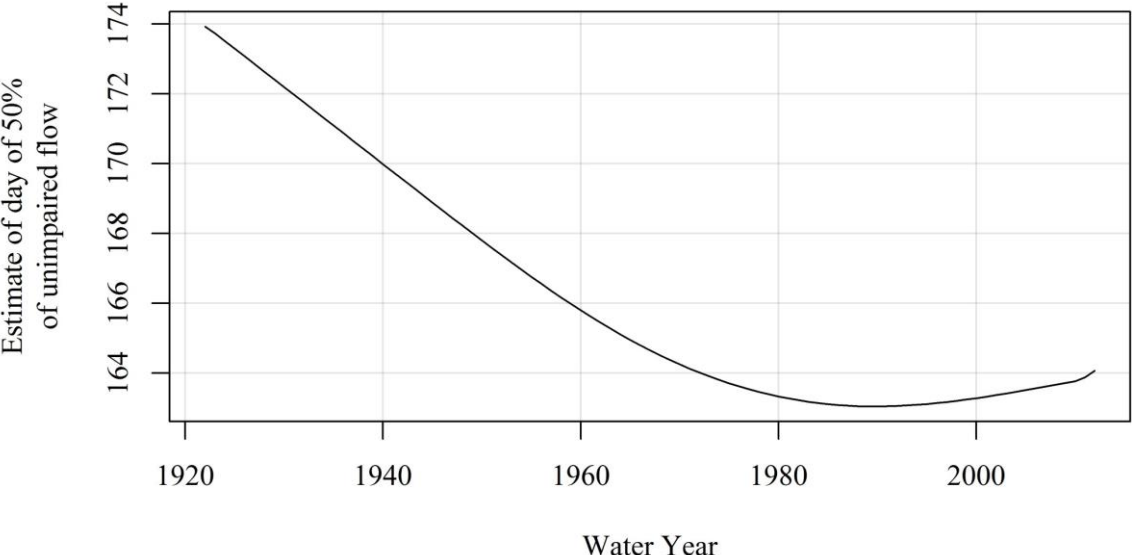
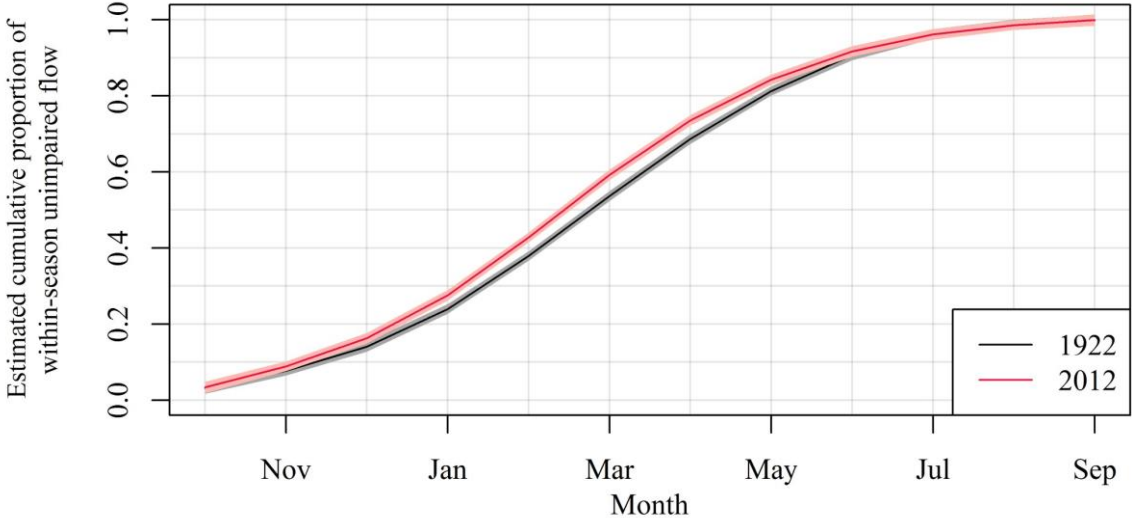
Runoff Factors for Valley Flow



Water Balance with Valley Floor Terms Added



Effect of Climate Change on Unimpaired Flows



Key Findings

- Although there are decreases in **annual** Net Delta outflows (NDO), there are no statistically significant trends over 1922-2009
- This is counterintuitive given the extensive changes in the watershed, and partly explained by flows shifting between months, and by the large variability in the system
- Significant trends in **monthly** Net Delta outflows are observed
- Over the entire period of record, the MK test suggests a nominally upward trend in July and August, both related to reservoir releases, and downward trends in winter/spring (significant in February, April and May), related to upstream reservoir storage
- The pre-Project period (1922-1967) saw significant increases in late summer and fall (August–November) NDO, associated with the increase in reservoir capacity and releases in these months
- In the post-Project period (1968-2009), these trends were largely reversed, with NDO trending downward in September–November, suggesting continuing growth in withdrawals—in the Delta or further upstream in the Central Valley—that counteract the reservoir releases
- Sacramento Valley inflows to the Delta are best explained by using the rim flows as well as valley floor sources
- Climate change effects (over the past nine decades) are detectable in the unimpaired flows, but are masked downstream of the reservoirs