Precipitation Sensitivity of Central Valley Floor Hydrology in CalSim 3

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Modelling Support Office

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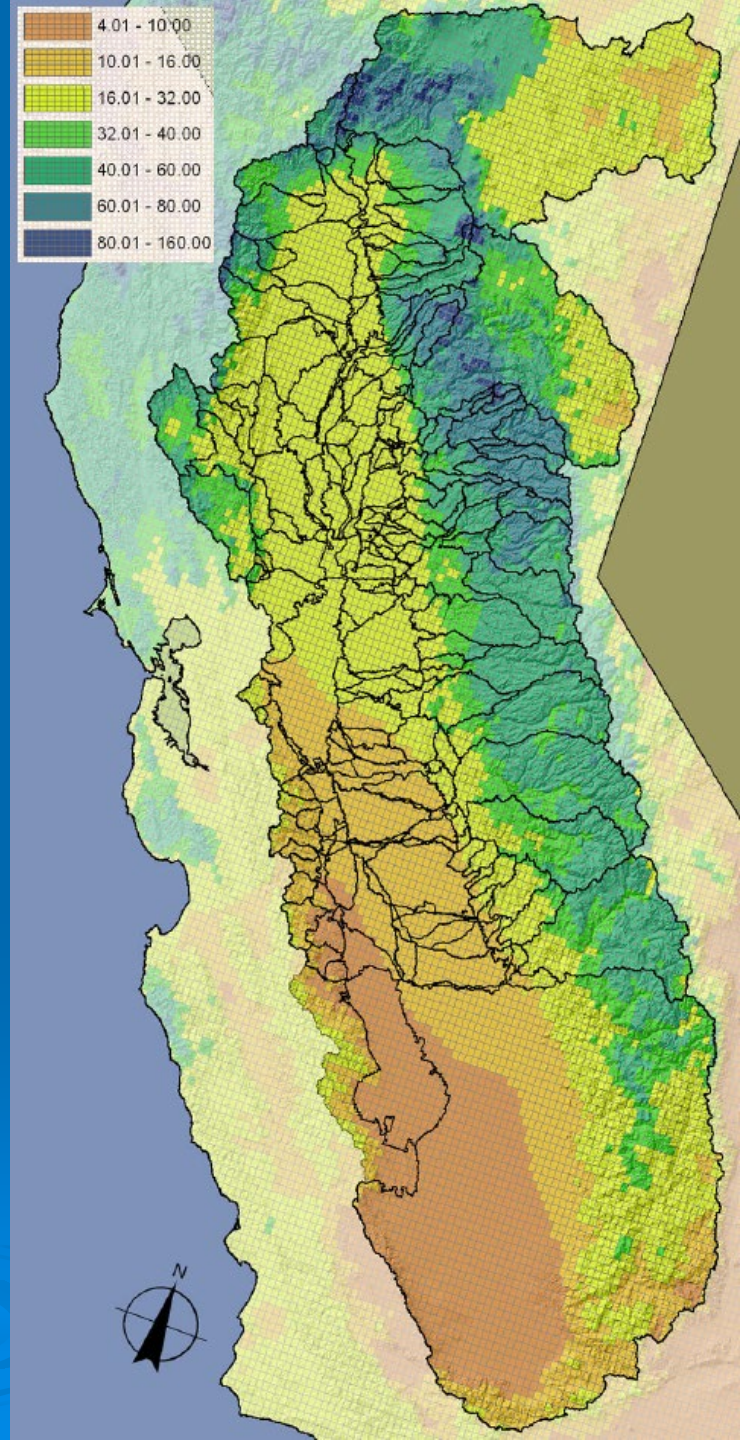
Outline

- Background
  - CalSimHydro Model and Valley Floor Hydrology
  - Changes in precipitation interannual variability
  - Historical precipitation adjusting method
- Precipitation Sensitivity Analysis
- Summary and Discussion.

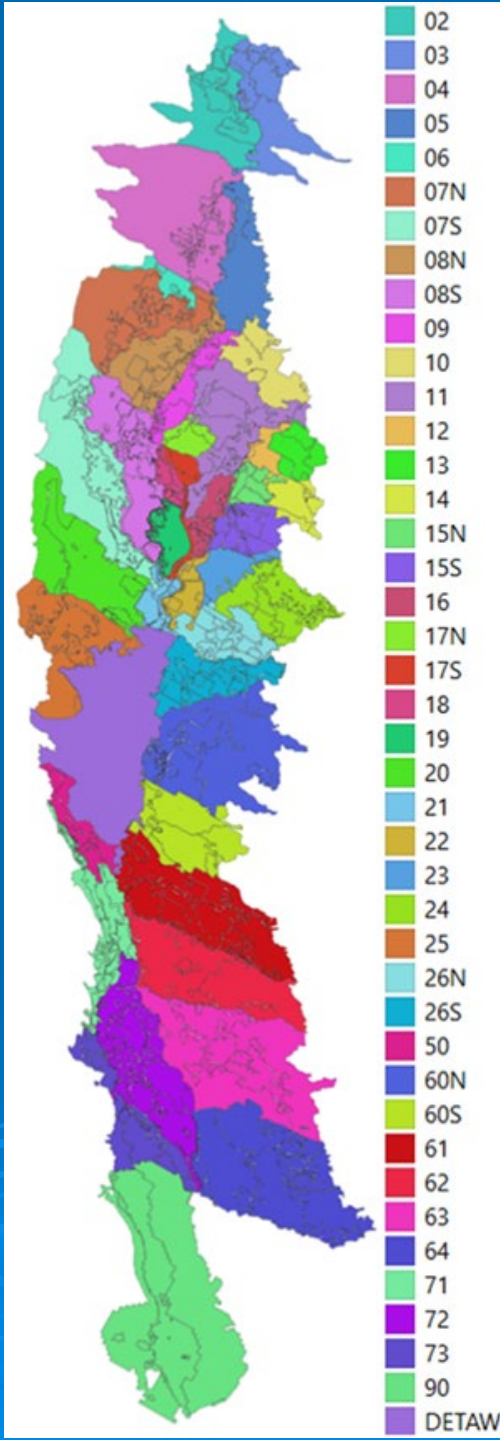
Background

DWR's Historical Data Adjustment Workgroup met regularly in 2022 on the subject of adjusting historical hydrology to reflect the current climate conditions in California, which let to the work of this presentation.



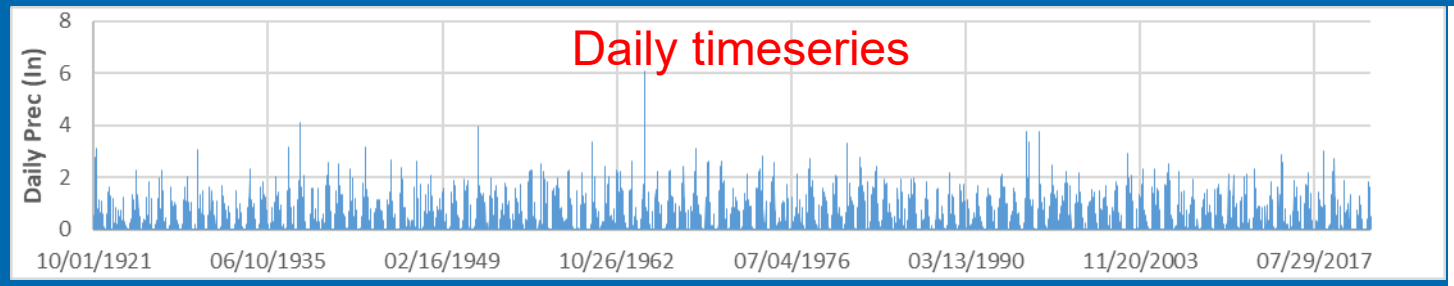
Background

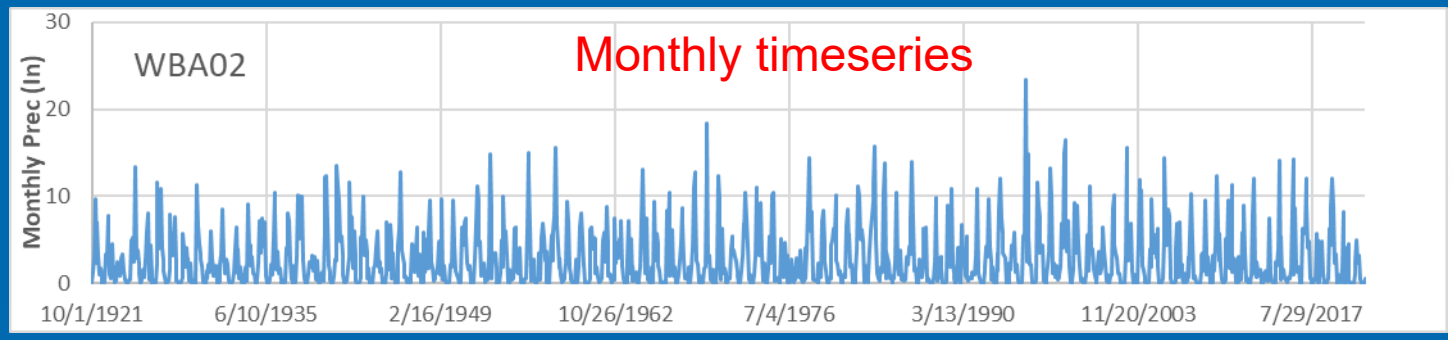
- **CalSimHydro Model and Valley Floor Hydrology**
  - 4 Sub models:
    - Daily Rainfall Runoff Model
    - IDC – Irrigation Demand Calculator
    - Rice Water Use Model,
    - Refuge Water Use Model
  - 42 water budget areas (WBAs) and 235 demand units
  - Inputs: precipitation, soil property, land use data, crop evapotranspiration, min soil moisture requirement, rice/refuge operation parameters
  - Hydrology Outputs: surface runoff, deep percolation (recharge to GW), applied water (irrigation), tailwater (return flow), evapotranspiration

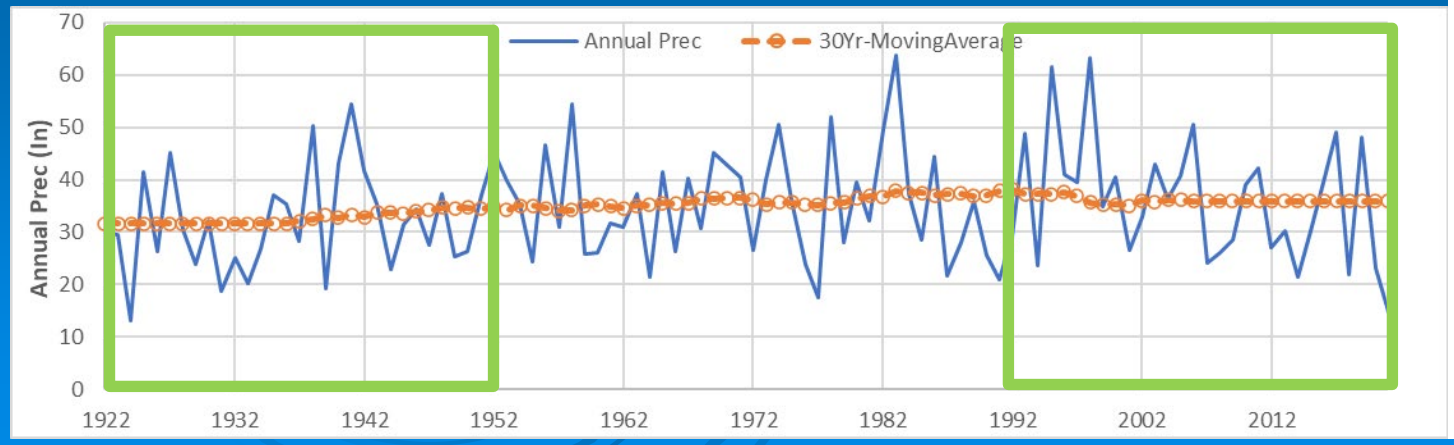


Background

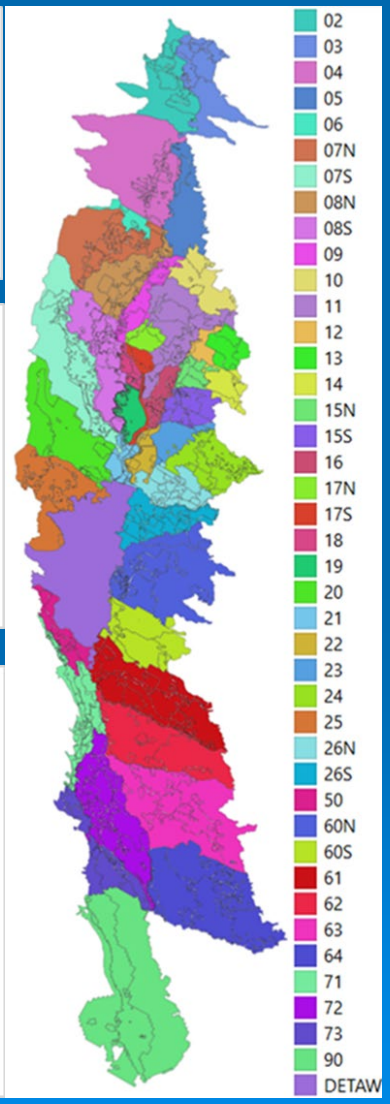
- **Changes in Precipitation Interannual Variability**







- Annual timeseries
- 30-year moving average timeseries



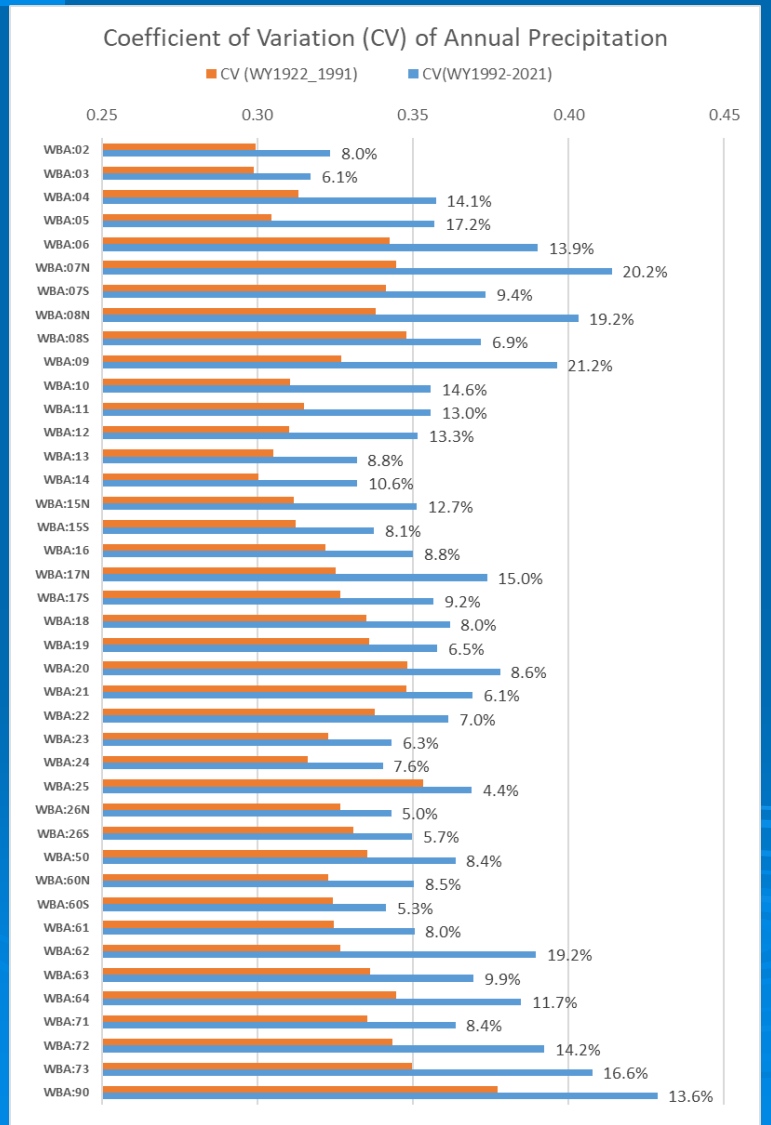
Background

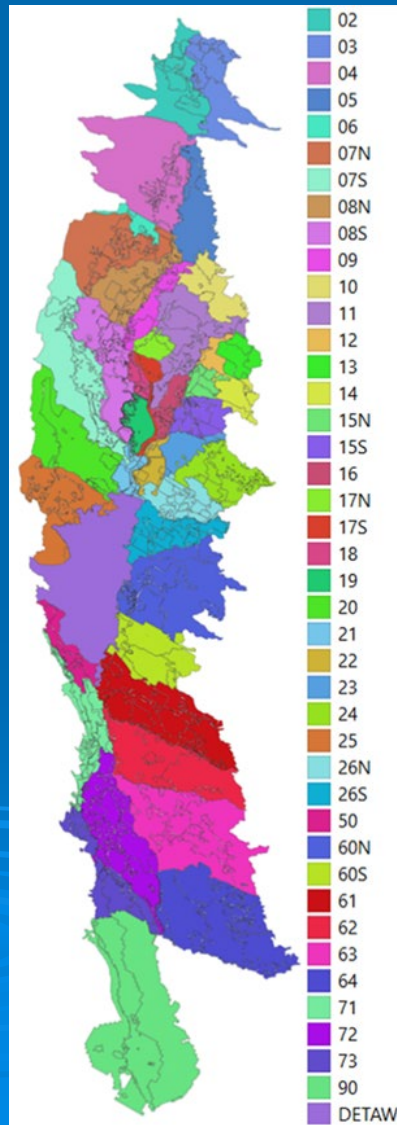
- **Changes in Precipitation Interannual Variability over Valley Floor's WBAs**

$$CV(WY1922-1991) = \frac{\sigma_{his}}{\mu_{his}}$$

$$CV(WY1992-2021) = \frac{\sigma_{ref}}{\mu_{ref}}$$

σ_{his}, σ_{ref} are standard deviations of annual precipitation in historical (WY1922-1991) and reference (WY1992-2021) periods
μ_{his}, μ_{ref} are means in historical and reference periods





Background

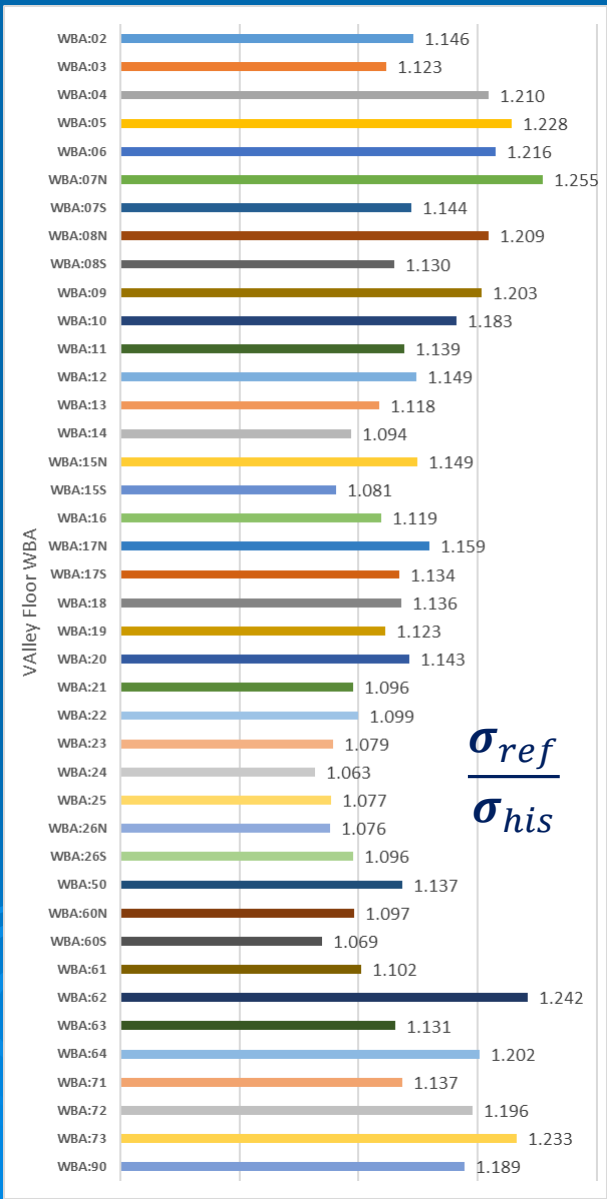
- **Historical Precipitation Adjusting Method**

To adjust annual precipitation in the historical period (WY1922-1991) to have the standard deviation in the reference period (WY1992-2021)

- Mean Distance Scale (MDS) Equation

$$PY_{adj}(y) = \boldsymbol{\mu}_{his} + \frac{\boldsymbol{\sigma}_{ref}}{\boldsymbol{\sigma}_{his}} \cdot [PY(y) - \boldsymbol{\mu}_{his}]$$

- Parameters
  - Three parameters are computed directly from observation data
    - $\boldsymbol{\sigma}_{ref}$ – Standard Deviation in reference period (WY1992-2021)
    - $\boldsymbol{\sigma}_{his}$ – Standard Deviation in historical period (WY1922-1991)
    - $\boldsymbol{\mu}_{his}$ – Mean in historical period
- Results
  - Only the standard deviation of annual precipitation in the historical period is adjusted to the one in reference period, $\boldsymbol{\sigma}_{adj} = \boldsymbol{\sigma}_{ref}$
  - The mean of the adjusted annual precipitation does not change $\boldsymbol{\mu}_{adj} = \boldsymbol{\mu}_{his}$
  - Wet year wetter and dry year drier.

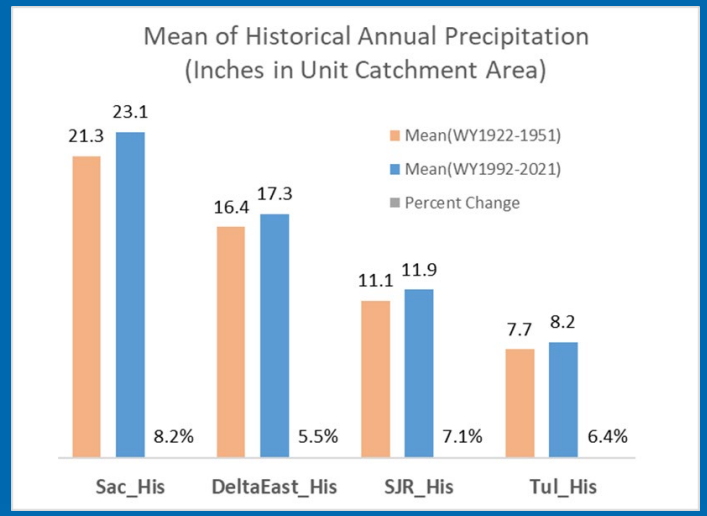


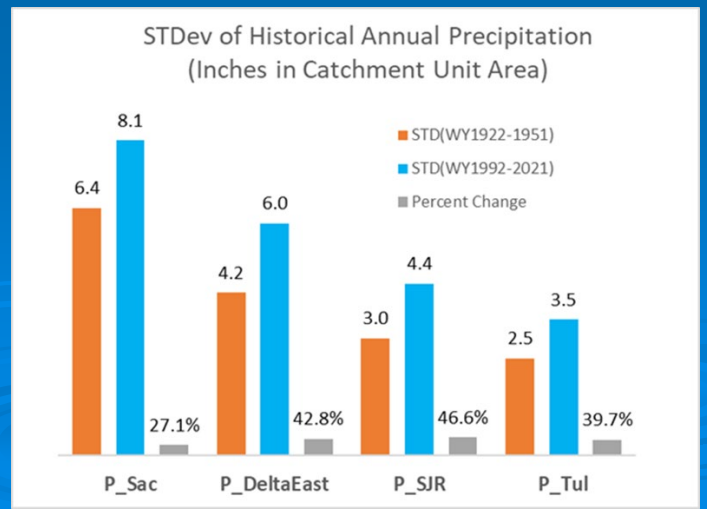
Sensitivity Analysis

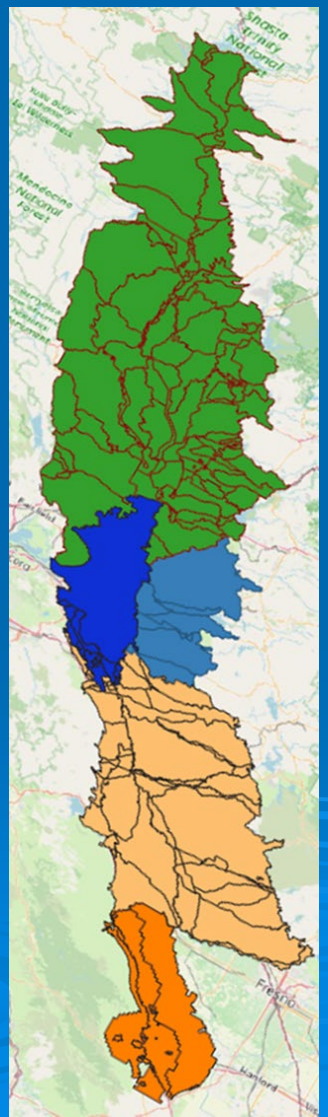
I. Group WBAs into 4 groups based on spatial locations
   a) Sac – WBAs in Sacramento River
   b) DeltaEast – WBAs in Delta Eastside
   c) SJR – WBAs in San Joaquin River (SJR)
   d) Tul – WBAs in Tulare Basin

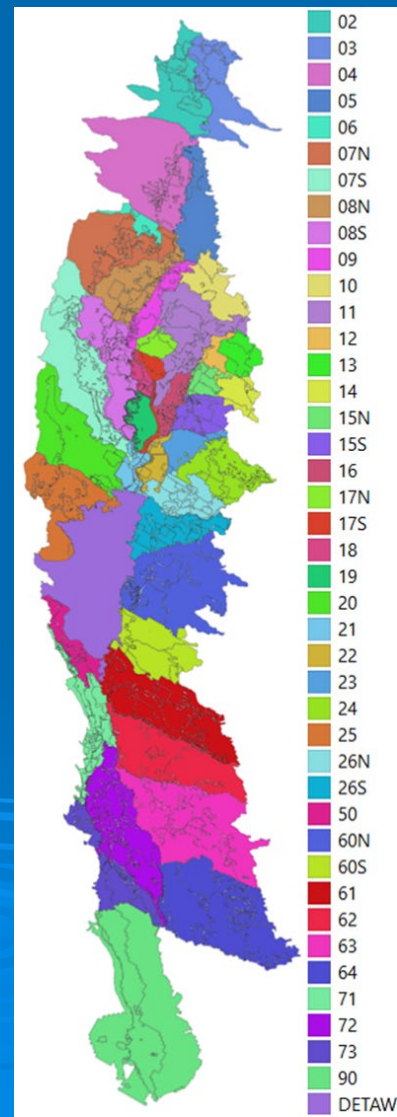
II. Calculate annual mean and 30-year moving average, and 30-year moving standard deviation for each group for both historical and adjusted datasets

III. Plot 30-year moving average, standard deviation for temporal comparison of changes in recent 100 years. (WY1922-1951) is the first 30-year period, and (WY1992-2021) is the last 30-year period.







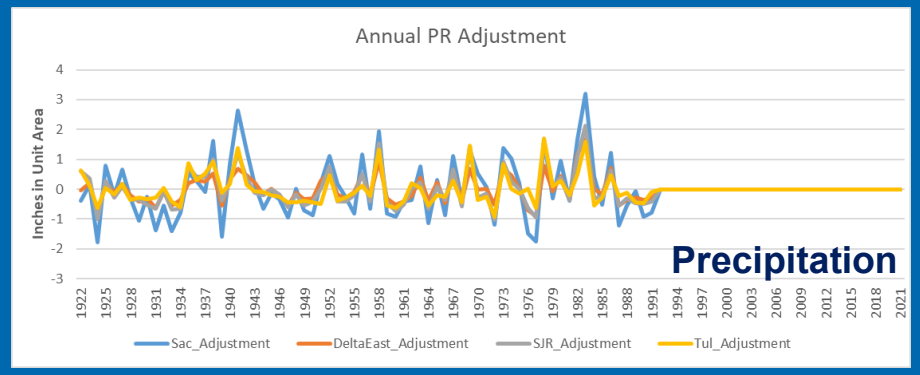


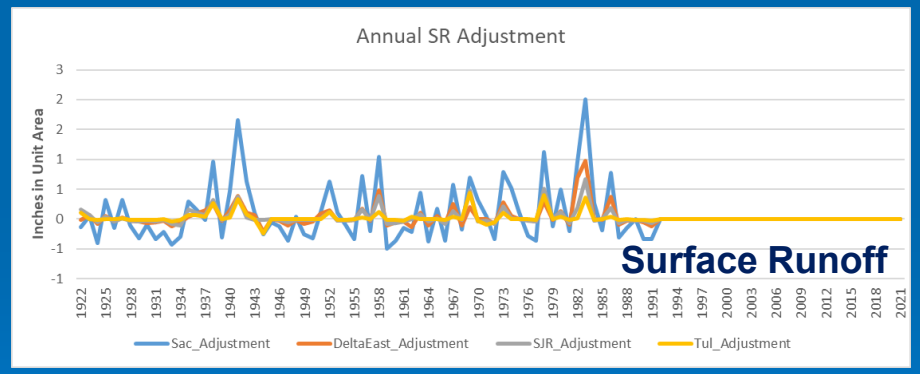
Sensitivity Analysis

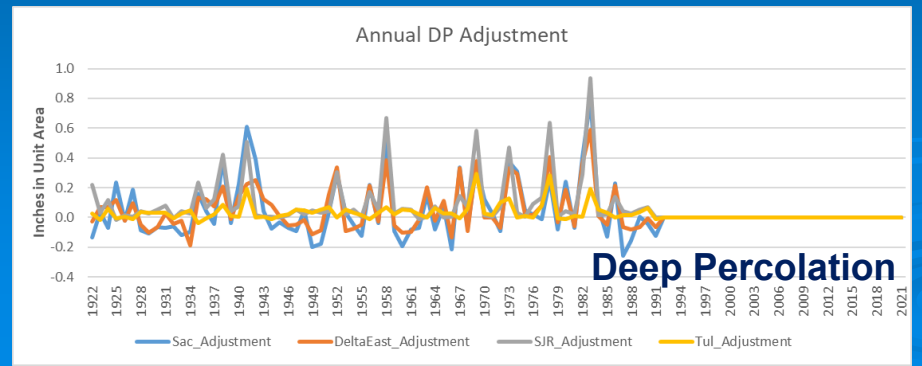
Four different ways to illustrate the precipitation sensitivity of the 5 outputs of CalSimHydro: surface runoff, deep percolation, applied water, return flow, and evapotranspiration,

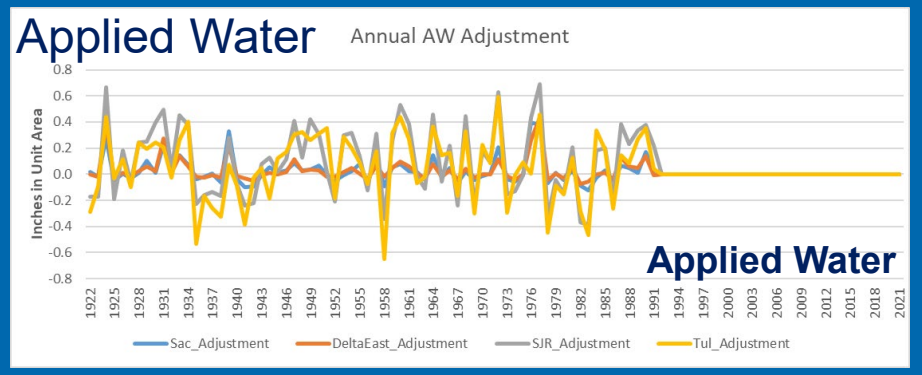
1) Annual differences of outputs using historical and adjusted precipitation timeseries
2) Annual percentage change of outputs using historical and adjusted precipitation timeseries
3) Percentage change of 30-year moving average of outputs using historical and adjusted precipitation timeseries
4) Percentage change of 30-year moving standard deviation of of outputs using historical and adjusted precipitation timeseries

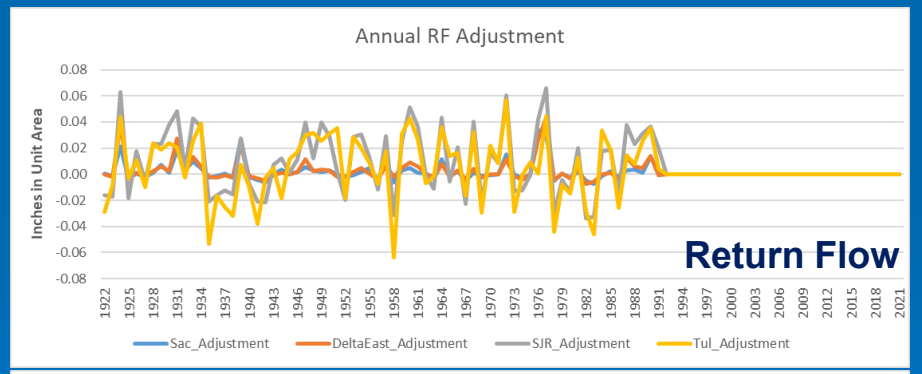
Sensitivity Analysis

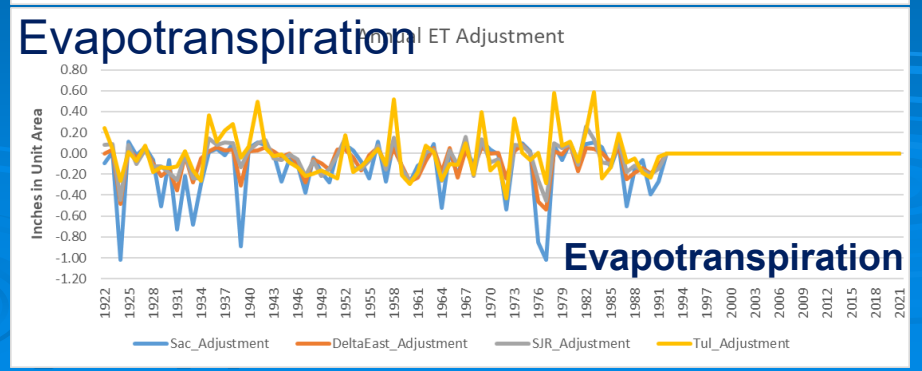


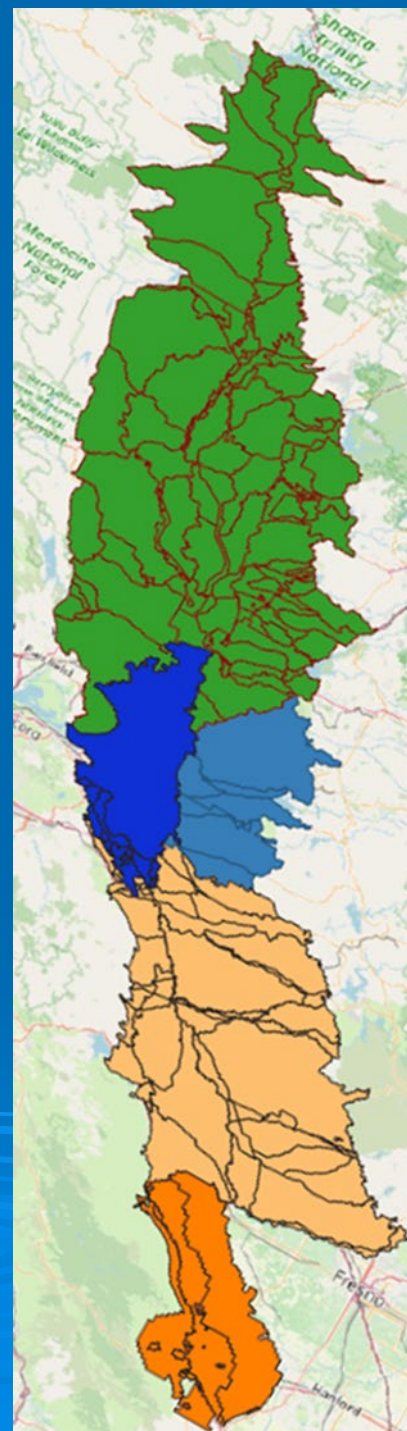












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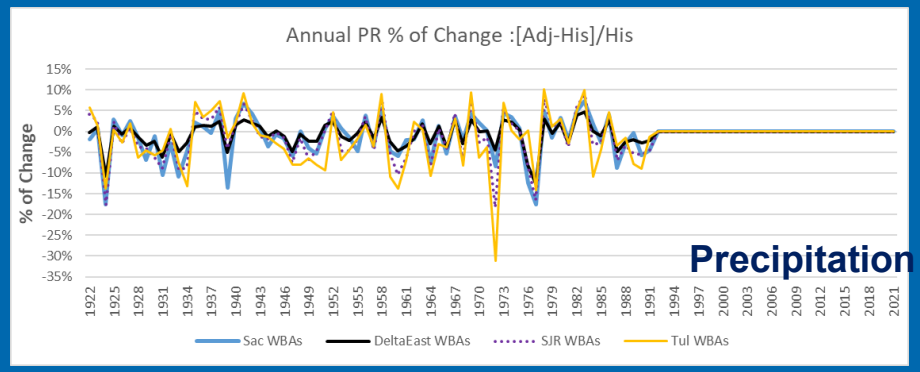
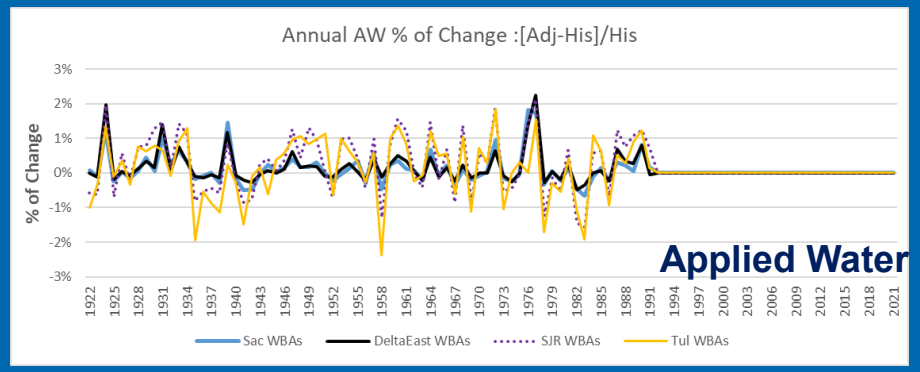
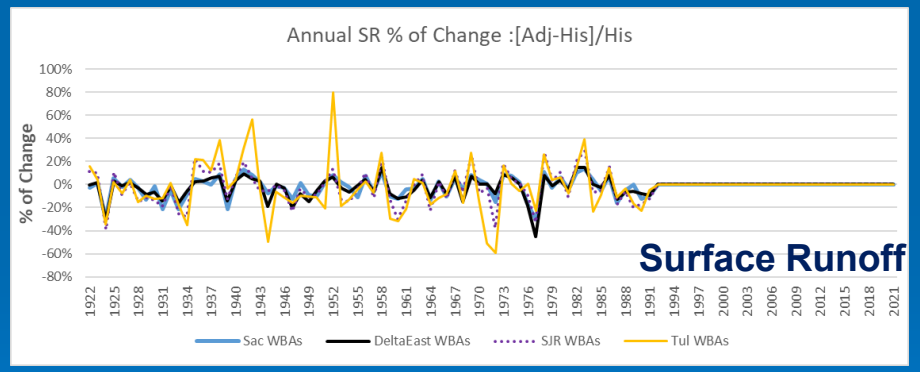
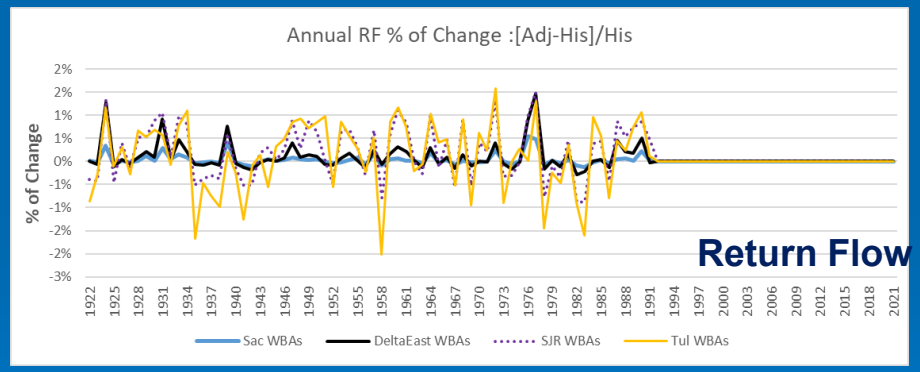
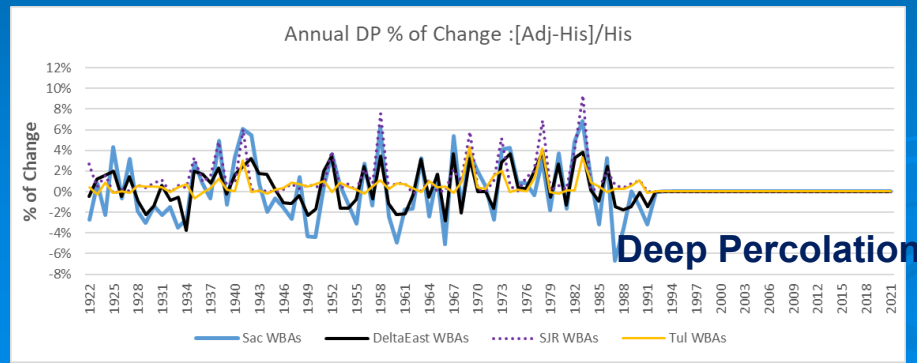
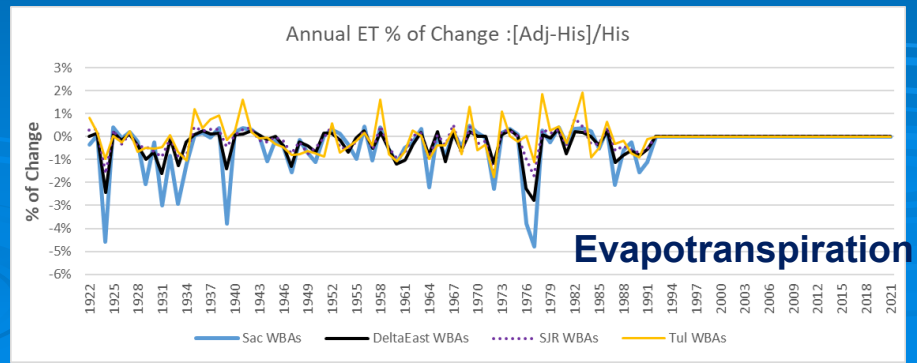


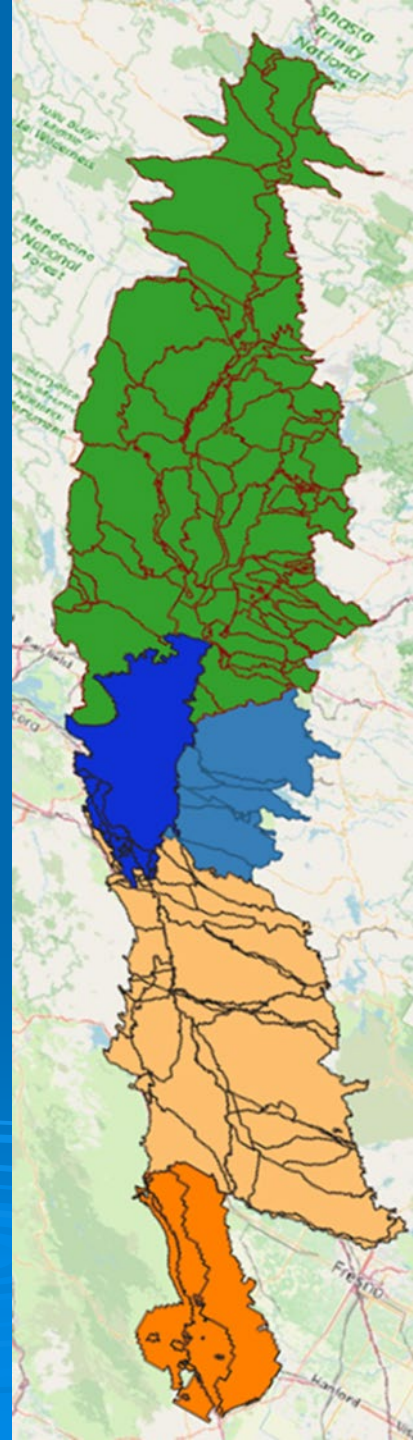




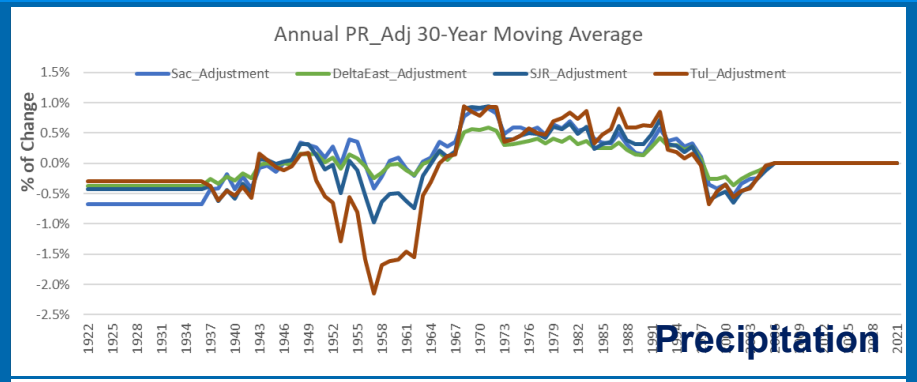




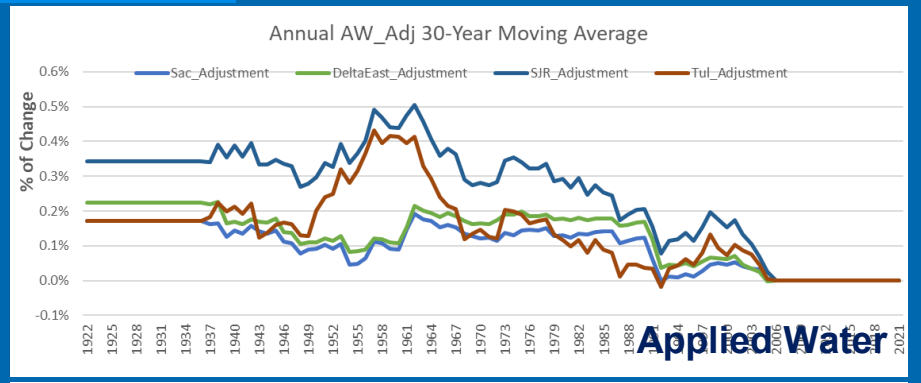




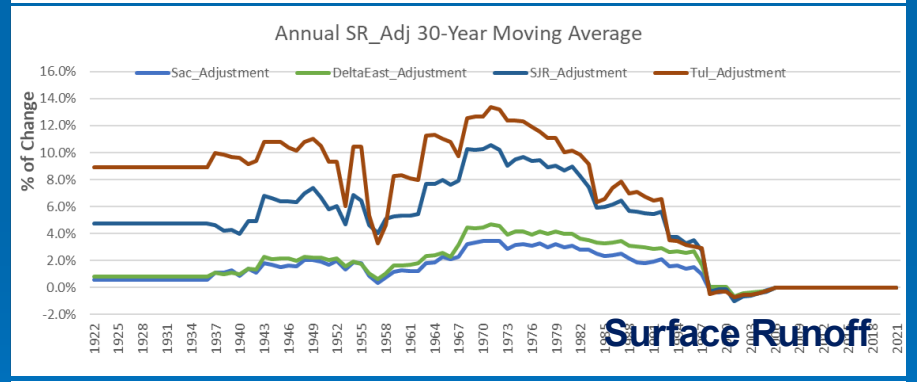
Sensitivity Analysis



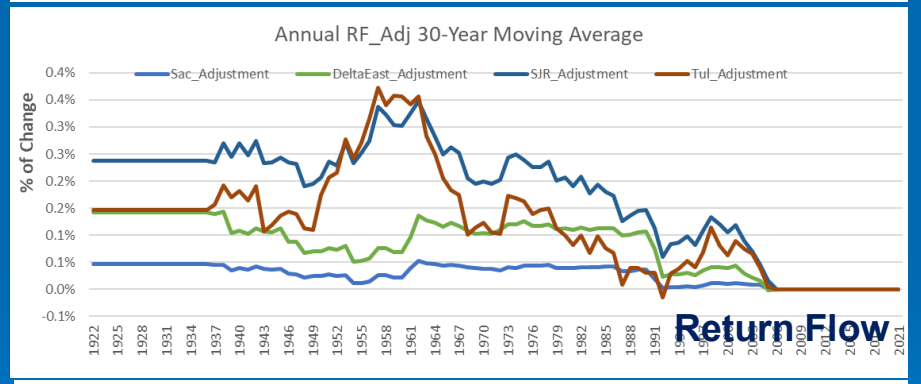
Precipitation



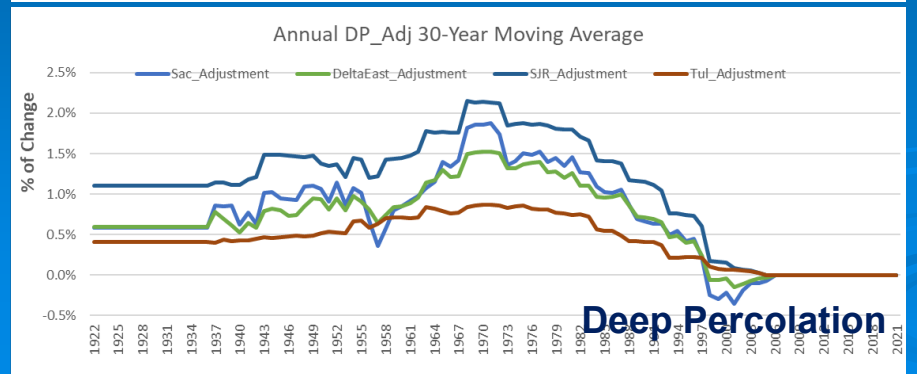
Applied Water



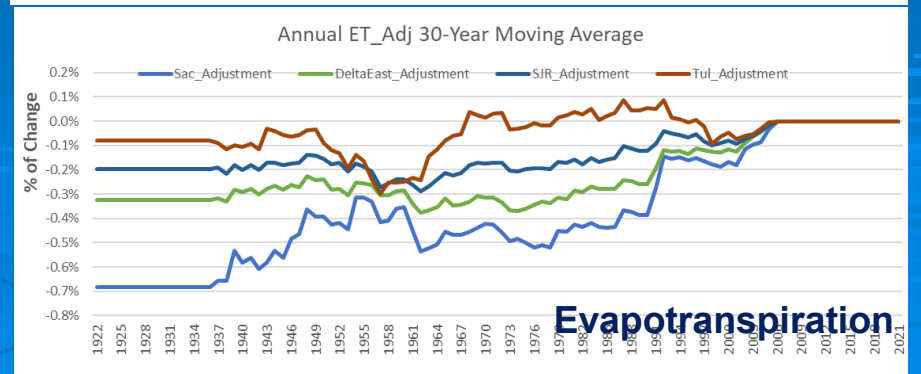
Surface Runoff



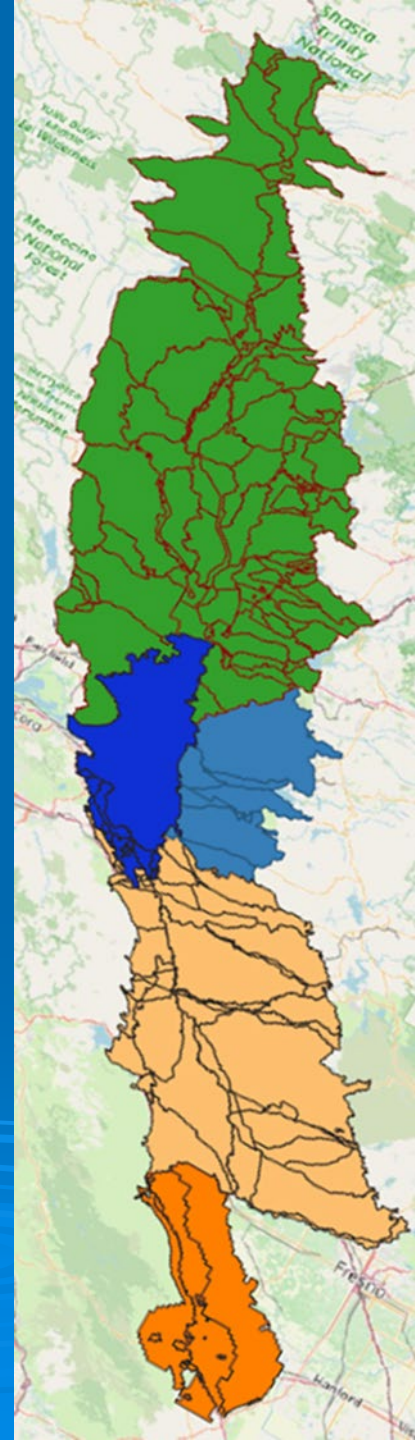
Return Flow



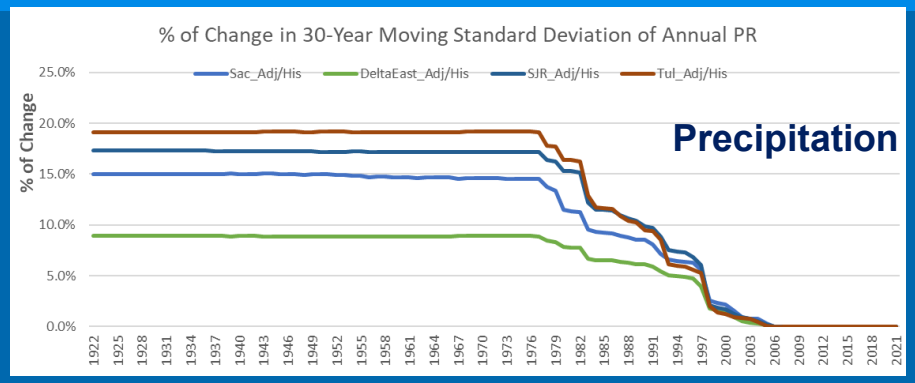
Deep Percolation

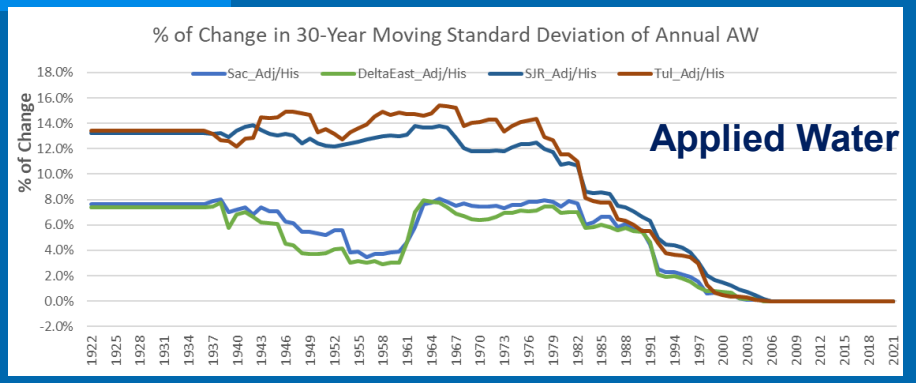


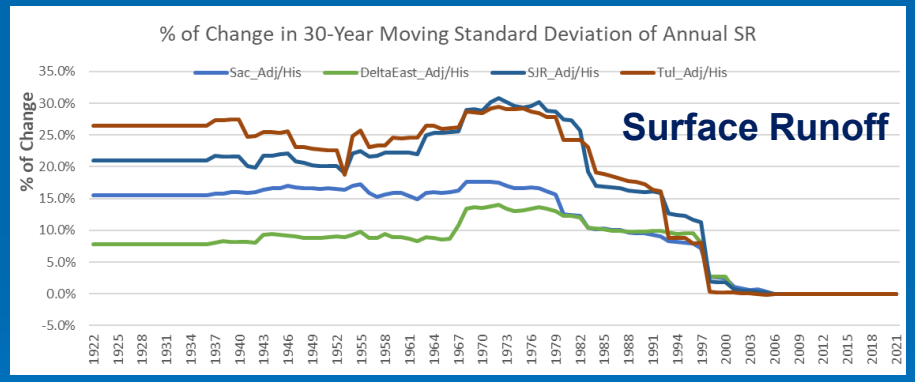
Evapotranspiration

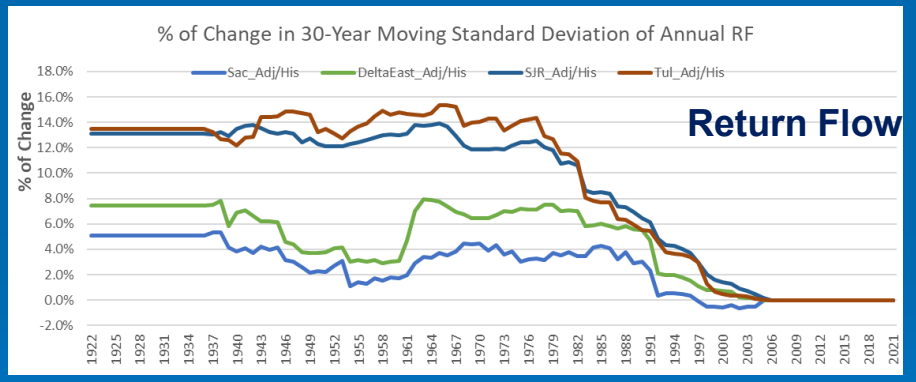


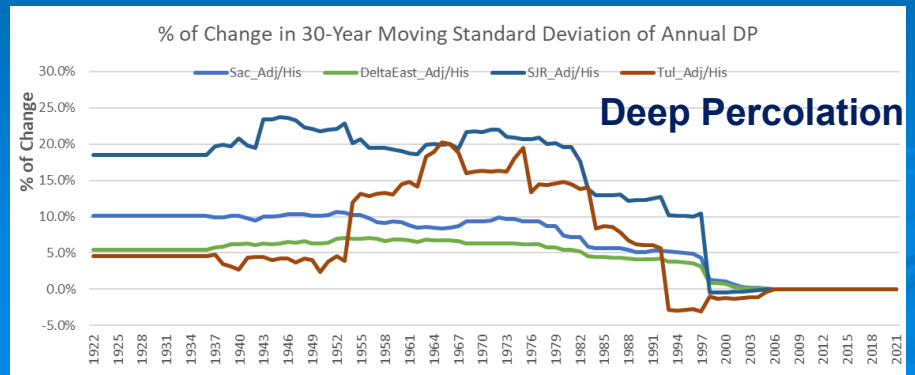
Sensitivity Analysis

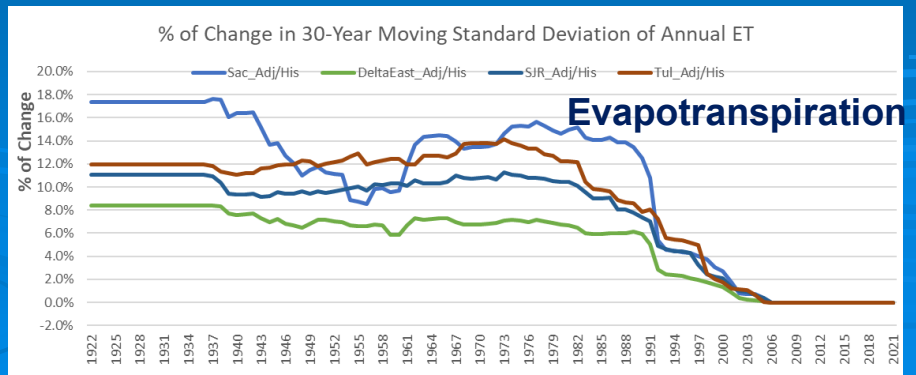


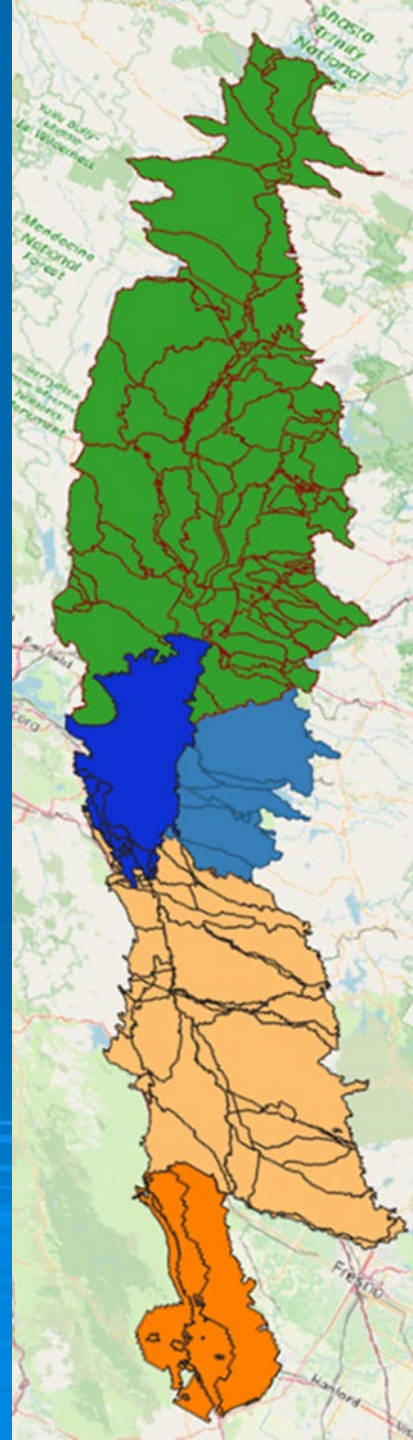












Summary and Discussion

- Precipitation Interannual Variabilities in the Central Valley floor's WBAs have increased significantly in recent 100 years.
- Annual precipitation can be adjusted to make dry years drier and wet years wetter.
- Drier WBAs in San Joaquin basin are more sensitive to precipitation adjustment.
- Precipitation adjustments can be -2 to +3 inches/year which is equivalent to individual annual change of (-30% to 10%).
- Surface runoff, Deep percolation and evapotranspiration are relatively sensitive to precipitation changes while applied water and return flow are relatively less sensitive.
- Challenges/Caveats
  - Adjustment to precipitation depends on the selection of the reference period.
  - Surface runoff will increase even the long term change in precipitation is zero when interannual variability of precipitation increases.
  - CalSimHydro parameters, such as crop evapotranspiration, will also affect the response of CalSimHydro to precipitation change.

Acknowledgement

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Question?