Development of Hydrologic Time Series from 1850 to 1920

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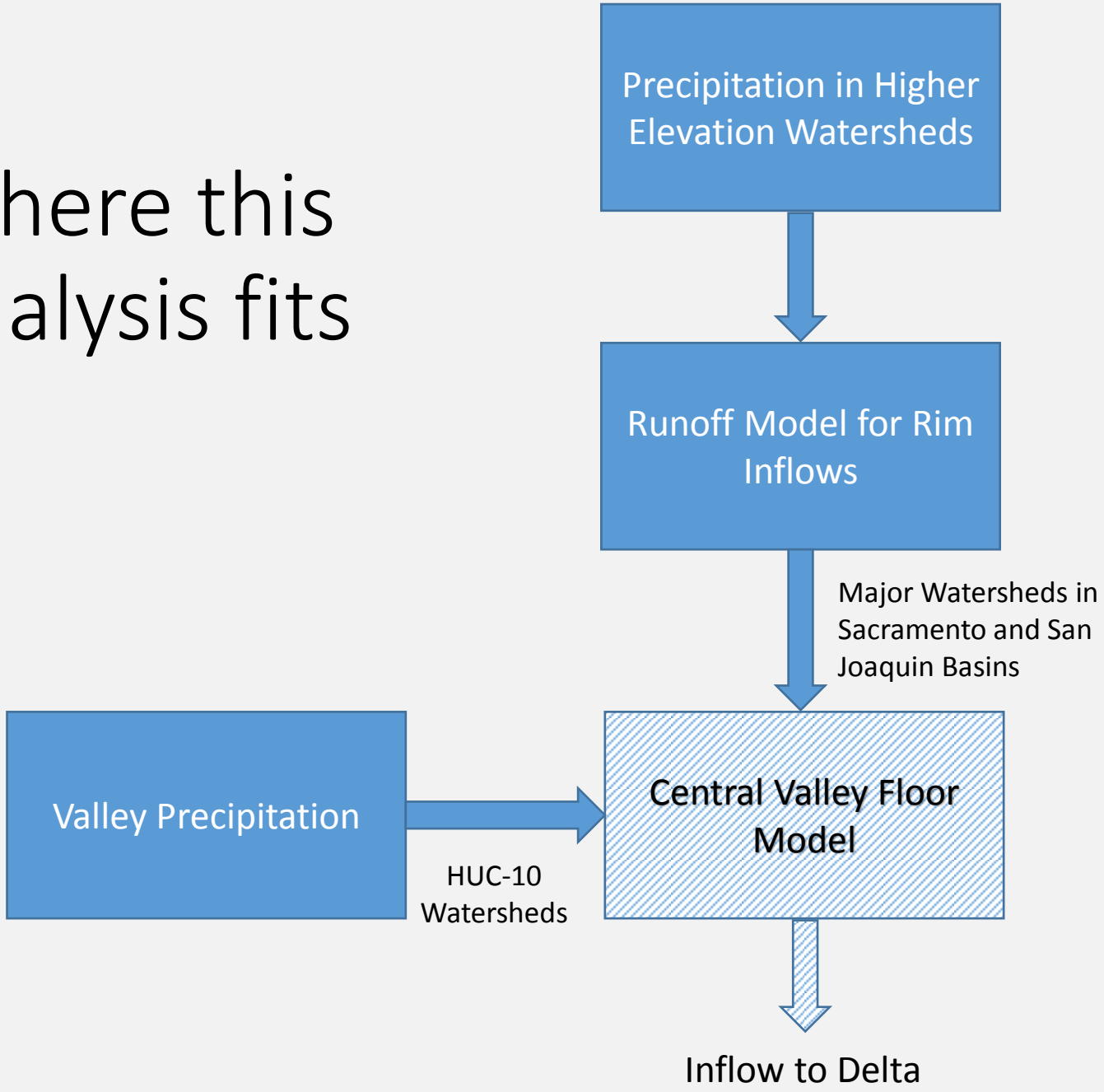
Background

- Goal of this study was the development of a consistent precipitation and streamflow time series for the Sacramento and San Joaquin Valleys, for the period of 1850-1920.
- Over this period, streamflow observations are limited prior to the 1880's and precipitation data are sparse for 1850-1890.
- Observational data for both flow and precipitation are more commonplace beginning in the mid-1890's.
- We therefore used a suite of estimation approaches to develop the spatial precipitation and runoff time series, and fill in the gaps in the early part of the record.
- Incorporated reconstructed annual precipitation data from tree ring studies
- Runoff-precipitation relationships for the surrounding watersheds were developed from recent data, and employed to estimate monthly runoff in the early part of the record.

Where this analysis fits



Data

- 4 km gridded monthly PRISM[1] data (PRISM Climate Group, http://prism.oregonstate.edu/, 1895 onwards)
- Central Valley Unimpaired Flow Data (DWR, water year 1922 onwards)
- Tree Ring Reconstructed Annual Precipitation (Meko et al., 2011; Diaz and Wahl, 2015; last several centuries)
- Pre-1922 flows from USGS (NWIS and Water Supply Papers; selected stations from late 1800s)
- NWS COOP station monthly precipitation data (San Francisco from 1850, Sacramento from 1877)

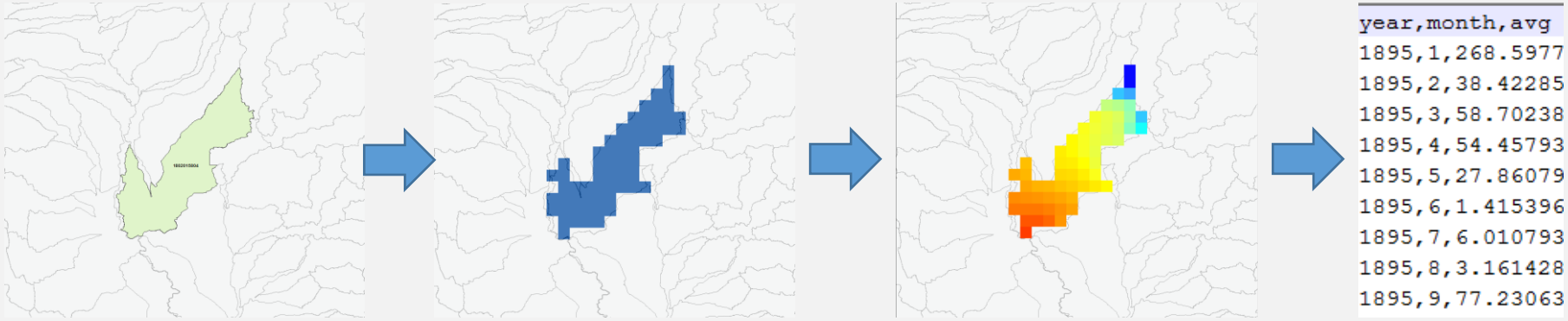
[1]Parameter elevation Regression on Independent Slopes Model

Methods

- Compute PRISM monthly area-weighted averages for precipitation across each watershed (1895-1980)
- Regression for watershed average precipitation using monthly San Francisco observations and annual tree ring reconstructions (1895-1980)
- Calculate precipitation for valley floor and rim watersheds (1850-1894)
- For rim watersheds, develop statistical runoff models based on unimpaired flow data from 1922-1980
- Apply runoff model and calculated precipitation to estimate runoff from 1850 to 1921

Watershed Precipitation Calculations

- Valley Floor: HUC 10 boundaries and PRISM
  - HUC10s were each converted to the same resolution as PRISM rasters
  - Each PRISM raster was clipped for each HUC10 and mean value calculated, then consolidated into a single monthly file of monthly averages

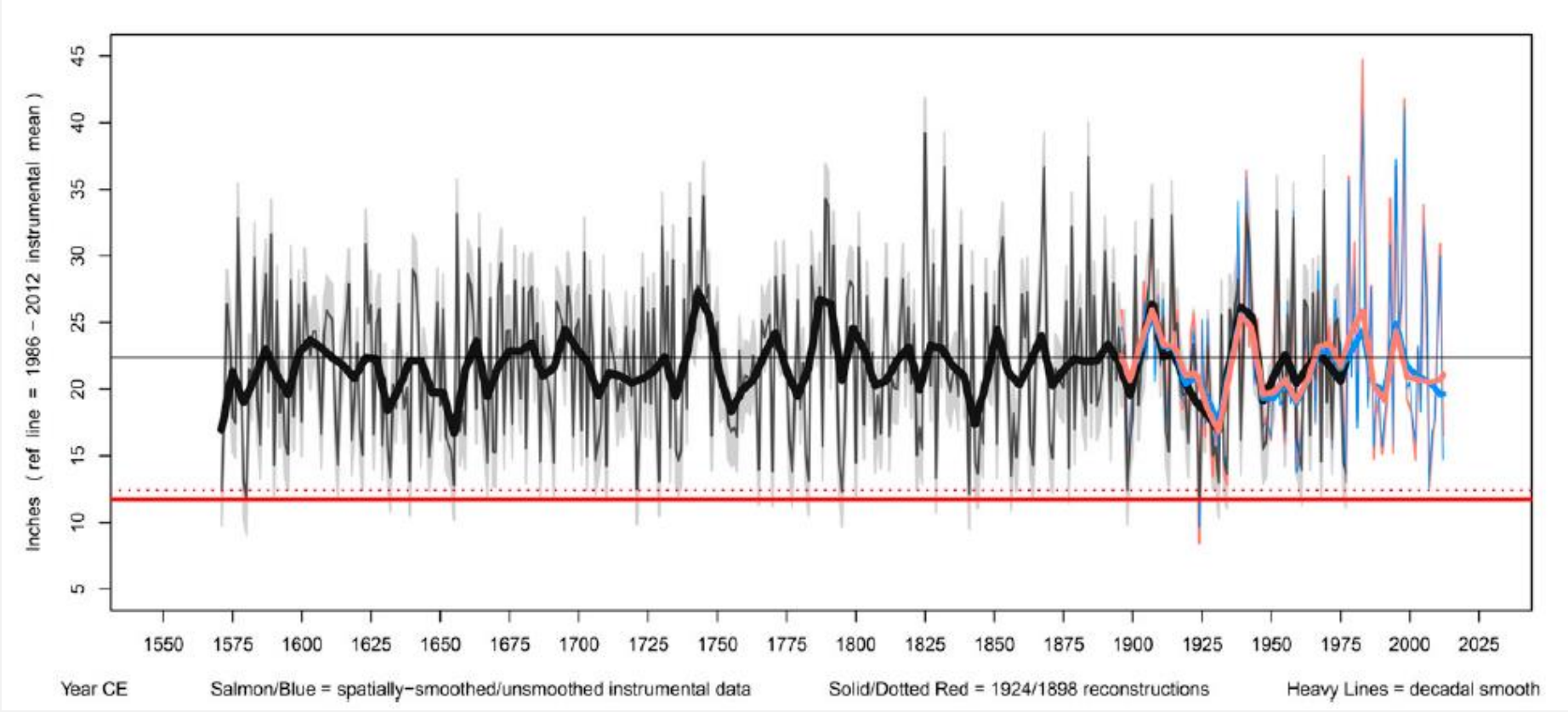


year	month	avg
1895	1	268.5977
1895	2	38.42285
1895	3	58.70238
1895	4	54.45793
1895	5	27.86079
1895	6	1.415396
1895	7	6.010793
1895	8	3.161428
1895	9	77.23063

- Rim Watersheds: defined based on DEM, same procedure as HUC 10

Data From Tree Ring Reconstructions

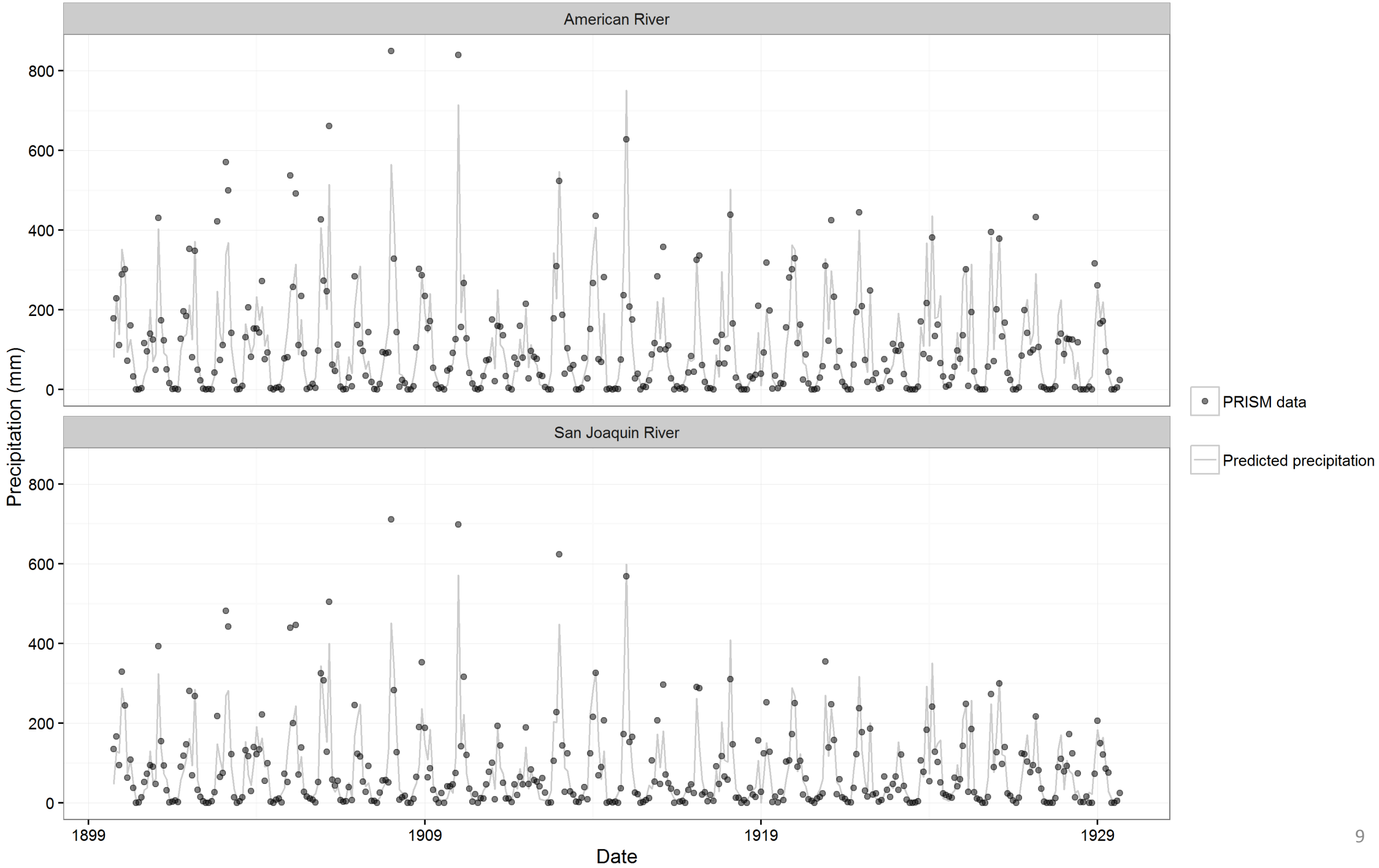
- Primary source of data (Diaz and Wahl, 2015)
- Spatial interpolation over all of California and western Nevada
- Reconstructed annual precipitation for 1571-present



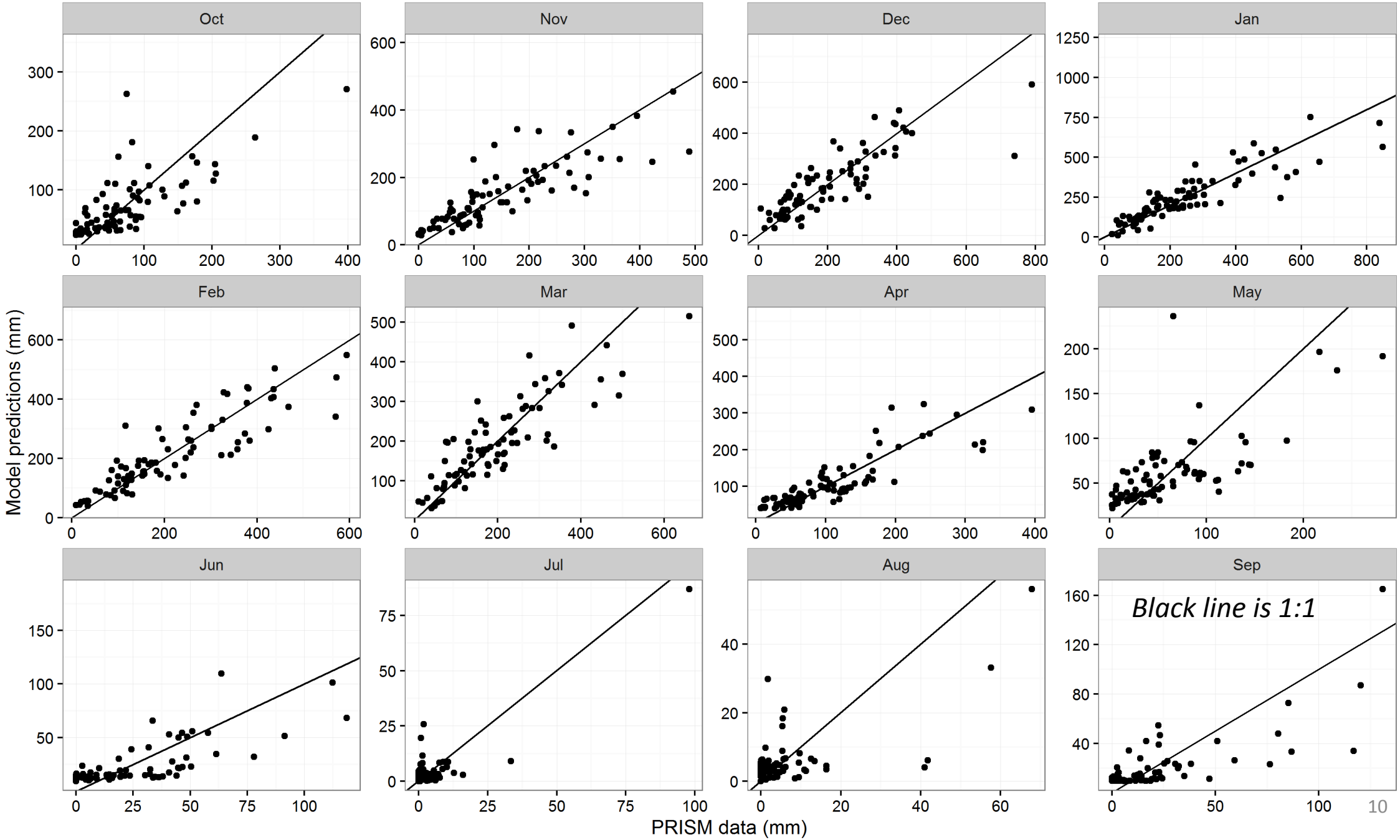
Diaz and Wahl, 2015. Recent California Water Year Precipitation Deficits: A 440-Year Perspective. *J. Climate.* http://dx.doi.org/10.1175/JCLI-D-14-00774.1

Precipitation regressions

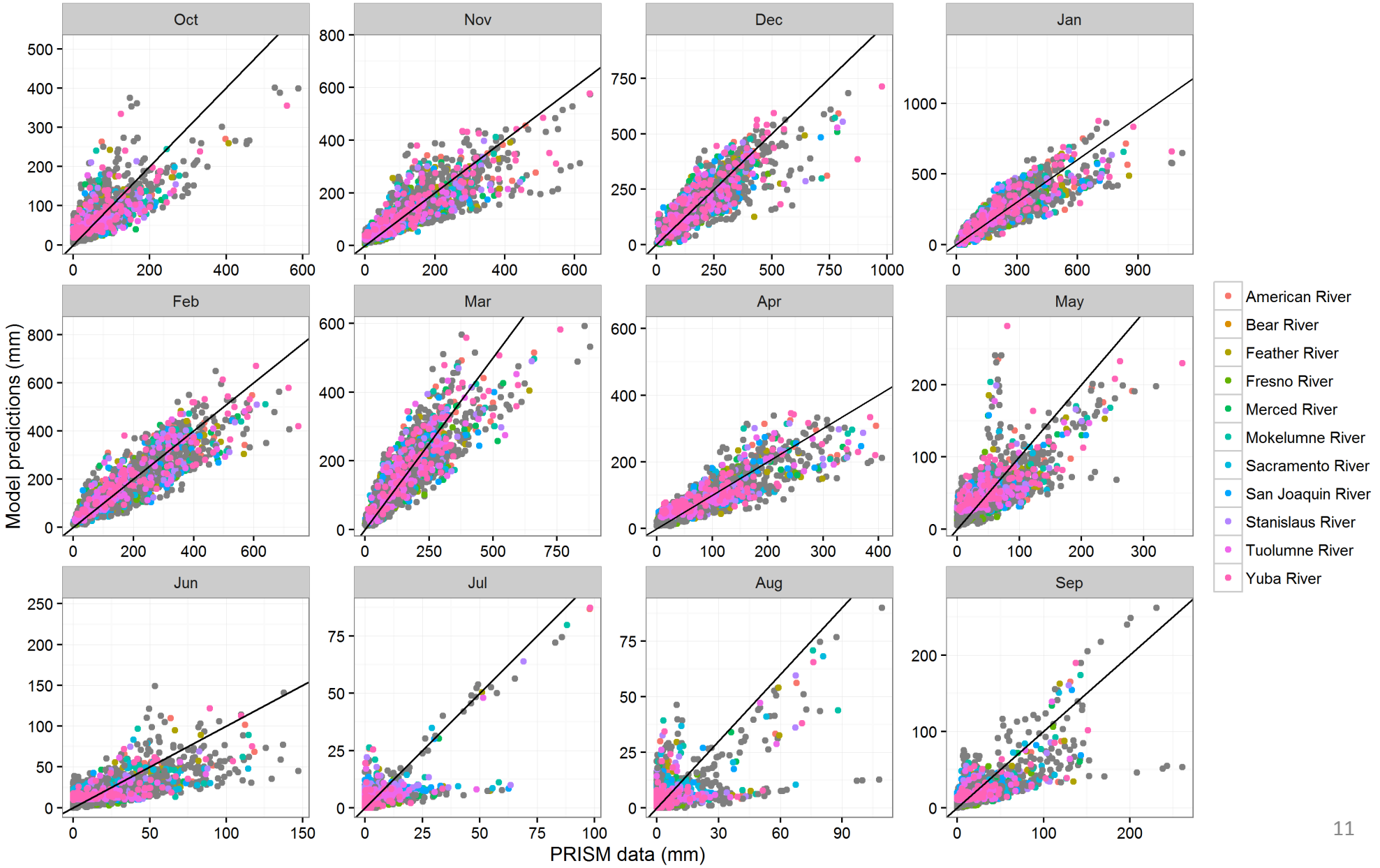
- Linear regression of area-weighted watershed precipitation (PRISM) on San Francisco monthly precipitation
- Also include closest tree ring construction with annual value repeated each month
- Separate regression for each month for each target watershed


American River
San Joaquin River
Precipitation (mm)
0
200
400
600
800
1899
1909
1919
1929
Date
PRISM data
Predicted precipitation

American River (1922-1980)

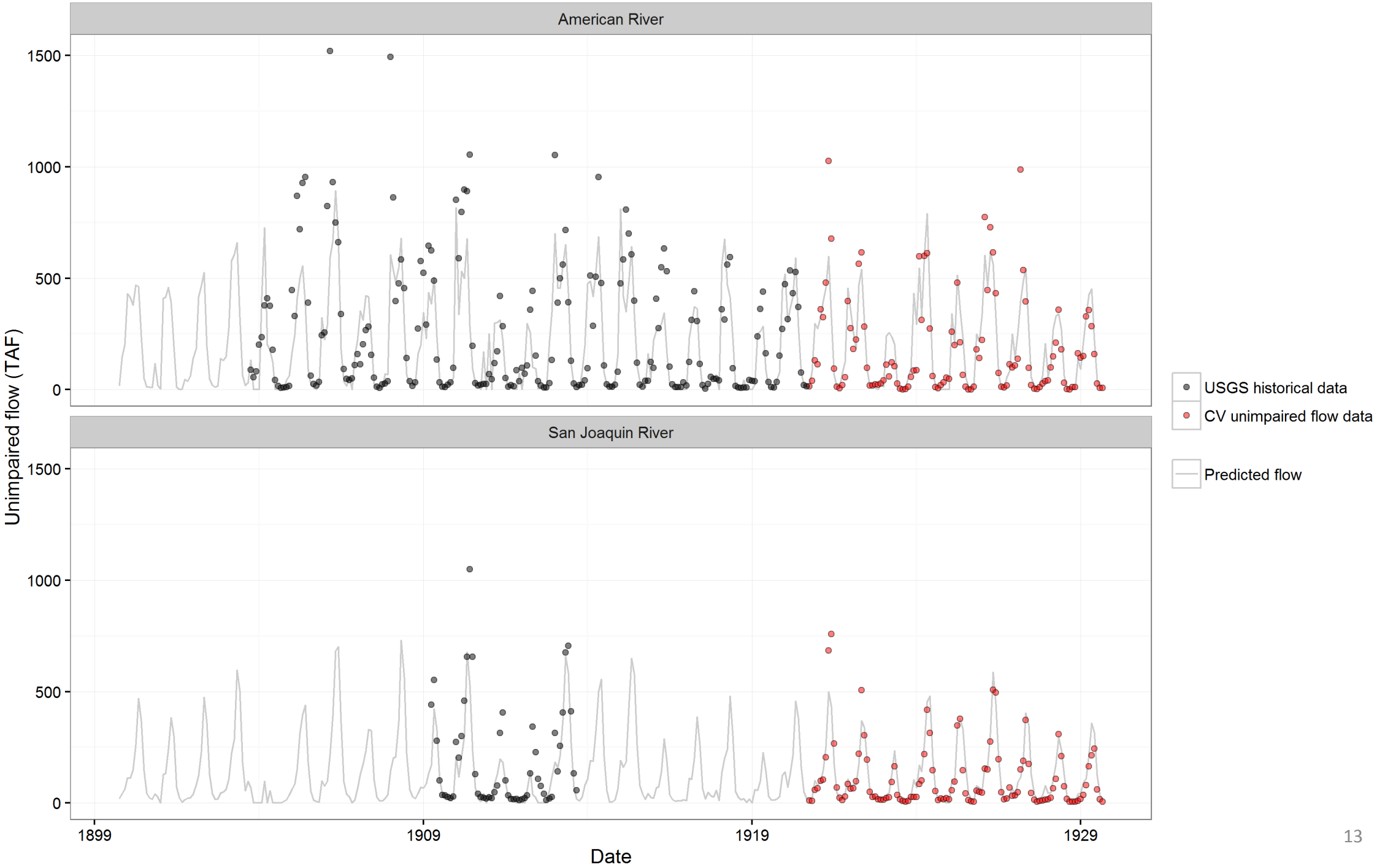


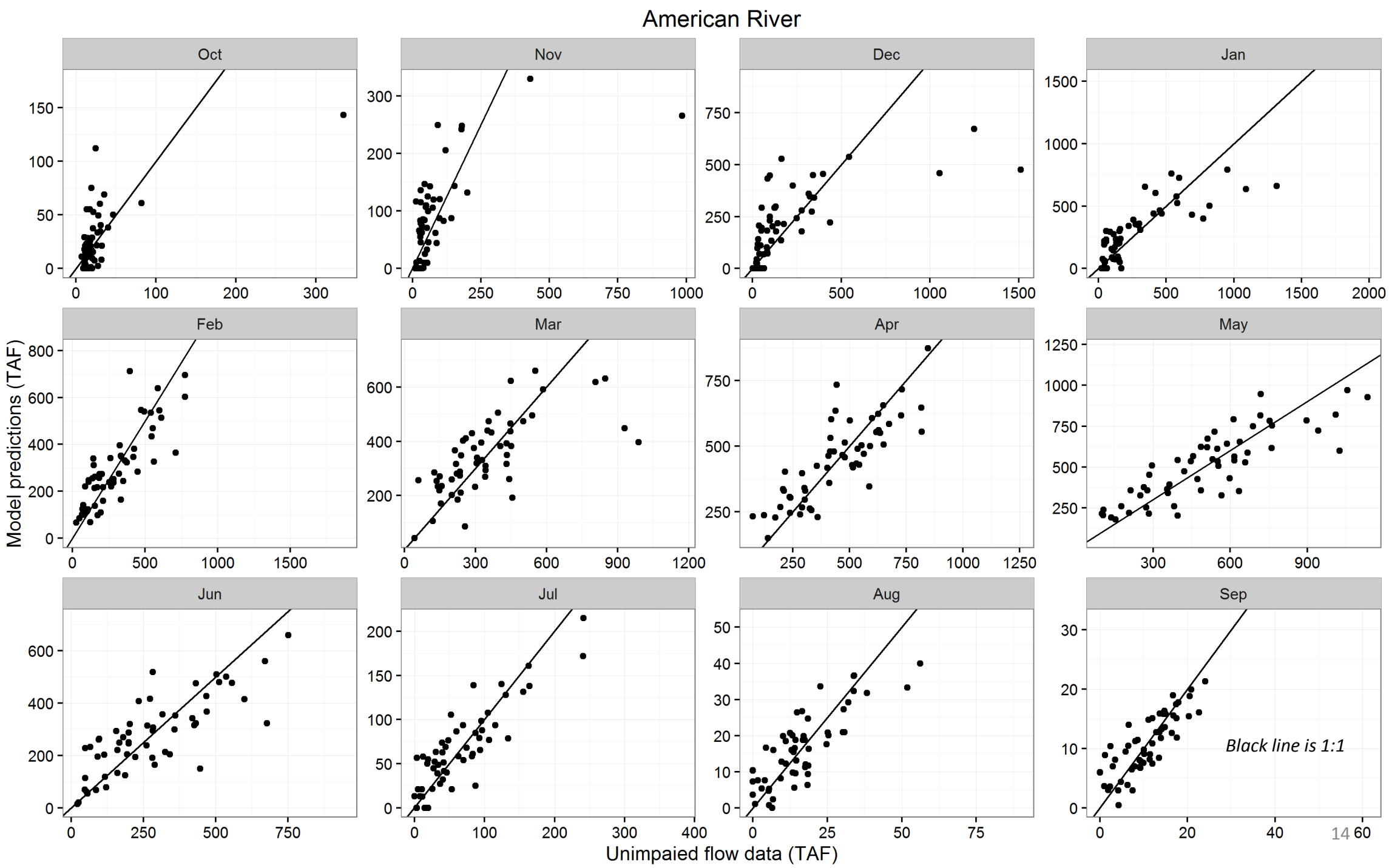
Precipitation Predictions across Individual Watersheds



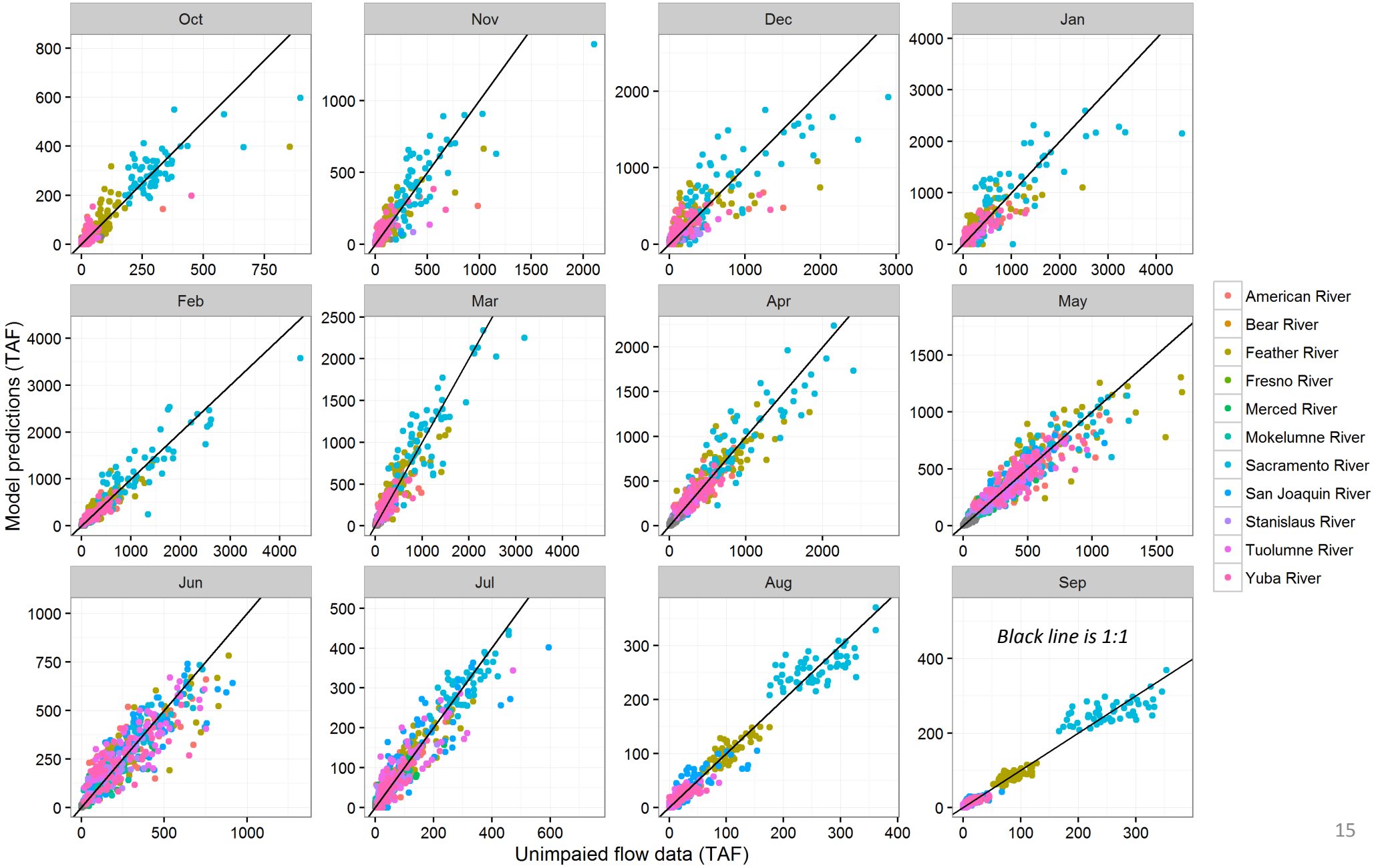
Regressions of unimpaired flow on area weighted precipitation

- For each month, predict unimpaired flow using each of the previous 12 months' precipitation (12 coefficients, 1 intercept per month)
- Developed for each of the watersheds in the basin
- For certain watersheds with development before 1922, impairment modeling needed

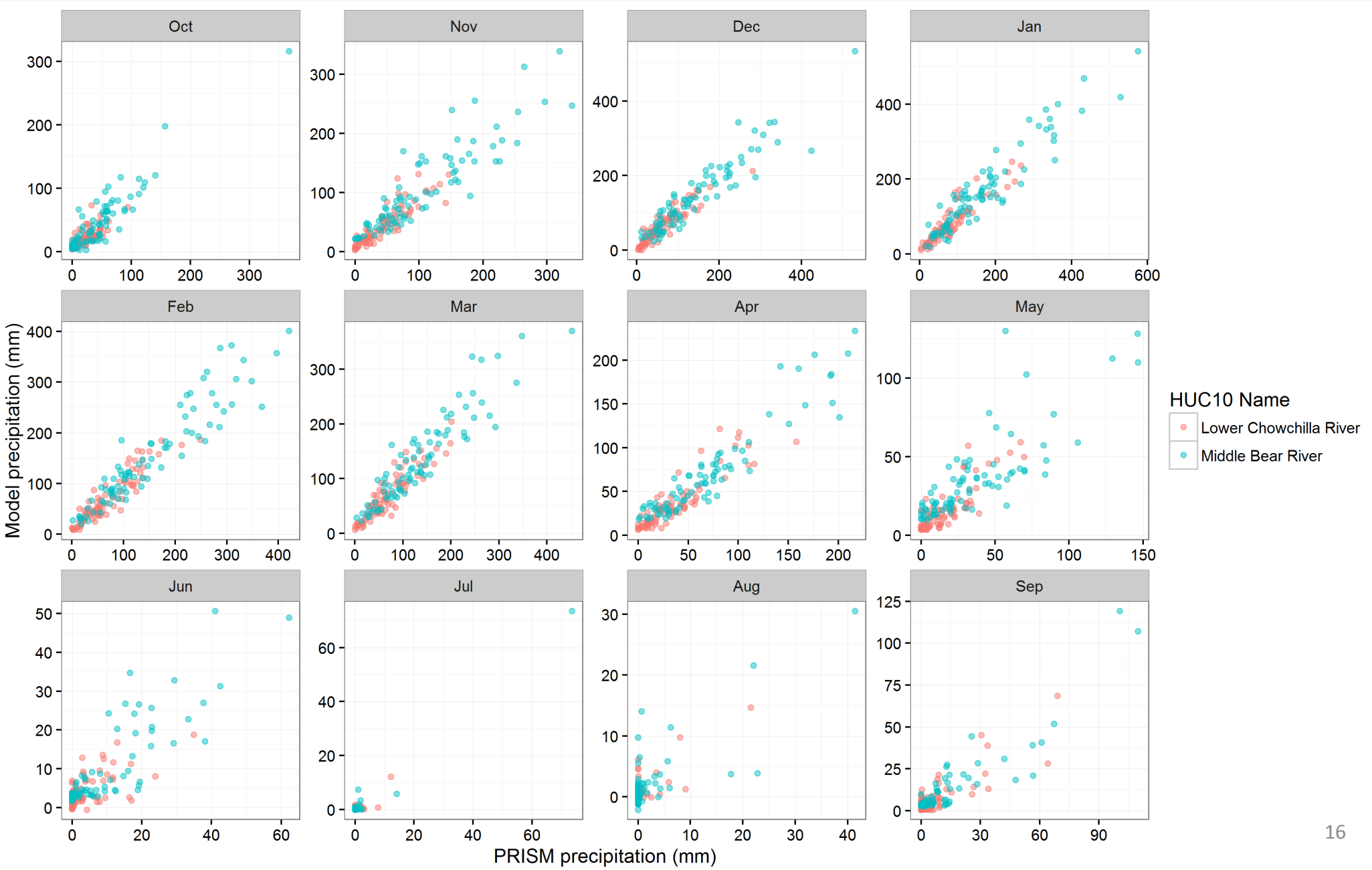

American River
San Joaquin River
Unimpaired flow (TAF)
1500
1000
500
0
1899
1909
1919
1929
Date
USGS historical data
CV unimpaired flow data
Predicted flow


American River
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Model predictions (TAF)
Unimpaied flow data (TAF)
Black line is 1:1

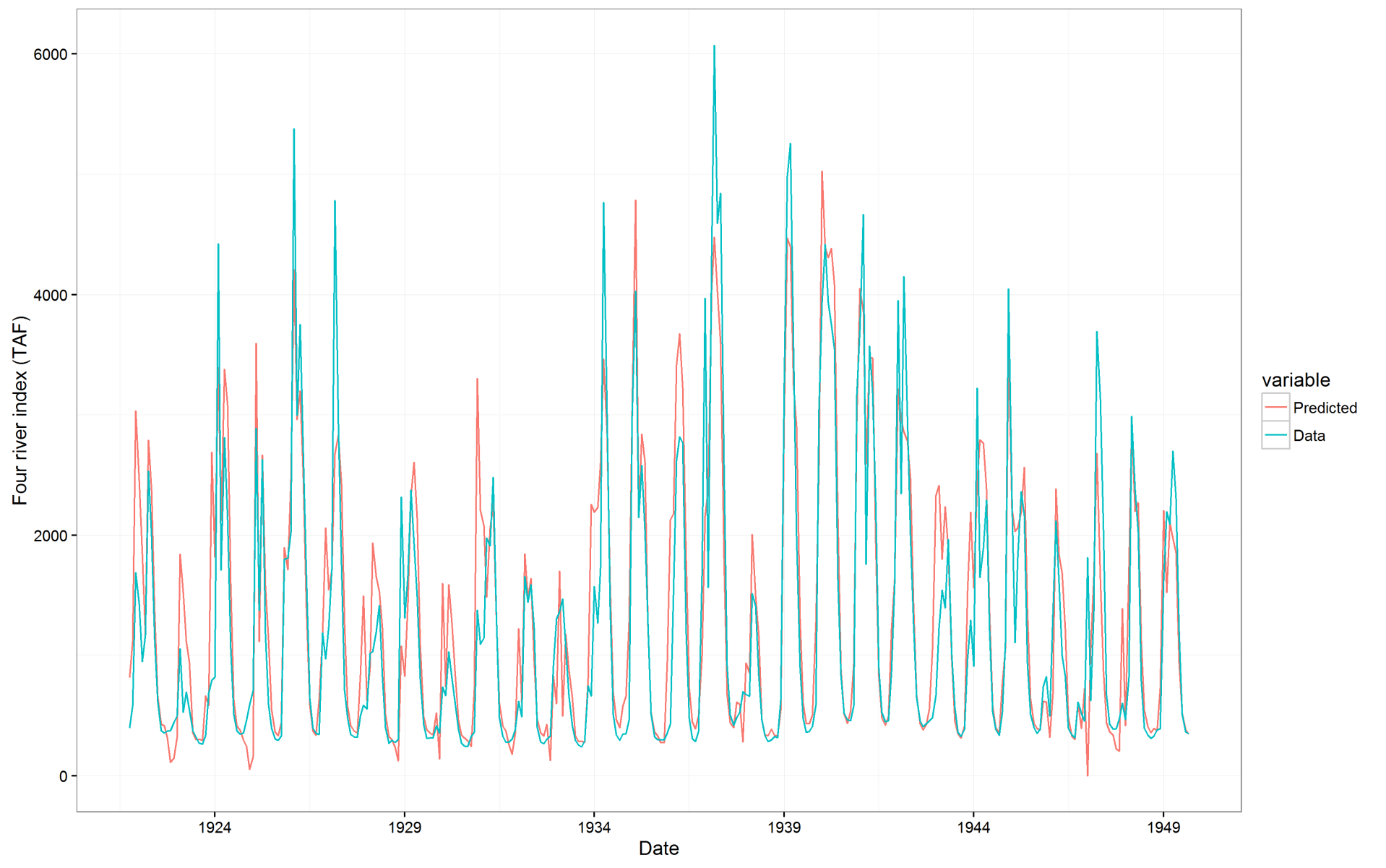
Runoff Predictions across Individual Watersheds



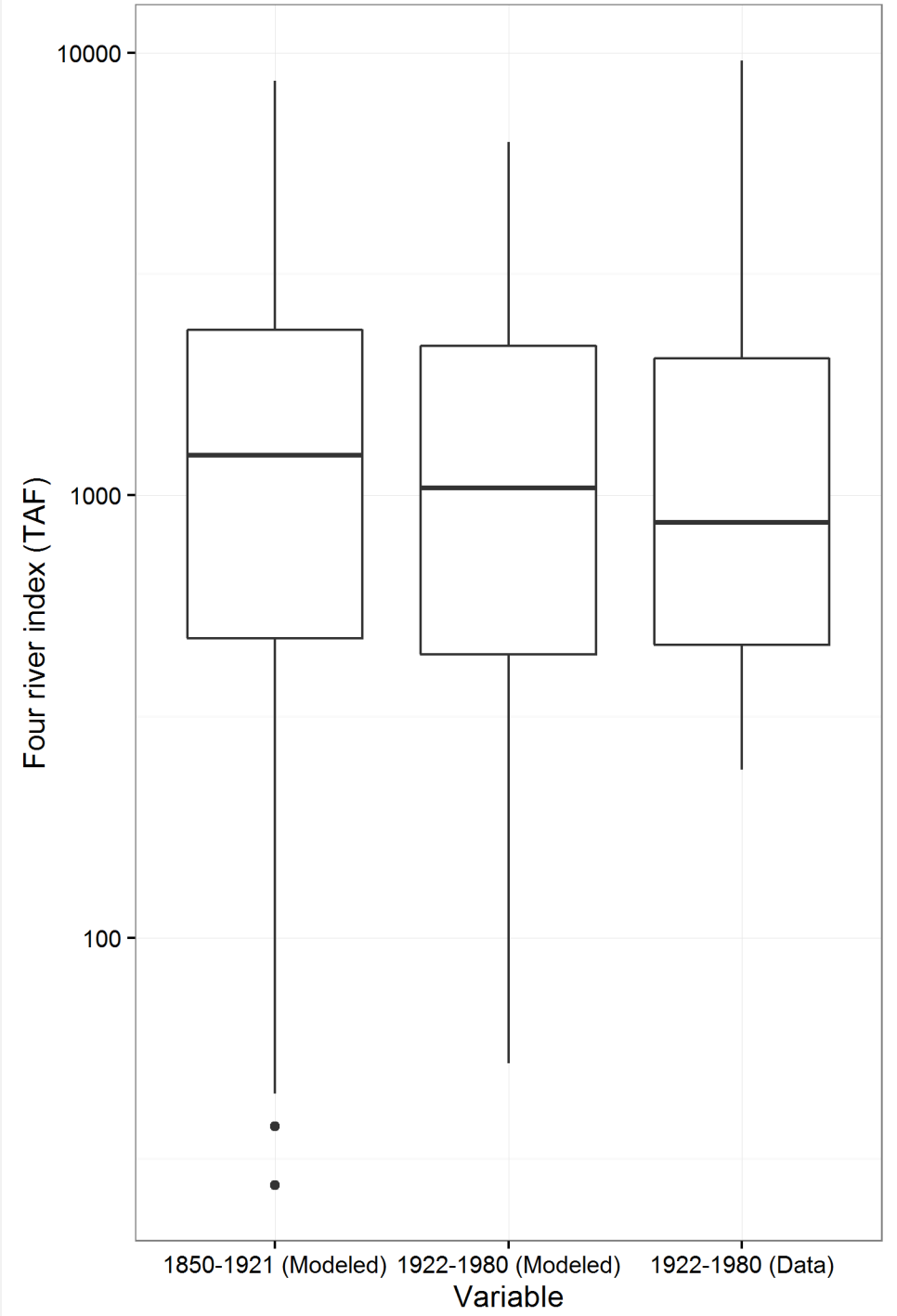
Precipitation Predictions across Valley Floor HUC10 Watersheds



Four River Index
Sacramento, American, Feather, and Yuba Rivers



Comparing 4 River Index over Different Periods



Summary

- Using the current month's precipitation at San Francisco and annual information from the tree rings—while fairly simple in concept—captures much of the precipitation variability across the Central Valley
- In an environment with limited data, simple models are attractive; the recent time history of precipitation (previous 12 months) is able to accurately predict watershed runoff
- Predicted values of four river index are generally higher than values from 1922 onwards
- These boundary flows will be used in a Central Valley model to calculate inflow to the Delta

Future Work

- Refinement of statistical models
  - Additional regression terms, incorporation of Sacramento precipitation
  - Spatial correlation
- Unimpaired flow for smaller streams
- Include uncertainty estimates in rim flows
- Compare statistical runoff models to other watershed modeling frameworks