Representative Hydrology and Salinity Conditions for Machine Learning

Lily Ann Tomkovic, Ph.D.
Eli Ateljevich, Ph.D.
Modeling Support Office, DWR

Delta Salinity Management in Drought: Surrogate Development under Drought, Landscape Change and Sea Level Rise

CWEMF Annual Meeting
September 24, 2024

Pilot Project Objective

Develop and test a methodology for creating fast surrogate models for use in CalSIM representing the relationship of Delta salinity to hydrology and operations under management alternatives intended to mitigate impacts of extended droughts

Modeling Workflow

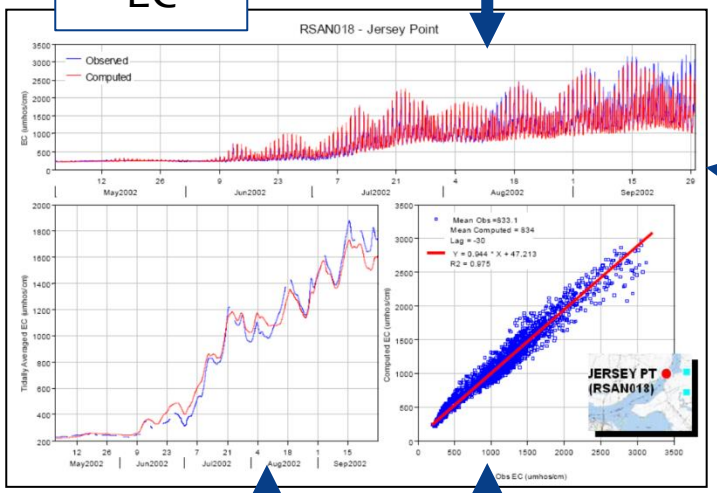
Topics

* Causes of Salinity Intrusion
  * Primary mixing and transport mechanisms
  * What happens during drought and sea level rise?
  * Managing Salt Accumulation over the Dry Season
* Salinity Impact vs Operational Response
  * Detailed models and CalSim surrogates
  * Broadening/shortening training data
  * "Round trip" back to Delta impact?
* Prototype Scenarios and Modeling Example

Delta Time Series Data
Observed versus Computed…

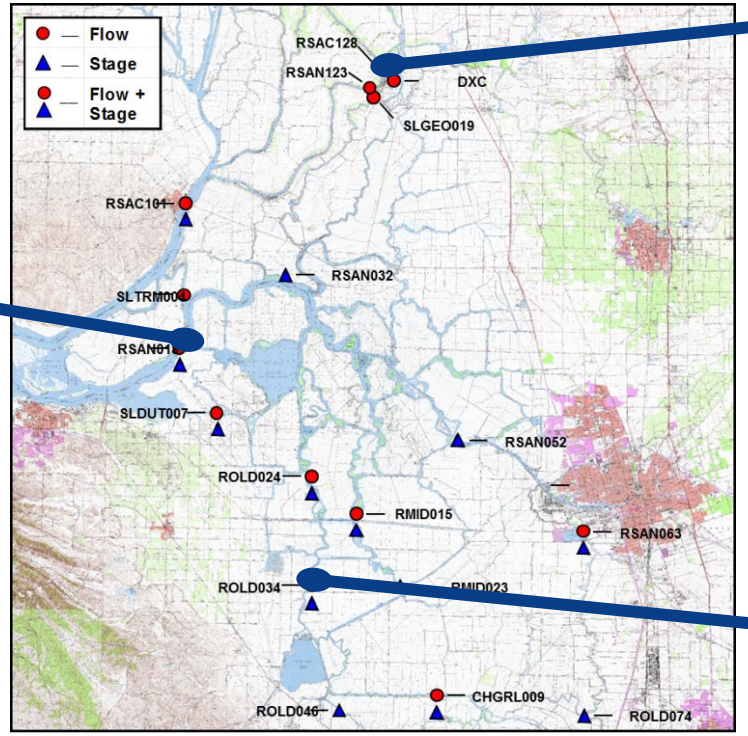
Tidal Time Scale

EC

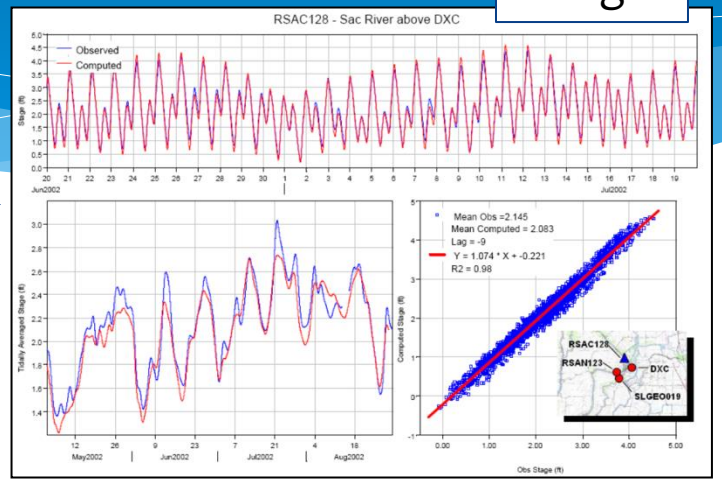


Tidally Averaged Time Scale

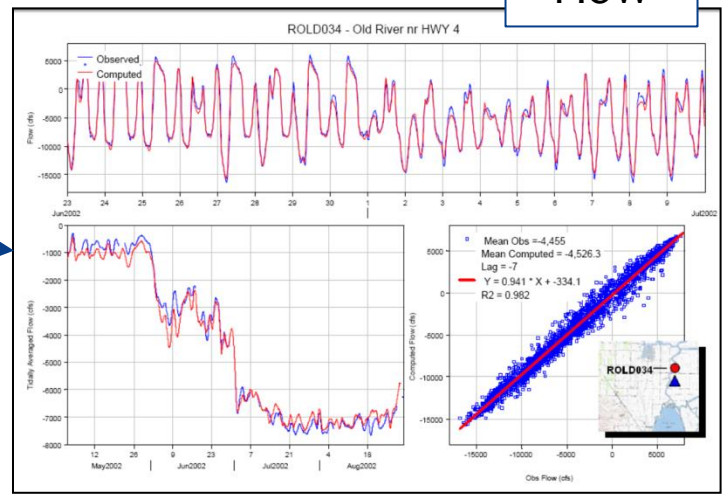
Statistical Comparison



Stage



Flow

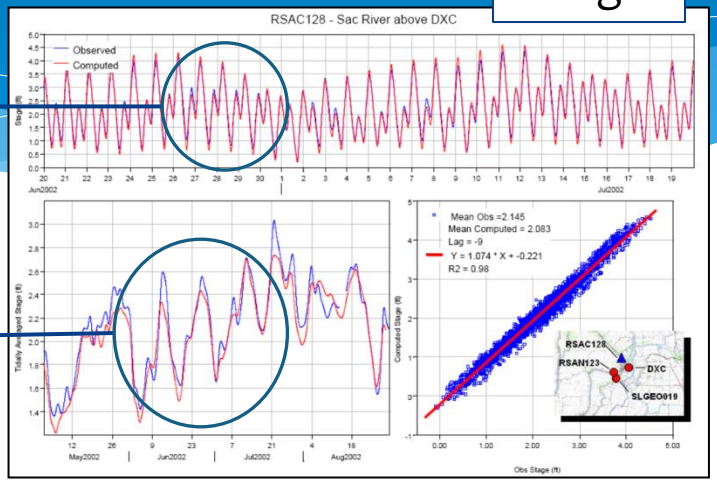


Example plots from RMA Model Calibration, Water Year 2002

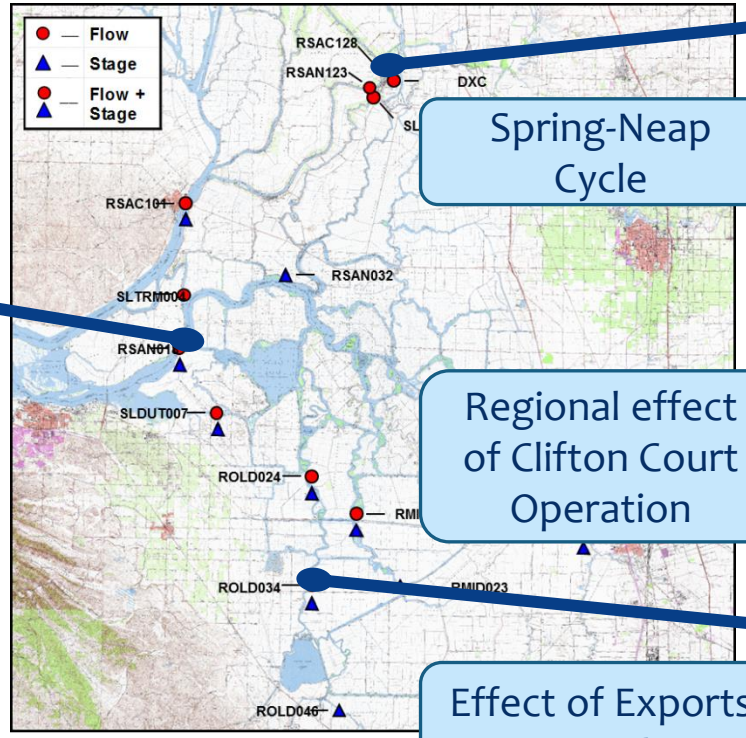
Delta Time Series Data
What can you see in the wiggly lines?

Stage

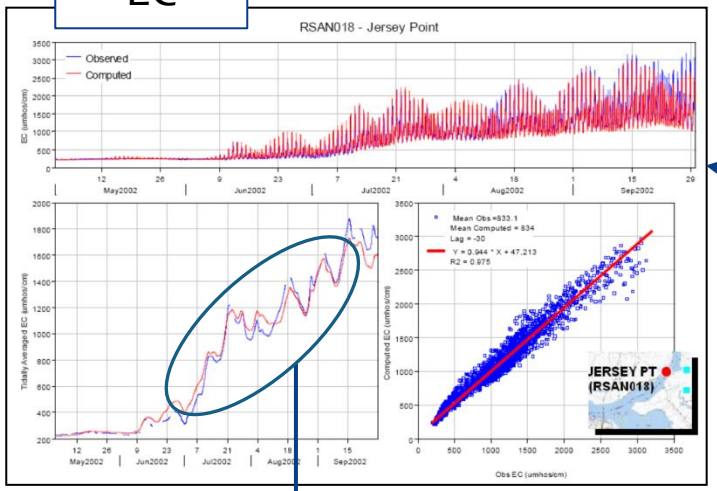
Tide Phase and Amplitude



Spring-Neap Cycle



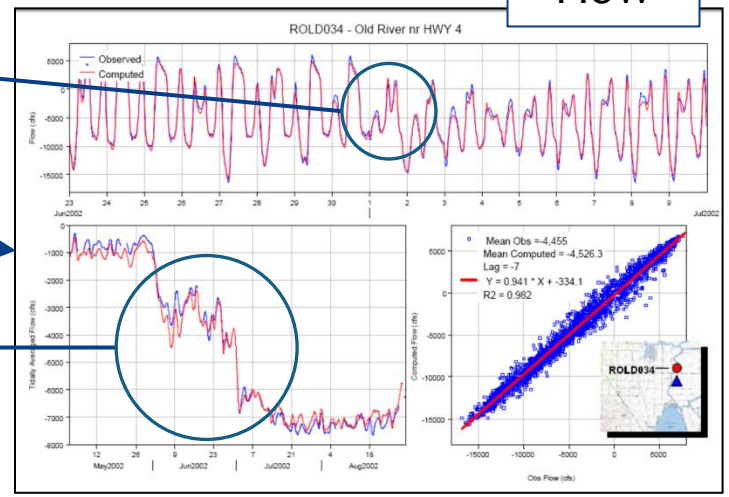
EC



Rate of salt intrusion

Regional effect of Clifton Court Operation

Flow



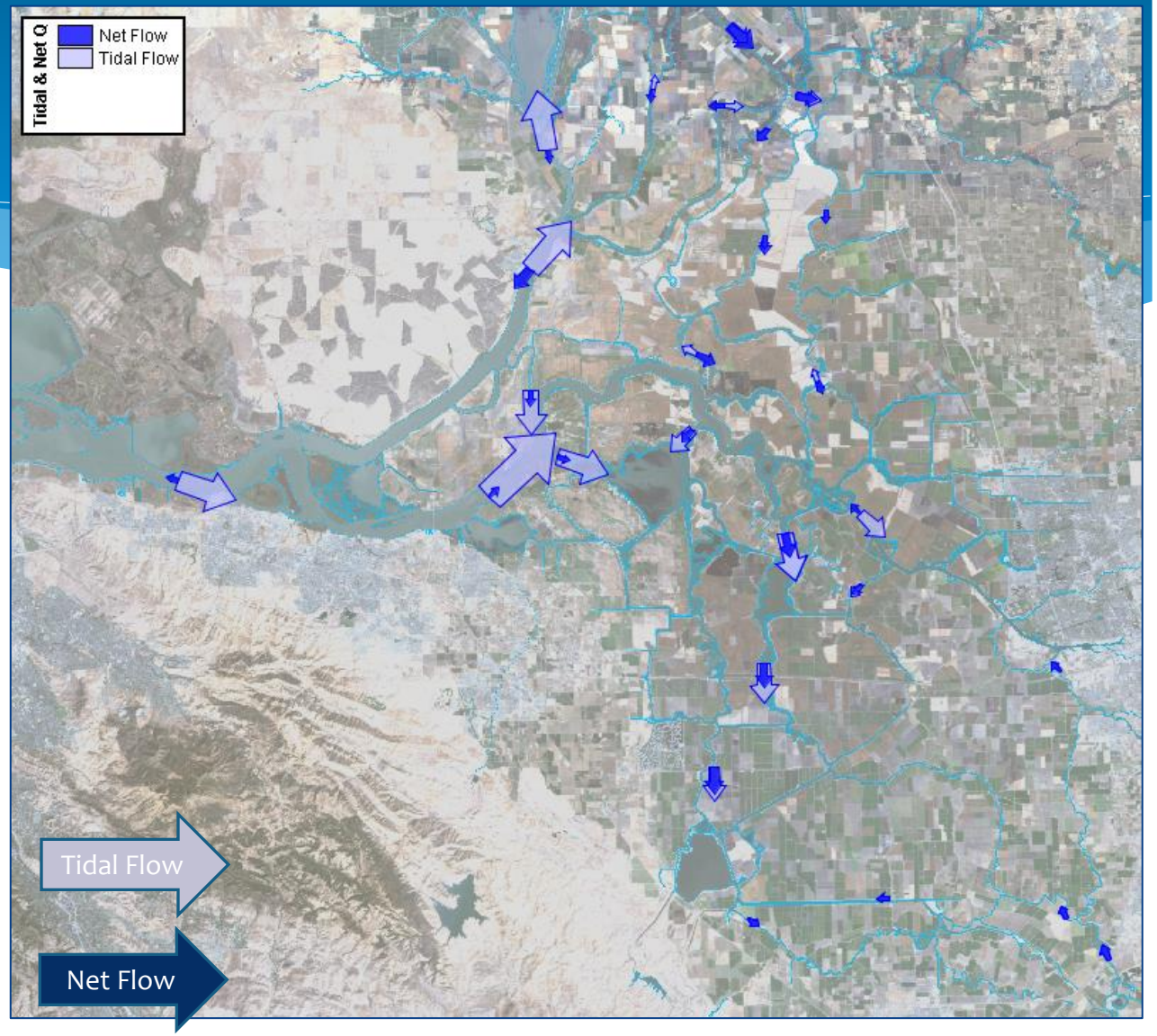
Effect of Exports on net Flow

Example plots from RMA Model Calibration, Water Year 2002

Tidal and Net Flow

Demonstration of increasing river inflows bringing net Delta outflow from 2,000 to 100,000 cfs with typical summer exports (not an historical condition)

- Tidal flows dominate the Western Delta
- Net transport of fresh water from north to south typical of summer and fall operation
- As Sacramento Inflow increases, more of the North Delta becomes riverine
- As San Joaquin flow increases the net flows change from south to north in the southern Delta

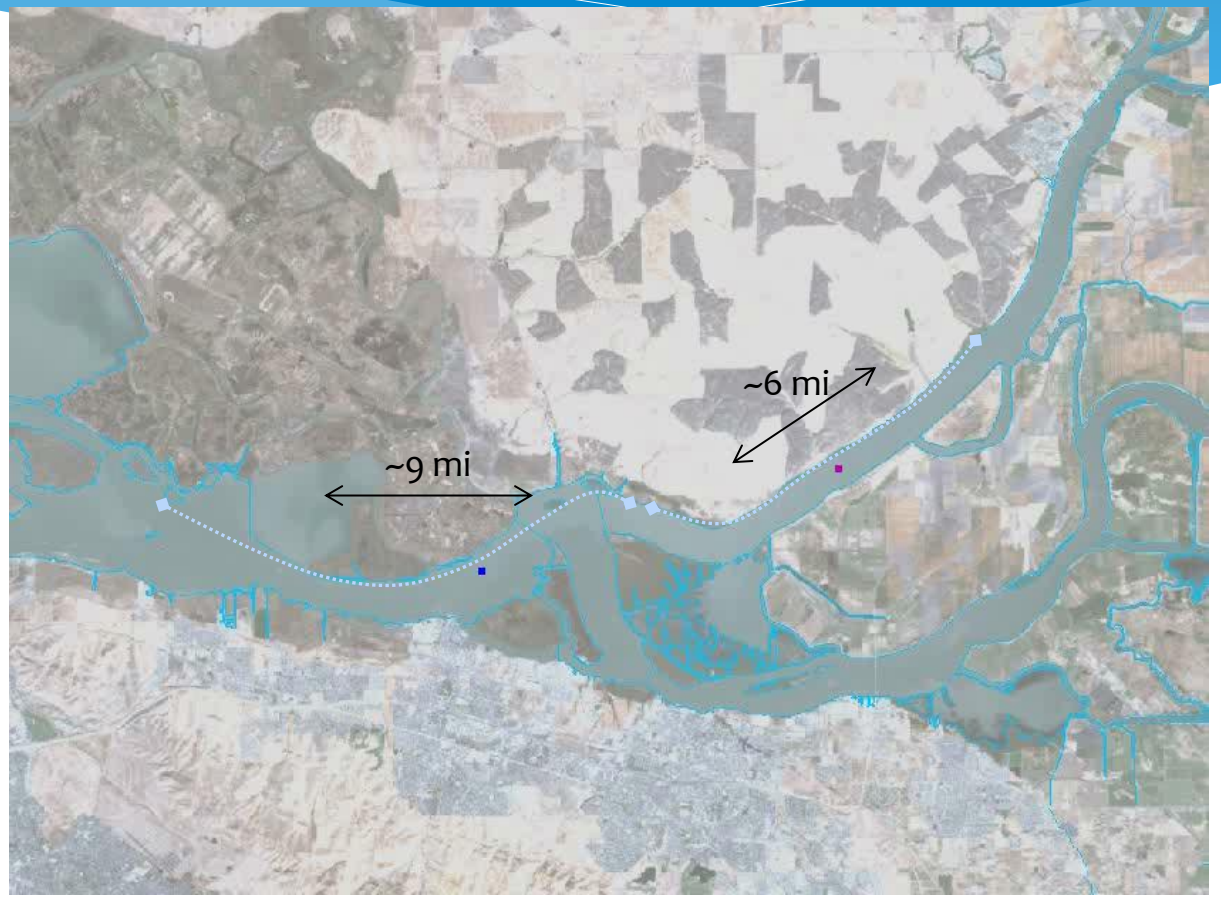


Animation created by Resource Management Associates, using RMA Model results

Excursion and Mixing

Groups of Particles released at two locations on the lower Sacramento River near the center of the channel

- Tidal Excursion is on the order of 6 to 9 miles(!) in this area of the Delta
- The water velocity varies vertically and laterally in a channel
- Turbulent mixing causes a group of particles released at one location experience slightly different velocities causing the group to spread over time



Animation created by Resource Management Associates, using RMA Model results

Excursion and Mixing

Particles released hourly at two cross sections of the lower Sacramento River and stopping after traveling for one tidal cycle

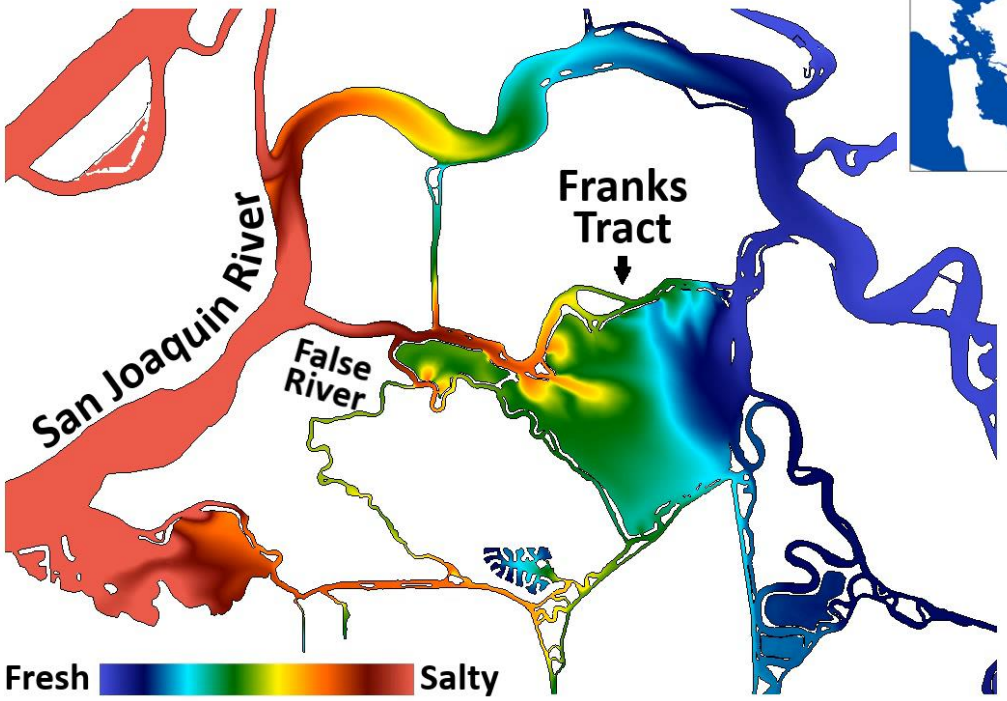
- The distribution of particles after traveling for one tidal cycle (~24.75 hours) illustrates the impact of tidal mixing, one of the key processes that brings ocean salinity into the Delta

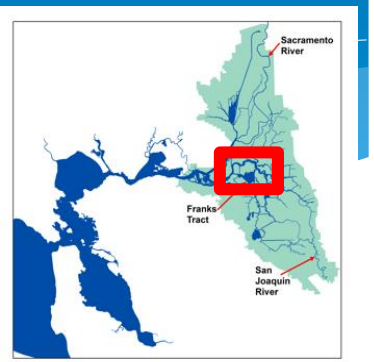
Animation created by Resource Management Associates, using RMA Model results

Salinity

Mixing in the Central Delta during a typical low flow period

- Fresh water moves from north to south drawn by south Delta exports and in-Delta demand
- Sacramento River water moves through Threemile Slough to the San Joaquin on flood tide
- Tidal flows move higher salinity water from the lower San Joaquin to False River where it is drawn into Franks Tract



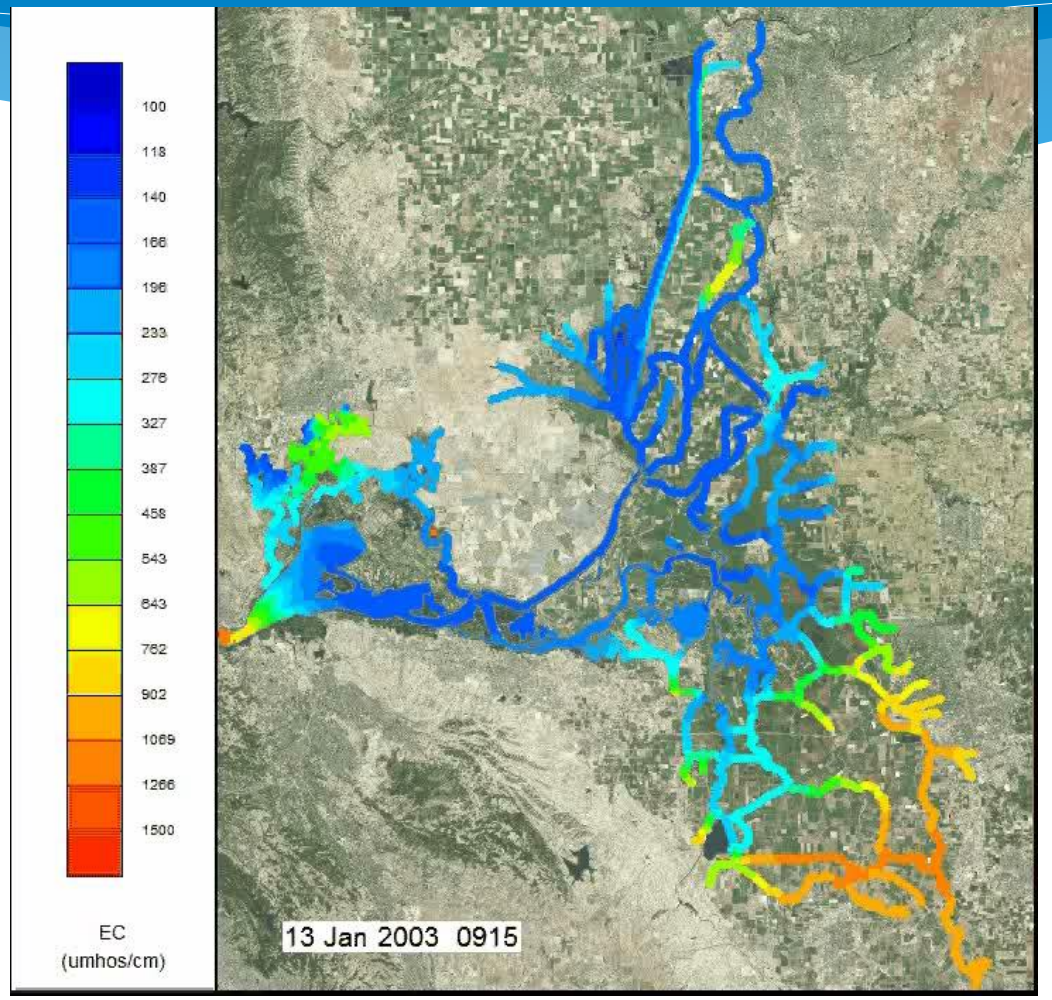


Animation created by DWR Delta Modeling Section, using Bay-Delta SCHISM Model results

Salinity

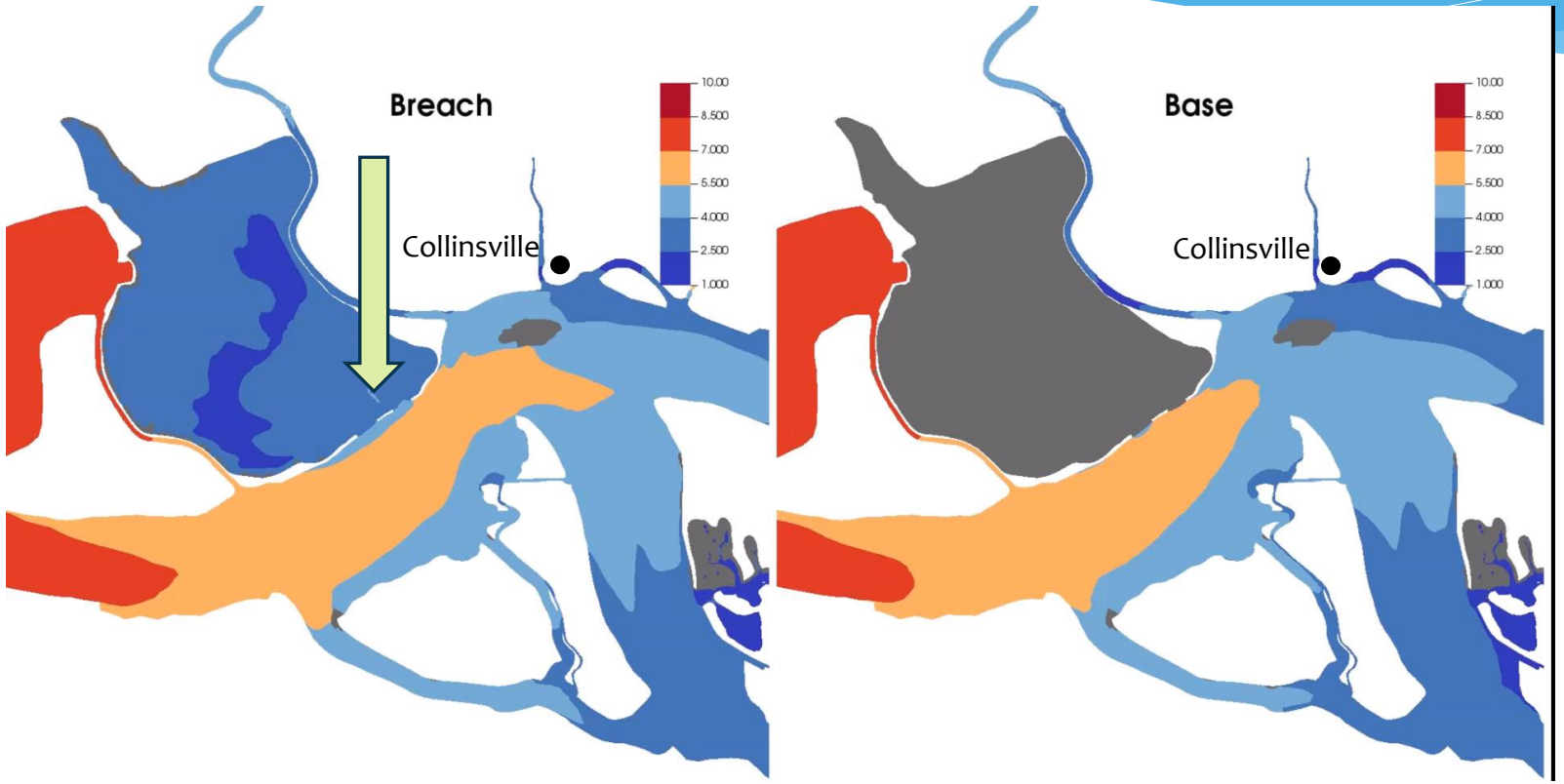
Tidally averaged Delta salinity distribution (as Electrical Conductivity) , 2002 Historic Conditions

- Sacramento River water drawn into the south Delta by exports
- San Joaquin River inflow typically higher in salt than other tributary inflows
- Salt from the ocean boundary moves slowly eastward over the summer and fall period



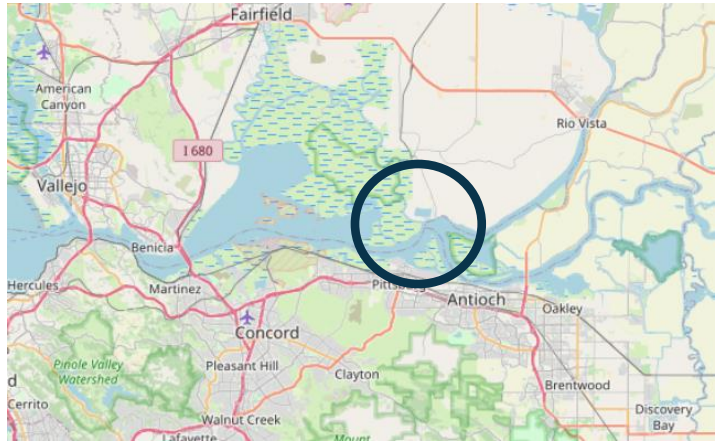
Animation created by Resource Management Associates, using RMA Model results

Dispersion at Breaches

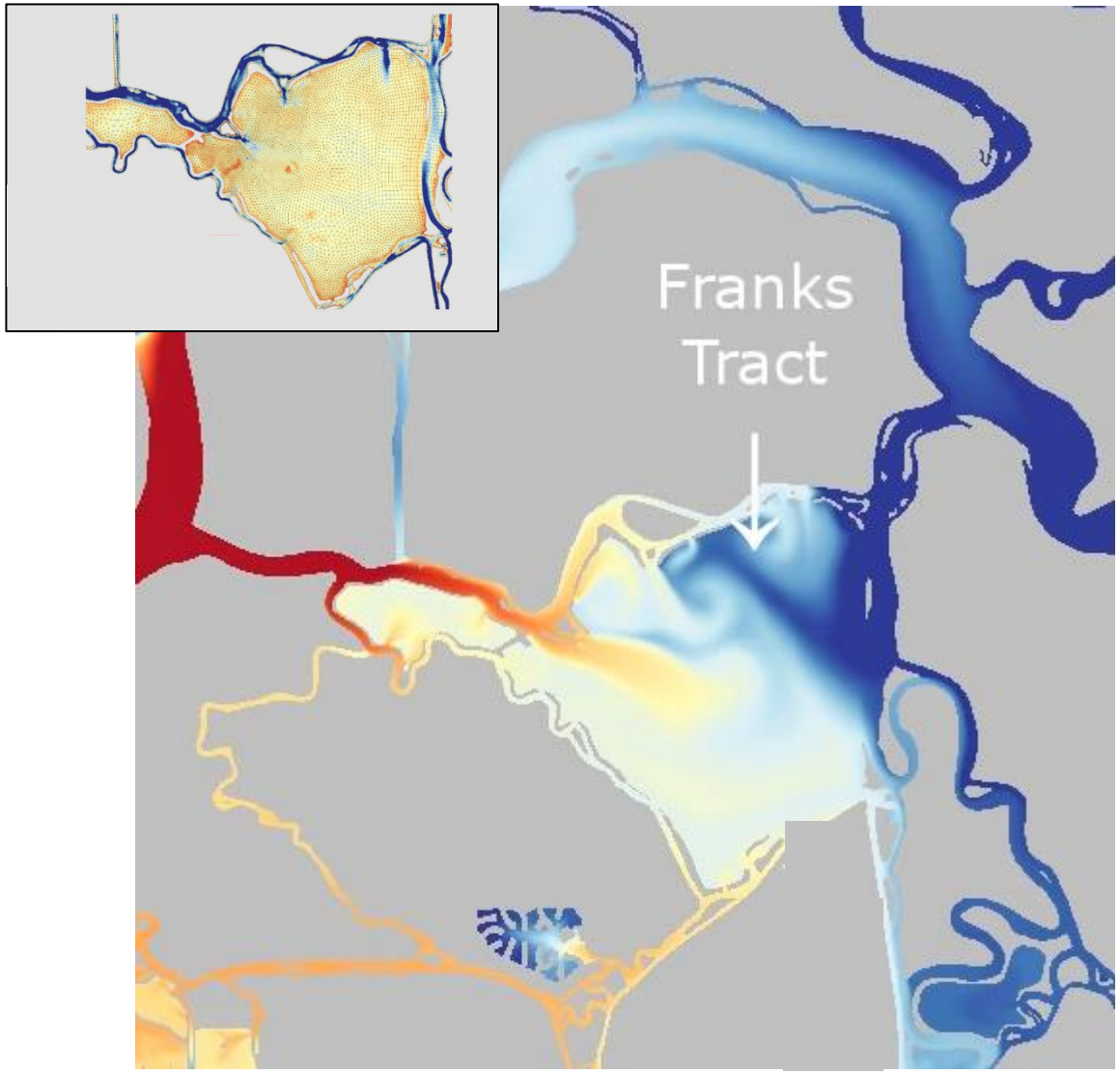


Van Sickle Island Breach Expanded
Result from Bay-Delta SCHISM

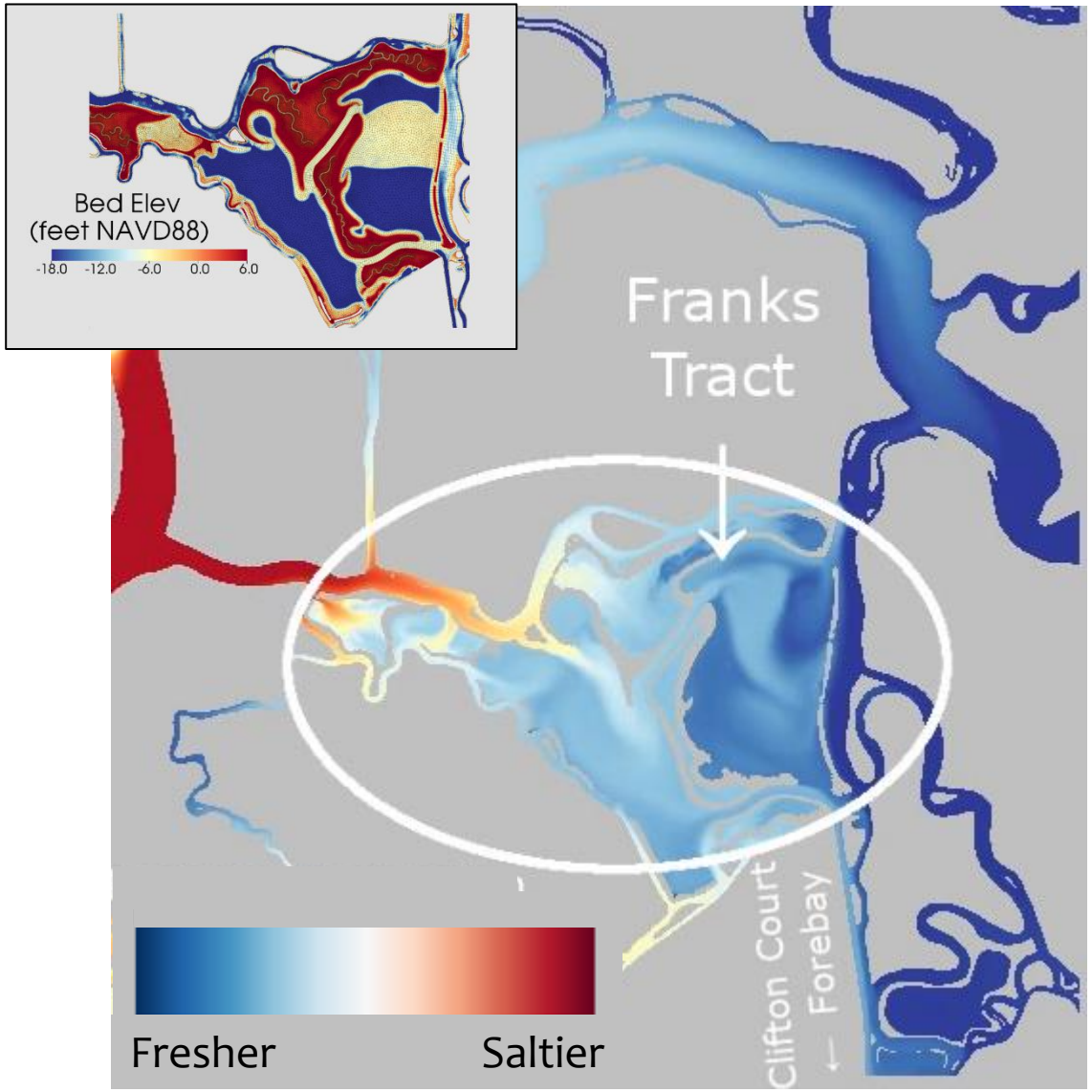
* Asynchronous:
  * Tidal turnaround
  * Concentration
* Cumulative



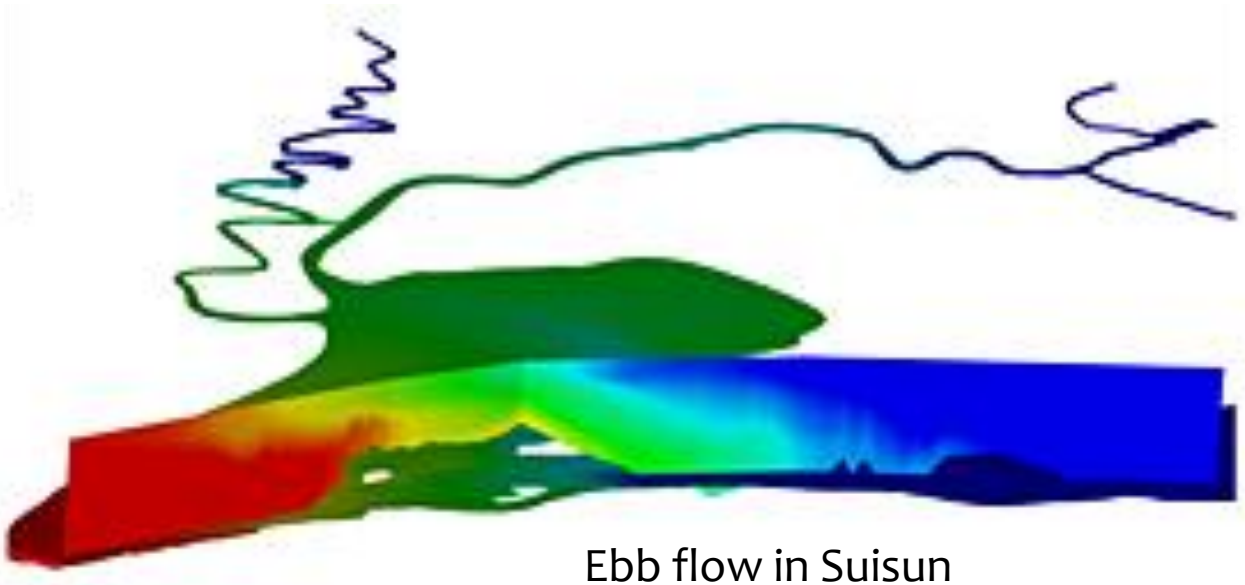
Current Geometry



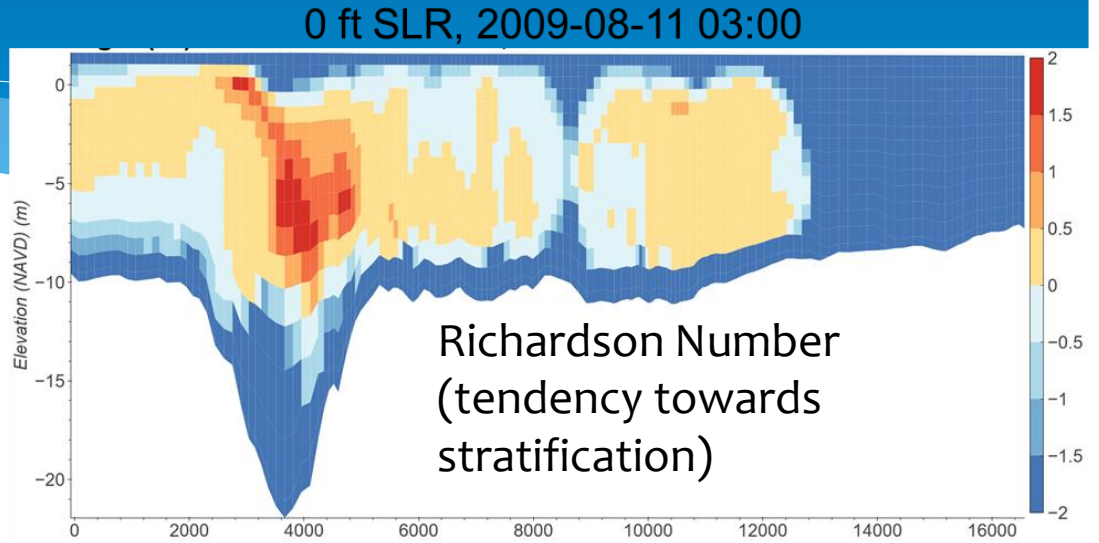
Franks Tract Futures

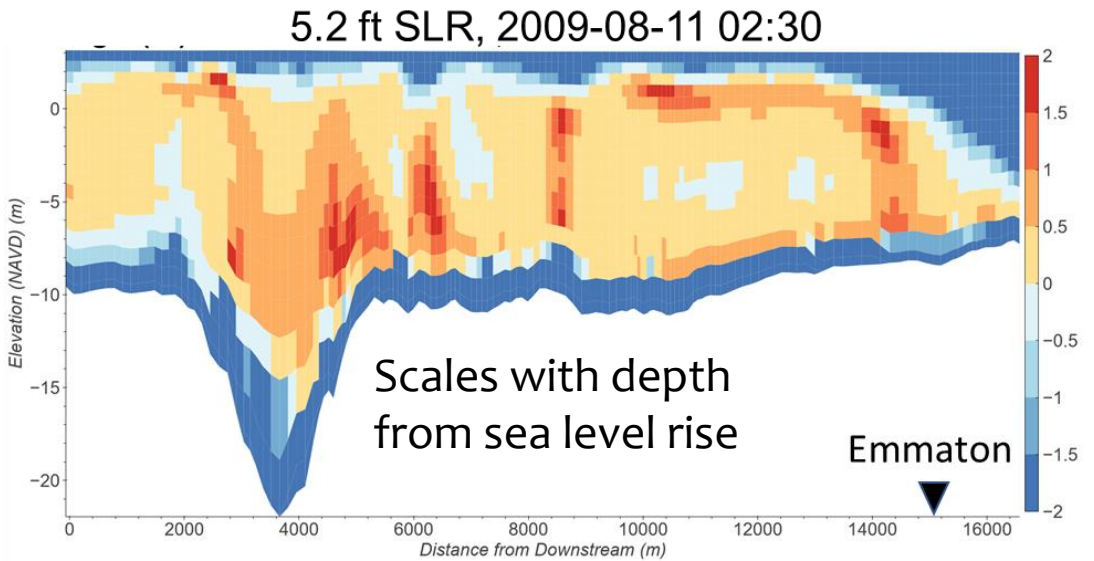


Sea Level Change: Density-Driven Mixing



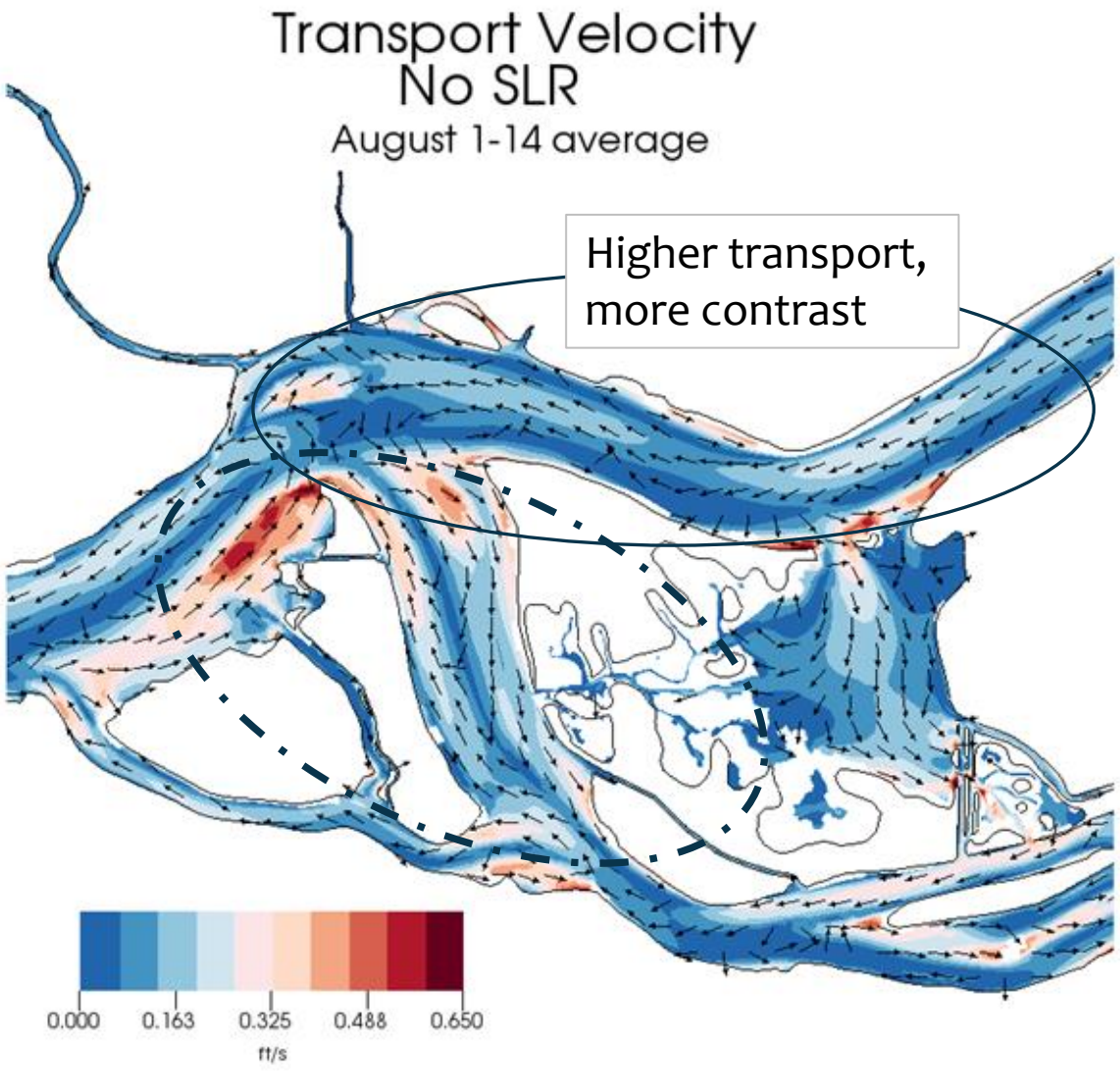
Ebb flow in Suisun Bay with enhanced stratification

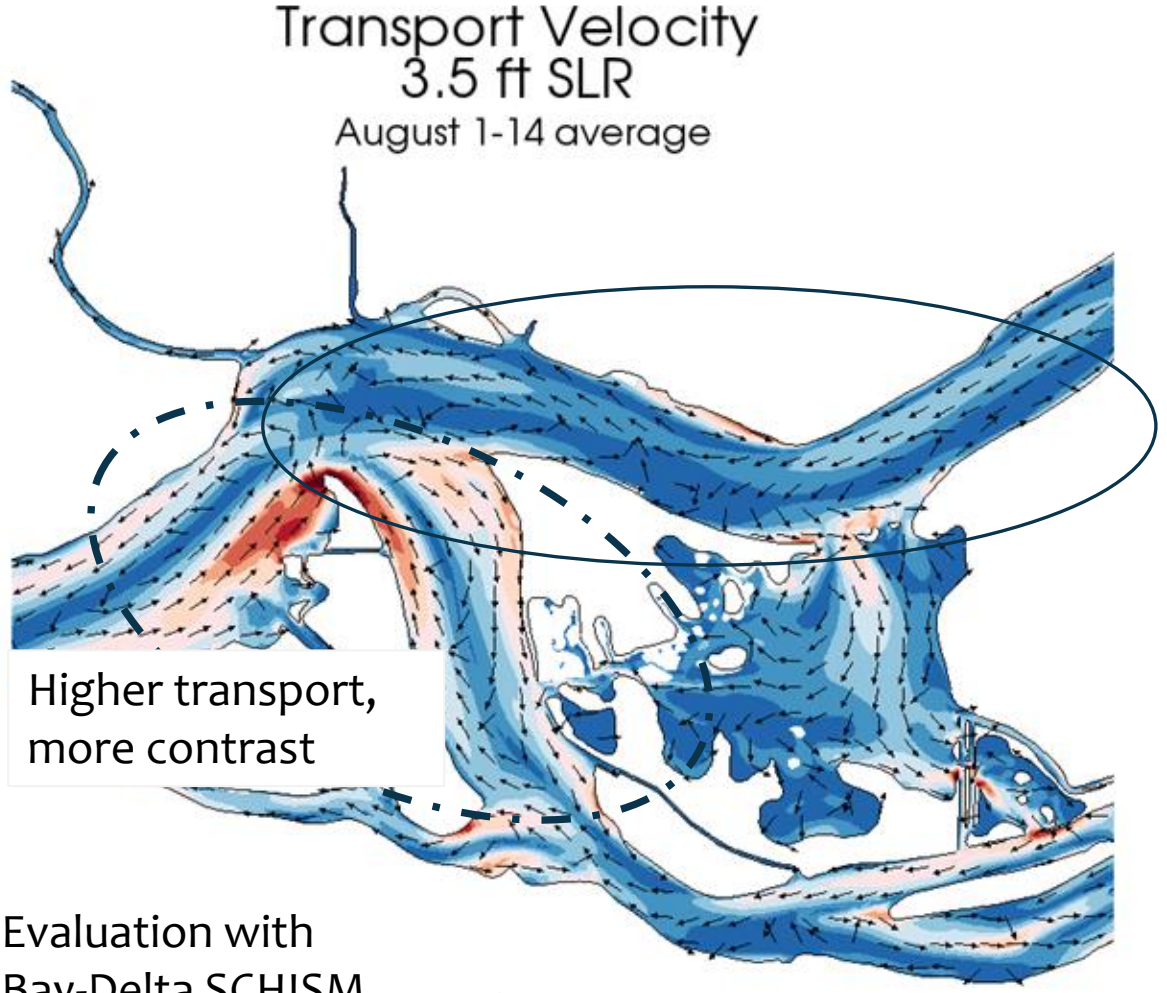




Stratification relevant at both tidally averaged and periodic time scales

Sea Level Change: Horizontal Transport

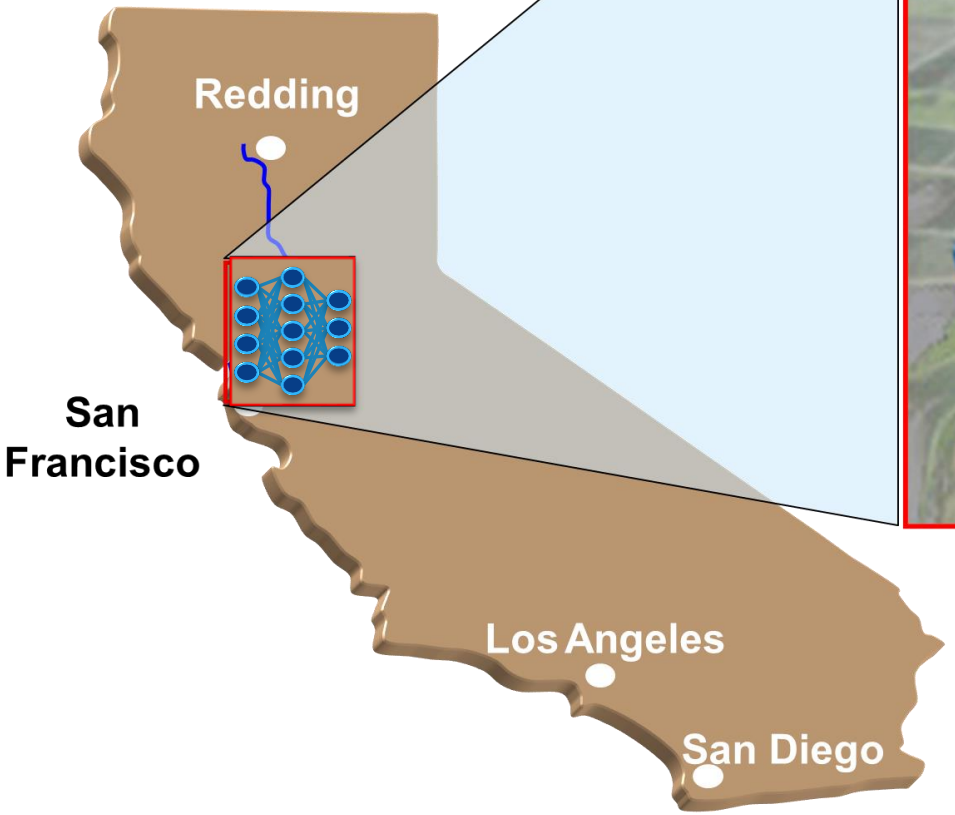


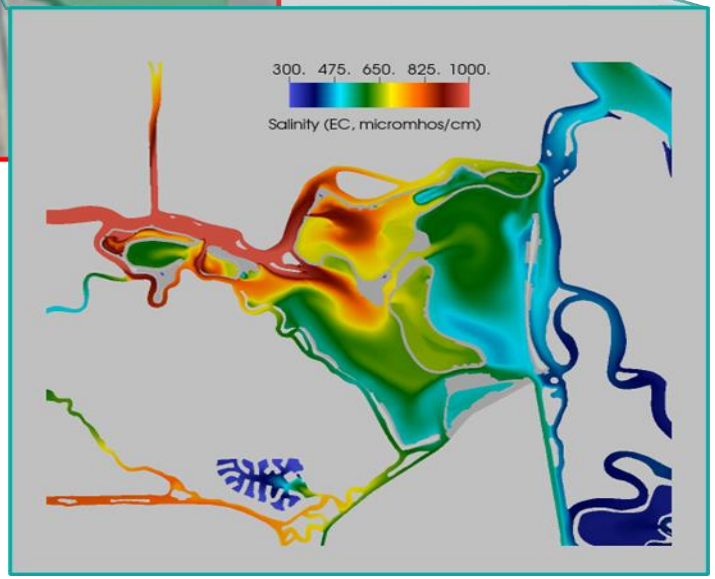


Evaluation with
Bay-Delta SCHISM

Operational Response and Salinity Impact vs Water Cost

How will altered Delta salinity-flow affect water management?

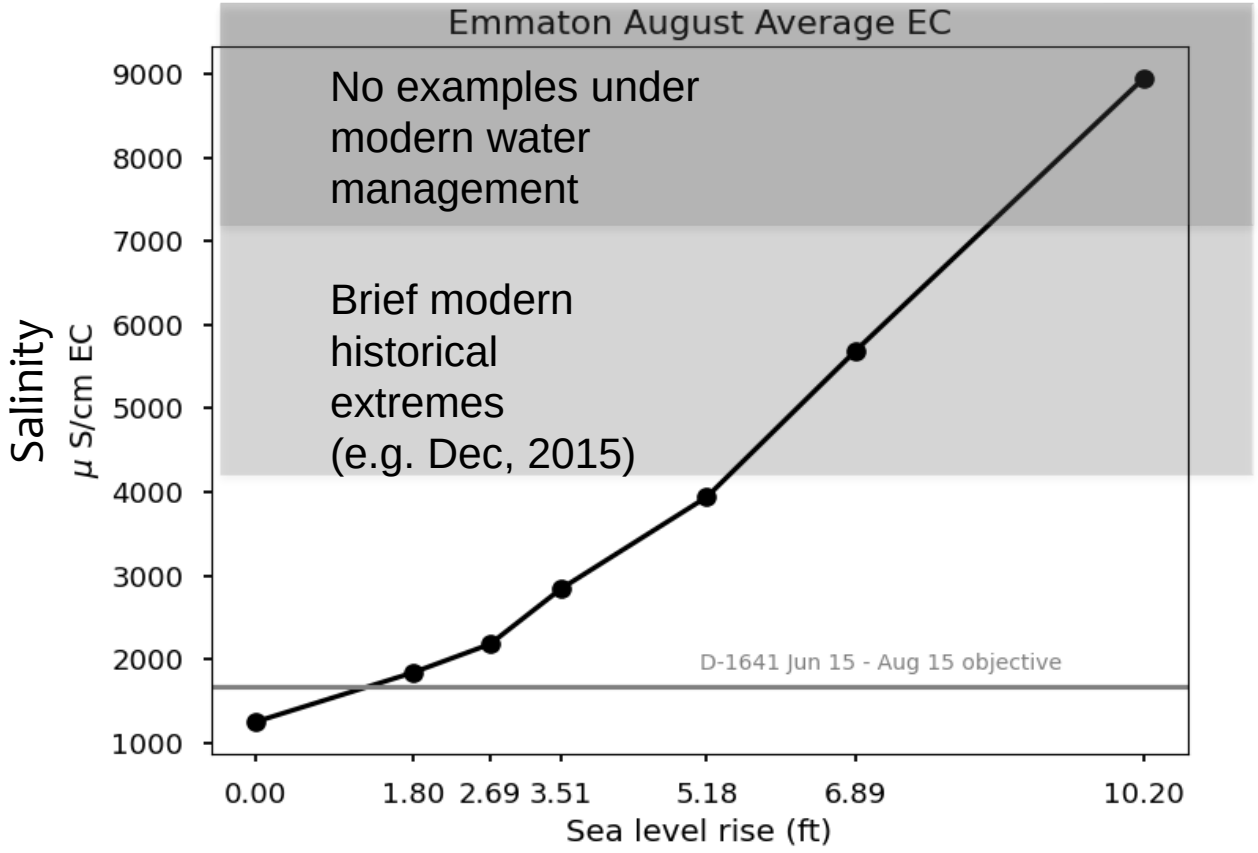




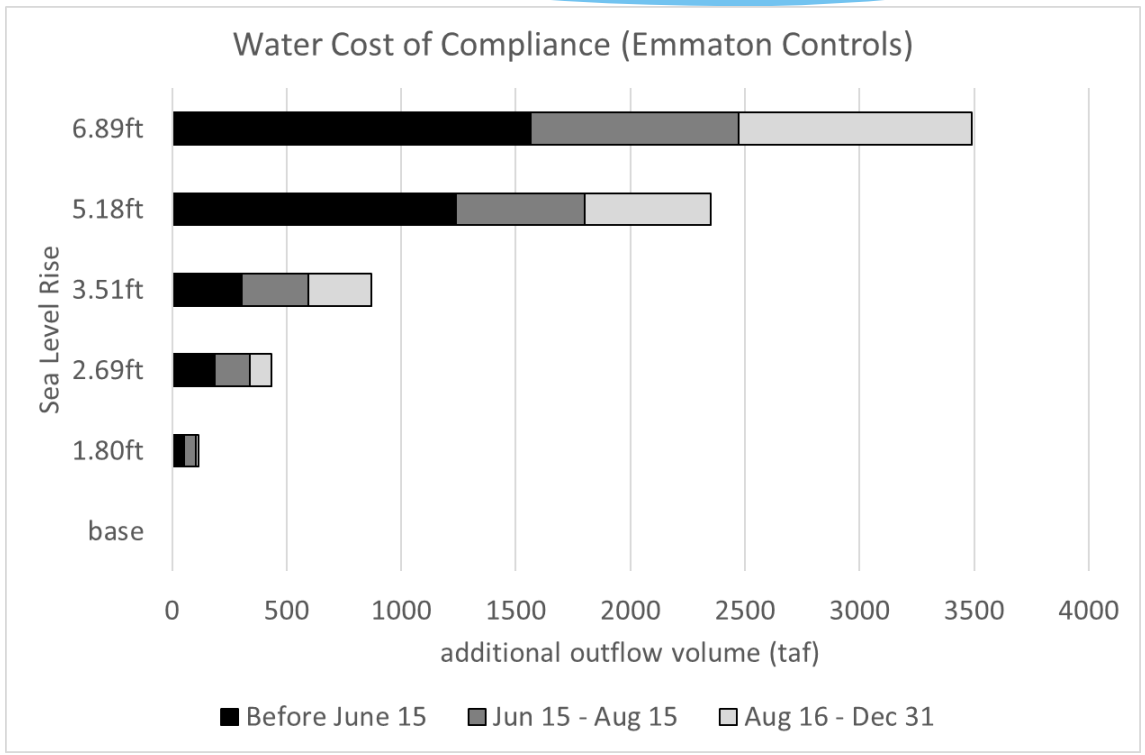
How will operational response change the benefits of actions?

Sea Level Rise: Impact vs Water Cost

Impact: Inflows/Exports Held Constant

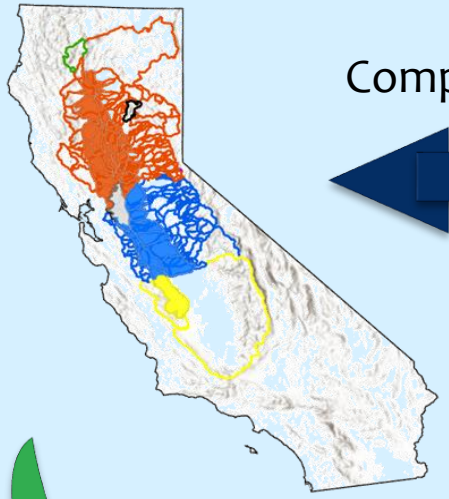


Water Cost: Net Delta Outflow Adjusted for Compliance

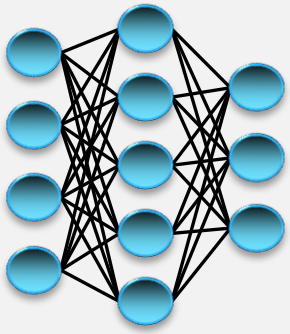


Results are for August 2009 Using Bay-Delta SCHISM

Operations Models (e.g. CalSim)



Compliance

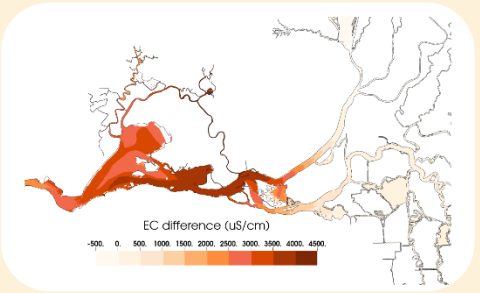


ANN

Artificial Neural Network Surrogate

Metrics:

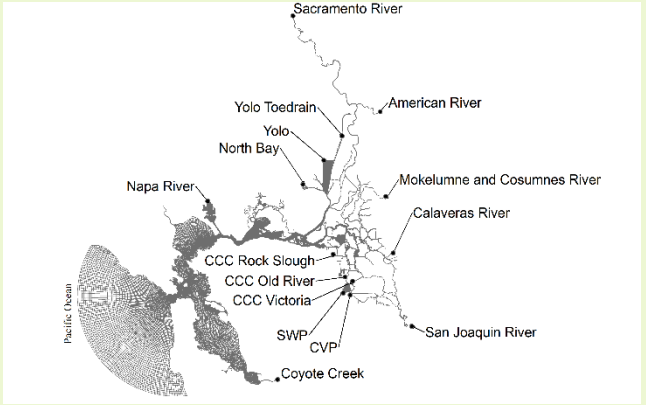
Flow, Salinity, Residence Time



Training

Flows

Detailed Models (e.g. SCHISM, RMA2D)



Validation and detail

Cluster Analysis for Representative Years

Operations Models (e.g. CalSim)

Compliance

ANN

Artificial Neural Network Surrogate

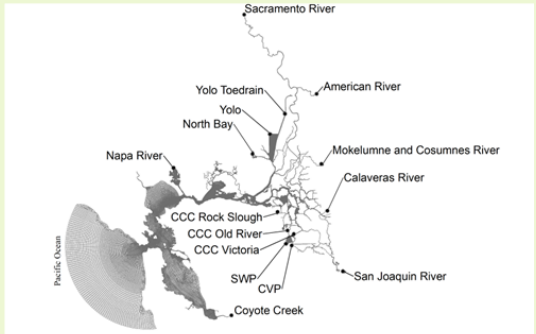
Metrics: Flow, Salinity, Residence Time

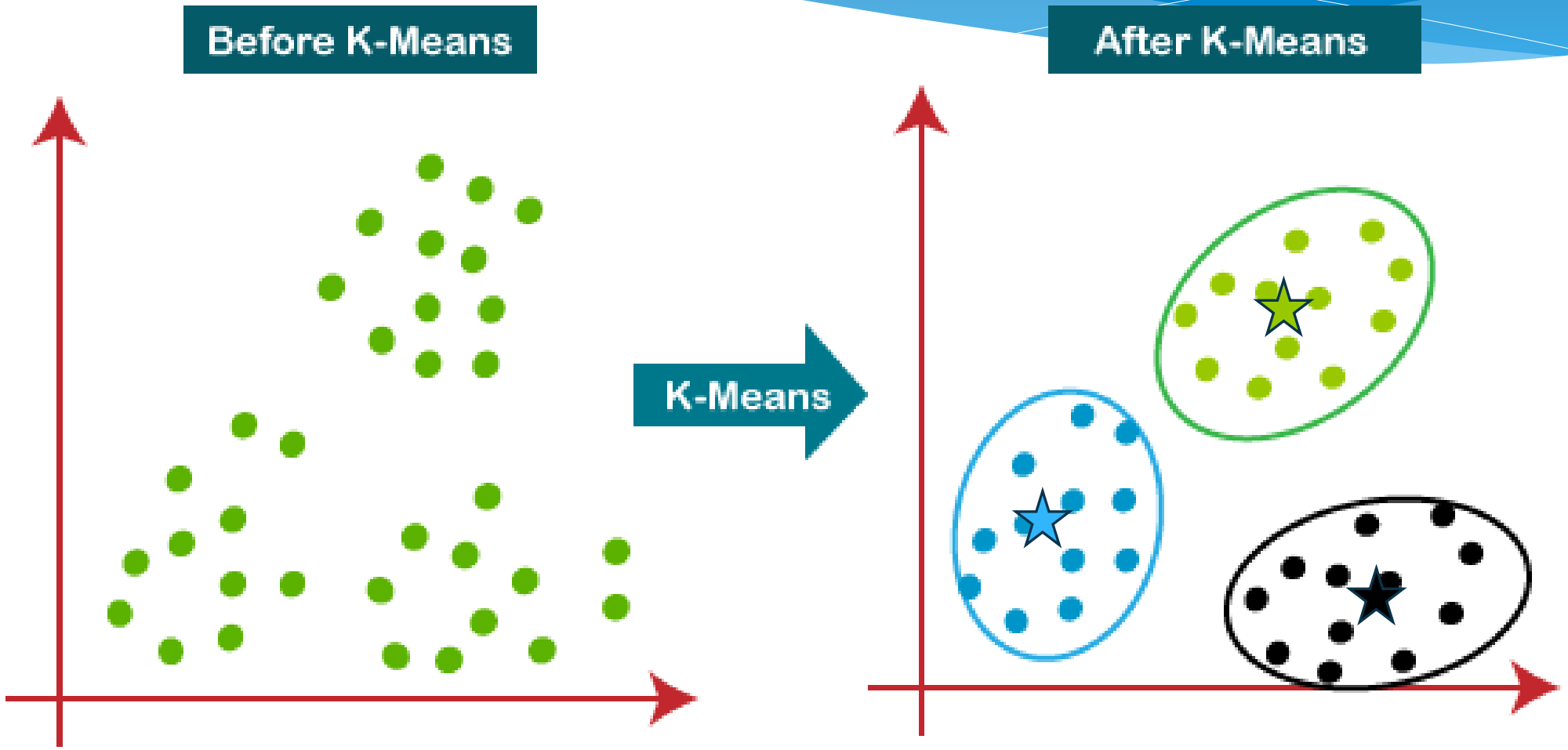
Training

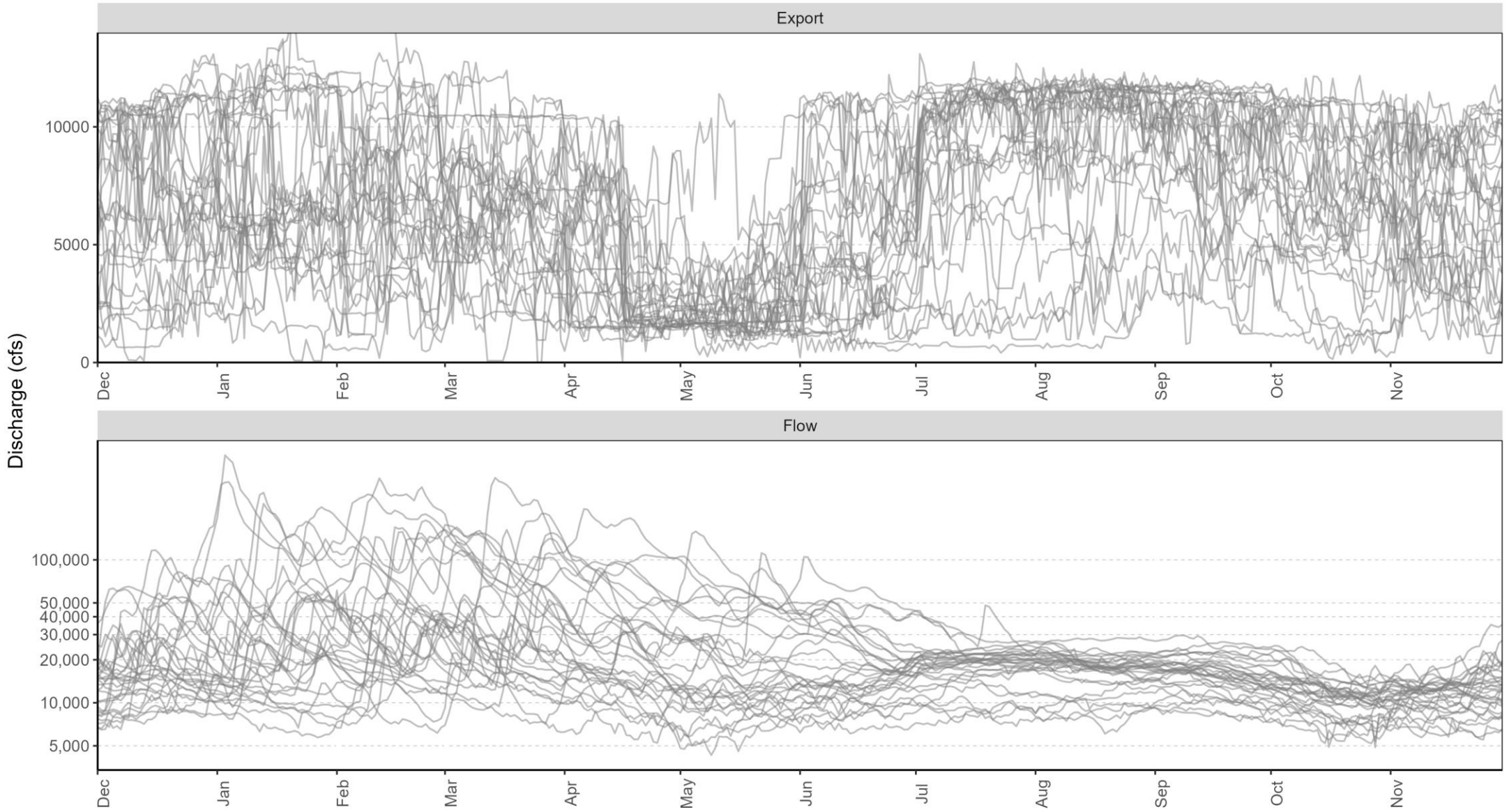
Flows

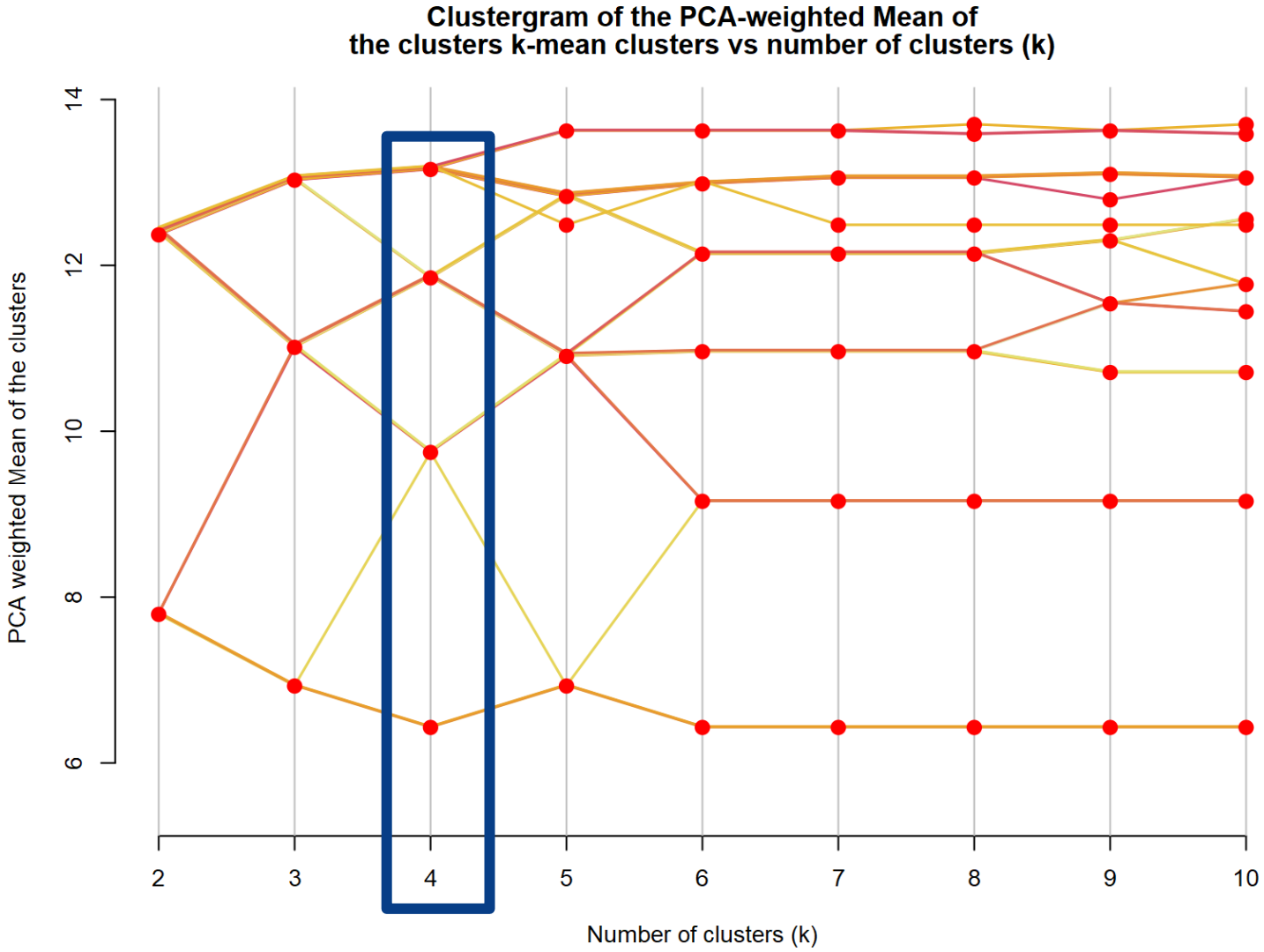
Validation and detail

Detailed Models (e.g. SCHISM, RMA2D)

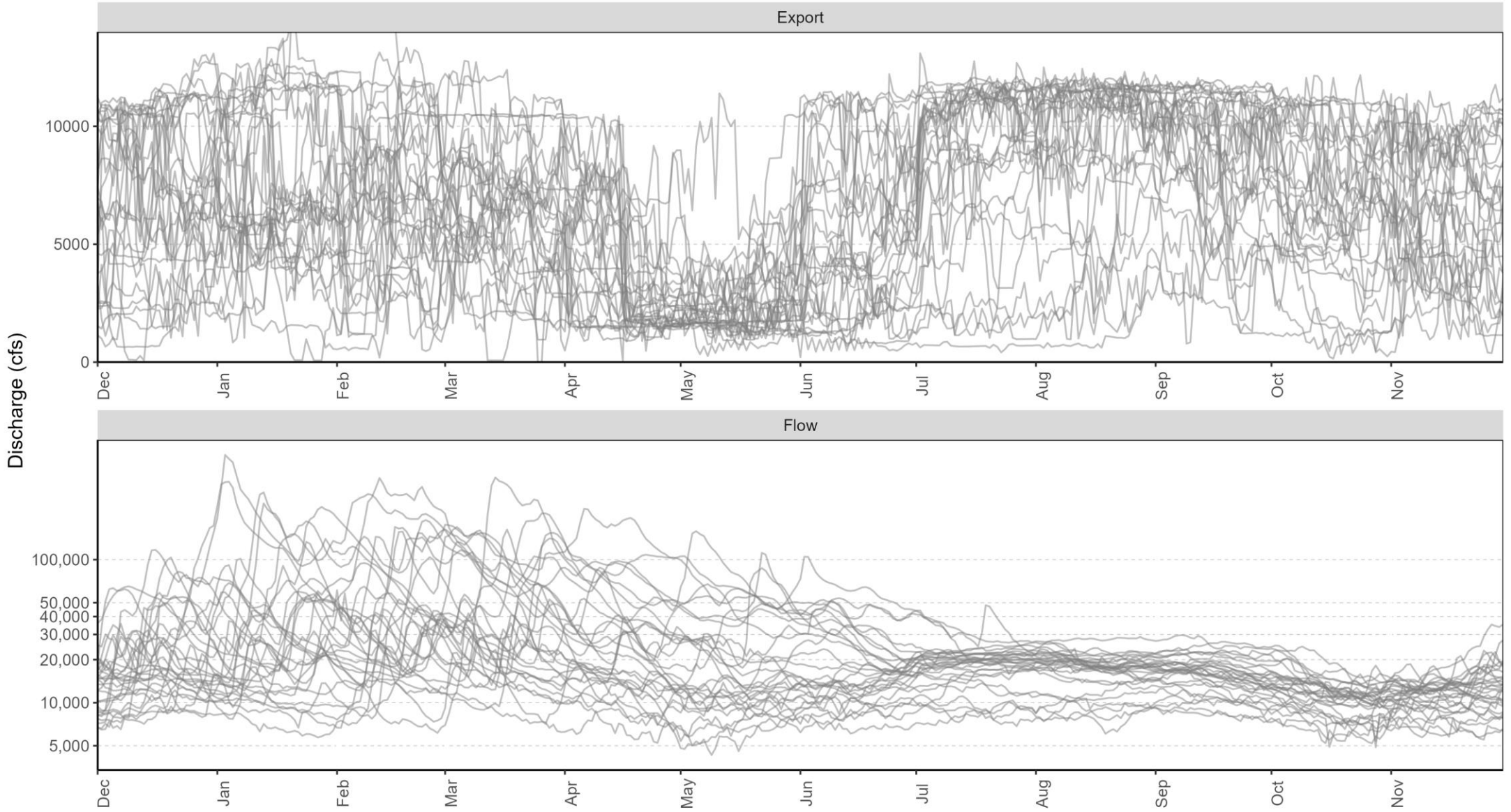


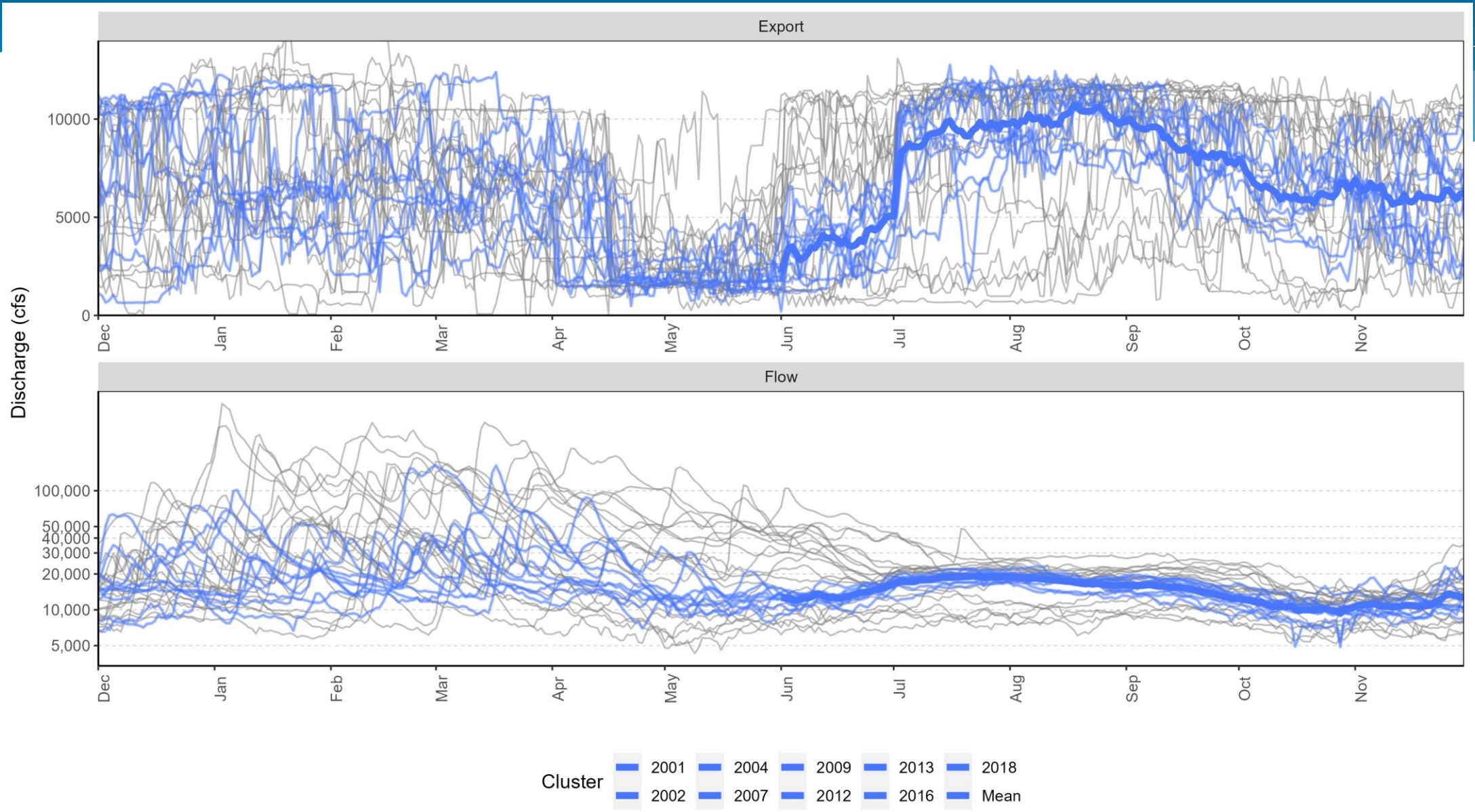

Before K-Means
K-Means
After K-Means

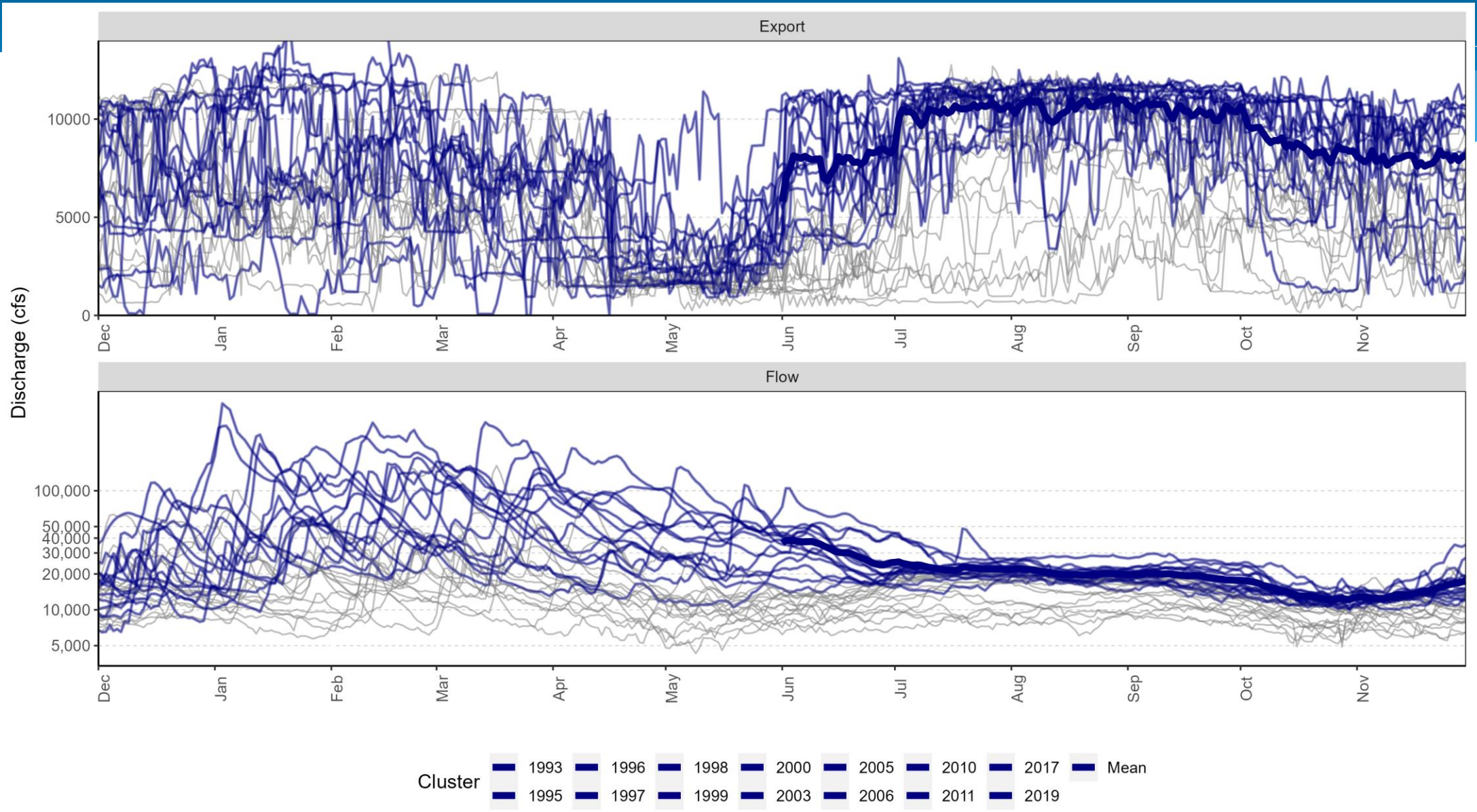

Export
Flow
Discharge (cfs)
0
5000
10000
5,000
10,000
20,000
30,000
40,000
50,000
100,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov

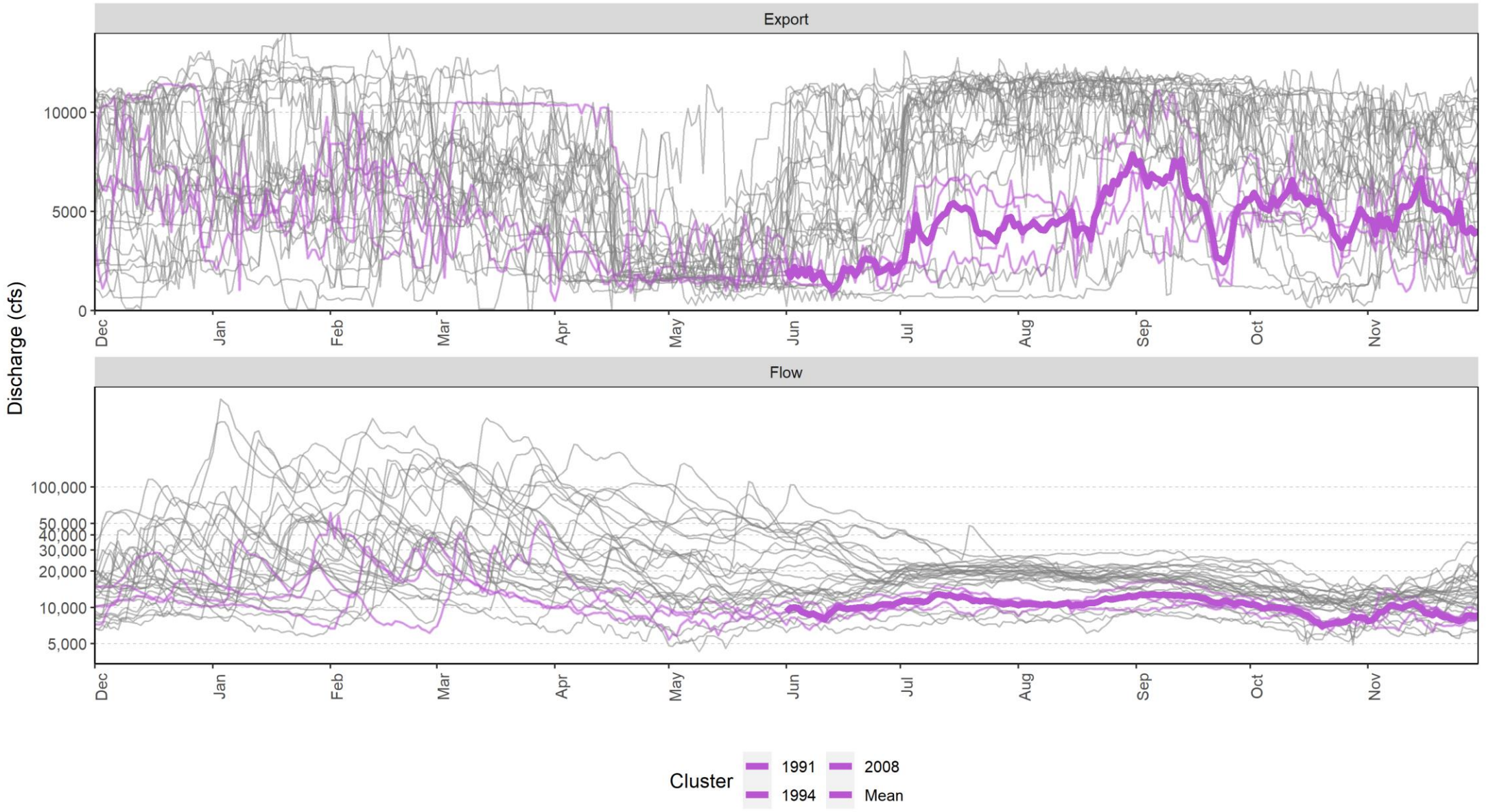


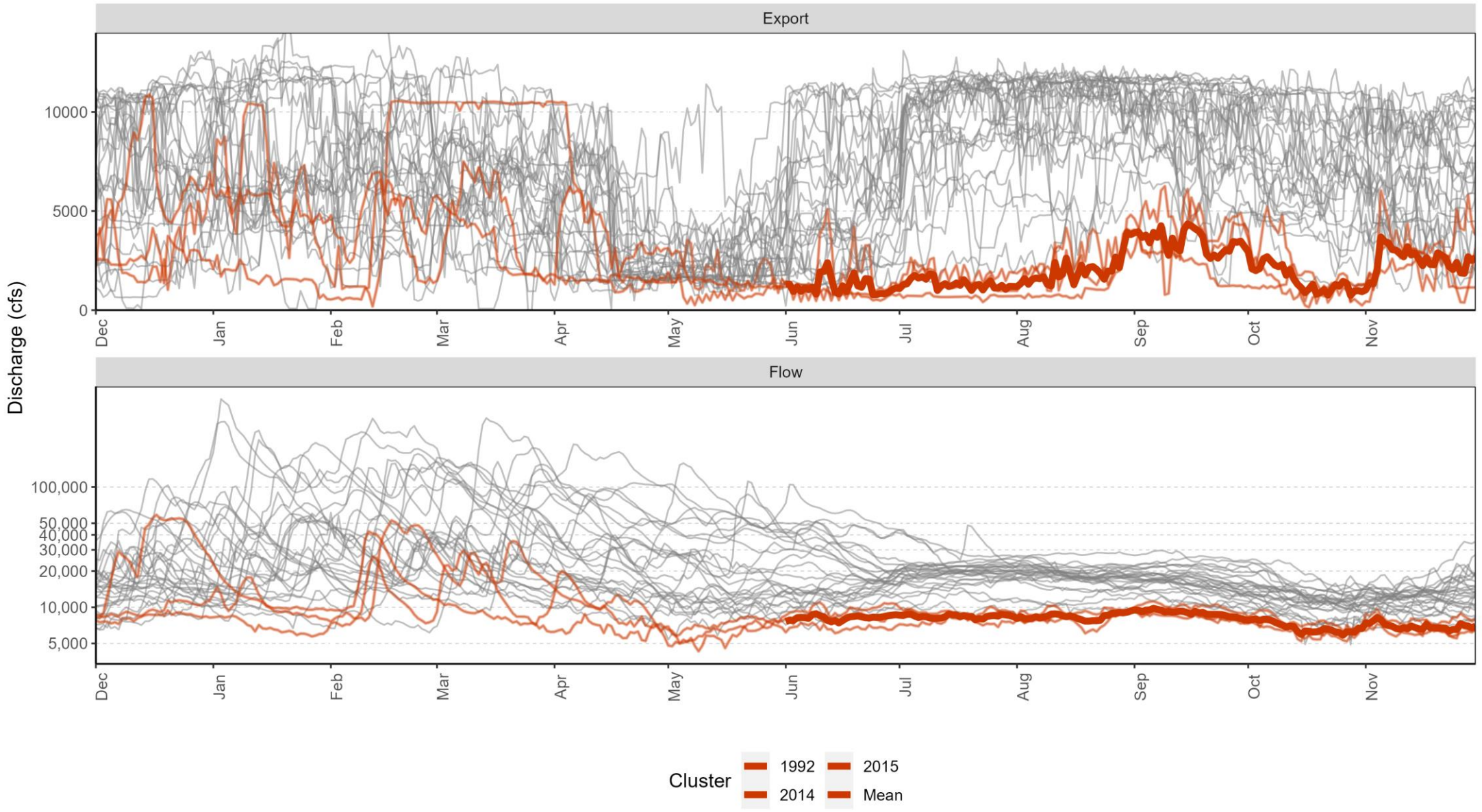
Difference in characteristics between clustered groups

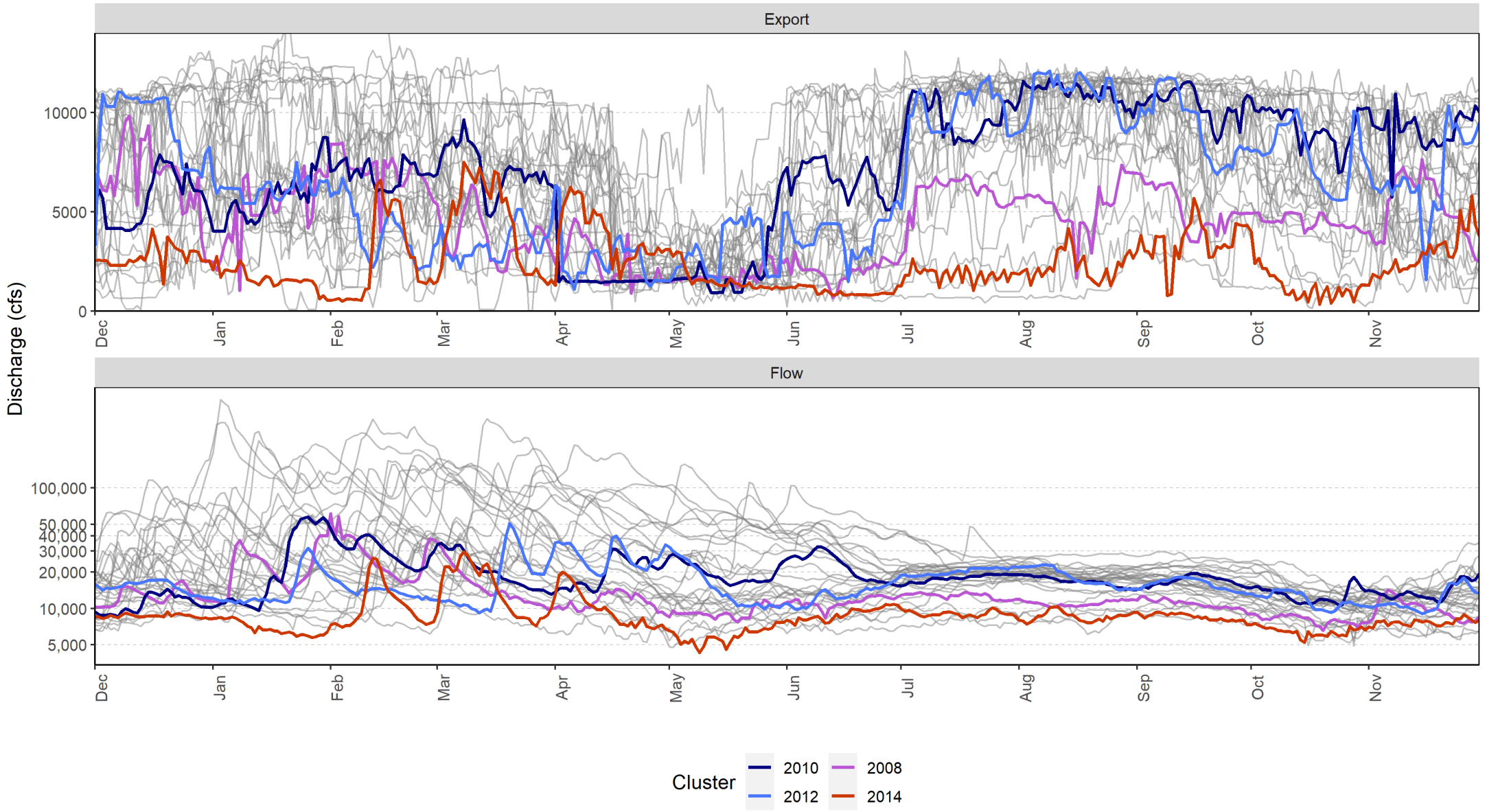

Export
Flow
Discharge (cfs)
0
5000
10000
5,000
10,000
20,000
30,000
40,000
50,000
100,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov


Export
Flow
Discharge (cfs)
10000
5000
0
100,000
50,000
40,000
30,000
20,000
10,000
5,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Cluster
2001
2002
2004
2007
2009
2012
2013
2016
2018
Mean

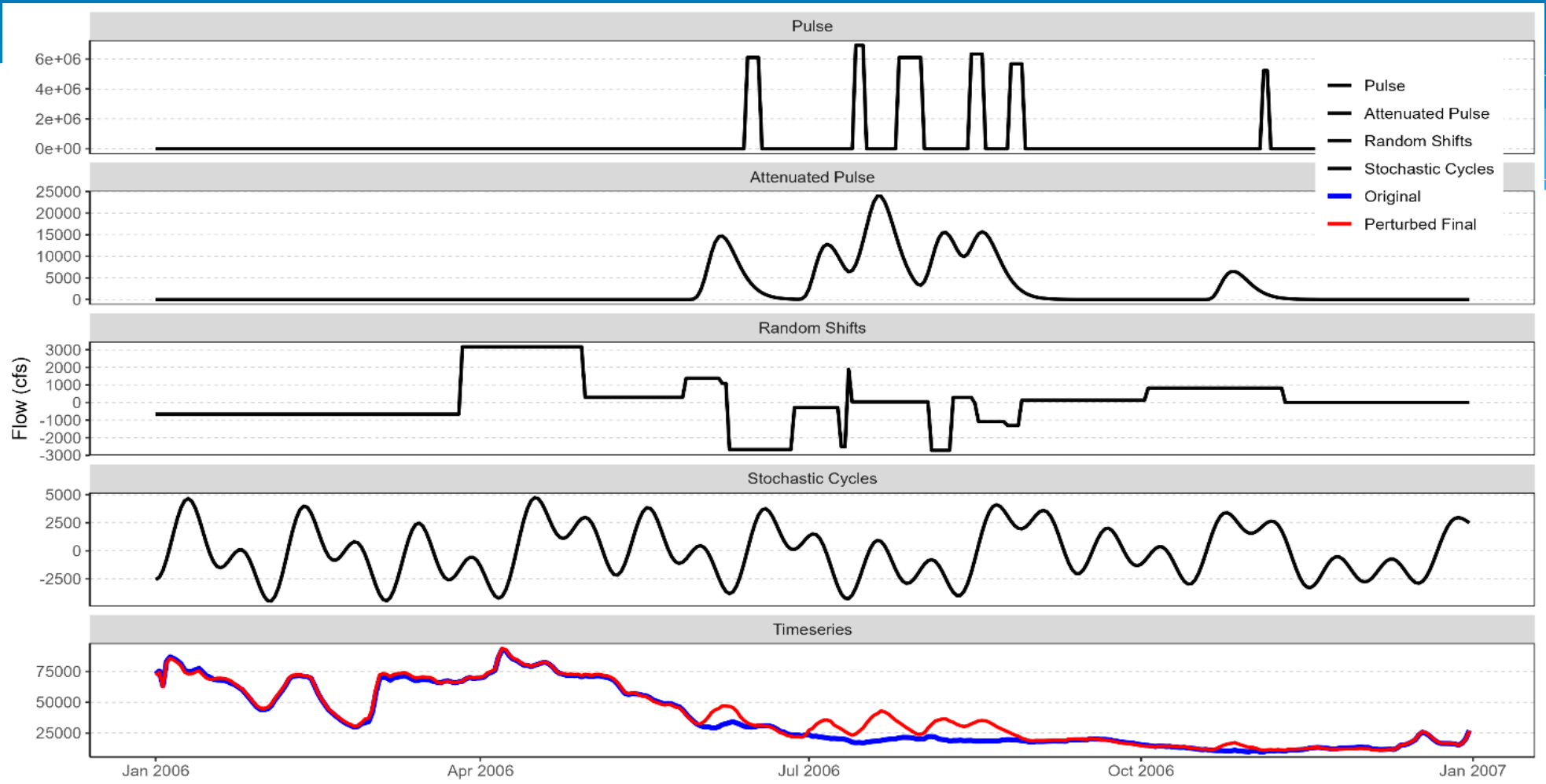

Export
Flow
Discharge (cfs)
10000
5000
0
100,000
50,000
40,000
30,000
20,000
10,000
5,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Cluster
1993
1995
1996
1997
1998
1999
2000
2003
2005
2006
2010
2011
2017
2019
Mean


Export
Flow
Discharge (cfs)
10000
5000
0
100,000
50,000
40,000
30,000
20,000
10,000
5,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Cluster
1991
1994
2008
Mean

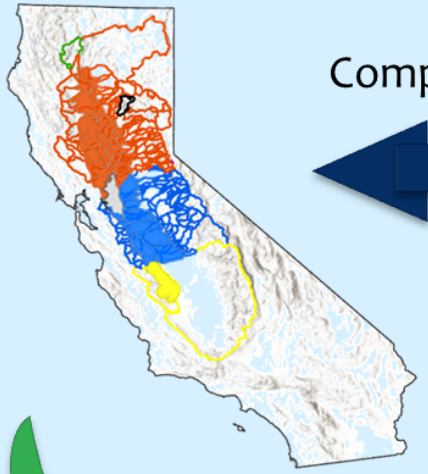

Export
Flow
Discharge (cfs)
10000
5000
0
100,000
50,000
40,000
30,000
20,000
10,000
5,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Cluster
1992
2014
2015
Mean


Export
Flow
Discharge (cfs)
10000
5000
0
100,000
50,000
40,000
30,000
20,000
10,000
5,000
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Cluster
2010
2008
2012
2014

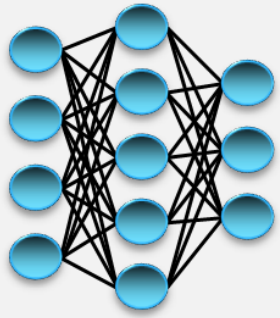
Variations At Multiple Scales



Operations Models (e.g. CalSim)



Compliance

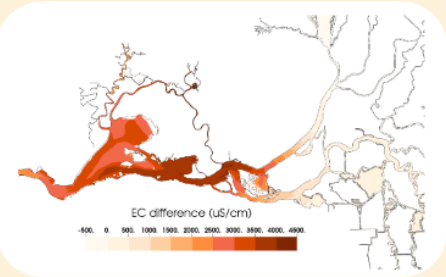


ANN

Artificial Neural Network Surrogate

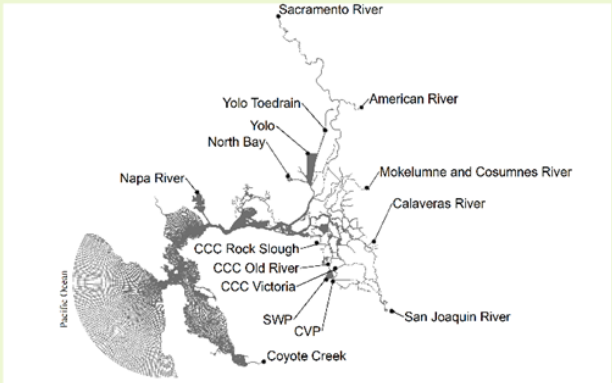
Training

Metrics:
Flow, Salinity, Residence Time



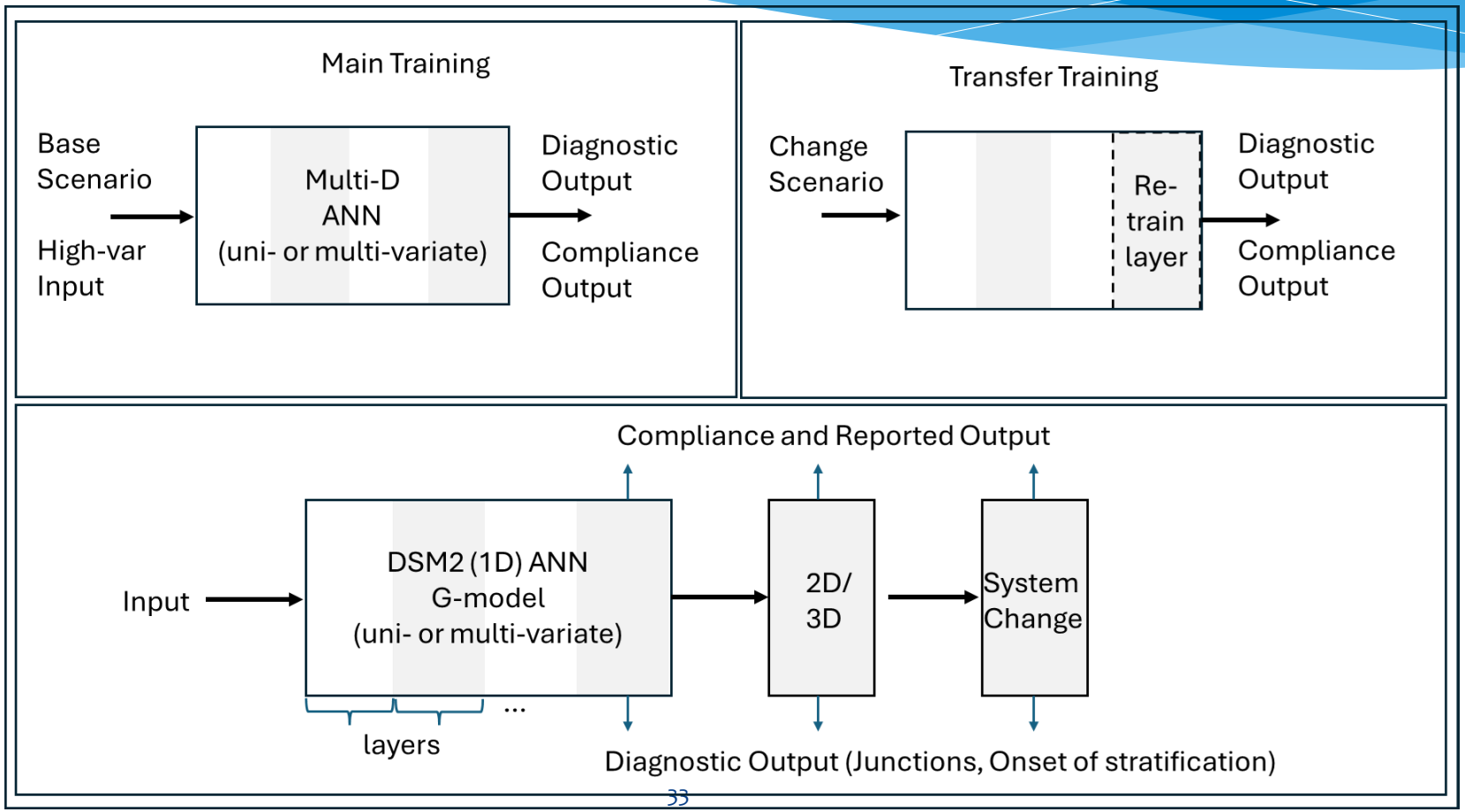
Flows

Detailed Models (e.g. SCHISM, RMA2D)

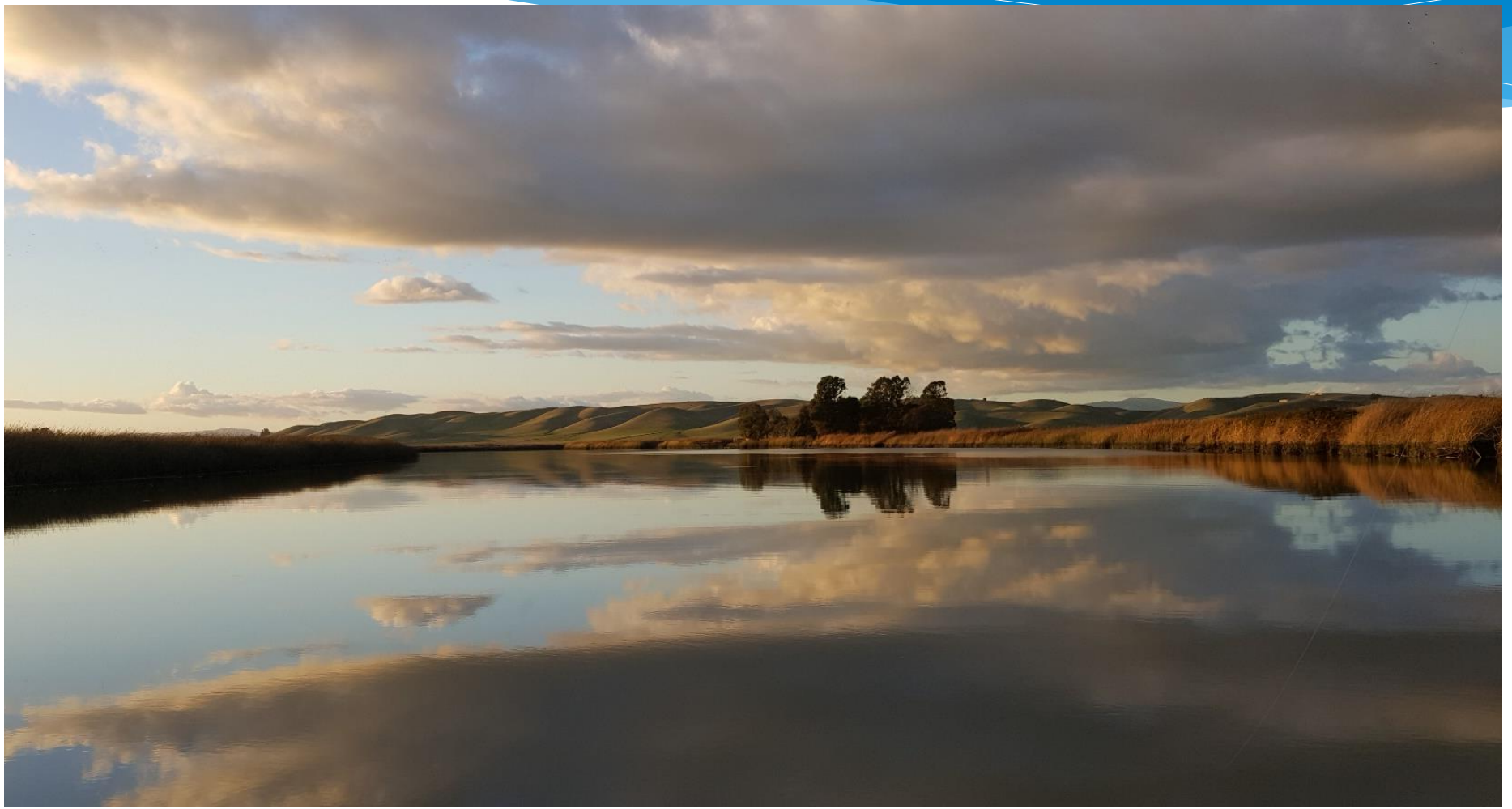


Validation and detail

Surrogates for Alternate Cases: Transfer/Residual Modeling



Questions?



Contact Information

John F. DeGeorge, Ph.D., P.E.
Resource Management Associates, Inc.
4171 Suisun Valley Road, Suite J
Fairfield, CA 94534
(707) 864-2950
jfdegeorge@rmanet.com
www.rmanet.com

Eli Ateljevich, Ph.D., P.E.
California Department of Water Resources
1516 Ninth St, 2-207
Sacramento, CA 95814
(916) 902-6984
Eli.Ateljevich@water.ca.gov