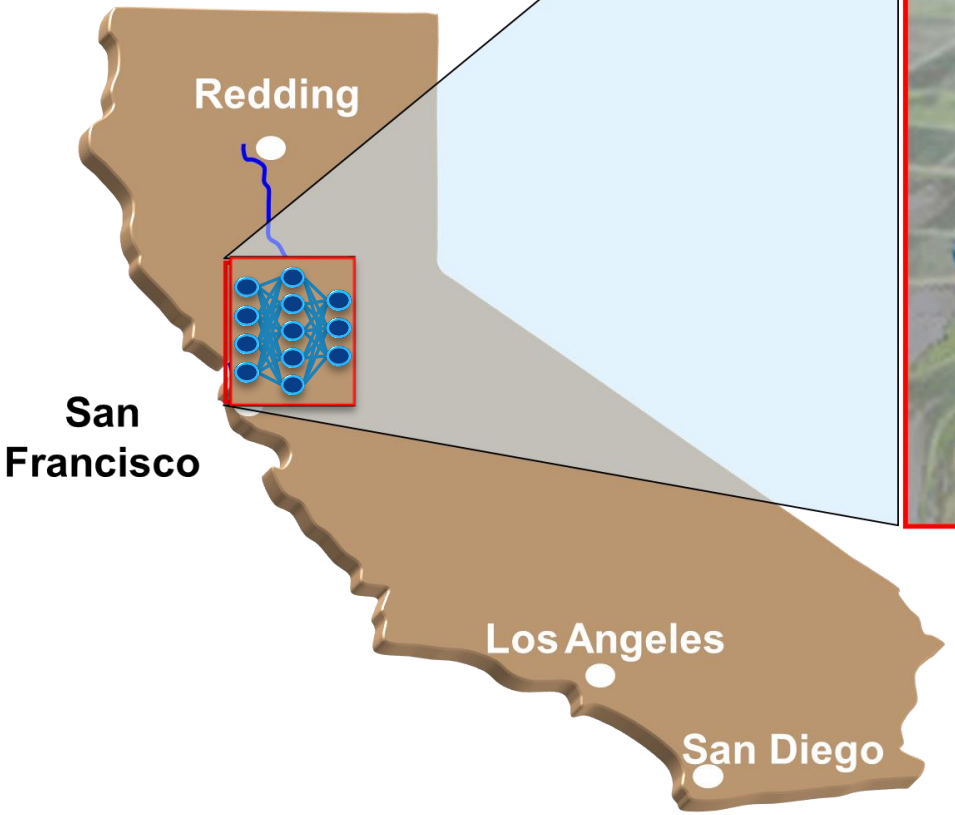
Increasing Transparency and Flexibility of CalSIM Salinity Surrogates

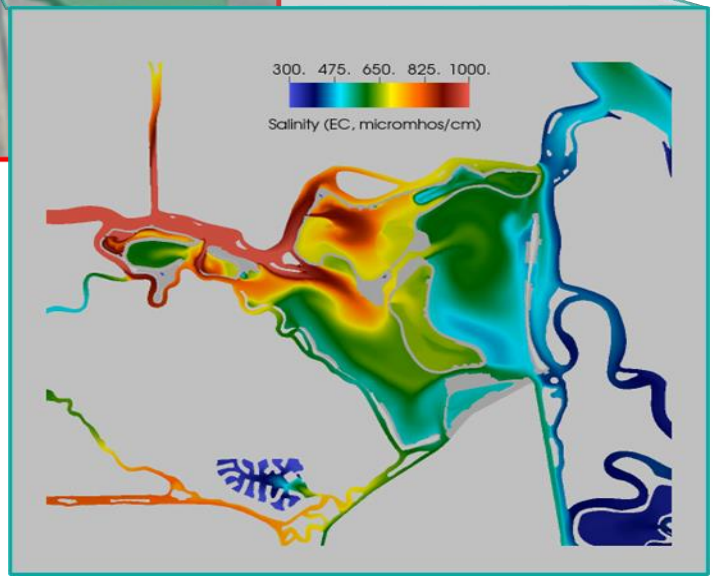
Eli Ateljevich, Ph.D.
Modeling Support Office, DWR

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

CWEMF Annual Meeting
September 24, 2024

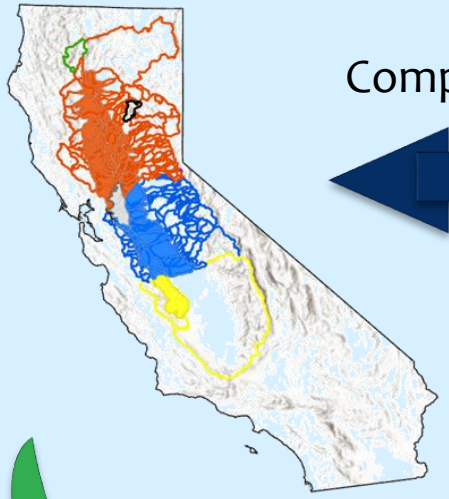
How will altered Delta salinity-flow affect water management?



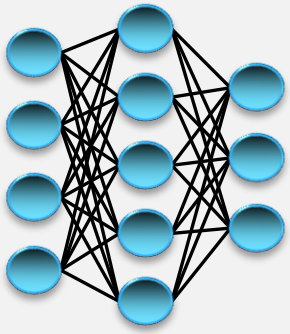


How will operational response change the benefits of actions?

Operations Models (e.g. CalSim)



Compliance

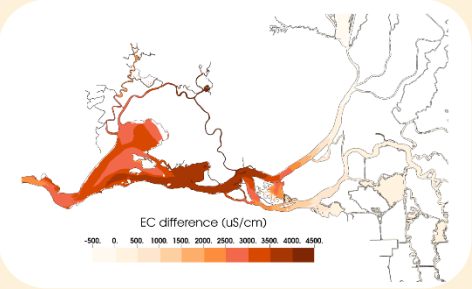


ANN

Artificial Neural Network Surrogate

Metrics:

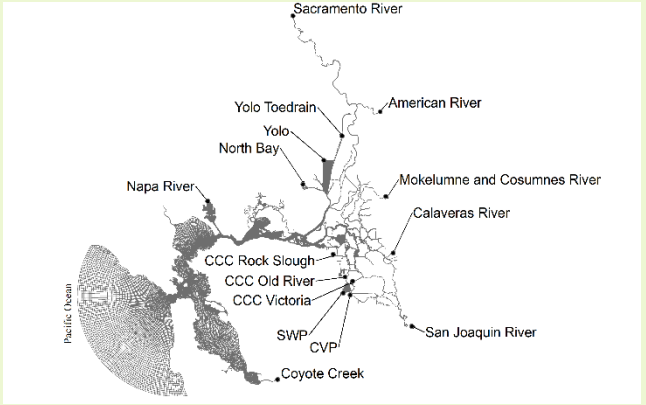
Flow, Salinity, Residence Time



Training

Flows

Detailed Models (e.g. SCHISM, RMA2D)

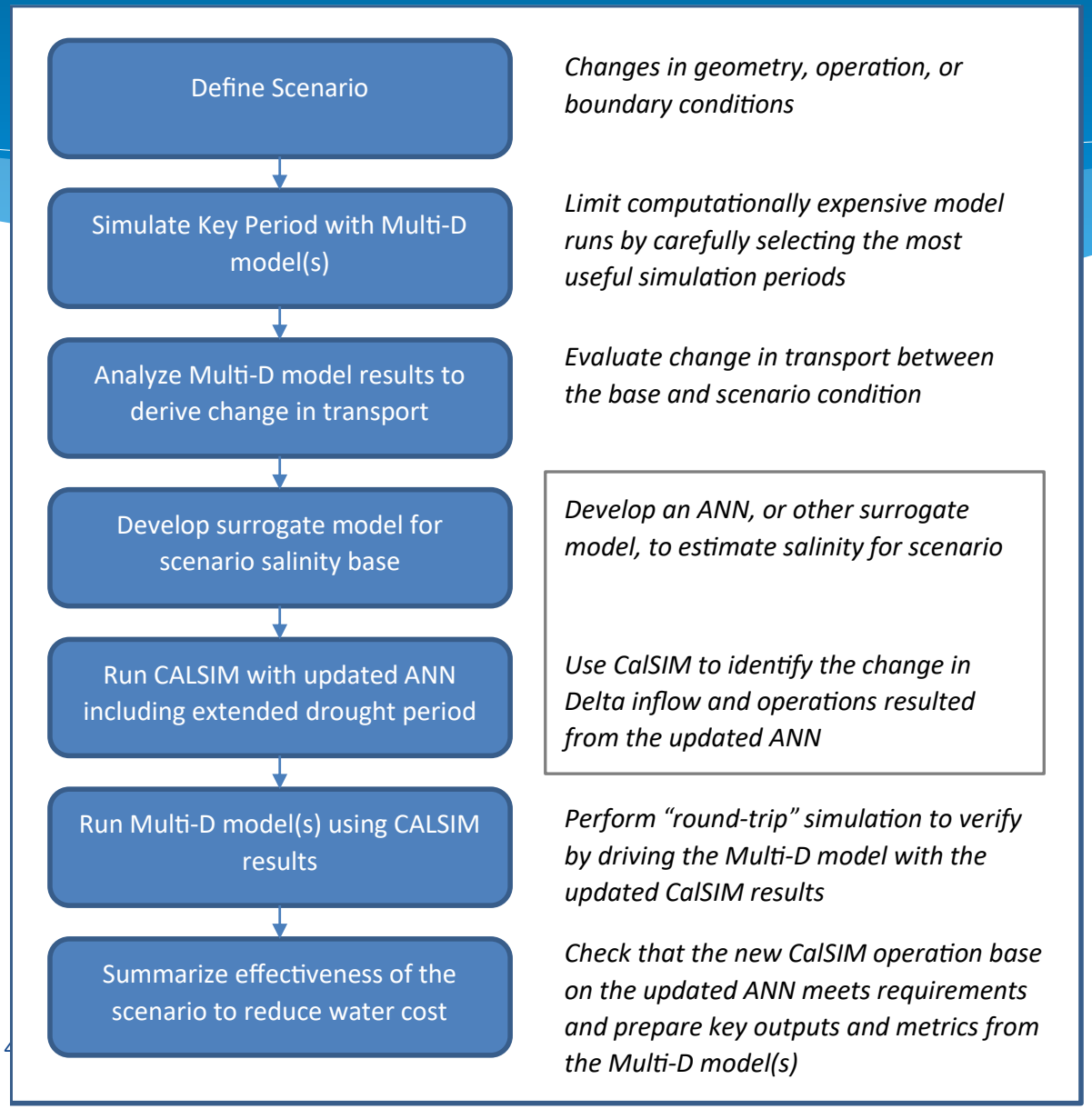


Validation and detail

DSP Project Objective

Develop and test 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, changes in landscape, and sea level rise

Modeling Workflow

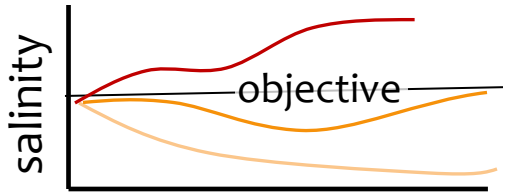


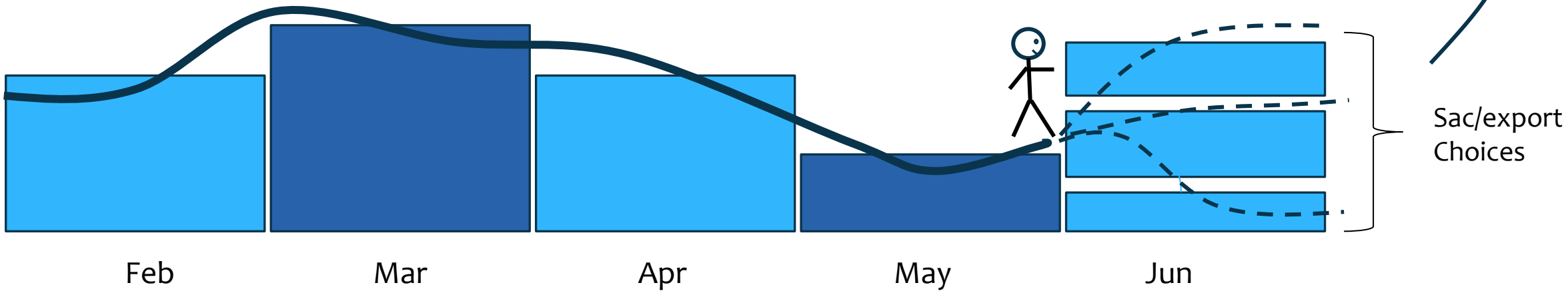
This Talk: Getting it Into CalSIM

* What do the CalSIM surrogates do?
* New library (calsurrogate) for using a wider variety
* How the features relate to issues we've seen
* A few new ways to construct tests and a few new thoughts about training

CalSIM Salinity Surrogate Tasks

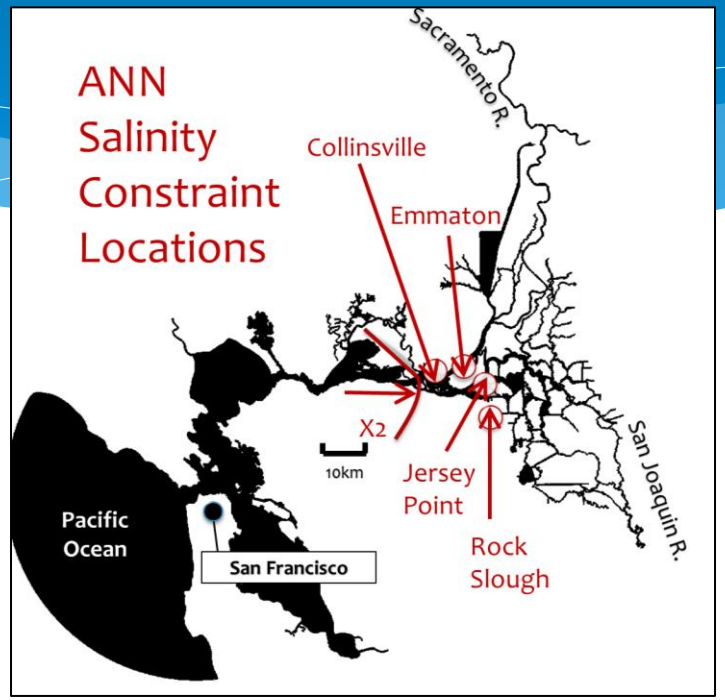
* What Sac and Exports combos EC compliant?
  * ANN/surrogate is further linearized for current month
  * Requires Values, Gradients/sensitivities
* Surrogates also:
  * Provide diagnostic EC estimates at other locations
  * Invert required Sacramento R. water for compliance given Exports

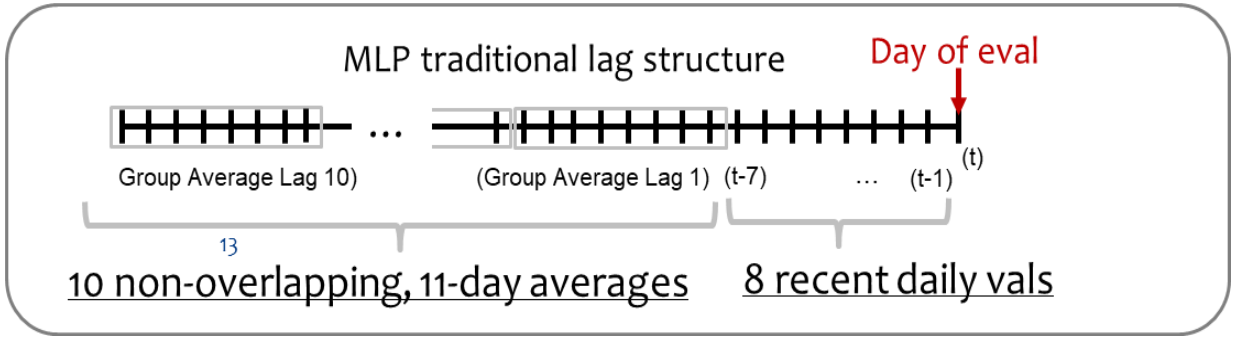




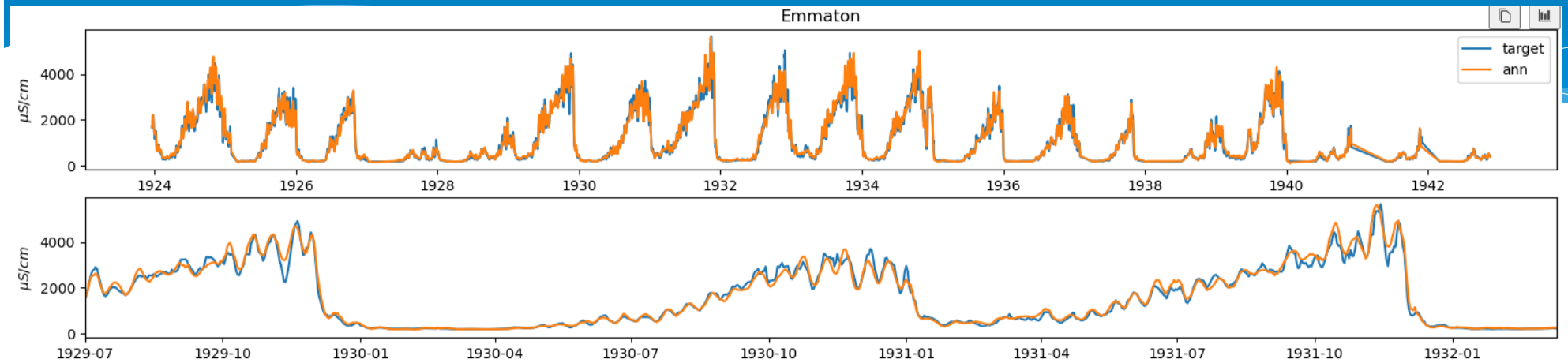
Standard CalSIM Salinity ANNs

* Emmaton, Jersey Point, Rock Slough, Collinsville
  * Inputs: Sac flow, Exports, Consumptive use, San Joaquin flow, tidal range, Cross Channel, Suisun Marsh Gate
  * Outputs: Univariate: One ANN Per location
* X2:
  * Inputs: Net Delta Outflow, Tidal range, Suisun gate
  * Output: Univariate X2
* Other "diagnostic" locations not part of constraints
* Multilayer Perceptron (MLP) configuration
* Trained on CalSIM (1-mon) run output
* Within CalSIM current month linearized
* Lag structure:



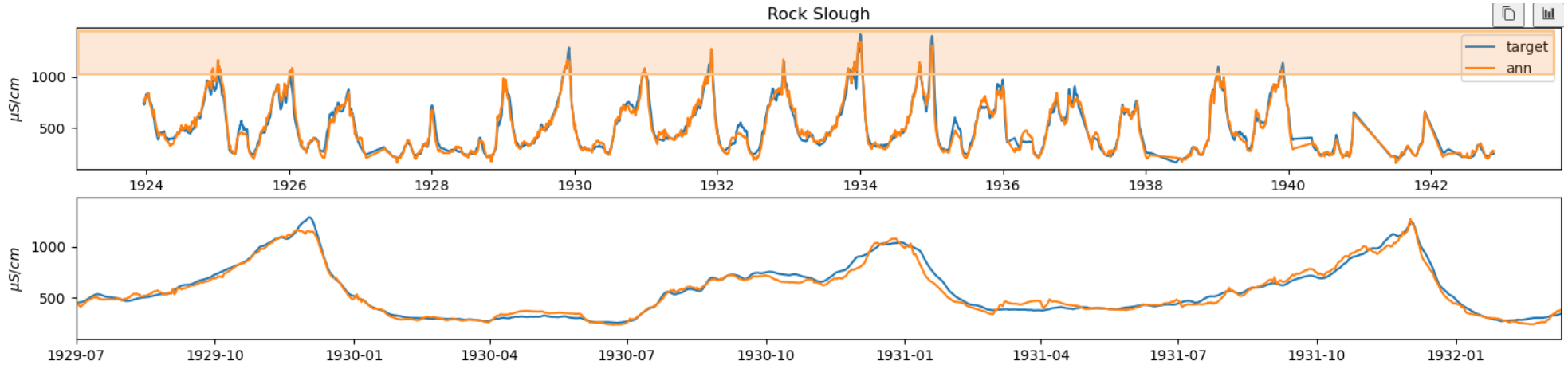


Representative Training-level Results



Test data

Close up



Test Data

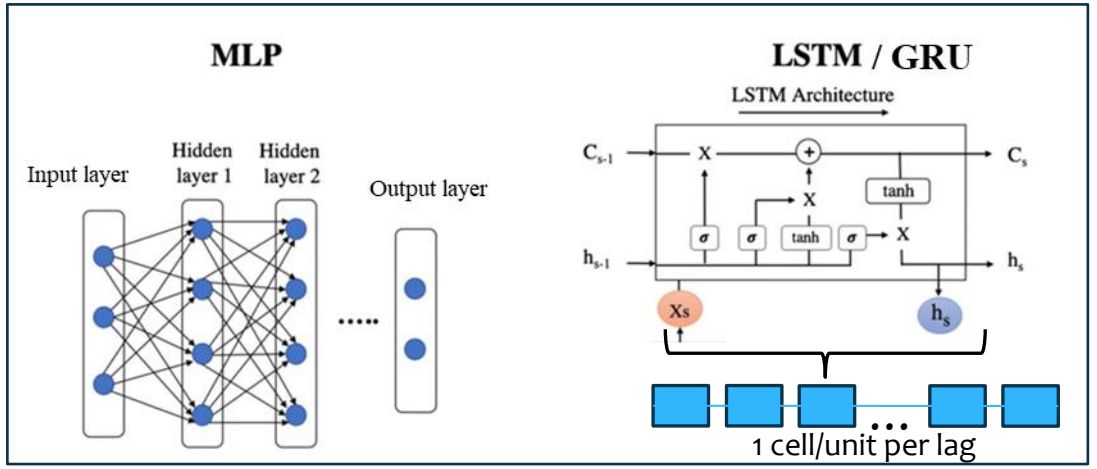
Close up

Traditional CalSIM MLP training: CalSIM decades from 1942-2015, testing 2023-2042

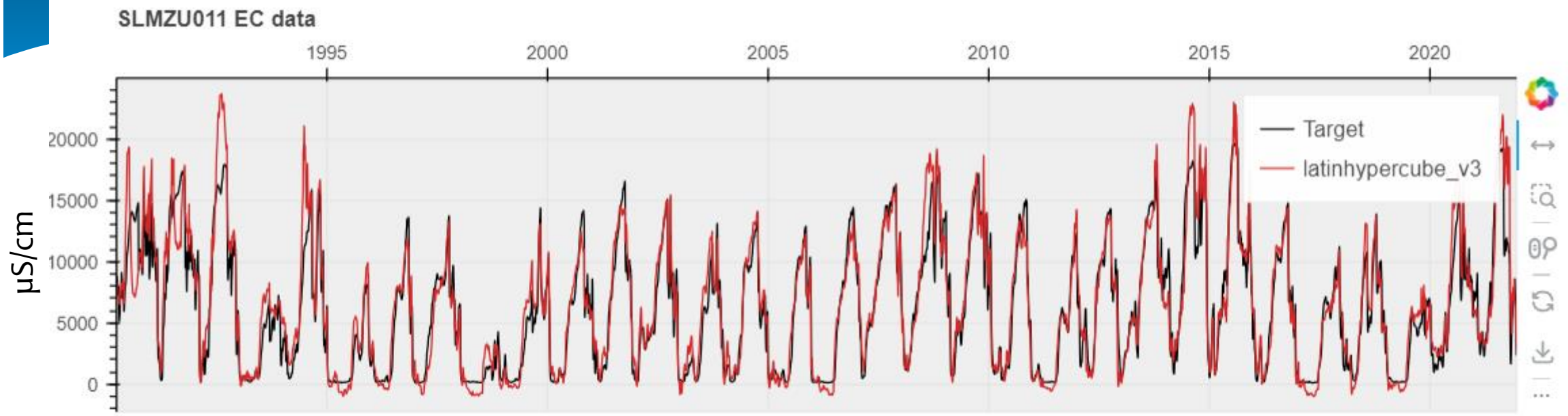
Surrogate Model Flexibility

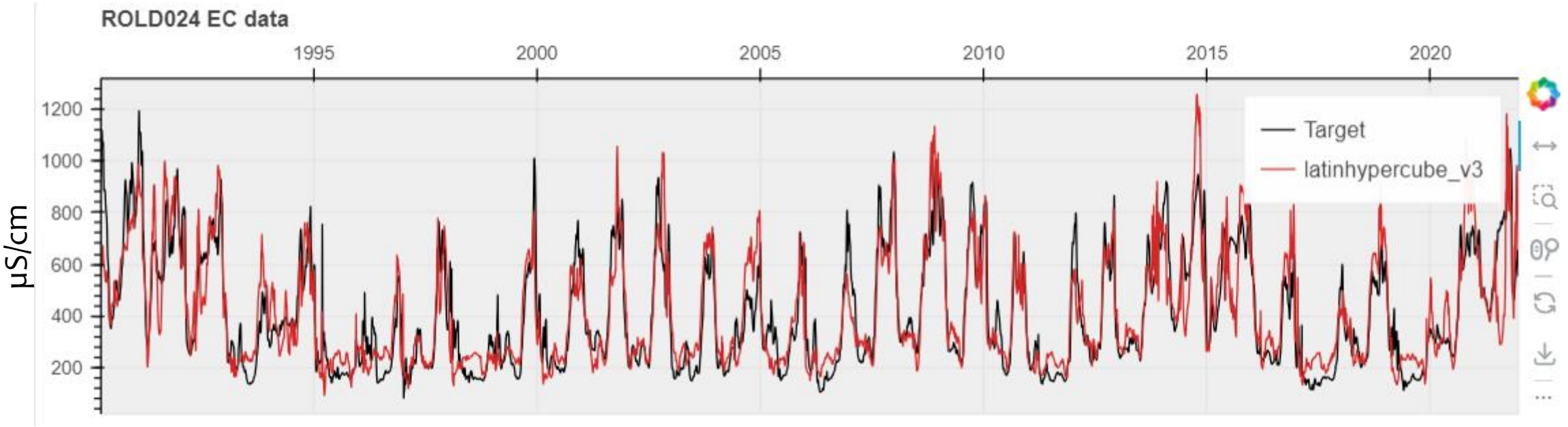
* Swap ANN software (e.g. TensorFlow vs Matlab)
* Swap architecture (e.g. MLP vs LSTM)
  * Time aggregations of input.
* Single vs multi-station output
* Swap in arbitrary exogenous time series
  * e.g. measure of tidal energy
* Simpler WRESL, accurate linearization
* Unit tests
* Applied test problems that elicit:
  * Bad gradients
  * Poor generalization to novel situations
* Easier for non-experts in CalSIM to get a start

Multilayer Perceptron (MLP) vs
Long Short Term Memory (LSTM) and
Gated Recurrent Unit (GRU)



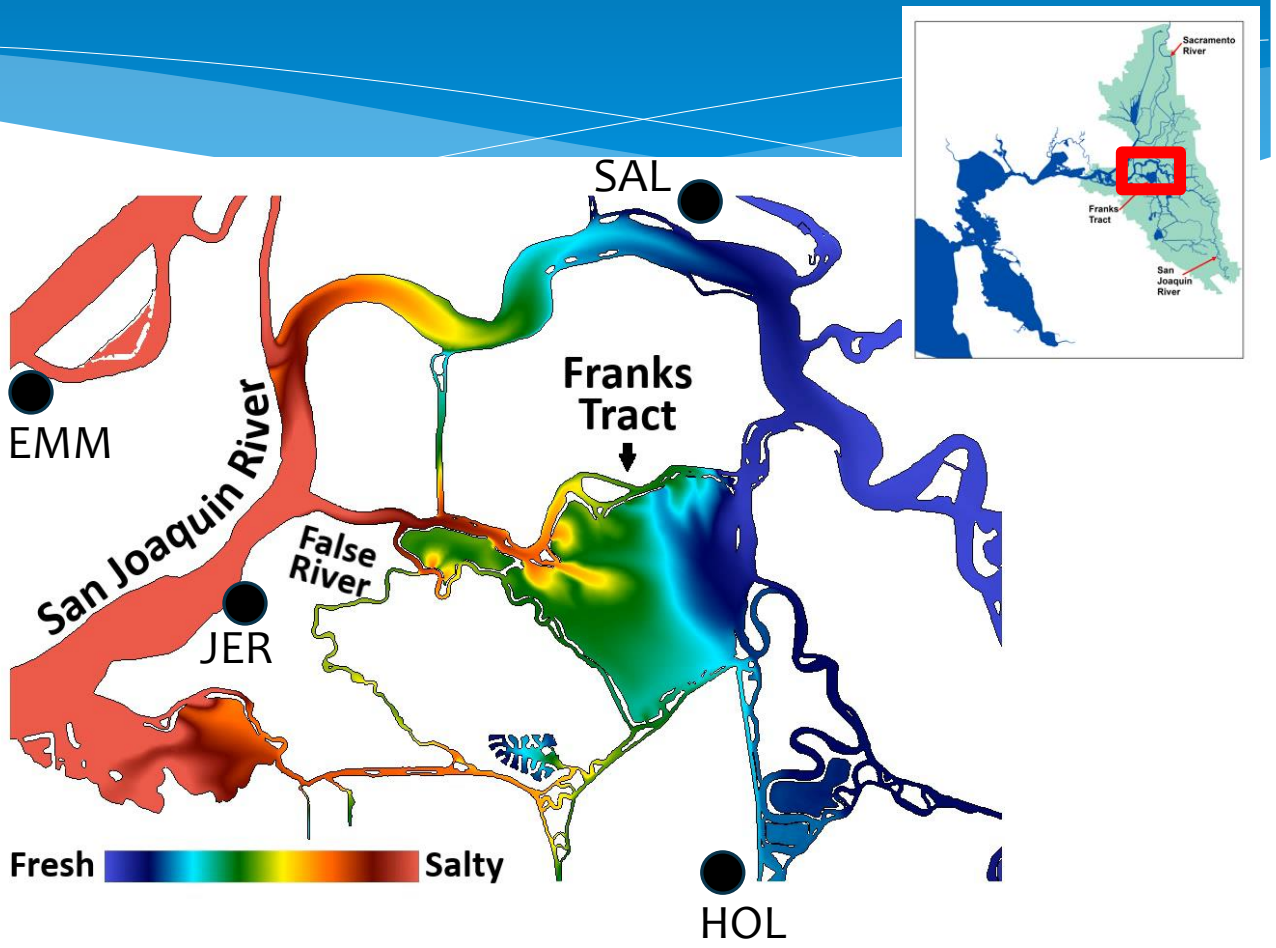
LSTM Architecture, Trained on 7 1-2 year cases based on 4 canonical periods + variations





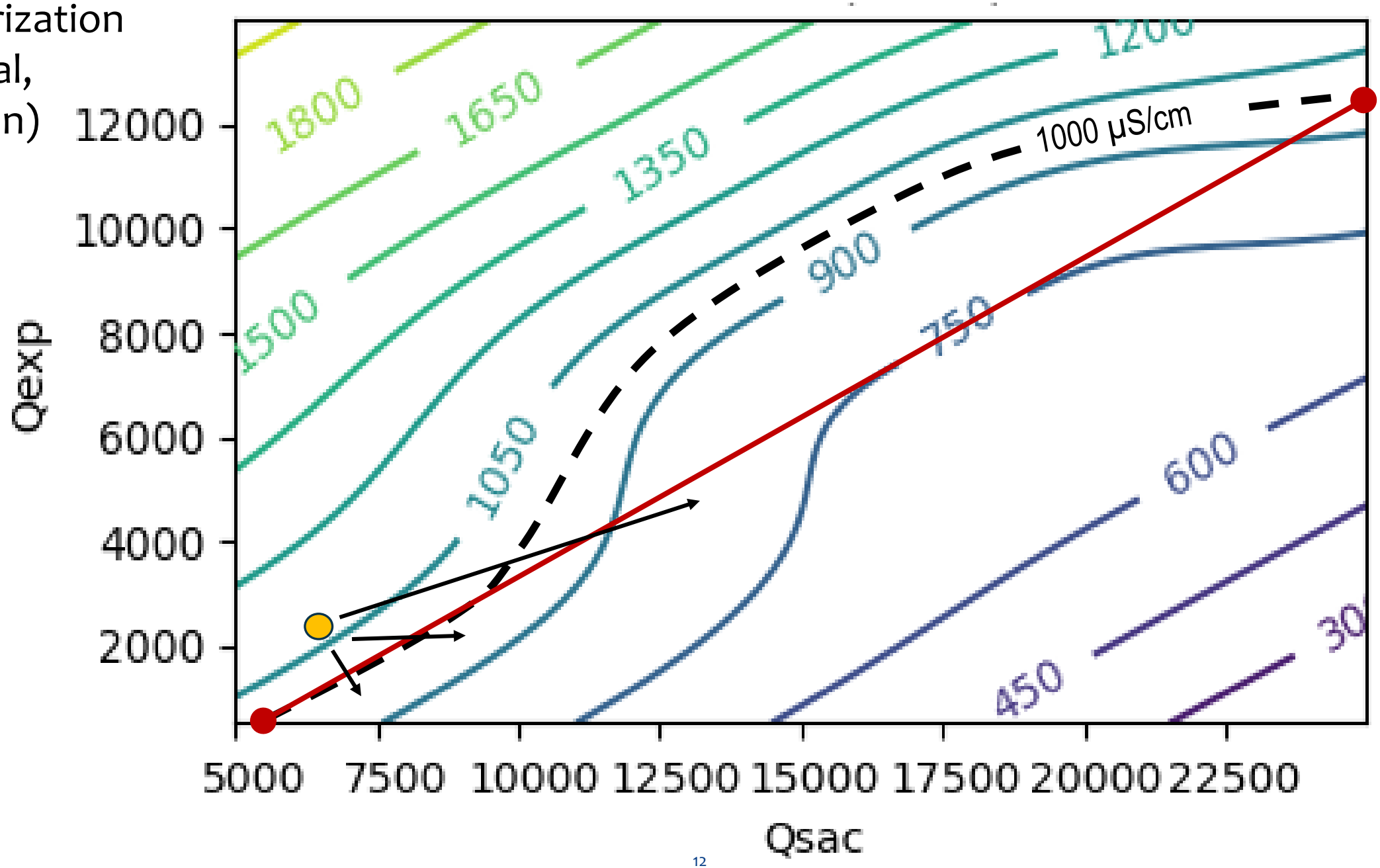
Why Multivariate?

- Elicits features that make transfer learning (e.g. after landscape alteration) easier
- Multiple outputs gives each of our 7 inputs something identifiable to do
* Marginally faster

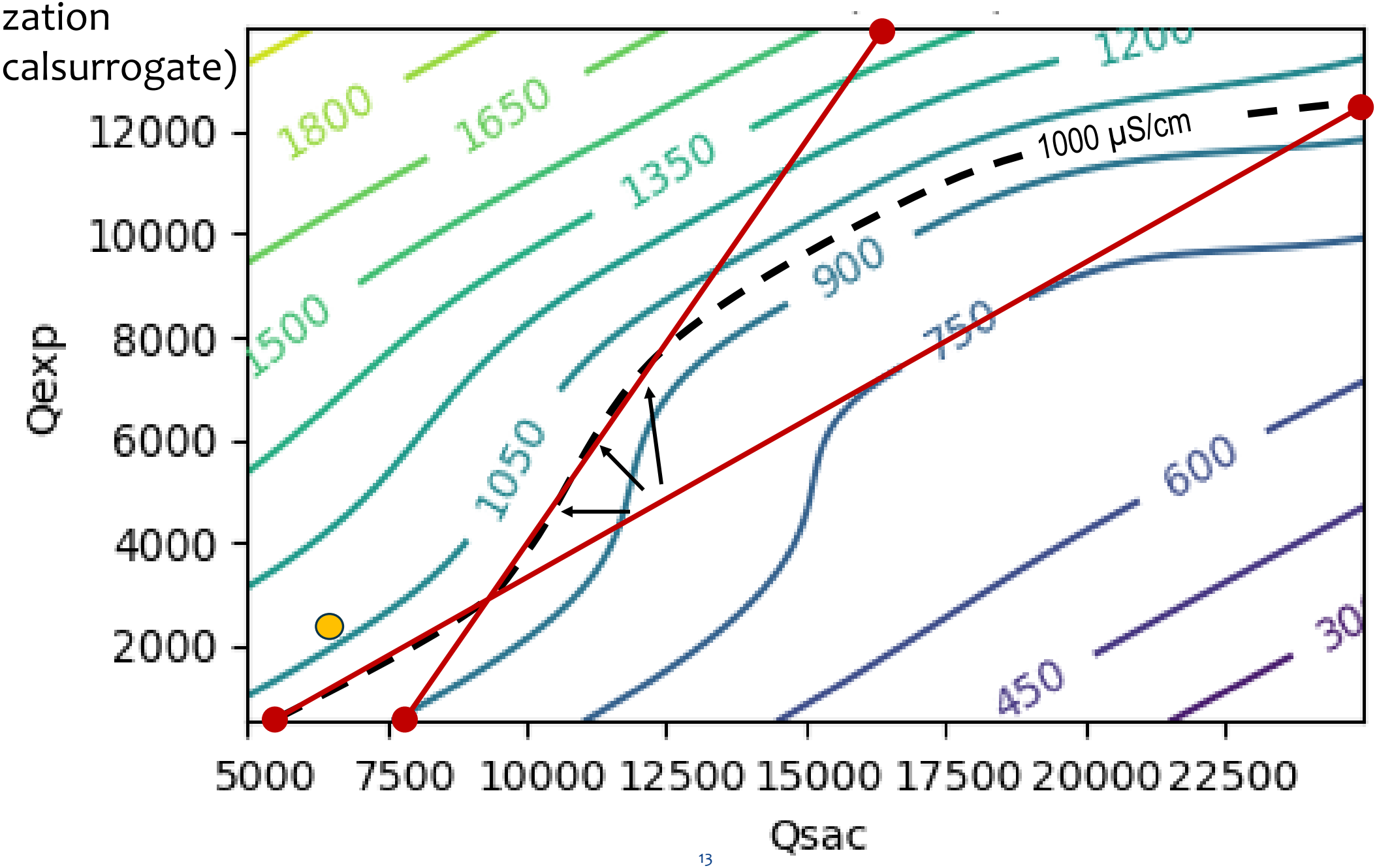


Animation created by DWR Delta Modeling Section, using Bay-Delta SCHISM Model results

Linearization (Global, linegen)

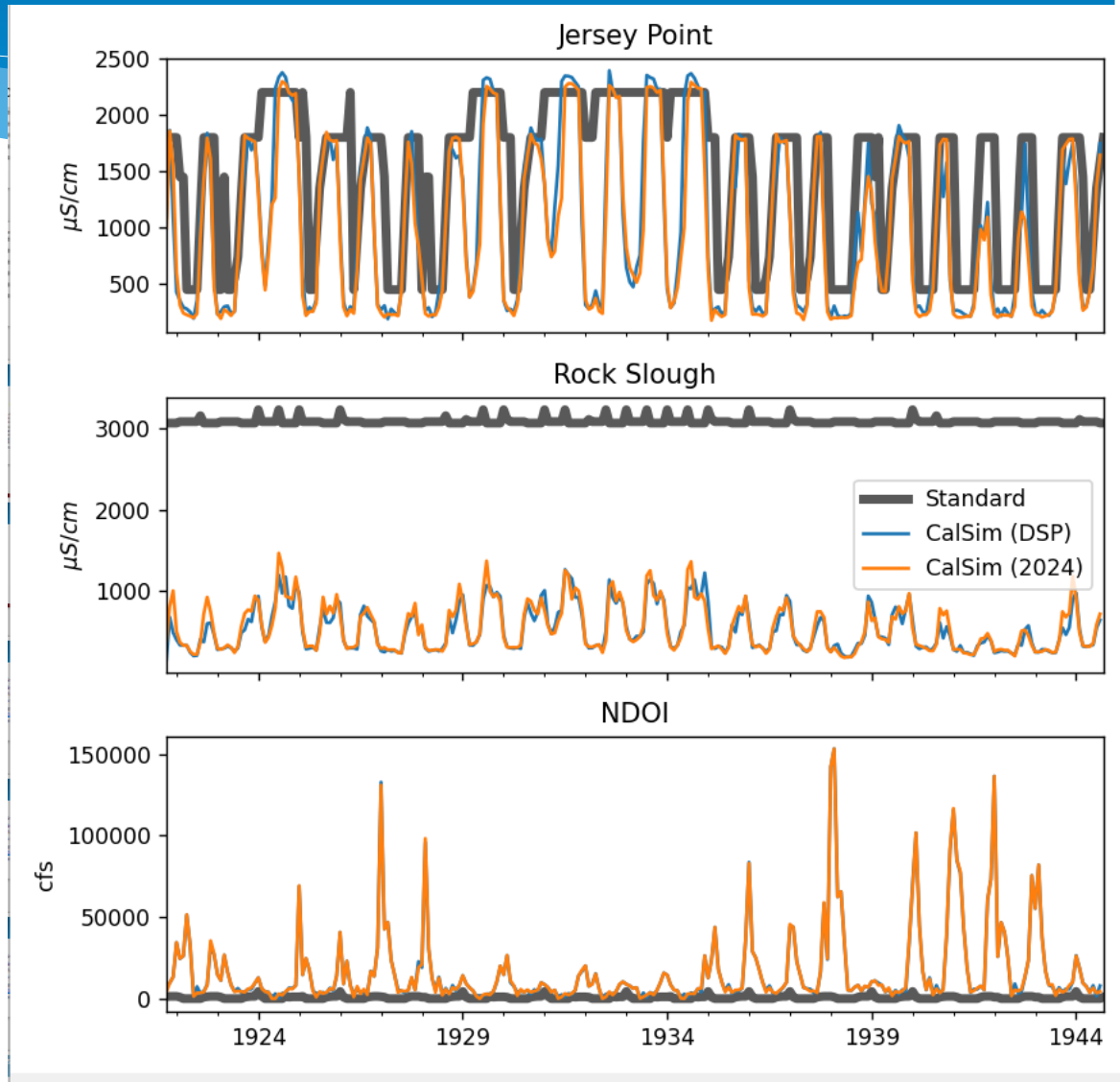


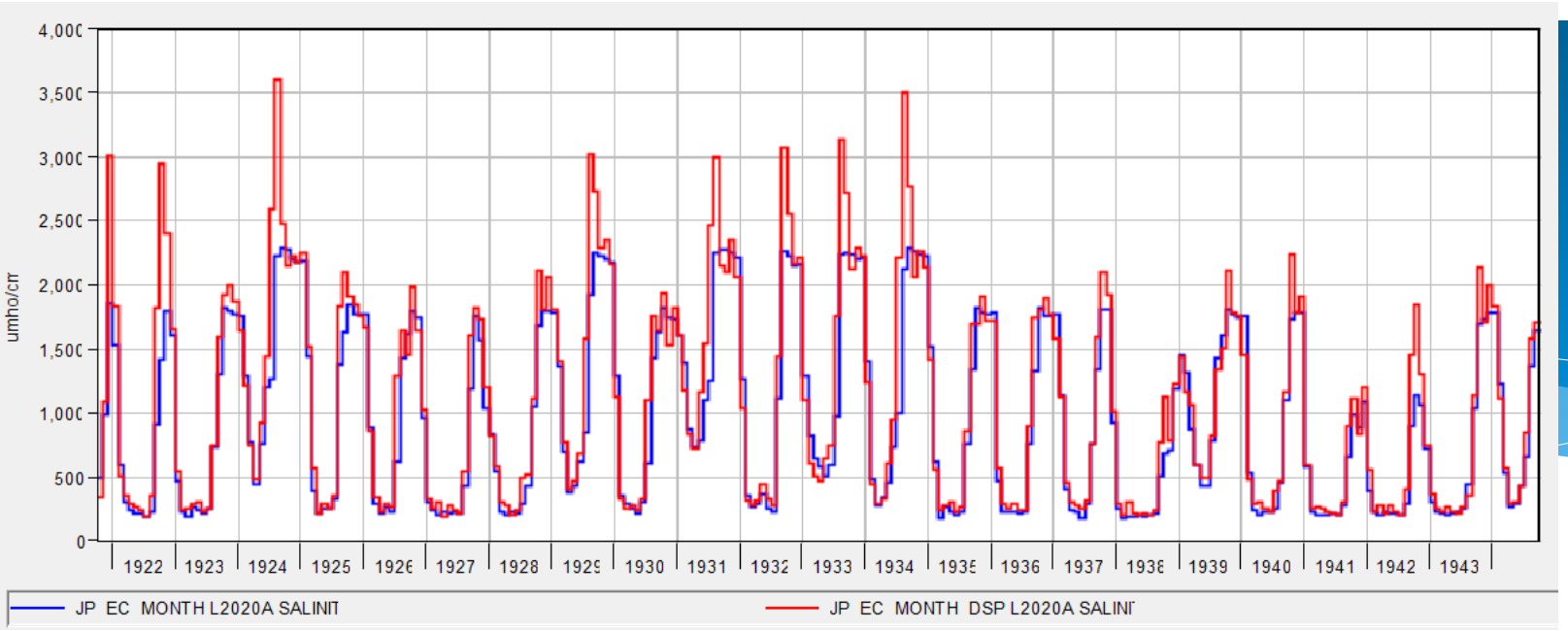
Linearization
(Local,calsurrogate)

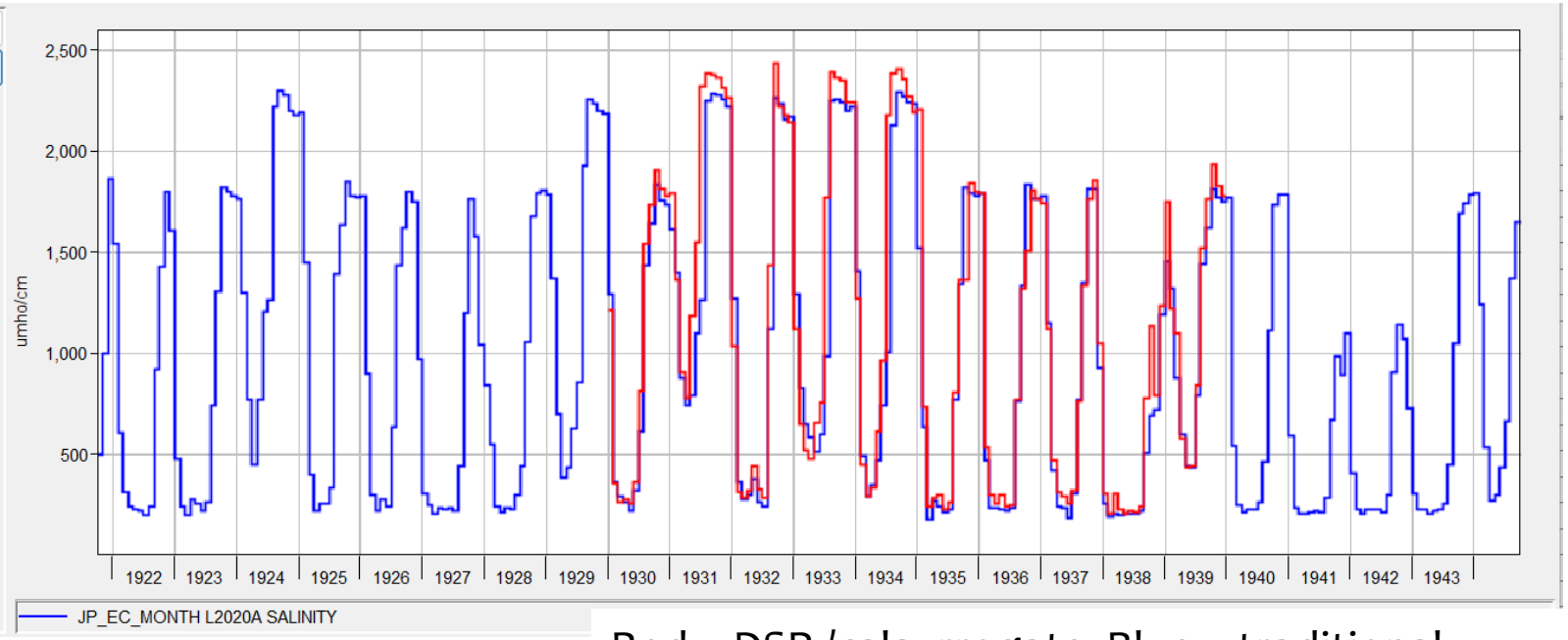


Testing The Framework

* Based on CalSIM
* Each test problem is controlled by one EC time varying constraint
  * Others made “easy”
* EC constraint stretched all year







Red = DSP /calsurrogate Blue = traditional

Uncertainty and Current State

Potential sources

* Fit of the ANN in the typical train-test set
  * Source data is a mellow compliant run
* Generalization to challenging new circumstances
* For DSP project: short histories.
* One-sided spline of time history
* Linearization of the function

Remarks

* Basic fit looks good. Generalization is tougher.
* Perturbations, training at compliance limit
* Short run is OK for training but need more testing.
* One more case to handle a leave-one-out?
* Perhaps this could be a

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

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

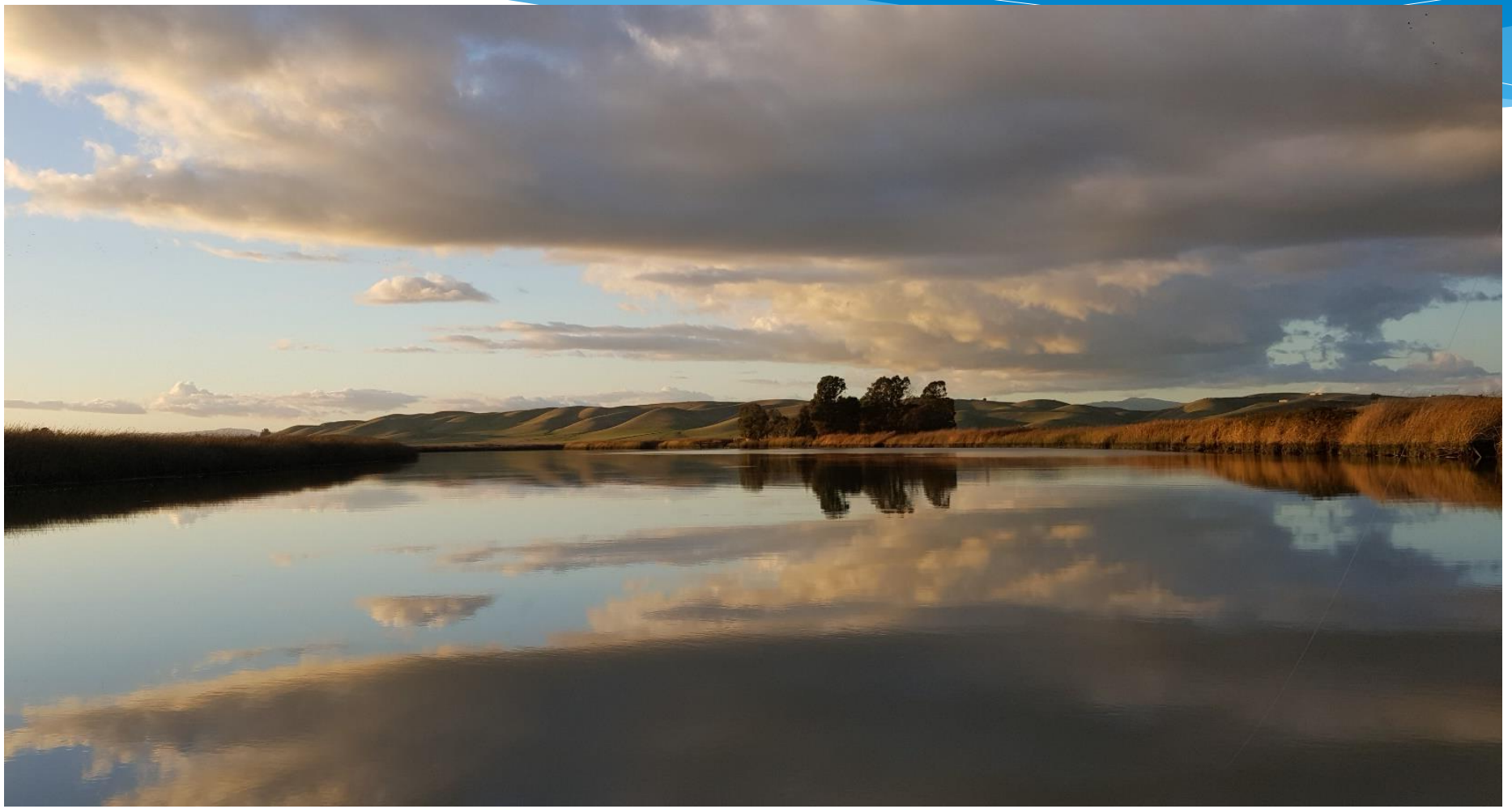
Eli Ateljevich, Ph.D., P.E.
California Department of Water Resources
1516 Ninth St, 2-207
Sacramento, CA 95814
(916) 902-6984
Eli.Ateljevich@water.ca.gov

Contact Information

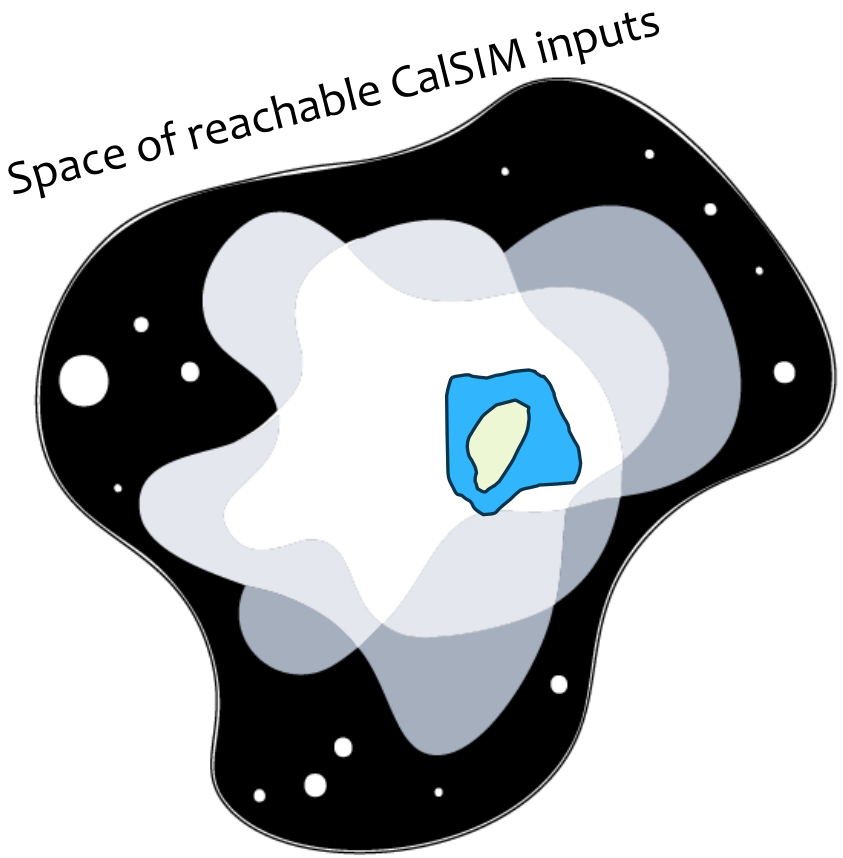
John F. DeGeorge, Ph.D., P.E.
Resource Management Associates, Inc.
4171 Suisun Valley Road, Suite J
Fairfield, CA 94534
(707) 864-2950
jfdegeorge@rmanet.com
www.rmanet.com

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

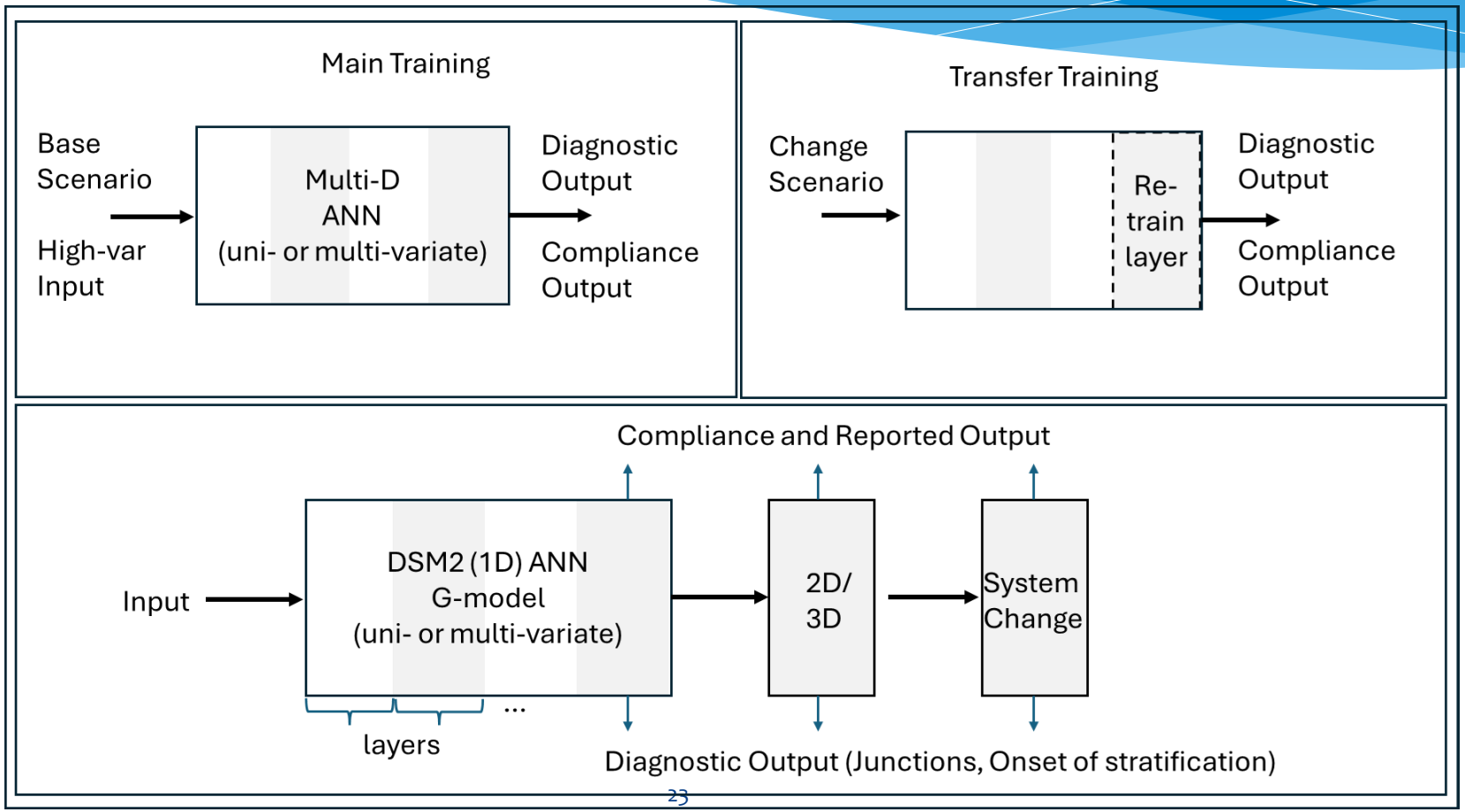
Questions?



General 126
dimensional space



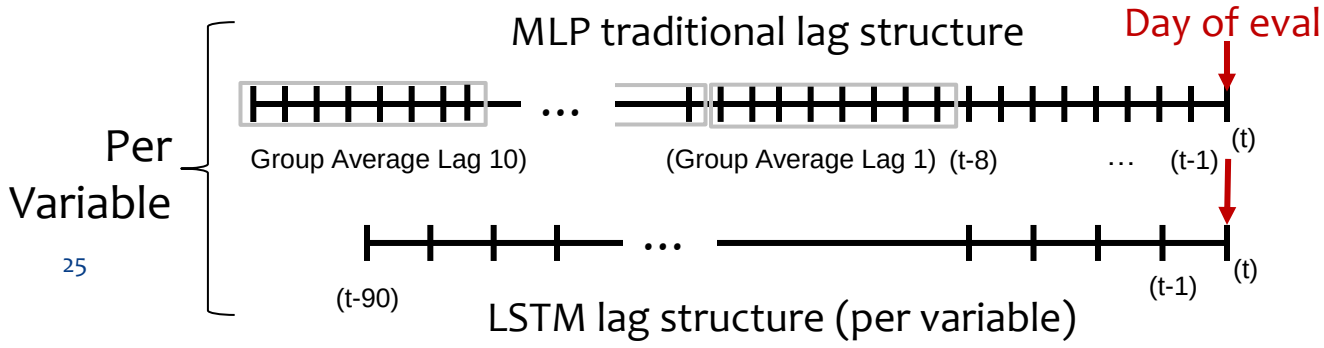
Surrogates for Alternate Cases: Transfer/Residual Modeling



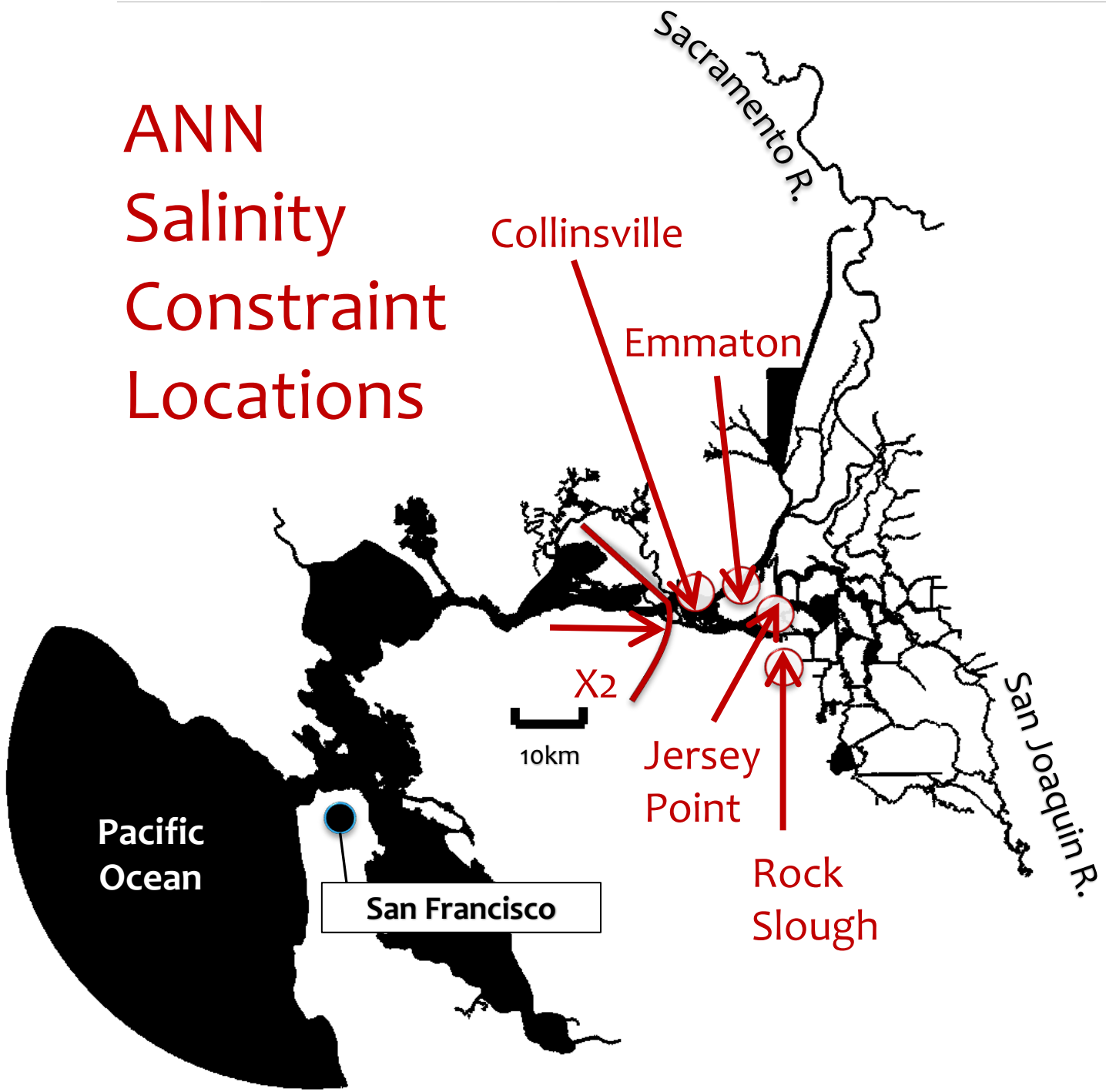
Progress To Date and Work To Do

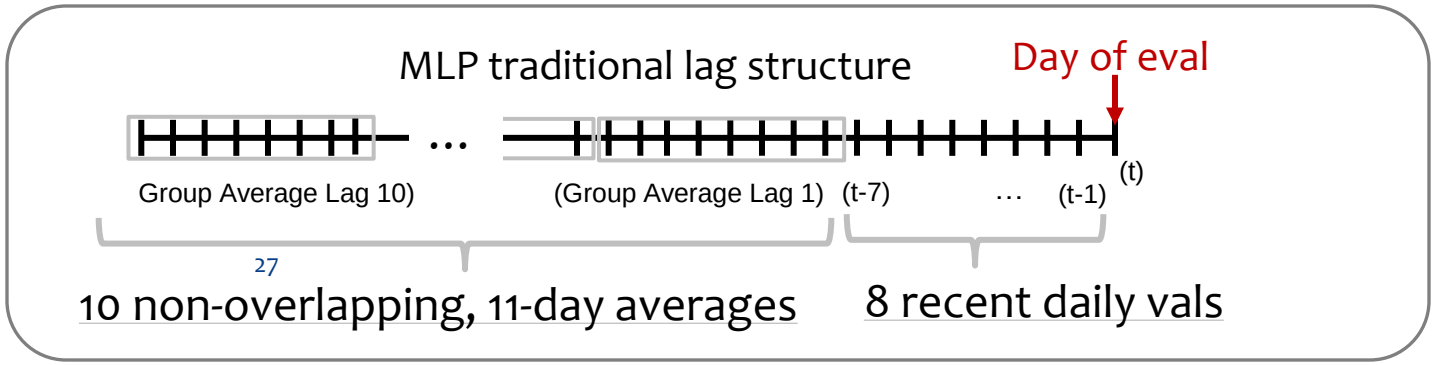
* Scenario Selection
  * Cache Suite, Suisun Suite, Cache and Suisun Combined, Franks Tract, Sea Level Rise
* Surrogate Training Methodology
  * Code development complete, ready for initial implementation
* Preparation of Training Boundary Conditions
  * Cluster analysis complete, data sets ready to use in Multi-D models
* Scenario simulations to provide surrogate training data
  * Underway
* Surrogate Training
  * Will begin as scenario simulations are completed
* CalSim runs to evaluate water cost change, and final round trip modeling
  * Will begin once alternate surrogates are prepared

Why might you want a mul



ANN Salinity Constraint Locations




MLP traditional lag structure
Day of eval
Group Average Lag 10)
(Group Average Lag 1)
(t-7)
…
(t-1)
(t)
27
10 non-overlapping, 11-day averages
8 recent daily vals