Machine Learning Based Salinity Emulator Dashboard

Machine Learning Brown Bag
April 7, 2023

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CALIFORNIA DEPARTMENT OF WATER RESOURCES

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Study Objectives

Develop machine learning based tools to estimate Delta salinity, with specific goals to:

- Explore novel deep-learning approaches beyond the conventional Multilayer Perceptron (MLP) model.
- Develop ML models in the multi-task learning (MTL) paradigm allow a single model to evaluate outputs at multiple study locations.
- **Develop a browser-based dashboard to facilitate user interaction (Focus of this presentation)**

Study Background

The Dashboard is based on the ML Architectures presented in two recent studies:

Multi-Location Emulation of a Process-Based Salinity Model Using Machine Learning

by Siyu Qi [1,*], Minxue He [2,*], Zhaojun Bai [3], Zhi Ding [1], Prabhjot Sandhu [2], Yu Zhou [2], Peyman Namadi [2], Bradley Tom [2], Raymond Hoang [2] and Jamie Anderson [2]

https://www.mdpi.com/2073-4441/14/13/2030

Application of Multiple ML Architectures:

- Multi-layer perceptron (MLP)
- Long-Short-Term Memory (LSTM)
- Gated Recurrent Unit (GRU)
- Residual Network (ResNet)

Target (label): daily DSM2 historical simulations ("noise free") of EC from 1990-2019

Novel Salinity Modeling Using Deep Learning for the Sacramento–San Joaquin Delta of California

by Siyu Qi [1,*], Minxue He [2,*], Zhaojun Bai [3], Zhi Ding [1], Prabhjot Sandhu [2], Francis Chung [2], Peyman Namadi [2], Yu Zhou [2], Raymond Hoang [2], Bradley Tom [2], Jamie Anderson [2] and Dong Min Roh [4]

https://www.mdpi.com/2073-4441/14/22/3628

Applied novel architectures:

- residual long short-term memory (Res-LSTM) network
- residual gated recurrent unit (Res-GRU) model

Target (label): observed data from 2001–2019

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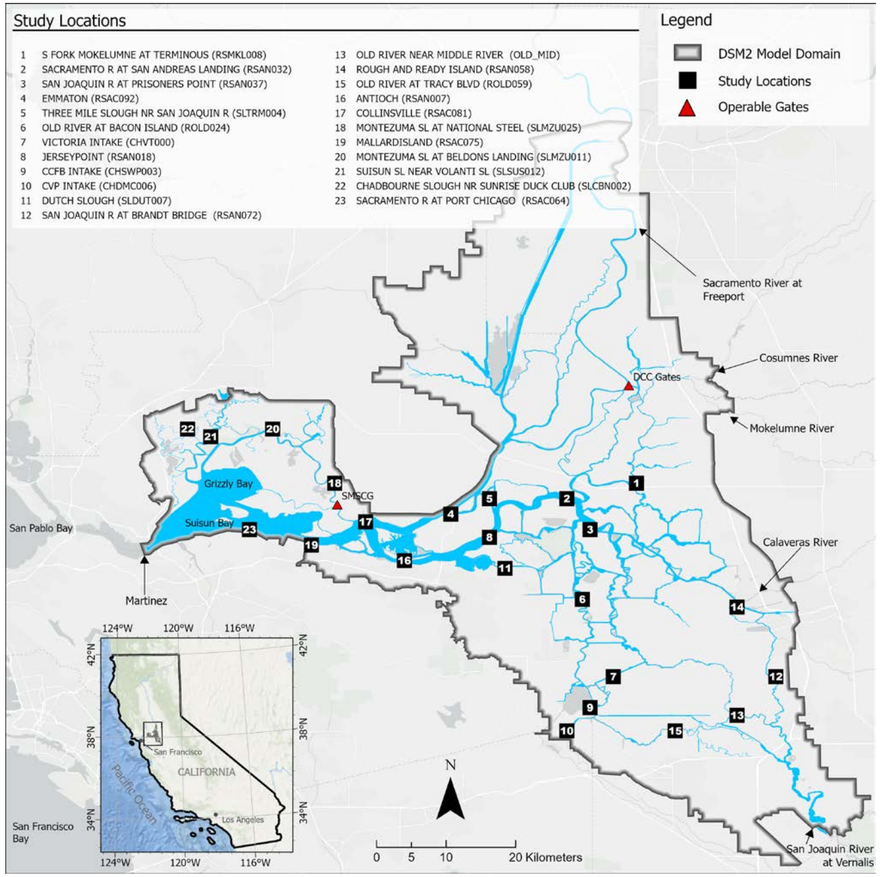
Study Domain

8 Input variables

Index	Input Feature Name	Definition
1	Northern Flow	Sum of Sacramento, Yolo Bypass, Mokelumne River, Cosumnes River, and Calaveras River flows.
2	San Joaquin River Flow	San Joaquin River at Vernalis Flow.
3	Pumping	Sum of pumping from Banks Pumping Plant, Jones Pumping Plant, and Contra Costa Water District at Rock Slough, Old River, and Victoria Canal.
4	Delta Cross-Channel Gate Operation	Delta Cross-Channel Gate Openings.
5	Consumptive Use	Net Delta Consumptive use estimated by Delta Channel Depletion (DCD) and Suisun Marsh Channel Depletion (SMCD) models.
6	Martinez Tidal Energy	Tidal energy at Martinez, calculated as the daily maximum–the daily minimum astronomical tide at Martinez.
7	San Joaquin River EC	Electrical conductivity measured at San Joaquin River at Vernalis.
8	Sacramento River EC	Electrical conductivity measured at Sacramento River at Greens Landing.

23 Electrical Conductivity (EC) Monitoring Stations



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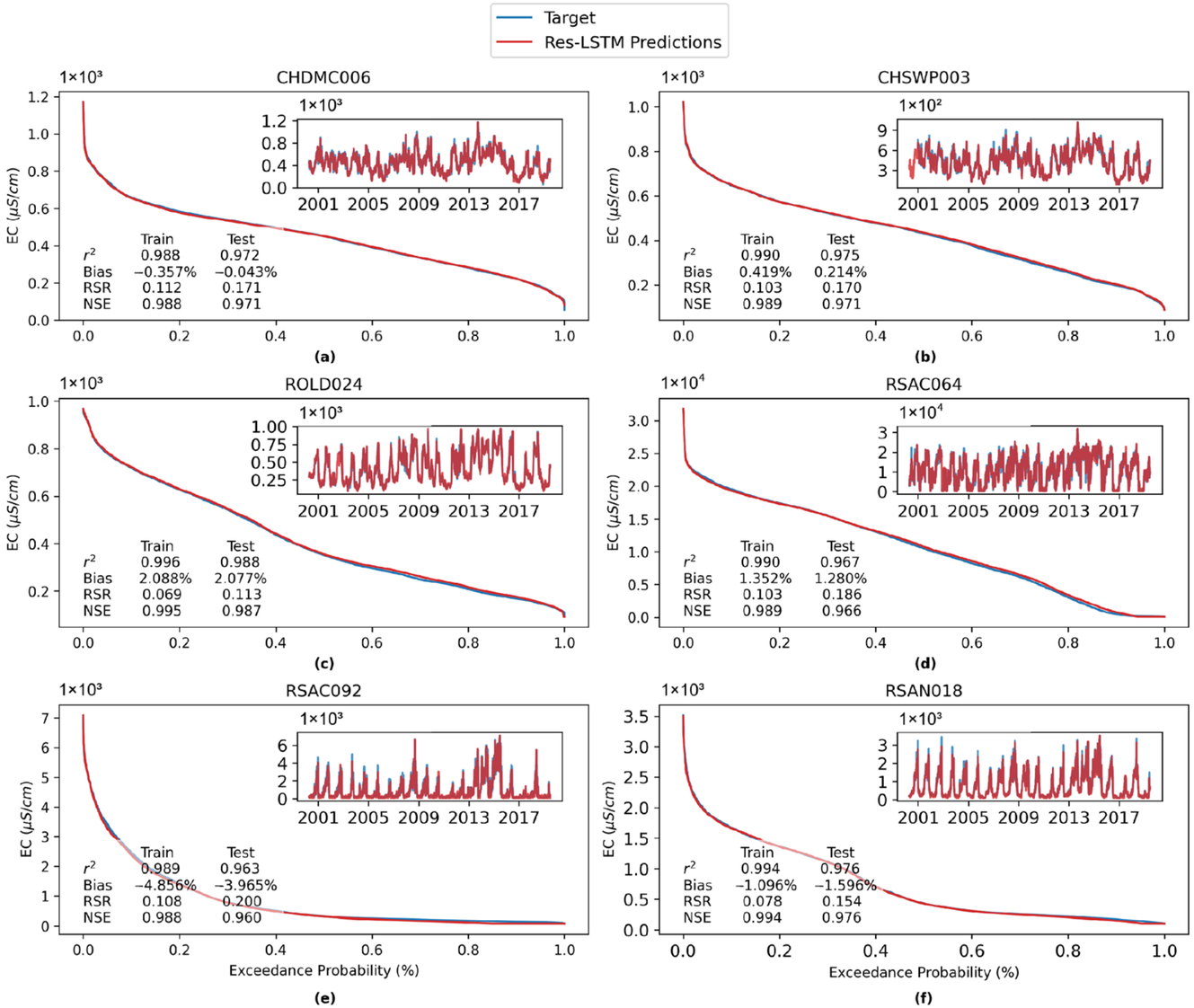
Results



Exceedance probability plot and time series plot of Res-LSTM simulated versus observed salinity at daily time step.

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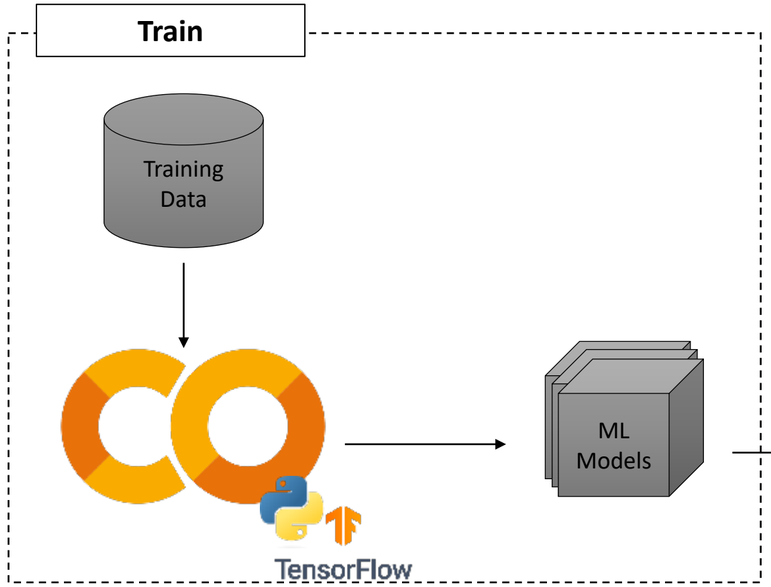
Dashboard Introduction

- A complementary browser-based Delta Salinity Dashboard was developed to serve as the **front-end user interface for the DSM2 salinity emulation machine learning models described in the previous slides.**

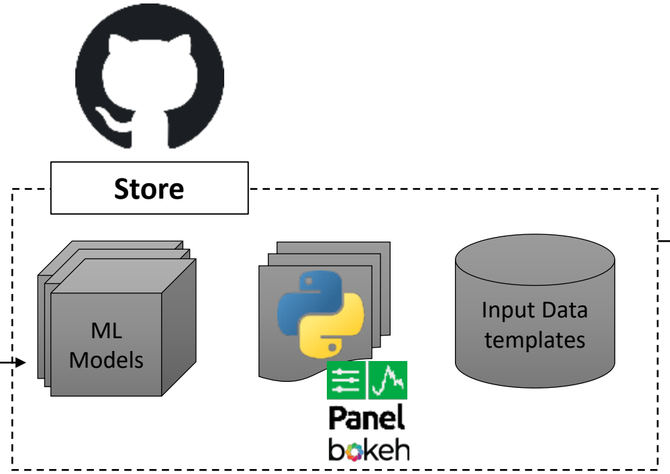
- Users can **interactively explore hypothetical scenarios** (e.g., by varying Delta boundary conditions including inflows, export levels, boundary salinity, etc.) and view the corresponding salinity outputs at key compliance locations during user-defined simulation periods.

Dashboard Architecture

Models are trained on **Google Colab** using the scripts reviewed today (they can also be trained locally).



Models, template input data, evaluation dashboard scripts are stored in a **GitHub** repository.



Pre-trained emulator models are hosted on **Microsoft Azure**, and *evaluation* of the models are computed on their servers.

Servers can be scaled up or out to accommodate higher machine workloads (for more complex models) or larger user volumes.

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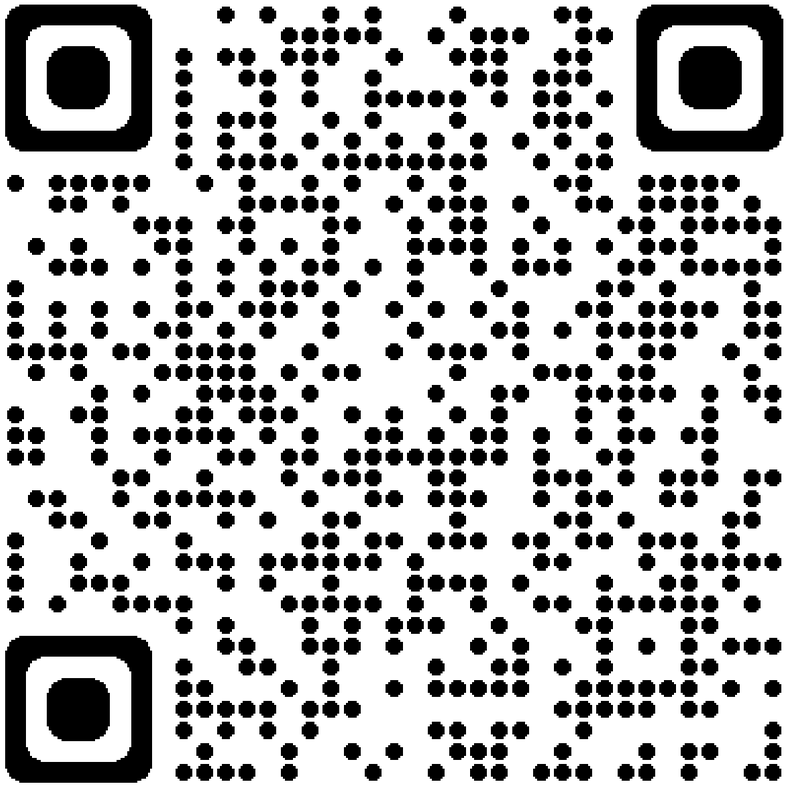
Dashboard Access



dwrbdodash.azurewebsites.net

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DSM2 Emulator Dashboard

A browser-based Delta Salinity Dashboard which serves as the front-end user interface for the DSM2 salinity emulation machine learning models co-developed by the California Department of Water Resources and University of California, Davis.

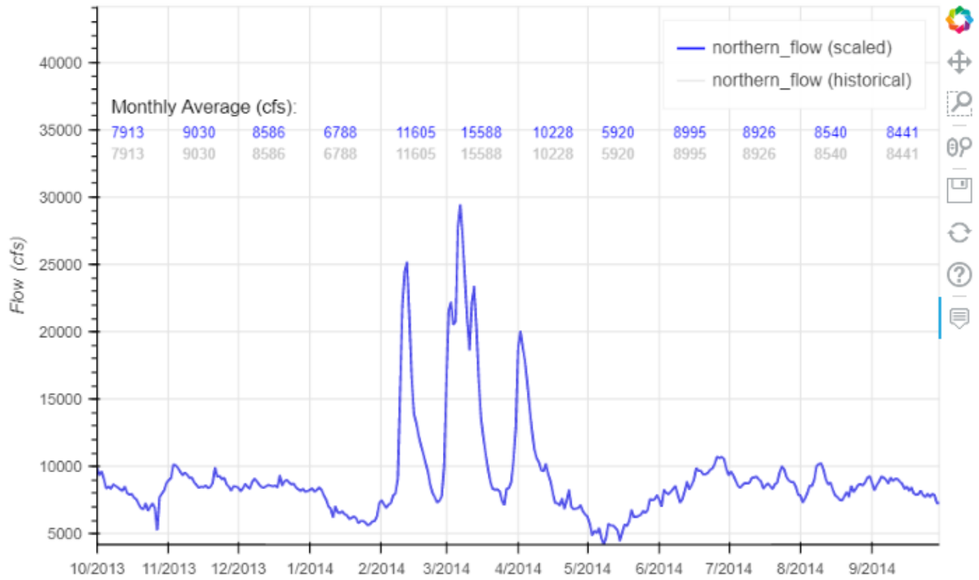
Simulation Period (WY)

1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 **2014** 2015 2016 2017 2018 2019 2020 2021

ANN Inputs - Input Scaler

Northern Flow | Pumping | SJR flow | SJR Vernalis EC | Sac Greens EC

Oct: 1.00 Nov: 1.00 Dec: 1.00 Jan: 1.00 Feb: 1.00 Mar: 1.00 Apr: 1.00 May: 1.00 Jun: 1.00 Jul: 1.00 Aug: 1.00 Sep: 1.00

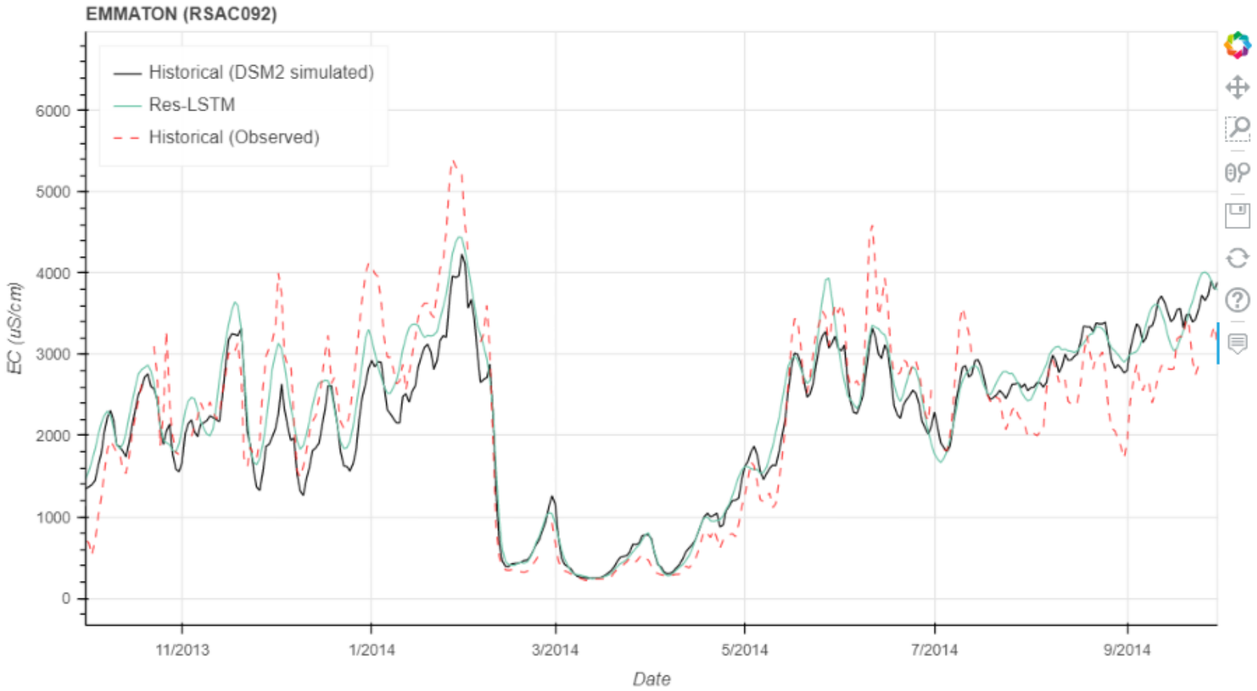


ANN Outputs

Plots

Output Location

EMMATON



☑ Res-LSTM ☐ Res-GRU ☐ LSTM ☐ GRU ☐ ResNet

☑ Overlay Observed Data

Download ANN Input Data | Download ANN Output Data | Refresh Plot

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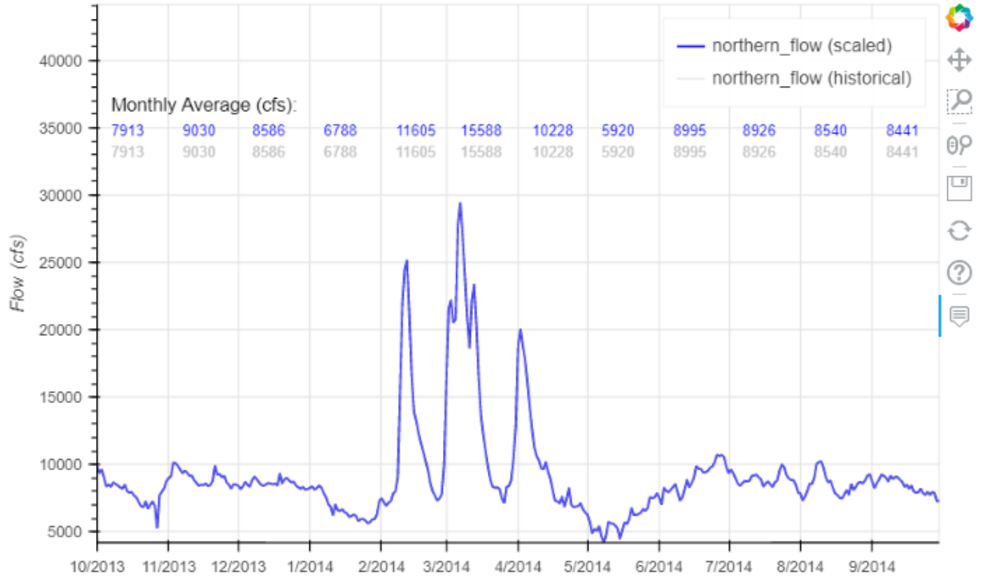
Input Modification Controls



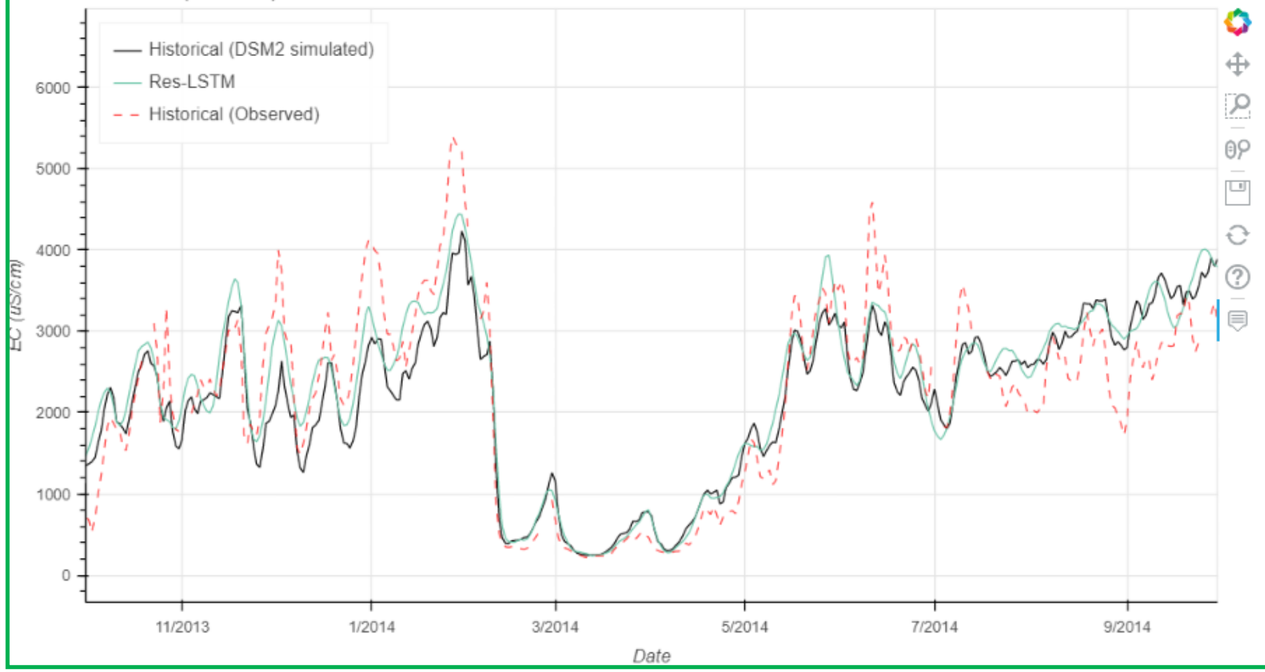
ANN Outputs

Plots

Output Location

EMMATON

Output Location Selector



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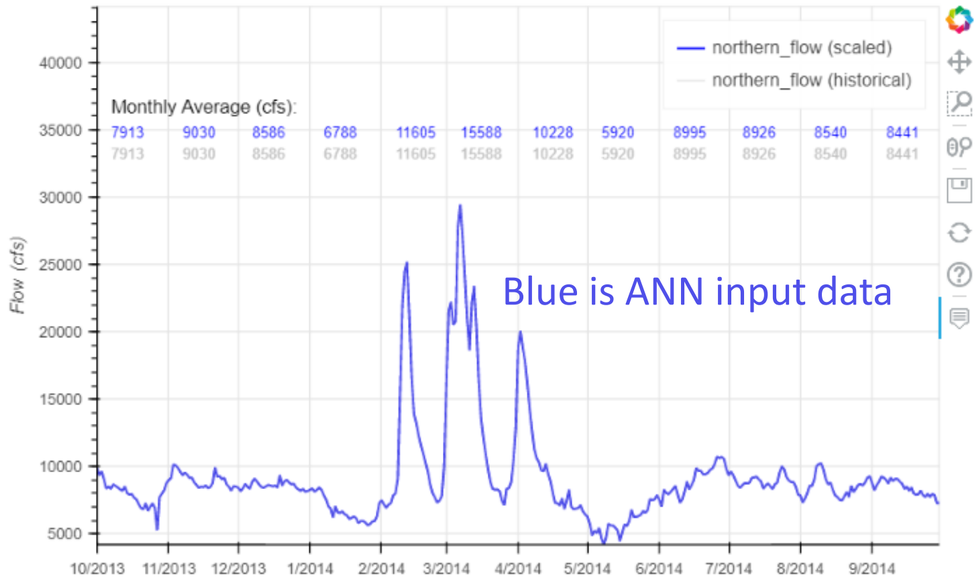
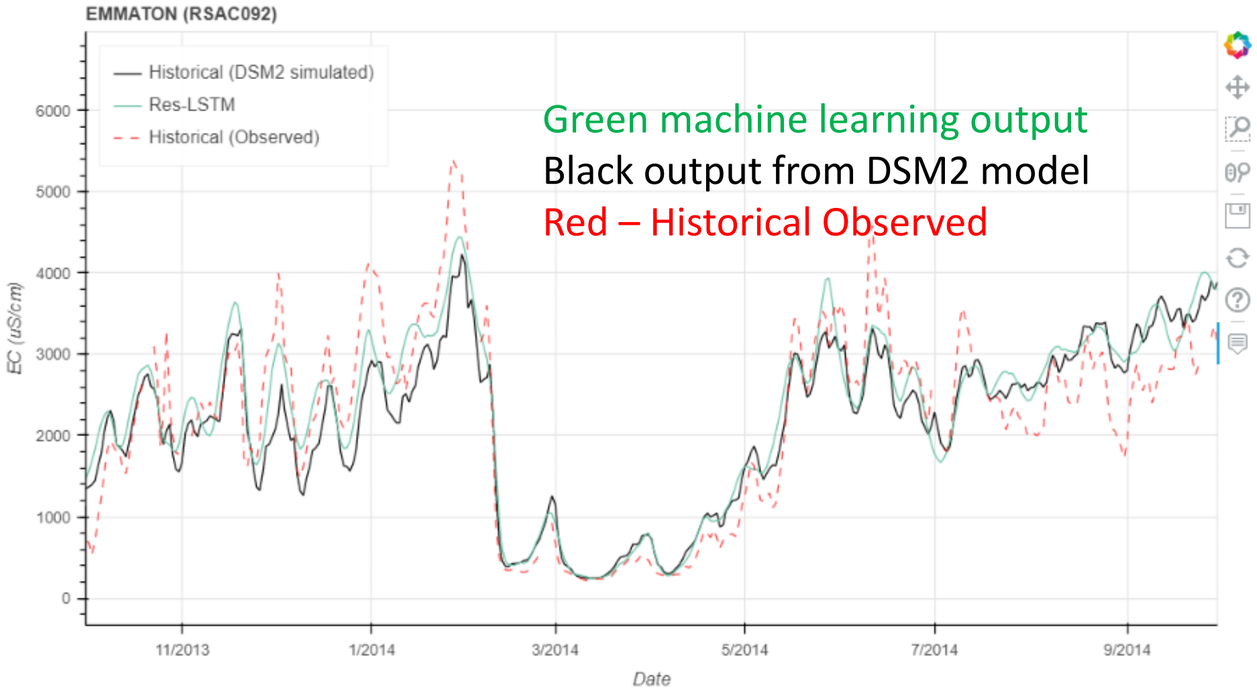


ANN Outputs

Plots

Output Location: EMMATON



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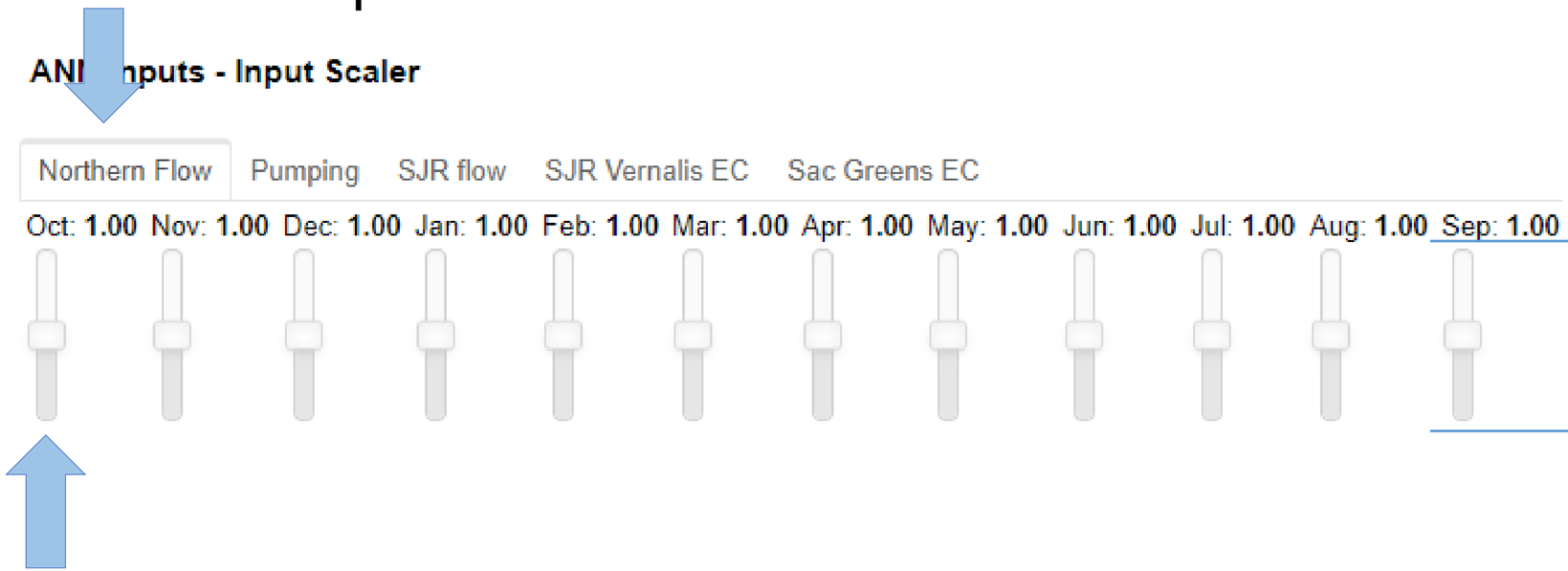
1 Select Simulation Year

2 Click tab for parameter to be scaled



Can **increase** values by up to 20% (scale factor 1.2)

Can **decrease** values by up to 20% (scale factor 0.8)

3 Adjust monthly scaling sliders

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QUESTIONS