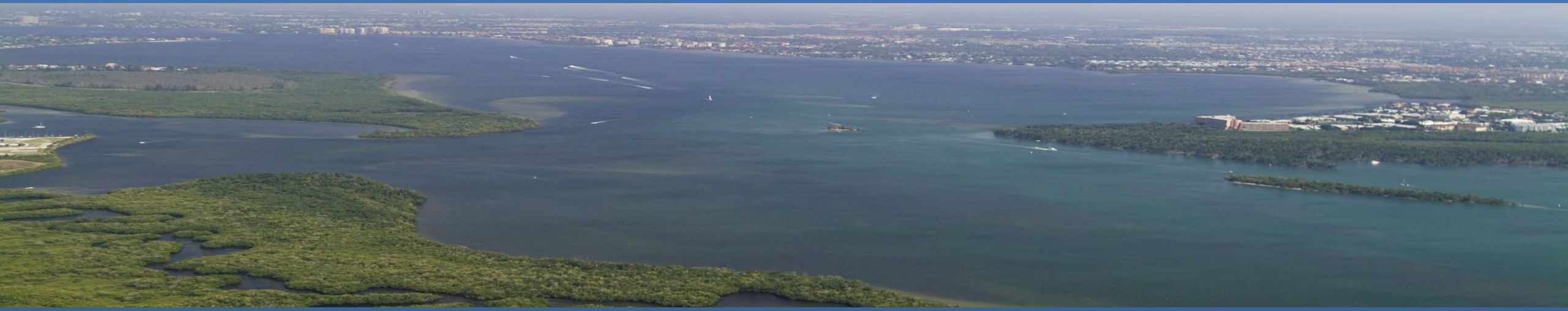
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Caloosahatchee Estuary in Fort Myers



Near-Real Time Runoff Estimation for Operations and Emergency Modeling

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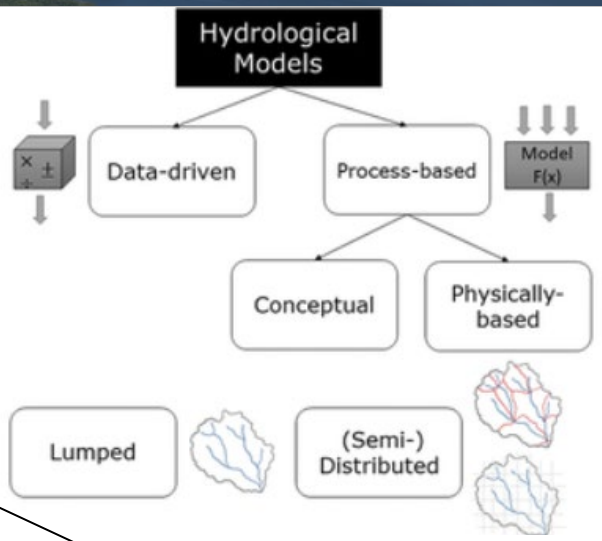
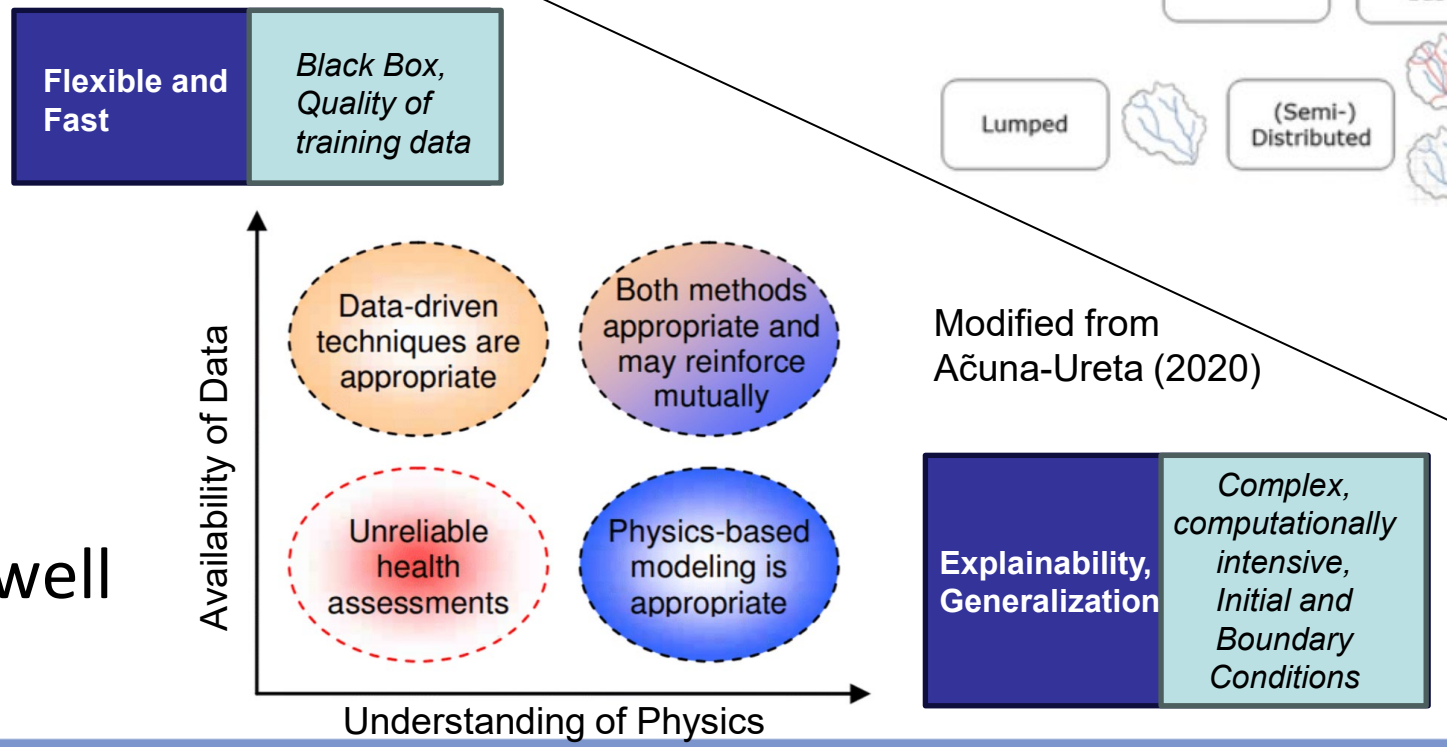
Introduction

- Approaches for hydrologic modeling
  - Physics-based
  - Conceptual
  - Data-driven
  - Hybrid
- South Florida is a data rich environment
- System operation decisions integrate recent data and as well as forecasts

Harvey et al. (2024)

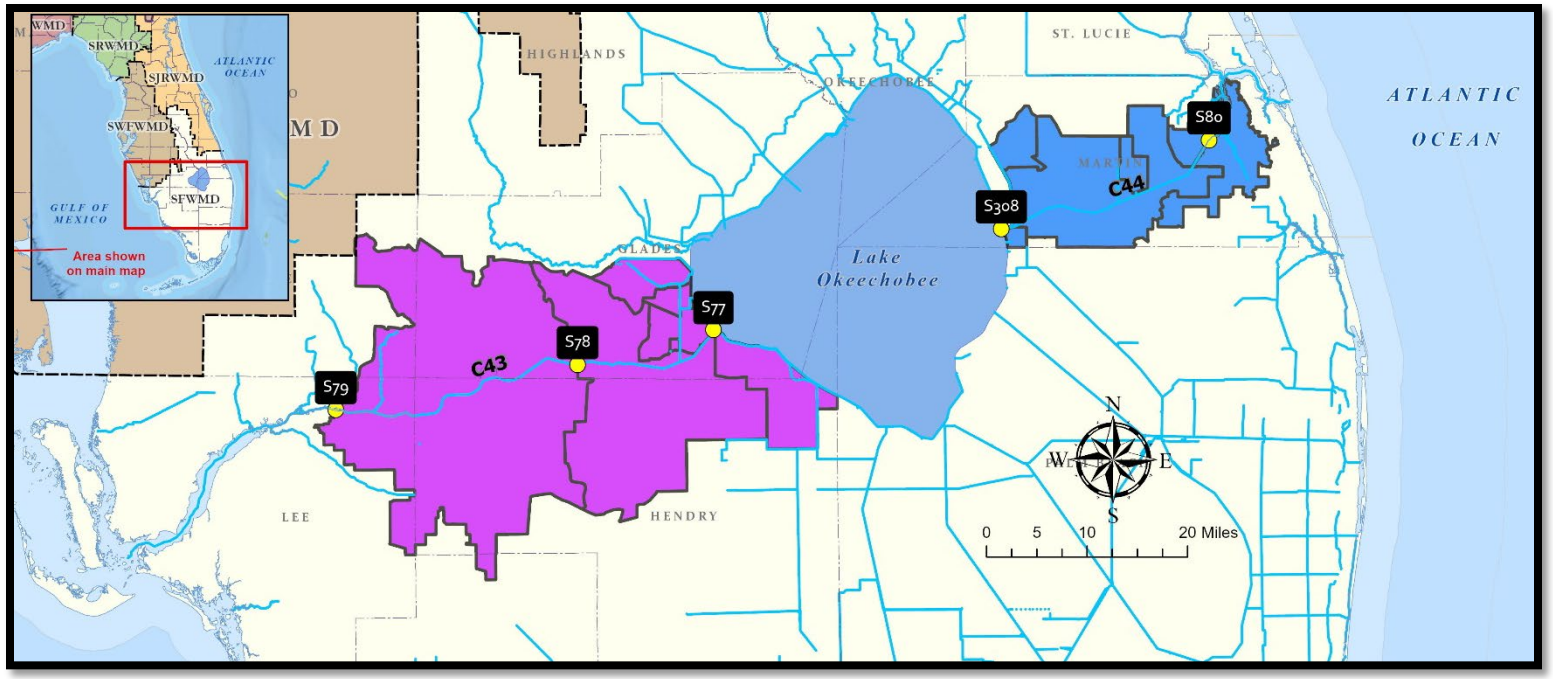




Modified from Ačuna-Ureta (2020)

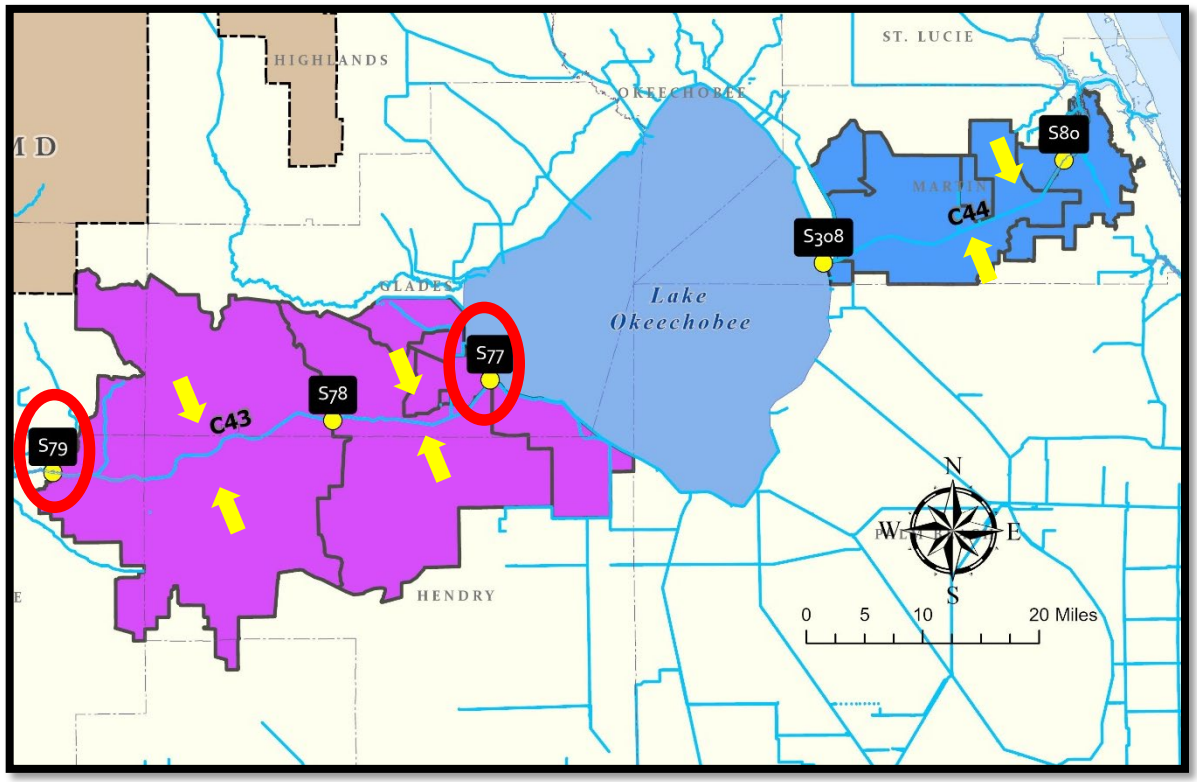
Objective

To develop deep learning-based models to estimate local runoff in the Caloosahatchee (C43) and St. Lucie (C44) basins to support water release decisions with projected rainfall and near-term historical runoff as the only predictive variables.



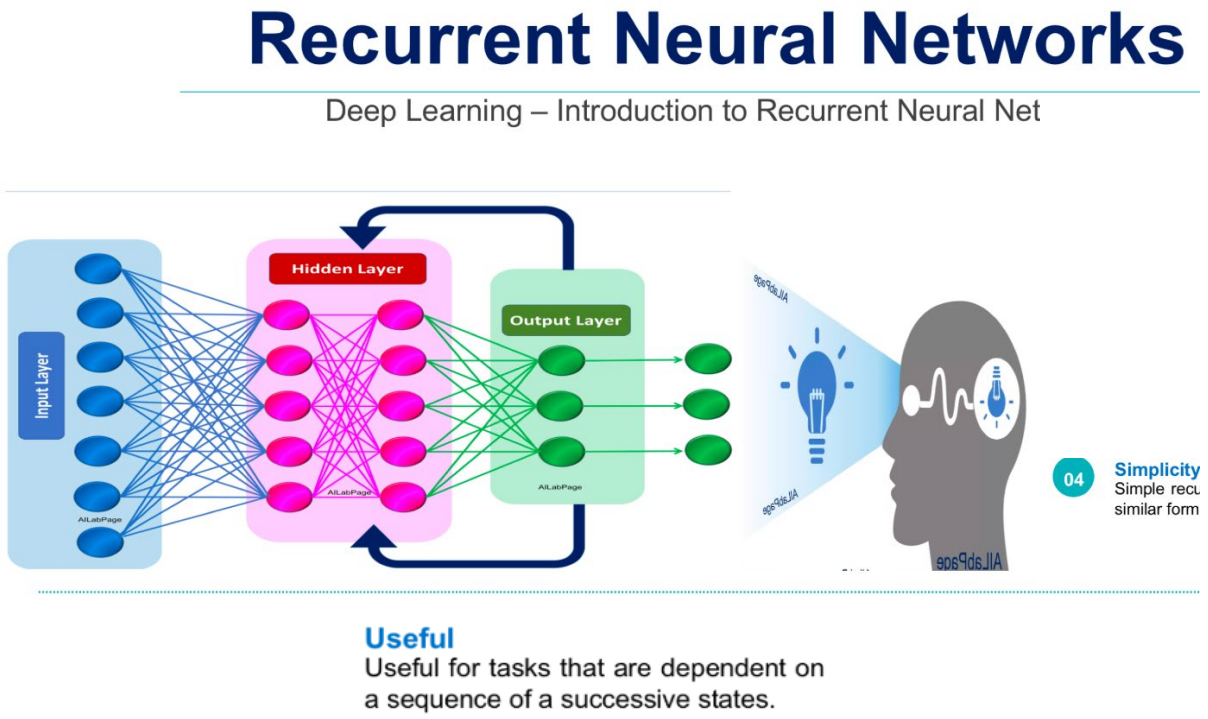
Methodology: Training Dataset

- Period of Record: 2011-2020 (10 years)
- Data: Daily flows at S77, S79, S308, and S80
- Data Source: USACE
- Equations for local basin runoff:
  - $C43\_Runoff_i = \max(0, S79_i - S77_i)$
  - $C44\_Runoff_i = \max(0, S80_i - S308_i)$
- Rainfall
  - Daily rainfall volumes for sub-basins
  - SFWMD's Gage-Adjusted Radar Rainfall



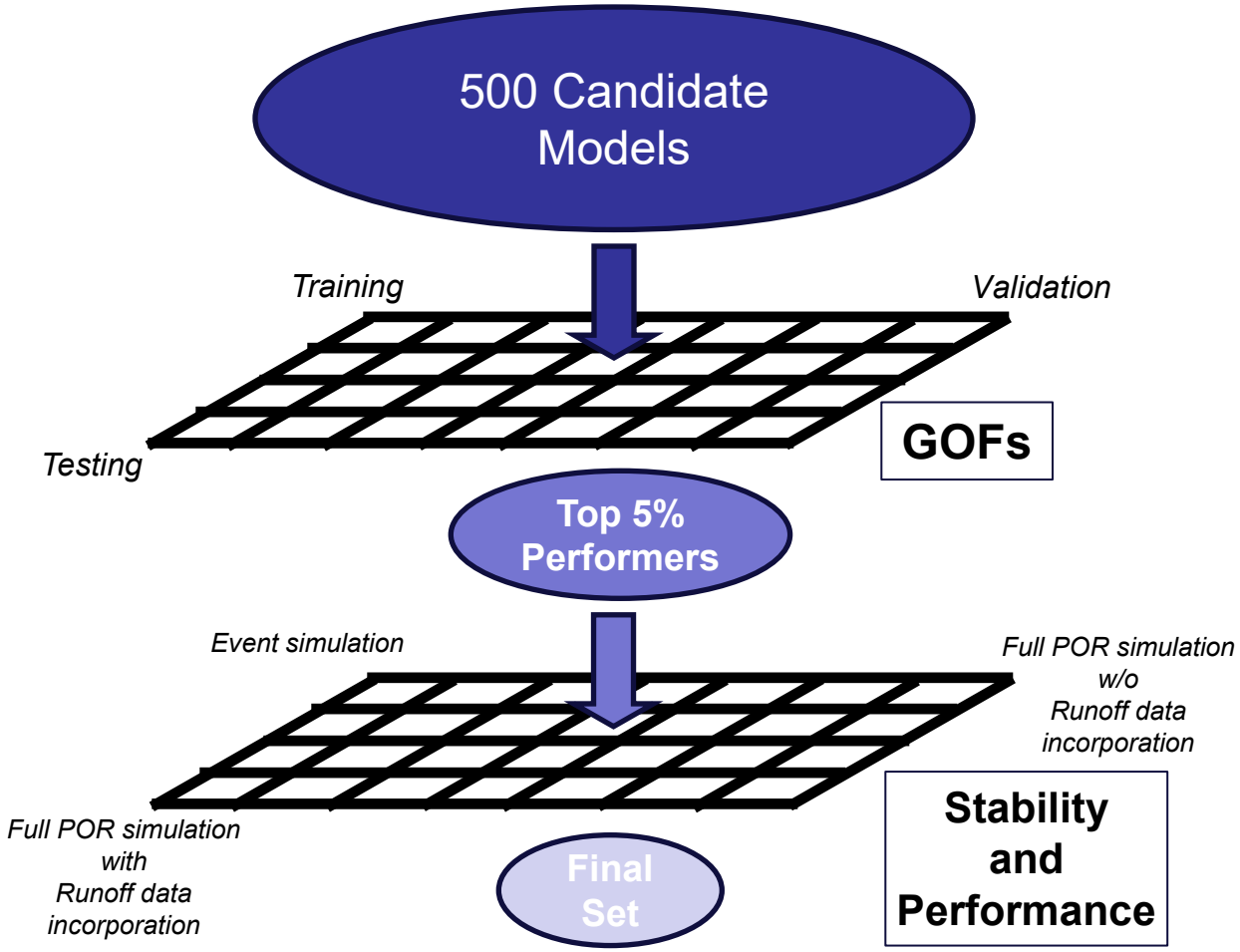
Methodology: Model Development

- Exploratory analysis (three approaches)
- Recurrent Neural Network (RNN)
  - Suitable for timeseries
- Hyperparameter Optimization Framework
- For each model
  - Randomly select 60% of the historical data
  - Partition into
    - 60% training, 20% validation, 20% testing
- 500 candidate models
- Several goodness of fit (GOF) measures
  - R^2, NSE, PBIAS, RMSE, MAE, RSR



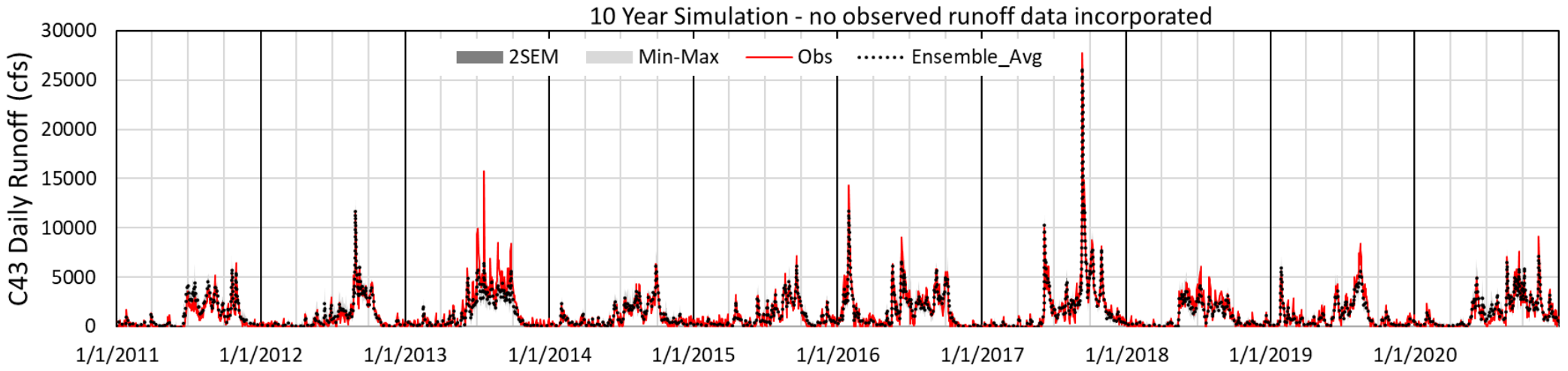
https://vinodsblog.com/2019/01/07/deep-learning-introduction-to-recurrent-neural-networks/

Methodology: Model Selection



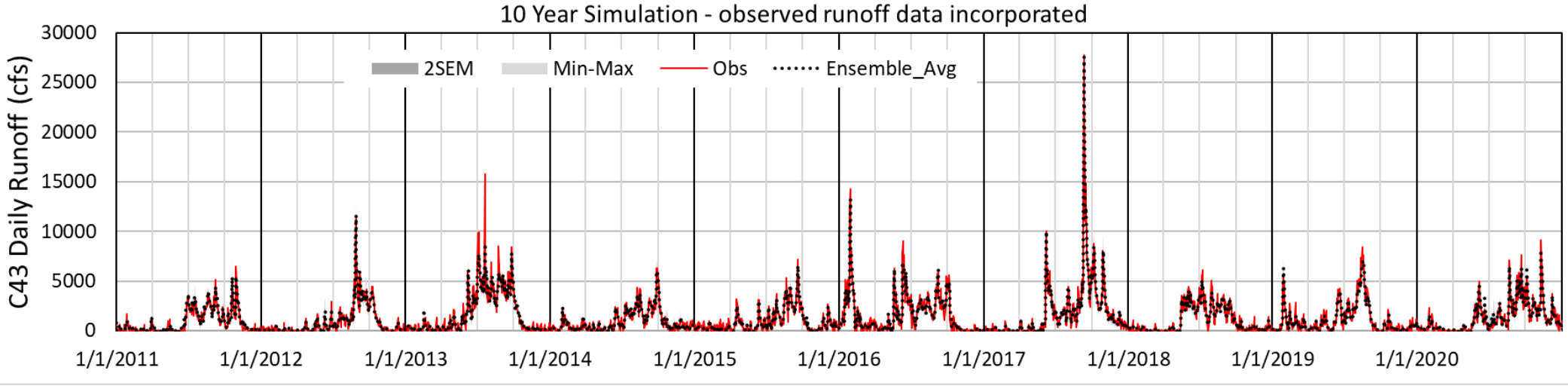
- Two phase selection
  - Phase 1: Based on GOFs for training, validation and testing sub-sets
  - Phase 2: Model stability and performance over long term simulation as well as storm events
- C43: Ensemble of 8 models
- C44: Ensemble of 6 models

Results: C43 Runoff Long Term Simulation



GOF	Value	Classification*
NSE	0.91	Very Good
PBIAS	1.9%	Very Good

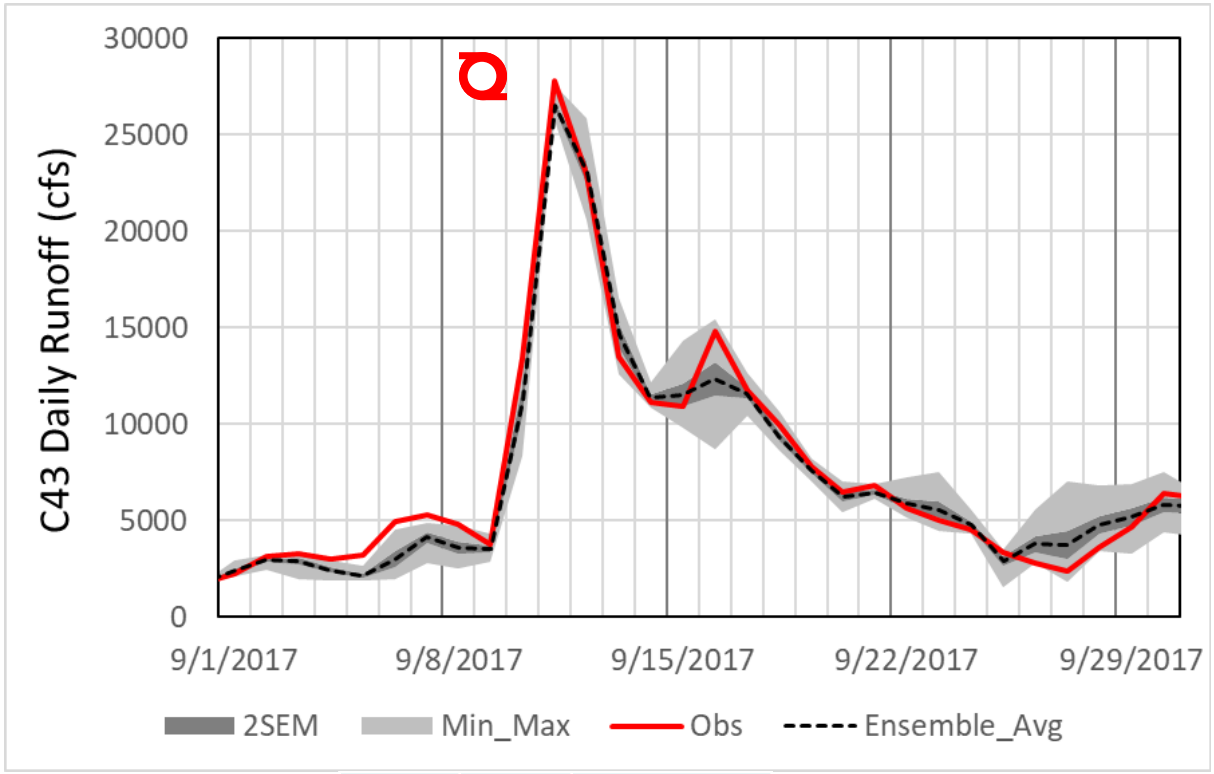
GOF	Value	Classification*
NSE	0.95	Very Good
PBIAS	0.3%	Very Good



* Moriasi et al. (2015), Trans. of ASABE

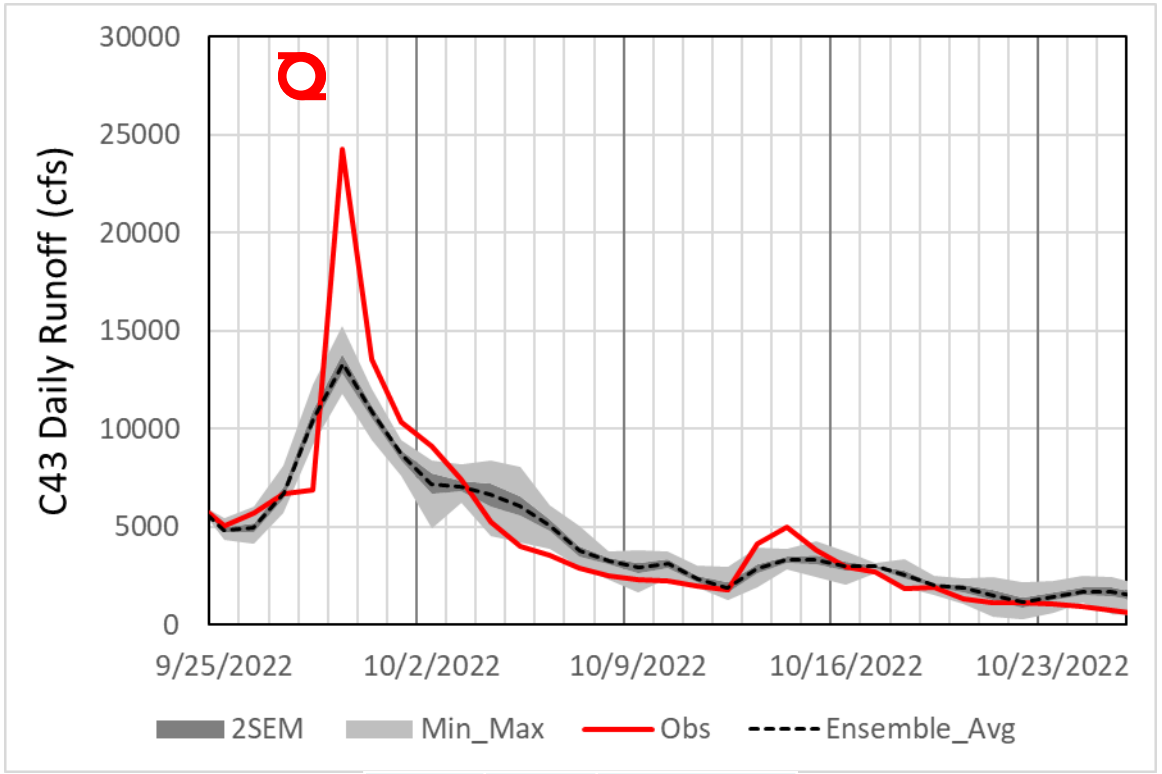
Results: C43 Runoff for Large Storm Event

Hurricane Irma



GOF	Value	Classification*
NSE	0.97	Very Good
PBIAS	3.5%	Very Good

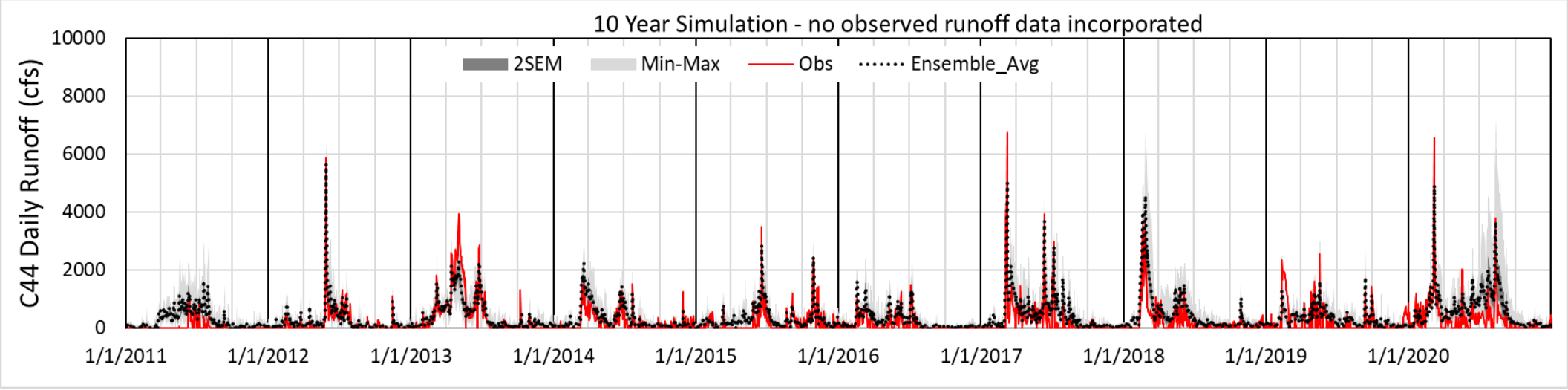
Hurricane Ian



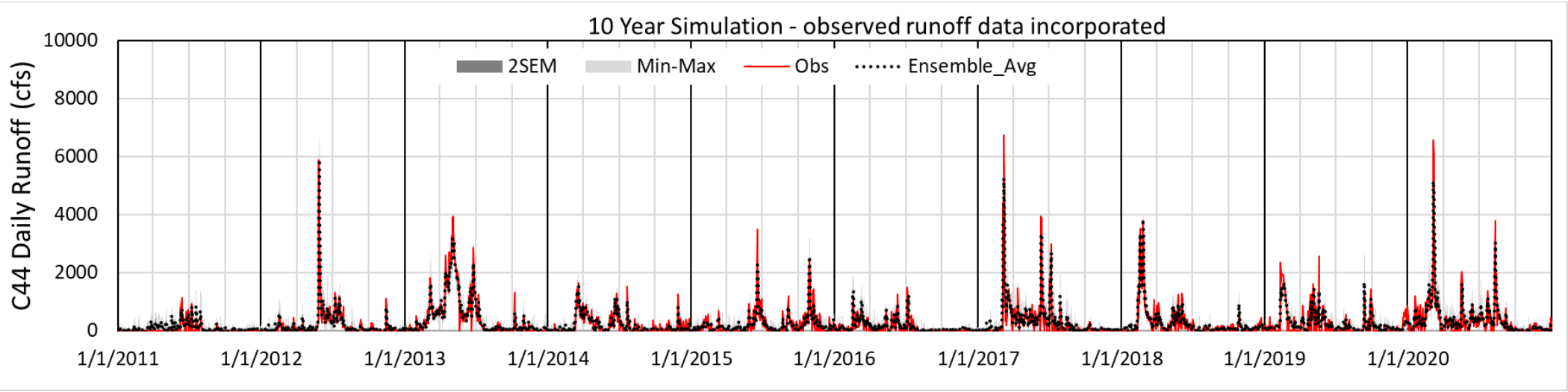
GOF	Value	Classification*
NSE	0.75	Very Good
PBIAS	3.9%	Very Good

* Moriasi et al. (2015), Trans. of ASABE

Results: C44 Runoff Long Term Simulation



GOF	Value	Classification*
NSE	0.57	Satisfactory
PBIAS	-67%	*Not Satisfactory*

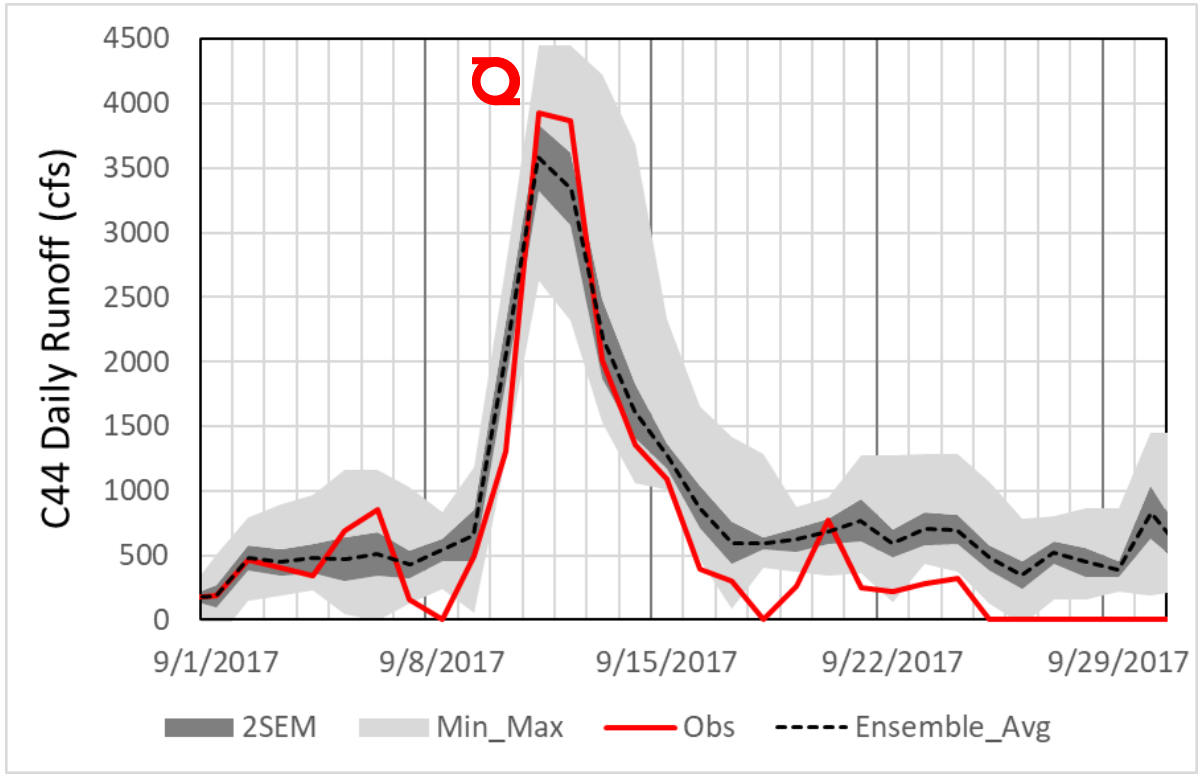


GOF	Value	Classification*
NSE	0.88	Very Good
PBIAS	-14%	Satisfactory

* Moriasi et al. (2015), Trans. of ASABE

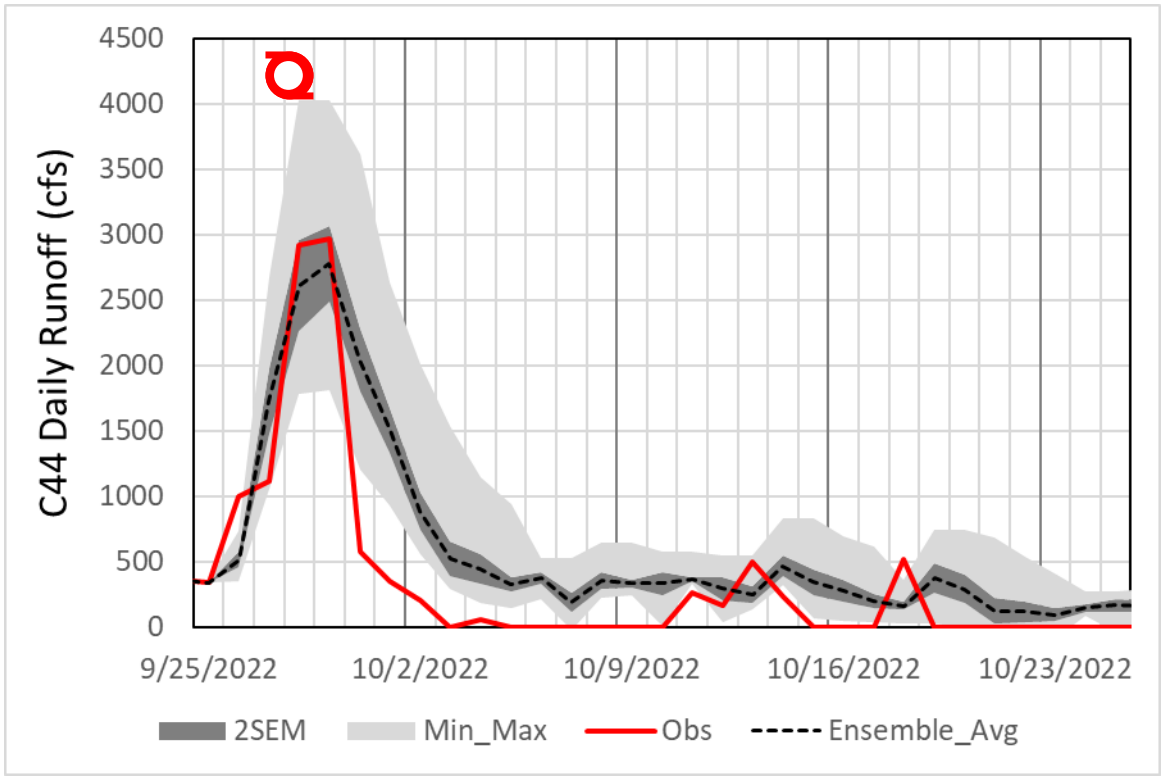
Results: C44 Runoff for Large Storm Event

Hurricane Irma



GOF	Value	Classification*
NSE	0.83	Very Good
PBIAS	-39%	*Not Satisfactory*

Hurricane Ian

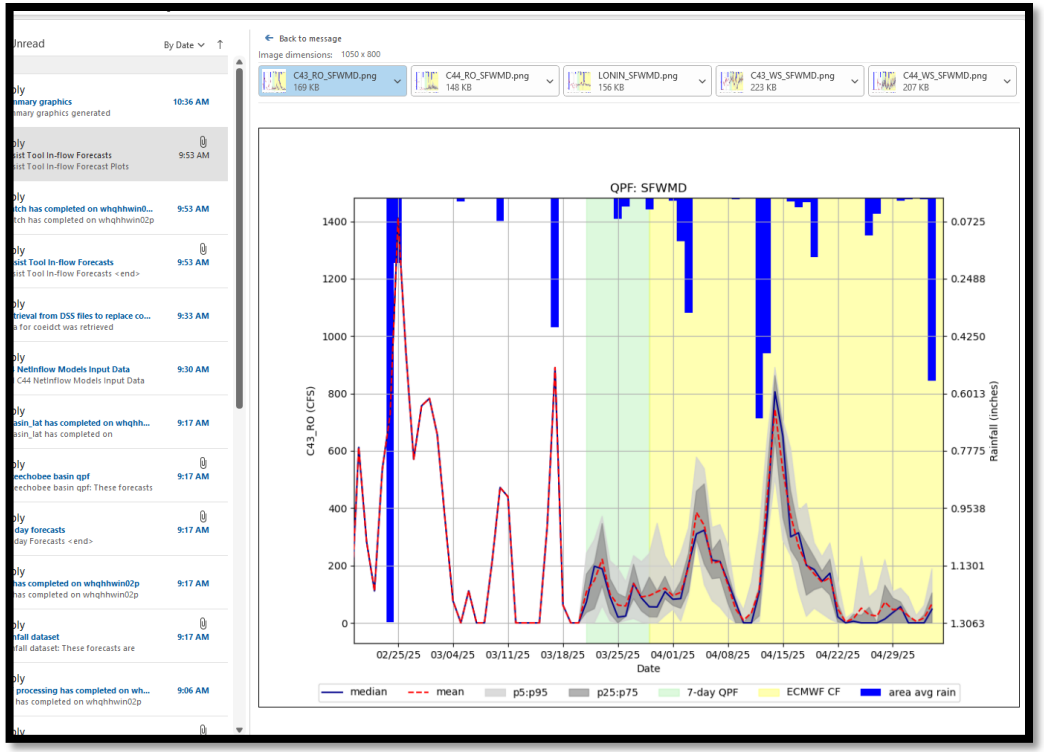


GOF	Value	Classification*
NSE	0.62	Satisfactory
PBIAS	-51%	*Not Satisfactory*

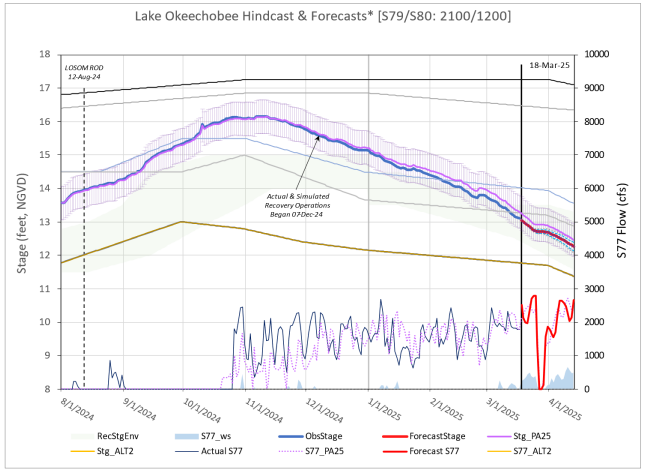
* Moriasi et al. (2015), Trans. of ASABE

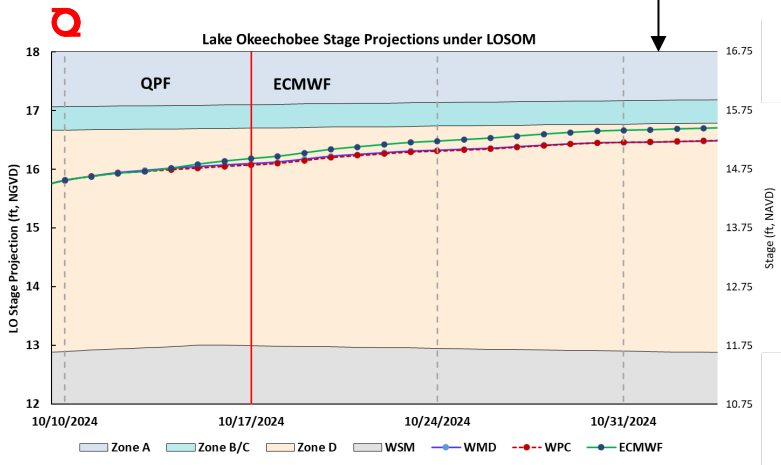
Applications

- Automated daily model runs



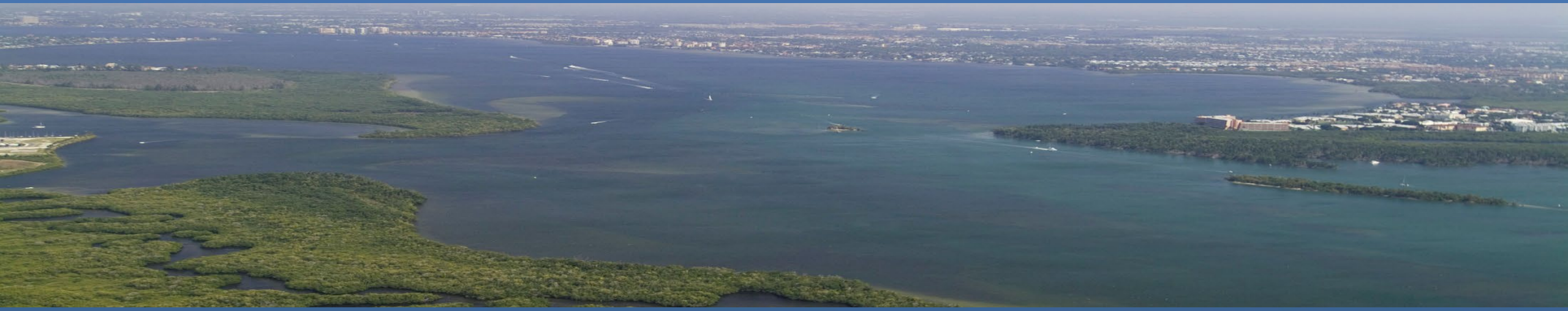
- Two applications
  - Weekly LOSOM regulatory release decision support.
  - Lake Okeechobee stage projection during storm events.
- Up to 3 sources rainfall forecasts
  - WMD, WPC, ECMWF





Conclusions

- Runoff estimation models were successfully developed using deep learning technique (Recurrent Neural Network).
- Model for C43 local basin runoff estimation showed very good performance.
- Model for C44 local basin runoff estimation is able to capture the runoff dynamics but overestimates the flows. Further improvements are warranted.
- Models were deemed to be useful for near real-time applications, incorporating quantitative precipitation forecasts to provide perspective on operations for Lake Okeechobee.
- Retrain models once substantial data becomes available after C43 and C44 reservoir operations start



Questions