VILLANOVA UNIVERSITY
COLLEGE OF ENGINEERING

CENTER FOR RESILIENT WATER SYSTEMS

PREDICTING PERFORMANCE OF GREEN STORMWATER INFRASTRUCTURE USING DEEP NEURAL NETWORK REGRESSION

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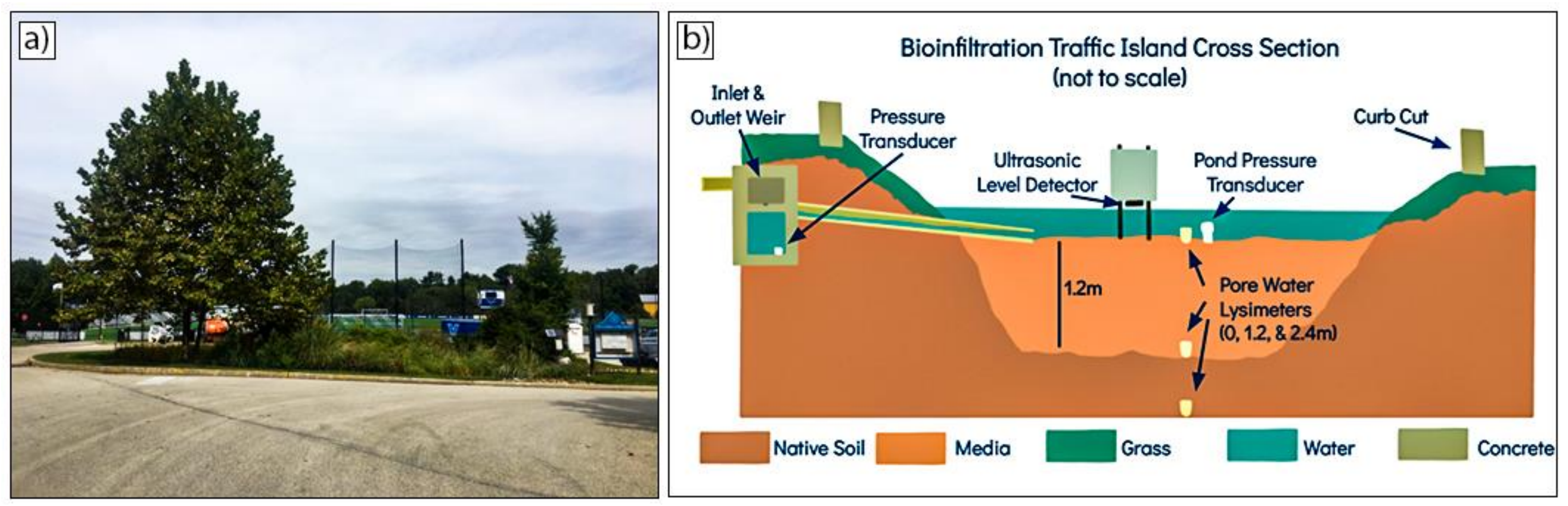
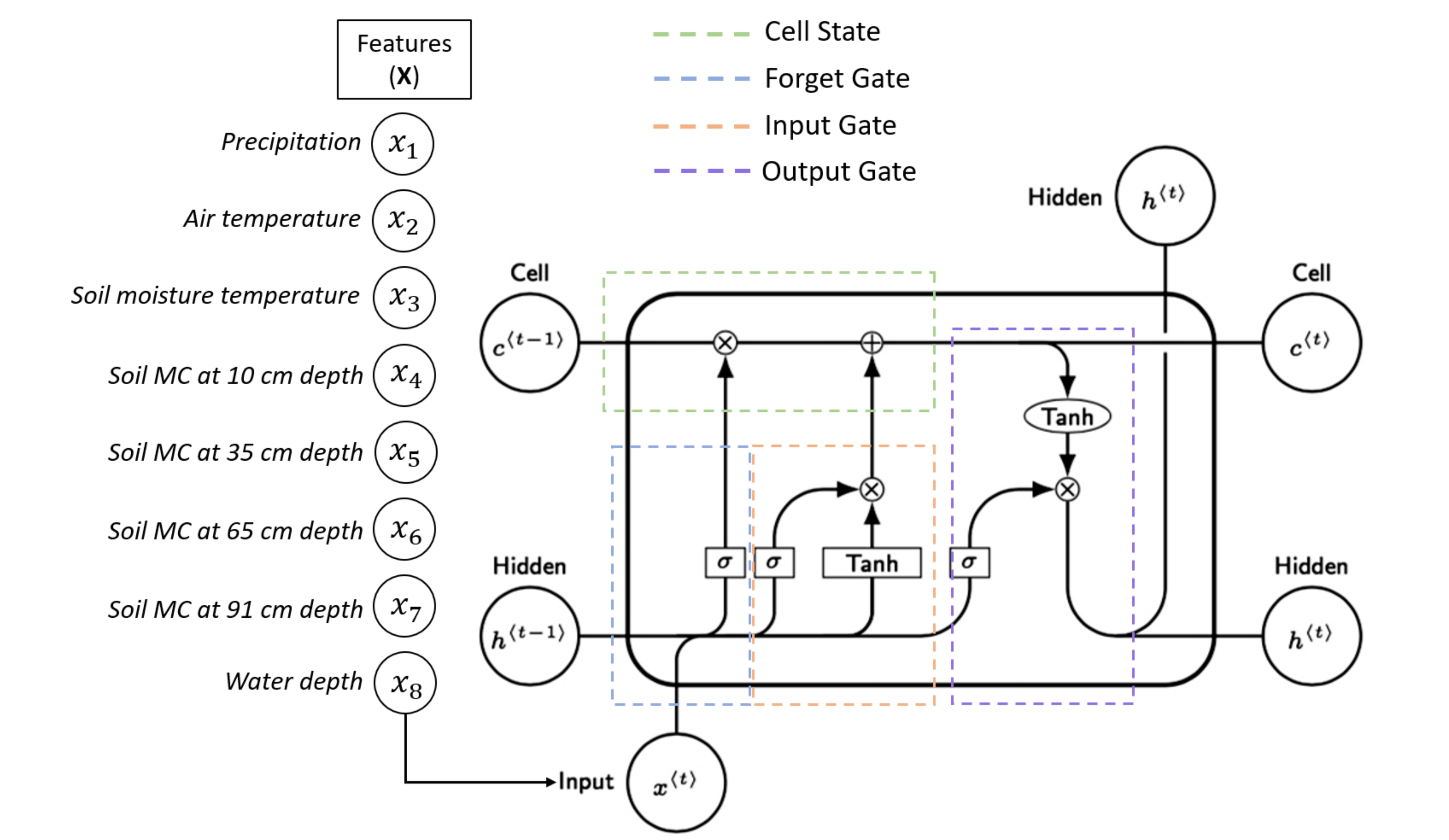
OVERVIEW

- Various anthropogenic and climatic processes can introduce long-term effects on the performance indicators of the Green Stormwater infrastructure (GSI), skewing the distribution of the outcomes of numerical models.
- Data-driven predictive models based on **deep learning** techniques offer an exciting ground to estimate GSI performance accounting for its highly dynamic and constantly evolving nature through leveraging advancements in observational data.
- **LSTM (Long Short-Term Memory) neural network** is used to predict the GSI performance through **Recession Rate of rainwater depth** using **five years of observational data.**
- A comparative study with a numerical model in SWMM (Storm Water Management Model) is performed to show efficiencies of the models.
- **Bio-infiltration Traffic Island (BTI)**, a raingarden situated on the Villanova University Campus is selected as an example GSI. It has been designed to hold and infiltrate incoming runoff from storms smaller than 25 mm.
- The BTI treats over 1.27 acres of stormwater runoff from the west campus in Villanova university.

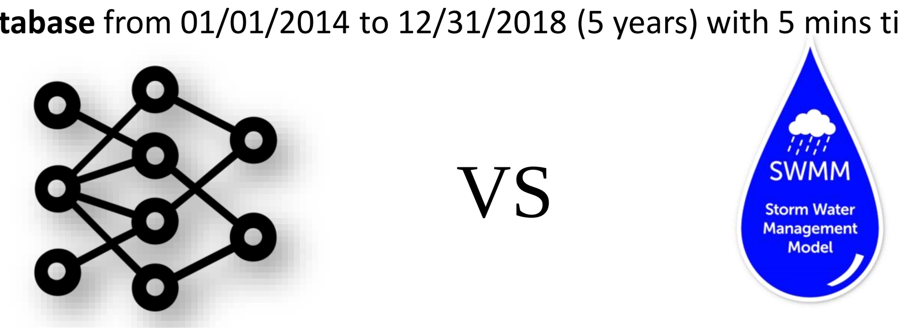


Front view (a) and cross-section (b) of the Bio-infiltration Traffic Island (BTI) on Villanova University campus, Villanova, PA.

PREDICTIVE MODEL

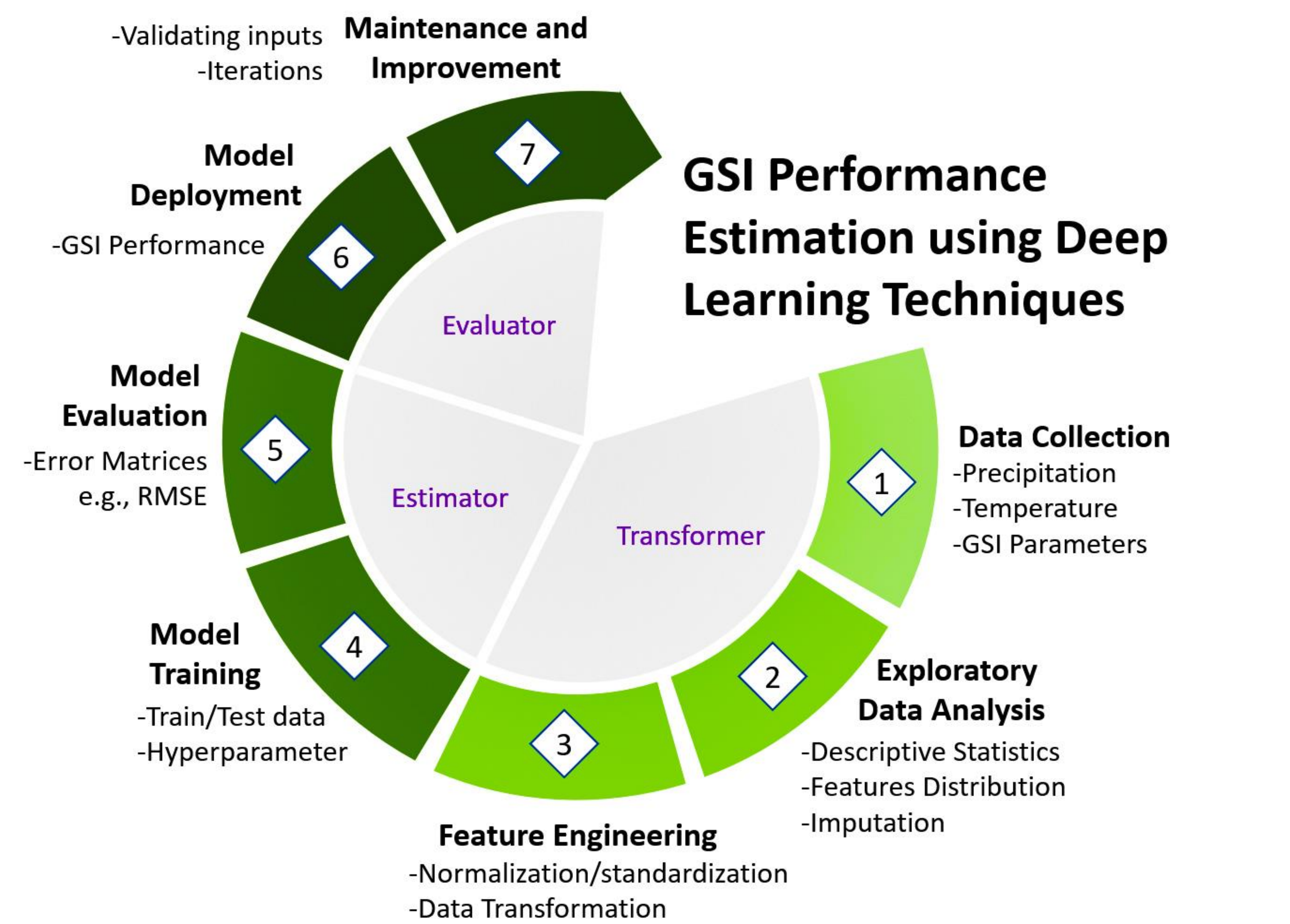


Schematic of LSTM Neural Network with all input features. A set of eight features were considered for training the neural network model. All the features and target variables (recession rate) are retrieved from the **Villanova Center of Resilient Water System (VCRWS) database** from 01/01/2014 to 12/31/2018 (5 years) with 5 mins time interval.

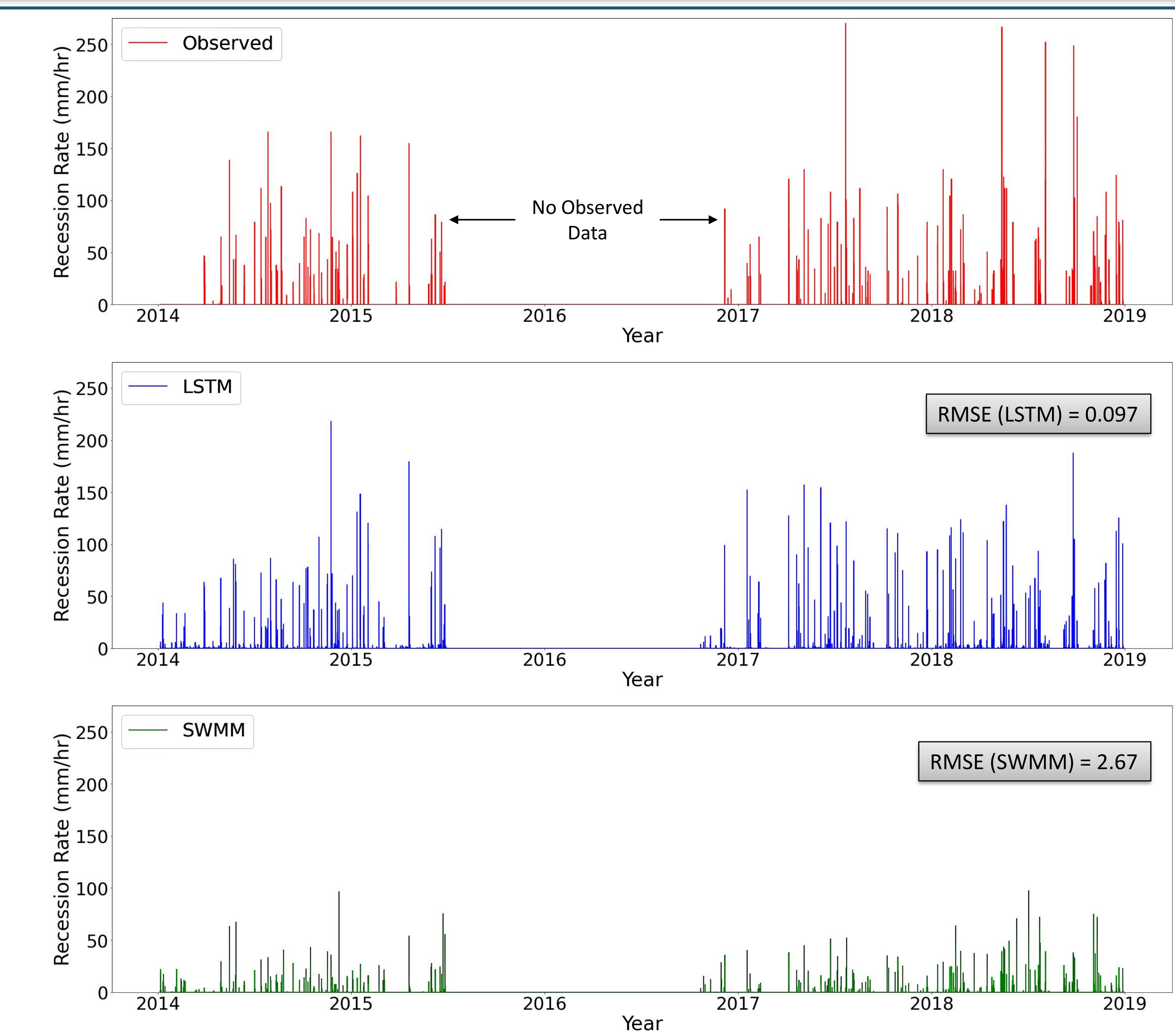


Comparative study is performed between LSTM neural network and EPA SWMM for an additional validation of LSTM model

WORKFLOW

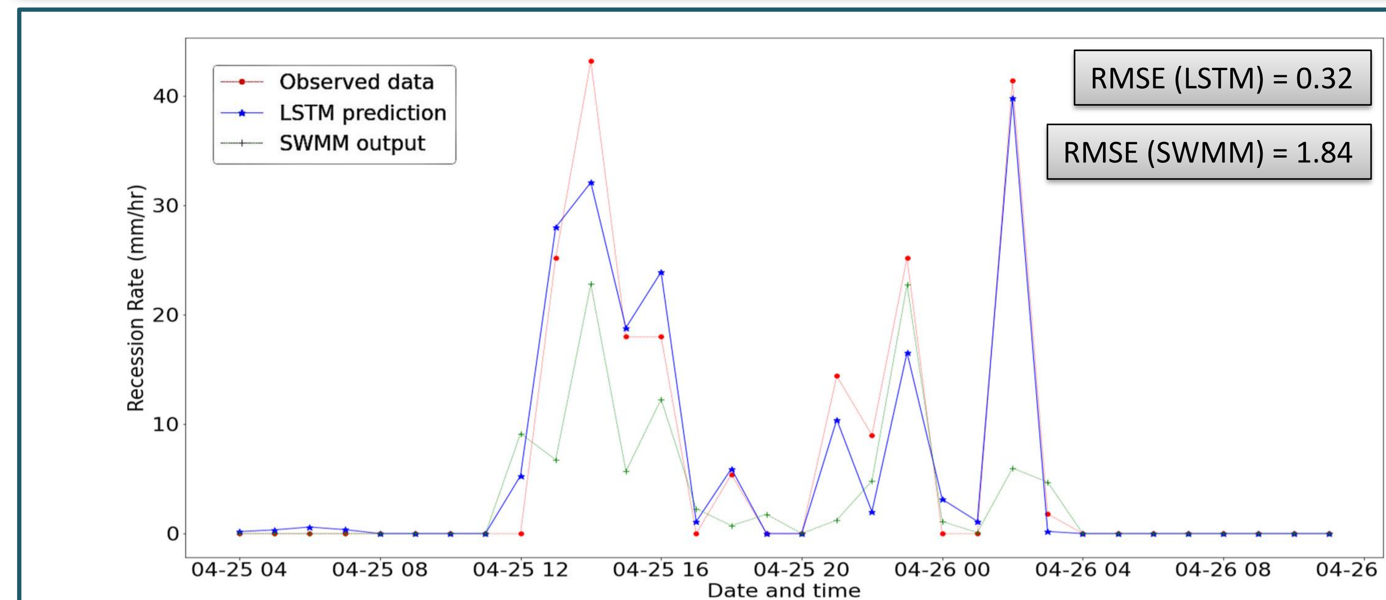


CONTINUOUS RECESSION RATE



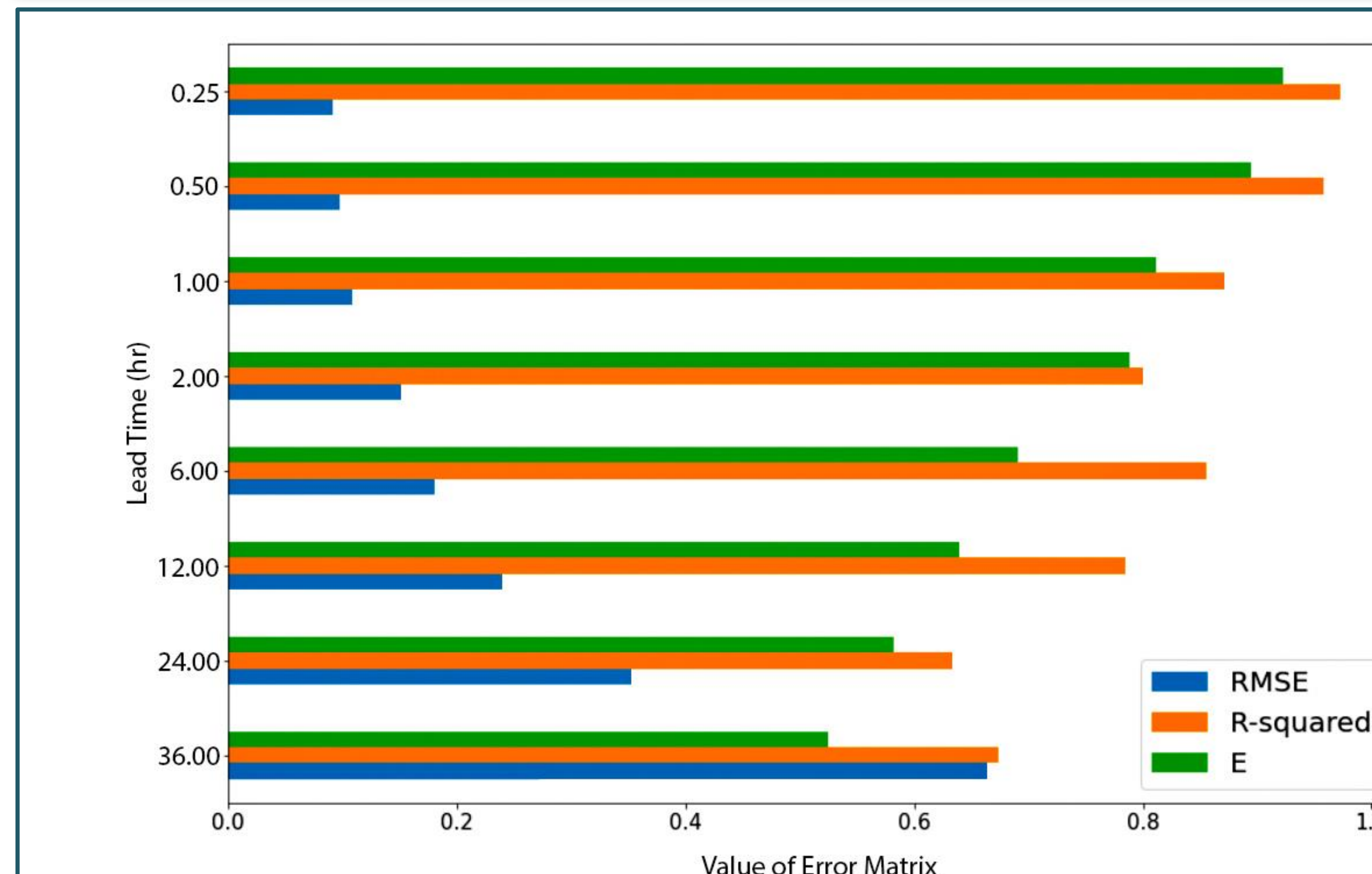
Recession rate of the water depth from observed data, LSTM and SWMM model. The LSTM model conveyed a performance score, Root Mean Square Error (RMSE), of 0.067 outperforming the SWMM with a score of 2.67.

SINGLE STORM



Recession rate values from observed data, LSTM and SWMM models of an example storm events from the year 2017

MODEL PERFORMANCE



LSTM model performance for increasing lead time. Lead time is the length of a cutout of a time series that is used to predict the output (recession rate) at future time step (e.g., 6 hours).

CONCLUSION

- LSTM algorithm outperformed the SWMM model in estimating recession rate with the full range of observed data as well as specific storm event.
- These findings have the potential to provide insight into the planning and maintenance of GSI with observed data only, ultimately facilitating lower maintenance costs and more sustainable GSI.
- Learned LSTM model parameters can be transferred to other GSIs at similar physiographic locations.
- The application of neural networks is a crucial stride towards real-time forecasting of GSI performance in a cloud-computing platform and catchment-wide application with multiple GSIs.

References:

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[2] Li, S., Kazemi, H., Rockaway, T.D., 2019. Performance assessment of stormwater GI practices using artificial neural networks. Science of The Total Environment 651, 2811–2819.

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