## DSS for Operation of a Network of Storage Ponds for Mitigating Floods

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## Acknowledgements



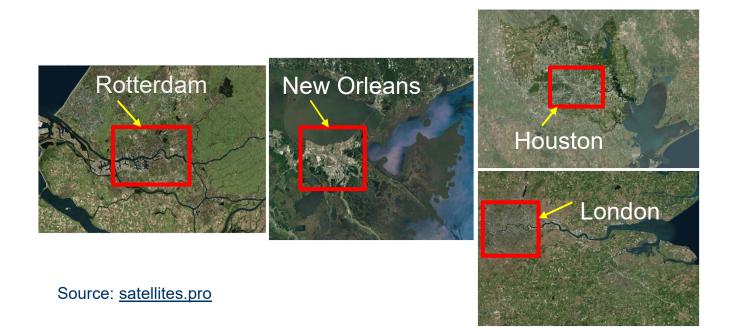
#### **Students that contributed in this area:** Ali Alnahit, Li Qin, Ahmet Yolcu, Vivek Verma, Linlong Bian, Aditia Rojali, Dogukan Ozecik.

## Outline

- 1. Motivation of study
- 2. Overview of flood control methods
- 3. Low-cost hardware
- 4. Decision Support System (DSS)
- 5. Case study
- 6. Conclusions



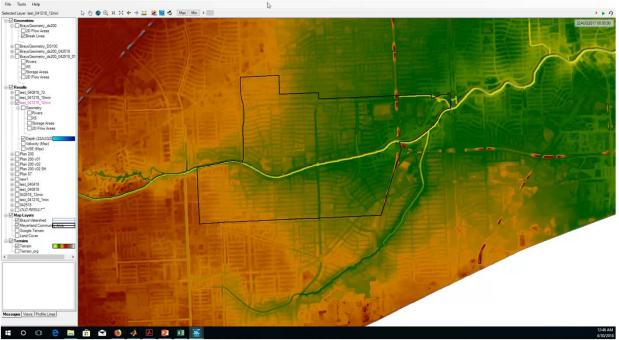
# Motivation: Some major cities affected by recurrent flooding



#### Flooding simulation (Computational Cost)

#### Meyerland area (Houston) during Hurricane Harvey





## Flood control methods Structural measures (traditional approach)



Source: cbc.ca

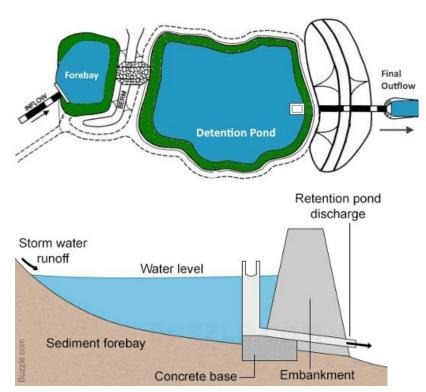
## Motivation (Cont.)

**Nonstructural measures:** Watershed management, floodplain management, floodplain zoning, flood Warning System, preserving and maintaining wetlands



#### Retrofitting of existing storage systems

#### **Example: Detention pond**



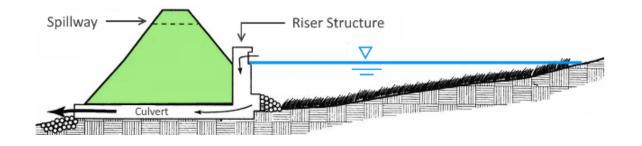
**Source:** https://helpsavenature.com/detention-ponds-vs-retention-ponds

- Small rain events: function as usual
- Flooding conditions: function as controlled systems





#### Drainage of Storage Systems 1) Remotely-controlled gates in downward pipes





- Remotely operated
- Require a small amount of solar energy for gate operation/sensor communication
- May require substantial construction for gate installation



#### Drainage of Storage Systems (Cont.)

- 2) Smart siphons
- Remotely operated (3G/4G cellular/radio/Satellite)
- No construction is required (only anchoring)
- Small amount of solar energy (priming)
- Fail-safe
- Relatively inexpensive (\$3500 for a 12" siphon)



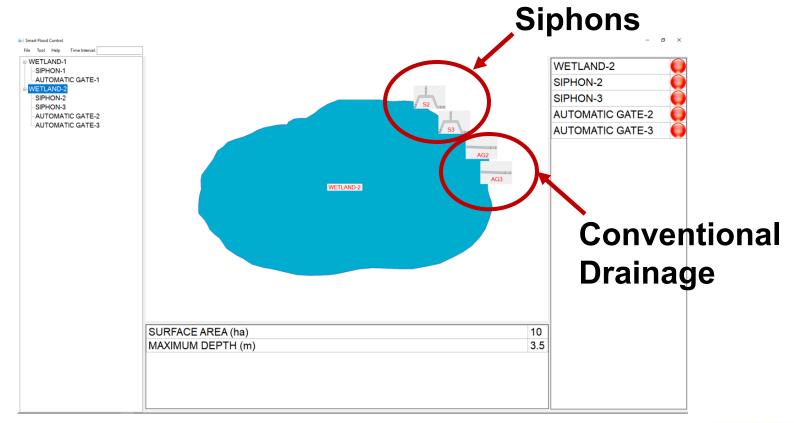
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#### The Interface of our Control Software



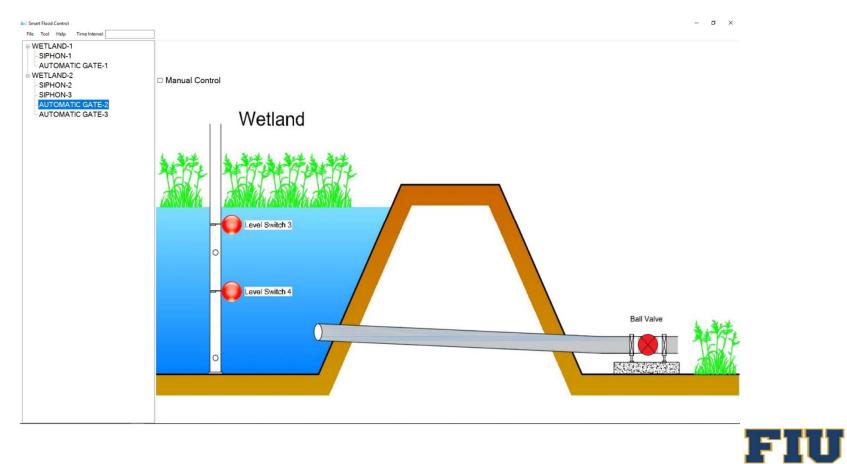


#### The Interface of our Control Software

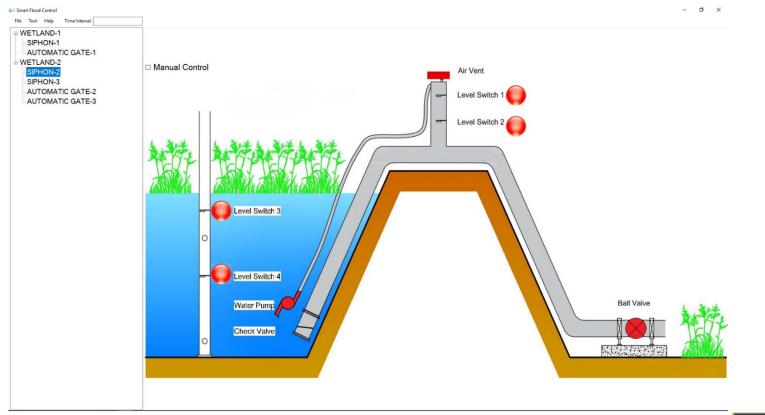




#### The Interface of our Control Software

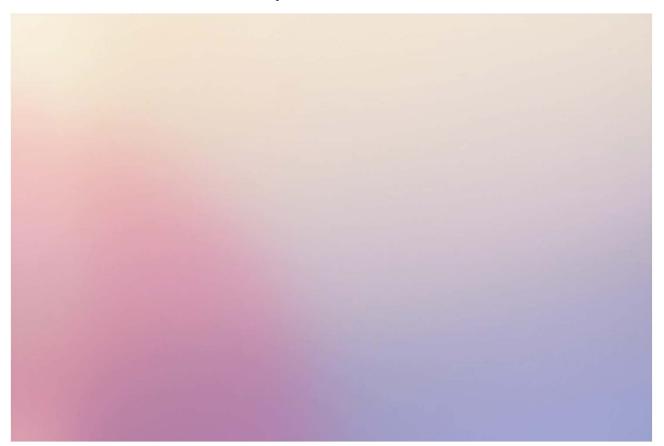


#### The Interface of our Control Software (Cont.)



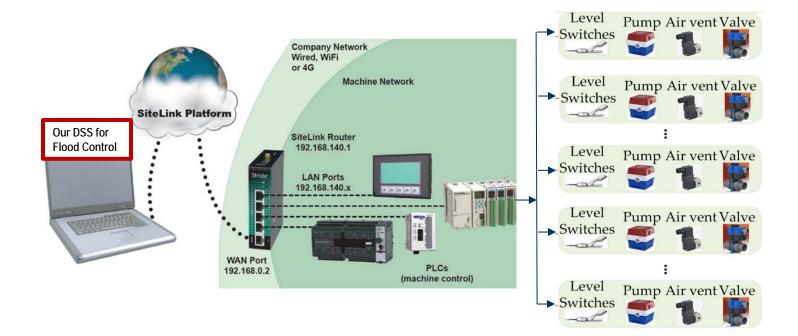


#### Our siphon in action

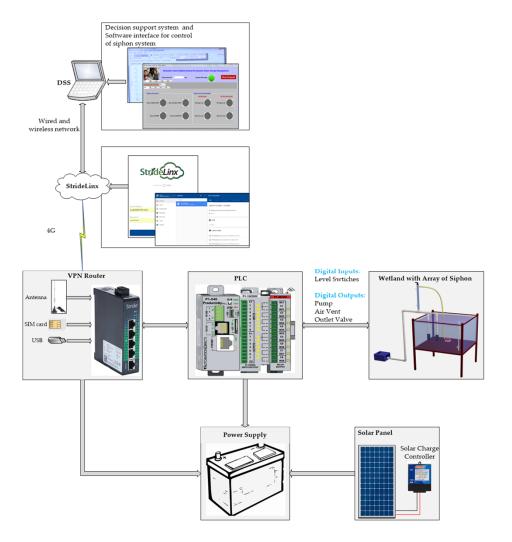




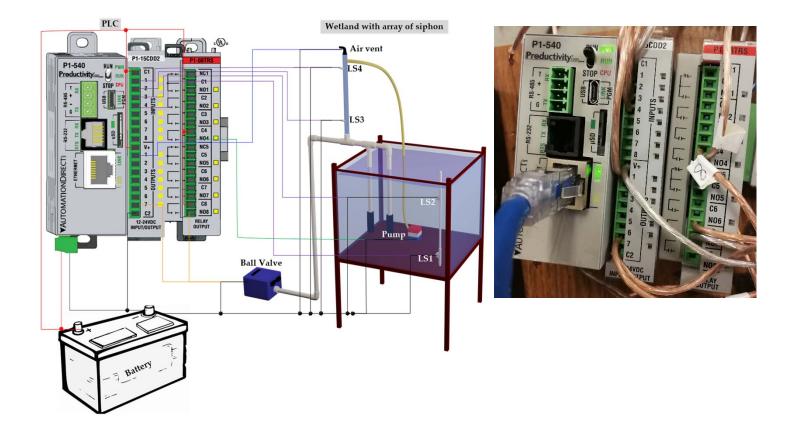
## Schematic of our remotely operated siphon system



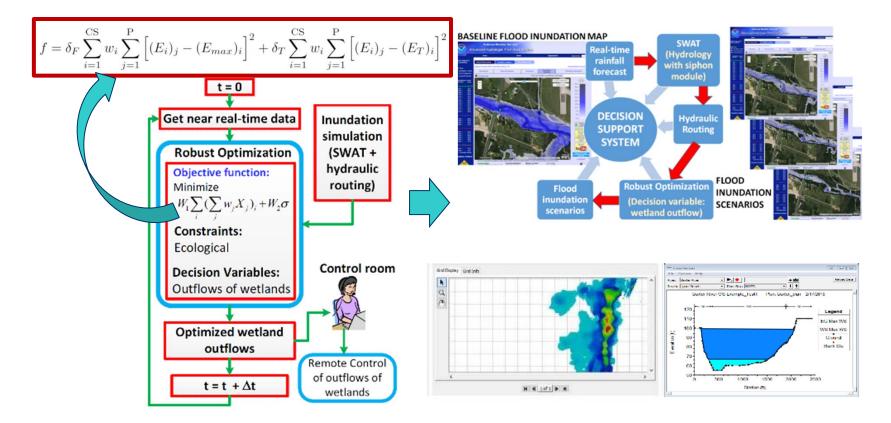
#### Architecture of our remotely operated hardware



#### Connection between PLC, sensors and power



### How to optimally control the water release? Our Decision Support System (DSS) - Fully automated



#### **Decision Support System**

#### Software and Scripts

- Python scripts
- MATLAB scripts
- GA/pattern search Optimization
- HEC-DSSVue
- HEC-RAS
- HEC-HMS

System is modular (software can be easily replaced with another) and simultaneous calculations of software

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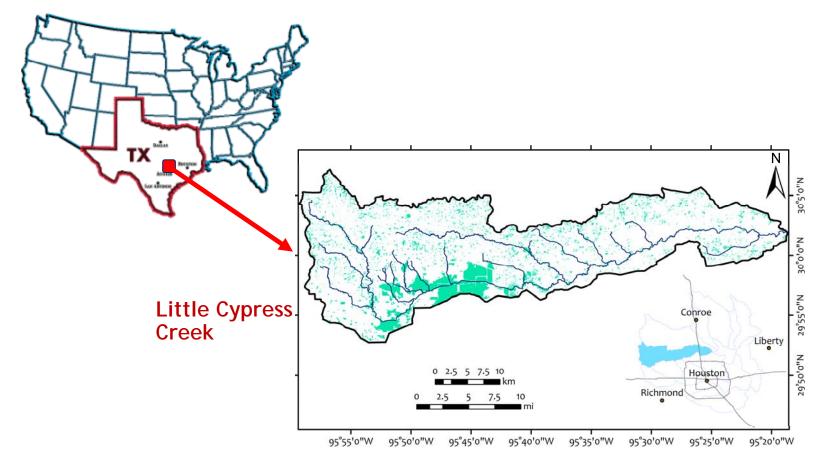
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#### Case Study: Flood Control in Little Cypress Creek, Houston, Texas, USA.

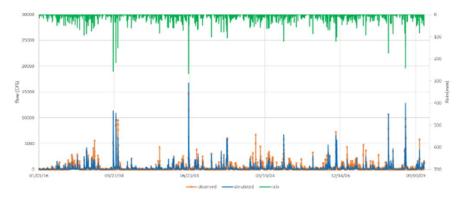




**GA** Optimization



Hydrological Model (e.g., HEC-HMS)



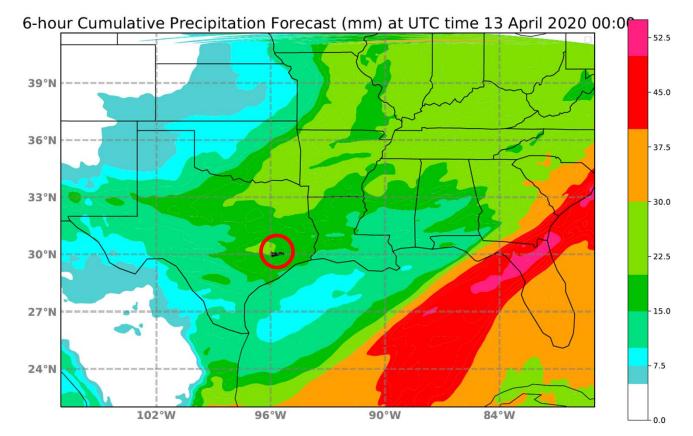
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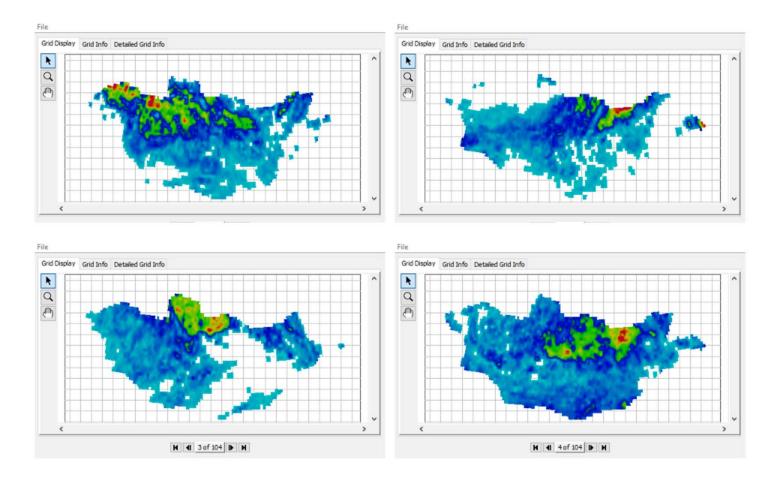


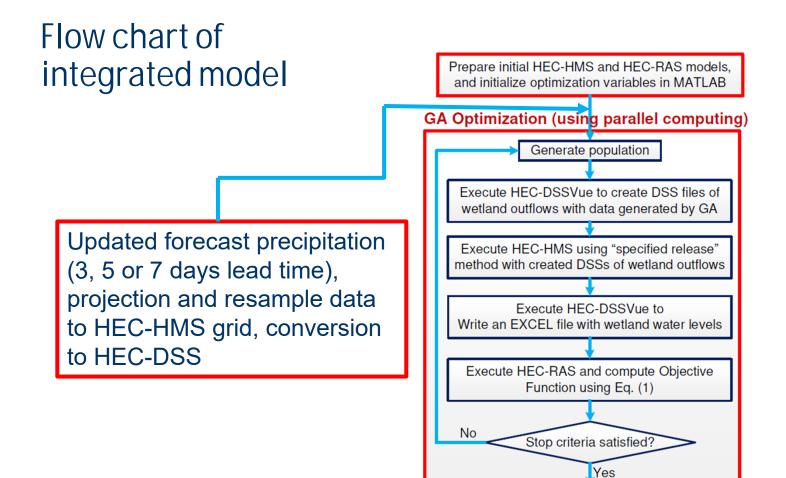
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## Precipitable water forecast generated with our Python script



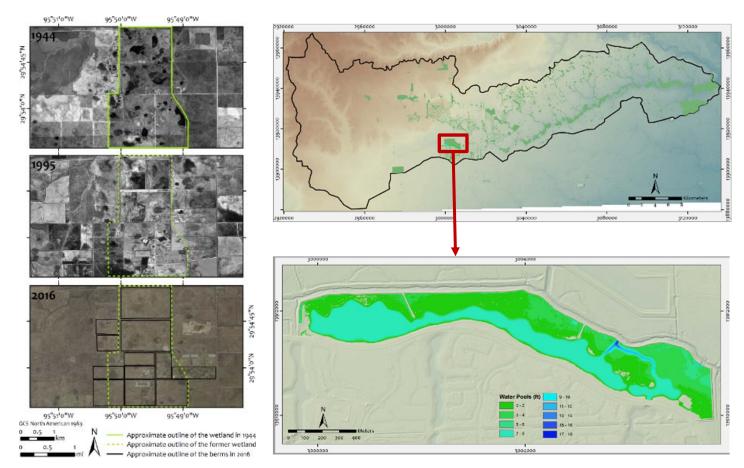
#### Multiple precipitation forecasts (3, 5 and 7-day)



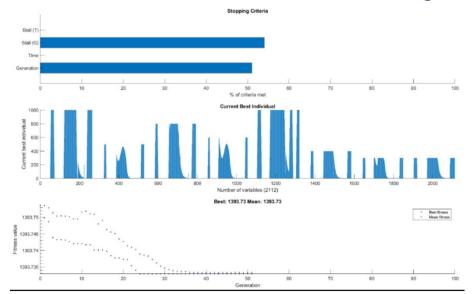


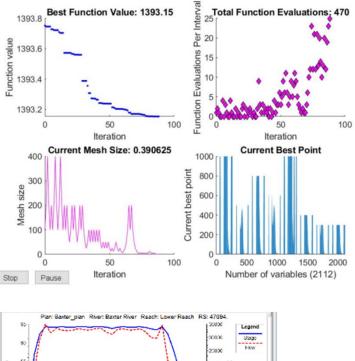
Plot optimal wetland outflows and optimal inundation scenarios

#### Engineering wetlands for flood control in Little Cypress Creek, Texas

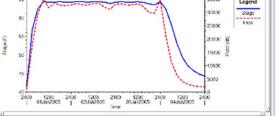


## GA and PS typical convergence process for optimal schedule of storage outflows

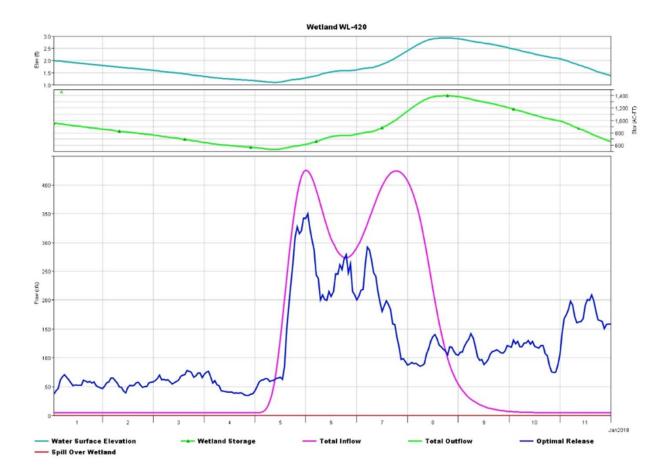




## Flow and discharge at control section

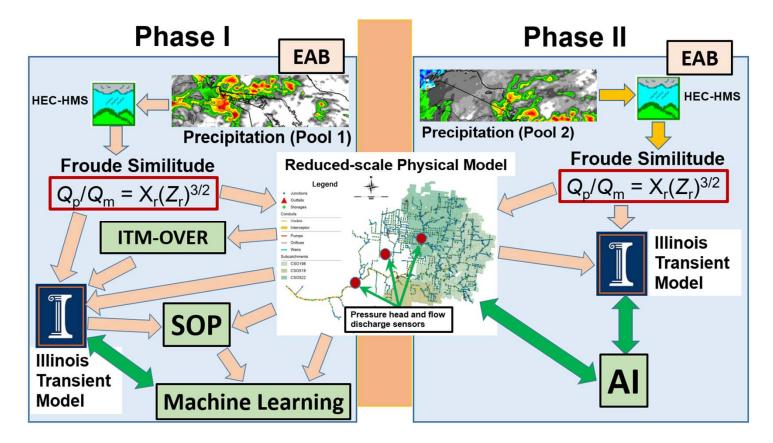


#### Typical optimization results of DSS:



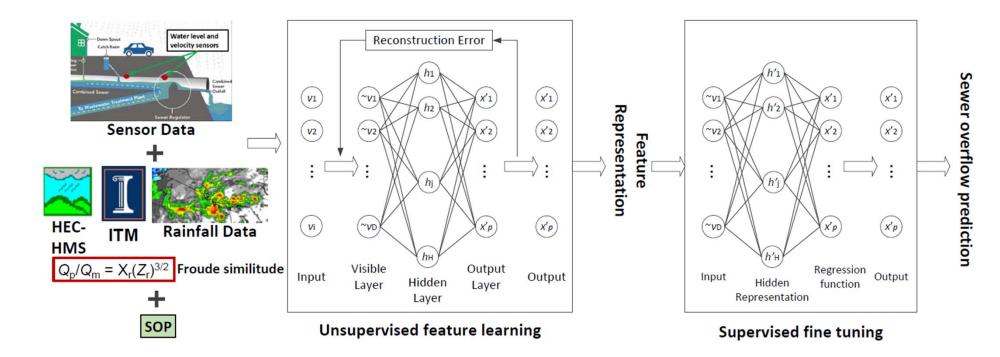
#### Current work

#### Artificial Intelligence for Much Faster Results



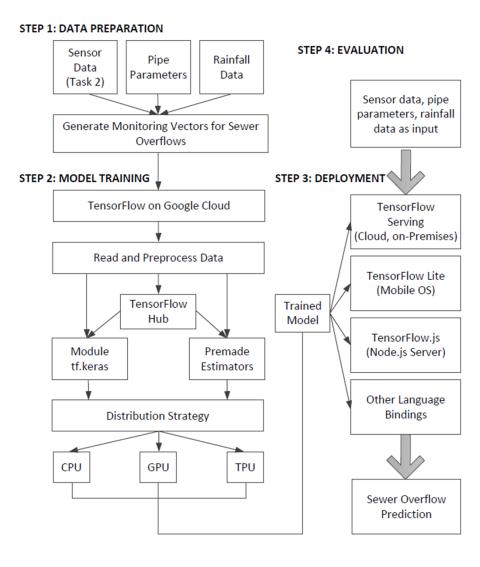
#### Current work (Cont.)

#### Artificial Intelligence for Much Faster Results



### Current work (Cont.)

#### Artificial Intelligence for Much Faster Results



#### **Concluding Notes**

- Conventional storage systems could be retrofitted for its controlled operation, although this may require substantial construction.
- The remotely-controlled siphon system can be a relatively **inexpensive** method to manage water storage in shallow ponds and wetlands
- The developed DSS aims to maximize the available storage in the watershed and maximize the flow conveyance in the main rivers (ahead and during flooding events).
- The proposed DSS/hardware can be expanded for other applications such as **aquatic habitat improvement**, water quality improvement, etc.
- Machine learning techniques could be used to speed up the computations



#### Arturo S. Leon, Ph.D., P.E., D.WRE Research website: <u>https://web.eng.fiu.edu/arleon/index.html</u> Email: arleon@fiu.edu

THANK YOU FOR YOUR ATTENTION!

