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

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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

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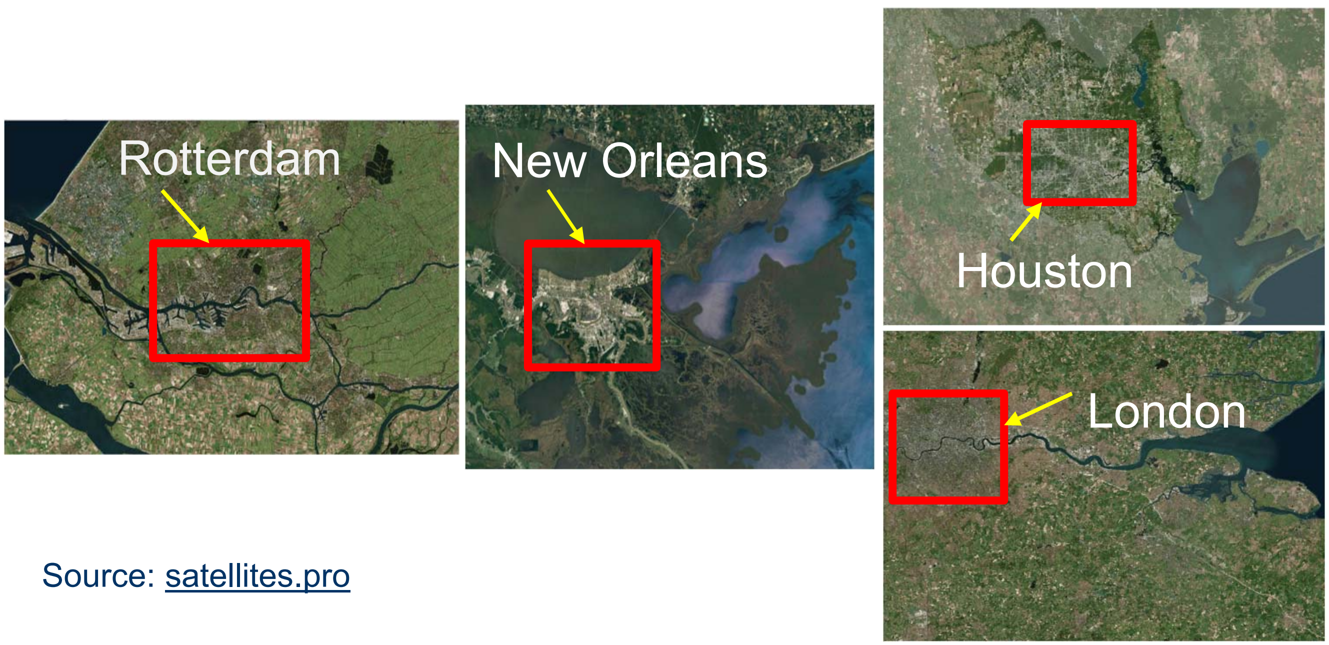
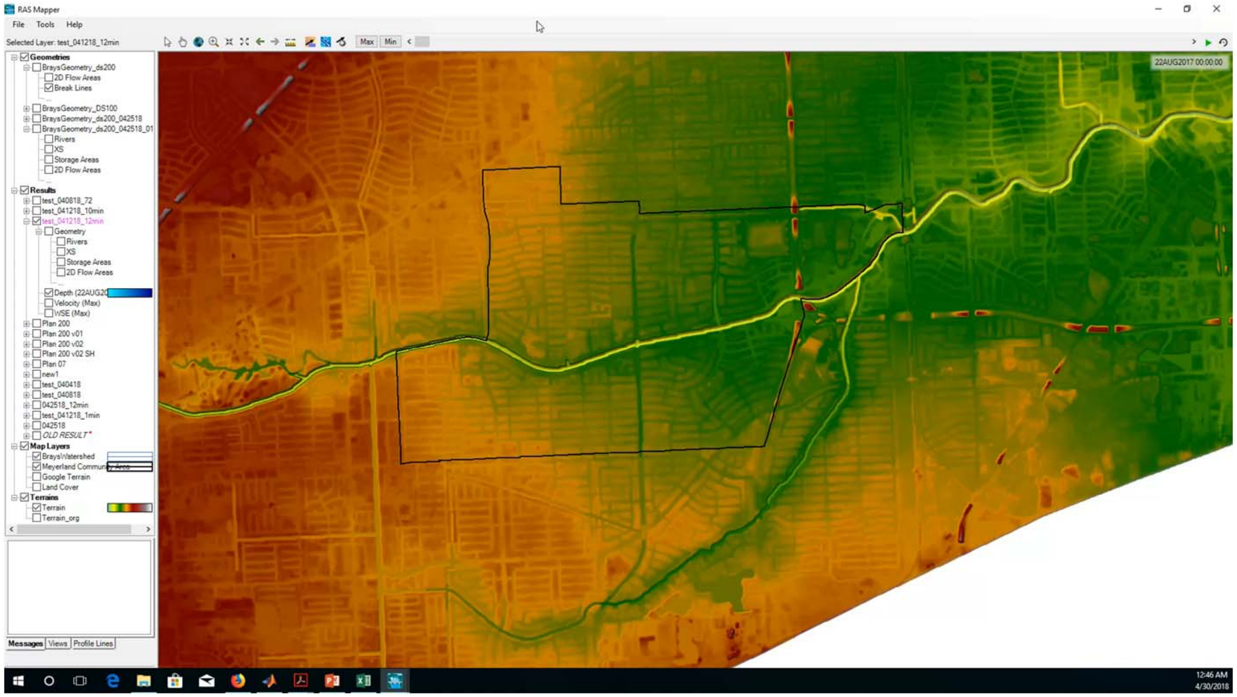
Motivation: Some major cities affected by recurrent flooding



Source: satellites.pro

Flooding simulation **(Computational Cost)**

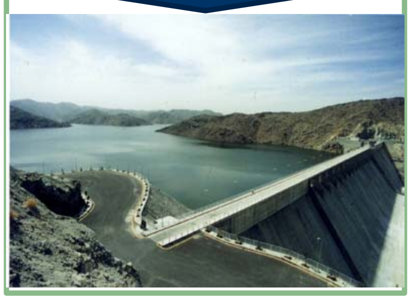
Meyerland area (Houston) during Hurricane Harvey



Flood control methods

Structural measures
(traditional approach)

Dam and Reservoirs



Detention ponds

Levees/rings

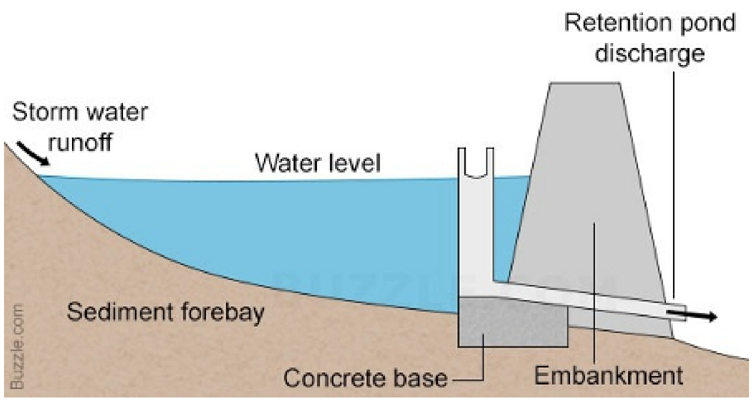
Source: cbc.ca

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**

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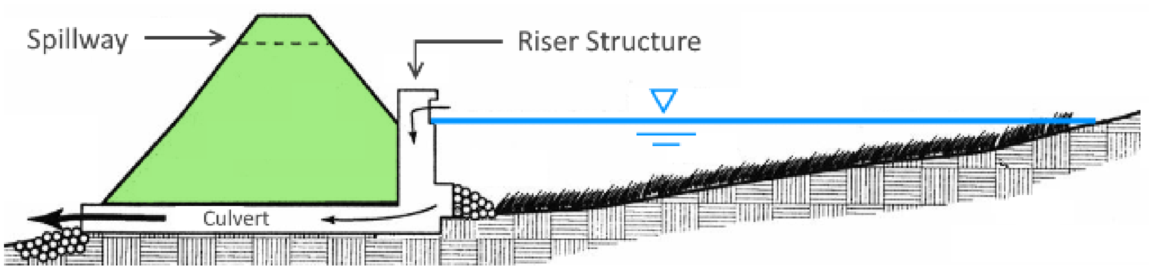
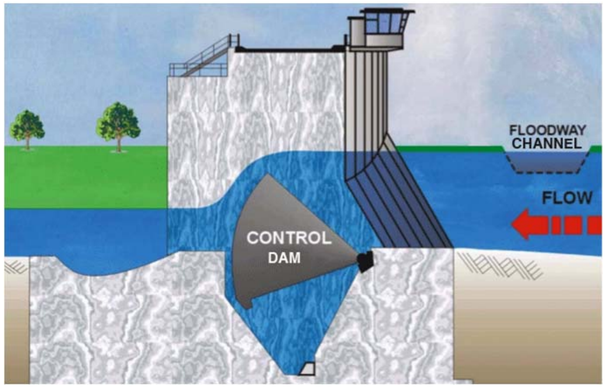
Drainage of Storage Systems

1) Remotely-controlled gates in downward pipes

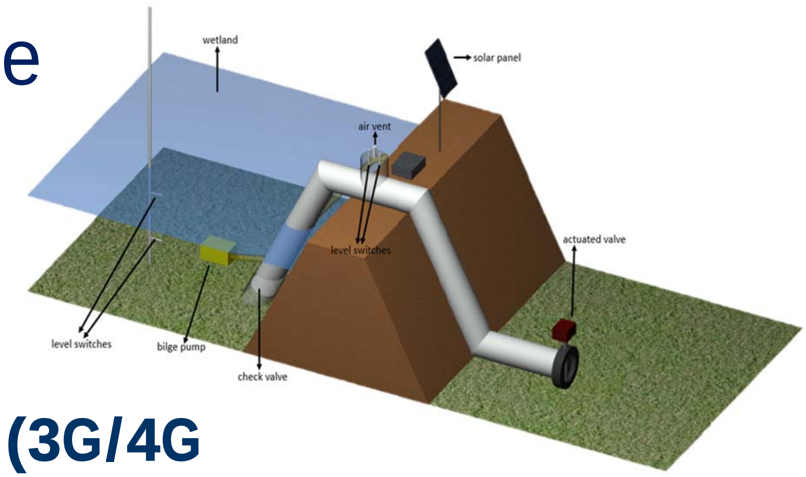




- **Remotely operated**
- **Require a small amount of solar energy for gate operation/sensor communication**
- **May require substantial construction for gate installation**

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

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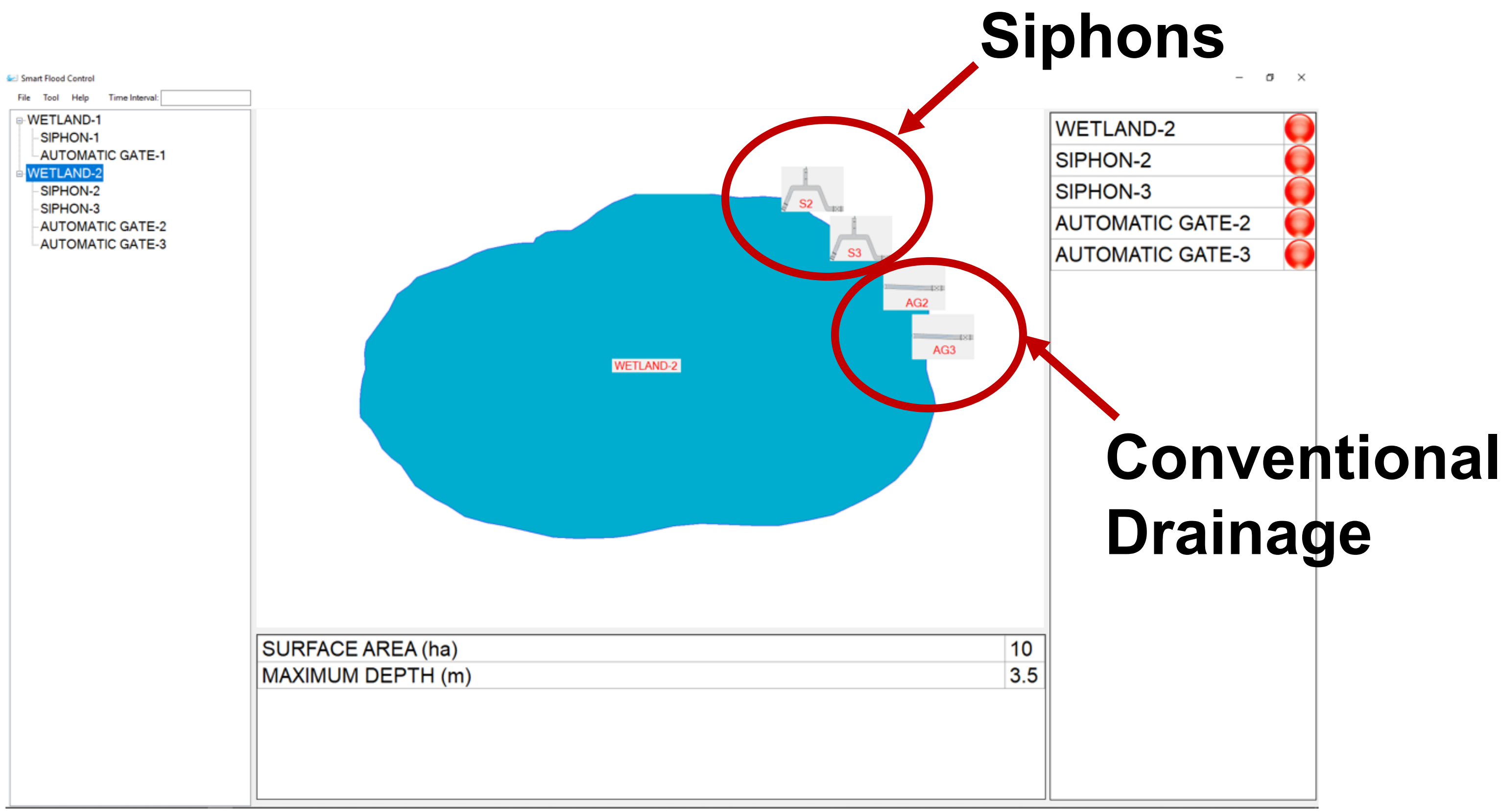
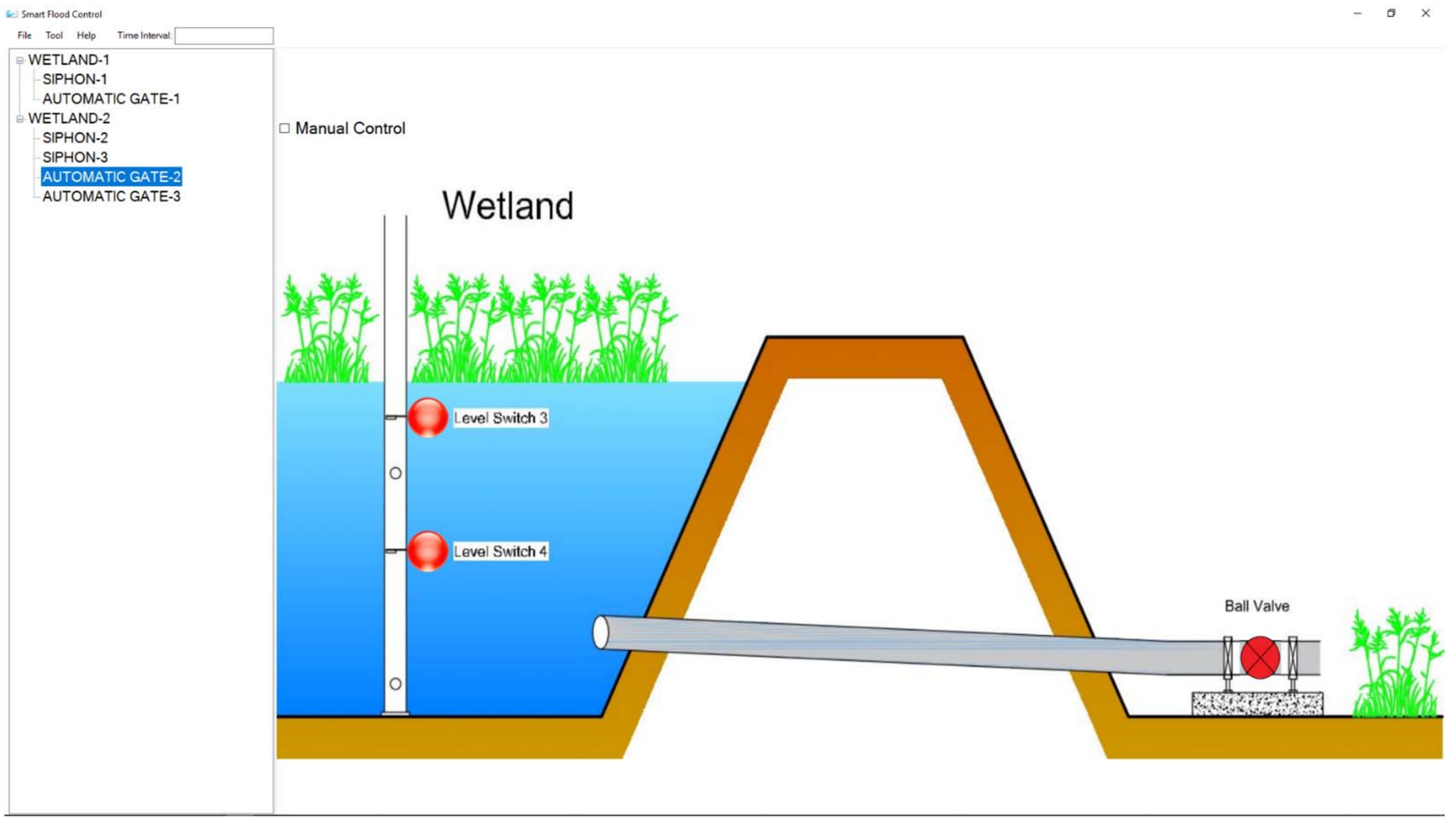
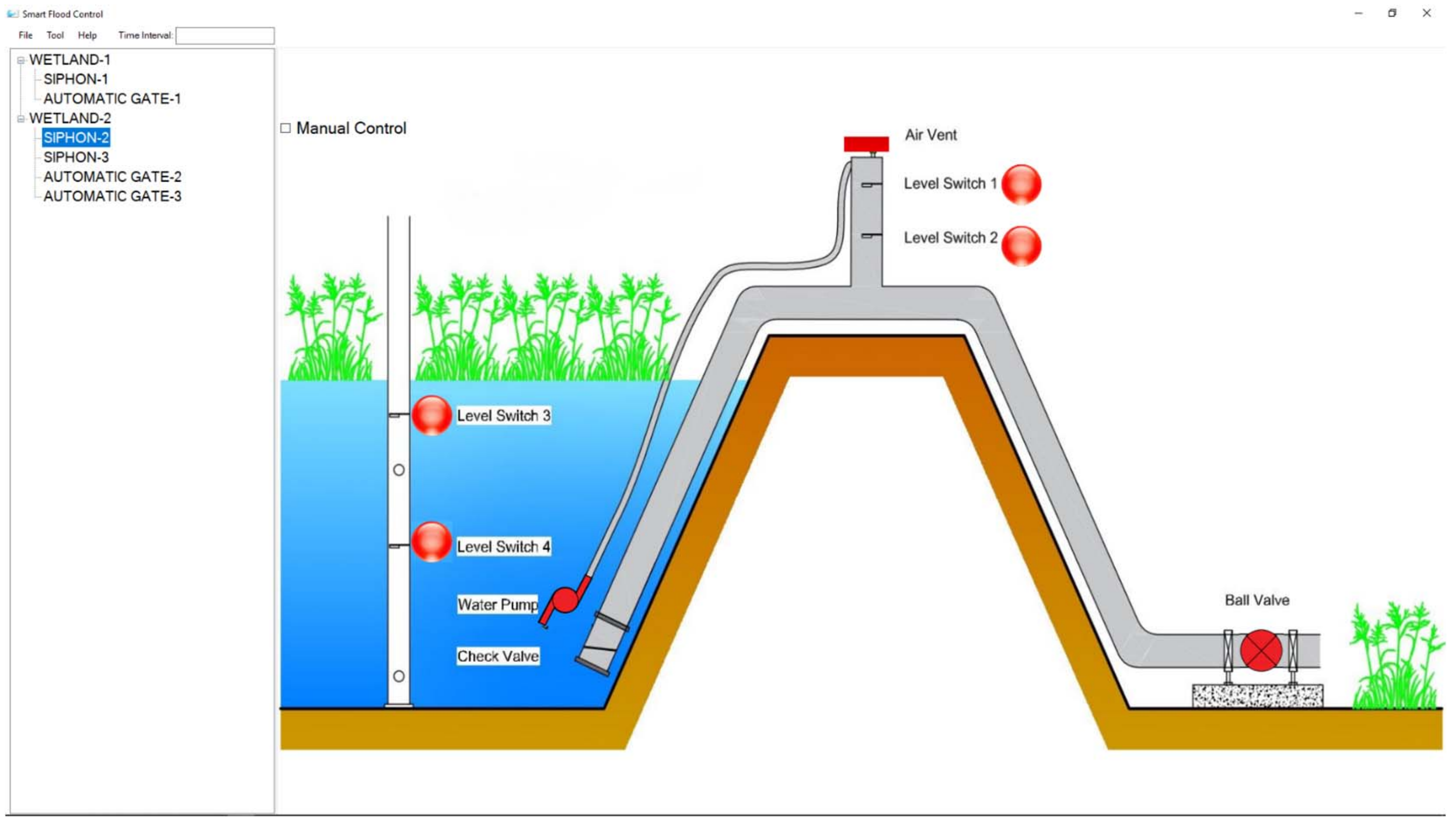


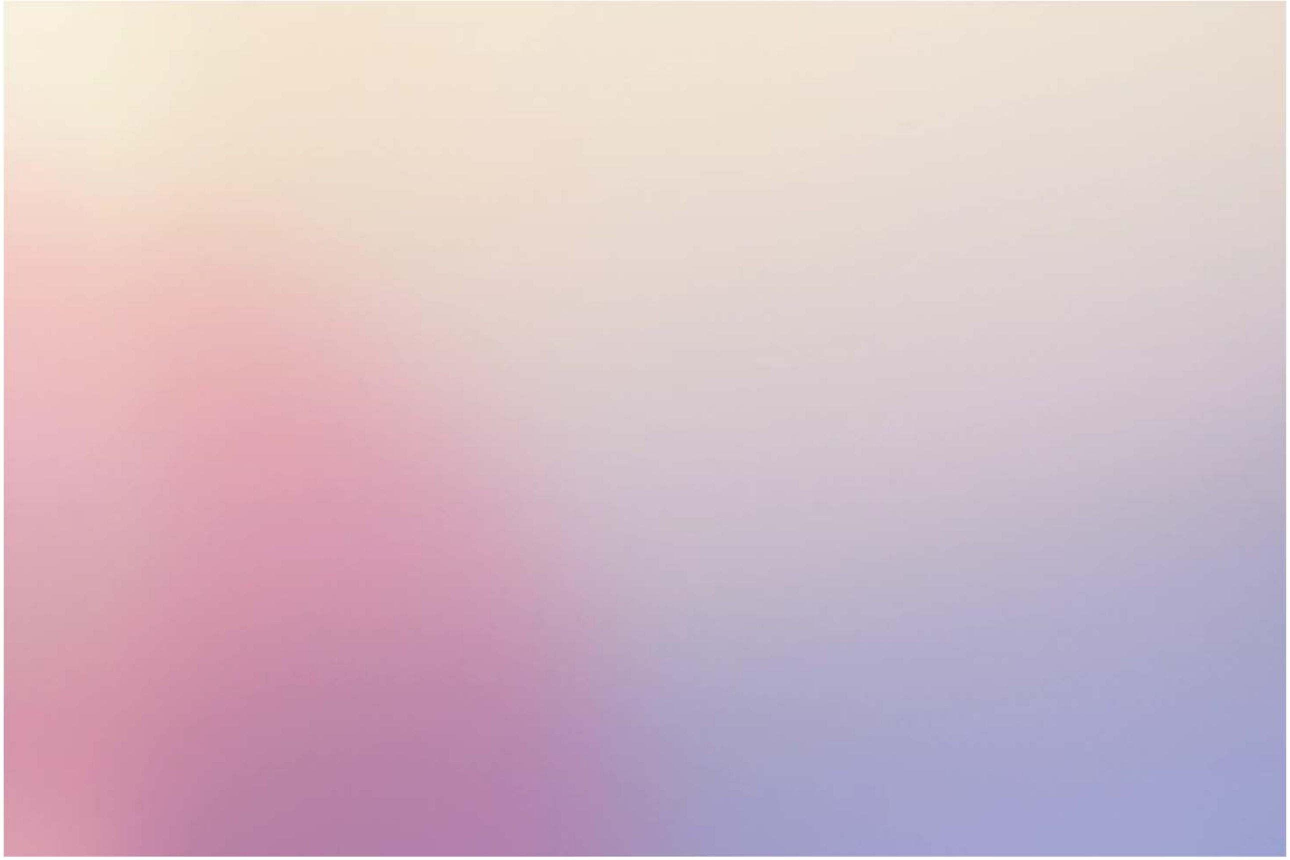
The Interface of our Control Software



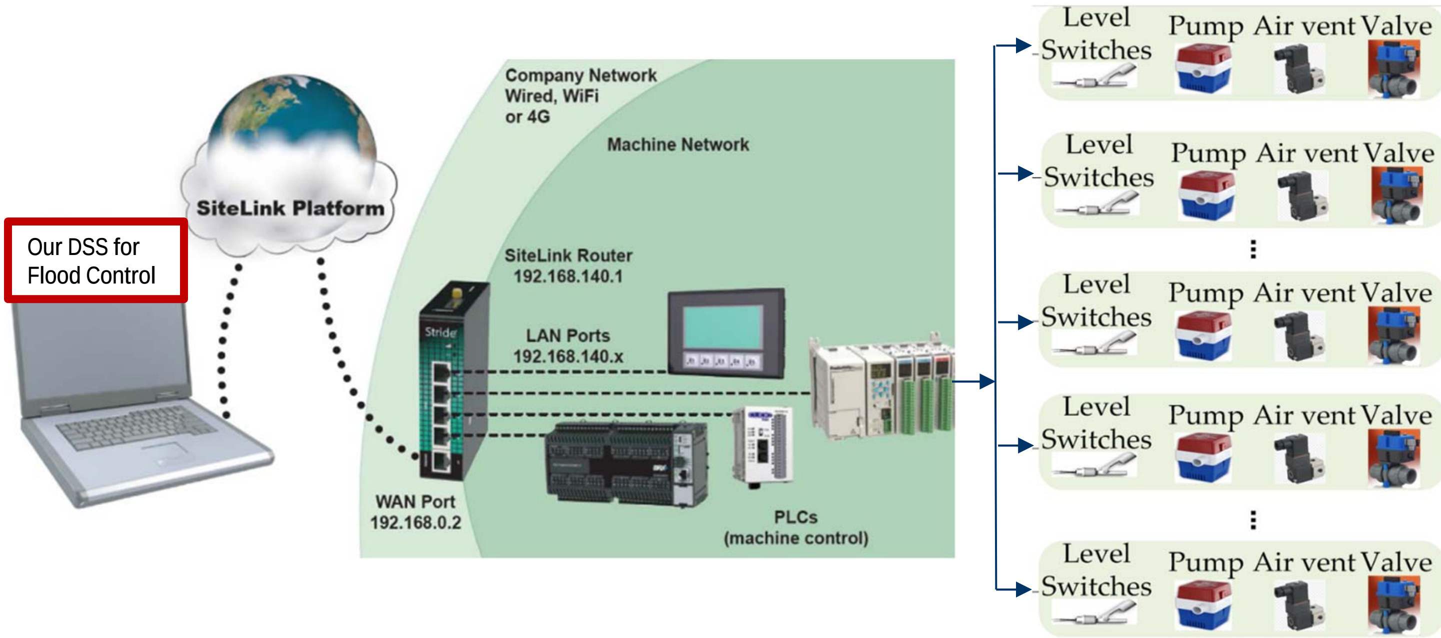
The Interface of our Control Software (Cont.)



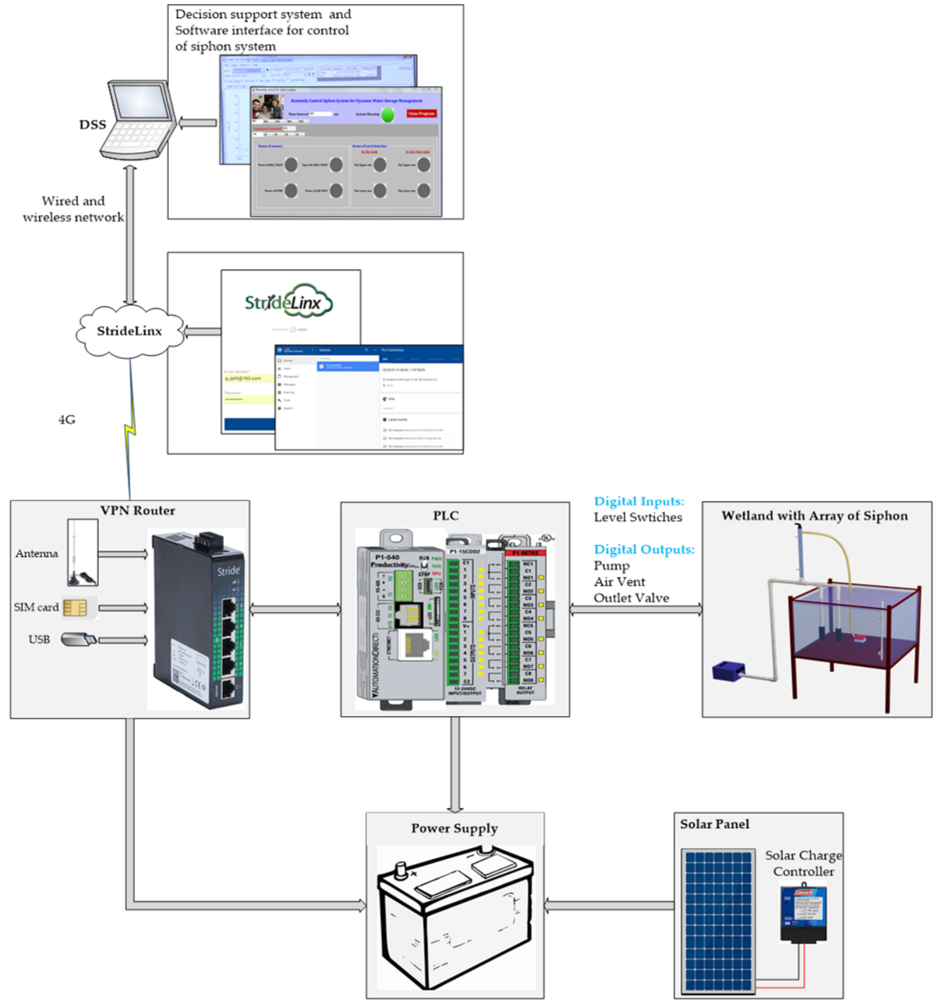
Our siphon in action



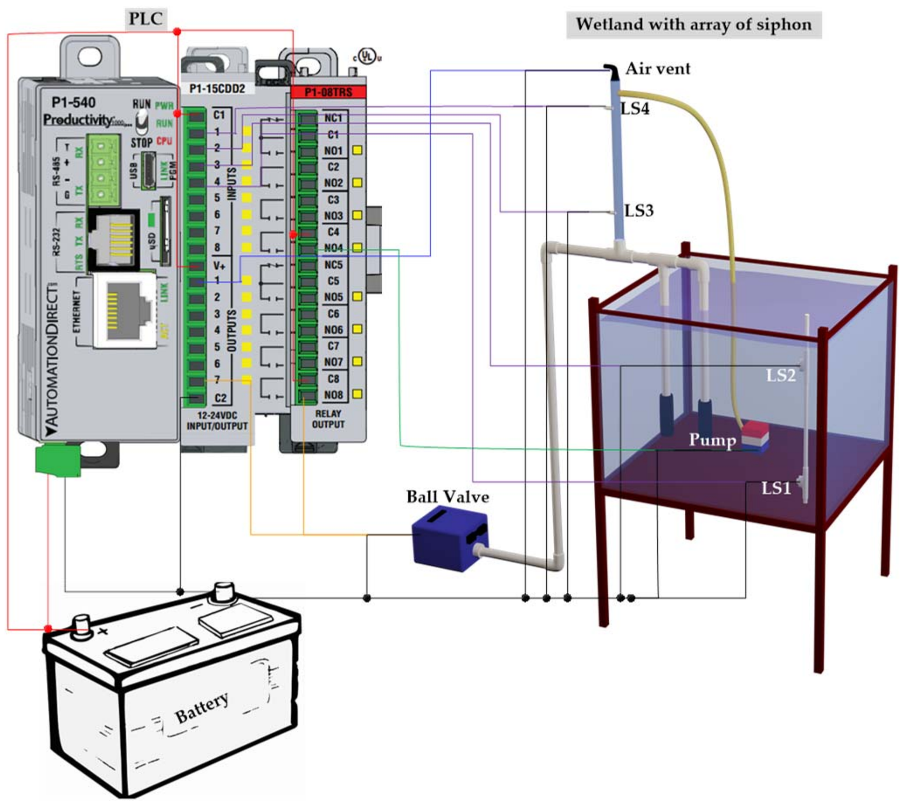
Schematic of our remotely operated siphon system

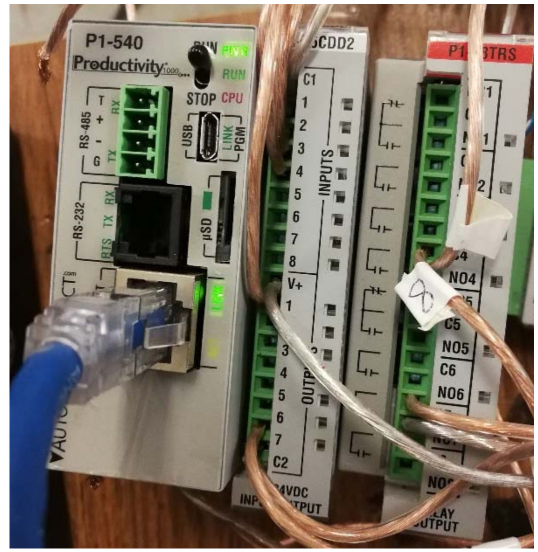


Architecture of our remotely operated hardware



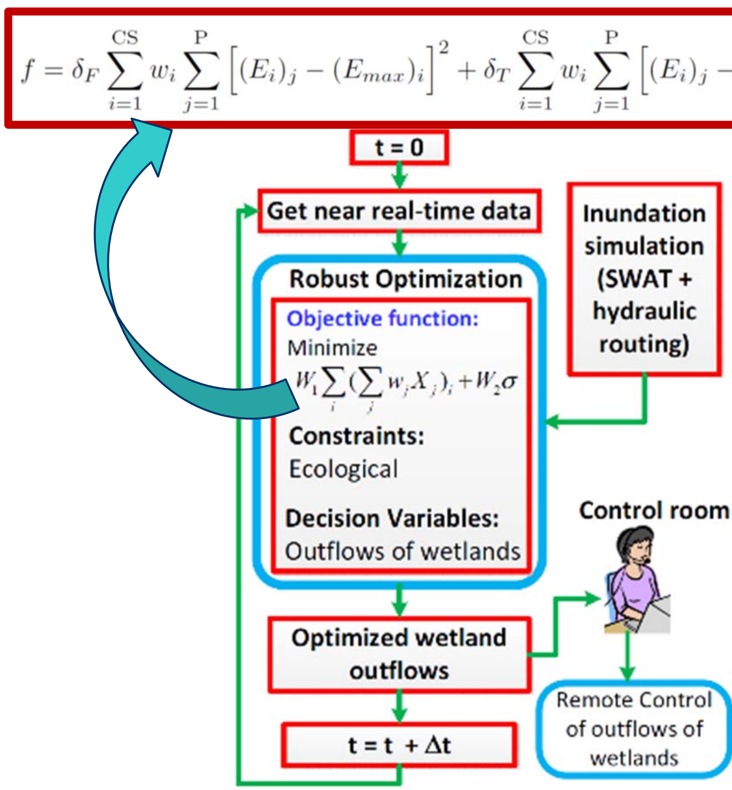
Connection between PLC, sensors and power

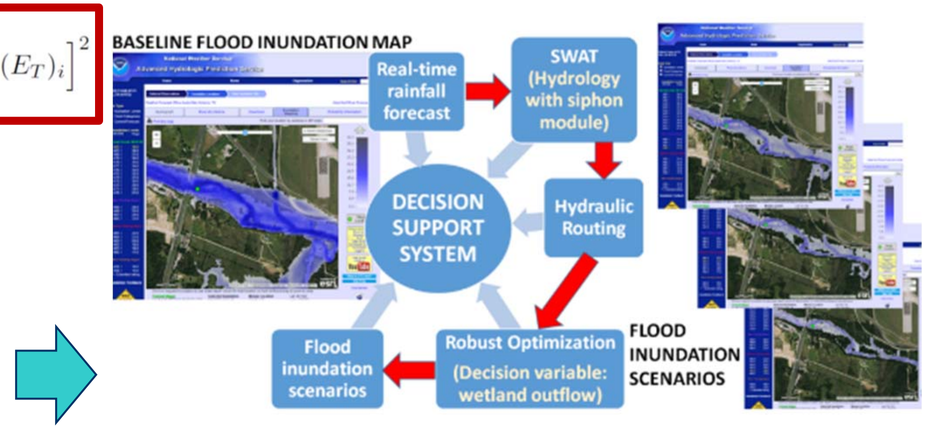


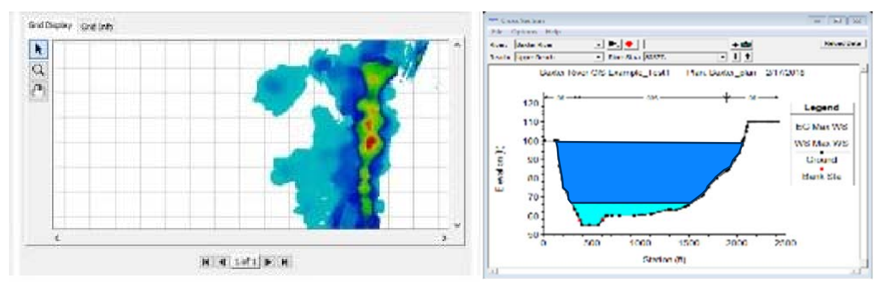


How to optimally control the water release?

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

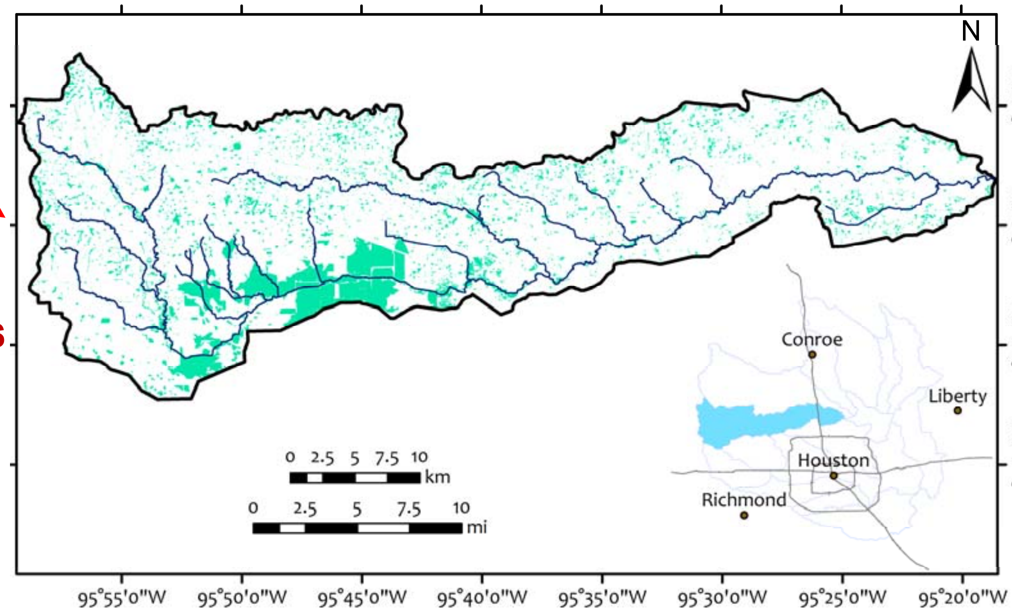
System is modular (software can be easily replaced with another) and simultaneous calculations of software

Batch_ASCIIToDSS	4/28/2019 12:38 AM	Windows Ba
ASCToDSS_Create_Names	4/28/2019 12:38 AM	PY File
UTMToASCII	4/27/2019 11:54 PM	PY File
Projection	4/27/2019 4:45 PM	PY File
WGSToUTM_Resample	4/27/2019 3:21 PM	PY File
ASCIIToRasterFinal2	4/27/2019 3:12 PM	PY File
Arturo_script	4/27/2019 2:50 PM	ArcGIS ArcM
ASCIITORaster_NEW	4/24/2019 11:30 PM	PY File
Extract_NetCDF_files	4/21/2019 5:15 PM	PY File
resample	4/21/2019 12:37 AM	PY File
ASCIIToRasterFinal	4/18/2019 1:06 AM	PY File
ASCIIToRasterFinal	4/17/2019 12:39 AM	Text Docum
ASCIIToRaster	4/17/2019 12:23 AM	PY File
Plot_optim_flow_storage_wetlands	11/30/2018 2:10 PM	PY File

Write_Python_for_Weland_Mass_balance	10/20/2018 8:29 PM
Write_Python_for_Plot_Opt_Wetl_variables	11/10/2018 7:59 PM
Wetlands_system_culverts_simulation	4/7/2018 7:13 PM
Wetlands_system_culverts_Optimization	4/14/2018 3:58 PM
Wetlands_interaction_RAS	4/23/2018 11:52 AM
Wetlands_basic_info	4/13/2018 6:17 PM
Wetland_calculations_FINAL	10/5/2018 10:09 PM
Siphon_flow_rate_calculation	8/23/2018 3:51 PM
runobjconstr_parallel	3/6/2018 7:52 PM
runobjconstr	3/5/2018 10:01 PM
Run_WriteDSS_Main_BAT_file_OLD_DELETE	10/14/2018 12:21 ...
Run_WriteDSS_Main_BAT_file	10/14/2018 12:21 ...
Run_HMS	10/7/2018 6:49 PM
Match_decision_variables_and_plot_state...	10/5/2018 8:56 PM
Main	11/30/2018 1:04 PM
gaoutfun	10/20/2018 11:12 ...
Fitness_vectorized	11/30/2018 1:11 PM

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

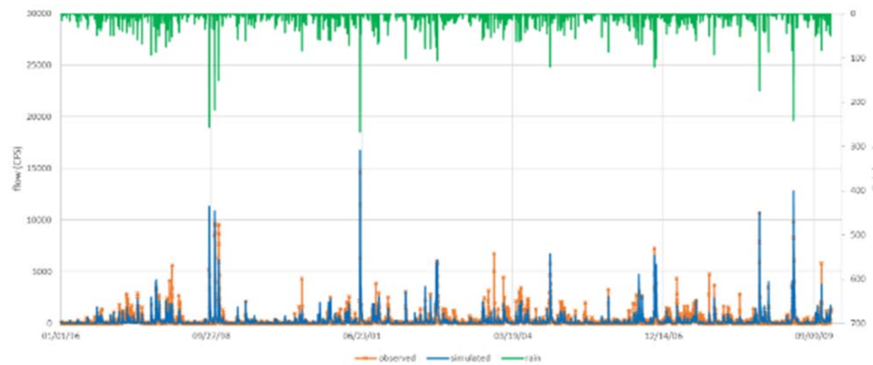
Little Cypress Creek

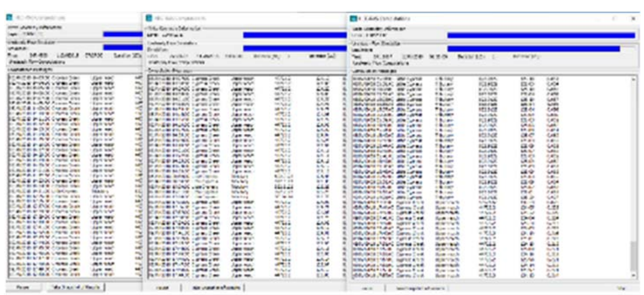


Case Study (Cont.)

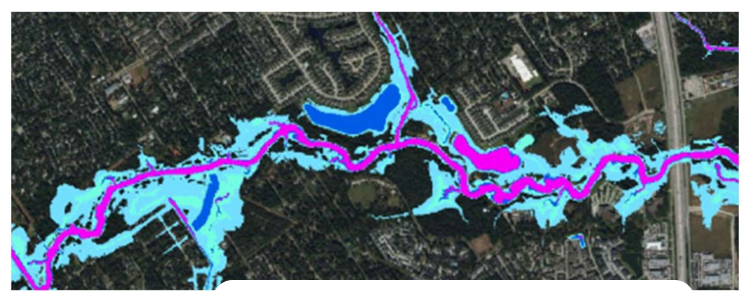
GA Optimization

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



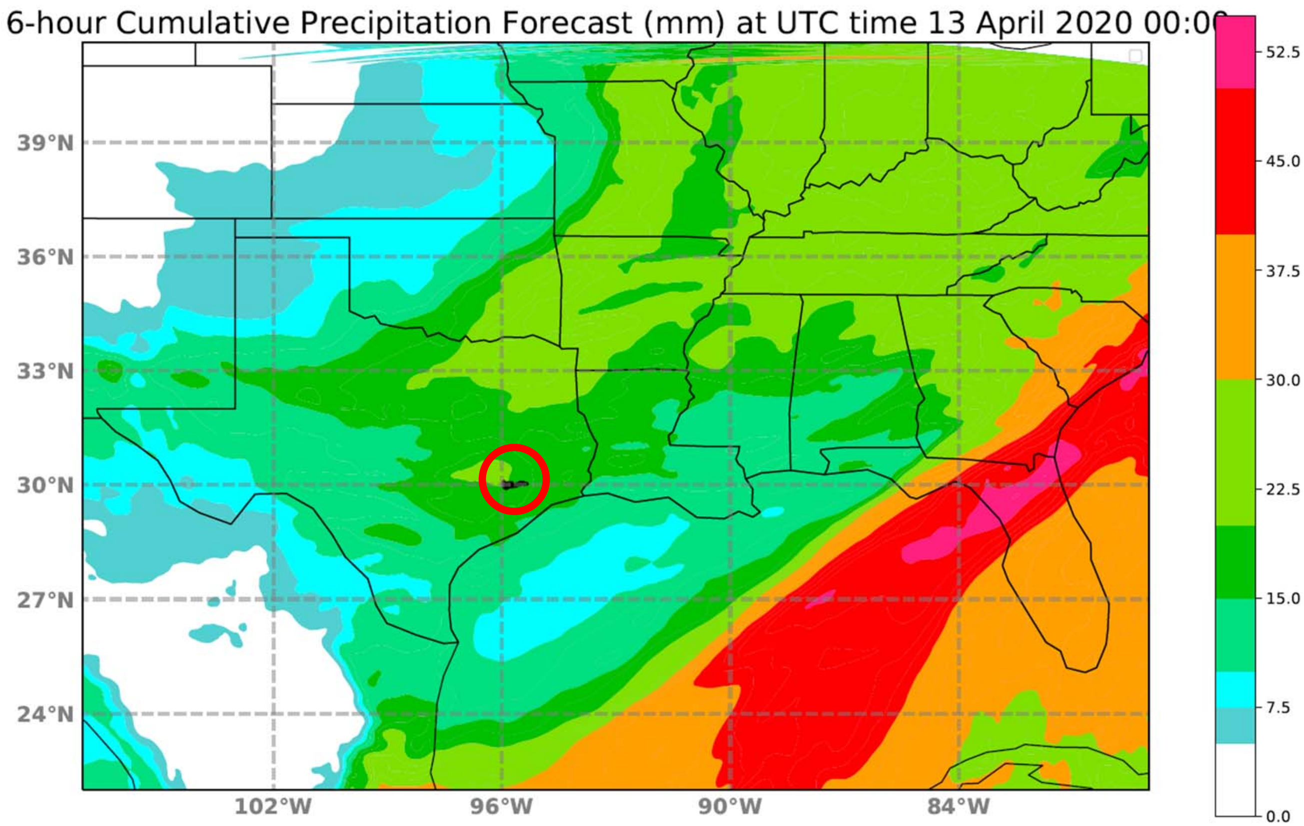


Parallel-computing

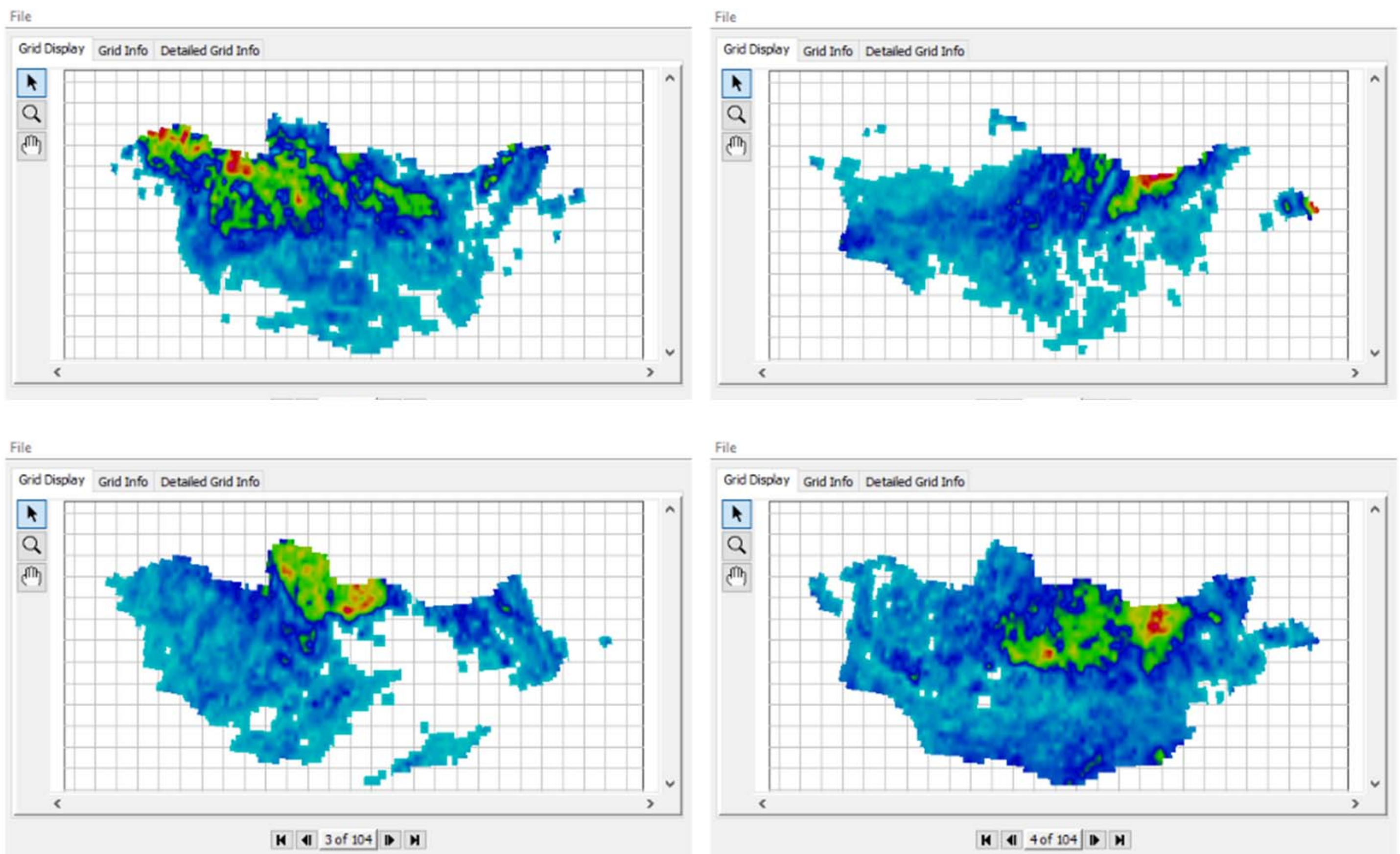


HEC-RAS, TELEMAC

Precipitable water forecast generated with our Python script

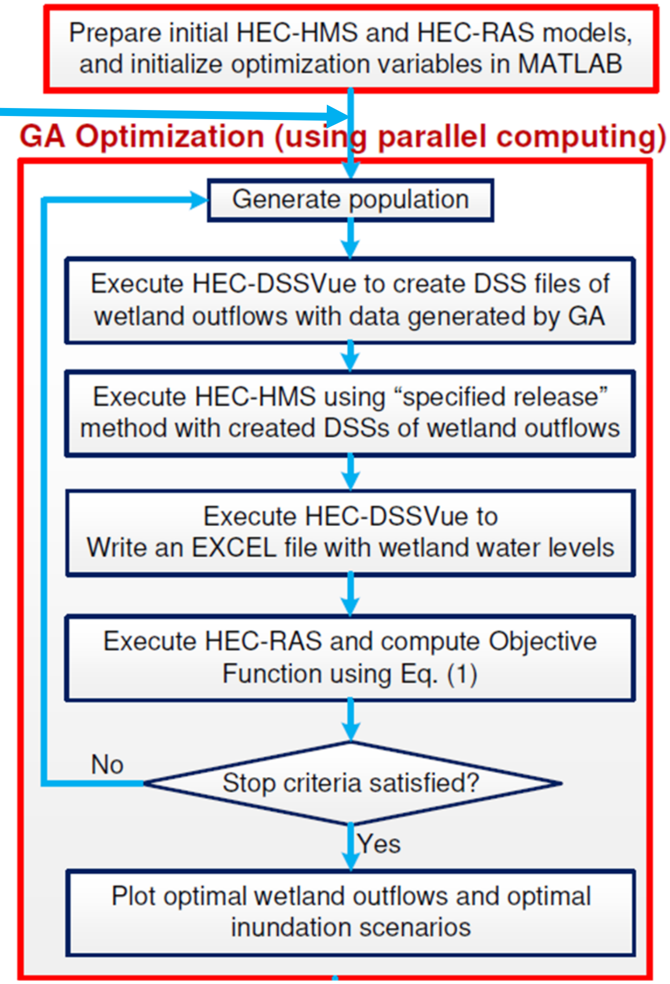


Multiple precipitation forecasts (3, 5 and 7-day)

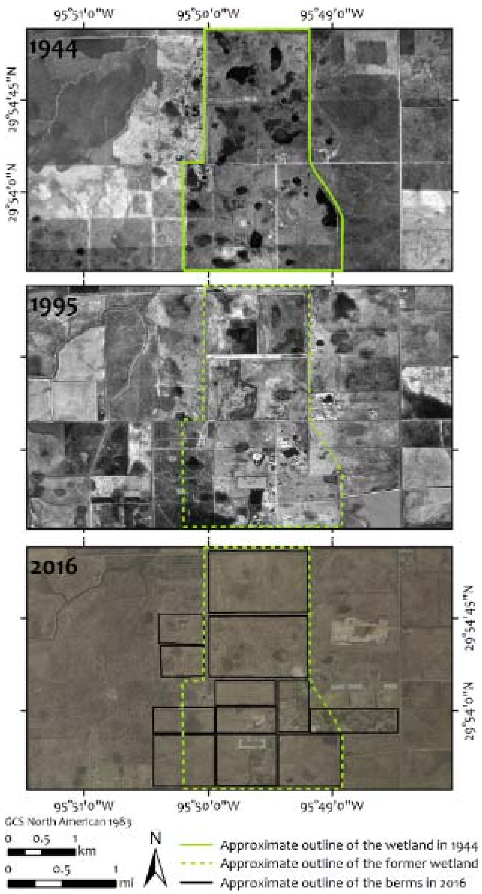


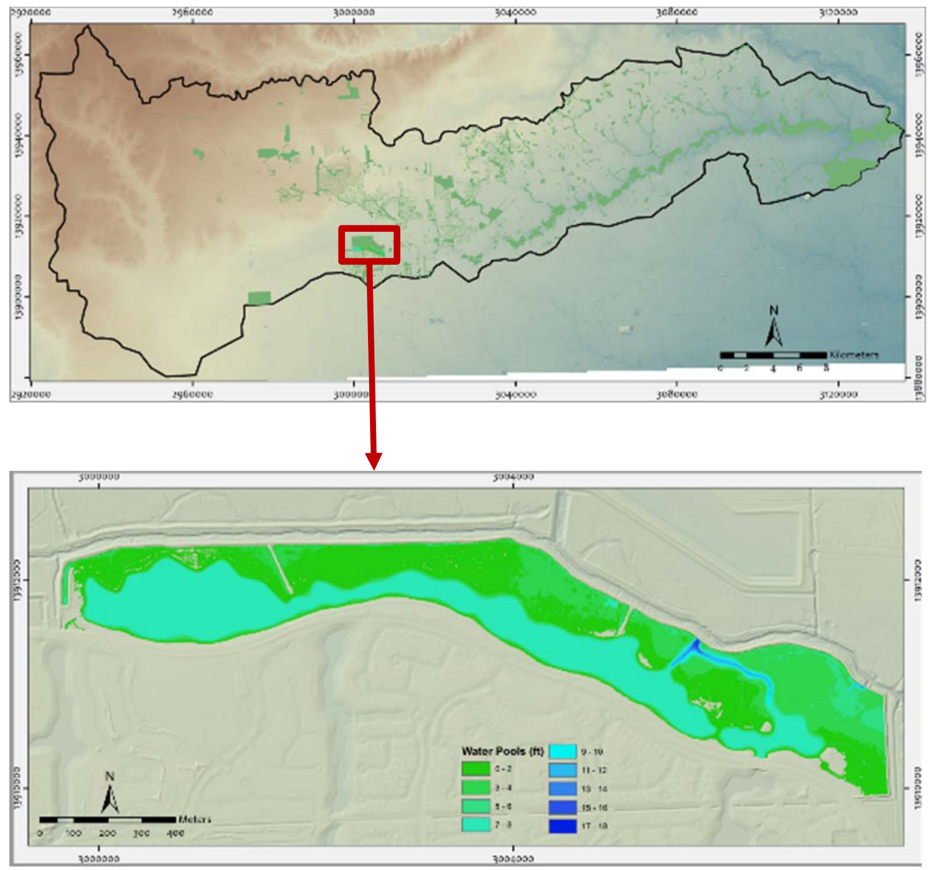
Flow chart of integrated model

Updated forecast precipitation (3, 5 or 7 days lead time), projection and resample data to HEC-HMS grid, conversion to HEC-DSS

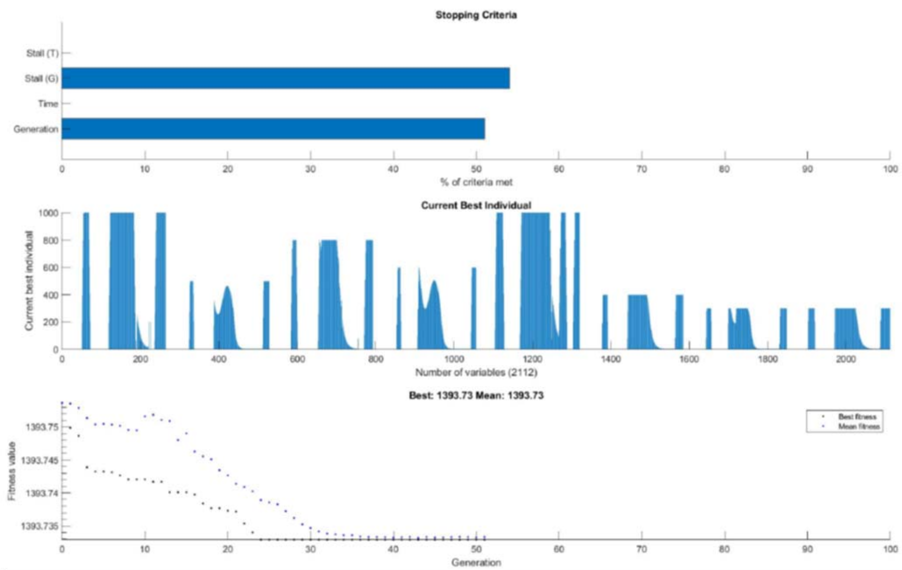


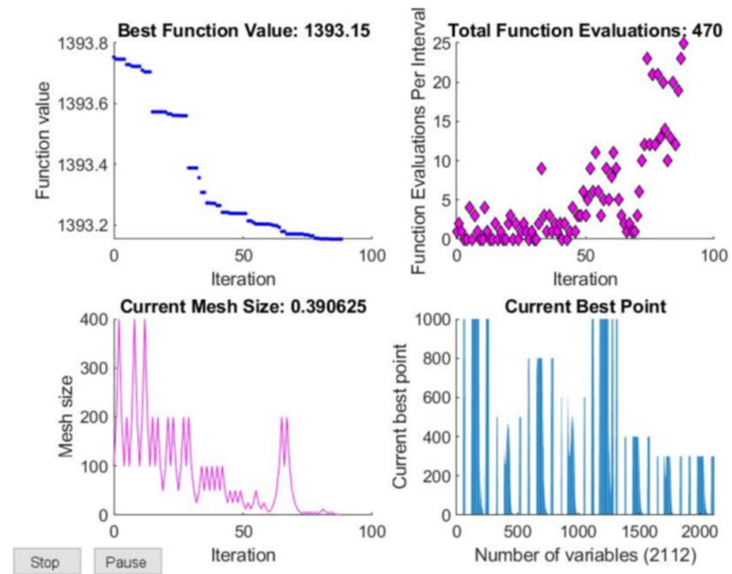
Engineering wetlands for flood control in Little Cypress Creek, Texas



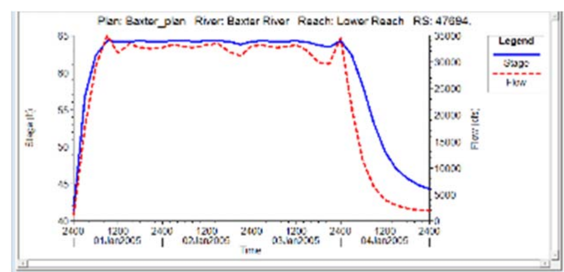


GA and PS typical convergence process for optimal schedule of storage outflows

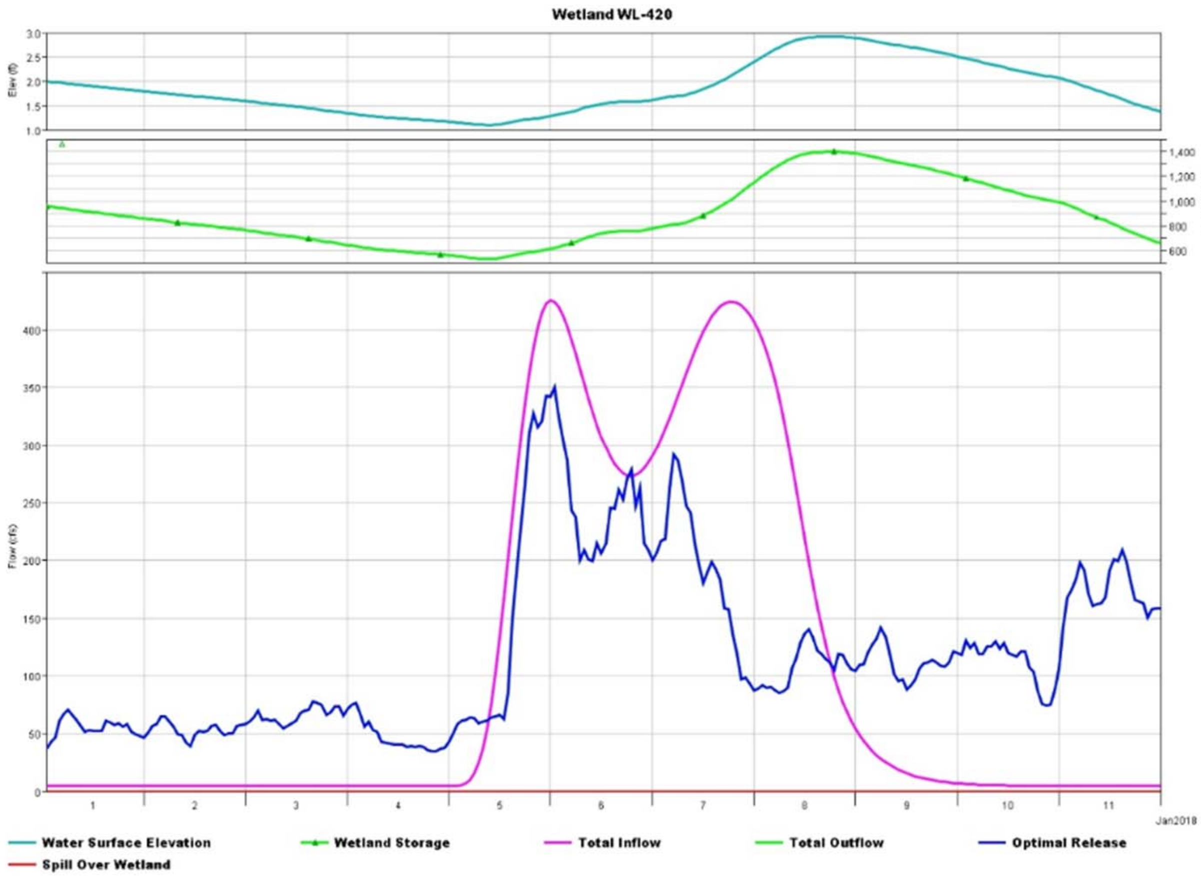




Flow and discharge at control section

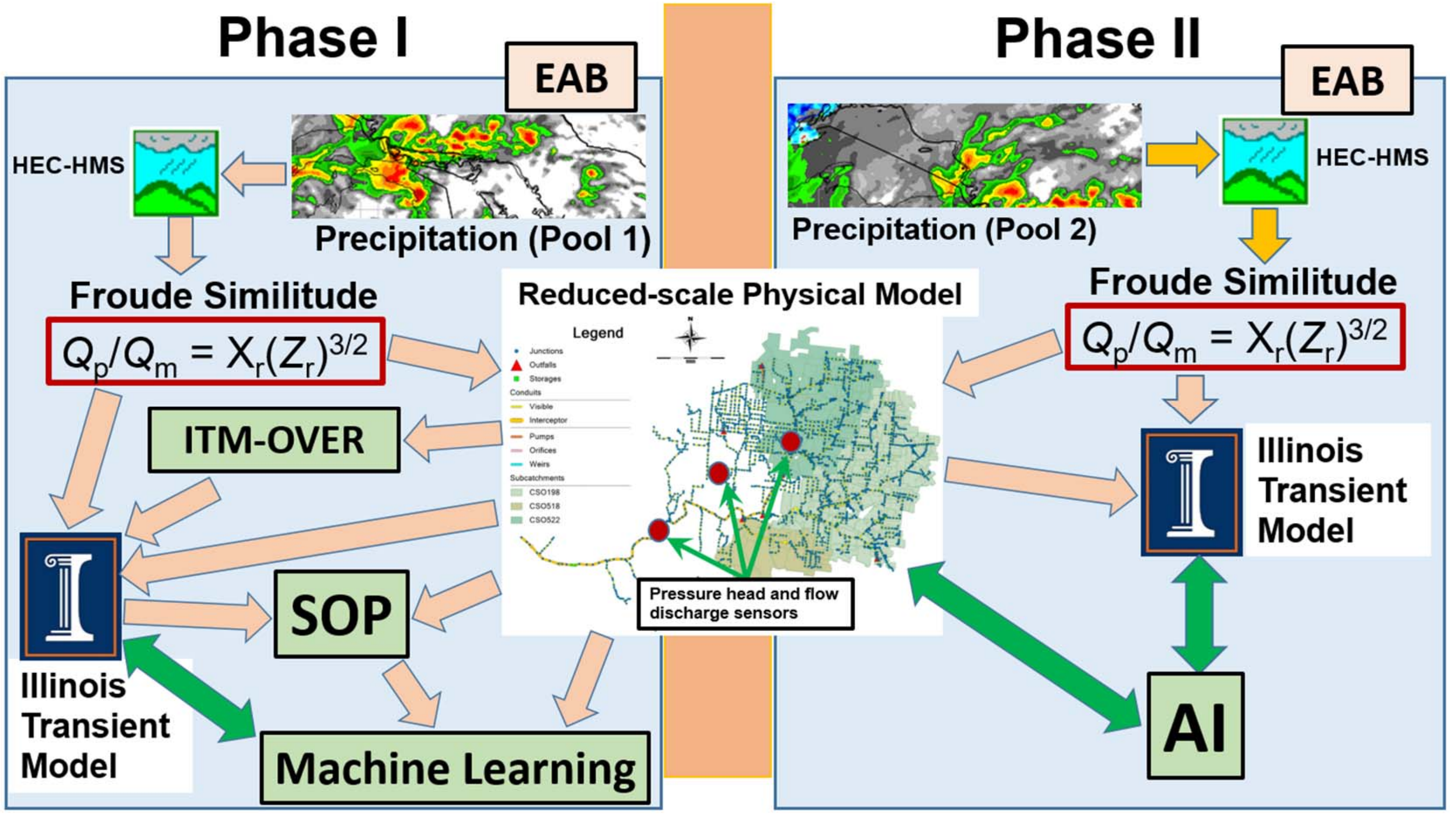


Typical optimization results of DSS:



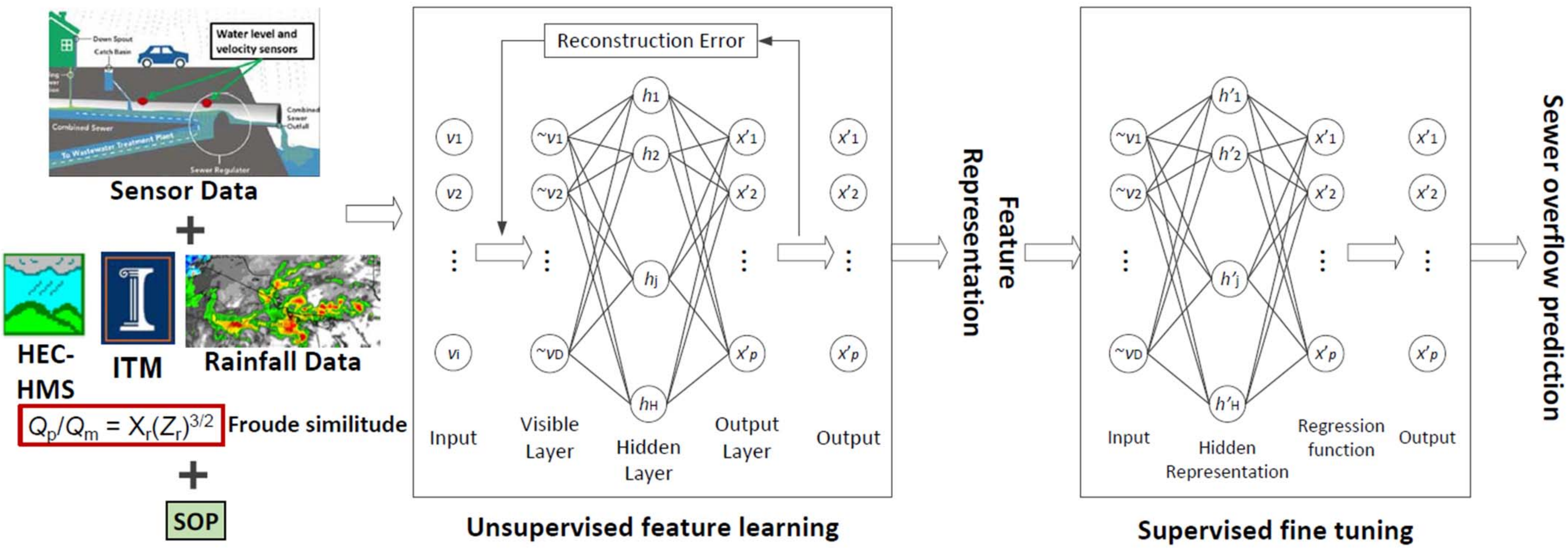
Current work

Artificial Intelligence for Much Faster Results



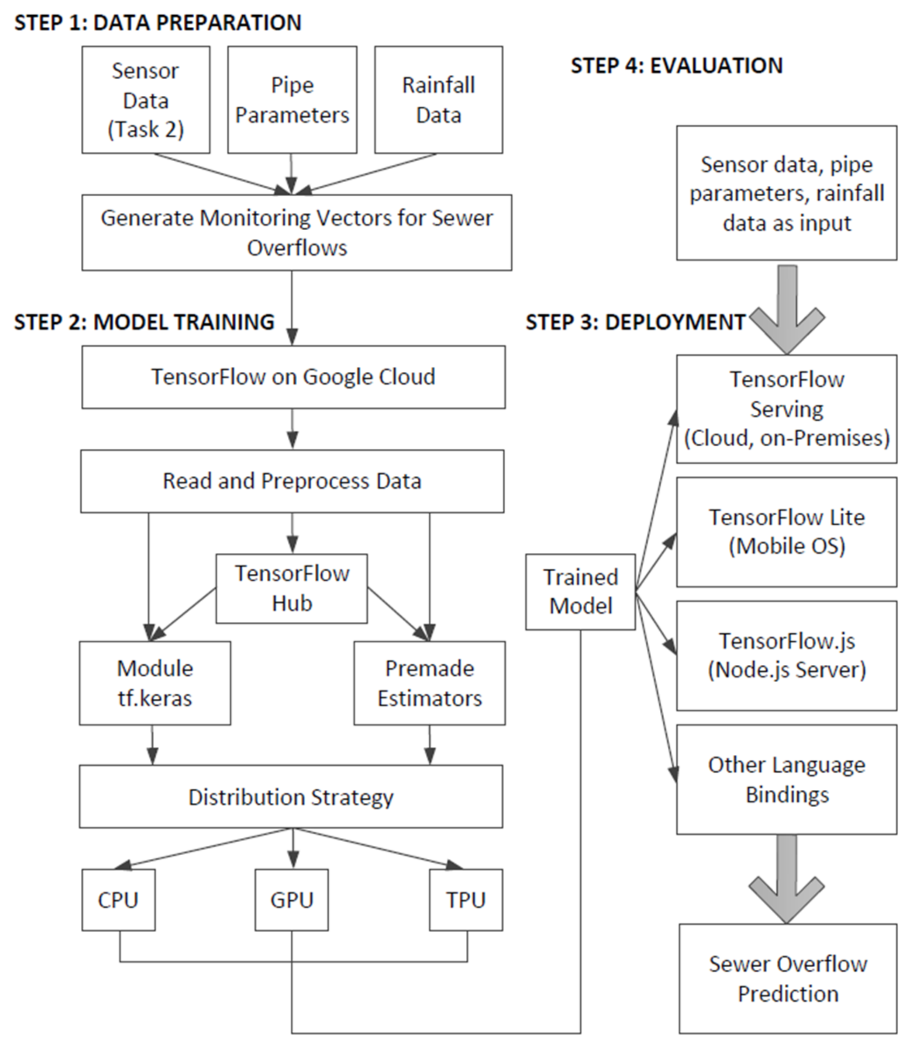
Current work (Cont.)

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

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Research website: https://web.eng.fiu.edu/arleon/index.html

Email: arleon@fiu.edu

THANK YOU FOR YOUR ATTENTION!

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