

H&H Modeling vs. ML Modeling

<p>H&H modeling</p> <p style="text-align: center;"> </p> <p>Rules are defined in modeling software and by importing Input, the Output is computed</p>	<p>Examples</p> <p>Input </p> <p>Rules</p> $Q = 1.48 \left[\frac{1.49}{1.48} \right]^{0.58} A R^{0.78} S^{0.48}$ $S = \frac{24800}{Q} - 254$ <p>Output </p>
<p>ML modeling</p> <p style="text-align: center;"> </p> <p>Input and Output are available (Observations) and through machine learning process Rules are explored</p>	

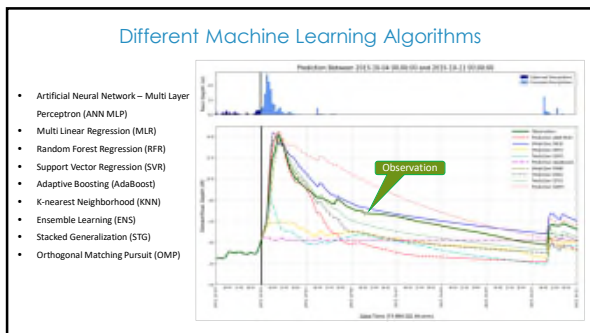
Traditional H&H Models for Forecasting

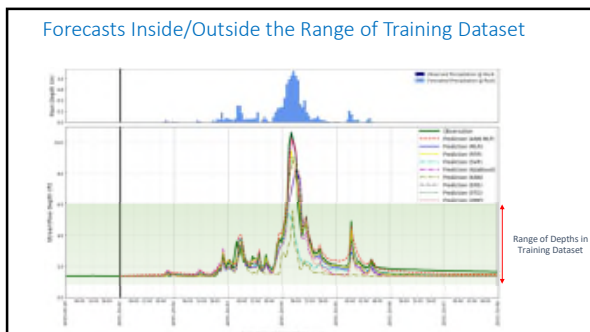
Machine Learning Models

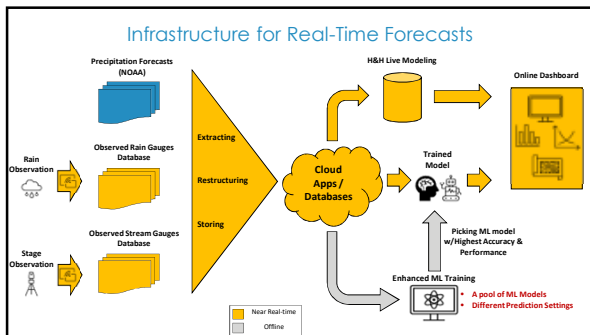
Arthur Samuel (1959) - "A field of study that gives the computers the ability to learn without being explicitly programmed"

- Machine learning provides the capability of **identifying the patterns** in massive noisy datasets with an accuracy that usually exceeds that of human domain experts.
- Machine learning models are very good at **capturing correlations and finding relationships** between input and output.

-W-







Why is Live Modeling Compelling?

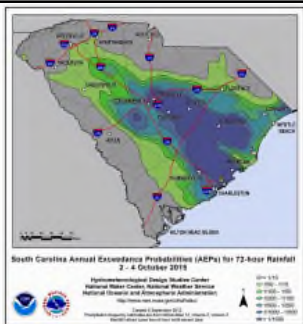
- Short term predictions
- Short term resource allocations
- Higher confidence level
- Cross coordination across departments
 - EMD
 - Public Works
 - Resiliency
 - Transportation
 - Fire and Rescue
 - Law Enforcement
- Timely public notifications
- Worst case scenarios



W

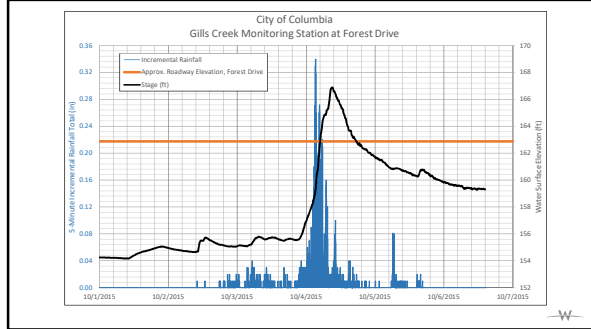
October 2015

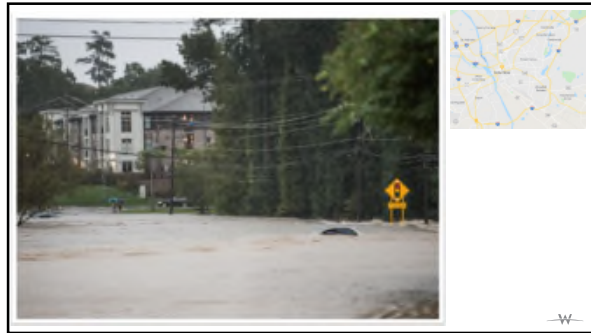


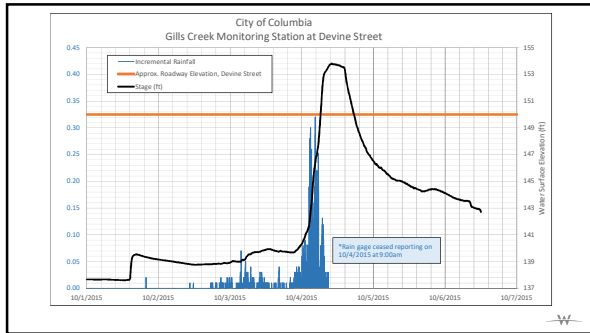


W

Gauge Name	Rainfall (Inches)									
	Total	1 Hour	2 Hours	3 Hours	6 Hours	12 Hours	24 Hours	2 Days	3 Days	4 Days
KCAC	11.46	1.56	2.83	3.80	5.06	7.23	8.98	10.79	11.26	11.66
KCOR	12.45	1.97	3.19	4.49	6.43	8.68	9.71	11.79	12.40	12.45
KMMT	11.47	2.41	4.38	6.75	8.23	8.66	10.20	11.08	11.37	11.46
Tribe to Rocky Branch	11.30	1.97	2.88	4.17	5.96	7.73	8.83	10.57	11.27	11.30
Columbia-OLA_RG	16.30	2.88	5.05	7.15	9.05	12.04	13.47	15.28	16.18	16.30
Columbia-OLB_RG	13.84	2.77	4.69	6.73	8.34	11.46	12.33	13.62	13.84	13.84
Columbia-OLC_RG	10.88	2.14	3.20	4.60	6.58	8.37	9.17	10.63	10.88	10.88
Columbia-RocA_RG	13.63	1.17	2.28	3.30	4.12	6.63	10.10	12.58	13.48	13.63
Columbia-RocB_RG	12.39	2.59	3.62	4.95	6.00	6.54	9.74	11.68	12.28	12.39
Columbia-Roc_CG	14.62	1.99	3.10	4.20	7.06	9.31	10.69	12.69	13.40	13.64
Columbia-SmiB_RG	14.58	2.39	3.79	5.41	7.02	10.19	11.69	13.72	14.50	14.58
PR005	14.63	2.28	4.08	5.82	6.57	10.87	12.12	13.88	14.51	14.63
PR005	13.32	1.80	2.84	4.29	6.46	8.64	9.91	11.86	12.38	12.82
PR003	11.97	2.12	3.04	4.35	6.09	8.04	9.23	11.14	11.87	11.97
PR004	12.95	2.08	3.27	4.80	6.32	8.34	10.30	12.18	12.81	12.95
PR001	13.81	2.46	4.29	6.02	7.87	10.06	11.96	13.38	13.80	13.81
PR007	14.11	2.39	3.97	4.88	7.36	10.13	11.77	13.64	14.05	14.10
PR002	15.43	2.78	4.85	6.60	9.18	11.31	12.71	14.62	15.42	15.43



















October 2015

20+ inches of rain on coast and central SC

20 USGS gauge stations exceeded record flood stage

19 fatalities

- 9 in Richland County
- Primarily trapped in vehicles swept into high water

410 Roads and bridges closed

- 71 miles of I-95
- I-20 Broad River Bridge
- I-126 Broad River Bridge
- I-26 Sakuda River Bridge

36 Regulated dam failures

100+ Non-regulated dam failures

1,500+ Water rescues

The cover of a report titled "The Historic South Carolina Floods of October 1-5, 2015" by the Army Engineer. It features a photograph of a flooded road and the U.S. Department of Commerce logo. A small 'W' logo is in the bottom right corner.

How Could We Have Known?


US Army Corps Report 1988

- Special Project Storm 15-in, 24-HR
- Predicted flood elevations within 6-in
- Predicted which dams would breach
- Suggested Projects
- Collecting dust

The cover of a report titled "INTERIM REVIEW OF REPORT SANTEE RIVER-SOUTH CAROLINA DRAFT GILLS CREEK FLOOD CONTROL FEASIBILITY STUDY" dated July 1988. It features a photograph of a person wading in a flooded area. A small 'W' logo is in the bottom right corner.

With Live Modeling

- Hazard notifications
 - Reverse 911
 - TV alerts
 - Cell phone alerts
 - Door to door
 - Local and State government web sites
- Evacuations in Flood Zone
- Evacuations below at-risk dams
- Road closures
- Shelters set up
- Government personnel on call
- Equipment and personnel staging
- Sand bags
- Etc., etc....



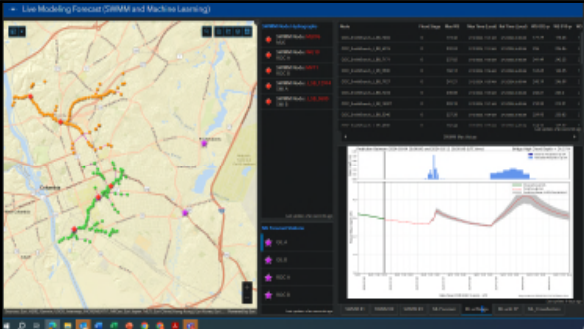
W

City of Columbia

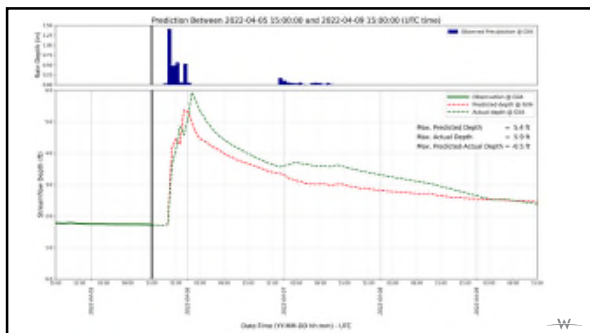
Live Model Dashboard

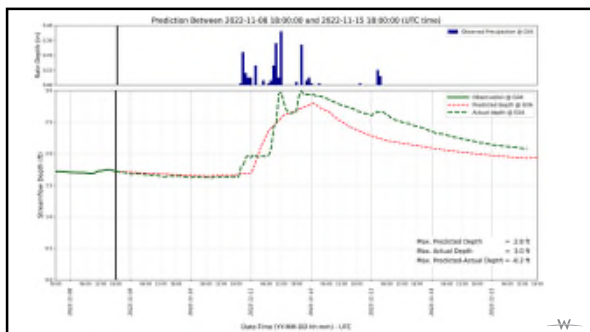
W

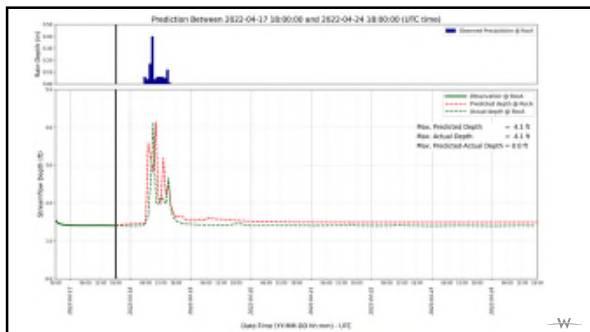
Live Modeling Forecast (MIEM and Machine Learning)



W

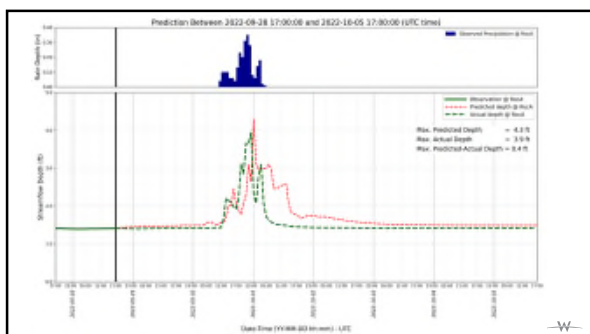


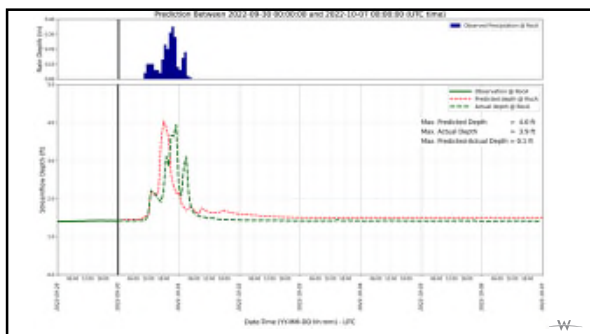


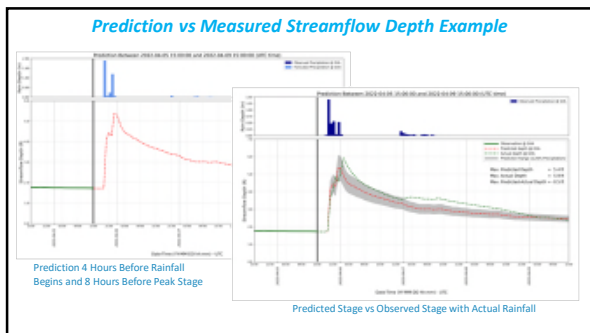


Hurricane IAN

Prediction vs Observed

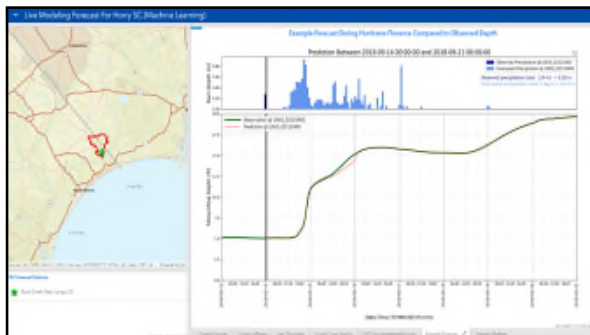


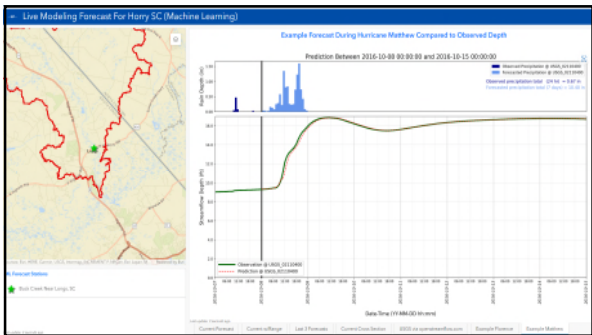


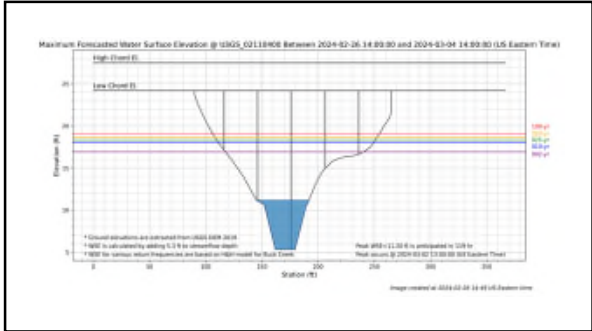


Horry County

—W—







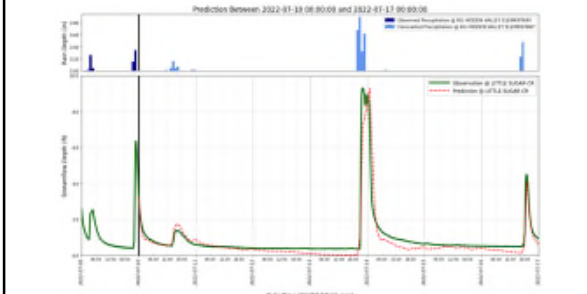
Mecklenburg County
Little Sugar Creek Example

ML Model Example - 6535: LITTLE SUGAR CREEK at 36th STREET

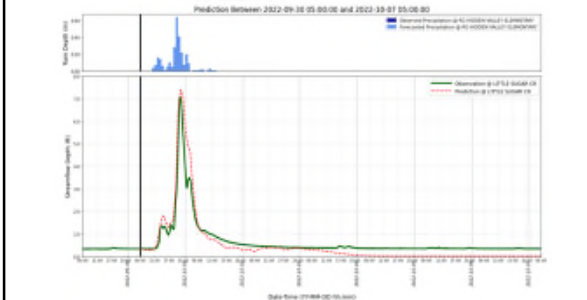


Rain Gauge(s) - 1
Stream Gauge(s) - 1
Training Dataset:
2013 to 2021
Validation Dataset:
2022
ML Model (selected):
Artificial Neural Network

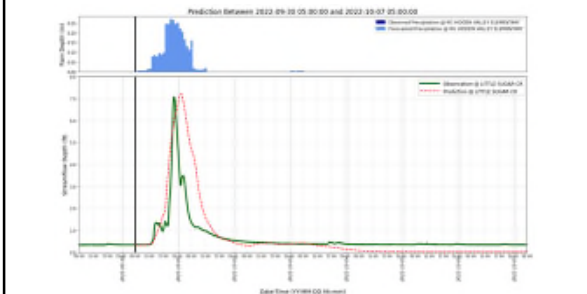
Machine Learning Model Validation - July 13, 2022 (Gauge Rainfall)



Machine Learning Model Validation - Hurricane Ian (Gauge Rainfall)



Machine Learning Model - Hurricane Ian (NBM Forecasted Rainfall)



Adaptive (or Dynamic) Outlet Control

- Optimize discharges based on real-time data and near real-time rainfall forecasts.

