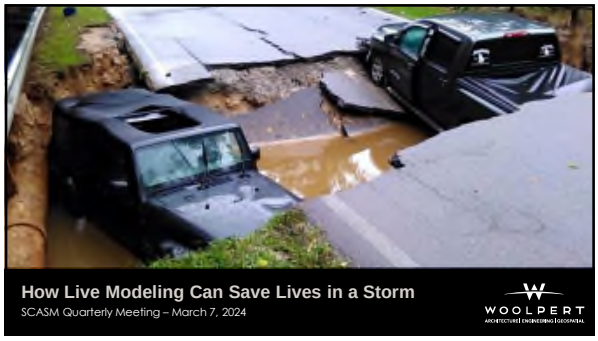
The information provided here is for informational and educational purposes and current as of the date of publication. The information is not a substitute for legal advice and does not necessarily reflect the opinion or policy position of the Municipal Association of South Carolina.
Consult your attorney for advice concerning specific situations.

3/11/2024



What is Live Modeling?

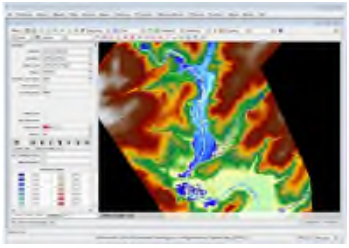
What is Live Modeling?

Traditional Modeling

- Historically statistically based
- Design Storms (e.g. 25-YR, 24-Hr, Type II)
- Physically based algorithms
- Predictions based on interpolation

Live Modeling

- Near Real Time
- Short term forecasting
- Adaptive
  - Measurements
  - Updated forecasting



H&H Modeling vs. ML Modeling

H&H modeling

Input → Rules → Output

Rules are defined in modeling software and by importing **Input**, the **Output** is computed

ML modeling

Input → Rules → Output

Input and **Output** are available (Observations) and through machine learning process **Rules** are explored

Examples

Input

Rules

Output

Traditional H&H Models for Forecasting

XPSWMM, HEC-RAS, EPA SWMM, HEC-HMS, InfoWorks, PCSWMM

H&H Modeling

Outflow, WSE, Velocity

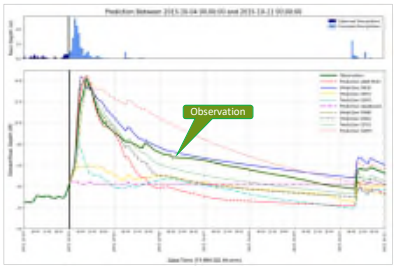
Machine Learning Models

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

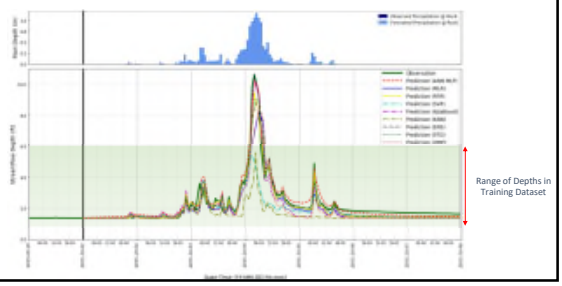
- Machine learning provides the capability of identifying the patterns in massive noisy datasets with an accuracy that usually exceeds that of human domain experts.
- Machine learning models are very good at capturing correlations and finding relationships between input and output.

Different Machine Learning Algorithms

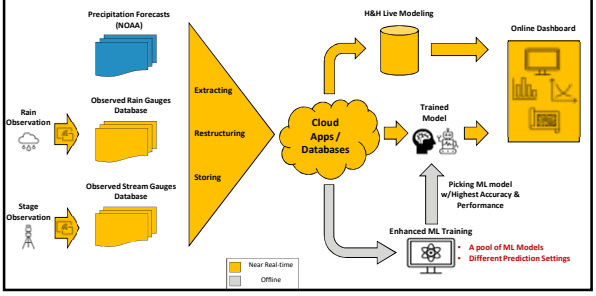
- Artificial Neural Network – Multi Layer Perceptron (ANN MLP)
- Multi Linear Regression (MLR)
- Random Forest Regression (RFR)
- Support Vector Regression (SVR)
- Adaptive Boosting (AdaBoost)
- K-nearest Neighborhood (KNN)
- Ensemble Learning (ENS)
- Stacked Generalization (STG)
- Orthogonal Matching Pursuit (OMP)



Forecasts Inside/Outside the Range of Training Dataset

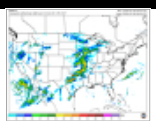


Infrastructure for Real-Time Forecasts

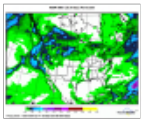


NOAA Datasets – GRIB Processing

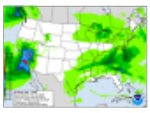
QPE - Multi-Radar / Multi- Sensor (2-mins)



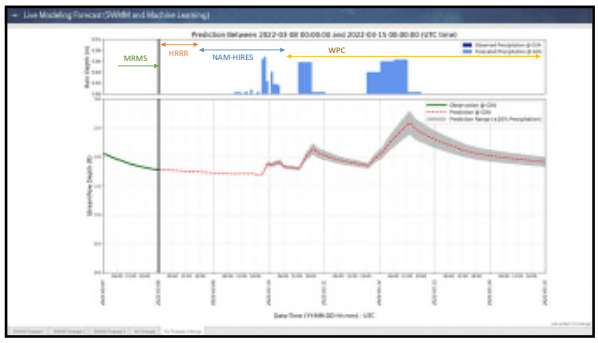
QPF – HRRR (Hourly)



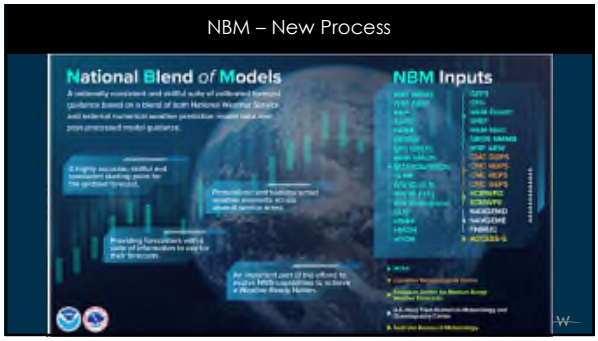
QPF – NAM HiRES (6 hrs)



QPF – WPC (6 or 12 hr)



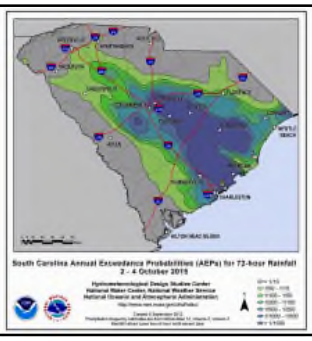
NBM – New Process



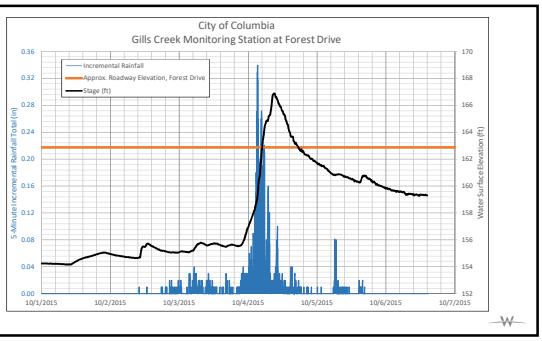
Why is Live Modeling Compelling?

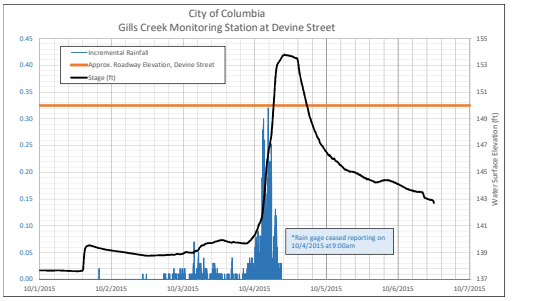
- Short term predictions
- Short term resource allocations
- Higher confidence level
- Cross coordination across departments
  - EMD
  - Public Works
  - Resiliency
  - Transportation
  - Fire and Rescue
  - Law Enforcement
- Timely public notifications
- Worst case scenarios

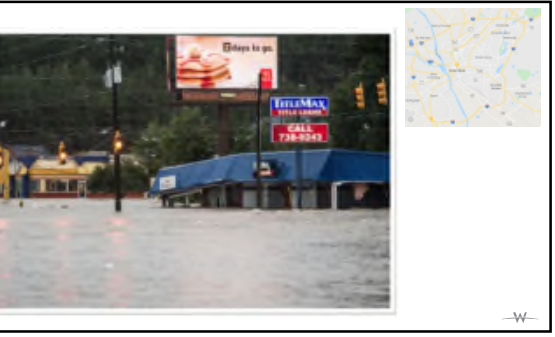
October 2015

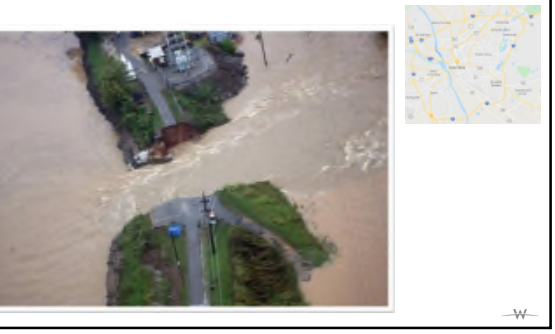


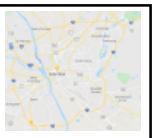
Gauge Name	Rainfall (Inches) Total	1 Hour	2 Hours	3 Hours	6 Hours	12 Hours	24 Hours	2 Days	3 Days	4 Days
KCAE	11.46	1.56	2.83	3.60	5.46	7.33	8.68	10.75	11.35	11.46
KCLB	12.45	1.67	3.16	4.49	6.43	8.48	9.71	11.79	12.40	12.45
KMMT	11.47	2.41	4.36	6.75	8.23	8.66	10.20	11.08	11.37	11.46
Trib to Rocky_Branch	11.30	1.87	2.86	4.17	5.96	7.73	8.83	10.57	11.27	11.30
Columbia-GILA_RG	16.20	2.88	5.05	7.15	9.82	12.04	13.47	15.28	16.18	16.20
Columbia-GILB_RG	13.84	2.77	4.69	6.73	9.34	11.46	12.33	13.82	13.84	13.84
Columbia-GILC_RG	10.88	2.14	3.20	4.60	6.58	8.37	9.17	10.83	10.88	10.88
Columbia-RocA_RG	13.63	1.17	2.26	3.30	6.12	8.63	10.10	12.58	13.49	13.63
Columbia-RocB_RG	12.39	2.59	3.62	4.95	6.60	8.54	9.74	11.66	12.26	12.39
Columbia-Kin_RG	14.65	1.99	3.10	4.70	7.06	9.31	10.69	12.69	13.42	13.94
Columbia-SmiB-RG	14.58	2.39	3.72	5.41	7.92	10.18	11.69	13.72	14.50	14.58
PRG06	14.63	2.28	4.08	5.82	8.57	10.67	12.12	13.88	14.51	14.63
PRG05	13.32	1.80	2.84	4.29	6.46	8.64	9.91	11.86	12.38	12.82
PRG03	11.97	2.12	3.04	4.35	6.09	8.04	9.23	11.14	11.87	11.97
PRG04	12.95	2.08	3.27	4.80	6.92	8.94	10.30	12.18	12.81	12.92
PRG01	13.81	2.46	4.39	6.02	7.87	10.06	11.36	13.36	13.80	13.81
PRG07	14.11	2.39	3.97	4.88	7.36	10.13	11.77	13.64	14.05	14.10
PRG02	15.43	2.78	4.85	6.65	9.18	11.31	12.71	14.52	15.42	15.43




City of Columbia
Gills Creek Monitoring Station at Devine Street
Incremental Rainfall
Approx. Roadway Elevation, Devine Street
Stage (ft)
*Rain gage ceased reporting on 10/4/2015 at 9:00am
Water Surface Elevation (ft)
10/1/2015
10/2/2015
10/3/2015
10/4/2015
10/5/2015
10/6/2015
10/7/2015


TitleMax
CALL
730-9243





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
- 74 miles of I-95
- I-20 Broad River Bridge
- I-126 Broad River Bridge
- I-26 Saluda River Bridge

36 Regulated dam failures

100+ Non-regulated dam failures

1,500+ Water rescues

How Could We Have Known?

US Army Corps Report 1988

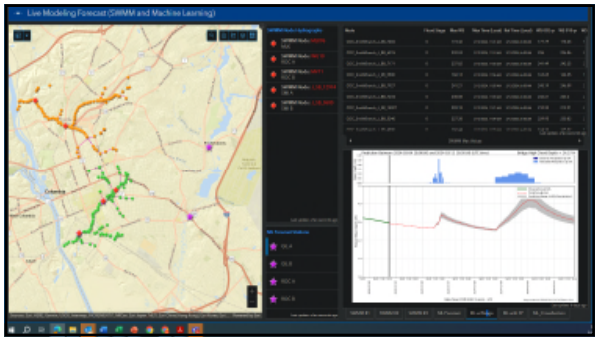
- Special Project Storm 15-in, 24-HR
- Predicted flood elevations within 6-in
- Predicted which dams would breach
- Suggested Projects
- Collecting dust

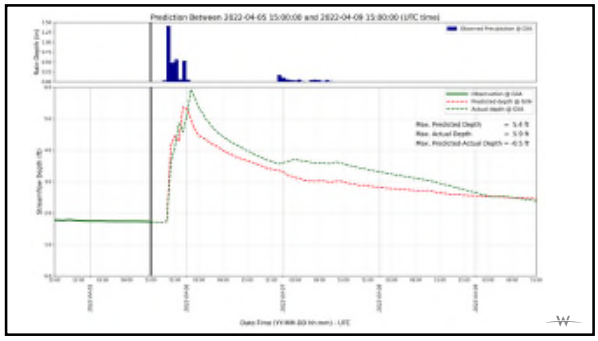
With Live Modeling

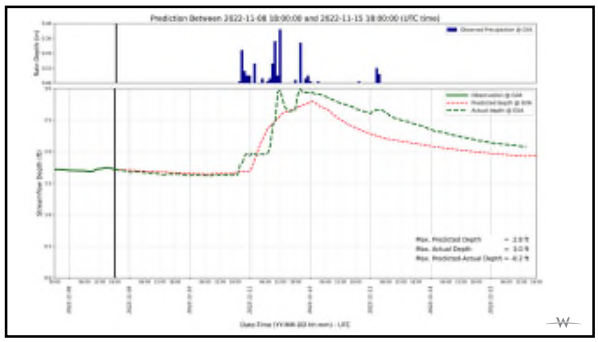
- Hazard notifications
  - Reverse 911
  - TV alerts
  - Cell phone alerts
  - Door to door
  - Local and State government web sites
- Evacuations in Flood Zone
- Evacuations below at-risk dams
- Road closures
- Shelters set up
- Government personnel on call
- Equipment and personnel staging
- Sand bags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

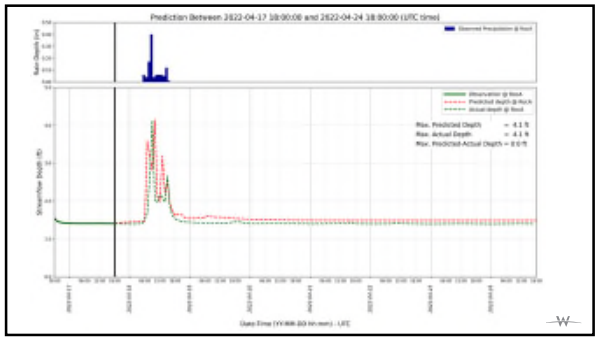
City of Columbia

Live Model Dashboard



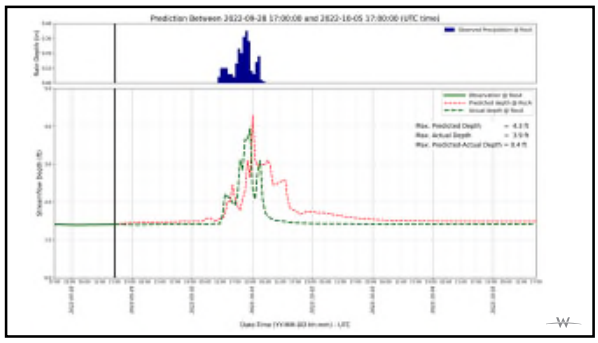

Prediction Between 2022-04-05 15:00:00 and 2022-04-08 15:00:00 (UTC time)

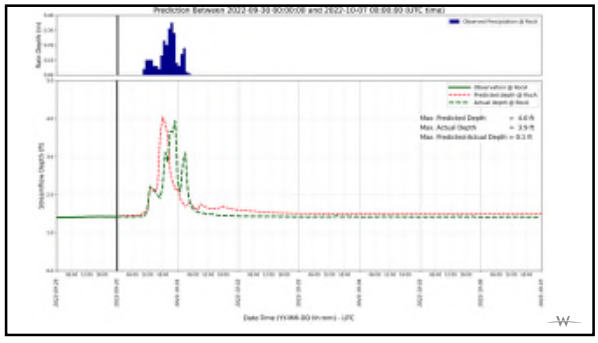

Prediction Between 2022-11-08 18:00:00 and 2022-11-15 18:00:00 (UTC time)


Prediction Between 2022-04-17 18:00:00 and 2022-04-24 18:00:00 (UTC time)

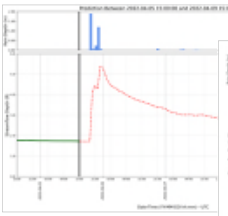
Hurricane IAN

Prediction vs Observed

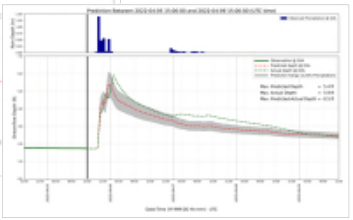




Prediction vs Measured Streamflow Depth Example

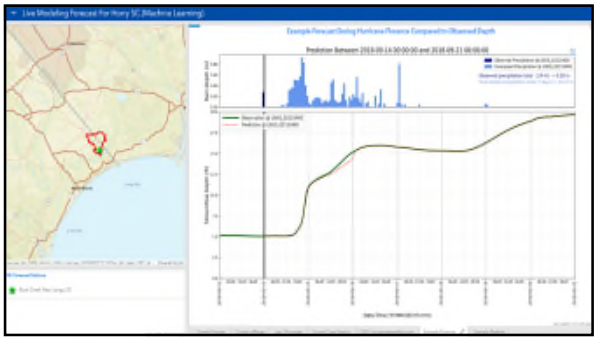


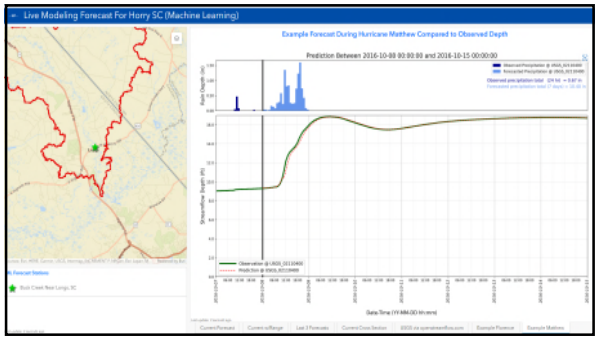
Prediction 4 Hours Before Rainfall
Begins and 8 Hours Before Peak Stage

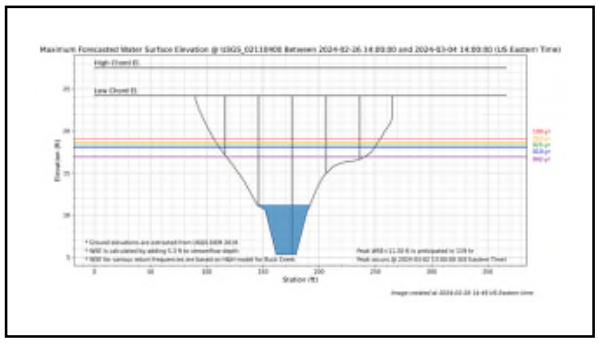


Predicted Stage vs Observed Stage with Actual Rainfall

Horry County



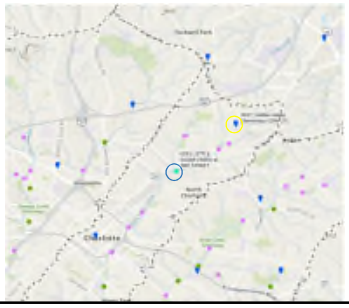




Mecklenburg County

Little Sugar Creek Example

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



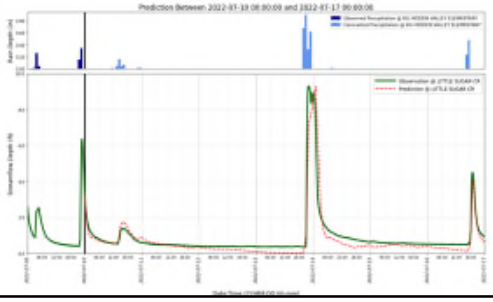
Rain Gauge(s) - 1
Stream Gauge(s) – 1

Training Dataset:
2013 to 2021

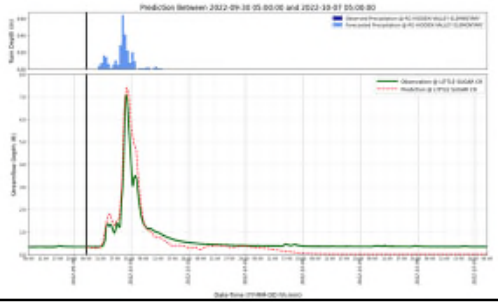
Validation Dataset:
2022

ML Model (selected):
Artificial Neural Network

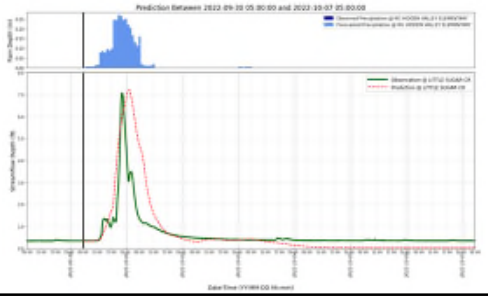
Machine Learning Model Validation - July 13, 2022 (Gauge Rainfall)



Machine Learning Model Validation - Hurricane Ian (Gauge Rainfall)

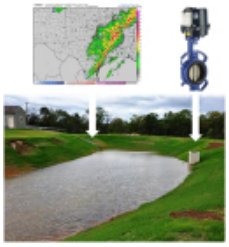


Machine Learning Model - Hurricane Ian (NBM Forecasted Rainfall)



Adaptive (or Dynamic) Outlet Control

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




WOOLPERT
ARCHITECTURE | ENGINEERING | GEOSPATIAL