



Depicting Probabilistic Flood Maps Using Ensemble Forecasts and Flood Inundation Model Uncertainty



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*1 LYNKER *2 NOAA OWP

Presentation Notes



Objective

- R&D determination of uncertainty in flood model
- Prototype of visualization of model uncertainty
- **Not a final product**

Motivation

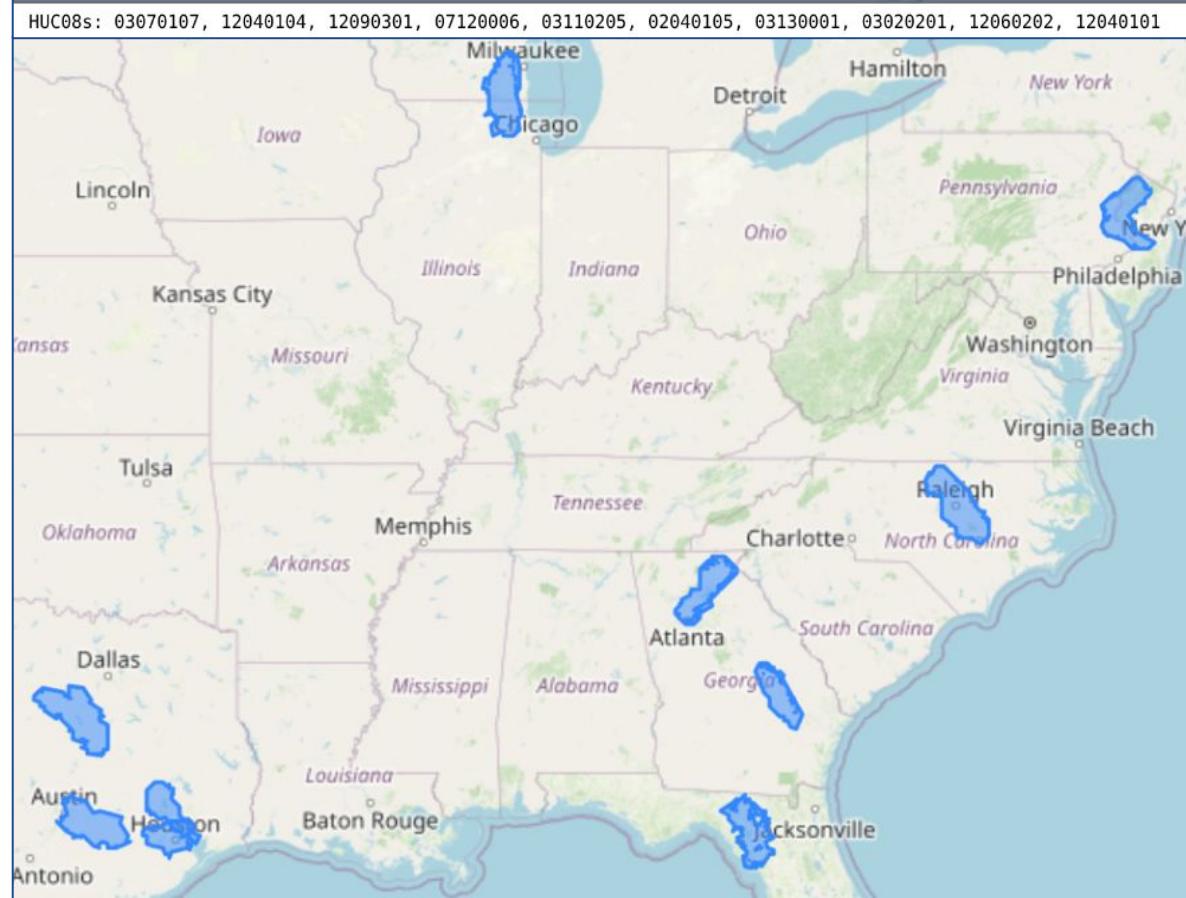
- Understanding uncertainty and optimizing performance
- Effective communication of uncertainty to emergency response coordinators and public

Structure of Presentation

1. Sensitivity Analysis
2. Fitting Streamflow Retrospective Record
3. Bayesian Updates
4. Mixture Model
5. Visualization

Scope of Study

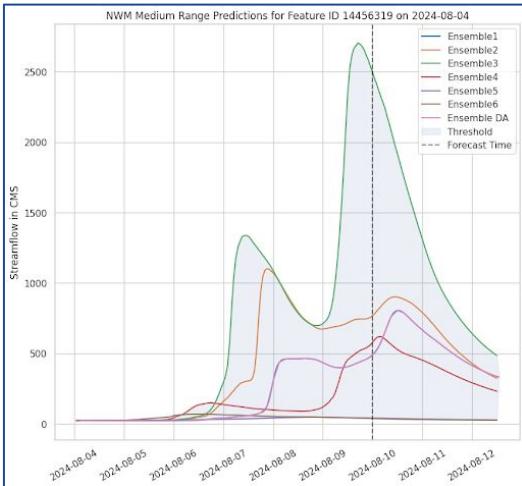
- Study Covered 10 HUC08s specifically
- Covers their applicability to other HUC08s



Step 1. Sensitivity Analysis

Choice of Parameters

NWM Medium Range Forecasts



- Input Streamflow

HAND Model

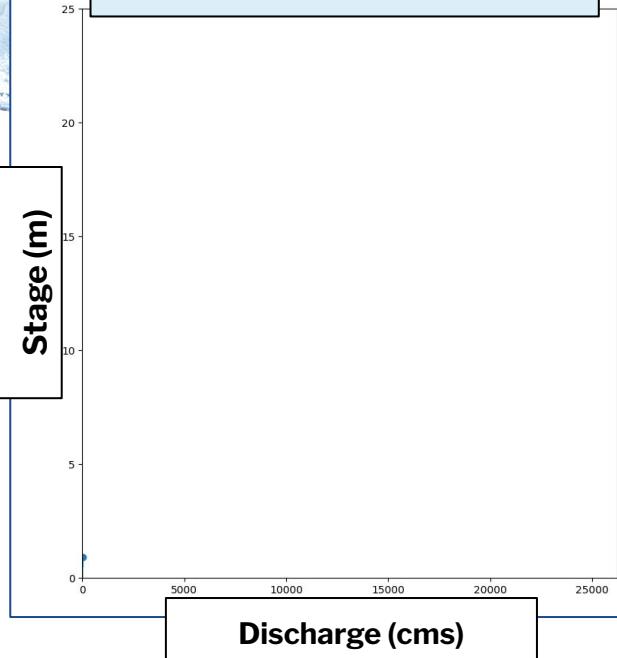
Manning Equation

$$Q = \left(\frac{1.0}{n}\right) A R^{\frac{2}{3}} \sqrt{S}$$

HAND Catchment

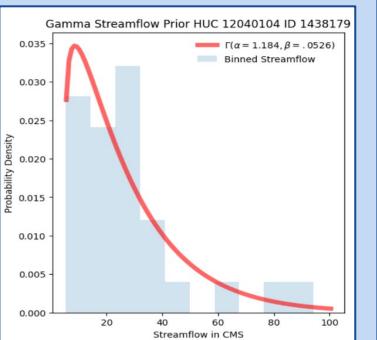
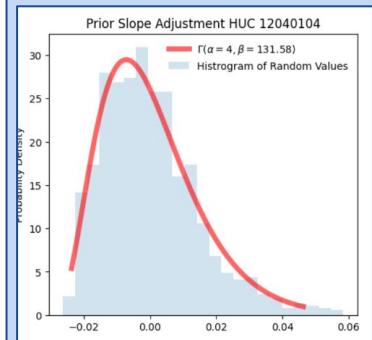
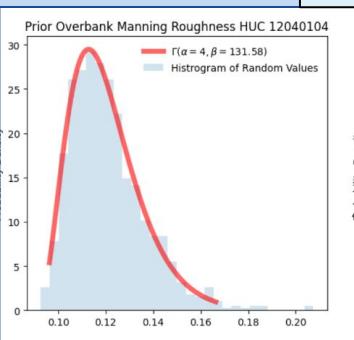
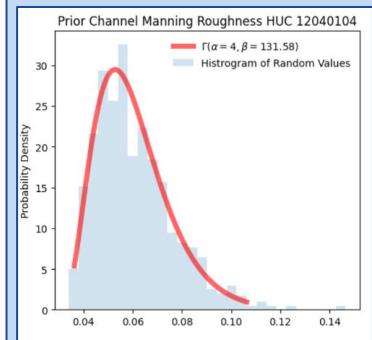


Synthetic Rating Curve



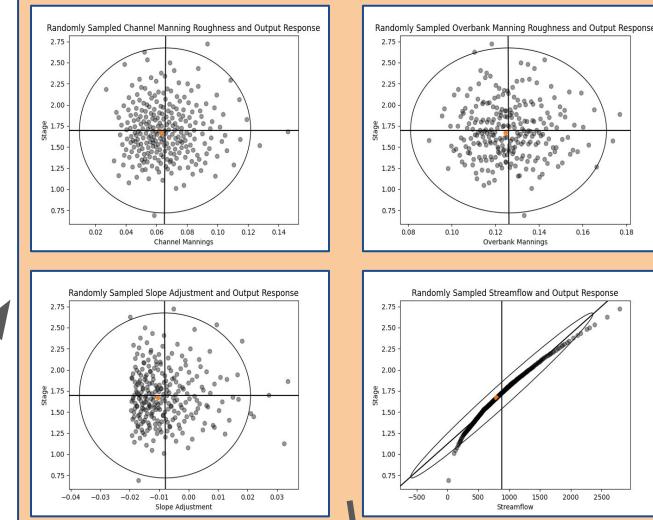
- Channel Manning Roughness
- Overbank Manning Roughness
- Slope (Adjustment to what was calculated)

Sensitivity Analysis



*1

*3



*2

*4

$$G(H_j) = \int_0^{H_j} \sigma^2(1 - r_j(h_j)) dh_j$$

H = perturbation scale

σ^2 = variance

$r = 1 - d$ correlation function

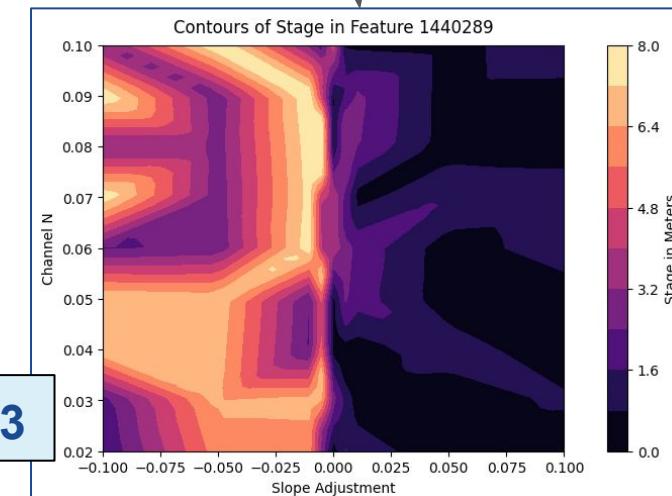
h = numeric distance between variables

*1: Distributions to vary parameters

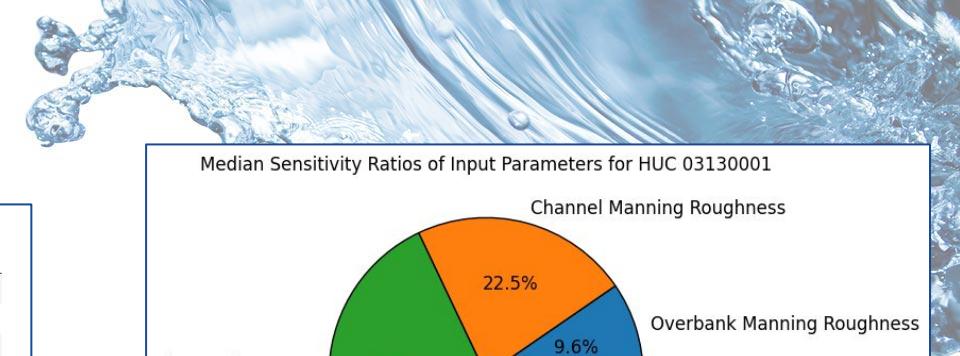
*2: Example Sampling Points from distribution

*3: Output response surface of stage (water depth)

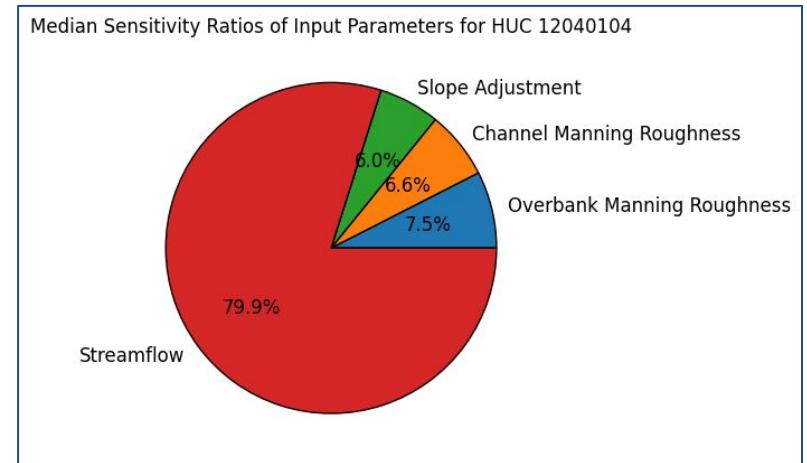
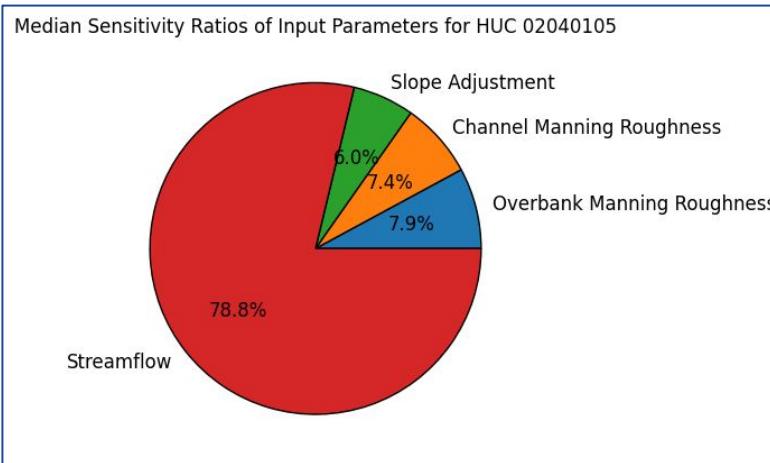
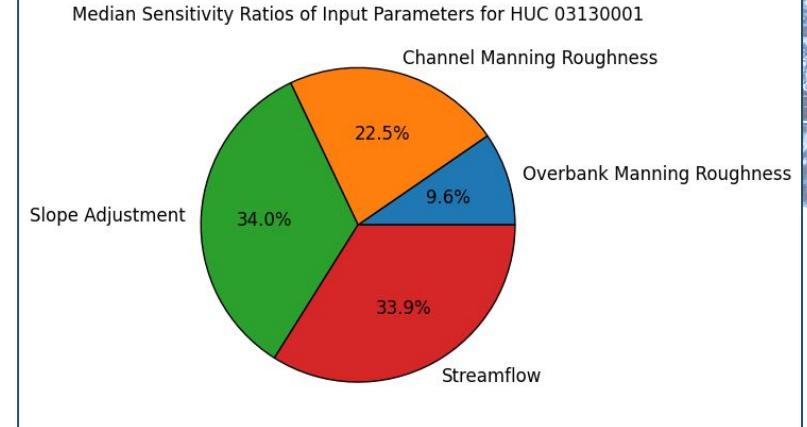
*4: Equation for DVARS



Sensitivity Analysis Continued

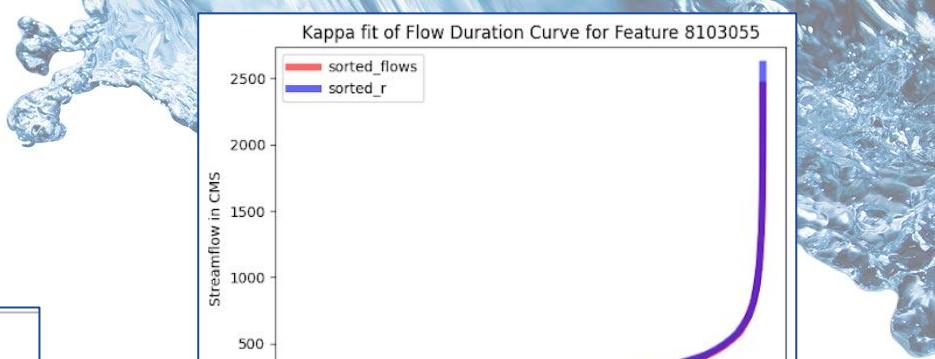


huc	overbank_mannings_ratio	channel_mannings_ratio	slope_ajustement_ratio	streamflow_ratio
02040105	7.885479	7.356752	5.996754	78.761016
03020201	7.936134	17.831024	37.866919	36.365922
03070107	6.122656	3.124802	1.963718	88.788824
03110205	8.103175	7.998000	8.870477	75.028348
03130001	9.587040	22.469130	34.016195	33.927635
07120006	8.147362	17.838243	41.627829	32.386566
12040101	6.923970	15.657022	39.757992	37.661015
12040104	7.505340	6.642353	5.969829	79.882478
12060202	6.482317	14.910311	38.145765	40.461607
12090301	6.160316	14.049705	38.275623	41.514356

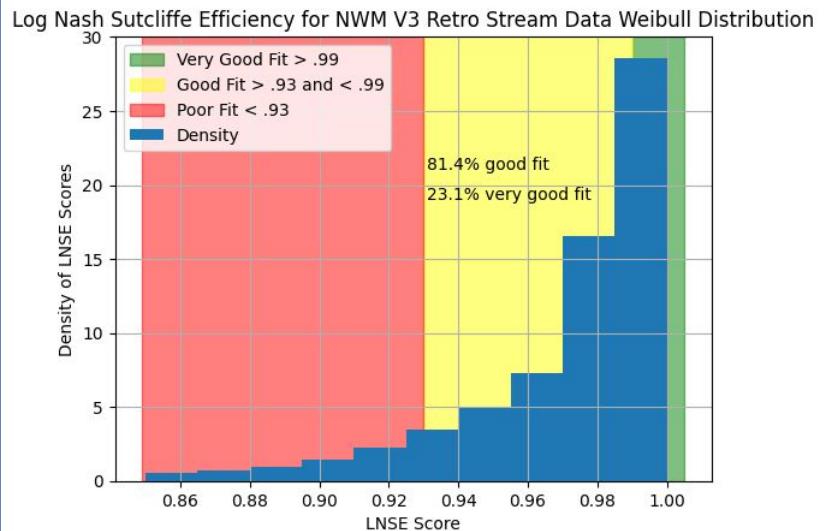
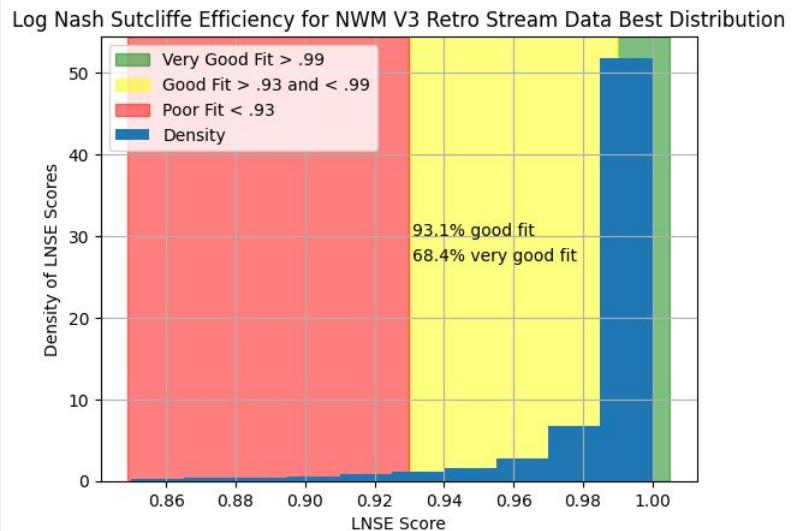
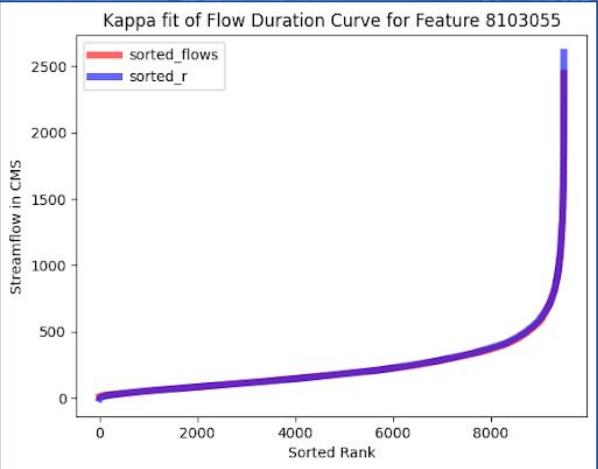


Step 2. Fitting Retrospective Streamflow Data

Fitting Retrospective Streamflow Data



$$LNSE = 1 - \frac{\sum_{x=1}^X (\log(Q_{flow}) - \log(Q_{pred}))^2}{\sum_{x=1}^X (\log(Q_{flow}) - \log(Q_{mean}))^2}$$



Step 3. Bayesian Updates

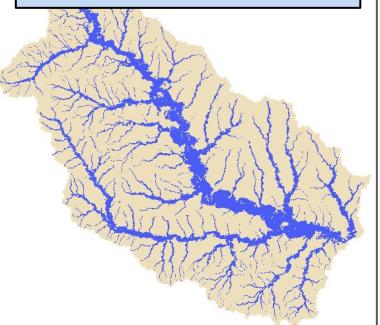
Generating Metrics As Data

Gridded Parameters
for Roughness and
Slope Adjustment

25 Best and Roughness/Slope
Adjustment Data

	huc08	site	stage	manning's n	overbank_manning's n	slope	balanced_accuracy	critical_success_index	equitable_threat_score	metric_score
0	12040101	Na	100yr	0.10	0.15	0.000	0.853468	0.649668	0.588337	0.216556
1	12040101	Na	100yr	0.10	0.14	0.000	0.862267	0.647930	0.587306	0.215991
2	12040101	Na	100yr	0.10	0.13	0.000	0.850944	0.646667	0.586154	0.215082
3	12040101	Na	100yr	0.10	0.12	0.000	0.849430	0.645091	0.584674	0.214474
4	12040101	Na	100yr	0.09	0.15	0.000	0.849020	0.644554	0.584133	0.214290
5	12040101	Na	100yr	0.09	0.14	0.000	0.847885	0.643373	0.583030	0.213834
6	12040101	Na	100yr	0.10	0.11	0.000	0.847729	0.643251	0.582930	0.213779
7	12040101	Na	100yr	0.09	0.13	0.000	0.846637	0.642057	0.581797	0.213330
8	12040101	Na	100yr	0.10	0.10	0.000	0.846575	0.640969	0.580733	0.212840
9	12040101	Na	100yr	0.09	0.12	0.000	0.846245	0.640525	0.580344	0.212755
10	12040101	Na	100yr	0.09	0.11	0.000	0.846340	0.639867	0.578544	0.212074
11	12040101	Na	100yr	0.08	0.15	0.000	0.843608	0.638563	0.578406	0.212067
12	12040101	Na	100yr	0.08	0.14	0.000	0.842621	0.637338	0.577236	0.211617
13	12040101	Na	100yr	0.09	0.10	0.000	0.841726	0.636256	0.576189	0.211227
14	12040101	Na	100yr	0.08	0.13	0.000	0.841499	0.635954	0.575907	0.211113
15	12040101	Na	100yr	0.08	0.12	0.000	0.840558	0.634237	0.574231	0.210506
16	12040101	Na	100yr	0.09	0.09	0.000	0.839465	0.633333	0.573298	0.210215
17	12040101	Na	100yr	0.08	0.11	0.000	0.838417	0.632084	0.572100	0.209764
18	12040101	Na	100yr	0.07	0.15	0.000	0.838649	0.629965	0.569991	0.209944
19	12040101	Na	100yr	0.08	0.10	0.000	0.836518	0.629519	0.569547	0.208892
20	12040101	Na	100yr	0.10	0.15	0.001	0.837141	0.628796	0.567216	0.208735
21	12040101	Na	100yr	0.07	0.14	0.000	0.835780	0.628553	0.566898	0.208559
22	12040101	Na	100yr	0.10	0.14	0.001	0.835842	0.628176	0.565514	0.208145
23	12040101	Na	100yr	0.07	0.13	0.000	0.834563	0.626915	0.566076	0.208000
24	12040101	Na	100yr	0.08	0.09	0.000	0.834291	0.626400	0.566423	0.207849

1024
Modeled/Simulated

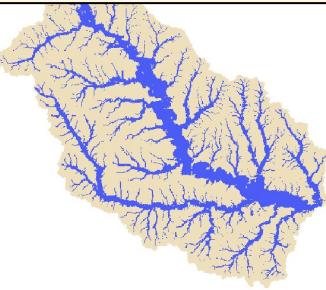


Weights

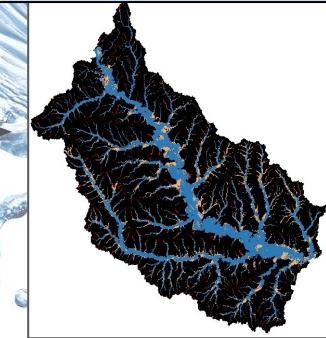
Metric	Weight
True Positive Rate	1
False Discovery Rate	1
Critical Success Index	3
Equitable Threat Score	2
Matthew's Correlation Coefficient	2

Benchmark Source	Weight
100 Year BLE	3
Major Stage NWS	3
Moderate Stage NWS	2
Minor Stage NWS	1

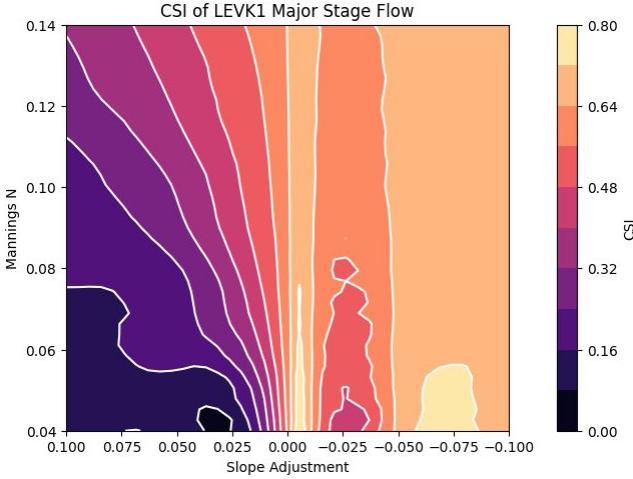
Observed/Benchmark/
Validation Maps



1024 Agreement Maps



Metric Response Surface

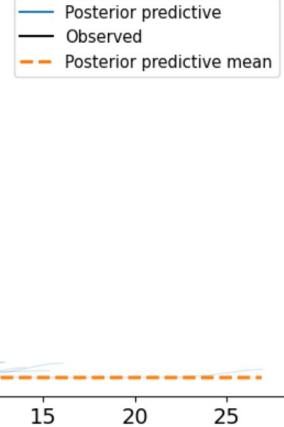


Bayesian Updates Continued

25 Best and Roughness/Slope Adjustment Data

	huc08	site	stage	mannings	n	overbank	mannings_n	slope	balanced_accuracy	critical_success_index	equitable_threat_score	metric score
0	12040101	Na	100yr	0.10	0.15	0.000	0.853488	0.649068	0.588337	0.218056		
1	12040101	Na	100yr	0.10	0.14	0.000	0.852267	0.647930	0.587306	0.215981		
2	12040101	Na	100yr	0.10	0.13	0.000	0.850944	0.646667	0.586154	0.215082		
3	12040101	Na	100yr	0.10	0.12	0.000	0.849430	0.645591	0.584674	0.214474		
4	12040101	Na	100yr	0.09	0.15	0.000	0.849020	0.644554	0.584133	0.214290		
5	12040101	Na	100yr	0.09	0.14	0.000	0.847983	0.643373	0.583030	0.213884		
6	12040101	Na	100yr	0.10	0.11	0.000	0.847729	0.642351	0.582900	0.213779		
7	12040101	Na	100yr	0.09	0.13	0.000	0.846937	0.642057	0.581797	0.213330		
8	12040101	Na	100yr	0.10	0.10	0.000	0.845735	0.640969	0.580733	0.212940		
9	12040101	Na	100yr	0.09	0.12	0.000	0.845245	0.640525	0.580344	0.212755		
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12	12040101	Na	100yr	0.08	0.14	0.000	0.842621	0.637738	0.577238	0.211817		
13	12040101	Na	100yr	0.09	0.10	0.000	0.841716	0.636256	0.576189	0.211227		
14	12040101	Na	100yr	0.08	0.13	0.000	0.841439	0.635054	0.575907	0.211113		
15	12040101	Na	100yr	0.08	0.12	0.000	0.840958	0.634237	0.574231	0.210906		
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24	12040101	Na	100yr	0.08	0.09	0.000	0.834291	0.626400	0.566423	0.207849		

NUTS Sampling Update



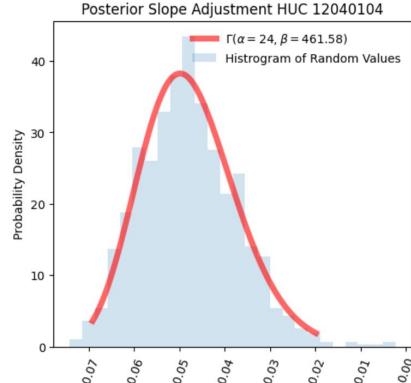
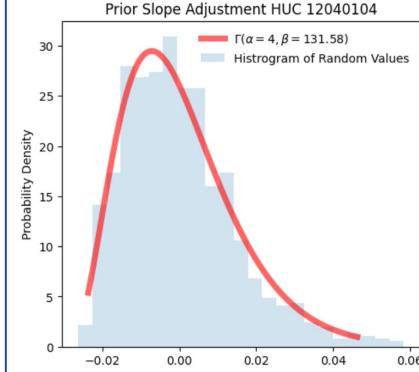
Example Analytical Update Equation

$$\pi(x) = \Gamma(\alpha_0 + \alpha * n, \beta_0 + \sum_{i=0}^n x_i)$$

π = posterior probability density function
 α_0 = shape parameter from prior
 α = shape parameter from likelihood
 β_0 = rate parameter from prior
 n = cardinality of observed data
 x_i = observed data at index i

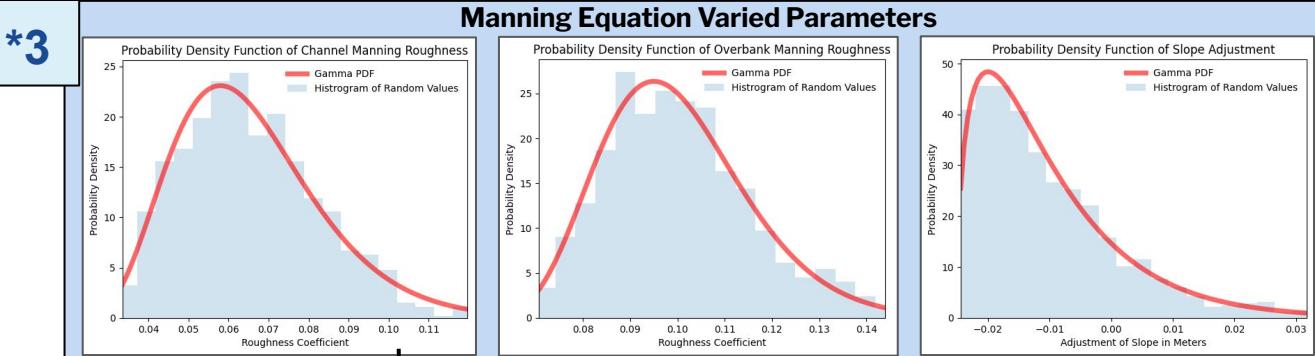
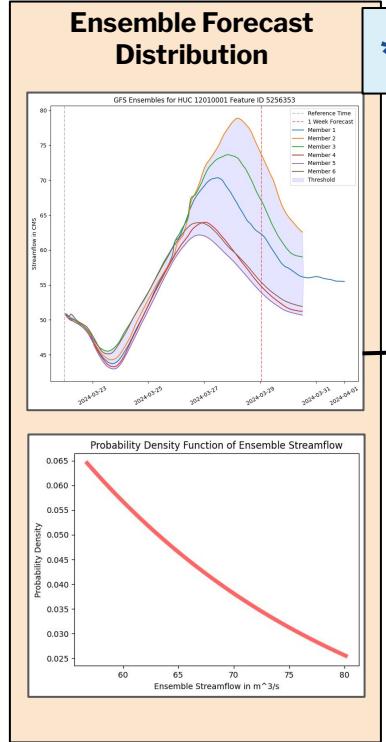
Analytical Update

Observed Data:
[-0.1 -0.05 -0.01 -0.01 -0.01]



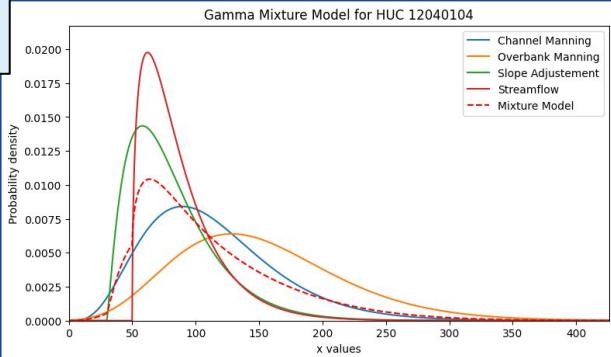
Step 4. Mixture Model

Workflow



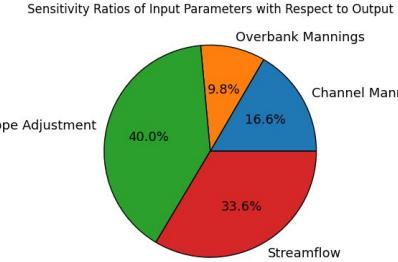
*2

*4



*1

Example of Model Sensitivity Ratios



*1: Sensitivity Analysis

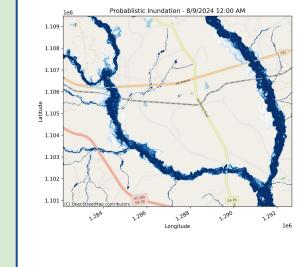
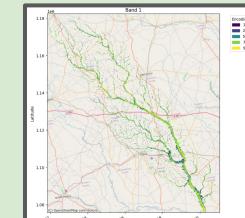
*2: Fitting Retrospective Streamflow Data

*3: Bayesian Updates

*4: Mixture Model

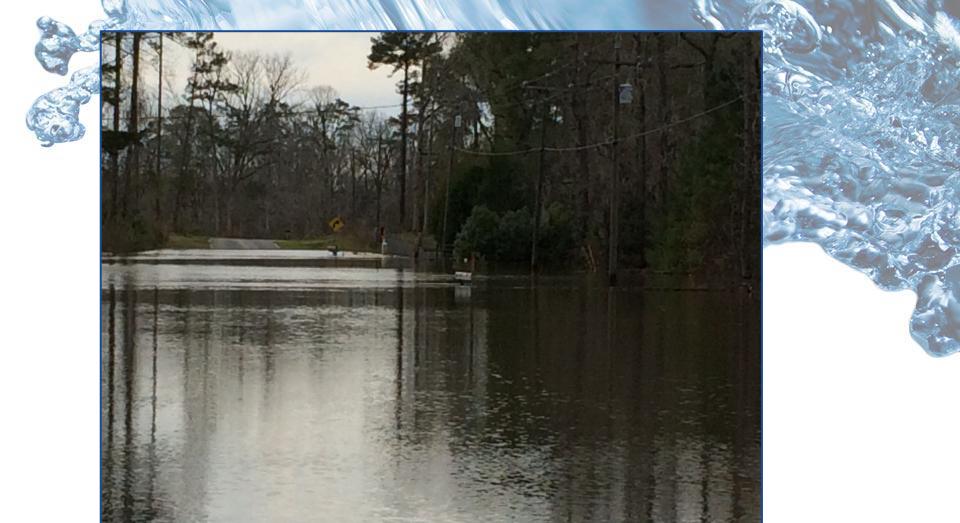
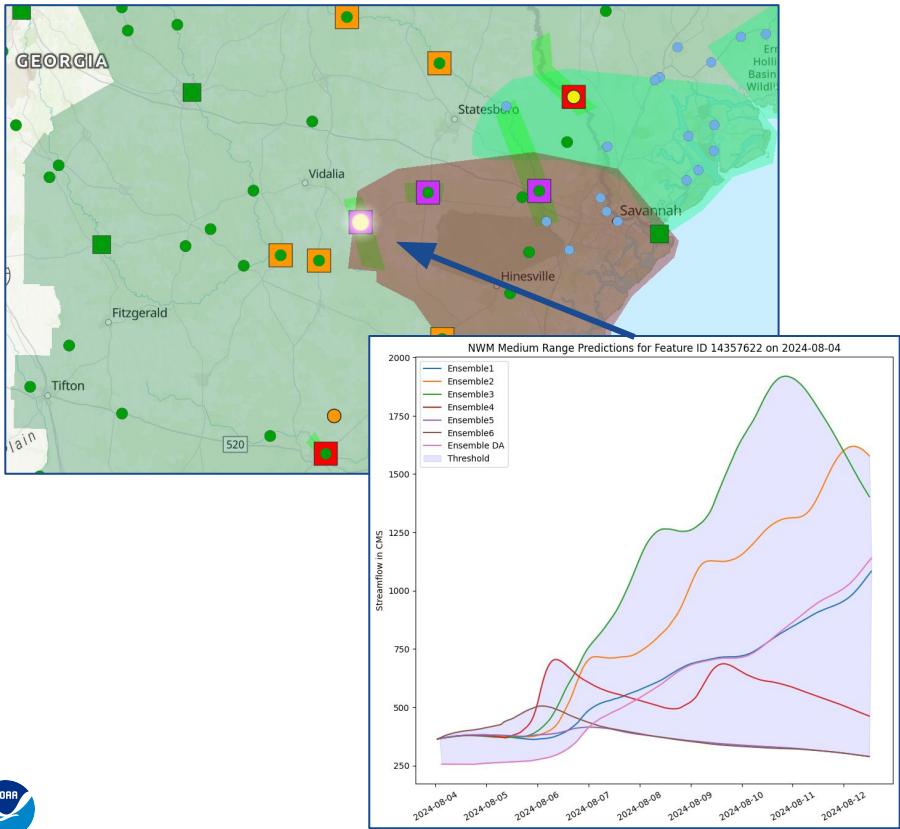
*5: Visualization

Probabilistic FIM



Step 5. Visualization

Ohoopee River Near Reidsville, GA

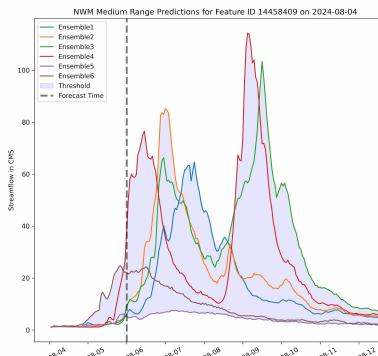


2013 Flood of Ohoopee River

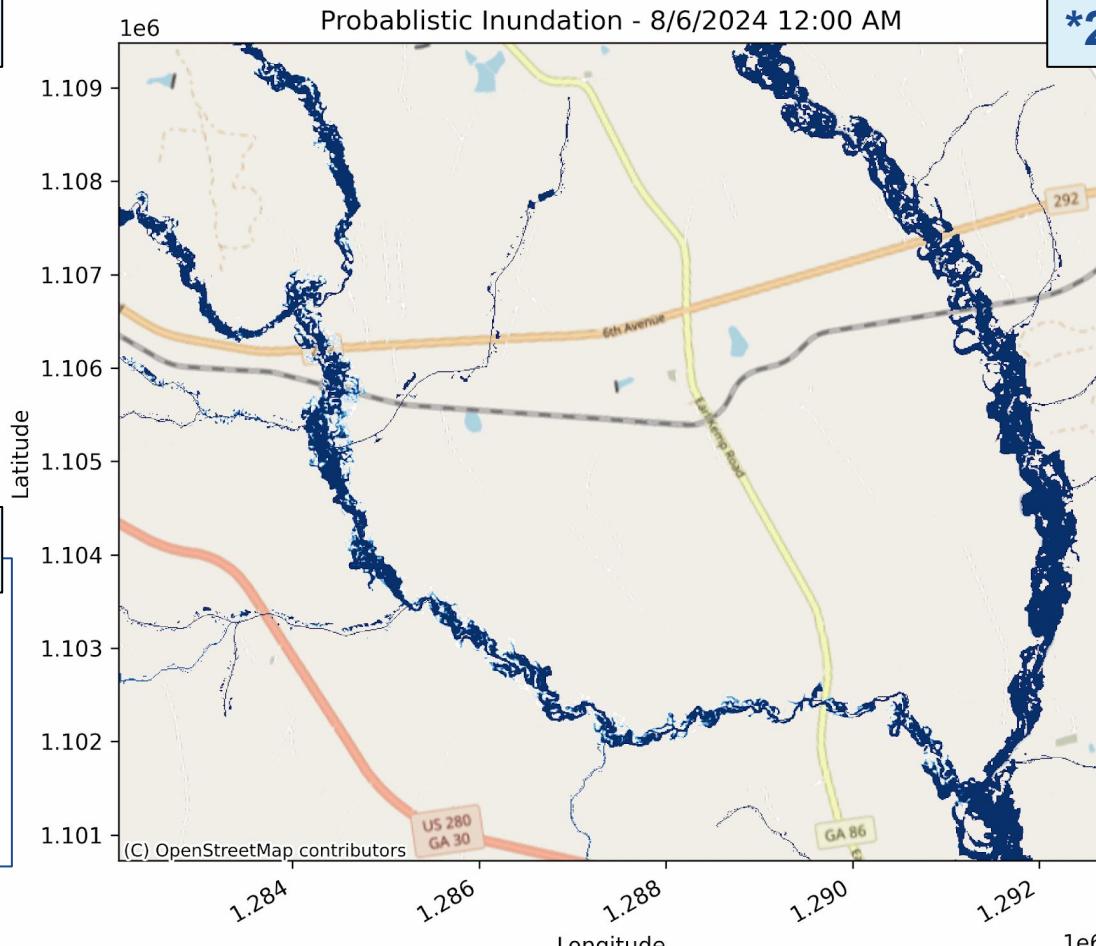


Visualization

*1



*2

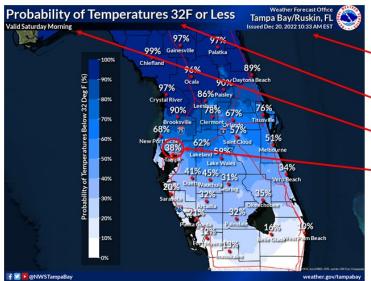


*1: Medium range NWM forecasts for one stream

*2: Probabilistic FIM over time

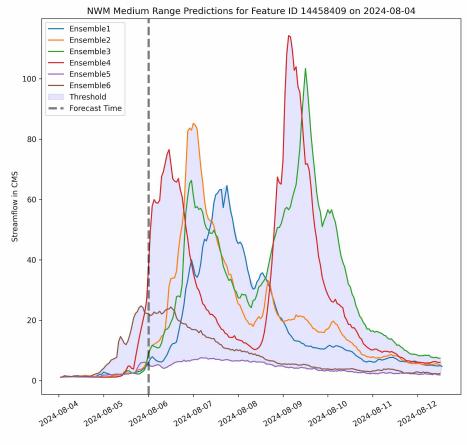
*3: Probability of Temperature Map (Inspiration for color scheme)

*3

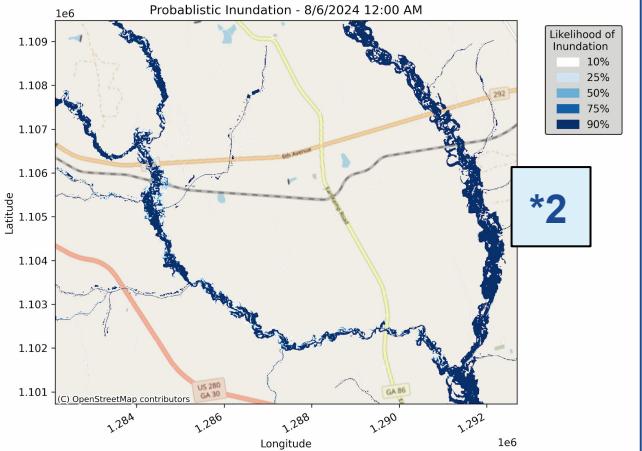


Visualization Continued

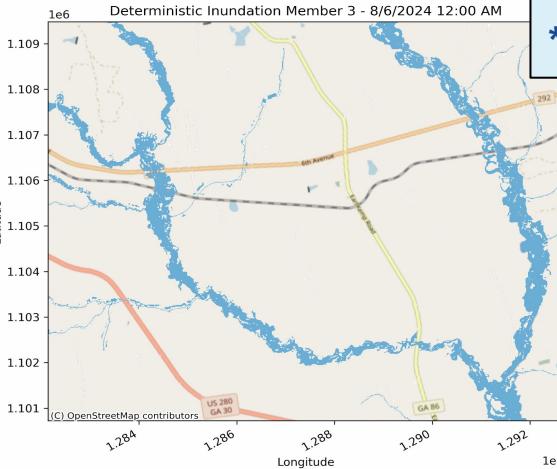
*1



*1: Medium range nwm forecasts for one stream

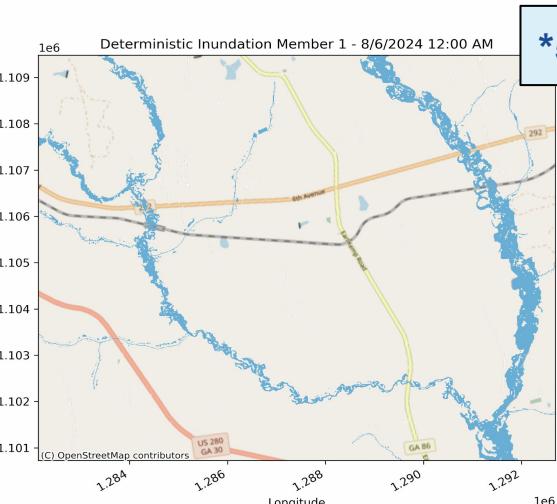


*2



*3

*4



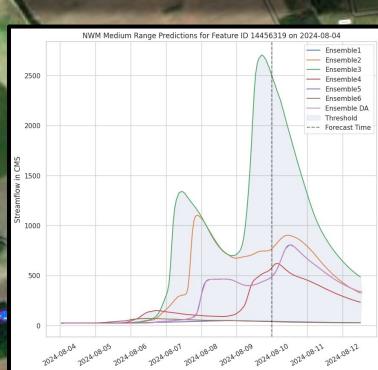
*5

*2: Probabilistic FIM over time

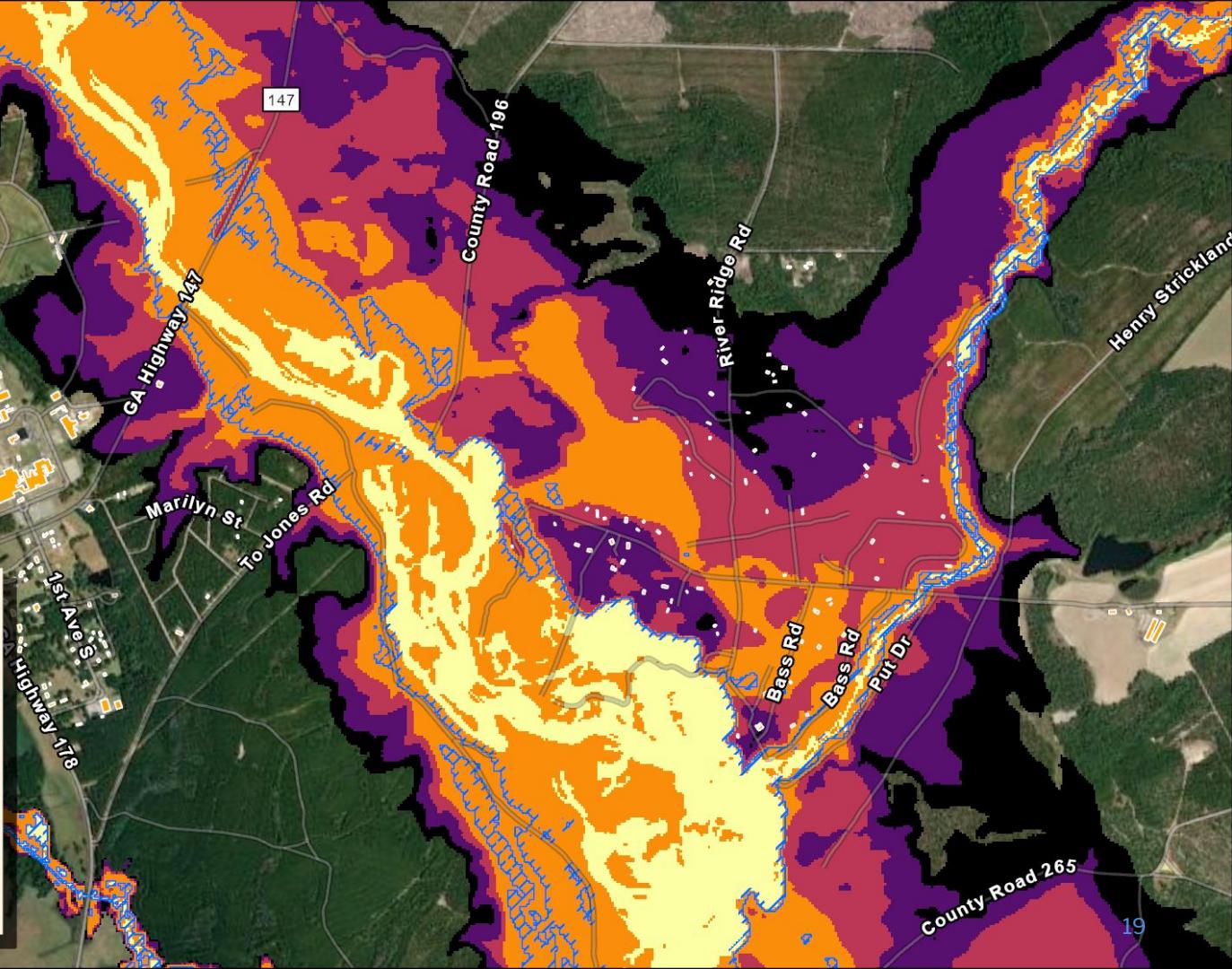
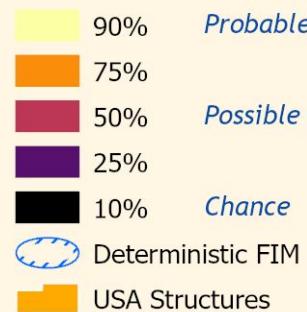
*3-5: Deterministic FIM (ensemble members 3, 1, and 6 respectively)



Visualization Continued



Likelihood of Inundation





Thank You!



Greg Petrochenkov



greg.petrochenkov@noaa.gov



<https://water.noaa.gov>



OWP | OFFICE OF
WATER
PREDICTION

