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RTI Center for Water Resources

2020 SCAHM Annual Conference

Advances in Flood Forecasting Technology

Photo: www.jaybirdaerials.com

Flood Forecasting

Modeling

Operational

Assimilation

Stage

Mods

Sub-basin

Flood Early Warning

Mapping

Real-time

Nowcasting

Inundation

ALERT

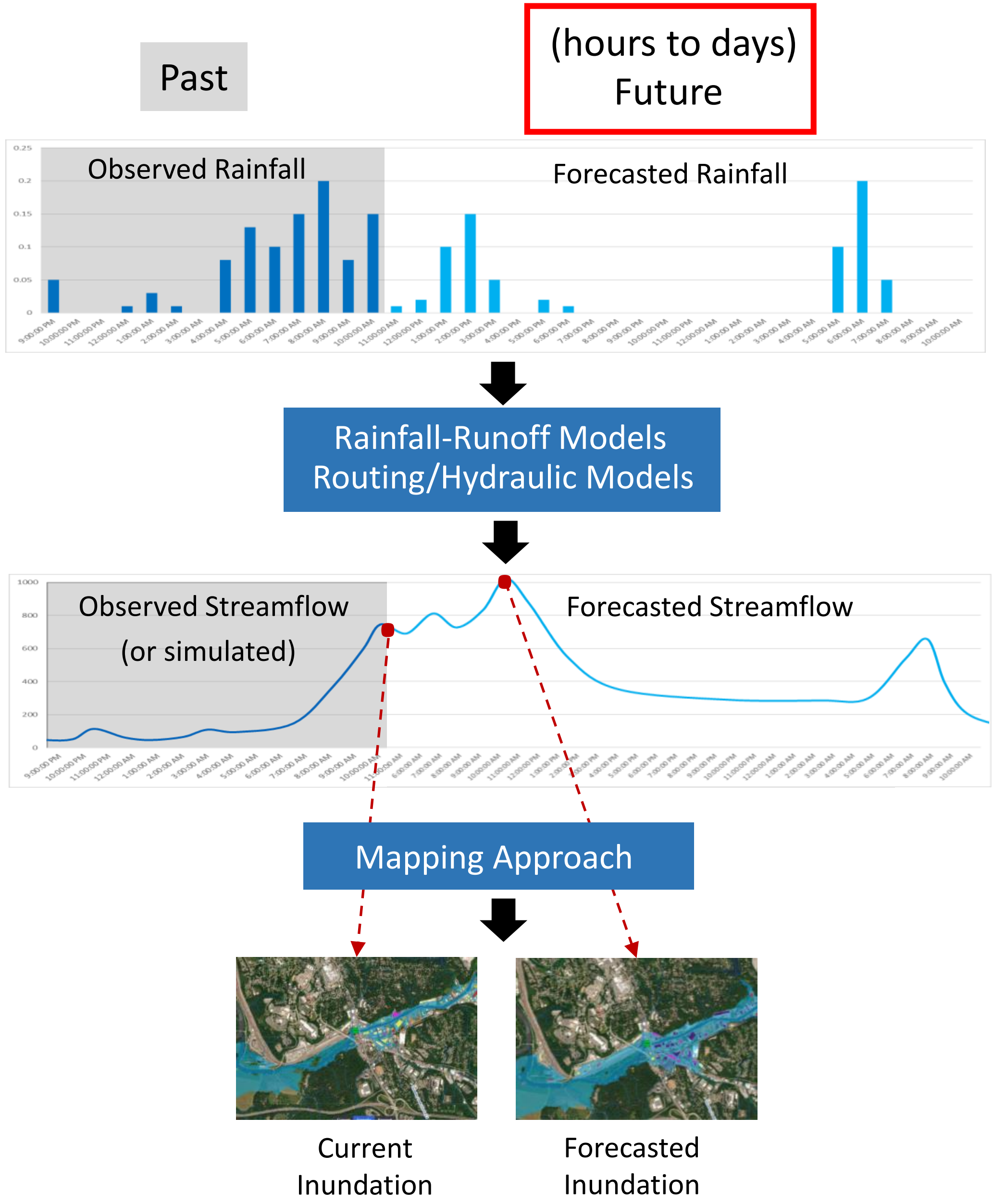
Rain-on-Grid

Flood Forecasting – In a Nutshell

Collect observations and forecasts of **precipitation…**

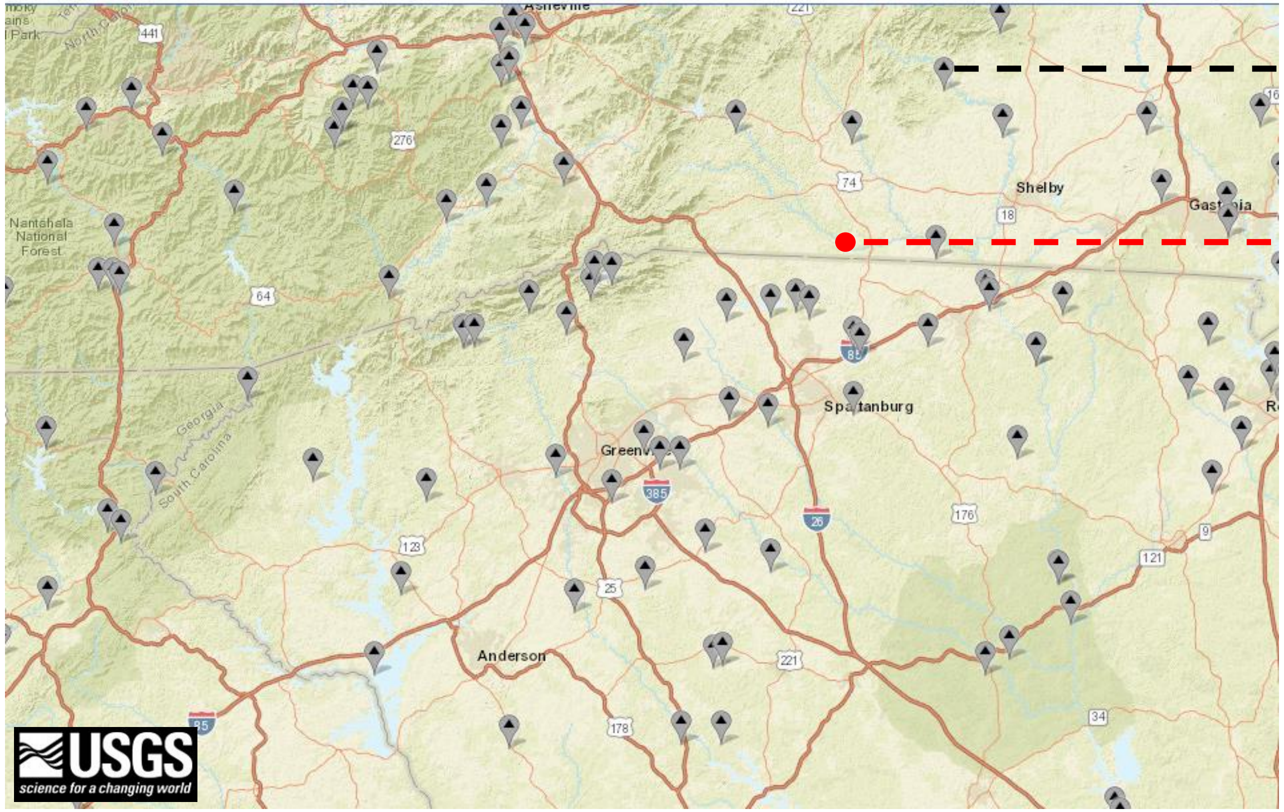
translate into <u>forecasts</u> of **hydrology…**

to guide **decisions…**


Past
(hours to days)
Future
Observed Rainfall
Forecasted Rainfall
Rainfall-Runoff Models
Routing/Hydraulic Models
Observed Streamflow
(or simulated)
Forecasted Streamflow
Mapping Approach
Current
Inundation
Forecasted
Inundation

Key Points – Ungauged Streams

Gauges are not everywhere



gauged stream

ungauged stream

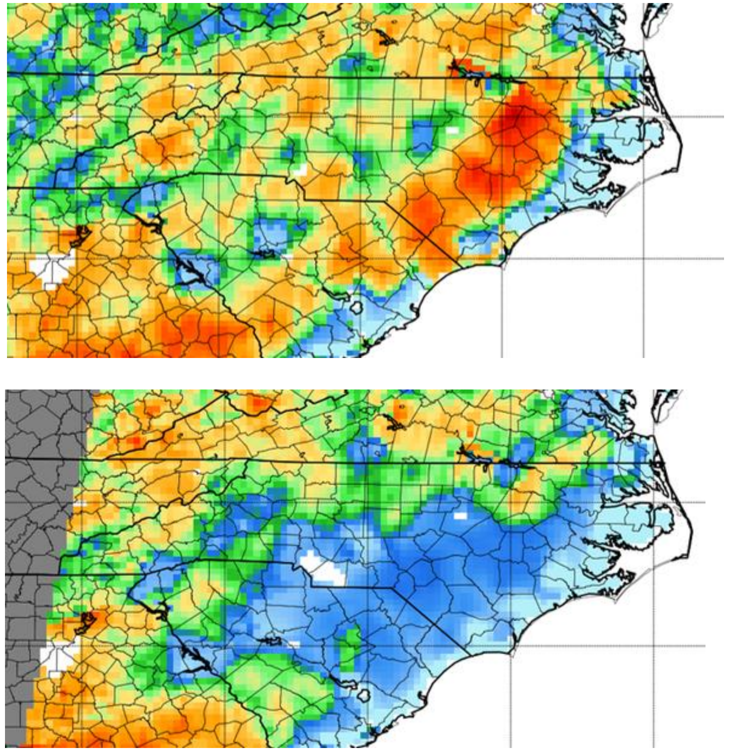
past	future
observed streamflow	forecasted streamflow
<u>simulated</u> streamflow	forecasted streamflow

Models can <u>also</u> fill data gaps of current conditions

Greater uncertainty than a measurement

Key Points – Soil Moisture

Soil Moisture



1. Continuous Soil Moisture Accounting

1. Get most recent data
2. Run models with stored states as initial cond.
3. Store model states

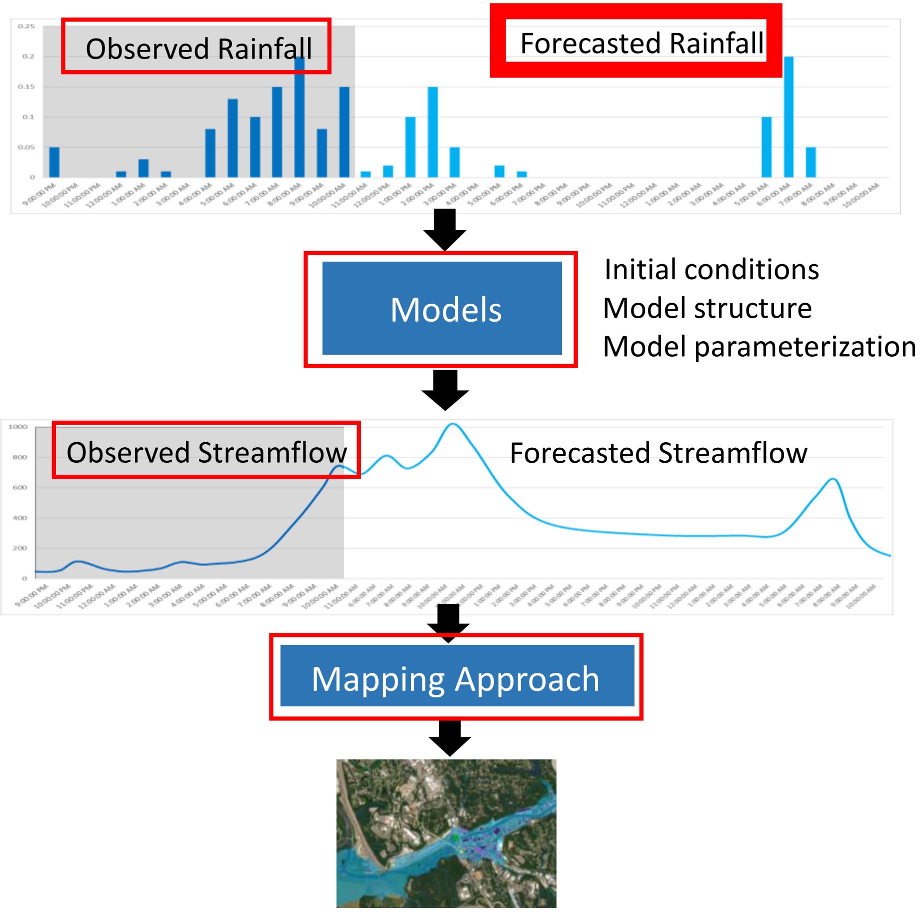
Every day, rain or shine

2. Event Modeling

1. Get past and recent data
2. Estimate initial conditions
3. Run models

During events

Key Points – Sources of Uncertainty and Error



Forecasted Inundation

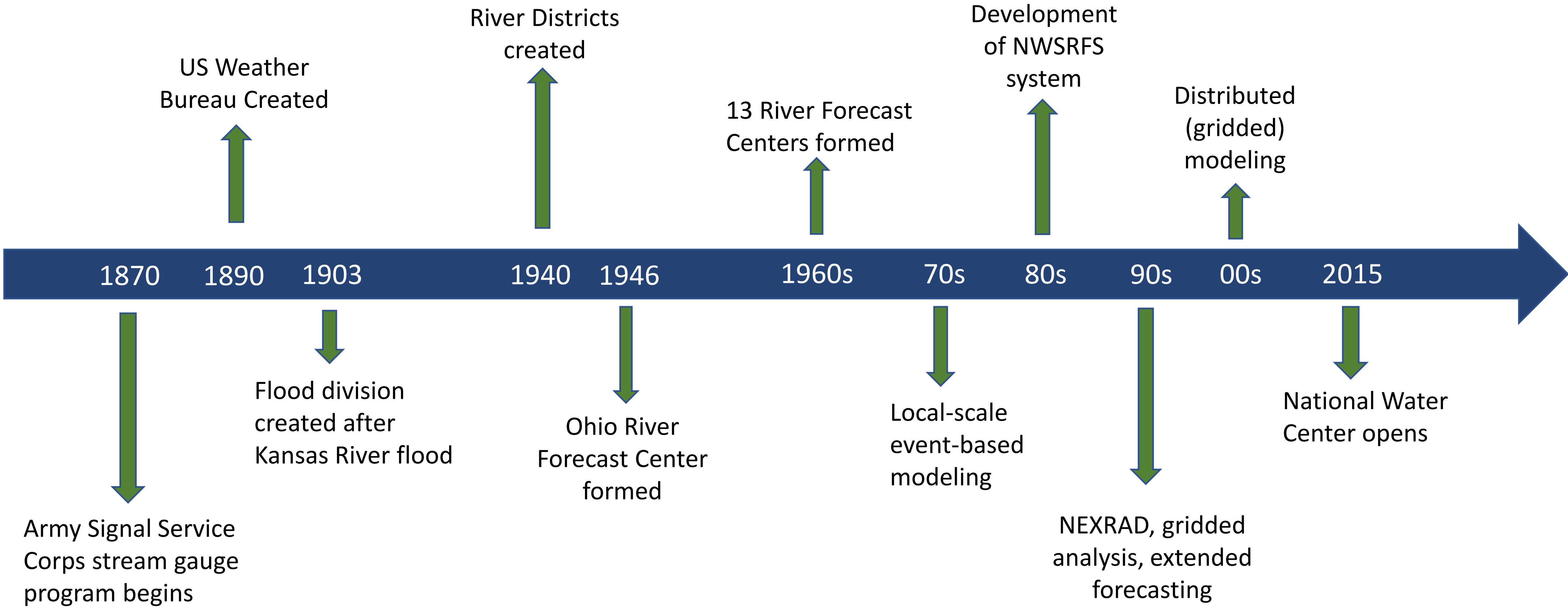
Who is doing it?

(generating forecasts)

e.g.

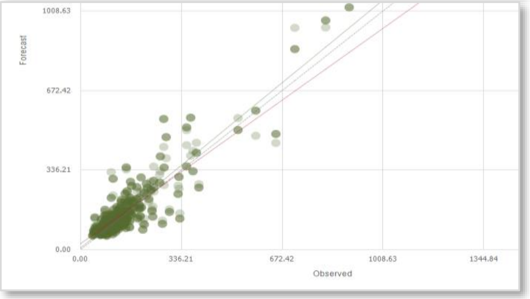
- NWS - River Forecast Centers
- NWS - National Water Center
- US ACE – some districts
- State agencies/entities
- River basin commissions/authorities
- Large hydropower operators
- Cities/local governments
- Private vendors

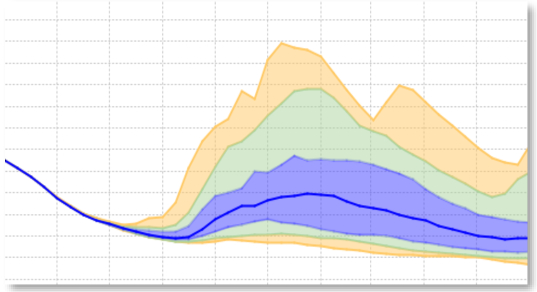
A Little History – River Forecasting at the NWS



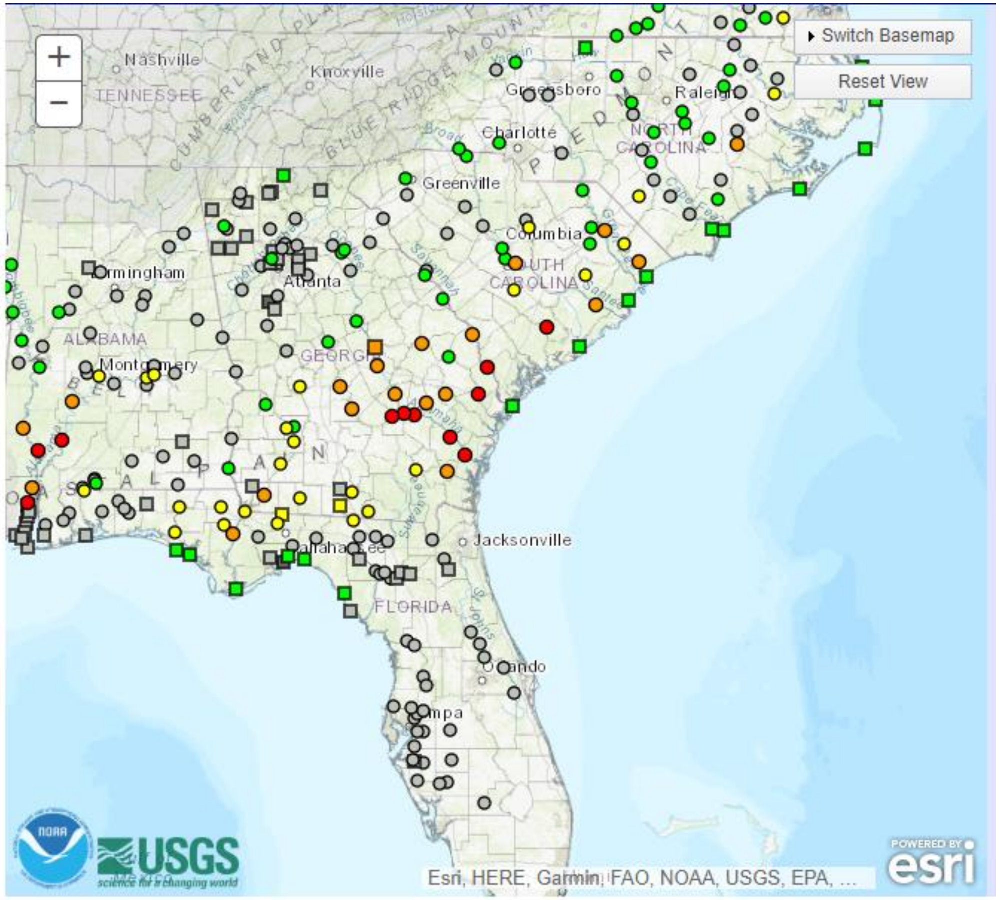
Recent/Ongoing Advances

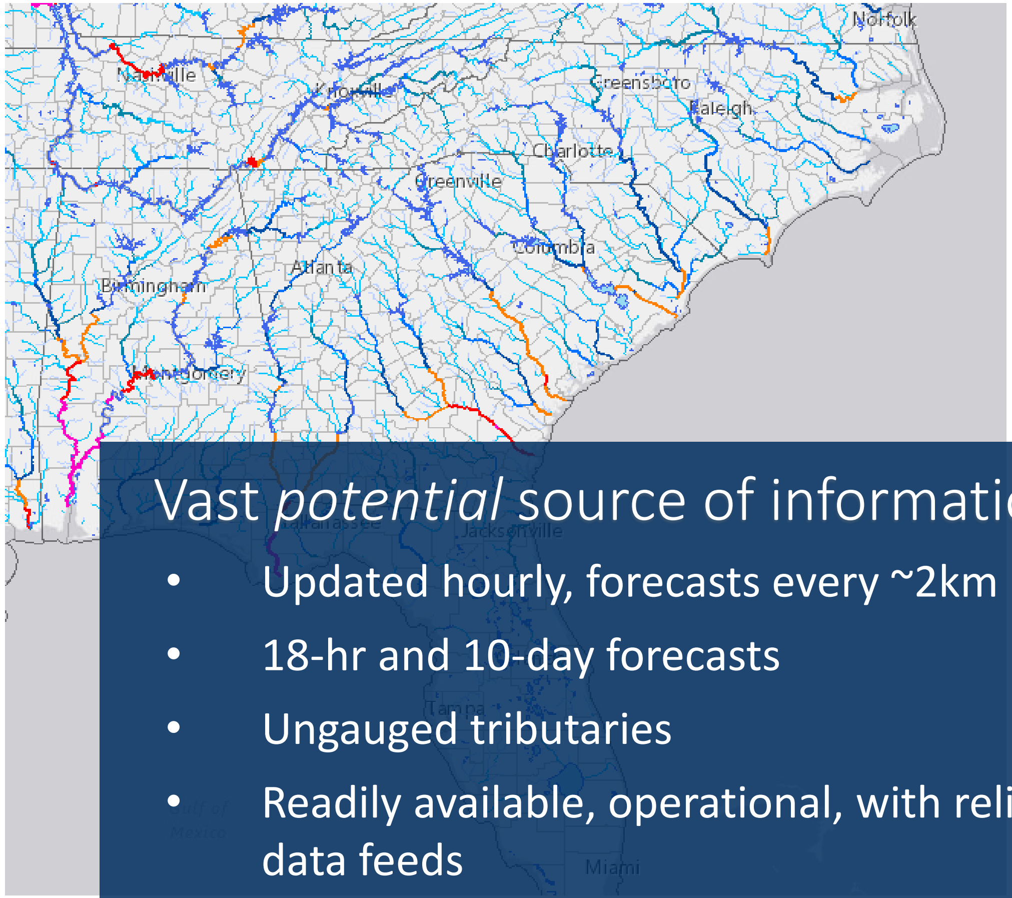
1. Scale – forecasts ‘everywhere’
2. Methods – AI/ML
3. Use – Systematic verification
4. Uncertainty – Ensemble approaches
5. Impact – Rapid inundation mapping





1. Scale - High Resolution Operational Forecasts

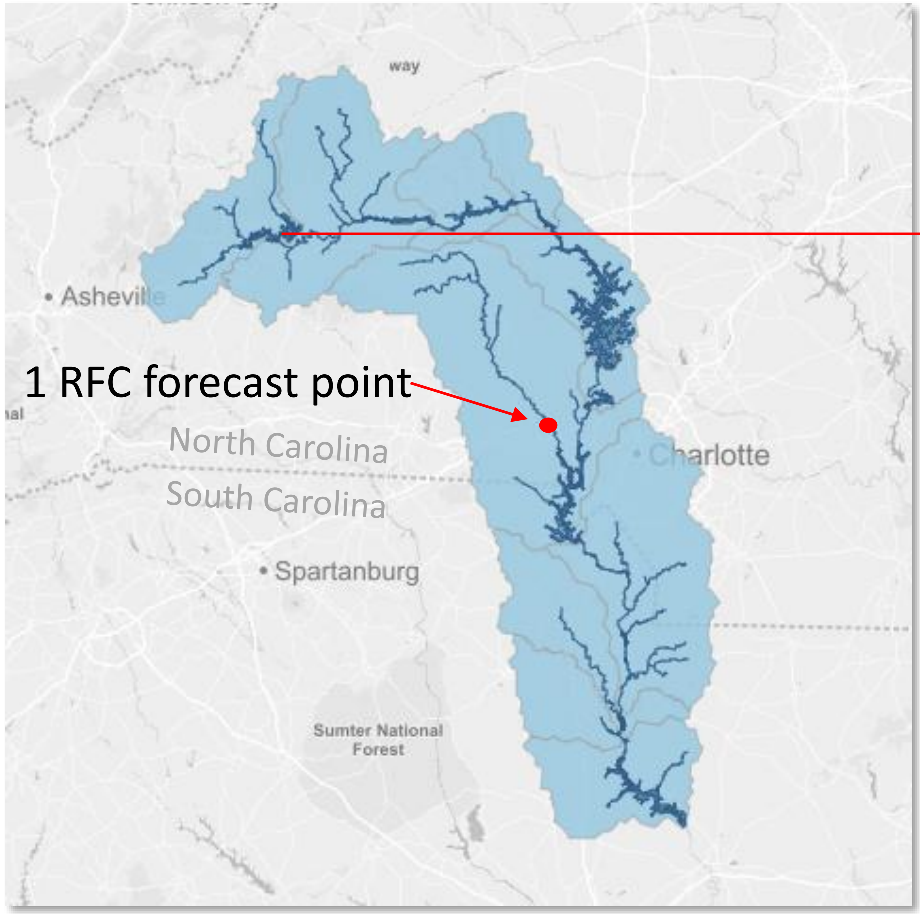


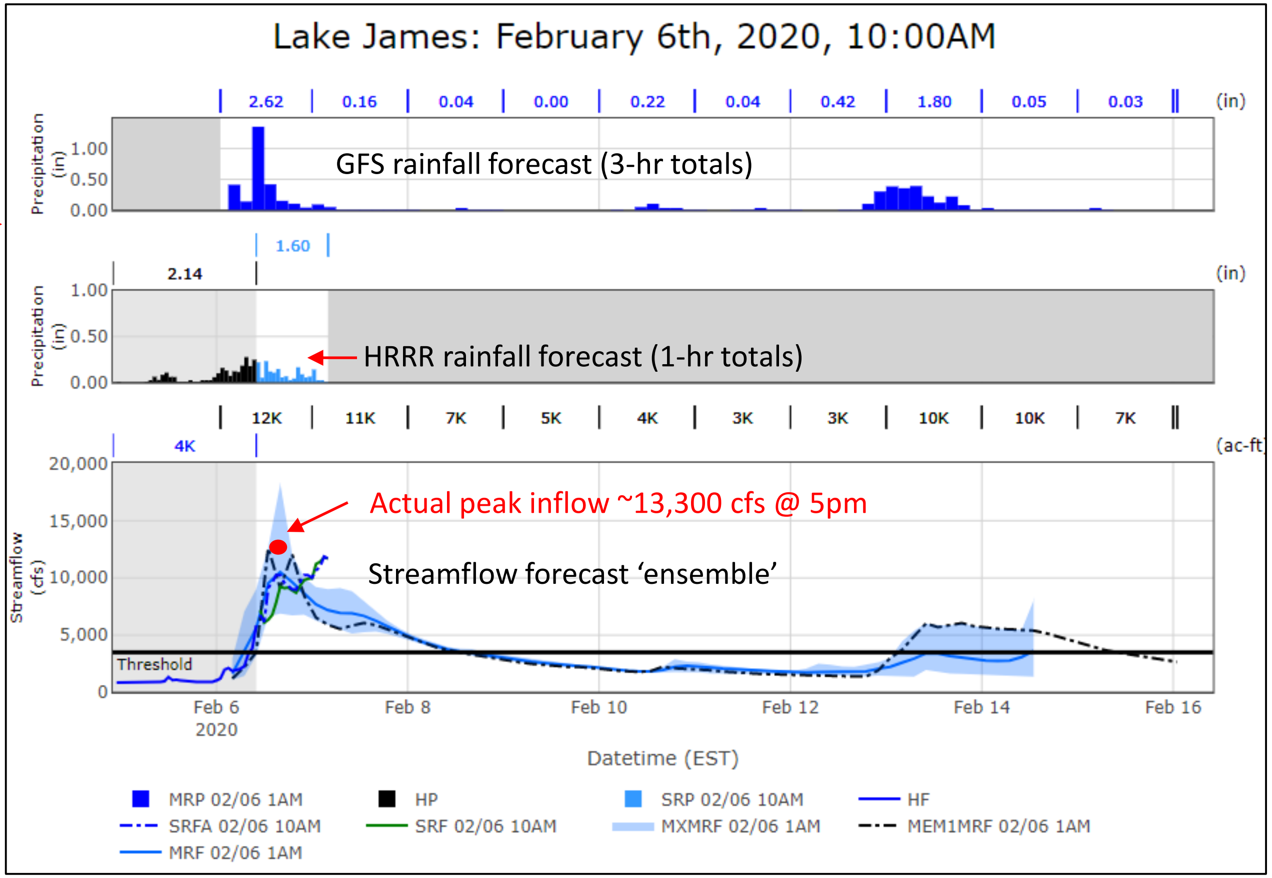


Vast *potential* source of information

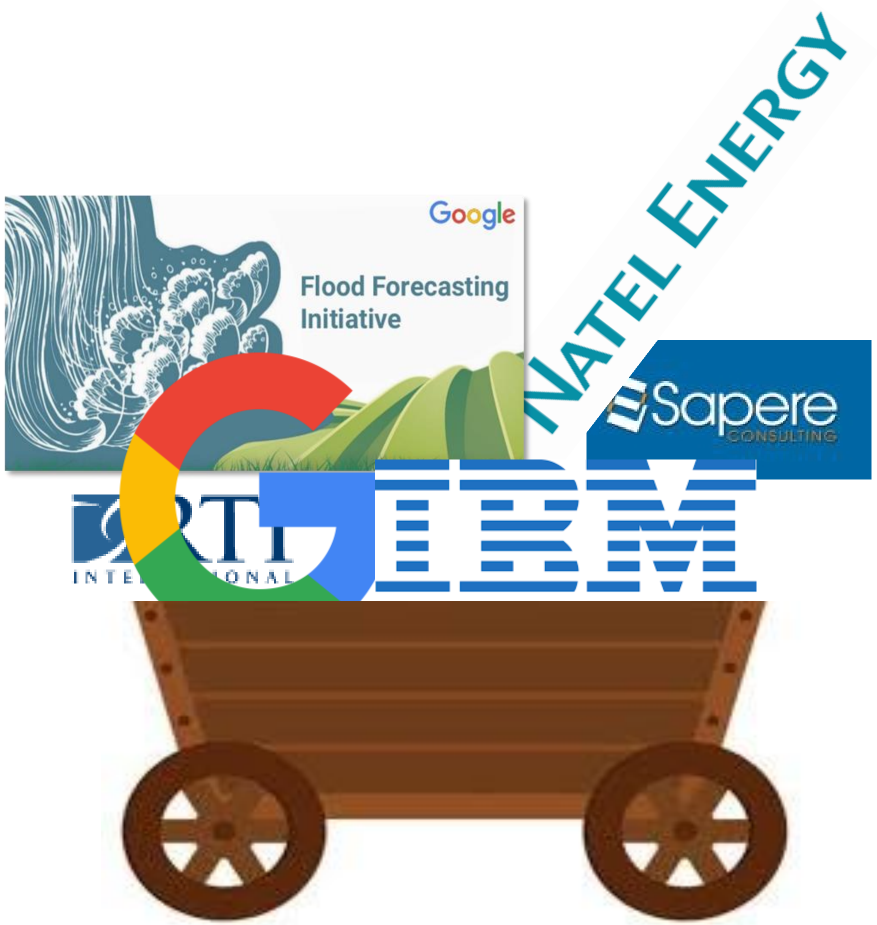
- Updated hourly, forecasts every ~2km reach
- 18-hr and 10-day forecasts
- Ungauged tributaries
- Readily available, operational, with reliable data feeds

e.g. Catawba Basin





2. Methods - Emerging AI/ML-Based Forecasts



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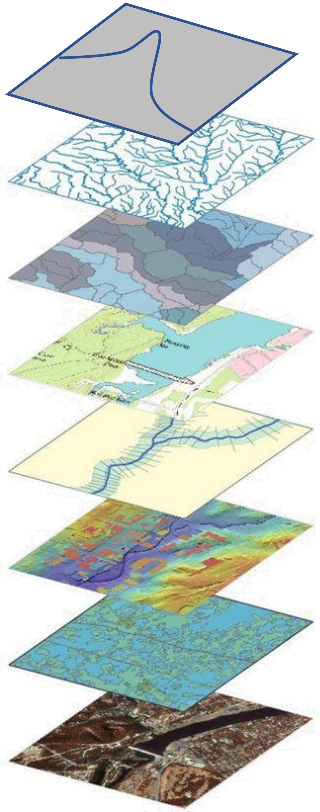
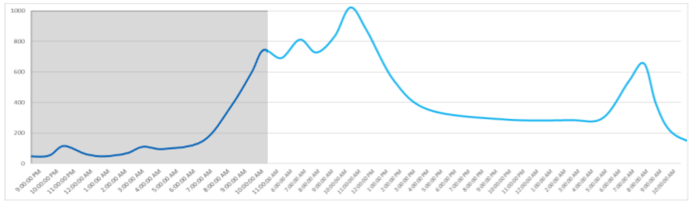


Streamflow forecasts



Long-Short Term Memory Recurrent Neural Network (LSTM RNN)

Forcings
QC'd Observations and Forecasts

Hydrologic Model

Reservoir Model

Recurrent Neural Network

Inflow Forecasts

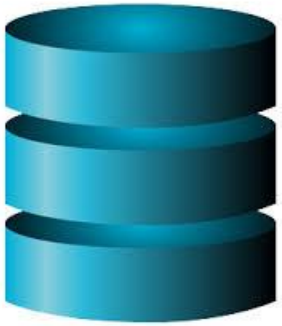
3. Use – Continuous, Systematic Verification

How “good” is my forecast?

- Depends on the event
- Depends on the location
- Depends on the use
- One event is not enough

TVA River Forecast Center

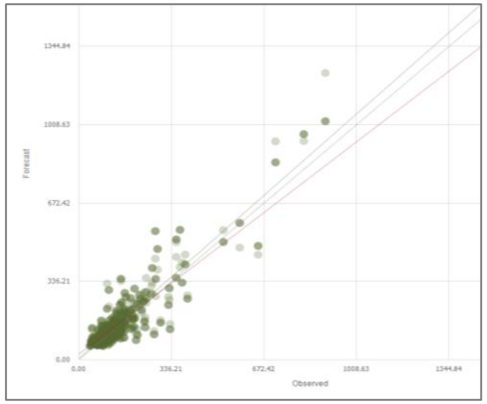
Components of a verification system



Database

Archived Forecasts
Simulations
Observations

Organized by
- lead time
- flow magnitude, etc.

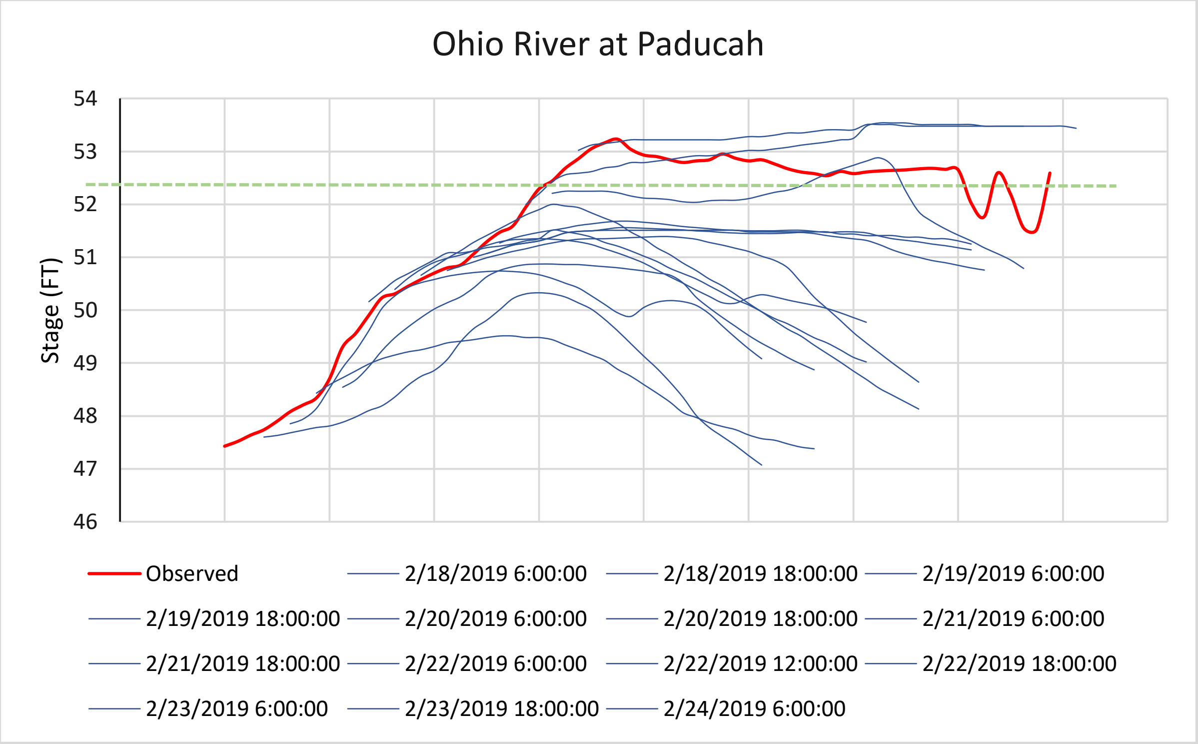


Graphical visualization
&
Statistics

<u>MANY</u> possibilities

3. Use – Continuous, Systematic Verification

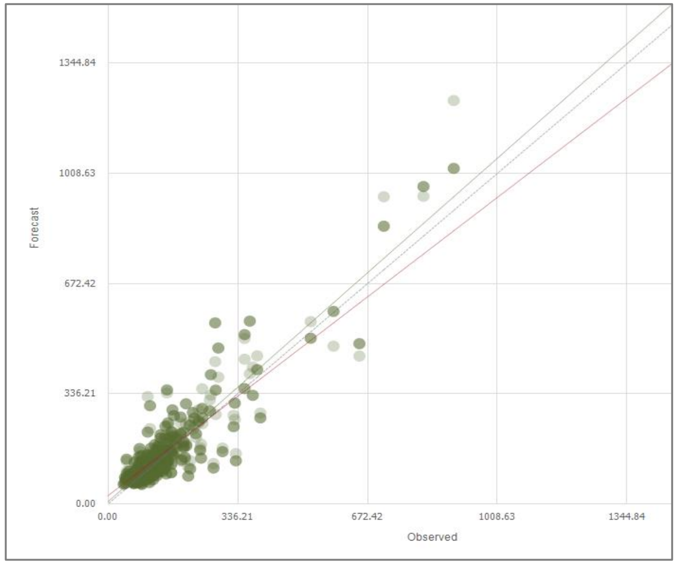
- Learning from meteorology!
- Less used in hydrologic forecasting, particularly outside of NWS



(Source: TVA)

Lead-time based statistics

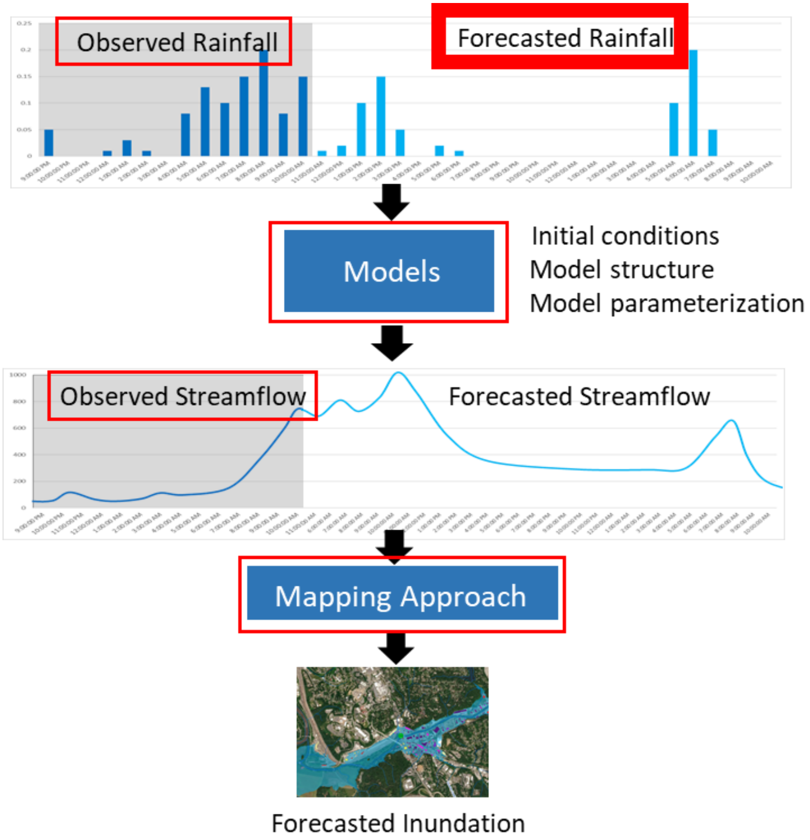
e.g. 6-hour lead time
Forecast vs. Observed



3. Use – Continuous, Systematic Verification

4. Characterizing Uncertainty – Ensemble Forecasting Approaches

Recap: Sources of Uncertainty



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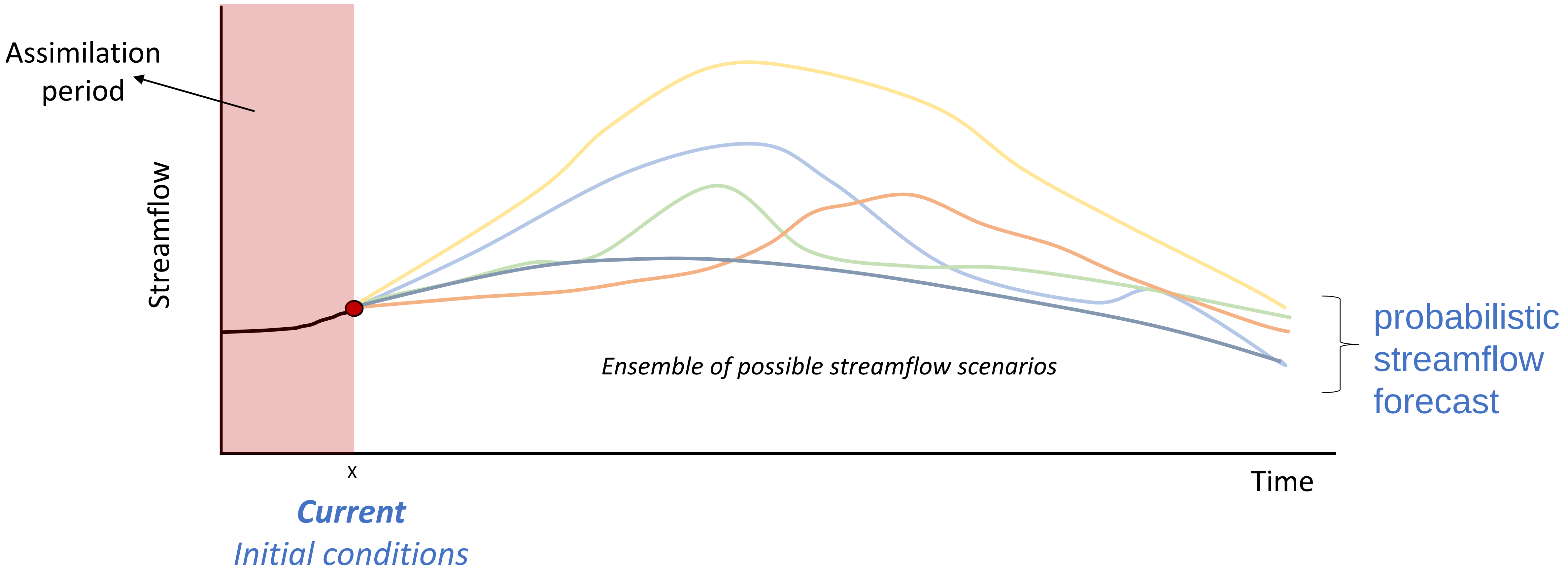
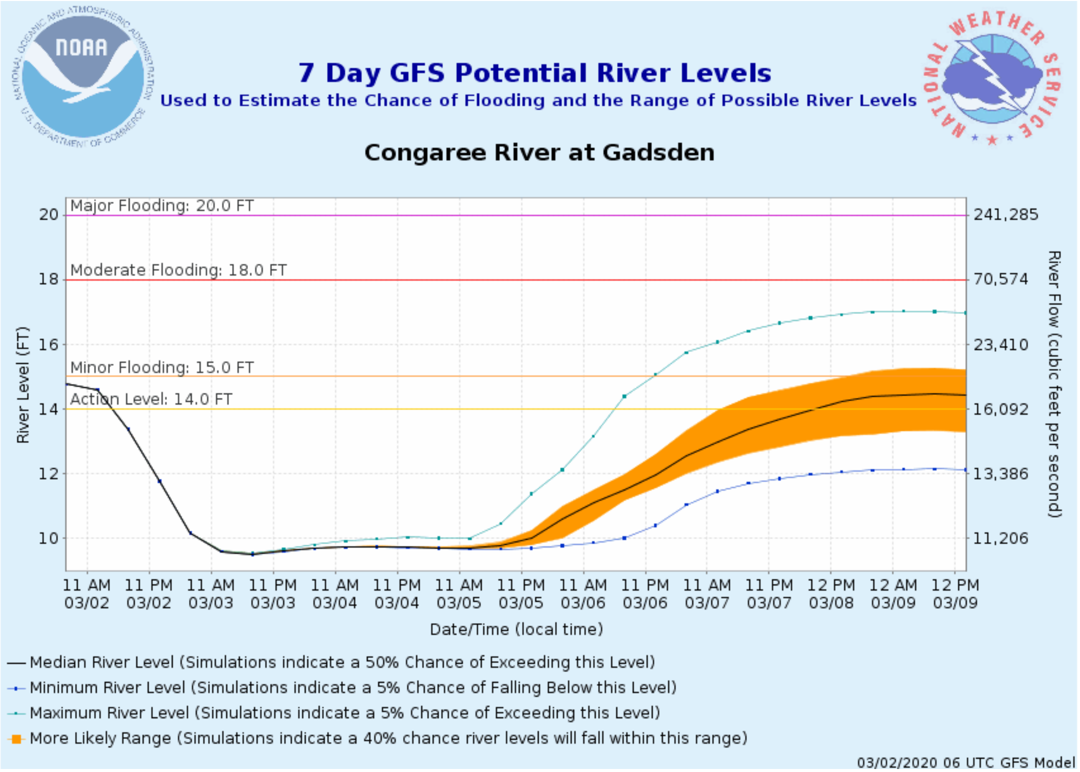
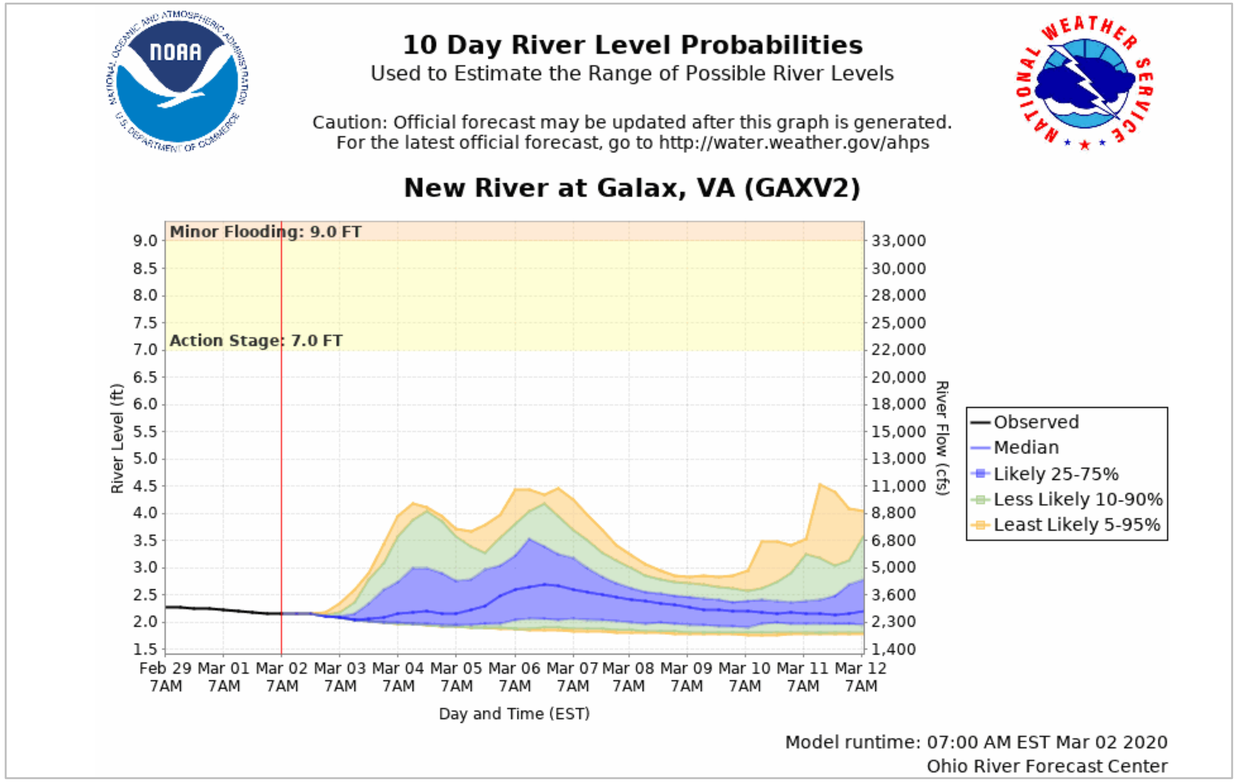


4. Characterizing Uncertainty – Ensemble Forecasting Approaches

MMEFS – Weather (Precip) Uncertainty



HEFS – Total (Weather + Hydrologic) Uncertainty

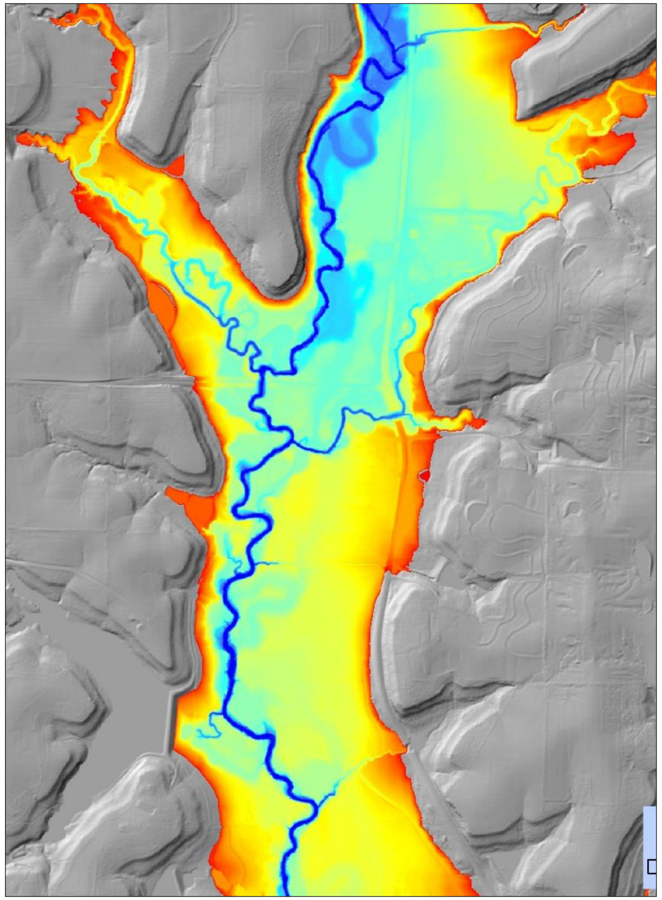


5. Impacts – Rapid Inundation Mapping for Real-Time Application

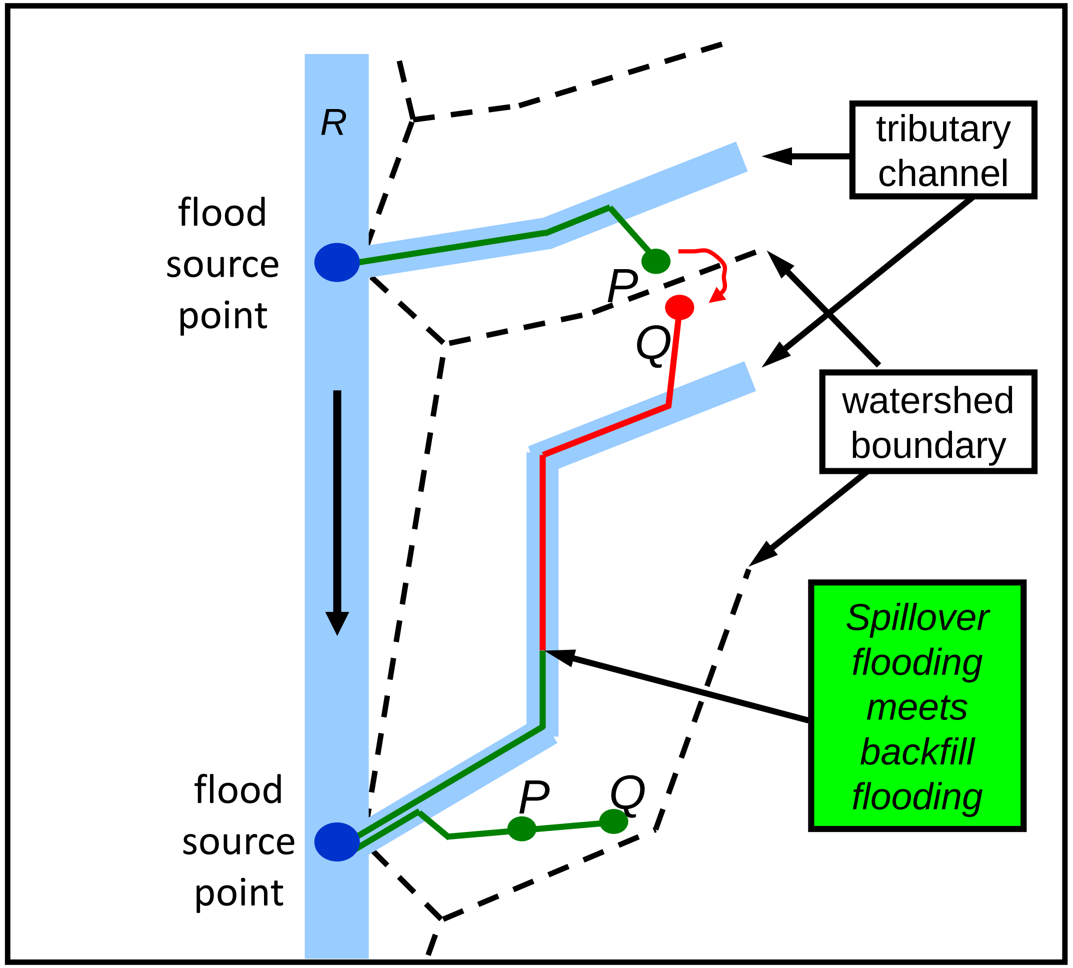
"SLIE" – Segmented Library of Inundation Extents

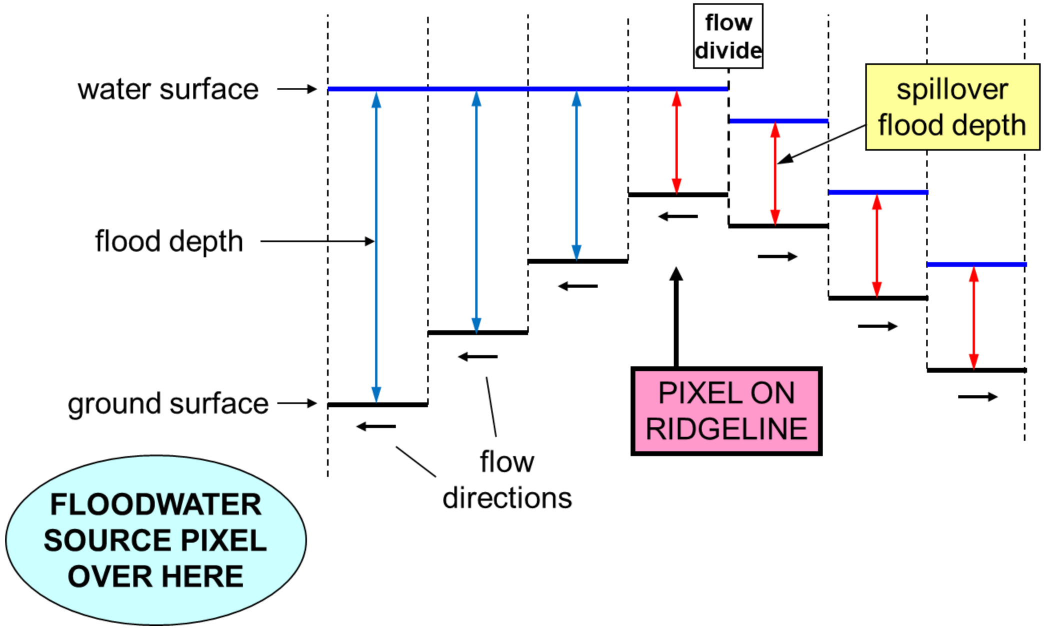
- Developed at the University of Kansas - FLDPLN
- Implemented for State of KS (underway)
- RTI developed utilities to use in real-time systems

- Up-front grid processing and modeling (e.g. steady)
- Handles 'spillover' flooding from multiple sources
- Accurate and FAST map development
    - Allows extensive coverage
    - Real-time animations

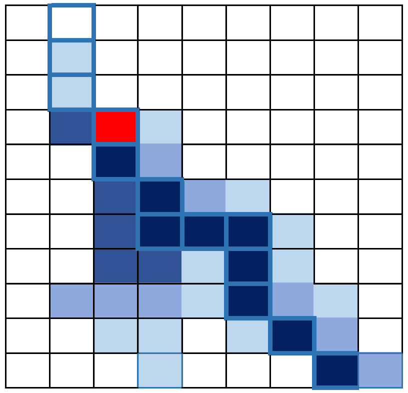


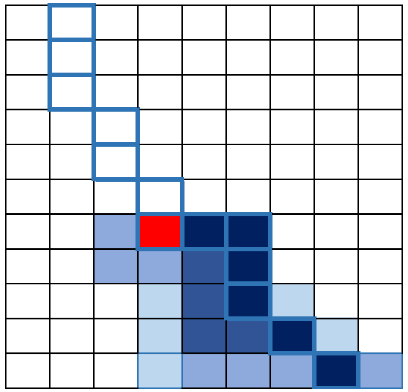
Including Spillover





“SLIE” Approach

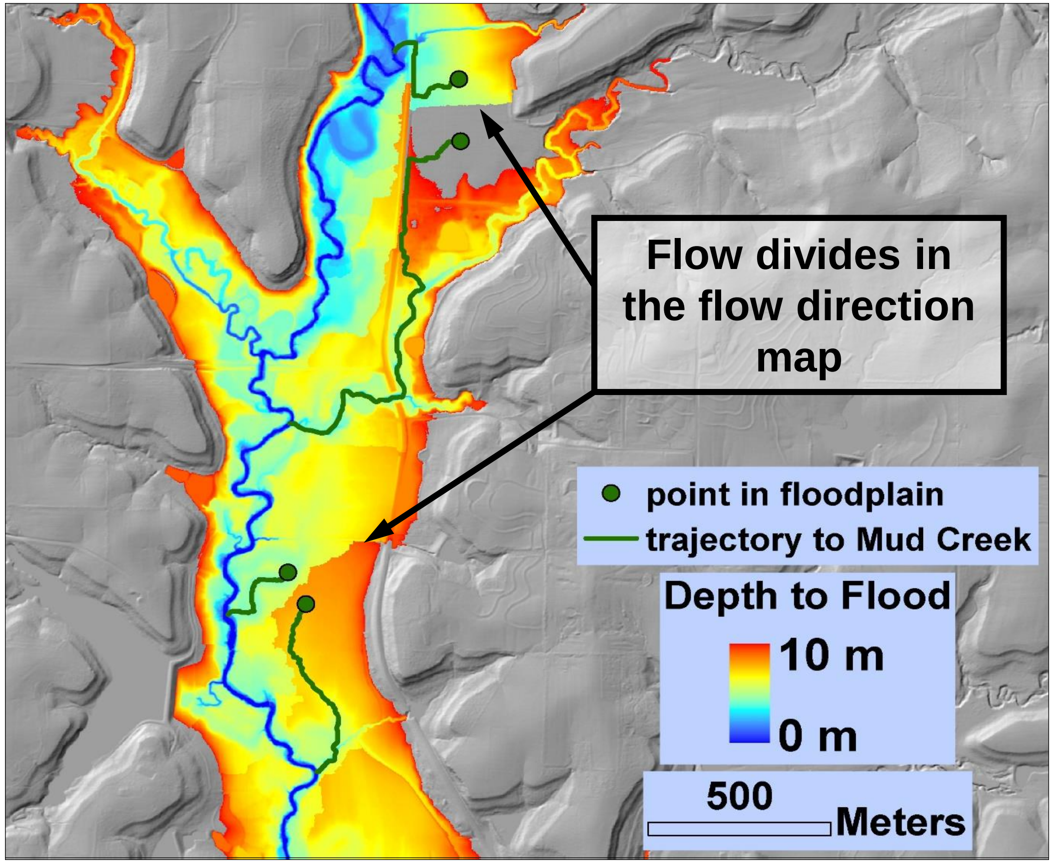




- For different depths at <u>each source pixel</u>, identify which pixels are inundated and by how much – including due to spillover
- Store a database of grids <u>for every source pixel</u>

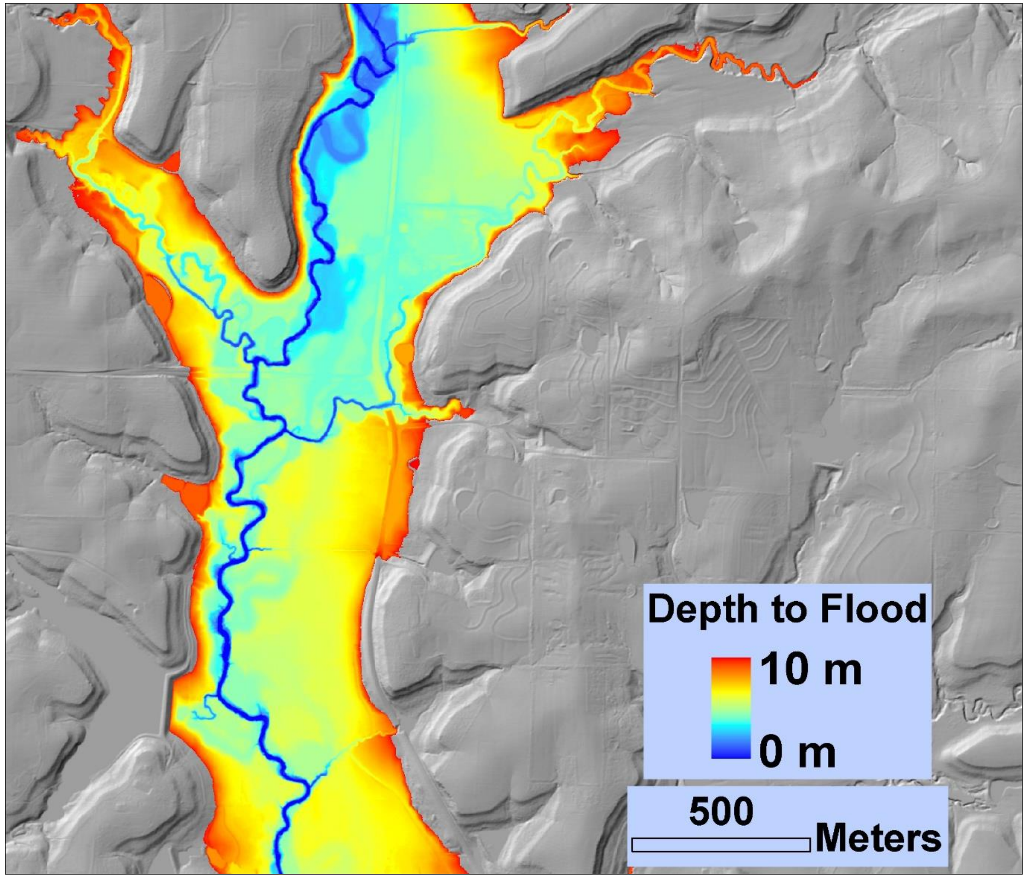
Backfill flooding-only approach

- DTF map determined using backfill flooding.
- Note the erroneous discontinuities.
- These are caused by ridgelines in the DEM.



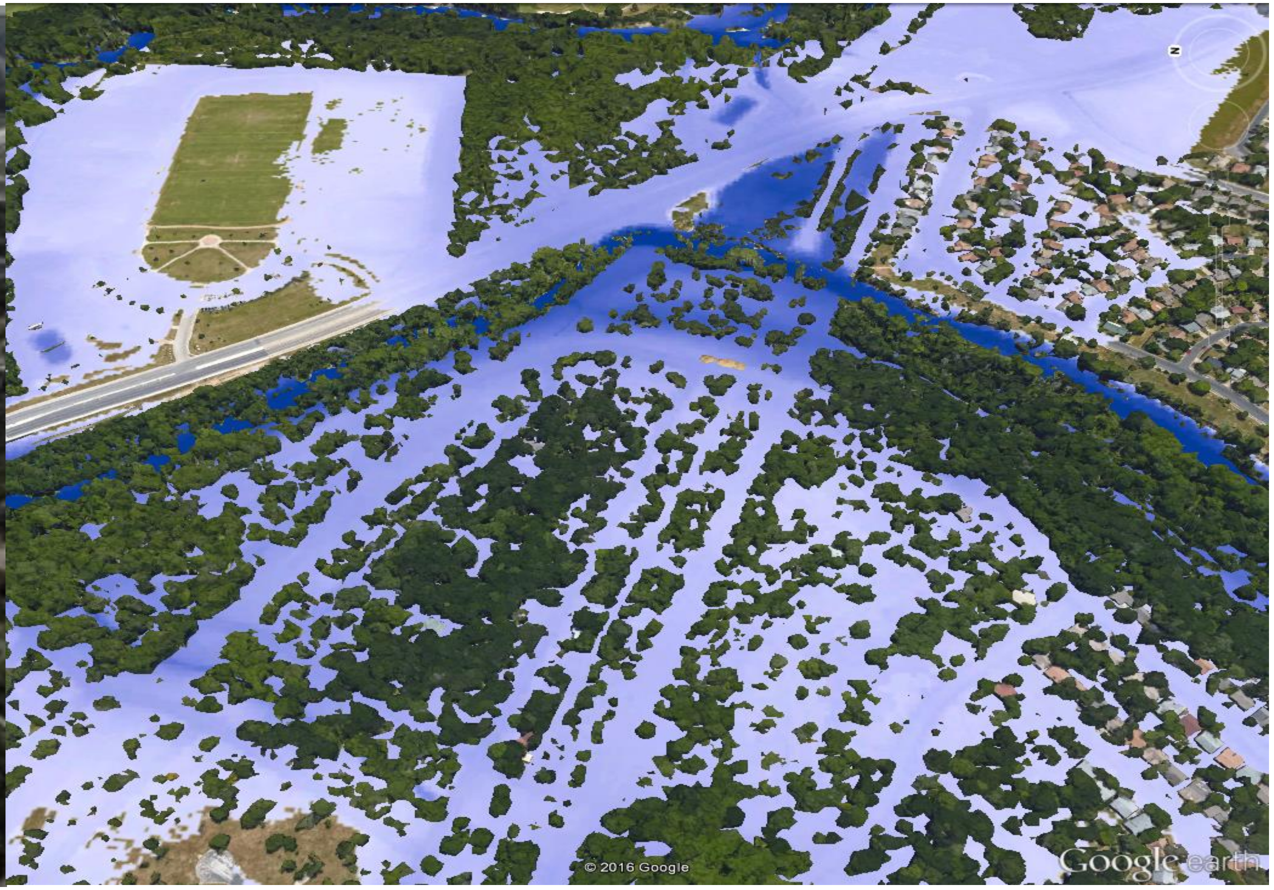
Backfill flooding + Spillover approach (SLIE)

By backfill flooding and allowing spillover flooding to occur, the DTF discontinuity problem is mostly resolved.

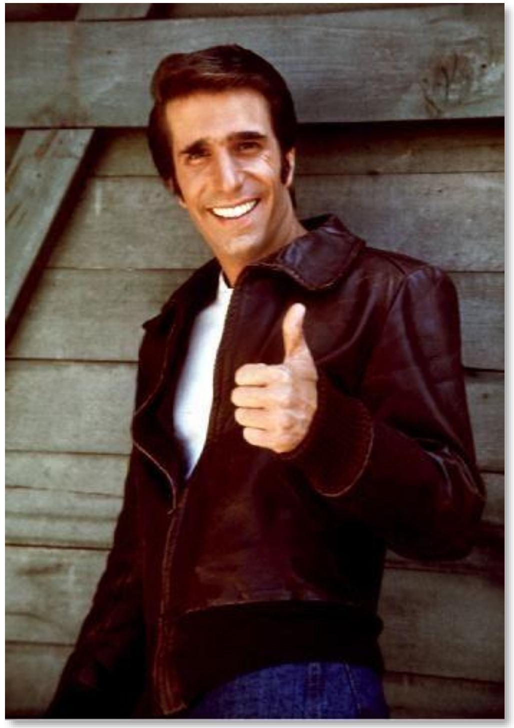


- Ideal for <u>real-time</u> mapping
- More versatile and accurate than libraries for dynamically changing conditions
- Runs in minutes over large basins and easily automated

Onion Creek, TX 2013



In Summary… forecasting is cool.



Lots of exciting stuff going on

Thank You!

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