



Quantifying Flood Risk and Impacts through Detailed Physical Process and Geospatial Representation using the WRF-Hydro Modeling System

NCAR Research Applications Lab

D. Gochis, A. Dugger, L. Read, D. Yates, K. Sampson, M. Barlage, L. Pan, Y. Zhang, J. McCreight, A. RafieeiNasab, L. Karsten, K. Fitzgerald, J. Mills, A. Gaydos, R. Cabell, J. Grim, E. Towler

NOAA Office of Water Prediction

B. Cosgrove, F. Salas, Y. Liu, X. Feng, T. Flowers, E. Clark,
T. Graziano, F. Ogden, S. Kahn, N. Frazier, C. Phan, Z. Cui, D. Johnson

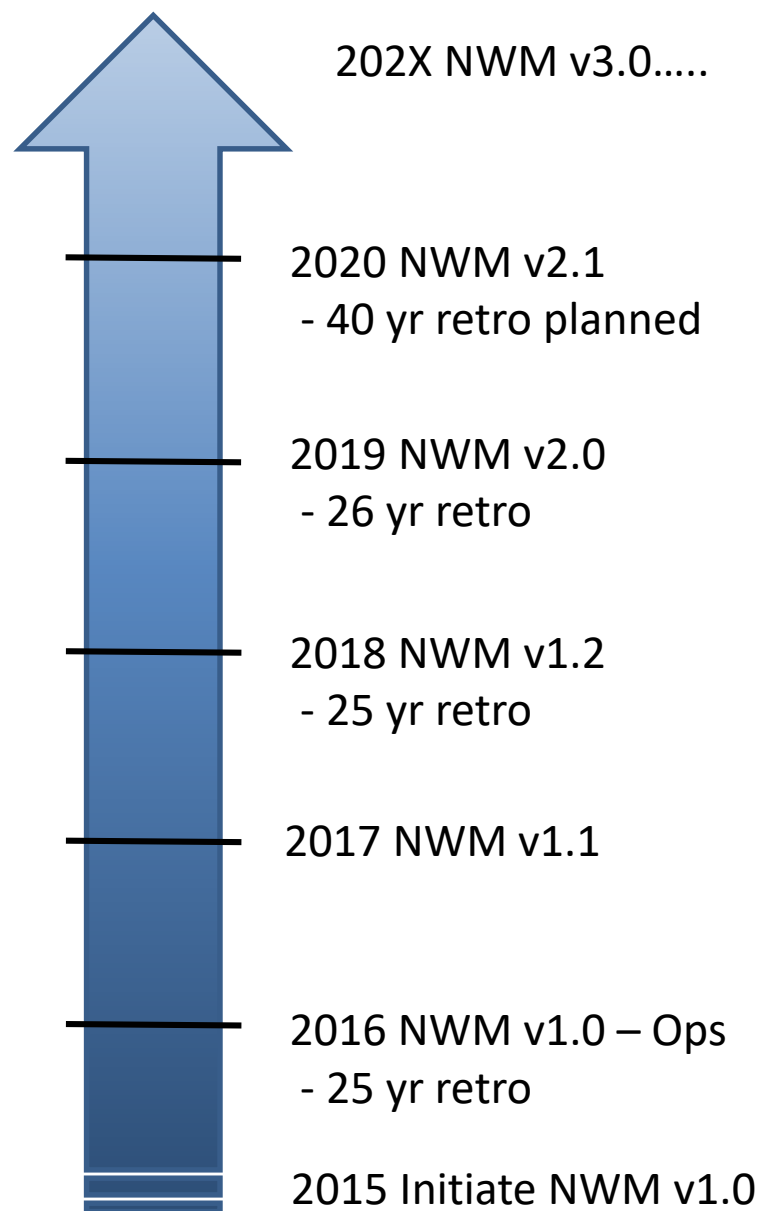




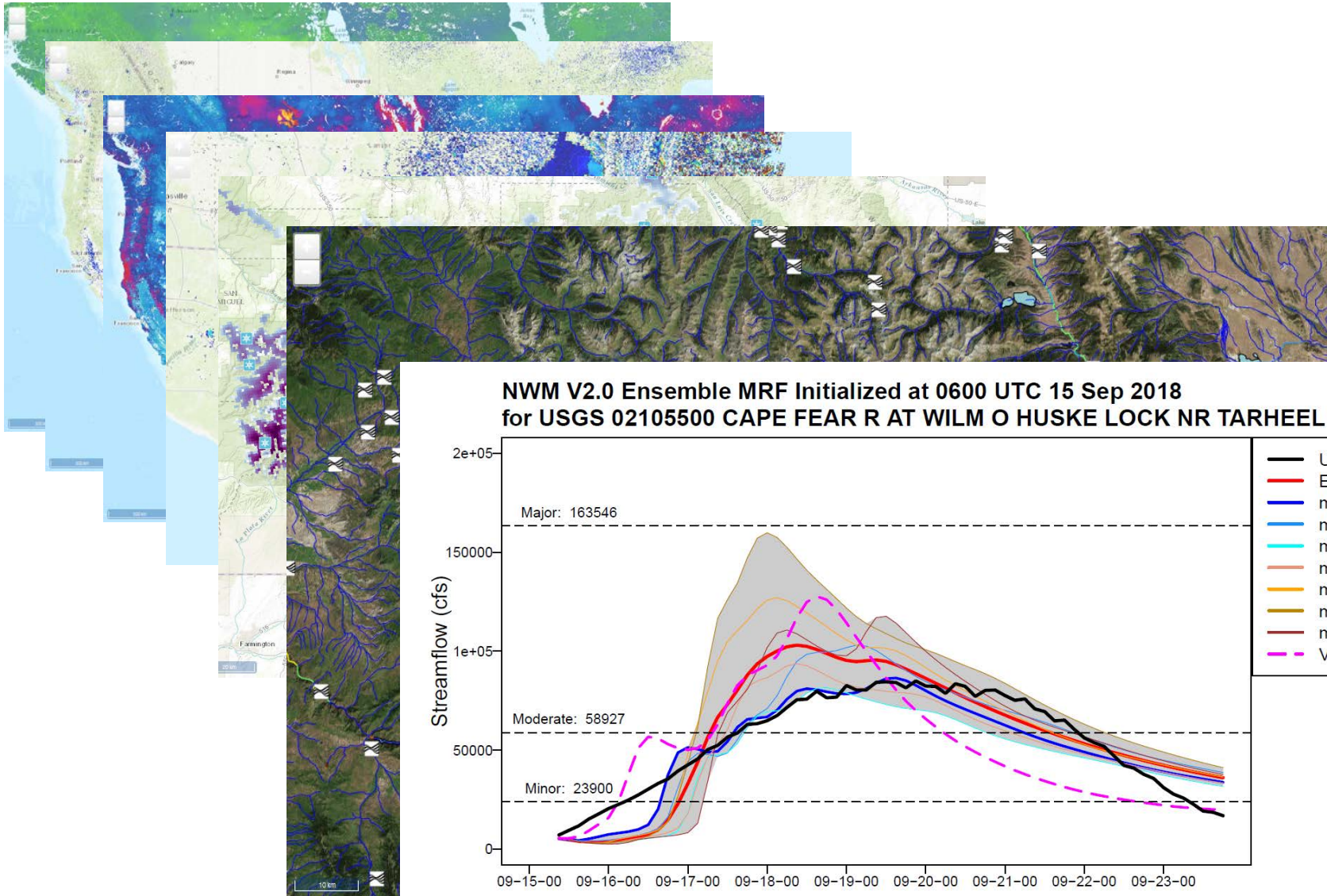
- Recap of NCAR role in current role/structure
- Value added NWM applications and emerging WRF-Hydro research areas:
 - Archive of long term simulation fields for statistical use
 - Downscaled flood inundation products
 - Hyper-resolution modeling
 - Constituent transport/tracer modeling



- NCAR Role:
 - Build and maintain underlying WRF-Hydro modeling architecture
 - Enhance physics options and input data into NWM
 - Conduct training and capacity building services
 - Perform version-over-version evaluation and assessment
 - Execute long-term retrospective model integrations for statistical benchmarking
- 25- and 40-year retrospective runs aligned with v2.0 and v2.1 of the NWM respectively



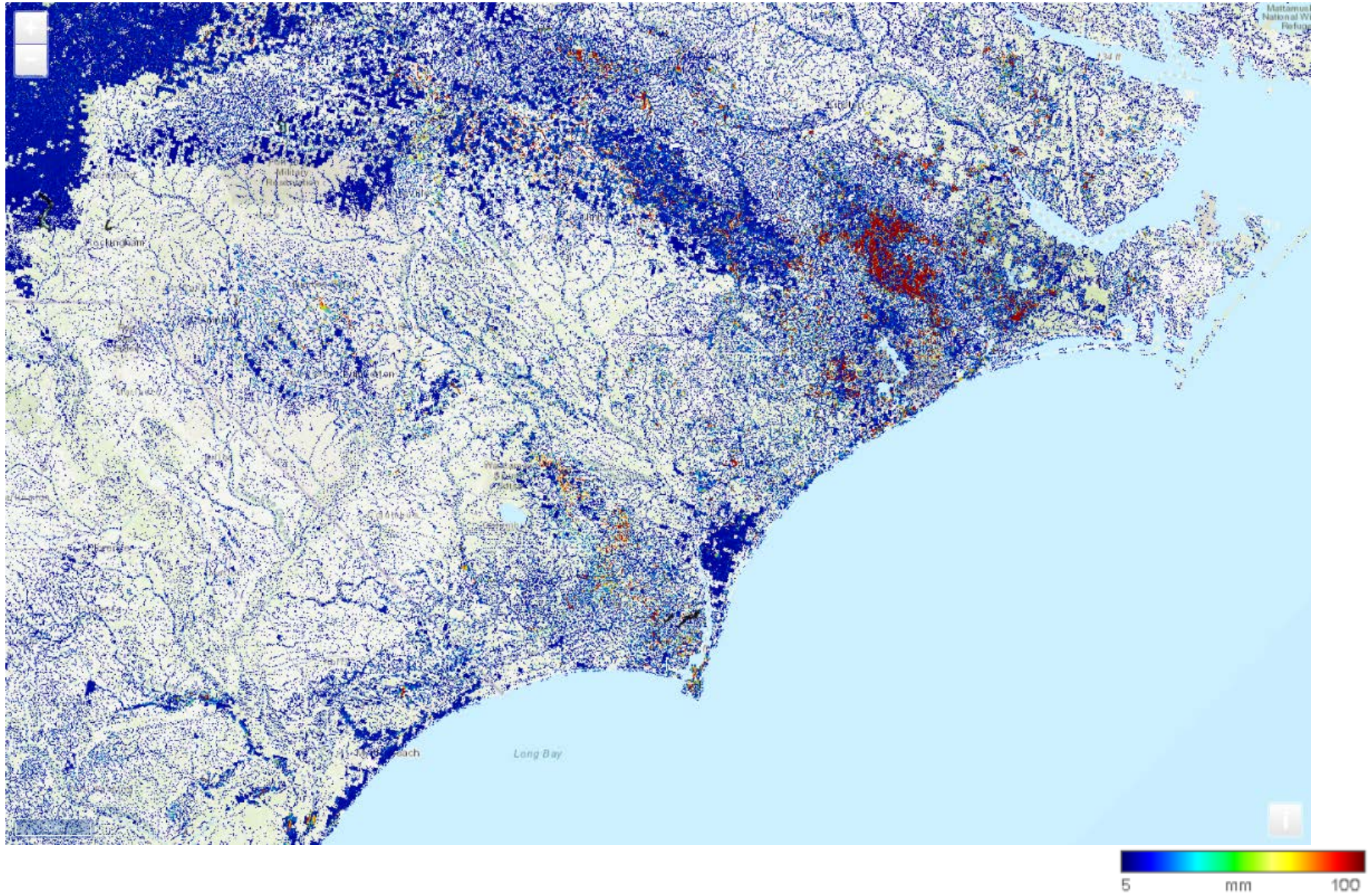
Model Outputs

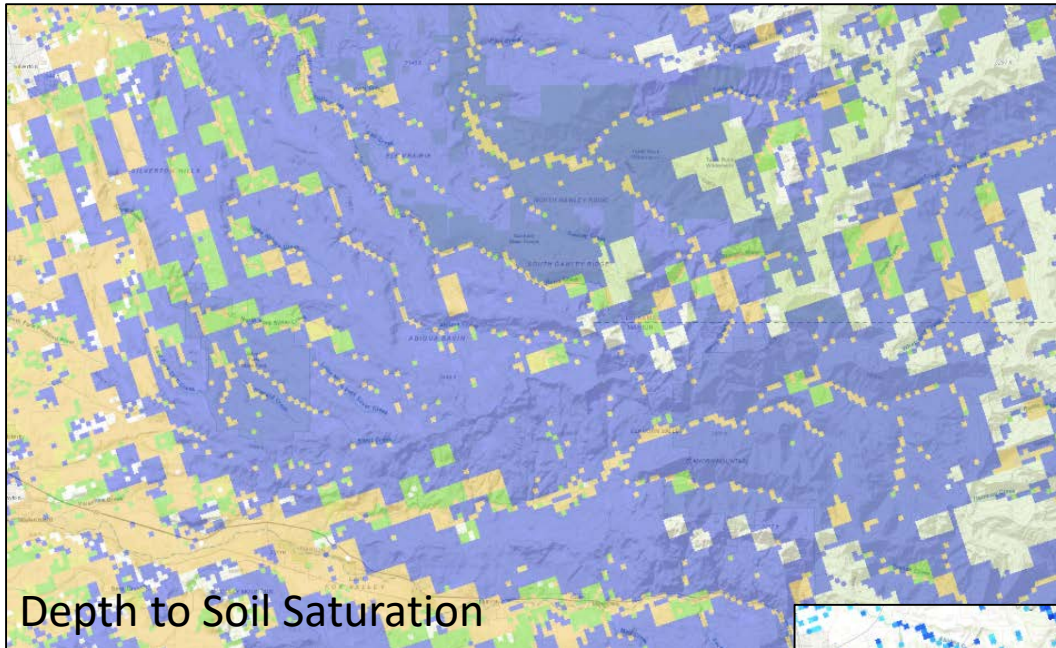


Ensemble streamflow predictions

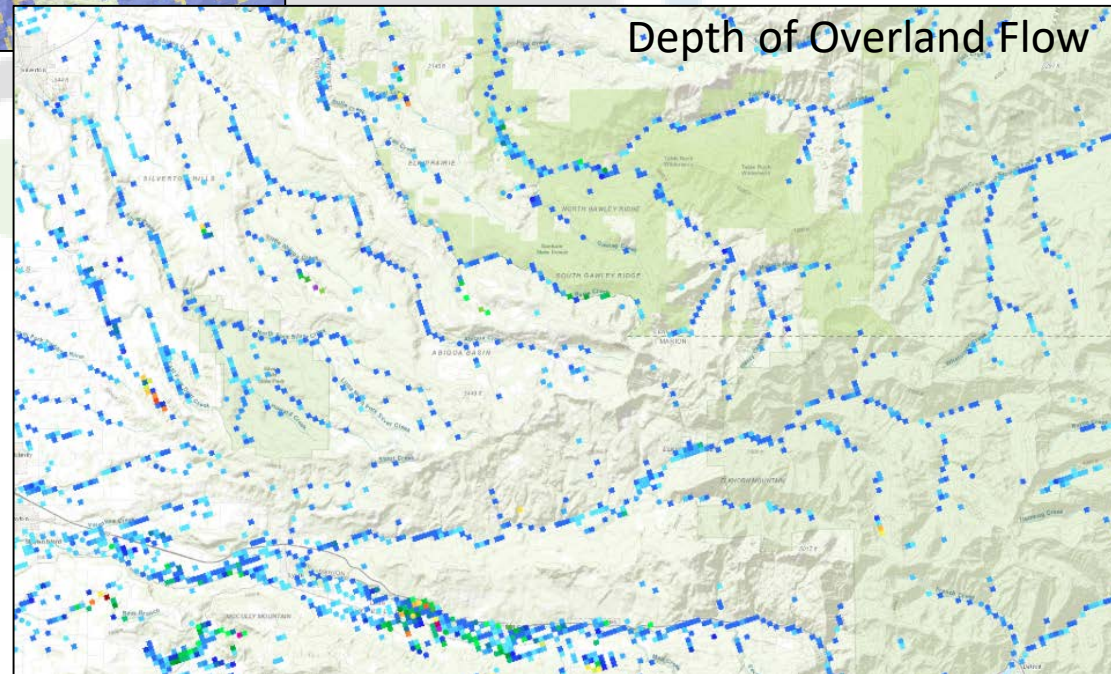


NWM v1.2 Medium Range Forecast Surface Overland Flow Water Depth (mm):
Eastern N. Carolina, Hurricane Florence....Forecast guidance up to 6 days in advance

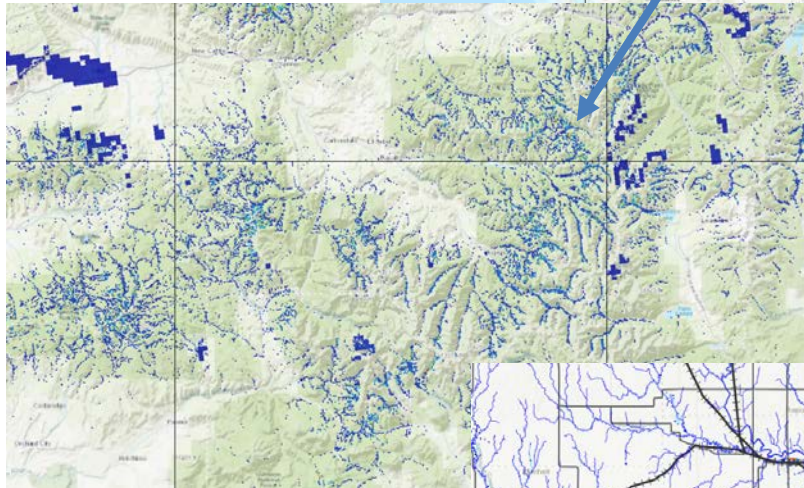
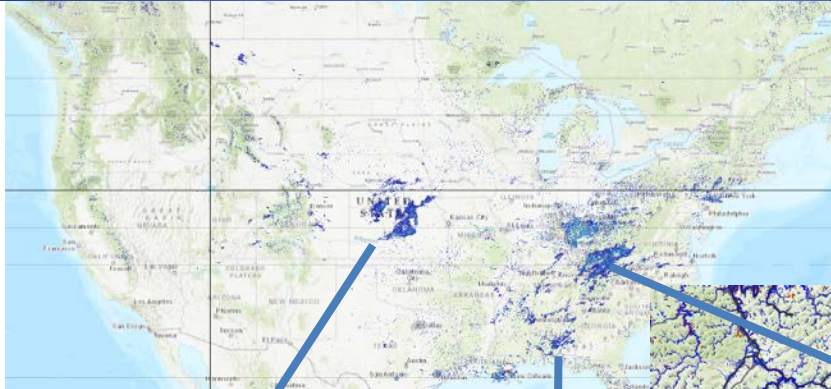




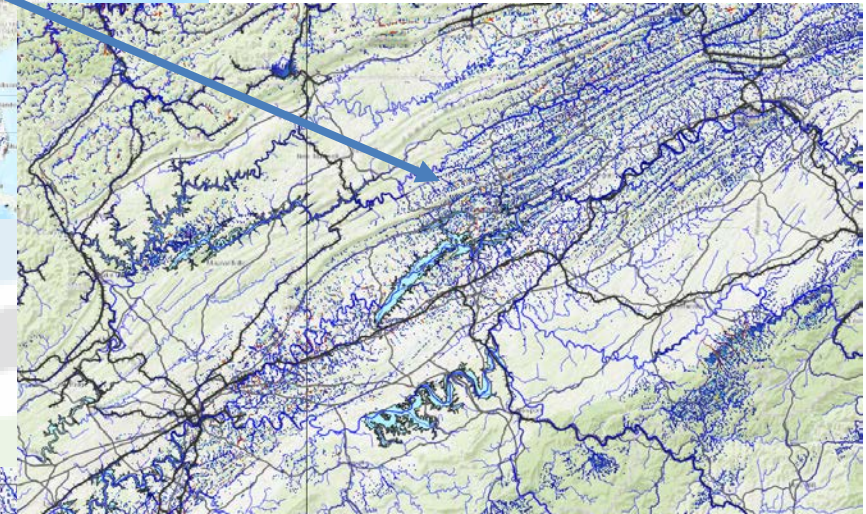
- Soil column saturation
- Exfiltration to surface
- Overland flow production



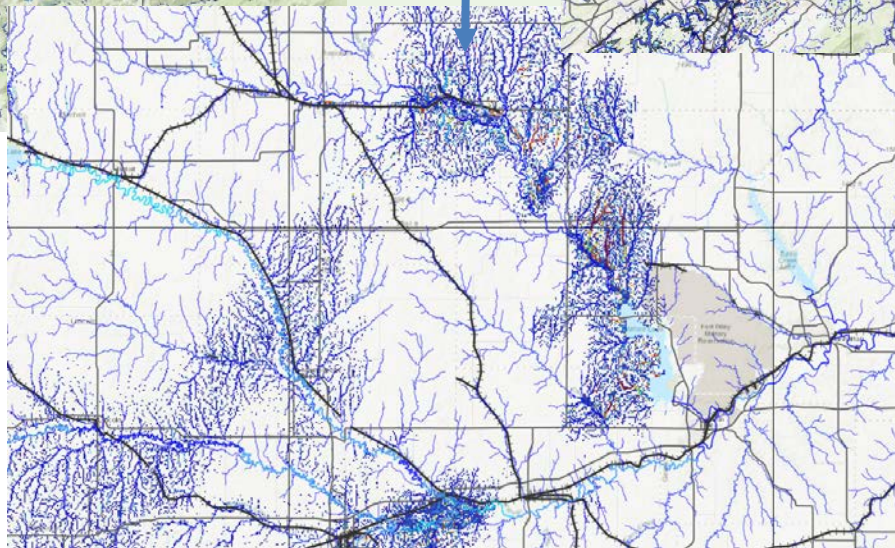
WRF-Hydro Research: Capturing multiple flooding mechanisms



Rapid snowmelt/rain-on-snow driven flow



Heavy rainfall-driven flow

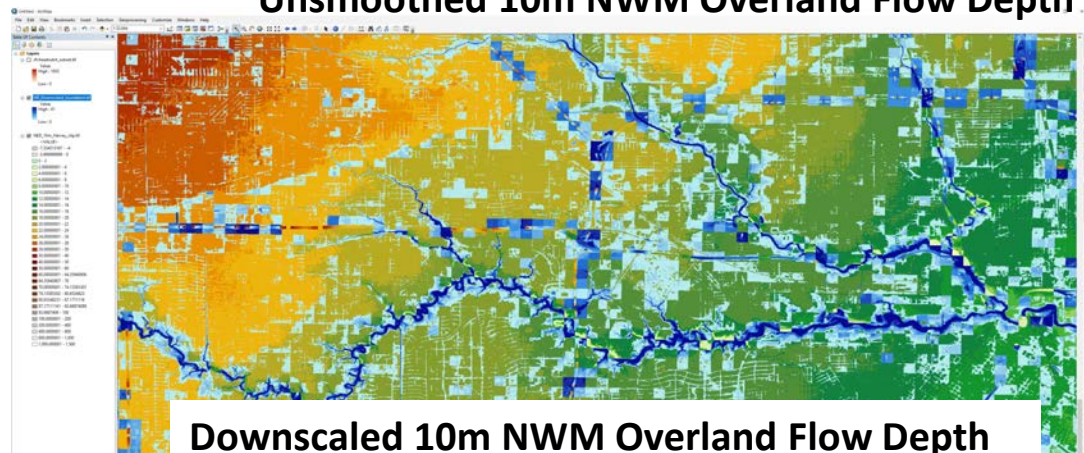


Heavy rainfall-driven flow

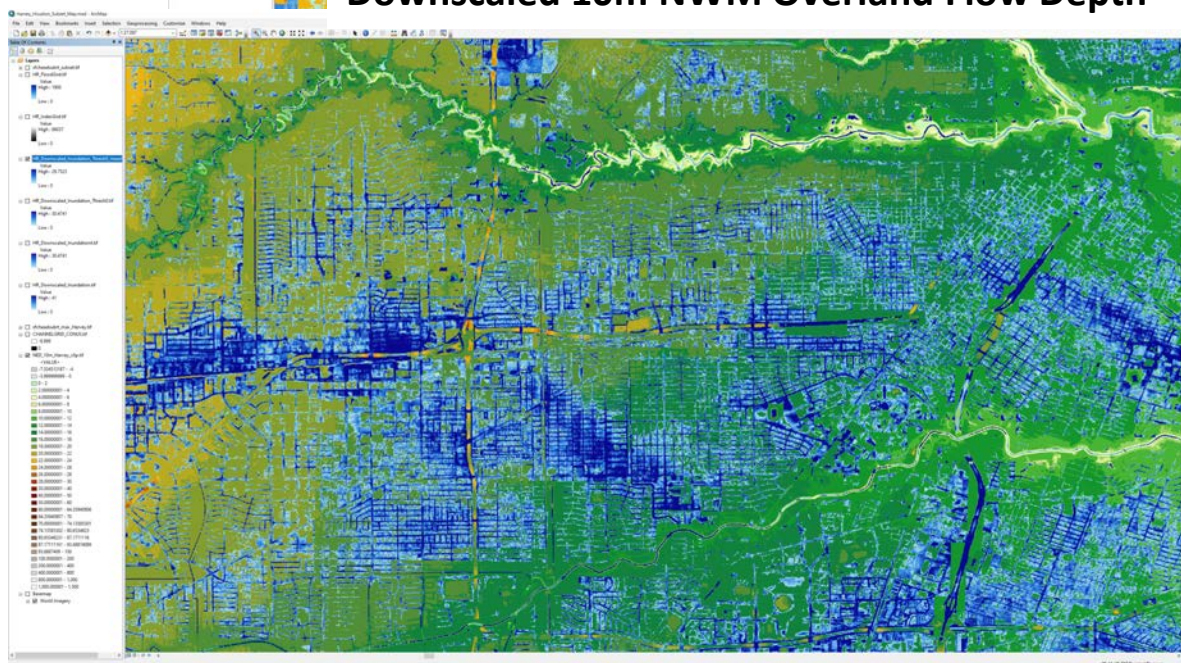


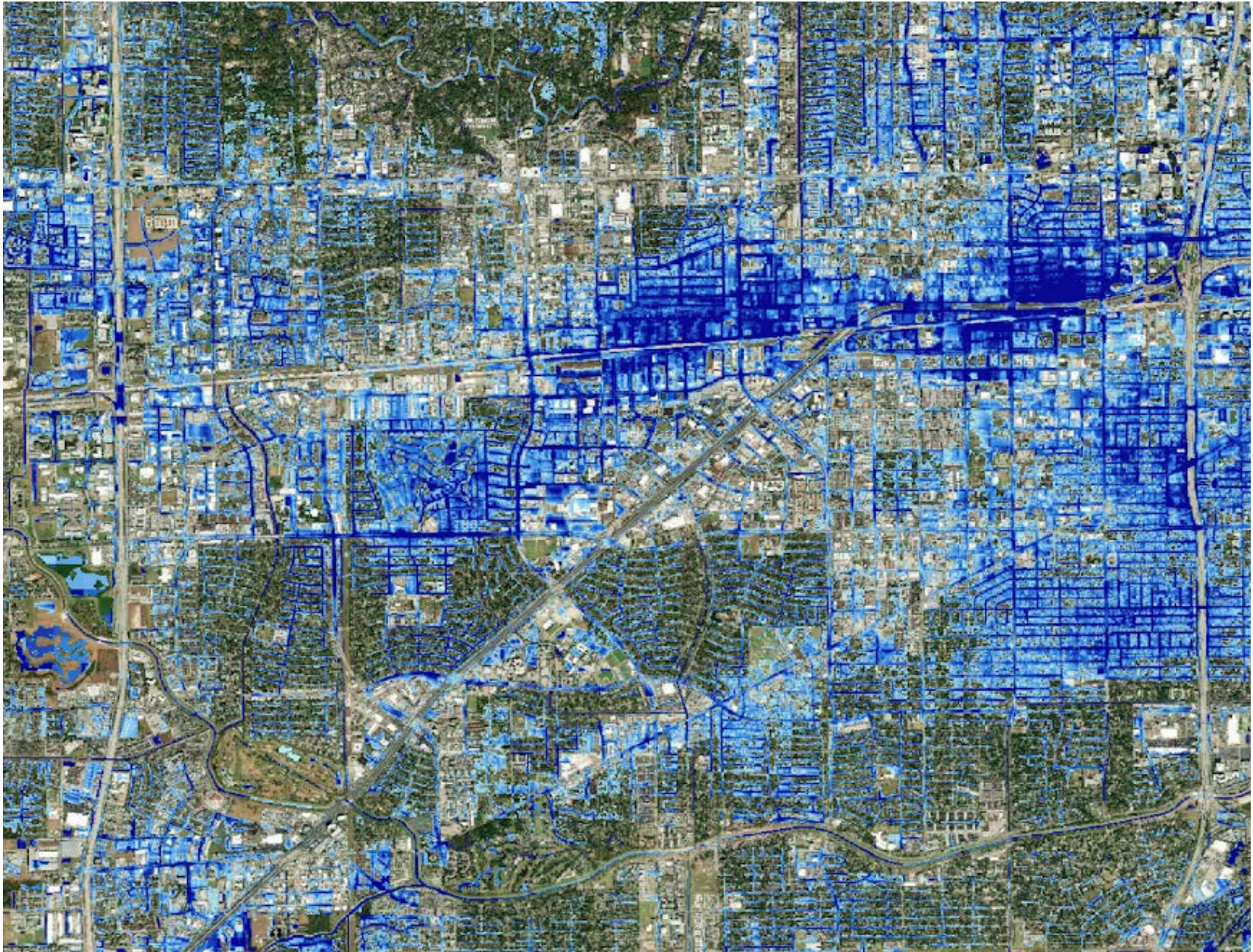
- Terrain-downscaled inundation maps
- 2-step hybrid blended product:
 - Downscaled max. overland flow depth
 - Riverine inundation
 - Utilize ensembles forecasts to make probabilistic product
 - Adopt workflow to 'on-demand' service via HydroInspector
- Applications in:
 - Operational prediction
 - Long term risk analysis

Unsmoothed 10m NWM Overland Flow Depth



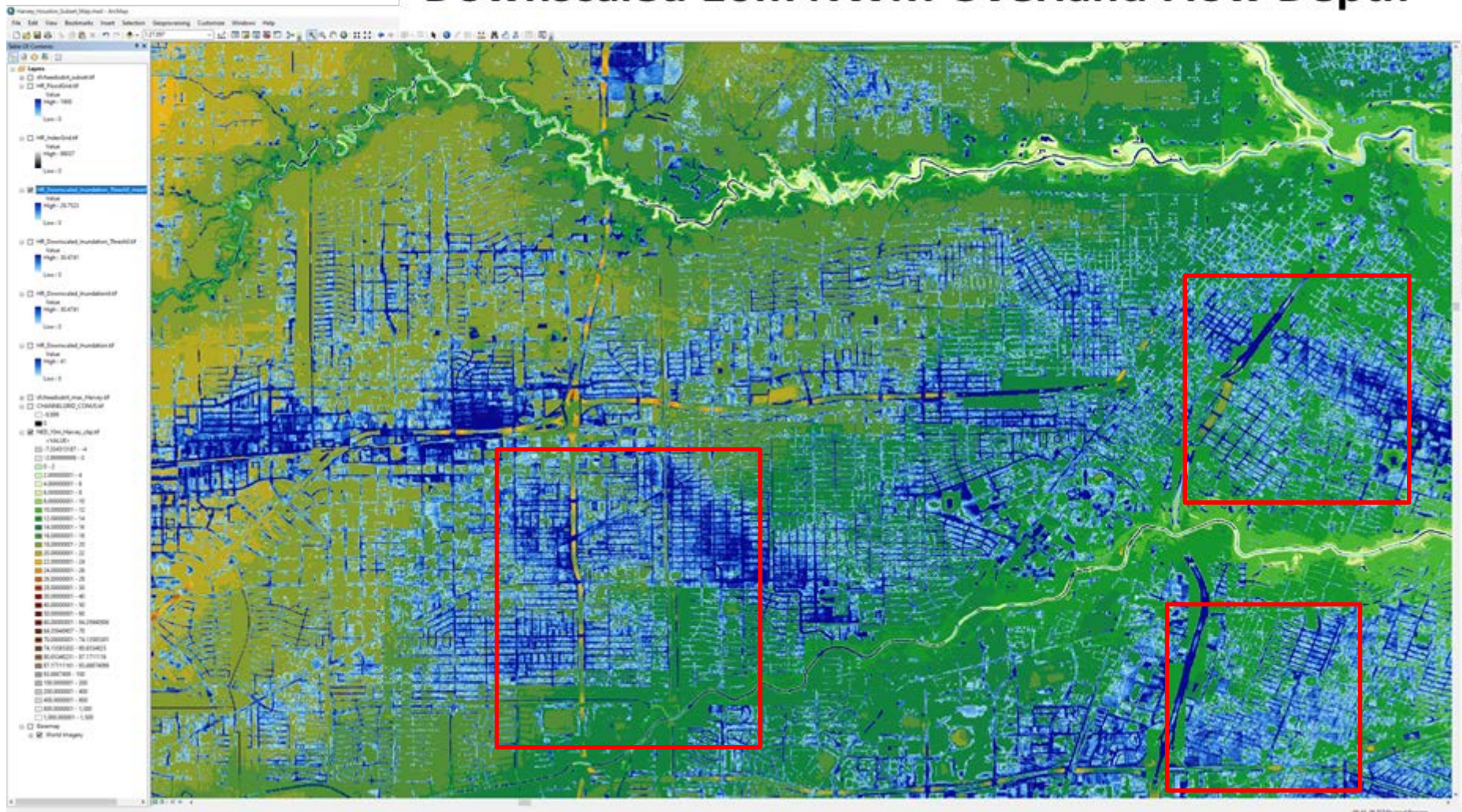
Downscaled 10m NWM Overland Flow Depth







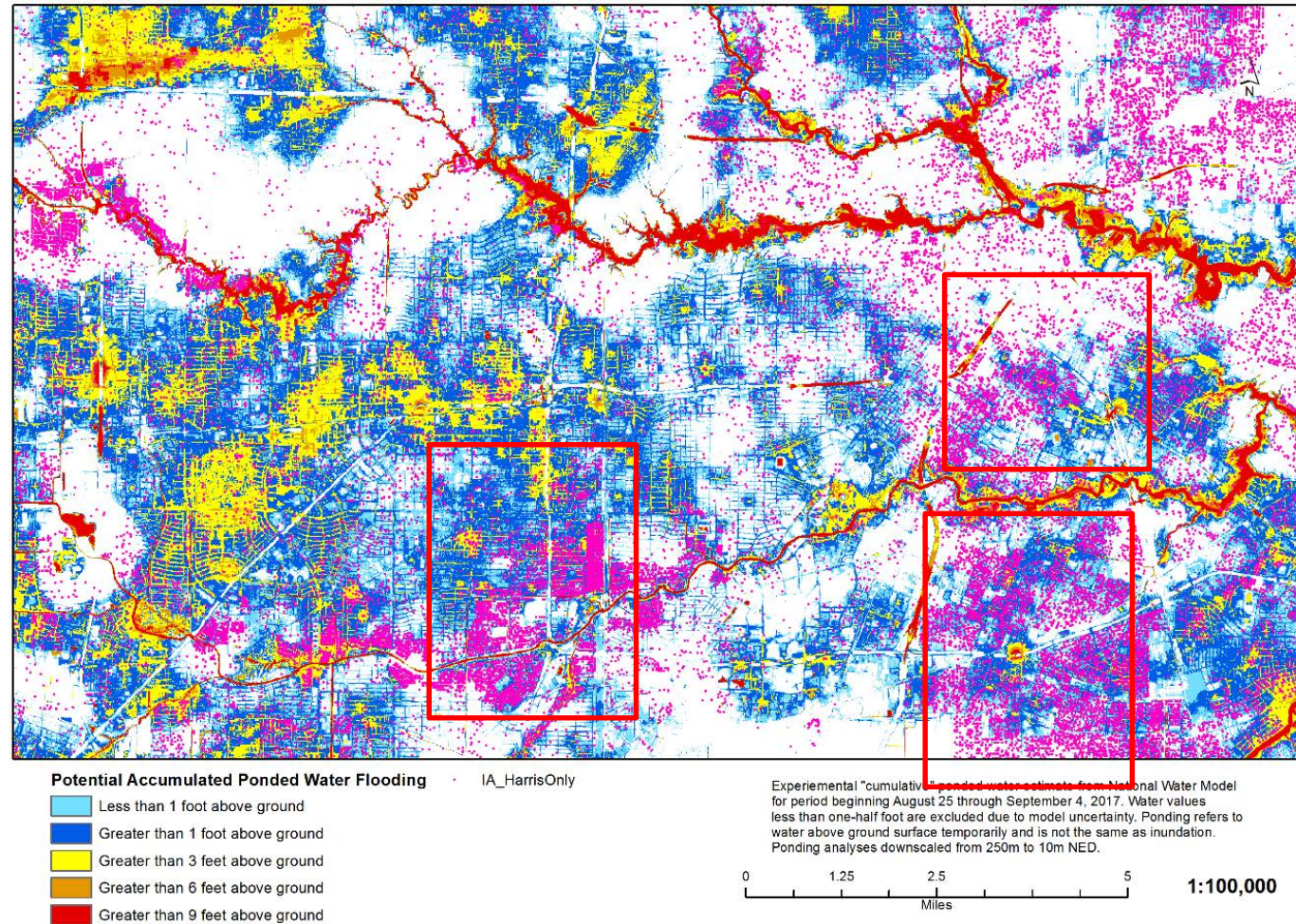
Downscaled 10m NWM Overland Flow Depth



- Work to blend overland flow with riverine flood inundation products is ongoing

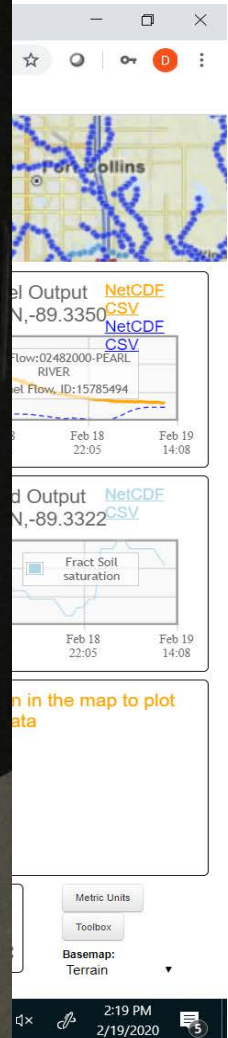
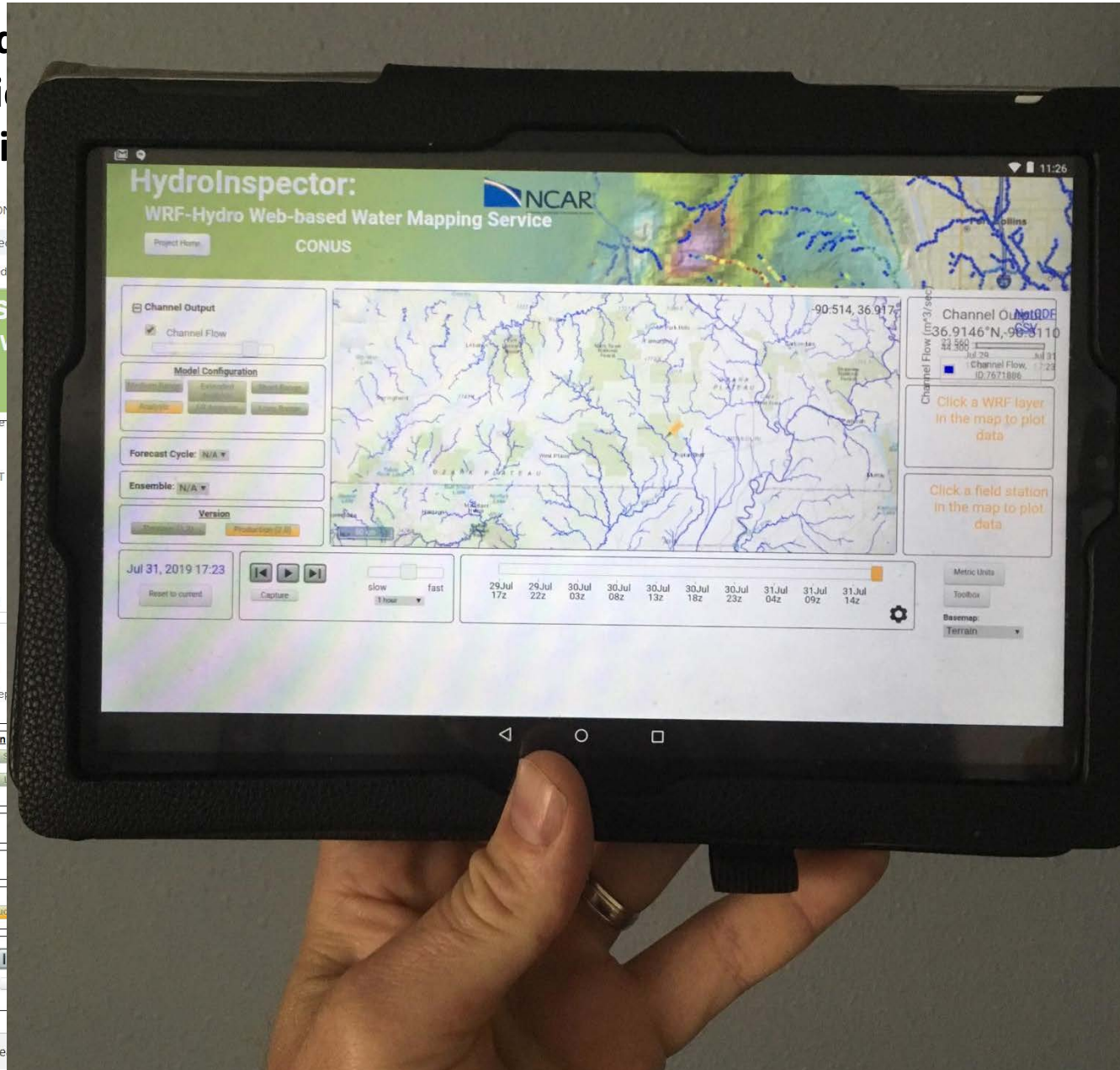
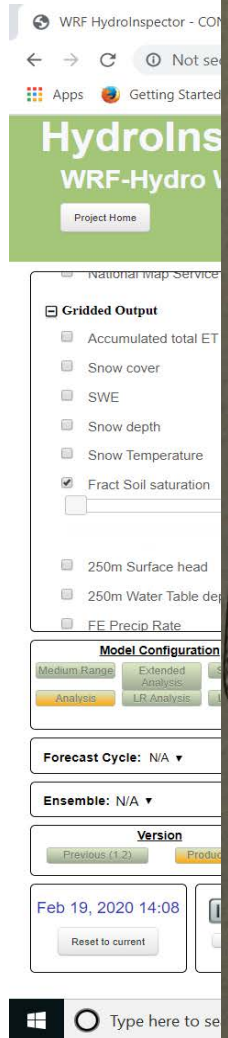


- Guidance for validating FEMA damage claims
- Building capability for cloud-based, on-demand production



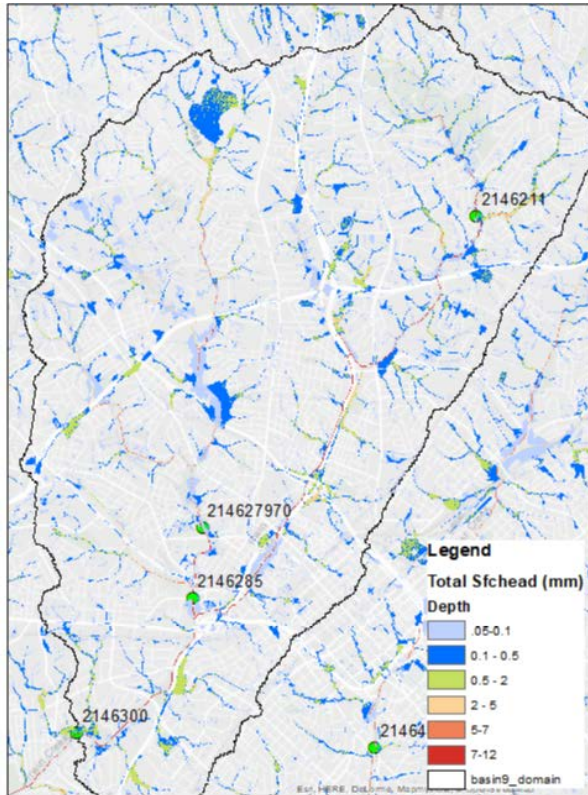
Customized, portable viewing applications for 'on-demand' intel

1. Cloud
2. Service
3. Mobile

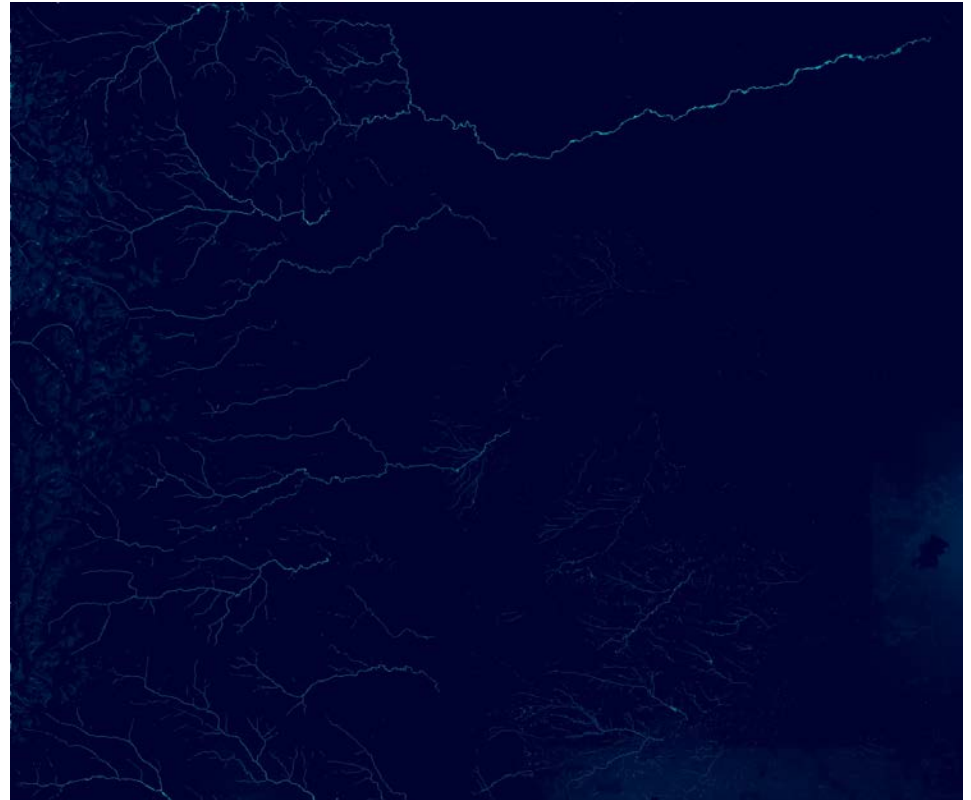


- Explicit characterization of landscape-constrained inundation modeling
 - Spatial scale of 1's to 10s' of meters explicit modeling
 - Akin to Large Eddy Simulation for atmosphere (not CFD though...)

10m model of Charlotte, NC



30m model of 2013 Colorado Floods

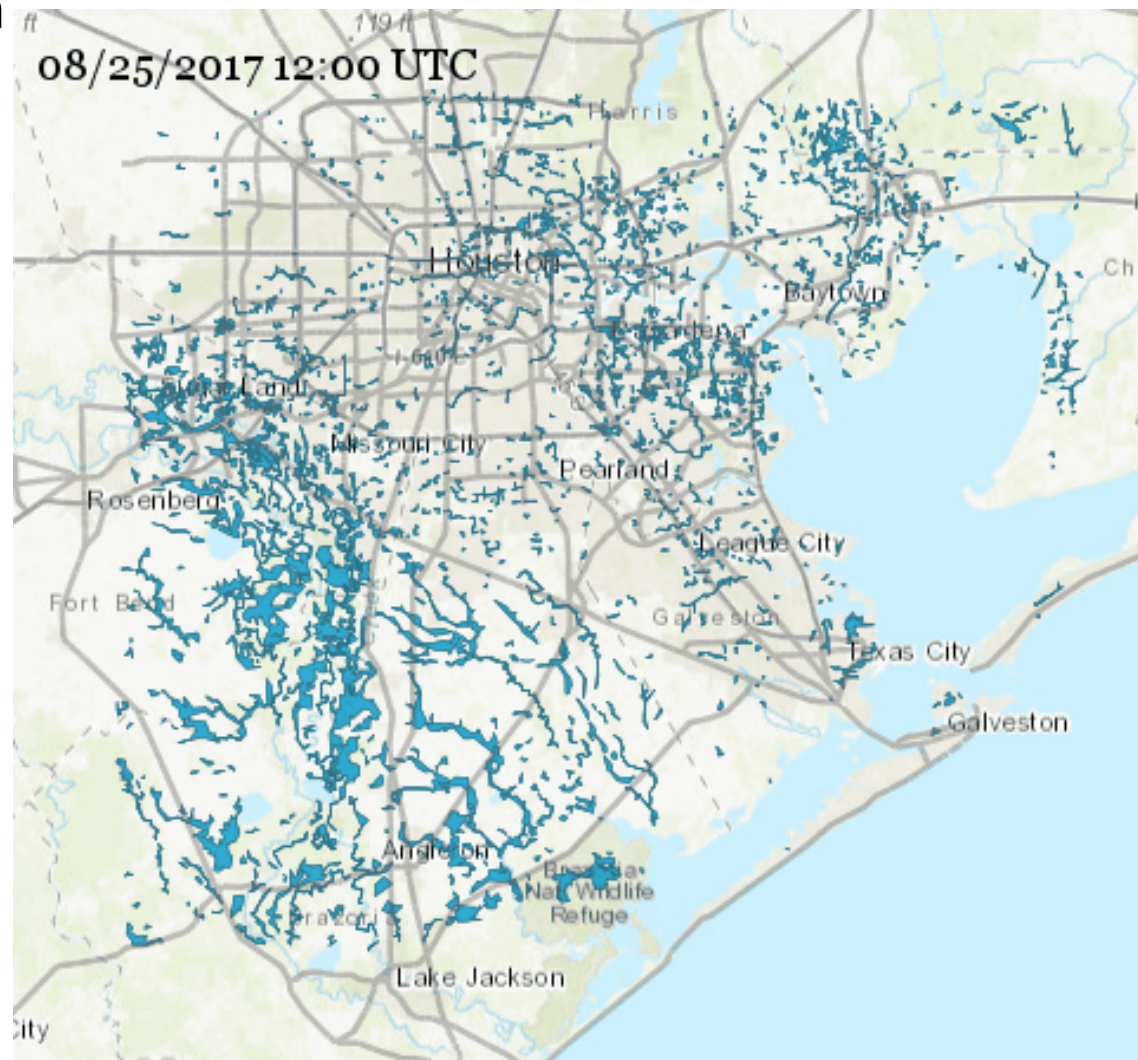


Hurricane Harvey Inundation Area Hyper-Resolution Modeling:



2D Grid Evaluation
(example: hyper-resolution
inundation):

Inundation now being
evaluated using CYGNSS
retrievals via UCAR
President's Fund project

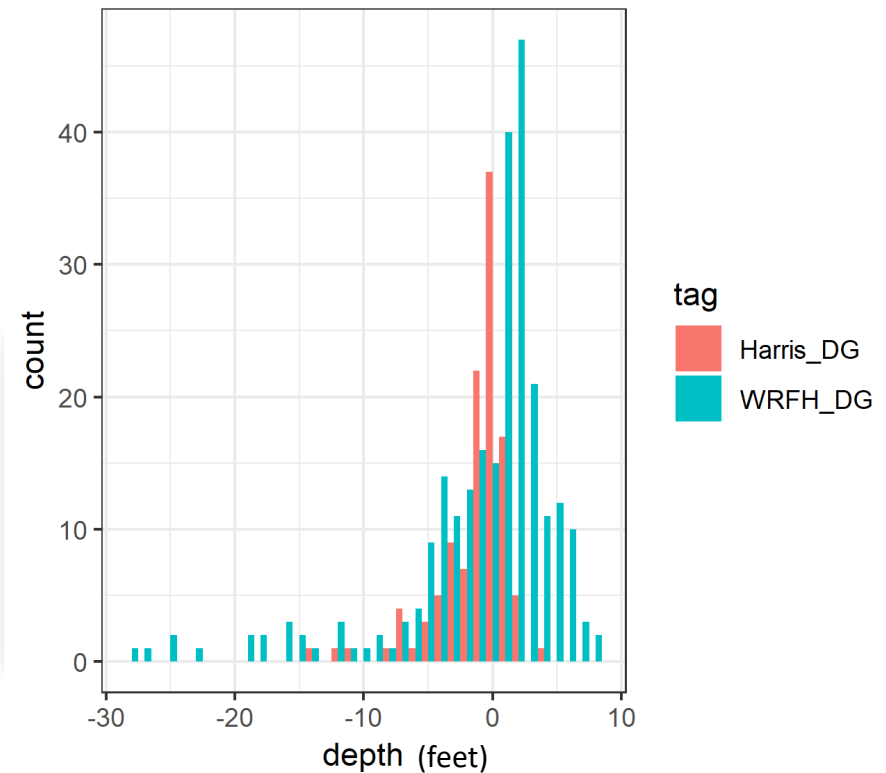
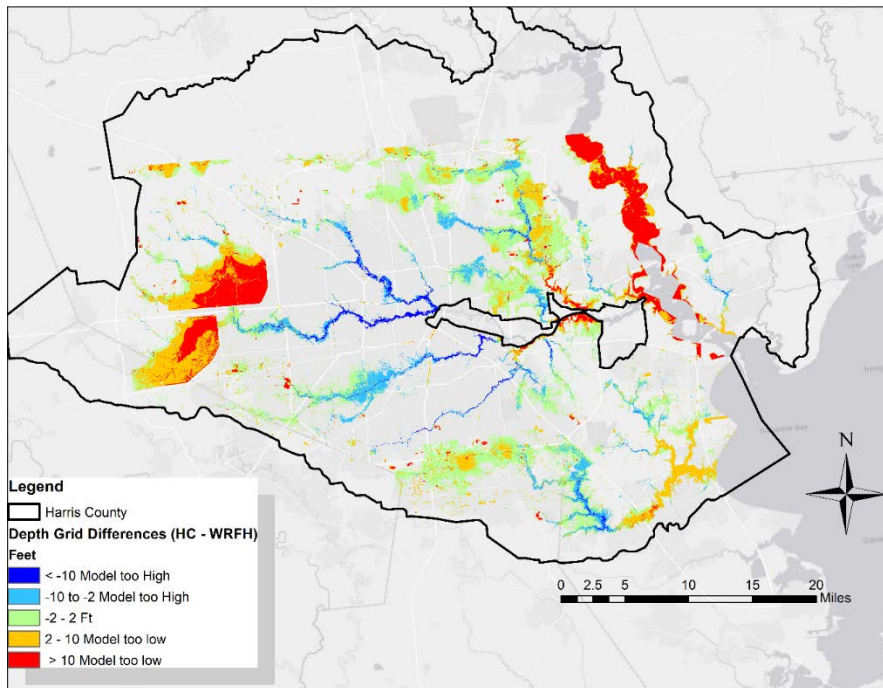


Hurricane Harvey hyper-resolution simulation



WRF-Hydro Research: Evaluating depths in Hurricane Harvey

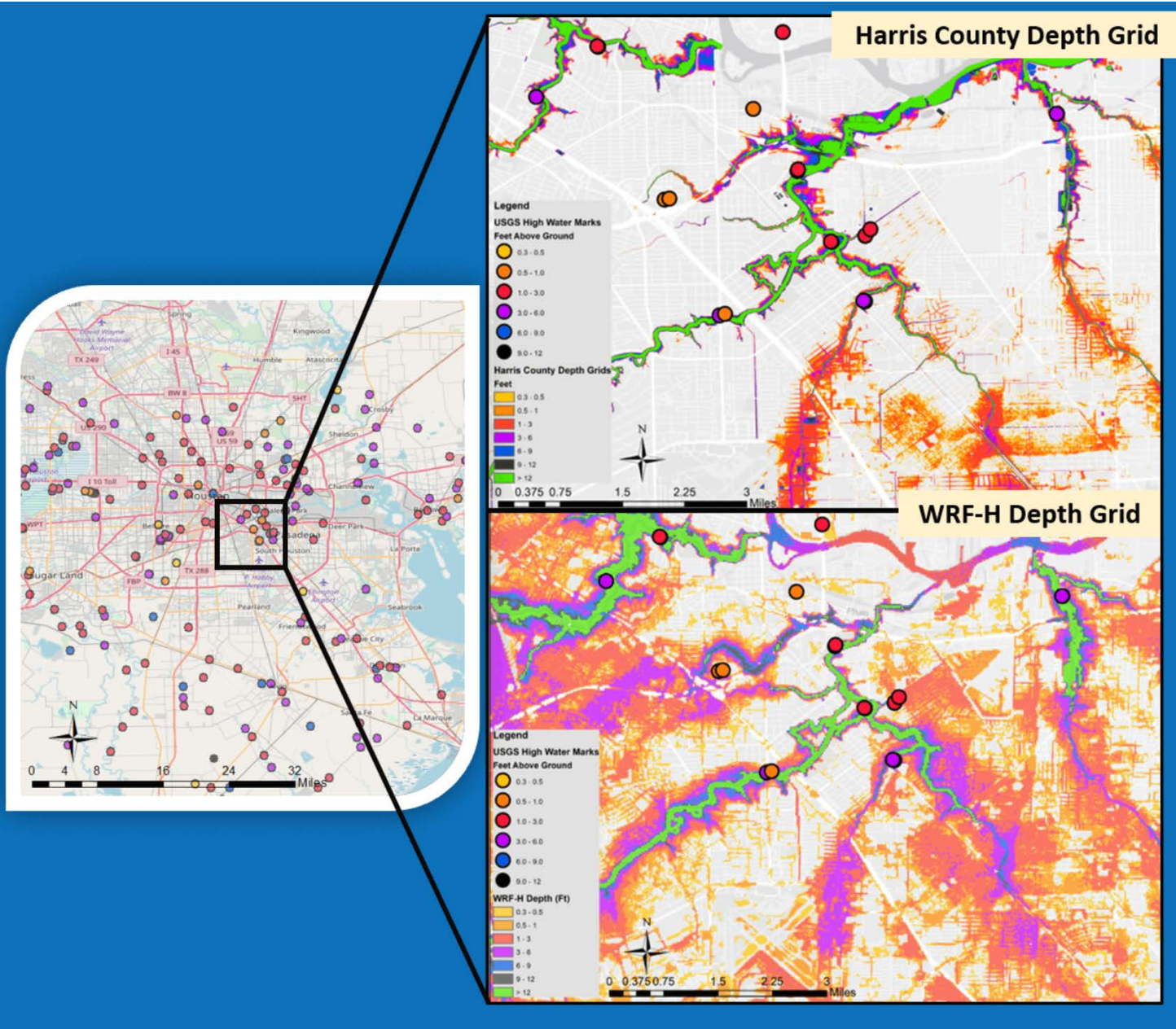
Maximum inundation in Harris County. WRF-Hydro simulation compared with Harris Co. depth grids.

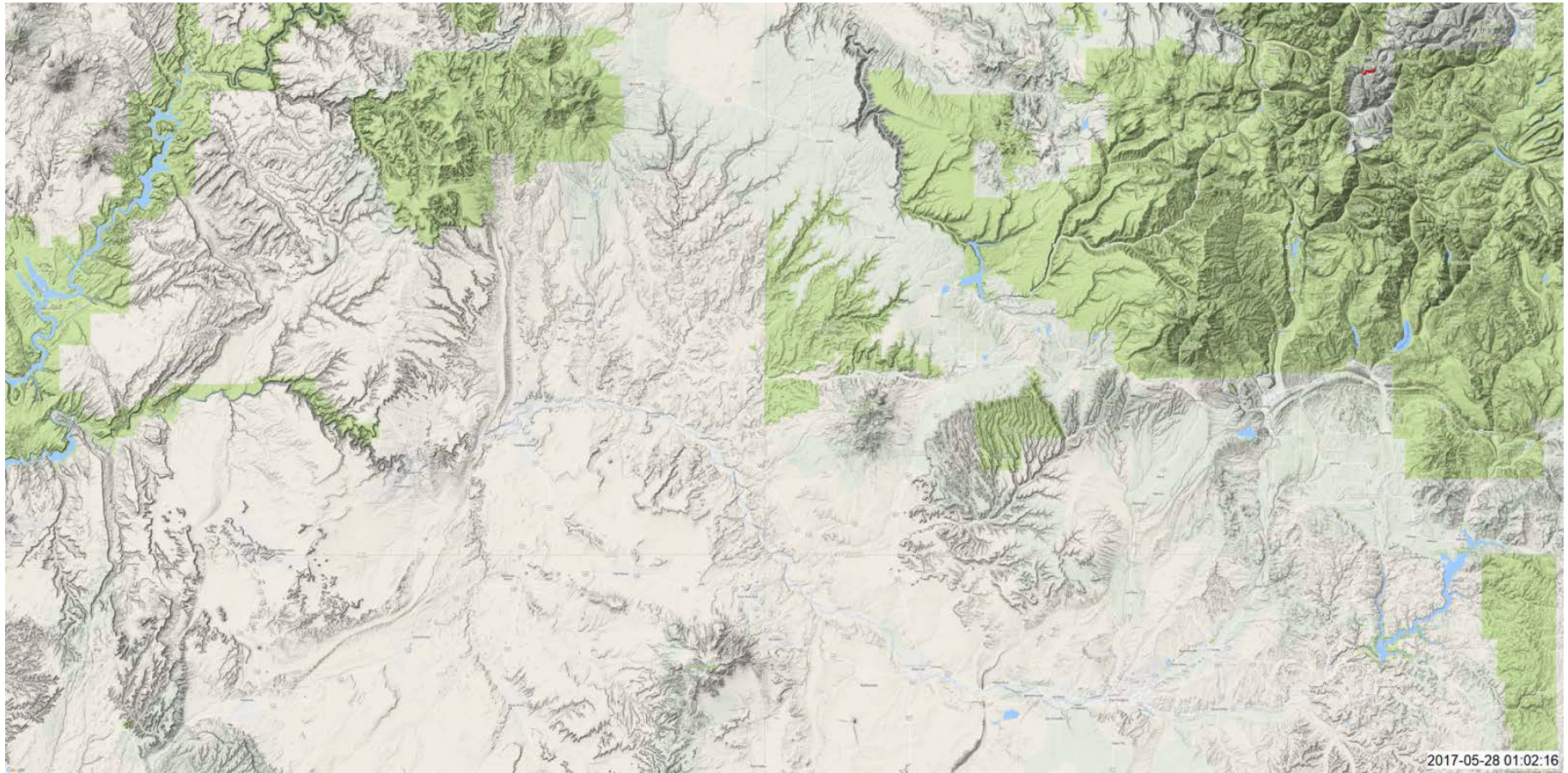


WRF-Hydro shows some areas of under prediction, mainly in detention ponds that were not initialized properly.



WRF-Hydro Research: Capturing multiple flooding mechanisms





- Environmental tracers for transport timing prediction
- On-demand capability using existing operational NWM
- Nearly instantaneous response
- Amenable to stochastic perturbation of flows to generate probabilistic guidance
- Example of the Gold King Mine Spill



Real-time, on-demand flow path tracing:

WRF HydroInspector - CONUS

Not secure | hydro.rap.ucar.edu/HydroInspector/CONUS/

Apps Getting Started Concur Imported From Fire... Photo in Fieldwork... Winter Weather Gr... Authorization to att... Duo Security Coupled-Ocean-At...

HydroInspector: WRF-Hydro Web-based Water Mapping Service

Project Home CONUS

Gridded Output

- ☐ Accumulated total ET
- ☐ Snow cover
- ☒ SWE
- ☐ Snow depth
- ☐ Snow Temperature
- ☐ Fract Soil saturation

Model Configuration

Medium Range Extended Analysis Short Range

Analysis LR Analysis Long Range

Forecast Cycle: N/A

Ensemble: N/A

Version

Previous (1.2) Production (2.0)

Feb 19, 2020 14:08

Reset to current

slow fast

1 hour

17Feb 14z 17Feb 18z 17Feb 22z 18Feb 02z 18Feb 06z 18Feb 10z 18Feb 14z 18Feb 18z 18Feb 22z 19Feb 02z 19Feb 06z 19Feb 10z

Metric Units

Toolbox

Basemap: Terrain

Toolbox

> Search Tools

v Map Tools

Save Map Image

Basemap: Terrain

Basemap opacity

v Measurement Tools

Start Node End Node Get Path

v Data Availability

NWS watches warnings

Accumulated total ET

Snow cover

SWE

Snow depth

Snow Temperature

Fract Soil saturation

02/17 14:00 02/17 22:00 02/18 06:00 02/18 14:00 02/18 22:00 02/19 06:00 02/19 14:00

500 km

2:15 PM 2/19/2020



- NCAR continues to support development of the baseline operational National Water Model
- Numerous value-added products and services are being developed using NWM outputs OR custom configurations of the WRF-Hydro system
 - Statistical analysis of 25 & 40-year retrospective runs
 - Downscaled flood inundation maps
 - On-demand, hyper-resolution modeling
 - Constituent tracing through model fields
 - Portable, cloud based web mapping services and analysis applications



Thank you!

Resources:

WRF-Hydro Community Model:
https://ral.ucar.edu/projects/wrf_hydro

