A Conceptual Framework for the National Flood Interoperability Experiment (NFIE)

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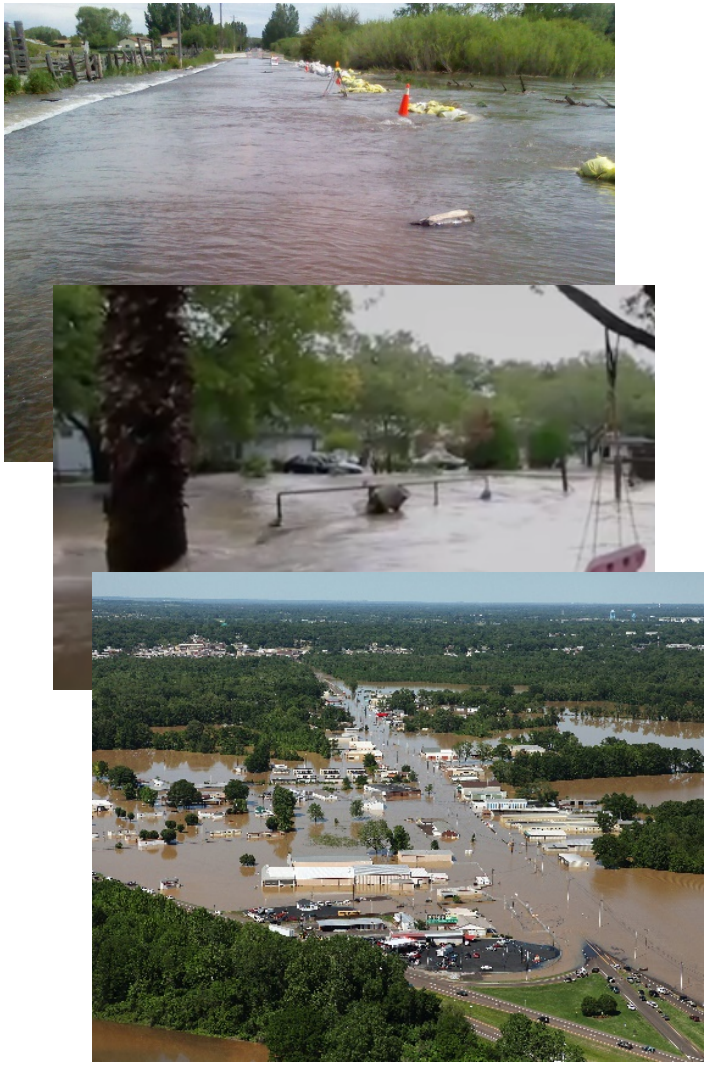
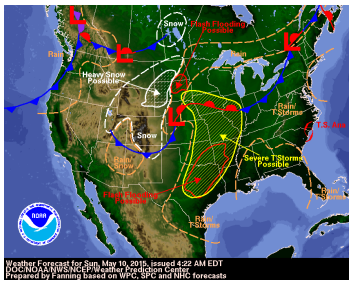
For additional information see: http://www.cuahsi.org/nfie
Conceptual Framework Paper:
https://www.cuahsi.org/Files/Pages/documents/13623/nfieconceptualframework_revised_feb_9.pdf

The majority of the slides presented are from, or adapted from David Maidment

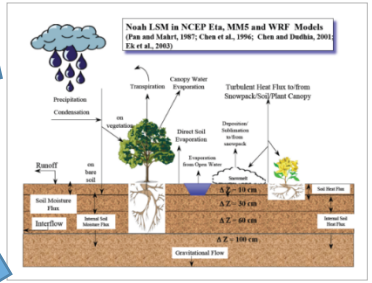
Flooding

On average, more people die annually from flooding than from any other form of natural disaster

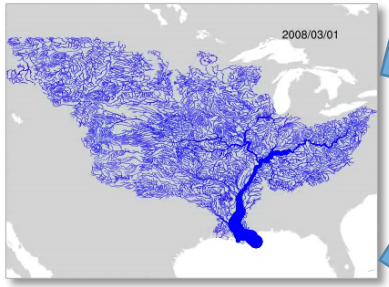




Weather



Hydrology



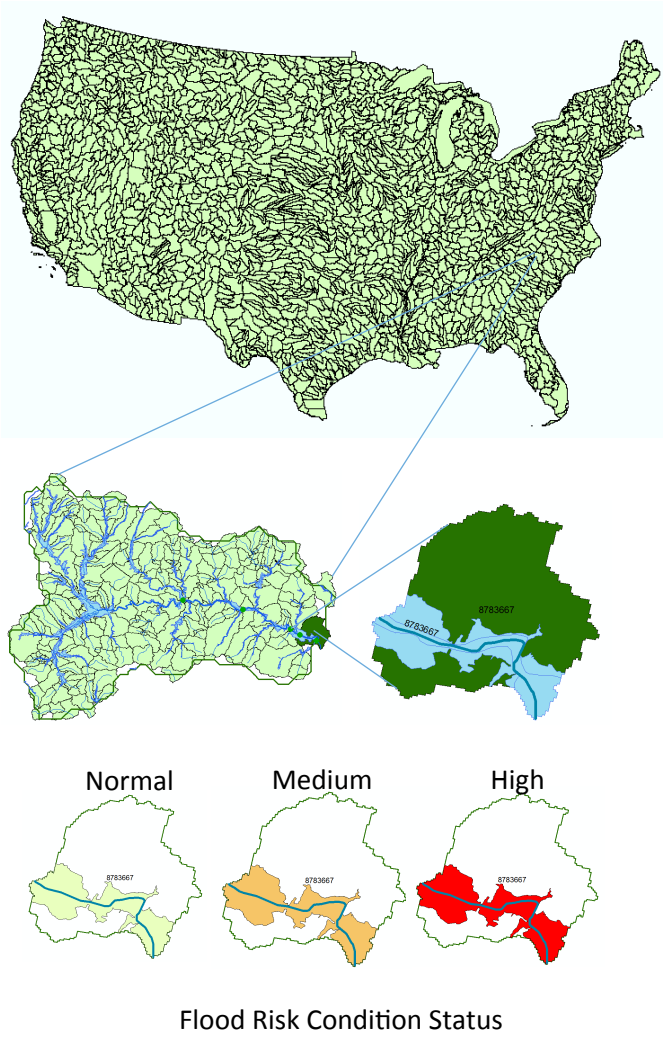
Hydraulics

Response

Partnership with the academic research community

- National Weather Service has joined with CUAHSI to conduct a one-year National Flood Interoperability Experiment (NFIE)
- Includes a Summer Institute for students and faculty at the National Water Center, June 1 to July 17, 2015

NFIE Goal: Connect National Scale Flood Modeling with Local emergency planning and response

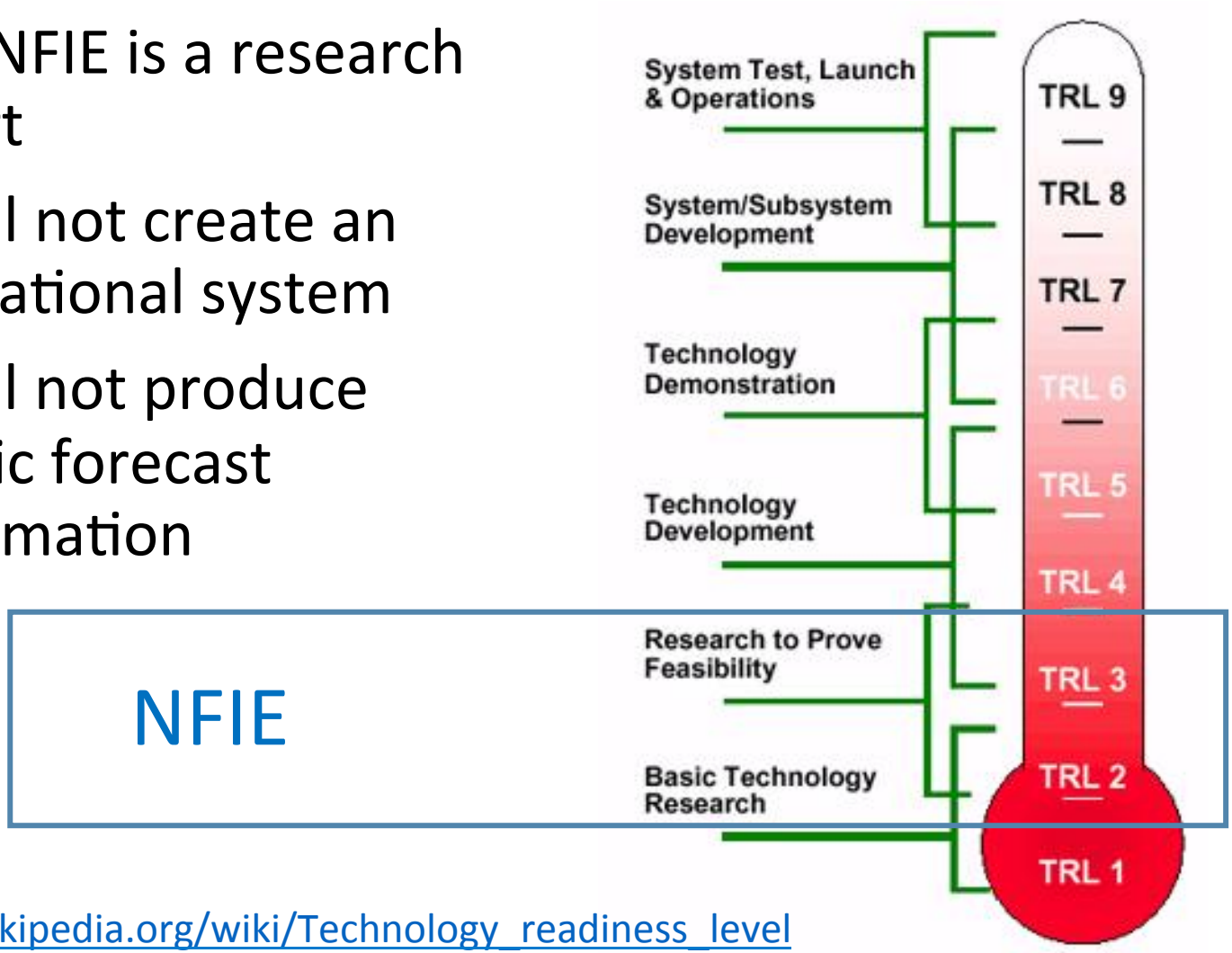


Flood Risk Condition Status

1. How can near-real-time hydrologic simulations at high spatial resolution, covering the nation, be carried out using the NHDPlus or next generation *hydro-fabric* (e.g. data structure for hillslope, watershed scales)?
2. How can this lead to improved emergency response and community resilience?
3. How can an improved interoperability framework support the first two goals and lead to sustained innovation in the research to operations process?

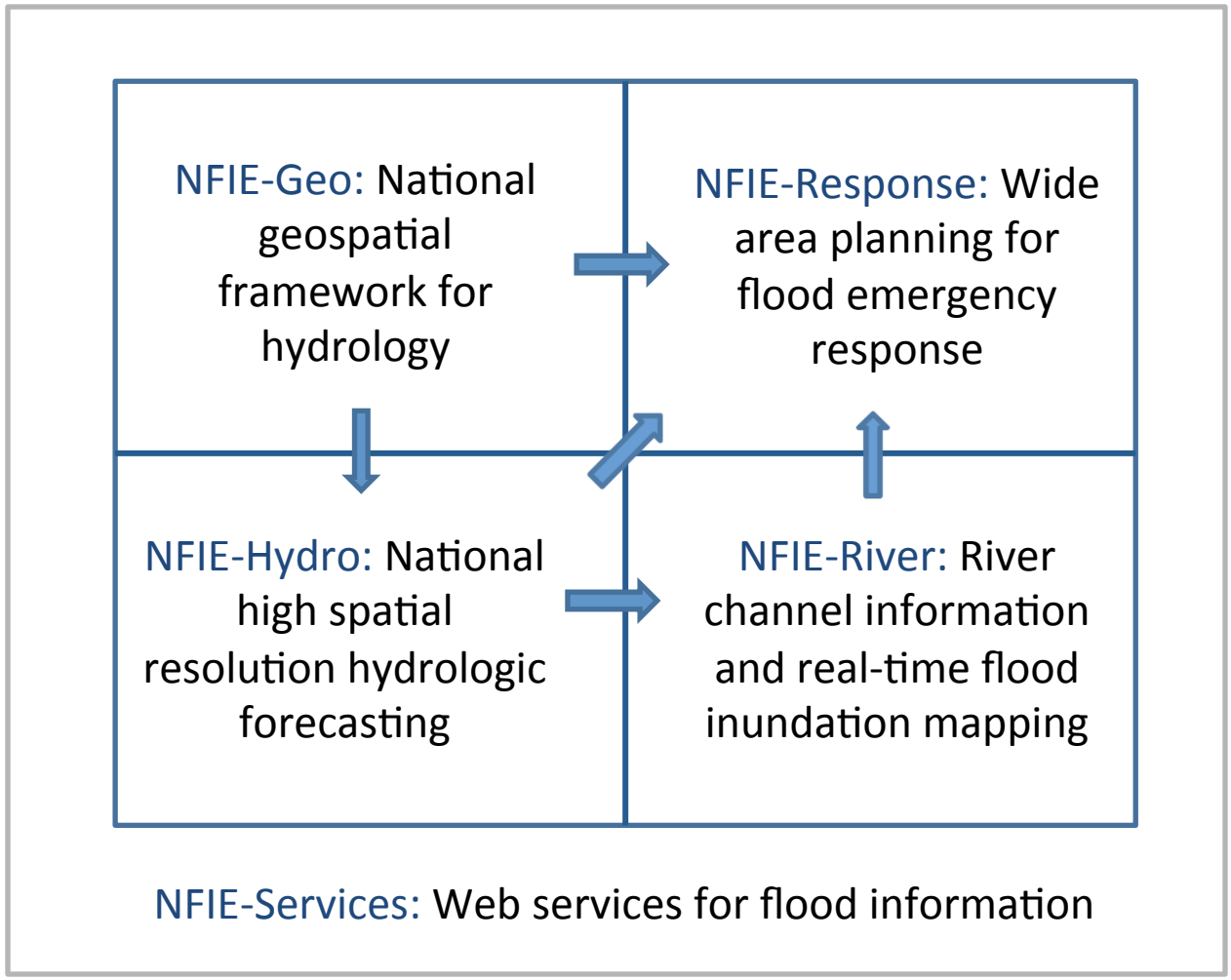
Technology Readiness Levels

- The NFIE is a research effort
- It will not create an operational system
- It will not produce public forecast information



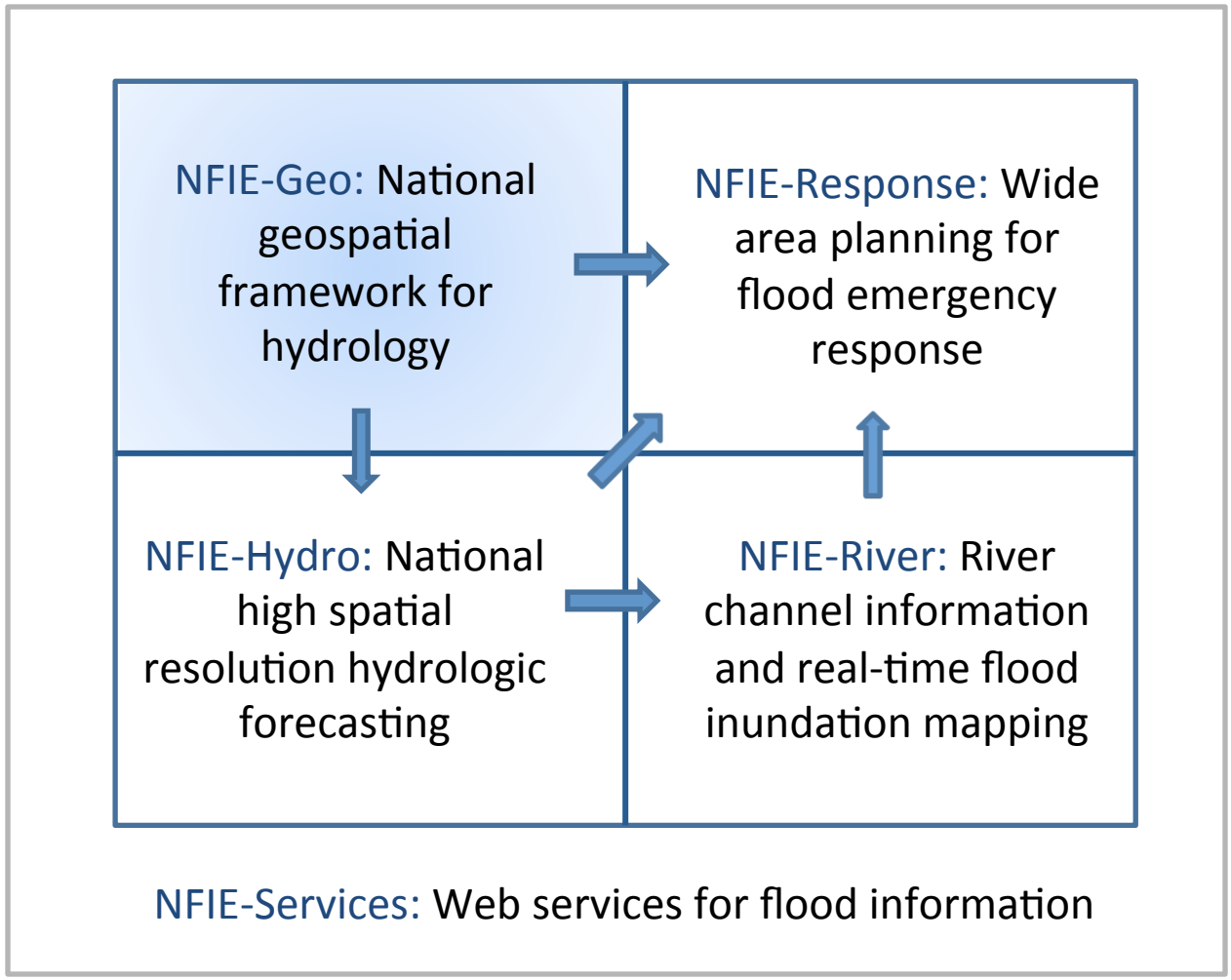
http://en.wikipedia.org/wiki/Technology_readiness_level

National Flood Interoperability Experiment (NFIE): Five Components



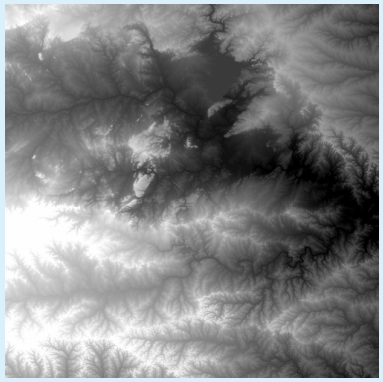
National Flood Interoperability Experiment (NFIE)

Component One: NFIE-Geo



NHDPlus Version 2

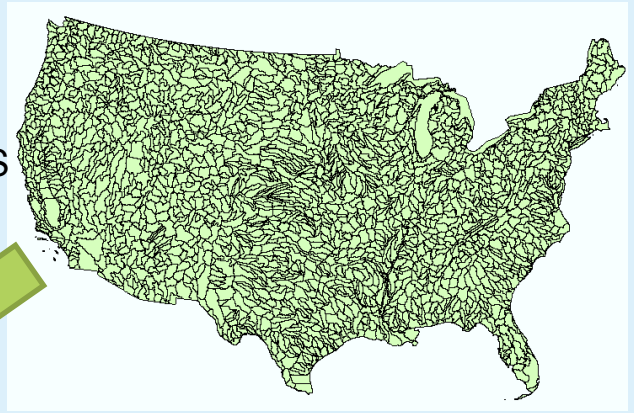
Geospatial foundation for a national water data infrastructure



National Elevation Dataset

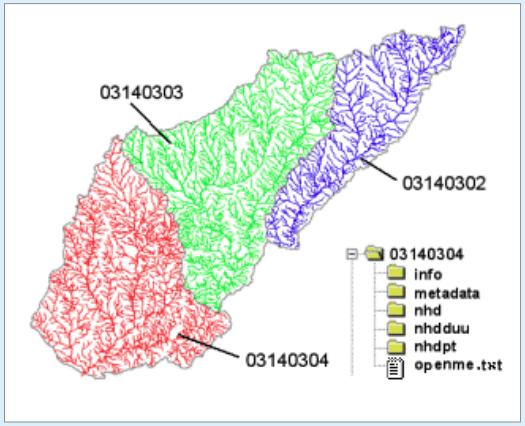
NHDPlus

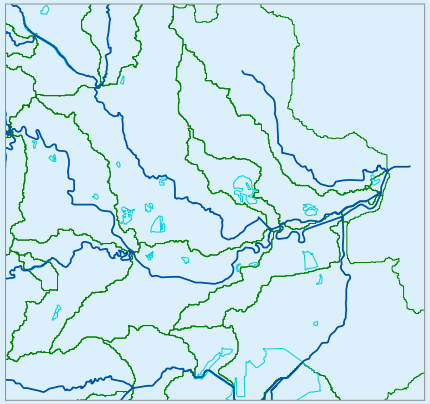
2.67 million reach catchments in US
average area 3 km^2
reach length 2 km



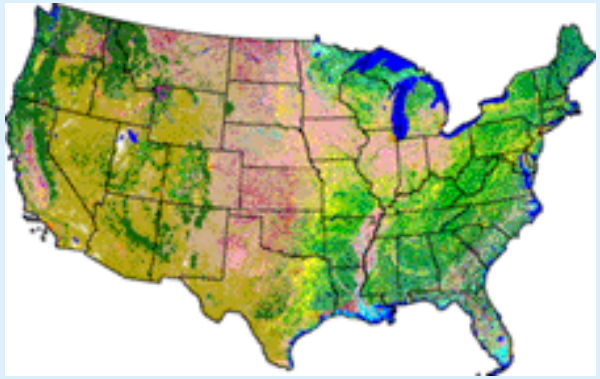
Watershed Boundary Dataset

National Hydrography Dataset



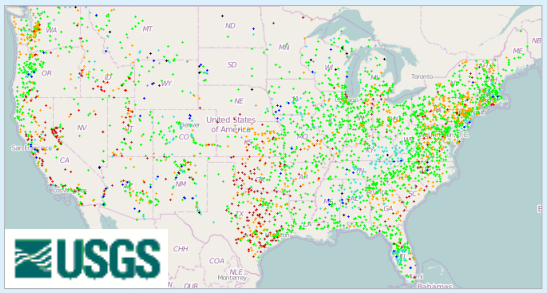


National Land Cover Dataset

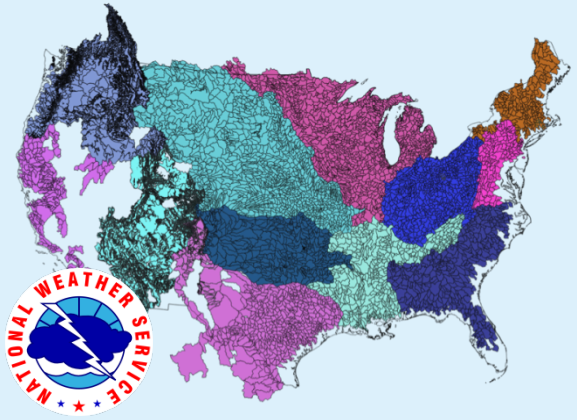


NFIE-Geo for National Flood Interoperability Experiment

Enhanced geospatial database for a national water data infrastructure

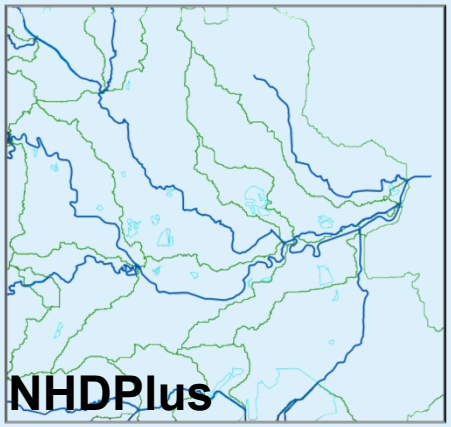


USGS Water Watch Points



NWS Basins and Forecast Points

National Flood Hazard Layer



NFIE-Geo

9 feature classes

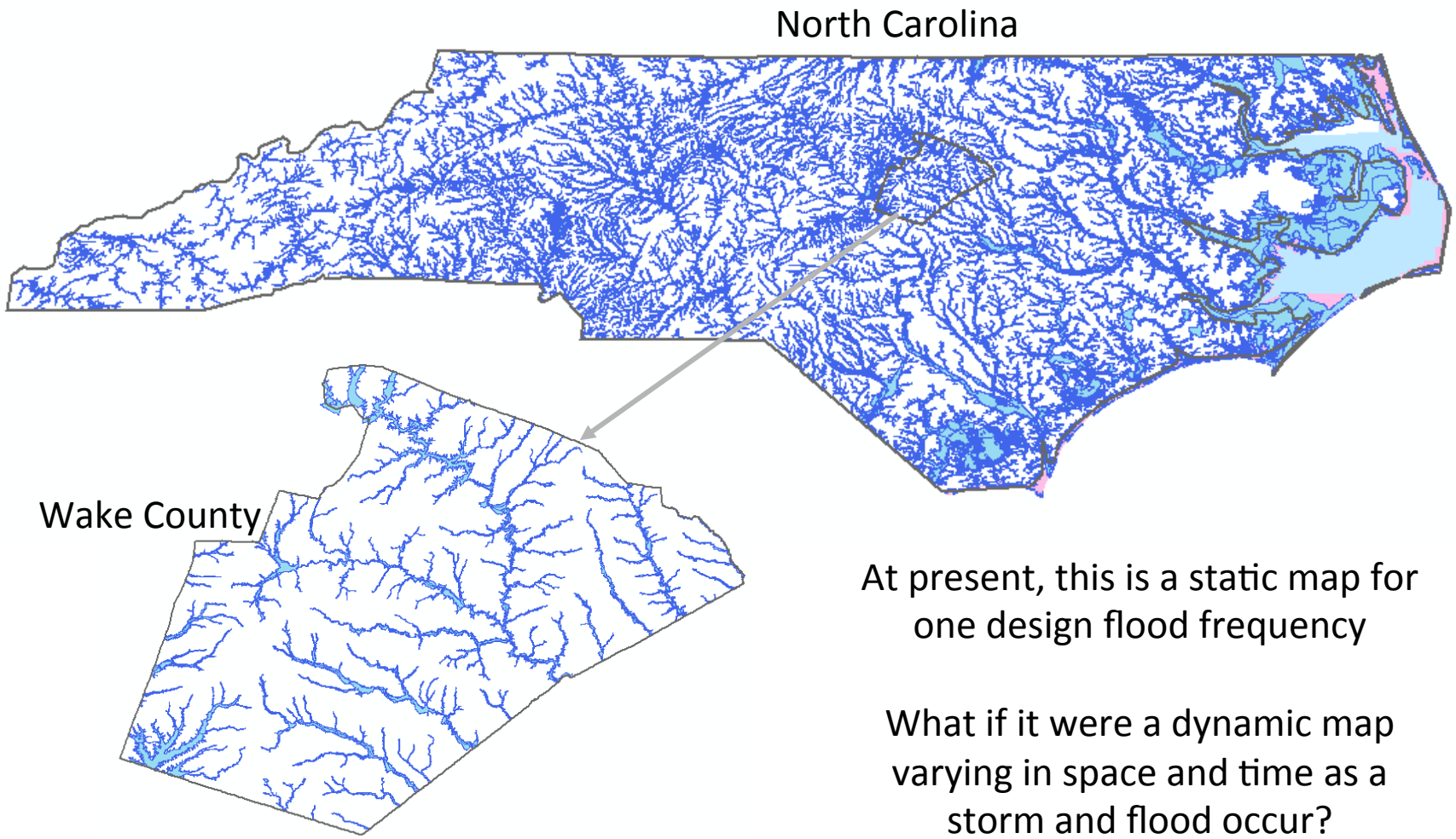
- **5 from NHDPlus**
- **4 from IWRSS**

Feature classes:

Subwatershed (HUC12)
Catchment
Flowline
Waterbody
Dam

NFIE Geo Example

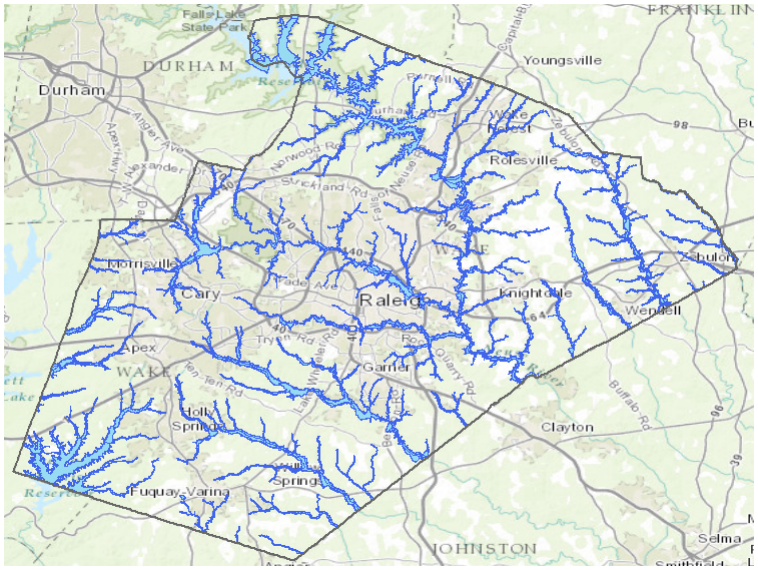
National Flood Hazard Layer (NFHL)



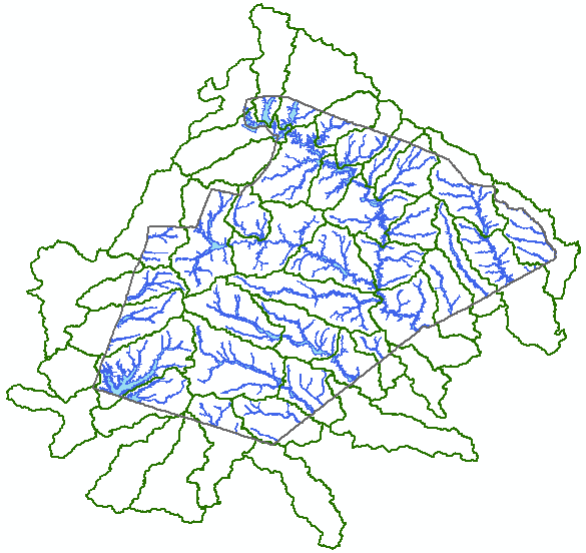
At present, this is a static map for one design flood frequency

What if it were a dynamic map varying in space and time as a storm and flood occur?

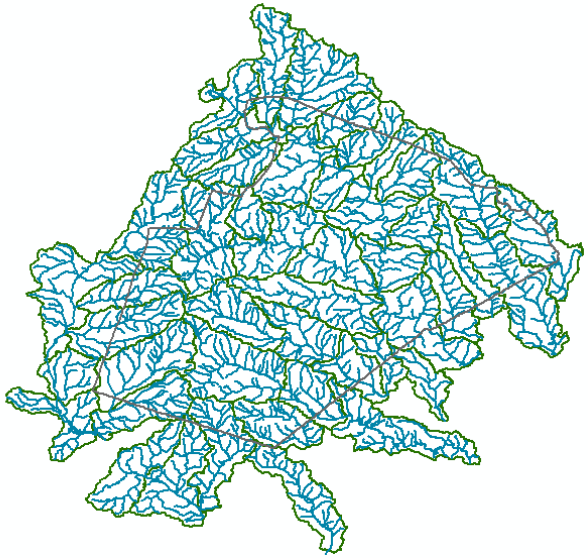
NFHL for Wake County



46 Wake County HUC12 Subwatersheds



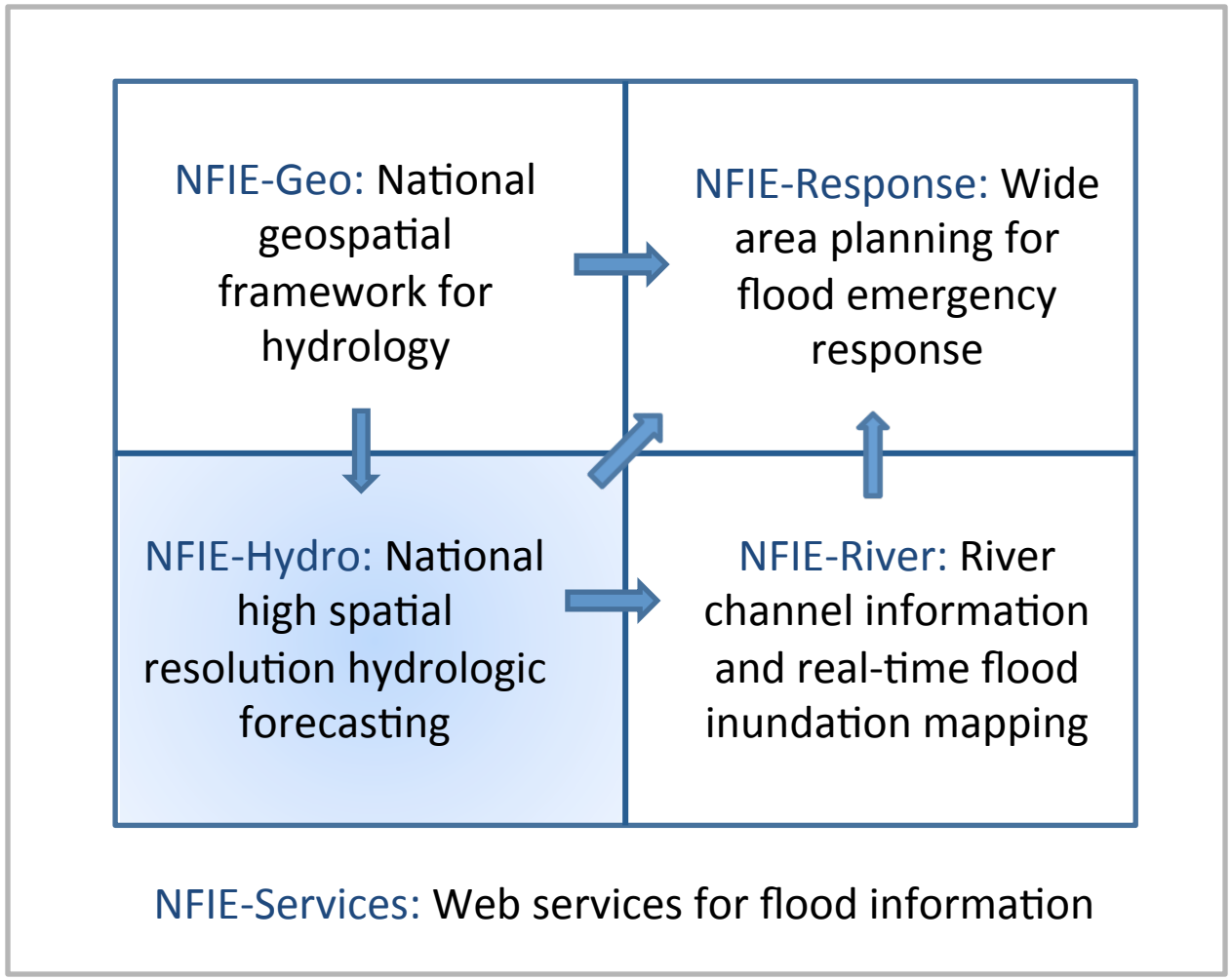
NHDPlus Flowlines



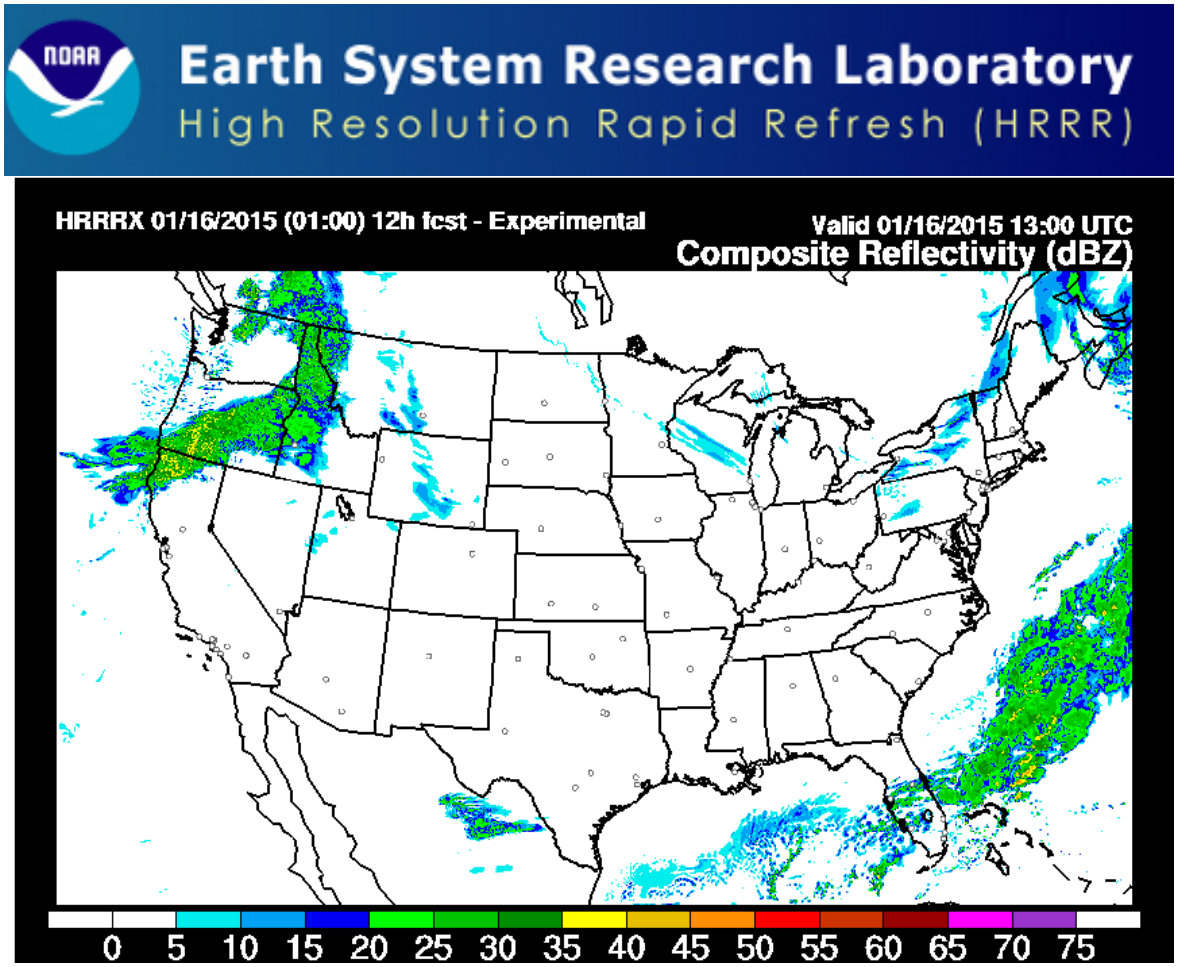
3423 NHDPlus Catchments

National Flood Interoperability Experiment (NFIE)

Component Two: NFIE-Hydro

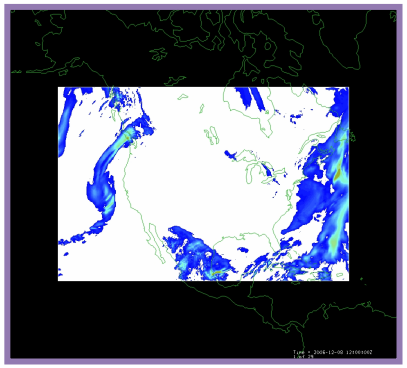


Rainfall Forecast (15 hours ahead)



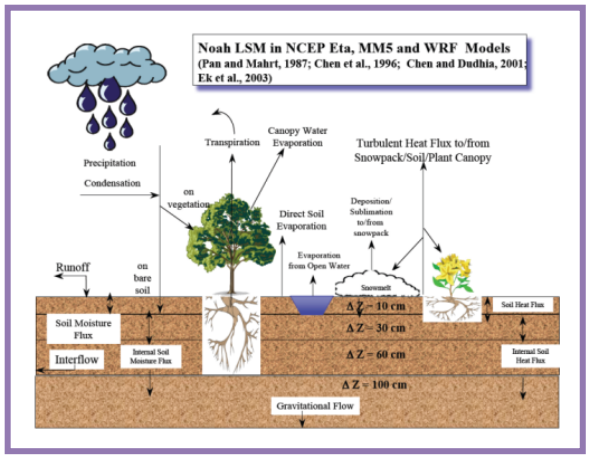
Forecast the flood before the rain begins

Modeling of Weather, Hydrology, River Flow in WRF-Hydro



Observations
Datasets, Numerical
Weather Model

Forcing:
- **Radiation**
- **Precipitation**
- **Surface climate**

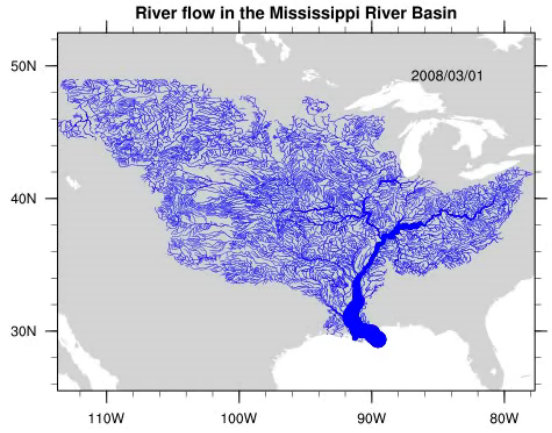


Land Surface Model

Soil
Vegetation
Terrain

Evaporation
Soil Moisture
Runoff
Recharge

Network River Flow



http://www.geo.utexas.edu/scientist/david/rapid.htm

Tavakoly et al. (201x), in preparation

RAPID: River Routing
on NHDPlus

Runoff Downscaling Weight Table

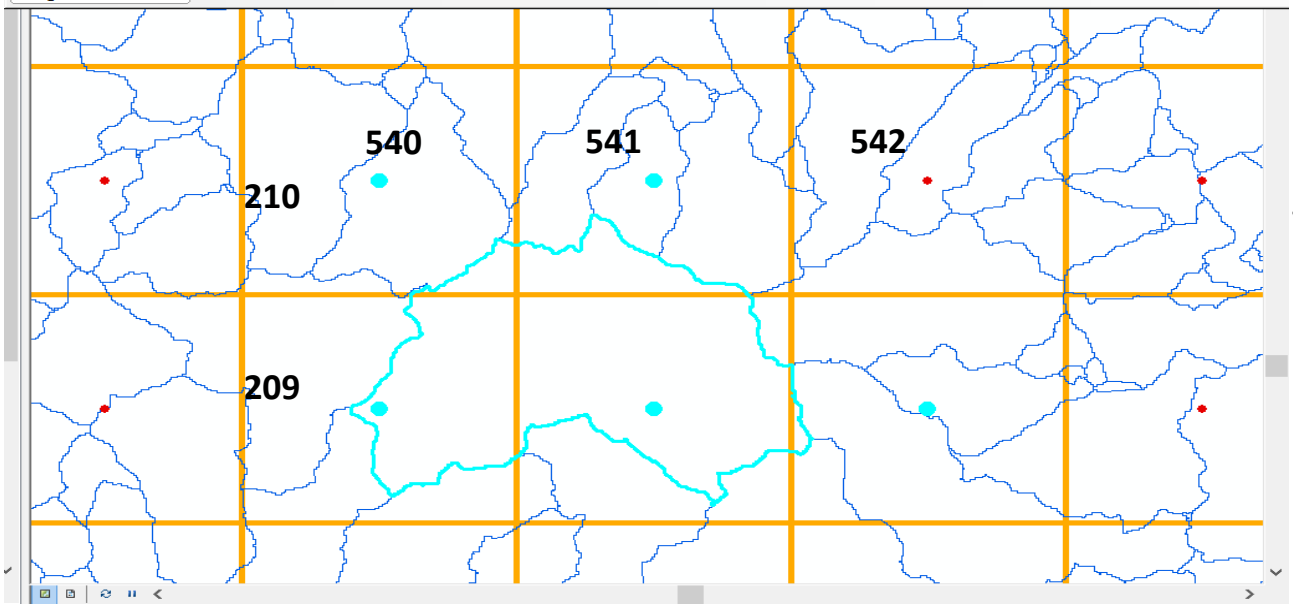
Table

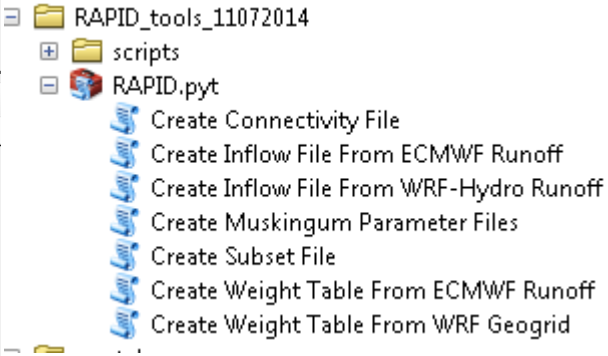
weight_table_Austin

FEATUREID	area_sqm	west_east	south_north	npoints	weight	Lon	Lat	x	y
5781267	1386865.500248	539	208	4	0.239062	-97.9382	30.2538	-89999.87397	-1063998.65758
5781267	4166813.79135	539	209	4	0.718257	-97.9387	30.2898	-89999.87397	-1059998.65758
5781267	112928.443165	540	208	4	0.019466	-97.8965	30.2542	-85999.87397	-1063998.65758
5781267	134681.356616	540	209	4	0.023216	-97.897	30.2902	-85999.87397	-1059998.65758
5781269	6023486.550729	540	209	5	0.303491	-97.897	30.2902	-85999.87397	-1059998.65758
5781269	705421.674022	540	210	5	0.035542	-97.8975	30.3262	-85999.87397	-1055998.65758
5781269	10569975.138555	541	209	5	0.532564	-97.8553	30.2906	-81999.87397	-1059998.65758
5781269	2357583.361926	541	210	5	0.118786	-97.8557	30.3266	-81999.87397	-1055998.65758
5781269	190879.262251	542	209	5	0.009617	-97.8135	30.291	-77999.87397	-1059998.65758
5781271	3372897.22071	538	209	2	0.973442	-97.9804	30.2893	-93999.87397	-1059998.65758
5781271	92019.765456	539	209	2	0.026558	-97.9387	30.2898	-89999.87397	-1059998.65758

1 (5 out of 2042 Selected)

weight_table_Austin



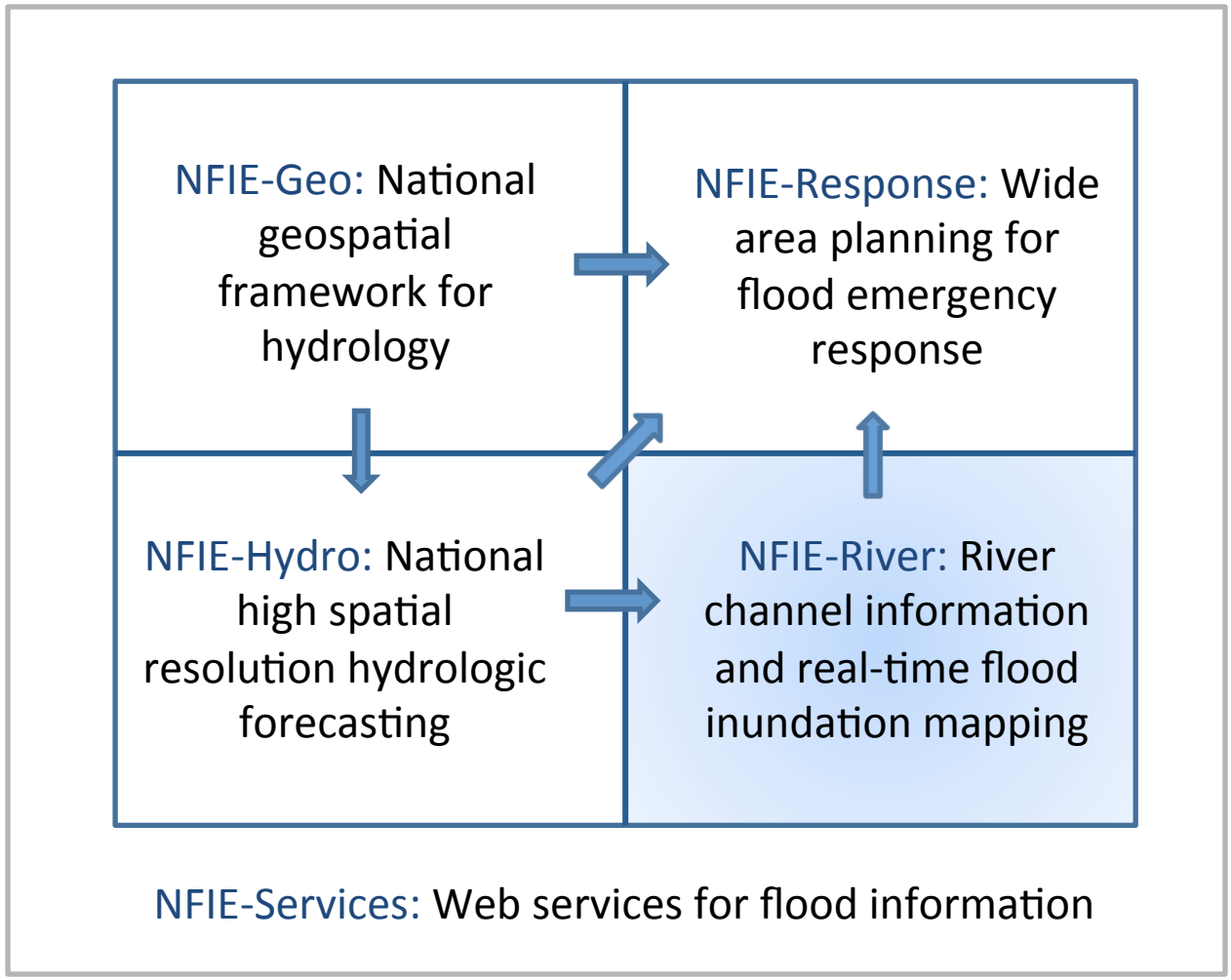


How to connect gridded input runoff data (WRFHydro) to NHDplus network

From: Deng Ding/Nawajish Noman (ESRI)

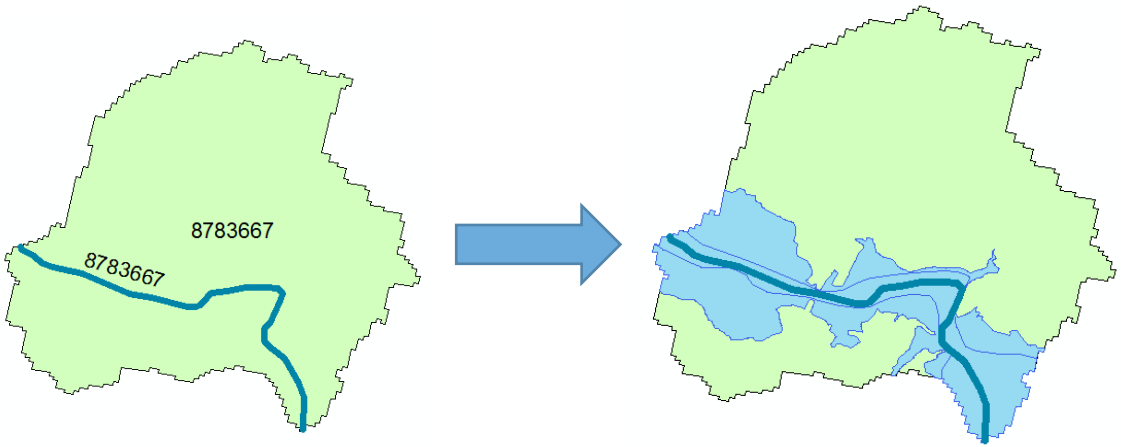
National Flood Interoperability Experiment (NFIE)

Component Three: NFIE-River



Flood risk zones…

- Each catchment has a flood hazard zone defined from FEMA flood data
- Probabilistic forecast from NFIE-Hydro defines flood risk
- Color the zones according to risk



Color of icon indicates category of flooding.

Extensive inundation of structures and roads. Significant evacuations of people and property.

Some inundation of structures and roads near stream – some evacuations of people and property.

Minimal or no property damage, but possibly some public threat.

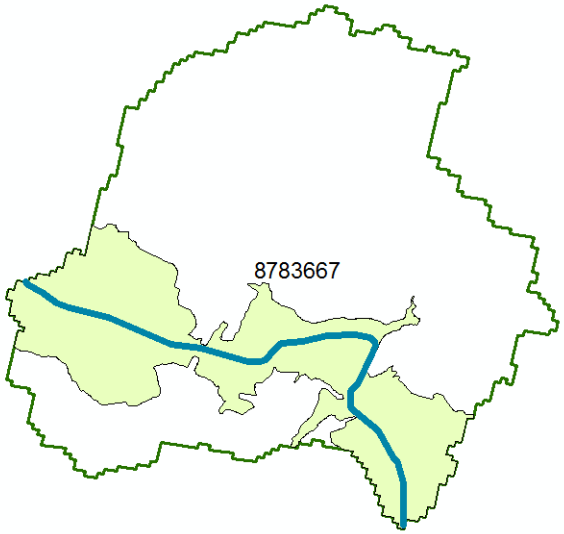
River or stream level approaching flood stage.

River or stream level below flood stage.

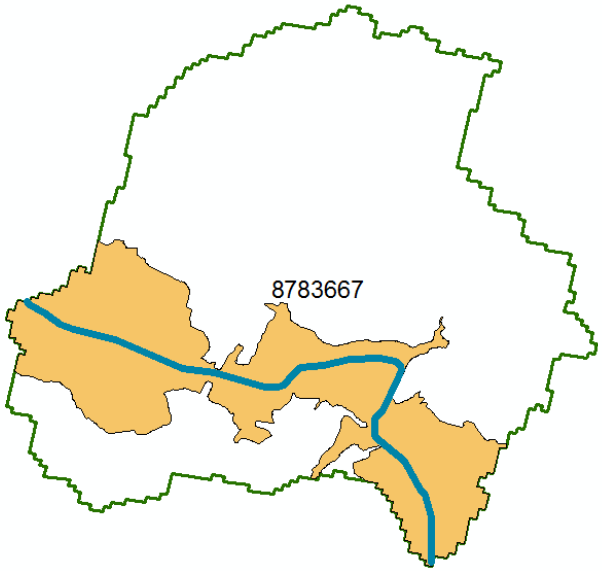
Flood Risk Condition Status

When Flood Risk Condition is High: Action to Evacuate or Shelter in Place is taken

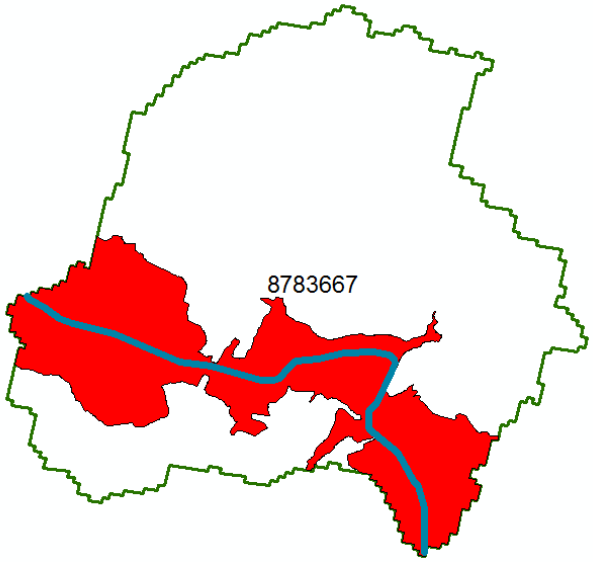
Normal



Medium

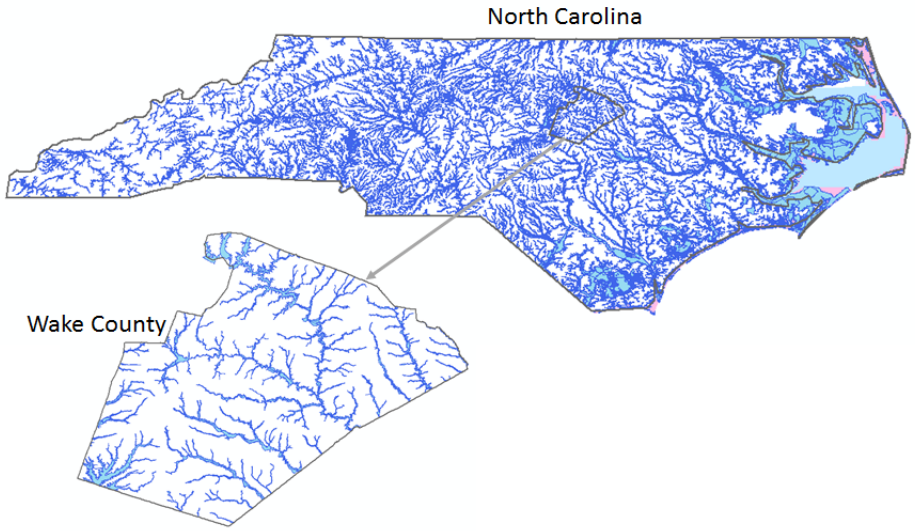


High

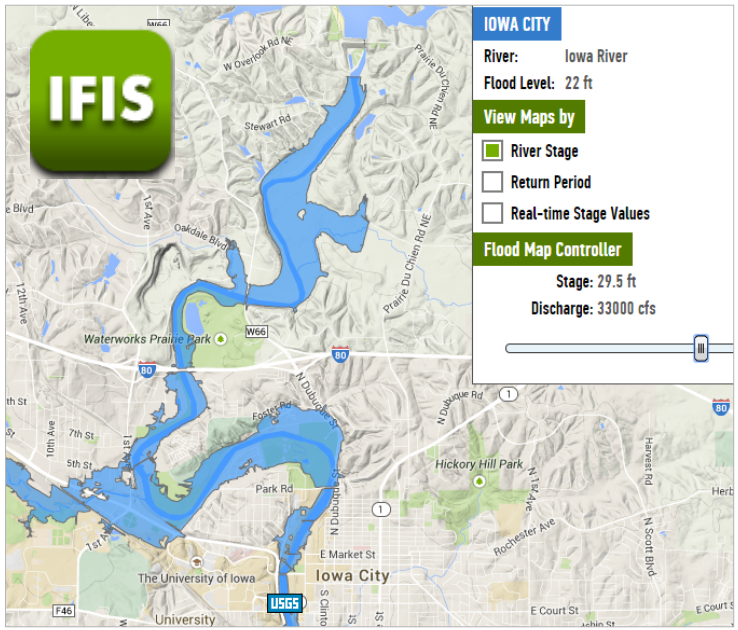


More comprehensive solution…

- NFIE-River: Dynamic flood modeling, forecasting and inundation mapping in space and time
- Requires LIDAR terrain data so can only be done for particular regions



North Carolina Floodplain Mapping Program

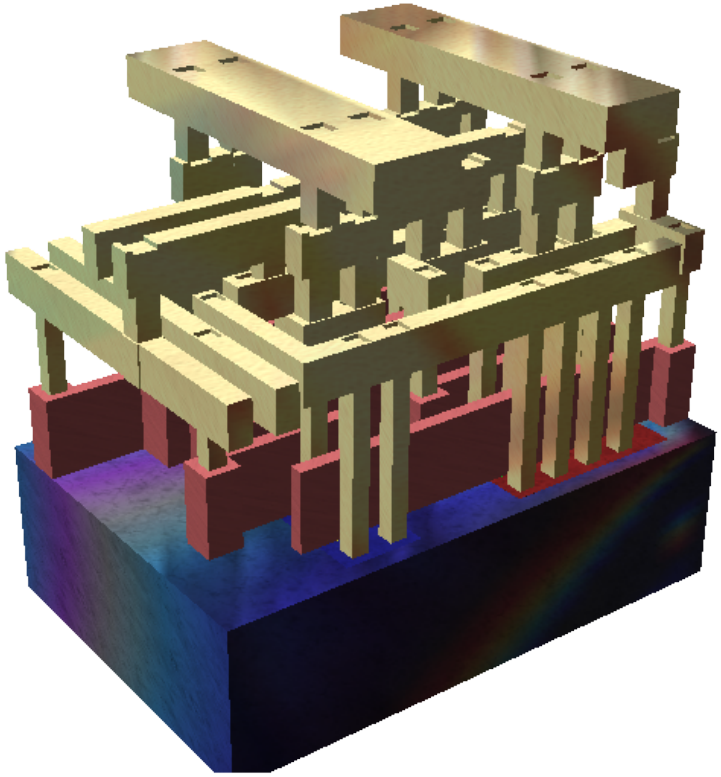


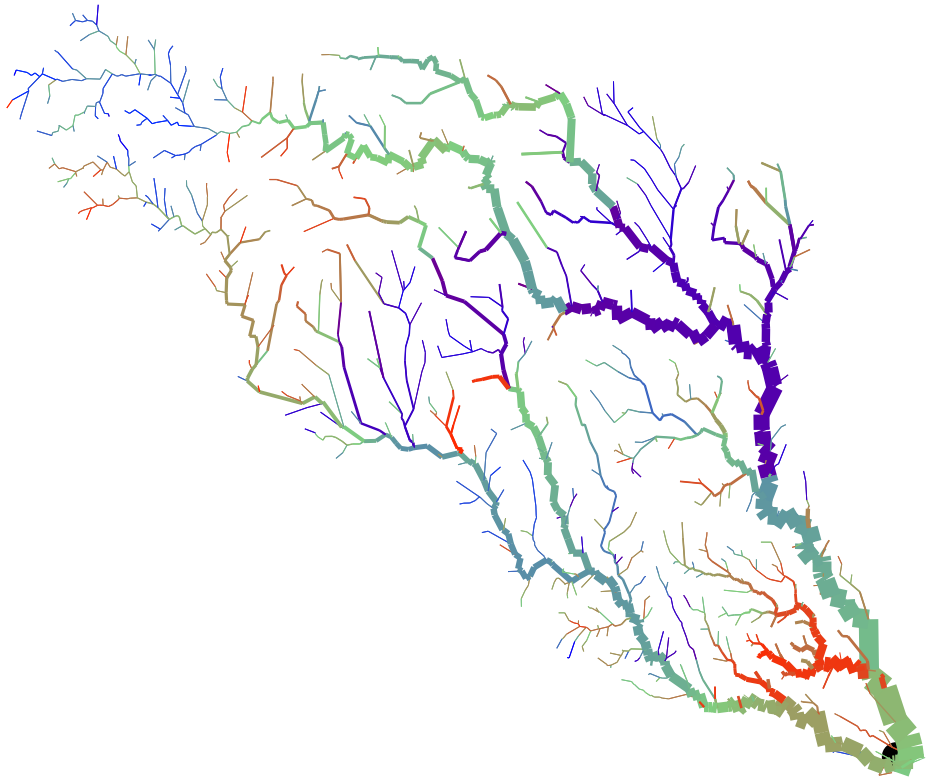
Iowa Flood Information System

Frank Liu
IBM Research Austin
Ben R. Hodges
Univ. of Texas at Austin

SPRNT

Simulation Program for River NeTworks



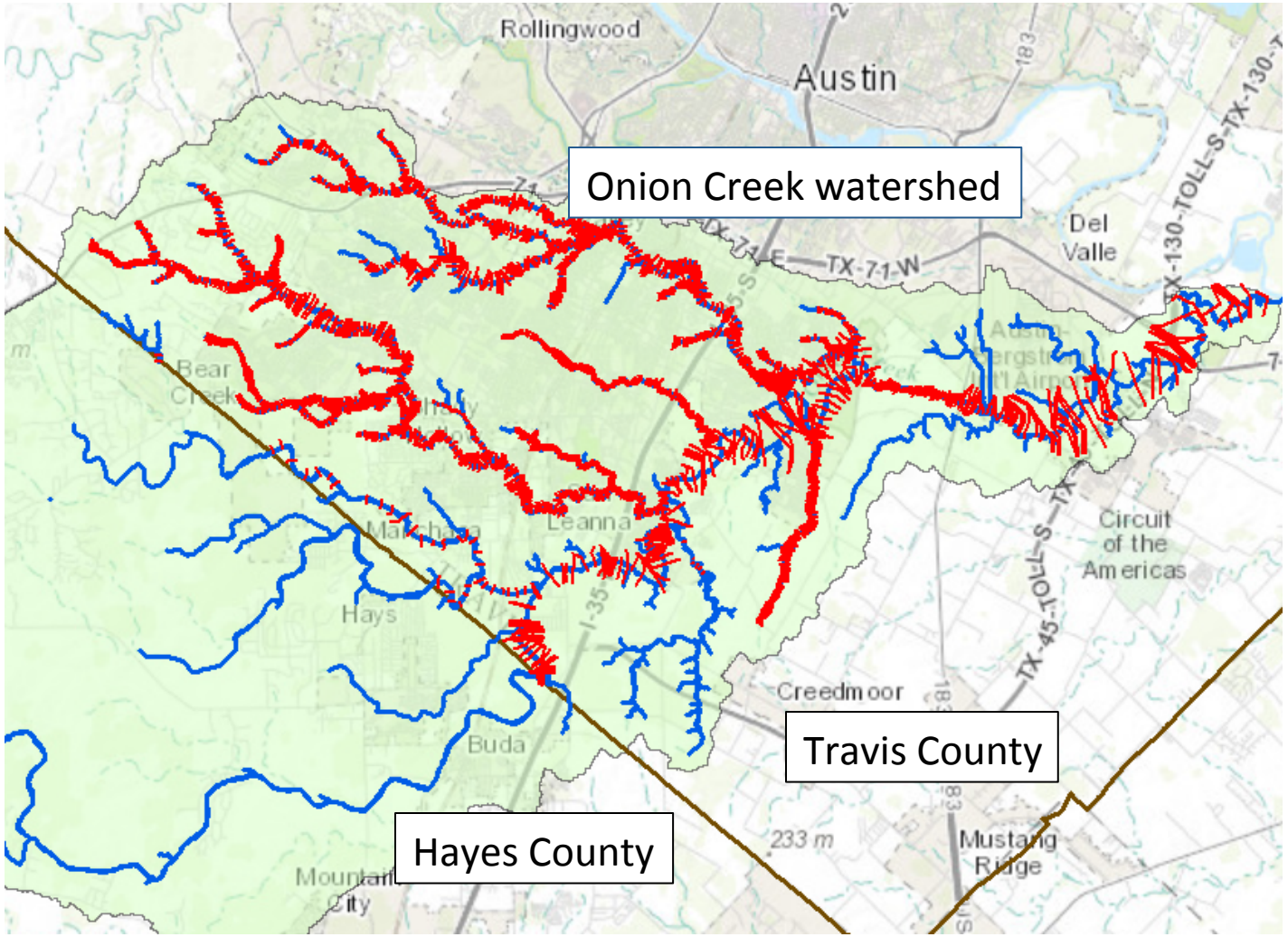


Using ideas from computer chip design for river network analysis for fast solution

Slide: Ben Hodges

Cross-sections from HEC-RAS models

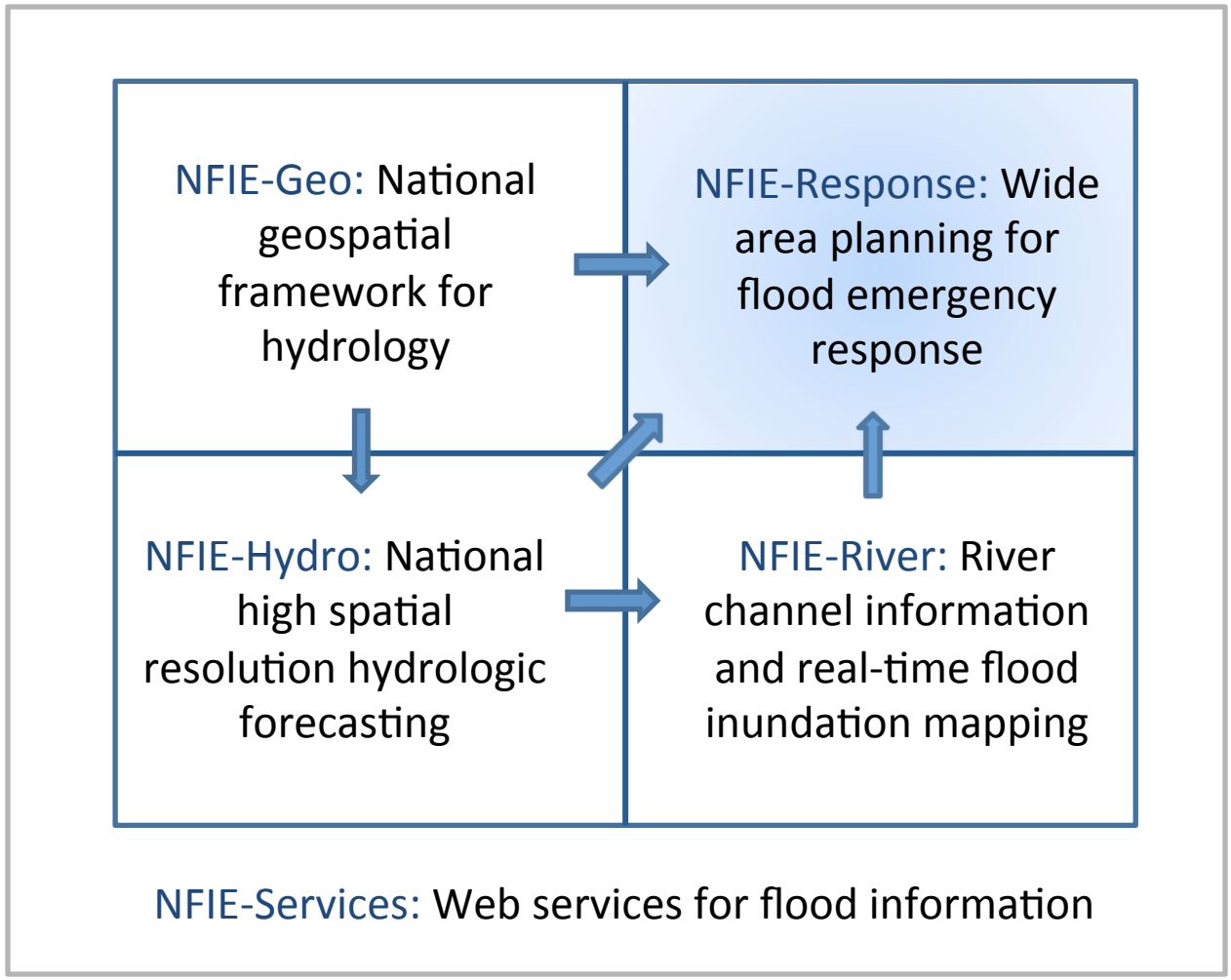
We need a national repository -- use HydroShare



Map: Xing Zheng, Data Source: City of Austin

National Flood Interoperability Experiment (NFIE)

Component Four: NFIE-Response



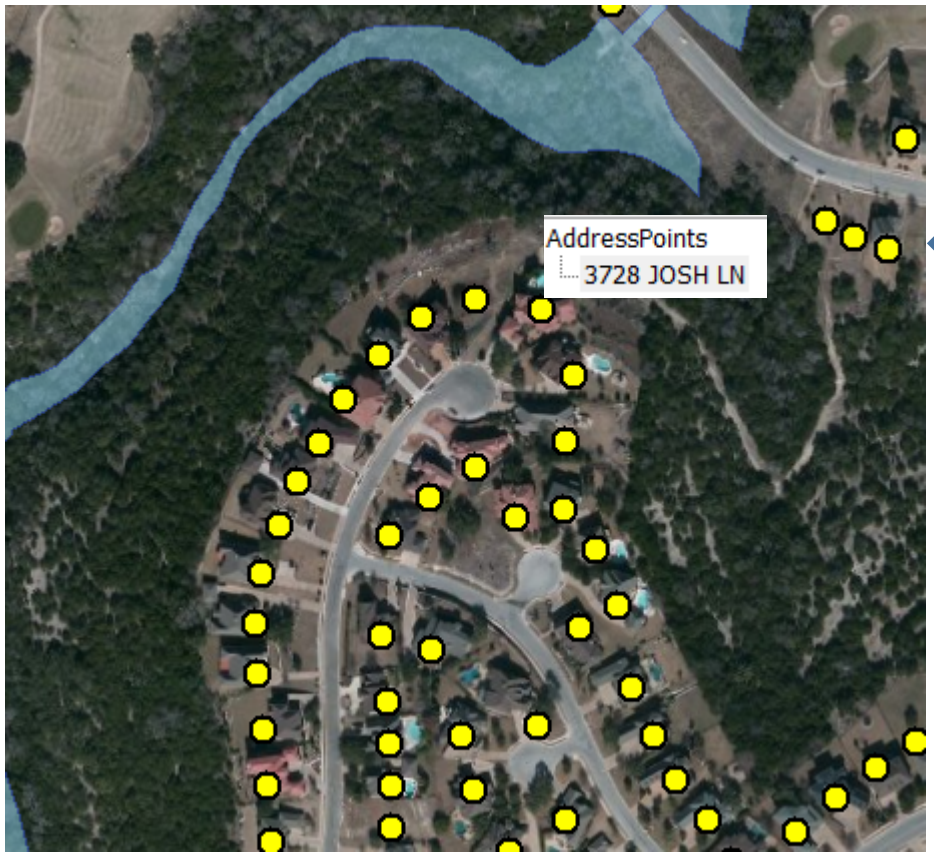
Link with the First Response Community

Harry Evans, Chief of Staff
Austin Fire Department

Responsible for flood
emergency response in Austin

https://www.youtube.com/watch?v=ympaR6YUxiA&feature=youtube

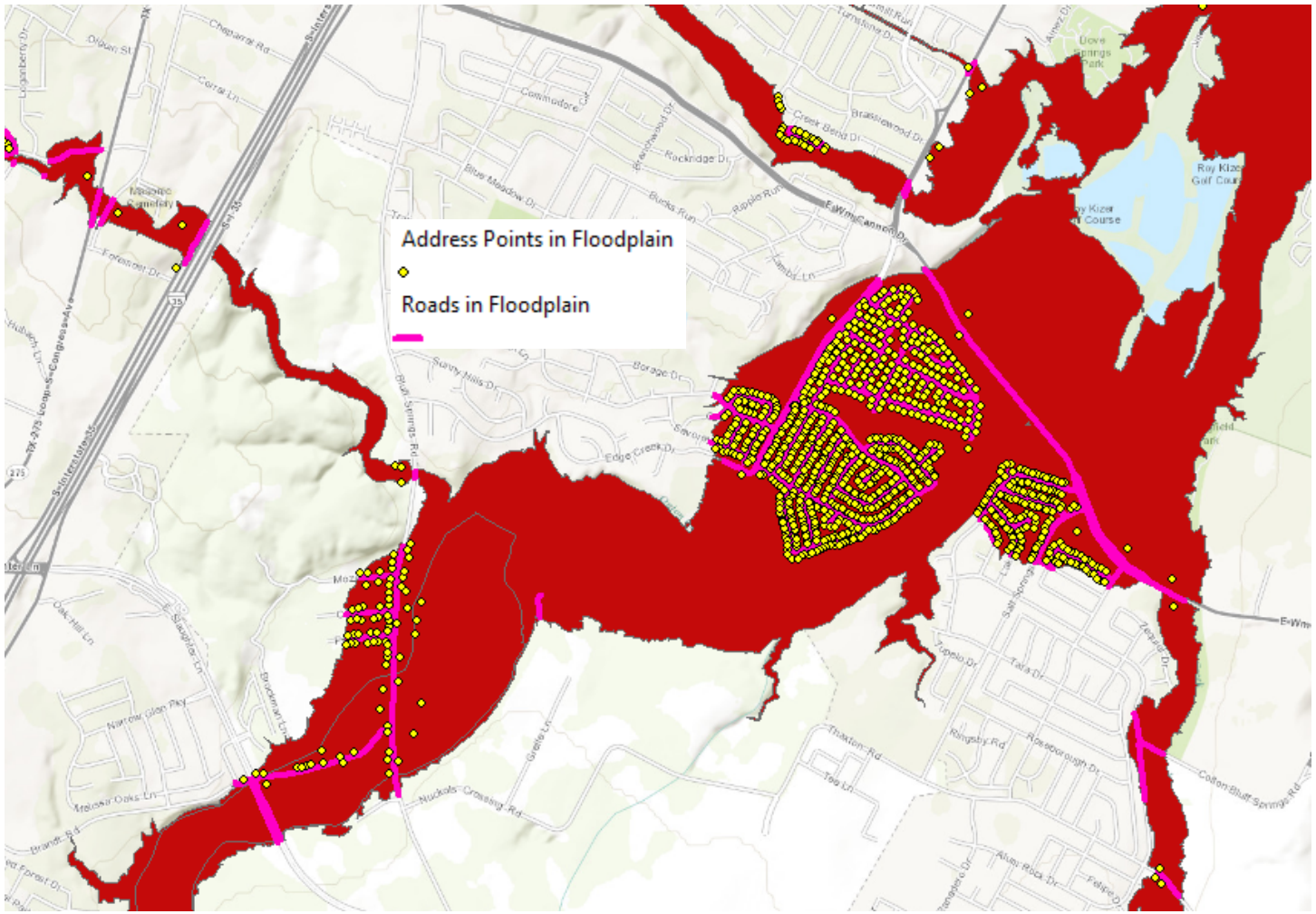
Address Points -- used for directing emergency response vehicles



All legal residences have an address point

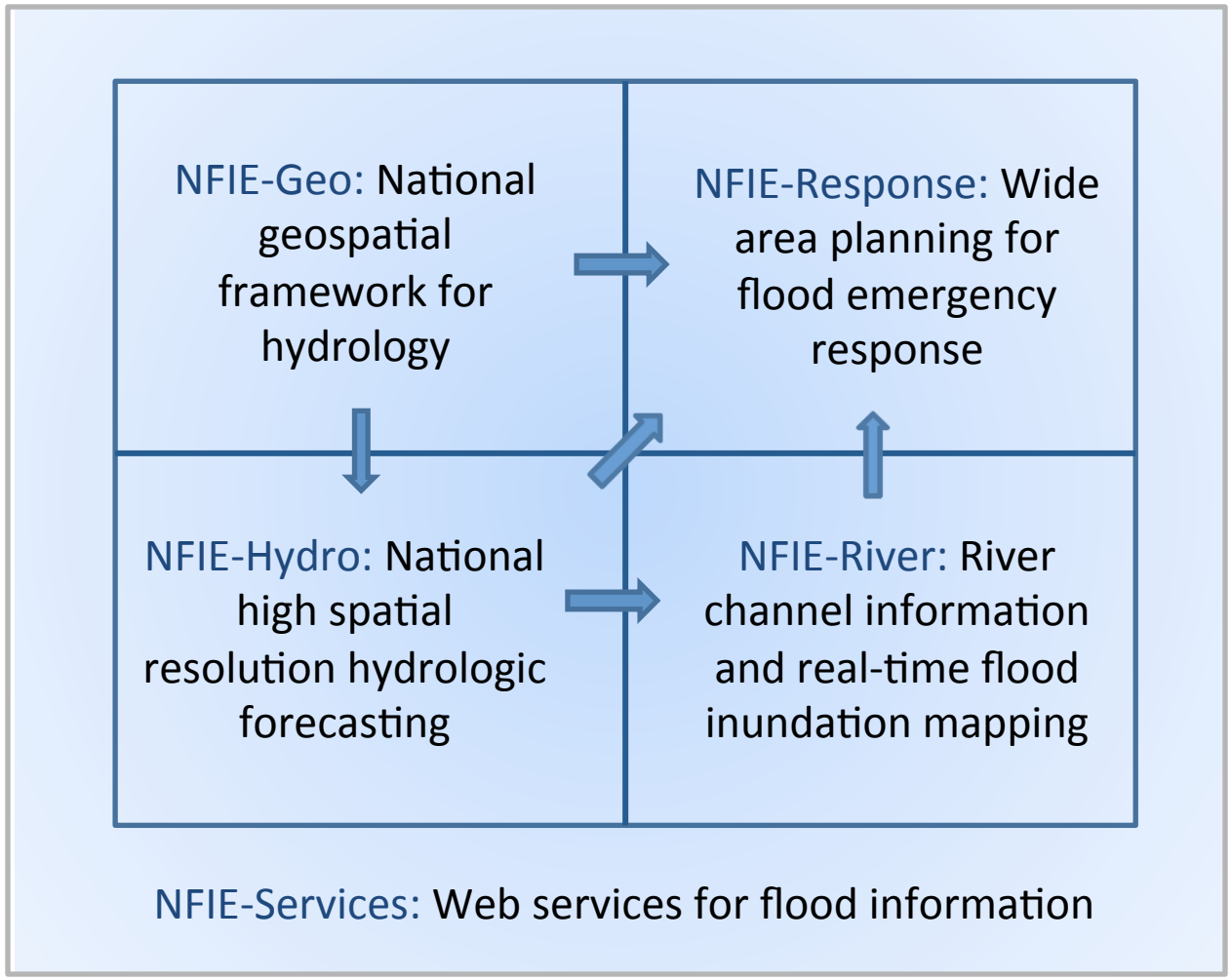
Established when the lot is legally platted and registered with the county

Address Points and Roads in Floodplain of Onion Creek

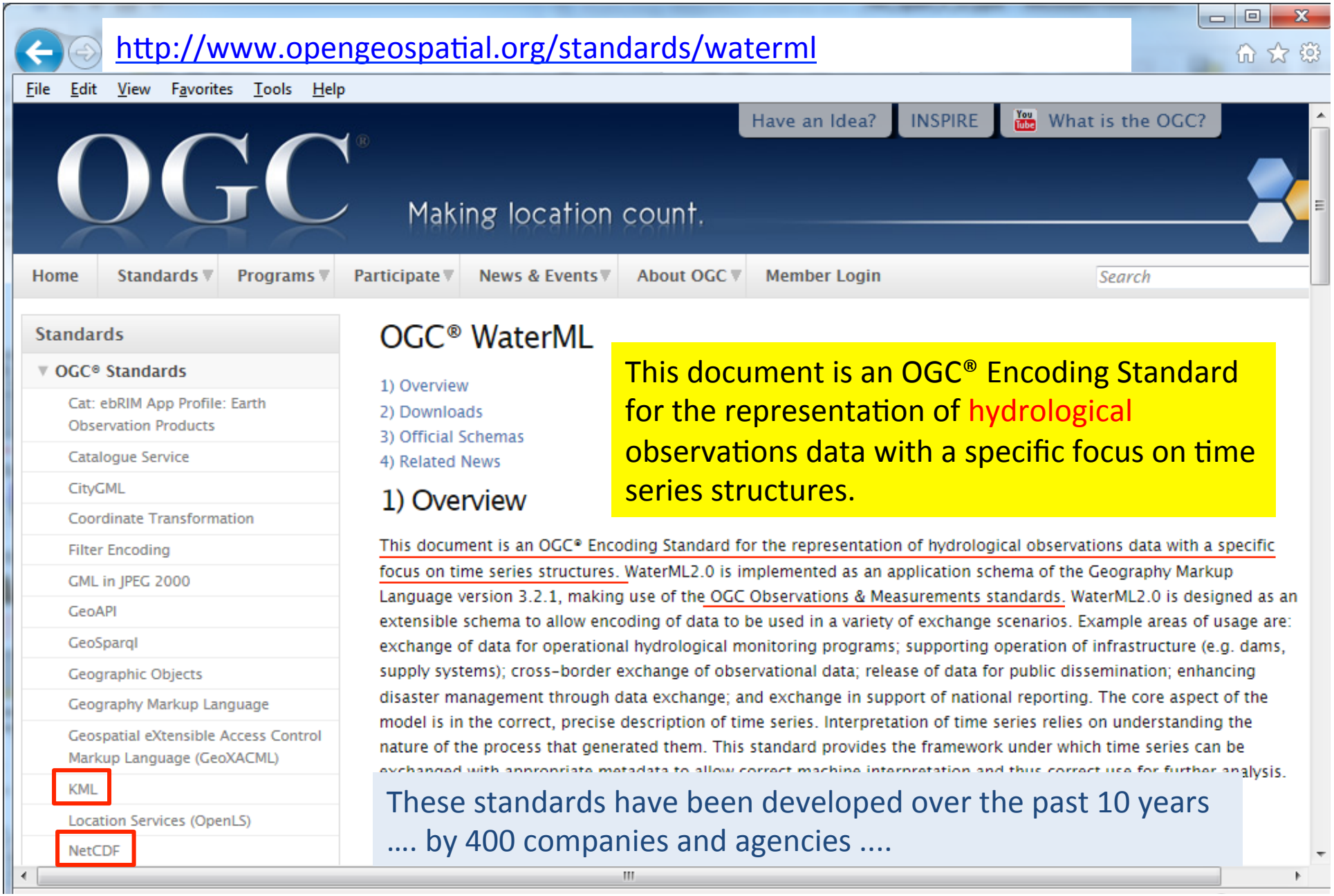


National Flood Interoperability Experiment (NFIE)

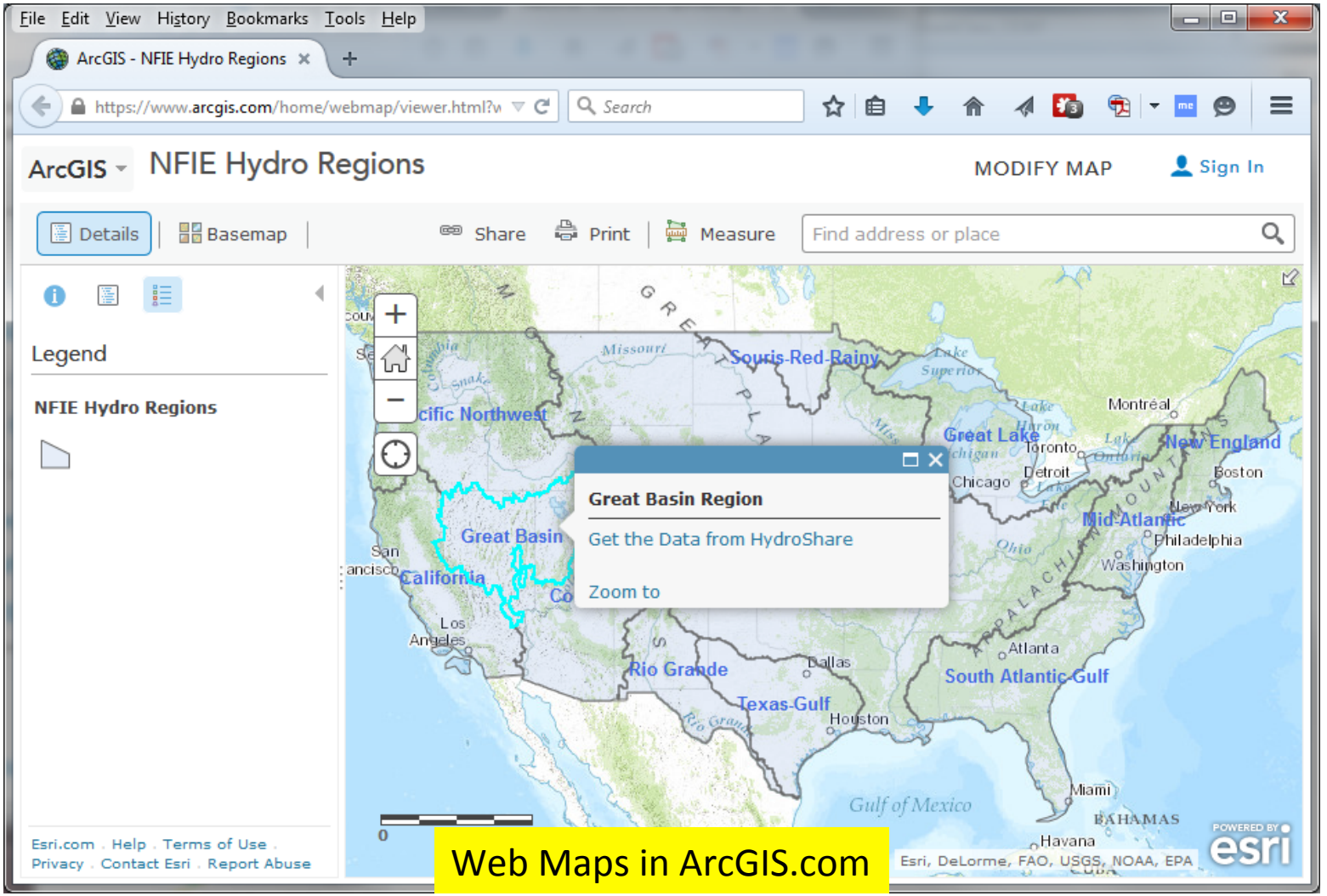
Component Five: NFIE-Services



Open Geospatial Consortium Web Service Standards



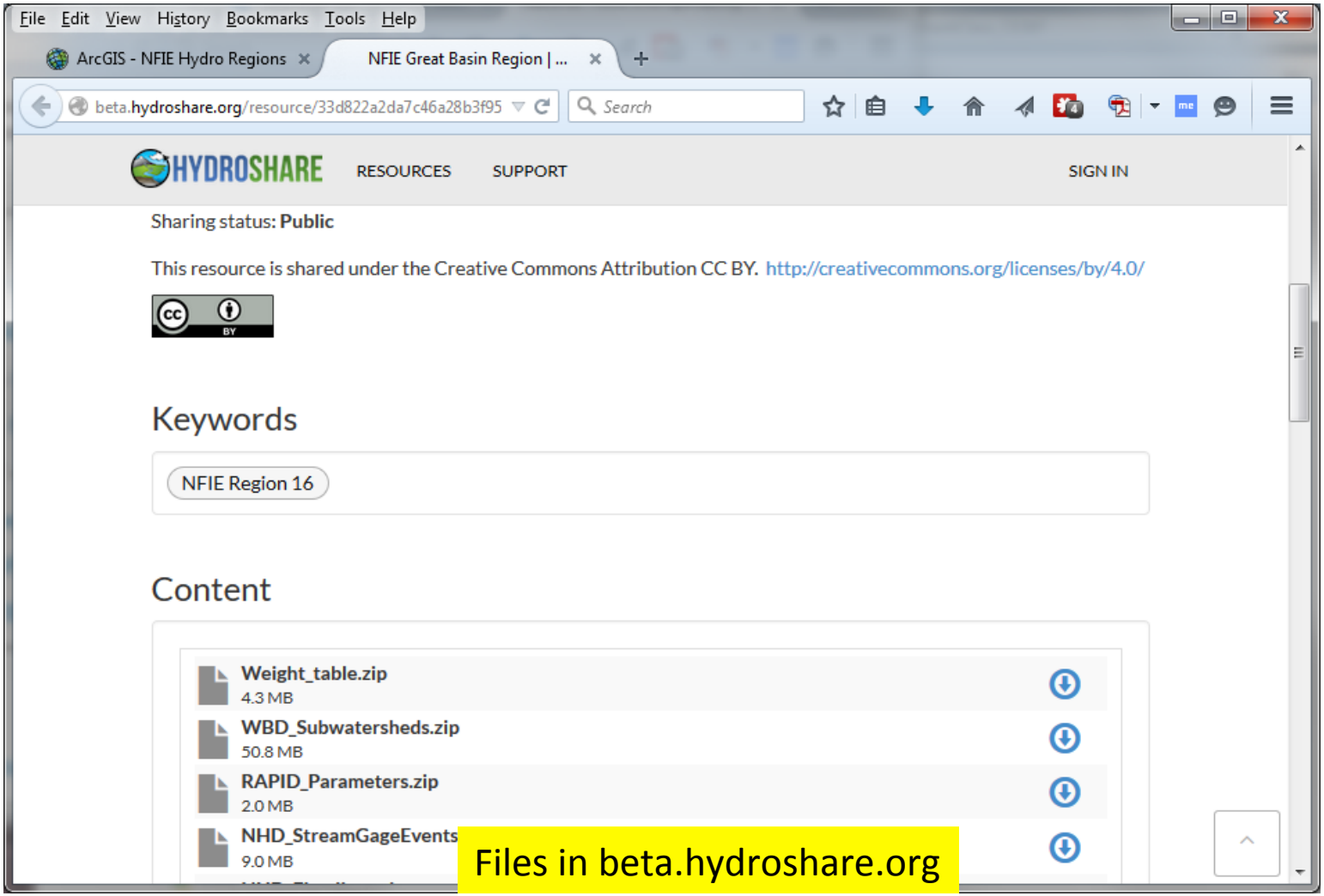
Interoperability through web services enables us to establish a system combining multiple components



Web Maps in ArcGIS.com

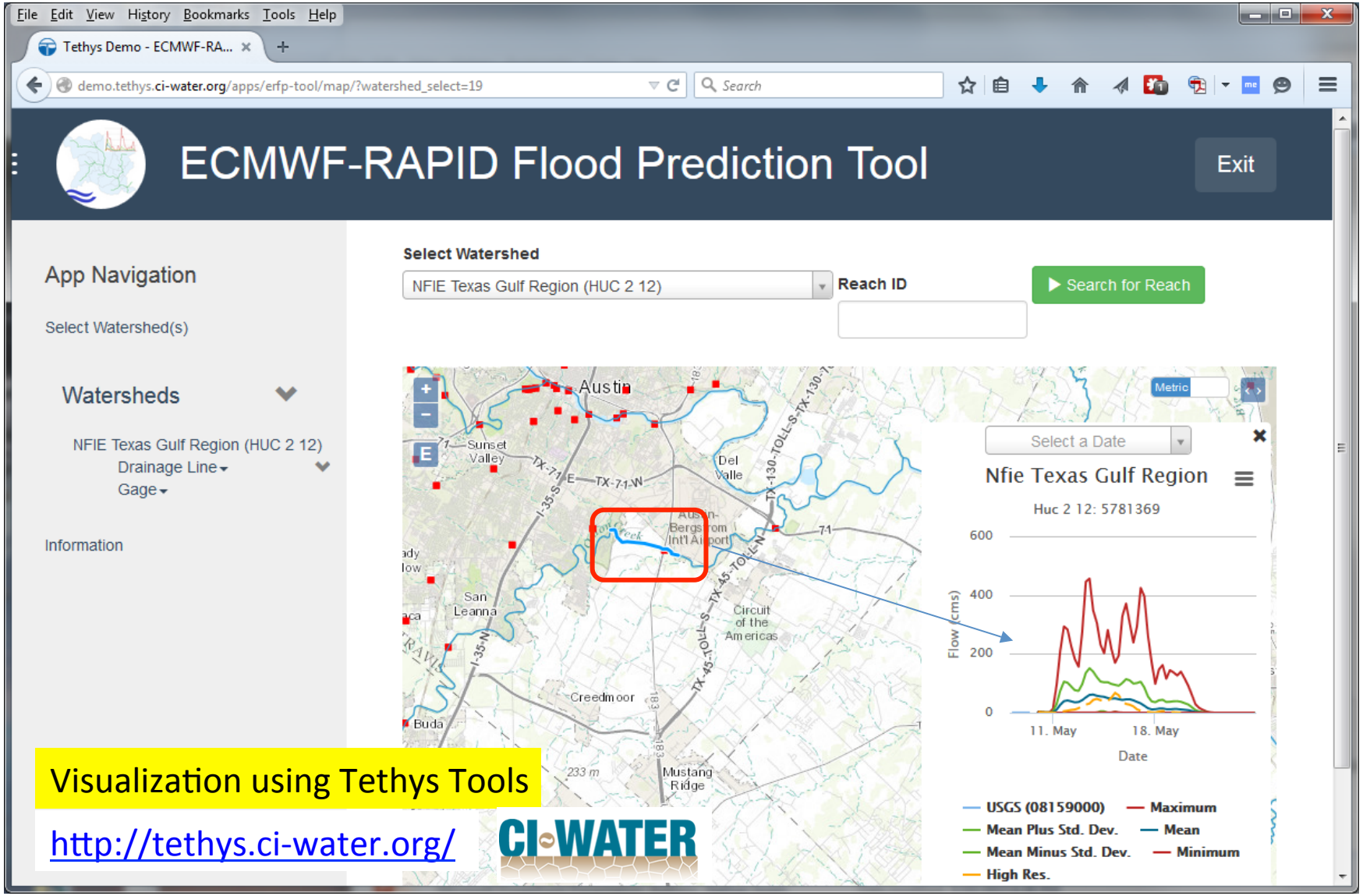
Industry

Interoperability through web services enables us to establish a system combining multiple components



University

Interoperability through web services enables us to establish a system combining multiple components



Visualization using Tethys Tools

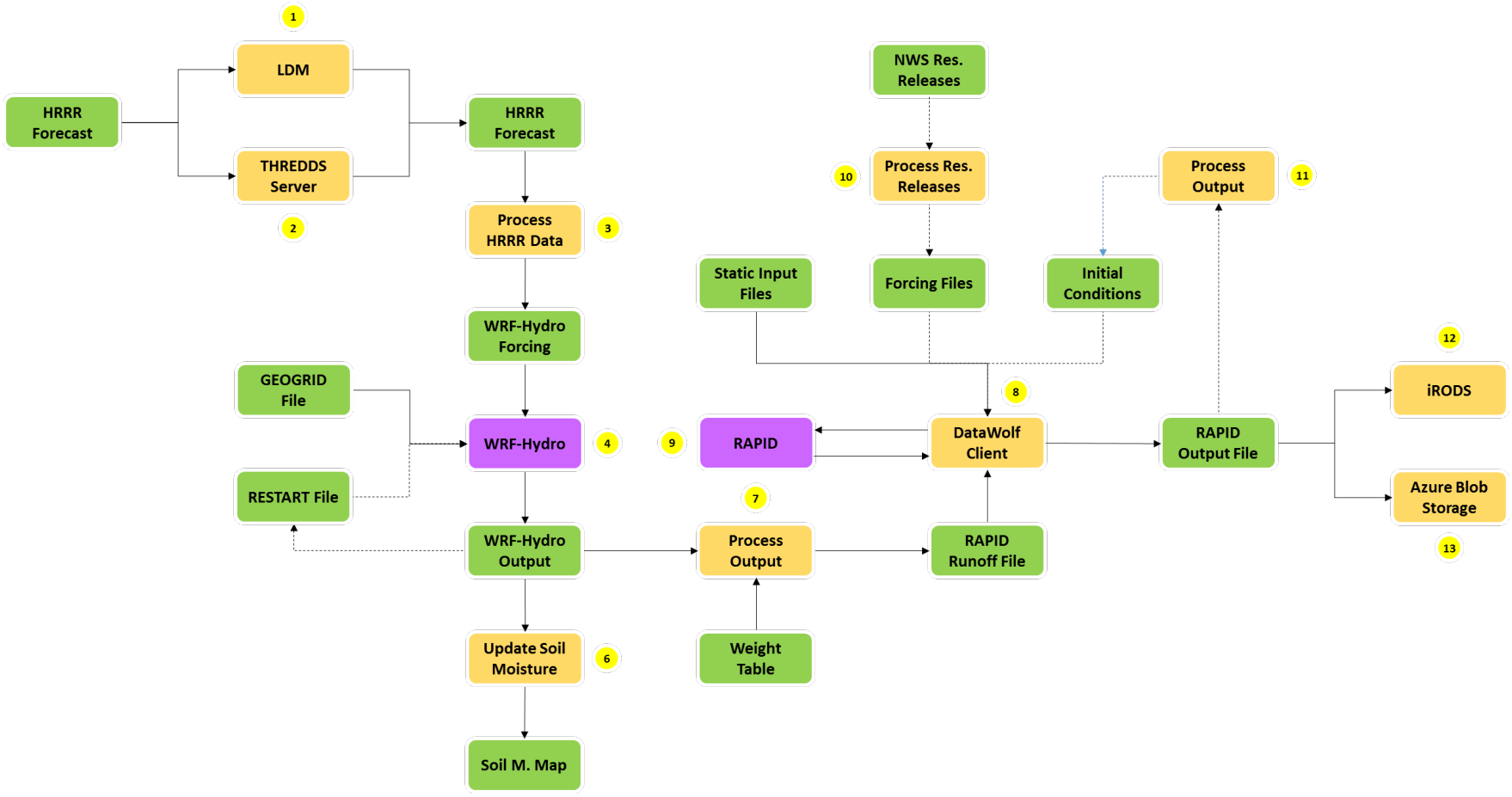
http://tethys.ci-water.org/

CI-WATER

NFIE Summer Institute Plan

- Establish a baseline end to end model
  - 2 week boot camp at beginning
- Form teams to focus on improving specific components
  - Iterative refinement
  - Metrics to quantify efficacy
- Daily “flood” briefing
- Report results weekly
- Capstone event 3rd CUAHSI conference on HydroInformatics, "Model and Data Interoperability: From Theory to Practice" July 15-17, Tuscaloosa Alabama. https://www.cuahsi.org/Posts/Entry/26293

NFIE-Hydro Baseline Workflow



Implemented in Microsoft Azure

Evaluating component refinements

- Can runoff forecasts be improved by using alternative, possibly more detailed hydrologic models (NoahMP, VIC, PIHM, RHESSys, SUMMA).
- In cold regions can forecasts be improved by using alternative snow models (e.g. Snow17, UEB, SNTHRM).
- How does improvement translate through to flooding and response.
- How to quantify and represent uncertainty
- What metrics to use to evaluate forecasts

Examples of the type of questions that summer institute students will do projects on

Evaluating component refinements

- Can flow forecasts be improved by using alternative routing approaches (RAPID, SPRNT, HEC-RAS)
- What additional data is needed for any improvements. Use case studies in locations with high resolution data (e.g. North Carolina) to evaluate and quantify its added value to support additional data acquisition
- Can the spatial specificity of inundation maps be improved using high resolution topography data from LiDAR in conjunction with more detailed hydraulic modeling

Examples of the type of questions that summer institute students will do projects on

NFIE Summer Institute Team

Course Coordinators

- Fernando Salas, University of Texas at Austin
- Sagy Cohen, University of Alabama
- Joseph Gutenson, University of Alabama
- Sarah Praskievicz, University of Alabama

Theme Leaders

- Hydrology - Sagy Cohen, University of Alabama
- Hydraulics - Jim Nelson, Brigham Young University
- Uncertainty - David Maidment, University of Texas at Austin
- Emergency Response - Barbara Minsker, University of Illinois at Urbana-Champaign

Steering Committee

- David Maidment (Chair), University of Texas at Austin
- Andy Ernest, University of Alabama
- Barbara Minsker, University of Illinois at Urbana-Champaign
- David Gochis, NCAR
- Richard Hooper, CUAHSI
- David Tarboton, Utah State University
- Jon Goodall, University of Virginia

National Flood Interoperability Experiment: Summary

- Community Initiative: private sector, academia, federal agencies
- Explore next generation of national flood hydrology and emergency response
  - Prototype advancing from 3600 forecast locations used at present to 2.67 million locations (each NHDPlus reach)
  - Emergency response community engagement to enhance translation and applicability of information
- Research grade (low technology readiness level)
- Operational implementation responsibility of agencies