Flood Vulnerability Assessment by Modeling and Remote Sensing Methods

Emmanouil Anagnostou
CIRCA & Eversource Energy Center
University of Connecticut

Methodology

- Modeling approach to flood risk analysis
  - Hydrological Modelling
  - Flood Frequency Analysis
  - Hydraulic Modelling
- Mapping of flood inundation in near-real-time
  - Optical Based Retrieval
  - SAR Based Retrieval
  - Integration to map flood inundation in near-real-time

Modelling Approach

Hydrological Simulation

- Atmospheric Forcing
- GIS/Soil Maps
- Flow time series

Flood Frequency Analysis

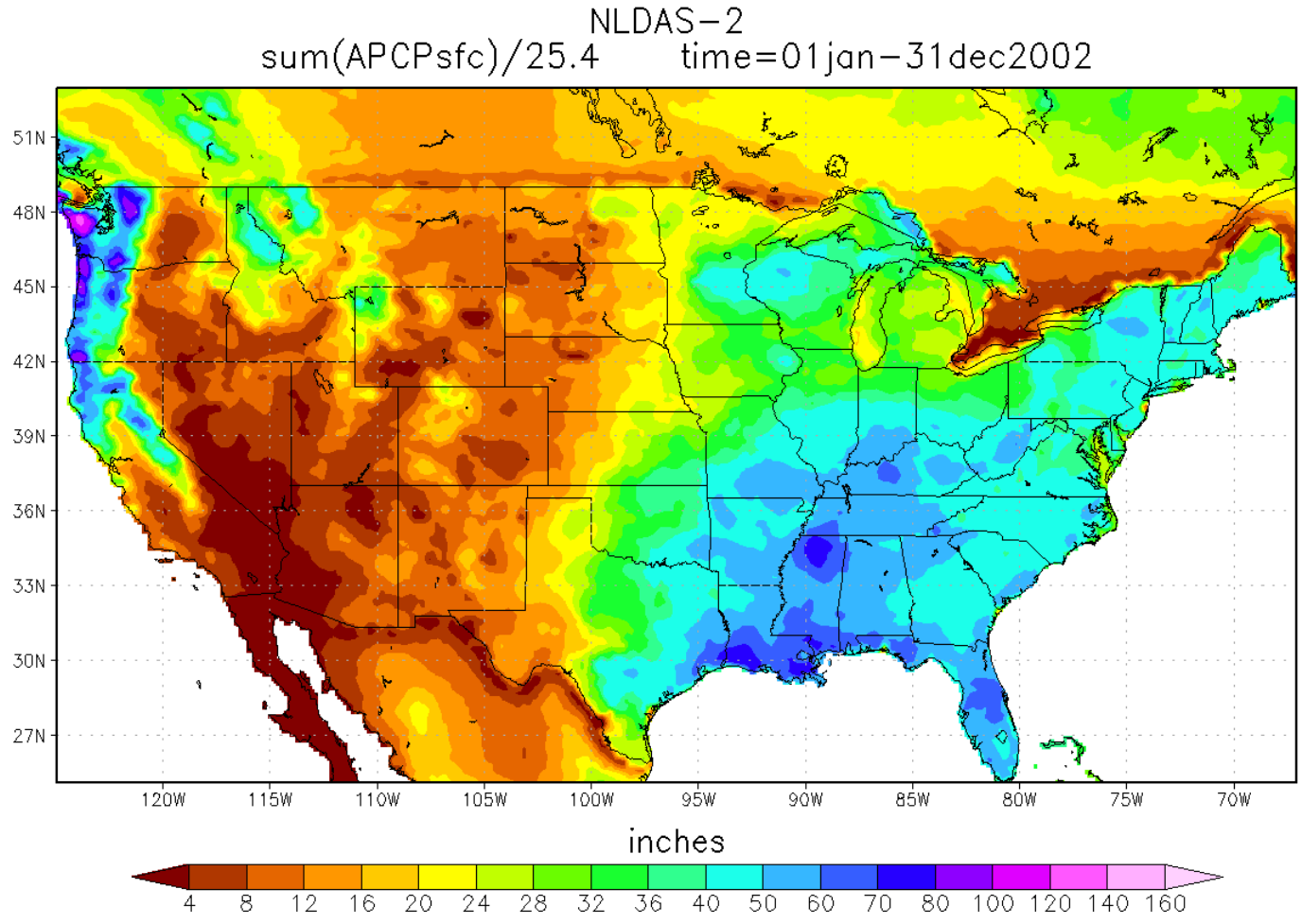
- Annual Flow Peaks (simulated and observed)
- Estimations of 50-500 year return period flood peaks

Hydraulic Simulation

- Synthetic Event Hydrograph
- High resolution river bathymetry
- Derivation of inundation maps
- Risk of overtopping for hydraulic structures (culverts, dams)

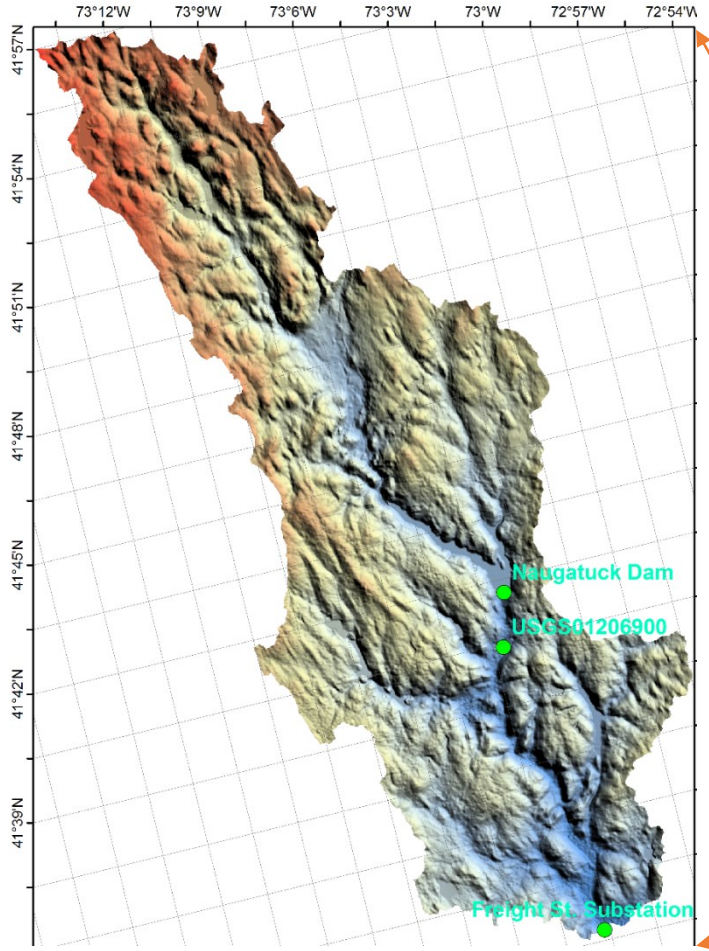
Hydrological Simulation

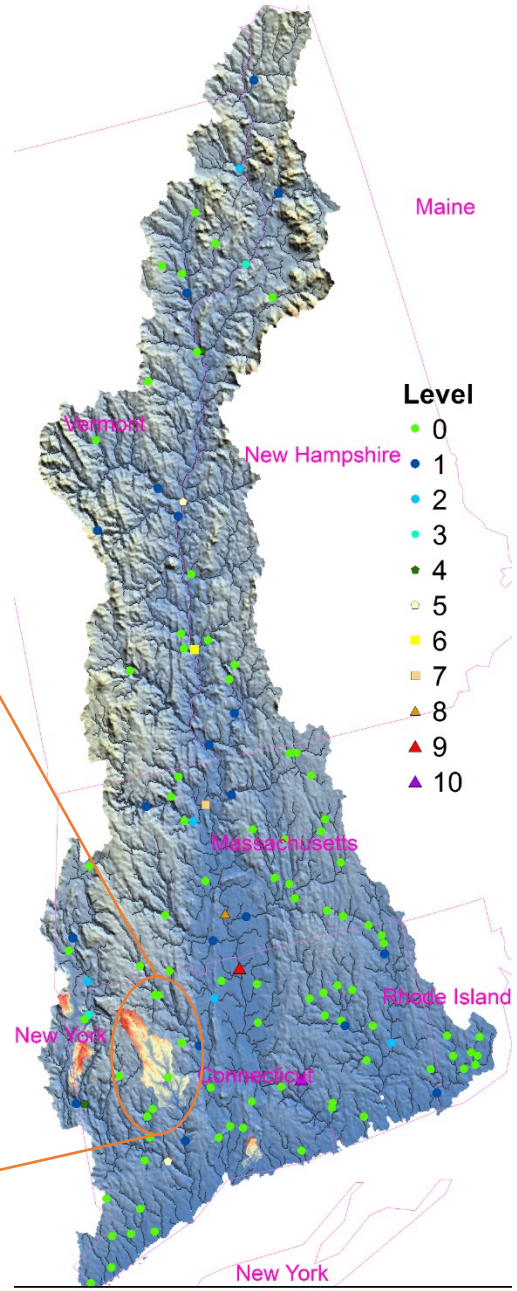
- **Forcing Data**
  - **State-of-the-art Atmospheric Reanalysis: NLDAS-2**, North American Land Data Assimilation System (39 years: 1979-present, 1h/12km spatial resolution)



Hydrological Simulation

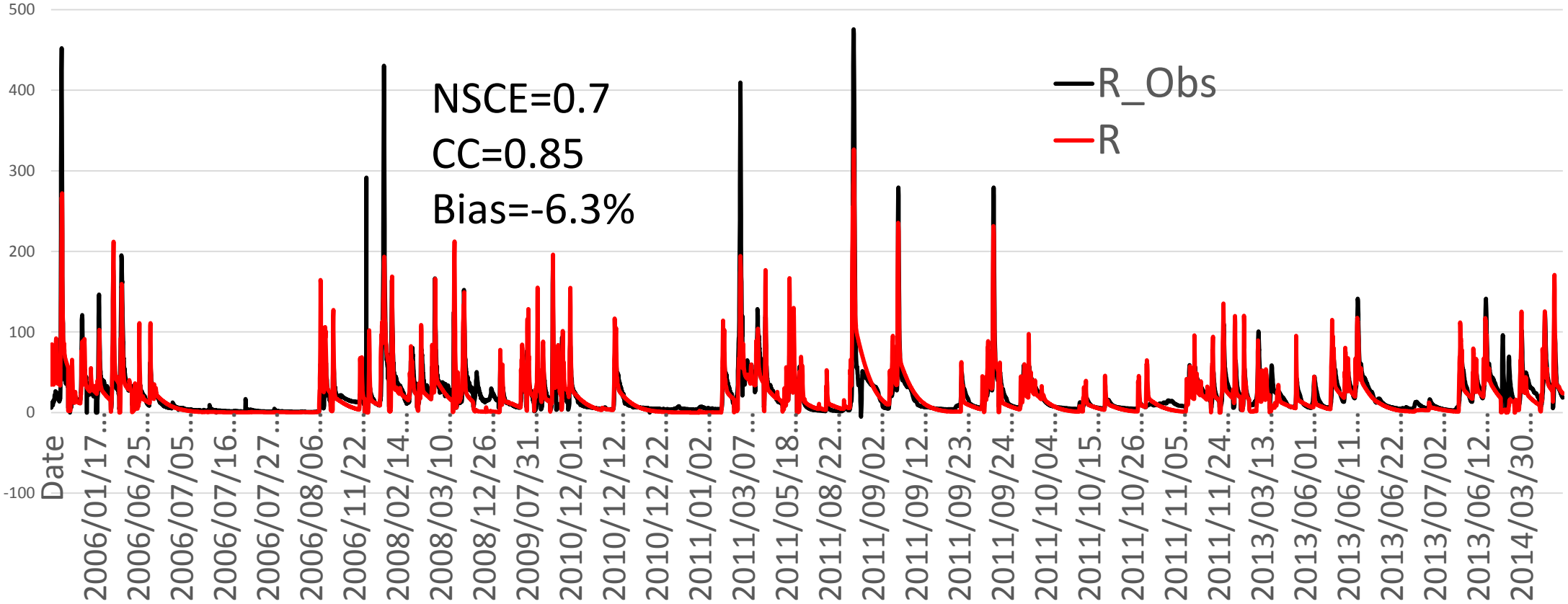
- **Case Study in CT**
  - Naugatuck River
  - Thomaston Dam in the middle of the River
  - Critical Infrastructure at Freight St., Waterbury, CT





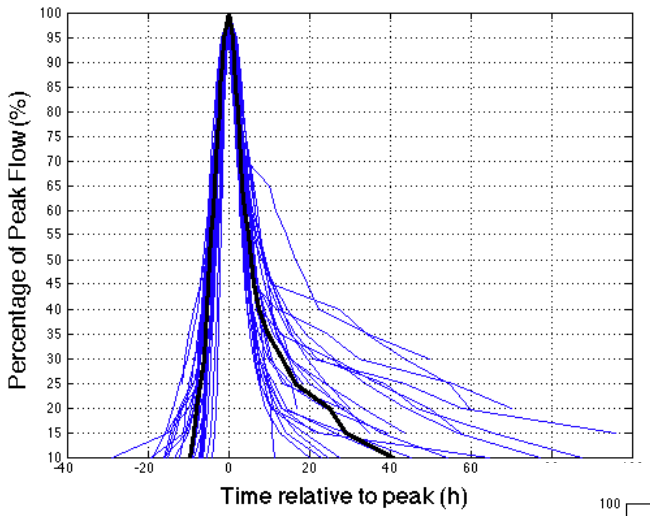
Hydrological Simulation

- 45 events -- 9/36 calibration/validation (~9 years period with USGS observations)
- 37 years of hourly simulations

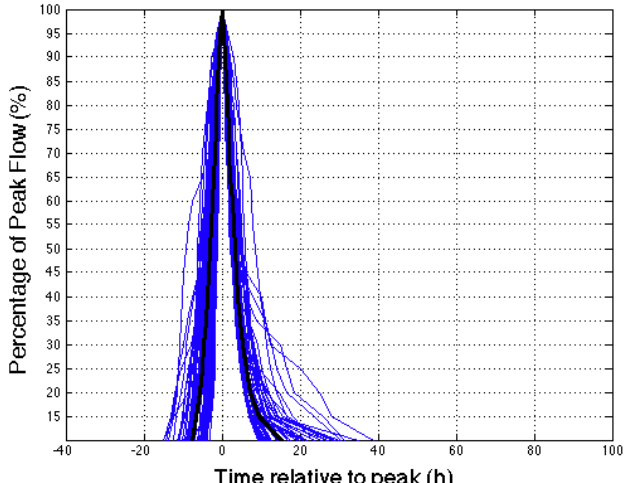


Synthetic Hydrograph

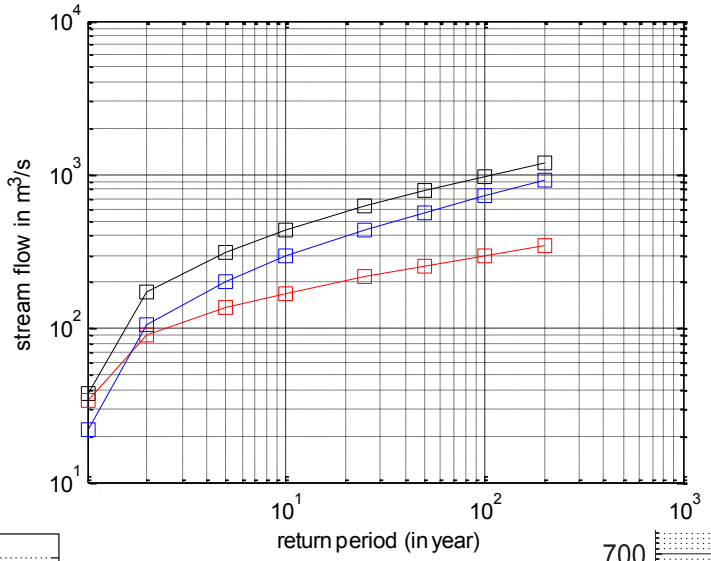
- Timing



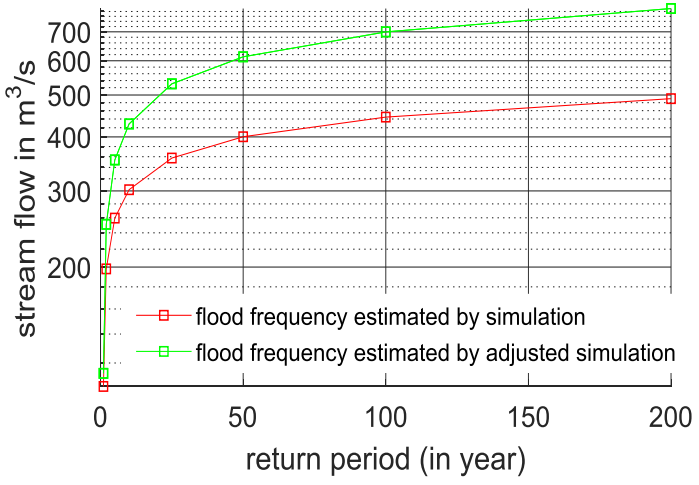
Upstream of Thomaston Dam



- Magnitude (Flood Frequency Analysis)

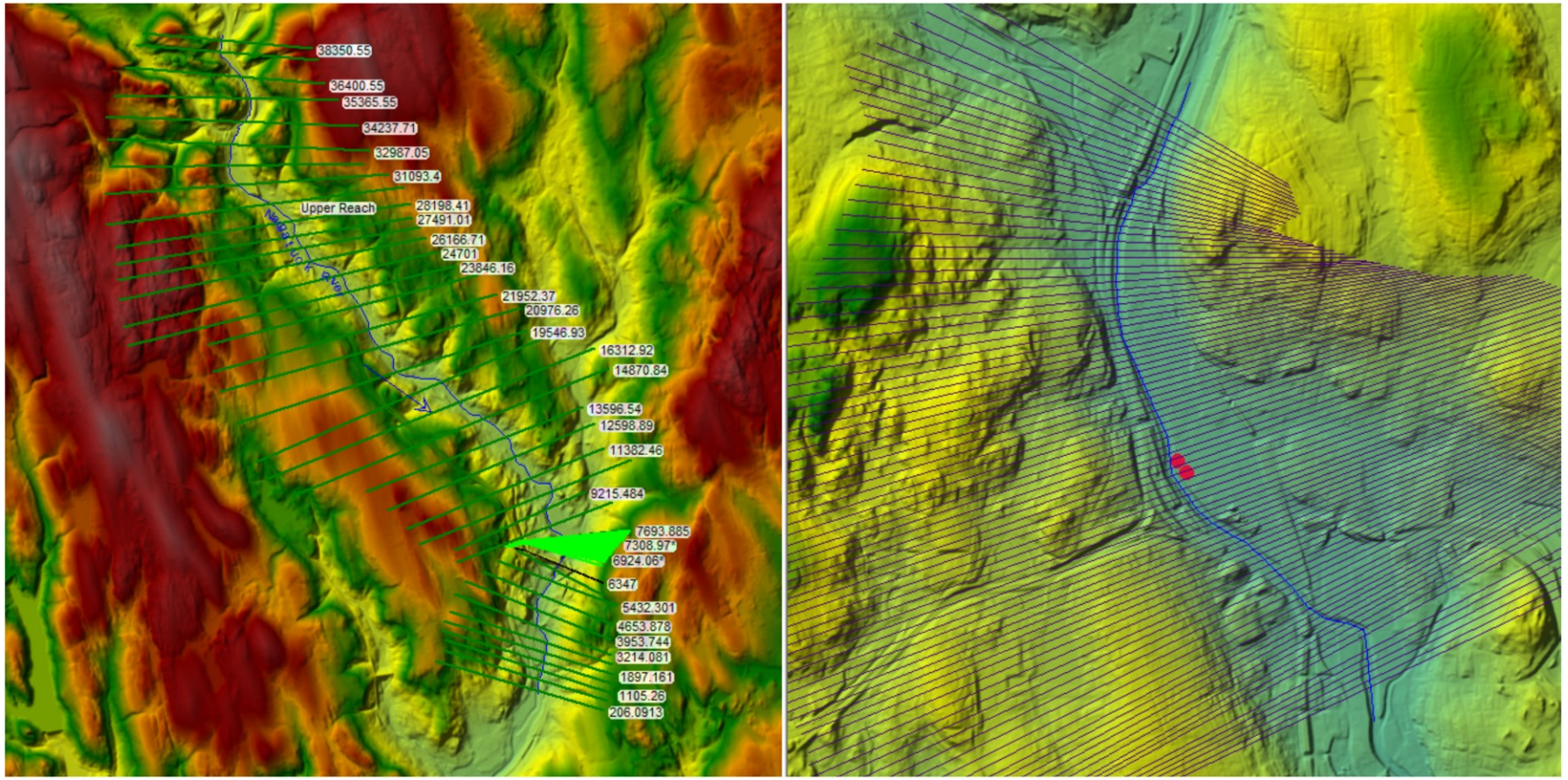


Downstream to Thomaston Dam

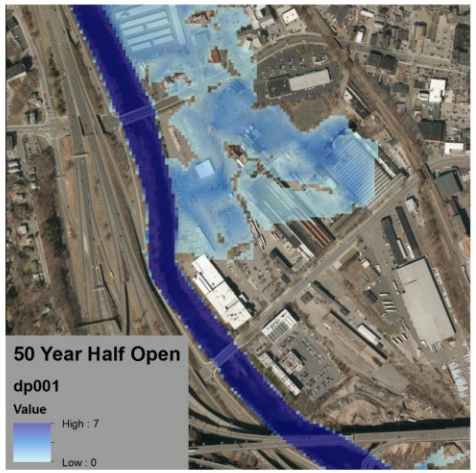


Hydraulic Simulation

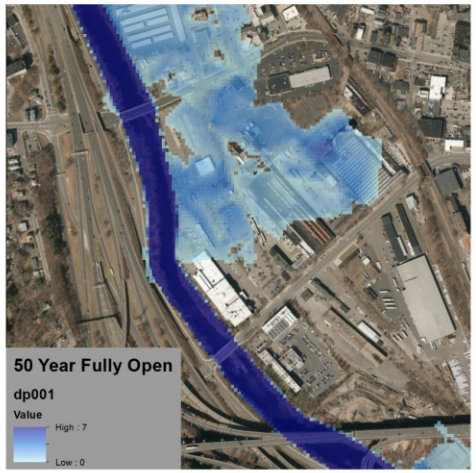
- River Profiling by 1m Airborne LiDAR DEM

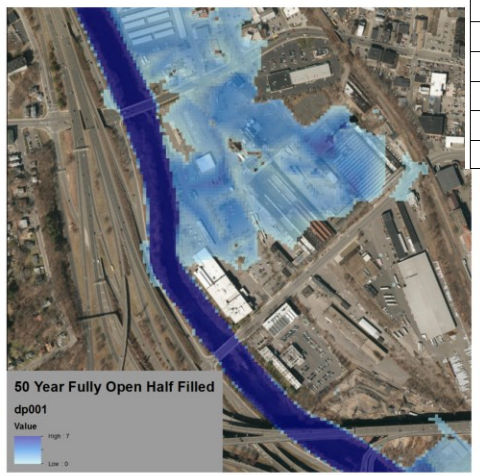


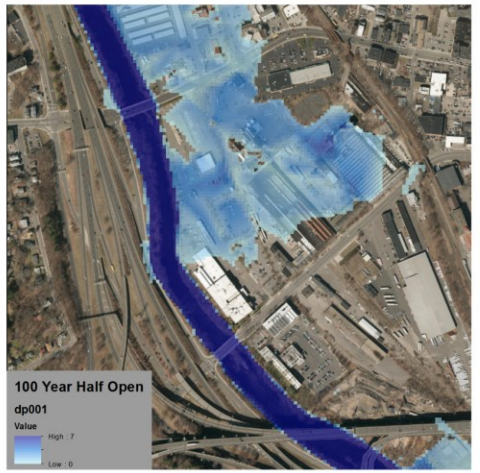
Hydraulic Simulation-- 50/100-year flood event caused inundation

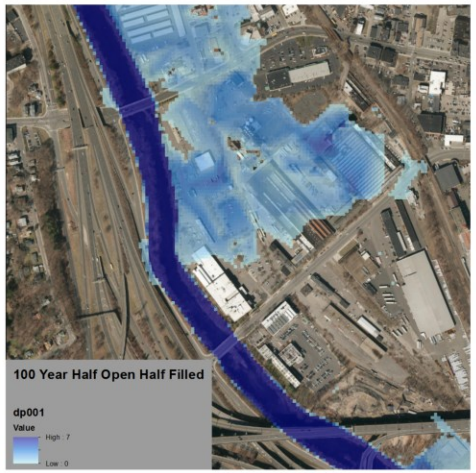


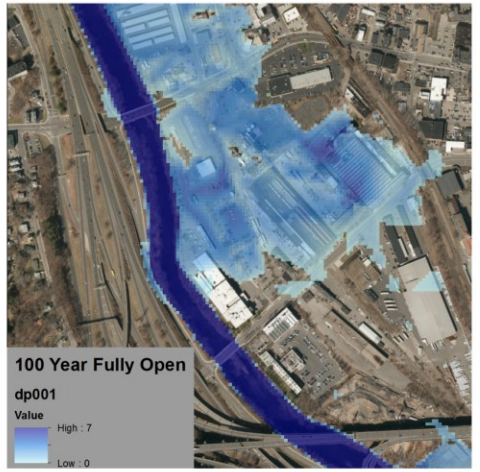
Flooding Scenario	Maximum Water Depth (feet) Outside Transformer	Building
50 Year		
Half Open	0.40	0.00
Half Open Half Filled	0.44	0.00
Fully Open	1.06	0.00
Fully Open Half Filled	1.73	0.00
100 Year		
Half Open	1.37	0.00
Half Open Half Filled	1.70	0.00
Fully Open	2.60	0.26
Fully Open Half Filled	3.36	1.29
200 Year		
Half Open	3.10	1.04
Half Open Half Filled	3.30	1.34
Fully Open	3.33	1.39
Fully Open Half Filled	3.51	1.55
500 Year		
Half Open	4.01	2.12
Half Open Half Filled	4.20	2.22
Fully Open	4.28	2.57
Fully Open Half Filled	4.63	2.69

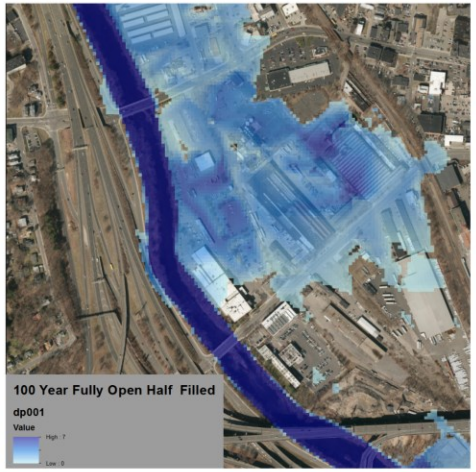




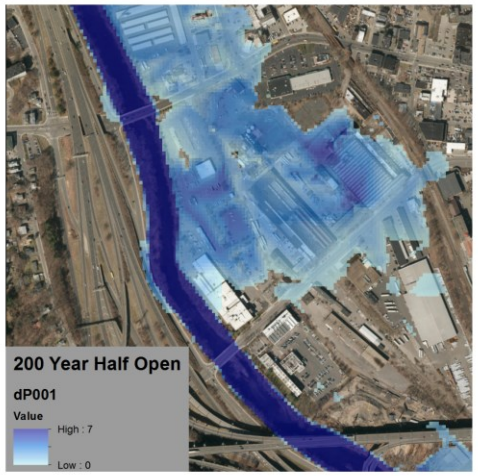


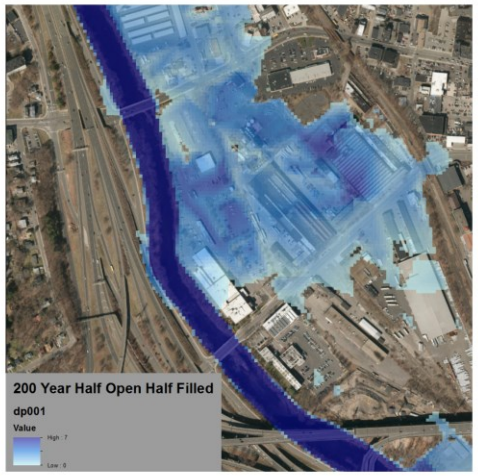






Hydraulic Simulation-- 200-year and 500-year





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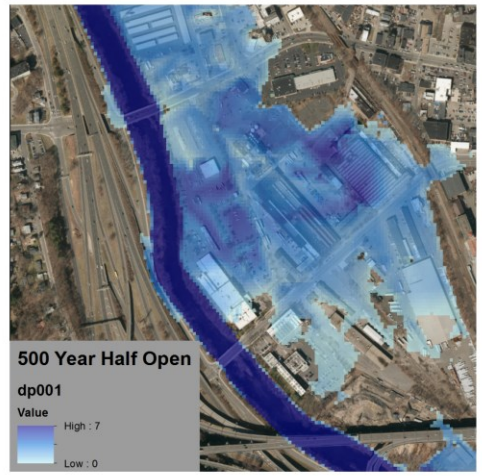

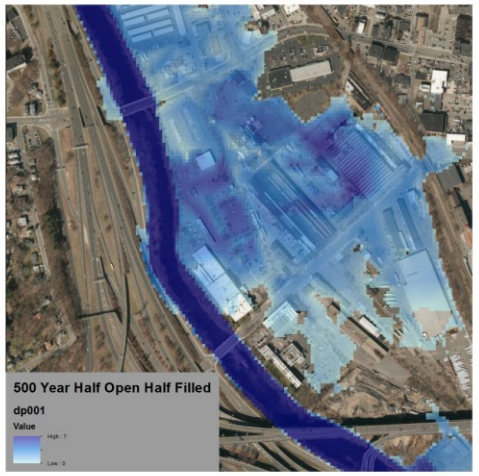

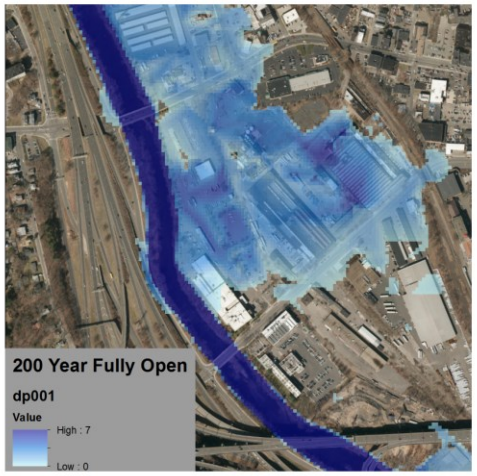

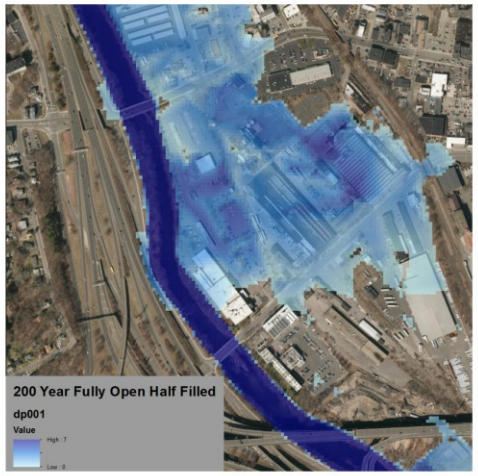

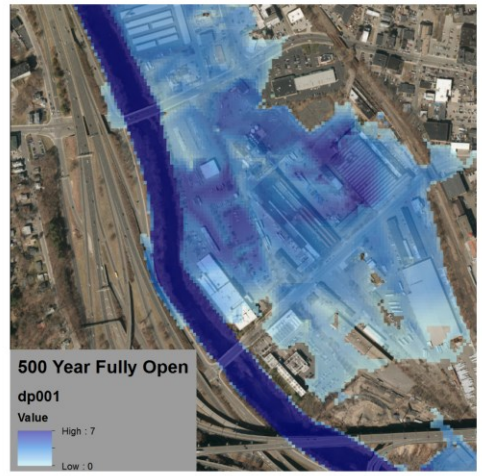

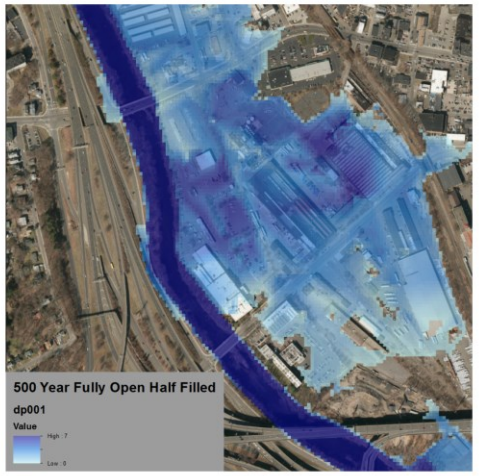

Contribution of Dam Operations

Dam Peak Streamflow Contribution (cfs)		
Flooding Scenario	Half Open	Fully Open
50 Year		
Empty Reservoir	22930 (9.94%)	24890 (16.90%)
Half Filled Reservoir	23369 (11.52%)	25862 (20.07%)
100 Year		
Empty Reservoir	25514 (9.20%)	27558 (15.78%)
Half Filled Reservoir	25922 (10.52%)	28453 (18.45%)
200 Year		
Empty Reservoir	28168 (8.56%)	30289 (14.80%)
Half Filled Reservoir	28549 (9.67%)	31116 (17.07%)
500 Year		
Empty Reservoir	31810 (7.83%)	34024 (13.68%)
Half Filled Reservoir	32161 (8.73%)	34776 (15.52%)

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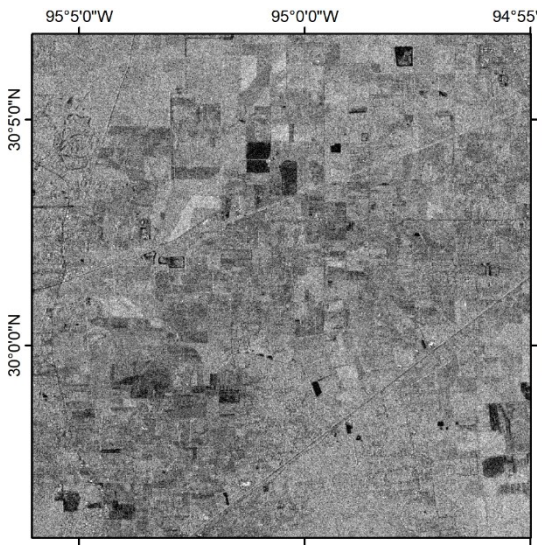
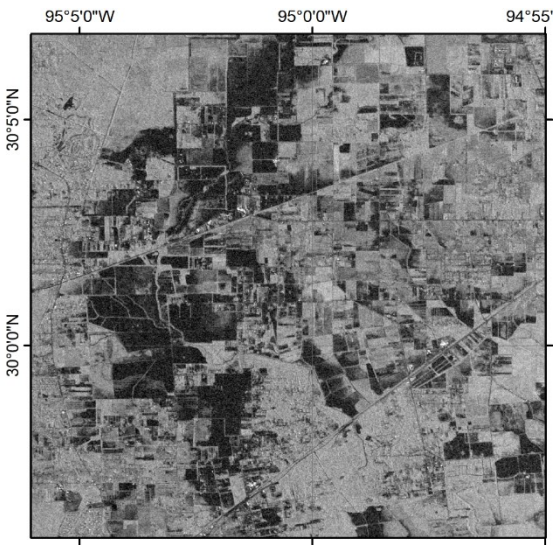
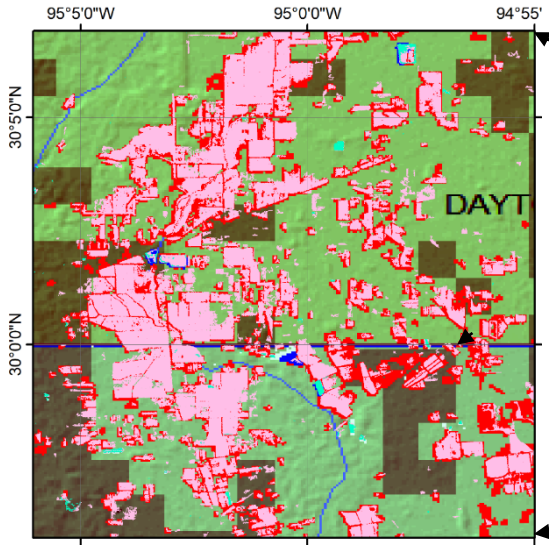
Mapping of Flood Inundation from Remote Sensing

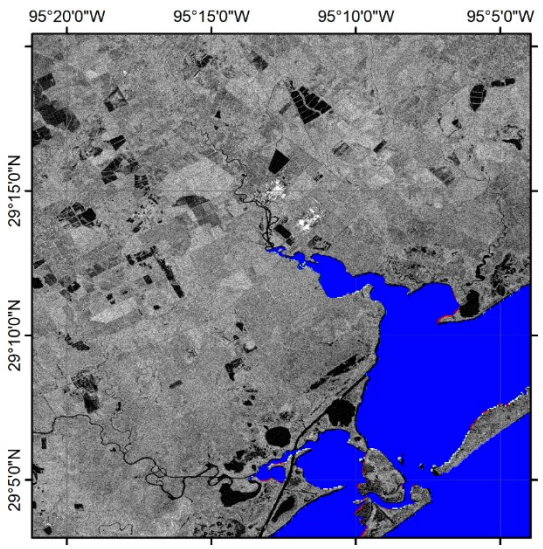
Methods	Optical Index	SAR statistics	Integrated methods
Quality	Simple and accurate	Complex and noisy	Complex and accurate
Automation	automated	Tedious manual processing	Automated (UConn RAPID technique)
Availability	Available only during clear days (no near-real-time)	All weather day and night (near-real-time)	All weather day and night (near-real-time)

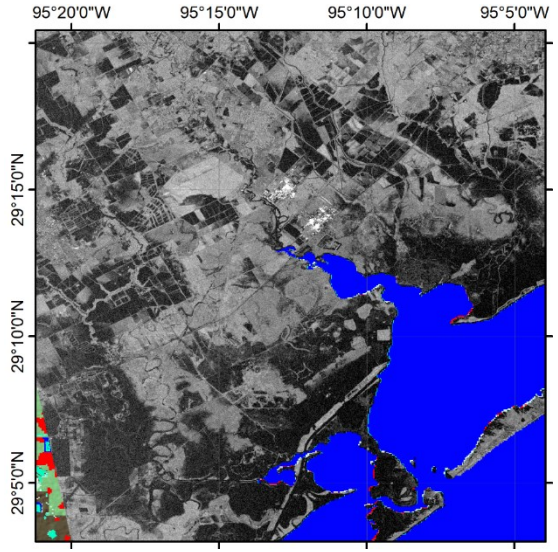
Hurricane Harvey, TX, 2017

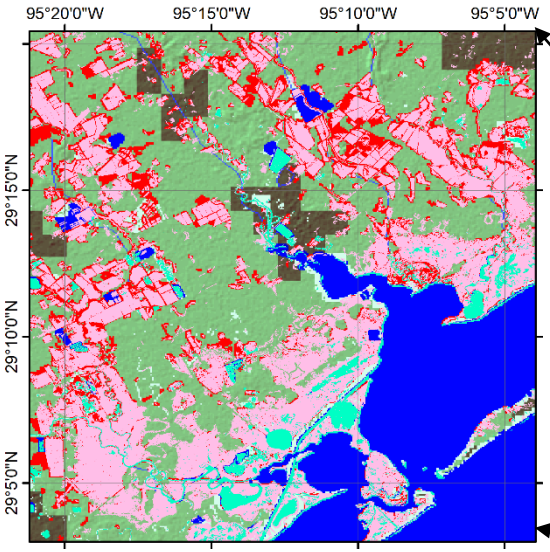


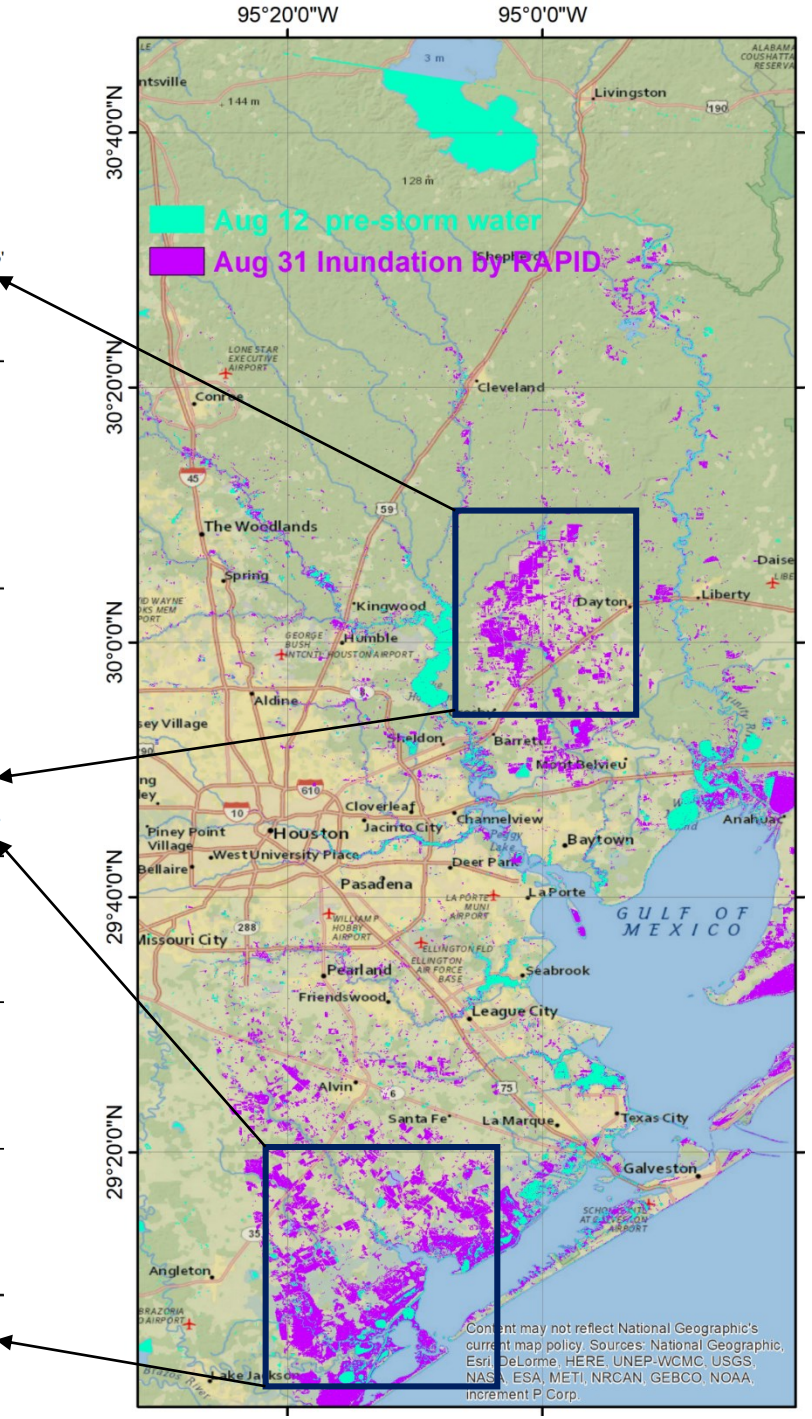










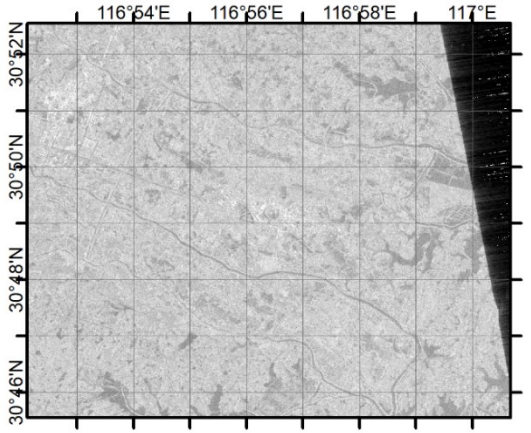


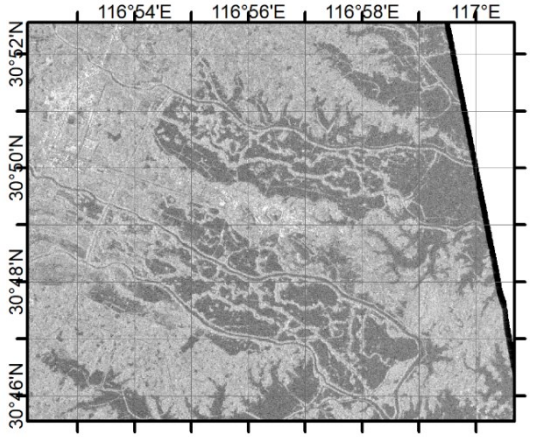
Pre-Flood SAR

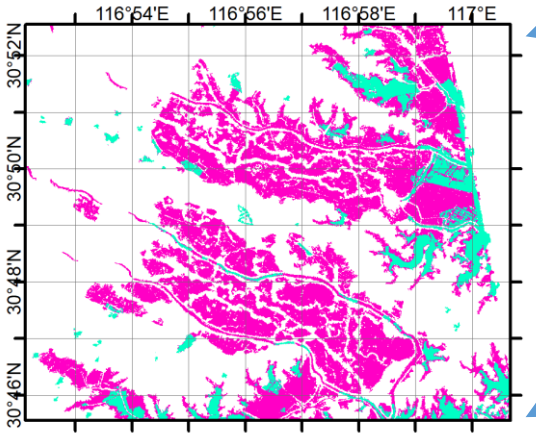
In-Flood SAR

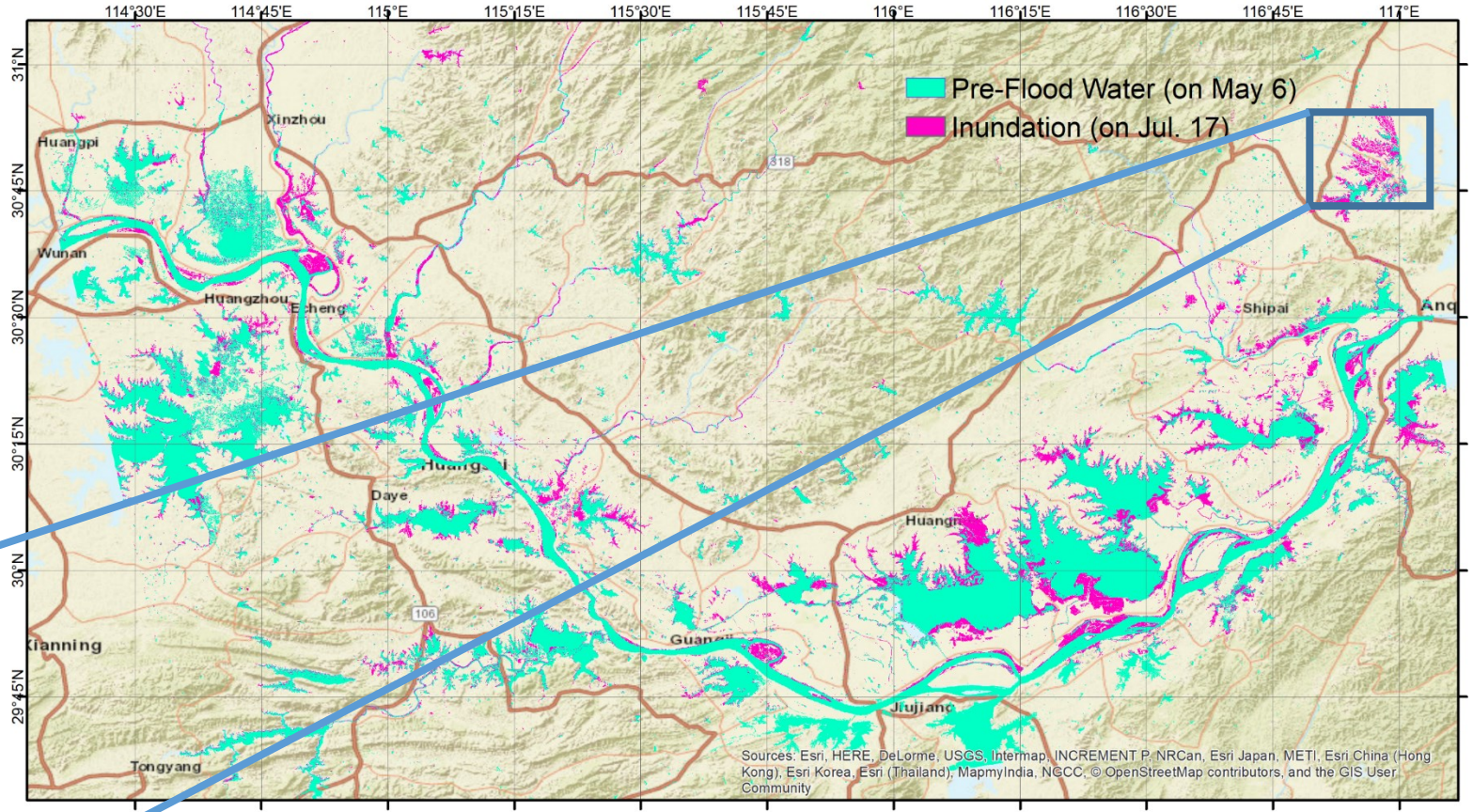
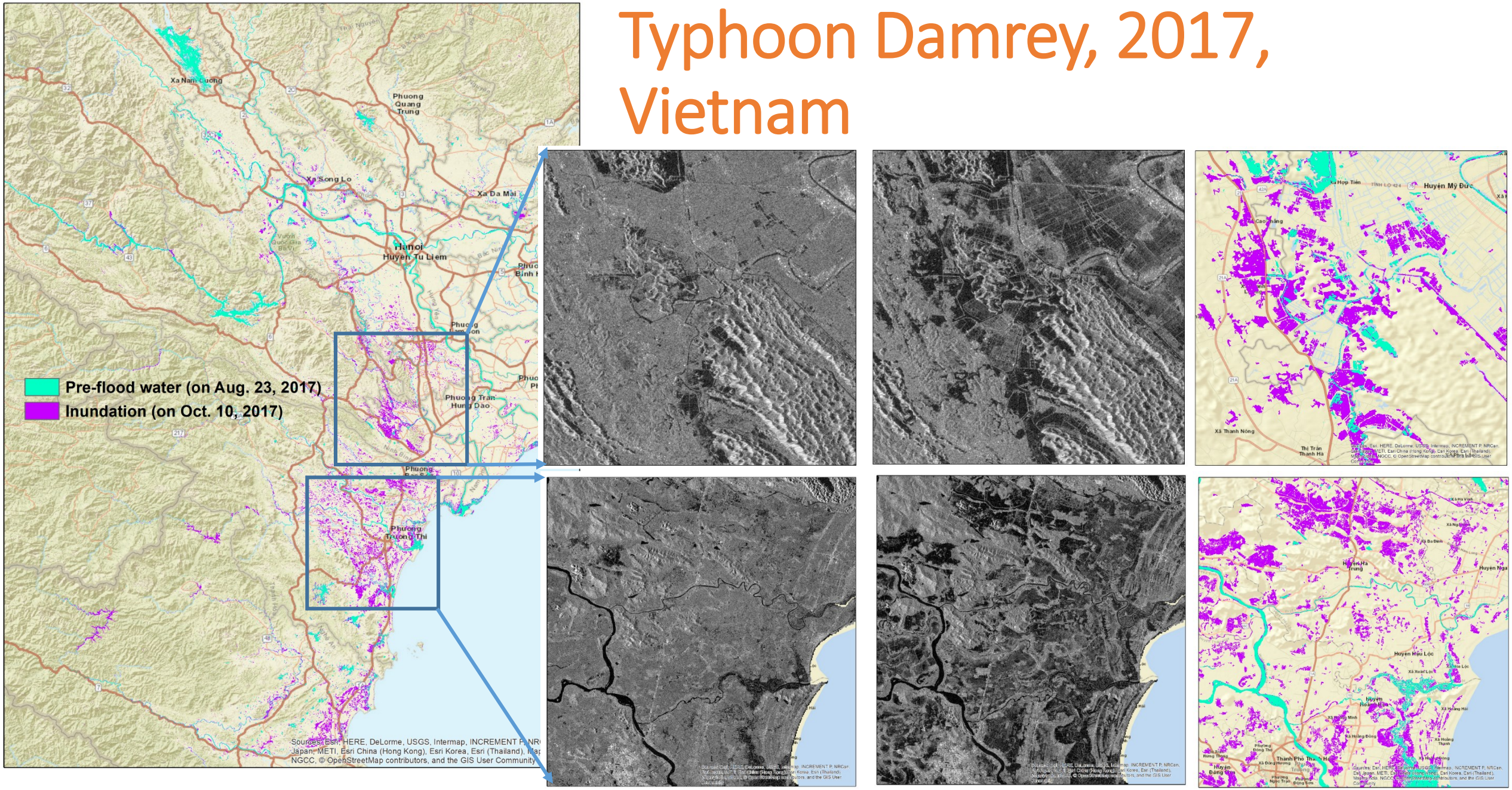
RAPID vs.

Typhoon Nepartak 2016, Yangtze River, China









Typhoon Damrey, 2017, Vietnam