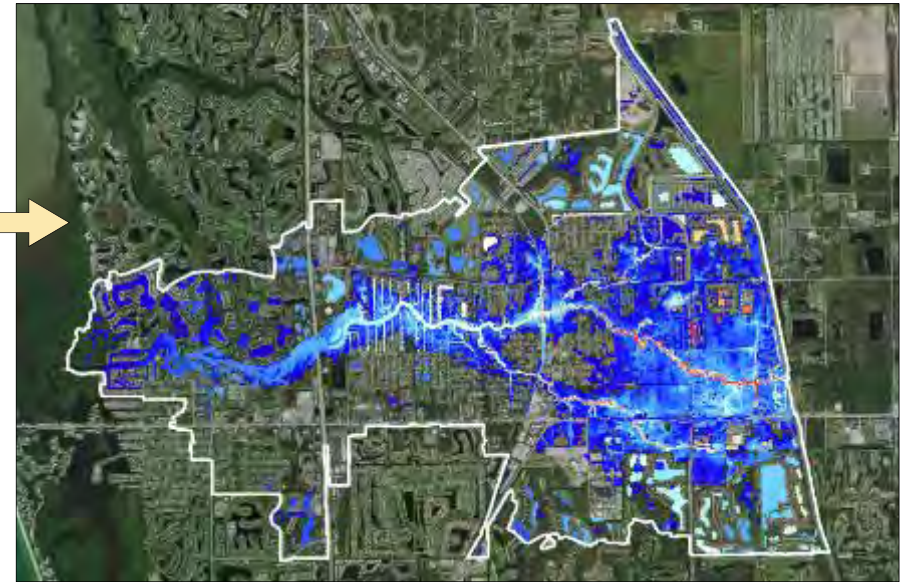
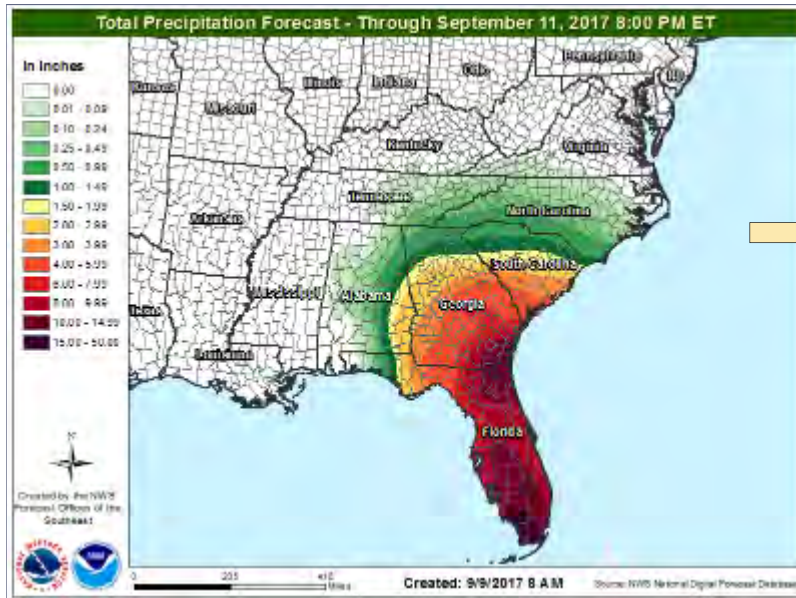


Automated Flood Forecasting System for the Imperial River at Bonita Springs



Florida Stormwater Association
2019 Annual Conference
Sanibel Harbour Resort
Ft. Myers, Florida (June 19 – 21)

Peter J. Singhofen, P.E.
Streamline Technologies, Inc.
psinghofen@icpr4.com

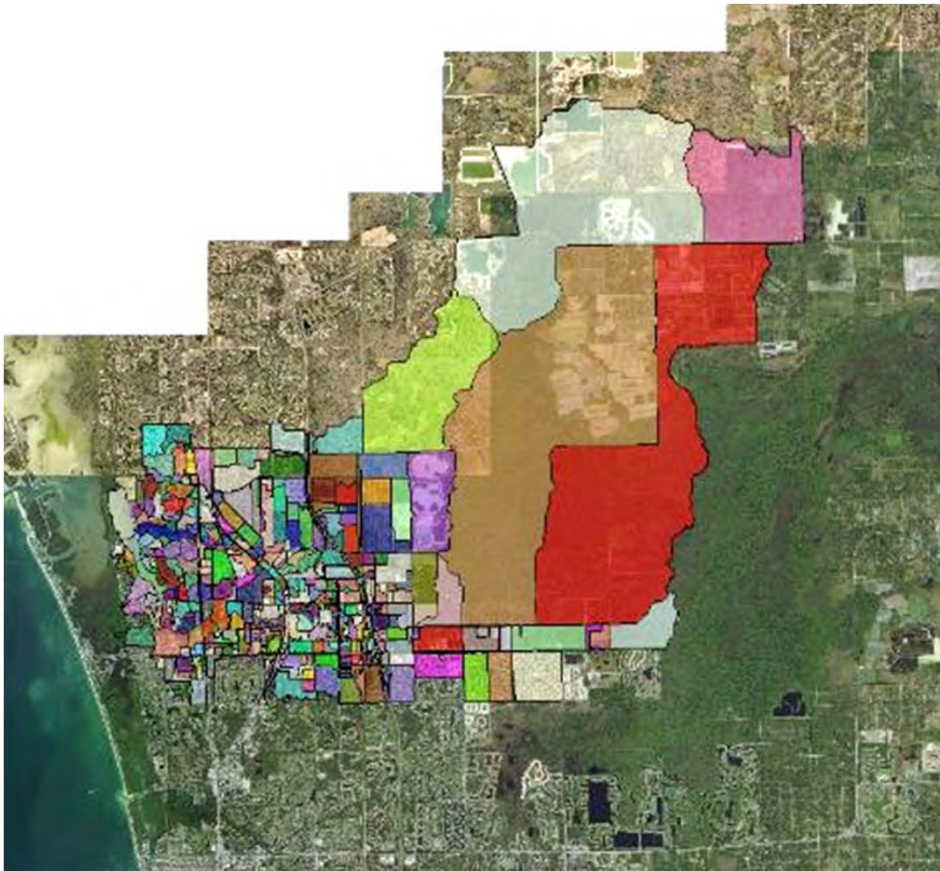
Objectives

- Proof of Concept
 - ✓ ICPR4 as an Automated Flood Forecasting Tool
- Test Case
 - ✓ Imperial River at Bonita Springs
- Goal
 - ✓ Operational for the 2019 hurricane season

Terminology

- Hindcast
 - ✓ what has already happened
 - ✓ model calibration/verification
- Nowcast
 - ✓ what is happening now
 - ✓ initial conditions for forecasts
- Forecast
 - ✓ what will happen in the near future
 - ✓ predict near-future flood conditions

Model Development and Validation

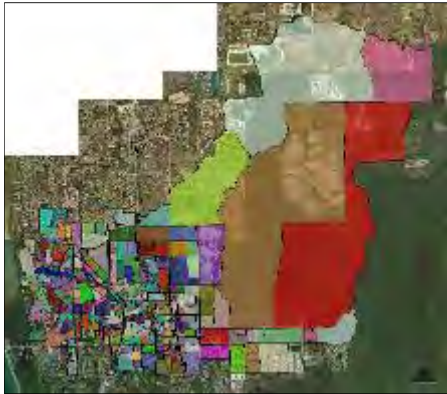


“2010” ICPR3 Bonita Springs Model

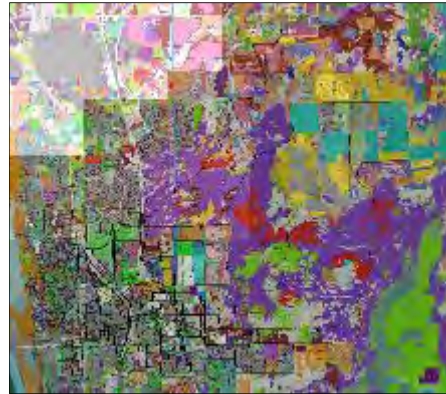
- Migrate to ICPR4
- Replace CN method with physically-based vertically layered soil methodology
- Incorporate ET
- Use gridded rainfall products

Model Development and Validation

BASINS



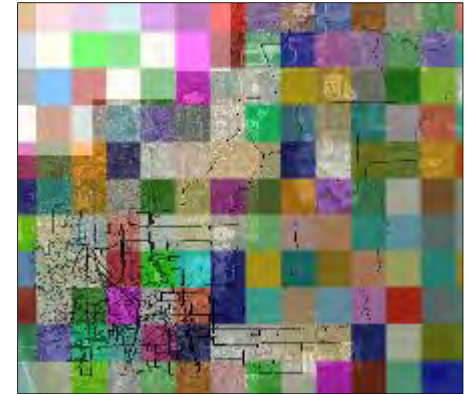
LAND USE (FDEP)



SOILS (NRCS)



NEXRAD (SWFWMD)



Name: B0116

Scenario: VL-NEXRAD

Node: NB0116

Hydrograph Method: NRCS Unit Hydrograph

Infiltration Method: Vertical Layers

Time of Concentration: 45

Max Allowable Q: 999999

Time Shift: 0

Unit Hydrograph: Uh484

Peaking Factor: 484

Comment:

Create Delete

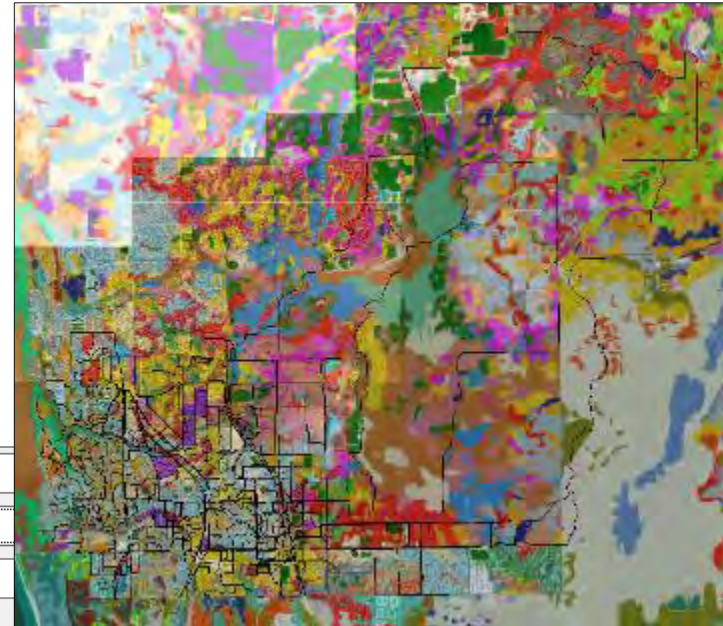
Manual Basin Sub-Basin Edit

Area	Land Cover Zone	Soil Zone	Rainfall Name	Crop Coefficient Zone	Reference ET Station
20.975069	1400: Commerci...	3102857	54860	1400: Commercial an...	54860
1.442195	1400: Commerci...	3102839	54860	1400: Commercial an...	54860
10.182185	1400: Commerci...	3102944	54860	1400: Commercial an...	54860
0.181887	1820: Golf Courses	3102857	54860	1820: Golf Courses	54860
0.217562	6215: Cypress- ...	3102839	54860	6215: Cypress- Dome...	54860
0.146556	6215: Cypress- ...	3102944	54860	6215: Cypress- Dome...	54860
0.001538	6215: Cypress- ...	3102857	54860	6215: Cypress- Dome...	54860
1.401194	6250: Hydric Pin...	3102857	54860	6250: Hydric Pine Flat...	54860
1.201331	6250: Hydric Pin...	3102944	54860	6250: Hydric Pine Flat...	54860
2.526882	6250: Hydric Pin...	3102857	55334	6250: Hydric Pine Flat...	55334
1.034068	6250: Hydric Pin...	3102944	55334	6250: Hydric Pine Flat...	55334
2.147934	1400: Commerci...	3102857	55334	1400: Commercial an...	55334

Model Development and Validation

Parameters for vertical soil layers derived from NRCS SSURGO Data

SOILS (by "MUKEY")



"Soil Zone" = "MUKEY"

Soil Zone: 3102852

Allow Recharge: Groundwater Only

WT Initial: 1.5

Create Delete

Vertical Layers Layer Grid

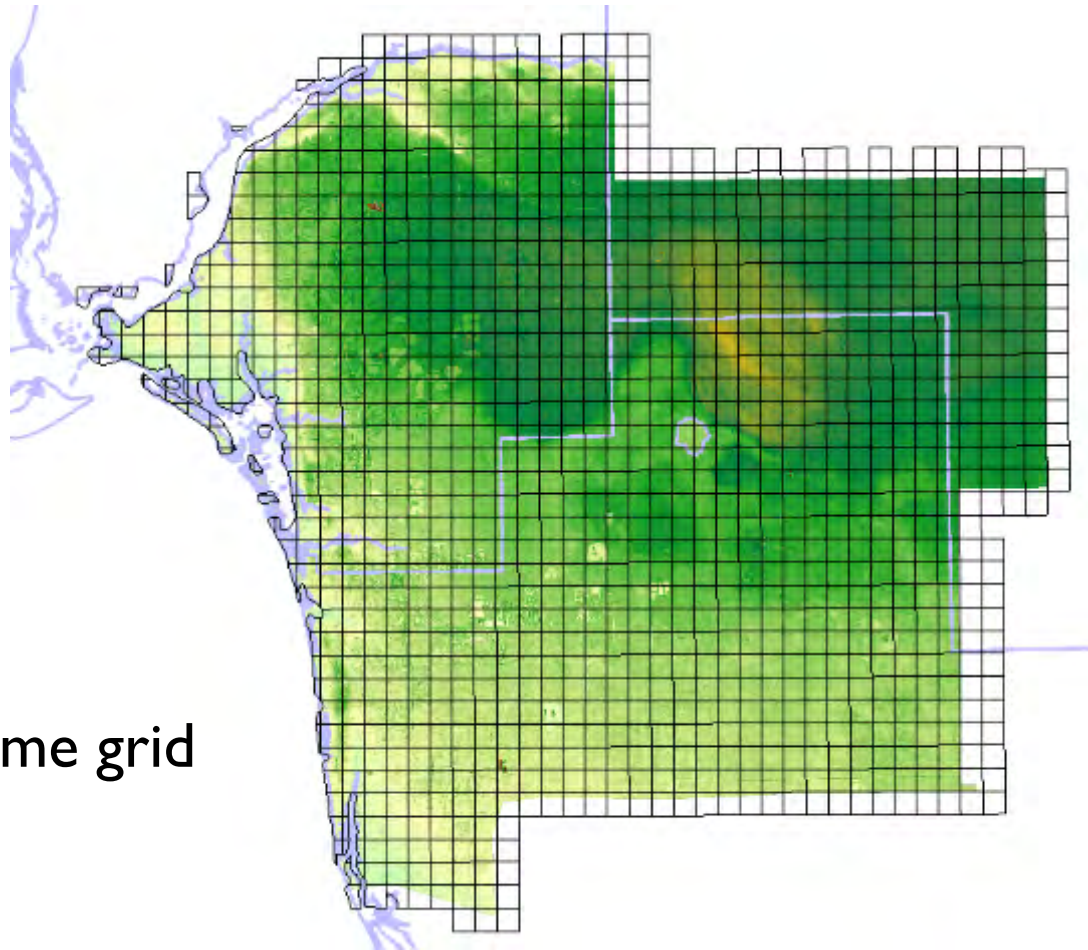
Layer ...	Kv Saturated	MC Saturated	MC Residual	MC Initial	MC Field	MC Wilting	Pore Size Index	Bubble Pressure	Layer Thickness	# of Cells per Layer
0	13.00252	0.382528	0.019	0.105	0.105	0.038	0.603237	1.765732	0.590551	1
1	13.00252	0.375509	0.004	0.052	0.052	0.008	0.616939	1.844711	1.410761	2
2	4.001103	0.31234	0.057	0.208	0.208	0.114	0.394572	8.017484	0.984252	1
3	13.00252	0.354453	0.0205	0.108	0.108	0.041	0.55644	2.006039	3.674541	4

Vertical Layers Soil Parameters by "MUKEY"

Model Development and Validation

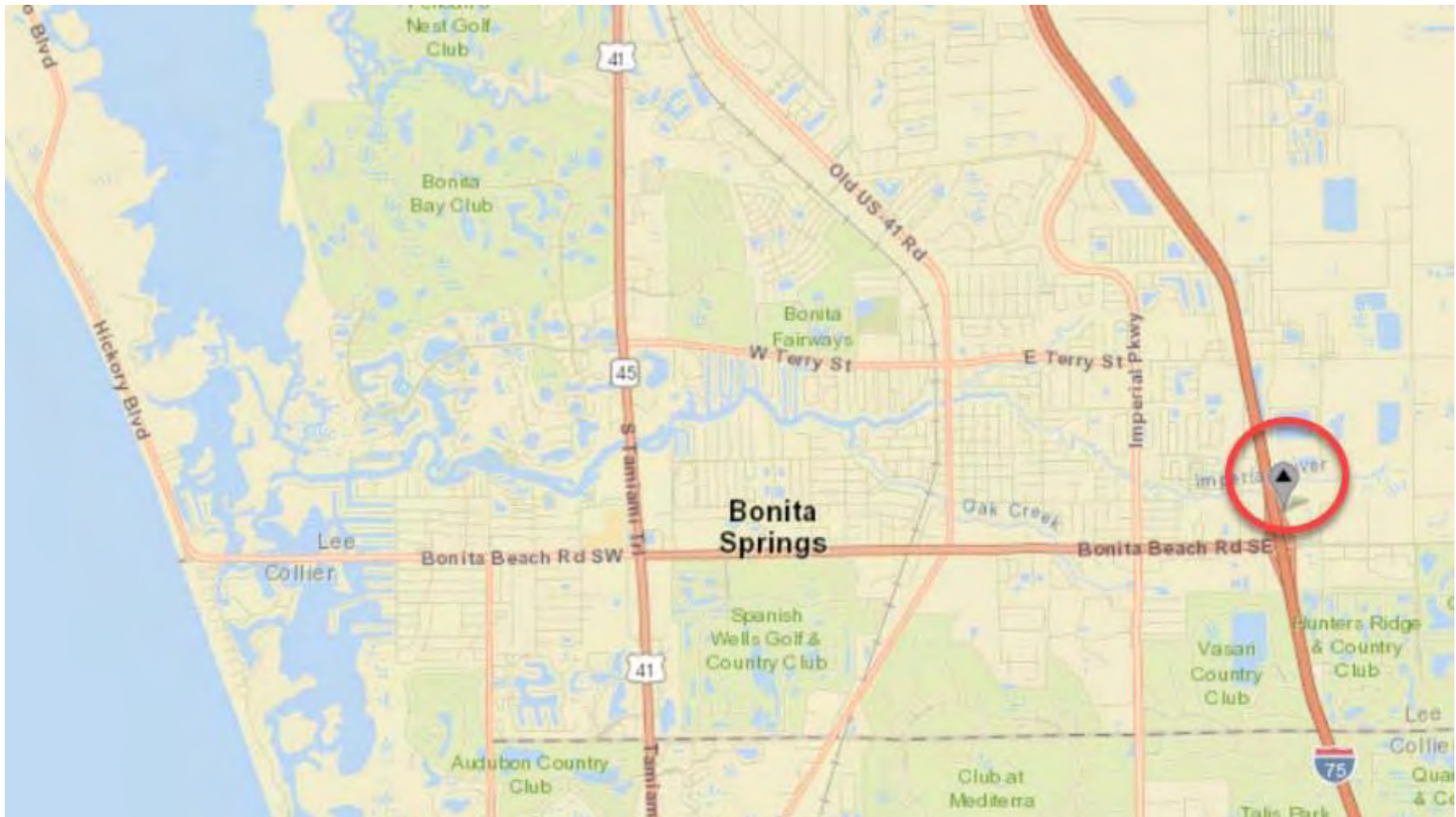
NEXRAD Rainfall Data

- 2-km grid
- 15-min incs
- 1995 to present
- USGS daily ET on same grid
- *hindcast*



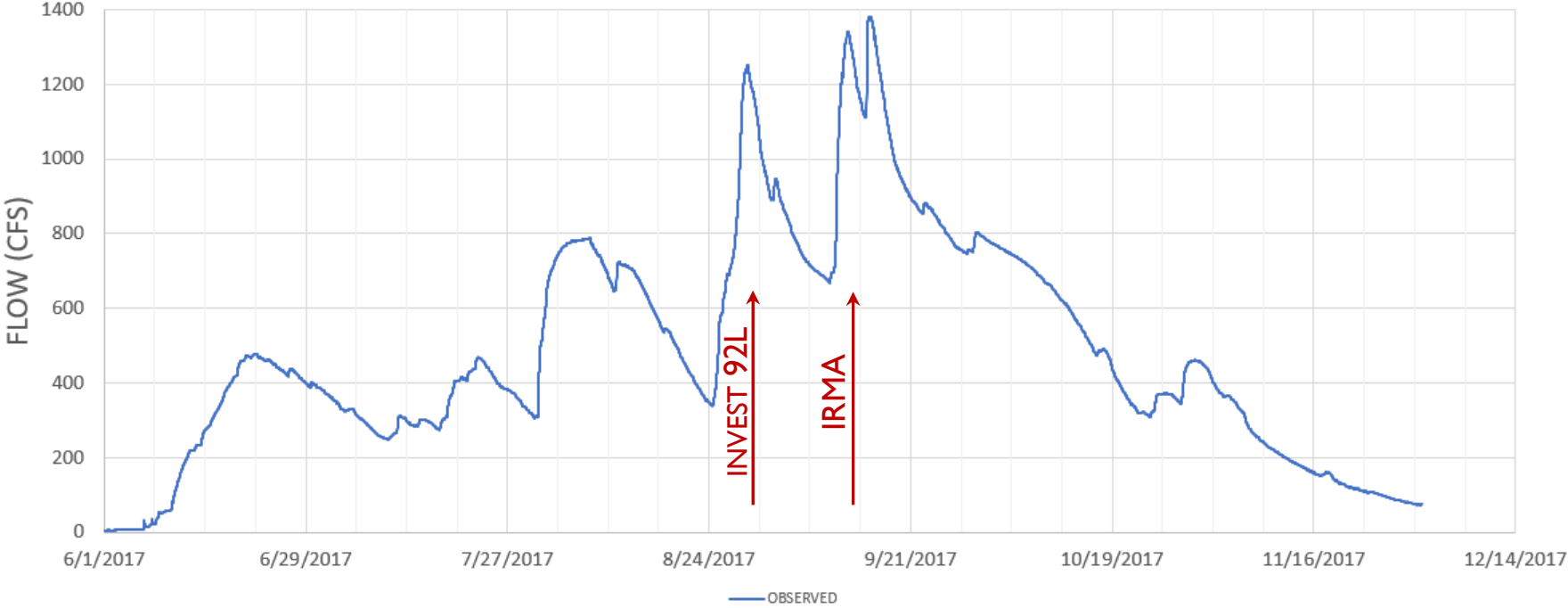
Model Development and Validation

USGS GAGE 02291500 - Imperial River Near Bonita Springs, Florida



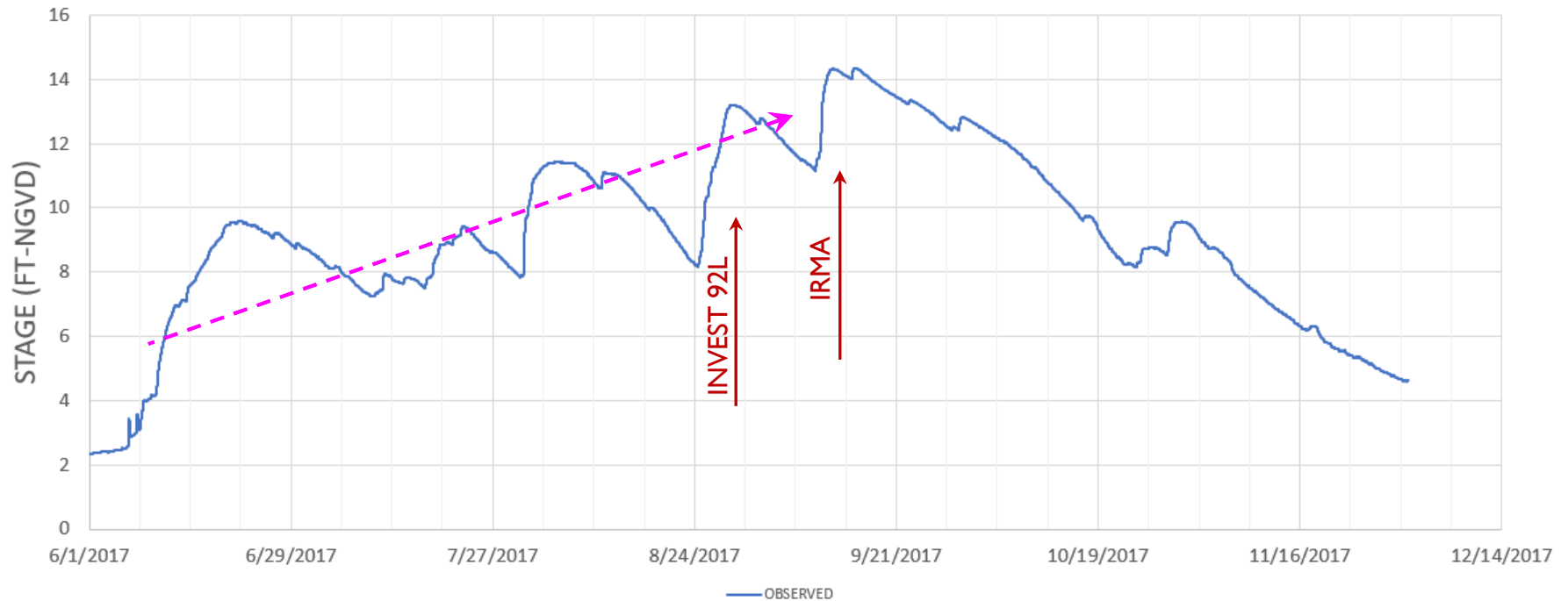
Model Development and Validation

USGS GAGE 02291500 - Imperial River Near Bonita Springs, Florida



Model Development and Validation

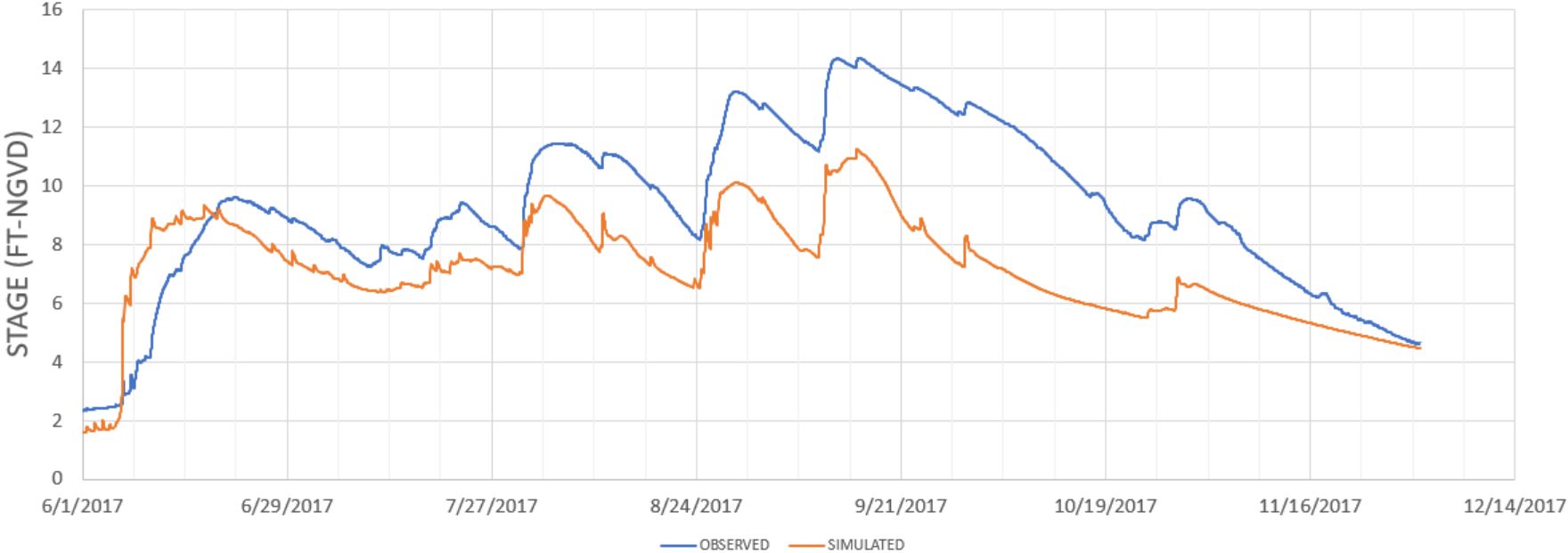
USGS GAGE 02291500 - Imperial River Near Bonita Springs, Florida



- Aggregating Antecedent Conditions -
continuous simulation beginning June 1st is important

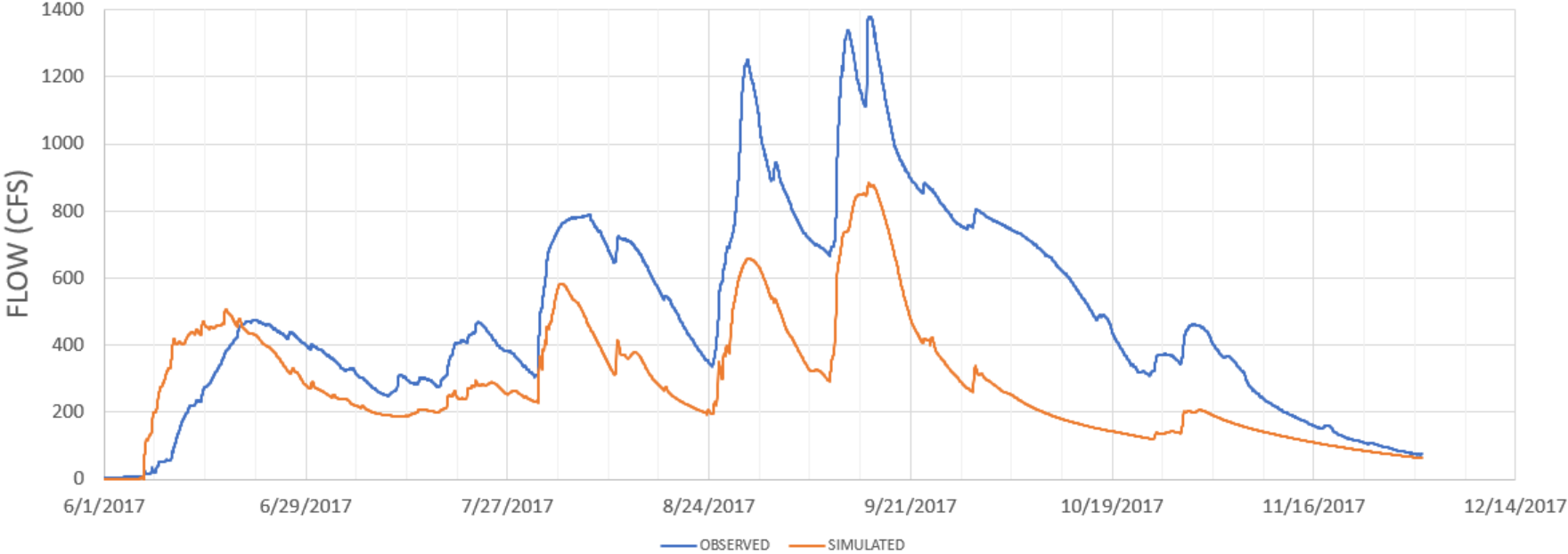
Model Development and Validation

STAGE COMPARISON AT USGS GAGE 02291500
- Original Model Extents -



Model Development and Validation

FLOW COMPARISON AT USGS GAGE 02291500
- Original Model Extents -



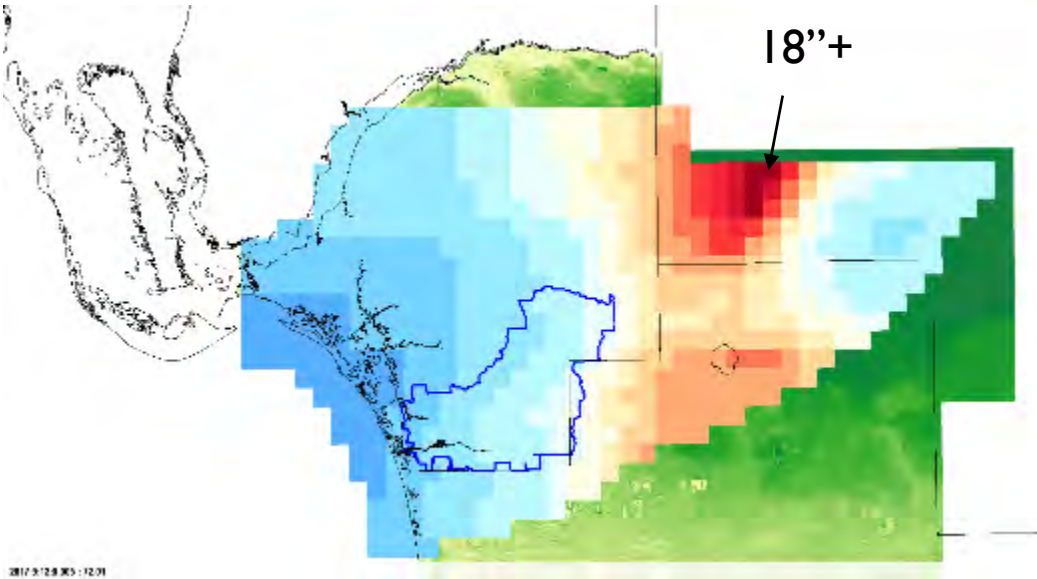
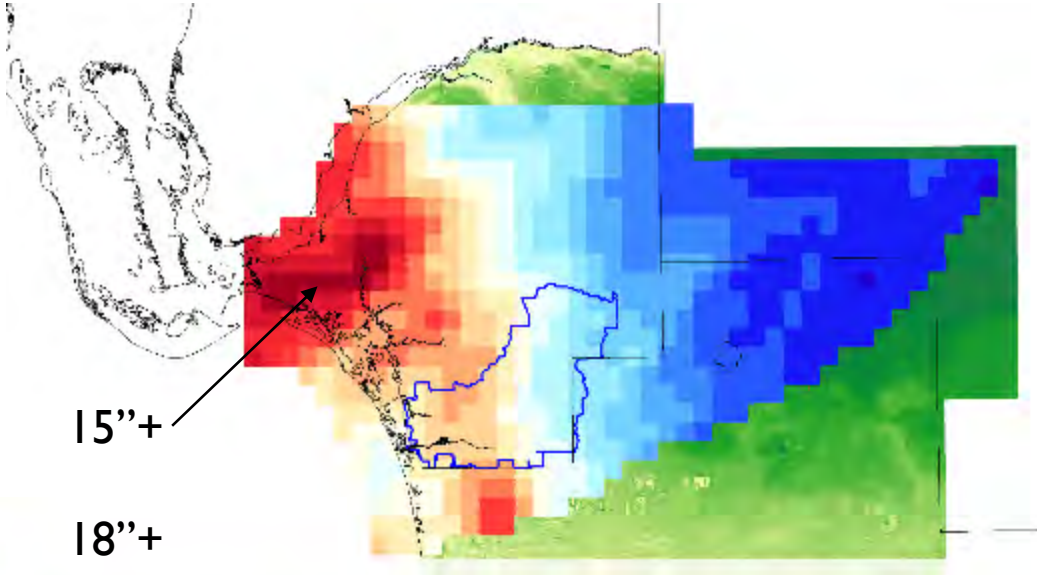
Model Development and Validation

VOLUME COMPARISON AT USGS GAGE 02291500
- Original Model Extents -



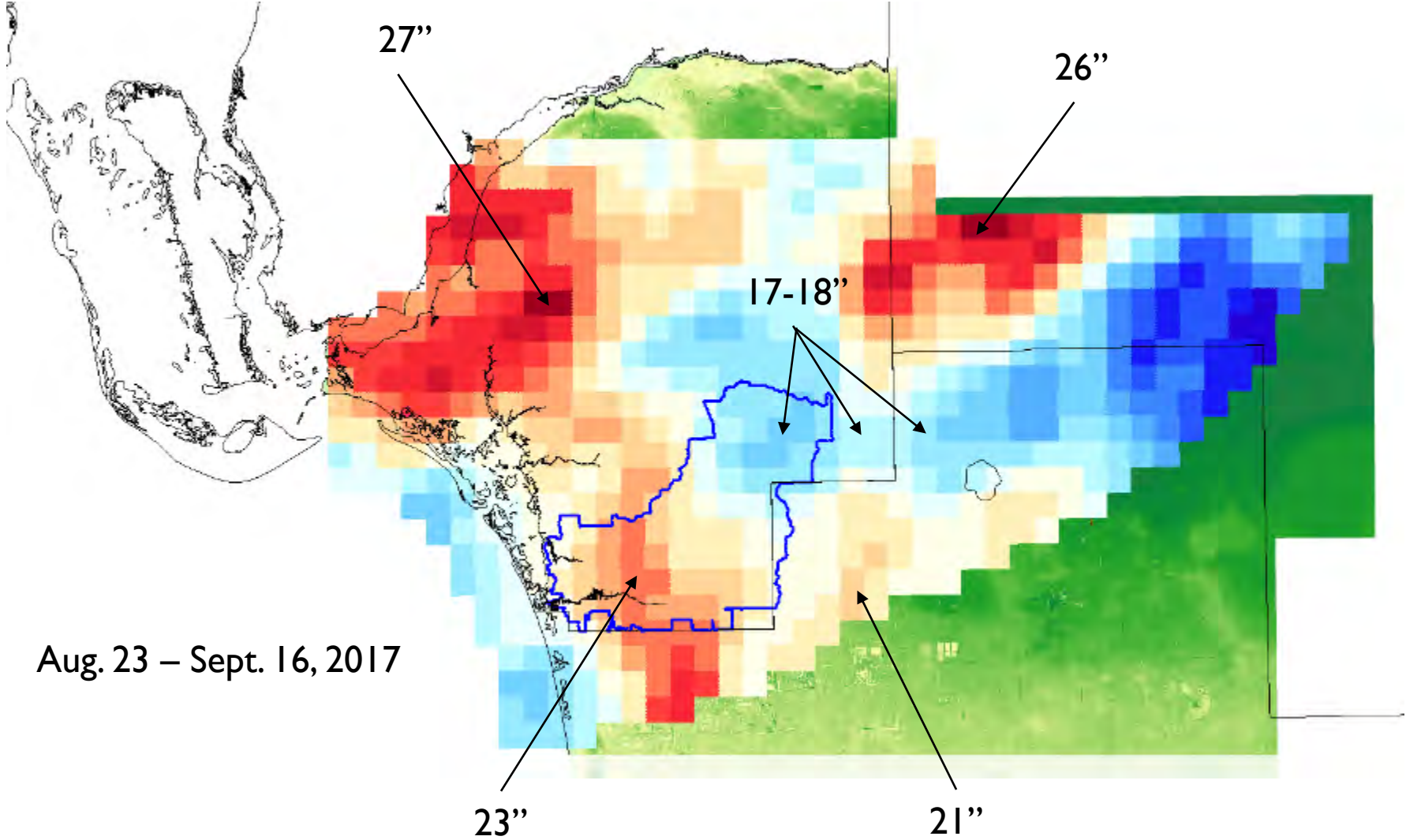
Model Development and Validation

INVEST 92L
August 25-27, 2017

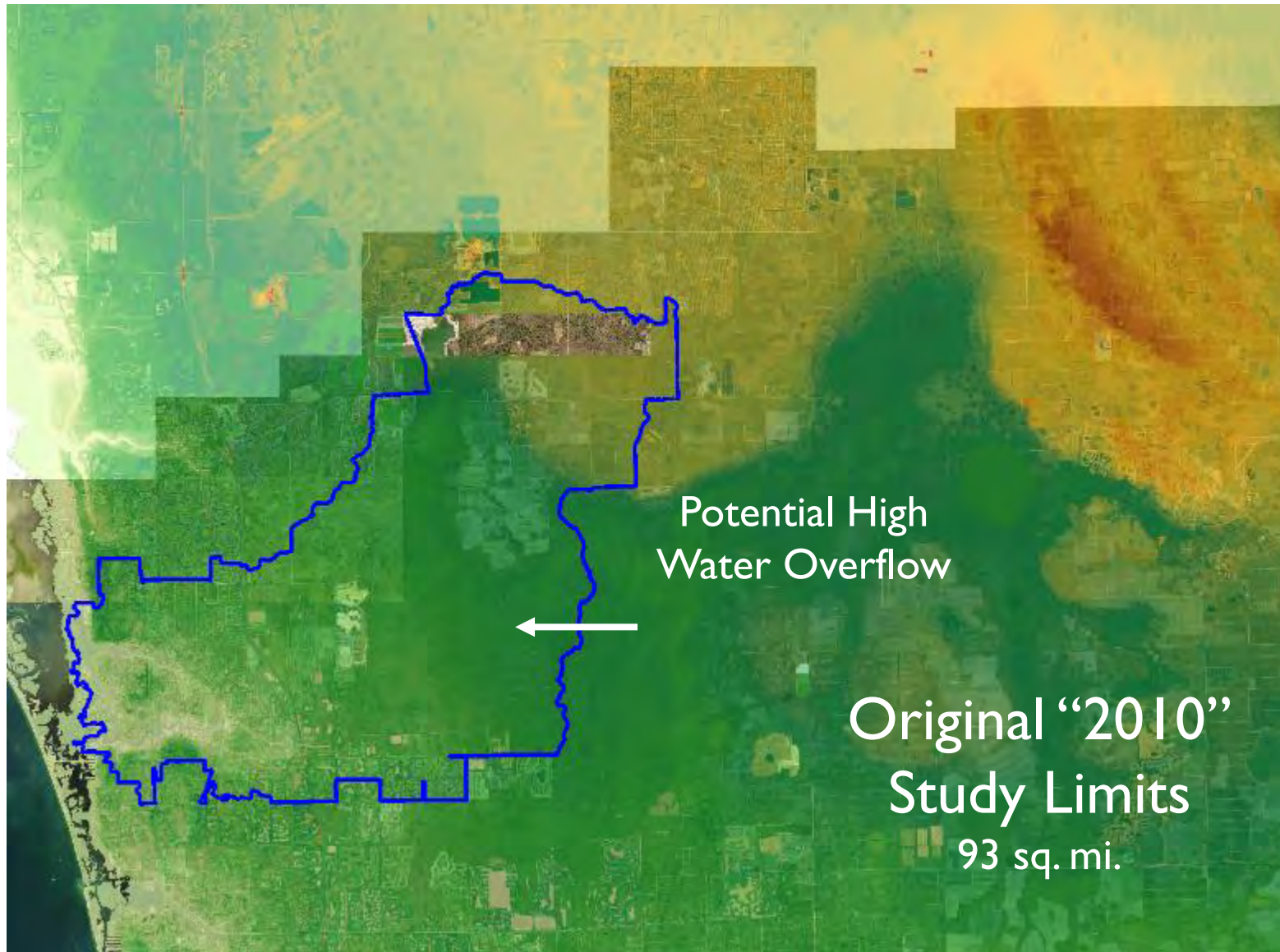


IRMA
September 9-11, 2017

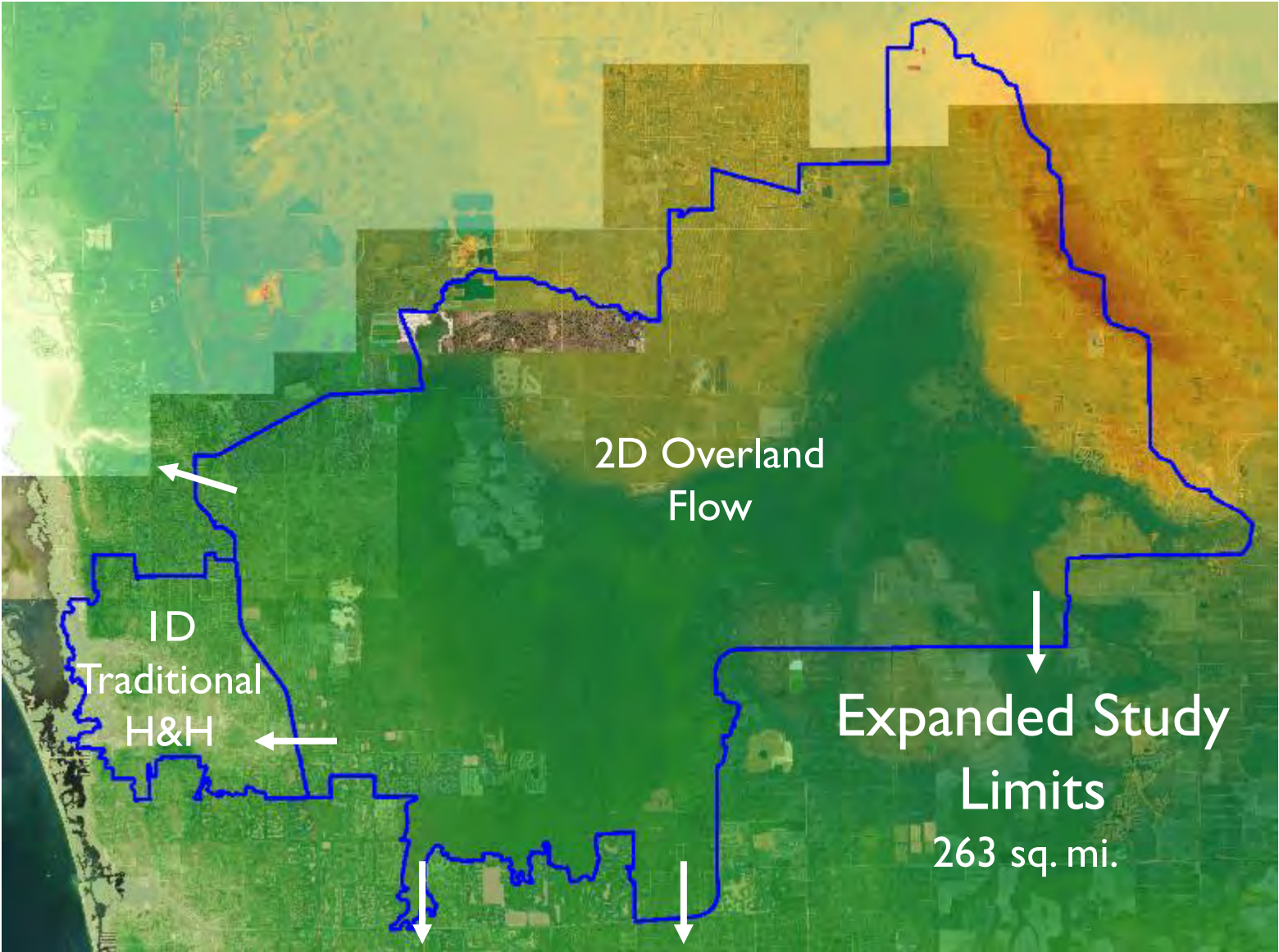
Model Development and Validation



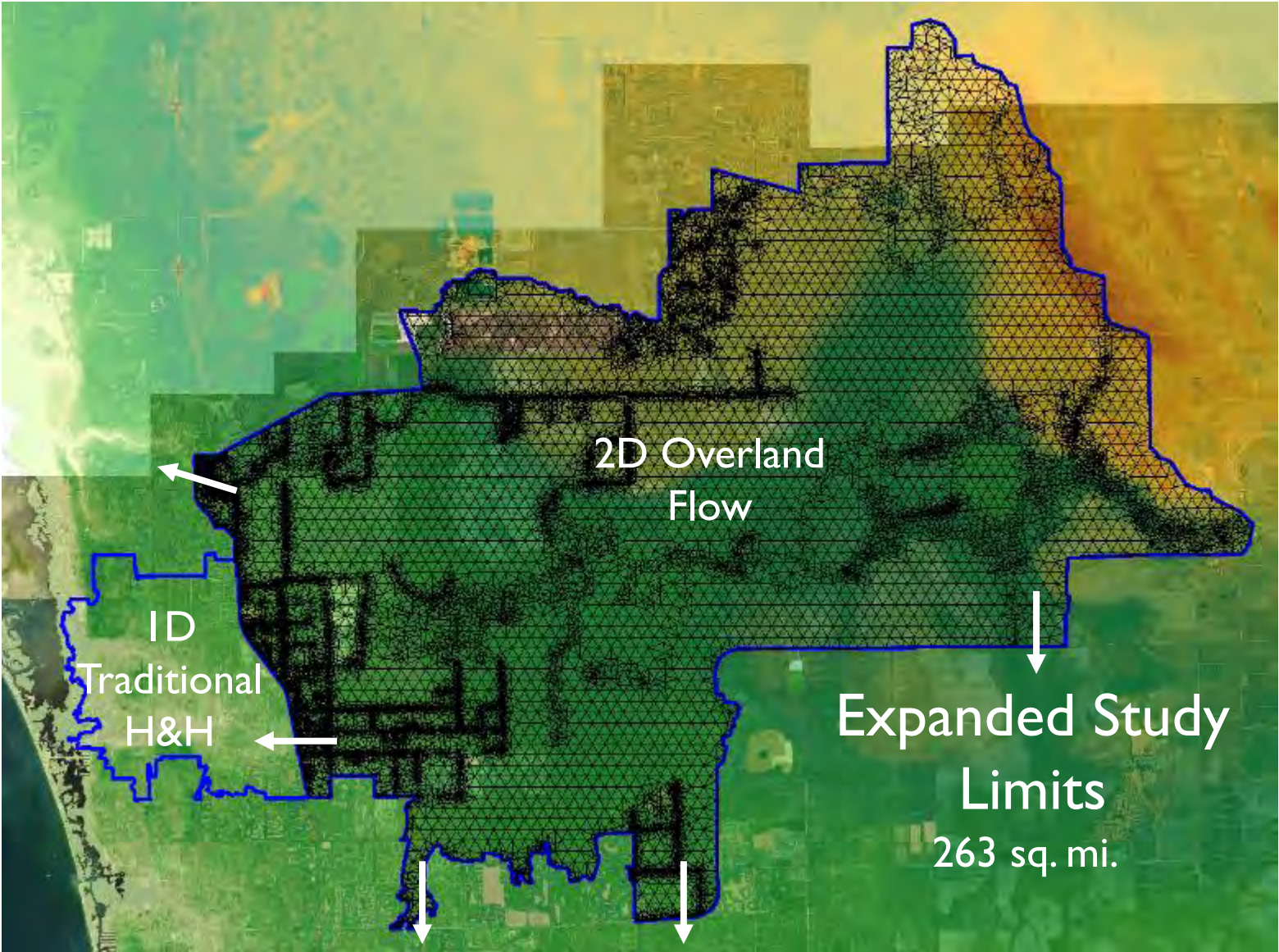
Model Development and Validation



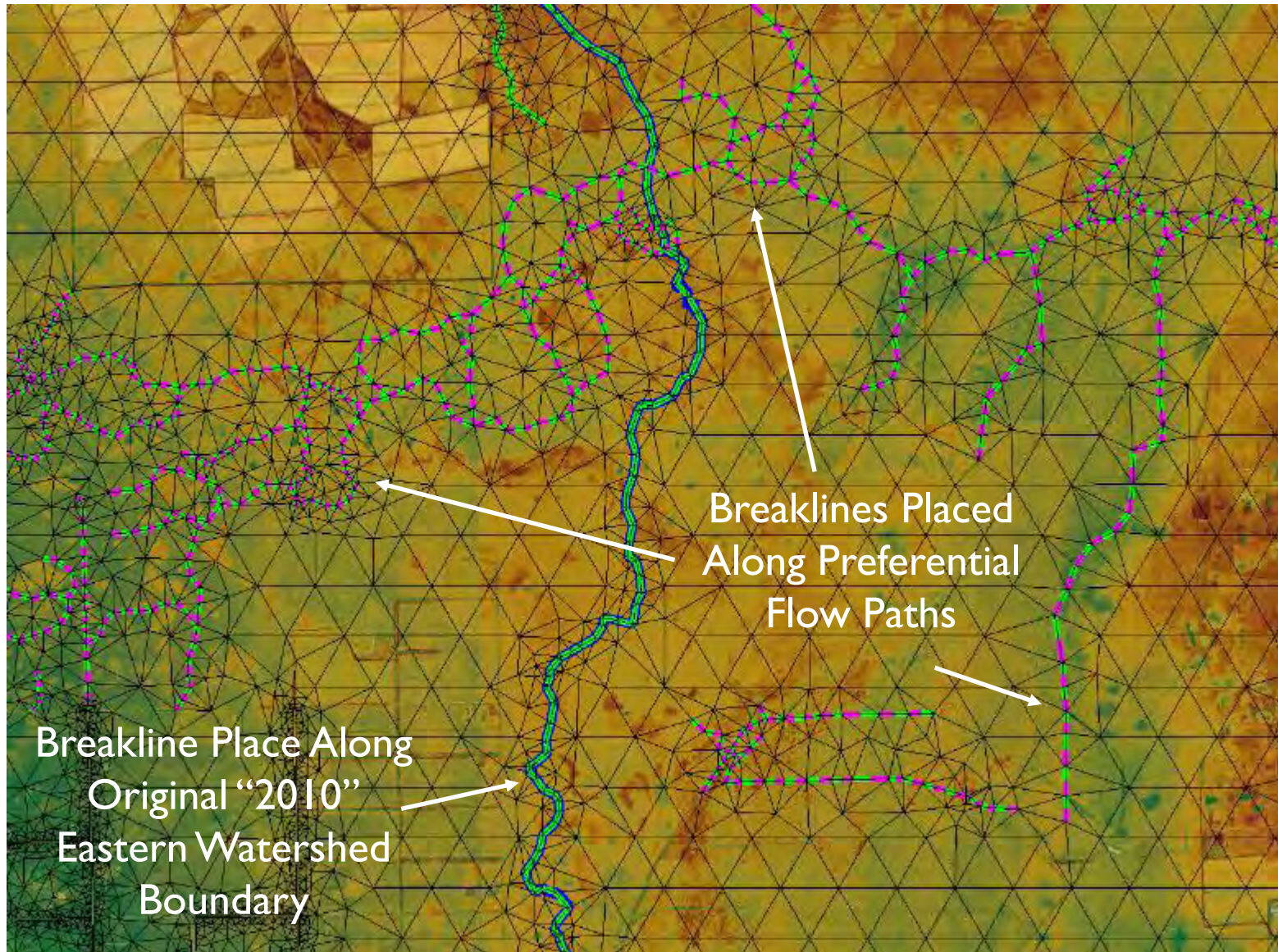
Model Development and Validation



Model Development and Validation

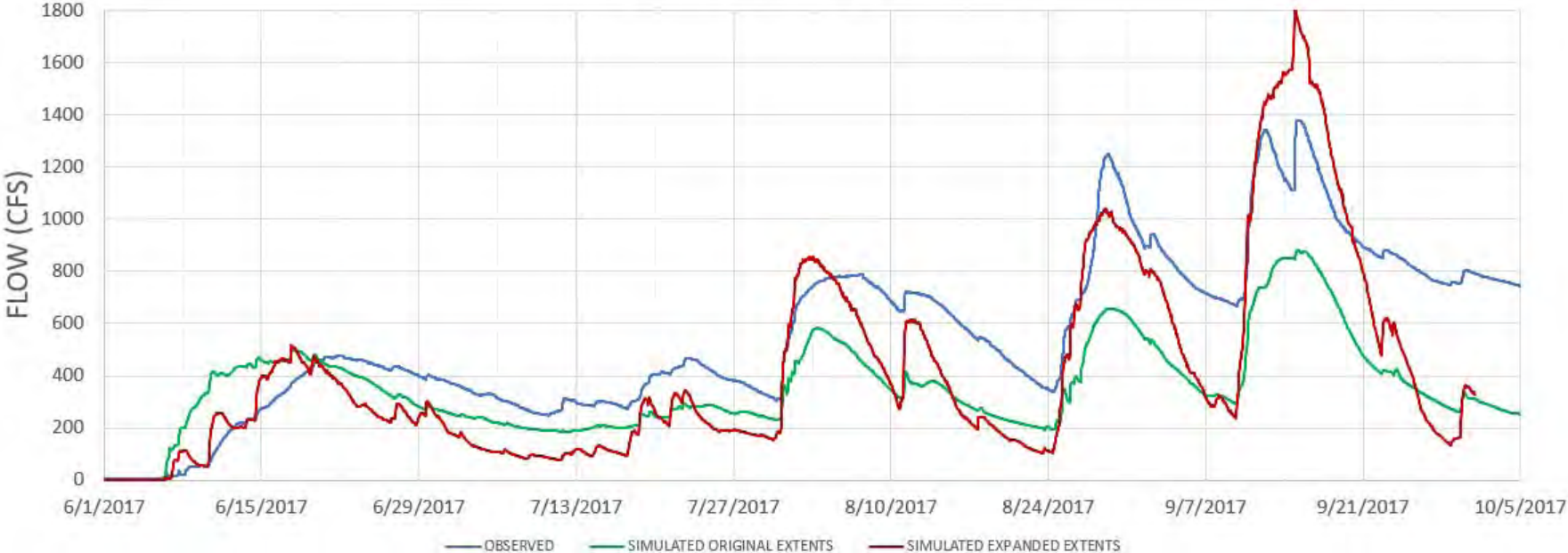


Model Development and Validation



Model Development and Validation

FLOW COMPARISON AT USGS GAGE 02291500
- Expanded Study Limits -



Model Development and Validation

STAGE COMPARISON AT USGS GAGE 02291500
- Expanded Study Limits -

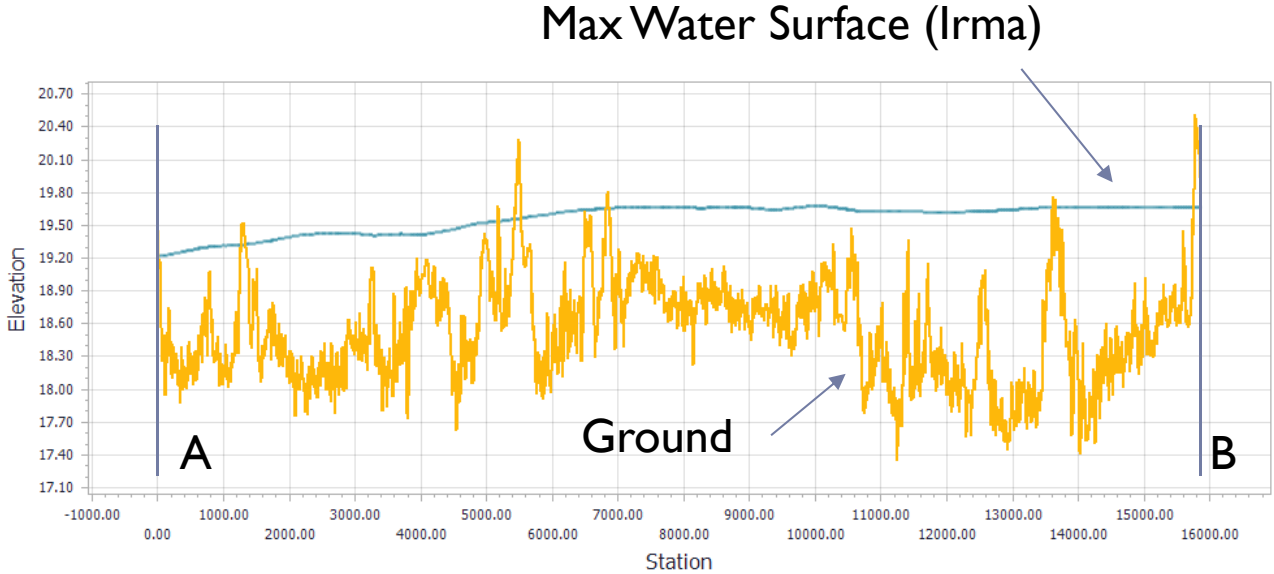
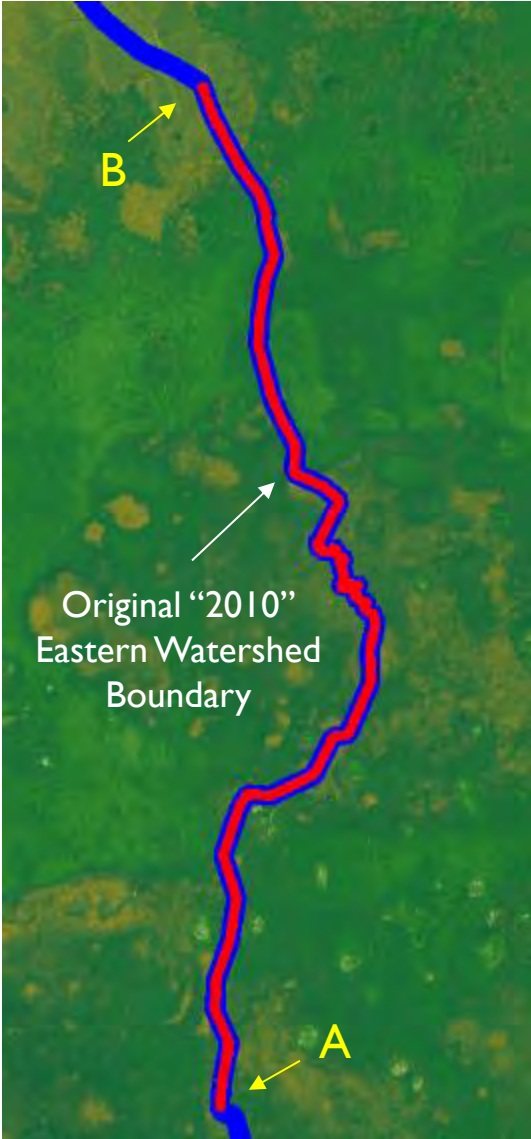


Model Development and Validation

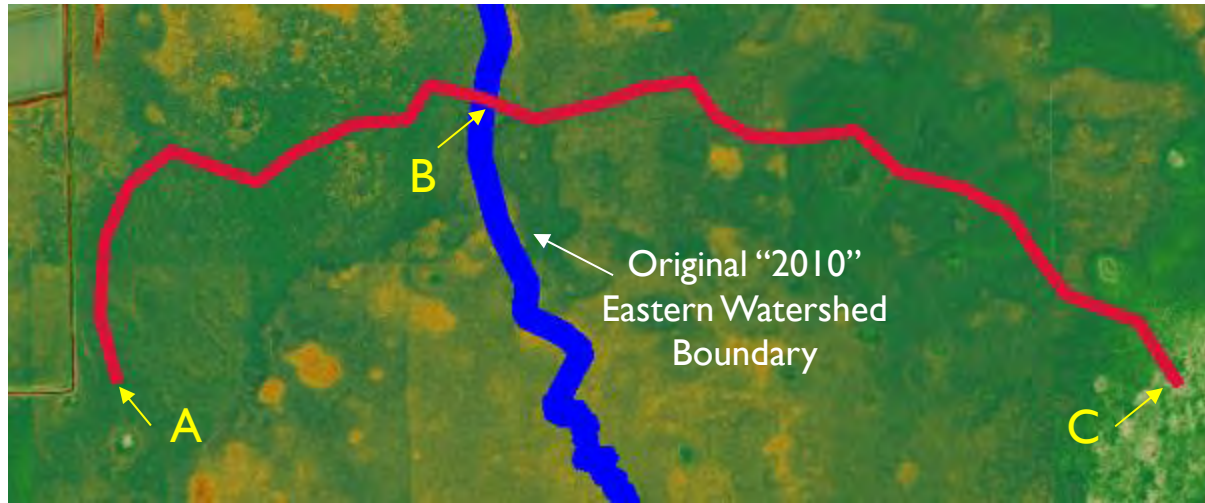
STAGE COMPARISON AT USGS GAGE 02291500
- Expanded Study Limits, Incorporate Groundwater -



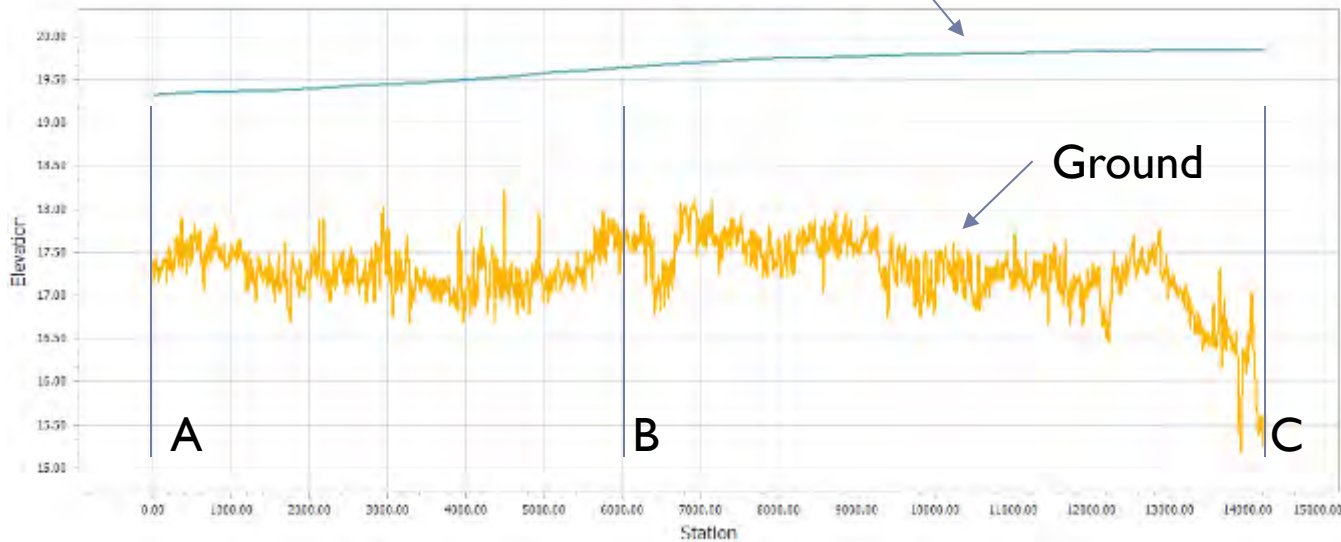
Model Development and Validation



Model Development and Validation

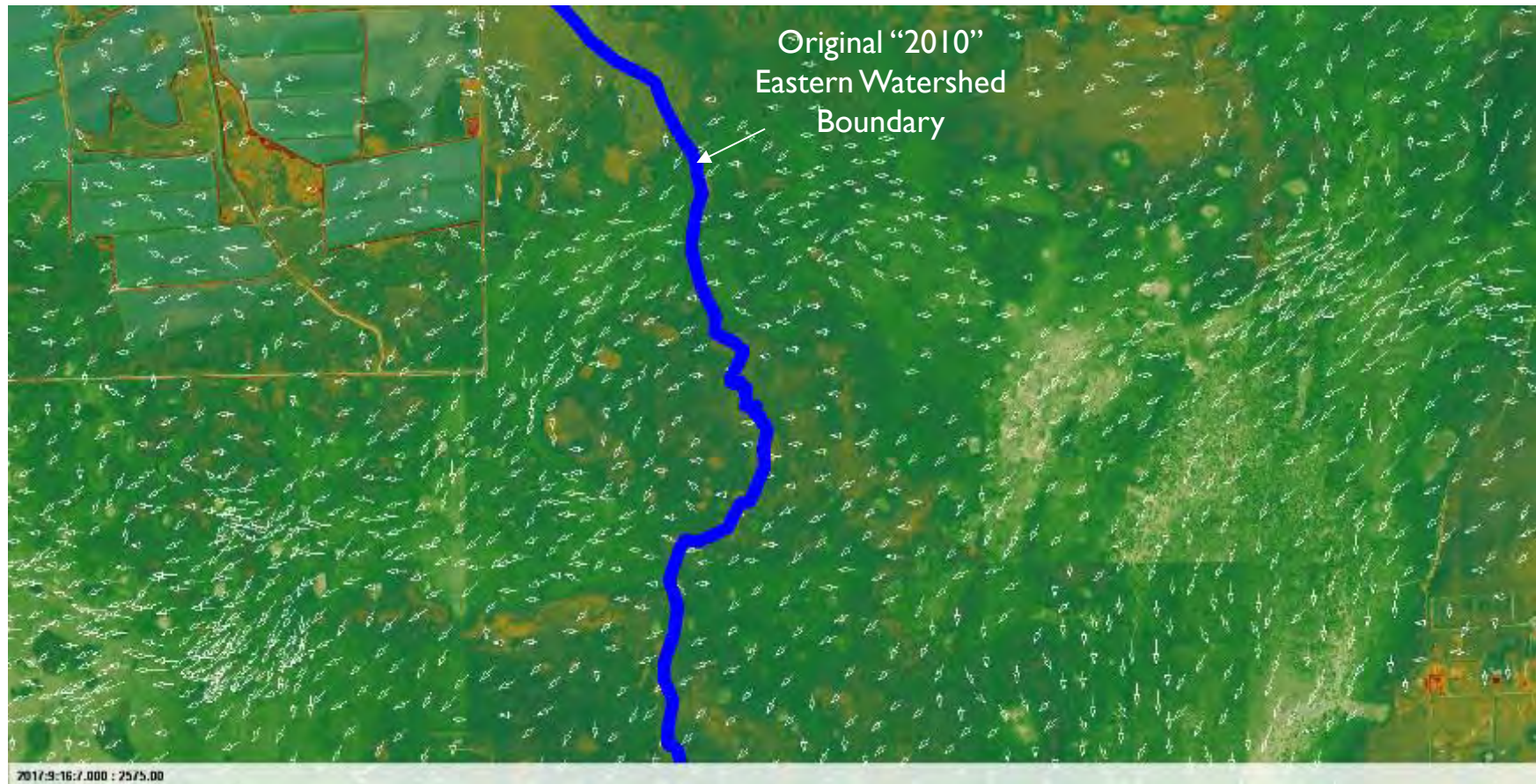


Max Water Surface (Irma)



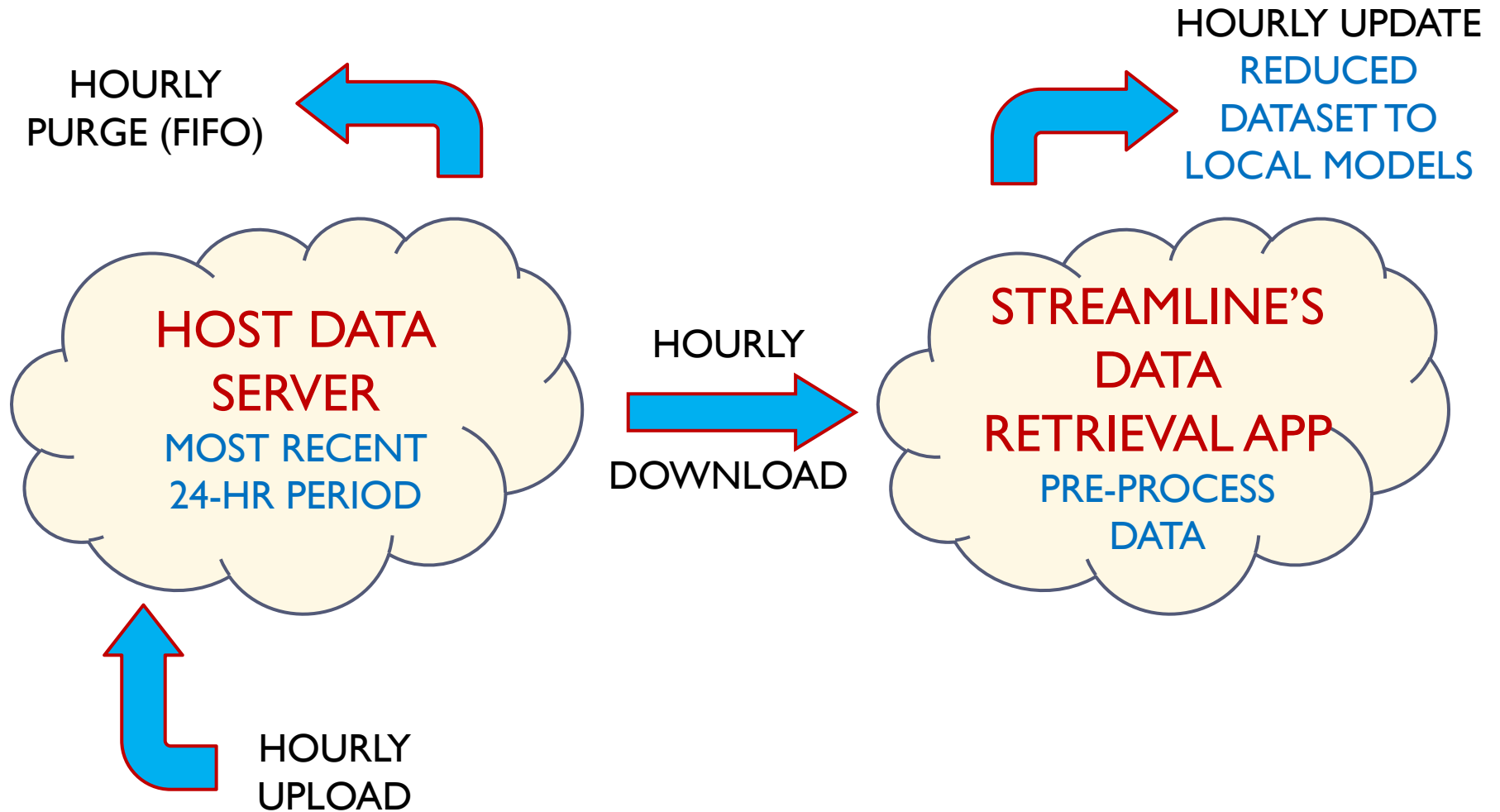
Model Development and Validation

Velocity Vectors 5 Days After Hurricane Irma (Sept. 16, 2017)



Automated Nowcast/Forecast System

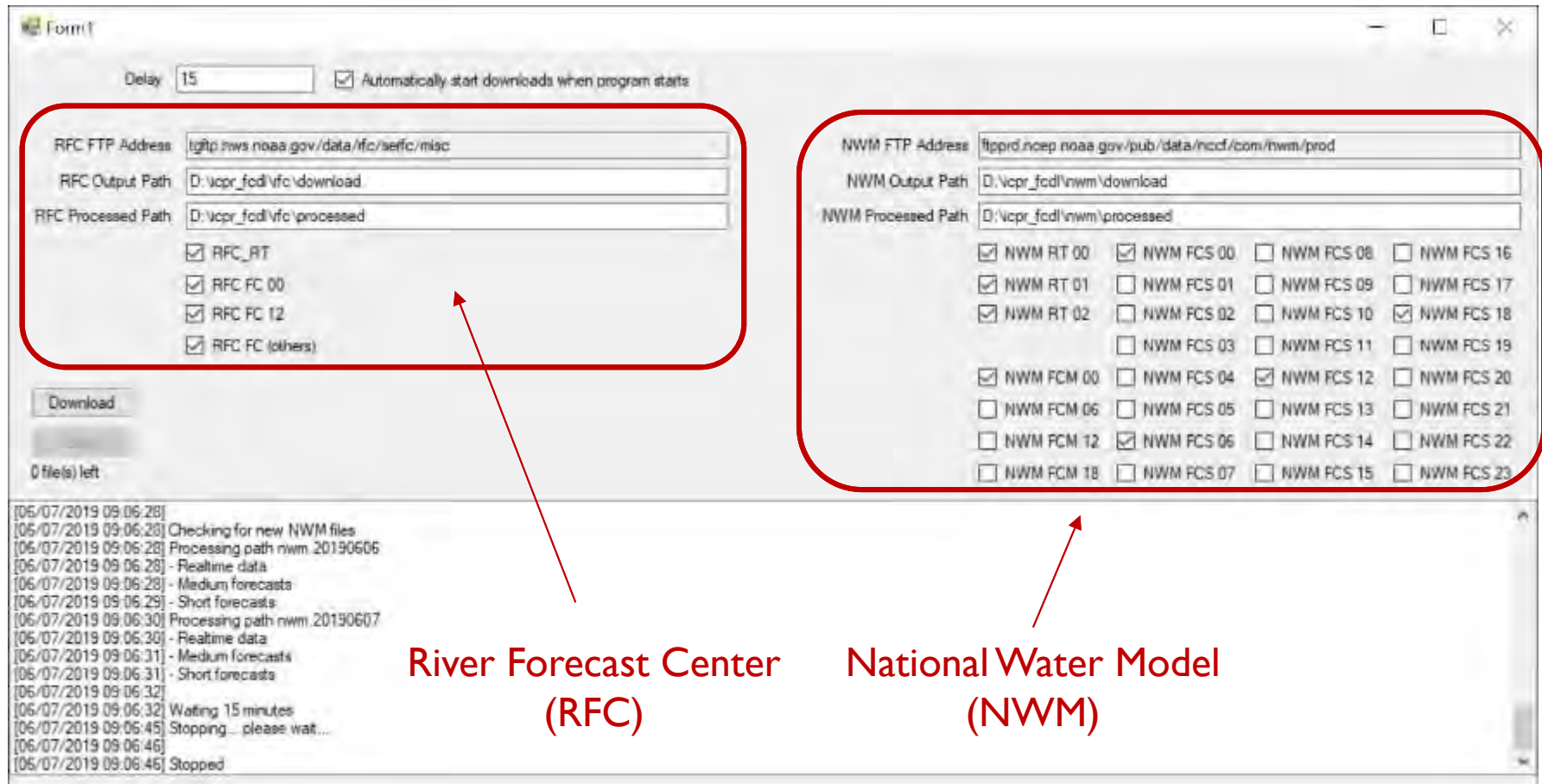
How Does it Work?



Automated Nowcast/Forecast System

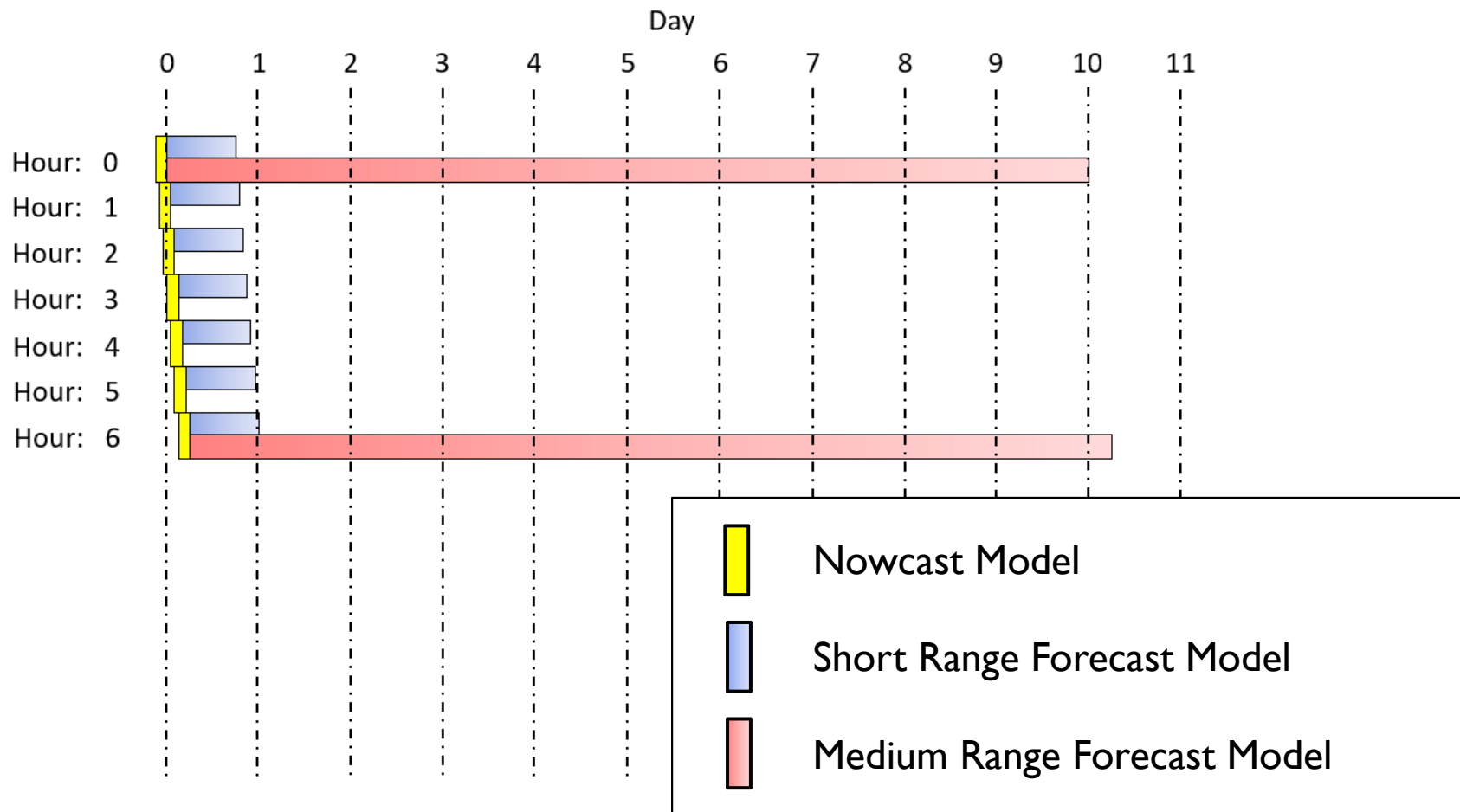
How Does it Work?

Streamline's Data Retrieval App



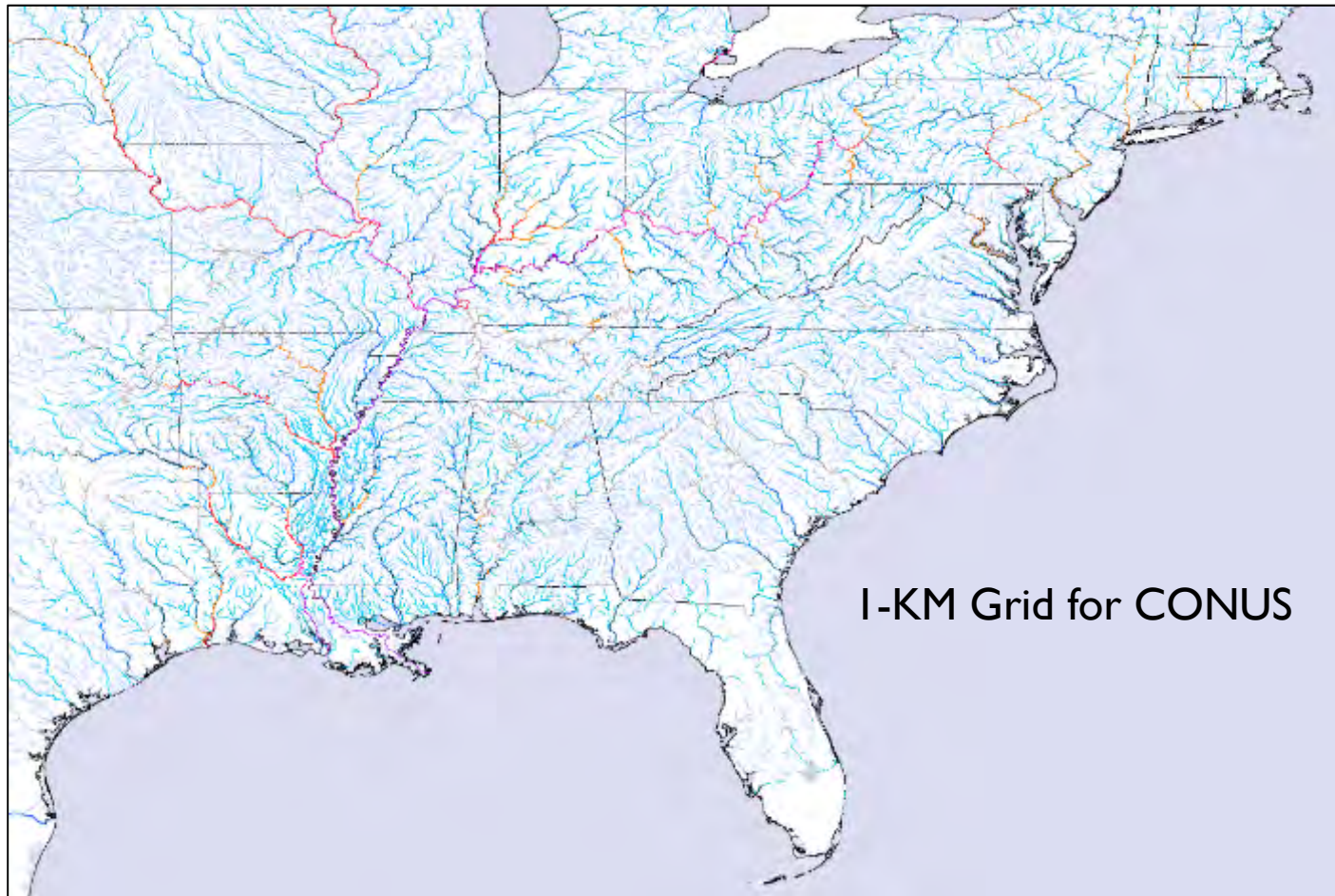
Automated Nowcast/Forecast System

How Does it Work?



Automated Nowcast/Forecast System

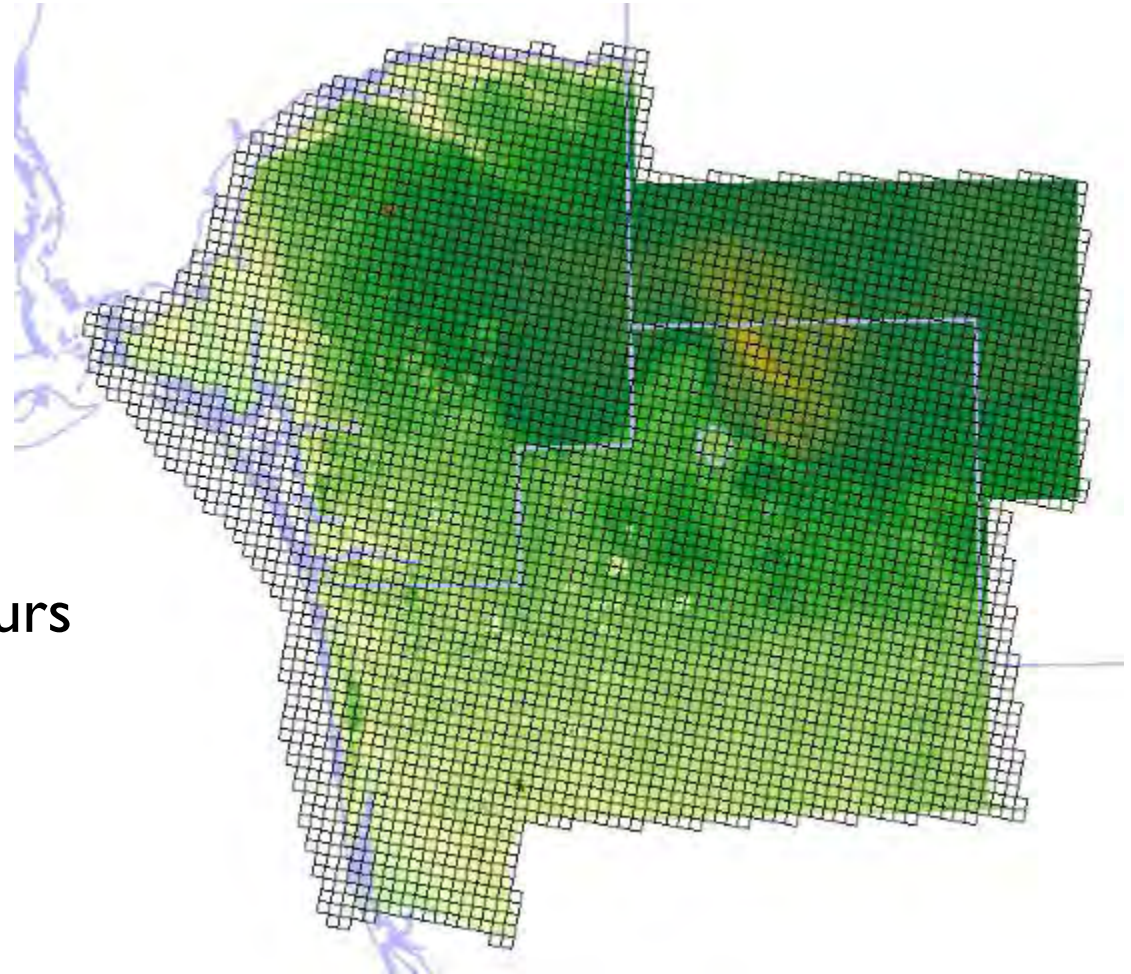
The National Water Model (NWM)



Automated Nowcast/Forecast System

The National Water Model (NWM)

- 1-km grid
- 1-hr incs
- most recent 24 hours
- ET parameters
- *nowcast/forecast*



Automated Nowcast/Forecast System

The National Water Model (NWM)

Gridded Forcing Data Products (Rainfall/ET)

Near Real Time (72 files per day)

Present Time Minus 1&2 Hours (Radar Only)

Present Time Minus 3 Hours (Gage Adjusted)

Short Range Forecast (432 files per day)

Forecast Duration: 18 hours in 1-hour Increments

Forecast Frequency: Every hour

Medium Range Forecast (960 files per day)

Forecast Duration: 10 days in 1-hour Increments

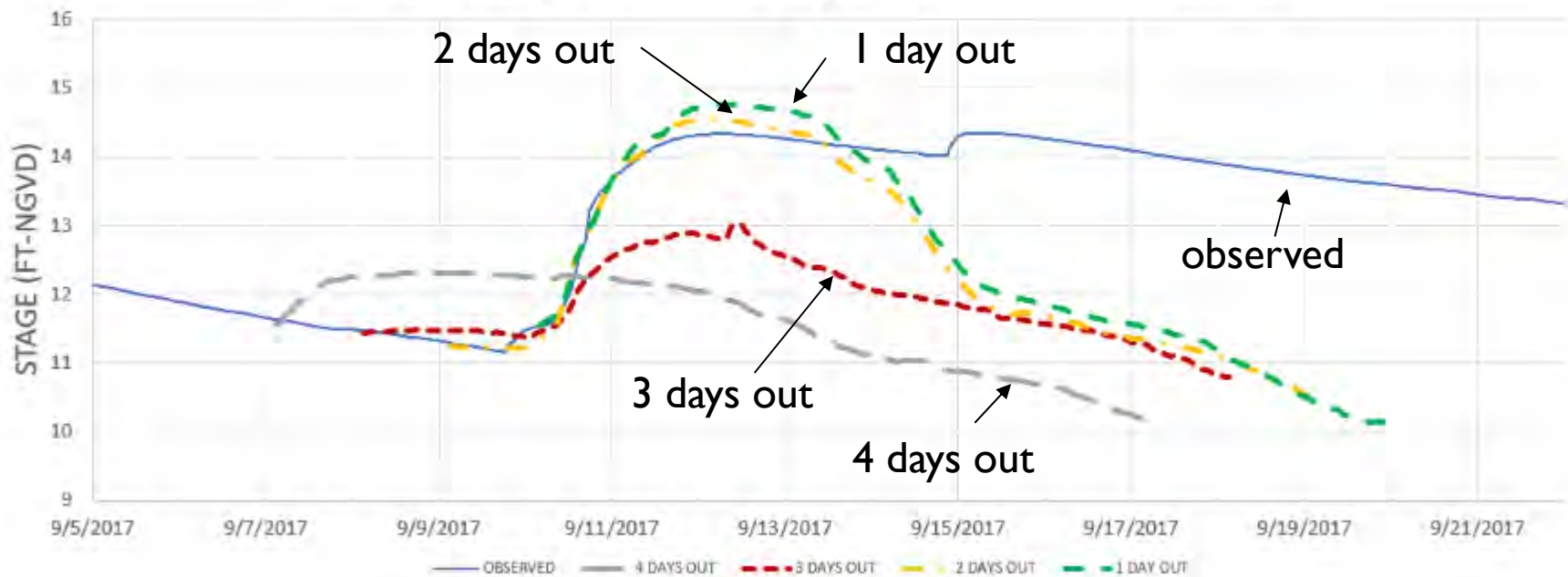
Forecast Frequency: Every 6 hours

1,464 files per day (~250GB)!

Automated Nowcast/Forecast System

The National Water Model (NWM)

STAGE COMPARISON AT USGS GAGE 02291500
- Medium Range Forecasts, Adjusted for Initial Conditions -

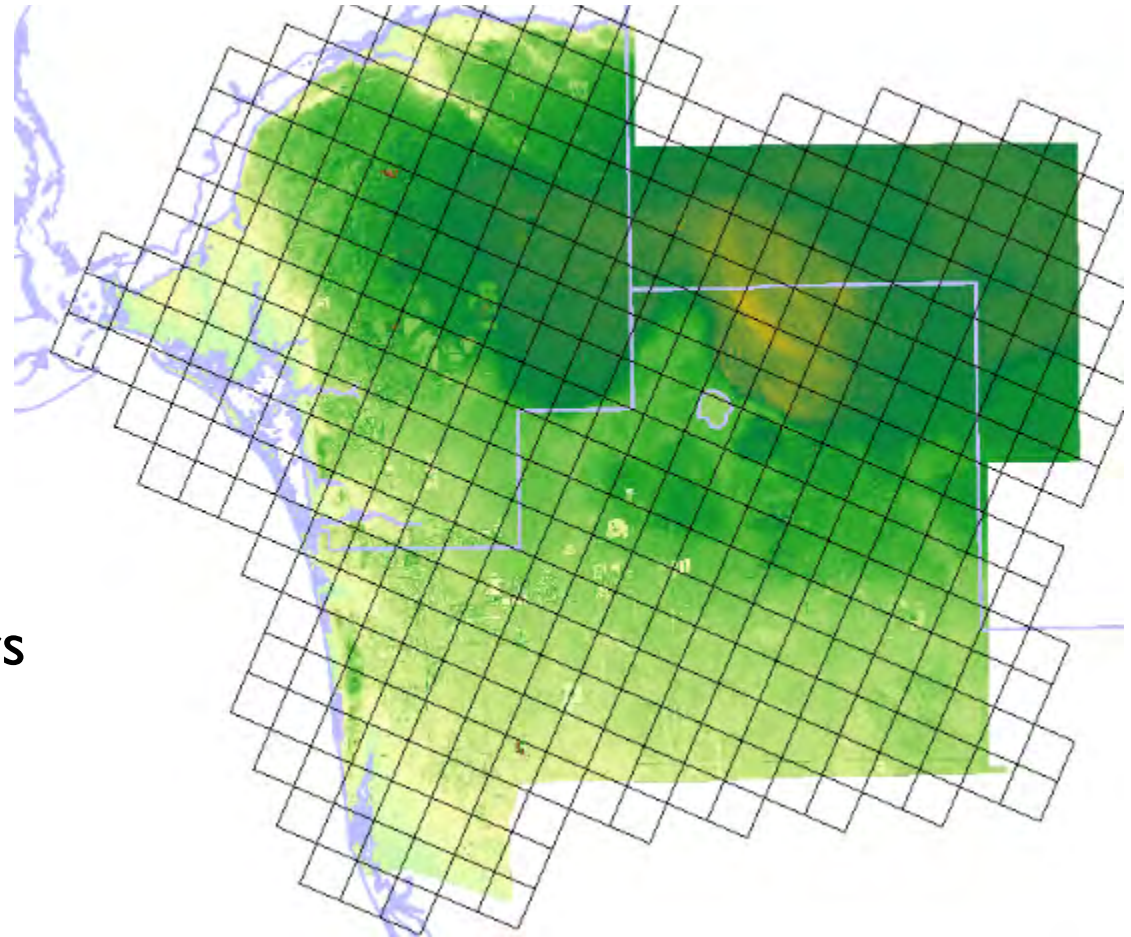


The entire data set for the 2017 rainy season was not available, therefore initial stages and soil moisture conditions were estimated.

Automated Nowcast/Forecast System

The National Weather Service

Southeast River Forecast System (SERFC)



- 4-km grid
- 1-hr incs
- most recent 24 hours
- no ET
- *nowcast/forecast*

Automated Nowcast/Forecast System

Practical Considerations

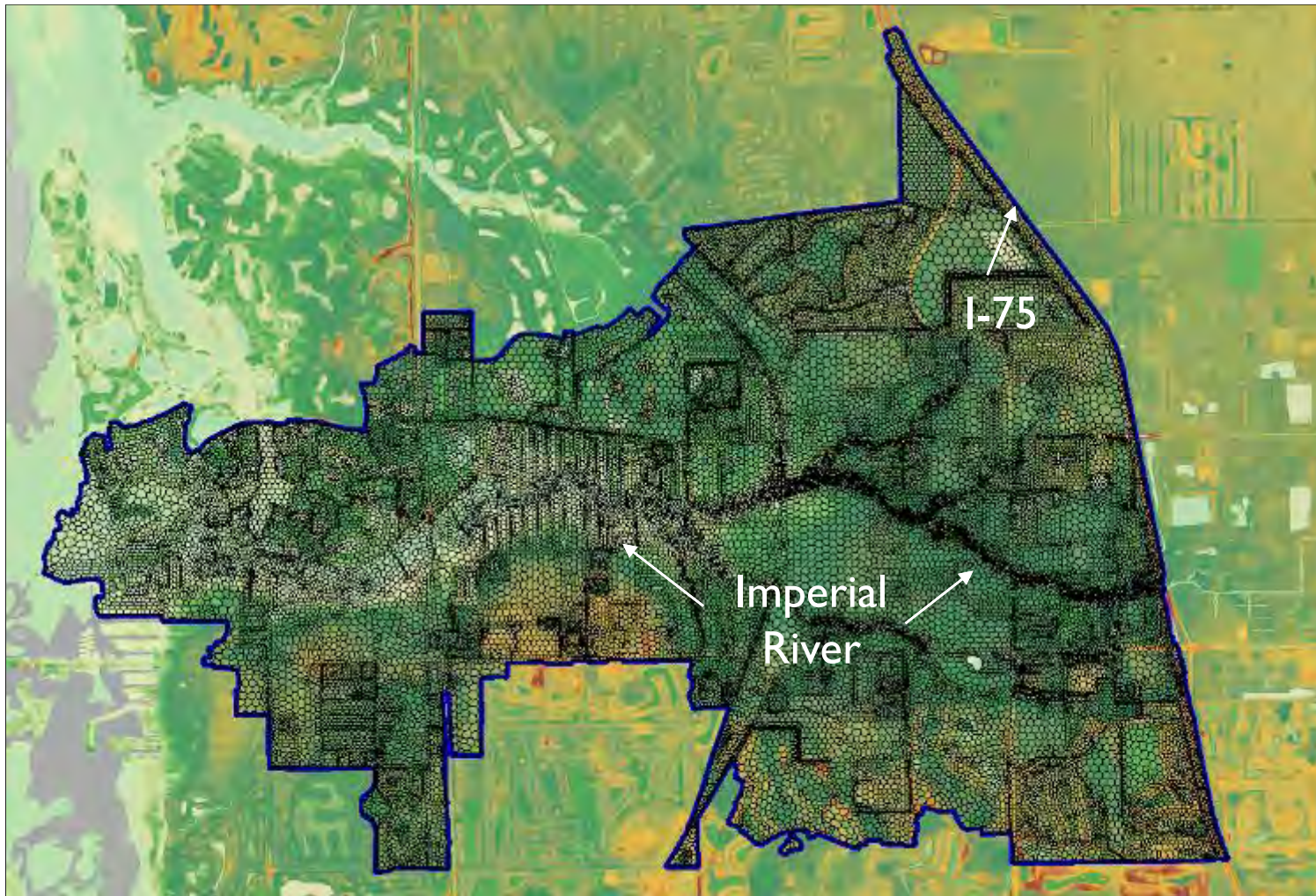
- Software/Hardware Updates (*inconvenient restarts*)
- Downloads at mercy of the Internet (& Forecast Hosts)
- Latency Issues with Huge Downloads
- Integration with Coastal Surge Models

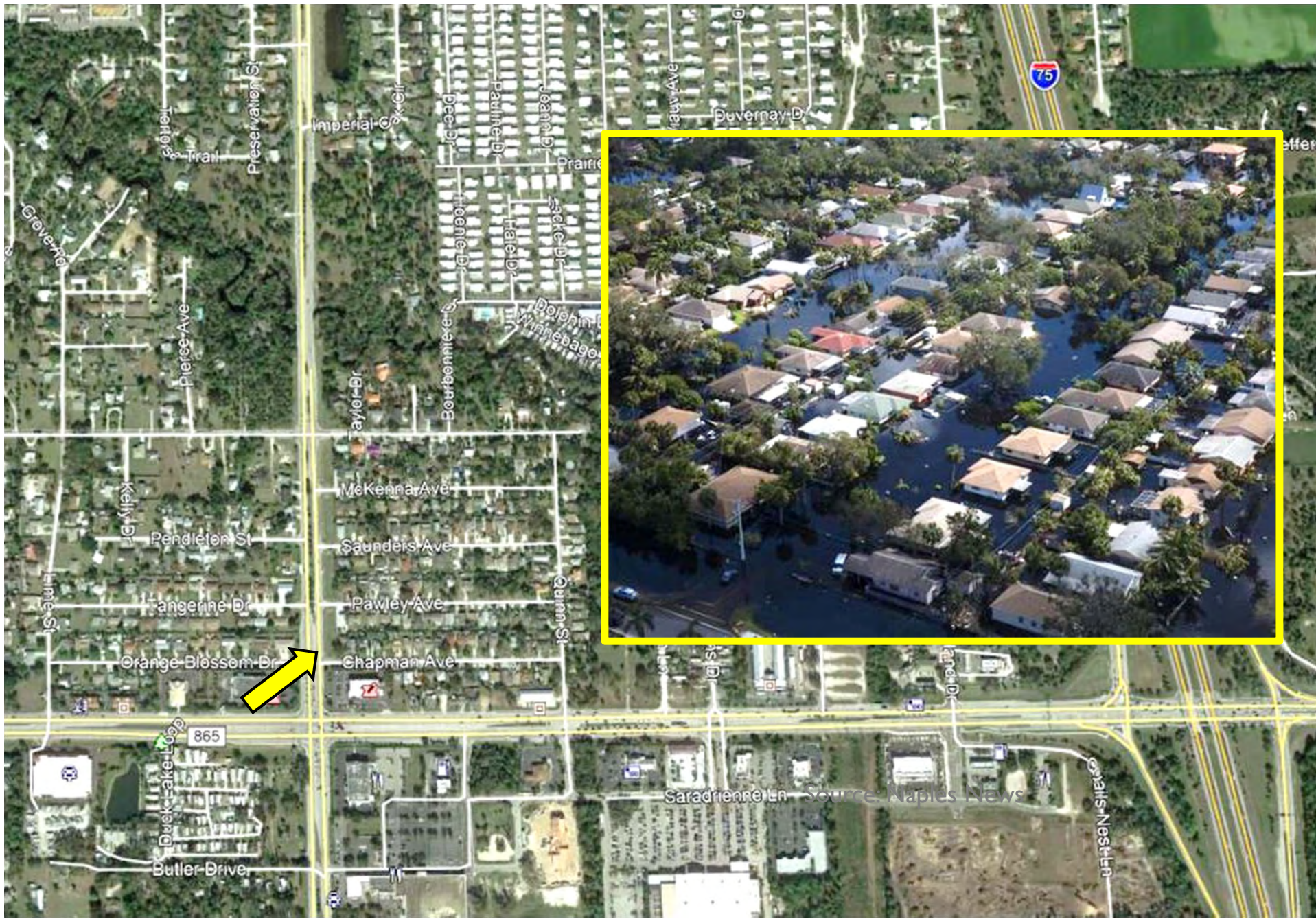
Summary

- The ICPR4 *Imperial River Watershed Flood Forecast Model* is fully operational for the 2019 hurricane season
- Model runs automatically and continuously to track *aggregating antecedent conditions*
- 2D surface flow used east of I-75 to overcome *elastic watershed* issues
- 1D H&H is used west of I-75 for *speed optimization*
- Exploring use of *hyper-resolution 2D surface flow in urban areas*
- Currently running on an *Intel I9 desktop computer*
- Runs about *100 simulation hours per clock hour*

2D Hyper-Resolution Model in Urban Areas

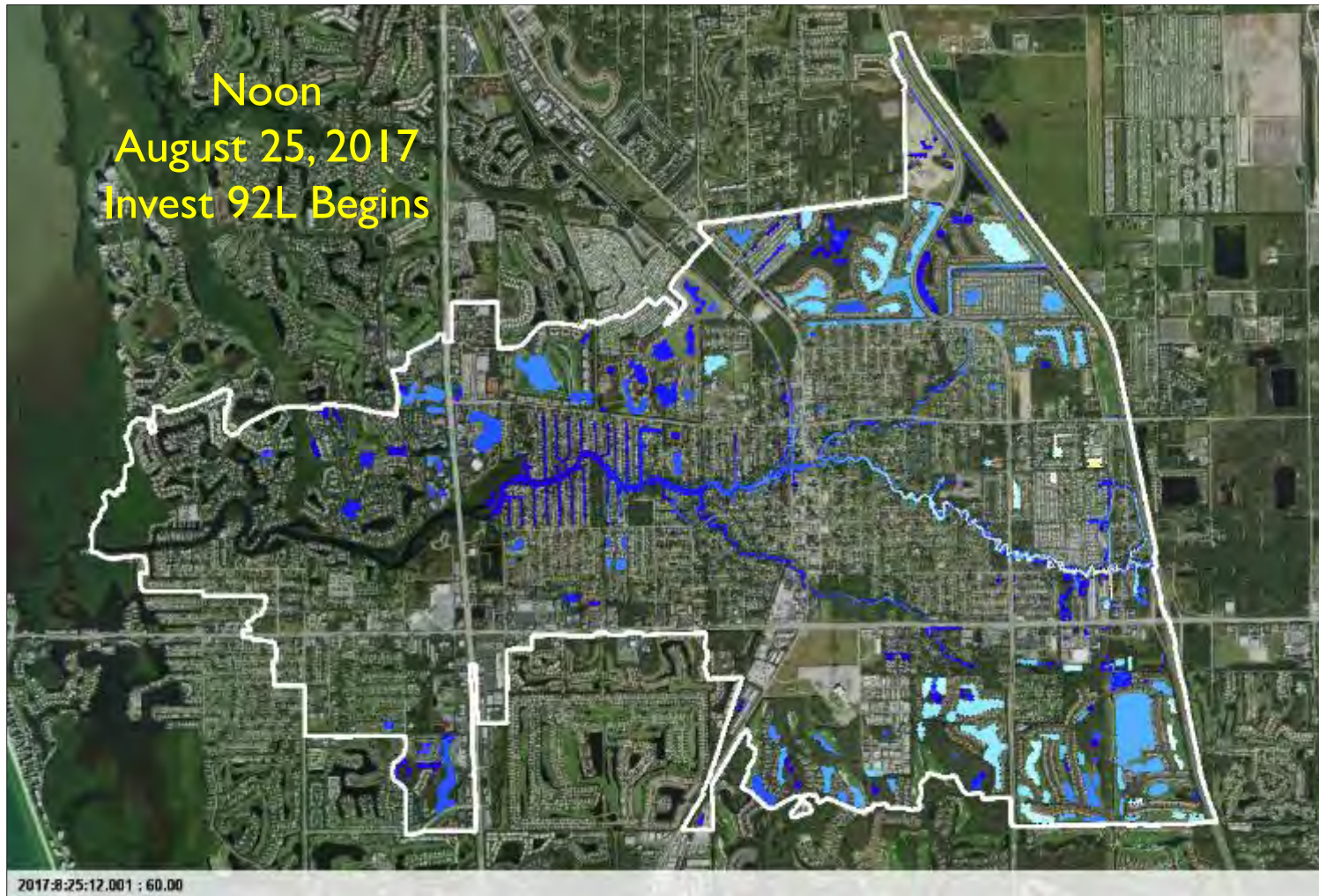
Street Level Flood Visualization & Actionable Intelligence





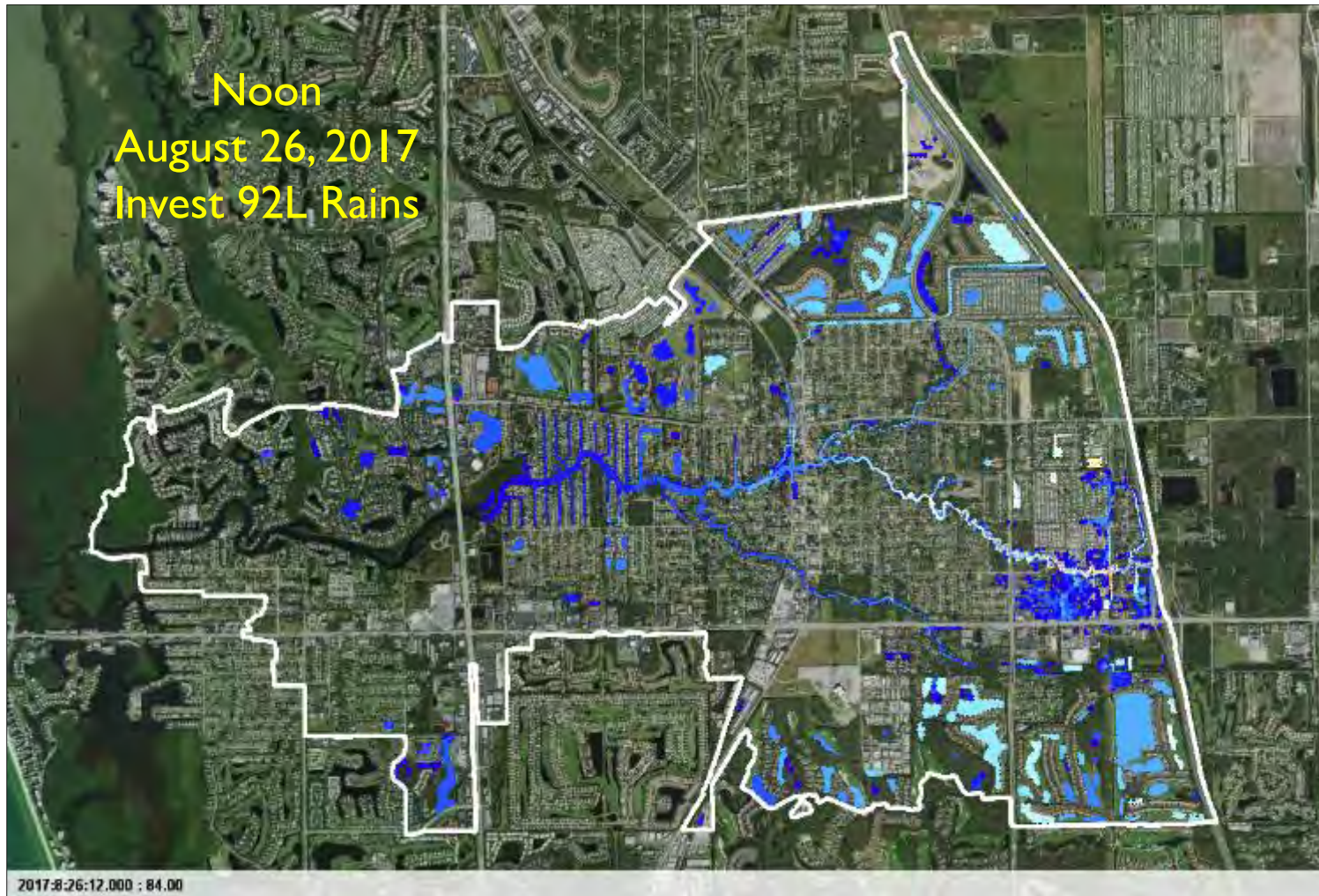
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



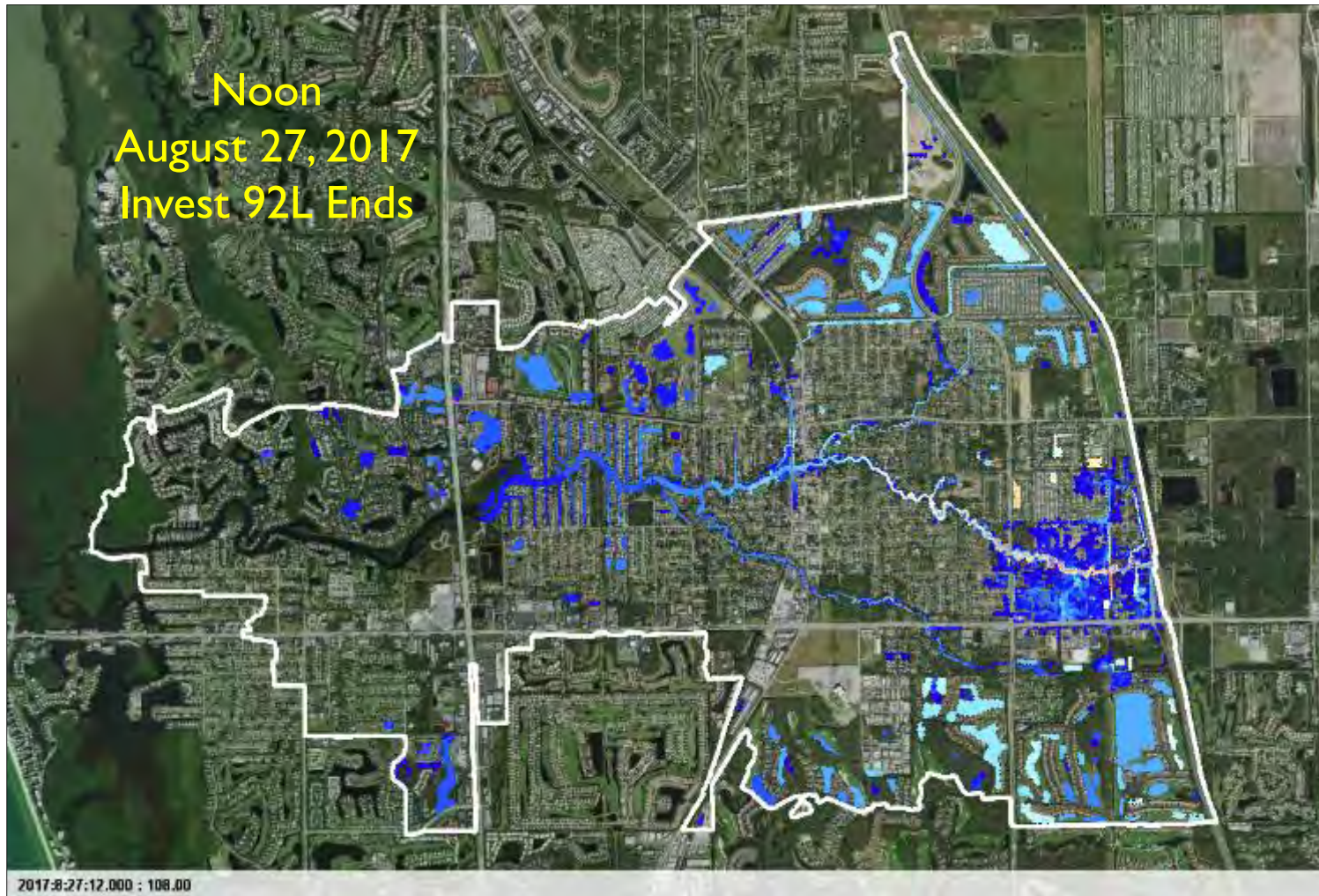
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



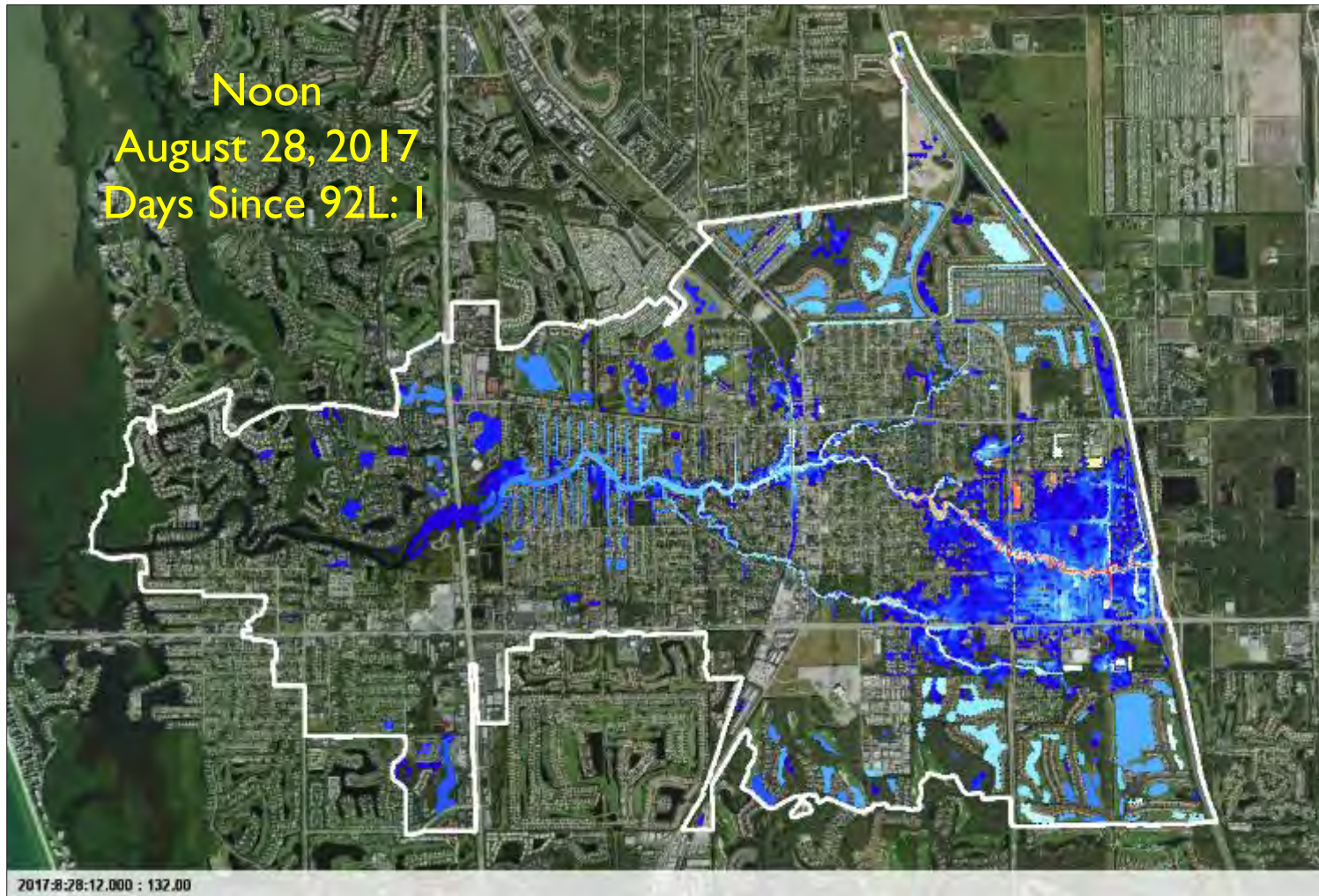
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



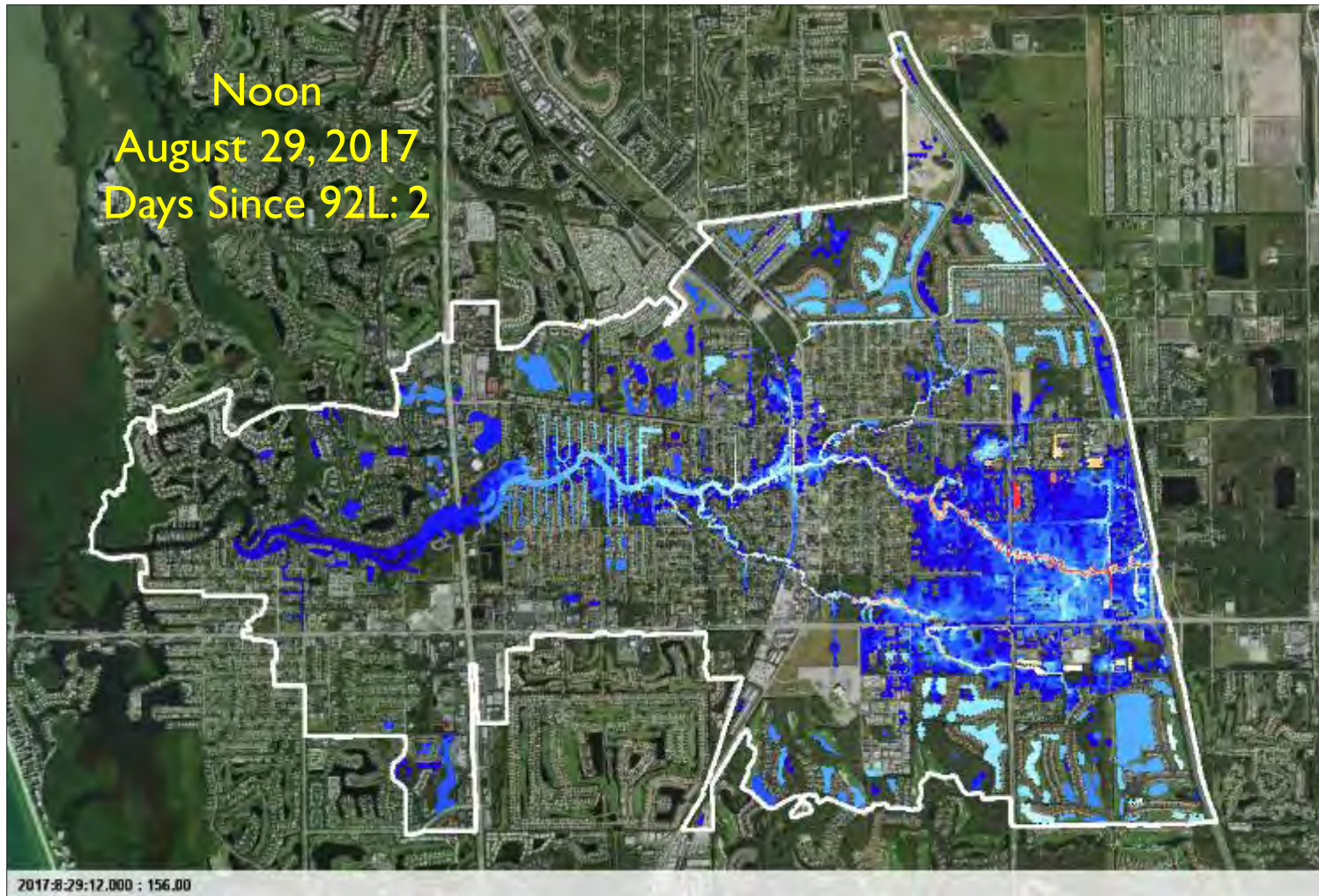
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



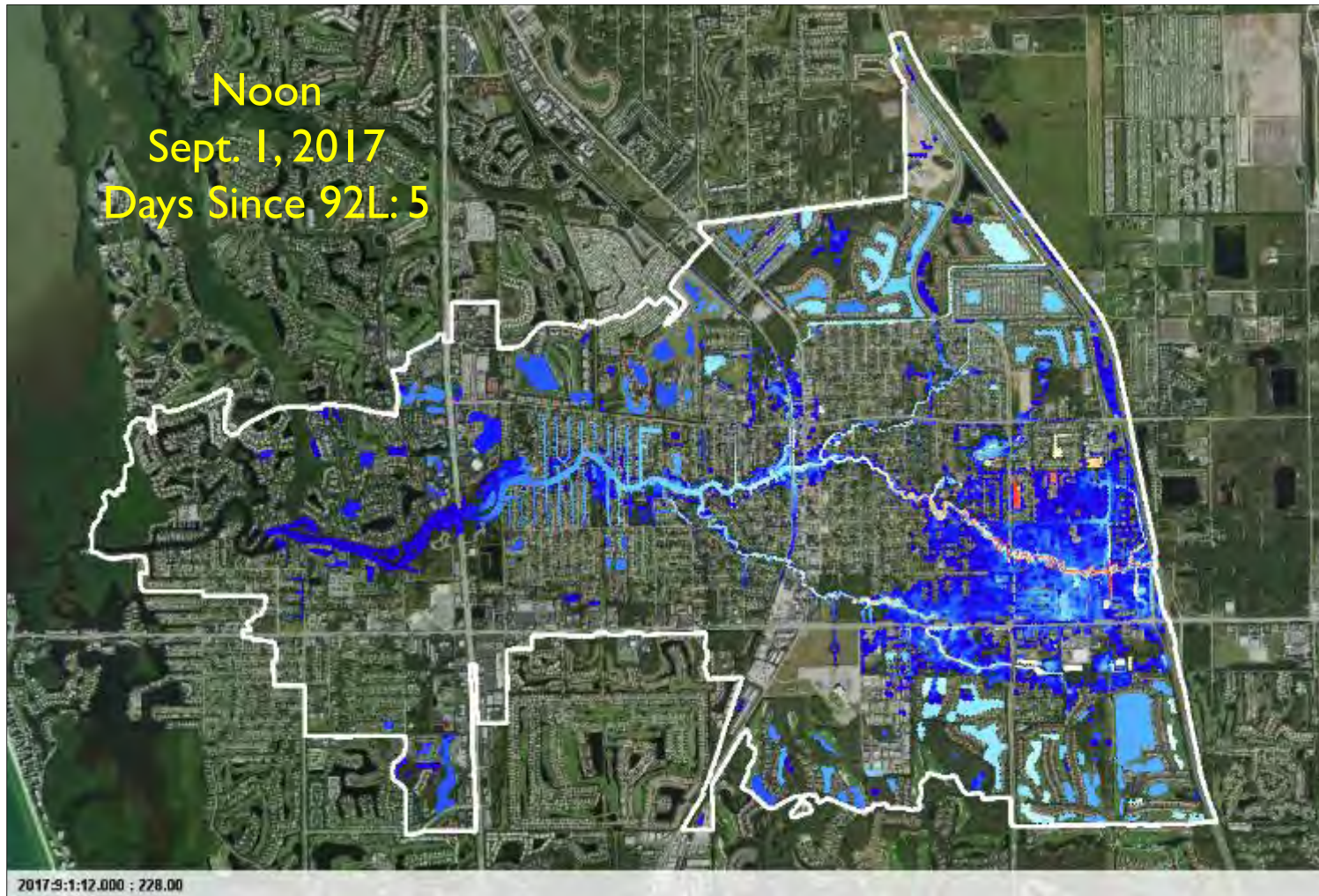
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



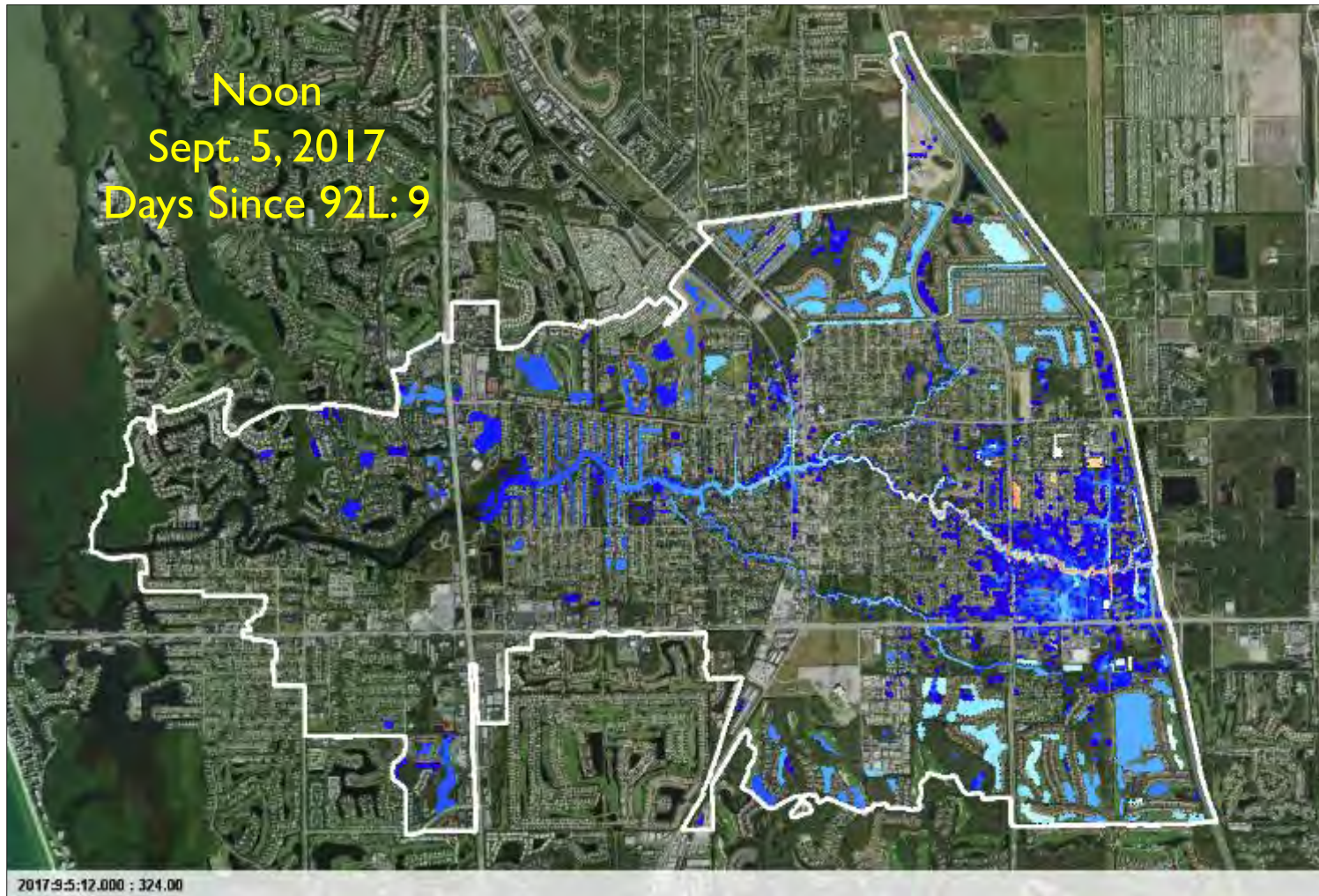
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



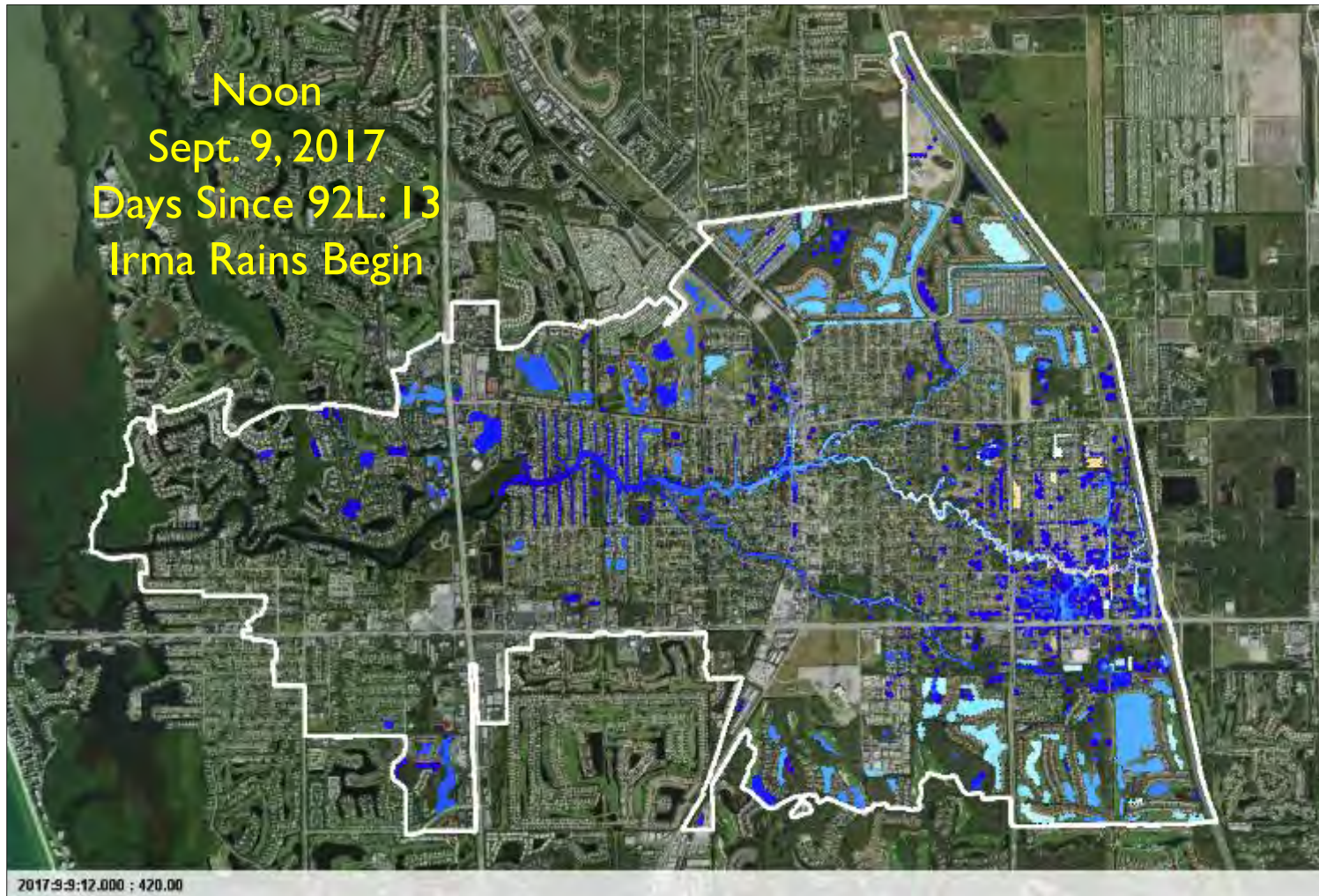
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



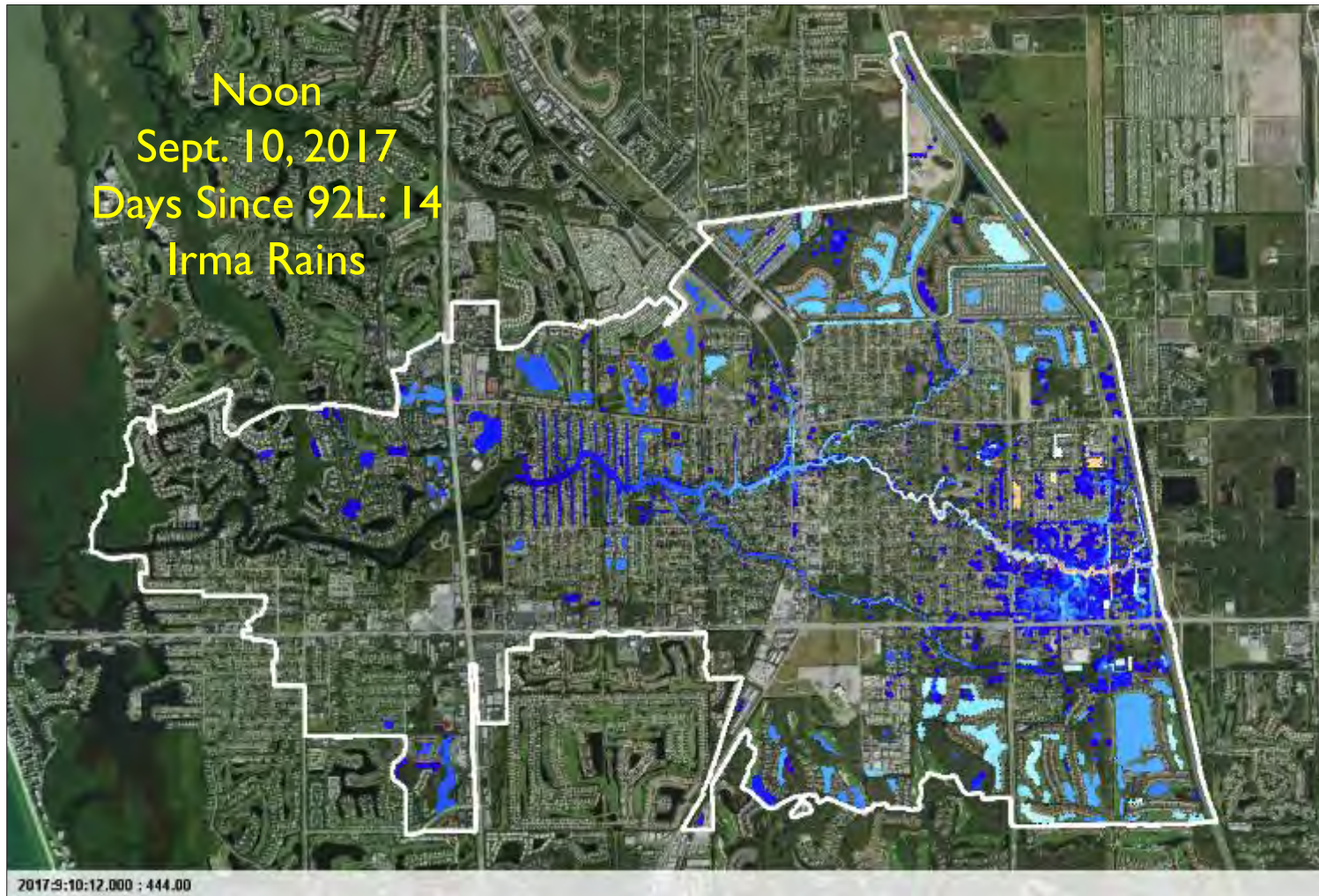
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



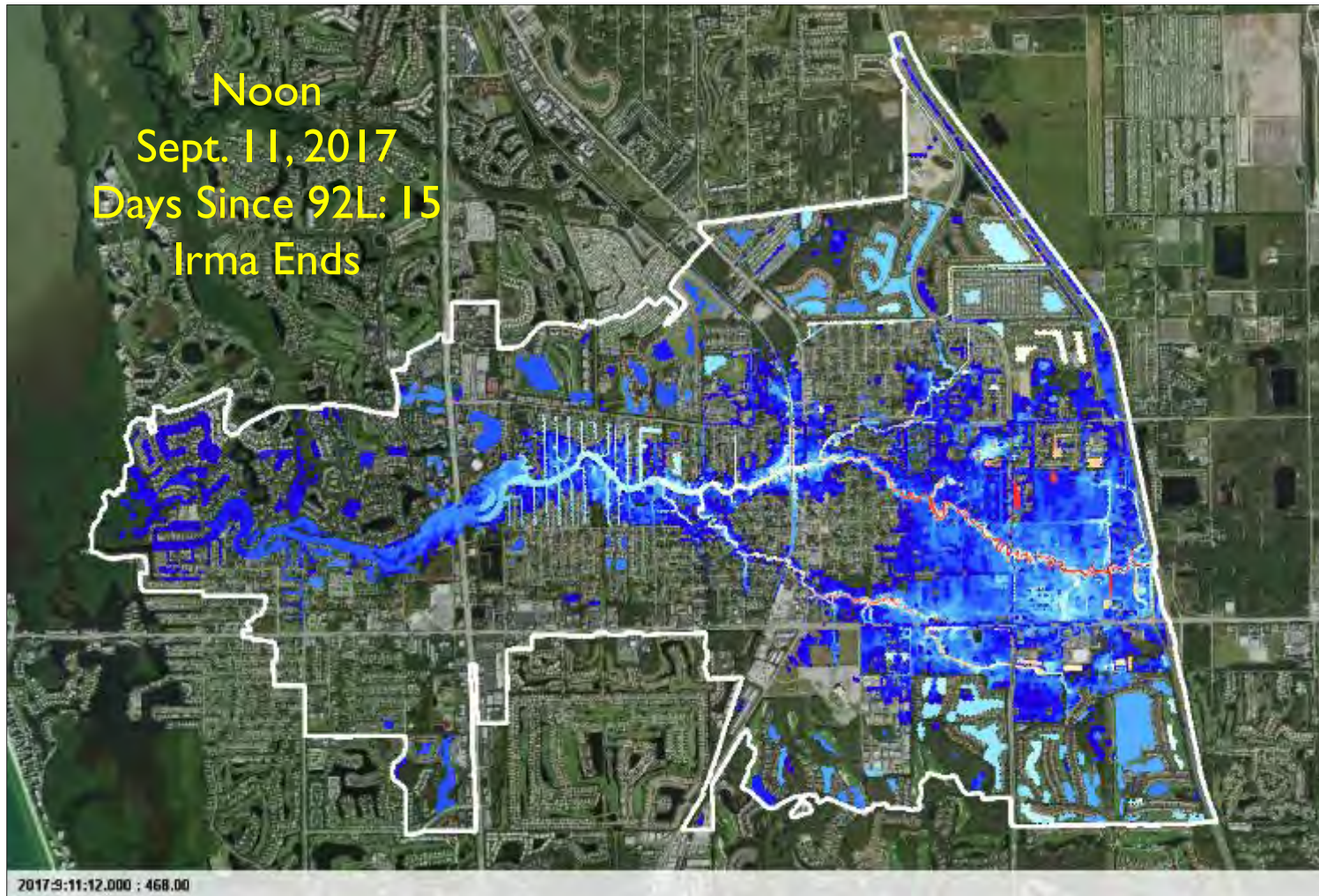
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



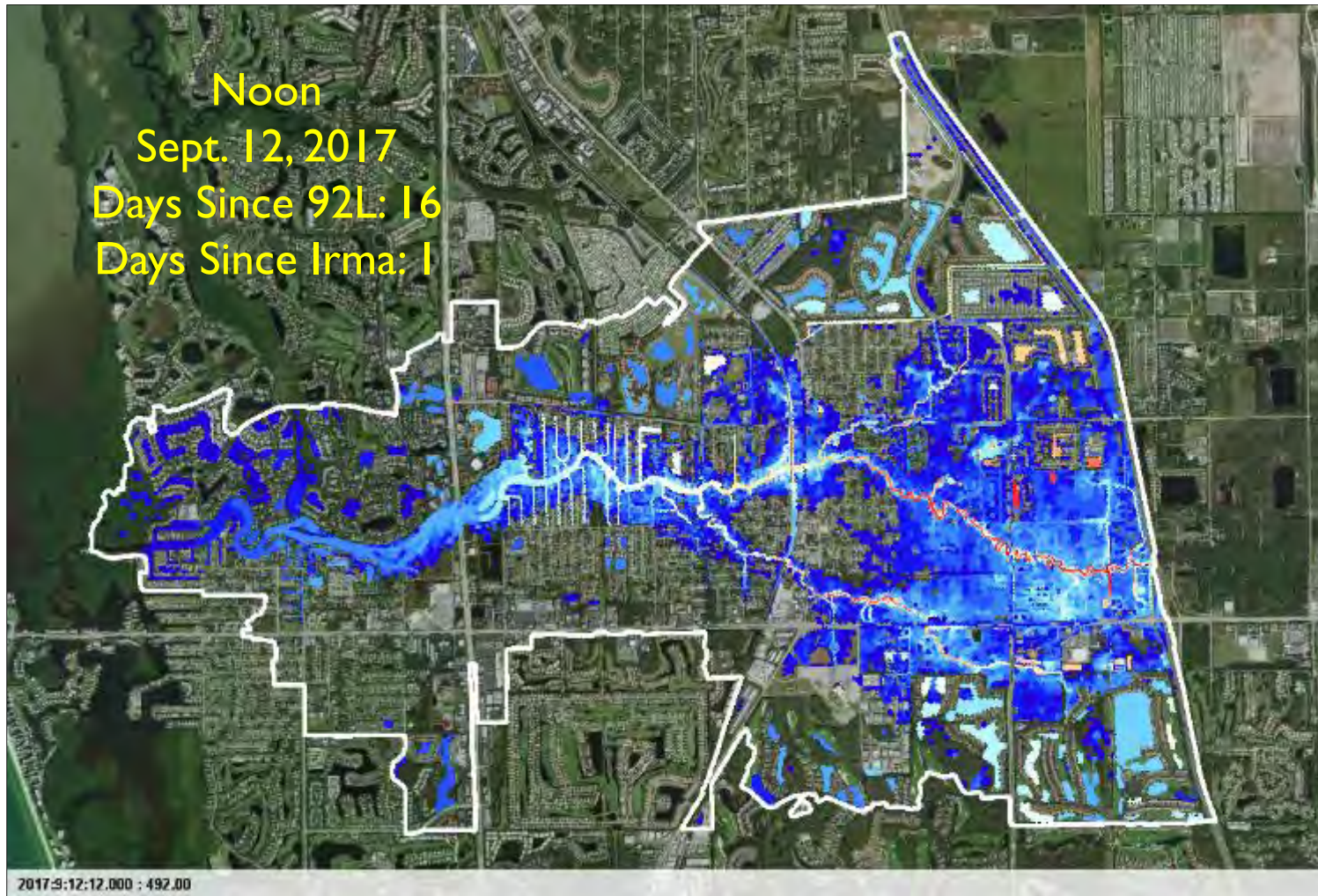
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



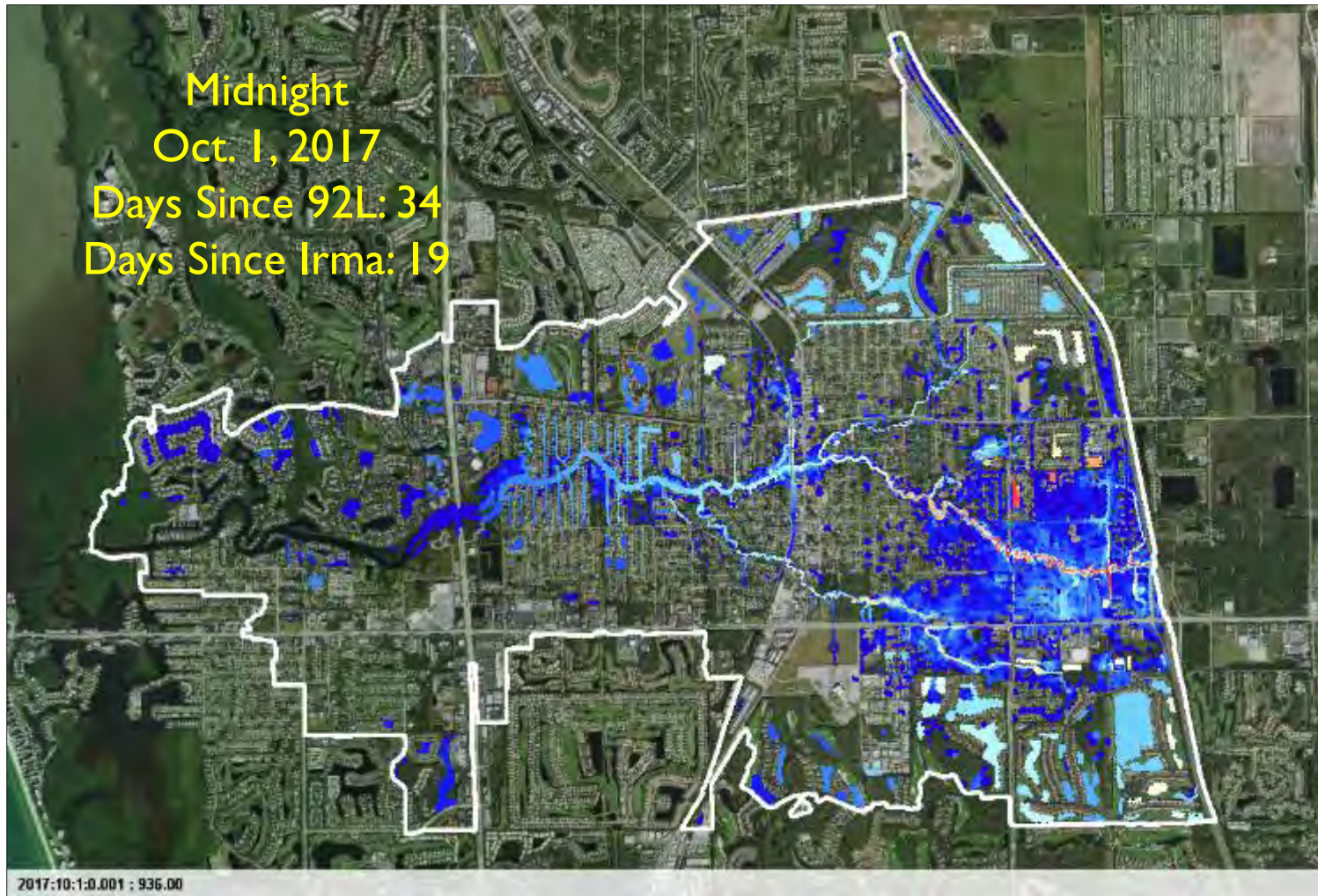
2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



2D Hyper-Resolution Model in Urban Areas

Street Level Flood Visualization & Actionable Intelligence



*“Everybody talks about the weather but
nobody does anything about it”*

Mark Twain/Charles Dudley Warner



... until now?

psinghofen@icpr4.com