

# A new high-resolution flood modeling framework using SWAT and LISFLOOD-FP

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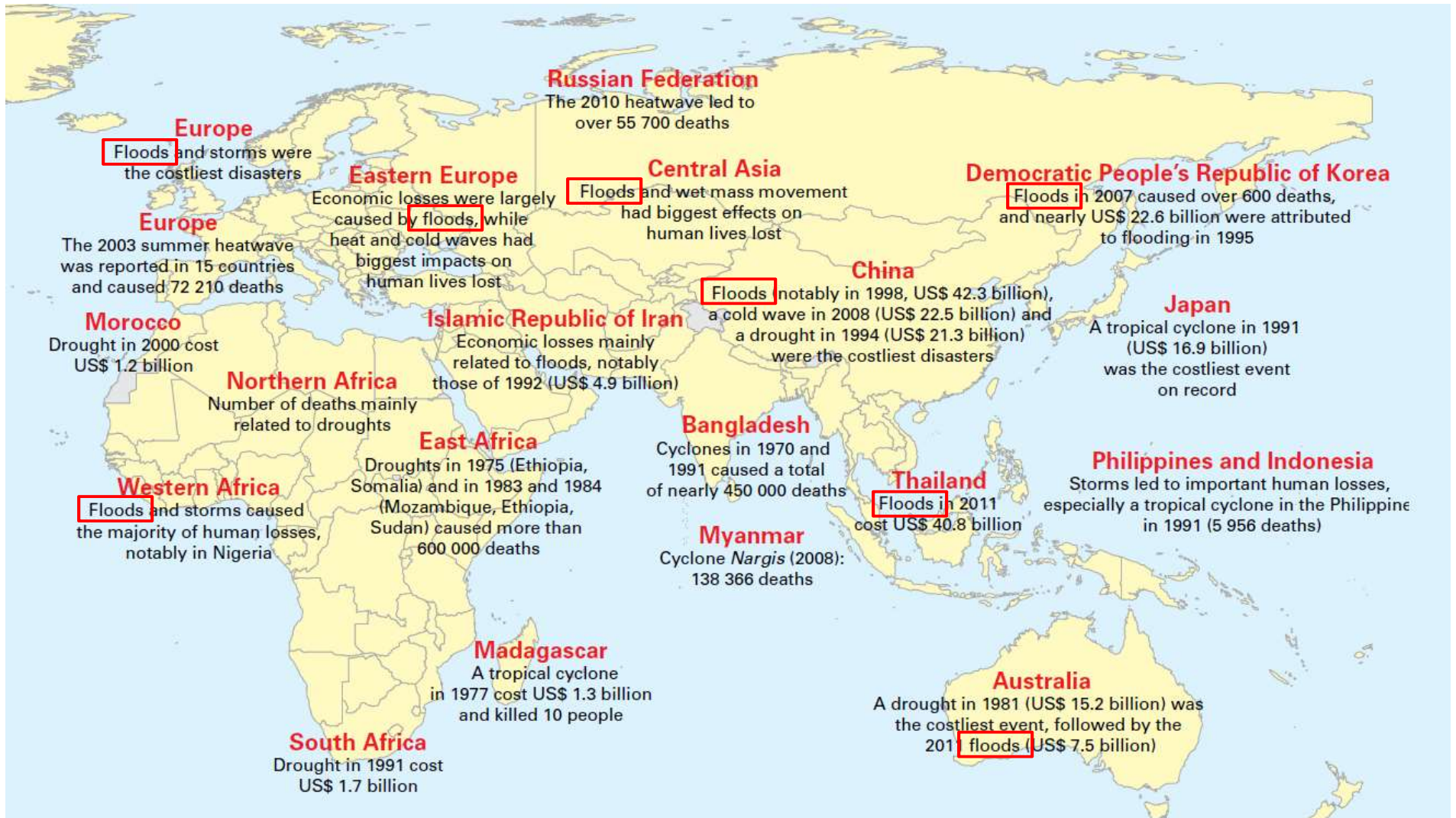
**Ahmad A. Tavakoly**

US Army Engineer Research and Development Center

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## Major reported disasters linked to weather, climate and water extremes

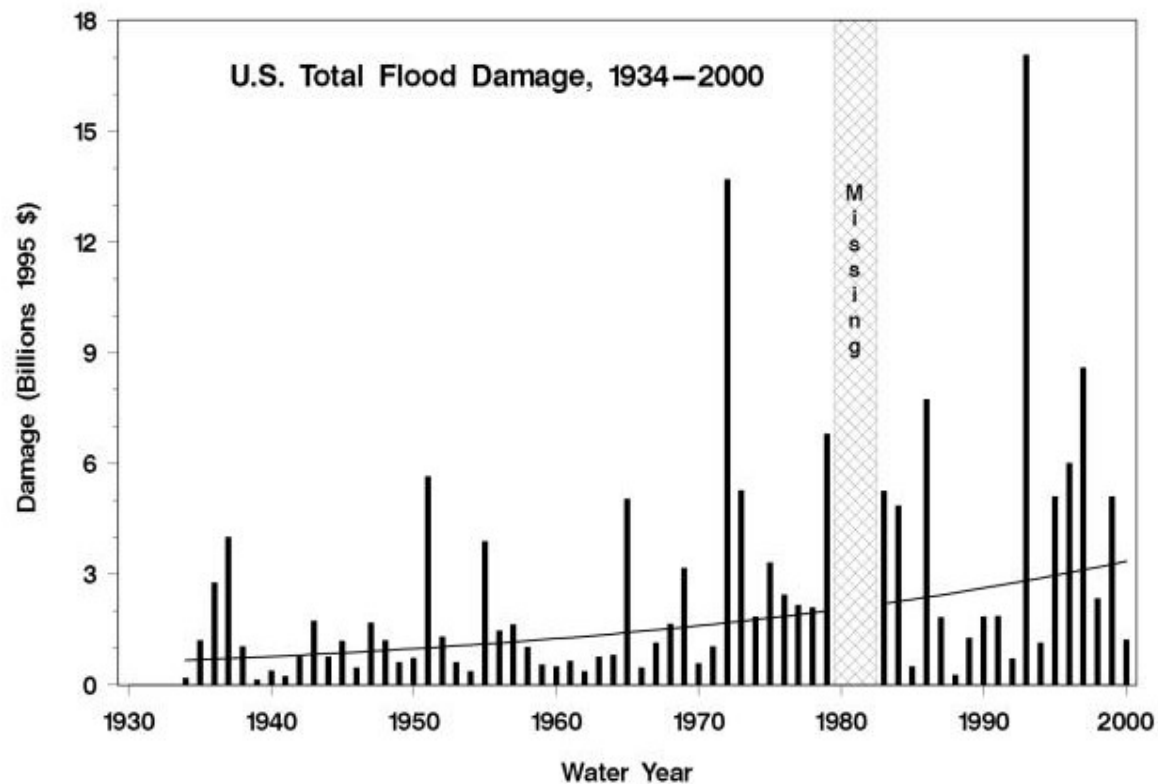


WMO Report: Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970 – 2012)

# Flood Damages in the United States

## MOST DAMAGING OF ALL NATURAL DISASTERS

- More than 50% of all deaths (US: 140 deaths/year)
- 1/3 of total economic loss (US: \$6 billion/year)





**FOX NEWS**  
9:08 MT

**DONALD TRUMP & MIKE PENCE ARRIVE IN LOUISIANA TO SURVEY FLOOD DAMAGE**

**FOX NEWS ALERT**

# What can we do?

**Stop it?**



**Fight it?**



**Deal with it?**

# Dealing with Floods

## Need for High Resolution Flood Mapping Capability

### Example of Ohio Basin

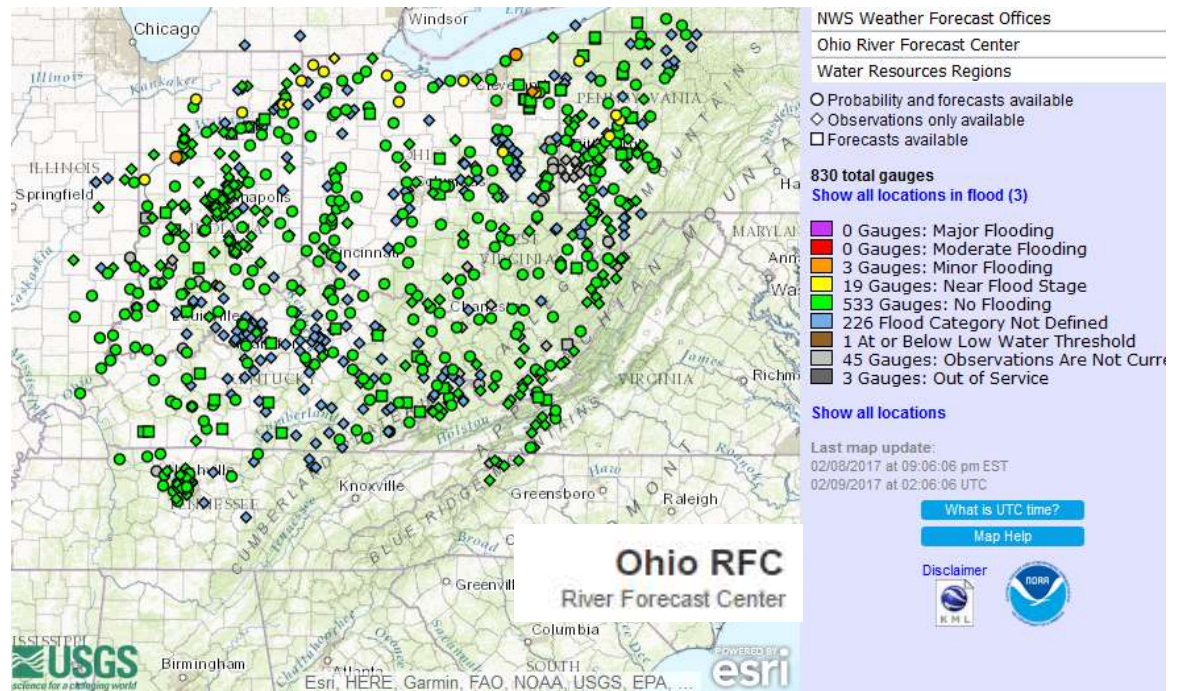
~800 streamflow gauging stations with continuous records

T  
C  
r 700 km<sup>2</sup>



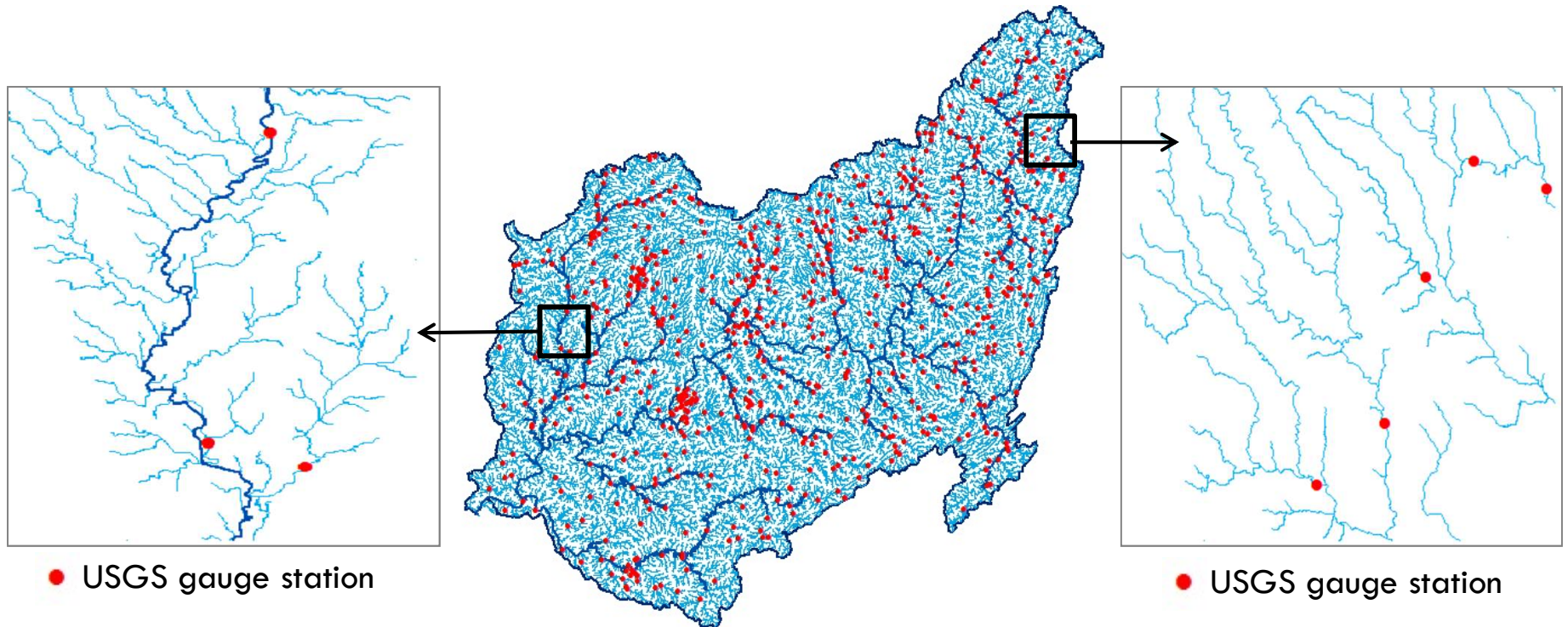
km<sup>2</sup>  
r 700 km<sup>2</sup>

  **NATIONAL WEATHER SERVICE**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
<http://www.weather.gov/ohrfc/>



# Motivation

## Limitation in our current information capacity



### Number of NHDPlus Rivers/Streams

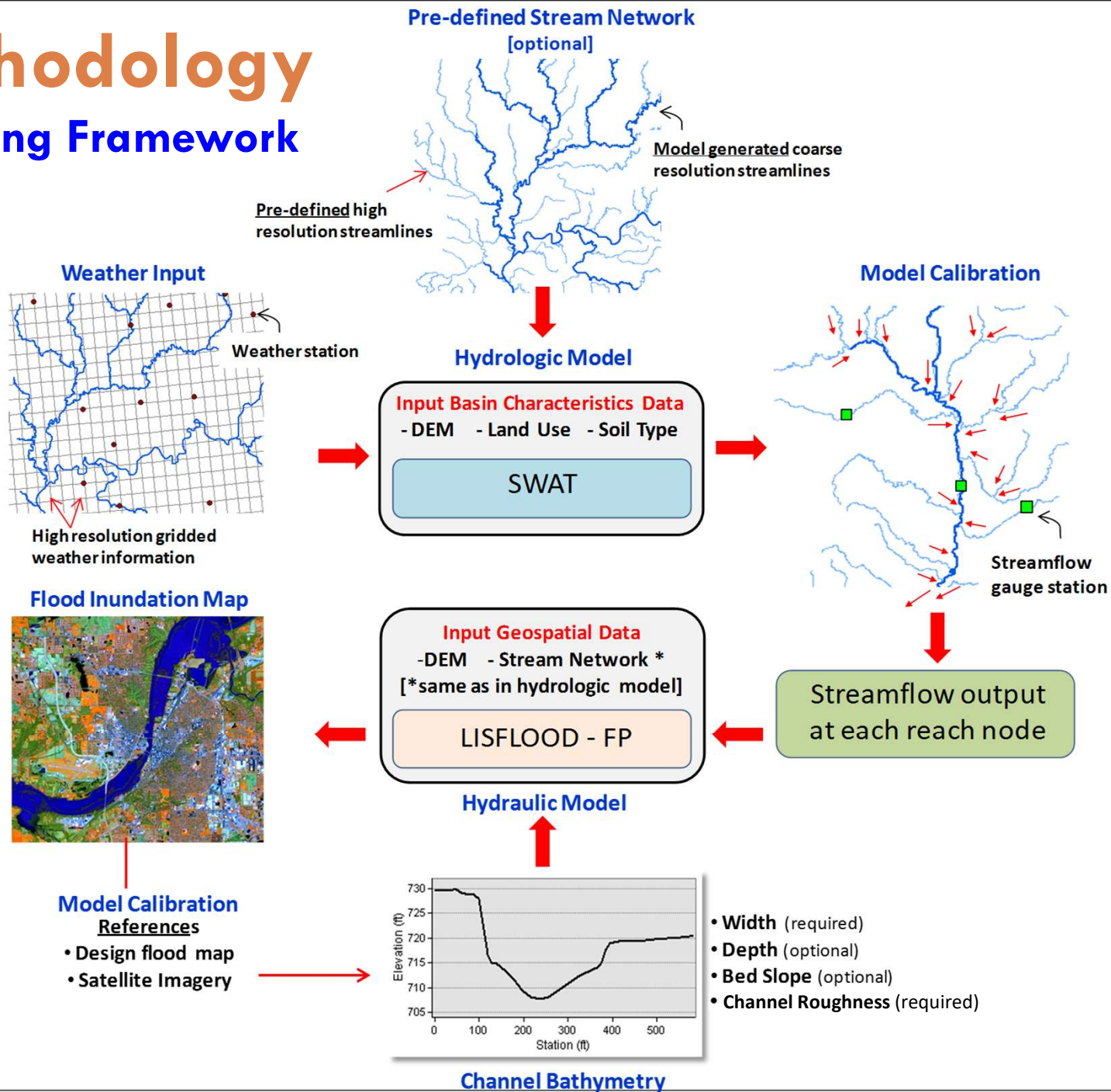
Ohio Basin ~ 100,000

Continental United States ~ 2.7 million

**How can we generate near-real time information EVERYWHERE?**

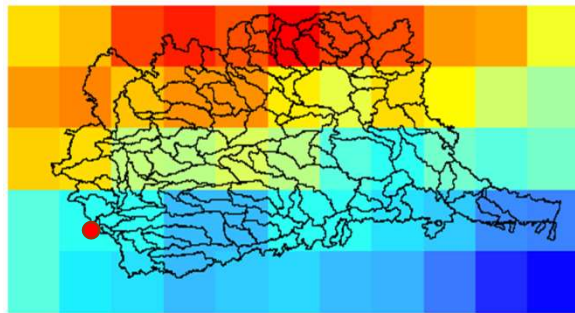
# Methodology

## Modeling Framework

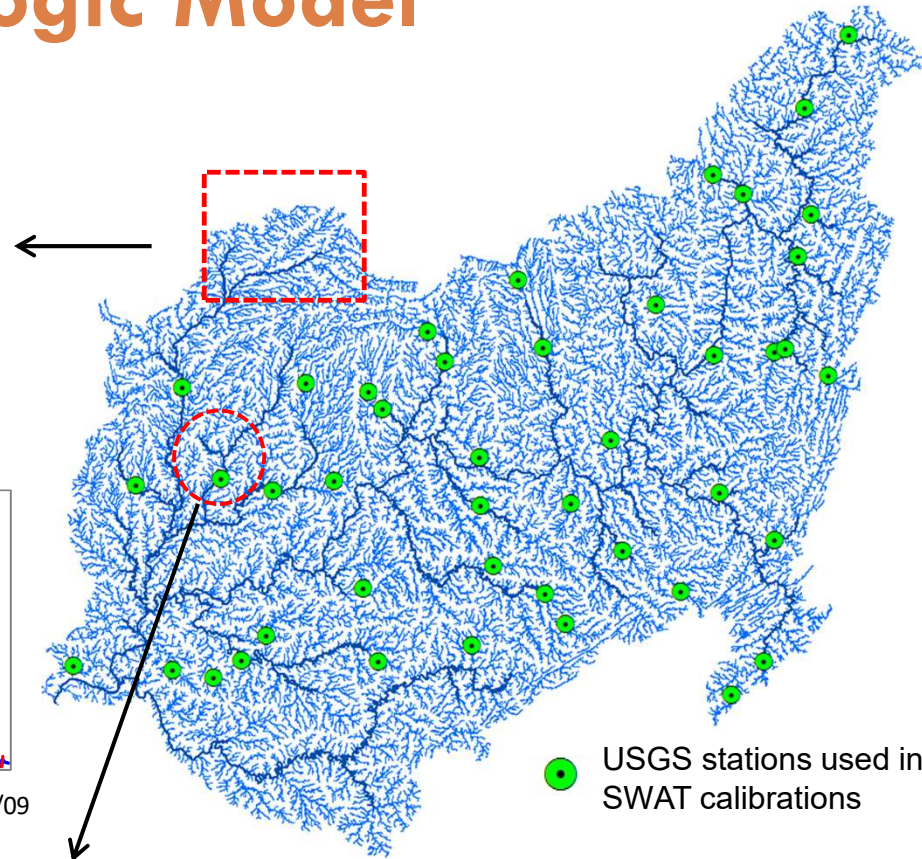




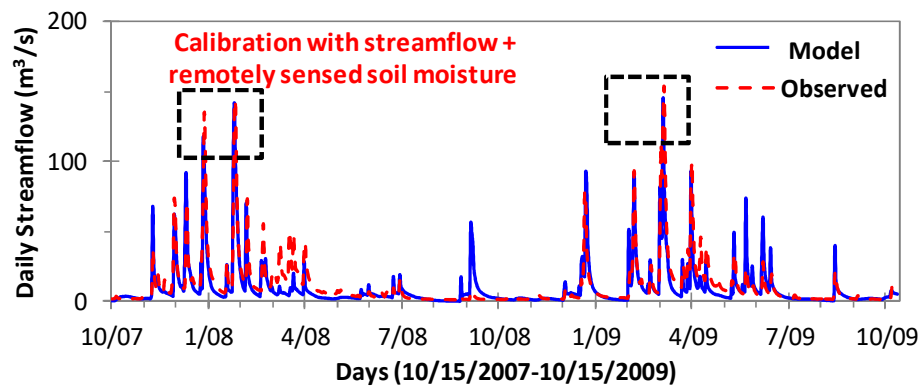
# Calibration of Hydrologic Model



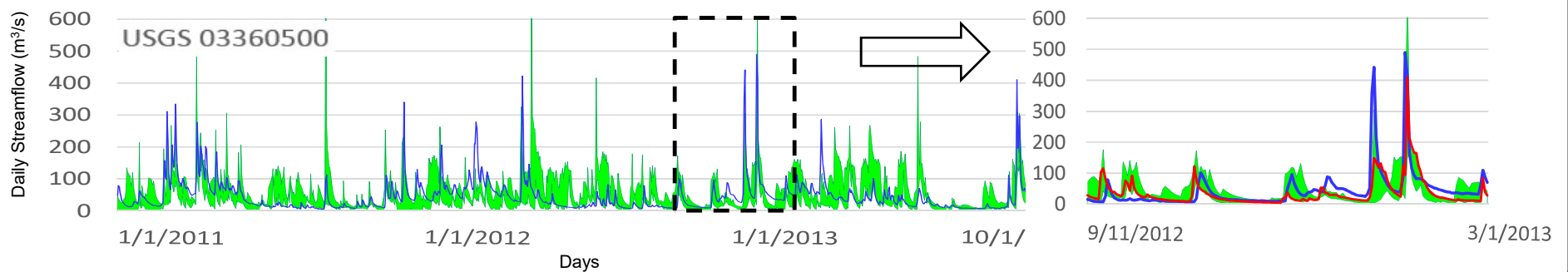
Satellite based soil moisture data



USGS stations used in SWAT calibrations



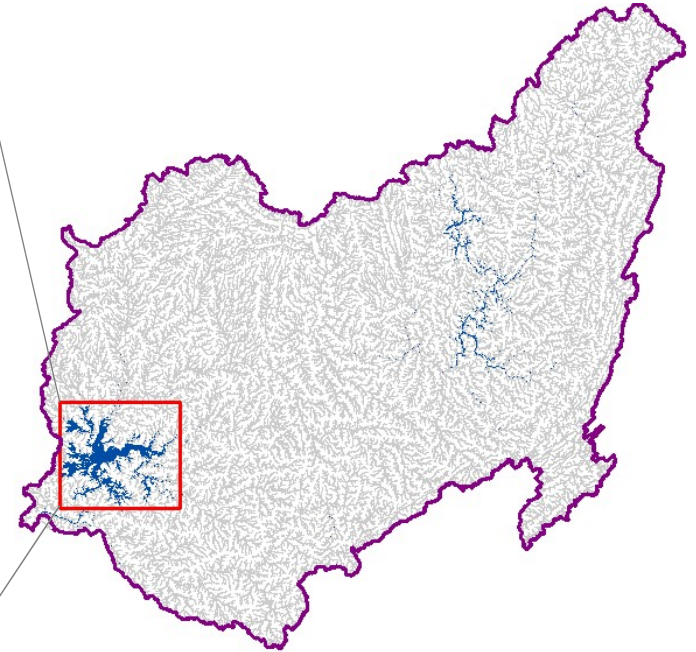
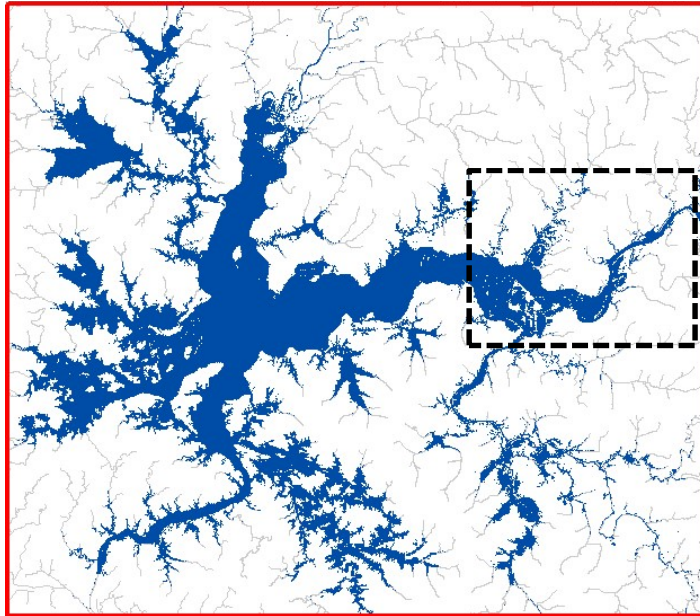
SWAT simulated range      Observed Data      Best Estimate



# Evaluation for a Real Flood Event

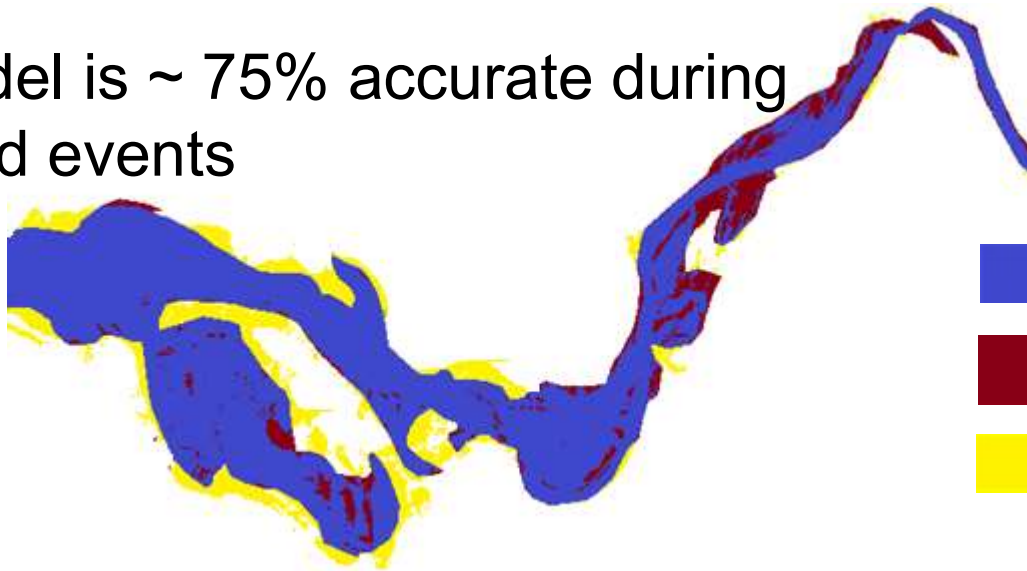
## Reference:

Landsat satellite  
[May 4, 2011]



$$F = 0.75$$

Our model is ~ 75% accurate during  
real flood events



# Realization of “Model Uncertainty”

## Model Uncertainty

### Input Uncertainty

- Weather
- Topography

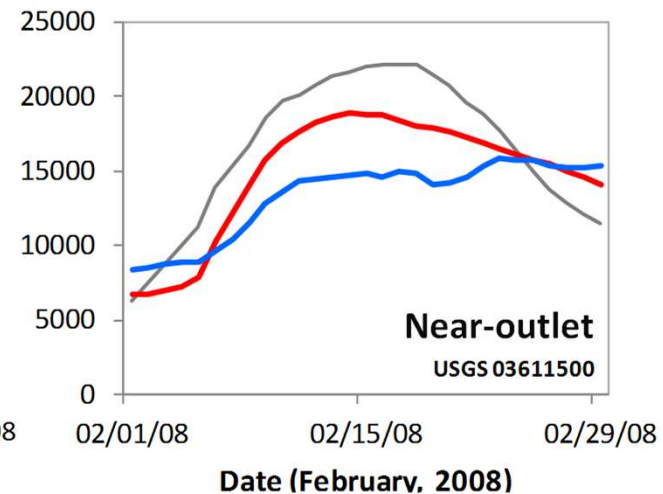
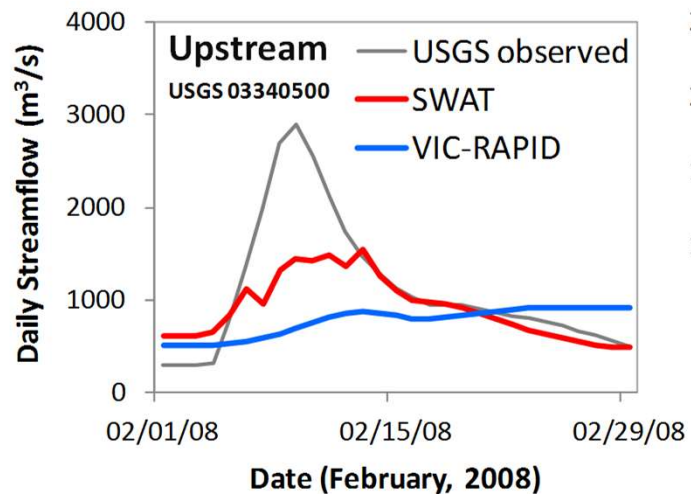


### Hydrologic + Hydrodynamic Uncertainty

- Process representation
- Parameter equifinality
  - Two different models
  - Two setups of the same model

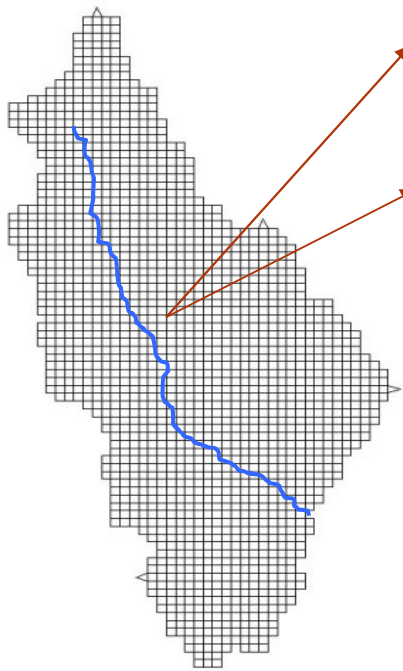
Streamflow comparison in Ohio Basin

SWAT vs. VIC-RAPID (same weather input)



# Path to Realistic Predictions

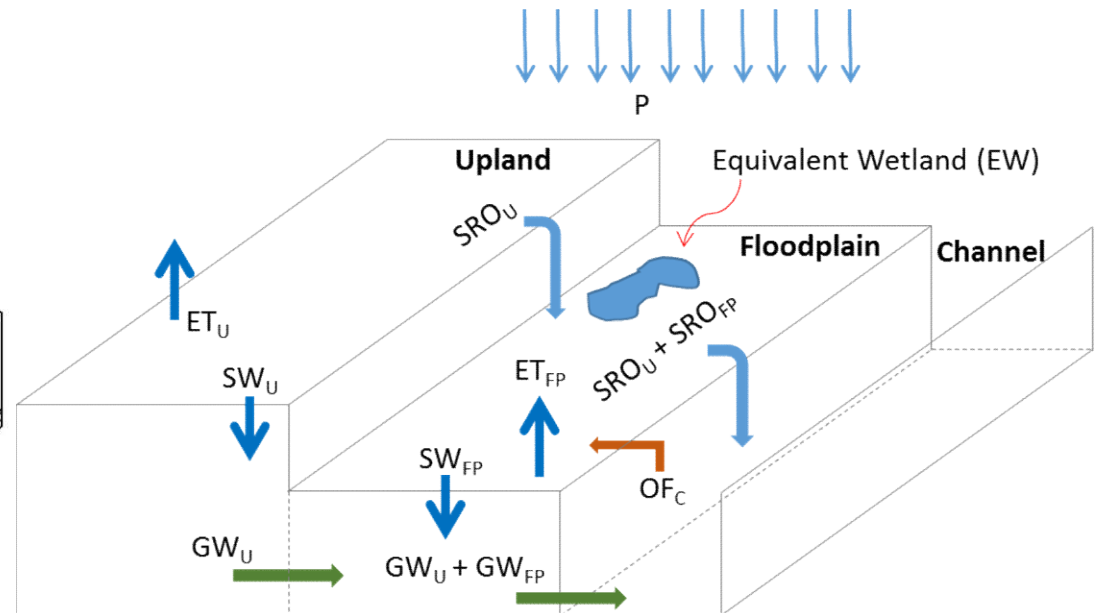
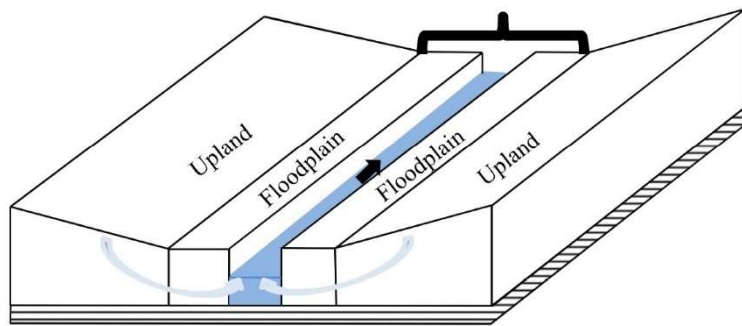
## SWAT with Channel and Floodplain Properties?



Most of the large scale land surface/ hydrologic models DO NOT have any floodplain representation (e.g. VIC, Noah-MP)

Hydrologic fluxes (surface runoff, baseflow) from the grids are generally dumped at the sub-basin outlet for routing

**A new SWAT modeling approach that integrates channel and Floodplain information**



# Visit our poster tomorrow!

## June 28, 10.00 am

### Integrated SWAT and LISFLOOD-FP Modeling for High Resolution Flood Inundation Mapping

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#### Abstract

Most large scale hydrologic models are not created to generate streamflow hydrographs for lower order ungauged streams. Similarly, most flood inundation mapping studies are performed at major stream reaches. As a result, it is not possible to get reliable flow estimates and flood extents for vast majority of the areas where no stream gauging stations are available. The objective of this study is to loosely couple spatially distributed hydrologic model, Soil and Water Assessment Tool (SWAT), with a 1D/2D coupled hydrodynamic model, LISFLOOD-FP, for large scale fine resolution flood inundation modeling. In the current framework, a SWAT model is developed to generate streamflow time-series for more than 100,000 NHDPlus stream reaches in the 491,000 km<sup>2</sup> Ohio River Basin (ORB). The current modeling framework lays foundation for near real-time streamflow forecasting and prediction of time-varying flood inundation maps along the NHDPlus network.

#### Modeling Framework

- The proposed integrated modeling framework involves loosely coupling SWAT hydrologic model with LISFLOOD-FP (Subgrid) hydrodynamic model for ORB.
- SWAT model, built upon the NHDPlus stream network, is fed with weather station data, DEM, land use data as well as soil information, and calibrated using recorded streamflow observed at selected USGS gauging stations.
- The output streamflow from SWAT is used to drive LISFLOOD-FP, which takes the flow, DEM, land use as input and provides water surface elevation and inundation extent for each of the stream reaches, after being calibrated for channel roughness parameters.

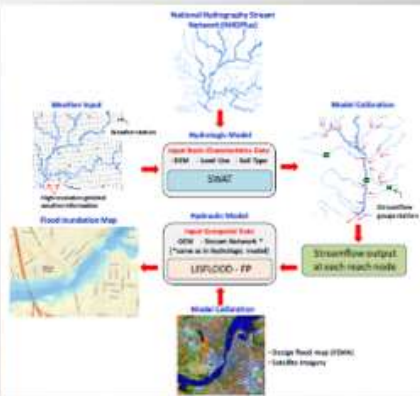
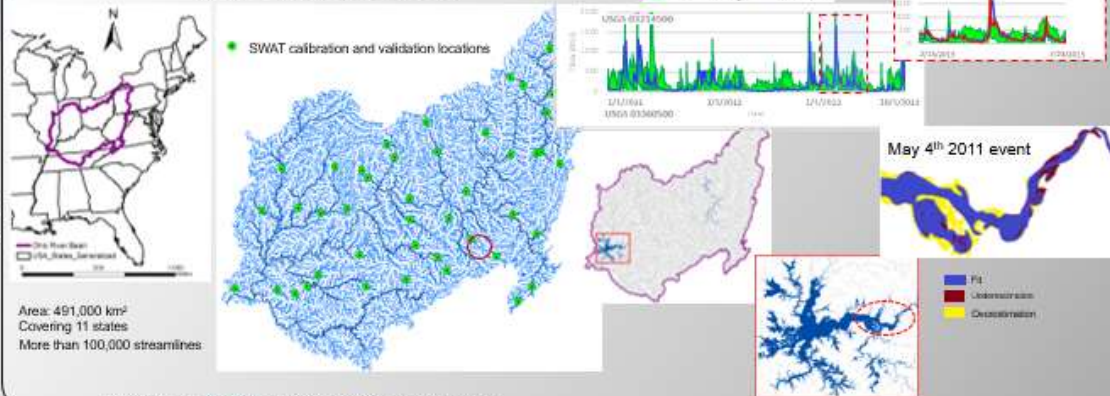


Fig. 1. SWAT-LISFLOOD-FP modeling framework (Merwade et al., 2016)

#### Models Calibration and Validation



Area: 491,000 km<sup>2</sup>  
 Covering 11 states  
 More than 100,000 streamlines

Fig. 2. Ohio River Basin, NHDPlus stream network and the SWAT calibration/validation sites

#### Cyberinfrastructure for Historic and Near Real-time Forecasting and Visualization



<https://mygeohub.org/groups/water-hub/swatflow>



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# Questions?

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The views presented here are those of the authors and do not necessarily reflect policies of the US EPA, US ACE and NSF