Key Issues in Developing and Using Flood Risk Data

2015 Seminar on Reinsurance
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Topics

- What's included in the flood model
  - Modeling approach – 1D vs 2D
  - Riverine (fluvial) flooding and/or Surface Water (pluvial) flooding
  - Tropical cyclone rainfall
- Digital Elevation Models
  - Resolution
  - Accuracy
- How to use flood hazard maps
- Beyond hazard maps

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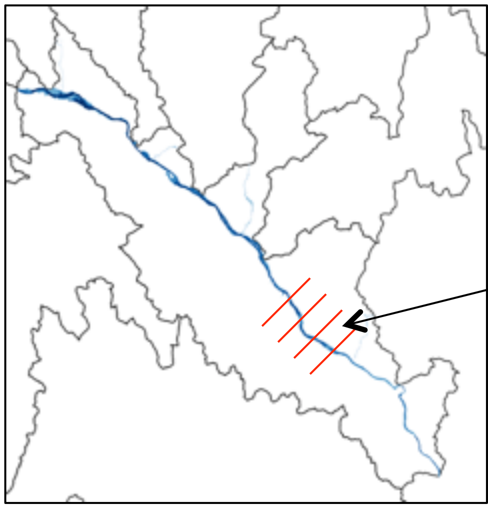
Some Definitions

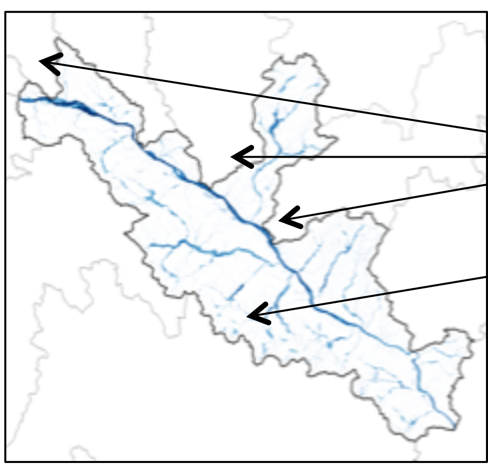
- Pluvial Flood Modeling – modeling of precipitation and the flow of water over the ground surface to streams and rivers.
- Fluvial Flood Modeling – modeling of the river flow from one catchment to the next downstream catchment and overtopping of river banks.
- DTM – KatRisk has utilized the 10 meter USGS National Elevation Dataset (bare earth) in developing our flood model.

1D and 2D Modeling Approaches



1D

1. Define Rivers and Return Period Flows
2. Convert flow to surface water elevation using rating curves
3. Create cross sections across the river at regular intervals (e.g. 500m).
4. Calculate extent of flooding at each cross section



2D

1. Define catchment boundary conditions
   a) Flow from upstream catchments
   b) Precipitation and runoff over a catchment
2. Model flow of water over land (pluvial) and down rivers (fluvial) using 2D hydraulic equations

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Coverage and Extent of Modeling

Red outlines – FEMA 100 year flood zones

- FEMA FIRMs cover much but not all of the US
- In many areas they cover the main rivers but not smaller streams and surface water flooding
- Need to model the the water getting to the rivers as well as out of the rivers

Blue – high resolution model including pluvial (surface) and fluvial (riverine) flooding

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Pensacola Flooding April 2014

Flooded Downtown Area Outside of FEMA Hazard Zones

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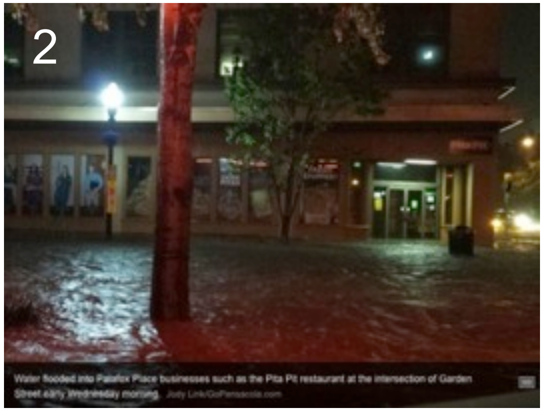
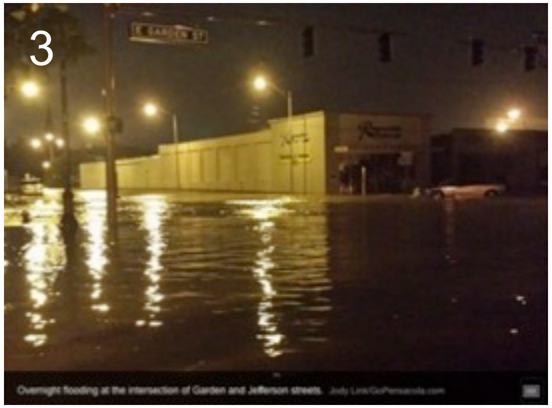
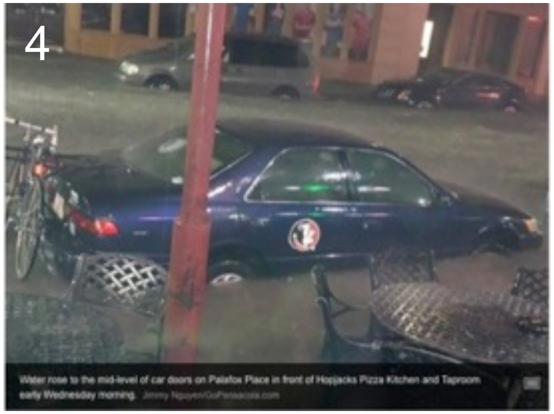
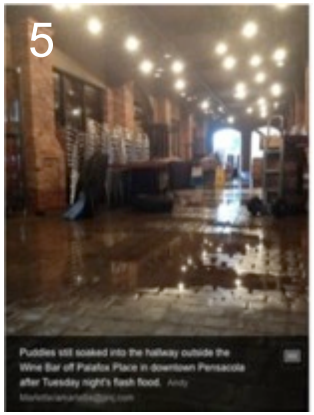
Pensacola Flooding April 2014

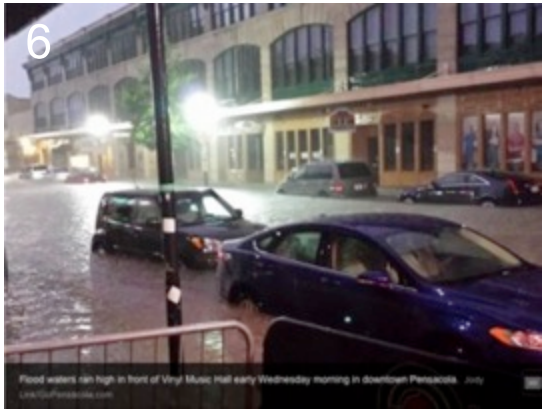


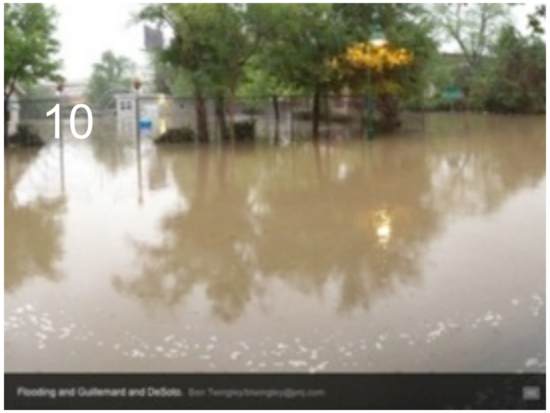






Photos
Pensacola News Journal





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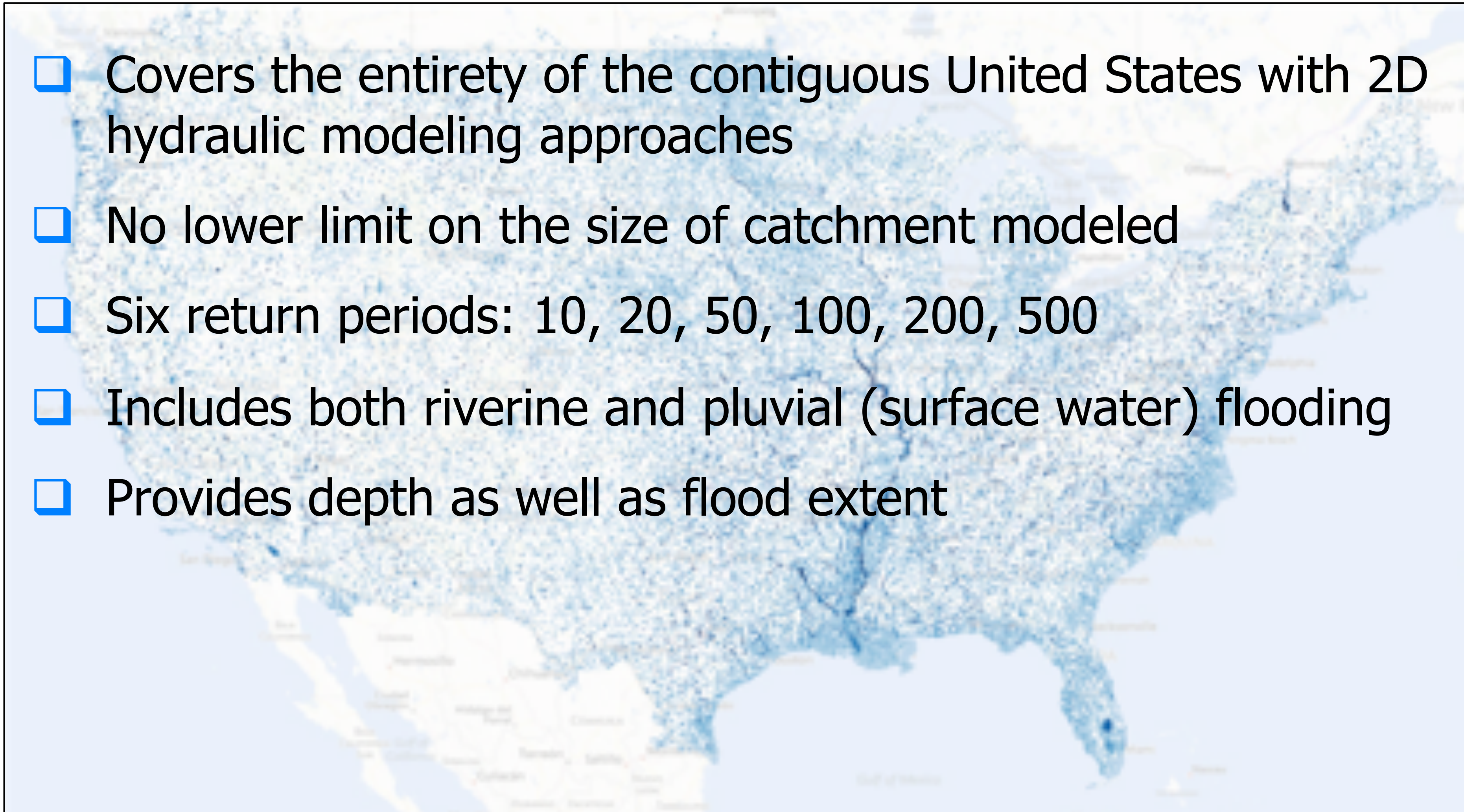
US Flood Data

- Covers the entirety of the contiguous United States with 2D hydraulic modeling approaches
- No lower limit on the size of catchment modeled
- Six return periods: 10, 20, 50, 100, 200, 500
- Includes both riverine and pluvial (surface water) flooding
- Provides depth as well as flood extent



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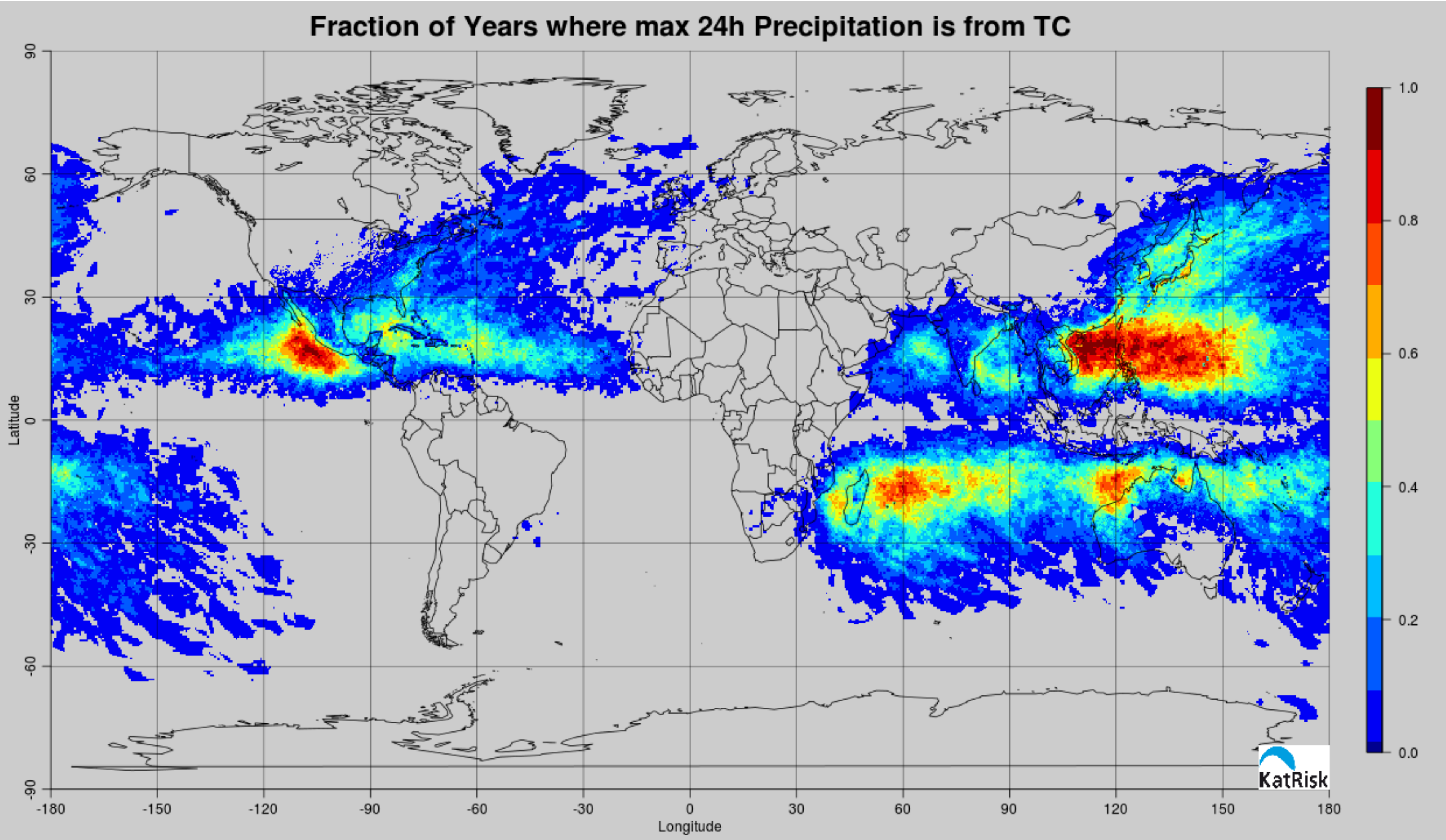
Tropical Cyclone Rainfall



Resolution and DTMs

- The resolution of models should correspond to the quality of the DTMs
- Especially complex hydrodynamic models are sensitive to DTM inaccuracies

Three Examples

USA: 10m resolution
Excellent quality
Random errors
Removed bridges

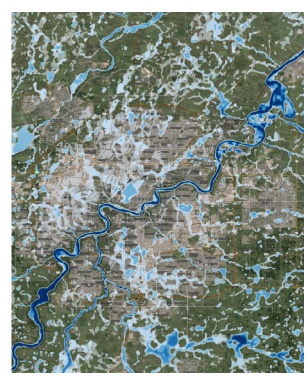
Canada: 30m resolution
Medium quality
DTM problems on state boundaries
Removed bridges
Burned in rivers

Asia: 90m resolution
Low quality
Noisy DTM: significant filtering
Removed bridges
Burned in rivers

Colorado

Calgary

Edmonton



Bangkok

High Resolution 10m Results

Detroit, August 2014

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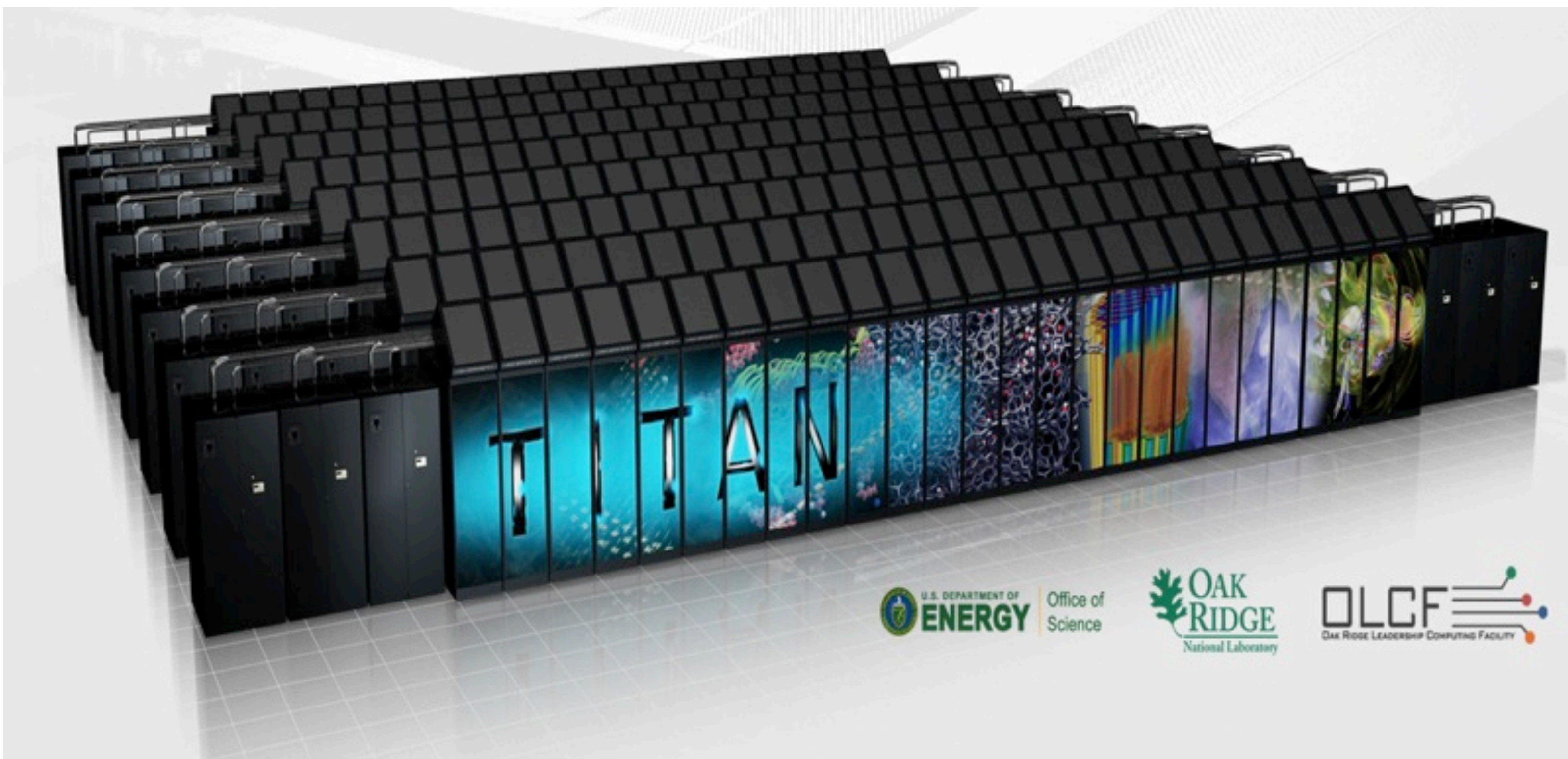
TITAN Supercomputer

Utilized resources of the Oak Ridge Leadership Computing Facility at the Oak Ridge National Laboratory, which is supported by the Office of Science of the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.



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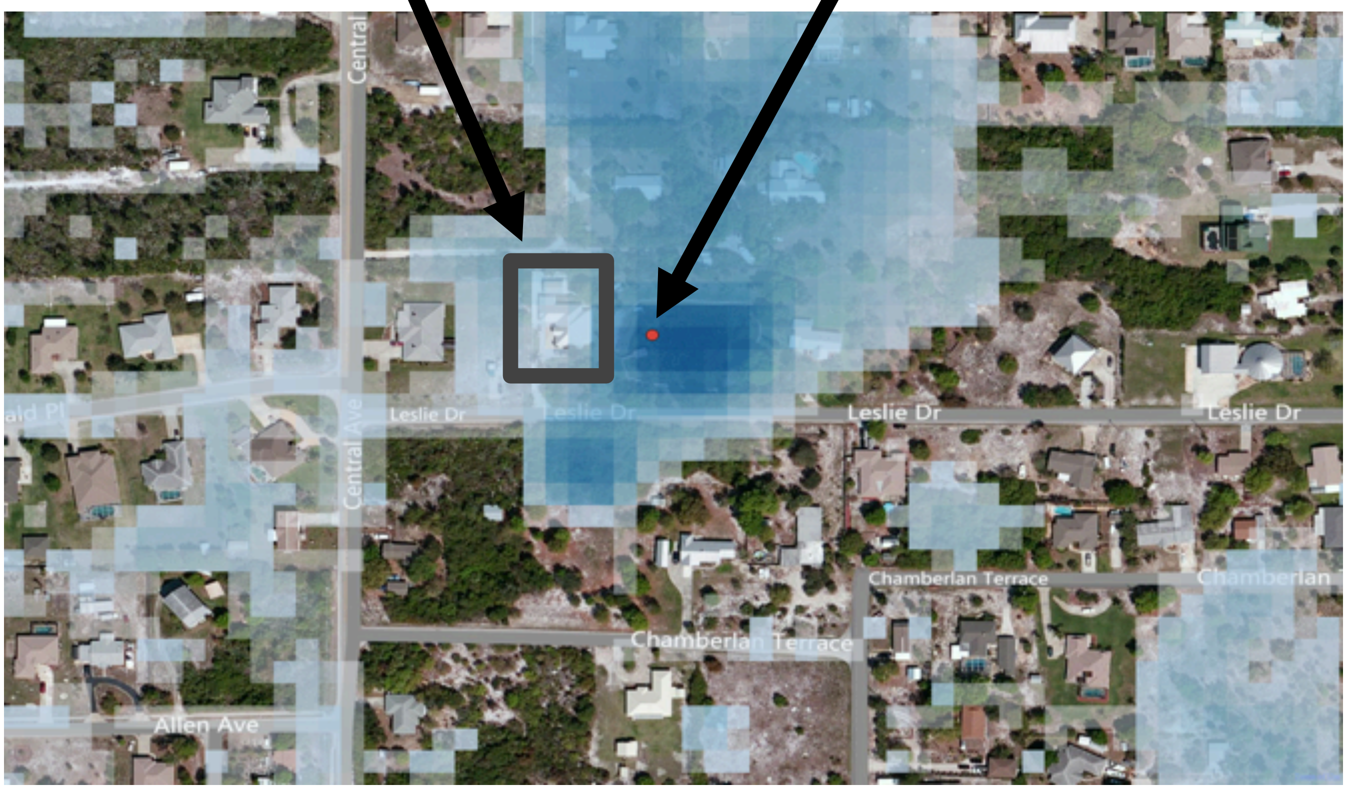
Geocoding Accuracy

Sharp gradients in flood risk put an even greater emphasis on accurate geocoding

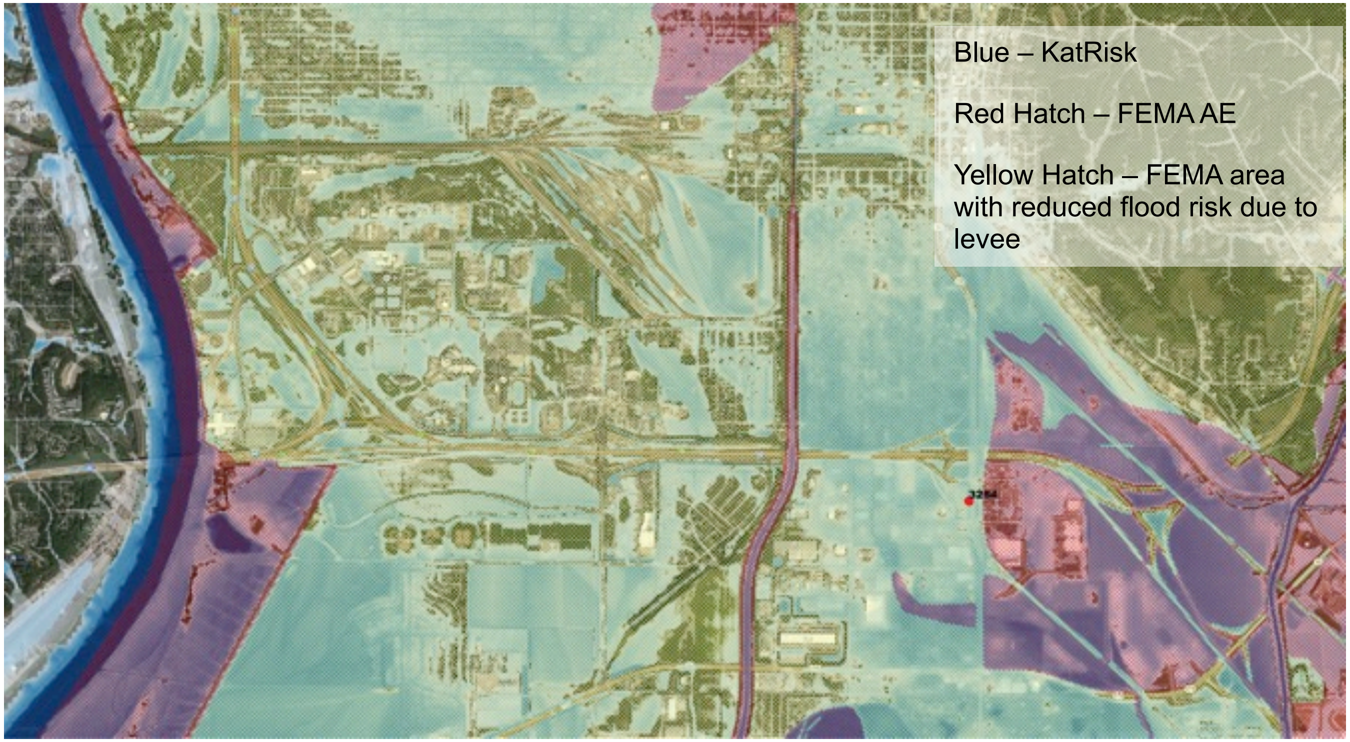
Building location

Geocoded location (pond)



Defenses

- Hazard maps do not explicitly include defenses
- However, many defenses are built up areas of earth that are in the DTM and therefore implicitly included in the hazard maps
- On FEMA maps, areas protected by levees at a 100 year return period are designated as Zone X – Area with reduced flood risk due to levee



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Defenses - Probabilistic Event Model

- In calculating losses, we include the impact of levees by assigning a probability of failure
- We have digitized on our 10m grid two sources of data to identify protected areas

USACE – Leveed Areas

FEMA Areas Designated as Protected by Levee

Mississippi River 1993 Flood

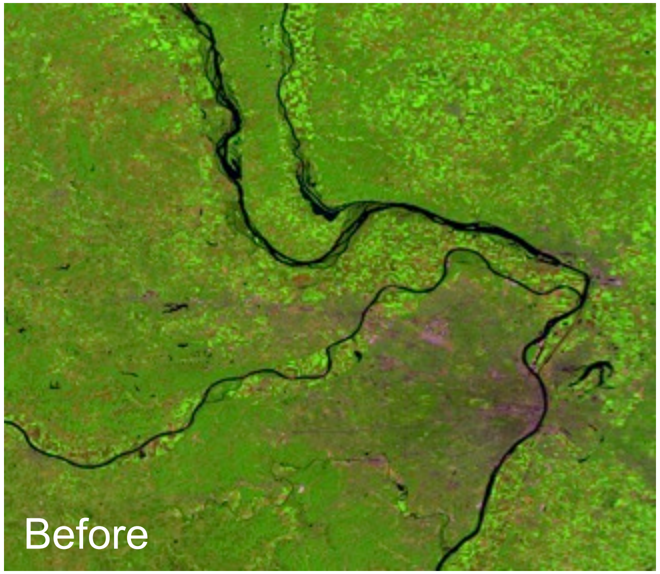
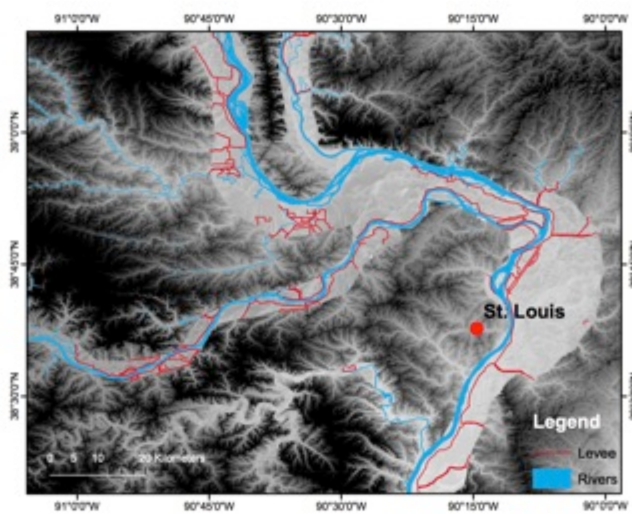
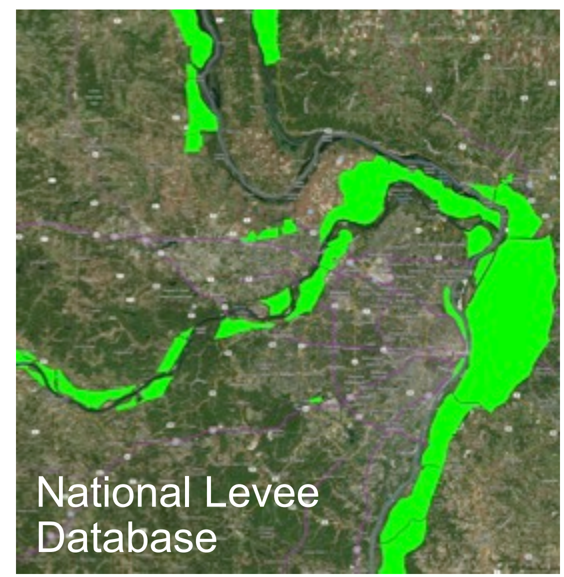


Table 2. Levee failures during the Great Flood of 1993 (from Larson, 1996).

Corps of Engineers District	Number of failed or overtopped levees	
	Federal	**Non-Federal**
St. Paul, MN	1 of 32	2 of 93
Rock Island, IL	12 of 73	19 of 185
St. Louis, MO	12 of 42	39 of 47
Kansas City, MO	6 of 48	810 of 810
Omaha, NE	9 of 31	173 of 210
Totals	40 of 226	1,043 of 1,345





Using Flood Maps (and Beyond)

Flood Hazard

- Flood depth
- Six return periods
- Relative Risk (L/M/H)
- Comparison to FEMA

Location Loss

- Multiple return periods
- Incorporation of vulnerability
- Location level AAL and EP

Event Based Portfolio Models

- Calculation of portfolio EP curves
- Capturing correlation between locations

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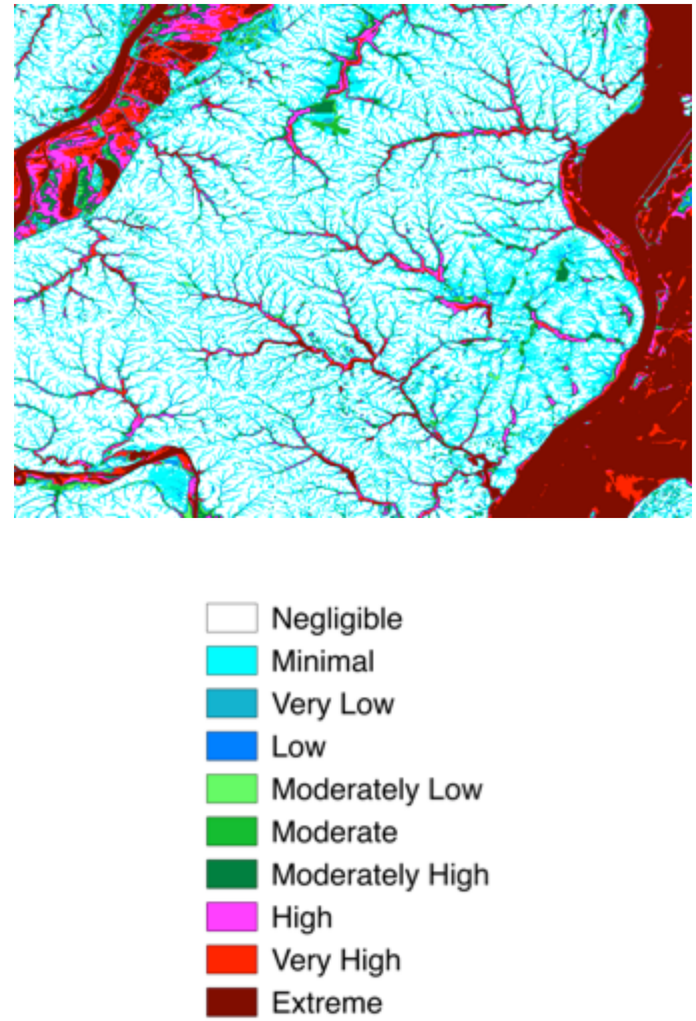
Using Hazard Data

Risk selection metrics

- Flood Depth at 6 return periods
- Presence of levees
- FEMA zone designation

Ambler, PA May 2014

Relative Risk Score



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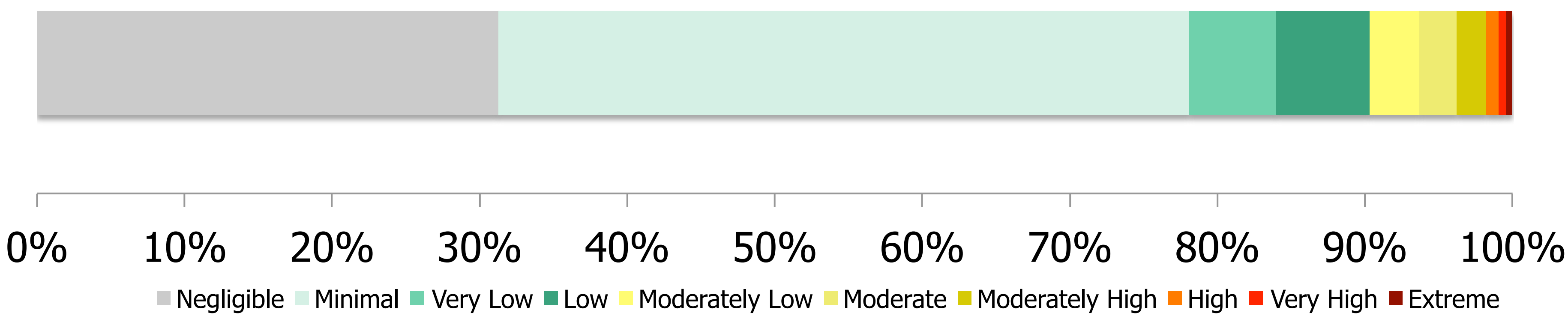
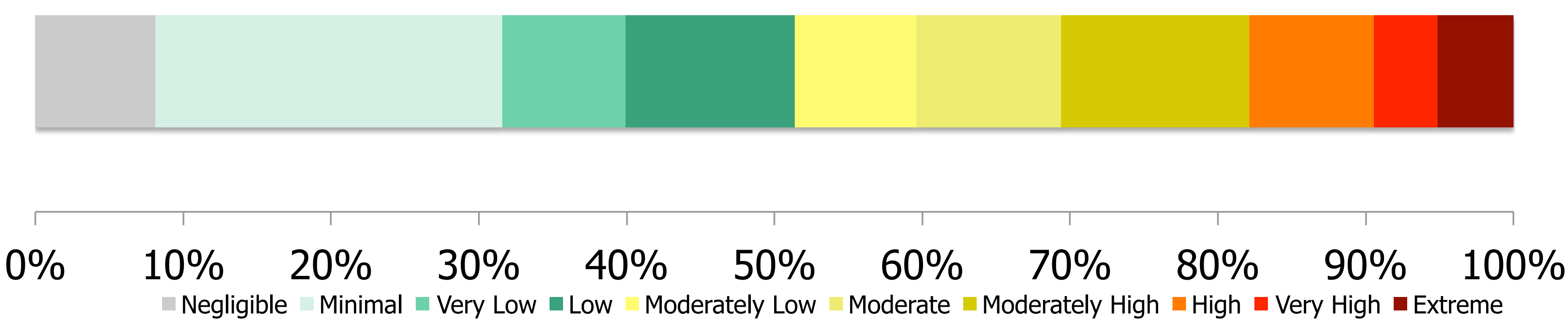
Portfolio Risk Analytics

Low/Moderate Risk Portfolio



High Risk Portfolio – over ½ in FEMA A Zones



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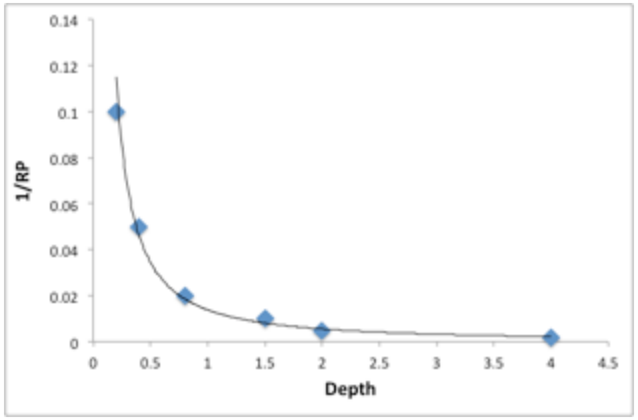
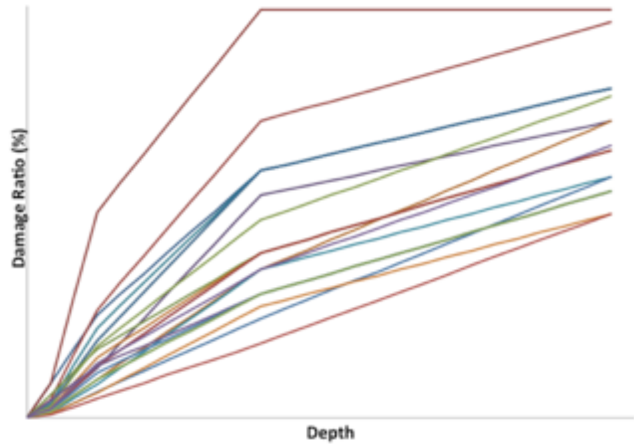
Location Loss Metrics

- Multiple return period hazard



- Vulnerability
  - Occupancy
  - Construction
  - Number of Stories
  - Limits/Deductibles
  - …



- Location AAL and EP
- For a demo: http://www.katrisk.com/analytics/

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Event Based Portfolio Models

- Starting this year, KatRisk is developing event based probabilistic models that are consistent with flood hazard maps
- Covering all sources of flooding within a correlated event set
  - Inland flood
  - Explicit modeling of tropical cyclone rainfall and storm surge (along with wind)
- Representing correlations in space and time of weather and climate events
- Having a flexible modeling framework that allows for the inclusion of climate change scenarios and forecasting

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Summary

- Understand what is included in a flood model
  - Modeling approach – 1D vs 2D
  - Riverine (fluvial) flooding and/or Surface Water (pluvial) flooding
  - Is tropical cyclone rainfall included
  - Resolution and basis of the underlying digital elevation model
- Using flood maps
  - Flood depth by return period
  - Relative risk scores
- Beyond hazard maps
  - Location Average Annual Loss Metrics
  - Event Based Probabilistic Models

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