# Modeling Community Resilience: Update on the Center for Risk-Based Community Resilience Planning and the Computational Environment IN-CORE

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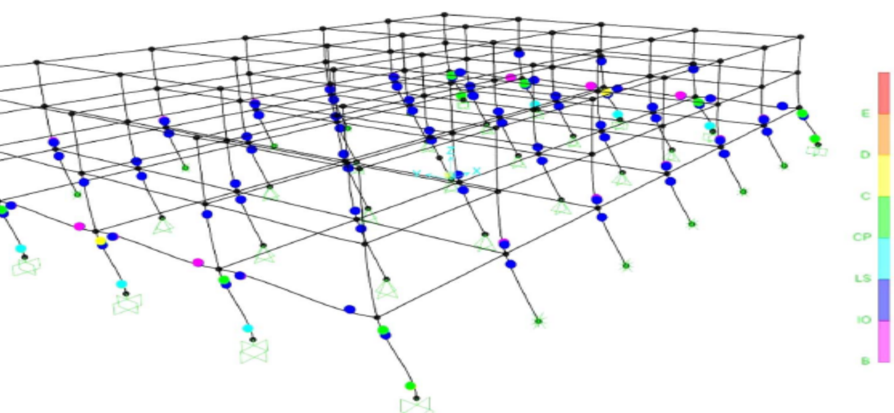
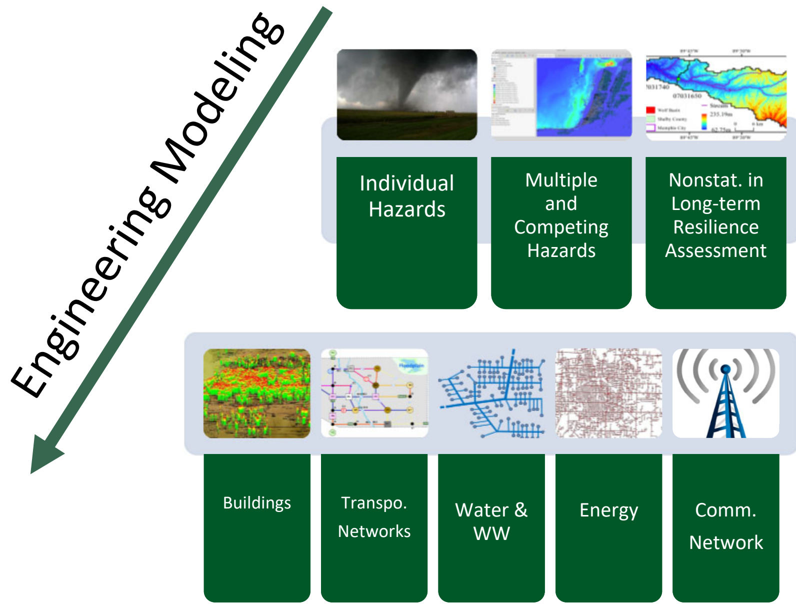



- Damage to physical infrastructure
- Loss of function
- Performance of mitigations

Social Science and Economic Models


- Vulnerable populations
- Services availability
- Population dislocation
- Business disruption
- Planning

Engineering Modeling

Community Resilience

Social Science and Economic Models

**1: IN-CORE**

disciplinary computational environment with
tegrated supporting databases: "The
pendent **N**etworked-**Co**mmunity **R**esilience
ng **E**nvironment".

**2: Data Management Tools for Community**
**nce Systems**

dardized data ontology, robust data architecture,
ective tools to support IN-CORE.

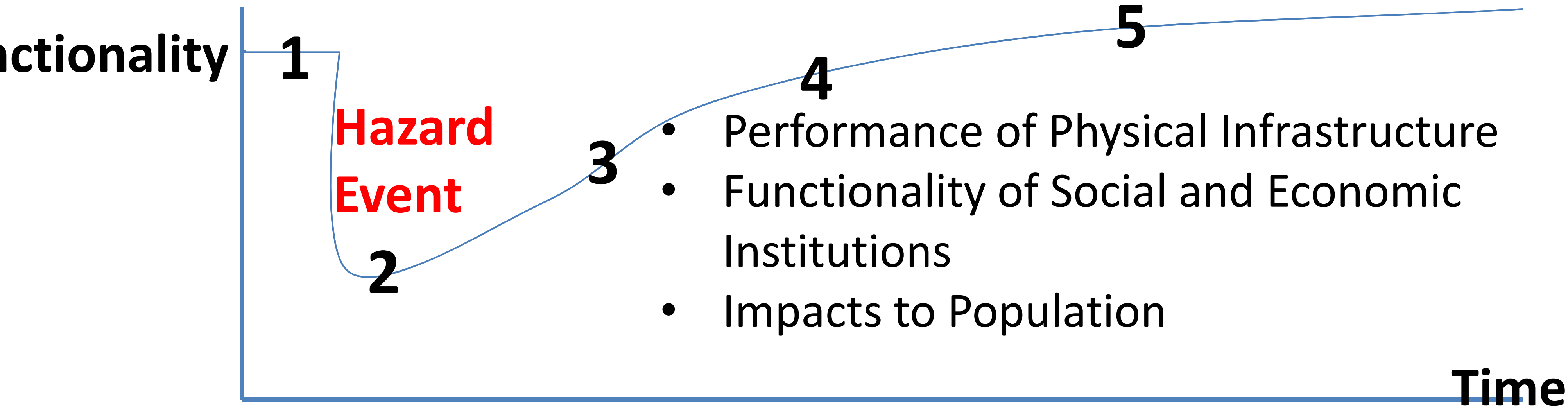
**3: Resilience Data Architecture Validation**
**s**

sts and forecasts to test the data collection
s and its integration into IN-CORE. Validate
and decision algorithms; field studies.

| Centerville | Seaside Oregon | Memphis TN, MSA | Galveston, TX Hurricane |
|---|---|---|---|
| EQ<br>Tornado | EQ<br>Tsunami | EQ<br>Flood | -Surge<br>-Waves<br>-Wind |

ce

# Stages of Resilience




**urrent state**
- Existing vs. Desired
- Performance
- Dependencies

**2. Immediate damage**
- Loss of Life/Injury
- Physical Damage
- Loss of Function
- Decision Support

**3-5. Recovery Stages**
- Social and Economic
- Repaired Damage
- Recovered Functions
- Decision Support

# Significant Features of IN-CORE

lodular in nature

- Embedded (library or core modules)
- User-supplied modules

tilizes the Jupyter Notebook - script in Python

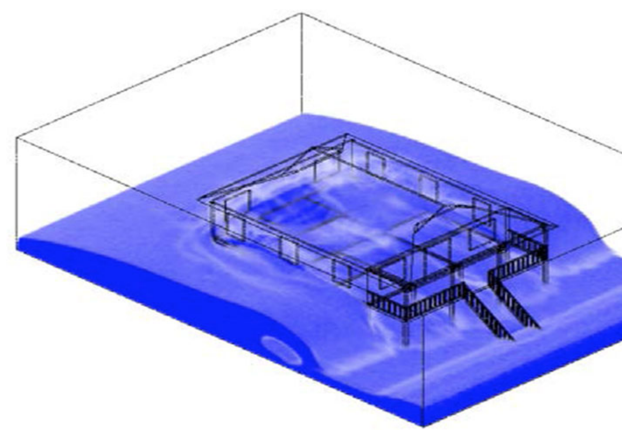
exibility in analysis, depending on analysis objectives

- Assessment of community performance
- Comparison of alternatives for enhancing community resilience
- Development of optimal strategies for enhancing community resilience

'isualization and risk communication of decision lternatives

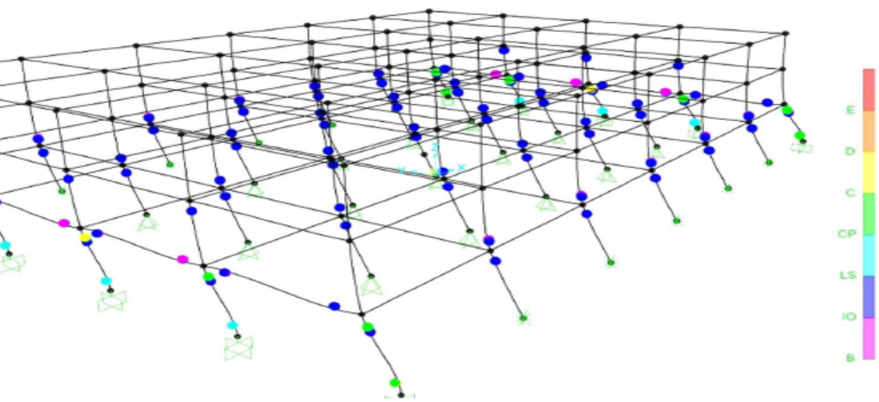
Resilience IN-CORI

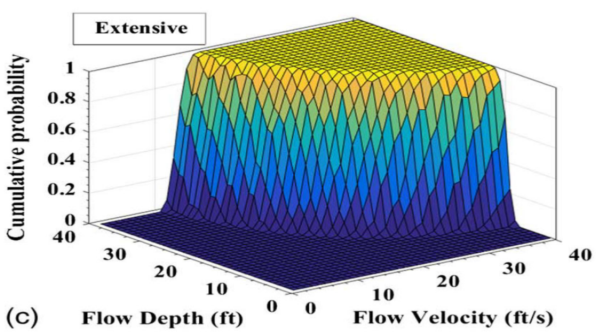
This work is developed by Center for Risk-Based Community Resilience Planning, NIST Center of Ex



# ne examples of new additions to fragilities

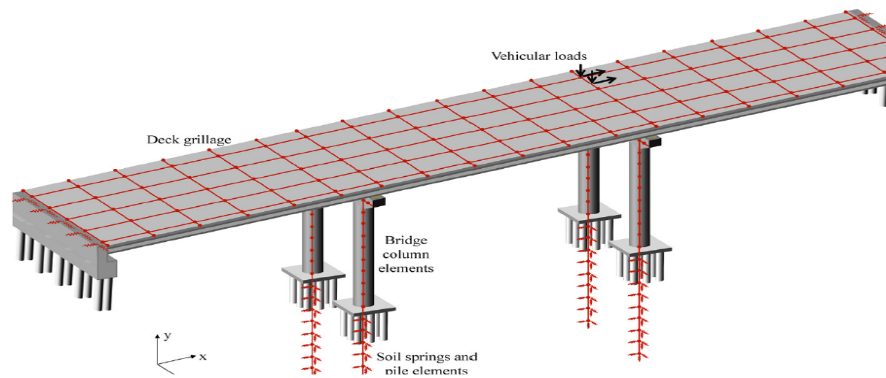
## Building – Tsunami

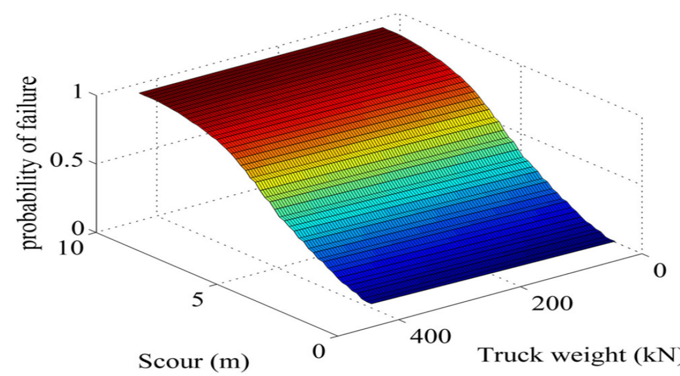



Attary and van de Lindt et al. 2017

## RC Bridge – Scour Flooding




Kameshwar and Padgett 2018

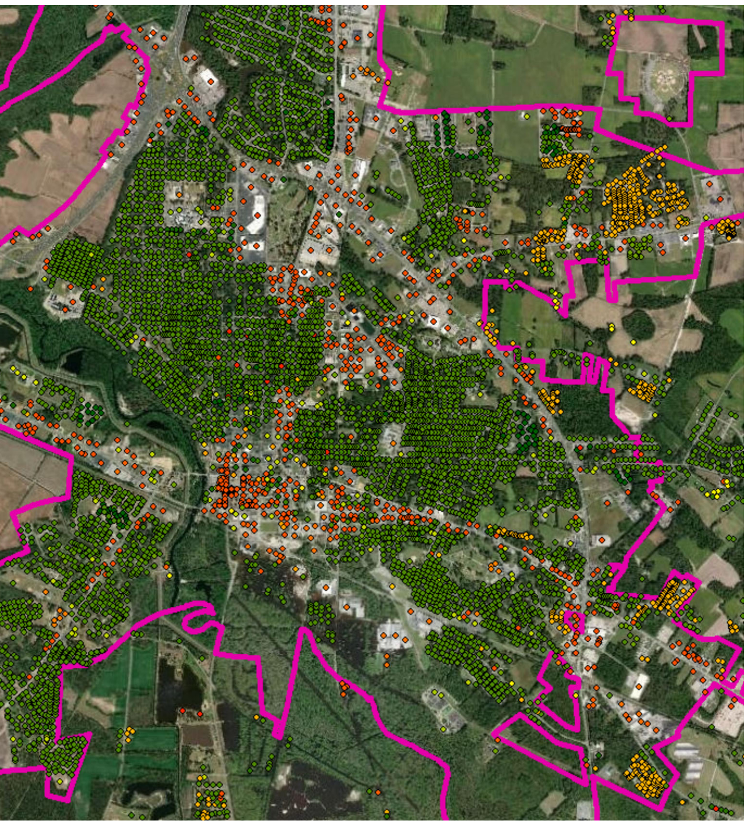
# Physical
# astructure I

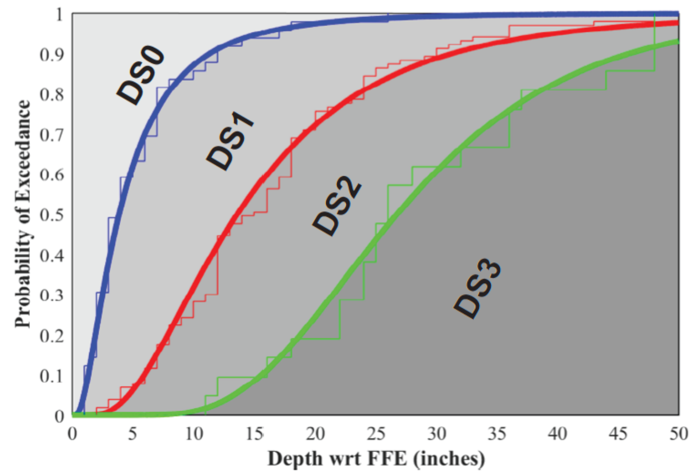
GIS datafile with building locations

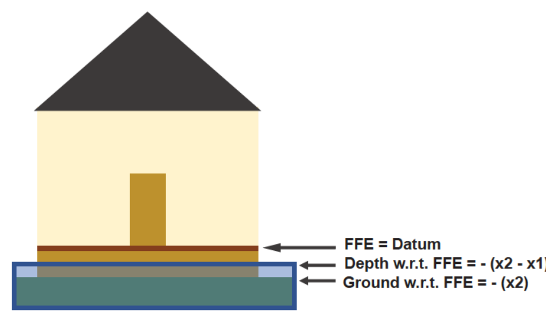
Layers with attributes:

Damage fragilities

Interdependen description






$$\mathbf{A} = \begin{bmatrix} \mathbf{A}^{(WN)} & \mathbf{A}^{(W} \\ \mathbf{A}^{(EPN,WN)} & \mathbf{A}^{(} \end{bmatrix}$$

Nofal et al, 2018

Lumberton Report – Wave I

Guidotti et al, 2016

# vo hazard tiers

**r 1 Research Tools:** Executed completely within IN-
ORE.

**r 2 Research Tools:** Will run in IN-CORE but import da
the hazard portion of the analysis, e.g. a wind field shap
from an outside software (or other) source, overland sur
v from ADCIRC, etc.

# Scenarios

**Earthquakes Tier 1**
- Rupture
- Magnitude
- Distance
- Depth

**Earthquakes Tier 2**
- 3-D physics-based
- Seismic wave propagation
- Example MMSA

- **Windstorms – Tier 1**
  - 3-sec wind gust over specified region

- **Tornado – Tier 1**
  - Statistical representations
  - Historical estimated wind field from an event

- **Hurricane: Wind, Wave, and Surge – Tier 1**
  - Data-driven wind field models from past hurricanes
  - USACOE Coastal Hazard System

- **Hurricane: Wind, Wave, and Surge – Tier 2**
  - ADCIRC, SWAN
  - Surrogate Models

# enarios

**UI Fire – Tier 1**
- Propagation in wildlands using CA
- Propagation inside a community

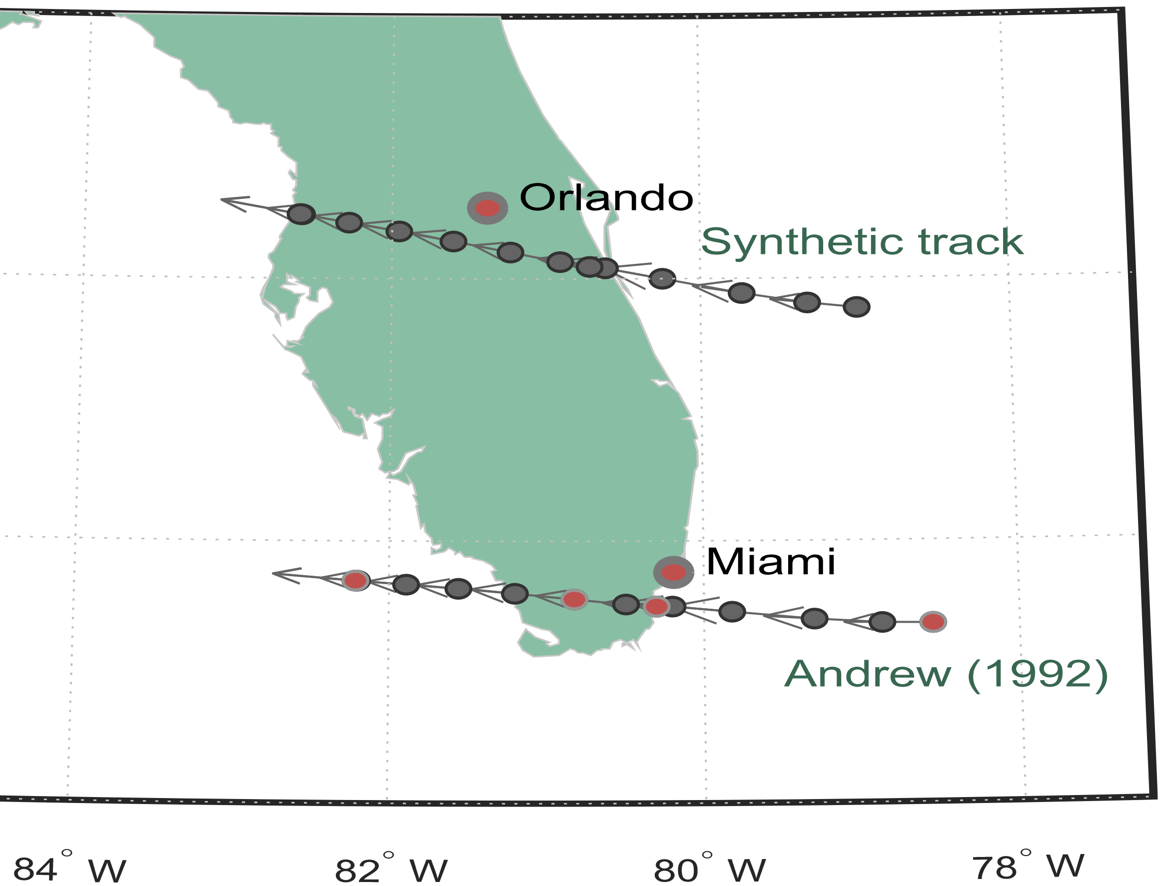
**unami – Tier 1**
- ASCE 7 Procedures

**unami – Tier 2**
- Time dependent numerical model
- Specified bathymetry and bare-earth topography

- **Flood – Tier 1**
  - NFIP Maps
  - Flood depth w/o velocity

- **Flood – Tier 2**
  - Fluvial (riverine)
  - Pluvial (excessive precipitation)
  - Coastal (sea level rise)
  - Example will be available for Wolf River basin in Shelby Co., TN

# Tier 1 Example in IN-CORE: Simulation of Synthetic Hurricane




## User inputs:

- model='Andrew'; (different models are available in Table 1)
- resolution=desired spatial resolution [ km] (default: 6)
- TransD=Initial direction of hurricane he [unit: degree];
- Landfall location=[long lati];

## Outputs:

- Synthetic track
- Simulated wind field
  (maximum 1-min sustained surface wind speeds at a height of 10 m over open terrain and open water) – Convert to 3- sec gu

# Hurricane Suite available in IN-CORE

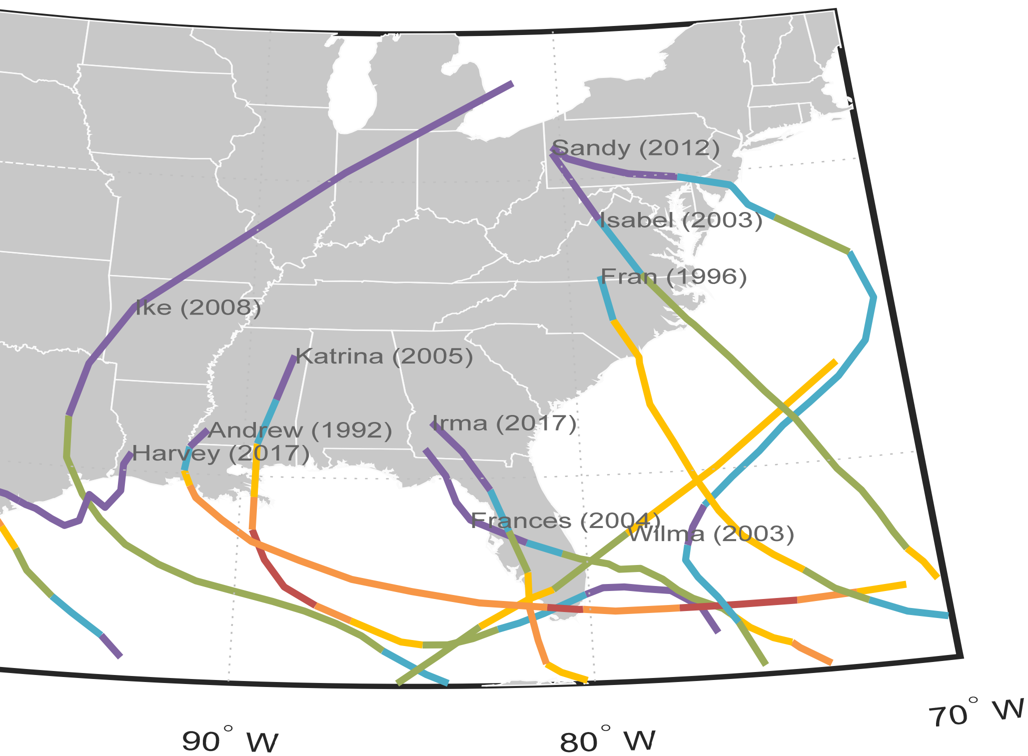



Table 1. Model Name

| CAT | Gulf Coast | Florida | Eas |
|---|---|---|---|
| 1 | **'Katrina'** | **'Katrina2'** | **'S** |
| 2 | **'Ike'** | **'Frances'** | **'Is** |
| 3 | **'Katrina'** | **'Wilma'** | Fran |
| 4 | Harvey (2017)* | Irma (2017)* | |
| 5 | - | **'Andrew'** | |

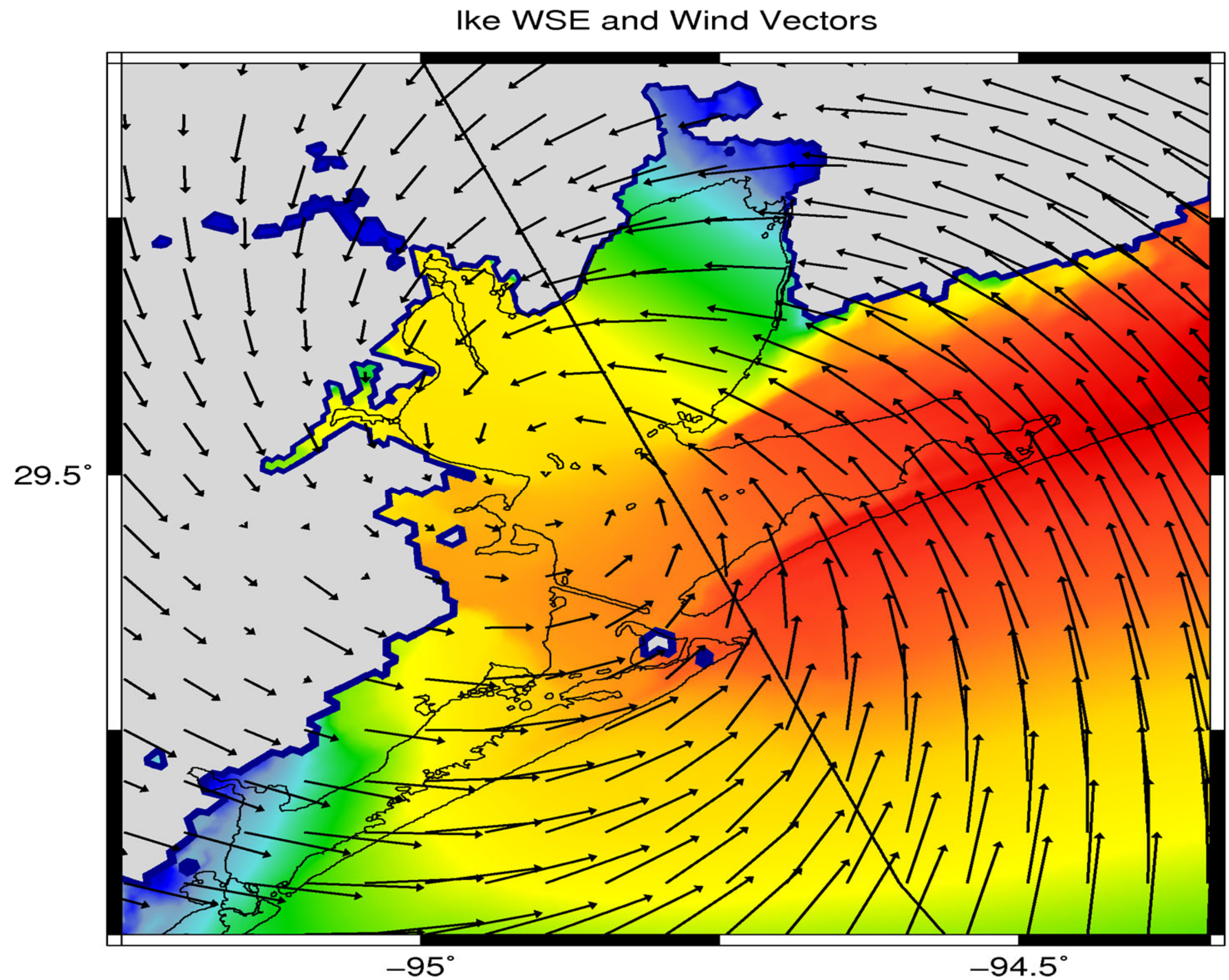
*Note: Models are currently not available for these events due to lack of data

# Tier 2 Example in IN-CORE: Simulation of Wind, Wave, Surge

ater levels and wind vectors

mplete hindcast of Hurricane Ike has
en completed and all pertinent
ensity measures are available

nilar model results are also available
 20-yr, 100-yr, and 200-yr return
riod hurricanes. Samples of flood
undation depth) rasters are available
 use in IN-CORE



# 2 Example for Earthquake: MMSA testbed

model consists of about 7M spectral elements

del features

nodel of the fault system and the rupture mechanism

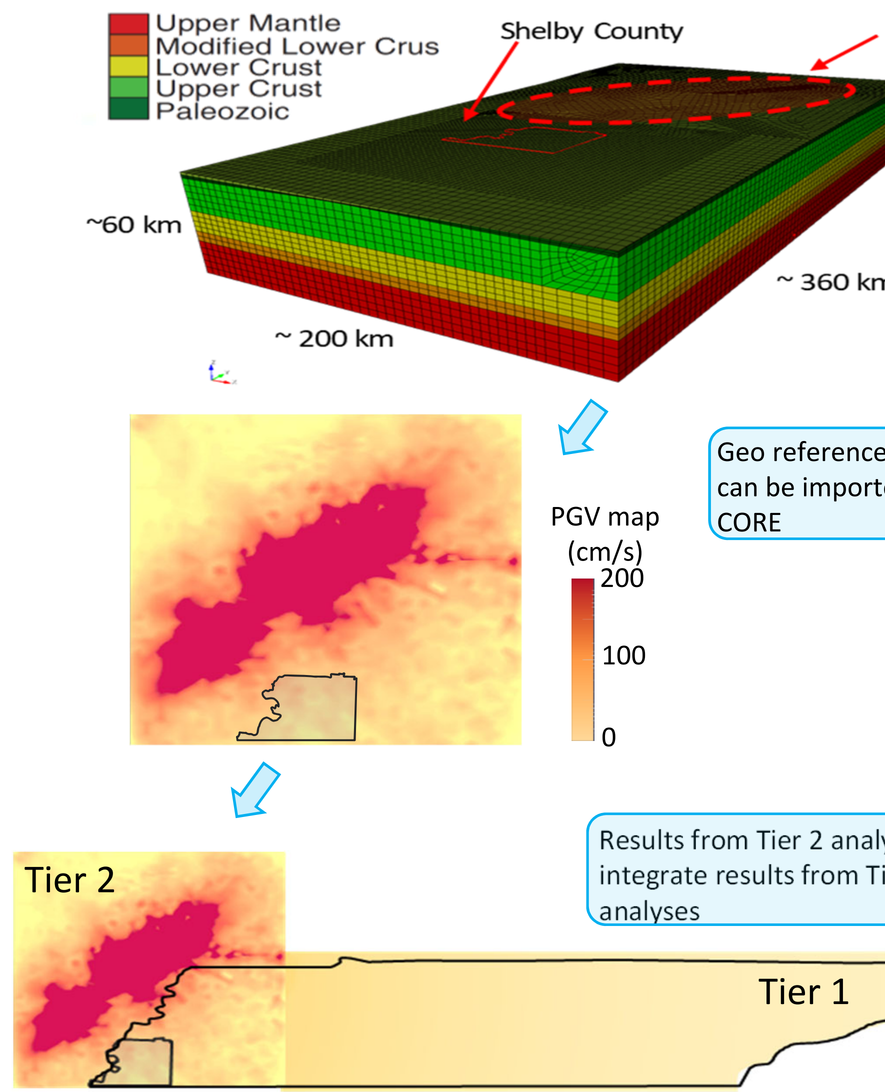
orizontally layered deep geological structure

accurate description of the topography of the thick layer of
diments beneath the MMSA

per 16, 1811 New Madrid earthquake

cluding peak ground values of acceleration, velocity, displacement
ctral acceleration at different periods) can be imported in IN-CORE
referenced raster file (e.g., TIFF format)

ping a surrogate model using the data from the Tier 2 analyses that
be included in IN-CORE




n, S., and Gardoni, P. "Simulation of seismic wave propagation in the Metro Memphis Statistical Area (MMSA)". *Seismological Research Letters* (in preparation).

# rdependent al System cription

**IN-CORE Present**

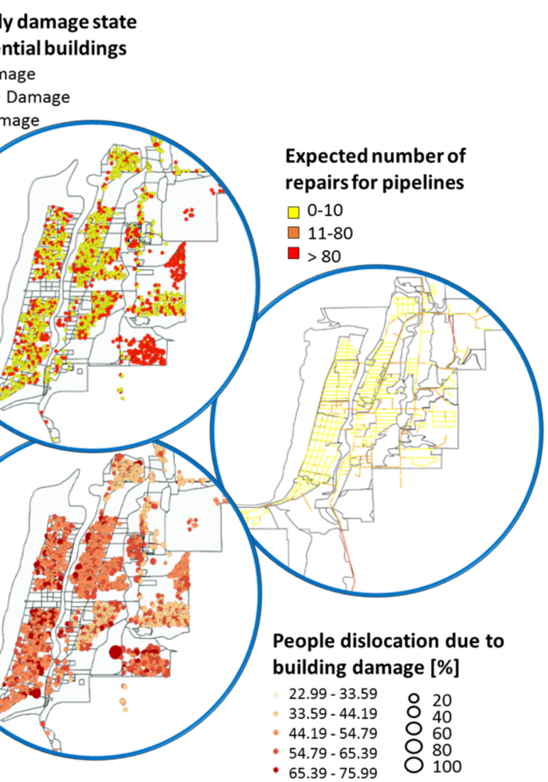
- Population Inventory
- Stochastic Merge ▼
- Building Inventory

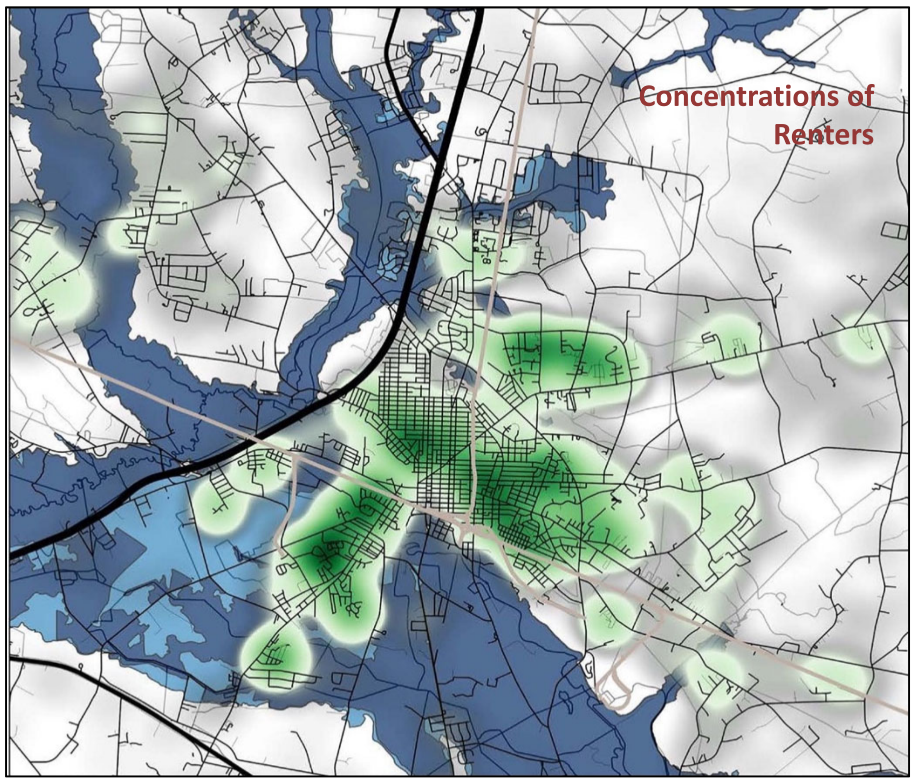
**IN-CORE Future**

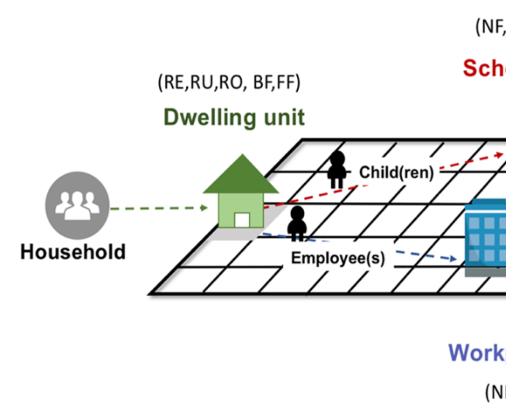
- Jobs Inventory ▼ Building Inventory
- Social Needs Inventory ▼ Social Institution Infrastructure

**Example of S Institution**

- School Ag Populatio ▼
- School Inver
- Health Care ▼
- Hospita



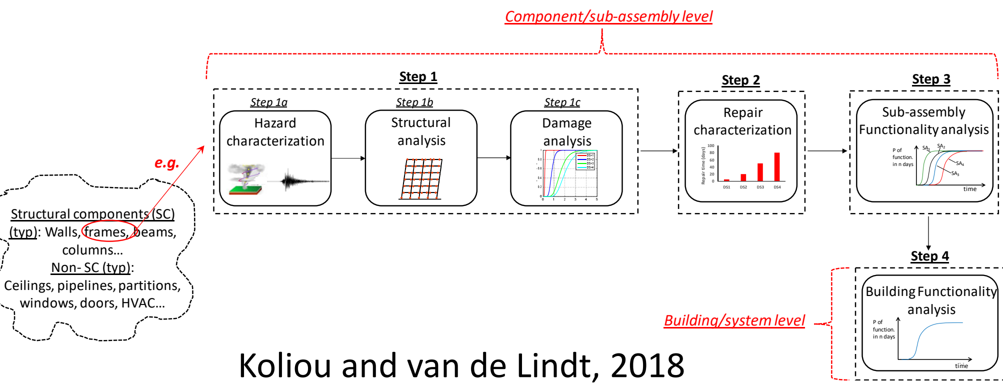



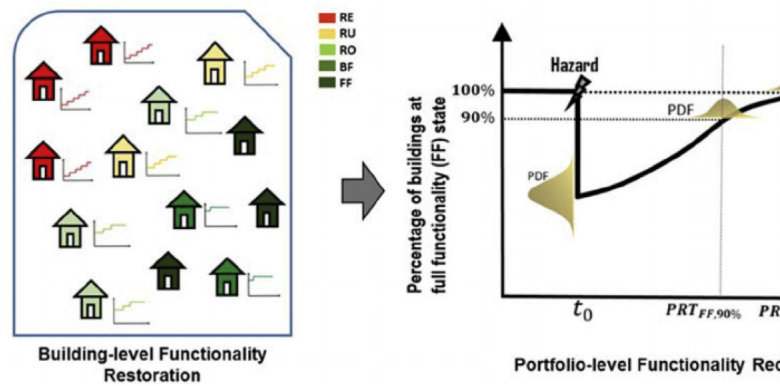


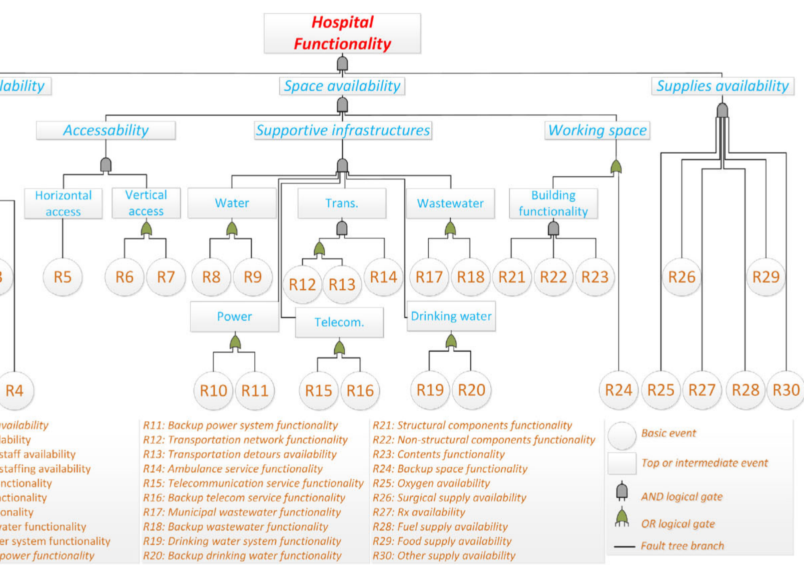

Guidotti, Rosenheim & Gardoni 2018 Lumberton Report – Wave I Lin, Rosenheim, Wang, Peacock & Hu

# Functionality and Recovery Modeling: Some Examples




Koliou and van de Lindt, 2018




Hassan and Mahmoud, 2018

| Functionality States (ATC Placard) | | | Damage Condition | Utility Availability | Building Repair Class | & Specific Repair I |
|---|---|---|---|---|---|---|
| 5 | FF | Fully Functionality (Green Placard) | None | All available | N/A | |
| 4 | BF | Baseline Functionality (Green Placard) | Minor cosmetic structural and nonstructural damage | Critical ones available | Repair Class 4 (RC4) | • Minor structural dama shear wall, link beam wall; Minor nonstructu such as stairs, partitio |
| 3 | RO | Re-Occupancy (Green Placard) | Minor to moderate structural and nonstructural damage | Unavailable | Repair Class 3 (RC3) | • Minor structural dama moderate nonstructur Mechanical equipmer systems, emergency |
| 2 | RU | Restricted Use (Yellow Placard) | Moderate structural or nonstructural damage that does not threaten life safety | N/A | Repair Class 2 (RC2) | • Moderate to heavy no damage such as glaz partitions, elevator, pi sprinkler drops |
| 1 | RE | Restricted Entry (Red Placard) | Extensive structural or nonstructural damage that threatens life safety | N/A | Repair Class 1 (RC1) | • Heavy structural dam Heavy nonstructural d that threatens life saf |

Lin and Wang, 2017

# Please mark your calendars and join us on May 1, 2019 for a NIST Center Webinar on Risk-Informed Decision for Community Resilience

Resilience

Center for Risk-Based Community Resilience Planning

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# hank you.

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ous researchers with the Center of Excellence contributed to the contents of this presentation and a ou is due to everyone affiliated with the Center for Risk-Based Community Resilience Planning.

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