Disaster & Failure Studies Updates on Enhancing the Readiness of Teams

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NIST's Disaster and Failure Studies Program

Statutory Thrust

- Evaluate hazard events against deployment criteria
- Manage identification, vetting, and onboarding of NCSTAC members
- Develop agenda, manage logistics, and set frequency for NCSTAC meetings
- Create annual NCST reports to Congress
- Coordinate statutory activities across programs related to disasters.
- Conduct field studies under various authorities

Procedures Thrust

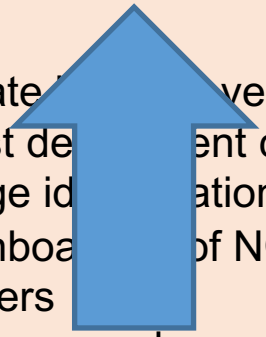
- DFS Standard Operating Procedures
- HOT Team membership, training, and credentials
- Field and safety protocols
- Human subjects protocols
- Manage equipment for disaster metrology and personnel protection
- Data preservation, security, and management
- Field tools (NDA's, permissions, survey instruments)
- MOUs with other agencies, academics, and others
- NIST Disaster Working Group

Research Thrust

- Research program focused on disaster metrology, including structural performance and social sciences
- Coordinate research activities with NIST EL Groups, Disaster Statutory Programs, NIST EL Divisions, and other NIST Labs
- Coordination with the Center of Excellence of Risk-Based Community Resilience Planning on field studies
- NSF/NIST Disaster Resilience Research Grants Program
- Outreach and dissemination

NIST's Disaster and Failure Studies Program

Statutory Thrust



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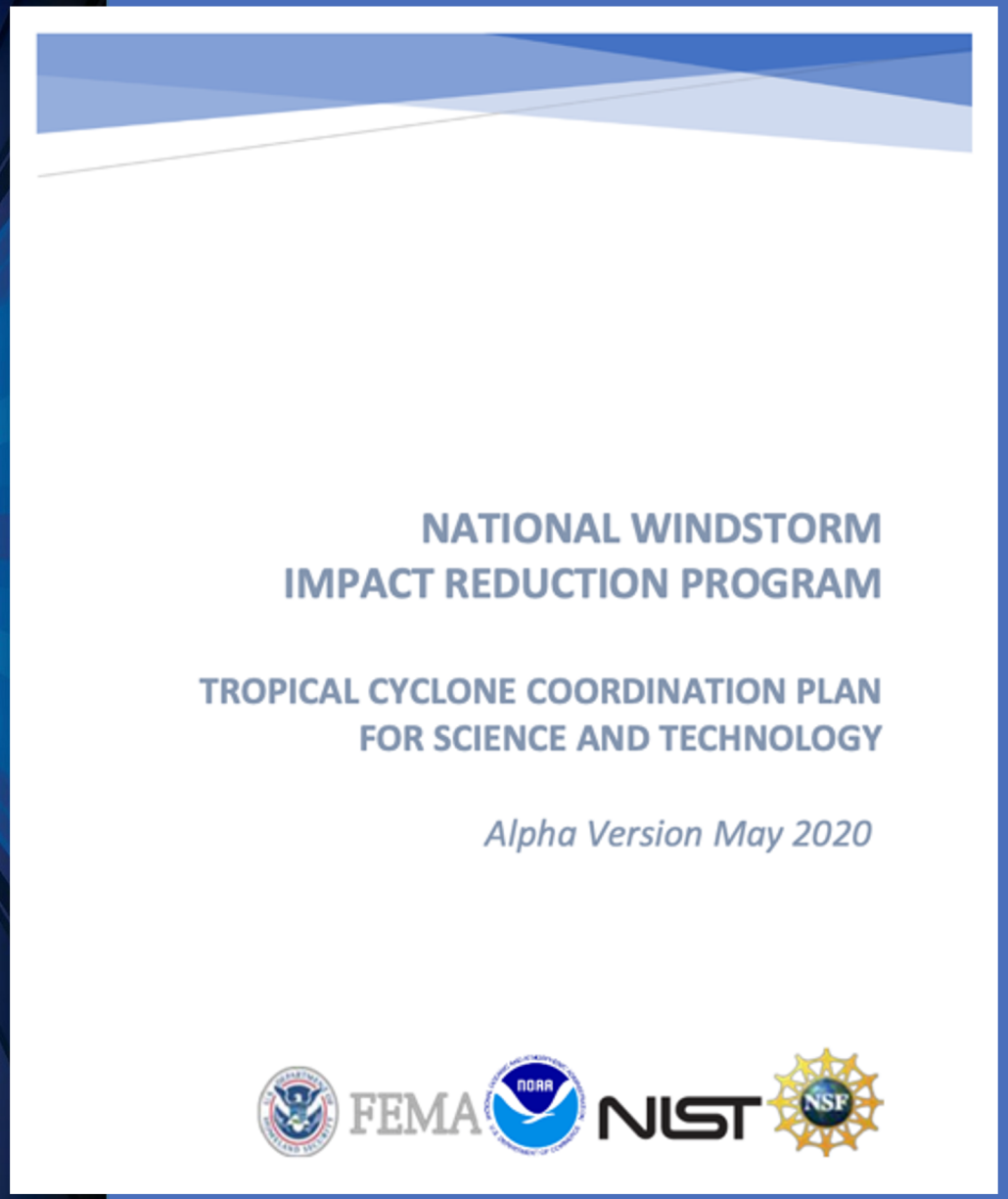
Events Scoring

**NIST deployed a team*	**Disasters Scored Oct 2020 – June 2021**		
Date	Event	Event Consequence Score (max=5.0)	Evacuation & Response Score (max=5.0)
12/17/2020	Arecibo Observatory Collapse	3.0	1.0
1/14/2021	Sulawesi Indonesia Earthquake	3.3	4.0
1/25/2021	Fultondale, Alabama Tornado	2.0	1.5
1/27/2021	Tallahassee, Florida Tornado	0.8	0.5
2/17/2021	Texas Winter Storm	3.4	3.0
3/26/2021	Southeastern US Tornado Outbreak	2.7	1.3

NWIRP Coordination Plan for Tropical Cyclones



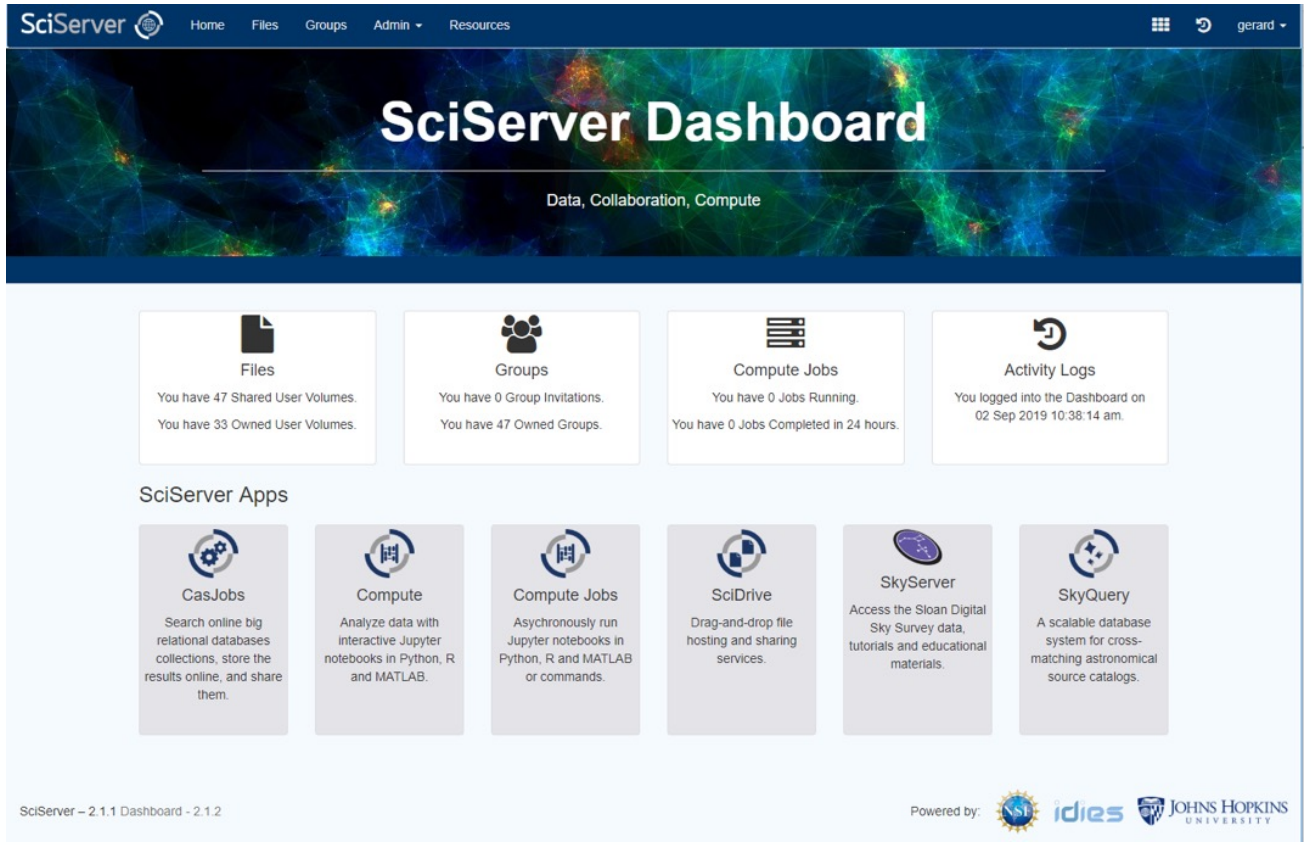
- Plan provides an overview of relevant agency activities in the pre and post windstorm space.
- Detailed agency roles and responsibilities for information sharing as a function of temporal phases
  - Phase zero (- 2 weeks to zero hour)
  - Phase 1 (Event Occurrence – Two Weeks)
  - Phase 2 (Two Weeks – Two Months)
  - Phase 3 (> Two Months)
  - *Extent of agency activities are dependent upon phase relevance*
- Data Dissemination
- Plan Revision Process

NIST SciServer: Collaborative Science Platform

NIST-JHU PREP Project

- Project Goal: add computer science capacity to NIST disaster statutory programs via the NIST's Professional Research Experience Program (PREP)
- NIST Associates: Prof. Alex Szalay, Dr. Gerard Lemson, and Dr. Arik Mitschang
- Project Scope: adopt data semantic standards and foster interoperability between other disaster repositories; design a public database that can easily be managed by NIST; combine traditional data management and access services with computing resources (e.g., Python and R).

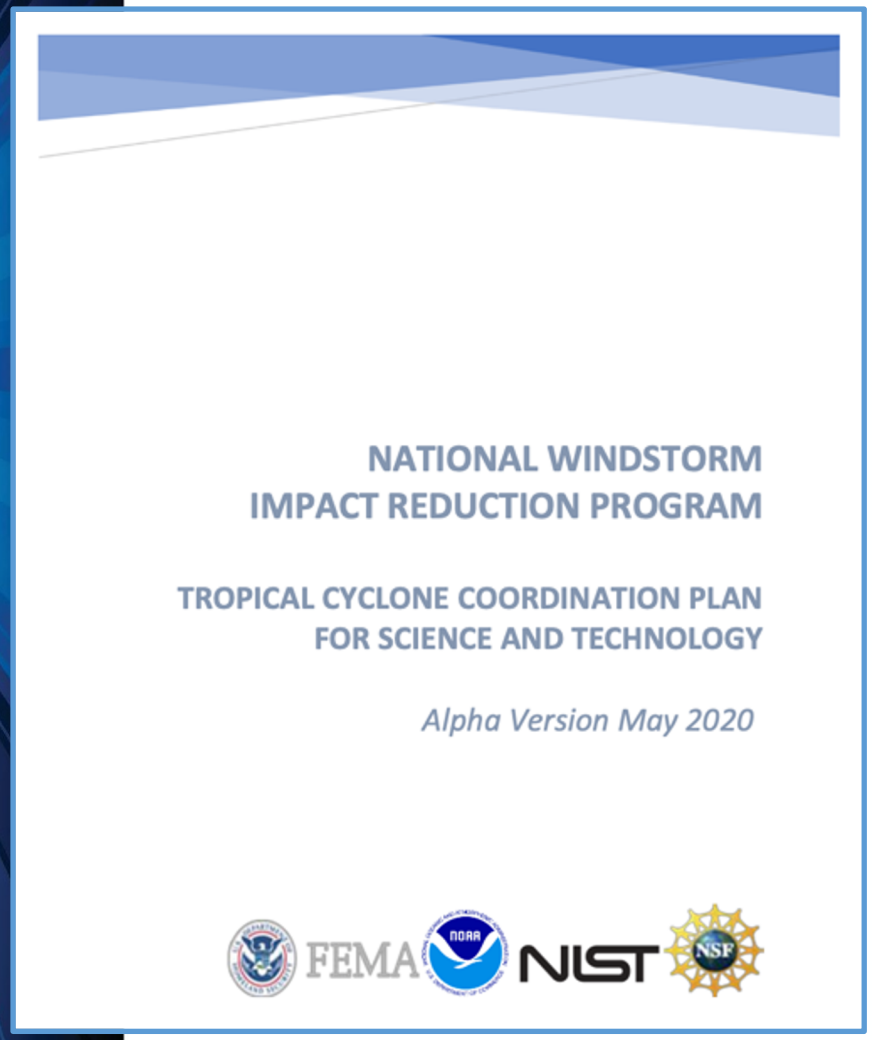
SciServer is a system allowing scientists and researchers across multiple domains to host and share their datasets and provide query and analysis tools for collaborative work.

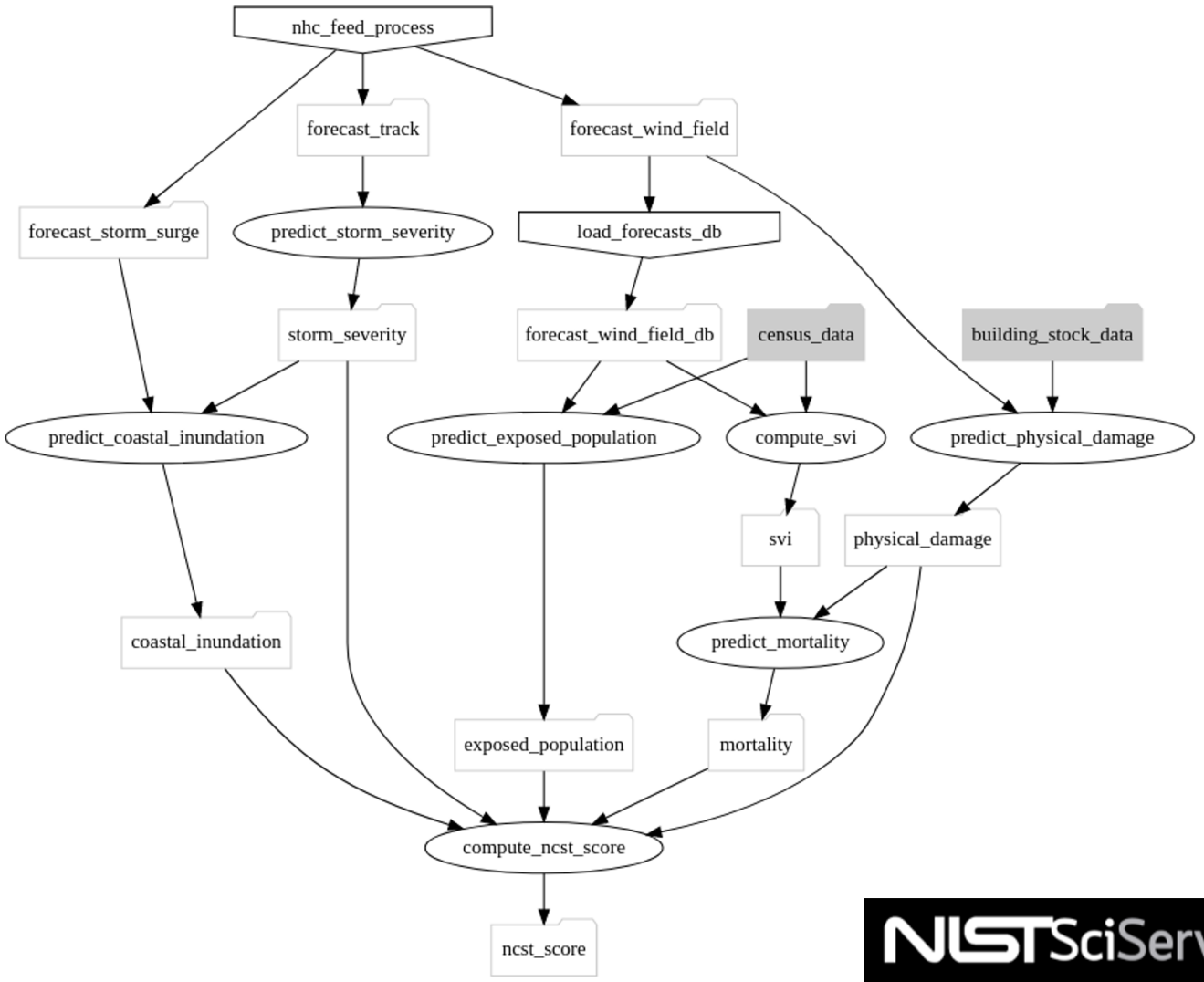


http://www.sciserver.org/
(with permission from Prof. Szalay)

Automated Event Scoring: SciServer example (1/8)

Implementation of coordinated activities across disaster statutory programs for NCST event scoring: fully automated workflow to calculate “Event Consequence” score during NWIRP’s *phase zero*





NIST SciServer

Automated Event Scoring: SciServer example (2/8)

Implementation of coordinated activities across disaster statutory programs for NCST event scoring: fully automated **Hazard and/or Failure Intensity** score during NWIRP's *phase zero*

Hurricane Michael's NCST Score Sheet

1.0 Event Consequence			
	Low	Medium	High
A. Mortality			
Facility context	0	1 to 2	>2
Community context[1]	0 to 3	4 to 9	>10
Regional context[2]	0 to 5	6 to 19	>20
B. Exposed Population			
Facility context	<100	100 to 499	≥500
Community context	<1 000	1 000 to 9 999	≥10 000
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C. Hazard and/or Failure Intensity			
Earthquake	≤ MMI IV	MMI V to VII	≥MMI VIII
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Fire Spread in Structures	Fire spread not beyond area of origin	Fire spread throughout a structure	Fire spread beyond structure of origin
Wildland Urban Interface Fire (WUI)	High Forest Service Fire Danger Rating	Very High Forest Service Fire Danger Rating	Extreme Forest Service Fire Danger Rating
Blast	< 99 lbs. TNT-equivalent	100 - 999 lbs. TNT-equivalent	> 1000 lbs. TNT-equivalent
Impact	< 1 x 10^6 ft lb/sec	1 x 10^6 to 1 x 10^7 ft lb/sec	> 1 x 10^7 ft lb/sec
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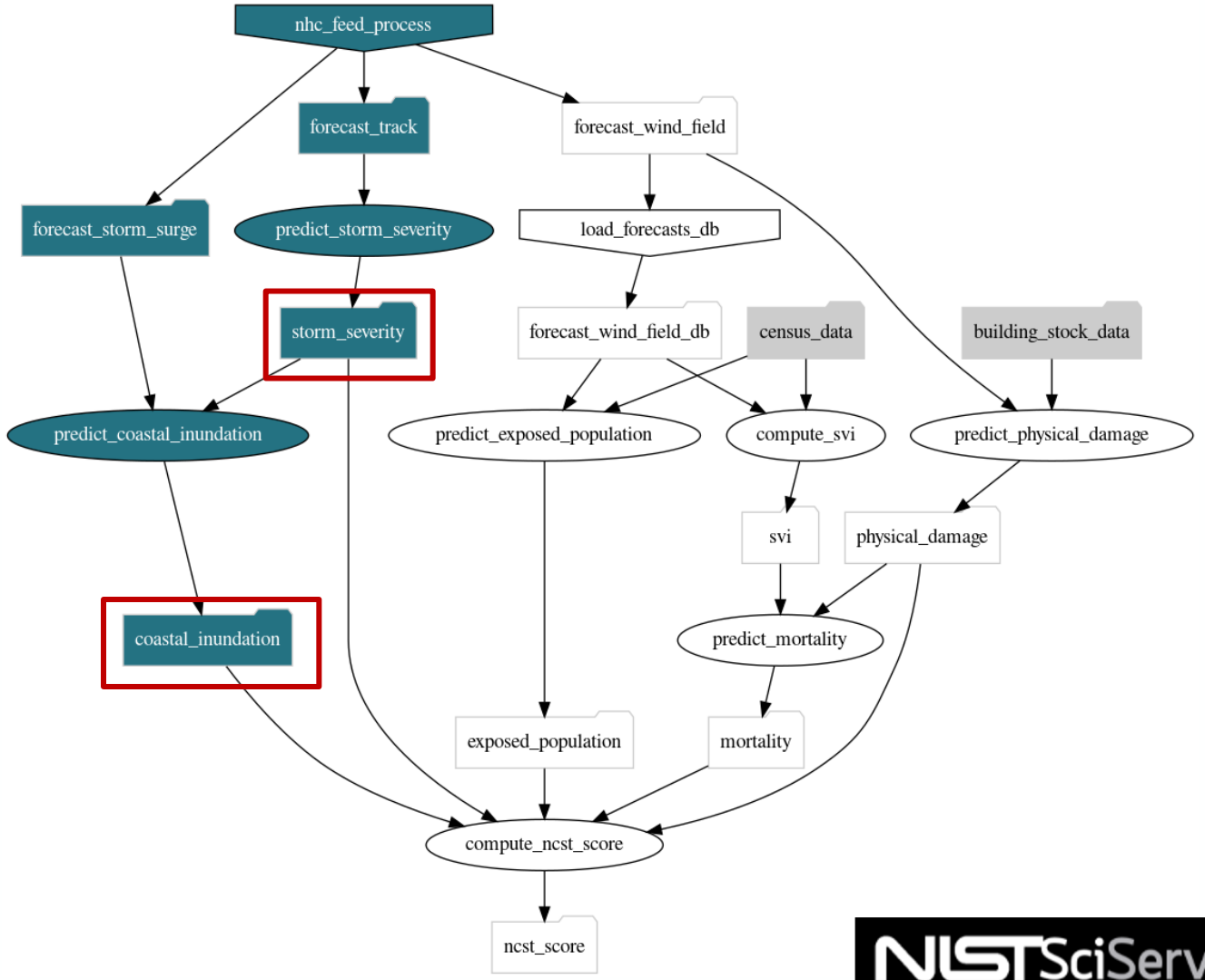
Count x Weight:	0 x 1 = 0	2 x 3 = 6	5 x 5 = 25
Event Consequence Score:	**31/7 = 4.43**		



Automated Event Scoring: SciServer example (3/8)

Implementation of coordinated activities across disaster statutory programs for NCST event scoring: fully automated **Hazard and/or Failure Intensity** score during NWIRP's *phase zero*

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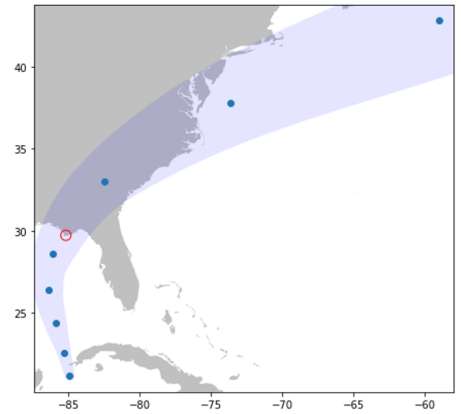

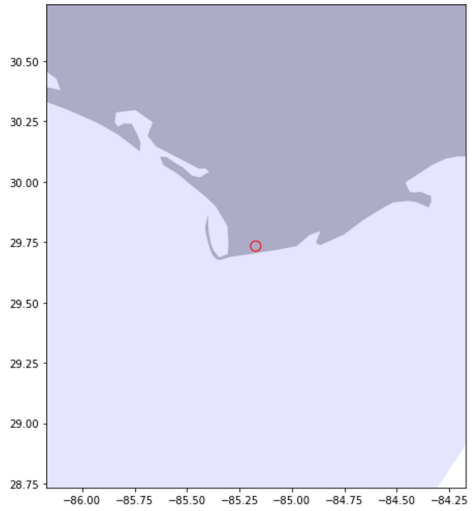

In [31]:

```
html = ''
if len(points_in_land) != 0:
    from IPython.core.display import HTML
    CAT_MAP = pd.DataFrame({
        'min': [0, 64, 83, 96, 113, 137],
        # 'min': [0, 74, 96, 111, 130, 157], MPH
        'cat': ['Non-Hurricane', 'I', 'II', 'III', 'IV', 'V']

    })
    landfall_time = dt.datetime.utcfromtimestamp(landfall_pt.timestamp)
    cat = CAT_MAP[CAT_MAP['min'] < landfall_pt.wind].iloc[-1]['cat']
    html = (
        f'<h1><span style="color:silver">Estimated Time of Landfall:</span> {landfall_time} UTC </h1>'
        f'<h1><span style="color:silver">Estimated Wind speed at Landfall:</span> {landfall_pt.wind:0.2f} knots '
        f'<span style="color:silver">Gust:</span> {landfall_pt.gust:0.2f} knots</h1>'
        f'<h1><span style="color:silver">Estiamted Hurricane Category at Landfall:</span> {cat}'
    )
HTML(html)
```

Out[31]:

Estimated Time of Landfall: **2018-10-10 18:11:00.055285 UTC**

Estimated Wind speed at Landfall: **89.54 knots** Gust: **110.68 knots**

Estiamted Hurricane Category at Landfall: **II**

World Imagery Map Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Automated Event Scoring: SciServer example (4/8)

Implementation of coordinated activities across disaster statutory programs for NCST event scoring:
fully automated **Hazard and/or Failure Intensity** score during NWIRP's *phase zero*

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1.0 Event Consequence	Low	Medium	High
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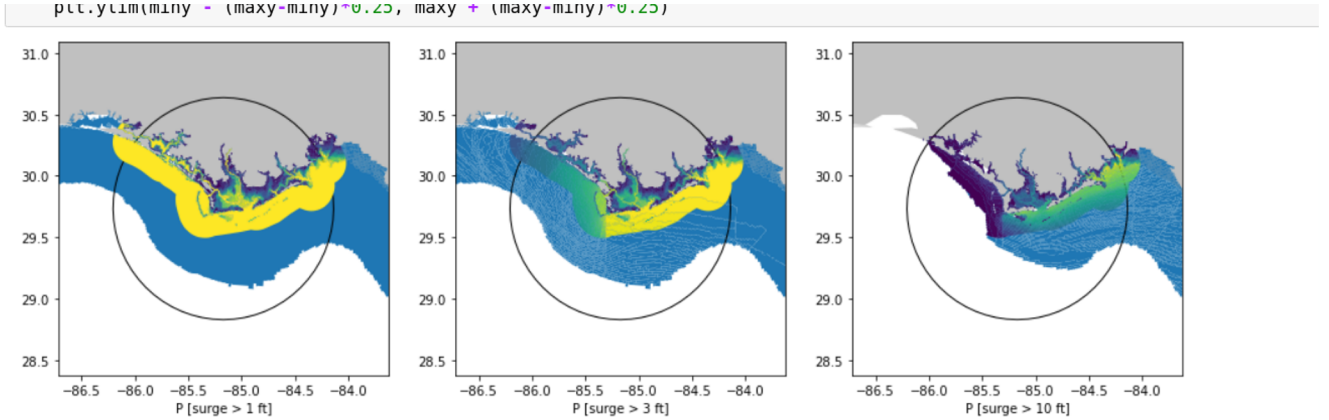

Compute a boolean for if the surge is in regions of interest corresponding to the NCST decision cirteria rubric

```
In [13]: passes = [
             surge_prob[surge].query(f'PSurge{surge:02d}c > {MIN_PROB}').to_crs(proj_crs).area.sum() / surge_prob[surge].to_crs(proj
             for surge in SURGE_INDEX
         ]
```

```
In [14]: smax = 0
         for i in range(len(SURGE_INDEX)):
             if passes[i]:
                 if i == 2:
                     smax = None
                 else:
                     smax = SURGE_INDEX[i+1] - 1
         smax
```

```
Out[14]: 9
```

World Imagery Map Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Automated Event Scoring: SciServer example (5/8)

Implementation of coordinated activities across disaster statutory programs for NCST event scoring:
fully automated **Exposed Population** score during NWIRP's *phase zero*

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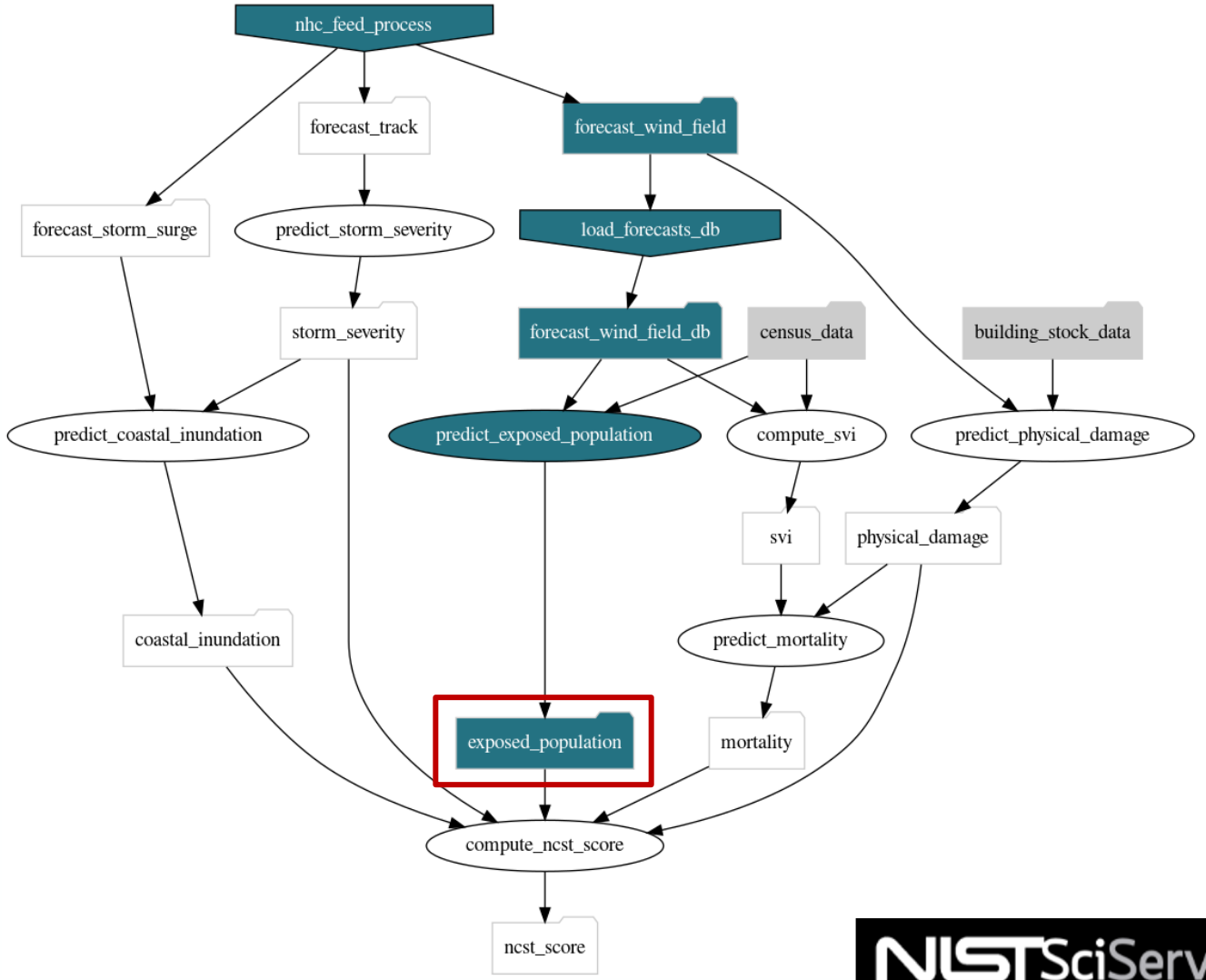

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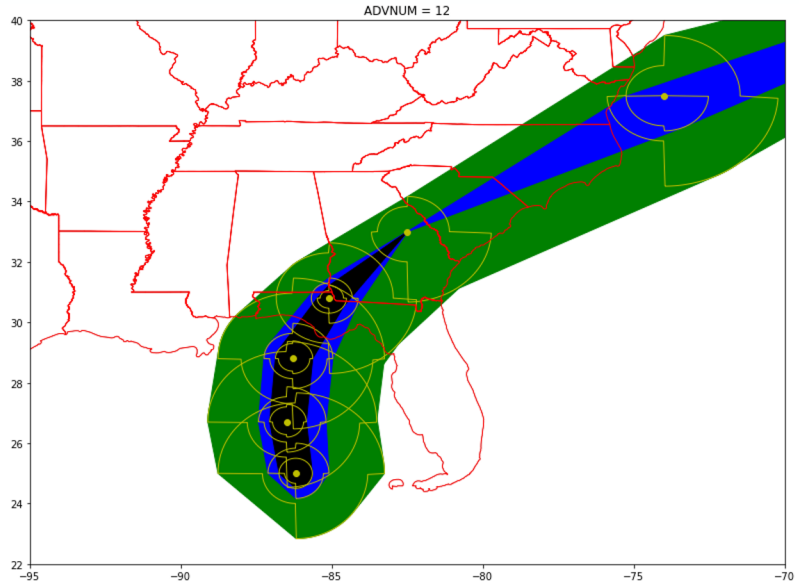

Map Source: Census Bureau TIGER/Line Shapefiles

Calculate exposed population

Similar query as above, but only return the exposed population for each wind speed swath and using a Table Valued Function to get the final swaths as union-aggregated polygons.

In [4]:
```
%%time
sql=f"""
select h.radii
,      sum(isnull(t.s0601_c01_001e,0)) as totpop
,      count(gt.tractce) as nTract
  from dbo.ForecastRadiiHulls({year},'{code}','{advnum}') h
  join GEO_tl_2018_us_tract gt
    on gt.geometry.STIntersects(h.hull) = 1
  join census.S0601_tract t
    on t.year={year} and t.state=gt.statefp and t.county=gt.countyfp and t.tract=gt.tractce
 group by h.radii
"""
df=cj.executeQuery(sql,"NWIRP")
df
```

```
CPU times: user 25.8 ms, sys: 8.14 ms, total: 34 ms
Wall time: 6.13 s
```

In [5]:
```
from IPython.core.display import HTML
if 64 in df.radii.values:
    h=df[df['radii']==64].iloc[0]
    message=f'<h1><span style="color:silver">Population predicted to be exposed to Hurricane force winds:</span> {h.totpop} </h1>'
else:
    message='<h1>No prediction for hurricane winds yet</h1>'
HTML(message)
```

Out[5]:

Population predicted to be exposed to Hurricane force winds: **733632**

Automated Event Scoring: SciServer example (7/8)

Implementation of coordinated activities across disaster statutory programs for NCST event scoring:
fully automated **Mortality** (CDC's Social Vulnerability Index used as proxy) score during NWIRP's *phase zero*

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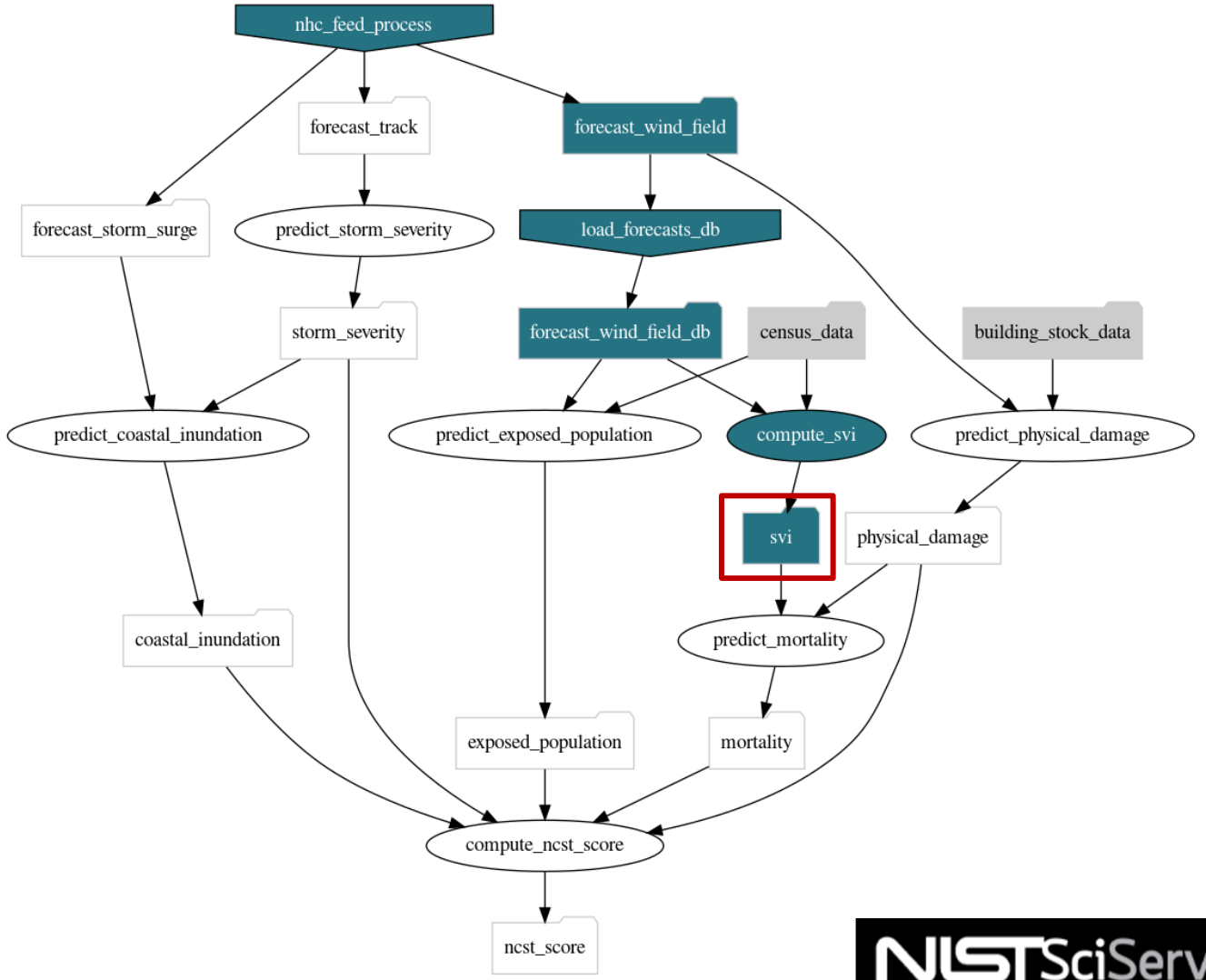

Automated Event Scoring: SciServer example (8/8)

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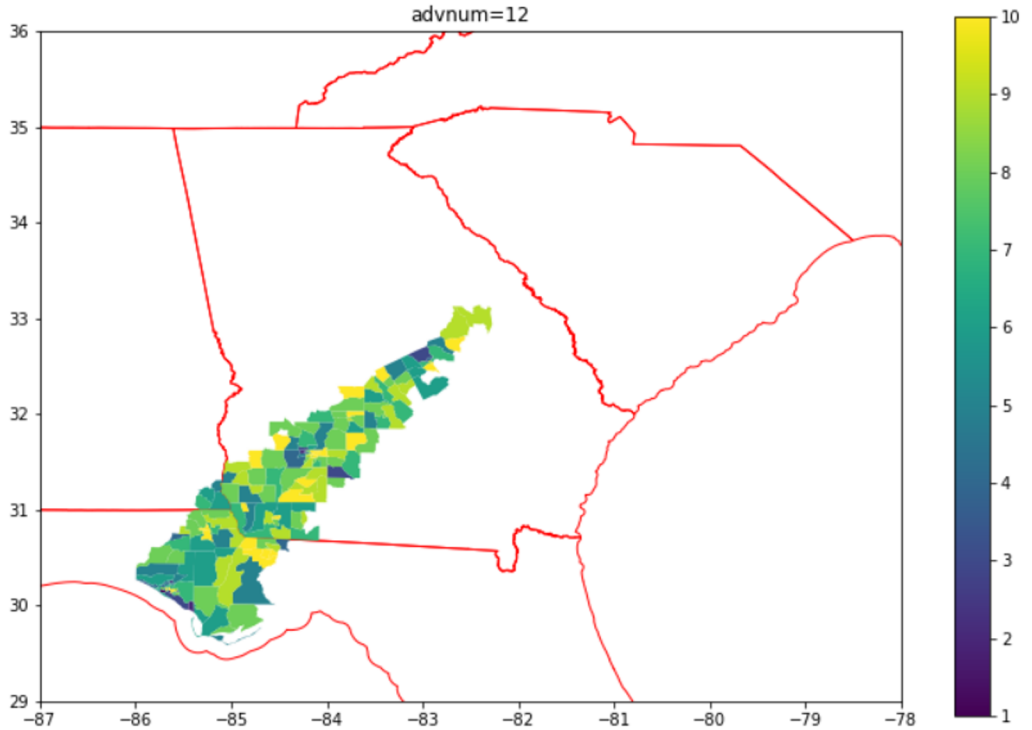
Hurricane at Landfall	≤Cat 3	Cat 4	Cat 5
Tornado	≤EF3	EF4	EF5
Coastal Inundation	< 3 ft	3 to 9 ft	≥ 10 ft
Fire Spread in Structures	Fire spread not beyond area of origin	Fire spread throughout a structure	Fire spread beyond structure of origin
Wildland Urban Interface Fire (WUI)	High Forest Service Fire Danger Rating	Very High Forest Service Fire Danger Rating	Extreme Forest Service Fire Danger Rating
Blast	< 99 lbs. TNT-equivalent	100 - 999 lbs. TNT-equivalent	> 1000 lbs. TNT-equivalent
Impact	< 1 x 10^6 ft lb/sec	1 x 10^6 to 1 x 10^7 ft lb/sec	> 1 x 10^7 ft lb/sec
D. Physical Damage[3]			
Failure during Construction or in Service[4]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Engineered Building Systems[5]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Transportation & Utility Systems[6]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Non-Engineered Building Systems	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Count x Weight:	0 x 1 = 0	2 x 3 = 6	5 x 5 = 25
Event Consequence Score:	**31/7 = 4.43**		

```
In [12]:
ax=states.plot(figsize=(12,8),color='none',edgecolor='r',linewidth=1)
# if len(hull)>0:
#     hull.plot(ax=ax,color='k',edgecolor='k',alpha=.3)
if len(tracts)>0:
    tracts.plot(ax=ax,column='spl_tile',legend=True)#,color='none',edgecolor='b')

plt.xlim(-87,-78)
plt.ylim(29,36)
plt.title(f"advnum={advnum}");
```



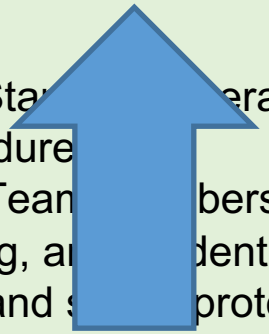
Map Source: Census Bureau TIGER/Line Shapefiles

NIST's Disaster and Failure Studies Program

Statutory Thrust

- Evaluate hazard events against deployment criteria
- Manage identification, vetting, and onboarding of NCSTAC members
- Develop agenda, manage logistics, and set frequency for NCSTAC meetings
- Create annual NCST reports to Congress
- Coordinate statutory activities across programs related to disasters.
- Conduct field studies under various authorities

Procedures Thrust



- DFS Sta erating Procedure
- HOT Tean bership, training, a dentials
- Field and s protocols
- Human subjects protocols
- Manage equipment for disaster metrology and personnel protection
- Data preservation, security, and management
- Field tools (NDA's, permissions, survey instruments)
- MOUs with other agencies, academics, and others
- NIST Disaster Working Group

Research Thrust

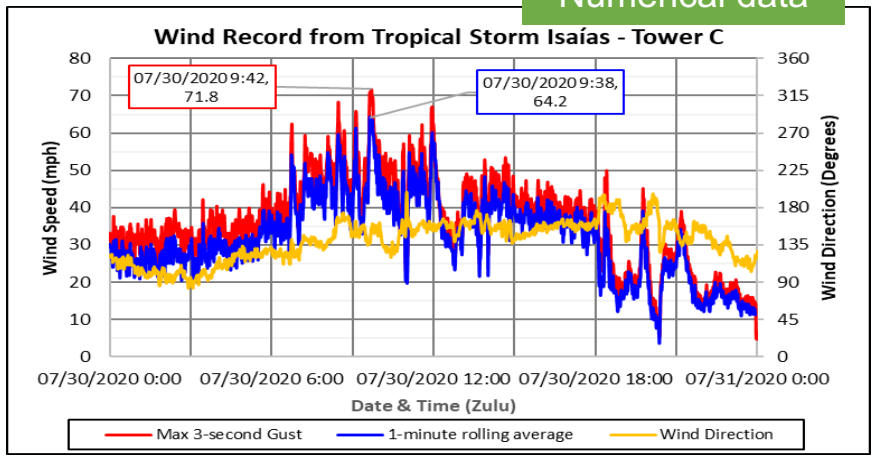
- Research program focused on disaster metrology, including structural performance and social sciences
- Coordinate research activities with NIST EL Groups, Disaster Statutory Programs, NIST EL Divisions, and other NIST Labs
- Coordination with the Center of Excellence of Risk-Based Community Resilience Planning on field studies
- NSF/NIST Disaster Resilience Research Grants Program
- Outreach and dissemination

Investigation Data Procedures

The Challenge:

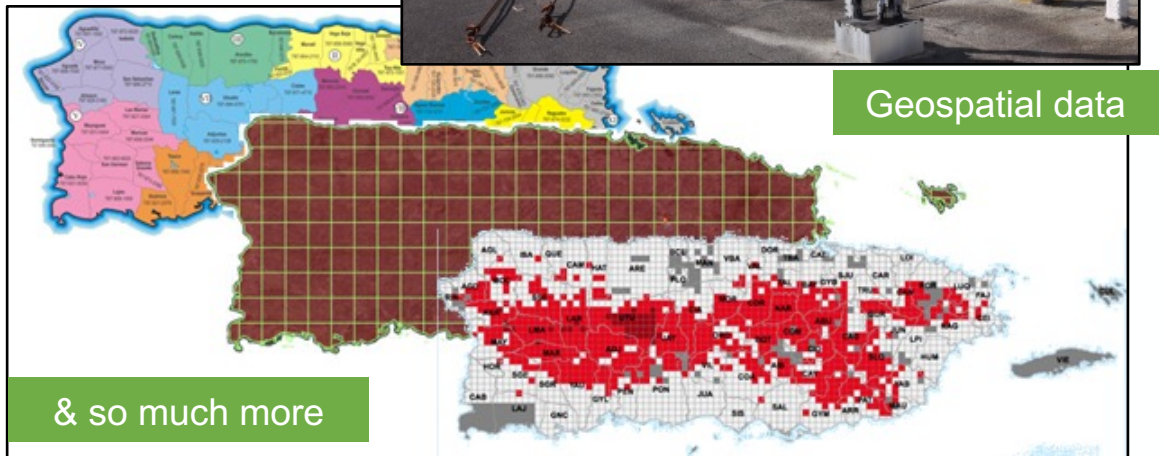
- Heterogeneous data with different attributes, including:
  - Data type
  - Data owner/Source
  - Level of Sensitivity
  - Restrictions on Access
  - Restrictions on Use

Numerical data



Photos and videos

Geospatial data

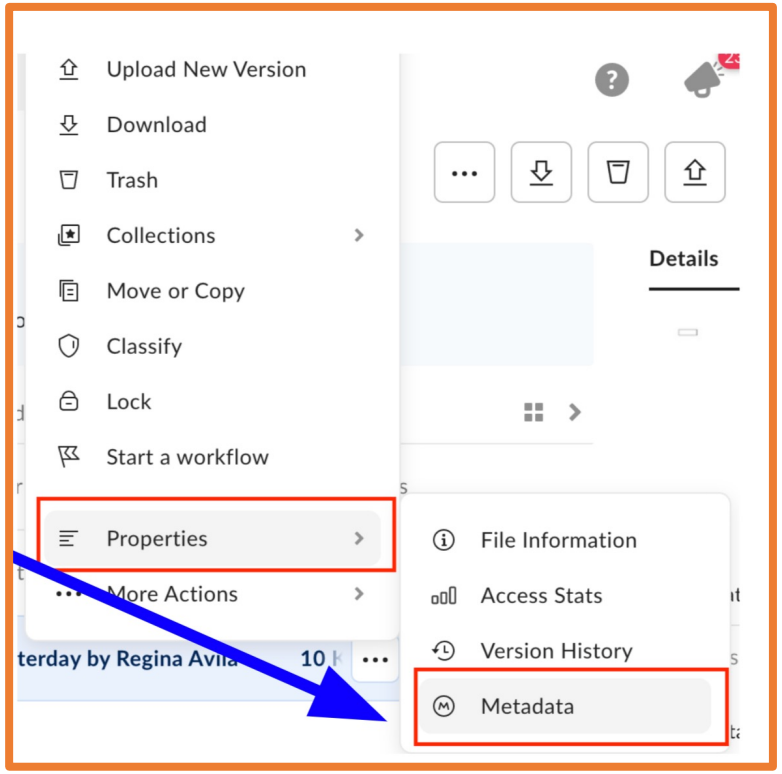


& so much more

Investigation Data Procedures

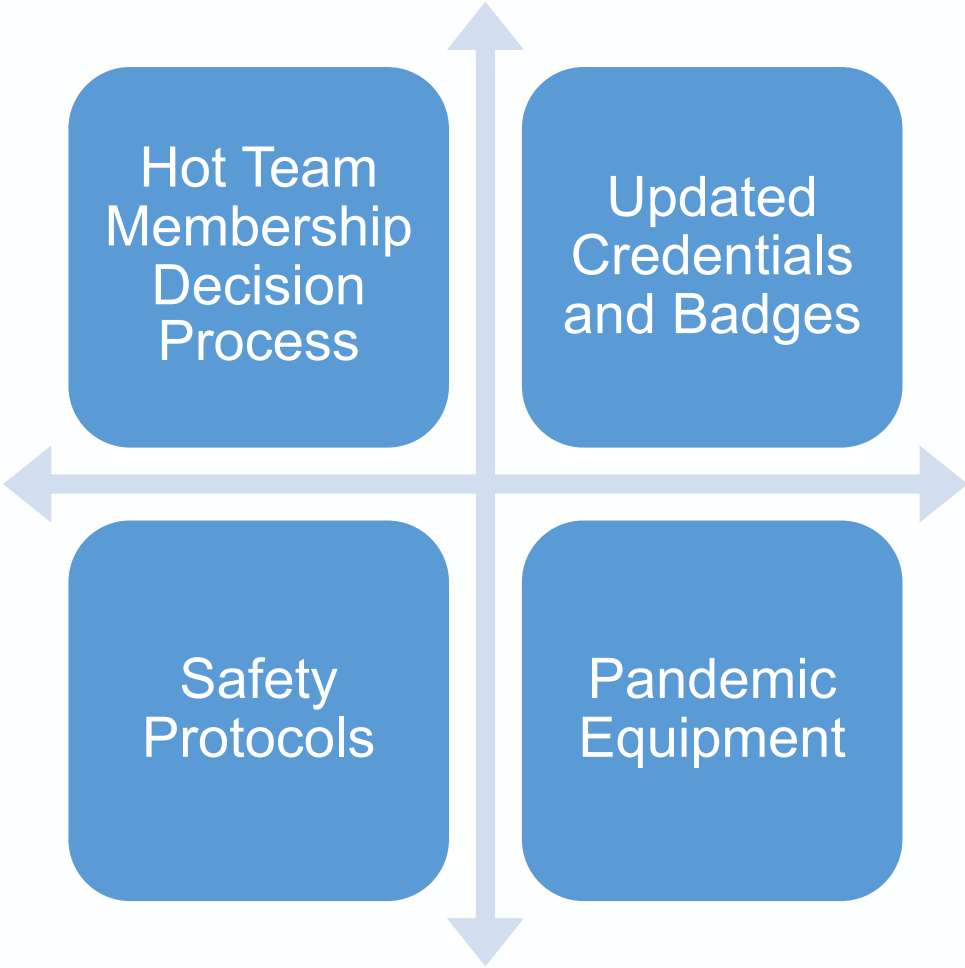
The Solution:

- Steps to ensure data is findable, such as:
  - Organizing data using various platforms for collaboration (e.g., Google Drive, Box, Zotero)
  - Documenting data with metadata templates
  - Creating README files
  - Documenting curation guidelines
- Steps to address data sensitivity, such as:
  - Privacy Impact Assessment of data system
  - Employ platform features, e.g., Classifying data and access permissions in Box
  - Guidance on Tagging/Handling Personally Identifiable Information (PII) in Collected Files

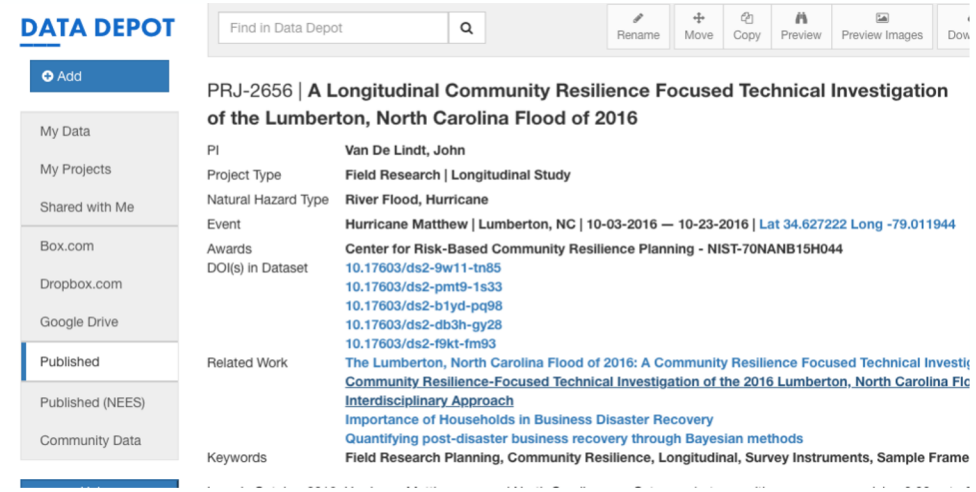


DFS Procedures

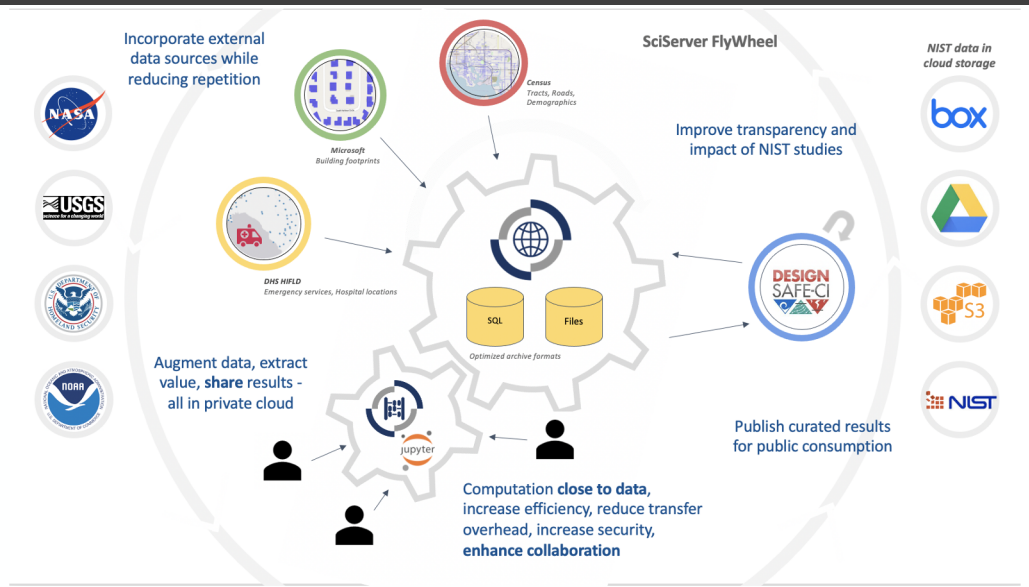
- Hot Team Membership Decision Process, enacted in September 2020
- NIST Emergency Services Office and Department of Commerce Office of Security supporting DFS in updating credentials and badges for Hot Team members
- Safety protocols for field teams
  - NIST First Level Hazard Review recognized with a NIST Safety Award in FY21
  - DFS safety procedures referenced in SDR report, *Integrating Science and Technology with Disaster Response* (Science for Disaster Reduction Interagency Coordination Group 2021)
- Necessary field equipment (e.g., PPE, contactless thermometers) in place for upcoming deployments



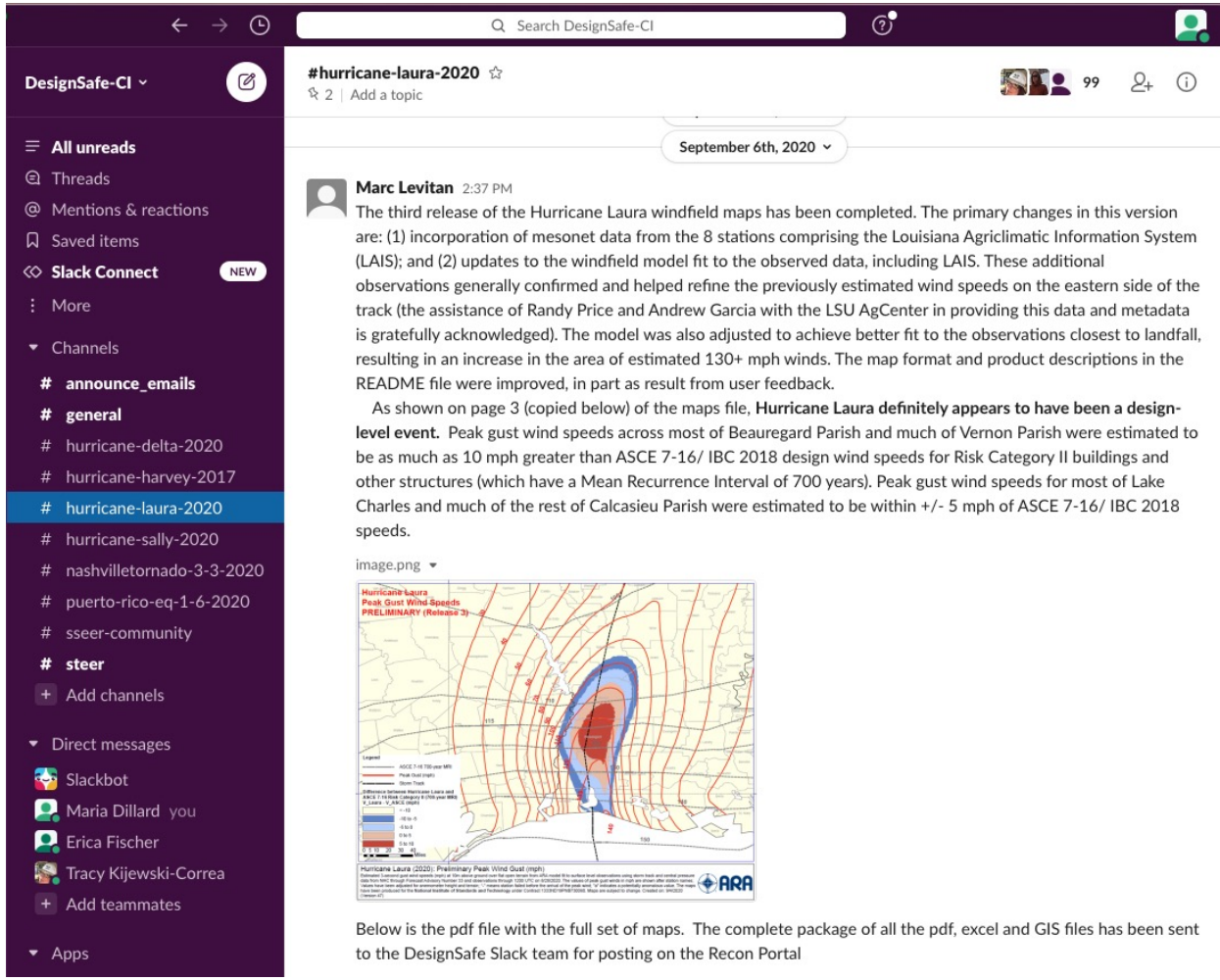
DFS Uses of DesignSafe



- Sharing disaster metrology instruments and protocols



- Interoperability with NIST SciServer



- Collaboration during hazard event evaluation via Slack

NIST's Disaster and Failure Studies Program

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- HOT Team membership, training, and credentials
- Field and safety protocols
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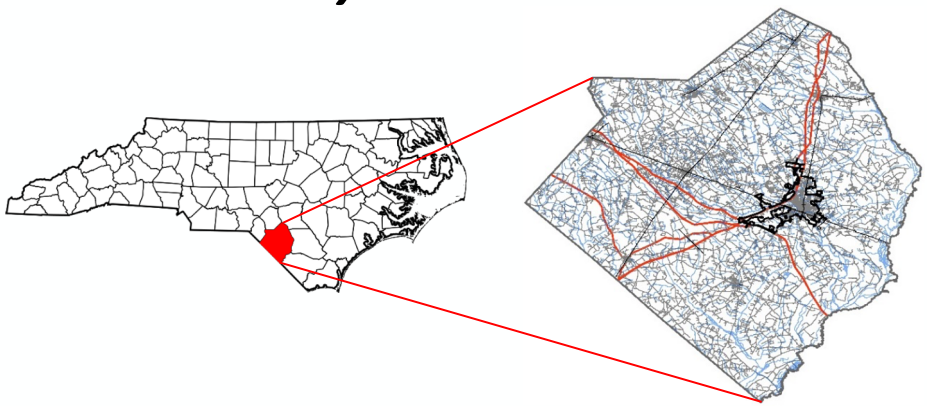
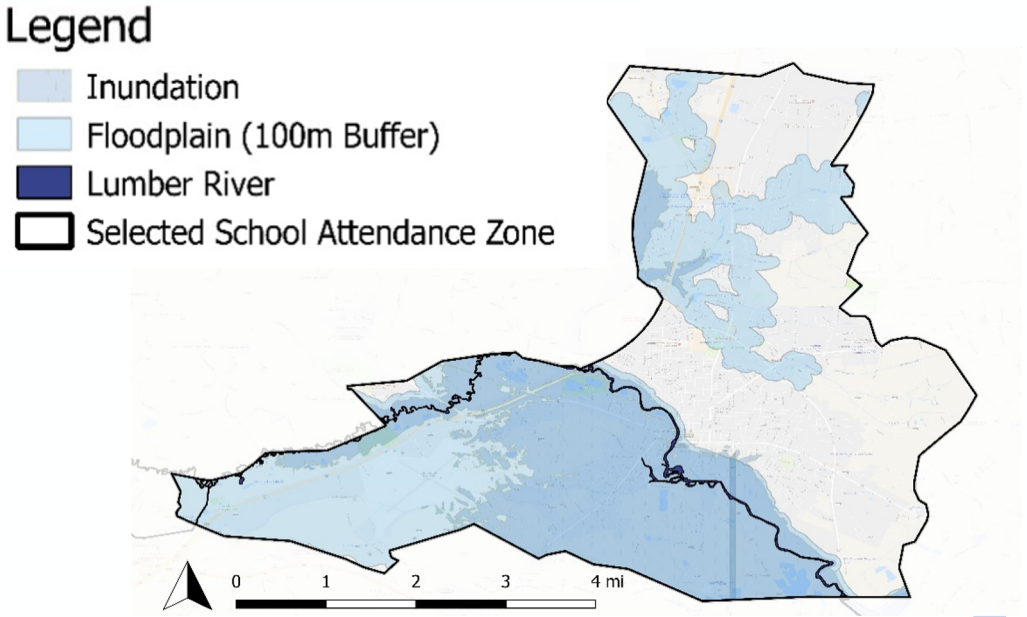
NIST/CoE Collaborative Field Study in Lumberton, North Carolina

Field Study Area



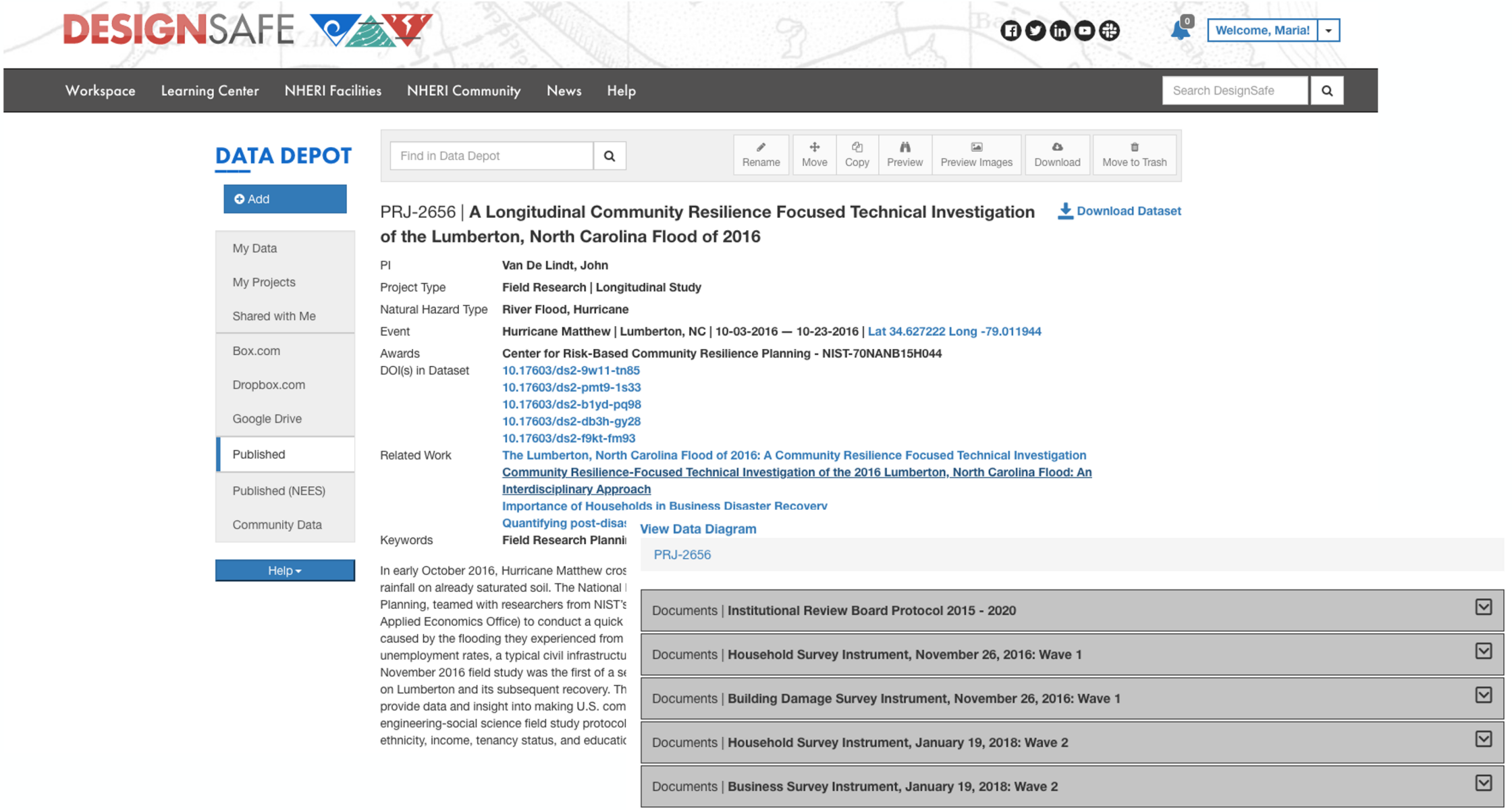
North Carolina (above left); Robeson County with City of Lumberton in gray (above right)
Lumberton Study Area (left)



Field Study Timeline

- Hurricane Matthew Oct 2016
- Wave 1 Nov 2016
- Wave 2 Jan 2018
- Hurricane Florence Sept 2018
- Wave 3 Oct 2018-Apr 2019
- COVID-19 2020
- Wave 4 Ongoing

Standardized Protocols, Instruments, Data Structures for Measuring Hazard Impacts and Community Recovery



Measuring Hazard Impacts: Damage

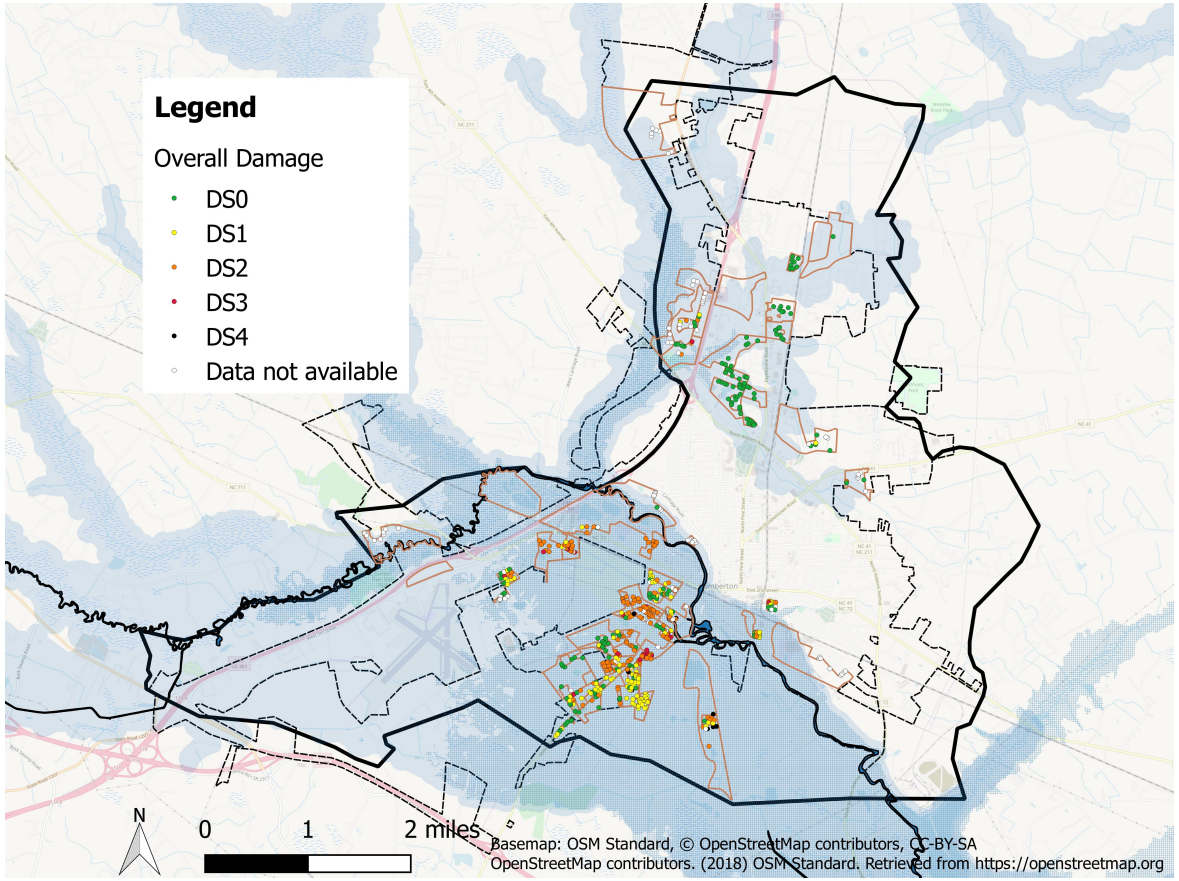
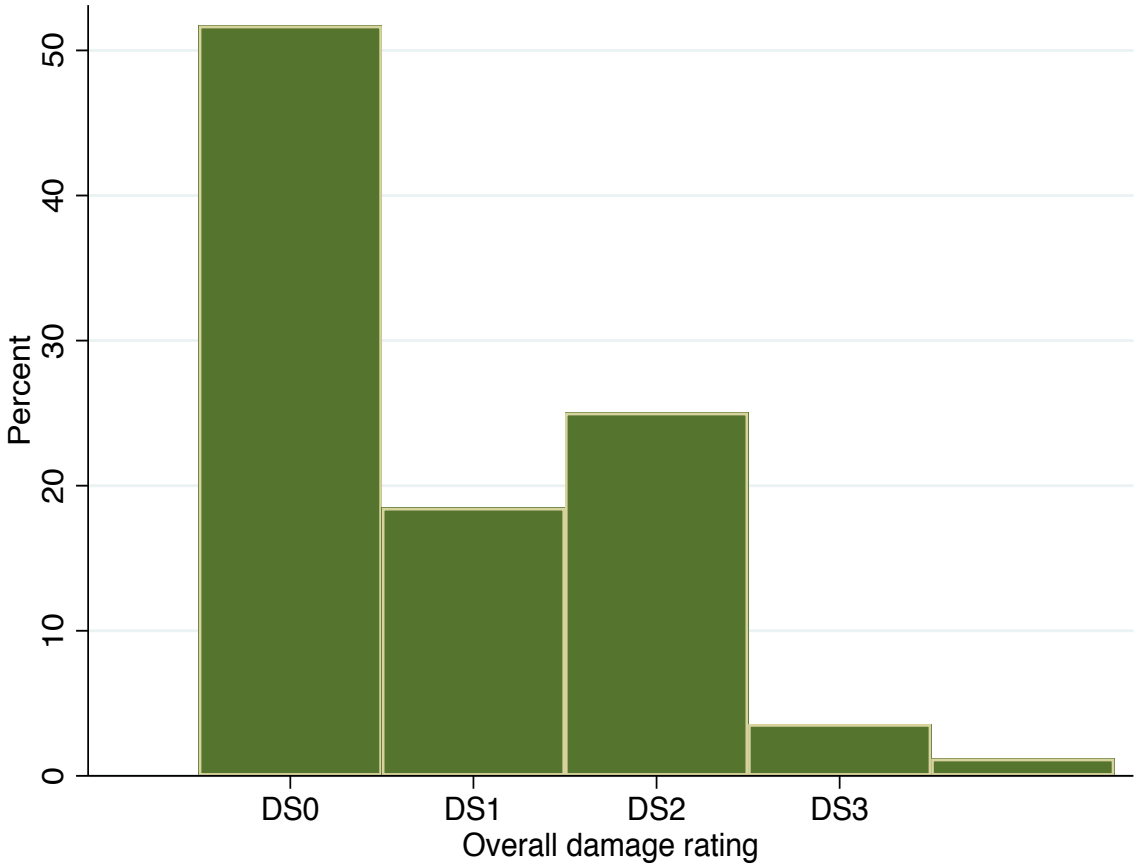


Figure 4-6. Overall damage state rating of residential housing units. [1 mile = 1.61 km]

Figure 4-7. Overall damage state ratings of residential housing units.



Source: https://www.nist.gov/publications/lumberton-north-carolina-flood-2016-community-resilience-focused-technical

Table 1: Least square linear regression models

Variable	Model 1 Number of Days to Repair Completion	Model 2 Number of Days to Re-Occupancy
Damage State 1	-	-15.5
Damage State 2	96.03	36.5*
Damage State 3	135.93*	173.1***
Not-Hispanic White	-103.28*	-9.4
Has Insurance	115.09	19.2
Received Insurance	-155.81**	-25.6
Received Gov. Funds	65.74	16.3
Received NGO Funds	81.50	113.7***
Income $20k-$50k	-130.89*	-32.9
Income $50k-$100k	-103.37	-74.8***
Income $100k+	-107.24	-42*
_constant	293.41***	56.2***
R^2	0.39	0.72

Note: Model1 n = 58; Model2 n=104 from 664 observations
*p≤0.05 (one-tailed)
**p≤0.05 (two-tailed)
***p≤0.01 (two-tailed)

Measuring Recovery: Repairs

Key factors influencing days to repair completion:

- Damage
- Race/ethnicity
- Receipt of insurance
- Income $20-50k

Key factors influencing days to re-occupancy:

- Damage
- Receipt of NGO funds
- Income $50-100k
- Income $100k+

Source: Sutley, E.J., Hamideh, S., Dillard, M.K., Gu, D., Seong, K., van de Lindt, J.W. Integrative Modeling of Housing Recovery as a Physical, Economic, and Social Process. at the 13th International Conference on Applications of Statistics and Probability in Civil Engineering, ICASP13 Seoul, South Korea, May 26-30, 2019.

Field Study Wave 2 Report Published in FY21

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LONG-TERM NIST COMMUNITY RESILIENCE STUDY RELEASES SECOND REPORT

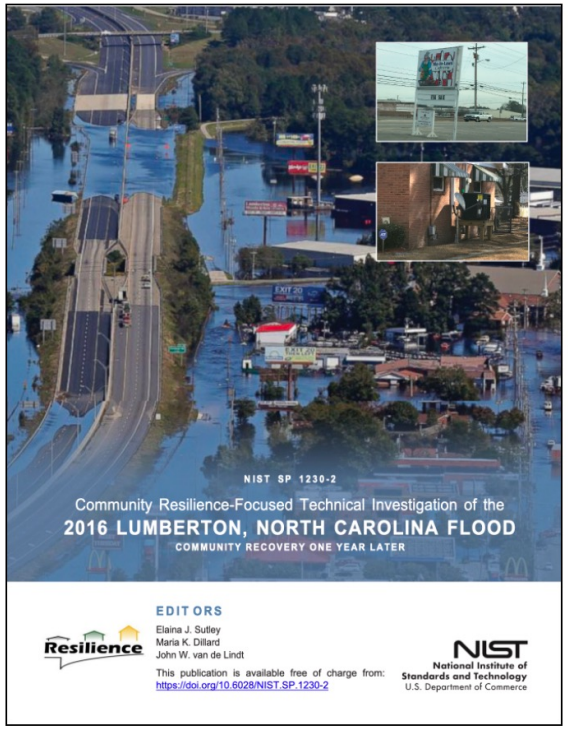
Published on April 26, 2021

In early October 2016, Hurricane Matthew crossed North Carolina as a category 1 storm with some areas receiving 15 in. to 18 in. of rainfall on already saturated soil. The small city of Lumberton, NC, experienced significant flooding from the Lumber River. A group funded by the National Institute of Standards and Technology, NIST, conducted a field study in Lumberton immediately after the flooding. One year later, the group returned to the city to document its recovery — and continue what has become an ongoing, long-term look at community resilience.

This multidisciplinary, longitudinal study is led by the NIST Center for Risk-Based Community Resilience Planning, teaming with researchers from NIST's Community Resilience, Disaster Failure Studies, and Applied Economics programs.

In April 2021, the team released its second report, Community Resilience-Focused Technical Investigation of the 2016 Lumberton, North Carolina Flood: Community Recovery One Year Later. The report, NIST Special Publication 1230-2, was edited by the field study leadership team: Elaina Sutley at the University of Kansas, Maria Dillard at NIST, and John van de Lindt at Colorado State University.

The Center and NIST team is studying Lumberton's recovery progress with an emphasis on the city's housing, businesses, schools, community and state-level decisions, and the intersection of these sectors in community recovery. This type of investigation is critical for the study of community resilience,



Related Links

Lumberton Project Survey Instruments

Lumberton Wave 1 Report

Lumberton Wave 2 Report

NIST Center for Risk-Based Community Resilience Planning

Source: https://www.nist.gov/publications/community-resilience-focused-technical-investigation-2016-lumberton-north-carolina-0

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maria.dillard@nist.gov

Contributors: Regina Avila, Carmen Martinez*, Shane Crawford*, Judith Mitrani-Reiser*, Scott Weaver*, Alex Szalay^, Gerard Lemson^, Arik Mitschang^, and NIST Community Resilience Center of Excellence*

**NIST*
^Johns Hopkins University PREP Associates

Questions?

Please 'raise your hand' using the Blue Jeans Participant window and unmute your audio and video