



# Assessing exposure to hurricanes and other tropical storms for epidemiological research

Drexel University Environmental and Occupational Health  
Research Seminar

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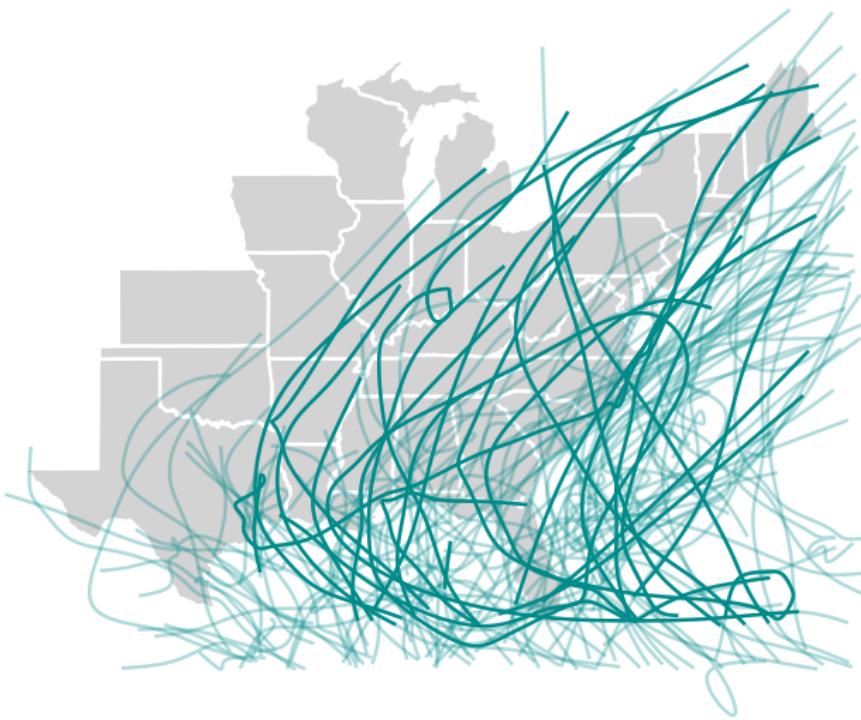
## Motivation



## Assessing exposure



# Study data





## Hazard-specific metrics

### Tropical storm hazard metrics

- Distance from the storm
- High winds
- Rainfall
- Flood events
- Tornado events

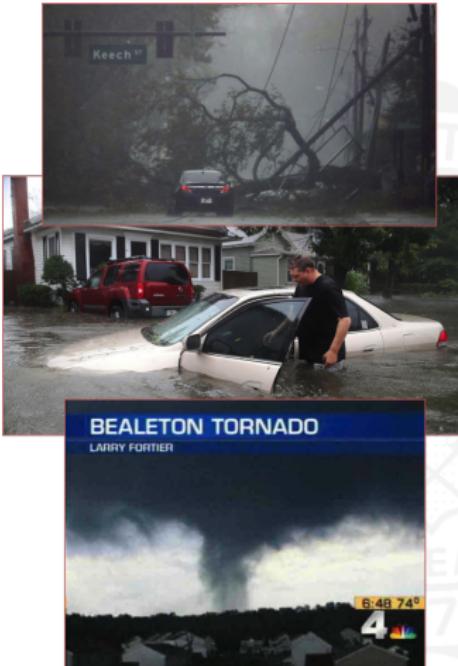


Image sources: Los Angeles Times, NBC



# Distance from storm

[Intro to best tracks]





# Distance from storm

[Importance of interpolating tracks]





# Wind exposure

[Reminder of best tracks, intro to Willoughby model]



## Wind exposure

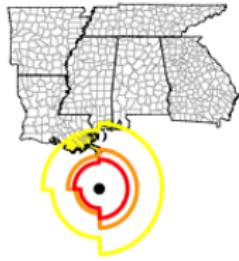
[Factors of doing the modeling (transferring from surface to gradient and back, etc.), other applications of the model]



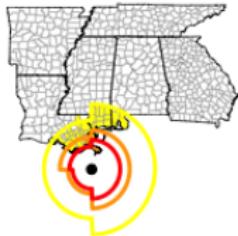
# Wind exposure

Wind radii from Extended Best Tracks data for Katrina

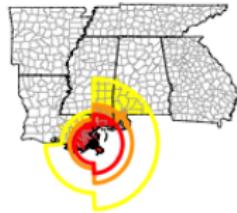
00:00 UTC August 29, 2005



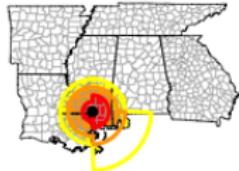
06:00 UTC August 29, 2005



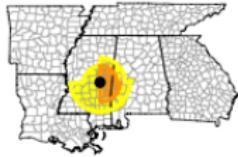
12:00 UTC August 29, 2005



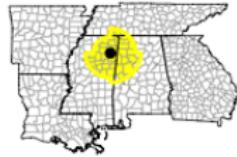
18:00 UTC August 29, 2005



00:00 UTC August 30, 2005



06:00 UTC August 30, 2005

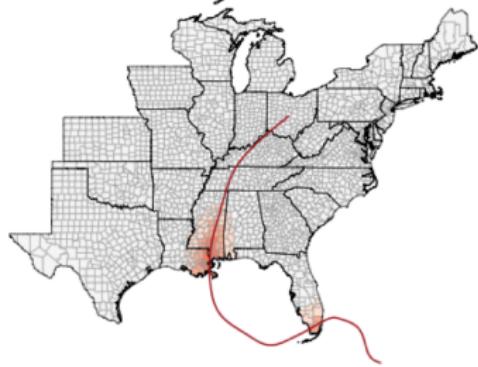




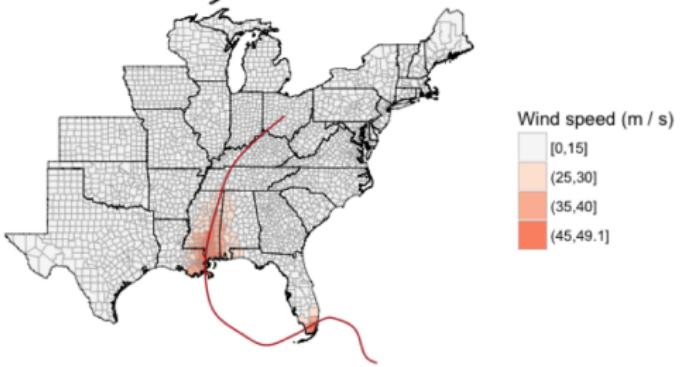
# Wind exposure

Evaluating wind model: Hurricane Katrina, 2005

Willoughby Wind Model



Extended Best Tracks

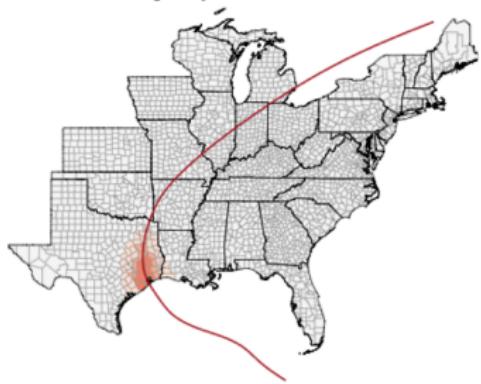




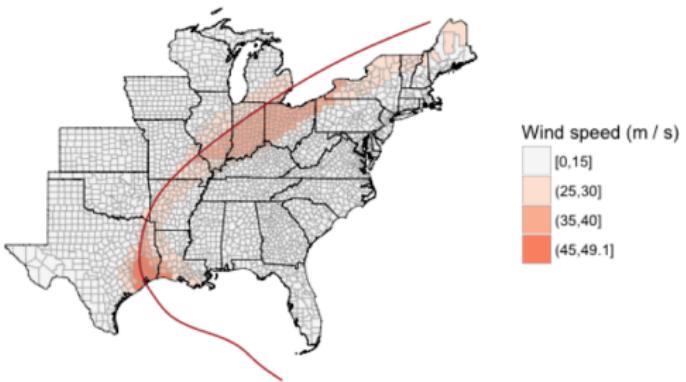
# Wind exposure

Evaluating wind model: Hurricane Ike, 2008

Willoughby Wind Model



Extended Best Tracks

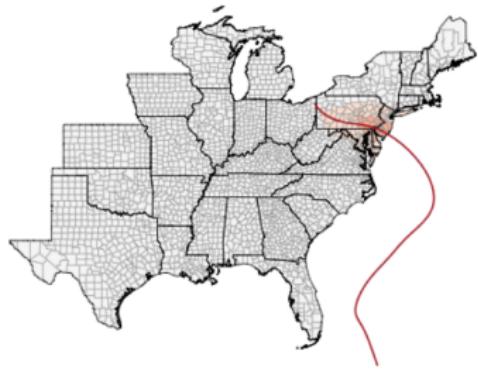




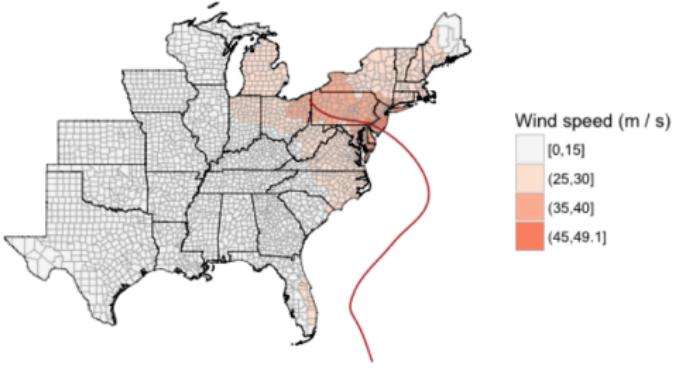
# Wind exposure

Evaluating wind model: Hurricane Sandy, 2012

Willoughby Wind Model



Extended Best Tracks



Wind speed (m / s)
[0,15]
(25, 30]
(35, 40]
(45, 49.1]



## Rain exposure

### NLDAS-2 precipitation

- Find out more:  
<http://ldas.gsfc.nasa.gov/nldas/>
- Also available at county-level through CDC Wonder: <https://wonder.cdc.gov>

### NLDAS-2 precipitation data for Tropical Storm Lee

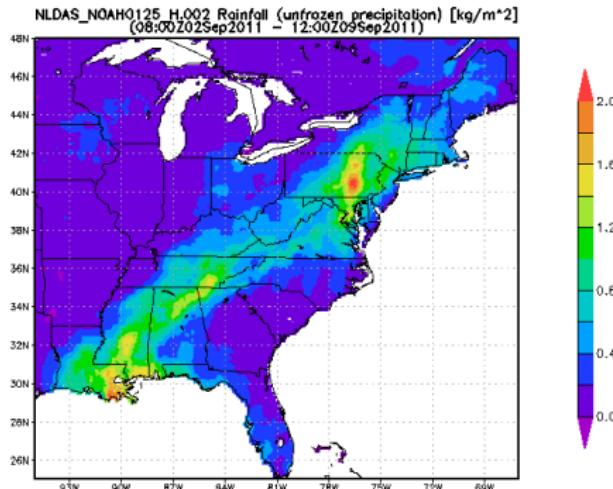


Image source: Goddard Earth Sciences DISC



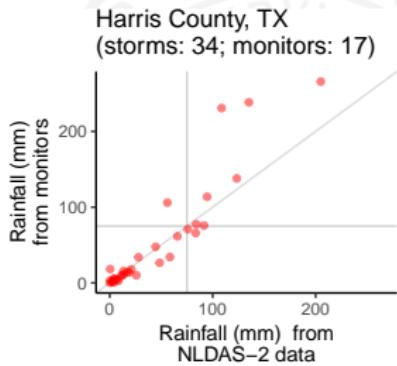
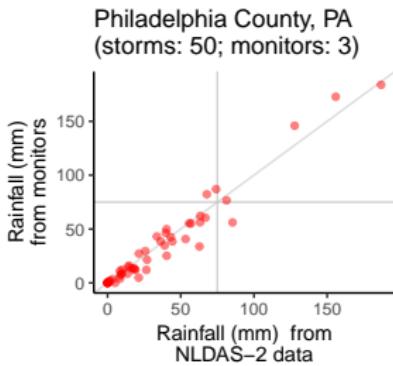
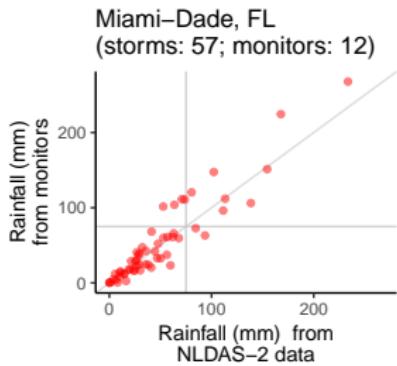
# Rain exposure

[Showing how to ID date of closest approach]





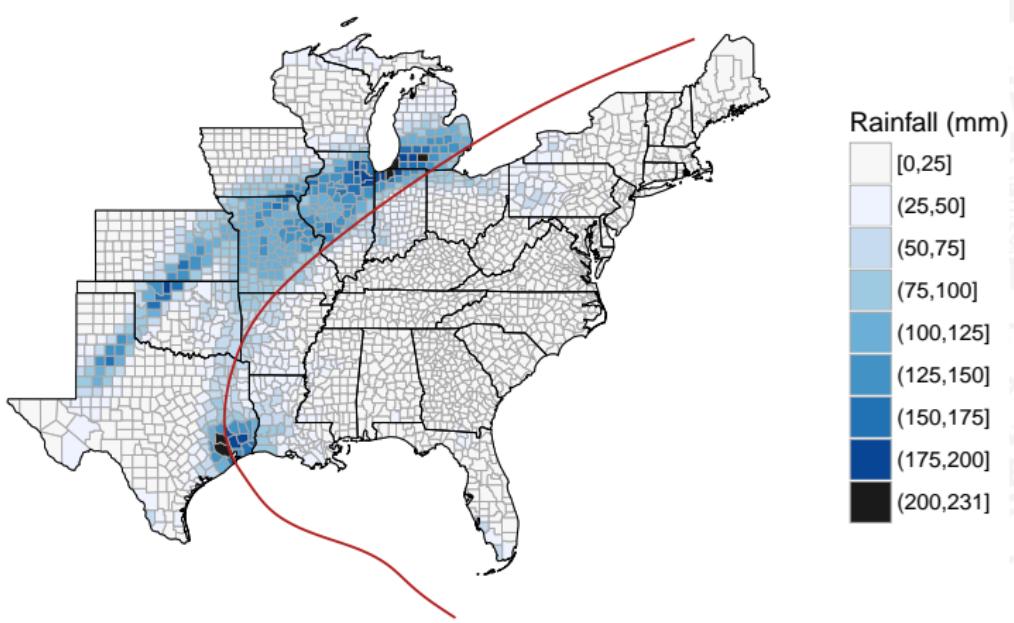
# Rain exposure





# Rain exposure

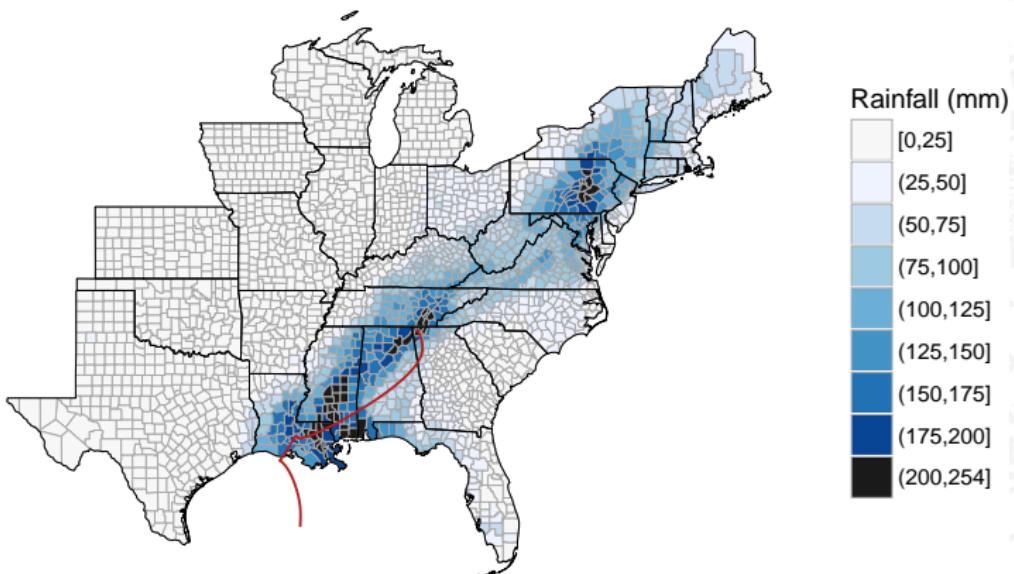
Rainfall during Ike, 2008





# Rain exposure

Rainfall during Lee, 2011





# Flood and tornado events



**NOAA** NATIONAL CENTERS FOR  
ENVIRONMENTAL INFORMATION  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



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NCEI > Storm Events Database

## Storm Events Database

### Data Access

- [Search](#)
- [Bulk Data Download \(CSV\)](#)
- [Storm Data Publication](#)

### Documentation

- [Database Details](#)
- [Version History](#)
- [Storm Data FAQ](#)
- [NOAA's NWS Documentation](#)
- [Tornado EF Scale](#)

### External Resources

- [NOAA](#)

## Storm Events Database

The Storm Events Database contains the records used to create the official [NOAA Storm Data publication](#), documenting:

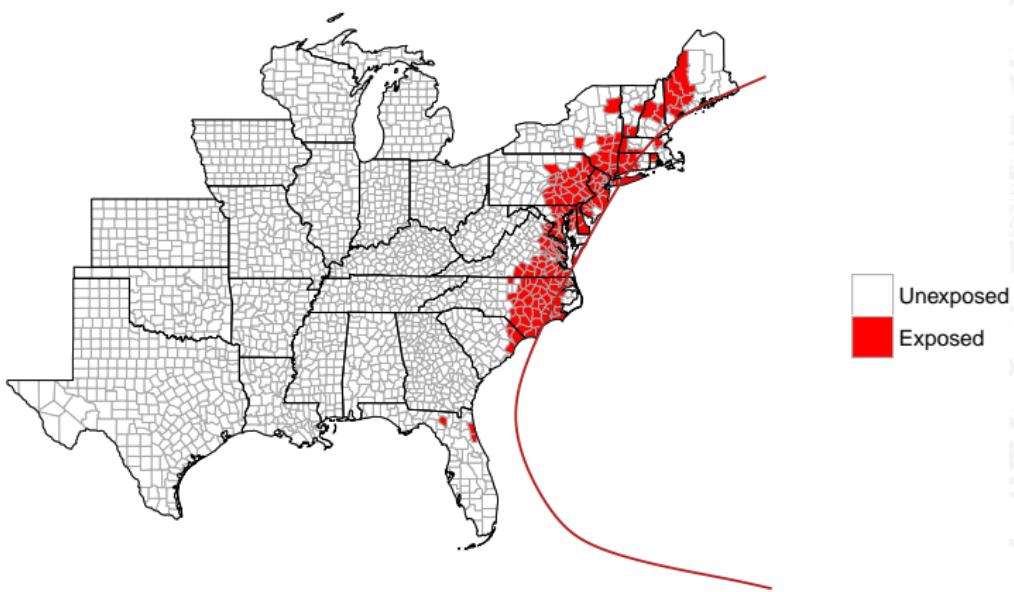
- a. The occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce;
- b. Rare, unusual, weather phenomena that generate media attention, such as snow flurries in South Florida or the San Diego coastal area; and
- c. Other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occur in connection with another event.

Website: <https://www.ncdc.noaa.gov/stormevents/>



# Flood and tornado events

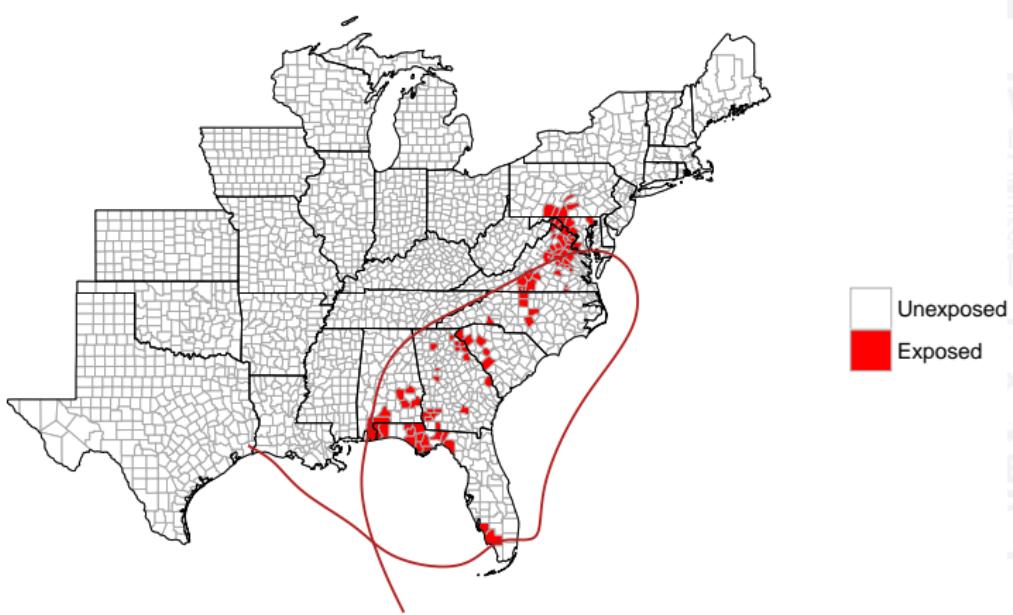
## Flood events during Floyd, 1999





# Flood and tornado events

Tornado events during Ivan, 2004





## Agreement between exposure metrics



## Storm exposure

Exposure metric	Criterial for exposure
Distance	County population mean center within 100 km of storm track
Rain	County received 75 mm or more rain over the period from two days before to one day after the storm's closest approach and the storm passed within 500 km of the county
Wind	Modeled wind speed at county's population mean center met or exceeded 15 m / s during the storm
Flood	Flood event listed with a start date within two days of the storm's closest approach and county within 500 km of storm track
Tornado	Tornado event listed with a start date within two days of the storm's closest approach and county within 500 km of storm track



## Storm exposure

Exposure metric	Median number of exposed counties (IQR)	Storm with most counties exposed
Distance	62 (12, 156)	Beryl, 1994 (330)
Rain	32 (4, 133)	Frances, 2004 (464)
Wind	26 (3, 65)	Ike, 2008 (355)
Flood	9 (0, 39)	Ivan, 2004 (317)
Tornado	1 (0, 9)	Ivan, 2004 (91)

\*Note: Flood and Tornado events only include storms in 1996–2011. All other event listings cover storms in 1988–2011.

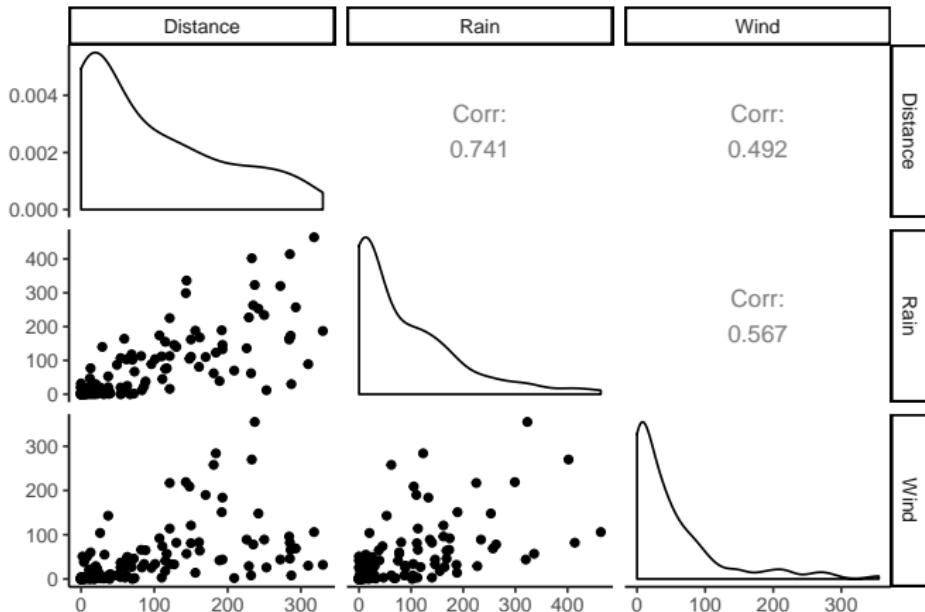


# Storm-specific severity

[How we measured this: Spearman's rank correlation]



# Storm-specific severity





## Storm-specific severity

	Distance	Rain	Wind	Flood	Tornado
<b>Distance</b>	-	-	-	-	-
<b>Rain</b>	0.79	-	-	-	-
<b>Wind</b>	0.71	0.69	-	-	-
<b>Flood</b>	0.46	0.54	0.44	-	-
<b>Tornado</b>	0.43	0.50	0.45	0.78	-



## County-specific classification

We measured agreement in county-specific exposure classifications for different storm hazards using **Cohen's Kappa**:

$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

where:

- $p_o$ : Observed agreement between two hazard classifications
- $p_e$ : Expected agreement between two hazard classifications if ratings were independent



# County-specific classification

[What we found]





# Discussion





# Software



# Software as a research product

[Open science, ROpenSci, influence of example packages]



# Software as a research product

The screenshot shows the landing page for the 'Mastering Software Development in R Specialization'. On the left, a sidebar lists navigation links: 'About This Specialization', 'Courses', 'Creators', and 'FAQs'. Below these is a large title: 'Mastering Software Development in R Specialization'. The main content area features a map of the United States with a blue shaded region over the eastern coast and Great Lakes, overlaid with a red diagonal line. The text 'Build the Tools for Better Data Science' is prominently displayed in white. A subtitle below the map reads: 'Learn to design software for data tooling, distribute R packages, and build custom visualizations'. At the bottom of the main content area, there's another 'About This Specialization' link and a brief description of the specialization's focus on R software development for data science tools.

//www.coursera.org/specializations/r  
<https://bookdown.org/rdpeng/RProgDA/>



# Project software

[list of software, availability through CRAN, GitHub]



# Sharing exposure data

[hurricaneexposure, hurricaneexposuredata, web page]



# Modeling storm winds

[stormwindmodel]





# Working with NOAA Storm Events

[noaastormevents]





# Dealing with time zones

[countytimezones]

