Assessing county-level exposure to hurricanes and other tropical storms in the United States for epidemiological research

CHE: 20 Pioneers Under 40 in Environmental Public Health

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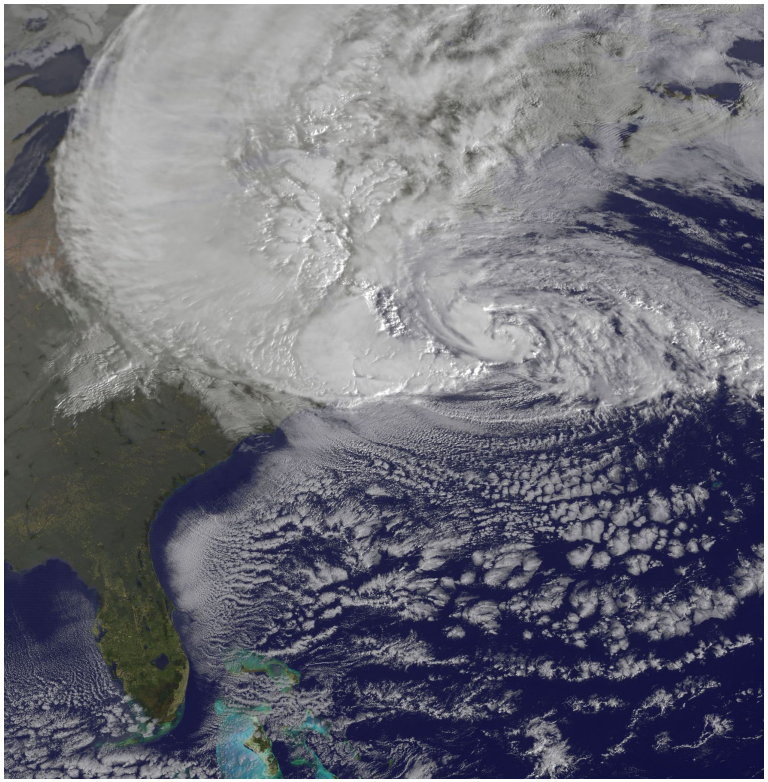
Health risks associated with Hurricane Sandy (2012)



Source: NOAA / NASA GOES Project

Health risks in storm-affected areas

- Change in patterns of emergency department visits (Kim et al. 2016)
- Increased outpatient cases of food and waterborne disease among elderly (Bloom et al. 2016)
- Increased rate of myocardial infarctions (Swerdel et al. 2014)
- Increased hospitalizations for dehydration (Lee et al. 2016)
- Difficulty obtaining medical care, medications, and medical equipment (Davidow et al. 2016)

Hazard-specific tropical storm metrics

Tropical storm hazard metrics

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

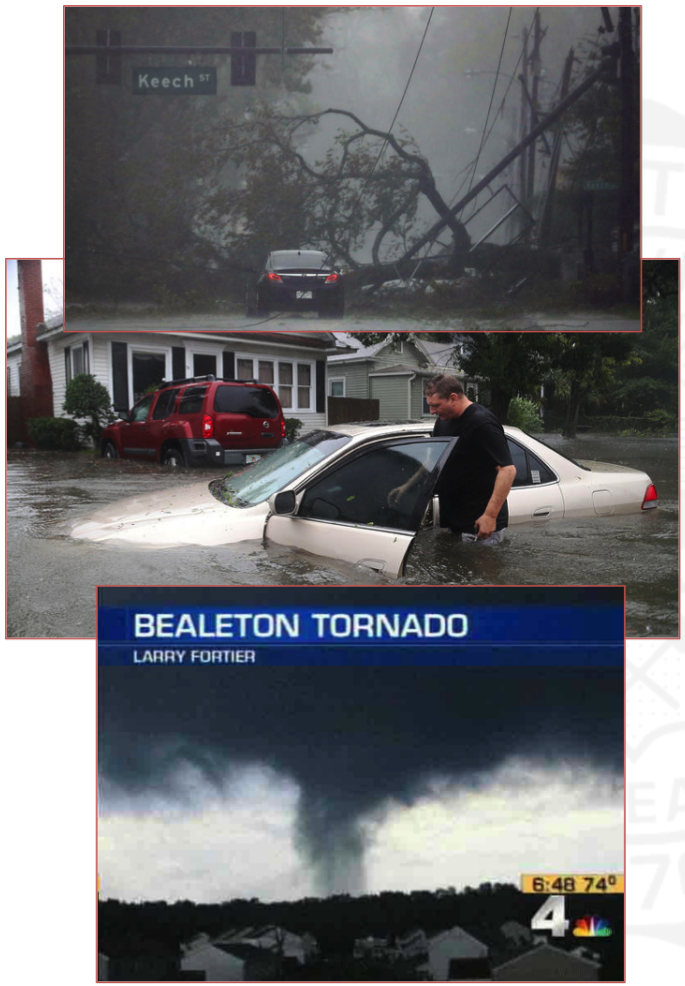


Image sources: Los Angeles Times, NBC

Assessing tropical storm exposure

Challenge for epidemiological research

How should we determine whether a county was exposed to a tropical storm for epidemiological research?

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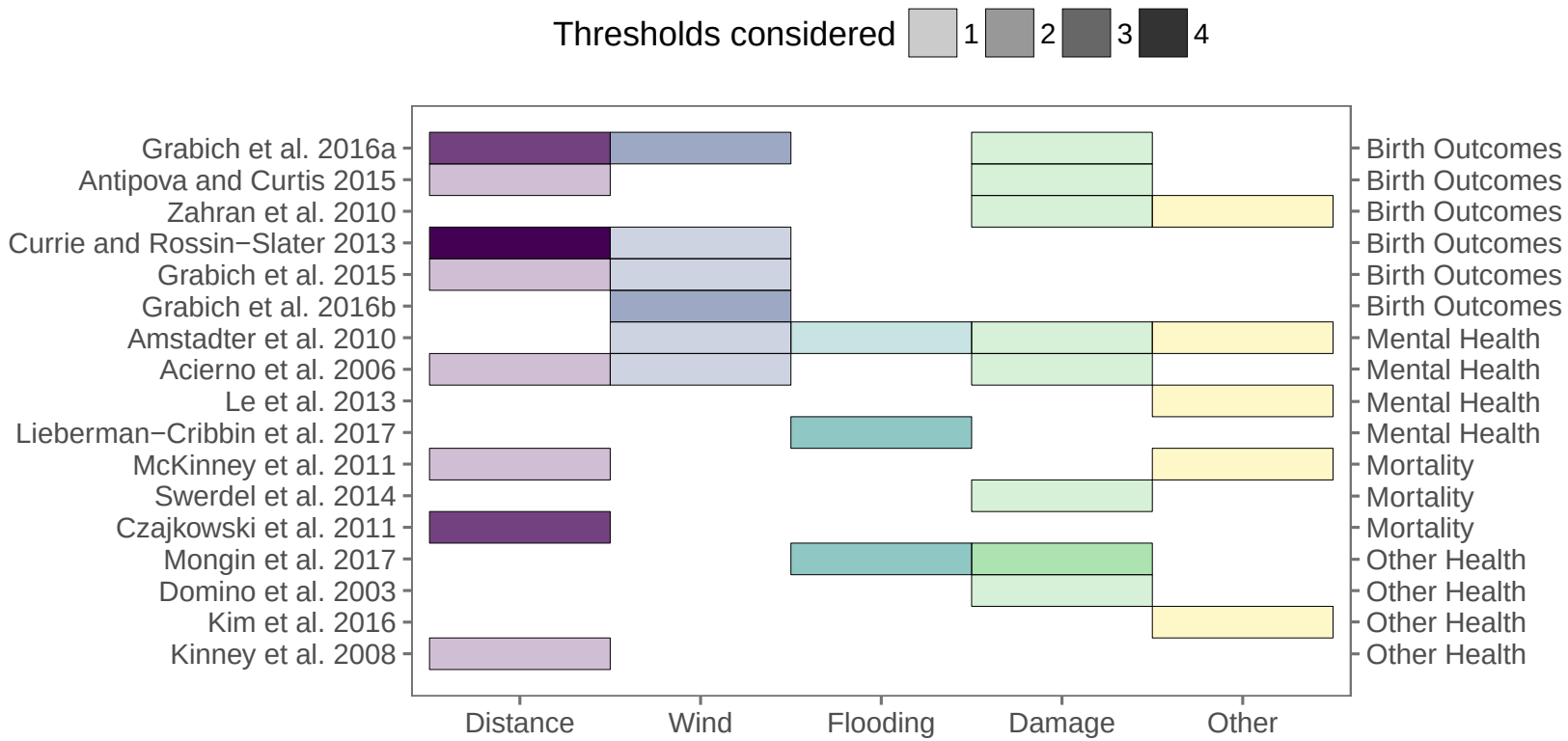

Project aims

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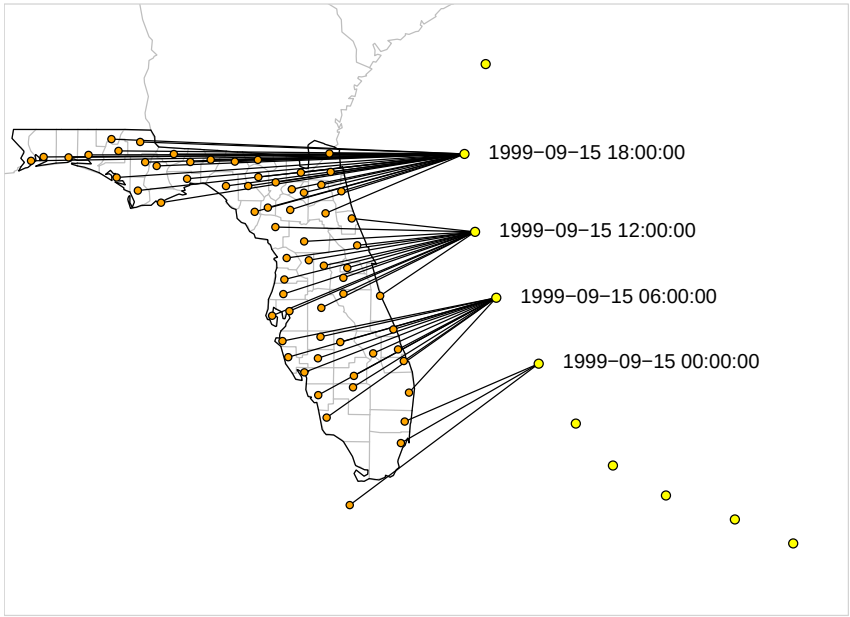
- Develop exposure classifications of all U.S. Atlantic basin tropical storms, 1996–2011, based on reasonable measurements of tropical storm hazards
- Assess agreement between hazard-based county-specific exposure classifications
- Make exposure assessments accessible to other researchers for epidemiological and other impact studies

Assessing tropical storm exposure



Example of "Best Tracks" data

Distance metric

- **Distance:** National Hurricane Center Best Tracks data
- **Wind:** Wind model based on Willoughby et al. (2006)
- **Rain:** Re-analysis rain data (NLDAS-2)
- **Flood and tornado events:** NOAA Storm Events database

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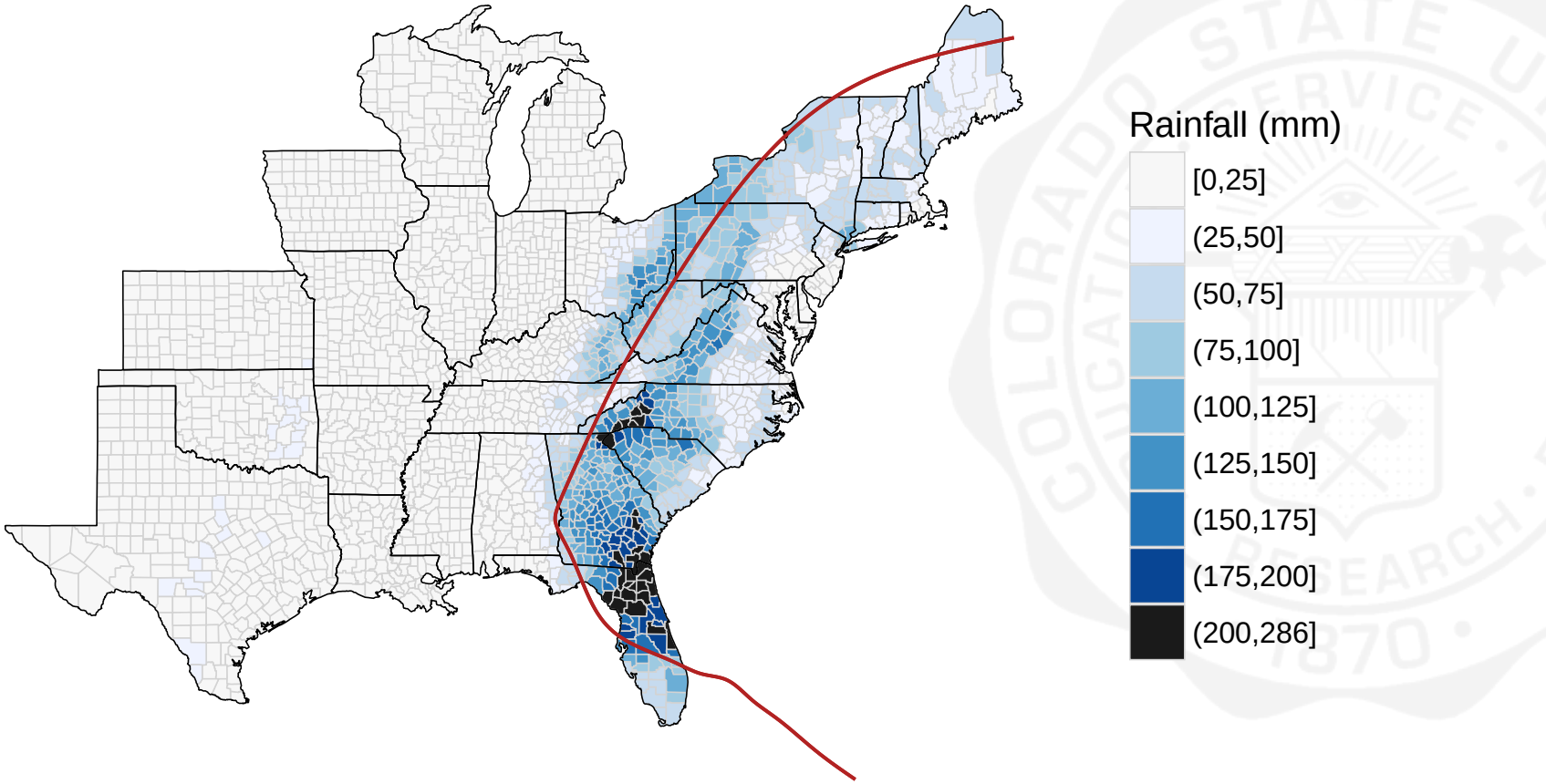
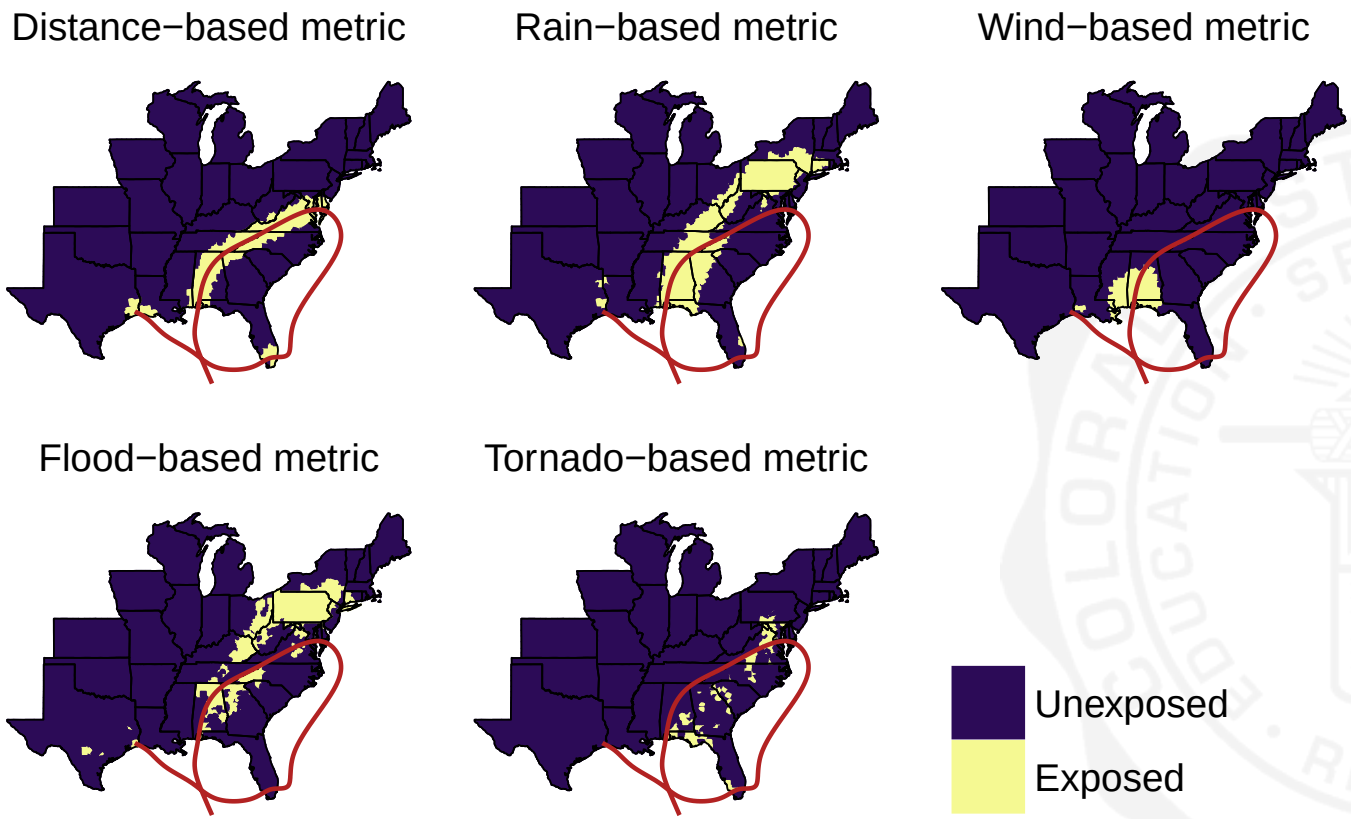
Rain exposure

Rainfall during Frances, 2004



County-level exposure to Hurricane Ivan (2004)



Criteria for exposure classifications: **Distance:** Within 100 kms of storm track. **Rain:** $\geq$ 75 mm of rain total for two days before to one day after storm. **Wind:** Modeled wind of $\geq$ 15 m/s. **Flood, Tornado:** Listed event in NOAA Storm Events database.

County-level agreement in storm exposure

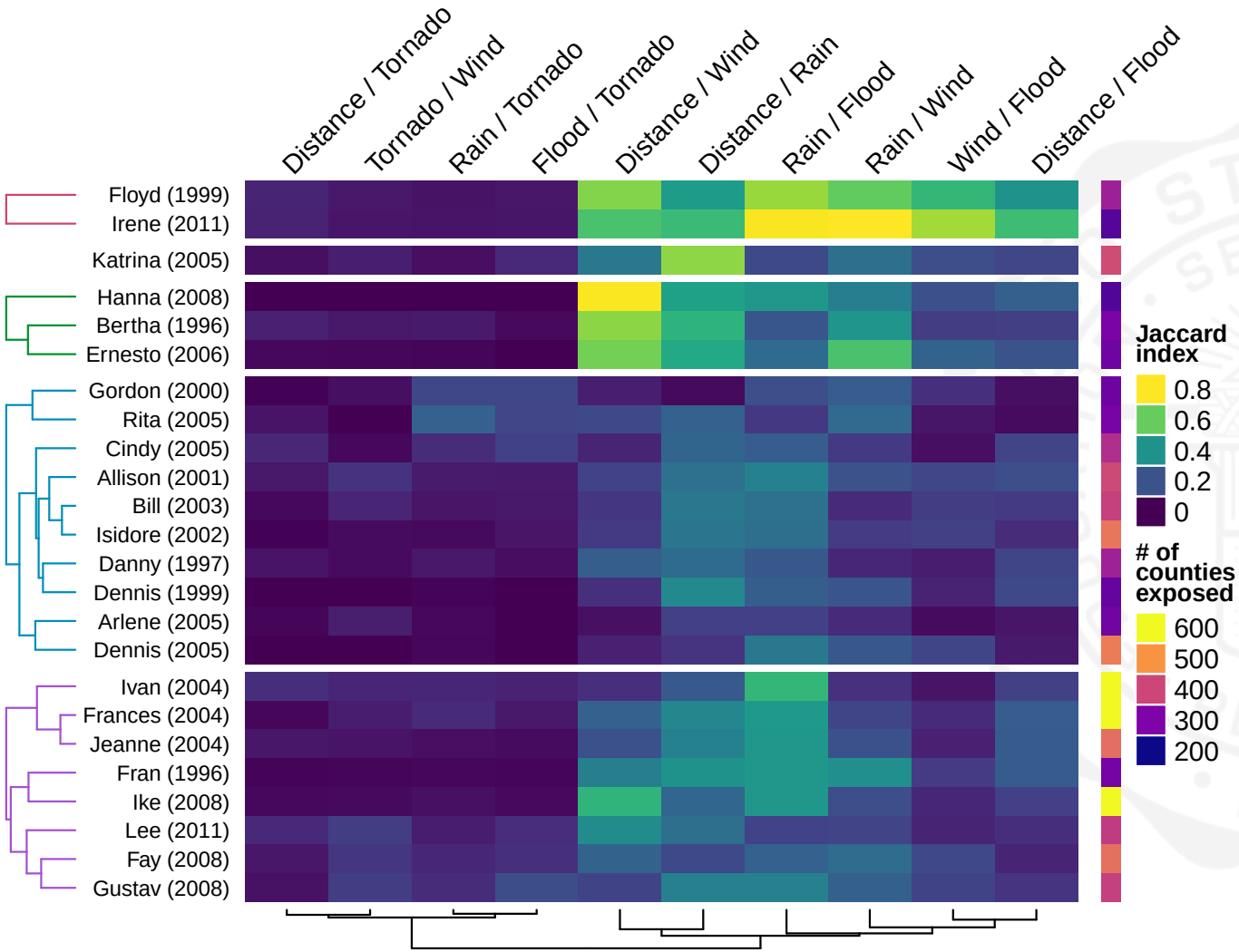
Assessing agreement in county classifications

For each storm and each pair of metrics, we measured the *Jaccard index* as a measure of county-level agreement in exposure classification for a storm:

$$J = \frac{X_1 \cap X_2}{X_1 \cup X_2}$$

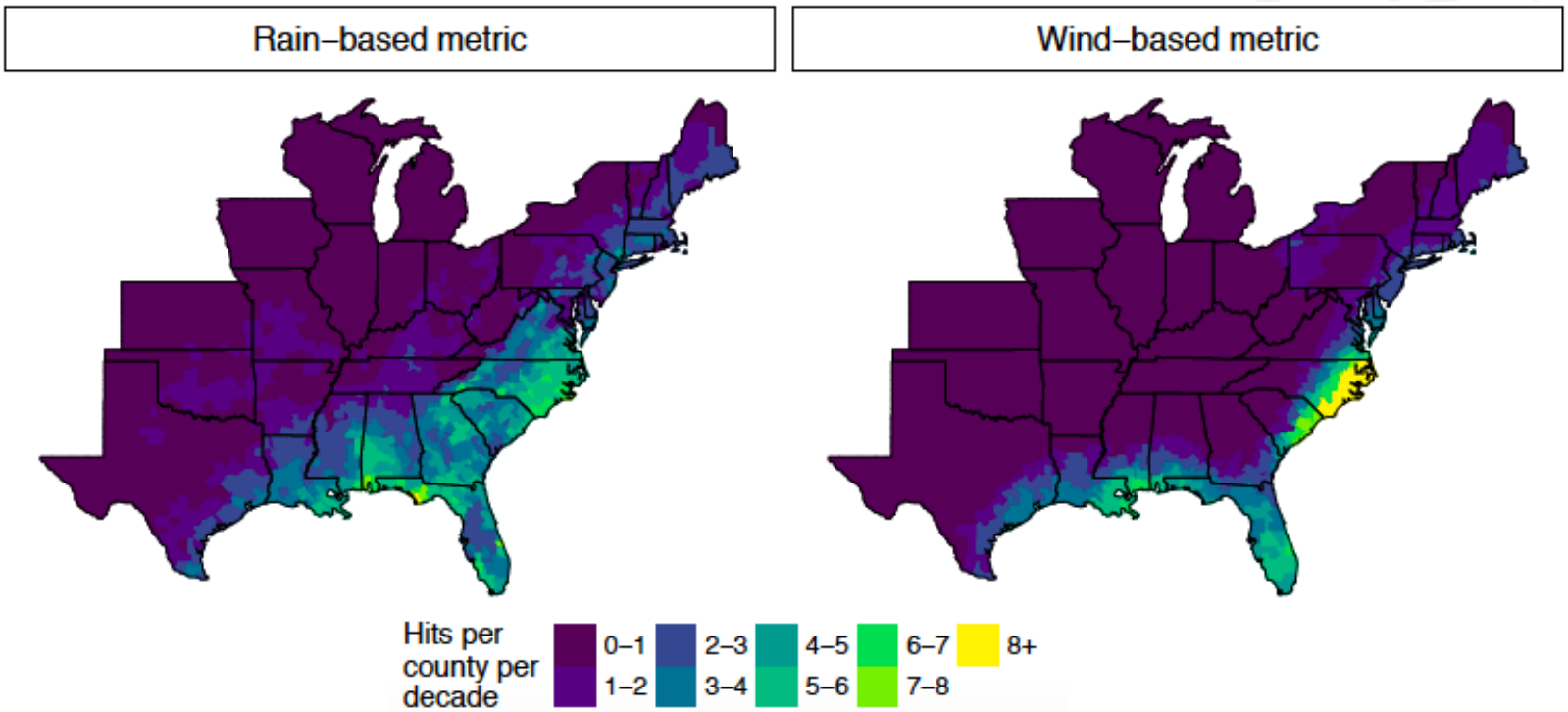
where X_1 is the set of counties exposed to a storm based on the first metric and X_2 is the set of counties exposed to the storm based on the second metric.

County-level agreement in storm exposure



Tropical storm exposure in U.S. counties

Storm hits per county per decade based on rain (left) and wind (right) exposure metrics.



Criteria for exposure classifications: **Rain:** $\geq$ 75 mm of rain total for two days before to one day after storm. **Wind:** Modeled wind of $\geq$ 15 m/s.

Project software

'hurricaneexposure'

Create county-level exposure time series for tropical storms in U.S. counties. Exposure can be determined based on several hazards (e.g., distance, wind, rain), with user-specified thresholds. On CRAN.

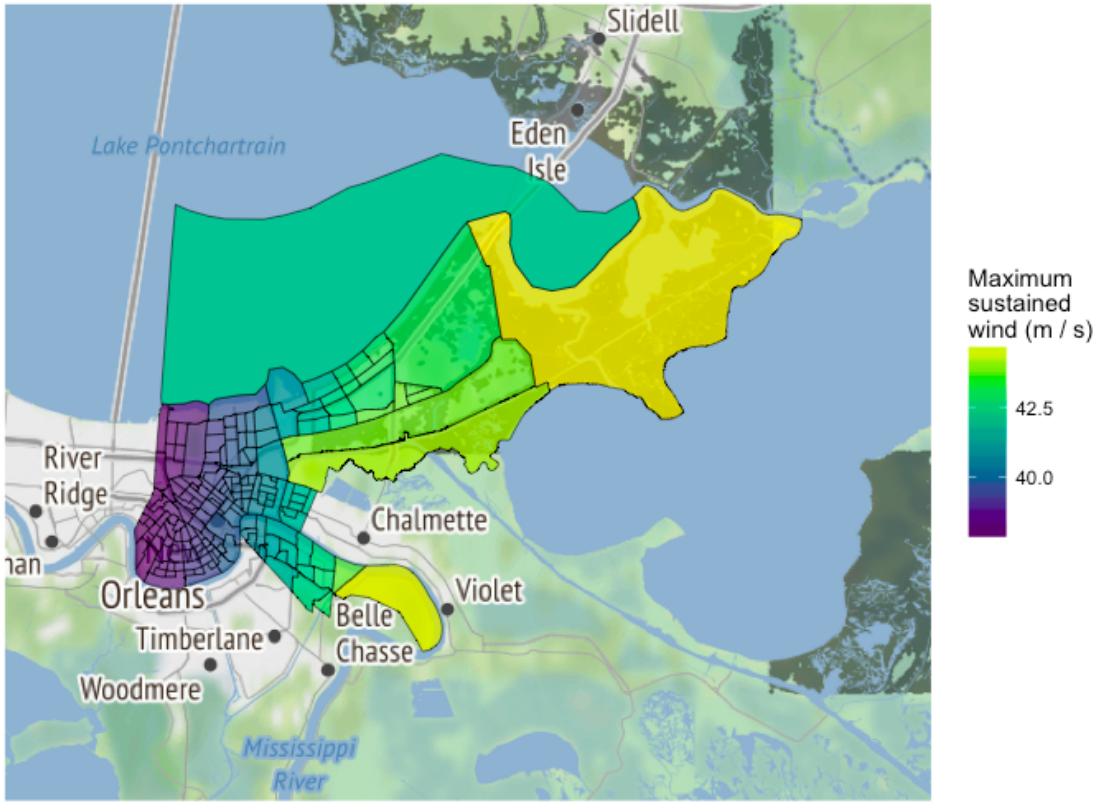
```
county_rain(counties = c("22071", "51700"), rain_limit = 100,
            start_year = 1995, end_year = 2005, dist_limit = 100,
            days_included = c(-1, 0, 1))
```

```
## # A tibble: 4 x 5
##       storm_id  fips closest_date storm_dist tot_precip
##          <chr> <chr>        <chr>      <dbl>      <dbl>
## 1    Bill-2003 22071   2003-06-30   38.78412      141.1
## 2 Charley-2004 51700   2004-08-14   43.01152      136.2
## 3   Cindy-2005 22071   2005-07-06   32.21758      113.2
## 4   Floyd-1999 51700   1999-09-16   46.50729      207.5
```

Project software

‘stormwindmodel‘

Model storm winds from Best Tracks data at U.S. locations. Includes modeling sustained and gust winds, as well as duration of sustained and gust winds above a specified threshold. On CRAN.



Project software

‘countyweather‘, ‘countyfloods‘

Download weather monitor data through NOAA and USGS APIs by U.S. county. Includes functions to map available monitors / gages for each county. On CRAN.

‘noaastormevents‘

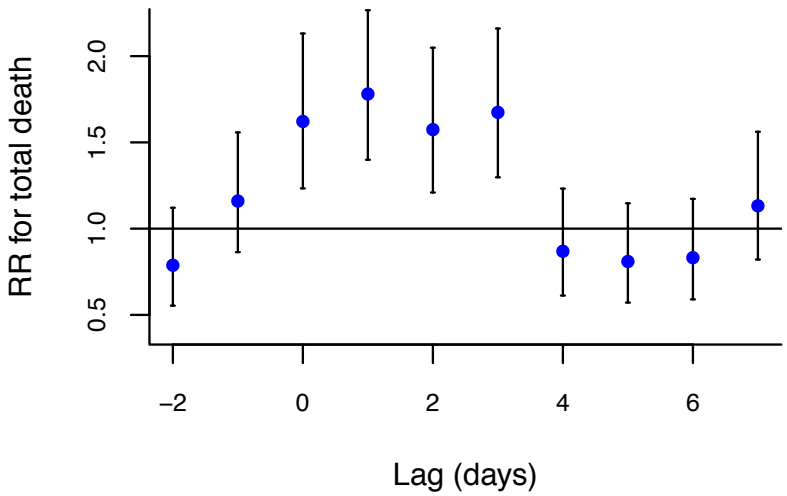
Download and explore listings from the NOAA Storm Events database. Includes the ability to pull events based on a tropical storm, using events listed close in time and distance to the storm’s tracks. On CRAN.

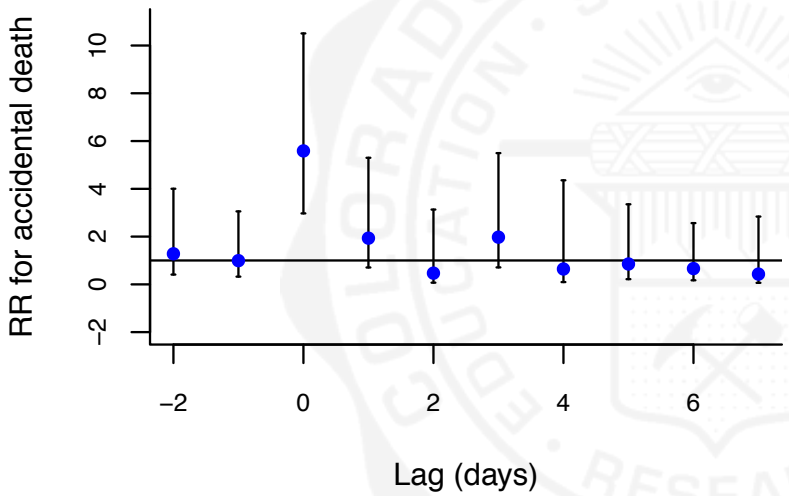
‘countytimezones‘

Convert time-stamps from UTC to local time zones for U.S. counties based on county FIPs. Facilitates merging weather observations with locally measured data, including health outcomes. On CRAN.

Continuing work

Relative risk for all-cause (left) and accidental (right) mortality in Miami, FL, at lags from the Hurricane Andrew storm day (lag 0) compared to non-storm days.





Estimates were obtained by comparing storm days to matched non-storm days in the same time of year and day of week in other years. Matched days were picked to exclude days near other storms. Lag 0 represents the storm day. Negative lags represent days before the storm and positive lags represent days after the storm. Vertical lines give 95% confidence intervals.

Acknowledgements

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Collaborators

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