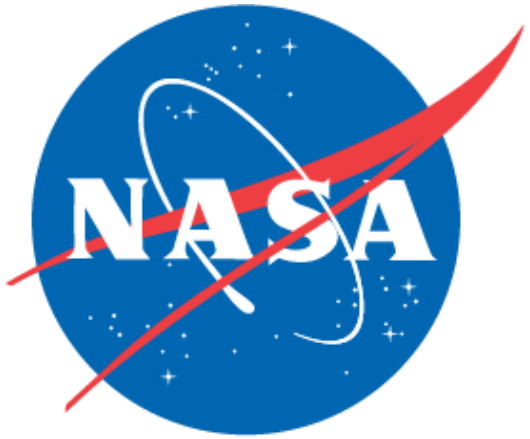


HEALTH & AIR QUALITY

EARTH SCIENCE
APPLIED SCIENCES

Quantifying distributional health damages of extreme weather events

Annual Grantee Meeting

Apr 23nd, 2024

Julia M Gohlke, Samarth Swarup, Ben Zaitchik, Ryan Calder, Annie Britton, Saurav Timilisina, Antonia Mendrinos, Balaji Ramesh

Quantification of health damages from climate change

- Benefit cost analysis for climate policy evaluation—a required component of federal regulations
- Health damages are a major contributor to estimated costs, however currently only account for temperature-related mortality

Table 3.1.4: Impact Category Disaggregation of Social Cost of Carbon ($SC\text{-}CO_2$) for 2030 under a 2.0% Near-Term Ramsey Discount Rate (in 2020 dollars per metric ton of CO_2)

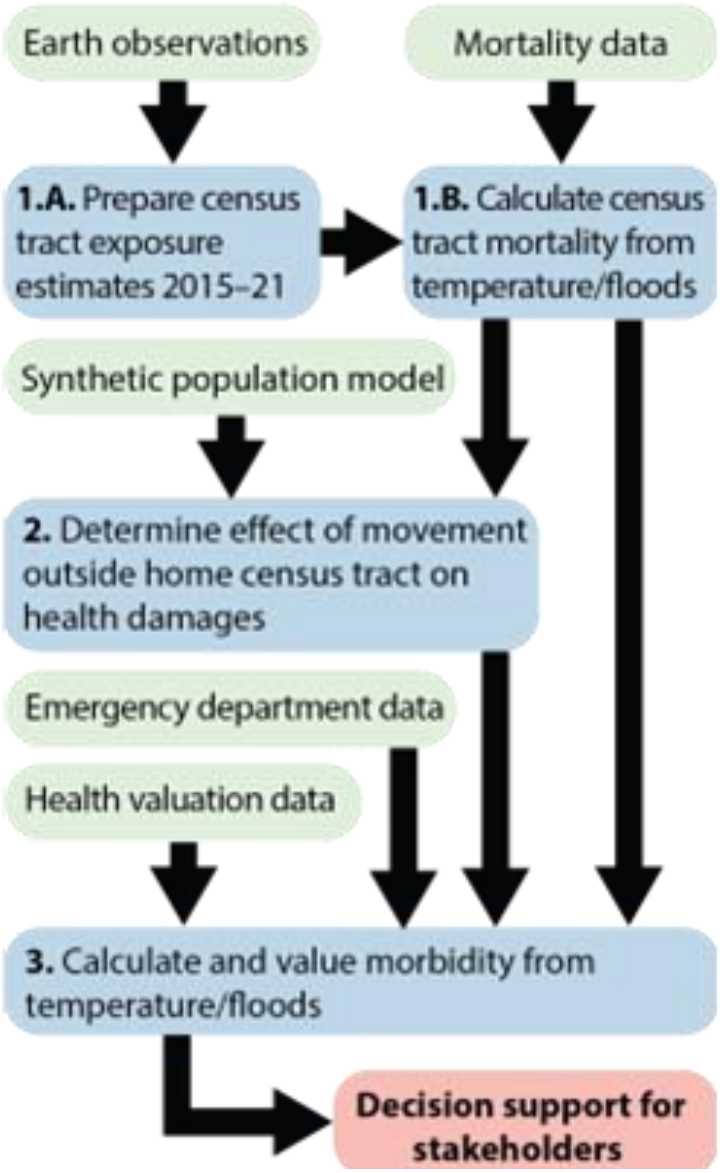
	Damage Module		
Impact category	DSCIM	GIVE	Meta-Analysis
Health	$179	$104	-
Energy	-$4	$10	-
Labor productivity	$47	-	-
Agriculture	$4	$103	-
Coastal	$3	$2	-
Total	$233	$219	$238

USEPA 2023, Docket ID No. EPA-HQ-OAR-2021-0317

Project Objectives

- Compare estimates of mortality associated with temperature extremes and flooding across urban and rural areas between 2015-2021.
- Determine contributions of movements outside of home census tract to health damages associated with extreme temperatures and flooding.
- Determine morbidity contributions to health damages associated with extreme temperatures and flooding.

Workflow


Earth observations
Mortality data
1.A. Prepare census tract exposure estimates 2015–21
1.B. Calculate census tract mortality from temperature/floods
Synthetic population model
2. Determine effect of movement outside home census tract on health damages
Emergency department data
Health valuation data
3. Calculate and value morbidity from temperature/floods
Decision support for stakeholders

Association between Summertime Emergency Department Visits and Maximum Daily Heat Index in Rural and Non-rural Areas of Virginia (2015-2022)

Setting and Data Sources

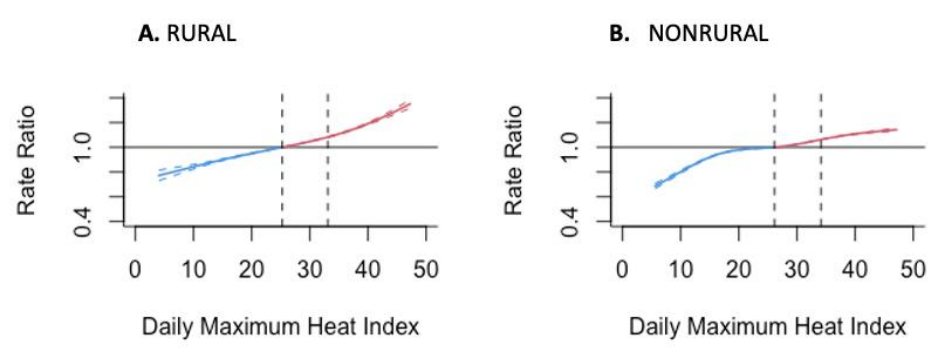
16,873,213 healthcare visits from Virginia facilities reporting to the Virginia Department of Health syndromic surveillance system (May to September 2015-2022)

Region, rurality, and age-specific estimates of ED visits attributable to extreme heat were produced.

Gridded hourly temperature, humidity, and pressure data	→	NLDAS2
Climate Zone Classification	→	Köppen
Rurality	→	US HHS Rural Health Grants Eligibility Analyzer

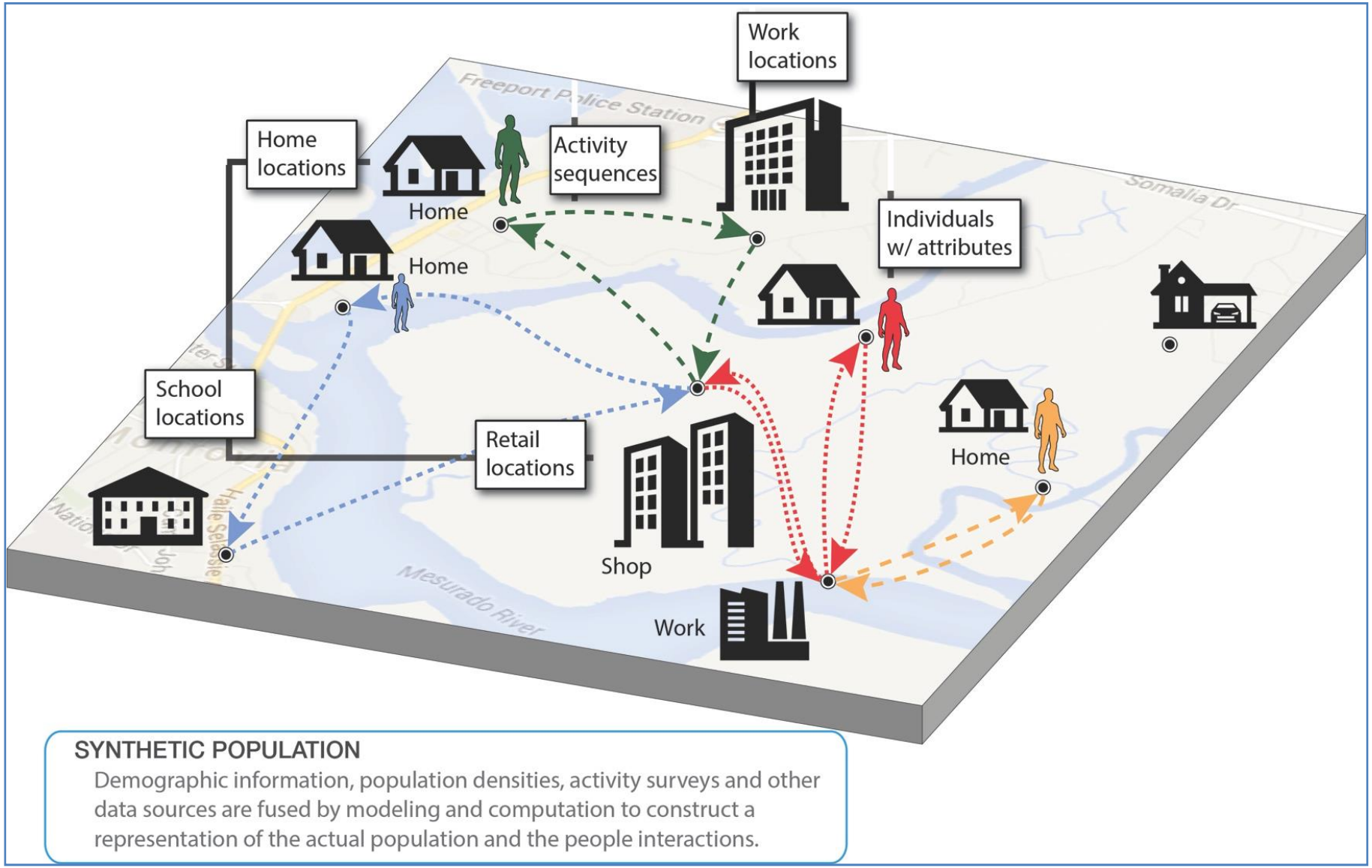
Distributed lag non-linear model (DLNM) used to assess healthcare visit association with heat index

Findings



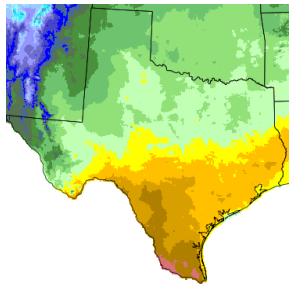
- Healthcare visits started increasing at a maximum daily heat index of ~26°C.
- There are differences in ED visit attributable fractions between rural and non-rural areas.
- Public health interventions tailored to rural areas to mitigate adverse health outcomes from heat exposure are needed.

Synthetic Populations



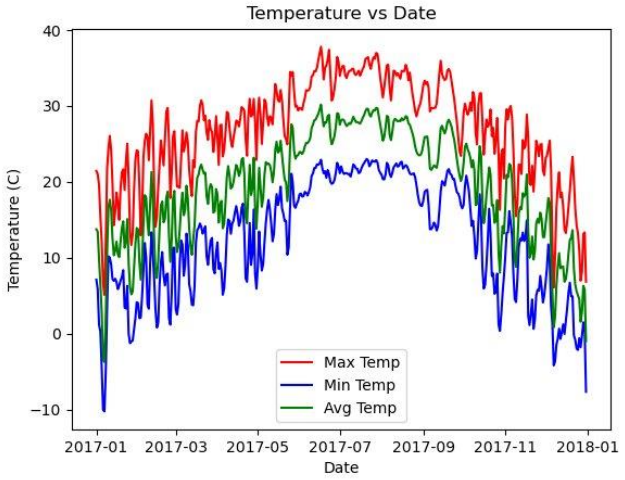
Environmental Data

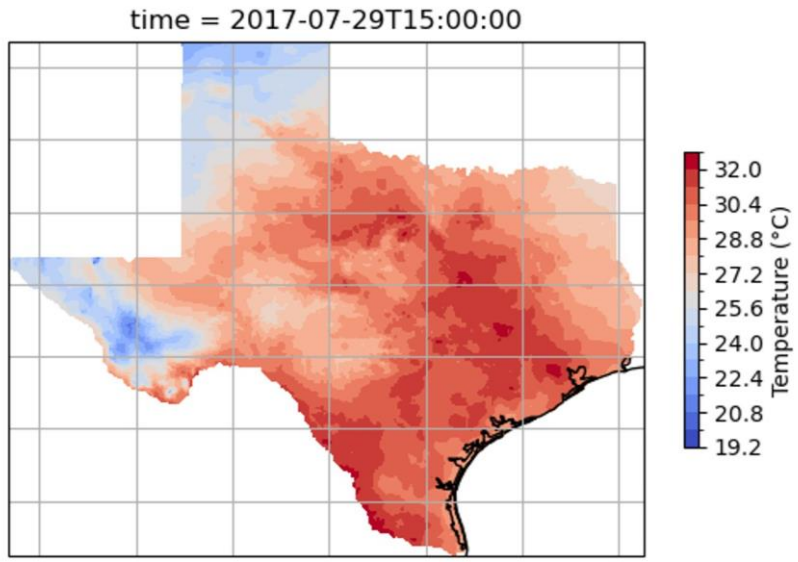
PRISM + MetSim

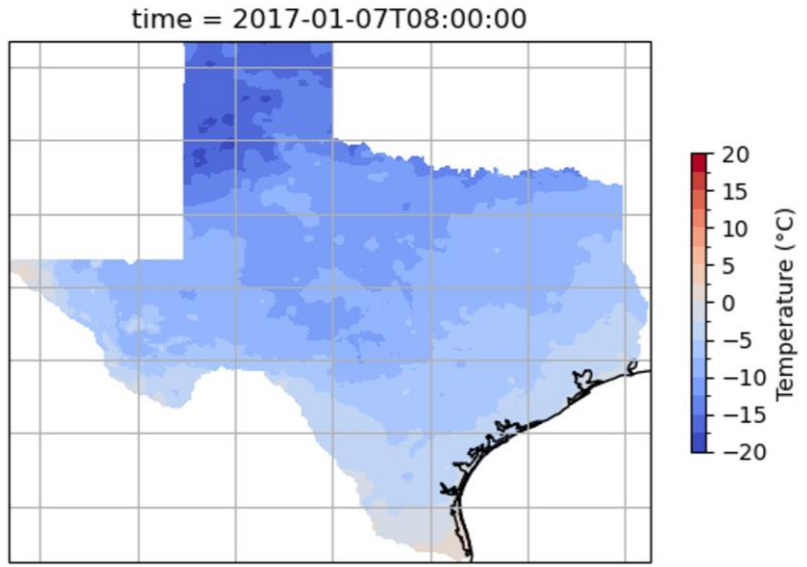


Environmental data

- Hourly heat estimates are generated using Parameter-elevation Regressions on Independent Slopes (PRISM) Model daily data and MetSim to fit a diurnal curve.
- Can easily be substituted with other environmental data.



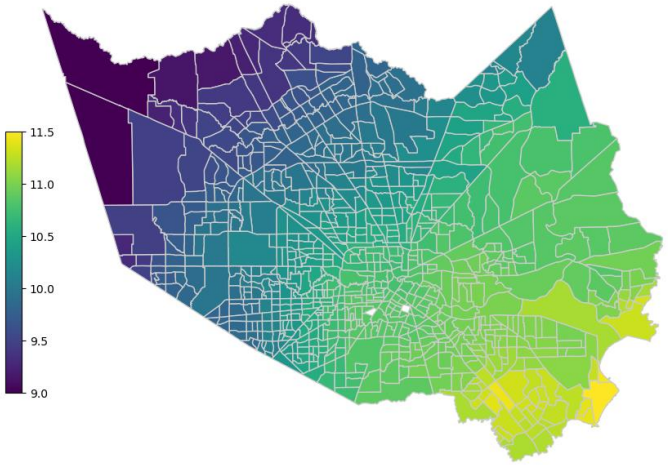




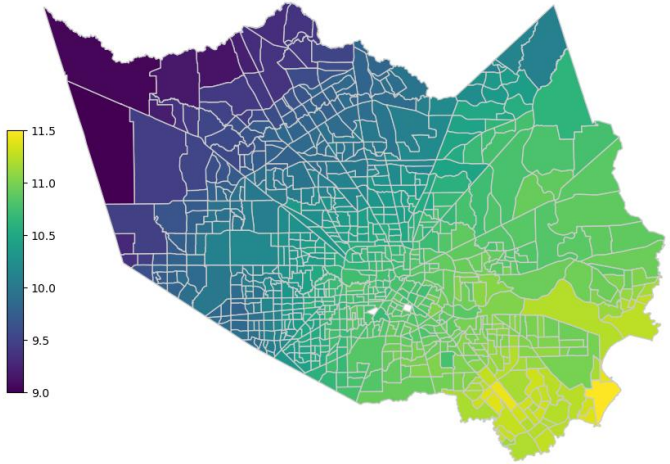
Preliminary Results

- Average weekly temperature, aggregated to Census tracts in Harris County, TX, for the first week of January 2017.
- Aggregation can be done in multiple ways, such as by demographic groups, by different geographies, and by temperature hotspots/coldspots.
- Next step is to relate differences to health outcomes. We have done this recently for flooding exposures during Hurricane Harvey evacuation/sheltering in combination with ED-visit data.

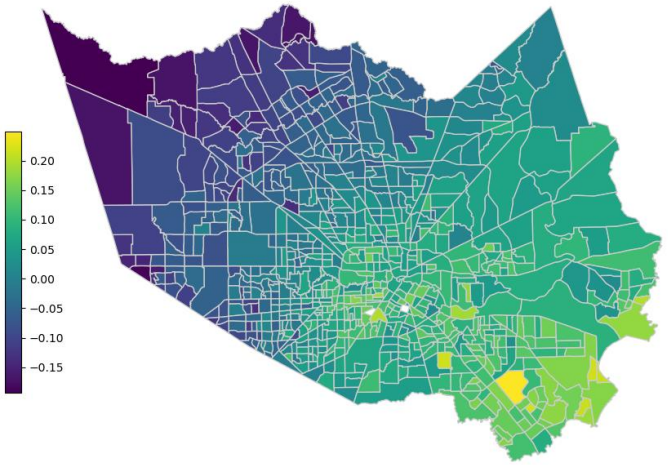
Avg. weekly temperature at home locations



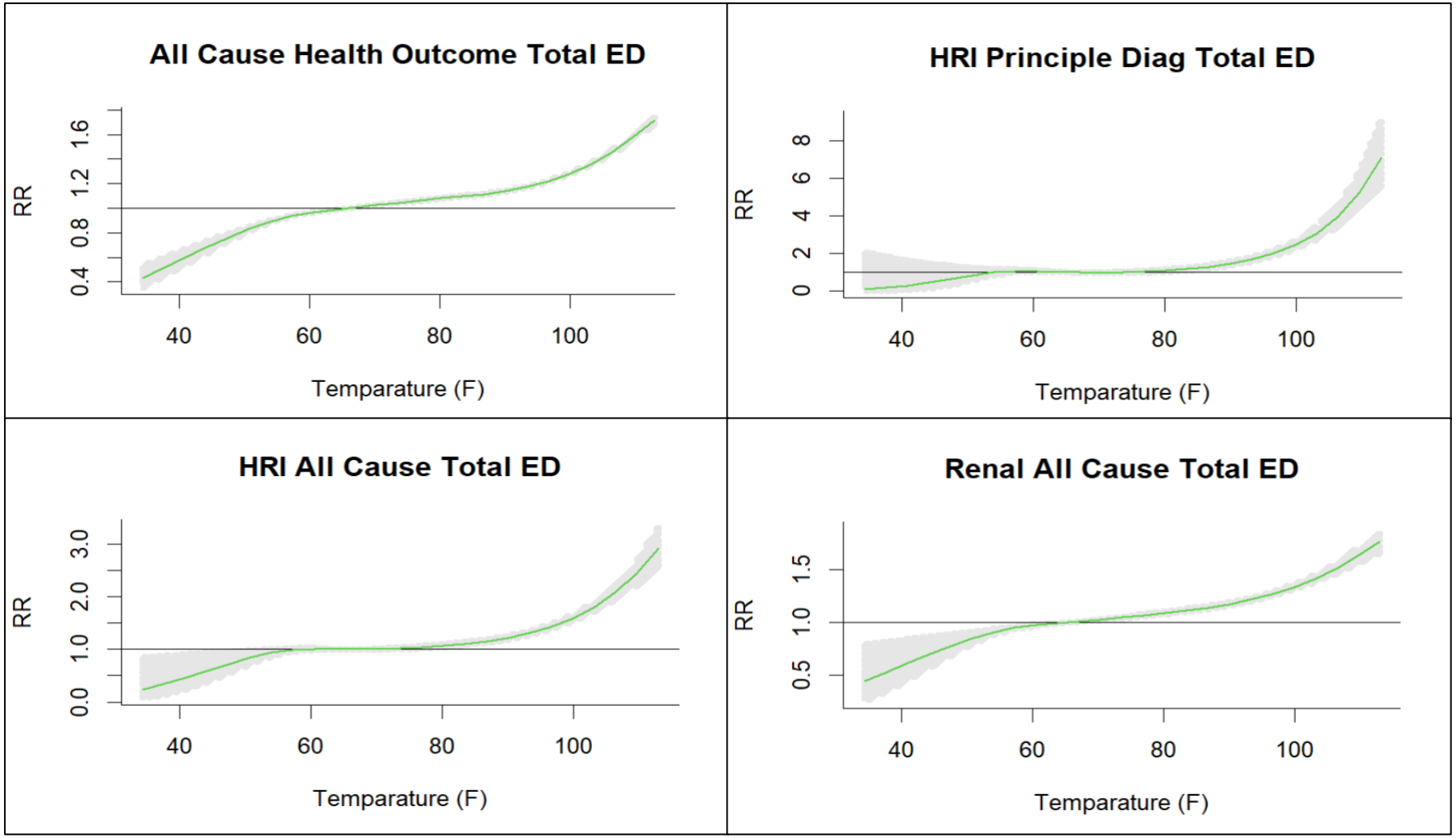
Avg. weekly temperature with activity modeling



Difference in avg. weekly temperature due to activity modeling



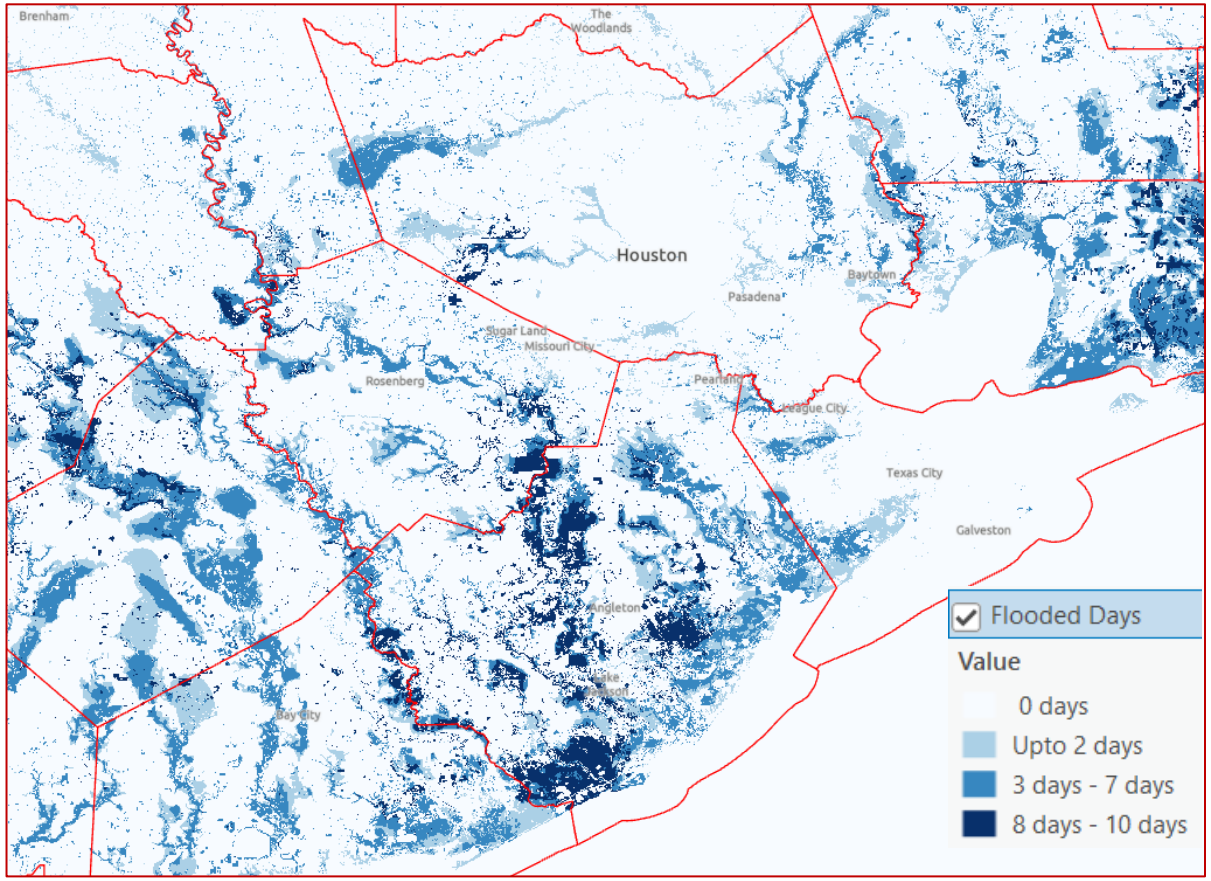
The temperature at which total and renal ED visits increases is lower than for those specifically coded as heat-related illness (HRI)



Flood maps that help to identify flooded areas differ by spatial and temporal resolution, and reporting observed or modelled flood.

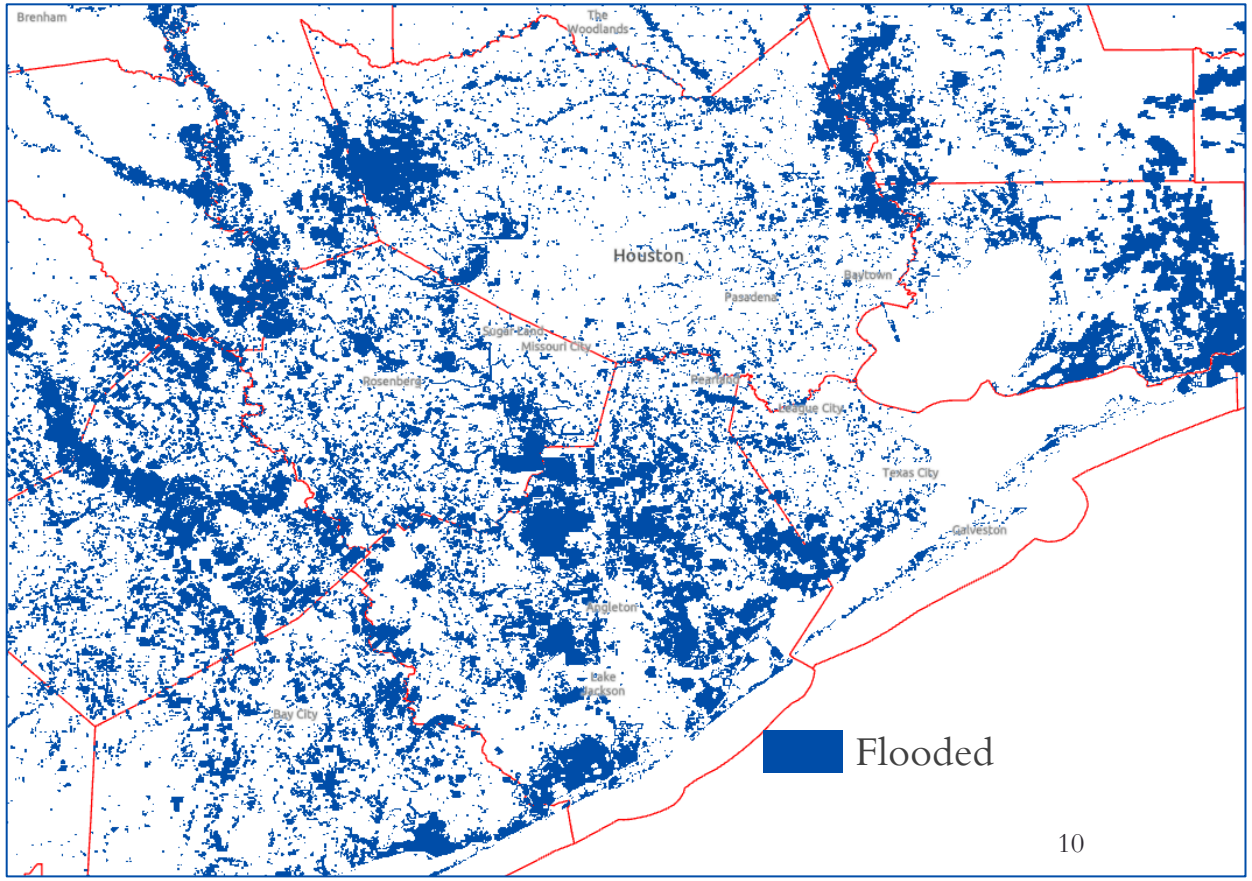
AER Flood Map

Spatial resolution: 22 km (enhanced to 90m)
Temporal resolution: Everyday

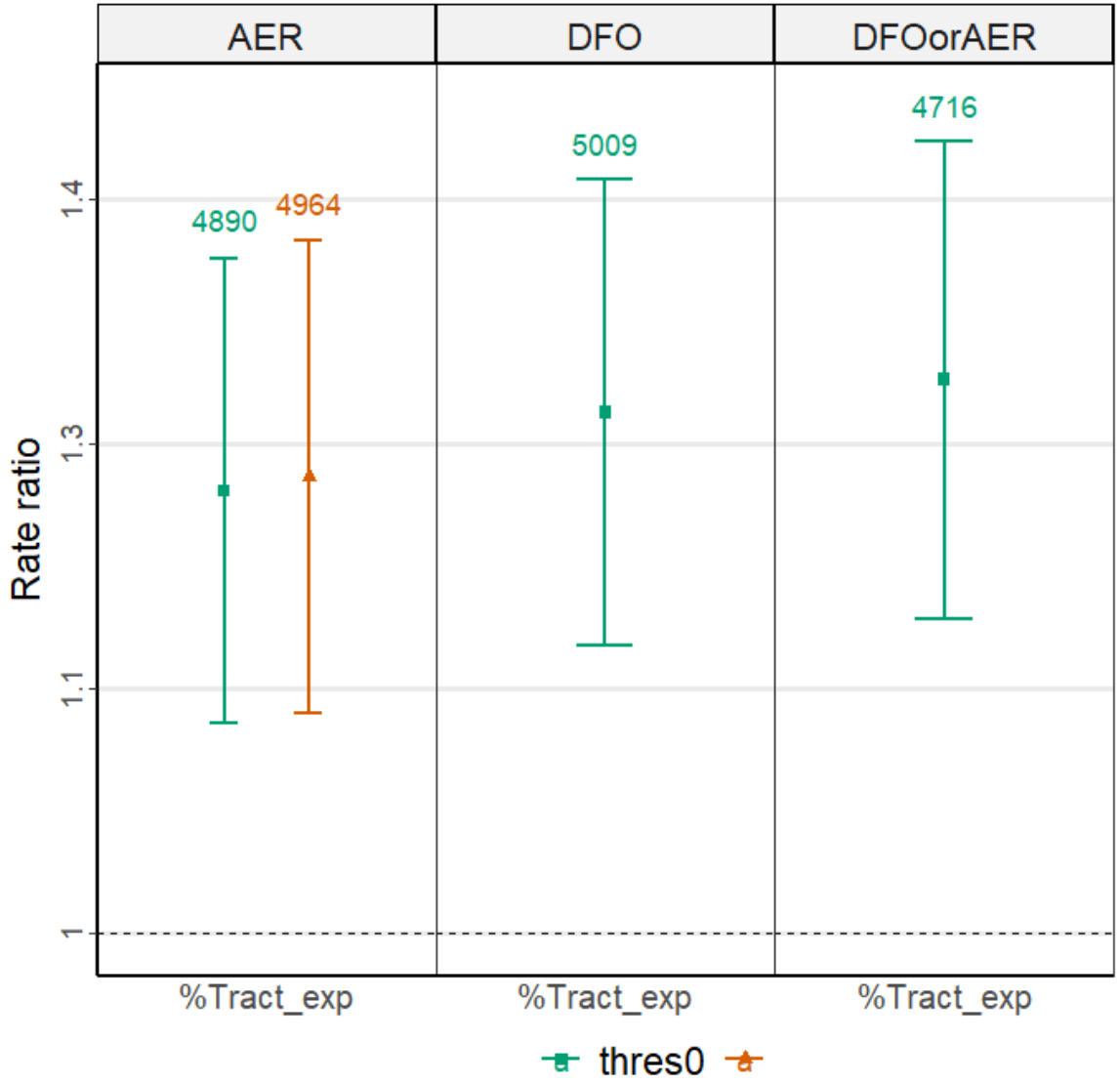


Dartmouth Flood Observatory Map

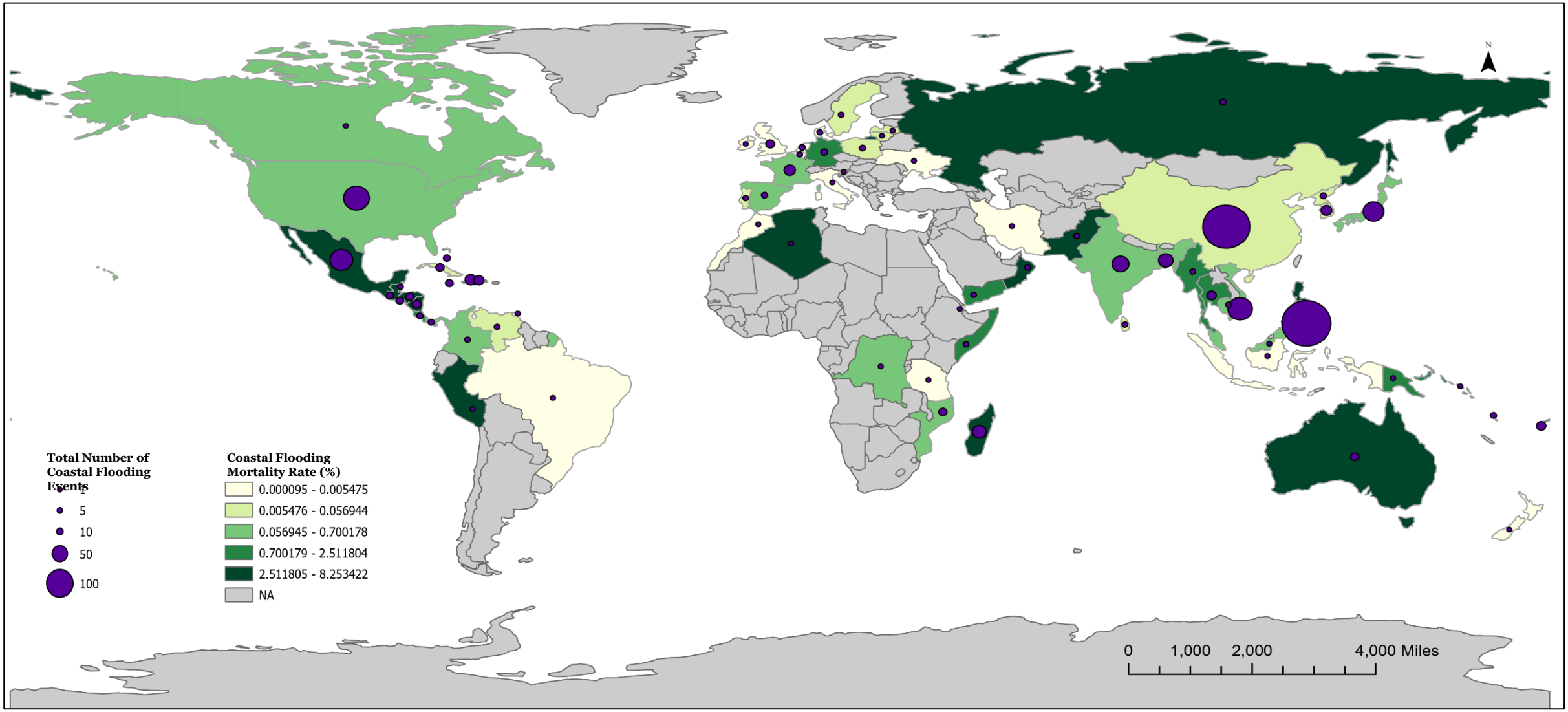
Spatial resolution: 200 m
Temporal resolution: Single snapshot



Combined DFO and AER flood exposure metric suggests higher rate ratio for gastrointestional-illness related ED visits



Global Flood mortality models suggest differential mortality rates across impacted countries.



Current ARL-5 Supporting Evidence

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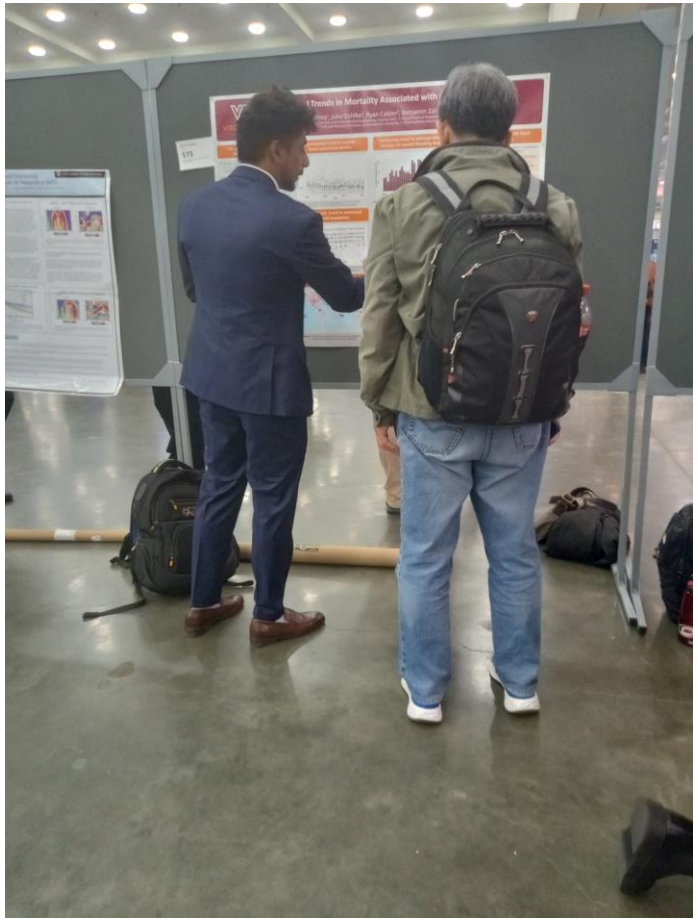
- **Application components have been integrated into a functioning prototype application system with realistic supporting elements.**
  - 3 different ways to estimate affected population in the global model and have evaluated country-level estimates and other covariates for regional level estimation.
  - Additional methods for flood inundation estimation using the Texas dataset.

- **The application systems potential to improve the decision-making activity has been determined and articulated (e.g., projected impacts on cost, functionality, delivery time, etc.)**
  - Updated mortality estimates for integration into the pyCIAM model
  - We are engaging with Virginia Department of Health stakeholders at an upcoming event at Virginia Tech (Apr 5th).
  - We are scoping a second engagement with EPA NCEE for summer/fall 2024 to update them on our global flood-mortality model.

Presentations and upcoming publications



- Association between Summertime Emergency Department Visits and Maximum Daily Heat Index in Rural and Non-rural Areas of Virginia (2015-2022). *Under revision at STOTEN.*
- Assessing the Global Threat of Coastal Flooding: A Mortality Risk Model. *In preparation*
- Poster and symposium presentations at AMS 2024

Publications

Ramesh, B*, Callender, R, Zaitchik, BF, Jagger, M, Swarup, S, & **Gohlke, JM*** (2023). Adverse Health Outcomes Following Hurricane Harvey: A Comparison of Remotely-Sensed and Self-Reported Flood Exposure Estimates. *GeoHealth* 7(4): e2022GH000710.

Crawford, MC, Bukvic, A, Rijal, S, & **Gohlke, JM** (2023). The exposure of vulnerable coastal populations to flood-induced Natech events in Hampton Roads, Virginia. *Natural Hazards*, 1-31.

Brower AE, Ramesh B, Islam KA, Mortveit HS, Hoops S, Vullikanti A, Marathe MV, Zaitchik B**, Gohlke JM**, Swarup S (2023). Augmenting the Social Vulnerability Index using an agent-based simulation of Hurricane Harvey. *Computers, Environment and Urban Systems,* Volume 105, 2023, 102020.

Brower AE, Corpuz B, Ramesh B, Zaitchik B, **Gohlke JM** and Swarup, S* (2023) Predictors of Evacuation Rates during Hurricane Laura: Weather Forecasts, Twitter, and COVID-19. *Weather, Climate, and Society*, *15*(1), pp.177-193.

Ramesh, B, Jagger, MA, Zaitchik, B, Kolivras, KN, Swarup, S, Deanes, L, Hallisey, E, Sharpe, JD and **Gohlke, JM*** (2022). Flooding and emergency department visits: Effect modification by the CDC/ATSDR Social Vulnerability Index. *International Journal of Disaster Risk Reduction*, *76*, p.102986.

Cromar KR*, Anenberg SC, Balmes JR, Fawcett AA, Ghazipura M, **Gohlke JM**, Hashizume M, Howard P, Lavigne E, Levy K, Madrigano J. (2022). Global Health Impacts for Economic Models of Climate Change: A Systematic Review and Meta-Analysis. *Annals of the American Thoracic Society*. 2022 Jan 24. Times Cited: 1

Wang, S, Wu, C, Austin, E, Davis, M, & **Gohlke, JM*** (2022). Healthcare Visits and Summertime Heat Index in Virginia: An Analysis of Syndromic Surveillance Data Collected From 2015-2020. *Journal of Environmental Health*, *84*(10).

Ramesh B, Jagger MA, Zaitchik BF, Kolivras KN, Swarup S, Yang B, Corpuz BG, **Gohlke JM*** (2022). Estimating changes in emergency department visits associated with floods caused by Tropical Storm Imelda using satellite observations and syndromic surveillance. *Health & Place*. Mar 1;74:102757.

Ramesh, B, Jagger, MA, Zaitchik, B, Kolivras, KN, Swarup, S, Deanes, L, & **Gohlke, JM*** (2021). Emergency department visits associated with satellite observed flooding during and following Hurricane Harvey. *Journal of Exposure Science & Environmental Epidemiology*, *31*(5), 832-841. Impact Factor: 5.56, Times Cited: 6