From Space to Front Porch: Connecting Earth Observations to Health Outcomes with an Environmental Exposure Modeling System

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NASA HAQ APPLICATIONS ANNUAL TEAM MEETING

SEPT 19TH, 2022

Project Goal and Objectives:

Enhance the CDC/ATSDR Social Vulnerability Index (SVI) through development of dynamic exposure estimates by:

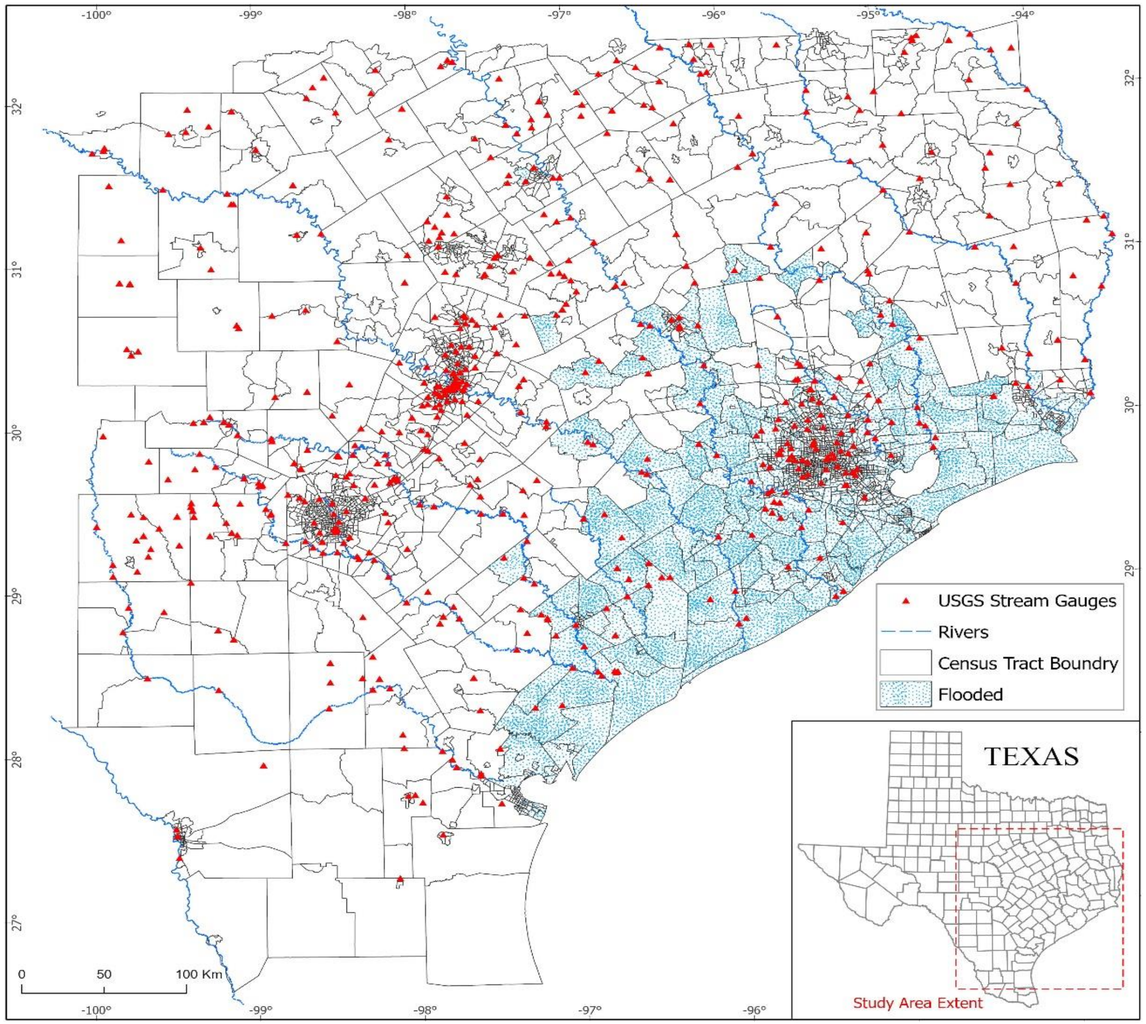
1. Incorporating Earth Observations (EO) datasets on flood inundation spatial extent, duration, and depth.

2. Developing a synthetic population model of movement of people prior to and during a flood event.

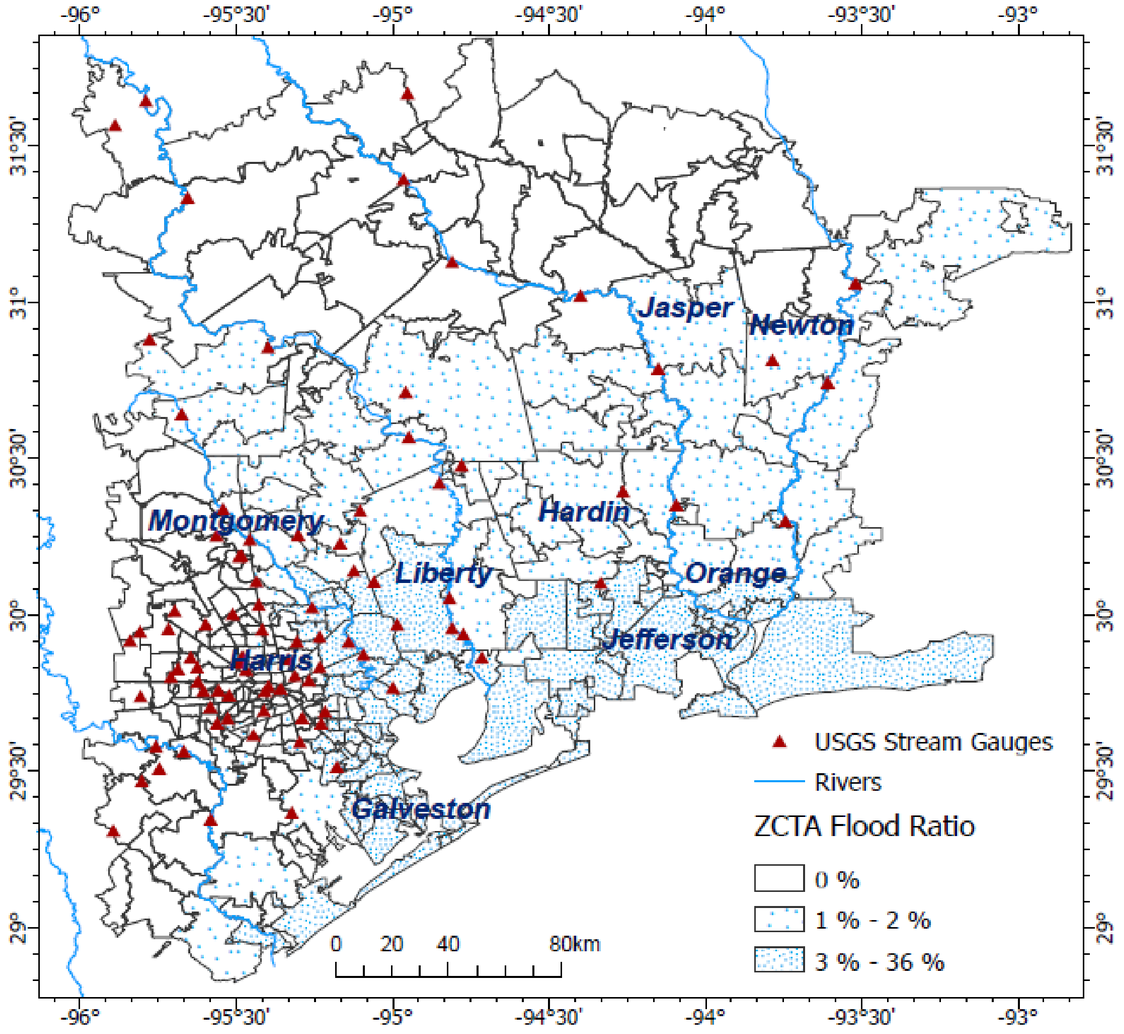
3. Characterizing flood-associated health outcomes and evaluating the utility of exposure enhancements through analysis of healthcare visit data.

Using EO to define spatial flooding extents during Hurricane Harvey (census tract) and Tropical Storm Imelda (ZCTA)

Hurricane Harvey (August 2017)

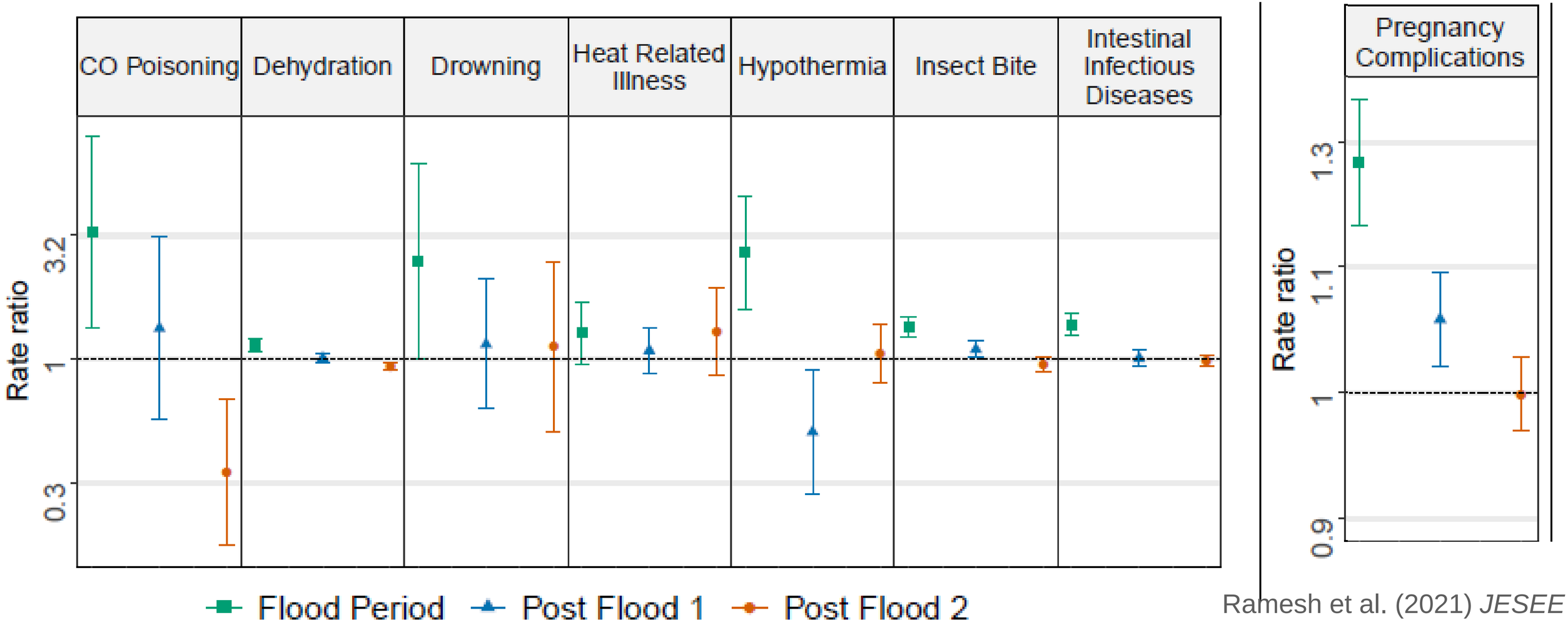


Tropical Storm Imelda (September 2019)



ED visits for pregnancy complications, intestinal infections, insect bites were elevated in flooded tracts following Hurricane Harvey

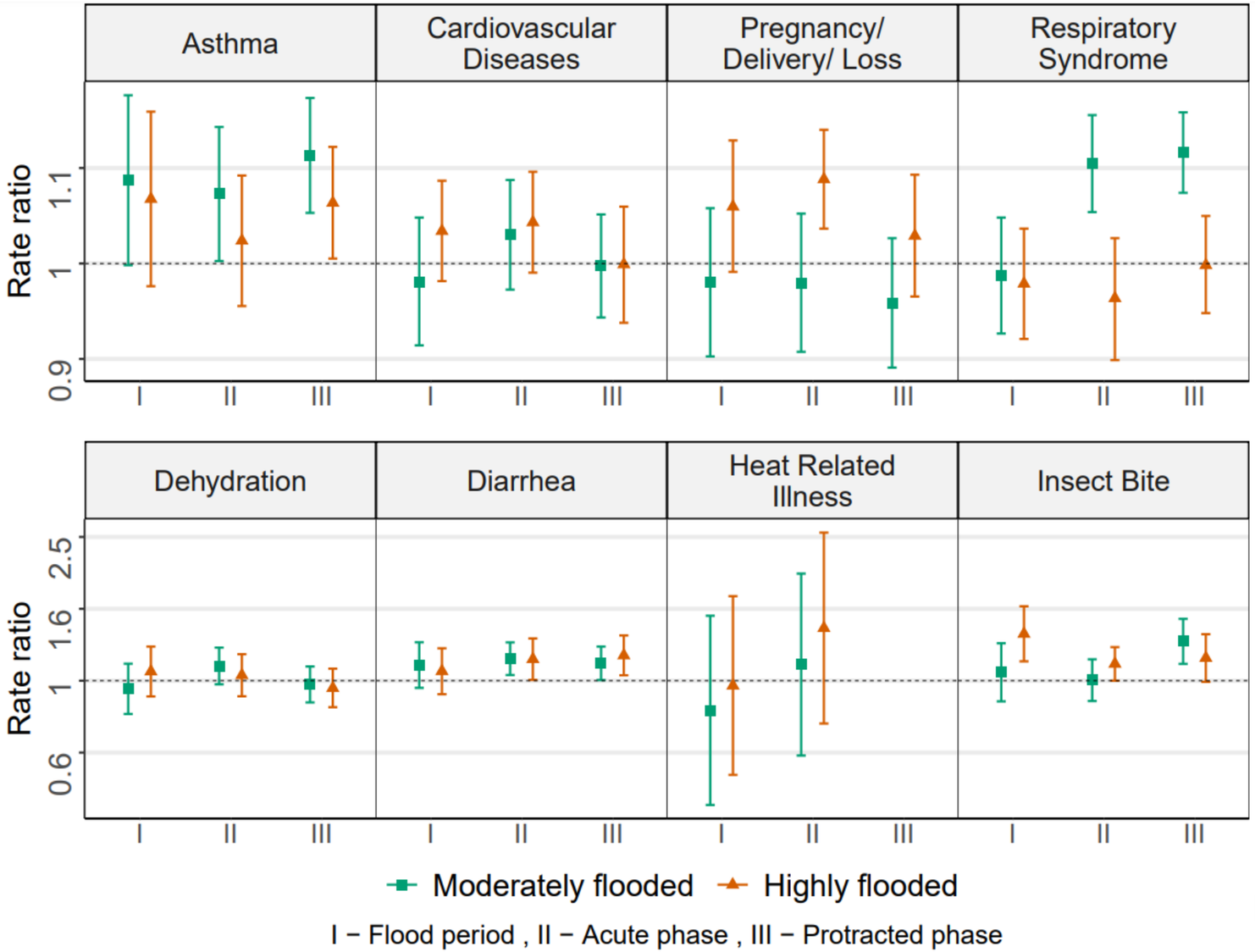
ARL 4, 5—Prototype and Potential Determined



Ramesh et al. (2021) *JESEE*

Tropical Storm Imelda: similar increases in cause-specific ED visits using syndromic surveillance data

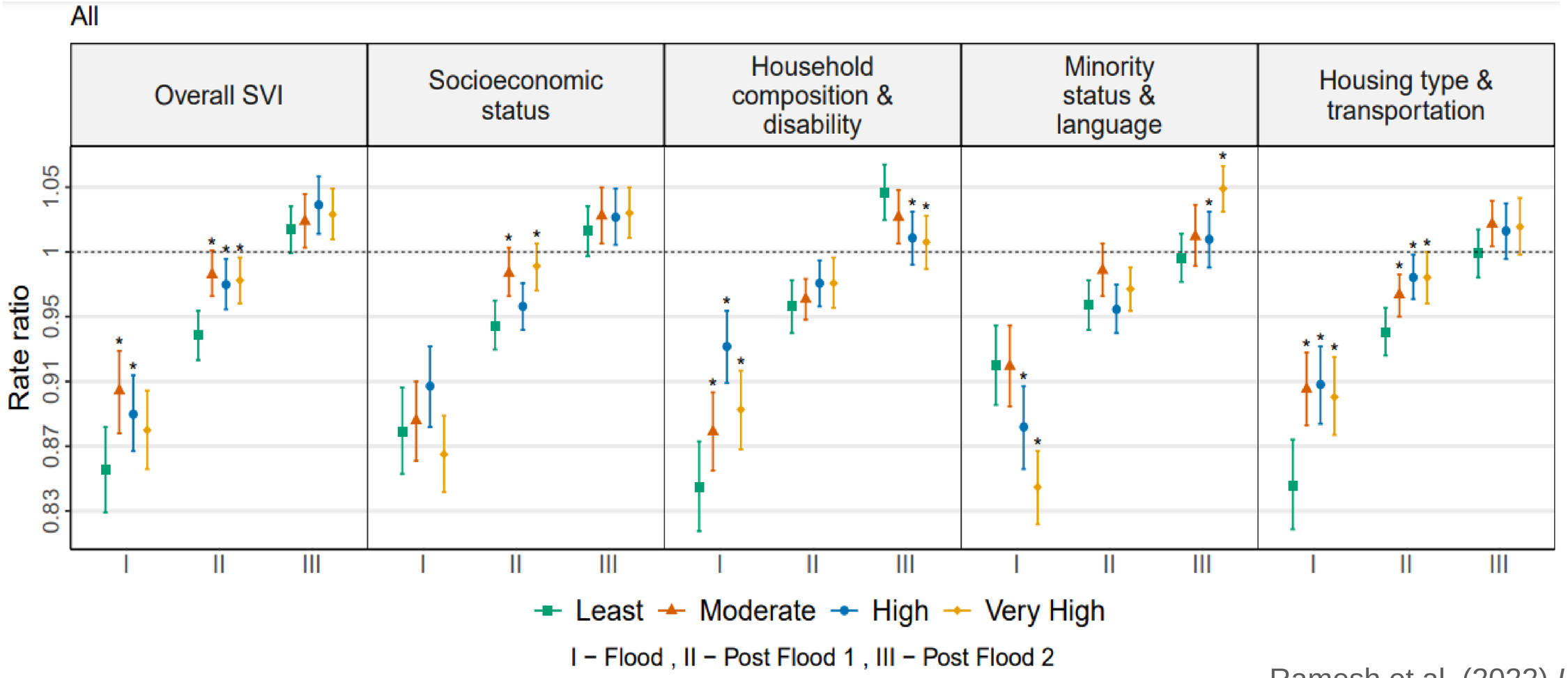
ARL 6—Potential Demonstrated



Ramesh et al. (2021) *Health and Place*

Census tract CDC/ATSDR SVI modifies the effect between flooding and ED visits

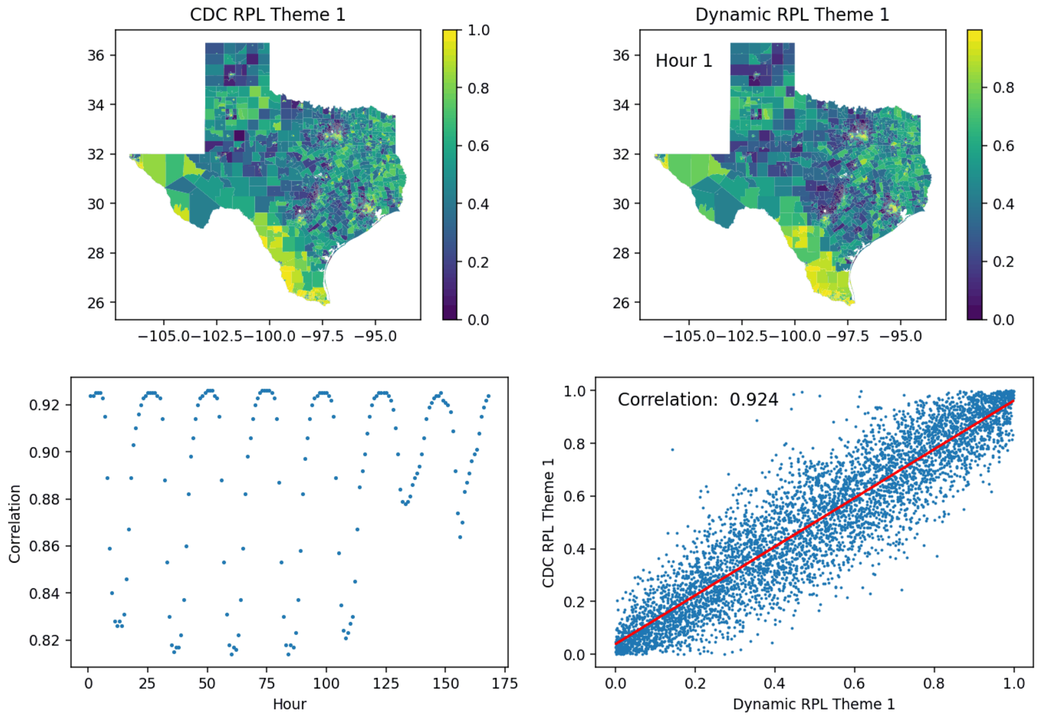
ARL 7—Functionality Demonstrated

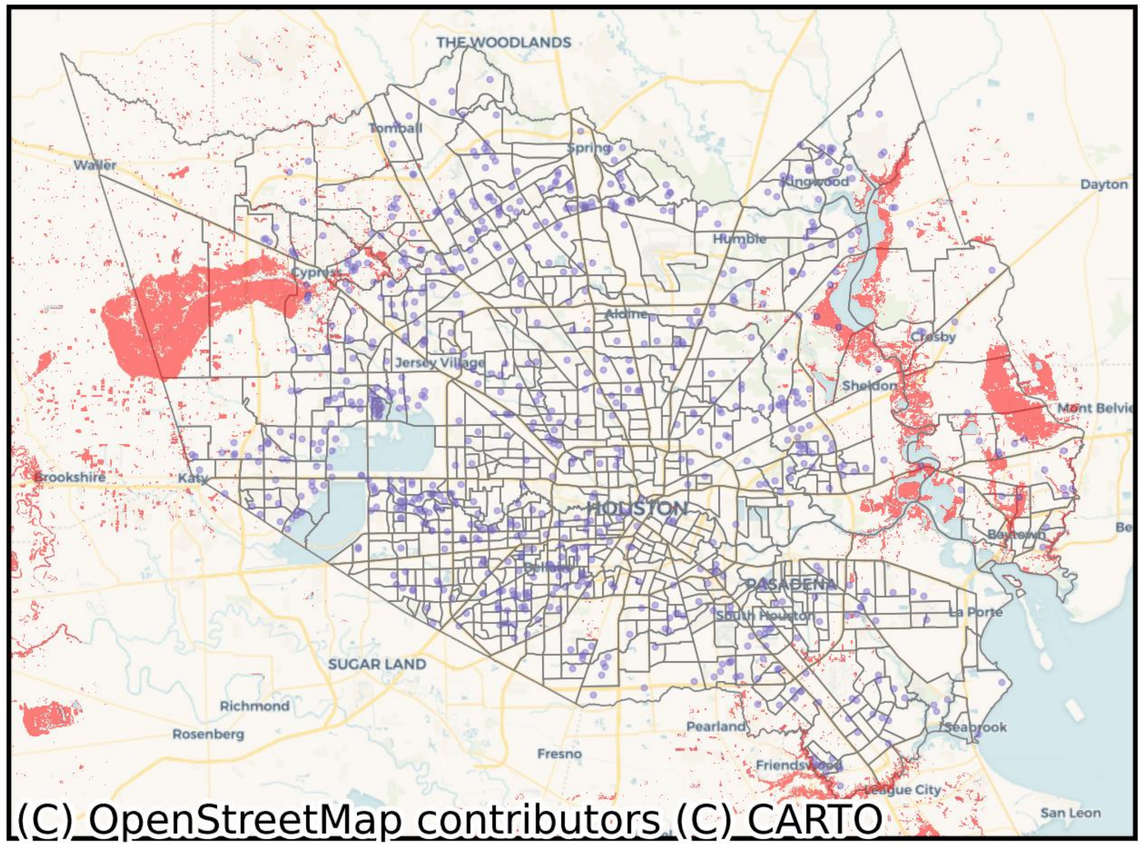


Ramesh et al. (2022) *IJDRR*

Augmenting the SVI Using an Agent-based Simulation of Hurricane Harvey

ARL 4,5—Prototype and Potential Determined

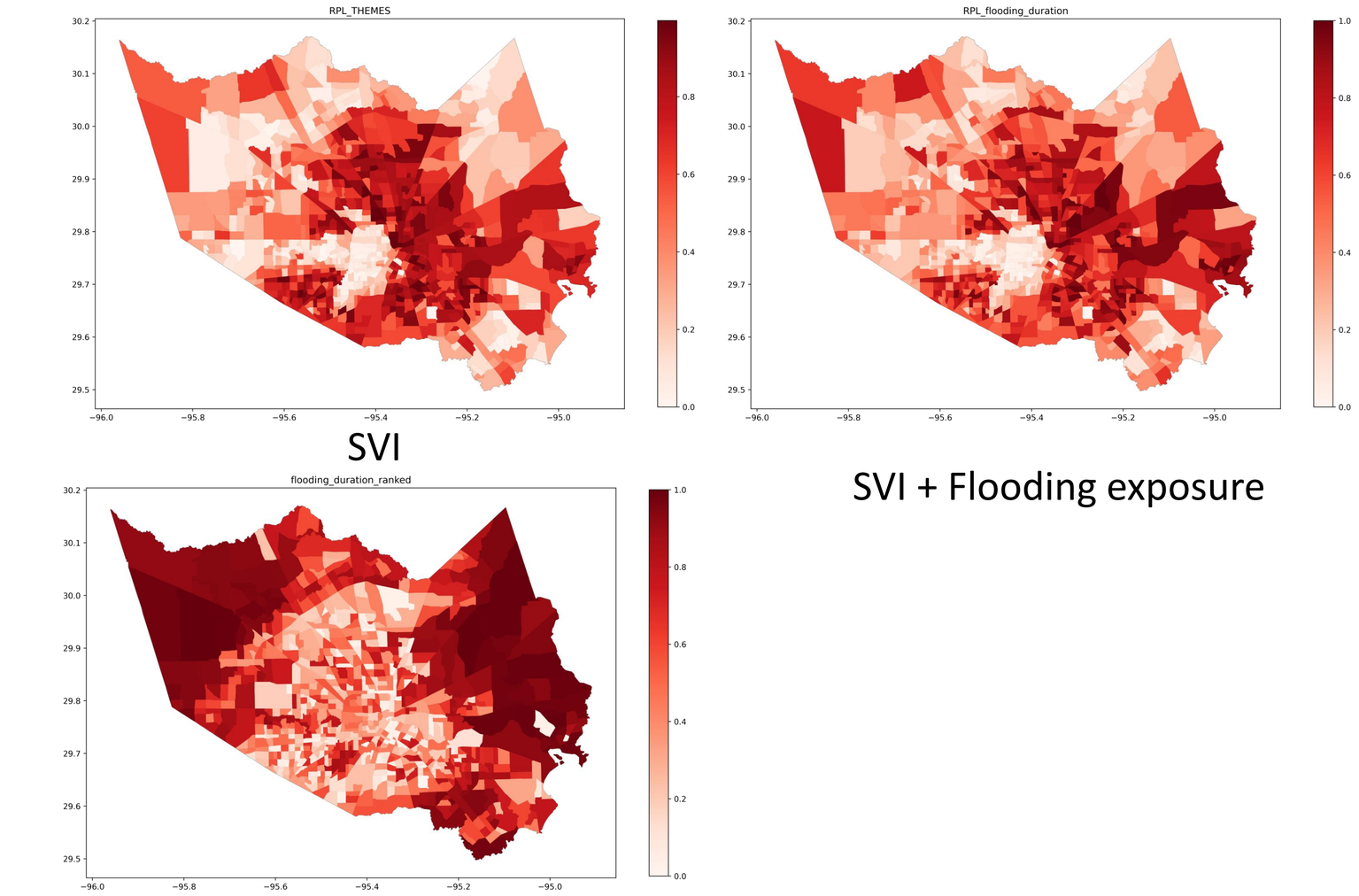




All households evacuating on August 28, 2017, 8:00 AM - 6:00 PM.
(modeled)

Dynamic SVI evacuation variables improve models of ED visits

ARL 6,7—Potential and Functionality Demonstrated



SVI

SVI + Flooding exposure

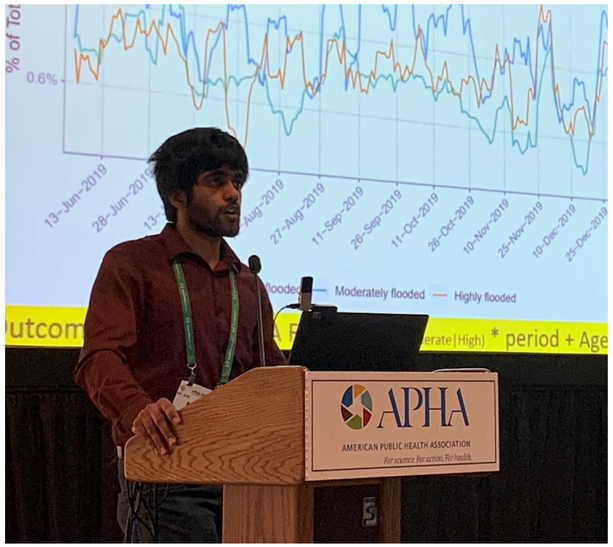
Dynamic flood exposure along evacuation routes and at residence

MODEL	TIME PERIOD	RELATIVE RATE RATIO (95% CIS) IN FLOODED TRACTS*	P-VALUE	AIC
Model 0: Base				2232746
	Evacuation	**0.94(0.91-0.98)**	**0.0009**	
	Flood	**0.97(0.94-1.00)**	**0.04**	
	Post-Flood	1.01(1.00-1.02)	0.11	
Model 1: Base + Evacuation proportion				2229945
	Evacuation	1.40(0.83-2.35)	0.20	
	Flood	**1.97(1.25-3.11)**	**0.003**	
	Post-Flood	1.02(0.87-1.18)	0.84	
Model 2: Base + Flood duration along evacuation route				2231500
	Evacuation	**1.12(1.07-1.17)**	**3.66E-07**	
	Flood	**1.09(1.05-1.14)**	**1.77E-05**	
	Post-Flood	**0.98(0.97-0.99)**	**2.71E-05**	
Model 3: Base + Flood duration along evacuation route +Evacuation proportion				2230288
	Evacuation	**1.12(1.07-1.17)**	**3.98E-07**	
	Flood	**1.09(1.05-1.14)**	**1.97E-05**	
	Post-Flood	**0.98(0.97-0.99)**	**2.64E-05**	

*This is the exponentiated interaction term for flood*time (base model) or flood*time*evacuation (or simulation) variable.

Brower et al. *In revision*
Brower et al. *In preparation*

STUDENT ACHIEVEMENTS



Balaji Ramesh, presenting at APHA 2021 Annual Meeting, currently a PhD student at Ohio State University, Department of Epidemiology

Anna Brower, University of Virginia Computer Science Program

Kick-off Team meeting held at CDC in Atlanta, GA in 2019

Attendees: Upper row left to right: Elaine Hallisey (CDC), John Fleming (HHD), Barry Flanigan (CDC), Grete Wilt (CDC), Samarth Swarup (UVA), Meredith Jagger (Consultant), Anabel Carter (JHU), Ben Zaitchik (JHU), Bottom Row left to right: Suwei Wang (VT), Lauren Deanes (JHU), Molly Richardson (VT), Biru Yang (HHD), Julia Gohlke (VT) Not shown but present at meeting: Caitlin Mertzlufft (CDC), David Rickless (CDC), and Amy Wolkin (CDC)

Peer-reviewed scientific publications:

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):832-41.

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

Ramesh, B, Jagger, MA, Zaitchik, BF, Kolivras, KN, Swarup, S, Yang, B, Corpuz, BG and 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,* 74, p.102757.

Brower AE, B Corpuz, B Ramesh, BF Zaitchik, JM Gohlke, S Swarup. Predictors of Evacuation Rates During Hurricane Laura: Weather Forecasts, Social Vulnerability, and Twitter. In Revision at *Weather, Climate, and Society*.

Ramesh, B, R Callender, BF Zaitchik, MJagger, S Swarup, JM Gohlke. Adverse health outcomes following Hurricane Harvey: A comparison of remotely sensed and self-reported flood exposure estimates. Under Review at *GeoHealth*

Brower AE, B Ramesh, KA Islam, HS Mortveit, S Hoops, A Vullikanti, MV Marathe, BF Zaitchik, JM Gohlke, S Swarup. Augmenting the Social Vulnerability Index Using an Agent-based Simulation of Hurricane Harvey. In Preparation for *Computers, Environment and Urban Systems*.