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

Julia Gohlke, Virginia Tech

Annual grantee meeting

Sept 21st, 2020

The Team

Elaine Hallisey, Barry Flanagan, and Danielle Sharpe at CDC GRASP

Biru Yang and John Fleming, Houston Health Department

Ben Zaitchik and **Lauren Deanes**, Johns Hopkins University

Samarth Swarup, **Anna Brower**, and Sanchit Sinha, University of Virginia

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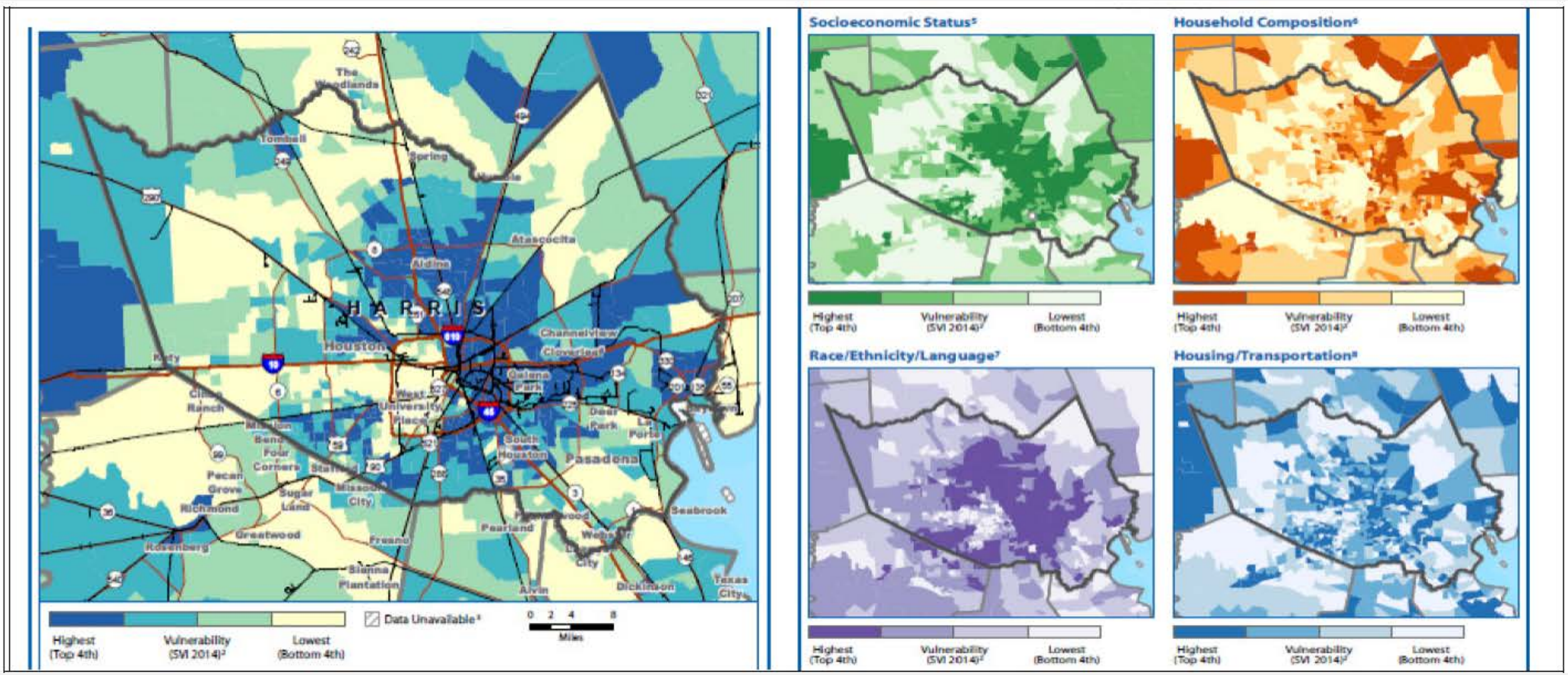
Meredith Jagger, Independent Consultant

The CDC SVI is used to estimate the amount of needed supplies, locations of emergency shelters, assisted evacuations, support response



https://svi.cdc.gov/

Project Goal and Objectives:

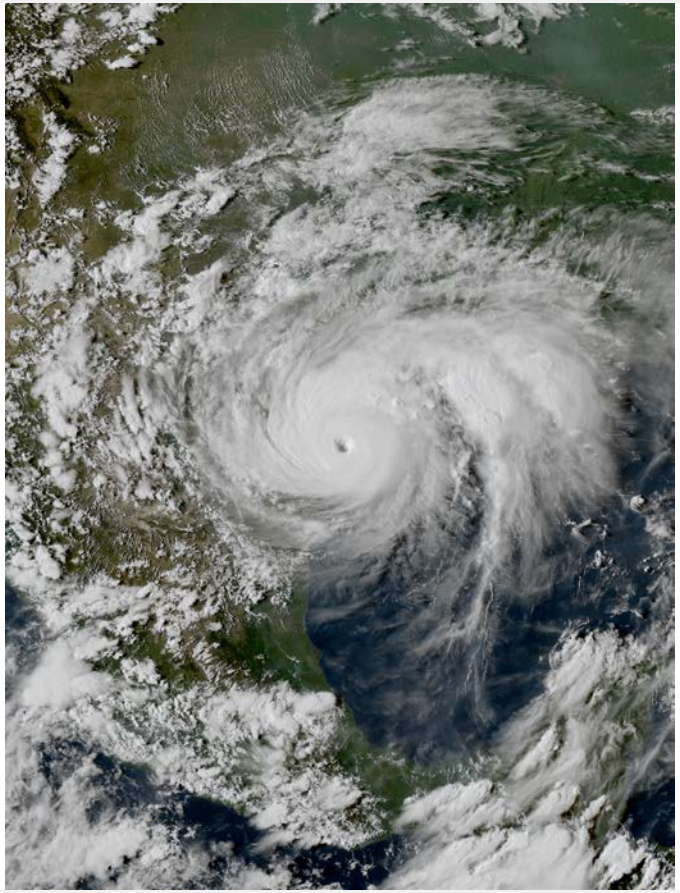
Enhance the CDC Social Vulnerability Index (CDC SVI) by adding exposure estimates, using Hurricane Harvey as case study:

1. Incorporating Earth Observations (EO) datasets on flooding, heat, power outages, and chemical emissions from industrial facilities.

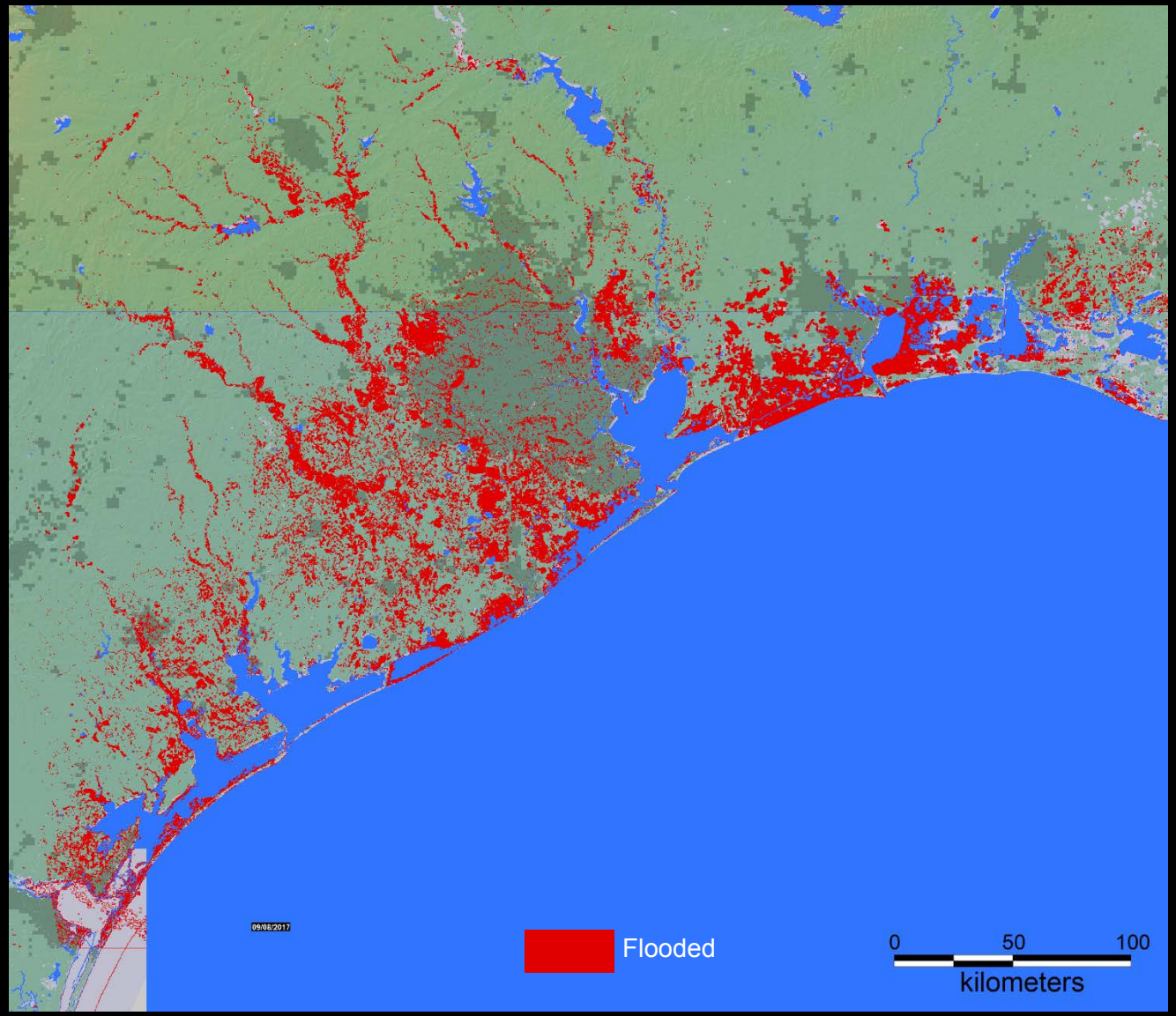
2. Incorporating a synthetic population model of movement of people pre, during and post disaster.

3. Evaluating the utility of these enhancements through analysis of healthcare visit data collected pre, during, and post Hurricane Harvey.

Hurricane Harvey



- August 2017
- Category 4 Storm
- Landfalls in TX and LA
- 4 days, 40+inches of rain



Spatial resolution : 200 m

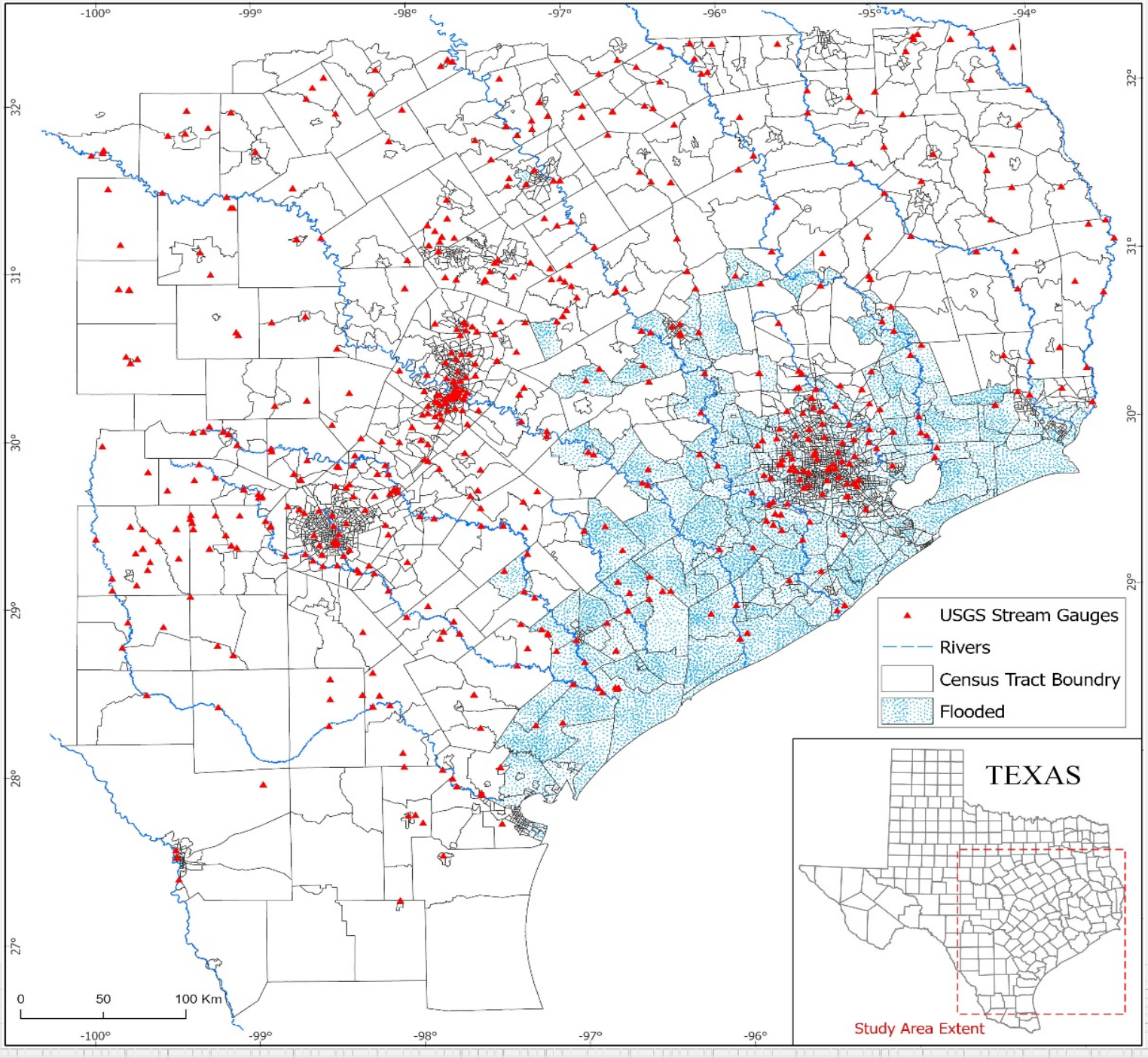
Inundation Data

Hurricane Harvey

Maximum Observed Flooding

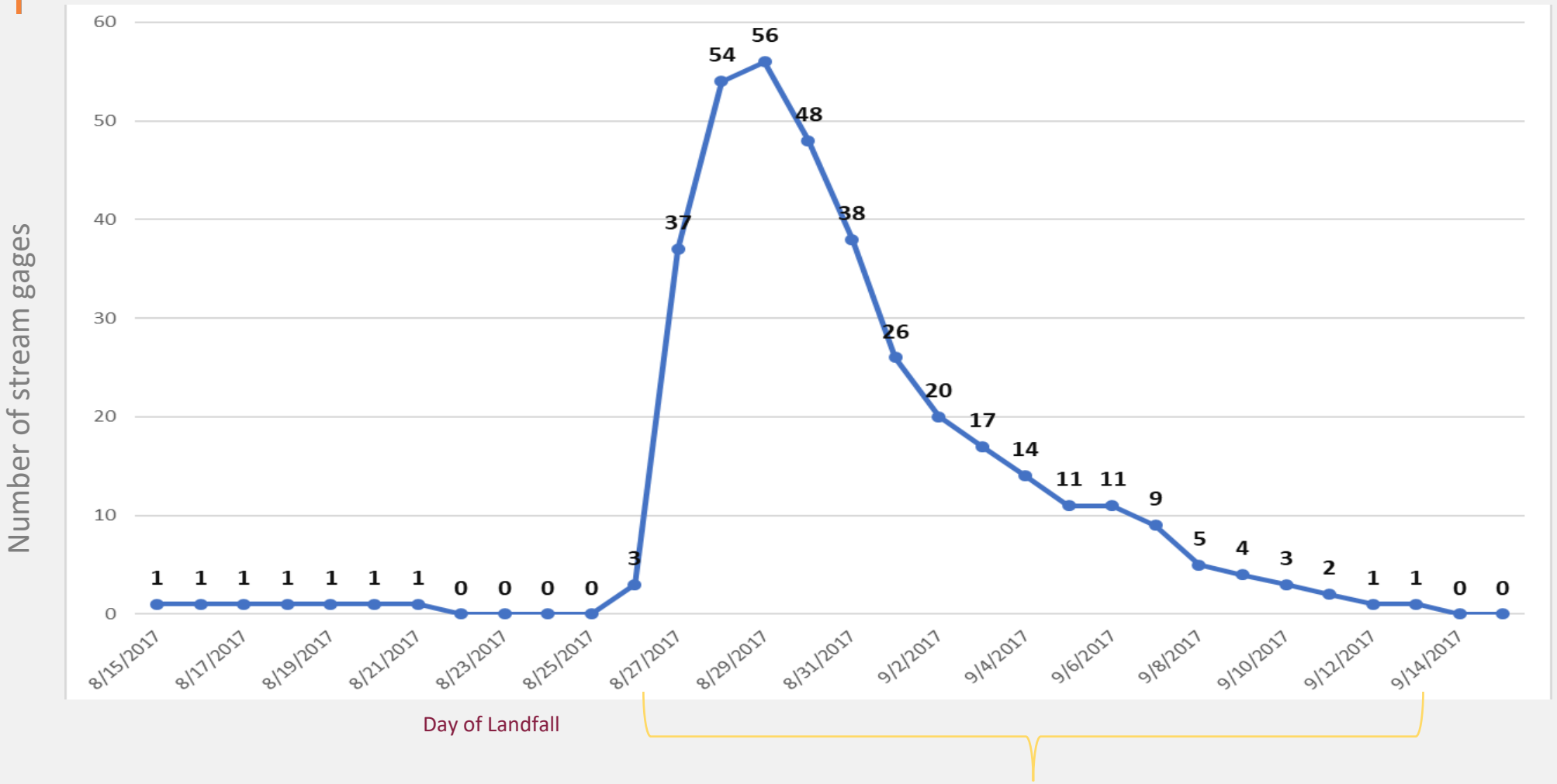
Brakenridge, G.R. and Kettner, A. J., 02-02-2020, "DFO Flood Event 4510", Dartmouth Flood Observatory, University of Colorado, Boulder, Colorado, USA, http://floodobservatory.colorado.edu/Events/2017USA4510/2017USA4510.html.

Defining the Texas study area and census tracks that experienced flooding versus those that did not from Dartmouth Flood Observatory data



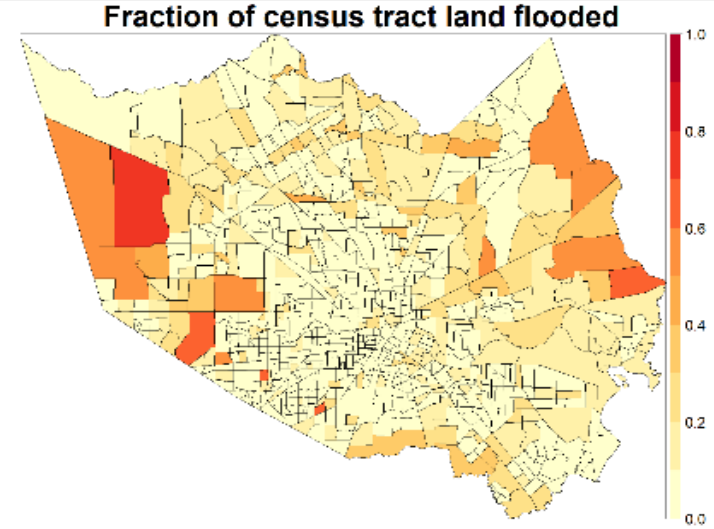
Defining the duration of the flood impact period of Hurricane Harvey using stream gauge data

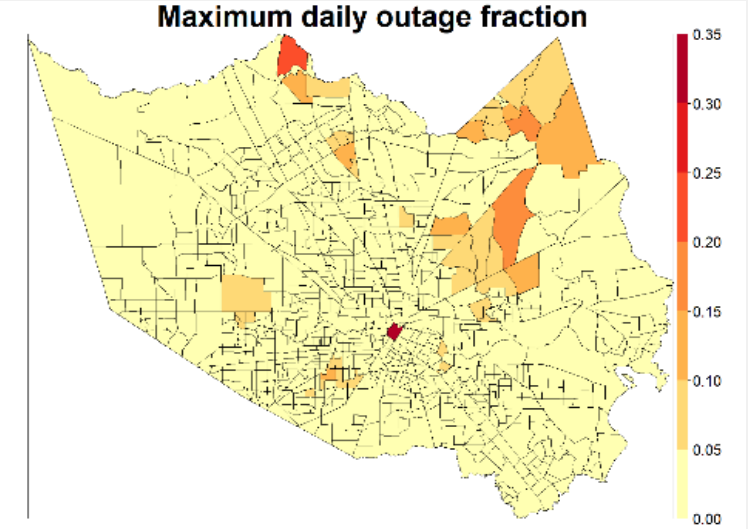
Number of steam gages measured stage higher than NWS- Flood Stage

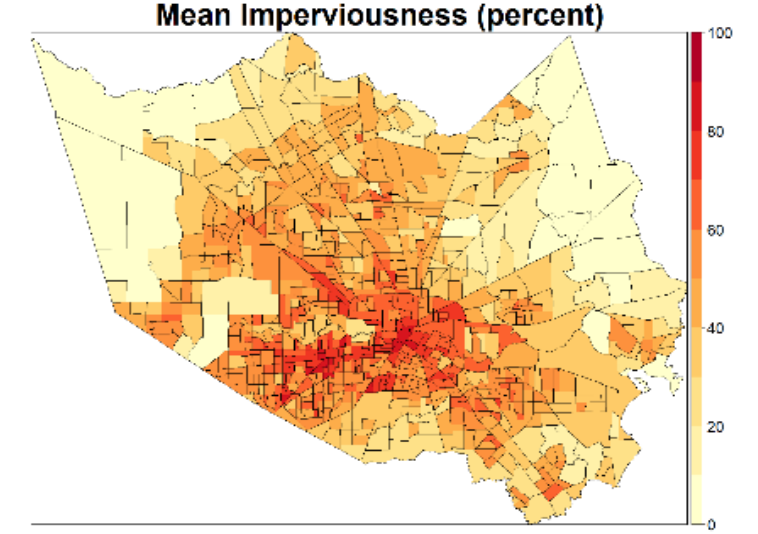


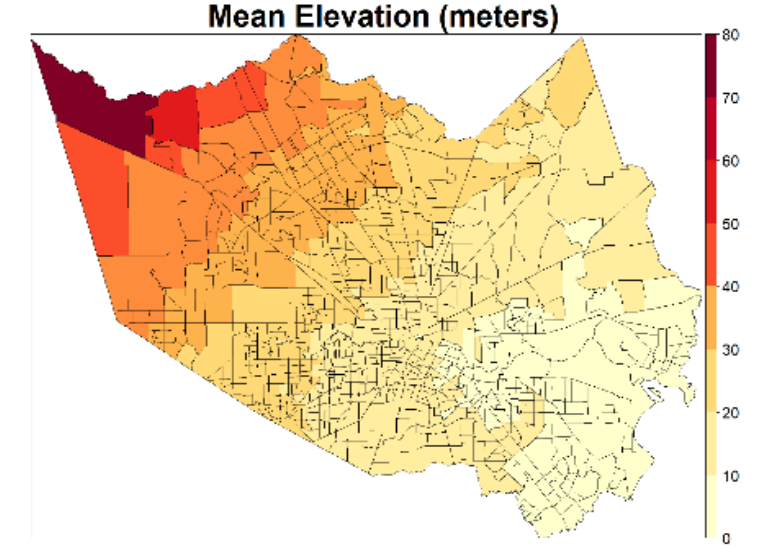
Data Source: USGS Current Water Data for Texas
URL: https://waterdata.usgs.gov/tx/nwis/rt?

Additional census tract level data processed for determining influences of spatially resolved Harvey-related exposures



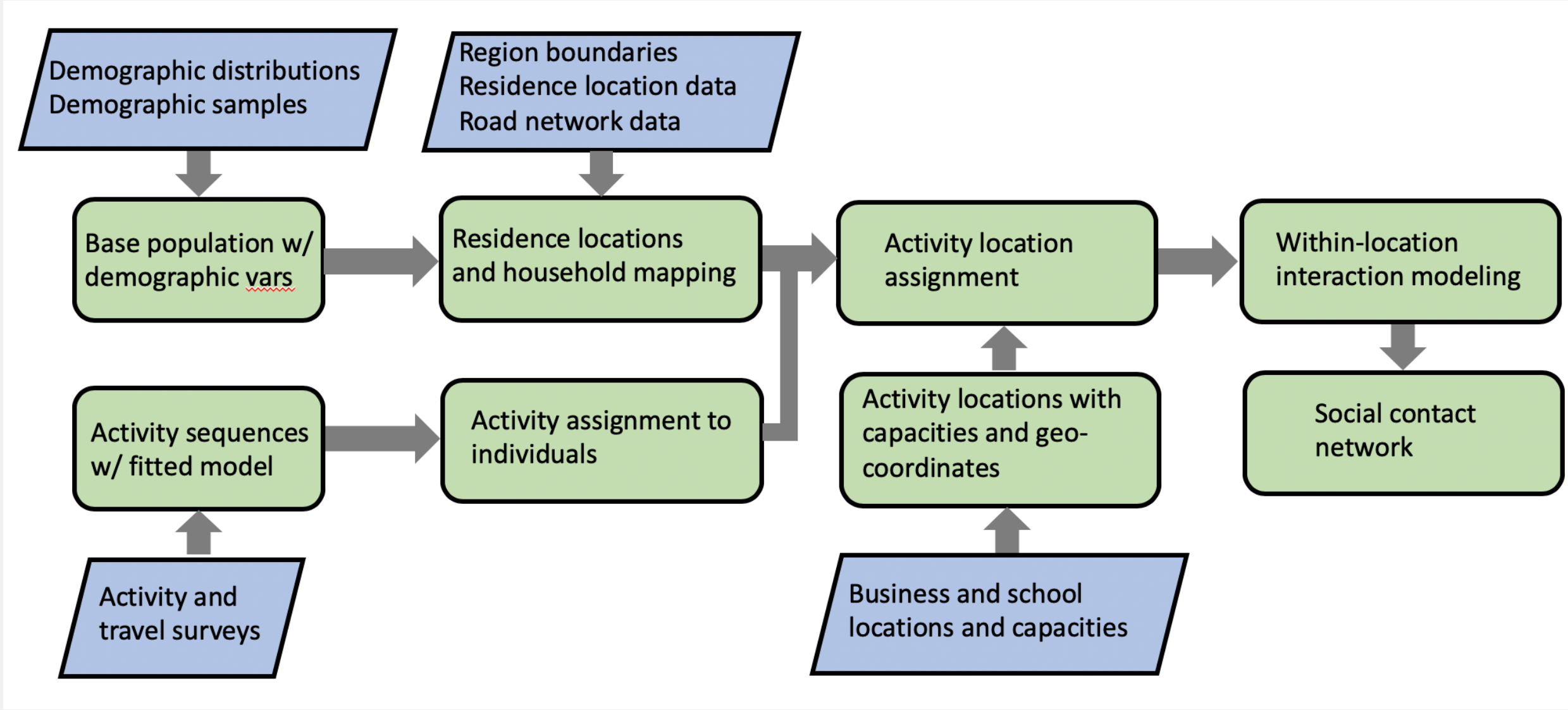




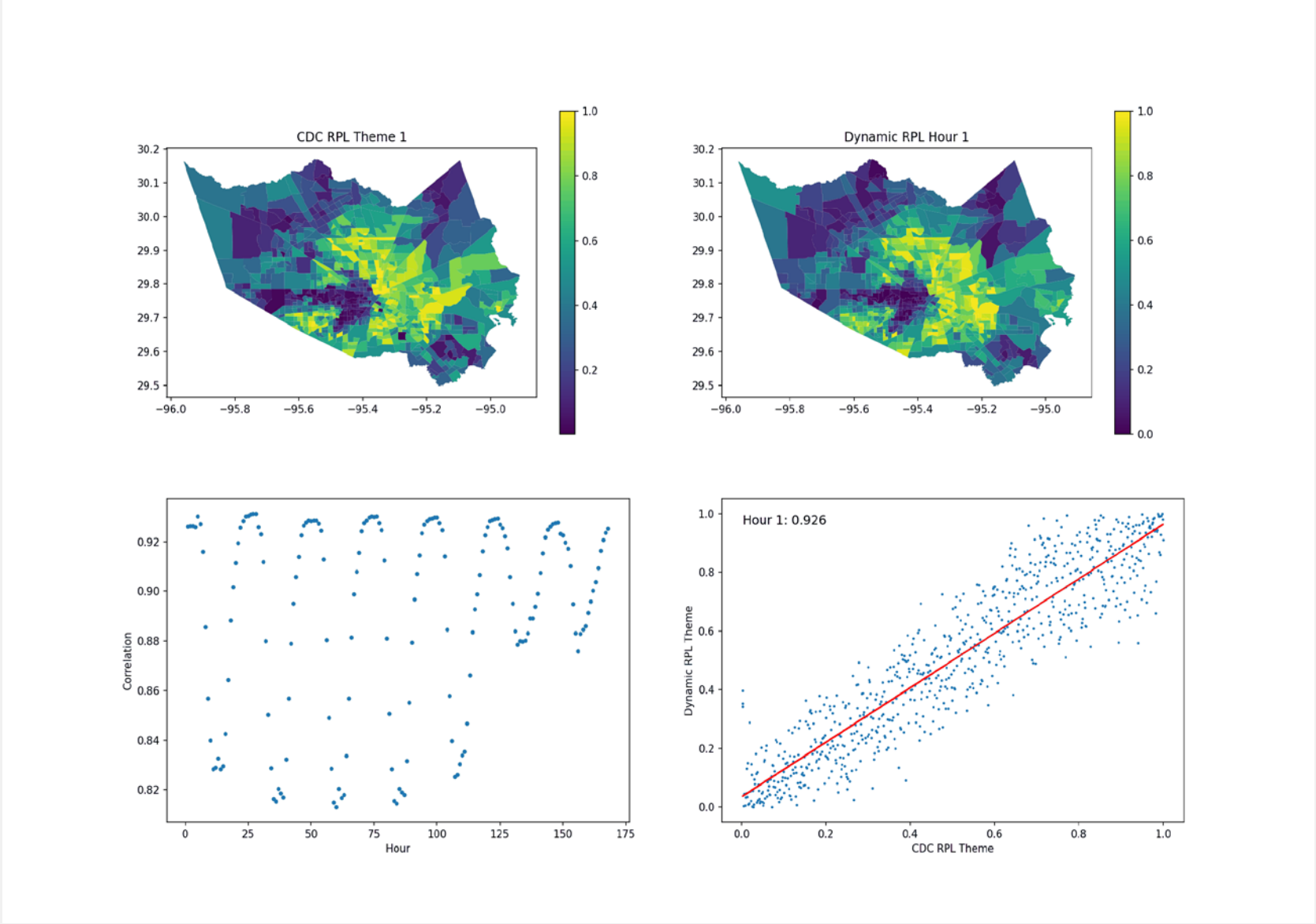


Obj. 2: Incorporating a synthetic population model of movement of people

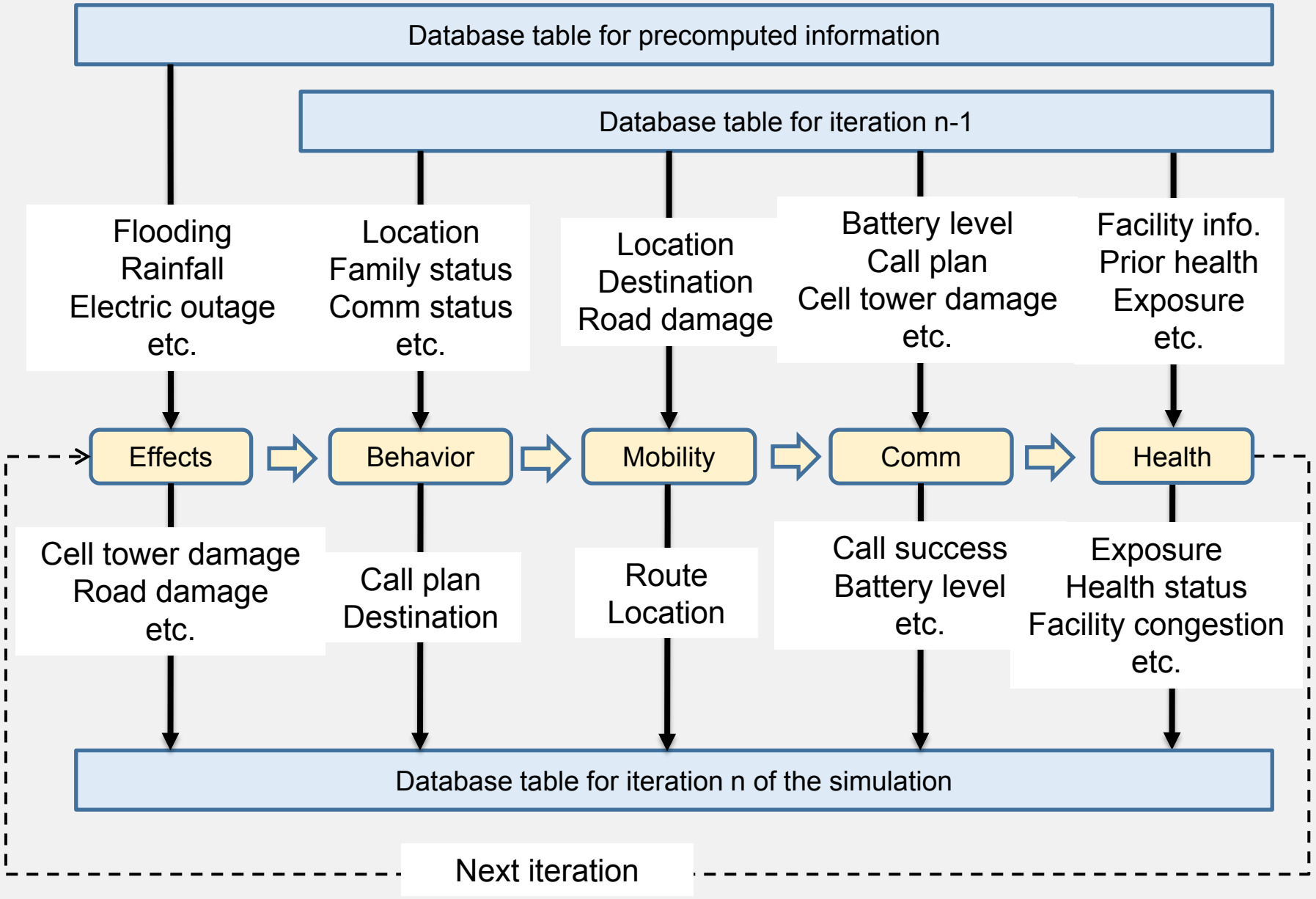
SYNTHETIC POPULATION STRUCTURE FOR CREATION OF A DYNAMIC SVI



The synthetic population exhibits high positive correlation with the CDC SVI, particularly at night



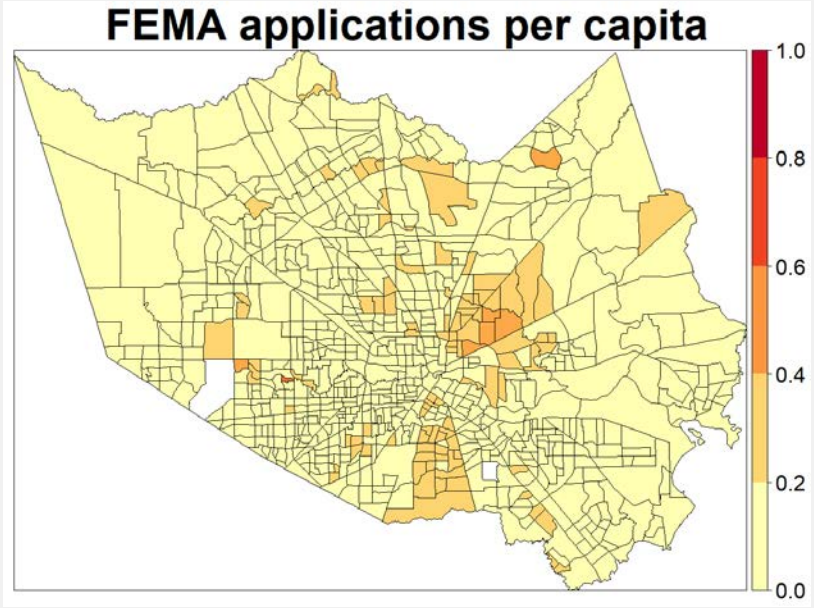
SIMULATION ARCHITECTURE FOR DETERMINING MOVEMENTS DURING HARVEY



Obj 3: Evaluating SVI enhancements through analysis of FEMA applications and healthcare data

FEMA individual assistance applications: Initial Results

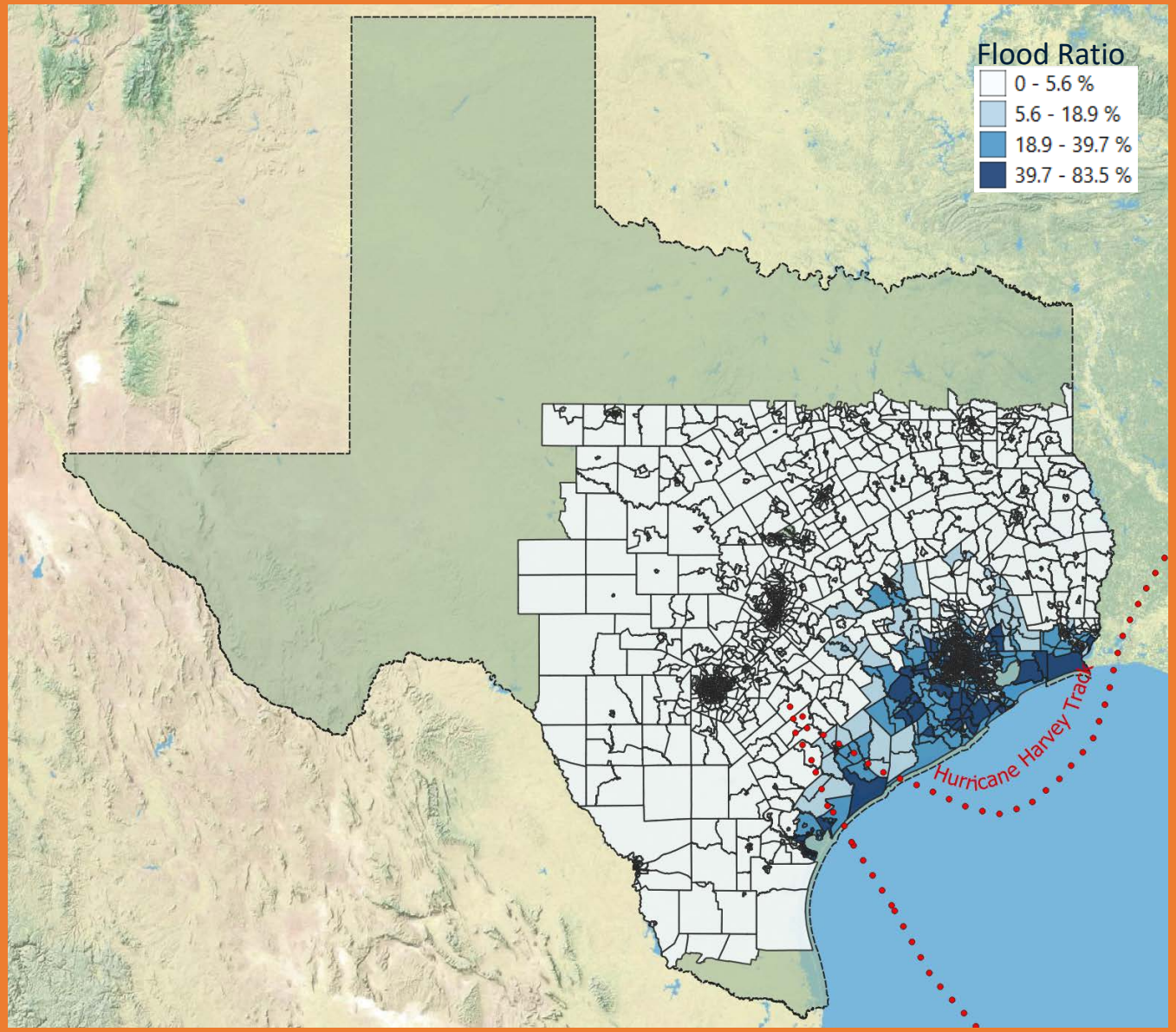
- Overall, adding EO led to improved model fits (increased adjusted R-squared values).
- Increases in SVI, flood ratio, outage fraction corresponded to increases in applications per capita.
- Increases in elevation, imperviousness corresponded to slight decreases in applications per capita.
- 25% most vulnerable tracts in Harris County submitted **1.8 times** as many apps (relative to pop.) as the 25% least vulnerable.



Deanes et al. *In preparation*

Health Outcome Datasets

- Texas Flood Registry, collaboration between Rice University and several organizations
- **Inpatient and Outpatient Emergency Department visits from the Texas Department of State Health Services (2016, 2017, 2018)**
- Syndromic surveillance data from Houston Health Department (2017, 2019)



Emergency Department (ED) Visit Data

- 1.2 Million Inpatient Records
- 7.9 Million Outpatient Records
- Geocoded to 2883 Census Tracts
- 117 Counties in Study Area

Variables

- Patient Zip and Census Block
- Sex, Age, Race, Ethnicity
- Diagnostic Codes
- Condition Codes
- Patient Status
- Statement Start Date
- Admission Date (IP)

Health outcomes evaluated

Outcome	Inclusion ICD10 Code	Exclusion ICD10 Code
ARI	J0, J1, J2	
Asthma	J45	
Insect Bite	T633, T634, W57	
Chest pain/Palpitations	R002, R079, R0789	
CO Poisoning	T58	
Dehydration	E860, E861, E869	
Drowning	T751, W67, W69, W73, W74	W65
Heat related illness	T67, X30	W92
Hypothermia	T68, X31, T33, T34	T885, R680
Intestinal infectious diseases	A0	
Pregnancy Complications	O03, O20, O60, O47, O23, O1, O24, O99	

Health Outcome Analysis Model

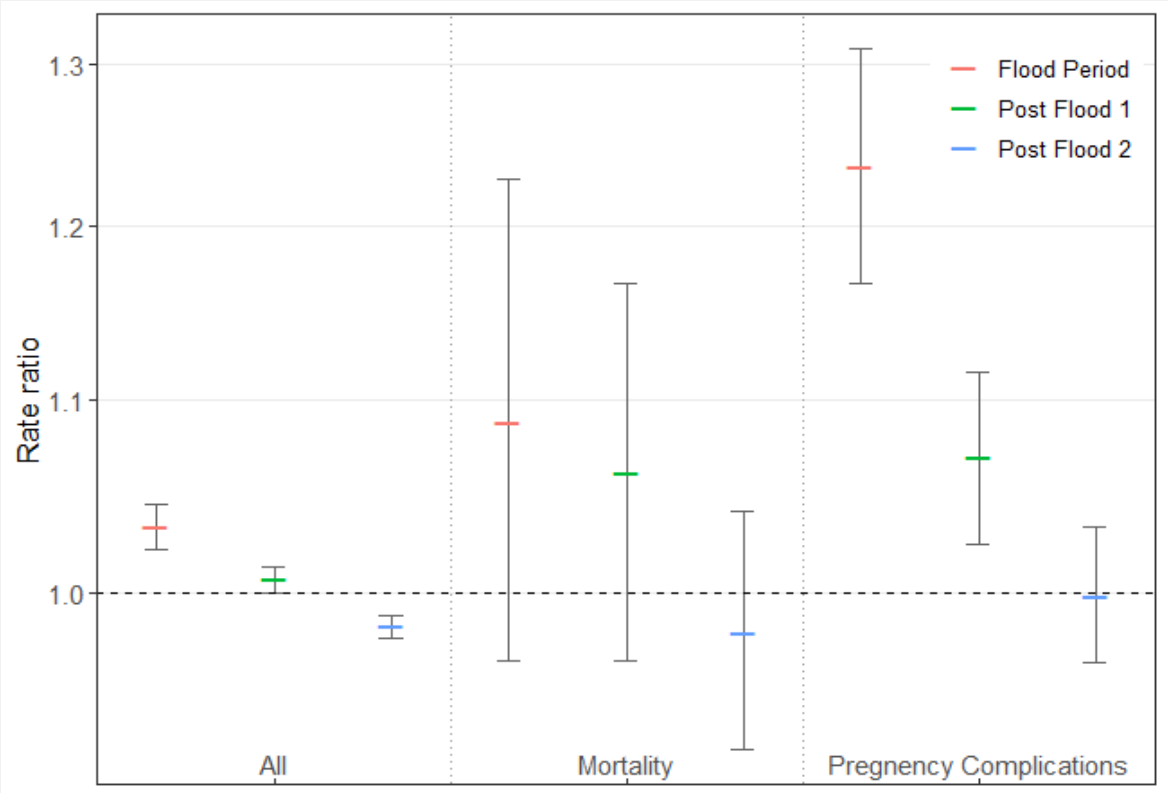
Poisson Regression Model

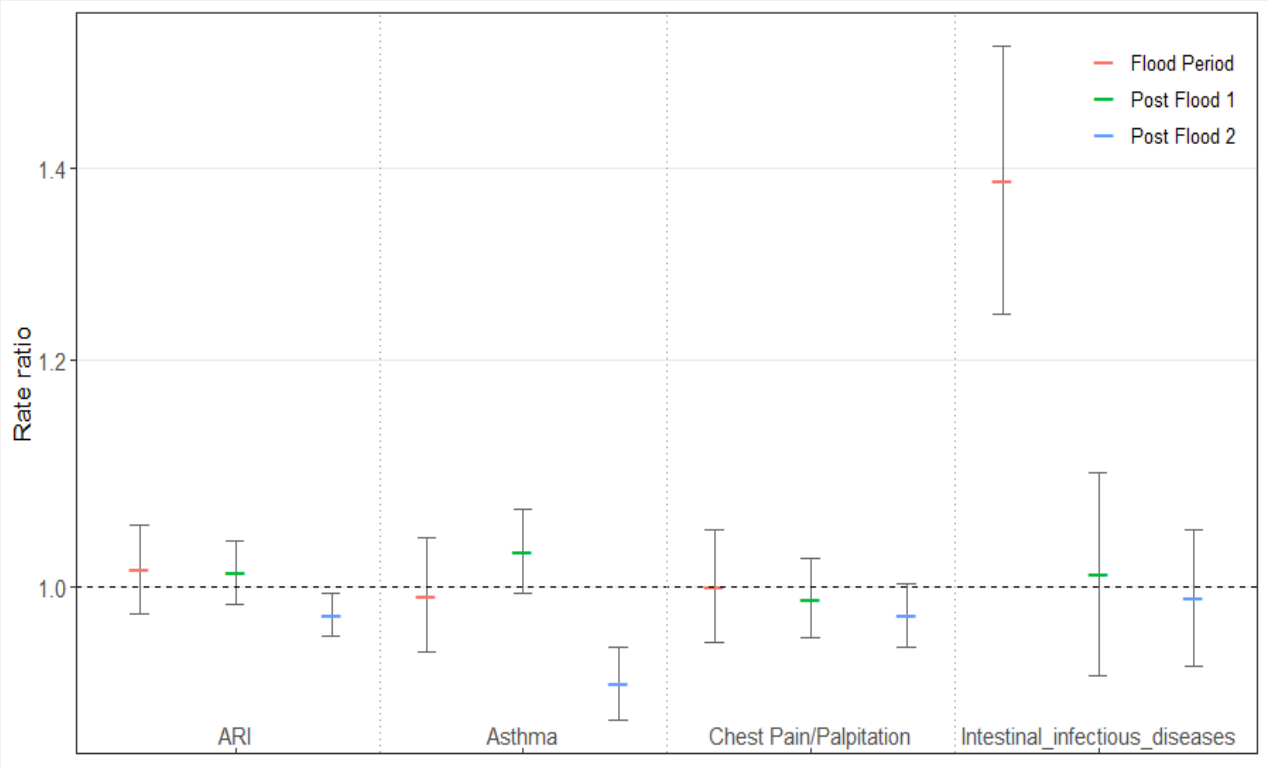
$$logE(Y) = \beta_0 + \beta_1 flooded + \beta_2 flood_t + \beta_3 flooded * flood_t + \beta_8 sex + \beta_9 age + \beta_{10} race + \beta_{12} ethnicity + \beta_{13} op + seasonality + logE(Total\ ED\ visits)$$

flooded: Y/N patient residence census tract flooded

$flood_t$: Control / Flood / Post flood period 1/Post flood period 2

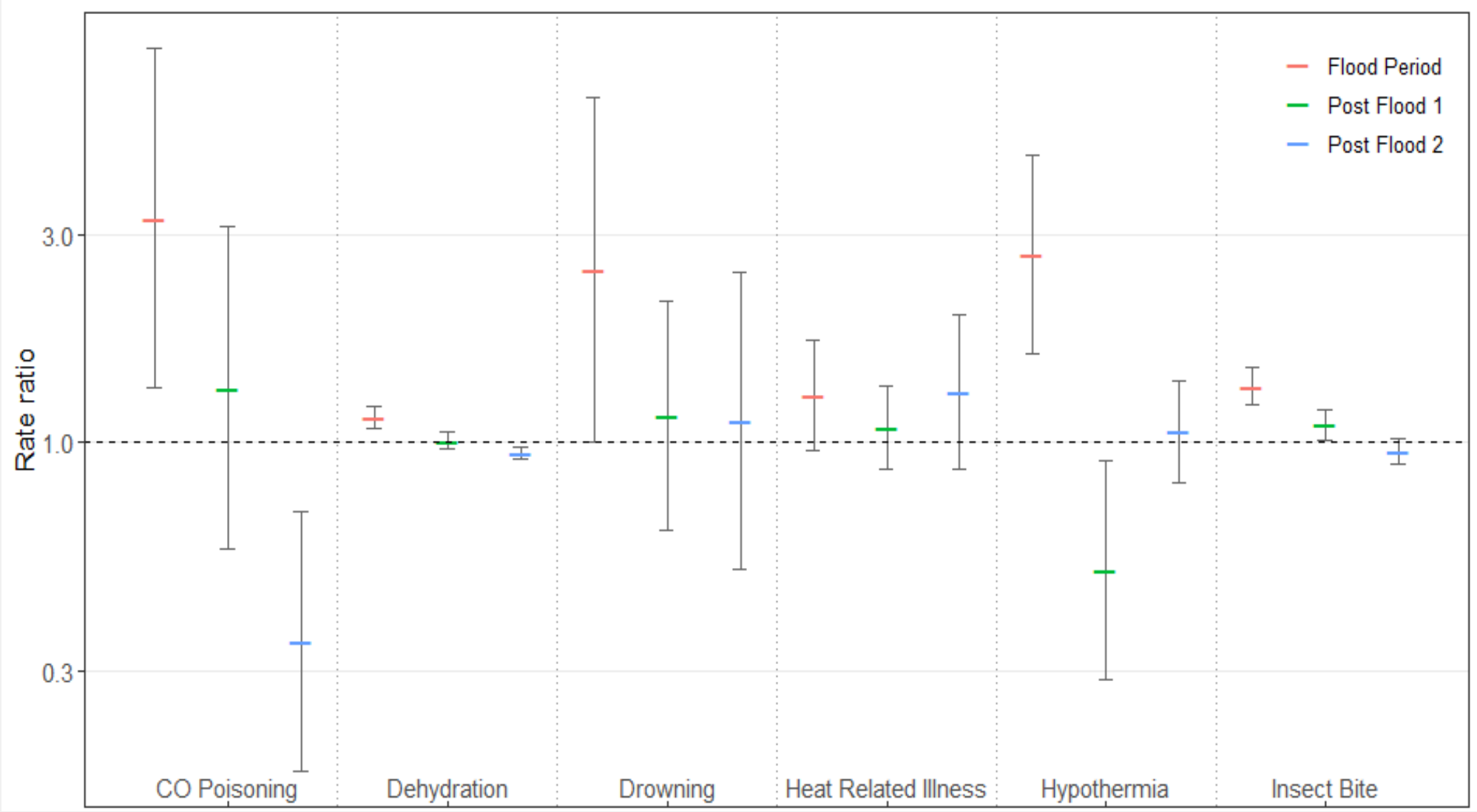
Rates of ED visits and ED visits for pregnancy complications and intestinal infections were elevated within flooded tracts during the flood period





Ramesh et al. *In preparation*.

Rates of ED visits for CO poisoning, dehydration, drowning, hypothermia and insect bites were elevated within flooded tracts during the flood period



Ramesh et al. *In preparation*.

Comparison of results when CDC SVI of patient census tract and visits during the flood and post flood periods only are modeled

- A 10% increase in the CDC SVI was associated with increased relative risks for intestinal infectious diseases and acute respiratory illness during the flood impact periods and acute respiratory illness and dialysis in post flood periods.

NEXT STEPS:

- Evaluate model performance with static CDC SVI or the enhanced dynamic SVI included.

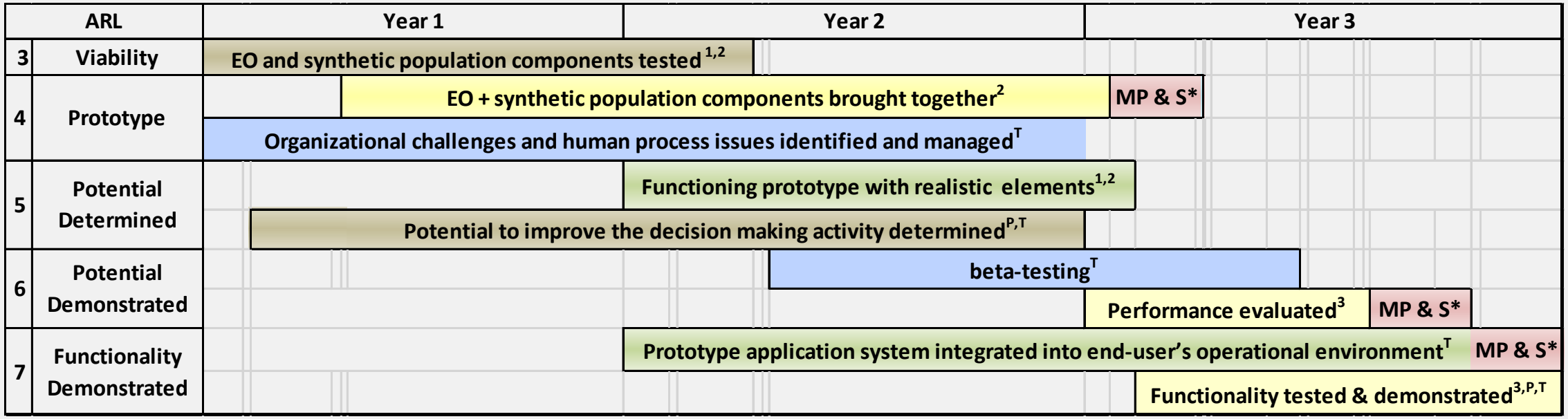
Health Outcome Next Step – Syndromic Surveillance Data Analysis

- Similar Poisson Modeling
- Definitions from chief complaint/discharge diagnosis queries and approximations of syndromes and subsyndromes
- 4 Million Records
  - June 2017 – December 2017
  - June 2019 – December 2019

Variables

- Date
- Time
- Zip code
- Age
- Sex
- **Chief Complaint**
- Discharge Diagnosis
- Provider Diagnosis
- Race
- Ethnicity
- Hospital Name
- Hospital Zip Code

Project schedule with Application Readiness Level (ARL) progression: Currently at ARL 5



[1]Obj 1, [2]Obj 2, [3]Obj 3, [P]Performance Measures, [T]Transition Plan, *MP & S Manuscript Preparation and Submission, which includes a white paper and User's Manual as well as peer-reviewed publications.

Project Challenges and Risks

Technical: Integration with CDC SVI: CDC GRASP website re-vamp

Project Management: Set up DUA and financial contract with Houston Health Department; however limited availability to aid in SyS data analysis.

2019 Kick-off Team Meeting at CDC in Atlanta, GA

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)