

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

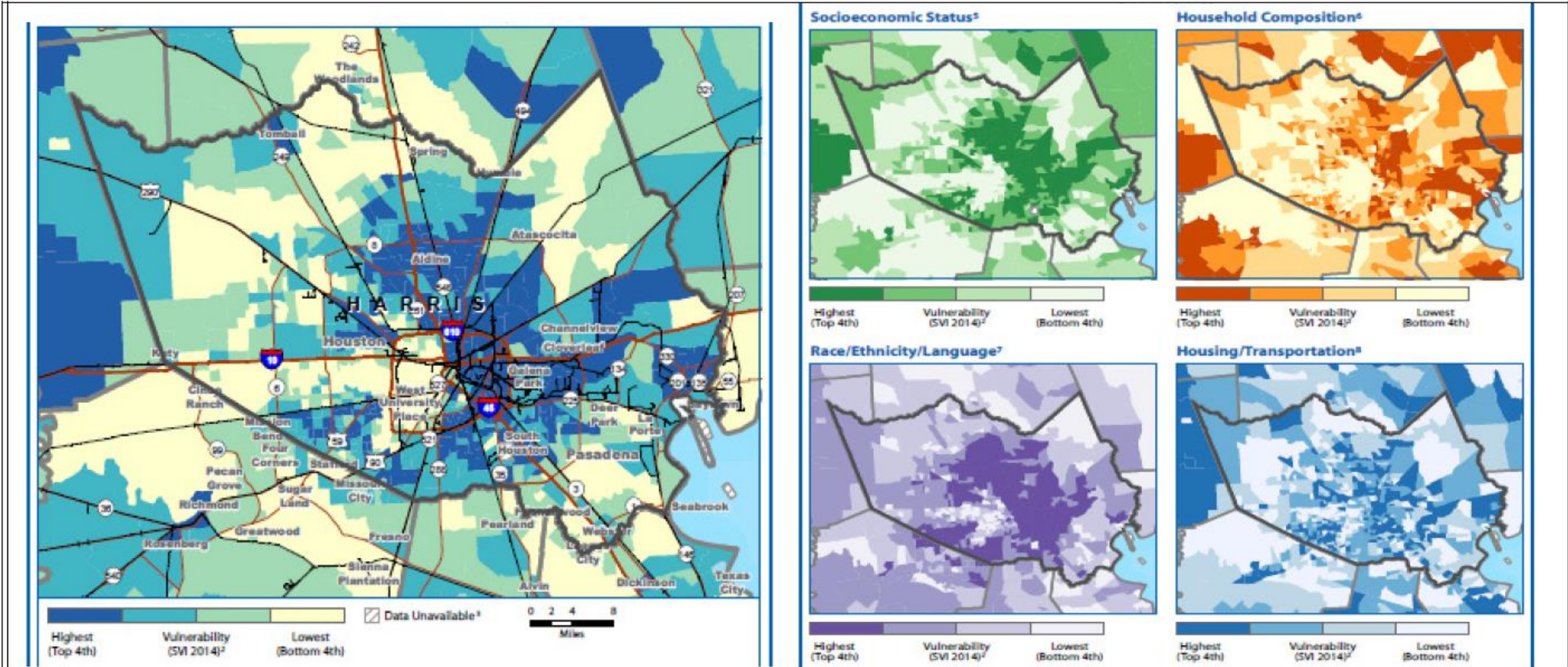
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ANNUAL GRANTEE MEETING
RAPID CITY, SOUTH DAKOTA,
SEPT 10TH, 2019

Goal and Objectives

Enhance the Social Vulnerability Index (SVI), a CDC hazard mitigation planning and emergency response product, by adding exposure estimates, using Hurricane Harvey as case study:

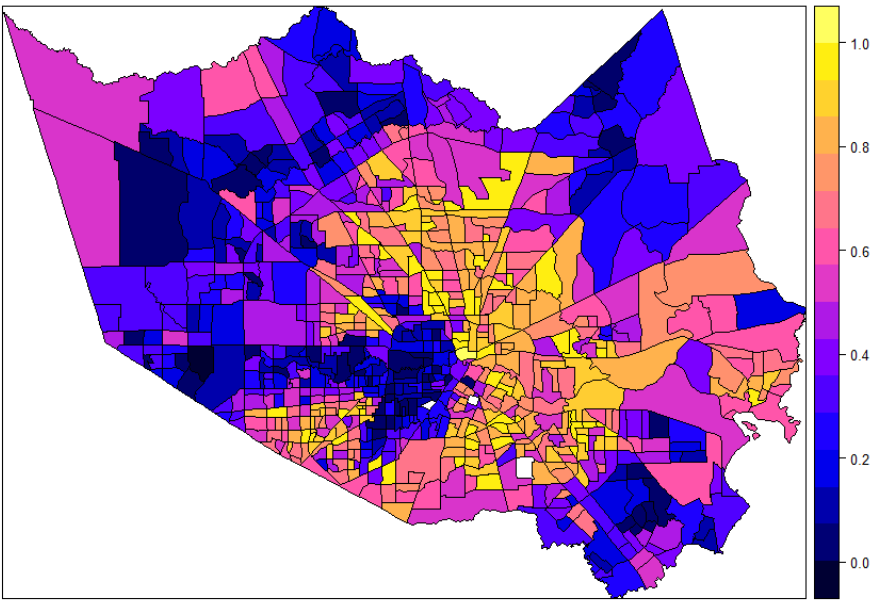
1. Incorporating EO datasets on flooding, heat, and power outages and chemical emissions from industrial facilities.
2. Incorporating a synthetic population model of movement of people pre, during and post disaster.
3. Evaluating the utility of these enhancements through analysis of healthcare visit data collected pre, during, and post Hurricane Harvey.

The CDC SVI is being used for estimating the amount of needed supplies, locations of emergency shelters, assisted evacuations, support post-disaster



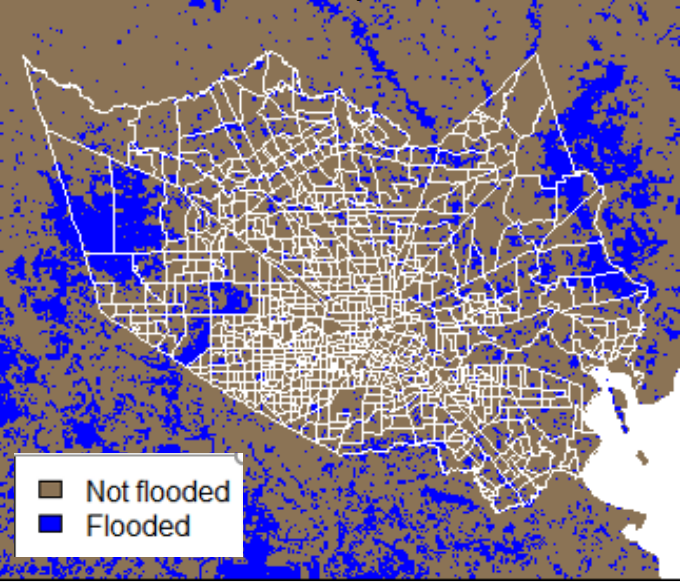
Is Harvey flood extent or SVI associated with applications to FEMA for assistance?

2016 Harris County, TX census tract summary SVIs

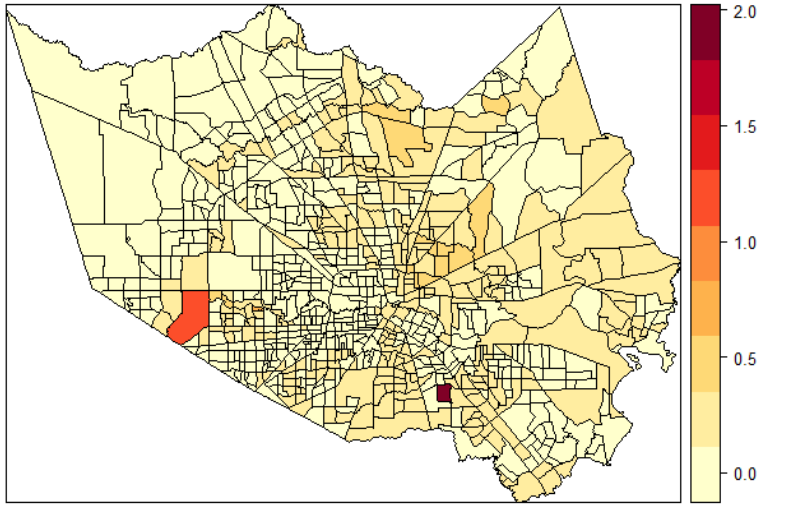


Higher SVI = Higher vulnerability

Harvey flood extent – Harris County, TX

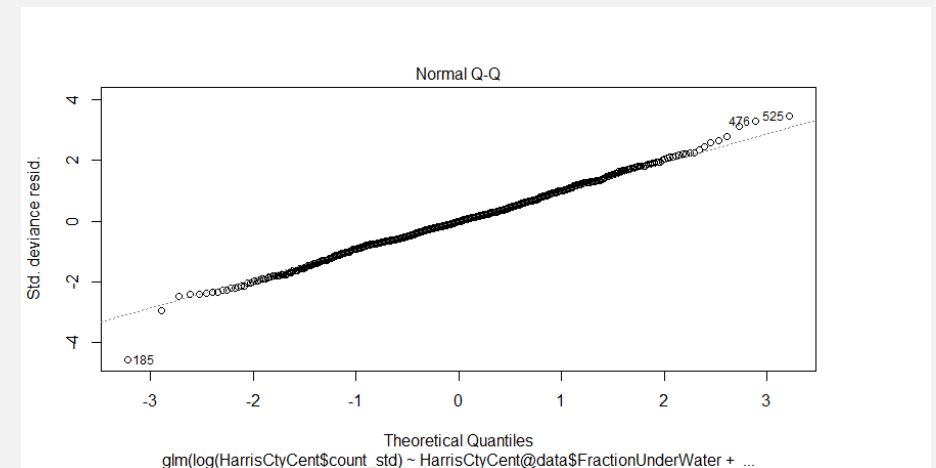
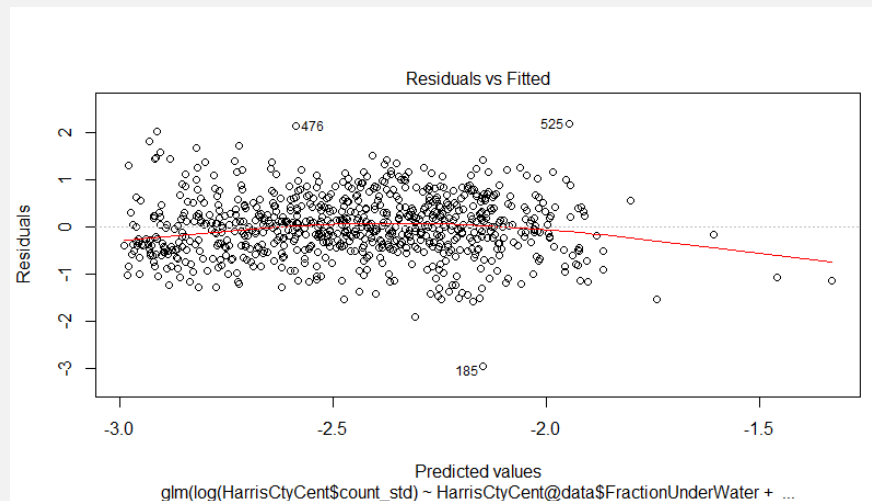


FEMA applications per tract, standardized by population



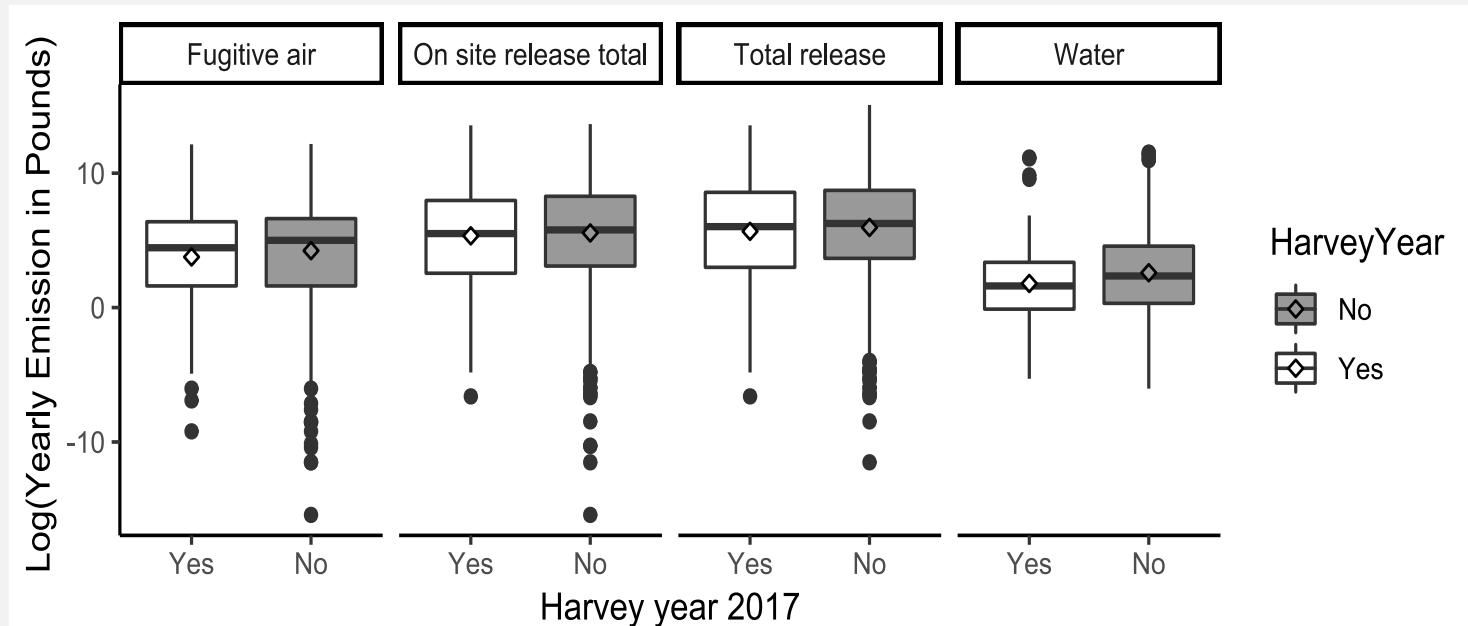
Initial models indicate both fraction of census tract flooded and SVI are positively associated with FEMA applications

Log(FEMA appl per capita)			
AIC	1542.6		
#observation	780		
#observation lost	3		
Fixed effects	Estimate	Std Err	P-value
Overall SVI	0.87	0.08	<2e-16
Fraction of census tract flooded	1.37	0.22	6.38e-10



Yearly Toxic Release Inventory reporting does not indicate changes in emissions based on flooding during Harvey

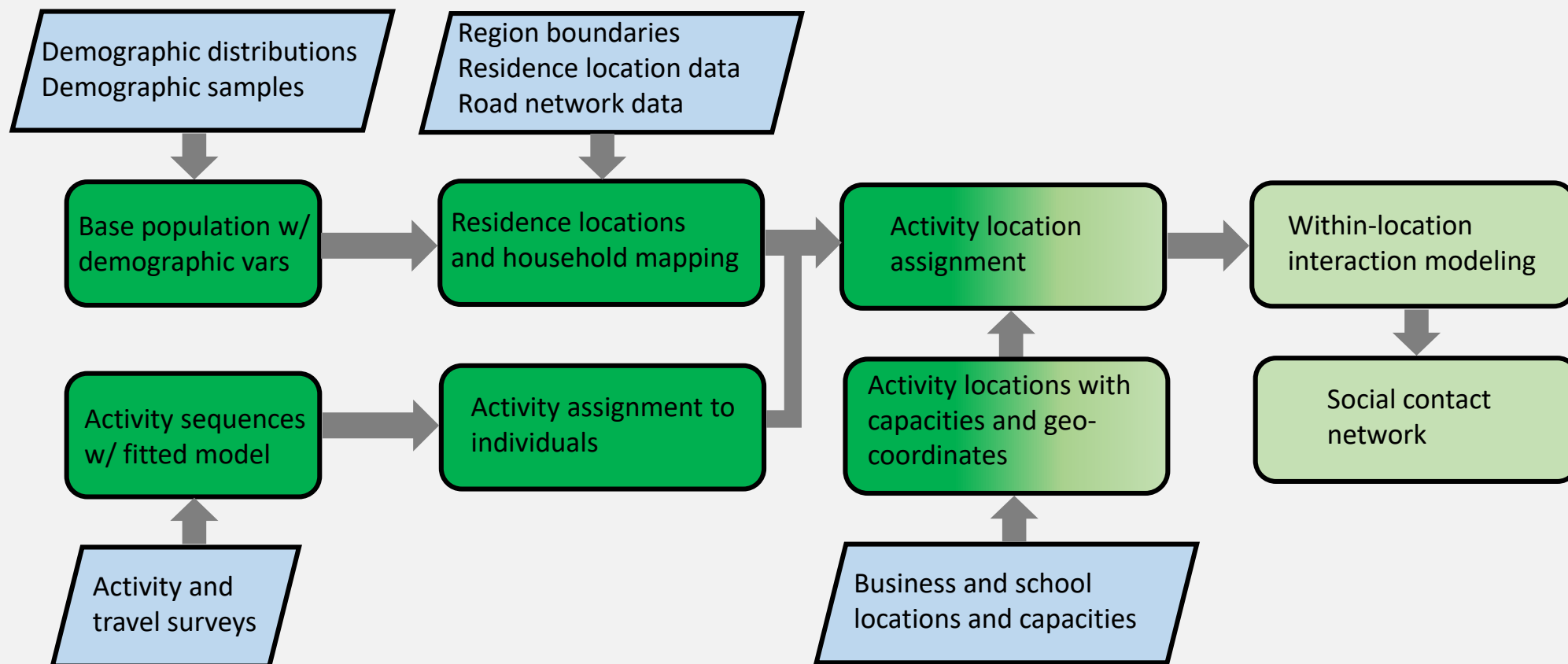
- Data reported to EPA by Texas facilities each year 2013-2018.
- Matched lat/long for facility to Harvey flood extent.
- Approximately 5% (231/4243) of facilities reporting to TRI within the greater Houston area were located within the Harvey flood extent.



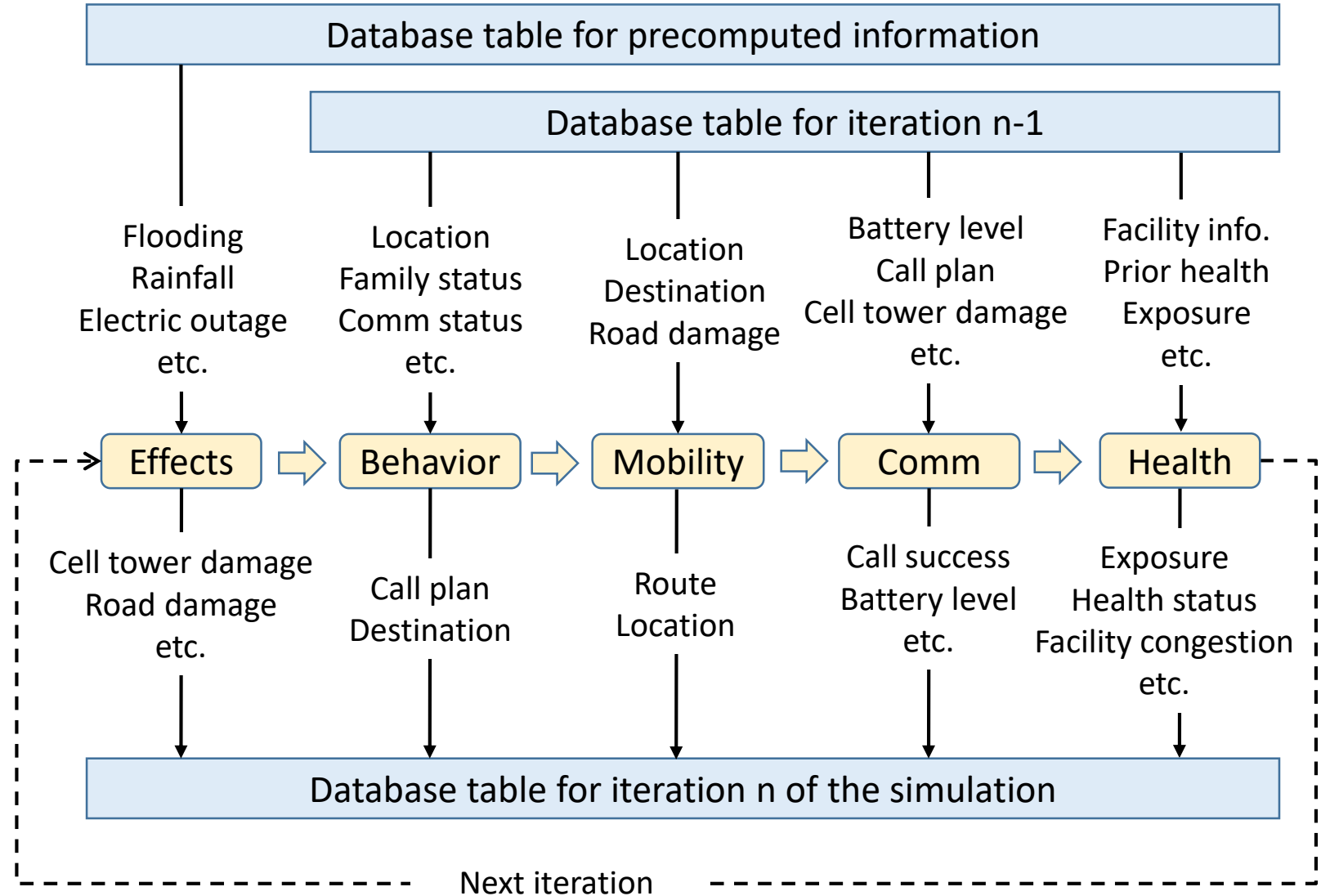
Initial models indicate no association between facility reported emissions and within Harvey flood extent or SVI

Log(Yearly Emission)	Fugitive Air			Water			Total Release			On Site Release Total		
AIC	23984.6			9540.7			31959.4			31289.9		
#observation	4961			1892			6635			6492		
#observation lost	3076			6145			1402			1545		
Fixed effects	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%
Overall SVI	-0.48	-1.89	0.91	-0.61	-4.11	2.87	0.59	-0.76	1.92	0.50	-0.68	1.67
Harvey Year	0.08	-0.12	0.28	0.06	-0.29	0.41	-0.06	-0.23	0.11	-0.04	-0.21	0.13
Flooded vs unflooded	-0.27	-1.81	1.27	2.50	-0.52	5.54	-0.39	-1.75	0.95	-0.63	-1.91	0.64

SYNTHETIC POPULATION: PROGRESS



SIMULATION ARCHITECTURE



Health data acquisition and processing plan

- Syndromic surveillance data query collation completed (chief complaint, triage notes, and discharge diagnosis fields)
 - IRB protocols approved by VT and HHD. Data use agreement and contract near finalization.
- Emergency department visits from the Texas Dept of Health and Human Services. Submitted packet to DSHS, awaiting review, which is scheduled for late September.
- Harvey Registry (n= ~16,000 responses collected to date). Collaboration between Rice University and several organizations. Submitted variables of interest to the data manager to initiate data use agreement process.

Data processing: Syndromic surveillance text query information collated

Query Name	Query Syntax	Developed By	Developed For	Query Field (CC/DD, triage)	Notes
Dehydration 1	^deh[yi]dr^ ,or, ^dry mouth^ ,or, ^drymouth^ ,or, ^hypovolemia^ ,or, ^volume depletion^ ,or, (, ^electrolyte^ ,and, (, ^abnormal^ ,or, imbalance^ ,),)	Oregon ESSENCE	Mass Gathering Surveillance	CC	Option 1 without codes; still captures some post-operative patients, but it limits it to people who SAY they are dehydrated; based on CSTE HRI guidance.
Dehydration 2	^[/]276^ ,or, ^[/]E86^ ,or, ^deh[yi]dr^ ,or, ^dry mouth^ ,or, ^drymouth^ ,or, ^hypovolemia^ ,or, ^volume depletion^ ,or, (, ^electrolyte^ ,and, (, ^abnormal^ ,or, imbalance^ ,),)	Oregon ESSENCE	Mass Gathering Surveillance	CC/DD	Option 2 with codes; captures a lot of post-operative patients; based on CSTE HRI guidance; Consider 2015 ICD9 exclusions but note overlap with ICD9/10 [andnot,(^[/]E861^ ,or, ^[/]E862^ ,or, ^[/]E863^ ,or, ^[/]E864^ ,or, ^[/]E868^ ,or, ^[/]E
ExcessiveHeat	HEAT CASUALTY (10)HEAT CRAMP (10)HEAT CRAMPING (10)HEAT EMERGENCY (10)HEAT EXACERBATION (10)HEAT EXHAUSTION (10)HEAT EXPOSURE (10)HEAT FATIGUE (10)HEAT ILLNESS (10)HEAT INJURY (10)HEAT PROSTRATION (10)HEAT RASH (10)HEAT RELATED (10)HEAT STRESS (10)HEAT STROKE (10)HEAT SYNCOPE (10)HEAT SYNDROME (10)HEAT TRAUMA (10)OVER HEAT (10)OVER HEATED (10)OVER HEATING (10)SUN EXPOSURE (10)SUN POISON (10)SUN POISONING (10)SUN RASH (10)SUN STROKE (10)	JHU	Base ESSENCE	Subsyndrome	
Heat-Related Illness, CSTE 2016 Definition	(^[/] J992^ ,OR, (^[/] JE900^ ,ANDNOT, ^[/] JE900.1^ ,ANDNOT, ^[/] JE9001^ ,), OR, ^[/] JT67^ ,OR, ^[/] JX30^ ,), OR, (^HEAT^ ,OR, ^HYPERTHERM^ ,OR, ^SUNSTR^ ,OR, ^SUN STR^ ,OR, ^TO HOT^ ,OR, ^TOO HOT^ ,OR, (, (^HEET^ ,OR, ^HOT^ ,), AND, (^EXCESSIVE^ ,OR, ^EXHAUST^ ,OR, ^EXPOS^ ,OR, ^FATIGUE^ ,OR, ^CRAMP^ ,OR, ^STRESS^ ,OR, ^IN CAR^ ,OR, ^OUTSIDE^ ,OR, ^PROSTRATION^ ,),), ANDNOT, (^ALLERG^ ,OR, ^FEELING HOT^ ,OR, ^FEELS HOT^ ,OR, ^FELT HOT^ ,OR, (^HOT^ ,AND, ^SENSATION^ ,), OR, ^HEAT SENSATION^ ,OR, ^INFLAM^ ,OR, (^PAIN^ , AND, (^LIMB^ ,OR, ^ARM^ ,OR, ^SHOULDER^ ,OR, ^ELBOW^ ,OR, ^WRIST^ ,OR, ^HAND^ ,OR, ^LEG^ ,OR, ^HIP^ ,OR, ^GROIN^ ,OR, ^THIGH^ ,OR, ^KNEE^ ,OR, ^ANKLE^ ,OR, ^FOOT^ ,OR, ^FEET^ ,OR, ^BACK^ ,OR, ^NECK^ ,OR, ^FLANK^ ,OR, ^RED^ ,OR, ^JAW^ ,OR, ^MOUTH^ ,OR, ^TEETH^ ,OR, ^TOOTH^ ,),), OR, ^RADIAT^ ,OR, ^REDNESS^ ,OR, ^SWELL^ ,OR, ^SWOLLEN^ ,OR, ^SURG^ ,OR, ^POST OP^ ,OR, ^IBUPROFEN^ ,OR, ^IBUPROPHEN^ ,OR, ^ALIEVE^ ,OR, ^MOTRIN^ ,OR, ^TYLENOL^ ,OR, ^INJURY^ ,OR, ^TRAUMA^ ,OR, (^HEAT^ ,AND, (^ICE^ ,OR, ^APPLIED^ ,OR, ^TRIED^ ,OR, ^USED^ ,OR, ^USING^	CSTE	NSSP CC/DD Category	CC/DD	Provided by Aaron Kite Powell at CDC via email. Double check chief complaint category. Does not include ICD-10 exclusion for man-made heat.

Project schedule with Application Readiness Level (ARL) progression

ARL	Year 1	Year 2	Year 3
3 Viability	EO and synthetic population components tested ^{1,2}		
4 Prototype	EO + synthetic population components brought together ²		MP & S*
	Organizational challenges and human process issues identified and managed ^T		
5 Potential Determined	Functioning prototype with realistic elements ^{1,2}		
	Potential to improve the decision making activity determined ^{P,T}		
6 Potential Demonstrated	beta-testing ^T		
		Performance evaluated ³	MP & S*
7 Functionality Demonstrated	Prototype application system integrated into end-user's operational environment ^T		
		Functionality tested & demonstrated ^{3,P,T}	

¹Obj 1, ²Obj 2, ³Obj 3, ^PPerformance Measures, ^TTransition Plan, *MP & S Manuscript Preparation and Submission, which includes a white paper and User's Manual as well as peer-reviewed publications.

The flood metric output files for integration with synthetic population have been completed and are being integrated with SVI and facilities reporting to TRI (Viability). The base synthetic population for the Houston area is under development with projected initial testing in Sept (Prototype). Organizational challenges have been identified and are being managed and the potential to improve disaster planning and response is being determined (Prototype, Potential Determined).

Project Challenges and Risks

Technical: Missingness in syndromic surveillance data. Addressed through acquisition of other datasets

Project Management: Setting up DUA and financial contract with Houston Health Department. Continuing to follow-up regularly.

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



Attendees: Upper row left to right: Elaine Hallisey (CDC), John Fleming (HHD), Barry Flanagan (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 Mertzluft (CDC), David Rickless (CDC), and Amy Wolkin (CDC)

The Team

Ben Zaitchik and Lauren Deanes, Johns Hopkins University

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

Julia Gohlke, Suwei Wang, and *Balaji Ramesh*, Virginia Tech

Meredith Jagger, Independent Consultant

Biru Yang and John Fleming, Houston Health Department

Elaine Hallisey, Barry Flanagan, and Caitlin Mertzlufft at CDC
GRASP