

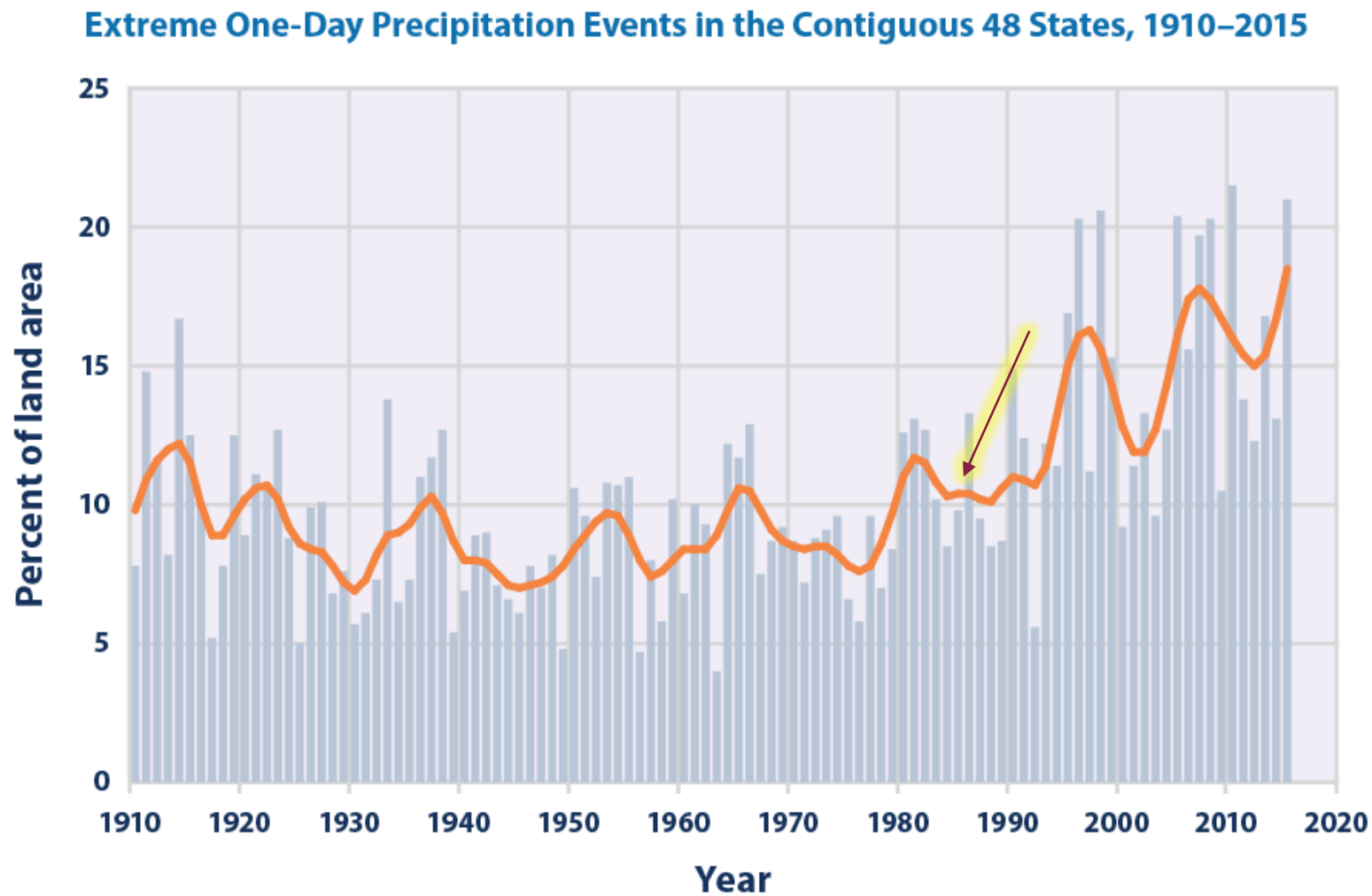


Sentinel-2 copernicus imagery of 08/30/2017

Leveraging earth observations for estimating health risks associated with flooding precipitated by heavy rains.

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Korine N Kolivras¹, Samarth Swarup³, Julia M Gohlke¹

The percent of land area that experienced extreme one day rainfall has increased over past three decades.

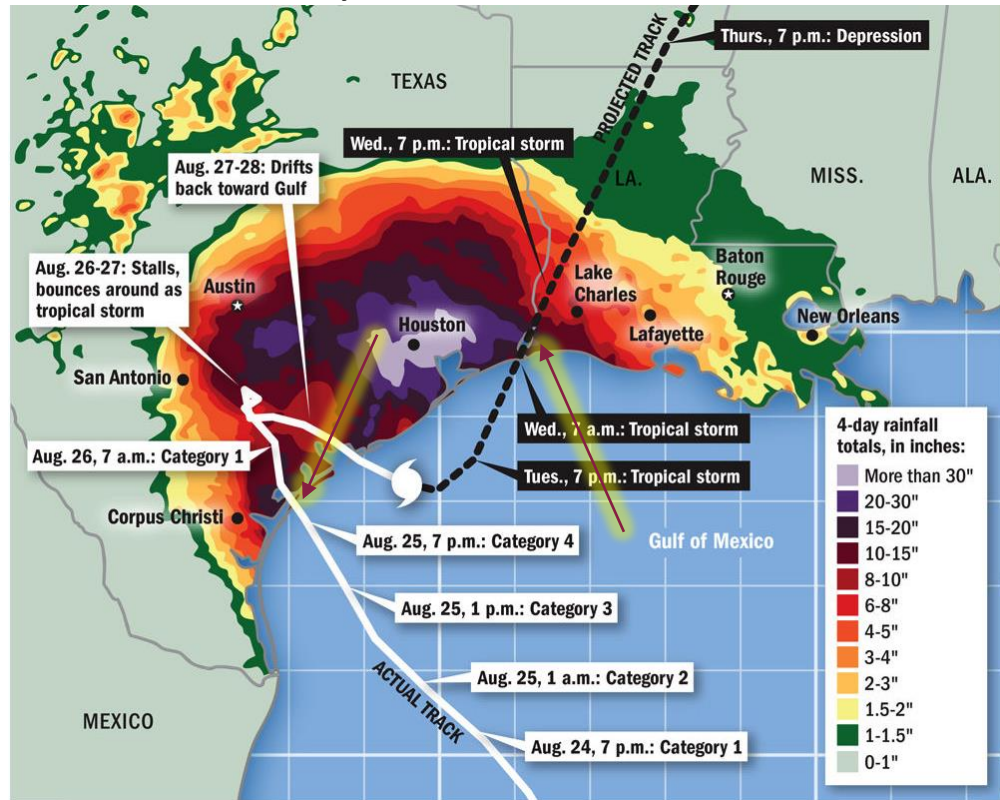


Data source: NOAA (National Oceanic and Atmospheric Administration). 2016. U.S. Climate Extremes Index. Accessed January 2016. www.ncdc.noaa.gov/extremes/cei.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

Hurricane Harvey, a category 4 hurricane, resulted in 40+ inches of rainfall in Texas

Hurricane Harvey Track

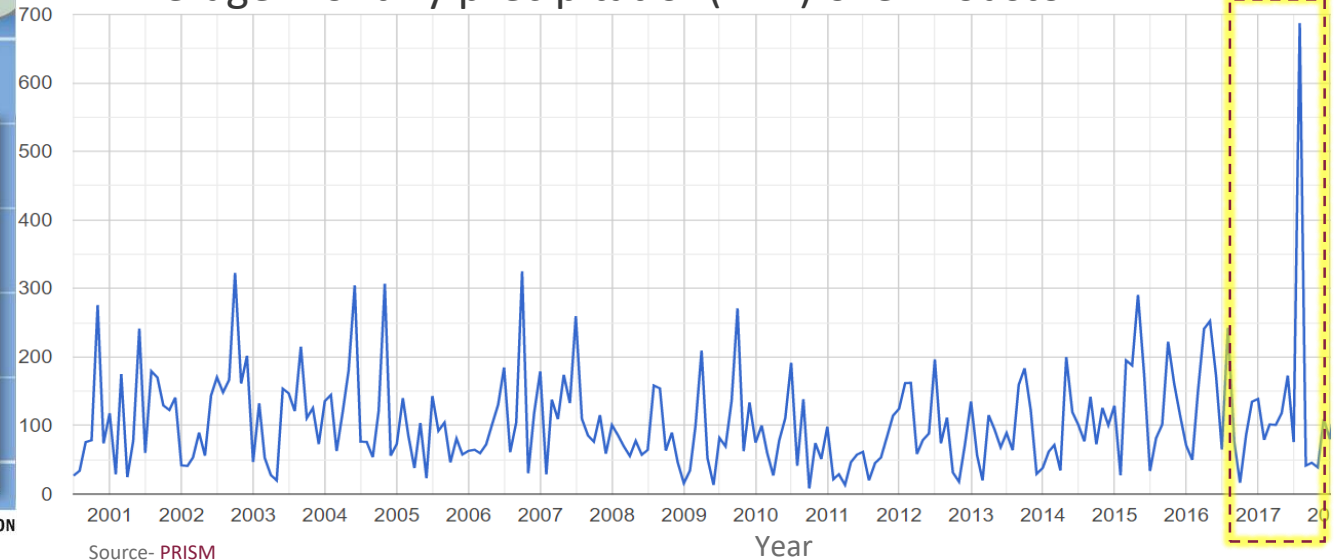


Source: National Weather Service

Advocate graphic by DAN SWENSON

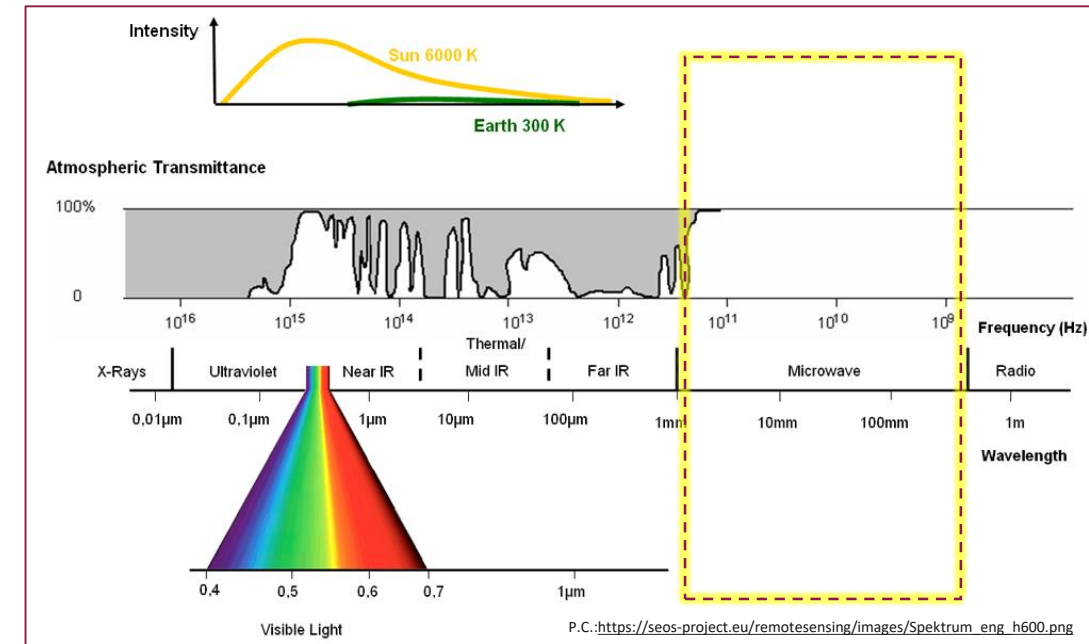
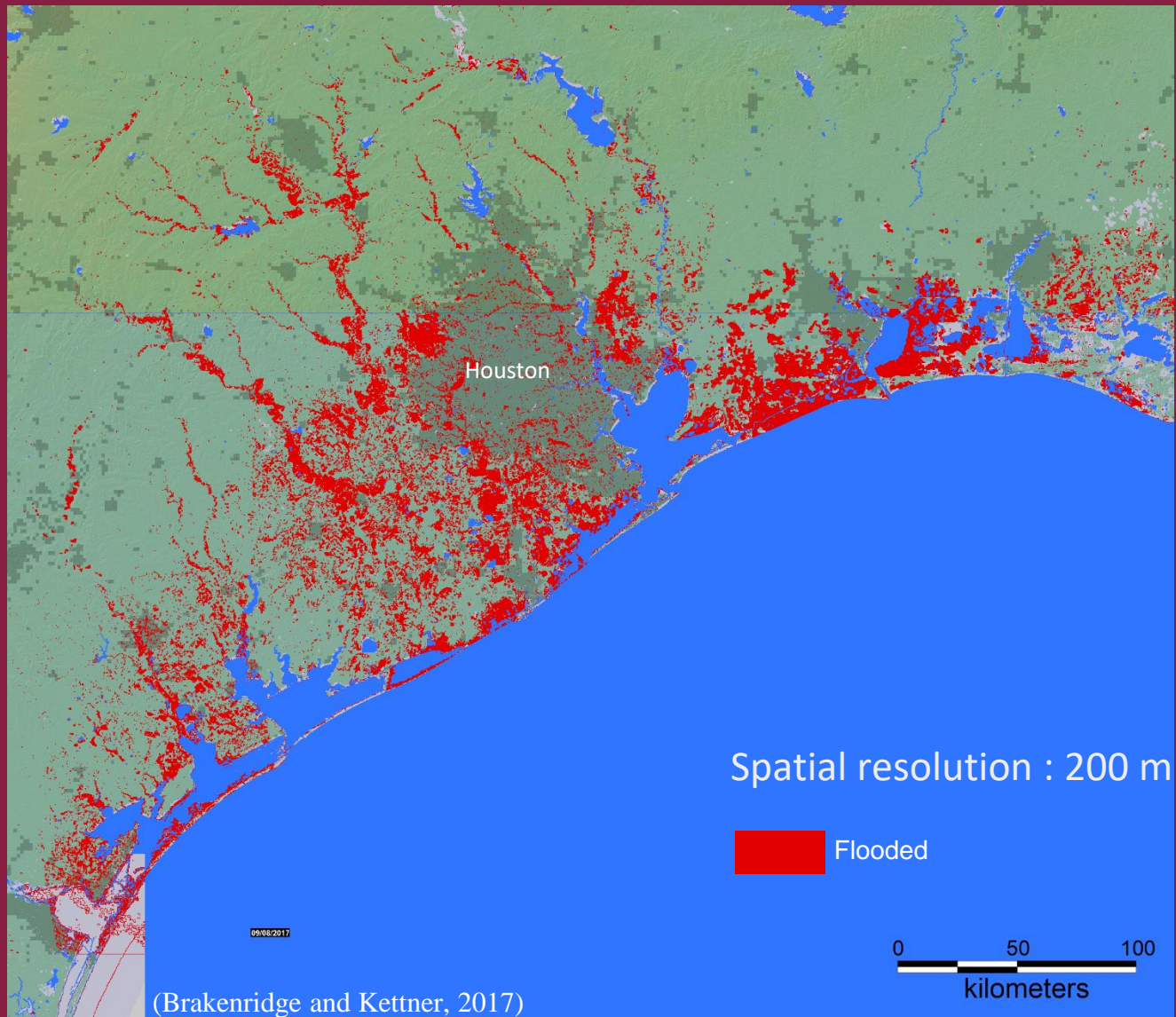
Img source- <https://www.weather.gov/grb/Harvey>

Average monthly precipitation(mm) over Houston



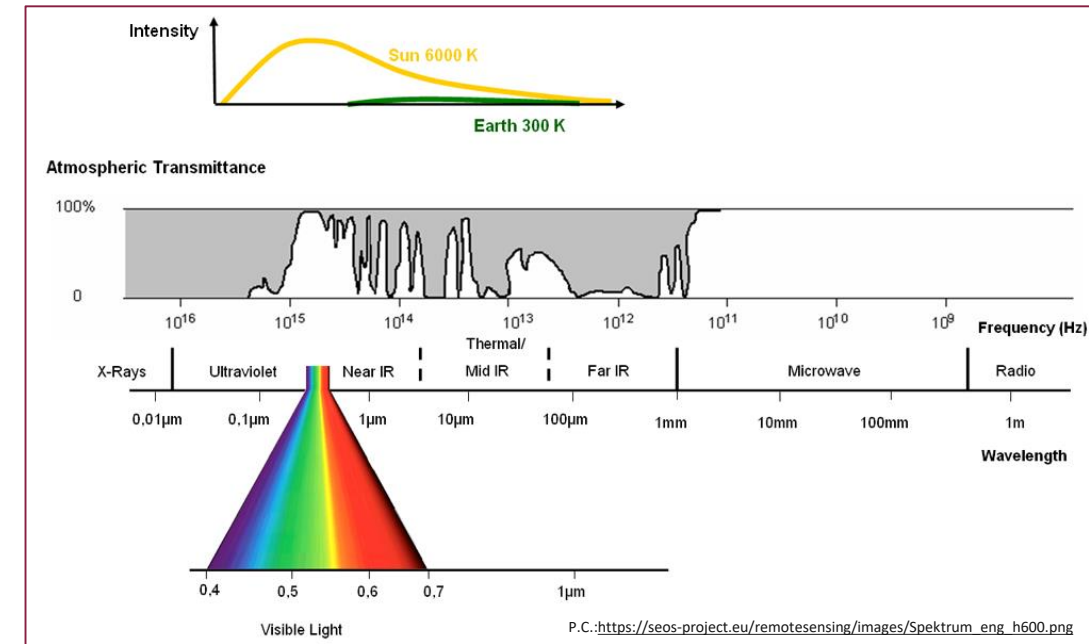
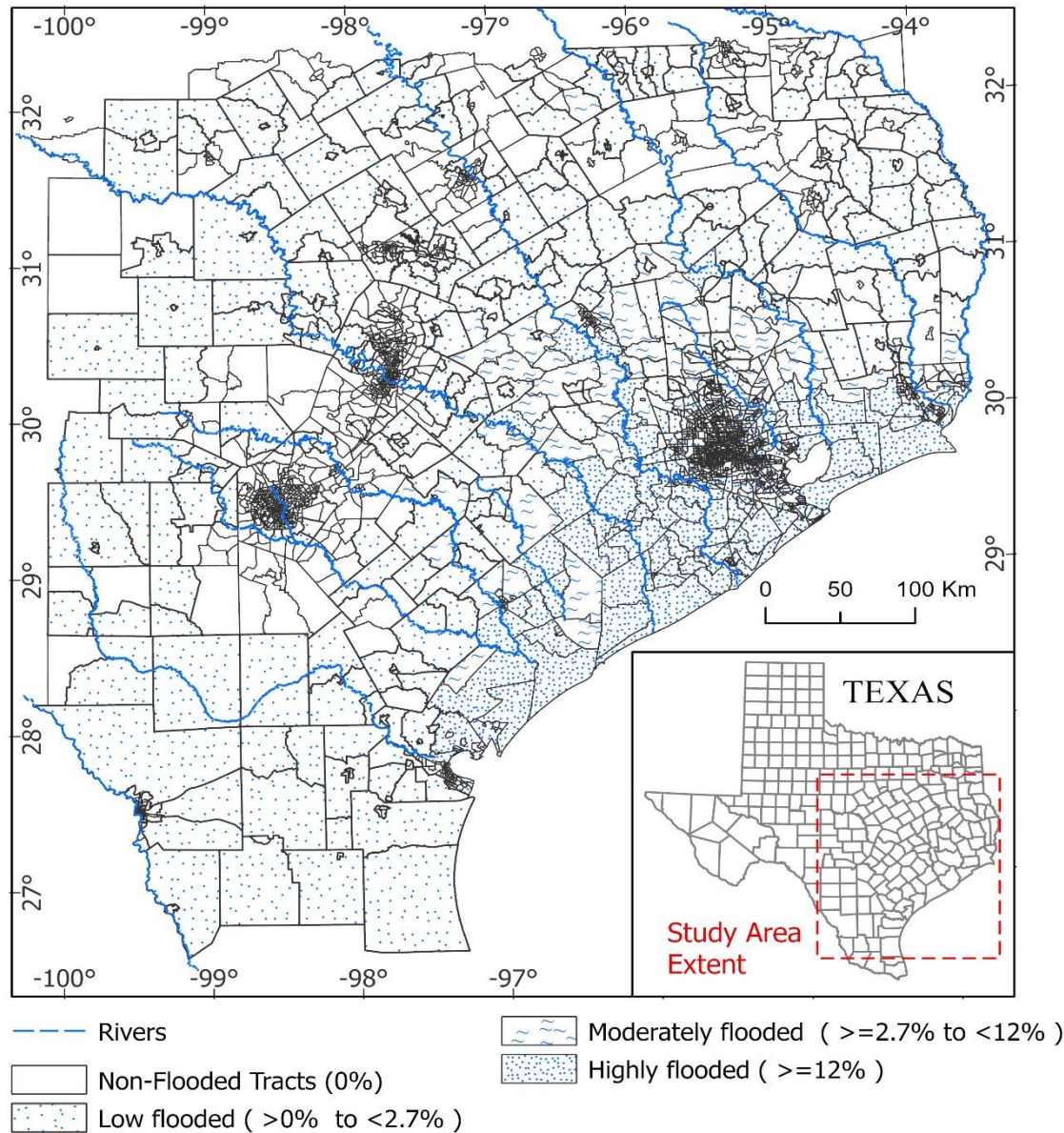
Flooding observed using remote sensing is positively associated with cause-specific ED visits related to flooding

Inundation as of 4th Sep, 2017 mapped using active remote sensing



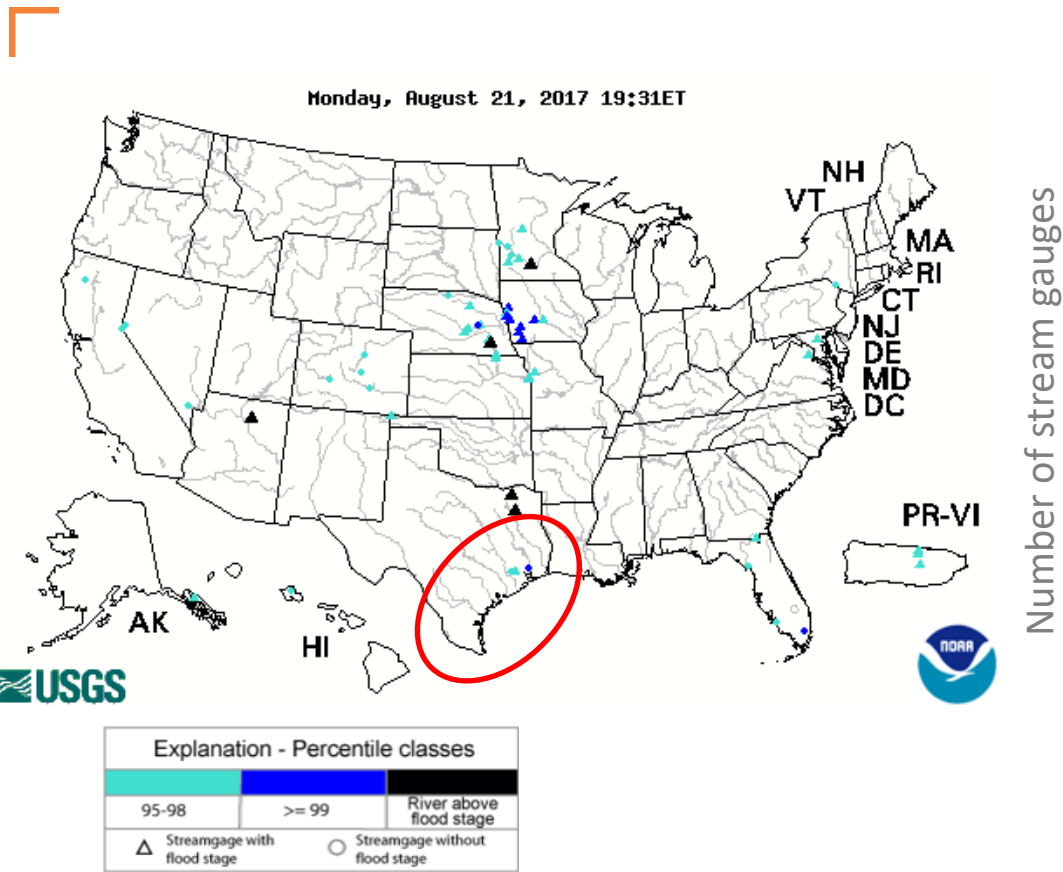
> Exposure > Outcome > Analysis > Results

Inundation as of 4th Sep, 2017 mapped using active remote sensing

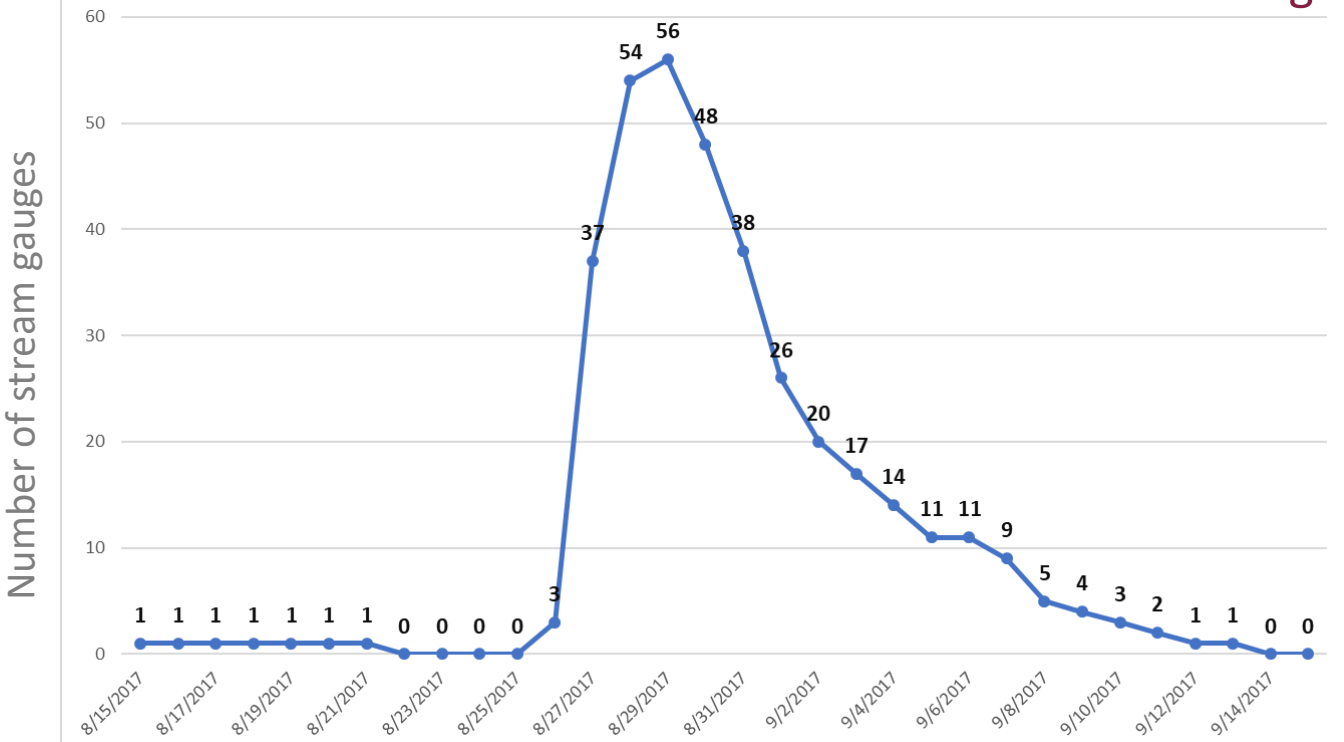


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Period of flood - Defined using USGS stream gauges measurements in the study area



Number of stream gauges measured stage higher than National Weather Service- Flood Stage



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

Flood Period
26th Aug – 13th September

> Exposure > Outcome > Analysis > Results

Emergency Department (ED) Visit Spatial Temporal Data was used to evaluate the health risks

VARIABLES

- Statement Start Date/ Admission Date - 2016, 2017, 2018
- Patient's Census Tract
- Patient's Age, Sex, Race, Ethnicity
- Hospital Name and Zip Code
- Diagnostic Codes
- Patient Address
- Patient Zip Code
- Patient Status During Discharge

Texas Hospital Inpatient and Outpatient Discharge Research Data File, 2016,2017,2018. Texas Department of State Health Services, Center for Health Statistics, Austin, Texas(2020)

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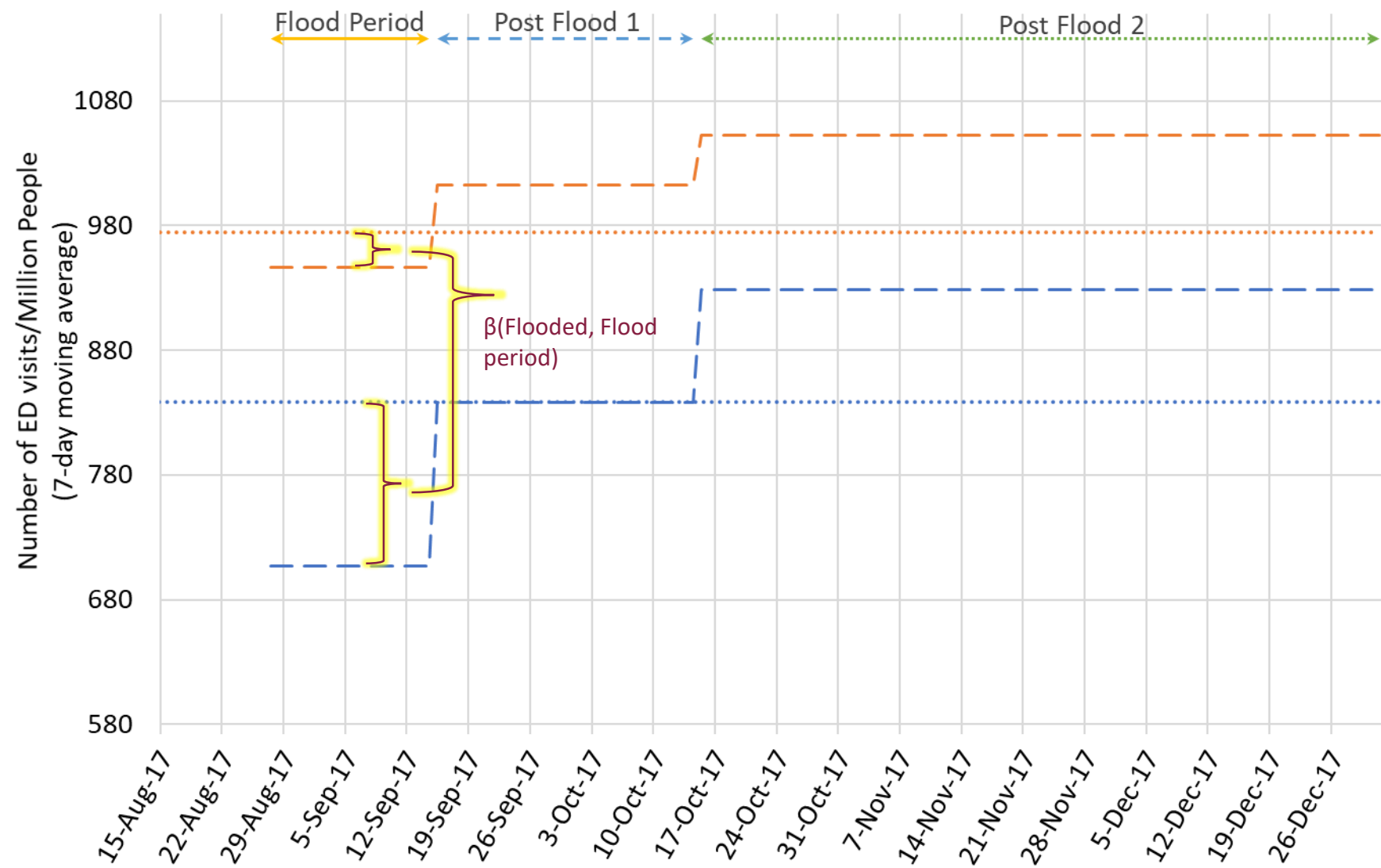
11 cause specific ED visits along with were filtered based on their observed association with flooding in previous studies

		Number of ED visits during flood and post flood periods		Literature	Potential reason
SL No	Outcomes	Flood Period	Post Flood		
1	Carbon monoxide(CO) poisoning	46	147	Chen et al., 2015; Noji, 2005; Van Sickle et al., 2007; Daley et al., 2001	Power outage & Use of portable generators without proper ventilation
2	Drowning	24	77	Daziano et al., 2015; Du et al., 2010	Direct outcome
3	Hypothermia	76	352	Diakakis et al., 2015; Du et al., 2010; CDC, 2000	Power Outage + Cold weather & Contact with cold flood water
4	Intestinal infectious Diseases	1631	11274	DAUDENS-VAYSSE et al., 2019;Waring et al., 2002; Zhang et al., 2019	Contamination of drinking water
5	Dehydration	5923	47121	Rosinger et al., 2018	Water insecurity
6	Insect Bite	1984	7737	CDC, 2000; Brewer et al., 1994; Faul et al., 2011; Bourque et al., 2006	Disturbance caused to insects habitat
7	Pregnancy complications	6821	42567	Grabich et al., 2069; Harville et al., 2009, 2015; Xiao et al., 2019	Mental stress; access to healthcare
8	Chest pain & Heart Palpitation	12831	82081	Hendrickson et al., 1997; Park et al., 2013; Reacher et al., 2004	Mental stress
9	Acute Respiratory Infections (ARI)	22442	254202	Saulnier et al., 2018; Milojevic et al., 2012	Molds and dampness in flooded buildings
10	Heat Related (Other than dehydration)	199	450	Dellinger et al.,1996	Clean up activities
11	Asthma	13060	85232	Hendrickson et al., 1997; Park et al., 2013; Reacher et al., 2004	Exacerbations due to the disaster impact and lack of access to medical resources

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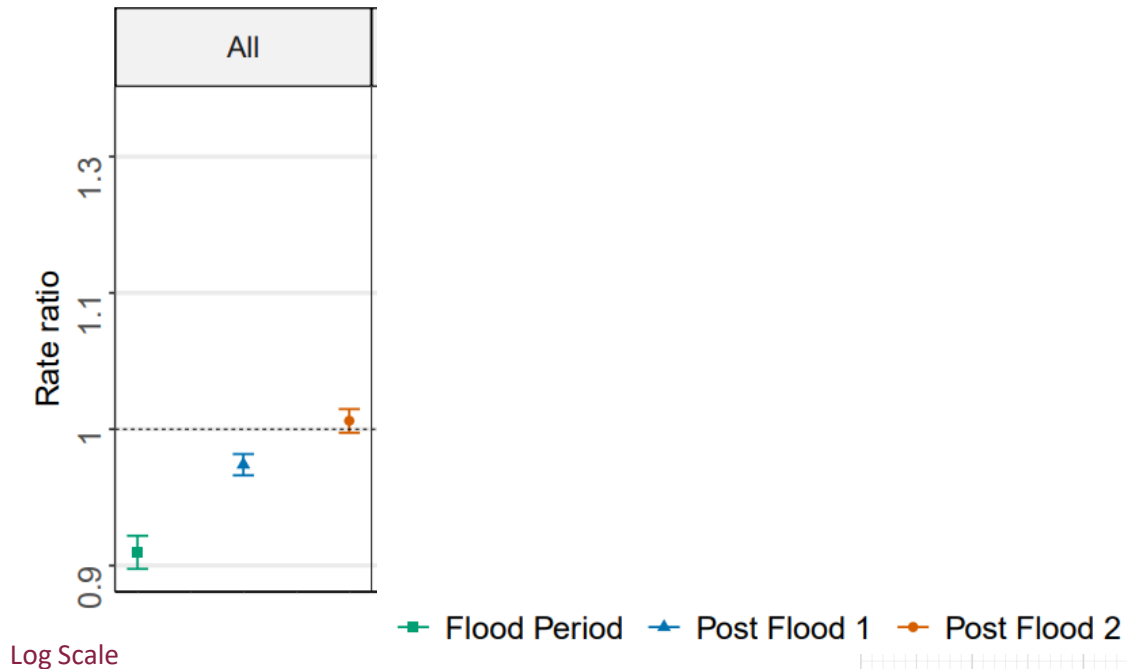
Study Design: Controlled Before And After Analysis: Poisson regression

Outcome (% of ED visits) ~ Tract Flooded (binary) * period + Patient Age + Sex + Race + Ethnicity + (year + month + day of week)

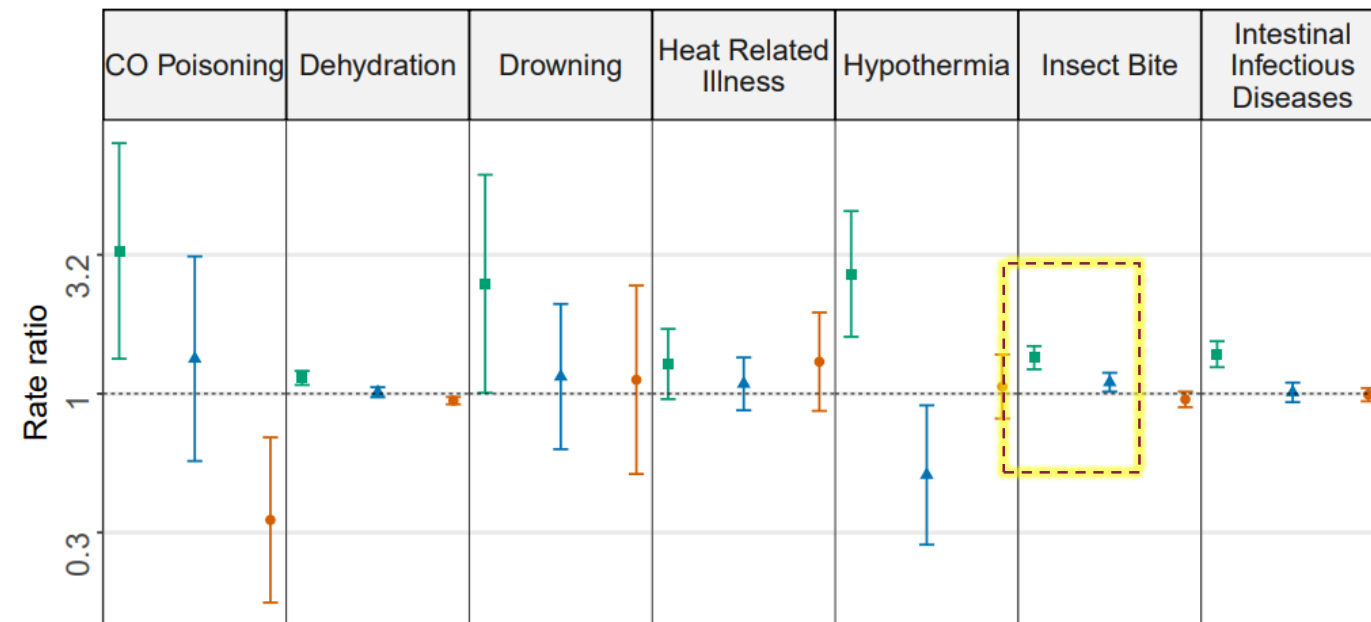


Periods:
Control Period/ Baseline:
1st Jul – 30th Dec 2016,
1st Apr- 19th Aug 2017,
1st Jul – 30th Dec 2018
Flood Period: 26th Aug – 13th Sep 2017
Post flood 1: 14th Sep – 13th Oct 2017
Post flood 2: 14th Oct – 30th Dec 2017

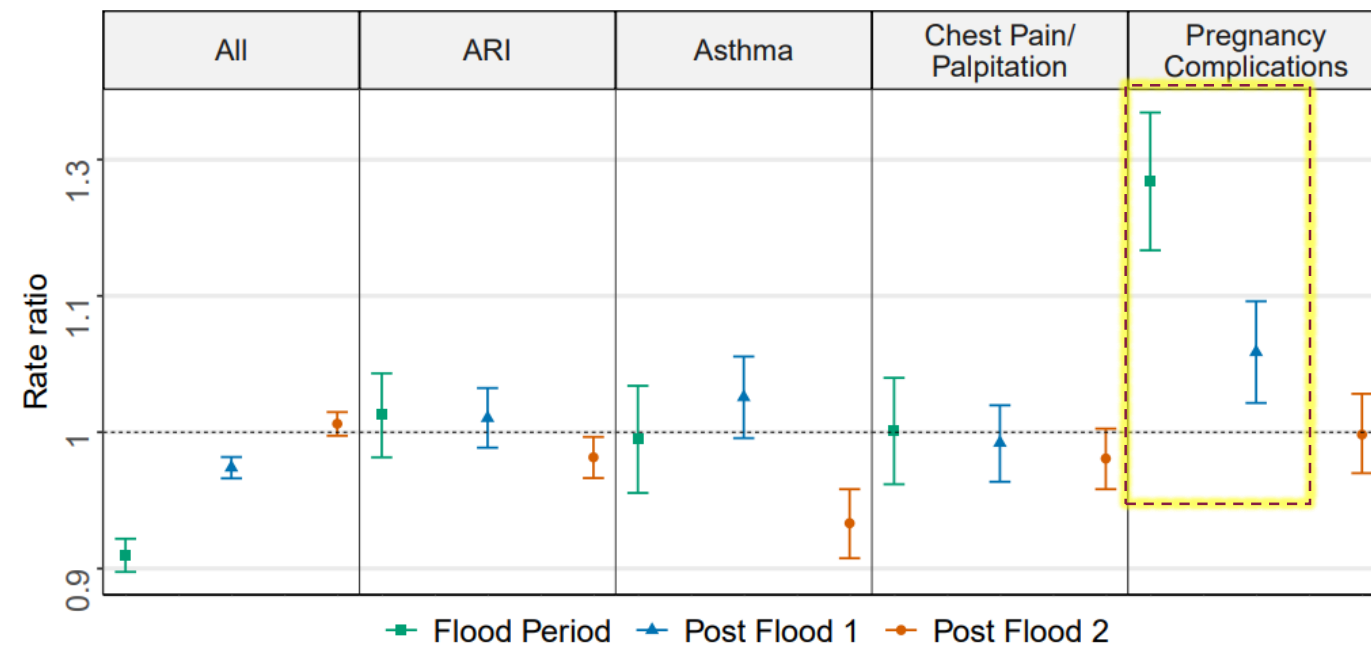
The average rate of ED visits over the flood period was less in flooded tracts compared to non-flooded tracts.



> Exposure > Outcome > Analysis > Results

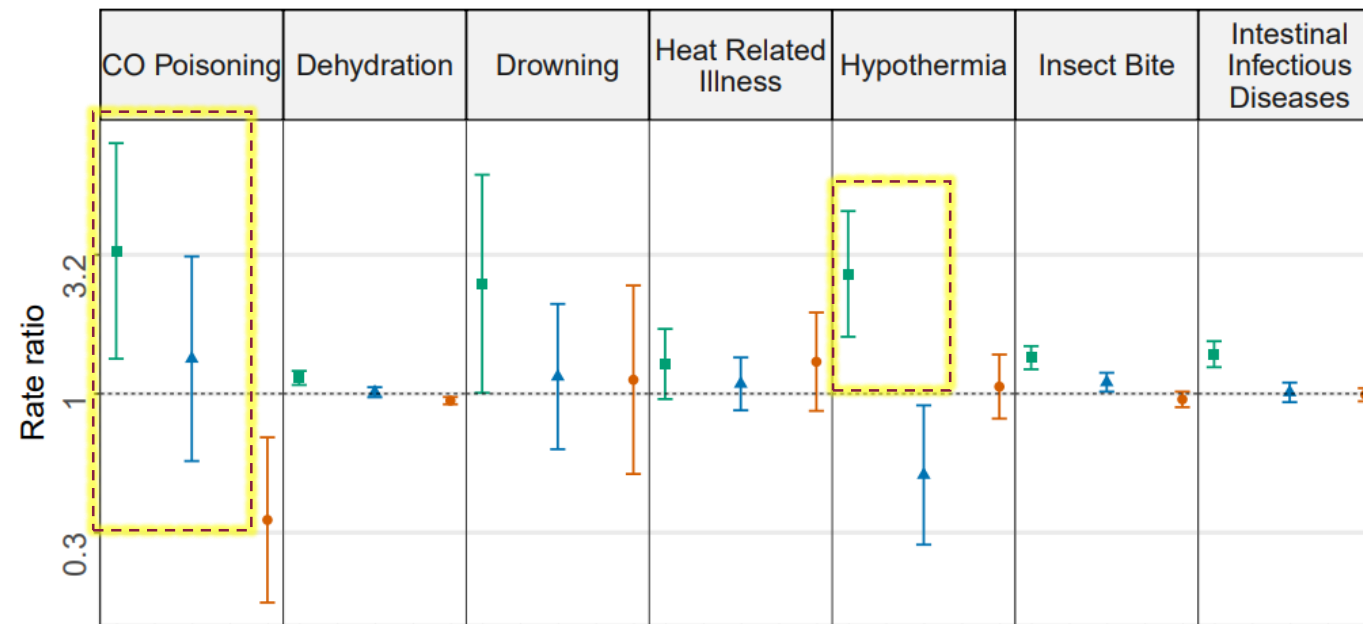


The ED visits related to insect bite and pregnancy complication were increased in flooded tracts compared to non-flooded tracts during both flood and post flood 1 periods.

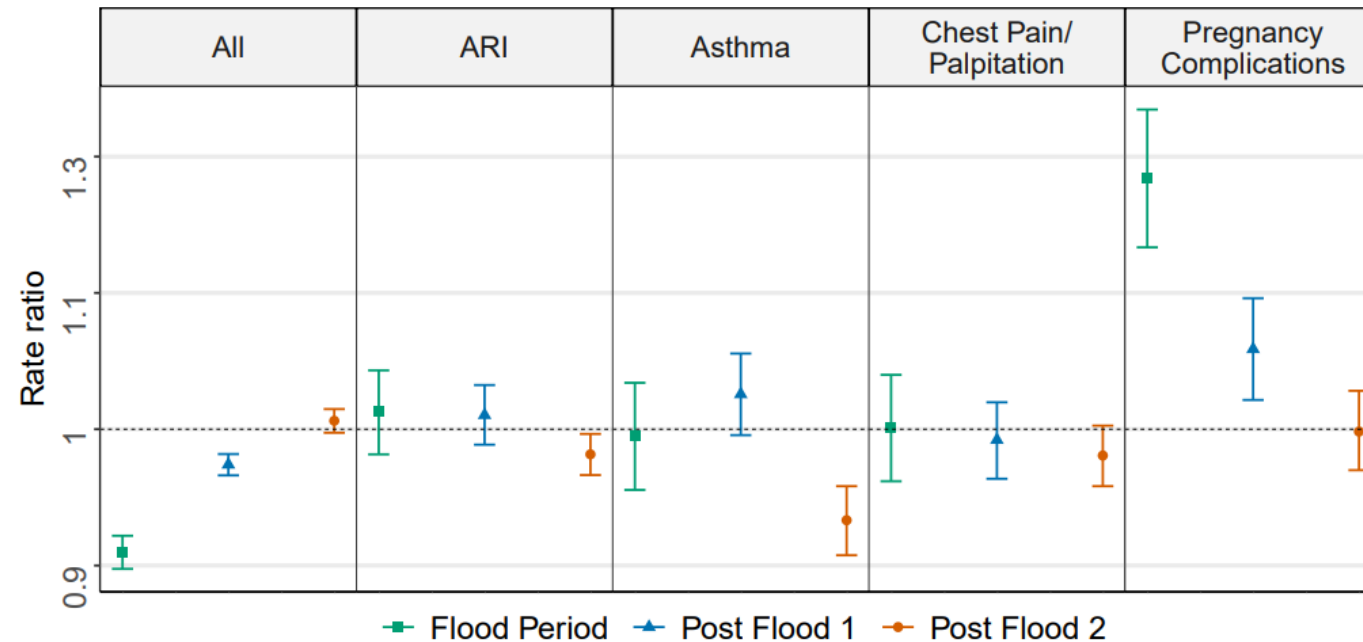


Log Scale

> Exposure > Outcome > Analysis > Results

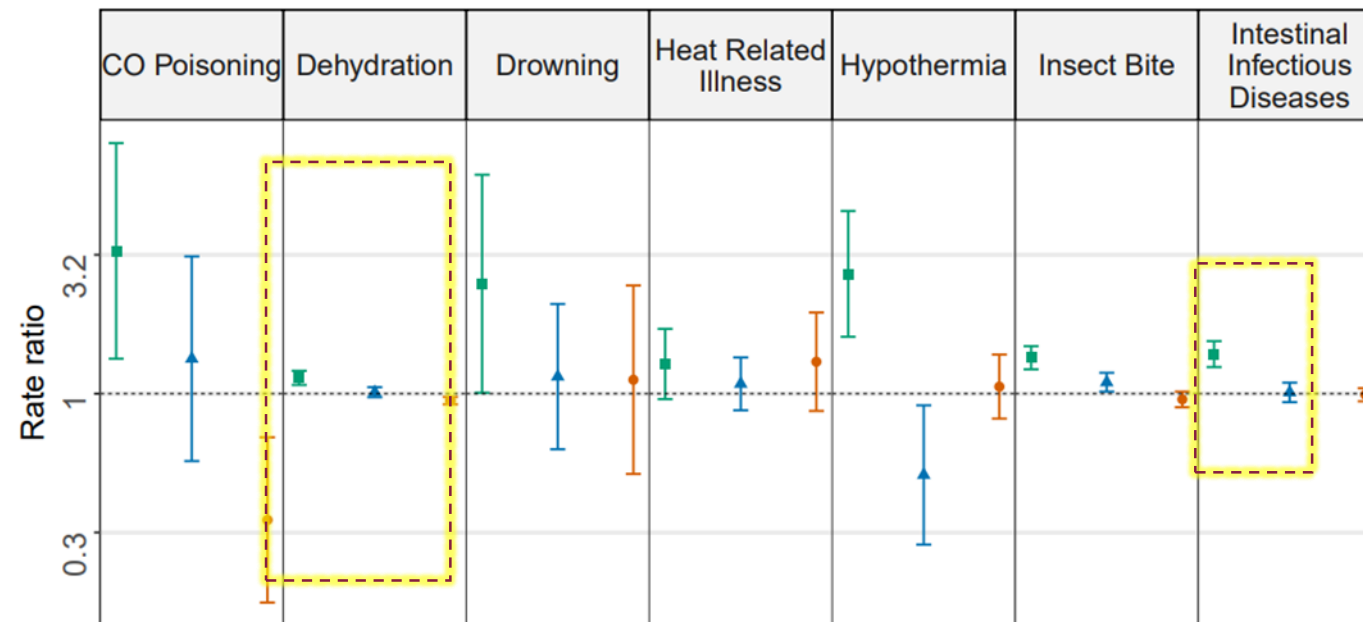


The average rate of ED visits related to CO poisoning and hypothermia increased by more than two times in the flooded tracts compared to non-flooded tracts.

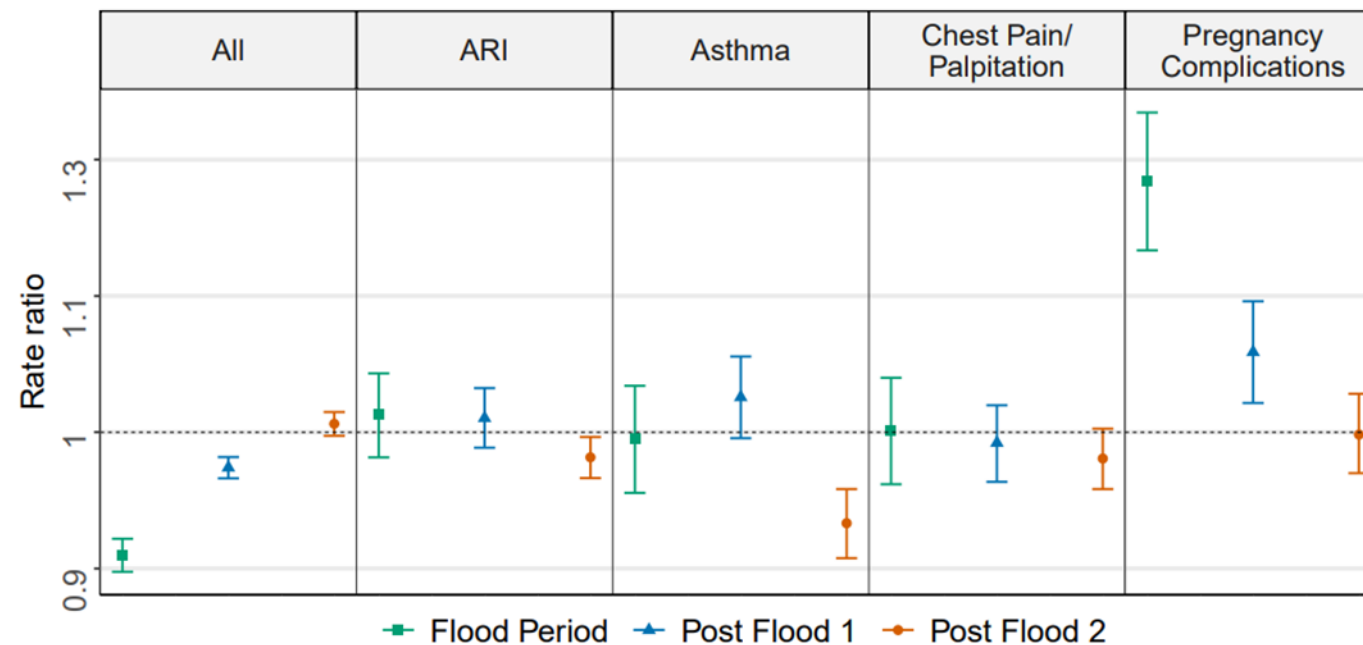


Log Scale

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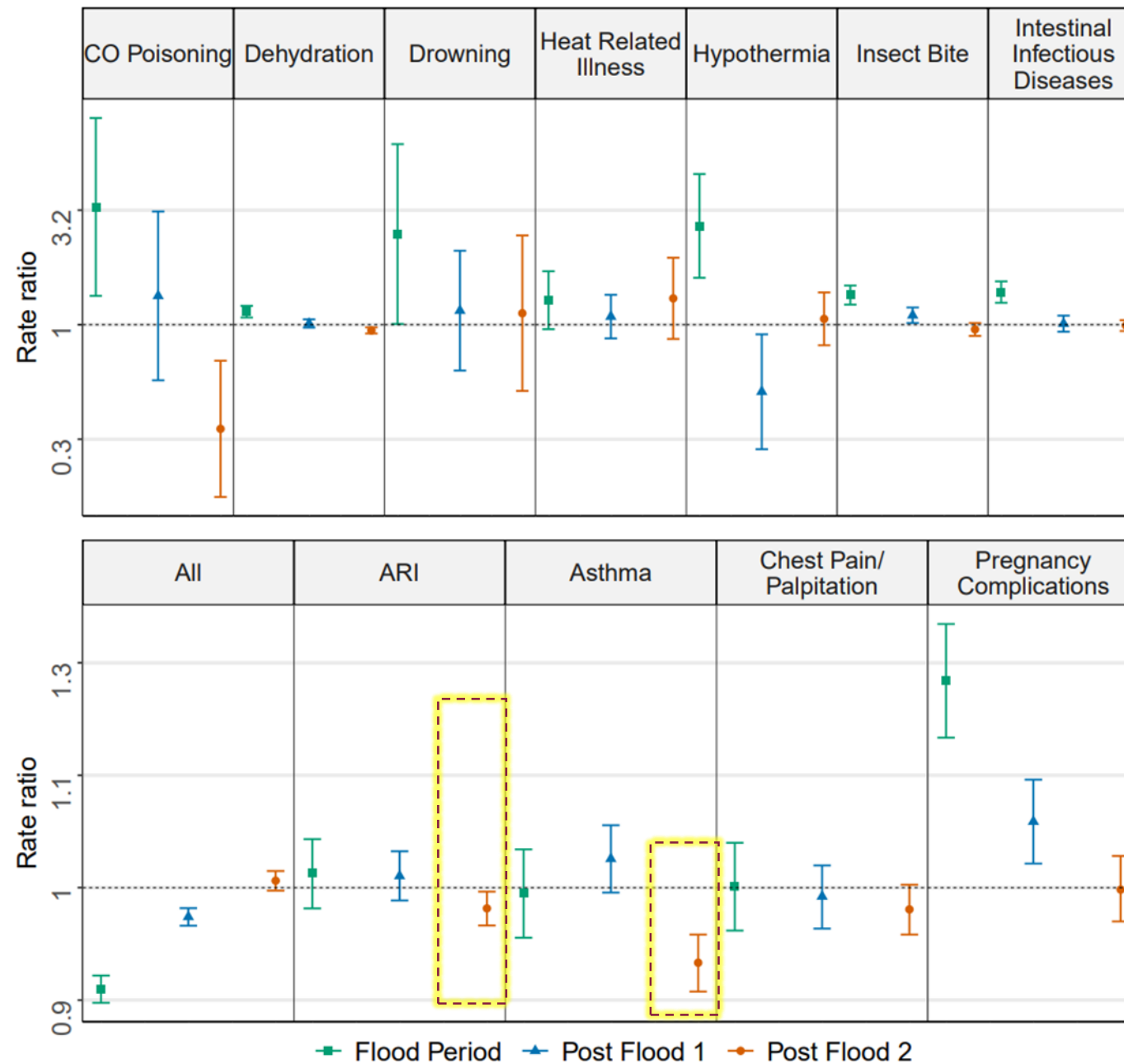
The ED visits related to Dehydration and Intestinal Infectious Diseases were increased in flooded tracts compared to non-flooded tracts during the flood period.



Log Scale

> Exposure > Outcome > Analysis > Results

The ED visits related to Acute Respiratory Infections (ARI) and Asthma were decreased in the flooded tracts compared to non-flooded tracts during the post flood 2



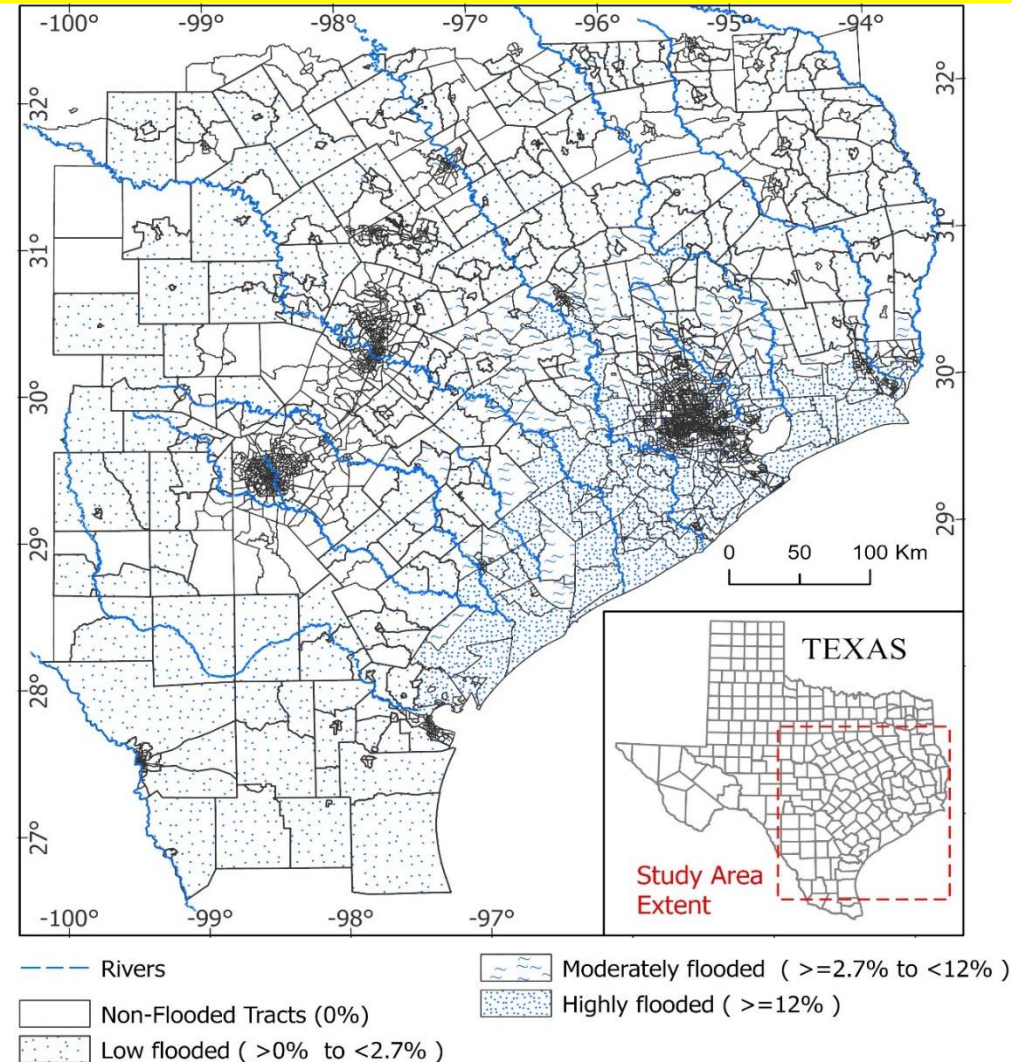
Log Scale

> Exposure > Outcome > Analysis > Results

Rate Ratio of ED visits for the low flooded, moderately flooded and highly flooded census tracts with respect to the non flooded tracts after adjusting for the baseline.

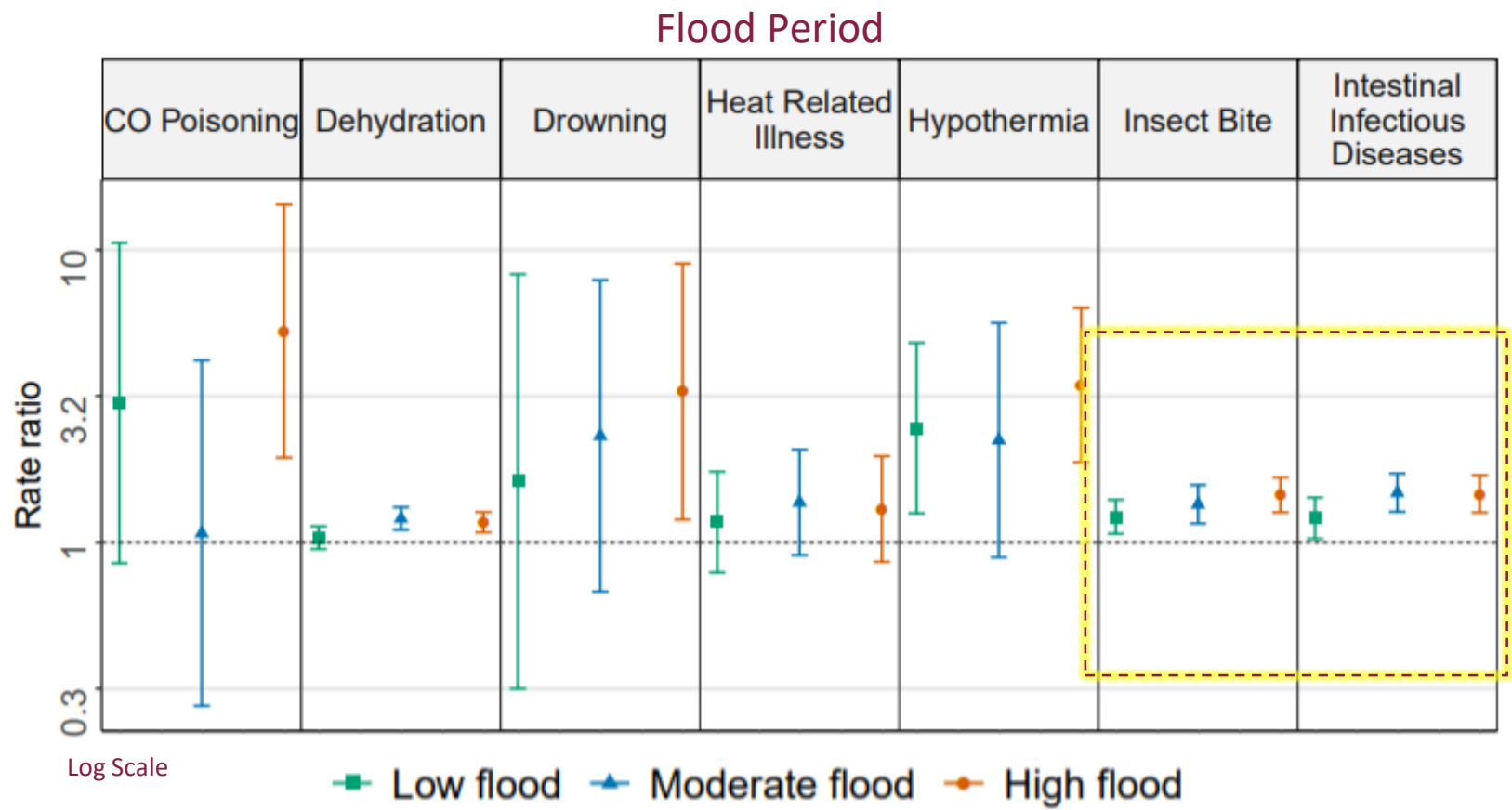
Outcome (% of ED visits) \sim Tract Flooded * period + Patient Age + Sex + Race + Ethnicity + (year + month + day of week)

1. No flooding (reference)
2. Low flooded
3. Moderately flooded
4. High Flooded



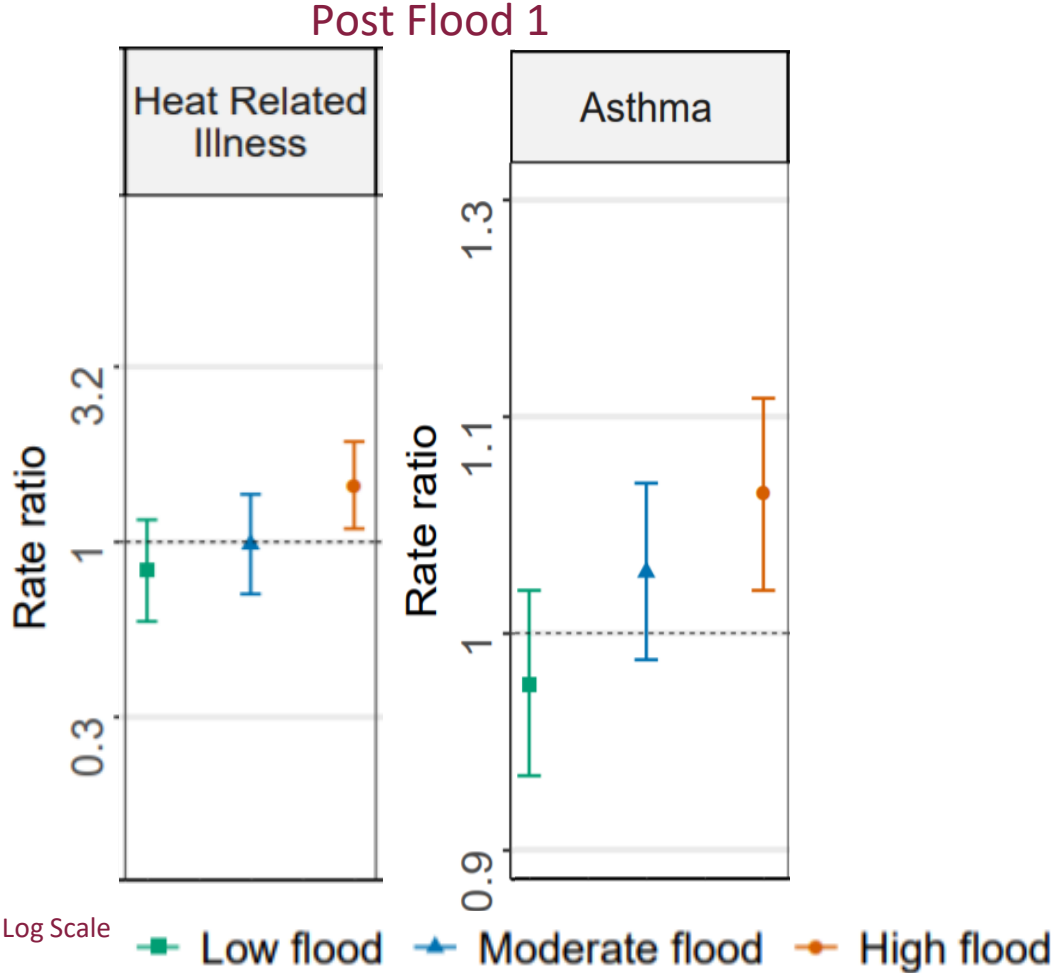
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The ED visits related to insect bite and intestinal infectious diseases were increased in all three flooded categories compared to non-flooded during the flood period.



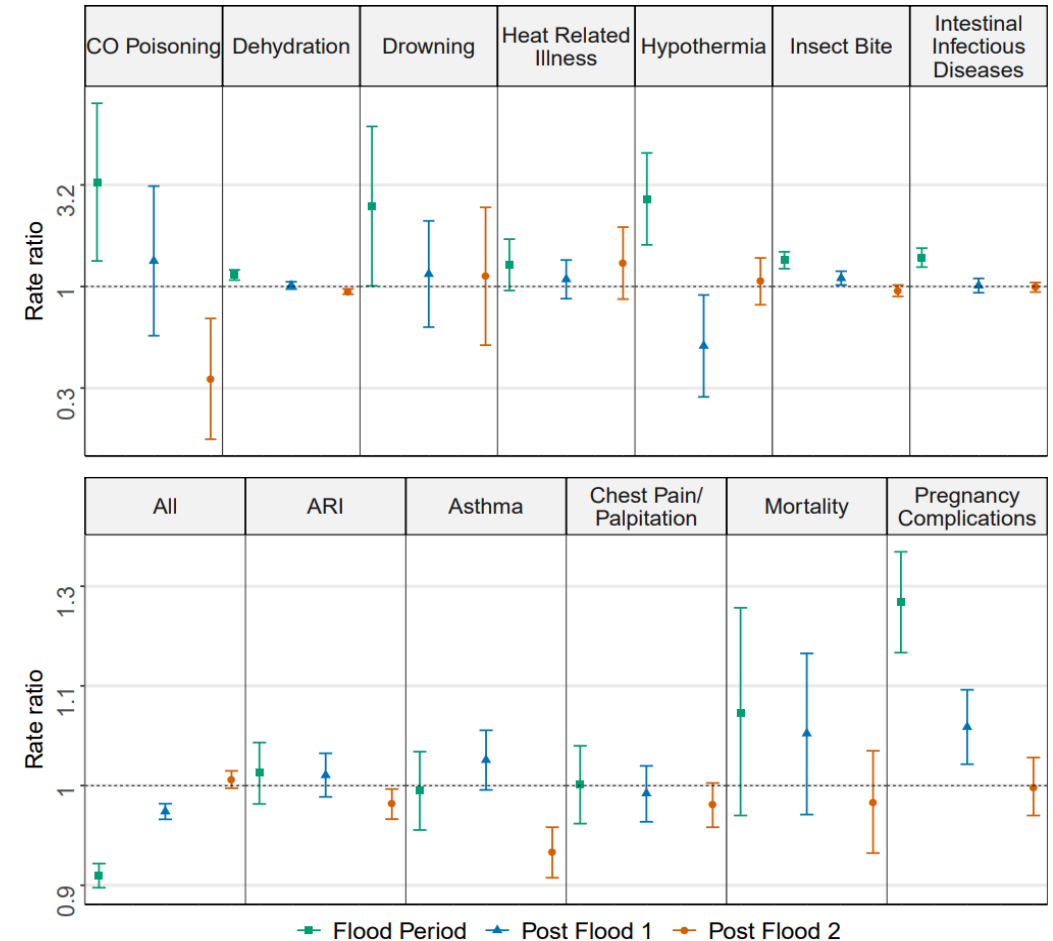
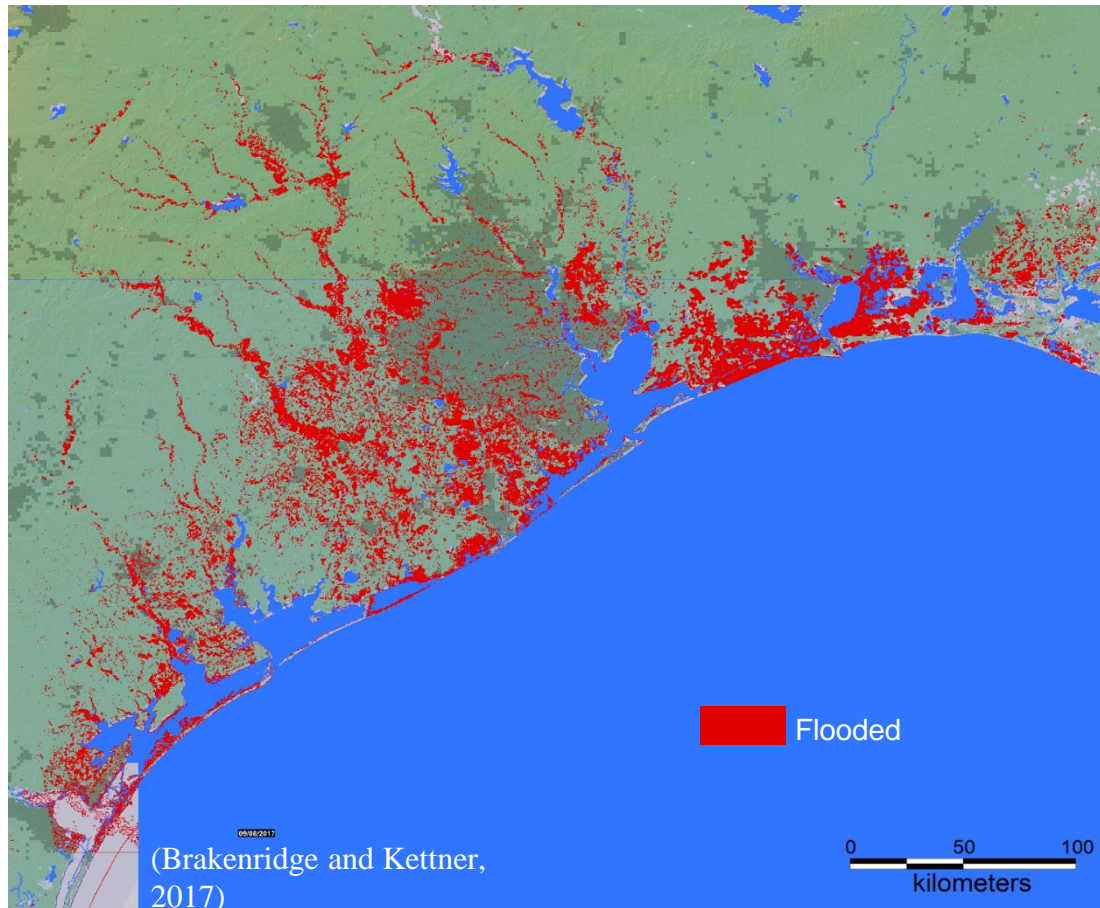
> Exposure > Outcome > Analysis > Results

ED visits for asthma and heat-related illness were increased among the highly flooded tracts with respect to non-flooded, which was not reflected in dichotomous analysis.



> Exposure > Outcome > Analysis > Results

Exposure of census tracts to floods assessed using earth observation was useful in understanding the health outcomes that increased after the flooding



> Results Summary & Limitations<

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Thank you

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Questions?