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**Weather or Wealth? Property Damage from Flooding in the Context of Climate Change and Economic Growth**

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# Weather or Wealth? Property Damage from Flooding in the Context of Climate Change and Economic Growth

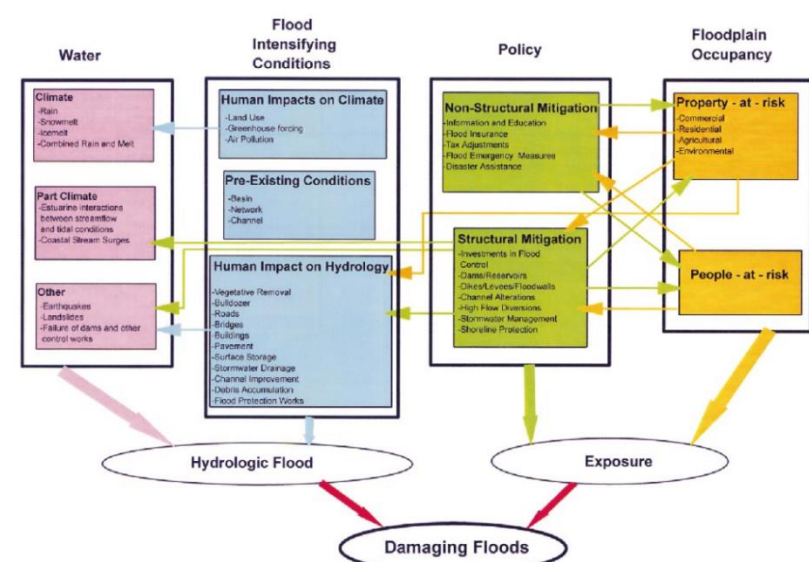
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## Motivation

- Flooding caused tremendous damage.
  - 16 out of 144 billion-dollar disasters since 1980 were related to flooding.
  - Total estimated loss exceeds \$60 billion (NCDC).
- Although the trend of increasing damage from floods has been well documents (Pielke et al. 2002), debates over the attribution continue.
  - Climate - extreme weather events
  - Economy - disaster by design
  - Policy - ineffective mitigation and adaptation measures
- Over the past decade, no systematic, large-scale, quantitative study has been done on the local-level causes, consequences and policy implication associated with repetitive flooding events (Brody et al., 2011).

## Conceptual Model

- Damage = **Hazard** \* **Exposure** \* **Vulnerability**
- Damage can be measured by total, per capita or per unit wealth damage.



Source: Pielke and Dondon, 2000

- Hazard: probability that a potentially damaging phenomenon occurs
- Exposure: values at risk
- Vulnerability: degree of loss resulting from a damaging event

## Objectives

- Use refined methods to measure floods-related risk factors – Hazard, Exposure and Vulnerability..
- Understand what risk factors play the dominant role in explaining damages from multitude chronic flooding disasters.
- Focus on extreme weather events. Show how sensitive analysis result is to the presence of extreme values.

## Measurements

### (1) Hazard

- Frequency metric: number of extreme days within a year
- Intensity metric: annual accumulation of extreme flow
- An extreme event is defined as the flow that is above 97.5 percentile of 30-year records (1980-2009)

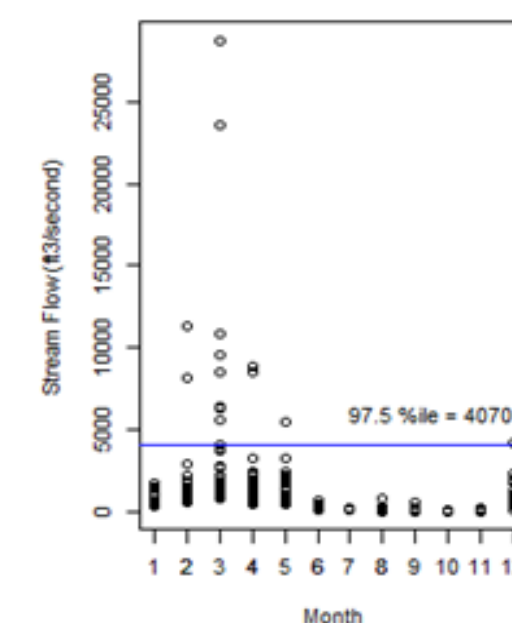


Fig.1. Scatter plot of daily flow data (left) for a sample station, blue line is the threshold for extreme event; Mean excess plot with 95% CI (right) for the proposed threshold.

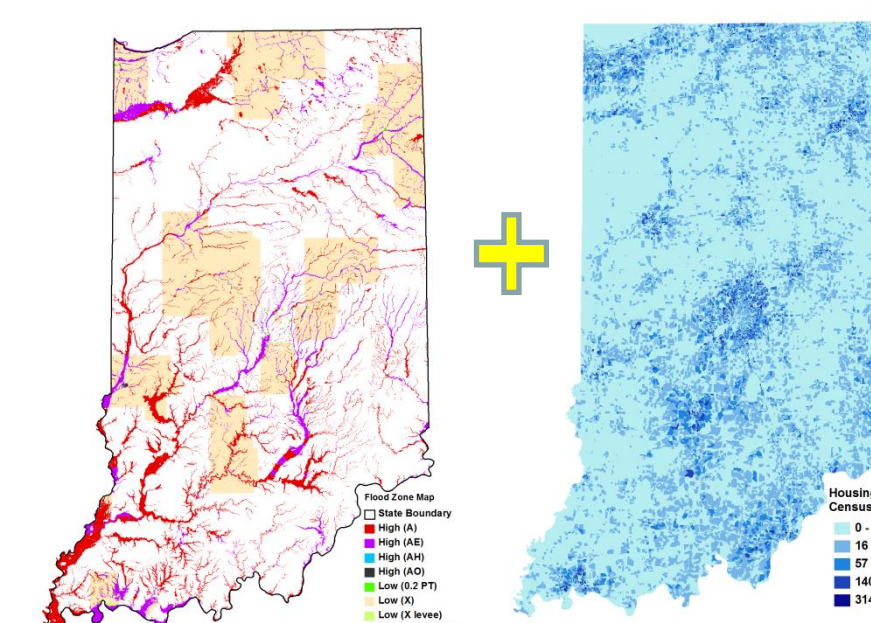
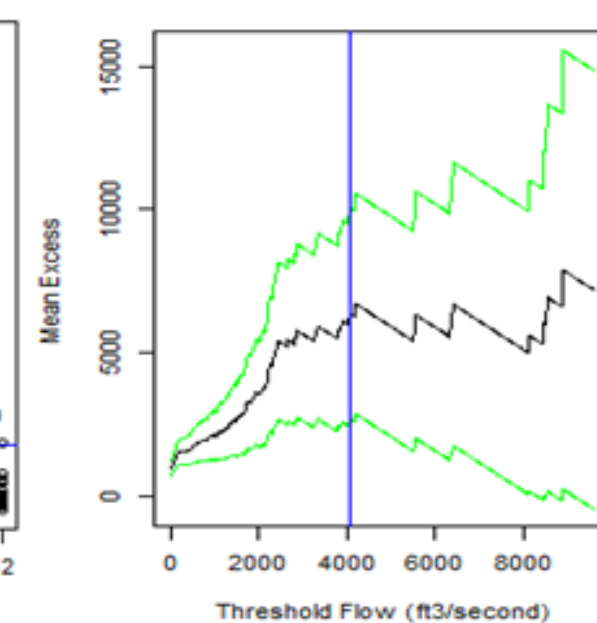


Fig.2. FEMA flood zone map (left); census block housing units (right)

### (2) Exposure

- Population and houses are used as a proxy in earlier research
- However, county data may not reflect the actual value at risk.
- We overlay flood zone map and census block population and housing units map to precisely measure the wealth located in a relatively small high-risk flood area (Fig.2).



Fig.3. NOAA nighttime light for Indiana State in 2010

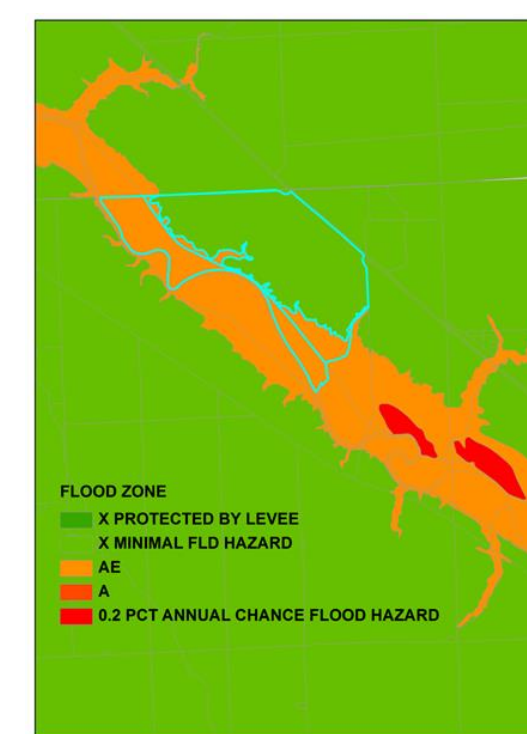


Fig. 4. Population and housing density is proportional to the brightness of nighttime light.

- If a census block runs across multiple flood zones with different levels of risk, we use NOAA nighttime light data (Fig.3) to split block population and property counts (Fig. 4).

### (3) Vulnerability

- Physical metric: number of vulnerable houses
- Institutional metric: adaptation, coping & recovery measures.

## Data

- Damage: Indiana county property loss from flooding (1993-2009) extracted from the Spatial Hazard Events and Losses Database for the United States (SHELDUS)

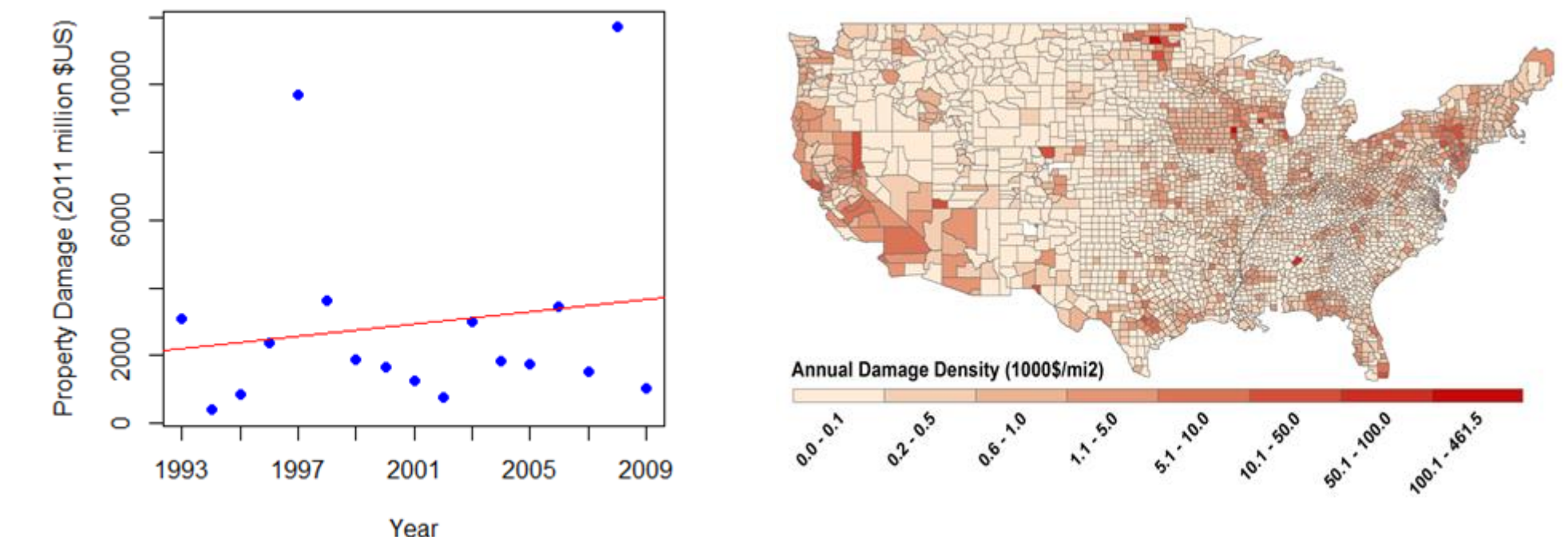


Fig.5 Trend of national property damage (left); Average annual damage density, 1993-2009 (right)

- Hazard: USGS Surface-Water Daily data
- Exposure: FEMA flood zone map and Census data
- Vulnerability: FEMA Hazard Mitigation Program Summary

## Empirical Strategies

- Tobit model with county indicators, which controls for unobserved time-invariant county characteristics
- Allows correlation between covariates and unobserved effects, a more realistic assumption than random effects

$$D_{it} = \alpha + X_{it}'\beta + u_i + v_{it}$$

## Results and Discussions

Variable	Mean Marginal Effects (\$)	P-value
Annual Extreme Flow (0.1 mn. ft3/second)	681,185	0.095
Annual Frequency of Extreme Events (day)	57,417	0.074
Housing units at risk (10k)	26,985,035	<.0001
Population at risk (10k)	-10,881,979	<.0001
Vulnerable housing units (10k)	-4,596,434	<.0001
Number of damage in the last 5 years	-206,928	0.001

Dependent variable is county per capita damage

- Adjustment to human activity in flood prone areas has the potential to substantially reduce realized damages.

- Keeping or excluding extraordinary disaster events alters the relative size of the estimated marginal effects with respect to risk factors.
- It's important from a policy perspective to determine whether the interest is "the extreme of the extremes", or more frequent, but less extreme, stream flows.