A Simple Relationship Between Hurricane Flood Damage and Physical and Anthropogenic Factors

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Hurricane Flood Damage Relationship
Outline

- Motivation, methods, summary
- Geographic location
- Definition of impacted area
- Anthropogenic contributions
- Physical contributions
- Simple damage scale
- Applications
- Conclusions and future work

Hurricane Flood Damage Relationship
Motivation, Methods and Summary

Motivating questions:

- How are hurricane flood damages impacted by:
  1. The scale of the surge event?
  2. Anthropogenic factors?
- Is it possible to predict damages using a **simple** scale?

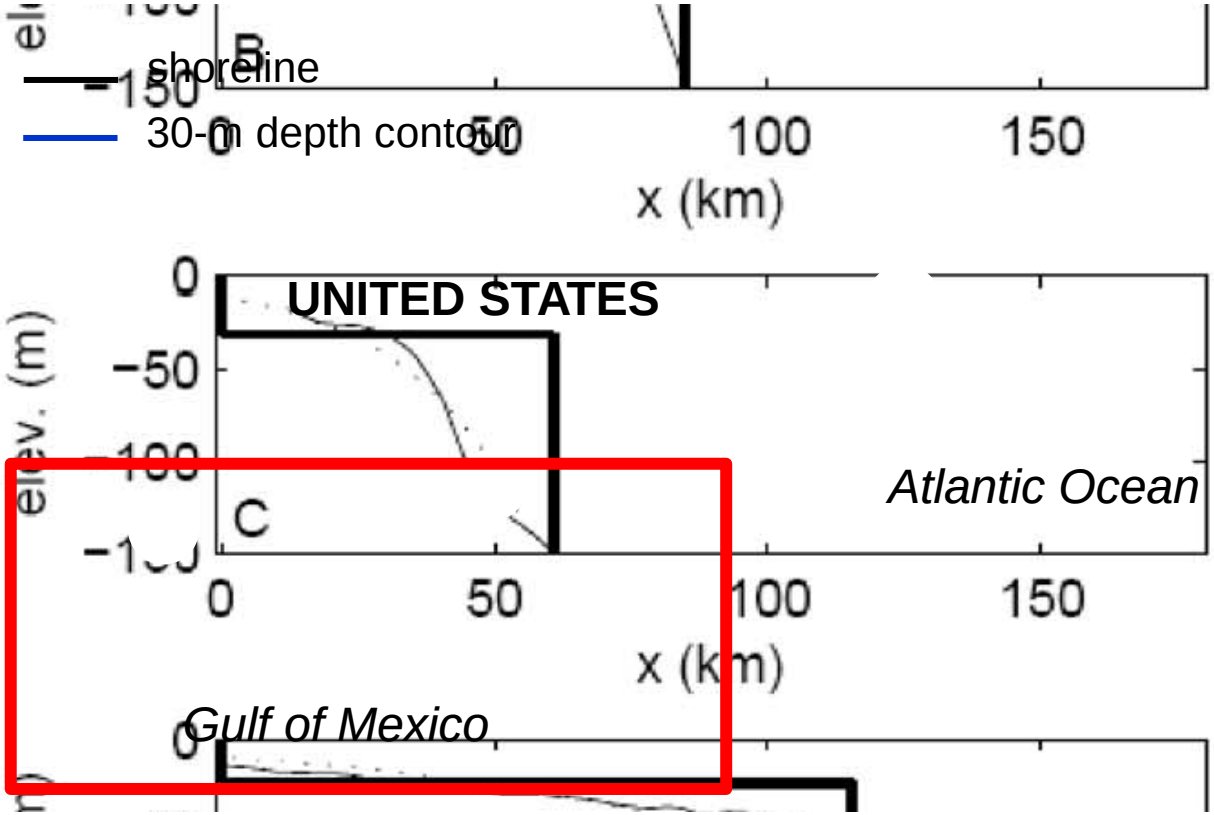
Methodology:

- Identify which hurricane physical characteristics and census information correlate with direct damages.
- Develop damage scale by considering both dominant physical and anthropogenic factors.

Summary:

- Damages scale with the product of population density and “surge volume”

Hurricane Flood Damage Relationship
Geographic Location



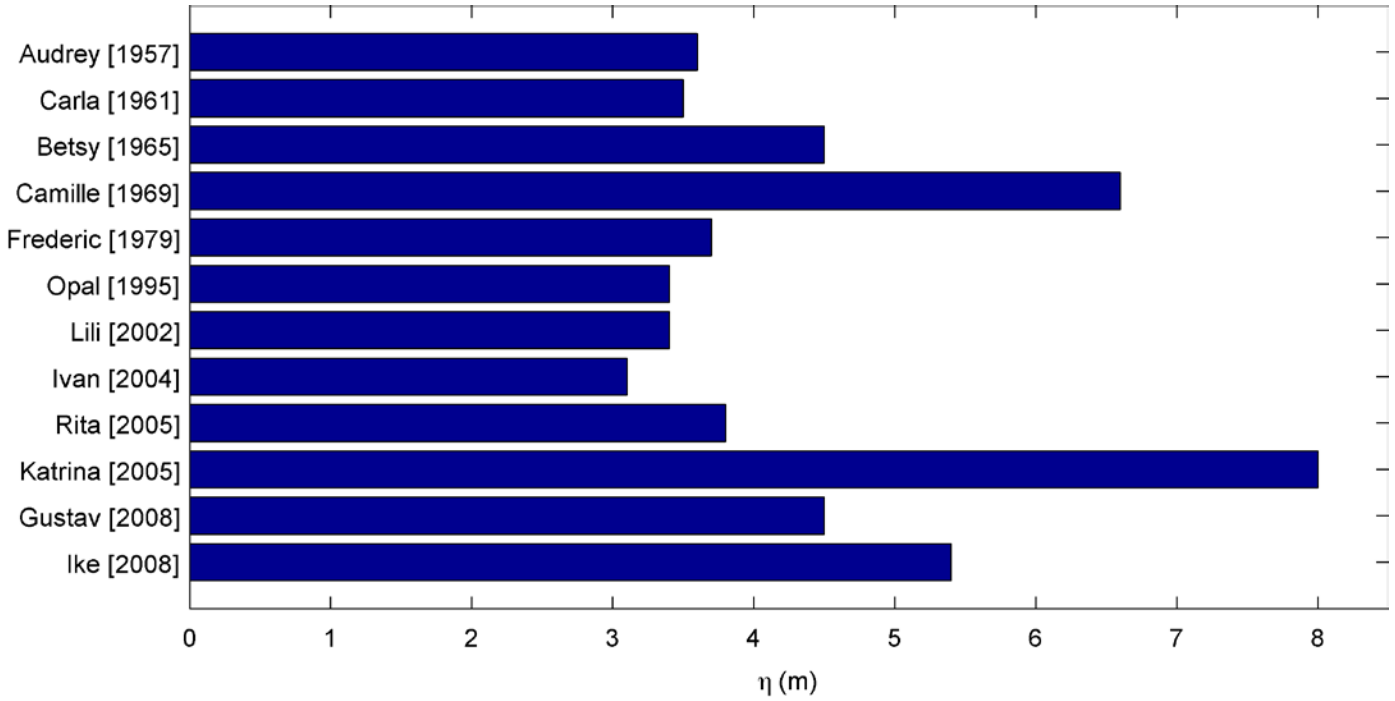
Northern Gulf of Mexico:

- Small tidal range
- Single storm population for surges
- Equalized damage estimates available

Hurricane Flood Damage Relationship
Geographic Location: Storm Selection

Criteria:

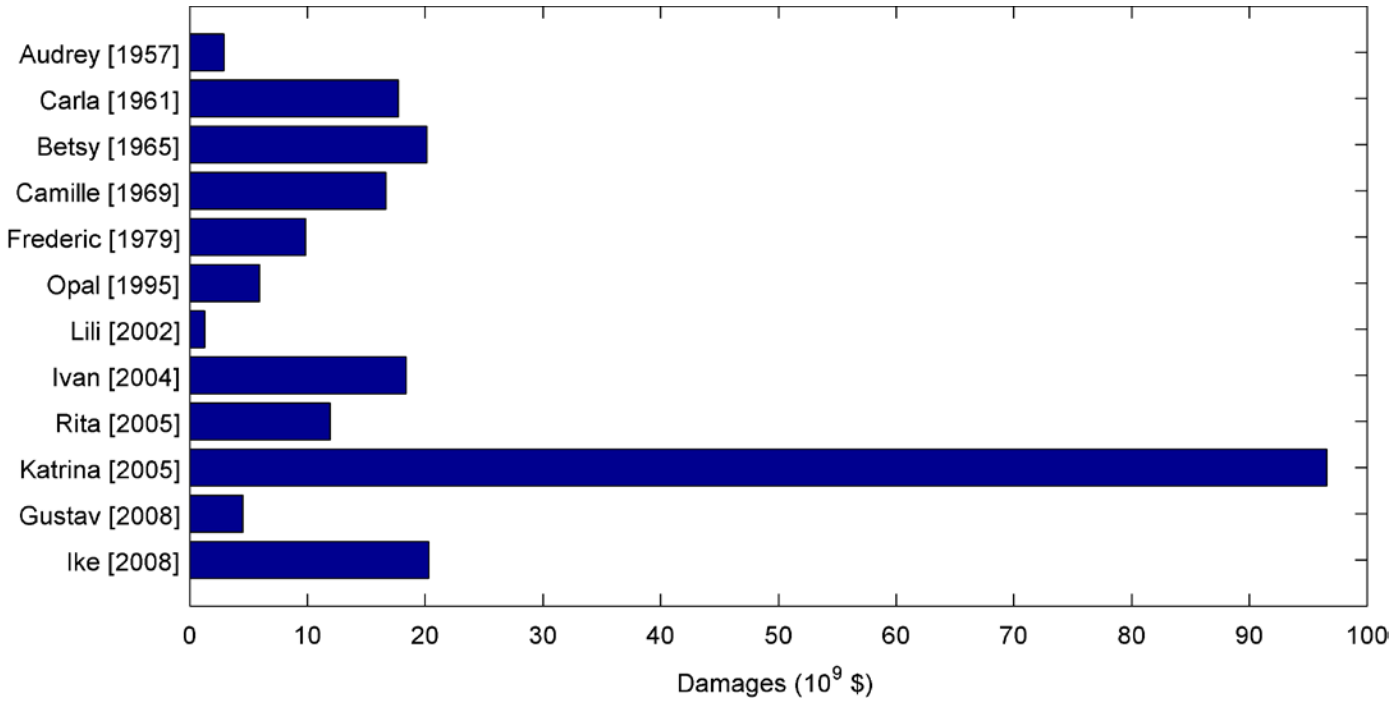
- Hurricanes since 1950
- Maximum open coast surge of 3 m or greater ← **Surge-dominated events**



Hurricane Flood Damage Relationship
Geographic Location: Damage Estimates

Pielke et al. (2008, *Nat. Hazards Rev.*):

- "Direct economic damages": direct losses in weeks after event
- Estimate for historical hurricane if it occurred today:
  - National inflation
  - Population changes
  - Housing changes



Hurricane Flood Damage Relationship
Definition of Impacted Area

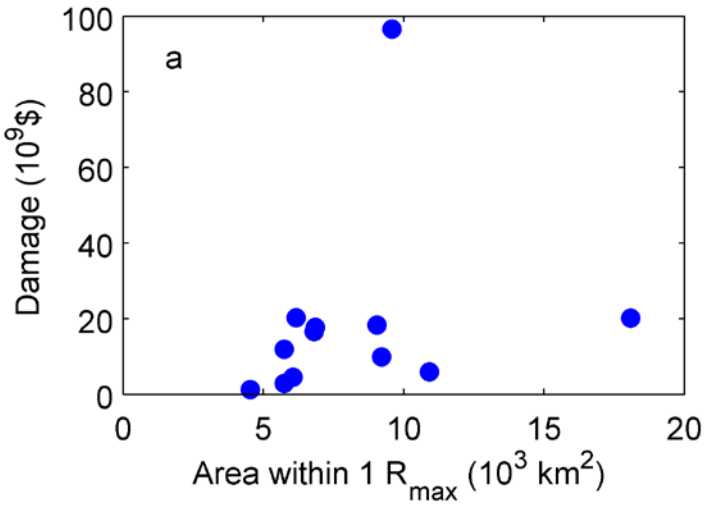
b, R_p = 65.9 km

From Irish et al., 2009, *Nat. Hazards*

$$x' = \frac{(x - x_o)}{R_p} - \lambda$$

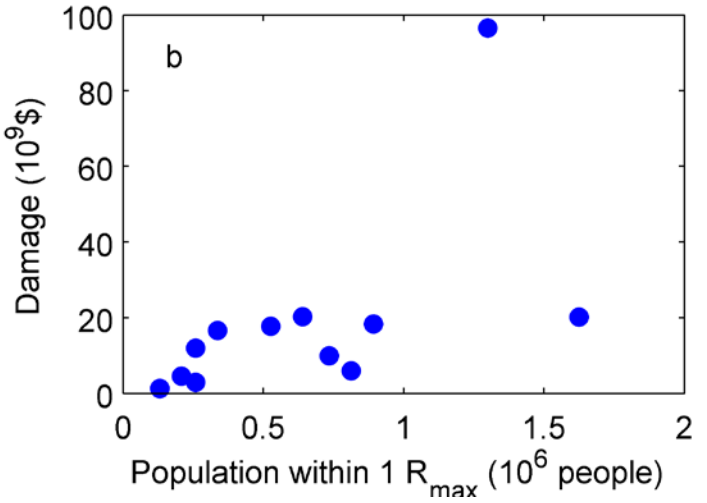
Assume alongshore extent impacted proportional to R

Hurricane Flood Damage Relationship
Anthropogenic Contributions



Area impacted:

R^2 = 0.05 (0.17 without Katrina)

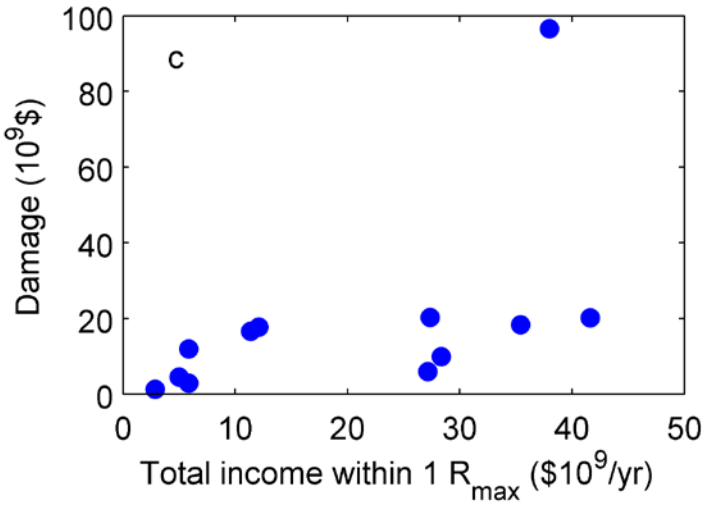


Population impacted*:

R^2 = 0.33 (0.34)

*US Census data for coastal counties within one R

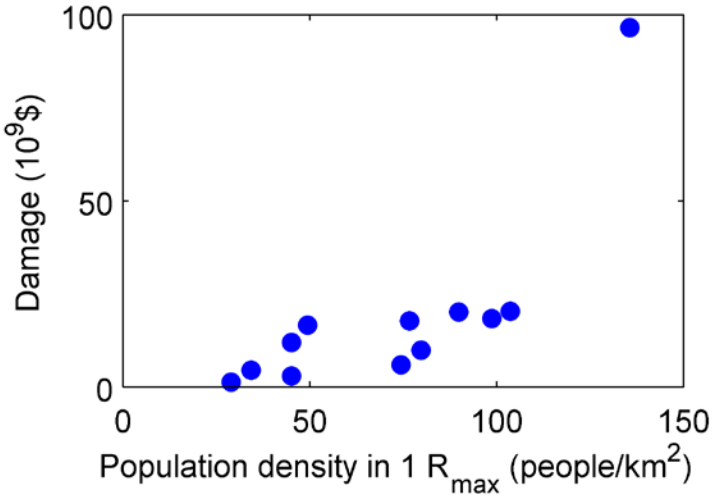
Hurricane Flood Damage Relationship
Anthropogenic Contributions



Income impacted*+:

R^2 = 0.28 (0.37)

+(population impacted)*(mean income)



Population density*:

R^2 = 0.58 (0.57)

Reflects differences in infrastructure, residential structures, etc.

*US Census data for coastal counties within one R

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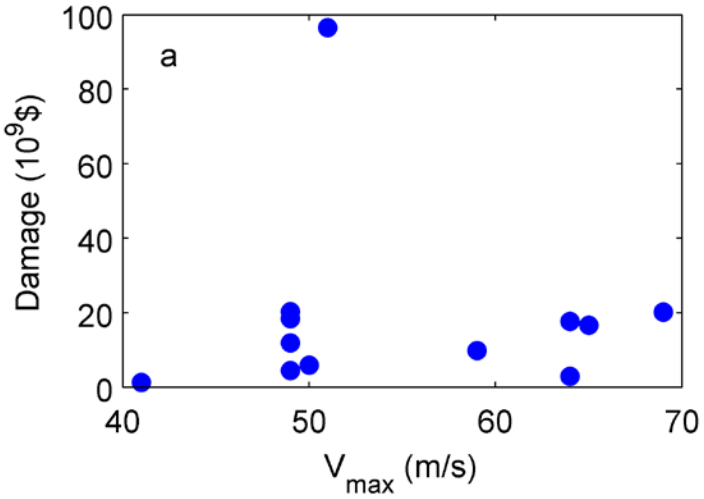
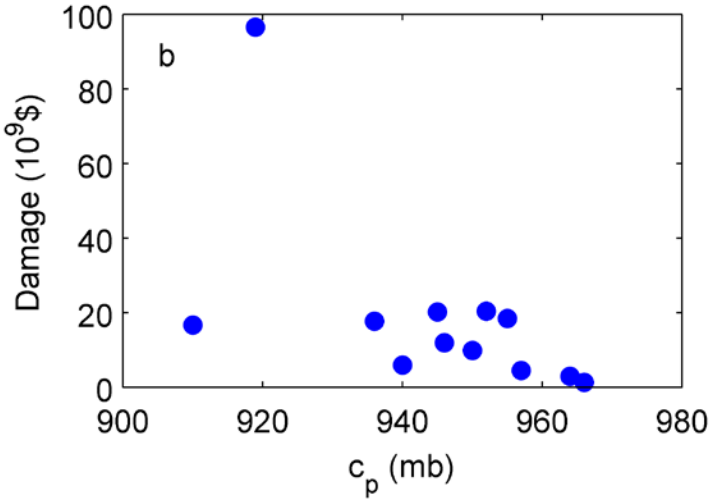
Hurricane Flood Damage Relationship
Physical Contributions



Maximum wind speed:

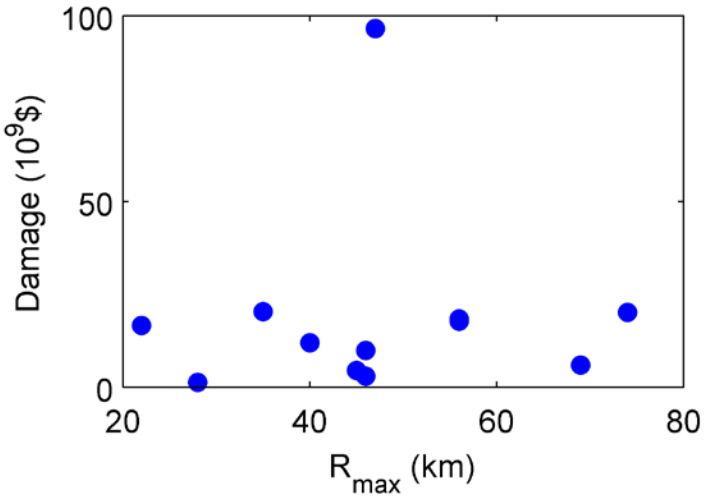
$R^2 = 0.00\ (0.15)$



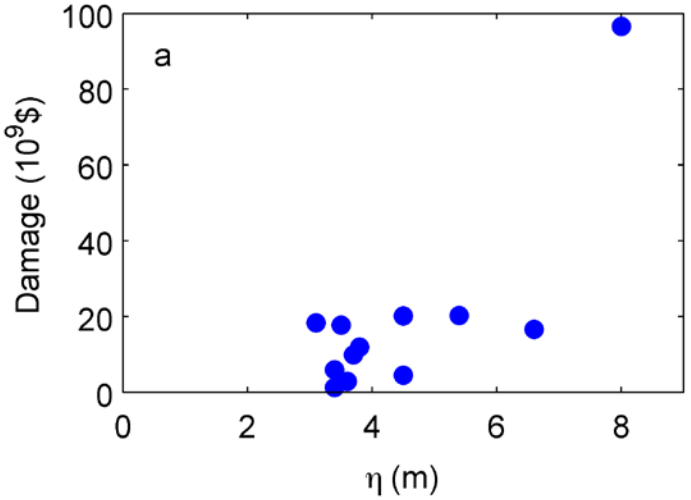
Central pressure:

$R^2 = 0.34\ (0.25)$

Hurricane Flood Damage Relationship
Physical Contributions



Radius to maximum wind (*R*):
R^2 = 0.00 (0.03)



Maximum open-coast surge (η):
R^2 = 0.62 (0.16)

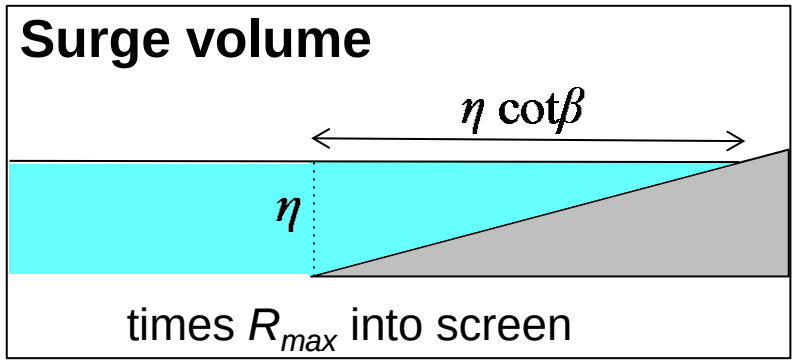
Hurricane Flood Damage Relationship
Simple Damage Scale

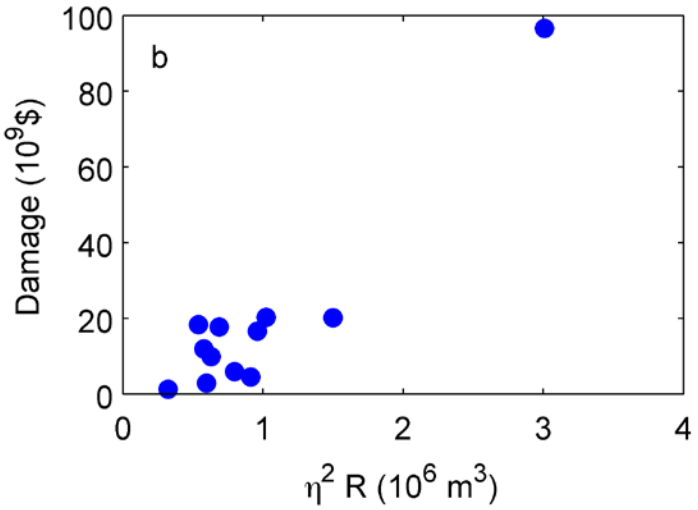
- Damages assumed to scale with surge magnitude and extent:

$$D = C\,\eta^m R$$ (from Irish and Resio, 2010, *Ocean Eng.*)

- Assume $m = 2$, represents **"surge volume"**:

$$D = C\,\eta^2 R$$





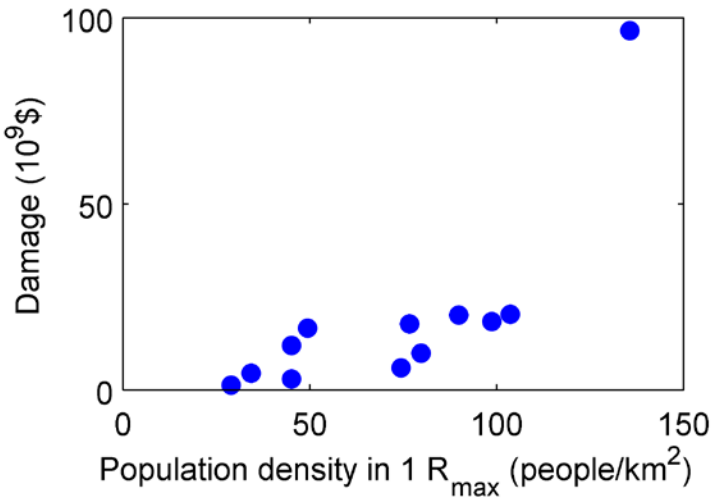
"Surge volume":

$R^2 = 0.87$ (0.29)

Hurricane Flood Damage Relationship
Simple Damage Scale

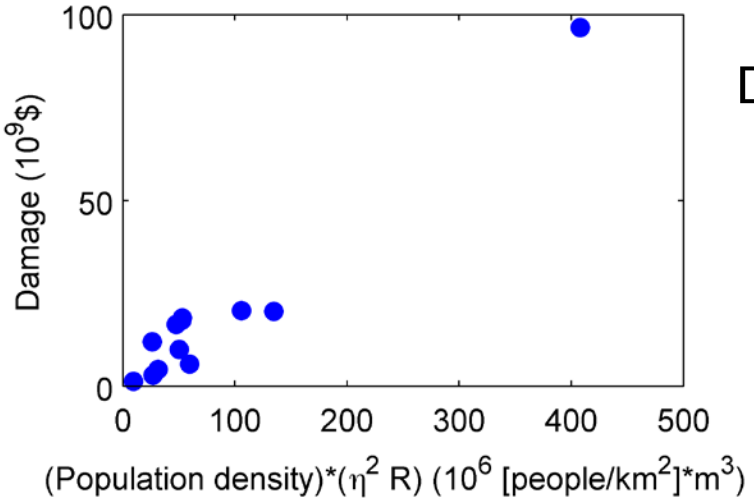
- Assume C represented by population density (PD) of impacted region (counties within one R_{max}):

$$D = PD\,\eta^2 R$$



Population density:
R^2 = 0.58 (0.57)

- Finally:



Damage scale:
R^2 = 0.95 (0.53)

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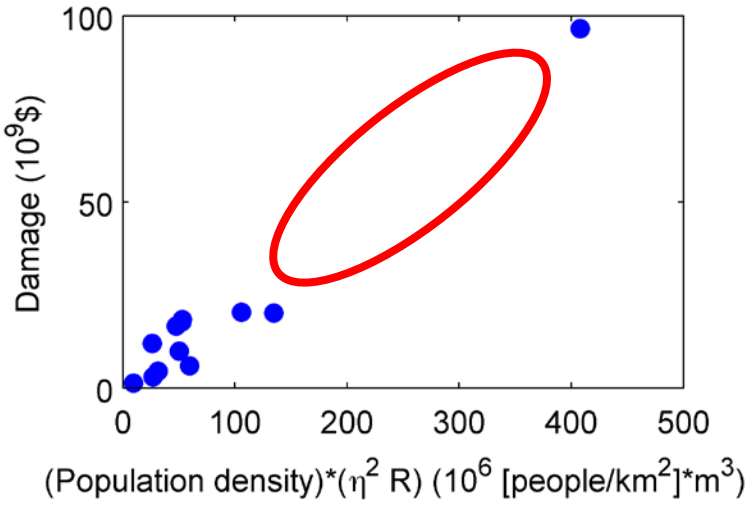
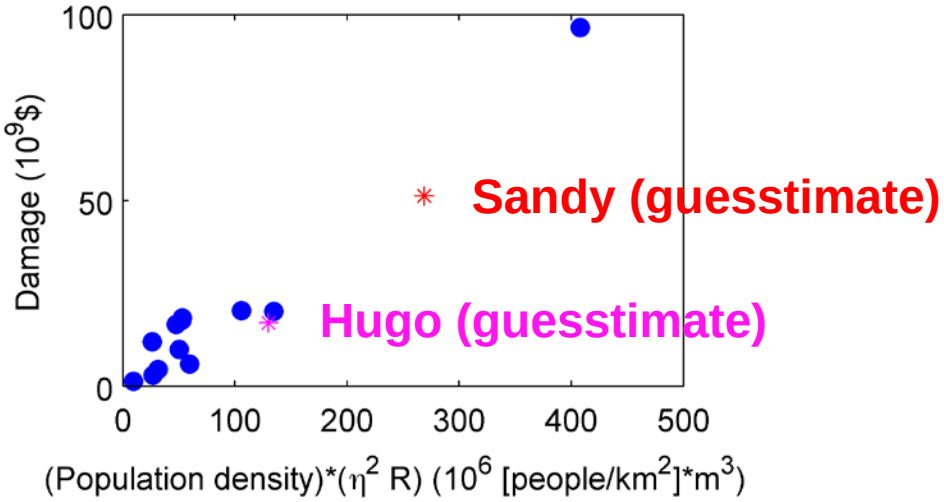
Hurricane Flood Damage Relationship
Simple Damage Scale

- But, what about?

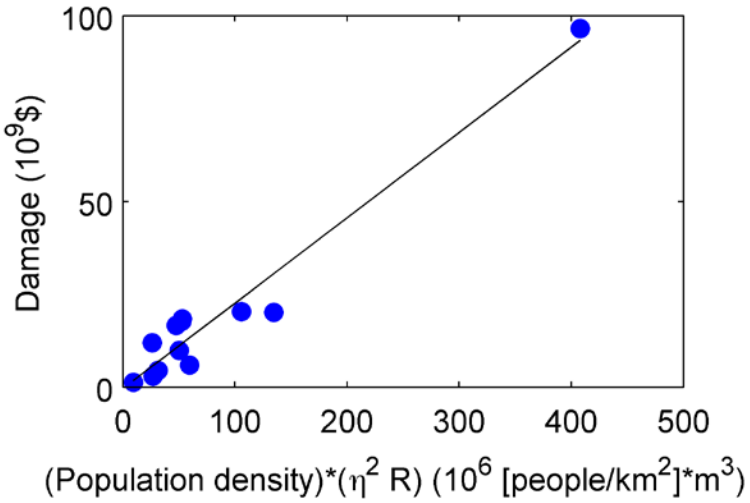
$$D = PD\,\eta^2\,R$$





Hurricane Flood Damage Relationship
Applications: Future Damage Projections [PRELIMINARY]

- Linear fit gives: $D \approx 2.3\text{E-}7[PD\,\eta^2 R] - 0.4$ (in 10^9 $)

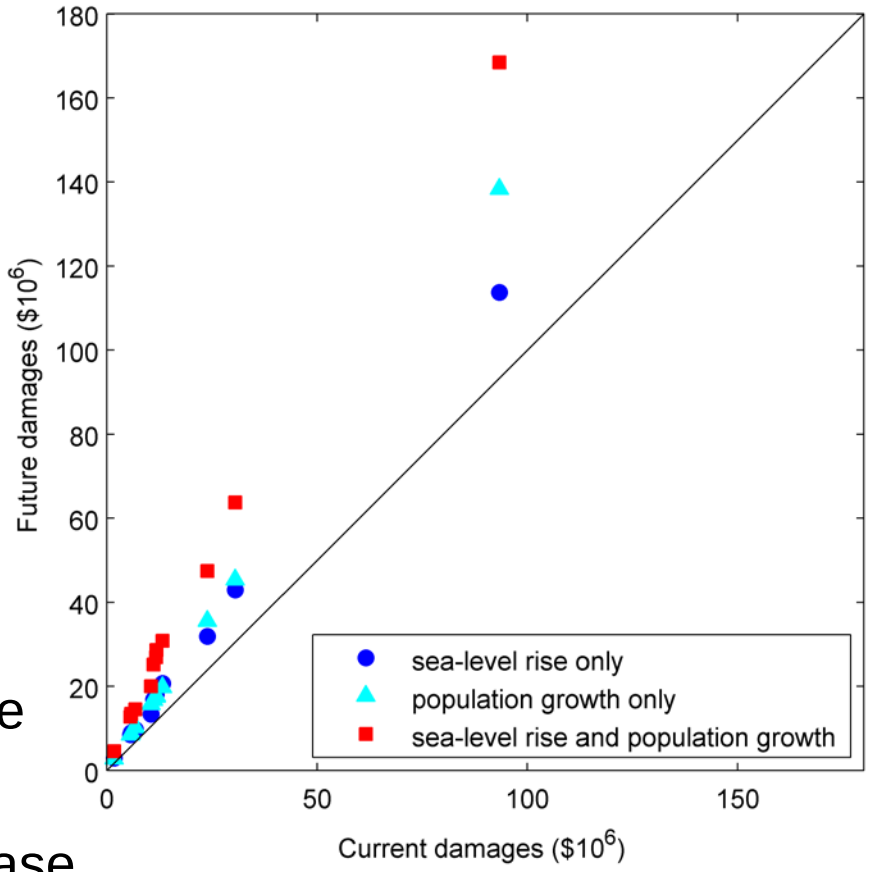


- Consider changes in population density with time: $PD(t)$
- Consider changes in flood elevations with time: $\eta(t)$

Hurricane Flood Damage Relationship
Applications: Future Changes by 2100 [PRELIMINARY]

Between 2000-2100:

- Global sea-level rise = 82.7 cm
  (National Research Council, 2012)
- Population growth = 48%
  (United Nations, 2012)



Northern Gulf Damage Projections:

(Preliminary)

- Sea-level rise (SLR) alone: 36% increase
- Population growth alone: 49% increase
- SLR and population growth: 102% increase

Hurricane Flood Damage Relationship
Conclusions and Future Work

Conclusions:

- Generalized, simple damage scale exists
- Coupled impact of:
  - Population density
  - Surge height
  - Extent of flooding

  } "Surge volume"
- Straightforward means to project future impacts

Future work:

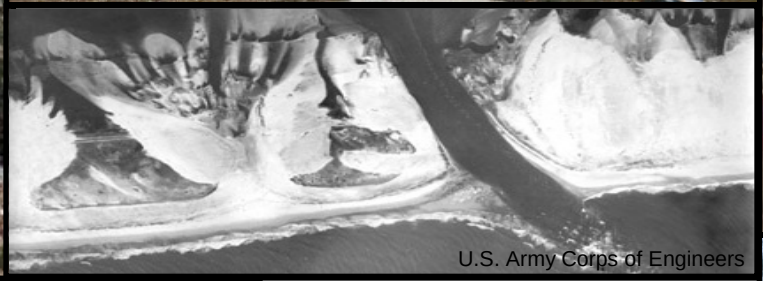
- Extend to US East Coast
- Interpret globally
- Interpret statistically

Questions?

www.coastal.cee.vt.edu


Associated Press

UPI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