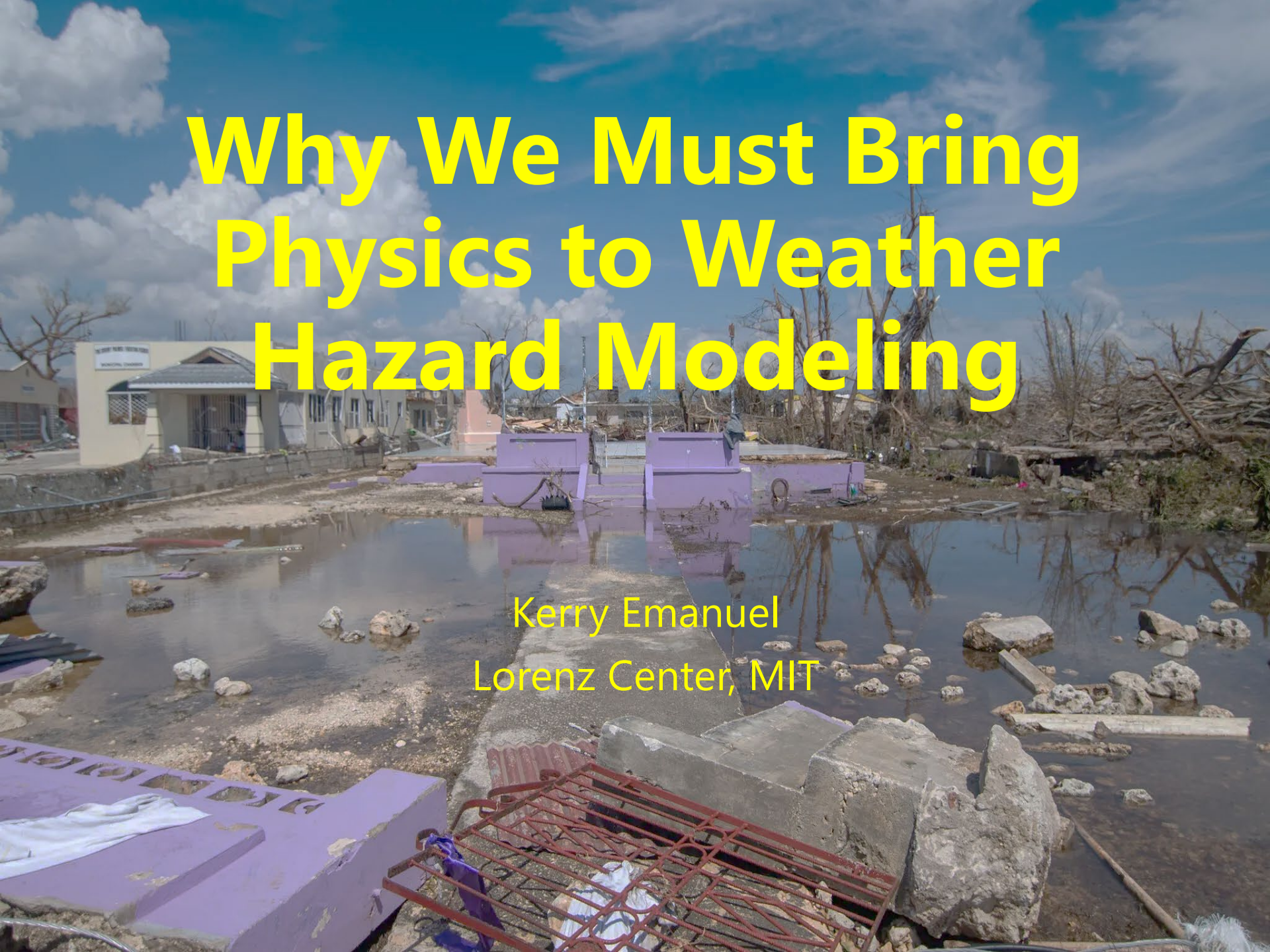


Why We Must Bring Physics to Weather Hazard Modeling

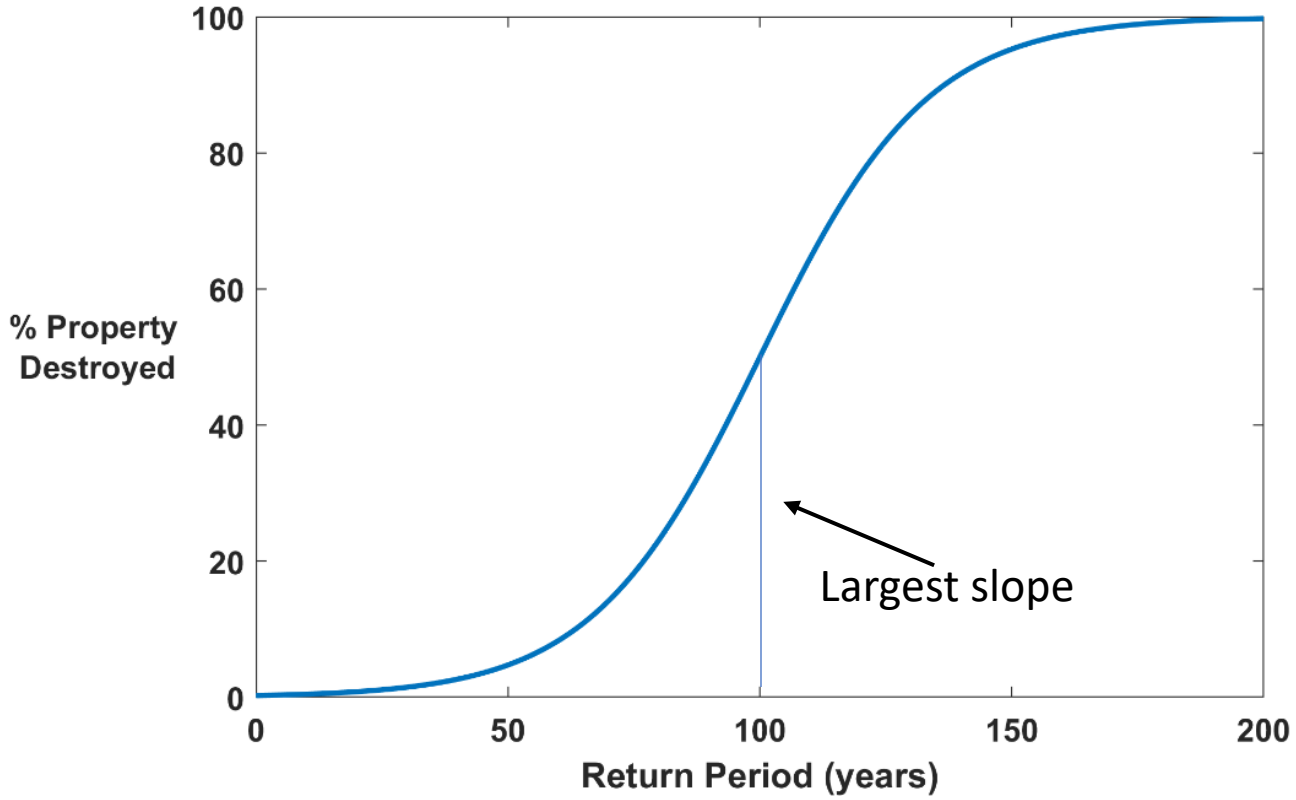
Kerry Emanuel
Lorenz Center, MIT

Flawed Basis of Current Hazard Modeling

- Most current risk assessments are based on historical statistics
- Historical records are flawed and too short
- Moreover, **the past 50-150 years is a poor guide to the present owing to climate change that *has already occurred***
- We need to bring physics to bear on weather hazard risk

Why Natural Hazard Risks are Dominated by Extreme Events:

- Societies are usually well adapted to frequent events (> 1/100 yr)
- Societies are often poorly adapted to rare events (< 1/100 yr)
- Large cost increases result when > 100-yr events become < 100-yr events



Example: Flooding from Hurricane Harvey, 2017

Three independent scientific studies appeared in 2017:

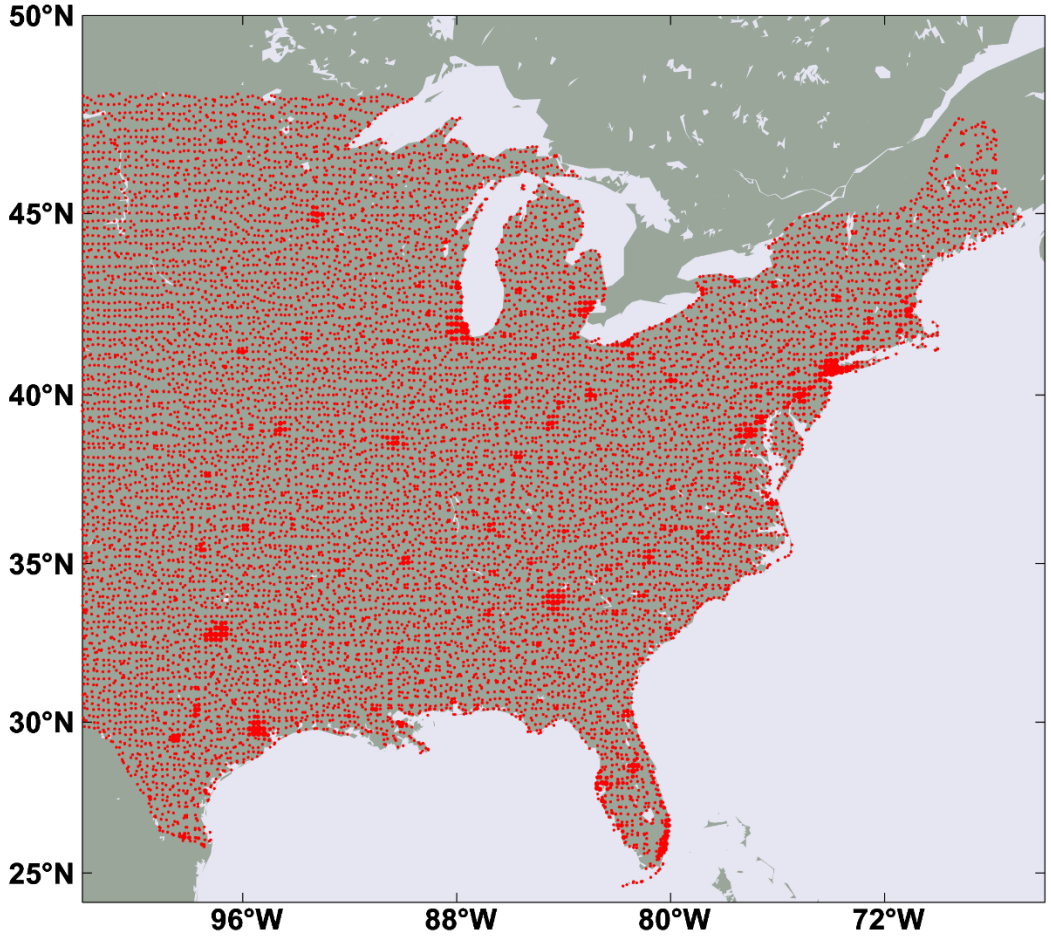
- **van Oldenborgh et al**: *"We conclude that global warming made the precipitation about 15% (8%–19%) more intense, or equivalently made such an event three (1.5–5) times more likely."*
- **Risser and Wehner:** *"We find that human-induced climate change likely increased the chances of the observed precipitation accumulations during Hurricane Harvey in the most affected areas of Houston by a factor of at least 3.5."*
- **Emanuel:** *"In 2017 the annual probability* [of Hurricane Harvey's rainfall in Harris County] *would be 6%, a sixfold increase since the late 20th century.*

Advantages of Physics-Based Hazard Modeling

- Except for a single calibration point, it is independent of hurricane history
- Can be applied, without alteration, to any location and any climate
- Can generate an arbitrarily large set of events, virtually eliminating sampling uncertainty
- Can simulate such features as secondary eyewall structures

Exposure database

LITPOP exposure database (ETH, Zurich)



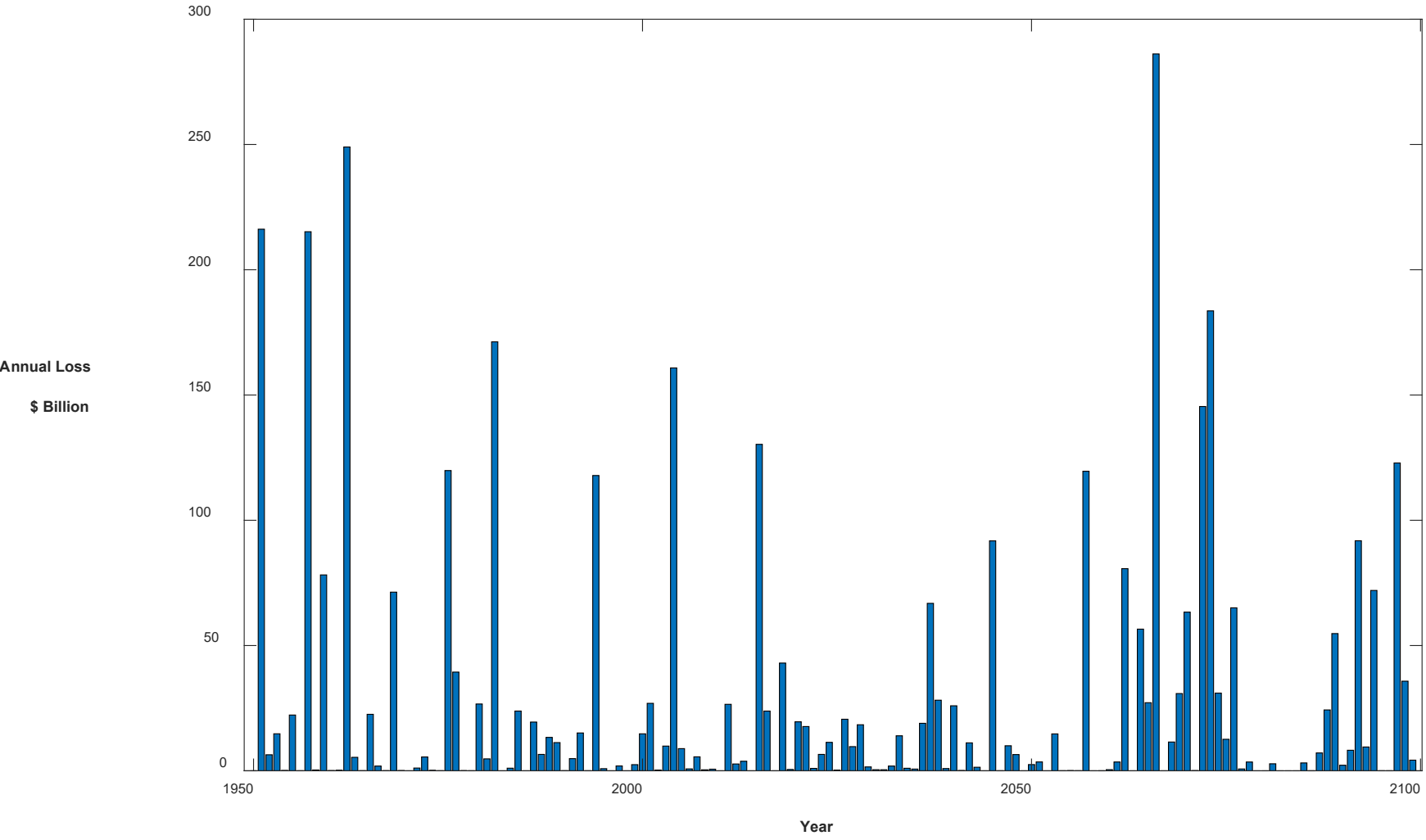
Net Value: ~$ 41.1 trillion

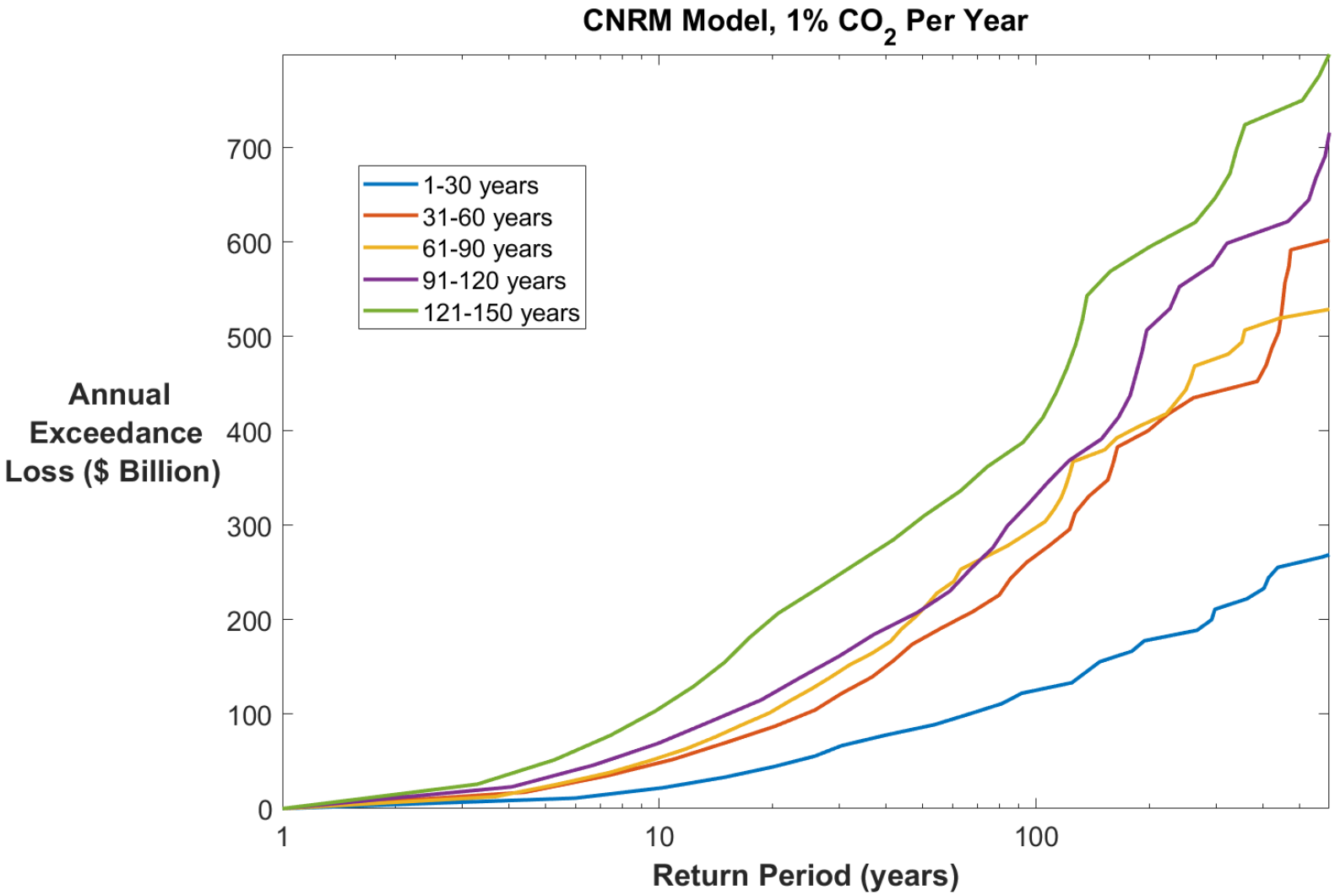
11,781 20 x 20 km blocks

Example of Probabilistic Portfolio Loss Calculation

- Downscale a CMIP6 climate model in which CO_2 is increasing at a rate of 1% per year for 150 years.
- Create 1,000 U.S. landfalling tropical cyclone each year for 150 years (total of 15,000 events)
- Use these to create a 10,000 member, 150-year time series of portfolio-summed loss

Example (one of 10,000) 150-year portfolio loss time series




CNRM Model, 1% CO2 Per Year
1-30 years
31-60 years
61-90 years
91-120 years
121-150 years
Annual Exceedance Loss ($ Billion)
0
100
200
300
400
500
600
700
1
10
100
Return Period (years)