STARDUST

PUSHING THE BOUNDARIES OF
SPACE RESEARCH TO SAVE OUR FUTURE

UNIVERSITY OF Southampton

Utilizing Risk to Define Thresholds for Impact Threat Response Actions

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UK SPACE AGENCY

UNCOPOUS – SMPAG / IAWN

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Outline

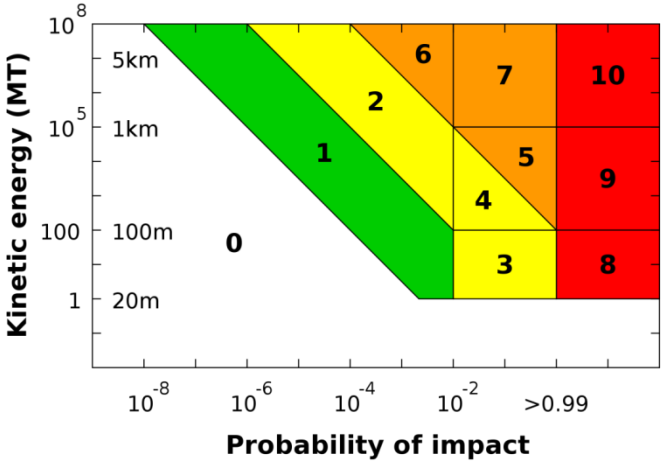
- Problem: When is the right time to decide on Planetary Defense actions?
  - Initiate dedicated observation mission
  - Plan civil defence measures
  - Initiate deflection mission
- Comparison to Torino/Palermo scale
- Risk Definition
- Asteroid Risk Calculation
- Example Calculation
- Conclusions

RISK IN COMPARISON TO TORINO/PALERMO

Torino and Palermo Scale

Torino

- **Kinetic Energy**
- **Impact Probability**

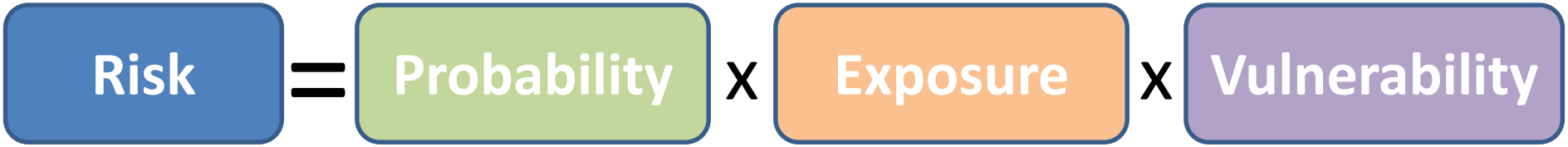


Palermo

- **Kinetic Energy**
- **Impact Probability**
- Lead Time
- Comparison to background threat

- **Kinetic Energy as proxy for consequences**
  - Indifferent to impact location, impact situation, effect on population

Risk definition



- How bad would it be if X happens?
  - What is exposed?
  - How much of what is exposed would be lost?
- How likely is it that X happens in the first place?

Asteroid Impact Risk

Impact Probability "How likely is it?"	Exposure (Population) "What is at stake?"	Vulnerability "How bad would it be?"
Low Probability		
Medium Probability		
High Probability		

Asteroid Impact Risk

Impact Probability "How likely is it?"	Exposure (Population) "What is at stake?"	Vulnerability "How bad would it be?"
Low Probability		
Medium Probability		
High Probability		

Low Risk

Asteroid Impact Risk

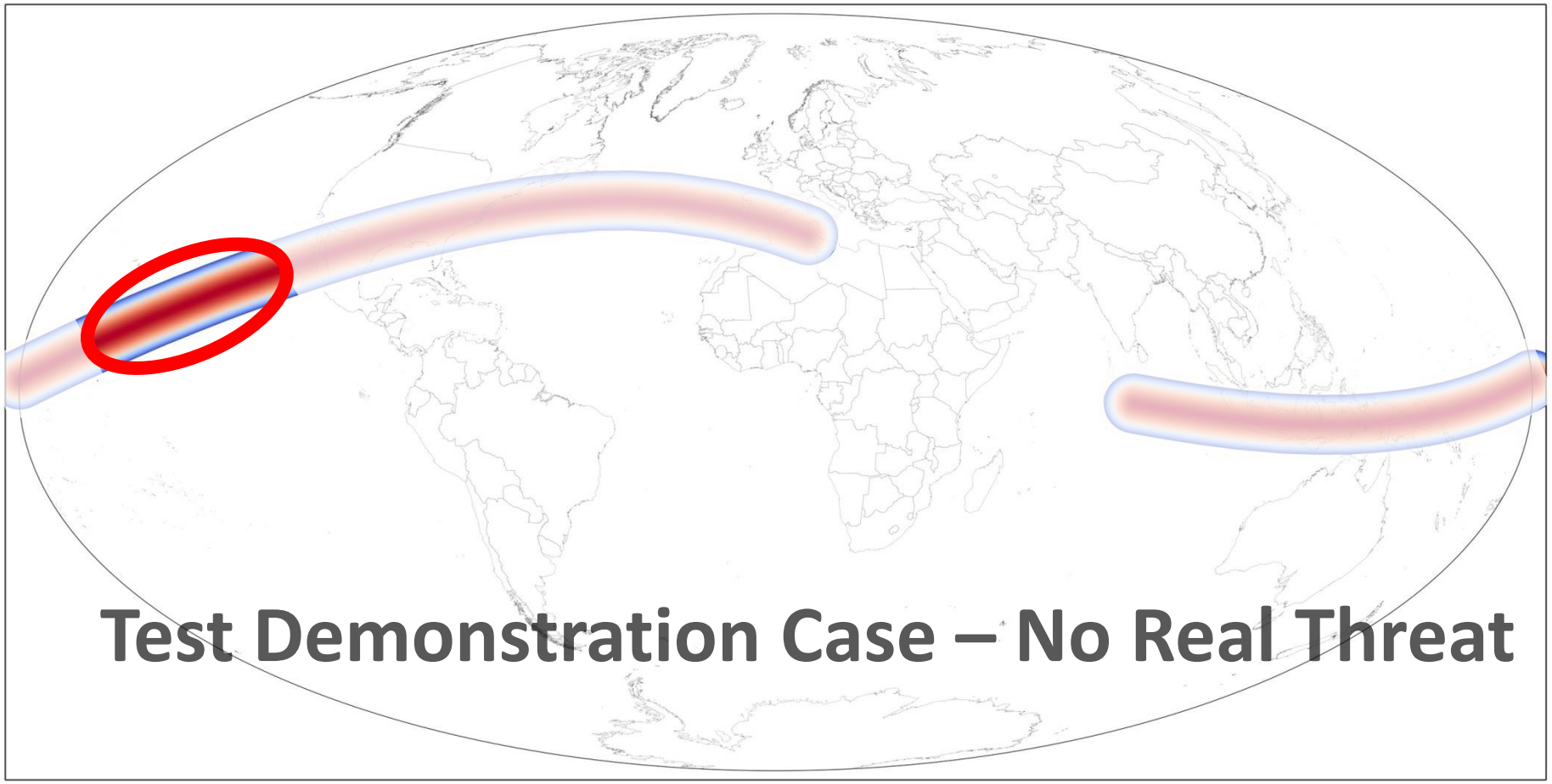
Impact Probability "How likely is it?"	Exposure (Population) "What is at stake?"	Vulnerability "How bad would it be?"
Low Probability		
Medium Probability		
High Probability		

High Risk

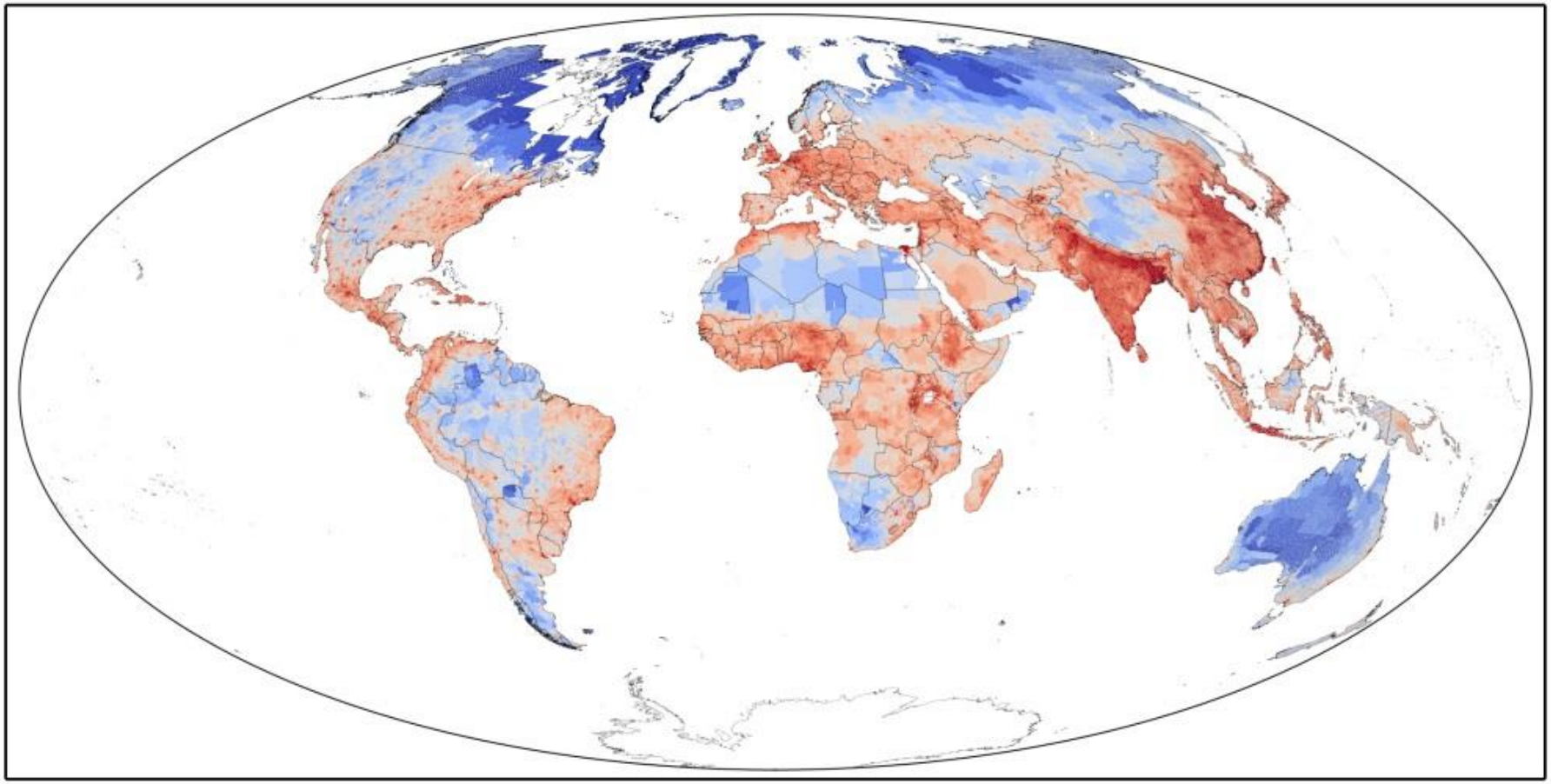
- Risk Elements: Probability, Exposure, Vulnerability
- Available data and method

ASTEROID RISK CALCULATION

Probability – Evolves Over Time



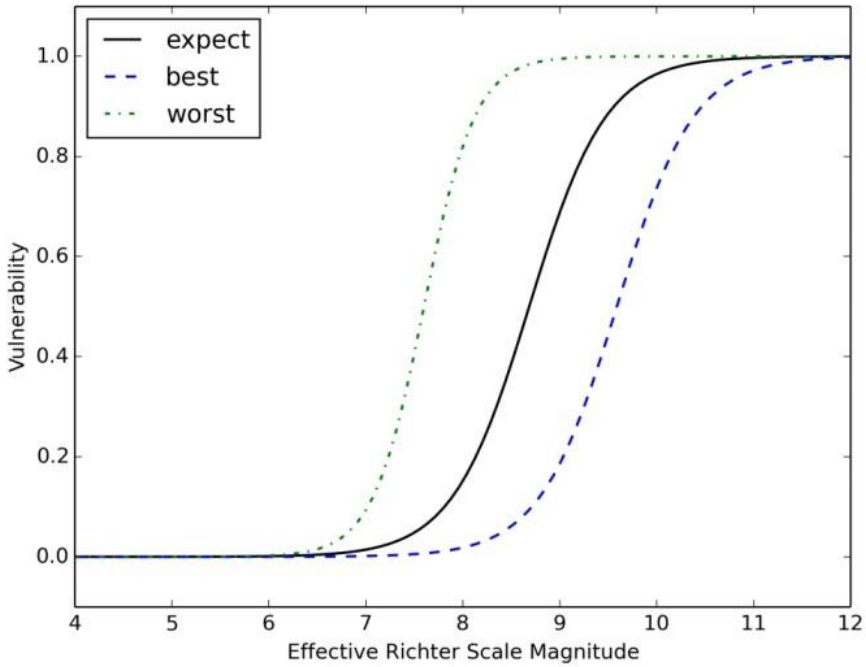
Exposure – World Population



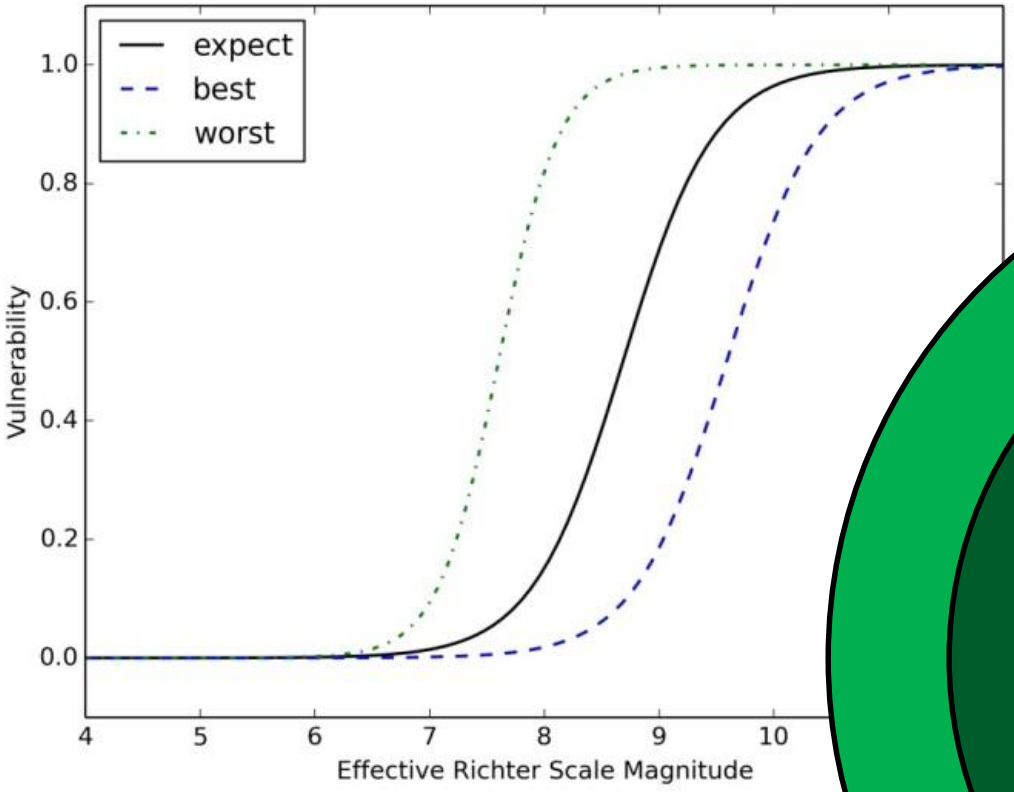
Impact Effects and Vulnerability

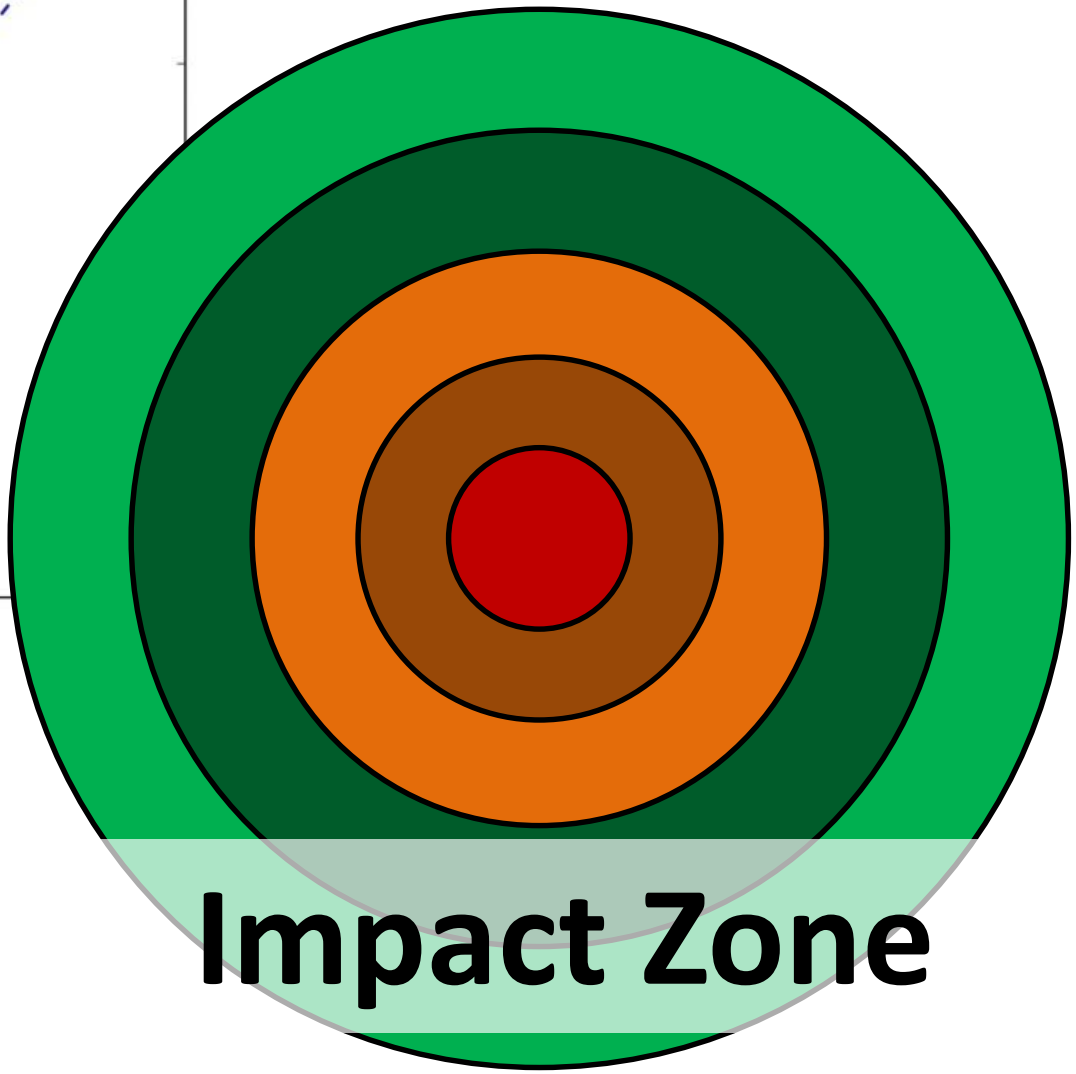
- Impact Effects [Collins 2005]:
  - Thermal Radiation
  - Cratering
  - Seismic Shaking
  - Aerodynamic Shock
  - Ejecta Blanket Deposition
  - Tsunami

- Effect strength determines Vulnerability

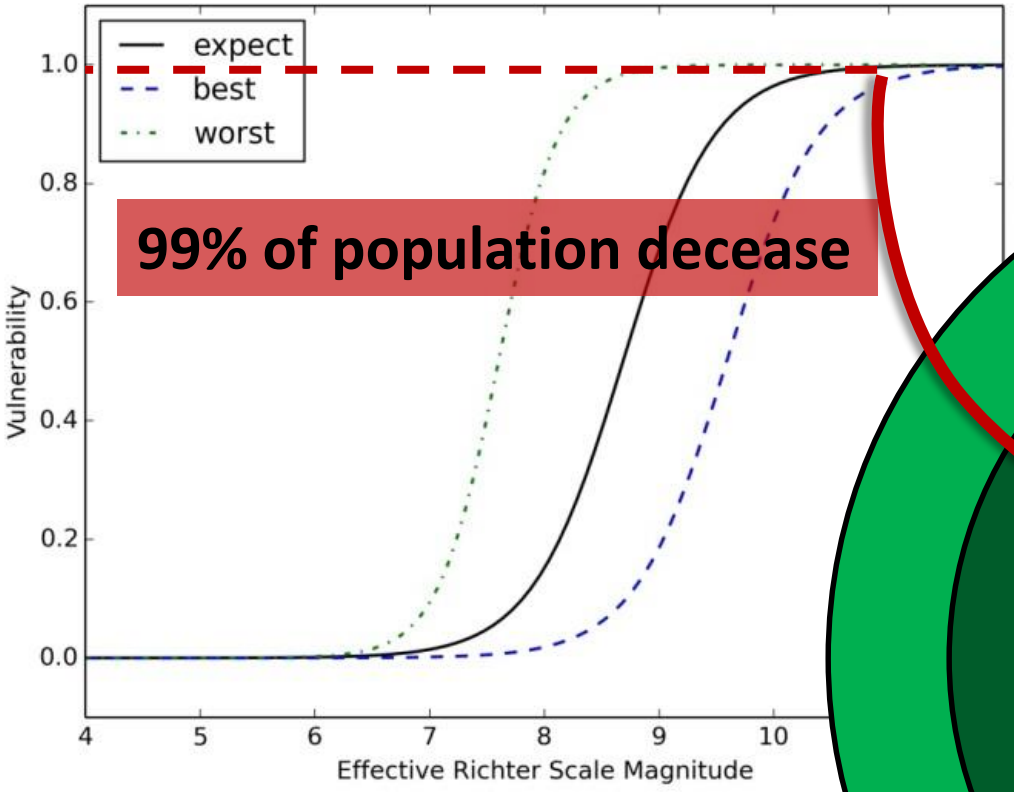


Vulnerability

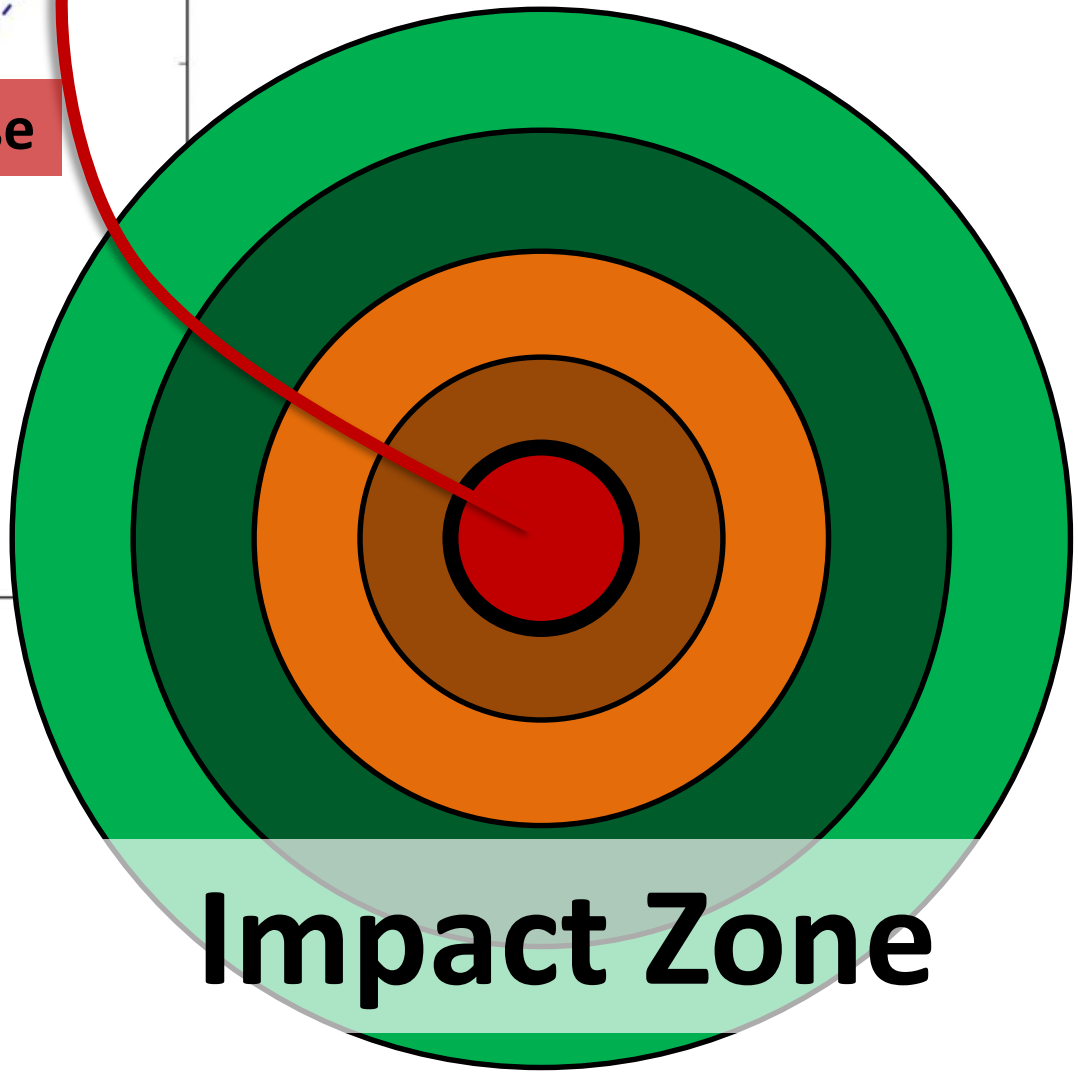




Vulnerability

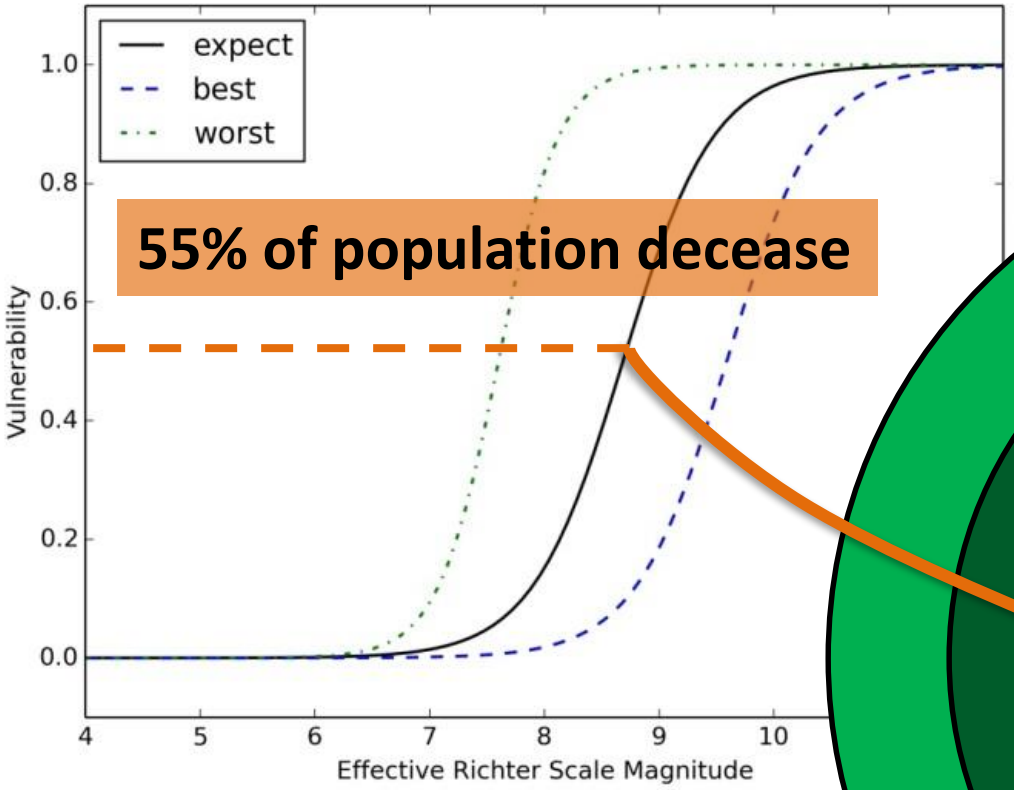


99% of population decease

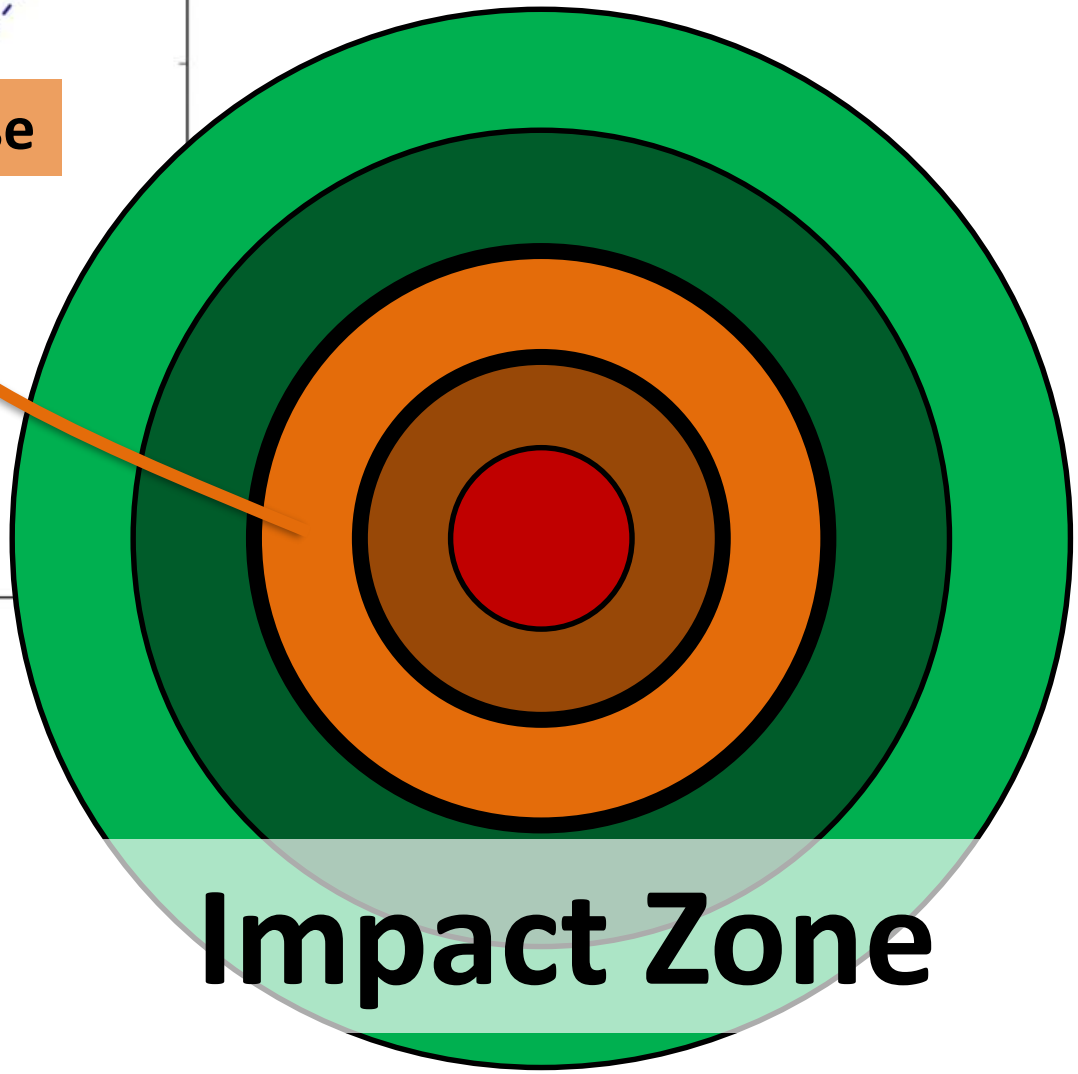


Impact Zone

Vulnerability

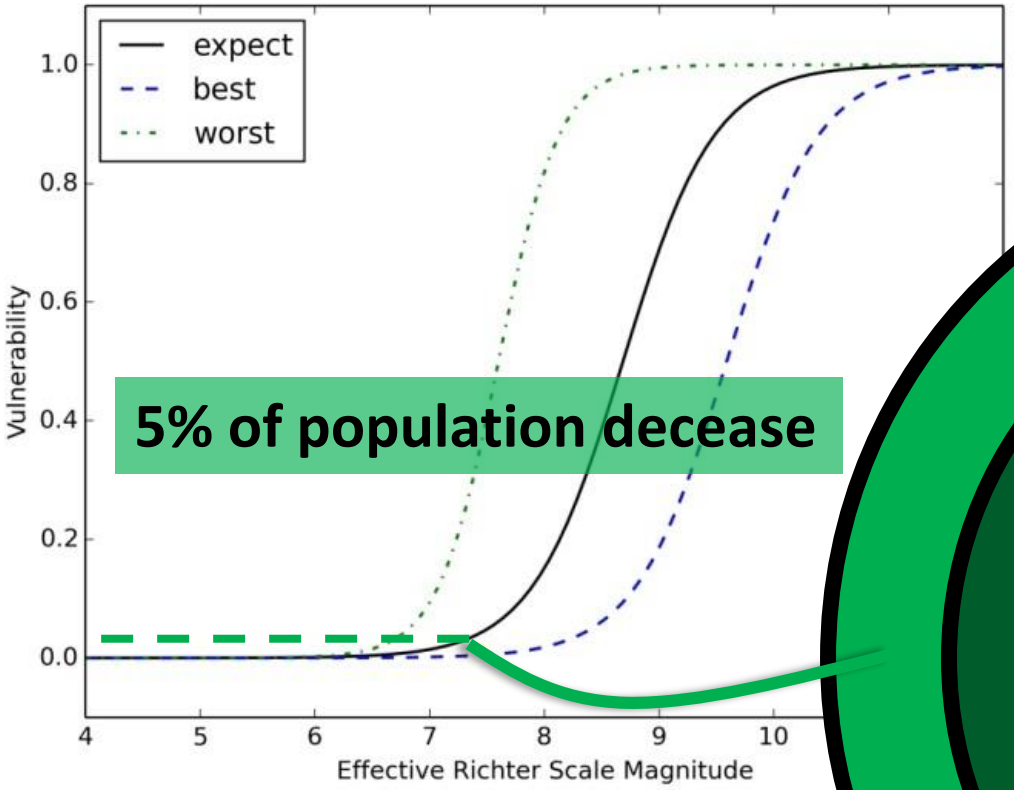


55% of population decease

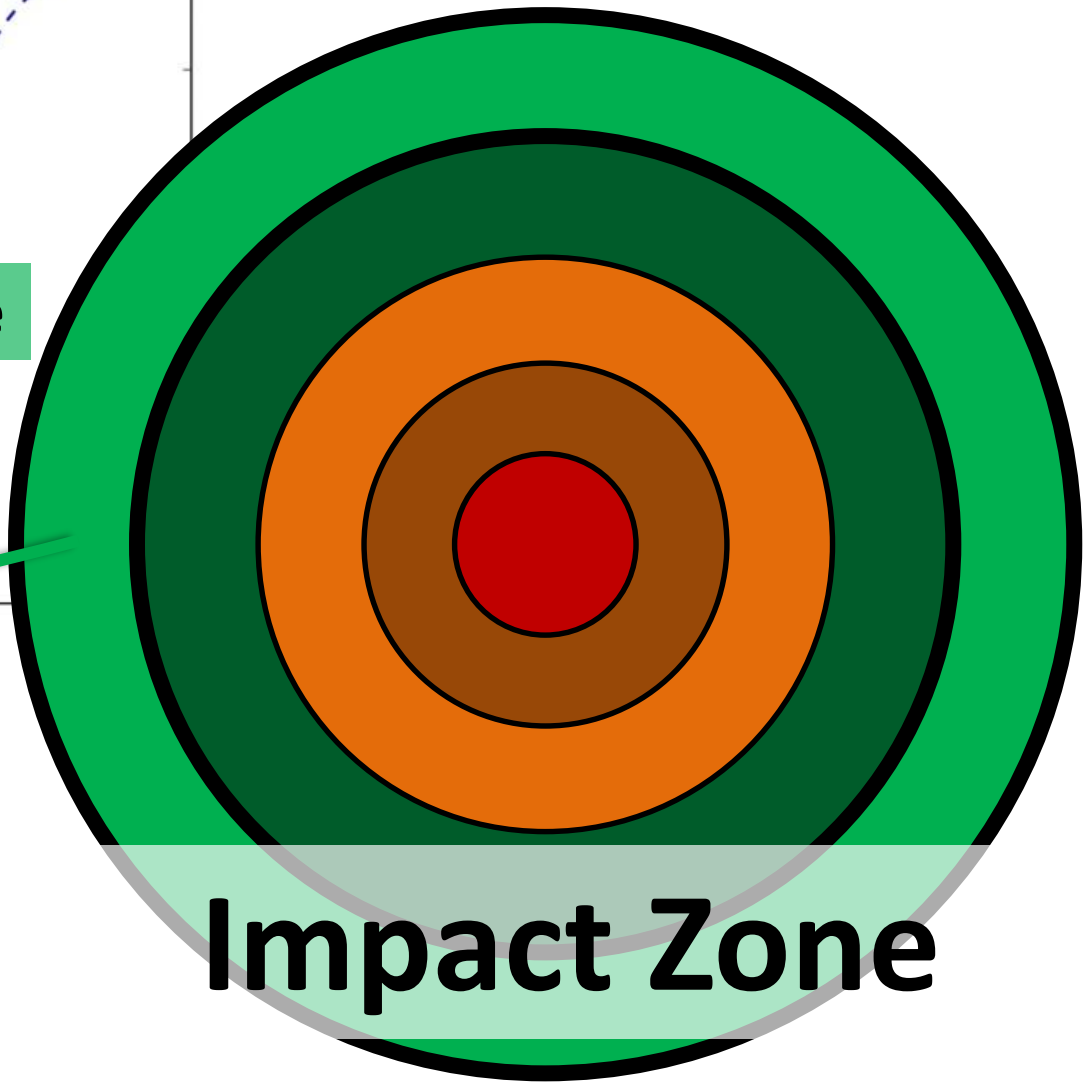


Impact Zone

Vulnerability



5% of population decease

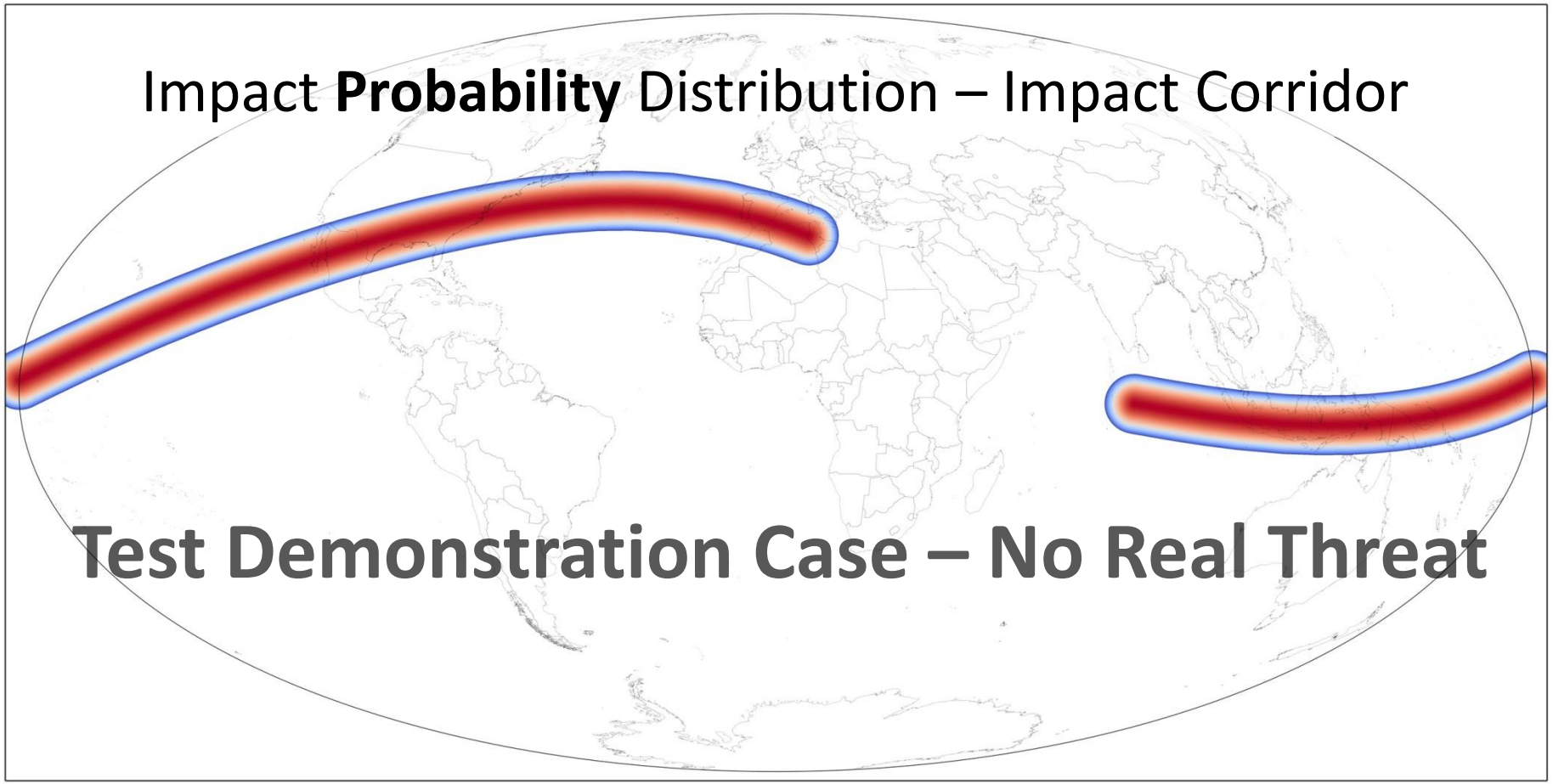


Impact Zone

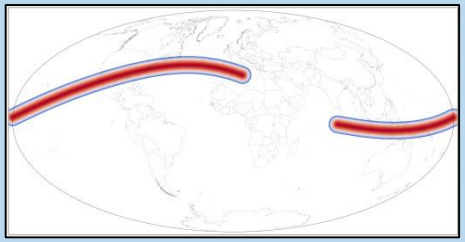
RISK CALCULATION – AN EXAMPLE

Risk Calculation - Practical Example

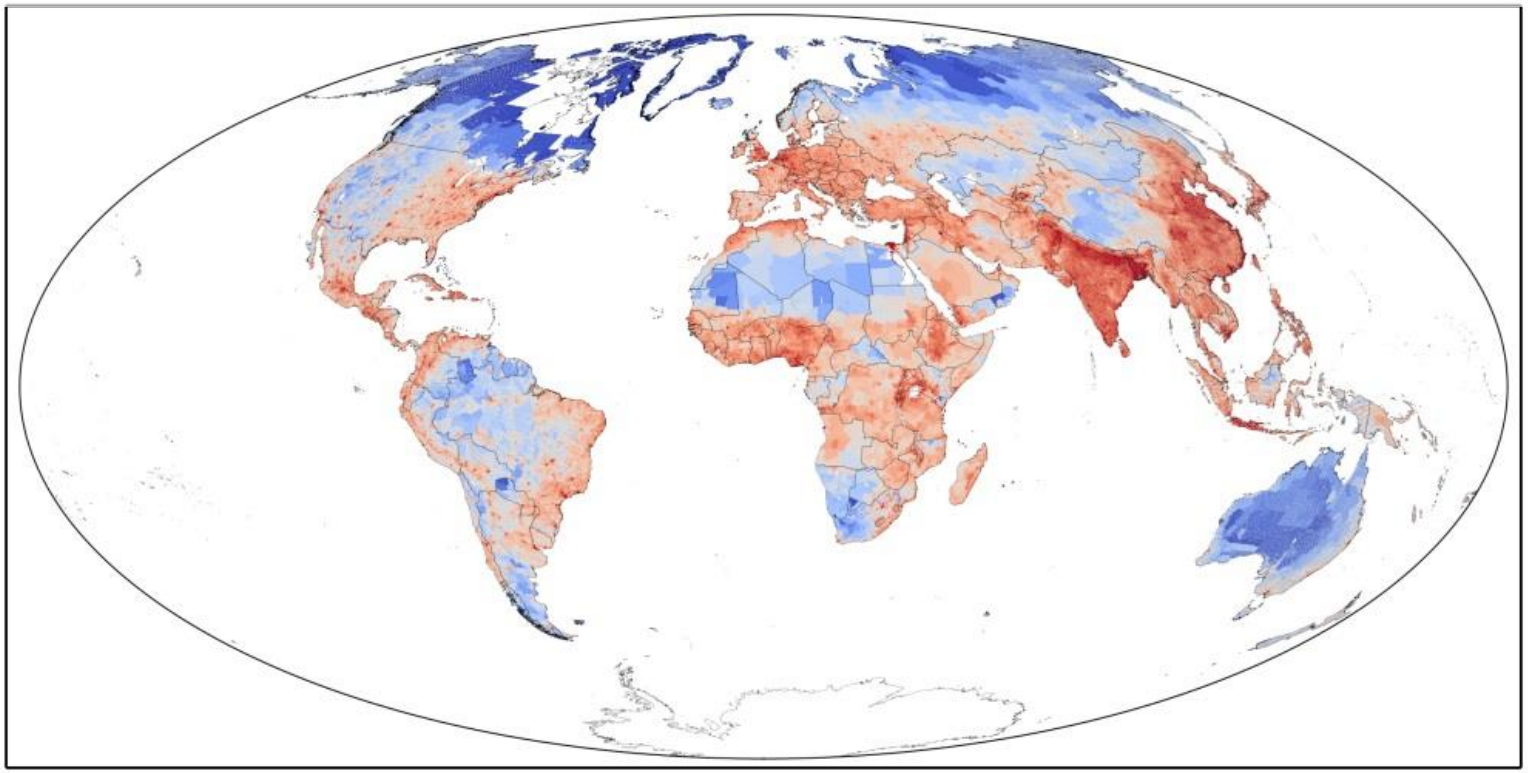
- Object Size: 120 m
- Global Impact Probability: 3.06 x 10^{-6}



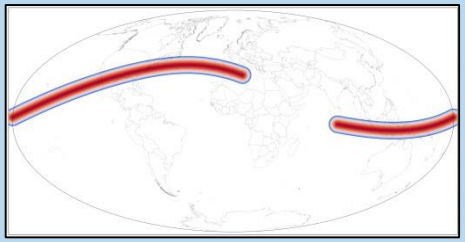
Risk Calculation - Practical Example

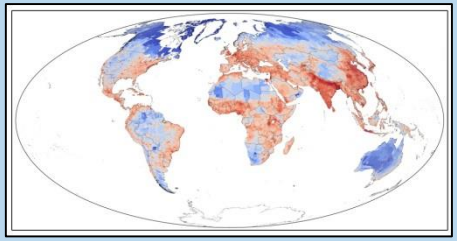


Exposure – Global Population

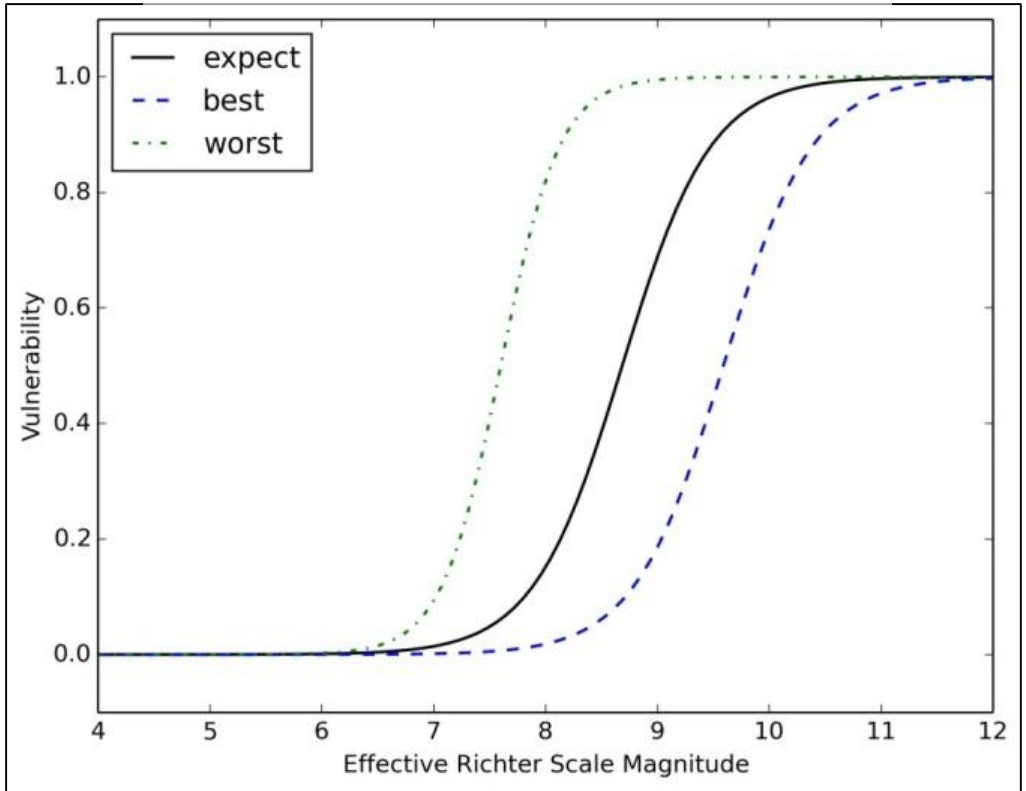


Risk Calculation - Practical Example

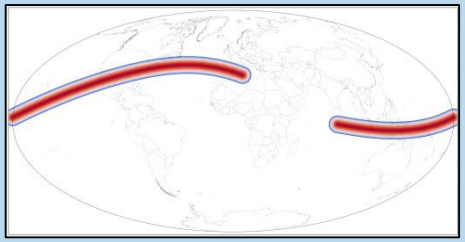


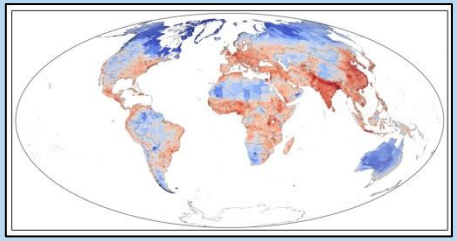


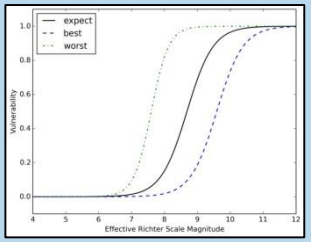
Vulnerability

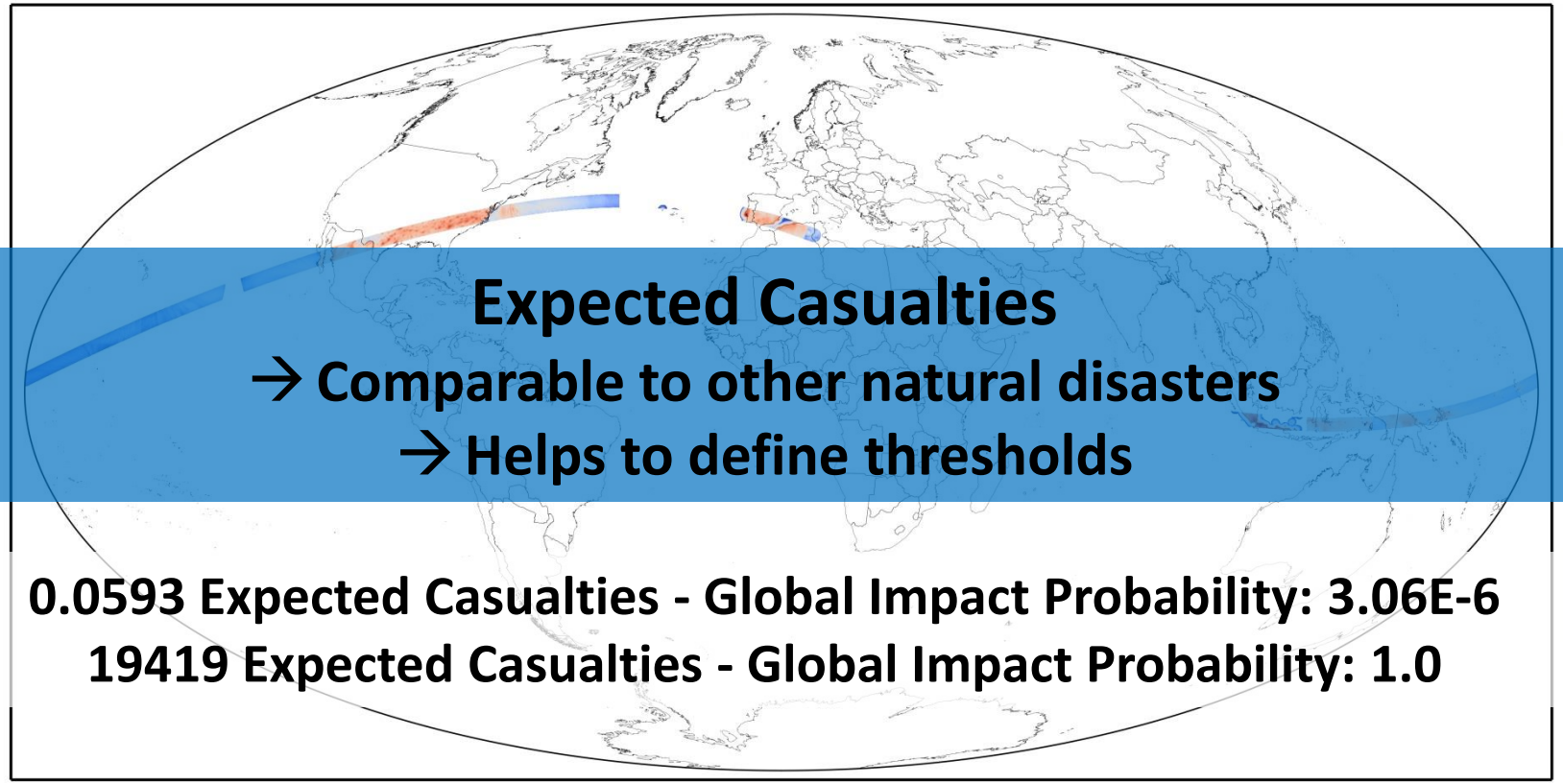


Asteroid Impact Risk









Expected Casualties

→ Comparable to other natural disasters

→ Helps to define thresholds

0.0593 Expected Casualties - Global Impact Probability: 3.06E-6

19419 Expected Casualties - Global Impact Probability: 1.0

Purpose of Presentation

- Showcasing what is possible today
- Showing how this could help the cause of Planetary Defense
- The system shown here is a research project and serves this purpose well
  - It is not ready to be implemented in an automated system
  - Many areas to improve and fine tune
  - I am happy to assist

Conclusions

- Risk calculation applied to asteroids
- Distinguishes from Torino/Palermo:
  - Takes into account location
  - Takes into account effects
  - Takes into account population
- Risk figures evolve with better information
  - New observations modify impact probability
  - New observations collapse impact corridor
- Results are expressed in **Expected Casualties**
  - Directly comparable to other disasters
  - Help for threshold definition

Thank You For Your Attention

Presenter: Clemens Rumpf