Next Steps in Impact Risk Assessment

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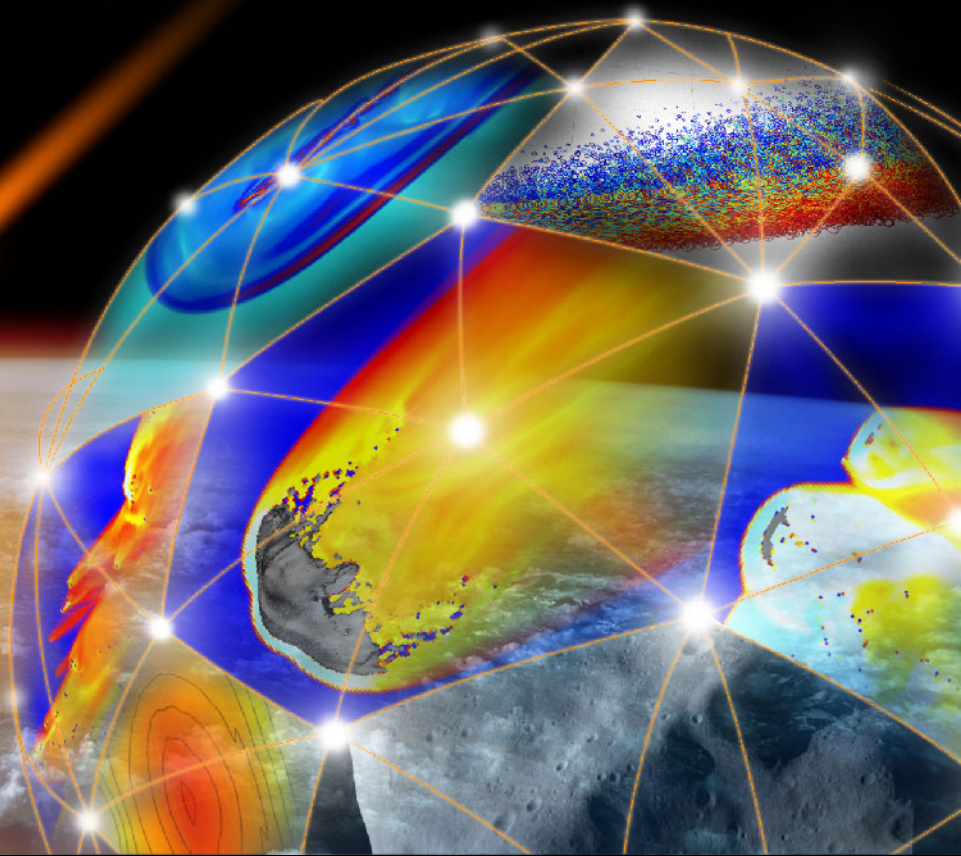

Probabilistic Asteroid Impact Risk Model

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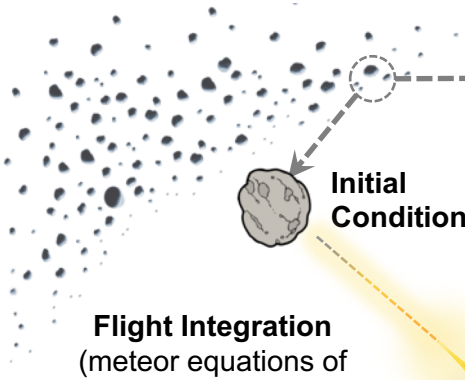
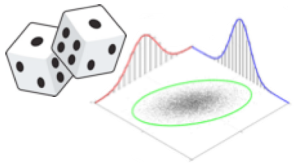
NASA

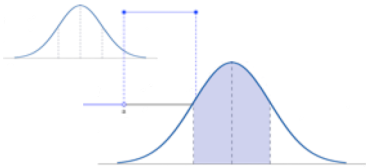
Asteroid Characterization → **Input Parameter Distributions**

Monte Carlo Sampling



Initial Conditions





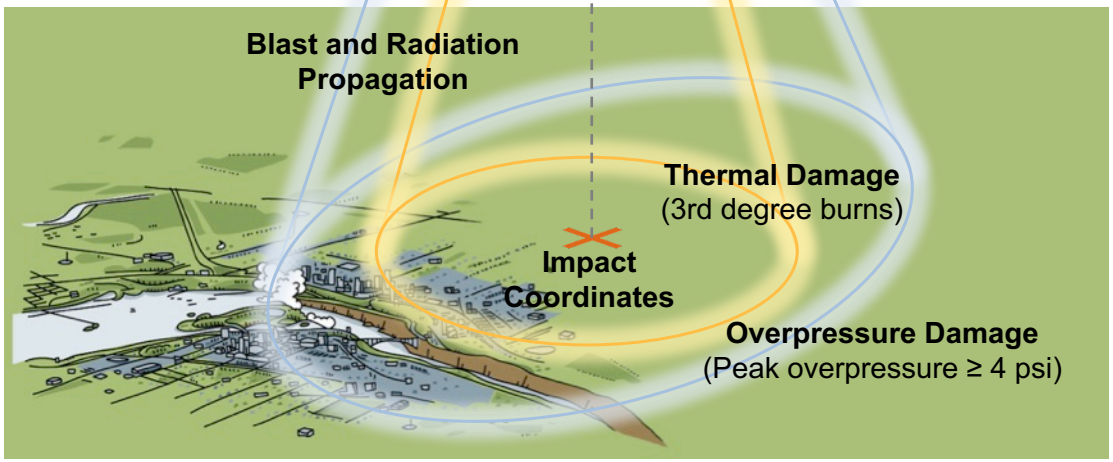
PHA Measurements
- H-magnitude
- Albedo
- Orbital trajectory
- Asteroid class
- Composition

Impact Parameters
- Diameter
- Density
- Strength
- Luminous efficiency
- Velocity
- Entry angle
- Azimuth angle
- Impact coordinates

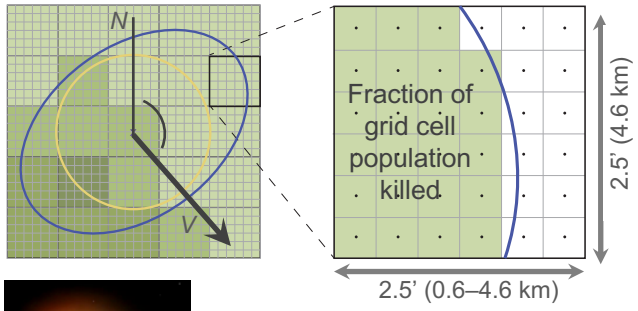
Flight Integration
(meteor equations of motion, ablation)

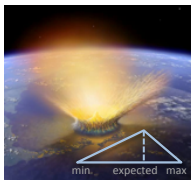
Fragment-Cloud Model
(breakup and energy deposition)

Airburst Altitude
(peak energy deposition)



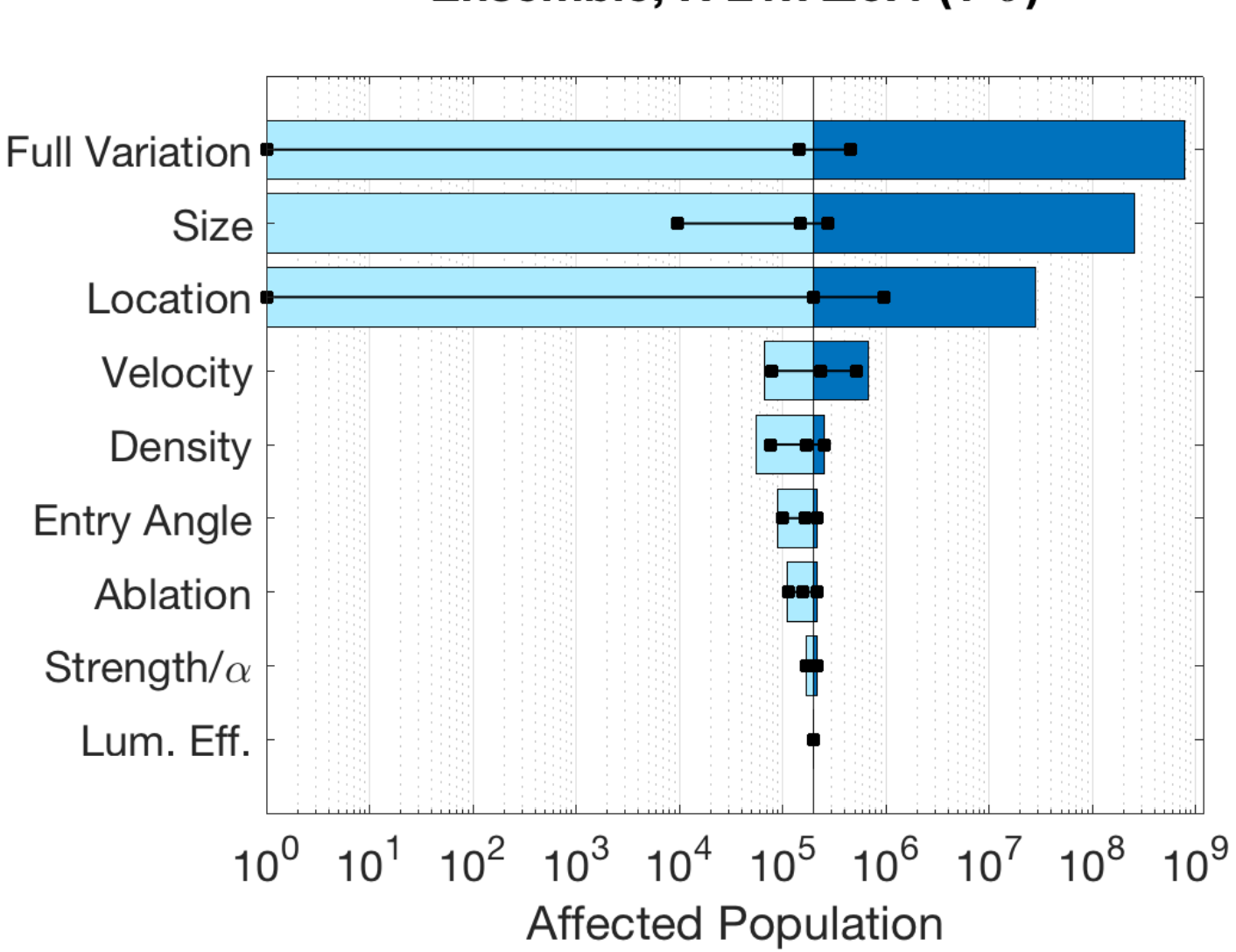
Local Land Impact Casualties
(Gridded population within largest damage area)



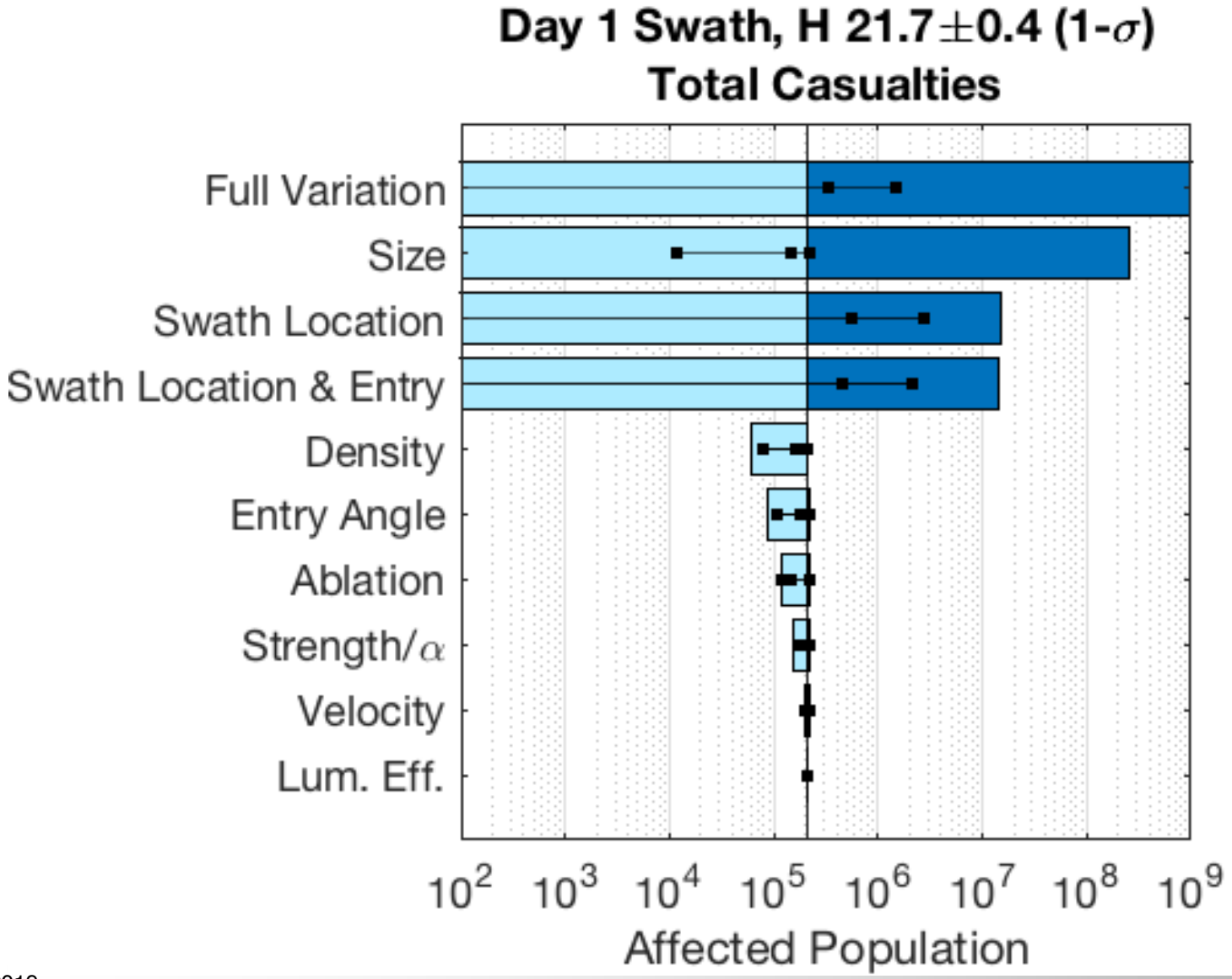


Global Effects Casualties
(Percentage world population killed by climatic effects)

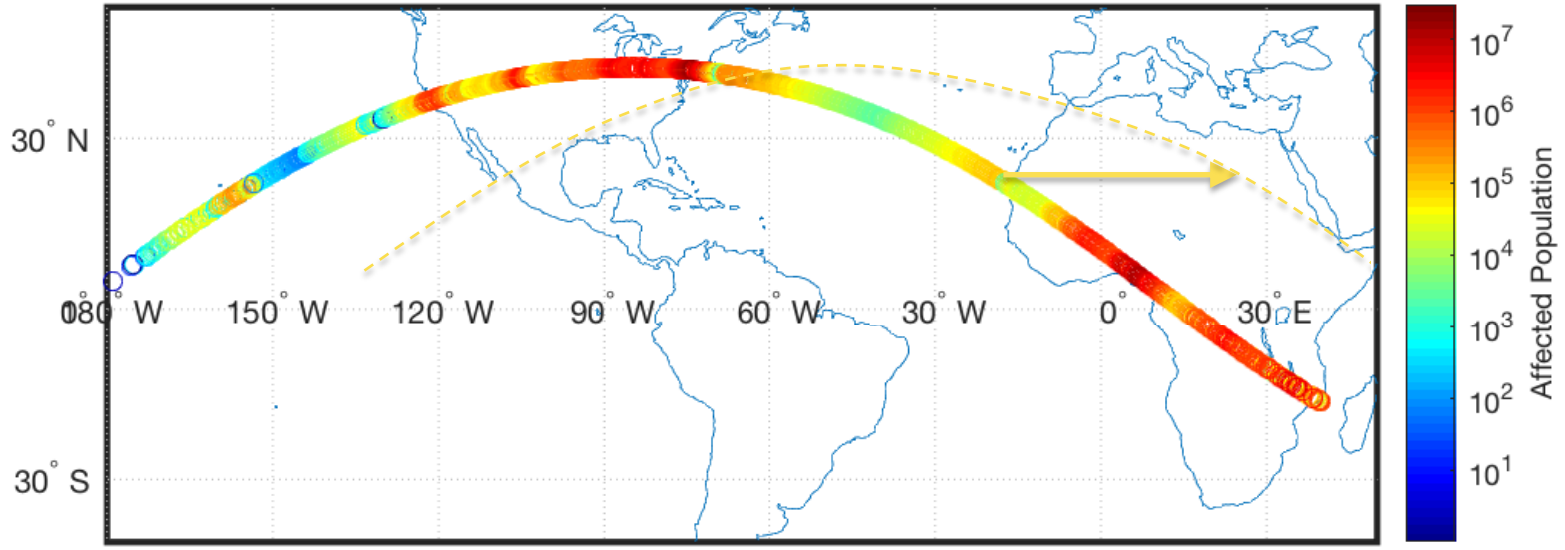
Ensemble Lornado (Total Casualties, All Hazards)



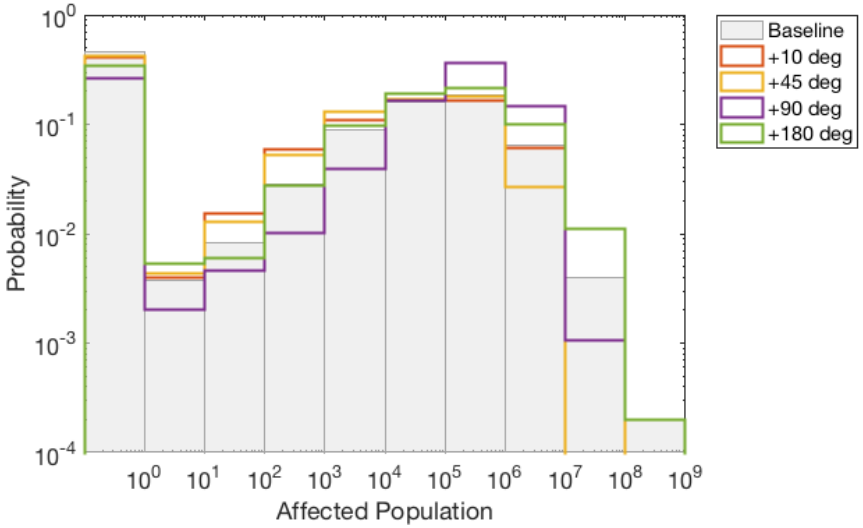
Day 1 Swath Lornado (Total Casualties, All Hazards)



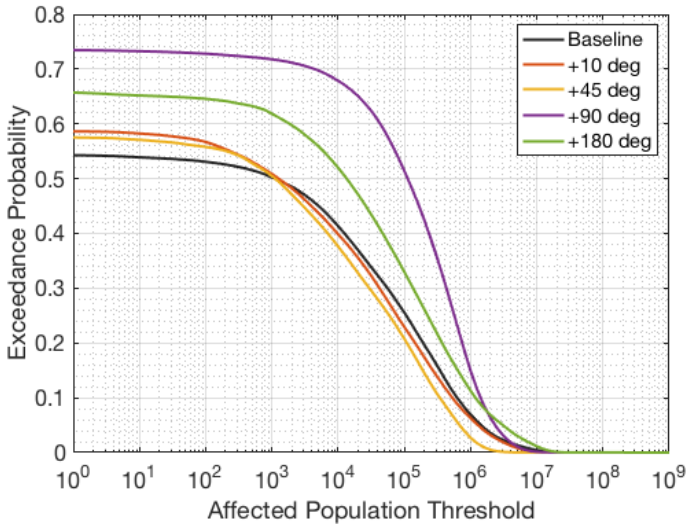
Comparison of Rotated Swaths



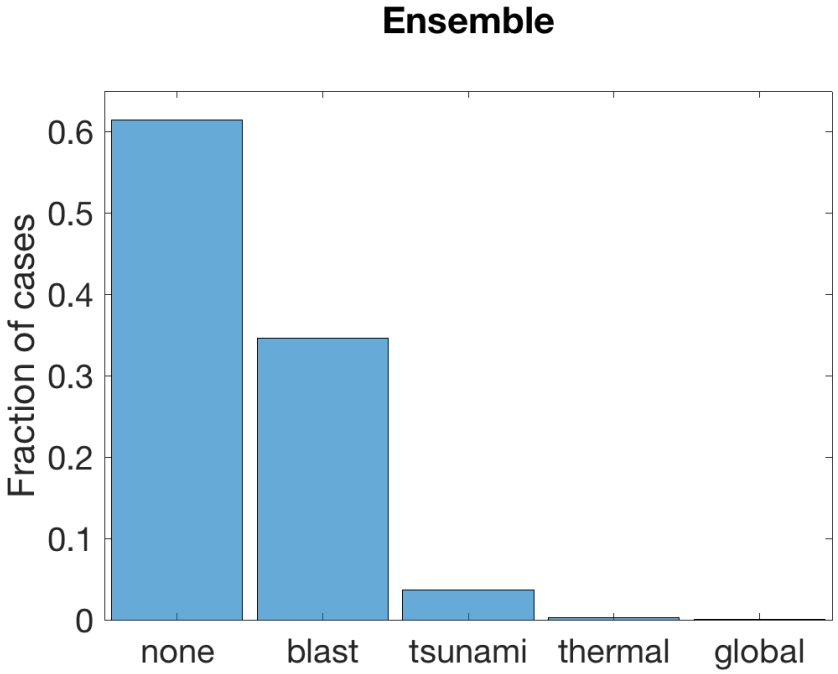
Conditional Damage Risk

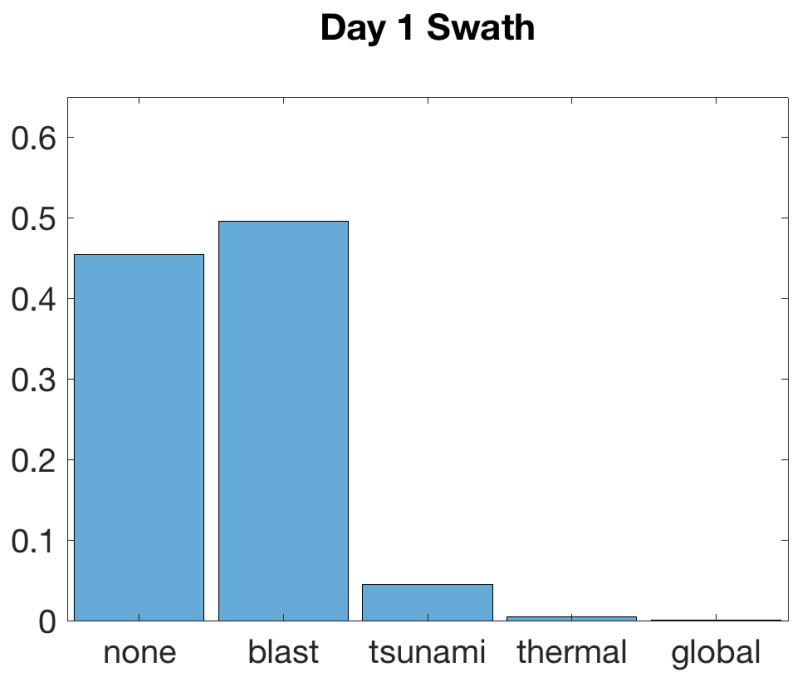


Conditional Damage Exceedance Probabilities



Hazard Breakdown



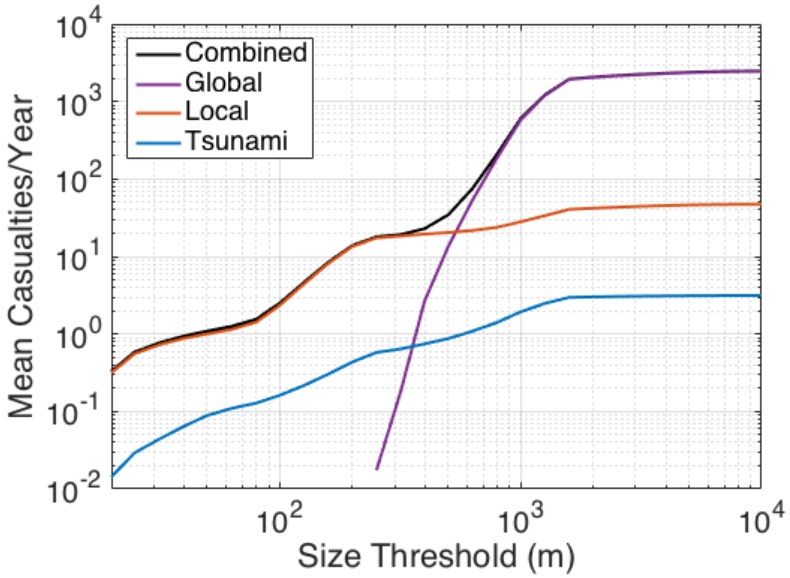


- Ensemble impacts most likely to cause no ground damage.
- Day 1 corridor impacts most likely to cause local blast damage.
- Tsunami risk ~10% of blast risk.
- Thermal and global effects unlikely drivers in current results.

Ensemble Risk Assessment

- Uncertainty in scenario specific details swamp modeling fidelity related to
  - Blast overpressure
  - Asteroid Generated Tsunami
- Thermal radiation damage appears bounded by blast overpressure, but luminous efficiency values highly (100x) uncertain.
  - Need to quantify luminous efficiency uncertainty relative to thermal damage

The NEO SDT report (2017) showed that long-term expected casualties driven by large impact scenarios



- Global effects models for ensemble risk assessment are ad hoc and need basis in higher fidelity modeling.
- Regional impacts (local weather, flight pattern disruption, etc.) completely unrepresented in current ensemble risk modeling.

Scenario Risk Assessment

- Initial uncertainty dictates that scenario assessments begin like ensemble assessments.
  - Balance of modeling accuracy versus state of knowledge (inputs) is key.
- Once scenario evolves, higher fidelity tools exist but best practices need to be established
  - Blast overpressure
  - Asteroid Generated tsunami
  - Thermal radiation
- Regional/global impact consequences have been assessed for specific cases, but broader analysis requirements need to be defined.

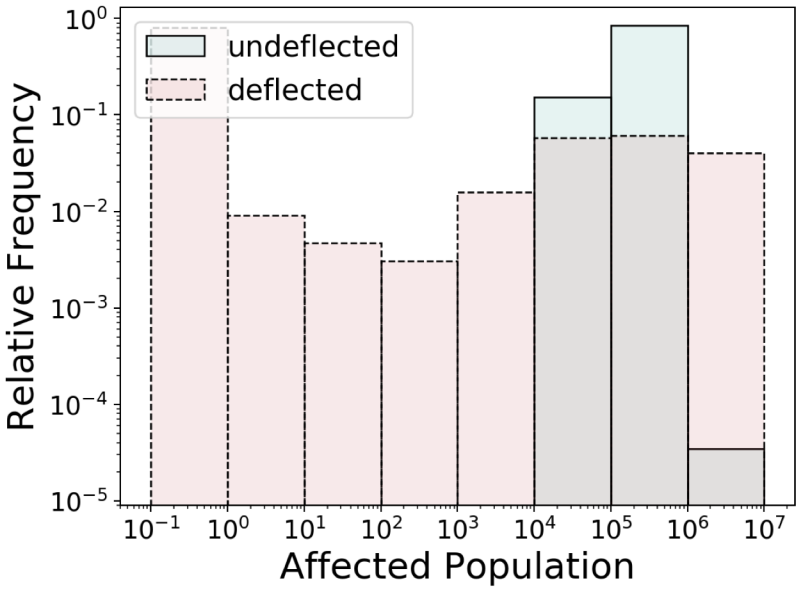
Mitigation Uncertainty for Risk Assessment

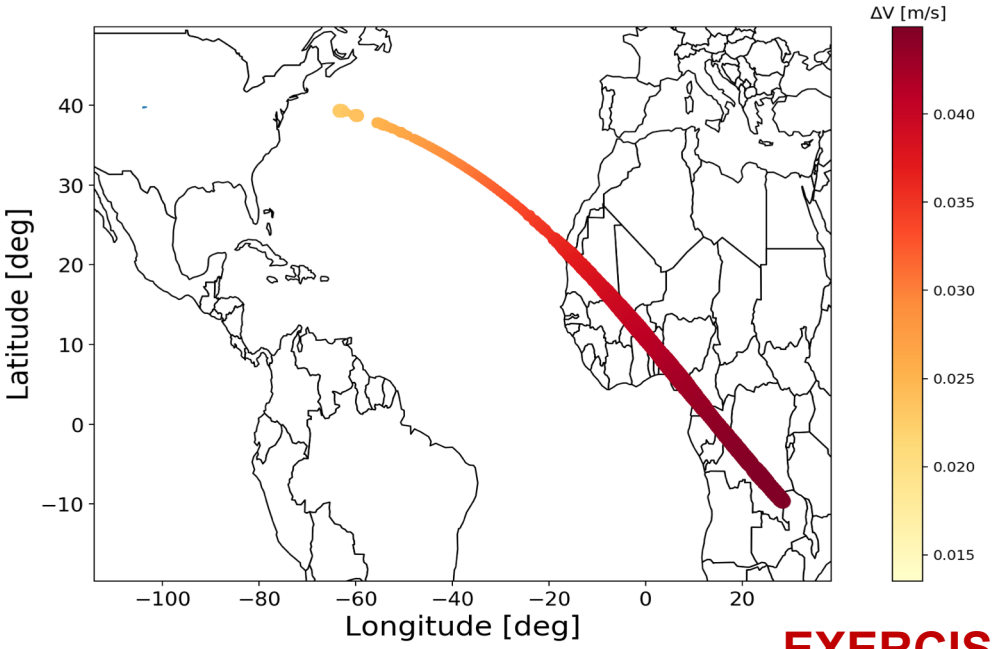
Ames Research Center

EXERCISE

PDC2019 Hypothetical Example—Day 3 Example

- Earth impact probability reduced to 30.7% (from 100% in the non-deflected case)
- Remaining possible impacts shift from Denver to Africa
- Average affected population reduced by 52.0% from 302,000 to 145,000
- Risk of largest affected population numbers increases greatly





EXERCISE

Summary

- Ensemble hazard assessment models adequately bound risk for sub-global impacts.
- Scenario specific assessment techniques exist but require establishment of current best practices
  - Blast overpressure
  - Asteroid generated tsunami
- Thermal radiation appears bounded by blast overpressure, but uncertainty of luminous efficiency needs quantification.
- Regional/global effects models need development
  - Link impact/ejecta and climate models for scenario assessment
  - Create new set of reduced order models for ensemble risk assessment
- Link between mitigation uncertainty and impact risk in initial stages and needs development to inform mission design.

Impactor Property Distributions