



Uncertainty in Asteroid Impact Global Effects Modelling

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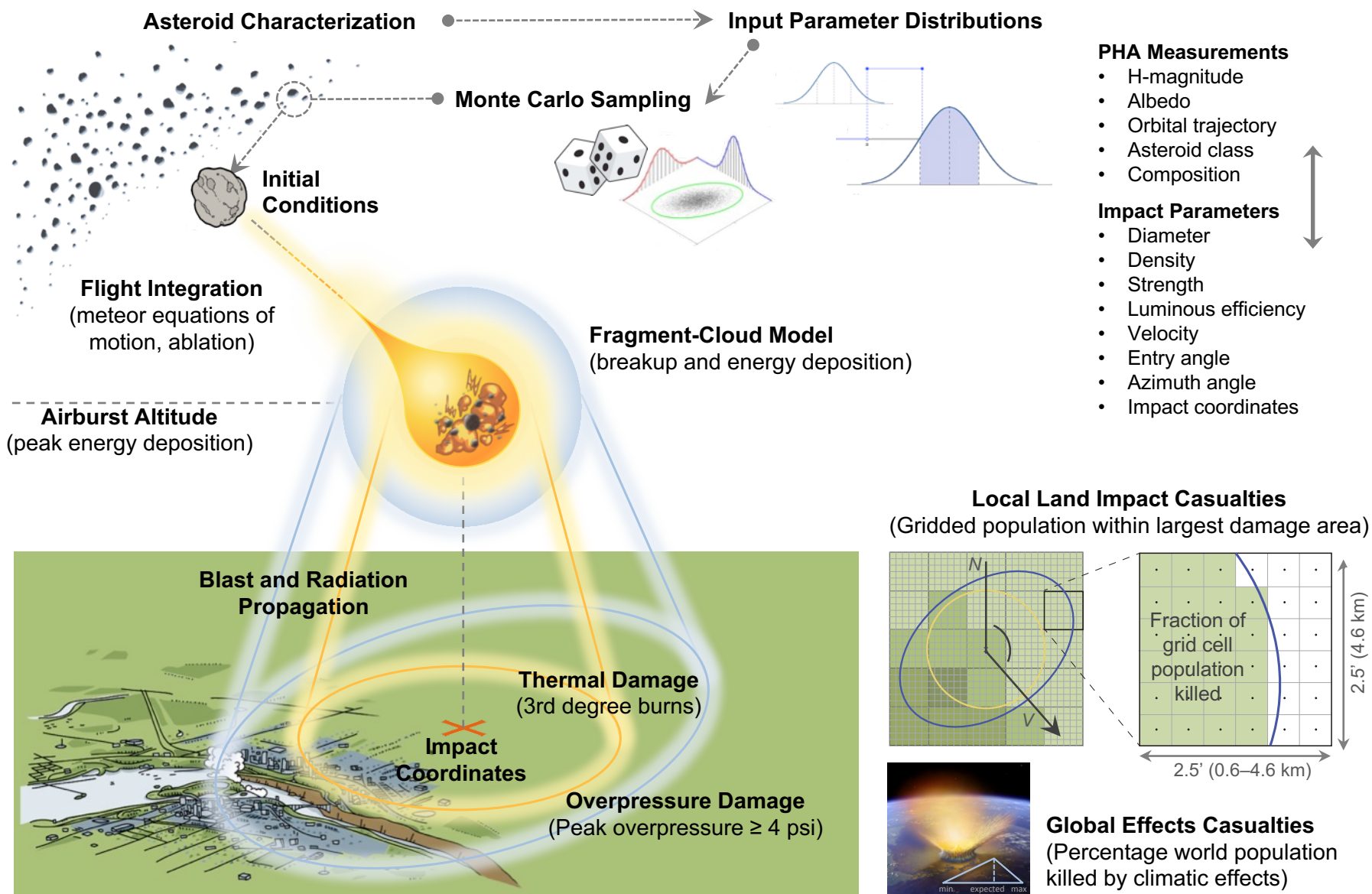
NASA Ames Research Center

Impact Global Effects TIM

12-13 July 2022

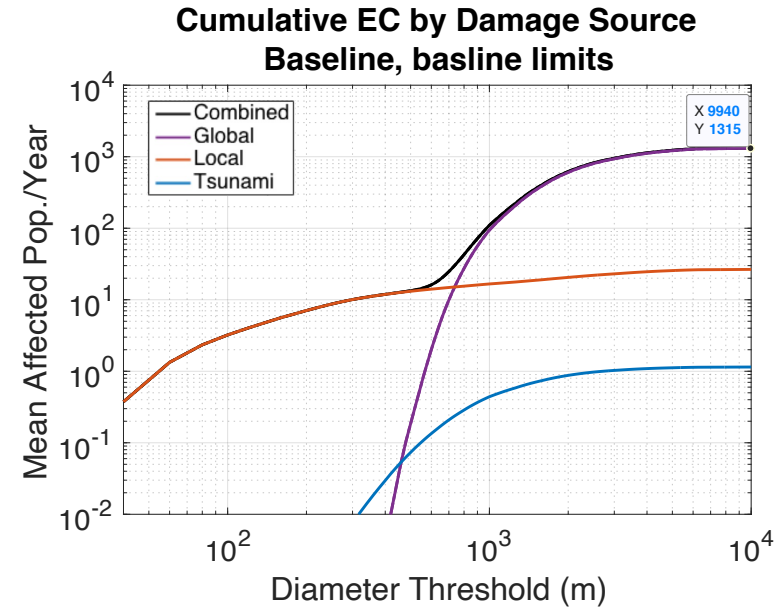


Probabilistic Asteroid Impact Risk Model

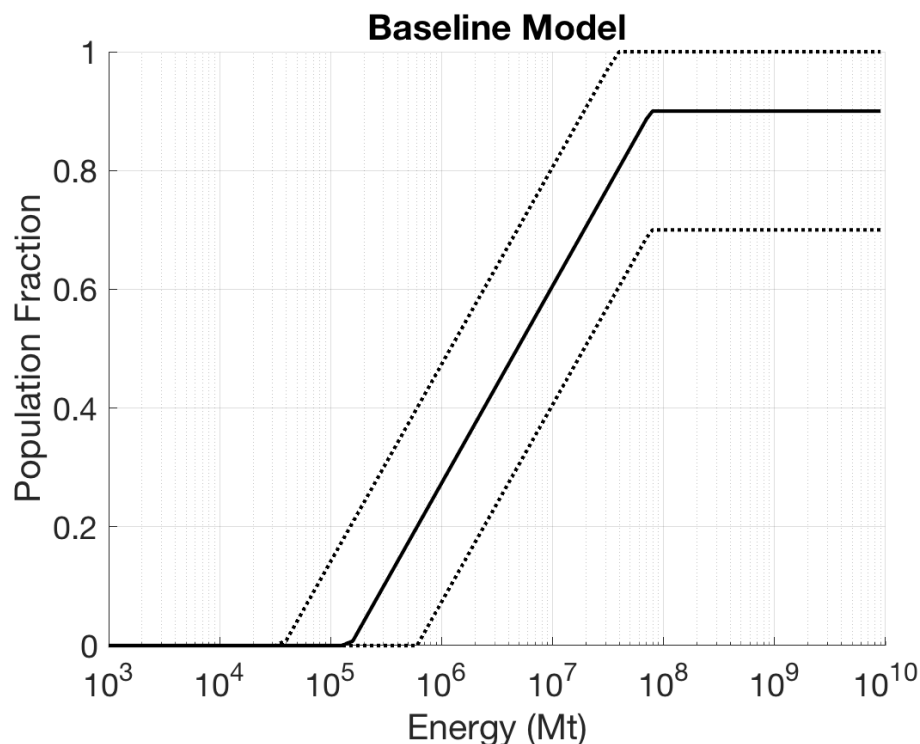


Ensemble Risk Assessment

- Probabilistic Asteroid Impact Risk (PAIR) model was run to generate ensemble risk estimate.
- Affected population estimates are shown as a function of impactor diameter for each hazard group.
 - Local damage due to blast and thermal
 - Asteroid generated tsunami
 - Global effects
- Global effects dominate the mean results—greater damage potential offsets the decreased impact frequency.
- Sensitivity of the results to global effects modeling assumptions will provide insight into recommended model improvements.



Baseline Global Effects Model



Natural log fit of population fraction ranges vs impact energy (E) in megatons:

- $F = m (\ln E) + b$

Nominal Fraction Fit

- Slope $m = 0.11427$
- Y-intercept $b = -1.7196$

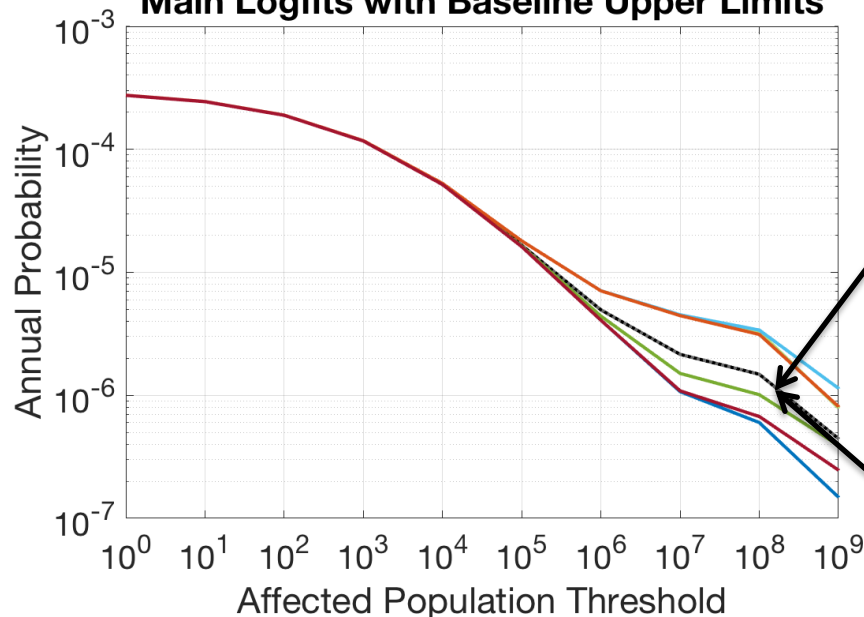
Min/Max Uncertainty Range

- $F_{\text{max/min}} = F_{\text{nom}} \pm 0.2$
- Factor of ~ 4 ($10^{\pm 0.6}$) in energy

	GE onset energy (Mt)	GE upper limit
Pessimistic	4e4	100% at 4e7 Mt
Nominal	1.5e5	90% at 8e7 Mt
Optimistic	6e5	70% at 8e7 Mt

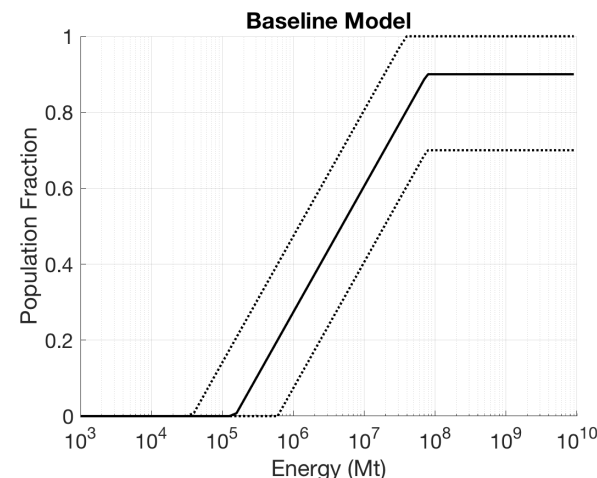
Baseline Model

Damage Exceedance: All Hazards
Main Logfits with Baseline Upper Limits

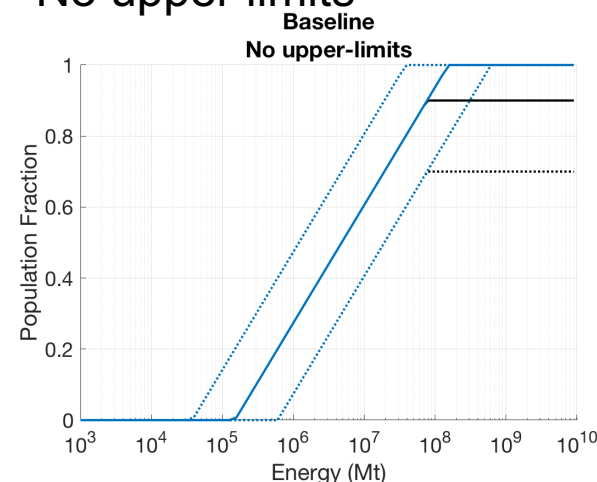


- Baseline, baseline limits
- Baseline, no limits
- 2x frac range, baseline limits
- 1/2 frac range, baseline limits
- Shift pessimistic, baseline limits
- Shift optimistic, baseline limits
- Slope decrease, baseline limits
- Slope increase, baseline limits

Baseline model

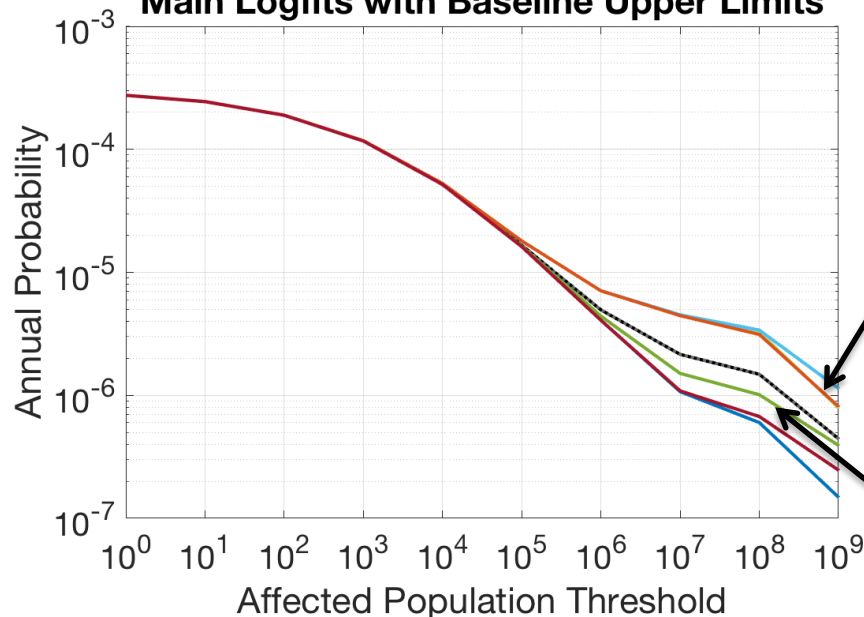


No upper limits



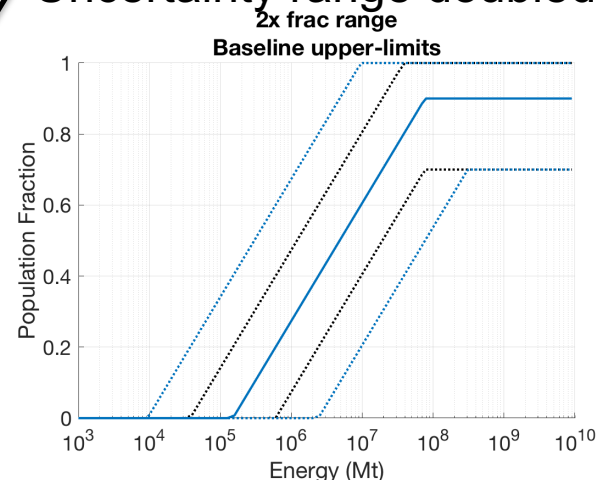
Uncertainty Variation

Damage Exceedance: All Hazards
Main Logfits with Baseline Upper Limits

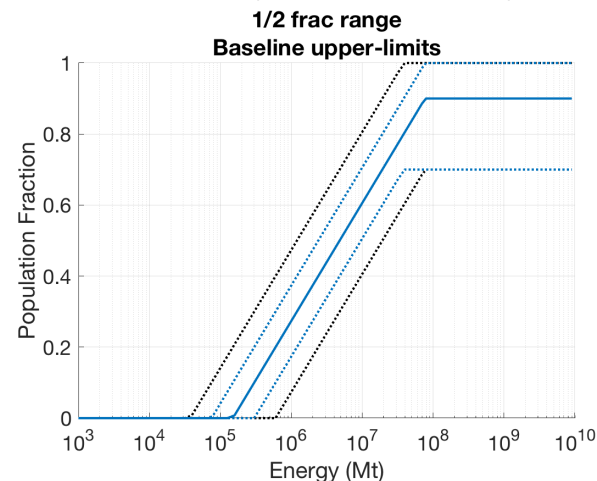


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- 2x frac range, baseline limits
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Uncertainty range doubled

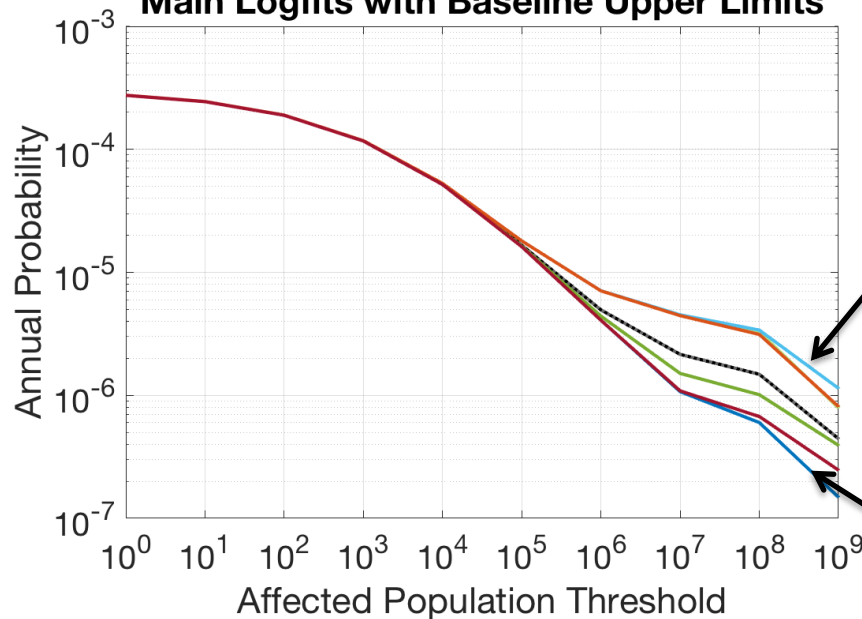


Uncertainty reduced by half



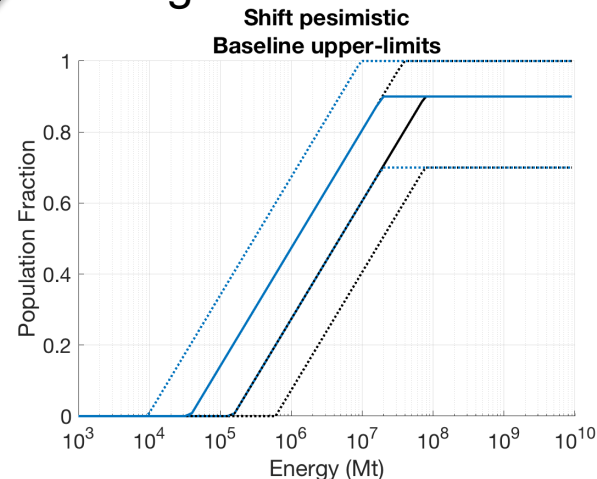
Shifting Model

Damage Exceedance: All Hazards
Main Logfits with Baseline Upper Limits

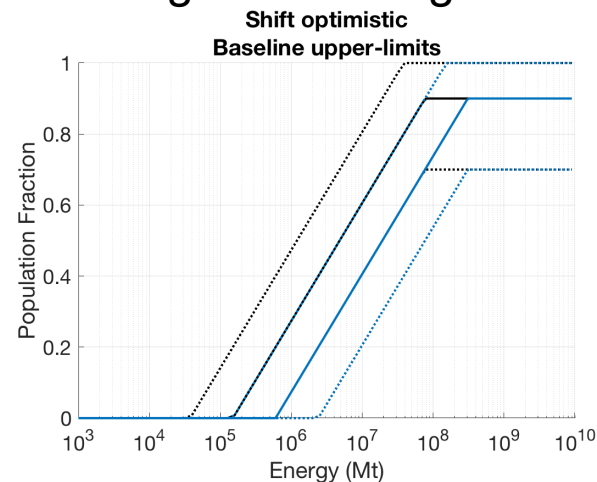


- Baseline, baseline limits
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- 2x frac range, baseline limits
- 1/2 frac range, baseline limits
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- Shift optimistic, baseline limits
- Slope decrease, baseline limits
- Slope increase, baseline limits

Shifting onset to lower energy

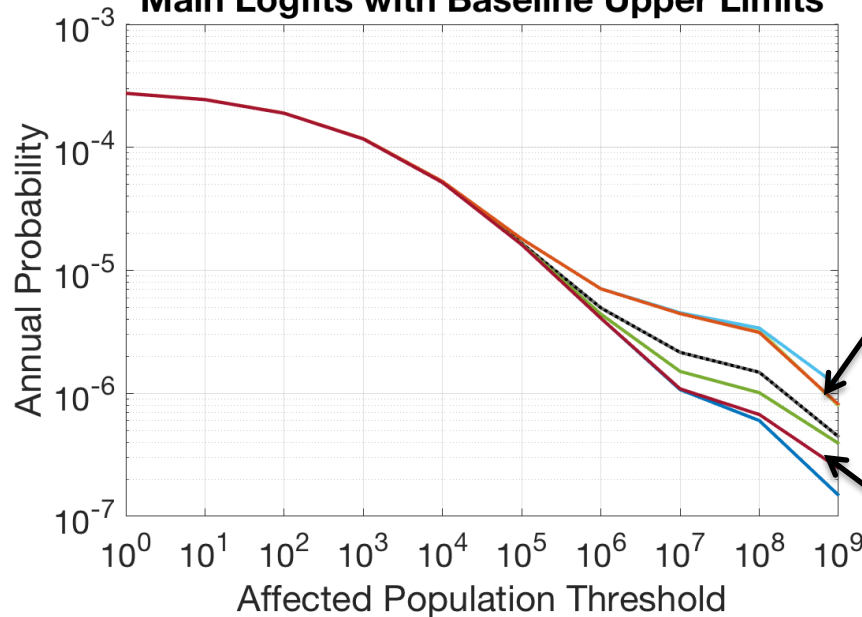


Shifting onset to higher energy



Model Slope Change

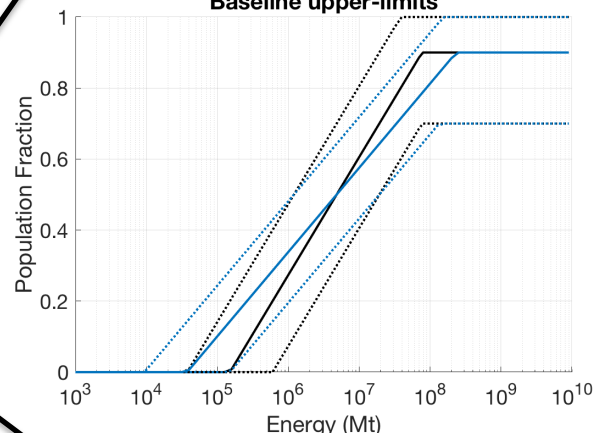
Damage Exceedance: All Hazards
Main Logfits with Baseline Upper Limits



- Baseline, baseline limits
- Baseline, no limits
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- Shift pessimistic, baseline limits
- Shift optimistic, baseline limits
- Slope decrease, baseline limits
- Slope increase, baseline limits

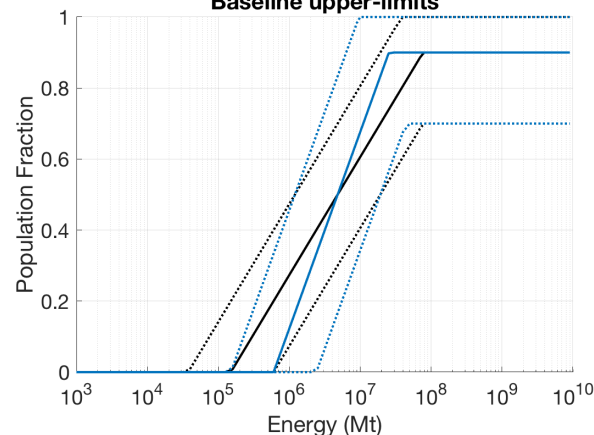
Slope decreased

Slope decrease
Baseline upper-limits



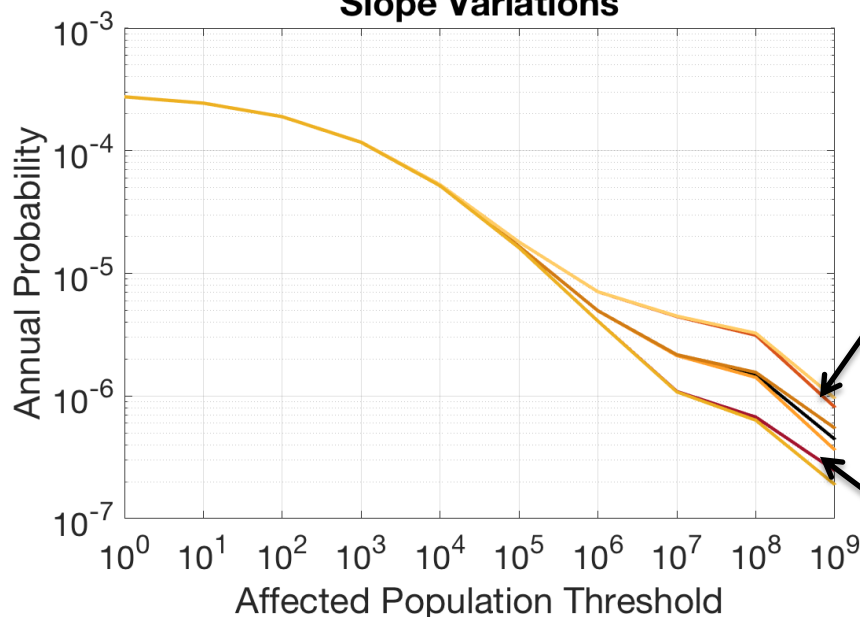
Slope increased

Slope increase
Baseline upper-limits



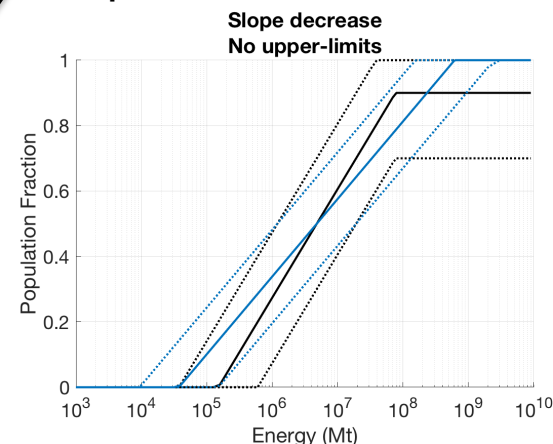
Model Slope Change (midpoint fixed)

**Damage Exceedance: All Hazards
Slope Variations**

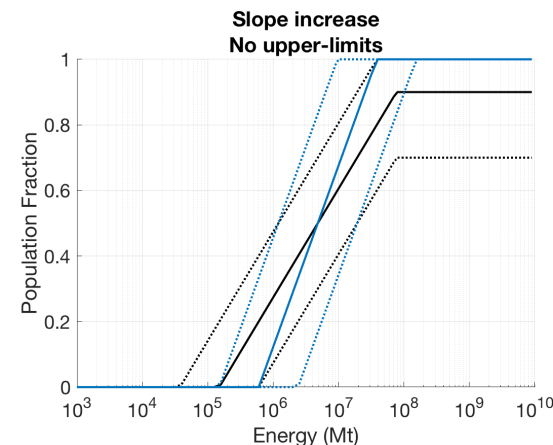


- Baseline, baseline limits
- Slope decrease, baseline limits
- Slope increase, baseline limits
- Slope decrease (min fixed), baseline limits
- Slope increase (min fixed), baseline limits
- Slope decrease (max fixed), baseline limits
- Slope increase (max fixed), baseline limits

Slope decreased

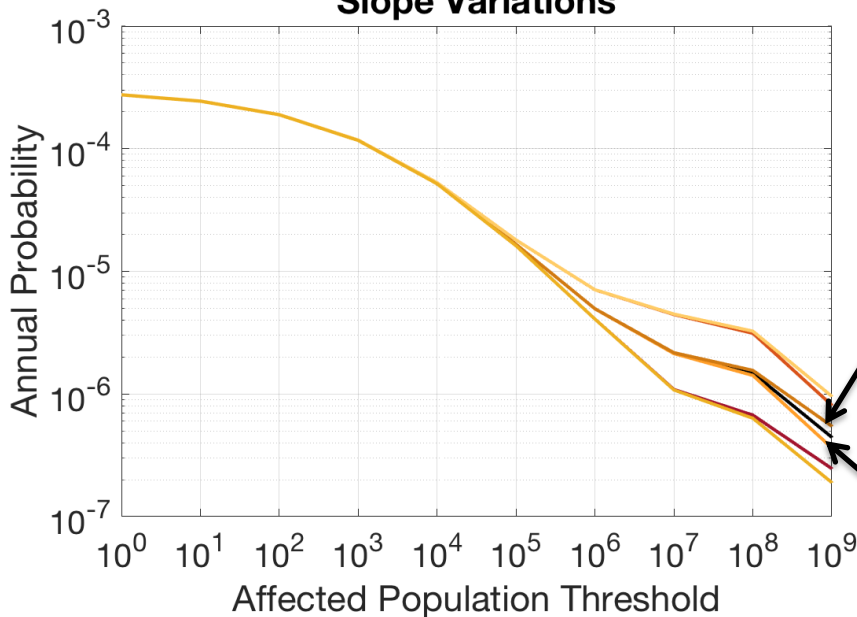


Slope increased



Model Slope Change (lower fixed)

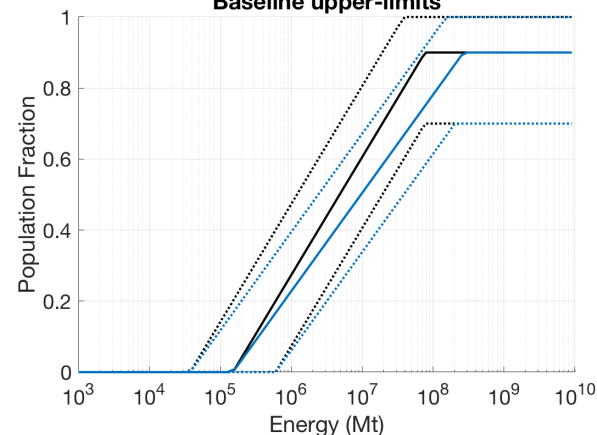
**Damage Exceedance: All Hazards
Slope Variations**



- Baseline, baseline limits
- Slope decrease, baseline limits
- Slope increase, baseline limits
- Slope decrease (min fixed), baseline limits
- Slope increase (min fixed), baseline limits
- Slope decrease (max fixed), baseline limits
- Slope increase (max fixed), baseline limits

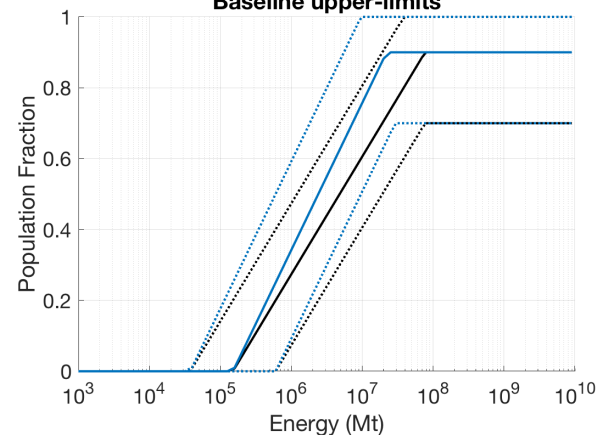
Slope decreased

Slope decrease (min fixed)
Baseline upper-limits



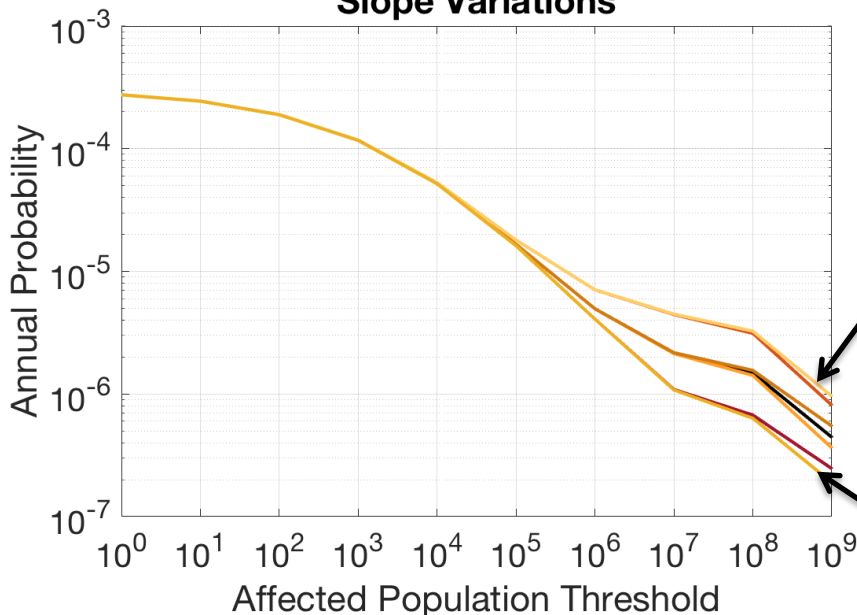
Slope increased

Slope increase (min fixed)
Baseline upper-limits



Model Slope Change (upper fixed)

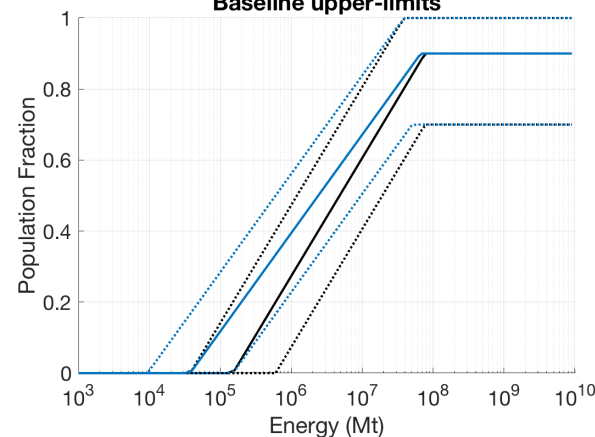
**Damage Exceedance: All Hazards
Slope Variations**



- Baseline, baseline limits
- Slope decrease, baseline limits
- Slope increase, baseline limits
- Slope decrease (min fixed), baseline limits
- Slope increase (min fixed), baseline limits
- Slope decrease (max fixed), baseline limits
- Slope increase (max fixed), baseline limits

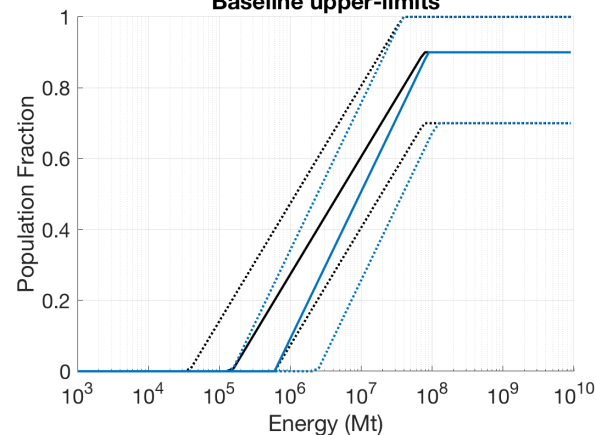
Slope decreased

Slope decrease (max fixed)
Baseline upper-limits



Slope increased

Slope increase (max fixed)
Baseline upper-limits



Summary

- Large impactors drive the long-term expected (ensemble) risk.
- Global effects model fidelity lags the local hazard models.
- Sensitivity studies were conducted to identify GE model parameters that most strongly influence results.
 - Model cutoff limits on upper range
 - Shifting onset model
 - Varying uncertainty ranges
 - Slope changes
 - Midpoint of curve
 - Upper range fixed
 - Lower range fixed
- Model results are driven by the onset energy of the GE models.