# Impact Risk Assessment:

## 2026 PDC27 Hypothetical Asteroid Impact Exercise

## *Epoch 1*

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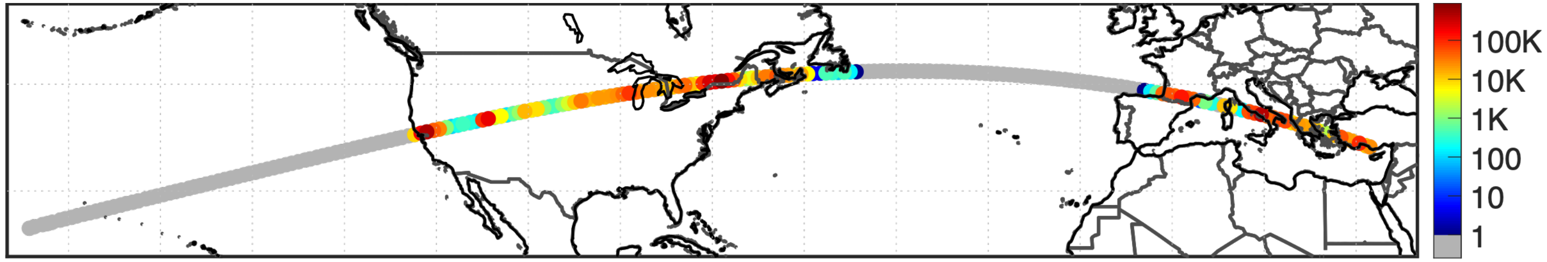
# Impact Hazard & Risk Overview

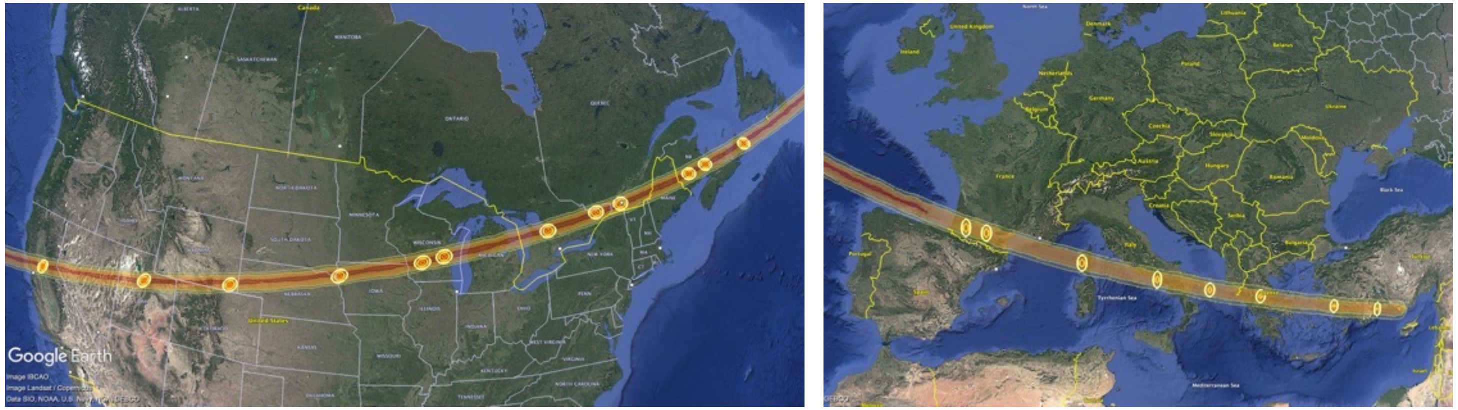
## Epoch 1 assessment: 1 August 2026

**~19% chance of Earth impact** in 12 years by an asteroid **75–90 m** in diameter with **10–50 Mt** of energy. Large ranges of potential damage sizes, severities, and locations are possible.

**Average affected population along potential impact locations**




**Potential damage risk regions**




- ~50% chance of damage to populated regions if asteroid hits Earth (9.3% total chance with impact probability)
- Primary hazard is a high-energy airburst causing a highly destructive blast wave over large areas
- Blast damage would likely extend ~30–50 km in radius, or possibly out to 100 km in the largest cases
- Airbursts in this size range are unlikely to cause significant tsunami

**Population risk:** Potential damage could affect **0–3M people**, with an average of **~26K** among Earth-impact cases. Impact over land could likely affect thousands to tens-of-thousands of people.

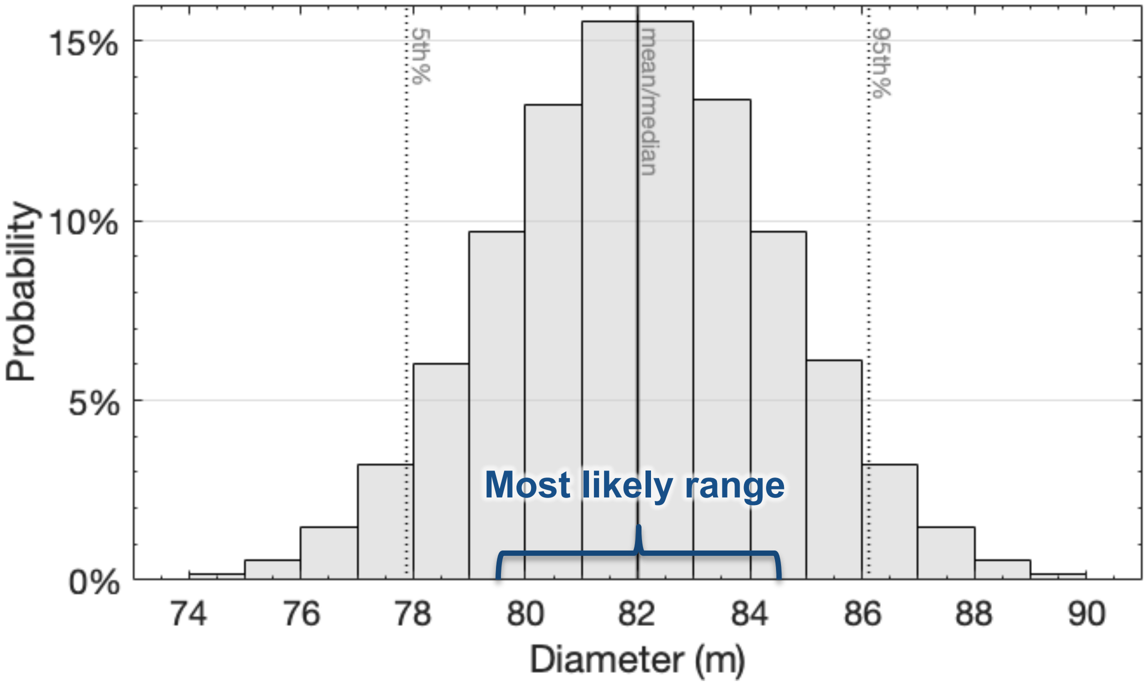
# Asteroid Size & Properties

Asteroid size range ~75–90 meters in diameter with a stony type composition and impact energy ~10–50 megatons

- Available observation data to-date:
  - Initial ground-based observations estimated sizes based on brightness (H magnitude)
  - JWST observation measured diameter of 82±2.5 meters and identified type S spectral class
- Estimated asteroid size and property ranges:
  - Asteroid diameter is most likely between ~80–85 m but could be ~75–90 m if unusually reflective or dark
  - Stony type composition with bulk densities potentially ~1.2–3.7 g/cm$^3$ and macroporosity between 0–60%
  - Unknown structure, strength, and breakup properties ranging from weak rubble pile to stronger monolith
  - Impact energy range is most likely ~20–30 Mt, but could be ~10–50 Mt (entry velocity ~17.6–18.4 km/s)

[Property inference model: J. Dotson et al., 2024]

## Asteroid Size Ranges & Probabilities



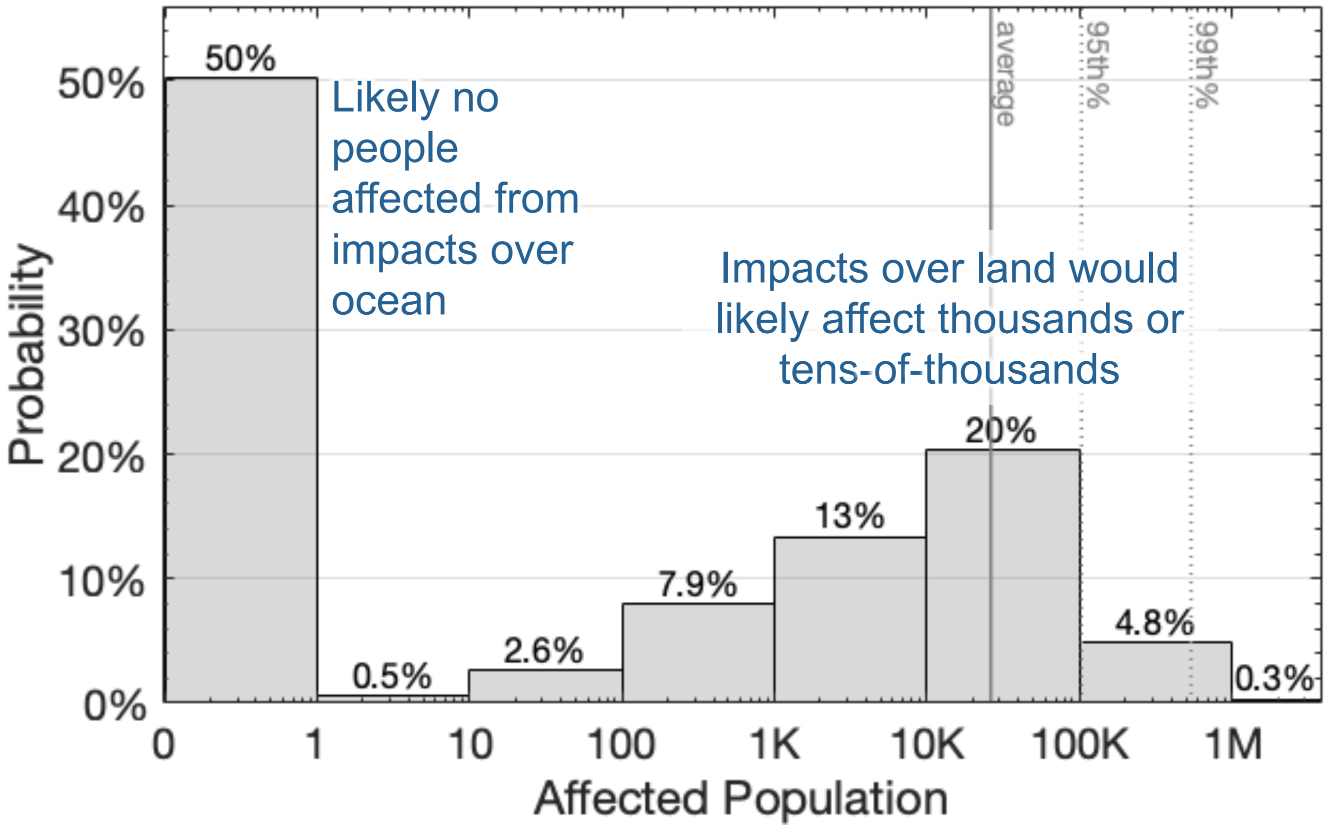

| | Diameter (m, ft) | Mass (kg) | Energy (Mt) |
|---|---|---|---|
| **Median** | 82 m (269 ft) | 6.39e8 | 25 |
| **Average** | 82 m (269 ft) | 6.49e8 | 25 |
| **Most likely 68%** | 79–84 m (260–277 ft) | 4.70e8–7.86e8 | 18–32 |
| **5th–95th %** | 78–86 m (256–282 ft) | 4.16e8–9.17e8 | 15–37 |
| **Range Modeled** | 74–91 m (242–299 ft) | 3.01e8–1.18e9 | 11–48 |

* Property stats are computed *independently* and **cannot be combined** to represent a single asteroid.

# Affected Population Risks

## *(relative probabilities if Earth impact occurs)*

**Damage probabilities *among Earth-impacting cases***




~50% chance of damage to populated regions, with impacts over land likely to affect >1K–100K people, potentially up to 3M people

| **Affected population threshold** | **Chance of damage *exceeding* threshold** |
|---:|---:|
| Any | 50% |
| >1K | 39% |
| >10K | 25% |
| >100K | 5% |
| >1M | 0.3% |

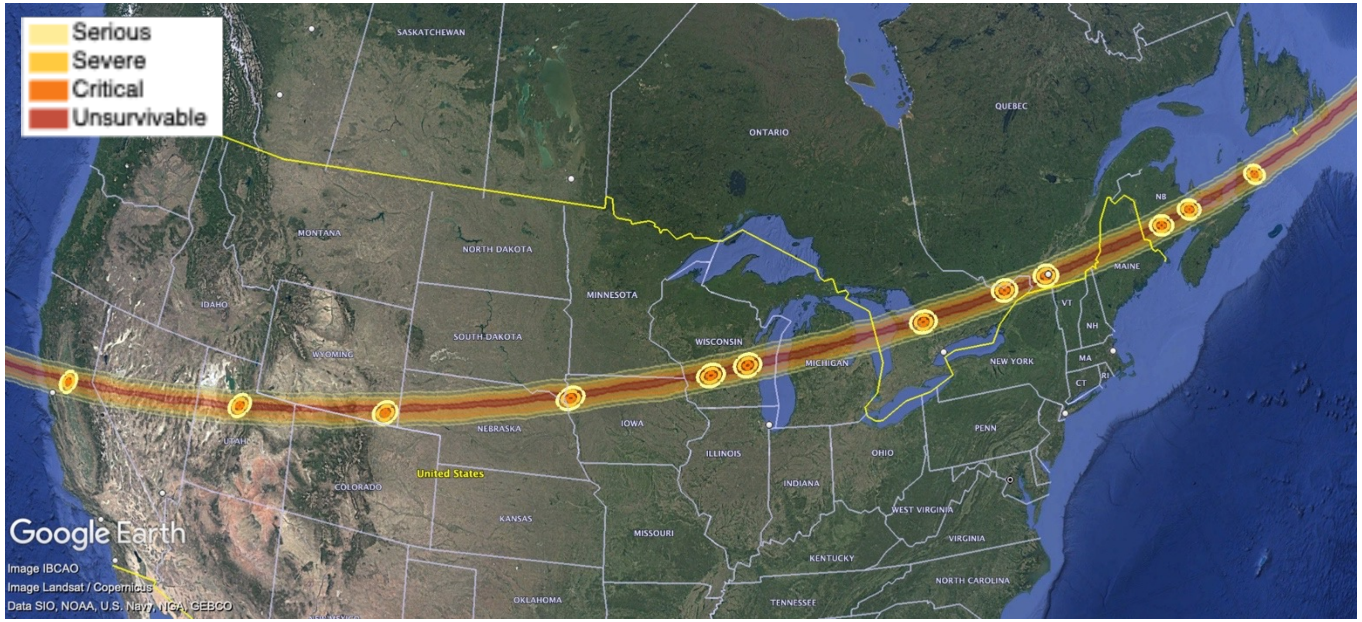
Affected population range: **0–3 million** people

**~26 thousand people affected on average** *if* Earth impact occurs

(~5 thousand total average population risk with 19% Earth impact probability)


HYPOTHETICAL EXERCISE

# Ground Damage Risk Swath




If the asteroid hits Earth, areas ***potentially*** at risk to blast damage span across USA, Canada, France, Italy, Greece, and Turkey

- Risk swath shows the extent of regions ***potentially*** at risk to local ground damage, including the range of possible locations and damage sizes*
- Rings show median-sized damage footprints at sample high-population locations
- Colors show potential damage severity level

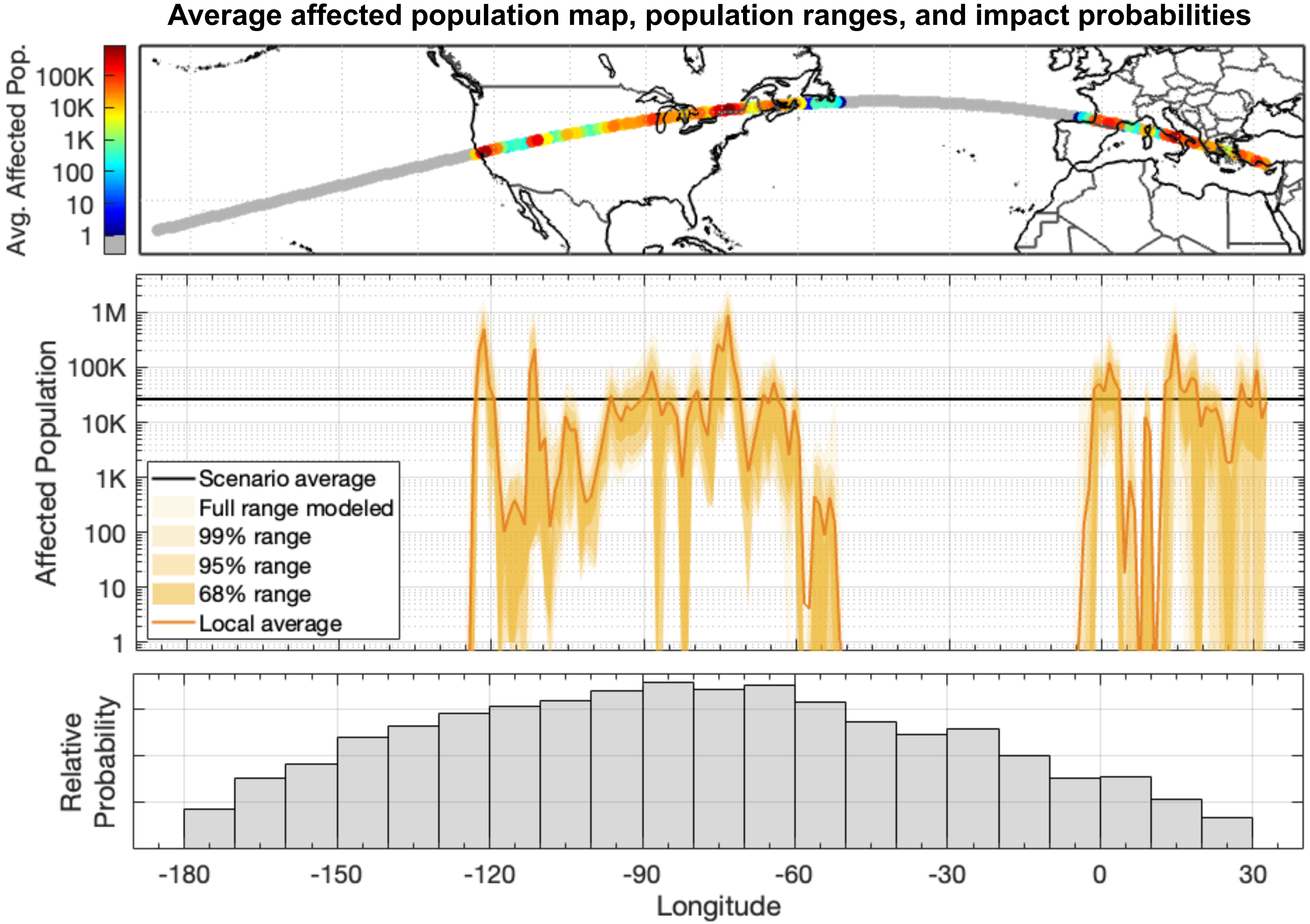

| | Damage Level Description |
|---|---|
| **Serious** | Windows shatter, some structure damage |
| **Severe** | Widespread structure damage or third-degree burns |
| **Critical** | Residential structures collapse or clothing ignites |
| **Unsurvivable** | Devastation, structures flattened or burned |

* Potential swath extents are shown out to the 95$^{th}$ percentile damage size *if an impact were to occur in a region.* The chance of damage occurring in any one region is a very small fraction of the total Earth impact probability (currently 19%).


HYPOTHETICAL EXERCISE

# Relative Population Risk Along Swath

## *(relative probabilities if impact occurs in a region)*



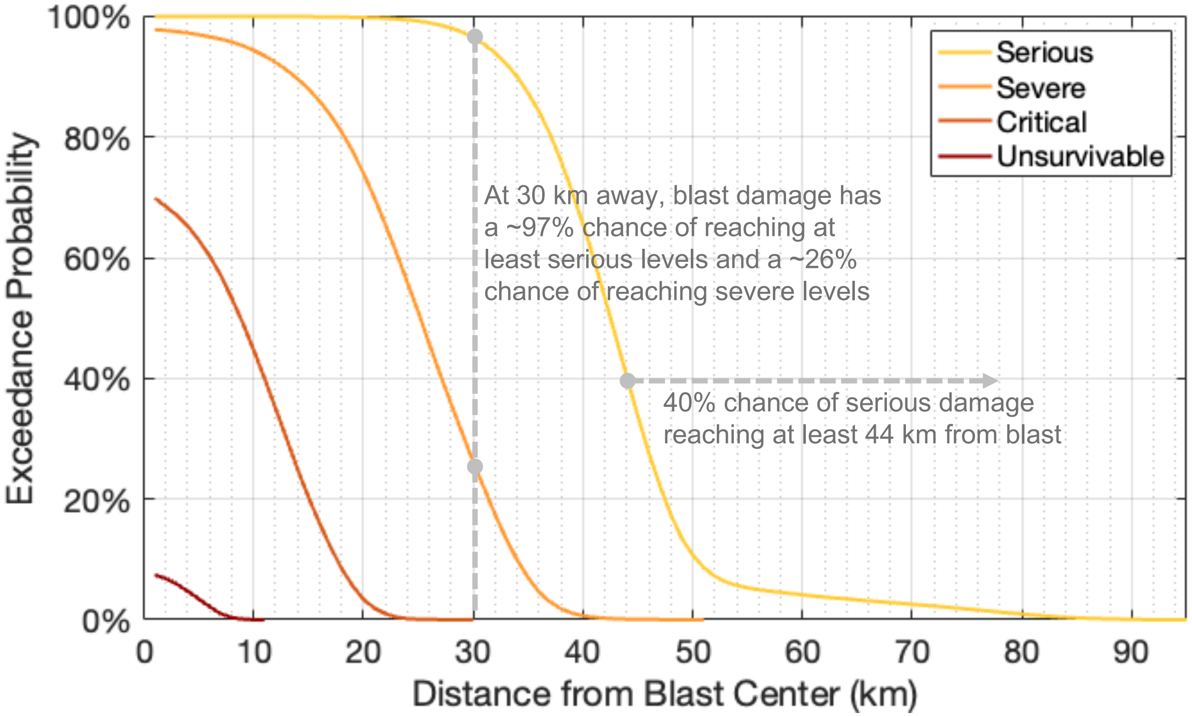

*If* asteroid hits Earth, moderate to large affected populations would be likely across most potential land impact regions

- Impacts over high-population areas could affect hundreds-of-thousands to millions of people
- Impacts over less populated regions could affect hundreds to thousands
- The potential impact location is more likely to occur over North America and less likely to occur over European regions

# Local Damage Size & Severity Risks

*(relative probabilities if Earth impact occurs)*

## Chance that damage levels will reach given distances or more from the blast center




## Chance of damage levels occurring

| Serious | Severe | Critical | Unsurvivable |
|---|---|---|---|
| **100%** | **98%** | **70%** | **7.4%** |

- Serious damage would extend at least 20 km, most likely ~35–50 km, and potentially as far as ~100 km
- Severe damage would most likely extend ~20–35 km, potentially as far as ~50 km
- Critical damage would most likely extend ~0–13 km, potentially as far as ~30 km
- Unsurvivable damage is less likely to occur, but could reach as far as ~11 km in the largest cases

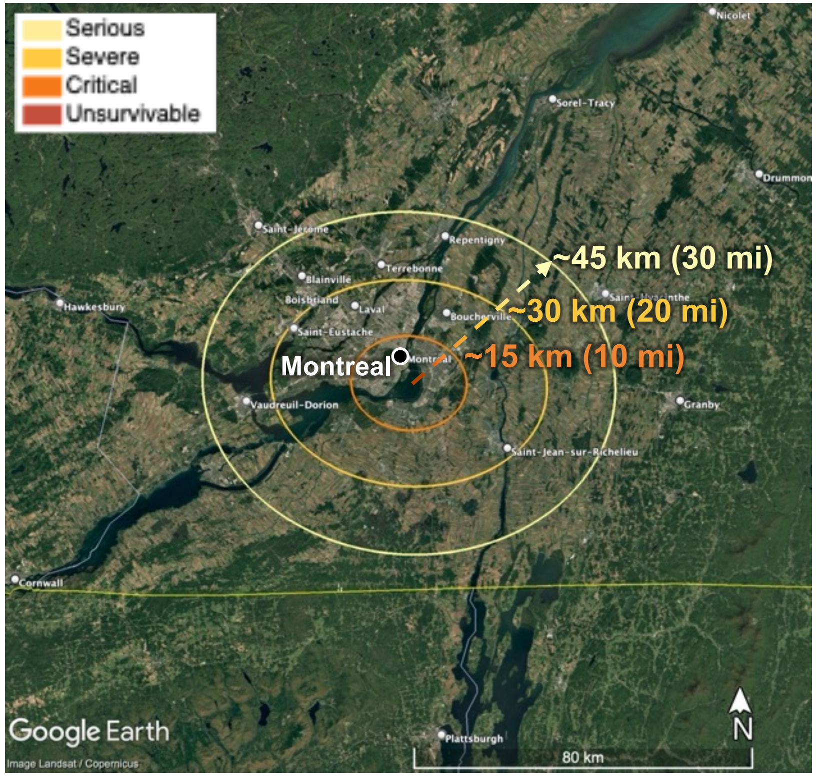
**Relative probabilities of damage levels reaching further than given distances from blast center, if Earth impact occurs**

| | >1 km | >5 km | >10 km | >20 km | >30 km | >40 km | >50 km | >60 km | >70 km | >80 km | >90 km |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Serious | 100% | 100% | 100% | 100% | 97% | 66% | 11% | 4.1% | 2.6% | 1.0% | 0.07% |
| Severe | 98% | 97% | 94% | 74% | 26% | 0.7% | 0% | | | | |
| Critical | 70% | 63% | 45% | 3.4% | 0% | | | | | | |
| Unsurvivable | 7.4% | 3.4% | 0% | | | | | | | | |

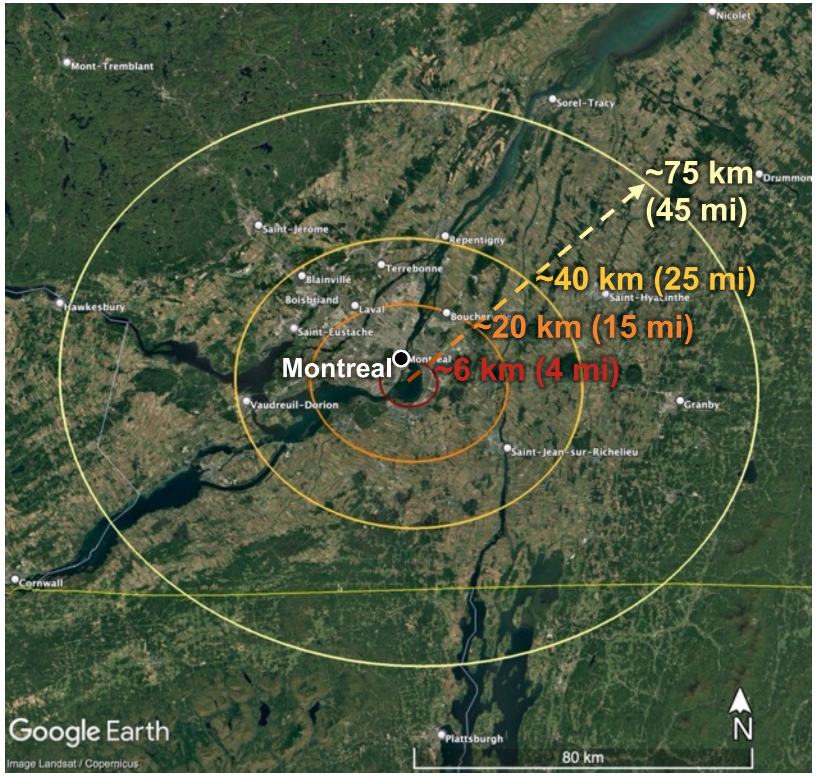
# Potential Ground Damage Size Ranges

## Example over Montreal, Canada – Highest population damage region along swath

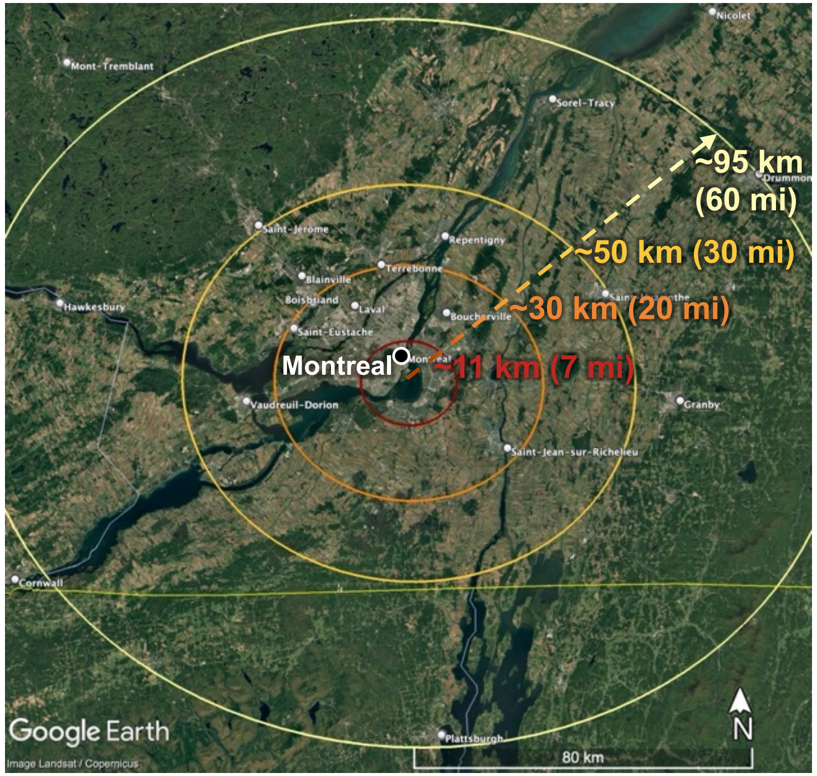
### Median ($50^{th}$%) Damage




### Large ($95^{th}$%) Damage




### Largest Modeled




Likely damage could span large metro areas, reaching critical damage levels

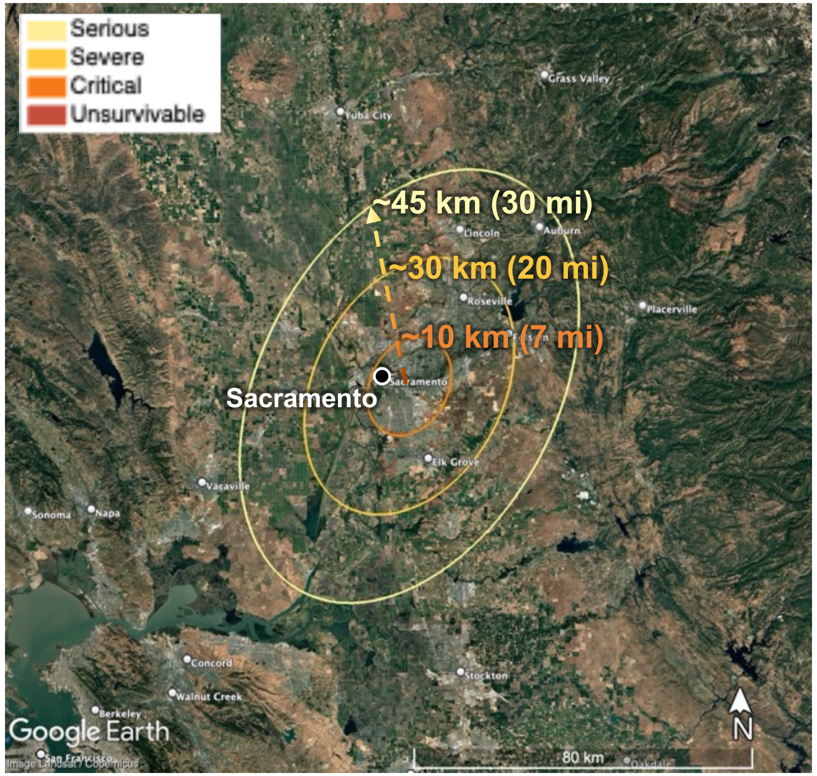
Large damage sizes could span multiple cities or counties, reaching unsurvivable levels

* Damage sizes and shapes vary along the potential impact corridor due to different entry angles and airburst altitudes. Radii given are circular area equivalents, with larger values rounded to nearest 5 km/mi.

# Potential Ground Damage Size Ranges

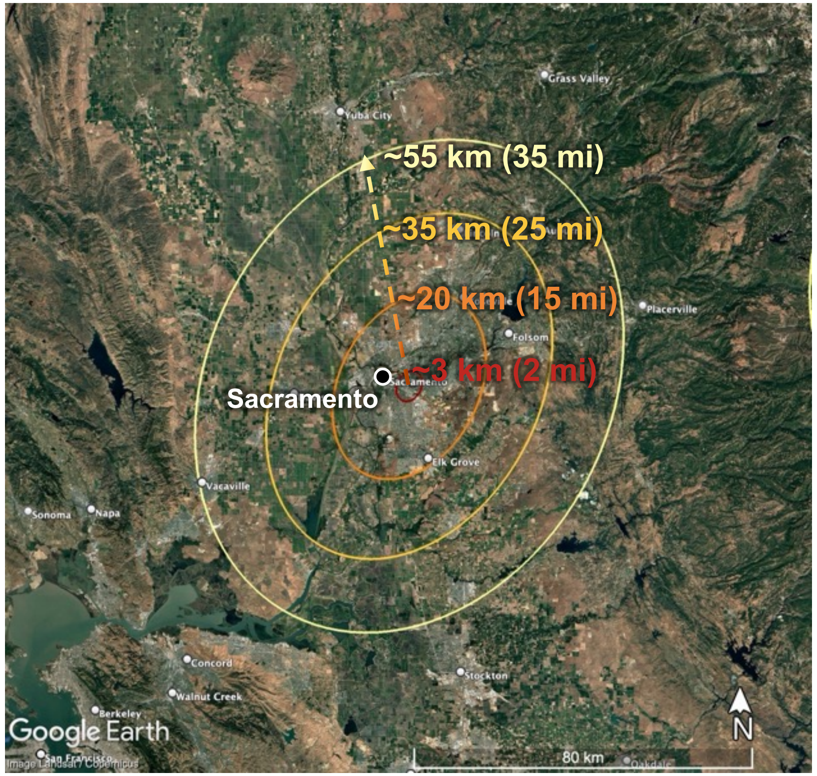
## Example over Sacramento, CA USA – Highest U.S. population damage region

### Median (50th%) Damage



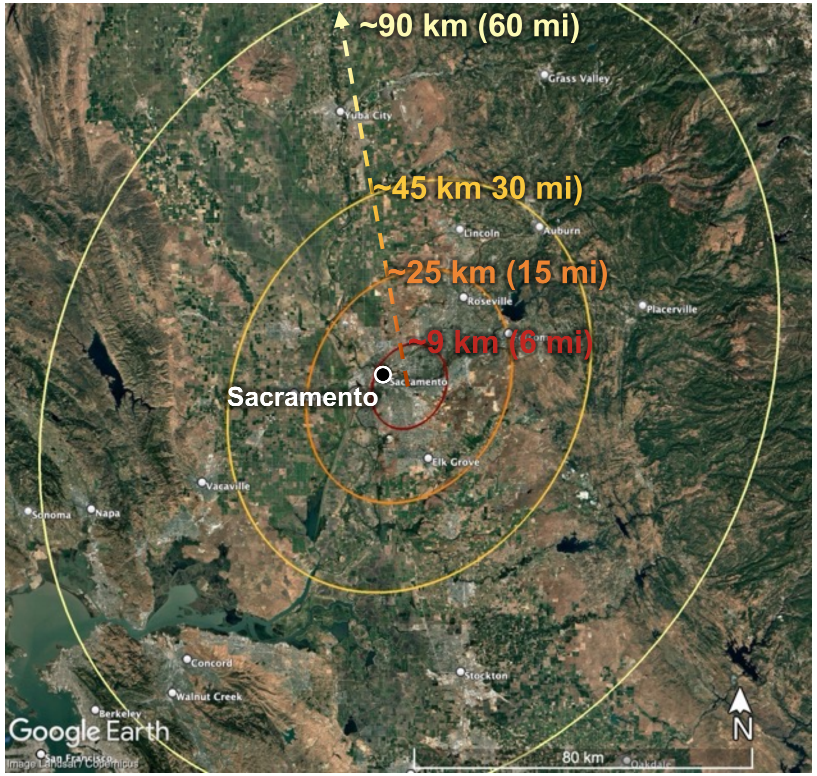

Likely damage could span large metro areas, reaching critical damage levels

### Large (95th%) Damage




Large damage sizes could span multiple cities or counties, reaching unsurvivable levels

### Largest Modeled

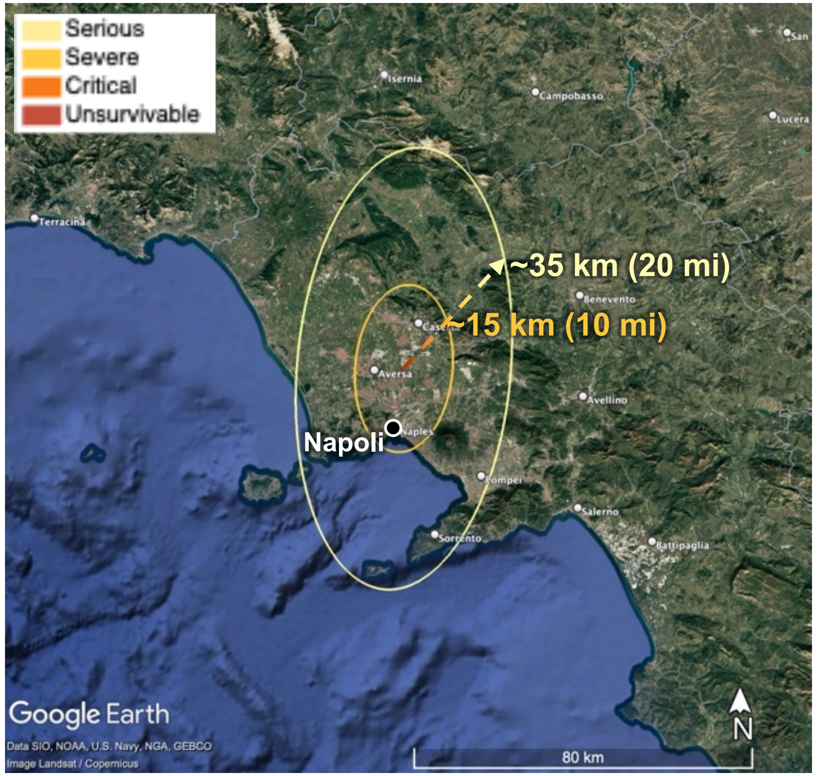



* Damage sizes and shapes vary along the potential impact corridor due to different entry angles and airburst altitudes. Radii given are circular area equivalents, with larger values rounded to nearest 5 km/mi.

# Potential Ground Damage Size Ranges

## Example over Naples, Italy – Highest European population damage region

### Median (50$^{th}$%) Damage

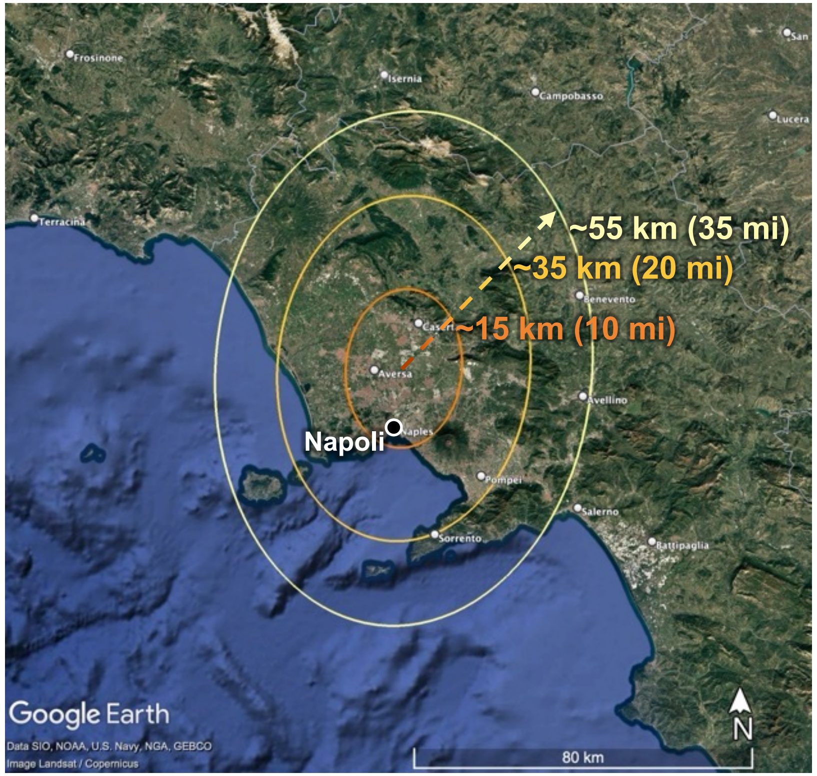



Likely damage could span large cities, reaching severe damage levels

### Large (95$^{th}$%) Damage


Large damage sizes could span large metro areas, reaching critical damage levels

### Largest Modeled



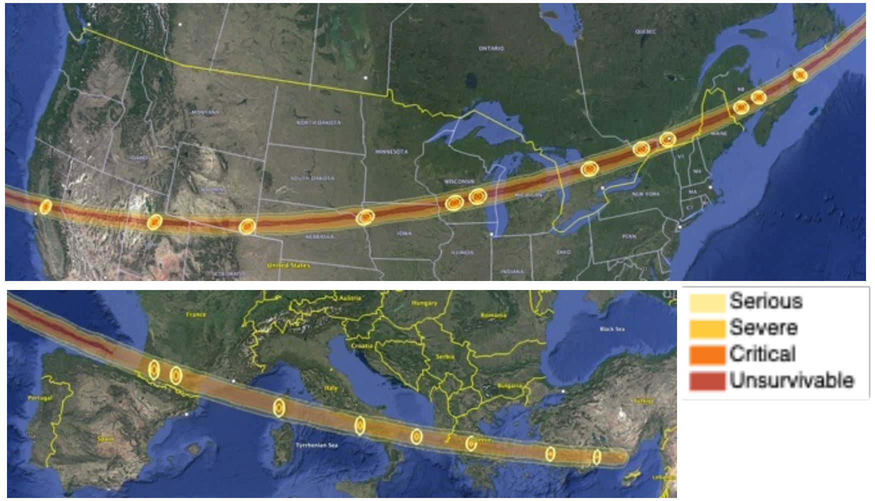

* Damage sizes and shapes vary along the potential impact corridor due to different entry angles and airburst altitudes. Radii given are circular area equivalents, with larger values rounded to nearest 5 km/mi.

# Impact Risk Summary

## Epoch 1 assessment: 1 August 2026

### Asteroid Characterization Summary

- ~19% chance of Earth impact on 10 July 2038 (~12 years) from a large asteroid
- Available observation data: Ground-based brightness estimates; JWST estimated diameter and determined S taxonomy
- Diameter: ~75–90 m (250–300 ft), most likely ~80–85 m (260–280 ft), median size 82 m (269 ft)
- Impact Energy: 10–50 Mt, most likely 20–30 Mt, median 25 Mt
- Properties: S type bulk density ranges, unknown structure



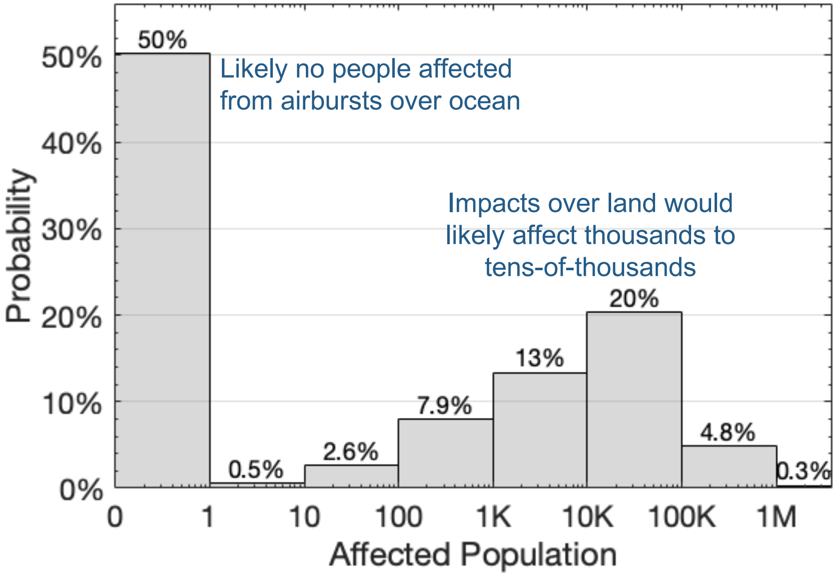

### Risk Region Swath Map

Regions potentially at risk, given range of damage locations and sizes. Median-sized damage areas are shown at sample locations.

### Hazard Summary

- Primary hazard is a high-energy airburst and fireball causing a destructive blast wave over large areas
- Blast damage could reach unsurvivable levels near airburst, with serious damage likely extending ~30–50 km (~20–30 mi) in radius, and possibly out over ~100 km (60 mi) or more
- Likely damage sizes could span large cities or metro areas, while large damage sizes could span multiple large counties
- Airbursts in this size range are unlikely to cause significant tsunami

### Affected Population Risks (given Earth-impact)




Probabilities of how many people could be affected by the potential damage

Range: 0–3M ppl

~26K avg. if Earth impact occurs

~5K total avg. risk (with 19% Earth-impact probability)


HYPOTHETICAL EXERCISE

# Additional PDC Scenario Resources

- Additional scenario information, results, and tools available on the CNEOS exercise website: https://cneos.jpl.nasa.gov/pd/cs/pdc27/
  - **Interactive impact risk dashboard:** Additional PAIR impact risk results for this exercise scenario can be explored in an interactive web dashboard tool, which includes additional hazard summaries, detailed plots and data tables on the damage sizes and severities, and zoomable maps of the damage risk swath and sample damage footprint examples.
  - **Google Earth damage risk maps:** A Google Earth KMZ file of the damage risk swath and sample damage footprint sizes for this exercise scenario.
  - **Introduction to Asteroid Impact Risk Assessment presentation**: Introductory background information on the asteroid threat assessment processes, key hazards and factors, and PAIR modeling details.
  - **Asteroid physical properties file:** A csv file containing 5,000 sampled realizations of the object spanning the current distributions of possible asteroid properties for this scenario.
  - **Orbital details:** JPL/CNEOS orbit information, data, and tools.
- ATAP impact risk modeling references:
  - Details on the **Probabilistic Asteroid Impact Risk (PAIR)** model and impact threat assessment process used to produce these results are published in: Wheeler et al., 2024 [ doi:10.1016/j.actaastro.2023.12.049 ]
  - Details on the **Asteroid Property Inference Network (APIN)** model used to generate the asteroid property cases for this assessment are published in: Dotson et al., 2024 [ doi:10.1016/j.actaastro.2024.04.020 ]
  - See reference slide for additional ATAP PAIR, hazard modeling, and entry modeling journal papers.

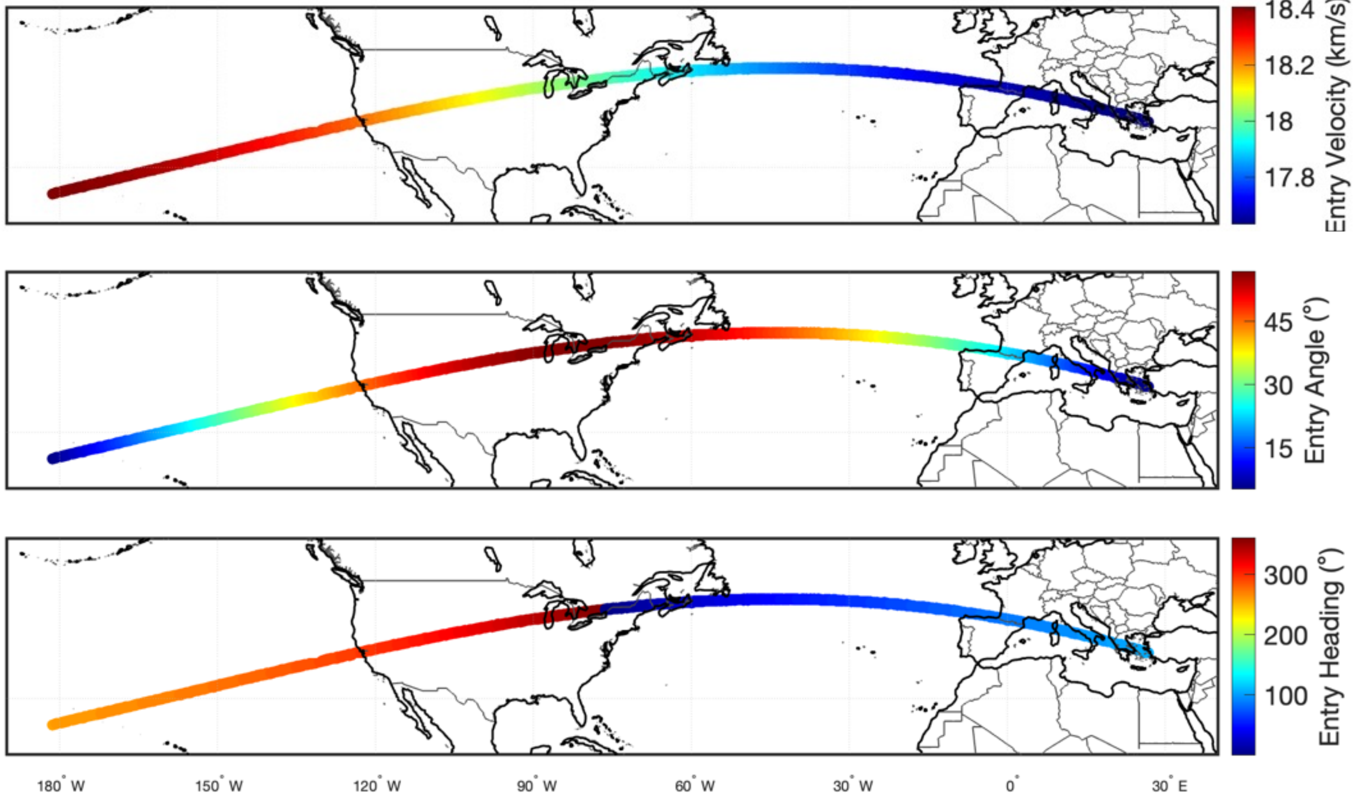

HYPOTHETICAL EXERCISE

# ADDITIONAL SCENARIO DETAILS

# Entry Parameters & Locations

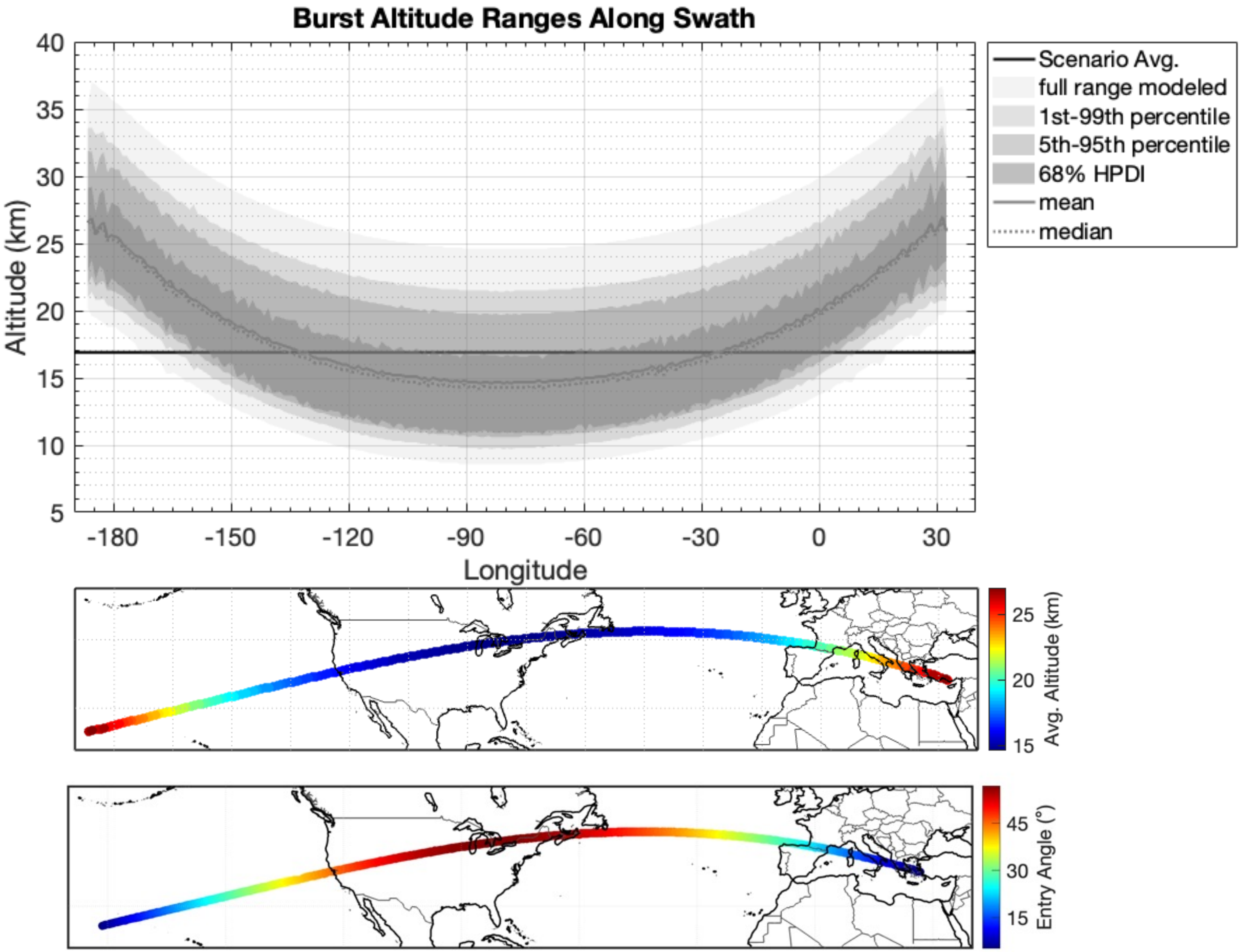
- **~19% chance of Earth impact somewhere along a globe-spanning corridor as of 1 Aug. 2026**
  - Potential entry corridor spans from the N. Pacific to West Asia, crossing the U.S. and Canada, the Atlantic, Southern France Italy, Greece, Turkey.
  - Entry parameters vary across the potential entry corridor, but are well-known for given entry points
- **Entry Velocity:**
  - ~18.0 km/s (~17.6–18.4 km/s)
  - Velocity decreases slightly from West to East along the corridor
- **Entry Angle:**
  - Maximum entry angle of ~57°
  - Moderate 44–57° entries over N. America
  - Shallower 30–5° entries over Mediterranean
  - Entry angle affects the airburst altitudes and resulting blast damage sizes and shapes
- **Entry Direction (Heading):**
  - Northward (0°) over the US/Canada border
  - ~WSW (~260°) along-track at westmost end
  - ~ESE (105°) along-track over eastmost end

**Entry velocity, angle, and heading at atmospheric entry (100 km altitude)**




[Impact entry data: D. Farnocchia, CNEOS/JPL, https://cneos.jpl.nasa.gov/pd/cs/pdc27/]

# Airburst Altitude Ranges along Swath




- Entry and breakup modeling estimates effective asteroid airburst altitudes ranging between ~8–35 km depending on the entry angle and asteroid properties
  - Altitudes are most likely between ~10–20 km at steeper entry angles over North America
  - Altitudes are most likely between ~15–30 at shallower angles over Europe & Mediterranean regions
- Airburst altitude factors
  - Entry angle varies with location along the potential impact corridor
  - Asteroid size, density, strength and compositions affect potential breakup and ablation and rates


HYPOTHETICAL EXERCISE

# Local Blast & Thermal Damage Area Sizes

*(relative probabilities if Earth impact occurs)*

- Significant blast damage is certain to occur, ranging from large areas of shattered windows and structure damage to potentially unsurvivable devastation near the airburst
- Thermal damage could also occur, but is much less likely and much smaller than the corresponding blast regions
- Outer serious damage extent would most likely be ~35–50 km (~20–30 mi), but the largest blasts could extend out ~100 km (~60 miles)

## Potential Blast Damage Severities and Sizes

| Damage Level | Potential Blast Effects | Chance of Occurring | Damage Radius Ranges (km) | | |
|---|---|---|---|---|---|
| | | | Median | Most Likely | Range |
| **Serious** | Shattered windows, some structure damage | 100% | 43 | 35–50 | 0–95 |
| **Severe** | Widespread structure damage | 98% | 30 | 20–35 | 0–50 |
| **Critical** | Most residential structures collapse | 71% | 14 | 0–15 | 0–30 |
| **Unsurvivable** | Complete devastation | 8% | 0 | 0 | 0–11 |

## Potential Thermal Damage Severities and Sizes

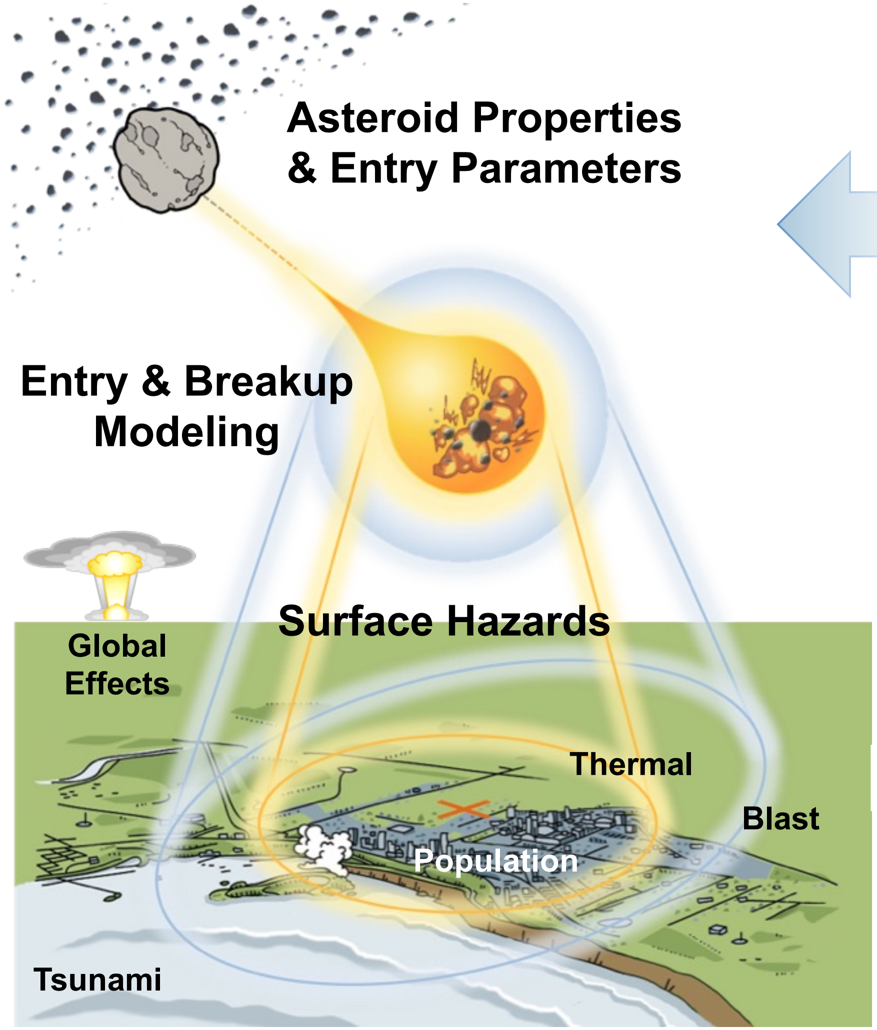
| Damage Level | Potential Thermal Effects | Chance of Occurring | Damage Radius Ranges (km) | | |
|---|---|---|---|---|---|
| | | | Median | Most Likely | Range |
| **Serious** | 2nd degree burns | 10% | 0 | 0 | 0–25 |
| **Severe** | 3rd degree burns | 3% | 0 | 0 | 0–15 |
| **Critical** | Clothing ignition | 0.3% | 0 | 0 | 0–8 |
| **Unsurvivable** | Structure ignition | 0.02% | 0 | 0 | 0–4 |

* Damage sizes and shapes vary along the potential impact corridor due to different entry angles and airburst altitudes, becoming smaller and more elliptical toward the corridor edges. Damage radius ranges given here are circular equivalents of damage areas among all potential entry locations.

# PROBABILISTIC ASTEROID IMPACT RISK MODELING DETAILS & REFERENCES

# Asteroid Impact Threat Assessment

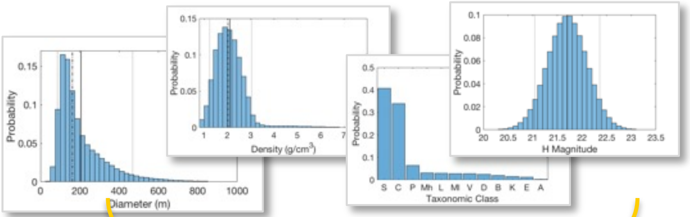
## Probabilistic Asteroid Impact Risk (PAIR) Model




[PAIR model details: Wheeler et al., 2025

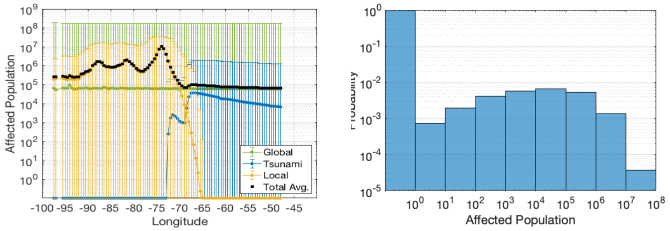
## Impact Threat Scenario

### Asteroid Property Distributions





### Probabilistic Damage and Risk

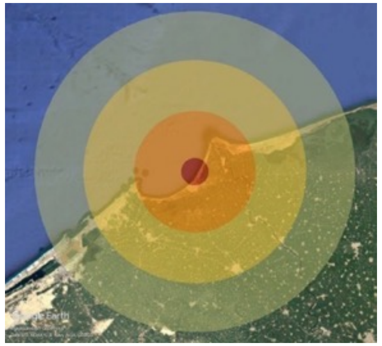



- Risk model uses fast-running physics-based models to assess millions of impact cases representing the range of possible asteroid properties and impact locations.
- Atmospheric entry, breakup, and resulting hazards (blast, thermal, tsunami, global effects) are modeled for each case.
- Probabilities of the resulting damage sizes, severities, and affected populations are computed.
- Regions at-risk to local damage are mapped.


HYPOTHETICAL EXERCISE

# Local Blast & Thermal Damage Effects

- Large impacts and airburst can generate destructive blast waves and thermal heat radiation that can cause various levels of injury, fatalities, structural damage, and/or fires extending far around the impact location.
- Blast and thermal ground damage are assessed *independently* at four equivalent severity levels
  - The damage region for each severity level is determined from the *larger* of the equivalent blast *or* thermal damage area
  - Local ground damage regions indicate *either* blast or thermal effects could exceed the given severity threshold (*not* necessarily the occurrence of both effects within the entire region)
  - Local affected population estimates within each region are scaled by the relative severity of each damage level
- Blast is the predominant hazard for most airbursting and sub-global-scale asteroid sizes
  - Blast tends to be larger and more severe than the potential thermal damage in most cases, and usually defines the larger outer damage risk regions for emergency response planning
  - Depending on blast energy, airbursts can cause larger blast damage than ground impacts, while thermal damage decreases with airburst altitude



| Damage Level | Relative Severity | Blast Damage Effects | Thermal Damage Effects |
|---|---|---|---|
| **Serious** | 10% | Shattered windows, some structural damage | 2nd degree burns |
| **Severe** | 30% | Widespread structural damage | 3rd degree burns |
| **Critical** | 60% | Most residential structures collapse | Clothing ignites |
| **Unsurvivable** | 100% | Complete devastation | Structures ignites, incineration |

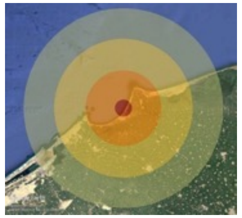

HYPOTHETICAL EXERCISE

# Affected Population Risks

- For each impact case modeled, PAIR computes the estimated number of people affected by each hazard type, based on the modeled damage location, area, severity, and local population
  - **Local blast & thermal ground damage:** affects 10–100% of local population depending on severity (additional details in following slides)
  - **Tsunami:** affects up to 10% of the local population depending on flood depth in each coastal area (based on tsunami wave height and ground elevation)
  - **Global effects:** affects estimated fractions of total world population, based on total impact energy and a randomly sampled severity factor
  - **Total affected population** estimates for each impact case are taken as the number of people affected by the largest hazard produced (not sums of multiple hazards)
- **Affected population risks:** population results for each impact case are aggregated to compute total population ***risks,*** reflecting the likelihoods of the possible effects for the overall impact scenario (i.e., probabilities of the impact affecting given ranges or thresholds of people)
- **Population data source:** SEDAC Gridded Population of the World (GPW) v4.11 gridded population counts, year 2020 UN-adjusted values

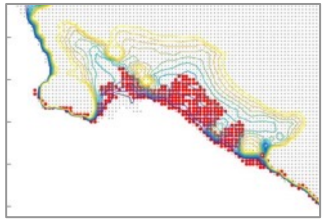
[PAIR model details: Wheeler et al., 2025

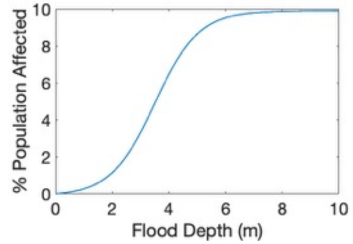
**Local Blast & Thermal Affected Population**



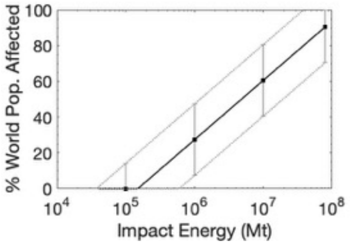
| Severity | % Pop. Affected |
|---|---|
| Serious | 10% |
| Severe | 30% |
| Critical | 60% |
| Unsurvivable | 100% |

**Tsunami Affected Population**





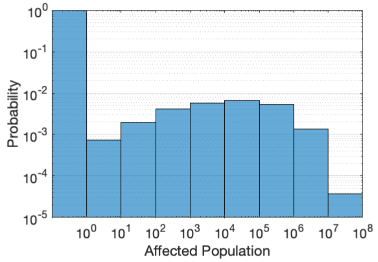

**Global Effects Affected Populations**




| Impact Energy (MT) | % Population Affected | | |
|---|---|---|---|
| | Min | Nominal | Max |
| 4.E+04 | 0 | 0 | 0 |
| 8.E+04 | 0 | 0 | 10 |
| 2.E+05 | 0 | 0 | 20 |
| 3.E+05 | 0 | 10 | 30 |
| 6.E+05 | 0 | 20 | 40 |
| 1.E+06 | 10 | 30 | 50 |
| 2.E+06 | 20 | 40 | 60 |
| 5.E+06 | 30 | 50 | 70 |
| 1.E+07 | 40 | 60 | 80 |
| 2.E+07 | 50 | 70 | 90 |
| 4.E+07 | 60 | 80 | 100 |
| 8.E+07 | 70 | 90 | 100 |

**SEDAC Gridded Population Data**

**Population Risks**



# ATAP Impact Risk & Hazard Modeling Papers


## Probabilistic Asteroid Impact Risk (PAIR) & Asteroid Characterization:

- **Wheeler et al., 2024.** Risk assessment for asteroid impact threat scenarios. Acta Astronautica. doi:10.1016/j.actaastro.2023.12.049
- **Dotson et al., 2024.** Consequences of asteroid characterization on the state of knowledge about inferred physical parameters and impact risk. Acta Astronautica. doi:10.1016/j.actaastro.2024.04.020
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