Properties of Decameter Earth Impactors

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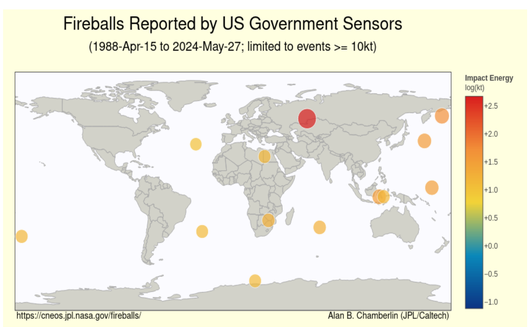
Why are decameter (~10m-size) impactors interesting?

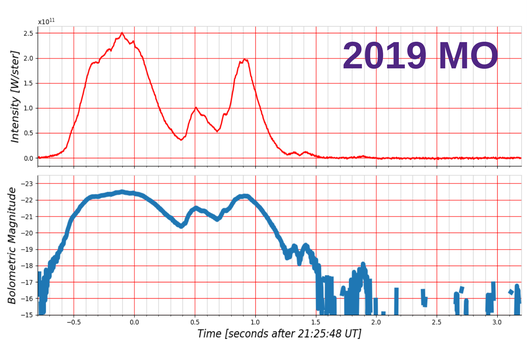
Main impact hazard – 1600 people injured in 2013 Chelyabinsk explosion

Previously classified US Government (USG) sensor data released in 2022

Scientific/ commercial (in-situ resource utilization) interest

Size range where there are both telescopic surveys of near-Earth objects (NEOs) and fireball observations of Earth impactors



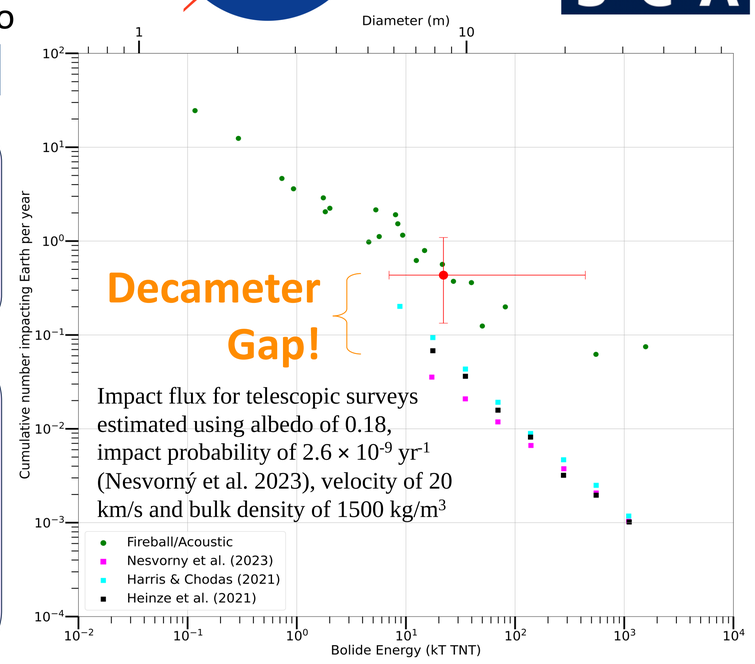


Telescopic surveys: ~**20-40 years**

USG satellites: ~**2-3 years**

Much higher impact rate than expected from telescopic surveys!

Tidal disruption of a larger body? (e.g. Nesvorný et al. 2023)



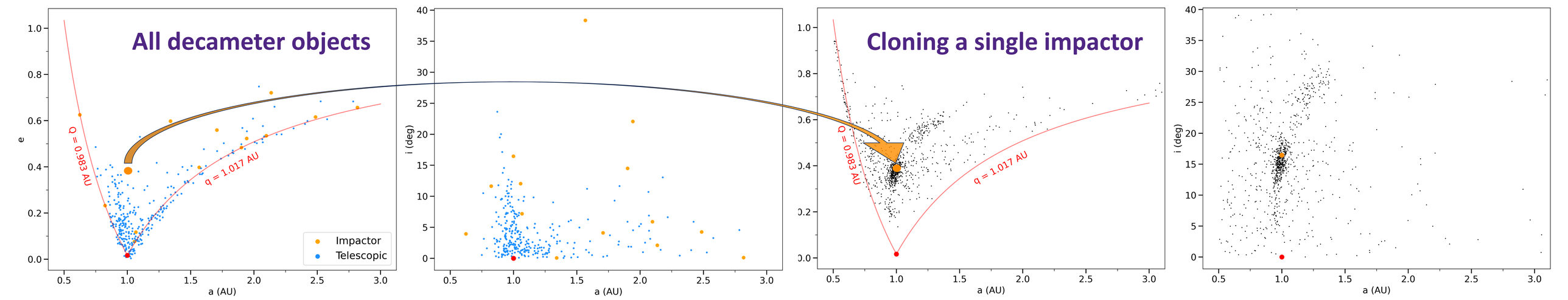
Estimating orbital uncertainties

Use a calibrated set of all 18 fireballs observed both by ground-based telescopes and USG sensors

Generate distributions for speed and radiant uncertainty using calibrated fireball data

Sample 1000 Monte Carlo "clones" of each decameter impactor from estimated speed/radiant uncertainty distributions

Compute orbits



Big Questions

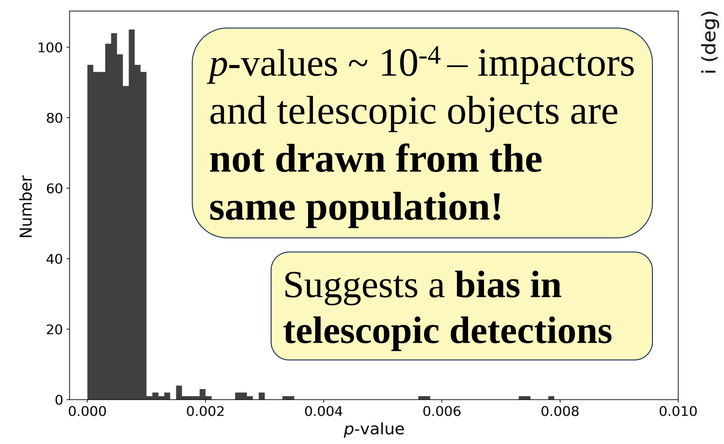
Are the orbits of decameter impactors similar to telescopically observed NEOs?

Where do decameter-sized asteroids originate from in the asteroid belt?

Could recent (<10^4 yrs) tidal disruption explain the impact rate discrepancy?

Orbital Similarity

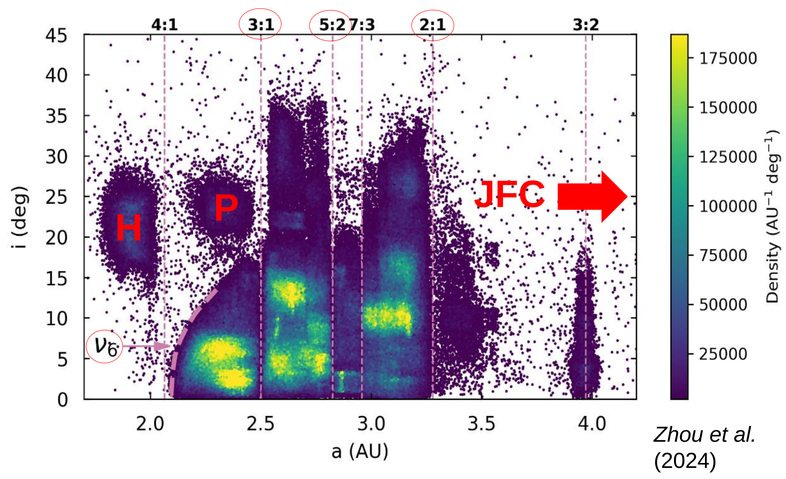
Compare 3-D *a*, *e*, *i* distribution of cloned impactors and telescopic orbits using a multivariate Kolmogorov-Smirnov test



p-values ~ 10^{-4} – impactors and telescopic objects are **not drawn from the same population!**

Suggests a **bias in telescopic detections**

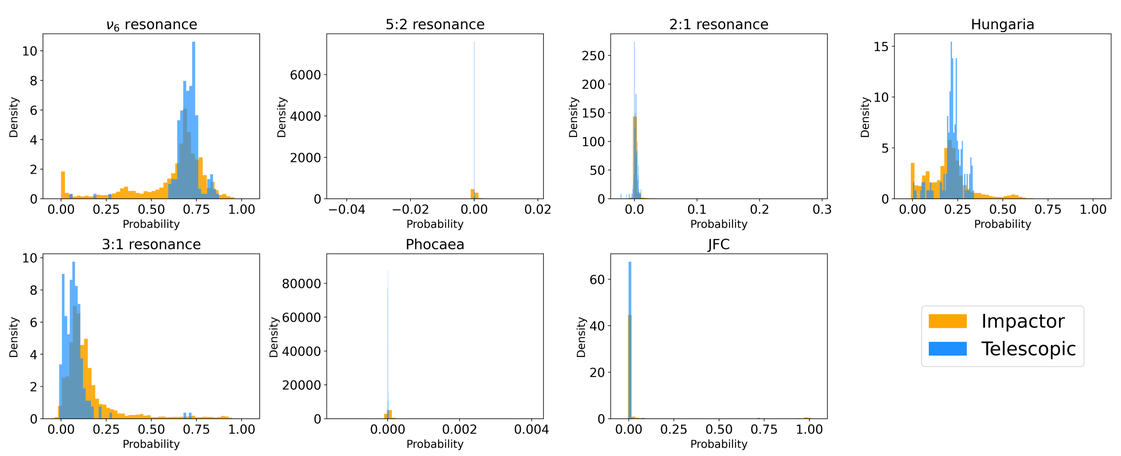
Source Regions



Probabilistically determine all object (incl. clones) source regions using 4-D *a*, *e*, *i*, *H* model of Granvik et al. (2018)

7 source regions: ν_6 secular resonance, 3:1, 5:2, 2:1 Jupiter MMR, Hungarias, Phocaeas, Jupiter-family comet (JFC)

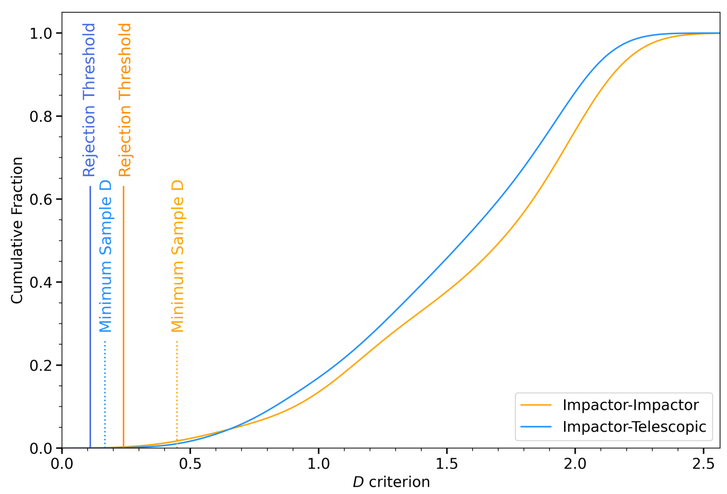
Decameter impactors and telescopic NEOs originate from similar source regions!



Impact Discrepancy

Quantify similarity of two orbits using *D* criterion to determine recent physical association (i.e. tidal disruption) – lower *D* value means the orbits are more similar

D(i, i) and D(i, t) above rejection limit for all impactors i and telescopic objects t



Recent tidal disruption not supported!

Conclusions

Orbits of decameter impactors are distinct from telescopically observed NEOs – suggests a bias in telescopic detections

Decameter impactors and telescopic NEOs have similar origins – mostly from the ν_6 complex with some contribution from the 3:1 Jupiter MMR and the Hungaria family

Recent tidal disruption is not supported as the cause of the impact rate discrepancy

Decameter objects originate from **inner main asteroid belt – primarily the ν_6 secular resonance with small contributions from 3:1 J MMR and Hungarias**

Decameter objects are likely to be stony S/V type asteroids rather than carbonaceous C/D type