OSIRIS-REx
Activity Presentation

Bennu craters in the context of planetary defense

Beau Bierhaus

Lockheed Martin Space

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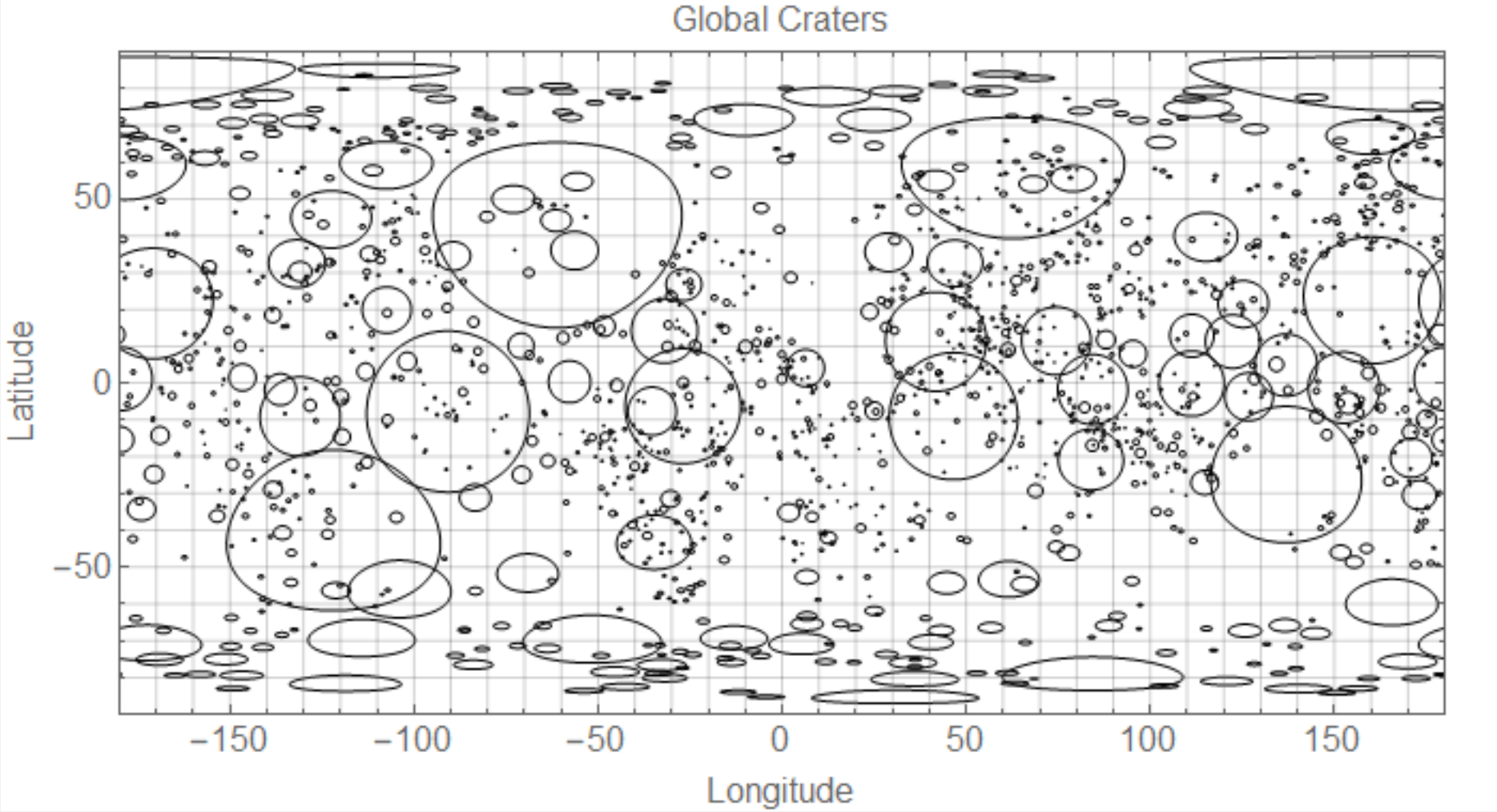
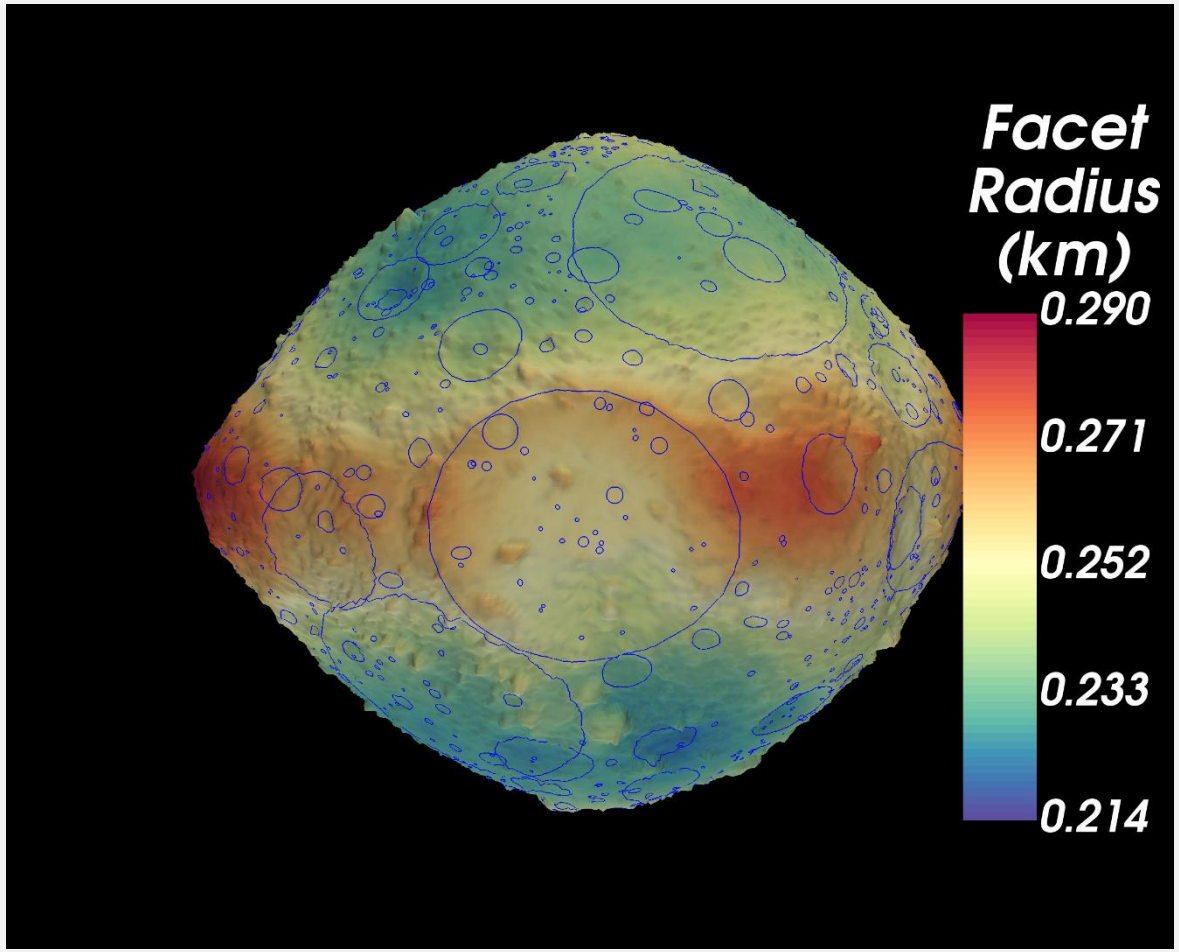
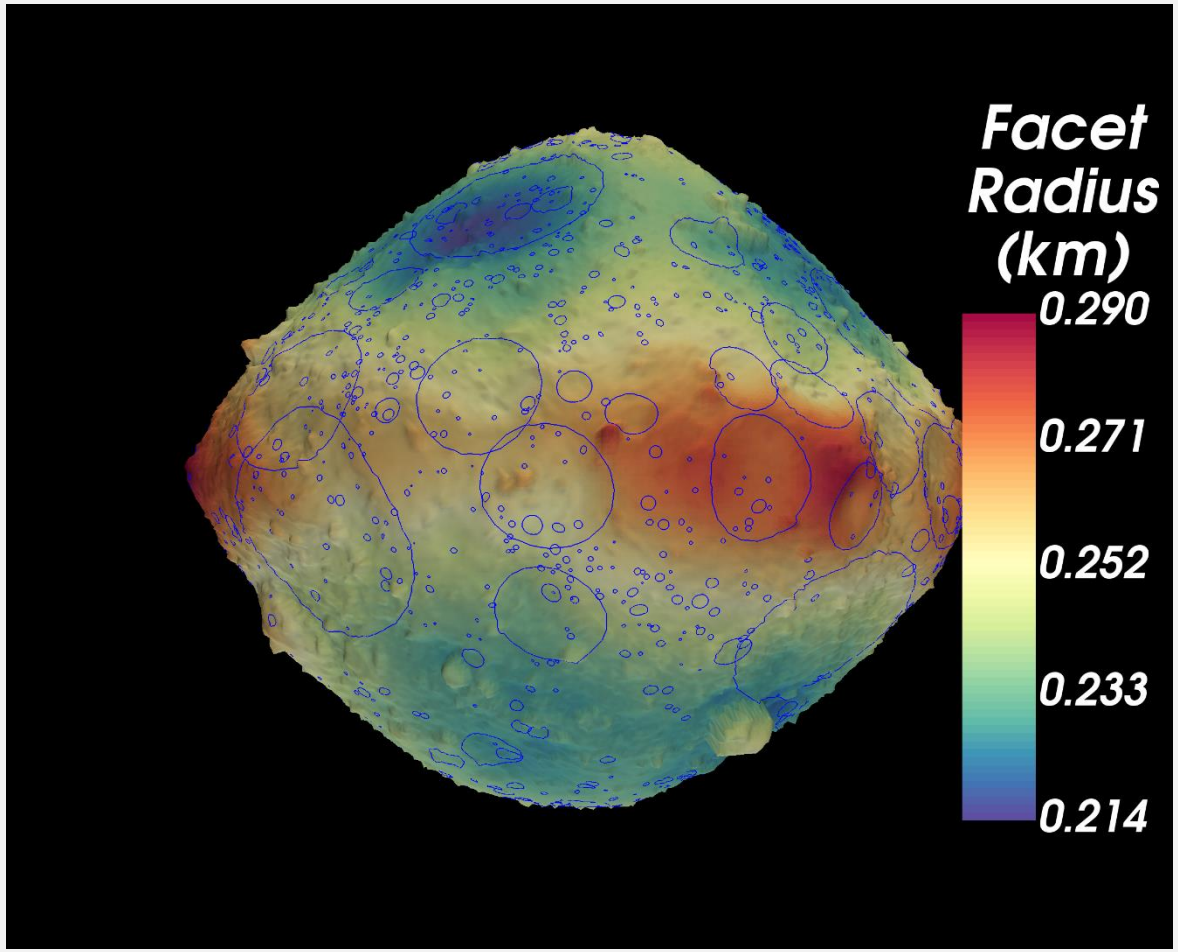
Bennu's craters

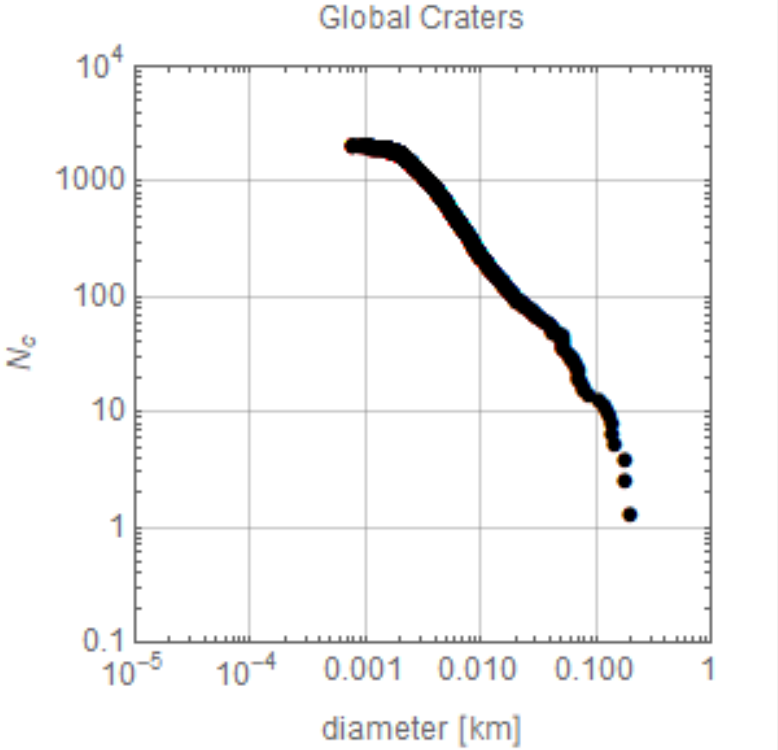


Projected on the shape model

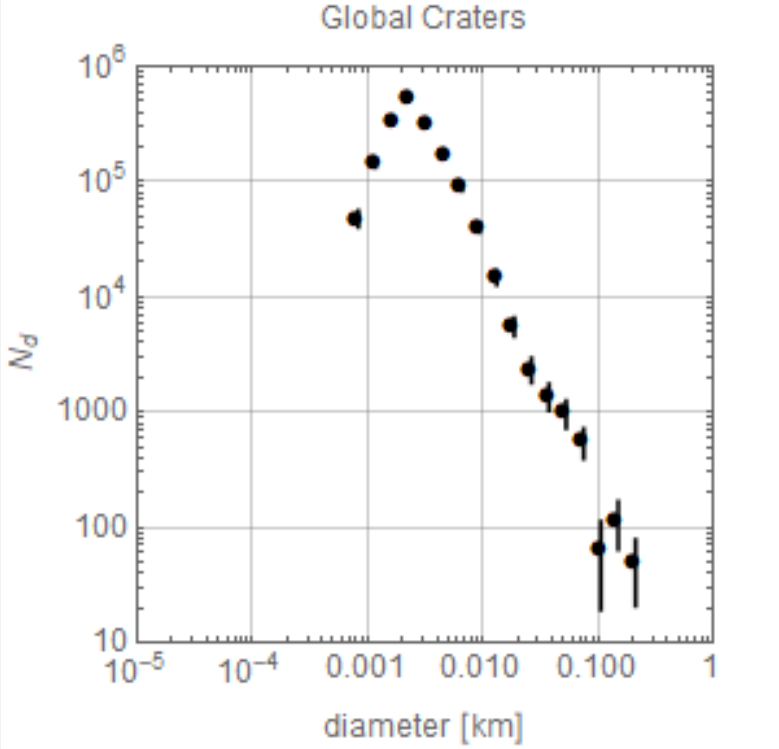




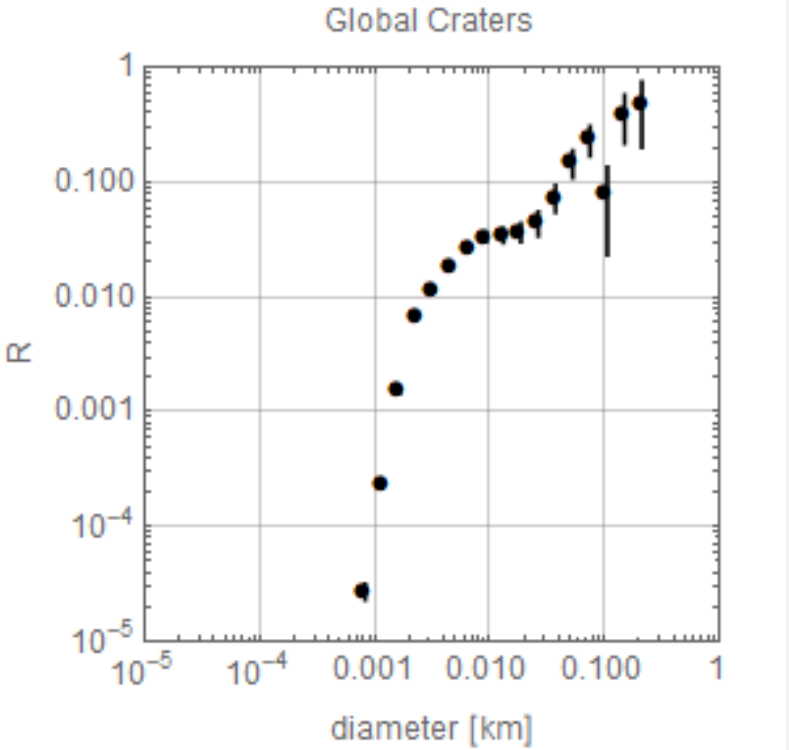
Crater SFD



cumulative



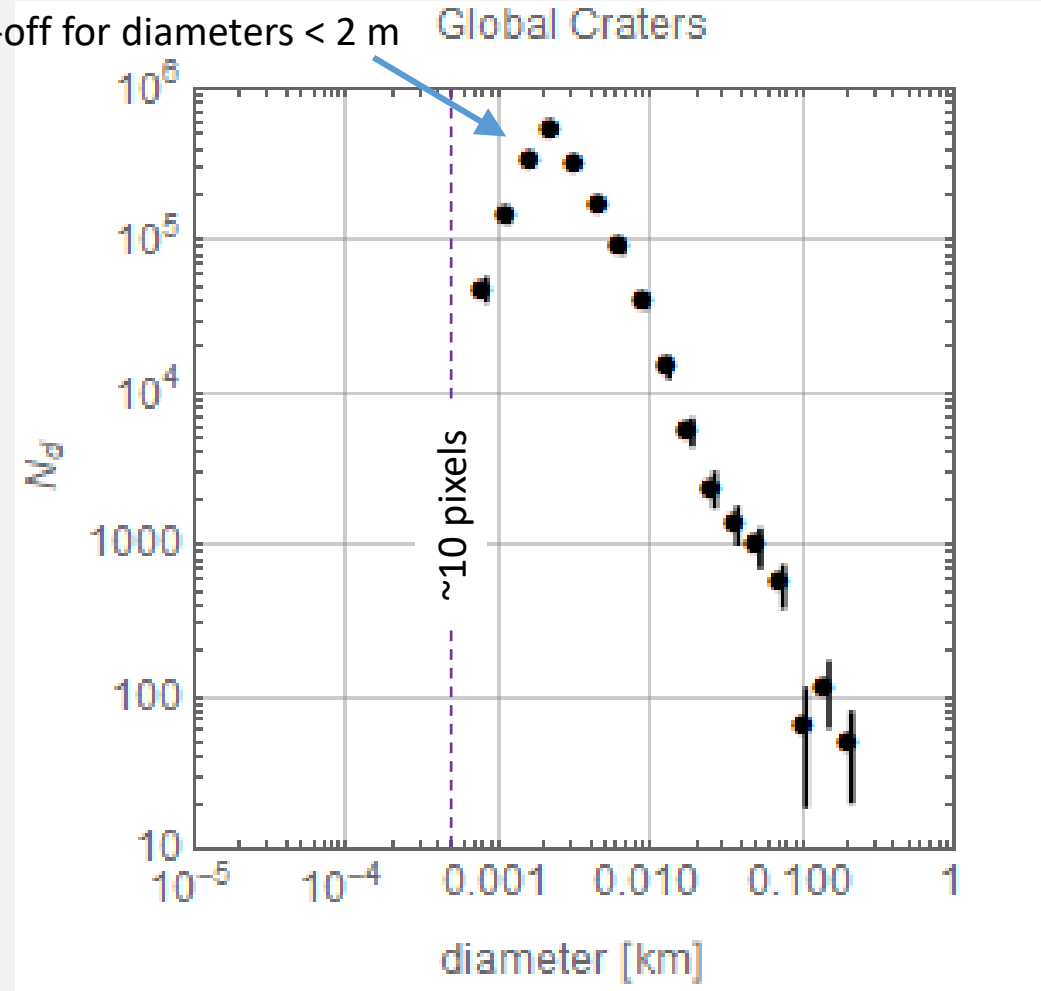
differential



Relative

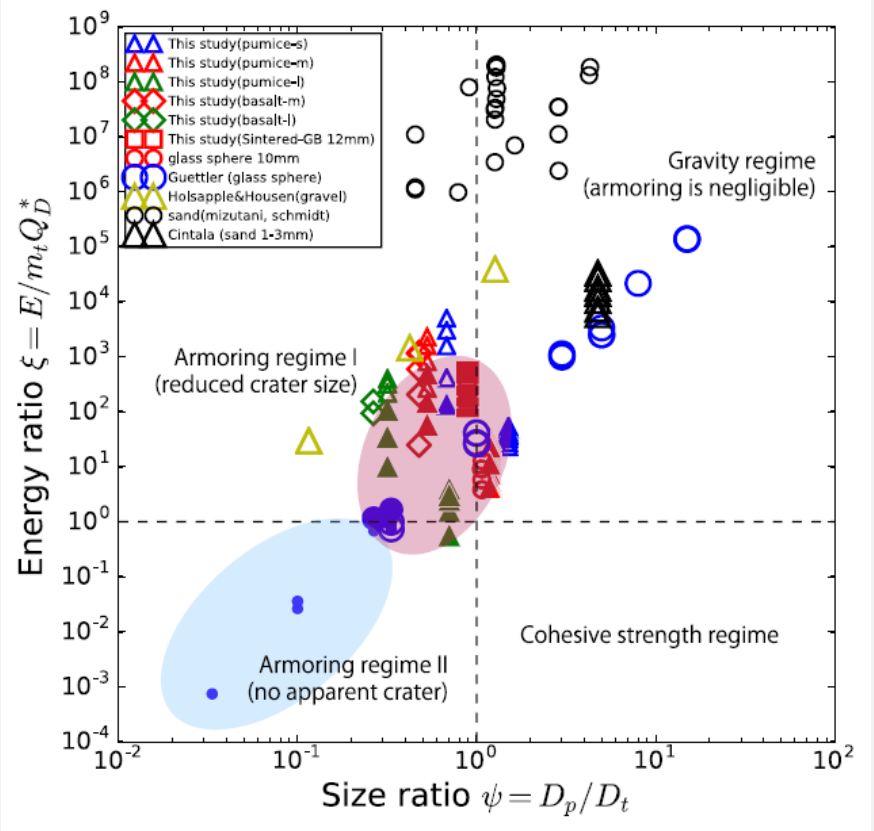
Completeness . . . or not ?!

- The rapid fall-off at diameters < 2 m typically would be a sign of the completeness limit (decreasing ability to sample population because of finite image resolution)
- However . . .
- 2 m corresponds to 40 pixels (!) in the detailed survey images, which are typically ~5 cm/pix
  - This is well above typical completeness limit values of 5-10 pixels
- **The roll-over is a real observation, and not a completeness-limit effect!**



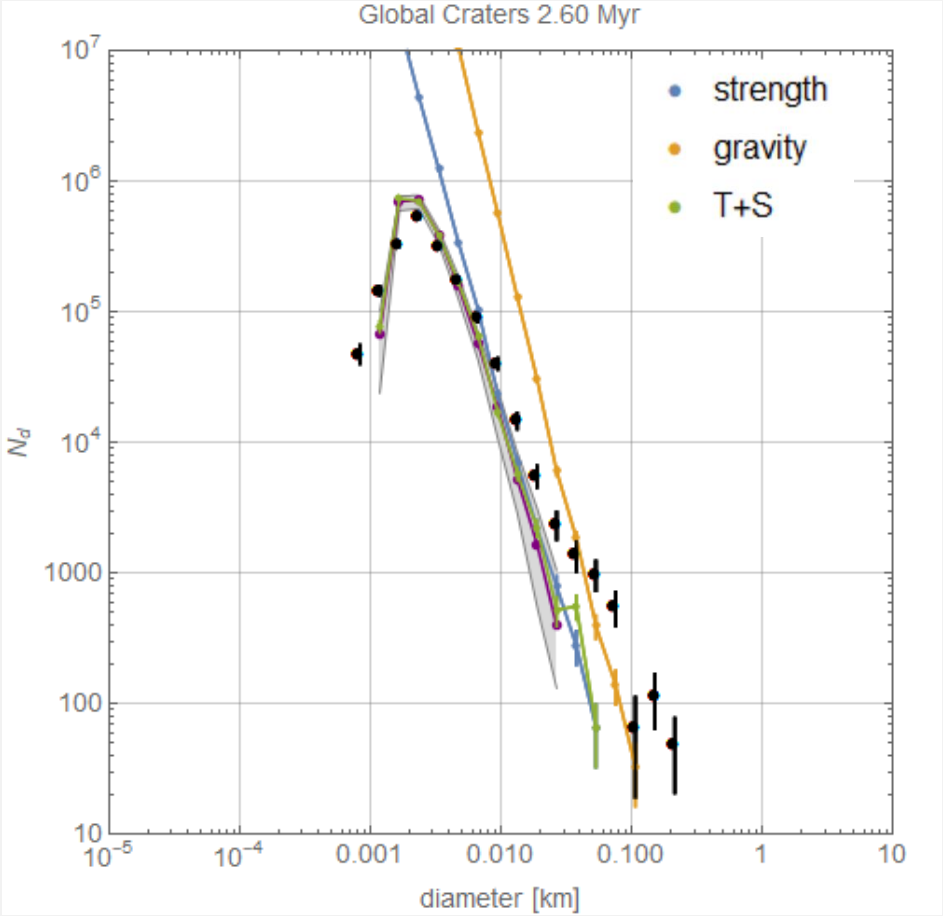
Impact armoring

- Tatsumi and Sugita (2018) [TS2018] conducted a series of experiments that elucidated an “impact armoring” behavior
- Occurs when the impactor size is comparable to the average grain size of the target surface
- They updated standard crater-scaling relationships to include this armoring effect
- We implemented simulations to apply TS2018 scaling to Bennu



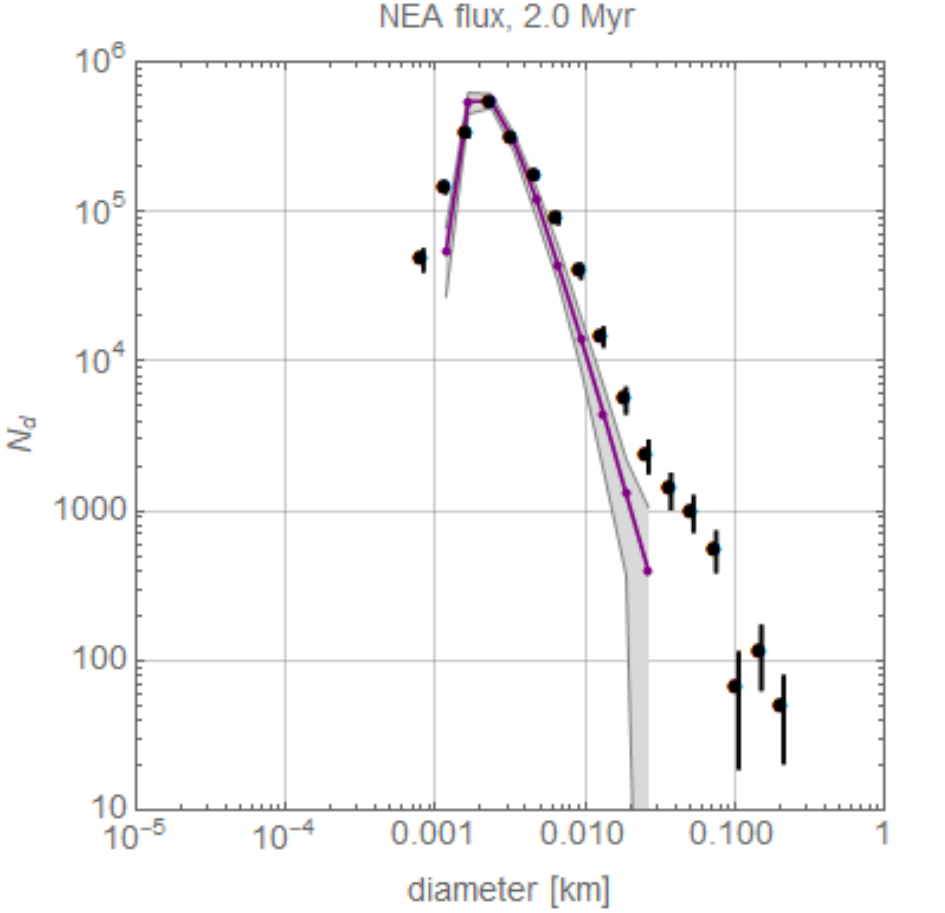
Tatsumi and Sugita (2018), Figure 17

Model results compared with the observations



- **Black** data = Bennu observations
- **Purple** data = median of 100 simulations for 2.6 Myr NEA flux, using TS2018 scaling
- **Gray** band = 99% range of modeled outcomes
- **Orange** = gravity scaling
- **Blue** = strength scaling
- **Green** = a single run of TS2018 scaling
- TS2018 scaling matches the “fish hook” of the differential SFD

Another look, comparison with TS2018 only



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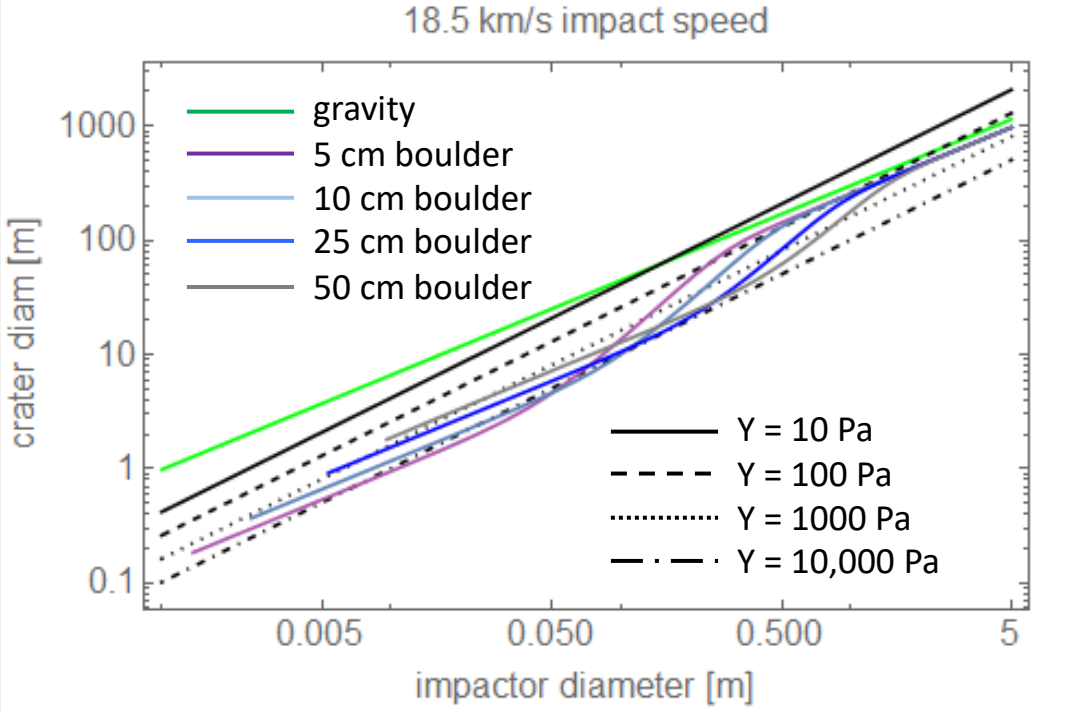
Armoring is like a strength value in crater-scaling relationships for smaller impacts

- Plot is crater size vs. impactor size for strength, gravity, and TS2018 scaling
  - Single **green** line for gravity
  - **Black** lines are different strength values
  - Other colors are TS2018 for different target boulder sizes
- TS2018 results span a range of 10^3 Pa in strength for small impactor sizes and boulder sizes



Consequences for planetary defense

- On a rubble-pile asteroid the same projectile will have different outcomes depending on the size of the target boulder
  - The impact energy may be transmitted to the bulk object efficiently, or
  - The impact energy may be dissipated largely by disrupting a boulder
- An important consideration for the DART mission: is it possible to determine the size of the boulder(s) that reside at the impact point?
- Any impact-deflection mission should consider the outcome variability introduced by the size of the target boulder