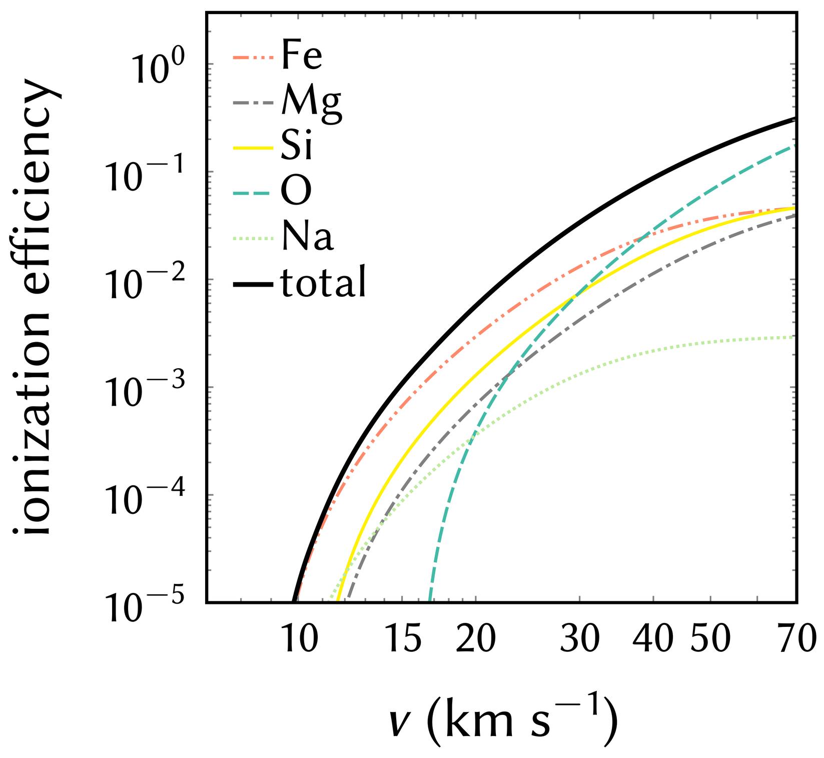
The velocity and density distribution of Earth-intersecting meteoroids: implications for environment models

Introduction

- Meteoroid environment models describe population characteristics such as speed, directionality, and density.
- We revise the speed distribution using radar meteor observations and a modern treatment of the ionization efficiency.
- We revise the density distribution based on a study of optical meteors that uses T_J as a proxy.
- Both corrections affect the relative importance of sporadic sources for *in situ* experiments.

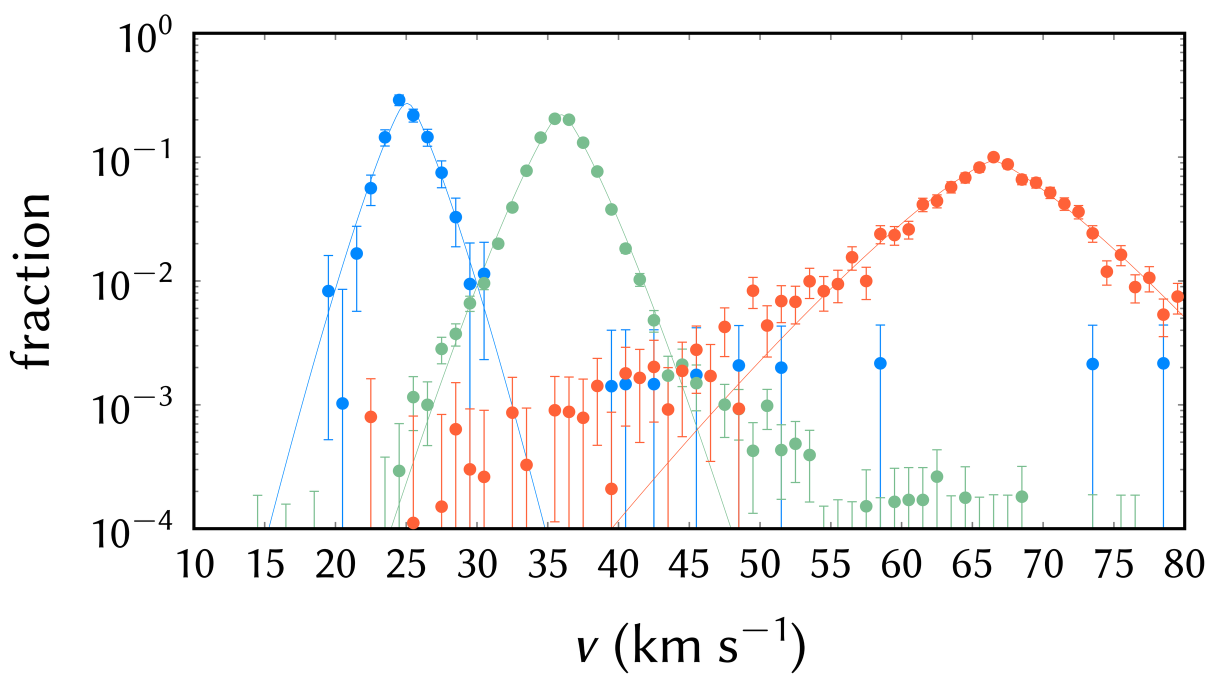
Velocity de-biasing

- Meteor ionization increases with speed, and does not occur below $v_0 \sim 9$ km s^{-1}.
- Detections are complete to smaller masses at higher speeds, producing bias.
- We use the Jones ionization efficiency [1, 2] to de-bias the radar meteor speed distribution [3].

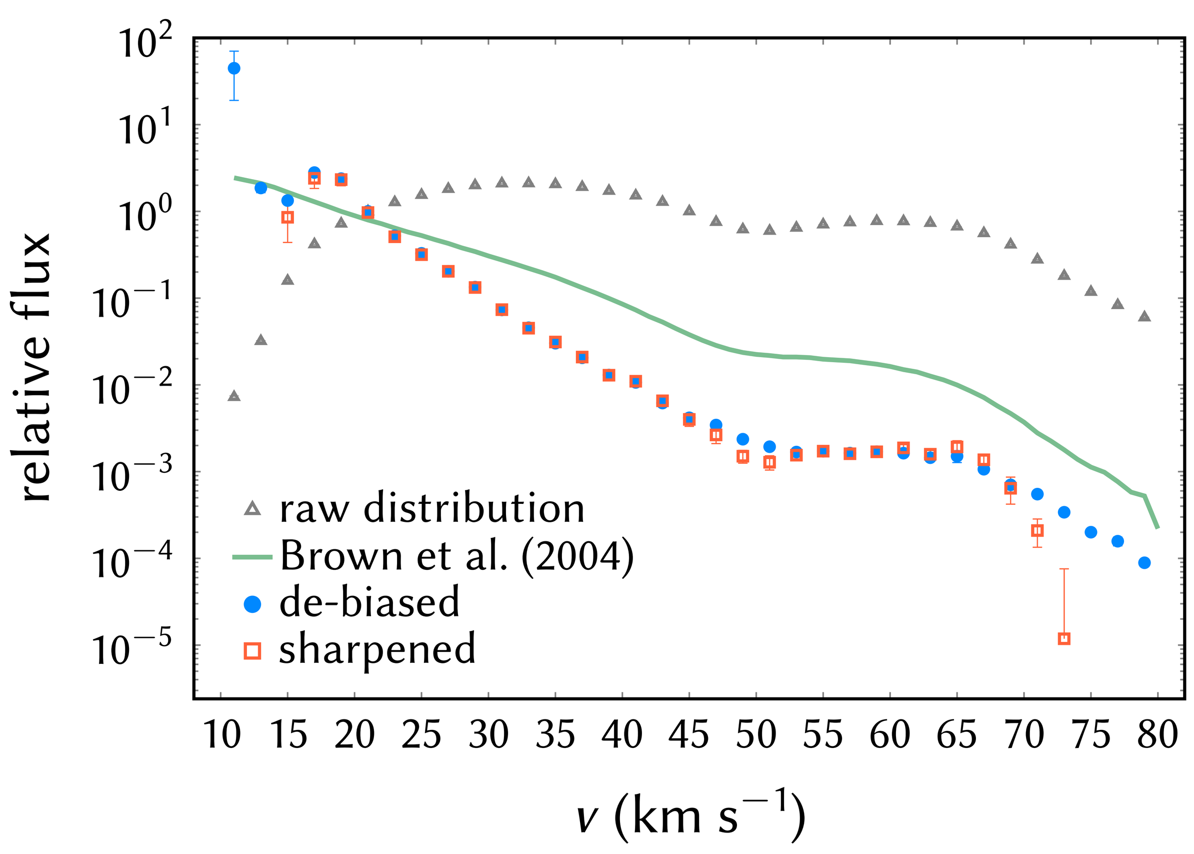


Velocity "sharpening"

- Measurement uncertainties "smear" the speed distribution like a point-spread function blurs images.
- We used meteor showers to characterize this effect:



- We inverted this filter to sharpen the observed top-of-atmosphere speed distribution. The sharpened distribution naturally lacks "hyperbolic" meteors as well as those slower than 14 km s^{-1}.
- The spike in slow meteors is removed from the speed distribution:



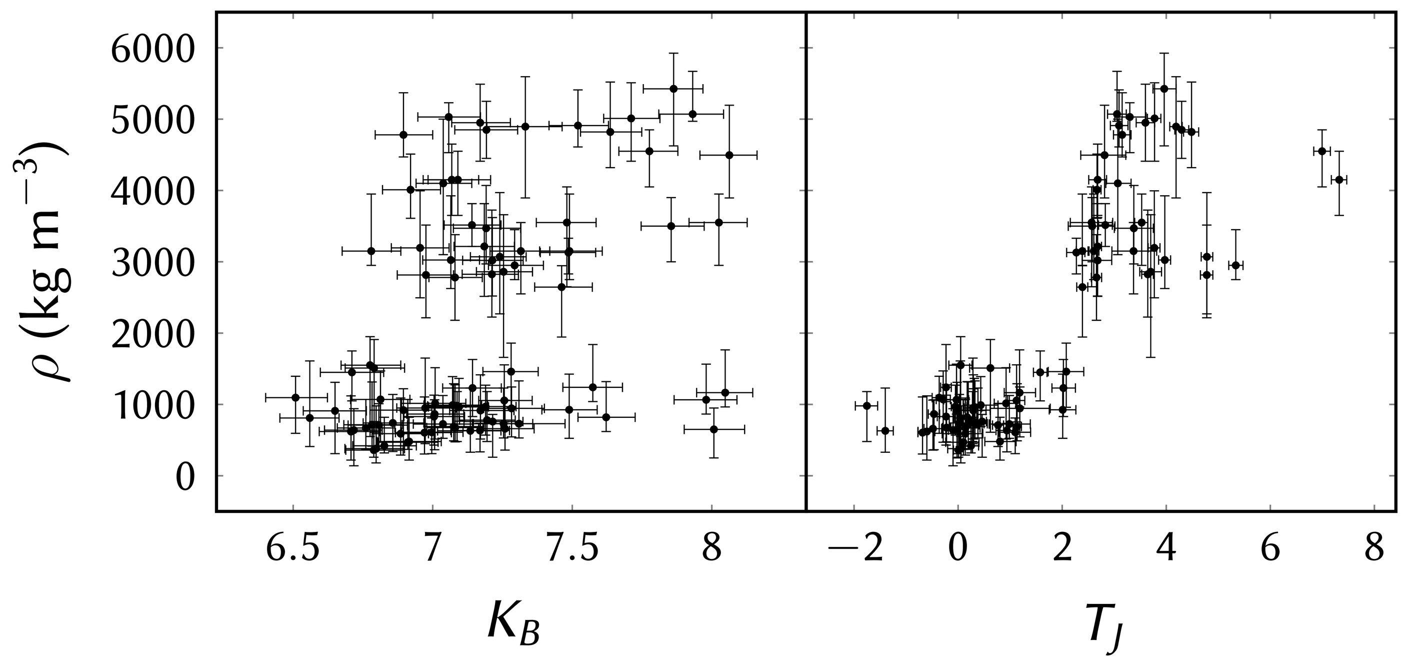
References

[1] Jones W., 1997, *MNRAS*, **288**, 995-1003
[2] Thomas E., 2016, *GRL*, **43**, 3645-3652
[3] Moorhead A. et al., 2017, *P&SS*, accepted
[4] Ceplecha Zd., 1958, *BAICz*, **9**, 154-159
[5] Kikwaya J.-B. et al., 2011, *A&A*, **530**, A113

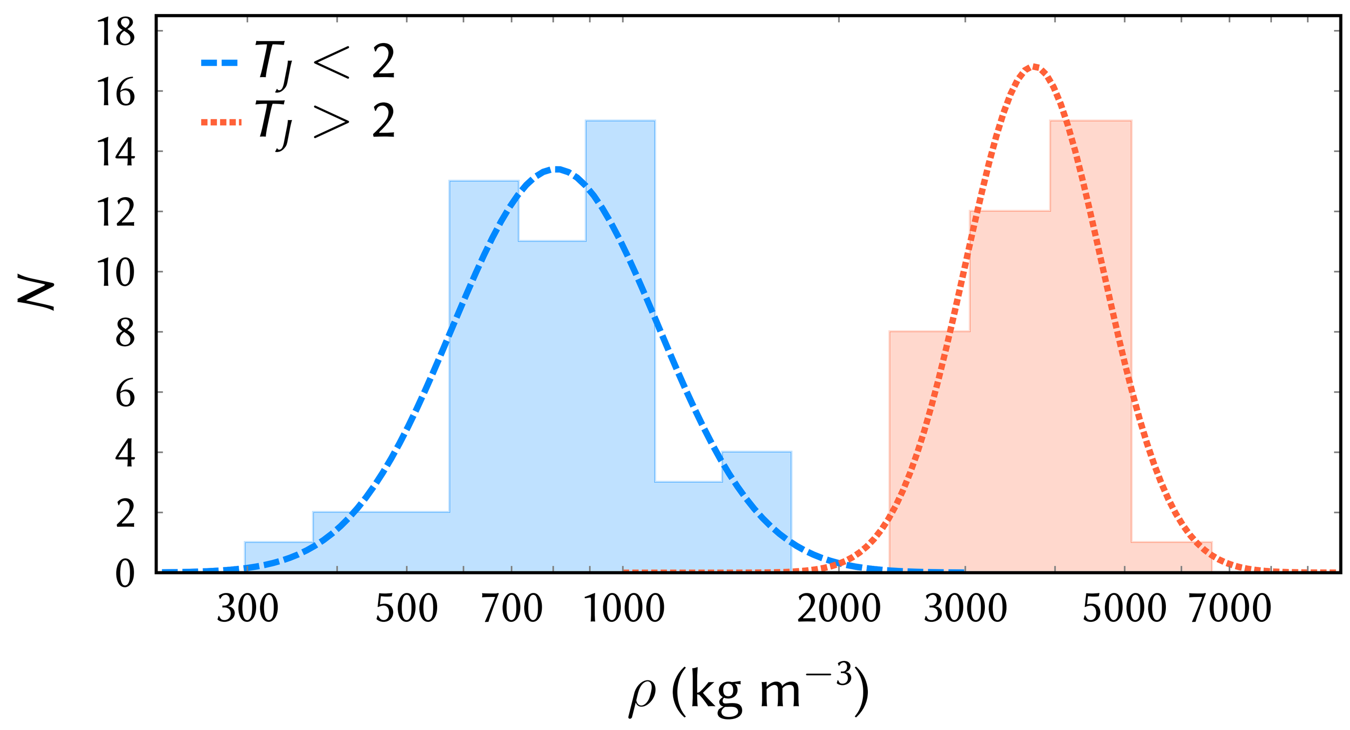
This work was supported in part by NASA Cooperative Agreement NNX11AB76A and by the Natural Sciences and Engineering Research Council of Canada.

Density distribution

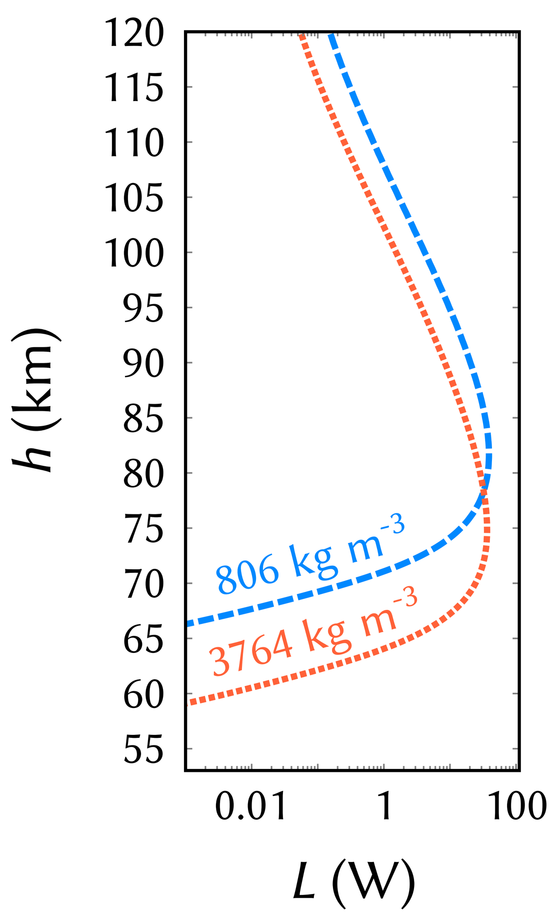
- K_B (a classification based on meteor start height [4]) was not a good proxy for density in any data set we examined



- T_J served as a good proxy for density in one study [5]; we fit two log-normal distributions to these data.
- High density = helion and antihelion meteoroids
  Low density = apex and toroidal meteoroids



Effect of density on observations and models



- Density does not affect peak brightness (L); denser meteors simply peak at lower heights (see plot).
- Impact crater depth *does* depend on ρ:

$$\text{depth} \propto \rho^{4/27}$$

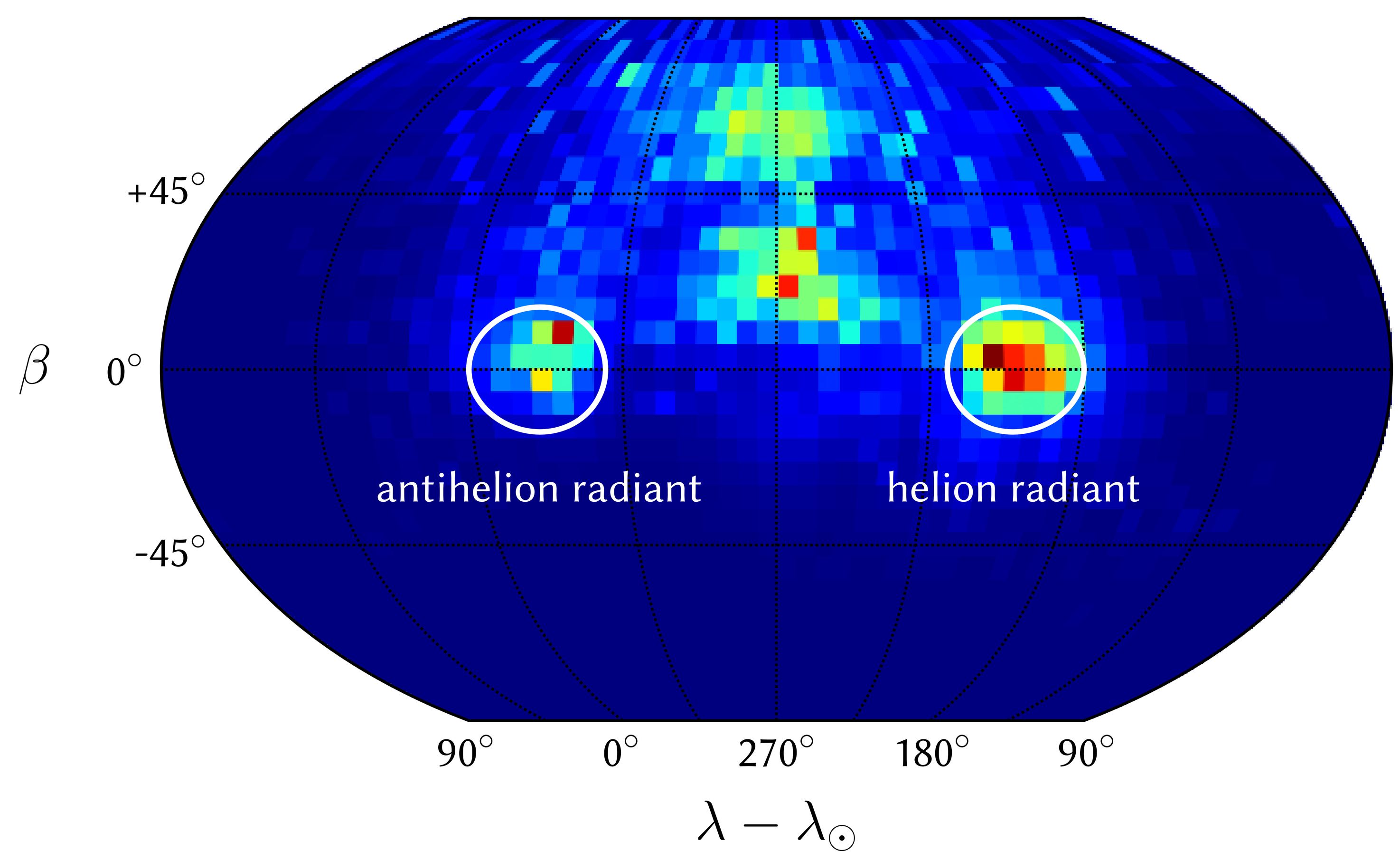
- Ratio of radiation pressure to gravity also depends on ρ:

$$F_r / F_g \propto \rho^{-2/3}$$

- Density affects the conversion of β-limited to mass-limited distributions, or mass-limited to crater-limited distributions.

Crater-limited radiant distribution

The de-biased radiant distribution is dominated by the helion and antihelion sources. We predict up to 93% of impact craters (vs. 38% of radar meteors) are produced by helion and antihelion meteoroids.



A.V. Moorhead,[1] P.G. Brown,[2] M.D. Campbell-Brown,[2] D.E. Moser,[3] R.C. Blaauw,[4] W.J. Cooke[1]
althea.moorhead@nasa.gov
[1]NASA Meteoroid Environment Office, Marshall Space Flight Center, USA, [2]Dept. of Physics and Astronomy, Univ. Western Ontario, London N6A3K7, Canada
[3]Jacobs, ESSSA Group, MSFC, Huntsville, Alabama 35812, USA, [4]All Points Logistics, Jacobs ESSSA Group, MSFC, Huntsville, AL 35812, USA