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

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Meteoroids are known to damage spacecraft: they can crater or puncture components, disturb a spacecraft's attitude, and potentially create secondary electrical effects. Because the damage done depends on the speed, size, density, and direction of the impactor, accurate environment models are critical for mitigating meteoroid-related risks. Yet because meteoroid properties are derived from indirect observations such as meteors and impact craters, many characteristics of the meteoroid environment are uncertain. In this work, we present recent improvements to the meteoroid speed and density distributions.

Our speed distribution is derived from observations made by the Canadian Meteor Orbit Radar [1]. These observations are de-biased using modern descriptions of the ionization efficiency [2,3]. Our approach yields a slower meteoroid population than previous analyses (see Fig. 1 for an example) and we compute the uncertainties associated with our derived distribution [5].

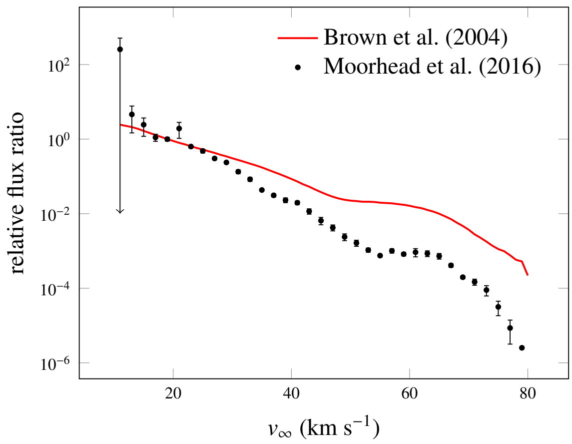

Figure 1. The top-of-atmosphere meteoroid speed distribution observed by CMOR, de-biased using two different methods [4,5].

We adopt a higher fidelity density distribution than that used by many older models. In our distribution, meteoroids with $T_J < 2$ are assigned to a low-density population, while those with $T_J > 2$ have higher densities (see Fig. 2). This division and the distributions themselves are derived from the densities reported by Kikwaya et al. [6].

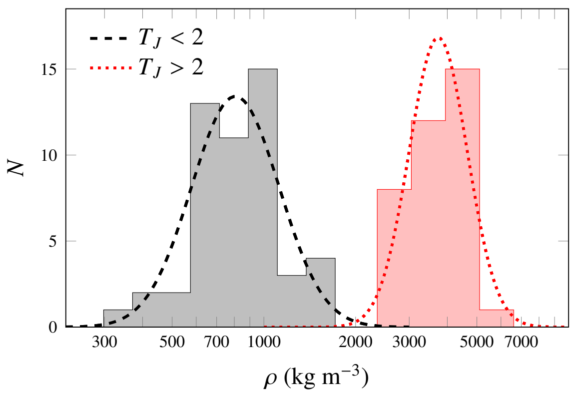

Figure 2. A two-population density distribution derived from Kikwaya et al. [6].

These changes have implications for the environment: for instance, the helion/antihelion sporadic sources have lower speeds than the apex and toroidal sources and originate from high-T_J parent bodies. Our on-average slower and denser distributions thus imply that the helion and antihelion sources dominate the meteoroid environment even more completely than previously thought [7]. Finally, for a given near-Earth meteoroid cratering rate [8,9], a slower meteoroid population produces a comparatively higher rate of satellite attitude disturbances.

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

References:
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