Asteroid to Airburst; Comparing Semi-analytical Airburst Models to Hydrocodes

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Near-Earth Objects, 1-100 m in size, are abundant, difficult to observe, and strike the Earth with little to no warning [1]. There is likely to be at least one significant event in a human lifespan (e.g. Chelyabinsk, Tunguska), so being able to model their potential energy deposition and damage on the ground accurately is imperative. Semi-analytical models are a fast predictors of energy deposition, but they make many assumptions and have several free parameters that are poorly defined [2-4]. These parameters are usually tuned to fit a particular data set, such as the 2013 Chelyabinsk event in Russia [4]. In previous work, we showed that it is possible to tune multiple different semi-analytical models to match the Chelyabinsk energy deposition [5], however, when these same models are then applied to a different event, such as Tunguska, the results diverge [6]. Moreover, all of the existing semi-analytical models in popular use predict unphysically large spreading limits, several times greater than the initial asteroid diameter, which raises concerns about their predictive capacity.

Shock physics codes rely on fewer simplifying assumptions but have a higher computational cost than semi-analytical models. Here we use the iSALE shock physics code [7-9] to simulate the atmospheric entry of meteoroids. We consider the effect of asteroid strength and porosity on the rate of deceleration and spreading. From our simulation results, we produce synthetic energy deposition curves with known initial entry conditions. This provides an additional data set with which to calibrate existing semi-analytical models and develop new approaches for the fast prediction of airburst outcomes necessary for probabilistic hazard assessment or rapid decision making.

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