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Sensitivity to Uncertainty in Asteroid Risk Assessment

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Abstract

A Probabilistic Asteroid Impact Risk (PAIR) model [1] was developed to quantify impact risk posed by an ensemble asteroid population, to study risk drivers in impact scenarios, and to examine sensitivity to uncertainty in impactor knowledge and modeling approaches. PAIR consists of a Monte Carlo framework that simulates hypothetical impact scenarios by sampling from uncertainty distributions that describe input parameters: density, Earth impact velocity, aerodynamic strength, impact angle and location. Each scenario consists of a unique combination of inputs that serves as the initial conditions for the atmospheric entry model. The flight trajectory is integrated using the fragment-cloud model (FCM) developed by Wheeler et al. [2]. FCM produces an energy deposition curve, resulting from the conversion of pre-entry kinetic energy into thermal radiation, atmospheric pressure/winds, and melt/vaporization of the object surface. The energy deposition curve is then used to estimate the ground damage associated with the scenario. FCM includes the effects of thermal ablation and fragmentation during the entry process. In Mathias et al. [1] the energy deposition curves were used to assess the local damage due only to blast overpressure and thermal radiation.

In the current study, this analysis is extended to consider impact scenarios larger than those causing only local damage, but smaller than those causing global extinction. In particular, we will consider the additional risk due to asteroid generated tsunami as well as the onset of so-called global effects (GE) due to ejecta in the atmosphere. In the ensemble assessment, it is shown that the local damage dominates the risk up to the energy regime at which GE start to manifest, and beyond this transition energy, GE dominate in spite of the long times between impacts. Unfortunately, the existing GE models appropriate for Monte Carlo risk assessment approaches are ad-hoc and driven by simplifying assumptions.

In this work, the sensitivity of impact risk results to model uncertainty is compared with uncertainties attributed to the state of knowledge about an impactor. It is shown that this sensitivity varies with object size. We then compare these results to those attained using variations in modeling the onset of GE.

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References

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[2] Wheeler, L., Mathias, D. and Register, P.: A fragment-cloud model for asteroid breakup and atmospheric energy deposition, Icarus, Vol. 295, pp. 149-169, 2017.