Advancing Asteroid Threat Assessment

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NASA's Asteroid Threat Assessment Project (ATAP) develops a range of models, simulations, and characterization tools geared toward advancing asteroid impact risk assessment capabilities for planetary defense. At the core of these capabilities is the Probabilistic Asteroid Impact Risk (PAIR) model, which combines fast-running analytic and semi-analytic models of asteroid entry and damage in a Monte Carlo framework to assess the risk posed by asteroids with uncertain properties and characteristics. To efficiently model the atmospheric entry and breakup for these diverse asteroid populations, ATAP has also developed the Fragment-Cloud Model, which represents the breakup process using a combination of discrete fragmentations and expanding debris clouds. This approach enables the model to produce a range of energy deposition characteristics, which can both capture uncertainty in airburst behavior for probabilistic risk assessment, and can also match detailed features of observed meteor light curves to study breakup behavior or infer pre-entry asteroid properties.

To anchor and refine these models, the ATAP team performs a spectrum of high-fidelity simulations and experiments, focused on providing greater insight into key entry and damage physics that drive impact risk or uncertainty levels. These efforts include: CFD blast propagation simulations, which have been used to improve upon nuclear-based height-of-burst maps for blast footprint prediction; hydrocode simulations of entry with different material properties, tsunami wave formation for ocean impacts, and ejecta from large-scale impact cratering to evaluate potential global effects; coupled multiphysics radiation simulations to refine ablation coefficients and luminous efficiency parameters for thermal damage models and meteor inference studies; multi-body hypersonic flow experiments; and Arcjet testing of the ablation and meltflow properties of various meteorite and terrestrial material samples.

Additionally, to expand and leverage current knowledge of asteroid properties, the ATAP project runs a meteorite laboratory and hosts an online data warehouse of asteroid properties and meteorite physical properties. This growing data then feeds Bayesian inference models that are being developed to generate data-driven asteroid property distributions and correlations for probabilistic risk assessments. Another recent effort is using Geostationary Lightning Mapper (GLM) sensor data from a pair of GOES satellites to detect bolide events and expand the availability of bolide light curve data for research.

Together, these characterization, simulation, and risk modeling capabilities support a number of planetary defense objectives, including ensemble risk assessments to guide NEO survey goals, risk assessment for specific impact scenarios and exercises, risk-informed design support for mitigation missions, and risk sensitivity studies to prioritize model refinement or research. This talk presents an overview of the ATAP project's current work and ongoing efforts to advance key assessment capabilities.