EVALUATING FIDELITY OF EMPIRICAL ENERGY RELATIONS FOR DETERMINING BOLIDE ENERGY DEPOSITION AND IMPLICATIONS FOR IMPACT HAZARD.

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Introduction: Meteoroids in the size range of up to several tens of meters in diameter are one of the least constrained populations in the Near-Earth environment. This is because these objects are not abundant enough, and too small to be readily detected via optical means. However, meteoroids in this size range may present a significant hazard if they impact the atmosphere [1], as exemplified by the spectacular breakup of the Chelyabinsk bolide over Russia in 2013 [2]. These objects deposit tremendous amounts of energy during their passage through the atmosphere and during the catastrophic breakup, also known as airburst [3]. Therefore, it is important to study energy deposition and destructive potential of these objects. The estimates of energy deposition of bolides is typically obtained through observations of light emissions (e.g. from space [4] and ground), and from infrasound (low frequency acoustic wave) records. Infrasound is a product of shock waves generated by meteoroids as they interact with the atmosphere [3,5,6]. Most empirical energy relations relying on infrasound records were originally developed for estimating yield of nuclear and chemical explosions, and later adopted for bolide energy estimates [6-7]. However, the recurring issue is that various relations produce very different results, making accurate predictions of energy deposition difficult. We evaluate the fidelity and consistency of various energy relations based on infrasound records, with the goal to better understand how these vary and what the implications are for our current knowledge of bolide properties.

Methods: In our systematic and detailed study, we use well-documented and well-characterized published bolide records, and apply various energy relations developed over the years [7] to compare and evaluate the outcomes, and establish the implications for impact hazard. We perform additional analyses to quantify the potential damage, which will be presented in more detail through a future publication. We also compare our results to energy deposition estimates determined through space based sensor data to better constrain the validity of various energy relations and evaluate the applicability to observations where only infrasound records might be available.

Summary: When a large extra-terrestrial object enters the Earth's atmosphere at hypervelocity, it produces a shock wave. The shock induced phenomena can cause damage on the ground to both life and infrastructure. Oftentimes, infrasound observations of bolides might be the only means of detections (e.g. daylight events and events over remote regions) [7,8], and determining the object properties (such as size) might be obtainable only through such records. However, applying various empirical energy relations might lead to contradicting results, making it difficult to constrain bolide properties and accurately evaluate energy deposition. Thus far, to the best of our knowledge, no study has compared all known energy relations in the context of bolide class impacts in order to better constrain how these relations might affect our present knowledge of energy estimates and impact hazard.

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