INSIGHTS INTO IMPACT-CLASSIFICATION SCHEME BASED ON THE FIREBALL ANALYSIS.

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Introduction: It is widely accepted by the scientific community that near-Earth object (NEO) impacts represent a long term global threat to the collective welfare of humanity. Such impacts have occurred much more frequently in the past. Earth would be heavily cratered if it did not have its geologically active lithosphere, and the atmosphere that effectively shields the planet from all but the larger meteoroids and asteroids. Solving a problem of estimating risks associated with low-probability high-impact bolide events is often desicionaly postponed due to the lack of evidence that such impact would occur 'soon' – if so, there considered to be no necessity to map it in the next years of global political and economical developments. However, while the likelihood of a globally threatening event is low, the statistical expectation (i.e., the product of the probability of the occurrence of an impact and the cost associated with its occurrence) is realistic due to the catastrophic consequences caused to the entire ecosphere [1].

In recent years, several world-wide initiatives began with the goal of collecting accurate information and improving the present knowledge of the near-Earth environment. These initiatives include dedicated NEO-surveys, such as NEOWISE [2], PanSTARRS [3], and the Catalina Sky Survey [4]. As a result of these large investments into NEO tracking, the past decade has brought impressive improvements in large-scale asteroid discovery. In contrast to these advances, a comprehensive model capable of tracking a hazardous object from its current location in orbit to its intersection with Earth and which would account for all possible scenarios and result in reliable forecasts of regional environmental consequences on the ground is still missing.

Bridging the gap: To improve the current understanding of possible outcomes of meteoroid interaction with the atmosphere, we utilize physically-based parametrization described in [5]. The parametrization is based on introducing dimensionless expressions, which combine the pre-atmospheric meteoroid parameters, together with other characteristic parameters and enables unique (case-wise), but also one-solution handling (i.e. uniquely resolvable in mathematical sence) in the analysis of each particular event. These solutions allow us to analyse and compare different events. The ballistic coefficient, α, characterizes the mass ratio, or the drag intensity – it is proportional to the mass of the atmospheric column meteoroid has to make through to reach the ground divided by the pre-atmospheric meteoroid mass. The mass loss parameter, β, reflects the ratio of the pre-atmospheric kinetic energy of the impactor divided by the energy required to be applied for its destruction in the atmosphere. Once these parameters are found based on observations, they can be used to mathematically describe the changes in height, mass, velocity, and luminosity along the atmospheric trajectory [6,7]. Attention is given to adequately account for the actual atmospheric conditions at the concurrent time and location of a meteor. Lyytinen and Gritsevich [8] have recently proposed to tackle this problem by introducing atmospheric corrections into the model developed in [9]. Their approach can be inferred to produce more reliable estimates of the meteoroid's characteristic parameters and masses, since it uses an improved representation of the atmospheric density. In practice, these atmospheric corrections have already aided in a rapid recovery of the Annama meteorite based on the observations by the Finnish Fireball Network [10,11].

Application to the real data: We analyse and compare the solutions obtained based on the analysis of the famous fireball events observed over Russia. These events cover a representative sample of observational data, from meteorite-producing fireballs appearing annually, such as Annama, to larger scale impactors, such as Chelyabinsk, Sikhote-Alin, and Tunguska. The comparison between these allows us to sum up the key features which are characteristic for each considered 'fireball group'. From a wider perspective, we demonstrate the suitability of the proposed impact-classification scheme as a cornerstone of an advanced future model capable to robustly forecast consequences of meteoroids' interaction with the Earth's atmosphere and surface prior to their actual impact with the ground.

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