Prediction of consequences of meteor events based on atmospheric trajectory analysis

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In this study, we develop a model which describes how meteoroid enter the atmosphere of a planet, and categorize different consequences of the collisions of cosmic bodies with the atmosphere and the surface of a planet. We focus on two types of possible results: (1) meteorite fall, when a fragment of a meteoroid can be found on the surface, and (2) full ablation, when meteoroid does not reach the ground. The model is based on the analytical solution of the classical equations of meteor-body deceleration [1,2]. The dimensionless solution for the mass-velocity dependence and the height-velocity dependence can be expressed using two main dimensionless parameters: the ballistic coefficient, which shows the ratio between the mass of the atmospheric column along the trajectory and the body's pre-entry mass, and the mass loss parameter, which is proportional to the ratio between the initial kinetic energy of the body and energy required to insure total mass loss of the body due to ablation and fragmentation. Thus, every given meteoroid case is described by a pair of these parameters.

To distinguish the two possible impact consequences (meteorite fall or full ablation) we use the meteorite fall condition: the terminal mass of a meteoroid exceeds or is equal to a certain chosen value. This condition can be written using the parameters introduced above. Thus, we get a boundary curve in the parameter plane and associate different events with the location of the point relative to this curve. This theory is applied in the classification of collisions of cosmic bodies with the Earth's atmosphere and surface. The observational data are used to calculate the values of the parameters used in current study, and these values are shown in the parameter plane and their locations are compared against the location of boundary curve in each case. The obtained results show a good agreement with the known consequences for the observed fireballs, including ones registered by the Canadian, Prairie and European Fireball Networks [3,4].

As an extension of this theory, we model the meteoroid entry into the Martian atmosphere using introduced parameters. A number of investigations by different authors show an increasing interest to this subject, e.g. [5–9]. To apply our theory, we take two meteoroid types as an example: a chondrite with the entry velocity 10 km/s, and an iron meteoroid with the entry velocity 15 km/s. For each type, we take several pre-entry mass values and show the impact consequences by constructing the boundary curve on the parameter plane and the point corresponding to the meteoroid. These results are also compared with the meteoroid entries into the terrestrial atmosphere with the same pre-entry characteristics. It is shown that for some pre-entry mass range, a meteoroid would be fully ablated for the case of Earth, but a fraction of it would reach the surface for the case of Mars.

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