ANALYTICAL MODEL FOR DETERMINING THE OUTCOME OF METEOROID ENTRY INTO THE MARTIAN ATMOSPHERE

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Introduction: Solar system bodies are subjected to a continuous flux of meteoroids, from μm-sized dust to km-sized asteroids or comets. While the Earth's atmosphere provides an effective shield against meteoroids up to several meters, on Mars, the boundaries between hard-impact, meteorite soft landing, and complete atmospheric ablation in the planet's thin atmosphere strongly depend on meteoroid properties, such as speed and bulk density.

In this study, we describe a model based on the analytical solution of the meteoroid body deceleration and ablation equations [1,2]. We focus on two types of impact events: meteorite fall, when a fragment of a meteoroid can be found on the planetary surface, and full ablation of a meteoroid in the atmosphere. Our approach can provide useful insights for the investigation of meteorites on Mars once observations become available.

Modeling approach and results: The analytical solution for the mass-velocity dependence and the height-velocity dependence can be expressed using the two main dimensionless parameters: (i) the ballistic coefficient α, which shows the ratio between the mass of the atmospheric column along the trajectory and the body's pre-entry mass, and (ii) the mass loss parameter β, which is proportional to the ratio between the initial kinetic energy of the body and energy which is required to insure total mass loss of the body due to ablation and fragmentation [3-5]. To determine the possible consequences of impact, we define the meteorite-fall condition: the terminal mass of the meteoroid should exceed or be equal to a certain chosen value. Writing this condition using the parameters α and β, we obtain the impact consequences as the position relatively to a curve in the (α,β) space. The model was tested using the data from historical well-documented meteorite falls including Pribram, Lost City, Innisfree, Neuschwanstein, Bunburra Rockhole, Park Forest, Annama and Košice [6-11].

We modify our approach to describe the meteoroid entry into the Martian atmosphere. Two representative cases are investigated: for surface impact and for the meteoroid that fully ablates and thus never reaches the ground. We analyse the results for two meteoroid types: 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. The obtained results are compared with the similar meteoroid entry into the Earth's atmosphere. This comparison indicates the existence of a range of parameters that correspond to the full ablation in the terrestrial atmosphere, and to the surface impact in case of Mars.

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