EPSC Abstracts
Vol. 11, EPSC2017-881-1, 2017
European Planetary Science Congress 2017

Impact Effects Calculator. Orbital Parameters.

S.A. Naroenkov(2), D.O. Glazachev(1), A.P. Kartashova(2), I.S. Turuntaev(1), V.V. Svetsov (1), V.V. Shuvalov(1), O.P. Popova(1) and E.D. Podobnaya(1)
(1)Institute for Dynamics of Geospheres RAS, Moscow, Russia (glazachevd@gmail.com / Fax: +7-499-1376511),
(2)Institute of Astronomy RAS, Moscow, Russia

Abstract

Next-generation Impact Calculator for quick assessment of impact consequences is being prepared. The estimates of impact effects are revised. The possibility to manipulate with the orbital parameters and to determine impact point is included.

Introduction

The population of near-Earth objects (NEOs, both asteroids and comets) contains a wide variety of bodies with diverse physical and dynamical properties, and presents a permanent threat to our civilization [1]. The number of undiscovered potentially hazardous asteroids with sizes from 140 meters to 1km is estimated as about 20 000 objects, the number of potentially dangerous bodies with sizes from 50 m to 140 m is estimated to exceed 200 000 objects [2]. The recent Chelyabinsk event demonstrated that even a small object, only 20 m in diameter, has enough energy to cause considerable destruction of property.

1. Impact calculator

Detection of new objects proceeds continuously. The characteristics and orbital parameters of an already discovered body are also regularly refined. For any discovered object it is necessary to assess the potential risk and damage resulting from the possible collision of such body with the Earth. Physical processes, which occur during the impact, are complex and their simulations are time consuming. An instrument for quick estimation of the consequences of a comet or asteroid impact on the Earth is needed. Such Web-based calculator was created by Collins et al [3].

We are going to elaborate the next generation version of an impact calculator. Extensive numerical simulations of impacts are carried out using a hydrodynamic model, equations, and a numerical technique described, e.g., in [4]. It is assumed that the cosmic object has no strength, deforms, fragments, and vaporizes in the atmosphere. After the impact on the ground, formation of craters and plumes are simulated. Results obtained in these simulations will be used to get interpolations for rapid assessment of the impact effects. As an example, in the calculator [3] thermal damage from crater-forming impacts is considered based on nuclear explosions results and crater plume luminous efficiency estimates but the radiation from the objects decelerated in the atmosphere is not included [3]. For our calculator, the systematic modeling of the entry of asteroidal and cometary bodies of various sizes (20-3000 m), including the determination of thermal fluxes and exposures, was carried out [5], and scaling relations for thermal fluxes on the ground were found [6]. These and other similar scaling relations will be used for fast online estimates of impact effects in our calculator. These relations are dependent only on cosmic body density, size, velocity and angle of entry.

To predict impact effects in any location one must determine the place of the impact (or the point of maximum energy deposition) or to find it based on suggested orbital parameters of the impacting object. So we decided to include an orbital block into our calculator.

2. Orbital characteristics and impact point

Our impact consequences calculator allows to create a virtual (hypothetical) orbit of the celestial body, which will lead to a collision with the Earth. The impact point may be determined based on this orbit. The creation of a virtual orbit can be realized by two ways.

In the first way, the user, setting five parameters of the Keplerian orbit, the date of collision, the size of the object, creates a dangerous orbit and collision conditions. For the first method, the place, speed and energy of the collision are predicted. The second way allows to predict a dangerous orbit based on the time and place of collision, the angle of entry into the atmosphere, the direction and speed of the impact. We believe that both possibilities can be interesting and in demand.

To determine the orbit, a numerical model is used, which takes into account perturbations from the Earth, the Moon, the Sun, the rotation of the atmosphere, and the resistance of the atmosphere. This numerical model was tested at the orbits of such bodies as the Chelyabinsk meteorite [7], 2008 TC3, Novato meteorite [8], meteoroid 2014 AA.

For the parameters of Chelyabinsk meteoroid orbit [7], we determined the flight trajectory. The coordinates of the largest meteorite fall site were compared with the projection of our predicted trajectory on the Earth's surface. The distance between the fall and our trajectory was 600 meters. These results confirmed the correctness of the numerical model for the orbit and the impact point determination. We also studied the circumstances of the fall of known asteroids, which can hypothetically collide with the Earth. For the study, 27 near-Earth asteroids were selected, in which the minimum distance between the orbit of the asteroid and the orbit of the Earth is less than 6378 km. We determined that most of the collision occurs at speeds of 15 to 25 km/sec, the angle of incidence on average is 45 degrees.

3. Summary

Next-generation Impact Calculator for quick assessment of impact consequences is being prepared. The estimates of impact effects are revised. The possibility to manipulate with the orbital parameters and to determine impact point is included.

Acknowledgements

This work was supported by the Russian Science Foundation, project no. 16-17-00107.

References

[1] Harris A. W., Boslough M., Chapman C. R., Drube L., Michel P., and Harris A. W. (2015) Asteroid impacts and modern civilization: Can we prevent a catastrophe? In Asteroids IV (P. Michel et al., eds.), pp. 835–854. Univ. of Arizona, Tucson.

[2] Committee to review near-Earth object surveys and hazard mitigation strategies. Defending planet Earth: Near-Earth object surveys. The National Academies Press, 152 p. 2010.

[3] Collins G.S., Melosh H.J., Marcus R. (2005) Earth Impact Effects Program: A Web-based computer program for calculating the regional environmental consequences of a meteoroid impact on Earth // Meteorit. Planetary Sci. V. 40. Nr.6. P.817-840

[4] Shuvalov, V.V., Svettsov, V.V., Artem'eva, N.A., Trubetskaya, I.A., Popova, O.P., and Glazachev, D.O.: Asteroid Apophis: Evaluating the impact hazards of such bodies, Sol. Sys. Res., Vol. 51, pp. 44-58, 2017.

[5] Svetsov, V.V., Shuvalov V.V.: Thermal radiation from large bolides and impact plumes. Abstract (this conference).

[6] Glazachev D.O., Popova O.P., Podobnaya E.D., Svetsov V.V. and Shuvalov V.V.: Radiation and ablation of large meteoroids decelerated in the Earth's atmosphere. Abstract (this conference).

[7] Emelyanenko V.V., Naroenkov S.A., P. Jenniskens, O. P. Popova. The orbit and dynamical evolution of the Chelyabinsk object. // Meteoritics & Planetary Science, 2014, V. 49, Is. 11, p 2169- 2174

[8] Jenniskens, P et al,. Fall, recovery, and characterization of the Novato L6 chondrite breccia. METEORITICS & PLANETARY SCIENCE, Volume: 49, Issue: 8 Pages: 1388-1425