Numerical simulations of large marine target impacts

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More than two thirds of the Earth's surface is covered by seas and oceans. Therefore, most of the cosmic bodies colliding with the Earth fall into the water. During impacts of cosmic bodies on a solid surface, the main damaging factors are the shock wave, which causes maltiple destruction, and radiation, which causes maltiple fires. The ejection of a substance into the atmosphere determines the long-term consequences. When cosmic bodies fall into the ocean, destruction by a shock wave and fires are not so relevant. Therefore, the main damaging factors for such impacts are tsunami waves and the ejection of target and impactor matter into the atmosphere, which is significantly affected by the presence of a water layer. These two effects are considered in this study.

The calculations performed show that even when 10 km asteroids fall into the ocean, a large amount of soil matter is ejected into the atmosphere. At depths up to 3 km, the maximum mass of soil material ejected into the atmosphere differs by no more than 2–3 times from the mass of ejecta during an asteroid impact on a solid surface. Moreover, calculations show that the mass of soil matter remaining in the atmosphere after deposition in the gravitational field at depths up to 5 km is even greater than when falling onto a solid surface. And only at depths of the order of 7 km and more the ejection of solid matter noticeably decreases compared to the ejections during the fall of asteroids on land. In addition, when hitting water, a large amount of water and the salts contained in it are ejected into the atmosphere. Thus, we can conclude that when asteroids about ten kilometers in size fall into the ocean, the impact on the Earth's atmosphere will apparently be no less strong than when asteroids fall on land.

The numerical experiments performed show that during impacts of cosmic bodies larger than the depth of the ocean, the presence of a water layer has little effect on the process of formation and dimensions of the bottom crater, and the tsunami wave is formed mainly due to the "raking" of water by the ejecta cone from the crater in the soil. At distances greater than 1000-3000 km, the tsunami wave becomes linear and then decays according to the law $\sim$r-1/2 , where r is the distance from the point of impact, which corresponds to the theory of shallow water. At shorter distances, the wave is noticeably nonlinear and decays faster. The greater the depth of the ocean and the size of the impactor, the longer the nonlinear stage lasts. Thus, we can conclude that when asteroids about 10 km in size fall into the ocean at distances of 1000–3000 km from the impact point, tsunami waves with a length of more than 100 km are formed, similar to tsunamis generated by earthquakes.