PDC2017
Tokyo, Japan

IAA-PDC-17-06-06

√ Impact Consequences

THREE-DIMENSIONAL SIMULATIONS OF OBLIQUE ASTEROID IMPACTS INTO WATER

Galen R Gisler, Tamra Heberling, Catherine S Plesko, and Robert P Weaver
Los Alamos National Laboratory, Los Alamos NM USA
galengisler@mac.com, theberling@lanl.gov, plesko@lanl.gov, rpw@lanl.gov

Keywords: Asteroid ocean impacts, hydrocode simulations, impact wave generation

ABSTRACT

Waves generated by impacts into oceans may represent the most significant danger from near-earth asteroids and comets. For impacts near populated shores, the crown splash and subsequent waves, accompanied by sediment lofting and high winds, are more damaging than storm surges from the strongest hurricanes. For asteroids less than 500m in diameter that impact deep water far from shores, the waves produced may be detectable over large distances, but probably not significantly dangerous. We present new three-dimensional simulations of oblique impacts into deep water, with trajectory angles ranging from 20 degrees to 60 degrees (where 90 degrees is vertical). These simulations are performed with the Los Alamos Rage hydrocode, and include atmospheric effects including ablation and airbursts. These oblique impact simulations are specifically performed in order to help determine whether there are additional dangers from the obliquity of impact not covered by previous two-dimensional studies. Water surface elevation profiles, surface pressures, and depth-averaged mass fluxes within the water are prepared for use in propagation studies.

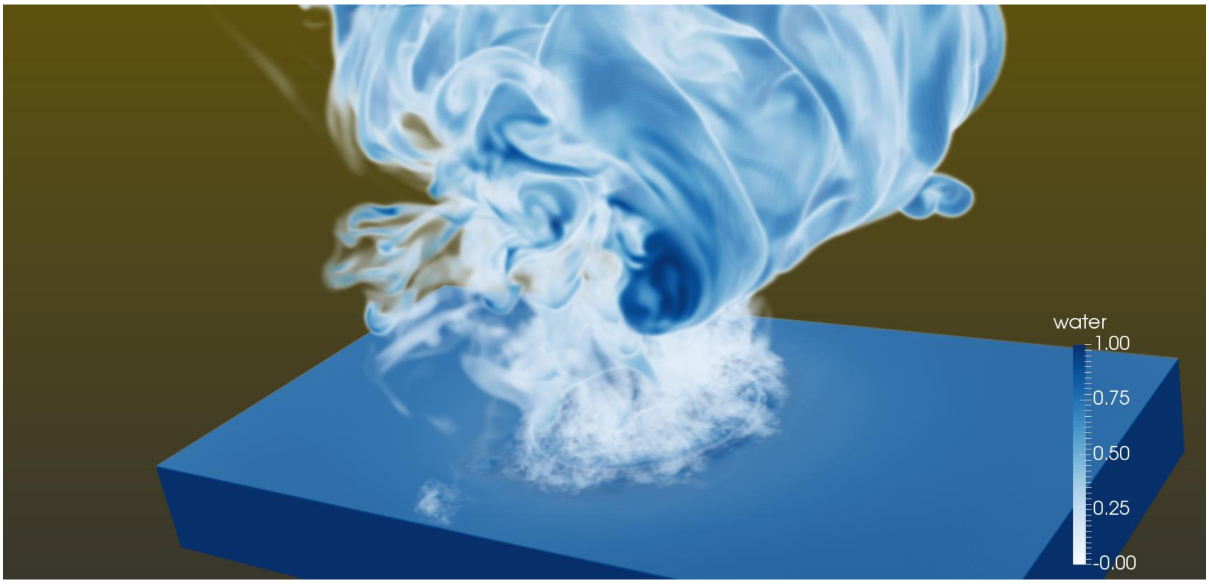
An ocean impact within ten to twenty kilometers of a populated coastline would be devastating. The crown splash and rebounding jet reach many kilometers into the air and will lead to severe flooding. High temperatures generated by the disintegration of the asteroid accompanied by hurricane-force winds will be destructive to lives and property on shore. Shock waves from airbursts are also locally destructive, as in the Chelyabinsk and Tunguska events.

Because asteroid impacts produce high-amplitude but short waves, propagation into the far field is not expected to be efficient, and this conclusion is supported by wave-propagation studies. Airbursts produce pressure fields over wider regions, and had been thought capable of generating propagating waves, but the amplitudes are much lower than in direct impacts, and the wavelengths are not significantly longer.

A large fraction of the impacting asteroid's kinetic energy is consumed by the vaporization of water from the transient crater, as shown in the Figure. Much of this water vapor is buoyantly lofted into the stratosphere, where it may linger for months to years. Because water vapor is a potent greenhouse gas, there may be significant effects on climate.

The range of impactor size considered, namely 100m to 500m diameter asteroids, is found (as expected) to bracket the threshold for danger being considered by NASA. The ongoing searches for hazardous near-earth objects should continue down to 140m diameter.

Figure. Volume rendering of water mass fraction 94 seconds after the impact of a



250-meter diameter asteroid into a 5-km depth ocean.

****