Tsunami Generation, Consequences on Coastlines, and Potential Global Climate Effects due to Asteroids Impacting Earth's Oceans

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Despite that the annual probability of an asteroid impact on earth is low, but over time, such catastrophic events are inevitable and can have negative global consequences. Several institutions around the world have come together to address global consequences of asteroids impacting earth. For example, interest in assessing the tsunami generation and impact consequences has led us to develop a physics-based framework to seamlessly simulate the event from source (asteroid entry) to ocean impact (splash) to long wave generation, propagation, and their catastrophic risk to people and infrastructure in coastal regions such inundation of the shoreline. The non-linear effects of the asteroid impact on the ocean surface are simulated using the hydrocode GEODYN to create the impact source for the shallow water wave propagation code, SWWP. The GEODYN-SWWP coupling is based on the structured adaptive mesh refinement infrastructure; SAMRAI developed at LLNL. Another consequence of ocean impact is the potentially global effects of an event that would otherwise be of only regional or local importance, should it occur on land. Only a fraction of the total impact energy is converted into water waves that have the ability to globally propagate in the oceans. The remaining energy is consumed by the “evaporation” of the asteroid, the ocean water being transformed into vapor and mist and the fractionization of ocean water and vapor into chlorine and bromine which alter the atmospheric chemistry, therefore impacting globally the Ozone layer and earth temperature. In this paper, we present our scheme of creating the source -- including nonlinear transient cratering and nearfield waves, generating the vapor cloud and the chemical speciation source load of chlorine and bromine to assess the global circulation of those plumes and their effects on the climate. We also present our coupling scheme of the hydrodynamic source using GEODYN with the global atmospheric circulation code GEOSCCM and illustrate the scheme on the PDC 2017 and PDC 2019 asteroid impact scenarios. We illustrate the coupling scheme for asteroids impact along the US, Europe and Asia shorelines. We illustrate, by examples, how the predictions of these numerical tools can help international, state and local government agencies reduce the risks and prepare and implement a response and recovery plan. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.