National Aeronautics and Space Administration

Simulating Atmospheric Impacts: From Pebble- to Mountain-Size Meteoroids

Marian Nemec NASA Ames Research Center

> SC17, Denver, CO November 13-16, 2017

www.nasa.gov



Fireballs Reported by US Government Sensors (1988-Apr-15 to 2017-Oct-26)



https://cneos.jpl.nasa.gov/fireballs/

Meteoroid flux: ~50 tonnes each day (primarily sand-grain to centimeter-size bodies)

Alan B. Chamberlin (JPL/Caltech)







"Asteroid Threat Assessment Project" presentation to Small Bolide Assessment Group

ATAP Overview



Earth map of hypothetical damage zones modeled for an asteroid impact exercise performed at the 2017 Planetary Defense conference. NASA's Probabilistic Asteroid Impact Risk model was run on the Pleiades supercomputer to evaluate damage zones and affected populations over the course of the five-day exercise, as information about the invented scenario evolved from initial detection with a large potential impact swath and little knowledge about the asteroid, to a specific, imminent impact threat. Lorien Wheeler, NASA/Ame

NASA's Asteroid Threat Assessment Project has developed an advanced probabilistic asteroid impact risk model to assess the potential threat posed by asteroids striking Earth. Running on the Pleiades supercomputer, the model is able to analyze millions of impact cases to determine the range and likelihood of damage due to blast waves, thermal radiation, tsunamis, and global effects for asteroids of different sizes and properties striking all over the world. High-fidelity simulations of asteroid entry and hazards are also performed to advance our understanding of key impact effects and refine analytic risk models. Impact risk results are used to support asteroid survey, mitigation, and response planning, and estimate potential consequences of specific impact

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ATAP Supercomputing



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Propagation and Overpressure Prediction ATAP - Prediction of meteor-generated sonic boom

- Obtained observations for a small meteor from 2008 and backed out conditions
- Performed CFD simulations for both sphere and rock-like shapes w/ Cart3D using equilibrium air
- Propagate near-field pressure 74 km to observatory using sonic-boom propagation code
- Currently obtaining recorded ground signature from observatory for comparison







Airbursts: Flow-field Initialization

















Temperature Contours









Ground Overpressure











HPC Perfomance





Tsunami Coupling

- Ground footprint evolution drives tsunami
- Coupled Cart3D surface pressure to GeoClaw package (U.Wash + NYU) for tsunami simulation

South China Sea, 200m diameter

- Domain Extent:
 240 x 240 x 80 km high ~58,000 km² of surface
- ~105 M total cells
- 20 m resolution along trajectory,
- 80 m resolution at sea level
- 3D time-dependent simulations using Cart3D
- Resources
 (1000 cores x ~12 hrs) on NAS Pleiades system







Tsunami



M. Berger / M. Aftosmis