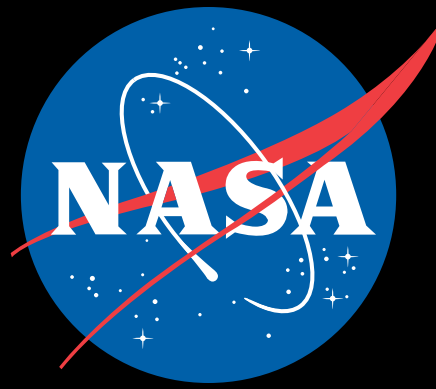


Simulating Atmospheric Impacts: From Pebble- to Mountain-Size Meteoroids

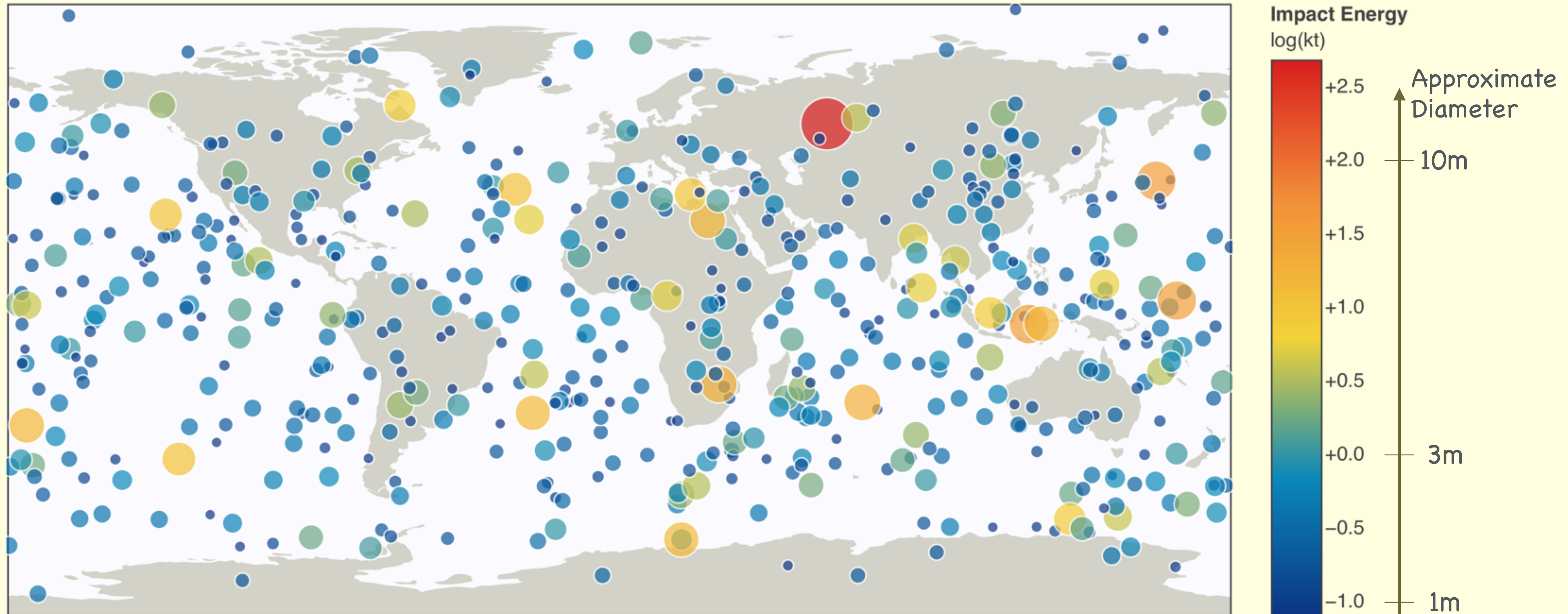
Marian Nemec
NASA Ames Research Center

SC17, Denver, CO
November 13-16, 2017



Fireballs Reported by US Government Sensors

(1988-Apr-15 to 2017-Oct-26)

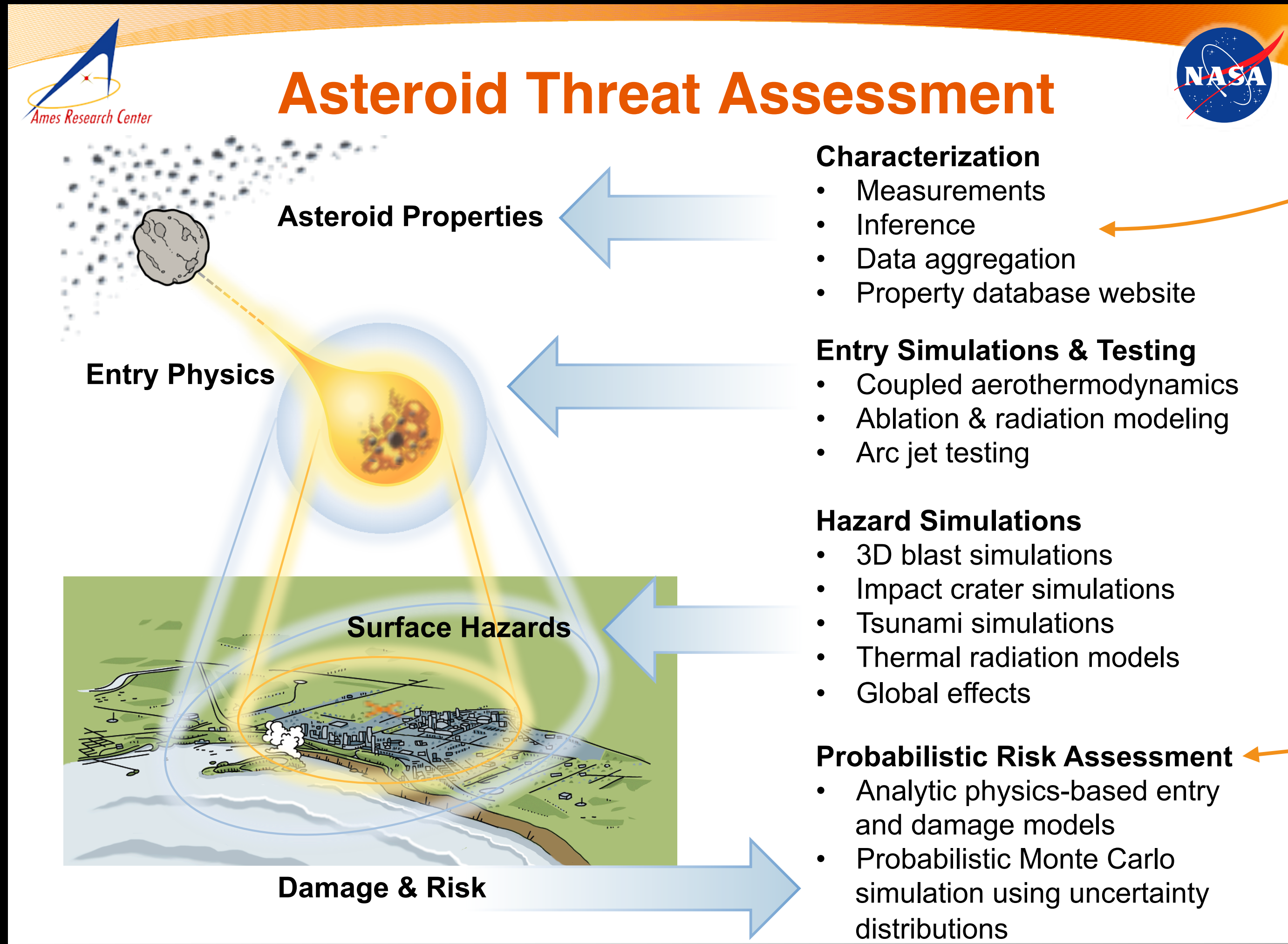
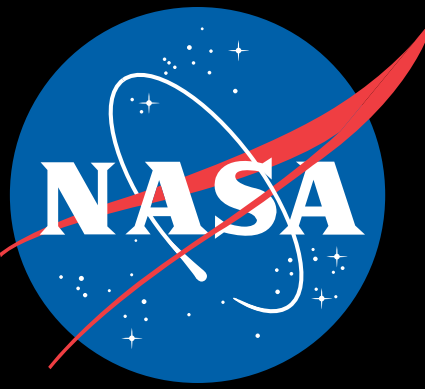


<https://cneos.jpl.nasa.gov/fireballs/>

Alan B. Chamberlin (JPL/Caltech)

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

ATAP Overview



National Aeronautics and Space Administration

Asteroid Impact Risk Assessment

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 scenarios if a threat were to be discovered.

Lorien Wheeler, Donovan Mathias, NASA/Ames

Simulation of tsunami and blast waves generated by the impact of a 1-gigaton, 100-meter diameter iron asteroid into the ocean, produced with the ALE3D hydrocode. Blue contours show water velocities, and orange contours show the velocity of air pressure waves emanating from the vertical entry column and the surface impact. This frame shows a snapshot right after impact when a column of water is rebounding up from the initial impact cavity. Darrel Robertson, NASA/Ames

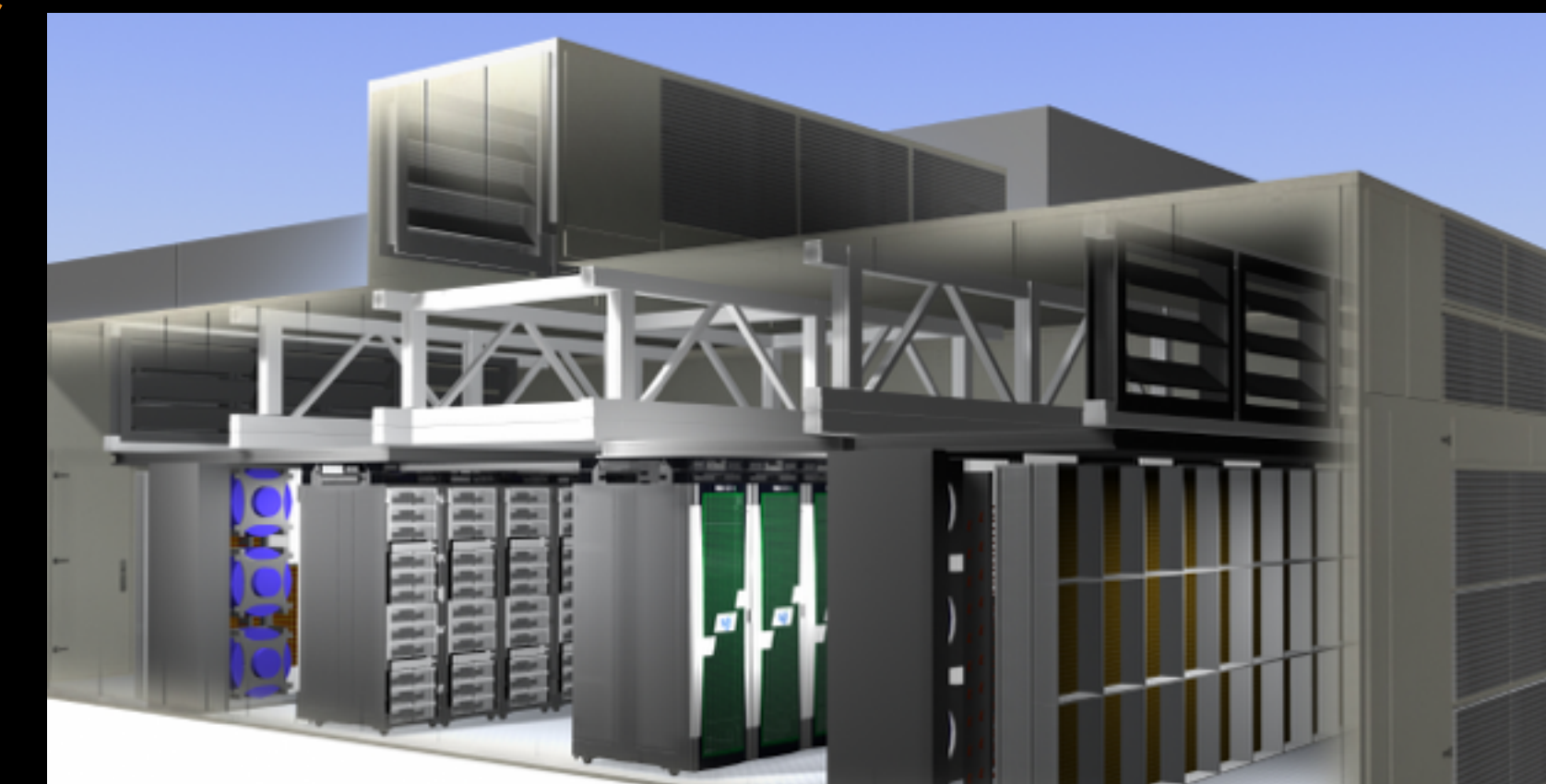
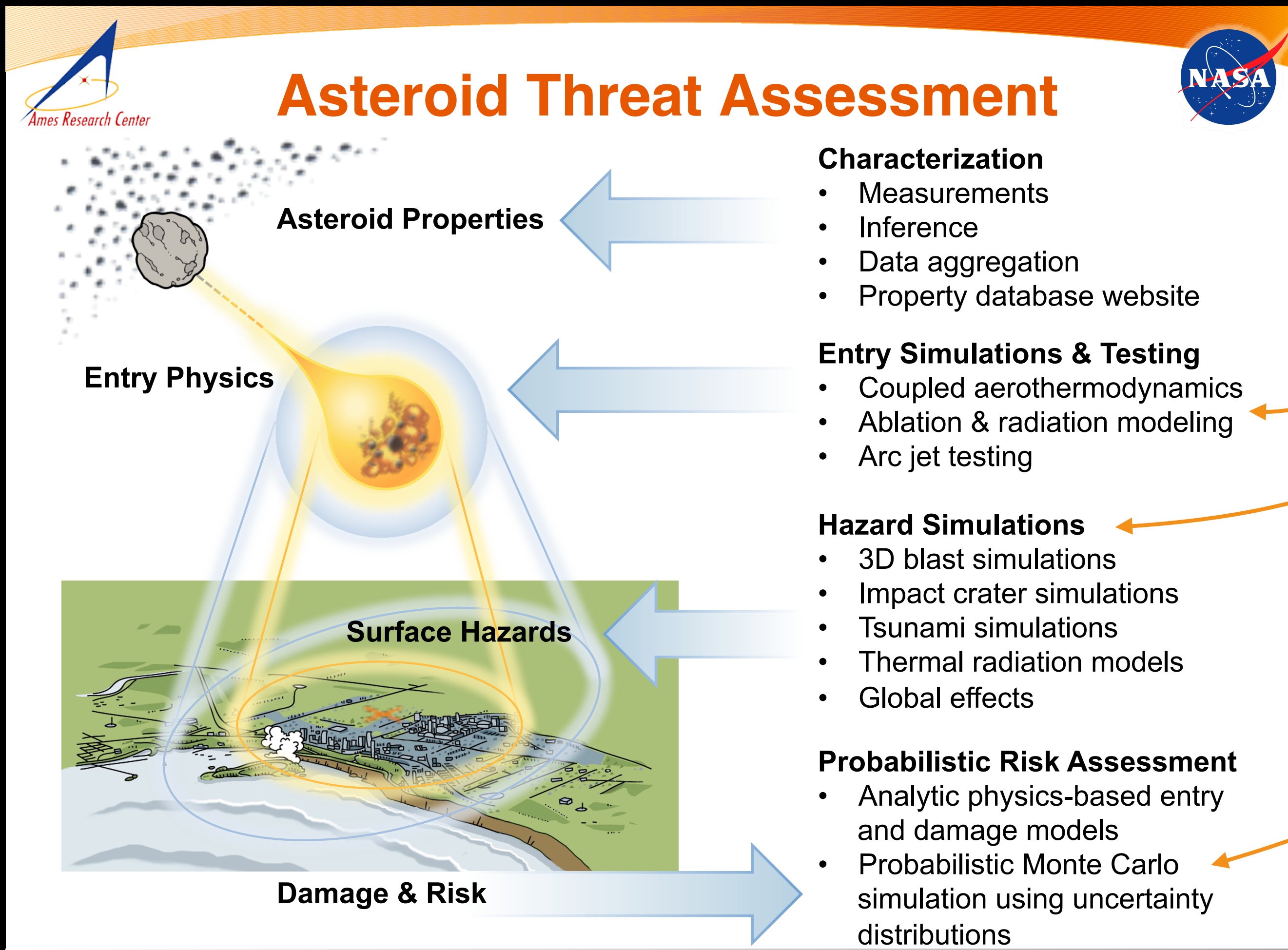
Google Earth map of hypothetical damage zones modeled for an asteroid impact exercise performed at the 2017 Planetary Defense Conference. NASA's Probabilistic Asteroid Impact Risk model was run on the Pleiades supercomputer to evaluate damage zones and affected populations over the course of the five-day 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/Ames

www.nasa.gov

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“Asteroid Threat Assessment Project” presentation to Small Bolide Assessment Group

ATAP Supercomputing



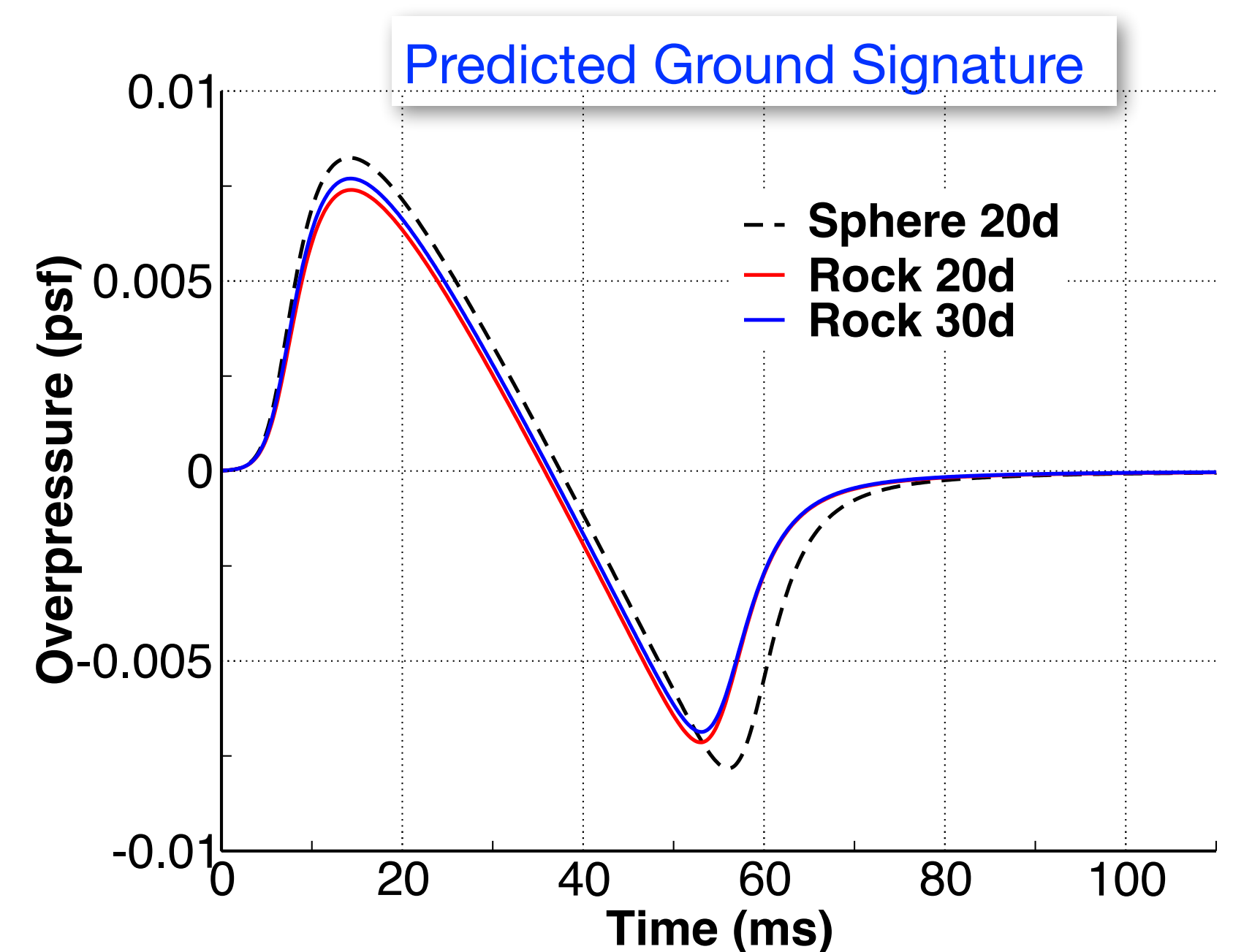
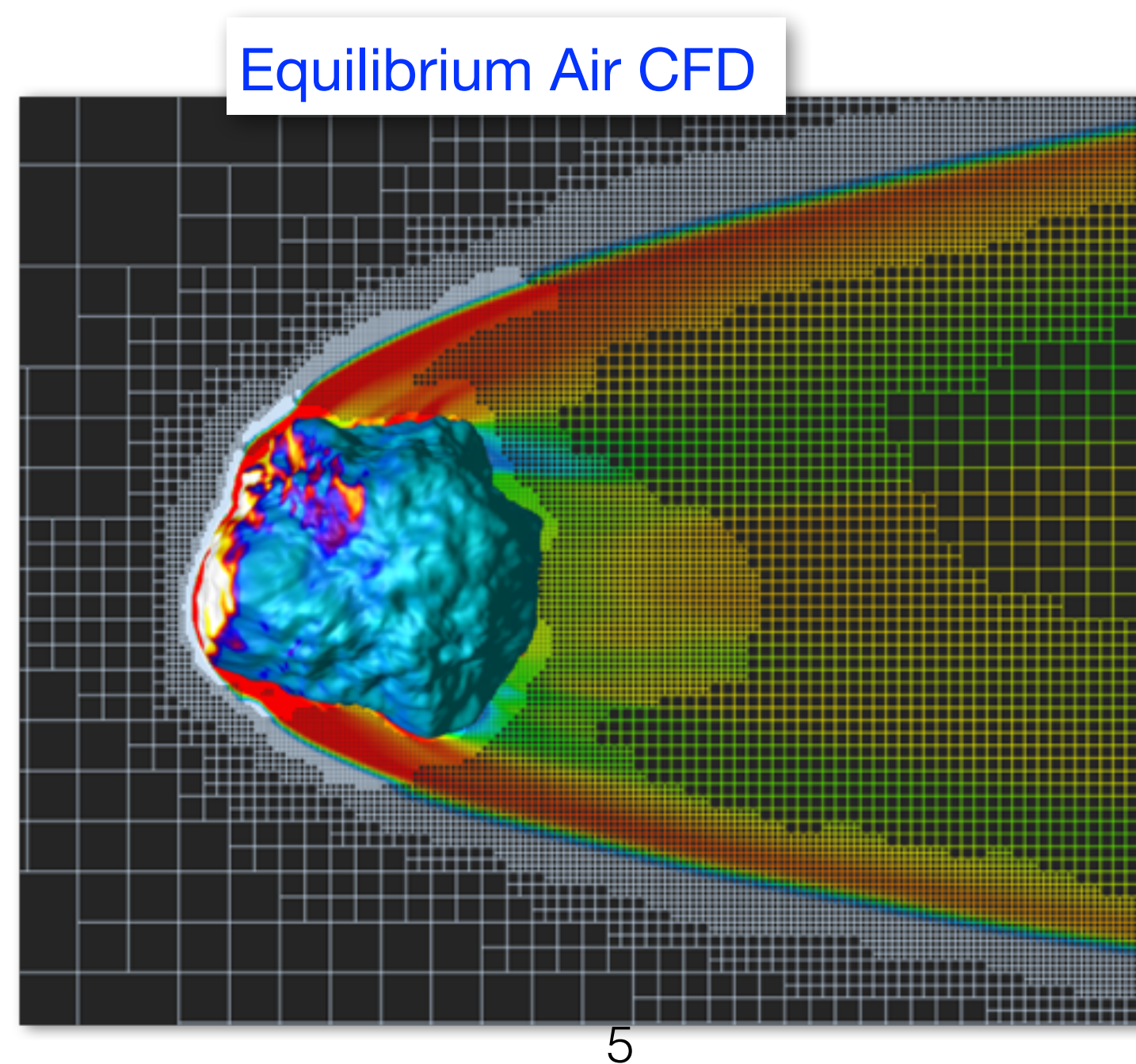
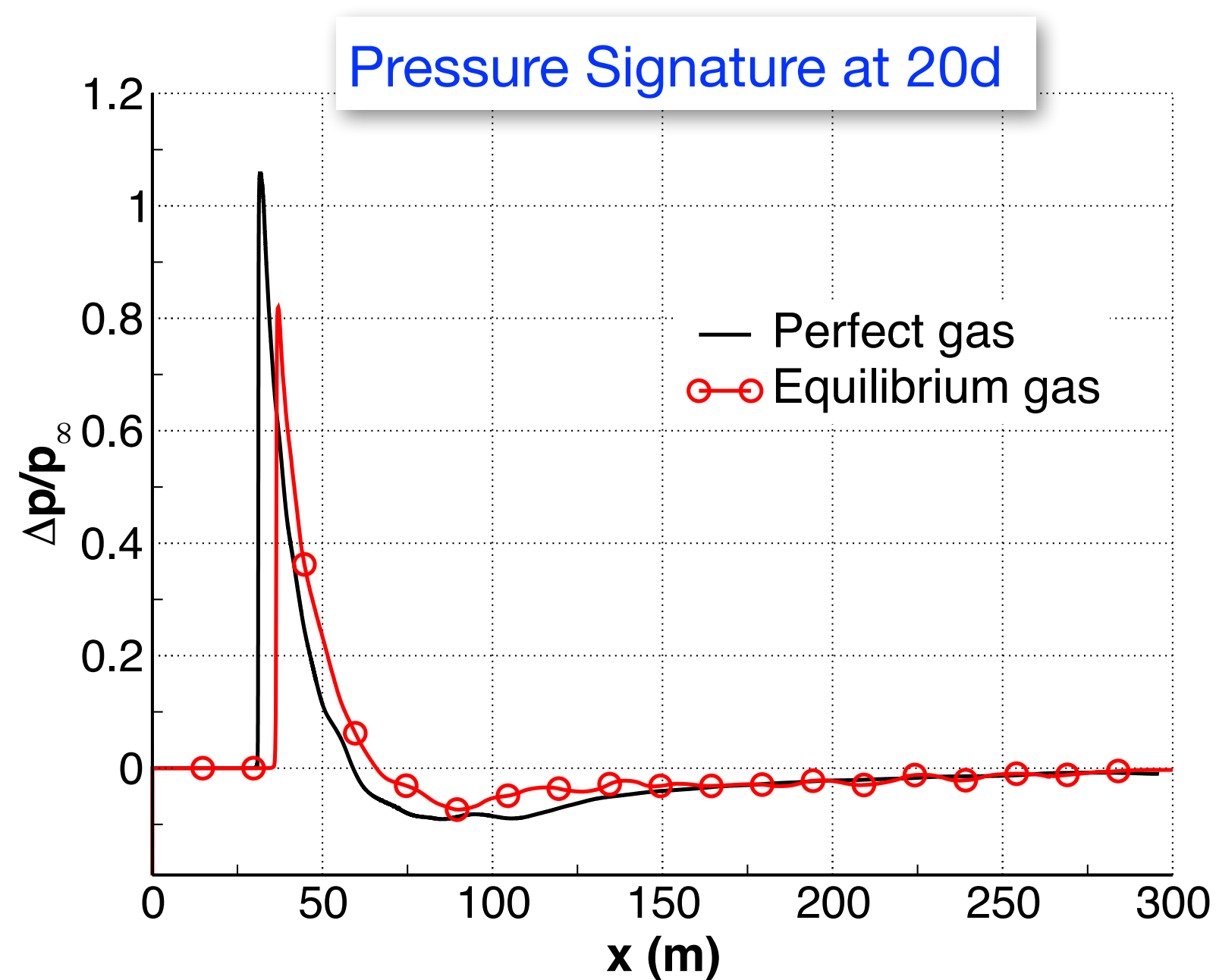
“Asteroid Threat Assessment Project” presentation to Small Bolide Assessment Group

Propagation and Overpressure Prediction

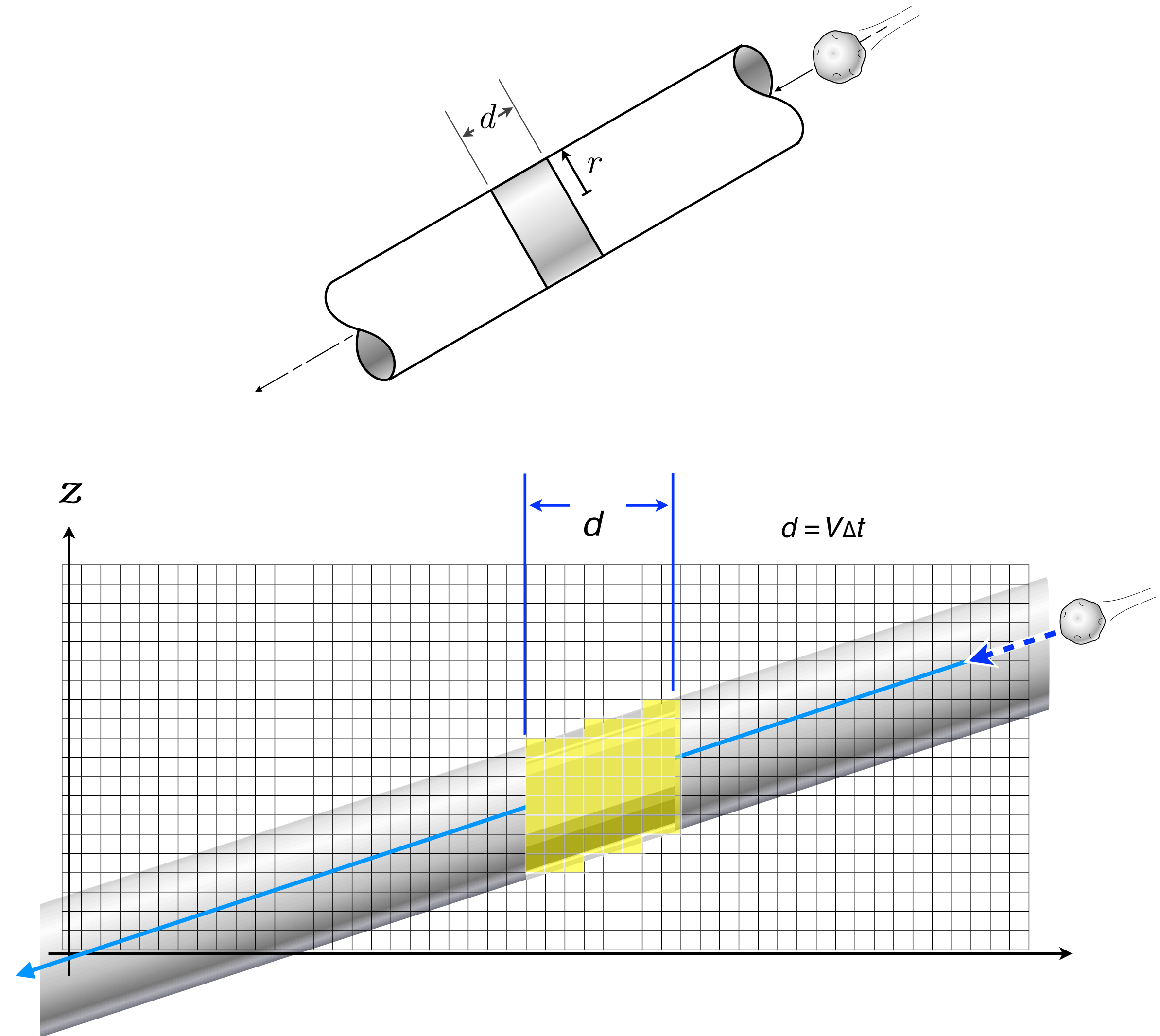
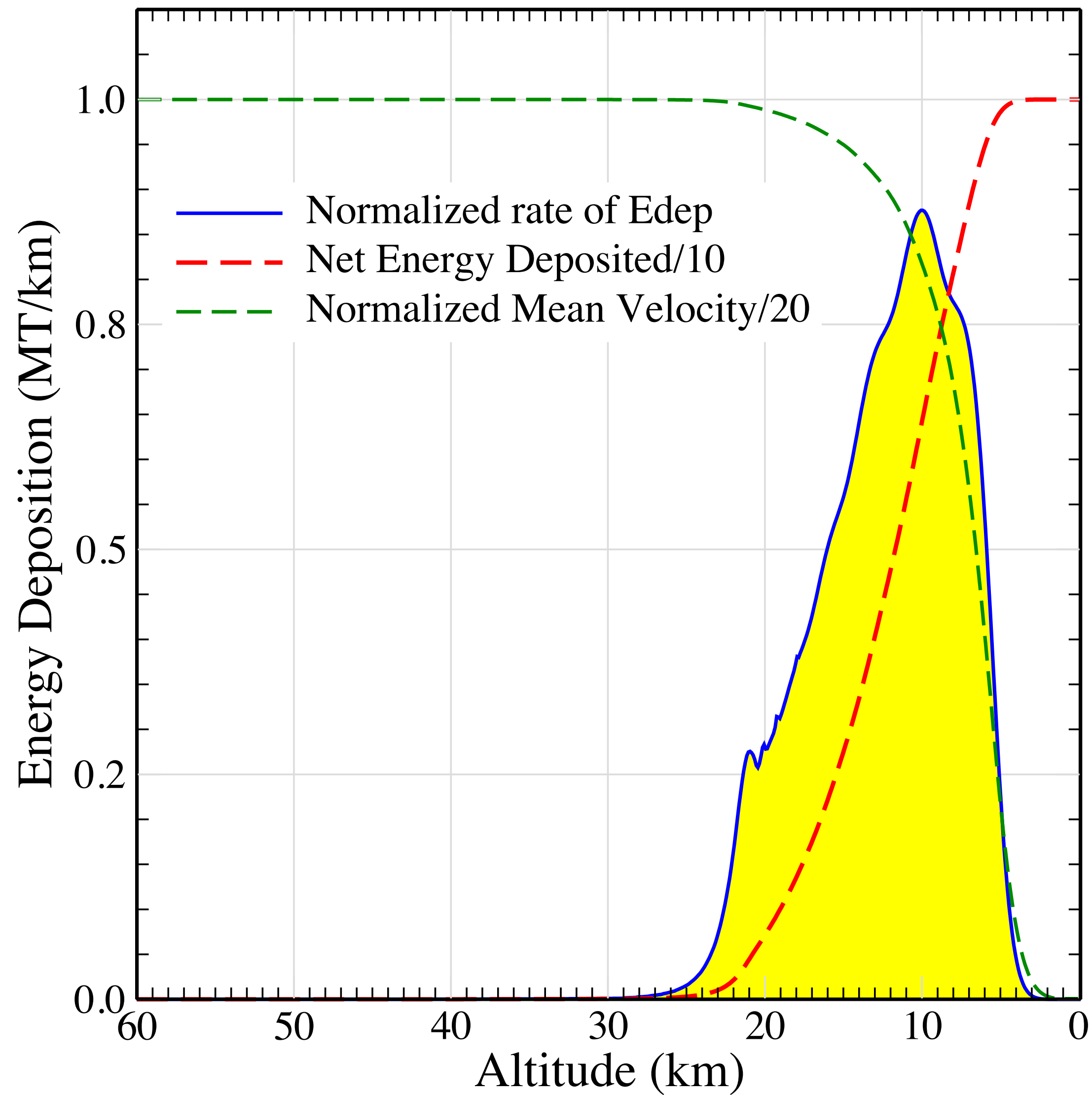
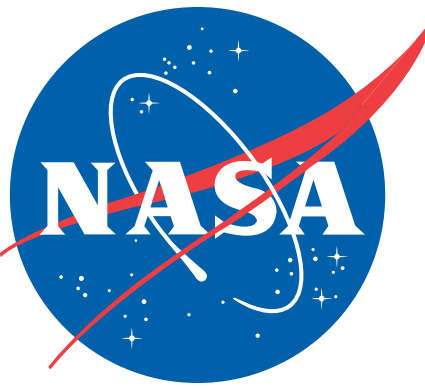


ATAP - Prediction of meteor-generated sonic boom

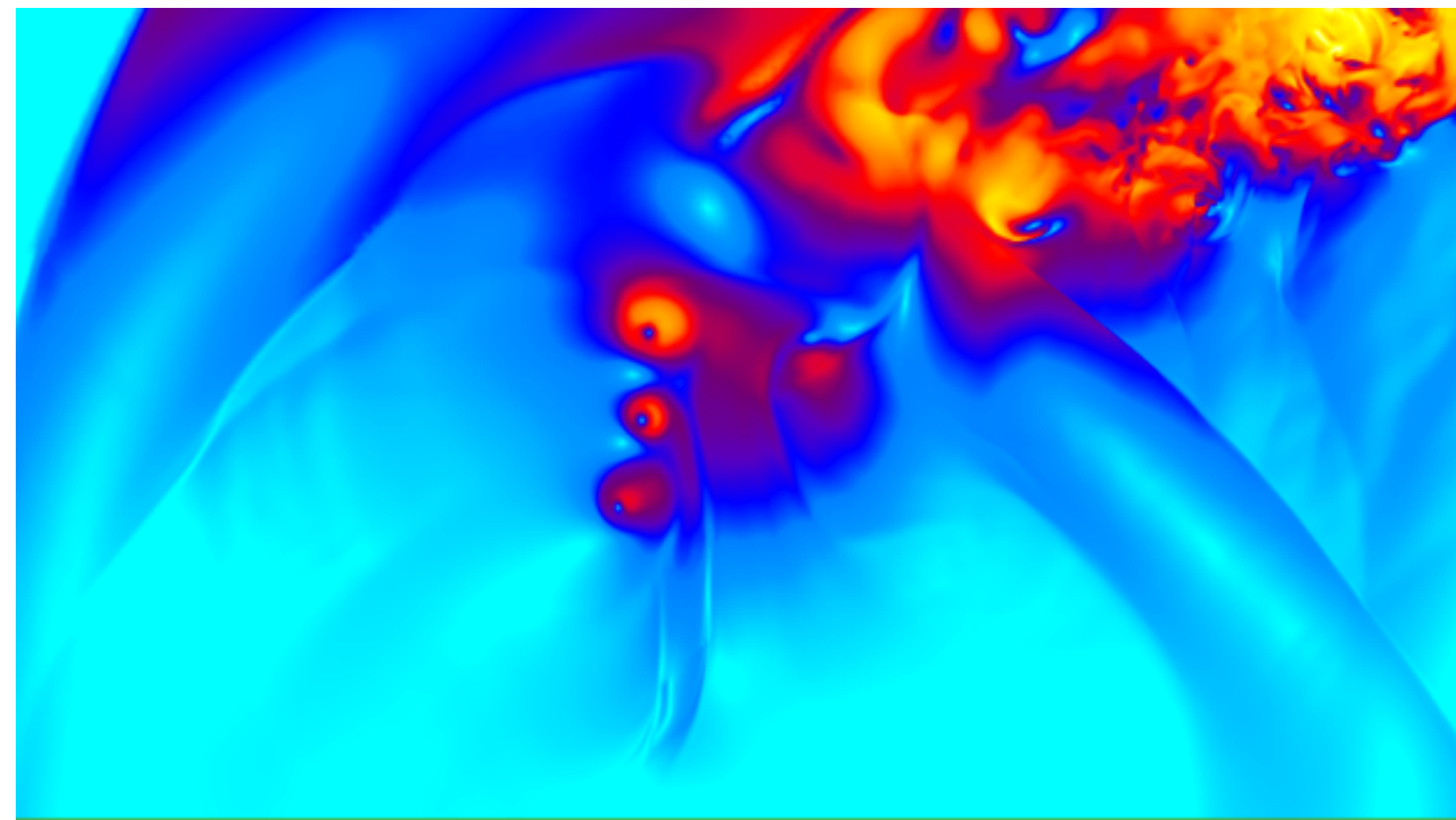
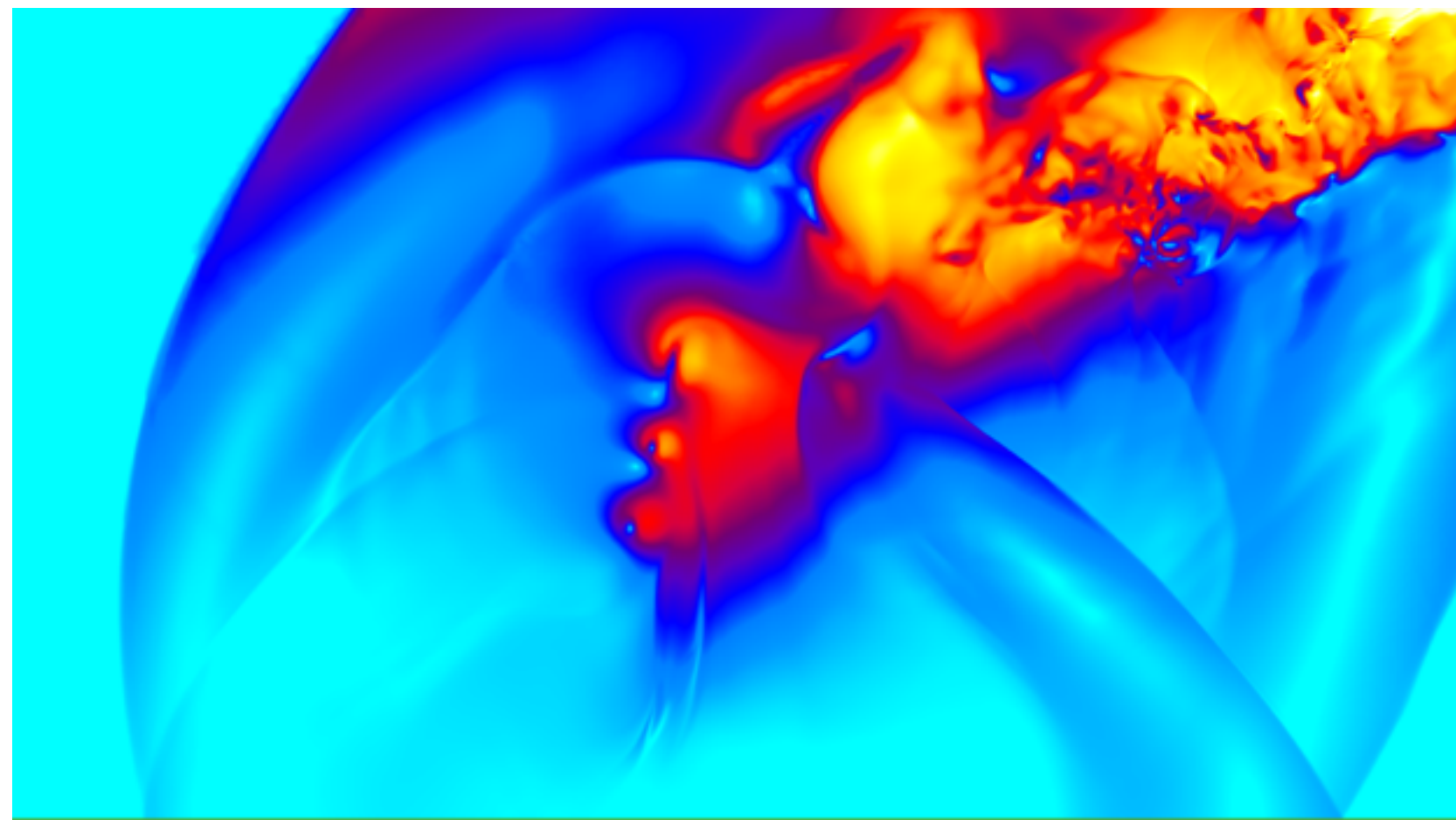
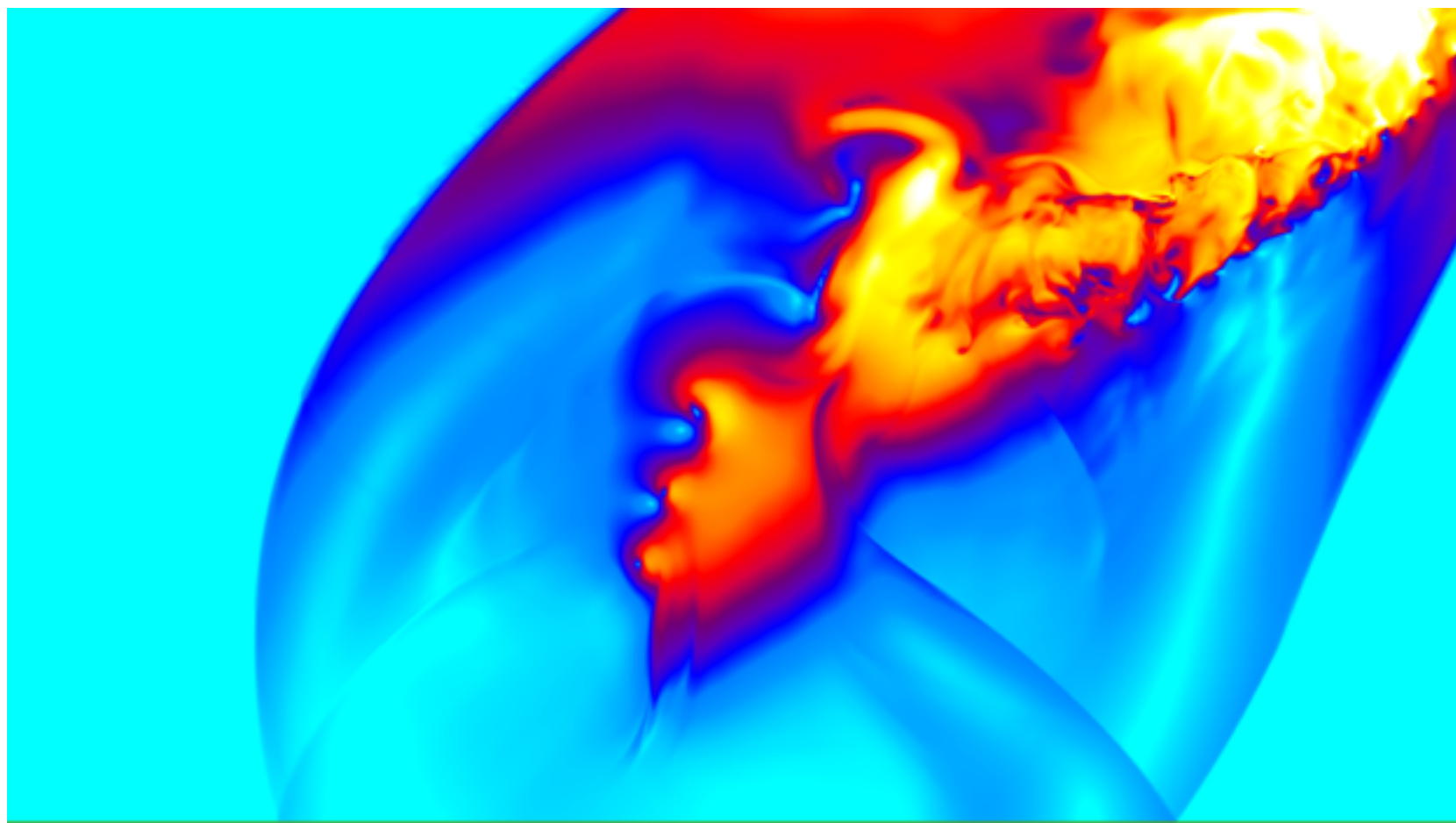
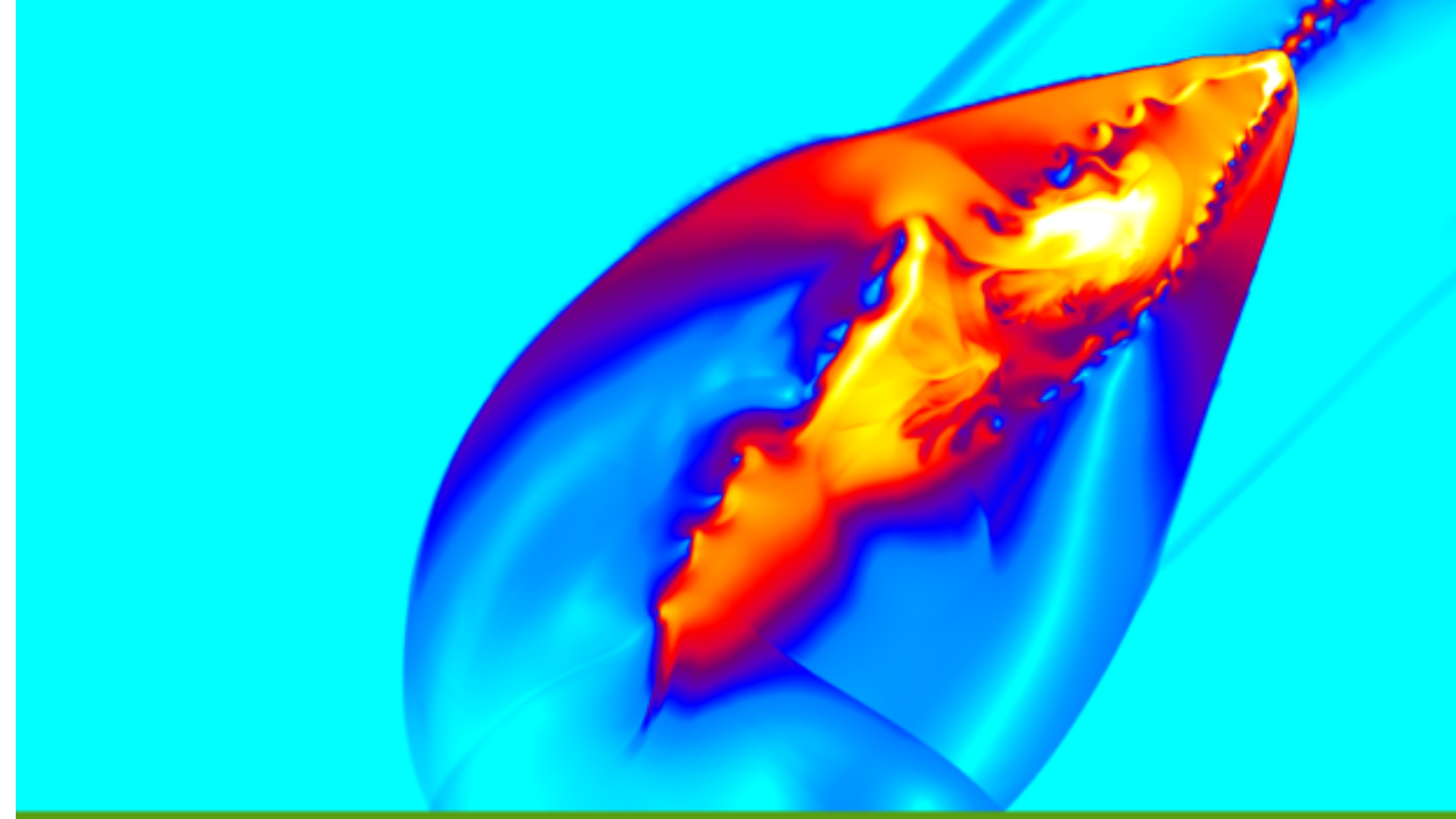
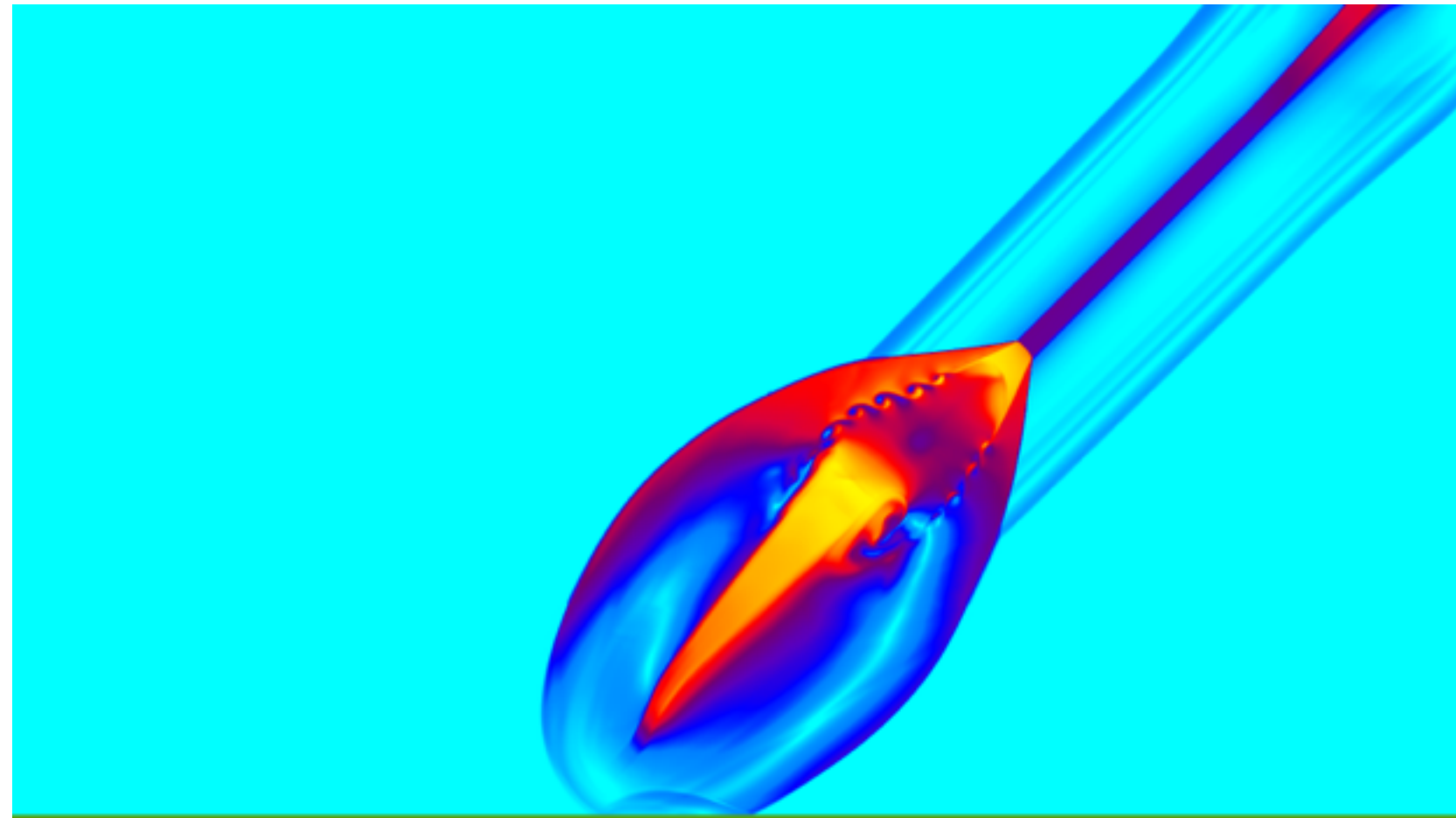
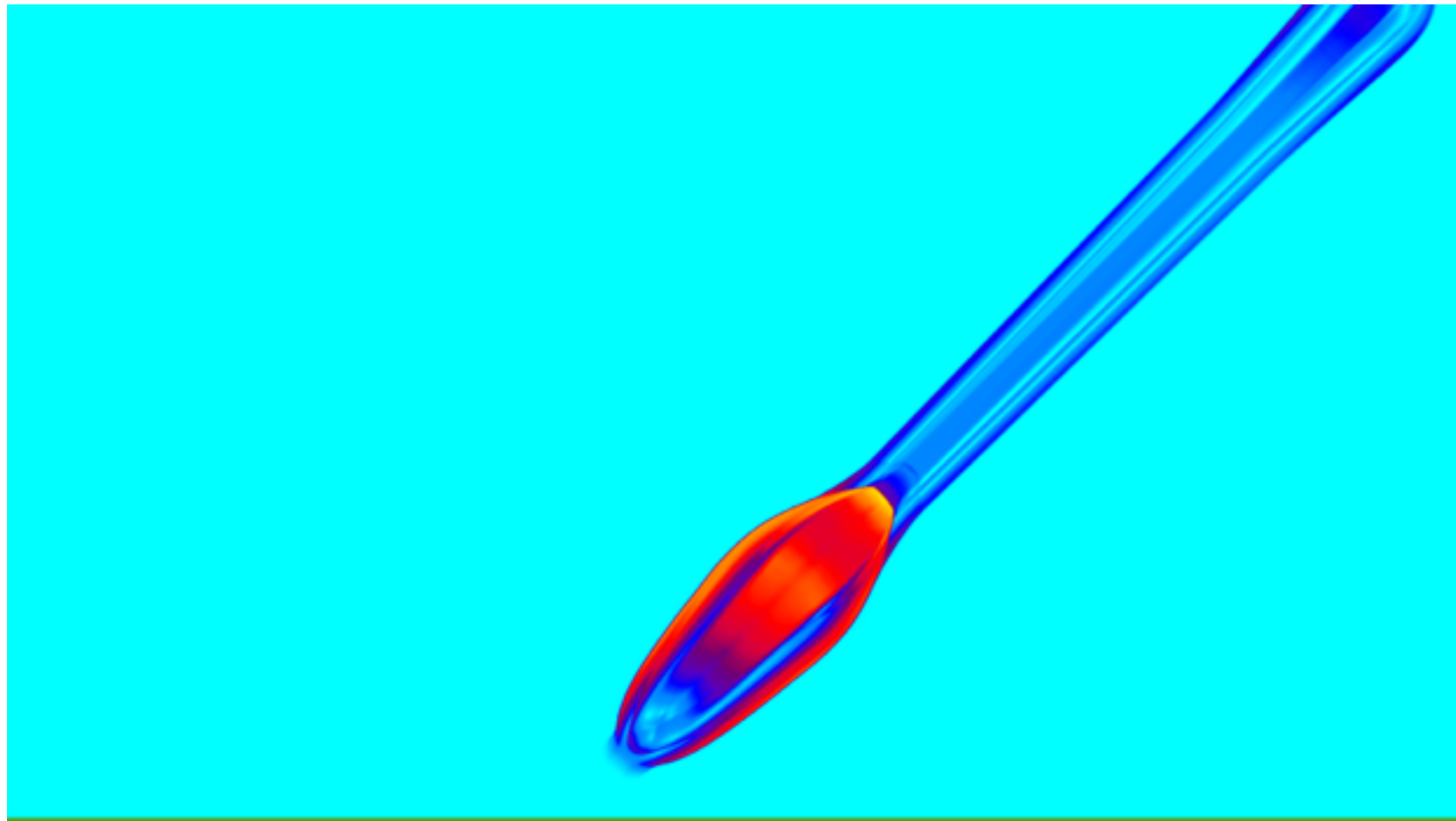
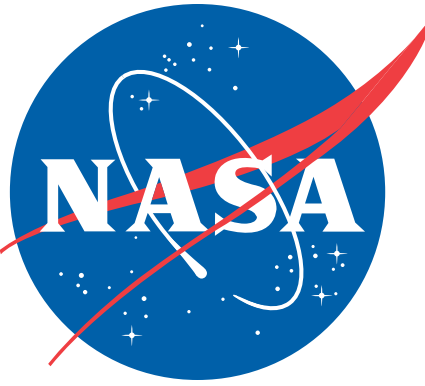
- Obtained observations for a small meteor from 2008 and backed out conditions
- Performed CFD simulations for both sphere and rock-like shapes w/ Cart3D using equilibrium air
- Propagate near-field pressure 74 km to observatory using sonic-boom propagation code
- Currently obtaining recorded ground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



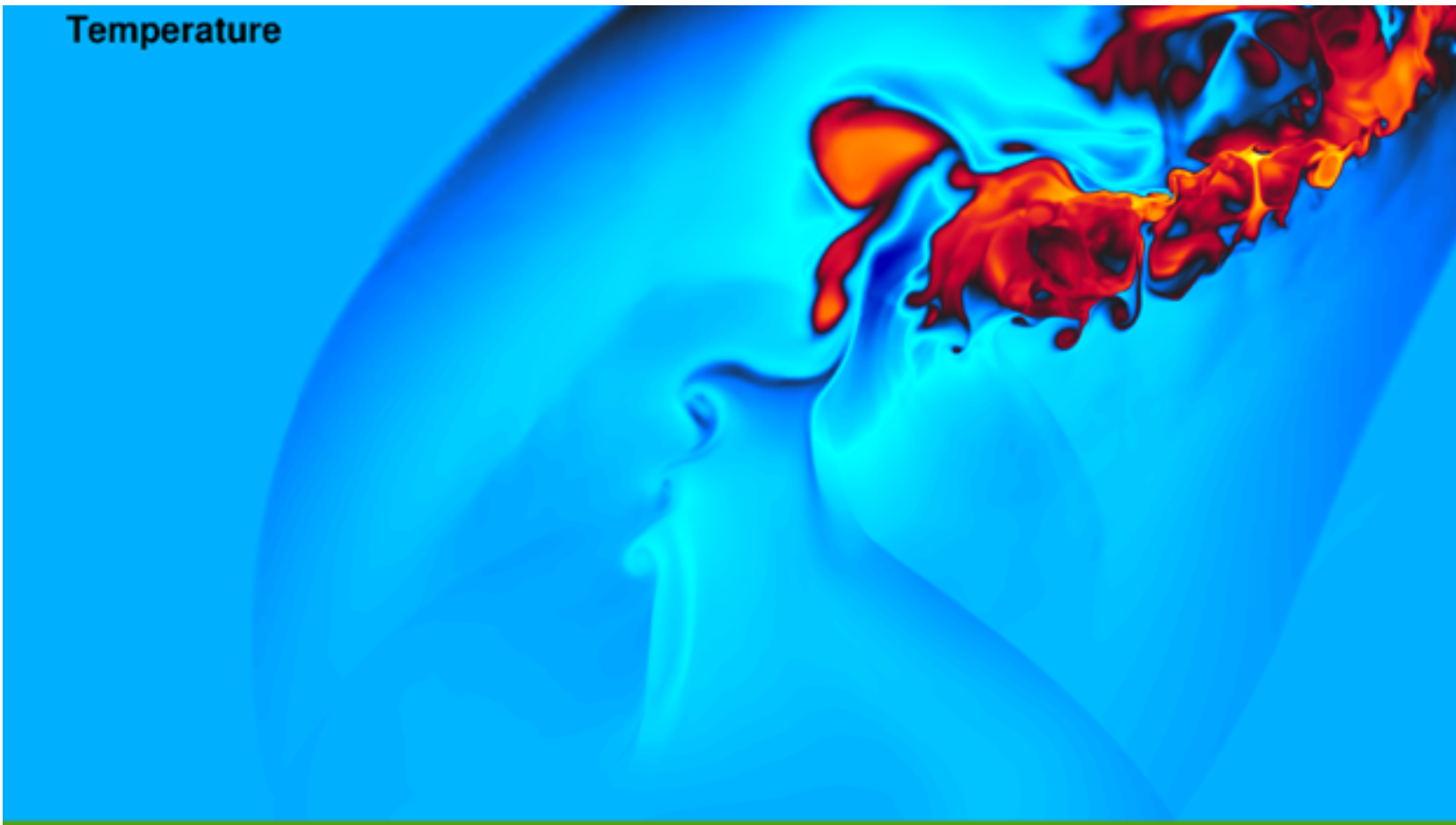
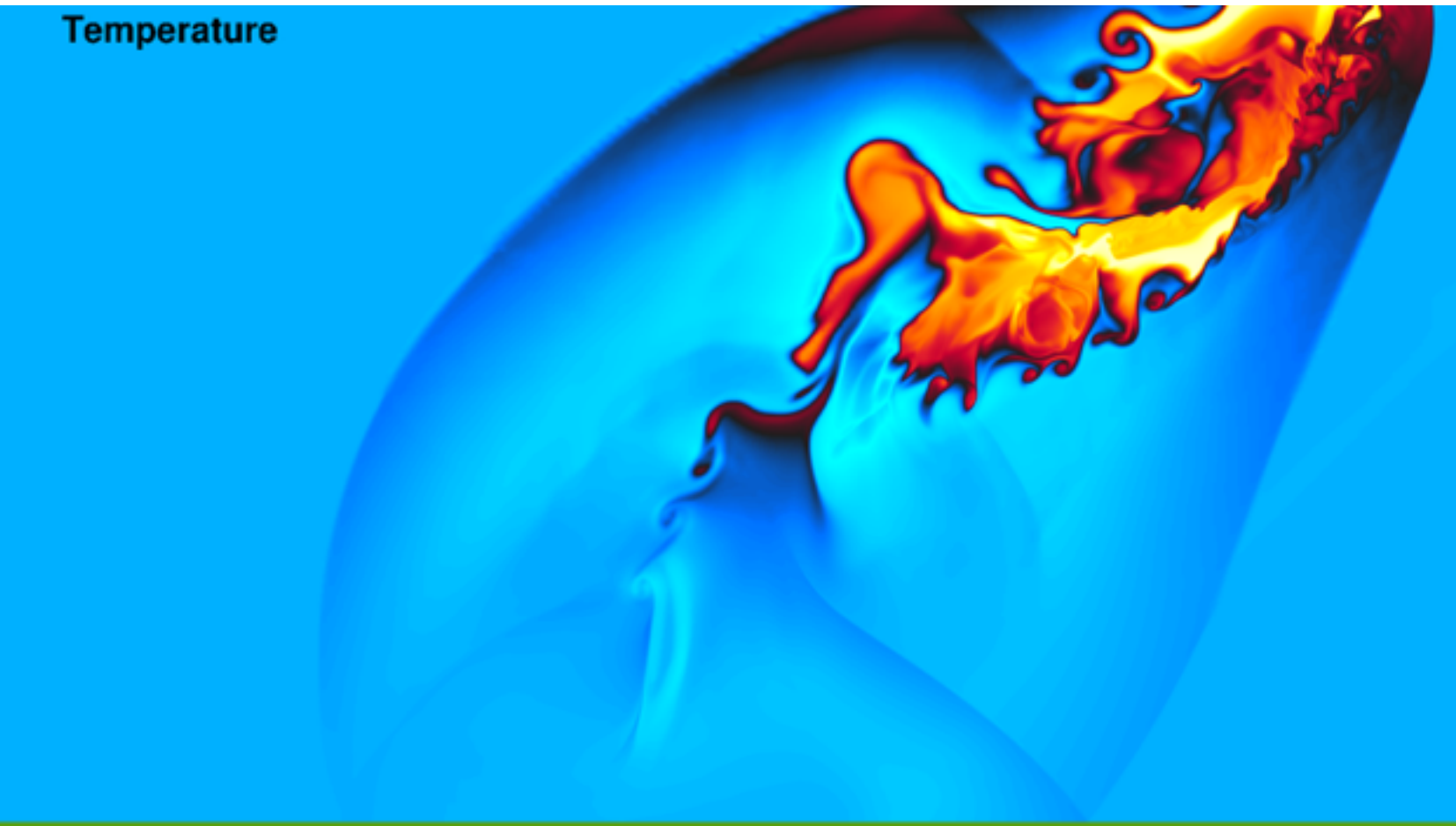
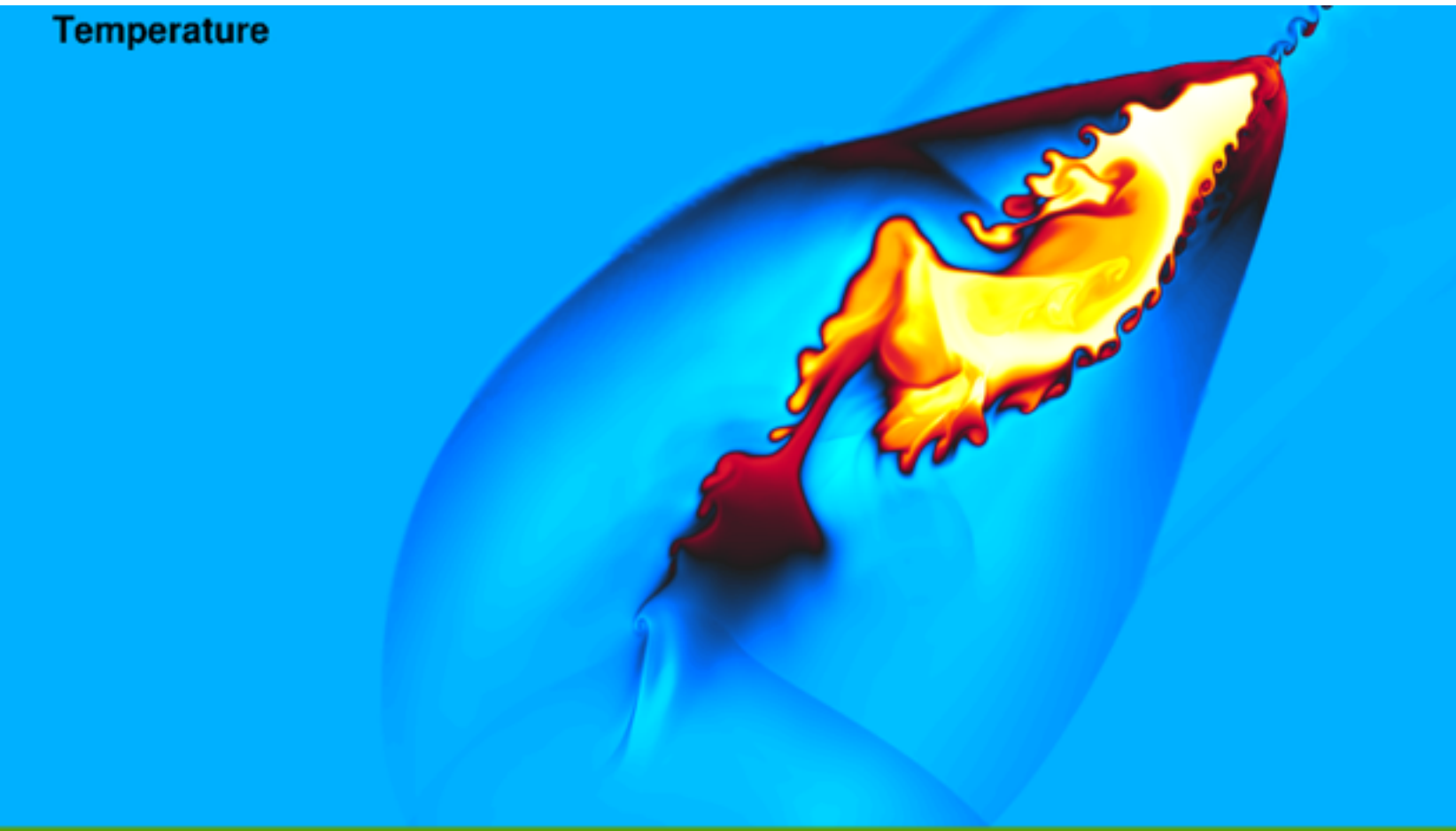
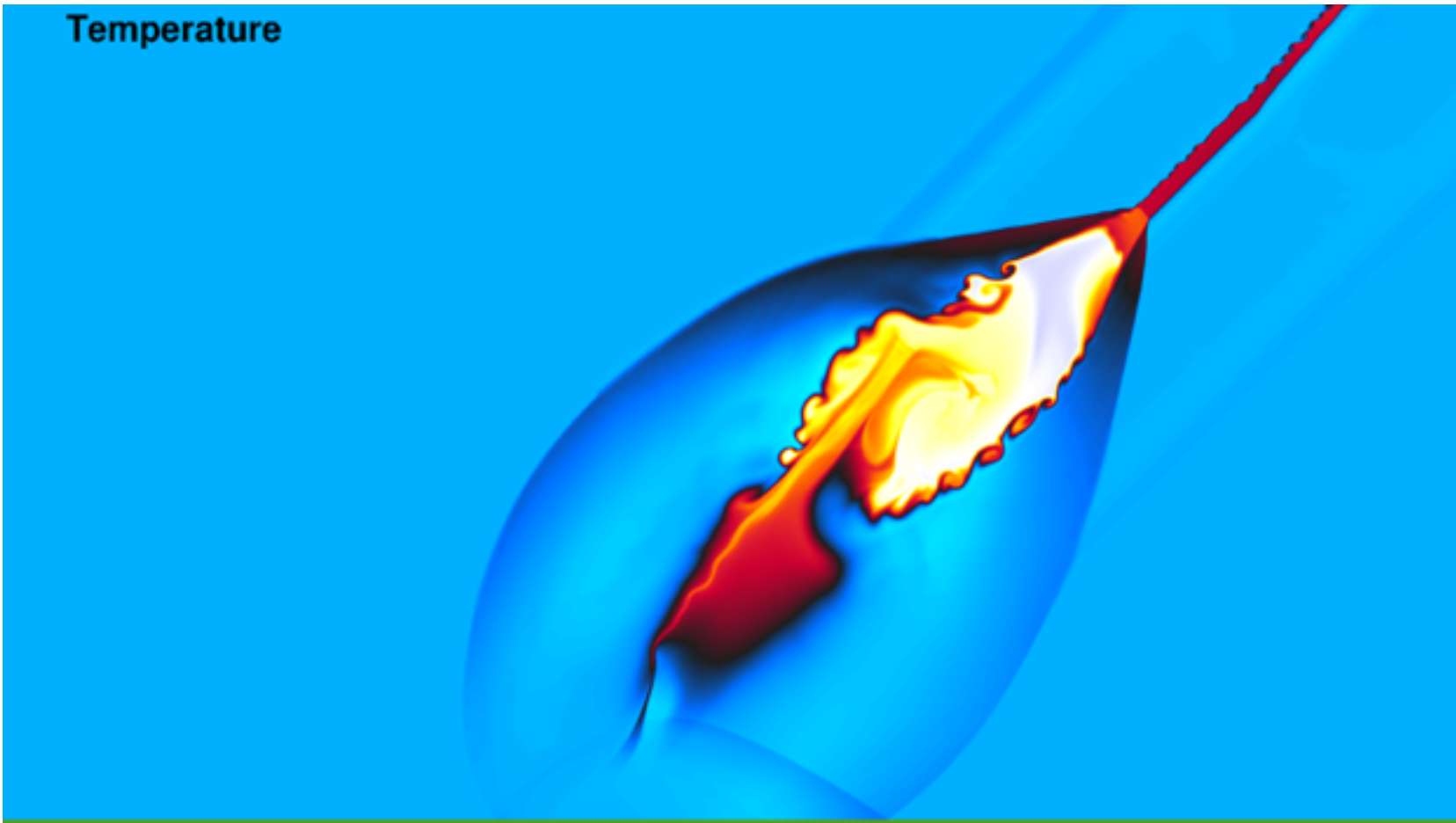
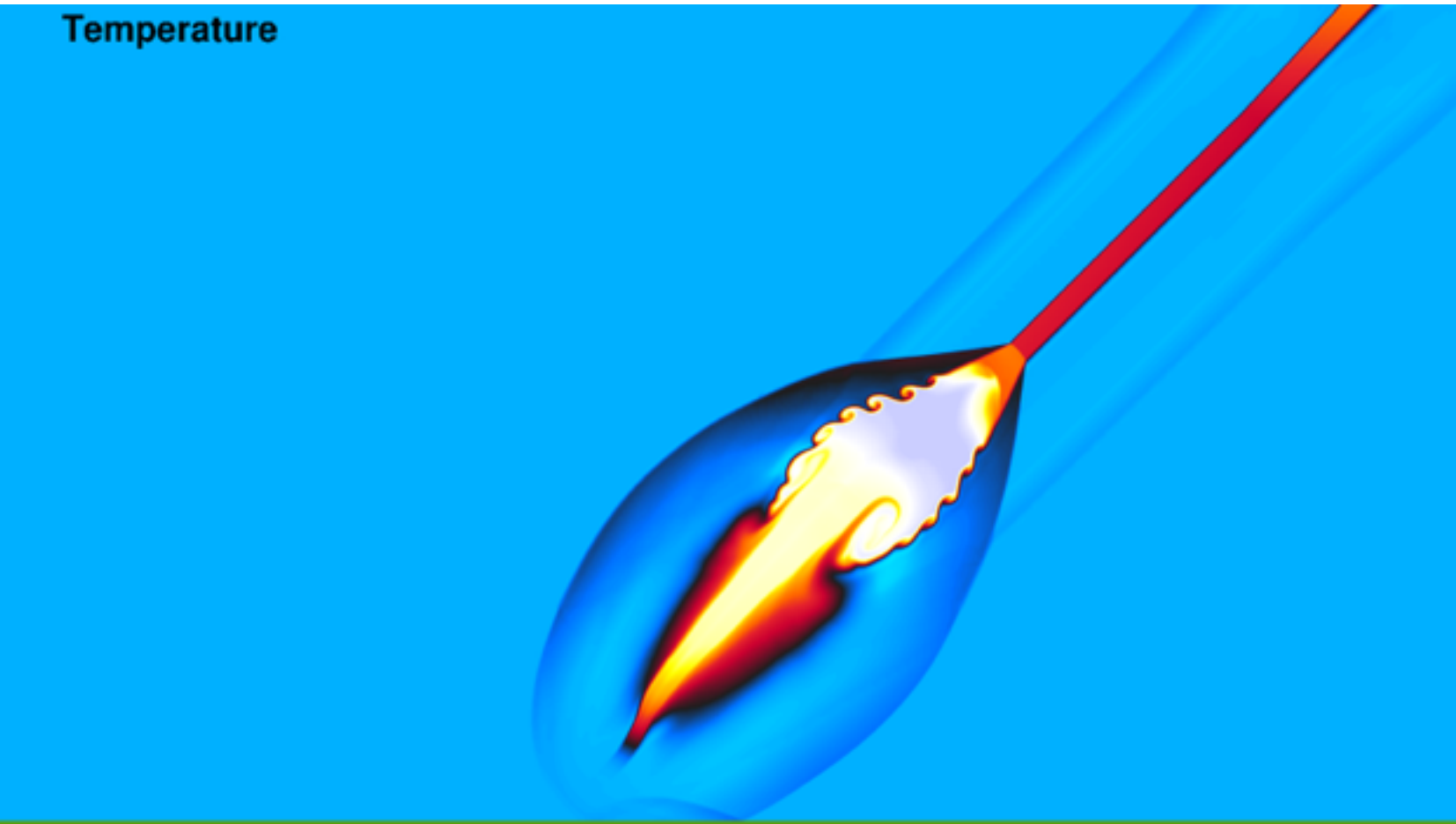
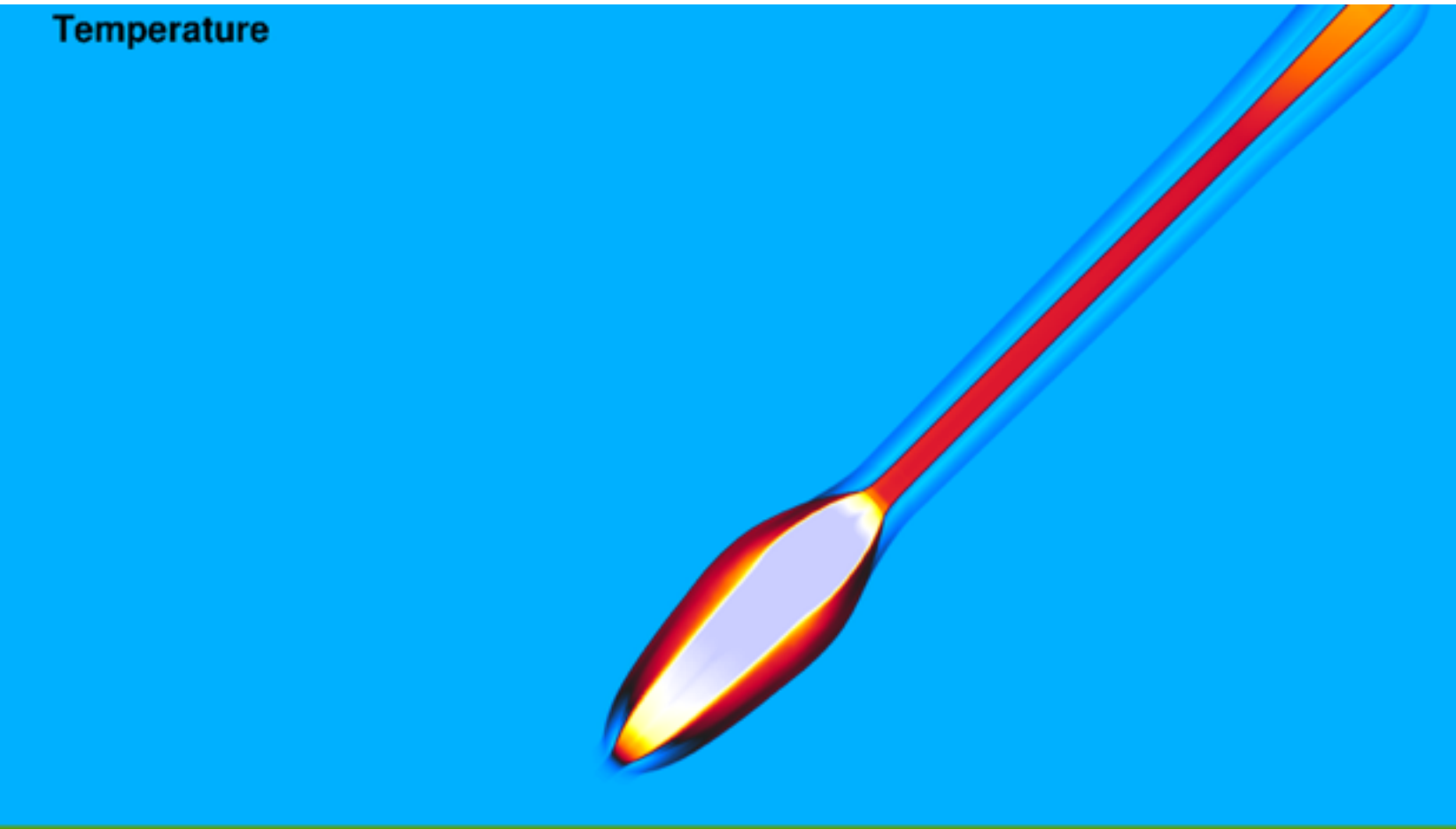
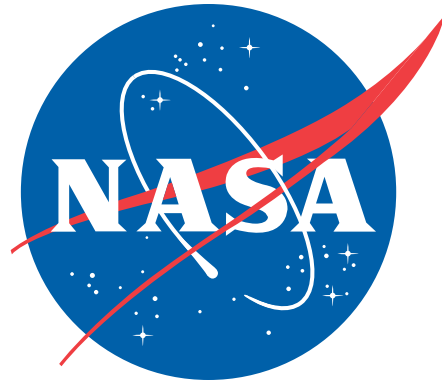
Airbursts: Flow-field Initialization



Mach Contours

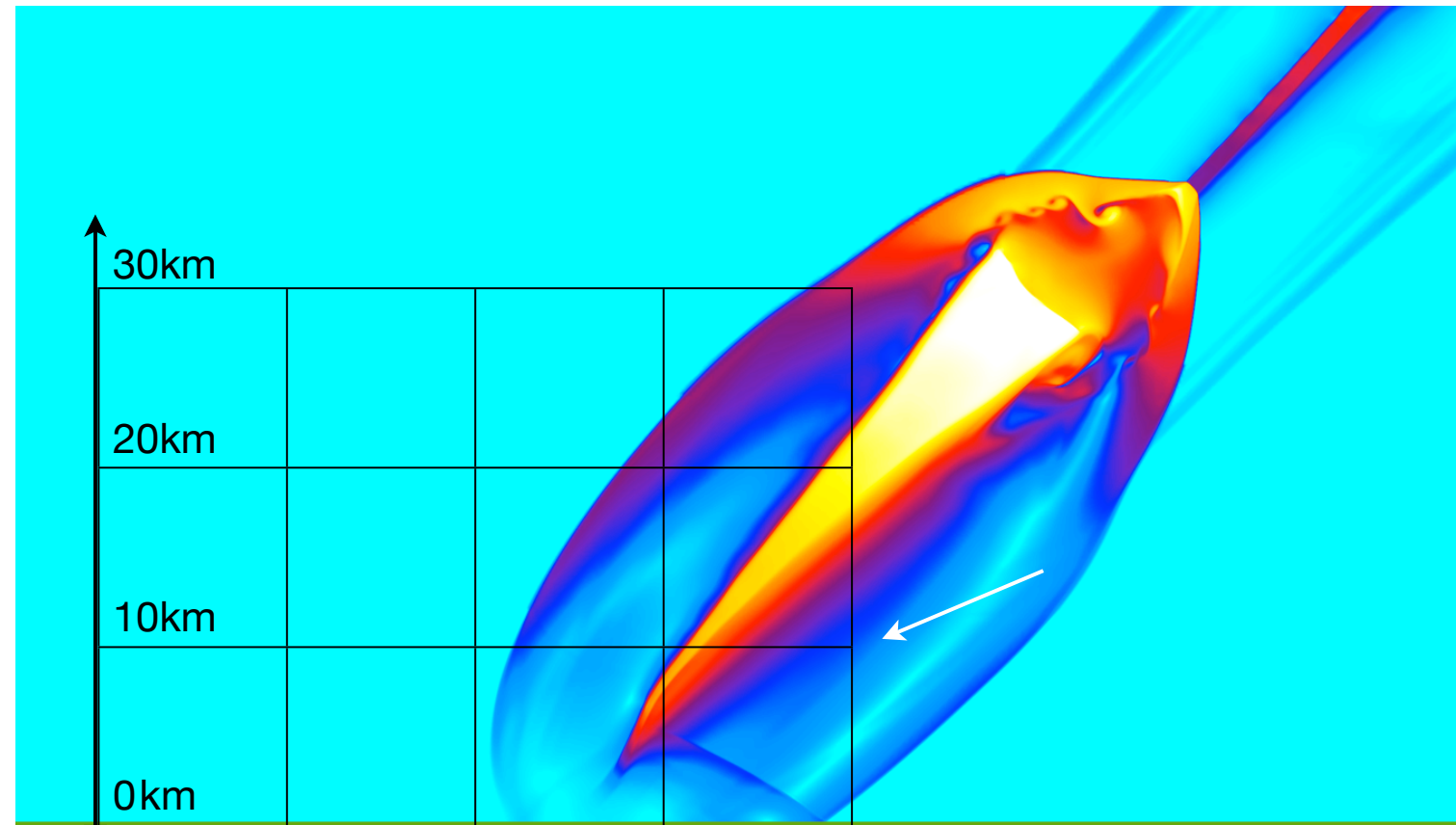


Temperature Contours

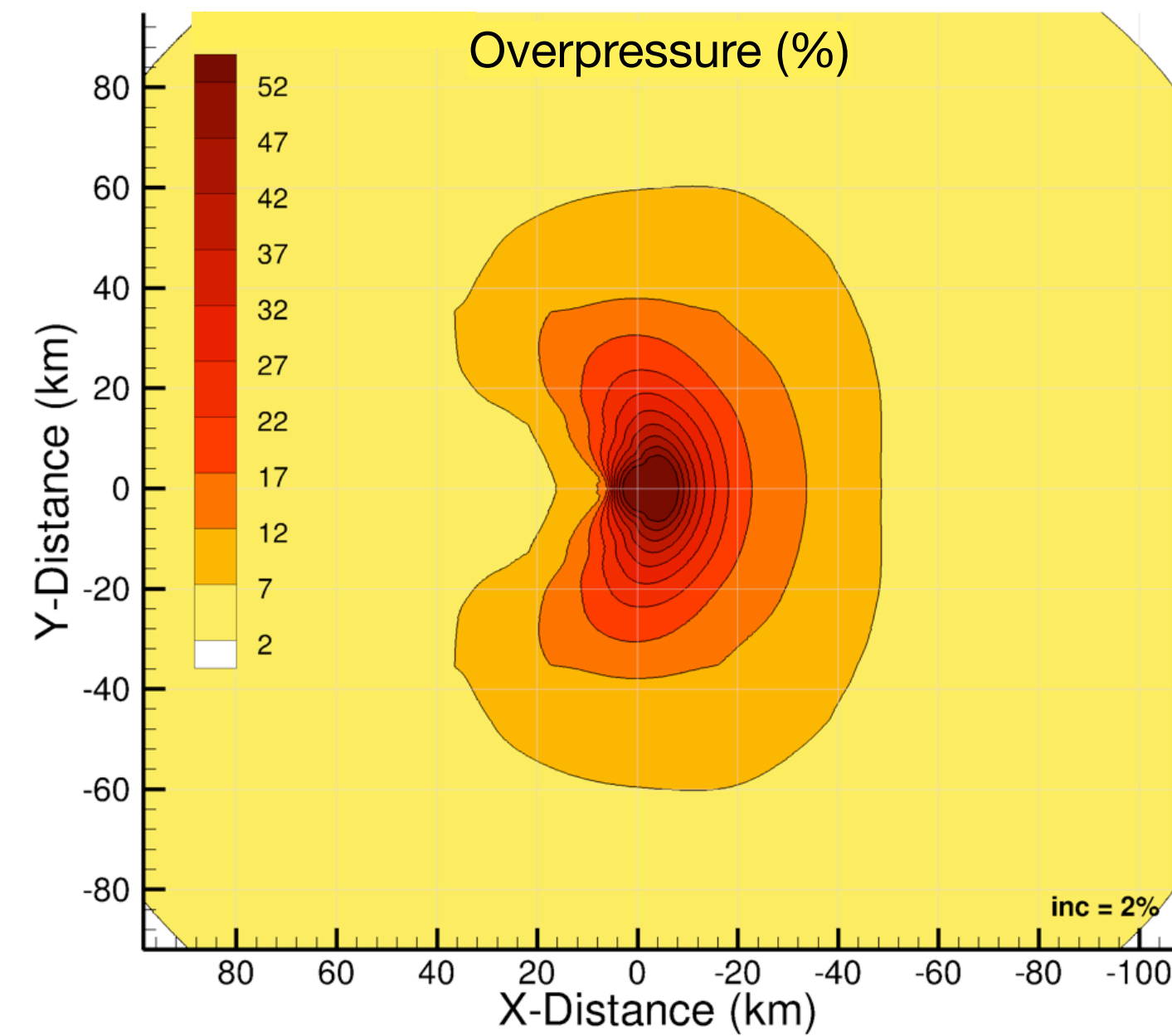
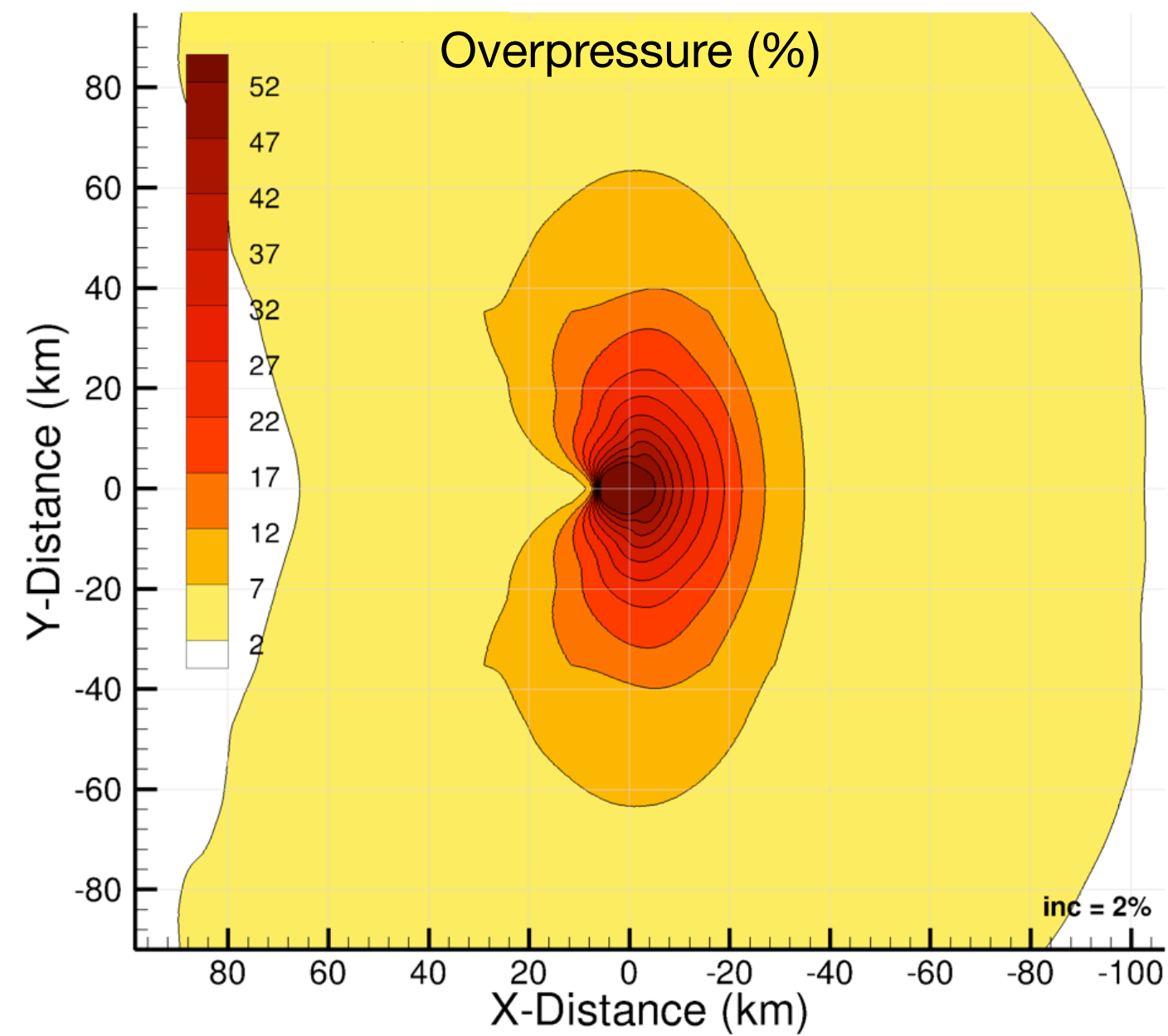
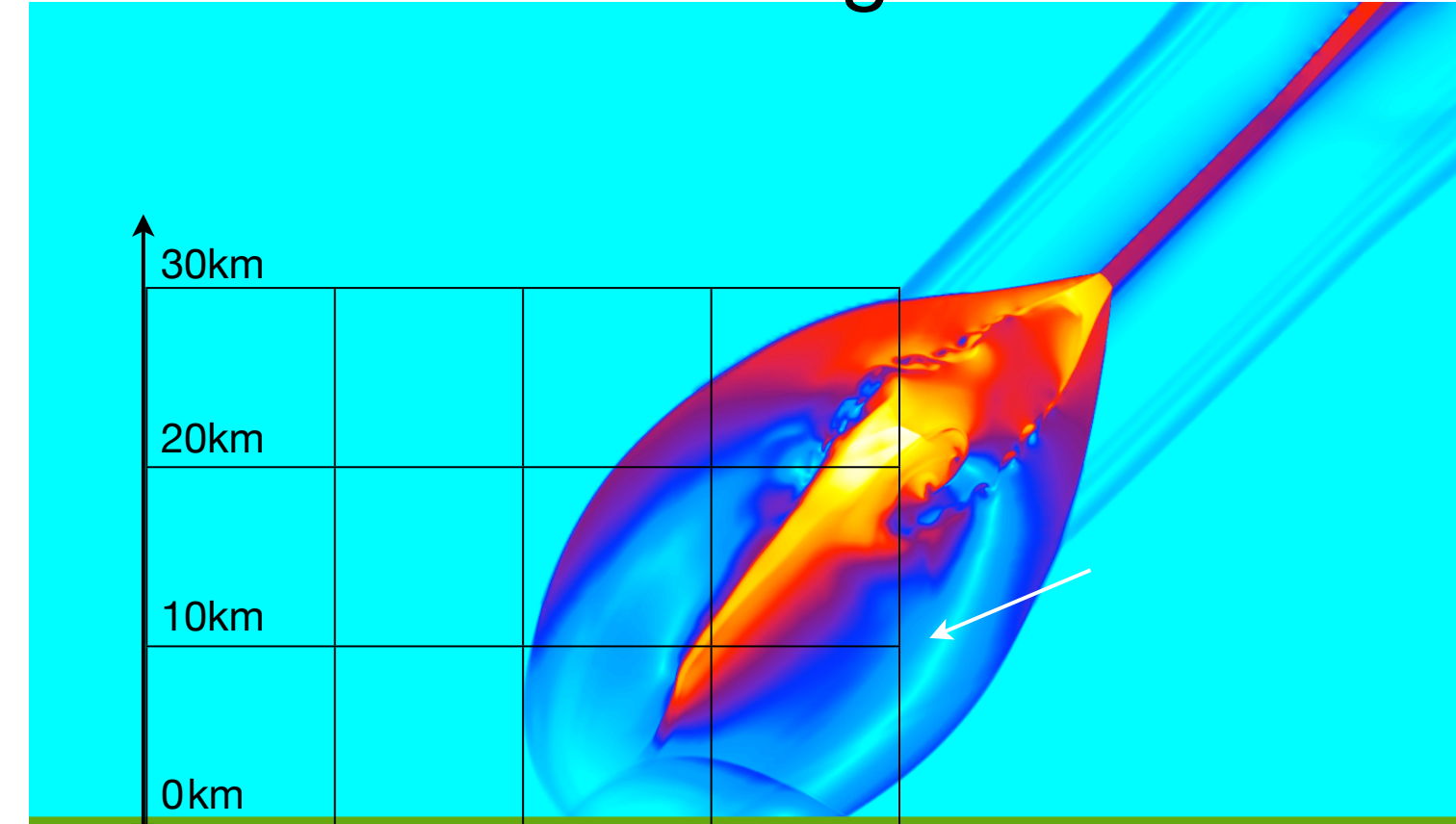


Ground Overpressure

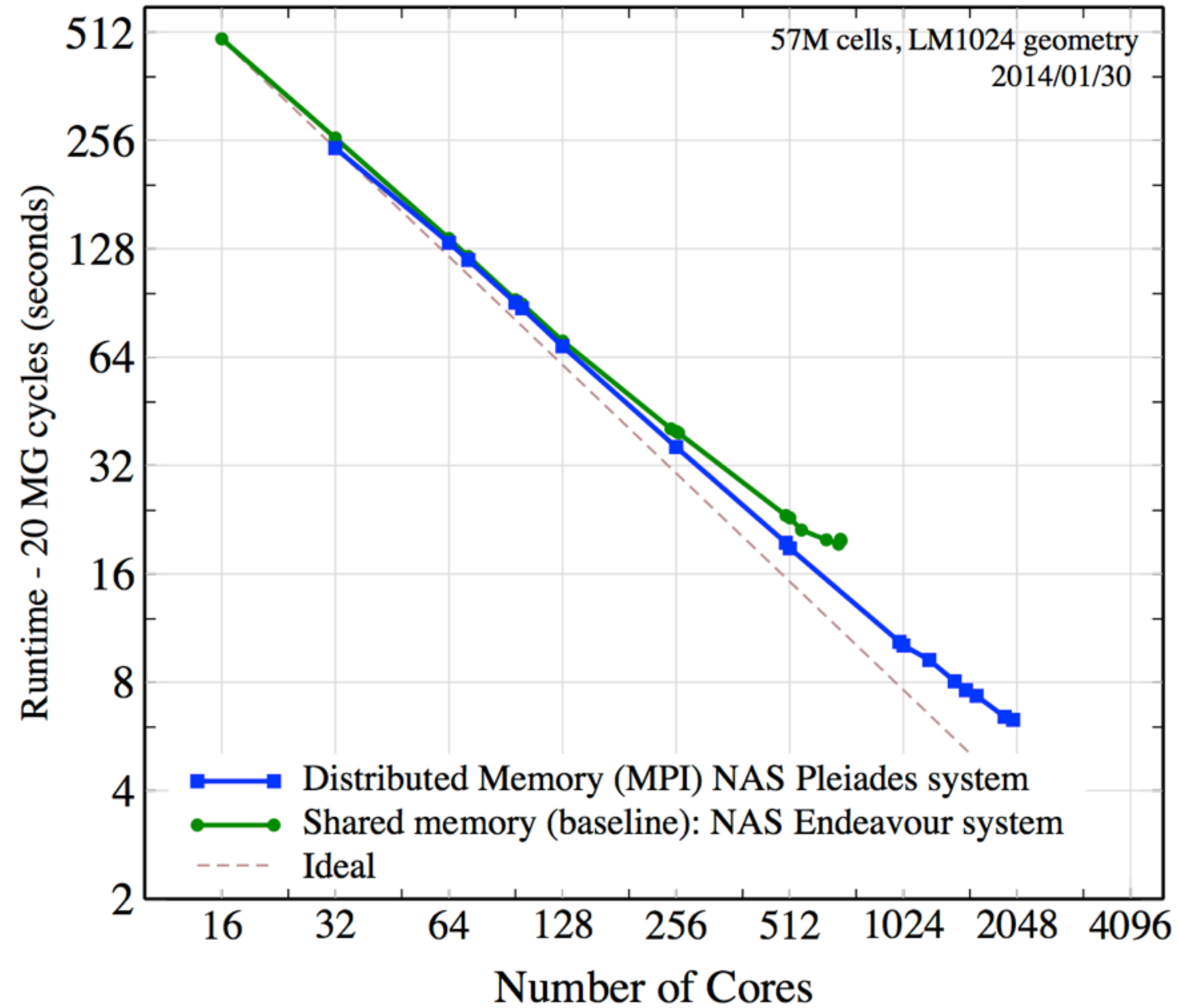
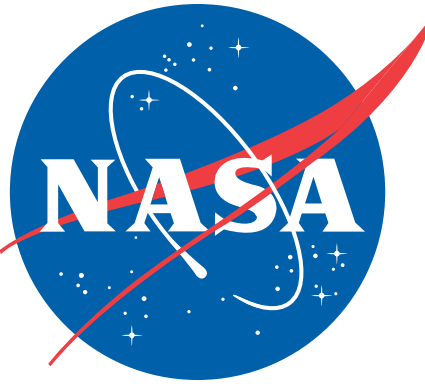
Nominal



“Strong”



HPC Performance

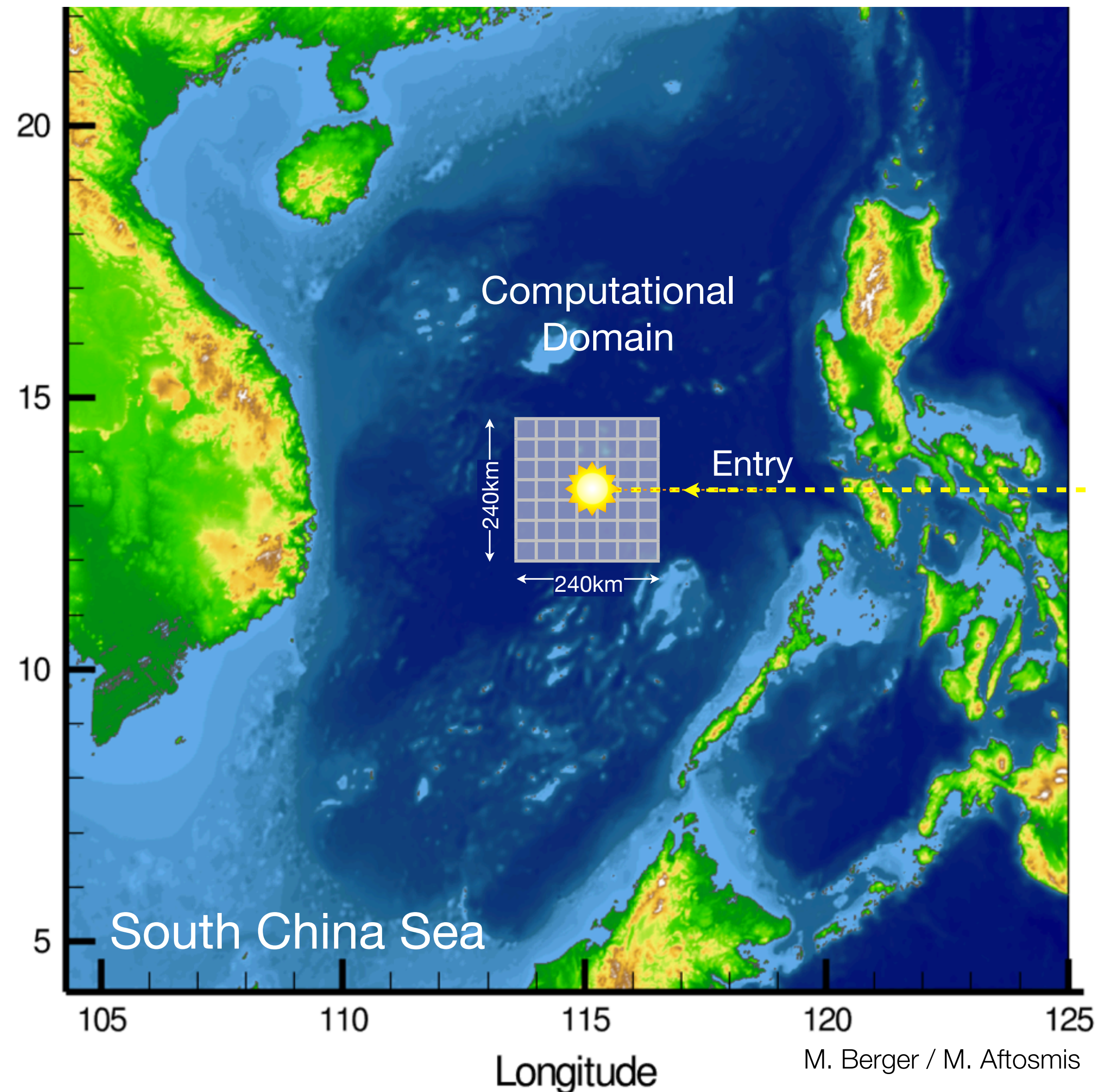


Tsunami Coupling

- 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 $\sim 58,000$ 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

