INTERACTING ATMOSPHERIC PLUMES FROM BOLIDE SWARMS; M.B. Boslough and D.A. Crawford, Sandia National Laboratories, Albuquerque, NM 87185-0820.

We have used the Sandia shock physics code, CTH, to simulate the interaction of atmospheric impact plumes generated by an array of simultaneous impact events on Earth. This work was stimulated by advances in the understanding of atmospheric impact processes since the impact of comet Shoemaker-Levy 9 (SL9), and by our desire to apply what we have learned to terrestrial processes. We performed 2-D axisymmetric calculations with pseudoperiodic boundary conditions to determine the effects of the interaction of plumes resulting from a cluster of impacts, compared to a single, isolated event. We simulated a plume from the impact of a 20 km/s, 34 meter-diameter asteroid (kinetic energy of 3 megatons) at vertical incidence, and compared its evolution and collapse to interacting plumes from arrays of impacts with near-neighbor separation distances of 40, 100, and 200 km. As expected, the closer-packed arrays lead to denser plumes that reach higher altitudes and generate higher temperatures within denser air upon collapse. These results can be applied to models for generation of layered tektites by radiative heating from an impact-heated atmosphere. Simulations of interacting plumes from bolide swarms can also be used to consider dispersed rubble-pile models for SL9.

The 1994 collision of SL9 provided a unique opportunity to directly observe the results of large atmospheric impact events. Interpretation of the observational data within the context of computational models [1,2] has advanced our understanding of such processes, and can be applied to impacts on Earth. Impact plumes are rare transient events on Earth, so no direct observational data exist. However, Wasson [3] has suggested that atmospheric deposition of energy from a disrupted comet or asteroid may have led to the formation of layered (Muong-Wong) tektites by a process of radiative coupling, so there is possible evidence in the geologic record for atmospheric plume phenomena. As a first step toward modeling such a process, we have approximated a swarm of equally-spaced impacts by performing an axisymmetric simulation in a cylinder with reflecting boundary conditions. The diameter of the cylinder is roughly the distance between plumes in a hexagonal array with periodic boundary conditions, so these boundary conditions can be considered "pseudoperiodic" (Figure 1). In this highly simplified geometry, the lateral extent of the cluster is infinite, but for a 1000 km cluster the effects of the edge will not reach the center of the collective plume until after it has collapsed. These simulations made use of the energy deposition model developed by Crawford [2,4]

Two time steps of the results (5 and 12 minutes after impact) of each simulation is shown in Figure 2, where the shading is proportional to log(density) with a cutoff density of 10^{-10} g/cm^3. At

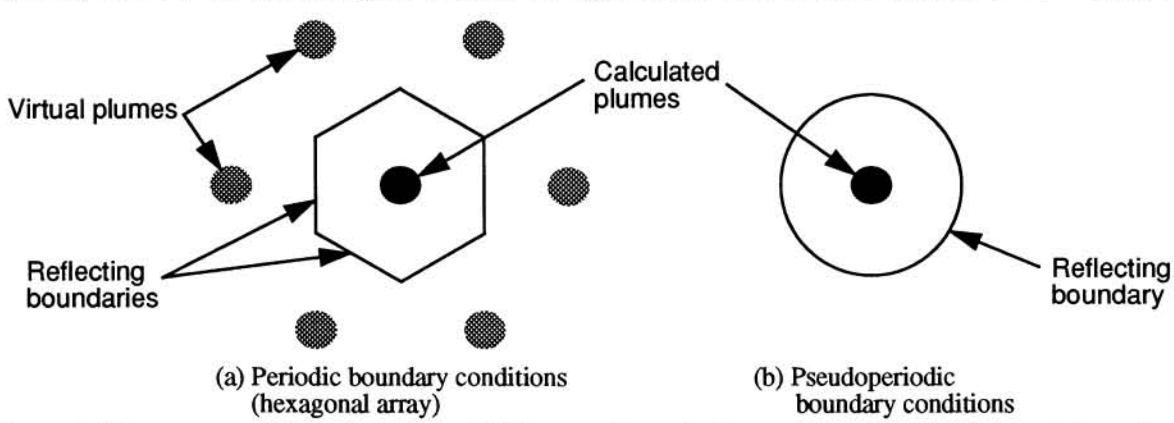

Figure 1. Diagrammatic explanation of 2-D pseudoperiodic computational scheme (plan view).

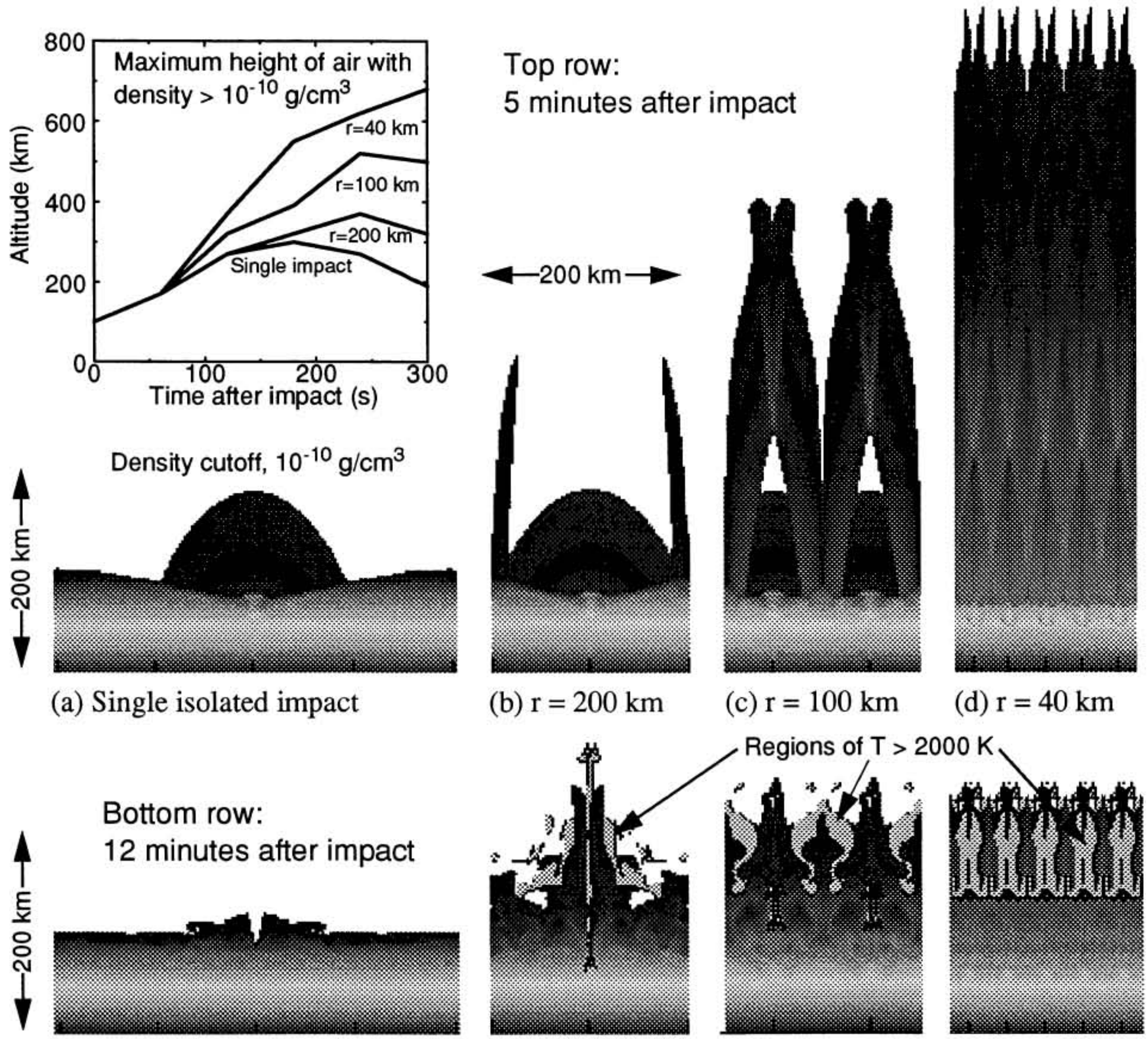

Figure 2. Plumes from clusters of 3 MT impacts; top row shows density bands five minutes after impact; bottom row shows density of collapsed plume at 12 minutes after impact, with regions where temperature exceeds 2000 K; r is the interaction distance between neighboring impacts.

12 minutes (lower row) the regions where the temperature is greater that 2000 K are also shown. The inset graph provides maximum altitude as a function of time of air with density greater than 10^{-10} g/cm^3. Because more mass is ejected per unit area for the tighter cluster, the density of the plume is higher and much more atmospheric mass is heated upon its collapse. The energy transport in these simulations neglects radiation, so the actual late-time atmospheric temperatures may be lower. To fully assess the effects of radiative energy coupling to the ground will require a simulation that includes detailed opacity calculations.

References: [1] Boslough M.B. *et al.* (1995) *Geophys. Res. Lett. 22*, 1821-1824. [2] Crawford D.A. (1996) in *The Collision of Comet Shoemaker-Levy 9 with Jupiter*, (in press). [3] Wasson J.T. (1995) in *Lunar Planet Sci. XXVI*, 1469-1470. [4] Crawford D.A., this volume.

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