USING HST PLUME HEIGHT DATA TO PLACE LOWER BOUNDS ON COMET SHOEMAKER-LEVY 9 FRAGMENT MASS AND PENETRATION DEPTH* D. A. Crawford and M. B. Boslough, Sandia National Laboratories, Albuquerque, NM, 87185.

Models of Comet Shoemaker-Levy 9 fragments entering the Jovian atmosphere and subsequent plume evolution are strongly constrained by the seemingly contradictory observations that plumes observed by the Hubble Space Telescope (HST) all had approximately the same maximum altitude yet the dark ejecta they left behind varied considerably in albedo and lateral extent[1]. We modeled plume evolution for fragments with diameters of 125-2000 m using the CTH shock-physics code[2]. Initial conditions were provided by an analytical model that has been calibrated against numerical entry simulations[3,4]. The plume simulations show that maximum altitude of a specific isodensity contour is an increasing function of fragment size and mass. However, if the tops of the plumes observed by HST are derived from material originating from a specific level of the atmosphere (an isocomposition contour), then maximum plume heights are independent of fragment size provided the fragments penetrated at least 30 km below this level. For example, if the tops of the plumes originated from the visible cloud tops, then fragment masses greater than 4×10^{12} g (equal to 200 m diameter fully dense water ice) are required to explain the observations. If the visible plumes originated from the NH_4SH layer, then masses greater than 3×10^{13} g (400 m water ice) are required.

Figures 1 and 2 show results from the 8 numerical fireball simulations that we have performed. The initial conditions for each simulation were given in the form of energy deposition per unit altitude derived from an analytical meteoroid entry model that has been calibrated against CTH simulations [3,4]. A two dimensional representation, symmetric to the 45° entry angle, was used to simulate the first 3 minutes of fireball evolution in CTH. Tracer particles were added to the simulations to represent the Jovian cloud layers (Fig. 2). At the end of the CTH simulation, the locations of the tracer particles were ballistically extrapolated in 3-D to follow plume evolution to maximum height and subsequent collapse. Provided the observable plumes were derived from the cloud layers (represented by tracer particles), maximum plume heights of 3000 km are independent of fragment size (Fig. 1) and consistent with HST observations [1]. According to this model, the radial extent and mass density of the observable plume are functions of fragment cross-sectional area and directly relate to the radial extent and albedo of the resulting ejecta patterns. The apparent gap between the central disturbance of the impact site and the inner front of the crescent-shaped ejecta may reflect the fragment's depth of penetration below the source of the visible ejecta.

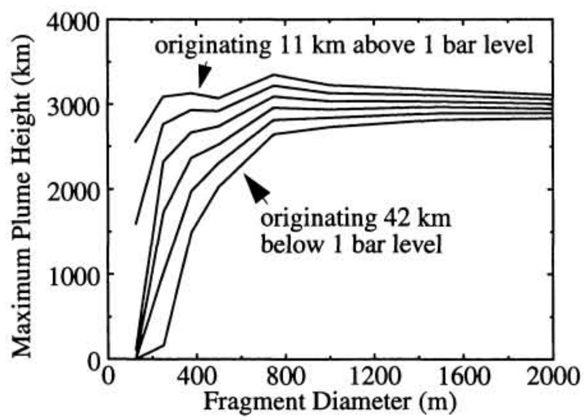

Fig. 1. Maximum altitude vs. fragment diameter for atmospheric cloud layers represented by tracer particles in numerical simulations. Eight tracer layers are shown corresponding to cloud layers originating at 11, 0, -11, -21, -32, and -42 km respectively.

References: [1] H. B. Hammel et al., *Science, 267*, 1288-1296 (1995). [2] J. M. McGlaun *et al.*, Sandia National Laboratories Report, *SAND89-0607*, Albuquerque, NM (1989). [3] D. A. Crawford, Models of Fragment Penetration and Fireball Evolution, in *The Collision of Comet Shoemaker-Levy 9 with Jupiter*, Keith Noll, ed., Cambridge University Press, (in press). [4] D. A. Crawford, (this volume).

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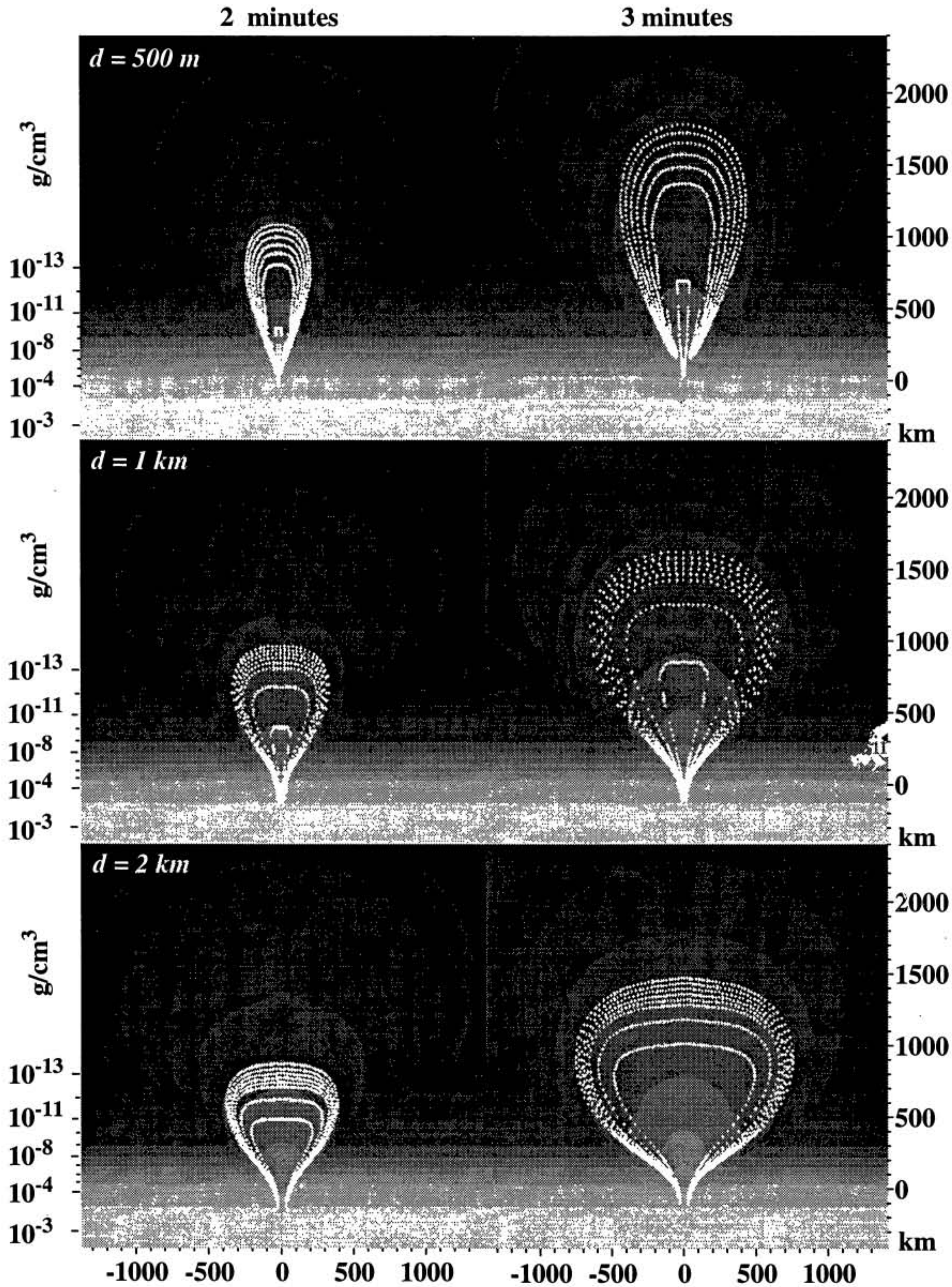

Fig. 2. Simulations of fireballs from 500, 1000 and 2000 meter fragments entering the Jovian atmosphere: 2 and 3 minutes after impact. Gray scale is proportional to log(Density). One thousand tracer particles, representing the Jovian cloud layers, are superimposed (white dots). Material derived from the clouds reach nearly the same altitude at the end of the simulations whereas isodensity contours do not.