# BLAST WAVES AND THE BLOW-OFF EFFECT IN TERRESTRIAL ATMOSPHERES; 
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We have developed a new computational method for describing the atmospheric blast waves produced from the point of a hypervelocity impact on a planetary surface. The method employs the approximations that neglect both the role of the vapor cloud produced by the impact, as well as the ambient pressure in the atmosphere, but remains useful so long as the mass of the vapor cloud is less than that contained within one scale-height radius of the point of impact. These conditions are relevant for describing the blast wave from, for example, a $\sim 10^{15}$ g, $10^{27}$ erg, or ~1 km diameter bolide impacting the Earth. Such a bolide would produce a moderate sized (~5 km) impact crater on the Earth. The impact is at least $10^3$ less energetic than the K-T extinction bolide or the cases considered by the atmospheric cratering models described by Vickery and Melosh [1]. We employ a set of shock hydrodynamic approximations first developed by Kompaneets [2] together with an *analytic* solution method developed by Courant and Hilbert [3] to closely approximate the blast wave behavior. Kompaneets solved the problem for an isothermal atmosphere. In contrast, we are able to treat the Earth's detailed atmospheric structure, and later, those of the other terrestrial planets. We find subtle influences in the shock structure due to the departure of these atmospheres from isothermality, including features at the tropopause and the stratosphere. The essential feature of such blast waves is that, once they have expanded beyond one scale height in distance, the hemispherical symmetry breaks owing to the diminished resistance of the atmosphere at the top of the shock. For terrestrial planetary atmospheres, the lateral extent that a shock can expand is $\pi$ times the scale height, or about 30 km in radius, a result derived by Kompaneets. We generalize this conclusion for more realistic atmospheres, including those of the terrestrial planets, showing that the blast wave punches a narrow column through the atmosphere rather than blowing away a hemispheric cloud. Moreover, at high altitudes in the atmosphere, ballistic considerations for the trajectory of the blast can be expected to produce a fountain-like behavior. We display below the evolution of a blast wave from a ~$10^{27}$ erg impact at representative times for the Earth's present atmosphere [4] (Fig. 1). The shock front variable, y, which relates time, t, volume enclosed by the atmospheric blast wave, V, an empirical constant, $\lambda \cong 1.1$, the energy in the atmospheric blast wave, E, the polytropic exponent, $\gamma$, and the density at the base of the atmosphere, $\rho_o$, is given as [2]:

$$y = \int_o^t \sqrt{\lambda E(\gamma^2 - 1)/(2\rho_0 V)}$$

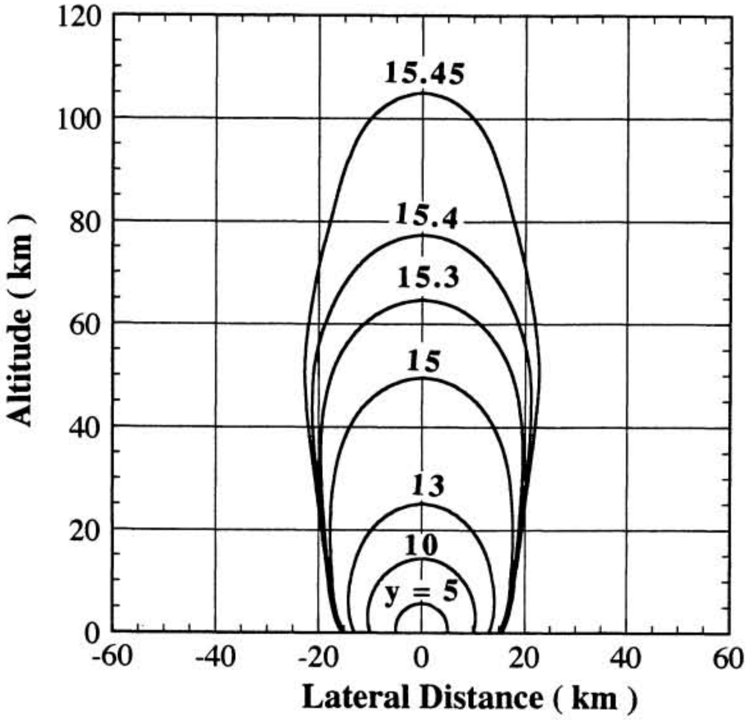

Fig. 1. Shock wave position at various times, specified by the variable, y, for an impact of < $10^{27}$ erg at the surface of the Earth's atmosphere [4].

REFERENCES: [1] Vickery A. M. and Melosh H. J. (1990) in *Global Catastrophes in Earth History* (Sharpton V. L. and Ward P. D., eds.), pp. 289-300. Geol. Soc. Am. Special Paper #247. [2] Kompaneets A. S. (1960) *Sov. Phys. Doklady*, 5, 46-48. [3] Courant R. and Hilbert D. (1962) *Methods of Mathematical Physics,* Interscience Publishers, New York, 75-88 pp. [4] Chamberlain J. W. and Hunten D. M. (1987) *Theory of Planetary Atmospheres,* Pergamon Press, New York, 481 pp.