P03 Nuclear Cloud Formation and Rise in Urban Environments

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Abstract:

Recent high resolution numerical calculations of possible terrorist nuclear detonations in urban scenarios reveal that the behavior of the fireball is significantly modified by the presence of nearby surrounding structures. The first modification is caused by the primary shock reflection from the structures. The reflected shocks limit the horizontal growth of the fireball, while the streets and open areas allow relatively free growth. The "arms" thus generated, produce large surface areas for radiative cooling and interface mixing of ambient air. The interaction of the shock with structures generates strong vortices at the edges of each building. These vortices provide a means of mixing cool ambient air with the hot fireball gasses and radioactive material, thus cooling the fireball. The combined reflected shocks, in the horizontal direction, force the fireball to expand upward. At a time of 2 seconds, the urban fireball from a near surface 1 kt detonation has a vertical radius that is more than twice the horizontal diameter.

At a time of 5 seconds, the maximum temperature in a free-field fireball is 5 times the maximum temperature in an urban fireball. The rise of the urban fireball after 5 seconds is impeded by a combination of a large surface area, an irregular shape, inhibited in-flow and reduced buoyancy. The maximum vertical velocity in the urban fireball is about two thirds of that from a free field detonation. By a time of 20 seconds, the urban fireball has risen to about three quarters of the height of a free-field fireball, even though it was significantly higher at 5 seconds.

The implications of this behavior for fallout are significant. Radioactive debris is trapped near the ground by vortices, the temperatures are much lower and will not vaporize entrained material, the cloud will not rise as high, and fallout will be more localized.

This paper presents results of calculations for several cities and for two different yields with comparisons to free-field results.

Notes: