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A3_8 Thumbs up for Surviving a Nuclear Apocolypse

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Abstract

This paper investigates the theory proposed in the Fallout game series, where if you observed a nuclear blast, you would need to hold your thumb up at an arm's length and compare the size of the mushroom cloud stem to the width of your thumb. If the stem of the cloud was bigger than your thumb then you would be in danger and would need to start running. We found that if a Hiroshima sized mushroom cloud appeared just larger than your thumb you could escape most negative radiation effects by running laterally to the direction of the wind for 1.65 km in a half an hour period.

Introduction

The Fallout games are set in a future post apocalyptic world that has been destroyed by nuclear weapons. A friendly looking mascot known as Vault Boy helps to guide the survivors by giving them helpful tips for living in a world that they would no longer recognise. Vault Boy is often depicted giving a thumbs up, while on the surface this may seem like a friendly encouraging gesture, it has a more practical meaning. If a person was to see a nuclear blast, they should do as Vault Boy does and stick out their thumb at arms length to see if the stem of the mushroom cloud is wider than their thumb. If it is then they are within the radiation zone and they need to evacuate quickly. The nuclear weapons that are used in this post apocalyptic world are small in relation to the largest that currently exist [1], so a small nuclear blast was investigated.

Theory

In this paper, a Hiroshima sized nuclear blast of 15 kilotons was considered as it is relatively small in comparison to those that would occur from the largest existing nuclear weapons. Firstly, the solid angle created by the thumb at a distance of an extended arm from the eye was calculated using equation which is taken from the definition of a solid angle

$$\Omega = \frac{A_1}{r_1^2}, \tag{1}$$

Where A_1 is the area of the thumb and was calculated by estimating the thumb to be circular with a radius of 0.01 m. r_1 is the length of an extended arm estimated to be 0.7 m. From these values the solid angle was calculated to be 6.411×10^{-4} sr. Using this solid angle, the distance to the nuclear blast was calculated by considering the thumb just covering the stem of the cloud. This was calculated by rearranging equation 1 and substituting the previously calculated solid angle.

$$r_2 = \left(\frac{A_2}{\Omega}\right)^{\frac{1}{2}} \tag{2}$$

Where A_2 is the area of the stem of the mushroom cloud, estimated to be circular with a radius of 180 m [2]. The stem of the cloud can be modelled as a circle as we are only concerned with the width of it and the height can be disregarded, it simply makes the calculations easier if both the thumb and cloud are taken to be circular.

Results and discussion

Using equation (2) the distance to the mushroom cloud was calculated to be 12.6 km. Assuming the detonation occurred on the ground, the radius for avoiding all burns is 4.67 km away from the blast centre and the radius for radiation sickness symptoms is 1.56 km [2]. This would mean that you would be safe from the initial blast effects of radiation and burns. However, the wind would immediately start carrying the radiation outwards so you are not guaranteed to be safe from harm by staying where you are. Assuming an average wind speed of 24 kmh^{-1} the fallout would reach you within approximately half an hour if you were to be standing directly upwind. From a simulated blast using the discussed conditions [2] the fallout contours were visualised as can be seen in Figure 1. At a distance of 12.6 km away from the nuclear blast the maximum width for a fallout contour of 100-350 rads per hour would be 2.3 km upwind. Meaning that if you were to stand upwind you would find yourself within this contour. 100-350 rads per hour could result in acute radiation syndrome [3] which you would want to avoid. If you are unfortunate enough to be located upwind at the centre of the fallout contour, you would need to run 1.65 km laterally to the direction of the wind within half an hour before the fallout reaches you. This would place you in a much safer 10 rads per hour zone, meaning that it is entirely possible to avoid harmful radiation effects using the Fallout rule of thumb.

Conclusion

This investigation showed that if a 15 kiloton nuclear bomb was to detonate, and your thumb extended at an arm's length just covered the blast, you could survive most negative radiation effects by running laterally to the direction of the wind for a minimum of 1.65 km in half an hour given that you are standing directly upwind to the blast. While this theory works for a relatively small nuclear detonation, further investigation is required to test whether it would also extend to larger nuclear blasts. Further research is also required to investigate the survival likelihood if the cloud appeared larger than your thumb. Having the stem of the mushroom cloud smaller than your thumb may mean that you could be relatively safe, but it is still always a good idea to evacuate anyway.

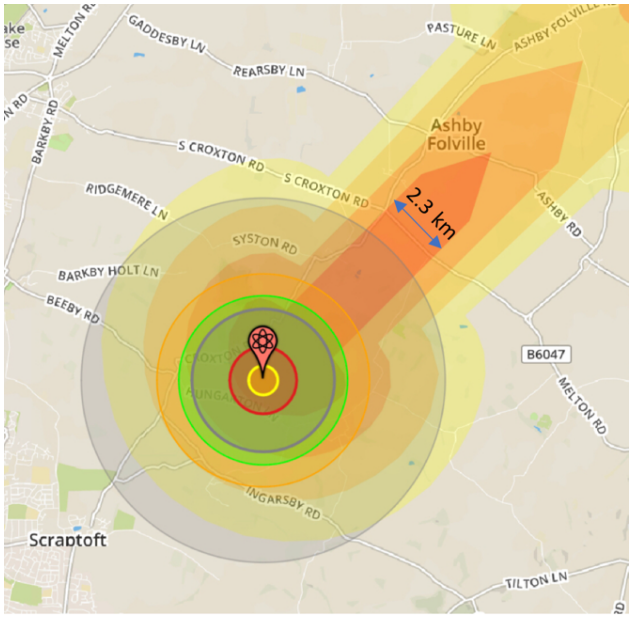

Figure 1: Figure 1: A simulation of a 15 kiloton nuclear bomb being detonated in Leicester with the 100-350 rads per hour fallout contour show in orange to be 2.3 km wide

References

[1] `http://fallout.wikia.com/wiki/Nuclear_weapons` [Accessed 20/11/2018]

[2] `https://nuclearsecrecy.com/nukemap/` [Accessed 20/11/2018]

[3] The Effects of Nuclear Weapons, Revised ed., US DOD 1962, pp. 592–593