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WEATHER INDUCED WIDESPREAD NUCLEAR FALLOUT EFFECTS

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Abstract: In the event of the detonation of an improvised nuclear device many non-nuclear states would be looking towards the UK, France and NATO to offer support and expertise. Understanding some of the key factors in advance has the potential to save thousands of lives. Radioactive dust and debris from such an event can be lofted high into the atmosphere and is affected by both local and regional meteorological conditions; the effect of precipitation on nuclear fallout could cause severe problems in neighbouring countries throughout the region. This is especially relevant in Europe where many countries are closely packed together and may not necessarily have the required expertise or knowledge to deal with such an event.

Key words: *Nuclear Detonation, Fallout, Atmospheric Transport, Dispersion, Wet deposition, Scavenging, Radioactivity, Crisis and Consequence Management (CCM), Emergency Response, Modelling, NAME, Radiation-Hydrodynamics, CFD,*

BACKGROUND

In the event of a nuclear detonation, the resulting fireball can reach hundreds of metres across, have temperatures of millions of Kelvin and contain a mixture of hundreds of radioactive fission products. The hot, buoyant fireball will start to rise, forming a vortex ring and the characteristic mushroom cloud.

At the same time, near-field interactions of the blast wave create a huge amount of dust and debris. This material can then be swept up into the rising fireball by the induced winds, mixing with the fission and activation products. As the fireball cools, the radioactive materials start to nucleate and condense on the dust and debris.

Unlike conventional explosives, nuclear clouds can easily breach the boundary layer and stabilise high in the troposphere. Most of the radioactivity is concentrated in the core of the vortex ring in the form of particles typically less than 1 micron in diameter; these are lofted the highest in the atmosphere and disperse over a great distance, decaying slowly without causing any adverse effects on the ground.

When the nuclear cloud comes into contact with natural clouds, however, the radioactive particulates can agglomerate and act as cloud condensation nuclei for water vapour. Consequently, rain downwind of the event can scavenge radioactive material. This can create higher doses and be a serious cause for concern for emergency lifesaving operations.

The disparate length and time scales make modelling nuclear detonations an interesting but difficult problem. AWE have developed a number of radiation-hydrodynamics codes that can simulate the aftermath of such events and employ them for validation purposes against our emergency response and counter terrorism capabilities as well for generating schooled solutions for exercises.

PROJECT METHODOLOGY

A joint collaboration between AWE and the UK Met Office was set up to better understand the complex sensitivities and relationships of both emplacement conditions and meteorological environments by coupling the radioactive tracking capability one of AWE’s 3D, first-principles physics rad-hydrocodes, called Hardrain, with the Lagrangian particles in the UK Met Office dispersion code, NAME.

A number of meteorological conditions were needed for comparison (described in Table 1), so a location in Cardington (0.42 W, 52.10 N, 29 m msl) was selected to represent the detonation point for each run due to the vast amount of available NWP data in the region. For each scenario in Table 1, both near-surface explosions and explosions in the air were considered due to the vast difference in properties of the resulting fallout particulates (with a total of 12 simulations).

Table 1. Meteorological scenarios considered in this study.

Scenario	Conditions	Date and time	Notes
1	Clear sky (no wet-deposition)	29/09/2015 12 UTC	
2	Heavy widespread frontal rain	24/07/2015 16 UTC	~ 4 mm/hr
3	Light rain/drizzle	01/12/2015 01 UTC	~ 1 mm/hr
4	Light snow	02/02/2015 23 UTC	
5	Scattered heavy rain showers (with convective hotspots)	31/03/2015 18 UTC	
6	Widespread heavy rain showers	06/10/2015 13 UTC	

CURRENT STATUS

The Hardrain simulations using the NWP atmospheric data have been completed and, as expected, show large differences in the size, structure and shape of the nuclear cloud as well as the distribution of fallout particulates.

The Hardrain particulates have been successfully coupled to NAME V7.1 and a postprocessor has been written to include the full list of attributes of the nuclear fallout to the NAME output. The NAME runs are currently underway, which will then allow the full analysis of the outputs to take place. It is hoped that this will be completed by the time of the HARMO 18 conference and be included in the final poster presentation.

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