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The Buncefield oil depot fire: an overview of actual events and the Met Office's dispersion modelling response

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On the morning of Sunday 11 December 2005, a major explosion ripped through the Buncefield oil depot on the edge of the UK town of Hemel Hempstead (located approximately 30 km to the northwest of central London). The accident happened shortly after 06:00 GMT, with the fires ignited by the blast continuing to burn for several days, in an incident which became the largest industrial blaze in Europe to date. A serious fire-fighting operation commenced on the Monday and the last fire was finally extinguished on the Wednesday – four days after the original blast.

The storage tanks at the Buncefield site contained refined petroleum products (mainly petrol and low-sulphur diesel) and the open nature of the fires produced a plume containing large quantities of soot (black carbon). It quickly became apparent that the fire was a large-scale incident with potential impacts on health and the environment both locally and at the regional scale (i.e. tens to hundreds of kilometres downwind). The output provided by short-range dispersion models (ordinarily used for industrial accidents) was inadequate for an event of this scale, and it was necessary to consider more comprehensive dispersion modelling using our Lagrangian dispersion model, NAME. Anticyclonic conditions existed over the south of the UK during the Sunday. The lower atmosphere was stable, with vertical mixing being suppressed, and a significant degree of vertical wind shear (a north-westerly wind at low levels veering to a north-easterly wind aloft). The plume rose vertically upwards, due to its high buoyancy and the light winds, penetrating the boundary-layer top and rising to a height of about 3000 m. The temperature inversion at the top of the boundary layer then acted to trap much of the plume aloft and prevented material from returning to the surface.

The resulting plume was observed on satellite imagery and had a fan-like appearance caused by the significant wind shear. Later on the Monday, there was a higher risk of some grounding of the plume as it became less buoyant but the extent of any surface impacts away from the source has been difficult to assess although is thought to be small.

The Met Office's Environmental Monitoring And Response Centre (EMARC) became aware of this explosion at 07:30 GMT, and provided advice to decision makers throughout the course of the incident. The services included providing weather forecasts as well as satellite imagery and model predictions of the atmospheric dispersion. Research teams in the Met Office supported these efforts, with involvement of both the Met Research Flight and the Atmospheric Dispersion teams. A research aircraft conducted several flights to investigate the plume and provided information on its spatial extent, chemical composition and aerosol characteristics. This information assisted in the dispersion modelling, allowing us to deduce estimates for the source strength and to improve our assessment of the risk of plume grounding and the implications if this were to happen. The modelling also included involvement of the EU ENSEMBLE consortium, which was alerted to the incident on the Monday afternoon. This multi-model ensemble approach takes predictions from multiple dispersion models (also using different sources for their met forecasts) and the good agreement observed on this occasion increased our confidence in the dispersion predictions from our NAME model.

In summary, the Buncefield depot explosion and subsequent fire was a major industrial accident, almost unique in its severity. The case illustrates the importance of atmospheric stability and the 3-D atmospheric structure in influencing a plume's evolution, and the necessity to adequately represent the rise of the buoyant plume for this type of scenario. The scale of incident, having the potential for impacts at hundreds of kilometres from the accident site, also shows the limitations of short-range dispersion models. There was generally very good agreement between our NAME model predictions of plume transport and available observations of the plume (satellite imagery, in-situ aircraft measurements, etc.). However, one of the main uncertainties during the episode was the level of risk associated with the plume reaching the ground and the likely impacts of such an occurrence. Post-episode analysis of the incident is on-going and will further explore the features of the Buncefield plume.