Dispersion Modelling of Routine Atmospheric Discharges from Proposed UK New Nuclear Build Site Locations

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1 Introduction

Accurate simulation of the transport, dispersion and deposition of radioactive material in the atmosphere is of fundamental importance for assessing doses resulting from routine discharges from nuclear facilities. Here, we present the results of simulations which have been performed using HYSPLIT[1,2,3], a Lagrangian atmospheric dispersion model developed by the US National Oceanic and Atmospheric Administration (NOAA). This model was driven by ERA-Interim[4,5] reanalysis meteorological data provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). These results have been used in an assessment of the UK new nuclear build programme currently being undertaken in Ireland. Modelling has been performed over a 21 year period to ensure that the values used to estimate future doses are representative of the long-term climatology and to enable intra- and inter-annual variability to be assessed.

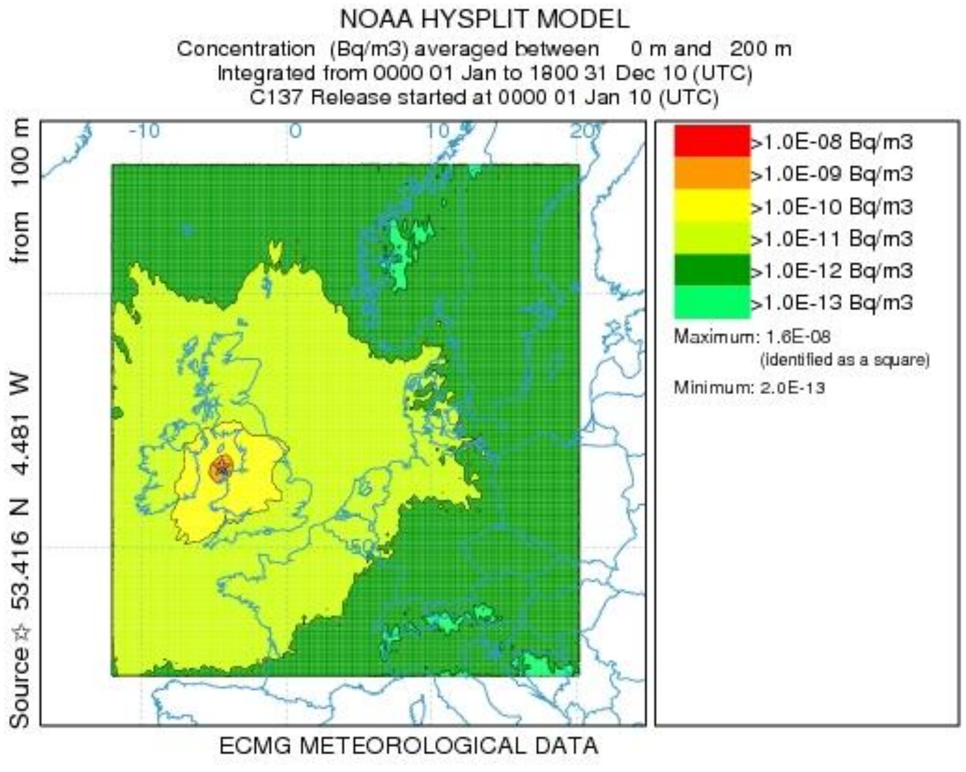
2 Objectives

To provide conservative yet realistic estimates of annually averaged air concentrations and deposition rates of all significant radionuclides expected to be discharged from the eight currently-proposed new nuclear build site locations in the UK.

3 Methods

Constant and continuous releases were modelled in HYSPLIT, separately for each location and radionuclide, by a large number of model particles (which may also represent gases) released each time step into the 'model atmosphere'[6] defined by meteorological parameters from the meteorological data. The ERA-Interim dataset used covered the period 1990 – 2010 inclusive, with spatial and temporal resolutions of 0.75 degrees and 6 hours respectively and a model domain covering the northern hemisphere. In each five minute timestep, 26 model particles were released. The selected release height was 100m above ground. Each particle was ascribed an activity which when integrated over all particles represented a 1 Bq/s emission profile. The HYSPLIT computation includes advection of the particles by the wind field, then addition of a turbulent transport component representing dispersion in the atmosphere. Depletion of iodines and particulates in the plume by scavenging was calculated using appropriate parameters for dry (deposition velocity) and wet (in-cloud and below-cloud) deposition. A diameter of 1 μm was assumed for all particulates. Particles were assigned a radioactive half-life and their activities decay corrected to the time of release. Results were calculated for a concentration grid of height 200 m, spacing 0.1 degree and span covering North-West Europe.

Figure 1. Average Cs-137 Air Concentrations, Wylfa, 2010



4 Results

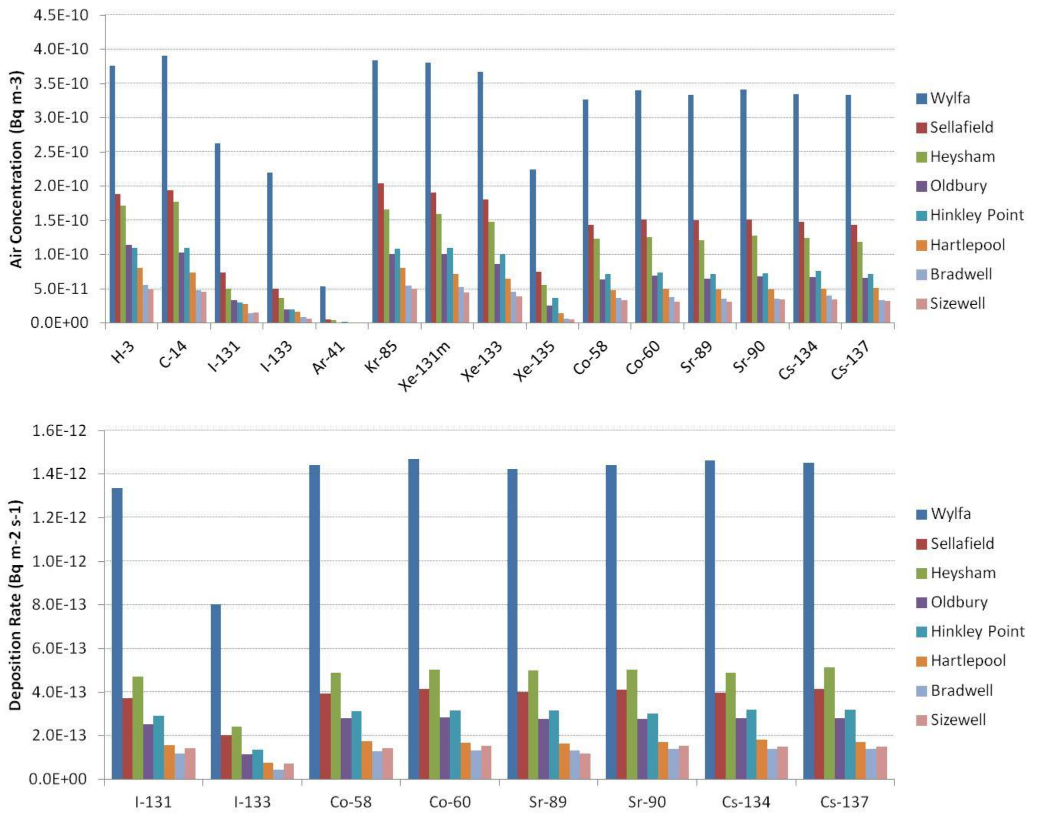
Annual average atmospheric transfer coefficients (CTA) for air concentrations (s/m3) and deposition (s/m2) have been calculated and mapped for each new build site, radionuclide and year. An example is presented in Figure 1.

Derived maps of time integrated air concentrations and accumulated deposition of Cs-137 released from Sellafield in 1995 and 1996 qualitatively compare well with those calculated using a different dispersion model and meteorological data[6]. Air concentrations for Kr-85, I-131 and Cs-137 and deposition rates for I-131 and Cs-137 have been published for a range of receptors in a related paper[7]. The ratio of our predictions to these authors' were in the ranges 0.3 – 1.1, 0.6 – 2.4, 0.6 – 3.1, 0.2 – 0.8 and 0.8 – 2.2 respectively for the five parameters listed.

- Inter-annual variation: the relative standard deviations for annually-averaged air concentrations for all locations and radionuclides were in the range 30.0 – 92.1%. For deposition rates, the range was 24.0 – 73.7%.
- Intra-annual variation: talking Wylfa as an example, over the 21 year period assessed, non-zero daily-averaged air concentrations of C-14, H-3 and noble gases were recorded in 12% of cases. For particulates and iodines, non-zero daily-averaged air concentrations and deposition rates were recorded for 23% and 28% of cases respectively.

Annually-averaged air concentrations and deposition rates have been extracted for a receptor located at Dublin, Ireland. Representative values for use in the dose assessment have been derived by calculating the 95th percentile value from the set of 21 annual results for each radionuclide and proposed new nuclear build site location. The results are presented in Figure 2. The locations are presented in order of distance from Dublin.

Figure 2. Annually-averaged air concentrations and deposition rates (unit releases)



5 Discussion/Conclusions

HYSPLIT, a widely used and extensively validated medium and long range atmospheric dispersion model has been used with the ERA-Interim reanalysis meteorological dataset, the best available from the ECMWF, to calculate estimates of air concentrations and deposition rates resulting from discharges from the proposed new nuclear build site locations in the UK.

A comparison of air concentrations and deposition rates extracted at the Dublin receptor demonstrates the strong influences of the source-receptor distance and the radioactive half-lives. No upward or downward trends in the calculated parameters were observed over 21 year period covered. Significant inter-annual variability in the calculated parameters were found. By modelling over multiple years we have ensured that representative values of air concentrations and deposition rates have been identified. The analysis of intra–annual variability demonstrated significant daily variability and that on most days there would be no contribution to air concentrations and deposition rates.

Acknowledgement

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