HYSPLIT's Capability for Radiological Aerial Monitoring in Nuclear Emergencies: Model Validation and Assessment on the Chernobyl Accident

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1. Introduction

The Chernobyl accident took place on 25 April 1986 in Ukraine. Consequently large amount of radionuclides were released into the atmosphere. The release was a widespread distribution of radioactivity throughout the northern hemisphere, mainly across Europe. A total of 31 persons died as a consequence of the accident, and about 140 persons suffered various degrees of radiation sickness and health impairment in the acute health impact. The possible increase of cancer incidence has been a real and significant increase of carcinomas of the thyroid among the children living in the contaminated regions as the late health effects [1]. Recently, a variety of atmospheric dispersion models have been developed and used around the world. Among them, HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) model developed by NOAA (National Oceanic & Atmospheric Administration)/ARL (Air Resources Laboratory) is being widely used. To verify the HYSPLIT model for radiological aerial monitoring in nuclear emergencies, a case study on the Chernobyl accident is performed.

2. Methods and Results

2.1 HYSPLIT model

HYSPLIT is a complete system for computing simple trajectory, complex dispersion, and deposition using either puff or particle approaches. The model imports gridded meteorological data using one of three conformal map projections; polar, Lambert, and Mercator [2]. The model's calculation method is a hybrid between a Lagrangian approach for the advection and diffusion calculations and an Eulerian approach for the concentration calculations [3]. The HYSPLIT model requires the meteorological data which contain U, V (the horizontal wind components), T (temperature), Z (height) or P (pressure), and P_0 (pressure at the surface) at the minimum.

2.2 Source term

The location of the Chernobyl accident site is N 51.39 ^{o} E 30.10 ^{o}. The accurate source term data from the Chernobyl accident have not been known yet. So, the previous research data are referred in this analysis [4]. The approximate release heights are 225m, 425m, 715m, 1090m, 1575m, and 2225m. And the release dates are from 8/25/1986 to 8/30/1986. Only cesium-137 release rates are used for convenience sake. The simulations run for 240 hours (10 days).

2.3 Meteorological data

The reanalysis meteorological data are used to calculate the atmospheric dispersion in this study. The reanalysis meteorological data are produced by the NCEP (the National Centers for Environmental Prediction)/NCAR (the National Center for Atmospheric Research) Reanalysis Project. These data have the 2.5 degree latitude-longitude global grid and present outputs every 6 hours. Available data period are from 1948 year to 2006 year in the present.

2.4 Results

Figure 1 shows calculated forward trajectories of radionuclides following the Chernobyl accident. The radionuclides initiated at the Chernobyl site move around the Europe depending on the release height.

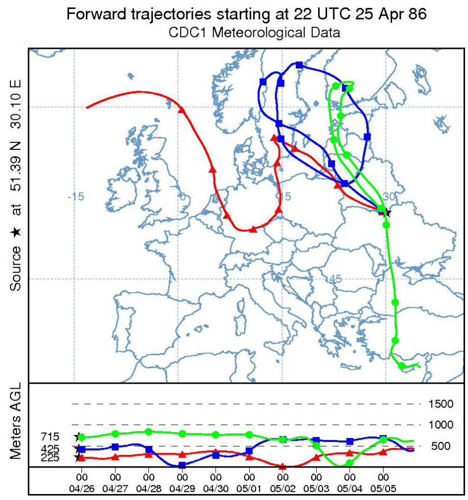

Figure 1. Calculated trajectories of radionuclides following the Chernobyl accident

Figure 2 shows the result of concentration analysis. The air contamination is wide spread in Europe and the maximum concentration is $5.7 \times 10^2 Bq/m^3$ during April 29, 1986 and April 30, 1986.

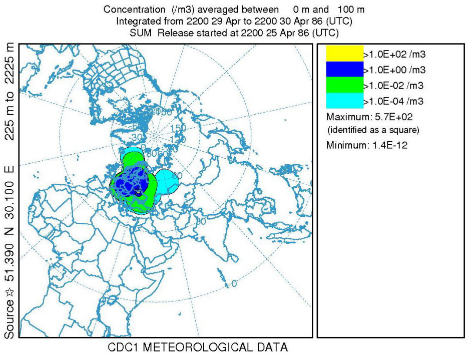

Figure 2. Calculated concentration distributions following the Chernobyl accident.

To compare between the measured data and the calculated data, 26 measured data from the Radioactivity Environmental Monitoring (REM) database of the Institute for Environment and Sustainability (IES), DG Joint Research Center (JRC) are used. Figure 3 shows one comparison result. The maximum concentration of the measured and calculated data is 11.1 Bq/m^3 and 14.932 Bq/m^3, respectively, at the Brotjacklriegel station in Germany. Other most comparison results show similar aspects, but some comparison results differ about 100 times.

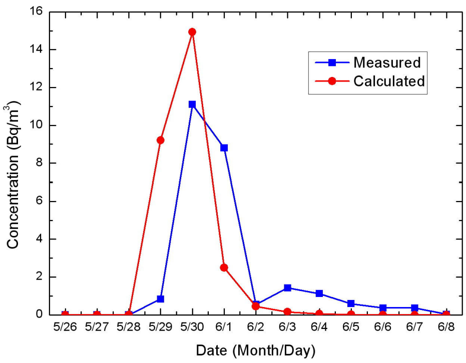

Figure 3. Concentration between the measured data and the calculated data at the Brotjacklriegel station in Germany.

3. Conclusion

Atmospheric dispersion analysis of cesium-137 from the Chernobyl accident using the HYSPLIT Model is performed in this study. The calculated data are relatively similar with the measured data. These are very good result although the HYSPLIT model is long range dispersion model and the source term have large amount of uncertainty. It is demonstrated that using the HYSPLIT model for radiological aerial monitoring in nuclear emergencies is suitable.

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