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Aerial Radioactivity Monitoring Using Atmospheric Dispersion Model

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1. Introduction

Since North Korea announced the underground nuclear test on last October 9th, 2006, many countries including South Korea have worried about the atmospheric dispersion and pollution of radioactive material by nuclear test. To verify the existence of nuclear test by detecting radioactive materials such as xenon and krypton at the early stage, to locate the position of test site, and to chase the trajectory of radioactivity have been heavily issued. And radioactivity detection and radiation monitoring technology using an aircraft have been recently examined by an authority concerned in South Korea. Although various techniques of aerial radioactivity monitoring are developed and operated in the world such as United States of America, Japan, Germany, etc., the relevant technical development or research is wholly lacking in our country. In this study, we performed some case studies on North Korea's nuclear test and accidental releases from nuclear power plant (NPP) using HYSPLIT (HYbrid Single Particle Lagrangian Integrated Trajectory) model developed by National Oceanic & Atmospheric Administration (NOAA) of U.S. Department of Commerce. We also investigated a feasibility of HYSPLIT to the aerial radioactivity monitoring system in terms of deciding potential measuring location and time.

2. Methods and Results

In this study, we performed a case study on tracking trajectory of radioactive materials using HYSPLIT model [1,2]. 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. FNL meteorological data offered by Air Resources Laboratory (ARL) of NOAA are used for HYSPLIT model. The data are on hemispheric 129 by 129 polar stereographic grids. They include U-component and V-component of vector wind, temperature, geopotential height, pressure, pressure at surface, etc.

2.1 Forward trajectory analysis of North Korea's nuclear test

After North Korea's nuclear test, the Yellowknife observatory of the comprehensive nuclear-test-ban treaty organization (CTBTO) in Canada detected Xe-133 of 0.3~0.6 mBq/m^3 exceeding the variation of normal times. In this study, forward trajectory analysis is performed and compared with measurements of Yellowknife observatory. Figure 1 shows that particles starting at North's Korea's test site fly over Canada via Sea of Okhotsk and Alaska. HYSPLIT model can be interlocked with Google™ Earth as shown in Figure 2. It is found that radioactivity trajectory passes the Yellowknife observatory neighborhood about 200 km between daybreak 1 o'clock and 3 o'clock on October 18, 2006. Actually, Yellowknife observatory announced that they collected Xe-135 on October 22~23 and 26~28, 2006. In spite of the limitation of long range meteorological model and the uncertainty of meteorological data, HYSPLIT gives meaningful results.

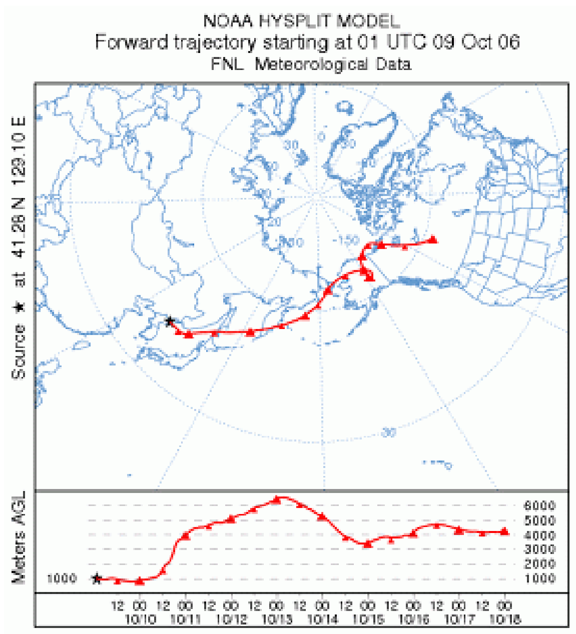

Figure 1. Radioactivity trajectory per every 12 hours.

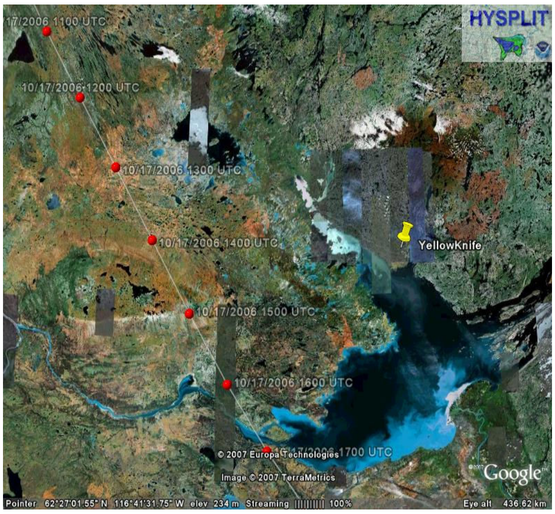

Figure 2. Trajectory near Yellowknife observatory.

2.2 Backward trajectory analysis of North Korea's nuclear test

After North Korea's nuclear test, on the assumption that radioactivity materials were observed at Ulleung-do observatory of Integrated Environmental Radiation Monitoring Network (IERNet), a possible test site is chased using backward trajectory analysis. Figure 3 shows that a particle starting at Ulleung-do passes about 10 km neighborhood of latitude 41.275^{o} longitude 129.095^{o} where is reported to the suspicious nuclear test site on October 9, 2006.

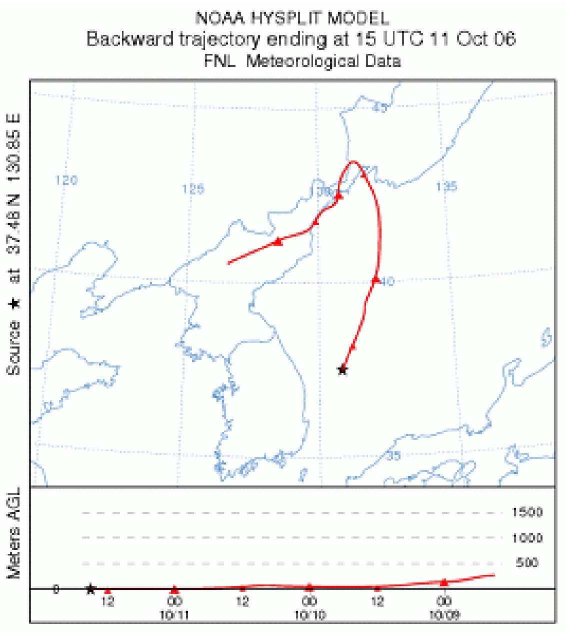

Figure 3. Tracking of radioactivity using backward trajectory

2.3 Forward trajectory analysis of accidental releases from nuclear power plant

It is assumed that radioactive materials are released from Yonggwang NPP to simulate their moving trajectories as time goes on as shown in Figure 5. All of radioactivity particles fly to Japan via Gwangju at each height of 100, 500, and 1,000 m due to the effect of usual northwest wind in winter season.

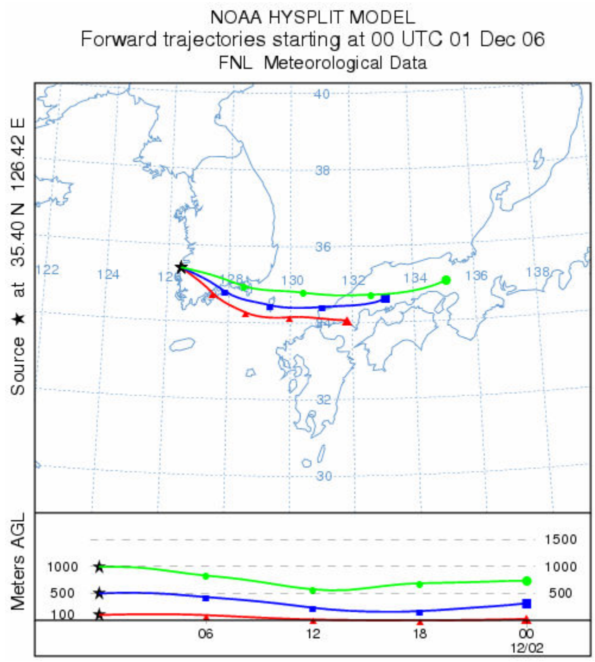

Figure 4. Result of HYSPLIT of Yeonggwang NPP

3. Conclusion

Calculation results of radionuclide trajectory for North Korea's nuclear test using HYSPLIT model show a good agreement with measured values at the Yellowknife observatory in Canada. Backward trajectory analysis is useful to find the possible time and place of nuclear test. It is demonstrated that an atmospheric dispersion model such as HYSPLIT could be successfully implemented with aerial radioactivity monitoring system hereafter.

REFERENCES

[1] R. Draxler and G. Rolph, HYSPLIT Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html).
[2] R. Draxler, B. Stunder, G. Rolph, and A. Taylor, HYSPLIT4 User's Guide, Air Resources Laboratory, Silver Spring, Maryland, 2006.