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Technical Note

Real time analysis for atmospheric dispersions for Fukushima nuclear accident: Mobile phone based cloud computing assessment

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A R T I C L E I N F O

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A B S T R A C T

The radioactive material dispersion is investigated by the system dynamics (SD) method. The non-linear complex algorithm could give the information about the hazardous material behavior in the case of nuclear accident. The prevailing westerlies region is modeled for the dynamical consequences of the Fukushima nuclear accident. The event sequence shows the scenario from earthquake to dispersion of the radionuclides. Then, the dispersion reaches two cities in Korea. The importance of the radioactive dispersion is related to the fast and reliable data processing, which could be accomplished by cloud computing concept. The values of multiplications for the wind, plume concentrations, and cloud computing factor are obtained. The highest value is 94.13 in the 206th day for Seoul. In Pusan, the highest value is 15.48 in the 219th day. The source is obtained as dispersion of radionuclide multiplied by 100. The real time safety assessment is accomplished by mobile phone.

1. Introduction

The radionuclide pollution is investigated by the system dynamics (SD) method from the view point of ecological variations. For the accident case, the Fukushima nuclear power plants (NPPs) disaster is modeled. Korea, which is on the west of the Japan, is modeled as the nation subjected to the consequences of the accident in this modeling. The convection of the thermal air and global air circulation could affect the western side of the accident region (Woo, 2013). In the Fukushima accident, the radioactive contaminated fallouts reached Korea by rain. The air stream of the radioactive fallouts had come in from the southern regions by the air circulations. Therefore, the air stream has too many uncertainties to predict exactly. This could be calculated by random number generations of the wind speed and direction. In addition, the importance of the radioactive dispersion is related to the fast and reliable data processing. Hence, it is needed to analyze the real time investigations where simulating results are obtained by very short time interval. This could be accomplished by cloud computing concept, where the data transferring center acts as the real-time communication network (Wikipedia, 2013). Then, SD performs as data productions with random number generations for real-time data transferring, because the data could be produced randomly and continuously. Fig. 1 shows that urgent event is the earthquake, cloud computing is the data transferring center incorporated with the mobile phone, and system dynamics is the tool for fast and continuous randomized data generations. It is specialized as the personal and portable system like the mobile phone is used for the processing. Cloud computing comes into focus only when you think about what information technology (IT) always needs: a way to increase capacity or add capabilities on the fly without investing in new infrastructure, training new personnel, or licensing new software (Knorr and Gruman, 2012). The Monte Carlo simulation can give us the numerical values of the nuclear fallout possibility, where the random number is used of the decision of the radioactive material quantities and the directions. SD has been used for management's consultants with the work field client.

There are some published papers in the literature, where the SD code STELLA software system has been used as the modeling platform (ISEE Systems, 2011). The dynamical environment related to climate change model has been built using the STELLA software program where it was based on theoretical economic hypotheses of behavioral studies of organizations and evolutionary theories (Bleda and Shackley, 2008). Otherwise, Richards et al. used the Vensim modeling techniques to develop mental models and Bayesian Belief Networks (BBNs) based on their beliefs, especially for climate change (Richards et al., 2013).

2. Method

It is important for analysis to find how to describe the dispersion of radionuclide. The configurations are described for the atmospheric dispersions, which are usually used in the meteorological estimation. The Gaussian plume model is typically applied to point

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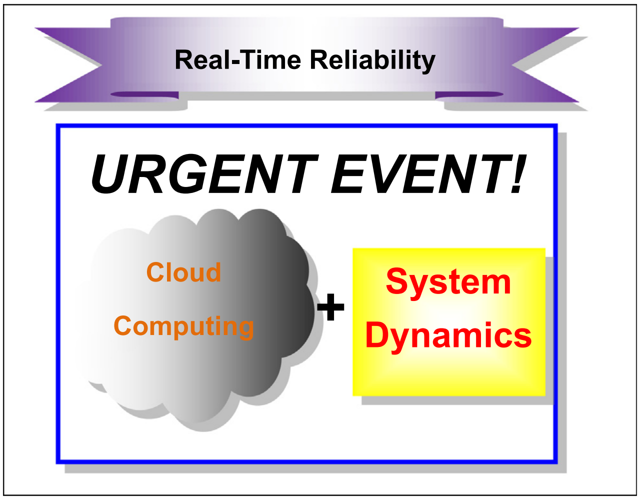

Fig. 1. Scheme of real-time reliability (Urgent event (earthquake), cloud computing (data transferring center incorporated with the mobile phone), system dynamics (fast and continuous randomized data generations)).

source emitters, such as coal-burning electricity-producing plants (Shodor, 2012). Here, the radioactive fallout dispersion is applied by this model, where there are non-point source emitters. The lateral dispersion depends on value of the atmospheric condition, a measure of the relative stability of the surrounding air and the

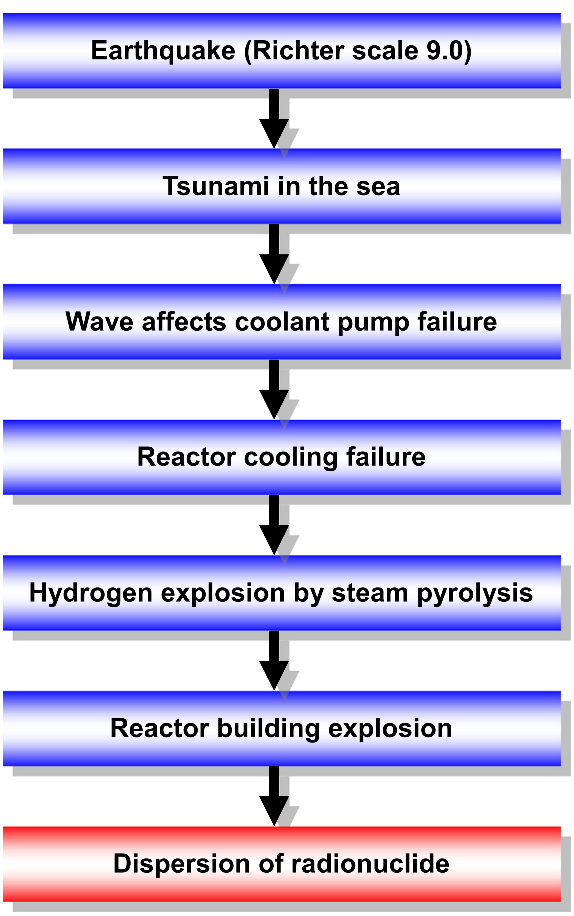

Fig. 2. Event sequence of dispersion of radionuclide in Fukushima nuclear power plants (NPPs).

Table 1
Frequency of occurrence of earthquake (USGS, 2012).

Magnitude	Average annually
8 and higher	1
7–7.9	15
6–6.9	134
5–5.9	1319
4–4.9	13,000
3–3.9	130,000
2.2.9	1,300,000
Total	About 20,000

Table 2
Specially modified event likelihood of occurrence for natural disaster events based on SECY-93-092 (USNRC, 1993).

Event	Frequency of occurrence
Likely events	$>10^{-2}$/plant-year
Non-likely events	10^{-2}–10^{-4}/plant-year
Extremely non-likely events	10^{-4}–10^{-6}/plant-year
Very rare events	$<10^{-6}$/plant-year

Table 3
Frequency of occurrence of earthquake (USGS, 2012).

Event	Numeric Value
Earthquake (Richter scale 9.0)	Random number (0, 1) < 0.3 then 1, else 0
Tsunami in the sea	Same to Earthquake (Richter scale 9.0)
Wave attacks coolant pump failure	Random number (0, 1) < 1.0 then 1, else 0
Reactor cooling failure	Random number (0, 1) < 0.7 then 1, else 0
Hydrogen explosion by steam pyrolysis	Random number (0, 1) < 0.6 then 1, else 0
Reactor building explosion	Random number (0, 1) < 0.6 then 1, else 0

Table 4
Comparisons for mean speed (m/s) and most frequency direction.

	Seoul	Pusan
2010	25, WNW	33, NNE
2006	24, WNW	31, NNE
2002	21, W	39, ENE
1998	22, ENE	38, NE
1994	23, NW	39, NNE

Table 5
Comparisons for mean speed (m/s) and most frequency direction of averaged values.

	Seoul	Pusan
Speed (m/s)	23	36
Direction	0.4 (WNW)	0.26 (NE)

model assumes that dispersion in these two dimensions will take the form of a normal Gaussian curve, with the maximum concentration in the center of the plume (Shodor, 2012). The Gaussian plume dispersion model is written as follows (Sutton, 1932).

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} e^{-\frac{y^2}{2\sigma_y^2}} \left(e^{-\frac{(z+H)^2}{2\sigma_z^2}} + e^{-\frac{(z-H)^2}{2\sigma_z^2}} \right) \tag{2.1}$$