A COMPARATIVE ANALYSIS OF THE IMPACT OF VARIOUS SPATIAL GRID SETTINGS FOR EFFECTIVE OFFSITE CONSEQUENCE ANALYSIS

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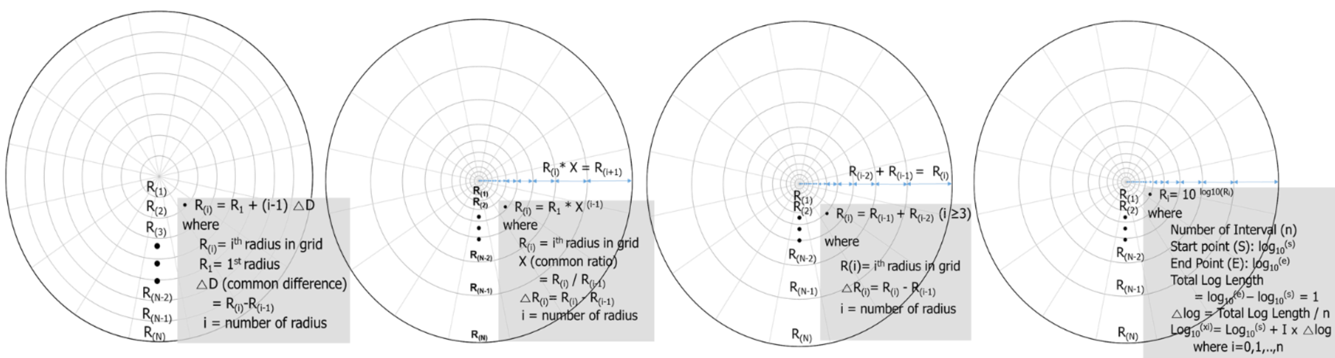
EXTENDED ABSTRACT

In the event of an offsite nuclear power plant accident, atmospheric dispersion and deposition represent the quickest environmental pathways by which radioactive material can spread, potentially affecting a large number of residents over a wide area. To analyze the consequences, the accident source term is regarded to be released from a reference point. This necessitates the establishment of a spatial grid to calculate the dispersion and deposition patterns from this location. The objective of this study is to define various divisions of spatial grids and to examine their impact on analysis accuracy and speed. Arithmetic, Geometric, Fibonacci and Logarithmic growth are applied to set the radius of the polar coordinate of spatial gird and their impact on the accuracy and speed of analysis compared to the best estimate case was investigated.

Fig.1 depicts the various spatial grid settings used in this study. Except for Arithmetic growth using monospacing, Geometric, Fibonacci, and Logarithmic growth employed proportional spacing. Each grid settings are employed for near-field, the precautionary action zone (PAZ) within 5 km range, and far-field, the urgent protective action planning zone (UPZ) within 30 km range.



(a) Arithmetic Growth (b) Geometric Growth (c) Fibonacci Growth (d) Logarithmic Growth

FIGURE 1. Spatial Grid Settings Used in This Study

For spatial grid settings for near-field (PAZ) analysis, the analysis range (distance), analysis direction, and spatial grid were set as follows.

- Analysis range: 5 km
- Angular direction: 16
- Maximum number of radial rings: 24 (basecase)
- Grid: Arithmetic, Geometric, Fibonacci and Logarithmic Growth

For spatial grid settings for far-field (UPZ) analysis, the analysis range, direction, and spatial grid were set as follows.

- Analysis range: 30 km
- Angular direction: 16
- Maximum number of radial rings: 31 (basecase)
- Grid: Arithmetic, Geometric, Fibonacci and Logarithmic Growth

An impact analysis of offsite consequences was conducted based on the spatial grid settings using the arithmetic, geometric, Fibonacci, and logarithmic sequences suggested in this study. Sensitivity analyses were performed for both near-field and far-field areas across a sample source term category (STC) of the OPR1000. The MACCS code was employed for offsite consequence analysis. Although MACCS supports Gaussian Plume, Gaussian Puff, and Lagrangian particle tracking models, the Gaussian Plume model was consistently applied in this study.

Table 1 illustrates the health effect for the near-field and far-field when different spatial grid settings are applied. In the PAZ near-field analysis, the spatial grid models with errors within 10% for both early fatality and cancer fatality were arithmetic growth d(0.25) and d(0.5), geometric growth r(1.25), and logarithmic growth spacing. Regarding analysis time, there is a reduction in analysis duration proportional to the number of radial rings used.

In addition, in the UPZ far-field analysis, spatial grid models within 10% errors for both early and cancer fatality were observed for the geometric r(1.25) and logarithmic growth spacing. Similar to the near-field analysis, the analysis time decreases proportionally with the number of radial rings.

TABLE 1. Impact of Spatial Grid Settings (Health Effects)

	Near-Field (PAZ)					Far-Field (UPZ)				
			Number of Radial Rings	Relative Error(%)	Time			Number of Radial Rings	Relative Error(%)	Time
Early Fatality	Basecase	d=0.2	24	0.0%	100.0%	Basecase	d=1.0	31	0.0%	100.0%
	Arithmetic Growth	d=0.25	19	0.8%	79.1%	Arithmetic Growth	d=2.0	16	18.8%	51.9%
		d=0.5	10	0.8%	41.4%		d=3.0	11	40.6%	35.6%
		d=1.0	6	4.6%	24.9%		d=5.0	7	66.2%	22.8%
	Geometric Growth	r=1.25	11	1.5%	45.6%	Geometric Growth	r=1.25	19	3.1%	62.1%
		r=1.5	7	3.8%	29.2%		r=1.5	11	3.1%	36.1%
		r=1.75	5	6.1%	20.8%		r=1.75	8	4.5%	26.3%
		r=2.0	4	9.2%	16.7%		r=2.0	7	8.8%	23.1%
	Fibonacci Growth		9	3.1%	37.5%	Fibonacci Growth		13	0.3%	42.6%
	Logarithmic Growth		13	0.8%	55.7%	Logarithmic Growth		15	0.0%	50.1%
Cancer Fatality	Basecase	d=0.2	24	0.0%	100.0%	Basecase	d=1.0	31	0.0%	100.0%
	Arithmetic Growth	d=0.25	19	1.0%	79.1%	Arithmetic Growth	d=2.0	16	5.5%	51.8%
		d=0.5	10	5.7%	41.3%		d=3.0	11	10.0%	35.5%
		d=1.0	6	12.2%	24.9%		d=5.0	7	16.9%	22.7%
	Geometric Growth	r=1.25	11	8.2%	45.9%	Geometric Growth	r=1.25	19	7.5%	62.1%
		r=1.5	7	14.9%	29.2%		r=1.5	11	16.2%	36.0%
		r=1.75	5	19.1%	20.9%		r=1.75	8	21.6%	26.2%
		r=2.0	4	21.7%	16.9%		r=2.0	7	24.5%	23.0%
	Fibonacci Growth		9	14.3%	37.6%	Fibonacci Growth		13	17.1%	42.7%
	Logarithmic Growth		13	7.6%	55.5%	Logarithmic Growth		15	7.6%	50.0%

This study investigated the effects of different spatial grid divisions on the accuracy of offsite consequence analysis results. To assess their impact, numerical sequences such as Arithmetic, Geometric, Fibonacci, and Logarithmic were employed to set the radii in polar coordinate spatial grids, with results compared to the best estimate scenario. Further research could explore additional dispersion models and other proportional grid spacings to investigate the impact of spatial grid settings. The findings from this study are expected to aid in the optimization of spatial grid settings in subsequent studies.

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