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Characterization of Local Wind Patterns around the Kori Nuclear Power Plant using Cluster Analysis and WRF meteorological modeling

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1. Introduction

After the Fukushima Daiichi nuclear disaster on 11 March 2011, it became a chance to confirm that risk of serious nuclear is high. To accurately predict the atmospheric diffusion of radioactive effluent, detailed analysis of local wind patterns nearby nuclear power plants are necessary. In this study, the characteristics of typical local winds around the Kori Nuclear Power Plant (Kori NPP) were investigated using the cluster analysis and Weather Research and Forecasting (WRF) meteorological modeling.

2. Methods

2.1. Cluster Analysis

To identify the representative local wind patterns around the Kori NPP, the cluster analysis was performed based on the average linkage and K-means methods using Statistical Analysis System (SAS) program. The meteorological variables used for the cluster analysis were u and v wind components. The components were derived from the wind speed and direction, which are observed at 22 Automatic Weather System (AWS) sites and 6 Automated Surface Observing Systems (ASOS) site around the Kori NPP during the day (i.e. 0900 - 1800 LST) in 2012.

The average linkage was used to determine the number of clusters representing the local meteorological fields on the basis of the statistical parameters (R^2, Pseudo-F, and Pseudo-t^2). Once the number of clusters was determined from the average linkage solution, a nonhierarchical technique, called convergent K-means, was subsequently applied to classify the output data into each cluster. Finally, cluster numbers corresponding to the study period (the year 2012) were produced. This two-stage algorithm was commonly recommended because it is superior to a one-stage approach, such as only the average linkage in terms of cluster cohesiveness [1], [2].

2.2. WRF Configuration

The NCAR (National Center for Atmospheric Research) Advanced Research WRF ARW model (version 3.5) was used to investigate the characteristics of the representative local wind patterns. The WRF domains were designed with horizontal resolutions of 27, 9, 3 and 1km. The 2nd, 3rd and 4th domains include two-way interactive grids. The initial and lateral boundary conditions were obtained from 1°x1° NCEP (National Centers for Environmental Prediction) Final Analyses and 0.5°x0.5° NCEP RTG SST (Sea Surface Temperature). Detailed descriptions of WRF configurations are listed in Table Ⅰ.

Table Ⅰ: WRF Model Configuration

Domains	D01	D02	D03	D04
Horizontal grid	131x124	85x73	85x79	120x120
Horizontal resolution	27km	9km	3km	1km
Vertical layers	43 layers			
Microphysics	WSM3	WDM6		
Cumulus	Kain-Fritsch			
Radiation (long/short wave)	RRTMG and RRTMG radiation			
Planetary Boundary layer	YSU scheme			
Initial Field	FNL 1°x1°/ SST 0.5°x0.5°			

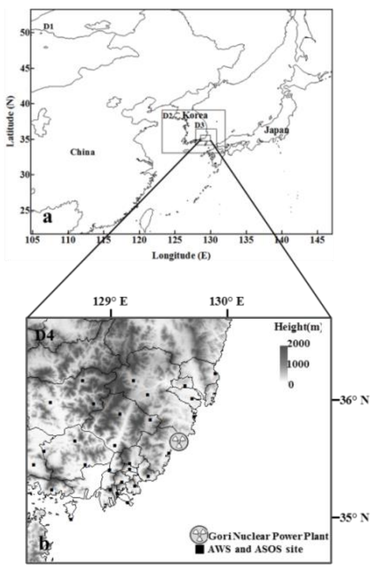

Fig. 1. (a) The four nested domains for the WRF modeling and (b) the final domain with terrain heights and the locations of AWS and ASOS meteorological sites.

3. Results

3.1. Major Patterns of Wind Field

Table Ⅱ summarizes the results of the average linkage analysis (hierarchical stage). In general, the number of clusters is selected when both pseudo-F and pseudo-t^2 were maximal, with the largest drop in R^2 as the number of clusters decreased [3]. Finally, four local wind patterns (P1-P4) were selected during the study period (2012). P1, P2, P3, and P4 accounted for 14.5%, 14.5%, 43.7% and 27.3%, respectively.

Table Ⅱ: Statistical tests for determining number of clusters to retain.

No. of Cluster	Pseudo-F	Pseudo-t^2	R^2
10	54.2	48.5	0.58
9	59.9	4.4	0.574
8	63.4	17.1	0.555
7	72	7.6	0.548
6	78.5	19.2	0.523
5	95.9	5	0.517
4	126	3.4	0.512
3	11.3	335	0.059
2	20.1	4	0.053
1	-	20.1	0

3.2. A case study for Major Wind Field

To identify the detailed wind distributions near the Kori NPP, the case days for the WRF simulation were selected for each wind (8 December (period (P) 1), 25 June (P2), 22 May (P3), and 20 October 2012 (P4)). The WRF simulation for each period was conducted consecutively for five simulation days including the spin-up period of two to minimize the effects of initial conditions (e.g. uncertainties).

Fig. 2 is the horizontal distribution of the simulated winds at 1200 LST and 1500 LST on 25 June 2012 (P2). At both 1200 and 1500 LST, strong northeasterly winds prevailed near the Kori NPP due to the strong synoptic weather conditions. In this case, it is expected that the radioactive effluents from the Kori NPP are dispersed toward its adjacent areas (e.g. Busan) along the northeasterly winds occurring over the entire study domain.

4. Conclusions

In this study, the local wind characteristics around the Kori NPP were analyzed using cluster analysis and WRF meteorological modeling.

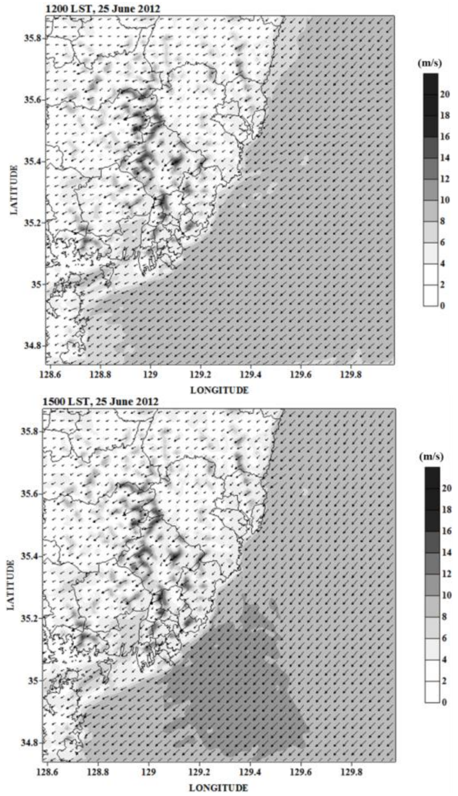

Fig. 2. Horizontal distributions of the simulated wind vector and wind speed from the WRF meteorological modeling at 1200LST and 1500LST on 25 June 2012.

As a result of the cluster analysis, four wind patterns around the Kori NPP were selected. The model study indicated the possibility that the local winds in the target area can largely contribute to the atmospheric diffusion of radioactive effluents.

Acknowledgements

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