Atmospheric Dispersion Simulation for Level 3 PSA at Ulchin Nuclear Site using a PUFF model

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1. Introduction

After the Fukushima accident, the level 3 PSA (Probabilistic Safety Assessment) has introduced as one of the most significant issues for a safety assessment. Air dispersion prediction is a key in the level 3 PSA to predict radiation releases into the environment for preparing an effective strategy for an evacuation as a basis of the emergency preparedness. To predict the atmospheric dispersion accurately, the specific conditions of the radiation release location should be considered.

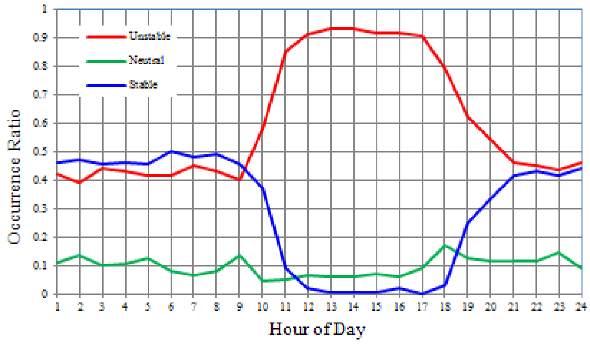
There are various level 3 PSA tools and MACSS2 is one of the widely used level 3 PSA tools in many countries including Korea. Due to the characteristics of environmental conditions in Korea, it should be demonstrated that environmental conditions of Korea nuclear sites can be appropriately illustrated by the tool. In Korea, because all nuclear power plants are located on coasts, sea and land breezes might be a significant factor.

The objectives of this work is to simulate the atmospheric dispersion for Ulchin nuclear site in Korea using a PUFF model and to generate the data which can be used for the comparison with that of PLUME model.

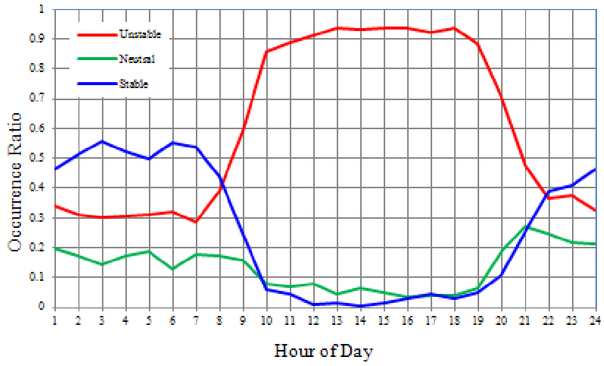
2. Atmospheric Stability

Fig. 1 shows the atmospheric stability using weather data for the year 2004 of Ulchin nuclear site on the east coast of the Korean peninsula [1]. Fig. 1 provides daily atmospheric stability charts for winter and summer, showing the following basic features [1]:

- The atmospheric stability was changed according to day or night.
- In the daytime, the atmosphere became strongly unstable (> 90%), whereas the dominant tendency of atmosphere in the nighttime was stable (~ 50%) or some was unstable (~ 30%).
- The transient time was changed by the duration of day and night according to the seasonal differences.
- In summer, a stable class was observed with a higher frequency compared with winter.



(a) Winter season



(b) Summer season

Fig. 1. Daily atmospheric stability charts in Ulchin NPP [1]

As shown in the analysis results, the characteristics of the atmospheric stability in Ulchin site has huge differences from the nuclear sites in USA. Fig. 2 and Fig. 3 show the atmospheric stabilities in Peach-Bottom and Surry sites in USA. The occurrence ratio for 'Unstable' is relatively low in Fig.2 compared to the Fig. 1 and Fig 3 shows very low 'Unstable' occurrence ratio all the time.

That means the effects of sea and land breezes are significant on the sites locating on the coast such as Ulchin site. Therefore, even though the PLUME model used in MACSS2 tool is able to well demonstrate the atmospheric dispersion in USA plant sites, it could be inappropriate for evaluating the atmospheric dispersion in Korea due to the different environmental characteristics of Korea nuclear sites.

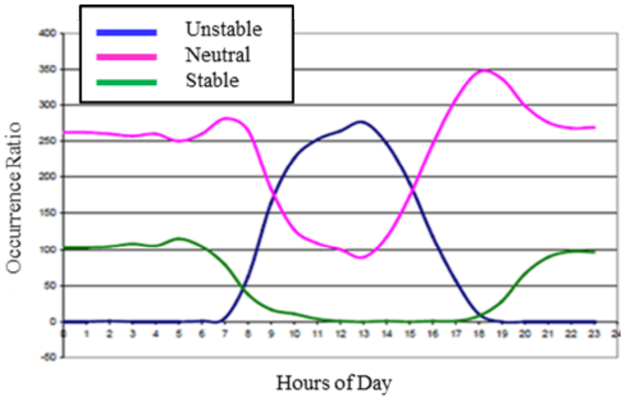


Fig. 2. Daily atmospheric stability charts in Peach-Bottom NPP [1]

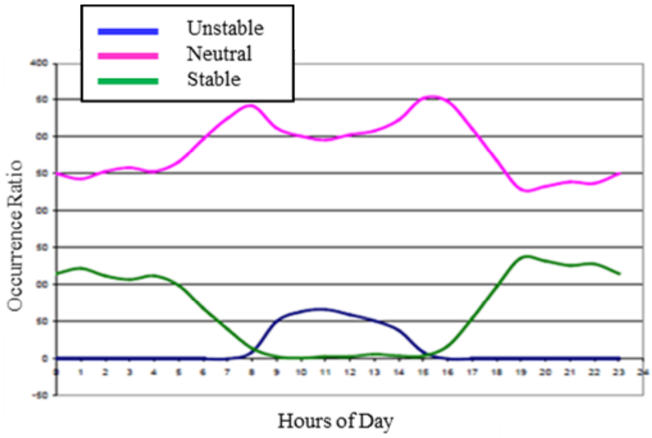


Fig. 3. Daily atmospheric stability charts in Surry NPP [1]

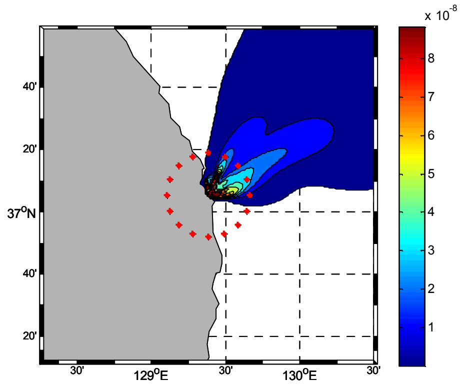
3. Simulation of Atmospheric Dispersion

A PUFF model has an ability to simulate the atmospheric circulation effect which cannot be considered by a PLUME model. In this work, CALPUFF was used to simulate the atmospheric dispersion with consideration of sea and land breeze effects [2].

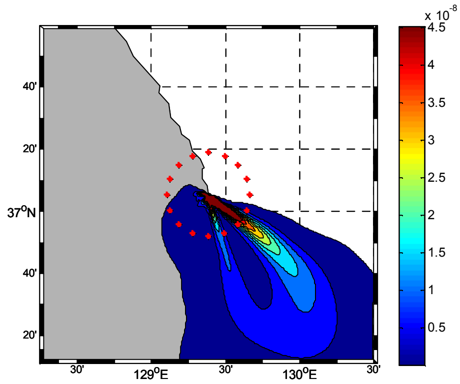
The data used for simulations are as follows:

- Location: Ulchin nuclear site
- Weather data: year 2011
- Simulation cases: 4 (four seasons)

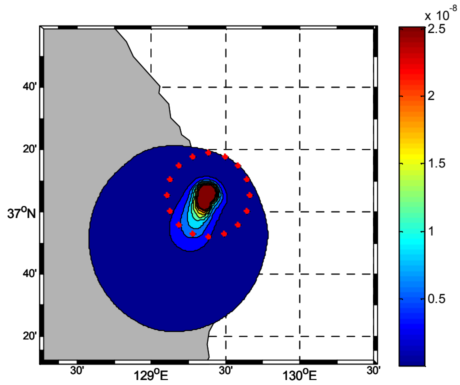
As shown in Fig. 4, the sea and land breeze effect was significant according to the season. Each season showed its unique characteristic of dispersion. In the summer season, the effect of an accident could be most severe because almost all the released radiation is dispersed to land. However, in the winter season, only a small amount of the released radiation is dispersed to land.



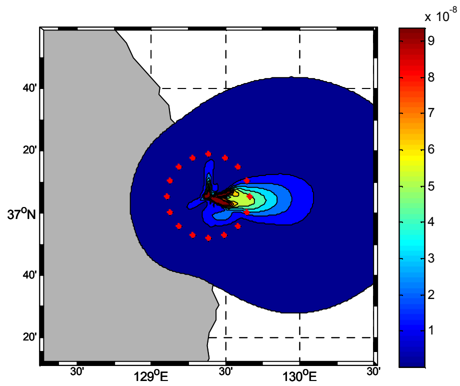
(a) January



(b) April

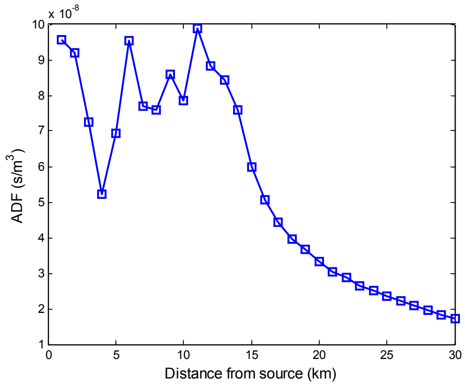


(c) July

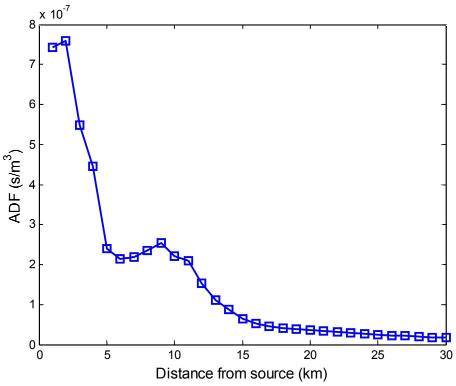


(d) October

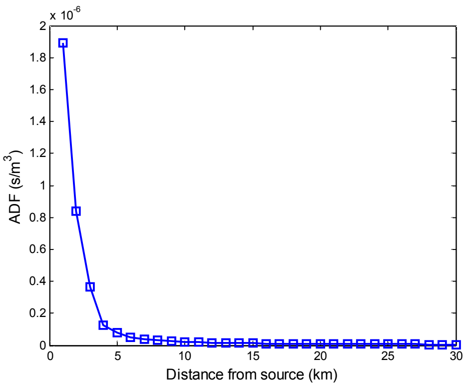
Fig. 4. Atmospheric dispersion for four seasons



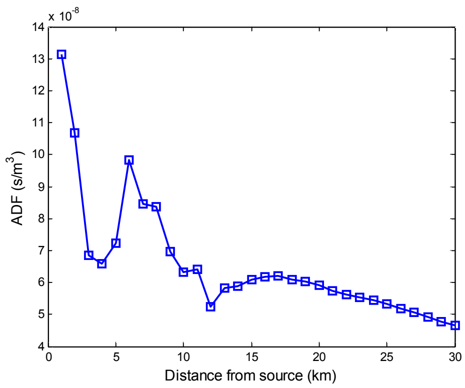
(a) ENE direction ADF in January



(b) SE direction ADF in April



(c) SSW direction ADF in July



(d) E direction ADF in October

Fig. 5. Atmospheric dispersion factor for four seasons

Fig. 5 shows the greatest ADF (atmospheric dispersion factor) for each season. In January, air dispersion in ENE direction is the greatest as shown in Fig. 4(a). Depending to the season, SE direction, SSW direction, and E direction have the most significant effects in April, July, and October respectively.

Usually, a PLUME model calculates an ADF based on the sample points of a year. If the greatest ADF for each direction from CALPUFF simulations is less than that of PLUME model results, it can be said that the PLUME model is more conservative than the PUFF model and also it might be appropriate to be used for Korea nuclear sites in terms of safety assessment.

4. Conclusion

A nuclear site has own atmospheric dispersion characteristics. Especially in Korea, nuclear sites are located at coasts and it is expected that see and land breeze effects are relatively high. In this work, the atmospheric dispersion at Ulchin nuclear site was simulated to evaluate the effect of see and land breezes in four seasons. In the simulation results, it was observed that the wind direction change with time has a large effect on atmospheric dispersion. If the result of a PLUME model is more conservative than most severe case of a PUFF model, then the PLUME model could be used for Korea nuclear sites in terms of safety assessment.

Acknowledgements

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REFERENCES

[1] S. J. Han, K. I. Ahn, A Preliminary Assessment of Daily Weather Conditions in Nuclear Site for Development of Effective Emergency Plan, Transactions of the Korean Nuclear Society, May 17-18, 2012, Jeju, Korea.
[2] J. S. Scire, and et al. A User's Guide for CALPUFF Dispersion Model, Earth Tech, Inc, 2000