A Comparative Study of Assessing the Release of Radioactive Materials during Nuclear Emergency Using Different Atmospheric Dispersion Models

Ahmed Abd El-Hameed and Juyoul Kim*
Department of NPP Engineering, KEPCO International Nuclear Graduate School,
658-91 Haemaji-ro, Seosaeng-myeon, Ulju-gun, Ulsan 45014
*Corresponding author: jykim@kings.ac.kr

Introduction

- **Background:** There are a lot of software used to simulate off-site consequences of radioactive material released during the nuclear emergency
- **Objective:** Comparing the results of air concentration and ground deposition for ^{137}Cs, ^{133}Xe and ^{131}I from different atmospheric dispersion models.
- **Target:** Comparing the results of air concentration and ground deposition for ^{137}Cs, ^{133}Xe and ^{131}I from three software RCAP, HOTSPOT and RASCAL to find the most conservative code.
- **Accident scenario:** The accident scenario is Long Term station blackout (LTSBO) in APR1400. This scenario was simulated by RASCAL code to estimate the amount of radioactive material released of ^{137}Cs, ^{133}Xe and ^{131}I.
- **Software**: Comparing between three software with different dispersion models.

1. Radiological Consequence Analysis Program (RCAP). It is a new software developed by Korea Atomic Energy Research Institute (KAERI) and the basic physical model for RCAP to evaluate the diffusion and transport of radioactive materials in the atmosphere and deposition on the surface is the Gaussian plume segment model.
2. Radiological Assessment System for Consequence Analysis (RASCAL). It developed by the U.S Nuclear Regulatory Commission (NRC) to be used by emergency responders. The atmospheric transport and dispersion model for RASCAL is Gaussian puff model.
3. HOTSPOT. It is developed by Lawrence Livermore National Laboratory's National Atmospheric Release Advisory Center (NARAC) and its model is Gaussian plume model (time independent).

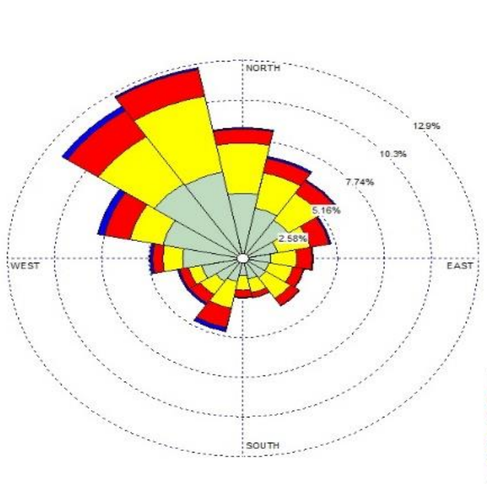
- **Final output**: Air concentration and ground deposition

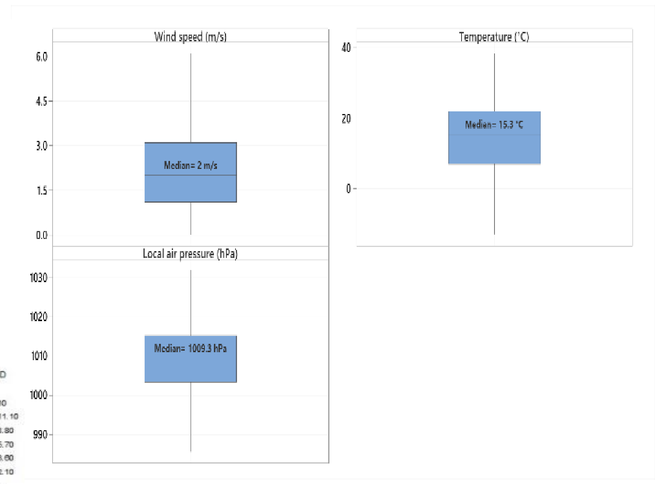
Methods

- **Accident Scenario:** The selected scenario for this study is Core damage scenario. An offsite event occurred, lead to loss of offsite power (LOOP) and reactor trip at 1:00, 1-Jan-2020. The emergency core cooling system not activated. Even though, Reactor cooling was continued by natural convection for a period of 8 hours after shutdown. The release started at 9:00, 1-Jan-2020 and continue for 24 hours.
- **Source term:**

Isotopes	Groups	Activity (Bq)
I-131	Halogen	7.4E+14
Xe-133	Noble gas	1.63E+15
Cs-137	Alkali metal	5.92E+13

- **Meteorological data:**
  - We used the median values of wind speed, Temperature and atmospheric pressure over 11 years of 2010 and 2021; it is more statistically significant than the average.

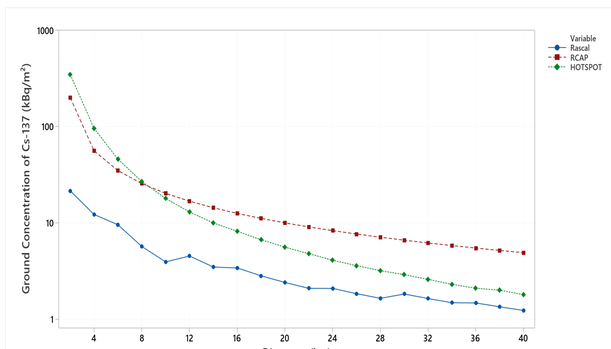


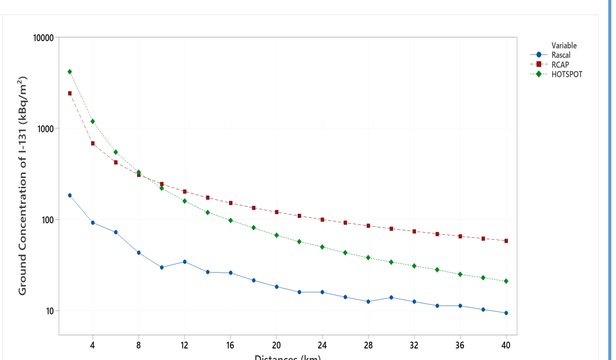


- Predominate wind direction in Ulsan city was North-northwest which is used in this study.
- Stability class B is the most frequently one from 2010 to 2021
- The release height is 60 m for APR 1400
- The deposition velocity for particles regarding to NUREG-1940 is 0.0064 m/s

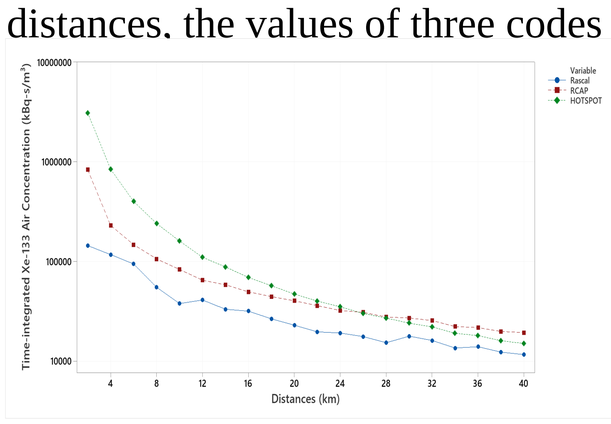
Results

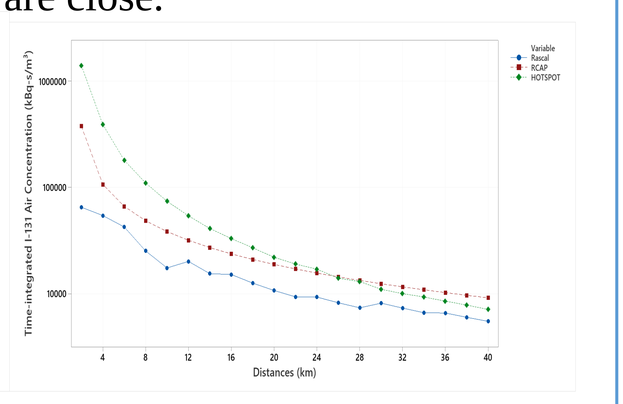
- **Ground deposition:** Figure 3 and figure 4 show the ground deposition for ^{137}Cs and ^{131}I respectively against downwind distance calculated using the three computer codes namely HOTSPOT, RASCAL and RCAP. Among the three codes HOTSPOT is the highest curve in the short distance but in long distances RCAP is the highest curve. The lowest curve represent RASCAL. RASCAL assumes the Gaussian Puff. The Gaussian Puff consider the varying wind speed hence the puff model result in relatively real estimates than plume model.





- **Air concentration:** Figure 5 and figure 6 show the airborne concentrations for ^{133}Xe and ^{131}I respectively against downwind distance calculated using the three computer codes namely HOTSPOT, RASCAL and RCAP. Among the three codes HOTSPOT is the highest curve in the short again. While in long distances the HOTSPOT curve is degraded quickly and the highest curve is RCAP. In the long distances, the values of three codes are close.





Conclusions

- The airborne concentration for ^{133}Xe and ^{131}I in addition to ground deposition for ^{137}Cs and ^{131}I were calculated by three different computer code with different dispersion model to verify the result of calculation. It was also found that, generally the HOTSPOT computer code estimated the higher values compared to the rest of the codes followed by RASCAL, RCAP in the mentioned order. HOTSPOT codes are a conservative (estimated radiation dose is usually greater) estimation of the radiation effects associated with the atmospheric release of radioactive materials.

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