清華大學核能技术设计研究院

Release rate estimation of both long- and short-lived radionuclides for the Fukushima Daiichi nuclear accident based on local-scale observations

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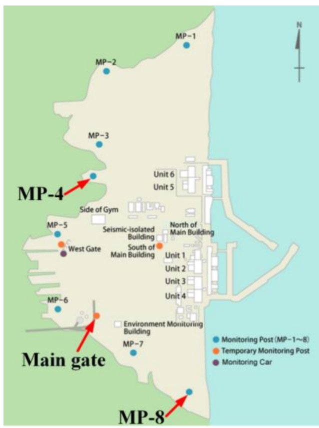
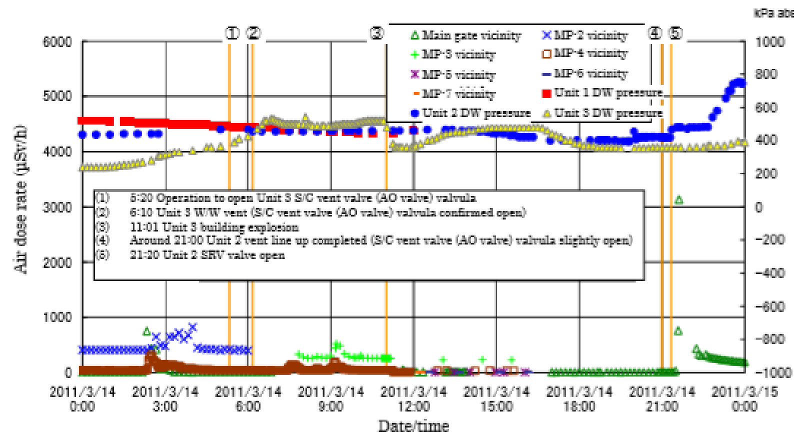
Background

- On-site gamma dose rates provide the most complete record of atmospheric releases of both long- and short-lived radionuclides.





- However, they are seldom used for source inversion, because the unknown radionuclide composition and the complexity in local meteorology.
- This prevents the estimation of some short-lived radionuclide releases, which dominates of the radiation dose in the early stage of an accident.
- Here, a method using on-site gamma dose rates is developed with the aim of determining the source term, including both long- and short-lived radionuclides

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Image courtesy of TEPCO

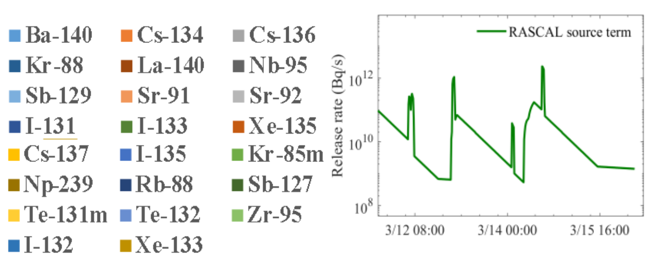
Methods

- A source inversion model considering both long- and short-lived radionuclides.

$$\boldsymbol{\mu} = \mathbf{A}(\mathbf{R}_{Inv}\mathbf{X} + \mathbf{R}_{Rea}\mathbf{Y})\bullet\mathbf{c}_{Inv}$$

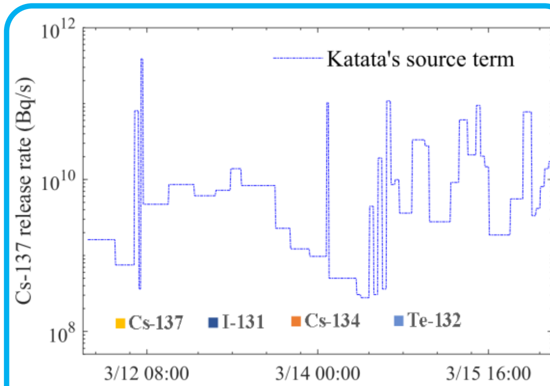
$$\mathbf{z} = (\mathbf{R}_{Inv}\mathbf{X} + \mathbf{R}_{Rea}\mathbf{Y})\bullet\mathbf{c}_{Inv}$$

  - Solve two weight vectors **X** and **Y** from the on-site gamma dose rates
  - Use **X** and **Y** to adaptively combine the radionuclide species information from forward and backward release rate estimates.
  - RASCAL[1-4] and Katata's release rates[5] are used as a priori information.[6]



RASCAL release rate

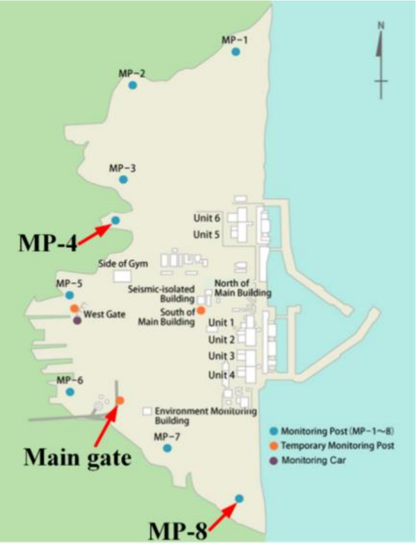
23 primary species, contributing to 99% gamma dose rates

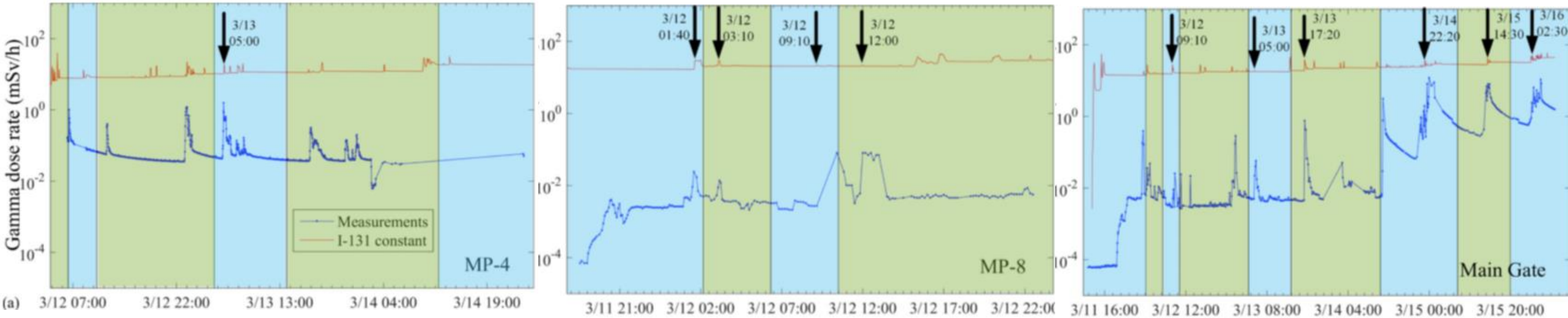


Katata's release rate:4 species

Methods

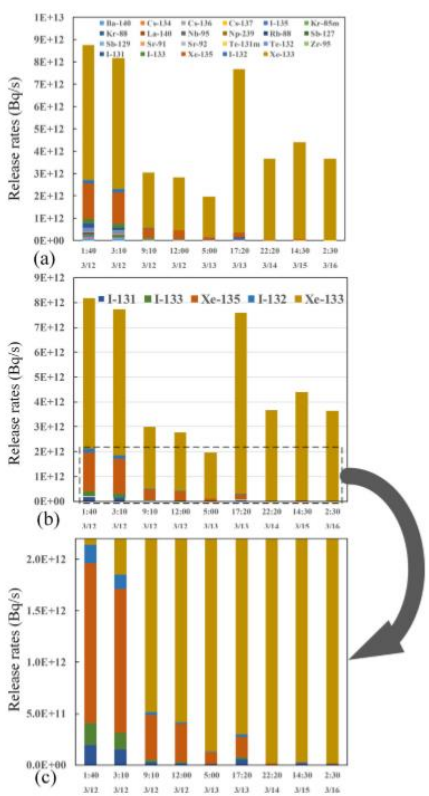
- Refined RIMPUFF model for local-scale simulation and inverse model setup
  - Dry and wet deposition model
  - Upgraded diffusion coefficient scheme for near-field calculation[7]
- Sensitivity analysis to reduce uncertainties in meteorology
  - RIMPUFF simulation with an artificial constant release rates
  - Consistency verification between model predictions and measurements for peak timing
  - The inversion only involves those peak dose rate data whose timing could be reproduced by RIMPUFF
- Uses the on-site gamma dose rates data

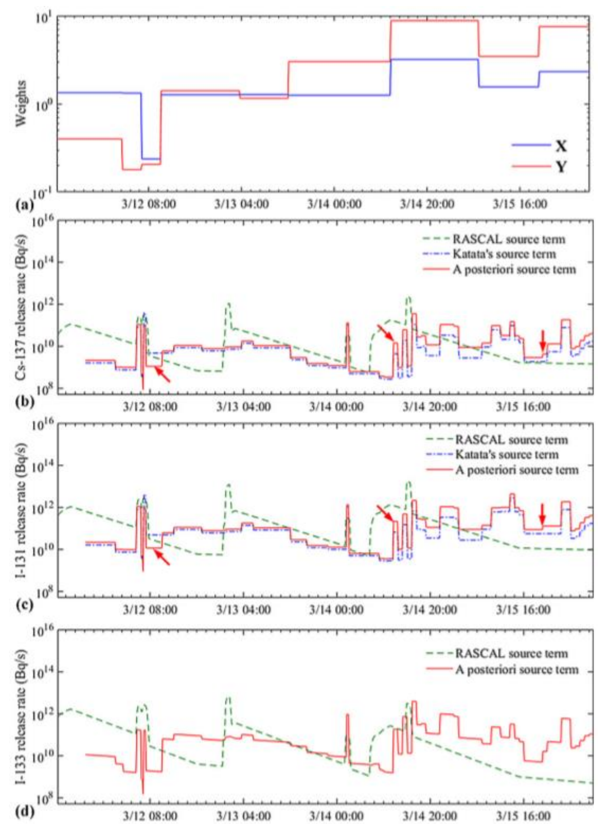




Results and discussions

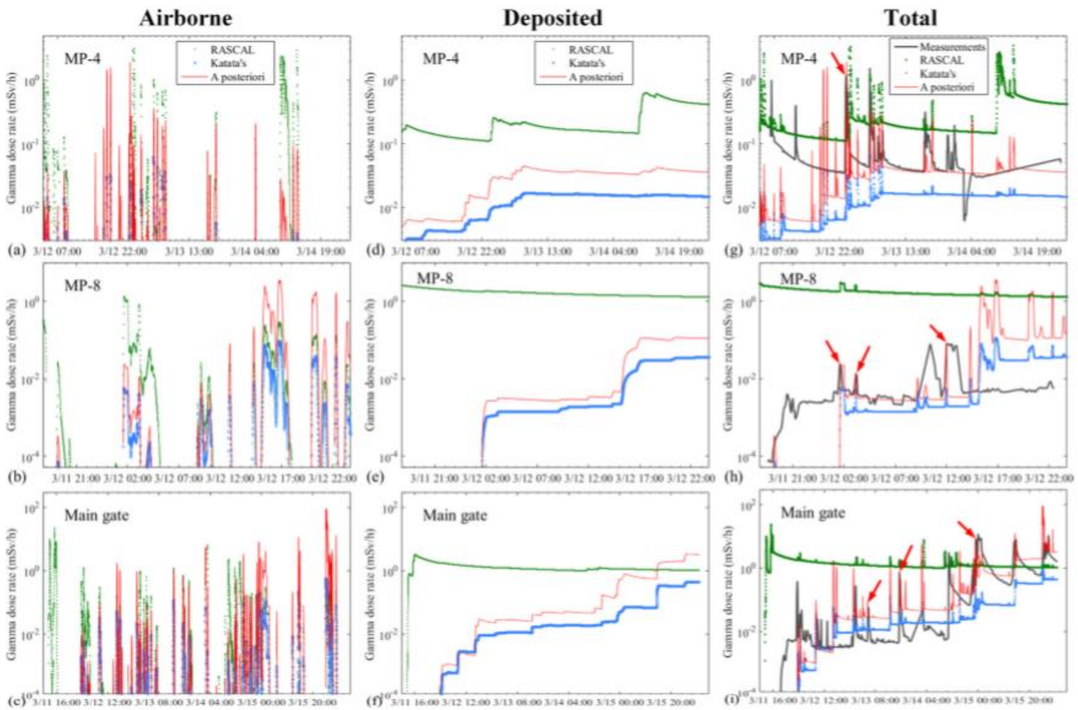
- The a posteriori release rate maintain both the advantages of both a priori information
  - The detailed a priori releases
  - Rich radionuclide species information including both long- and short-lived ones

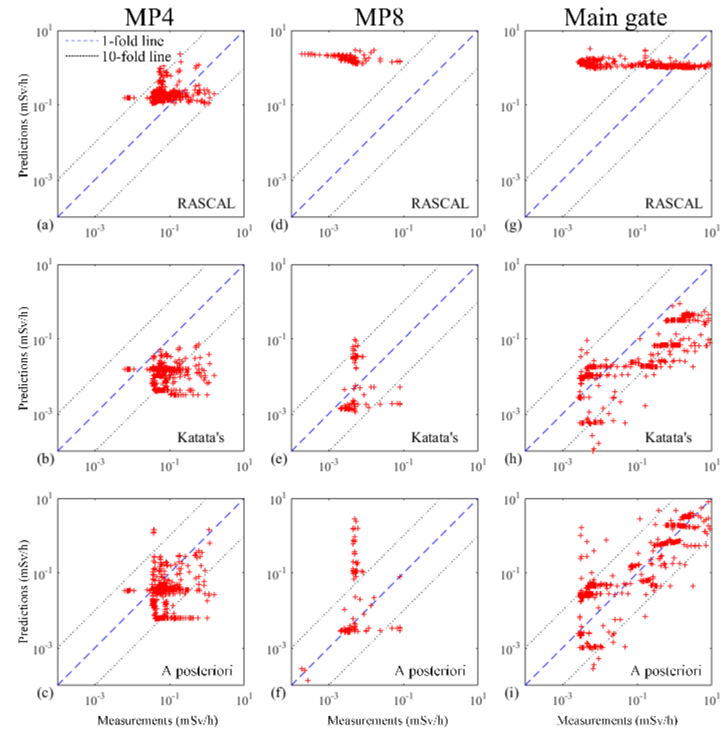




Results and discussions

- The a posteriori release rate improves the on-site gamma dose rates predictions at both local scales.

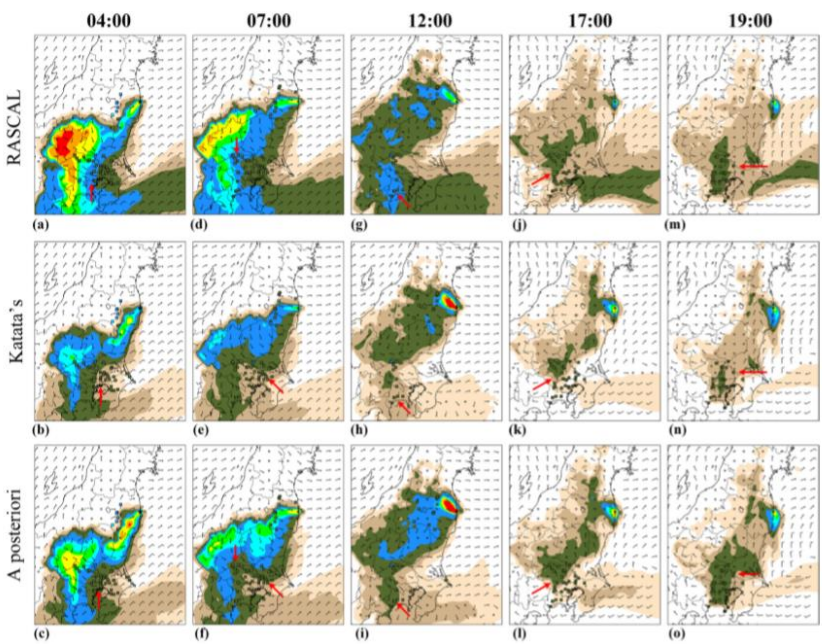


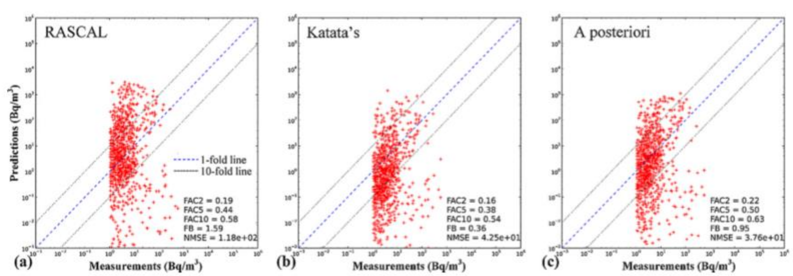


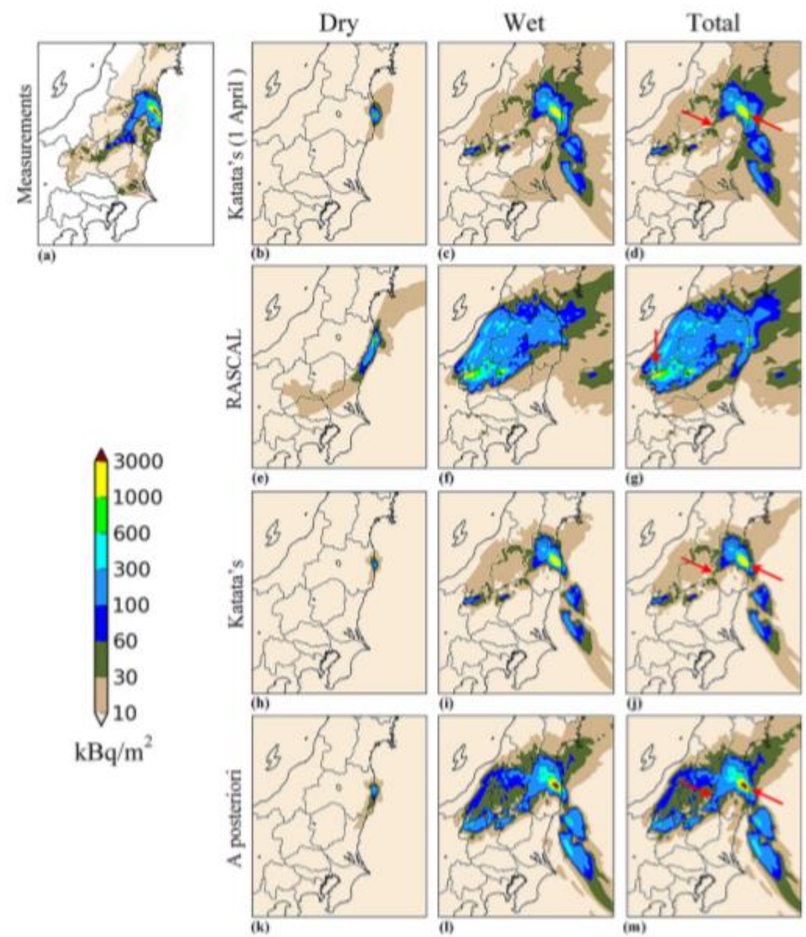
	RASCAL	Katata's	A posteriori
FAC2	0.12	0.07	0.46
FAC5	0.71	0.55	0.69
FAC10	0.76	0.78	0.91
MG	0.14	3.69	1.34
VG	1951.57	27.51	9.23

Results and discussions

- The a posteriori release rate improves the predictions at both local and regional scales.
  - Regional airborne Cs-137
  - Regional deposited Cs-137







Conclusions

- A method that provides the release rate for both long- and short-lived radionuclides based on long-overlooked onsite gamma dose rate data.
- The a posteriori release rate successfully combines the details of long-lived radionuclide release rates in Katata's release rate and the temporal variation of short-lived radionuclides in the RASCAL calculations.
- The a posteriori release rate allows the model predictions of the on-site gamma dose rates to be improved.
- With a detailed a priori reverse release rate, the a posteriori release rate significantly improves the model predictions of the on-site gamma dose rates.
- It substantially enhances the accuracy of model predictions for both atmospheric concentrations and the cumulative deposition pattern at the regional scale compared with the two a priori release rates.

Thank you for your attention!

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