Technical Considerations for Emergency Preparedness with a Probabilistic Accident Consequence Assessment Model

T. Homma, M. Kimura*, T. Matsubara**, and J. Ishikawa**

**Japan Atomic Energy Agency*

***Visible Information Center, Inc.*

PSAM9 Hong Kong, May 18 - 23, 2008

Background

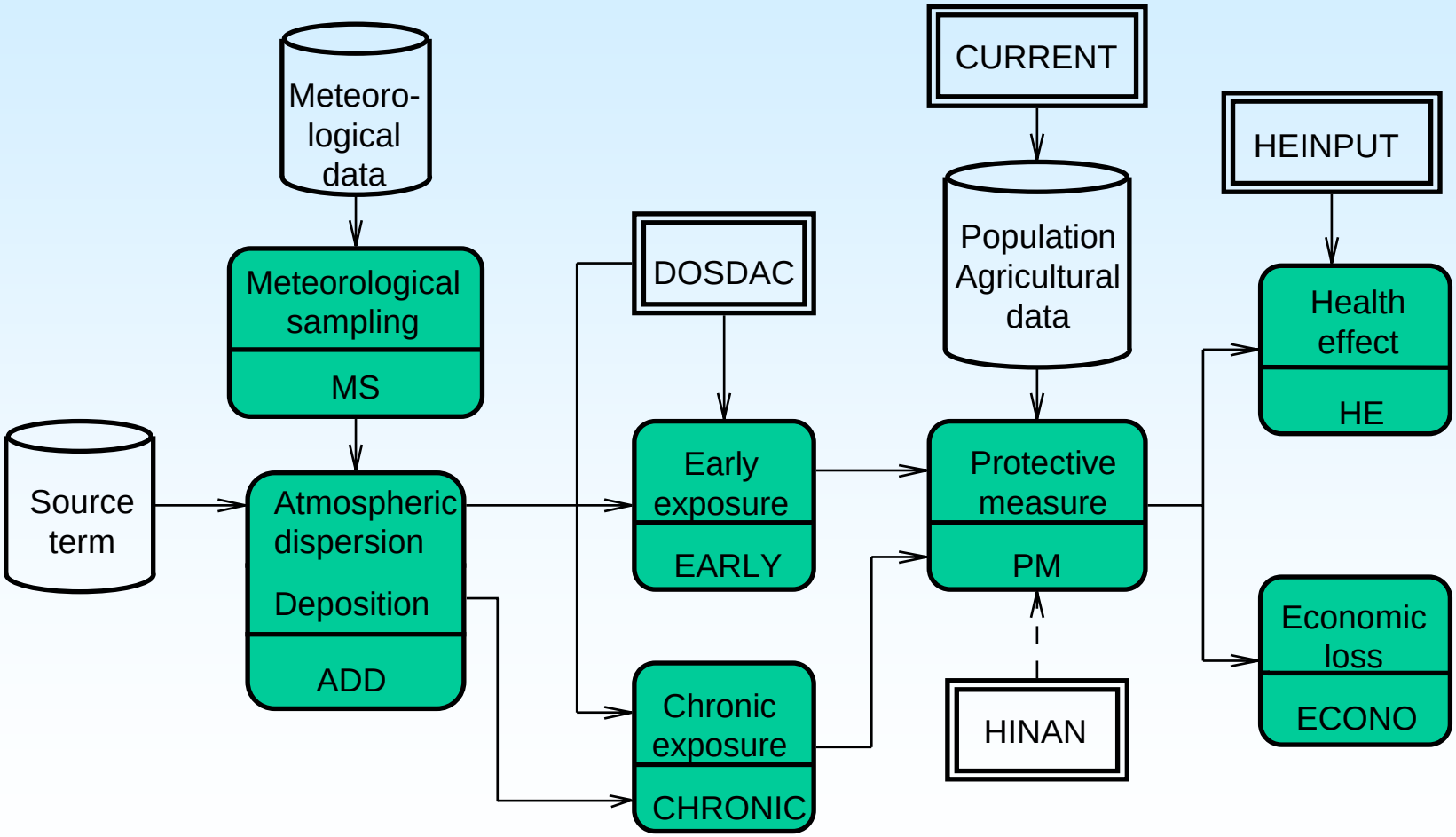
- IAEA Safety Requirements (GS-R-2, 2002)
  Safety Guide (GS-G-2.1, 2007)
- Management approach
  - –Practical goals (8 goals)
    - ✓Prevent the occurrence of deterministic health effects
    - ✓Prevent, to the extent practicable, the occurrence of stochastic health effects
  - –Intervention principles
  - –Efficient and cost-effective system
- ICRP (Publ.103, 2007)
  - –Optimization of overall strategy
- NSC's Guideline on emergency preparedness
  - –No practical guidance for protective measure strategy

Objectives

- Introduce a metabolic model of iodine to accurately evaluate the effect of reducing thyroid dose by intake of stable iodine
- Perform a risk informed analysis of protective measures, in order to formulate the technical basis for the effective strategy of protective measures
  - Combination of sheltering and evacuation with administration of stable iodine

Accident Consequence Model

OSCAAR (Off-Site Consequence Analysis of Atmospheric Releases of radionuclides)



Models of OSCAAR

Atmospheric Dispersion and Deposition

- Multi-puff trajectory model with two scale wind fields
- Take account of temporal changes in weather conditions and variable long duration releases

Meteorological Sampling

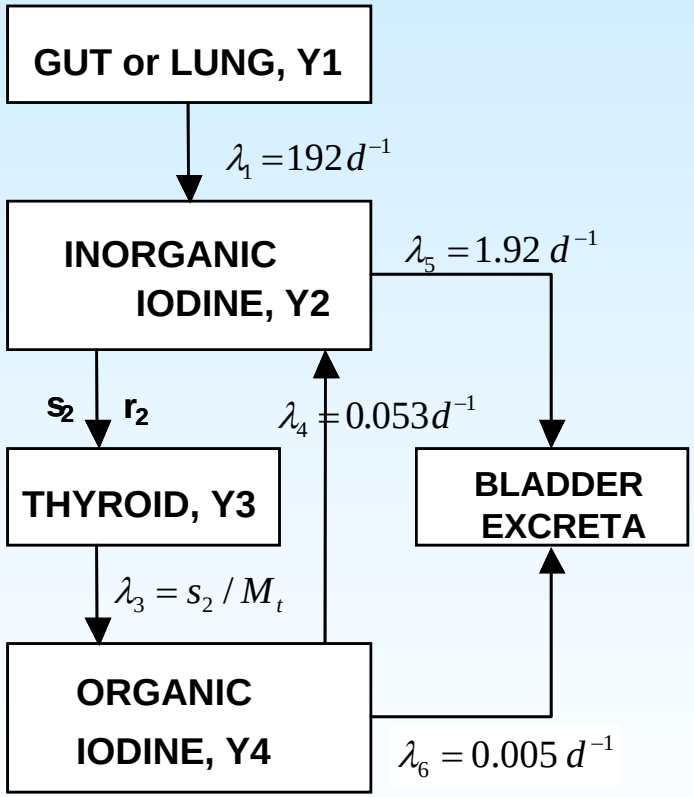
- Stratified sampling scheme appropriate for use with the trajectory dispersion model was designed and developed
- Select a representative sample of weather sequences for analysis (100-200 sequences)

Exposure Pathways

- Realistic estimates for all possible exposure pathways with protective measures with simple models such as sheltering, evacuation, relocation and food ban
  - Shielding and filtering factors for sheltering
  - Radial evacuation

Metabolic Model of Iodine in Man

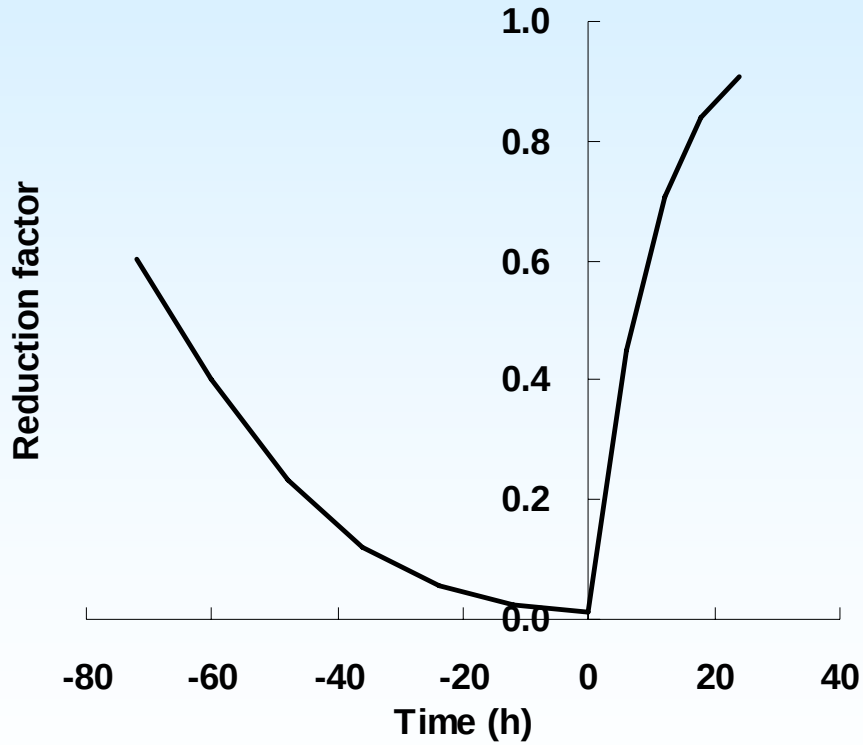
Johnson model(1981)



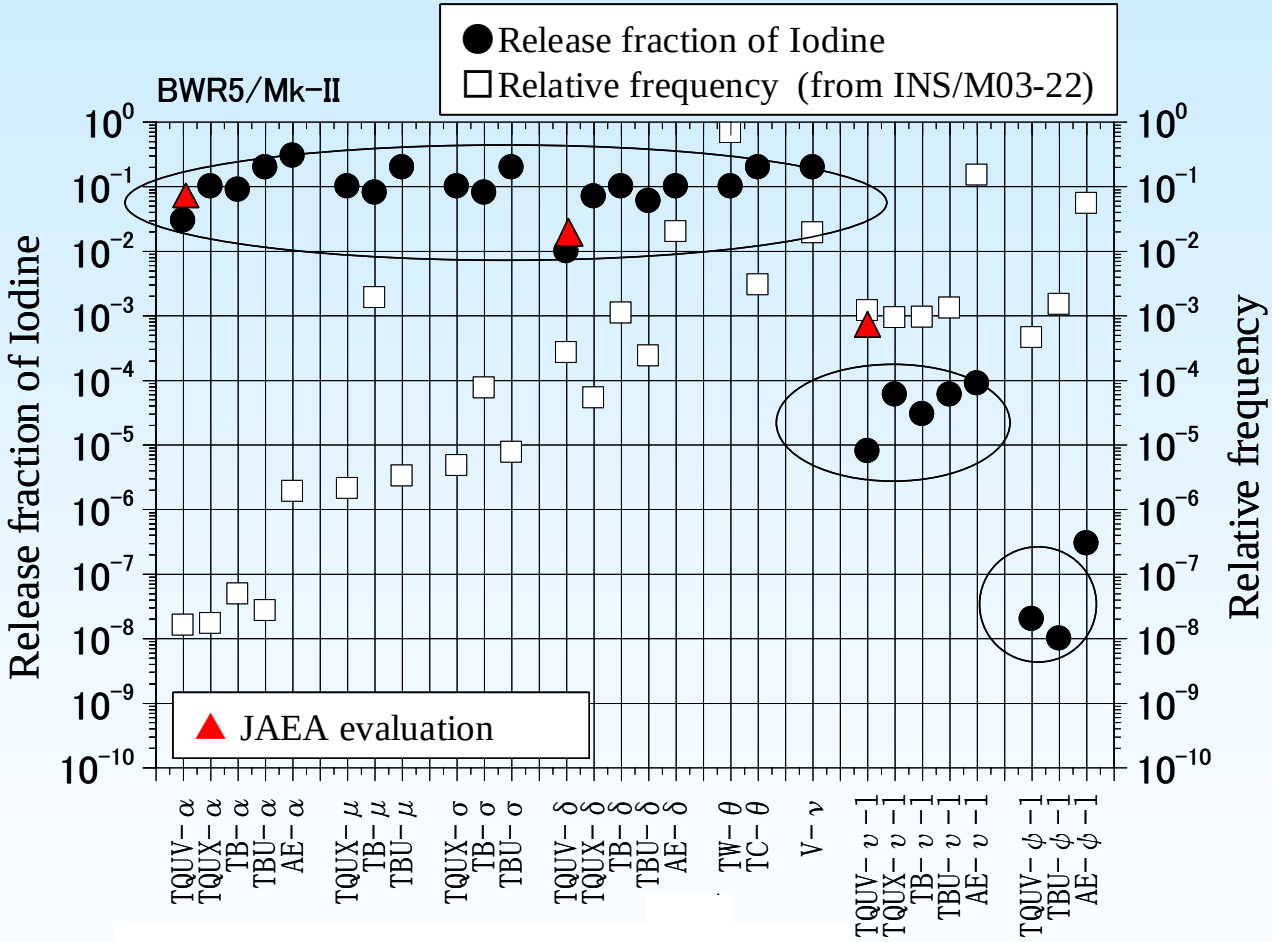
$$r_2 = s_2 (Y_2^r / Y_2^s)$$

r_2, s_2 : the rate of uptake of radioactive and stable iodine by the thyroid

Reduction in the committed thyroid dose to man (for adult, 100mg)

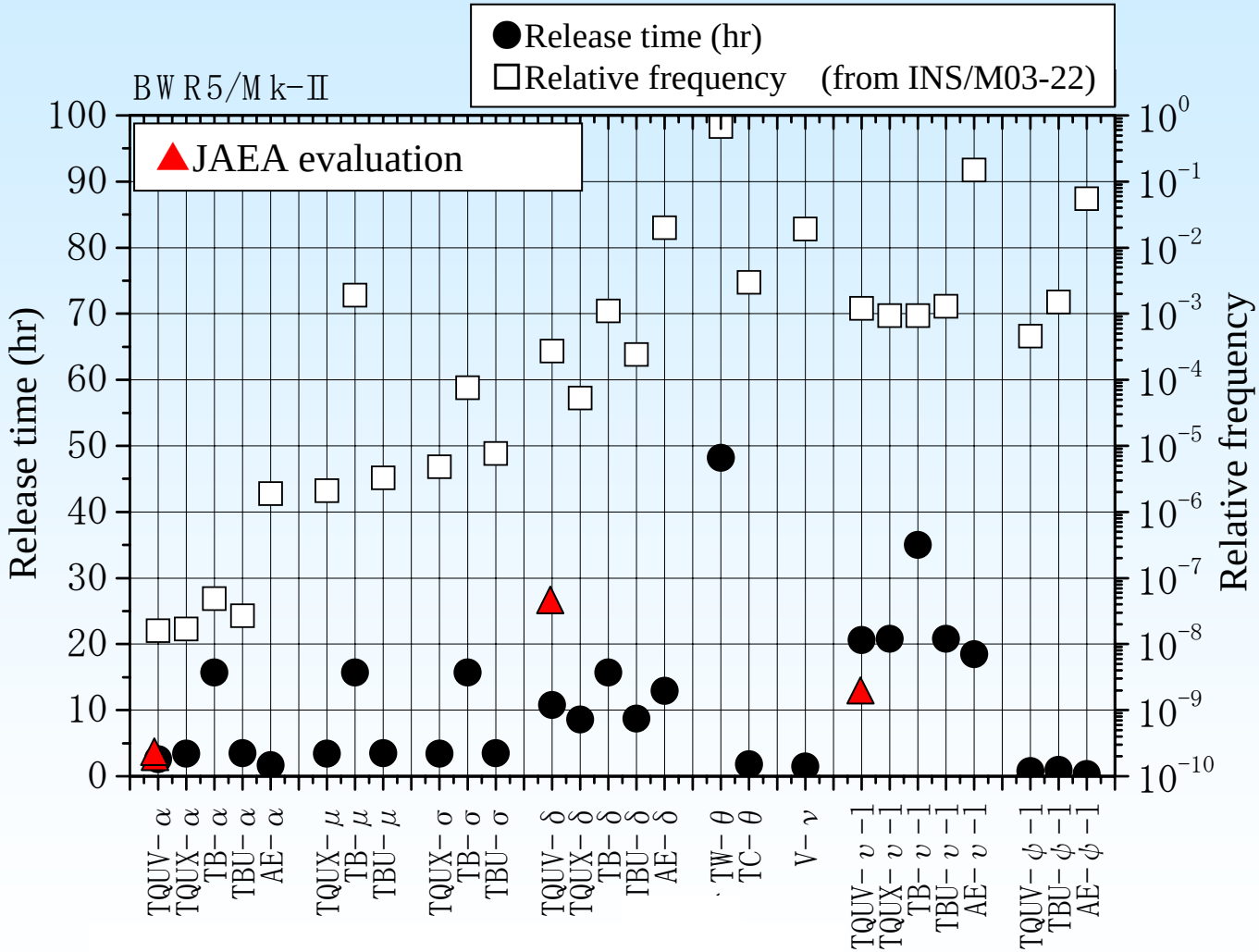


Source Term Development



- 10^{-1} Iodine release fraction : Energetic events, Overpressure, ISLOCA
- 10^{-5}～10^{-4} : Containment vent
- 10^{-7}～10^{-8} : Termination

Source Term Development



Source terms and PM strategy

Three source term scenarios

Release scenario	*Release time (hr after scram)*	*Duration of release (h)*	*Release fraction of iodine (%)*
Large early release	***3***	***1***	***7.9***
Large late release	***27***	***7***	***3.3***
Control release	***12***	***22***	***0.09***

Strategies of protective measures

- Large early release: precautionary evacuation with stable iodine intake
- Large late releases: evacuation and sheltering with stable iodine intake
- Control releases: sheltering with stable iodine intake

Site data

- A reference site is assumed to be located at a coastal area facing the Pacific Ocean (JAEA site at Tokai)

Steps for Consequence Evaluation

Calculation of dose from each pathway and time-dependent iodine concentrations in air at receptor points using OSCAAR

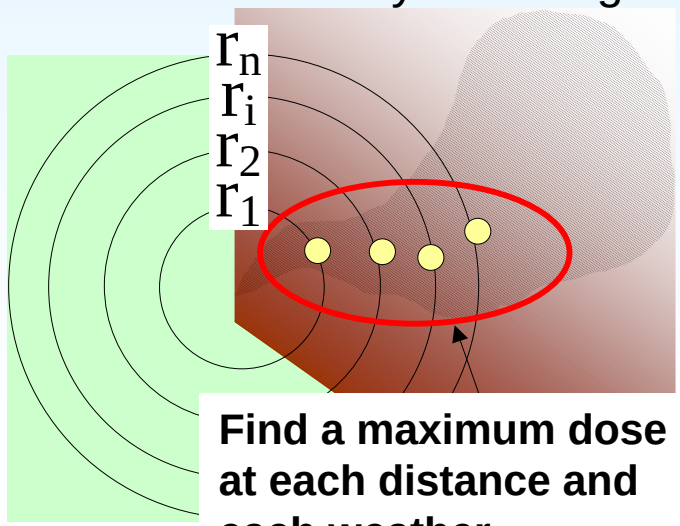
- 248 weather sequences selected by a stratified sampling method

Calculation of dose reduction effects by various combinations of protective measures

- Intervention levels for implementing each protective measure
  Sheltering：10 mSv, Evacuation：50 mSv（effective dose）
  Administration of stable iodine ：100 mSv (thyroid equivalent dose)
- Inhalation dose due to iodine intake based on ^{131}I contents in thyroid using a metabolic model by Johnson

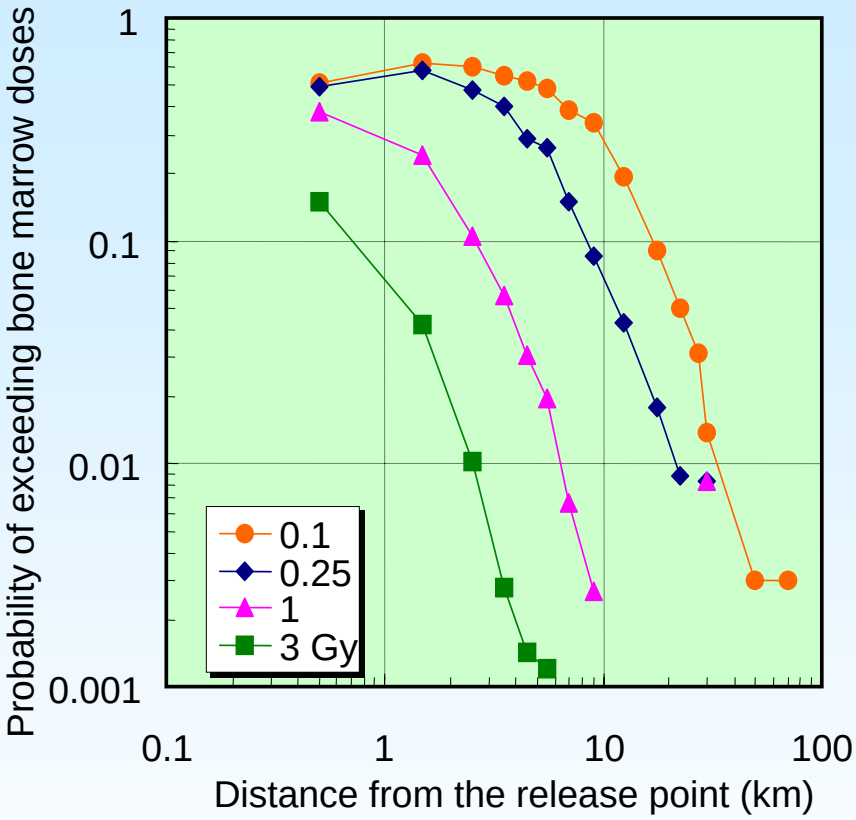
Calculation of maximum dose at each distance from the site and its probability of weather sequence

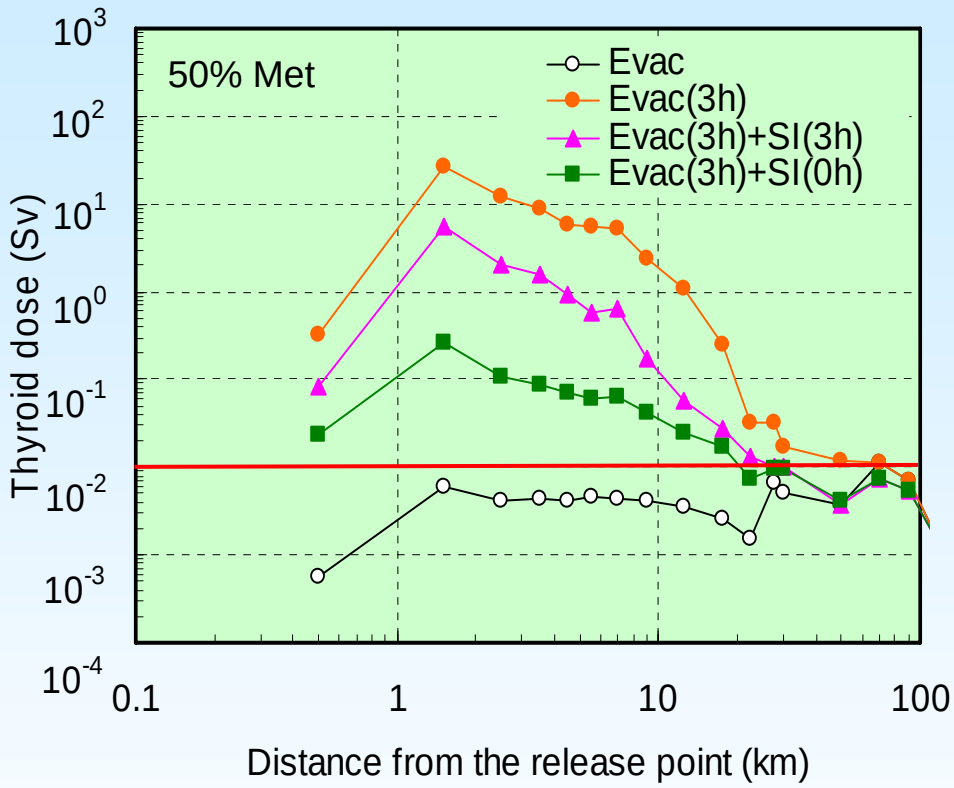
- Probability of exceeding a specific dose level
- Dose at each distance from the site at a specific cumulative probability of weather sequences



Find a maximum dose at each distance and each weather sequence

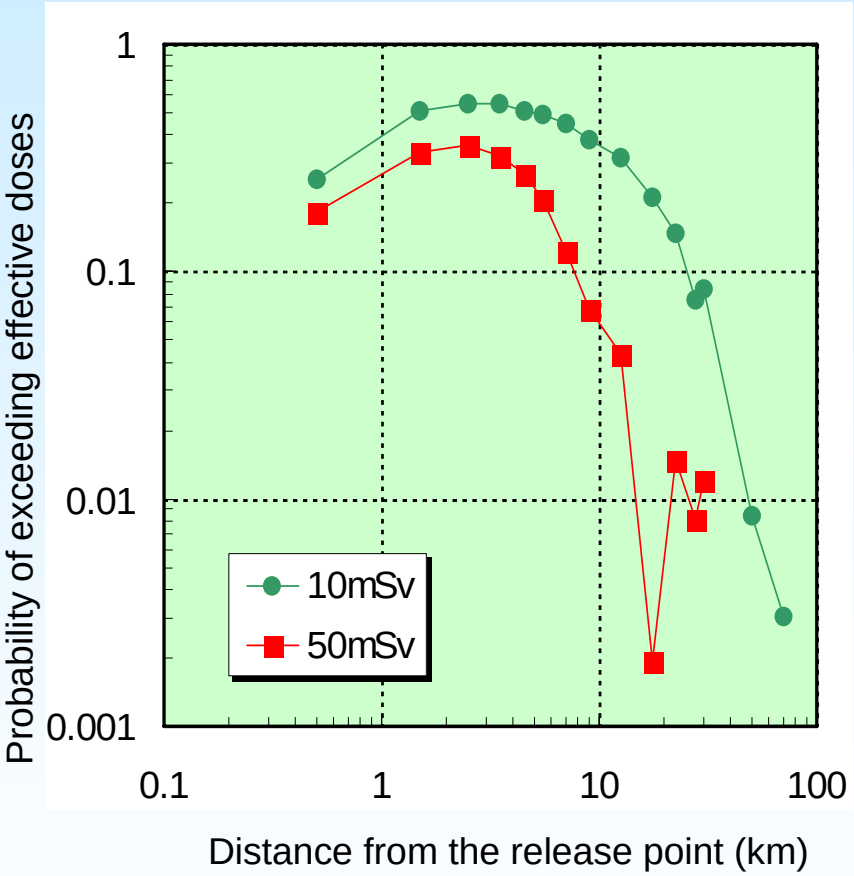
Large Early Release

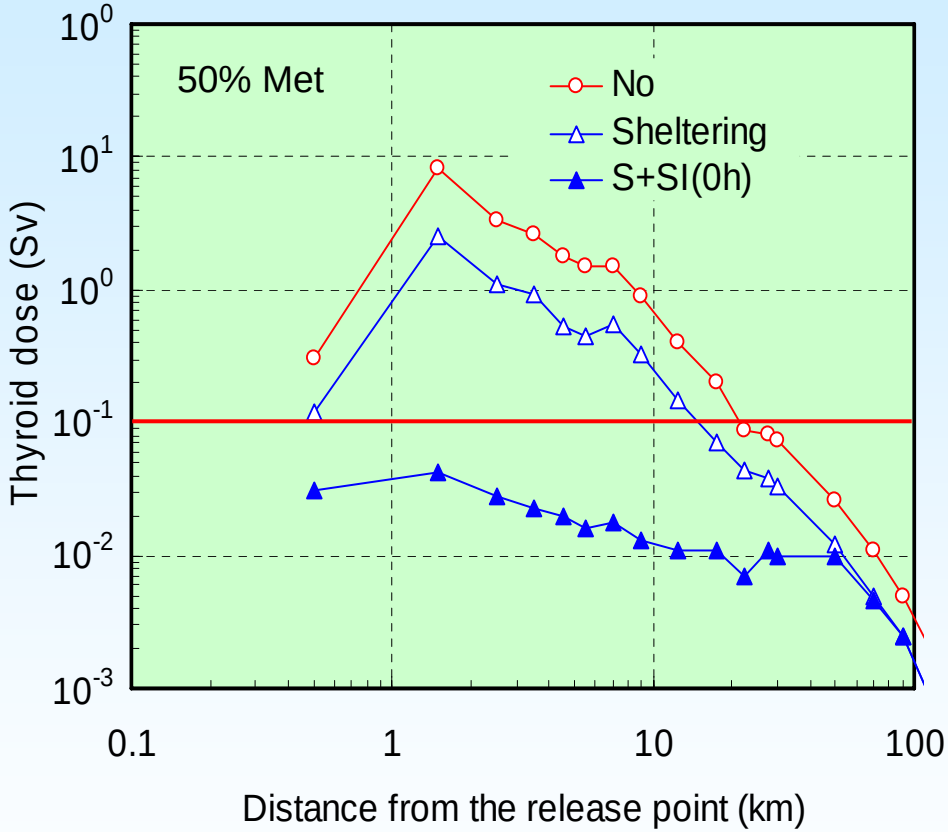




- Even for large early release without protective measures, mortality would be very unlikely to occur beyond about 5 km.
- Early stable iodine intake can be very effective to reduce the thyroid dose for the people close to the site even the delay of evacuation.

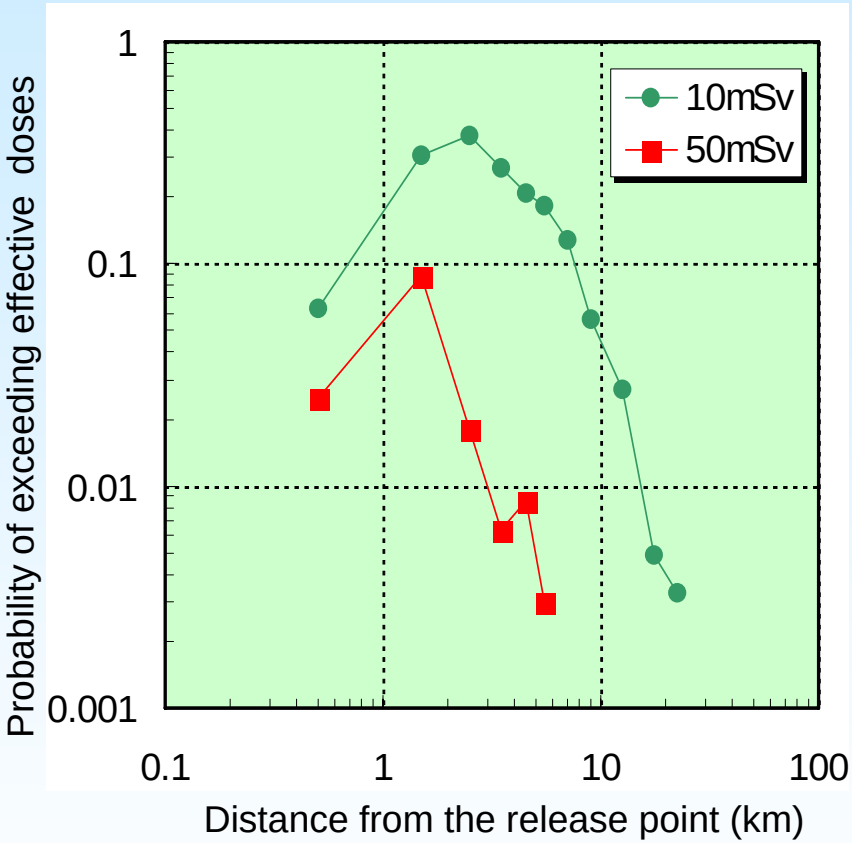
Large Late Release

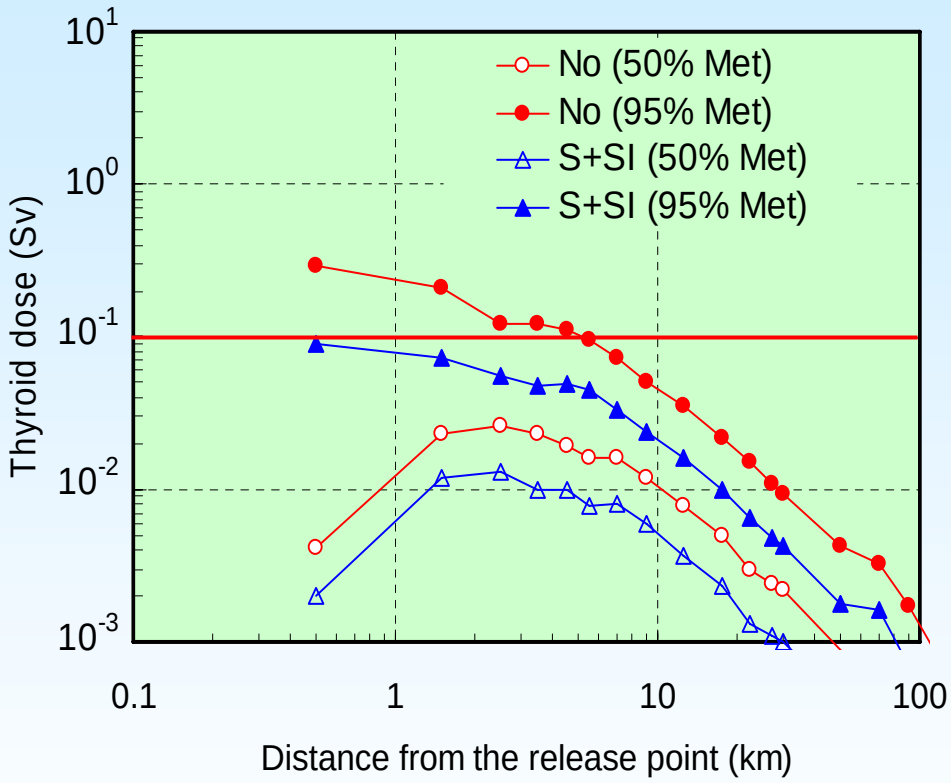




- For large late release, evacuation area is unlikely to occur beyond 10 - 20 km.
- For the sheltering area, stable iodine intake can be very effective to reduce the thyroid dose.

Control Release





- For control release, evacuation area is unlikely to occur beyond a few kilometers and sheltering area is unlikely to occur beyond about 10 km.
- For very severe weather conditions, sheltering with stable iodine intake is needed only close to the site.

Conclusions

- The metabolic model of iodine was successfully introduced with the probabilistic accident consequence model to accurately evaluate the effect of reducing thyroid dose by the intake of stable iodine.
- For the representative source terms defined by the level 2 PSA, the preliminary analysis has been performed using the probabilistic accident consequence model to evaluate the effectiveness of protective action strategy involving a combination of evacuation, sheltering and administration of stable iodine.
- The study indicated that pre-distribution of stable iodine might be considered for the people close to the site in planning.
- The study also indicated that administration of stable iodine should be considered as a supplement to sheltering at greater distances from the site in planning.
- The results of this study will be expected to form the basis for future technical guidance for protective action strategy.