IAEA
International Atomic Energy Agency
Atoms for Peace and Development

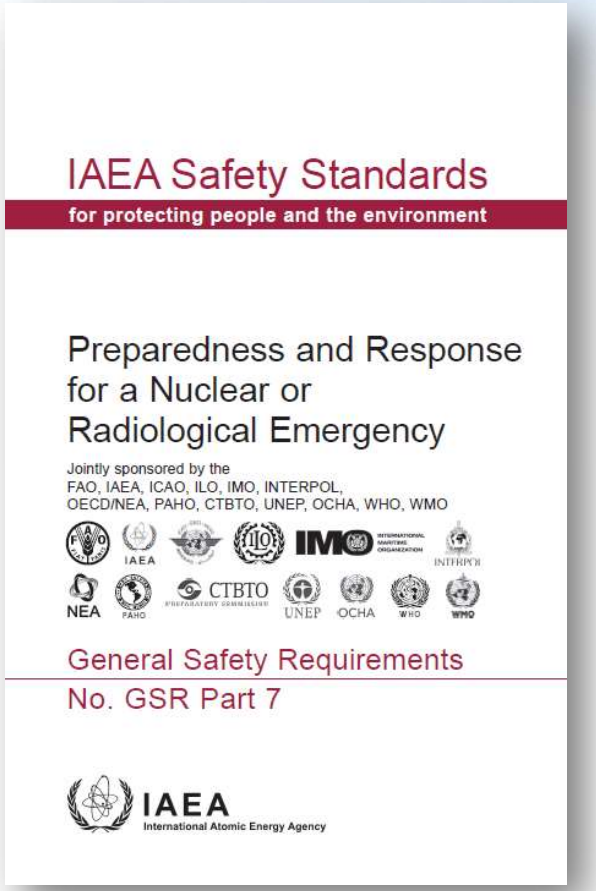
Arrangements for the Termination of a Nuclear or Radiological Emergency

Characterization of the Exposure Situation

Lecture 08

Introduction.
GSR Part 7

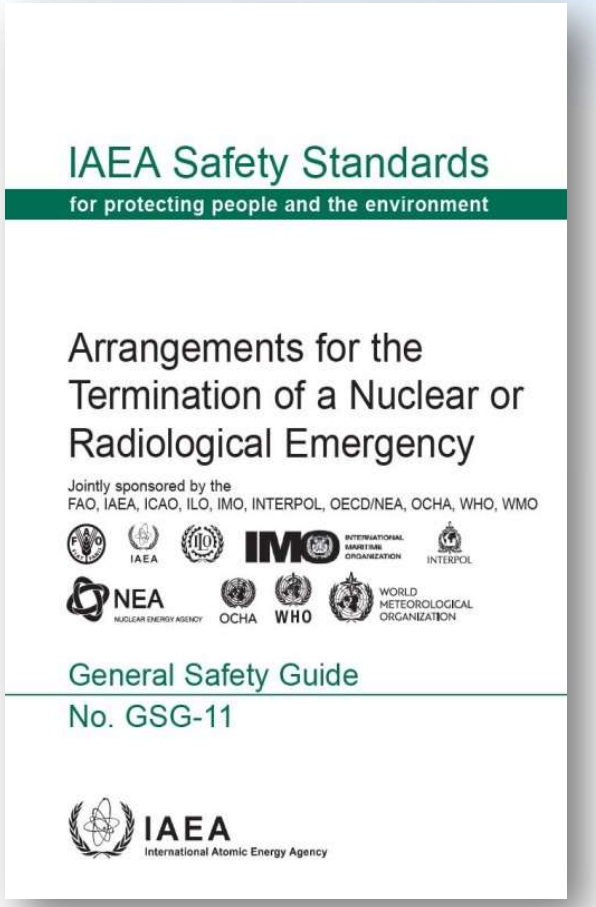
"Arrangements shall be made so that the magnitudes of hazards and the possible development of hazardous conditions are assessed initially and throughout a nuclear or radiological emergency in order to promptly identify, characterize or anticipate, as appropriate, new hazards or the extent of hazards and to revise the protection strategy."



Introduction.
GSG-11, Section 3

"Before the termination of the emergency, the radiological situation should be well characterized, exposure pathways should be identified and doses should be assessed for affected populations …"

" This characterization should consider the impact of lifting and adapting the protective actions … and, where applicable, possible options for the future use of land and water bodies…."



Purpose

- Present and discuss arrangements for characterizing the exposure situation during the transition phase.

Learning Objectives

- Recognize essential arrangements for characterizing the exposure situation during the transition phase.
- Recognize the uncertainties, issues and challenges associated with characterizing the exposure situation.
- Identify essential elements of a monitoring strategy for the transition phase.

Contents

- Introduction
  - What is ‘characterization’?
  - Its role in decision making
- Considerations for developing a monitoring strategy at the preparedness stage
  - Exposure pathways
  - Monitoring resources
  - Use of decision-aiding tools and models
- Implementing the monitoring strategy during transition phase

Discussion

What does characterization of an exposure situation encompass?

Introduction to characterization of the exposure situation

What does characterization of the exposure situation include?

- Dose rates and contamination mapped;
- Exposure pathways identified;
- Doses assessed.

➢ Past, Present, Future

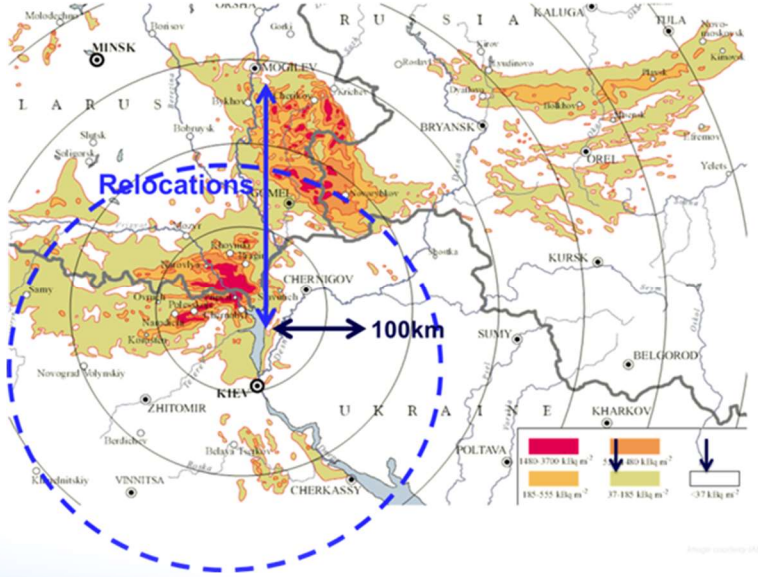


Image reproduced from Annex D, UNSCEAR (2008)

Characterization supports decisions on

- Adjusting the implementation of the protection strategy, including adapting or lifting specific protective actions
- Identifying measures necessary for protecting emergency workers and helpers
- Identifying individuals to be registered for long term medical follow up
- Termination of the emergency
- Planning for long term recovery within the new exposure situation

At the preparedness stage

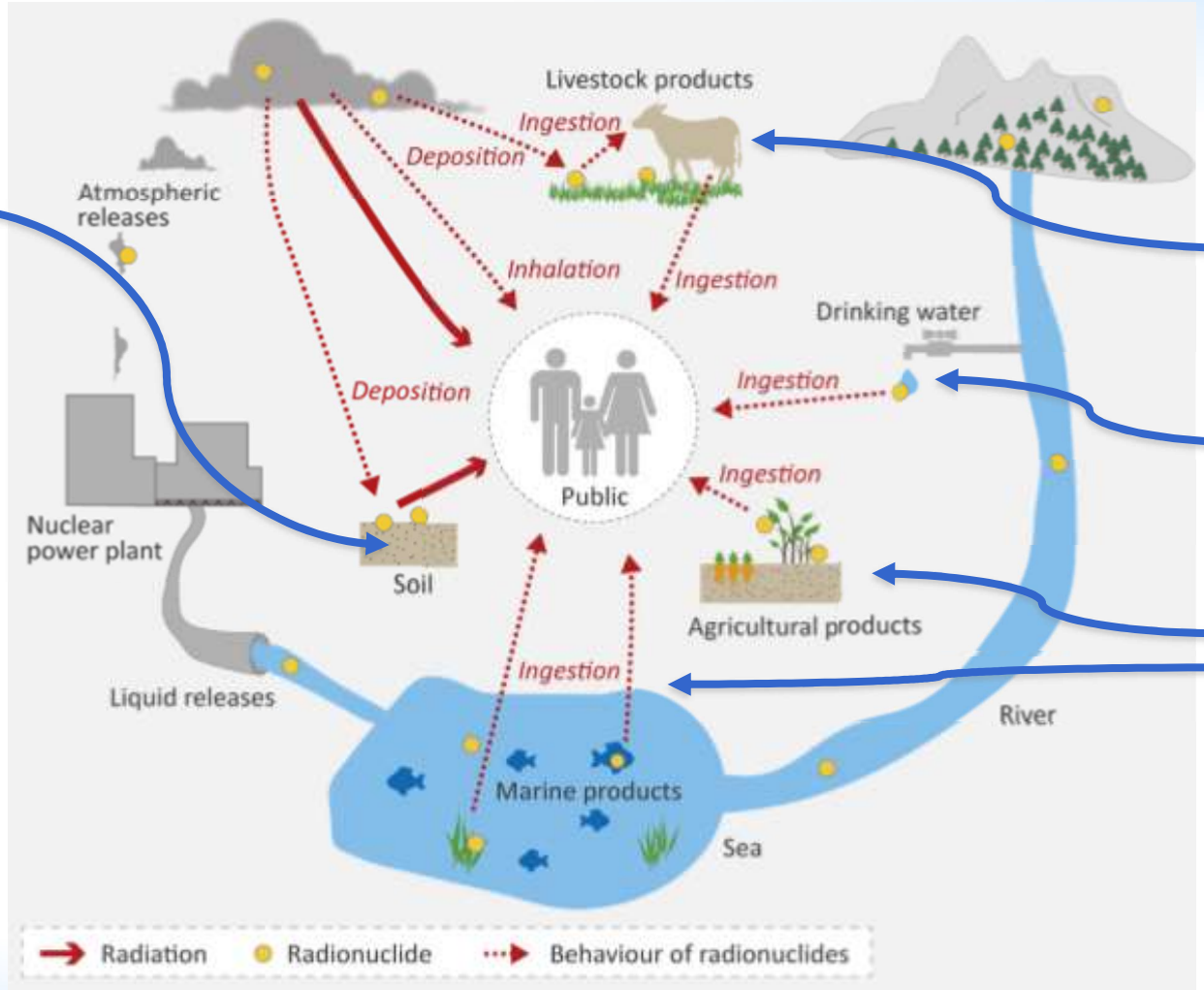
- To characterize the exposure situation and assess doses, develop a monitoring strategy based on:
  - Results of hazard assessment and potential consequences identified;
  - Available resources.
- Strategy should stipulate priorities for different phases of emergency response:
  - Aligned with protection strategy.

Key exposure pathways in the transition phase

External irradiation from radionuclides deposited on the ground

&

inhalation of resuspended materials



Ingestion of:

Milk

Water

Food

Image reproduced from ' The Fukushima Daiichi Accident ', IAEA, Vienna (2015)

Monitoring strategy: Resources

Who	• National and local monitoring organizations, expert bodies, local and national laboratories • Private institutes, universities, research centres
Capacity	• Human resources available • Technical capabilities, monitoring equipment • Dose assessment tools
Quality	• Mechanism to ensure comparability and consistency of measurements and interpretation • Training, quality management and inter-comparisons
Coordination	• Organization responsible for validation, recording and retention of monitoring results and assessments
Decision Making	• Mechanism for incorporating monitoring results and assessments into the decision making processes

Use of decision aiding tools and models

Deposition distributions of caesium-137

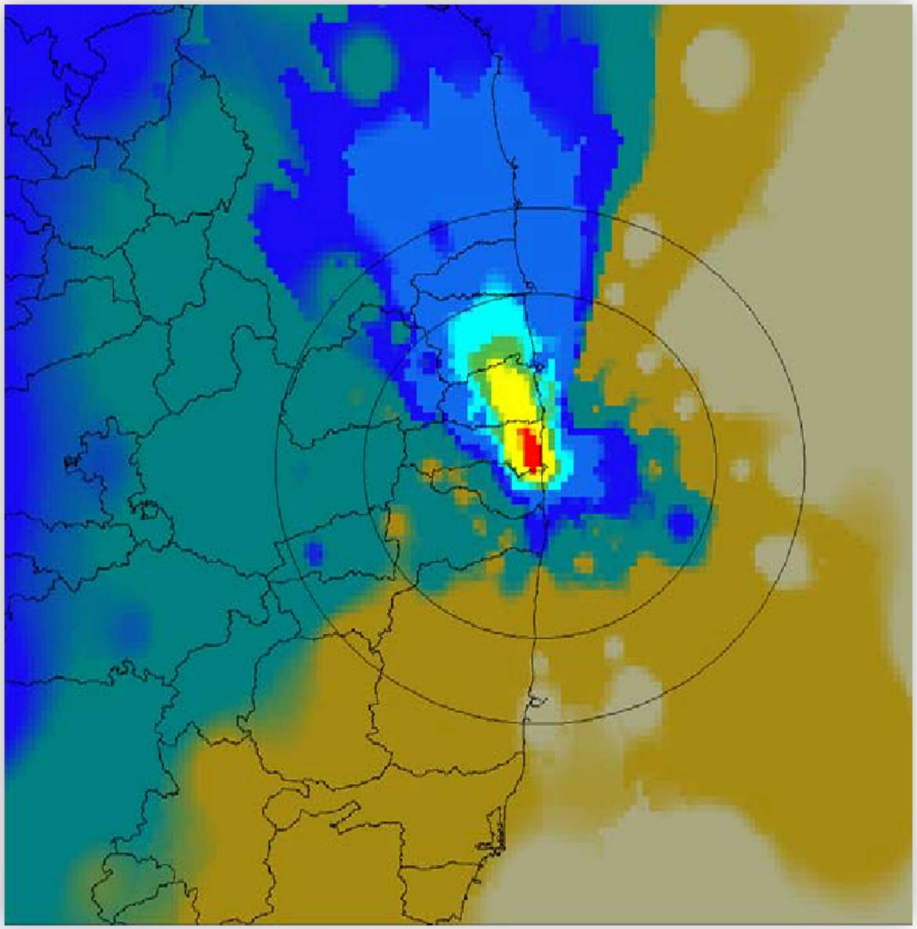
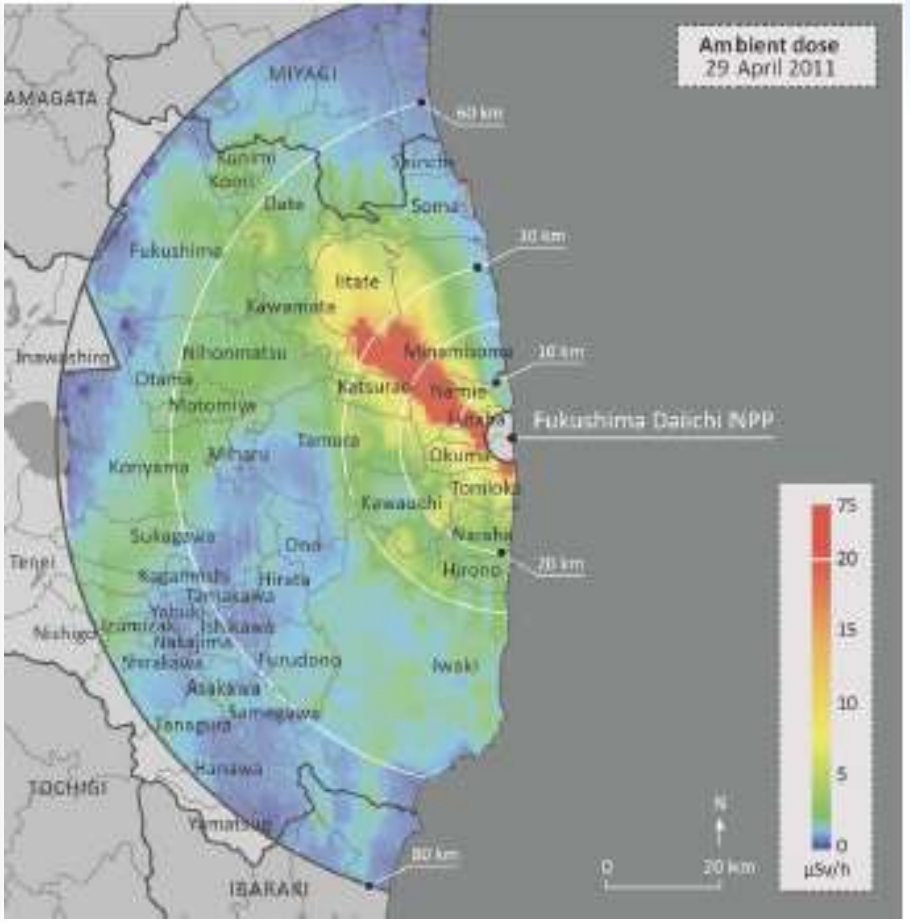


Image reproduced from Homma T., Takahara S., Kimura M., Kinase S., 2013. Radiation protection issues on preparedness and response for a severe nuclear accident: experiences of the Fukushima accident. Ann ICRP, 347-356



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Use of decision aiding tools and models (cont'd)

- Ensure that use and limitations of models and other tools are documented and communicated at the preparedness stage:
  - Models valuable in guiding monitoring priorities;
  - Not appropriate as a tool to decide on public protection actions in response;
  - Used in public communication only with suitable explanations.

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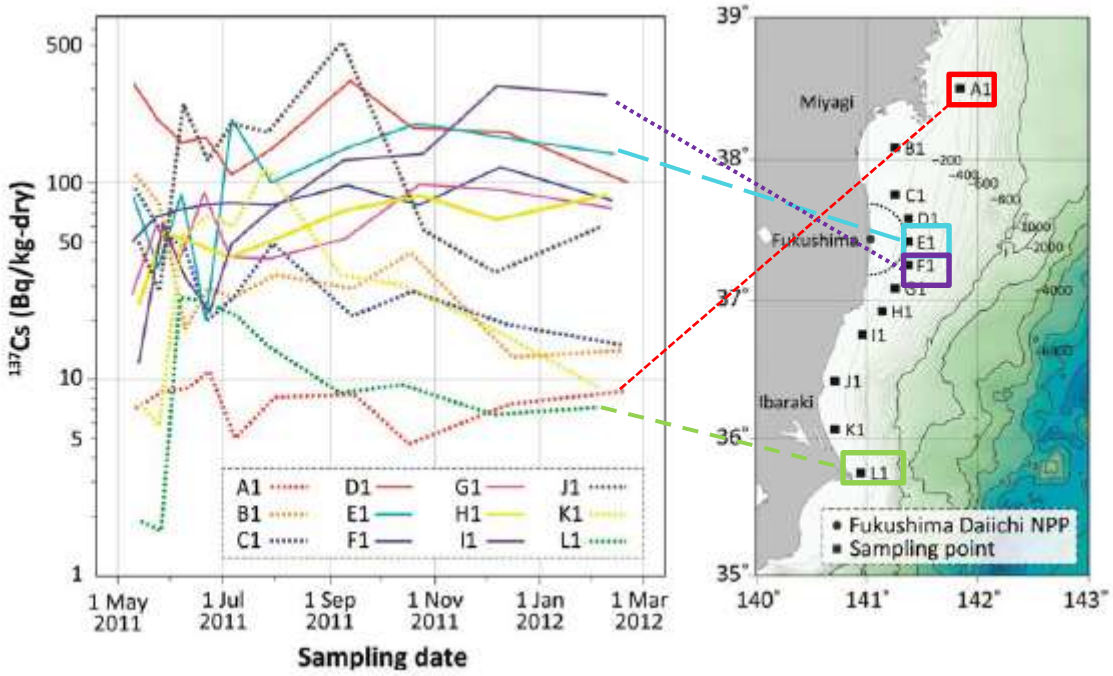
Uncertainties in monitoring results

- Technical sources of uncertainty include:
  - Variability of procedures for sampling, processing and measurement;
  - Spatial and temporal variability;
  - Variability of calibration techniques.

As illustrated in the following slides with some examples from the Fukushima Daiichi accident

Spatial and temporal variability



Images reproduced from 'The Fukushima Daiichi Accident', IAEA, Vienna (2015)

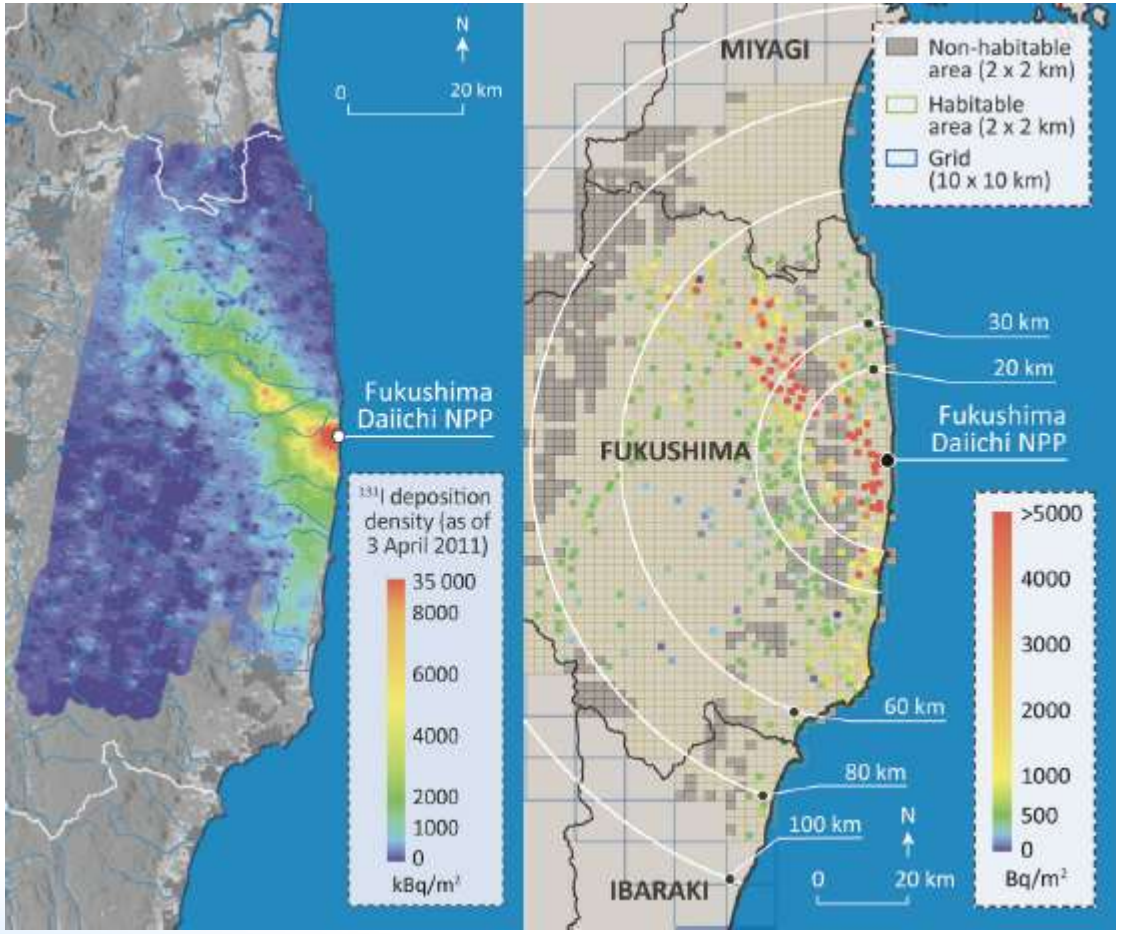
Variation in activity concentrations of Cs-137 in sediment samples between May 2011 and March 2012 around the Fukushima Daiichi NPP

Variability of procedures

Deposition density of I-131 measured by different methods

Aerial survey

(normalized to 2 April 2011)



Soil sampling and analysis

(normalized to 14 June 2011)

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Other sources of uncertainty in monitoring results

- Non-representativeness of samples;
- Human error;

- May be reduced by quality assurance procedures and training at the preparedness stage.

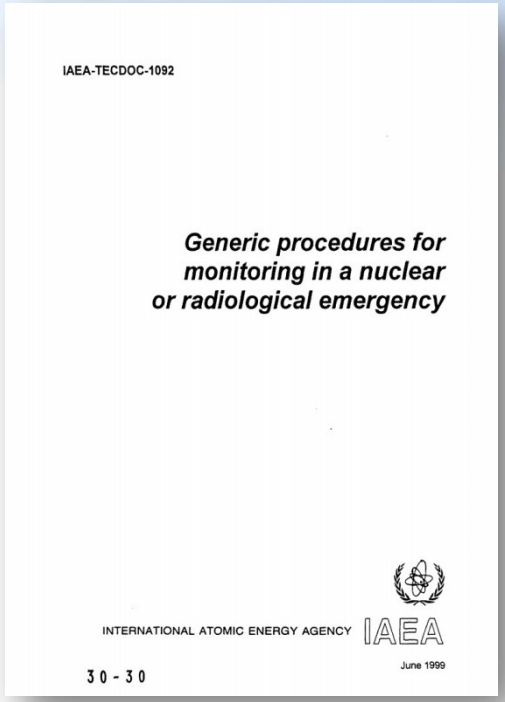
Discussion

What key information do we need to gather in the transition phase to characterize the exposure situation?

During transition phase

For emergencies involving releases to the environment, characterization may include:

- Atmospheric dispersion modelling;
- Wide area environmental modelling;
- Direct measurements.



Aim: reliable data from monitoring to characterize the radiological situation.

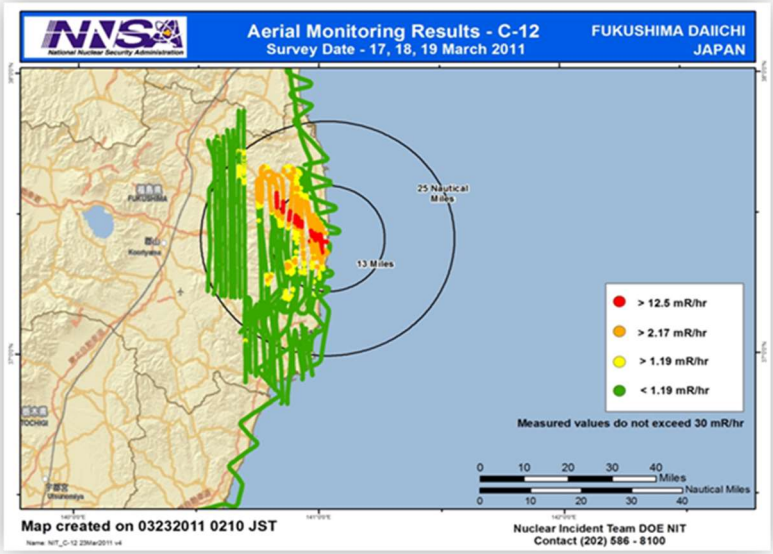
During transition phase (cont'd)

- Radionuclide composition has a major impact on doses incurred and significance of different exposure pathways.

Aim: Identify radionuclide composition of release or contamination as early as possible

Dose rate and deposition measurements

- An understanding of the distribution of the deposition is likely to be developed during both the early response phase and the transition phase:
  - Progressively more detailed dose rate and deposition measurements are possible as the emergency progresses.



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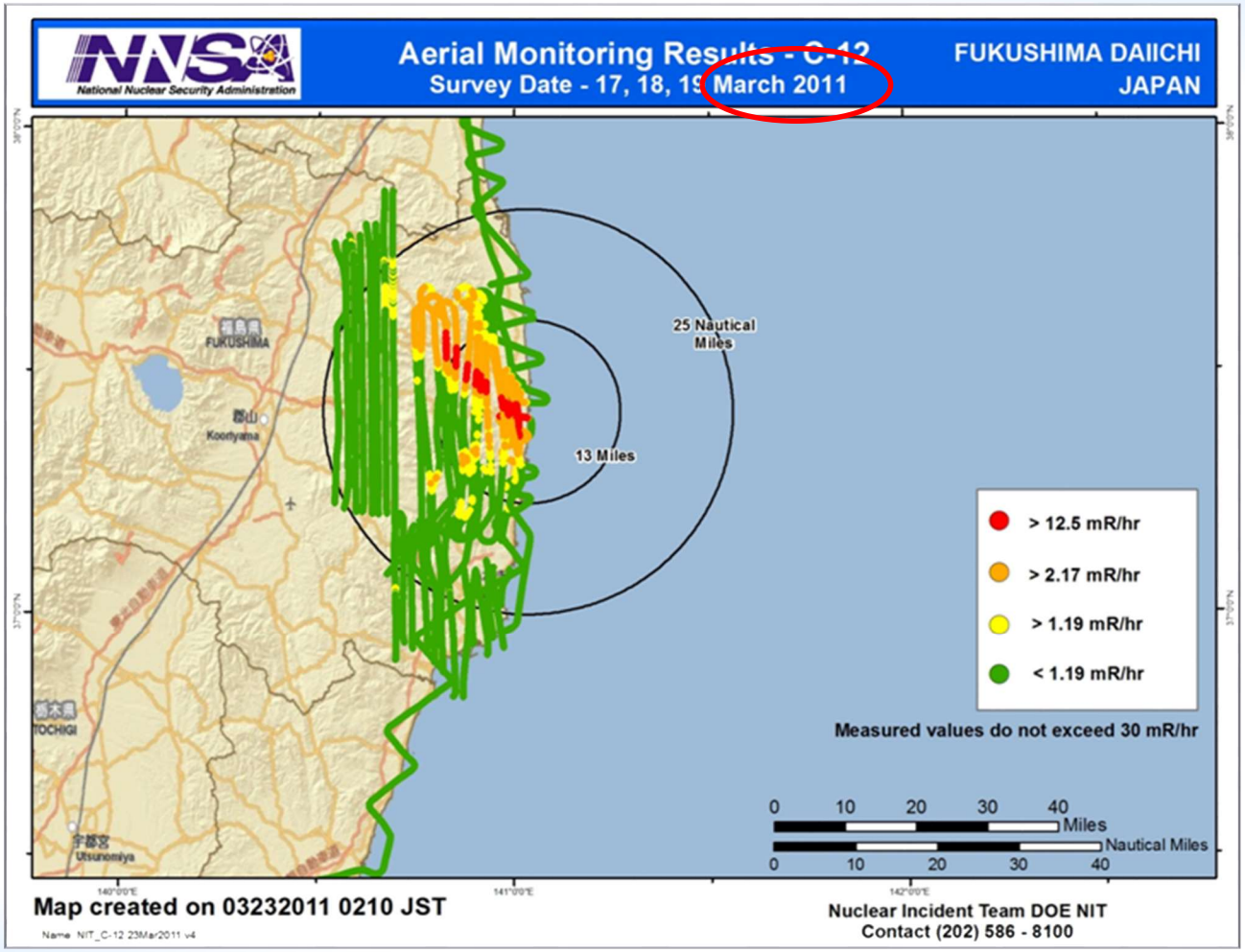
Fukushima Daiichi – aerial dose rate monitoring



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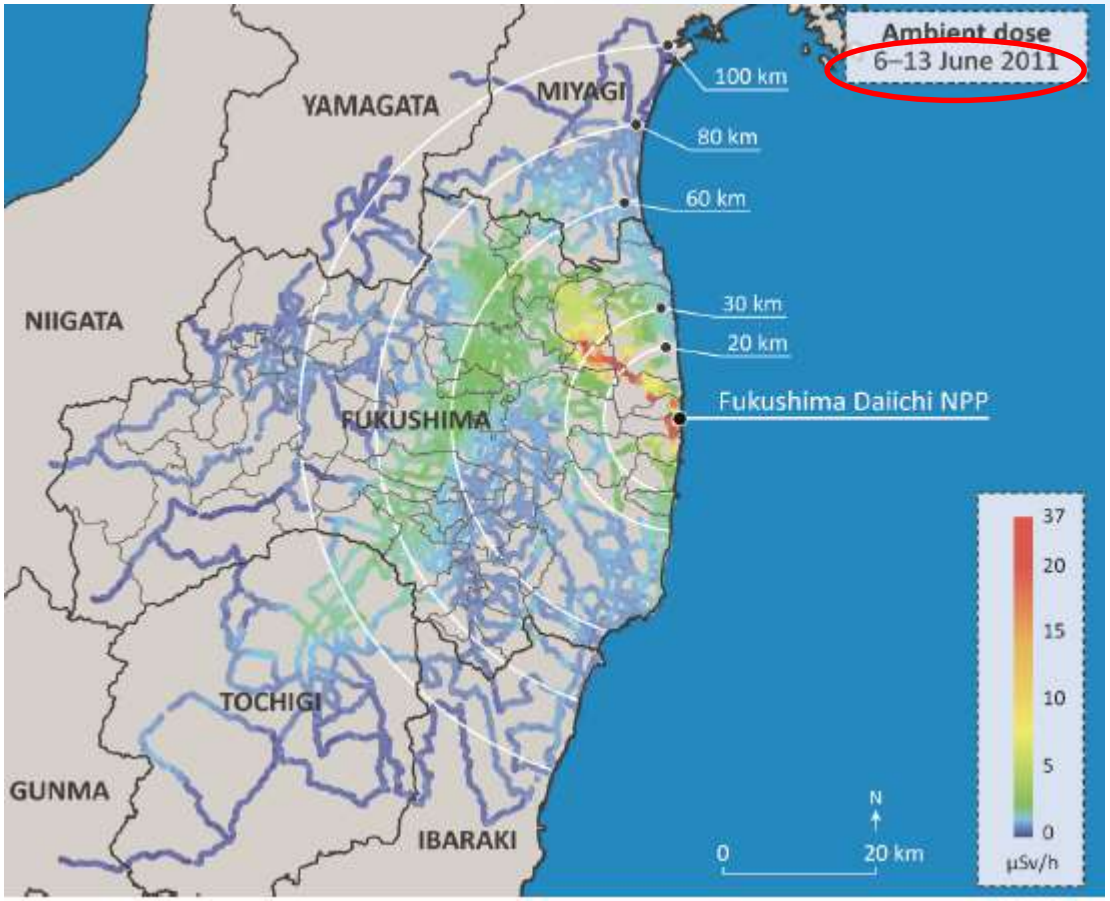
Initial measurements of gamma dose rate from aerial monitoring

A few days after the start of the accident

Vehicle-borne dose rate measurements



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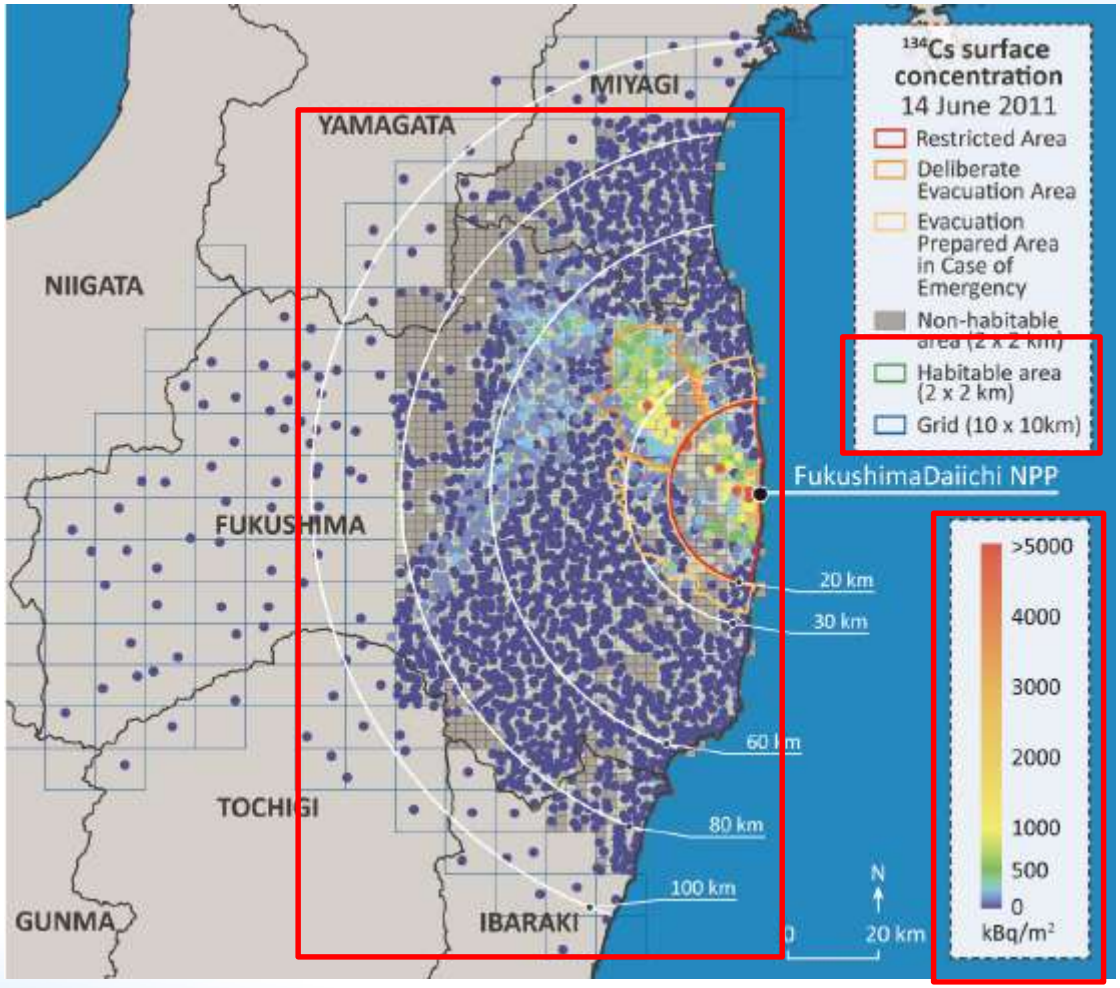
Results of vehicle-borne measurements of dose rates 1 m above ground taken 6–13 June 2011

Around 3 months after the accident

Measurements of surface concentration



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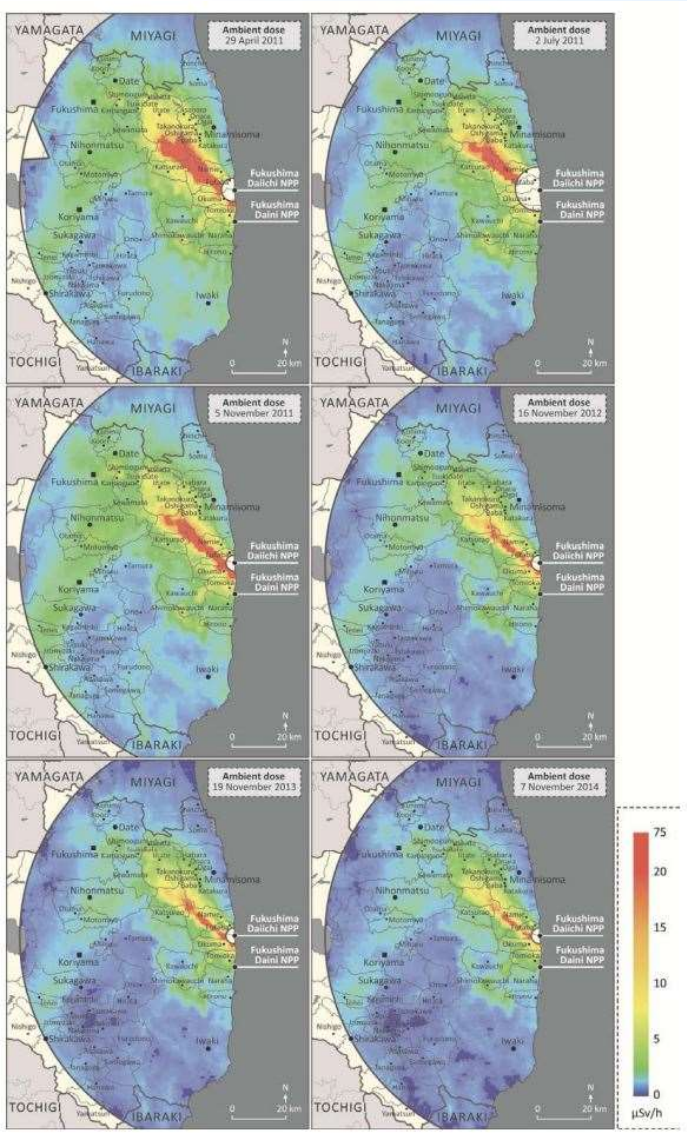
Derived from soil sampling and laboratory analysis (samples taken from 6 June to 8 July 2011)

- Surface samples (top 5 cm) were taken from about 2200 locations
- The sampling campaign involved more than 400 people from 94 organizations (incl. universities, medical institutions and private companies)

Mapping

- Need dose rate and deposition measurements:
  - Prepare detailed radionuclide-specific deposition maps and external gamma dose rate maps (update periodically).
- Pay attention to possible heterogeneity of deposition:
  - Use rainfall data and dispersion patterns to help identify.
- Share maps with interested parties:
  - Include plain-language explanations of health hazards and need for protective actions.

Fukushima Daiichi – examples of periodically updated maps



Measured aerial ambient dose equivalent rate from deposits (April 2011 – Nov. 2014)

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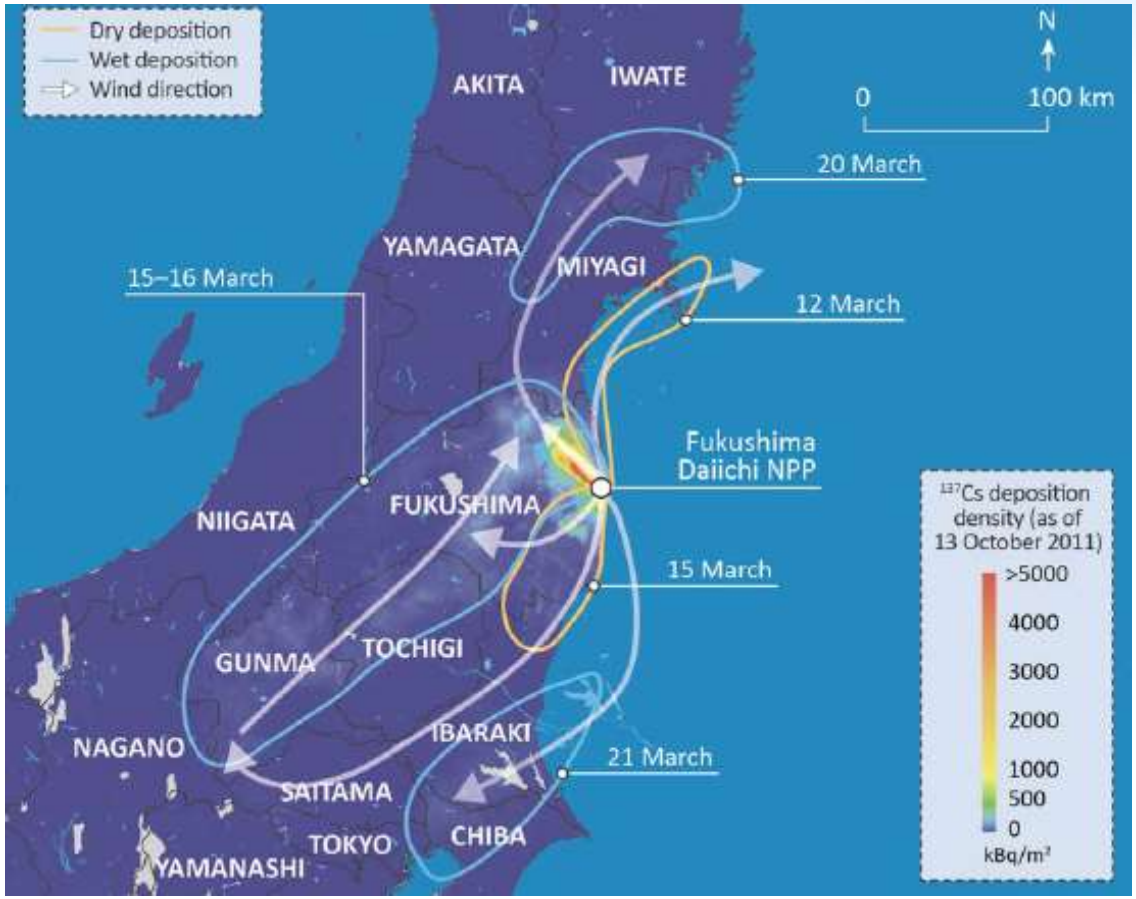
Pattern of deposition from the Fukushima Daiichi NPP



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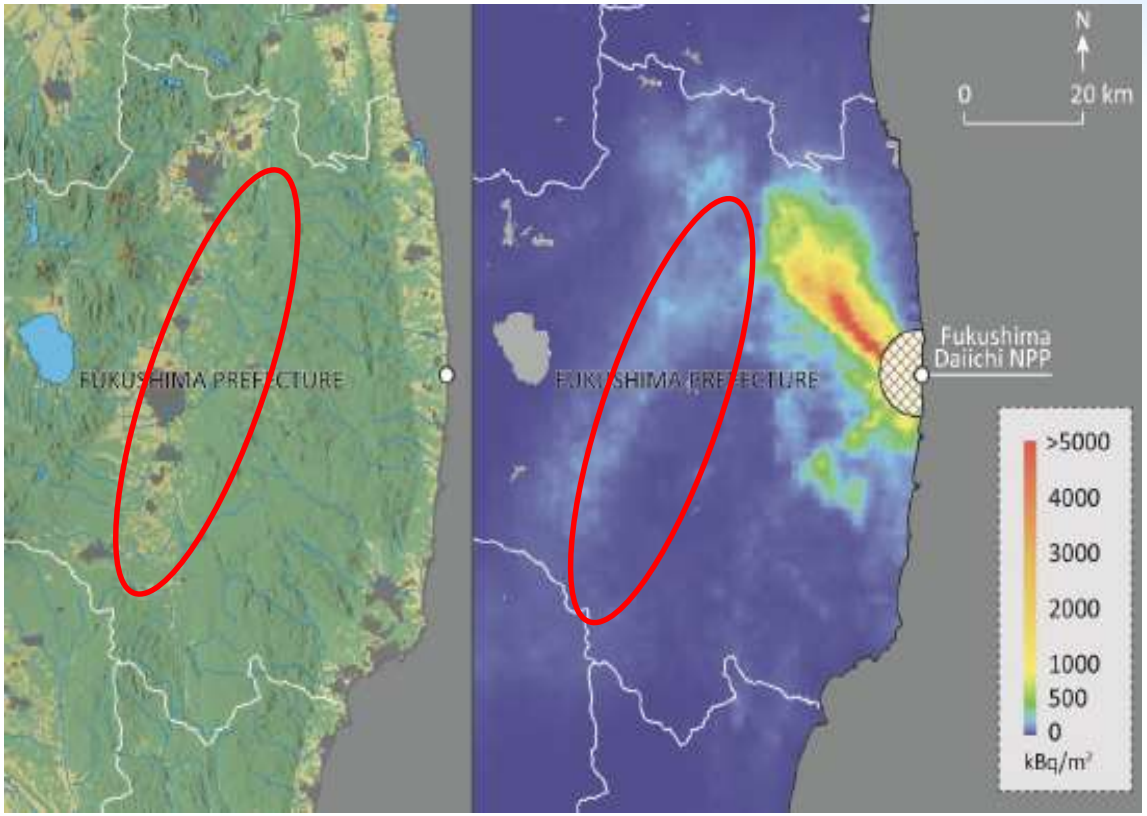
Higher deposition densities associated with wet deposition – the pattern will influence the monitoring strategy

Influence of topography



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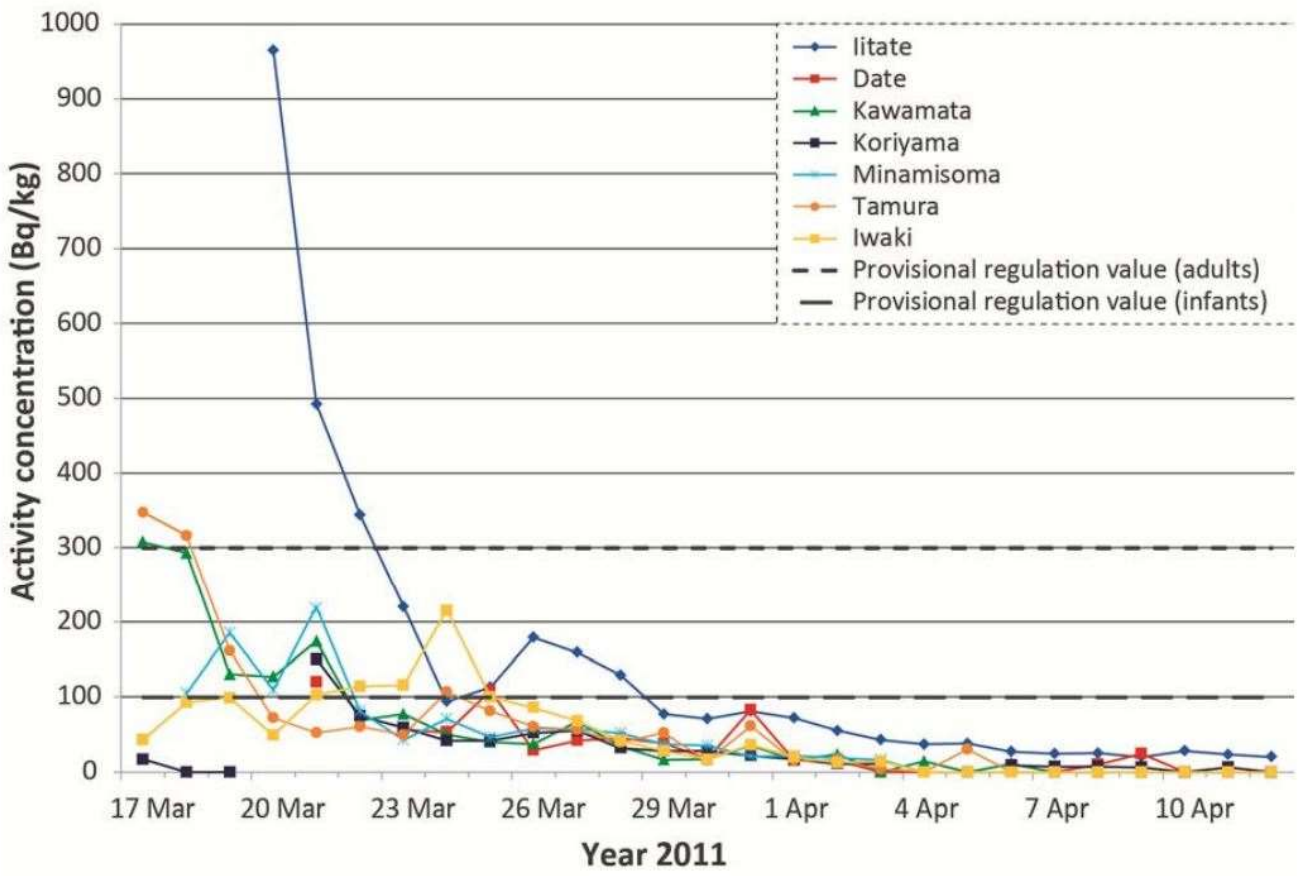
Pattern of deposition related to topographical features, e.g. mountains, which may also affect the monitoring strategy

Food, water and milk contamination and resuspension

- Need to assess doses from ingestion of food, milk, drinking water:
  - Comprehensive environmental sampling and monitoring programme accounting for local diet (and farming practices).
- Inhalation of resuspended material may become more important in this phase:
  - Dose contribution of this pathway is normally small, but more significant in some circumstances (e.g. arid areas). Consider in monitoring programme.

Tap water monitoring results



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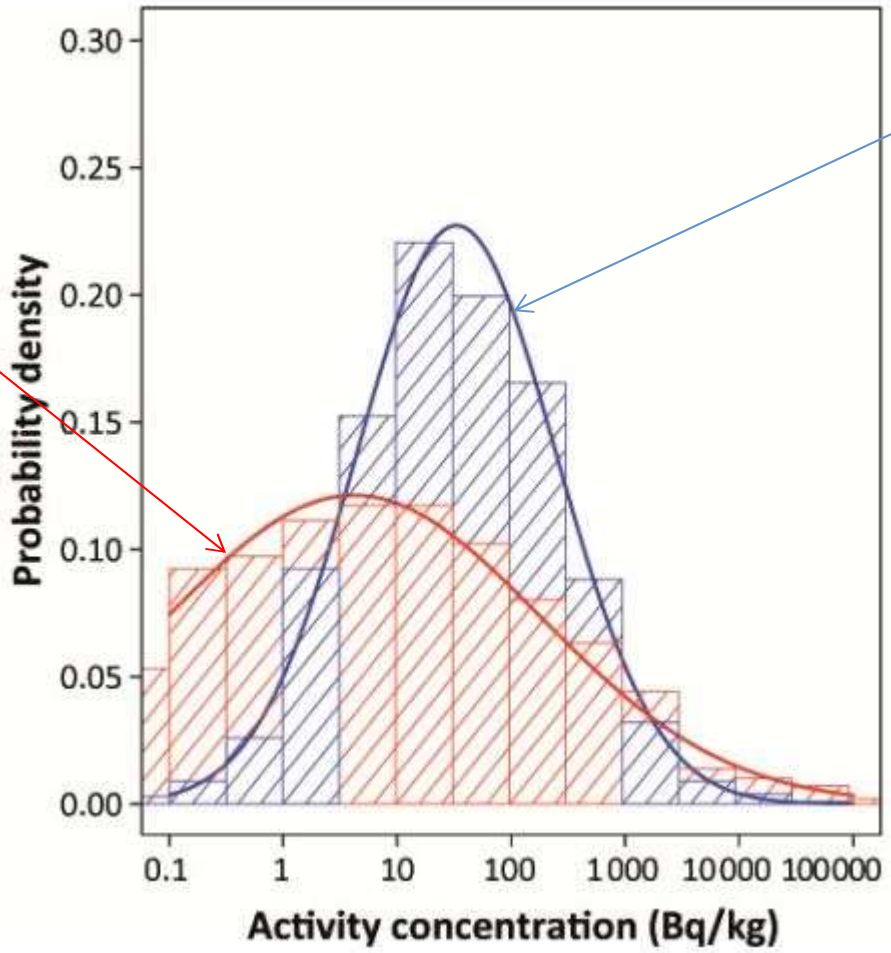
I-131 measurements in tap water supplies in Fukushima Prefecture (in the first year following in the accident)

Distribution of activity concentrations in milk and leafy vegetables

Activity concentration of I-131 in leafy vegetables in the first 3 months

Activity concentration of I-131 in milk in the first month



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Monitoring locally grown rice

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Discussion

How can the characteristics of an impacted area and its affected populations contribute to doses to be received in an emergency?

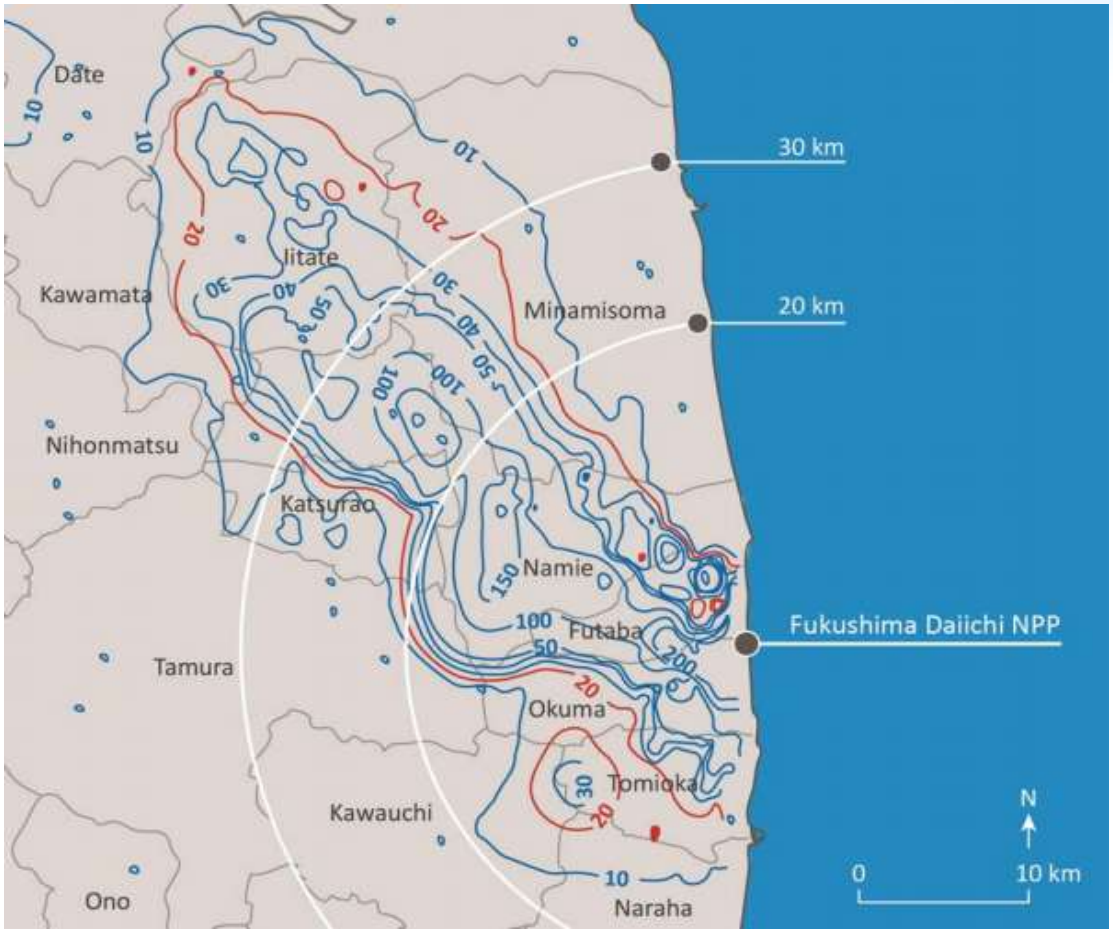
Other considerations for characterization and dose assessment

- Food production patterns;
- Local diets and food preferences;
- Activities carried out in an area:
  - e.g. those that may lead to additional exposures;
- Human behaviour;
- Characteristics of an area:
  - e.g. dusty or windy environment;
- Redistribution of radionuclides due to weathering or natural decay;

Other considerations for characterization and dose assessment (cont'd)

- Make dose estimates as realistic as possible for comparison with relevant criteria;
- Reassess doses continually in light of new information as it becomes available;
- Place health hazards in perspective when sharing the results of dose assessment publicly;

Fukushima Daiichi - estimated doses



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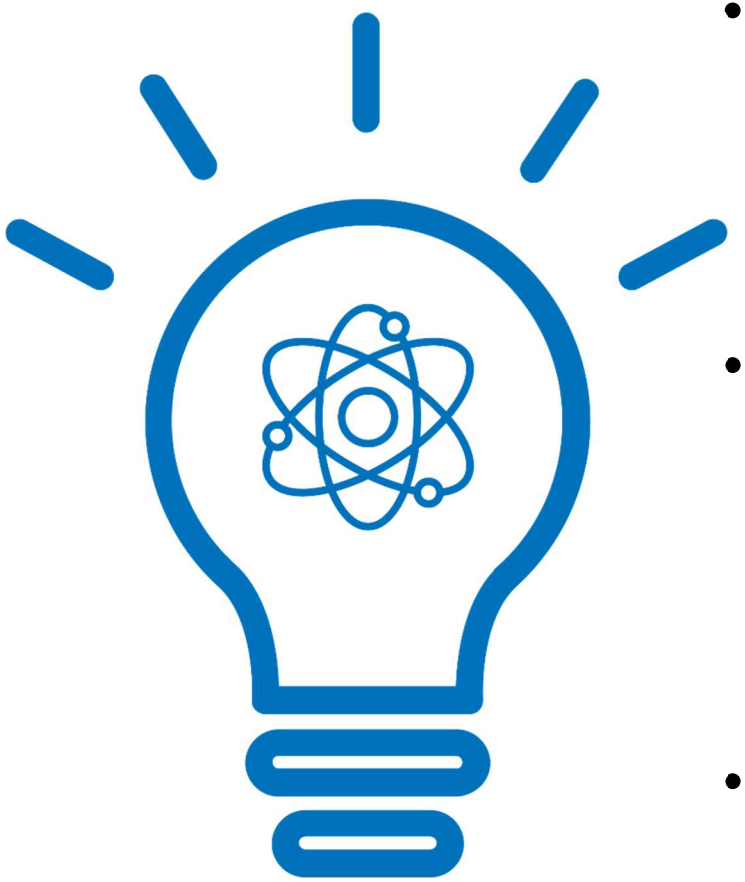
Estimated effective doses (mSv) received in the first year (up to 11 March 2012)

Summary



- The characterization of the exposure situation would require intensive monitoring. A monitoring strategy needs to be developed at the preparedness stage.
- Various aspects need to be taken into consideration in defining the priorities for monitoring and addressing uncertainties so that an informed adaptation of the protection strategy is possible.
- Deposition and dose rate maps shared publicly accompanied with plain language explanations that place health hazards and associated protective actions in perspective.

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Thank you!