Estimation of Internal Radiation Dose from both Immediate Releases and Continued Exposures to Contaminated Materials

Bruce Napier

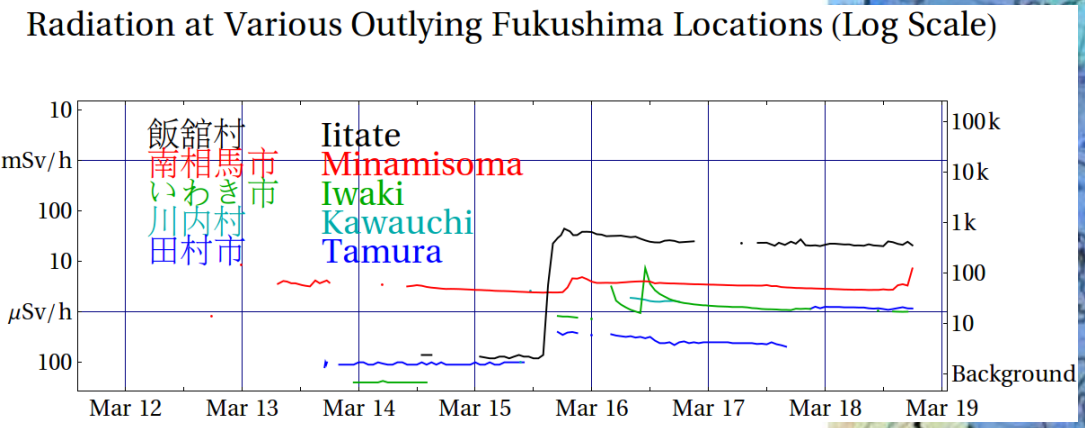
Pacific Northwest National Laboratory

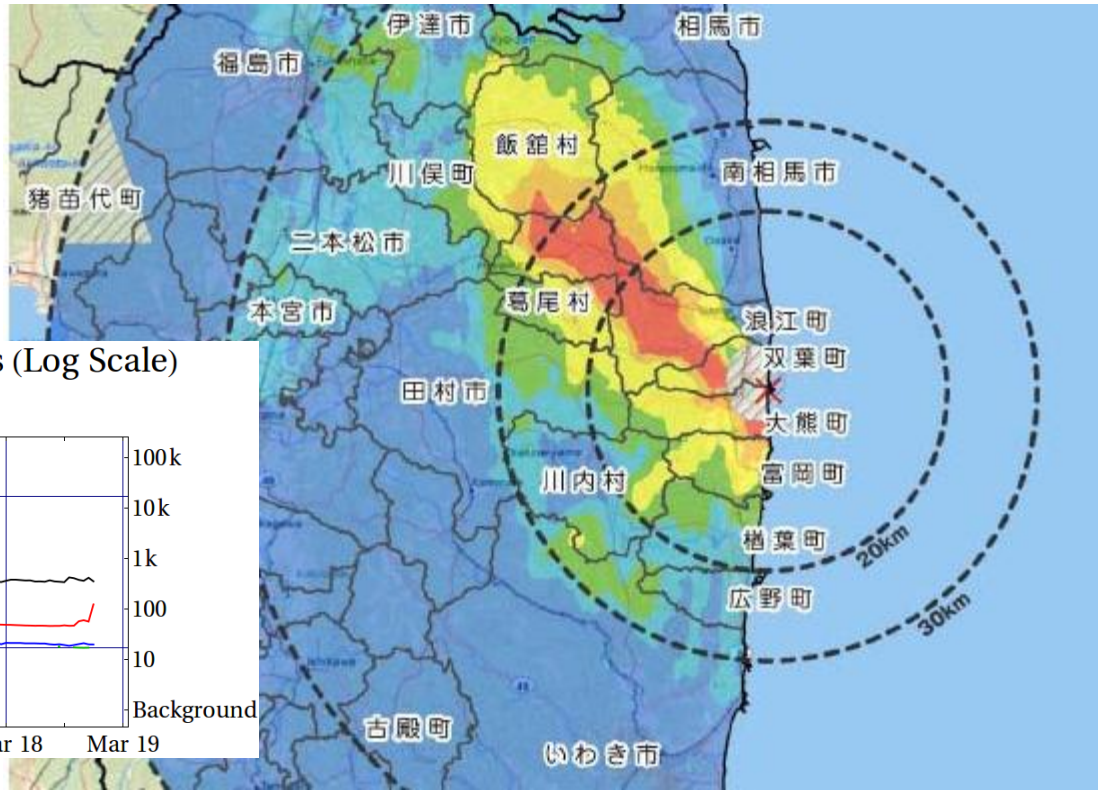
Presentation Topics

- Internal dose (radiation dose resulting from materials taken in to the body)
- Radiation dose reconstruction; principles and practices
- Effects of residual contamination in the environment

Environmental Radiation Measurements

- The available measurements tell us about the development of the radiation field. They don't actually define dose to individuals.



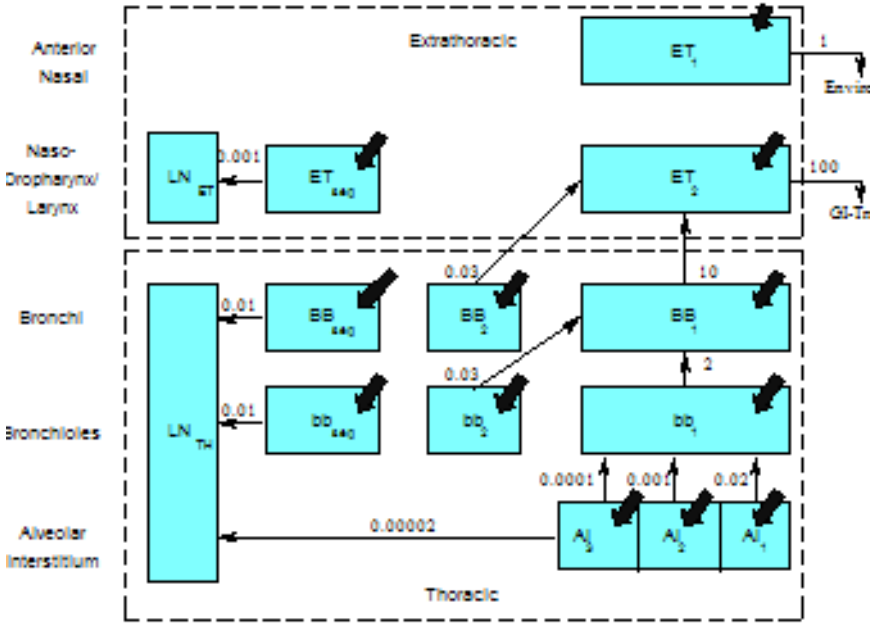


Radiation Exposure Pathways

- People are exposed to radiation in various ways:
  - Air submersion/direct exposure to fallout on soil (this can be directly related to the measurements)
  - Inhalation of airborne material (this is related to measured concentrations in air – but also to resuspension from soil)
  - Ingestion of food crops (this is related to fallout)
  - Ingestion of animal products (this is *indirectly* related to fallout)
  - Ingestion of seafood (may be related to air or water releases, ocean currents, and type of foodstuff)

Internal Radiation Dosimetry

- Ingested or inhaled material may be absorbed into the blood and distributed throughout the body
- Some materials have preferential locations for deposition
  - Iodine: thyroid
  - Strontium: bone
  - Cesium: soft tissues



- Various rates of metabolic elimination in addition to radioactive decay
- Radiation from one organ may irradiate other adjacent or distant organs

Estimating Exposure to Radionuclides

- Internal radiation dose cannot be measured
  - Although the amount of radioactivity may be measured in a person
- Therefore estimation is necessary; this involves use of various types of models
- This type of modeling is formally known as dose reconstruction
  - Retrospective assessment of dose to individuals or populations *by any means*

Dose Reconstruction Purposes

- Dose reconstruction can be done for a variety of purposes
  - Compensation for occupational disease (NPP workers)
  - Management of radiation emergencies (Worker overexposures)
  - Information for the public
  - Epidemiological use

Basic Elements/Foundation Issues

- Definition of exposure scenarios/exposed groups
- Identification of exposure pathways
- Development and implementation of dose reconstruction methods
- Evaluation of uncertainties
- Presentation/interpretation of results
- * Data and information
- * QA/QC

Dose Reconstruction Techniques

- Direct radiation measurements
  - Monitoring stations, Film badges, TLD
- Indirect radiation measurements or estimates
  - Environmental concentrations
  - Biodosimetry
    - Cytogenetic analyses (chromosome aberrations)
    - Genetic/molecular markers (Somatic mutations)
    - Electron Paramagnetic Resonance
  - Opportunistic dosimeters
    - Luminescence – natural TLD, OSL
    - Track Etch
    - Neutron activation

Basic Elements – Estimation of Uncertainty

- ALL dose estimates are uncertain
  - Lack of complete knowledge of exposure scenario
  - Variability in relevant measurements
  - Lack of knowledge of relevant processes
- Uncertainty can be *random* or *systematic*
  - Statistical fluctuations
  - Bias (e.g., calibration, desire for “conservatism”)
- Essential purpose is to provide a credible range within which there is a high degree of confidence the “true” dose lies

Basic Elements - Data

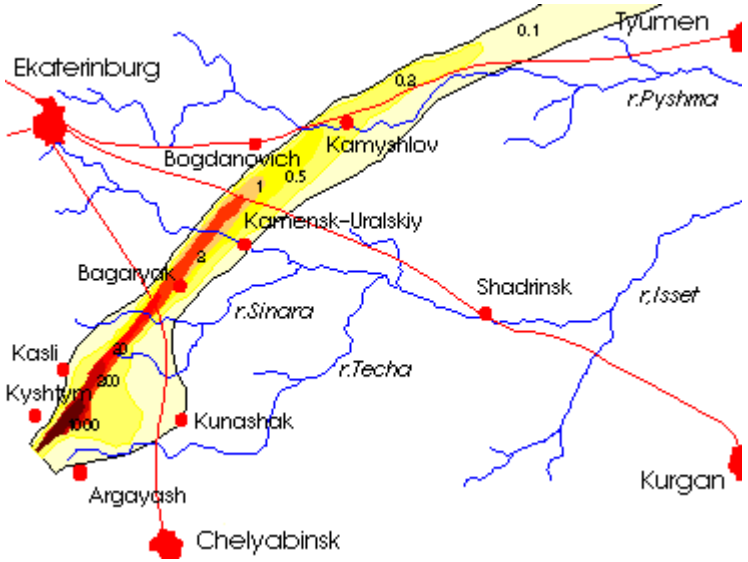
- Describe characteristics, locations, activities of people; Describe sources of radiation; Identify pathways of exposure
- *Can be a major challenge if dealing with tens of thousands of people*
- *Human subjects – privacy is important*

Residual Contamination

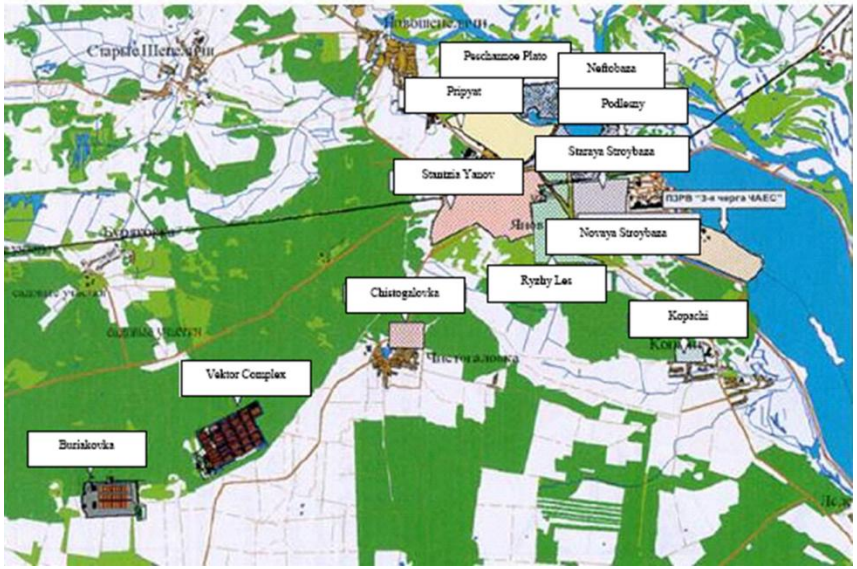
- Emergency remediation of the reactor site may result in large amounts of radioactive waste
  - In the reactor buildings
  - In the immediate vicinity
  - Throughout the evacuated zone
- More waste will be generated by future decommissioning activities
- Should we be concerned about exposures to these wastes?

Exposures like this have happened before – with long-term consequences

Mayak (Russia)



Chernobyl (Ukraine)



Environmental Remediation Measures

Mayak – Techa River/EURT

Dealing with Soil Contamination

- Deep Plowing (cover/dilution)
- Soil amendation (lime)
- Restrictions on crop types (industrial use, not foods)
- Restrictions on activities; Conversion to ‘research area’
- Permanent Relocation – area can be reduced over time

A comprehensive strategy for waste-management is needed

- Some material from NPP dismantlement should probably be placed in a geologic repository.
- Should large areas be remediated? This would be costly in terms of money and exposure to workers. A great deal of very low-level waste would need to be disposed – somewhere.