Risk evaluation of long-term exposure after a nuclear or radiological accident

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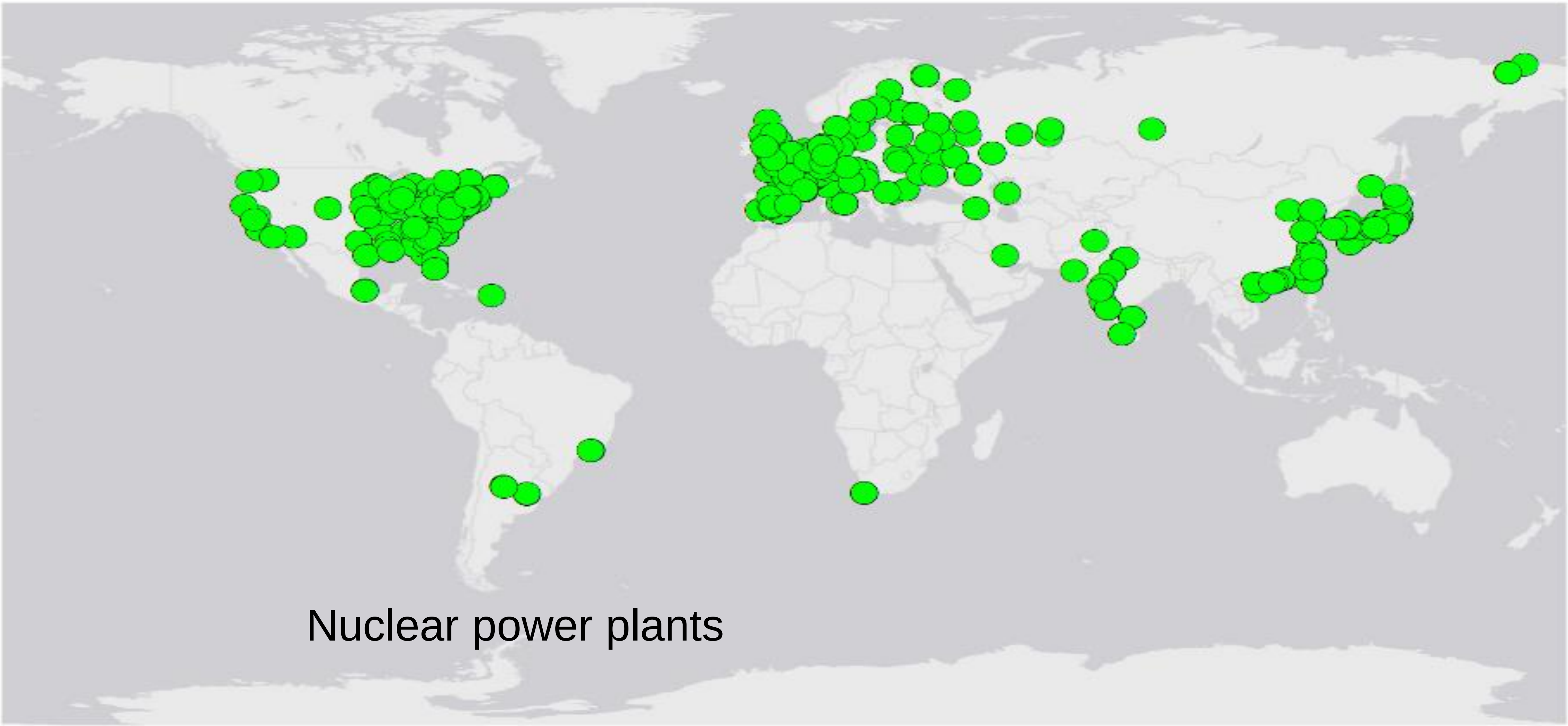
Presentation outline

- Long-term existing exposure situations
- Risk assessment and evaluation issues
- Regulatory decision making and risk assessments
- Case studies: Lessons learned from Chernobyl fallout management in Norway and cooperation project with Russian Federation on Mayak PA nuclear facility case
- Conclusion remarks, challenges

Long-term exposure situations

Legacies are a global issue, yet, there is no current international definition



What is a Legacy?

- Each legacy is different
- Present a complex variety of relevant prevailing circumstances:
  - *Sites and facilities affected by major accidents and incidents*
  - *Storage and disposal sites and facilities for radioactive waste*
  - *Nuclear technology and development centres and laboratories*
  - *Former uranium mining and milling facilities, and NORM*
  - *Former peaceful nuclear explosion and weapons testing sites*
- Standards for protection evolve as well as regulation requirements

Risk evaluation

ERICA ASSESSMENT TOOL

- Environmental risk assessment typically covers
  - human health assessment
  - ecological assessment
- Focus of short and long term risk assessment commonly differs
  - What should be expected after the accident?
  - What were the actual consequences of the accident?

Regulatory decision making and role of risk assessment

Planning, hazard recognition and problem formulation → **Technical steps Analyses** → **Risk evaluation Decision and/or Resolution**

Planning, hazard recognition and problem formulation

- Legislation: regulations, recommendations, guidelines etc.
- Regulatory framework, relevant and competent authorities
- Assignment of responsibility
- Definition of roles and timeframes

Technical steps Analyses

- Source term characterization
- Exposure pathways
- Mobility analyses and transport parametrization
- Effects analyses on the exposed populations
- Environmental impact and risk assessments

Risk evaluation Decision and/or Resolution

- Risk estimation
- Risk description
- Decide on intervention needs, establishment of reference levels if needed

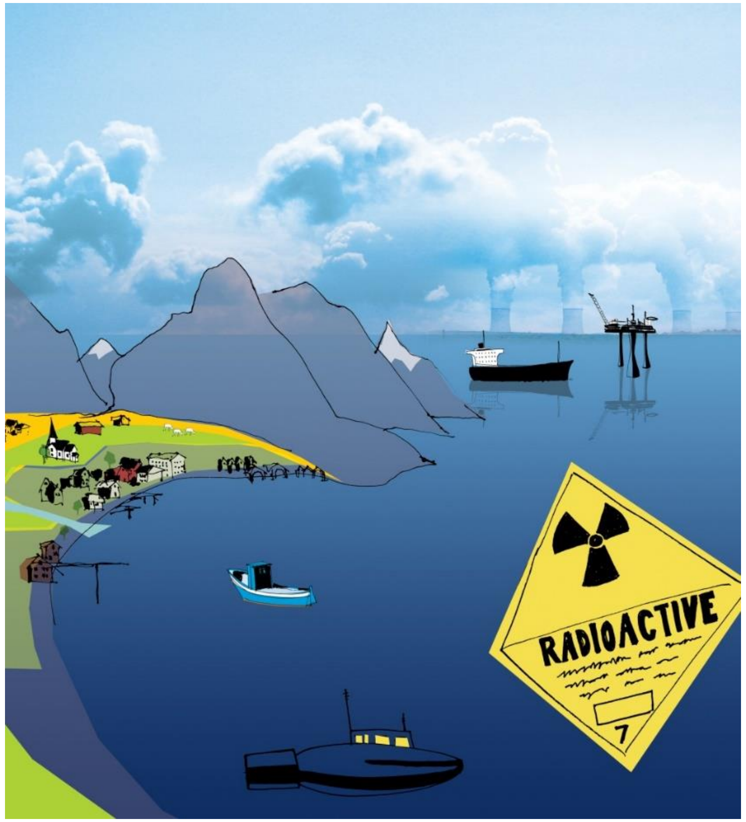
- Financial decisions within this horizontal process
- Social aspects and decisions: risk perception and communication
  stakeholders involvement

Environmental risk assessment

- Current state characterization of source term and site of interest
- Collection of information on the spatial and temporal patterns and variations, pathways analyses
- Identification of the target population – humans and biota
- Collection of as many individual-based radiation measurements as possible
- Collection of individual personal and lifestyle information that can be used for the estimation of individual dose
- Calculation of realistic radiation doses with efforts to minimize sources of bias
- Validation of the dose estimates by independent measurements or strategies
- Qualitative and quantitative evaluation of the uncertainties associated with dose estimates (model, parameter and scenarios uncertainties evaluation)

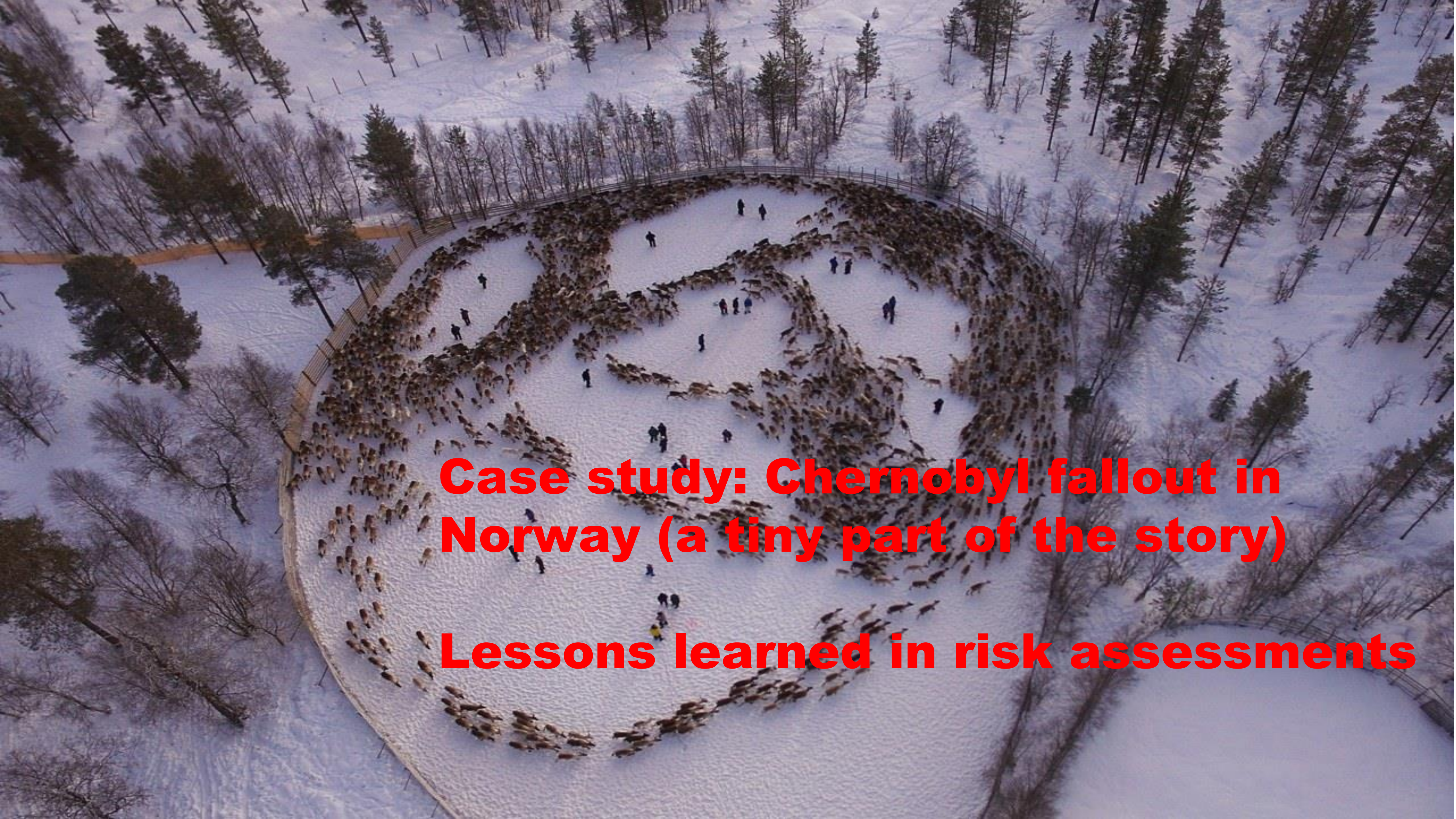
Demands of nuclear and radiological accidents after long period of time

- Re-estimation of consequences and risks within (large) endangered geographic areas
- Evaluation of applied countermeasures
- Evaluation of effects in many aspects of society
- Good coordination of information and continuous engagement of stakeholders
- Good international coordination and exchange of information



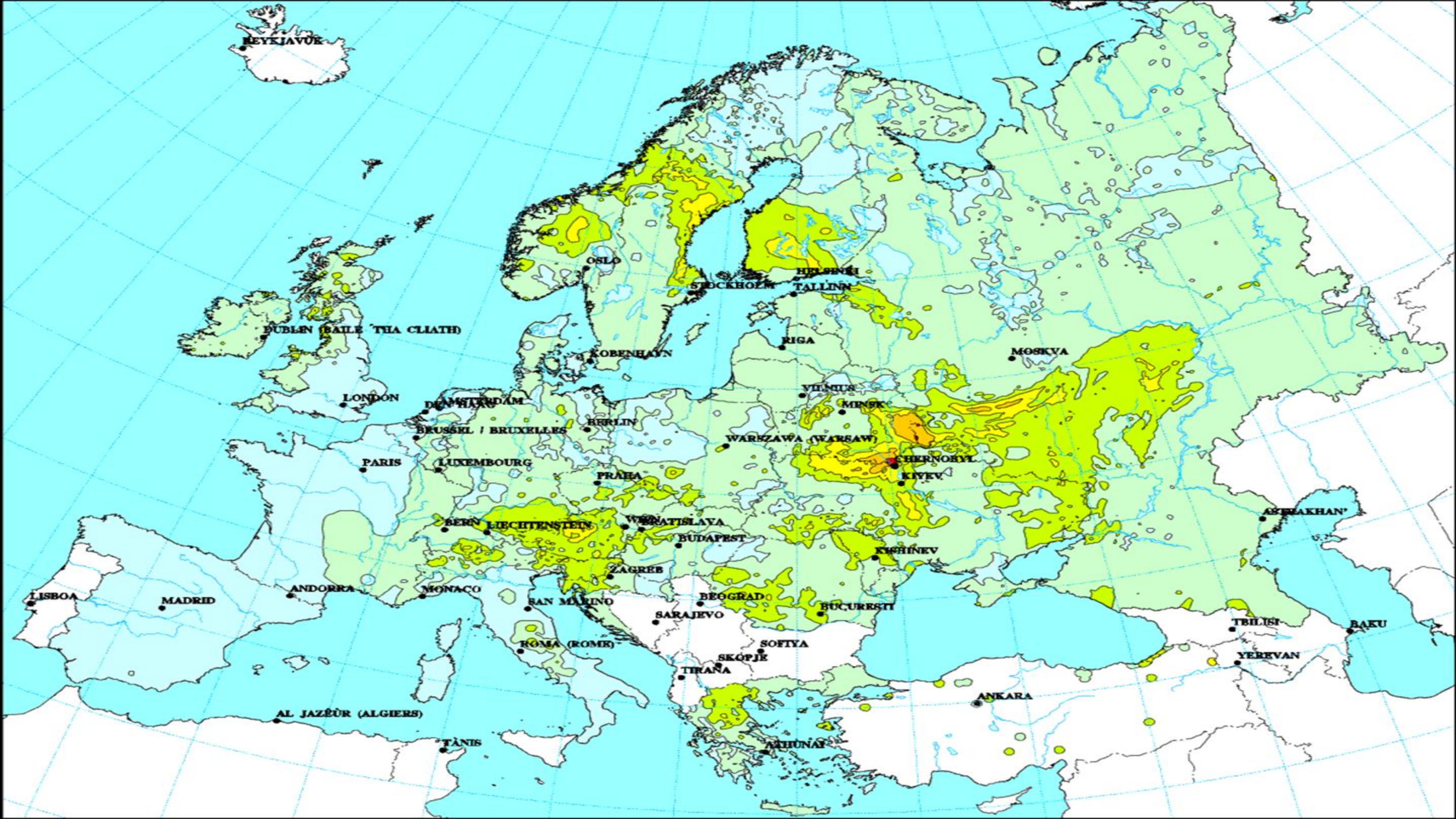
How to assess and manage radiation risks?

- No 'one' universal answer…**case specific approach according to prevailing conditions**
  - Radioactive source, variation in pollution degree, volume and activity of wastes present
  - Mixtures of radionuclides, chemical and physical hazards
- Need proportionate management of different risks, taking account of:
  - What, who, how and for how long?
  - Current and intended End State/End Use
- Guides appropriate allocation of resources for regulatory control measures



Case study: Chernobyl fallout in Norway (a tiny part of the story)

Lessons learned in risk assessments



OSLO
HELSINKI
TALLINN
DUBLIN (BAILE THA CLIATH)
RIGA
KOBENHAVN
MOSKVA
LONDON
AMSTERDAM
VILNIUS
MINSK
BERLIN
BRUSSEL / BRUXELLES
WARSZAWA (WARSAW)
PARIS
LUXEMBOURG
CHERNOBYL
KIYEV
PRAHA
BERN
LIECHTENSTEIN
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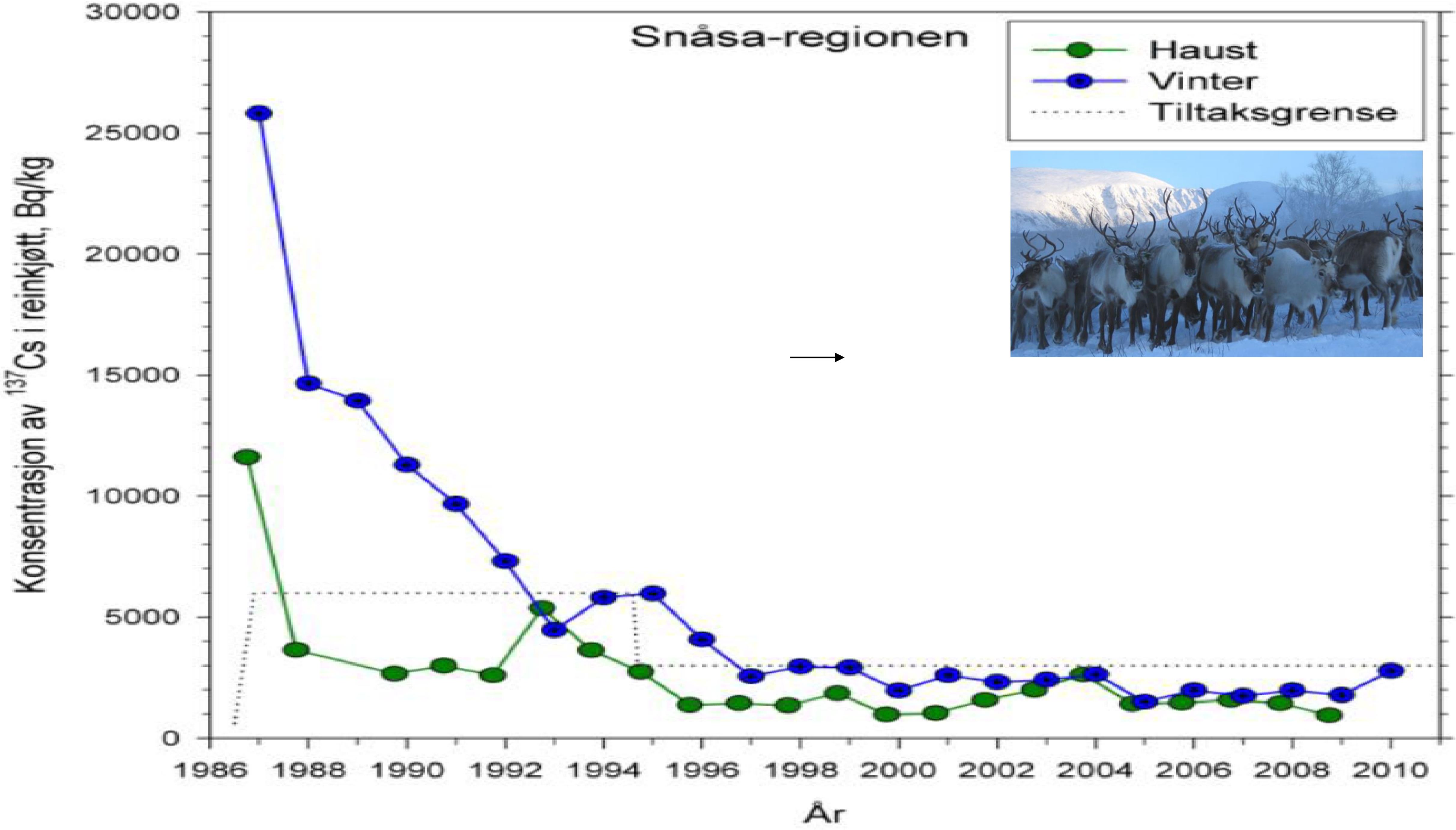
BAKU
ROMA (ROME)
SOFIYA
SKOPJE
YEREVAN
TIRANA
ANKARA
AL JAZEÜR (ALGIERS)
TÚNIS

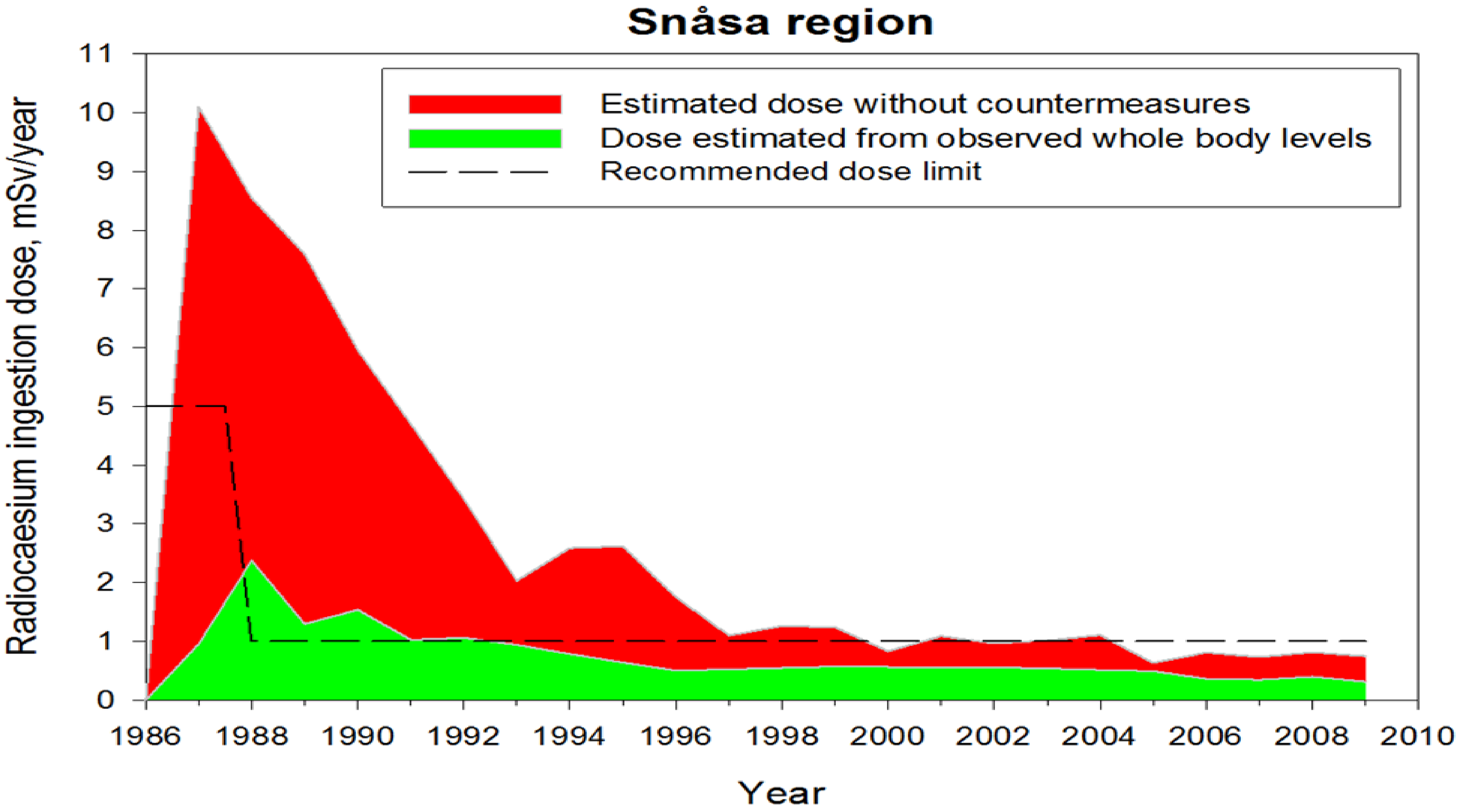
Lesson learned:Immediate transparency and effective communication *that does not cause panic*

- **Early May 1986:** Little information, but soon contaminated areas in other parts of Norway were discovered
- **May/June**
  - Measurements for overview and for food safety purposes
  - Regulation values for food contamination set for total cesium
  - Tonnes of food discarded: 100.000 sheep was discarded + reindeer!
- **July/August**
  - State financial coverage of countermeasures
  - Management system developed
  - Local monitoring stations established
- **Winter 86/87**
  - Method for live monitoring of animals developed
- **1988:** The use of Prussian blue tested

1988 → Continuation of countermeasures to 2018 and beyond


Snåsa-regionen
Haust
Vinter
Tiltaksgrense
Konsentrasjon av ^{137}Cs i reinkjøtt, Bq/kg
0
5000
10000
15000
20000
25000
30000
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
År

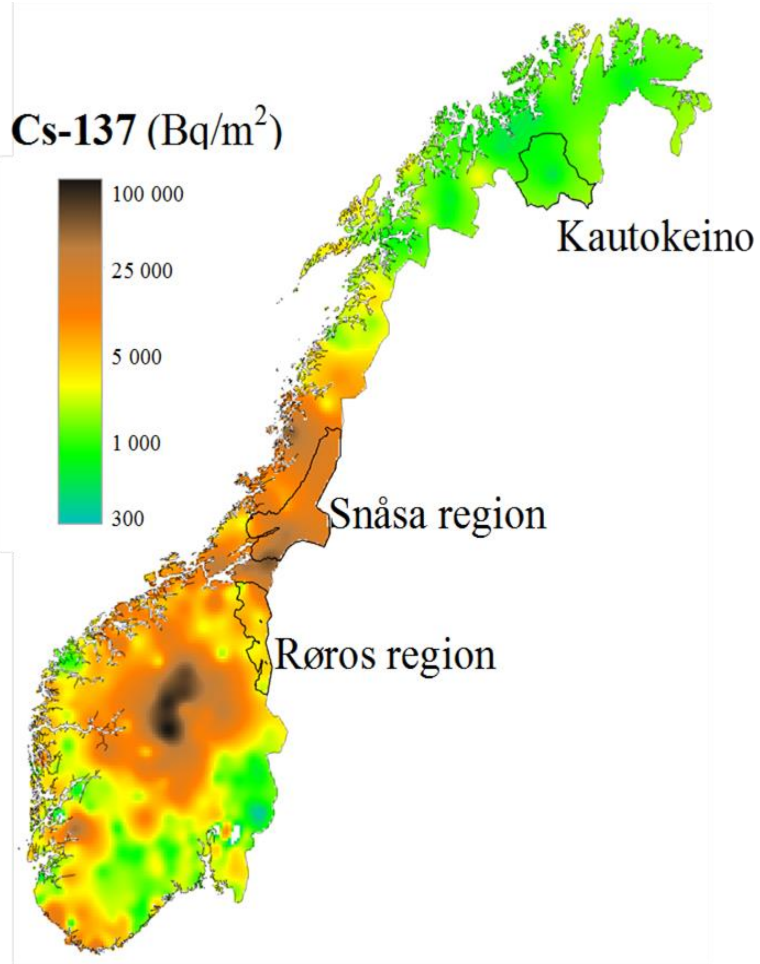
Long term monitoring and risk communication



Risk assessments during the years of mitigation

Focus on human health and food strategy

- Monitoring of the activity levels in environmental media of concern
- Radionuclides behaviour and transport pathways
- Follow the species that still are under the risk: mushrooms, reindeer, game, wild freshwater fish – biological half-lives of Cs-137 longer that predicted
- Monitoring exposure doses to Sami population
- Changing the reference levels in foodstuff over the time



Norwegian Scientific Committee for Food and Environment – long term risk evaluation

VKM report 2017:25: Risk assessment of radioactivity in food

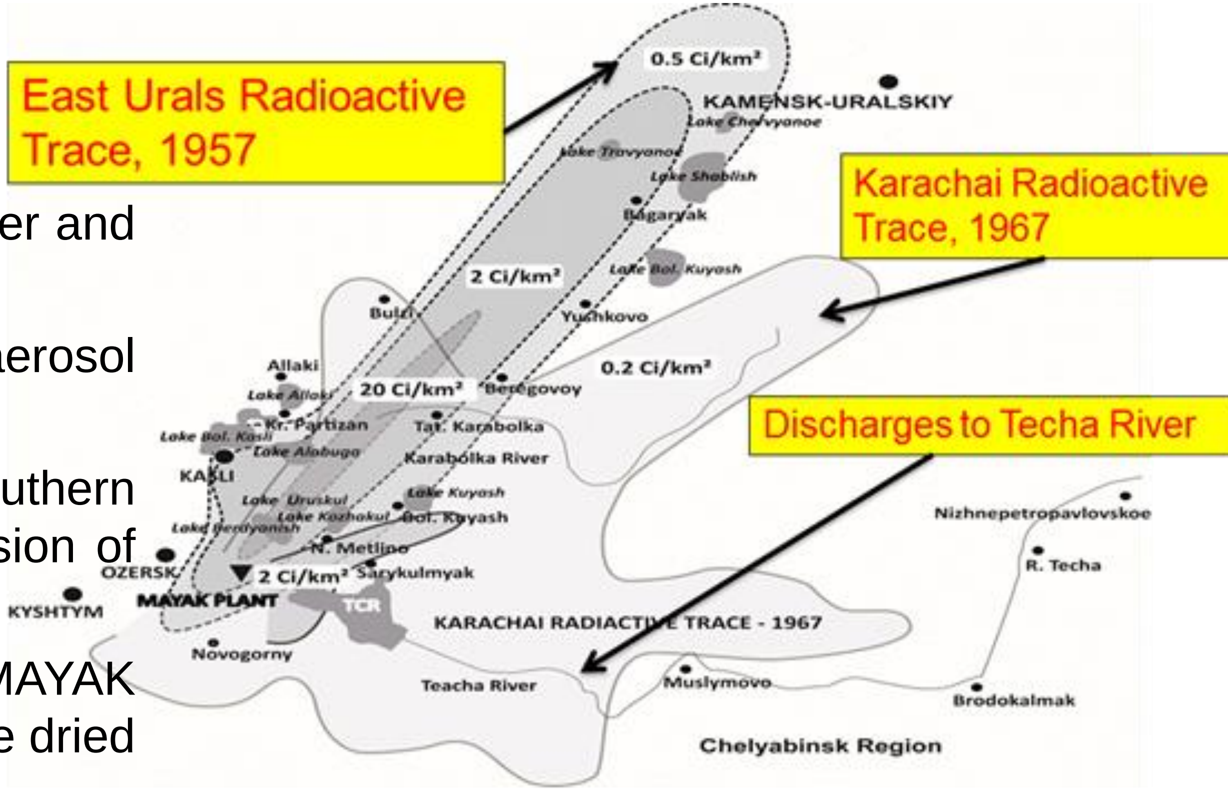
- ToR1: What is the current health risk from radioactivity in food – food gathering and hunting included – to the whole population and specific groups in Norway?
- ToR2: What health risk would the current levels of caesium-137 measured in live reindeer and sheep pose to the whole population and specific groups, if no efforts were made to reduce them?
- ToR3: What would be the implication to the health risk if the ML for reindeer meat was reduced from 3000 to 1500 or 600 Bq/kg, respectively – for the whole population and for specific groups?
- ToR4: Would the procedure and the maximum levels laid down in the Euratom Treaty regulation on radioactive contamination of foodstuffs and feedstuffs following a nuclear accident be appropriate for managing similar scenarios in Norway?

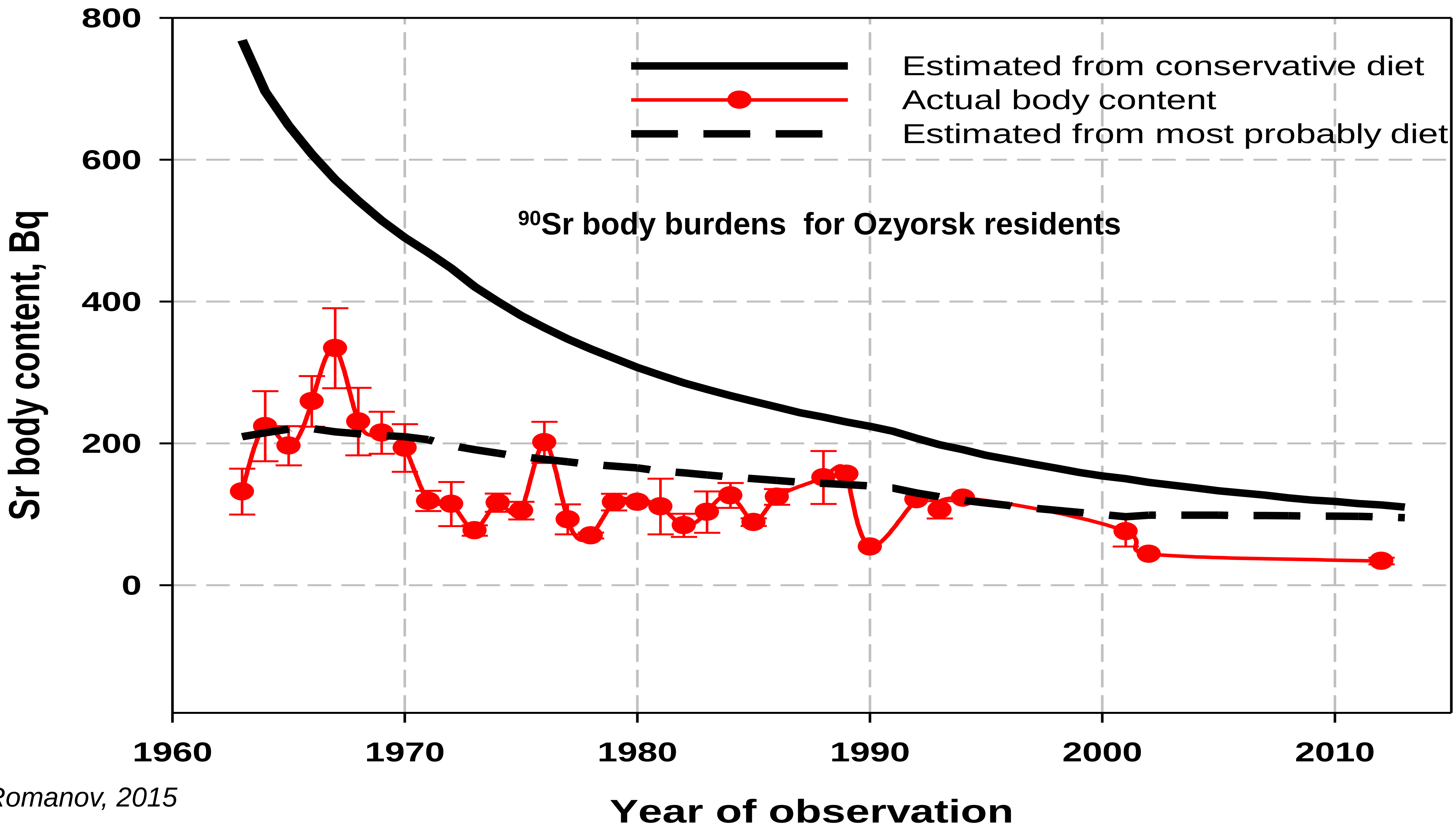
Case study: the area affected by historic releases from Mayak PA nuclear facility

Main consequences of the Mayak PA nuclear facility operations during the years

Main consequences of Mayak operations

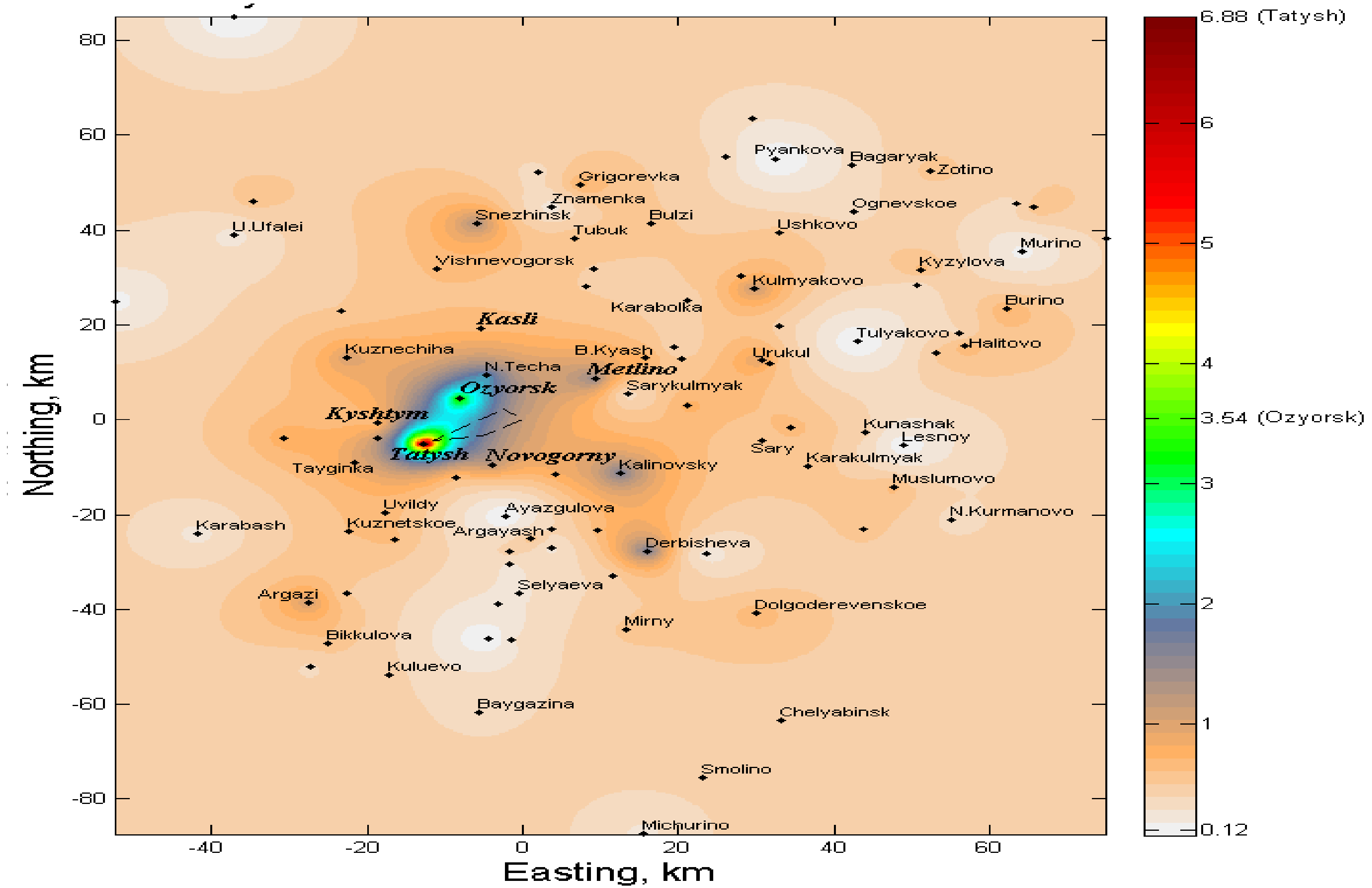
- Over-exposure of workers at the main Mayak facilities primarily in 1949-1958
- Discharge of radioactive liquid waste into the Techa river and open hydrographic net
- Exposure of population as result of Mayak's gas-aerosol emissions in 1949-1962
- Exposure of Mayak workers and population of the Southern Urals as a result of accident in 1957 (chemical explosion of radioactive waste tank)
- Exposure of the population residing in the vicinity of MAYAK from transfer by wind of radioactive substances from the dried up shallow banks of Karachay Lake in 1967

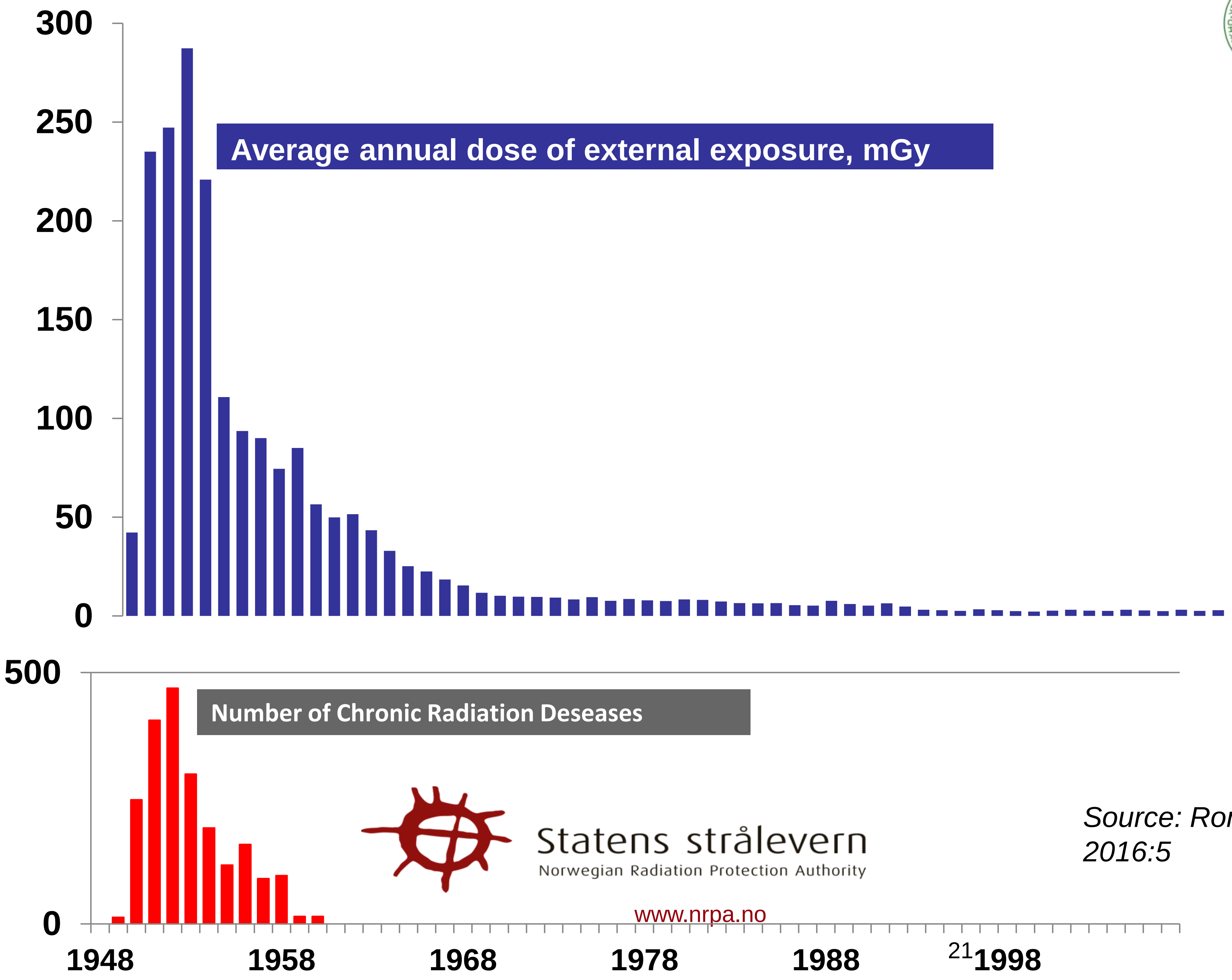




S. Romanov, 2015

The map of the ^{90}Sr and ^{239}Pu body burden (Bq) in the Chelyabinsk region population as of 2013





Statens strålevern
Norwegian Radiation Protection Authority
www.nrpa.no

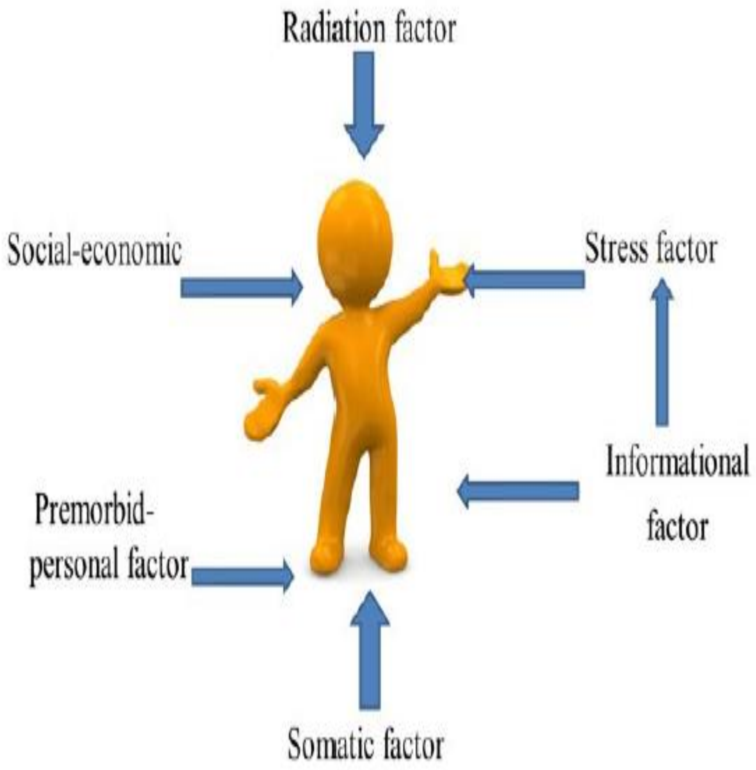
Source: Romanov S, 2015. NRPA 2016:5

Project conclusions on human health risks

- Significant improvement of radiation situation in the vicinity of the Mayak PA area in the last decade. The levels of ^{90}Sr and ^{239}Pu accumulation in population residing in the observation area in 2011-2013 decreased by 3-4 times as compared to the period of the 1980s
- Situation in XXI century: Annual effective dose for adult Ozersk population below 0.1 mSv. Is it real "contaminated area"?
- Obligatory of standard medical care. Epi. studies for small group of people and for population with low doses of exposure are uncertain and useless;
  - What criteria for additional medical care?

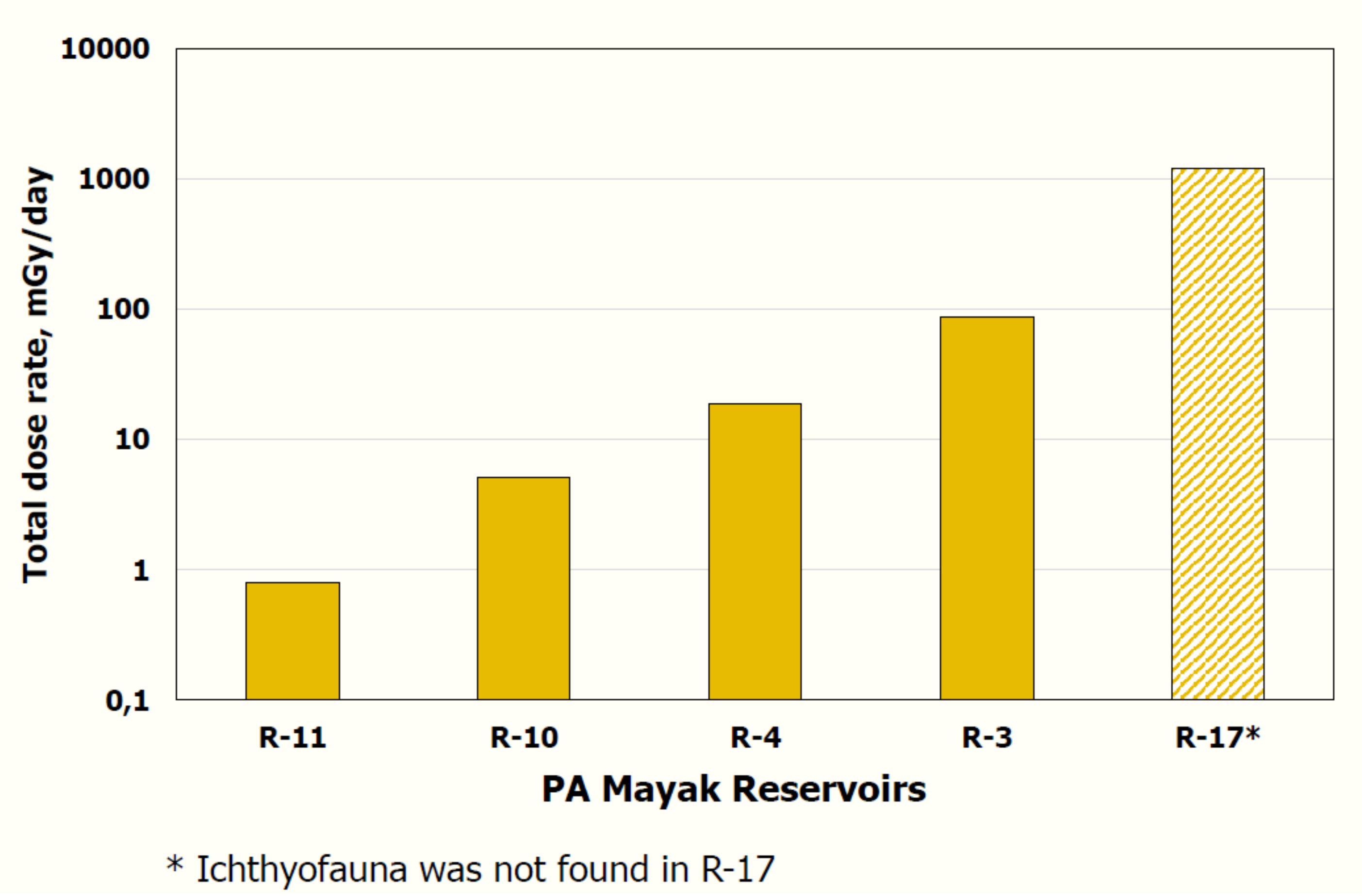
Social-physiological aspects of the usage of radioactively contaminated territories of Urals

- 1957 Mayak PA accident and East Urals Radioactive Trace (EURT) formation
- Emergency countermeasures, relocation started in time, food and fodder monitoring, countermeasures, affected zone
- Recently – question of return of the territory to normal use
- Number of factors determining the social-physiological status of populations living on long term exposure territories



E. Burtovaia, 2017

Exposure doses to ichthyofauna of contaminated reservoirs of the Techa river



- ERICA dose assessment for fish (perch, pike, roach) in MAYAK PA reservoirs
- Modelled dose rates were in range 3 – 150 µGy/day with dose rate decreasing down the river and with distance to Mayak PA
- Fish consumption could give rise to an effective dose up to 0.5 mSv
- Genotoxic effects, physiological and pathophysiological reactions and adaptive responses were investigated

E. Pryakhin, 2017

Concluding remarks

- Nuclear or radiological accident is not a linear process, rather a long, messy process of uncertainty which uncovers further problems with its progress - be patient, think rationally about all potential risks
- Assess the current state – prevailing circumstances and make a plan for risk estimation and evaluation – try to see the whole picture (all the current risks, all the affected domains of daily life)

  - Residual risks and related radiation exposures are site-dependent considerations; what may be acceptable for one site may not be in another
- Risk assessment – scientific help highlighted as support for risk calculations for both humans and biota

  - Knowledge gaps and need on new data bases improvement,
  - Modelling – need on further development of 'fit-for-purpose' models
  - Work on reducing the uncertainties and proper acknowledgment of these

Concluding remarks

- Transition of permissible levels in food and release of materials from emergency to existing exposure is recommended
- Development of generic international criteria?
  - Range of reference levels for existing exposures 1-20 mSv, variably used
  - Consumption habits and food types varying between populations
  - When an emergency ends and an existing situation begins?
- Rationalization of the different values applied would be beneficial, providing background on their derivation and the context in which they are meant to be applied; Justification and Optimization of protection strategies, Reference levels (ICRP)!
- Risk communication: public perceptions and the level of anxiety over long-term radiation exposure and possible health risks must be considered
- Stakeholder engagement, particularly local population at all levels in legacy management

Regulatory supervision of Legacy sites: from recognition to resolution

- Workshops organized by NRPA in collaboration with international organizations IAEA, ICRP, OECD NEA, IUR
  - Oslo, 2015; NRPA report 2016:5
  - Lillehammer, 2017, NRPA report 2018:4

https://www.nrpa.no/en/publications

Challenges:
Gap between Theory and Practice

- Decisions should be supported by science and address all environmental and human health issues, irrespective of the hazard
  - How to address short and long term risks to different populations, proportionately?
  - How to address all the environmental and human health issues, not just radiation in practice?
  - How to reduce uncertainties in prognostic assessment of future conditions and impacts?
  - How to make appropriate decisions in transition from emergency to existing exposure situation and later stages?

Principle of optimisation requires a common framework of protection objectives across different hazards, for people and the environment

Need for holistic ('multi-dimensional') approaches to human health and environmental protection from multiple hazards

Challenges: Effective Risk Communication

- Effective risk communication is a very important part of the engagement process, but communicating risks associated with different threats can be problematic
- Not only actual but public perception of risk should be carefully assessed and further addressed in remediation processes
- Successful resolution requires a wide range of stakeholders to be engaged (local, regional, national, international)
  - *Seek to obtain stakeholder support in a transparent and traceable decision-making process*
  - *Identify important social, cultural, environmental and economic factors to take into account*
  - *Helps people affected have a feeling of owning the solution*

Need to consider how confidence and trust can be improved among all stakeholders

Thank you for your attention

- **Acknowledgements**

Sergey Romanov, Southern Urals Biophysics Institute (SUBI)
Elena Burtovaia, Urals Research Center for Radiation Medicine (URCRM)
Evgeny Pryakhin, Urals Research Center for Radiation Medicine (URCRM)
Lavrans Skutterud, Norwegian Radiation Protection Authority (NRPA)