Radionuclides in Marine Environments: Results & Conclusions from the MODARIA I & II Marine Modelling Working Groups

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MODARIA I & II Marine Modelling: Participating Institutes

- Instituto de Engenharia Nuclear (IEN/CNEN, Brazil)
- Institut de Radioprotection et de Sûreté Nucléaire (IRSN, France)
- National Technical University of Athens (NTUA, Greece)
- Japan Atomic Energy Agency (JAEA, Japan)
- Korea Atomic Energy Research Institute (KAERI, Republic of Korea)
- Korean Institute of Ocean Science and Technology (KIOST, Republic of Korea)
- Norwegian Radiation Protection Authority/ Norwegian Radiation and Nuclear Safety Authority (NRPA/ DSA, Norway)
- ABmerit company (Slovakia)
- University of Seville (USEV, Spain)
- Institute of Mathematical Machines and System Problems (IMMSP, Ukraine)
- Defence Academy of the United Kingdom (AoD)
MODARIA I WG 10: Activities

Modelling of marine dispersion and transfer of radionuclides accidentally released from land-based facilities

• Dispersion of Chernobyl fallout on the Baltic Sea. Model results compared with measurement data from IAEA MARIS¹

• Dispersion of releases from the Fukushima Daichi NPS (atmospheric deposition and direct releases) in the North Pacific Ocean (NPO)

¹ IAEA Marine Radioactivity Information System
MODARIA I WG 10: Results

• Relatively good agreement in model-model and model-measurement comparisons obtained for the Baltic Sea scenario

• Model-model intercomparisons for the Fukushima scenario resulted in significant differences, mainly due to extreme sensitivity to the water circulation (hydrodynamics) in a region characterized by rapidly changing currents
Modelling of Marine Dispersion and Transfer of Radionuclides Accidentally Released from Land Based Facilities

Report of Working Group 10 Modelling of Marine Dispersion and Transfer of Radionuclides Accidentally Released from Land Based Facilities of MODARIA Topical Heading Marine Modelling

Modelling and Data for Radiological Impact Assessments (MODARIA) Programme

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Assessment of the Fate and Transport of Radionuclides Released in the Marine Environment

1. Further simulation of Fukushima releases:
   - spatiotemporal scale of simulations extended
   - biological uptake model included for predicting Cs-137 concentrations in biota

Results
   - Biological uptake model was successfully interfaced with marine transport models for this complex area
   - OK results for model-measurement\(^1\) comparisons for water, sediment and biota

2. Similar exercise carried out for the European Shelf Seas (releases from Sellafield and La Hague)

Result
   - Modelling coastal areas; small, enclosed seas; and narrow straights with coarse resolution global circulation models is not feasible

\(^1\) Data from Japan’s Sea Area Monitoring Plan sourced from IAEA MARIS
MODARIA II WG 7: More Activities

Assessment of the Fate and Transport of Radionuclides Released in the Marine Environment

3. Analysis of numerical implementation of Lagrangian models (spatial-temporal resolution; interpolation schemes)

4. Recommendations for the determination of *in-situ* sediment distribution coefficients ($K_d$s) and their use in marine transport models (*with WG4 Transfer Processes and Data for Radiological Impact Assessment*)

5. Recommendations for others considering development/ adoption of marine dispersion models (box, Eulerian, Lagrangian) for EPR considering endpoints and objectives

6. Simulation of hypothetical routine releases from a NPP located on the US Atlantic Coast (*with WG3 Assessments and Control of Exposures to the Public and Biota for Planned Releases to the Environment*)
• MODARIA made progress in validating marine transport models for different scenarios
• Led to a better understanding of physical oceanography (circulation, dilution, mixing, dispersion) & transfer pathways, particularly in the NPO
• MODARIA showed that for some scenarios (e.g. Baltic Sea) quite simple modelling is sufficient, whereas for others (e.g. Fukushima/ NPO) much more complexity is required
• The general principle that a simpler model is always better than a complex one, if they provide similar results for a given application, should be avoided
• Water circulation (hydrodynamics) seems to be the main uncertainty source in marine models
• Models to be used for EPR in dynamic marine environments should be carefully tuned for each individual location
• No single model exists which can be applied to all situations (e.g. all spatiotemporal scales) because of computational limitations
• Recommendations on the use and determinations of $K_d$s
• Recommendations on the selection of water/sediment interaction models (equilibrium, 1-step, 2-step, single sediment layer, multilayer). Site-specific kinetic rates are also recommended for use in emergency models
• Recommendations on the use of interpolation schemes in Lagrangian models. Sensitivity analysis to model resolution is encouraged
Thank you!