

Editorial: the main results of the European CONFIDENCE project

1 Introduction

In nuclear emergency management and long-term rehabilitation, dealing with uncertain information on the current situation, or predicted evolution of the situation, is an intrinsic problem for decision making. Uncertain information related to, for instance, incomplete information on the source term and the prevailing weather can result in dose assessments that differ dramatically from reality. Uncertainty is also an intrinsic part of model parameters. In the presence of uncertainty, ineffective decisions are often taken (*e.g.* too conservative or optimistic predictions, inadequately accounting of non-radiological risks), which may result in more overall harm than good due to secondary causalities as observed following the Chernobyl and Fukushima accidents. Therefore, the reduction of uncertainty, and how to deal with uncertain information, is essential to improve decision making for the protection of the affected population and to minimise disruption of normal living conditions.

Decisions on early countermeasures (*e.g.* evacuation, sheltering, and provision of iodine tablets) are often taken based on deterministic calculations considering the best available source term information and the state of the art numerical weather prediction data as inputs. The source term uncertainty is large and quantification difficult. Uncertainty in meteorological forecasts is routinely quantified by “ensemble predictions”. However, these predictions are not used in emergency management. One reason for this is the effort and time required to process 30 to 100 different weather sequences within atmospheric dispersion models.

At present, decision making in the early phase is mainly based on modelling followed by a period where monitoring has made enough progress to provide a robust contamination and dose map. However, in between some monitoring data will be available; however, no operational tool exists to combine simulated dose estimations with monitoring data to obtain a more consolidated picture of the radiological situation.

The key endpoint for all decision making is the dose and associated risk to affected population groups. However, in the case of the Fukushima accident, only order-of-magnitude dose bands were estimated from (local) contamination and model predictions, with no accounting for individual human behaviour patterns or location. Individual dose measurements could greatly reduce this uncertainty but are limited by capacity.

Completely missing from emergency management is the assessments of risk in the early and the transition phases. However, this is important for decision making on the need for medical surveys and long-term support of the affected population.

Operational decisions concerning land and food chain management rely on radioecological models that are mostly based on simple, but highly uncertain, transfer ratios to predict contamination in foodstuffs (though such data are few for some climatic areas, *e.g.* Mediterranean) and foodstuff-radionuclide combinations). Process-based models might provide an approach to reducing uncertainties associated with empirical ratio based models. However, the performance of such models has not been compared to empirical based approaches (*i.e.* how much added value do they give?).

To prepare the transition from emergency to existing exposure situations, proper planning is essential. For this purpose, plans need to be developed through a process of national dialogue with stakeholder involvement, taking into account the inherent uncertainties on the knowledge of the real consequences of an accident, the strategies to be implemented and the potential socioeconomic impact on the affected population. The current feedback from the Fukushima accident clearly emphasizes that there is a need for recommendations at international level as problems were identified that might also be relevant for Europe.

Experience from the Chernobyl and Fukushima accidents showed that dealing with uncertainties in radiological risk assessment and management has to take into account stakeholders’ values and needs, ethical aspects and public communication. However, behavioural, social, ethical and communicational aspects of uncertainty management have not been addressed in a structured and multi-disciplinary way. Furthermore, there is a need to investigate how citizens, decision makers and other stakeholders make sense of and respond to uncertainties, and to develop effective tools in order to communicate decisions with their uncertainties to all relevant stakeholders (public, media, industry, decision-makers).

To conclude, uncertainty handling in simulation models, and in particular in decision support systems, is far from being solved. Predictions are typically deterministic value, these are appreciated by decision makers as they facilitate easier decision making but they do not reflect the potential variability of the radiological situation. This approach leads to errors in decision making (as seen following the Chernobyl and Fukushima accidents).

2 Realisation

By mid of 2016, the CONCERT¹ project issued the first open call for proposals. The general ideas on the call were derived by consultation with relevant stakeholders, beneficiaries of CONCERT and the Radiation Protection Platforms. Two topics were identified for which proposals could be submitted:

- 1 Improvement of health risk assessment associated with low dose/dose rate radiation;
- 2 Reducing uncertainties in human and ecosystem radiological risk assessment and management in nuclear emergencies and existing exposure situations, including NORM.

The CONFIDENCE consortium applied for the second topic and was awarded by end of 2016.

CONFIDENCE addressed the key uncertainties relevant for decision making, aiming to reduce them if possible and communicate them such that decisions can be made in a more robust manner, reflecting the complexity of the real situation. The work could only be done by a multi-disciplinary approach and as a collaboration of all radiation protection platforms. CONFIDENCE collected expertise from five Radiation Protection Platforms being able to address the scientific challenges associated with model uncertainties and improving radioecological predictions and emergency management (NERIS and ALLIANCE), situation awareness and monitoring strategies (EURADOS), risk estimation in the early phase (MELODI), decision making and strategy development at local and national levels (NERIS) including social and ethical aspects (SHARE).

Thirty-one partners from 18 countries assured on the one hand side large scientific competences and on the other hand exploitation to many organisations in Europe. The work was organised in 6 scientific work packages, one work package for education and training and one administrative work package for the management of the project. Work included investigations on the uncertainty of meteorological and radiological data and their further propagation in decision support systems including atmospheric dispersion, dose estimation, foodchain modelling and countermeasure simulations. Enhancements in modelling and combining simulation with monitoring to obtain a comprehensive picture of the radiological situation are important to improve decision making under uncertainties. Consideration of social, ethical and communication aspects were also a key part of the activities. Finally, decision-making principles and methods were investigated, ranging from formal decision aiding techniques to simulation based approaches.

The CONFIDENCE Dissemination workshop “Coping with uncertainties for improved modelling and decision making in nuclear emergencies”, organized by VUJE, was held at Lindner Hotel, Bratislava, Slovak Republic in December, 02–05, 2019. About 90 scientists and decision makers attended the workshop including the CONCERT coordinator, Radiation Protection platforms such as ALLIANCE, EURADOS, NERIS and SHARE as well as international organisations such as IRPA and IAEA. The dissemination workshop allowed to present the results of the CONFIDENCE project, demonstrated the applicability of the developed methods and tools in interactive discussion sessions and to collect feedback from the participants and end users on the work performed.

3 Structure of the special issue

The objective of this special issue is to present the main achievements of the CONFIDENCE project. Accordingly, the structure follows the main structure of work packages of the project. General sections start with this editorial, contain a description of the CONFIDENCE project and main achievements, summarises the final dissemination workshop with two papers and describes the education and training activities within one paper. The six technical work packages are structured as follows:

- WP1 with 4 papers;
- WP2 with 3 papers;
- WP3 with 2 papers;
- WP4 with 3 papers;
- WP5 with 5 papers;
- WP6 with 6 papers.

The main findings and the way forward are part of the general papers on the dissemination workshop.

Last but not least, the editors would like to thank all the authors for their contributions to this special issue.

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¹ <https://www.concert-h2020.eu/en>.

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Partner	Abbreviation	Country
Karlsruhe Institute of Technology	KIT	Germany
Bundesamt für Strahlenschutz	BfS	Germany
UK Centre for Ecology & Hydrology	CEH	United Kingdom
Centre d'étude sur l'Évaluation de la Protection dans le domaine Nucléaire	CEPN	France
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas	CIEMAT	Spain
Environmental Protection Agency	EPA	Ireland
Greek Atomic Energy Commission	EEAE	Greece
Helmholtz Zentrum München – German Research Center for Environmental Health	HMGU	Germany
Institut de Radioprotection et de Sûreté Nucléaire	IRSN	France
MUTADIS	MUTADIS	France
Norwegian University of Life Sciences	NMBU	Norway
Norwegian Radiation and Nuclear Safety Authority	DSA	Norway
University of Zurich	University of Zurich	Switzerland
UK Department of Health (Public Health England)	DH PHE	United Kingdom
Technical University of Denmark	DTU	Denmark
National Institute for Public Health and the Environment	RIVM	Netherlands
Belgian Nuclear Research Centre	SCK•CEN	Belgium
Radiation and Nuclear Safety Authority	STUK	Finland
University of Milan	UMIL	Italy
VUJE, a.s.	VUJE	Slovak Republic
Royal Netherlands Meteorological Institute	KNMI	Netherlands
Agência Portuguesa do Ambiente, IP (Portuguese Environment Agency)	APA	Portugal
Dialogik non profite institute for communication and cooperation research	DIALOGIK	Germany
University of Warwick	WARWICK	United Kingdom
Instituto Superior Técnico	IST	Portugal
JSI Center, County Office Ljubljana	JSI	Slovenia
Wageningen Food Safety Research	WFSR	Netherlands
University of Extremadura	EXTREMADURA	Spain
UK Met Office	UK Met. Office	United Kingdom
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Further reading

- Bai S, Raskob W, Müller T. 2020. Agent based model. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020031>.
- Bedwell P, Korsakissok I, Leadbetter S, Périllat R, Rudas C, Tomas J, Wellings J, Geertsema G, de Vries H. 2020. Operationalising an ensemble approach in the description of uncertainty in atmospheric dispersion modelling and an emergency response. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020015>.
- Beresford NA, Barnett CL, Chaplow J, Loftis S, Wells C, Brown JE, Hosseini A, Thørring H, Almahayni T, Sweeck L, Guillén J, Lind O-C, Oughton DH, Salbu B, Teien H-C, Perez- Sánchez D, Real A. 2020. CONFIDENCE overview of improvements in radioecological human food chain models and future needs. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020019>.
- Bleher M, Gering F, Stöhlker U, Karhunen T, Nalbandyan-Schwarz A, Woda C, Mafodda A. 2020. Reduction of uncertainties in exposure assessment based on environmental monitoring data. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020016>.
- Brown JE, Beresford NA, Hosseini A, Barnett CL. 2020. Applying process-based models to the Borssele scenario. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020020>.
- Charnock T, Andersson K, Trueba C, Montero M. 2020. Uncertainties confronting stakeholders and decision-makers in planning intervention in urban and agricultural scenarios in the transition phase of a radiological emergency. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020021>.
- Durand V, Maître M, Crouaïl P, Schneider T, Sala R, Marques-Nunes P, Paiva I, Monteiro Gil O, Reis M, Hilliard C, Tafili V, Twenhöfel C, Van Asselt E, Trueba C, Montero M, Duranova T. 2020. Towards an improved decision-making process to better cope with uncertainties following a nuclear accident. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020023>.
- Duranova T, Raskob W, Beresford NA, Korsakissok I, Montero M, Müller T, Turcanu C, Woda C. 2020a. CONFIDENCE dissemination meeting: Summary on the scenario based workshop. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020009>.
- Duranova T, Beresford NA, Perko T, Raskob W. 2020b. Education and training activities in the Euratom CONFIDENCE project. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020011>.
- Duranova T, van Asselt E, Müller T, Bohunova J, Twenhöfel CJW, Smetsers. 2020c. MCDA stakeholder workshops. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020032>.
- French S, Haywood S, Oughton DH, Turcanu C. 2020. Different types of uncertainty. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020029>.
- Hamburger T, Gering F, Ievdin I, Schantz S, Geertsema G, de Vries H. 2020. Uncertainty propagation from ensemble dispersion simulations through a terrestrial food chain and dose model. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020014>.
- Korsakissok I, Périllat R, Andronopoulos S, Bedwell P, Berge E, Charnock T, Geertsema G, Gering F, Hamburger T, Klein H, Leadbetter S, Lind OC, Pázmándi T, Rudas C, Salbu B, Sogachev A, Syed N, Tomas J, Ulmoen M, de Vries H, Wellings J. 2020. Uncertainty propagation in atmospheric dispersion models for radiological emergencies in the pre- and early release phase: summary of case studies. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020013>.
- Leadbetter SJ, Andronopoulos S, Bedwell P, Chevalier-Jabet K, Geertsema G, Gering F, Hamburger T, Jones AR, Klein H, Korsakissok I, Mathieu A, Pázmándi T, Périllat R, Rudas C, Sogachev A, Szanto P, Tomas J, Twenhöfel C, de Vries H, Wellings J. 2020. Ranking uncertainties in atmospheric dispersion modelling following the accidental release of radioactive material. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020012>.
- López MA, Berkovskyy V, Ratia G, Challeton-de-Vathaire C, Davesne E, Eakins J, Franck D, Giussani A, Gregoratto D, Hernandez C, Kulka U, Mafodda A, Marsh JW, Navarro JF, Oestreicher U, Pérez B, Sierra I, Woda C. 2020. Improvement in individual dose measurements techniques following nuclear emergencies. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020017>.
- Montero M, Sala R, Trueba C, García-Puerta B, Abelshausen B, Bohunova J, Crouaïl P, Durand V, Duranova T, Hilliard C, Maître M, Mitrakos M, Monteiro Gil O, Nunes P, Paiva I, Reis M, Schneider T, Skuterud L, Smith V, Tafili V, Thørring H, Turcanu C, Twenhöfel C, Van Asselt E. 2020. Stakeholder involvement through national panels and surveys to address the issues and uncertainties arising in the preparedness and management of the transition phase. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020022>.
- Müller T, Bai S, Raskob W. 2020. MCDA handling uncertainty. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020030>.
- Nagy A, Perko T, Müller T, Raskob W, Benighaus L. 2020. Uncertainty visualization using maps for nuclear and radiological emergencies. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020033>.
- Perko T, Benighaus L, Tomkiv Y, Wolf HV. 2020. Guidance on communicating about uncertainties in nuclear emergency management. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020028>.
- Raskob W, Beresford NA, Duranova T, Korsakissok I, Mathieu A, Montero M, Müller T, Turcanu C, Woda C. 2020a. CONFIDENCE: project description and main results. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020008>.
- Raskob W, Beresford NA, Duranova T, Korsakissok I, Mathieu A, Montero M, Mueller T, Turcanu C, Woda C. 2020b. CONFIDENCE: Achievements and way forward. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020010>.
- Tomkiv Y, Perko T, Sala R, Zeleznik N, Maître M, Schneider T, Oughton DH. 2020. Societal uncertainties recognised in recent nuclear and radiological emergencies in Europe. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020025>.
- Turcanu C, Perko T, Baudé S, Hériard-Dubreuil G, Zeleznik N, Oughton DH, Tomkiv Y, Sala R, Oltra C, Tafili V, Benighaus L, Maître M, Schneider T, Crouaïl P, Duranova T, Paiva I. 2020a. Social, ethical and communication aspects of uncertainty management. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020024>.
- Turcanu C, Perko T, Sala R, Wolf HV, Oughton D. 2020b. Social uncertainties associated with stable iodine intake in a nuclear emergency. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020027>.
- Walsh L, Ulanowski A, Kaiser JC, Woda C, Raskob W. 2020. A new European cancer risk assessment tool for application after nuclear accidents. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020018>.

Zeleznik N, Benighaus L, Mitrakos D, Tafili V, Duranova T, Sala R, Benighaus C. 2020. Mental models of uncertainty management in nuclear emergency management. *Radioprotection* 55(HS1). <https://doi.org/10.1051/radiopro/2020026>.

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