Federal Office for Radiation Protection

The PREDICT Project- Overview and Status Quo

ImPRovements in atmospheric dispErsion moDellIng and proteCTive action strategies in case of nuclear detonations

C. Woda (on behalf of the PREDICT consortium)

PIANOFORTE EUROPEAN PARTNERSHIP FOR RADIATION PROTECTION RESEARCH

PREDICT

NERIS Workshop, Fontenay-aux Roses, 28 April 2026

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Introduction

- PREDICT aims to enable the major internationally used decision support systems JRODOS and ARGOS and other nationally used atmospheric dispersion and transport codes and follow-on foodchain models to simulate and predict consequences due to the fallout of a nuclear detonation in Europe or worldwide.
- Duration: 01 February 2024 – 31 January 2027
- 12 partners from seven European countries

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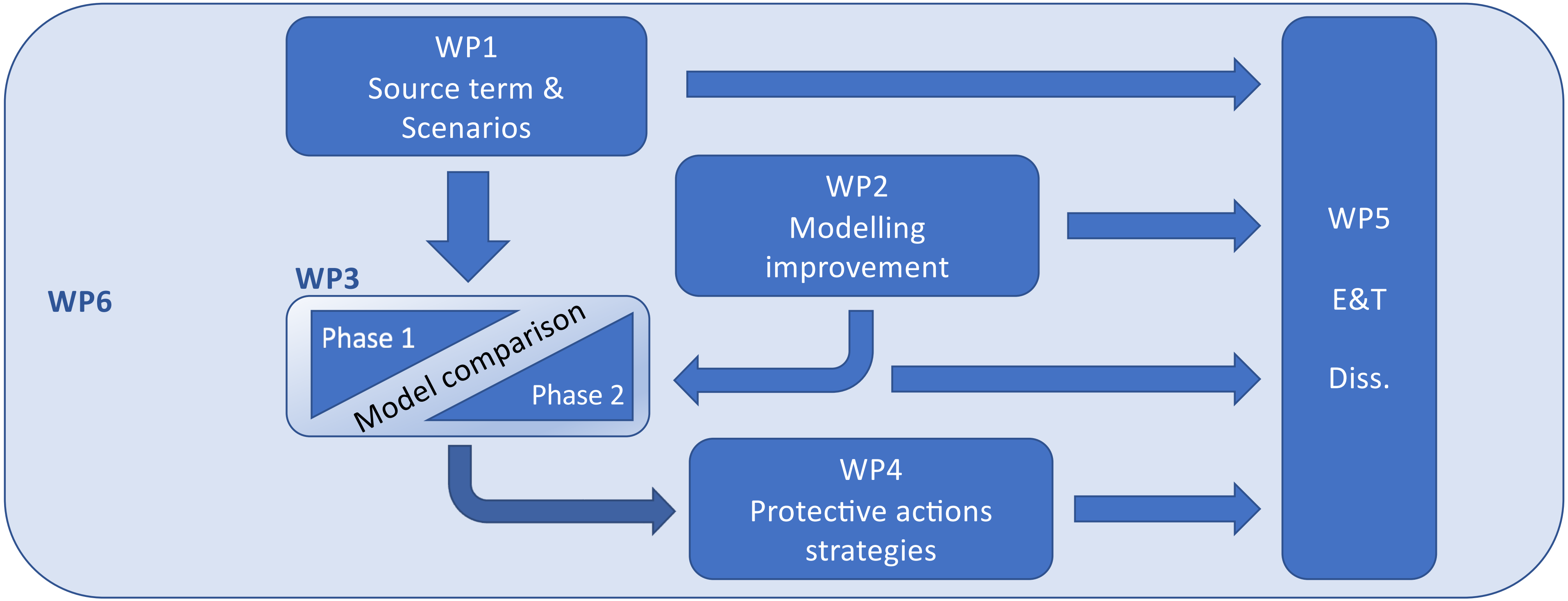
Project structure



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WP 1 - Characterization of airborne radiocontaminants (DTU)

WP completed:

- "Predict Nuclide vector": 359 radionuclides with max activity from fission of U-235, U-238 and Pu-239 after 10 min, ranked according to either dose from ground or cloud shine or ingestion dose; corresponding analysis for activation and unconsumed fuel residues
- Parameterization of cloud dimensions and review of different activity –height and activity- particle size distribution achieved
- Four scenarios (two yields, two HOB); combinations of cloud geometry and parameter distributions for sensitivity analysis

Table 2: Radionuclides accounting for 95 % of external exposure from the ground in three early time windows: 1) first 6 hours; 2) 6 hours - 24 hours, and; 3) 24 hours – 30 days after the explosion. All times are relative to t + 10 minutes.

Window 1: 0 - 6 hours		
Nuclide	Share of dose (%)	Cumulative share (%)
I-134	11.78	11.78
Cs-138	8.31	20.09
La-142	7.00	27.09
Tc-104	5.94	33.04
Rb-89	4.21	37.25
Mo-101	3.36	[illegible]
Sr-92	3.33	[illegible]

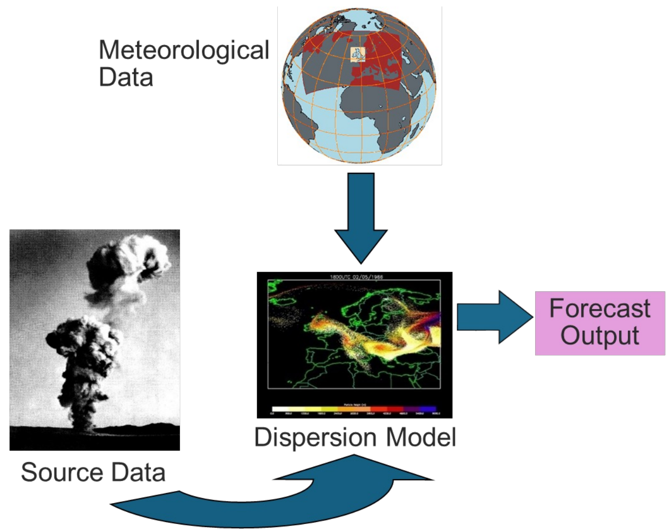
Window 2: 6 - 24 hours		
Nuclide	Share of dose (%)	Cumulative share (%)
I-135	15.37	15.37
Zr-97	8.08	23.45
I-133	6.62	30.07
Nb-97	6.57	36.64
Sr-91	6.53	43.17
I-132	5.82	48.99
Kr-88	5.74	54.73

WP2 - Modelling Improvement (UKHSA)

- Develop scientifically based recommendations for future improvements of atmospheric dispersion and radiological dose assessment models applied to nuclear detonation scenarios

Task 2.1 Improvements in dispersion modelling (UKMO)

- Modus operandi: Model & literature review, expert analysis
- Sources of uncertainty within atmospheric dispersion modelling
- Increased model resolution and/or model complexity are recommendations to improve modelling but…
  - Less robust
  - Additional requirements



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WP 2.1 - Recommendations

- Source term
  - Guided by subject experts
  - Enable a range of options
  - Fractionation needs further research
- Input meteorological data
  - Use high resolution NWP data
  - Increase temporal resolution
  - Update NWP data frequently
  - Preprocessing of NWP discouraged
  - Consider additional meteorological fields
  - Consider use of observations
- Atmospheric dispersion model parameterisations
  - Wet deposition recommendations
  - Dry deposition recommendations
  - Radioactive decay
- Output provided for downstream models (external dose, run-off and food chain)
  - Further research needed on particle size dependency

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WP 2.1 - Future directions identified

- Ensemble and probabilistic modelling
  - Operational implementation challenging
  - Engagement required with end users on communication of result
- Artificial intelligence & machine learning (AI/ML)
  - Use of AI NWP data as input
  - Development of ML atmospheric dispersion models
  - Data-driven surrogate model parameterisations within traditional physics-based atmospheric dispersion models
- Coupled meteorology-dispersion modelling
  - Enables feedback of the blast on meteorology
  - Out-of-scope? (Focus of task 2.1 on atmospheric dispersion modelling from the "stabilised cloud")

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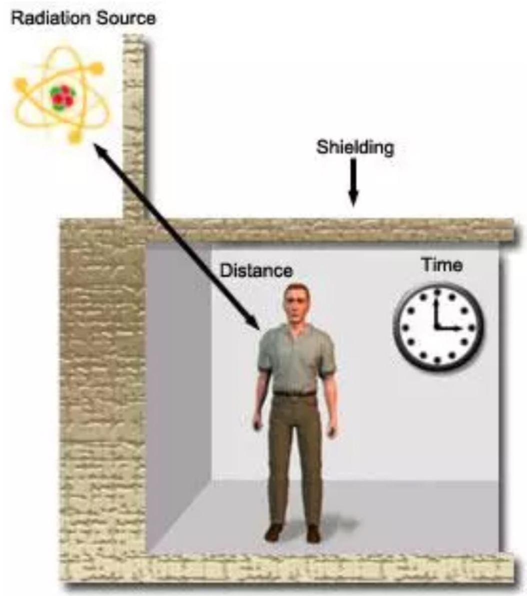
WP 2.2 - Improvements in modelling dose, tissue reactions and options for recovery following a nuclear detonation (UKHSA)

Four topic areas:

- External dose from deposition
- Review of the applicability of location factors
- Modelling tissue reaction effects
- Recovery options in inhabited areas



https://www.radiation-therapy-review.com/Radiation_Protection.html

WP 2.2 - Findings

- Advancing methodologies for the assessment of external dose following deposition…
  - Seek to improve all models from basic - complex.
  - Use of ICRP (144) dose coefficients for 0.5 g cm^{-2}
  - Modelling a truncated decay chain
  - Use of a tracer approach (cocktail DCC method)

- Application of location factors in the assessment of external dose…
  - Only simple model in ARGOS & RODOS
  - Improvements possible using GIS datasets
  - Application of the Dillon et al (2015) approach to the Norwegian city of Bergen
  - Assessment of strengths & weaknesses of a global building dataset

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WP 2.2 - Findings-continued

- Modelling tissue reactions…
  - Key tissue reactions identified
  - ICRP approach for threshold doses recommended, rather than IAEA
  - Is inhalation dose relevant for tissue reactions, especially for the fetus? Proposal of a method

- Improvements in the identification of recovery options following contamination in inhabited areas…
  - Extending ERMIN for ND scenarios
  - Considered particle forming processes & partitioning
  - Commonalities & analogues between deposition & retention
  - Recommendations of new model particle-groups
  - Addition of ^{125}Sb & its progeny ^{125m}Te to ERMIN recommended

WP 2.3 - Application of food-chain transfer models following a nuclear detonation (DSA Lead)

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Topic areas:

- Literature Review
- Derive 'ingestion dose products' from the initial (dose product) PREDICT vector, accounting for radioecological factors
- Create a short list of radionuclides for which model parameterisation is required (FARMLAND, PRISM and FDMT) and develop models accordingly
- Evaluation by and comparison with ND scenario using (updated) models

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Soil to plants ($CR_{rootup,r}$)

Element	Grass	Cereals	Leafy veg.	Root veg.	Potatoes	Fruit/berries
Ag		Grass			Root v.	
Ba						
Cd			NCRP	NCRP		Veg.
Ce						La
Cs						
I						
La						
Mo					Root v.	Veg.
Nb						
Nd		Ce, Pm	Ce, La	Ce, La, Pm, Pr	Ce, La, Pm	La
Pd		Ni	NCRP	NCRP	NCRP	Veg.
Pm	Ce, La, Nd, Pr, Sm		Ce, La			La
Pr			Ce, La		Ce, La, Pm	La
Rh	Co	Ru	NCRP	NCRP	NCRP	Veg.
Ru	Mul					
Sb						
Sm		Ce, Pm	Ce, La	Ce, La, Pm, Pr	Ce, La, Pm	La
Sn		Grass	NCRP	NCRP	NCRP	Veg.
Sr						
Te	Mul					
Y						
Zr						

Analogue element/nuclide — Model recommendations — Analogue species

Main sources:

International Atomic Energy Agency (2010). Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments. IAEA Technical Report Series No. 472. International Atomic Energy Agency, Vienna.

International Atomic Energy Agency (2009). Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments. IAEA TECDOC Series No. 1616.

Supplement for "grass":

Barnett, C. L., Beresford, N. A., Walker, L. A., Baxter, M., Wells, C., Copplestone D. (2014) Transfer parameters for ICRP reference animals and plants collected from a forest ecosystem. Radiat Environ Biophys 53:125–149.

Thørring H, Brown JE, Aanensen L, Hosseini A (2016a). Tjøtta – ICRP reference site in Norway (Summary report of the TRAP project). StrålevernRapport 2016:9. Østerås: Statens strålevern.

Model recommendations (no available data):

NCRP: NCRP Report No. 123 I (1996). Screening models for releases of radionuclides to atmosphere, surface water, and ground. Recommendations of the National Council on Radiation Protection and measurements.

Mul: Müller, H., Gering, F. and Pröhl, G. (2004). Model description of the Terrestrial Food Chain and Dose Module FDMT in RODOS PV 6.0., RODOS(RA3)-TN(03)06, Report (version 1.1, 18.02.2004).

WP 2.3 - Some findings

- ND-specific factors that may affect food-chain transfer: radionuclides, particle size, physicochemical form
- Importance of processes
  - Early period (7 and 30 days) drivers: deposition, interception, weathering
  - Late period (6 month, 1 year) drivers: root uptake and soil processes
- Inclusion of radioecological factors leads to a different ranking of radionuclides than the original PREDICT dose product of WP1
- Key radionuclides shift over time
- Models agree on trends but differ in certain details

Nuclide	Cum. (%)	Change
I-131	70,9 %	0
Sr-89	76,2 %	3
Ba-140	80,2 %	-1

Cs-137	91,7 %	10

Nuclide	Cum. (%)	Change
Sr-89	29,2 %	3
Sr-90	51,2 %	4
Cs-137	69,4 %	5

30 days

Nuclide	Cum. (%)	Change
Sr-89	29,2 %	3
Sr-90	51,2 %	4
Cs-137	69,4 %	5
Ru-106	82,0 %	-2
Ce-144	88,1 %	-4
Y-91	91,0 %	-3
Nb-95	92,6 %	-2
Te-127m	93,9 %	3
Ru-103	95,0 %	0
		-3
		5
		7
		1
		-4
		5
		10
		-4
		0
		-7
		-3
Te-127	99,9 %	0
Pr-144	100,0 %	-7
Nb-95m	100,0 %	-1
Ba-140	100,0 %	-1
Pr-143	100,0 %	0
La-140	100,0 %	-2

6 months

Ranking of radionuclides for ingestion dose product × radioecological transfer, their cumulative contribution and change in ranking (cf. original ingestion dose-product) for an adult diet at defined timepoints. Darker colours represent more dramatic promotion (red) and relegation (blue) of radionuclides in the ranking list once food-chain transfer has been accounted for.

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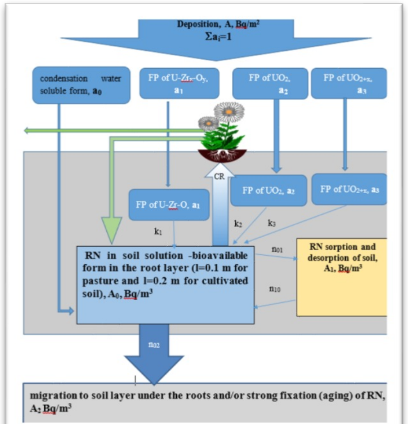
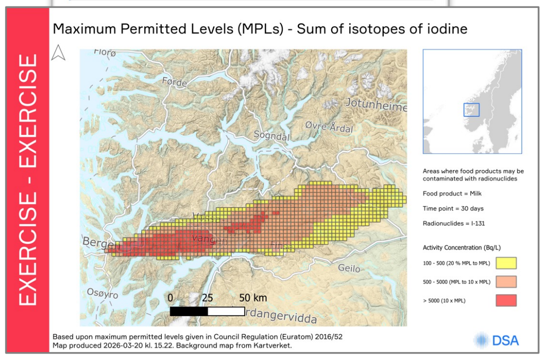
WP 2.3 - Some recommendations

- The ranking of radionuclides could be expanded
- Particle specific considerations
- Results from PREDICT model-model intercomparisons
- Account for uncertainties and practical application





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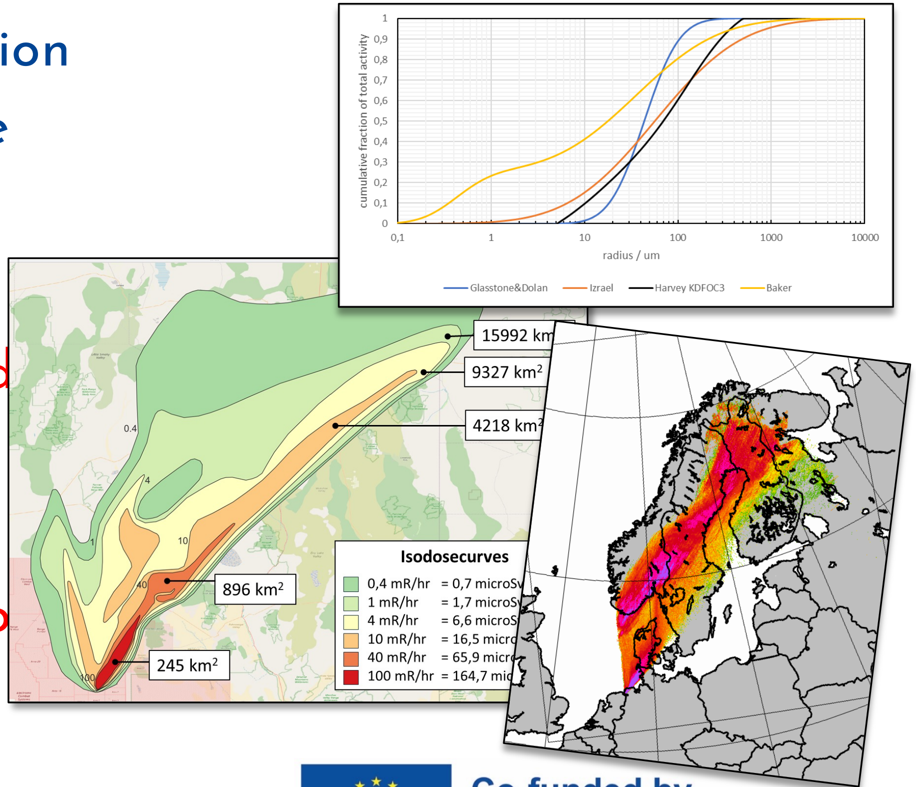
WP3 - Model Comparison (KIT)

3.1 Model validation with historical contamination data from 1950s weapon tests (accuracy of the prediction)

3.2 Sensitivity analysis for key source term mod parameters

3.3 Sensitivity analysis for key weather conditio

Details in next presentation



WP4 - Protective actions strategies (BfS, NMBU)

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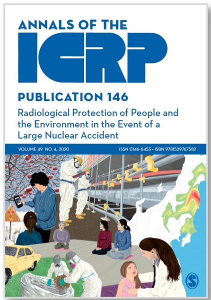
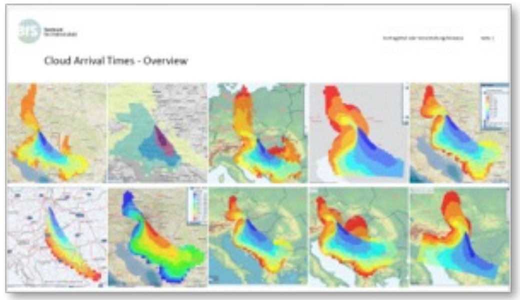
- Develop harmonized protective action strategies, based on the unified source terms of WP1 and specific endpoints of the uncertainty analysis in WP3 -> Presentation of Y. Tomkiv this morning
- Develop effective ways of communicating protective measures to the public, taking into account psychological, social and ethical consideration and utilizing results of a workshop with key players in emergency response. It will be co-organized with the final workshop of RRADEW (May 2026), to mutualize stakeholders and have opportunities to discuss transversal topics.

Advice for the Public on Protection in Case of a Nuclear Detonation





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WP 5 - Education, training and dissemination (NMBU)

Dissemination of project results:

- NERIS Workshops 2024, 2025, 2026
- ERPW 2024, 2025, 2026
- RICOMET 2024 & 2026 (SSH in Radiation Research)
- ARGOS and RODOS User Group meetings 2024 & 2025
- MARC - International Conference on Methods and Applications of Radioanalytical Chemistry, March 23-28, 2025, Hawaii
- Nordic nuclear safety research meeting (NKS-B REMSEM 2026)
- IRPA 2026

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WP 5 - Education, training and dissemination (NMBU)

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Education & Training:

- International exercises of the RODOS and ARGOS user groups (planned for 2027)

- Training course at NMBU (January 2026) "Nuclear preparedness" (RAD205) with PREDICT material:
    - ~25 participants
    - Communication materials on public advice (W
    - ARGOS with PREDICT test-runs

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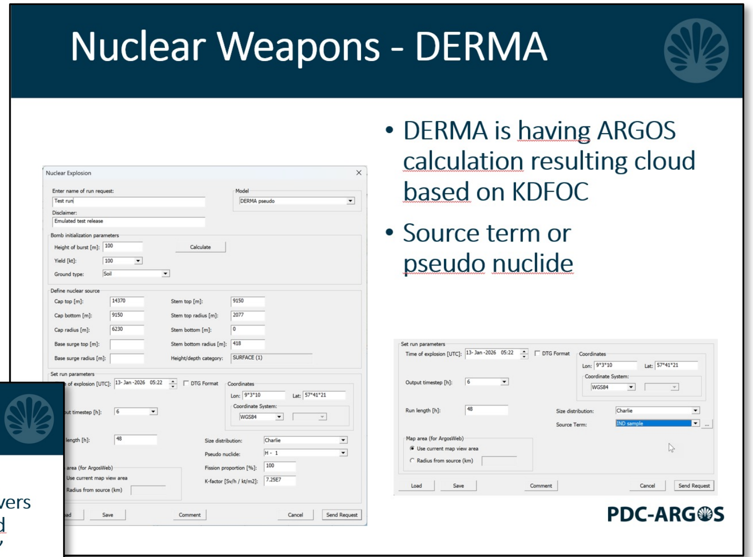
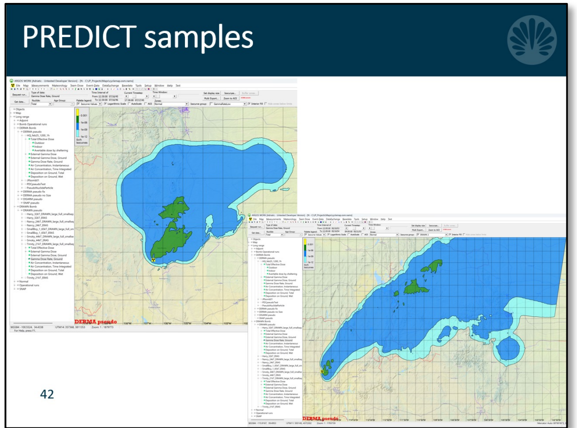
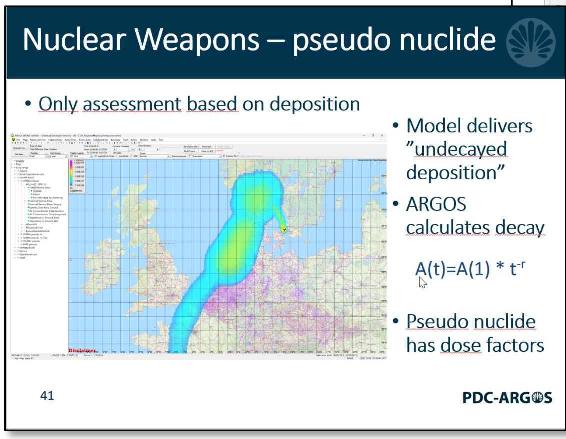
WP 5 - Education, training and dissemination (NMBU)

Training course at NMBU:

- Introduction to ARGOS DSS, including
  - Different approaches to calculation of FSC
  - Concept of dealing with pseudo nuclides
  - Samples of test-runs used in PREDICT presented in ARGOS







Data Management and Dissemination

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- All project deliverables will be openly accessible through the PIANOFORTE website. These include:
  1. Available parametrization (WP 1, January & April 2025)
  2. Recommendations for future research (WP 2, July 2026)
  3. Results from model comparison and testing (WP 3, December 2026)
  4. Recommendations for protective actions and crisis communication (WP 4, July & December 2026)
  5. Training materials (WP 5, April 2026)
- Publications, that will focus more on the methodological aspects of the derived data in the deliverables, will be made open access either through 'Gold' or 'Green' routes.
- Data generated within PREDICT will be made publicly available by deposition in the STORE^{DB} platform.

PIANOFORTE Partnership
European Partnership for Radiation Protection Research
Horizon-Euratom – 101061037

D6.1 - Establishing of the management structure and data management plan of the PREDICT project

Lead Authors: Clemens Woda
With contributions from: Management Group members
Reviewer(s): ??

Work package / Task	PREDICT WP 6	T 6.1
Deliverable nature:	Report	
Dissemination level: (Confidentiality)	Public	
Contractual delivery date:	Month 3 (Pianoforte MXX) | 30 April 2024	
Actual delivery date:	Month X (Pianoforte MXX) | XX YYYY 2024	
Version:	1.0	
Total number of pages:	X	
Keywords:	Management structure, data management plan	
Approved by the coordinator:	PIANOFORTE Month X	
Submitted to EC by the coordinator:	PIANOFORTE Month X	

STORE^{DB}

Thank you for your attention

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The PREDICT Consortium:

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