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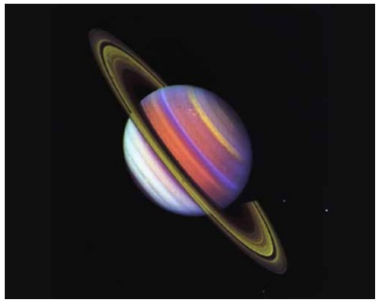
Support System for **A**ssessmen**T** of Risks to the Public and the Environment from **UR**a**N**ium Mining Activities

SATURN



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Objective

- To develop a web based support system (SATURN) for assessment of risks to the public and the environment from contaminated lands

  (focused of lands contaminated from uranium mining and milling activities)

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SATURN components

RA1

- **Website**

www. saturn.facilia.se

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The Website

- Uploading and downloading models, documentation and training materials.
- Adding and extracting data from the databases.
- Uploading and downloading of projects developed using the support system.
- Tracking of reports of non-conformities and suggestions for improving SATURN.
- Forum for users to discuss on usability and applications of SATURN.
- Links to useful web-sites, like websites where other useful models can be found (RESRAD, Hydrus, etc).
- Announcing training courses and other relevant events.

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SATURN components

RA2

- **Website**
- Set of relevant **methodologies** (Wiki Style)

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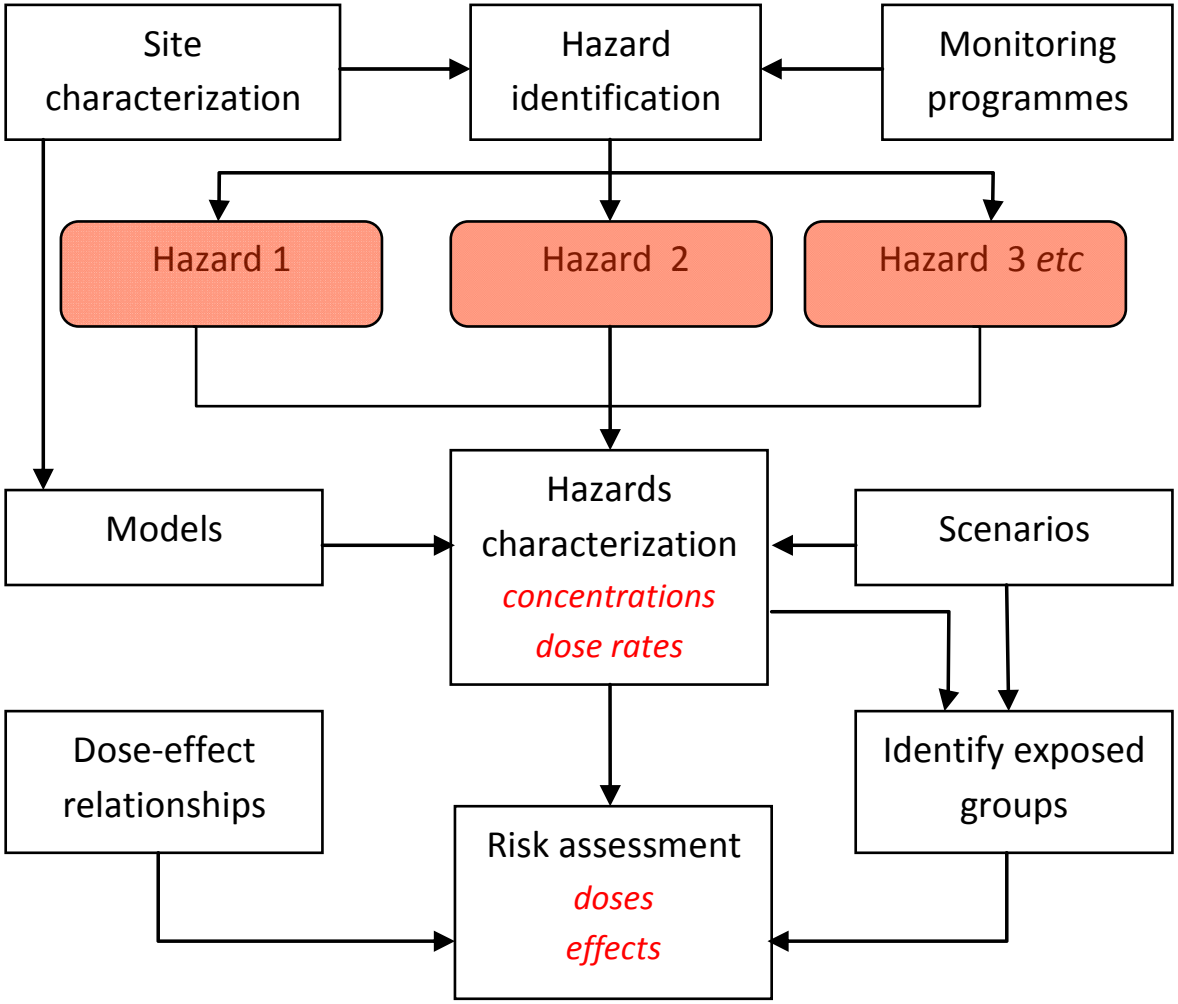
The SA Methodology (EMRAS II ?)



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Types of assessments

- Current situation – risk assessment
- Future situations – safety assessment

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RISK ASSESSMENT

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Identification of hazards

Hazards is the potential to cause harm whereas risk is the probability of harm

We define hazard as an area or object (ex. a water body with elevated (above background) radionuclide levels

Monitoring:

- Gamma dose rates outside and inside of buildings
- Radionuclide concentrations
  - aerosols, soils and tailing materials
  - in water and food products
- Radon concentrations outside and inside buildings

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Exposure assessment

- All main exposure pathways are considered:
  - External exposure (indoor and outdoor)
  - Inhalation of contaminated dust (indoor and outdoor)
  - Inhalation of radon and its short lived daughters (indoor and outdoor)
  - Ingestion of locally produced food
  - Direct ingestion of soil
- Detailed guidance with regard to data requirements
- Default values which can be substituted by site-specific values if available

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Exposure assessment (cont)

- Simplified models (for example for radon dispersion in air) which have been developed using complex models and have been calibrated and tested at a large number of sites
- Possibility to utilize these models and default parameters to develop investigation values (e.g. for radionuclide concentration in waste) which allow an easy determination whether the primary dose criterion is exceeded.

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SAFETY ASSESSMENT

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Assessments for future situations

- Start with an assessment for the current situation
- Identify new hazards that may appear in the future and how existing hazards can change
- Indentify potential new exposure pathways
- Characterize the hazards with the help of models
- Estimate exposure to different groups

Graded approach to the assessments

- The assessments can be performed at different levels of depth. Depending on the hazard potential of a site and the development stage of the project, screening models or more advance models may be used.
- The definition of screening models can benefit from comprehensive activities carried out in the **German uranium mining remediation project**. In this project, **different levels of screening approaches have been developed** and validated using the comprehensive data basis of actual measurement results which is available for many of the German sites.

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SATURN components

RA5

- **Website**
- Set of relevant **methodologies** (Wiki Style)
- An internationally agreed list of Features Events and Processes (**FEP**)

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FEP database

- Database of Features Events and Processes of relevant for SA of Uranium Mining Activities.
- Use of the FEP database for development of conceptual models and scenarios.
- Use of FEPs for storing parameter values and results from site characterization.

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Processes influencing the radionuclide transport

ATMOSPH	Rainfall Dry deposition Gas uptake			Rainfall Dry deposition Gas uptake	Rainfall Dry deposition Gas uptake	
Resuspension Volatilization/ Emanation Evaporation Transpiration	Source	Percolation Advection Diffusion Dispersion Colloid transp.		Erosion Surface runoff Sedimentation		
		Vadose	Recharge Advection Diffusion Dispersion Colloid transp.			
		Capillary rise Advection Diffusion Colloid transp.	GW		Discharge/Seepage	Pumping
Resuspension Volatilization/ Emanation Evaporation Transpiration		Inflitration Advection Diffusion Dispersion Colloid transp.		LAND SURFACE	Surface runoff	
			Recharge	Irrigation Flooding	SURFACE WATER	
				Irrigation		Well

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Processes in the source, the vadoze, the groundwater and the surface land components

INPUT						
	AQUEOUS	Adsorption / Surface complexation Ion exchange	Precipitation	Volatilization Heterogeneous reaction Diffusion Decay (Rn, Tn)		
	Desorption Ion exchange	SOLID	Co-precipitation	Decay (Rn, Tn)		
	Dissolution	Co-precipitation	SUSPENDED	Decay (Rn, Tn)		
	Condensation Diffusion Decay (Rn, Tn)	Decay (Rn, Tn)	Decay (Rn, Tn)	GASEOUS		
					MICROBES	
						OUTPUT

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SATURN components

RA6

- **Website**
- Set of relevant **methodologies** (Wiki Style)
- An internationally agreed list of Features Events and Processes (**FEP**)
- **Set of modules** implementing generic assessment models which can be used for developing site-specific assessment models and applying these in risk assessments.

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Mathematical Models for Assessing Remediation of Radioactively Contaminated Sites - ***MATHREM***

IAEA TECDOC – under development

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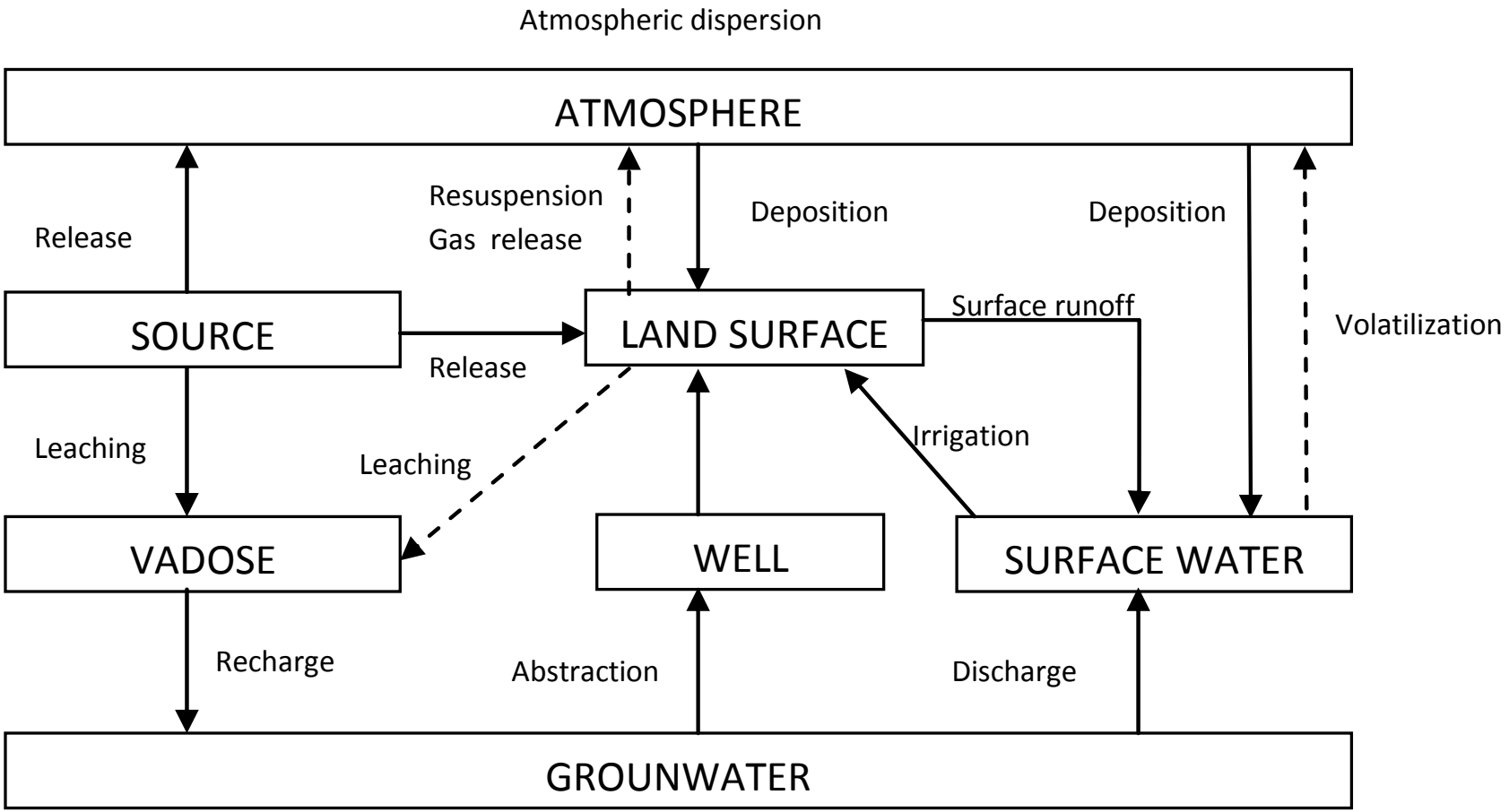
Simple Assessment Models (MATHREM)



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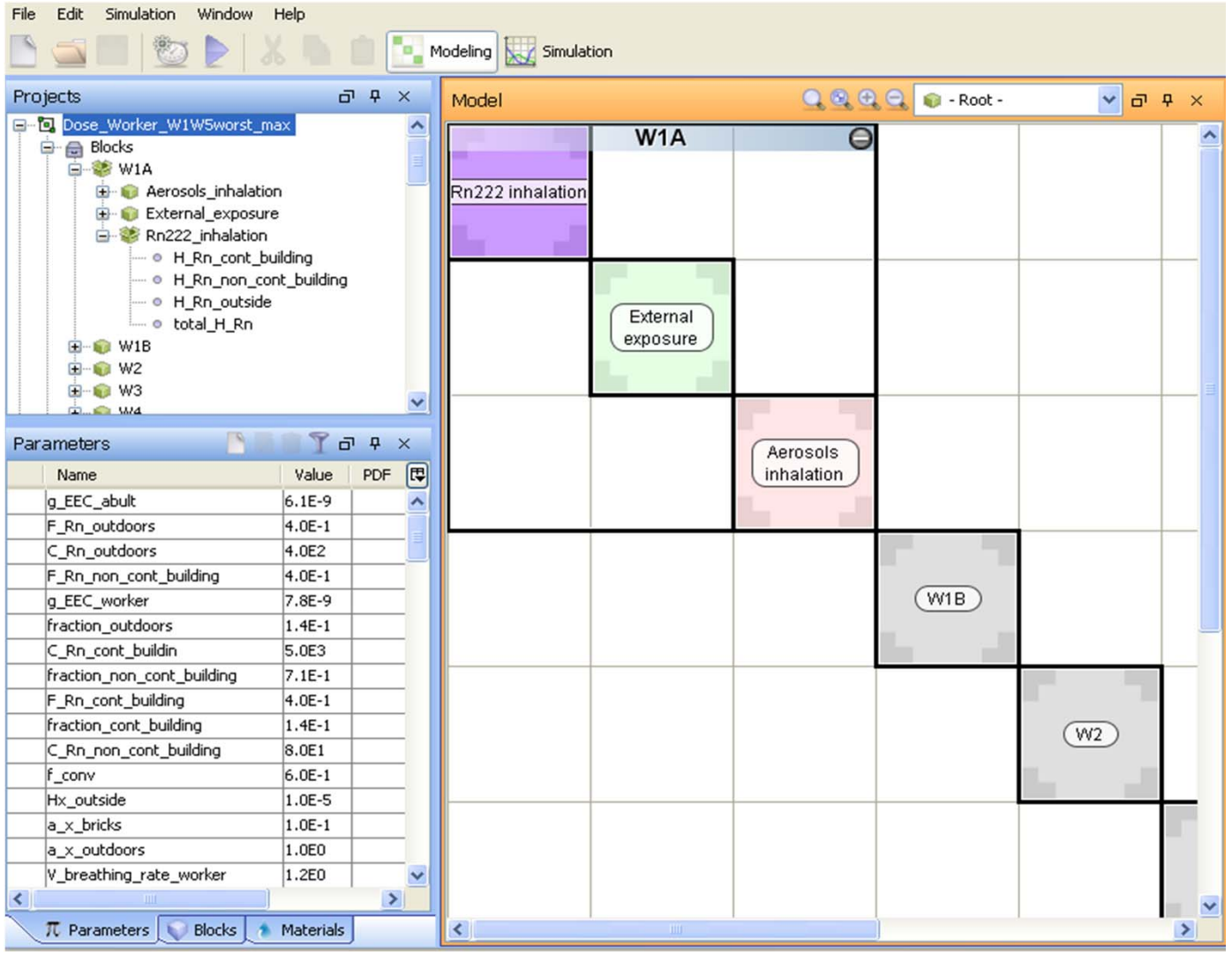
Toolbox of ready-made sub-models



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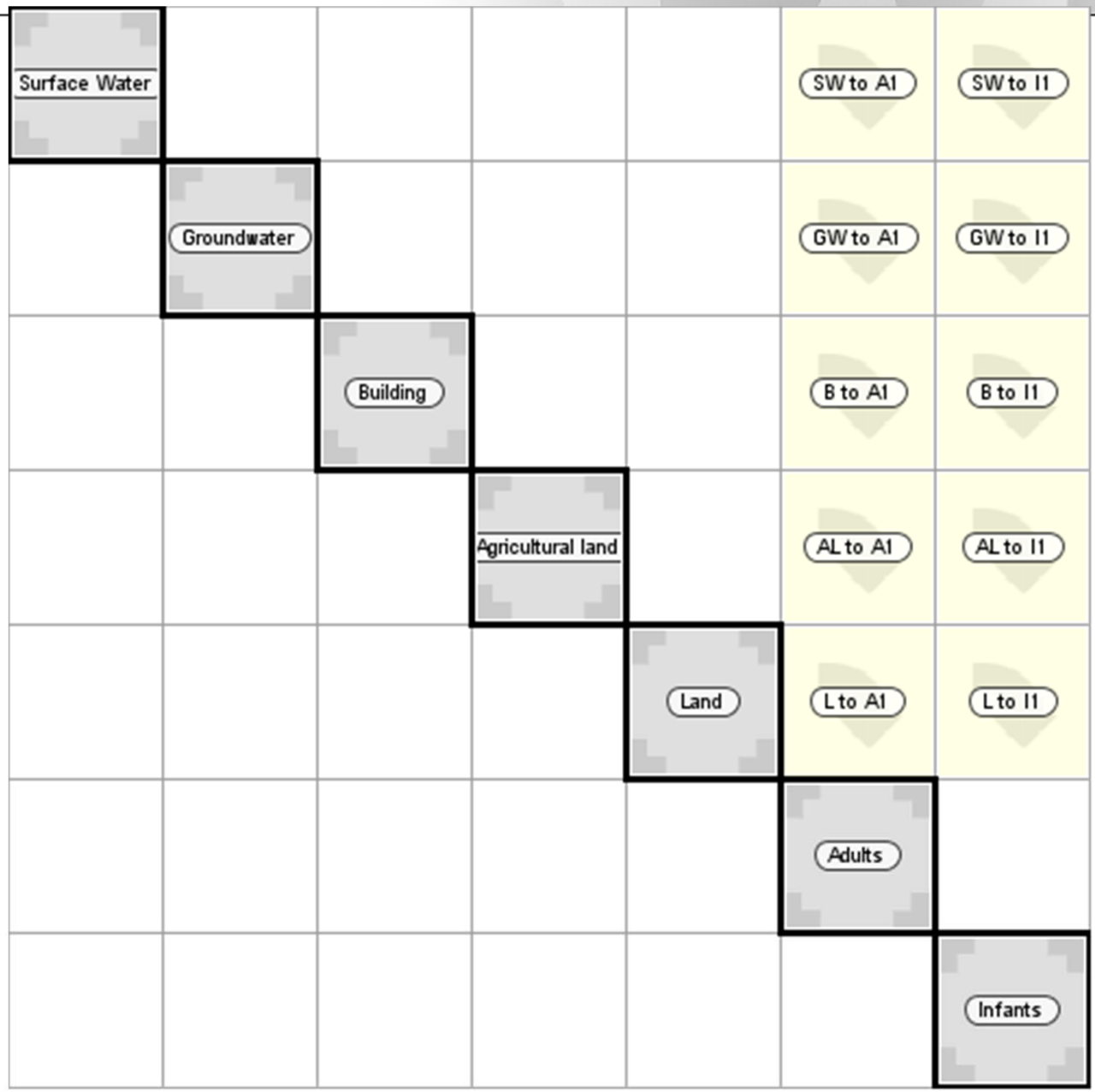
Surface Water
Groundwater
Building
Agricultural land
Land
Adults
Infants
SW to A1
SW to I1
GW to A1
GW to I1
B to A1
B to I1
AL to A1
AL to I1
L to A1
L to I1

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Sub-models

- **Exposure assessment –** for quantifying hazards using standardized exposure conditions and performing exposure assessments.
- **Surface runoff –** for modeling the transport of contaminants downstream from the source with surface runoff.
- **Surface water –** for modeling the transport of contaminants in surface water bodies and estimation of contaminant concentrations in water, sediments and biota. This sub-model will include the generic models described in (IAEA SR 19) for different types of surface water bodies, like rivers and lakes.

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Sub-models (cont)

- **LAND –** for modeling the behavior of contaminants in different types of lands, like agricultural lands and forests and estimation of contaminant concentrations in soil, air and terrestrial biota. This sub-model will include the generic models described in (IAEA SR 19) for different types of terrestrial ecosystems.
- **Vadose transport –** for modeling the vertical transport in the vadose zone of contaminants released from the source by leaching processes.
- **Groundwater transport –** for modeling the transport of contaminants in the saturated zone from the source to different receptors.

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Sub-models (cont)

- **Atmospheric dispersion** – for modeling the atmospheric transport of contaminants from the source to different receptors. This sub-model will include the generic models described in (IAEA SR 19) for different atmospheric dispersion situations.
- **Source Term** – for modeling releases of contaminants from the source to the atmosphere, sub-surface waters and groundwater.

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Simulations

Monte Carlo simulations

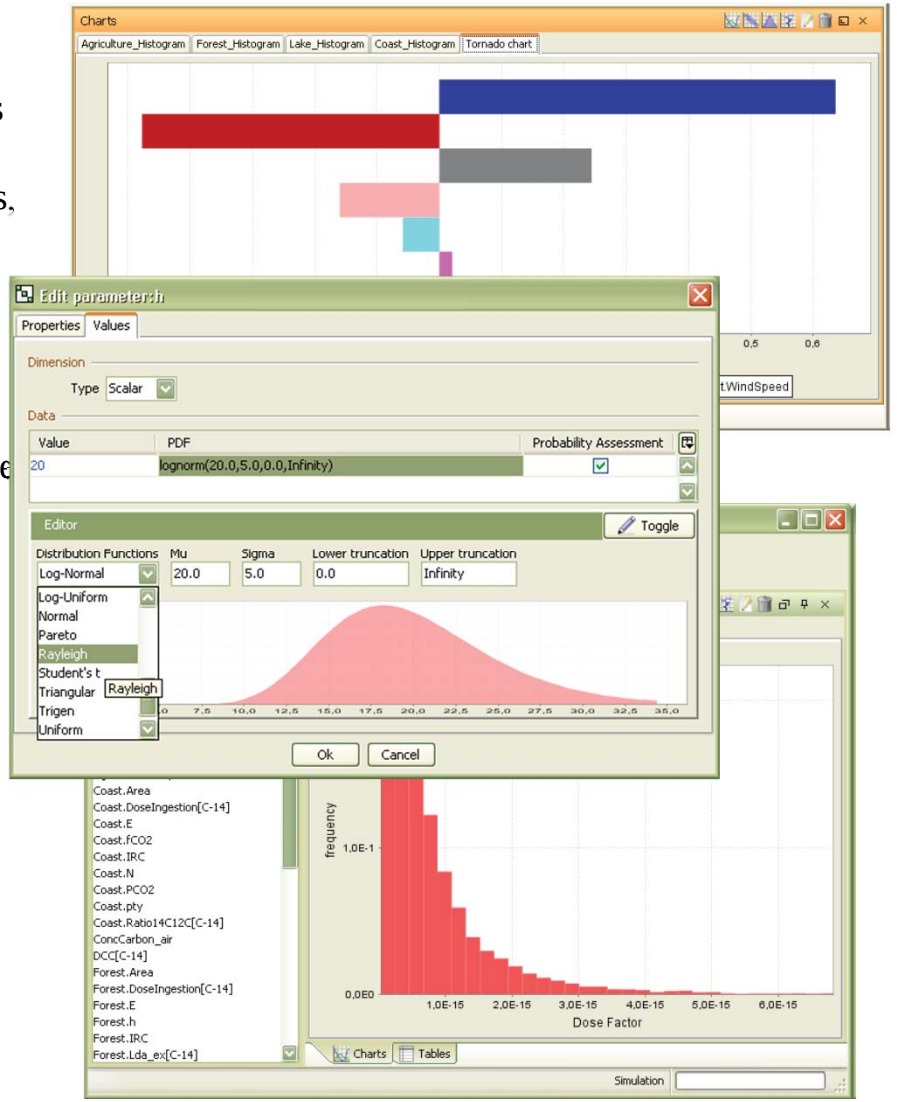
With an impressive list of probability density functions (PDFs), together with Monte Carlo and Latin Hypercube sampling and parameter correlation settings, Ecolego has everything needed for advanced probabilistic analysis.

Sensitivity analysis

Rank correlation coefficients are available for tornado plots or correlation tables. These can be used to find the parameters in a model that influence results the most.

Post-processing

Simulation outputs can be re evaluated using post-processing functions, without re-running simulations.



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EXAMPLE OF SUB-MODEL

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Sub-model: Agricultural Land

- Exposure pathways:
  - external irradiation
  - inhalation
  - soil ingestion
  - ingestion of crops
  - ingestion of milk
  - ingestion of meat
  - ingestion of breast milk
- Endpoints:
  - Hazard from occupancy
  - Hazard from food ingestion
  - Doses to identified groups

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Parameter types

1. Monitoring
2. Habits
3. Site data
4. Radioecological data
5. Dosimetric data

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Monitoring parameters sub-model Agricultural Land

- Equivalent dose rate (Sv/h)
- Concentration in air (Bq/m^3)
- Concentration in soil (Bq/kg DW)
- Concentration in crops (Bq/kg FW)
- Concentration in milk (Bq/L)
- Concentration in meat (Bq/kg FW)

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Index lists sub-model Agricultural Land

- Crops: leafy vegetables, vegetables, roots, cereals
- Milk types: cow, goat, sheep
- Meat types: beef, goat, sheep

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Habit parameters sub-model Agricultural Land

- Occupancy by adults and infants (h/year)
- Fraction of ingestion of crops by adults, infants and lactating mothers
- Fraction of ingestion of milk by adults, infants and lactating mothers
- Fraction of ingestion of meat by adults, infants and lactating mothers

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Options
sub-model Agricultural Land

1. Effective external dose– calculated from concentration in soil.
2. Concentration in air – calculated from soil concentrations.
3. Concentration in milk – calculated from concentration in pasture (Bq/kg DW), concentration in soil (Bq/kg DW) and concentration in water drinked by cows (Bq/m^3)

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Options
sub-model Agricultural Land

4. Concentration in meat – calculated from concentration in pasture (Bq/kg DW), concentration in soil (Bq/kg DW) and concentration in water drinked by cows (Bq/m^3)
5. Concentration in crops – several alternatives available:
   - calculated from concentration in soil
   - calculated from concentration in irrigation water (Bq/m^3)
   - calculated from deposition rate (Bq/(m^2.year)
   - calculated from deposition rate (Bq/(m^2.year) and from concentration in irrigation water (Bq/m^3)

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Options
sub-model Agricultural Land

6. Concentration in pasture – several alternatives available:
   - calculated from concentration in soil
   - calculated from concentration in irrigation water (Bq/m^3)
   - calculated from deposition rate ($Bq/(m^2.year)$)
   - calculated from deposition rate ($Bq/(m^2.year)$) and from concentration in irrigation water (Bq/m^3)

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Options
sub-model Agricultural Land

7. Concentration in soil – several alternatives available:
   - calculated from concentration in irrigation water (Bq/m^3)
   - calculated from deposition rate ($Bq/(m^2.year)$)
   - calculated from deposition rate ($Bq/(m^2.year)$) and from concentration in irrigation water (Bq/m^3)
8. Concentration in breast milk (Bq/L) – calculated from intake of radionuclides by the mother (Bq/y), which are calculated fom concentrations in crops, milk and meat.

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SATURN components

RA8

- **Website**
- Set of relevant **methodologies** (Wiki Style)
- An internationally agreed list of Features Events and Processes (**FEP**)
- **Set of modules** implementing generic assessment models which can be used for developing site-specific assessment models and applying these in risk assessments.
- **Databases** that collate monitoring data and parameter values needed for assessments with models.

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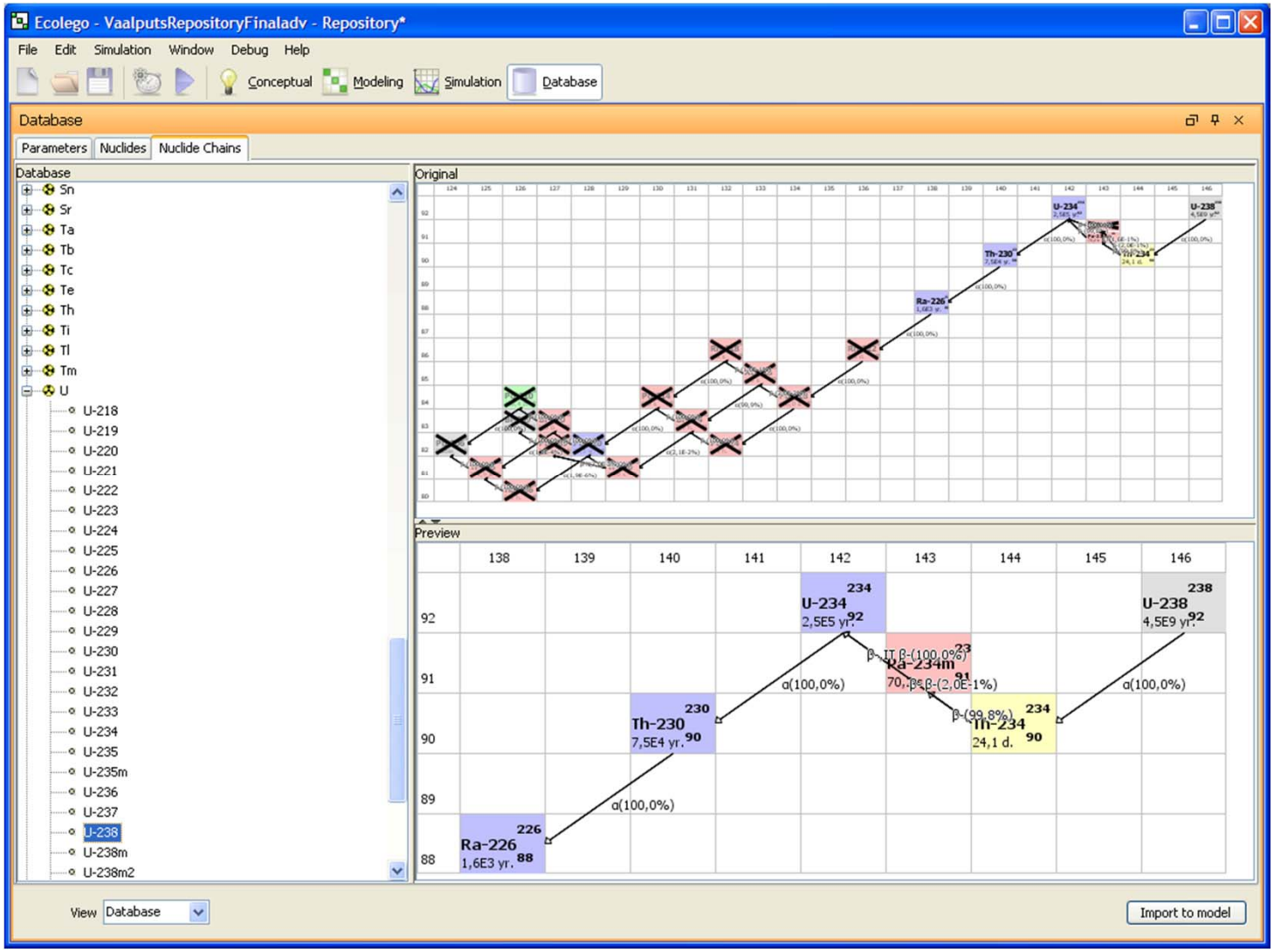
Database of radionuclides and parameters



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SATURN components

RA7

- **Website**
- Set of relevant **methodologies** (Wiki Style)
- An internationally agreed list of Features Events and Processes (**FEP**)
- **Set of modules** implementing generic assessment models which can be used for developing site-specific assessment models and applying these in risk assessments.
- **Databases** that collate monitoring data and parameter values needed for assessments with models.
- **Training material** covering basic knowledge, methodologies and assessment models.

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Work Plan 2011

1. Development of website – launching in February
2. Implementation of exposure sub-models – ready in March
3. Testing of exposure sub-models – ongoing (Test Cases from EMRAS II, project in Ukraine and IAEA projects in Central Asia) – ready in June
4. Implementation of transport sub-models – ready in June
5. Testing of transport sub-models (EMRAS II) - ???
6. Training course organized by the IAEA – November 2011