HARP - A Software Tool for Fast Assessment of Radiation Accident Consequences and their Variability

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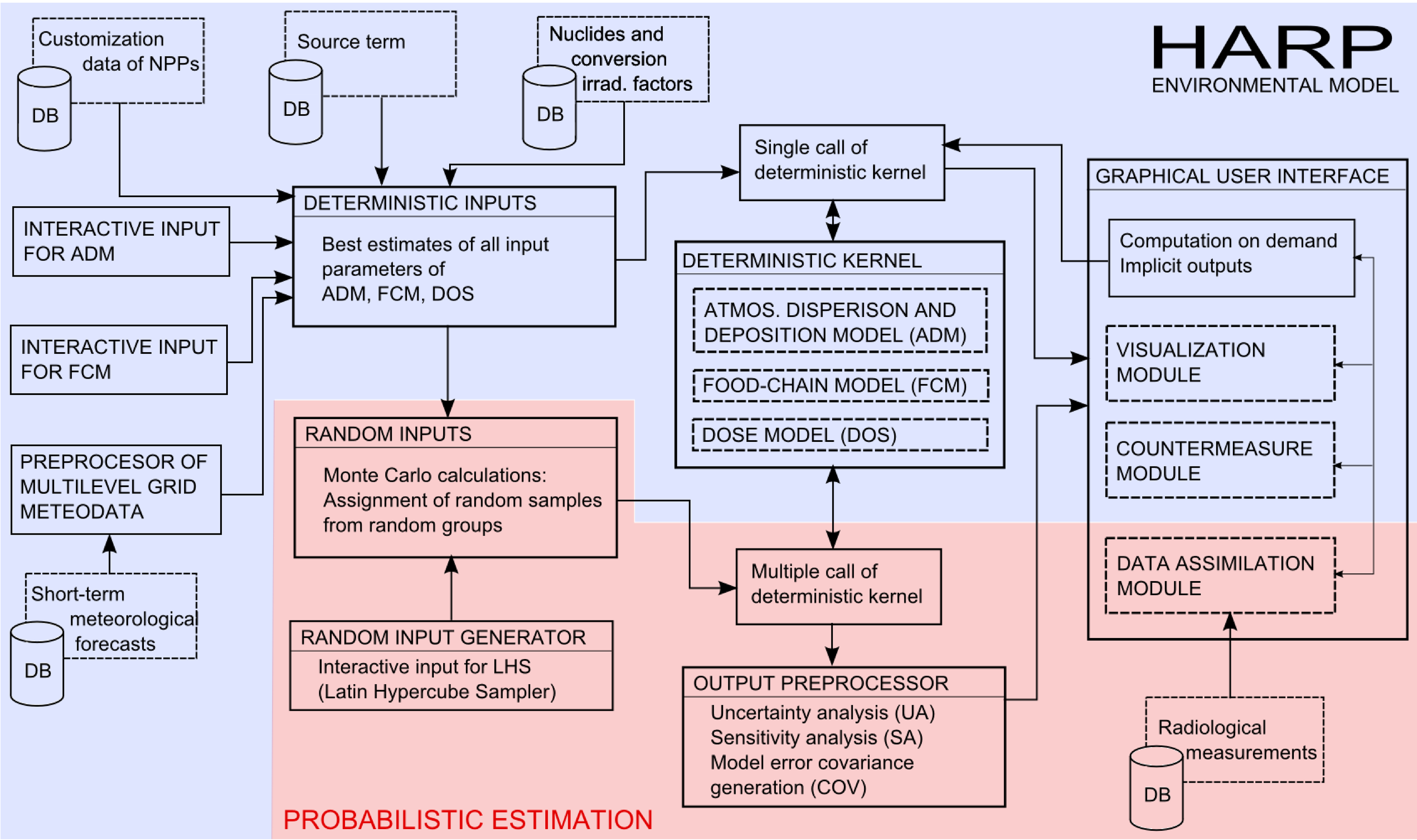
Introduction

System HARP is designed for fast assessment of radiological consequences of accidental releases of radionuclides into the living environment. Transport of toxic agens is studied from initial atmospheric propagation up to 100 kilometeres from the source of pollution. Dispersion, deposition and successive radioactivity transport toward human body is modeled. Deterministic estimation of consequences is superseded by **probabilistic approach**. The product is intended for its utilization e.g. for staff training and students' education.



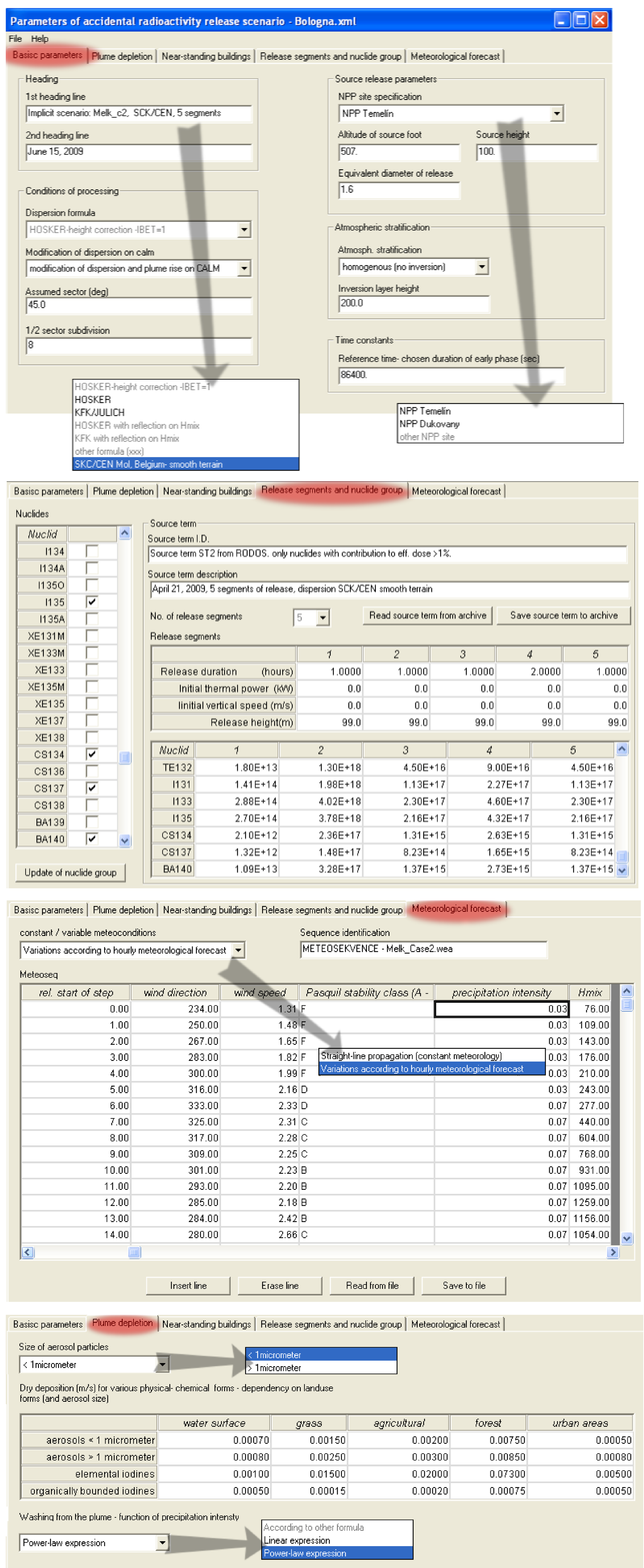
Interactive regime offers wide range of input data and model parameters alternative options thus enabling fast examination of their **variability** and **uncertainty** on random fluctuations of resulting outputs. The final goal of progression is integration of assimilation subsystem ([5],[4]) for improving the model predictions.

Interactive input subsystems

Prospective user has interactive access into "hot" input definitions of a given release scenario. Alternative options are offered for important input data or model parameters that helps to estimate uncertainty propagation through the model and to judge roughly the effects arising from imperfect parametrization of complex physical reality.

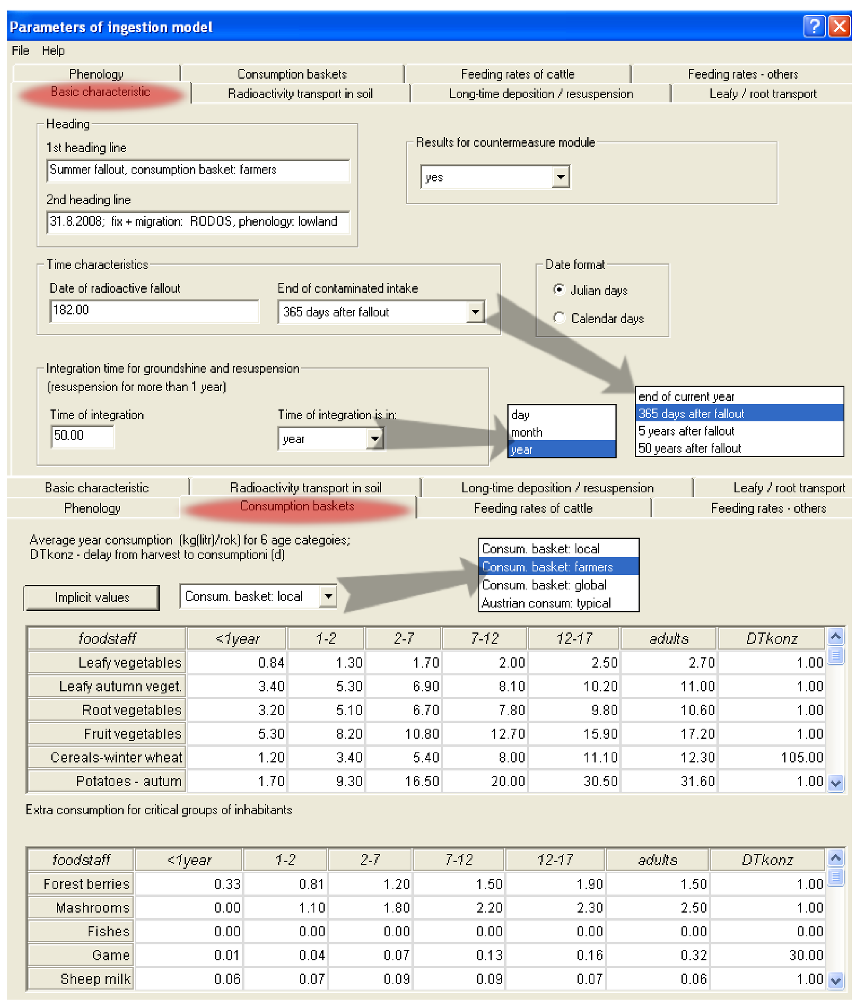
Entering ADM interactively

Atmospheric dispersion and deposition model (ADM) is based on segmented Gaussian plume approach [4] which can approximately account for release dynamics and short term meteorological forecast. Parameters of 6 subgroups (**Scenario, Plume depletion, Near-standing objects, Segments of release, Meteorology**) can be unrolled onwards. After filling up, the complete definitions are archived under selected run-id and can be recalled, possibly modified and re-run with fast response.



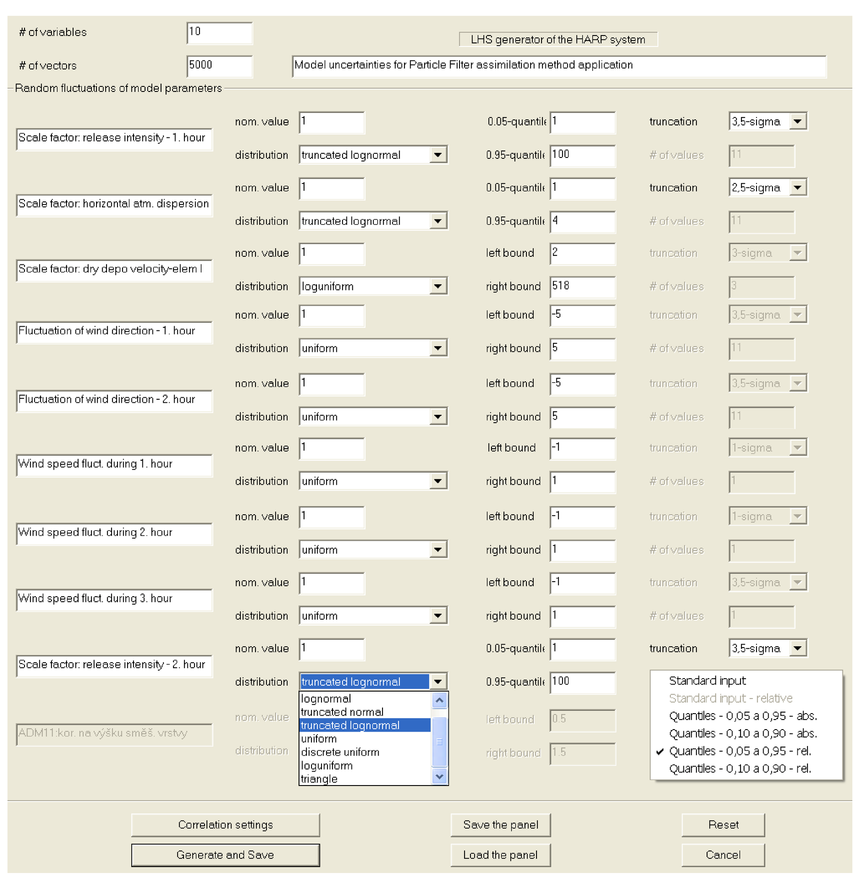
Ingestion control panel

Parameters of dynamic food chain model (FCM) [3] for estimation of internal irradiation due to consumption of contaminated foodstaffs are split into 8 subgroups, can be unrolled onwards and then archived, e.g.:



LHS sampling tool

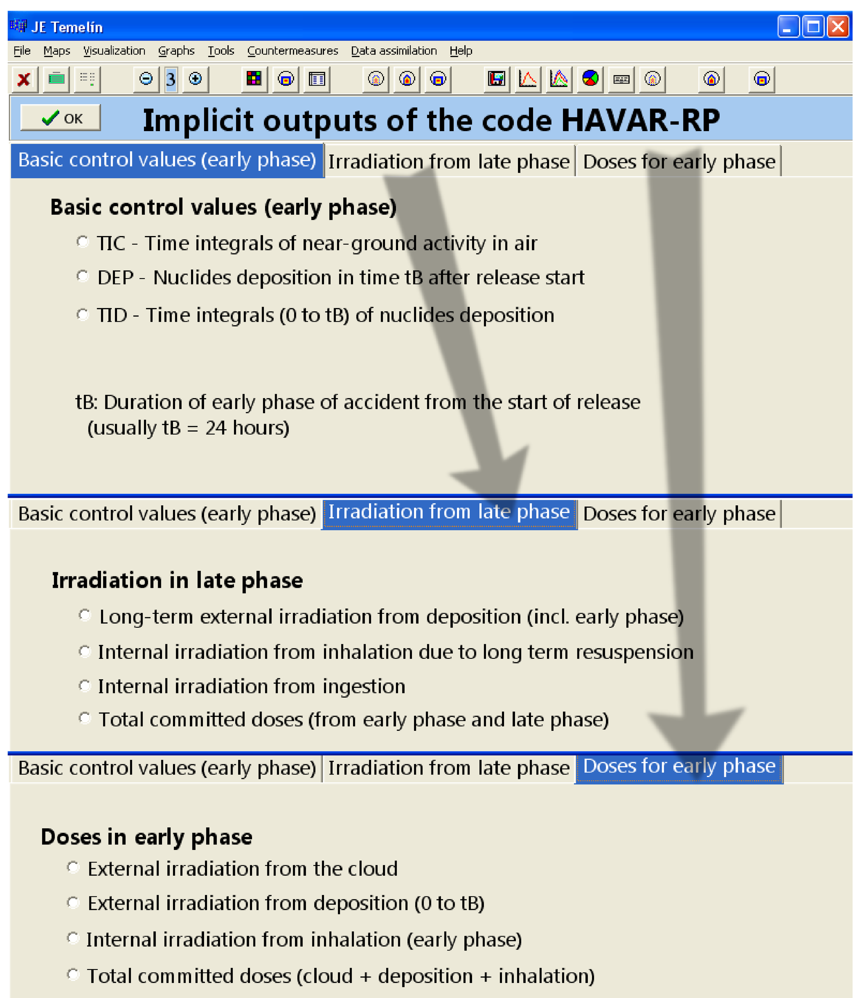
Generation of random samples from uncertainty groups of ADM, FCM and DOS models are constructed using Latin Hypercube Sampling algorithms. Distributions of random characteristics are selected according to expert judgment and elicitation procedures. Special solution for assignment of random variable range is demonstrated on the following panels:



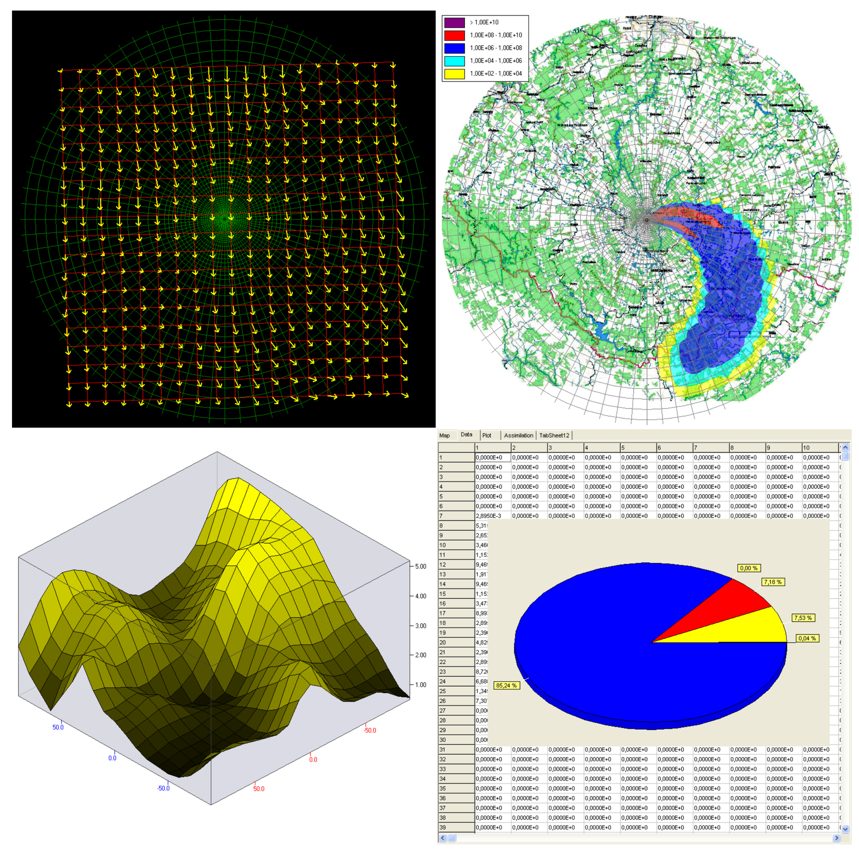
The HARP system in its probabilistic version offers 3 implicit groups of input data and model parameters. The first group consists of 14 random members and stands for ADM model. Subsequent group for FCM model offers 16 random items and group for dosimetric model DOS has 9 random members. The groups were assembled on basis of extensive literature review and expert judgments.

Conversational mode of result visualization

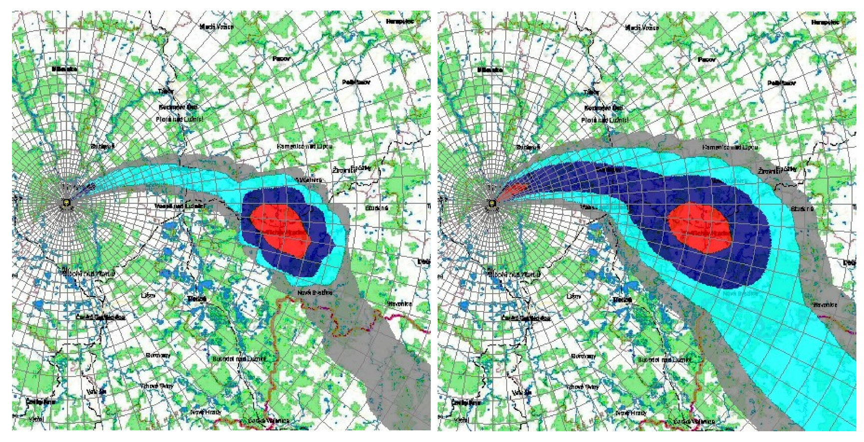
The main principal quantities of concentrations in air, time integrals of near-ground activity concentration, specific deposition on terrain and its time integrals are calculated in the early stage of accident by means of segmented Gaussian plume algorithm. Implemented numerical difference scheme enables to simulate approximately formation of important parent-daughter pairs. Just after the time consuming early-stage analysis is completed, the main task is waiting and the autonomous visualization subsystem is started. Both tasks are cooperating on–line and wide range of various graphical results can be demonstrated **conversationally**, on basis of **user demands**.



The main goal of the architecture lies in establishing of user friendly environment with fast response time and saving of computational resources. Identical principle "**on demand**" is embodied for assessment of some countermeasure actions introduced on protection of population. Some alternative ingestion scenarios can be compared conversationally, too. The product HARP is fully localized for both Czech NPP Dukovany and Temelin. The results are displayed on the proper map backgrounds provided by company PJSOFT.



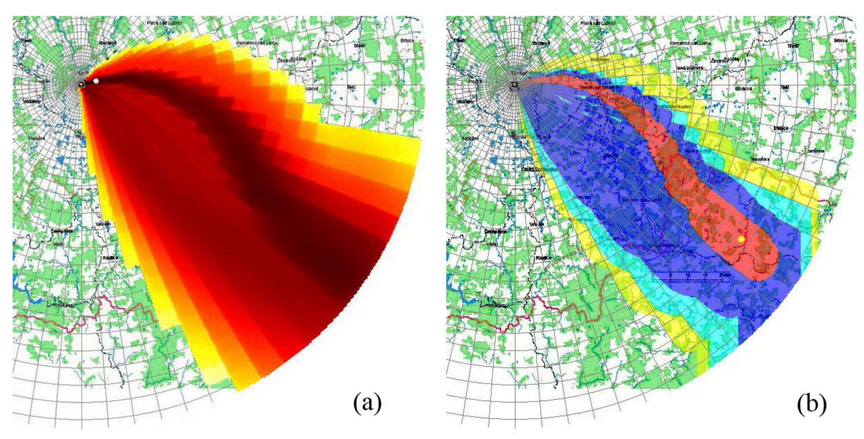
Picture below: *Spatial distribution of* $^{137}\mathrm{Cs}$ *activity deposition on terrain* [$Bq \cdot m^{-2}$]*. Deterministic "best estimate" (left) is compared with probabilistic calculation of sample mean (right – 5000 samples). Retrospective meteorological forecast sequence "CASE2" from June 28, 2002 with release start at 00 UTM was used (scenario from joint Czech-Austrian workshop STEP II b). The "red bull" eye in deposited activity is caused by local atmospheric precipitation, which occurred between hours 5 to 6 after the release start (random rain intensity has uniform distribution* $U[0; 6mm \cdot h^{-1}]$ *). Significance of probabilistic assessment approach is evident. It enables generate more informative probabilistic answers on assessment questions.*



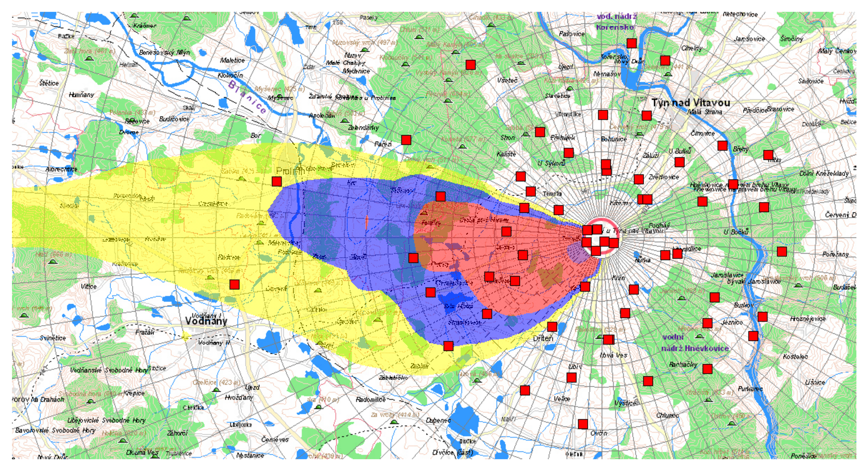
Data assimilation (DA): From model to reality

Detailed predictions of pollution infiltration into the living environment and propagation of uncertainties through the model is inevitable prerequisite for application of advanced statistical methods for assimilation of observations incoming from terrain with model results. The techniques are based on **optimal blending** of all information resources including prior physical knowledge given by model, observations incoming from terrain, past experience, expert judgment and intuition. In broader sense, assimilation techniques cover various methods from pure interpolation methods (none or poor informative model available) over empirical methods of successive corrections up to statistically constant methods of optimal interpolation (OI), that can handle model and measurement errors. Advanced DA techniques account for time evolution of forecast and model error covariance structure.

Real scenario of radioactivity dissemination represents complex problem, which requires a good degree of understanding and ad hoc developments. We have tested several DA techniques and applied them in the late stage of radiation accident (prediction of long term evolution of ^{137}Cs deposition on terrain [2]). The first results are achieved for early phase based on particle filter methodology [1].



Examples of model inputs to DA process: (a) Visualization of a section of model error covariance structure in a dimension (covariance of certain point of polar network with the rest of points); (b) Modeled values of estimated quantity



Prediction of ^{131}I *contamination on terrain juster after three hours from release start. Red squares are real positions of the Czech Radiation Monitoring Network measurement stations. Objective: improvement of model predictions in early phase on basis of incoming measurements.*

Acknowledgment

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