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DEVELOPMENT OF REAL-TIME BAYESIAN DATA ASSIMILATION SYSTEM FOR OFF-SITE CONSEQUENCE ASSESSMENT

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Decision support system HARP has been developed for more than 10 years. Since the first version, the system was vastly improved and nowadays it is a modern modeling, analysis and educational tool for emergency preparedness in radiation protection. Presented data assimilation (DA) module is a part of HARP.

DA refers to a group of mathematical methods for an efficient combination of observed data with a numerical model. We approach the challenging task of real-time correction of a dispersion model using Bayesian inference of available gamma dose measurements. Specifically, sequential Monte Carlo (SMC) methods are applied to estimate the most important variables describing the aerial propagation of radionuclides (source term, bias of meteorological data etc.). Contrary to point-wise (maximum likelihood) estimates or filters for parameterized densities (Kalman filter, variational methods), the SMC methods approximate the probability distributions of quantities of interest with a set of samples. Further statistical processing of these empirical distributions can provide probabilistic answers on questions of the decision makers, e.g.: What is the probability of exceeding a given threshold of deposition on terrain in a particular location? Moreover, these distributions can enter subsequent models like dynamic compartment ingestion model for simulation of radionuclide transport in the terrestrial biosphere (atmosphere-soil-vegetation-foodstuffs-human body). Currently, the DA module is developed with a Lagrangian puff model successfully validated against COSYMA, MACCS and RODOS. However, modular structure of the system enables insertion of an arbitrary dispersion model with appropriate application interface.

DA module is intended to operate in two regimes: (i) autonomous on-line regime; and (ii) supervised off-line regime. On-line regime is important during the early phase of an accidental release of radionuclides into the atmosphere. In this regime, measured radiological data are gathered on-line from a stationary radiation monitoring network (RMN) and/or mobile groups (e.g. drones). Forecast meteorological data are gathered using a meteorological preprocessor compatible with WRF and ALADIN numerical weather forecast models. Since this regime is fully autonomous, it continuously evaluates incoming measurements. DA procedure is automatically triggered if abnormal values are detected and prediction of spatiotemporal distribution of radionuclides is successively corrected real-time using these measurements. In off-line regime, radiological measurements and/or meteorological data are entered by user. This regime can be used for retrospective assessment of the release, simulation of "what-if" scenarios and for educational purposes. It can be also applied for testing of different settings of a RMN and assessing its capability to detect releases under various circumstances.

The system is implemented using client-server architecture, where the computational code running on a parallel architecture is the server side. Users can connect to it using web and desktop clients with a graphical user interface. The focus is paid to ease of use and illustrative visualization of DA results. The variety of client types and usage of open technologies (Python, Cython) make the system flexible and platform-independent. The development is supported by the project VG20102013018 provided by the Ministry of Interior of the Czech Republic.

KEYWORDS: Data Assimilation, Sequential Monte Carlo, Atmospheric Dispersion Modeling, Decision Support System, Client-Server Architecture