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Inverse modelling of radionuclide release rates using gamma dose rate observations

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Severe accidents in nuclear power plants such as the historical accident in Chernobyl 1986 or the more recent disaster in the Fukushima Dai-ichi nuclear power plant in 2011 have drastic impacts on the population and environment. The hazardous consequences reach out on a national and continental scale. Environmental measurements and methods to model the transport and dispersion of the released radionuclides serve as a platform to assess the regional impact of nuclear accidents – both, for research purposes and, more important, to determine the immediate threat to the population.

However, the assessments of the regional radionuclide activity concentrations and the individual exposure to radiation dose underlie several uncertainties. For example, the accurate model representation of wet and dry deposition. One of the most significant uncertainty, however, results from the estimation of the source term. That is, the time dependent quantification of the released spectrum of radionuclides during the course of the nuclear accident. The quantification of the source terms of severe nuclear accidents may either remain uncertain (e.g. Chernobyl, Devell et al., 1995) or rely on rather rough estimates of released key radionuclides given by the operators. Precise measurements are mostly missing due to practical limitations during the accident.

Inverse modelling can be used to realise a feasible estimation of the source term (Davoine and Bocquet, 2007). Existing point measurements of radionuclide activity concentrations are therefore combined with atmospheric transport models. The release rates of radionuclides at the accident site are then obtained by improving the agreement between the modelled and observed concentrations (Stohl et al., 2012). The accuracy of the method and hence of the resulting source term depends amongst others on the availability, reliability and the resolution in time and space of the observations. Radionuclide activity concentrations are observed on a relatively sparse grid and the temporal resolution of available data may be low within the order of hours or a day. Gamma dose rates on the other hand are observed routinely on a much denser grid and higher temporal resolution. Gamma dose rate measurements contain no explicit information on the observed spectrum of radionuclides and have to be interpreted carefully. Nevertheless, they provide valuable information for the inverse evaluation of the source term due to their availability (Saunier et al., 2013).

We present a new inversion approach combining an atmospheric dispersion model and observations of radionuclide activity concentrations and gamma dose rates to obtain the source term of radionuclides. We use the Lagrangian particle dispersion model FLEXPART (Stohl et al., 1998; Stohl et al., 2005) to model the atmospheric transport of the released radionuclides. The gamma dose rates are calculated from the modelled activity concentrations. The inversion method uses a Bayesian formulation considering uncertainties for the a priori source term and the observations (Eckhardt et al., 2008). The a priori information on the source term is a first guess. The gamma dose rate observations will be used with inverse modelling to improve this first guess and to retrieve a reliable source term. The details of this method will be presented at the conference.

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