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A Bayesian Algorithm for Assessing Uncertainty in Radionuclide Source Terms

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Inferring source term parameters for a radionuclide release is difficult, due to the large uncertainties in forward dispersion modelling as a consequence of imperfect knowledge pertaining to wind vector fields and turbulent diffusion in the Earth's atmosphere. Additional sources of error include the radionuclide measurements obtained from sensors. These measurements may either be subject to random fluctuations or are simple indications that the true, unobserved quantity is below a detection limit. Consequent large reconstruction uncertainties can render a "best" estimate meaningless. A Markov Chain Monte Carlo (MCMC) Bayesian Algorithm is presented that attempts to account for uncertainties in atmospheric transport modelling and radionuclide sensor measurements to quantify uncertainties in radionuclide release source term parameters. Prior probability distributions are created for likely release locations at existing nuclear facilities and seismic events. Likelihood models are constructed using CTBTO adjoint modelling output and probability distributions of sensor response. Samples from the resulting multi-isotope source term parameters posterior probability distribution are generated that can be used to make probabilistic statements about the source term. Examples are given of marginal probability distributions obtained from simulated sensor data. The consequences of errors in numerical weather prediction wind fields are demonstrated with a reconstruction of the Fukushima nuclear reactor accident from International Monitoring System radionuclide particulate sensor data.