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Towards non-linear inverse problem for atmospheric source term determination

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The basic linear inverse problem of atmospheric release can be formulated as $\mathbf{y} = M\,\mathbf{x} + \mathbf{e}$, where $\mathbf{y}$ is the measurement vector which is typically in the form of gamma dose rates or concentrations, M is the source-receptor-sensitivity (SRS) matrix, $\mathbf{x}$ is the unknown source term to be estimated, and $\mathbf{e}$ is the model residue. The SRS matrix M is computed using an atmospheric transport model coupled with meteorological reanalyses. The inverse problem is typically ill-conditioned due to number of uncertainties, hence, the estimation of the source term is not straightforward and additional information, e.g. in the form of regularization or the prior source term, is often needed. Besides, traditional techniques rely on assumption that the SRS matrix is correct which is not realistic due to the number of approximations made during its computation. Therefore, we propose relaxation of the inverse model using introduction of the term Δ_M such as $\mathbf{y} = (M+ \Delta_M)\,\mathbf{x} + \mathbf{e}$ leading to non-linear inverse problem formulation, where Δ_M can be, as an example, parametric perturbation of the SRS matrix M in the spatial or temporal domain. We estimate parameters of this perturbation together with solving the inverse problem using variational Bayes procedure. The method will be validated on synthetic dataset as well as demonstrated on real case scenario such as the controlled tracer experiment ETEX or episode of ruthenium-106 release over the Europe on the fall of 2017.