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Sensitivity Operator Inverse Modeling Framework for Advection-Diffusion-Reaction Models with Heterogeneous Measurement Data

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Air quality monitoring systems vary in temporal and spatial coverage, the composition of the observed chemicals, and the data's accuracy. The developed inverse modeling approach [1] is based on sensitivity operators and ensembles of adjoint equations solutions. An inverse problem is transformed to a quasi-linear operator equation with the sensitivity operator. The sensitivity operator is composed of the sensitivity functions, which are evaluated on the adjoint ensemble members. The members correspond to the measurement data elements.

This ensemble construction allows working in a unified way with heterogeneous measurement data in a single operator equation. The quasi-linear structure of the resulting operator equation allows both solving and analyzing the inverse problem. More specifically, by analyzing the sensitivity operator's singular structure, we can estimate the informational content in the measurement data with respect to the considered process model. This type of analysis can estimate the inverse problem solution before its actual solution and evaluate the monitoring system efficiency with respect to the considered inverse modeling task [1,2].

Numerical experiments with the emission source identification problem for air pollution transport and transformation model were carried out to illustrate the developed framework. In the numerical experiments, we considered in-situ, image-type, and integral-type measurement data.

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