

Parameter estimation and uncertainty quantification applied to advection-diffusion problems arising in atmospheric sources inversion

abstract

In this thesis we present a method to obtain an efficient algorithm to perform parameter estimation with uncertainty quantification of mathematical models that are complex and computationally expensive. We achieve this with a combination of emulation of the mathematical model using Gaussian processes and Bayesian statistics and inversion for the parameter estimation and uncertainty quantification. In particular we apply these ideas to a source inversion problem in atmospheric dispersion.

We explain the theory and ideas behind each relevant part of the process in the emulation and parameter estimation. The concepts and methodology presented in this work are general and can be applied to a wide range of problems where it is necessary to estimate parameters but the underlying mathematical model is expensive, rendering more classical approaches unfeasible.

To validate the concepts used, we perform a parameter estimation study in a model that is relatively cheap to compute and whose parameter values are known in advance. Finally we perform a parameter estimation with uncertainty quantification of a much more expensive atmospheric dispersion model using real data from a lead-zinc smelter in Trail, British Columbia. The parameter estimation includes approximating high-dimensional integrals with Markov chain Monte Carlo methods and solving the source inversion problem in atmospheric dispersion using the Bayesian framework.