PBDW: a non-intrusive Reduced Basis Data Assimilation method and its application to outdoor Air Quality Models

Janelle Katharine HAMMOND*▪, Rachida CHAKIR ▪, Fréderic BOURQUIN▪

and Yvon MADAY†◊

▪Université Paris Est, IFSTTAR, 14-20 Bd Newton, Cité Descartes, Champs-sur-Marne, 77447 Marne-la-Vallée Cedex 2, France
(janelle.hammond ; rachida.chakir ; frederic.bourquin)@ifsttar.fr

†Sorbonne Universités, UPMC Univ Paris 06, UMR 7598, Laboratoire Jacques-Louis Lions, F-75005, Paris, France;

◊ Institut Universitaire de France F-75005, Paris, France;
Division of Applied Mathematics, Brown University, Providence, RI 02912, USA
(maday@ann.jussieu.fr)

ABSTRACT

With increased pollutant emissions and exposure due to mass urbanization worldwide, air quality measurement campaigns and epidemiology studies on air pollution and health effects have become increasingly common to estimate individual exposures and evaluate their association to various illnesses. As air pollution concentrations are known to be highly heterogeneous, sophisticated physically based air quality models (AQMs), in particular models based on Computational Fluid Dynamics, can provide spatially rich approximations and enable to better estimate individual exposure. In this work we investigate reduced basis (RB) methods [1] to diminish the resolution cost of advanced AQMs developed for concentration evaluation at urban scales. These models depend on varying parameters including meteorological conditions and pollutant emissions, often unknown at the micro scale. RB methods use approximation spaces made of suitable samples of solutions of AQMs governed by parameterized partial differential equations (PDEs), to rapidly construct accurate and computationally efficient approximations. A key to this technique is decomposing computational work into an offline and online stage. The RB functions used to build approximation spaces and all expensive parameter-independent terms, are computed “offline” once and stored, whereas inexpensive parameter-dependent quantities are evaluated “online “ for each new value of the parameters. However, the decomposition of the matrices into offline-online pieces requires modifying the calculation code, an intrusive procedure, which in some situations is impractical.

In this work, we extend the Parameterized-Background Data-Weak (PBDW) method introduced in [2] to physically based AQMs. We will generate a sample of solutions from physical AQMs with varying meteorological conditions and pollution emissions to build the RB approximation space and combine it with experimental observations, using the method in [3], to improve pollutant concentration estimations, with the goal of collaboration with an epidemiology exposure assessment team at the University of California-Berkeley. The goal is to rapidly estimate “online” pollutant concentration(s) around an area of interest at micro scale, using available AQMs in a non-intrusive and computationally efficient manner.

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