PBDW: a reduced order variational data assimilation method for real-time monitoring of urban air quality

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As the population increases, cities must constantly reassess their urban planning. However, this must be done in such a way to preserve the quality of life of its inhabitants. Energy saving, sustainable water and air quality are some of the important challenges associated with growing cities. In this context, the monitoring of urban air quality is very important. For instance data assimilation approaches can be used in monitoring. These methods incorporate available measurement data and mathematical model to provide improved approximations of the physical state. The effectiveness of modeling and simulation tools is essential. Advanced physically-based models could provide spatially rich small-scale solutions, however the use of such models is challenging due to explosive computational times in real-world applications. Beyond computational costs, physical models are often constrained by available knowledge on the physical system such as input parameters. To overcome these difficulties, we resort the Parameterized-Background Data-Weak (PBDW) method introduced in [1]. The PBDW formulation combines a set of solutions (a reduced basis [2]) from the physical model, and available experimental observations, in order to provide a real-time and in-situ state estimate. The reduced basis is used to diminish the cost of using a high-resolution model by exploiting the parametric structure of the governing equations. In addition, variational data-assimilation techniques are used to correct the model error. In this work we extend the PBDW method to the study of urban air quality as an important case study but also as an example of the very generic approach which proves well suited to in-situ urban flow monitoring over large scales, and in the context of parameterized numerical models with observational data. In case studies presented here, the method allows to correct for unmodeled physics and treat cases of unknown parameter values, all while significantly reducing online computational time.

Références

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