Deep learning based rapid response tools for air pollution prediction and uncertainties analysis

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Abstract

In this work, we introduce an advanced rapid numerical predictive model for uncertainty analysis which is based on the machine learning and Singular Value Decomposition - Proper Orthogonal Decomposition (SVD-POD). SVD-POD or deep machine learning can be used to reduce the computational effort on several aspects: on the dimensional size of the original model and the dataset by identifying the most important data, or as a new method for data assimilation. Applying this new technology to uncertainty analysis, data assimilation and optimization methods will reduce the CPU time significantly. Having a very rapid reduced order modelling (ROM) compatibility developed here will be nothing short of revolutionary for a large number of disciplines not least of all pollutant flow based disciplines. For all application areas, having a rapid ROM could potentially make tractable computationally demanding predictive problems: uncertainty analysis, data assimilation, optimizing monitoring/sensors/instrumentation/observations, optimal experimental design and control. ROM's may be used in place of highly simplified (e.g. Gaussian plume dispersion modelling for air pollution) whilst maintaining the complexity of 3D models.

Optimal design and sensitivity analysis can be used to identify the key parameters (e.g. pollutant source location and intensity). Therefore, we will be able to guide the decision makers about the pollutant sources so they can prevent/combat/mitigate this by identifying where the pollutant is coming from. In this work, we will demonstrate the capabilities of this new rapid model by applying it to the realistic cases in the UK and China.

Key words: Deep learning, reduced order modelling, uncertainty analysis, air pollution.