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Real-time assessment of ventilation efficiency in mines: Accuracy improvement with data clustering and support vector classification

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The real-time assessment of ventilation efficiency in mines, presented in this work, is based on a methodology composed by two main steps: (a) Computational Fluid Dynamics (CFD) simulations, using a modified version of the buoyantPimpleFoam solver (OpenFoam 2012); and (b) Reduced Order Models (ROMs), generated with an in-house developed library (CAELIA TWINKLE¹) fed with the outputs of a number of CFD simulations. The resulting ROMs allow the air quality assessment in real time not only under the operating conditions previously simulated (CFD) but also for any operating conditions in between.

In this work, the methodology is applied for the ventilation assessment of a real use case (an underground mine).

The most challenging part of the methodology deployment is to build accurate ROMs. The precision of these ROMs depends on several factors, such as: (a) the accuracy of the CFD model outputs; and (b) the correct selection of the ROM technique and associated parameters. To ensure the first one, the CFD results are validated using data gathered from physical sensors. With regard to the second one, this work presents an improved workflow for ROM generation to properly capture the physics of the ventilation processes, where a small modification in the operating conditions can generate an abrupt change of the air pathlines (non-linear response / discontinuities).

This improved workflow is based on data clustering and Support Vector Classification (SVC). First, the CFD results are grouped using clustering techniques in different sets, according to the different pathlines distributions. Next, individual ROMs are built for every data set. Finally, for the given operating conditions (ROM input), SVC is applied to select the correct ROM to be evaluated.

Predictions of the ROMs built with this new methodology for a real use case are compared with both experimental data and predictions from other ROMs obtained by classical reduction (no data clustering nor SVC).

¹ <https://github.com/caelialTAINNOVA/Twinkle>