Reduced-order hygrothermal modeling based on Proper Generalized Decomposition for building simulation

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ABSTRACT

Detailed modelling of the combined Heat And Moisture (HAM) transfer in building envelopes is a very important issue for the precise assessment of building energy performance of new and retrofitted buildings, envelope durability and mould growth risks. Most of the models available in the literature are based on a numerical solution of heat and moisture transfer governing equations and require high computer run times. Indeed, several reasons can lead to increase the complexity of models. First, when there is heterogeneity the transport phenomenon needs to be considered in 2- or 3-dimensions. Secondly, due to the high moisture content dependence of material properties, short time step are required for long-time simulation periods of one or many years. Thus, innovative and efficient ways of solving the hygrothermal transfer are worth of investigation to reduce the computational complexity of HAM models and enable to speed up whole-building hygrothermal simulations to solve complex problems.

The bottleneck from the numerical viewpoint is represented by both the nonlinear coupling between the heat and moisture transfer problems and the wide separation between the thermal and hygrometric characteristic time scales which means in practice that long term simulations need to be performed using a very small time-step. To circumvent this problem we adopt a space-time separated-variables representation and solve the equations using the Proper Generalized Decomposition [1,2,3]. The non-linearity is treated using the so called "Cross-Approximation" approach that allows to efficiently evaluate the nonlinear terms from the low rank separated-variables approximation of the solution [4].

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