Bayesian Uncertainty Analysis to Estimate Thermal Properties of Walls from Indirect Measurements

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The RESBATI project, funded by the French National Research Agency, aims at developing a portable measurement device for evaluating the thermal resistance of walls and its associated uncertainty. The active method (a thermal gradient inside the wall is created by a step heating excitation applied on a face) chosen in the project allows to estimate the thermal resistance of a building wall in quite a short measurement time (less than 24 h) which improves on classical steady-state or dynamic methods.

In this work, we propose a Bayesian uncertainty analysis of the indirect measurement of thermal properties of walls from in-situ temperature and flux measurements, obtained with the active method using a one dimensional transient thermal model. We show that this approach is able to take into account the uncertainty associated with the input parameters of the thermal model and the uncertainty of the output observations, for a more reliable uncertainty estimation of the calibration parameters and any derived quantity. For this problem, we improve the classical inversion model by taking into account possibly underestimated reported output observation uncertainties, which is a frequently encountered issue in practice.

We illustrate this new methodology in a real case study to estimate the thermal resistance of a wall with inner wall insulation (IWI) built within the RESBATI project.

For this application, we compare results of the Bayesian approach of active measurements obtained in a climatic chamber with the guarded hot box (ISO 8990:1994, 1994) results in comparable experimental conditions. We perform a sensitivity analysis to study the effect of duration and input uncertainty on the thermal resistance and its associated uncertainty and we make recommendations for a more general use of the method.