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Bayesian multifidelity modeling to estimate thermal resistance of building walls

As more and more new materials (like raw earth, hemp concrete, etc) are used in the construction of building walls, their thermal resistance needs to be evaluated, not only at the laboratory scale, but also and more importantly in situ, at the building scale where potentially used in conjunction with other materials. A dedicated experimental prototype device limiting the influence of external weather conditions was designed within the French ANR RESBIOBAT project to produce surface temperatures and fluxes measurements to be used in an inversion procedure. However, classical inversion procedures may be limited by their capacity to handle uncertainty sources and by the prohibitive cost of the direct models used to reproduce complex physical phenomenon due e.g. to the presence of humidity in the wall and 3D effects.
This work investigates the use of multifidelity approaches in a Bayesian inversion framework to estimate the thermal resistance of opaque building walls. The approach combines low-fidelity models such as simplified thermal simulations with high fidelity thermal or hygro-thermal models. Utilizing Gaussian Process based surrogates of codes, this multifidelity Bayesian modeling technique allows for the integration of multiple sources of information with quantified uncertainties, enabling more robust and efficient parameter inference compared to conventional single-fidelity approaches. Posterior distributions of thermal resistance are computed, providing not only point estimates but also credible intervals that reflect both measurement and model uncertainties. This approach offers a promising direction for in-situ thermal characterization, particularly for new building materials and systems that challenge standard testing methods.

Special/ Invited session

Classification

Both methodology and application

Keywords

Bayesian analysis, uncertainty quantification, multifidelity

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