

Bayesian uncertainty quantification for transient heat conduction problems with temperature-dependent conductivity

Citation for published version (APA):

Silva, R. L. S., Verhoosel, C. V., & Quaeghebeur, E. (2023). *Bayesian uncertainty quantification for transient heat conduction problems with temperature-dependent conductivity*. Abstract from 5th International Conference on Uncertainty Quantification in Computational Science and Engineering, Athens, Greece.

Document status and date:

Published: 01/01/2023

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Bayesian uncertainty quantification for transient heat conduction problems with temperature-dependent conductivity

Rodrigo L. S. Silva^{*}, Clemens Verhoosel, Erik Quaeghebeur

Eindhoven University of Technology
5612 AZ Eindhoven

r.lima.de.souza.e.silva@tue.nl, c.v.verhoosel@tue.nl, e.quaeghebeur@tue.nl

ABSTRACT

We present an inverse analysis for the estimation and uncertainty quantification of a temperature dependent thermal conductivity. For that, we consider the one-dimensional problem of a slab made of steel with a temperature-dependent thermal conductivity, to which a constant heat flux is applied at both edges. After defining the mathematical formulation, we can numerically solve the direct problem and derive transient temperature values across the slab. A third-degree polynomial is used to model the temperature-dependence of the conductivity [1], so the estimation of this physical property is obtained through the estimation of the polynomial's coefficients. We use a Bayesian framework [2-4] to model the uncertainties involved, consisting of a likelihood and a prior. The likelihood models the temperature measurements and their uncertainties, and is chosen to be a normal distribution with mean at the solution of the direct problem and a standard deviation characterizing the errors. The prior models our pre-existing knowledge about the coefficients that describe the thermal conductivity. To gain insights about the impact of using different priors, we investigate both uniform and normal distributions. The prior and likelihood are combined into a posterior, which describes the coefficients for a given set of temperature measurements. This posterior cannot be computed analytically, and therefore we solve the inverse problem with the Metropolis–Hastings algorithm [3, 4], a Markov chain Monte Carlo method. Results showed that our approach could deal with all uncertainties involved, and not only provided an estimation of the thermal conductivity curve but also delivered uncertainty quantification using credible intervals. It can furthermore be modified to estimate thermal conductivity values instead of coefficients, allowing for a more physical formulation of the prior.

References

- [1] Aquino, Wilkins, and John C. Brigham. "Self-learning finite elements for inverse estimation of thermal constitutive models." *International journal of heat and mass transfer* 49.15-16 (2006): 2466-2478.
- [2] Gelman, Andrew, et al. *Bayesian data analysis*. Chapman and Hall/CRC, 1995.
- [3] Kaipio, Jari, and Erkki Somersalo. *Statistical and computational inverse problems*. Vol. 160. Springer Science & Business Media, 2006.
- [4] Özisik, M. Necati, and Helcio RB Orlande. *Inverse heat transfer: fundamentals and applications*. Routledge, 2018.