SpringerBriefs in Applied Sciences and Technology

Rachid Ababou · Juliette Chastanet · Jean-Marie Côme · Manuel Marcoux · Michel Quintard

Uncertainty Analyses in Environmental Sciences and Hydrogeology

Methods and Applications to Subsurface Contamination

Springer

SpringerBriefs in Applied Sciences and Technology

SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic.

Typical publications can be:

- A timely report of state-of-the art methods
- An introduction to or a manual for the application of mathematical or computer techniques
- A bridge between new research results, as published in journal articles
- A snapshot of a hot or emerging topic
- An in-depth case study
- A presentation of core concepts that students must understand in order to make independent contributions

SpringerBriefs are characterized by fast, global electronic dissemination, standard publishing contracts, standardized manuscript preparation and formatting guidelines, and expedited production schedules.

On the one hand, **SpringerBriefs in Applied Sciences and Technology** are devoted to the publication of fundamentals and applications within the different classical engineering disciplines as well as in interdisciplinary fields that recently emerged between these areas. On the other hand, as the boundary separating fundamental research and applied technology is more and more dissolving, this series is particularly open to trans-disciplinary topics between fundamental science and engineering.

Indexed by EI-Compendex, SCOPUS and Springerlink.

Rachid Ababou · Juliette Chastanet ·
Jean-Marie Côme · Manuel Marcoux ·
Michel Quintard

Uncertainty Analyses in Environmental Sciences and Hydrogeology

Methods and Applications to Subsurface Contamination

Springer

Rachid Ababou
Institut de Mécanique des Fluides de Toulouse (IMFT)
Toulouse, France

Jean-Marie Côme
GINGER
Lyon, France

Michel Quintard
Institut de Mécanique des Fluides de Toulouse (IMFT)
Toulouse, France

Juliette Chastanet
GINGER
Lyon, France

Manuel Marcoux
Institut de Mécanique des Fluides de Toulouse (IMFT)
Toulouse, France

ISSN 2191-530X ISSN 2191-5318 (electronic)
SpringerBriefs in Applied Sciences and Technology
ISBN 978-981-99-6240-2 ISBN 978-981-99-6241-9 (eBook)
https://doi.org/10.1007/978-981-99-6241-9

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Paper in this product is recyclable.

Acknowledgments

This book is based in part on previous research work performed in the framework of the ESPER project, funded by ADEME, the French environmental protection agency (Grant award number 1672C0022). The authors wish to acknowledge contributions from graduate students and junior researchers at the Institute of Fluid Mechanics in Toulouse: R. Leroux (IMFT post-doc) on fuzzy and possibilistic approaches; Y. Soumane (IMFT master student 2018-2019) on the 3D analytical model and ESPER-1 probabilistic package. The first author also thanks Pr. K. Alastal (IMFT visiting scientist 2019–2020) for additional help on MATLAB implementation of the 3D analytical model, and Pr. N. El Moçayd (UM6P) for his useful 2022 comment on Sobol indices versus Polynomial Chaos.

Contents

Chapter 1
Introduction, Objectives

The different alternatives for managing a contaminated site are based on a cost/benefit balance that requires predictive modeling to assess mass depletion and duration of contamination source in the subsurface. For instance, the ESPER[1] project (*Evaluation and Sensitivity of models for Predicting the depletion and Remediation of organic contamination sources in subsurface*) was aimed at developing a methodology and a software tool for facilitating the incorporation of uncertainty and sensitivity analyses into such subsurface contamination models.

Let us first clarify from the outset the term "uncertainty propagation."

Mathematical methods of uncertainty analyses can be viewed as "uncertainty propagation" methods, in the sense that they can "propagate" (or "carry") the uncertainty from the input parameters to the outputs of the model. The model may be analytical: a simple example is the first order decay model $C(t) = C_0 \exp(-\lambda t)$. Or it can be a more complex quasi-analytical model containing special functions and simple integrals. Or else, it can be a fully discretized space–time numerical model such as the MODFLOW- SURFACT™ code. It can also be, possibly, a polynomial "meta-model" ("surrogate model") derived from the initial model. The metamodel is essentially an input/output response function, derived from the original model, and which can be used to simplify the uncertainty propagation process (as will be explained later).

This book reviews and illustrates various approaches and methods for uncertainty analysis, and presents various models (from simple to complex) to illustrate these uncertainty analyses, including some model-specific results, and also, site-specific results, from the ESPER project in particular.

This book is organized as follows. After the present introduction, the next chapter (Chap. 2) covers different methods for carrying out uncertainty analysis, starting with an overview of different approaches and concepts. Chapter 3 develops a comprehen-

[1] The ESPER project was funded in part by ADEME, the French environmental protection agency.

R. Ababou et al., *Uncertainty Analyses in Environmental Sciences and Hydrogeology*,
SpringerBriefs in Applied Sciences and Technology,
https://doi.org/10.1007/978-981-99-6241-9_1