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Calibration robuste d'un modèle hydrologique de transfert de pesticides par métamodélisation

Katarina Radišić¹²³
Claire Lauvernet¹, Arthur Vidard²

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²Univ. Grenoble-Alpes, Inria, CNRS, Grenoble-INP, LJK

³ED MSTII

Table of contents

Introduction

Model calibration = minimization of a cost function

Methods

Robust minimizers

Case study

PESHMELBA

Moisture profiles

Results

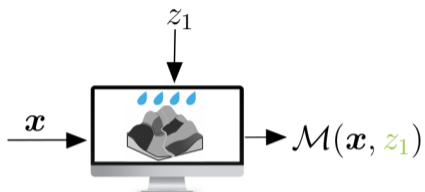
Problem formulation

Minimizers

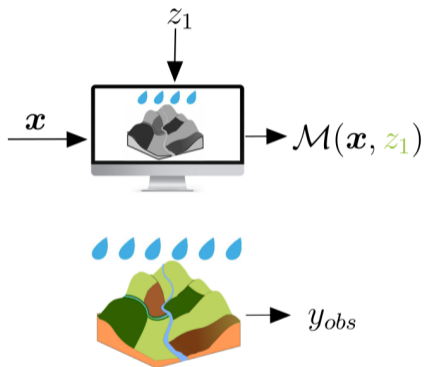
New simulations cost function

Conclusion

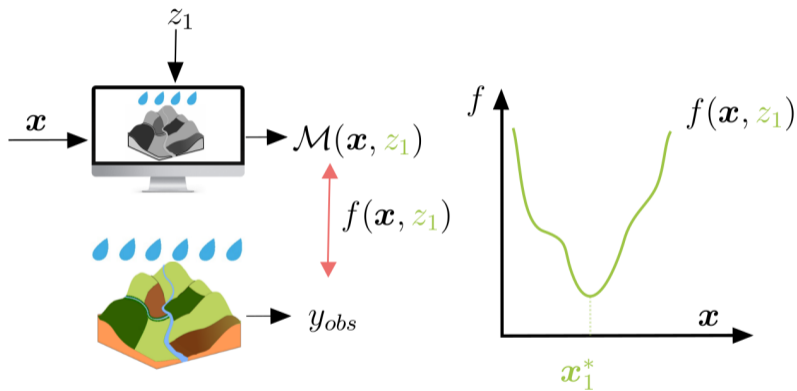
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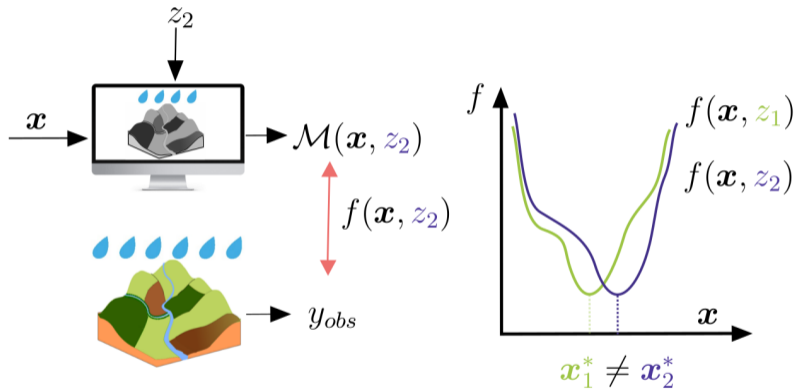
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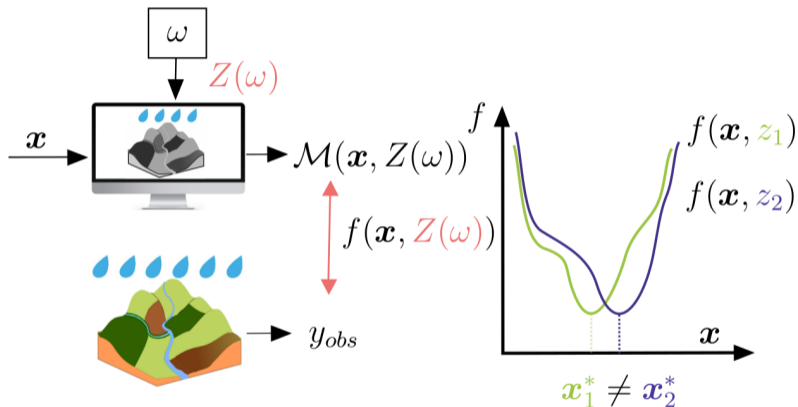
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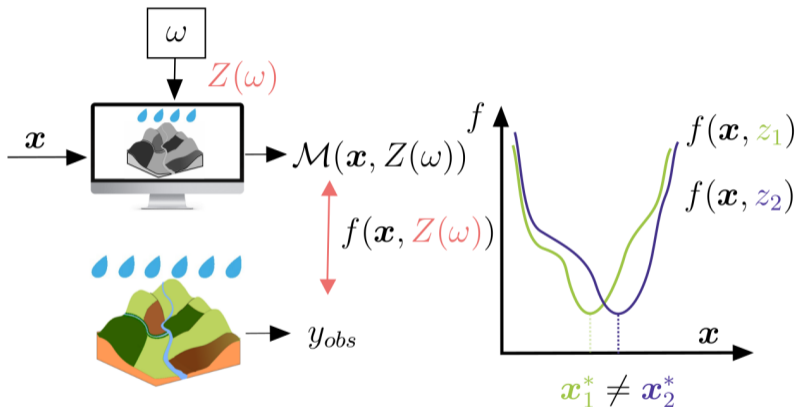
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Introduction: Model calibration = minimization of a cost function



Introduction: Model calibration = minimization of a cost function



How to minimize a stochastic function? → **robust calibration**

Table of contents

Introduction

Model calibration = minimization of a cost function

Methods

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PESHMELBA

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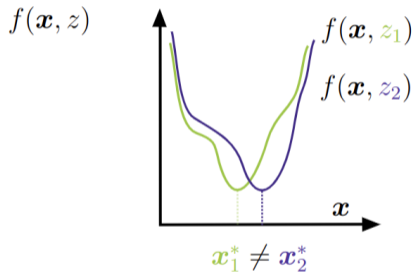
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Minimizers

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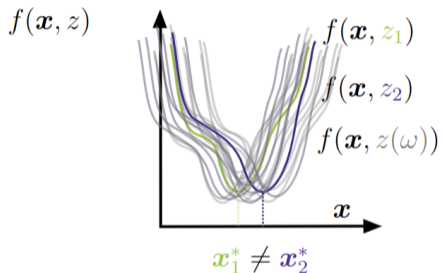
Conclusion

Methods: Robust minimizers



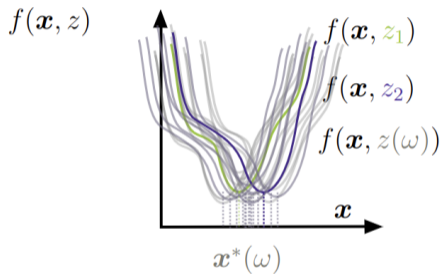
What criterion for the minimization of a stochastic cost function ?

Methods: Robust minimizers



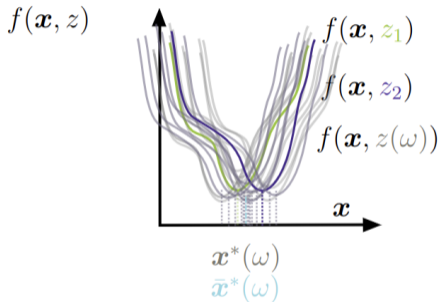
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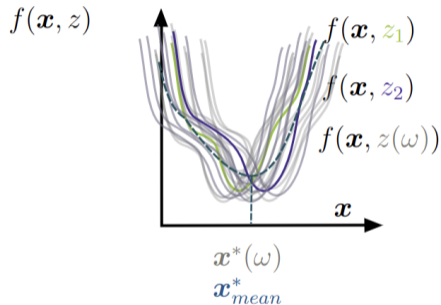
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What criterion for the minimization of a stochastic cost function ?

$$\bar{\mathbf{x}}^* = \mathbb{E}_{\omega}[\operatorname{argmin}_{\mathbf{x}} f(\mathbf{x}, \omega)],$$

Methods: Robust minimizers

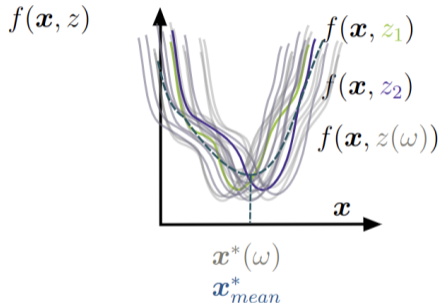


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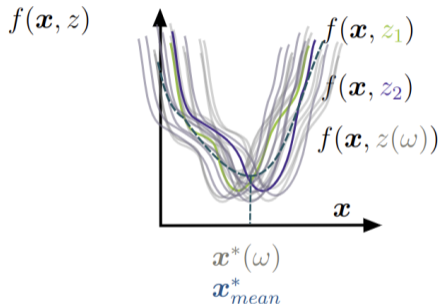
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Methods: Robust minimizers



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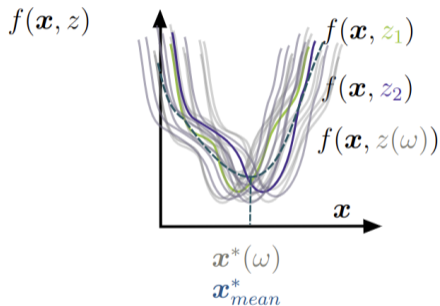
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Methods: Robust minimizers



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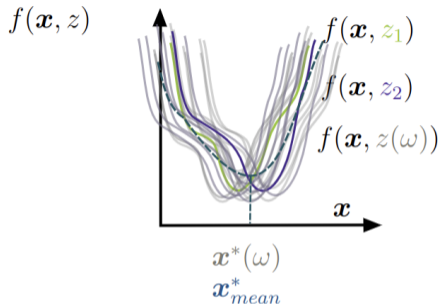
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Very expensive simulations

Methods: Robust minimizers



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...

Very expensive simulations

How to limit number of model evaluations ?

→ Metamodels = approximation of the original model (*or of the cost function*):
linear regression, neural networks ...

- **Polynomial Chaos Expansion**, Marelli and Sudret 2014
 - can be used for a large number of input parameters (+)
 - uses one-shot experimental designs (can be parallelized) (+)
 - approximate the cost function globally (-)
 - have to be validated (-)

Table of contents

Introduction

Model calibration = minimization of a cost function

Methods

Robust minimizers

Case study

PESHMELBA

Moisture profiles

Results

Problem formulation

Minimizers

New simulations cost function

Conclusion

Case study: PESHMELBA

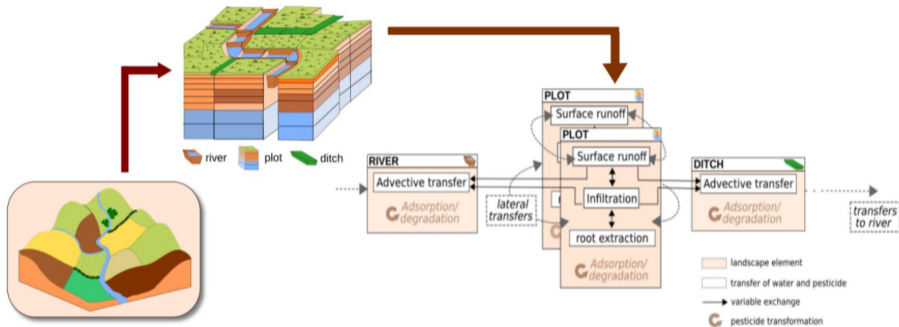


Figure: PESHMELBA model, Rouzies et al. 2019

Case study: PESHMELBA

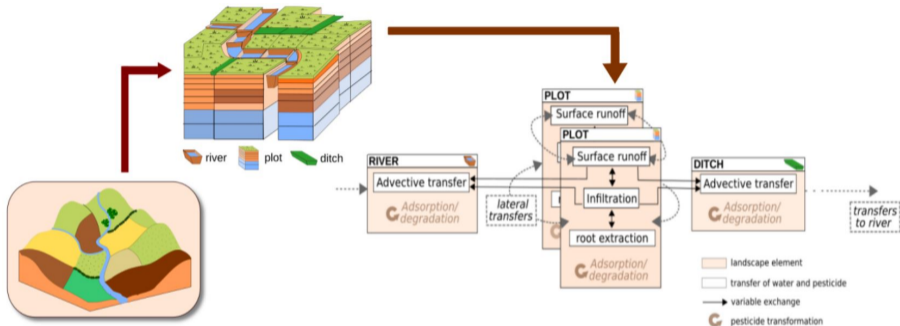


Figure: PESHMELBA model, Rouzies et al. 2019

- process-oriented, physically-based, coupling with landscape features

Case study: PESHMELBA

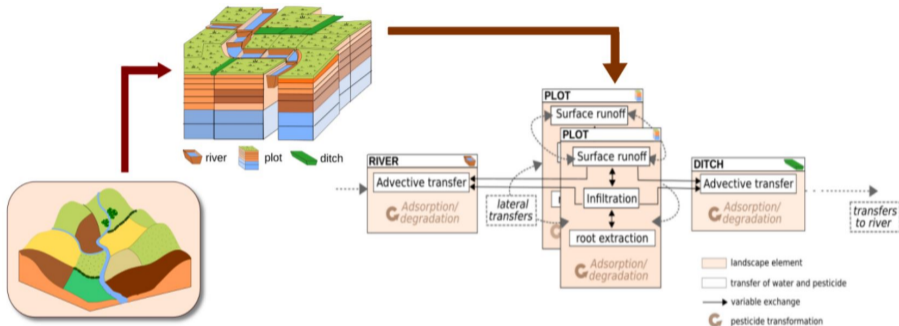


Figure: PESHMELBA model, Rouzies et al. 2019

- process-oriented, physically-based, coupling with landscape features
- simulates water and pesticide transfers on an agricultural catchment

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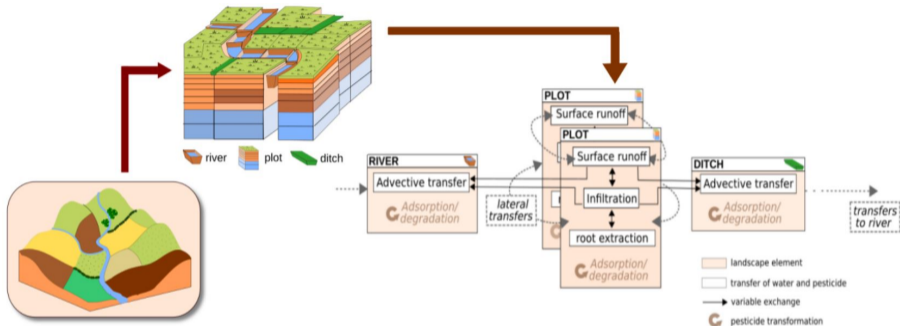


Figure: PESHMELBA model, Rouzies et al. 2019

- process-oriented, physically-based, coupling with landscape features
- simulates water and pesticide transfers on an agricultural catchment
- distributed model, numerous parameters to calibrate

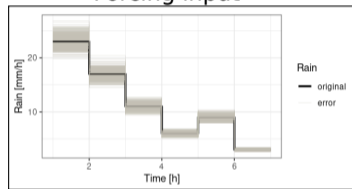
Case study: Moisture profiles

A simplified case study: moisture profile of one plot

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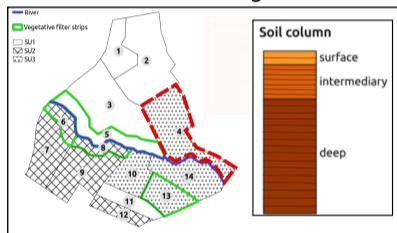
Forcing input



Parameters to calibrate

Name	Definition
$\theta_{s,surf.}$	water content at saturation (surface)
$\theta_{s,inter.}$	water content at saturation (intermediary)
$\theta_{s,deep}$	water content at saturation (deep)
$\theta_{r,deep}$	residual water content (deep)
$mn_{,deep}$	Van Genuchten retention curve parameter (deep)

PESHMELBA configuration



Observation = moisture profile of parcel 4

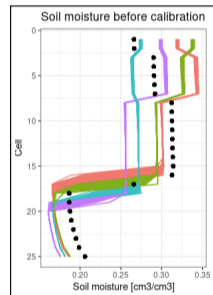


Table of contents

Introduction

Model calibration = minimization of a cost function

Methods

Robust minimizers

Case study

PESHMELBA

Moisture profiles

Results

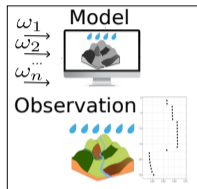
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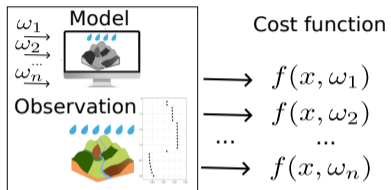
New simulations cost function

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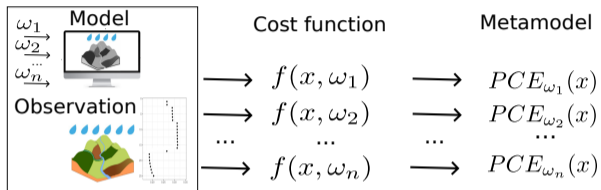
Results: Problem formulation



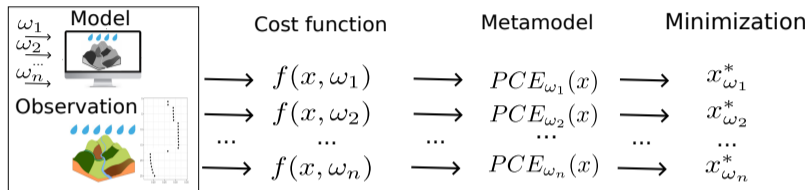
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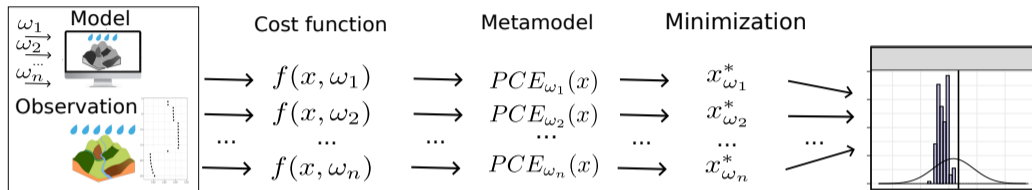
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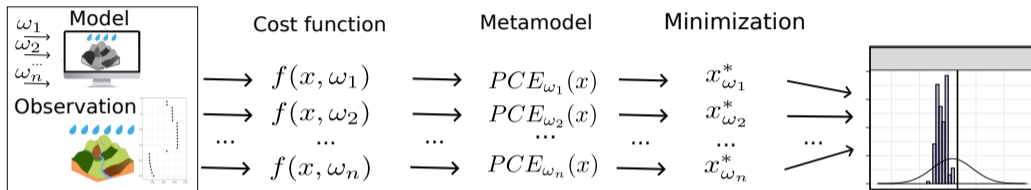
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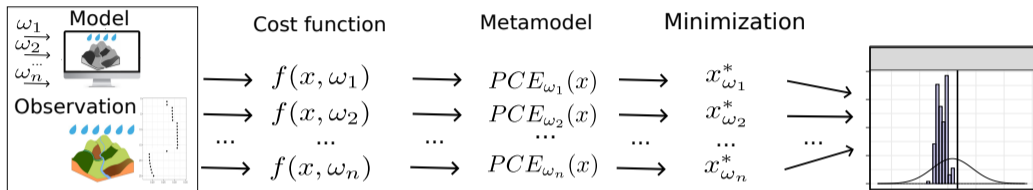


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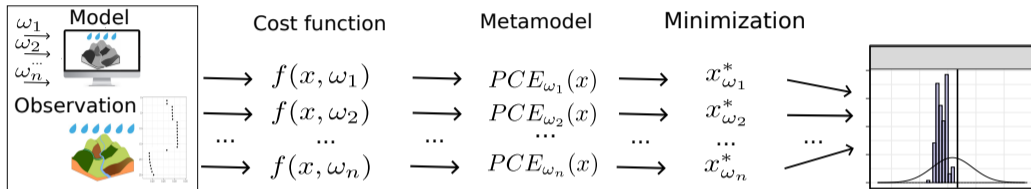
- the spread of minimizer histogram = the uncertainty propagation from forcings to calibrated values

Results: Problem formulation



- the spread of minimizer histogram = the uncertainty propagation from forcings to calibrated values
- all metamodels show very good R2 values > 0.95 (validation).

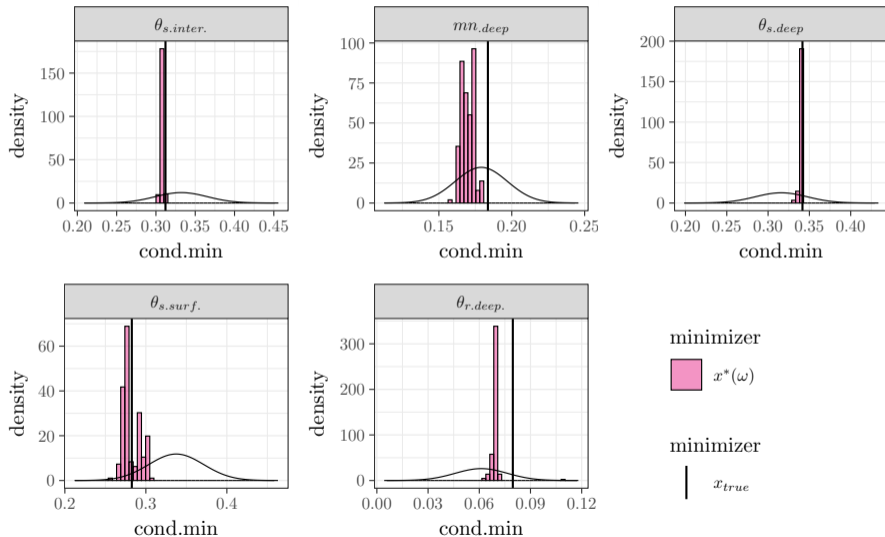
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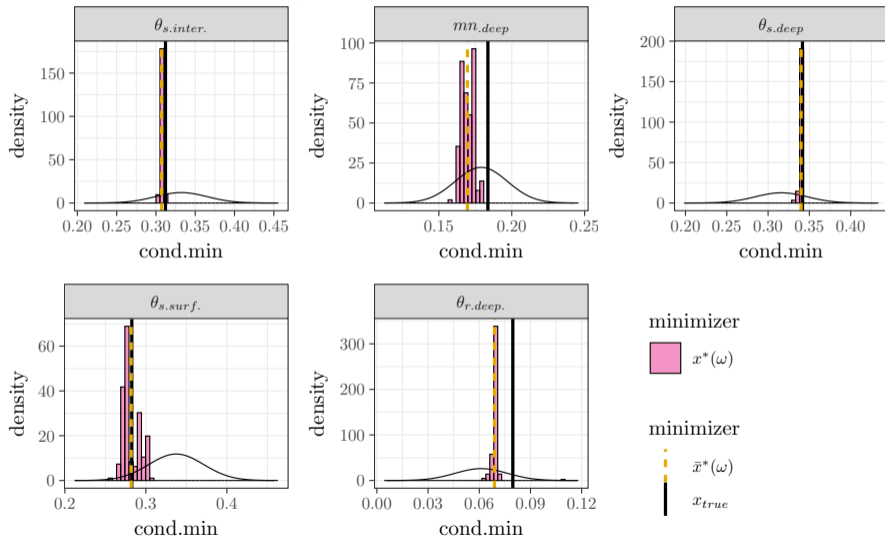
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Next: Compare classic minimizers with robust minimizers : x_{mean}^ and \bar{x}^* .*

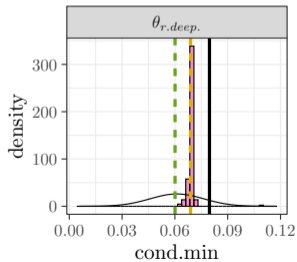
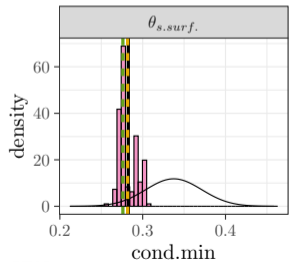
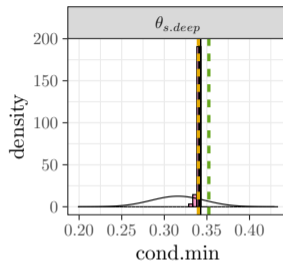
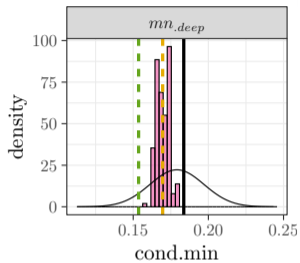
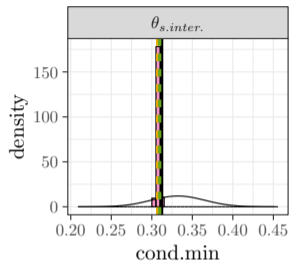
Results: Minimizers



Results: Minimizers



Results: Minimizers



minimizer

$x^*(\omega)$

minimizer

x^*_{mean}

$\bar{x}^*(\omega)$

x_{true}

Results: New simulations cost function

Is the calibration better with robust minimizers ?

Results: New simulations cost function

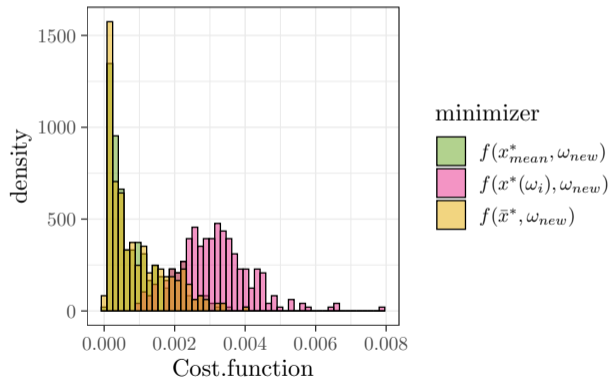
Is the calibration better with robust minimizers ?

→ compare cost function for new realisations of forcing uncertainty.

Results: New simulations cost function

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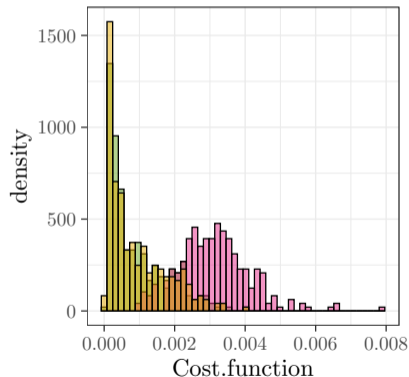
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Results: New simulations cost function

Is the calibration better with robust minimizers ?

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minimizer

- $f(x_{mean}^*, \omega_{new})$
- $f(x^*(\omega_i), \omega_{new})$
- $f(\bar{x}^*, \omega_{new})$

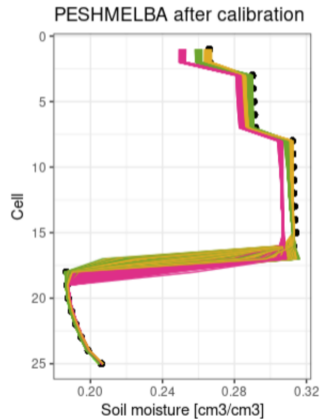


Table of contents

Introduction

Model calibration = minimization of a cost function

Methods

Robust minimizers

Case study

PESHMELBA

Moisture profiles

Results

Problem formulation

Minimizers

New simulations cost function

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What's next :

- complexify case study, passage to catchment scale, study propagation of uncertainty on pesticide application dates to the model calibration

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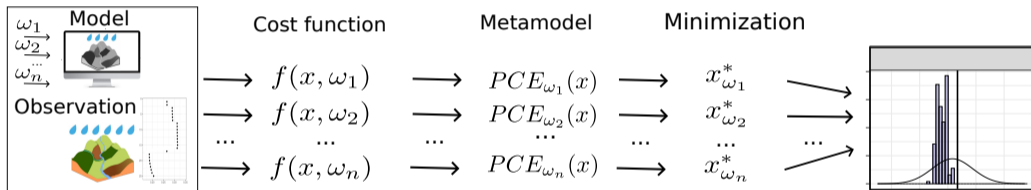
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- complexify case study, passage to catchment scale, study propagation of uncertainty on pesticide application dates to the model calibration
- compare Polynomial Chaos Expansion metamodelization with other metamodelization methods
- reduce the number of rain simulations used, interpolation in the rains → stochastic metamodel, Lüthen, Marelli, and Sudret 2023

Conclusion:



Bibliography I

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