Assessment of the MHYDAS-Pesticide-1.0 model in simulating pesticide concentrations in surface waters at plot-scale continuously over decades

Guillaume Métayer, Cécile Dagès, Jean-Stéphane Bailly, David Crevoisier, Marc Voltz

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A need to assess model performance to reproduce long-term pesticide contamination of surface water

Mechanistic model = cost-effective method compared to field studies

Scarcity of long-term evaluations at field-scale, especially for Mediterranean context (*e.g. Mudgal et al., 2010, Baffaut et al., 2019*)

- Most studies < 1 year (*e.g. Connolly et al., 2001, Malone et al. 2004*)

Poor knowledge about the simulation accuracy of pesticide concentrations in surface water

Objective of this study :

Assessing the performance of a mechanistic model in **reproducing pesticide concentrations** measured in runoff **at field-scale** on a **multi-year basis**

Simulating pesticide concentrations with a standard mechanistic model : MHYDAS-Pesticide-1.0

Crevoisier et al., 2021

Hydrology

Partition runoff / infiltration → **Richards' equation**
Ross solution

Runoff propagation → **Diffusive wave equation**
Hayami method

Pesticide fate

Reactive transport in soil →

Convection-diffusion equation

Degradation rate

- **First-order** kinetics
- **Decrease** with a decrease in **soil water content**

$$k = \left(\frac{\theta}{\theta_{ref}}\right)^{b} \frac{ln2}{t_{1/2}}$$

k : degradation rate coefficient (s^{-1})
θ_{ref}: reference water content ($m^3.m^{-3}$)
$t_{1/2}$: half-life (s)
b : Walker's function exponent

Instantaneous sorption equilibrium

$$s_a = K_D c$$

s_a : adsorbed-phase concentration ($kg.m^{-3}$)
K_D : adsorption partition coefficient
C : solution-phase concentration ($kg.m^{-3}$)

Extraction into runoff →

Uniform mixing of runoff water with the first soil layers

$$M_{runoff} + M_{soil} = h_{water}c + z_{mix}s_a$$

M_{runoff} : pesticide mass in runoff ($kg.m^{-2}$)
M_{soil} : pesticide mass in soil ($kg.m^{-2}$)
h_{water} : water level (m)
z_{mix} : depth of the mixing layer (m)

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4 calibrated pesticide parameters : $t_{1/2}$, b, K_D, z_{mix}

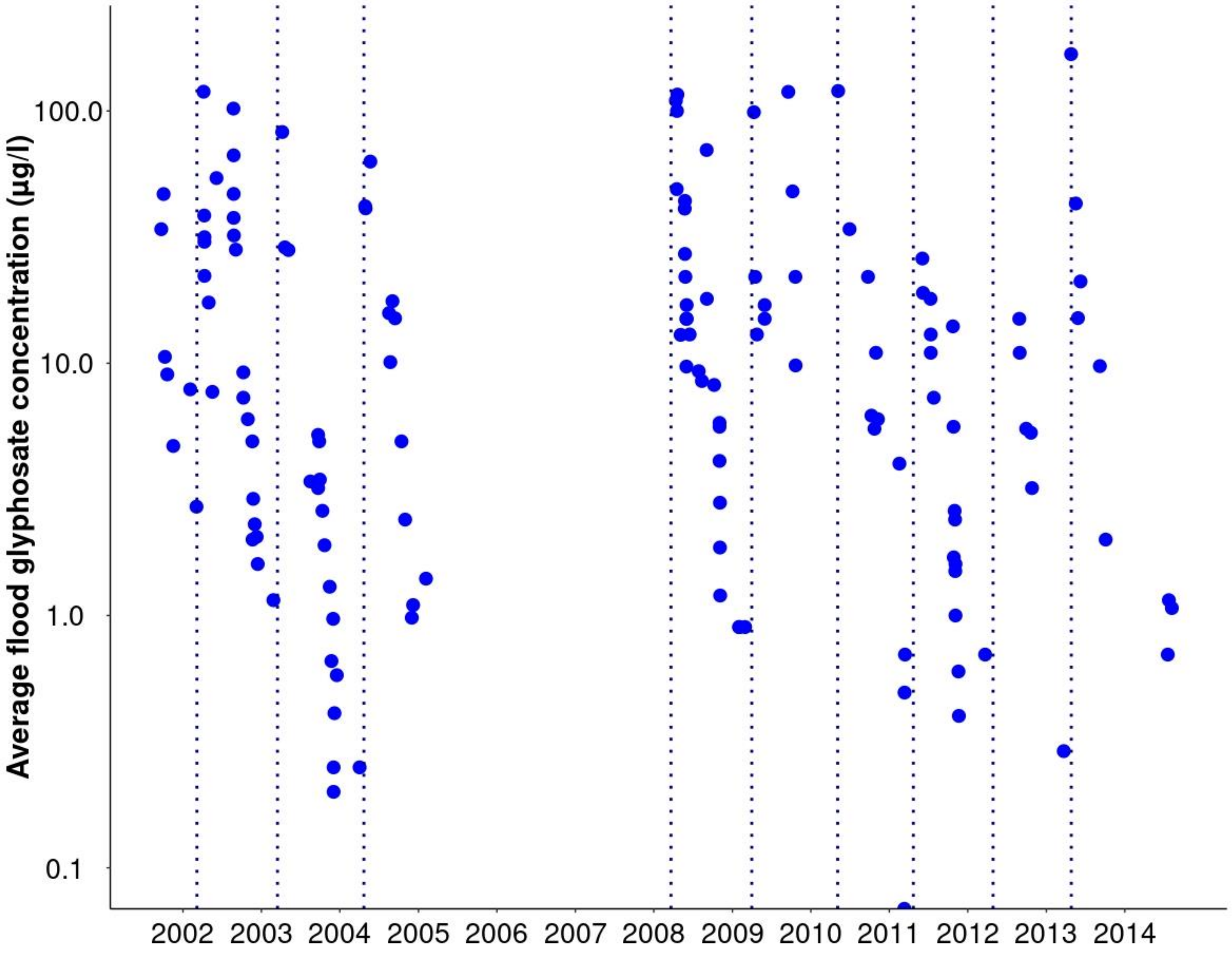
Study area : a vineyard field in the south of France

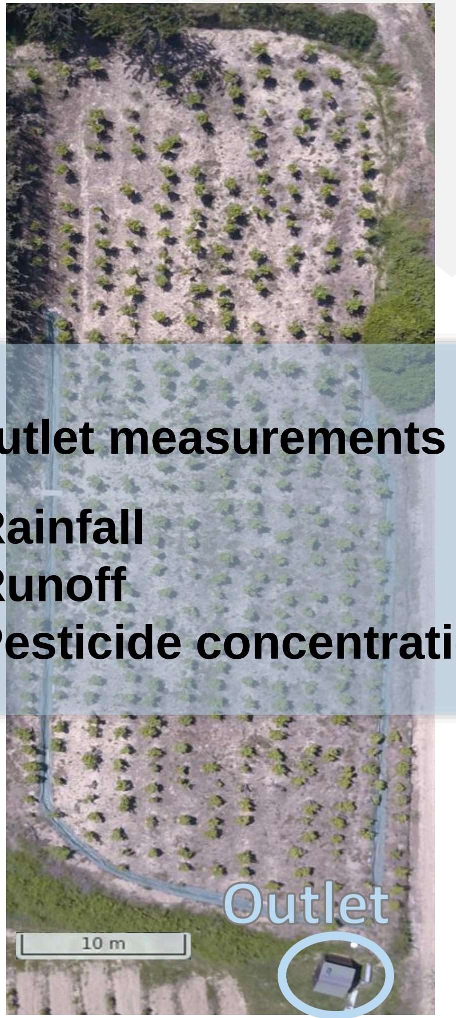
1. Introduction

2. Materials & Methods

3. Results

4. Conclusion





Outlet measurements :

- **Rainfall**
- **Runoff**
- **Pesticide concentration**

Mediterranean context

High inter and intra-annual hydrological variability

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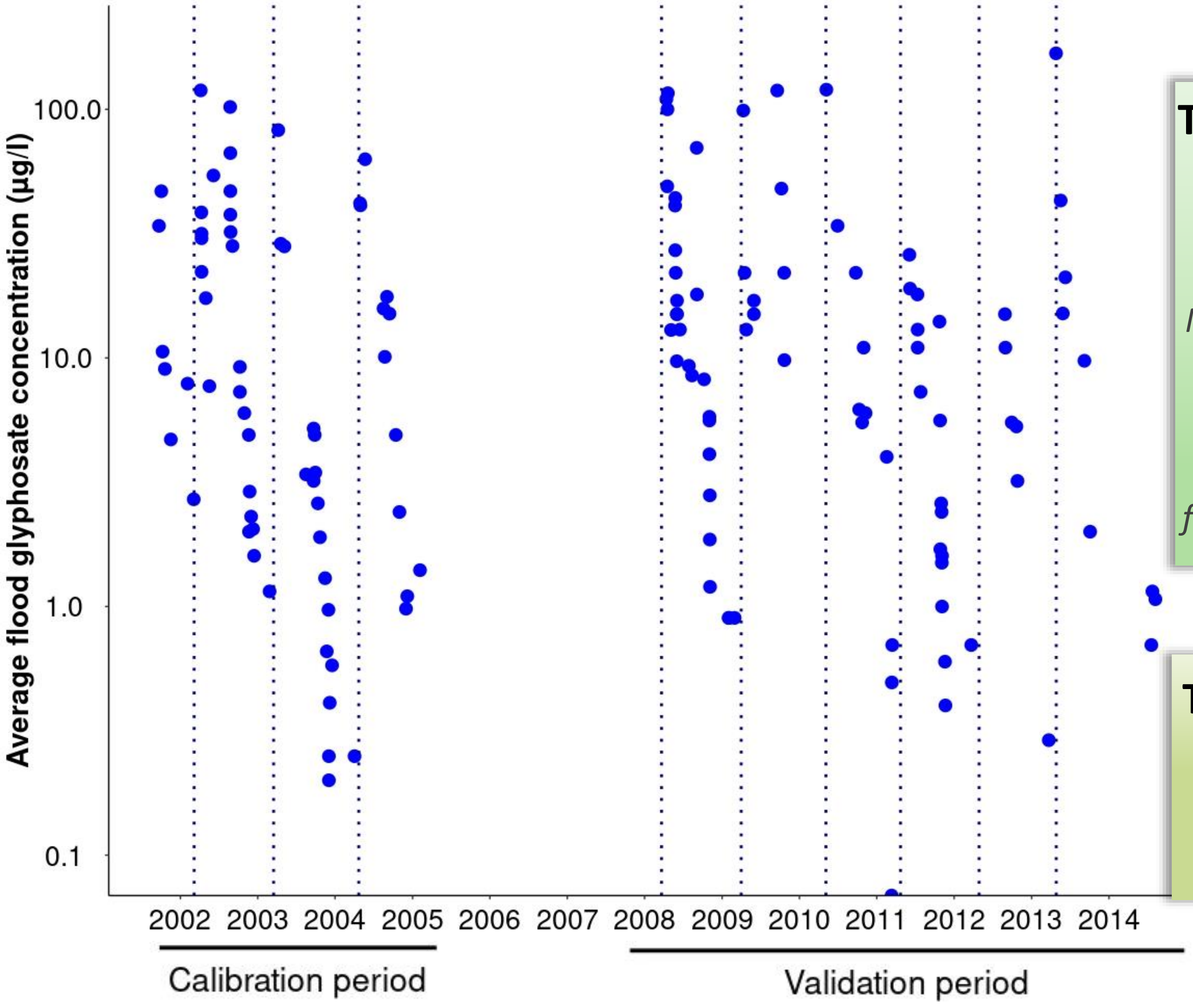

To assess global model performance

Statistical criteria

NSE
Nash Sutcliffe efficiency

PBIAS (%)
Percent bias

Variables of interest

C
flood concentration

logC
log(flood concentration)

To assess performance in simulating intra-annual variability

Analysis of error structure

Results

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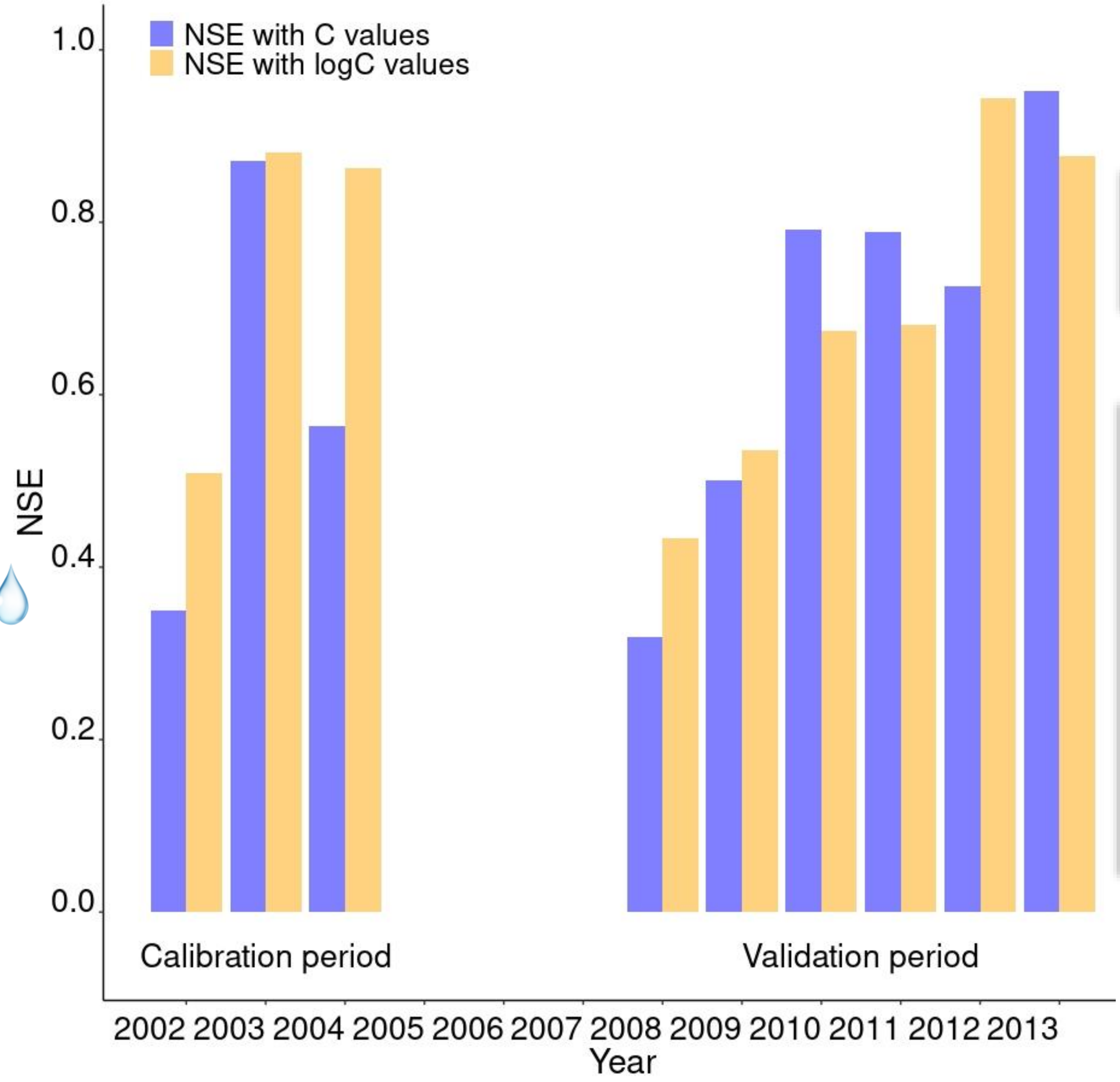


Satisfactory performance for C values and logC values

Calibration period :

- *NSE > 0.65*
- *PBIAS ± 15%*

→ **« very good » (Moriasi et al., 2015)**

Validation period :

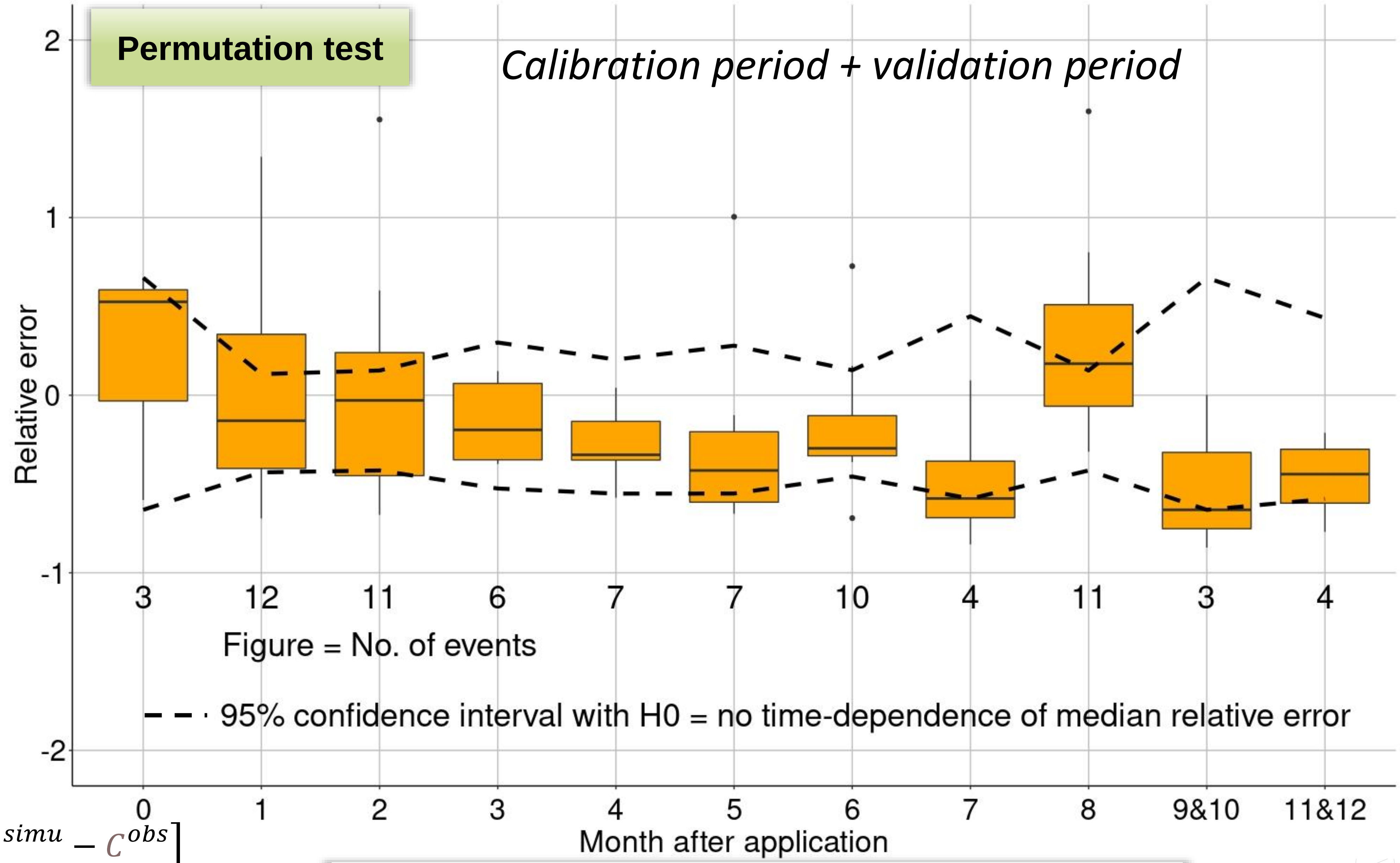
- *NSE > 0.5*
- *PBIAS ± 20%*

→ **« good » (Moriasi et al., 2015)**

Results

Permutation test

Calibration period + validation period



$$Relative\ error = \left[\frac{C^{simu} - C^{obs}}{C^{obs}}\right]$$

Relative error isn't statistically time-dependent

Conclusions

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A **standard mechanistic model** can satisfactorily reproduce **inter and intra-annual variability of pesticide concentrations** in surface water for a **mediterranean context**

Robust calibration achieved with **3 years data**

$t_{1/2}$, K_D, z_{mix} were found to be sensitive to logC **unlike Walker's exponent b despite expected soil drying effects in Mediterranean contexts**

This work = first MHYDAS-Pesticide-1.0 assessment
Further studies are needed to calibrate the model for other contexts

Thank you for listening

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