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Evaluation of Transfer Function Noise Modelling and Dimensionality Reduction Techniques for Karst Systems

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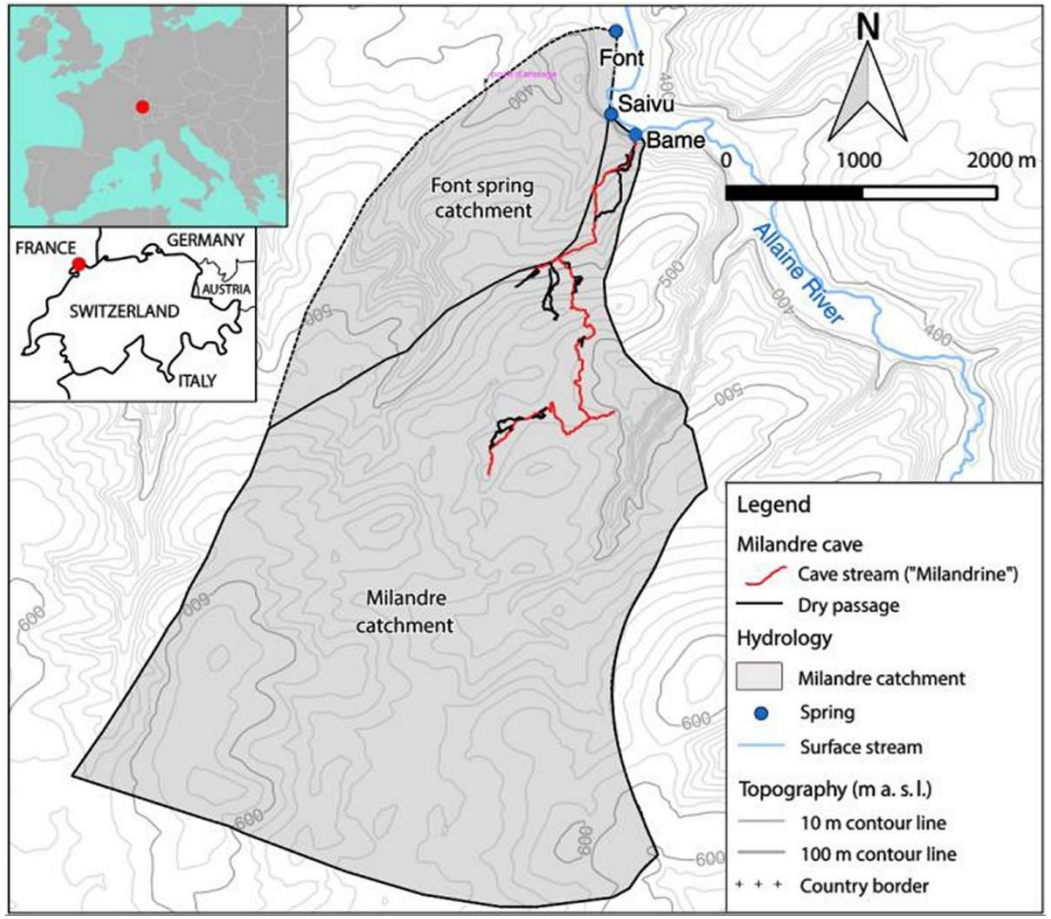
Approach, Motivation and Aim

- **Modelling** and forecasting of karst system spring discharge **still poses a challenge**
- **Distributed modelling** approaches often suffer from **insufficiently available data**
- **Lumped parameter** models often do not reflect **physical system understanding**

→ **Conceptually and (partially) physically interpretable data-driven model**

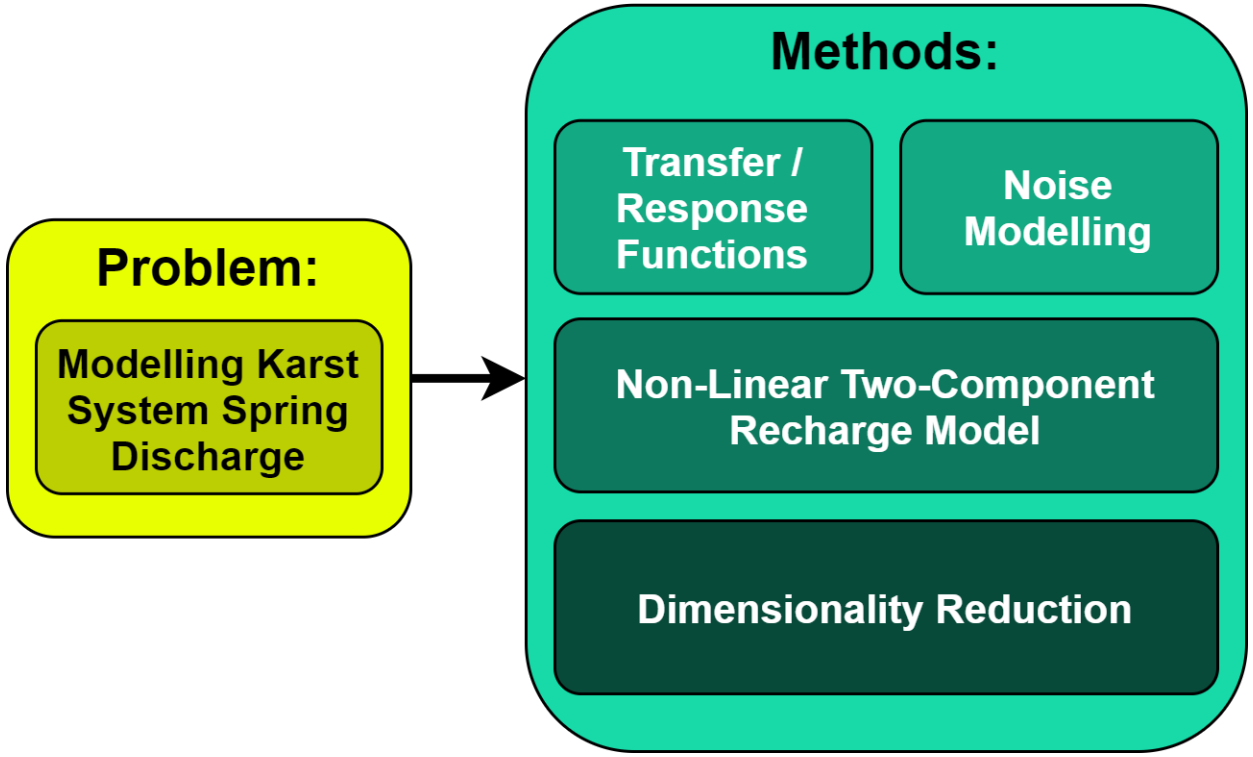
Milandre Karst System



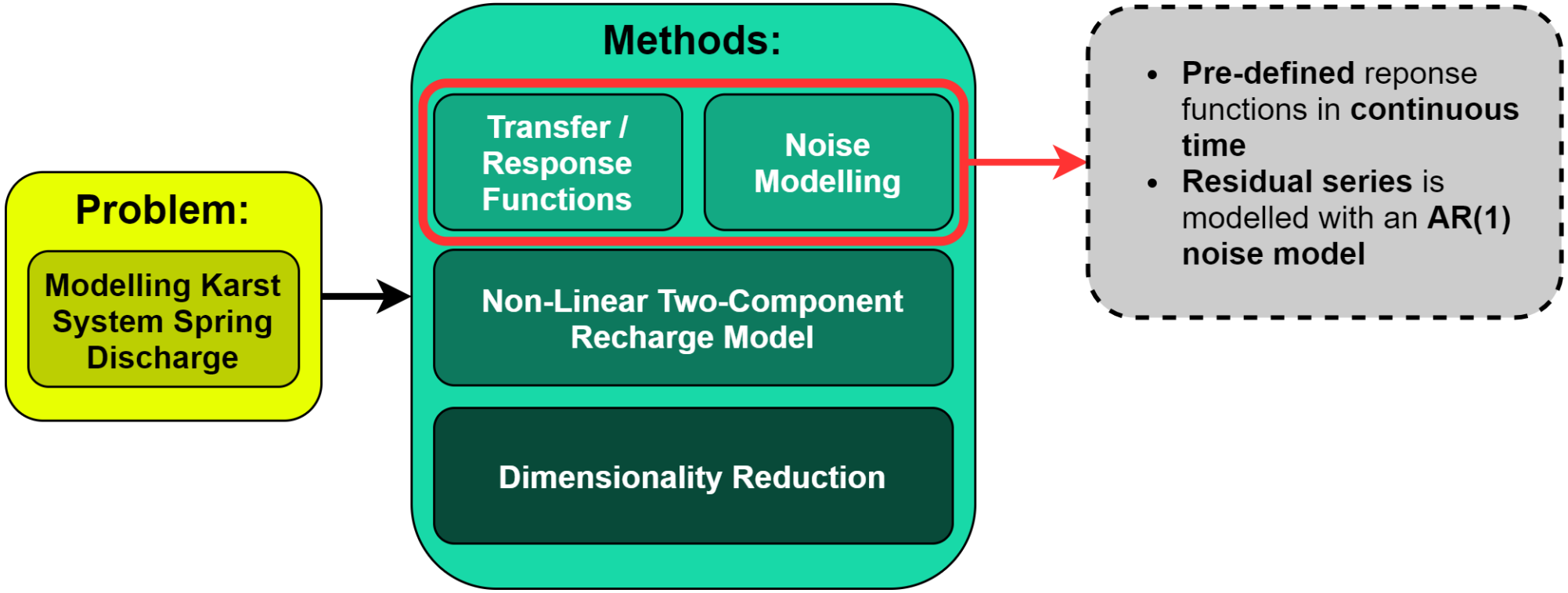
- Rauracian Limestone overlying Oxfordian Marls
- Catchment area approx. 13 km^2
- Two perennial springs (Font, Saivu)
- One overflow-spring (Bâme)
- Autogenic, diffuse recharge regime

Heavily studied and subject to the *Karst Modelling Challenge* (Jeannin et al., 2021)

Methodology



Methodology



Methodology

RM based on FlexModel introduced by *Collenteur et al. (2021)*

Problem:

Modelling Karst System Spring Discharge

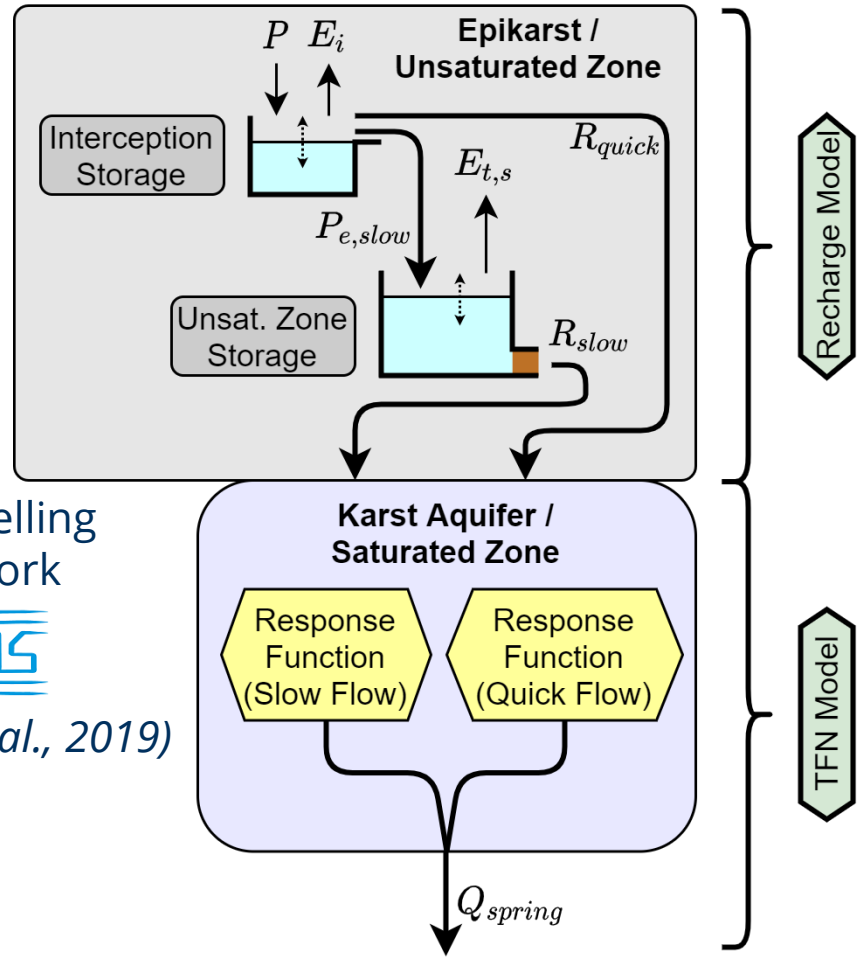
Methods:

- **Transfer / Response Functions**
- **Noise Modelling**
- **Non-Linear Two-Component Recharge Model**
- **Dimensionality Reduction**

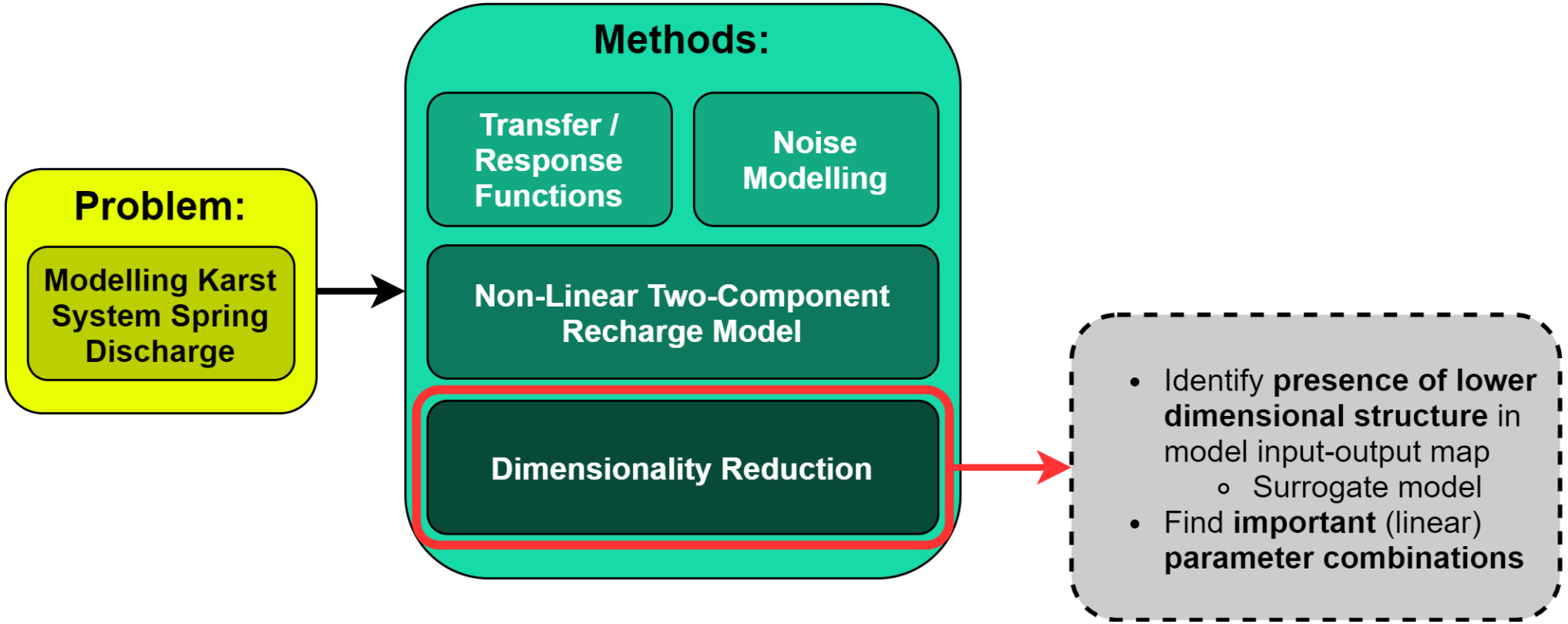
TFN modelling framework

PASTAS

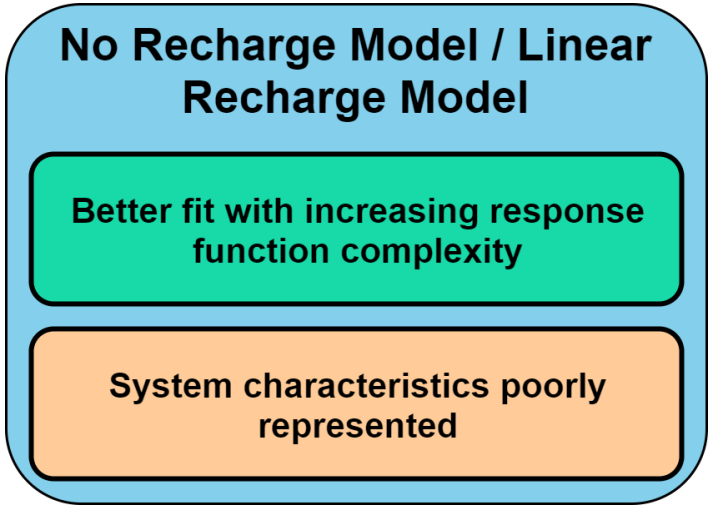
(Collenteur et al., 2019)



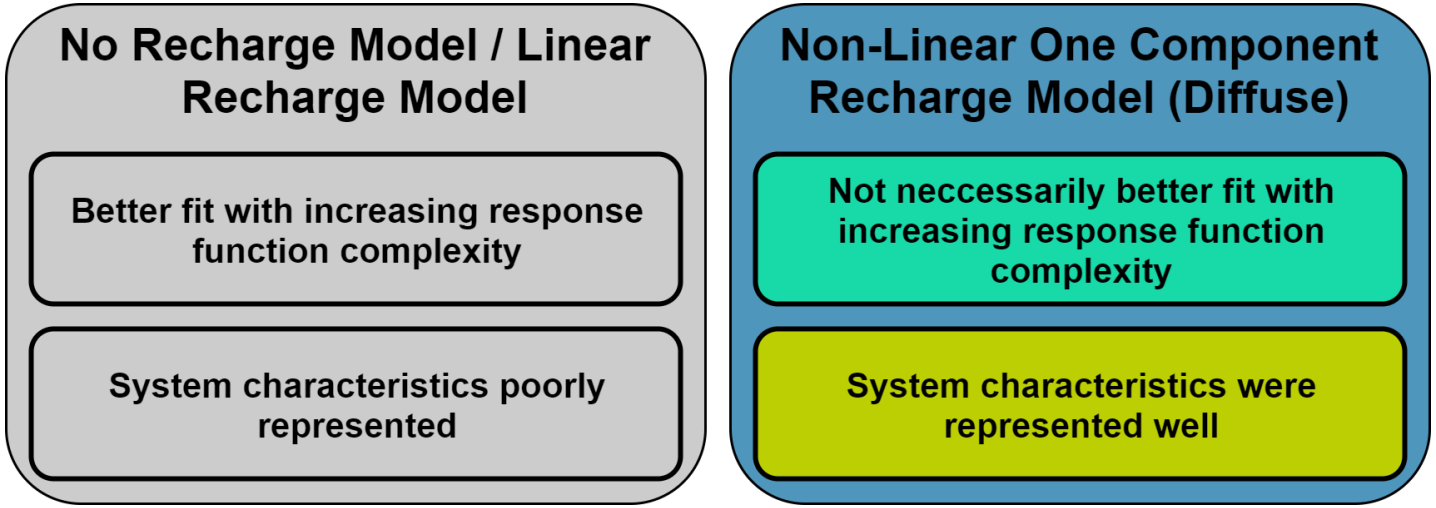
Methodology



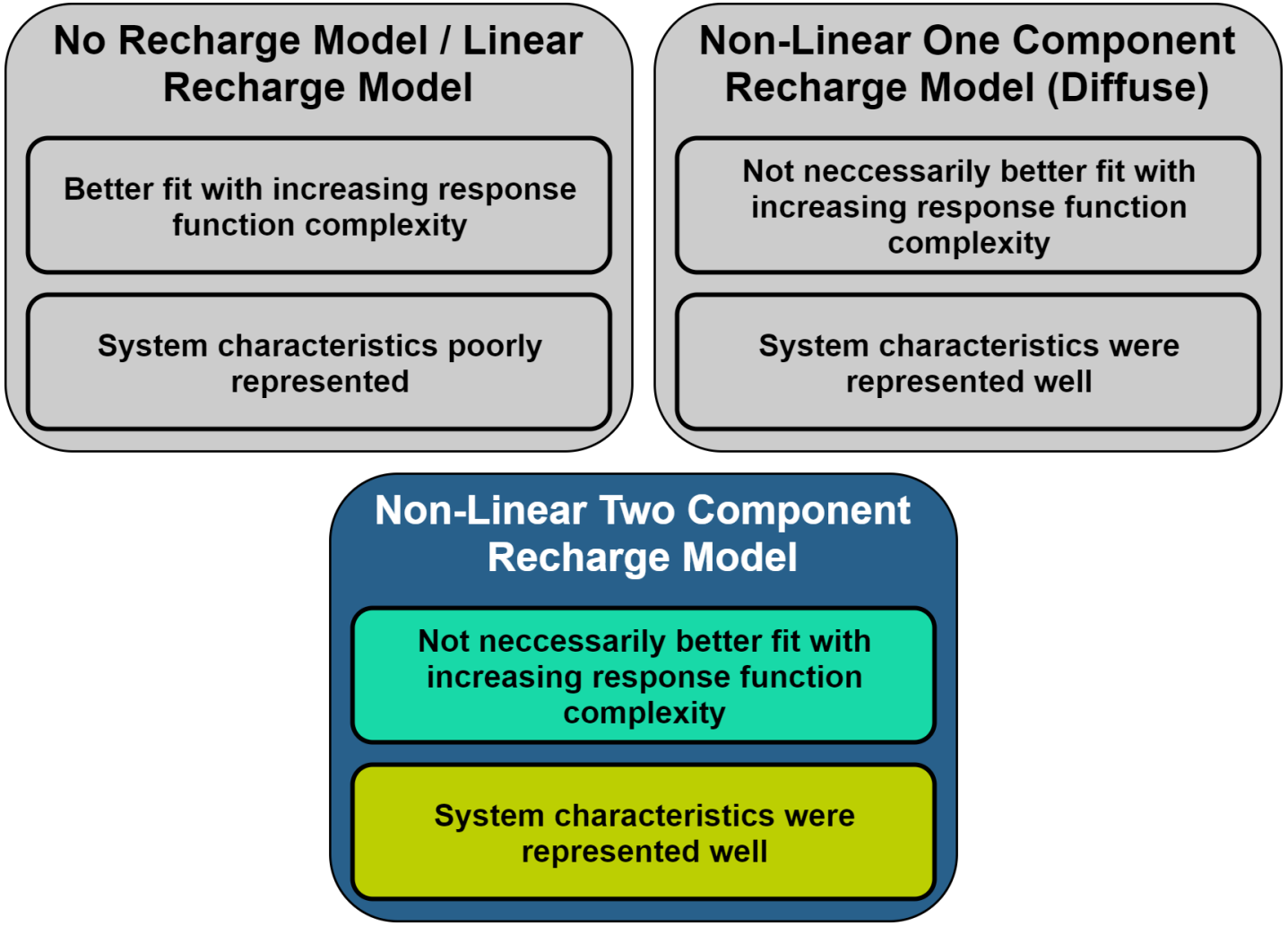
General Results



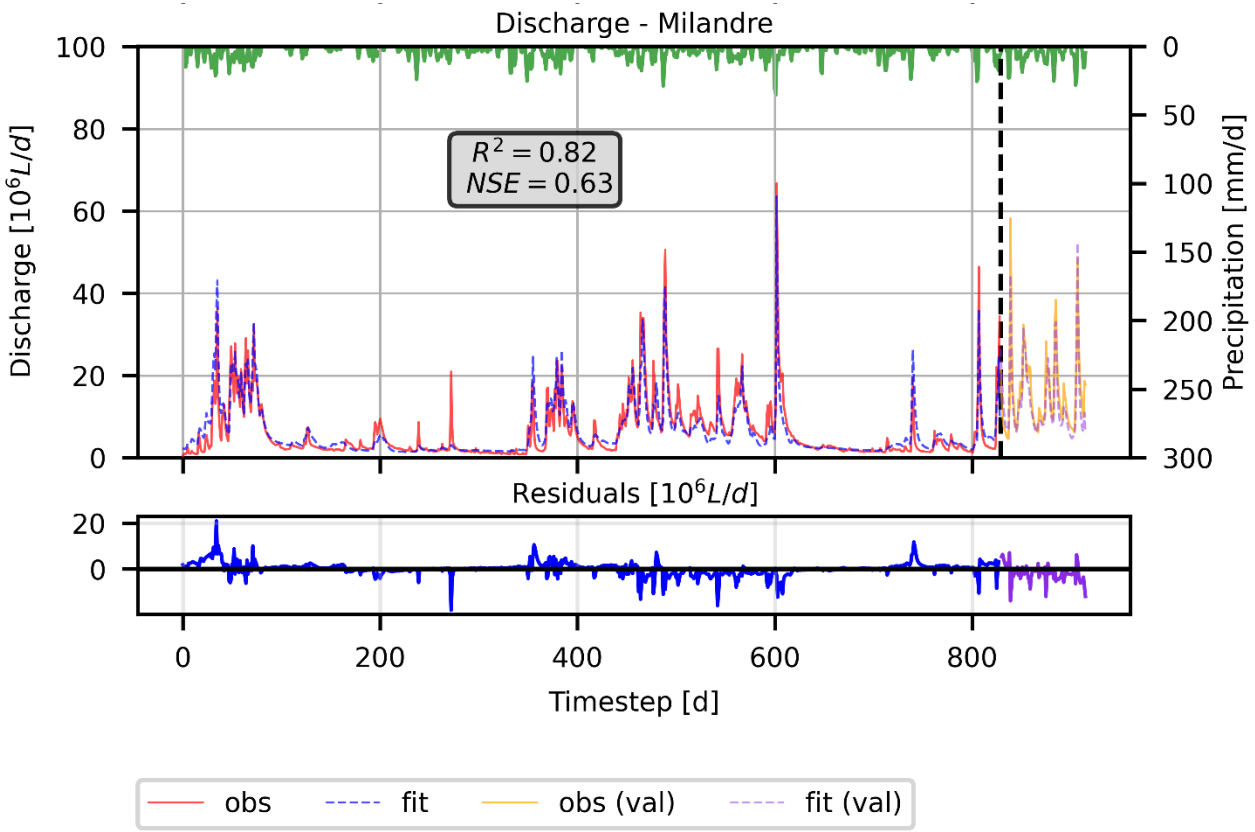
General Results



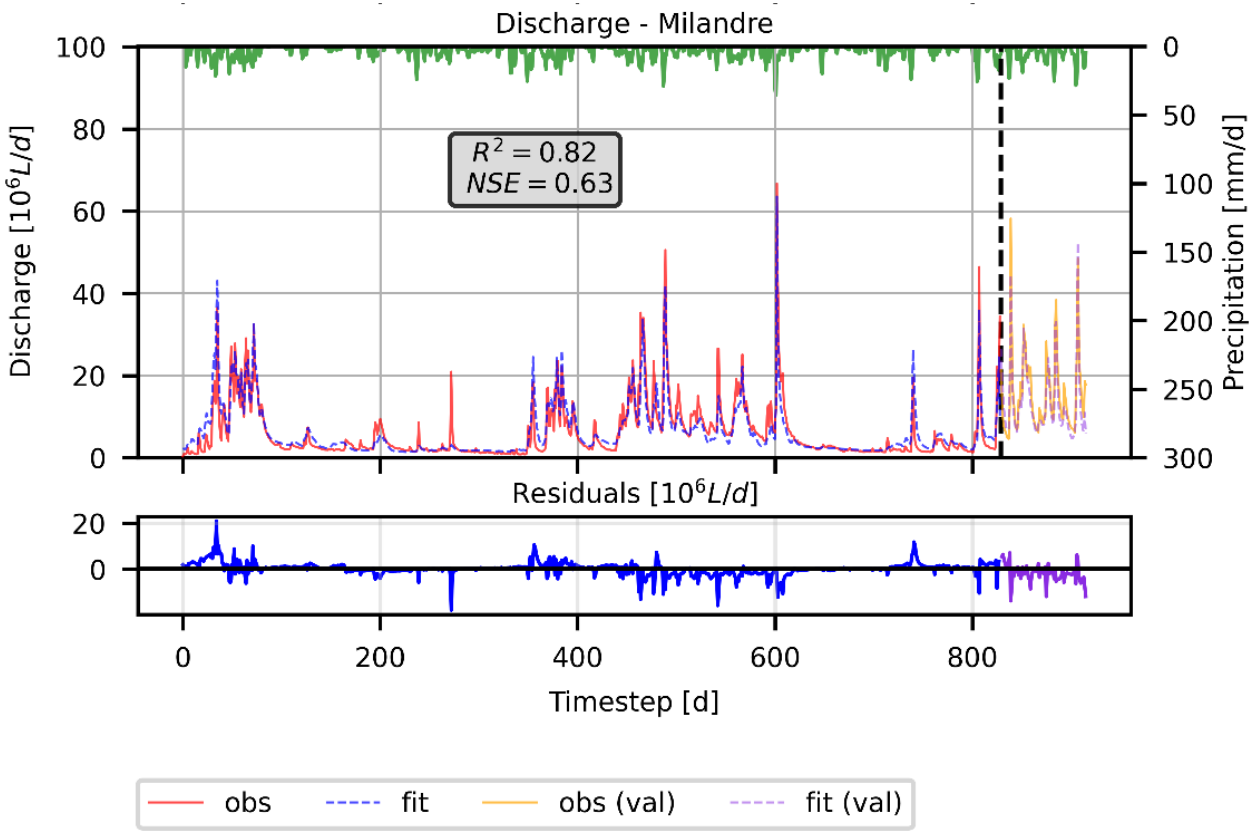
General Results

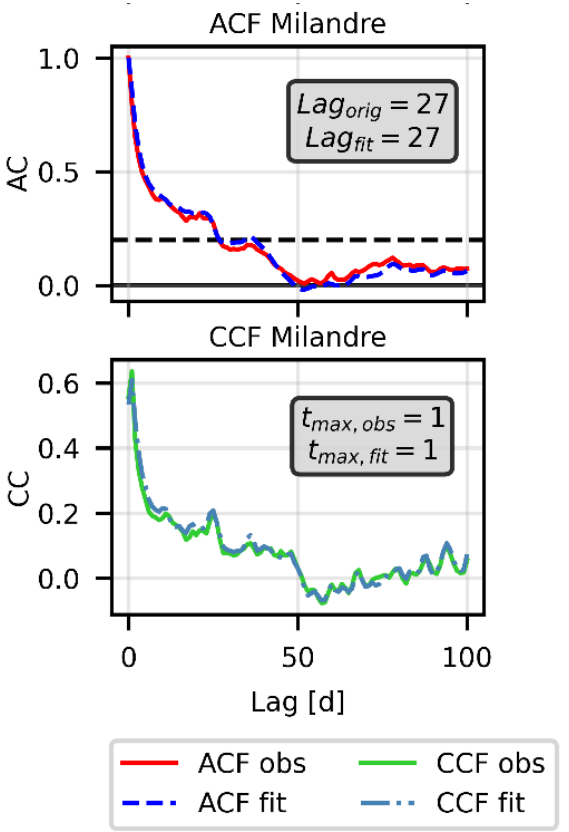


Results – Milandre Karst System

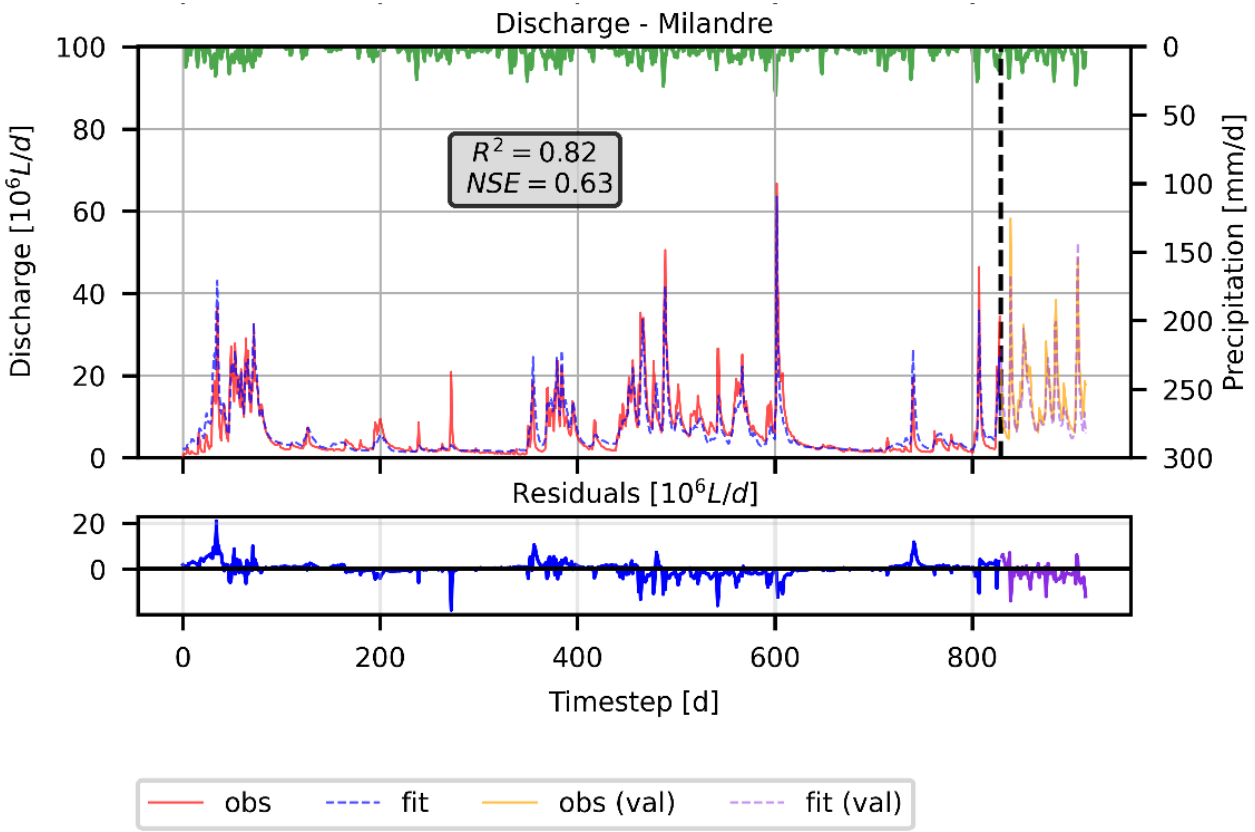


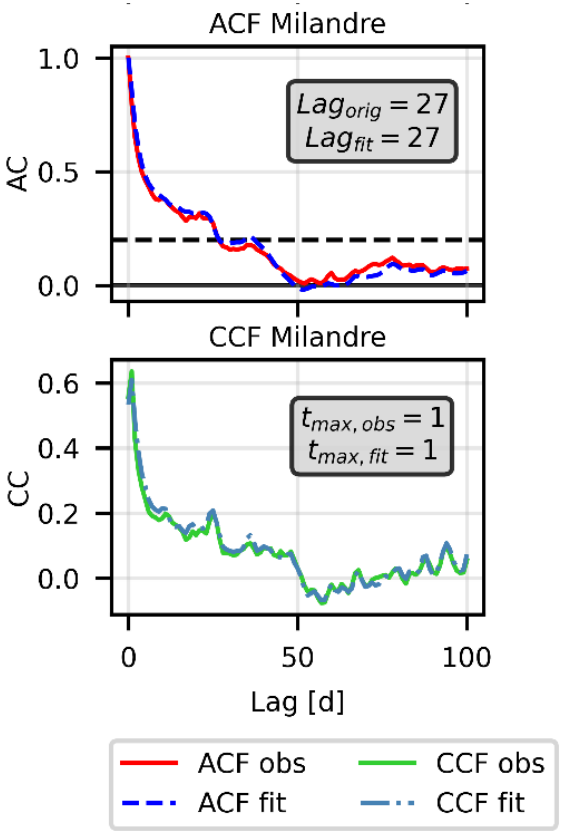
Results – Milandre Karst System

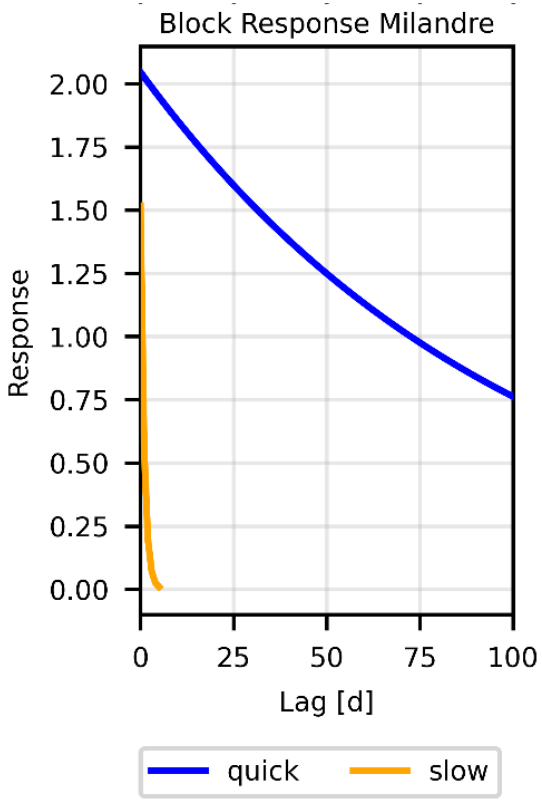




Results – Milandre Karst System





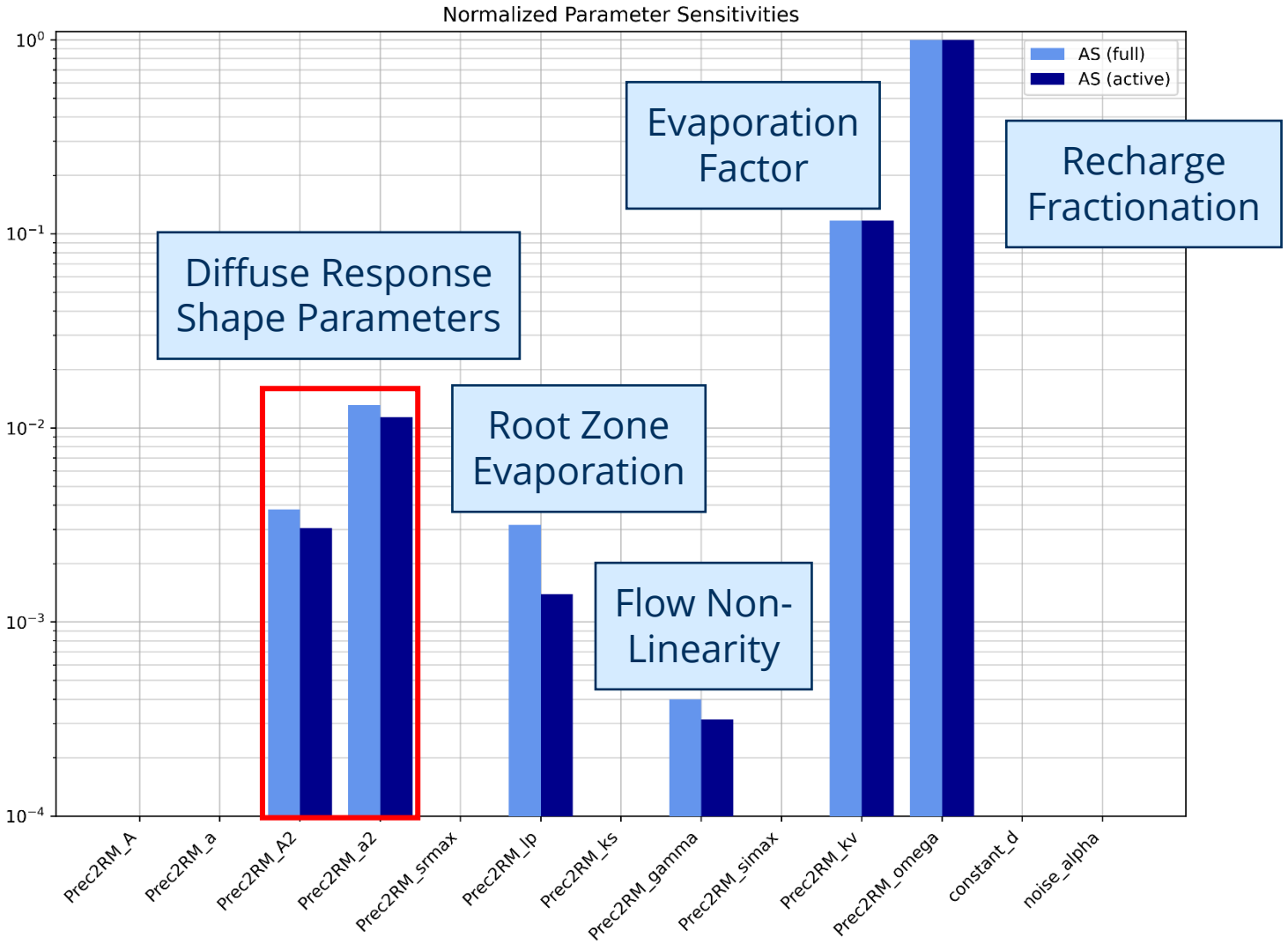


Results – Comparison to Other Modelling Approaches (KMC)

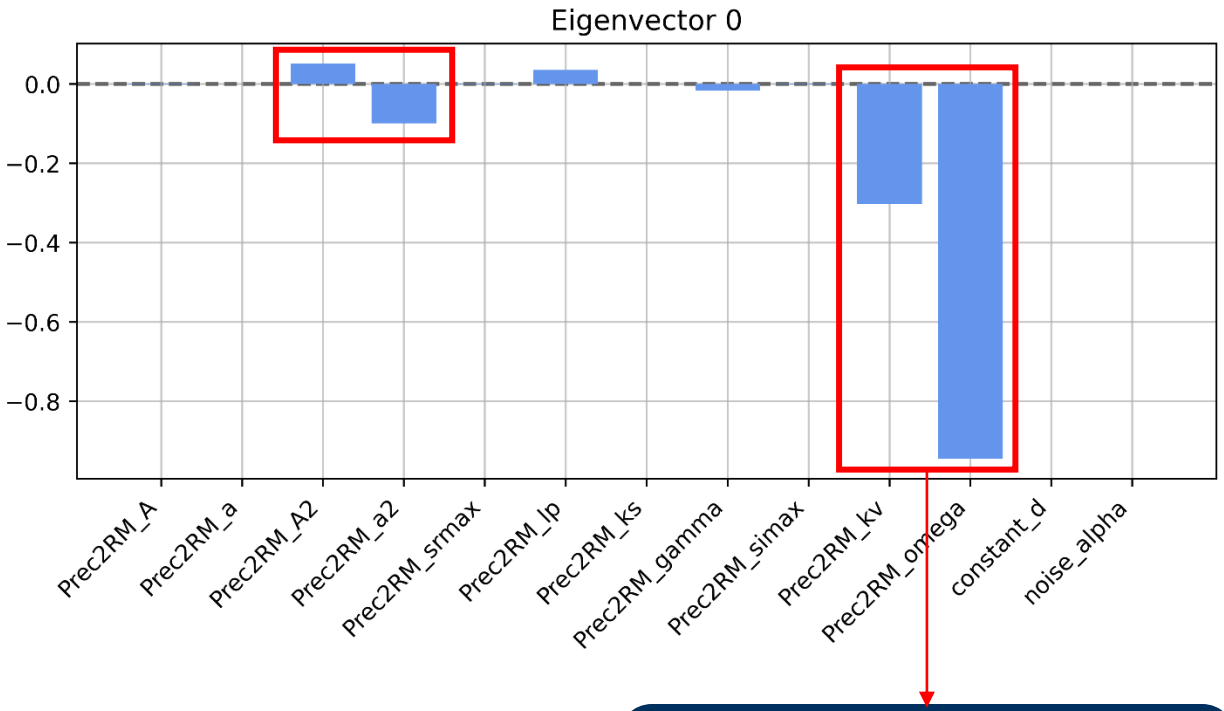
Fit evaluated for a validation period not available for calibration!

		KGE	VCC	NSE	Effort	Score
BRGM France	Gardenia	0.83	0.854	0.83	1day	0.84
Uni-Freiburg	Varkarst	0.80	0.85	0.79	1day	0.82
This Study	**TFN Model / Pastas**	0.76	0.89	0.72	1day	0.804
IMT Mines-Alès	ANN / rec_MLP	0.72	0.84	0.61	≈1day	0.75
SISKA-Switzerland	KRM_1	0.71	0.78	0.63	≈1day	0.72
IGME Madrid	KarstFLOW	0.71	0.78	0.63	3 days	0.72
TCD Dublin	InfoWorks	0.70	0.82	0.58	2-5 days	0.72
KIT-Karlsruhe	CNN	0.69	0.87	0.40	≈1day	0.71
KIT-Karlsruhe	NARX	0.68	0.90	0.35	≈1day	0.70
SNO KARST	KarstMod	0.68	0.72	0.65	1day	0.69
TU-Dresden	CFP-modified	0.54	0.72	0.25	≈7 days	0.55
TU-Freiberg	RCD-Seasonal	0.47	0.69	0.04	1day	0.47
Uni-Zürich	CHLEM	0.45	0.71	−0.10	1day	0.44
KIT-Karlsruhe	LSTM	0.37	0.59	−0.24	1day	0.34
	Color					
	Rating	Very Good	Good	Fair	Medium	Low

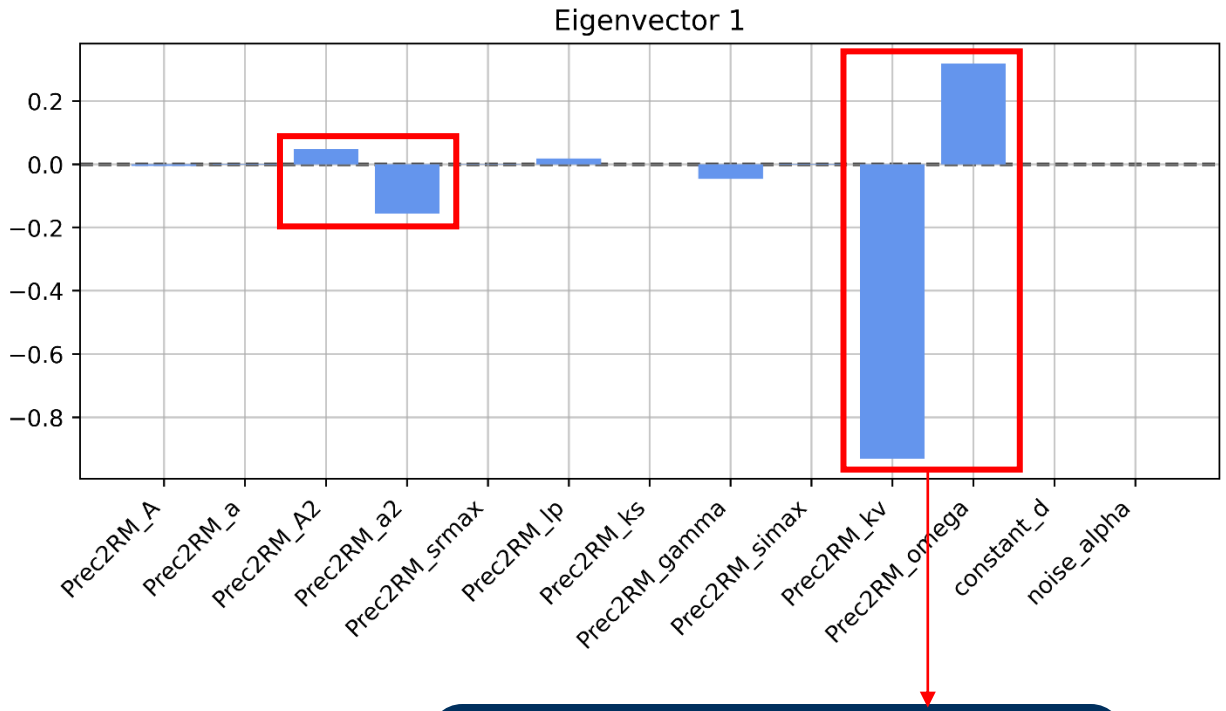
Results – Parameter Sensitivities (Active Subspaces)



Results – Linear Combinations (Active Subspaces)

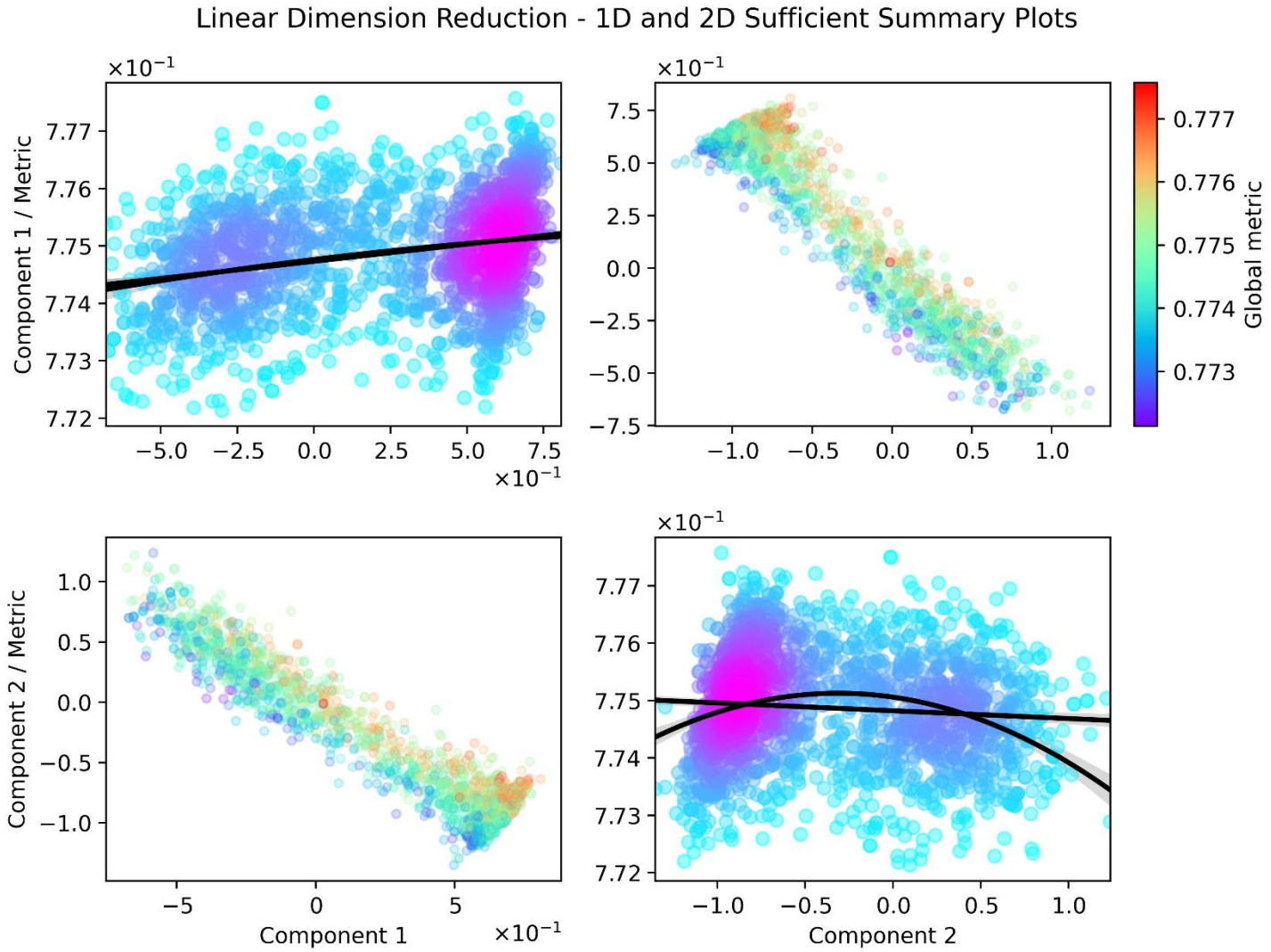


contribution of processes related to recharge fractionation



contribution of processes related to total ammount of recharge

Results – Sufficient Summary Plots (Active Subspaces)



Summary

- **Recharge process** representation is **highly important** and sensitive
- Non-linear **recharge model compensates** for karst system **non-linearity**
- Method is generally **suitable**
- Model **outperformed most other approaches** in the Karst Modelling Challenge

Thank You For Your Attention!

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Python

- programming language

Pastas

- open source TFN-model for Python
- available on GitHub