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Modeling pesticides fate in a river network using the aquatic biogeochemistry model pyNuts-Riverstrahler

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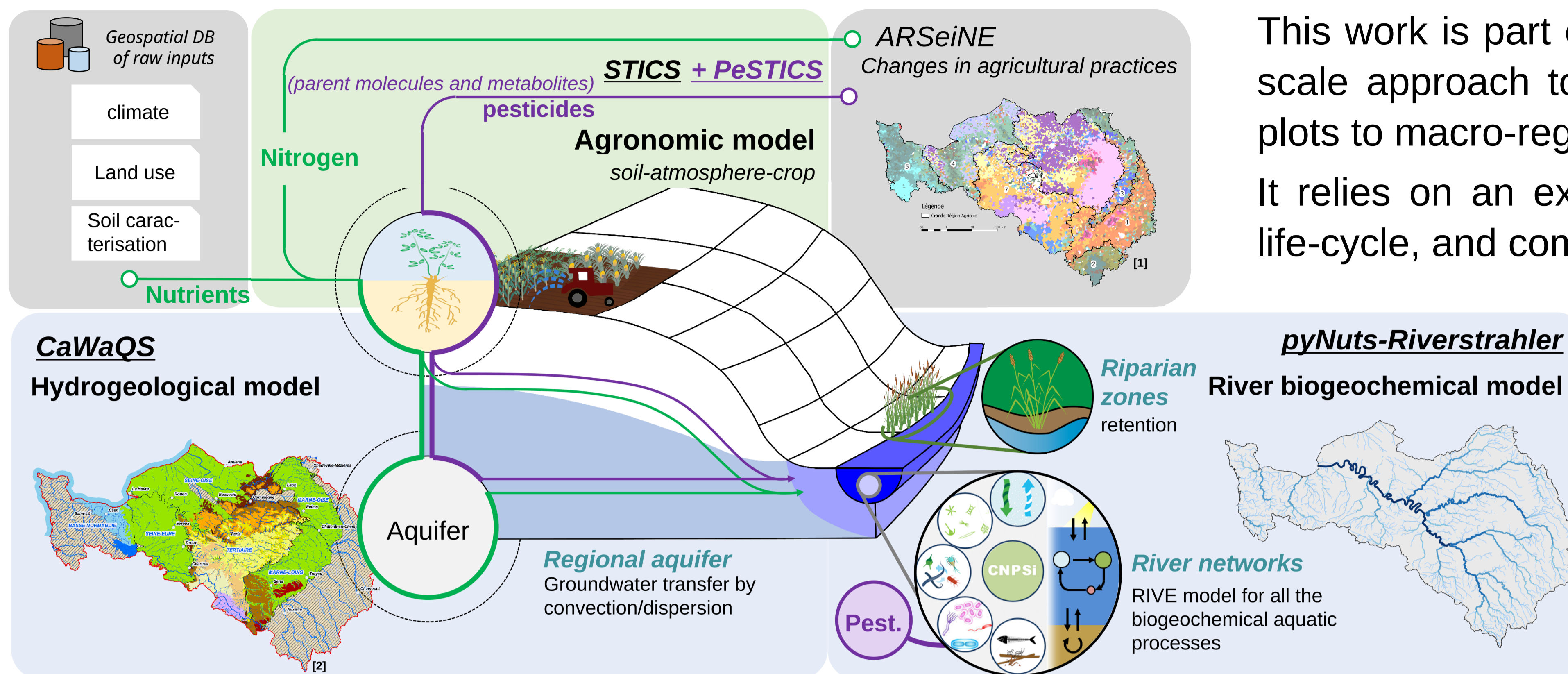
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CONTEXT



This work is part of a project aimed at providing an integrated multi-scale approach to the life cycle of pesticides, from the agricultural plots to macro-regional territory.

It relies on an existing model chain, initially dedicated to nutrients life-cycle, and composed of:

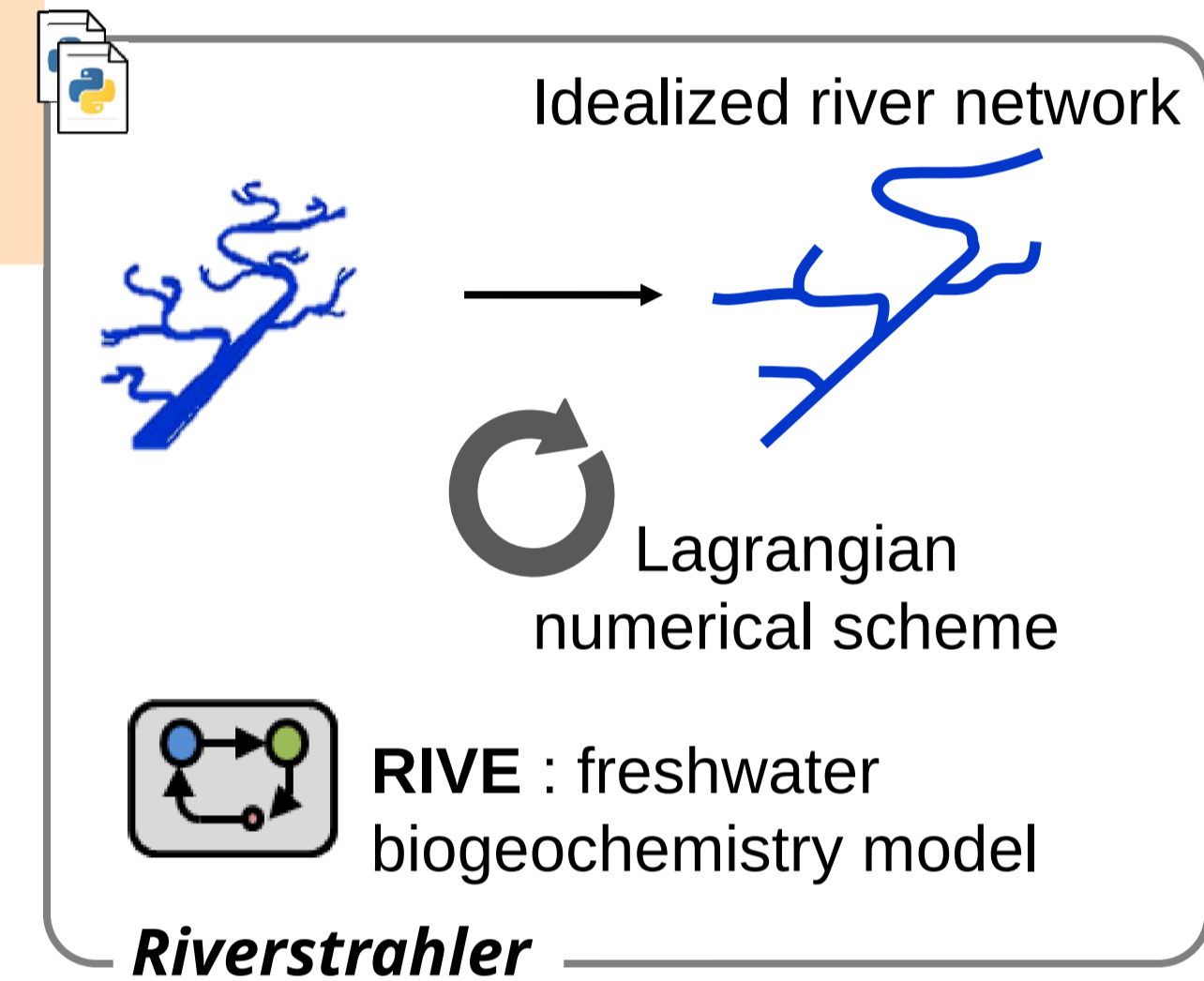
1. an agronomic model (**Stics**).
2. a distributed physics-based hydrogeological model (**CaWaQS**).
3. a river biogeochemical model **pyNuts-Riverstrahler**.

[1] T. Puech, C. Schott, C. Mignolet. Characterising the diversity and spatial differentiation of crop managements at a regional scale. European Journal of Agronomy, 2020, 120, pp.126112. (10.1016/j.eja.2020.126112).
 [2] Galois, N., Mod elisation actualis ee de l' tat de pollution nitrrique d'origine agricole des eaux souterraines du territoire Seine-Normandie sur la p riode 1970-2022. Dans Galois, N. et Thieu, V. (eds.), Impact des pratiques agricoles sur la qualit e de l'eau, PIREN-Seine, Rapport de synth ese phase VIII, Volume 2, 2024, pp. 5-35

Poster goal: to present the developments made on the pyNuts-Riverstrahler model with a first validation exercise on the Seine catchement.

METHOD

THE MODEL



PROCESSES IMPLEMENTED

Sorption/desorption on Particulate Organic Matter using linear model (K_{oc}):

$$C_w = \frac{1}{1 + K_{oc} * POM_{tot}} C_{tot}$$

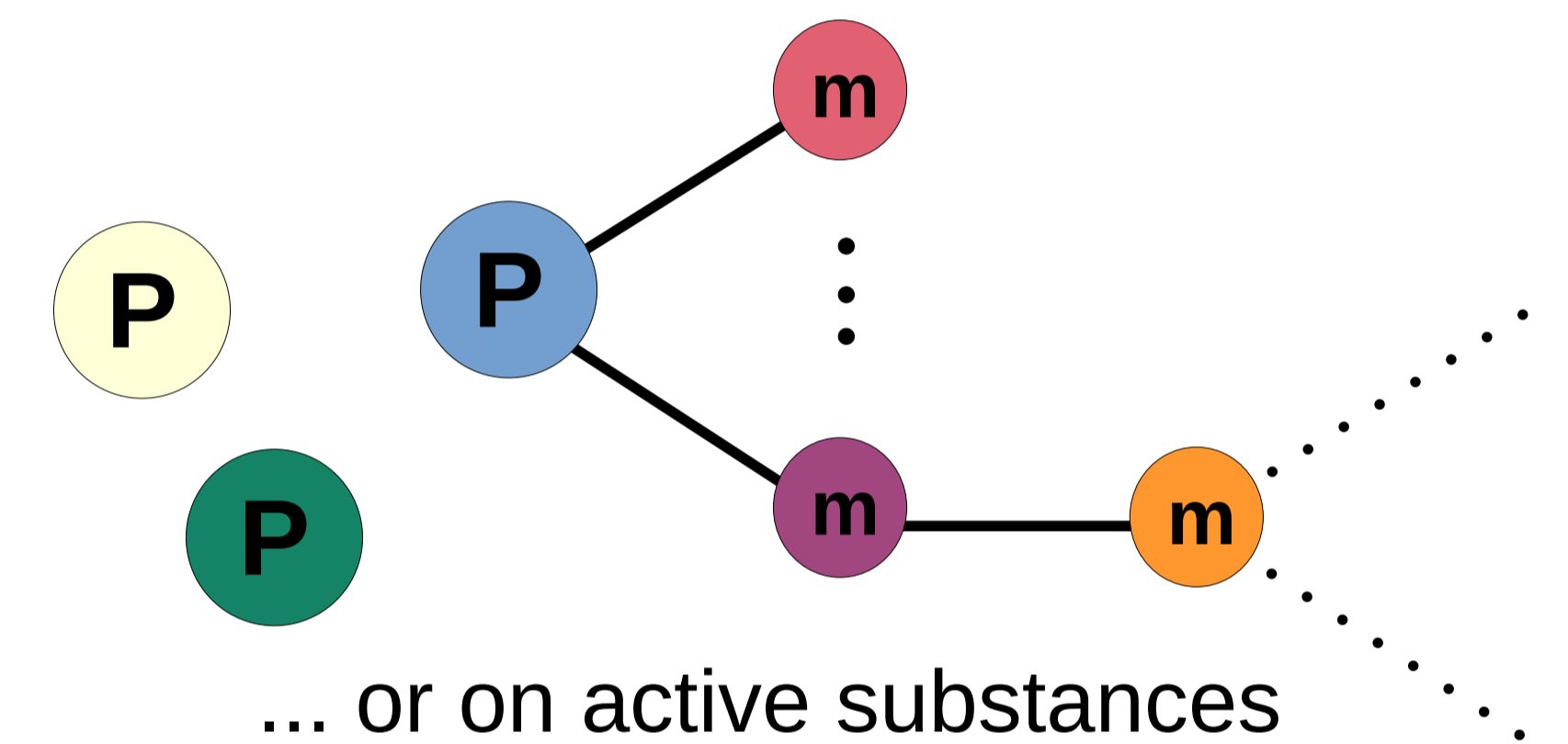
$$C_s = \frac{K_{oc} * POM_{tot}}{1 + K_{oc} * POM_{tot}} C_{tot}$$

Biodegradation as a first order reaction in water column (w) and benthic layer (s):

$$C_{(w,s)}(t) = C_{(w,s)_0} e^{-\frac{\ln 2}{DT_{50(w,s)}} t}$$

$$m_{m(w,s)} = degfrac * m_{p(w,s)} * \frac{M_m}{M_p}$$

No restriction on parent to metabolites relationships (multiples and in cascade) ...



... or on active substances

CASE STUDY

STUDY AREA

Seine basin

76 000 km² drainage area
27 500 km of river network

Modeling period

2016-2021

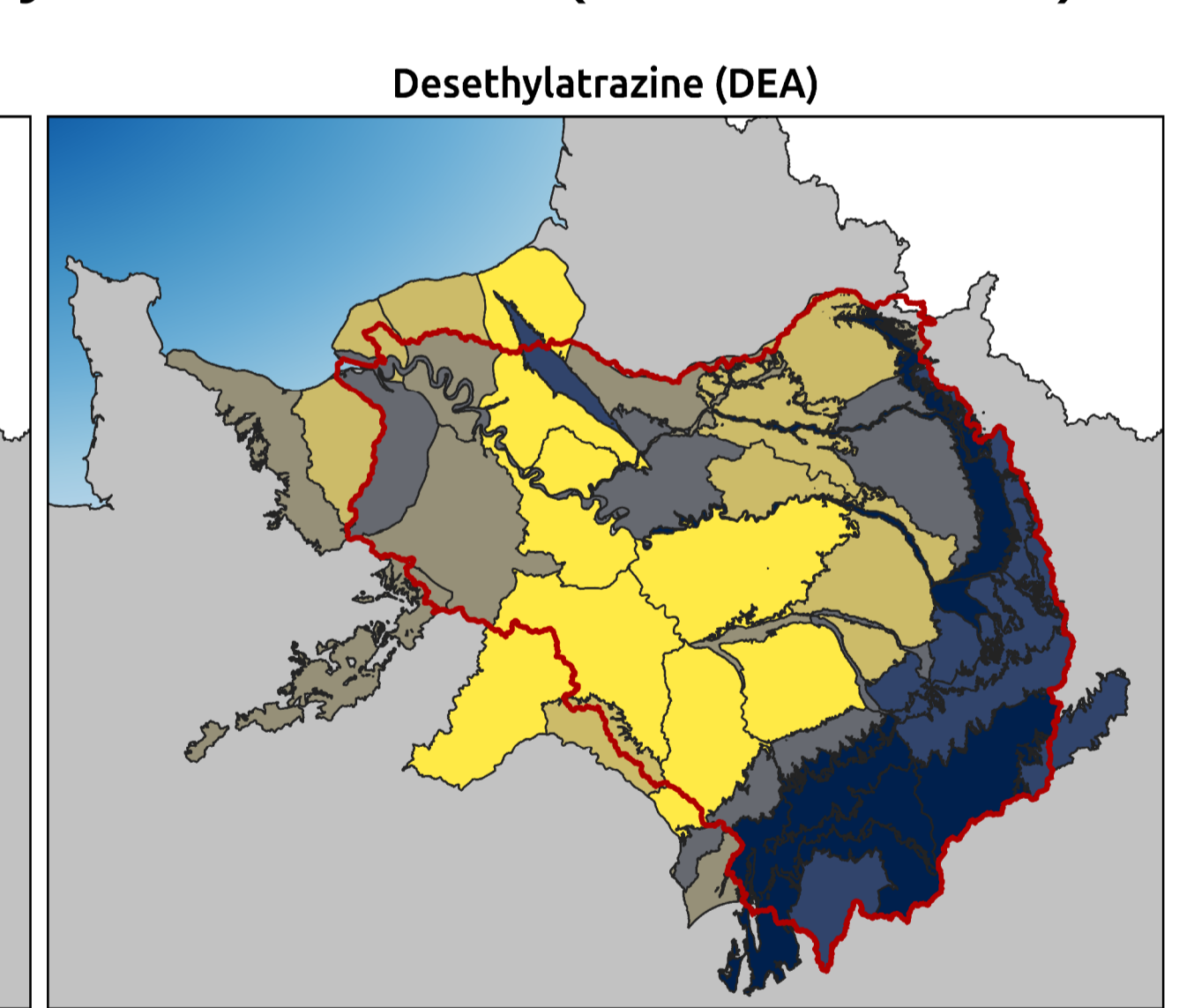
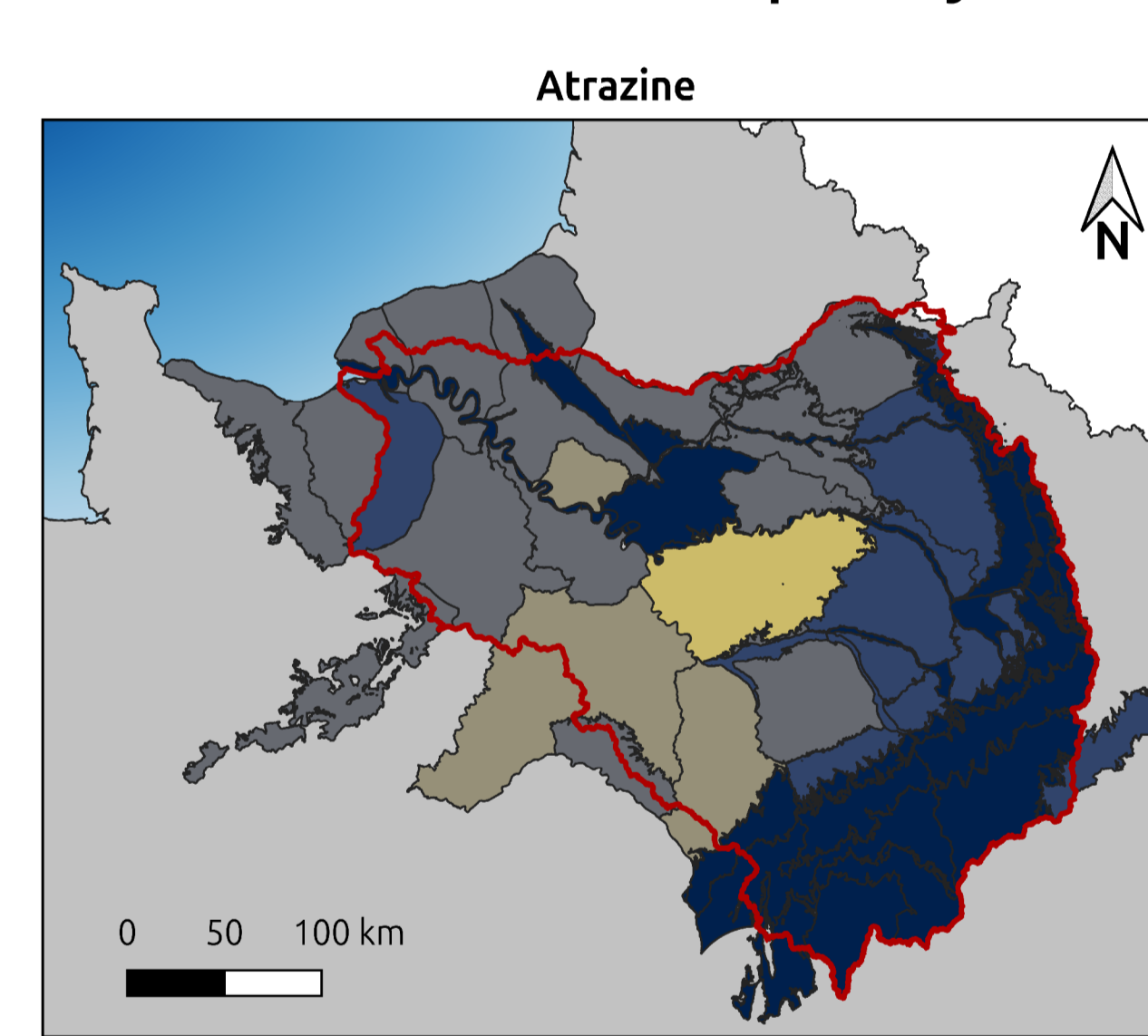
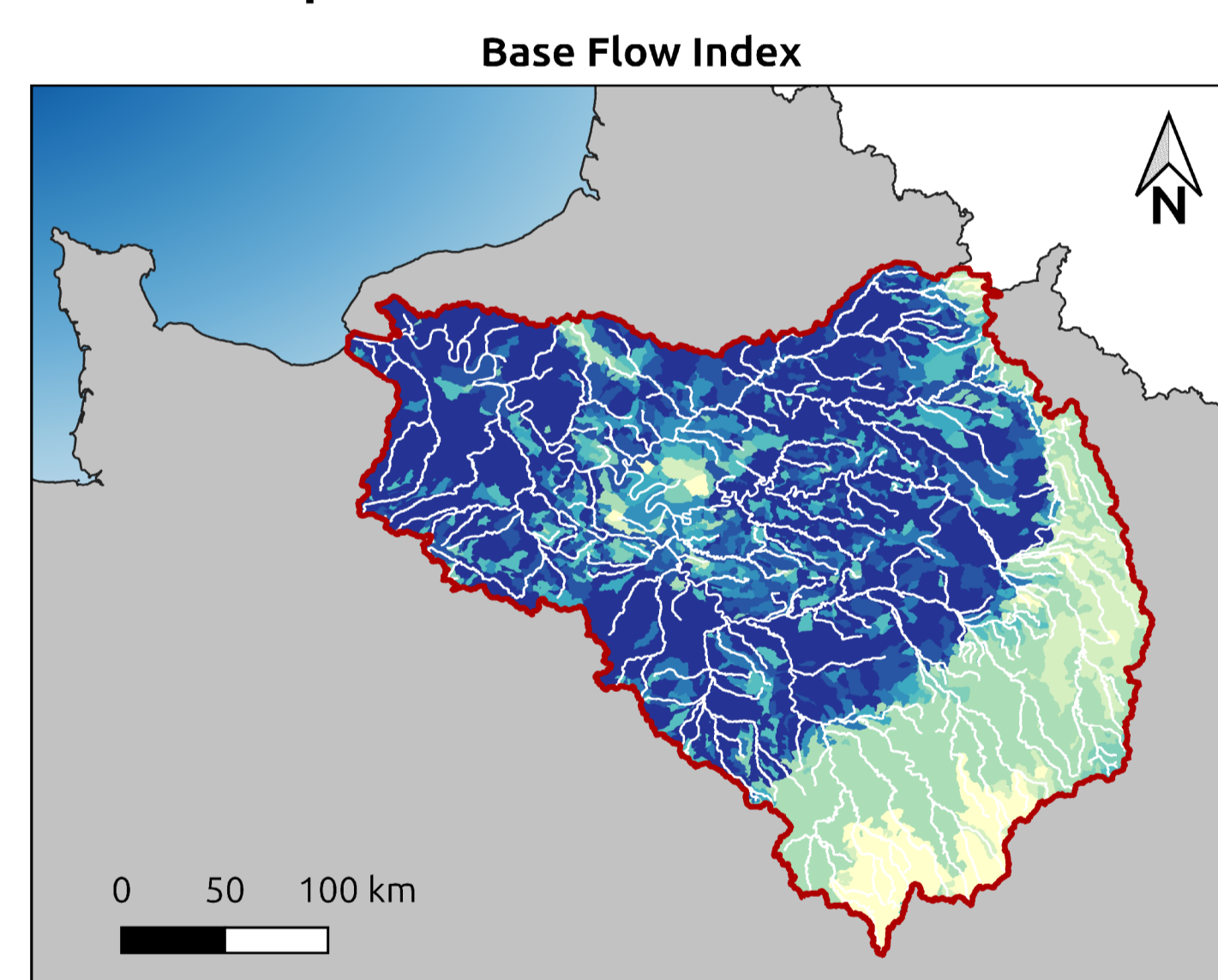
WORKING ASSUMPTIONS

1. Only pyNuts-Riverstrahler modeling (no implementation on other models yet).
2. Atrazine and its metabolite the DEA
 - forbidden since 2001
 - hypothesis: *groundwater as the only remaining transfer pathway*

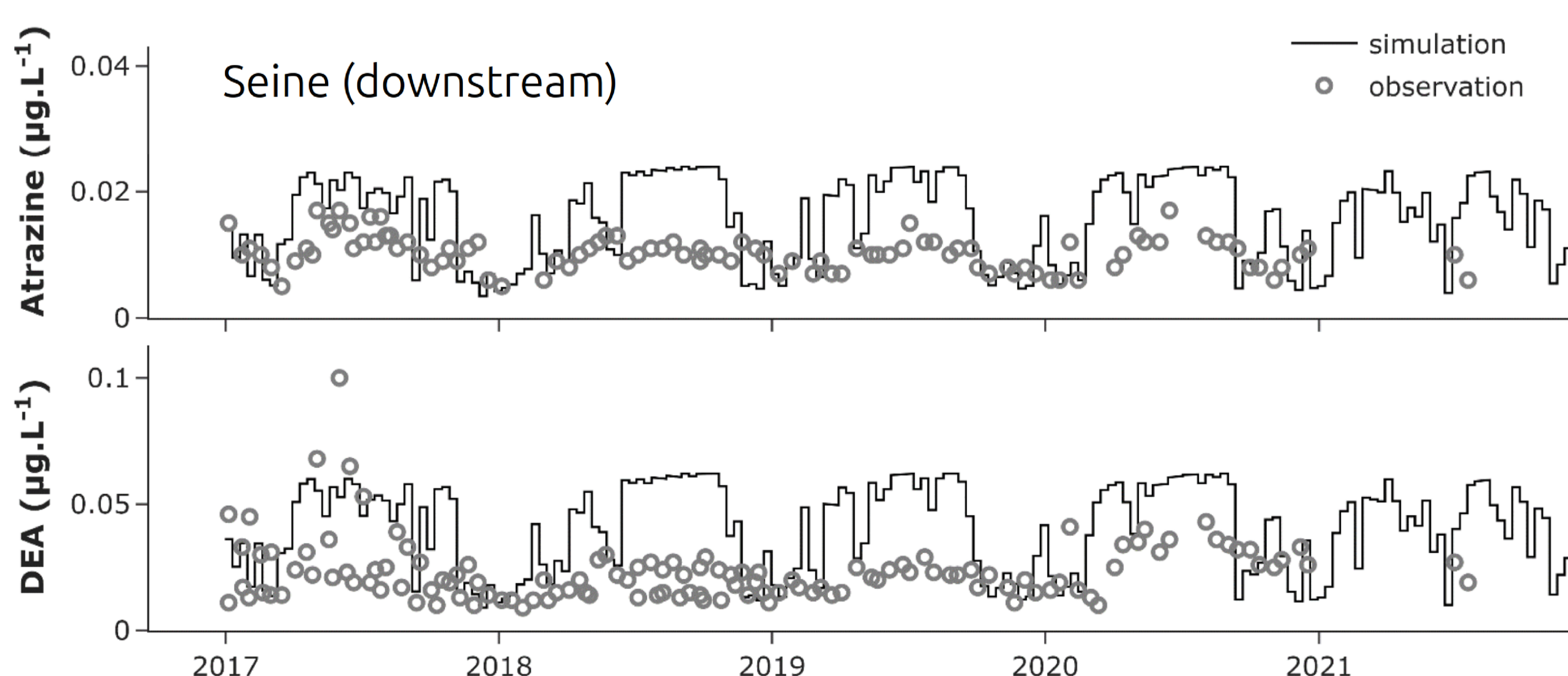
INPUTS

1. Water fluxes from CaWaQS model of the Seine basin at a daily timestep.

2. Atrazine and DEA inputs estimated as the average interannual values in groundwater bodies based on the national water quality analysis database (Hub'eau API).



RESULTS



1. Seasonal variations due to water flow seasonality.

2. Over-estimated concentrations
→ bad assumption?
→ missed processes?

3. Pesticides properties

Pesticide	K_{oc} (L.kgC ⁻¹)	DT50 _w (d)	DT50 _s (d)	Metabolite	degFrac
Atrazine	100	-	80	DEA	0.2
DEA	110	-	-	-	-

PERSPECTIVES

1. Add the possibility to use non-linear models for sorption processes.
2. Add photolysis and hydrolysis as degradation processes (more relevant in rivers).
3. Improve code to monitor processes to calculate detailed mass balance.
4. Study the effect of pesticides on microorganisms modeled by the RIVE model.
5. Complete the model chain from the crops to the river outlet.