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High Frequency Data Assimilation in ProSe-PA Water Quality Model

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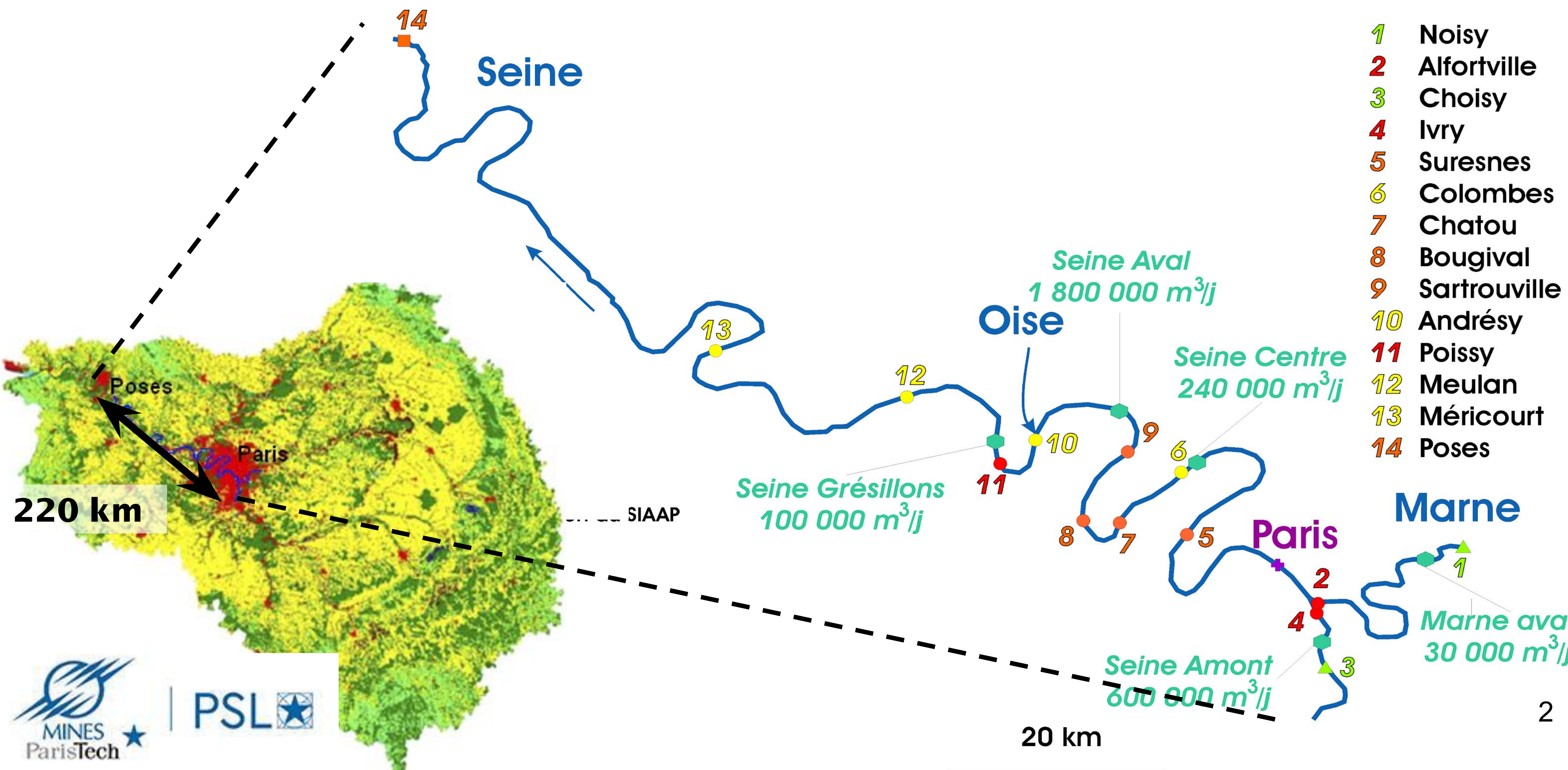
General Context

- Seine river basin is under high anthropogenic pressure
- Environmental challenges and improvements since last 30 years
- **RIVE** biogeochemical model implemented in **ProSe water quality** software
- CARBOSEINE: high frequency data (O_2)



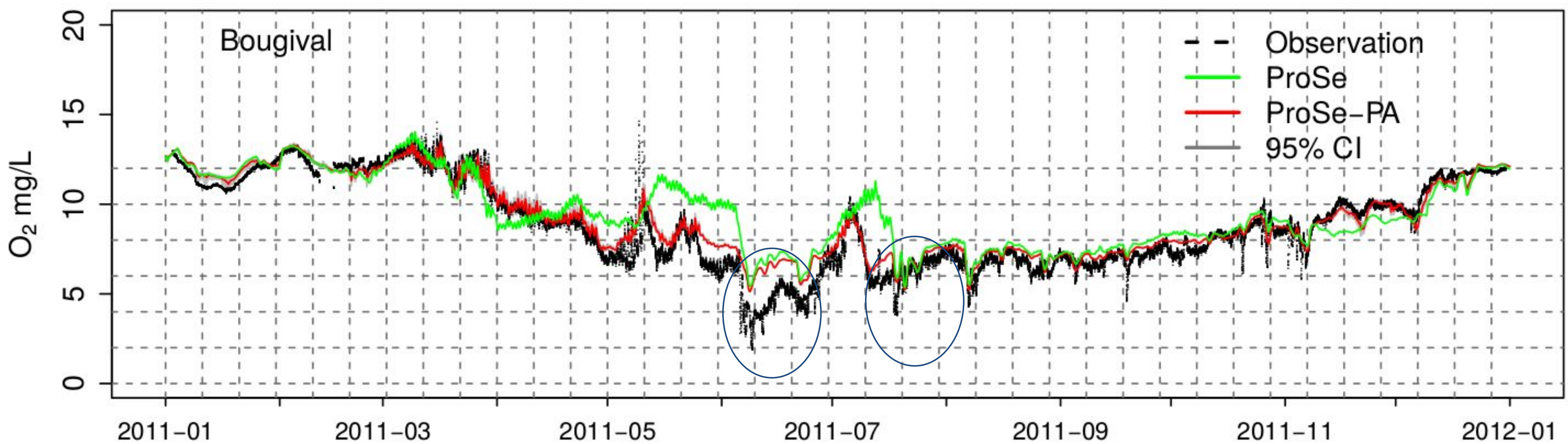
ProSe-PA Water Quality Software

ProSe-PA

ProSe software
(Even, 1995 ; Even et al., 1998, 2007 ; Flipo et al., 2004, 2007)

Particle filter Algorithm
(Wang et al, 2019)

- High Freq. Obs. data (O_2)
- To estimate temporal evolution of model parameters



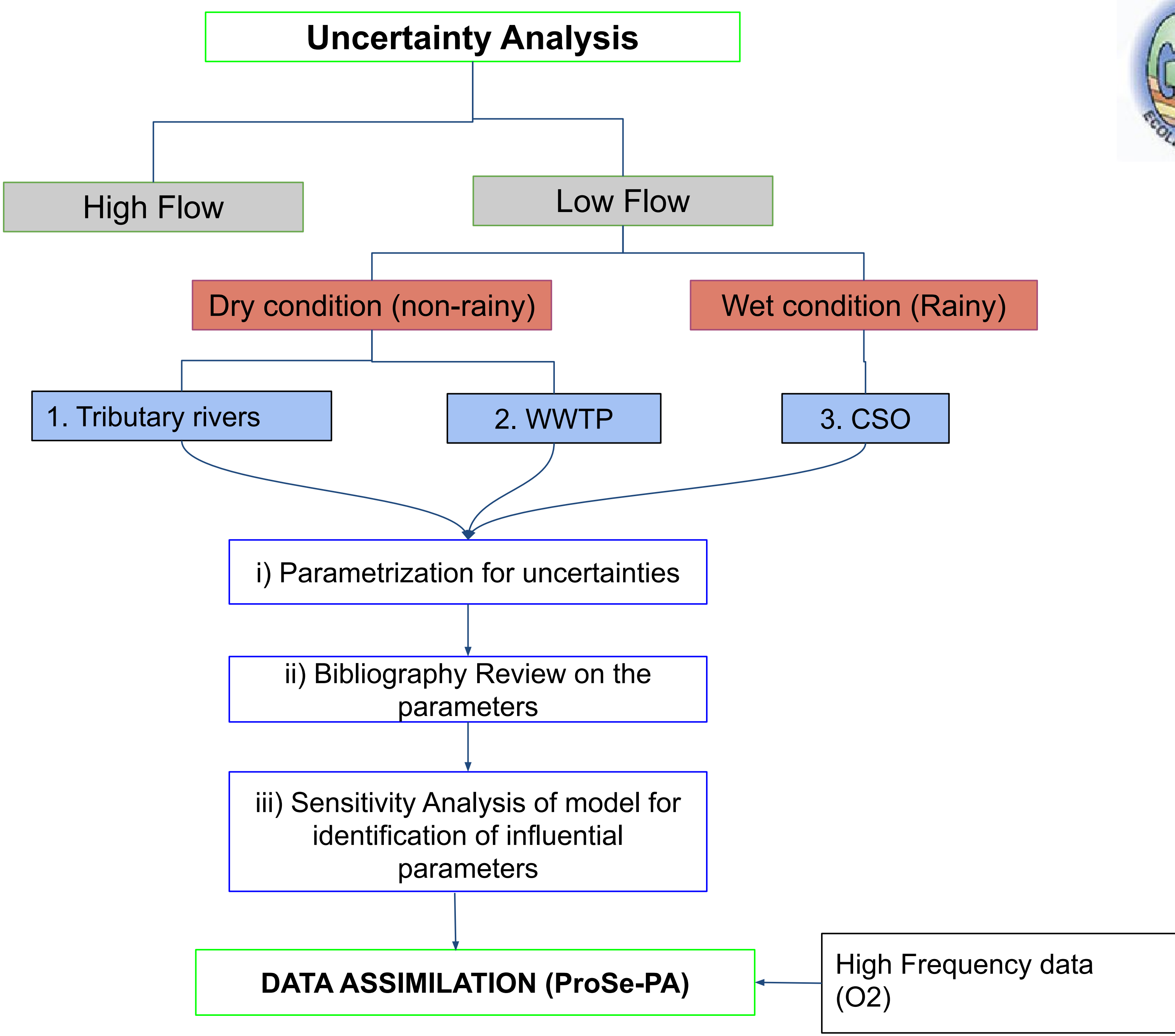
ProSe-PA Water Quality Software

Uncertainties

➔ Parameterization:
- Repartition of Organic matter (OM) from tributary rivers, WWTPs, CSOs
- Degradation kinetics of OM (hydrolysis, uptake)

OBJECTIVES

1. Improving the accuracy of model by reducing the uncertainties linked to parameterization
2. Insert the model into Integrated Water Quality Management System (Sanitation-WWTP-River)


Uncertainty Analysis
High Flow
Low Flow
Dry condition (non-rainy)
Wet condition (Rainy)
1. Tributary rivers
2. WWTP
3. CSO
i) Parametrization for uncertainties
ii) Bibliography Review on the parameters
iii) Sensitivity Analysis of model for identification of influential parameters
DATA ASSIMILATION (ProSe-PA)
High Frequency data (O2)

i) Parametrization for OM repartition and degradation

OM Degradation

K_s(mgC/L): half satu. constant for HB growth

$K_{hyd,max}$(h): Coeff. for hydrolysis of DOM_2 into DOM_1

K_{DOM2} (mgC/L): half satu. constant for hydrolysis of DOM2

OM repartition

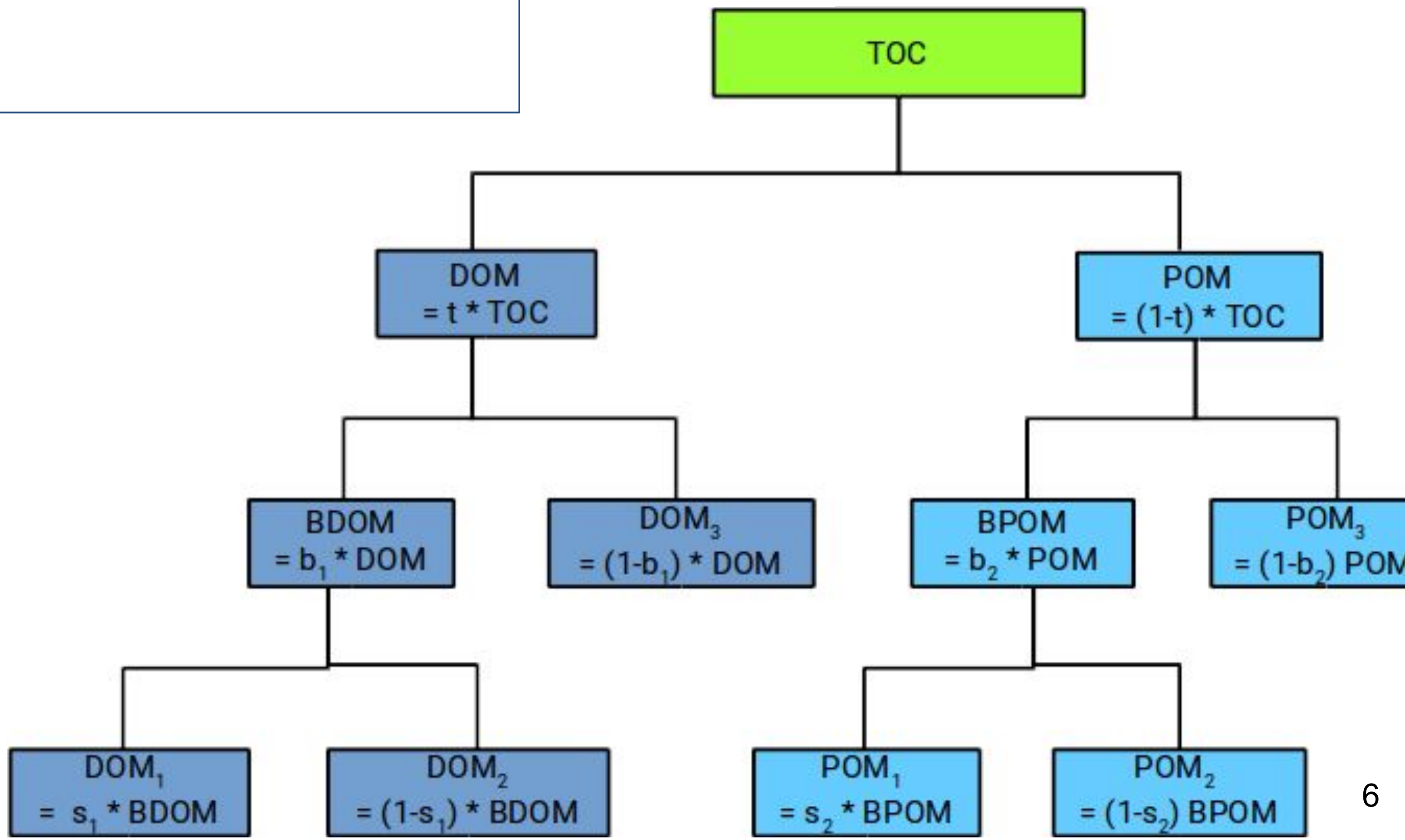
$$t = \frac{DOM}{TOC}$$

$$b_1 = \frac{BDOM}{DOM}$$

$$s_1 = \frac{DOM_1}{BDOM}$$

$$b_2 = \frac{BPOM}{POM}$$

$$s_2 = \frac{POM_1}{BPOM}$$



ii) Literature Review on Parameters' Variation Range

Parameter	Description	Min. Val.	Max. Val.	Unit
OM degradation parameters				
K_s *	constant of semi saturation for substrate uptake by bacteria	0.02	0.15	[mgC/L]
K_{DOM2}	constant of semi saturation for the hydrolysis of DOM_2	0.2	1.5	[mgC/L]
$K_{hyd,max}$	coefficient of the hydrolysis of DOM_2 to DOM_1	0.25	0.75	[/h]
OM share parameters				
t	ratio between dissolved and total organic matter (DOM/TOC)	0.4	0.9	[-]
b_1	ratio between biodegradable DOM and DOM (BDOM/DOM)	0.1	0.5	[-]
s_1	ratio between high biodegradable DOM and biodegradable DOM (DOM_1/BDOM)	0.4	0.95	[-]
b_2	ratio between biodegradable POM and POM (BPOM/POM)	0.1	0.5	[-]
s_2	ratio between high biodegradable POM and biodegradable POM (POM_1/BPOM)	0.4	0.95	[-]
Physical parameters **				
K_{navig}	rearation coefficient due to navigation of boats in the river	0	0.05	[m/h]
K_{wind}	rearation coefficient due to wind	0.885	1.475	[m/h]
Bacterial parameters **				
$T_{opt,hb}$	optimum temperature for bacterial growth	15	30	[°C]
σ_{hb}	standard deviation of temperature function for bacterial growth	12.75	21.25	[°C]
$V_{sed,hb}$	settling velocity of bacteria	0	0.1	[m/h]
$K_{O_2,hb}$	Half-saturation constant for dissolved oxygen	0.375	0.625	[mgO_2/L
$\mu_{max,hb}$ ***	maximum growth rate of bacteria	0.01	0.07	[/h]
Y_{hb}	bacterial growth yield	0.03	0.5	[-]
$mort_{hb}$	bacterial mortality rate	0.01	0.08	[/h]

17 parameters:

- ✔ 3 OM degradation
- ✔ 5 OM repartition
- ✔ 2 Physical
- ✔ 7 Bacterial

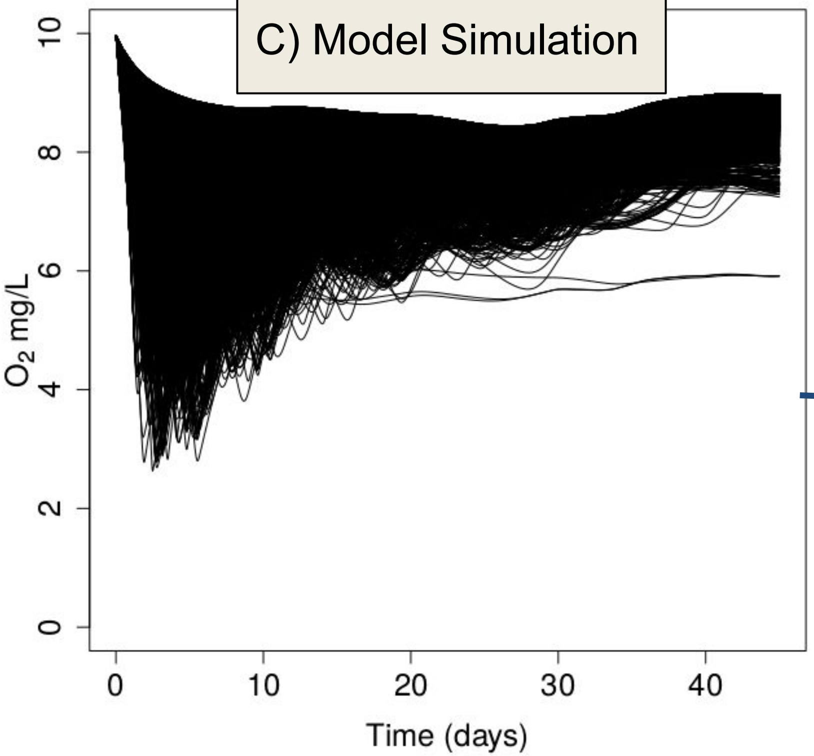
iii) Sensitivity Analysis: Methodology

A) Input Parameters Identif. (D=17) → B) Parameter Sampling

Matrix size: 190,000 X 17

t, b1, s1, b2, s2, Ks, Kmod2, Topt.max, …., …., Knavig | 17

C) Model Simulation

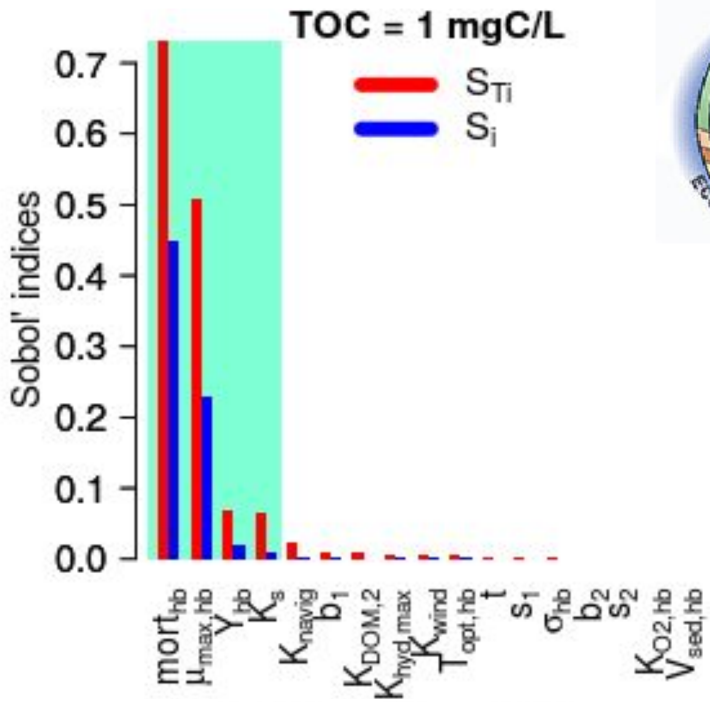


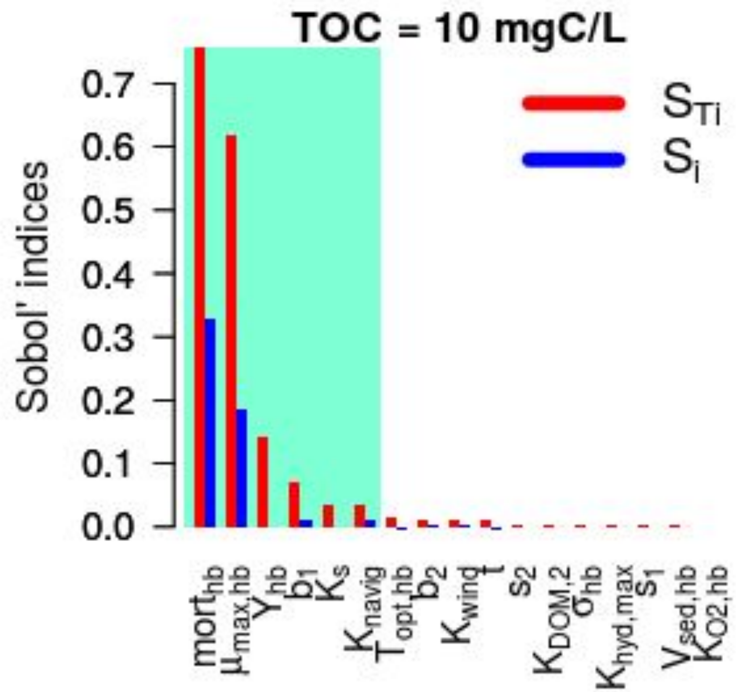
D) Sobol' Sensitivity Analysis (SA)

- Sobol' method
- First order Sens. index (main effect) $S_i = \frac{V_i}{V}$
- Total Sens. index $S_{Ti} = S_i + \sum_{j \neq i} S_{ij} + \ldots$

Results

- Barplots ranked by highest ST
- The influential parameters (green shaded region)
- No. of influential parameters increase with TOC
- $Mort_{hb}$ and μ_{max} are the most influential params
- Heterotrophic bacteria dominancy
- Ks, b_1 and K_{navig} last three influential parameters

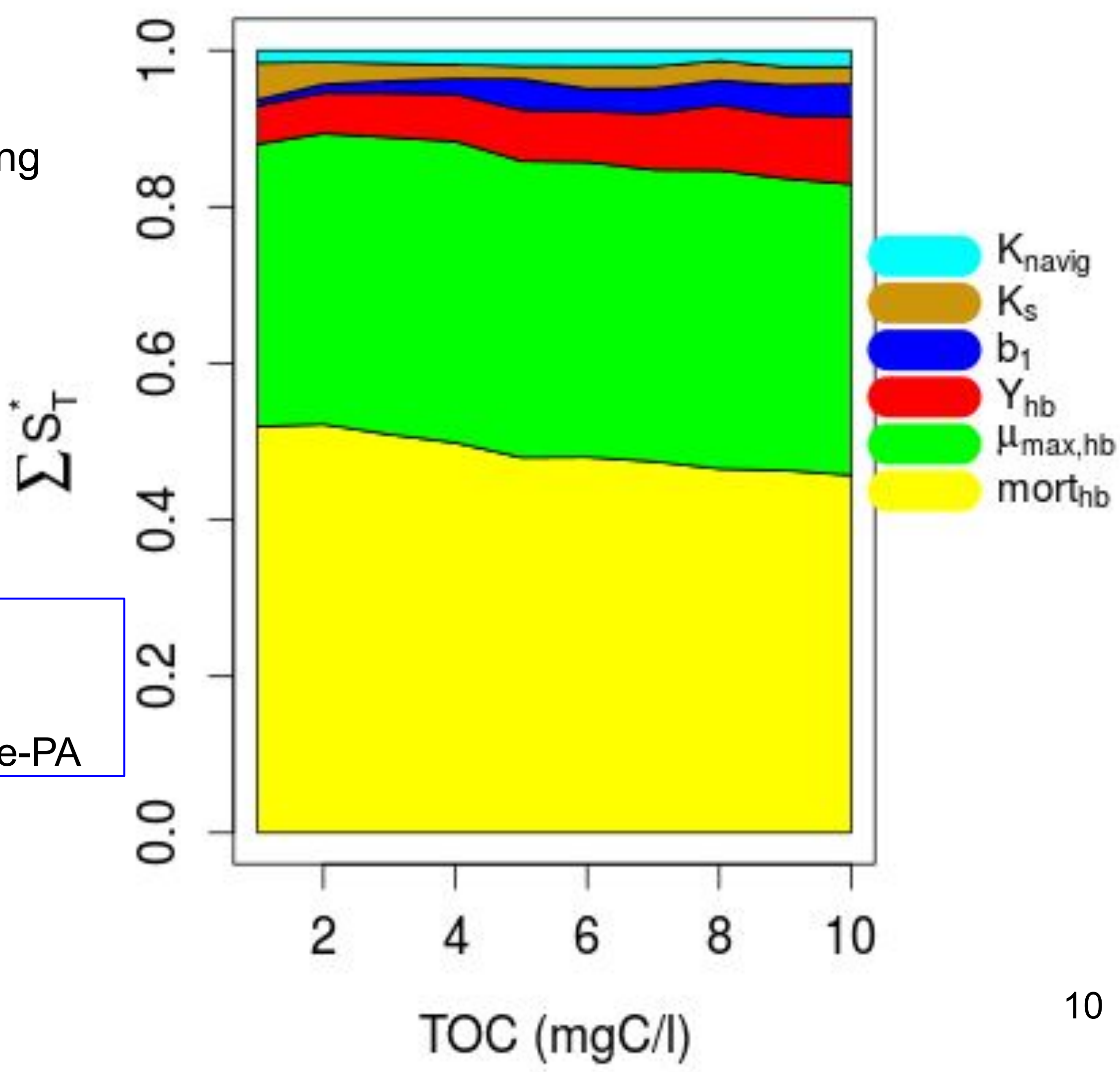




Discussion & Perspective

- Ks more important for TOC= 1-3 mgC/L
- Ks governs the OM degradation by representing the uptake of DOM1
- b1's influence increases for TOC ≥ 4 mgC/L
- b1 governs the OM repartition by characterizing the biodegradable fraction of DOM.

Impact of TOC on SA



Next step:

- To fix the non-influential parameters
- To insert the 6 influential parameters into ProSe-PA

Thanks For Your Kind Attention