Organic carbon pathways in the Seine River System

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Introduction

1. Context

The project "Carbon Cascades from Land to Ocean in the Anthropocene" (C-Cascades) is an interdisciplinary research project which will train 15 young scientists to work on the role of the carbon cycle in regulating earth's climate.
The aim is **to make important progress in understanding the carbon transfer between land and ocean and the consequences for atmospheric CO_2 and climate.** This integrated and cutting-edge research programme will be guided by 9 academic and 4 intersectoral European partners. (http://c-cascades.ulb.ac.be/)

The global carbon cycle involves reactions within and exchanges through the four global reservoirs : the atmosphere (612Pg.y^{-1}), the terrestrial biosphere (2000Pg.y^{-1}), the oceans (38 000Pg.y^{-1}) and the sediments (3440Pg.y^{-1}). [1]

The study site of the Metis-IPSL partner is the Seine Basin where Paris agglomeration represents 2/3 of its population and agriculture is particularly intensive.

Such a human impacted system is essential to study because it constitutes one of the next challenges our society has to confront. In this project, we will focus on the inorganic and organic carbon transport, transformation and fate along the land, streams, rivers and oceans.

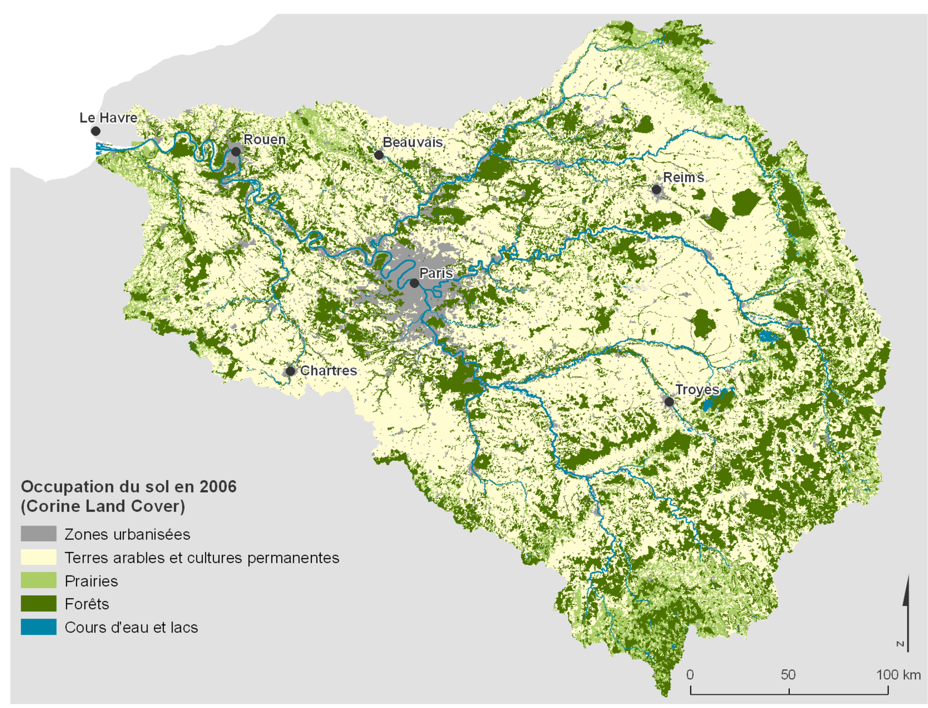
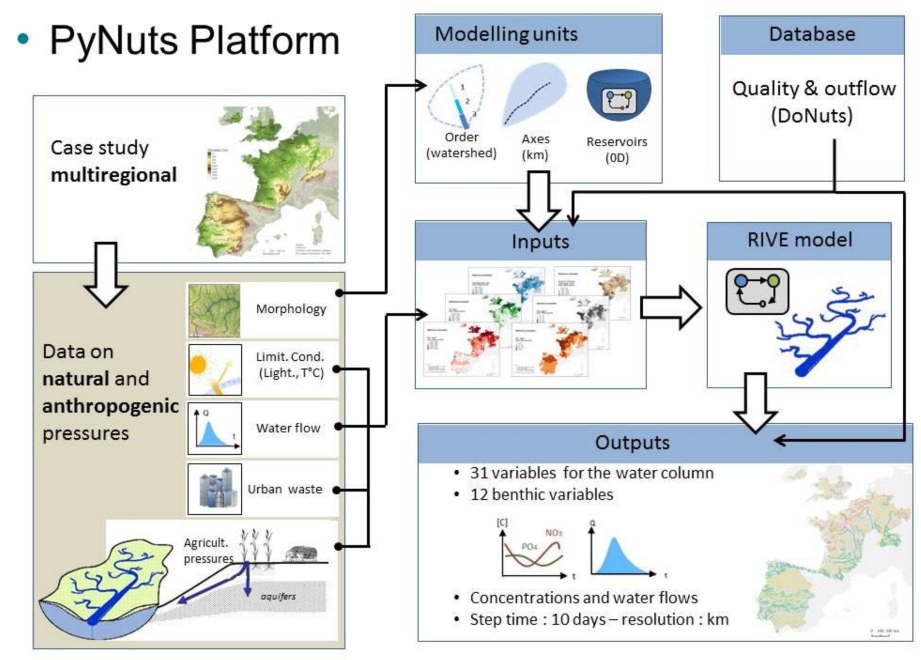


Fig. 1. Land use in the Seine Basin in terms of forest, grassland and cropland. Urban areas. The drainage network is also indicated as well as the main axis and location of Paris city.

2. pyNuts – Riverstrahler model

The "pyNuts" modelling platform has been recently designed for enabling a generic and large scale implementation of the Riverstrahler model, applicable at various scales, from few square kilometres to several tens of thousands square kilometres, with the distinctive feature to adapt it spatial resolution according to the modelling objectives.

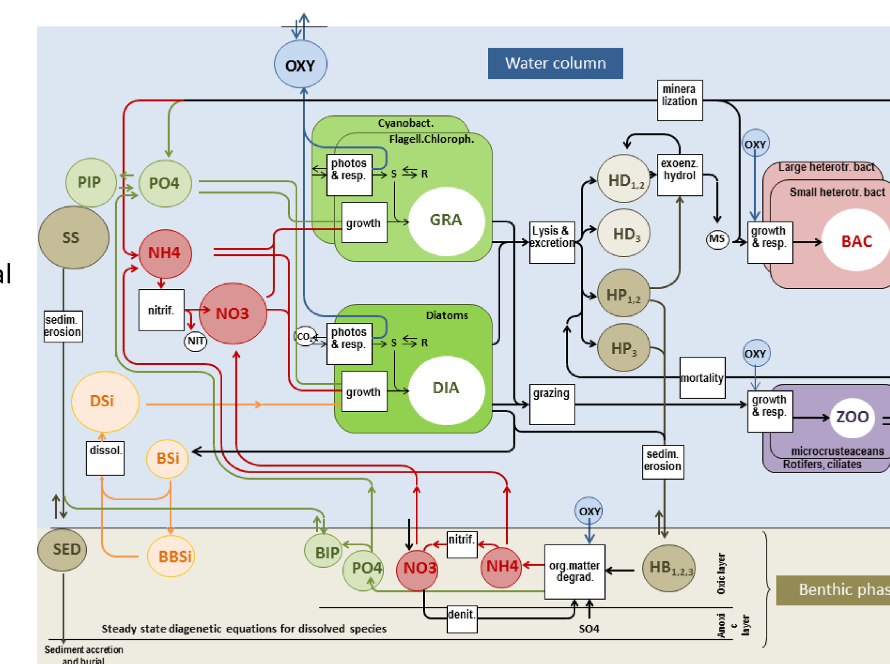
- PyNuts Platform



[↑] *Fig. 2.* Schematic representation of the PyNuts-Riverstrahler modelling framework [4]

[→] *Fig. 3.* Conceptual scheme of the RIVE model of biogeochemical processes in aquatic systems. [2,3]

The Riverstrahler model combines a routage of the discharge under two components based on Strahler stream order, and the RIVE ecological model [2,3].
It is a biogeochemical modelling approach, including microbiological processes, in the water column and at the water sediment interface, including C, O_2, N, P and Si cycles, from head waters to coastal zones.



The model calculates delivered fluxes and already takes into account dissolved and particulate organic carbon (DOC and POC) under 3 classes of degradability.

CO_2 is not yet explicitly represented in the Riverstrahler model.

3. Objectives

The aim of this research is to understand and quantify how an excess of anthropogenic nutrients entering the Seine River system may locally enhance primary production and C sequestration/emission and how the modification of organic C loads can influence C metabolism (autotrophic-heterotrophic). A new module representing the CO_2 emission will be implemented in complement to the one of organic carbon in the pyNuts-Riverstrahler model.

Materials & Methods

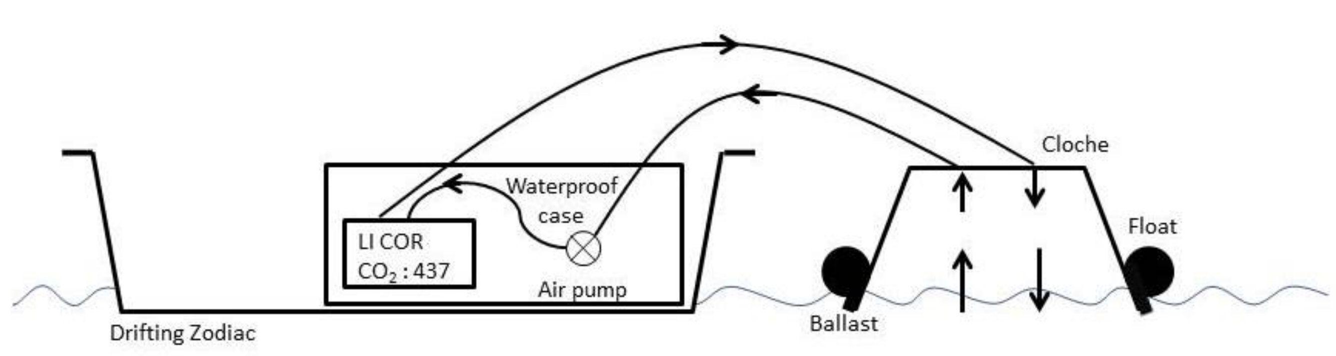
4. Data analysis

- Data base of surface (RNB) and groundwaters (ADES) : COT, COD
- Piren-Seine data: COD, BCOD, COP, Alkalinity, pH…
- Model simulations : COD, COP, primary production, heterotrophic bacterial activity

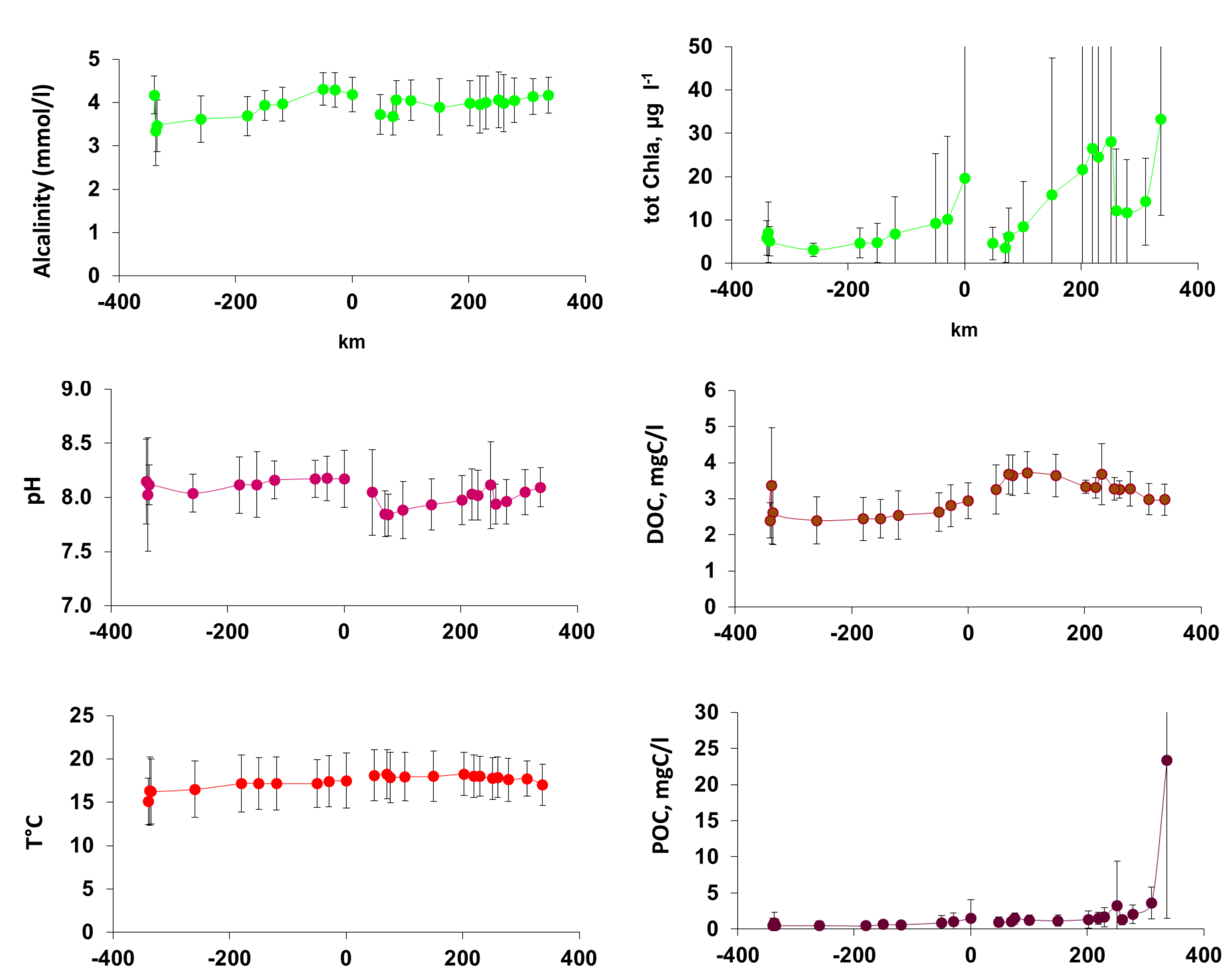
5. Field studies

- Measurements of alkalinity, COD, COP and their biodegradable forms
- Measurements of water-air CO_2 degassing (Fig. 3)

[→] *Fig. 4.* A schematic representation of the experimental design for measuring CO_2 fluxes



6. Example of results to be analyzed



11 low water campaigns from 2010 to 2014

CO_2 concentrations can be measured indirectly and directly.
We will use the two measurement strategies.

Direct measurements

-Cf. 5. Field studies

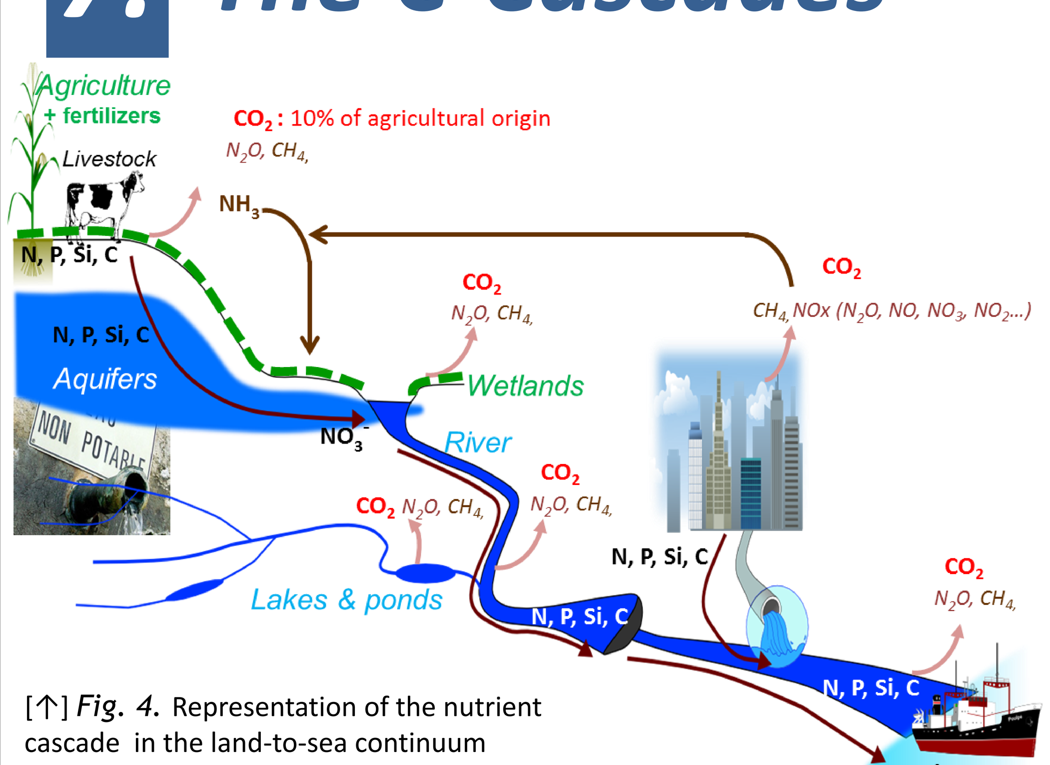
Indirect measurements

-pH; T°; Alkalinity [5]

[←] *Fig. 5.* Averaged longitudinal profiles of the Marne Branch (km -400 to 0), and of the lower Seine river from Paris to the estuary (km 0 to 400)

Modelling

7. The C-Cascades



[↑] *Fig. 4.* Representation of the nutrient cascade in the land-to-sea continuum

➔Along the river to sea continuum

- Implementation of a module of CO_2 emissions
- Determination of the C point and diffuse sources inputs
- Validation of the CO_2 module using field data (and existing N_2O and CH_4 ones)
- Spatial budgets of CO_2 emissions

➔Exploring scenarios

Exploring scenarios of future changes in land-to-ocean carbon transfers using the ISI-MIP climate scenarios, and scenarios for reducing eutrophication, hypoxia and nitric contamination from agriculture in a context of urbanization of the "Grand Paris" (improvements in waste water treatments, alternative agriculture etc.)

8. Major expected results

- Introduction of GHG in the Riverstrahler model
- Evaluating GHG emission of the rural vs. urban emissions
- Integrating theses results for a watershed with the results gathered by the others Ph-D

➔ Providing support for reducing GHG emissions

References :
[1] Emerson, S., & Hedges, J. (2008). Chemical Oceanography and the Marine Carbon Cycle, p. 374
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[5] Munhoven G. (2013). Geosci. Model Dev. 6, 1367–1388

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