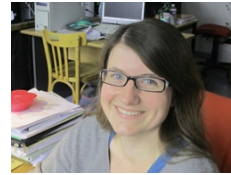


# Introducing the biogeochemical model PyNuts-Riverstrahler to assess prospective scenarios impact along the aquatic continuum in Western-EU rivers

Vincent Thieu<sup>2</sup>



Marie Silvestre<sup>1</sup>

Josette Garnier<sup>1,2</sup>



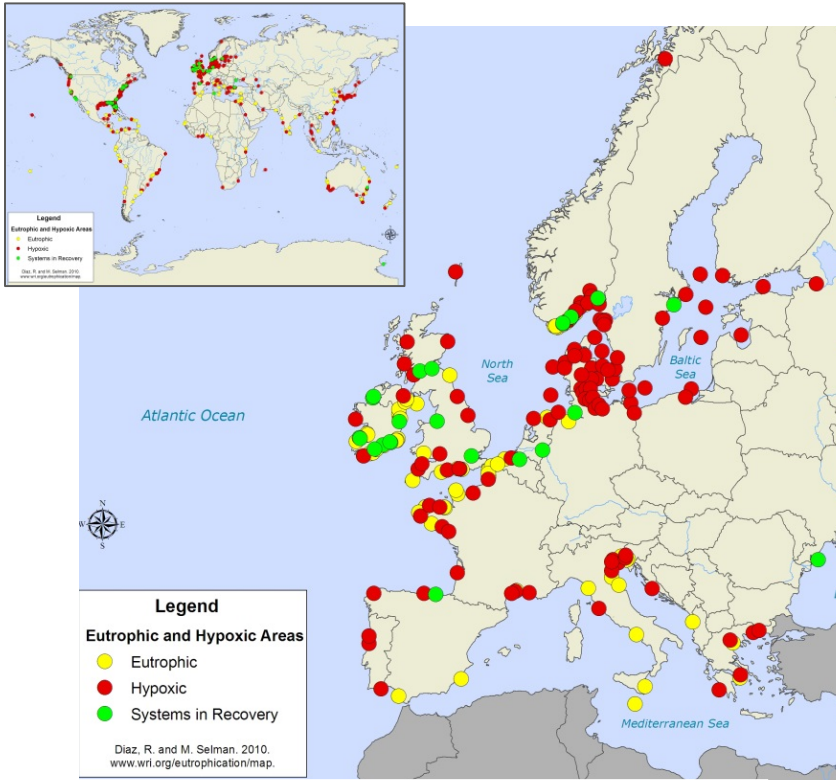
Gilles Billen<sup>2</sup>

<sup>1</sup>FIRE, Fédération Île-de-France de Recherche en Environnement, Paris, France

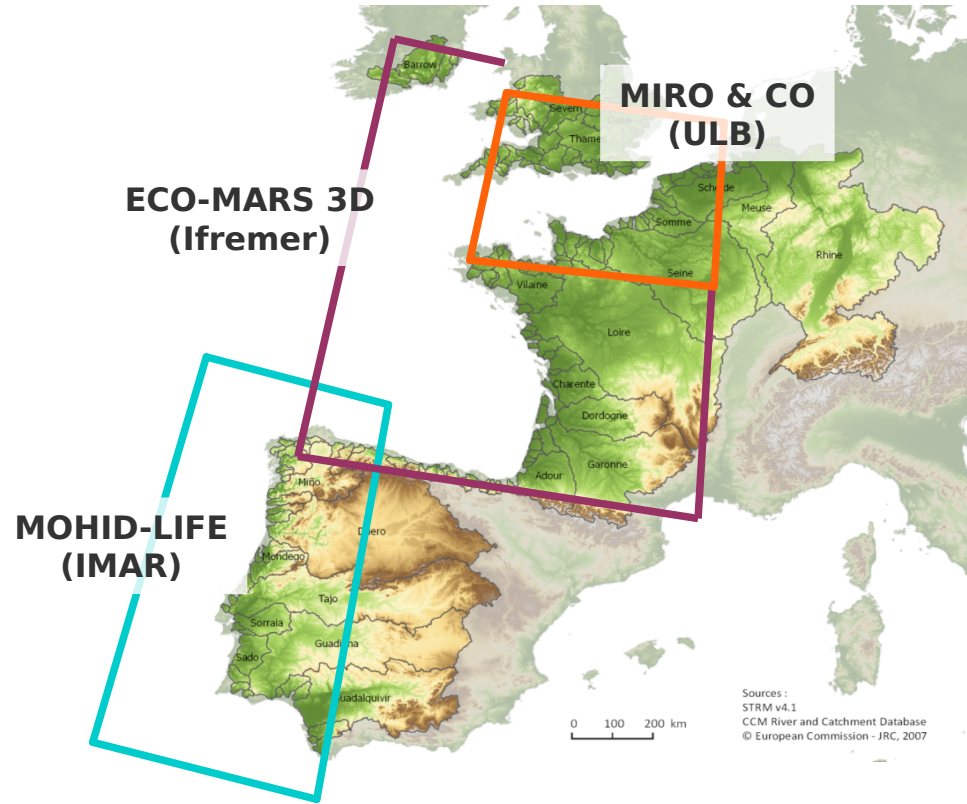
<sup>2</sup>METIS, Pierre & Marie Curie University, Paris, France



# Context



Diaz, R. and M. Selman. 2010  
[www.wri.org/eutrophication/map](http://www.wri.org/eutrophication/map)



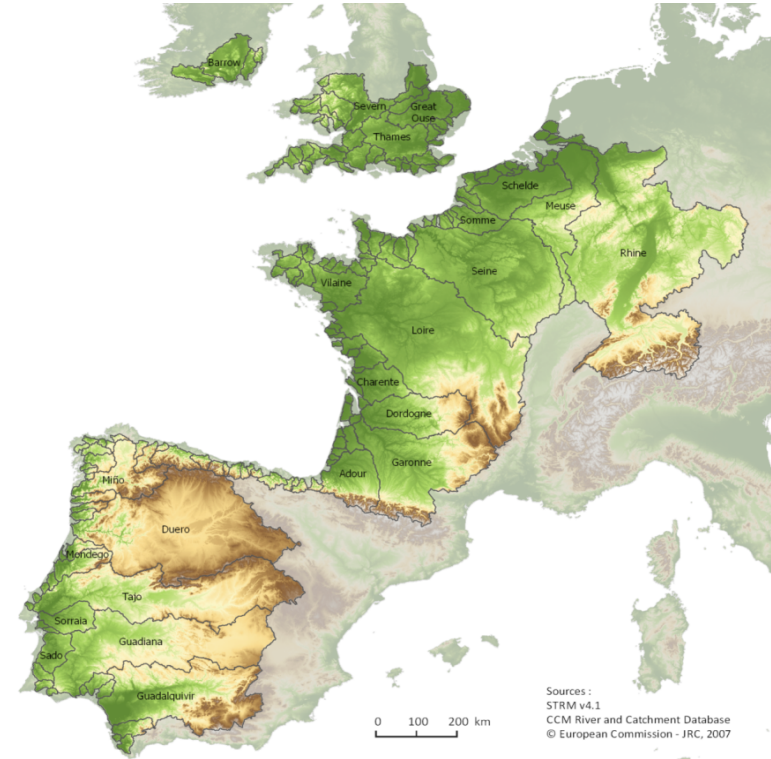
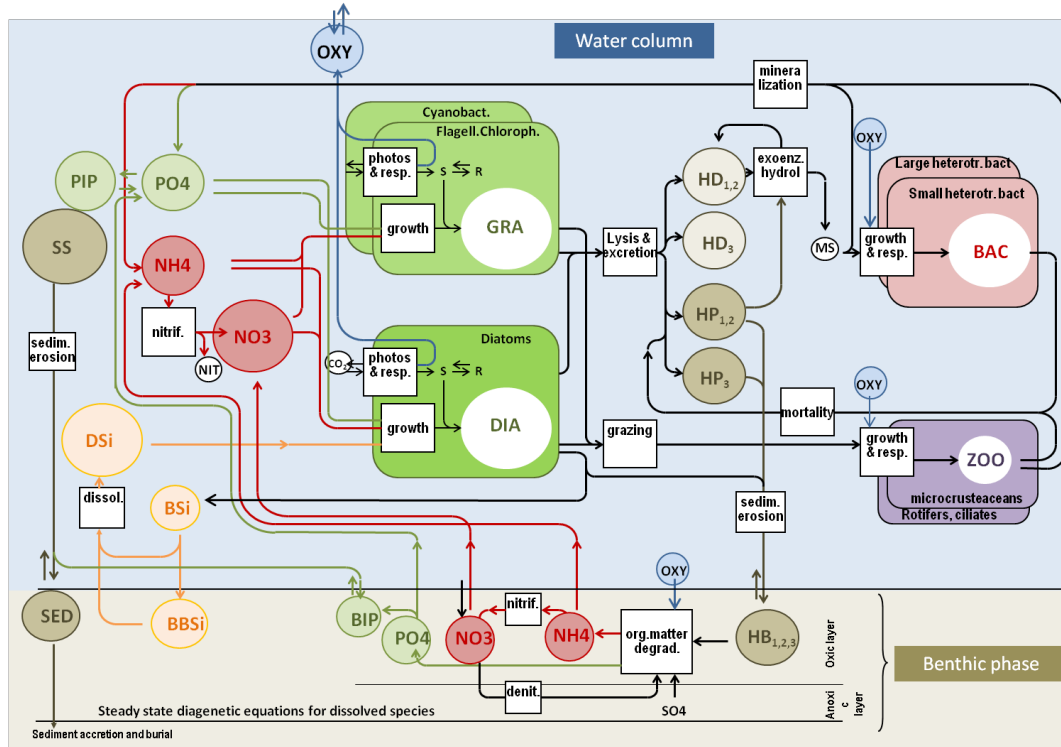
EU project Seas-era:

**EMoSEM**

**Ecosystem Models as Support to Eutrophication Management in the North Atlantic Ocean**

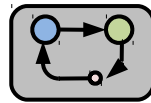
in collab. with ULB (BE), Ifremer (FR), IMAR (PT)

# Context



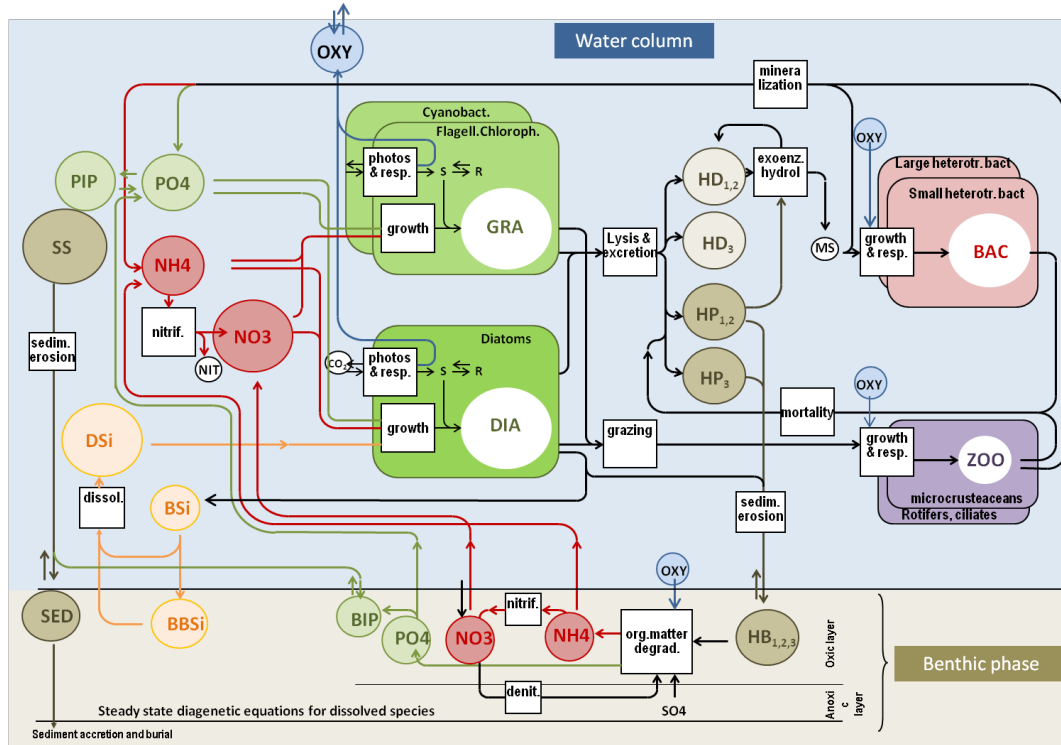
## The Riverstrahler model

*Billen et al (1994), Garnier et al (1995), Thieu et al. (2016)*

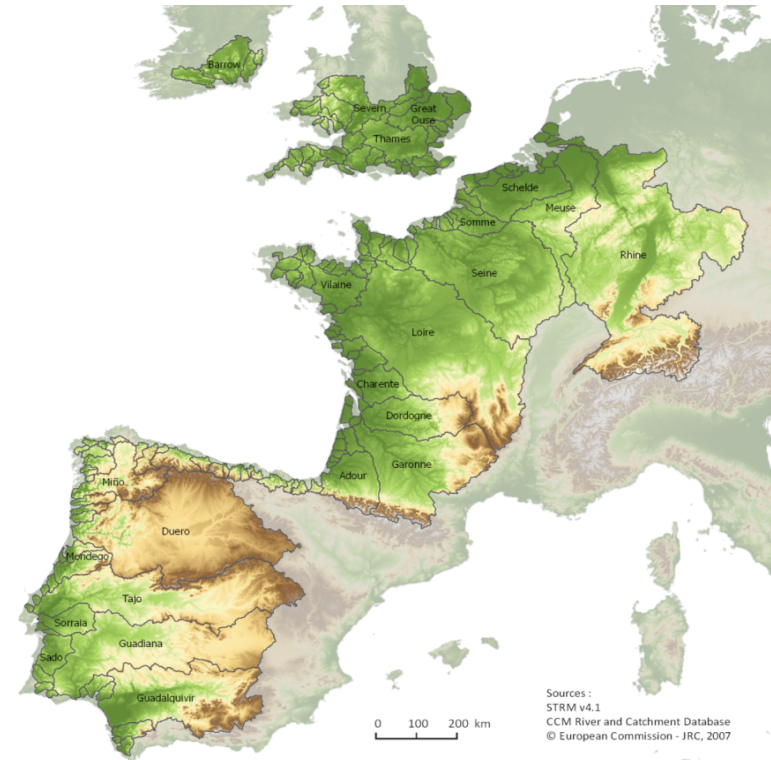


EMoSEM

# The challenge



Billen et al (1994), Garnier et al (1995), Thieu et al. (2016)

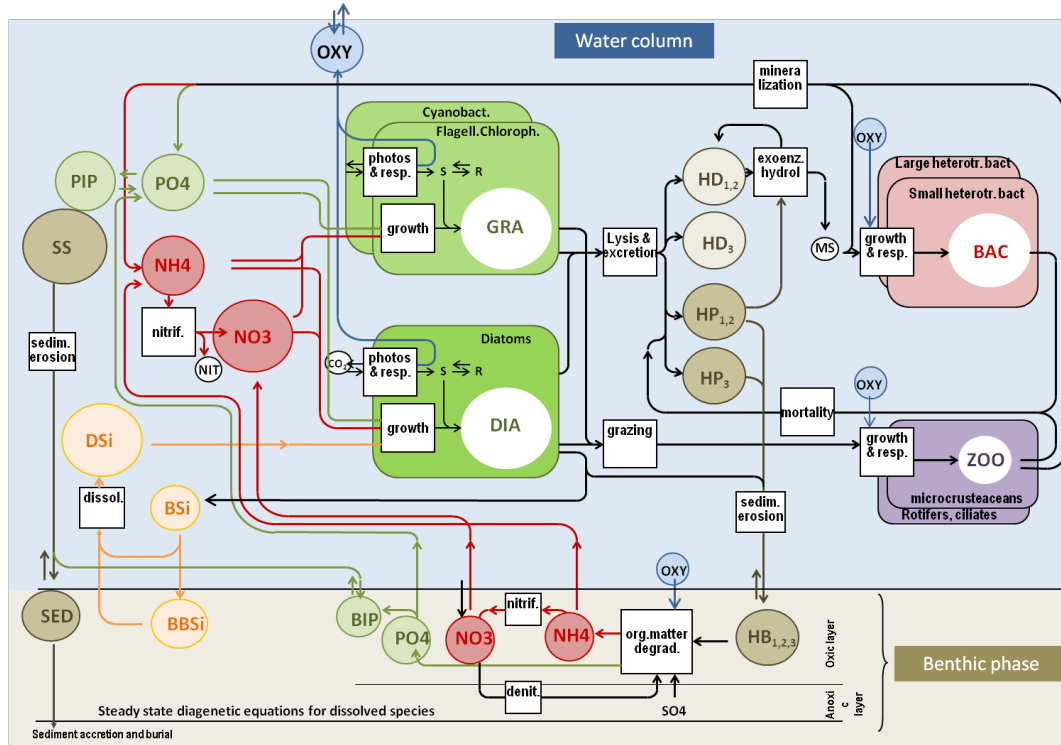


Sources :  
 STRM v4.1  
 CCM River and Catchment Database  
 © European Commission - JRC, 2007

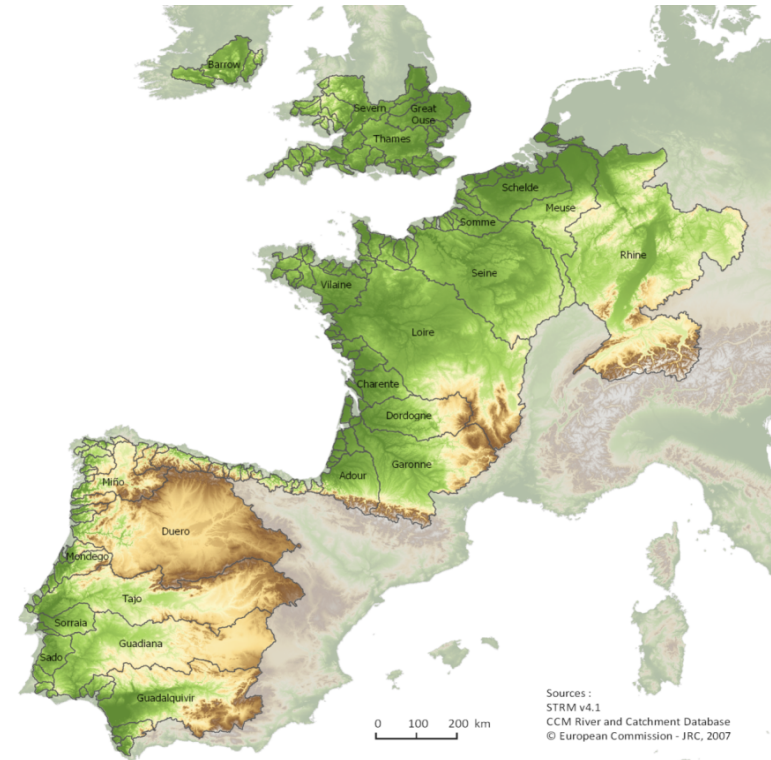
→ continental application of the Riverstrahler model  
 North East Atlantic (NEA) continental domain = 1 million km<sup>2</sup> and 356 823 km rivers



# The challenge



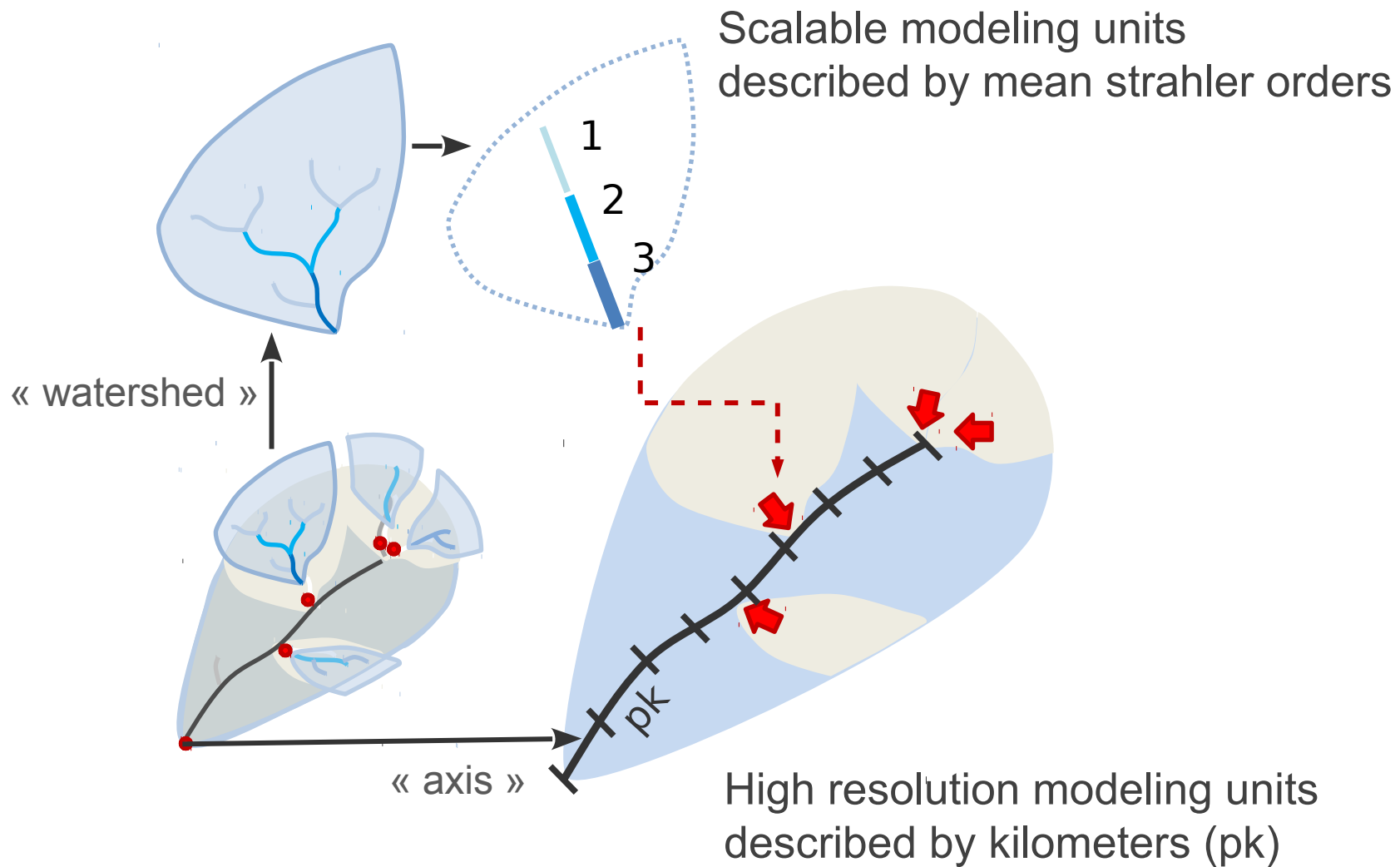
Billen et al (1994), Garnier et al (1995), Thieu et al. (2016)



## Outline

- Defining modeling units
- Building an atlas of land based emissions to rivers
- Validating on a pluri-annual period
- Impact of prospective scenarios on watersheds and coastal zones

# Modeling units



# Modeling units on the NEA continental domain

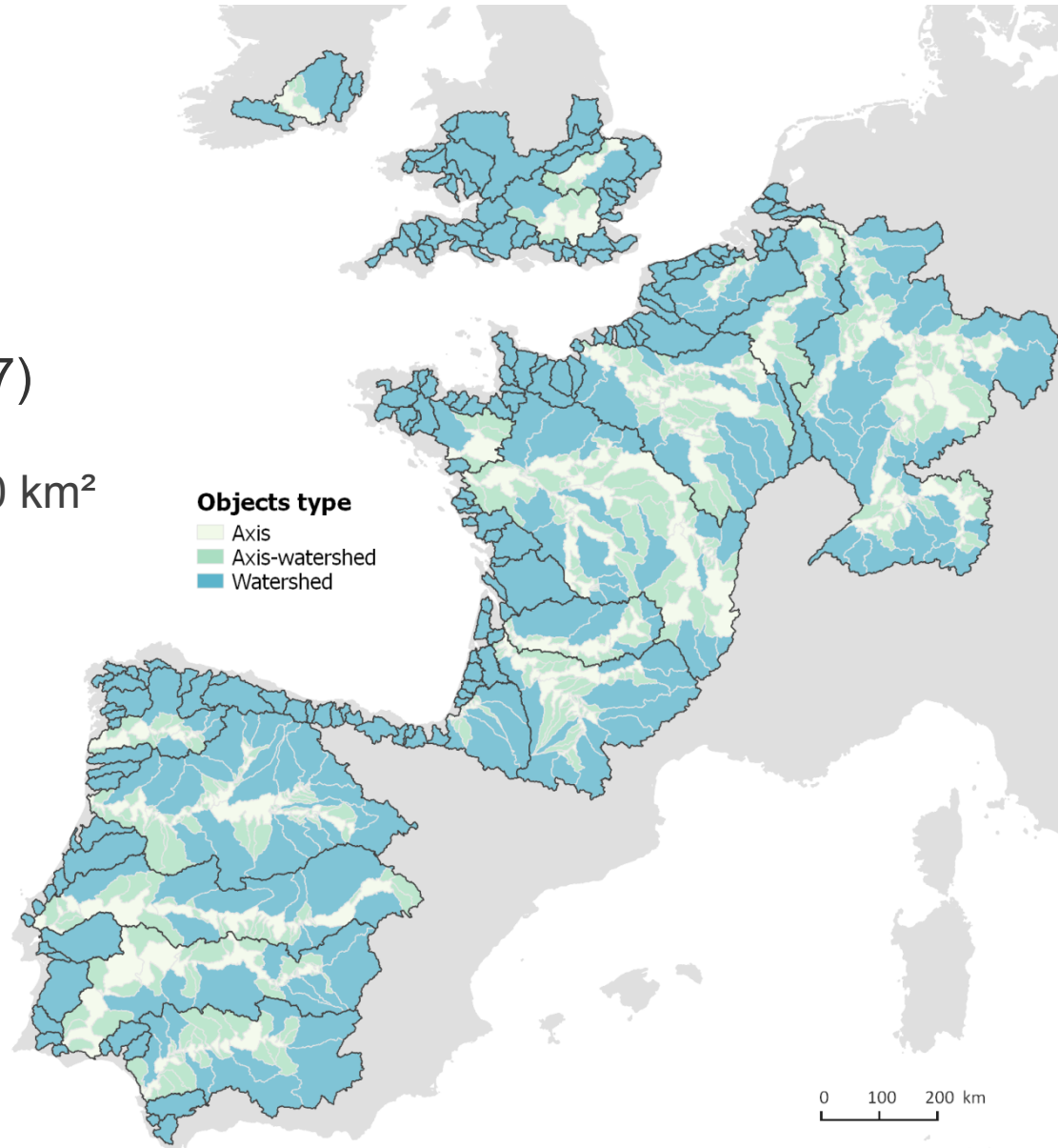


Hydrographic network

## CCM River and Catchment Database 2.1 (Vogt et al., 2007)

Selection criteria: river basin  $> 300 \text{ km}^2$   
17 main rivers basins divided  
154 smaller basins

→ **972 modeling units**



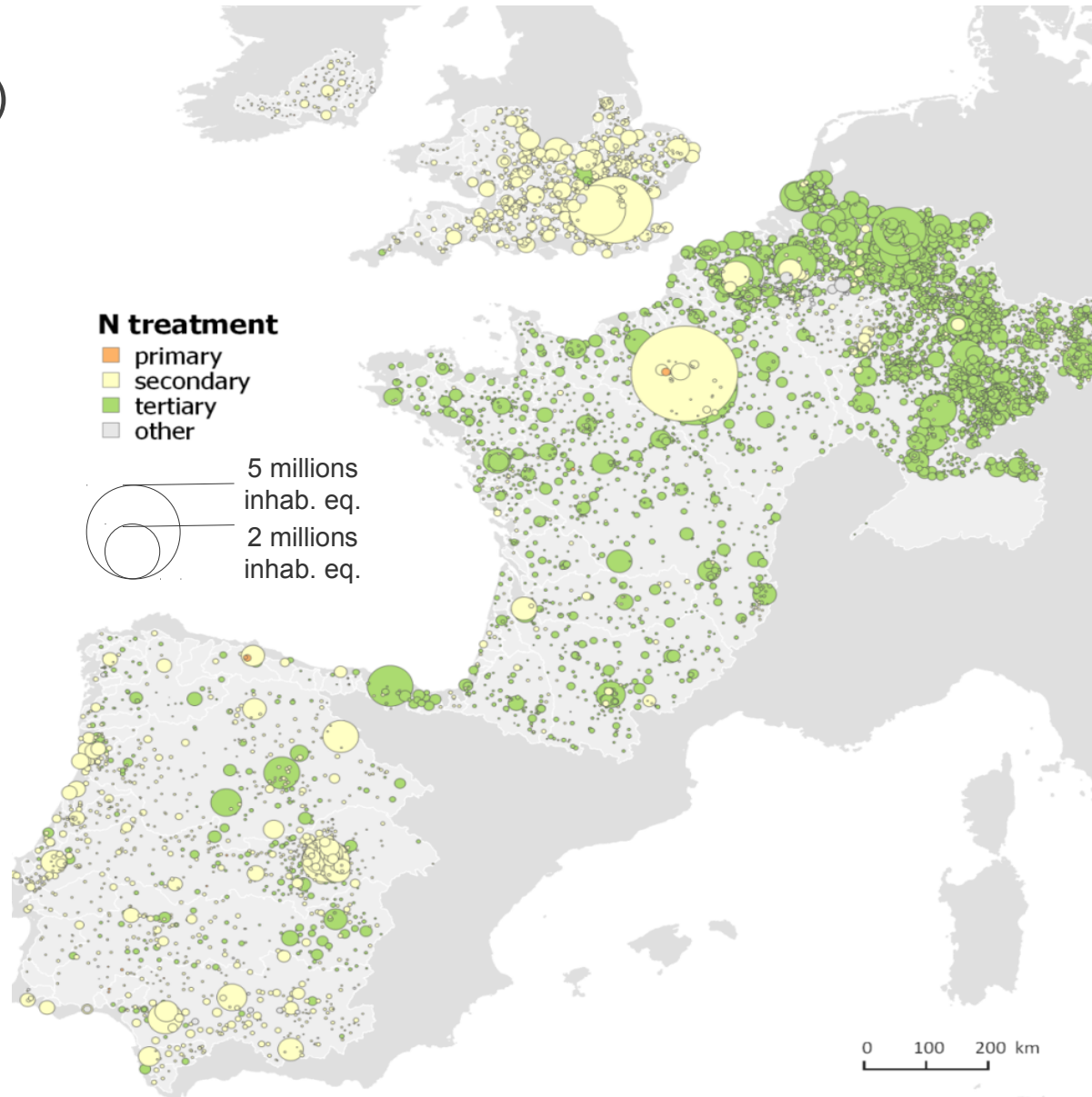
# Building an atlas of land-based emissions to rivers



Point sources (urban)

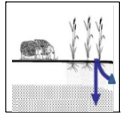
Direct release to river network:  
**Water base EEA, 2012**

a spatially explicit census  
of wastewater collection,  
connection to sewers and  
treatment in WWP  
discharged to the rivers





# Building an atlas of land-based emissions to rivers



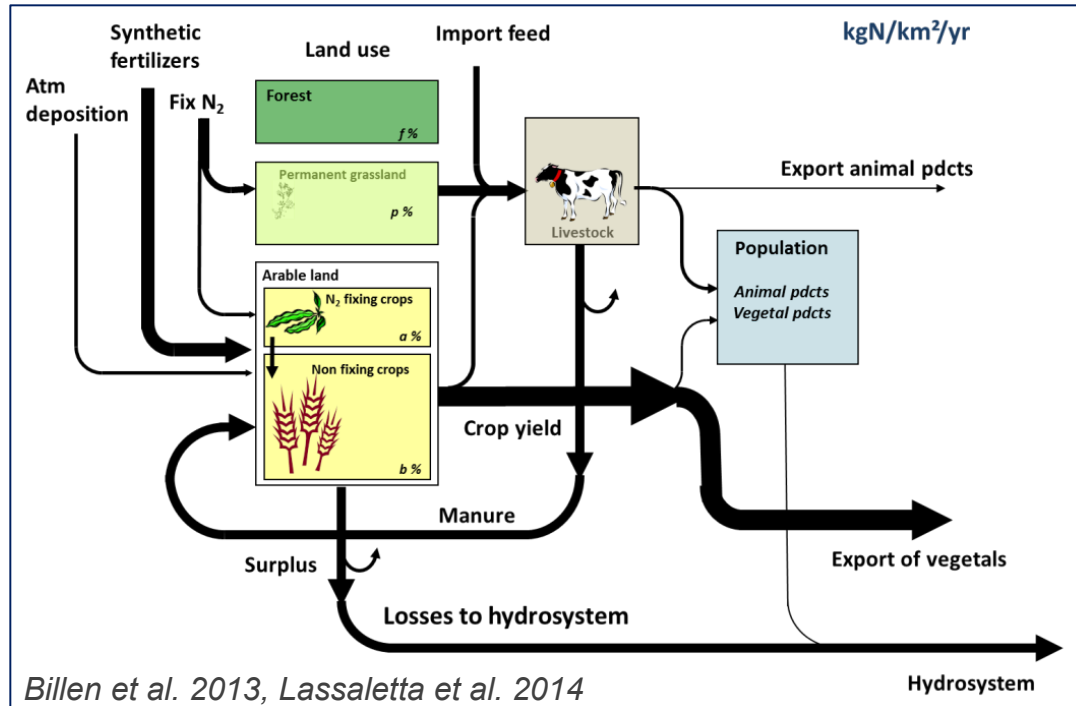
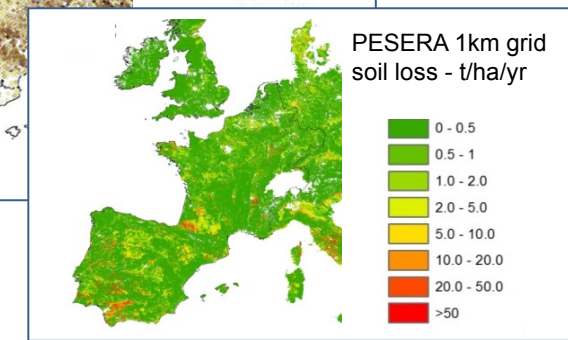
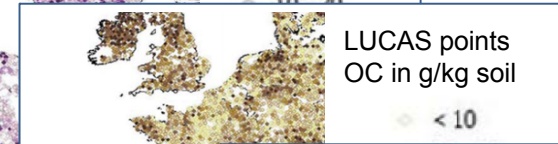
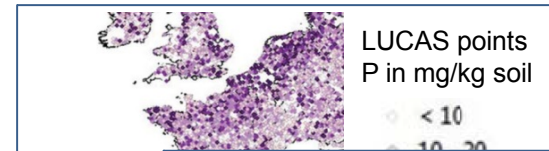
Diffuse sources (agriculture)

P, C, Si:

**LUCAS** (JRC 2013, census of soil contents)

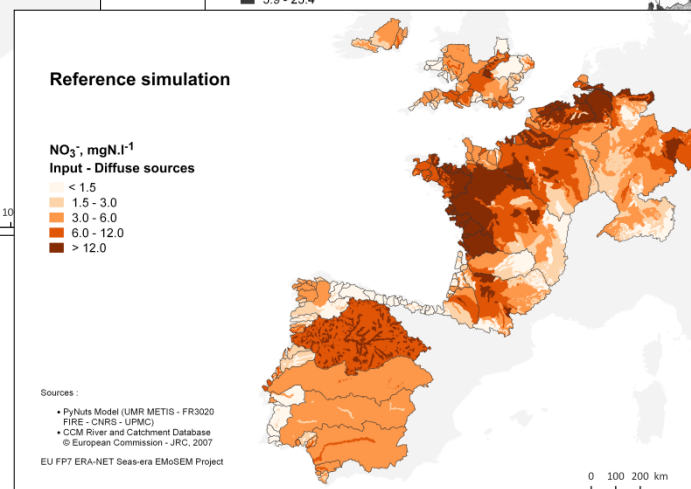
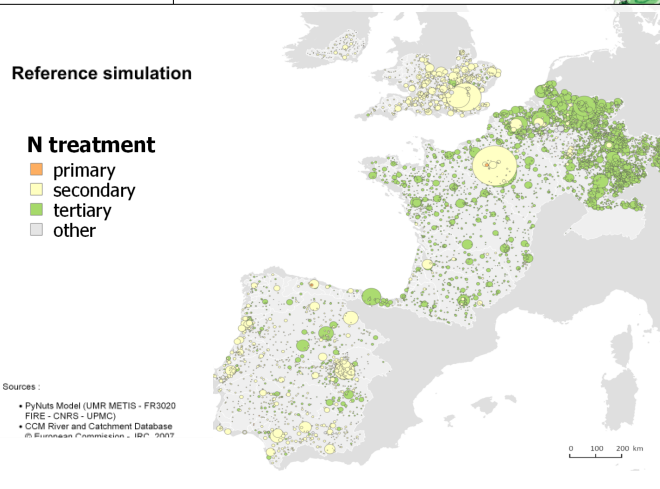
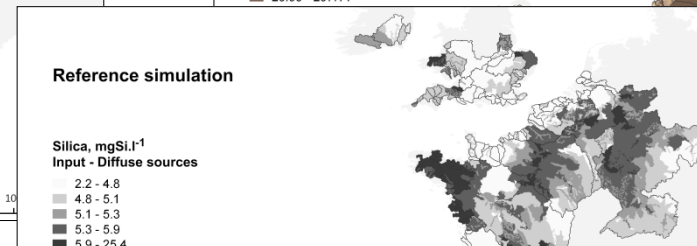
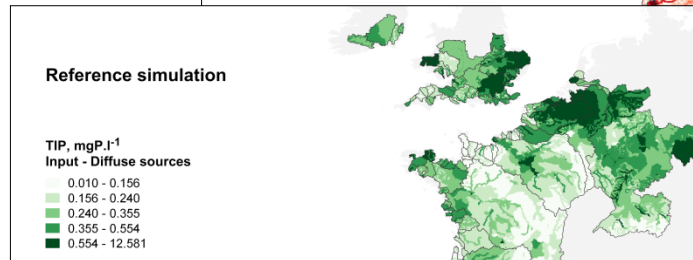
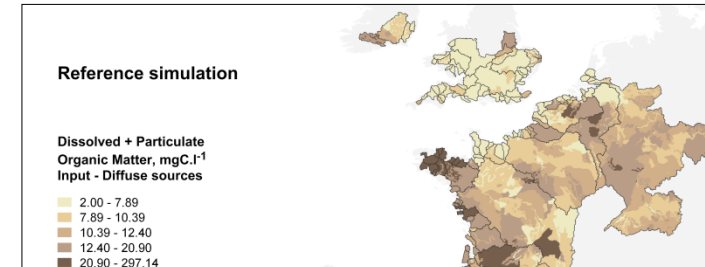
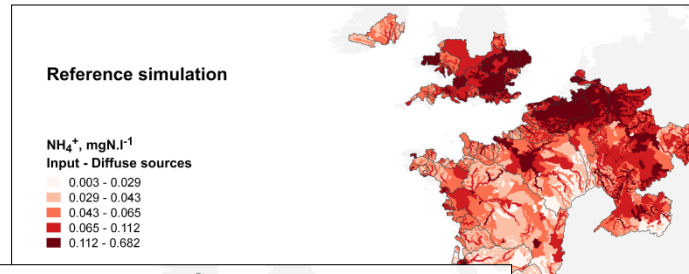
**PESERA** (JRC 2003, model output)

N:

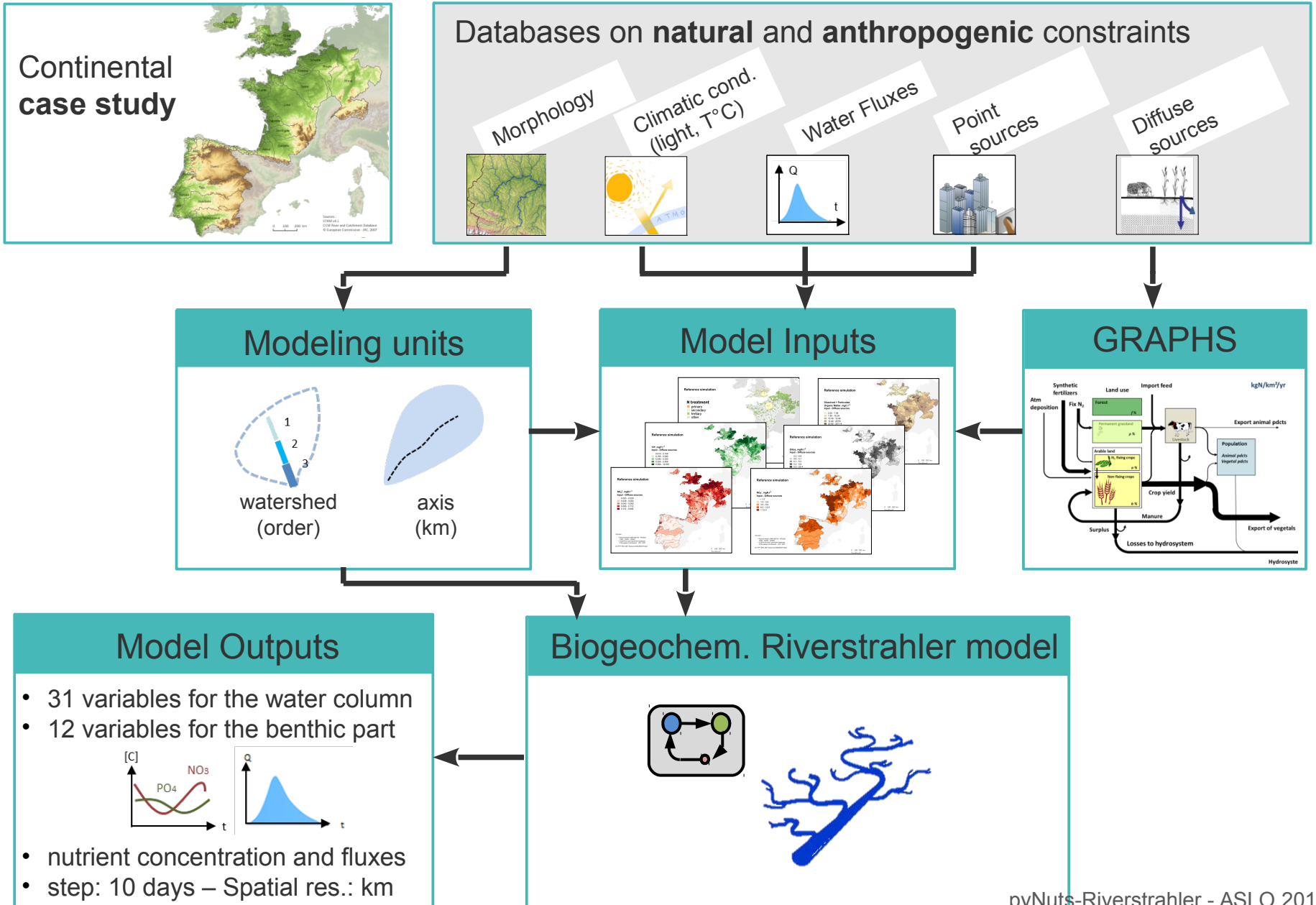


**GRAFS**  
(Generic Representation of Agro-Food Systems)

# Building an atlas of land-based emissions to rivers



# The pyNuts modeling platform



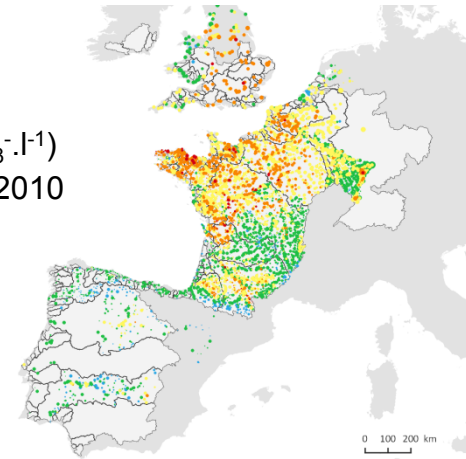
# Validating on a pluri-annual period

## DoNuts: **D**atabase of **O**bserved **NUT**rients in rivers**S**

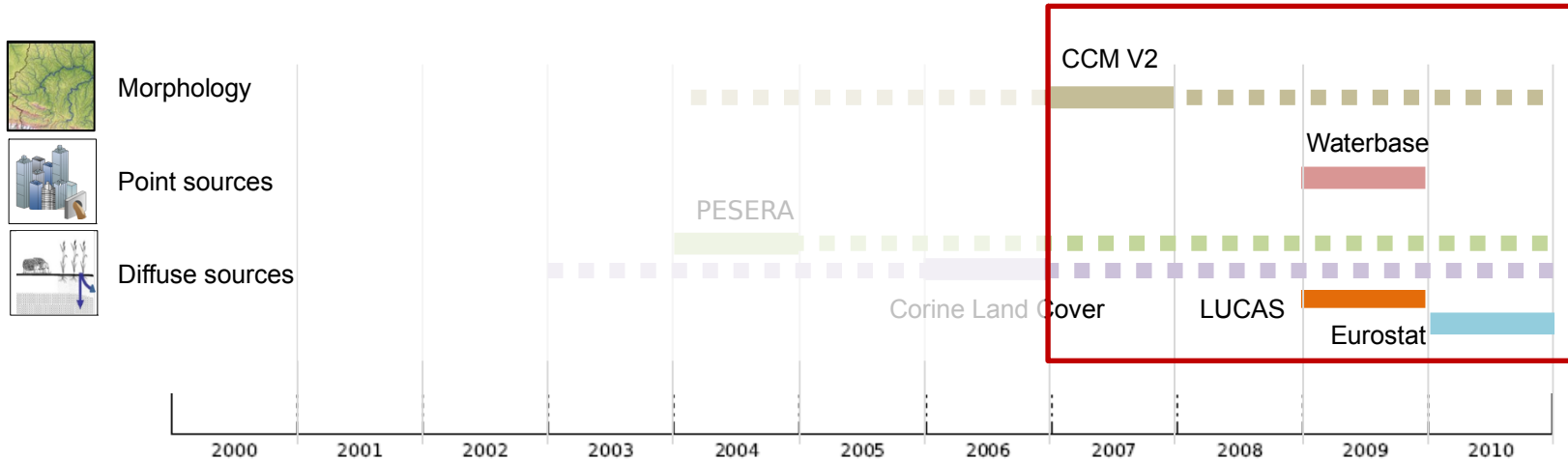
10 countries – 29 data producers  
~ 12 000 monitoring stations

Nitrate ( $\text{mgNO}_3\text{-l}^{-1}$ )  
average 2000-2010

- > 2
- 2 – 10
- 10 – 25
- 25 – 50
- > 50



## Validation timeframe:

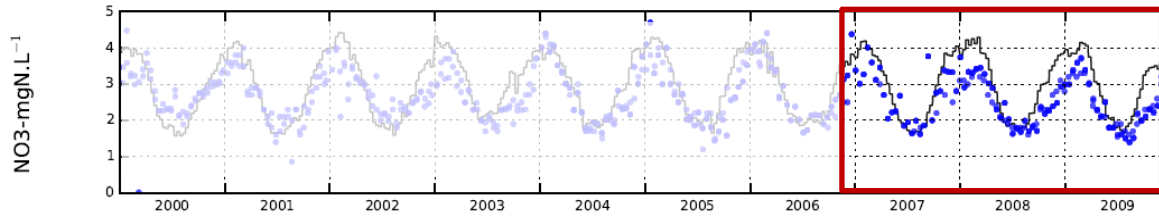


To capture pluri-annual variability: 11 years of hydrology (2000-2010)

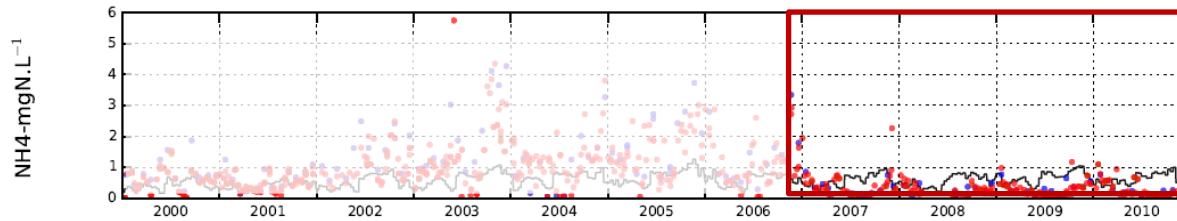


# Validating on a pluri-annual period

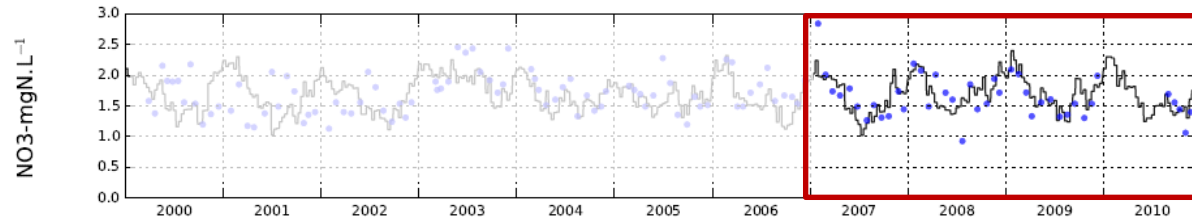
- Rhine (160 000 km<sup>2</sup>), **NO<sub>3</sub>** (mgN.L<sup>-1</sup>)



- Seine (76 000 km<sup>2</sup>), **NH<sub>4</sub>** (mgN.L<sup>-1</sup>)

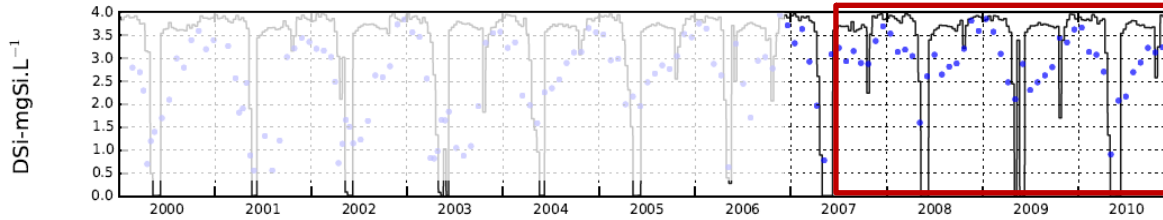


- Dordogne (24 000 km<sup>2</sup>), **NO<sub>3</sub>** (mgN.L<sup>-1</sup>)

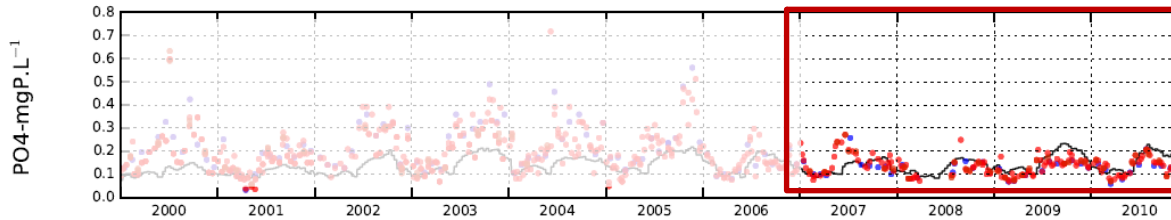


# Validating on a pluri-annual period

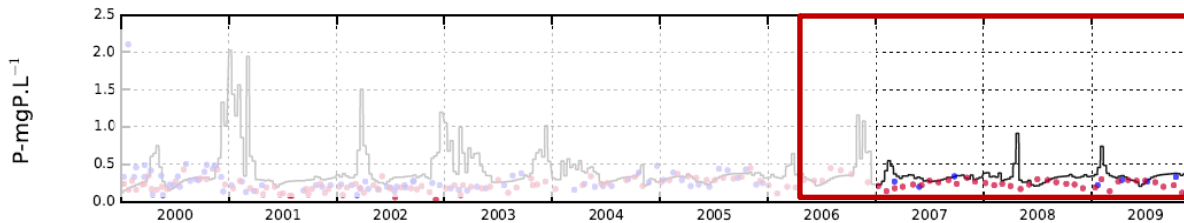
- Meuse (32 000 km<sup>2</sup>), **DSi** (mgSi.L<sup>-1</sup>)



- Seine (76 000 km<sup>2</sup>), **PO4** (mgP.L<sup>-1</sup>)



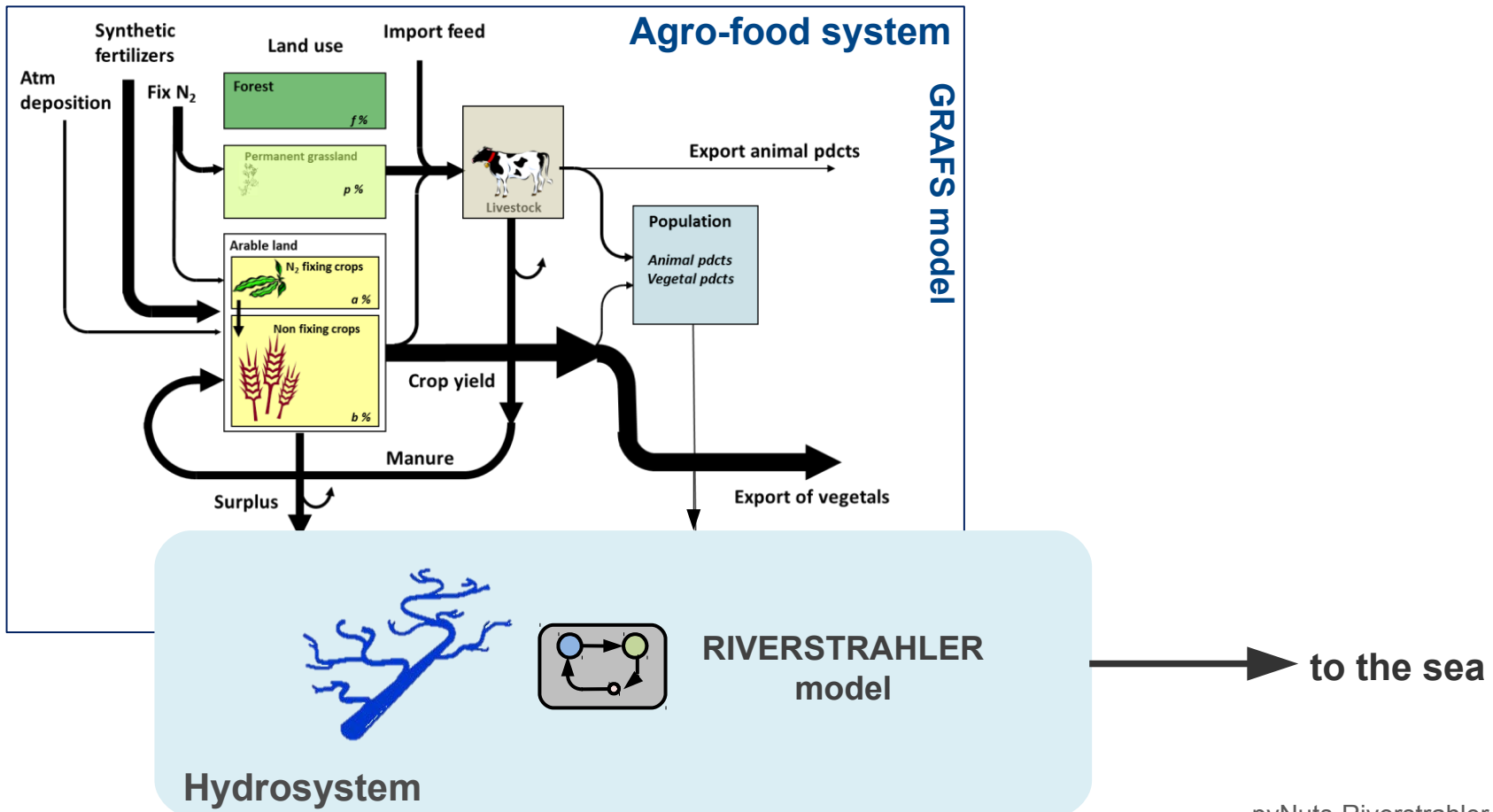
- Tajo (71 200 km<sup>2</sup>), **total P** (mgP.L<sup>-1</sup>)



# Prospective scenarios

→ impact on rivers and coastal zones  
of a modification of human activities on watersheds

## pyNuts modeling platform

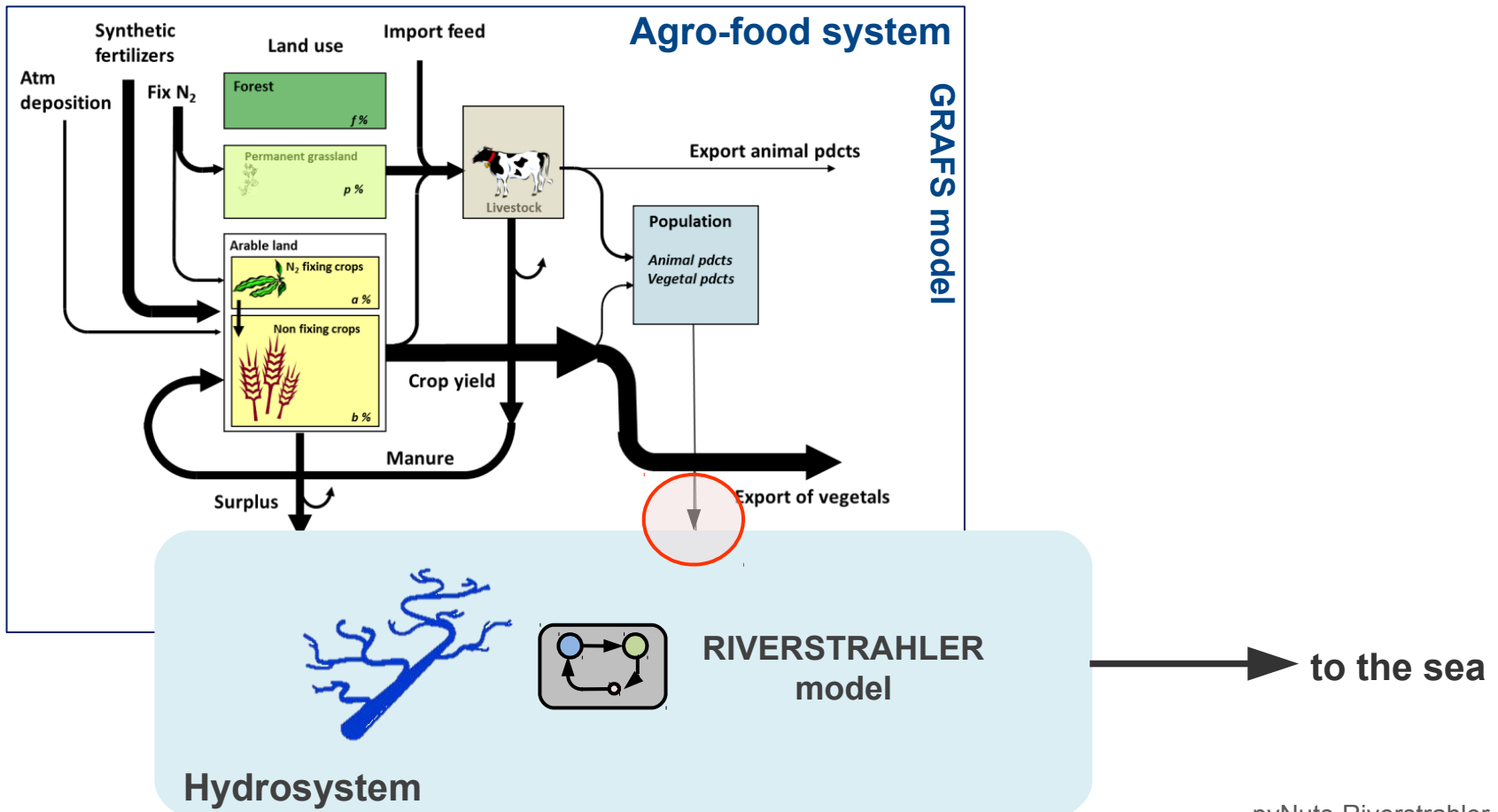


# Prospective scenarios

UWWTD

compliance with the European **Urban Waste Water Treatment Directive**

## pyNuts modeling platform





# Prospective scenarios

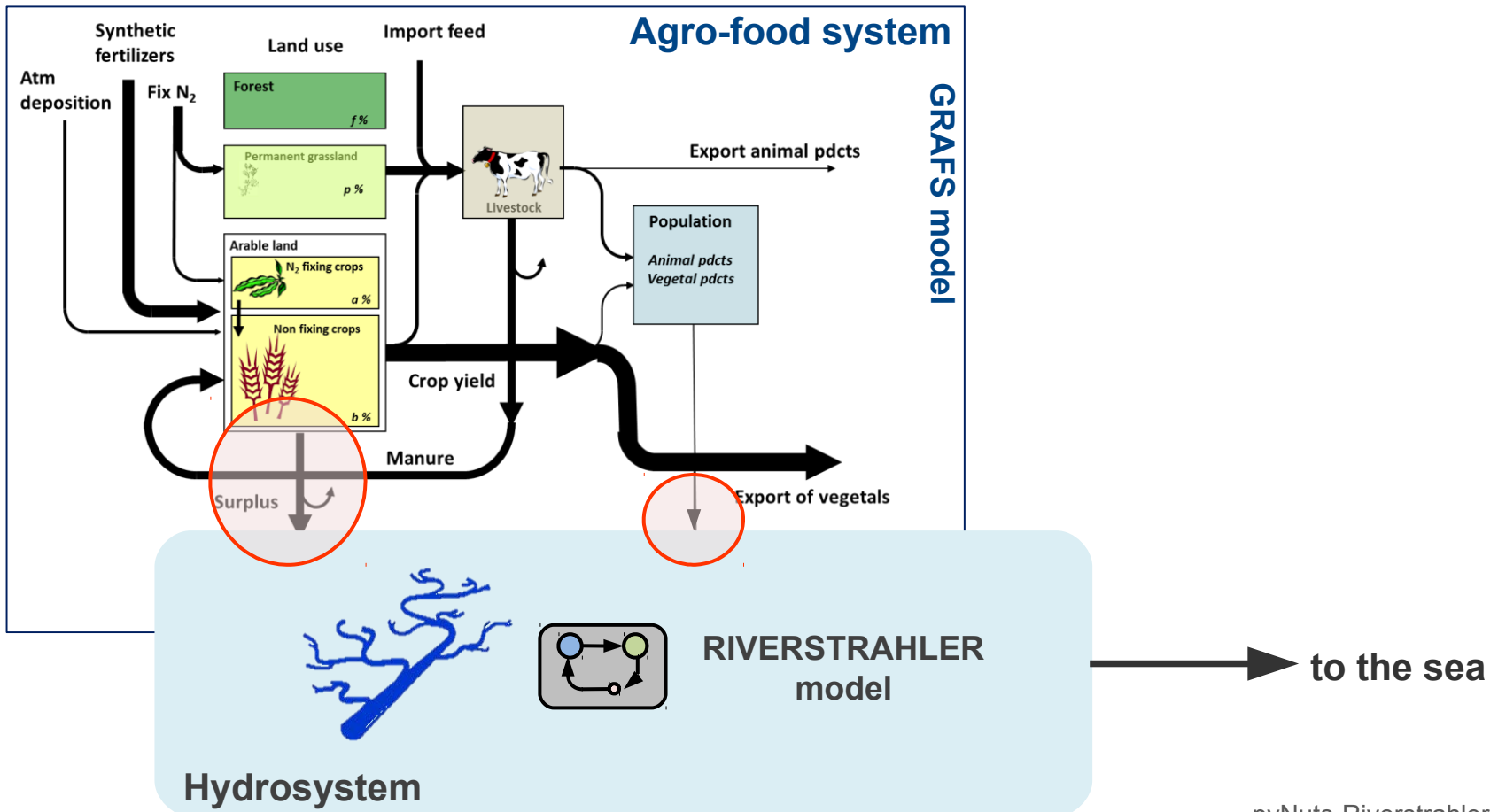
**UWWTD**

compliance with the European **Urban Waste Water Treatment Directive**

**GAP**

reasoned agriculture based on **Good Agricultural Practices**

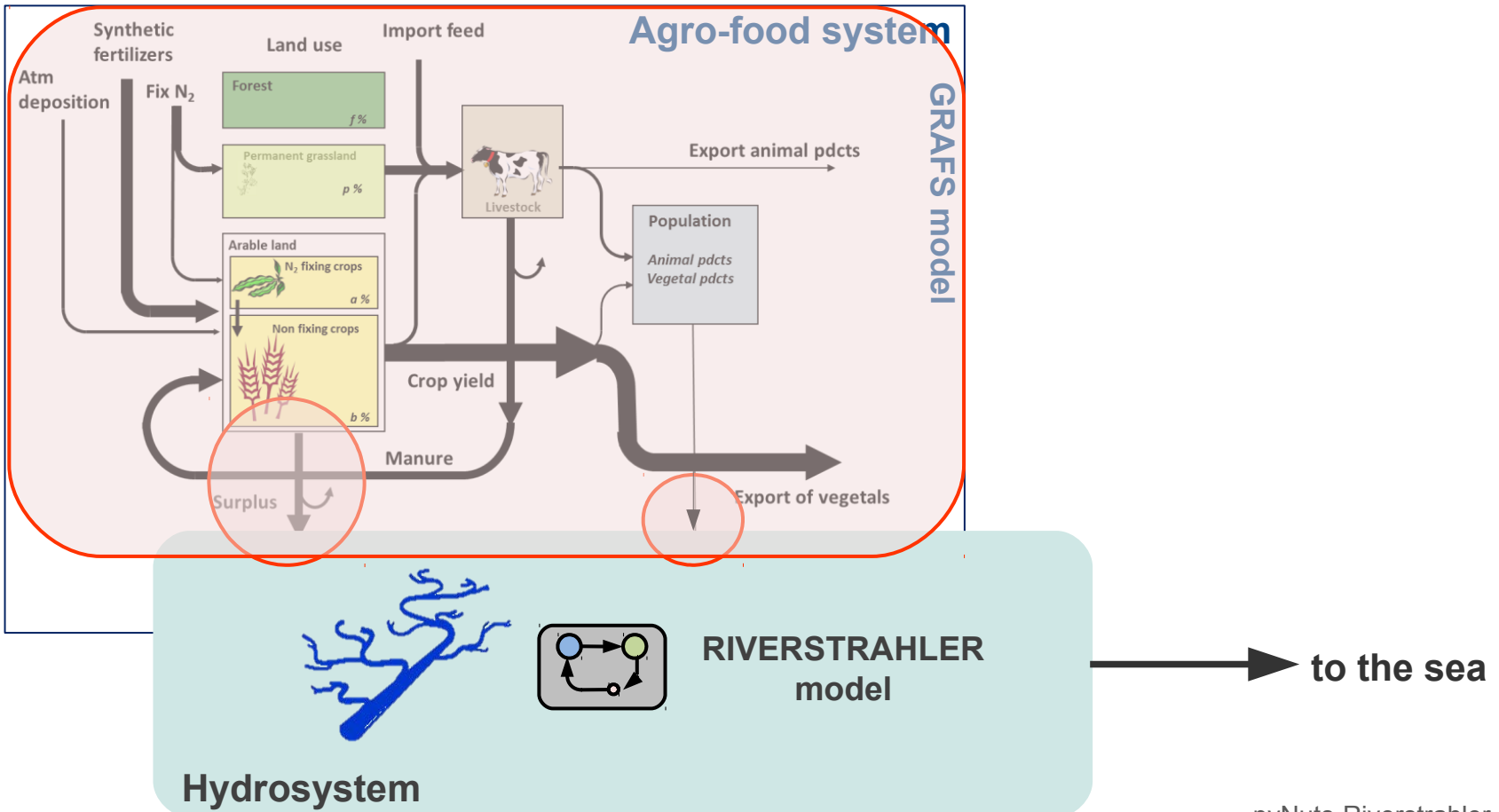
## pyNuts modeling platform



# Prospective scenarios

- UWWTD** compliance with the European **Urban Waste Water Treatment Directive**
- GAP** reasoned agriculture based on **Good Agricultural Practices**
- LocOrgDem** re**Localized** production, **Organic** farming, improved diet (**Demitarian**)

## pyNuts modeling platform



# Impact on rivers

## *Reference simulation*

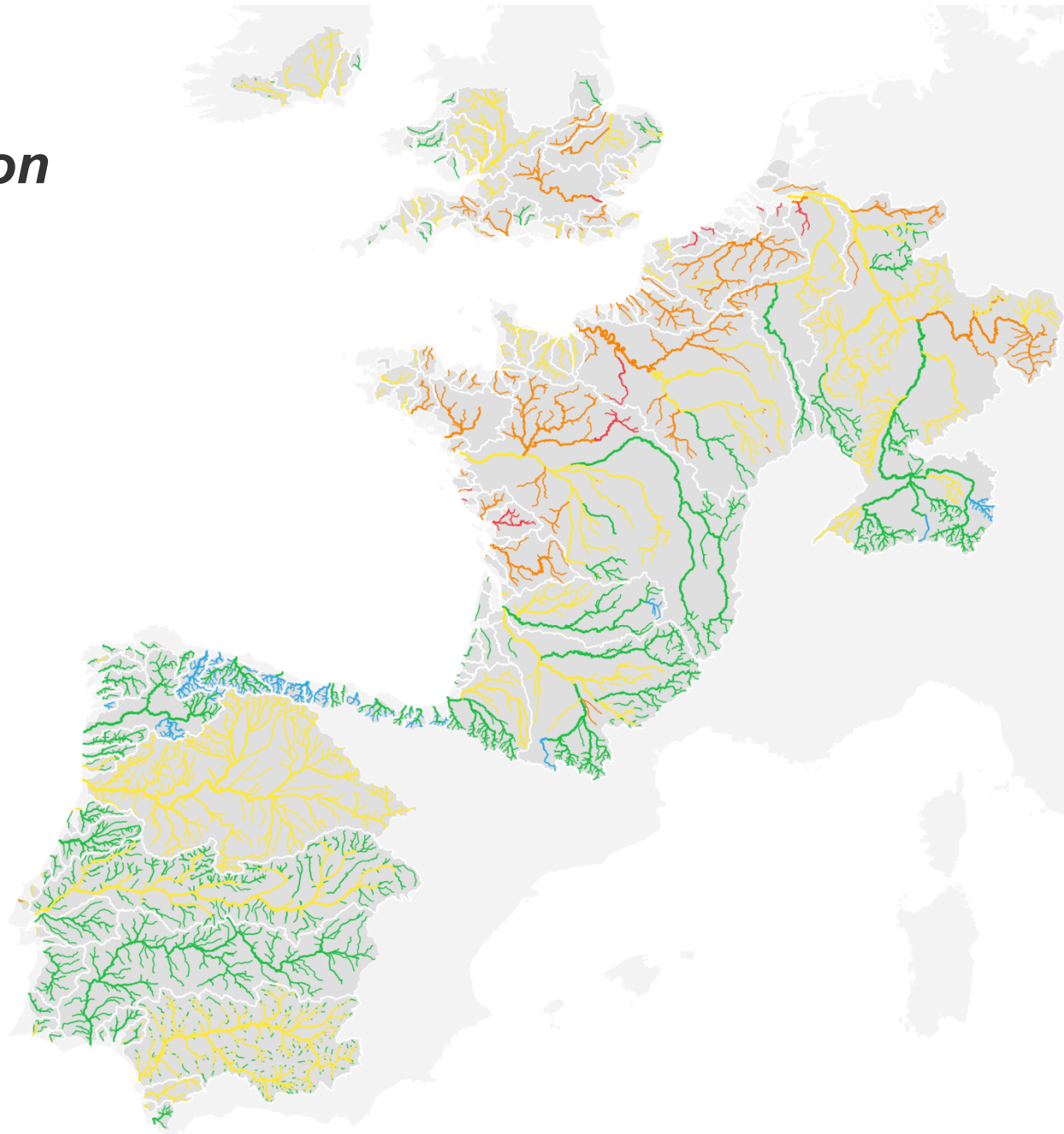
Nitrate ( $\text{mgNO}_3\text{-l}^{-1}$ )  
average 2000-2010

- > 2
- 2 – 10
- 10 – 25
- 25 – 50
- > 50

Sources :

- PyNuts Model (UMR METIS - FR3020  
FIRE - CNRS - UPMC)
- CCM River and Catchment Database  
© European Commission - JRC, 2007

EU FP7 ERA-NET Seas-era EMoSEM Project



# Impact on rivers

***UWWTD***

UE Waste Water Directive

+

***GAP***

Good Agricultural Practices

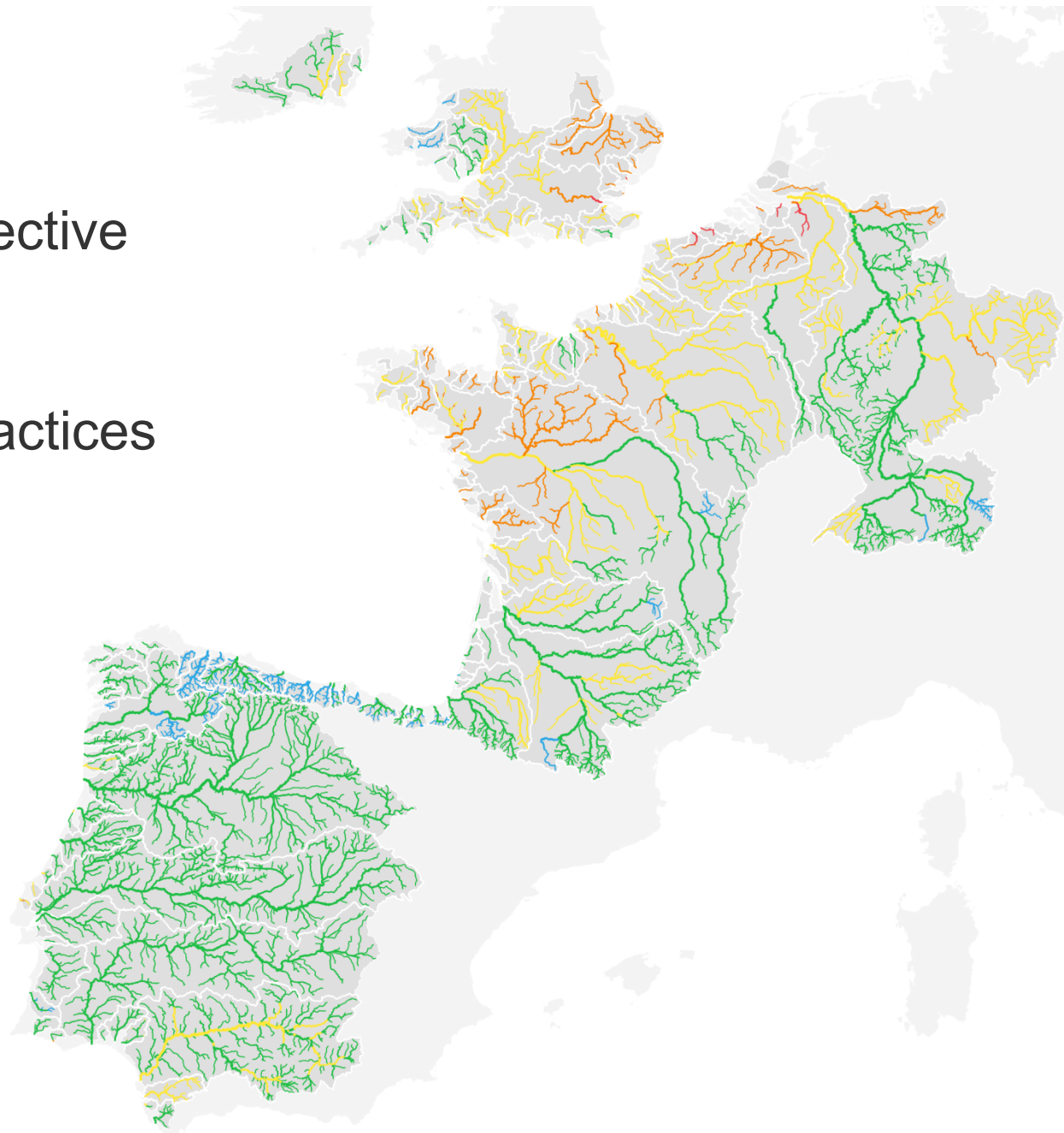
Nitrate ( $\text{mgNO}_3^- \cdot \text{l}^{-1}$ )  
average 2000-2010

- > 2
- 2 – 10
- 10 – 25
- 25 – 50
- > 50

Sources :

- PyNuts Model (UMR METIS - FR3020  
FIRE - CNRS - UPMC)
- CCM River and Catchment Database  
© European Commission - JRC, 2007

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# Impact on rivers

***Loc Org Dem***

Territorial reconnection

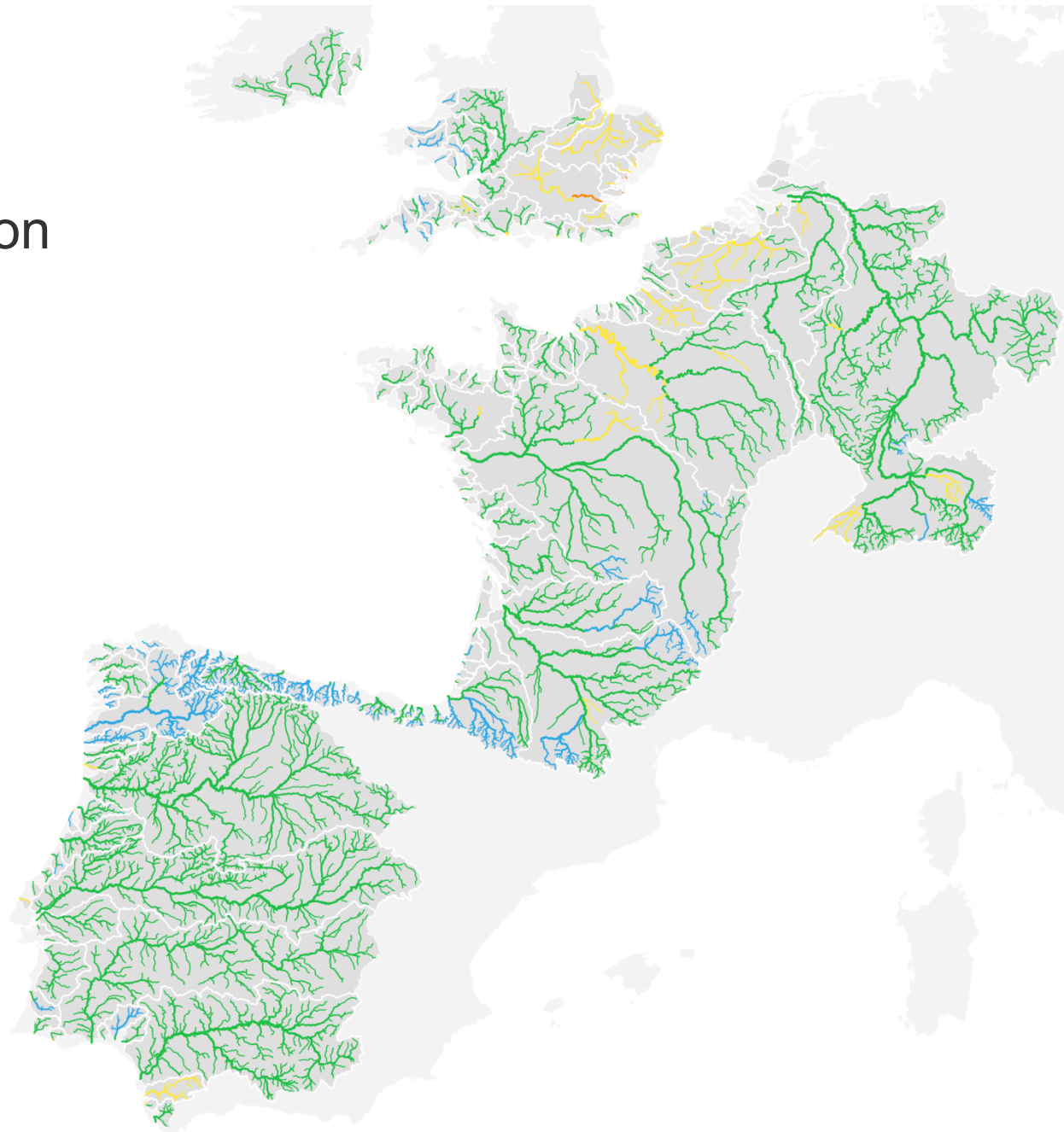
Nitrate ( $\text{mgNO}_3\text{-l}^{-1}$ )  
average 2000-2010

- > 2
- 2 – 10
- 10 – 25
- 25 – 50
- > 50

Sources :

- PyNuts Model (UMR METIS - FR3020  
FIRE - CNRS - UPMC)
- CCM River and Catchment Database  
© European Commission - JRC, 2007

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# Impact on rivers

## *Reference simulation*

**The Seine Bight**



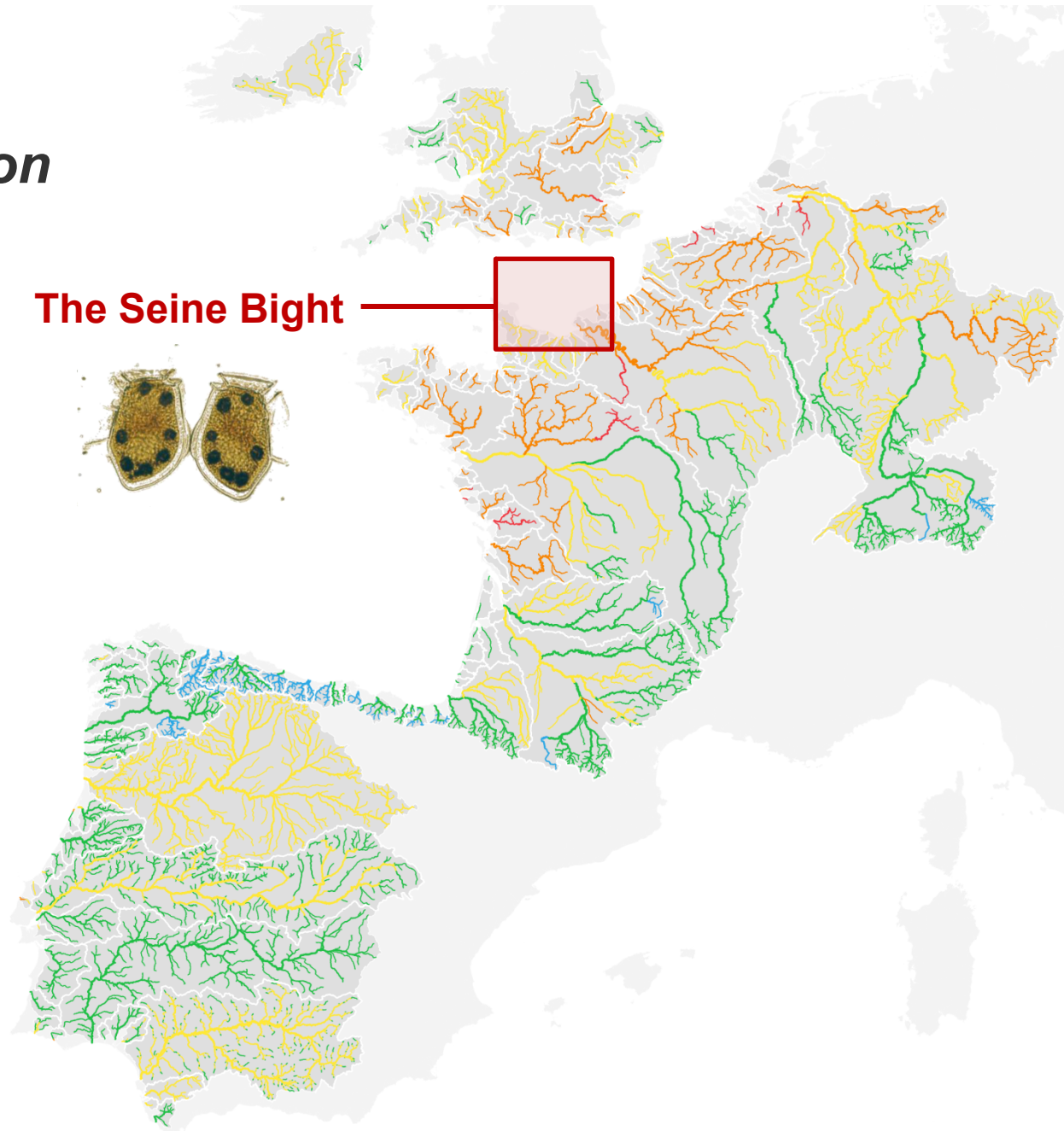
Nitrate ( $\text{mgNO}_3\text{-l}^{-1}$ )  
average 2000-2010

- > 2
- 2 – 10
- 10 – 25
- 25 – 50
- > 50

Sources :

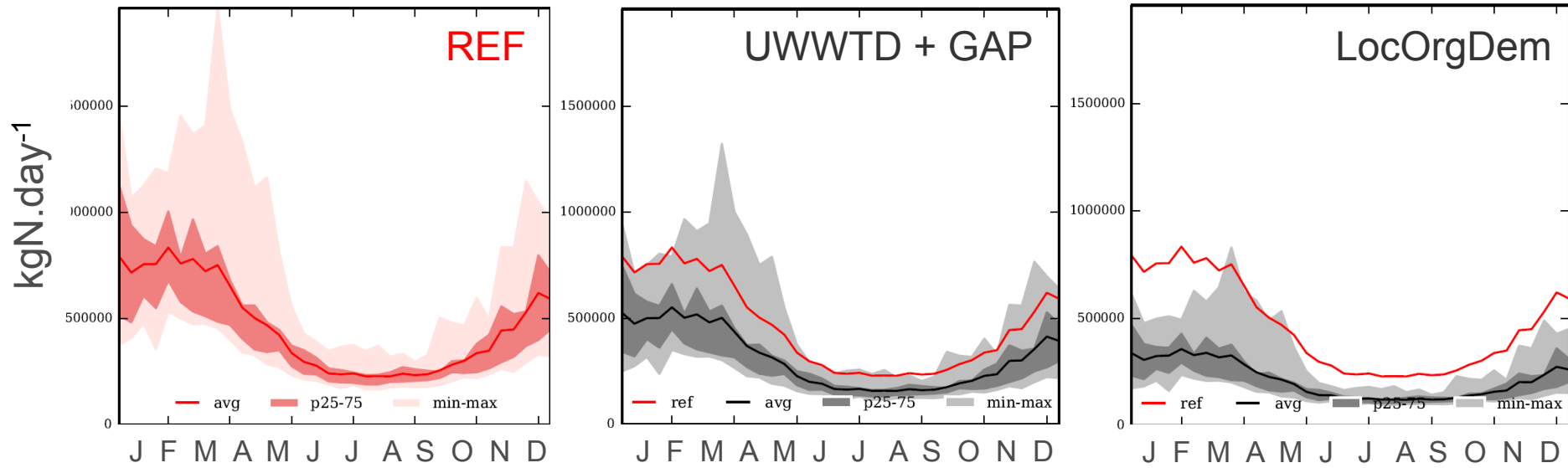
- PyNuts Model (UMR METIS - FR3020  
FIRE - CNRS - UPMC)
- CCM River and Catchment Database  
© European Commission - JRC, 2007

EU FP7 ERA-NET Seas-era EMoSEM Project

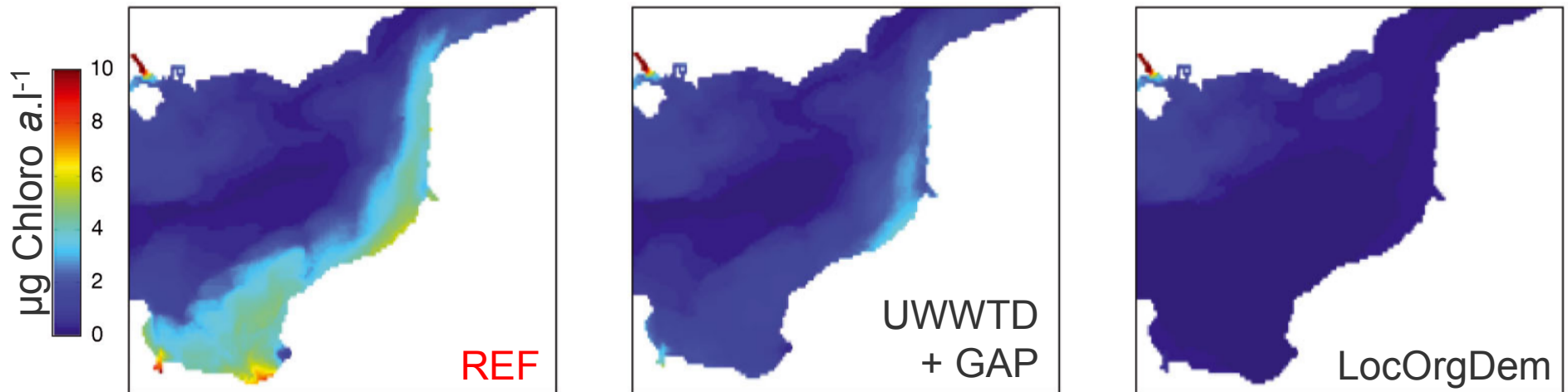


# Impact on nutrient exported to coastal zones

N fluxes exported to the Seine Bight (average over 2000-2010 hydrology)



Max annual dinoflagelates biomass in the Seine Bight



Passy et al (2016)

pyNuts-Riverstrahler - ASLO 2017

# Conclusion

Limited impact of scenarios based on current EU regulation  
(UWWTD, GAP almost fulfilled in western EU countries)

Exploring scenarios for a **radical change of the agro-food system** shows that room is left to reconcile agriculture and water resource protection.

On-going work: impacts induced by **climate change**  
→ see next talk by Mélanie Raimonet!



The Challenge:  
applying at a continental scale the **Riverstrahler** model

The **pyNuts-Riverstrahler** platform :  
a generic tool to build prospective scenarios and evaluate their impacts on river systems

# ASLO 2017 - Mountains to the Sea - Honolulu, Hawai`i

vincent.thieu@upmc.fr  
marie.silvestre@upmc.fr

EMoSEM

<http://odnature.naturalsciences.be/emosem/>

## Thank you!

Chlorophyll a P90  
( $\mu\text{g Chl.l}^{-1}$ )  
average 2000-2010

0 1 2 3 4 5 6 7 8



Nitrate ( $\text{mgNO}_3^{-}.\text{l}^{-1}$ )  
average 2000-2010



Work supported by the French national program EC2CO-Biohefect, project **MARICCA**  
and the European program Seas-era EU FP7 ERA-NET, project **EMoSEM**