Modelling long term mitigation measure scenarios for assessing impacts of non-point source pollution:

Application on two surface source water protection areas, Coulonge and Saint Hippolyte

Source : P. Nicolas

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irstea | PEER INSTITUT CARNOT Irstea | LuWQ 2015 International Interdisciplinary Conference on Land Use and Water Quality Agricultural Production and the Environment Vienna, Austria, 21-24 September 2015 | aGRICULTURES & TERRITOIRES CHAMBRE D'AGRICULTURE POITOU-CHARENTES | AGENCE DE L'EAU ADOUR-GARONNE ETABLISSEMENT PUBLIC DU MINISTERE DU DEVELOPPEMENT DURABLE

Motivation & objectives

Provide local and water resource stakeholders with decision-aid methods and tools to help them carry out an overall assessment of water resources, as specified in the European Water Framework Directive.

A three-step research plan:

- *Step 1:* assess the **effectiveness of BMPs modeling mitigation scenarios** on a watershed **using an integrated assessment (IA)** approach on a **3.6 km² wide** area delimited by **two surface source water protection** areas, Coulonge and Saint Hippolyte.

- *Step 2:* develop **specific decision aid methods & tools** and **transfer** them to local stakeholders.

- *Step 3:* upscale to the whole Charente watershed (10,000km² wide) with nitrate/pesticide IA.

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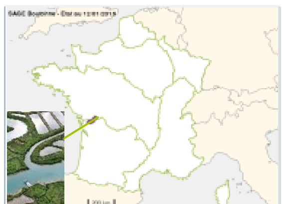
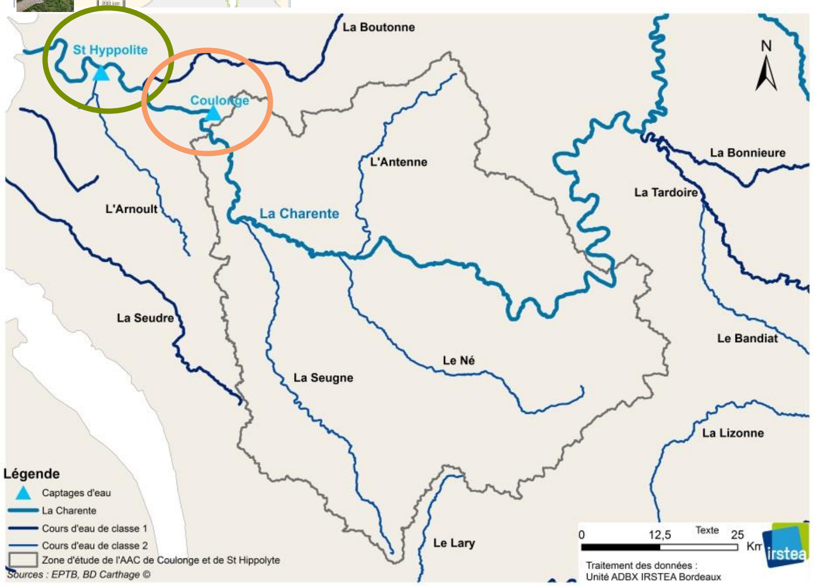
Degradation of water quality in streams and aquifers in the Charente river basin (SW France)

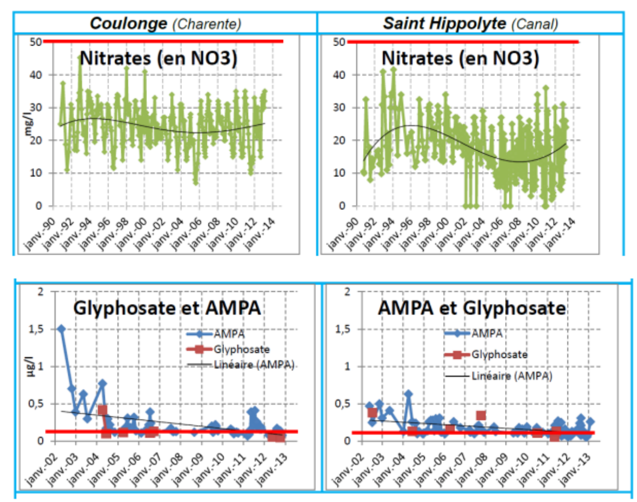
Periods of drought and a continuous and steady deterioration in the quality of raw water since the early 1970s have led to closure of some drinking water catchments.



STUDY AREA: SURFACE CATCHMENTS OF COULONGE AND SAINT-HIPPOLYTE

They produce **17 *10^6 m3 /yr for 290,000 inhab**., over **500,000** during the summer. These two catchments are part of the list of **507 priority catchments** ("Grenelle") (**WFD**).





Nitrate & pesticide concentrations in fresh water

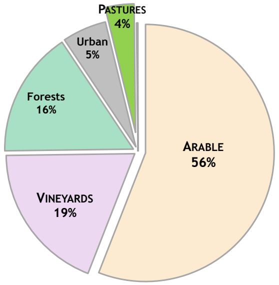
How to restore water quality?

Identifying and understanding the key processes involved
in this continuous degradation:

How can mitigation measures benefit the environment?

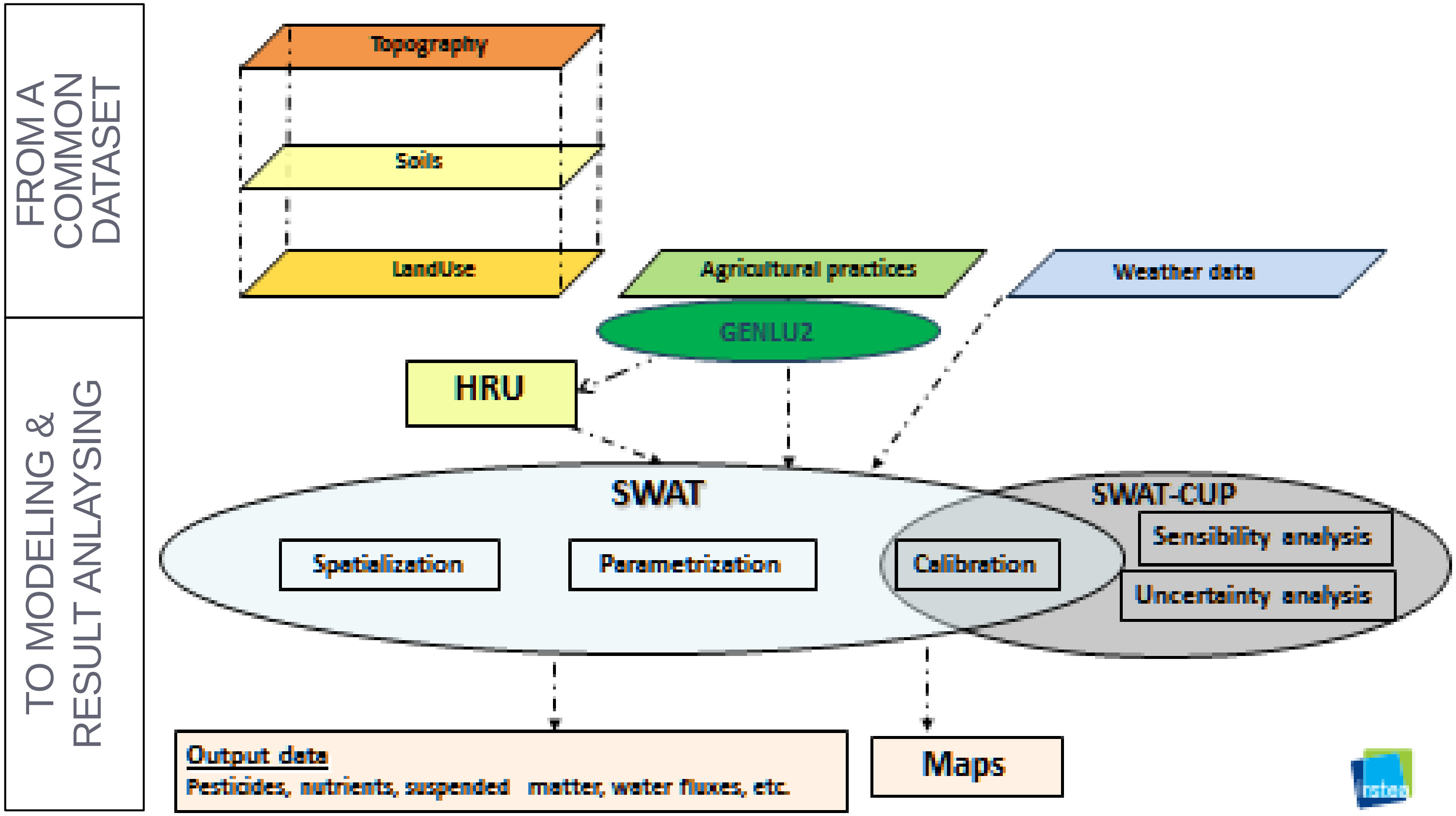
-> physical processes at catchment level
-> anthropic (mainly agricultural) processes in learning from the local actors

Determing and assessing impacts of land-use changes through long term mitigation measure scenarios in close co-operation with local actors (mainly farmers).



Some mitigation scenarios;
-> vegetative filter strips
-> increase of organic farming
-> decrease in agricultural inputs
-> substitution of crops by another
-> lengthening of crop rotations
-> cover crops

GenLU2 - SWAT modeling framework

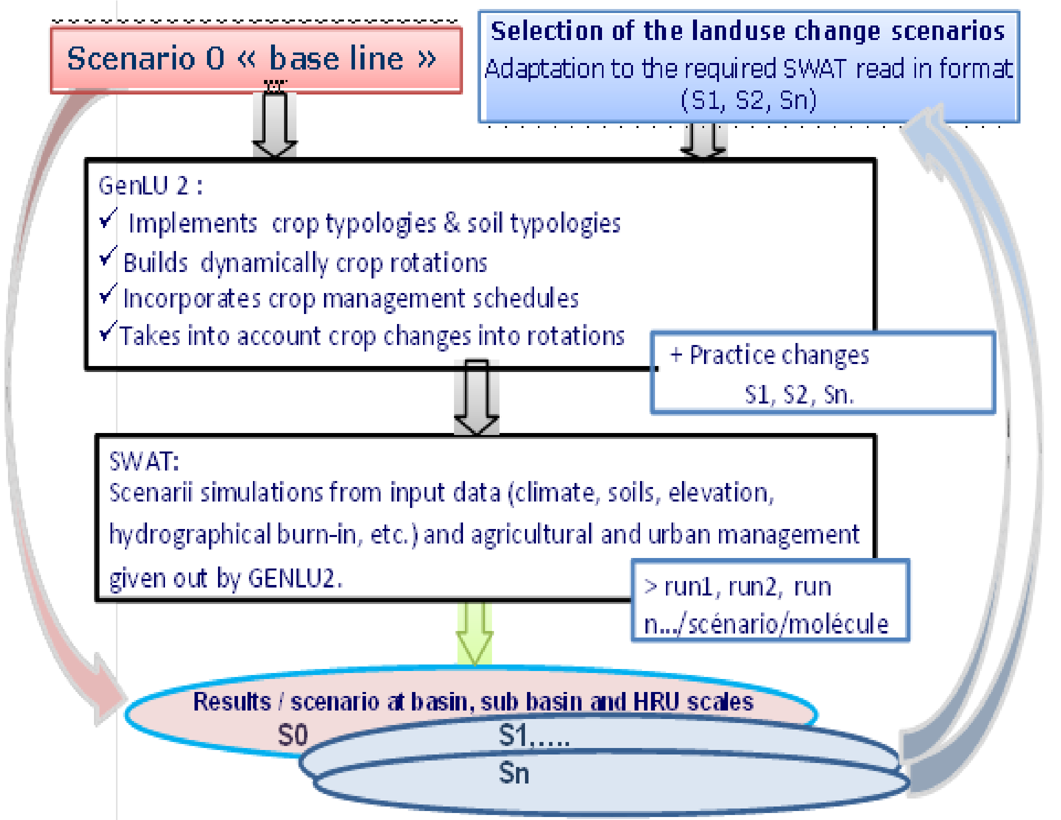


-> all required input data for agro-hydrological modeling
-> integration into the economical model at the calculation unit and comparison with indicators at sub basin level

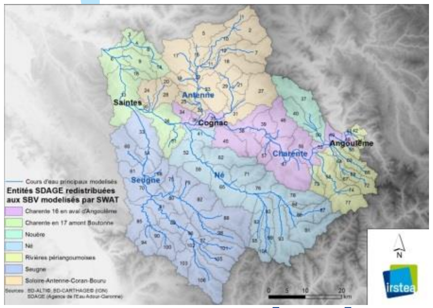
Assessing impacts of mitigation measures

Implementation of scenarios and land management practices

- Intermediate processing of landuse with **GenLU2 for model implementation**
- **SWAT (IRSTEA) - semi-distributed agro-hydrological watershed model** running at a daily time step

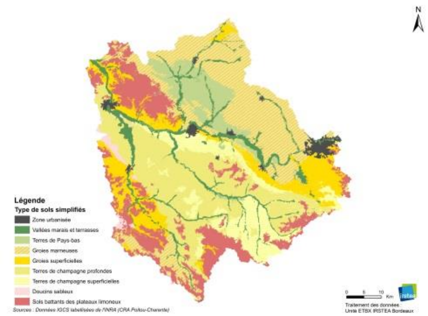


Modeling framework with SWAT Genlu2



106 watersheds

+

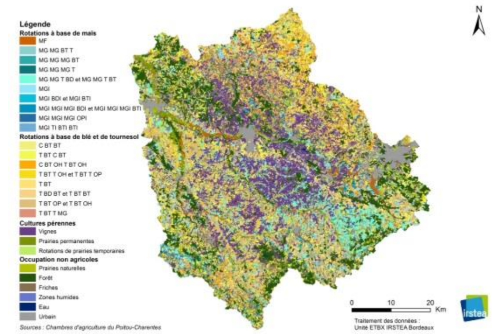


9 soil types

+

1 slope class

+



Landuse modeled from GenLU

Different Land uses

=

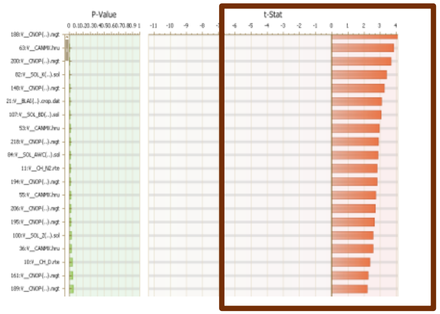
3659 HRUs

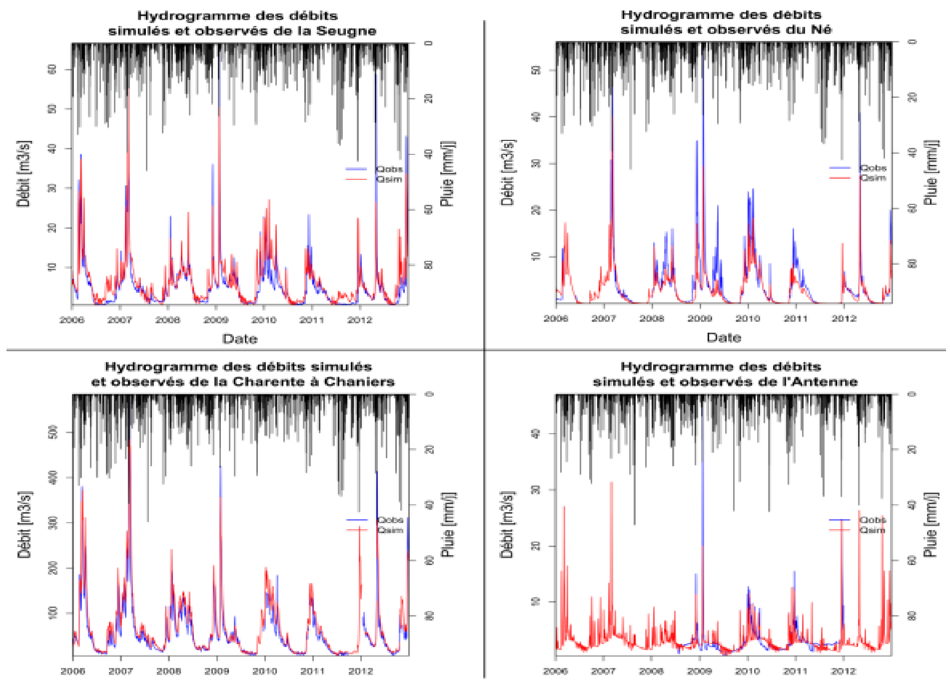
The Hydrological Response Unit **(HRU), unique combination for each sub-basin,** is the **calculation unit** of the model.

In-stream, transport and fate of pollutant are then **calculated** at the **outlet** of each sub-basin.

Calibration of the baseline scenario

Sensitivity analysis & Calibration according to stream flows





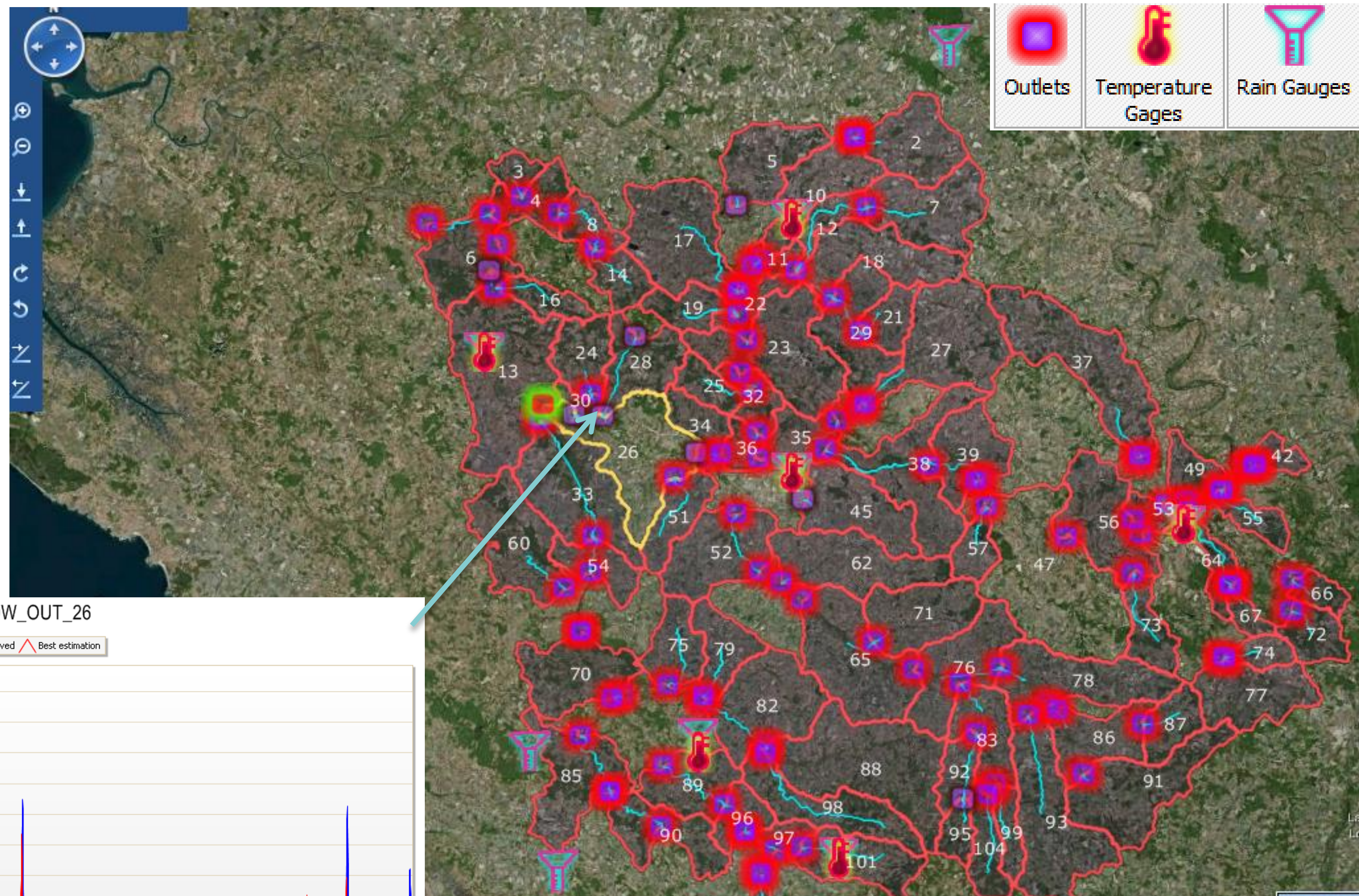
Goal_type= Nash_Sutcliffe (NS)

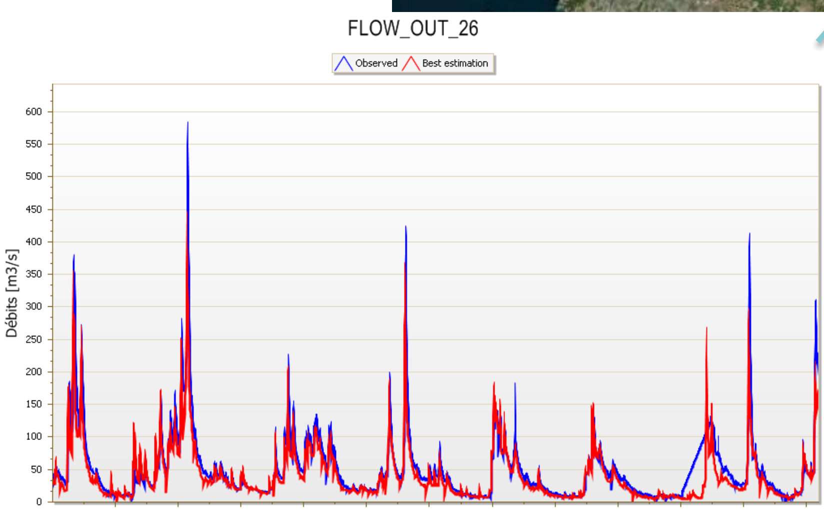
Sub Basin	p-factor	r-factor	R2	NS	bR2	MSE	SSQR	PBIAS	RSR
FLOW_OUT_23	0.24	0.43	**0.65**	**0.47**	0.4593	5.2e+000	3.4e+0	43.8	0.73
FLOW_OUT_26	0.36	0.10	**0.85**	**0.82**	0.6582	6.7e+002	1.8e+2	14.9	0.42
FLOW_OUT_54	0.36	0.41	**0.68**	**0.50**	0.6579	1.9e+001	4.2e+0	0.9	0.71
FLOW_OUT_59	0.21	0.28	**0.66**	**0.57**	0.3448	1.7e+001	8.0e+03	6.4	0.66

$$r^2 = \frac{\left[\sum_{i=1}^{N}\left(Q_{i.obs}-\overline{Q}_{obs}\right)\left(Q_{i.sim}-\overline{Q}_{sim}\right)\right]^2}{\left[\sum_{i=1}^{N}\left(Q_{i.obs}-\overline{Q}_{obs}\right)^2\right]\left[\sum_{i=1}^{N}\left(Q_{i.sim}-\overline{Q}_{sim}\right)^2\right]}$$

$$Nash-Suttcliffe = 1,0 - \frac{\sum_{i=1}^{n}(Q_{i.obs}-Q_{i.sim})^2}{\sum_{i=1}^{n}(Q_{i.obs}-\overline{Q}_{obs})^2} = 1,0 - \frac{MSE}{\partial_0^2} = 1,0 - \frac{(RMSE)^2}{\partial_0^2}$$

Calibration of the baseline scenario



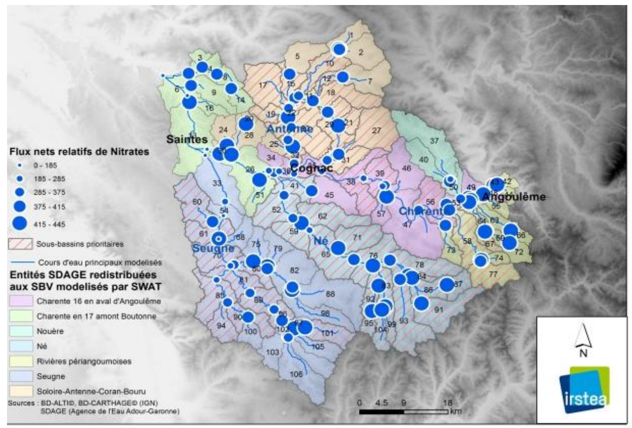


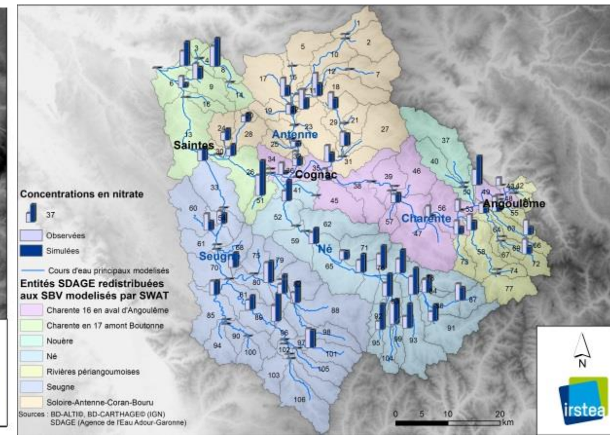
Sub-basin #26 (among 4 stream gauge stations)

NPS pollution assessment for baseline scenario

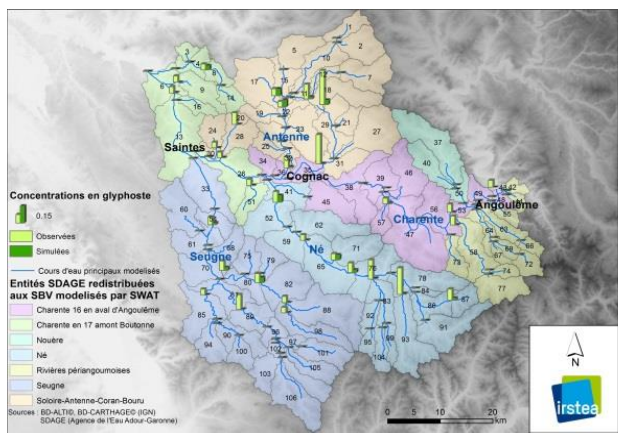
Spatializing nitrates and pesticide fluxes and concentrations at modeled sub-basin level

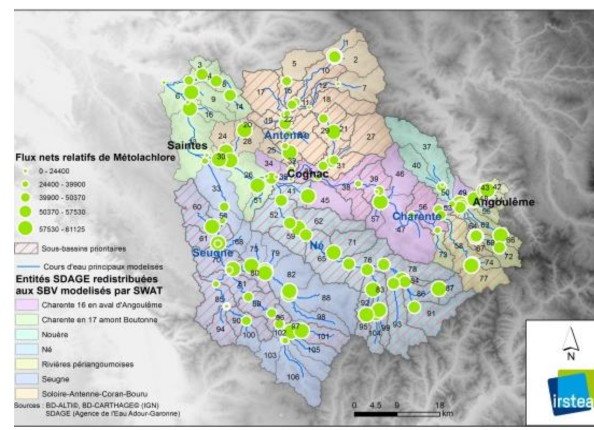
Average nitrate simulated fluxes (left) and simulated vs measured concentrations (right)





Glyphosate (left) and S-Metolachlor (right) (among 9 modeled pesticides)

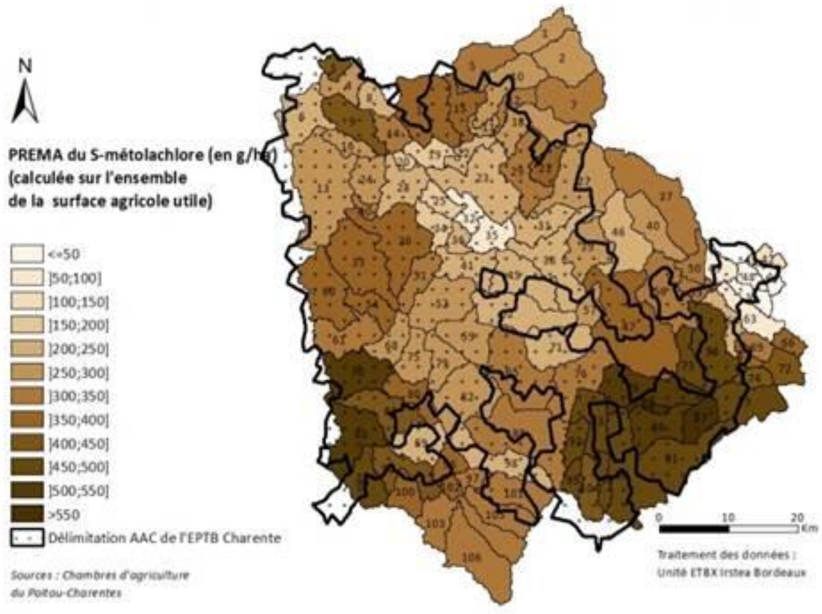


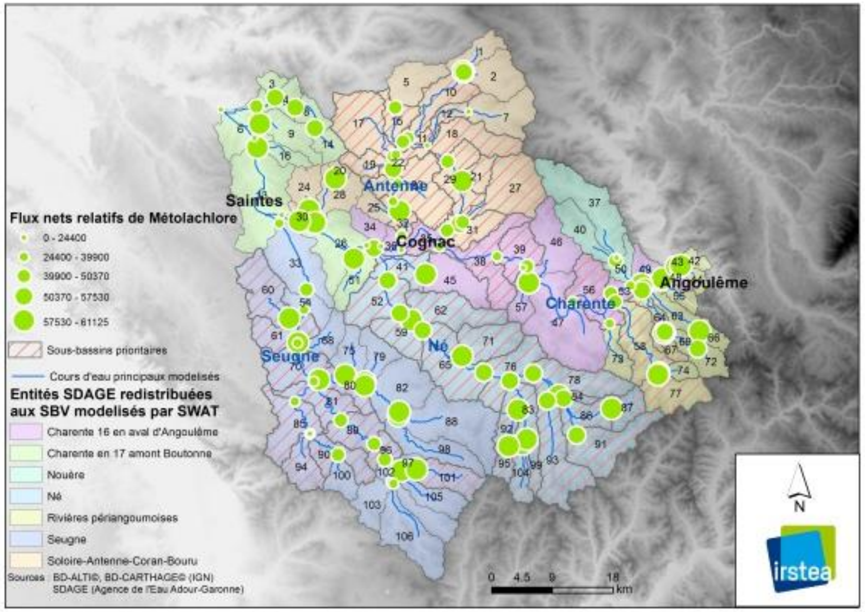


Pressure vs transport & fate

Impacts in relation to the baseline scenario

S-Metolachlor

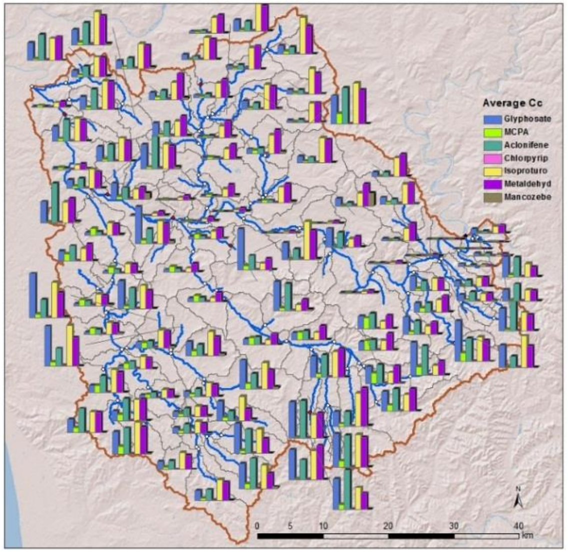


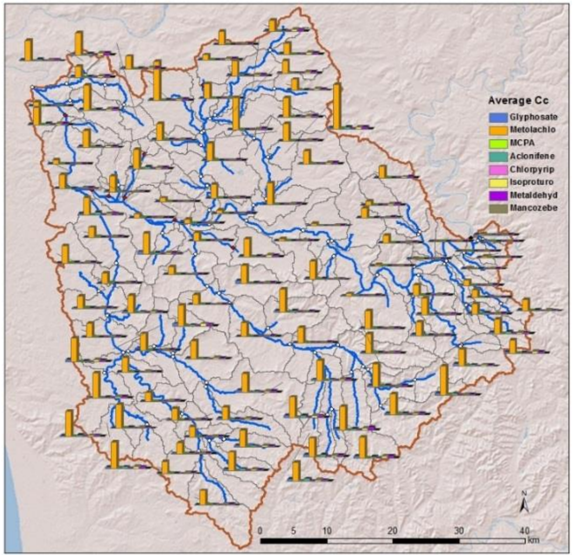


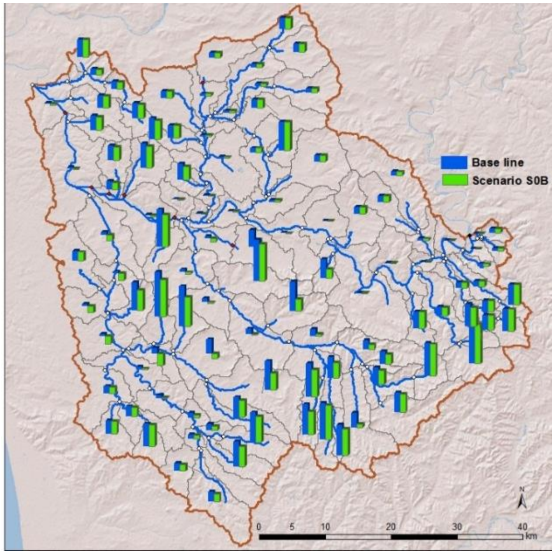
Impacts in relation to the baseline scenario

Pesticide concentrations in streams

IN COMPARISON TO COVER CROP AND ORGANIC VITICULTURE AND FARMING







Conclusions & perspectives

- The environmental assessment we have developed in recent years has proven to be effective in assessing the impacts of long term mitigation measures
- It enables us to take into account heterogeneous crop rotation systems and can be used on different physically based catchments …. provided there are sufficient and reliable gauging measures
- It raises the interest of local stakeholders for innovative IA methods with spatial features and ability on aggregating the sub-basin level to their level of management.
- It involves the question of scale changes

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Thank you for your attention!