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Evaluating the ecosystem services linked to water in agricultural ecosystems

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1.Green and Blue water: ecosystem services for farmers and society

Soils contribute significantly to ecosystem services (ES) to the whole society (e.g. global climate regulation, water quality regulation) and to farmers (e.g. biological regulations, nutrients provision to crop plants). As porous media, they especially store water and control its flows, whether these are transpired by plants for their biomass production or evaporated toward the atmosphere (**Green water**), or infiltrated or runoffed to groundwater or surface water (**Blue water**). In agricultural contexts, these processes are linked to both ES "**soil capacity to store and return water**" to (i) the farmer and (ii) the whole society. Assessing these two ES in an agricultural context is delicate, insofar as the contribution of humans – here the farmer through their agricultural practices including tillage, irrigation, fertilization, etc... – affect their level of provision. In the context of the French National Ecosystem Assessment (the EFESE program), we have developed **biophysical indicators to value water flows in soil-plan system for cropped systems over the whole French Territory**.

2. Defining ecosystem services and their biophysical indicators

Green Water Fluxes

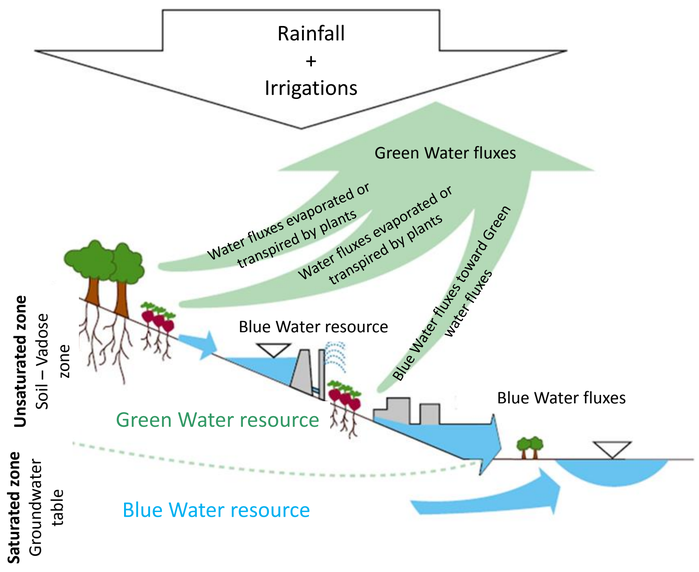
Transpired water by plants *+ Evaporated water from the soil*

↓ **Ecosystem service for farmers**

↓ *Not useful for farmers*

ES: Storing and returning water to crop plants
Benefit = Reducing the quantity of water brought by irrigation

Biophysical Indicator: quantity of water transpired by the cash crop between its seedling and its harvest



Blue Water Fluxes

Free water in lakes, rivers, etc..

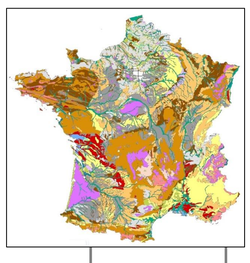
↓ **Ecosystem service for the whole society**

ES: Storing and returning Blue water
Benefit = available water for several uses

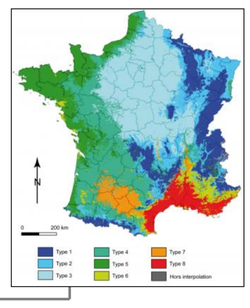
Biophysical Indicator: annual water yield, i.e. difference between the amount of water brought by rainfall and irrigation, and the amount of water evapotranspired over a year

3. Evaluating ES indicators by crop modelling

Soil data
European Geographical Soil Database at the 1:1 000 000



Climate data
French Meteorological data over 30 years at the 8x8 km resolution



Cropping systems
French Land Parcel Information System (2006-2012)



Agricultural practices
Field cropping practices survey (2006 & 2011)



Pedoclimatic units
~30,000
(including ~10,000 units with crops)

→ Pedoclimatic units x crops
~15,000

→ Pedoclimatic units x crops x agricultural practices
~22,000

→ Pedoclimatic units x crops x agricultural practices x soil properties
~32,000

Modelling platform
RECORD

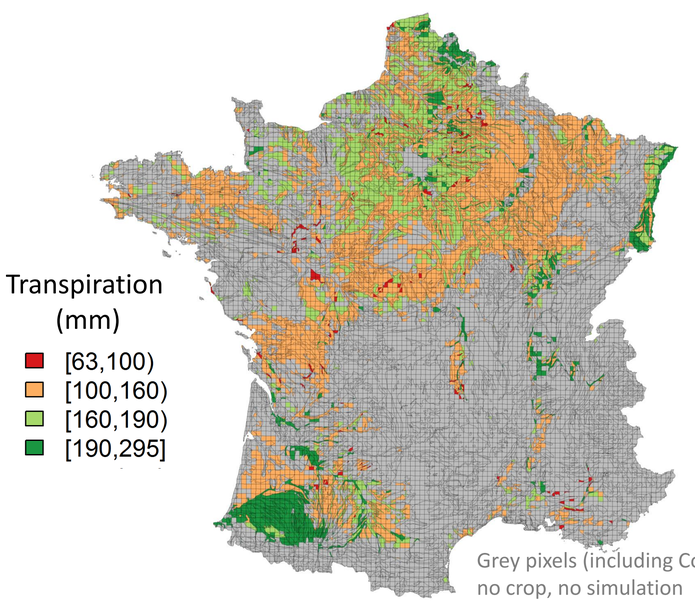
Crop model
STICS

Simulations protocol

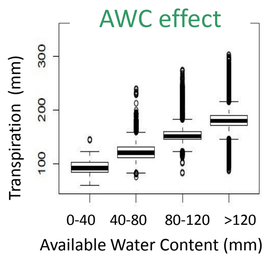
- Annual simulations chained during 30 years -> Dynamic simulations of cropping systems (rotation + practices) to estimate the annual average level of ES
- Simulations *without irrigation* (for the evaluation of the ES) but with other current agricultural practices (especially fertilisation)
- Simulations *including irrigation* practices to value the contribution of ES to the water requirement of an irrigated cash crop (Corn)

4. Transpiration and Water yield at the French national scale

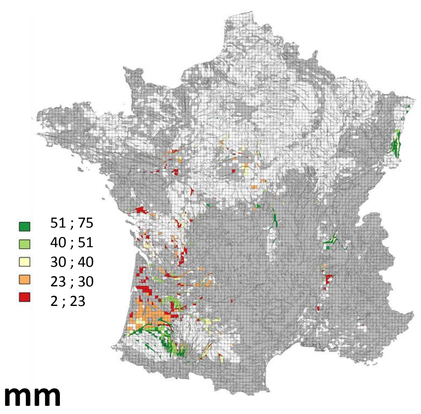
Transpiration of the cash crop
(simulations without irrigation)



AWC effect

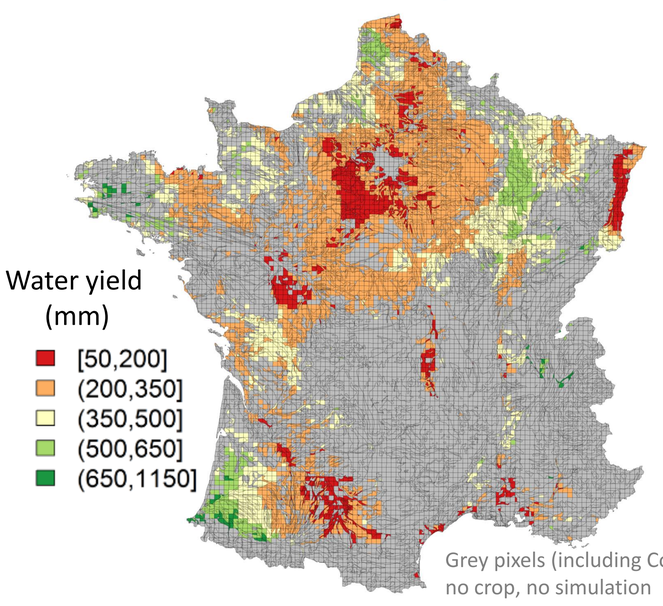


Effect of irrigation on ES

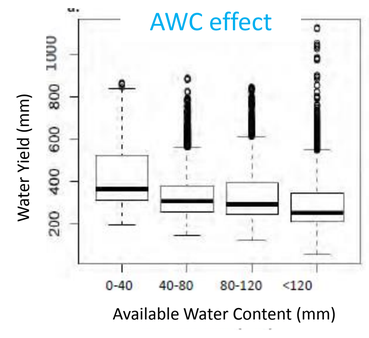


- Mean annual transpiration of French crops: **150 mm**
- Spatial structuration linked to **climate pattern**
- Effect of Soil **Available Water Content** (AWC): low transpiration for low AWC but large variability for high AWC
- In irrigated areas: ES contribute to transpiration from 2 to 75 % (100 % for rainfed crops)

Annual Water yield
(simulations without irrigation)

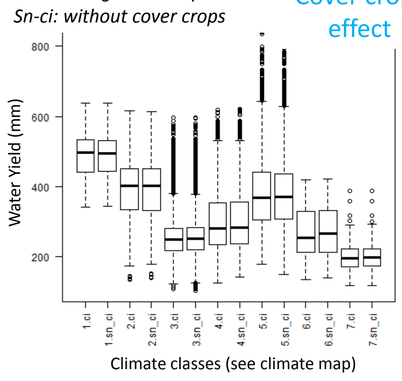


AWC effect



Cover crops effect

ci: including cover crops
Sn-ci: without cover crops



- Mean annual Water Yield over 30 years for French crops: **315 mm**
- Spatial structuration linked to **climate pattern**
- Effect of Soil **Available Water Content** (AWC): decreasing water yield with AWC but large variability for high AWC
- Insignificant effect of intermediate crops on annual water yield

For more information

Cousin I., « Stockage et restitution de l'eau » in Therond O. (coord.), Tichit M. (coord.), Tibi A. (coord.) et al., 2017. Volet "écosystèmes agricoles" de l'Evaluation Française des Ecosystèmes et des Services Ecosystémiques. Rapport d'étude, Inra (France), 966 pages. (in French) http://institut.inra.fr/Missions/Eclairer-les-decisions/Etudes/Toutes-les-actualites/EFESE-services-ecosystemiques-rendus-par-les-ecosystemes-agricoles

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