SWAT 2015
PULA / SARDINIA / ITALY

Hydrological modelling in highly anthropized basins: examples from the Garonne basin using the SWAT model

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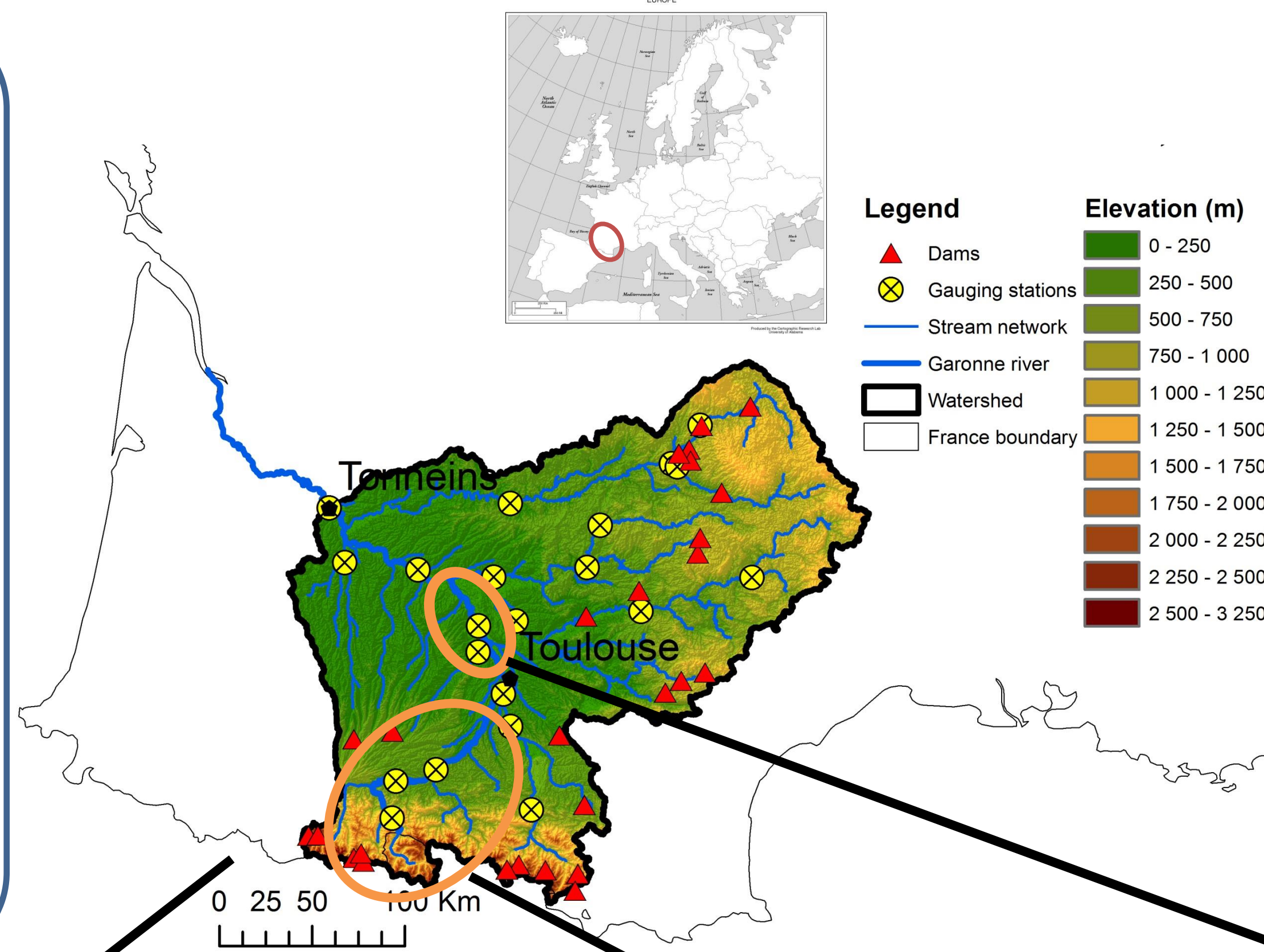
G-MOD

Scientifical Context and objectives :

REGARD (Modelling of Water Resources in the Garonne Watershed : interaction between natural and anthropic processes and income from remote sensing) is a French Interlaboratory research program, aiming to explore how remote sensing data and information on human activities combined with hydrological simulations, can provide a high spatial and temporal resolution of water resources in the Garonne watershed in the south of France. Several models, simulating water fluxes and bodies from the alluvial plain scale to the whole watershed scale, are used and compared in the project: **SAFRAN-ISBA-MODCOU** (CNRM-GAME), **SWAT** (ECOLAB), **MARTHE** (BRGM), **HEC-RAS** (IMFT), **MAELIA** (AGIR).
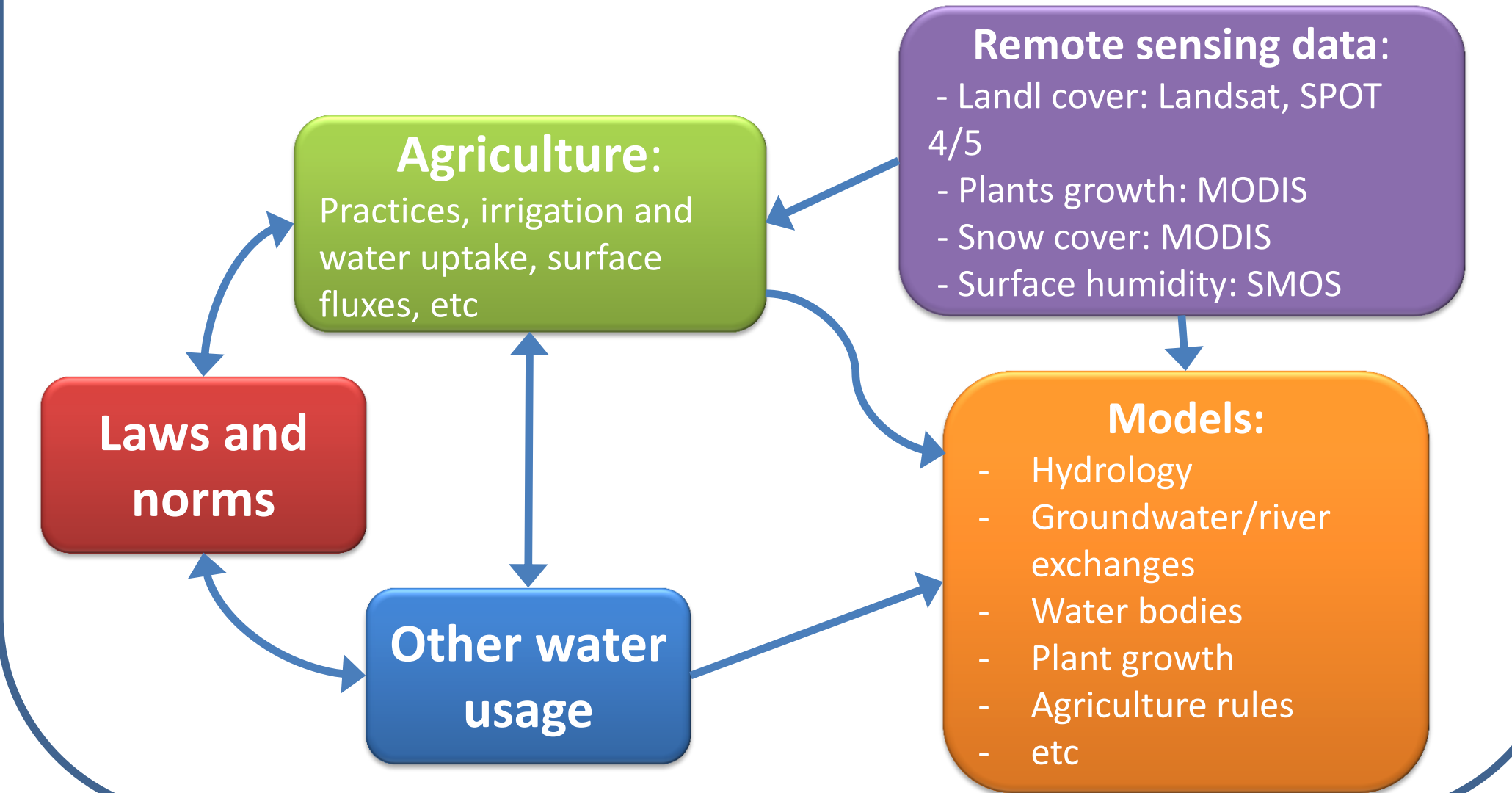
Study site and data

The goal being to simulate with precision all water fluxes at the surface, soil and aquifer levels and their links to the different water bodies, three scales are studied in the project:
- the **alluvial plain scale** at which the alluvial aquifer to river interaction can be simulated and tested with different models,
- a **subbasin scale** in the upstream part of the catchment where a validation of snow cover in the Pyrenees and dams integration can be assessed,
- the **whole catchment scale** where the total water balance and human impact can be tested (validation and calibration period fixed to 2003-2013) and where predictions for the near and far futures can be simulated.
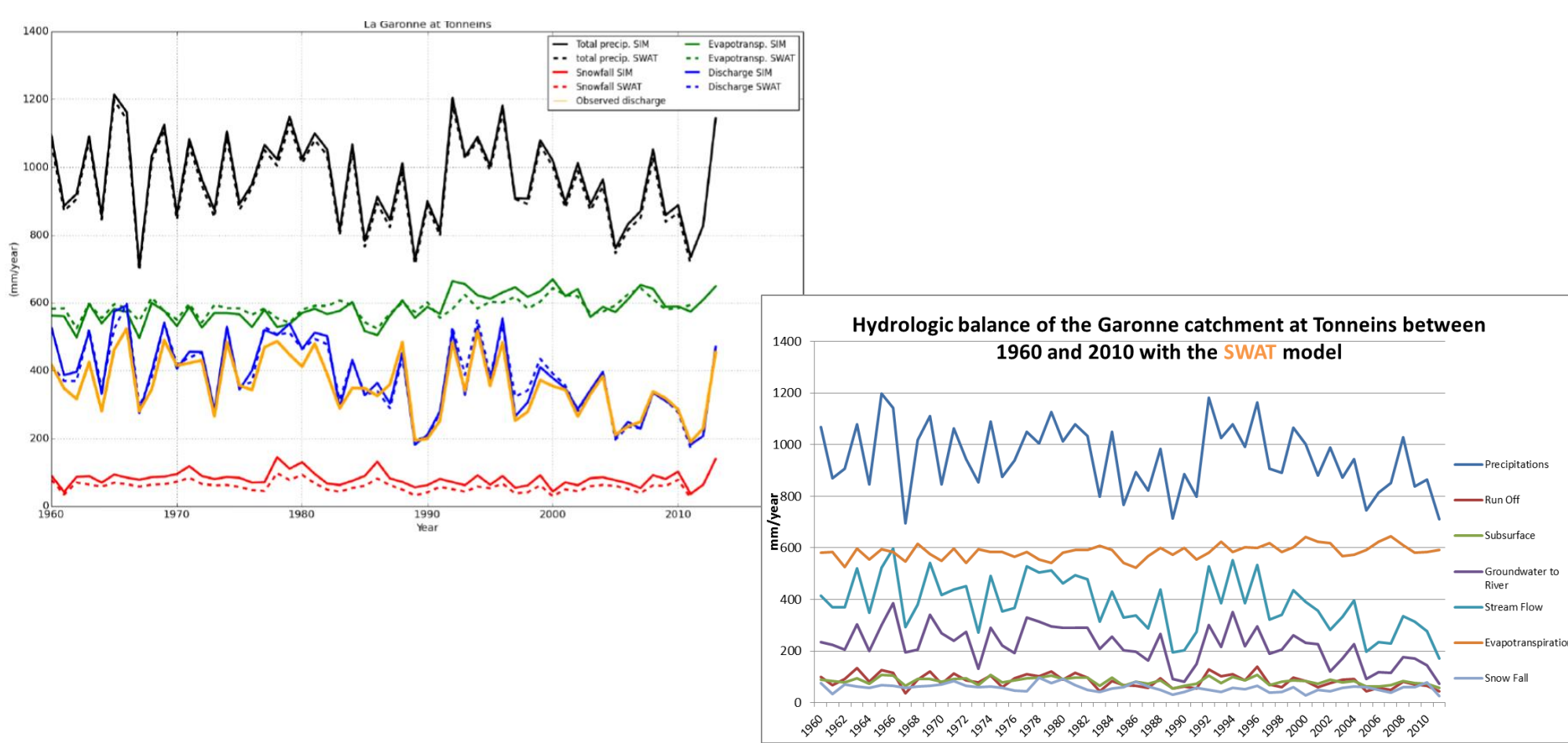

Legend
- Dams
- Gauging stations
- Stream network
- Garonne river
- Watershed
- France boundary

Elevation (m)
- 0 - 250
- 250 - 500
- 500 - 750
- 750 - 1 000
- 1 000 - 1 250
- 1 250 - 1 500
- 1 500 - 1 750
- 1 750 - 2 000
- 2 000 - 2 250
- 2 250 - 2 500
- 2 500 - 3 250

Tonneins

Toulouse

0 25 50 100 Km

Methodology

Remote sensing data (CESBIO, LEGOS) are used for land cover, crop dynamic and snow validation. Comparison of different models at different space scales is realized to better identify the best formalisms and assess the range of the simulations outputs.

Remote sensing data:
- Landl cover: Landsat, SPOT 4/5
- Plants growth: MODIS
- Snow cover: MODIS
- Surface humidity: SMOS

Agriculture: Practices, irrigation and water uptake, surface fluxes, etc

Laws and norms

Other water usage

Models:
- Hydrology
- Groundwater/river exchanges
- Water bodies
- Plant growth
- Agriculture rules
- etc

Garonne watershed scale

Water resource:

*Evolution of the main components of the water balance over the period 1958-2013 for the Garonne at Tonneins, as estimated by the Safran analysis system (precipitation and other climatic variables) and the **ISBA-MODCOU** and **SWAT** models.*

Irrigation rules and water uptakes:

An accurate simulation of irrigation practices and water uptakes in reservoirs, rivers and aquifers are a central goal toward a precise calculation of the water balance in a catchment as highly anthropized as the Garonne one is.
New rules for agricultural practices (**AGIR**) will be integrated in **SWAT** and tested at a small catchment scale first, then at the whole Garonne catchment scale.

Land use in the Garonne watershed showing the anthropization of the basin.
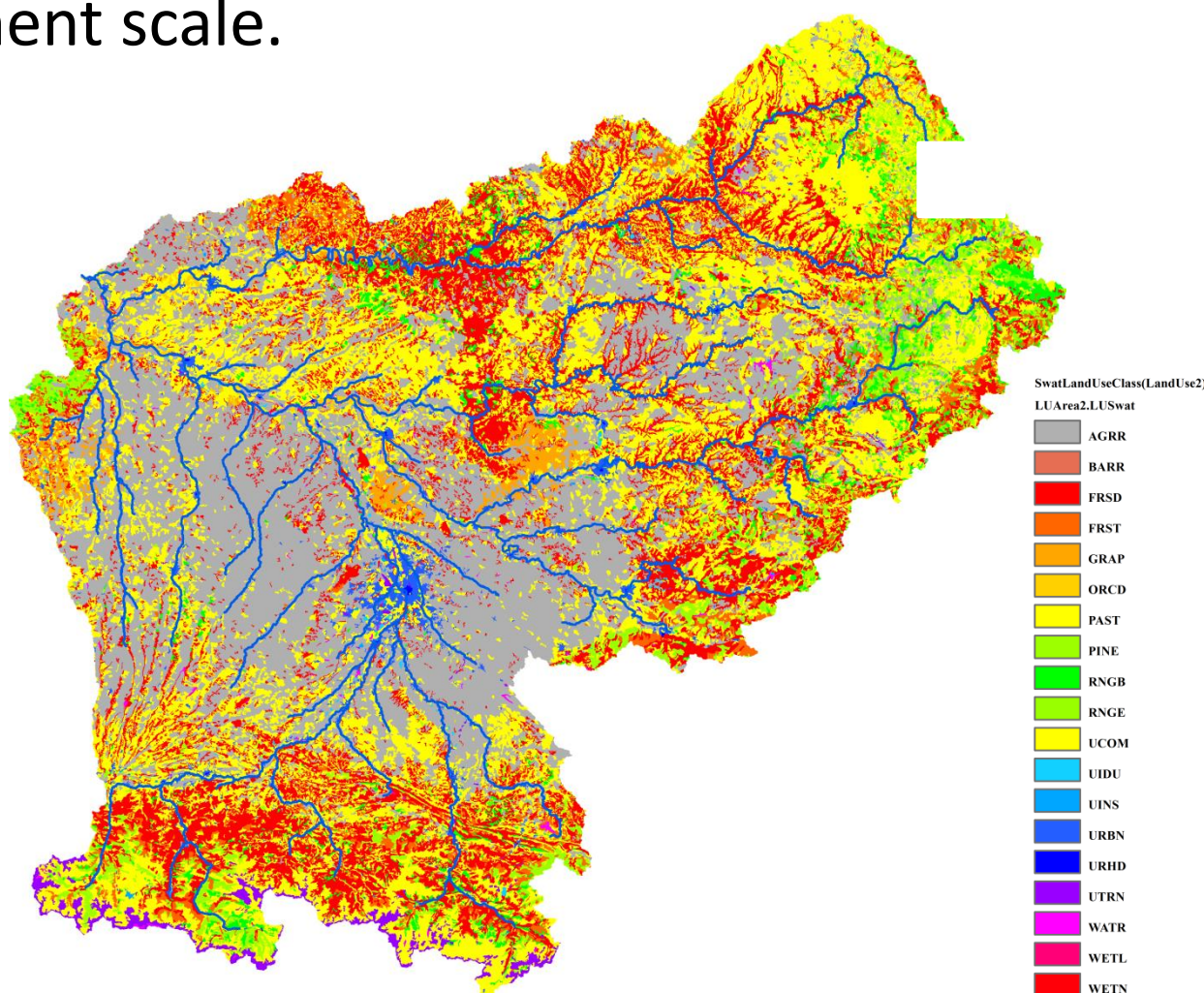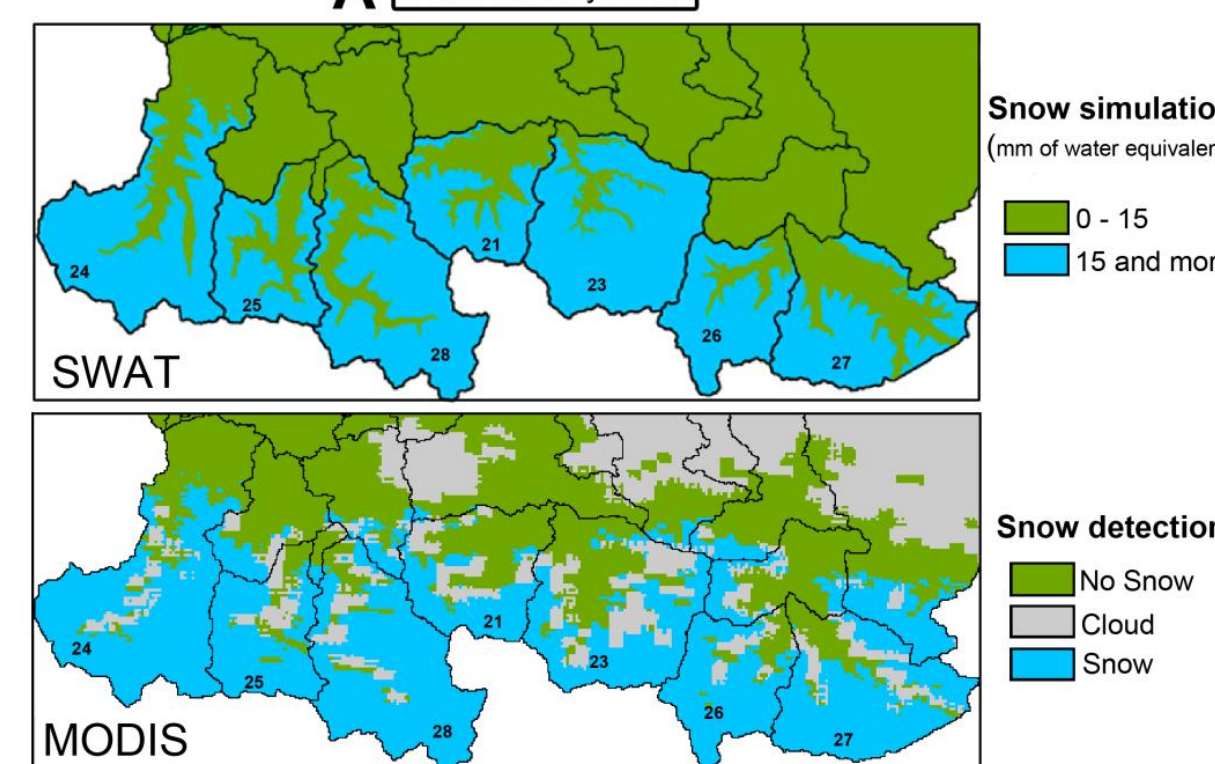
Predicting the future:

A goal of the project is to test impacts of climate change and variability on the hydrological processes in the long run and to understand the stress factors from those on human activities.

Subbasin scale (upstream part of Garonne)

Snow cover:

Snow cover and melting dynamics are determinant in order to have a good assessment of different water fluxes and reservoir at subbasin scale. Particular attention has been draw on the upper part of the catchment. Data from the **MODIS** satellite were then used to validate the simulated snow dynamics. Comparison with the **SAFRAN-ISBA-MODCOU** model has also been realized.

*Snow simulated over the Pyrenees in SWAT: comparison of the spatial spread with **MODIS***

A 10th February 2005

Snow simulation (mm of water equivalent)
- 0 - 15
- 15 and more

SWAT

MODIS

Snow detection
- No Snow
- Cloud
- Snow

*Snow water equivalent for the Ariège catchment at Foix: comparison of the snow water equivalent (mm) simulated by **ISBA** and **SWAT**.*

Dams:

Main dams of the watershed (*red triangles* on the figure at the top) will be integrated in the **SWAT** project to improve the assessment of water management for hydropower and agriculture. Dams data series at daily time step are used to calibrate the model. Management scenarios produce by **MAELIA** could be used to input dams for projection modelling.
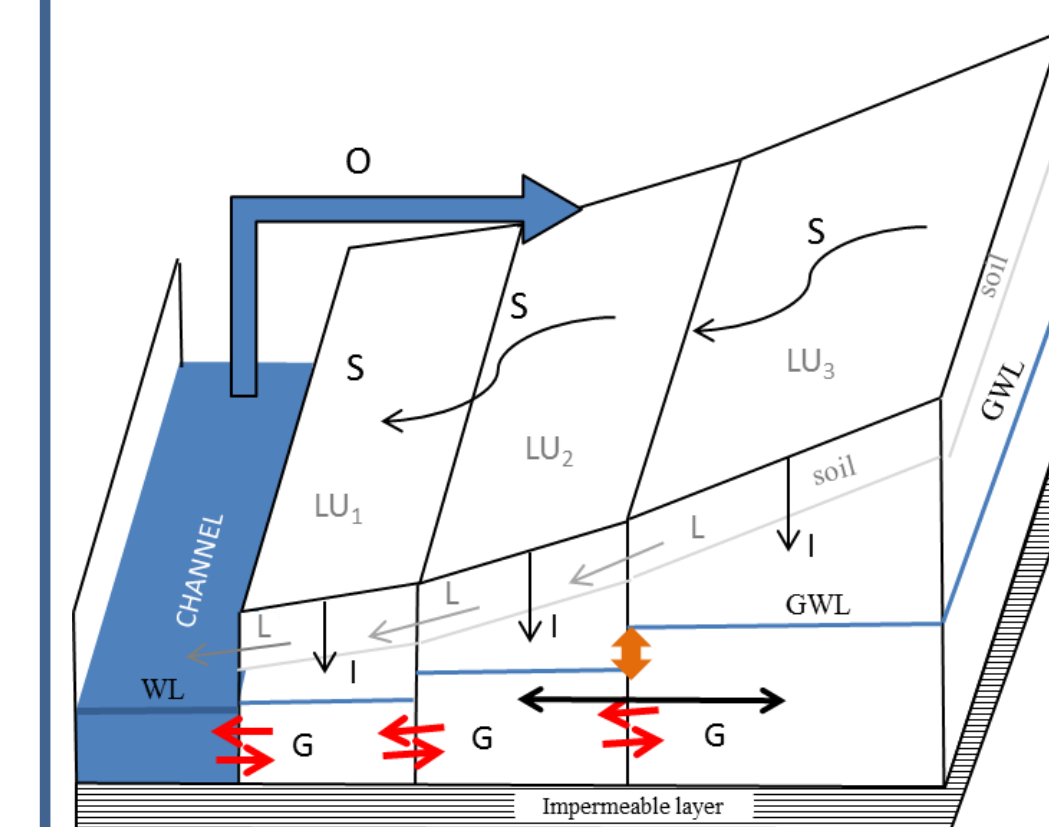
Hillside storage:

Hillside reservoirs data collecting and the logic behind their usage for irrigation in the Garonne watershed is underway. New algorithms for simulating the water uptake in those water bodies will be created (**AGIR**) and implemented and will consolidate the simulation of the impact of anthropization in the catchment's water balance.
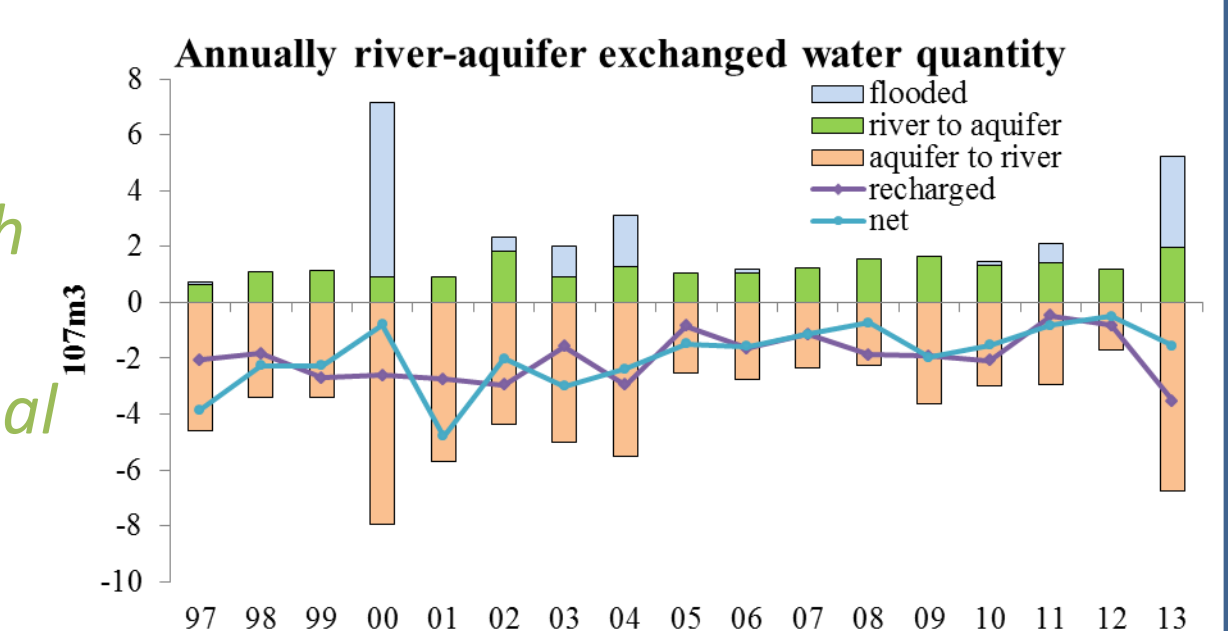
Alluvial plain scale

Alluvial Aquifer / River water exchanges:

Water exchanges between the river and the alluvial aquifer have been implemented with the **SWAT Landscape Units** model that uses the Darcy equation (**SWAT-LUD**).

*Description of the **SWAT-LUD** model with exchanges from the river to the alluvial aquifer and flooding water that can infiltrate the groundwater.*

*Water quantities from different processes with the **SWAT-LUD** model aggregated to an annual basis.*

Annually river-aquifer exchanged water quantity
- flooded
- river to aquifer
- aquifer to river
- recharged
- net

The model will be compared to the **MARTHE** model from the **BRGM** (enhanced with the **HEC-RAS** model (**IMFT**) for a 1D river) which takes into account an accurate model of the alluvial aquifer in 3 dimensions.

It will also be tested against water level data in alluvial aquifers (data from the **BRGM**).

A work for automatically generating those LUDs with the **ArcSWAT** interface is currently underway.

Water uptake

Water uptake for irrigation in the alluvial aquifer will be simulated. Uptakes can be simulated with the **MAELIA** (**AGIR**) model and then integrated in the **SWAT** simulation. Comparison with the **MARTHE** model will be done.

Conclusions

All first comparisons of the models have shown very promising results. Snow cover comparisons of **SWAT** results with the **SAFRAN-ISBA-MODCOU** model and with data from the **MODIS** satellite has allowed us to enhance the performance of the simulation over the watershed. We also tested the new river / alluvial aquifer interaction with the **SWAT-LUD** module and confirmed the validity of the approach at the alluvial plain scale. Next steps include the implementation of rules for the simulation of agriculture practices and water uptakes in reservoirs in order to have a better representation of the impact of human activities on the catchment's hydrology, the test of the **SWAT-LUD** model at the whole catchment scale and the calibration / validation of the model at the catchment scale with all the new formalisms an data included.

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