

Characterization of nonpoint source pollution using a SWAT-MARTHE coupling for integrated water resource management

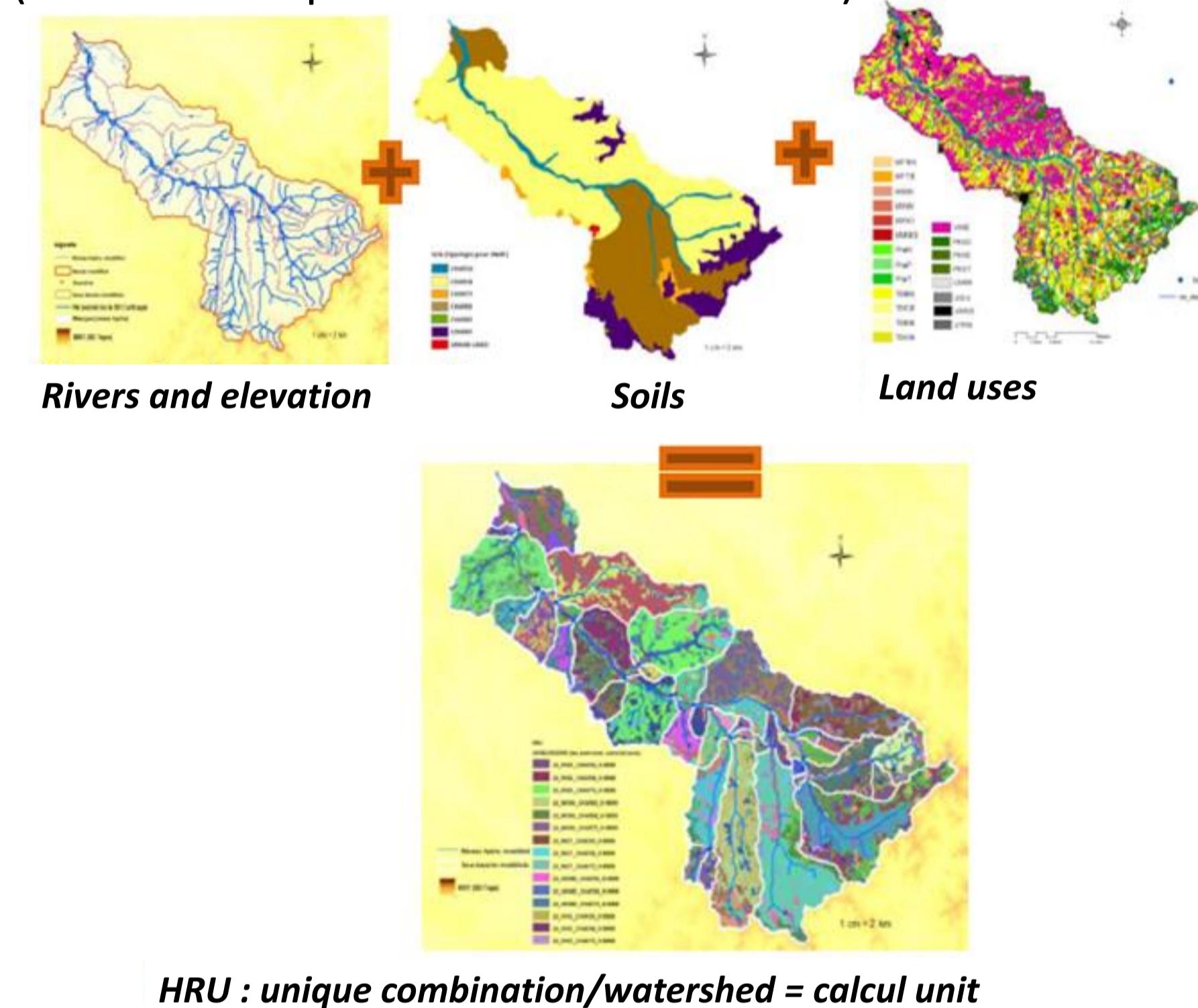
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Nonpoint source pollution from agricultural practices is of serious concern in the Charente Watershed in the southwest of France. This watershed is hydrogeologically complex, with numerous interactions between rivers and groundwater. The large diversity of soils implies a diversity of agricultural practices. National and local stakeholders are concerned and willing to get a global assessment of the water resource. They need a pertinent decision support to target appropriate measures on priority areas to restore the water quality and to comply with the European Water Framework Directive and Nitrate Directive.

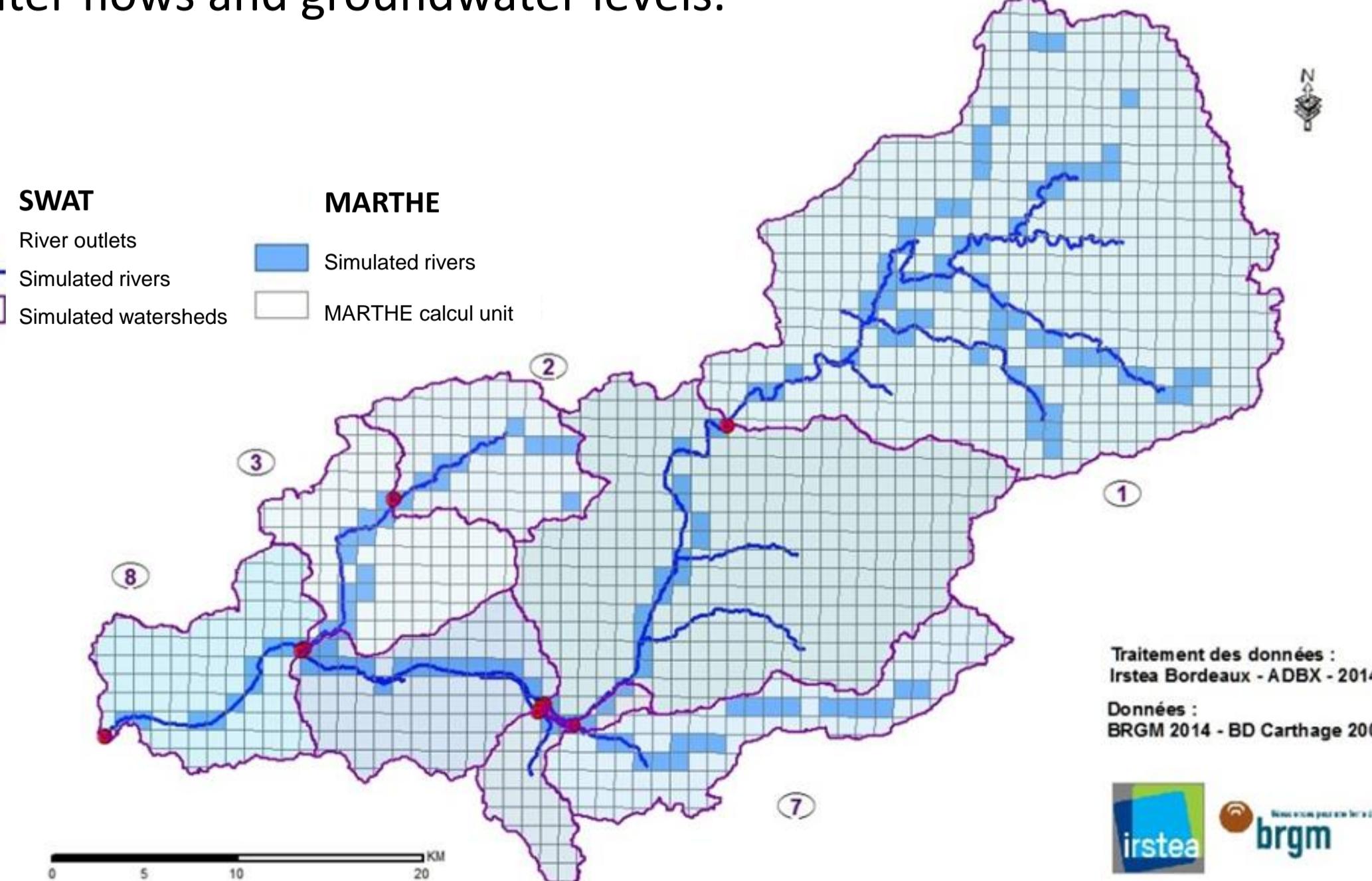
IRSTEA: SWAT (Soil and Water Assessment Tool)

SWAT is a watershed model which evaluates the impact of agricultural and urban practices on the environment. IRSTEA developed a model of the Charente basin to simulate the nitrate concentration in soils, and by extension in the river and the first aquifer. The calculations are performed at the scale of the Hydrological Response Unit (HRU), defined by the combination of sub-watersheds, soils and landuse. Its calibration is centered mainly on the good representation of the river flows. (Below: example on the Né watershed)



BRGM: MARTHE (hydrogeological modeling)

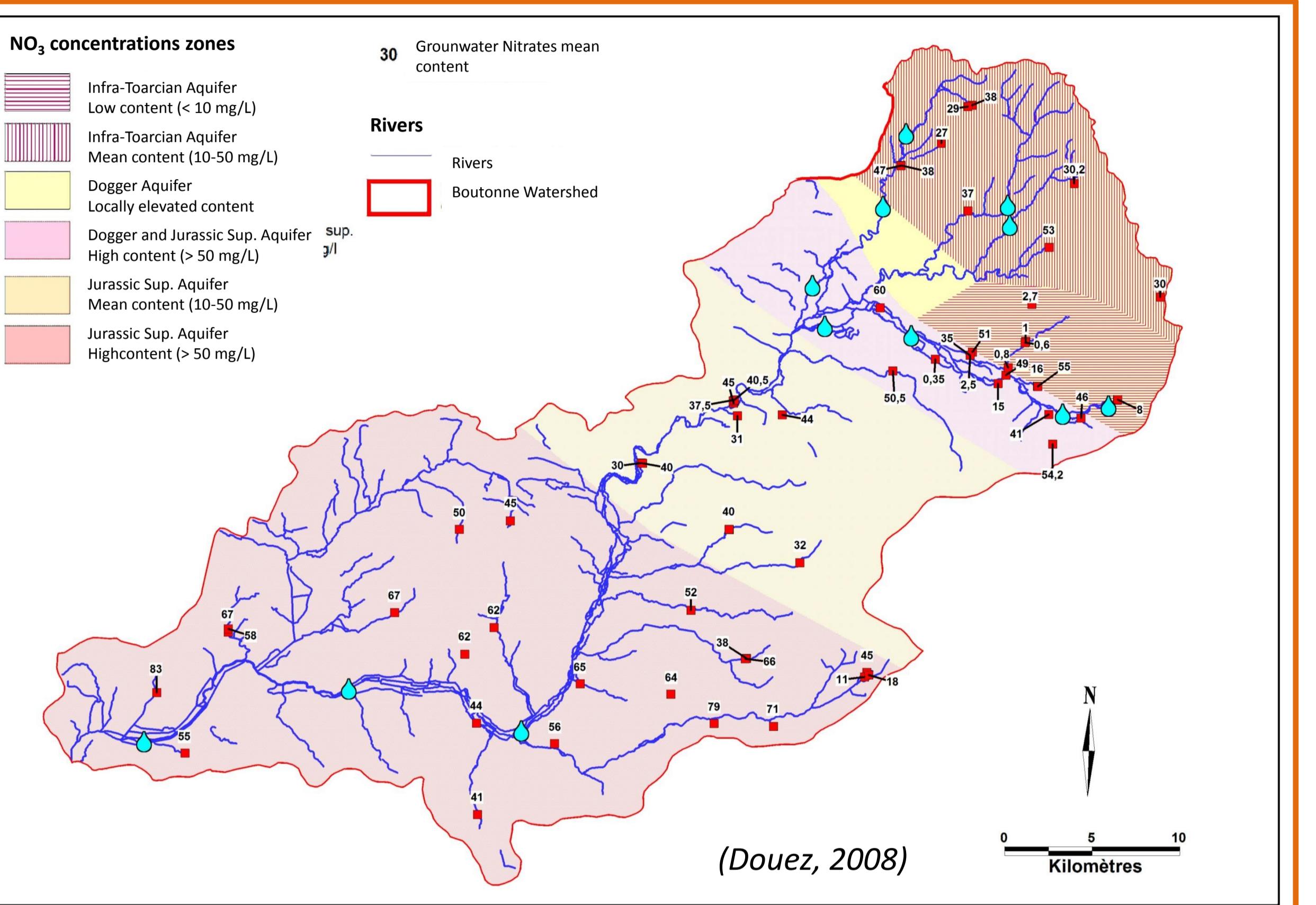
MARTHE simulates the aquifer flow and mass transportation within a porous medium. The interactions between rivers and aquifers can be modeled as well. BRGM has developed 2 models on the Charente basin, including 14 geological layers. The calculations are done each kilometric cell. Its calibration involves both water flows and groundwater levels.



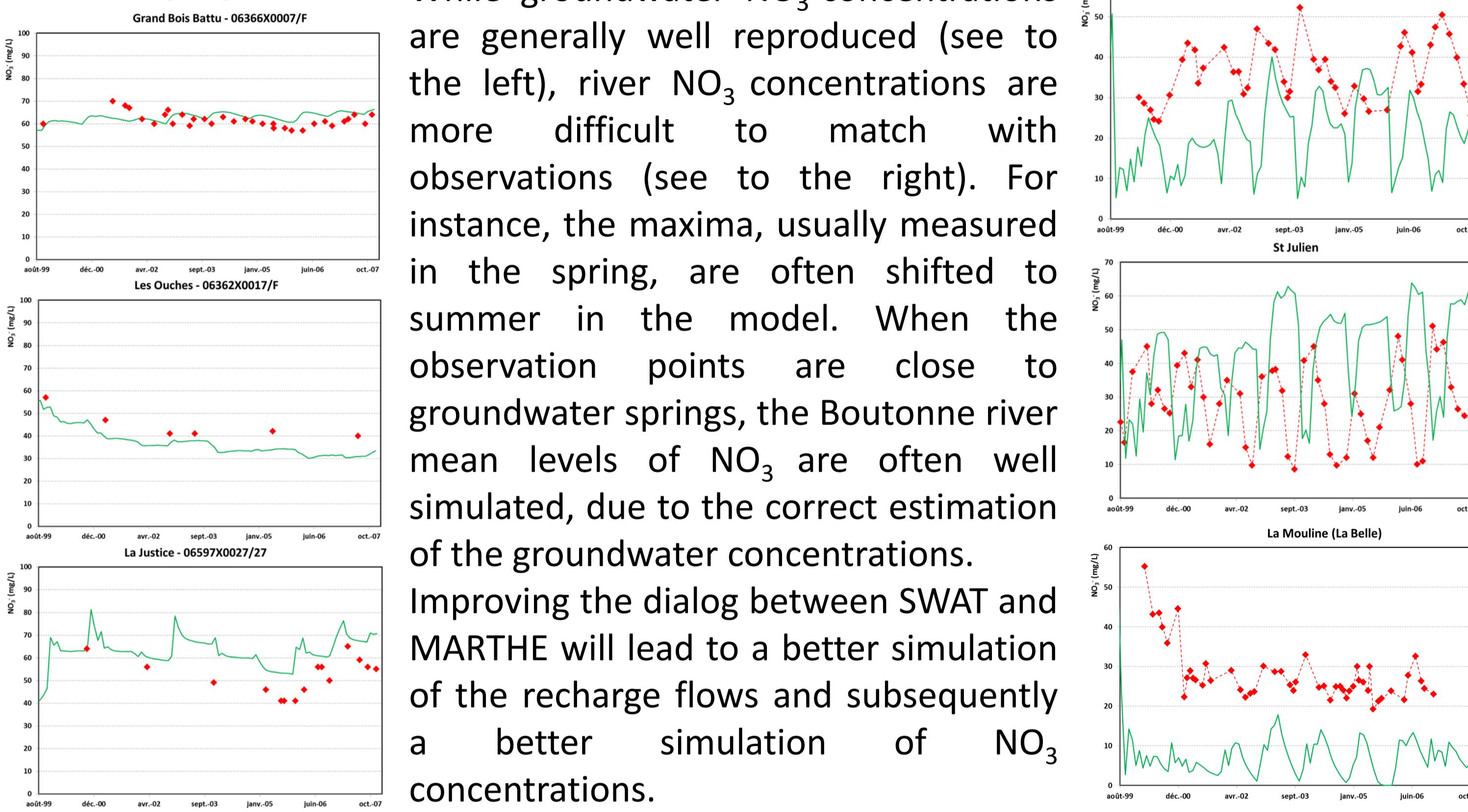
The Boutonne watershed

The Boutonne river is situated within the Charente watershed, in the southwest of France, Its watershed presents a complex geology, with numerous faults and four interconnected main aquifers.

Nitrates and pesticides concentrations especially affect the Boutonne watershed, mostly covered by agricultural lands. NO₃ concentrations are often over the 50 mg/L limit. IRSTEA worked on modeling the dynamics of agricultural practices on this basin, and on establishing new scenarios for agriculture in the research program MODCHAR. It was selected to test the SWAT-MARTHE coupling.



Encouraging results



While groundwater NO₃ concentrations are generally well reproduced (see to the left), river NO₃ concentrations are more difficult to match with observations (see to the right). For instance, the maxima, usually measured in the spring, are often shifted to summer in the model. When the observation points are close to groundwater springs, the Boutonne river mean levels of NO₃ are often well simulated, due to the correct estimation of the groundwater concentrations.

Improving the dialog between SWAT and MARTHE will lead to a better simulation of the recharge flows and subsequently a better simulation of NO₃ concentrations.

From SWAT outputs to MARTHE Inputs

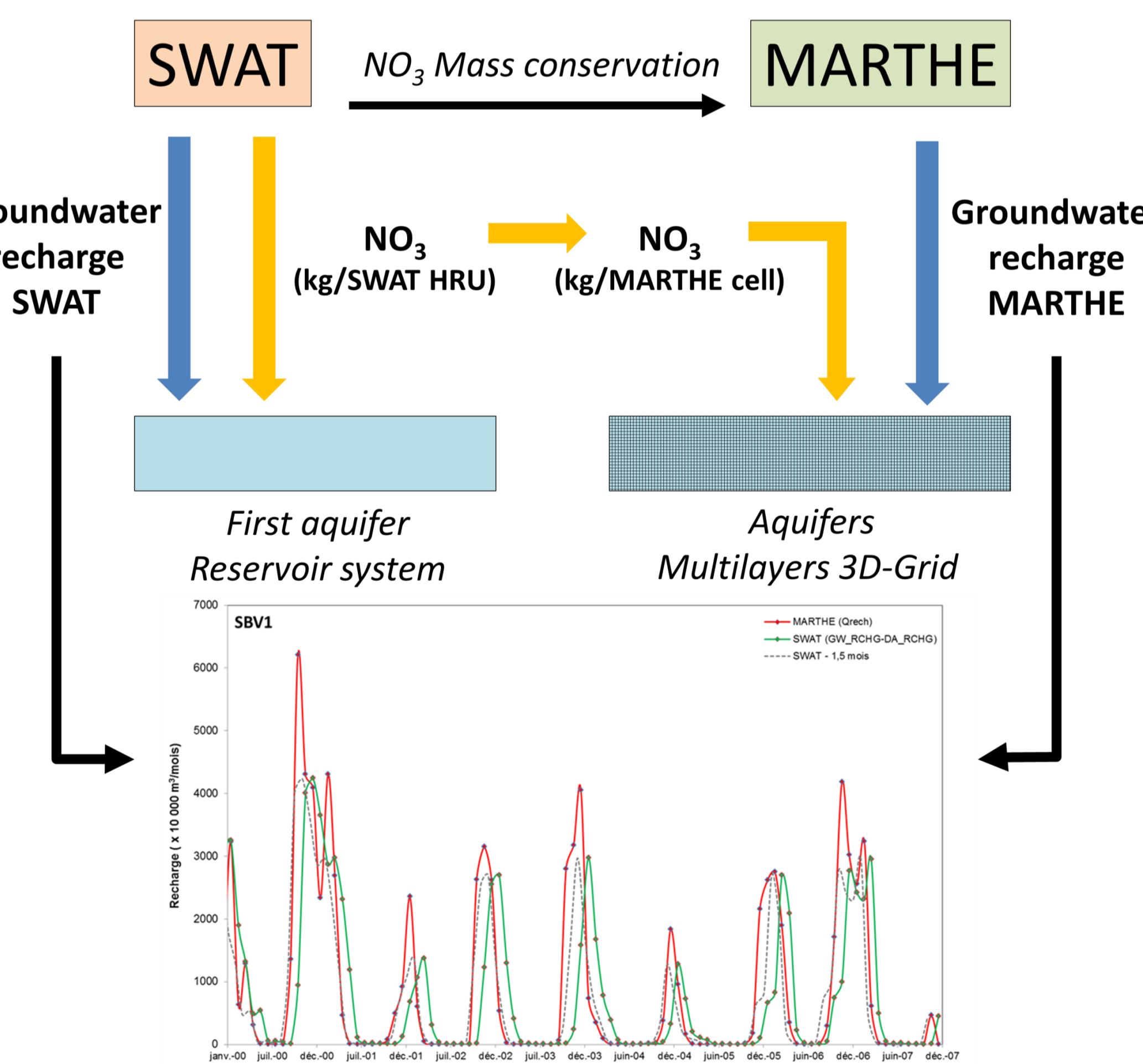
SWAT NO₃ outputs are used to generate MARTHE NO₃ inputs (see to the right).

Groundwater recharge is not calculated in the same way with SWAT and MARTHE.

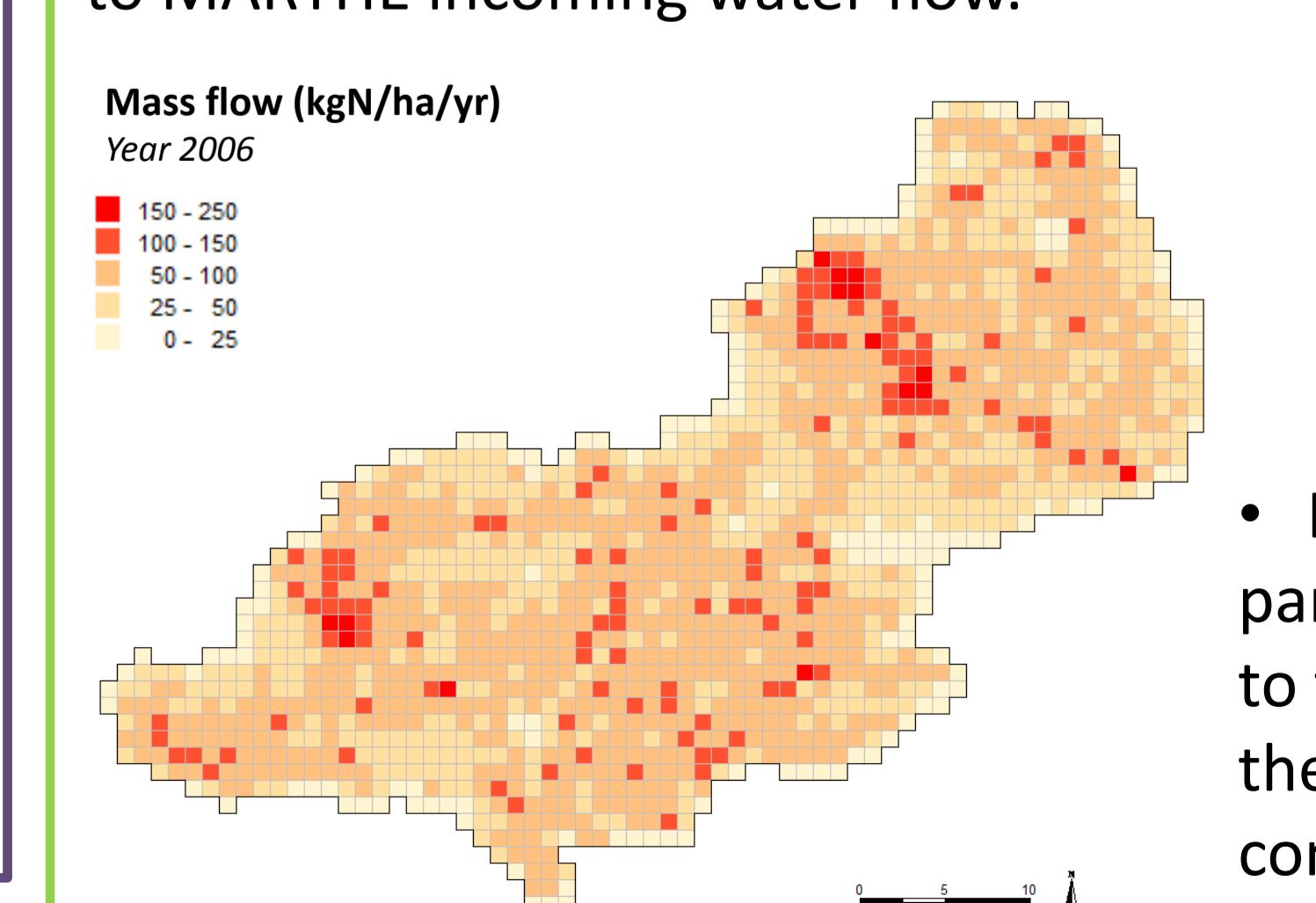
For example, SWAT works with a daily time-scale, whereas MARTHE uses a monthly time-scale. Moreover, SWAT doesn't have the same way to take into account river and groundwater pumping for agricultural uses as MARTHE.

SWAT and MARTHE calculations lead to very different groundwater recharges.

When recharge flows are not synchronized, it becomes difficult to transfer SWAT nitrates results to MARTHE incoming water flow.



- In order to test the SWAT-MARTHE coupling without having to change the parametrization of the recharge, it was decided first to shift the SWAT NO₃ flow to the next month. Secondly, if the recharge calculated by MARTHE was too low, the NO₃ flow was shifted again to the next month, to avoid artificially high NO₃ concentrations in the groundwater recharge.
- The obtained NO₃ mass flow mirrors the NO₃ concentrations (see to the left).



Conclusion : "work in progress"

SWAT is a "watersheds" model based on a "reservoirs" representation of rivers and groundwater, whereas MARTHE is mainly a tool for modeling groundwater hydrodynamics, based on a cells representation and physical equations.

The work that was initiated here aims to combine the benefits of each tool: SWAT expertise in agronomical simulations and MARTHE efficiency in groundwater simulation, to represent every aspect of the Boutonne watershed issues.

To succeed, BRGM and IRSTEA will have to work together on these points:

- A better understanding of the cultural practices on the long term, considering the groundwater inertia
- A better modeling of the aquifer recharge by both sources
- Modeling at a smaller timescale in MARTHE, to better simulate the recharge
- Taking into account the double porosity in the modeled media
- Working on the scale change between HRU and watersheds

The ultimate step could be to widen the current modeled area up to the whole Charente watershed (10 000 km² wide) and to transfer the application to the local stakeholders.

References

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