Regional-scale coupled modeling of water pollution by nitrate from agricultural sources: the Seine-Normandie hydrosystem case study

Nicolas Gallois, Pascal Viennot, Thomas Puech, Nicolas Beaudoin, Paul Passy, Florent Chlebowski, Christine Le Bas, Bruno Mary, Gilles Billen, Josette Garnier, et al.

6-7 January 2020 – Montpellier

BOOK OF ABSTRACTS

XIIth Stics users seminar

https://www6.paca.inrae.fr/stics_eng/

Stics2020 is a side event of the iCROP symposium (https://www.icropm2020.org/)

iCROPM 2020 | Crop Modelling for the Future

XIIth Stics users seminar

Book of abstracts

Montpellier

6-7 January 2020

Scientific committee

François Affholder - CIRAD/AIDA

Eric Justes - CIRAD/PERSYST

EPS Stics Team

Gatien Falconnier - CIRAD/AIDA

Guillaume Jégo – AFFC

Organization committee

François Affholder - CIRAD/AIDA

Michel Giner - CIRAD/AIDA

Brigitte Giudicelli - CIRAD/AIDA

Anne-Laure Fruteau de Laclos - CIRAD/AIDA

Remi Vezy - CIRAD/AMAP

Krishna Naudin - CIRAD/AIDA

EDITORIAL

The STICS team is happy to invite you to the 12th Stics users seminar.

This seminar is a side-session of the iCROPM symposium that gathers eminent crop modelers from all around the globe. The iCROPM will focus on advances in crop modelling in general, with a great diversity of models and views on crop modelling. This seminar will focus more specifically on the Stics model and on the scientists community familiar to, or interested in the way the model (i) conceptualizes and simulates cropping systems (ii) has evolves over the past years to account for an increasing range of cropping systems properties. It offers a unique opportunity to take advantage of the great diversity of the views and expertise of the scientists coming to Montpellier this week.

We chose to host the seminar at the Agropolis campus in Montpellier, at the French agricultural research and international cooperation organization CIRAD that works for the sustainable development of tropical and Mediterranean regions. It is not mere coincidence - it underlies our will to strengthen the ability of the Stics model to deal with issues at stake in tropical environments. This is also reflected in the program and the list of participants.

We truly hope you will enjoy this Stics2020 seminar, and that it will offer you the opportunity to connect and exchange with new people on your favorite topic as well as on other challenges you want to undertake for the future.

Thursday 6th February 2020

		Talk (min)	Discussion (min)	Speaker
8:00 - 9:00	Registration - CIRAD - Registration desk at Alliot Amphitheater			
		Chair:	E. Justes	
9:00 - 9:15	Welcome speeches	15		JP. Laclau (CIRAD) + P. Cellier (INRAE) + STICS team head
9:15 - 10:40	***Session 1: News from the last STICS workshop***			
	News and propects for the STICS team and network	20	5	E. Justes, D. Ripoche, M. Launay and S. Buis.
	The Red Book of STICS, towards version 2	2	-	N. Beaudoin
	The genesis of STICS v10 and new formalisms implemented in the next standard version	20	5	L. Strullu
	SticsRpacks: a set of packages for managing Stics from R	15	5	S. Buis S. & P. Lecharpentier
10:40 - 11: 00	*Coffee break*			
11:10 - 12:30	***Session 2: New formalisms and crop calibration for crop diagnosis***	Chair:	G. Falconnier	
	Development of a new formalism for the establishment of grain yield and protein for determinate growing plants in a dedicated research version of STICS	15	5	N. Beaudoin or B. Dumont
	Assessment of the impact of water stress on soybean yield in Canada using STICS	15	5	G. Jégo
	Comparison of sugarcane STICS model calibrations to simulate growth response to climate variability	15	5	M. Christina
	Use of the STICS model for simulating physiological and soil evolution in the Champagne vineyard under different scenarios	15	5	C. Demestihas
12:30 - 14:00	*Lunch break (Agropolis International - Vanille room)*			
14:00 - 15:30	***Session 3: Modelling intercropping with STICS***	Chair:	G. Louarn	
	How to model crop-weed competition for soil resources: Connecting the STICS soil submodel to the FLORSYS weed dynamics model	15	5	N. Colbach
	Improving the intercropping version of the STICS model for simulating inter-specific competition	15	5	R. Vezy
	Calibration and Evaluation of the STICS Intercrop Model for Two Cereal-Legume Mixtures	15	5	K. Paff

	Modelling the agronomic performance of millet-cowpea intercropping under the semi-arid environment of Senegal.	12	3	Y. Senghor
	Calibration of STICS soil-crop model for sorghum crop mixed with cowpea bean to evaluate the performance of this crop-system in sub-Saharan Africa	12	3	A. Traoré
15:30 - 16: 00	*Coffee break*			
16:00 - 17:30	***Session 4: Methods and new tools for modelling with STICS***	Chair:	F. Affholder	
	AgGlob: Workflow for simulation of agronomic models at a global scale	15	5	H. Raynal
	Preliminary coupling of STICS (v9.1) to PEcAn ecological informatics toolbox, and its comparison to BASGRA	15	5	I. Fer
	A global optimization tool for assimilation of leaf area index into STICS crop model	15	5	M. Mesbah
	STICS on SIWAA: A STICS Tool set deployed on the SIWAA Galaxy Web platform	12	3	P. Chabrier
	A new method for sensitivity analysis of models with dynamic and/or spatial outputs	12	3	S. Buis
17:30	**End of the 1st day**			
17:30 - 19: 00	***Free time and Transfer to Montpellier social dinner place with public transports***			
19:00 - 23 :00	Social dinner – Villa mont-riant - Montpellier - 6 boulevard vieussens			

Friday 7th February 2020

9:00 - 10:00	***Session 5: Environmental impact of cropping systems and soil C&N dynamics***	Chair:	I. Garcia de Cortazar	
	Verification and long-term simulations of STICS crop model to predict and analyze growing seasons N_2O fluxes of spring wheat in eastern Canada	15	5	E. Pattey
	Modelling decomposition and N_2O emissions of mulches varying in quantity and quality	15	5	B. Chaves
	Modelling short and long-term nitrogen and carbon budgets of agro-ecological cropping systems with a dedicated STICS research version	15	5	N. Beaudoin
10:00 - 10:50	***short talks (presentation of posters)***			
	STICS ability to simulate long-term soil organic matter dynamics in crop-grassland rotations	5	2	A.I. Graux (A. Cadero)
	Simulation of switchgrass biomass production in Eastern Canada with the STICS model	5	2	G. Jégo

	Modelling the impact of soil and climatic variability on sugarcane growth response to mineral and organic fertilisers	5	2	M. Chaput
	Impact of corn root growth parameters on soil moisture, evapotranspiration and crop growth in STICS model	5	2	E. Pattey (S. Saadi)
	Impacts of observed and projected climatic constraints on rainfed wheat yield under a typical Mediterranean condition	5	2	C. Yang
	Coupling Sentinel-2 images and STICS crop model to map soil hydraulic properties	5	2	K. Lammoglia
10:50 - 11:10	*Coffee break*			
11:10 - 12:30	***Session 6: Regional and large scale simulations using STICS***	Chair:	E. Pattey	
	Estimate demand for irrigation water and nitrogen fertilizers in Europe at different scales	15	5	PA Jayet
	Regional-scale coupled modelling of water pollution by nitrate from agricultural sources: the Seine-Normandy hydrosystem case study	15	5	N. Gallois
	Simulating innovative cropping systems aiming at producing biomass while reducing greenhouse gas emissions in the Hauts-de-France region	15	5	F. Ferchaud
	New crop fertilization strategies after introduction of anaerobic digesters in a territory and their consequences on carbon and nitrogen dynamics in soils: case study of the Versailles plain	15	5	C.Launay
12:20 - 14:00	*Lunch break (Agropolis International - Vanille room)*			
14:00 - 14:45	***Session 7: Scenario simulations using STICS***	Chair:	M. Launay	
	To maximize multiple ecosystem services without dis-service for water, the management of cover crops has to be climate and soil specific. A simulation approach using STICS model.	15	5	N. Meyer
	Simulating soil organic carbon dynamics in long-term bare fallow and arable experiments with STICS model	15	5	F. Ferchaud (H. Clivot)
	Participative approach with STICS for evaluation of nitrogen management scenarios in organic farming systems	5	2	N. Beaudoin
14:45 - 15:30	**Invited conference**: The “business” of developing and delivering a systems model – the APSIM experience	30	10	PJ Thorburn
15:30 - 16:00	**Concluding session**: Conclusion and General discussion on STICS team governance	15	20	STICS team head: E. Justes, D. Ripoche, M. Launay and S. Buis
16:00 - 16:30	*End of the Workshop with Coffee break*			

Content

Regional-scale coupled modelling of water pollution by nitrate from agricultural sources: the Seine-Normandy hydrosystem case study

Nicolas Gallois[1], Pascal Viennot[1], Thomas Puech[2], Nicolas Beaudoin[3], Paul Passy[4], Florent Chlebowski[3], Christine Le Bas[5], Bruno Mary[3], Gilles Billen[6], Josette Garnier[6], Marie Silvestre[4], Vincent Thieu[6]

[1] MINES ParisTech, PSL Université, Centre de Géosciences, ARMINES, 35 rue Saint-Honoré, F-77305 Fontainebleau, France
[2] INRA SAD, Unité Aster, 662 avenue Louis Buffet, F-88500 Mirecourt, France
[3] INRA, UR 1158 Agro-Impact, site de Laon, Pôle du Griffon, F-02000 Barenton-Bugny, France
[4] FIRE, CNRS, UMR 7619 METIS, 4 place Jussieu, F-75005 Paris, France
[5] INRA-US Infosol, 2163 avenue de la Pomme de Pin, F-45075 Orléans, France
[6] Sorbonne Université, UMR 7619 METIS, 4 place Jussieu, F-75005 Paris, France

Keywords: coupled modelling, nitrate pollution, nitrogen leaching, foresight scenarios

Introduction

Agricultural lands represent nearly 70% of the surface area of the Seine-Normandy basin. The multiplicity and diffuse nature of the hydro-physico-chemical processes involved in the transfer of agricultural-source nitrogen (N) make the characterization of their impacts on the quality of the basin water resources a challenging and complex issue. In this context, an original interdisciplinary modelling platform has been developed (Gallois and Viennot, 2018).

Material and method

The platform deals with the main processes affecting water quality along the aquatic *continuum* by linking the STICS, MODCOU and RIVERSTRAHLER models (Ledoux *et al.*, 1984; Billen *et al.*, 1994; Brisson *et al.*, 2009).

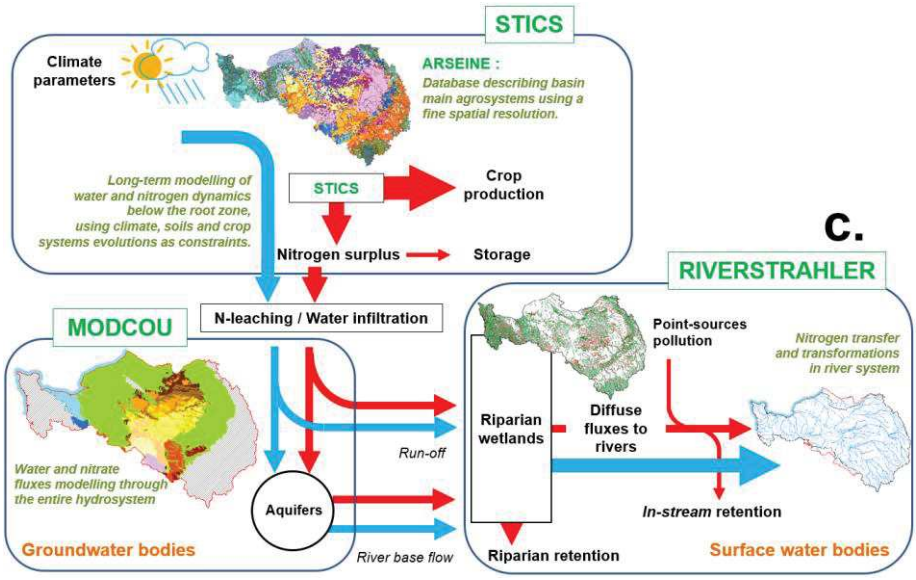

Figure 1: Diagram of the integrated modelling platform of the Seine-Normandy basin. Water flows in blue, N flows in red.

Over the simulated domain (100,000 km^2 approximately), model interactions (cf. Figure 1) are set in order to:

- Generate water and N flows below the sub-root zone using the STICS v10 code. STICS inputs resulted from the spatio-temporal evolutions of agricultural practices describing over 4,500 cropping systems since 1970 (ARSEINE v3.4.3 database, INRA Aster) (Puech *et al.*, 2018) as well as climate data

(SAFRAN, Météo-France) and soils characteristics (BDGSF, INRA InfoSol). A dedicated software allowed their integration and the STICS distribution over the territory (Gallois and Viennot, 2018);

- Synchronously model nitrate and water flows transiting through sub-surface, unsaturated and saturated compartments of the regional hydrosystem, using the MODCOU hydrogeological model;
- Model N transfer and transformations across the 36 000 km-long river system *via* the RIVERSTRAHLER model, computing geographical distributions of N-concentrations in the network.

Results and implementation

The platform's ability to reproduce the agro-hydrosystem behavior was assessed at three levels:

- *Indirect validation of STICS water drainage and N-leaching flows* : The development of a *Quality Assurance Protocol* (QAP) (Beaudoin *et al.*, 2018) combining sensitivity analysis and agronomic expertise of STICS inputs and outputs allowed to evaluate the reliability and consistency of STICS simulations at the macro-regional scale;
- *Direct validation on nitrate concentration rates in aquifer system*: The aquiferous nitrate content was predicted with a maximum absolute bias less than 10 $mgNO_3\ L^{-1}$ at 580 control points (cf. Figure 2);
- *Direct validation of nitrogen supply dynamics in the river system*: Simulated river concentrations were compared with available observations at the gauging station scale (cf. Figures 2a, 2b, 2c).

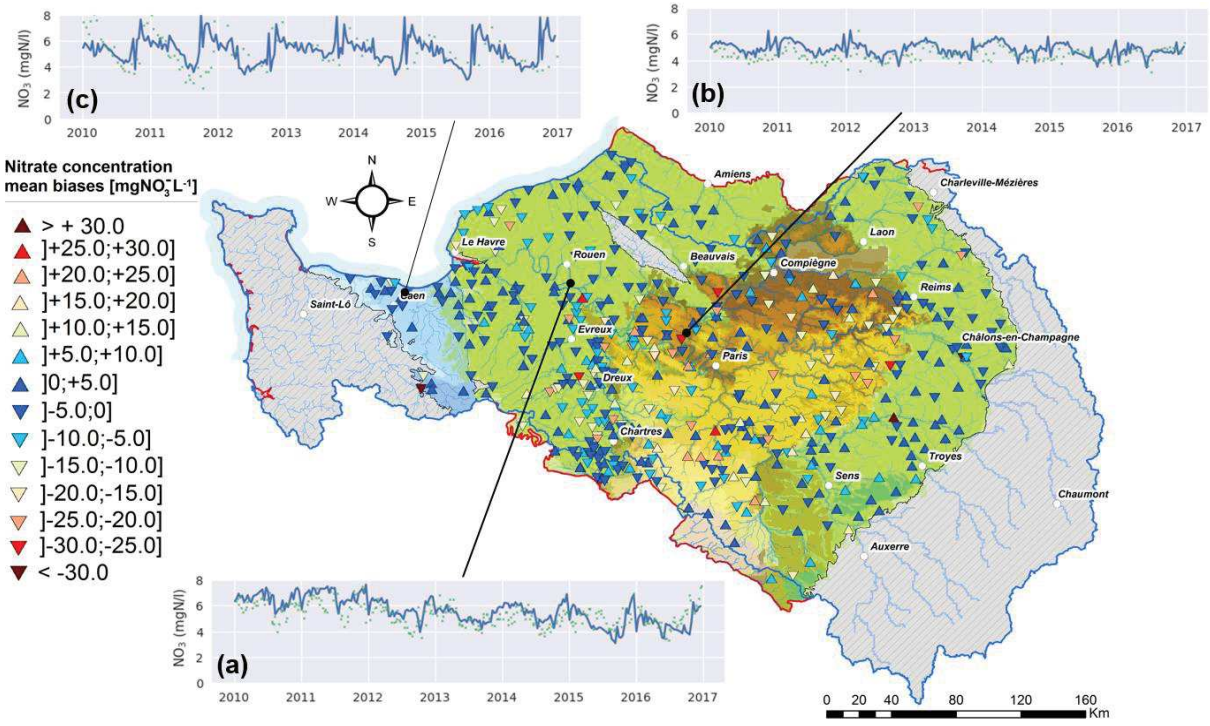

Figure 2. Average biases (1995-2016) between simulated aquiferous nitrate concentrations and measured data at the scale of instrumented boreholes. Three examples of synchronous time evolutions between observed and simulated concentrations in rivers (2010-2016; mgN-NO3 L^{-1}) at stations located at the (a) Seine, (b) Oise and (c) Orne river outlets are also displayed.

Relying on these performances, the platform allowed a complete assessment of N-related transfer and transformation processes along the soil-hydrosystem *continuum* over 50 years (Passy et al., 2018). It also permitted to study the sensitivity of groundwater to two contrasting foresight agriculture scenarios over 2017-2050 period (conventional and agro-ecological - Puech et al., 2018).

Bibliographical references

Beaudoin, N. *et al.* (2018) « Evaluation of a spatialized agronomic model in predicting yield and N leaching at the scale of the Seine-Normandie basin », *Environmental Science and Pollution Research*, 25, p. 23529‑23558. doi: 10.1007/s11356-016-7478-3.

Billen, G., Garnier, J. et Hanset, P. (1994) « Modelling phytoplankton development in whole drainage networks : The Riverstrahler model applied to the Seine river system », *Hydrobiologia*, 289, p. 119‑137.

Brisson, N. *et al.* (2009) *Conceptual basis, formalisations and parametrization of the STICS crop model*. Édité par Quae. Update Sciences and Technologies.

Gallois, N. et Viennot, P. (2018) *Modélisation de la pollution diffuse d'origine agricole des grands aquifères du bassin Seine-Normandie : Actualisation des modélisations couplées STICS-MODCOU – Modélisation de scénarios agricoles sous changement climatique*, ARMINES technical report, 268p.

Ledoux, E., Girard, G. et Villeneuve, J. P. (1984) « Proposition d'un modèle couplé pour la simulation conjointe des écoulements de surface et des écoulements souterrains sur un bassin hydrologique », *La Houille Blanche*, p. 101‑110.

Puech, T., Schott, C. et Mignolet, C. (2018) *Evolution des bases de données pour caractériser les dynamiques des systèmes de culture sur le bassin Seine-Normandie,* INRA technical report, 219p.