



**HAL**  
open science

## Hydro-climatic controls of stream dissolved organic carbon in headwater catchment

Guillaume Humbert, Anne Jaffrézic, Ophélie Fovet, Patrick Durand, Gérard Gruau

► **To cite this version:**

Guillaume Humbert, Anne Jaffrézic, Ophélie Fovet, Patrick Durand, Gérard Gruau. Hydro-climatic controls of stream dissolved organic carbon in headwater catchment. European Geosciences Union General Assembly 2014, Apr 2014, Vienne, Austria. 2014. hal-04163150

**HAL Id: hal-04163150**

**<https://hal.science/hal-04163150>**

Submitted on 17 Jul 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Guillaume Humbert\* (1,2), Anne Jaffrézic (1,2), Ophélie Fovet (1,2), Patrick Durand (1,2), Gérard Gruau (3)  
 (1) INRA, UMR 1069, Soil Agro and hydroSystem, F-35000 Rennes, France  
 (2) Agrocampus Ouest, Soil Agro and hydroSystem, F-35000 Rennes, France  
 (3) OSUR, UMR 6118 Géosciences Rennes, Campus de Beaulieu, 35042 Rennes Cedex, France

## Context

At landscape scale, groundwater table connects soils to stream:

Organo-mineral horizons of wetland soils are the main sources of river dissolved organic carbon (DOC) [1]

Organo-mineral horizons of upland soils may contribute up to 40% of storm flow exports [2]

Soil moisture and temperature control DOC production :

Microbial-derived DOC during dry season [3]

Mineralization, lixiviation or mobilization by reductive iron oxides dissolution during rewetting or saturated conditions [4] [5]

## Objectives

To identify hydro-climatic controllers and linked processes of discharge weighted mean DOC concentrations:

⇒ At annual scale

⇒ At seasonal scales, defined from catchment functioning

## Methods

Daily water table depth (WT), rainfall (R) and potential evapotranspiration (PET) are used to divide each year into periods of wetland soils water saturation (Fig. 2, green and orange periods) and catchment functioning (Fig. 2, hydrologic periods A, B and C).

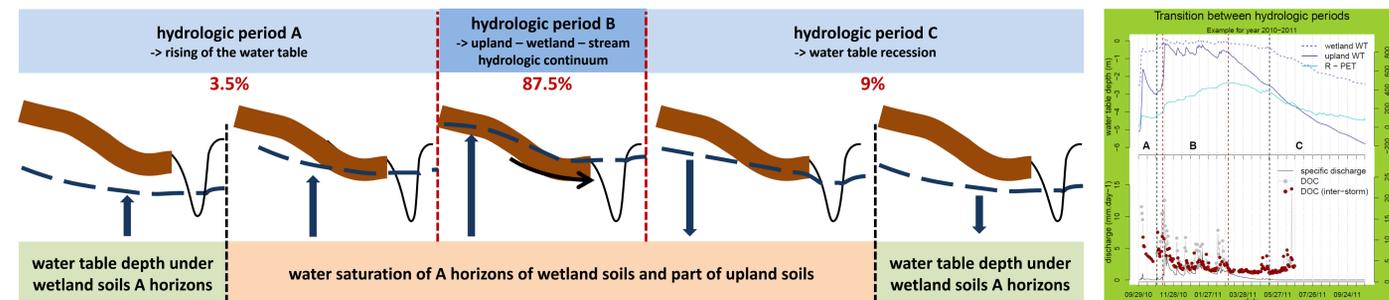


Figure 2: Cutting of the hydrologic year into wetland soils saturation cycles and watershed functioning periods. Processes of DOC production, DOC exportation and DOC sources connection are linked to each period. Contribution of each period to annual DOC exports is indicated in red. Water-table fluctuations and lateral flows are indicated with arrows blue and black respectively.

Storm and inter-storm flows are separated using hourly discharge data.

28 factors calculated from hydro-climatic data at annual and seasonal scales related to processes of either DOC production or DOC exportation or DOC sources connection (Table 1).

Stepwise multiple regression using a maximum of 4 hydro-climatic factors is computed to explain the variability of discharge-weighted mean DOC concentration of each period.

## References

- Morel et al., 2009. Sources of dissolved organic carbon during stormflow in a headwater agricultural catchment. *Hydrol. Process.*, 23: 2888–2901.
- Lambert et al., 2013. Hydrologically driven seasonal changes in the sources and production mechanisms of dissolved organic carbon in a small lowland catchment. *Water Resour. Res.*, 49, 4792–5803
- West et al., 1992. Microbial activity and survival in soils dried at different rates. *Aust. J. Soil Res.*, 30, 209–222
- Chow et al., 2006. Temperature, water content and wet-dry cycle effects on DOC production and carbon mineralization in agricultural peat soils. *Soil Biology & Biochemistry*, 38: 477–488
- Grybos et al., 2009. Increasing pH drives organic matter solubilization from wetland soils under reducing conditions. *Geoderma*, 154: 13–19

## Study site: Kervidy-Naizin

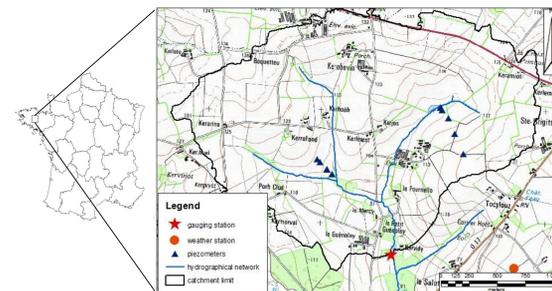


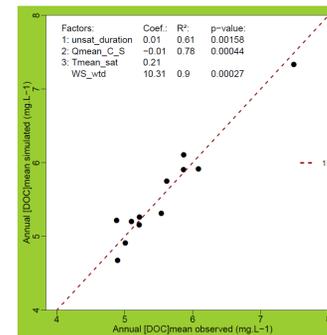
Figure 1: Localisation of the study site.

This catchment belongs to the French Environment Research Observatory (ERO) AgrHyS. Part of the French catchment network on critical zone (<http://rnbv.ipgp.fr/>)

5 km<sup>2</sup> lowland headwater catchment dominated by agricultural activities

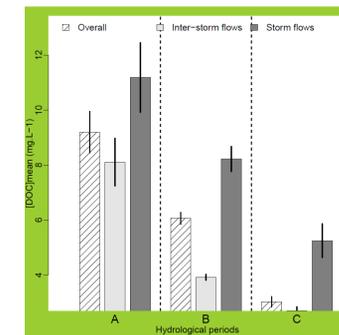
Meteorology, hydrology of groundwater, stream water and chemistry monitored since 2001. Data are available at: [http://www6.inra.fr/ore\\_agrhys\\_eng/Data/Naizin-Morbihan](http://www6.inra.fr/ore_agrhys_eng/Data/Naizin-Morbihan)

## Results & Discussion

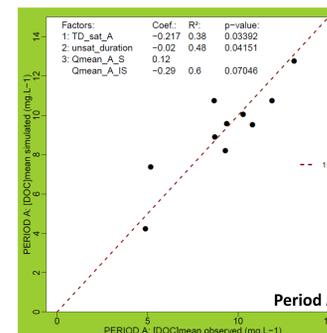


At annual scale: Mainly driven by time of production in wetland soils A horizons when unsaturated.

Concentrations are affected by depletion and/or dilution of storm DOC sources during period C.



At seasonal scale: Twelve years mean [DOC] decrease from 9 (period A) to 3 mg.L<sup>-1</sup> (period C).

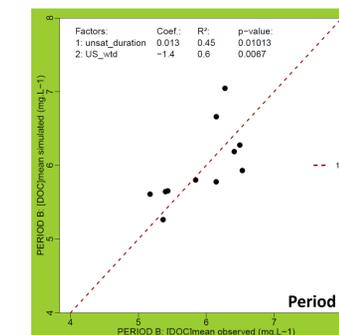


Period A: Main depletion driver is drainage.

Surprisingly the dryness or temperature of previous summer do not contribute.

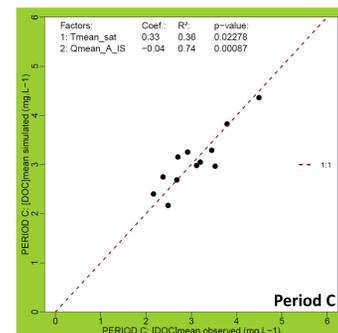
Table 1: Examples of hydro-climatic factors used. Processes of DOC production, DOC exportation and DOC sources connection are linked to each factor.

Hydro-climatic factors	Definitions	Units
unsat_duration	duration of water table depth under wetland soils A horizons	days
Tmean_sat	mean daily underground temperature (-10 cm) during saturation of wetland soils A horizons	°C
TD_sat_A	total specific discharge of hydrologic period A during saturation of wetland soils A horizons	mm
Qmean_A_S	mean storm discharge of hydrologic period A during saturation of wetland soils A horizons	L.s <sup>-2</sup>
Qmean_A_IS	mean inter-storm discharge of hydrologic period A during saturation of wetland soils A horizons	L.s <sup>-2</sup>
Qmean_C_S	mean storm discharge of hydrologic period C during saturation of wetland soils A horizons	L.s <sup>-2</sup>
WS_wtd	mean water table depth in the wetland soils	m
US_wtd	mean water table depth in the upland soils	m



Period B: Mainly driven by time of production in wetland soils A horizons when unsaturated.

Increasing in connection of DOC sources to the river mainly dilutes and/or depletes them.



Period C: Mainly driven by temperature of production in wetland soils A horizons when saturated.

Concentrations are also affected by depletion of DOC source connected in base flow of period A.

## Conclusion

In A horizons of wetland soils:

- DOC production and accumulation are mainly driven by the length of unsaturation period
  - To a smaller extent, temperatures of saturation period of wetland soils A horizons also activate DOC production.
- During saturation and connection to the river of wetland soils A horizons:
- Exports mainly happen during period B. As increasing in connection of DOC sources to the river does not increase mean [DOC], mechanisms of dilution and/or depletion should be the main drivers at this seasonal scale.
  - Controls of mean [DOC] of periods A and C are different and appear more complexes.

This proposed approach based on catchment functioning is helpful to analyze annual and seasonal variability of DOC under a diversity of rainfall and PET distributions.