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► **To cite this version:**

Guillaume Humbert, Anne Jaffrézic, Ophélie Fovet, Gérard Gruau, Patrick Durand. 13 years-long, high frequency monitoring of stream water DOC concentrations in a temperate headwater catchment : controlling factors and implications for DOC sources and DOC transfer processes. AGU Fall Meeting 2014, Dec 2014, San Francisco, United States. 2014. hal-04163185

HAL Id: hal-04163185

<https://hal.science/hal-04163185>

Submitted on 17 Jul 2023

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13 years-long, high frequency monitoring of stream water DOC concentrations in a temperate headwater catchment : controlling factors and implications for DOC sources and DOC transfer processes

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Context

At landscape scale, groundwater table connects soils to stream:

Organo-mineral horizons of wetland soils are unlimited sources of stream dissolved organic carbon (DOC) [1] [2]

In storm events, upland DOC contribution is temporally limited, decreasing from 30% of the stream DOC flux at the beginning of the high flow period to <10% later in this period [3]

Dry season controls DOC production:

By microbial-derived DOC accumulation in soils [4]

By increasing stream water DOC concentrations of the next hydrological period [5]

Study site: Kervidy-Naizin catchment

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 km² lowland headwater catchment dominated by agricultural activities

Meteorology, hydrology of groundwater, stream water and chemistry monitored since 2001. Data available at: http://www6.inra.fr/ore_agrhys_eng/Data/Naizin-Morbihan

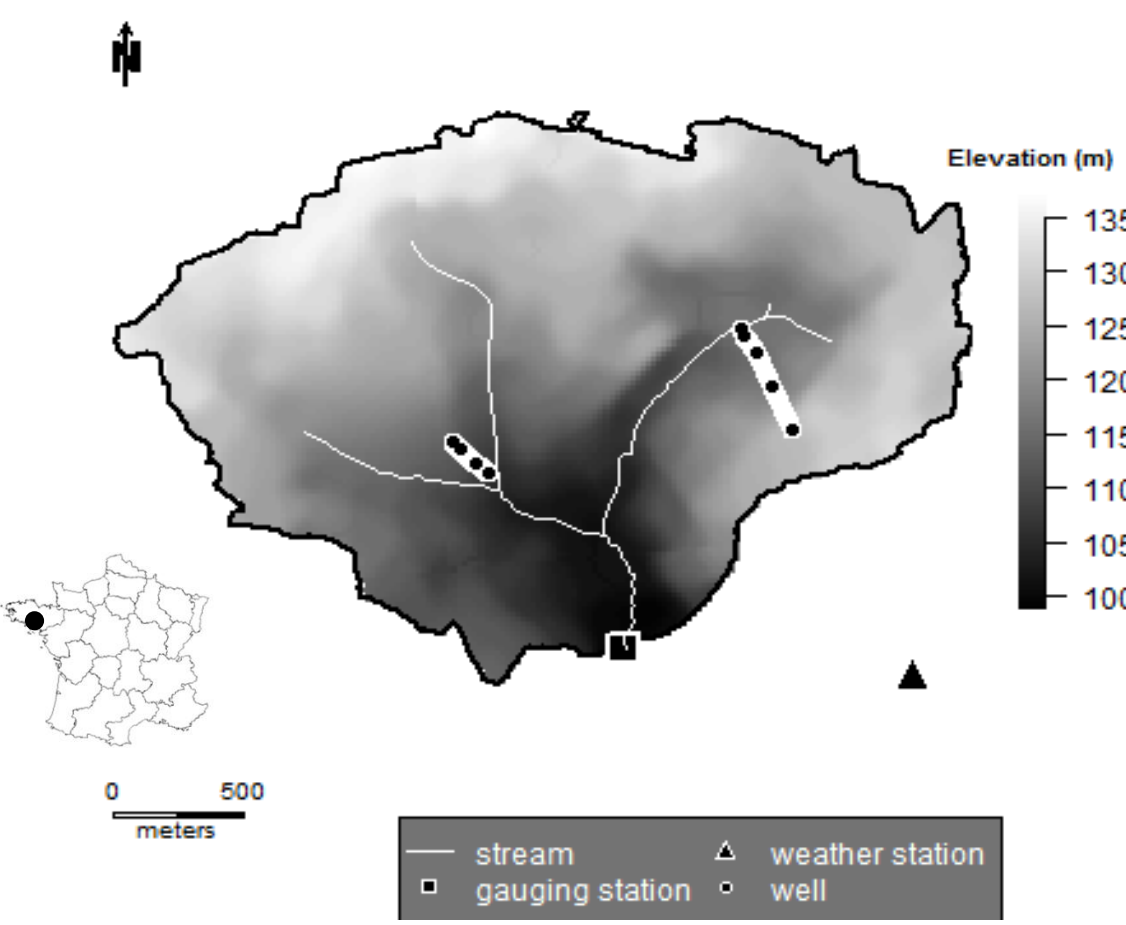


Fig. 1. Localisation and topographic map of the catchment.

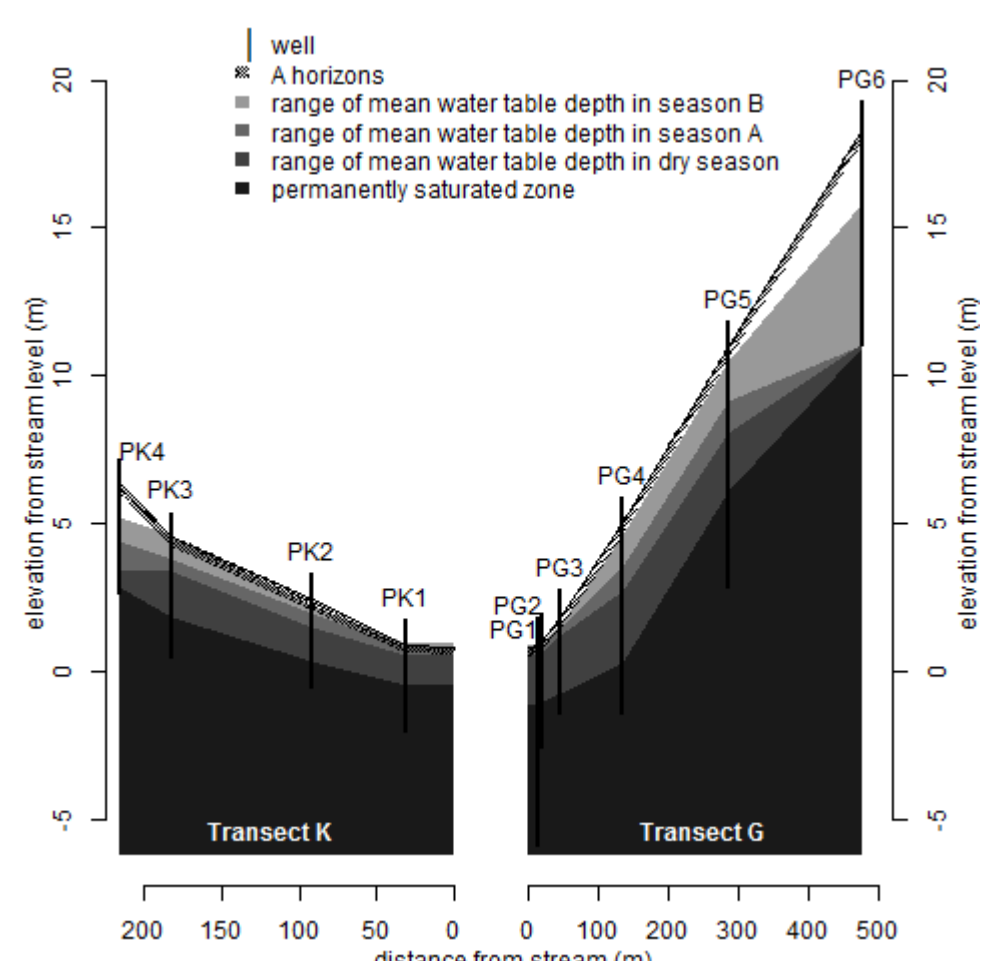


Fig. 2. Average water table depth along two transects depending on the season in the hydrological year

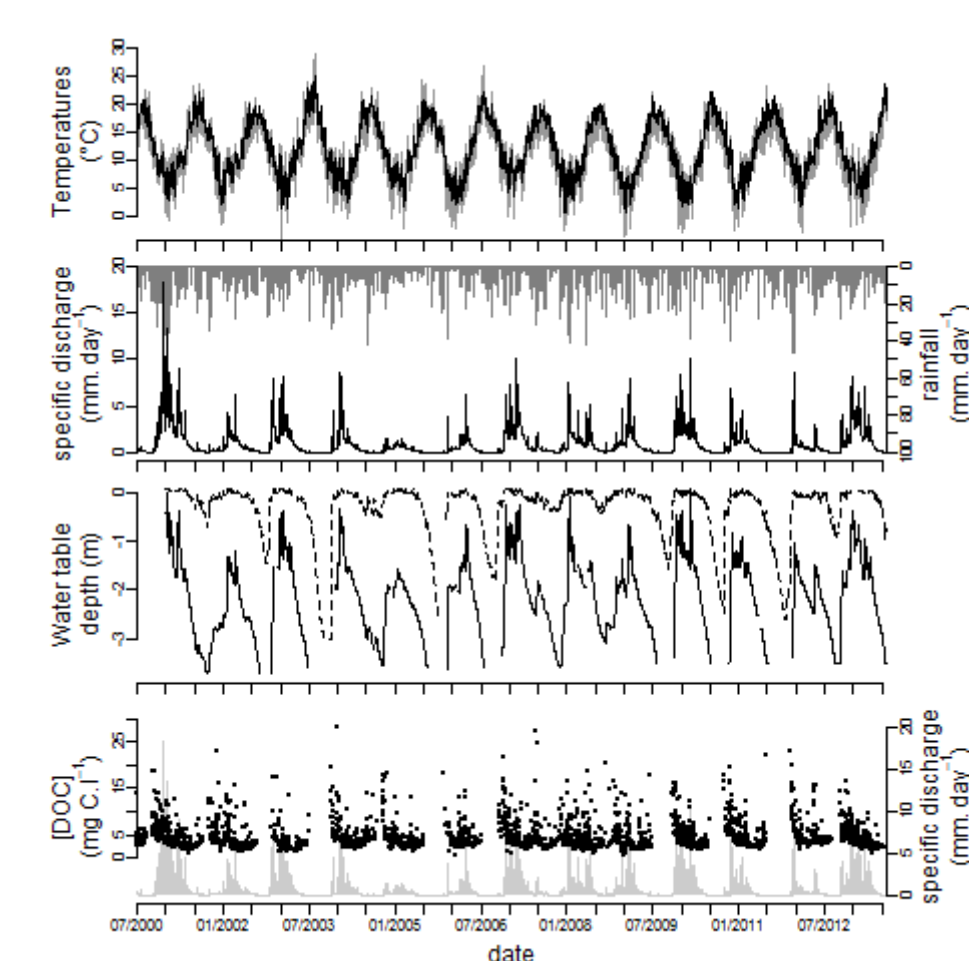


Fig. 3. Variations of temperatures, rainfall, discharge, water table levels and DOC concentrations over the study period.

Objectives

To confirm the conceptual model suggested from one year-long study

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

- at annual scale
- at hydrological season scales

Methods

Season D: dry season of continuous days of low water table levels (<-0.3 m) in the riparian wetland soils (Fig. 2)

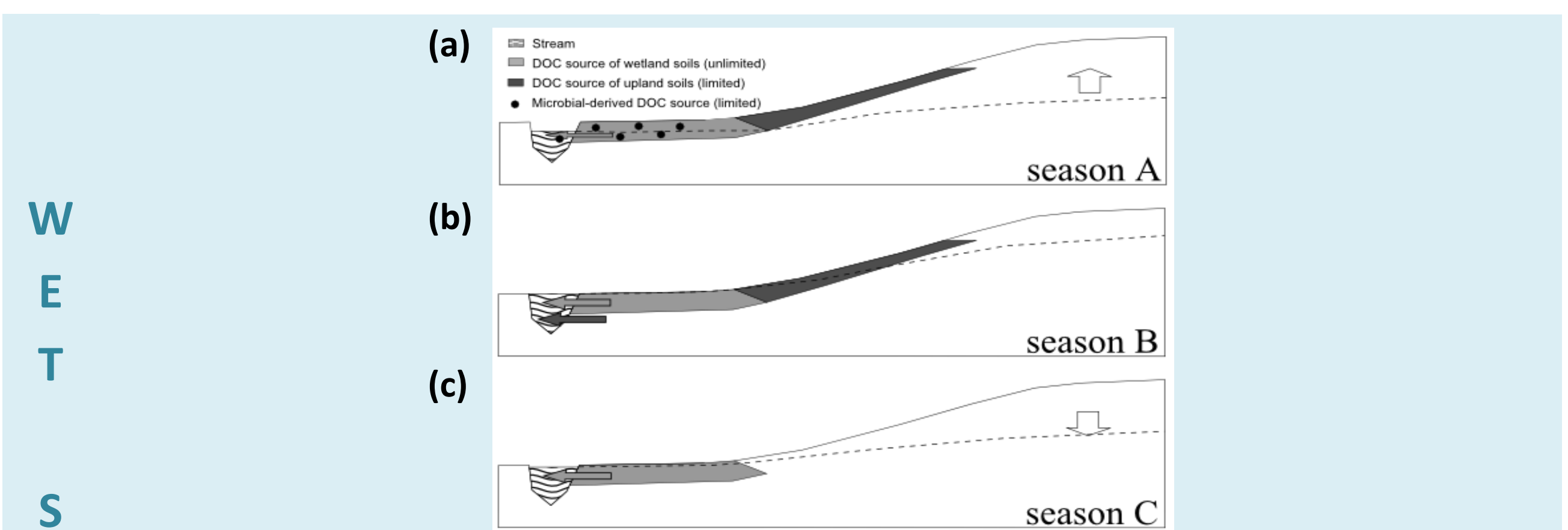


Fig. 4. Conceptual scheme of mobilisation of DOC pool-sources along the hydrological year.

Season A: Progressive rewetting of the uppermost soil layers of the riparian wetland soils (Fig. 2 and 4a)

Season B: Hillslope water table rising and holding high (Fig. 2 and 4b)

Season C: Drowdown of the hillslope water-table, with decreasing connection between topsoils and the stream (Fig. 4c)

Stormflows and baseflows are separated using hourly discharge data.

Partial least square regressions (PLSR) combined to linear regressions (SLR and MLR)

Results & Discussion

INTRA-ANNUAL VARIATIONS

Quick decreases in DOC concentrations in A are consistent with a first limited DOC source (Fig. 5).

Increase in DOC concentrations between the end of season A and the onset of season B is consistent with the connection to the stream of an upland DOC source.

Decrease of the concentrations to the same value of ca. 2-3 mg C.l⁻¹ in season B is coherent with the existence of two pools, a limited one and a quasi-infinite one.

Intra-annual dynamics controlled by initial concentrations and water runoff.

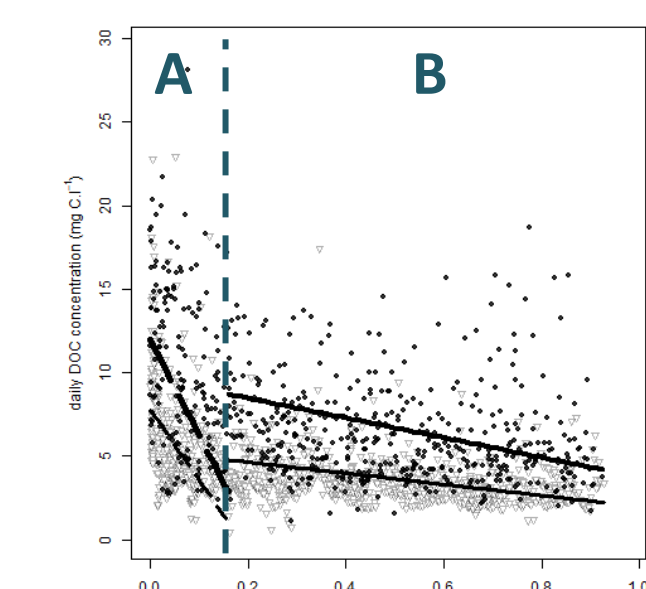


Fig. 5. 13 years of DOC concentrations dynamics

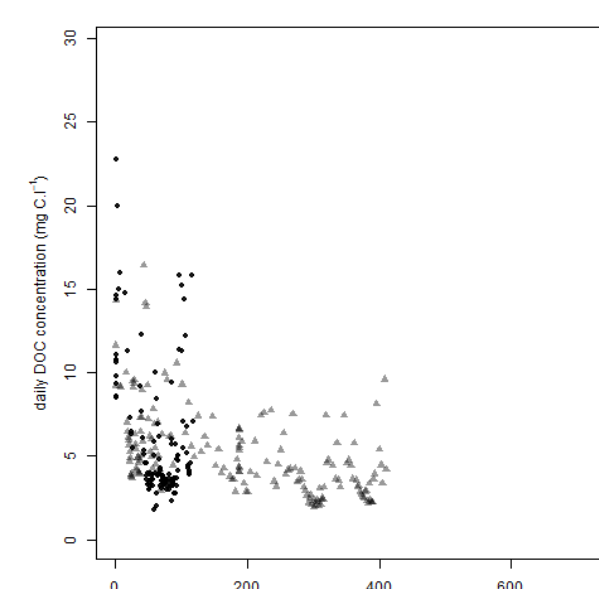


Fig. 6. DOC concentrations dynamics for 2 years

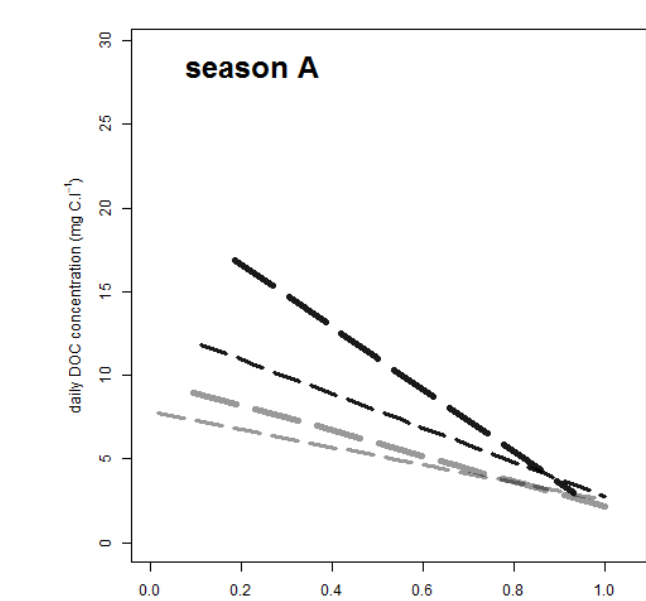
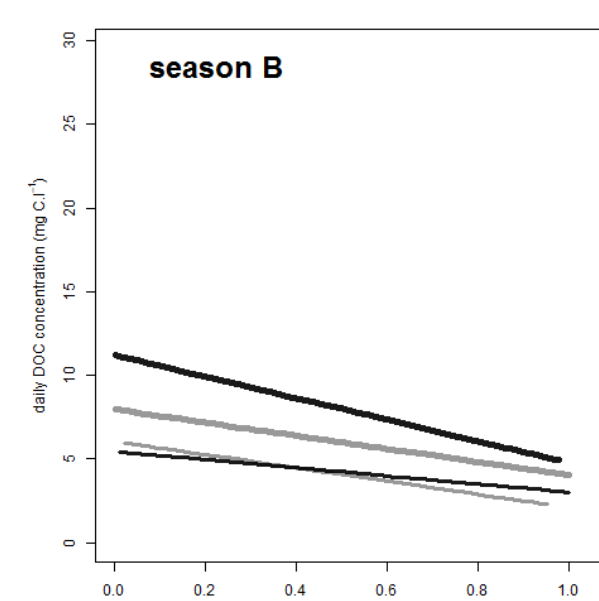


Fig. 7. Examples of changes in daily DOC concentrations dynamics within seasons A (left panel) and B (right panel)



INTER-ANNUAL VARIATIONS

No significant long-term trend (Fig. 8)

Year-to-year resilience with respect to the response of DOC to climatic variations (Fig. 3)

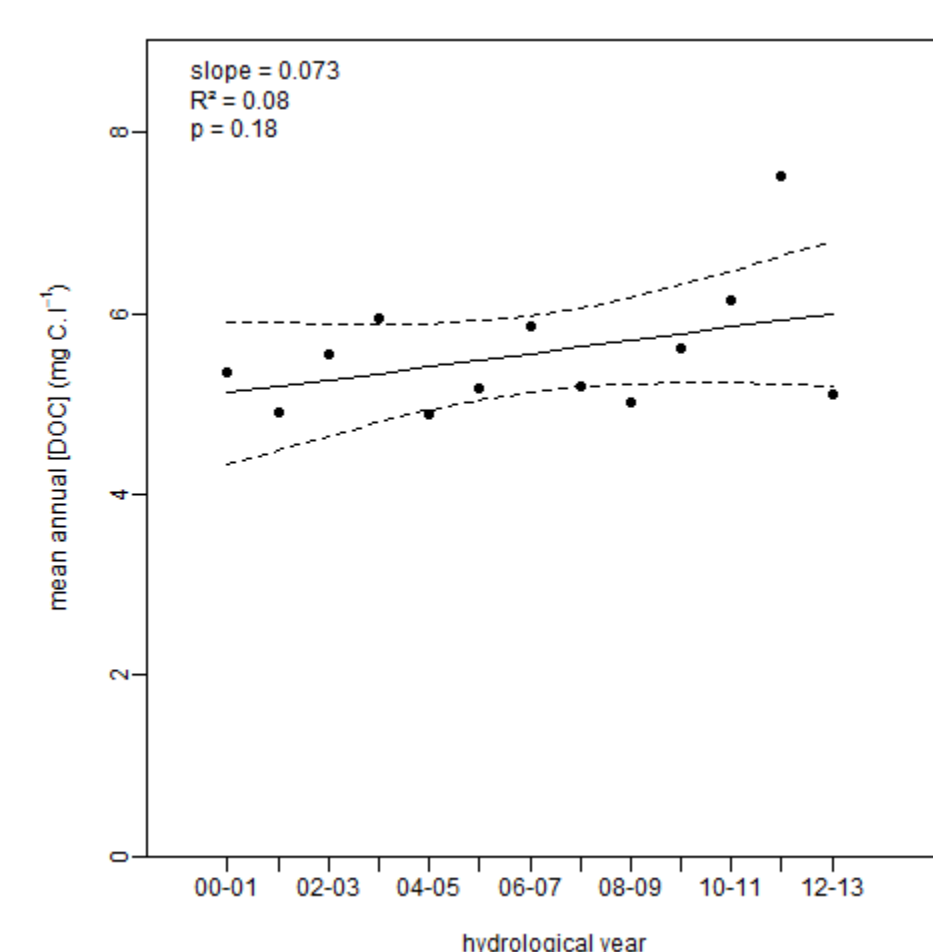


Fig. 8. Inter-annual variability of annual mean DOC concentrations (black dots).

PLSR – MLR RESULTS

Drought intensity controls the accumulation of the DOC into the pool-sources.

Wetness of seasons A and B controls the depletion of the DOC pool-sources.

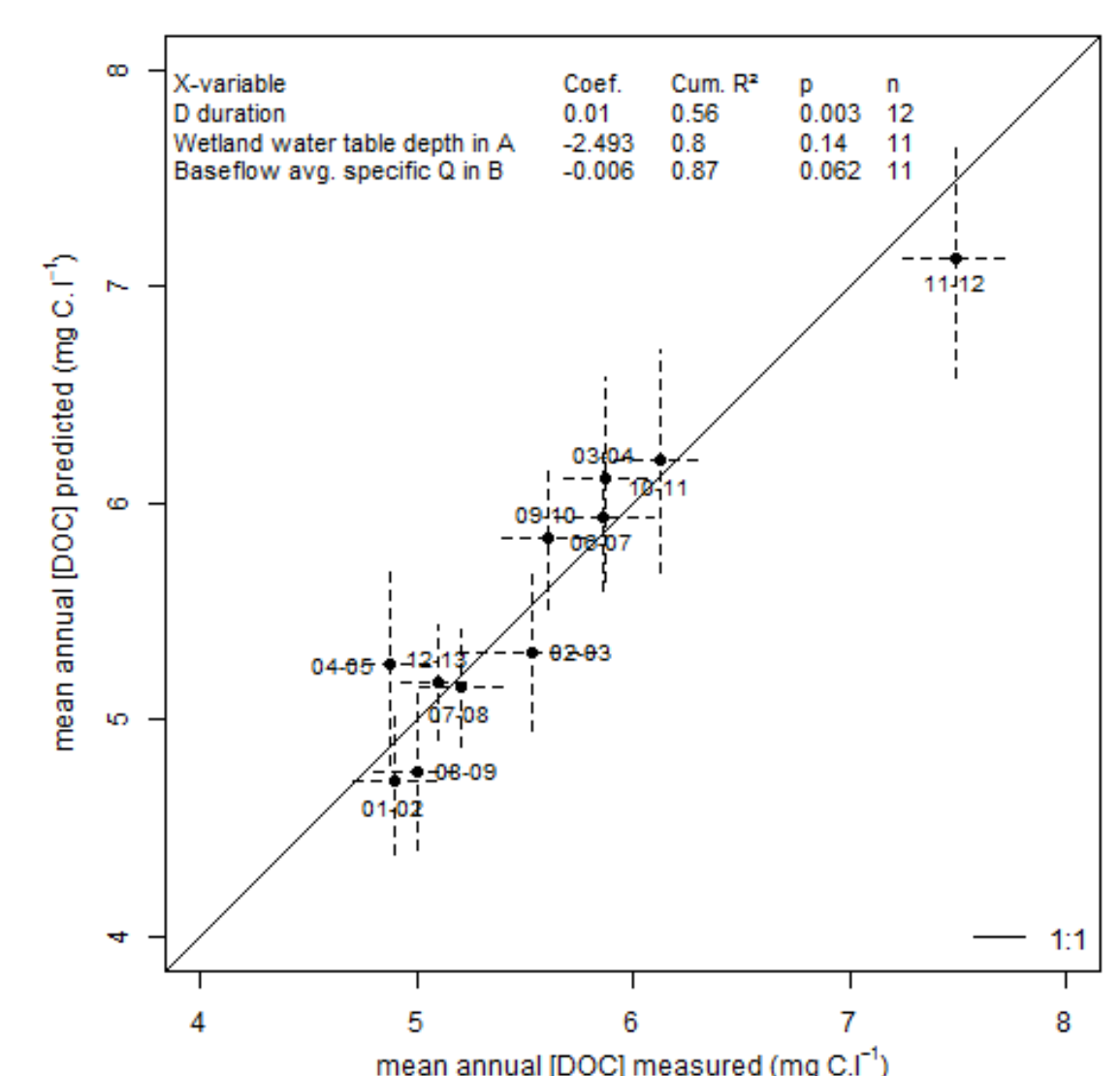


Fig. 9. Mean annual DOC concentrations modelled by multiple linear regressions.

Conclusion

Intra-annual stream water DOC concentrations dynamics confirmed the conceptual model of three DOC sources.

Water table fluctuations control the variations in mean annual DOC concentration:

- DOC accumulation in dry season
- DOC transfers and DOC sources depletion during the first wet seasons

Two alternating antagonist processes (accumulation and exportation) and predominance of an unlimited DOC pool-source explain the year-to-year resilience with respect to the response of DOC to climatic variations.

References

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