Impact of tile-drainage on the hydro-sedimentary responses of hydromorphic agricultural soils by tracing water and suspended solids from the field to the catchment scale.

Géosciences pour une Terre durable brgm

université de TOURS

Région Centre-Val de Loire

agence de l'eau Loire-Bretagne

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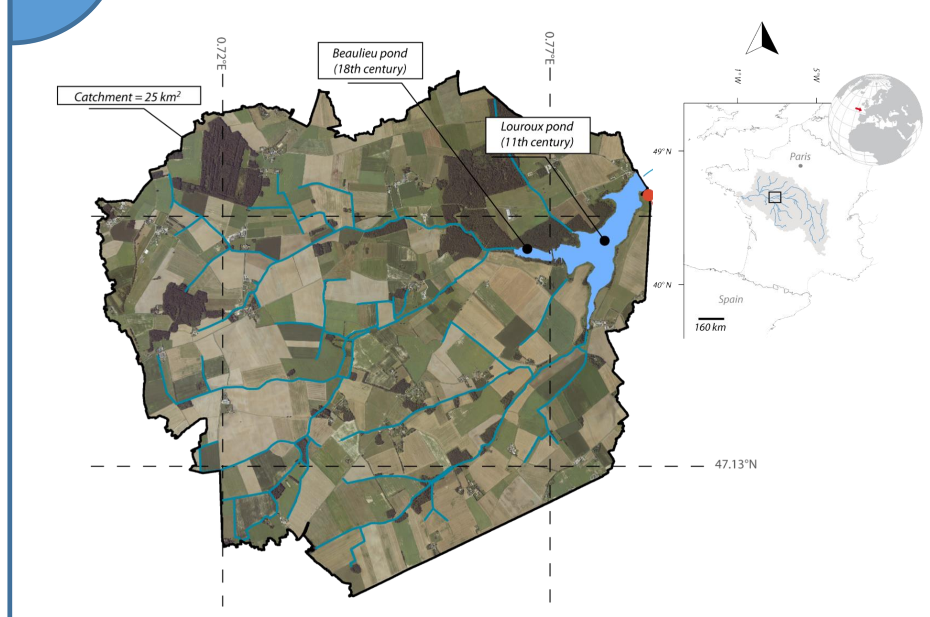
1 INTRODUCTION

More than 10 % of arable lands are drained in the world. Subsurface drainage increase water and sediment connectivity (Gay et al, 2016). The impact of subsurface drainage on the water regime is well understood (Skaggs et al., 1994 ; Gramlich *et al*, 2018) and numerous studies quantified erosion by subsurface drainage (Skaggs *et al.*, 1994 ; Montagne *et al*, 2009). But the understanding of water and suspended solids dynamics from field to catchment outlet is a key to set efficient conservation measures to reduce erosion up. Here, we focus water and suspended solids dynamics from the soil profile scale to the field scale.

OBJECTIVES

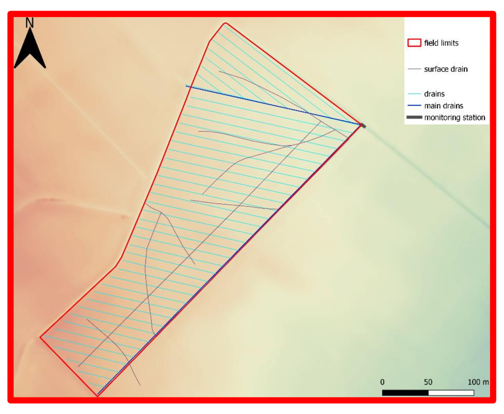
- **Determine the relative contributions between surface and subsurface sources for suspended solids**
- **Identify water pathways**

2 STUDY SITE



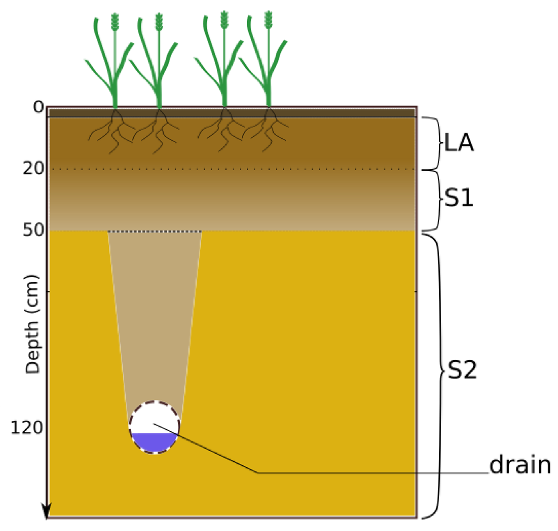
Agricultural drained catchment

Area: 2500 ha
Altitude: 94 – 129 m
Mean slope: 0,4 %
Land use: 76 % crop field, 17 % forest, 7 % grassland
Drained fields: > 50 %
Outlet: Louroux pond



Agricultural drained field

Area: 5 ha
Tillage: conventional
Crop: wheat
Mean slope: 1 %
Drainage type: subsurface and surface
Subsurface drains depth: 120 cm
Spacing: 10 m
Age of the drains: > 30 years



Hydromorphic soil

LA : Silt-loam
S1 : Silt-loam
S2 : Silty-clay

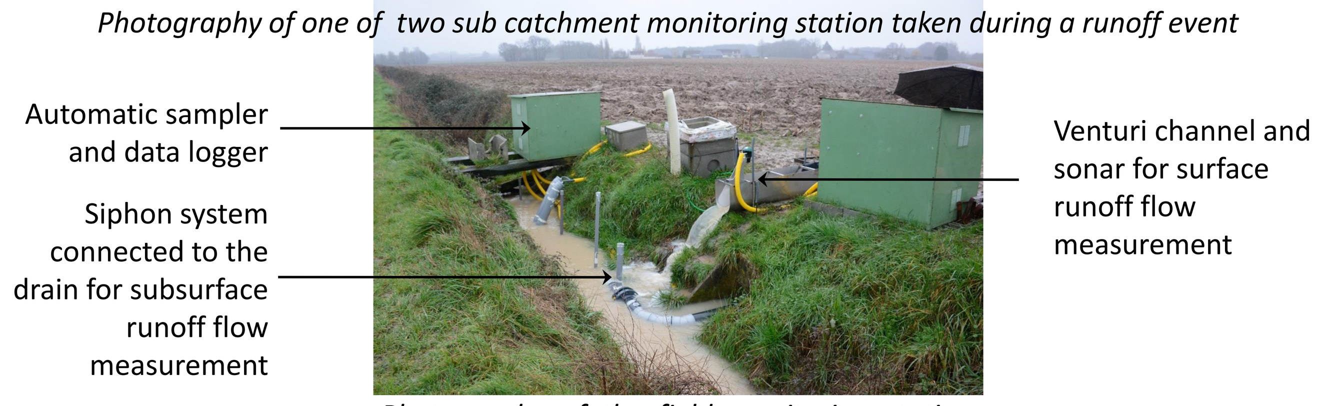
Hydromorphic marks from 25 cm

3 MATERIALS AND METHODS

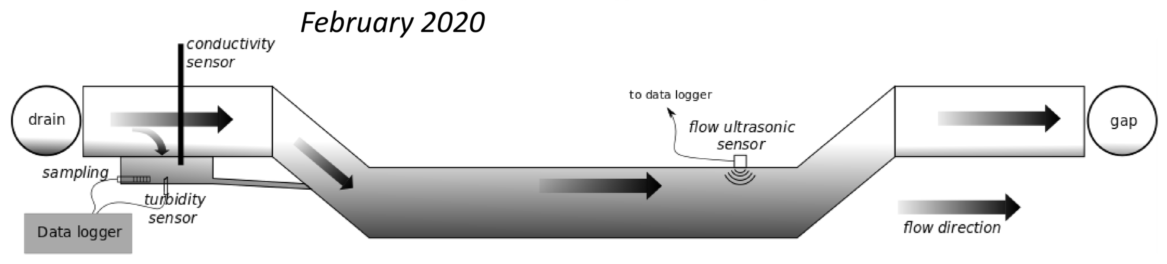
Sampling and monitoring at the catchment scale

Sampling and monitoring at the field scale

Photography of one of two sub catchment monitoring station taken during a runoff event



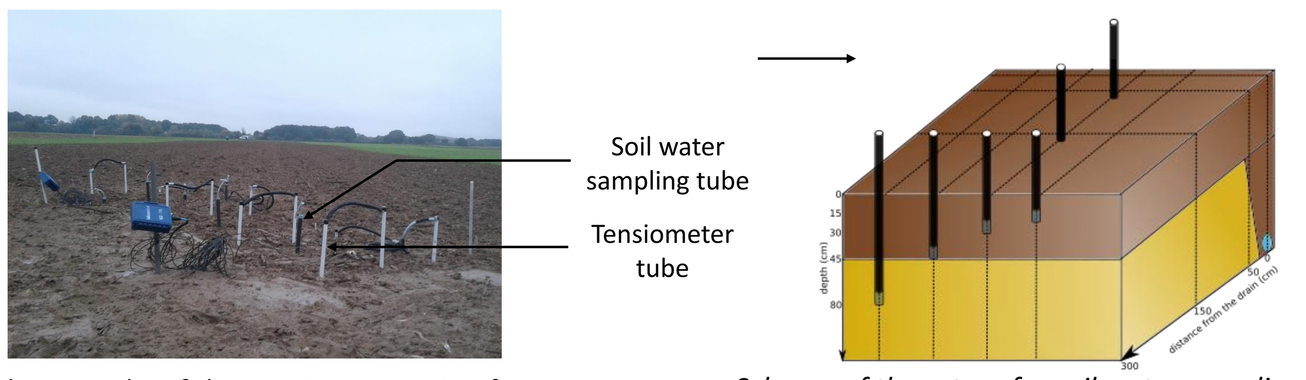
Photography of the field monitoring station taken during the runoff event of the 1st February 2020



Schema of the siphon system allowing to measure the subsurface runoff flow without disturbance of its natural hydraulics

- Sampling is volume dependent
- Water and suspended solids analyzed samplings are selected to represented the rising limb of the peak, the peak flow and the falling limb of the peak.

Soil water sampling



Photography of the monitoring station for measure of tension and soil water sampling

Schema of the set-up for soil water sampling

- 4 sampling tubes parallel to the drain at a depth of 15, 30, 45 and 80 cm
- 2 sampling tubes perpendicular to the drain at a depth of 30 cm

Water analysis :
anions (Cl^-,NO^{3-}, SO_4^{2-}), cations (Mg^{2+}, K^+, Na^{2+}) and stables isotopes (^{18}O and D)
Suspended solids analysis:
grain size (by laser grain sizer) and mineralogy (by DRX)

4 RESULTS

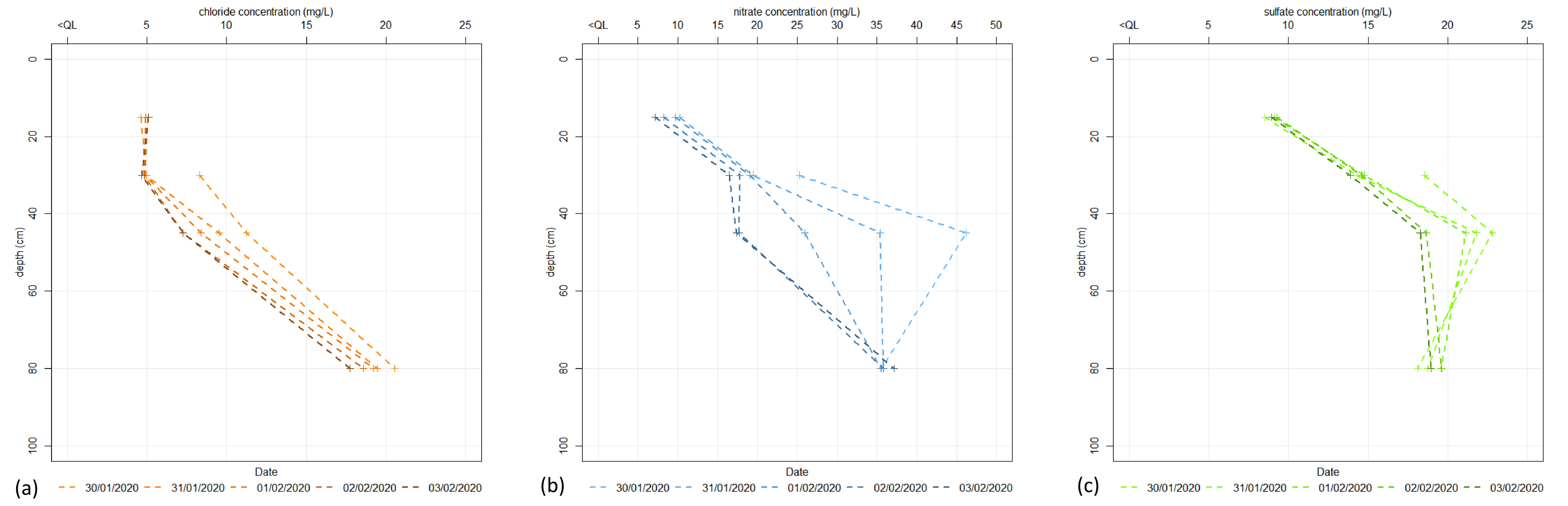
Case study of the runoff events occurred between the 30th January 2020 and the 3rd February 2020

- **Three rainfall events** :
  - 3.2 mm the 30th of January from 7:35 to 10:15 A.M. This event generated no runoff.
  - 7.4 mm the 1st of February from 4:20 to 7:50 A.M.
  - 9.2 mm the 2nd of February from 1:15 to 11:00 A.M.
- **Two subsurface and surface runoff events :**

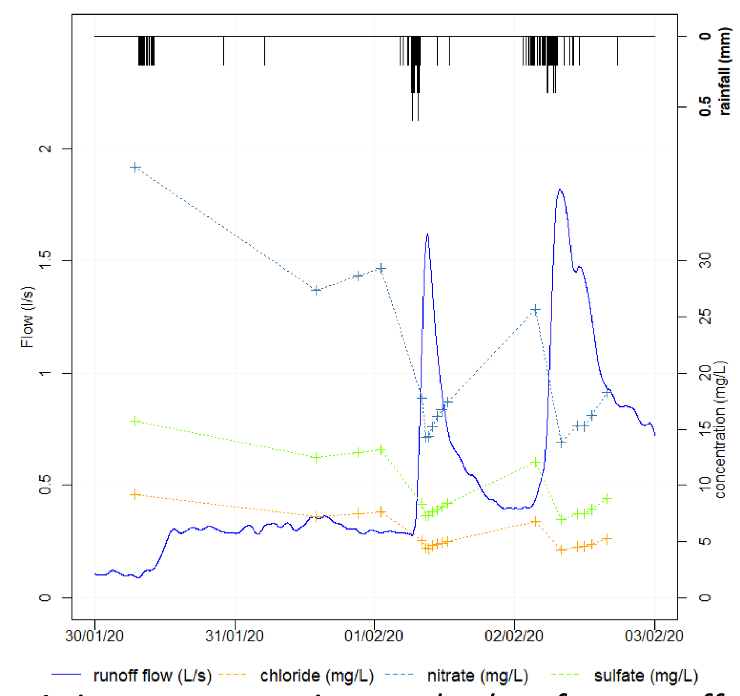
Runoff event of the 1st of February			
Runoff type	Volume (m³)	Max flow (L/s)	Lag time
Subsurface	42,4	1,62	2h33
Surface	84,9	13,15	1h49

Runoff event of the 2st of February			
Runoff type	Volume (m³)	Max flow (L/s)	Lag time
Subsurface	81,9	1,82	2h06
Surface	191,3	16,08	1h55

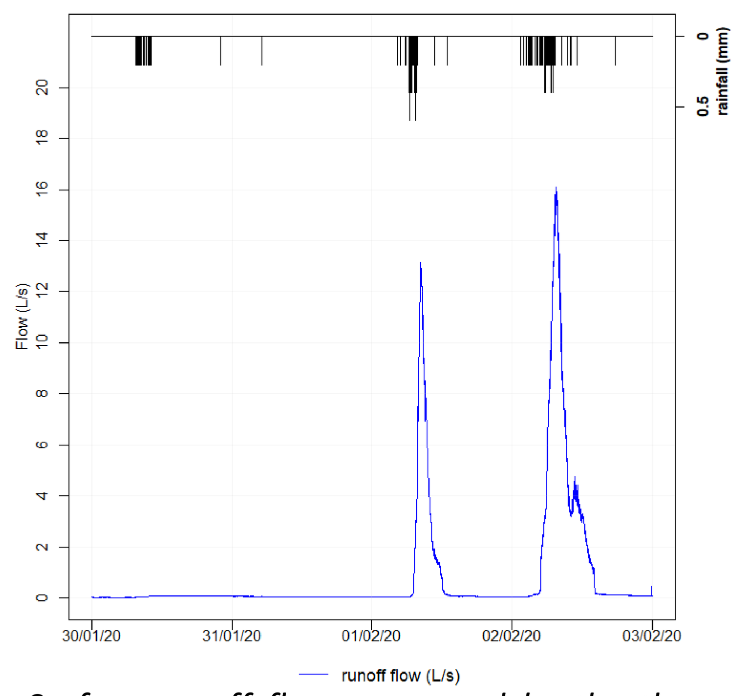
- **Anion concentrations :**
  - Rainfall samplings presents an anion concentrations under quantification limit.
  - Soil is the only anion source so anion concentration of the water increase with the time of residence in the soil.



Soil water anion concentrations evolutions as function of depth of sample along the five days of monitoring : (a) chloride, (b) nitrate, (c) sulfate.



Anions concentrations and subsurface runoff flow evolution corresponding the three rainfall events.



Surface runoff flow generated by the three rainfall events. Anions concentrations of the surface runoff samples are under quantification limit so they are not represented.

Depth (cm)	Chloride	Nitrate	Sulfate
15	+9.9 %	-30.3 %	+4.7 %
30	**-43.8** %	-34.7 %	**-25.2** %
45	**-35.4** %	**-62.4** %	**-19.9** %
80	-13.7 %	4.5 %	4.6 %

Variation of concentrations in soil water between the 30th January and the 3rd February 2020

5 CONCLUSIONS AND PERSPECTIVES

Time of residence in the soil of the water

- The low anion concentrations of surface runoff show that water of surface runoff directly come from the rainfall or its time of residence in soil is shorter than the time needed to get the chemical balance between water and soil.
- The decrease of anion concentration in the subsurface water during the two runoff events should be explain by a mixing process between soil water and more recent – from rainfall – water or by a piston effect which transfers old water volume – chemically balanced with the soil – first, follows by the recent water volume. This will be specified using stables isotopes results.
- Hydrodynamic of the soil will be compared to results of grain size and mineralogy to understand the sediment dynamic.

References
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