Deconvolution of the flood hydrograph at the outlet of the watershed Kolondieba in the south of Mali

(Déconvolution de l'hydrogramme de crue à l'exutoire du bassin versant de Kolondièba au sud du Mali)

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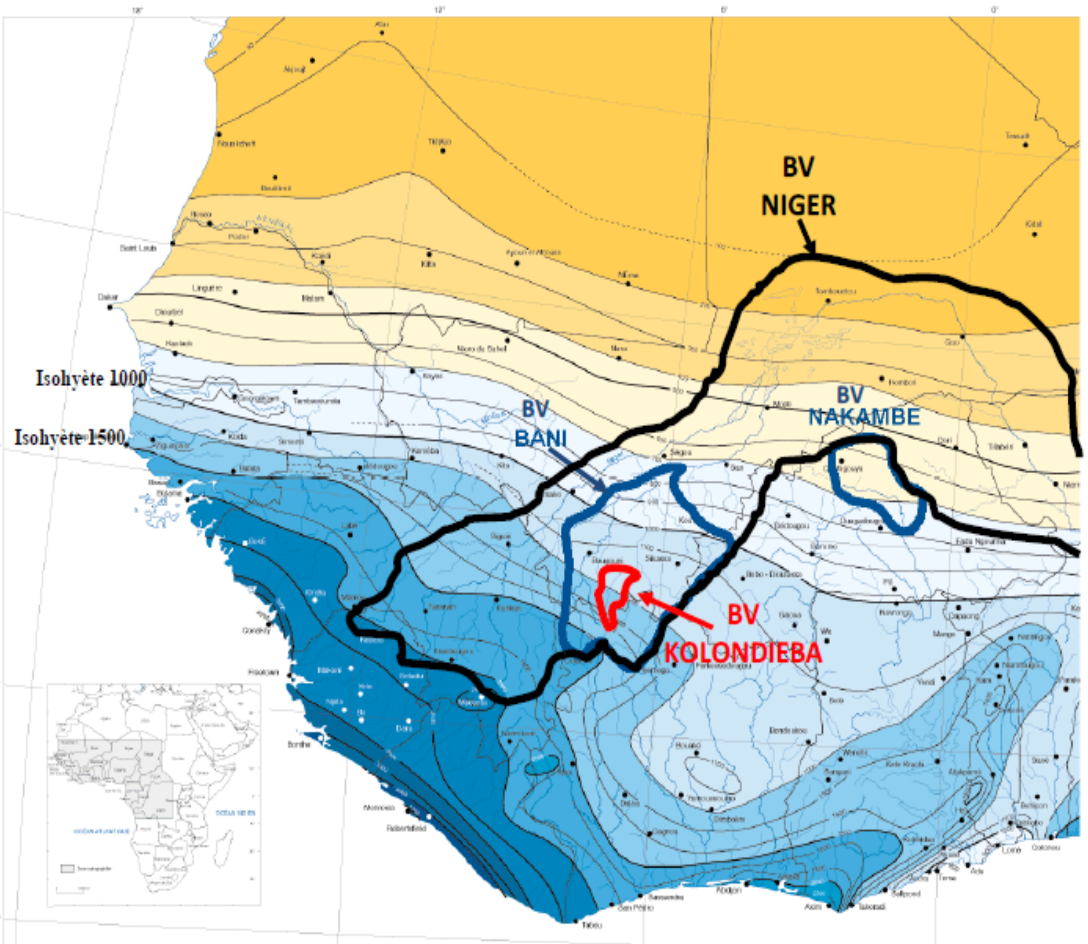
Study area

Watershed Kolondieba : Area = 3050 km^2, 95% in Mali and 5% in Ivory Coast



Localisation of the Kolondieba watershed in the NIGER basin (west Africa)

-**Sudanese Climate** (wettest in Mali), **Rainfall** is in **average 1125 mm/ Year** from **1960 to 2011**

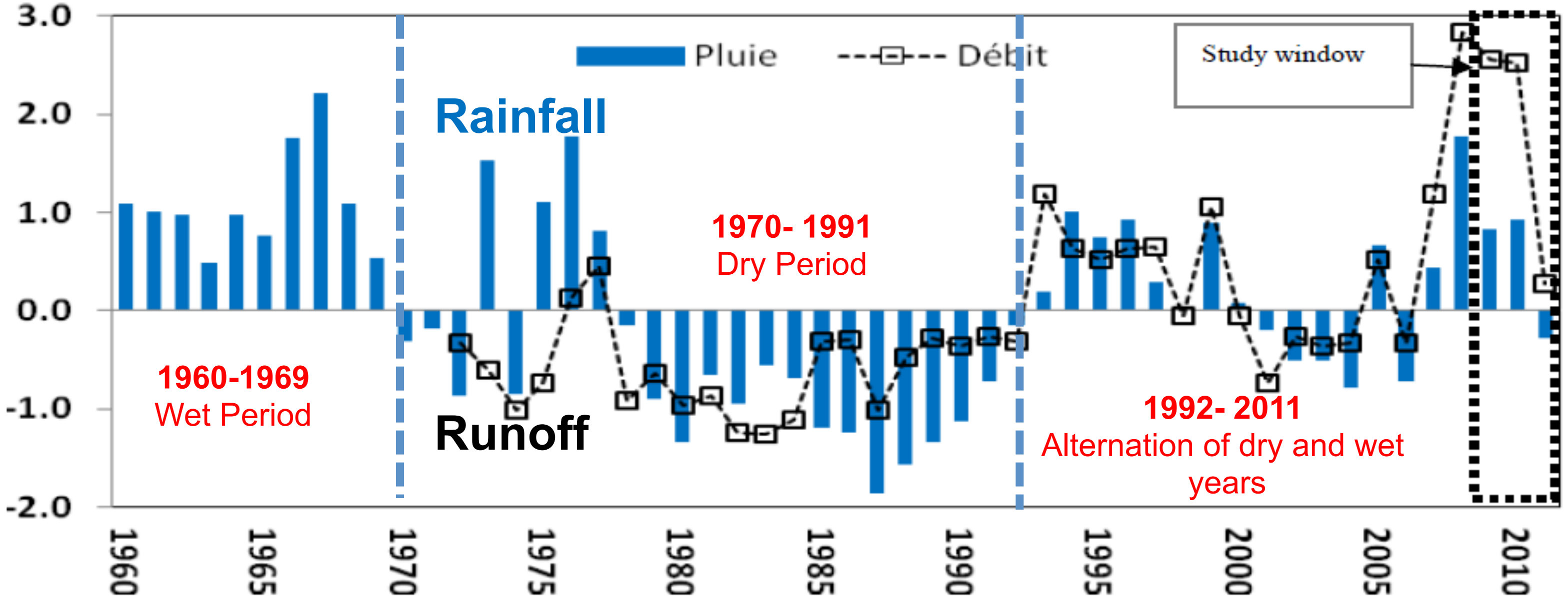
-**Relief** consists mostly of **plains** and **lowlands** varying between 320 m and 465 m from downstream to upstream

-**Soil** is **shallow** and mainly **ferruginous**

-**Aquifers** consist of **shallow and deep** ones in **granitic basement**

Context of the study

- Standard anomaly of Rainfall and runoff (1960 – 2011) in the watershed Kolondieba



- **Tests of Pettitt and Hubert applied to Rainfall and runoff data => 2 ruptures**

First in 1970 =>24% Rainfall deficit

Second in 1992 => 18% Rainfall excess
=>100% Runoff excess

After 1992, the Relationship between **Rainfall** and **runoff** in the watershed Kolondieba **is no-linear** like **several studies** results in **west and central Africa.**

- During the **rainy season**, groundwater level rises progressively to **reach its top at the peak of rainfall**. At this moment, the floods look like natural disaster causing the maximum of runoff.

- But shortly after the beginning of the **dry season**, the level of groundwater drops significantly and the wells are going dry somewhere and the runoff stops.

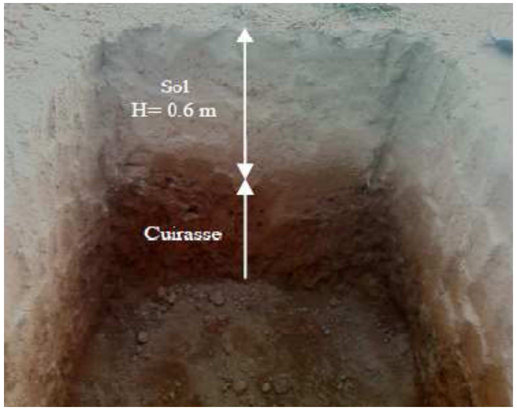
Land use

The **main economic** activity in the watershed is the **culture of cotton** which **acreage increased by 987%** from 1960 to 1997 (CMDT, 2003). The consequences of agricultural activities are:

Crusted soil on slope

Compacted soil in the lowland

Excavated soil by plowing



Shallow soil in armor

Relationship Land use -flow

▪ Crusted soil and excavated soil => **Hortonian Overland Flow** on the slope

▪Compacted soil => **satured Overland Flow)** in lowland,

▪Shallow soil in armor => **Returned Flow** and **SubSurface Satured Flow** on the slope

Aim

Know the hydrological process at the outlet of the watershed in a context of **strong climate variability** and **agricultural intensification**.

Hypothesis

At a given moment, water collected at the outlet provides from several sources (Tardy et al., 2004) :

- direct flow from **soil surface**,
- delayed flow from **groundwate**r (reterned flow, subsurface flow and baseflow).

View that the **Hydrographic network dries completely in the dry season,** what is the level of connection between **groundwater** and the **hydrographic network** in watershed Kolondieba?

Data and Methods

❖**Data**

-13 **Rainfall** stations

-17 **surface water** points

-36 **Wells** (shallow aquifers)

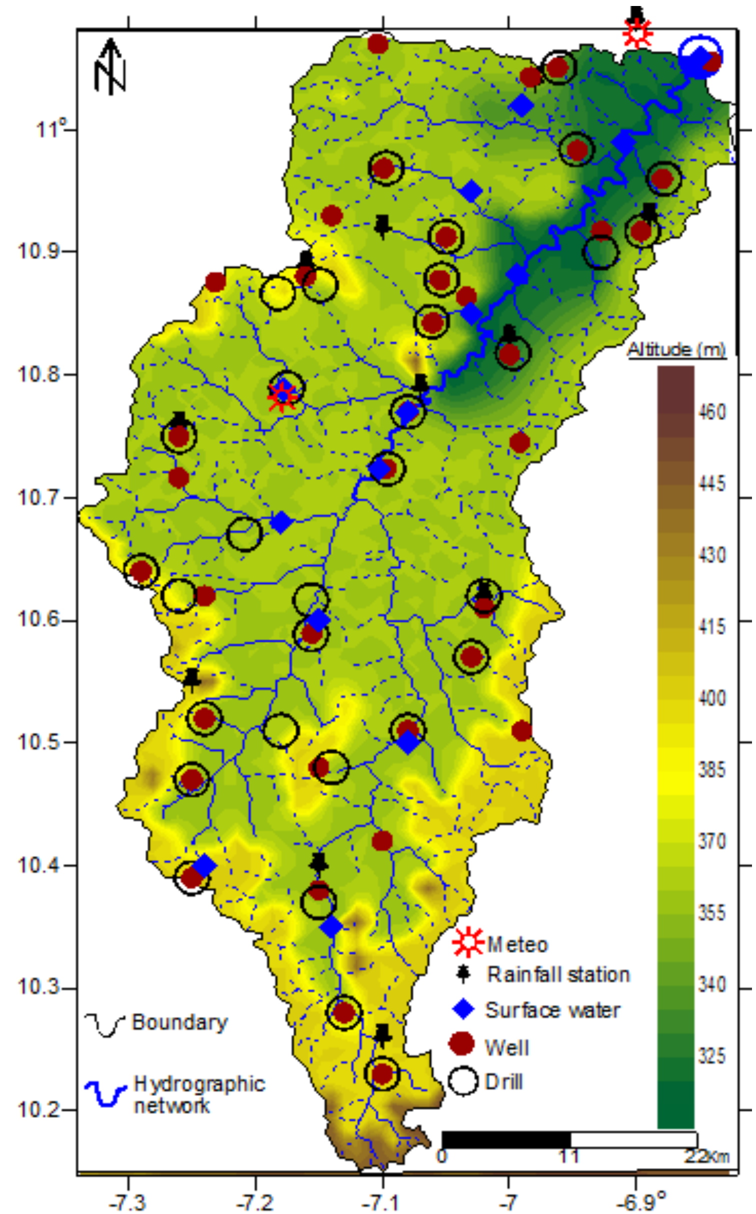
-34 **Drillings** (deep aquifers)

have been monitoring from 2009 to 2011 with the **runoff** at the **outlet.**

The physicochemical parameters which have been monitoring at the outlet are:

Temperature (**T°c**), **pH**, Electrical Conductivity (**EC**) and Total of Dissolved Solids (**TDS**)

with the multiparameter **CRISON MM 40**



Kolondieba watershed data measurement network

❖ Method of deconvolution

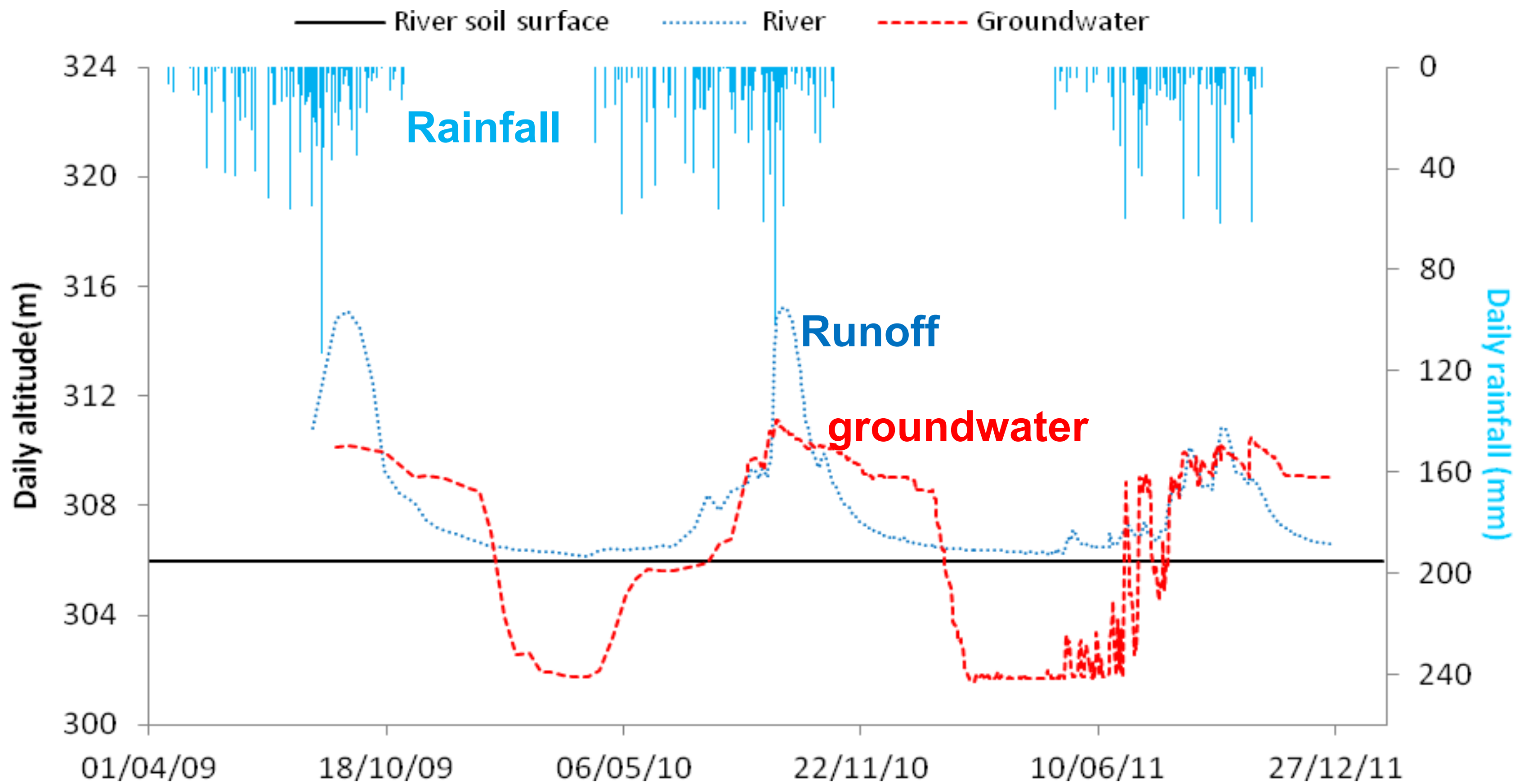
The deconvolution is a technic for separating components of a hydrograph with physical or chemical tracers **(Ribolzi, 1996).**

By the **hypothesis** the **runoff** at the outlet is **a mixture of *n* flow sources** which are characterized **geochemically by *m* tracers**, it possible to express the **mass conservation of water and tracers** with the following **expression** **(Joerin et al,2002).**

$$Q_t = \sum_{i=1}^{n} Q_i, \qquad Q_t C_t^j = \sum_{i=1}^{n} Q_i C_i^j \qquad j = 1, \ldots, m \quad (1)$$

- Where *Qt* is the total runoff , *Qi* the contribution of the source *i*
- $C_i^j(t)$ is the tracer *j* concentration in the source *i.*

Results : Relationship Rainfall-Runoff- groundwater

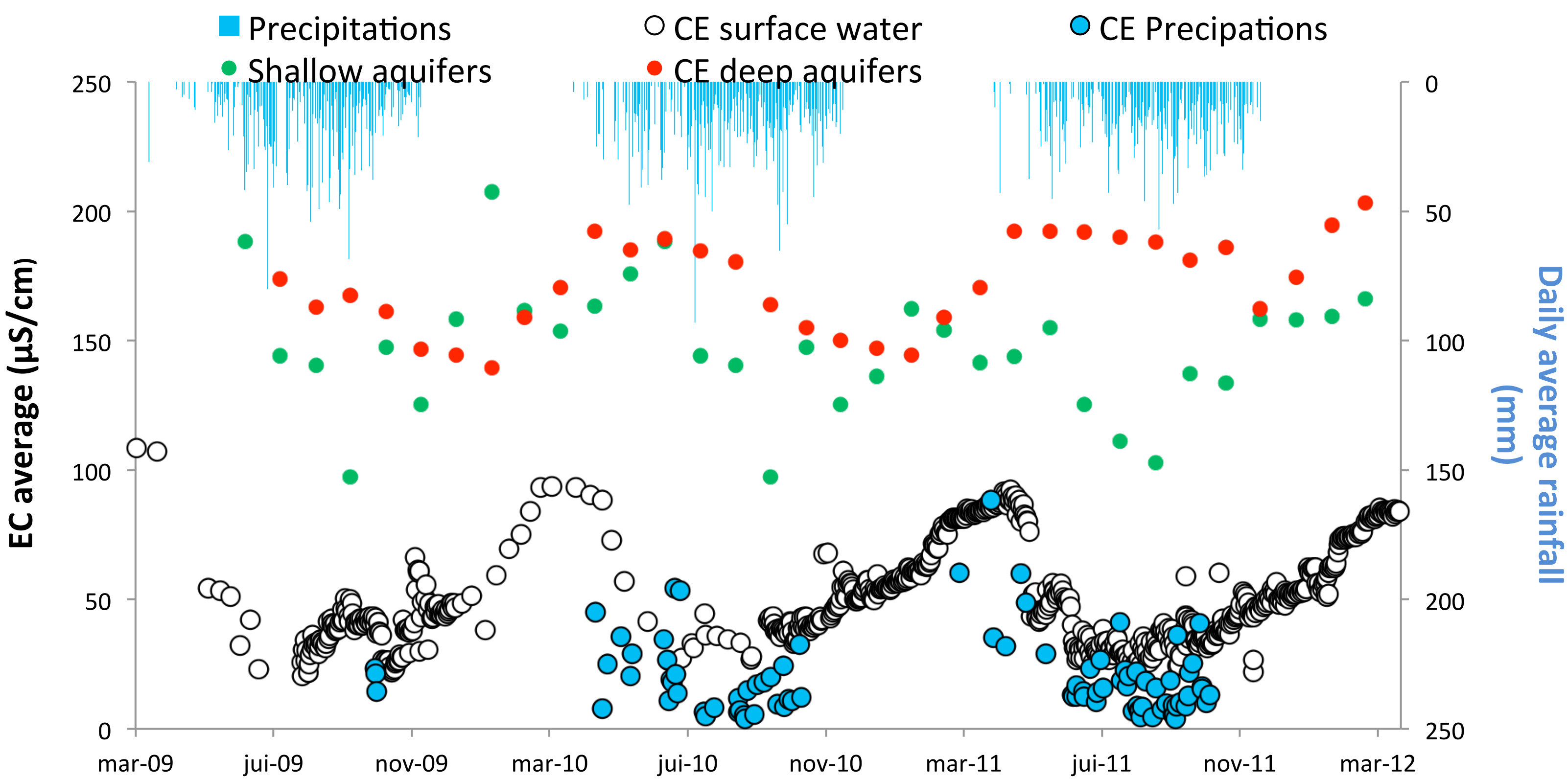


▪**Groundwater** rises **straightly** with the **beginning of rainfall ,** but starts emptying **before** the **end of the rainy season,**

▪**In dry season**, the **runoff goes to stop** when **groundwater drops** significantly,

=> So the **runoff** appears to be **tributary** of the **Rainfall** and **groundwater**

Results : Relationship runoff- mineralization of water compartments targeted



Seasonal variability of the mineralization of water compartments

- The **mineralization surface water** is **very close** to the **Precipitations** In the **rainy season,**

- it tends to **groundwater** In the **dry season, ** but those appear **to be disconnected** of surface water excepted **shallow aquifers,**

Results : Mean values of physicochemical parameters in different water compartments focused on the experimental period (2009-2011)

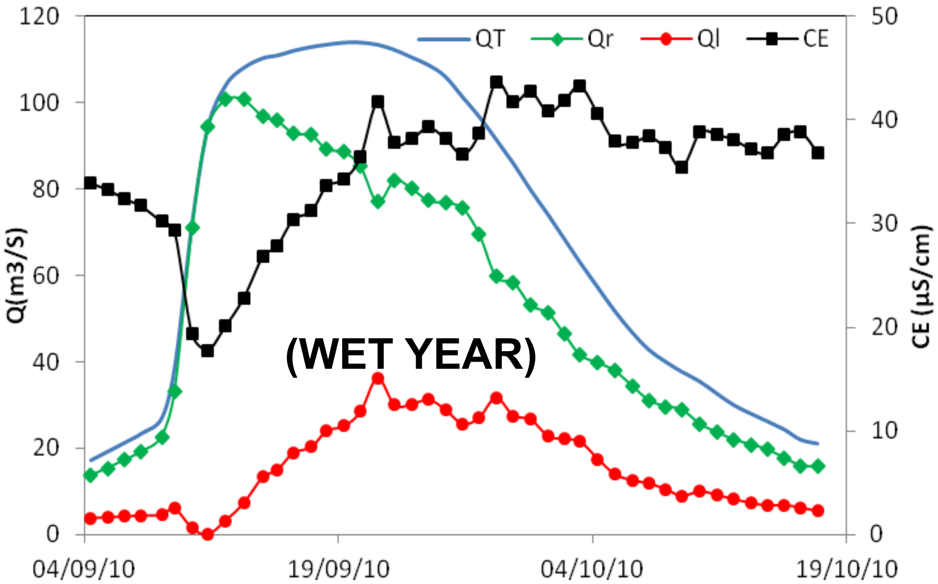
Origin	pH	T°c	EC (µS cm^{-1})	TDS (mg L^{-1})
Rainfall (Rf)	6.90 ± 0.56	23.87 ± 1.17	18.94 ± 10.47	12.79 ± 06.74
Outlet (out)	6.77 ± 0.24	24.99 ± 2.32	42.97 ± 18.89	27.48 ± 11.80
Shallow aquifers (shA)	6.17 ± 0.43	28.38 ± 1.15	124.10 ± 83.76	79.14 ± 53.65
Deep aquifers (deA)	6.19 ± 0.27	29.44 ± 0.87	134.30 ± 84.91	87.21 ± 56.20

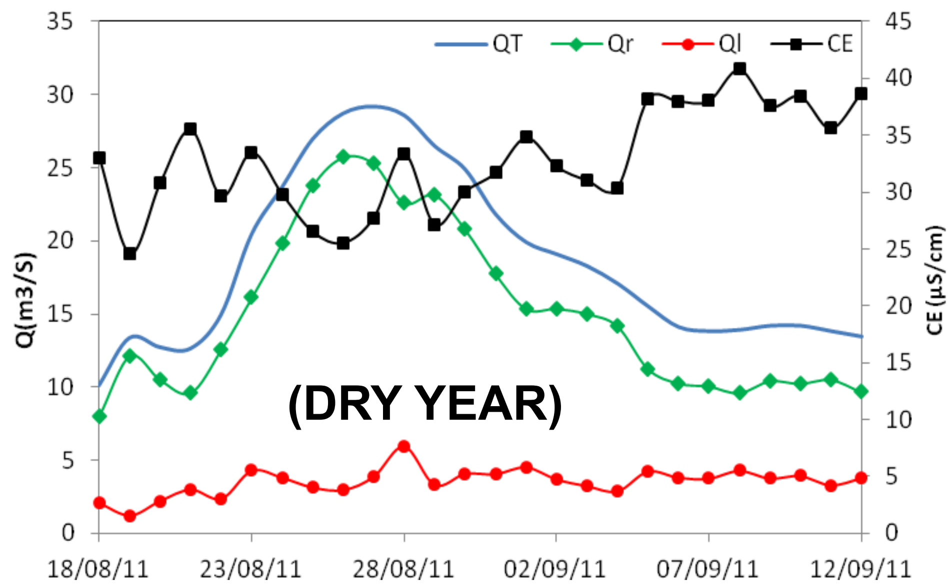
$$EC_{out} \approx 2EC_{Rf} \quad EC_{out} \approx \frac{1}{3} EC_{shA} \quad EC_{out} \approx \frac{1}{3} EC_{deA} \quad EC_{shA} < EC_{deA}$$

- **outlet mineralization** is between **Rainfall** and **shallow aquifers**, so deep aquifers do not contribute, this allows to choice **two origins for the runoff.**

- **EC** values of **Rainfall** and **shallow aquifers** where put in the **mixing model** to make the deconvolution.

Results : Deconvolution of the floods hydrograph





QT= Total Discharge (m3/s)

Qr = rapid flow (from the Rainfall)

EC = Electrical Conductivity

Qd= delayed flow (from shallow aquifers)

Hydric compartments	Rainfall		Shallow aquifers		Total of Runoff
Hydrochemical pole	$\%Q_r$	V_r ($10^6 m^3$)	$\%Q_d$	V_d ($10^6 m^3$)	($10^6 m^3$)
Wet year	77.46	202.270	22.54	58.872	261.142
Dry year	80.97	33.697	19.03	7.919	41.616

- During the flood, **surface inflow** goes **triple** to **quadruple** the **shallow aquifers inflow.**

Conclusion

watershed Kolondieba.

▪**Surface inflow** is more than the **shallow's** because of the **land use** which probably increases **hortonian overland** flows,

▪**Superficial groundwater** which contributes to the **runoff** is **still emptying** during the **rainy season**. This seriously reduce their inflow during **dry season**.

The hydrological process occurs in the watershed Kolondieba seems to be the same in the Oueme watershed (Benin) takes place in the same granitic basement. So the results can be generalized to tropical granitic area.

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Thank for your attention