Investigating the role of the Cuvette Centrale wetlands in the hydrology, sediment and carbon fluxes of the Congo River Basin (CRB)

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No of slides:20

The coupling of land, oceans, and atmosphere by rivers, lakes, and wetlands

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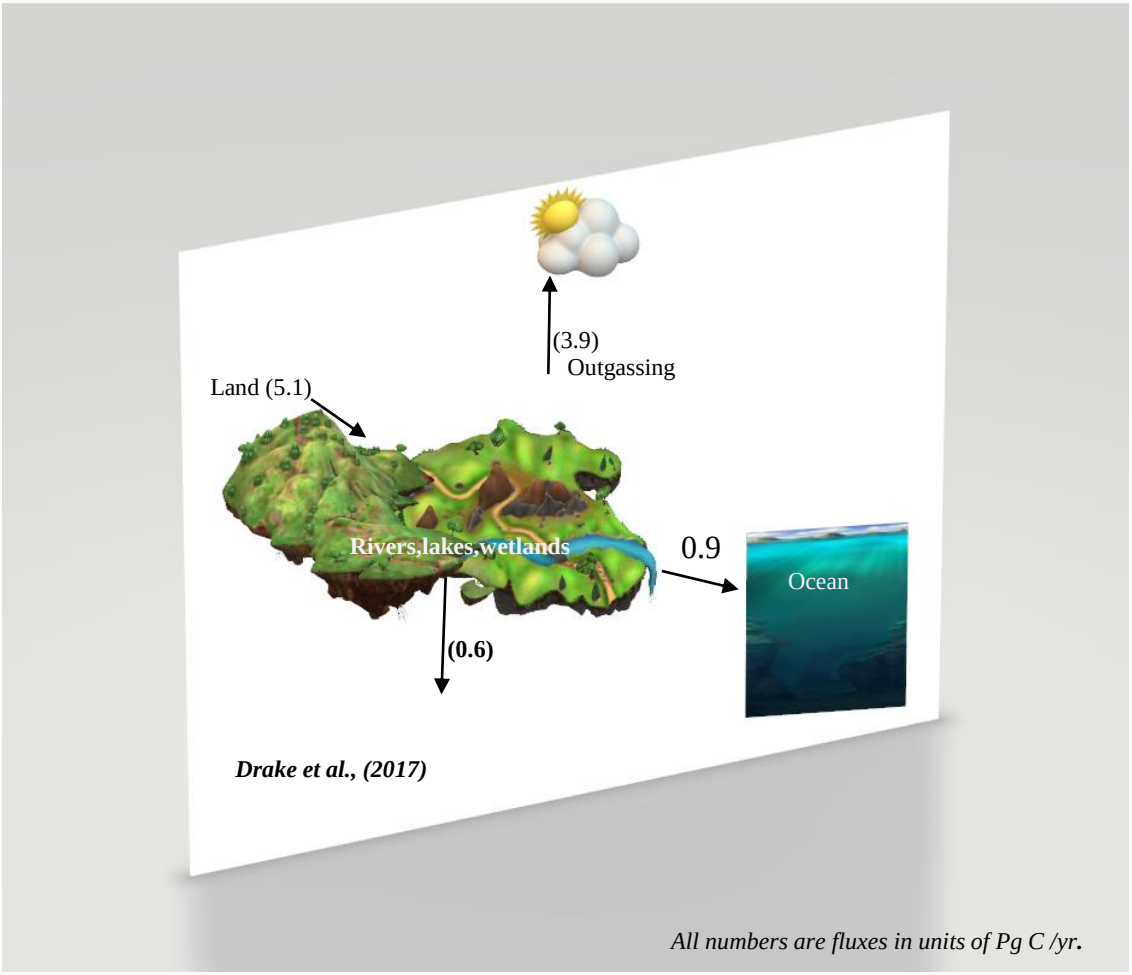

"Lateral export of C from terrestrial ecosystems – via rivers and other processes – may be substantial relative to Net Ecosystem Production or Net Ecosystem Exchange (Richey *et al., 2002; Billett et al,. 2004; Cole et al., 2007; Ciais et al., 2008)* "

"Carbon discharged to oceans is only a fraction of that entering rivers from terrestrial ecosystems (Aufdenkampe et al., 2011)"

Riverine transport is the only link between the soil-biosphere reservoir and the oceans (Probst et al ., 1994)

Particulate Organic Carbon (POC) and Dissolved Organic Carbon (DOC)

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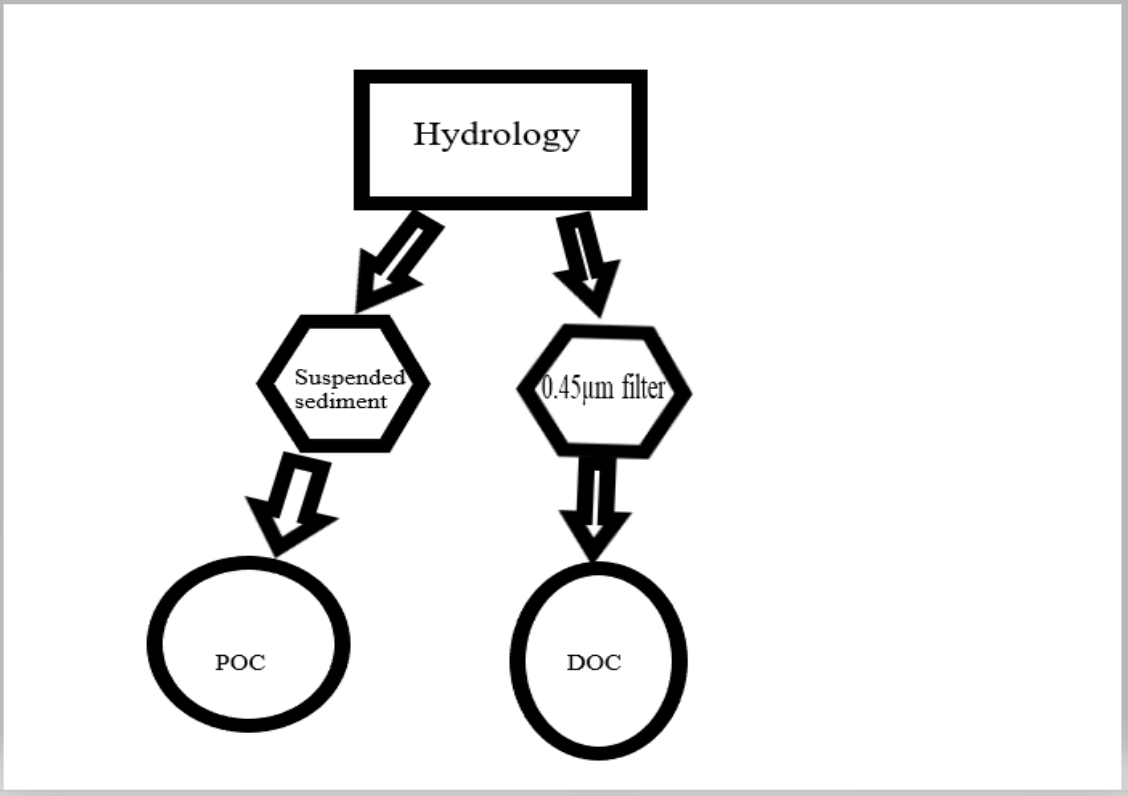
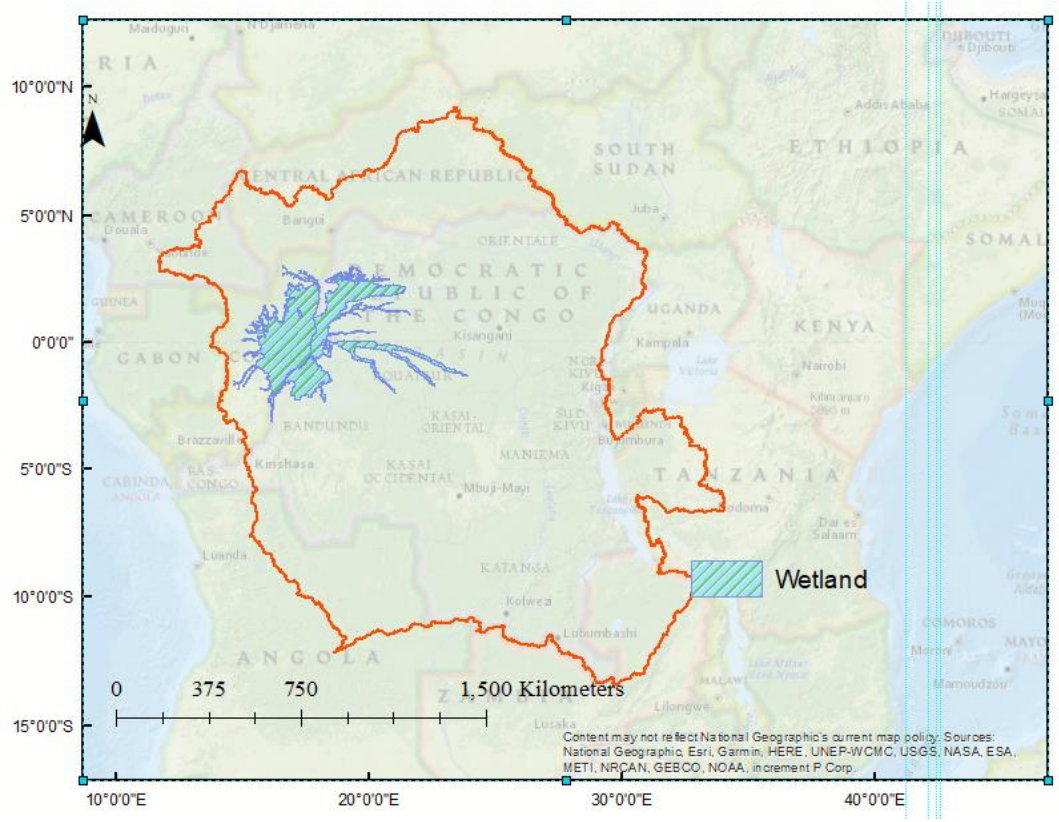


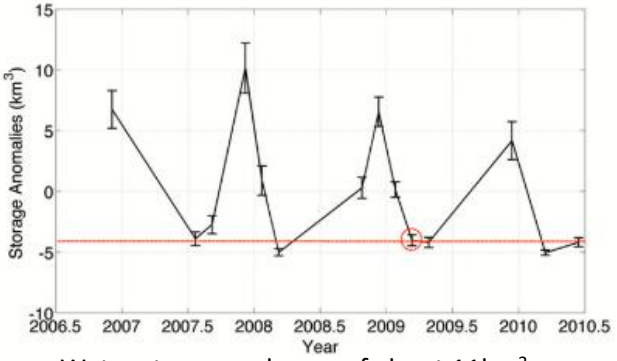
Congo wetlands : How important ?

"The cuvette is a sediment trap that impacts biogeochemical processes thus it is imperative to know the primary source of water as it affects sedimentation (Laraque et al .,2009)"

- Congo River Basin size-3,617,200 km^2 - Alsdorf et al ., (2016)
- Length - 4,374 km (Runge , 2007)
- Wetlands area of 32% in the "Cuvette Centrale", equivalent to 360,000 km^2 Bwangoy et al ., (2010).



Red polygon showing location of the Congo River basin in Africa above Brazzaville /Kinshasa including wetland areas of the Cuvette Centrale.Wetland area from the global wetland database -Lehner and Döll , (2004) .



Water storage volumes of about 11km^3 (Dec-2006), 10km3 (Dec-2007), and 9km3 (Dec-2008) Lee et al., (2015)

Hydrological measurements in the CRB

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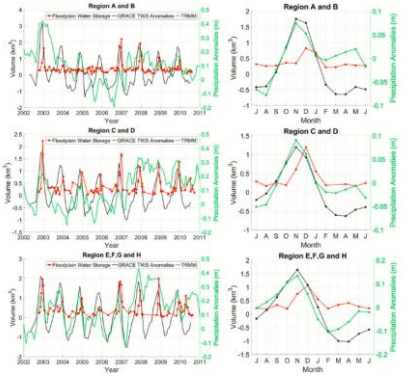
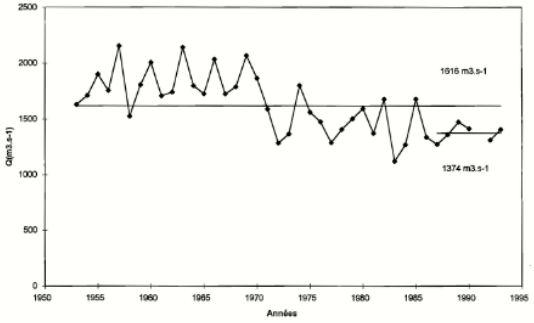
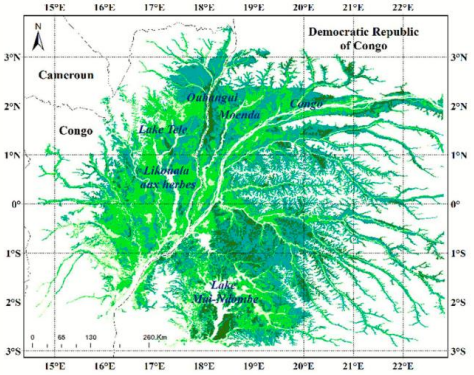
- Hydrological modeling
- Remote sensing
- Observations



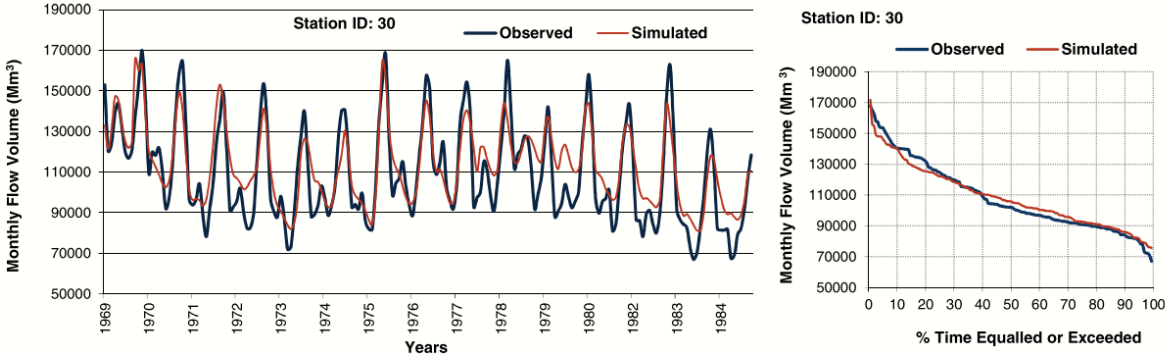
Lee et al ., 2017



Programme PEGI-GBF, 1995



Betbeder et al ., 2014



Tshimanga and Hughes .2014

Material fluxes in the CRB

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	Organic carbon		TSS	STUDY	Pub. DATE
	DOC (Tg/yr)	POC (Tg/yr)	FLUX (Tg/yr)		
1	18.6	13.2	-	Richey et al	1985
2	11	3	-	Probst et al	1987
3	8.9	1.1	-	Probst et al	1994
4	12.4	2.0	30.7	Coynel et al	2005
5	11.5	1.9	-	Seyler et al	2006
6	-	-	29	Laraque et al	2009
7	15	-	33	Laraque et al	2013
8	12.48	1.96	29.2	Spencer et al	2016

Aim of the study

- Establish a **hydrological model** for the CRB in order to Model **sediment** and **organic carbon exports** from the wetlands and **quantify the fluxes** that are discharged into the ocean.

- **Quantify** the exports of **DOC** and **POC** at a daily time step and at a subbasin scale at any point in the basin.

Methods

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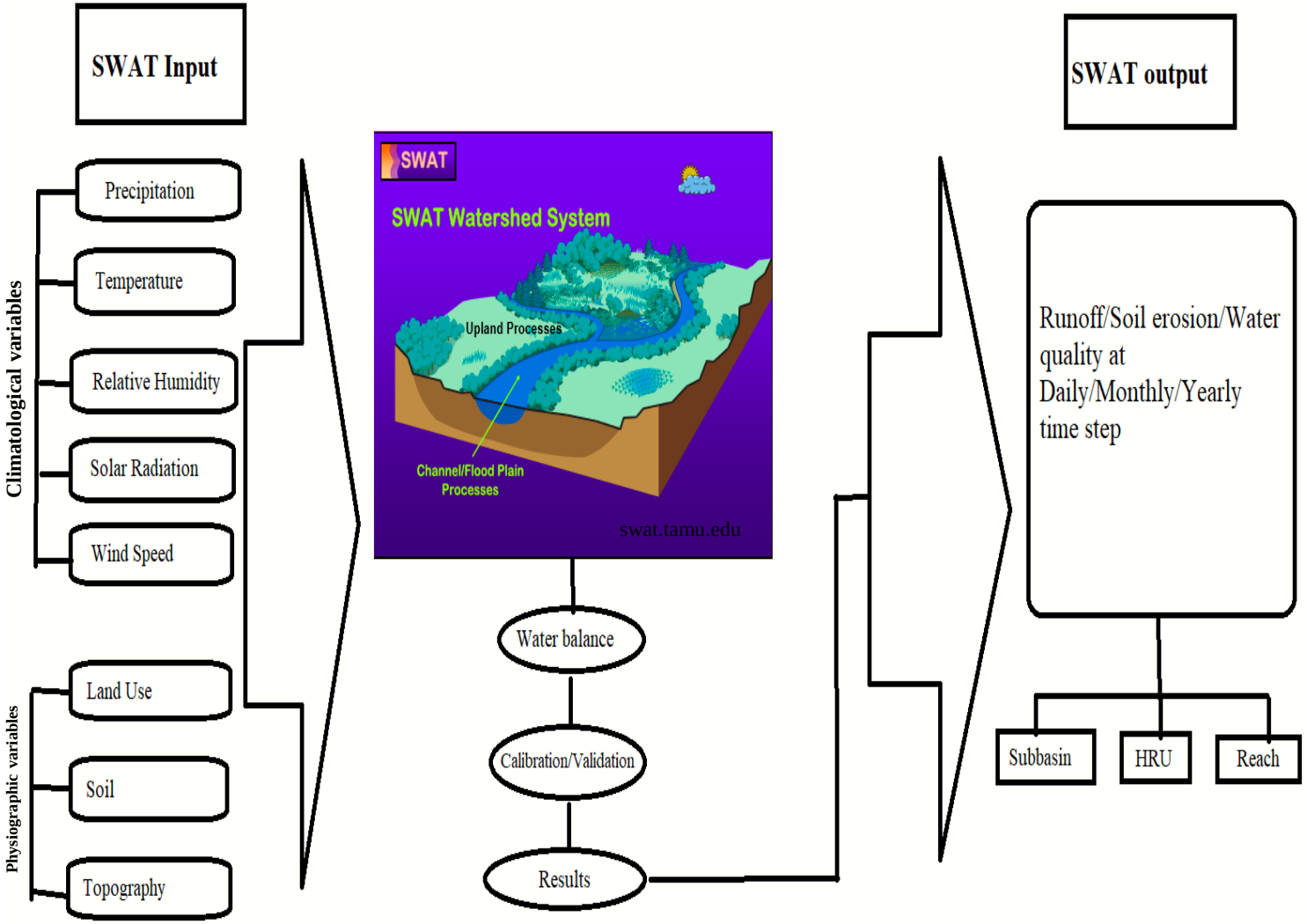
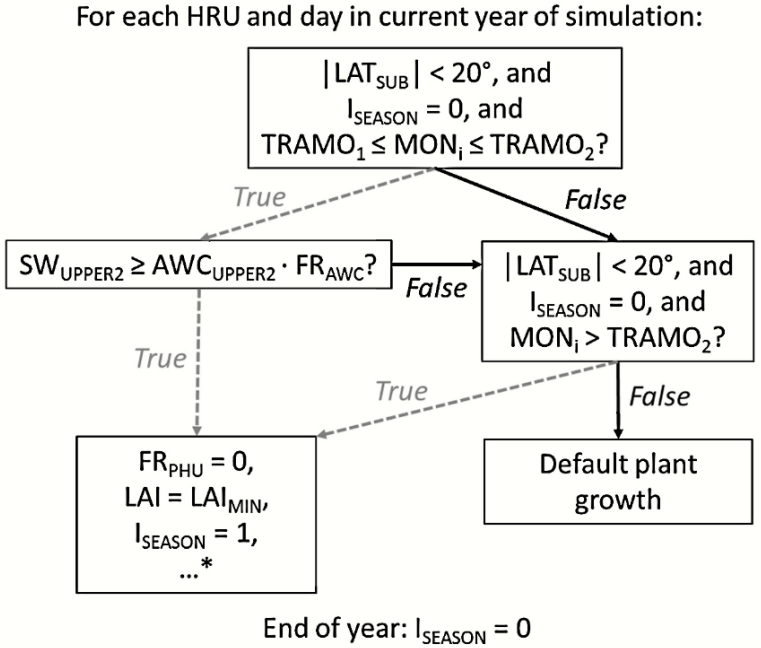
Main tool : Soil and Water Assesment Tool (SWAT) hydrological model



SWAT plant growth modification (Strauch & Volk, 2013)



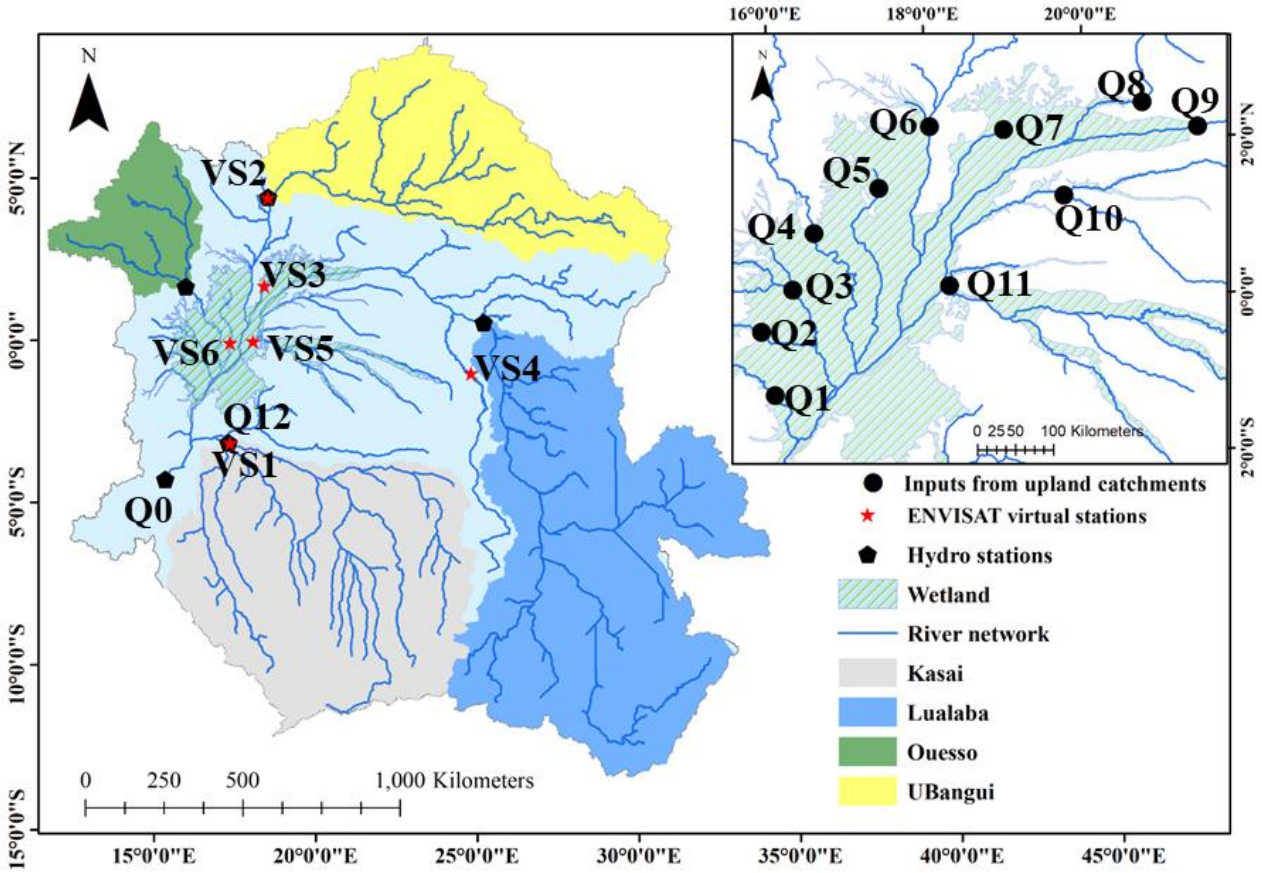
Implementation of soil moisture into the SWAT plant growth module (Strauch & Volk, 2013)

- SWAT initially customised for the Temperate regions
- Growth modification is for improved simulation of perennial vegetation in tropical watersheds with distinct dry and wet seasons
- By modifying the plant growth module, an alternative approach was presented in which annual growing cycles were initiated based on changes in soil moisture as against daily accumulated heat unit values.

Where :

LAT_{SUB} is the subbasin latitude
MON_i is the current simulation month
$TRAMO_1$ is the start month of the transition period .
$TRAMO_2$ is the ending month of the transition period
I_{SEASON} is a switch variable indicating whether or not a season change has occurred in the current simulation year,
SW_{UPPER2} is the simulated actual soil water content of the upper two layers in mm
AWC_{UPPER2} is the simulated available water capacity of the upper two layers,
FR_{AWC} is a user-defined fraction of available water capacity
FR_{PHU} is the simulated fraction of potential heat units and
LAI_{MIN} is the minimum LAI

Water Balance



Change in Storage

$\Delta S = P+Q_{1+}Q_{2+\ldots}Q_{11} - ET-(Q_0-Q_{12})$

Where :

S is the change in annual storage calculated in billions of cubic meters.

P is the Efficient precipitation over the Cuvette Centrale;

Q_i represents the River inflows;

ET is Evapotranspiration over the Cuvette Centrale and

Q_o- Q_{12} represents River outflows in the basin outlet

Monthly discharge simulation (2000-2012)

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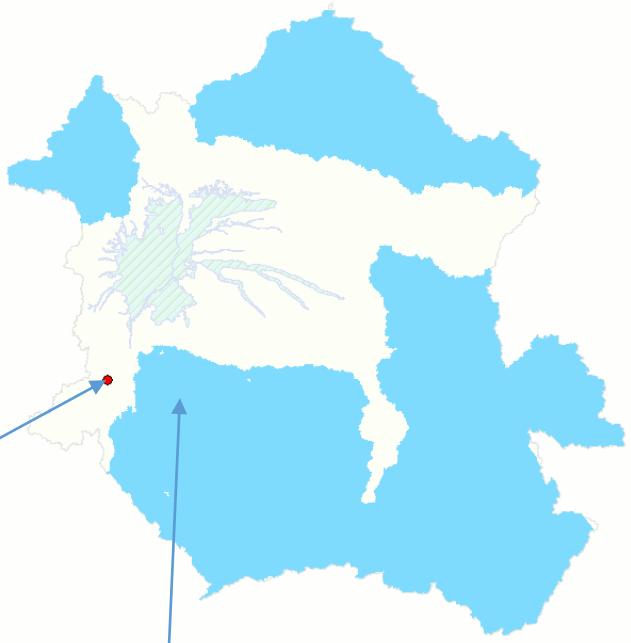
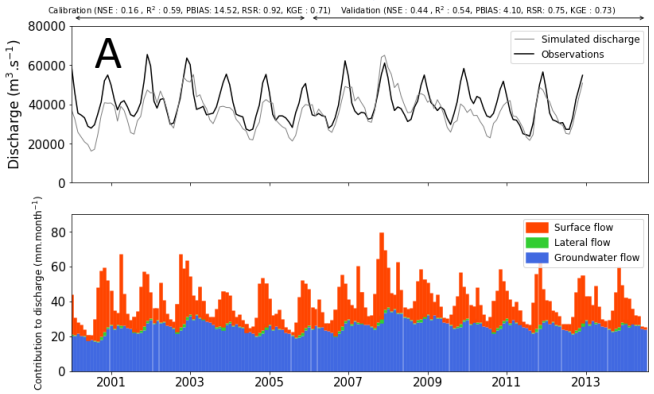
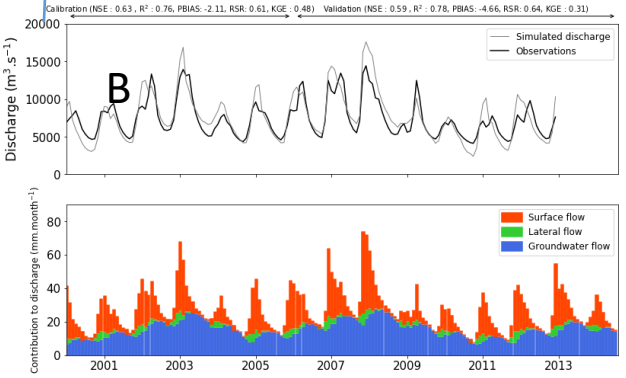
	Criteria	Bangui	Sangha	Kasai	Kisangani	*BRZ/KIN outlet
Calibration	NSE	0.81	0.67	0.63	**0.02**	0.16
	R^2	0.83	0.71	0.76	**0.49**	0.59
	PBIAS	4.01	8.37	-2.11	7.84	14.52
	RSR	**0.43**	0.57	0.61	0.99	0.92
	KGE	0.90	0.80	0.48	0.23	0.71
Validation	NSE	0.66	0.59	0.59	**0.08**	**0.44**
	R^2	0.67	0.65	0.78	**0.39**	0.54
	PBIAS	-0.86	-1.30	-4.66	-8.19	4.10
	RSR	0.58	0.64	0.64	0.96	0.75
	KGE	0.74	0.78	0.31	0.58	0.73





Brazzaville/Kinshasa



Kasai

Monthly discharge simulation (2000-2012)

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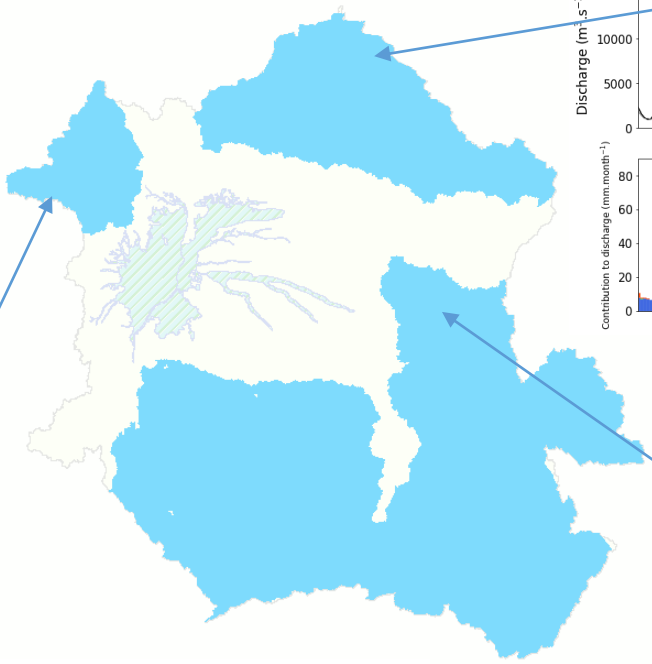
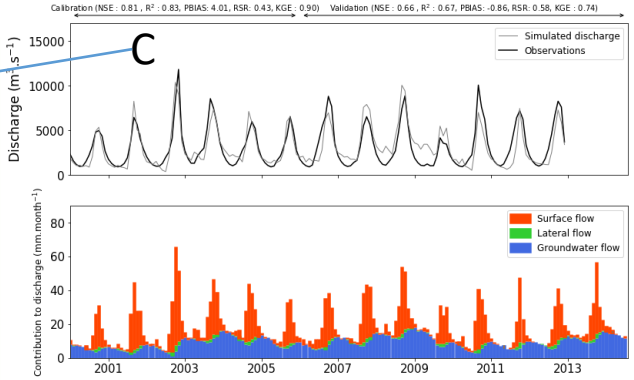
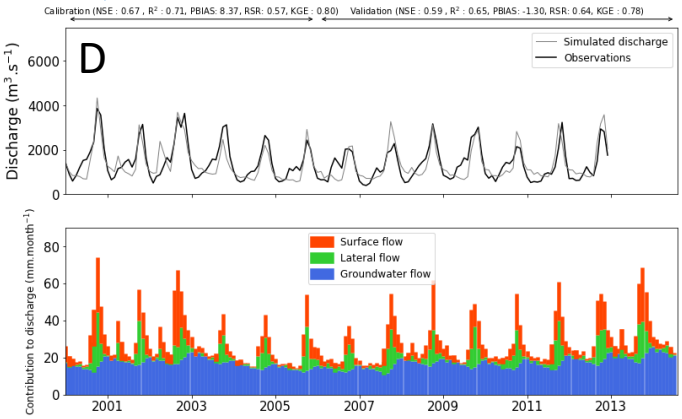
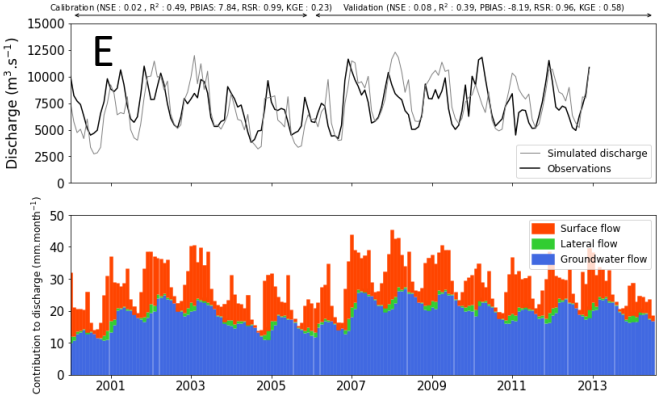




Oubangui

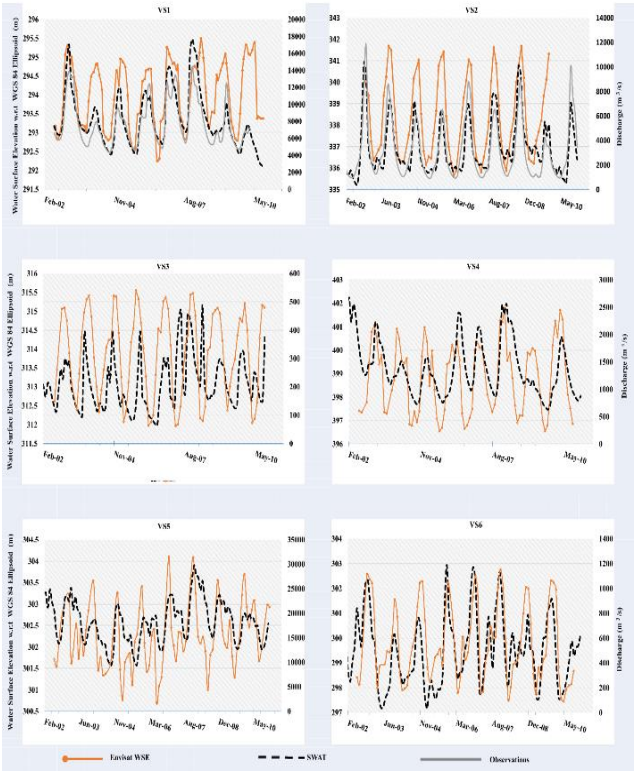


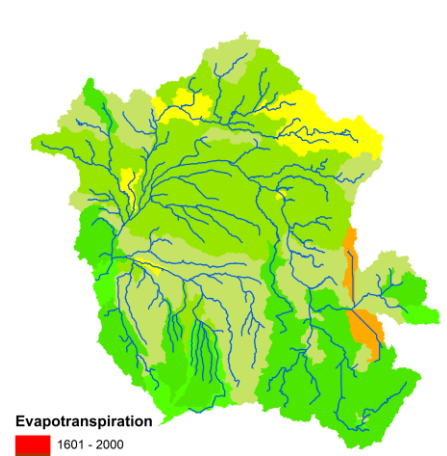
Sangha

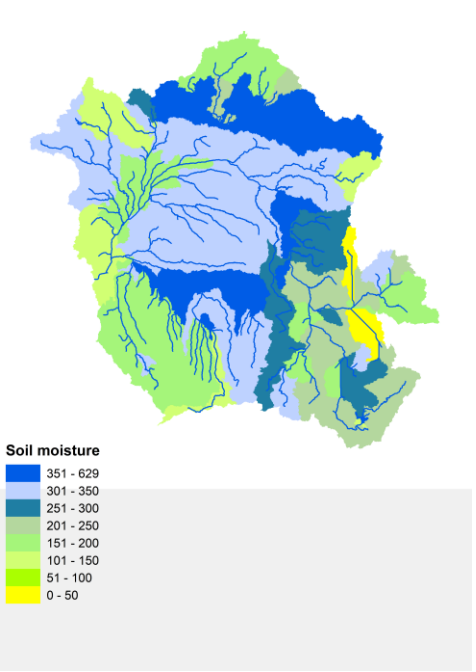


Lualaba

Validating







- Surface water elevation from ENVISAT radar altimetry showed good timing with discharge peaks. Coefficient of correlation range : 0.30-0.76

Water balance components ($mm.yr^{-1}$)	This study	Bultot 1971	Mahe, 1995	Bultot and Griffith (1972)	Nicholson 1997	Munzimi et al., 2019	Chishugi and Alemew (2009)
Precipitation	1510.7	1527	1560			1200	
Actual evapotranspiration	1058.3			970	1500	1071	1098
Potential evapotranspiration	1665.5			1110			
Runoff discharge	364				350	302	342

Cuvette Centrale Water Balance

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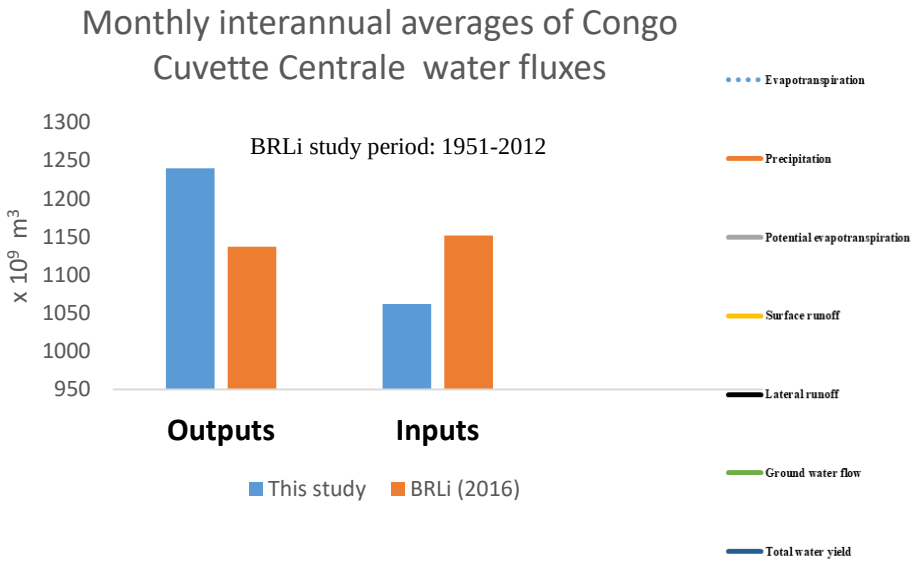

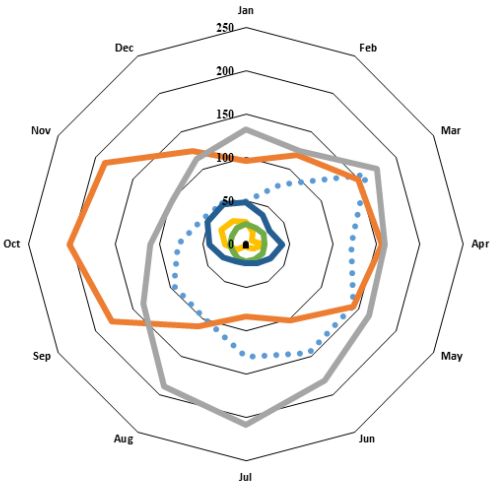

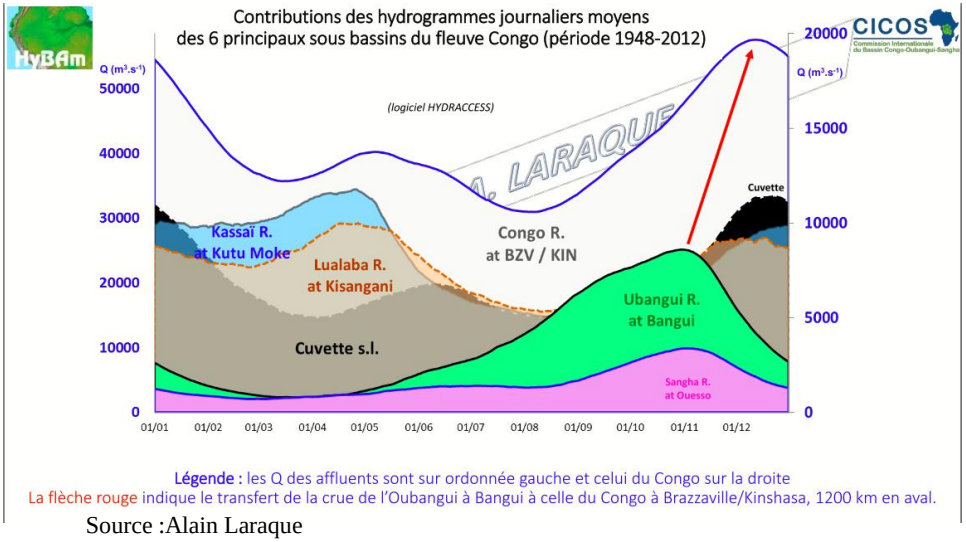

Source :Alain Laraque

Cuvette Centrale Water Balance

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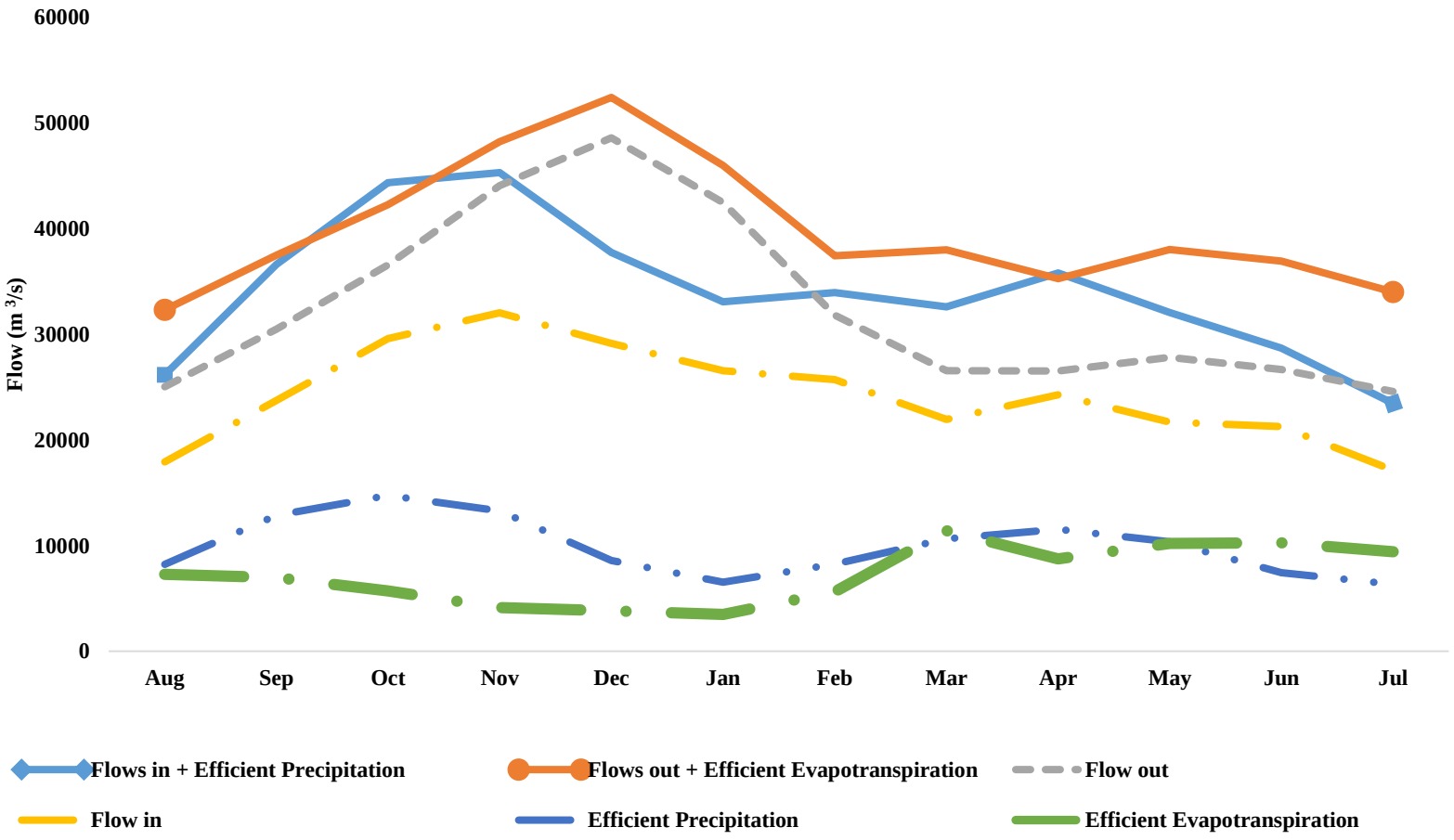
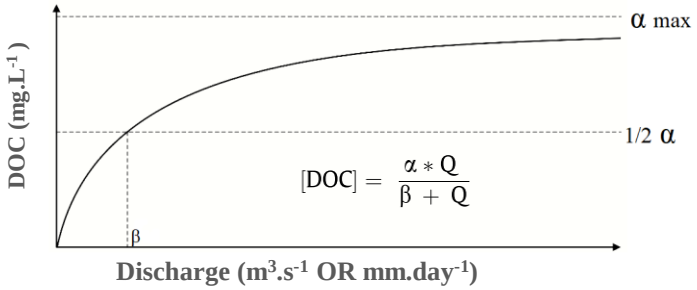
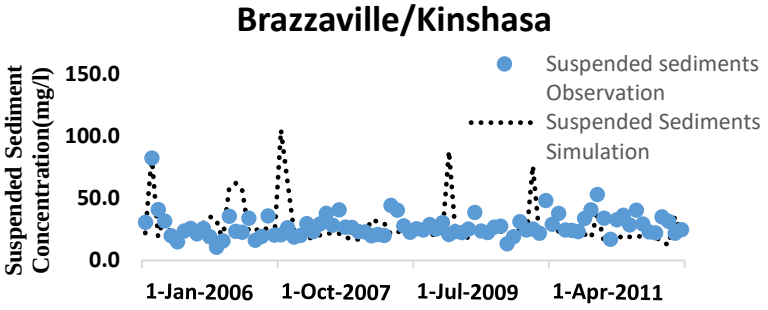


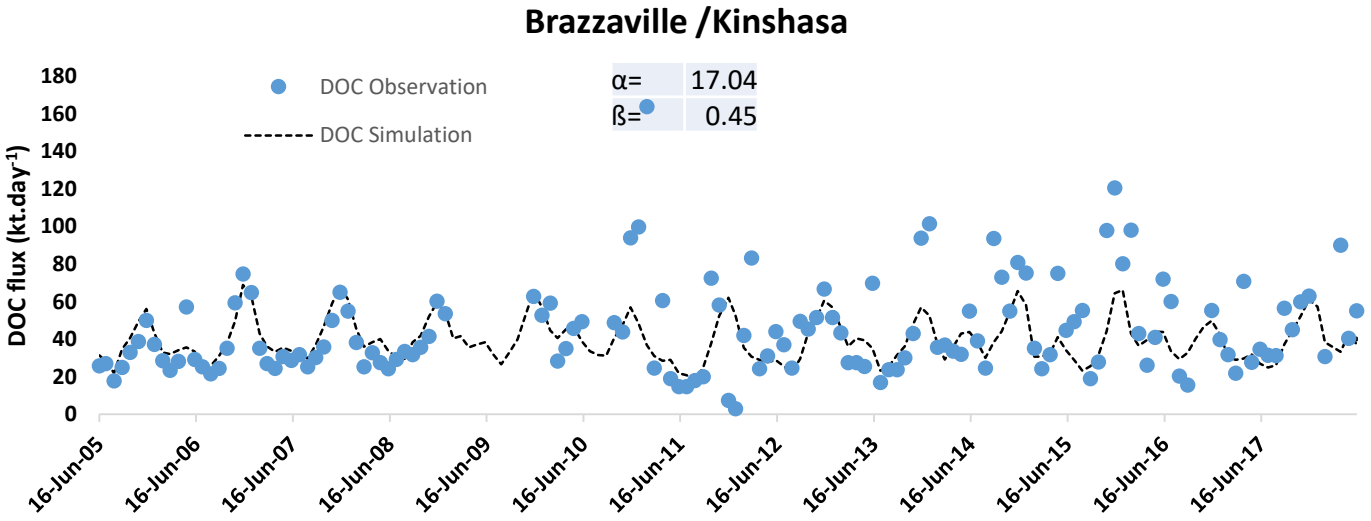
Organic carbon modeling

❖DOC equation adapted from Fabre et al., (2019)

❖Based on the relationship between discharge and DOC concentration







Organic carbon modeling

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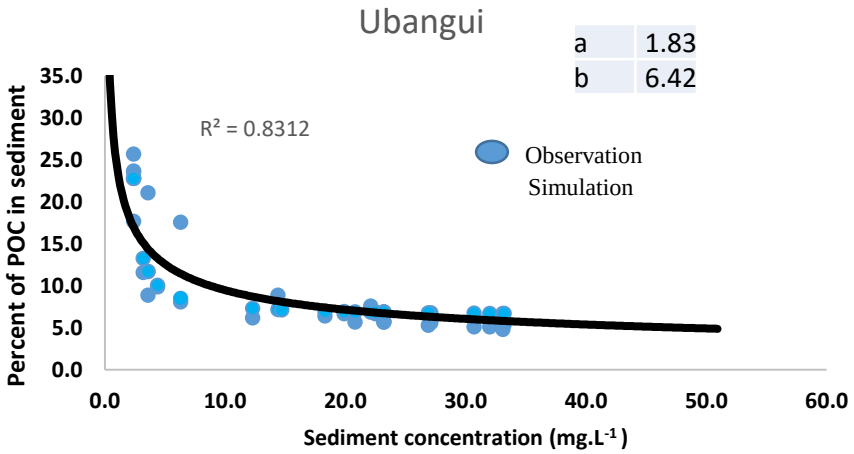
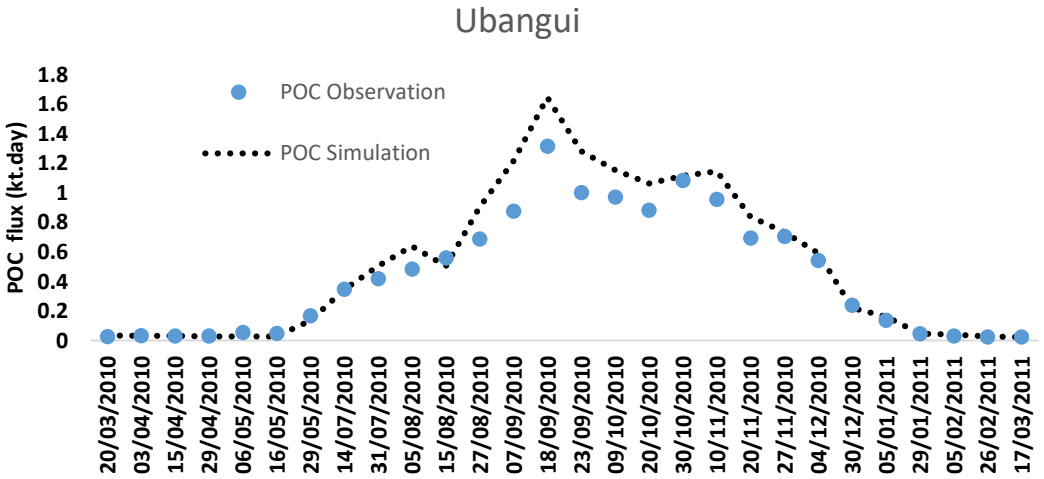
- POC equation adapted from Bothias et al., (2014)
- Based on the relationship between Total suspended sediments and POC content



$$\%POC = \frac{9.40}{[TSS] - a} + b$$



First results

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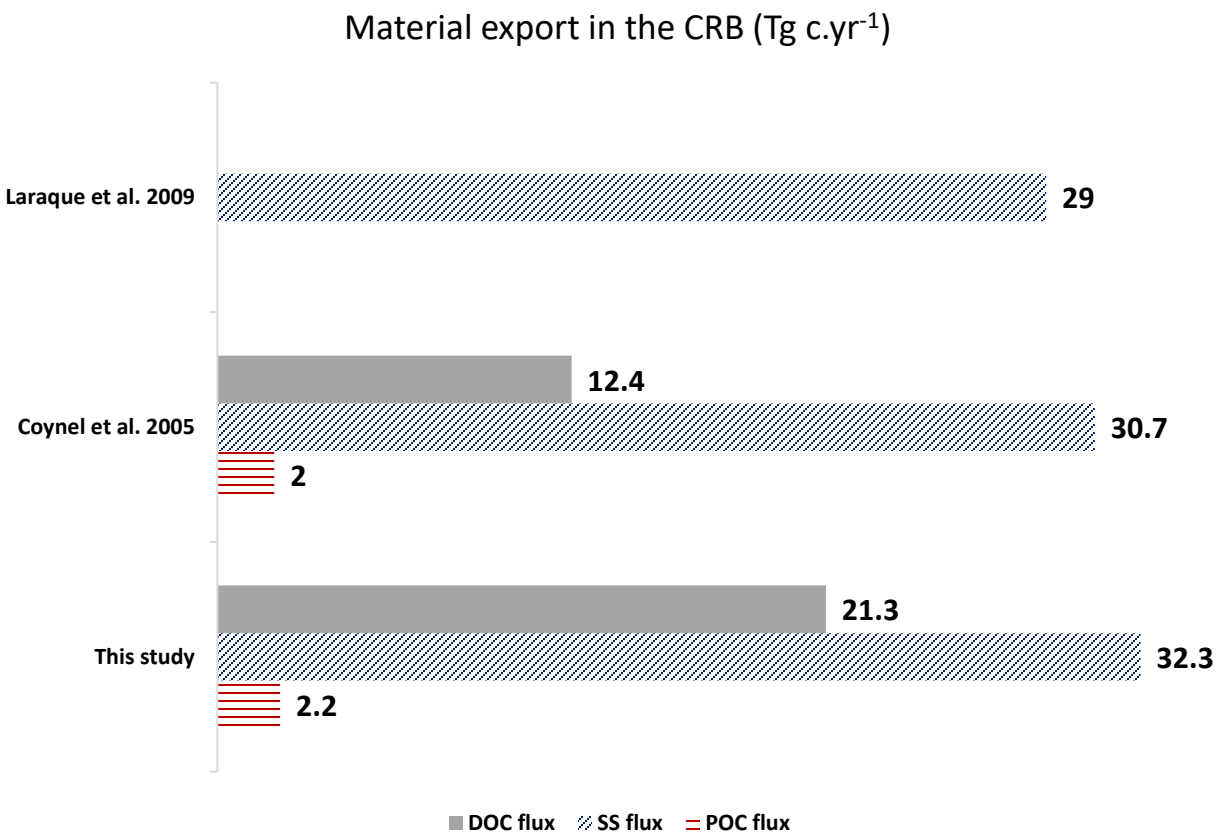
Applying the equations at basin outlet :



PERSPECTIVES

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- The parameters related to DOC and POC equations represent the characteristics of each sub-basin.
- These relationships can be used to predict the parameters and hence evaluate DOC and POC concentrations at any point in the watershed.
- We can then quantify the effect of the Cuvette Centrale on the sediments, POC and DOC dynamics in the basin.
- Furthermore this will allow us to characterize the spatial and temporal dynamics of these fluxes by identifying specific hotspots and hot moments and their trends in time and space in the context of global environmental change

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Thank You

http://gmod.cnrs.fr/research/