Hydrology

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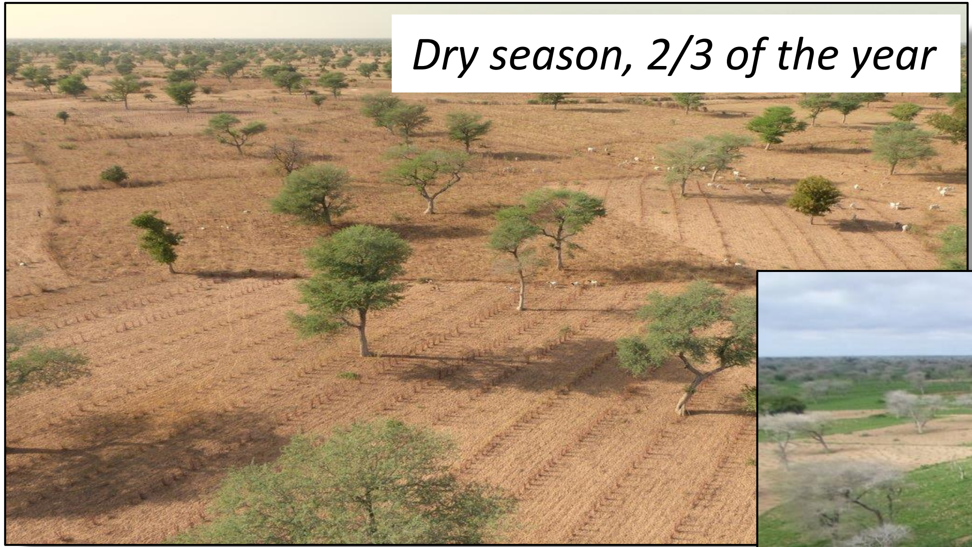
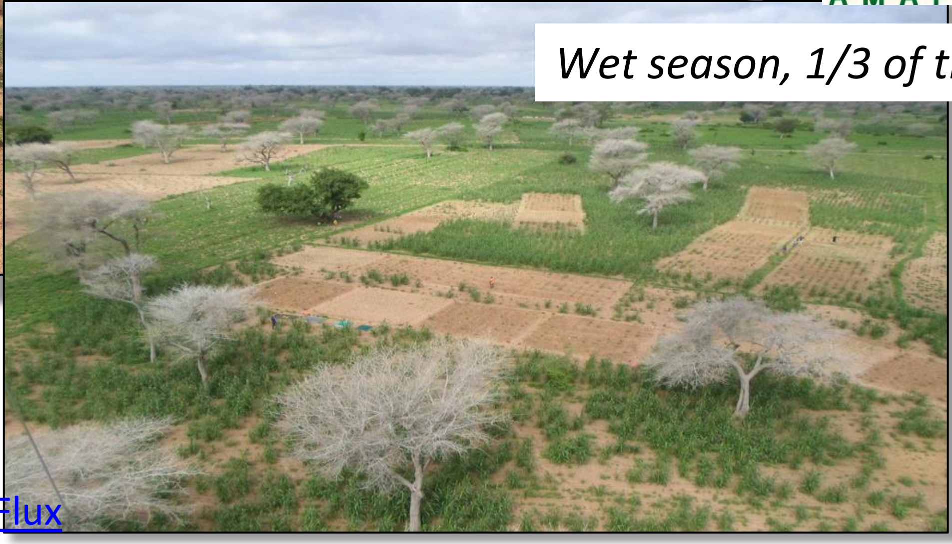
"*Faidherbia-Flux*": A long-term Collaborative Observatory on food security, GHG fluxes, ecosystem services, mitigation and adaptation in a semi-arid agro-silvo-pastoral ecosystem (groundnut basin in Niakhar/Sob, Senegal)

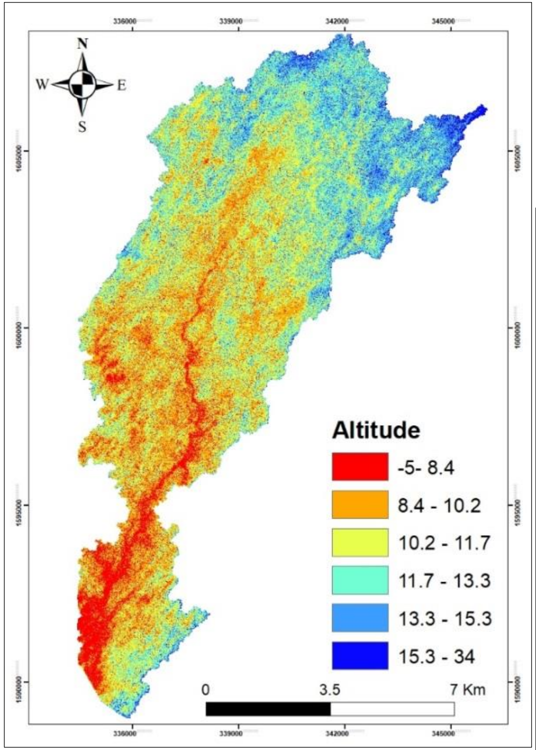




"*Faidherbia-Flux*" Web site :
https://lped.info/wikiObsSN/?Faidherbia-Flux

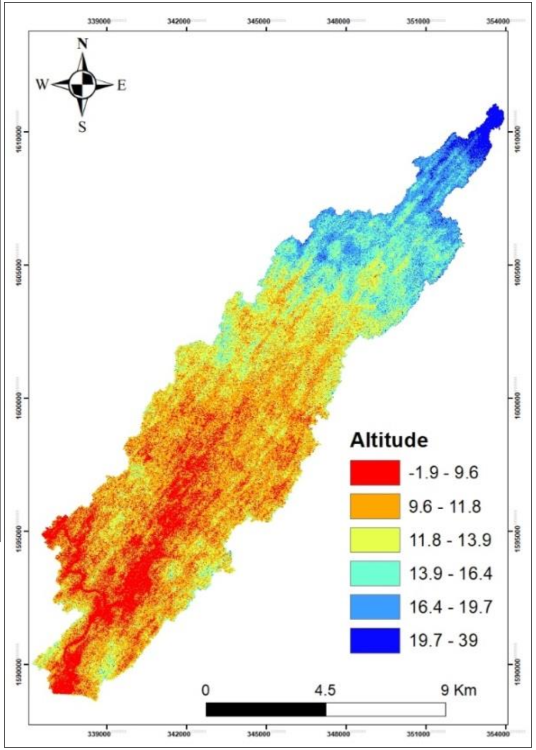
Contact: olivier.roupsard@cirad.fr

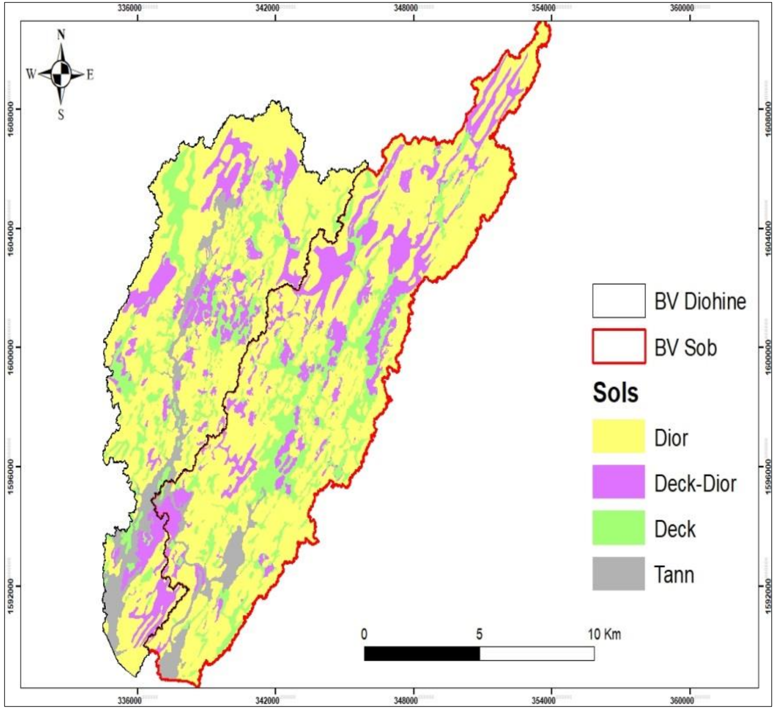
Ecohydrologie du bassin arachidier (cas de Niakhar): dynamique de l'infiltration et modélisation des aquifères superficiels dans un espace sylvopastoral semi-aride (Waly Faye)



Bassin versant de Diohine
87 km²

Bassin versant de Sob
112 km²





Diohine: 60% de sols Dior (sableux)
Sob: 64,5% de sols Dior (sableux)

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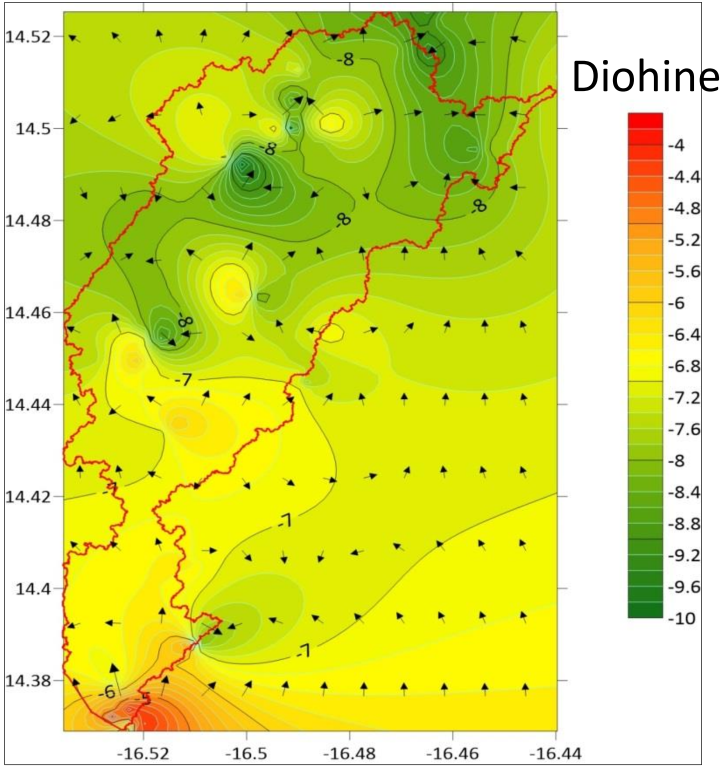
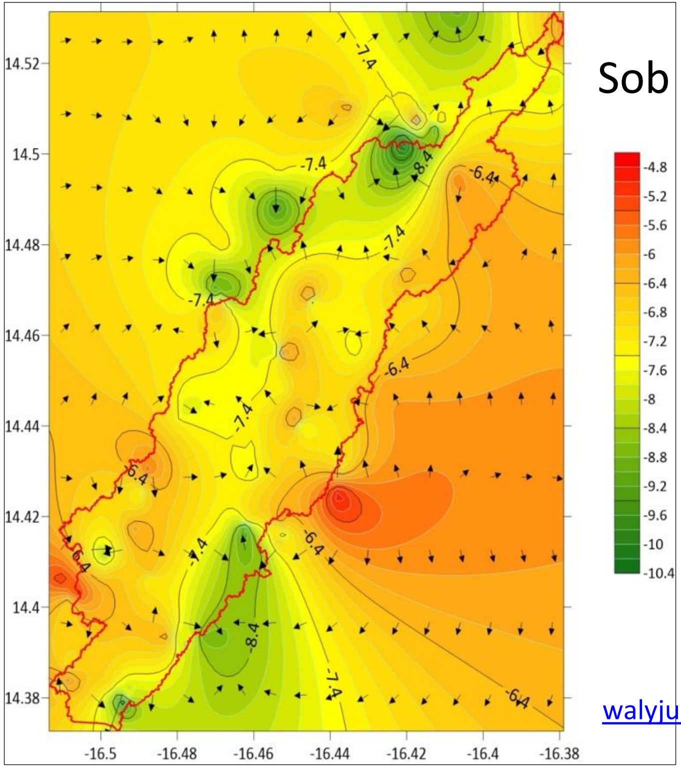
Altitudes piezométriques de la nappe superficielle





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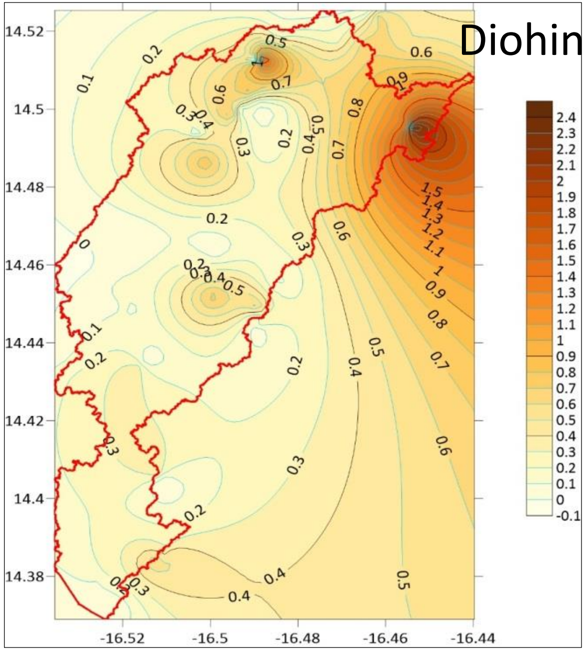
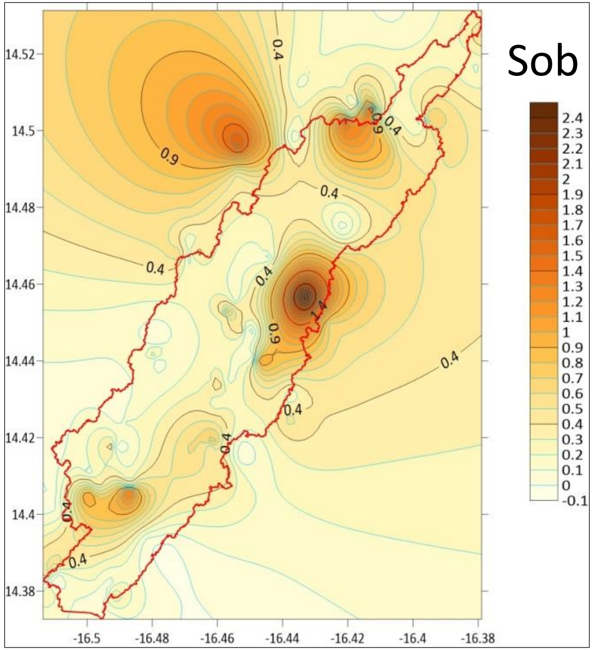
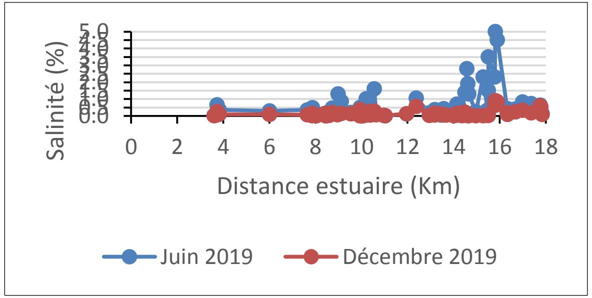
Chimie des eaux de

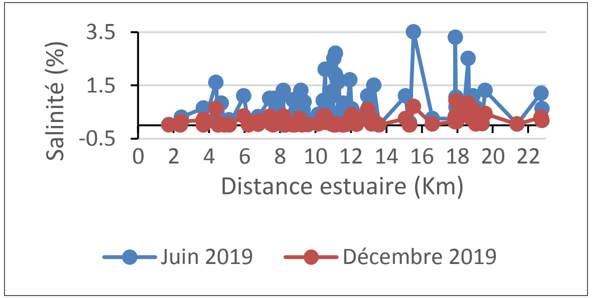
An	P(mm)	Diohine				Sob				Moyenne			
		pH	Cond (mS)	NS (m)	S (%)	pH	Cond (mS)	NS (m)	S (%)	pH	Cond (mS)	NS (m)	S (%)
2016	592	7.3 (0.4)	6.8 (5.8)	3.6 (1.2)	0.4 (0.3)	7.5 (0.3)	10.9(6.5)	6.0 (3.6)	0.6 (0.4)	7.44	8.8	4.88	0.49
2018	450	7.4 (1)	5.0 (6.4)	3.4 (1.7)	0.3 (0.3)	7.2 (0.8)	4.9 (5.8)	4.2 (1.8)	0.3 (0.4)	7.29	4.9	3.82	0.27
2019	527	7.4 (1)	5.3 (5.9)	3.3 (1.5)	0.4 (0.6)	7.0 (0.8)	4.4 (5.3)	4.1 (2.1)	0.4 (0.6)	7.23	4.7	3.68	0.39
Moy	523	7.4	5.7	3.4	0.3	7.3	6.7	4.8	0.4				

Distribution spatiale des teneurs en sel de la nappe superficielle

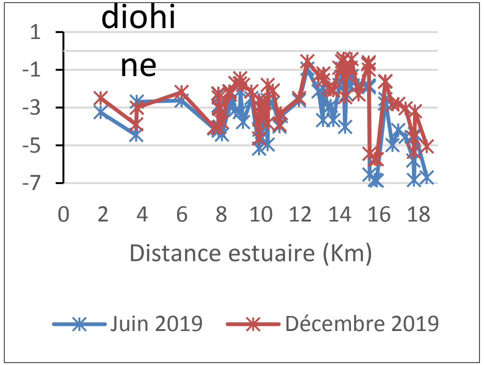


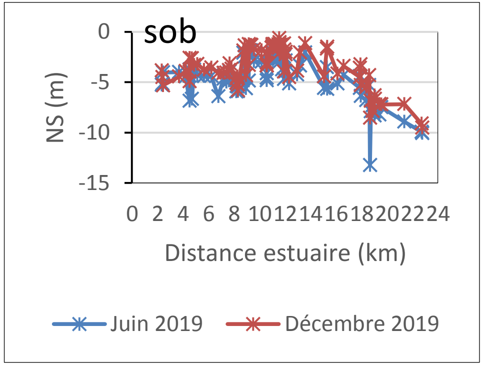






Variation du niveau statique





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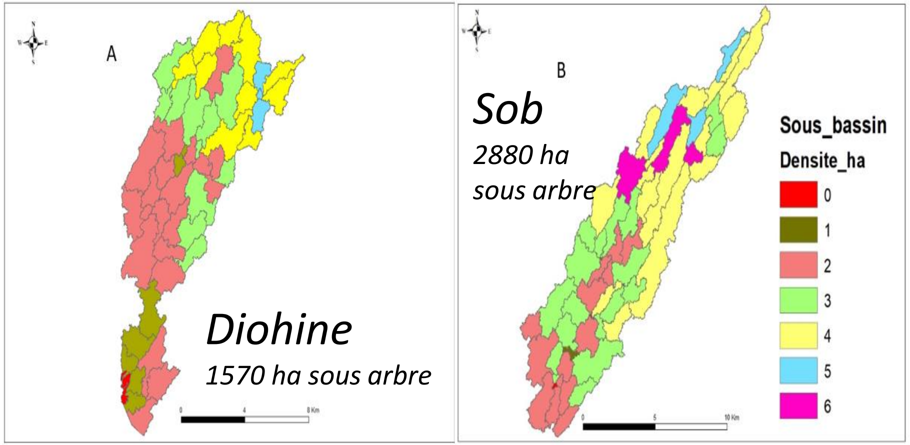
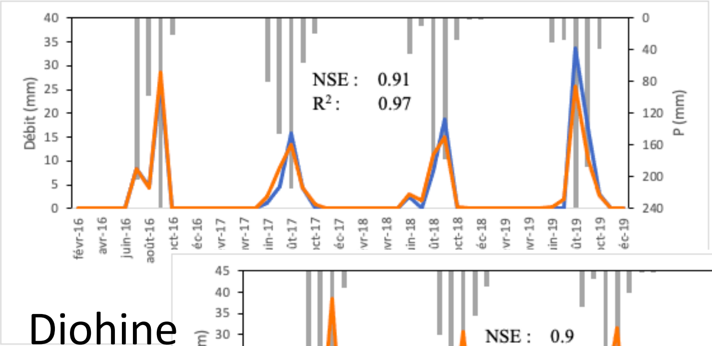
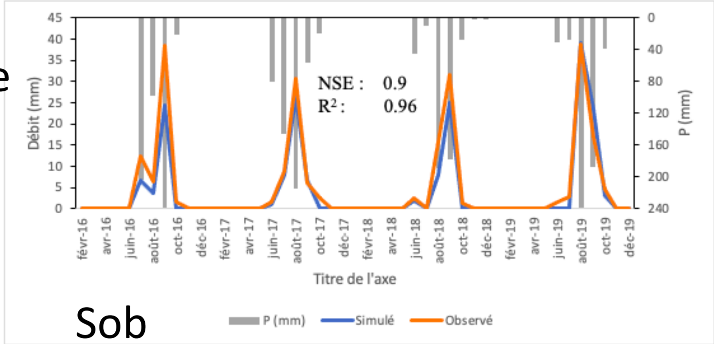
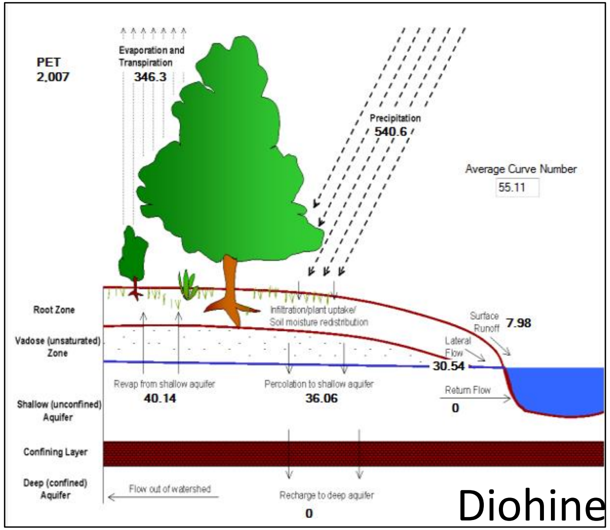
La salinité augmente vers l'amont des BV.

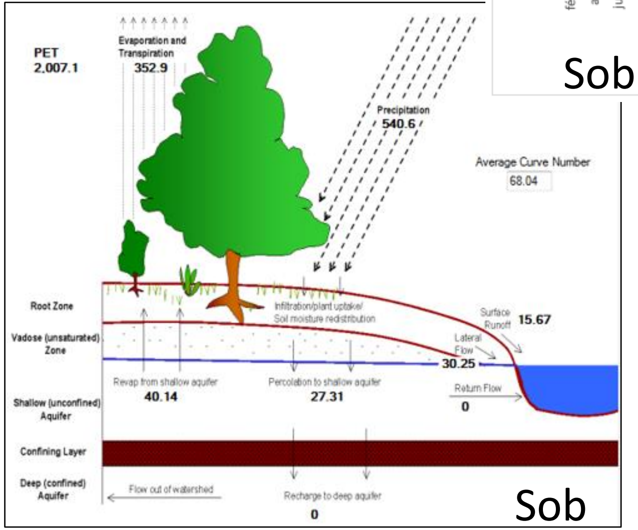
Estimation de la densité des arbres par imagerie Sentinel2











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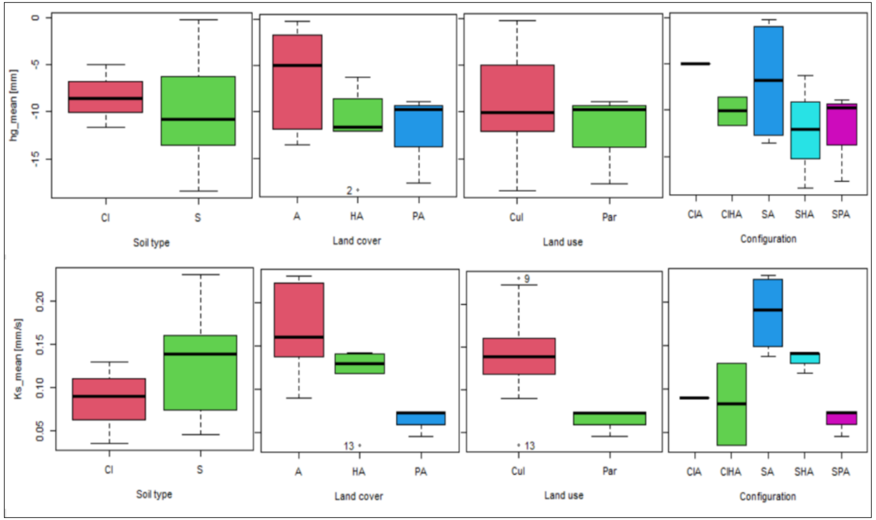
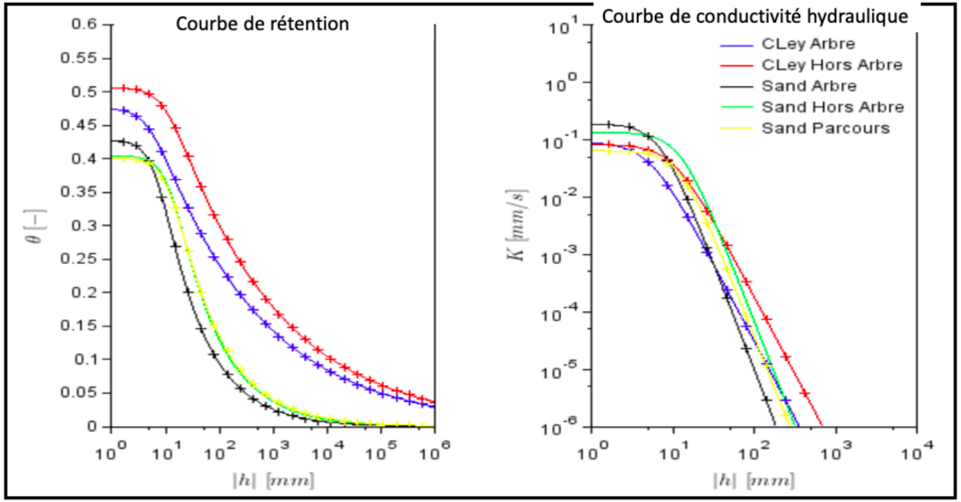
Modélisation SWAT

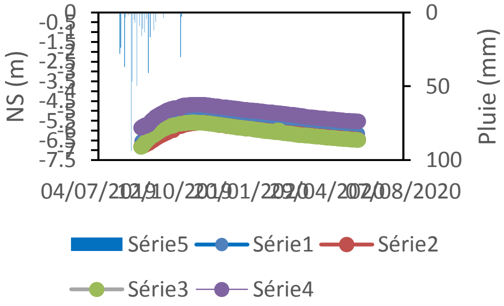
- Curve number: 55 à 68
- Ecoulement de surface:
  - ➢ 8 mm (Diohine)
  - ➢ 16 mm (Sob)

Grande variabilité du Ks moyen à l'échelle du paysage, peu de changement de la rétention moyenne

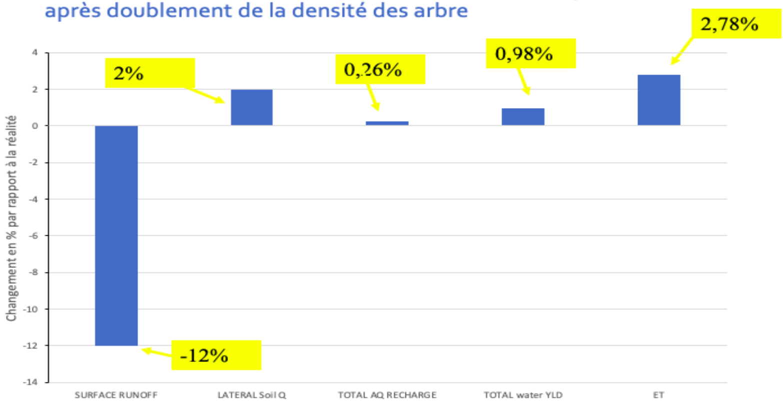




Recharge de la nappe retardée par rapport au centre de la saison des pluies



❖Réduction du ruissellement de surface, mais une augmentation de l'ET après doublement de la densité des arbre



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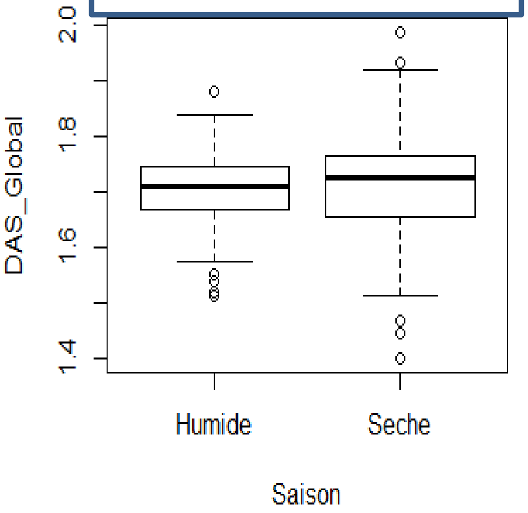
Soil Dry Bulk Density

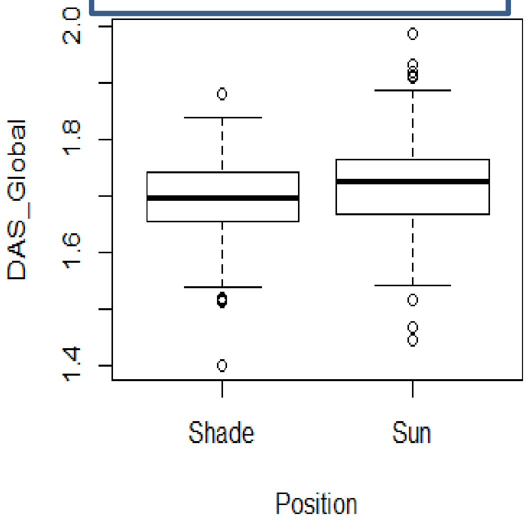
Wilcoxon test

P-value= 0.3384



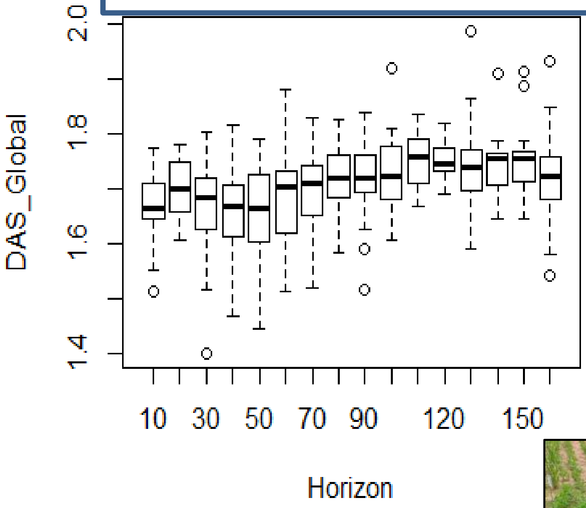
Wilcoxon test

P-value= 0.009442



Kruskal-Wallis test

P-value= 2.864^{e-5}



Soil DBD was measured 0-1.6 m using a vertical DBD auger. DBD was around 1.7 g cm^{-3} on average. There was no seasonal effect on DBD, but DBD is a little higher in full sun than under Fa. Trees and varies according to soil depth.

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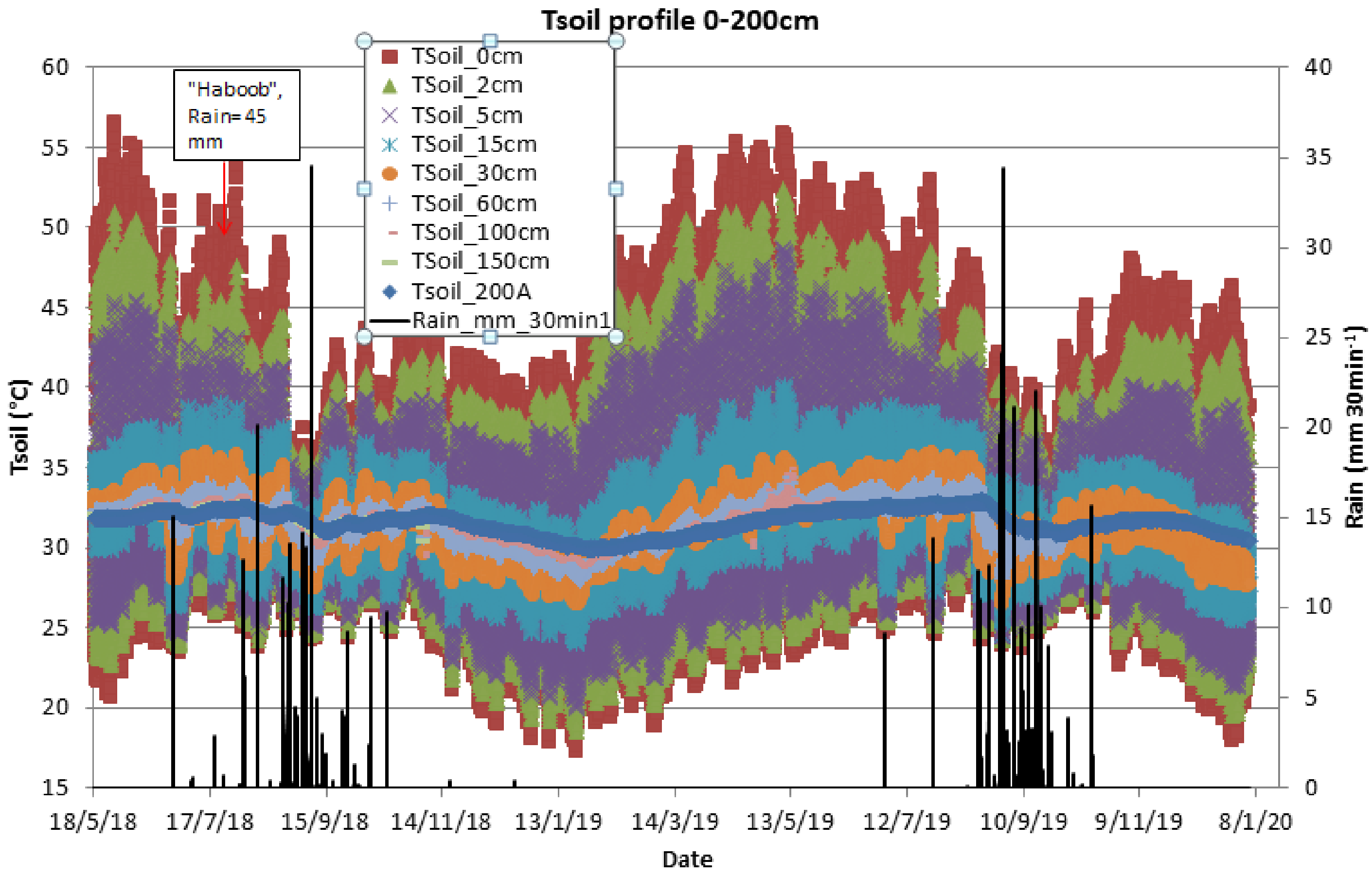
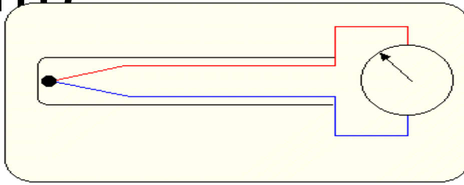
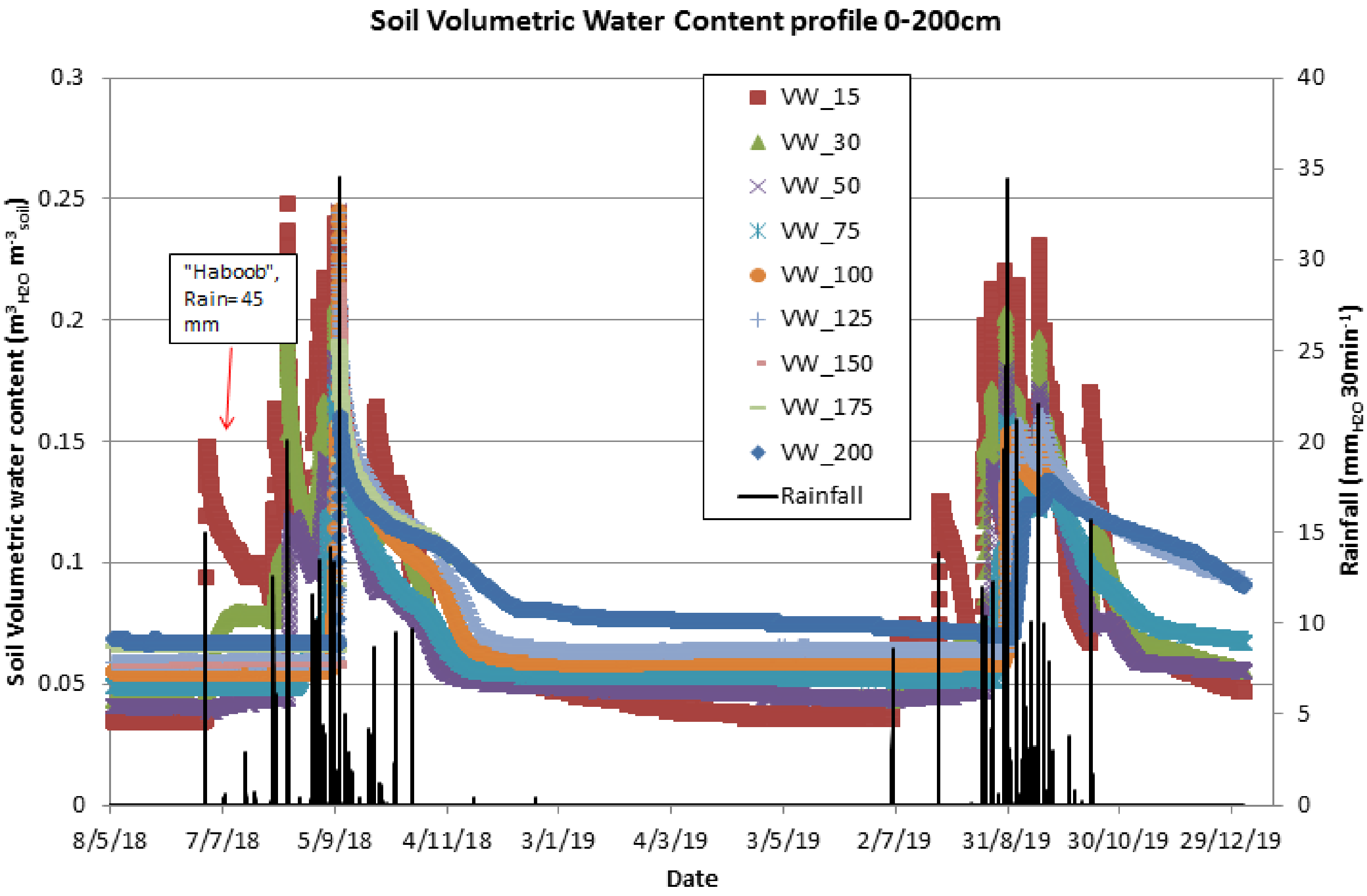
Soil temperature profile (0-200 cm)





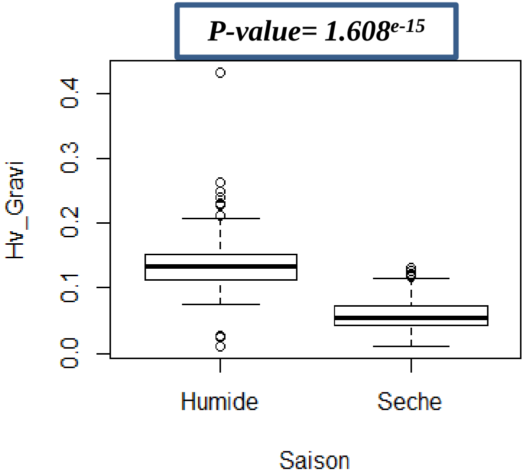
Soil temperature dynamics according to depth (0-200 cm). At 0 cm, Tsoil shows large (37°C) diurnal magnitude between 20°C at dawn and 57°C around noon. Deeper, the magnitude decreases progressively, until 150 cm where Tsoil is stable all year long at ca. 32°C. Note time shift between maxima, from surface to deep layers. Soil temperature drops in upper layers during the wet season.

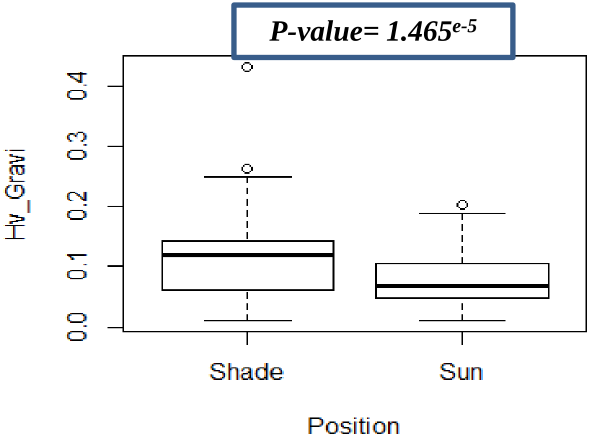
Soil Moisture TDR profile (0-200 cm)

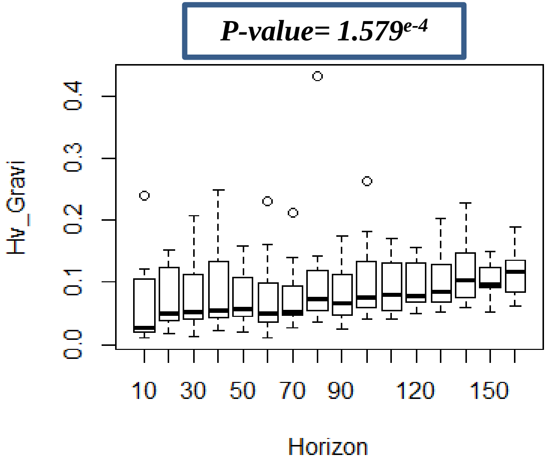


Soil moisture dynamics according to depth (0-200 cm). Values during drought started 3.5% (15 cm) and 6.7% at 200 cm. After the "Haboob", values in the 0-30cm soil layer increased to 15%, then, after 24h, started to flow into the next layer. Water reached deeper layers, progressively. 25% could be the field capacity of the upper layers. NB, the TDR equations still need to be calibrated for this specific soil. The minima were slightly higher in 2019

Soil volumetric water content ($VWC_{\_gravi}$) obtained from the gravimetric method (SWC + DBD)







$VWC_{\_gravi}$ was measured 0-1.6 m on the 15/11/2018 (dry season) and 05/09/2019 (wet season) in order to calibrate TDR and Diviner probes. $VWC_{\_gravi}$ was higher below shade, and increased with depth.

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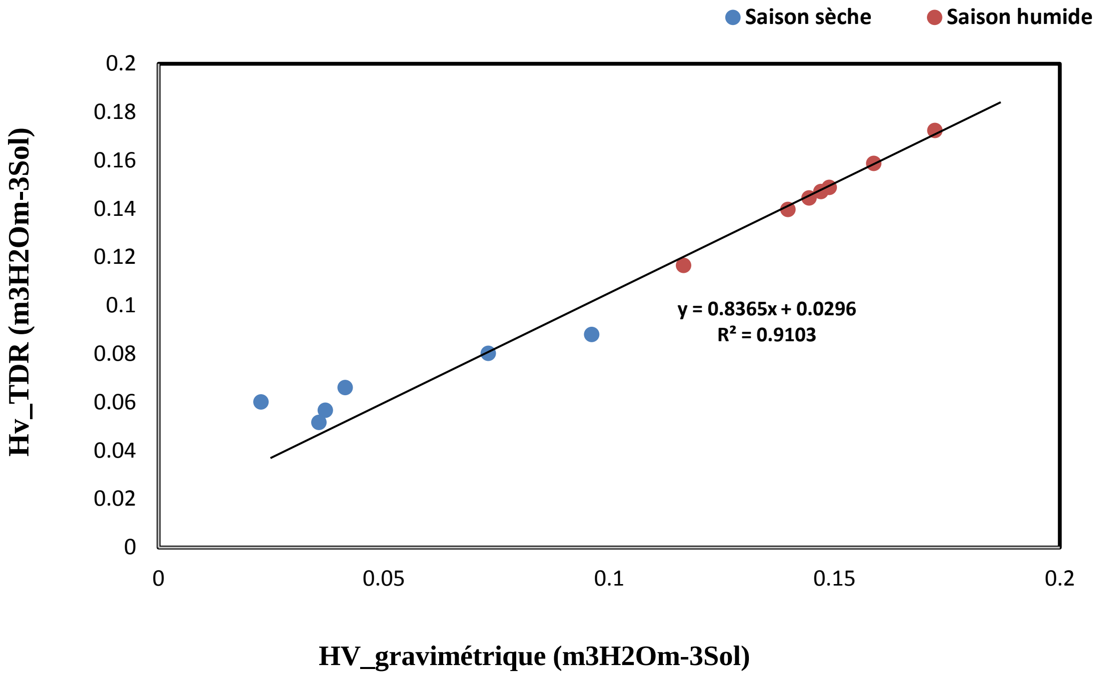
Calibrating the soil volumetric water content (VWC) indicated by TDR (Campbell CS615 probes)



$VWC_{\_gravi}$ was measured 0-1.6 m on the 15/11/2018 (dry season) and 05/09/2019 (wet season) from SWC + DBD and used to calibrate TDR. A single calibration equation was applied.

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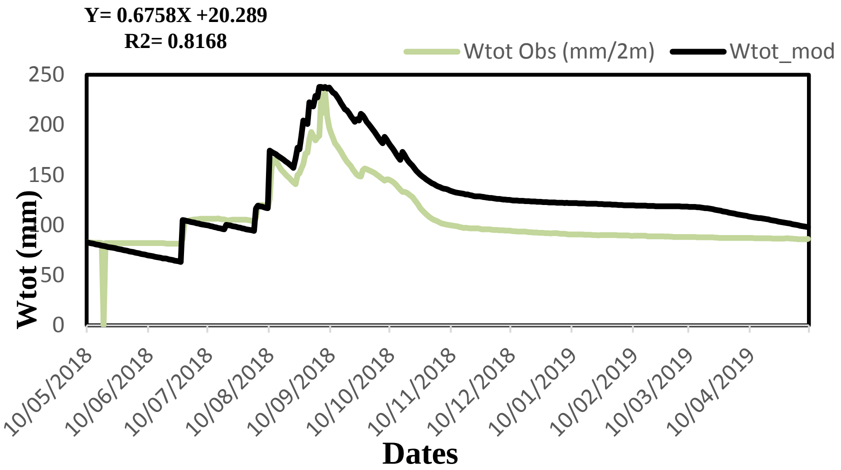
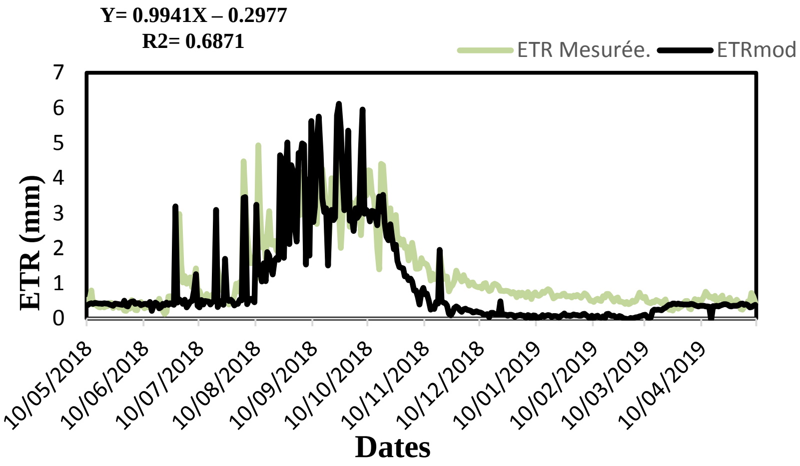
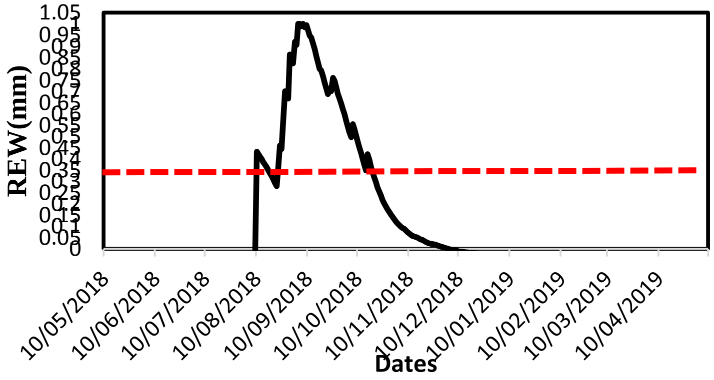
Calibrating a SVAT (BILJOU, Granier et al., 1999) to simulate the water balance of pure millet







After calibration of the TDR probes and of the parameters of BILJOU, VWC of the whole soil profile (0-2 m) and actual evapo-transpiration (ETR) were satisfactorily simulated for pure millet. BILJOU also simulated the duration and intensity of the stressed period, before the 10th of August and after the 20th of October 2018, i.e. when REW was below the threshold of 0.35.

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SUIVI DE L’HUMIDITE DU SOL ET DU NIVEAU DE LA NAPPE PHREATIQUE: rôle de l’arbre

Laboratoire Mixte International iesol
Intensification Ecologique des Sols Cultivés en Afrique de l’Ouest

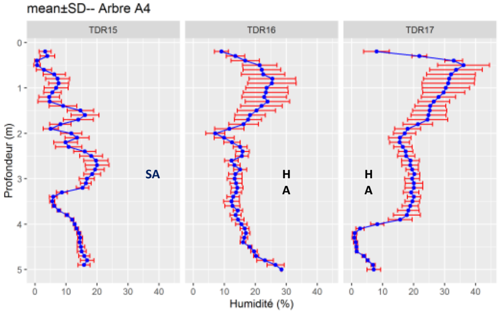
AG LMI IESOL
17-19 oct 2020

SESSION 3

1. TDR IHP : Suivi ponctuel de l’humidité et de la conductivité électrique à travers des tubes d’accès installés à plus de 5m (17 au total)

TDR IHP pico Trime

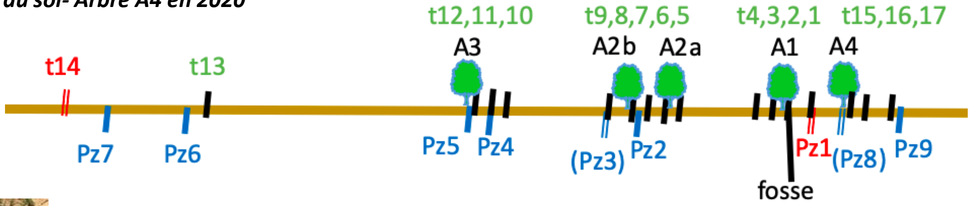
Suivi Humidité du sol à Sob- 2020



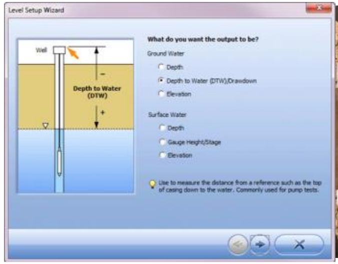
Profil humidité du sol- Arbre A4 en 2020

3. Infiltrométrie BEST automatique : Campagnes de mesures de la conductivité hydraulique des sols

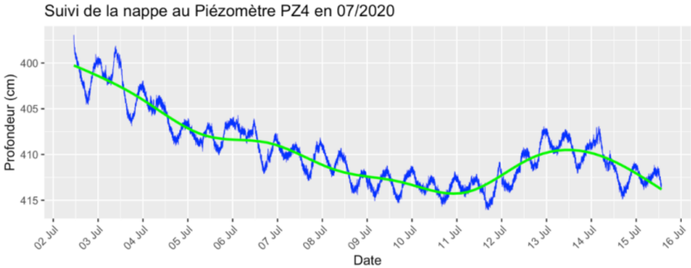
2. Sonde de pression Aqua Troll 100: Suivi de la profondeur et de la température à travers 6 piézomètres



piezomètre Troll 100

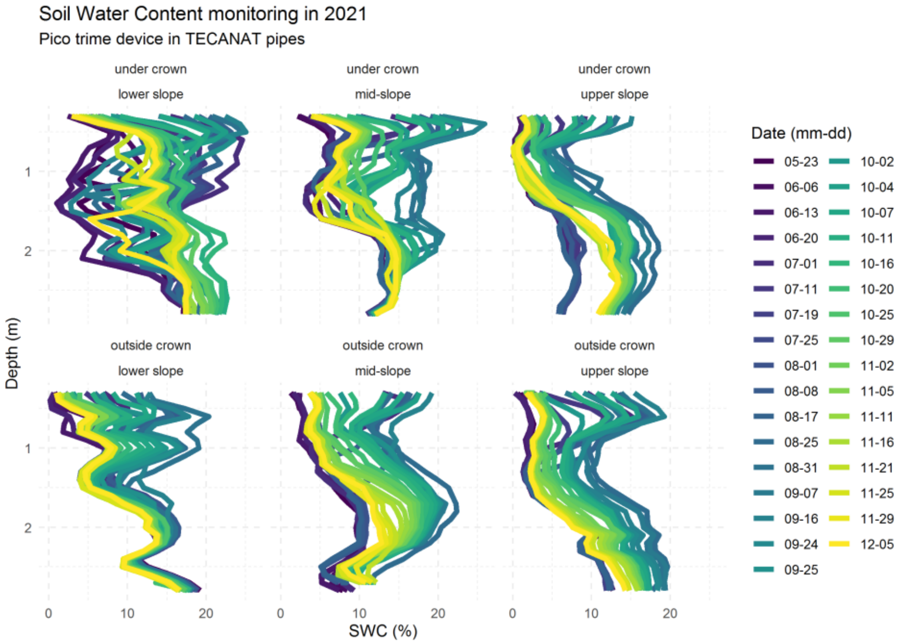


Paramétrage d’une sonde et installation à Sob

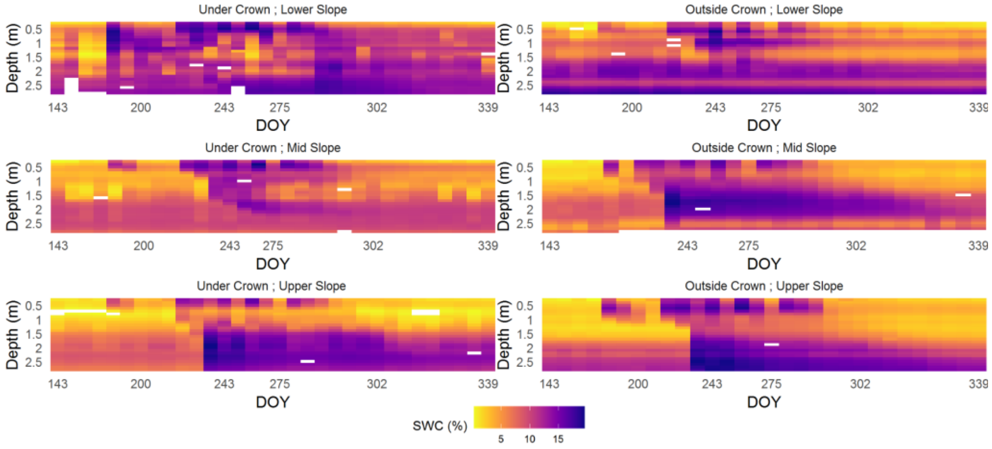


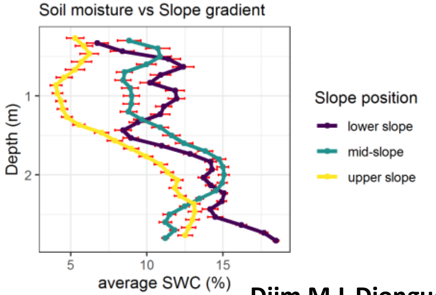
Evolution temporelle du Niveau statique à Sob (données non compensées)

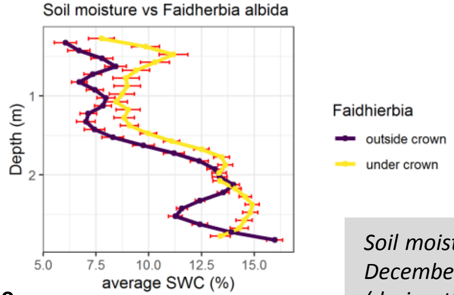
Impact of *Faidherbia albida* and slope position on soil water content dynamics



https://lped.info/wikiObsSN/?Faidherbia-Flux







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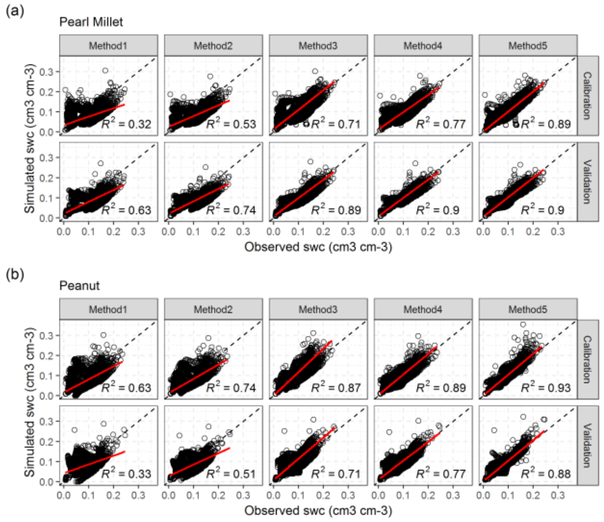
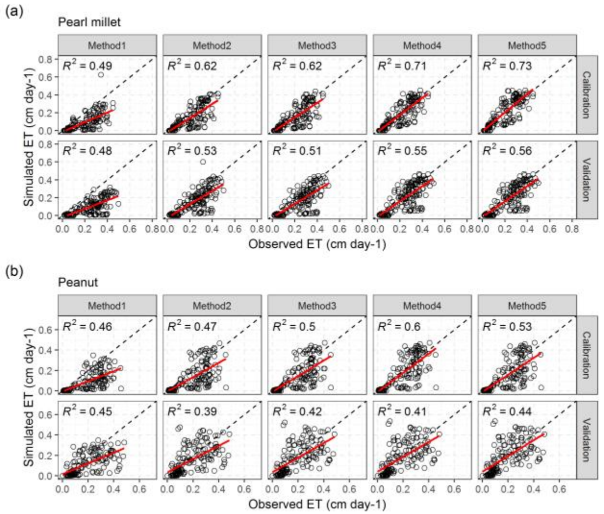
Soil moisture monitoring at "Faidherbia Flux" site using a TDR Pico trime sensor in TECANAT pipes from May to December 2021 using . Swc varies strongly according slope gradient with two main type of profile: a dry profile (during the dry season) and a wet profile during the rainy season, except for lower slope under crown, which varies independently of the date. Globally, the swc is higher under trees depending on the slope.

Estimation of soil hydraulic parameters water flow field experiment in Sahelian region

Table 1: Van Genuchten parameters assessed by five methods with Hydrus-1D : Pedotransfer from soil texture classification (Method1), pedotransfer from top soil description (Method2), pedotransfer from a three-layer soil description (Method3), Inverse estimation from a single soil layer (Method4) and inverse estimation from three-layer soil material (Method5)

Method	Depth (cm)	Crops	θ_r (cm cm^{-1})	θ_s (cm cm^{-1})	α (cm^{-1})	n (-)	K_s (cm h^{-1})	l (-)
Method 1	0-200	Pearl millet / Peanut	0	0.41	0.124	2.28	14.59	0.5
Method 2	0-200		0	0.34	0.036	2.2	6.41	0.5
Method3	0-50		0	0.33	0.039	1.94	4.18	0.5
	50-100		0	0.32	0.039	1.83	2.98	0.5
	100-200		0	0.32	0.036	1.75	2.48	0.5
Method 4	0-200	Pearl millet	0	0.37	0.018	1.84	7.78	0.5
	0-200	Peanut	0	0.37	0.039	1.90	8.68	0.5
Method 5	0-50	Pearl millet	0	0.32	0.02	1.68	5.71	0.5
	50-100		0	0.35	0.029	2.0	3.97	0.5
	100-200		0	0.31	0.025	1.85	3.7	0.5
	0-50	Peanut	0	0.41	0.032	1.93	5.5	0.5
	50-100		0	0.33	0.033	2.0	5.0	0.5
	100-200		0	0.30	0.033	1.89	3.5	0.5





https://www.pc-progress.com/en/Default.aspx?hydrus-1d

- ✓ *five different model parameterization approaches are tested using Hydrus-1D involving pedotransfer function from (1) soil texture class, (2) top soil description, (3) detailed multilayer soil description; and inverse estimation from soil moisture considering the soil profile as (4) single soil layer and (5) three-layer soil material.*
- ✓ *The model is calibrated and validation under millet (2018 and 2020) and peanut (2019 and 2021), respectively*
- ✓ *The most reliable mehod to properly simulate soil water content and actual evapotranspiration was the three-layer soil description for the pedotransfer function (Method 3) and the inverse estimation, whether it was a single-layer (Method 4) or multi-layer model (Method 5)*

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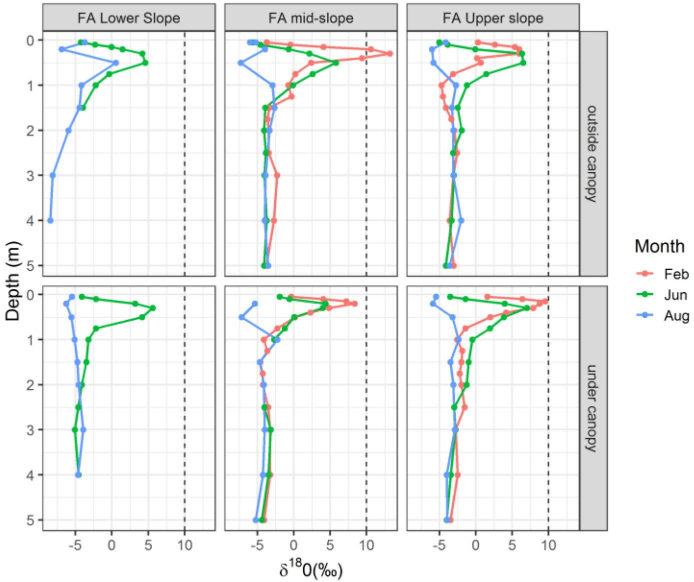
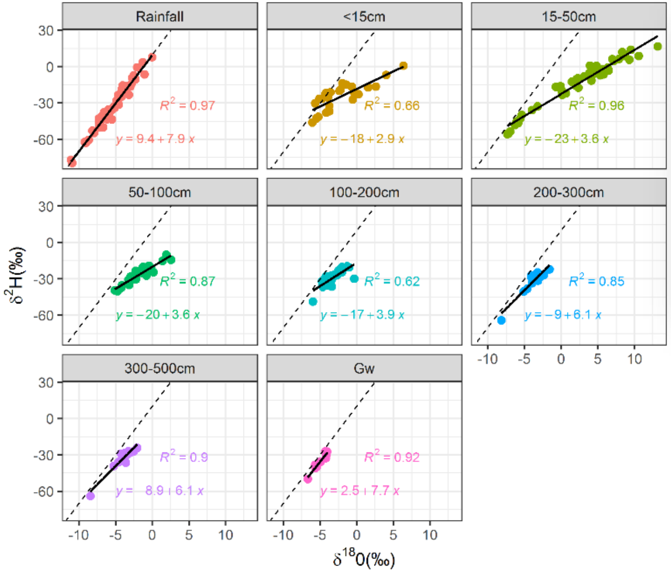
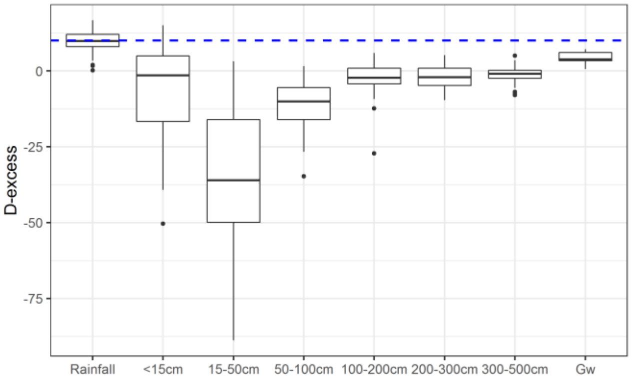
Stables isotopic composition of precipitation, soil water and groundwater of “Faidherbia Flux” site







- ✓ *The soil isotopes profile can be divided globally into two regions: mixing zone (0-100cm) and stabilized zone (>100cm) :*
- *Mixing zone represents the top zone where evaporation, transpiration and infiltration occur, and where the vaporation-affected water mixes with new infiltrated precipitation water. A large proportion of the mixed water returns to the atmosphere through evapotranspiration while a small proportion moves downward into the stabilized zone.*
- *The stabilized zone represents the subsurface zone where soil water isotopes no longer exhibit seasonality and are thus depth-invariant.*
- *During the wet season, the mixing zone is less depleted due to infiltration occurrence. This is evidenced by the d-excess blox and the evaporation lines which have different slope and intercept according to the season: a very low slope in dry season (feb and jun) due to evaporation and a slope of around 6-7 more close to the Local Meteoric Water Line.*

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- Diongue DML, Sow S, Faye W, Stumpp C, Roupsard O, Orange D, Jourdan C, Faye S, Do F. 2021. Estimation of soil hydraulic parameters from a transient water flow field experiment in an agroforestry system of Central Senegal. Conférence Intensification Durable (CID) 2021. Dakar, 23-26 nov. 2021: Senegal.
- Faye, W. et al., 2018. Climatic variability in the Sine-Saloum basin and its impacts on water resources: case of the Sob and Diohine watersheds in the region of Niakhar. ID 3917. China, 8th Global FRIEND-Water Conference. Hydrological Processes and Water Security in a Changing World. November 6-9, 2018.
- Faye, W., Fall, A.N., Orange, D., Do, F., Jourdan, C., Roupsard, O., Kane, A., 2020. Caractérisation des relations eau de surface eau souterraine dans un agrosystème à fortes contraintes climatiques du centre ouest du bassin arachidier : cas des bassins versants de Sob et de Diohine dans l'OPSE de Niakhar (Senegal). Cotonou, Benin, 20-24 November 2020, 4TH INTERNATIONAL CONFERENCE HYDROLOGY OF AFRICAN LARGE RIVER BASINS FRIEND/UNESCO/ INTERNATIONAL HYDROLOGICAL PROGRAMME.

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- Faye W. 2021. Ecohydrologie du bassin arachidier (cas de Niakhar): dynamique de l'infiltration et modélisation des aquifères superficiels dans un espace sylvopastoral semi-aride.

PhD, UCAD : Faculté des Lettres et Sciences Humaines, Géographie. Dakar, Sénégal. Thèse défendue le 10 décembre 2021

Shared databases

Faidherbia-Flux_Collaboratif\Database

https://baobab.sedoo.fr/