Meeting of SWATCH project
University of Cagliari
Via Marengo, 2 Cagliari, Italy

June 20-21, 2023

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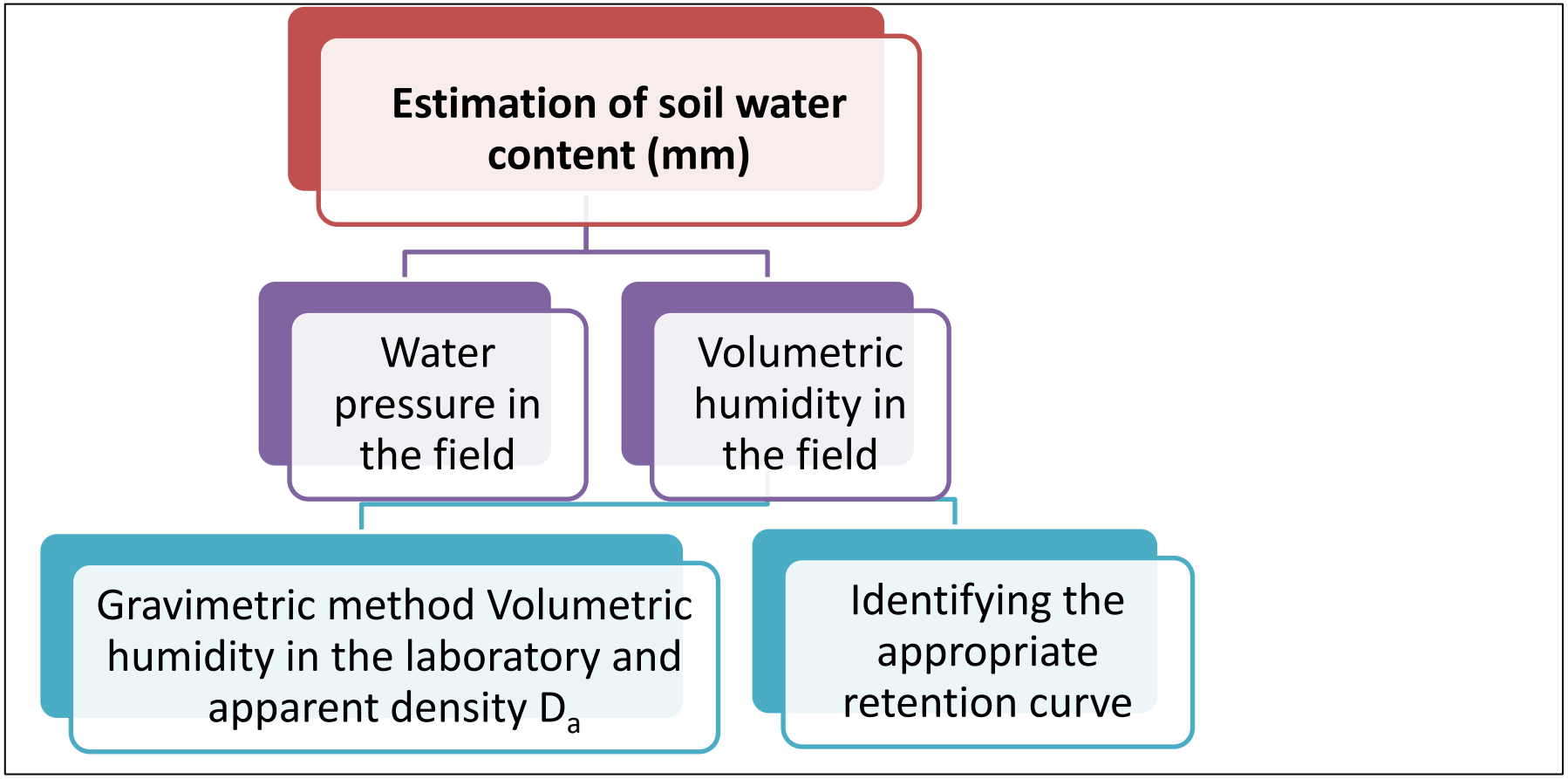
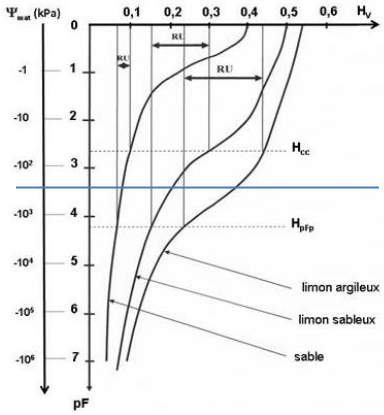
WP2 Monitoring of experimental fields and hydrological basins

Soil Water pressure and volumetric humidity


Estimation of soil water content (mm)
Water pressure in the field
Volumetric humidity in the field
Gravimetric method Volumetric humidity in the laboratory and apparent density D_a
Identifying the appropriate retention curve

préalablement séchés et broyés et dont la teneur en eau est « équivalente » à celle de la capacité au champ mesurée après ressuyage du sol. On reviendra plus loin (§ III.4) sur le bien-fondé de cette approximation. Les 3 flèches horizontales notées RU sur la figure 10 indiquent la gamme d'humidité utile pour chaque type de sol. On voit que pour le sol sableux grossier elle est comprise entre 0,07 et 0,1 soit 3% d'humidité volumique. Pour le sol sablo-limoneux elle est comprise entre 0,15 et 0,30 soit 15%, et pour le sol limono-argileux entre 0,23 et 0,43 soit 20%. Ces chiffres ne font qu'illustrer un phénomène très général bien connu : plus la texture est fine et plus la capacité du sol à stocker l'eau est importante.



Level of sensitivity of watermark device

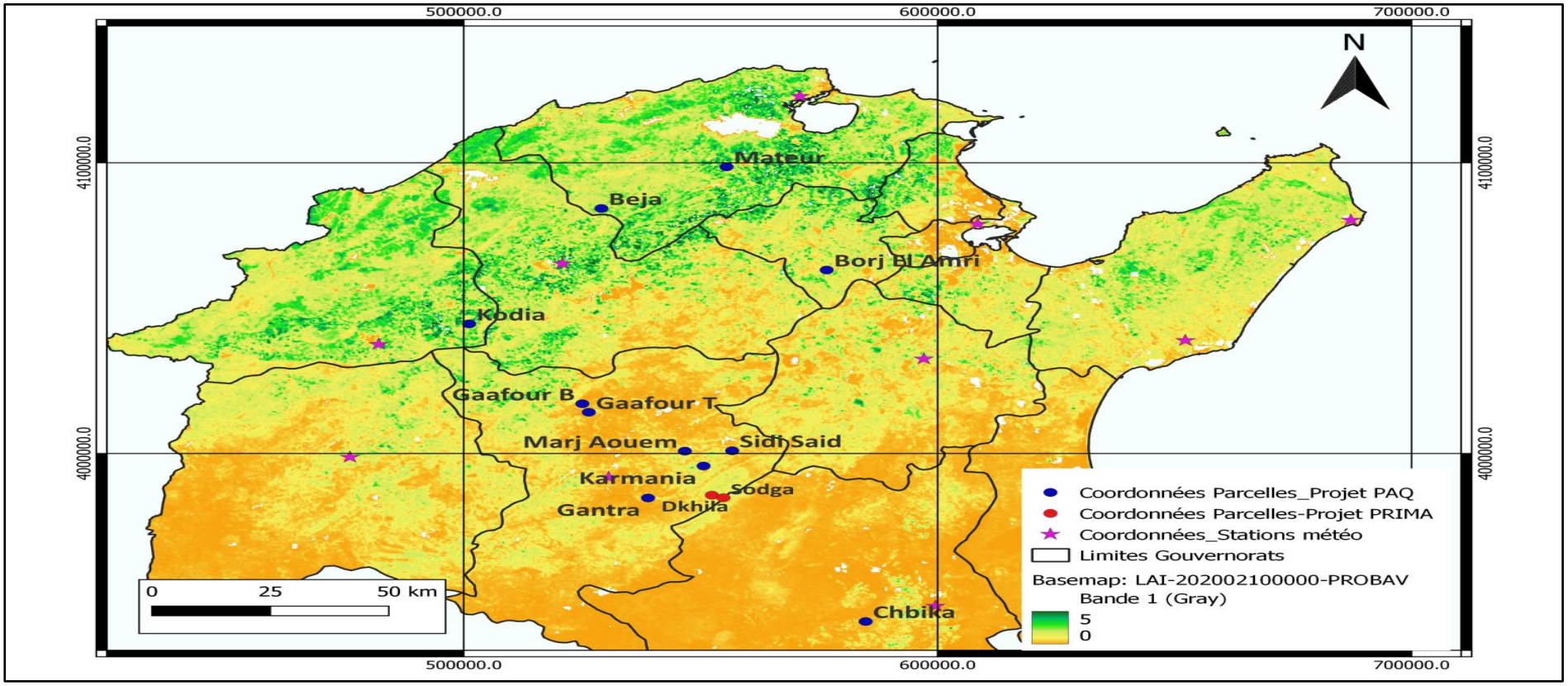
***Figure 10**. Exemple de courbes expérimentales potentiel hydrique – humidité volumique pour trois types de sol.*

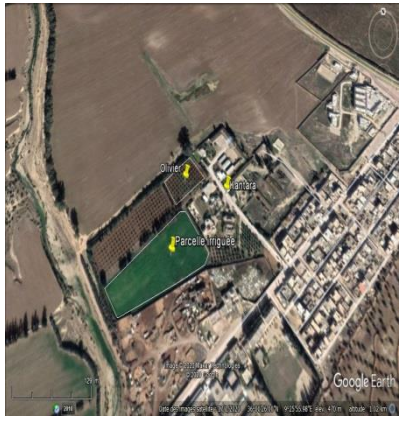
[1] Cette notion de point de flétrissement permanent est au départ purement agronomique et s'applique aux principales plantes cultivées. Les végétaux adaptés aux régions arides, ainsi que beaucoup d'espèces d'arbres ont la capacité d'extraire de l'eau du sol à des valeurs de potentiel hydrique plus faibles, donc au-delà de la valeur de pF 4,2

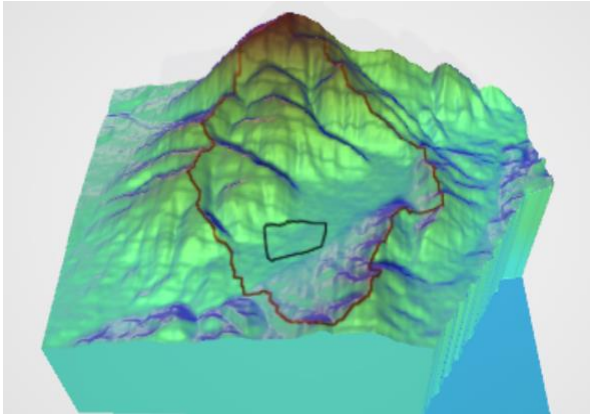
III.3.4. Principaux facteurs de variabilité de la relation potentiel-humidité

La relation Hv = f(Ψm) présentée ci-dessus joue évidemment un rôle majeur dans la description des transferts d'eau en sol non saturé, notamment lorsqu'il s'agit de modéliser l'évolution, au cours de la saison culturale par exemple, des composantes du bilan hydrique ou la distribution spatiale de l'eau dans le sol. L'observation montre

Studied sites (PRIMA and PAQ-Post PFE project)

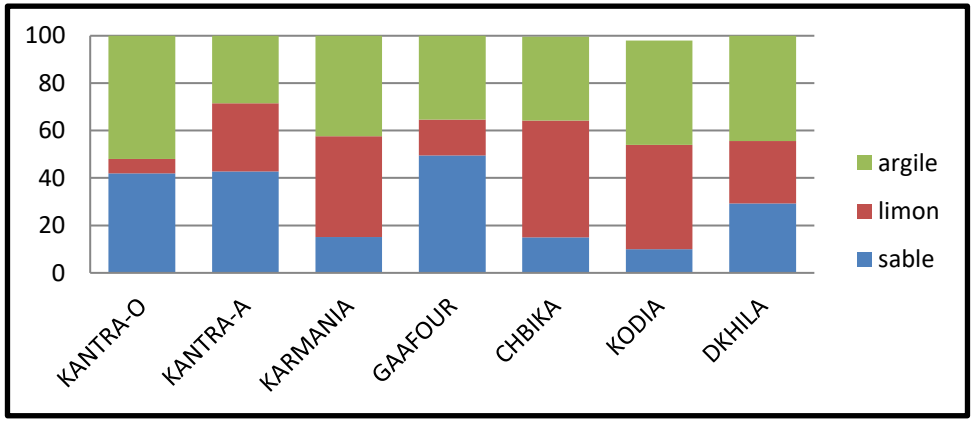






General information

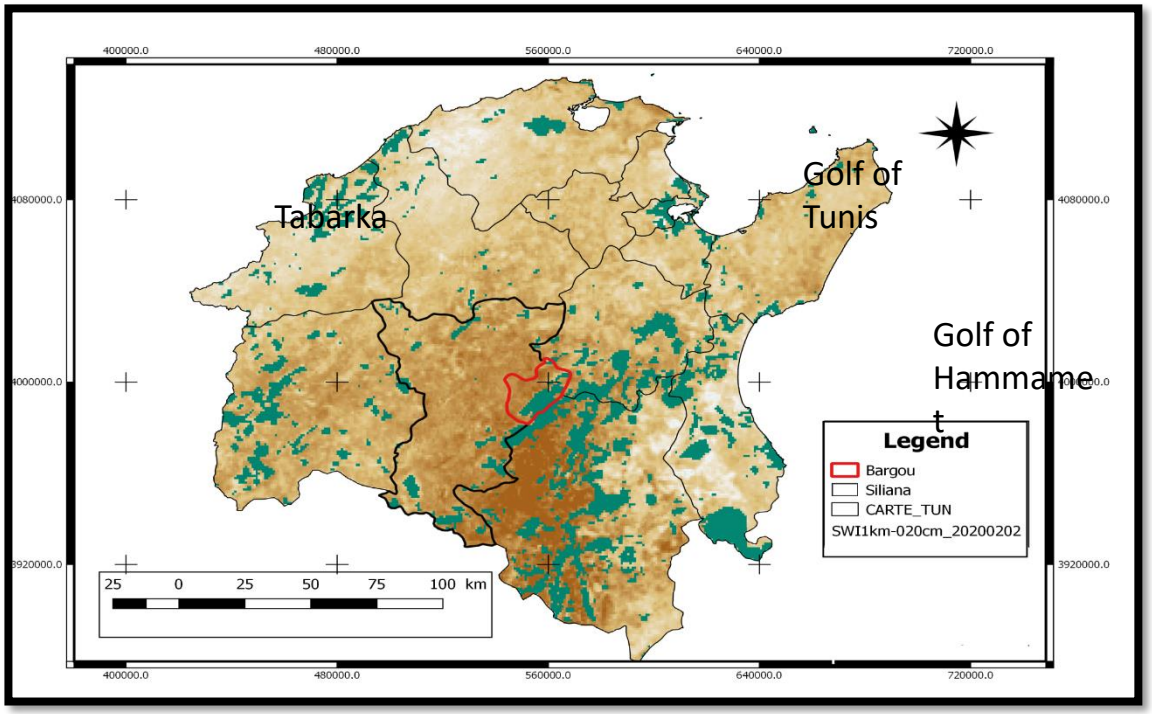
Parcelles	Crop type	Area ha	Texture (dominant)
GANTRA (PRIMA)	OLIVES	0.4	Argilo-sableuse
GANTRA	CEREALES (Avoine)	1.3	Limoneuse
KARMANIA	CEREALES	7	Argilo-limoneuse
GAAFOUR - BARAKETI	Arboriculture	10.6	Sablo-argileuse
CHBIKA	CEREALES	20.3	Limoneux argileux fin
KODIA	CEREALES	32.8	Argilo-limoneuse
DKHILA (PRIMA)	**Arboriculture**	**47**	**Argilo-limoneuse**

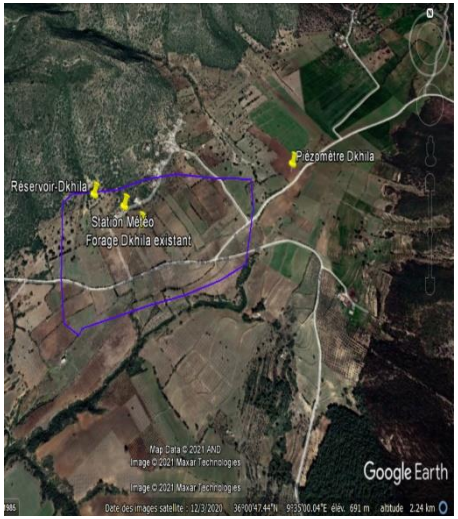


Study area for PRIMA

- Sodga and Dkhila Public irrigation districts are located in Bargou Mountain under Mediterranean climate with hot and dry summers. This region is 120 km far from Tunis Capital.
- Environmental risks are mainly floods, erosion and hails.
- Climate change risk is elevation of minimum and maximum temperature as well as reduction of rainfall.
- Natural forest occupation, mostly Aleppo pine and carob trees, together with cereal and arboriculture crops (mainly olives, apple and cherries) represents the land cover.
- Sodga Public irrigation district was implemented by local authority in 1984. It covers 120 hectares subdivided into 46 orchards belonging to 54 farmers.
- Dkhila district covers 50.5 ha belonging to 32 farmers.
- Both districts use turn drip irrigation using groundwater resources.
- Public district means that local authority provides irrigation infrastructure as well as pumping infrastructure and farmers provide land and intrants and pay for irrigation water access.

Study area: Dkhila located in Bargou, Siliana (map SWI_{sat})





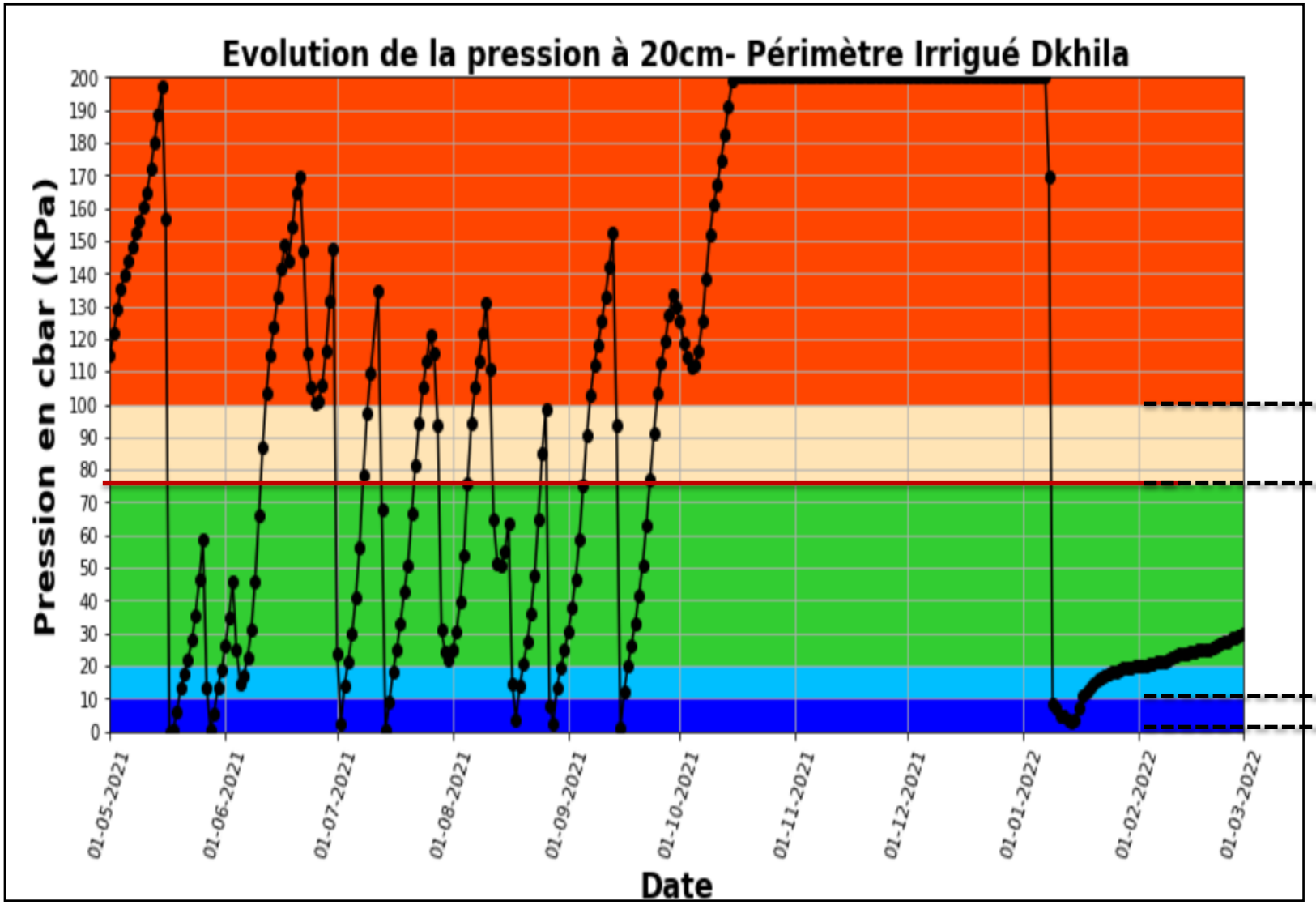
Experimentation in Dkhila

- 12 tensiometers (Watermark) to monitor soil water pressure under 4 apple trees at 20, 40 and 60 cm depth.
- 4 soil thermometers
- One single tree is monitored automatically at the three depths.
- Water use volumes are monitored by orchard by local NGOs representing farmers.
- Local water authority monitor groundwater table using piezometers.

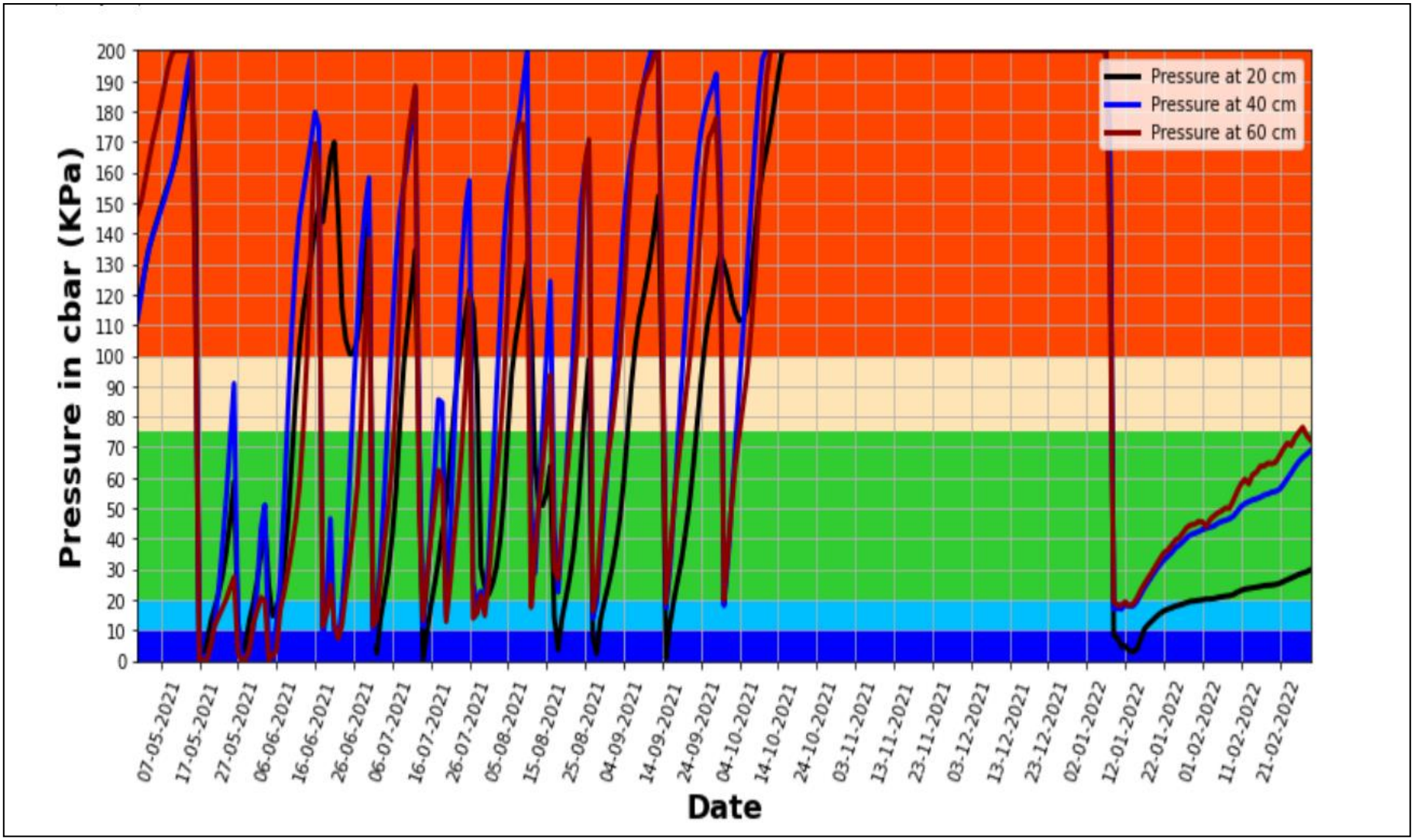
Water status according to soil water pressure

- 0-10 cbar saturation
- 10-20 cbar humid
- 20-40 cbar good conditions
- 40-100 cbar water supply by irrigation is needed (limits depend on soil texture)

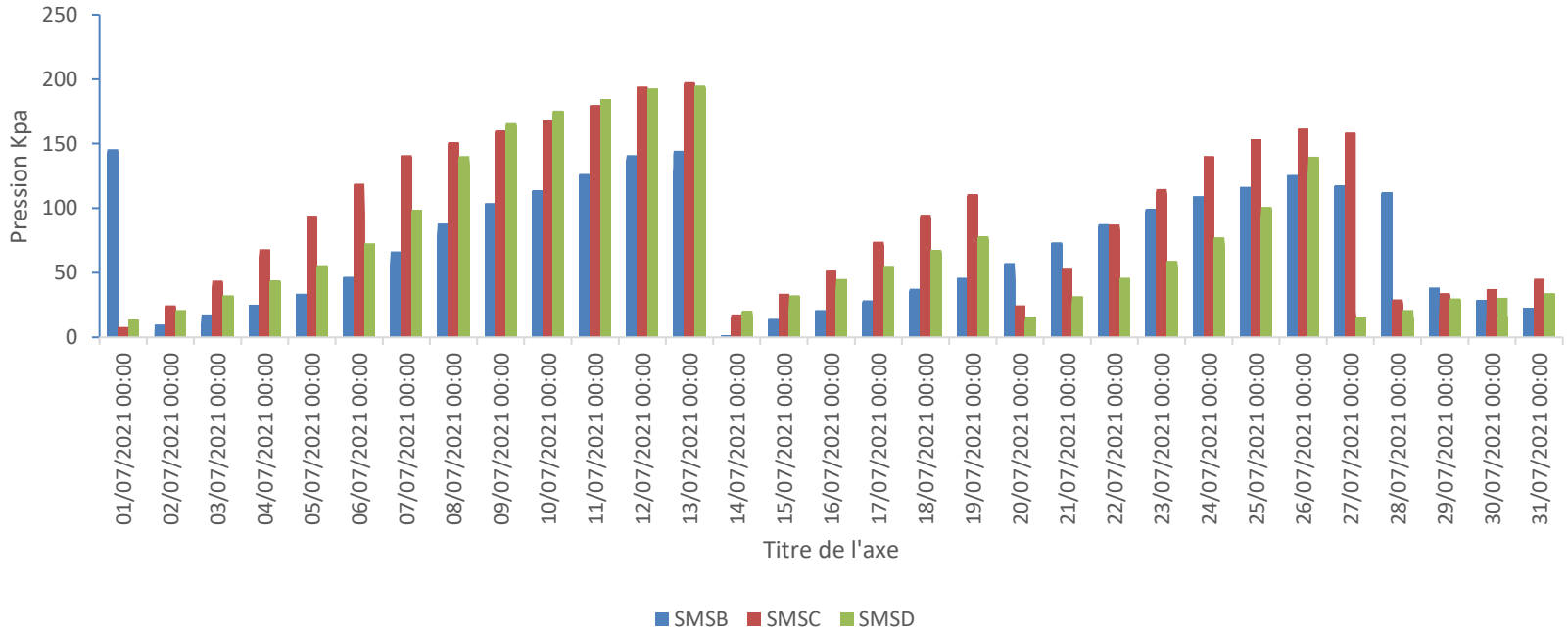
Observed pressures in Dkhila DATA LOGGER (DKHILA Argilo-limoneuse; threshold =75 cbar)



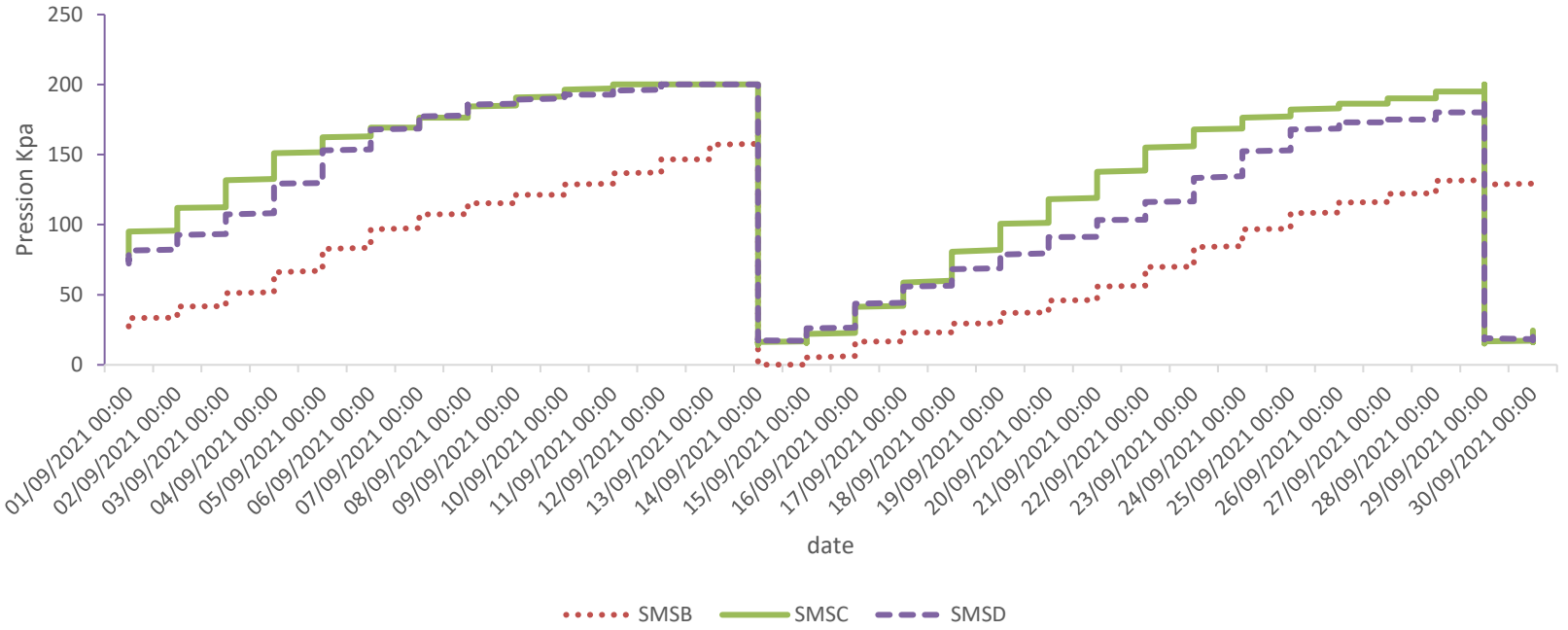
Pressure measurements recorded by the DATA LOGGER at 20, 40 & 60cm -IP DKHILA



July 2021
SMSD: 20 cm- SMSC: 40 cm- SMSB: 60 cm

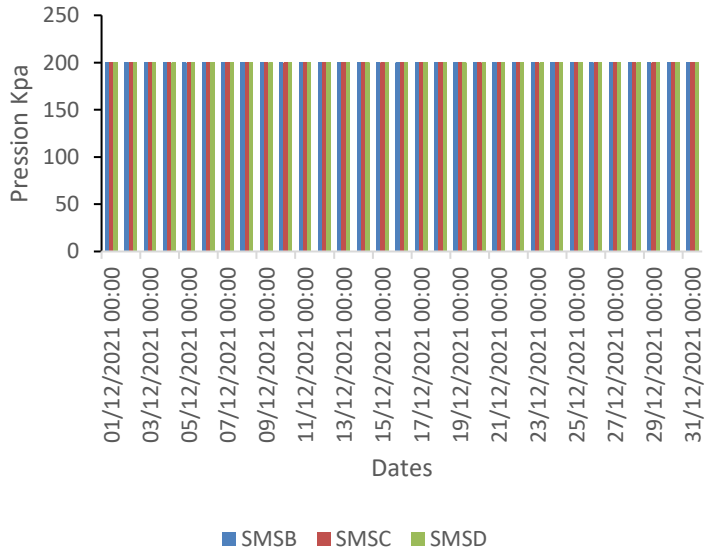


September 2021
SMSD: 20 cm- SMSC: 40 cm- SMSB: 60 cm

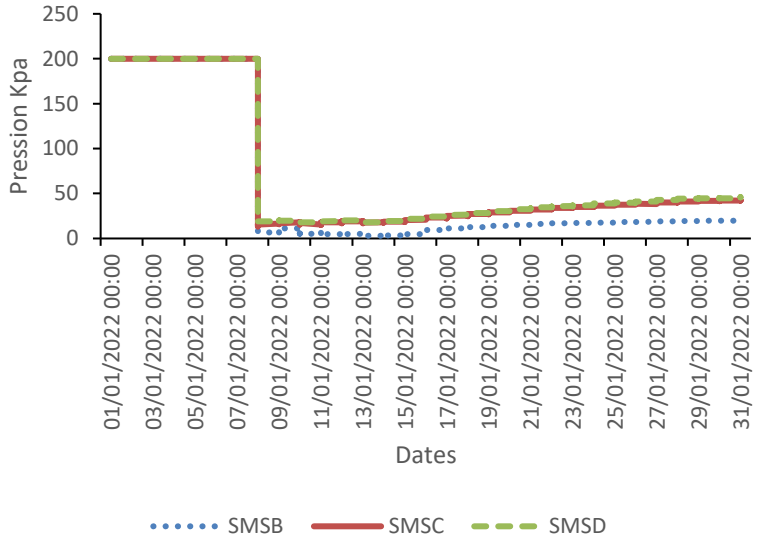


December 2021 et January 2022 SMSD: 20 cm- SMSC: 40 cm- SMSB: 60 cm

Décembre 2021

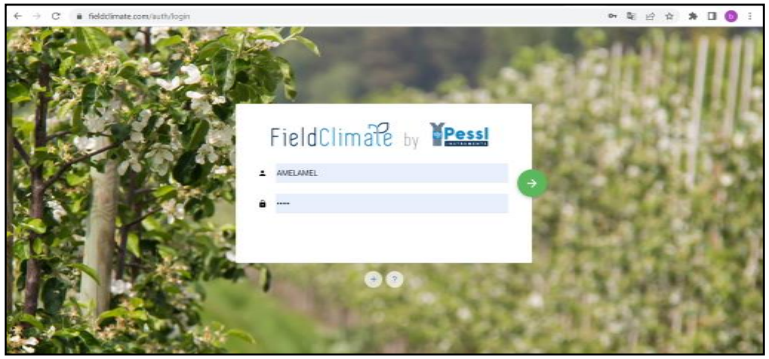


Janvier 2022

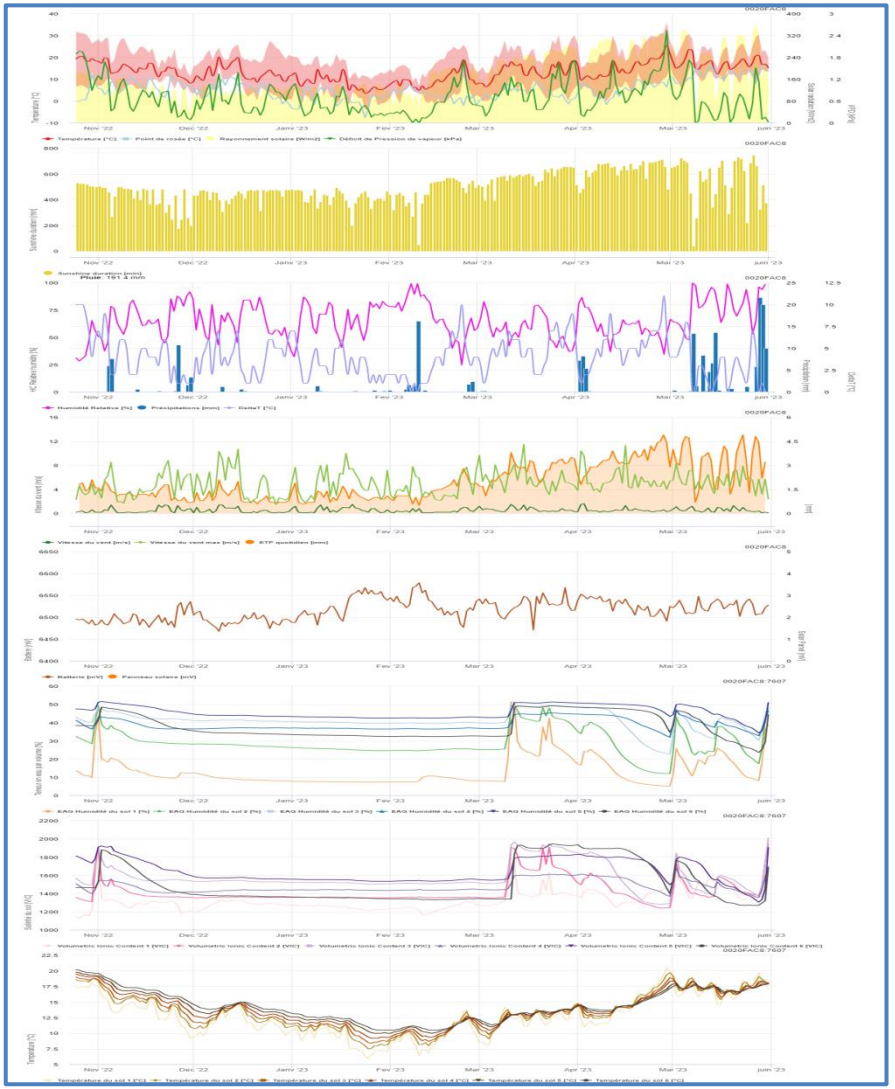


New meteorologic station in GANTRA

- Rainfall
- Air temperature
- Dew point temperature
- Relative air humidity %
- Solar energy
- Estimation of Potential evapotranspiration
- Wind velocity
- Soil moisture every 10 cm (%)
- Soil temperature every 10 cm
- Soil salinity

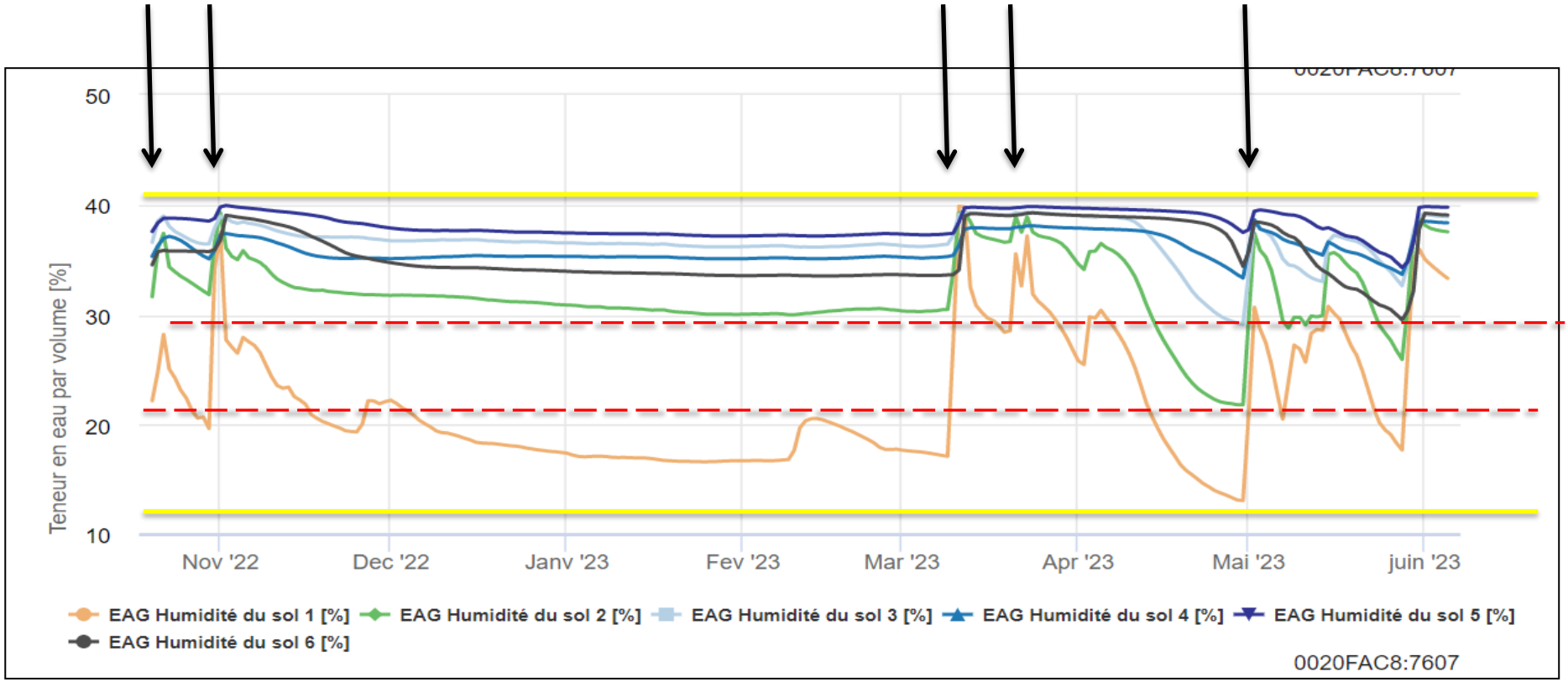


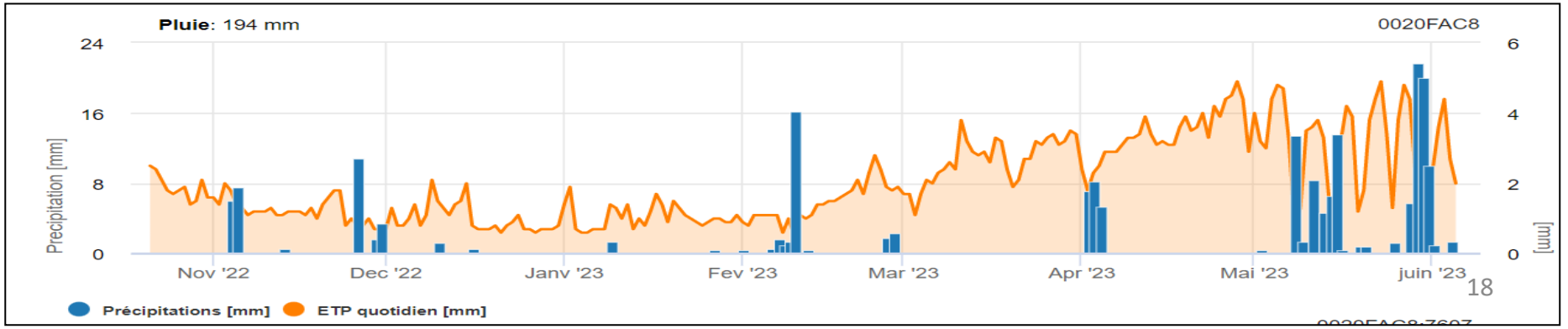
https://www.fieldclimate.com/



Date/heure	Température [°C]			Point de rosée ...		Ray...	Déficit de Pres...		Humidité Relat	
	moy	max	min	moy	min	moy	moy	min	moy	max
2022-11-15 06:00:00	7.74	8.5	7.19	6.7	6.3	0	0.07	0.05	93.46	94.6
2022-11-15 05:00:00	7.67	8.89	6.39	7.1	6.3	0	0.03	0	96.67	99.9
2022-11-15 04:00:00	6.93	7.24	6.63	6.9	6.6	0	0	0	99.99	99.9
2022-11-15 03:00:00	7.74	8.36	7.1	7.6	7	0	0.01	0	99.36	100
2022-11-15 02:00:00	9.5	10.41	8.58	8.4	7.7	0	0.08	0.04	92.87	96.3

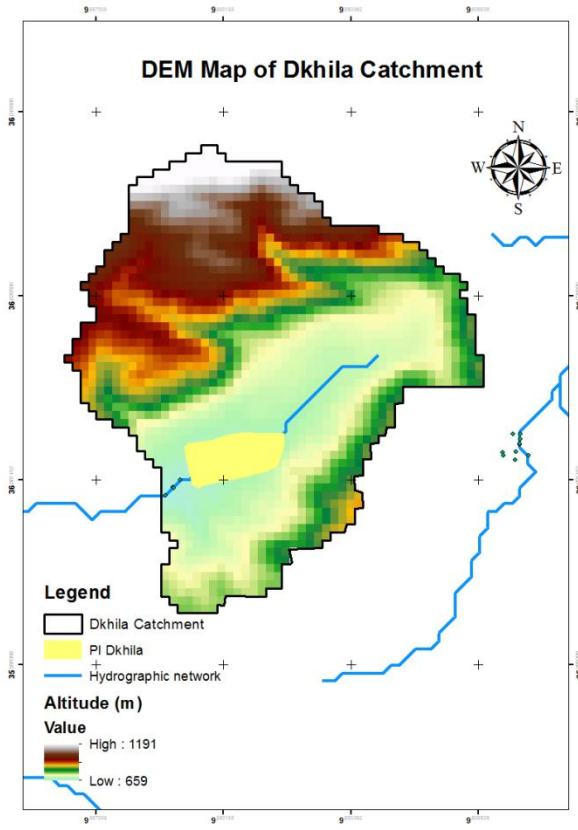
Gantra site Continuous observation of Volumetric humidity



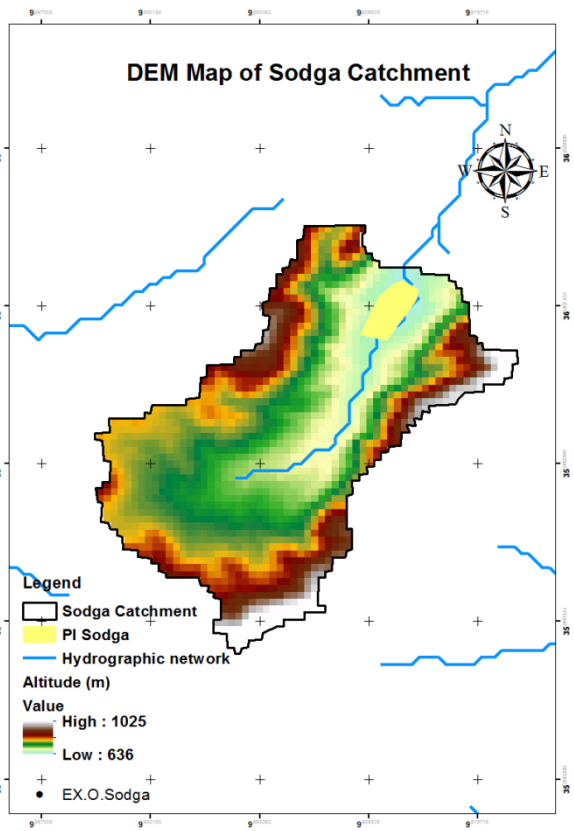


Dkhila and Sodga basins

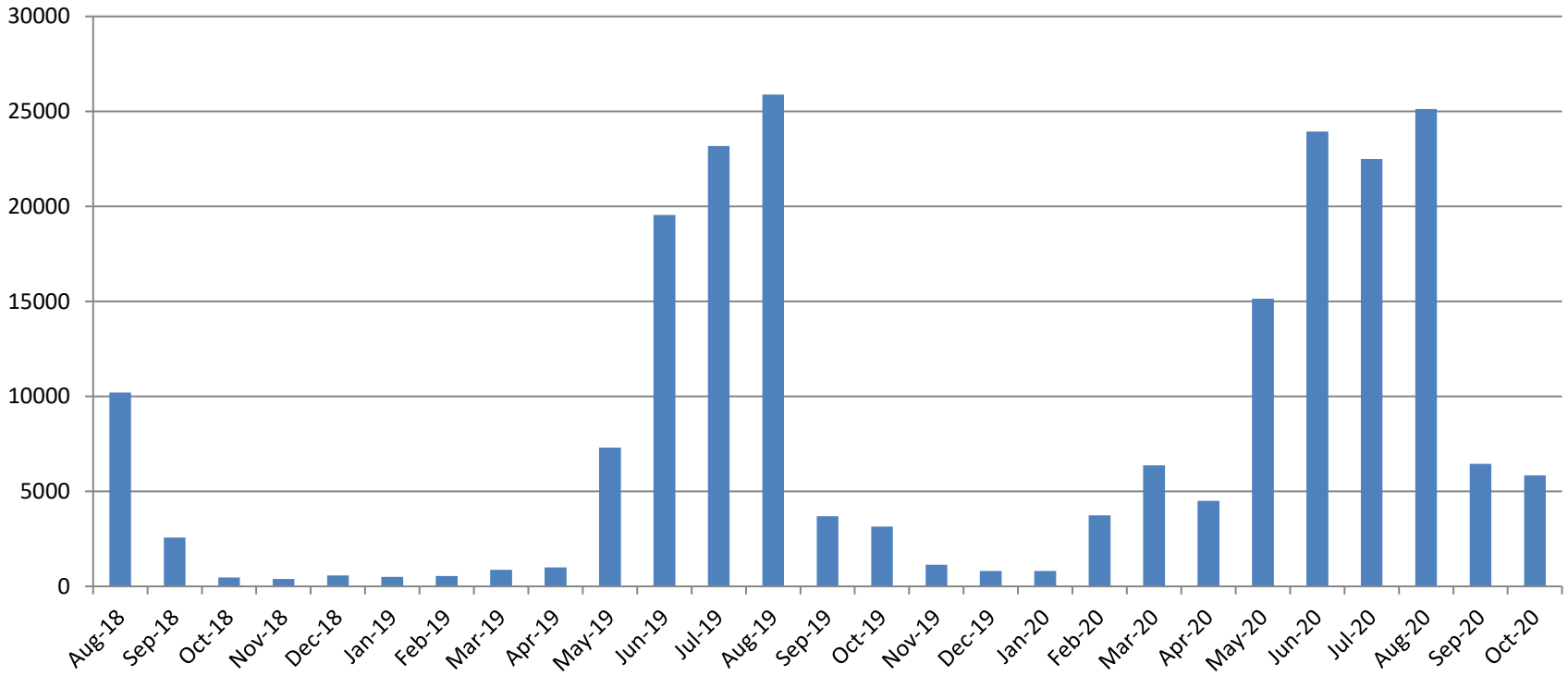
Dkhila



Sodga



Dkhila pumping energy consumption per month (KWH) in Dkhila (according to energy invoice)



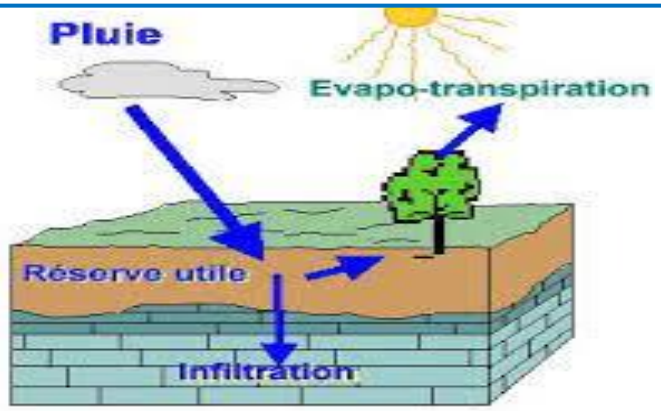
Annual Energy consuption (KWH)	**117355**
Annual Water consumption m3	**158142.00**
Energy efficiency (KWH/m3)	**0.70**

WP3 Ecohydrological modeling

BBH Model (Input & Output): (developed on the basis of Kobayashi et al., 2001)

$$\Delta W = W(t+1) - W(t) = (\mathrm{P} + \mathrm{I}) - (\mathrm{AET} + \mathrm{Rs} + \mathrm{Gd})$$

W : soil water content
AET : Actual evapotranspiration
Rs: Runoff
Gd: percolation



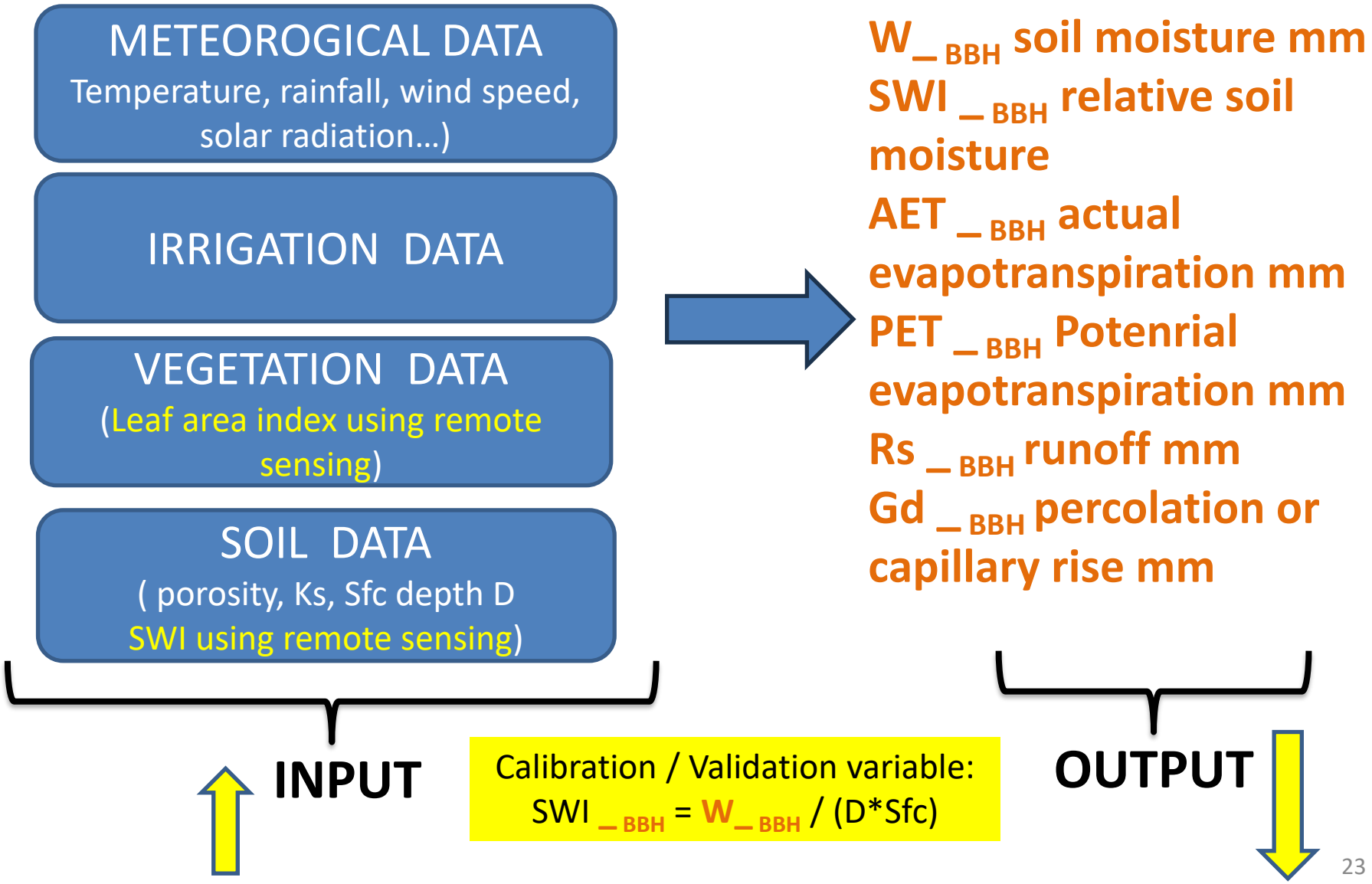
- Developments:
- Penman Monteith equation
- the Jarvis model for representing stomatal conductance using LAI threshold;
- a linear relationship between crop coefficient and satellite LAI observations

$$AET = K_s * K_c * ET_0$$

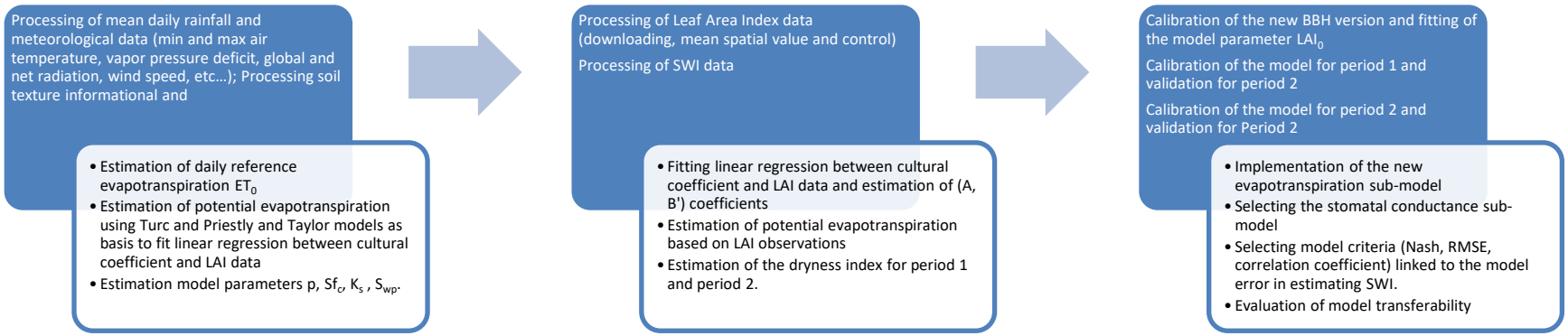
$$where\ Kc = A * LAI + B$$

$Ks =$ **meteorological data; LAI; water content)**

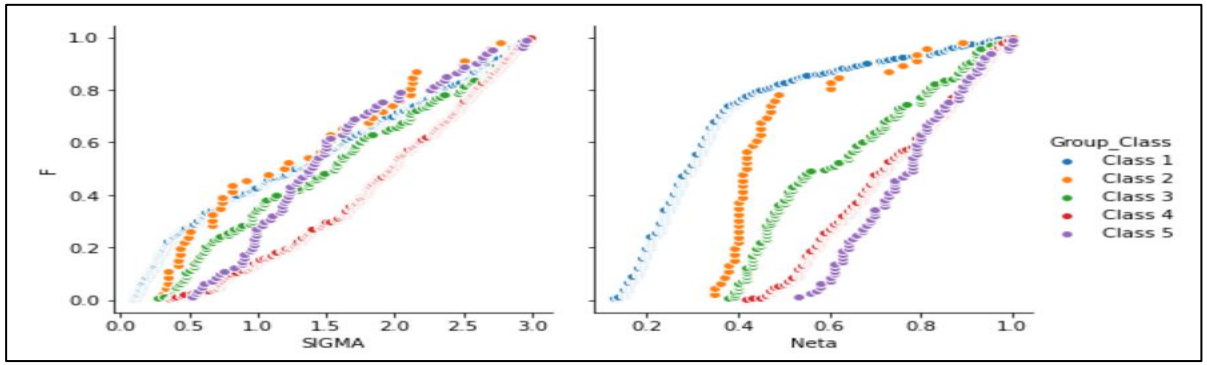
BBH Model new version (Inputs & Outputs)

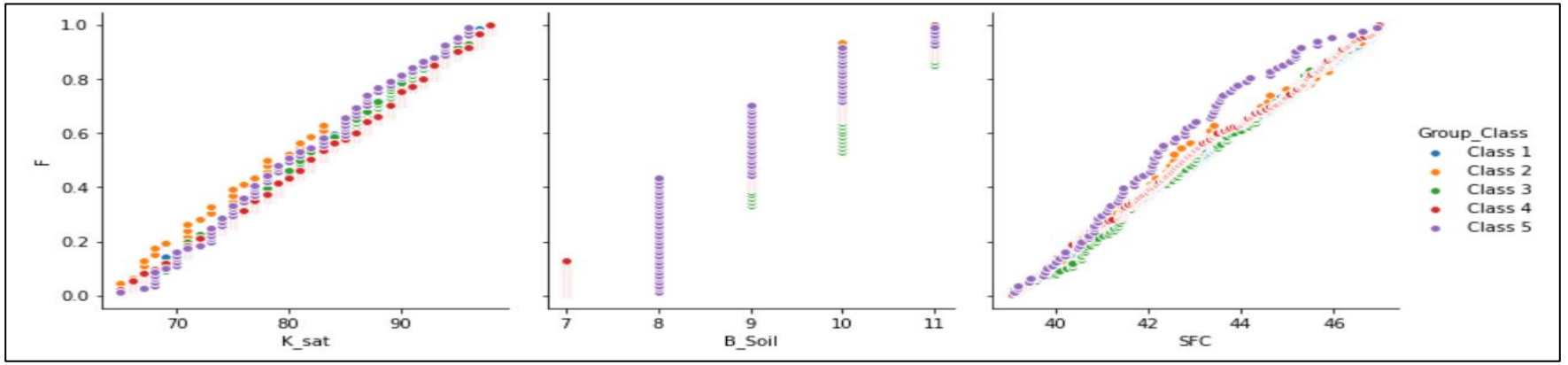


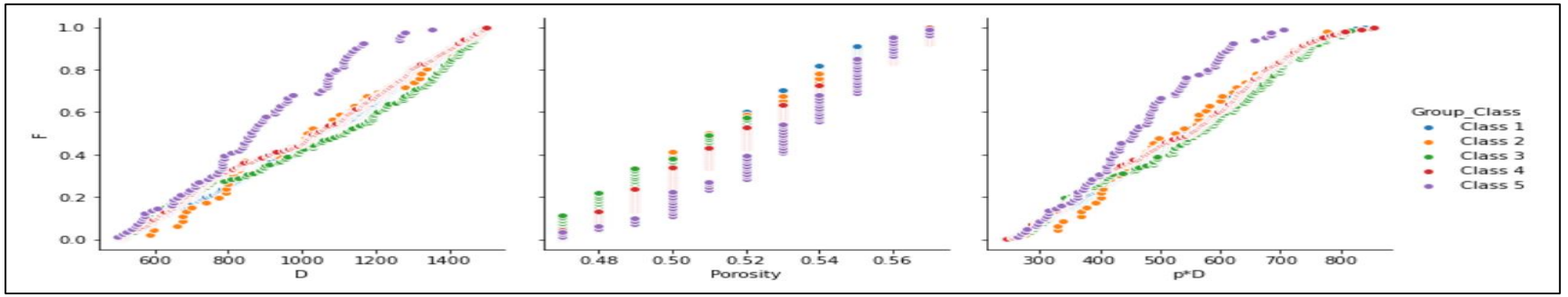
Methodology (use of two calibration- validation periods)
Sensitivity analysis (initial and improved version of the model)



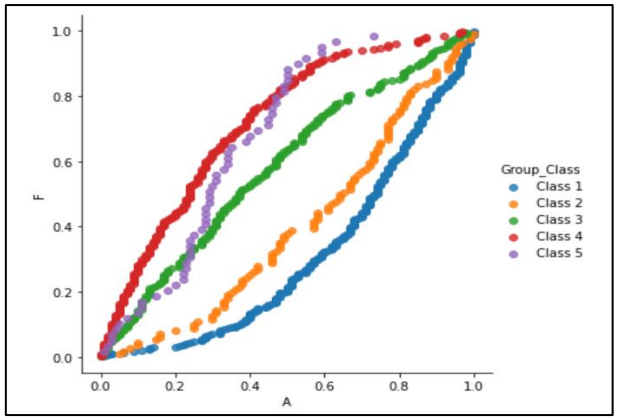
Sensitivity analysis Bargou crop land 1/9/2016 to 30/4/2017 : **Initial** BBH (rainfed cereals)

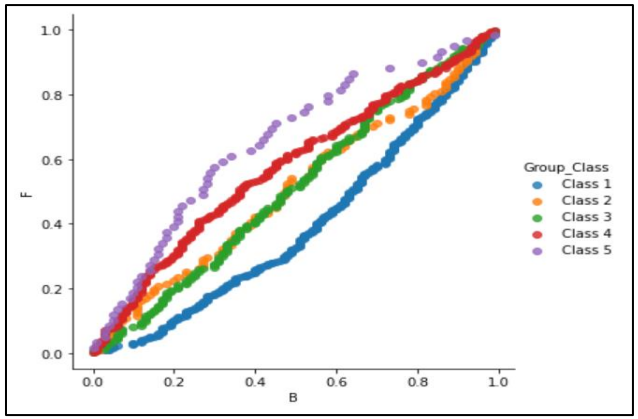


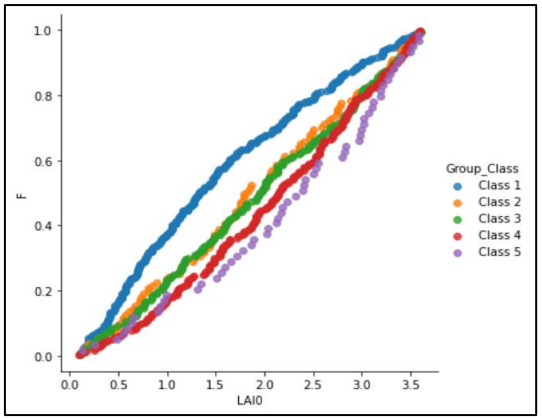


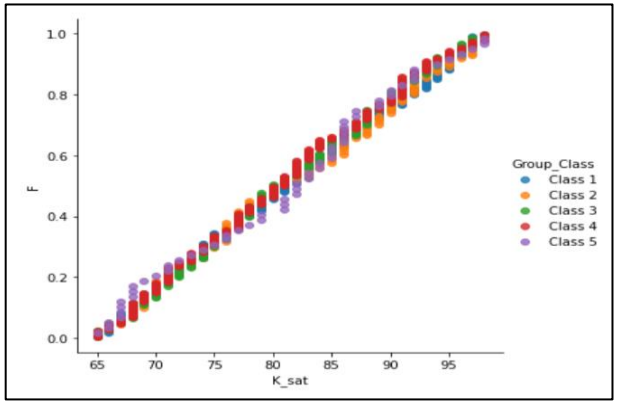


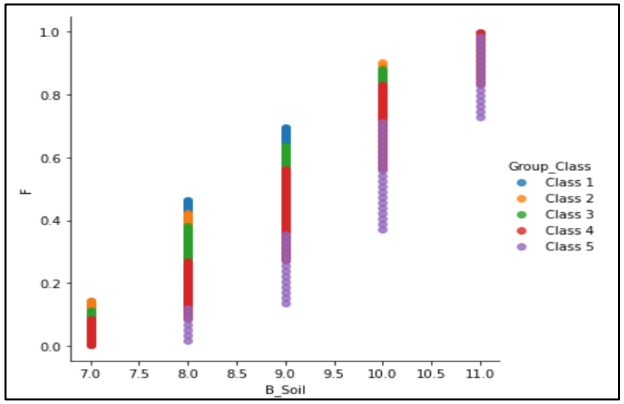
Sensitivity analysis Bargou crop land 1/9/2016 to 30/4/2017 : **Updated BBH** (rainfed cereals)

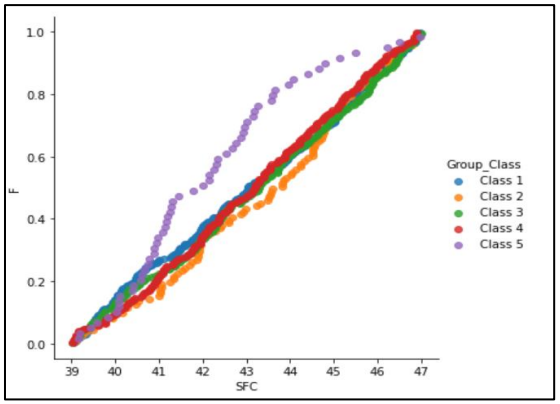


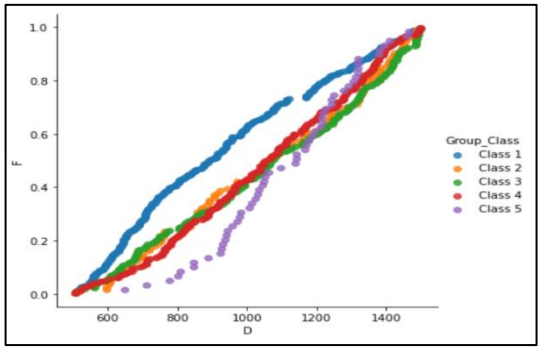


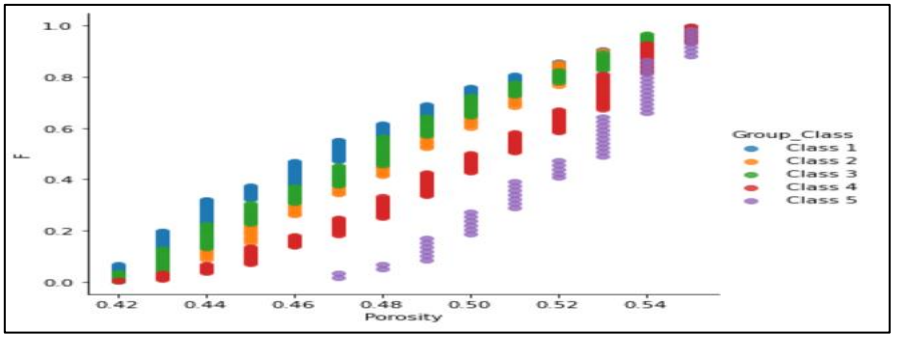










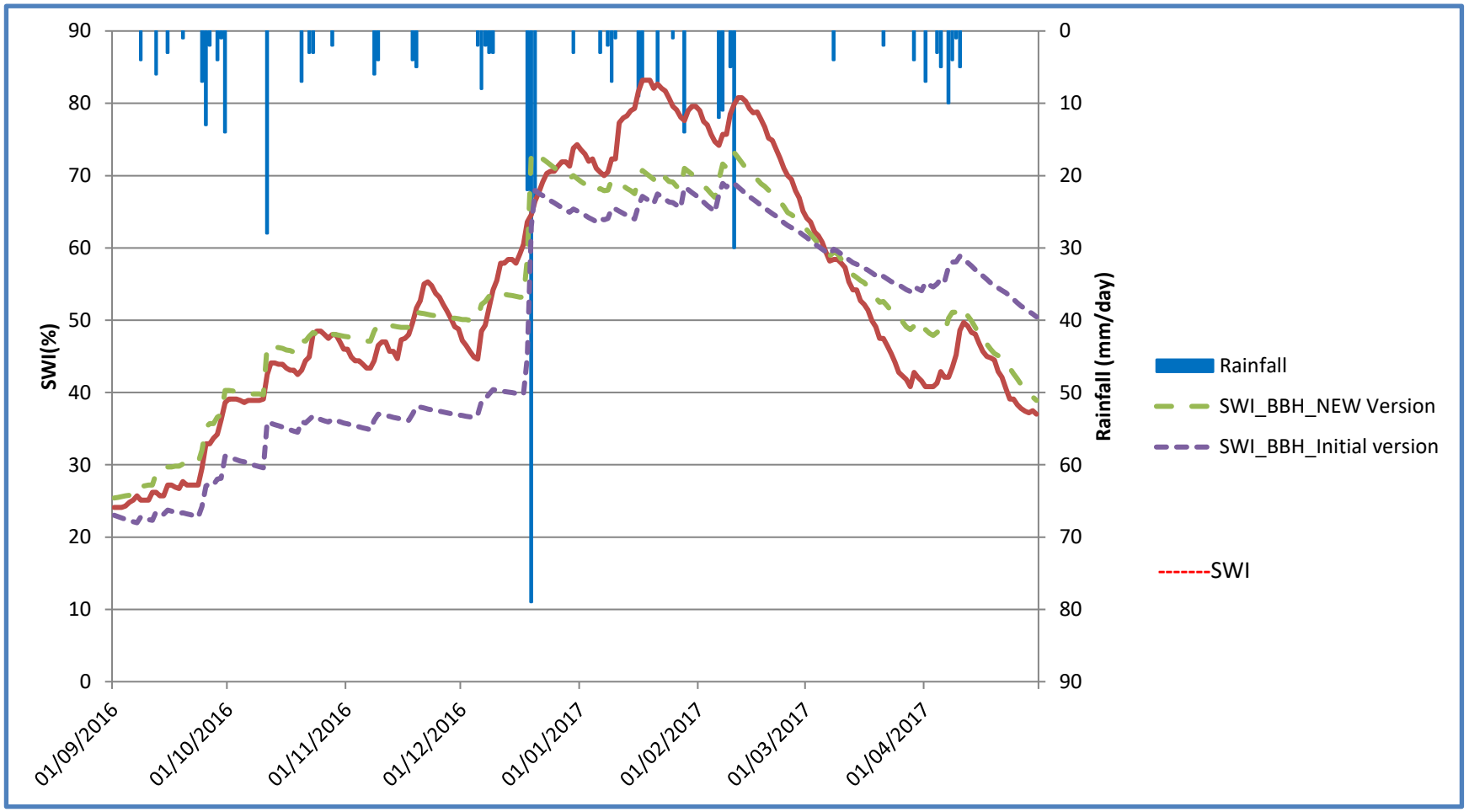


Improvement of AIC Criterion with the new model version Per1:1/9/2016 to 30/4/2017 ; Per2: 1/9/2017 to 30/4/2018 (rainfed cereals)

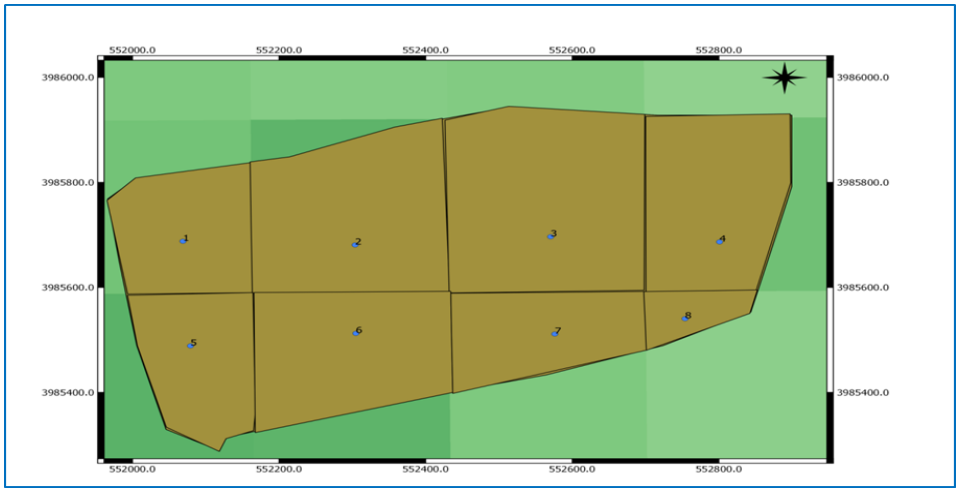
$$AIC = -2\ln(L) + 2k$$

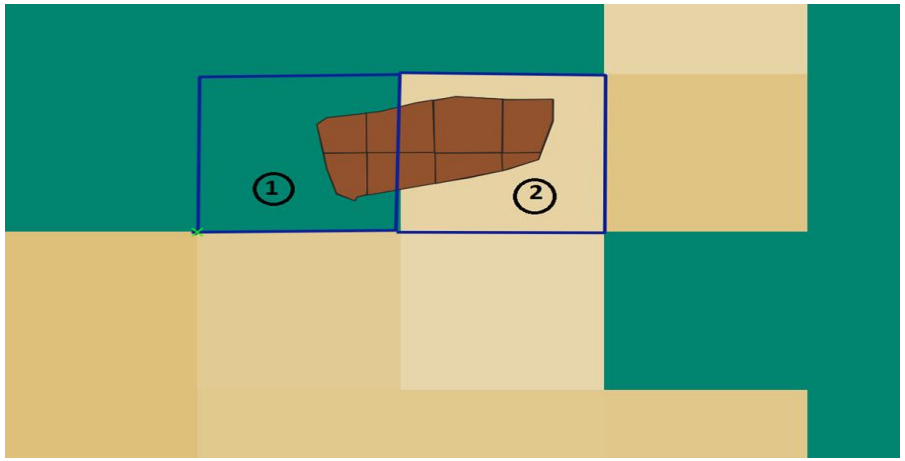
AIC Criterion	BBH initial	BBH New	Gain (%)
Bargou Per1	1414.3	1251.3	11.5
Bargou Per2	1589.2	1214.3	23.6
Mateur Per1	1690.6	1358	19.7
Mateur Per2	1604.6	1519.4	5.3
SidiSaid Per 1	1551.2	1351.6	12.9
SidiSaid Per 2	1633.9	1267.4	22.4

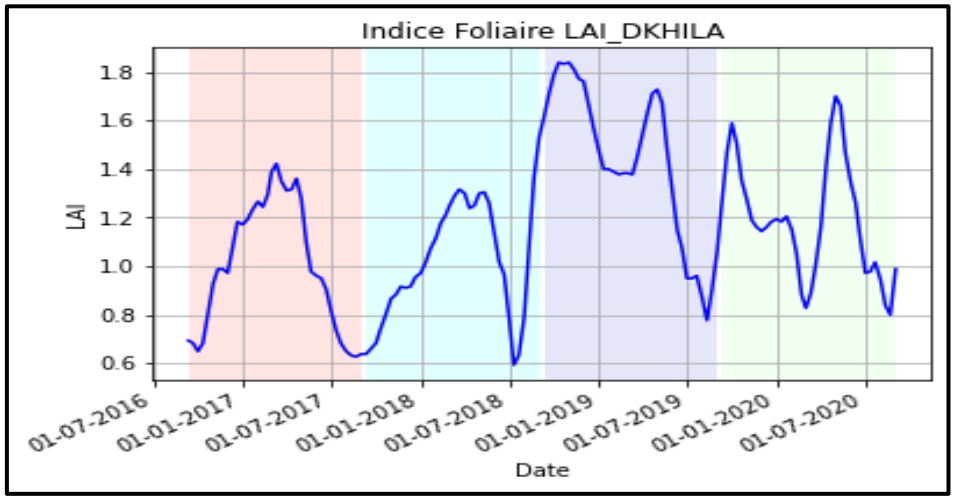
Comparaison of Initial to updated version of BBH Model (P1)

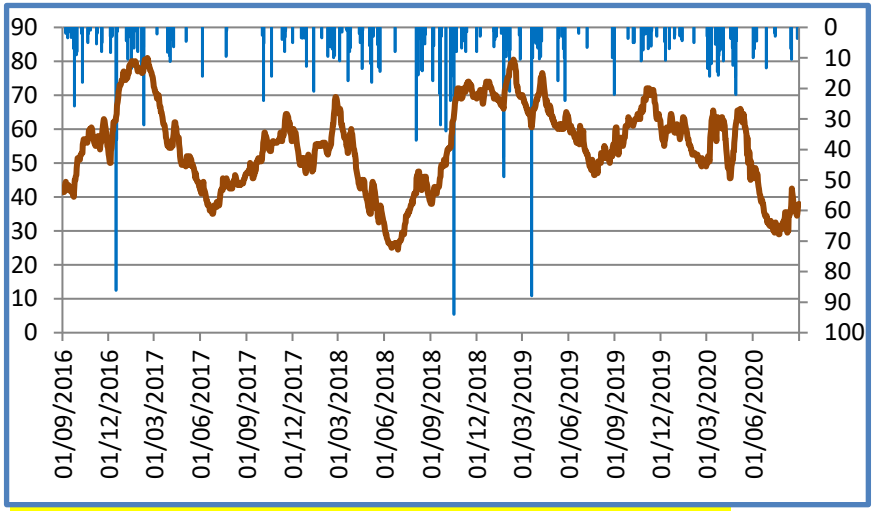


Estimation of satellite LAI & SWI









$$LAI_{moyen-Parcelle} = \frac{\sum(LAI_j * S_j)}{S_{tot}}$$

LAI and SWI time series

Meteorological Data:

→ **Nearest meteoroligical and rainfall station**

Soil data Pedotransfert function:

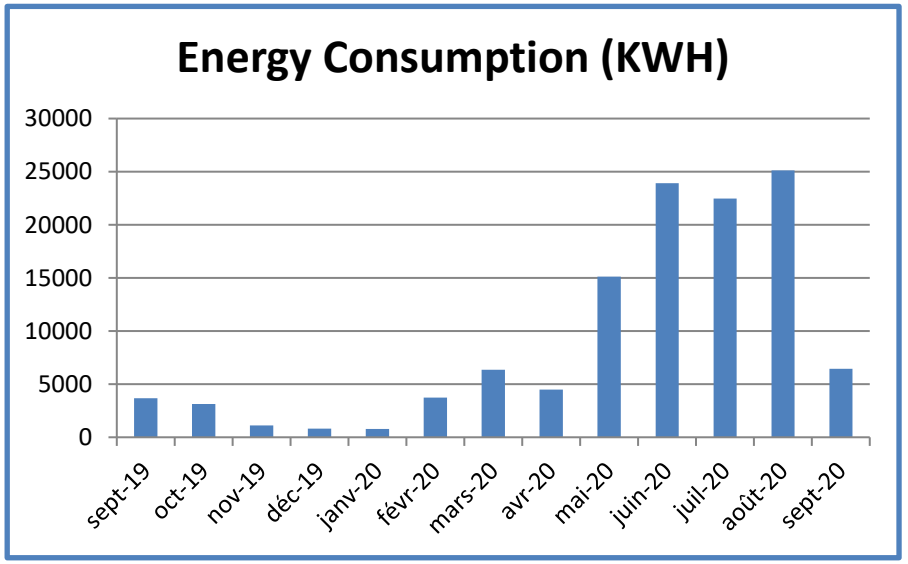
→ **Soil Map**

Surface(ha) DKHILA	texture	Sand fraction (%)	Clay fraction (%)
5,05	Sandy - Clay	52	42
37,84	Silty - Clay	6	47

	Sfc	porosity	Ks (mm/j)
DKHILA	0,47	0,49	124,3

Estimation of applied irrigation

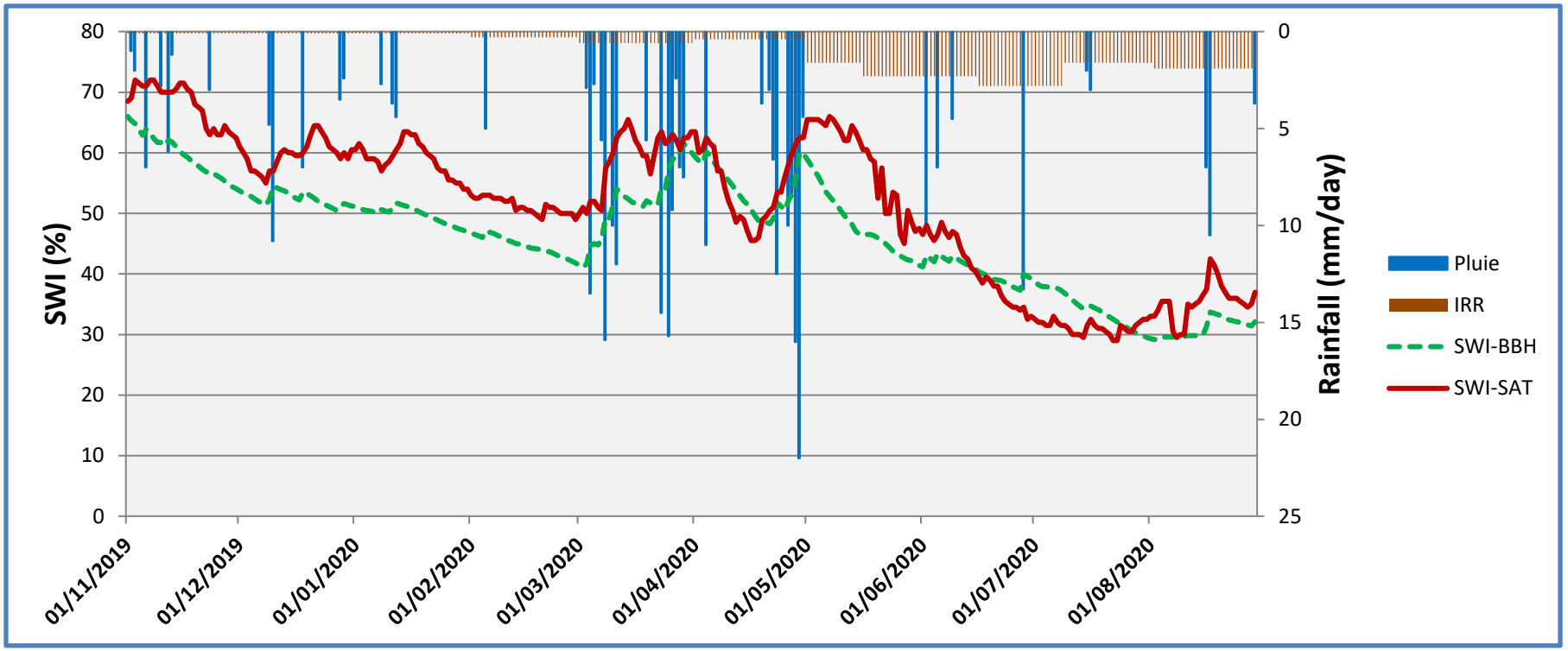
Water consumption per farmer and modelling water-energy to fill the gaps in water consumption data (statistical regression)

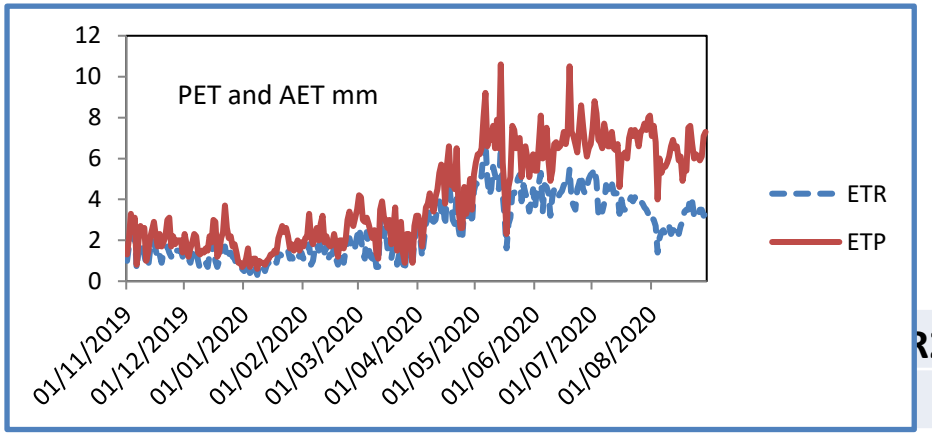


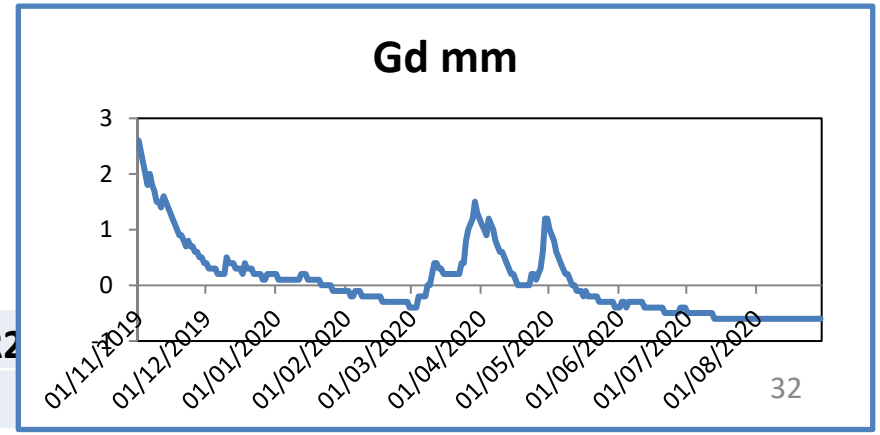
Period	Sum Sep 2019 May 2020	Sum 15 Mai -15 Juin 2020	Sum 15 June-8 July 2020	Somme 8 July – begining of August 2020	Sum August -20 sep 2020
Energy (KWH)	18432	19538	17773	16687	29425
Water Volume (m3)	33901	33324	30234	16824	46596
Consuption (mm/Period)	72.1	70.9	64.3	35.8	99.1
Conumptionn (mm/Jour)	2.49	2.29	2.80	1.49	1.98

Simulation Dkhila (2019-2020)

RMSE	Correlation R2	NASH
7.2	0.93	0.65







Water balance (November 2019- August 2020)
Rainfall 350 mm

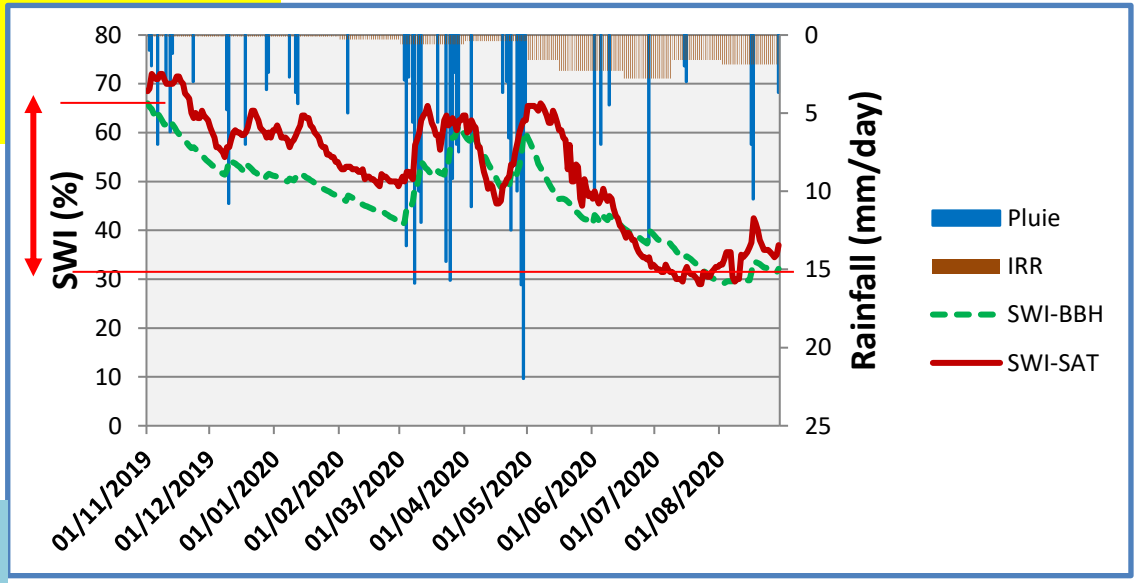
$$\Delta W = W(t+1) - W(t) = (\mathrm{P} + \mathrm{I}) - (\mathrm{AET} + \mathrm{Rs} + \mathrm{Gd})$$

W(Aug2020)-
W(Nov2019)= -148 mm

W(Aug2020) =
W(Nov2019) - 148 mm

Sfc*D= 470 mm

ΔW/ (Sfc*D)*100= 31.4 %



SWI initial:
68.5 %

SWI final:
34.5 %

changement:
- 34 %

P+I mm	650
PET mm	1259.8
E mm	777.6
E/PET	0.63
Rs mm	0
Gd mm <0 Percolation	60.4
Gd mm>0 cap. rise	80.6
E/(P+I)	1.2

Comparison between monthly BBH estimations and MODIS for Actual evapotranspiration