Task 3.2: modelling combined processes (leader: INAT)

- **Coupling distributed hydrology modelling along with crop growth modelling (**MHYDAS model and SAFY crop growth model within the OpenFLUID platform)

Partners : CESBIO, LISAH, INRGREF
Study area : Capbon

- **Semi-distributed hydrology along with subsurface hydraulic redistribution (SWAT model)**

Partners : INAT, UNICA.
Study areas: Merguellil

- **Hydrological modelling and climate forcing**

Partners: UCAM, CESBIO, UNICA.
Study areas: Tensift.

Coupling distributed hydrology modelling along with crop growth modelling

LISAH - INRGREF

Study area : Capbon

Task 3.2: modelling combined processes (leader: INAT)

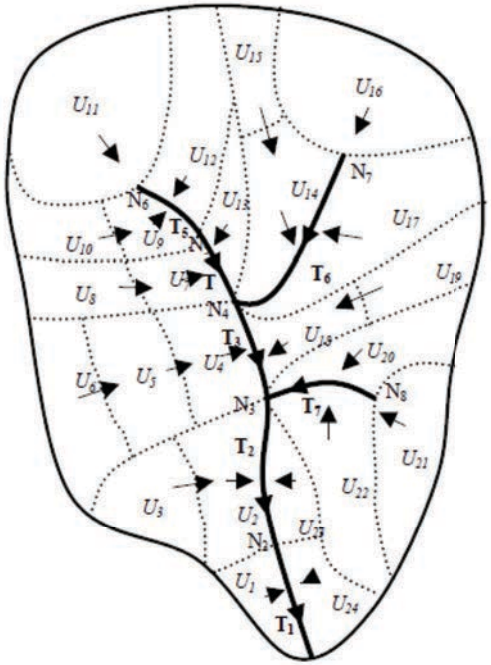
Coupling distributed hydrology modelling along with crop growth modelling

LISAH contribution

Context

- **Study site :** Kamech
- **Context :** PhD of Dhouib Mariem
- **PhD objective** : analysis of water use efficiency within a small rainfed farmed Mediterranean catchment in Tunisia, under the constraint of climate change, and by considering the spatial distribution of crops in the landscape as an action leverage for optimizing water use by crops and agricultural production.

Runoff-infiltration partitioning



Relationship between hydrological units/hydrographic network
(adapted from Chahinian, 2004)

understand the exchanges of water fluxes between fields and their impact on the available water for the crop

Runoff-infiltration partitioning under different climate and soil conditions :

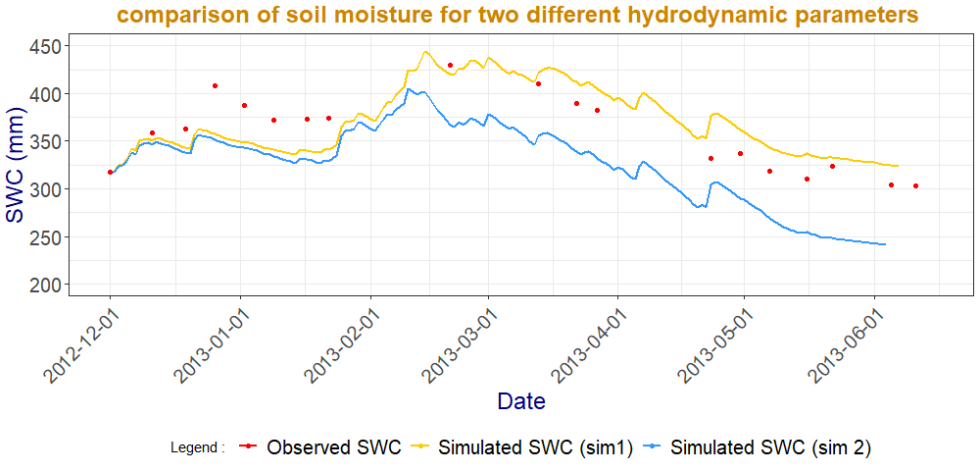
- Soil texture
- Soil depth
- crops

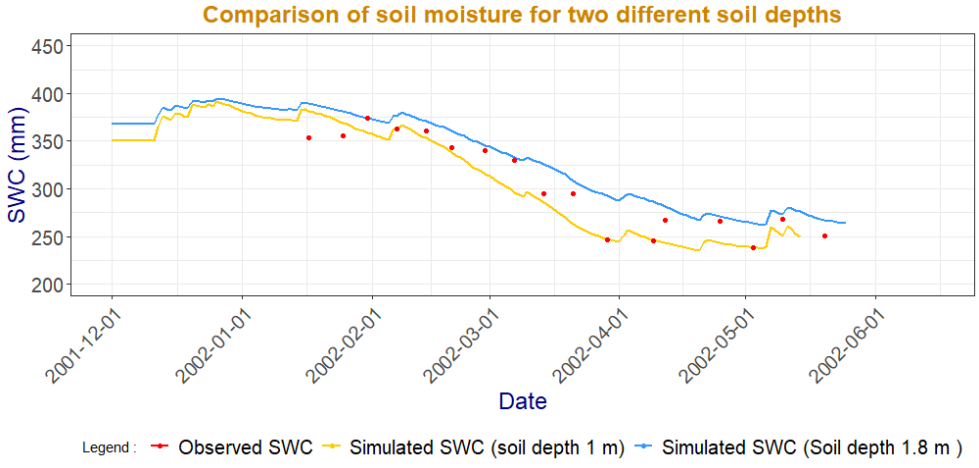
Example of AquaCrop's sensitivity analysis of soil caractristics (hydrodynamic properties ; depth)

AquaCrop is sensitive to soil depth, texture and hydrodynamic properties within the same texture class

	θ_{WP}(%)	θ_{FC}(%)	θ_{SAT}(%)
Sim 1	33	42	45
Sim 2	24	36	45

	Depth
Sim 1	1 m
Sim 2	1.8 m





Approach and perspectives

1. Evaluation of the impact of the spatial connectivity between two fields for different type of soil, depth and crops
2. Spatialization of the connectivity at level of the watershed

Integrated modelling / LISAH contribution

Cognitive objective: to analyse the co-variations of ecosystem functions of interest according to the composition and configuration of hillside reservoirs and crops, including crop rotation, and according to different climate scenarios.

Methodological objective: to design and develop an agro-hydrological model that simulates ecosystem functions in a Mediterranean watershed.

Persons in charge: J. Molénat, C. Dagès, L. Prévot, F. Jacob (LISAH).

I. Mekki, R. Zitouna (INRGREF).

Post-doc supervision [ALTOS granted, hiring process ongoing].

TK3.2 - Integrated modelling / LISAH contribution

Cognitive objective: to analyse the co-variations of ecosystem functions of interest according to the composition and configuration of hillside reservoirs and crops, including crop rotation, and according to different climate scenarios.

Method

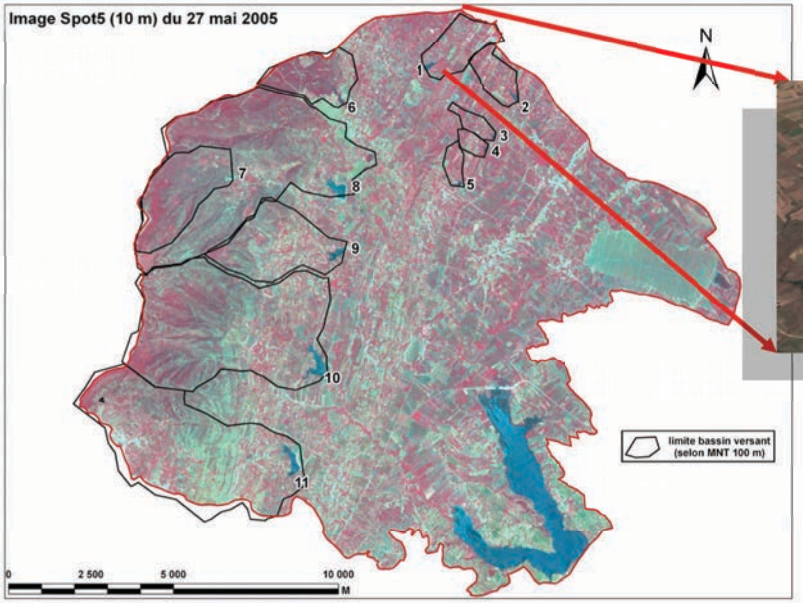
simulate

Persons

- Crop yields
- Soil water use efficiency of rainfed crops
- Performance/reliability of reservoirs [needs of irrigated crops]
- Water production for downstream [dam]
- Groundwater recharge ["zero recharge" hypothesis up to now]

TK3.2 - Integrated modelling / LISAH contribution

according to the composition and configuration of hillside reservoirs and crops, including crop rotation, and according to different climate scenarios.



Cap Bon peninsula

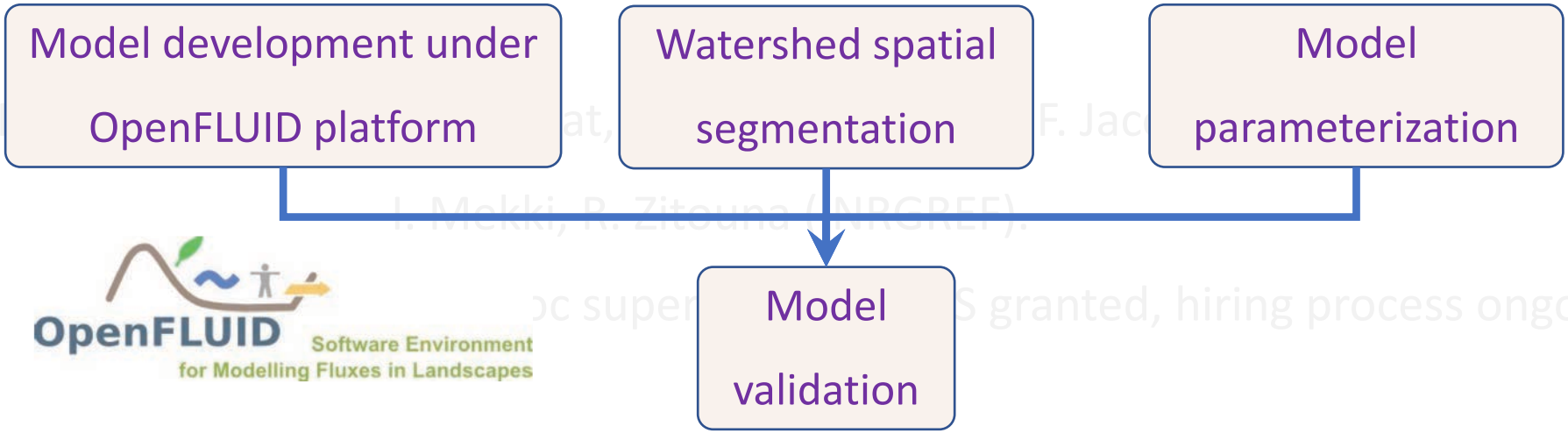
OMERE observatory

[existing dataset)

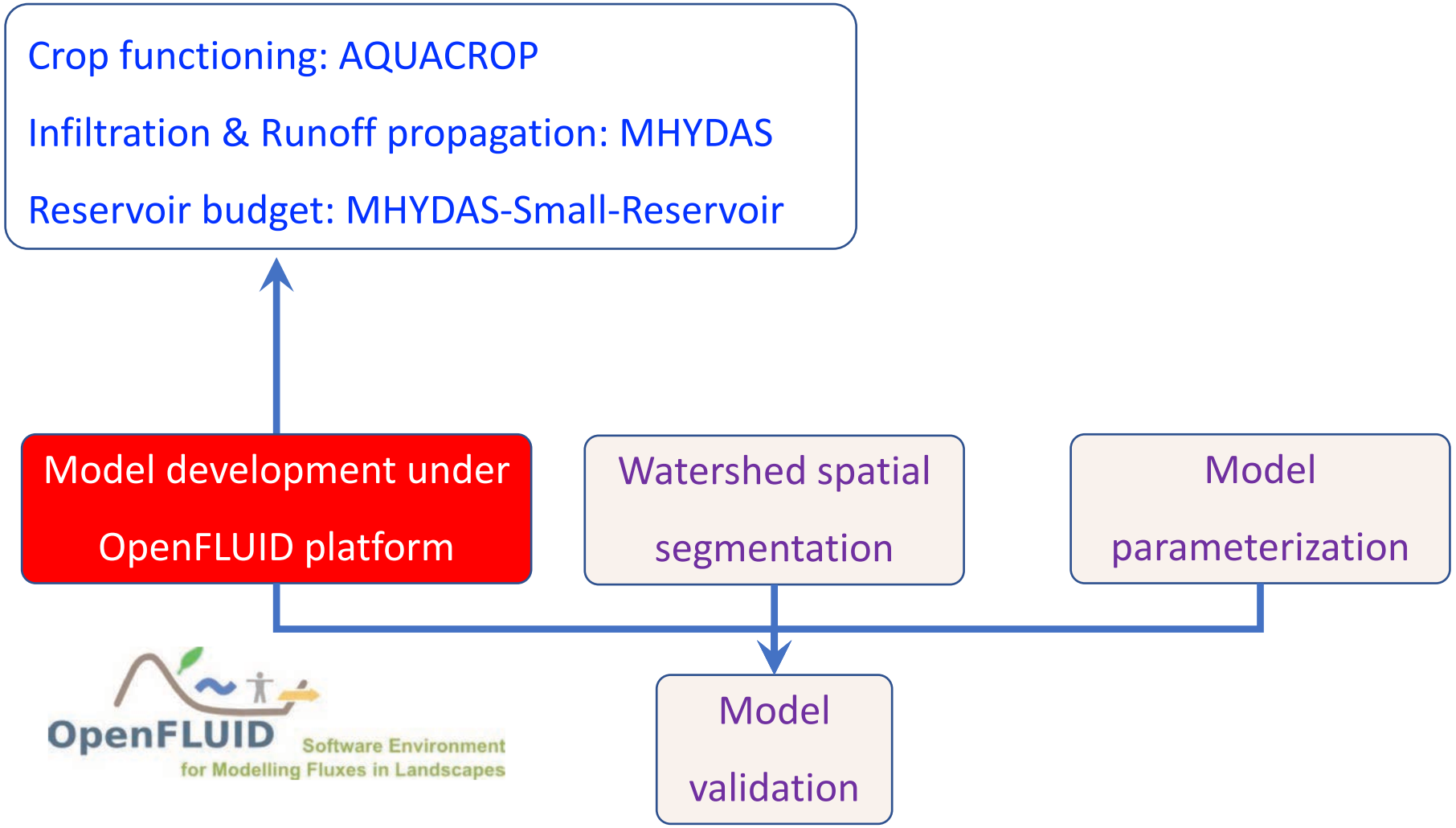
TK3.2 - Integrated modelling / LISAH contribution

Cognitive objective: to analyse the co-variations of ecosystem functions of interest according to the composition and configuration of hillside reservoirs and crops, including crop rotation, and according to different climate scenarios.

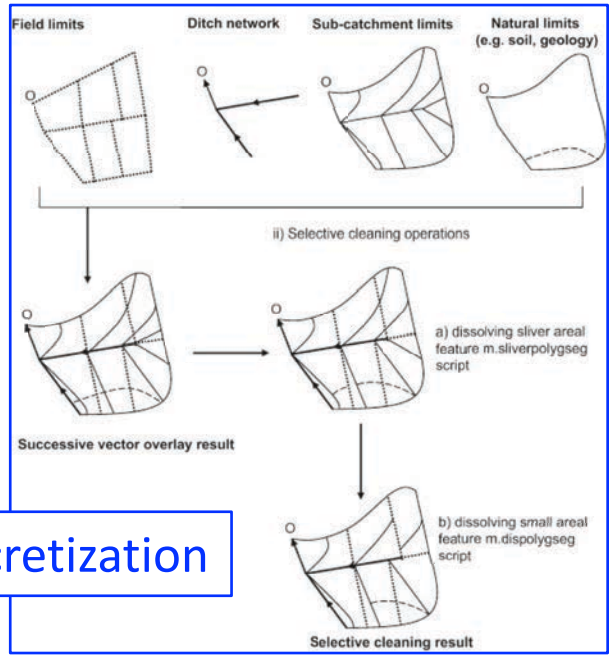
Methodological objective: to design and develop an agro-hydrological model that simulates ecosystem functions in a Mediterranean watershed.



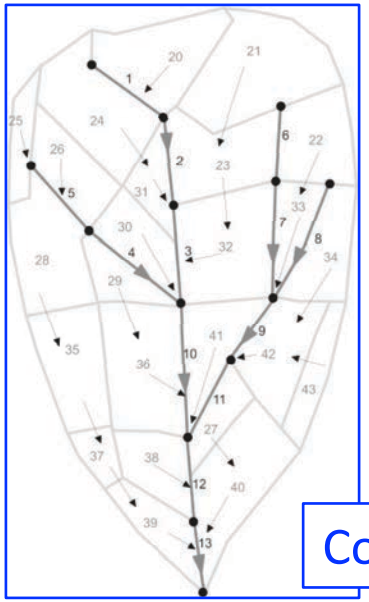
TK3.2 - Integrated modelling / LISAH contribution



TK3.2 - Integrated modelling / LISAH contribution



Discretization



Connectivities

Model development under OpenFLUID platform

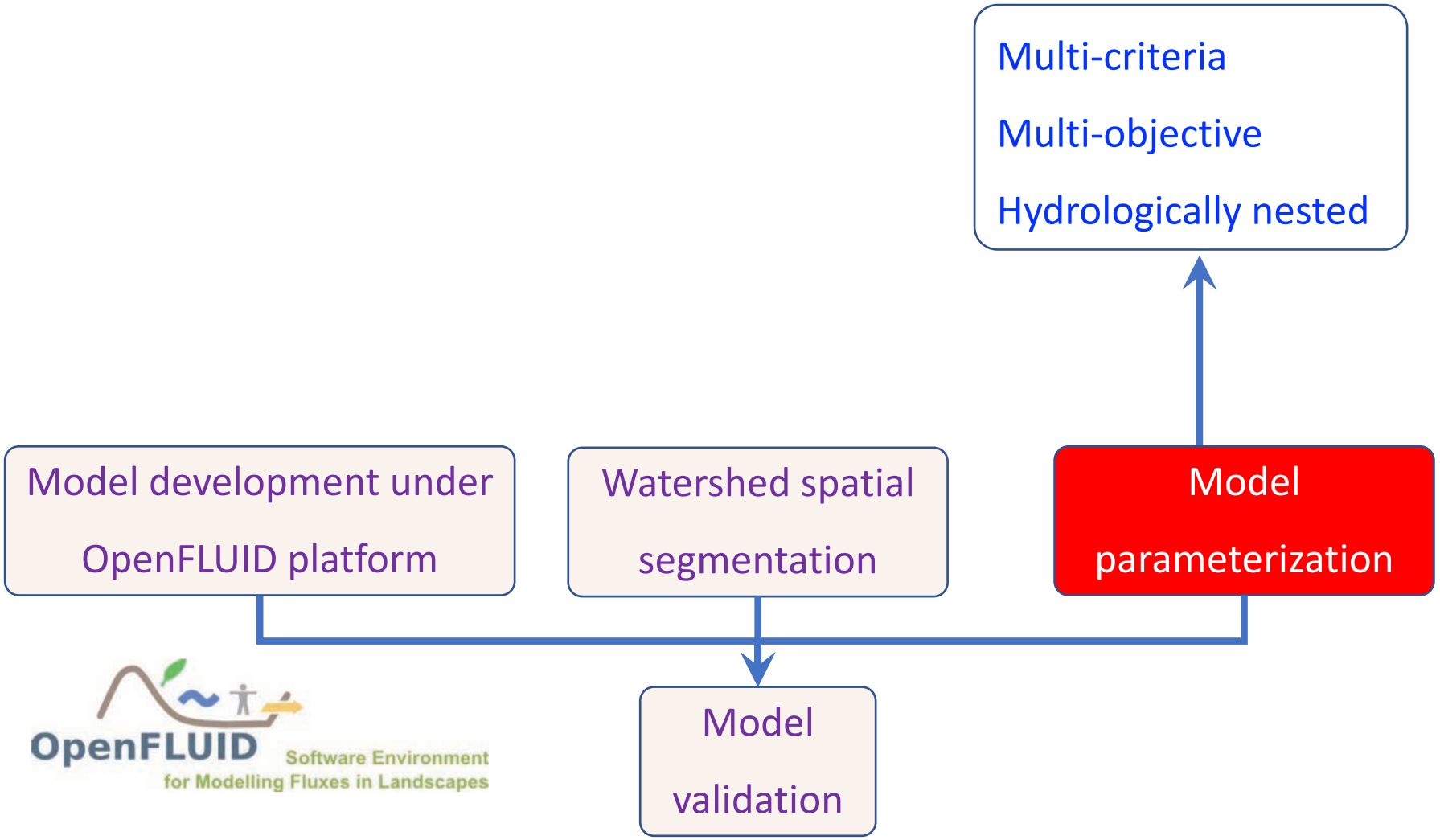
Watershed spatial segmentation

Model parameterization

Model validation

OpenFLUID Software Environment for Modelling Fluxes in Landscapes

TK3.2 - Integrated modelling / LISAH contribution



TK3.2 - Integrated modelling / LISAH contribution

Data set under construction

- Soil & DEM
- Crops biomass & yield
- Soil moisture & runoff
- Piezometric level

Model development under OpenFLUID platform

Watershed spatial segmentation

Model parameterization

Model validation

OpenFLUID Software Environment for Modelling Fluxes in Landscapes

Semi-distributed hydrology along with subsurface hydraulic redistribution

Partners : INAT, UNICA.

Study areas: Merguellil

UNICA

Task 3.2:

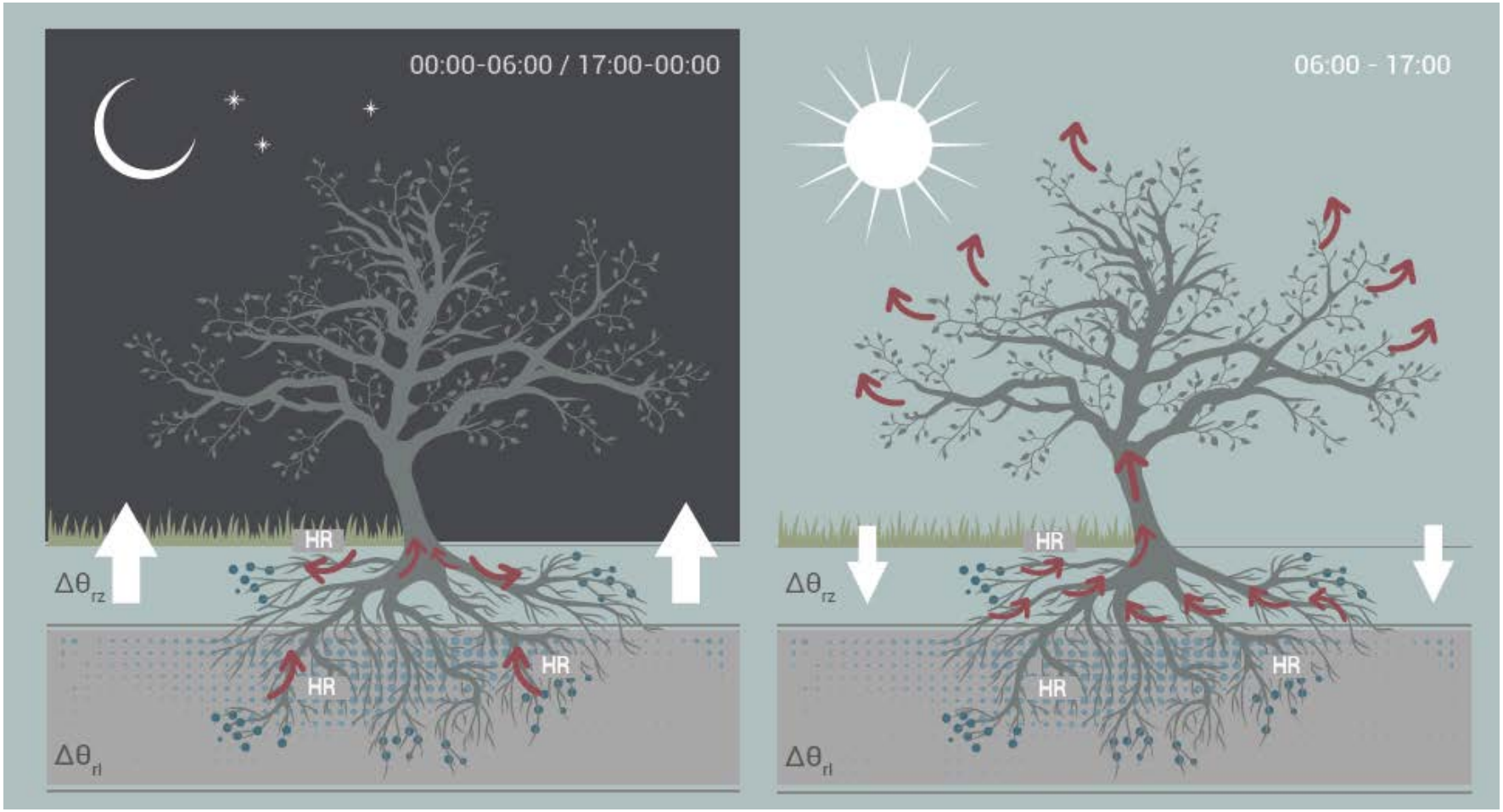
Modelling combined process: Semi-distributed hydrology along with subsurface hydraulic redistribution.

Activities:

-Improving of subsurface hydraulic redistribution in semi-distributed modelling

-Improving the SWAT model by including hydraulic redistribution

WP3: Ecohydrological modeling



Hydraulic redistribution model

$$HR = -C_{r,max} R_e \frac{\Delta\psi}{d_r}$$

$$R_e = f^{-1}\left[\left(\psi, \psi_{50}, b_{R_e}\right)\right]$$

Improving SWAT model by the inclusion of hydraulic redistribution

Potential Evaporation with Penman-Monteith

$$\lambda E = \frac{\Delta \cdot (H_{net} - G) + \rho_{air} \cdot c_p \cdot \left[e_z^o - e_z\right] / r_a}{\Delta + \gamma \cdot (1 + r_c / r_a)}$$

Water Uptake by Plants from the soil surface to a specified depth

$$w_{up,z} = \frac{E_t}{\left[1 - \exp(-\beta_w)\right]} \cdot \left[1 - \exp\left(-\beta_w \cdot \frac{z}{z_{root}}\right)\right]$$

- β_w = 10 Water use parameter

Potential water uptake $w_{up,ly} = w_{up,zl} - w_{up,zu}$

When there is a low water content in the first layer $w'_{up,ly} = w_{up,ly} + w_{demand} \cdot epco$

w_{demand} Water uptake demand not meet by the overlying layer

$epco$ Plant compensation factor, set manually. Range between 0.001 and 1

Actual Water Uptake $w_{actualup,ly} = \min\left[w''_{up,ly}, \left(SW_{ly} - WP_{ly}\right)\right]$

SW_{ly} Amount of water in the soil layer

WP_{ly} Water content at wilting point

Actual amount of transpiration $w_{actualup} = \sum_{ly=1}^{n} w_{actualup,ly}$ Sum of uptakes from the n layers

Problem to be solved: actual transpiration is not directly related to soil moisture of each soil layer

Task 3.2: modelling combined processes: Semi-distributed hydrology along with subsurface hydraulic redistribution

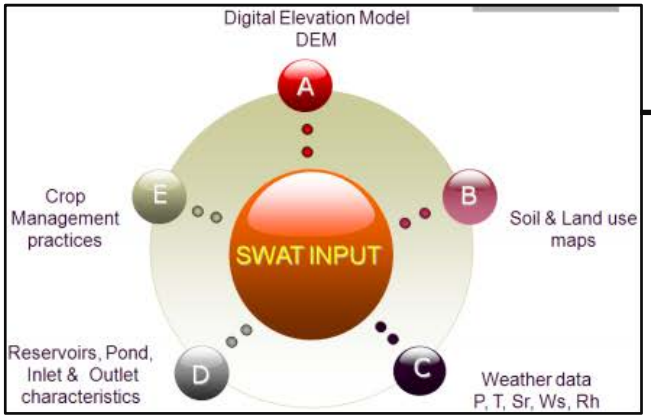


Figure 1: SWAT model Inputs

Many simulations with

many rain gages option

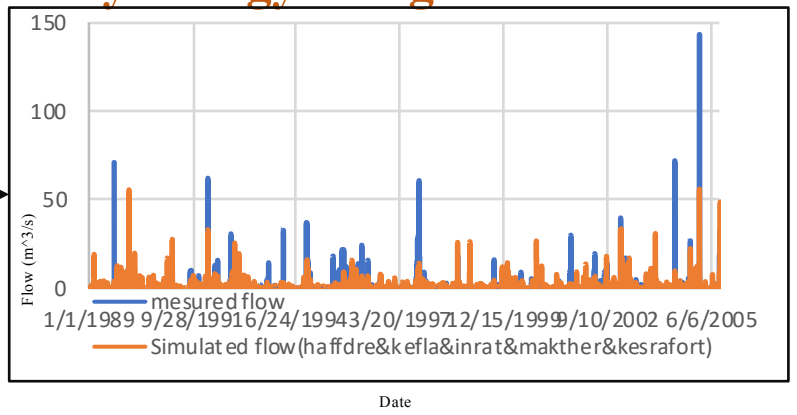


Figure 2: measured and modeled flows

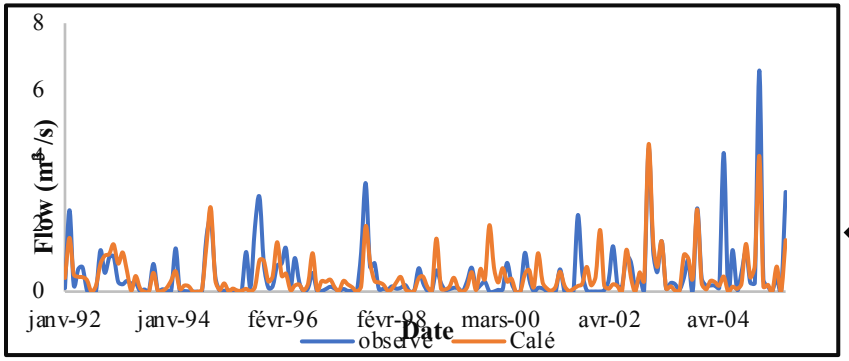


Figure 3: measured and calibrated flows

SWATCUP

SUFFI2 Algorithm

Time	Statistical coefficient	NSE	R^2	PBIAS	RMSE
Daily	Haffouz Dre Rain gage	**0.02**	0.14	10%	3.18
	Haffouz Dre & Oueslatia INRAT raingages	**-0.27**	0.13	26%	3.61
	Haffouz Dre, Oueslatia INRAT &El Alaa raingages	**-0.04**	0.16	21%	3.27
	Haffouz Dre, Oueslatia INRAT& kef laboid raingages	**0.04**	0.15	20%	3.14
	Haffouz Dre, Oueslatia INRA, kef laboid Makther & kesra forêt raingages	**0.04**	0.16	23%	3.14
	Haffouz Dre, kef laboid Makther & kesra forêt raingages	**0.13**	0.15	4%	2.99
Monthly	Haffouz Dre, kef laboid Makther & kesra forêt raingages	**0.29**	0.30	4%	0.78

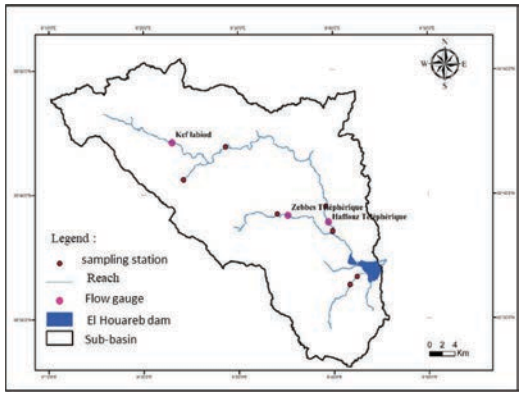
NSE	R^2	PBIAS	RMSE
0.52	0.53	3%	0.61

The SWAT model is greatly sensitive to rainfall variability

Task 3.2: modelling combined processes: Semi-distributed hydrology along with subsurface hydraulic redistribution

Purpose

Use outputs of tasks 1.1 and 1.2 to test the sensitivity of the model to the variability of different sources (in situ and satellite).



update of the database to test the impact of land use change on runoff and sediment.

Figure 4 : sediment measurement points

Problems

- Land accessibility (rough land, rugged mountain terrain)
- Corona virus (field observations and data collection postponed)

- D3.2.1 [Task 3.2]: report on modelling improvements via comparison exercises for integrated modelling schemes @ Month 33, to be shared within modelling workshops in WP5 @ Month 36.

- D3.2.2 [Task 3.2]: 2 submitted publications for methodological developments of integrated process modelling @ Month 36.

MS3: Update database to improved versions of integrated modelling schemes