WP2: Monitoring fluxes and storages

Task 2.1: water and chemical fluxes (leader: CERTE)

- 2.1.1.Evapotranspiration, soil moisture and crop growth.
- 2.1.2.Dam - aquifer transfers and upstream - downstream surface / subsurface transfers.
- 2.1.3.Chemical pollutants: hydrological fluxes and retention processes.

2.1.1.Evapotranspiration, soil moisture and crop growth.

- Targets: vegetation water status across growth cycle, yield, water use efficiency.
- Methodological innovations: joint use of eddy covariance / sap flow / isotopic measurements and optical / radar / thermal infrared remote sensing data, joint use of times series from in-situ and remote sensing data.
- Partners: INRGREF, SUPCOM, CESBIO, LISAH, UCAM, UNICA, IRTA.
- Study areas: Cap Bon, Merguellil, Tensift, Segre, Orroli.

LISAH & INRGREF contribution

LISAH

PhD
Mariem Dhouib

Study area : Kamech

Objectives

- **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
- **Data analysis objective :** Use of historical data in fluxes and storages modelling (WP3)

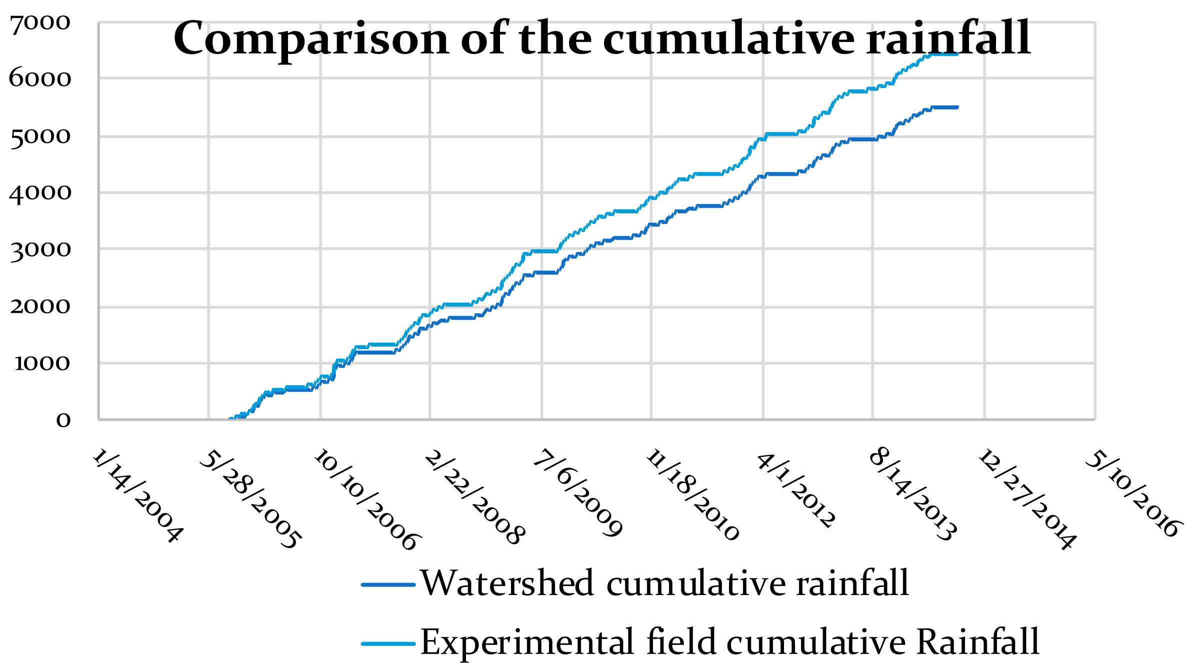
LISAH & INRGREF contribution

PhD
Mariem Dhouib

Results : Climate data analysis
example : rainfall analysis

- spatial variability of rainfall

Take this variability into account when modeling runoff-infiltration partitioning



LISAH & INRGREF contribution

PhD
Mariem Dhouib

Results : Crop growth's analysis

- LAI and canopy cover (CC) data measured on Lebna for 4 years and 5 different crops
- hemispherical images treated by CAN-EYE software, used to determine the LAI-CC relationship when only LAI mesurements are available

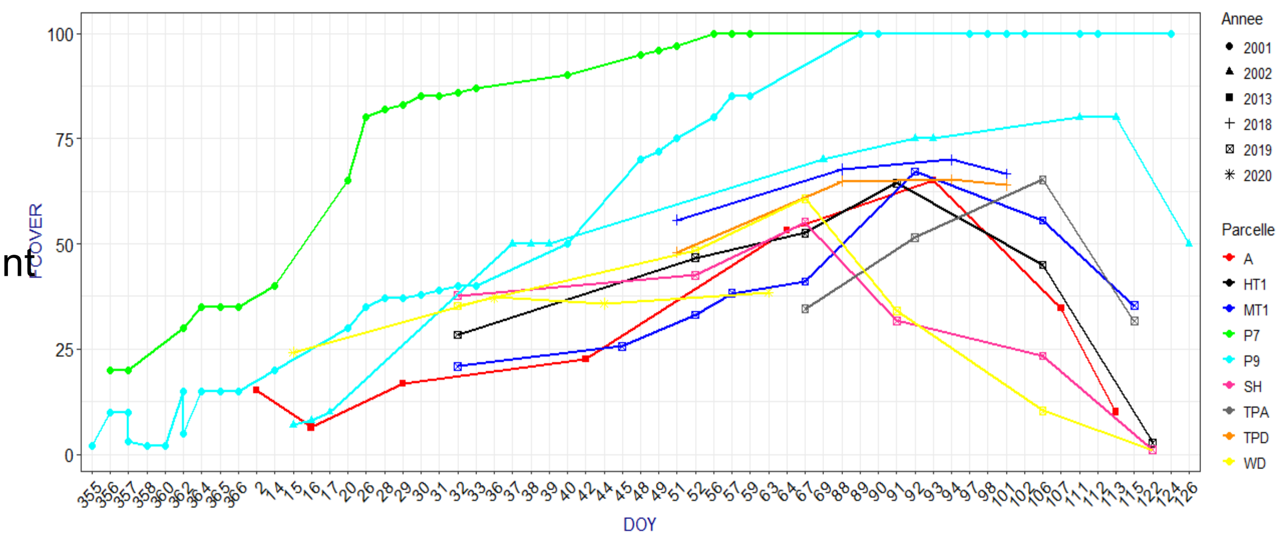
Example of Canopy cover analysis for wheat

↓

Annual variability of CC for different soil and climate conditions

↓

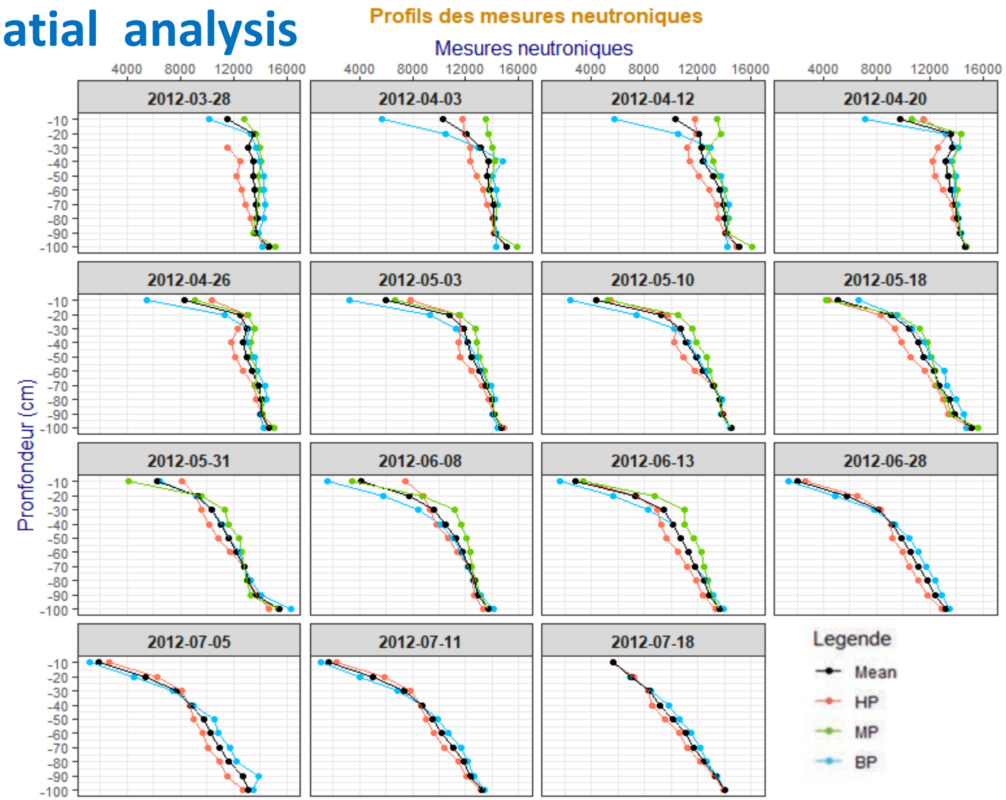
Parameterization of AquaCrop crop parameters



LISAH & INRGREF contribution

PhD Mariem Dhouib

Results : Soil moisture temporal et spatial analysis



- **Year : 2013**
- **Crop : wheat**

➔ Two horizons **: 0-30 and 30-100**

➔No difference in humidity between the different measuring points

➔The use of an average value of soil moisture is sufficient

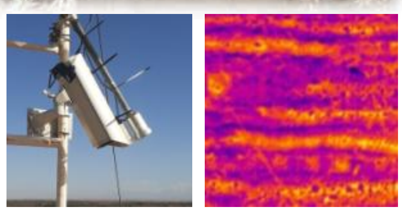
To be done

- Crop observations : continuation of the crop observation
- Soil observations :
  - Continuation of gravimetric soil sampling
  - 2021 installation of new sensors to measure the soil moisture

CESBIO contribution

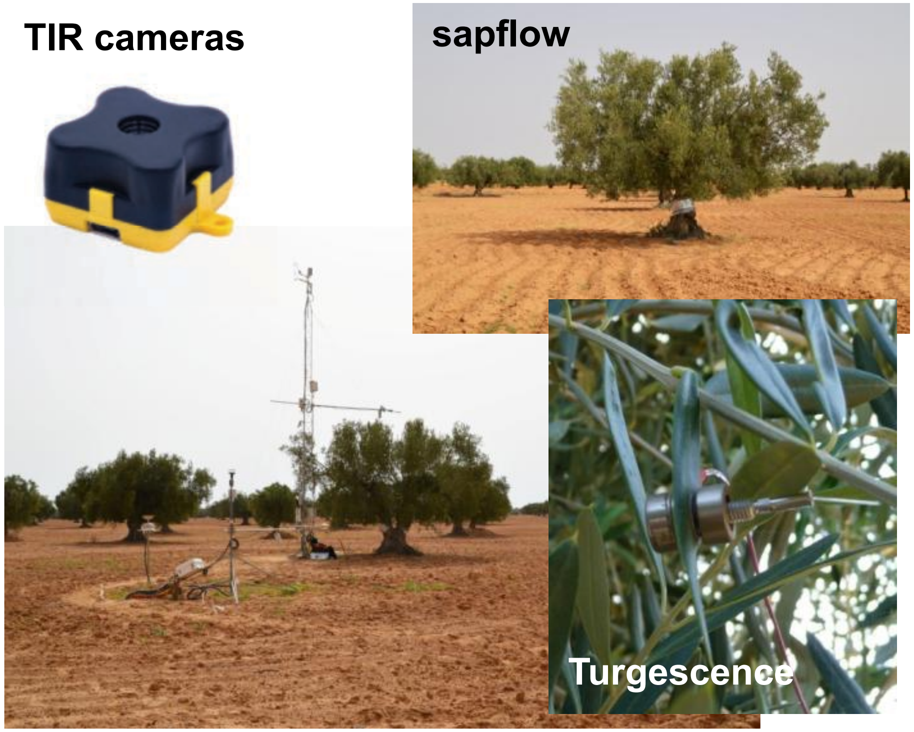
EVAPOTRANSPIRATION

Chichaoua drip irrigated olive (w/ UCAM)



TIR camera

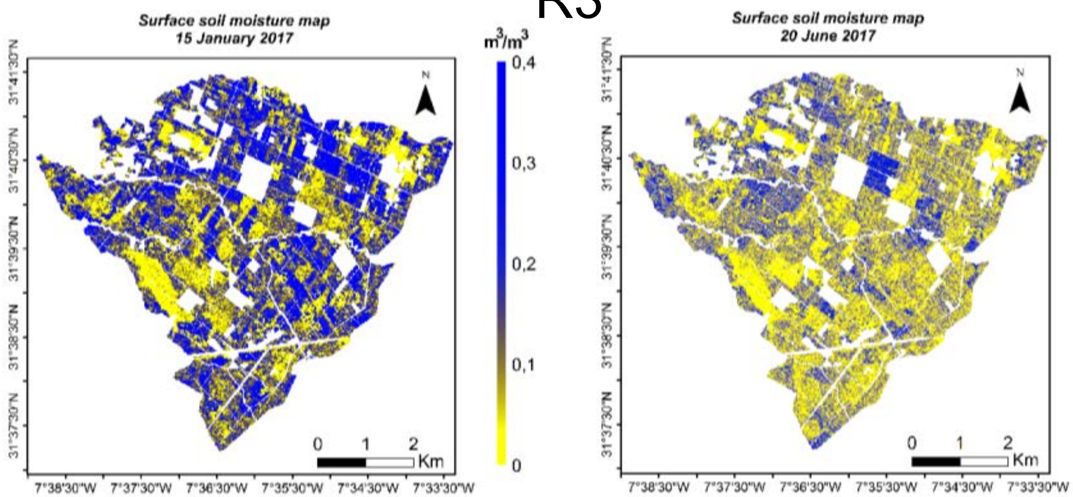
Taous rainfed olive (w/ Institut de l'Olivier)

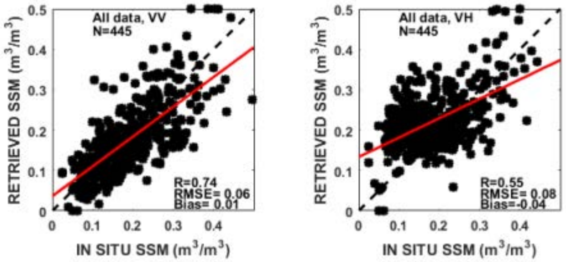


Task 2.1.1.Evapotranspiration, soil moisture and crop growth

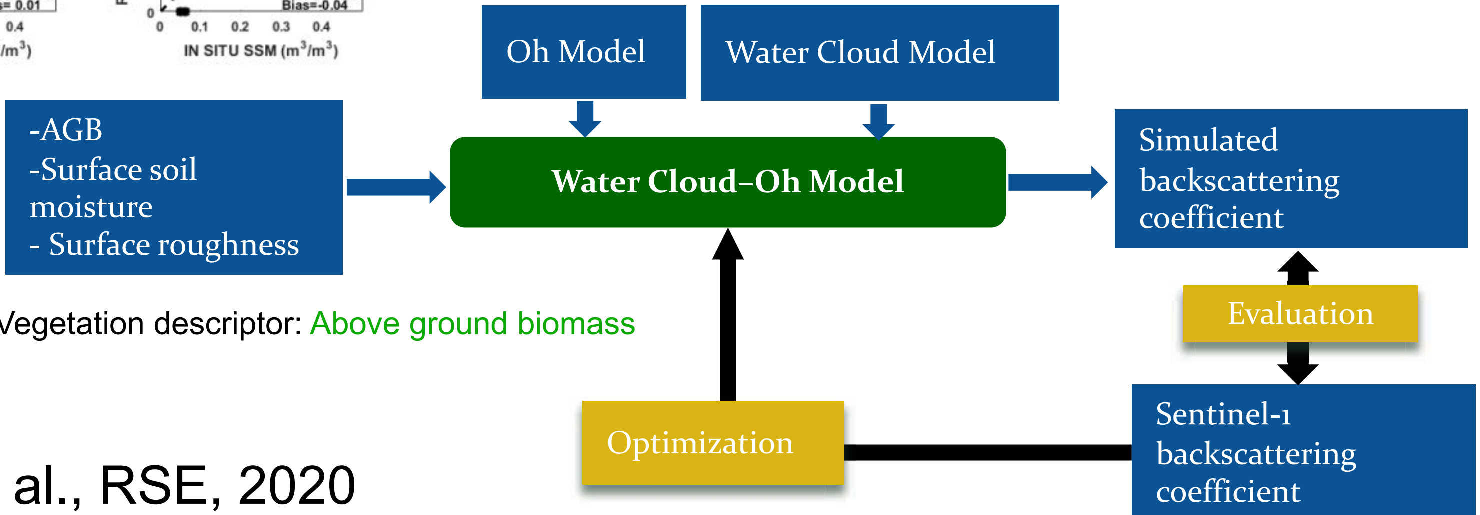
R3

SOIL MOISTURE





Haouz

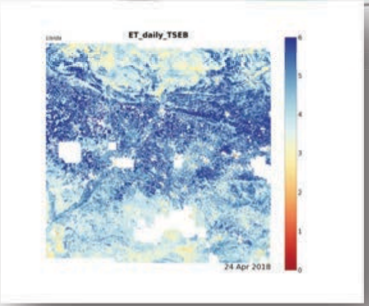


Vegetation descriptor: Above ground biomass

Ouaadi et al., RSE, 2020

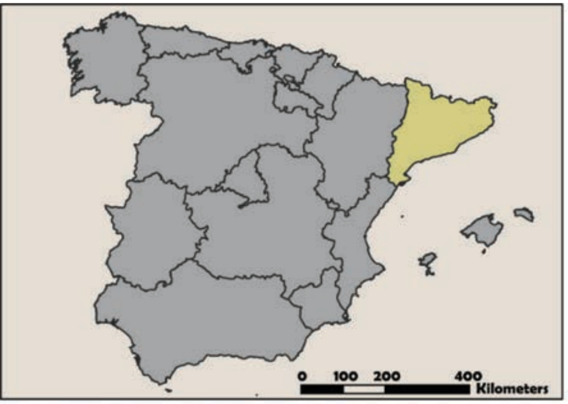
IRTA contribution

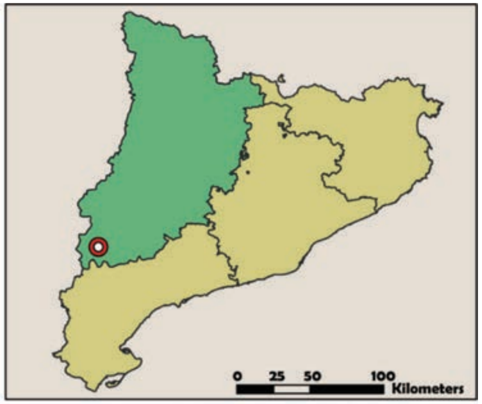
Time-series of biophysical parameters & ET in Lleida's region (Segre) using TSEB with sharpened Sentinel-2 and Sentinel-3 imagery



PhD: Christian Jofre-Cekalovic

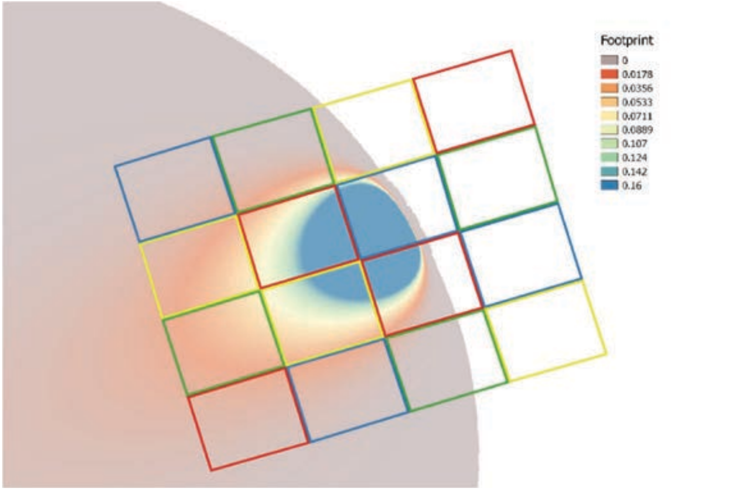
Daily at 20 m (2018-2021)



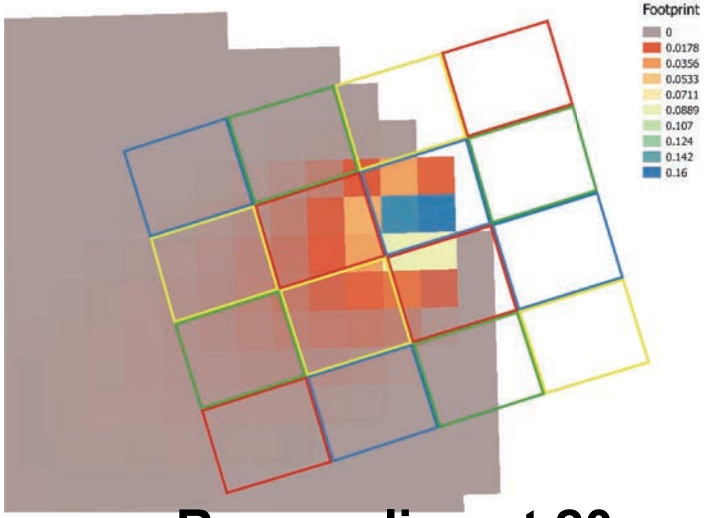


- To validate ET obtained with the TSEB model using sharpened S2+S3 imagery of an almond orchard
- To assess the total amount of water used by almond trees irrigated under diferent water regimes.

IRTA contribution



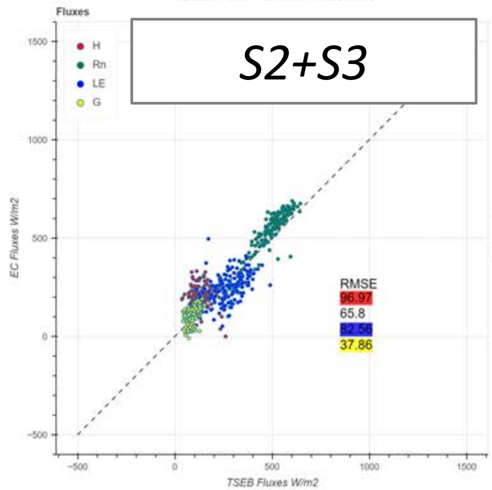
Footprint - *Kljun et al. (2015)*

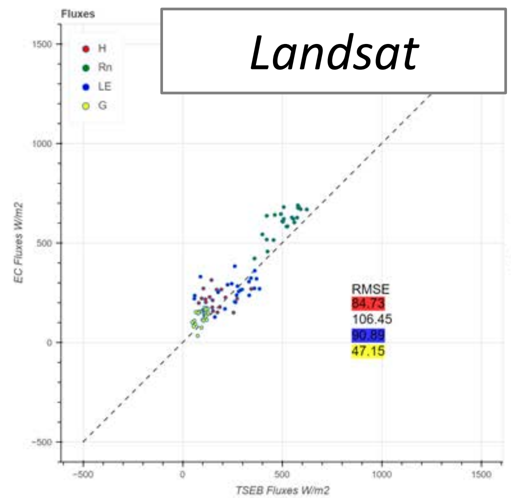


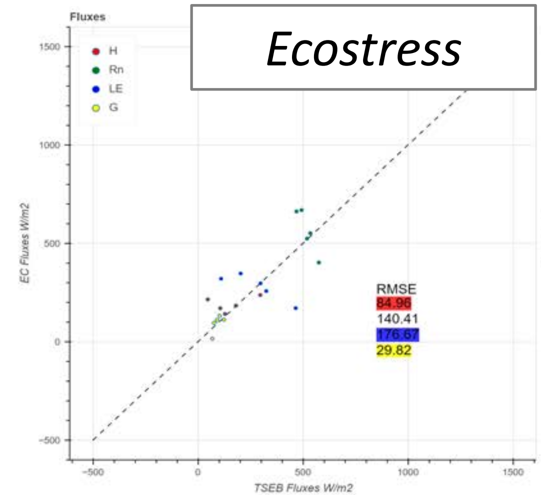
Resampling at 20 m

IRTA contribution IRTA

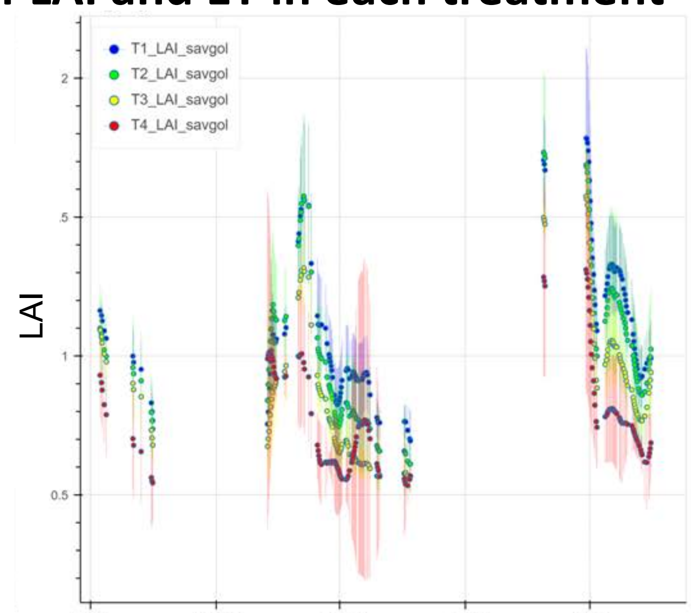
Validation

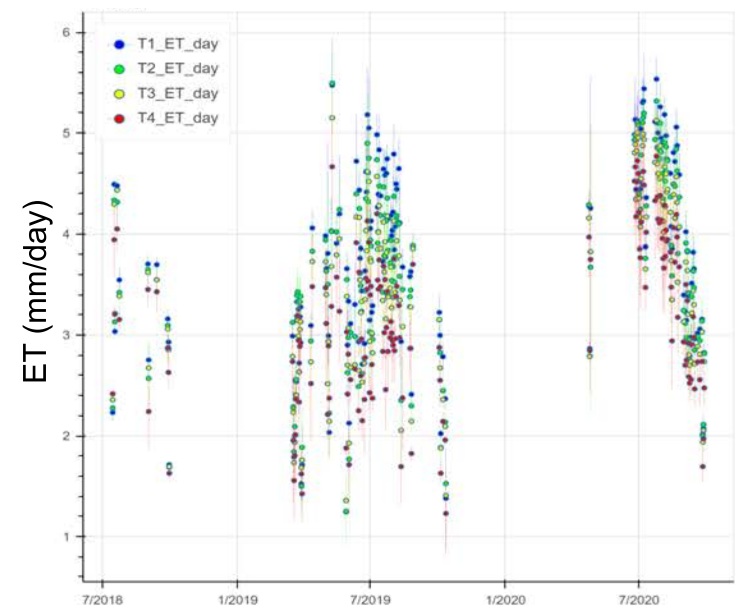






Time-series of LAI and ET in each treatment

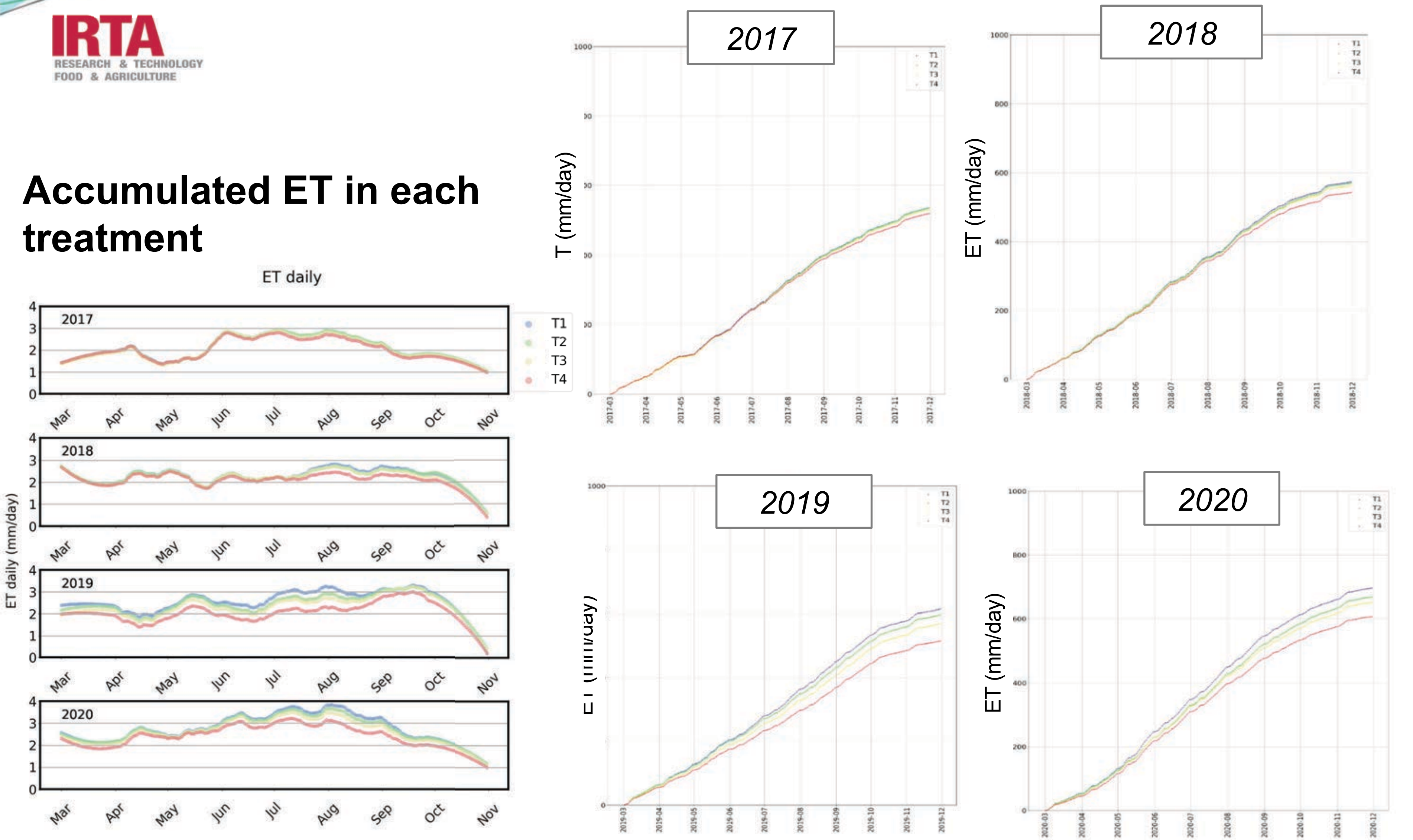




IRTA contribution

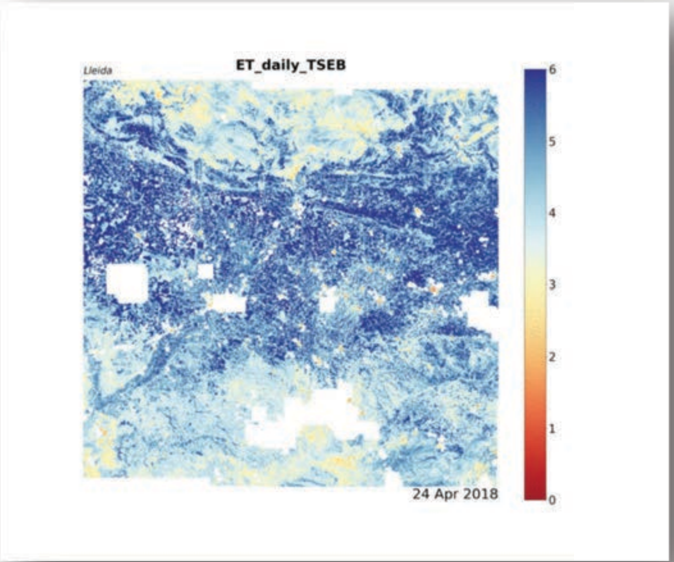
IRTA
RESEARCH & TECHNOLOGY
FOOD & AGRICULTURE

Accumulated ET in each treatment



IRTA contribution

https://www.hymex.fr/liaise/campaign.html

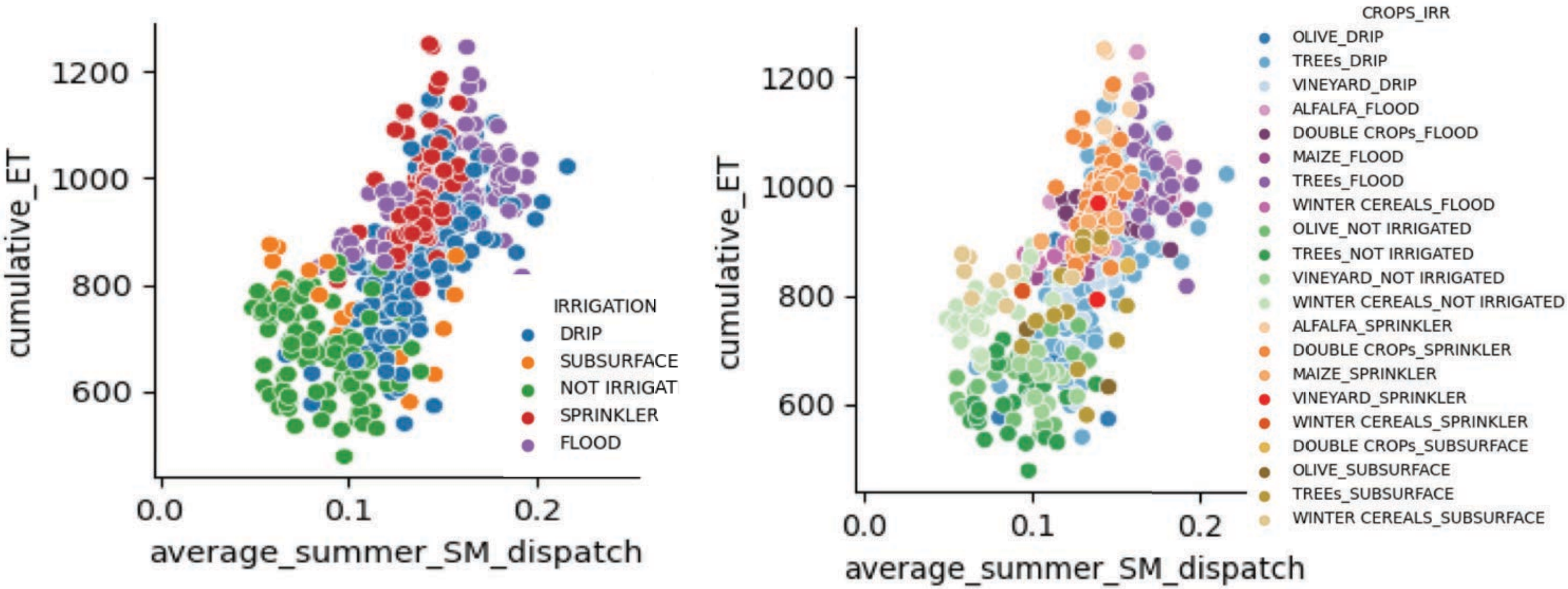


-> To obtain time-series of ET and to validate ET estimates in diferent fields.

-> To assess diferent spatal resolutions, viewing angles, etc. of LST into SEB models to improve estimates of ET

IRTA contribution

- Take advantadge of ET time-series, together with soil moisture estimates to identify and map irrigation systems



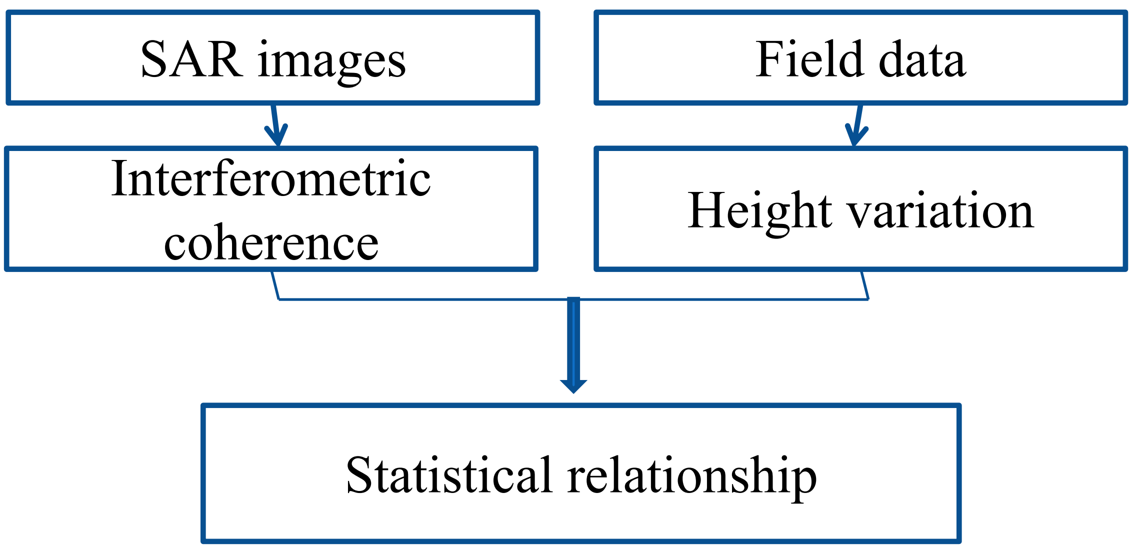
SUPCOM contribution

Monitoring of cereals height using INSAR coherence

Task objectives

1. Monitoring of two key crops wheat and barley using the interferometric SAR Sentinel-1 data with high temporal revisit.
2. Find a relationship between wheat and barley heights, measured at the field, and the Interferometric SAR coherence parameters, computed on the Sentinel-1 data.

Methodology



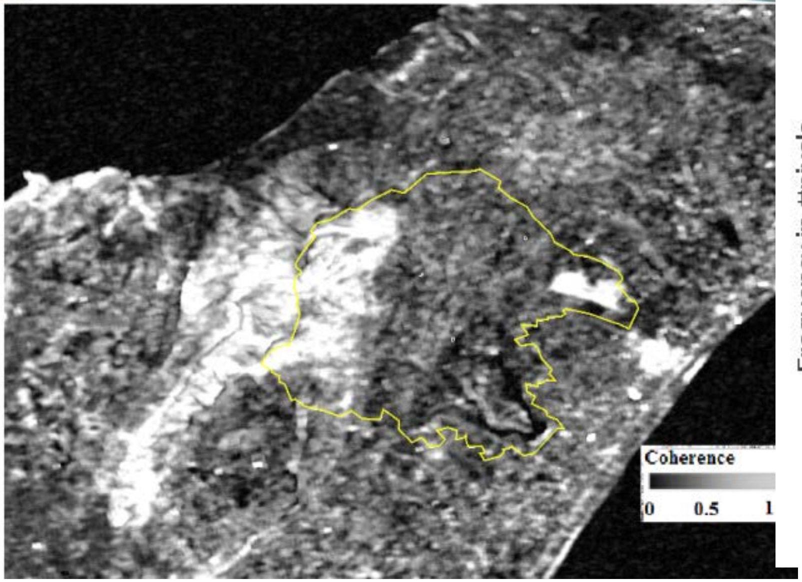
Used data :

Twelve Sentinel-1 data were considered for this study, from January to May 2019 (format is the interferometric wide swath mode (IW) with a 250 km swath at a spatial resolution of 5 m by 20 m).

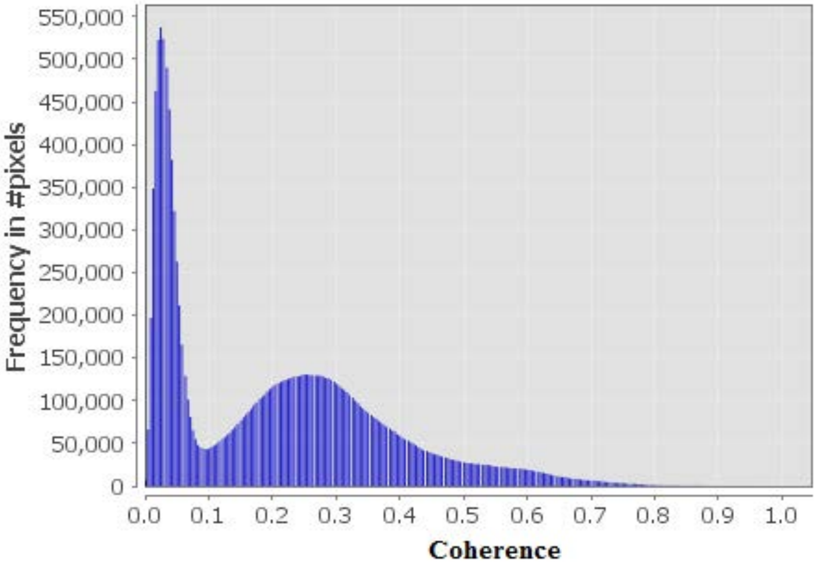
Performed work

- Time series of radar backscatter from Sentinel-1 data are analyzed and compared to ground measurements including phenological stage and height.
- Temporal variations in backscatter data were correlated to water content and structure associated with phenological development.
- The study focused on five pairs of images, related with four different phenological stages.
- From the selected pairs, 4 coherence maps were generated for each different pair and for each different polarization (VH, VV).
- Four phenological stages, were considered for the Interferometric coherence maps analysis in the Lebna watershed.

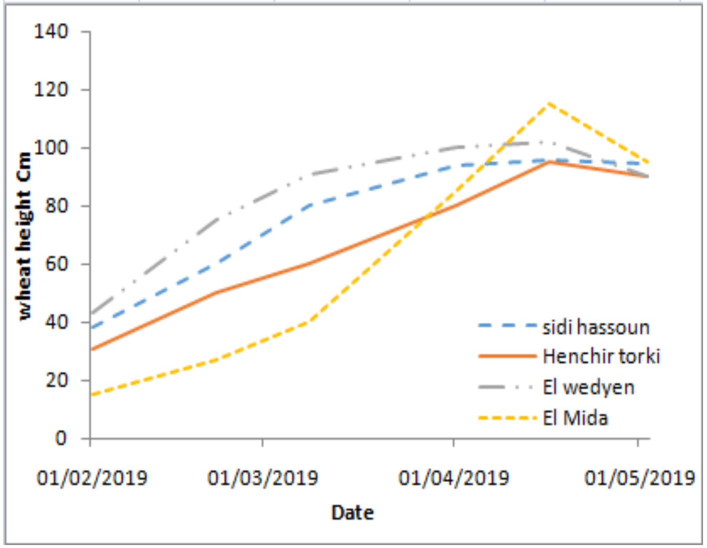
Results



Coherence map of the Lebna watershed area April 13-April 19, 2019



Coherence histogram of the Lebna watershed area April 13-April 19, 2019



Wheat and barley heights variation

Results

Correlation between wheat height and interferometric coherence

Cereals	wheat			barely
Sites	**Henchir turki**	**Sidi hassoun**	**El oudiane**	**El Mida**
Pearson correlation for VH	0.35	0.97	-0.84	-0.57
Pearson correlation for VV	0.64	0.24	-0.02	0.4

A high negative correlation in El Oudiane and Sidi Hassoun sites for VH polarization, this is explained by the high height values in these sites compared to other sites. Indeed, the height is high and the vegetation is dense and coherence is more sensitive to the density of crop cover in VH polarization. Therefore, when the variation of the vegetation is high the other source of variation can be omitted. The weak correlation for the other sites is explained by the intervention of an external factor that can cause a change such as the humidity of the soil, the roughness of the soil, the wind etc....

Results

A weak correlation for the barley and Henchir Turki site because the height value is weak in the first stage so the soil component is important. If we eliminate the first stage (the period between February, 1 and February, 21 the correlation coefficient becomes significant for the four sites

Correlation between wheat height and interferometric coherence without the first growth stage

Cereals	**wheat**			**barely**
Sites	**Henchir turki**	**Sidi hassoun**	**El oudiane**	**El Mida**
Pearson correlation for VH	0.35	0.97	-0.84	-0.57

Difficulties

- The dates of the field campaigns don't match exactly with the acquisition dates of the Sentinel-1 data,
- The number of measured samples per land parcel is not proportional to the land extent regarding the resolution cell of the Sentinel-1 data,
- The lack of certain parameters (plant moisture content and soil moisture content.) prevents us from having reliable results on relative vegetation contributions to the observed radar backscatter.

Task 2.1: water and chemical fluxes (leader: CERTE)

2.1.1.Evapotranspiration, soil moisture and crop growth.

2.1.2.Dam - aquifer transfers and upstream - downstream surface / subsurface transfers.

2.1.3.Chemical pollutants: hydrological fluxes and retention processes.

2.1.2.Dam - aquifer transfers and upstream - downstream surface / subsurface transfers

Targets: dam water budget and underlying leaks towards aquifer; subsurface flows and soil hydrodynamics for slopping terrains that link mountains to lowlands.

- Methodological innovations: joint use of:

(1) water budget calculation from hydrometric measurements (surface and subsurface inputs, water uses) and climate forcing data (rain, evaporation),

(2) piezometric network data,

(3) isotopic (stable δ18O and δ 2H) and geochemical tracing, and

(4) geophysical measurements from WP1.

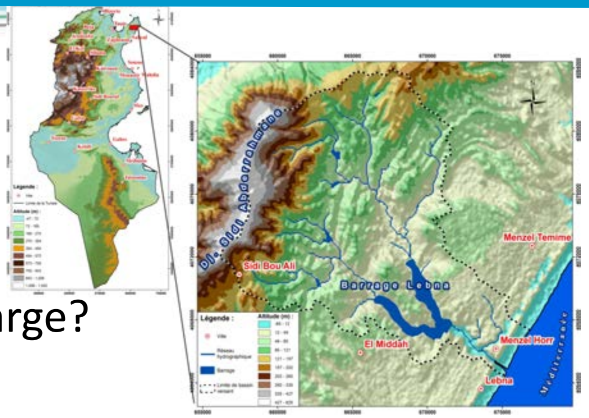
Partners: CERTE, LISAH, CNRS-L, UCAM, CESBIO, UNICA.

Study areas: Cap Bon, Tensift, Litani.

Task 2.1.2 : Dam - aquifer transfers and upstream - downstream surfacesub surface transfers.

CETRE & LISAH contribution

PhD Nejmeddine OUHICHI

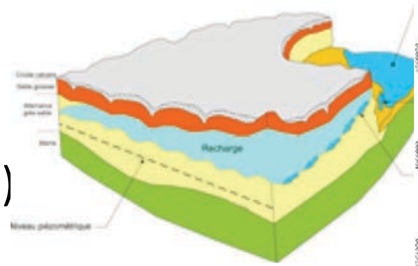


Objectives

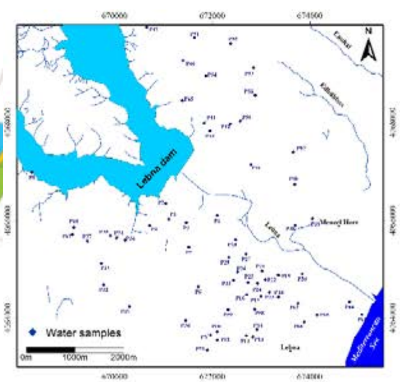
- Process study: How is the dam contributing to aquifer recharge?
- Quantification of the dam leakage
- Study the relationships: surface water / groundwater and Dam / Aquifer.

Worked performed

- 6 Piézométrics saisonnal surveys (71 boreholes)
- Monitoring with 13 PZ Divers ;
- Installation of 6 PZ (3 to 5m deep);
- Salinity monitoring (EC)
- Stable isotopes monitoring ($\delta^{18}O$ and $\delta\ ^{2}H$) (concerning Lake, rain, evaporation, and underground waters)



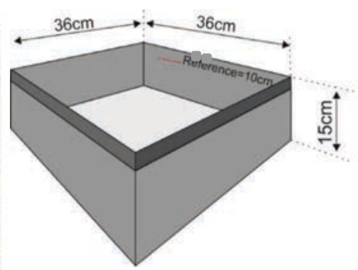
Geologique map



Piezometric monitoring well positions: 71 wells

Calendar & Difficulties

2020-2021



The evaporation pan

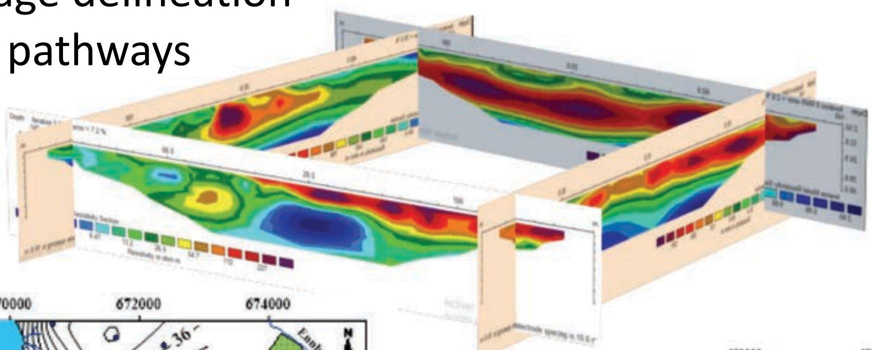
Task 2.1.2 : Dam - aquifer transfers and upstream - downstream surfacesub surface transfers.

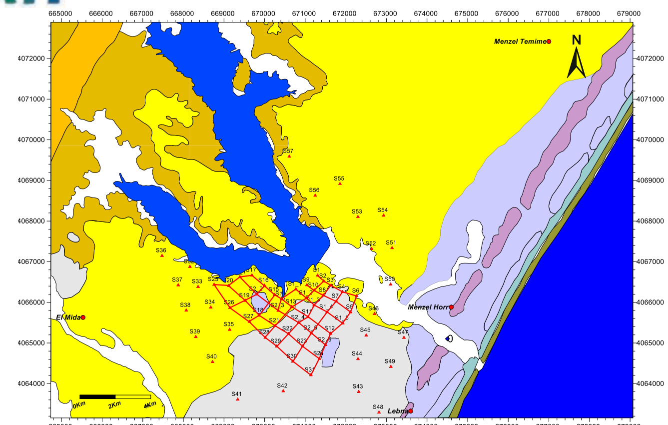
Geophysical measurements From WP 1

PhD
Nejmeddine
OUHICHI
CERTE
LISAH

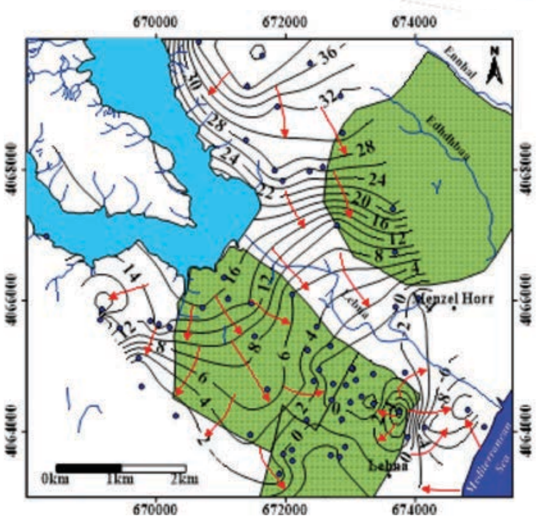
Results:

- Aquifer structure characterization around Lebna dam (Geometry, and lithology)
- Leakage delineation
- Flow pathways

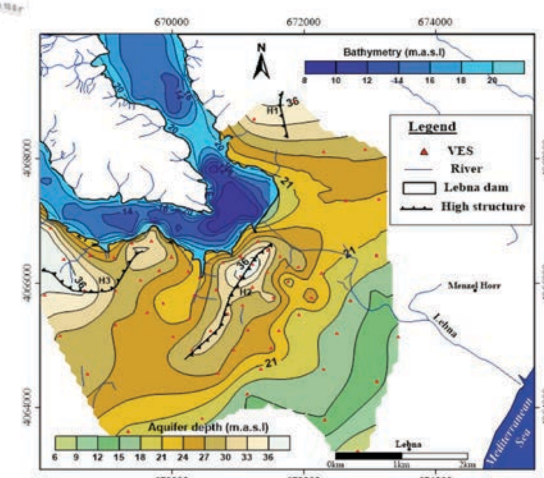




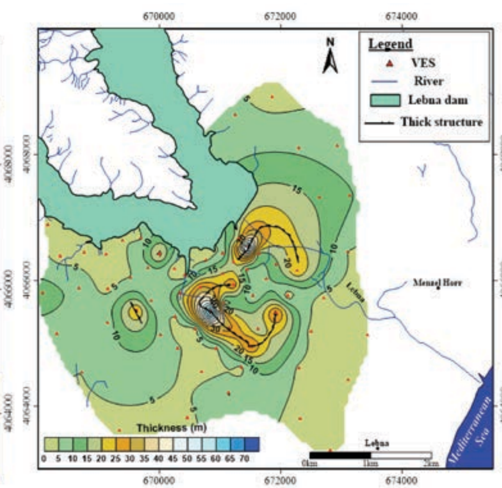
Positions of the 69 vertical electrical soundings



Coastal aquifer Piezometric maps in Feb.2020,



Isobath map of Lebna shallow aquifer



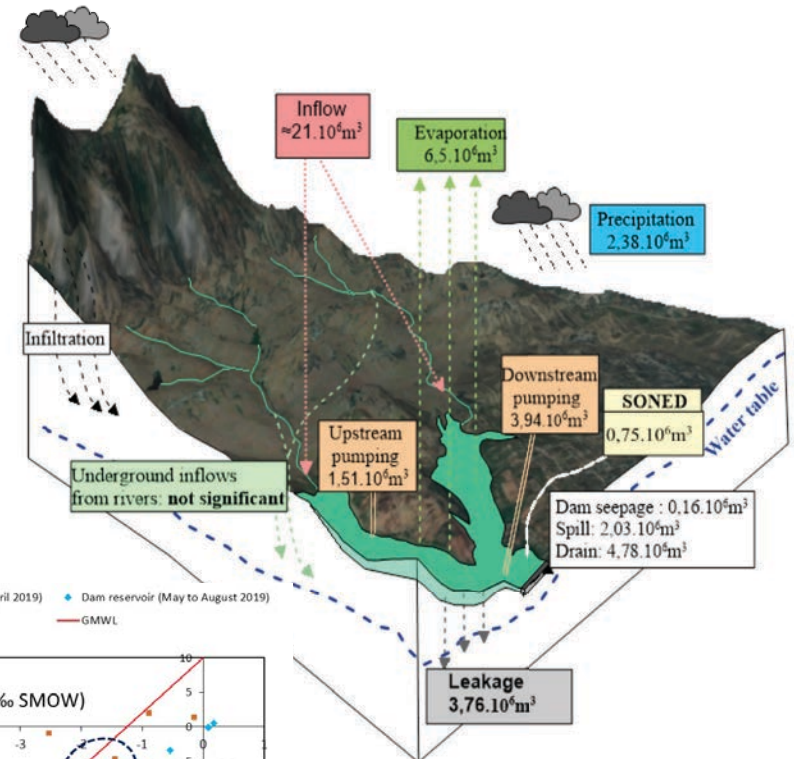
Isopach map of Lebna shallow aquifer

Task 2.1: water and chemical fluxes (leader: CERTE)

Task 2.1.2 : Dam - aquifer transfers and upstream - downstream surface subsurface transfers.

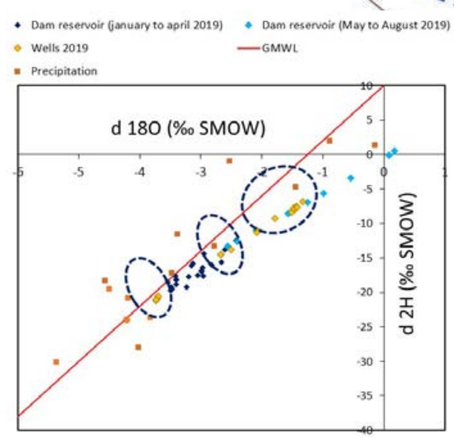
CETRE & LISAH contribution

PhD Nejmeddine OUHICHI



Results

- Leakage happens through a sandy layer of the southern bank (~ 3.8 million m^3y^{-1}).
- Leakage flux is related to the level of the lake
  - Starts when the level of the lake is higher than 16m.a.s.l.
  - increase according to a power law until the maximum 18m.a.s.l.
- The aquifer is heterogeneous
  - Underground flow paths are not straight
  - The lake plume water in aquifer is not regular in space and time;
  - Differentiation of groundwater origin.



To be done

- Integration of isotopic data and computing of evaporative term and mixing budgets
- PS Geophysical investigation (CERTE/UNICA/LISAH)

Deliverables

2.1.2 [Task 2.1]: submitted publications about data analysis @Month21.

MS2: update of databases : meeting @ Month 18,

UNICA contribution

Micro-metereological tower's instruments


Study area: Orroli site

Activities:

-Joint use of Eddy covariance and sap flow measurements, and remote sensing data

- dam-aquifer (Lebna - Tunisia)


UNICA contribution

Activities: Joint use of Eddy covariance and sap flow measurements, and remote sensing data

Objectives

Monitoring of water fluxes by the joint use of eddy covariance, sap flow measurements in stems and roots, and remote sensing data

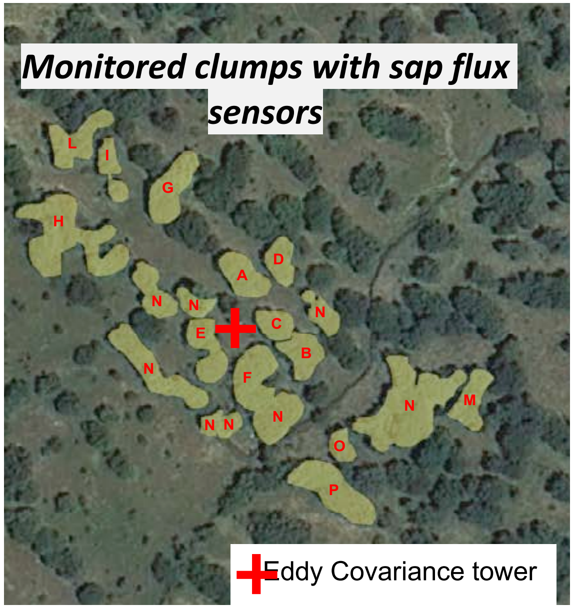
Work performed

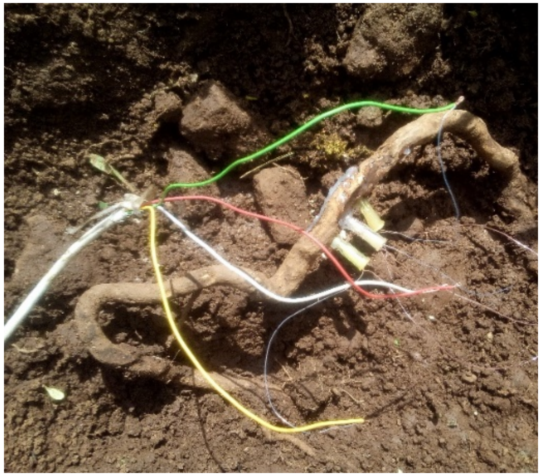
- Installation of an eddy covariance tower in the Orroli site; The tower is operative againfrom October 2020
- realization / installation of sap flux in the stems
- realization and installation of root sap flux;
- Acquisition of remote sensing data

Difficulties: Limited field activities due to the COVID19 pandemic restrictions

To be done:

Monitoring of land surface fluxes, vegetation status and water fluxes next summer





UNICA contribution

UNICA/CERTE/ILSAH Cooperation for geophysiscal methodologies and applications

1. Organization of a preliminary meeting between CERTE/UNICA/LISAH concerning the geophysical and remote- and proximal-sensing methodologies among the different sites of the project: Lebna (leaking dam) -Tunisia; Orroli (wild olive trees) – Italy; but, in case, also, Sfax (olive orchard – to be further discussed) – Tunisia
   1.1 interesting data are available or are going to be available on all the sites. In particular besides the "standard" ERT data, at least for the Lebna and Orroli cases, the acquisition of Self-Potential (SP) measurements is planned.
   In fact, SP data might highlight the fluid movements (clearly crucial, for studying the leaking of the dam and the dynamics of the wild olive trees – in this second case, especially, if correlated with sap-flow and evapotranspiration measurements).
   1.2 the data will be exchanged between partners in order to more efficiently test the algorithms developed by one of the partners and to get the best out of each dataset.
   Sharing data and procedures, not only will optimize the resources, but will also foster mutual capacity-building and collaboration (to be implemented also via shared scientific publications).
   1.3 together with geoelectrical measurements, acquisition of other proximal-sensing data could be performed (e.g. electromagnetic induction, EMI, measurements). Also in this case, data and procedures for the data elaboration can be shared. If the pandemic situation will allow it, joint field campaigns (sharing also instrumentation) can be arranged in late 2021.
   1.4 the (time-lapse) geoelectrical/EMI data can be integrated with the remote-sensing measurements. This, potentially, could pave the road to the data-informed spatial extrapolation of proximal/geophysical results (more logistically expensive, but with a larger depth of investigation, DOI) via the remote-sensing observations (with a shallower DOI, but ubiquitous).

UCAM Contribution

Objectives: **Groundwater sustainability in a semiarid irrigated piedmont in Tensift basin**

Work performed

Streamflow diversion data

Monthly diverted volumes from Ourika wadi between 2000 and 2018.

Piezometric measurements

Two piezometric surveys of 55 wells in September (dry season) and March (wet season) .

Environmental tracing

Precipitations (n=8) : 06 sites

Surface water (n=18) : 05 sites

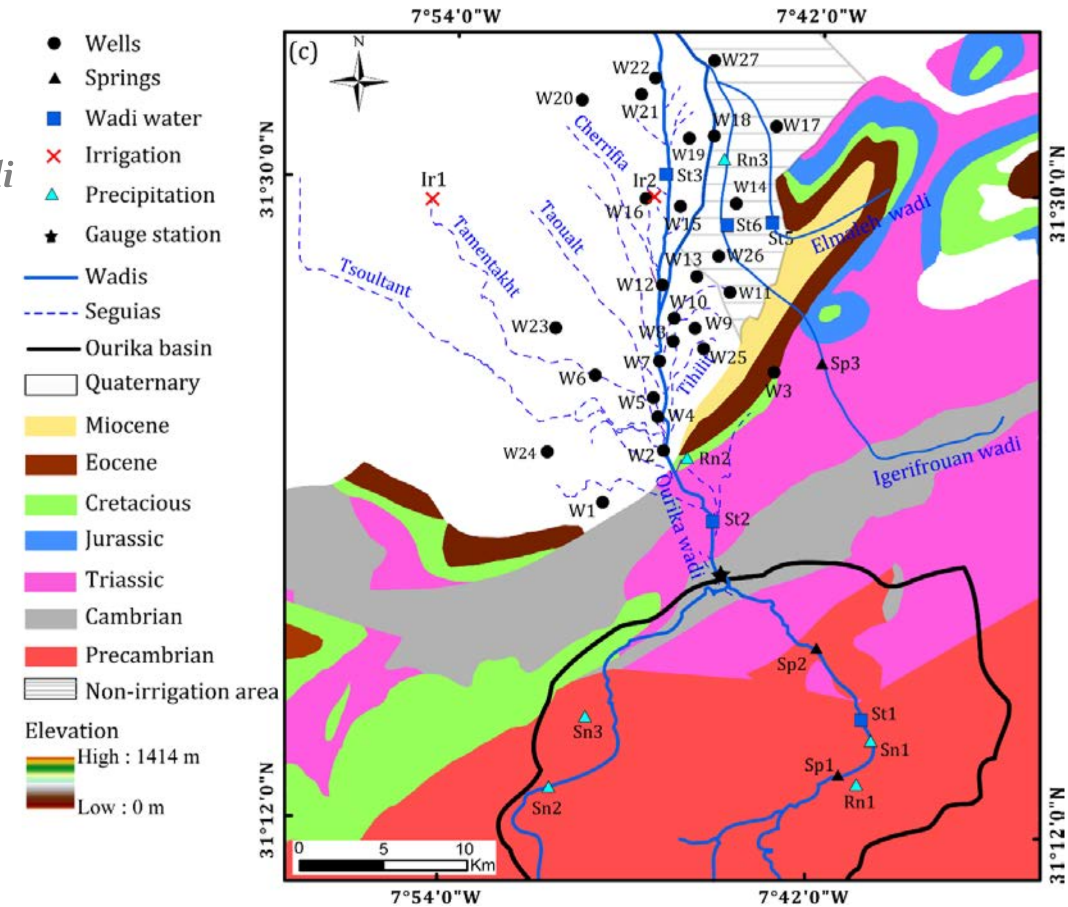
Springs (n=17) : 03 springs

Groundwater (n=56) : 27wells

Analyses:

Stables isotopes

Major ions



Calendar & Difficulties:

September 2017 to March 2018.

UCAM Contribution

Results

Irrigation area

Depleted in isotopes

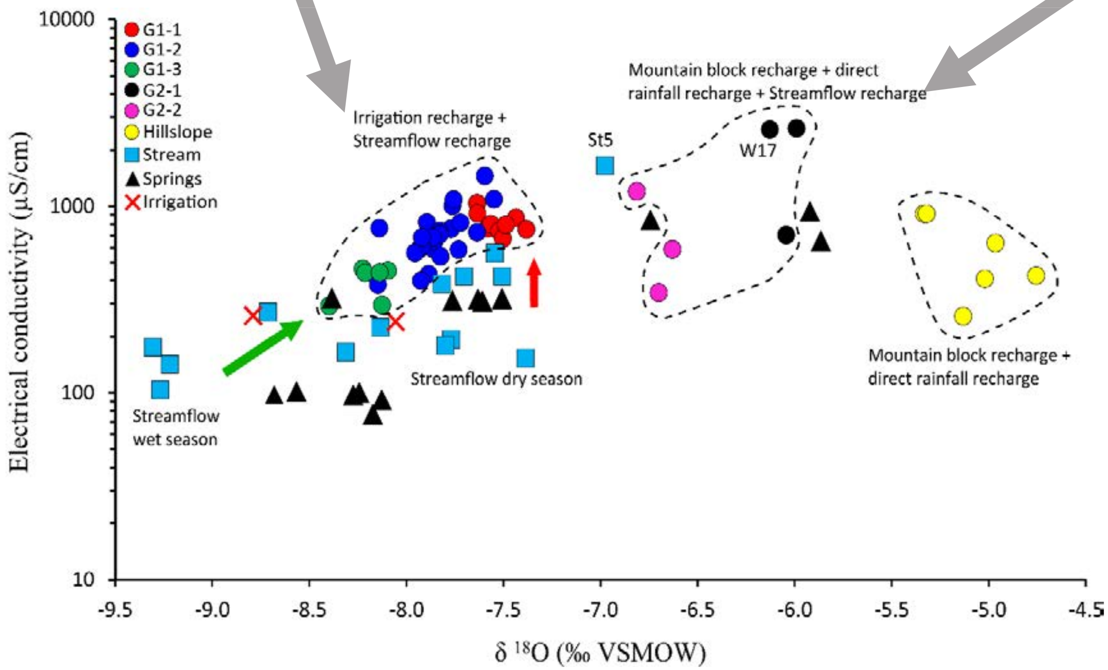
Similar to streamflow isotope content

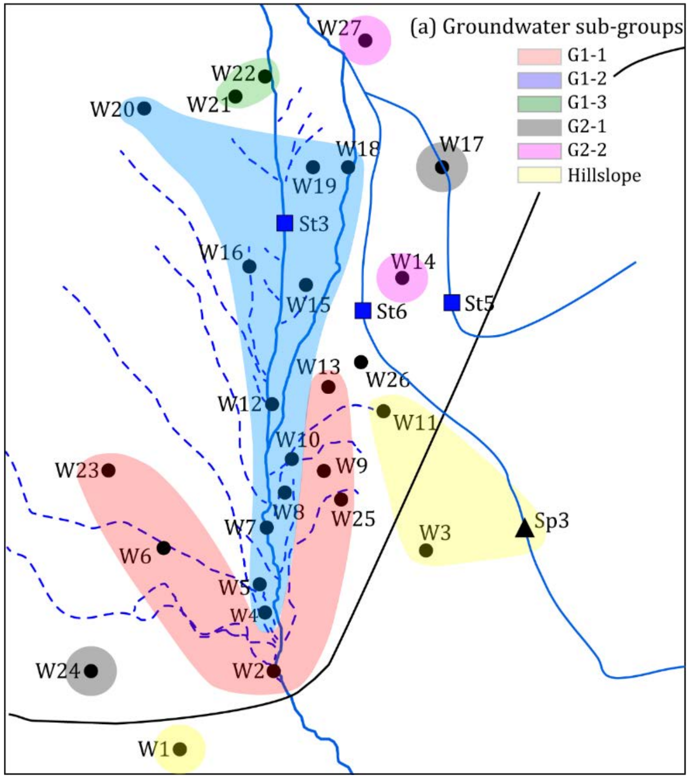
Non-irrigation area

Enriched in isotopes

Similar to low elevation rain

Similar to low elevation mountain groundwater

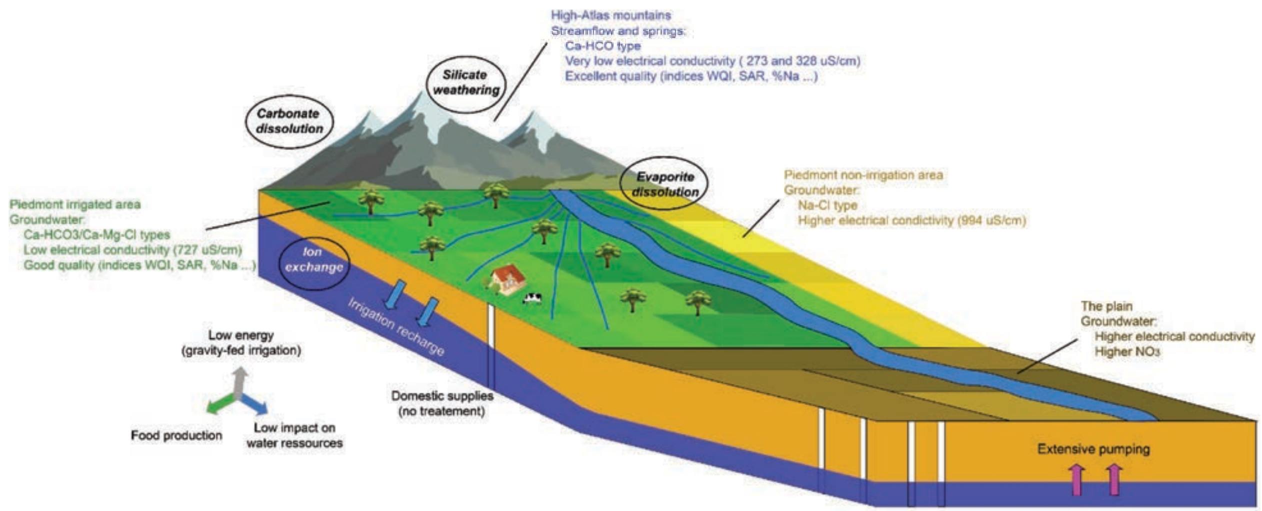




The traditional irrigation practices deeply influence the spatial and temporal patterns of groundwater recharge.

UCAM Contribution

Results



- Groundwater recharge sources in the piedmont: traditional irrigation, in-stream infiltration, rain and/or MBR.
- Groundwater quality is good to excellent with low anthropogenic influence.
- Seasonal freshening, no effect of evaporation = rapid interactions between surface and groundwater (high vulnerability for contamination).
- The long practiced traditional irrigation and agriculture seems to be benefic for groundwater sustainability.
- This traditional irrigation system provides a nexus between food production (olives, cereals, livestock), low energy (irrigation by gravity) and low environmental impact (good groundwater quality).
- Serious challenges: social changes and impact of climate change on streamflow.
- This system should be preserved and its resilience against rapid expanding modern agriculture threatens groundwater sustainability.

Task 2.1: water and chemical fluxes (leader: CERTE)

- 2.1.1.Evapotranspiration, soil moisture and crop growth.
- 2.1.2.Dam - aquifer transfers and upstream - downstream surface / subsurface transfers.
- **2.1.3.Chemical pollutants: hydrological fluxes and retention processes.**

2.1.3. Chemical pollutants: hydrological fluxes and retention processes.

Targets: chemical flows within surface water flows, reservoirs, soils, aquifers.

Methodological innovations: sampling protocols designed according to agricultural practices (WP1) and during hydrological events, joint use of in-situ soil passive samplers and laboratory soil column experiments.

Partners: INAT, LISAH, CNRS-L.

Study areas: Cap Bon, Litani.

LISAH contribution LISAH

Objective: **To get pre-modeling knowledge of pesticide active ingredients water contamination processes in pluvial and irrigated fields** in southern Mediterranean context
Comment : This task is shared pro-parte with the Eranet Med Project CHAAMS which focuses more specifically on herbicides in run off in pluvial context.

- **In pluvial context :**

  1- In OMERE site, study of glyphosate transfer by runoff. Post treatments, plot to watershed scale monitorings and rainfall simulation. => For modeling at the plot scale (Eranet Med Project CHAAMS) (Ghada Dahmeni activity) in 3.1

  2- In Lebna pluvial zone (9 hill reservoirs in sub-watersheds) Study of relationships between the treatments applied on the watersheds and the substances detected in lakes in 2018, 2019, 2020, 2021 (Herbicide ingredients involved in CHAAMS project, others pesticides accounted for PRIMA project).

- **In irrigated zone :**

  3- In irrigated zones : Study of influence of salinity of irrigation water in pesticide contamination processes. **Thesis Mariem Khouni** fully accounted for ALTOS (Started in Feb 2021)

LISAH contribution LISAH

Chemical pollutants : methodological and cognitive results will allow:

- To link treatments to actual contamination
- To discuss Tunisian water contamination in front of bibliographic sources about other Mediterranean countries and situations
- to discuss main drivers for runoff contamination in pluvial zone and percolation contamination in irrigated zones.
- To link scenarios to future contamination
- To obtain knowledge about the influence of salinity on contamination processes by pesticides

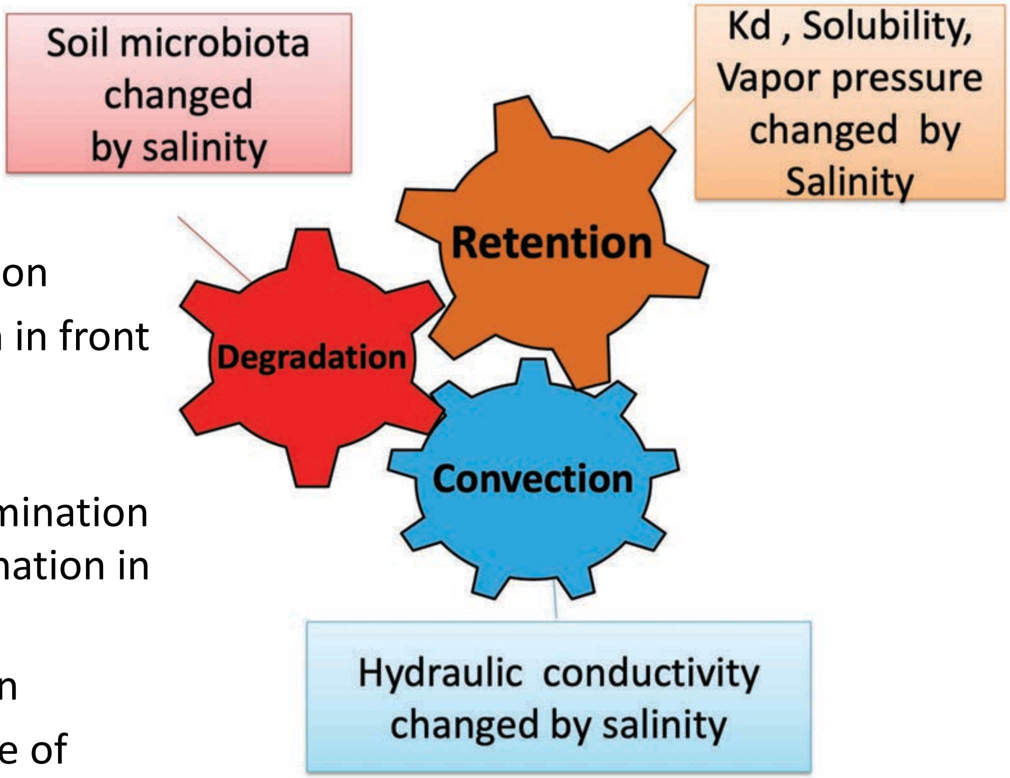


Illustration of inter-related processes
Driving pesticide fate upon salinity changes

LISAH contribution LISAH

Calendar & difficulties

- Pluvial zone pesticides
  - 80 % of field monitoring and experimental work is done in pluvial zone,
    - Last monitoring campaign (June).
    - Last laboratory experiments this Autumn
    - Modeling at plot scale for glyphosate. Resulting in Task 3.1 ? => 2022
    - Deliverables : Providing experiment and Monitoring DATA end 2021
- Irrigated zone pesticides
    - Bibliographic update about salinity influence on pesticide percolation (started this February 2021)
    - Choice of "model" active ingredients (and dyes)
    - Experimental work on salinity to be started (June2021)
      - Laboratory experiments based on conditions observed in Lebna coastal irrigated zone (from task 1.2
      - influence of salinity on degradation, retention, vaporization, solubility
        - ⇒ Lysimeters/soil columns experiments during 2022

          Deliverables experimental data end 2022
- Modeling salinity effect at soil profile scale => resulting in Task 3.1 ? Startiong beginning 2023.

- Main difficulties :
  - Budget for analysis
    - Partially included in Tunisian Budget part. To be spend now-days, to be used mostly in 2022.
  - Time gap between official start of the project (Feb 2020) and actual start of the study (Feb 2021) (mainly due to covid…)