ALTOS

Managing water resources within Mediterranean agrosystems by accounting for spatial structures and connectivities.

WP1 aims to characterize spatial structures and connectivities by developing innovating tools for observation and numerical representation:

- The **spatial structures** at local- and landscape- scales are:

(1) natural structures related to vegetation, soils, water resources and climate, as well as (2) anthropogenic structures such as landscaping features and agricultural practices.

- The **hydrological connectivities** are surface and subsurface connections between elements.

• *Innovative methodologies rely on the joint use of complementary observations with high spatio-temporal resolutions, as well as on typology based segmentations or deep learning-based processing of multisource information.*

Task 1.1: object geometries and landscape structures

- **Canopy (IRTA, UCAM, CESBIO)**
- Aquifers (CERTE, UNICA)
- Soils (CERTE, UNICA, LARI, INRGREF, INAT, LISAH, CESBIO)
- Climate variability (INAT, INRGREF, SUPCOM, LISAH, CESBIO, UNICA)

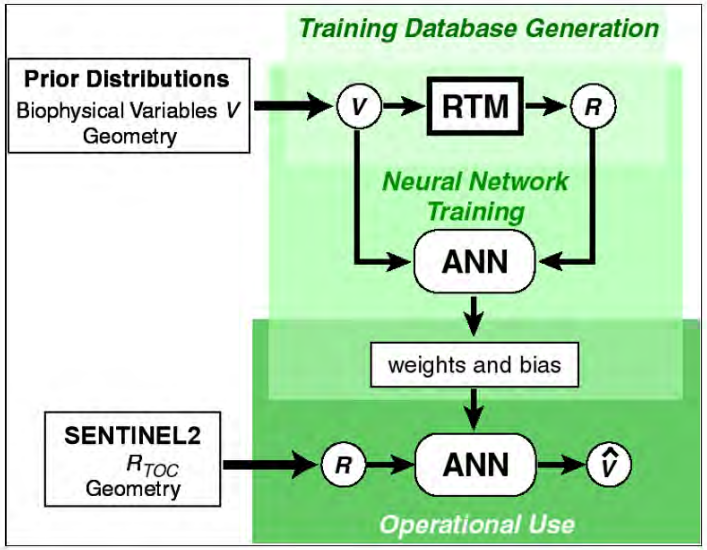
IRTA contribution to task 1.1

- **Canopy**

Motivations

- Accurate estimates of canopy transpiration (i.e. energy balance models or crop modelling) needs a good characterization of the biophysical parameters of the vegetation: LAI, FAPAR, FVC ...

- Sentinel2 ToolBox (*Weiss and Baret, 2016*) is able to obtain several biophysical variables: LAI, FAPAR and FVC at spatial resolution of 20. This has been obtained through a training data base -> Simulations with Radiative Transfer Models **(RTM)** (PROSAIL) -> Artificial Neural Network **(ANN)**



IRTA contribution to task 1.1

- **Canopy**

Motivations

Almond

Olive

Objective

To be able to improve the estimates of the biophysical parameters (LAI, FAPAR and FVC) using S2 imagery in heterogeneous orchards with different training systems.

Task 1.1: Object geometries and landscape structures (IRTA, Contribution)

Canopy (IRTA, Contribution)

- Targets: density, height and roughness, crown size, row spacing/direction, profiles of fraction cover and leaf area index
- Methodological innovations: photogrammetry, 2D and 3D RTM, Sentinel-2
- Partners: IRTA and UCAM
- Study areas: Segre (Lleida), and Marrakesh.

Confirmed activities : Characterize canopy spatial structures using RTM and photogrammetry techniques. Data collection.

Activities	Period	Study areas	Team
Use of 2D (PROSPECT & SAIL) and 3D RTM (DART) with Sentinel-2 to identify crops with different training systems, spacing distances, etc. -> improve estimates of LAI, FAPAR and FVC	2020? and 2021	Lleida (Spain) and Marrakesh (Marrocco) **Crops will be: almond, olive and grapevines**	C Jofre (PhD) J Bellvert M Pàmies A Pelechá S Er-raki
Photogrammetry techniques with high-resolution multispectral images to validate biophysical parameters of the vegetation: LAI … crown area, height, etc. in woody trees. Also, validations will be conducted with in-situ field data.	2019, 2020? and 2021		
Data collection of S2 satellite images in Lleida (others?): Land Use, biophysical parameters and ET components with Copernicus data	2019, 2020 and 2021		

IRTA
RECERCA I TECNOLOGIA AGROALIMENTÀRIES

ALTOS

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CERTE contribution

Task 1.1: object geometries and landscape structures

- Canopy
- **Aquifers**
- **Soils**
- **Climate variability**

Task 1.1: object geometries and landscape structures

Aquifers (CERTE, Contribution)

- Targets: 3D description of aquifer structure and flow pathways.
- Methodological innovations: joint use of geo-electrical methods, electromagnetic sounding, and stable isotopes (δ18O and δ2H).
- Partners: CERTE, UNICA.
- Study areas: Cap Bon, Merguellil.

Confirmed activities : Cap Bon (PhD, CERTE/LISAH)

Activities	Period	Study areas	Team
Geological investigation: outcrop mapping, lithological cross sections, geologic map	2019 and 2020	Lebna aquifer Cap Bon	**PhD, CERTE/LISAH** : N Ouhichi, F Lachaal, O Grünberger, R Hamdi, and C Leduc,
3D-Geometrie: Geophysical investigation: geo-electrical methods (69 SEV, 14 TRE).	2019 and 2020		
Stable isotopes (δ18O and δ2H).	2019 and 2020		

Proposition : Need to be approved by **LISAH and UNICA ?**

Activities	Period	Study areas	Team
3D aquifer structure with electromagnetic sounding	March 2021	Cap Bon	CERTE /LISAH / UNICA

Task 1.1: object geometries and landscape structures (CERTE, Contribution)

Soils (CERTE, Contribution)

- Targets: soil depth / horizon / texture / hydrodynamic properties.
- Methodological innovations: joint use of geo-electrical methods, electromagnetic sounding, and optical / radar satellite data.
- Partners: CERTE, UNICA, LARI.
- Study areas: Cap Bon, Merguellil, Litani.

Confirmed activities : Soil characterization Cap Bon

Activities	Period	Study areas	Team
Groundwater hydrodynamic properties: (transmissivity) in up stream of Lebna basin	February-April 2020	Cap Bon	**PhD, CERTE/LISAH**
Soil characterization with Geophysical investigation (geo-electrical methods)	2019 and 2020	Cap Bon	CERTE/LISAH

Proposition : Need to be approved **by SIBCOM / INERGREF/LISAH?**

Activities	Period	Study areas	Team
Soil charactrization (humidity, lithology, vegetation) with optical / radar satellite data	2021	Cap Bon	CERTE / SIBCOM / INERGREF/LISAH?
Combine of geophysics and optical / radar satellite data for soil characterization:	2021	Cap Bon	CERTE / SIBCOM / INERGREF/LISAH?

Task 1.1: object geometries and landscape structures

Climate variability (CERTE, Contribution)

- Targets: climate spatiotemporal structures.
- Methodological innovations: disaggregation of climate model simulations using multivariate statistics on various data (in-situ, remote sensing, high resolution meteorological model simulations) or using stochastic weather generator with SAR images.
- Partners: INAT, INRGREF, SUPCOM, LISAH, CESBIO, UNICA.
- Study areas: Cap Bon, Merguellil.

Confirmed activities : Climate variability, Cap Bon

Activities	Period	Study areas	Team
Assessment of Climate Change Impacts on Extreme Precipitation Events (Study case: Lebna basin).	2020-2021	Cap Bon	**Master, CERTE/HSM**

ALTOS

Managing water resources within Mediterranean agrosystems by accounting for spatial structures and connectivities.

LISAH contribution

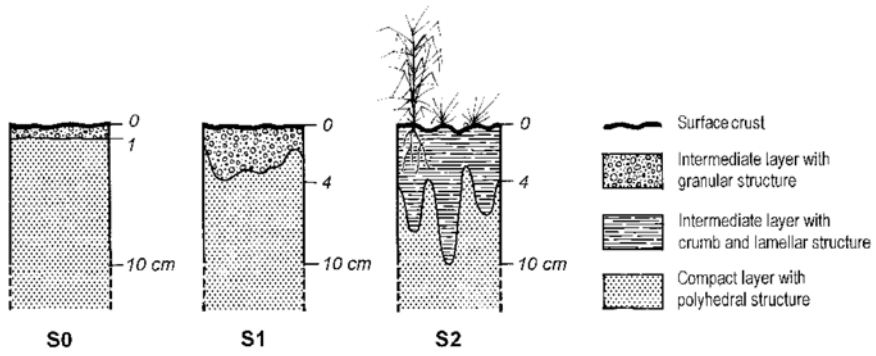
Task 1.1: object geometries and landscape structures

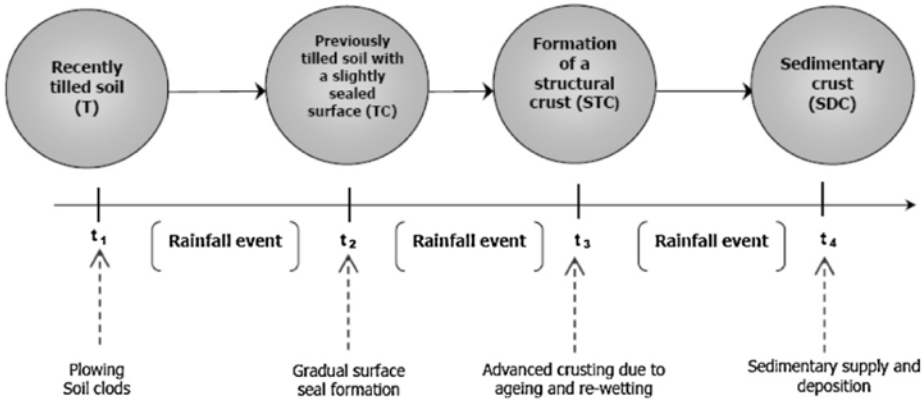
- Canopy
- Aquifers
- **Soils**
- **Climate variability**

Spatial variability in soil infiltrability / LISAH

Objectives: spatialised monitoring of soil infiltrability by using a typology of soil surface characteristics (SSC)

	Label	Definition	Mean infiltration rate
H-SSC classes	T	The surface is mainly composed of 5–10 cm size clods	31 (SD = 4.3; *N* = 5)
	TC	More than 50% of the surface is composed of clods with a slightly sealed surface	21 (SD = 6.5; *N* = 7)
	GC	More than 50% of the surface is composed of grass AND the rest is predominantly composed of structural crust	20.3 (SD = 10.8; *N* = 9)
	LC	More than 50% of the surface is composed of litter AND the rest is predominantly composed of structural crust	18.2 (SD = 6.3; *N* = 20)
	STC	More than 50% of the surface is composed of structural crust	10.8 (SD = 3.4; *N* = 8)
	SDC	More than 50% of the surface is composed of sedimentary crust	7.6 (SD = 2.6; *N* = 19)





Spatial variability in soil infiltrability / LISAH

Method

Characterising SSC

- From Sentinel-1 (microwave) & Sentinel-2 (solar spectrum) data
- By classifying spatial elements according to spatial and temporal dynamics
- To be validation with in-situ observations

Spatial variability in soil infiltrability / LISAH

Means

- Sentinel-1 (microwave) & Sentinel-2 : freely available, radiometrically and geometrically processed
- Classification procedure under implementation with CNES / TOSCA AMUSE project --> terminated in one year
- Validation data collected within OMERE observatory (20 years of continuous monitoring twice a month)
- 1 MSc is ALTOS / LISAH granted. 1 other to be planned with external funds

Spatial variability in soil infiltrability / LISAH

Partnership

- CESBIO

Road Map

- Not yet defined.

Spatial variability in soil infiltrability / LISAH

Difficulties

- Currently difficult to gather for brainstorming

Climate variability / LISAH

Objectives: simulate complete (i.e. no gaps) surrogate hydro-meteorological time series at fine scale (hectometric) within a study area over long time periods in the past or in the future (i.e. based on climate change scenarios)

Motivations

- For many impact models (e.g. energy balance, erosion), long and spatially coherent hydro-meteorological series are needed as inputs.
- Gauged networks are often too sparse to account for the spatiotemporal variability present in the study area, observation periods are short and there are numerous gaps in the record.
- Climate change scenarios rely on simulations at coarse spatial and temporal resolutions inadequate for impact studies.

Method

- Our proposal : a stochastic weather generator SWG at the sub-daily scale that serves to downscale large-scale information to a field of hydro-meteorological variables, i.e. spatially coherent and available at each fine resolution

Means (work done so far) :

- Given a series of hydro-meteorological observations at one station, the SWG can simulate complete and longer surrogate series over the past.
- Hydro-meteorological variables : precipitation, wind speed, air temperature, relative humidity, atmospheric pressure and global radiation
- Large-scale information is provided from reanalyses (ERA5, 31 km, hourly).
- Thanks to stochastic mechanisms, several surrogate series can be simulated at the same station thereby allowing to account for uncertainty

Climate variability / LISAH

Partnership

- SUPCOM, INRGREF, INAT, CESBIO, UNICA

Roadmap

- Spatial interpolation :
  - Include a spatial mechanism in the SWG to extend the series spatially and provide information over the whole catchment, i.e. spatial interpolation.
  - Data needed (in addition to gauged observations) : tailored regional climate model simulations at very high resolutions (3km, 1h) over the area of interest available for Merguellil but not for the Lebna
- Extreme events : an SWG specialized for precipitation based on models adapted for extreme events is being developed.

Roadmap

- Climate change scenarios
  - On future time periods, e.g. 2040-2060, climate change scenarios are conveyed by global/regional climate model simulations that operate on a different resolution than reanalyses'.
  - Interpolation and bias correction techniques must be applied to account for the scale mismatch between reanalyses and climate model and biases in the climate model

Climate variability / LISAH

Contracts

- Two Ph.D. candidates (INAT/CESBIO LMI NAILA and Sup'Com/ HSM IRD/ARTS fellowship) are working on the SWGs based on reanalyses, i.e. over past periods.
- One master traineeship ALTOS) will be dedicated to adapt the SWGs to rely on climate model simulations.
- Another master traineeship could be dedicated to obtain high resolution regional climate model simulations over the Lebna catchment.

Task 1.1: object geometries and landscape structures (leader: IRTA).

INRGREF activities on climate variability

1- PHD Nesrine Farhani (2018-2021)
(LMI NAILA)

2- Development of a spatio-temporal analysis tool and gap filling of agro-climatic data. (*Tunisia* - Cap Bon)

Master Rahma Timoumi (2019-2020)
(LMI NAILA)

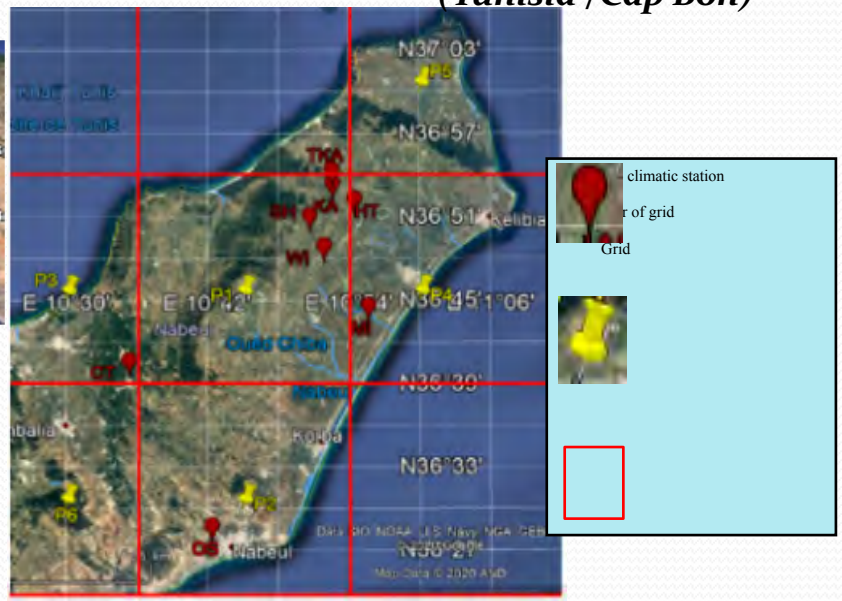
Development of a spatio-temporal analysis tool and gap filling of agro-climatic data. (*Tunisia* / Cap Bon)

- Development of a spatio-temporal analysis tool and gap filling of agro-climatic data in order to control the quality of observed agro-climatic data and gap fill the series

8 station meteorological :
Observed data
- 6 at Lebna watershed

ERA 5 Available data (1979→ now)

Data of six grids (Tunisia /Cap Bon)



Methods : (time scale = hourly, variables studied= temperature, relative humidity, global radiation and wind speed)

1. Realize **spatial comparison** using simple **linear regression** between:
   - Observed agro climatic and re analysis data
   - Observed agro climatic data

2. **Filtering** of aberrant data (eliminate the data at more or less 20% of the lineair regression

Gap filling (using the inter sites lineair regression)

Perspective

Application of this tool for precipitation

Test other methodology of processing of data filtering and gap filling particularly for air humidity and wind speed where more dispersion was observed

Make an easier application of the tool for development services

Task 1.1 object geometries and landscape structures

- Tree geometry: Taous rainfed Olive (Tunisia)
  - proxidetection (PRI, …) > maybe FLEX + LiDAR, TIR (within activities of TRISHNA TIR mission, with directional aspects)
  - DART 3D radiative transfer tool
  - ➢ PhD student + ALTOS Postdoc contract

- Spatial variability in soil infiltrability: Merguellil
  - Analysis of S1 time series
  - ➢ PhD student

- Climate variability: Merguellil
  - Downscaling of ERA5 using WRF and MODIS
  - ➢ PhD student

ALTOS KoF meeting

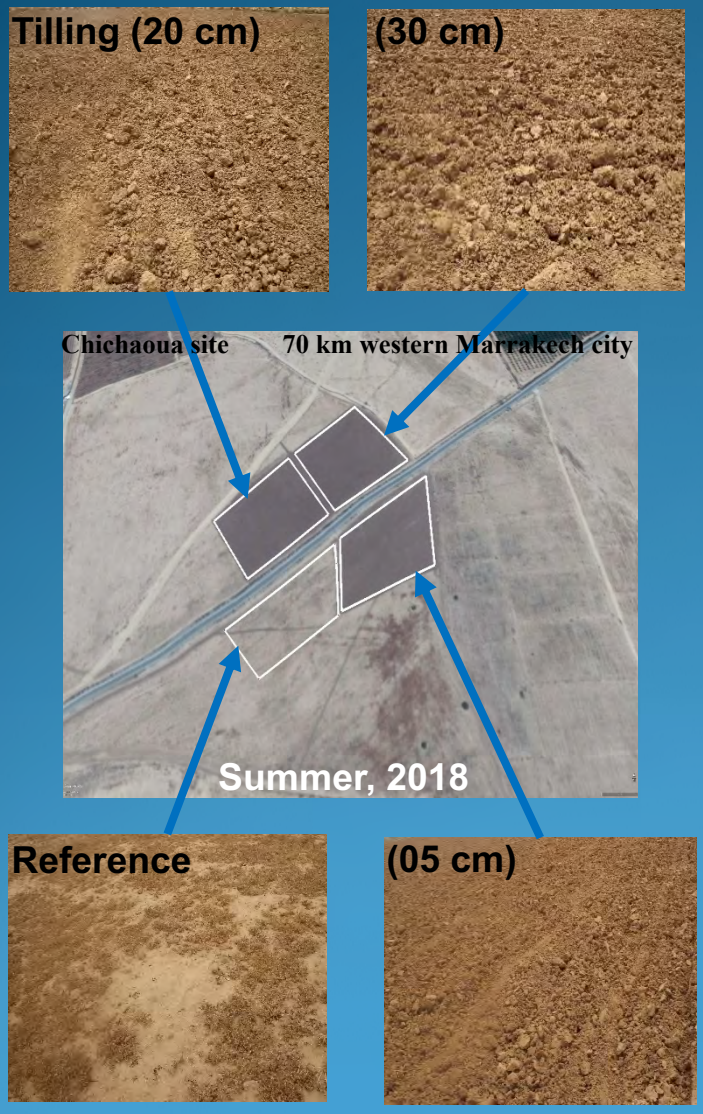
- Cadi Ayyad University UCA -

Tensift Site

WP1

April 20-21, 2020

Roughness and SMC measurements on bare soil



Main objectives:

- Investigation of the effect of surface roughness on the radar signal (C-band) over bare soils,
- Comparison of the backscattering coefficient derived from 3 radar models (IEM, Oh and Ulaby model),
- Retrieving surface soil moisture by using these models and Sentinel-1 data.

Surface soil moisture

Soil roughness

Thesis: Nadia Ouaadi

Rainfed wheat functioning (2017-date)

Main objectives:

- Retrieving temporal variation of stress coefficient from fc, LST and SM observations,
- Validation of ET-TSEB constrained by 1 km resolution MODIS LST, f_c and disaggregated SM-SMOS,
- Calibration of sentinel-1 data using optical/thermal data (Landsat 7/8).

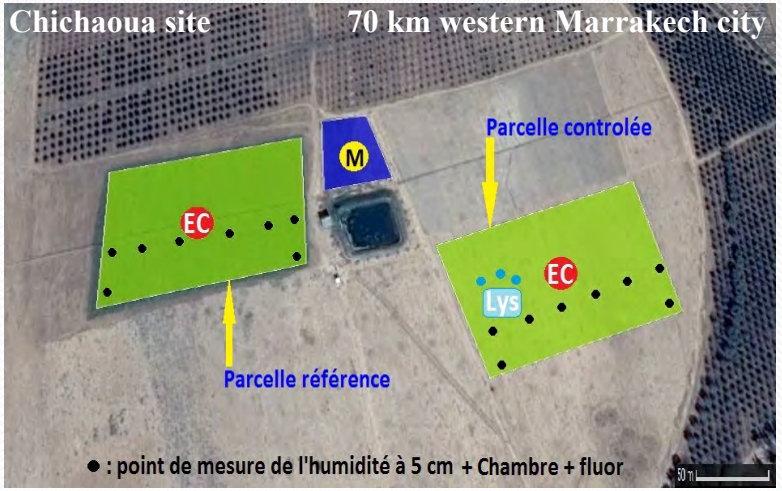
Continuous measurements

Field campaigns

Thesis: Nadia Ouaadi

Partitioning E/T and Crop water stress

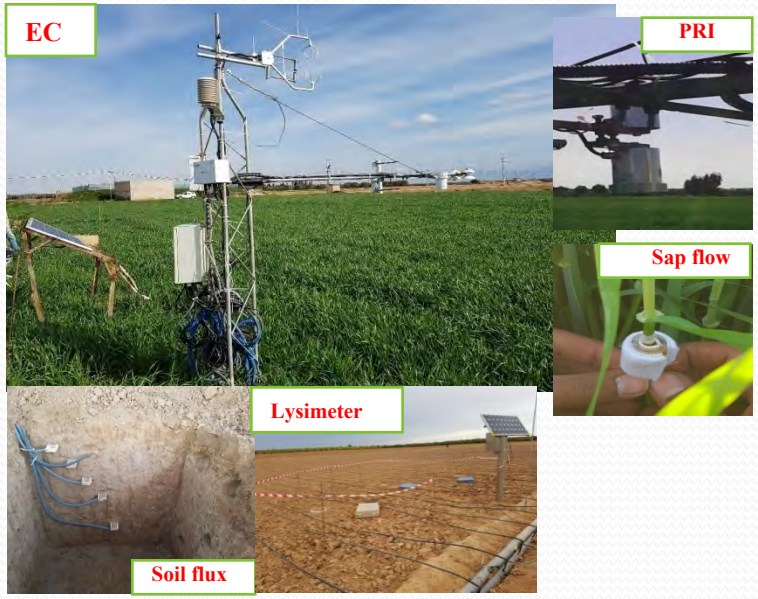
Stressed and not stressed wheat, drip irrigation (2017– date



➢ **Partitioning E/T**: comparison/complementary between different sensors monitoring the surface water balance terms with various spatio-temporal resolutions,

➢ **Crop water stress**: measurement and characterization:

(2 EC, 3 smart lysimeters, sap flow systems, fluorimeter, PRI, gas chambers, porometer) + LAI, biomass, vegetation and soil water content ...



Thesis: Zoubair Rafi

Derivation of major indexes for agriculture resilience

..... By modelling soil evaporation and plant transpiration

Chichaoua Site: data from 2016-date

In situ measurement

- Biomass
- LAI
- Height
- Canopy cover
- Soil moisture

- Sap flow (Transpiration)
- Lysimeter (Evaporation)
- Eddy-covariance system (Evapotranspiration)

Satellite data

- Thermal: LST from Landsat 7 and 8
- Optical: NDVI from Landsat 7 and 8, Sentinel 2
- Microwave: SM inverted from Sentinel 1 (Theia data) or disaggregated SM to 100m (DisPATCh)

Postdoc: Bouchra Ait Hssaine

Surface soil moisture retreiving

By using the machine Learning and backscattering models

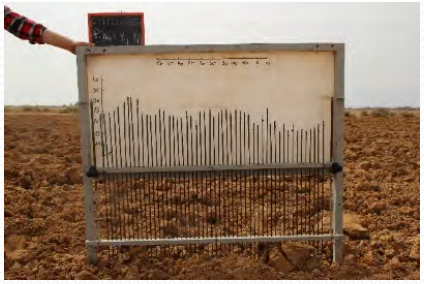
Chichaoua Site: data from 2016-date

Wheat measurement

- Biomass
- LAI
- Height
- Canopy cover

Soil Measurement

- Surface soil moisture
- Surface roughness (needle-profilometer)



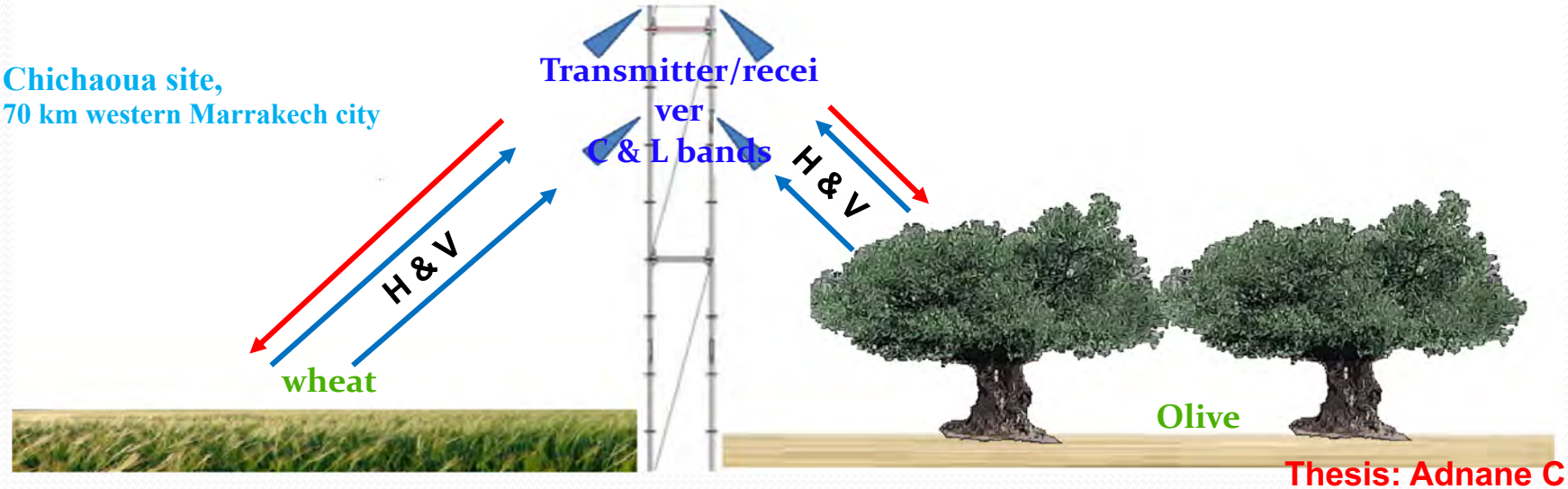
Meteorological data

- Rainfall

Observations des Cultures par Télédétection radAR

MOCTAR / Mission sentinel-1 (2019-2022)

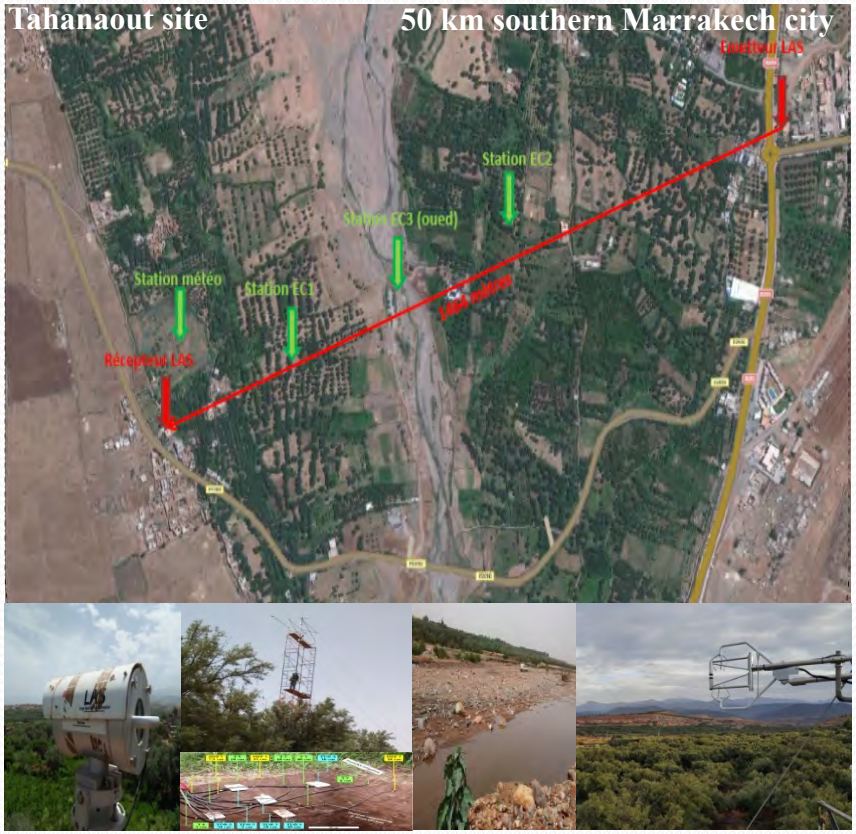
- Improve our understanding of the radar signal (C and L bands) on annual and perennial crops,
- Provide the key variables (biomass, soil moisture content) for monitoring evapotranspiration,
- Study the potential of Sentinel-1 data to monitor the crop water stress,
- Assessment of the complementary between the radar data (C and L bands) and optical data for piloting the crop models.

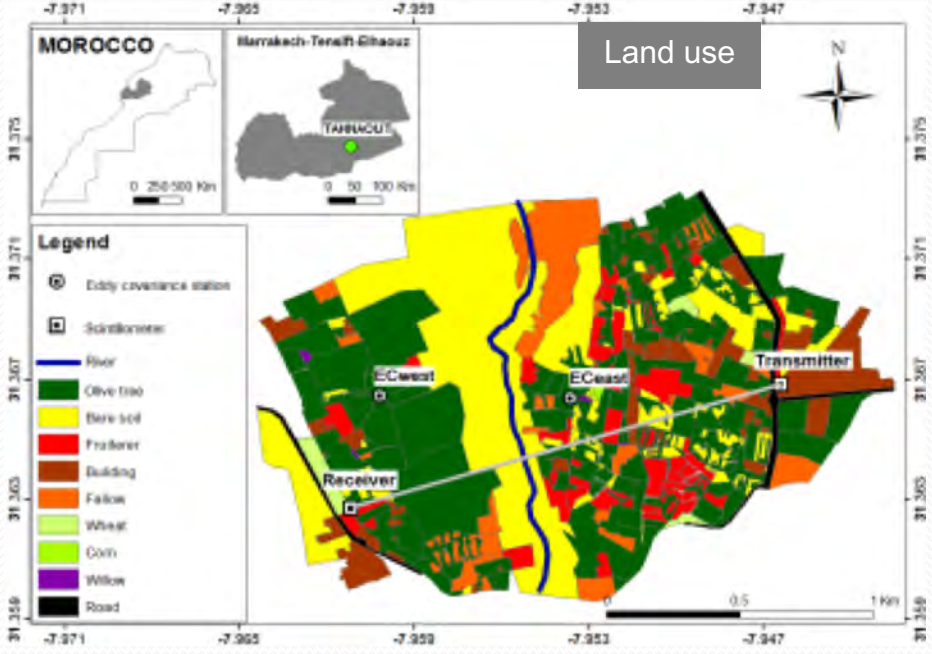


Thesis: Adnane Chakir

Hydrological functioning of the foot-mountain zone (2017-date)

- Evaluation of the ETR over the practiced heterogeneous covers,
- Extension of SAMIR Software,
- Estimation of deep percolation with water balance (groundwater recharge).





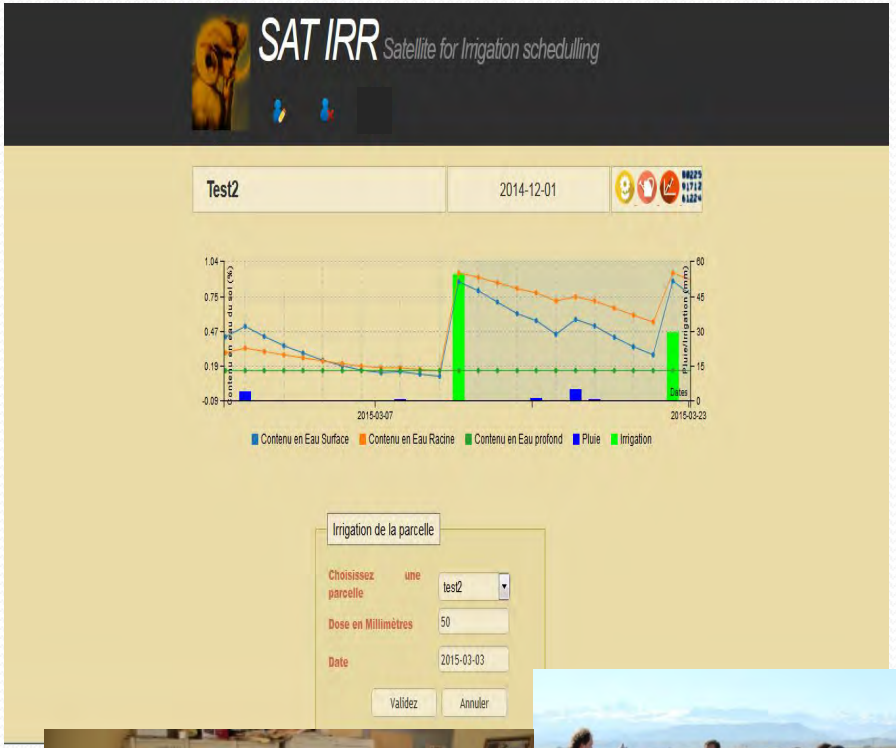
In situ measurements:

1 LAS (1.6km transect), 2 completes EC, 1 meteo station + OS, LAI

Thesis: Jamal Elfarekh

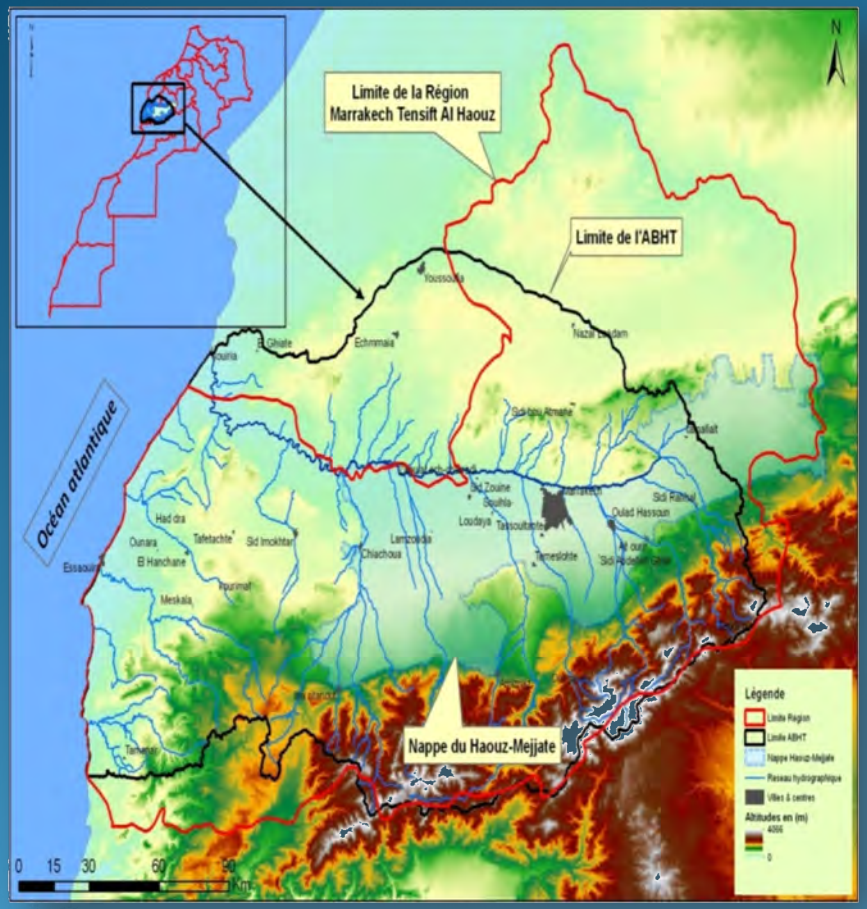
Test of SAT-IRR admissibility (2020-2021)

- Comparison with actual practices (dates and irrigation amounts),
- Assessment of the software admissibility,
- Evaluation of the irrigation conversion (from flood to drip) driven by the ORMVAH, in the frame work of “Green Moroccan plan”.



Thesis: Michel Le Page

GROUNDWATER RECHARGE IN THE HAOUZ-TENSIFT BASIN



Objectives:

- Identification and characterization of groundwater recharge sources.
- Quantification of exchanged fluxes between surface water and groundwater.

Tools :

- Hydrochemical and isotopic measurements and modeling

Snowmelt contribution to surface water and groundwater recharge resources

Methodology:

Isotope studies of the Atlas mountain snow.

The main goals:

- This project seeks to test the main hypothesis that determines the isotopic signal of rainfall, snowmelt, surface and groundwater at the watershed scale and develops an improved methodology to quantify the contribution of snow cover on water cycle at the basin scale,
- Integrating the north and south sides of the atlas series (both high and middle atlas), and sampling on many seasons.
- Integrating hydro-isotopic modelisation to quantify the recharge and having a clear idea of underground water resources,
- The velocity water transfer from upstream to downstream ought to be evaluated through two physico-chemical dating tools (Tritium measurements and Anthropic gases (Ccs, HCFCs, SF6))

PHD: XXXXXX

Snow sublimation and soil evaporation on the High Atlas mountain

The main goals:

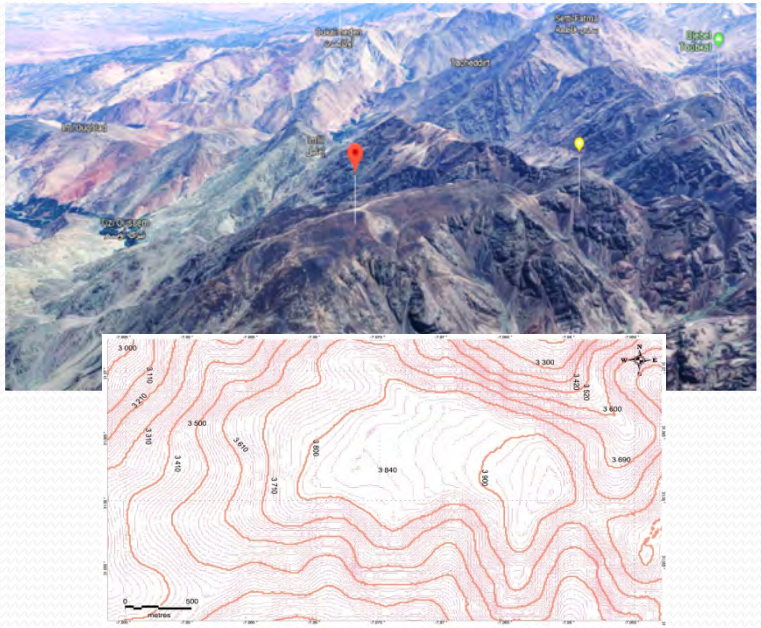
to better control the **water balance of mountain watersheds** and therefore the water resources supplying the Haouz plain.

Snow evaporation=?

Mountain soil evaporation=?

Methodology:

The experimental protocol consists of the installation of an **Eddy covariance system** and a device based on radio modems for data transmission on the **summit of Jbel Tazaghart (3850 m)** located in Toubkal park (*since summer 2020*).

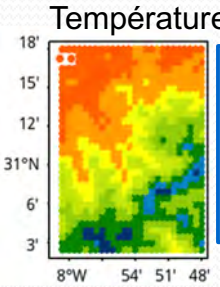


PHD: XXXXXX

Spatialization of meteorological variables over the Tensift catchments (Morocco)

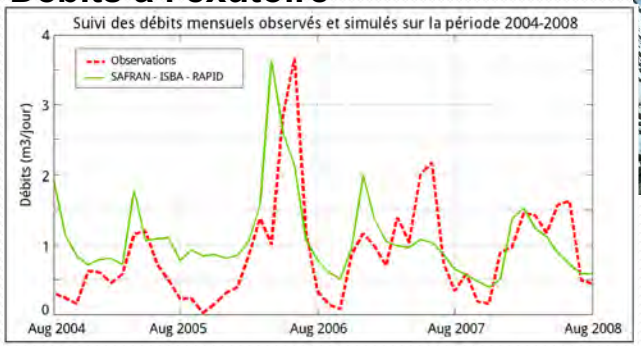
The main goal:

This study aims to set up the SAFRAN re-analysis system on the Tensift catchment, by using all the meteorological measurements acquired on the site from 2004 to 2018.



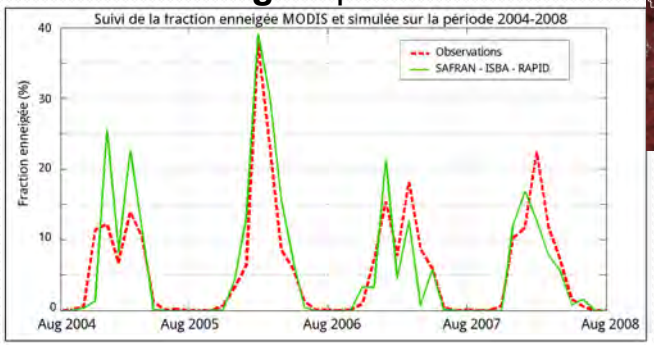
Forçage météo
(ré-analyse SAFRAN)
Quintana-Segui et al., 2008

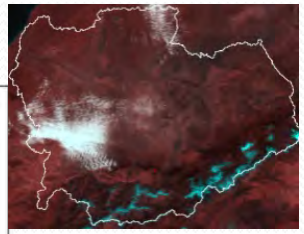
Débits à l'exutoire



Modèle SVAT et neige
(ISBA et ISBA-ES)
Noilhan et Mahfouf, 1996

Surface enneigée: produits MODIS





RAPID
(routage)
David et al., 2011

PHD: Ahmed Moucha