Task 2.2 : Characterization of spatial heterogeneities

Deliverable: Data-set to be collected and included in project clustered database.
Leader: Gilles Boulet / IRD-CESBIO

A – Taous, Tunisia : (CESBIO)

I. Implementation of new observation instruments in Taous site (Tunisia):

In the frame of the ALTOS project, new observation instruments have been implemented at the rain-fed olive orchard of Taous, Tunisia (Figure 1). The implementation of new instruments took place on June 16th to 18th , 2021. The new instruments aim to improve the ability to characterize the heterogeneity at the soil and canopy levels.

Figure 1: The instrumented rain-fed olive orchard site of Taous (Tunisia) bare soil station (left) and tree station (right)

Two instruments have been implemented during this action; root sap flow instruments and canopy thermal infrared sensors.

1) Root zone sap flow instruments:

These instruments have been implemented at three different spots in order the characterize the diurnal sap flow behavior and the measurement of the day-time and nighttime sap flows. Two sap flow instruments have been implemented in the root zone of the instrumented Eastern tree

(Figure 1, right) while a third one has been implemented in the root zone of the Western olive tree. All sap flow instruments have been implemented on roots of about 22-27 cm of circumference.

2) IRT cameras:

The IRT cameras (model MELIXIS ML90641 IRT 16x12) implemented in Taous olive orchard are thermal infrared sensors which have been set up around the Eastern olive tree crown to characterize the leaf temperature distribution. Four cameras have been implemented at Nadir, East, West and North directions.

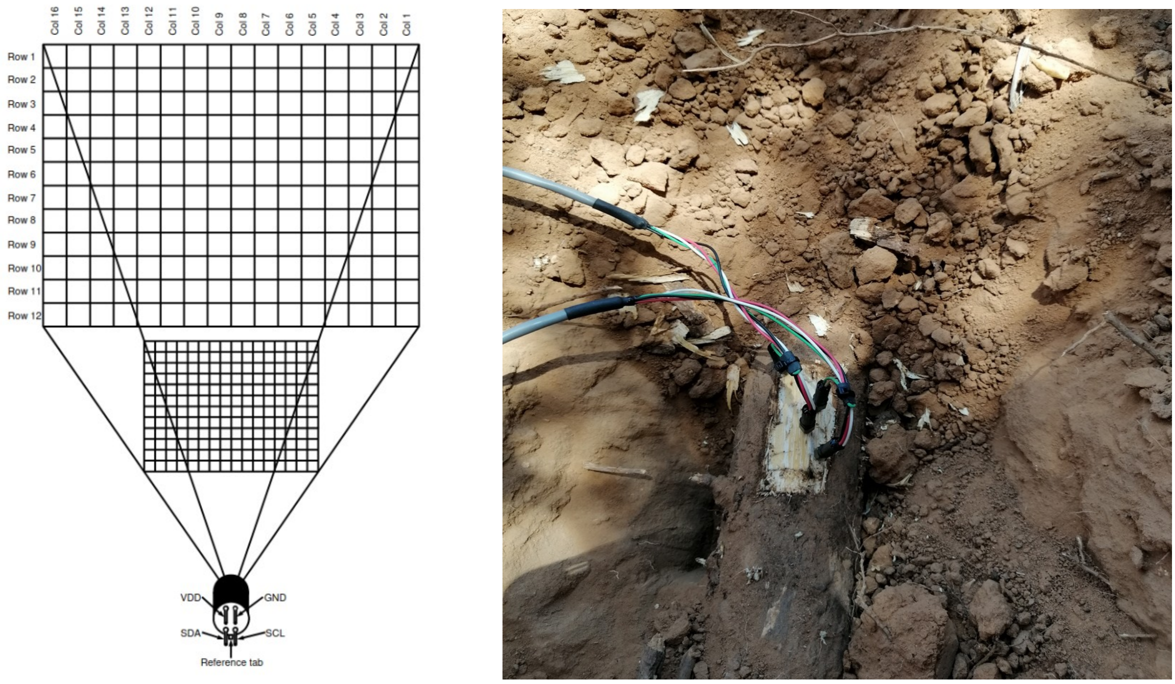


Figure 2: IRT cameras 16x12 pixels grid (left) and sap flow instrument implementation (right)

The collection of data has started on June 18th, 2021.

II. Processing of data for Taous rain-fed olive orchard (Tunisia):

Energy and water data have been processed for Taous site covering the period from April 26th, 2017 to October 15th, 2021. The following data has been produced:

- Net radiation (W m^{-2})
- Soil heat transport (W m^{-2})
- Sensible heat (W m^{-2})
- Latent heat (W m^{-2})
- Soil water content at 5, 10, 30, 50, 90 and 120 cm depth (%)

B – Segre, Spain: (IRTA)

IRTA – Estimate and monitor evapotranspiration components in grapevines using UAV imagery

Accurate estimations and monitoring of actual crop evapotranspiration and its partition of evaporation and transpiration are critical to determine crop water requirements. Nevertheless, separate measurements of soil evaporation and canopy transpiration are challenging. Some energy balance models allow to partition of both components by setting a resistances scheme, which includes soil and canopy temperature separately. The study conducted in Task 2.2.1 aimed to estimate the transpiration of grapevines under different water status through the Two-Source Energy Balance model (TSEB) and to validate it against sap-flow measurements. The TSEB inputs, such as the biophysical parameters of the vines, and the radiometric temperature were obtained from very high-resolution imagery. Besides, this study addressed the aerodynamic factors that affect wind speed attenuation to evaluate the effects of wind modeling on canopy transpiration in heterogeneous crops. Nine vines under two different irrigation treatments were continuously monitored with heat-pulse sap-flow sensors and infrared radiometers during the 2020 growing season. Also, two apogee sonic anemometers were placed above and below the canopy for accounting for the wind speed attenuation. Very high-resolution UAV images were collected throughout the growing season with a thermal, multispectral and RGB cameras. Concomitant to image acquisition, stem water potential, leaf transpiration, stomatal conductance, and photosynthesis will be measured.

At the current moment, we have created a dataset with all available data. We will start processing data during spring/summer 2022. We expect that the result of this study will show the feasibility of using remote sensing techniques to estimate actual transpiration and hence identify water stress in vines and additionally to identify heterogeneities in the crop that can lead to biased evapotranspiration estimations. Preliminary results show that wind attenuation was better modeled considering the foliage distribution in the canopy.

In the current link, there is the dataset collected during the growing season:
[redacted]

In the folder DATA, there is the following datasets available:

ACD: Measurements of leaf gas exchanges made with the ADC instrument (https://www.adc.co.uk/)

Balloon: dataset used to calibrate sapflows

IRT: data collected using thermal infrared Apogee sensors.

LP-80: measurements of PAR using the Decagon LP-80 Accupar ceptometer

Sap-flow: dataset of sapflows for each vine

SM-counters: obtained data of soil moisture sensors and water meters

Vuelos: measurements in the panels for radiometric corrections. Thermal and multispectral mosaicks are also available.

More detailed information is also available in IRTA's servers. Thus, please contact joaquim.bellvert@irta.cat

C – Lebna, Tunisia:

1) SAR data (SUPCOM):

The SAR (Synthetic Aperture Radar) data used withing the ALTOS project consists of six Sentinel-1 images, acquired during the period from January to June 2019. These images were acquired in the interferometric wide (IW) mode with a swath of 250 km and a spatial resolution of 5 m by 20 m. the table below summarizes the characteristics of these images.

Image acquisition	Satellite pass	Mission	Product type	Polarization	Swath	Resolution
12/02/2019	Descending	Sentinel1-A	SLC	VH-VV	IW1	5x20m
8/03/2019	Descending	Sentinel1-A	SLC	VH-VV	IW1	5x20m
1/04/2019	Descending	Sentinel1-A	SLC	VH-VV	IW1	5x20m
13/04/2019	Descending	Sentinel1-A	SLC	VH-VV	IW1	5x20m
07/05/2019	Descending	Sentinel1-A	SLC	VH-VV	IW1	5x20m
06/06/2019	Descending	Sentinel1-A	SLC	VH-VV	IW1	5x20m

From these images, coherence images were generated for each of the different pairs and for each polarization (VH and VV).

Pair number	Date SLC1	Date SLC2	Temporal baseline (days)	Perpendicular baseline
Pair 1	12/02/2019	8/03/2019	25	111
Pair 2	8/03/2019	1/04/2019	23	-91.53
Pair 3	1/04/2019	13/04/2019	12	49
Pair 4	13/04/2019	7/05/2019	24	44.37
Pair 5	7/05/2019	6/06/2019	31	-27.36

2) P-SBAS (Parallel Small Baseline Subset) Sentinel1 (CERTE) :

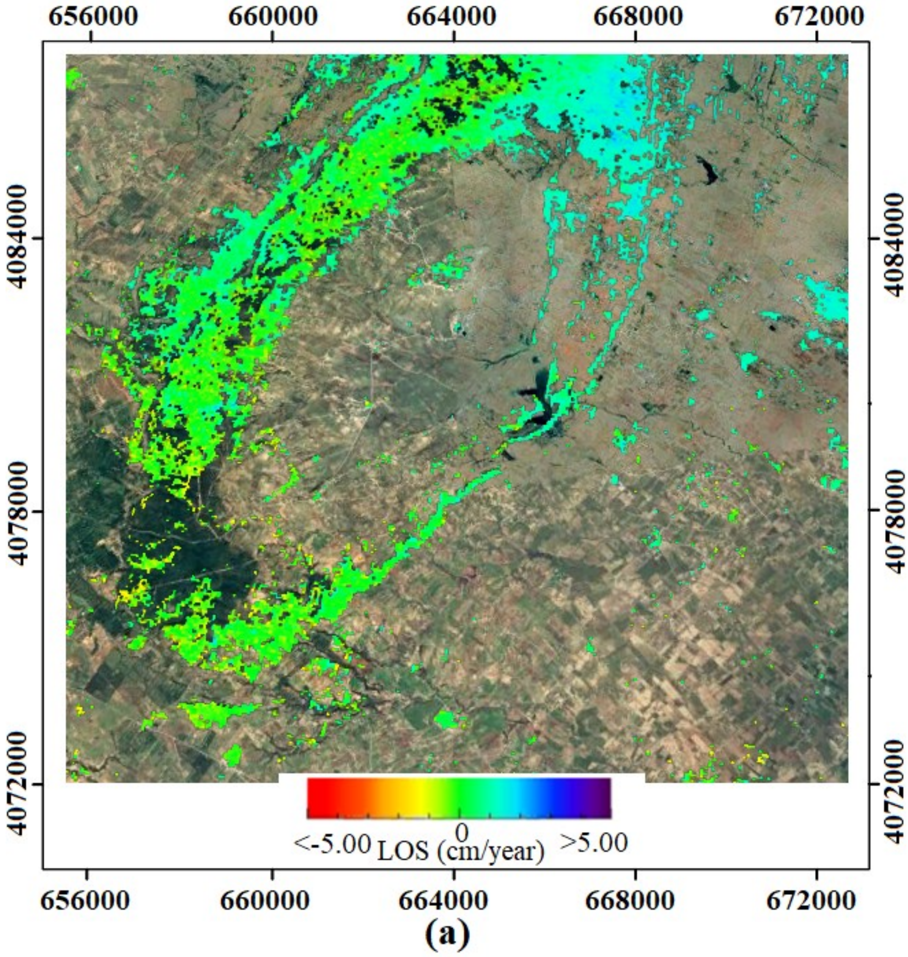
<u>Dataset 1</u> :

- Images acquired between August 2017 and August 2018:
  - Supermaster SAR: 2018-01-24
  - Resolution: 5x20m
  - Polarization: VV
  - Interferograms and P-SBAS maps are generated using CNR-IREA's Geohazard Exploitation Platform (GEP)

Image acquisitions
2017-08-21T05:21:19Z
2017-09-02T05:21:19Z
2017-09-14T05:21:19Z
2017-09-26T05:21:20Z
2017-10-08T05:21:20Z
2017-10-20T05:21:20Z
2017-11-01T05:21:20Z
2017-11-13T05:21:20Z
2017-11-25T05:21:20Z
2017-12-07T05:21:19Z
2017-12-31T05:21:18Z
2018-01-24T05:21:17Z
2018-02-17T05:21:17Z
2018-04-06T05:21:17Z
2018-04-18T05:21:18Z
2018-04-30T05:21:19Z
2018-05-12T05:21:19Z
2018-05-24T05:21:20Z
2018-06-17T05:21:21Z
2018-07-11T05:21:23Z
2018-07-17T05:20:41Z
2018-07-23T05:21:23Z
2018-07-29T05:20:42Z
2018-08-04T05:21:24Z
2018-08-10T05:20:42Z
2018-08-16T05:21:25Z

Interferograms
21082017S1A_02092017 S1A
21082017S1A_14092017S1A
21082017S1A_26092017S1A
21082017S1A_07122017S1A
21082017S1A_06042018S1A
02092017S1A_14092017S1A
02092017S1A_08102017S1A
02092017S1A_01112017S1A
14092017S1A_26092017S1A
14092017S1A_08102017S1A
26092017S1A_08102017S1A
26092017S1A_13112017S1A
26092017S1A_07122017S1A
08102017S1A_20102017S1A
08102017S1A_01112017S1A
08102017S1A_13112017S1A
20102017S1A_01112017S1A
20102017S1A_13112017S1A
20102017S1A_25112017S1A
01112017S1A_25112017S1A
01112017S1A_31122017S1A
01112017S1A_17022018S1A
13112017S1A_25112017S1A
13112017S1A_07122017S1A
25112017S1A_07122017S1A
25112017S1A_31122017S1A
07122017S1A_31122017S1A
07122017S1A_24012018S1A
07122017S1A_06042018S1A
31122017S1A_24012018S1A
31122017S1A_17022018S1A
31122017S1A_30042018S1A
24012018S1A_06042018S1A
24012018S1A_18042018S1A
24012018S1A_30042018S1A
17022018S1A_30042018S1A
17022018S1A_12052018S1A
06042018S1A_18042018S1A
06042018S1A_17072018S1B
18042018S1A_30042018S1A
18042018S1A_24052018S1A

18042018S1A_17062018S1A
18042018S1A_17072018S1B
30042018S1A_12052018S1A
30042018S1A_24052018S1A
12052018S1A_24052018S1A
12052018S1A_11072018S1A
12052018S1A_29072018S1B
24052018S1A_17062018S1A
24052018S1A_11072018S1A
17062018S1A_11072018S1A
17062018S1A_17072018S1B
17062018S1A_23072018S1A
17062018S1A_04082018S1A
11072018S1A_23072018S1A
11072018S1A_29072018S1B
17072018S1B_04082018S1A
17072018S1B_16082018S1A
23072018S1A_29072018S1B
23072018S1A_04082018S1A
23072018S1A_10082018S1B
29072018S1B_10082018S1B
04082018S1A_10082018S1B
04082018S1A_16082018S1A
10082018S1B_16082018S1A



P-SBAS result for the Lebna study region between August 2017 and August 2018: velocity map in the direction of the line of sight

Dataset 2 :

- Images acquired between September 2018 and November 2019
  - Supermaster SAR: 2019-04-12
  - Resolution: 5x20m
  - Polarization: VV
  - Interferograms and P-SBAS maps are generated using CNR-IREA's Geohazard Exploitation Platform (GEP)

Image acquisitions
2018-09-20T17:20:28Z
2018-11-07T17:20:28Z
2018-11-19T17:20:28Z
2018-12-13T17:20:27Z
2019-01-06T17:20:26Z
2019-01-18T17:20:26Z
2019-01-30T17:20:25Z
2019-02-11T17:20:25Z
2019-02-23T17:20:25Z
2019-03-07T17:20:25Z
2019-03-19T17:20:25Z
2019-03-31T17:20:25Z
2019-04-12T17:20:25Z
2019-04-24T17:20:26Z
2019-05-06T17:20:26Z
2019-05-18T17:20:27Z
2019-05-30T17:20:27Z
2019-06-11T17:20:28Z
2019-06-23T17:20:29Z
2019-07-05T17:20:29Z
2019-07-17T17:20:30Z
2019-09-15T17:20:34Z
2019-09-27T17:20:34Z
2019-10-09T17:20:34Z
2019-10-21T17:20:34Z
2019-11-02T17:20:34Z

P-SBAS result for the Lebna study region between September 2018 and November 2019: velocity map in the direction of the line of sight

interferograms
20092018S1A_07112018S1A
20092018S1A_19112018S1A
20092018S1A_30012019S1A
20092018S1A_23022019S1A
20092018S1A_24042019S1A
07112018S1A_19112018S1A
07112018S1A_13122018S1A
07112018S1A_06012019S1A
07112018S1A_15092019S1A
19112018S1A_13122018S1A
19112018S1A_30012019S1A
13122018S1A_06012019S1A
13122018S1A_18012019S1A
13122018S1A_30012019S1A
06012019S1A_18012019S1A
06012019S1A_19032019S1A
06012019S1A_06052019S1A
06012019S1A_11062019S1A
06012019S1A_15092019S1A
18012019S1A_30012019S1A
18012019S1A_19032019S1A
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30012019S1A_23022019S1A
30012019S1A_19032019S1A
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11022019S1A_07032019S1A
11022019S1A_19032019S1A
23022019S1A_07032019S1A
23022019S1A_31032019S1A
23022019S1A_24042019S1A
07032019S1A_19032019S1A
07032019S1A_31032019S1A
07032019S1A_12042019S1A
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19032019S1A_06052019S1A
19032019S1A_18052019S1A
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24042019S1A_02112019S1A
06052019S1A_18052019S1A
06052019S1A_11062019S1A
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18052019S1A_11062019S1A
18052019S1A_23062019S1A
18052019S1A_05072019S1A
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30052019S1A_27092019S1A
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11062019S1A_15092019S1A
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23062019S1A_17072019S1A
23062019S1A_27092019S1A
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05072019S1A_15092019S1A
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17072019S1A_27092019S1A
15092019S1A_27092019S1A
15092019S1A_09102019S1A
27092019S1A_09102019S1A
27092019S1A_02112019S1A
09102019S1A_21102019S1A
21102019S1A_02112019S1A

D – Orroli, Italy: (UNICA)

UNICA dataset

Micrometeorological measurements

The Unica dataset includes all the variables acquired from the micrometeorological instruments installed on the 10 m micrometeorological tower in the Orroli site, and consist of latent heat (LE), sensible heat measurements obtained through the application of eddy covariance method, air temperature, incoming and outgoing shortwave and longwave radiation components, specific humidity, precipitation, three-dimensional time series sampling of wind velocity, CO_2, water vapor concentration and soil water content within the root-zone. The data are measured at 10 Hz and then aggregated over 30 min intervals.

Sap flow data measurements on three stem and three roots are provided at a temporal at half hourly temporal resolution. The data are available for a period between 2015 and 2017 and from September 2020 to now.

The dataset is provided in text or .xlsx format. Missing data values are indicated with NAN as a replacement value, independent of the cause for the missing value.

[redacted]

Below a sample of half-hourly data file for the Orroli eddy covariance tower

Date	***Precipitation [mm]***	***Air Temperature [Deg K]***	***Air Humidity [%]***	***Wind velocity [m\s]***	***Incoming shortwave solar radiation [W\ m2]***
'01-Jan-2015 09:00:00'	0.16	275.12	97.5	2.80	89
01-Jan-2015 09:30:00'	1.65	275.755	97	1.86	178.5
'01-Jan-2015 10:00:00'	1.43	277.107	96	1.3	320.5
01-Jan-2015 10:30:00'	0.2	277.78	94	1.39	406.67
'01-Jan-2015 11:00:00'	0	278.541	93	1.51	452.67
01-Jan-2015 11:30:00'	0	279	92.5	1.54	493
'01-Jan-2015 12:00:00'	0	279.564	89	1.33	516.33
01-Jan-2015 12:30:00'	0	280.023	88	1.31	519.33
'01-Jan-2015 13:00:00'	0	280.493	88	1.42	511.67
01-Jan-2015 13:30:00'	0	280.773	86	1.68	487
'01-Jan-2015 14:00:00'	0	280.934	81.5	1.96	447
01-Jan-2015 14:30:00'	0	281.143	72	2.25	116.67
'01-Jan-2015 15:00:00'	0	280.611	68	2.58	39
01-Jan-2015 15:30:00'	0	280.393	57.5	3.24	31.333

Remote sensing.

The Remote sensing dataset consist of the remote sensor products retrieved from the Sentinel, and Landsat, satellite constellations. Below a table with the available data and its specifics.

Data Processor	SATELLITE	Country	Name	Parameter	Site	Period	Temporal resolution	Spatial resolution
UNICA	Sentinel 1	Italy	Sentinel 1 - S1A_IW_GRDH_1SDV	soil moisture	Flumendosa (Orroli) -	from 2015 to 2018	6 days in average	10-30 m
UNICA	Sentinel 2	Italy	Sentinel 2 - L1C	NDVI	Flumendosa (Orroli) -	from 2015 to 2018	6 days in average	10 - 20 - 60 m
UNICA	Landsat 8	Italy	LT08_L1TP_192_032_LEVEL_1	NDVI	Flumendosa (Orroli) -	from 2016 to 2020	16 days	30 m
UNICA	Landsat 8	Italy	LT08_L1TP_192_032_LEVEL2	NDVI	Flumendosa (Orroli) -	from 2016 to 2020	16 days	30 m

Scientific publications to be considered.

Montaldo N, Fois L, Corona R. Soil Moisture Estimates in a Grass Field Using Sentinel-1 Radar Data and an Assimilation Approach. Remote Sensing. 2021 Jan;13(16):3293; https://doi.org/10.3390/rs13163293

Montaldo, N., Corona, R., Curreli, M., Sirigu, S., Piroddi, L. and Oren, R., 2021. Rock water as a key resource for patchy ecosystems on shallow soils: Digging deep tree clumps subsidize surrounding surficial grass. *Earth's Future*, *9*(2), p.e2020EF001870. **https://doi.org/10.1029/2020EF001870**