# ICOS Ecosystem Station Labelling Report

## Station: IT-SR2 (San Rossore 2)

*Viterbo (Italy), Antwerp (Belgium), Bordeaux (France), October 28th 2019*

## Description of the Labelling procedure

The Step2 procedure has the aims to organize the building the station in accordance with the ICOS Instructions, to establish the link with the ETC, and to validate all the data formats and submission. Furthermore, it involves also defining the additional steps needed after the labelling to complete the station construction according to the station Class. During the Step2 a number of steps are required and organized by the ETC in collaboration with the PI.

**Preparation and start of the Step2**

The station started the Step1 of the labelling on March 30th 2017 and got the official approval on May 31st 2017. The Step2 started officially on October 19th 2017 with a specific WebEx between the ETC members and the station team members where the overall procedure was discussed and explained.

**Team description**

The station PI has to describe the station team and provide the basic information about the proposed station using the BADM system. The submission is done using a specific ICOS interface.

**Sampling scheme implementation**

The sampling scheme is the distribution of points in the ecosystem where a number of measurements must be done. It is composed by two different type of sampling locations: the Sparse Measurement Plots (SP) that are defined by the ETC following a stratified random distribution on the basis of information provided by the PI and the Continuous Measurement Plots (CP) where continuous measurements are performed.

**Measurements implementation**

The measurement of a set of variables must be implemented in the Step2 labelling phase. The compliance of each proposed sensor and method is checked by the ETC and discussed with the PI in order to find the optimal solution. In case for specific reasons it is not possible to follow the ICOS agreed protocols and Instructions an alternative solution, equally valid, is defined and discussed also with the MSA if needed.

Once the sensors and methods are agreed the station Team has to implement the measurements using calibrated sensors, submit the metadata to the ETC and start to submit data Near Real Time for the continuous measurement. Also vegetation samples must be collected and shipped to the ETC chemical laboratory in France. The list of variables to be implemented during Step2 is reported in Table 1. Adaptation of the table to specific ecosystem conditions are possible and always discussed with the PI and the MSA.

In addition to the variables reported in Table 1 there is an additional set of measurements that are requested and that must be implemented after the labelling in the following 1-2 years. For all these variables (in particular for the soil sampling) an expected date and specific method to be used is discussed and agreed before the end of the Step2 process.

| Group | Variable |
|---|---|
| EC fluxes CO2-LE-H | Turbulent fluxes<br>Storage fluxes |
| Radiations | SW incoming<br>LW incoming<br>SW outgoing<br>LW outgoing<br>PPFD incoming<br>PPFD outgoing |
| Meteorological above ground | Air temperature<br>Relative humidity<br>Air pressure<br>Total precipitation<br>Snow depth<br>Backup meteo station |
| Soil climate | Soil temperature profiles<br>Soil water content profiles<br>Soil heat flux density<br>Groundwater level |
| Site characteristics | History of disturbances<br>History of management<br>Site description and characterization |
| Biometric measurement | Green Area Index<br>Aboveground Biomass |
| Foliar sampling | Sample of leaves<br>Leaf Mass to Area Ratio |
| | |
| **Additional variables for Class1 stations** | |
| Radiation | SW/PPFD diffuse |
| Meteorological | Precipitation (snow) |
| Biometric measurement | Litterfall |

Table 1 – Variables requested for Step2

## Data evaluation

Stations entering Step2 have been already analyzed during Step1 of the labelling but the optimal configuration and the possible presence of issues can be checked only looking to the first data measured. For this reason a number of tests will be performed on the data collected during the Step2 (NRT submissions, that can be integrated if needed by existing data) and the results discussed with the PI in order to find the best solution to ensure the maximum quality that is expected by ICOS stations. Four tests are performed:

### *Test 1 - Percentage of data removed*

During the fluxes calculation the raw data are checked by a number of quality tests and some of them will lead to data exclusion and gaps. It is calculated the number of half hours removed by these QAQC filters and the target value is to have less than 40% of data removed. If the test fails, an in depth analysis of the reasons is performed in order to find solutions and alternatives.

***Test 2 – Footprint and Target Area***

The Target Area is the area that we aim to monitor with the ICOS station. The test will analyze using a footprint model (Klijun et al. 2015) the estimated contribution area for each half hour and check how many records have a contribution coming mainly from the target area. The target is to have at least 70% of measurements that are coming mainly (70% of the contribution) from the Target Area. If the test fails, a discussion with the PI is started in order to find solutions and alternatives, in particular changing the measurement height or wind sectors to exclude.

***Test 3 – Data Representativeness in the Target Area***

The aim is to identify areas that are characterized by different species composition or different management (and consequently biomass and density) and analyze, using the same footprint model (Kljun et al. 2015), the amount of records coming from the different ecosystems, checking their representativeness in terms of day-night conditions and in the period analyzed. The target is to get, for the main ecosystem types, at least 20% of the data during night and during day and also distributed along the period analysed. If not reached, a discussion with the PI is started in order to find solutions and alternatives, in particular changing the measurement height or wind sectors to exclude.

***Test 4 – CP Representativeness in the Target Area***

The CPs must be as much as possible representative of the Target Area and this will be checked on the basis of the results of the site characterization, in particular in relation to species composition, biomass and management. The target is to have the percentage of the two main species and their biomass in the CP not more that 20% different respect to the measurements done in the SP plots. In case the CPs proposed do not represent a condition present in the Target Area they are relocated or one or more additional CPs can be added.

## Station Description

The site San Rossore 2, with ICOS code IT-SR2, is located inside the Parco Regionale Migliarino, San Rossore, Massaciuccoli approximately 8 Km west of Pisa, with coordinates: Latitude 43.732022 °C, Longitude 10.290910 °C, at an elevation of 4 m above sea level. The site is marked by the following climate characteristics: Mean Annual Temperature 15.3 °C, Mean Annual Precipitation 950 mm, Mean Annual Radiation 175 W $m^{-2}$. The offset respect to the Coordinated Universal Time (UTC) is +01. The ecosystem under investigation is a very homogeneous and dense stand of *Pinus pinea* L., in addition only scarce occurrences of *Quercus ilex* L., *Fraxinus excelsior* L. and *Alnus glutinosa* (L.) Gaertn.

Figure 1 - The IT-SR2 tower

## Team description

The staff of the site has been defined and communicated in October 2017. It includes in addition to the PI, the Manager and the affiliated person. Below the summary table of the Team members is reported.

| MEMBER_NAME | MEMBER_INSTITUTION | MEMBER_ROLE | MEMBER_MAIN_EXPERT |
|---|---|---|---|
| Nicola Arriga | EC-JRC | PI | |
| Ignacio Goded | EC-JRC | MANAGER | LOGISTIC |
| Giovanni Manca | EC-JRC | AFFILIATED | MICROMET |

Table 2 - Description of team members roles at IT-SR2

## Spatial sampling design

For the spatial sampling design at IT-SR2, the Station Team (ST) proposed, in addition to the Target Area (TA) and an area to be excluded from sampling (EA), 2 continuous measurement points (CP). Figure 2 shows the extent and position of such spatial features in relation to the actual site area in addition to the randomly sampled first order sparse measurement plots SP-I.

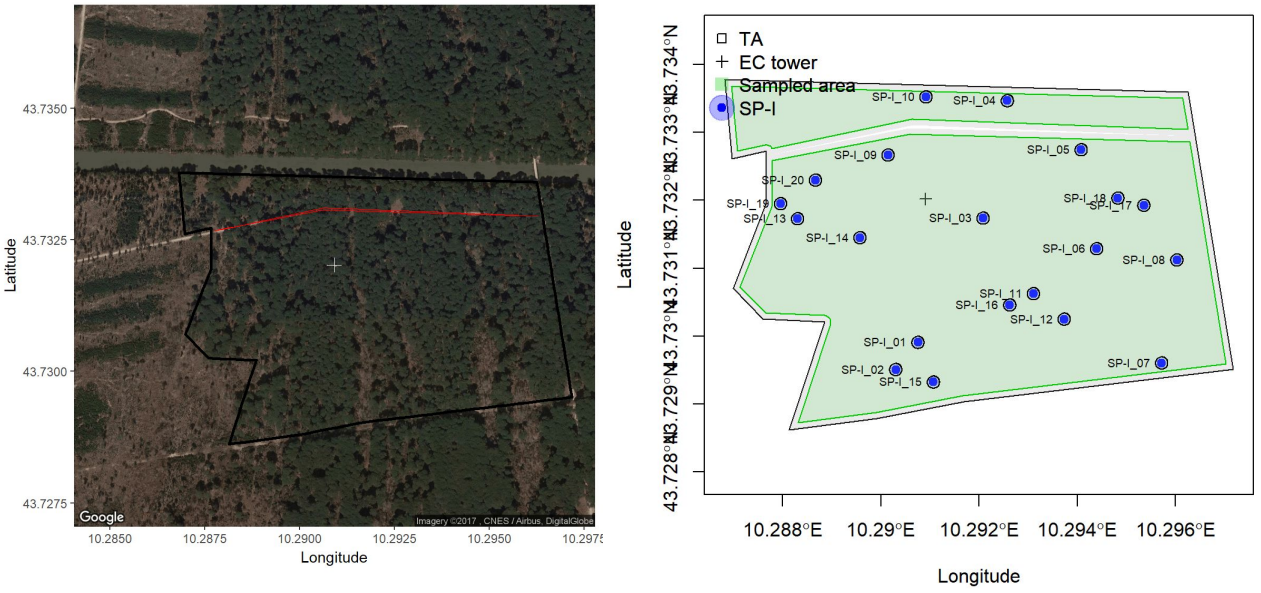



Figure 2: Aerial map of IT-SR2 and proposed spatial features according to the reported target area, exclusion area and ICOS requirements. Note that the CP areas have not been excluded from the sampled area. The TA surface is 37.62 Ha, the total excluded area is of 0.17 Ha and the minimum distance between SP-I centers is 37.22 m.

Being a forest ecosystem, CP areas have been further subsampled to extract the coordinates of the 5+5 subplots for biomass sampling which were sent to the station team (see also Figure 3 below in the soil measurement section).

The station team performed a first location of SP-I in the field, but ETC noted some coordinates mismatches with the sampled ones. The PI repeated the field location using a high accuracy GPS and the new coordinates were compliant with the ICOS minimum requirements. All the SP-II were correctly placed considering their relative positions with respect to the parental SP-I (field coordinates). The current points coordinates are thus definitive and the sampling design is closed.

## Station implementation

*Eddy covariance:*

ICOS EC instruments are installed at the site since October 2017. The calibration of the IRGA will expire on spring 2020, and the station is well equipped with spare sensors to be used during calibration times. A plan for keeping the IRGAs properly factory calibrated has been agreed with the ETC. Also for the SAT, two spare sensors exist and the factory calibrations are planned to keep the system calibrated. The reference point of the station is few meters away from the EC system, corresponding to the NW corner of the tower structure. The SAT was oriented at 150 degrees from N, as suggested by the ETC during the Step1 of the labeling (153 degrees N). The measurement height is 24.3 m from the ground, as agreed. The firmware of the SmartFlux2 and of the 7550 have been updated to the latest version available.

| EC System | | |
|---|---|---|
| **MODEL** | GA_CP-LI-COR LI-7200 | SA-Gill HS-50 |
| **SN** | 72H-0152 | H000231 |
| **HEIGHT (m)** | 24.3 | 24.3 |
| **EASTWARD_DIST (m)** | 1.6 | 1.6 |
| **NORTHWARD_DIST (m)** | -3.15 | -3.15 |
| **SAMPLING_INT** | 0.1 | 0.1 |
| **LOGGER** | 7 | 7 |
| **FILE** | 1 | 1 |
| **GA_FLOW_RATE** | 12 | - |
| **GA_LICOR_FM_SN** | FM1-0414 | - |
| **GA_LICOR_AIU_SN** | AIU-0543 | - |
| **SA_OFFSET_N** | - | 150 |
| **SA_WIND_FORMAT** | - | U, V, W |
| **SA_GILL_ALIGN** | - | Spar |

| | |
|---|---|
| **ECSYS_SEP_VERT** | -0.03 |
| **ECSYS_SEP_EASTWARD** | 0.1 |
| **ECSYS_SEP_NORTHWARD** | 0.2 |
| **ECSYS_WIND_EXCL** | 330 |
| **ECSYS_WIND_EXCL_RANGE** | 20 |

The the sequential scheme was selected for storage measurement at IT-SR2. Data acquisition and valve control is done with a dedicated Campbell CR3000 data logger. The gas analyser, mass flow meter and data logger are located inside a protective hut, whereas the valves, pumps and manifold are located in a protective enclosure on the tower structure.

The LI-7000 (*Li-Cor*) gas analyzer is used (a spare unit is also available), air temperature and relative humidity profiles are measures by HMP155 sensors (*Vaisala*) at each of the sampling heights with aspirated housing. Line pressure is measured by the LI-7000. The flow is controlled by the mass flow meter XFM17A-VHL6-A2 (*Aalborg*), located just before the gas analyser. 8 inlet manifold, configured for 8 independent lines with solenoid valves for line switching (Buerkert Type 331) will manage the air flow (7 lines are continuously flushed, one is sampled), while manual valve before each inlet of manifold is used to balance the flow of all 8 lines (SONV22A21-6, *Serto*). 4 double-head pumps are used, configured for 8 independent pumping lines N 85.3 KTE (*KNF*). The profile is configured with 8 sampling heights at (#1) 24.3 m, (#2) 18.9 m, (#3) 14.1 m, (#4) 9.9 m, (#5) 6.5 m, (#6) 3.8 m, (#7) 1.7 m and (#8) 0.5 m and 1 inlet at sampling heights #1 to #6, 2 inlets at #7, 4 inlets at #8. For sampling heights #1 to #6, a buffer volume consisting of a 6 litre drum is placed directly at the inlet that also has a bug screen and acts as rain-cup. For sampling height #7, a bug screen/rain-cup is installed at each inlet and a mixing volume of 10 litres with 2 inlets after 35 m of tubing mixes the flow from the 2 inlet points. For sampling height #8, a bug screen/rain-cup is installed at each inlet and a mixing volume of 6 litres with 4 inlets after 35 m of tubing mixes the flow from the 4 inlet points. The nominal flow for all lines is 3.8 l/min, measured with Aalborg mass flow meter. The switching between each line is made every 15 s, and each line has its specific nominal flushing time.

*Radiations:*

For SW-LW radiations the *CNR-4* (Kipp & Zonen) pyranometer will be used in combination with the *CNF4* ventilation and heating unit while for the PPFD radiations the *LI190R-L* (Li-Cor) quantum sensor will be used. Concerning the diffuse radiation the Team proposed to use the *BF5* (Delta T) sensor, which is not fully ICOS compliant. ETC proposed to discuss its use as an exception if measured in parallel with another sensor used for the absolute value (and *BF5* used for the ratio diffuse/total). The PI agreed and *BF5* will be used for diffuse/total ratio.

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| RAD_4C-K&Z CNR4 | 121119 | 24.3 | 4 | -1.6 | SW_IN_1_1_1 |
| | | | | | SW_OUT_1_1_1 |
| | | | | | LW_IN_1_1_1 |
| | | | | | LW_OUT_1_1_1 |
| RAD_PAR-LI-COR LI190 | Q36446 | 24.3 | 3.5 | -1 | PPFD_OUT_1_1_1 |
| RAD_PAR-LI-COR LI190 | Q39257 | 24.3 | 3.5 | -1 | PPFD_IN_1_1_2 |

*Precipitation:*

For total precipitation it will be used the *Pluvio 2s* (OTT) weighing gauge in combination with the Alter type windshield PWS (OTT). The PI proposed an exception for installing the main weighing gauge at the backup station and the secondary gauge (tipping bucket) on the tower top. ETC accepted the exception considering the use of the tipping bucket data as reference for the tower place.

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| PREC-OTT Pluvio2 | 406072 | 1.5 | -529 | -870.7 | P_2_1_1 |

*Air temperature, relative humidity and air pressure*

In the table below are reported the sensors installed at the station for measurements of TA, RH and PA. In addition to the main thermohygrometer installed at the same height as EC system (Vaisala HMP155 at 24.3 m), those installed in the storage profile are also reported. All of them are shielded and ventilated. All the sensors, including PA (Vaisala PTB110), are ICOS compliant. The ETC acknowledged the station to use a recently calibrated spare sensor for TA/RH measurements, same model as the main one, while this latter is out for factory calibration. PI decided to leave the same variable names for the spare sensor, and then the same file name.

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| RHTEMP-Vaisala HMP155 | P0520502 | 24.3 | 2.4 | 0.8 | TA_1_1_1 |
| | | | | | RH_1_1_1 |
| RHTEMP-Vaisala HMP155 | J2850021 | 18.9 | 0.3 | 0.1 | TA_1_2_1 |
| | | | | | RH_1_2_1 |
| RHTEMP-Vaisala | J2850023 | 14.1 | 0.3 | 0.1 | TA_1_3_1 |

| | | | | | |
|---|---|---|---|---|---|
| HMP155 | | | | | RH_1_3_1 |
| RHTEMP-Vaisala HMP155 | J2850022 | 9.9 | 0.3 | 0.1 | TA_1_4_1 |
| | | | | | RH_1_4_1 |
| RHTEMP-Vaisala HMP155 | J2850024 | 6.5 | 0.3 | 0.1 | TA_1_5_1 |
| | | | | | RH_1_5_1 |
| RHTEMP-Vaisala HMP155 | J2850025 | 3.8 | 0.3 | 0.1 | TA_1_6_1 |
| | | | | | RH_1_6_1 |
| RHTEMP-Vaisala HMP155 | J2850027 | 1.7 | 2.4 | 0.8 | TA_1_7_1 |
| | | | | | RH_1_7_1 |
| RHTEMP-Vaisala HMP155 | J2850026 | 0.5 | 2.4 | 0.8 | TA_1_8_1 |
| | | | | | RH_1_8_1 |
| PRES-Vaisala PTB110 | M4240699 | 21.8 | 1.4 | 0.3 | PA_1_1_1 |

*Backup meteorological station*

The backup station has independent power and logging. The sensors installed are all ICOS compliant except the radiometer (K&Z CMP3), which however was accepted as an exception for backup as not too far from ICOS requirements. The backup pluviometer, a tipping-bucket gauge (ARG100), is not installed with the other backup station, but in the main tower (powered and logged independently): this was agreed with the ETC as an adapt clearing doesn't exist at short enough distance from the main sensors, then the position of the two sensors were switched. The need for calibration of these sensors will be checked by comparison against the main ones

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| PREC-EML ARG100 | 44814 | 24.3 | 1.6 | 0.4 | P_1_1_1 |
| RHTEMP-Vaisala HMP155 | J2850031 | 2.2 | -527.9 | -868 | RH_2_1_1 |
| | | | | | TA_2_1_1 |
| RAD_SW-K&Z CMP3 | 174968 | 8 | -528 | -868.5 | SW_IN_2_1_1 |

*Soil temperature, soil water content, soil heat flux density and water table depth*

The station team has installed the full set of soil meteo sensors required for a Class 2 forest station. The sensors are installed at locations in the target area that comply with the ICOS Instructions: two soil plots each in the vicinity of the center of the two installed Continuous Measurements plots (CPs), plus two additional soil heat flux plates in the target area (see Figure 3). The set-up of each soil plot and each additional soil heat flux plate, shown in Figure 4, is compliant with the ICOS Instructions in terms of sensor models, number of sensors and sensor

depths. The station team has furthermore submitted all requested metadata on the installed soil meteo sensors.

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| TEMP-Meter TH3-x | 128_1 | 0 | -35.21 | 3.97 | TS_2_1_1 |
| TEMP-Meter TH3-x | 128_2 | -0.05 | -35.21 | 3.97 | TS_2_2_1 |
| TEMP-Meter TH3-x | 128_3 | -0.15 | -35.21 | 3.97 | TS_2_3_1 |
| TEMP-Meter TH3-x | 128_4 | -0.25 | -35.21 | 3.97 | TS_2_4_1 |
| TEMP-Meter TH3-x | 128_5 | -0.45 | -35.21 | 3.97 | TS_2_5_1 |
| TEMP-Meter TH3-x | 128_6 | -0.95 | -35.21 | 3.97 | TS_2_6_1 |
| TEMP-Meter TH3-x | 125_1 | 0 | 46.1 | -5.78 | TS_3_1_1 |
| TEMP-Meter TH3-x | 125_2 | -0.05 | 46.1 | -5.78 | TS_3_2_1 |
| TEMP-Meter TH3-x | 125_3 | -0.15 | 46.1 | -5.78 | TS_3_3_1 |
| TEMP-Meter TH3-x | 125_4 | -0.25 | 46.1 | -5.78 | TS_3_4_1 |
| TEMP-Meter TH3-x | 125_5 | -0.45 | 46.1 | -5.78 | TS_3_5_1 |
| TEMP-Meter TH3-x | 125_6 | -0.95 | 46.1 | -5.78 | TS_3_6_1 |
| TEMP-Meter TH3-x | 126_1 | 0 | -41.4 | -30.14 | TS_4_1_1 |
| TEMP-Meter TH3-x | 126_2 | -0.05 | -41.4 | -30.14 | TS_4_2_1 |
| TEMP-Meter TH3-x | 126_3 | -0.15 | -41.4 | -30.14 | TS_4_3_1 |
| TEMP-Meter TH3-x | 126_4 | -0.25 | -41.4 | -30.14 | TS_4_4_1 |
| TEMP-Meter TH3-x | 126_5 | -0.45 | -41.4 | -30.14 | TS_4_5_1 |
| TEMP-Meter TH3-x | 126_6 | -0.95 | -41.4 | -30.14 | TS_4_6_1 |
| TEMP-Meter TH3-x | 387_1 | 0 | 55.38 | 6 | TS_5_1_1 |
| TEMP-Meter TH3-x | 387_2 | -0.05 | 55.38 | 6 | TS_5_2_1 |
| TEMP-Meter TH3-x | 387_3 | -0.15 | 55.38 | 6 | TS_5_3_1 |
| TEMP-Meter TH3-x | 387_4 | -0.25 | 55.38 | 6 | TS_5_4_1 |
| TEMP-Meter TH3-x | 387_5 | -0.45 | 55.38 | 6 | TS_5_5_1 |
| TEMP-Meter TH3-x | 387_6 | -0.95 | 55.38 | 6 | TS_5_6_1 |
| SWC-IMKO Trime-PICO XX | 37004 | -0.05 | -34.76 | 3.15 | SWC_3_1_1 |
| SWC-IMKO Trime-PICO XX | 37009 | -0.15 | -34.7 | 2.9 | SWC_3_2_1 |
| SWC-IMKO Trime-PICO XX | 37007 | -0.25 | -34.5 | 2.67 | SWC_3_3_1 |
| SWC-IMKO | 37010 | -0.45 | -34.15 | 3.65 | SWC_3_4_1 |

| | | | | | |
|---|---|---|---|---|---|
| Trime-PICO XX | | | | | |
| SWC-IMKO Trime-PICO XX | 37003 | -0.95 | -34.05 | 2.9 | SWC_3_5_1 |
| SWC-IMKO Trime-PICO XX | 37002 | -0.05 | 47.2 | -6.33 | SWC_4_1_1 |
| SWC-IMKO Trime-PICO XX | 36999 | -0.15 | 47.38 | -6.44 | SWC_4_2_1 |
| SWC-IMKO Trime-PICO XX | 37008 | -0.25 | 47.53 | -6.49 | SWC_4_3_1 |
| SWC-IMKO Trime-PICO XX | 37001 | -0.45 | 48.44 | -7.07 | SWC_4_4_1 |
| SWC-IMKO Trime-PICO XX | 37000 | -0.95 | 48.02 | -6.85 | SWC_4_5_1 |
| SWC-IMKO Trime-PICO XX | 37006 | -0.05 | -41.42 | -31.02 | SWC_5_1_1 |
| SWC-IMKO Trime-PICO XX | 37005 | -0.05 | 55.74 | 5.26 | SWC_6_1_1 |
| SOIL_H-Hukseflux HFP01SC | 3865 | -0.05 | -35.18 | 3.57 | G_4_1_1 |
| SOIL_H-Hukseflux HFP01SC | 4397 | -0.05 | 46.62 | -6.07 | G_5_1_1 |
| SOIL_H-Hukseflux HFP01SC | 3867 | -0.05 | -41.47 | -30.55 | G_6_1_1 |
| SOIL_H-Hukseflux HFP01SC | 3866 | -0.05 | 55.33 | 5.41 | G_7_1_1 |
| WTD-Campbell CS45X | 70010001 | -2.62 | -37.38 | 5.8 | WTD_2_1_1 |
| WTD-Campbell CS45X | 70010078 | -2.79 | 47.44 | -9.06 | WTD_3_1_1 |

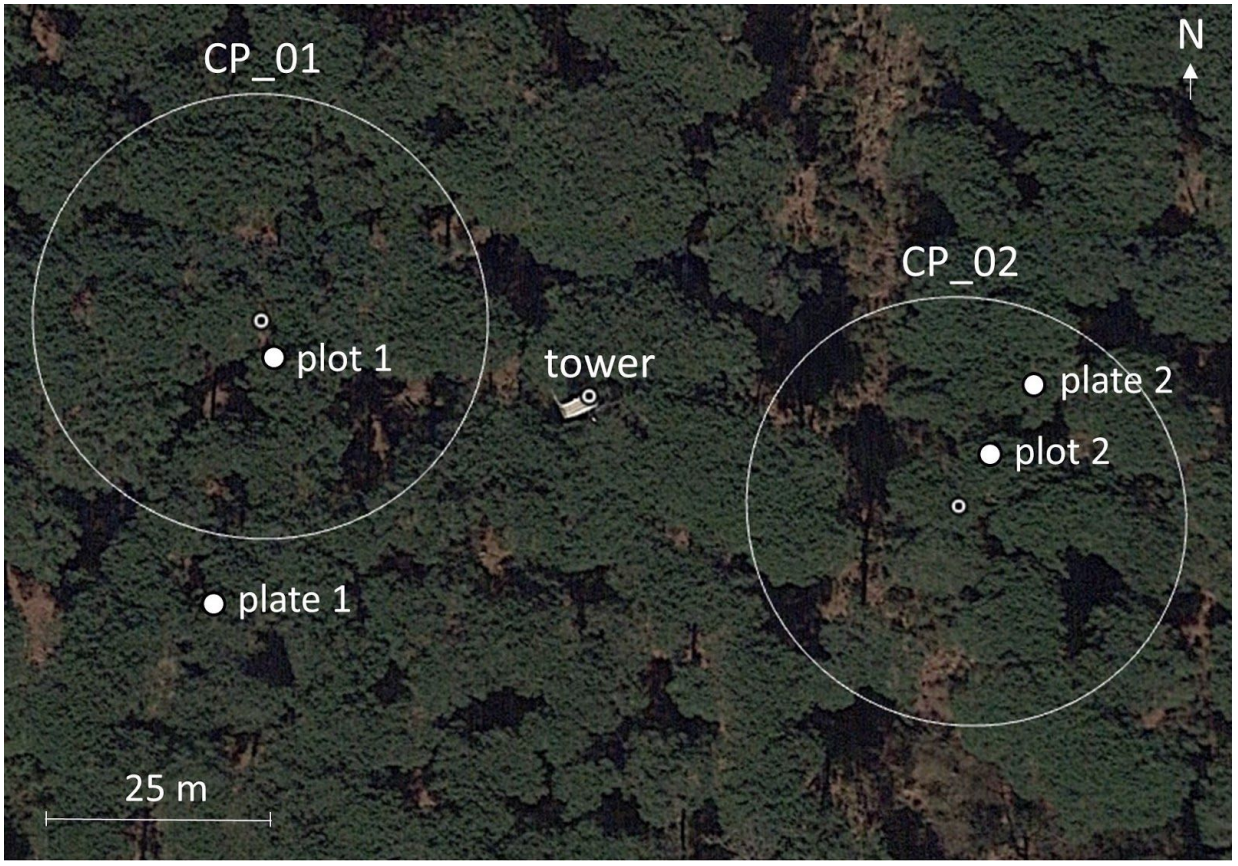



Figure 3: Location of the soil plots (plot 1 & 2) and the additional heat flux plates (plate 1 & 2) around the EC tower. CP = Continuous Measurements plot.

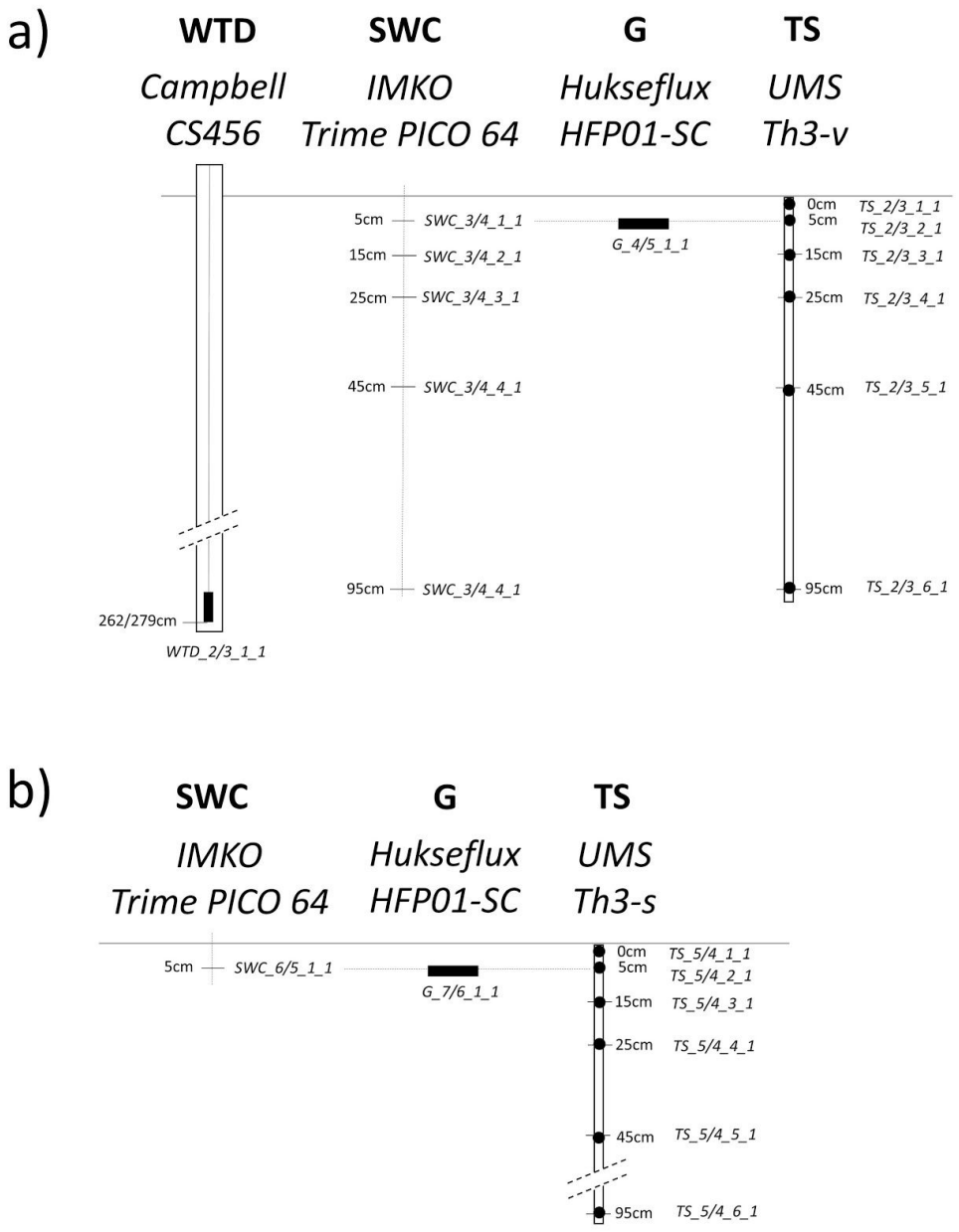



Figure 4: Set-up of a) the two soil meteo plots and b) the two additional heat flux plates with accessory sensors. WTD = water table depth, SWC = soil water content, G = soil heat flux density, TS = soil temperature.

*Spatial heterogeneity characterization*

*Aboveground biomass:* The station team has collected in the spring of 2018 the full data set of tree data that is requested for the characterisation of the target area and its spatial heterogeneity. This data set comprises the species, DBH, height and health status of all trees above the stem diameter threshold of 5 cm that grow inside the 20 SP-I plots installed in the target area. The ETC has quality checked and processed these data. Figures 5, 6 and 7 summarize the dataset, showing for each plot respectively the tree density per species, the basal area per species, and the percentage-wise species contribution to the total basal area of the plot. Basal area is used as proxy for Aboveground biomass. As can be seen from the figures, the target area is dominated by stone pine

(*Pinus pinea L.)* with sparse presence of holm oak (*Quercus ilex L.*), field elm (*Ulmus minor Mill.*), white poplar (Populus alba L.*)*, common alder (*Alnus glutinosa (L.) Gaertn.*) and narrow-leafed ash (*Fraxinus angustifolis Vahl.*).

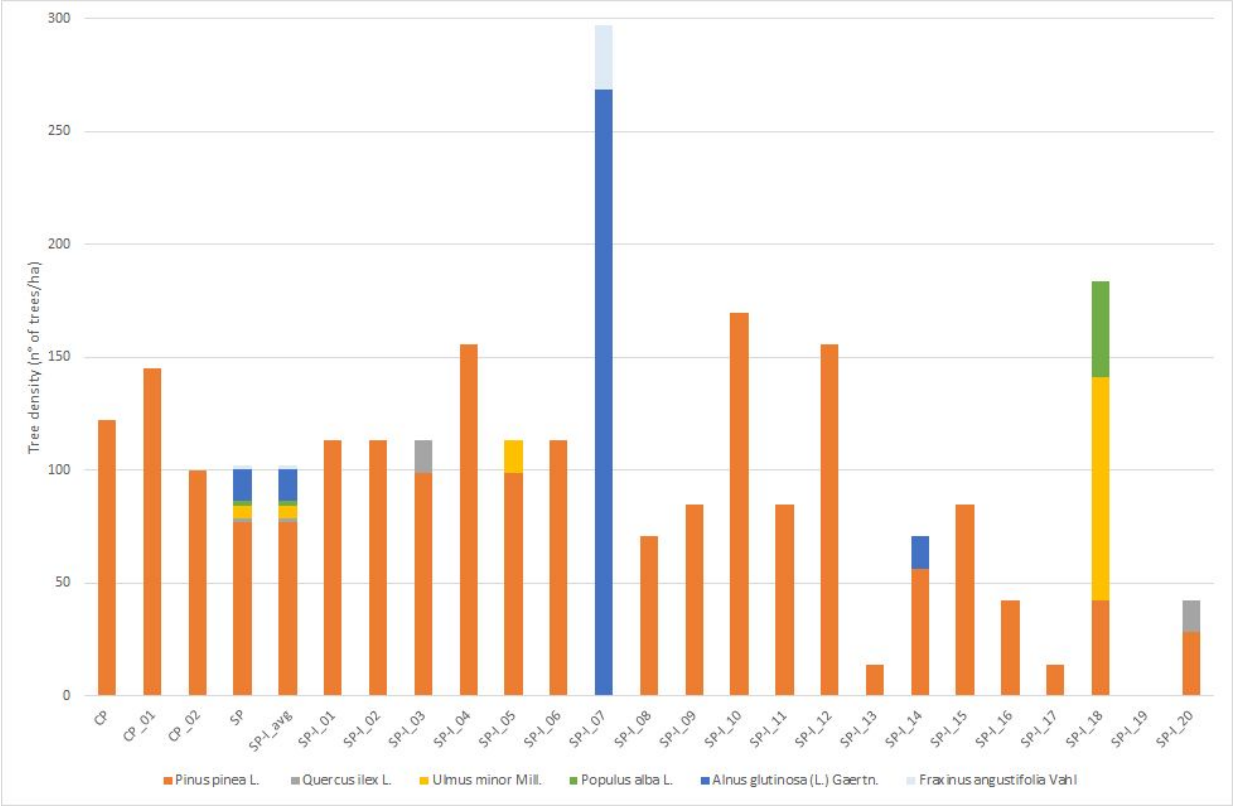



Figure 5: Tree density per species, shown for the twenty SP-I plots and the two CPs installed in the target area.

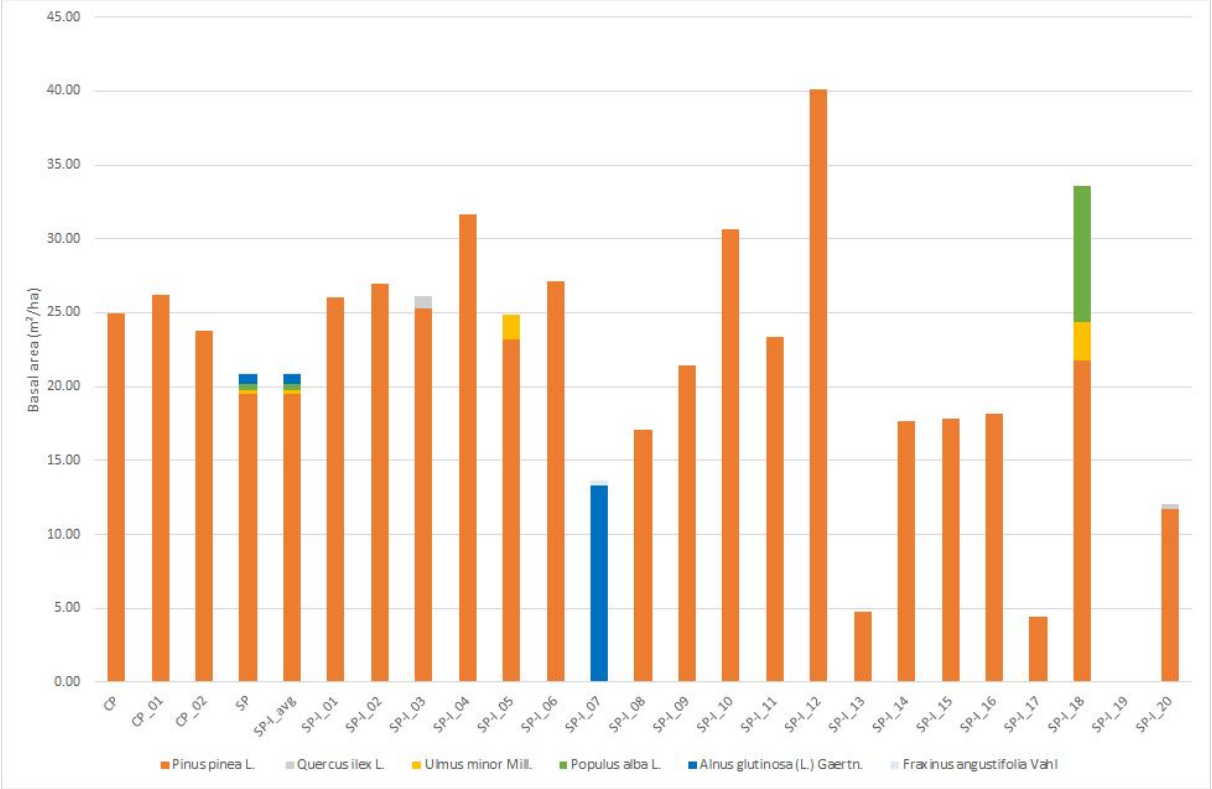



Figure 6: Basal area per species, shown for the twenty SP-I plots and the two CPs installed in the target area.

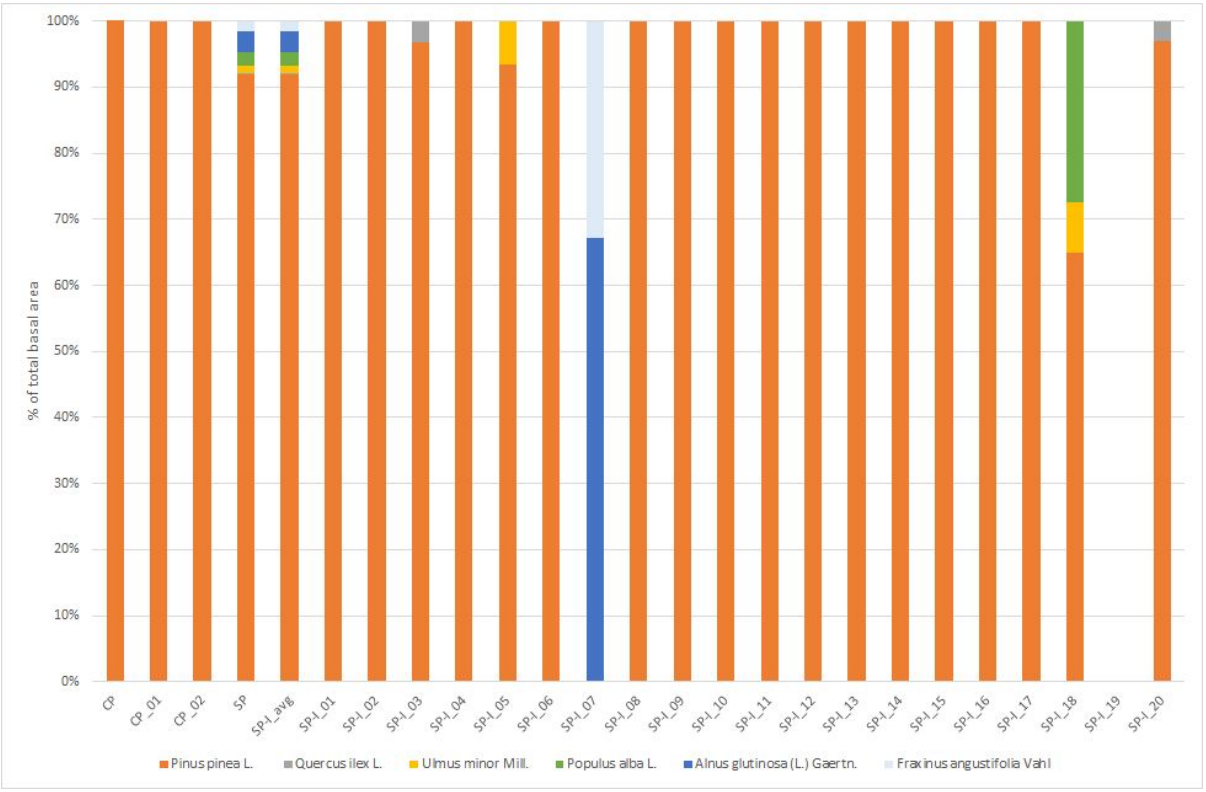



Figure 7: Percentage-wise contribution of each species to the total basal area of the plot, shown for the twenty SP-I plots and the two CPs installed in the target area.

*Green Area Index:*

The station team has carried out all the Green Area Index measurements in the 20 SP-I plots that are requested for the characterization of the target area and its spatial heterogeneity. The measurements have been done between mid July and mid September 2018 by means of Digital Hemispherical Photography. As prescribed in the ICOS Instructions, five hemispherical images were taken in each SP-I plot and nine pictures for each CP plot. The ETC has quality-checked and processed the images. Figure 8 shows the plot results. several retakes were needed for some of the pictures because the cloudless conditions during the summer at the station. However for most of the plots the retakes were successfully submitted to the ETC. SP-I_19 doesn't contain any trees and therefore doesn't have any value for GAI.

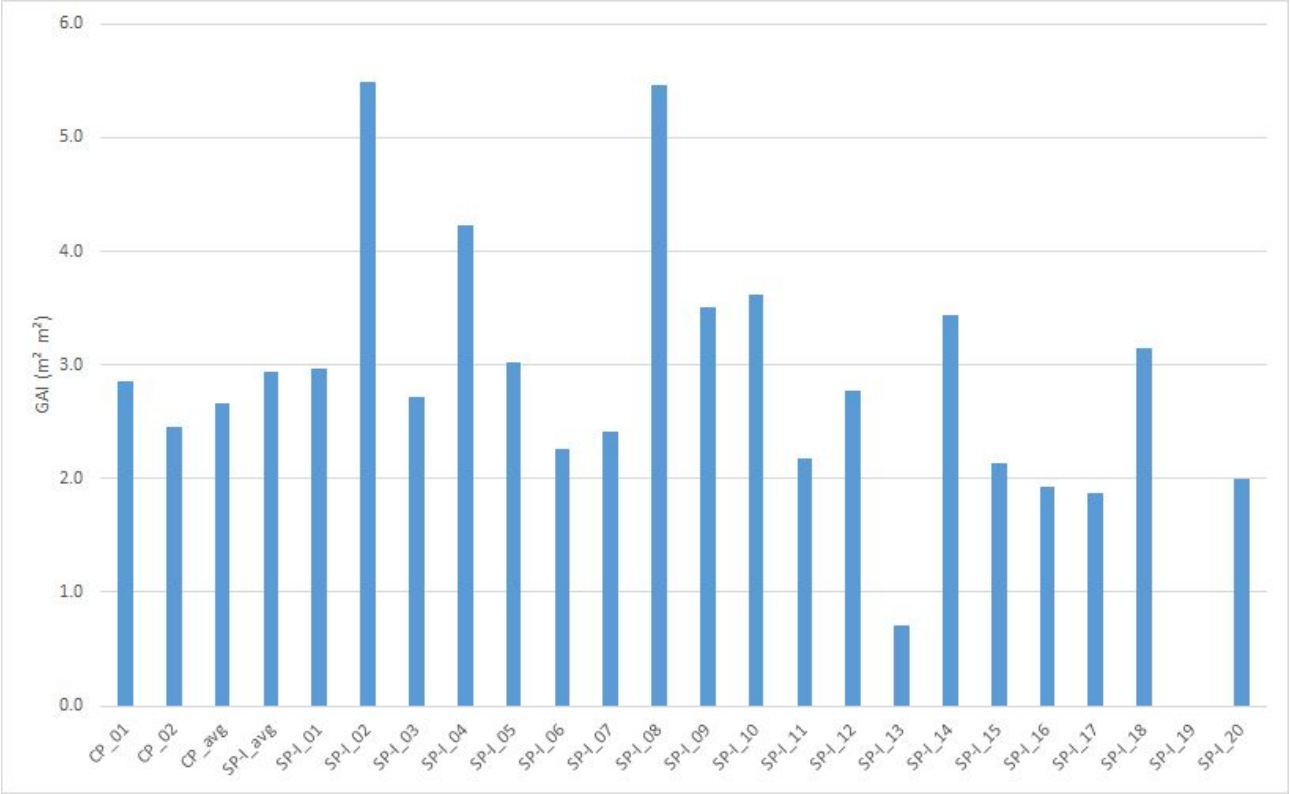



Figure 8: Green Area Index (GAI) for the twenty SP-I plots and the four CPs installed in the target area. All measurements were performed between mid July and mid September 2018.

The site characterisation revealed a relatively high variability in basal area and Green Area Index within the target area. The present variability is due to natural variability and very typical for a open mediteranean pine forest. As stated the SP-I_19 plot didn't contain any trees and therefore doesn't hold a value for the inventory nor the GAI data. There was no pattern or gradient in the species composition within the target area, as confirmed by the station team. Therefore we decided to consider the target area as one vegetation type.

*Green Area Index*

The station team has collected the minimum of two sets of GAI measurements that are requested for the step 2 labelling. As prescribed in the ICOS Instructions, GAI was measured by means of Digital Hemispherical Photography and at each measurement date nine hemispherical images were taken in each CP. The first set of measurements was collected in April 2018 in two CPs. The ETC quality-checked and processed the images. The second set of measurements was collected between mid July and mid September 2018 in two CPs and all 20 SP's. The ETC quality-checked and processed the images, some pictures need to be retaken, however due to the difficult weather conditions (open sky during summer) not all pictures were suitable for analysis.

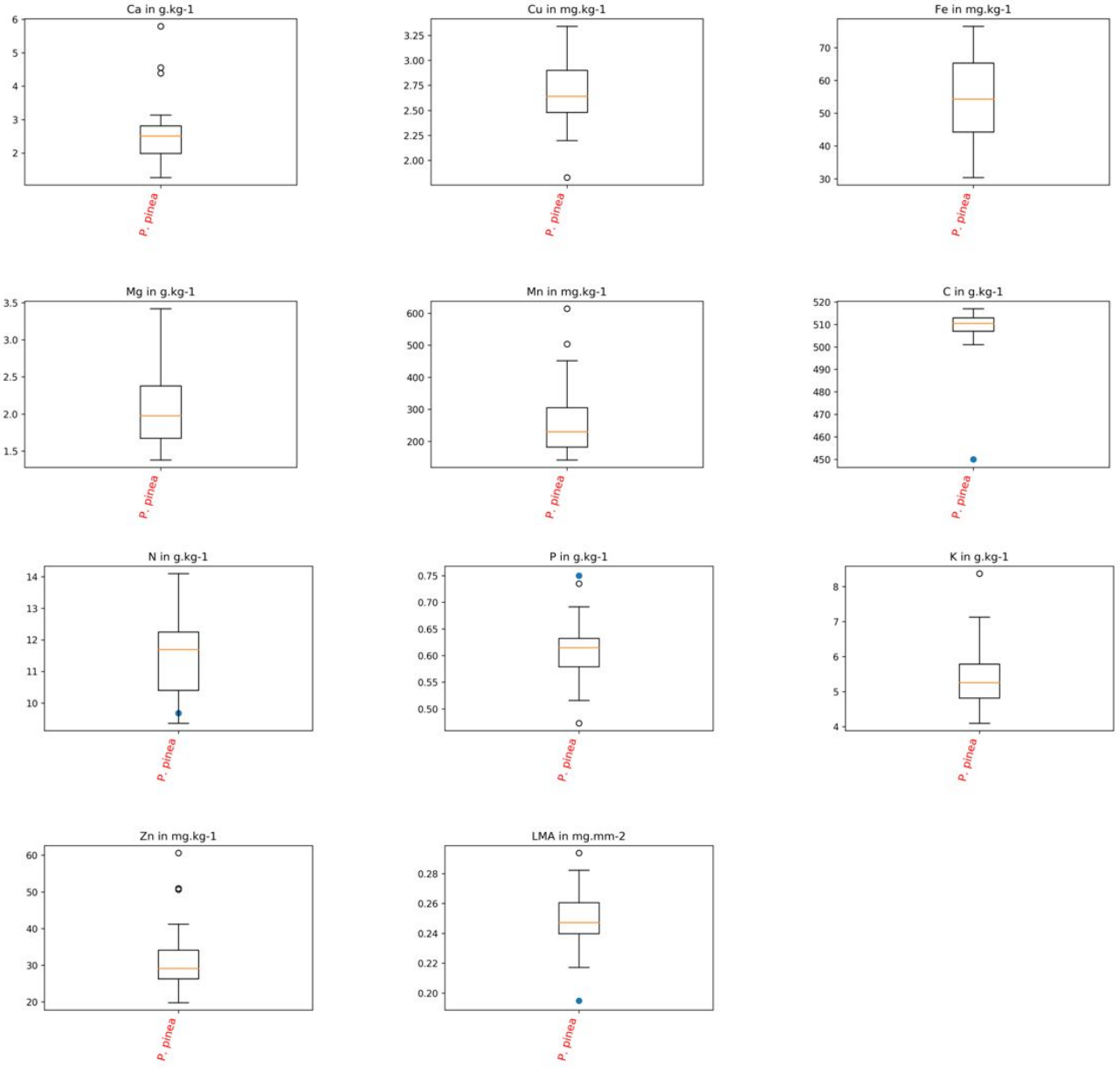
*Above Ground Biomass*

The station team has collected in the spring of 2018 the tree data required for the Aboveground biomass assessment in the step 2 labelling phase. These data comprise the position, species, DBH, height, health status and dendrometer presence of all trees above the stem diameter threshold of 5 cm that are growing inside the four proposed CPs that the station team has installed. The ETC quality-checked and processed these data. Figures 5, 6 and 7 show for each of the four CPs respectively the tree density per species, the basal area per species, and the percentage-wise species contribution to the total basal area of the plot. Basal area is used here as a proxy for Aboveground biomass. As can be seen in the figures, the CPs are entirely dominated by stone pine (*Pinus pinea L.*).

*Vegetation sampling and analysis*

The sampling strategy has been discussed with ETC and agreed. The first data set have been sent by March 2018 and the analysis were operated. The values of the mass ratio of foliar nutrients and LMA are in the range expected for *Pinus pinea*, with however a low value of P content and high value of N content.

## Foliar Analyses for station IT-Sr2, 2018-02-21




*Mean value of the **Pinus pinea** from TRY-db Data when available.* (https://www.try-db.org/TryWeb/Home.php)

## Data check and test

*Data quality analysis (Test 1)*

The quality control (QC) procedure aims to verify that at least 60% of half-hourly values in a given temporal window (e.g. 3 months) are of the highest quality possible. This means that the total percentage of missing and removed data after the QC filtering do not exceed the 40% threshold value.

On the basis of the current state of scientific knowledge, tests involved in the QC procedure aim at detecting (i) fluxes originating from wind sectors to exclude, (ii) instrument malfunction as provided by sonic anemometer (SA) and gas analyser (GA) diagnostics and by Vickers and Mahrt (1997) statistical tests; (iii) anomalous values of the spectral correction factor; (iv) lack of well developed turbulence regimes (Foken and Wichura, 1996) and (v) violation of stationary conditions (Mahrt, 1998).

By comparing each test statistic with two pre-specified threshold values, severe and moderate evidences of systematic error are provided (hereinafter denoted as SevEr and ModEr). Subsequently, the data rejection rule involves a two-stage procedure as described. In the first stage half-hourly fluxes affected by SevEr are directly discarded, whereas those affected by ModEr are removed only if they are also identified as outlying values.

Concerning IT-SR2 site, the testing period involves raw data sampled in 2018 from April 1$^{st}$ to July 11$^{th}$. Of 4848 expected half-hourly files for NEE fluxes, 76.9% were retained after QC routines as illustrated in Figure 9. In particular, about 10.7% of raw-data files were missed, 31.9% of calculated half-hourly fluxes were discarded because affected by severe error, while an additional 1.2% of them were discarded because identified as outlier and affected by moderate errors. Being the percentage of missing data equal to 33.1% and below the 40% threshold value, we conclude that IT-SR2 site reaches the minimum requisite expected for the Step 2 of the labelling.

***References***

*Foken T and Wichura B (1996) Tools for the quality assessment of surface-based flux measurements, Agric For Meterol, 78, 83-105*

*Mahrt L (1998) Flux sampling errors for aircraft and towers, J Atmosph Ocean Techn, 15, 416-429*

*Vickers D and Mahrt L (1997) Quality control and flux sampling problems for tower and aircraft data, J Atmosph Ocean Techn, 14(3), 512-526*

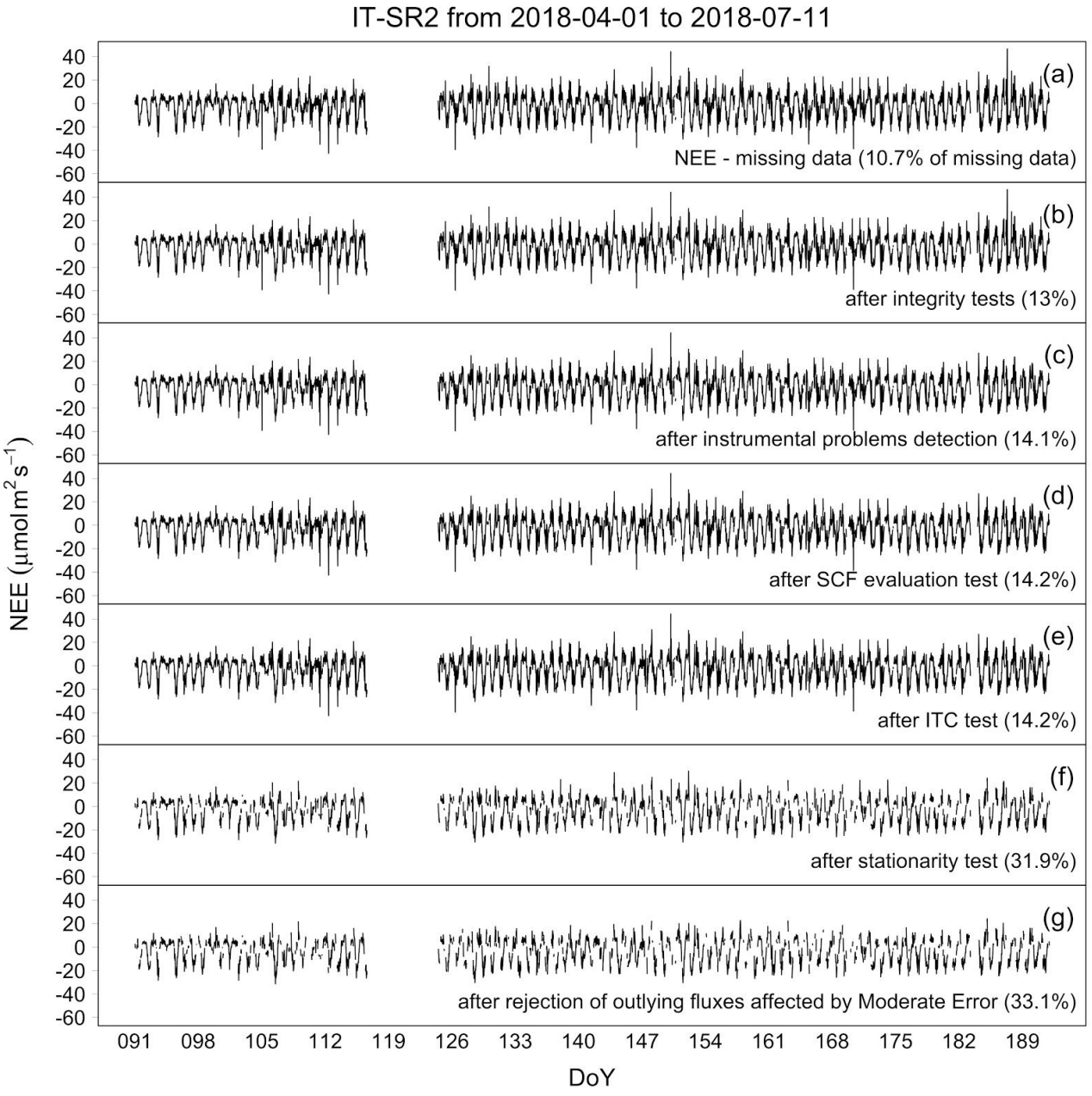



Figure 9: Summary of the quality control tests applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at IT-SR2 site from 2018/04/01 to 2018/07/11. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe errors according to the following criteria: (b) wind sectors to exclude and diagnostics provided by sonic anemometer (SA) and gas analyser (GA); (c) instrumental problems detection; (d) anomalous spectral correction factor (SCF) check; (e) integral turbulence characteristic (ITC, Foken and Wichura, 1996); (f) stationarity test by Mahrt (1998). Bottom panel displays the retained high-quality NEE time series after the additional removal of outlying fluxes affected by moderate evidences of error.

*Footprint analysis (Test 2)*

The test aimed to evaluate if half-hourly flux values are sufficiently representative of the target area (TA). It was performed on 3 months of data, after QA/QC filtering procedure (previous

Section). The model of Klijun et al. (2015) has been used to obtain the 2-dimensional flux footprint for each half-hour which was compared to the TA spatial extent. Results showed that the majority of the whole data have a cumulative contribution of at least 70 % from the Target Area, and this holds also for daytime and nighttime conditions (Figure 10, *left panels*). In addition, the test was performed on sub-periods and results the latter results were confirmed (Figure 10, *right panels*).

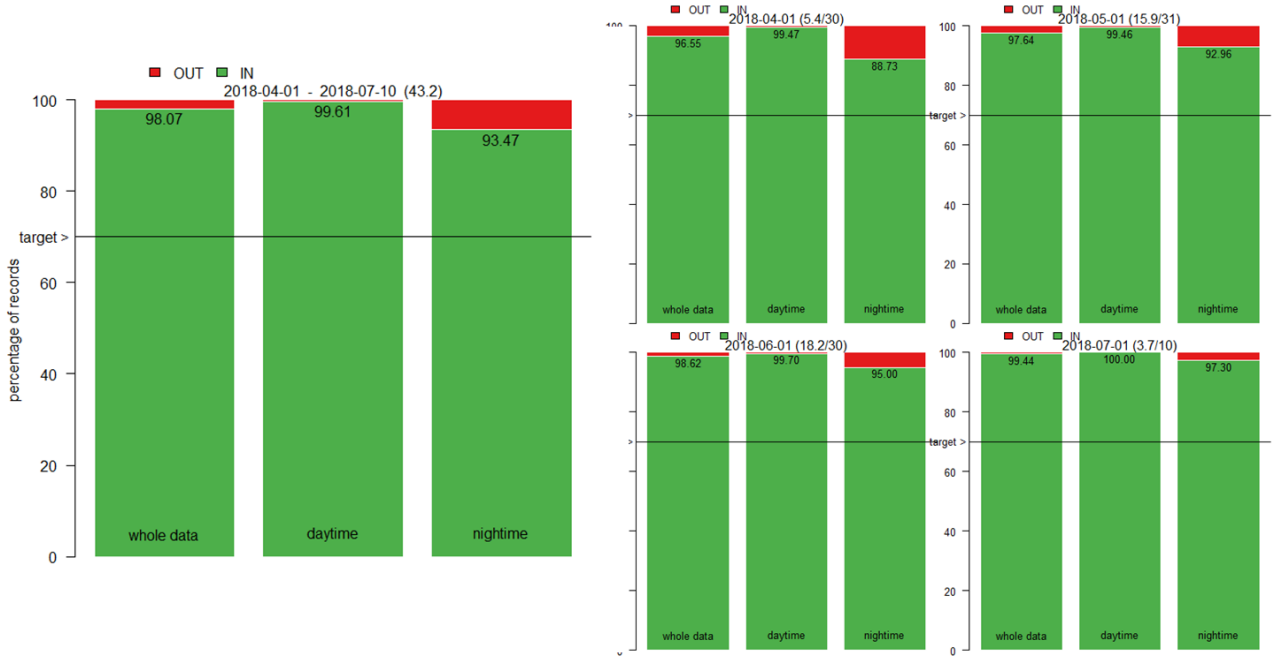



Figure 10: test results showing the percentage of half-hours with a footprint cumulative contribution of 70% from the target area. The target value is that the 70% of data must hold this condition in each considered period.

Exemplary half-hourly footprints at IT-SR2 are related to the TA in Figure 11.

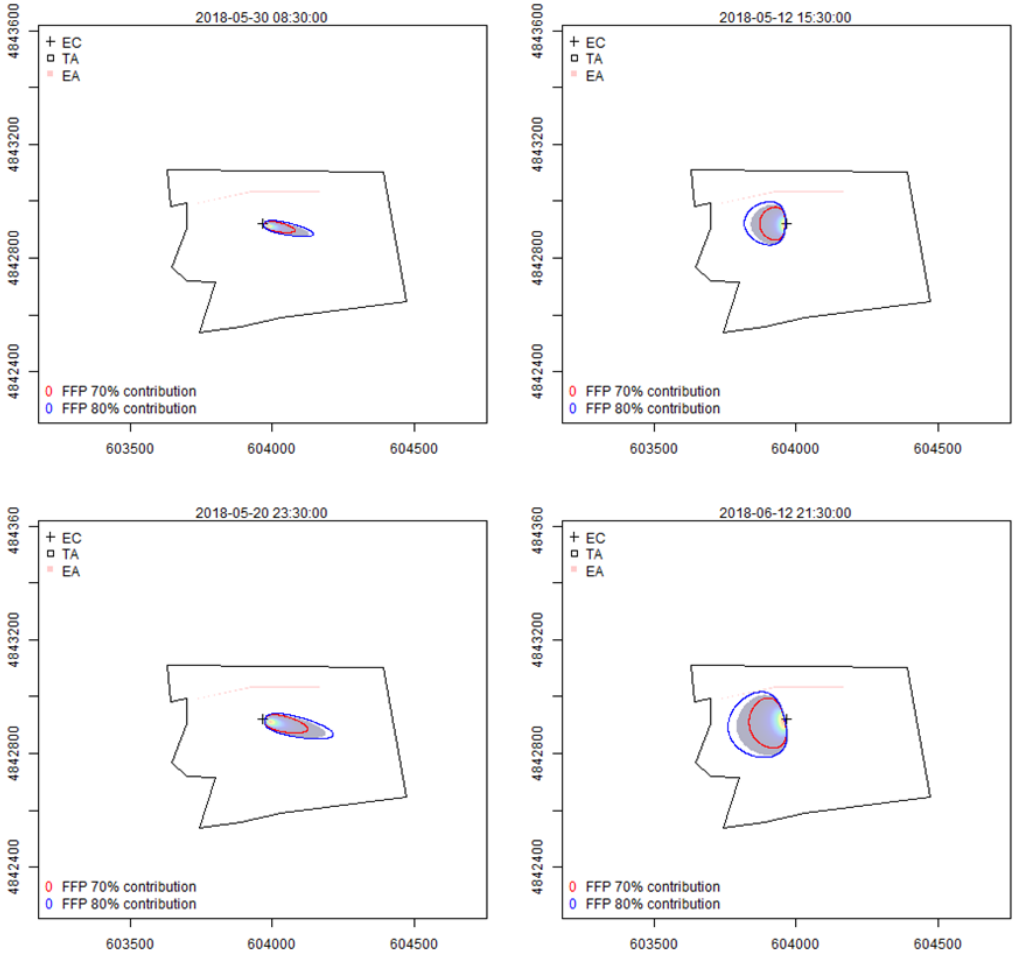



Figure 11: exemplary 2D half-hourly footprints at IT-SR2 are related to the TA. The 70 and 80% cumulative distribution are reported in black and blue respectively.

*Data representativeness analysis (Test 3)*

This test aimed to evaluate the representativeness of the possible different land cover tipologies inside the Target area (TA). At IT-SR2 the analysis on vegetation (Test 4, Section below) revealed a unique vegetation typology, e.g. pine stand, with negligible contribution of other species (e.g. *Alnus* sp.). Consequently, the entire TA was considered homogeneous and the Test 3 became unnecessary.

*Ancillary plot representativeness (Test 4)*

The representativeness of the CPs was evaluated by comparing each CP with the SP-I-order plots in terms of (i) standing biomass, i.e. the tree density and basal area of the plot, (ii) species composition, i.e the percentage basal area of the main species, and (iii) Green Area Index. As explained in the introductory section of this report, a CP is deemed representative when values

are less than 20% different with respect to the target area's average, i.e. the average of the 20 SP-I-order plots.

A representativity analysis showed that the basal area of the all CP's differs less than 20% from the average basal area of the SP's. We excluded two SP-I plots from the analysis because they contained no trees (SP-I_19) and no trees from the dominant tree species (SP-I_07). Except SP-I_17 which had some contribution of white poplar all SP-I were dominated by stone pine. Overall the target area was quite heterogeneous for GAI and basal area which is typical for an open meditearnean pine forest. However the station team confirmed that there was not a gradient or specific pattern. Therefore the target area is considered as one vegetation type.

Even though the target area was quite heterogeneous the CP's were found representative for the SP's in the target area for both basal area and GAI values because the values deviated less than 20% from the average values of the SP-I plots.

## Near Real Time data transmission

The station started the submission of NRT data in February 2018. All the file types (eddy, meteo and storage) are ASCII compressed files. The EC files are being created with the LICOR SmartFlux2 logger, while the BM and ST variables are collected by Campbell Scientific dataloggers. The files are ICOS compliant, after discussion with ETC to fix some inconsistencies. The BM and ST files need post-editing to fill in missing rows with NaN. All the inconsistencies that were found from time to time due to hardware and software implementations or in the BADM completion were solved during the labelling, before and especially after the selection of the new PI on summer 2019.

## Plan for remaining variables

*Soil sampling*

According to our correspondence with station team, the sampling of the soil for the calculations of the organic carbon and nitrogen stocks is planned in the months after the labelling.

## Labelling summary and proposal

On the basis of the activities performed and data submitted and after the evaluation of the station characteristics, the quality of the data and setup, the compliance of the sensors and installations and the team capacity to follow the ICOS requirements for ICOS Ecosystem Stations we recommend that the station San Rossore 2 (IT-SR2) is labelled as ICOS Class 2 Ecosystem station.

Dario Papale, ETC Director

*October 28th 2019*