ICOS Ecosystem Station Labelling Report

Station: FR-Bil (Bilos)

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 also involves 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.

<u>Preparation and start of the Step2</u>

The station started the Step1 of the labelling on March 11th 2016 and got the official approval on October 26th 2016. The Step2 started officially on November 16th 2016 with a specific WebEx between the ETC members and the station team members where the overall procedure was discussed and explained.

<u>Team description</u>

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.

<u>Sampling scheme implementation</u>

The sampling scheme is the distribution of points in the ecosystem where a number of measurements must be done. It is composed of 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.

<u>Measurements implementation</u>

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 Storage fluxes
Radiations	SW incoming LW incoming SW outgoing LW outgoing PPFD incoming PPFD outgoing
Meteorological above ground	Air temperature Relative humidity Air pressure Total precipitation Snow depth Backup meteo station
Soil climate	Soil temperature profiles Soil water content profiles Soil heat flux density Groundwater level
Site characteristics	History of disturbances History of management Site description and characterization
Biometric measurement	Green Area Index Aboveground Biomass
Foliar sampling	Sample of leaves 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

<u>Data evaluation</u>

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 Bilos site, code ICOS FR-Bil, is located in the Landes forest, 50 Km south west of Bordeaux, France. The site is a managed Pine forest with coordinates in WGS84 system: Latitude 44.493672 °N and Longitude 0.956082 °W, at elevation of 39.18 m above sea level and having an offset respect to the Coordinated Universal Time (UTC) equal to +01. The site is marked by the following climate characteristics: Mean Annual Temperature 12.9 °C, Mean Annual Precipitation 960.1 mm, Mean Annual Radiation 140.9 Wm^{-2}.

Fig.1 - The FR-Bil “radiation” tower; this picture was taken from the EC tower, July 2018.

Team description

The staff of the site has been defined and communicated in March 2017. It includes in addition to the PI, two CO-PI, the Manager, the technical-scientific staff and affiliate staff. Below the summary table of the Team members is reported.

MEMBER_NAME	MEMBER_INSTITUTION	MEMBER_ROLE	MEMBER_MAIN_EXPERT
Denis Loustau	INRA	PI	PLANT

Christophe Chipeaux	INRA	MANAGER	MICROMET
Sebastien Lafont	INRA	DATA	DATAPROC
Christelle Aluome	INRA	DATA	BIOMASS
Jean-Luc Denou	INRA	TEC-ANC	BIOMASS
Alain Kruszewski	INRA	TEC-ANC	BIOMASS
Patricia Braconnier	INRA	ADMIN	LOGISTIC

Spatial sampling design

For the spatial sampling design at FR-Bil, the Station Team (ST) proposed in addition to the Target Area (TA), 2 areas to be excluded from sampling (EA). 4 continuous measurement points (CP) were submitted after the sampling was done (being class 2 site, 2 CP would be mandatory). In addition, the proposed CP have a rectangular shape, as expected in case of plantations or forests with trees distributed along rows. 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. Being a forest ecosystem, CP areas have been further subsampled to extract the coordinates of the 5+5 subplots for biomass sampling (Figure.3).

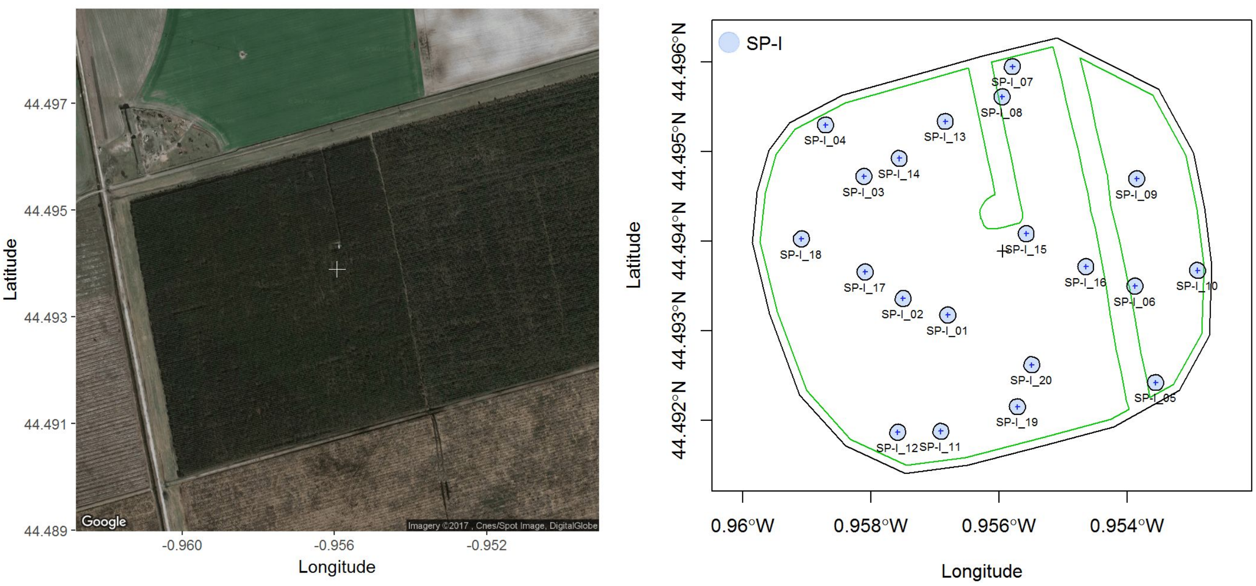


Figure 2: Aerial map of FR-Bil and proposed spatial features according to the reported target area, exclusion area and ICOS requirements. Note that the CP areas have not been excluded from the sampled area. The TA surface is 23.88 Ha, the total excluded area is of 0.61 Ha.

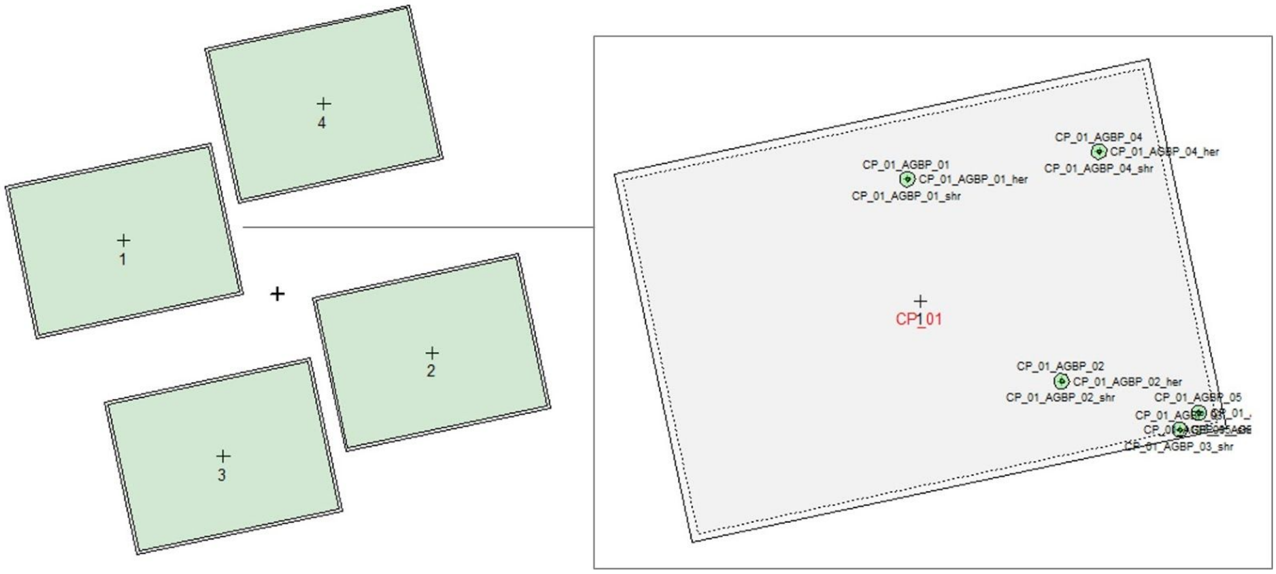


Figure 3: Rectangular CP at FR-Bil in relation to the EC tower (left) and an example of biomass plots into CP_01.

The field location of SP-I and SP-II points (field coordinates), have been achieved and coordinates submitted to ETC. While all the SP-I were accepted, 14 out of 100 SP-II exceeded the maximum tolerated distance with a variable degree. They were relocated in May 2018 and sent back to ETC. All points were then accepted (i.e. their coordinates match with the randomly extracted values) and the respective (reported) coordinates are definitive.

Station implementation

Eddy covariance:

EC System		
MODEL	GA_CP-LI-COR LI-7200	SA-Gill HS-50
SN	72H-0429	H000228
HEIGHT (m)	15.6	15.6
EASTWARD_DIST (m)	0	0
NORTHWARD_DIST (m)	0	0
SAMPLING_INT	0.05	0.05
LOGGER	3	3
FILE	1	1
GA_FLOW_RATE	15	-
GA_LICOR_FM_SN		-

GA_LICOR_AIU_SN	AIU-0349	-
SA_OFFSET_N	-	305
SA_WIND_FORMAT	-	U, V, W
SA_GILL_ALIGN	-	Spar
ECSYS_SEP_VERT	0	
ECSYS_SEP_EASTWARD	0.1638	
ECSYS_SEP_NORTHWARD	-0.115	
ECSYS_WIND_EXCL	125	
ECSYS_WIND_EXCL_RANGE	20	

ICOS compliant sensors (ultrasonic anemometer Gill HS and infrared gas analyser LICOR LI-7200) are installed at the station. The IRGA was purchased less than two years ago (20180115) while the sonic a bit more (20170701): the PI agreed to send the sonic to the factory for calibration as soon as a new agreement will be found between the ETC and the Gill. The sonic, selected as the reference point for the station, is oriented at 305 degrees from N as proposed and agreed during the Step1. The height of the instruments, however, is about 15m, while during the Step1 the ETC and the PI agreed to lower the instruments at 11-12 meters. The PI argued however that based on their footprint analysis this is not needed: the footprint test made in the Step2 (see the corresponding section below) by ETC confirmed his argument, then the ETC accepted 15.6 m as measurement height.

Some trees in a part of the TA were damaged during a thinning in spring 2019 by the logging company (sector North of the forest). The EC system was not affected by the cut, and the area is not in the main wind direction, then we expect only minor impact on the EC fluxes.

For the storage measuring system the PI proposed to use the sequential sampling scheme with a single gas analyser. This scheme is appropriate for the concerning ecosystem, well designed and had been thus accepted.

The PI proposed to place the storage measurement system on a mast distant by 59.7 m from the EC mast, with the rationale of minimizing wind obstruction effects from other bodies on the sonic. ETC decided to possibly accept it only in case experimental results confirm the equivalence of the system with the standard setup (profile along the EC tower). The station team provided simultaneous measures of CO_2 concentration sampled at 2 levels, at the same heights, on both towers. The minimum time requirement was 1 month of data. Two levels were used for the comparison (number 6 and 1 of the profile already in place, at 1.6 and 15.6 m respectively). The CO_2 was measured by a LI-840 at the current profile mast (from now SC mast) and by a LI-7500 and LI-7200 at the EC tower (EC mast) respectively.

After having processed the data according to the ICOS approach, the test results showed that the SC fluxes are rather low in general, with interquartile range of -0.36 - 0.35 and -0.66 - 0.71 umolCO_2 $m^{-2}s^{-1}$ at the SC (*SC_pro*) and EC towers (*SC_ec*) respectively. The absolute and percentage difference on the whole flux series is reported in Tab. 1. It must be noted that, excluding certain periods in which the *SC_ec* is sensibly higher than *SC_pro*, the two estimates are in a general agreement (Figure 4). The periods of apparent disagreement are mostly due to the different tower set-up, in particular, to the open path analyser used on level # 6 at the EC tower (much more noise on concentrations with respect to the closed path).

Table 1: statistics on storage fluxes difference as measured at the dedicated mast and at the EC mast (umolCO_2 m^{-2}s^{-1}).

	abs diff	rel diff
Min.	-12.14	0.10
1st Q	-0.49	51.60
Median	-0.04	144.60
Mean	-0.03	3698.80
3rd Q	0.49	546.60
Max.	9.96	2850383.30

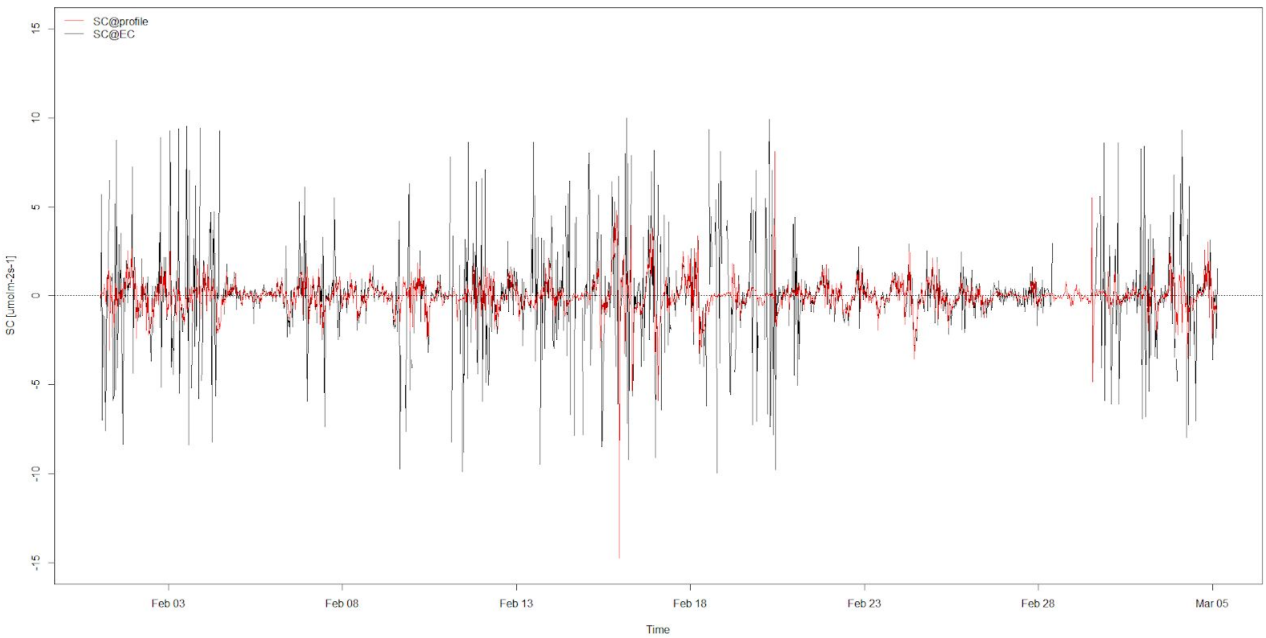


Figure 4: storage fluxes half-hourly series at FR-Bil.

The agreement is indeed more evident when looking at the daily cycle (Figure 5).

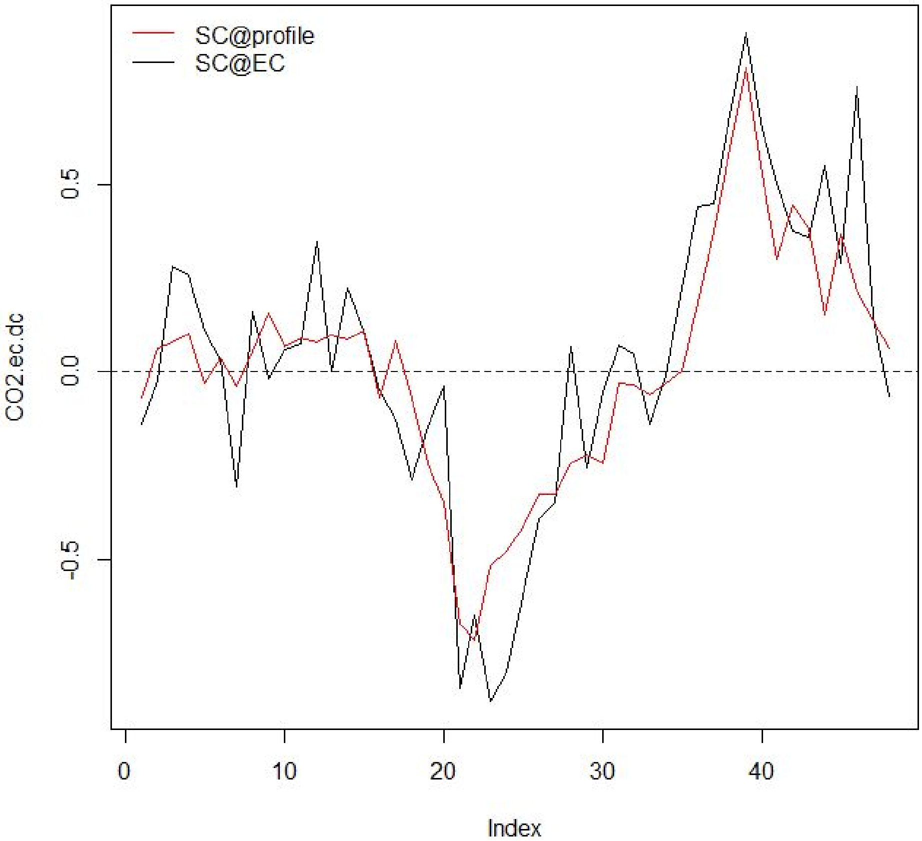


Figure 5: storage fluxes daily cycles at FR-Bil.

The official comparison of the two storage fluxes was made basing on the thresholds proposed in ICOS to evaluate the chance of whether instal a storage system or not (measurement height below 4 m, see the storage measurement instruction document). Results showed that, considering the SC fluxes higher than 2 µmolCO_2 m^2 s^{-1}, a difference between storage fluxes of at least 10% is noticeable in the 4% of data only.

Consequently, it has been agreed that at FR-Bil there is no need to place the profile system at the EC tower location (below the EC system). The storage flux can be estimated from the dedicated mast at the current location (i.e. 59.7 m from the EC system).

The number of proposed sampling levels (i.e. 7) is compliant according to the EC system eight of 15.6 m (6 levels is the minimum requirement). ETC have believed that their vertical distribution, while compliant, may have been possibly improved by considering the exponent *b* of the relevant formula (see instruction) as *exp(1).* The PI proposed as alternative to modify the original profile configuration adding a new level near the ground at 0.08 m so as have the profile configuration as reported in Table 2. The PI proposal was definitely accepted by ETC.

Table 2: FR-Bil agreed storage profile configuration.

level	z (en m)	notation	number of intakes/level
8	0.1	z8	4
7	0.5	z7	2
6	1.6	z6	1
5	3.4	z5	1
4	5.7	z4	1
3	8.5	z3	1
2	11.8	z2	1
1	15.6	z1	1

The instrumentation will consist of: a *LI-840A* (Li-Cor) gas analyser, *HMP155* (Vaisala) probes in ventilated Young shield thermo-hygrometers, *HBD.S* (Air liquide) pressure sensor, *FR2A14BVBN* (Key instrument) mass flow controller, *Series 750* (MATRIX mechatronics) solenoid multi-valve, *N811-KN18* (KNF) and *TD02-13* (Parker) pumps (1 bigger for the main flow, 1 smaller for the subsampling to the gas analyser).

The air system is composed by synflex tubes 6 mm OD and inox tubes 6 mm OD, inox swagelok connectors and Festo QSY 6 mm Push-in Y connectors.

With the addition of the 8th level, each one (8 in total) will be sampled for 30 s resulting in a profile return time of 240 s. With a tube volume of 0.324 L, a mixing volume of 3 L and a flow rate of 2 L min-1, the whole volume turnover time is about 100 s.

Radiations:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RAD_4C-K&Z CNR4	100154	15.6	41.008	-11.71	SW_IN_1_1_1
					SW_OUT_1_1_1
					LW_IN_1_1_1
					LW_OUT_1_1_1
RAD_PAR-K&Z PQS1	110356	15.6	41.008	-11.71	PPFD_IN_1_1_1
RAD_PAR-K&Z PQS1	110361	15.6	41.008	-11.71	PPFD_OUT_1_1_1
RAD_SW-K&Z CMP22	110318	15.6	41.008	-11.71	SW_IN_1_1_2

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 PQS1 (Kipp & Zonen) quantum sensor will be used.

Precipitation:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
PREC-MPS TRwSx5	549	7.8	23.488	33.87	P_1_1_1

For precipitation measurement the PI asked for an exception because there are no clearings at the site large enough for satisfying the fetch requirements. After a discussion, given the impossibility to find a place that meets the ICOS recommendation, the proposed setup with the main pluviometer mounted on a separate mast at the canopy top level has been accepted (Figure 6). The main pluviometer is a *TRwS415* (MPS system sro). PI asked for an additional exception, to not instal the windshield. The request was motivated by the consideration that the crowns around the gauge will play a sufficient attenuation of the wind disturbance. ETC asked the ST to document the actual conditions so as to better evaluate the effective attenuation according to the instruction document. The PI replied that the pluviometer was originally mounted at 9.0 m, while the average tree height is around is 9.4 m. Since the average distance inbetween is 6.0 m, the Station Team lowered the pluviometer down to 7.8 m. This modification made the new setup compliant with the ICOS requirement of having the distance of the shielding trees comprised between 2 and 4 times the height of the crowns exceeding the gauge level, thus the wind-shield a cannot be used at FR-Bil.

As snow is not expected at the site, snow depth measurements will not be taken.

Figure 6: Actual location of the precipitation gauge at FR-Bil (exception agreed on location). Currently the top of the surrounding canopies is about 0.4 m m above the gauge rim, at an average distance of 6.0 m. The gauge was lowered to 7.8 m in April 2018.

Air temperature, relative humidity and air pressure

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RHTEMP-Vaisala HMP155	G4620029	15.6	35.474	44.6	TA_1_1_1 RH_1_1_1
RHTEMP-Vaisala HMP155	J2110058	11	35.474	44.6	TA_1_2_1 RH_1_2_1
RHTEMP-Vaisala HMP155	J2110055	8.22	35.474	44.6	TA_1_3_1 RH_1_3_1
RHTEMP-Vaisala HMP155	J2110054	5.12	35.474	44.6	TA_1_4_1 RH_1_4_1
RHTEMP-Vaisala HMP155	L3840283	2.4	35.474	44.6	TA_1_5_1 RH_1_5_1
RHTEMP-Vaisala HMP155	J2110056	1.25	35.474	44.6	TA_1_6_1 RH_1_6_1
RHTEMP-Vaisala HMP155	L4150134	0.5	35.474	44.6	TA_1_7_1 RH_1_7_1
PRES-Young 61302	3908	15.6	35.474	44.6	PA_1_1_1
WDWS-Gill WindsonicX	15260093	0.4	35.474	44.6	WS_1_1_1 WD_1_1_1
WDWS-Gill WindsonicX	13130018	1.93	35.474	44.6	WS_1_2_1 WD_1_2_1
WDWS-Gill WindsonicX	13130015	3.1	35.474	44.6	WS_1_3_1 WD_1_3_1
WDWS-Gill WindsonicX	13130014	5.78	35.474	44.6	WS_1_4_1 WD_1_4_1
WDWS-Gill WindsonicX	13130013	8.93	35.474	44.6	WS_1_5_1 WD_1_5_1
WDWS-Gill WindsonicX	15260095	11	35.474	44.6	WS_1_6_1 WD_1_6_1
WDWS-Gill WindsonicX	13130016	15.62	35.474	44.6	WS_1_7_1 WD_1_7_1

The sensors used at the station for TA and RH, and for PA are ICOS compliant: Vaisala HMP155 and Young 61302V, respectively. In addition, a profile of TA and RH is also present, made of all Vaisala

HMP155 sensors. Also, a wind profile made of 2D sonic anemometers is present, not mandatory for Class 2 stations. All the sensors were purchased or factory calibrated in 2019, then the calibration will have to be repeated on 2021, except the PRES-Young 61302 3908, for which the ETC accepted the station plan for calibration on Dec 2019. All the WSWD sensors are also out of the calibration window, but as they are not mandatory this is not relevant.

Backup meteorological station

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RHTEMP-Vaisala HMP155	R0210225	3.5	8.835	71.97	TA_2_1_1 RH_2_1_1
PRES-Vaisala PTB101B	V1240030	0.5	8.835	71.97	PA_2_1_1
PREC-PrecMec R013029	22252	2.5	8.835	71.97	P_2_1_1
RAD_SW-K&Z CM5	7852222	3.5	8.835	71.97	SW_IN_2_1_1
RAD_PAR-Skye SKP215	S10021306	3.5	8.835	71.97	PPFD_IN_2_1_1

The backup meteorological station is powered by direct power and solar panel with backup bacteries, so has independent power in case of outage. The sensors installed for TA/RH and P measurements are ICOS compliant: the VAISALA HMP155 and the tipping bucket R01 3029 from Précision mécanique. The sensor for PA is not requested, and the model is not ICOS compliant, but acceptable as a backup (data will be processed). Also the PAR radiometer is not needed, but the PI decided to install it anyway, and the ETC accepted (data will be processed). The SW_IN radiometer is an old, retired sensor from Kipp&Zonen, that can be used as backup sensor. The need for factory calibration of these sensors will be evaluated against the main ones.

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 installed in the vicinity of the center of a Continuous Measurements plot (CP), plus two additional soil heat flux plates installed in the target area (and which are here also installed within extra CPs ; see Figure 7). The set-up of each soil plot and each additional soil heat flux plate, shown in Figures 8 and 9, 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 sensors.

The station team has mentioned that, due to the looseness of the sandy soil, it is not possible to install the soil water content and soil temperature profiles in a soil plot closer than 1 to 1.5 m away from each other. Soil pit walls tend to collapse and this disturbs already installed sensors that are too close to the pit. The station team has therefore asked if it is allowed to install the profiles in the plot further away from each other than prescribed in the Instructions. The ETC has accepted this deviation from the Instructions, but on the condition that the heat flux plate plate is buried in between the two profiles, so that the distance between each profile and the plate is not more than 0.5 to 0.75 m.

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
TEMP-MicroStep PT100D	286	0	34.438	-16.58	TS_1_1_1
TEMP-MicroStep PT100D	284	-0.05	34.438	-16.58	TS_1_2_1
TEMP-MicroStep PT100D	303	-0.08	34.438	-16.58	TS_1_3_1
TEMP-MicroStep PT100D	360	-0.12	34.438	-16.58	TS_1_4_1
TEMP-MicroStep PT100D	359	-0.24	34.438	-16.58	TS_1_5_1
TEMP-MicroStep PT100D	363	-0.47	34.438	-16.58	TS_1_6_1
TEMP-MicroStep PT100D	331	-1.05	34.438	-16.58	TS_1_7_1
TEMP-MicroStep PT100D	355	0	-49.38	14.33	TS_2_1_1
TEMP-MicroStep PT100D	324	-0.05	-49.38	14.33	TS_2_2_1
TEMP-MicroStep PT100D	371	-0.08	-49.38	14.33	TS_2_3_1
TEMP-MicroStep PT100D	352	-0.16	-49.38	14.33	TS_2_4_1
TEMP-MicroStep PT100D	350	-0.2	-49.38	14.33	TS_2_5_1
TEMP-MicroStep PT100D	335	-0.54	-49.38	14.33	TS_2_6_1
TEMP-MicroStep PT100D	369	-0.95	-49.38	14.33	TS_2_7_1
TEMP-MicroStep PT100D	327	0	8.6	48.81	TS_4_1_1
TEMP-MicroStep PT100D	368	-0.05	8.6	48.81	TS_4_2_1
TEMP-MicroStep PT100D	348	0	-12.904	-38.24	TS_5_1_1
TEMP-MicroStep PT100D	326	-0.05	-12.904	-38.24	TS_5_2_1
SWC-Stevens Hydraprobe	239643	-0.055	34.438	-16.78	SWC_1_1_1
SWC-Stevens Hydraprobe	239661	-0.08	34.438	-16.78	SWC_1_2_1
SWC-Stevens Hydraprobe	239642	-0.12	34.438	-16.78	SWC_1_3_1
SWC-Stevens Hydraprobe	239633	-0.24	34.438	-16.78	SWC_1_4_1
SWC-Stevens Hydraprobe	239634	-0.47	34.438	-16.78	SWC_1_5_1
SWC-Stevens Hydraprobe	239635	-1.05	34.438	-16.78	SWC_1_6_1
SWC-Stevens Hydraprobe	239636	-1.97	34.438	-16.78	SWC_1_7_1
SWC-Stevens Hydraprobe	239631	-0.05	-49.03	14.13	SWC_2_1_1
SWC-Stevens Hydraprobe	239638	-0.08	-49.03	14.13	SWC_2_2_1

SWC-Stevens Hydraprobe	239637	-0.1	-49.03	14.13	SWC_2_3_1
SWC-Stevens Hydraprobe	239641	-0.16	-49.03	14.13	SWC_2_4_1
SWC-Stevens Hydraprobe	239630	-0.54	-49.03	14.13	SWC_2_5_1
SWC-Stevens Hydraprobe	239639	-0.94	-49.03	14.13	SWC_2_6_1
SWC-Stevens Hydraprobe	239640	-1.25	-49.03	14.13	SWC_2_7_1
SWC-Stevens Hydraprobe	239660	-0.05	8.8	48.46	SWC_4_1_1
SWC-Stevens Hydraprobe	239663	-0.05	-13.104	-38.24	SWC_5_1_1
SOIL_H-Hukseflux HFP01SC	3117	-0.05	34.538	-16.68	G_1_1_1
SOIL_H-Hukseflux HFP01SC	3116	-0.05	-49.205	14.23	G_2_1_1
SOIL_H-Hukseflux HFP01SC	3120	-0.05	8.7	48.635	G_4_1_1
SOIL_H-Hukseflux HFP01SC	2515	-0.05	-13.004	-38.415	G_5_1_1
Campbell Scientific CS451	14011135	-1.92	32.538	-17.18	WTD_1_1_1
Campbell Scientific CS451	14011088	-1.7	-51.205	14.73	WTD_2_1_1
Campbell Scientific CS451	14010091	-3.7	23.488	33.87	WTD_3_1_1

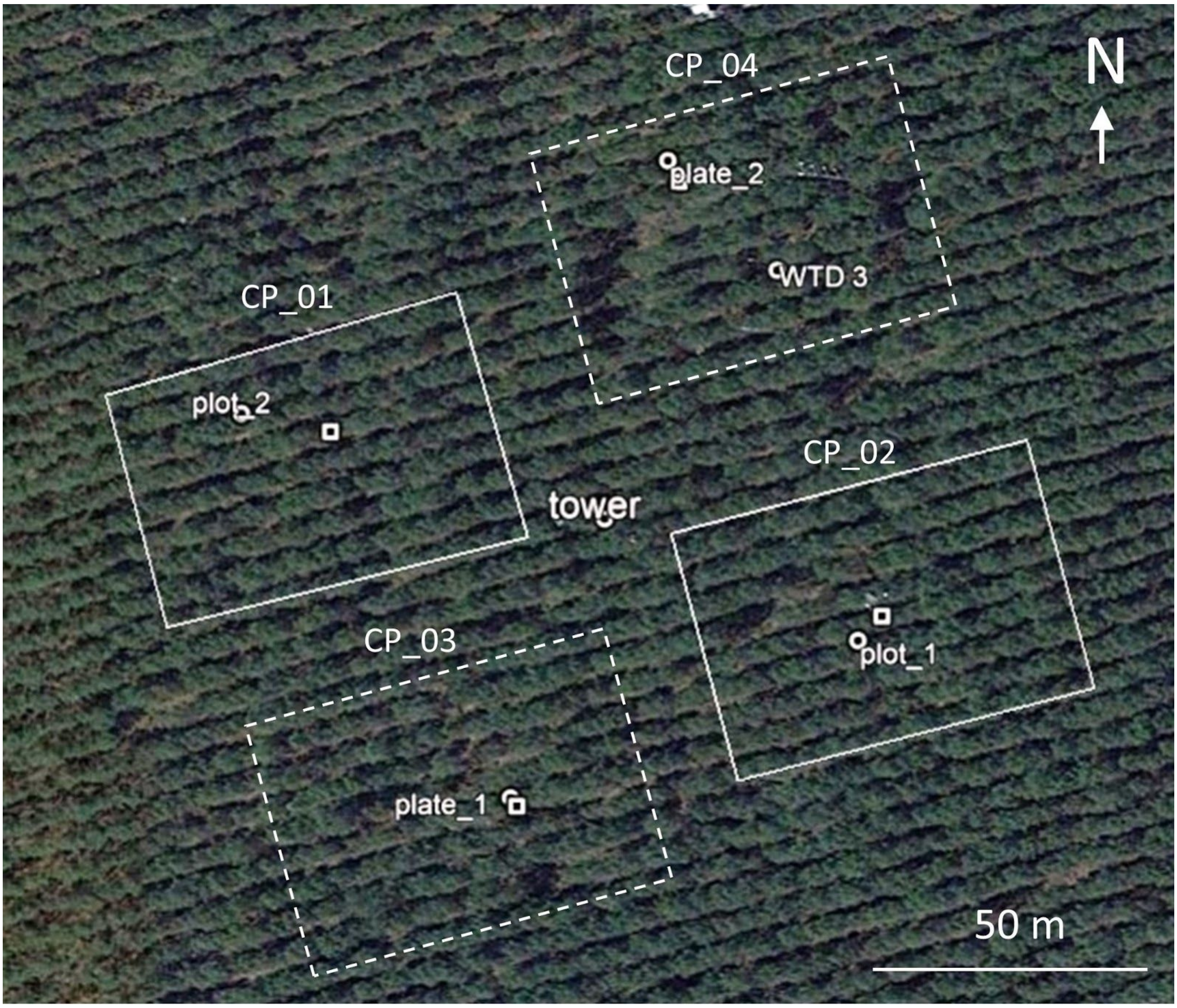


Figure 7: Location of the soil plots (plot 1 & 2), each installed in one of the two official Continuous Measurements plots (CP_01 and CP_02). Location of the two additional heat flux plates (plate 1 & 2), each installed inside two extra CPs that the station team laid out around the EC tower (CP_03 and CP_04). Note: the station team also installed an extra monitoring well for WTD measurements (WTD 3).

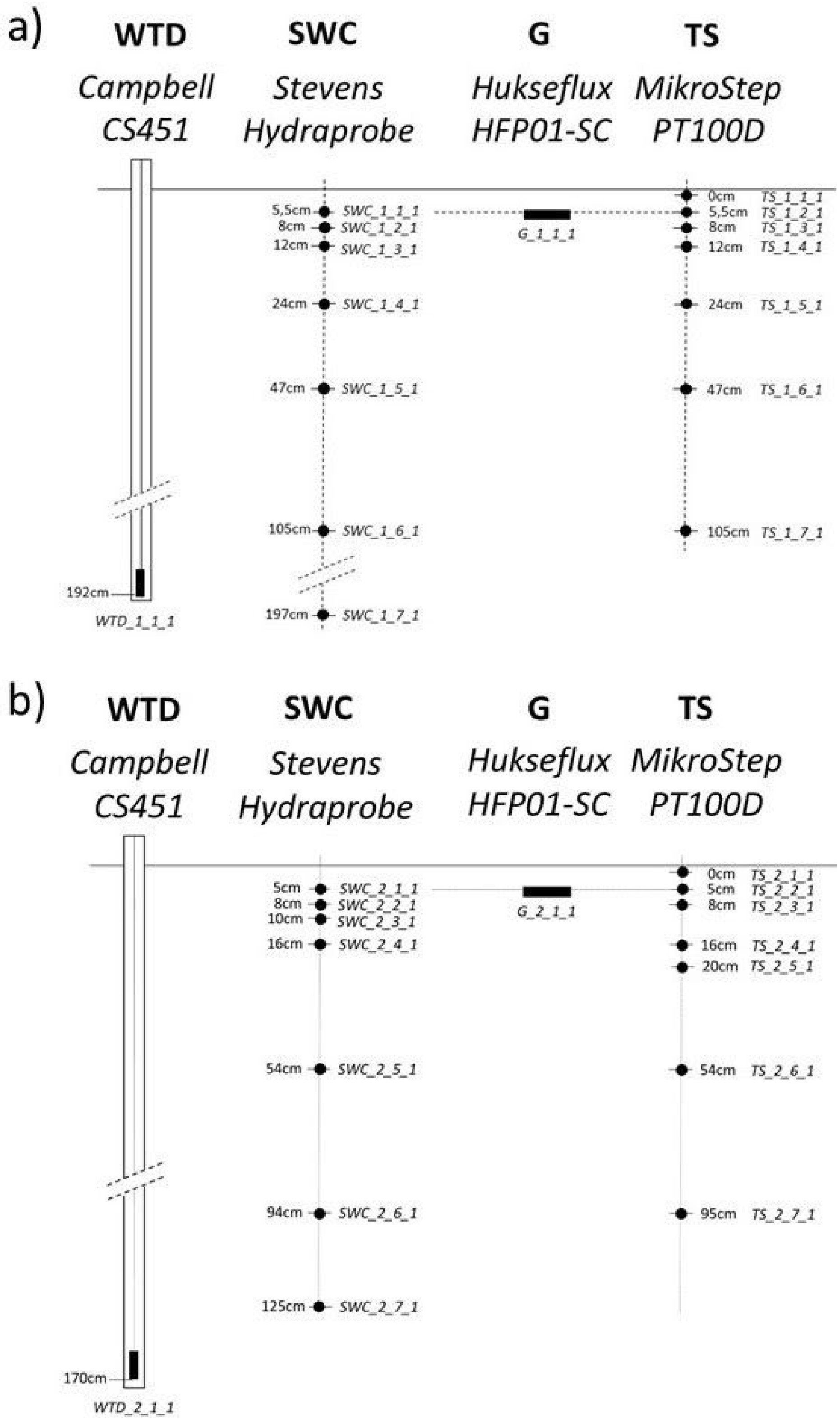


Figure 8: Set-up of the two soil meteo plots. a) plot 1 and b) plot 2. WTD = water table depth, SWC = soil water content, G = soil heat flux density, TS = soil temperature.

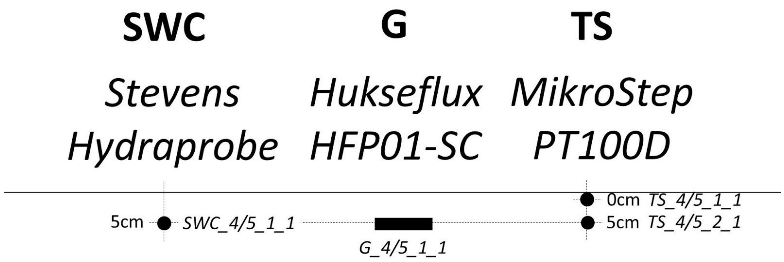


Figure 9: Set-up of the two additional heat flux plates with accessory sensors. SWC = soil water content, G = soil heat flux density, TS = soil temperature.

Spatial heterogeneity characterization

Aboveground biomass:

The station team has collected in the spring of 2019 the full set of tree data that is requested for the characterization of the target area and its spatial heterogeneity. These measurements were performed after a thinning had been taken place at the site, which removed between 30 and 50% of the trees. The dataset used for the labelling comprises the species, DBH and health status of all trees above the stem diameter threshold of 5 cm that are growing inside the 20 SP-I plots installed in the target area. Since the vegetation under study is a tree plantation with even aged trees planted in regular rows, the station team correctly followed the spatial sampling design of tree plantation with rectangular plots for all 20 SP-I and four CP plots, measuring 720 m² and 1856m² respectively. the station team requested an exception for the tree height measurements (see below) and performed the measurements accordingly. The ETC has quality-checked and processed these data. Figures 9 and 10 summarize the dataset, showing for each plot respectively the tree density per species, the basal area per species. Basal area is used here as a proxy for Aboveground biomass. As can be seen in the figures, the target area is a mono species culture of maritime pine (Pinus pinaster Aiton).

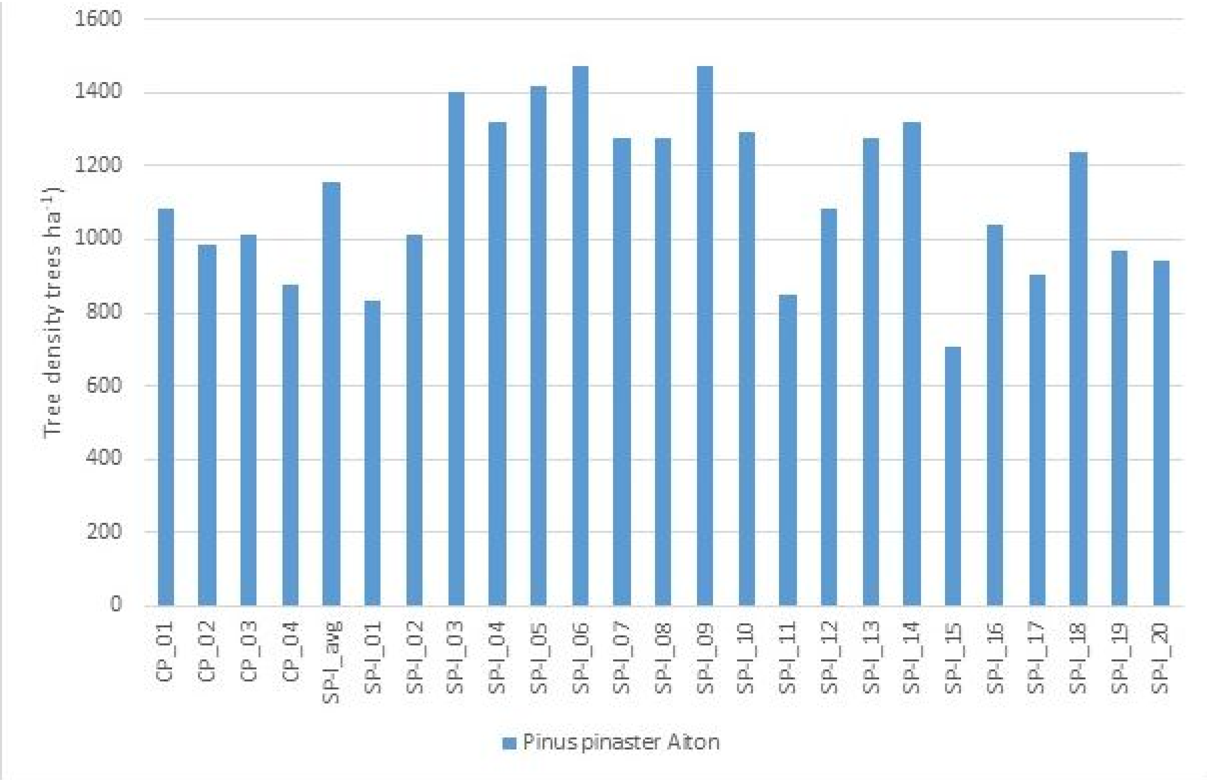


Figure 9: Tree density shown for the twenty SP-I plots and the four CPs installed in the target area.

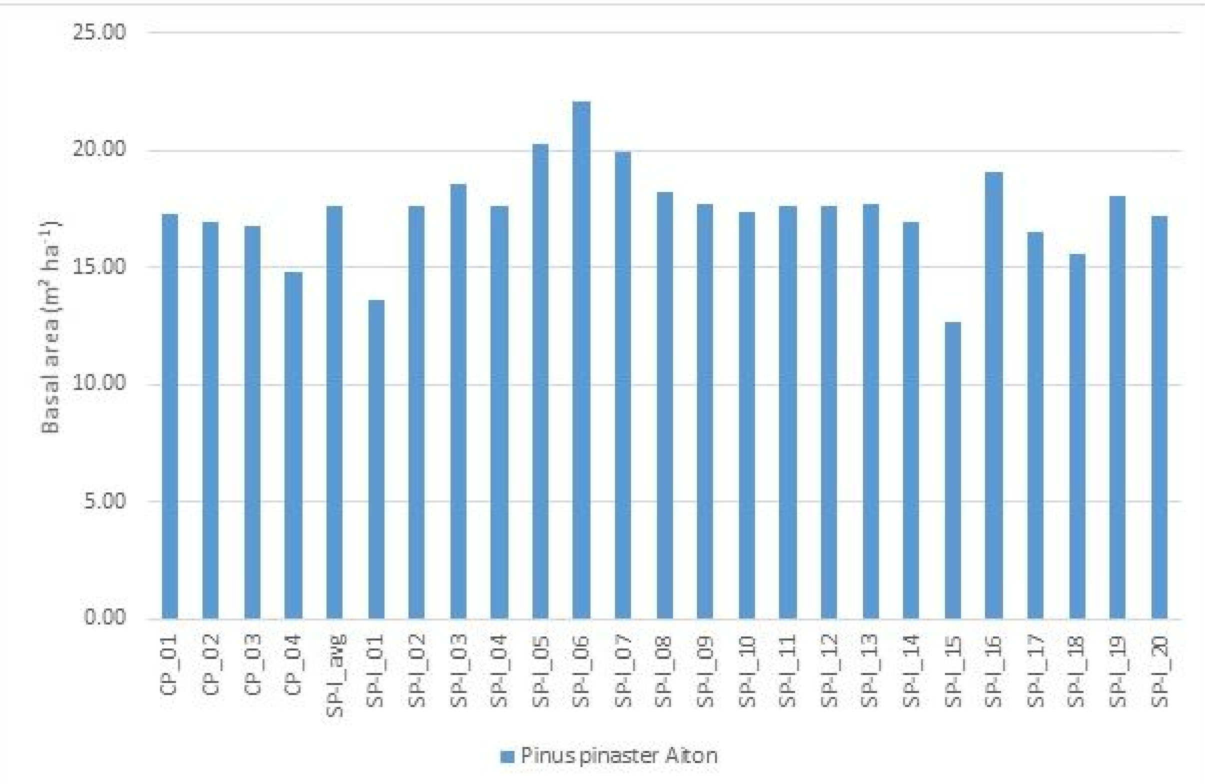


Figure 10: Basal area shown for the twenty SP-I plots and the four CPs installed in the target area.

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 in the second part of June 2019 by means of Digital Hemispherical Photography. As prescribed in the ICOS Instructions, five hemispherical images were taken in each SP-I plot. The ETC has quality-checked and processed the images. A small number of images did not pass the quality check and were therefore not used for this analysis. Figure 11 shows the plot results.

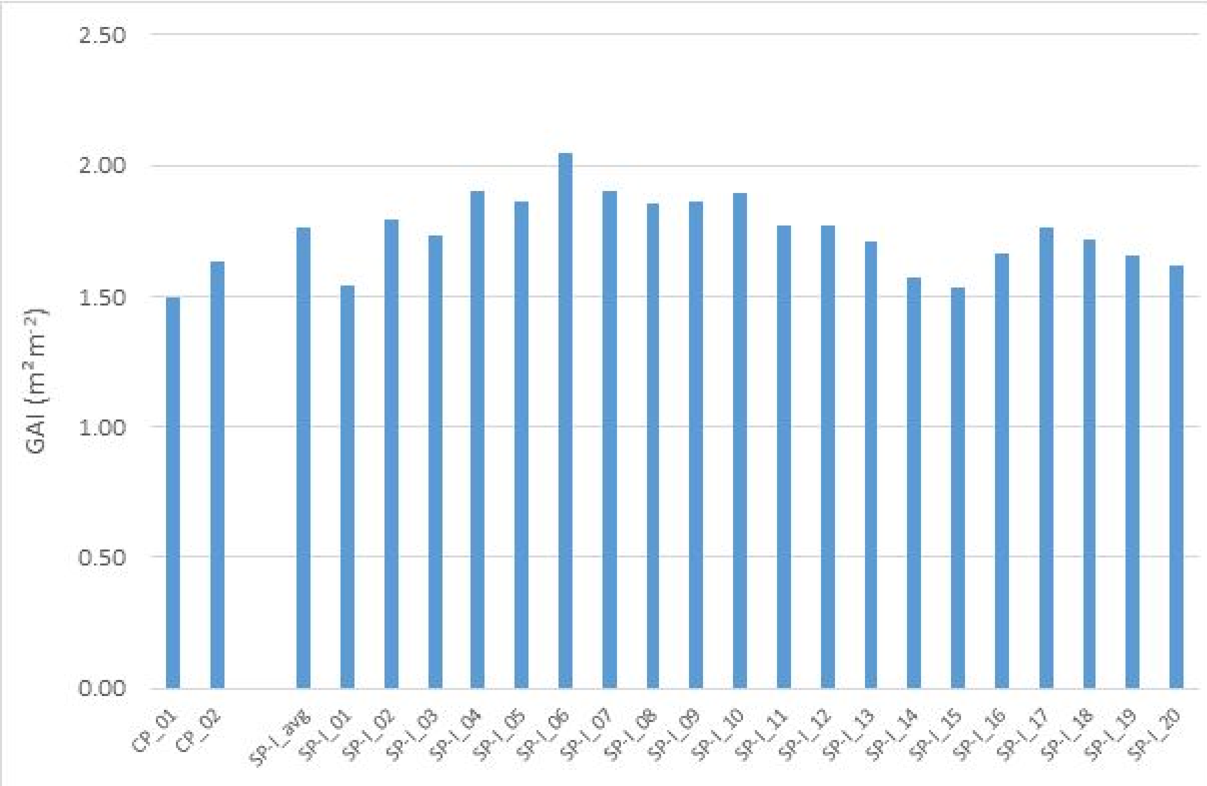


Figure 11: Green Area Index (GAI) for the twenty SP-I plots and the two CPs installed in the target area.

The site characterization measurements revealed a relatively low large variability in tree density, basal area, and Green Area Index within the target area. As communicated by the station team the site had been thinned in the winter period 2018-2019 and has resulted in a decrease of the tree density between 30 and 50%. The station team indicated that a small area of the target area has not been thinned (SP-I_05, SP-I_06, SP-09, SP-I_10). It is indeed apparent from the data that the tree density in these four plots is higher than the average tree density of the plantation. However the difference is decreasing when looking at the basal area, which is probably due to a higher amount of trees with a small diameter in these plots. The remained thinning of these plots should be discussed well in advance with the ETC in order to maintain the homogeneity within the stand.

Green Area Index

The station team has collected the minimum of two sets of GAI measurements that are requested for the step 2 labelling. A first set of pictures at all 20 SP-I plots was taken in October 2018, before the thinning took place. A second set was taken in June 2019, after the thinning and submitted with delays to the ETC. The ETC quality-checked and processed the images. Some images did not pass the quality check and were not included in the analysis. It should be noted that once the station is labelled we will not allow a large delay between the field measurements and the submission. Pictures from CP_03 were not of sufficient quality and therefore this plot was excluded from the analysis.

Aboveground biomass

The station team has collected in the spring of 2019 the tree data required for the Aboveground biomass assessment in the step 2 labelling phase. These data comprise the position, species, DBH, health status and dendrometer presence of all trees above the stem diameter threshold of 5 cm that are growing inside the four originally proposed CPs that the station team has. The station team has asked the ETC whether it suffices to measure tree height only on a subsample of trees that has been selected semi-randomly earlier from all trees in the CPs and for which height has been monitored for several years now. This subsample includes 10% of all the trees in the CPs. The ETC has accepted this request because:

(i) tree height is not needed as input for tree biomass calculation (Shaiek et al., 2011), hence it must not necessarily be measured on all trees, and

(ii) based on tree data collected in January 2018, it can be concluded that the subsample of trees is well representative of the CPs (see Figure 12).

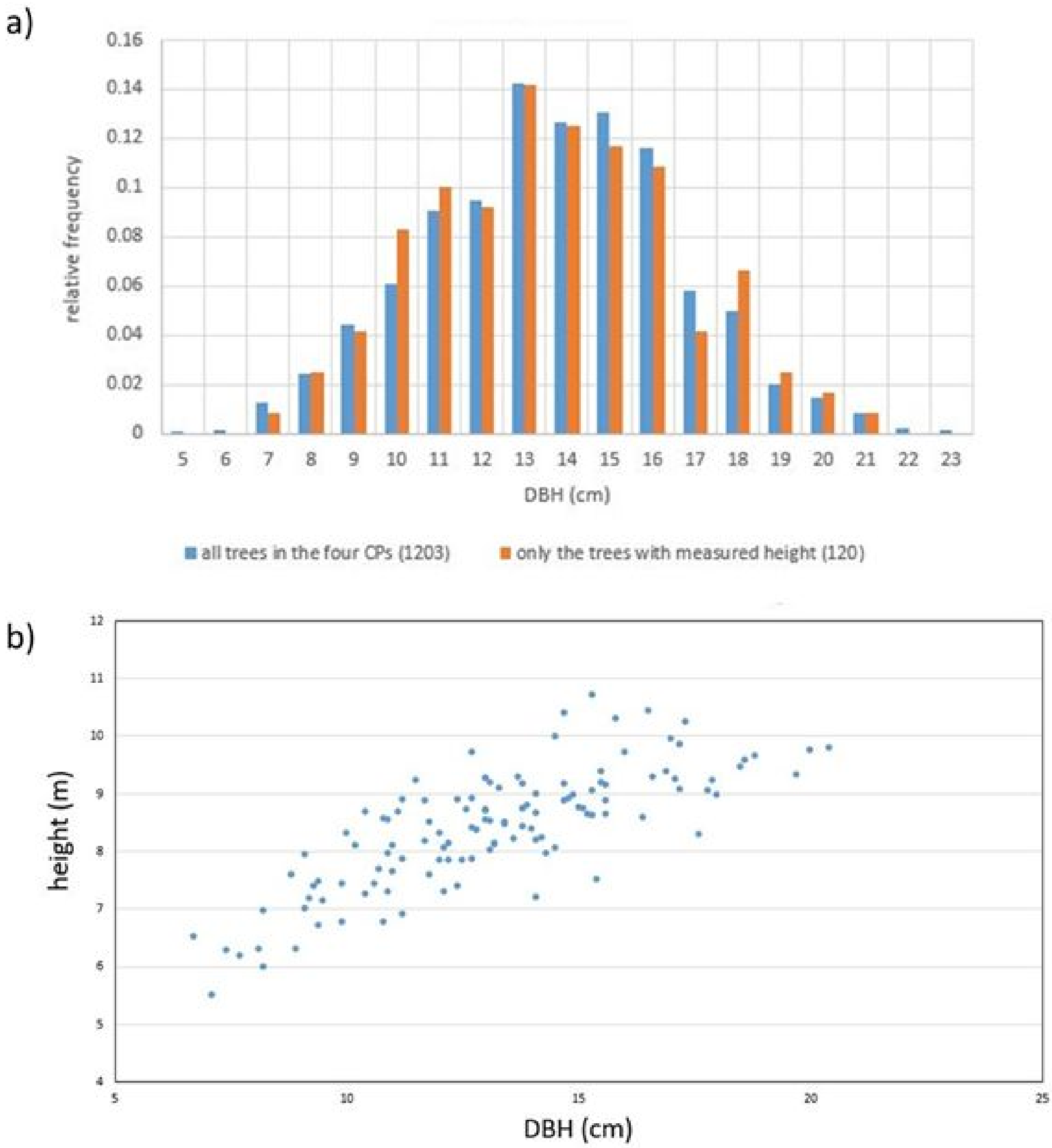


Figure 12 : a) Relative DBH-based frequency distribution of all trees in the CPs (blue) and the subsample of trees selected for tree height measurements (red). b) relationship between tree height and DBH for that subsample of trees.

The ETC quality-checked and processed these data. Figures 9 and 10 show for each of the four CPs respectively the tree density per species, the basal area per species. Basal area is used here as a proxy for Aboveground biomass. As can be seen in the figures, the CPs are entirely dominated by maritime pine (*Pinus pinaster* Aiton)

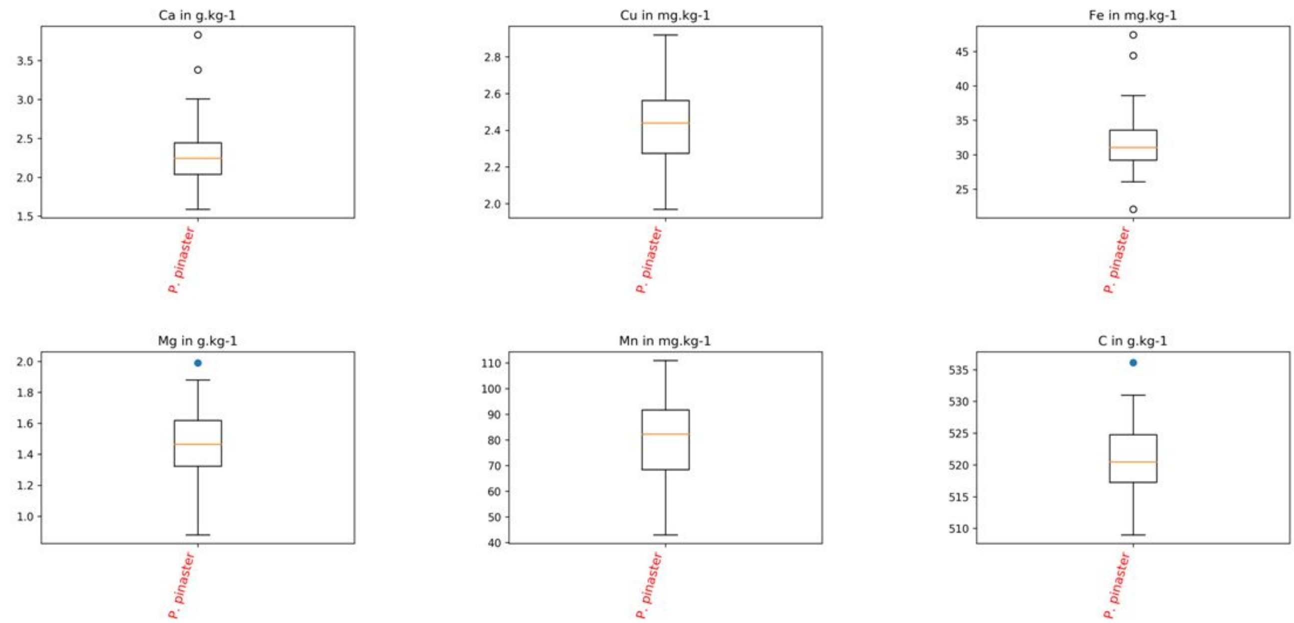
Note: Even though FR-Bil is a Class 2 station and doesn't need to provide litter biomass measurements, it will measure litter in all four installed CPs following the methodology prescribed by ICOS.

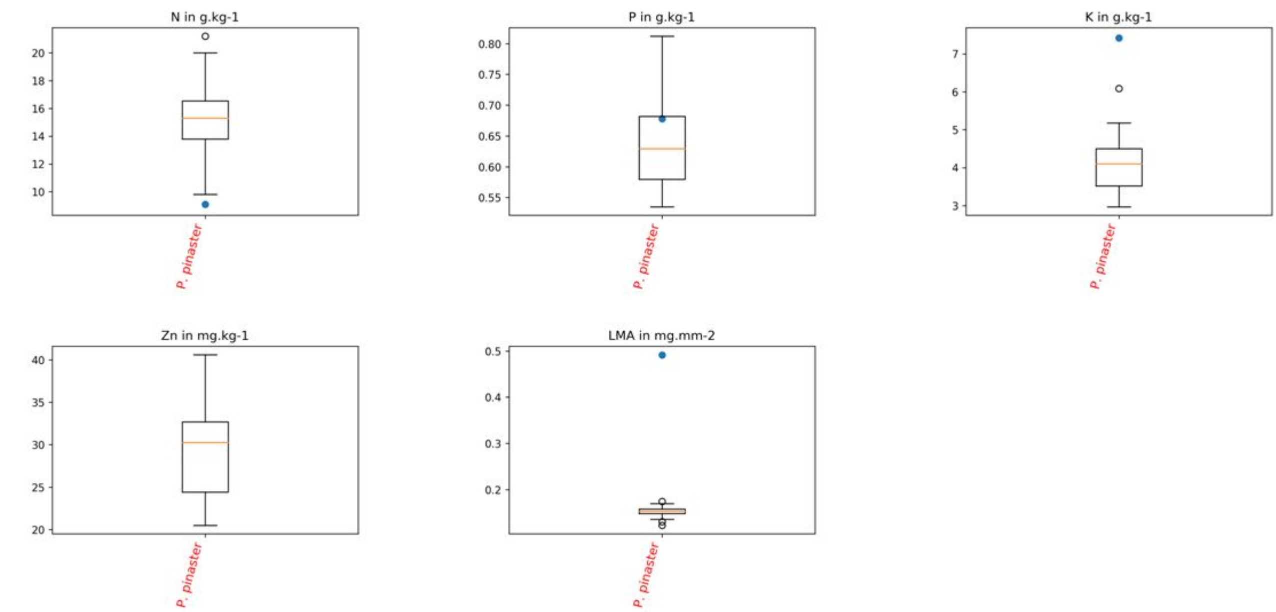
Shaiek O., Loustau D., Trichet P., Meredieu C., Bachtobji B., Garchi S., El Aouni M.H., 2011. Generalized biomass equations for the main aboveground biomass components of maritime pine across contrasting environments. Ann For Sci 68:443-452.

Vegetation sampling and analysis

The sampling scheme has been agreed by the ETC. The foliar chemical analysis and leaf mass-to-area ratio have been carried out by 2018 31st January. The values reported below and are acceptable.

Foliar Analyses for station FR-Bil, 2018-01-31





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

The nitrogen content of pine needles are in the upper range of current values, probably due to the abundance of dwarf gorse in the understorey. Conversely, the P content values are scattered and low despite the phosphate application at the plantation reported by the station team, as well as potassium needle content. The LMA values reported by the station team are within the expected range (whereas the TRY database values are aberrant).

Data check and test

<u>Data quality analysis (Test 1)</u>

The test aims at quantifying the availability of NEE half-hourly data after the application of Quality Control (QC) procedures. The requirement expected for the Step 2 of the station labelling is that the total percentage of missing and removed data after the QC filtering does not exceed the 40% threshold value. This threshold was agreed between the ETC and the ecosystem MSA, and has the goal to maintain the ICOS data quality standard.

Tests involved in the QC procedure aim at detecting NEE flux estimates contaminated by the following sources of systematic error: (i) EC system malfunction occurring when fluxes originate from unrepresentative wind sectors or evidenced by diagnostics of sonic anemometer (SA) and gas analyzer (GA); (ii) instruments malfunction as provided by Vickers and Mahrt (1997) statistical tests; (iii) lack of well developed turbulence regimes (Foken and Wichura, 1996); (iv) violation of the stationary conditions (Mahrt, 1998). By comparing each test statistic with two pre-specified threshold values, flux data are identified as affected by severe, moderate or negligible evidences about the presence of specific sources of systematic error (hereinafter denoted as SevEr, ModEr and NoEr). Subsequently, the data rejection rule involves a two-stage procedure: in the first stage half-hourly fluxes affected by SevEr are directly discarded, whereas, in the second stage, those affected by ModEr are removed only if they are also identified as outliers.

Concerning FR-Bil site, the testing period involves raw data sampled in from 2018, November 27th to 2019, March 04th. Of 4657 expected half-hourly files for NEE fluxes, 66.2% were retained after QC routines as illustrated in Figure 13. In particular, about 3.2% of raw-data was missed, 32.4% of calculated half-hourly fluxes was discarded because affected by SevEr, while an additional 1.4% was discarded because identified as outliers and affected by ModEr.

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

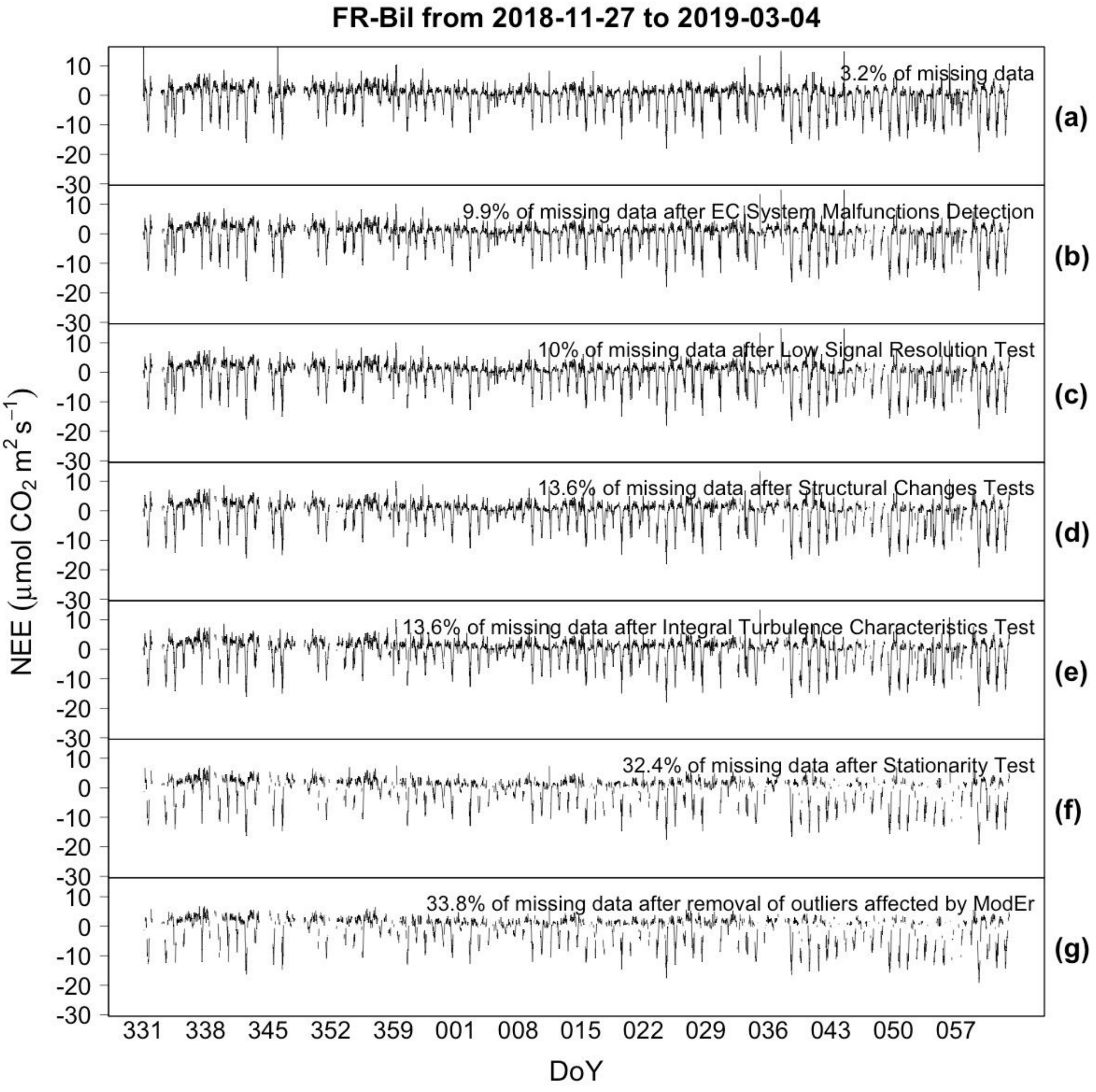


Figure 13: Summary of the data cleaning procedure applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at FR-Bil site from 2018/11/27 to 2019/03/04. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe evidences of error 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) integral turbulence characteristics test (ITC, Foken and Wichura, 1996); (e) stationarity test by Mahrt (1998). Bottom panel displays the time series of retained high-quality NEE after the additional removal of outlying fluxes affected by moderate evidences of error.

Footprint analysis (Test 2)

The test aims to evaluate whether half-hourly flux values are sufficiently representative of the target area (TA) or not. It was performed on about 3 months of data (98 days), after QC filtering procedure (previous Section) were achieved. The model by Klijun et al. (2015) were used to obtain the 2-dimensional flux footprint for each half-hour, which was compared to the TA spatial extent. After the QC procedure and additional filtering according to footprint model requirements, the 46.8 % of the data was used for the test.

Results showed that basically the 100% of the data have a cumulative contribution of at least 70% from the TA (Fig. 14, leftmost bars block), and this holds for daytime and nighttime periods too. In addition, the test was performed on 5 sub-periods based on monthly scale and results confirmed the percentages obtained on the whole period (Fig. 14).

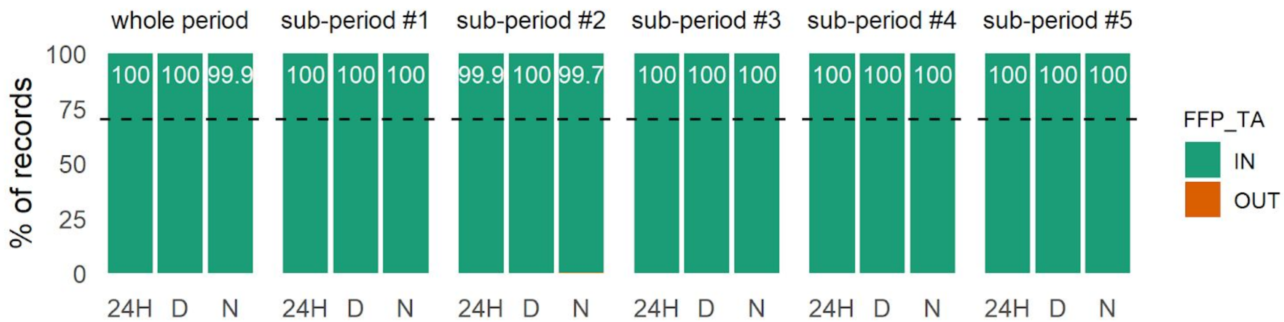


Figure 14: Test 2 results obtained over the whole period (leftmost block) and sub-periods, showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value (dashed horizontal line) is that the 70% of data (half-hourly fluxes) must hold this condition. The analysis was done considering the whole day (‘24H’) and daytime and nighttime separately (‘D’ and ’N’ respectively).

The footprint climatology for FR-Bil, estimated over the period under consideration is reported in Figure 15, by which it is possible to noticed that the 70% footprint cumulative contribution (even 80% actually) is always included in the TA.

According to these results, the test is passed.

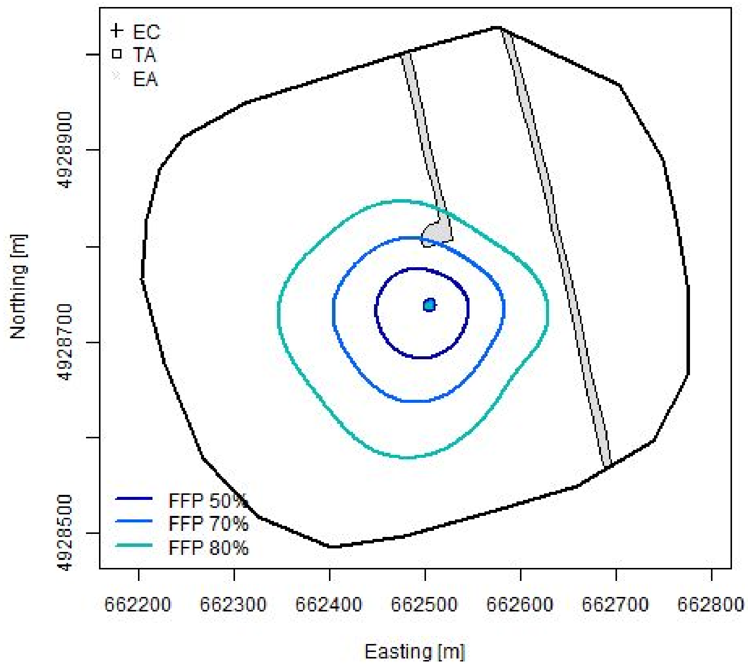


Figure 15: Footprint climatology at FR-Bil in relation to the TA, the EC tower (EC), and the excluded areas (EA, see the spatial sampling Section). The 50, 70 and 80 % cumulative contribution isopleths are reported.

Data representativeness analysis (Test 3)

The test aims to quantify, for possible ecosystem patches in the TA which contribute with at least 70% of the fluxes in at least 20% of the data (good data after filtering for QA/QC), the number of records collected during daytime, nighttime and for each of two periods obtained dividing the dataset in two parts. The target values is that each group includes at least 20% of data.

According to the spatial heterogeneity characterization (see the respective Section above, and the Test 4 results) at FR-Bil were defined 2 land cover typologies, a thinned and an unthinned stand, here named as LCT_01 and LCT_02 respectively. Exemplary half-hourly footprints at FR-Bil in relation to the TA and the different land cover typologies are reported in Figure 16.

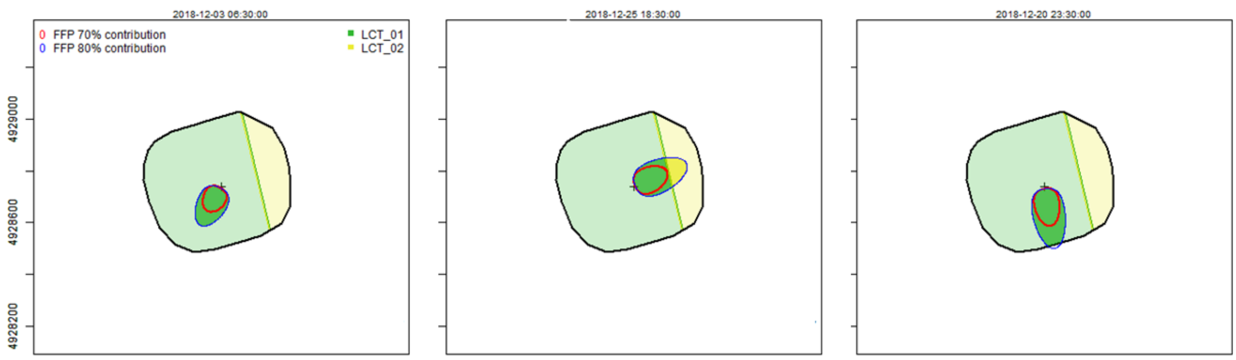


Figure 16: exemplary 2D half-hourly footprints at FR-Bil in relation to the TA and the two envisaged land cover typologies (LCT). The footprint 70 and 80% cumulative contribution isopleths are reported in red and blue respectively.

The test showed that only LCT_01 contributes for more than 70% in more than the 20% of records while LCT_02 is only seldom sampled by the EC system (Figure 17). So, taking into account the results from test 2 , the test 3 is considered as passed.

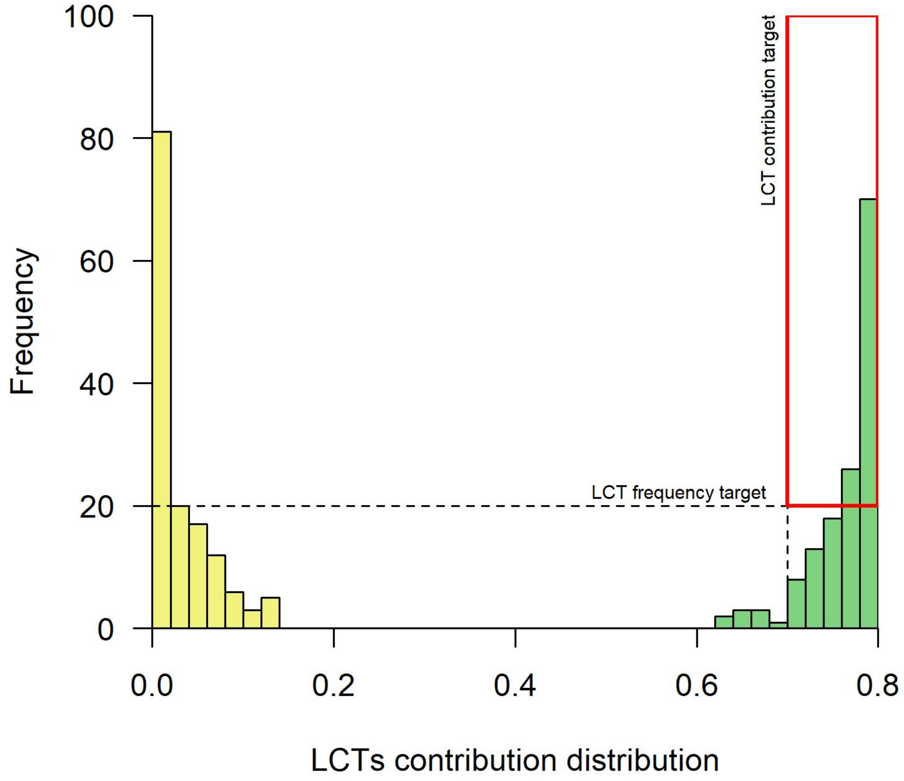


Figure 17: Individual footprint cumulative contributions from the two envisaged land cover typologies (LCT) at FR-Bil.

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 the 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. In addition the station team confirmed that management will be performed in the near future (2020) in the remaining SP-I plots that were not thinning during the winter 2018-2019. The station team should communicate this management operation well in advance to the ETC and discuss the details in order to keep the homogeneity of the vegetation within the target area.

The results from the Green Area Index measurements showed that when comparing the GAI values of the CP's and the SP's for the campaign in June 2019 that the CP_01 and CP_02 are representative for the SP's because they both fall within the accepted range of 20%. CP_03 was not considered as the quality pictures were not according the ICOS standards as described in the instruction document. However, since the station is a class 2 station two CP’s are sufficient and the representativity test is thus fulfilled.

Near Real Time data transmission

The NRT submission of EC and BM files is currently running.

For the EC files, the station is using a SmartFlux2 logger from LICOR. Files received are ICOS compliant. The station received the green light for data submission of EC files (L03_F01) on 20181130.

For BM files the station team got the green light for data submission of files L01_F01, L01_F02, L02_F01, L04_F01, L05_F01, L06_F01, L07_F01, L10_F01 on 2018, June 20th. However, some changes were requested by the ETC (Maarten) for some sensors. When these changes were made, the files were sent again for the check, together with some new files. The following files got the green light from this new check on October 08th 2018: L05_F01, L07_F01, L08_F01, L09_F01. The files L04_F01 and L06_F01 had instead an error in the external header file at first, which should not be the case as they already received previously the green light. Everything is fixed now. Few warnings remain in some periods for some BM files when SWC and WTD variables are out-of-range: for the SWC the reason is physical, and due to the “sandiness” of the soil, while for the WTD the problem is more technical due to the depth of the pits. None of them involves the file format, though, and the values will be continuously monitored.

Plan for remaining variables

Soil sampling

The first field survey for soil sampling is planned beginning of 2020. No major deviation from the protocol is expected.

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 Bilos (FR-Bil) is labelled as ICOS CLASS 2Ecosystem station.

Dario Papale, ETC Director

October 28th 2019