# ICOS Ecosystem Station Labelling Report

## Station: FI-Hyy (Hyytiälä)

*Viterbo (Italy), Antwerp (Belgium), Bordeaux (France), November 6th 2018*

## 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 16th 2016 and got the official approval on June 15th 2016. The Step2 started officially on January 13th 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 and some of them will lead to data exclusion and gaps. It is be 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 station with ICOS code FI-Hyy, is called Hyytiälä and is located in the Hyytiälä Forestry Field Station of the University of Helsinki, 220 km NW from Helsinki, with coordinates in WGS84 system: latitude 61.84741 °N, longitude 24.29477 °E, at an elevation of 181 m above sea level, the offset respect to the Coordinates Universal Time (UTC) is equal to +02. The station is located in a rather homogenous Scots pine (*Pinus sylvestris* L.) stand on a slightly hilly terrain. The site is marked by the following climate characteristics: Mean Annual Temperature 3.5 °C, Mean Annual Precipitation 711 mm, Mean Annual Radiation 100 W $m^{-2}$.

Fig.1 The FI-Hyy tower

## Team description

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

Table 2 - Description of team members roles at FI-Hyy

| MEMBER_NAME | MEMBER_INSTITUTION | MEMBER_ROLE | MEMBER_MAIN_EXPERT |
|---|---|---|---|
| Ivan Mammarella | University of Helsinki | PI | MICROMET |
| Timo Vesala | University of Helsinki | CO-PI | MICROMET |
| Janne Levula | University of Helsinki | MANAGER | |
| Jaana Back | University of Helsinki | SCI | |
| Jukka Pumpanen | University of Eastern Finland | SCI | SOIL |
| Mari Pihlatie | University of Helsinki | SCI | |
| Pasi Kolari | University of Helsinki | DATA | DATAPROC |
| Heikki Laakso | University of Helsinki | TEC | |
| Teemu Matilainen | University of Helsinki | TEC | |
| Pekka Rantala | University of Helsinki | AFFILIATED | |
| Juho Aalto | University of Helsinki | AFFILIATED | PLANT |

## Spatial sampling design

For the spatial sampling design at FI-Hyy, the Station Team (ST) proposed in addition to the Target Area (TA), 10 areas to be excluded from sampling (EA). Four continuous measurement points (CP) were submitted and after verifying their compliance, the respective areas were excluded from the surface available for sampling. 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 which were sent to ST.

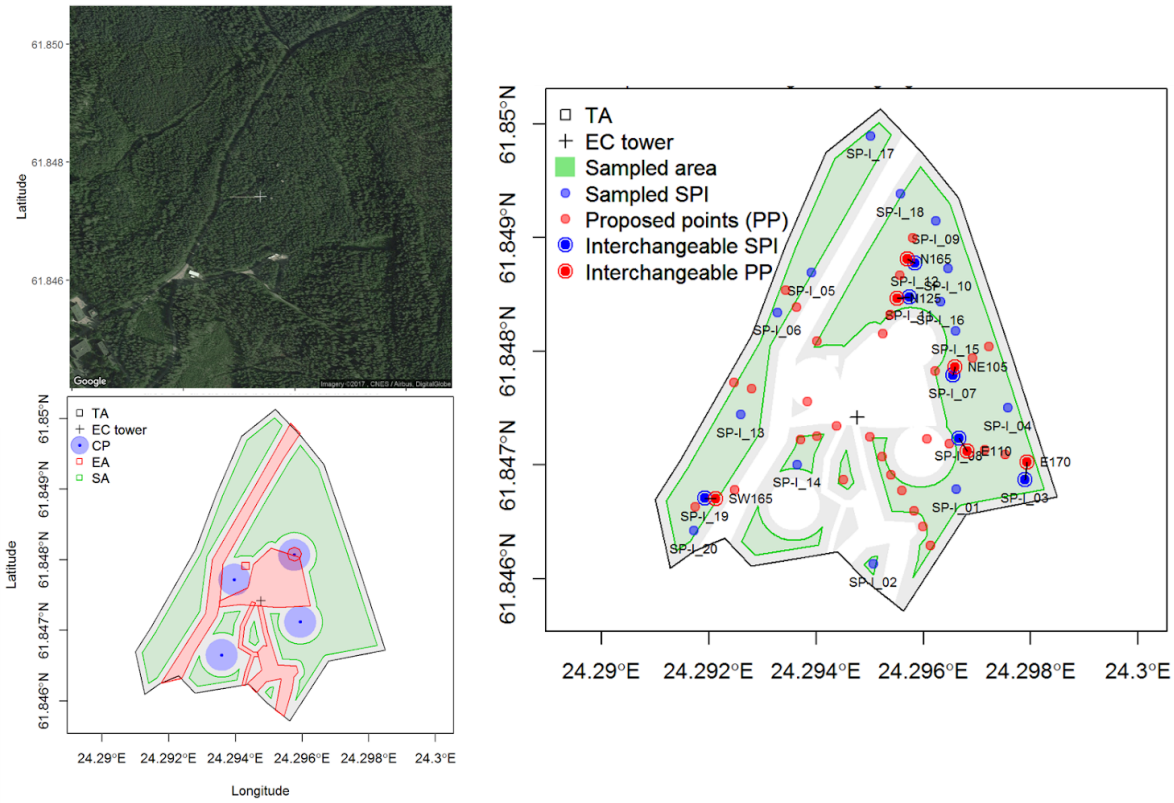


Figure 2: Aerial map of FI-Hyy (top-left panel) and proposed spatial features according to the reported target area (TA), exclusion areas (EA), continuous plots (CP) and ICOS requirements (bottom-left panel). Note that the CP areas have been excluded from the sampled area. The panel on the left shows the grid of proposed (pre-existing) points to be used as SP-I locations (red), the sampled SP-I locations (blue) and the ones (6) that were actually accepted (highlighted red/blue dots). The TA surface is 10.51 Ha, the total excluded area is of 2.15 Ha.

The PI proposed a grid of 36 pre-existing points (historically used for biomass sampling) to evaluate the possibility to use some of them as SP-I. ETC accepted the proposal and, after the 20 SP-I locations were randomly extracted according to the standard procedure, the proposed points that were at a distance of less than 20 m from a sampled position were identified and considered as an effective SP-I. In total 6 out of 36 proposed points were used as SP-I.

The definitive location of SP-I and SP-II points (recorded field coordinates), have been reported by the ST, checked and approved by ETC.

## Station implementation

*Eddy covariance:*

| EC System | | |
|---|---|---|
| **MODEL** | GA_CP-LI-COR LI-7200RS | SA-Gill HS-50 |
| **SN** | 72H-0860 | H170304 |
| **HEIGHT (m)** | 27 | 27 |
| **EASTWARD_DIST (m)** | -0.8 | -0.8 |
| **NORTHWARD_DIST (m)** | 3.5 | 3.5 |
| **SAMPLING_INT** | 0.1 | 0.1 |
| **LOGGER** | 10 | 10 |
| **FILE** | 2 | 2 |
| **GA_FLOW_RATE** | 12 | - |
| **GA_LICOR_FM_SN** | FM1-0619 | - |
| **GA_LICOR_AIU_SN** | AIU-1918 | - |
| **SA_OFFSET_N** | - | 337 |
| **SA_WIND_FORMAT** | - | U, V, W |
| **SA_GILL_ALIGN** | - | Spar |
| **ECSYS_SEP_VERT** | -0.01 | |
| **ECSYS_SEP_EASTWARD** | 0.07 | |
| **ECSYS_SEP_NORTHWARD** | -0.2 | |
| **ECSYS_WIND_EXCL** | 157 | |
| **ECSYS_WIND_EXCL_RANGE** | 20 | |

An ICOS-compliant eddy covariance system is running at FI-Hyy station since 2014 at 33 m. Given the patchy situation of the ecosystem, the PI agreed during the Step1 of the labelling to lower the measuring instruments at 27 m by installing a new system. The installation with brand new sensors was completed in March 2018. The SAT has been provided with a heating tape according to the solution provided by Meelis Moolder and officially calibrated by Gill. The PI also proposed to avoid the ICOS compliant field calibration of the IRGA and replacing it by an automatic home-built calibration. While interesting, the need for standardisation and reliability of ICOS procedures led the ETC to reject this exception (PI agreed). The EC system height is compliant with what proposed and agreed in Step 1 of the labelling procedure, and the orientation, while not following ICOS recommendations, was accepted during the Step1, but will be tested as soon as a long enough dataset will be available.

For the storage system the PI proposed to use the sequential sampling scheme with a single gas analyser. This scheme is appropriate for the concerning ecosystem, the setup is compliant (see sampling scheme in Fig. 3) and have been accepted.

The setup proposed by FI-Hyy was very well design from a technical point of view, the sampling levels number (i.e. 9) was compliant and so as the ramification at the two lowermost levels. However, according to the originally proposed distribution of sampling levels, the lowest level was too far from the ground (at 1 m). After a discussion with the ST, the ETC proposed to re-consider the profile design according to the exponent b = 1.9, so as to harmonize the lower part of the profile instead of moving only the two lowermost. The PI agreed and the resulting sampling levels distribution is definitive.

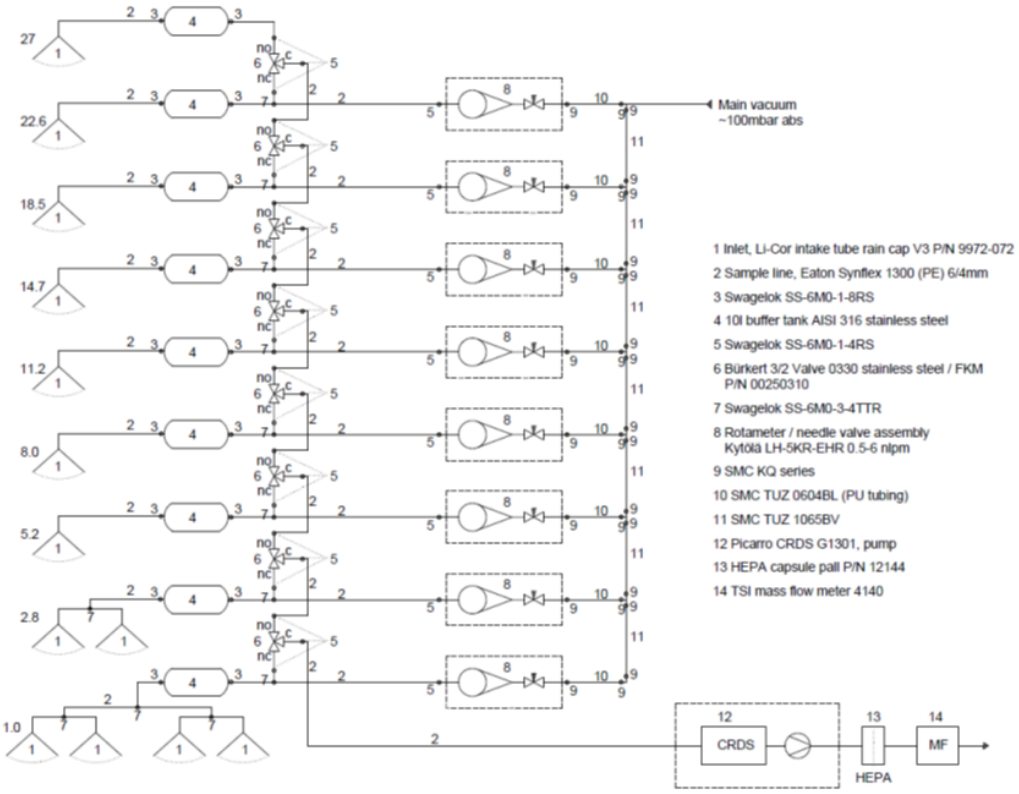


Figure 3: Proposed sampling setup at FI-Hyy.

The air system has individual lines of length between 53.2 and 75 m. The main line is composed by Eaton Synflex 1300 (PE) 6/4mm tubes and Swagelok connectors (S-6M0-1-4RS, S-6M0-3-4TTR). After the valves, Polyurethane tubing (SMC TUZ 0604BL, and SMC TUZ 1065BV) and SMC KQ series fittings are used. The current valve system (Bürkert 3/2 Valve 0330 stainless steel) is ICOS compliant. The unique pump, is placed after the CRDS GA (Picarro CRDS G1301). The flow is monitored by a TSI mass flow meter 4140.

Buffers volumes, valves, CRDS and pump will be placed into the main hut of the station. The mixing volume (10 L) turnover will be between 219 and 213s (including the tubing). The whole

profile cycle will complete in 300 s. This would mean CDRS measurement of about 33 s from each buffer (level).

*Radiations:*

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| RAD-4C-KZCNR4 | 171206 | 70 | 1 | -2 | SW_IN_1_1_1 |
| | | | | | SW_OUT_1_1_1 |
| | | | | | LW_IN_1_1_1 |
| | | | | | LW_OUT_1_1_1 |
| Delta-T BF5 | 77/10_1 | 35 | 45 | -113 | PPFD_IN_1_1_1 |
| Delta-T BF5 | 77/10_2 | 35 | 45 | -113 | PPFD_DIF_1_1_1 |
| Li-Cor LI-190R | Q104351 | 70 | 1.05 | -2.2 | PPFD_OUT_1_1_1 |
| Li-Cor LI-190R | Q52876 | 35 | 45.5 | -113 | PPFD_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 (factory calibrations will be in winter 2018-19). For the PPFD radiations the LI-190R quantum sensor will be used.

*Precipitation:*

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| OTT Pluvio2 | 267651 | 1.5 | -335 | -415 | P_1_1_1 |
| Jenoptik SHM 30 | 90532 | 1.5 | -345 | -415 | D_SNOW_1_1_1 |

For total precipitation it will be used the weighing gauge *OTT PLuvio2* (OTT Hydromet) with the Alter type windshield. The snow depth will be measured by the sonic ranging depth sensor *SHM-30* (Jenoptik).

*Air temperature, relative humidity and air pressure*

Sensors for TA and RH measurements were purchased less than 2 years ago, while the sensor for PA factory calibrated recently. During the Step2 the PI asked for an exception on the location of the PA sensor, as they wanted to have it on the ground instead of close to the EC system. The ETC replied that this exception could have been accepted only with a tube connecting the sensor to an area at maximum 10 m below the EC system, and the PI preferred to place directly the sensor

close to the EC system. A profile of TA and RH sensors is also present to allow the calculation of the storage flux. Also these sensors (Rotronic MP102H) are ICOS compliant, and they are brand new sensors. The ETC is updating the system for describing the installation and variable mapping of multi-sensors like these in the BADM. No action is requested to the station team: the ETC will communicate soon the new rules, and update the existing entries. The station is also having a 2D sonic anemometer for measuring wind speed and direction, which is required for Class 1 stations, but the model reported in the comments of BADM INST is too generic, and the part number shall be provided (can be 4.382x.0x.xxx, 4.382x.3x.xxx, 4.382x4x.xxx). However, as this is not mandatory for the Step2, this can be done even later.

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| Rotronic MP102H | 61543725_2 | 27 | 1 | -1 | TA_1_1_1 |
| Rotronic MP102H | 61543725_1 | 27 | 1 | -1 | RH_1_1_1 |
| Vaisala PTB210 | L1330615 | 30 | 0 | 0 | PA_1_1_1 |
| Rotronic MP102H | 61797123_2 | 26.9 | 1 | -1 | TA_1_2_1 |
| Rotronic MP102H | 61797123_1 | 26.9 | 1 | -1 | RH_1_2_1 |
| Rotronic MP102H | 61797122_2 | 21.6 | 1 | -1 | TA_1_3_1 |
| Rotronic MP102H | 61797122_1 | 21.6 | 1 | -1 | RH_1_3_1 |
| Rotronic MP102H | 61797121_2 | 16.8 | 1 | -1 | TA_1_4_1 |
| Rotronic MP102H | 61797121_1 | 16.8 | 1 | -1 | RH_1_4_1 |
| Rotronic MP102H | 61797120_2 | 12.5 | 1 | -1 | TA_1_5_1 |
| Rotronic MP102H | 61797120_1 | 12.5 | 1 | -1 | RH_1_5_1 |
| Rotronic MP102H | 61797119_2 | 8.8 | 1 | -1 | TA_1_6_1 |
| Rotronic MP102H | 61797119_1 | 8.8 | 1 | -1 | RH_1_6_1 |
| Rotronic MP102H | 61797118_2 | 5.8 | 1 | -1 | TA_1_7_1 |
| Rotronic | 61797118_1 | 5.8 | 1 | -1 | RH_1_7_1 |

| | | | | | |
|---|---|---|---|---|---|
| MP102H | | | | | |
| Rotronic MP102H | 61818468_2 | 3.3 | 1 | -1 | TA_1_8_1 |
| Rotronic MP102H | 61818468_1 | 3.3 | 1 | -1 | RH_1_8_1 |
| Rotronic MP102H | 61818467_2 | 1.5 | 1 | -1 | TA_1_9_1 |
| Rotronic MP102H | 61818467_1 | 1.5 | 1 | -1 | RH_1_9_1 |
| Rotronic MP102H | 61818466_2 | 0.4 | 1 | -1 | TA_1_10_1 |
| Rotronic MP102H | 61818466_1 | 0.4 | 1 | -1 | RH_1_10_1 |
| Thies 2D | 3162224 | 34 | 1 | -2 | WS_1_1_1 |
| | | | | | WD_1_1_1 |

*Backup meteorological station*

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| Rotronic MP102H | 61797124_2 | 35 | 43 | -111 | TA_2_1_1 |
| Rotronic MP102H | 61797124_1 | 35 | 43 | -111 | RH_2_1_1 |
| Campbell ARG-100 | 181629 | 35 | 43 | -113 | P_2_1_1 |
| Middleton EQ08 | 5096 | 35 | 44.5 | -113 | SW_IN_2_1_1 |

The discussion on the backup station was mainly focussed on the independent power. The PI proposed to use various sensors “spread” around instead of having a backup mast: the ETC accepted provided that 1. the sensors are compliant and 2. the power+logging are independent. From the submitted BADM we can see that the TA and RH sensors are ICOS compliant, as well as the pyranometer, and that they all have been purchased from less than 2 years. The sensor installed for backup P measurements at the beginning was not compliant (optical sensor with an accuracy of +- 30 %, in the range 0.5-20 mm/h, that is too low even for a backup sensor). The ETC rejected the proposal of rescaling the measurements against the main sensor, and cast doubts on using a sensor managed by the Finnish Meteorological Institute with sampling interval of 10 minutes. Then the PI proposed to replace it with an ARG100 (compliant tipping bucket), but in the meanwhile sending data with the optical sensor. The ETC agreed. The PI asked as exception to have these sensors connected to the main power and then an UPS+diesel generator+batteries as a backup. The ETC accepted this exception, provided that data on the time of switching on of the backup system are reported. For all the backup sensor, a comparison with the main instruments

will be necessary to check the need for factory calibration. See Air meteo section on the rules to submit metadata about multisensor in the BADM

*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 their Class 1 forest station. The station is exempt from water table depth measurements, because the site is located on a hill where the soil is shallow (about 1 m) and where there is no formation of groundwater, as the excess water flows away on the bedrock surface. Furthermore, it was observed at the site that no groundwater accumulated in the pits dug for the installation of the soil meteo instrumentation and neither have earlier installed soil water content sensors indicated any waterlogging.

| MODEL | SN | HEIGHT (m) | EASTWARD_DIST (m) | NORTHWARD_DIST (m) | VARIABLE_H_V_R |
|---|---|---|---|---|---|
| Delta-T ST4 | ST4-558 | 0 | 52.7 | 74 | TS_1_1_1 |
| Delta-T ST4 | ST4-559 | -0.05 | 52.7 | 74 | TS_1_2_1 |
| Delta-T ST4 | ST4-557 | -0.1 | 52.7 | 74 | TS_1_3_1 |
| Delta-T ST4 | ST4-554 | -0.3 | 52.7 | 74 | TS_1_4_1 |
| Delta-T ST4 | ST4-555 | -0.5 | 52.7 | 74 | TS_1_5_1 |
| Delta-T ST4 | ST4-556 | -0.75 | 52.7 | 74 | TS_1_6_1 |
| Delta-T ST4 | ST4-553 | 0 | 61.7 | -32 | TS_2_1_1 |
| Delta-T ST4 | ST4-552 | -0.05 | 61.7 | -32 | TS_2_2_1 |
| Delta-T ST4 | ST4-551 | -0.1 | 61.7 | -32 | TS_2_3_1 |
| Delta-T ST4 | ST4-550 | -0.3 | 61.7 | -32 | TS_2_4_1 |
| Delta-T ST4 | ST4-548 | -0.5 | 61.7 | -32 | TS_2_5_1 |
| Delta-T ST4 | ST4-549 | -0.6 | 61.7 | -32 | TS_2_6_1 |
| Delta-T ST4 | ST4-574 | 0 | -61.3 | -85 | TS_3_1_1 |
| Delta-T ST4 | ST4-564 | -0.05 | -61.3 | -85 | TS_3_2_1 |
| Delta-T ST4 | ST4-561 | -0.1 | -61.3 | -85 | TS_3_3_1 |
| Delta-T ST4 | ST4-563 | -0.3 | -61.3 | -85 | TS_3_4_1 |
| Delta-T ST4 | ST4-562 | -0.5 | -61.3 | -85 | TS_3_5_1 |
| Delta-T ST4 | ST4-575 | -0.75 | -61.3 | -85 | TS_3_6_1 |
| Delta-T ST4 | ST4-560 | 0 | -41.3 | 35 | TS_4_1_1 |
| Delta-T ST4 | ST4-567 | -0.05 | -41.3 | 35 | TS_4_2_1 |
| Delta-T ST4 | ST4-568 | -0.1 | -41.3 | 35 | TS_4_3_1 |
| Delta-T ST4 | ST4-569 | -0.3 | -41.3 | 35 | TS_4_4_1 |
| Delta-T ST4 | ST4-570 | -0.5 | -41.3 | 35 | TS_4_5_1 |

| | | | | | |
|---|---|---|---|---|---|
| Delta-T ML3 | M004629 | -0.05 | 53.3 | 74 | SWC_1_1_1 |
| Delta-T ML3 | M004628 | -0.1 | 53.3 | 74 | SWC_1_2_1 |
| Delta-T ML3 | M004627 | -0.3 | 53.3 | 74 | SWC_1_3_1 |
| Delta-T ML3 | M004626 | -0.5 | 53.3 | 74 | SWC_1_4_1 |
| Delta-T ML3 | M004623 | -0.75 | 53.3 | 74 | SWC_1_5_1 |
| Delta-T ML3 | M004606 | -0.05 | 62.3 | -32 | SWC_2_1_1 |
| Delta-T ML3 | M004607 | -0.1 | 62.3 | -32 | SWC_2_2_1 |
| Delta-T ML3 | M004608 | -0.3 | 62.3 | -32 | SWC_2_3_1 |
| Delta-T ML3 | M004609 | -0.5 | 62.3 | -32 | SWC_2_4_1 |
| Delta-T ML3 | M004625 | -0.6 | 62.3 | -32 | SWC_2_5_1 |
| Delta-T ML3 | M004617 | -0.05 | -60.7 | -85 | SWC_3_1_1 |
| Delta-T ML3 | M004616 | -0.1 | -60.7 | -85 | SWC_3_2_1 |
| Delta-T ML3 | M004615 | -0.3 | -60.7 | -85 | SWC_3_3_1 |
| Delta-T ML3 | M004614 | -0.5 | -60.7 | -85 | SWC_3_4_1 |
| Delta-T ML3 | M004624 | -0.75 | -60.7 | -85 | SWC_3_5_1 |
| Delta-T ML3 | M004621 | -0.05 | -40.7 | 35 | SWC_4_1_1 |
| Delta-T ML3 | M004620 | -0.1 | -40.7 | 35 | SWC_4_2_1 |
| Delta-T ML3 | M004619 | -0.3 | -40.7 | 35 | SWC_4_3_1 |
| Delta-T ML3 | M004618 | -0.5 | -40.7 | 35 | SWC_4_4_1 |
| Hukseflux HFP01-SC | 4661 | -0.05 | 53 | 74 | G_1_1_1 |
| Hukseflux HFP01-SC | 4662 | -0.05 | 62 | -32 | G_2_1_1 |
| Hukseflux HFP01-SC | 4660 | -0.05 | -61 | -85 | G_3_1_1 |
| Hukseflux HFP01-SC | 4659 | -0.05 | -41 | 35 | G_4_1_1 |

The soil meteo sensors are installed at locations in the target area that comply with the ICOS Instructions for Class 1 stations, i.e. four soil plots each in the center of the four installed Continuous Measurements plots (CPs; see Figure 4). The set-up of each soil plot, shown in Figure 5, 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.

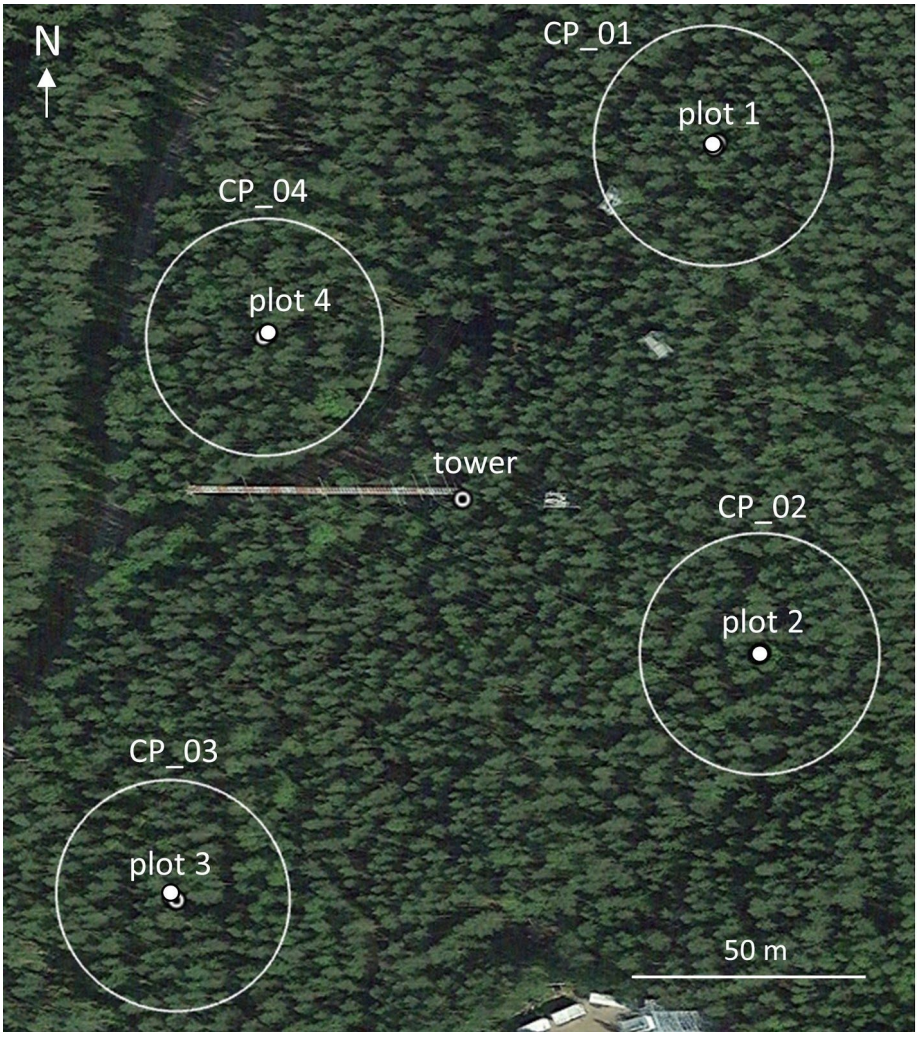


Figure 4: Location of the soil plots (plots 1 to 4) around the EC tower. CP = Continuous Measurements plot.

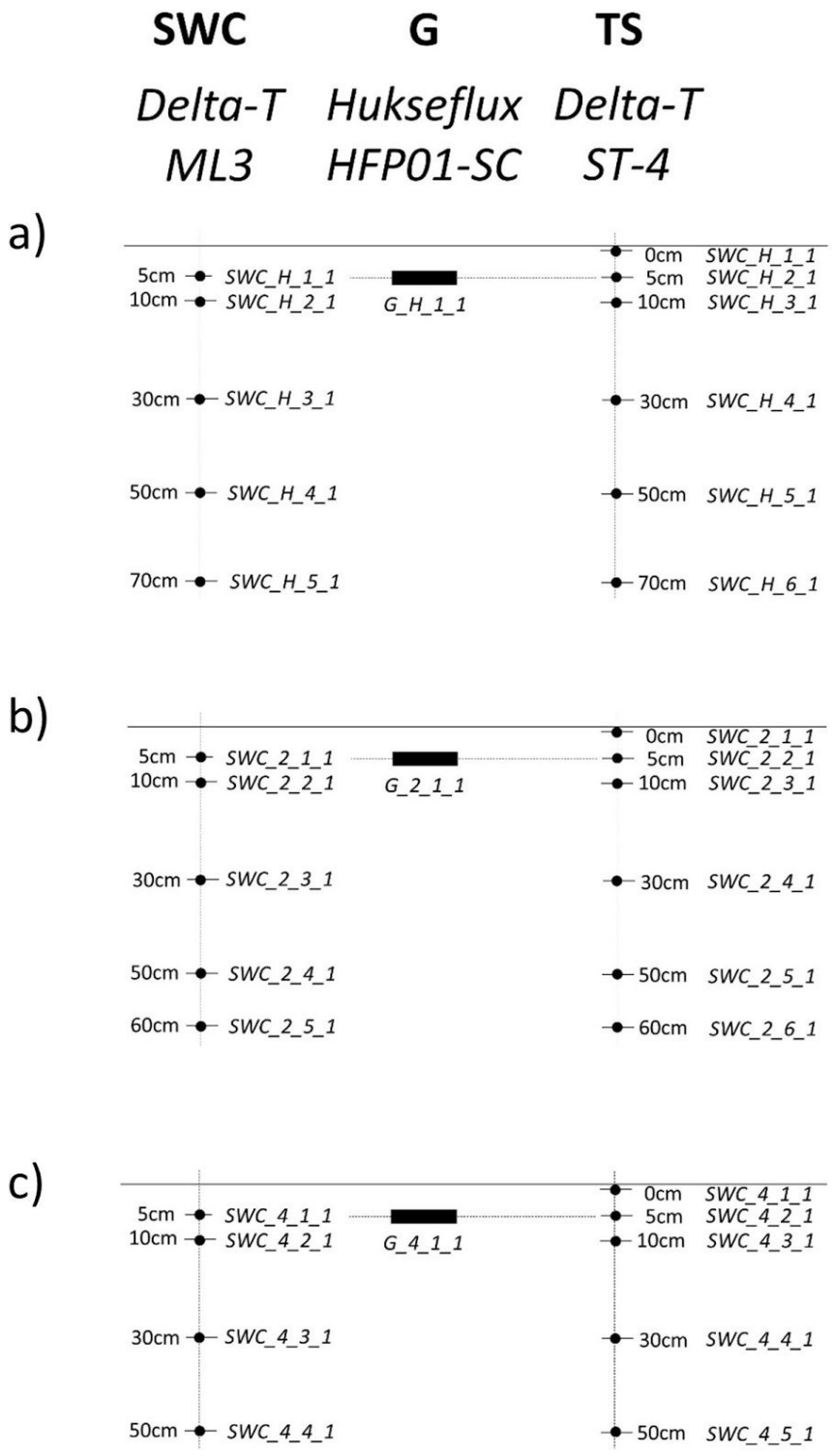


Figure 5: Set-up of the four soil meteo plots: a) plots 1 and 3 (H = 1 and 3), b) plot 2, and c) plot 4. SWC = soil water content, G = soil heat flux density, TS = soil temperature.

*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 6, 7 and 8 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 Scots pine (*Pinus sylvestris L.)* and Norway Spruce (*Picea abies (L.) H. Karst.*), with sparse presence of downy birch (*Betula pubescens Ehrh.*), silver birch (*Betula pendula Roth*), grey alder (*Alnus incana (L.) Moench.*), goat willow (*Salix caprea L.*), common juniper (*Juniperus communis L.*), mountain ash (*Sorbus aucuparia L.*), common aspen (*Populus tremula L.*).

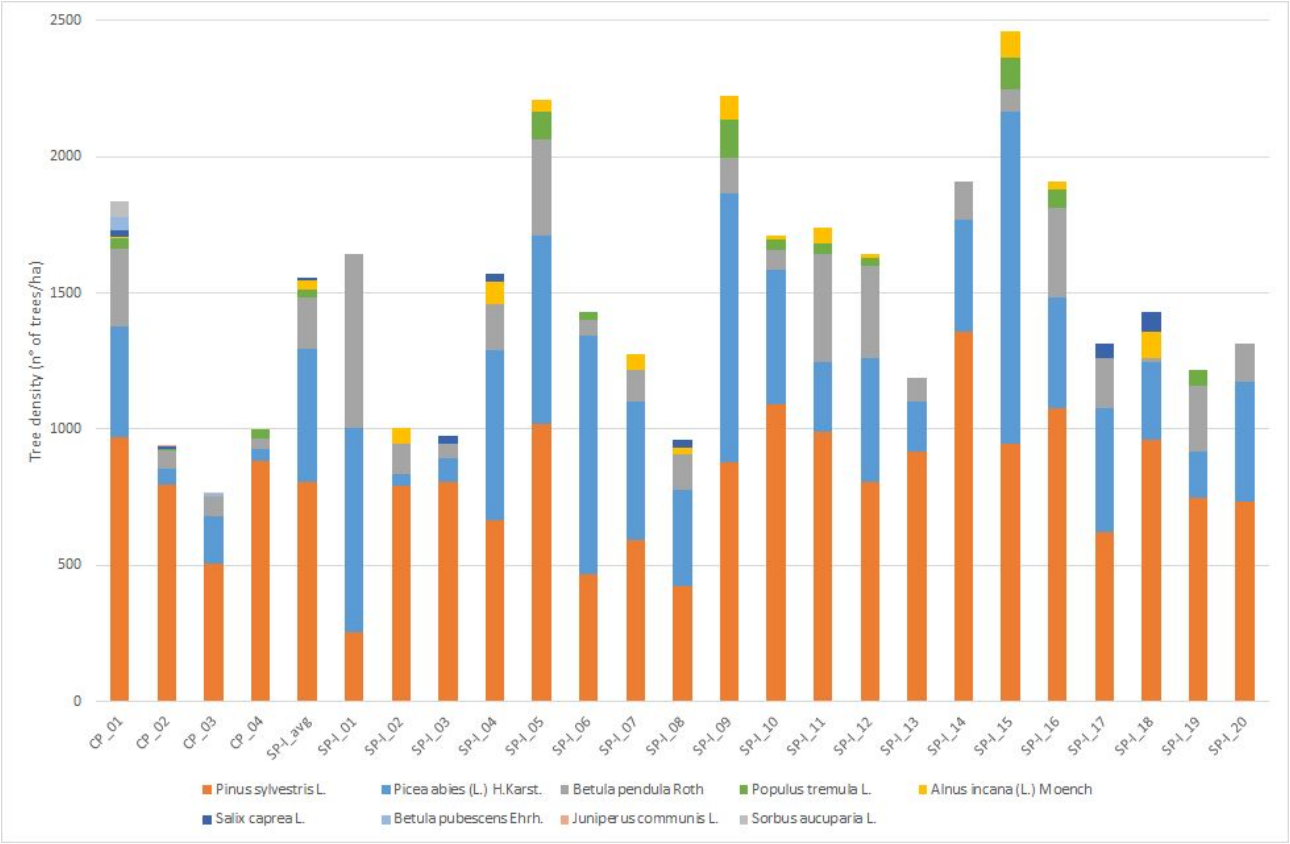


Figure 6: Tree density per species, shown for the twenty SP-I plots and the four CPs installed in the target area.

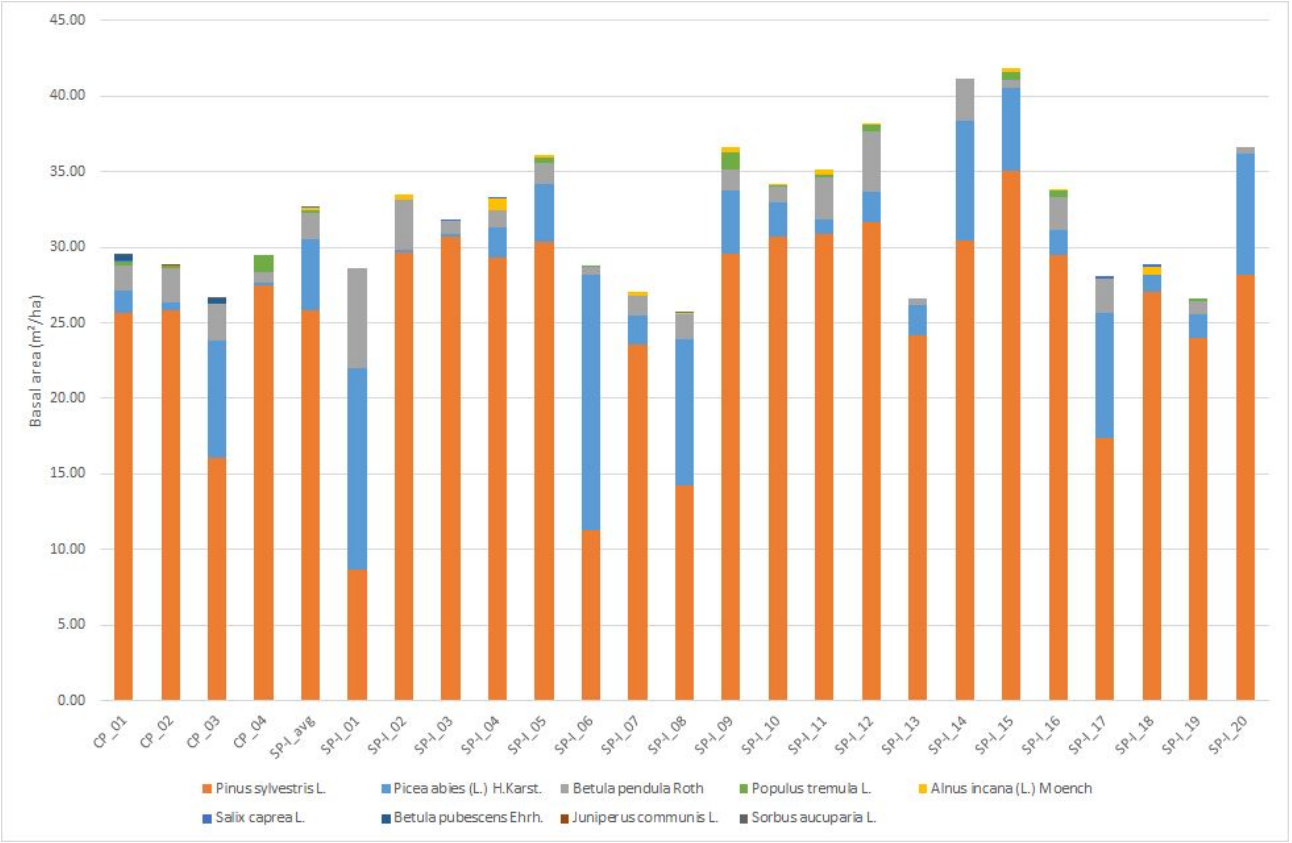


Figure 7: Basal area per species, shown for the twenty SP-I plots and the four CPs installed in the target area.

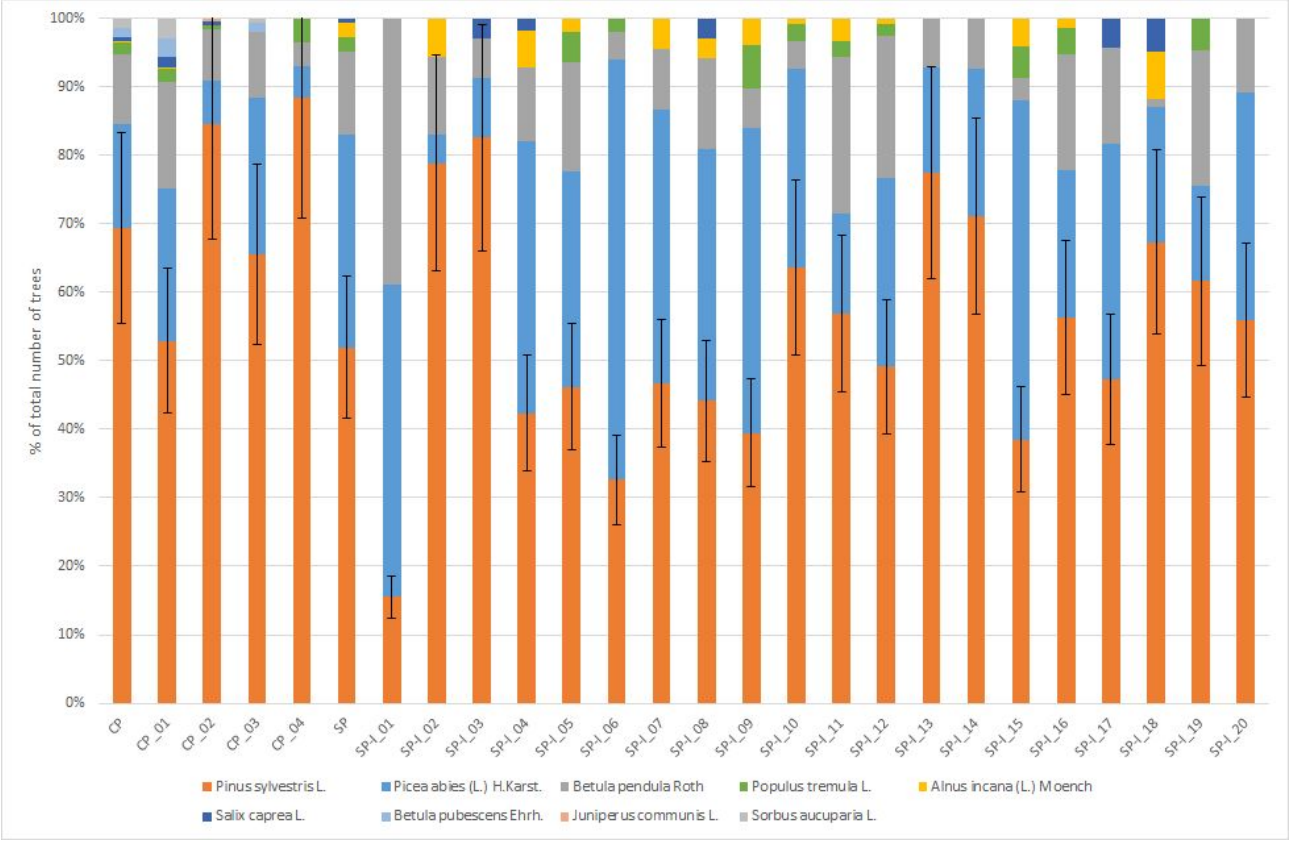


Figure 8: Percentage-wise contribution of each species to the total basal area of the plot, shown for the twenty SP-I plots and the four CPs installed in the target area.

*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 August 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 9 shows the plot results.

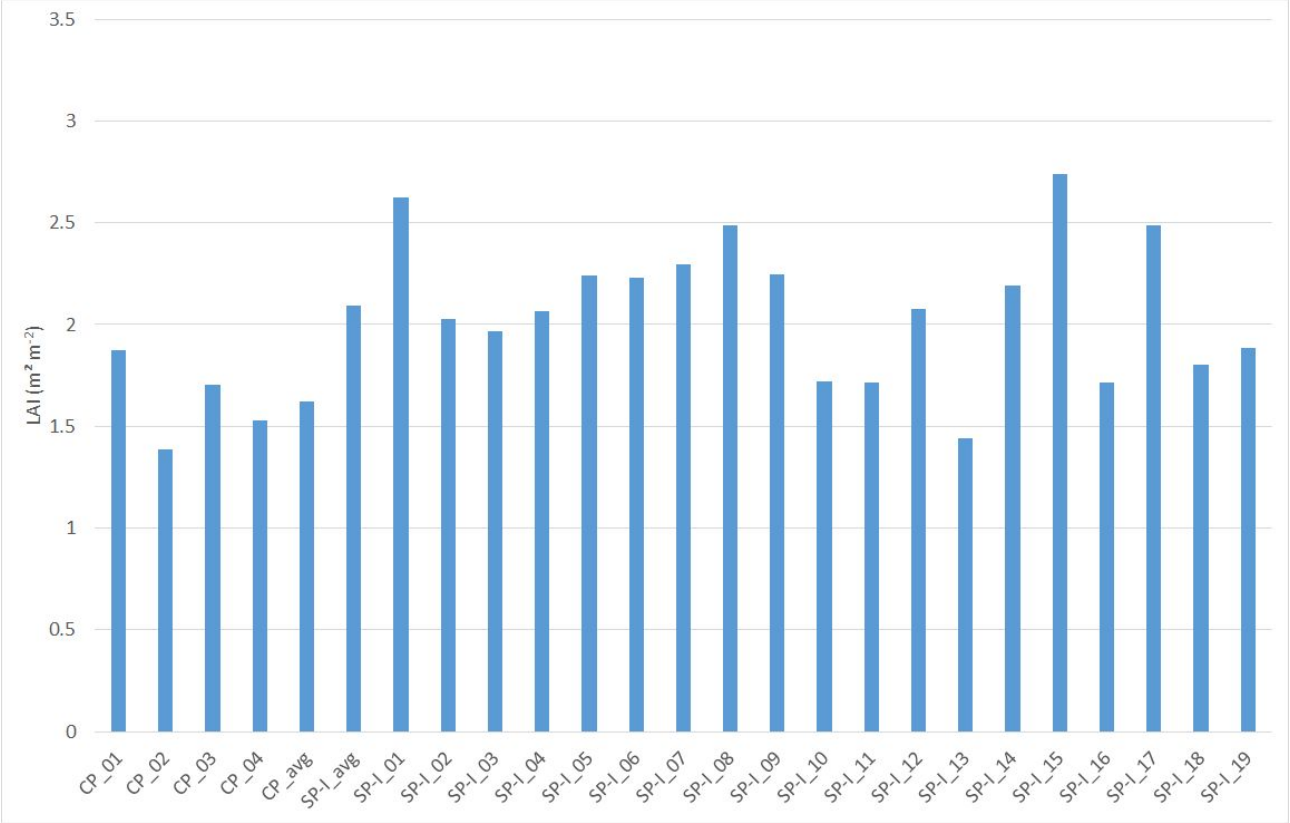


Figure 9: Green Area Index (GAI) for the twenty SP-I plots and the four CPs installed in the target area. All measurements were performed in August 2018.

The site characterisation revealed a relative low variability in basal area and Green Area Index within the target area. The present variability is due to natural variability and 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 May 2018 in two CPs. The ETC quality-checked and processed the images. The second set of measurements was collected mid July 2018 in four CPs. A third set of pictures was taken at the end of August in all CP's and SP's. The ETC quality-checked and processed the images, some pictures need to be retaken, however current weather conditions do not permit this so this will be postponed until the next growing season. The preliminary results for the representativity analysis are shown in Figure 9.

*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 6, 7 and 8 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 Scots pine (*Pinus sylvestris L.*) and Norway spruce (*Picea abies (L.) H.Karst.*

*Vegetation sampling and analysis*

ETC has received needle samples collected by July 27th 2018 and the analysis are still on their way. Results will be delivered within one, maximum two weeks. The sample area reported in the Foliar BADM file give high values of LMA but has been checked by the station team.

## 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 FI-Hyy site, the testing period involves raw data sampled in 2018 from June 15 to October 22. Of 6240 expected half-hourly files for NEE fluxes, 79.2% were retained after QC routines as illustrated in Figure 10. In particular, about 2.3% of raw-data files were missed, 18.7% of calculated half-hourly fluxes were discarded because affected by SevEr, while an additional 2.1% of them were discarded because identified as outlier and affected by ModEr. Being the

percentage of missing data equal to 20.8% and less than 40% threshold value, we conclude that FI-Hyy site reaches the minimum requisite expected for the Step 2 of the labelling.

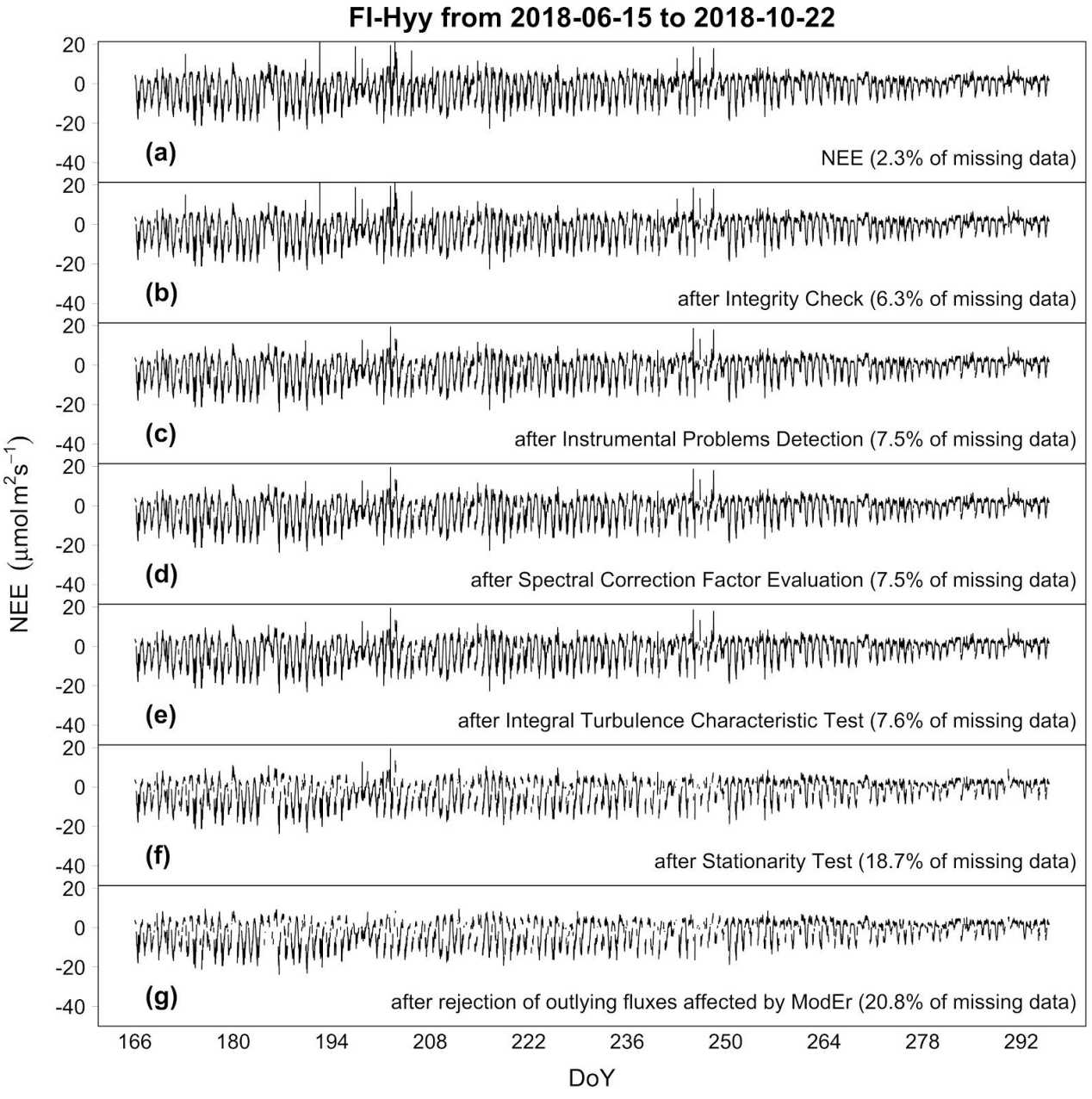


Figure 10: Summary of the quality control tests applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at FI-Hyy site from 2018/06/15 to 2018/10/22. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe 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) anomalous spectral correction factor (SCF) check; (e) integral turbulence characteristics test (ITC, Foken and Wichura, 1996); (f) 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 4 months of data, after QA/QC filtering procedure (previous Section) has been achieved. 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. After the QA/QC procedure and additional filtering according to footprint model requirements, about the 59 % of the test data was used for the test.

Results showed that the the majority of the whole data have a cumulative contribution of at least 70 % from the TA (Fig. 11, left panel, first bar on the left), and this holds also for daytime and nighttime conditions (Fig. 11, left panel). In addition, the test was performed on 5 sub-periods separately. With the exception of the first subperiod (referred to June 2018) results were confirmed (Fig. 11, right panels).

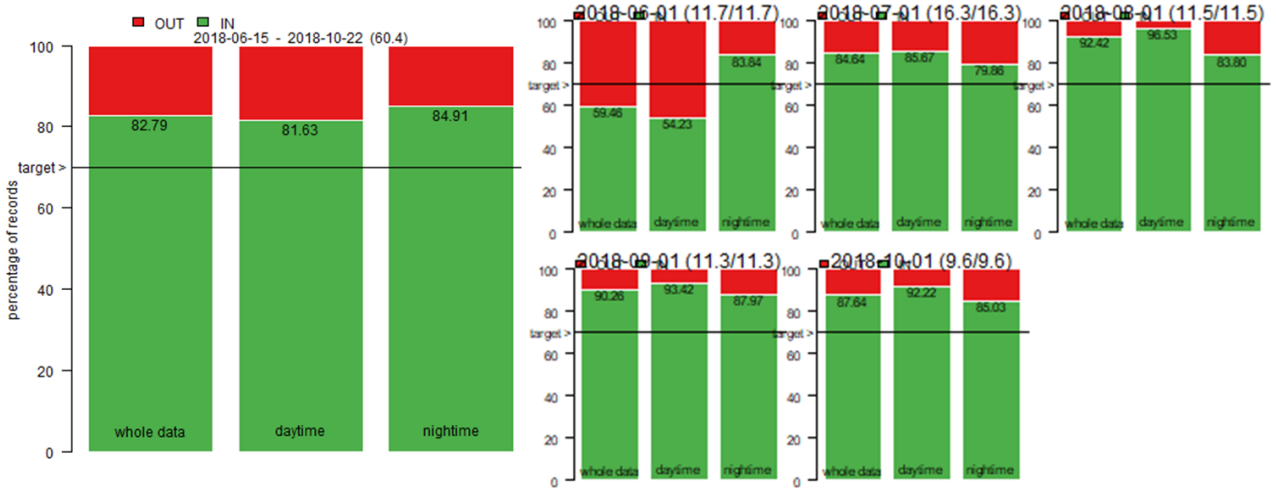


Figure 11: Test results showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The test target value is that the 70% of data must hold this condition in each considered period. Right panel: whole analyzed period; left panels: monthly sub-periods.

The footprint climatology for FI-Hyy, for the period under consideration is reported in Fig. 12, by which it is possible to noticed that the footprint 70% contribution is included in the TA for the majority of its extension.

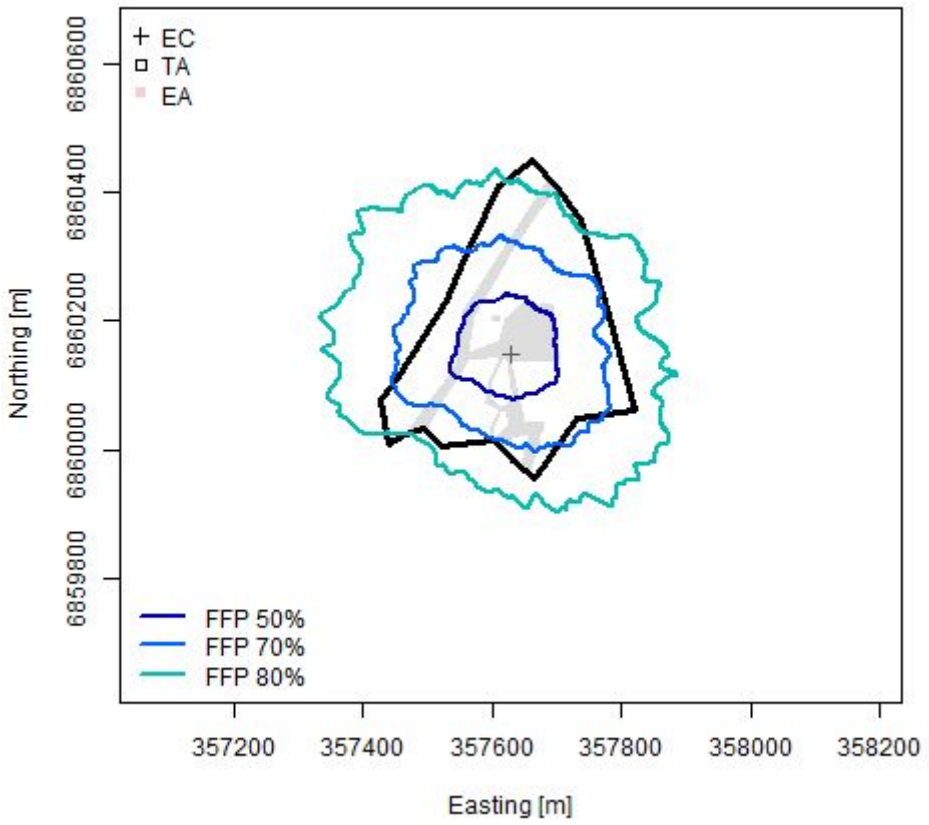


Figure 12: Footprint climatology at FI-Hyy in relation to the TA, the EC tower (EC), and the excluded areas (EA, see the spatial sampling Section). The 50, 70 and 80 % cumulative distribution isopleths are reported.

Exemplary half-hourly footprints at FI-Hyyr in relation to the TA are reported in Fig. 13.

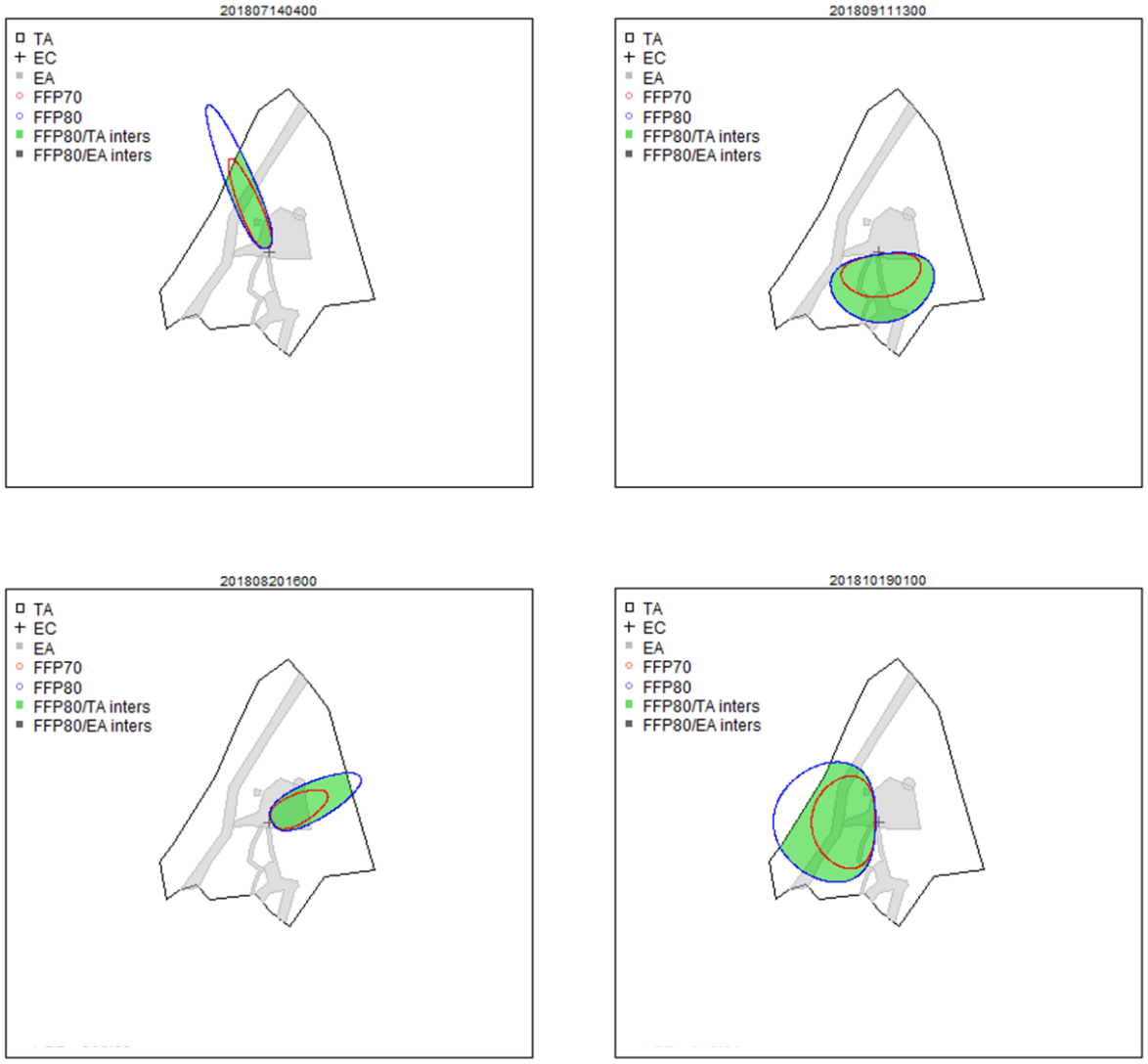


Figure 13: exemplary 2D half-hourly footprints at SE-Nor are related to the TA. The footprint 70 and 80% cumulative distribution isopleths are reported in red and blue respectively.

According to the results, the test is considered as passed.

*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 FI-Hyy not any particular land cover patch was identified in addition to the main one in the TA.

Consequently, the analysis was not achieved and the test considered as passed.

*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. When breaking the analysis down to species level, the ratio of CP's contain less Norway spruce than the SP's. Especially CP_02 and CP_04 contain on average less Norway spruce and are mainly dominated by Scots Pine. However, since Pinus sylvestris is the dominant and target species and Norway spruce is a secondary species contributing on average only 14% of the basal area we will accept this deviation. In addition the station team confirmed that management will be performed in the near future (2020) where it is planned to have a more homogeneous species distribution within SP's and CP's. The station team also confirmed that the species distribution within the target area is heterogeneous and does not contain a gradient or specific pattern. Therefore the target area is considered as one vegetation type.

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 August that the CP_01 and CP_03 are representative for the SP's because they both fall within the accepted range of 20%. However, CP_02 and CP_04 fall just outside the accepted range. Given that this concerns a preliminary analyses and due to the abovementioned management plans in the near future (2020) towards a more homogeneous species composition we accepted the current CP's as representative for the SP's.

## Near Real Time data transmission

An exception was asked for BM data submission: the PI asked to modify the time resolution of precipitation sensors (both the main and the backup one) to 10 minute. The ETC rejected this exception (no reasons to be different from all the other stations), and the resolution was set to the standard 60 seconds.

For the ST example file, instead, a problem with the frequency led to 7 timestamp repeated, a file shorter than one day with the last timestamp wrong, 42254 missing rows and 42645 missing timestamps. The PI asked the exception of accepting these files, but the ETC rejected it (too risky). The issue is due to the gas analyser used (slow response Picarro): the ETC agreed with the PI to test a fast response Picarro to check if this can fix the issue. The test is ongoing: the ETC accepted

this plan of the PI and moved on with the labelling. The PI and the ETC agreed to begin with the NRT submission of EC and BM files, which started on May 31st 2018.

On July 5th the EC files landing in the CP repository changed structure (from 28 to 32 columns), because some additional diagnostics were added to the file. An error however occurred because the file name was not changed. The files changed name starting from 20181003. For the past file, the ETC will agree with the CP a way to proceed.

## Plan for remaining variables

*Soil sampling*

The following sampling scheme was adopted.

1. Three soil pits down to 1.0m will be dug for describing the soil down to 1.0 m. In those pits, two samples for soil density and organic CN determination at each depth level requested will be collected. Where the soil is less deep than 1.0m, the sample must be adapted to the soil depth.
2. A total of 100 locations will be sampled using a soil corer, when no obstacle is met, deeper soil samples will be extracted, until 1m depth where feasible. Where the soil is shallower, of course the sampling will stop at the soil lower limit.

The soil sampling (field operations) has been carried out by September 2018.

## 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 Hyytiala (FI-Hyy) is labelled as ICOS Class 1 Ecosystem station.

Dario Papale, ETC Director

November 6th 2018