ICOS Ecosystem Station Labelling Report

Station: SE-Htm (Hyltemossa)

Viterbo (Italy), Antwerp (Belgium), Bordeaux (France), April 19th 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 April 15th 2016 and got the official approval on August 28th 2016. The Step2 started officially on November 23rd 2016 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 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

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 QC routines 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 Hyltemossa, with ICOS code SE-Htm, is located in southern Sweden. The site is a evergreen needleleaf managed forest with the following coordinates in WGS84 system: Latitude 56.09763°N, Longitude 13.41897°E. The offset respect to the Coordinated Universal Time (UTC) is +01 and the elevation above sea level is 115 m. The site is located in a temperate, maritime climate, the Mean Average Temperature is 7.4 °C, the Mean Annual Precipitation is 707 mm, the Mean Annual Radiation is 110 W m-2. The forest in the target area composed of two stands, 29 and 34 years old, and dominated by *Picea abies* (L.) H.Karst (Norway spruce) with a small fraction of *Betula spp.* (birch) and single occurrence of *Pinus sylvestris* L. (Scots pine). Understory vegetation is sparse. The forest floor is mainly covered by moss.

Figure 1 - The SE-Htm tower

Team description

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

Table 2 - Description of team members roles at SE-Htm

MEMBER_NAME	MEMBER_INSTITUTION	MEMBER_ROLE	MEMBER_MAIN_EXPERT
Michal Heliasz	Lund University	PI	
Janne Rinne	Lund University	CO-PI	
Tobias Biermann	Lund University	MANAGER	
Meelis Mölder	Lund University	SCI-FLX	
Thomas Holst	Lund University	SCI	
Jutta Holst	Lund University	DATA	

Spatial sampling design

For the spatial sampling design at SE-Htm, the Station Team (ST) proposed, in addition to the Target Area (TA) and a number of area to be excluded from sampling (EA), 4 continuous measurement points (CP). Figure 3 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. The field location of SP-I points correctly matched with the proposed design, and such coordinates are currently definitive and used for specific vegetation and soil samplings.

This was not the case, originally, for the second order sparse measurement plots SP-II. The PI reported difficulties in having a good GPS accuracy in the forest and proposed a list of replacement points (SP-II-R, Tab. 3), used in place of some sampled SP-II because of physical constraints. Some points were localized using polar coordinates. The list was accepted and replacement correctly implemented. After some interactions between the ST and ETC to tune the field positioning of points, all of them have been accepted (distance mismatches between the sampled and field-located points were all less than tolerance) and coordinates become definitive.

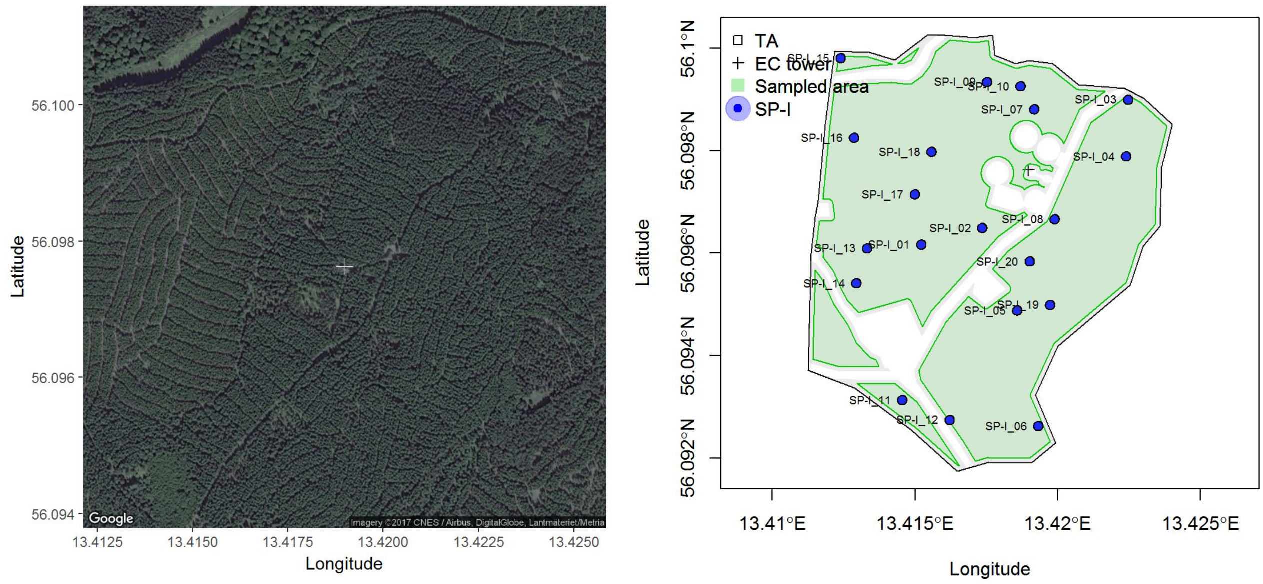

Figure 3: Aerial map of SE-Htm and proposed spatial features according to the reported target area, exclusion area and ICOS requirements. Note that also the CP areas have been excluded from the sampled area. The TA surface is 53.43 Ha, the total excluded area is of 5.13 Ha and the minimum distance between SP-I centers is 58.37 m.

Table 3: List of SP-II-R (ID_rep) used in place of some originally sampled SP-II (ID_or).

ID_or	ID_rep	Note
SP-II_01-02	SP-II_01-01-R	Tree
SP-II_02-04	SP-II_02-01-R	Stone
SP-II_03-02	SP-II_03-01-R	Tree stump
SP-II_04-01	SP-II_04-01-R	Stump
SP-II_06-04	SP-II_06-01-R	Tree
SP-II_07-01	SP-II_07-01-R	Tree
SP-II_07-05	SP-II_07-02-R	Stones and close to a tree
SP-II_08-02	SP-II_08-01-R	Tree
SP-II_09-02	SP-II_09-01-R	Stone
SP-II_09-03	SP-II_09-02-R	Stone
SP-II_10-01	SP-II_10-01-R	Tree
SP-II_10-02	SP-II_10-02-R	Tree

SP-II_10-04	SP-II_10-03-R	Stone
SP-II_10-05	SP-II_10-04-R	Tree
SP-II_11-01	SP-II_11-01-R	Tree
SP-II_11-02	SP-II_11-02-R	Tree
SP-II_11-03	SP-II_11-03-R	Tree
SP-II_11-05	SP-II_11-04-R	Stump
SP-II_13-01	SP-II_13-01-R	Tree
SP-II_13-02	SP-II_13-03-R	Pile of stones
SP-II_13-03	SP-II_13-05-R	Tree
SP-II_13-04	SP-II_13-06-R	Stone
SP-II_14-02	SP-II_14-01-R	Tree
SP-II_14-03	SP-II_14-02-R	Stone
SP-II_14-04	SP-II_14-03-R	Stone
SP-II_16-01	SP-II_16-02-R	Tree
SP-II_16-02	SP-II_16-07-R	Tree stump
SP-II_16-03	SP-II_16-08-R	Stone
SP-II_17-02	SP-II_17-01-R	Tree
SP-II_19-05	SP-II_19-01-R	Tree

Summary of sampled vs field located points

- Max SP-I offset: 61.17 cm
- Average SP-I offset: 35.81 cm
- Max SP-II offset: 173.49 cm
- Average SP-II offset: 45.79 cm

Station implementation

Eddy covariance:

Table 4: List of parameters linked to the Eddy covariance system

EC System		
MODEL	GA_CP-LI-COR LI-7200	SA-Gill HS-50
SN	72H-0531	H162511
HEIGHT (m)	27	27
EASTWARD_DIST (m)	-2.49	-3.02
NORTHWARD_DIST (m)	-2.88	-2.62
SAMPLING_INT	0.05	0.05
LOGGER	1	1
FILE	1	1
GA_FLOW_RATE	12	-
GA_LICOR_FM_SN	FM1-0464	-
GA_LICOR_AIU_SN	AIU-1242	-
SA_OFFSET_N	-	221
SA_WIND_FORMAT	-	U, V, W
SA_GILL_ALIGN	-	Axis
ECSYS_SEP_VERT	0.01	
ECSYS_SEP_EASTWARD	-0.01	
ECSYS_SEP_NORTHWARD	-0.2	
ECSYS_WIND_EXCL	36	
ECSYS_WIND_EXCL_RANGE	30	

The station is running an EC system since before the beginning of the Labelling, however using a non-ICOS SAT. The Gill HS has been bought by the station PI in May 2017. As in northern climates issues are arising in quality of SAT data and on T_SONIC time-series in case of snow/rain/dew/cold, a discussion is ongoing with all the Swedish stations and the Gill on how to deal with that. The reference point of the station lies few meters apart from the EC instruments. The measurement height is 27 meters from the ground as proposed and accepted during the Step1 of the Labelling procedure, and the orientation of the sonic is 221 degrees from N as agreed. The calibration of the LI7200 has been done during the labelling Step2, while the sonic was purchased less than 2 years ago (May 2017).

Concerning the storage system, the PI proposes to use the sequential sampling scheme with a single gas analyser (Li-Cor LI-7200). This scheme is appropriate for the concerning ecosystem and was accepted.

The system setup were agreed at the end of a fruitful discussion with the SCI-FLX team member which proposed a setup as summarized in Tab. 5 and shown in Fig. 4. One of the main requested exception was the use of additional sampling levels above the EC system (because already installed and operative), without reporting them as ICOS variables. ETC decided to accept the sampling of further levels, in addition to the ones dedicated to ICOS measurements, in consideration of the scientific importance of such a rare setup. Then ETC raised some concerns with respect to 1) the number of the 'ICOS level' which was not compliant (currently 7 while it should be 9 considering the default value of 2/3 for the exponent *a* in the relevant formula of the instructions); 2) their vertical distribution which is also not compliant (suggesting to rearrange the levels according to an exponent *b* = 1.8); 3) the ramification of the two lowermost levels (not specified).

Table 5: characteristics of the proposed (by PI) storage sampling scheme for SE-Htm

Feature	*unit*	*value*
Tower height	(m)	150
Flux height	(m)	27
ICOS levels	(m)	1, 4, 9, 14, 19, 24, 30
Additional levels	(m)	40, 55, 70, 85, 100, 125, 148
Number of ICOS levels + 1		7+1
Number of additional levels		7
Flow rate	(L/min)	7
95% response for H2O change	(s)	11
Presently switched in steps of	(s)	30
Time for ICOS levels	(min)	4
Time for all levels	(min)	7.5

After the discussion an agreement was found and the ETC decisions were 1) in consideration of the already long cycle time and that it is not feasible to add extra levels, the current levels number has been accepted; 2) considering that the current profile design is optimized to the local conditions and the current system do not allow for any modification, the current configuration was also accepted; 3) the ramification of the lowest two levels has been implemented and the design was accepted, with air inlets placed at about 30 meters far from the tower because the environment at the base of the tower is disturbed and not representative of the target ecosystem. At level # 14 (1 m), 4 inlets will be installed in a star design interspaced by 5 m. At level # 13 (4 m), 2 inlets will be installed interspaced by 4 m.

According to info in Tab. 5, the flow rate is 7 L/min, the switching between levels is done each 30 s. All 14 (15) level sampling takes 7.5 minutes, while the 'ICOS levels' (8 considering the repetition of the lowermost level to allow for a good stabilization of concentration signals after switching from the highest to the lowest level) takes 4 minutes. This timing was accepted. The air system tubing is in high-density polyethylene, 6 mm inner diameter, ca 200 m long (tubes are of the same length and insulated).

The system is composed by a *Li-Cor* LI-7200 gas analyser, *Kytola* LH-8TR-HR (3-20 L/min Rotameter) mass-flow controller, *Flo control* CODE 609500/671 valves, *Gast* DAA-512-GD (sample pump) *Gast* 1023-101Q-SG608X (ventilation pump). Buffer volumes are of 8 L, resulting in an average time constant of about 56 s.

Figure 5: Storage system structure at SE-Htm.

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 installed a *CMP21* (Kipp & Zonen) pyranometer close to the BF5 to use as reference for the direct radiation. Radiation sensors at SE-Htm have been in operation since summer 2014 (except the PAR sensors), hence they need to be send for factory calibration. It has been agreed that the station team will wait for the agreement between ETC and the sensor producer to be signed (preferential calibration process in the ICOS framework).

Table 6: Description of sensors used for radiation measurements at SE-Htm

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RAD-4C-KZCNR4	140118	50	1.89	-5.49	SW_IN_1_2_1
					SW_OUT_1_1_1
					LW_IN_1_1_1
					LW_OUT_1_1_1
Delta-T BF5	46/02	150	0.2	0	PPFD_IN_1_1_1
					PPFD_DIF_1_1_1
Li Cor Li-190R	Q105118	50	1.73	-5.01	PPFD_OUT_1_1_1
Li Cor Li-190R	Q105119	50	1.73	-5.01	PPFD_IN_1_2_1

Precipitation:

Table 7: Description of sensors used for precipitation measurements at SE-Htm

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
Geonor T200BM	26114	1.5	562.524074999965	-459.128910000436	P_1_1_1
Campbell SR50 ATH	5786	1.9	562.524074999965	-459.128910000436	D_SNOW_1_1_1

For total precipitation SE-Htm will use the *T200BM* (Genor) weighing gauge in combination with the Geonor Alter type windshield and an intake heating ring. Snow depth will be measured by the *SR50AT* (Campbell) sonic range sensor.

Air temperature, relative humidity and air pressure

The sensors proposed and installed for TA, RH and PA (Rotronic MP-102H with Rotronic HC2-S3 and Vaisala PTB210) are compliant with ICOS (see Tab 8). Their calibration is expired, but a plan for the Rotronic exists: the PI will buy a new sensor soon, and will use the proposed one as spare sensor. It will be sent for factory calibration end of 2019, and they will be swapped again. For the

PA sensor a similar plan is also present: a spare sensor has been ordered by the station team, and when available it will replace the currently installed one that will be shipped for factory calibration. The PI asked the exception of acquiring the data from these sensors with 5 seconds resolution, and the ETC accepted.

Table 8: Description of sensors used for air meteo measurements at SE-Htm

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
Rotronic MP102H	61444669	24	-1.1	-1.7	TA_1_1_1
					RH_1_1_1
Campbell Scientific 105T	TA_2_1_1	148	-3.02	-2.62	TA_2_1_1
Campbell Scientific 105T	TA_2_2_1	125	-3.02	-2.62	TA_2_2_1
Campbell Scientific 105T	TA_2_3_1	100	-3.02	-2.62	TA_2_3_1
Campbell Scientific 105T	TA_2_4_1	85	-3.02	-2.62	TA_2_4_1
Campbell Scientific 105T	TA_2_5_1	70	-3.02	-2.62	TA_2_5_1
Campbell Scientific 105T	TA_2_6_1	55	-3.02	-2.62	TA_2_6_1
Campbell Scientific 105T	TA_2_7_1	40	-3.02	-2.62	TA_2_7_1
Campbell Scientific 105T	TA_2_8_1	30	-3.02	-2.62	TA_2_8_1
Campbell Scientific 105T	TA_2_9_1	24	-3.02	-2.62	TA_2_9_1
Campbell Scientific 105T	TA_2_10_1	19	-3.02	-2.62	TA_2_10_1
Campbell Scientific 105T	TA_2_11_1	14	-3.02	-2.62	TA_2_11_1
Campbell Scientific 105T	TA_2_12_1	9	-3.02	-2.62	TA_2_12_1
Campbell Scientific 105T	TA_2_13_1	4	-27.72	-1.03	TA_2_13_1
Campbell Scientific 105T	TA_2_14_1	1	-27.72	-1.03	TA_2_14_1
Thermometer SR50	TA_5786	1.2	562.53	-459.14	TA_4_1_1
Vaisala PTB210	K2340006	3.5	34.4440649999888	-18.5934000005946	PA_1_1_1

Backup meteorological station

For the backup station it was proposed by the PI the use of a pre-composed commercial station (Weatherhawk WH 610), whose sensors for TA, P and SW_IN were not compliant, while the one for RH was. However, the sensor for TA has been accepted for the backup station having requirements close to the ICOS ones. For SW_IN the PI proposed to use a different, compliant sensor (Kipp & Zonen CMP21, Tab. 9), which will be powered and logged independently. Its calibration however expired, but a plan for calibration exists (end of summer/early fall 2018). For backup measurements of P the station team proposed a different sensor, ICOS compliant, accepted by ETC. The new sensor is on its way to the station: in the meanwhile the ETC accepted to have installed at SE-Htm for a limited period the P sensor of the commercial station, even if not compliant, to temporarily avoid gaps. The location proposed by the station team for the new sensor is not optimal as it would be in a small clearance and surrounded by trees 10-12 meters taller than the sensor height. However due to the difficulties in finding a proper spot, the ETC agreed with this location, but the first weeks of data will be used to check the consistency among the backup and the main sensor. The backup rain gauge is a heated model, and the heating will be powered at the main grid with no backup. The ETC accepted this exception as the main sensor will be powered independently, so even in case of blackout no gaps will be caused. Finally, the PI also decided to buy a new Rotronic sensor for backup of TA and RH measurements, that will replace the commercial station: so the final agreement with the ETC is to have the Weatherhawk station installed as a temporary solution for TA, RH, and P (currently metadata sent via the BADM system), that will be replaced in time with new sensors. The info on the replacement and other maintenance operations will have to be reported promptly via the BADM system. The PI also intends to have a backup pressure sensor at SE-Htm station. The PI asked the exception of acquiring the data from these sensors with 5 seconds resolution, and the ETC accepted.

Table 9: Description of sensors used for backup meteo measurements at SE-Htm

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
Weatherhawk	TA_1044_WH	2	561.52	-458.13	TA_3_1_1
Weatherhawk	RH_1044_WH	2	561.52	-458.13	RH_2_1_1
Weatherhawk	PA_1044_WH	2	561.52	-458.13	PA_2_1_1
Weatherhawk	P_1044_WH	2	561.52	-458.13	P_2_1_1
Kipp&Zonen CMP21	140001	150	0	0	SW_IN_1_1_1

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

With the exception of the soil temperature sensors, the station team has installed all soil meteo sensors required for a Class 2 forest station and this at locations in the target area that comply with the ICOS Instructions. These Instructions prescribe at least two soil plots each installed in the vicinity of the center of the two installed Continuous Measurements plots (CPs). The station team has in fact done more than strictly needed and installed four CPs and four soil meteo plots (see Figure 6). The set-up of the soil plots, shown in Figure 7, is compliant with the ICOS Instructions in terms of sensor models, number of sensors and sensor depths and distances. Since the station team had for the measurements of soil temperature initially proposed thermocouples, which were not accepted, and is now waiting for good soil conditions to install newly selected compliant sensors, it has requested a relaxation of the need to have the soil temperature sensors installed and running before the end of the labelling phase. The ETC has agreed with the station team that the installation of the soil temperature sensors is not a requirement for the station to get the ICOS label, but that the sensors must be installed before the summer 2018.

As regards the measurement of soil heat flux density, the station team has sent data to ETC showing that self-calibrations of the heat flux plates installed at their station take between 1 hour and 2.5 hours to complete. On the basis of these data, the ETC and the station team have agreed to self-calibrate the plates once per day and to evaluate after the 2018 growing season whether the self-calibration procedure can be omitted and replaced with a 'fixed' sensitivity factor that is function of the soil moisture level.

All sensors installed so far have been registered by the station team (see Table 10) and all required metadata on the installed sensors have been submitted.

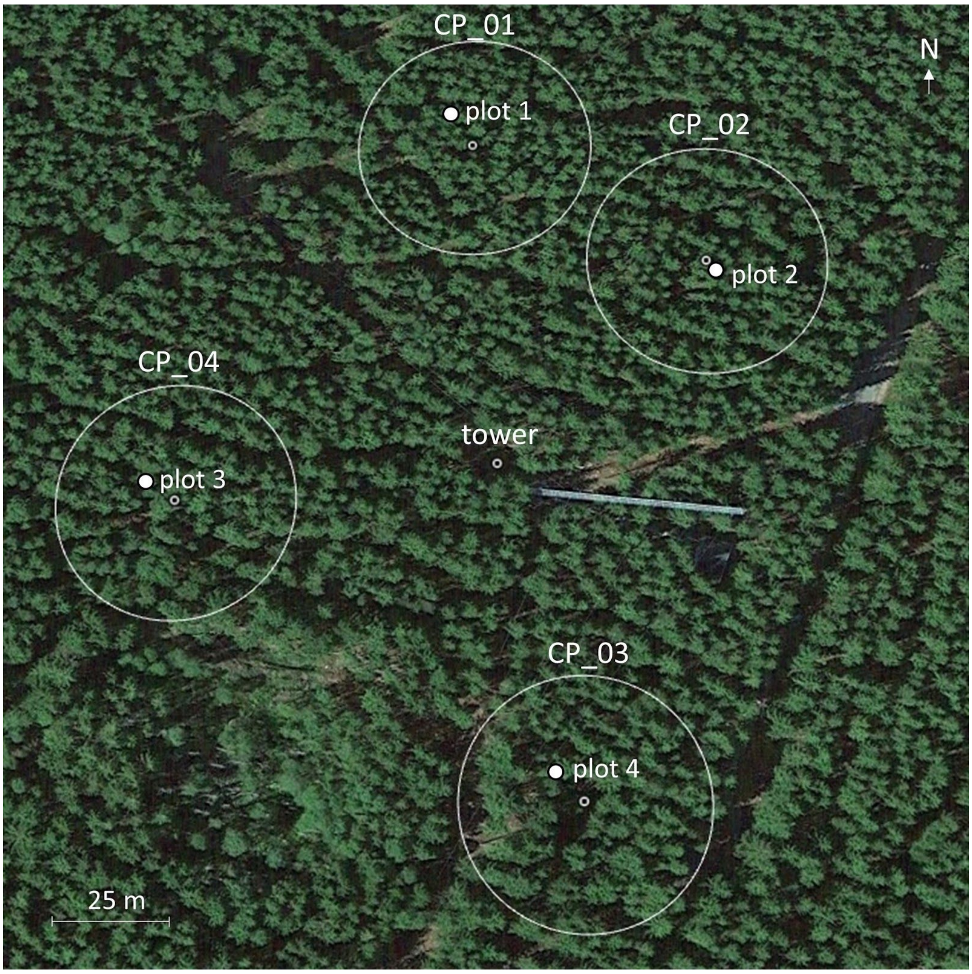

Figure 6: Location of the soil plots (plots 1 to 4) around the EC tower. CP = Continuous Measurements plot.

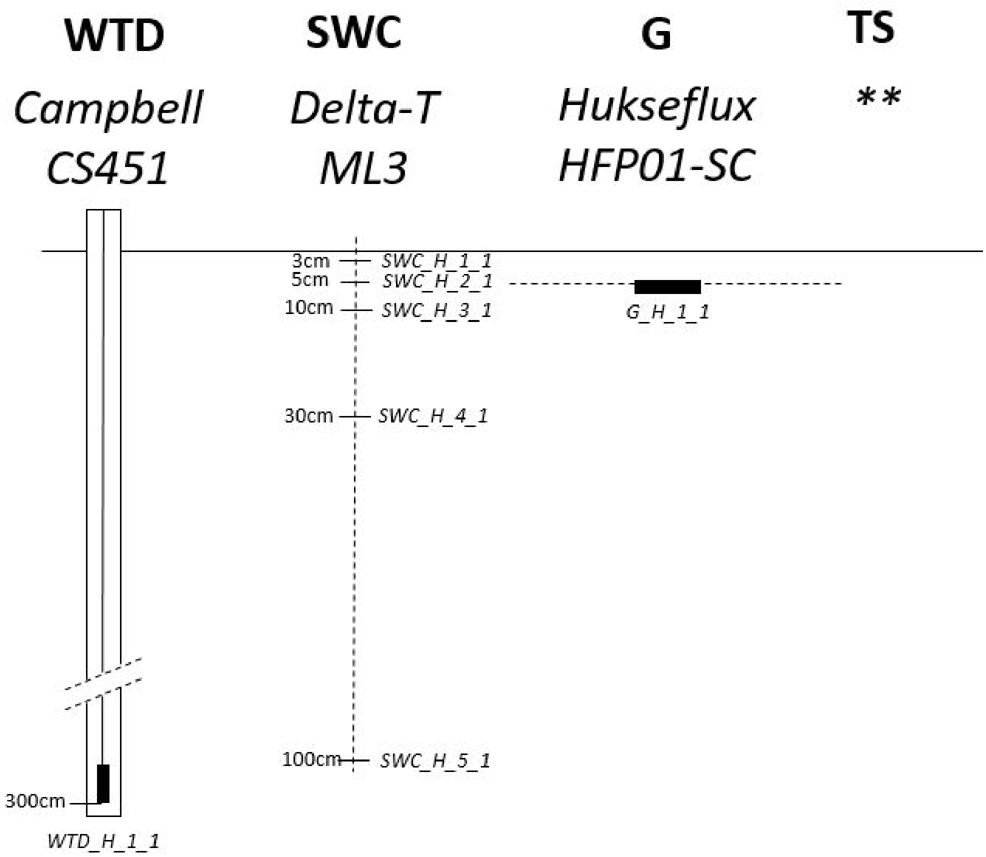

Figure 7: Set-up of all four soil meteo plots (H = 1 to 4). WTD = water table depth, SWC = soil water content, G = soil heat flux density, TS = soil temperature. In two plots, one of the sensors is installed at a different depth that indicated in this figure: in plot 2 the WTD sensor is installed at a depth of 400 cm and in plot 3 the deepest SWC sensor is installed at 75 cm. ** As agreed with the station team, soil temperature sensors will be added later in spring 2018.

Table 10: Description of sensors used for soil meteo measurements at SE-Htm. Soil temperature sensors will be installed later.

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
ML3 ThetaProbe	Htm_SWC_1_1	-0.03	-8.788483	74.93773	SWC_1_1_1
ML3 ThetaProbe	Htm_SWC_1_2	-0.05	-8.788483	74.93773	SWC_1_2_1
ML3 ThetaProbe	Htm_SWC_1_3	-0.1	-8.788483	74.93773	SWC_1_3_1
ML3 ThetaProbe	Htm_SWC_1_4	-0.3	-8.788483	74.93773	SWC_1_4_1
ML3 ThetaProbe	Htm_SWC_1_5	-1	-8.788483	74.93773	SWC_1_5_1
ML3 ThetaProbe	Htm_SWC_2_1	-0.03	39.759888	46.18648	SWC_2_1_1
ML3 ThetaProbe	Htm_SWC_2_2	-0.05	39.759888	46.18648	SWC_2_2_1
ML3 ThetaProbe	Htm_SWC_2_3	-0.1	39.759888	46.18648	SWC_2_3_1

ML3 ThetaProbe	Htm_SWC_2_4	-0.3	39.759888	46.18648	SWC_2_4_1
ML3 ThetaProbe	Htm_SWC_2_5	-1	39.759888	46.18648	SWC_2_5_1
ML3 ThetaProbe	Htm_SWC_3_1	-0.03	11.784065	-63.9894	SWC_3_1_1
ML3 ThetaProbe	Htm_SWC_3_2	-0.05	11.784065	-63.9894	SWC_3_2_1
ML3 ThetaProbe	Htm_SWC_3_3	-0.1	11.784065	-63.9894	SWC_3_3_1
ML3 ThetaProbe	Htm_SWC_3_4	-0.3	11.784065	-63.9894	SWC_3_4_1
ML3 ThetaProbe	Htm_SWC_3_5	-0.75	11.784065	-63.9894	SWC_3_5_1
ML3 ThetaProbe	Htm_SWC_4_1	-0.03	-73.365782	-1.22169	SWC_4_1_1
ML3 ThetaProbe	Htm_SWC_4_2	-0.05	-73.365782	-1.22169	SWC_4_2_1
ML3 ThetaProbe	Htm_SWC_4_3	-0.1	-73.365782	-1.22169	SWC_4_3_1
ML3 ThetaProbe	Htm_SWC_4_4	-0.3	-73.365782	-1.22169	SWC_4_4_1
ML3 ThetaProbe	Htm_SWC_4_5	-1	-73.365782	-1.22169	SWC_4_5_1
Hukseflux HFP01SC	3812	-0.05	-8.788483	75.23773	G_1_1_1
Hukseflux HFP01SC	3813	-0.05	39.459888	46.18648	G_2_1_1
Hukseflux HFP01SC	3814	-0.05	11.784065	-64.2894	G_3_1_1
Hukseflux HFP01SC	3815	-0.05	-73.365782	-1.52169	G_4_1_1
Campbell CS451	70010628	-3.3	-9.215483	80.7307	WTD_1_1_1
Campbell CS451	70010606	-4	42.9959	46.6955	WTD_2_1_1
Campbell CS451	70010626	-3	12.7761	-62.3174	WTD_3_1_1
Campbell CS451	70010627	-3	-72.99978	-2.95	WTD_4_1_1

<u>Spatial heterogeneity characterization</u>

The station team has collected all the tree data in the 20 SP-I plots installed in the target area and has carried out all the Green Area Index measurements in these plots that are requested for the characterization of the target area and its spatial heterogeneity.

The set of tree data comprises the species, DBH, height, and health status of all trees above the stem diameter threshold of 5 cm that are growing inside the SP-I plots. The ETC has quality checked the dataset submitted by the station team. Figure 8 summarizes the dataset, showing for each SP-I plot the tree density and basal area for the main species found in the plots. Basal area is used here as a proxy for Aboveground Biomass. As can be seen in this figure, the target area is entirely dominated by Norway spruce (*Picea abies (L.) H.Karst.*), with only sparse presence of Scots pine (*Pinus sylvestris L.*) and silver birch (*Betula pendula Roth*) and single occurrences of a few other species (*Betula pubescens Ehrh.* and *Quercus robur L.*).

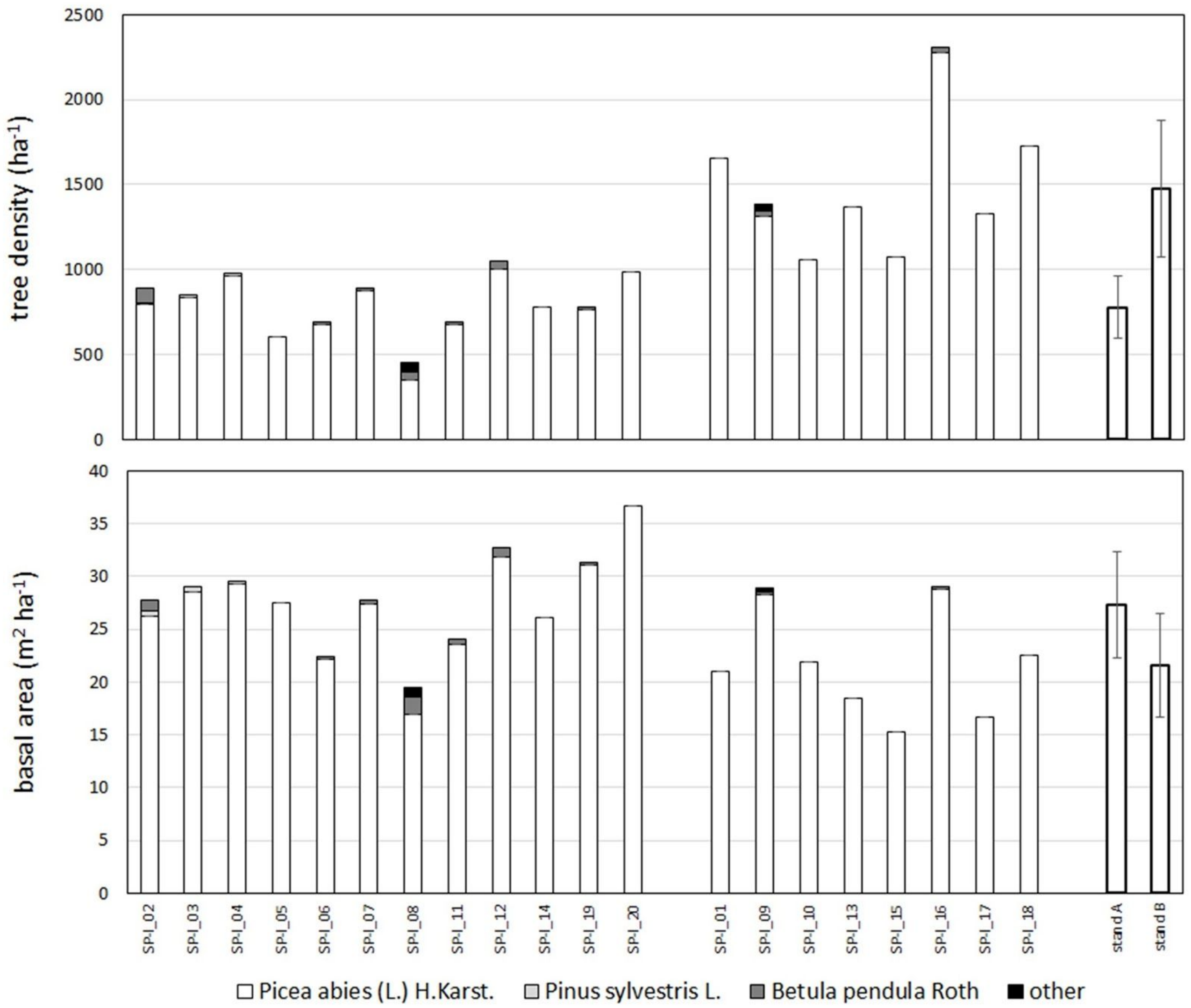

Figure 8: Tree density (upper panel) and basal area (lower panel) for each of the 20 SP-I plots. The plots are grouped per stand included in the target area. The left group of SP-I plots are located in stand A, the right group in stand B (see map in Figure 10). Also shown are the mean tree density and mean basal area of the plots located in stand A and stand B, respectively. These values are based on *Picea abies* only; dead trees not included. Error bars show the standard deviation to the mean.

The Green Area Index measurements in the 20 SP-I plots were done by means of Digital Hemispherical Photography and were carried out during late Oct/early Nov 2017. 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 submitted by the station team. Figure 9 shows the plot results.

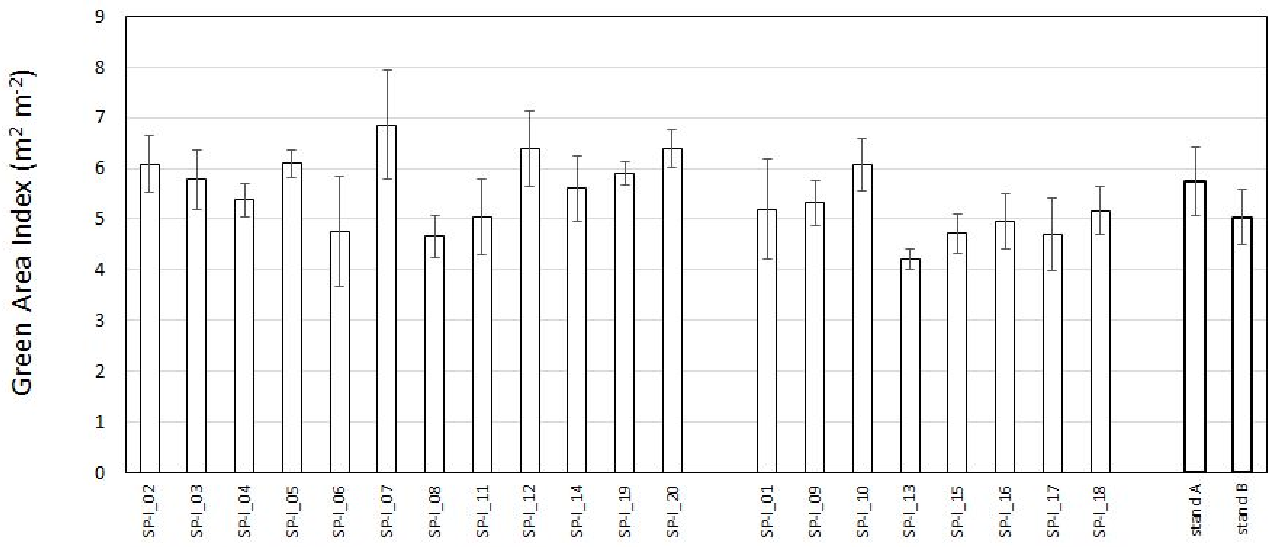

Figure 9: Green Area Index (GAI) for each of the SP-I plots. Error bars indicate the standard deviation to the shown mean GAI per plot. The plots are grouped per stand included in the target area. The left group of SP-I plots are located in stand A, the right group in stand B (see map in Figure 10). Also shown are the mean GAI of the plots located in stand A and stand B. Here the error bars show the standard deviation to the mean GAI of the plots.

The measurements in the SP-I plots reveal a large variability in tree density and basal area within the target area. Also Green Area Index varies, but to a lesser extent. Part of this variability can be explained by the fact that the target area includes two differently-aged and differently-thinned stands: (i) a large 34-year-old stand that includes the eddy covariance tower and the 4 CPs and that has been thinned for 25% in 2009 and for 15% in 2013, and (ii) a smaller 29-year-old stand located west of the eddy covariance tower and that has been thinned for 30% in 2015 (see Figure 10, stands A and B). Although average tree density is much lower in stand A than in stand B, stand A contains considerably more basal area (Figure 8). This is because the trees in stand A are on average much larger than the trees in stand B (data not shown). Also Green Area Index is on average higher in stand A (Figure 9).

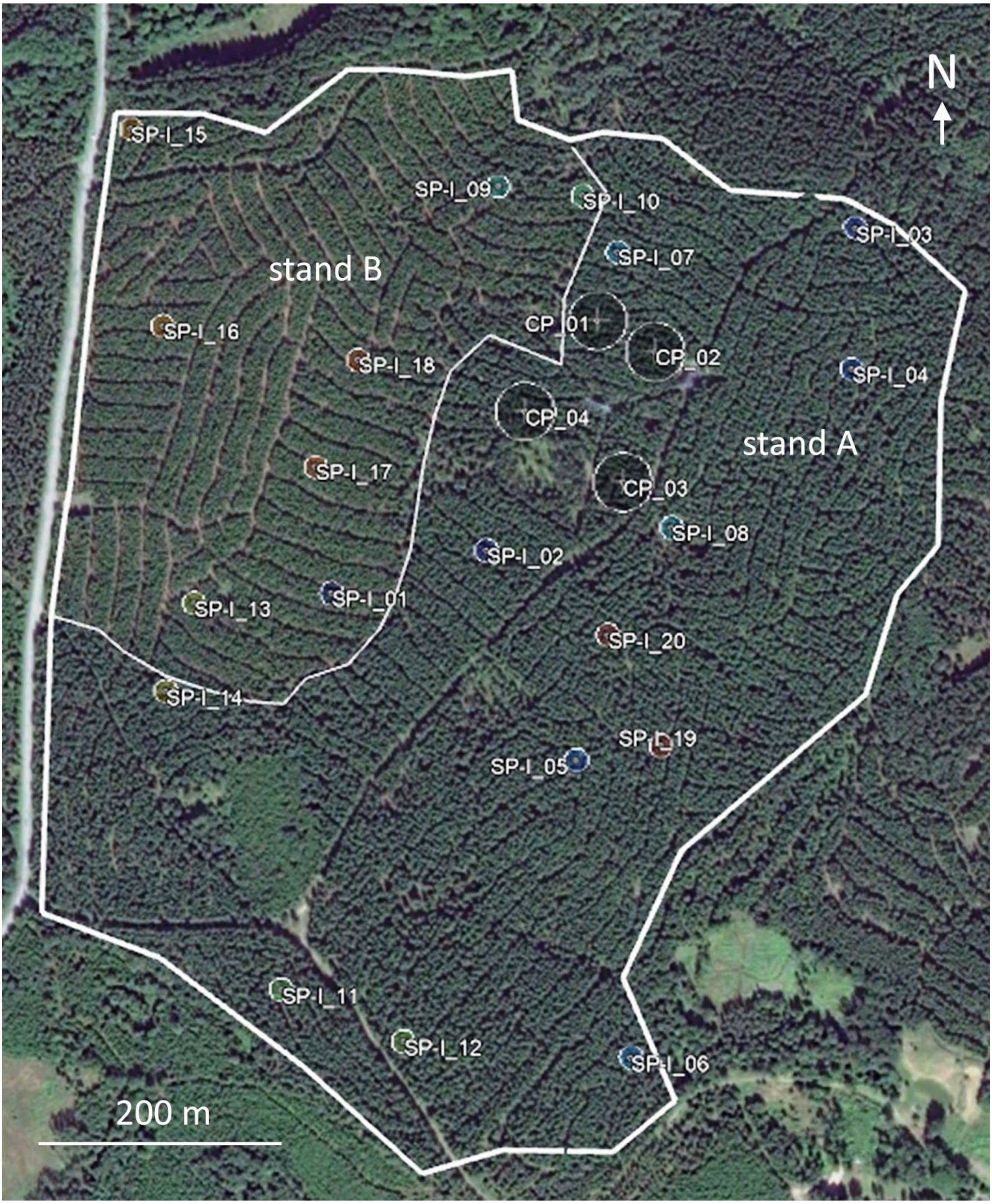

Figure 10: The target area with an indication of the two stands that make up the target area (stands A and B). Also shown are the locations and areas of the CPs and the SP-I plots.

Aboveground Biomass

The station team has collected all 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 CPs that the station team has installed. (For this Class 2 station, only two CPs are mandatory). The ETC has quality checked the dataset submitted by the station team. Figure 11 summarizes the dataset, showing for each of the CPs the tree density and basal area for each species found in the CP. Basal area is here used as a proxy for Aboveground Biomass. This figure shows that, like the SP-I plots, the CPs are entirely dominated by Norway spruce (*Picea abies (L.) H.Karst*.), with only sparse presence of Scots pine (*Pinus sylvestris L.*) and silver birch (*Betula pendula Roth*) and single occurrences of a few other species (*Betula pubescens Ehrh.* and *Quercus robur L.*).

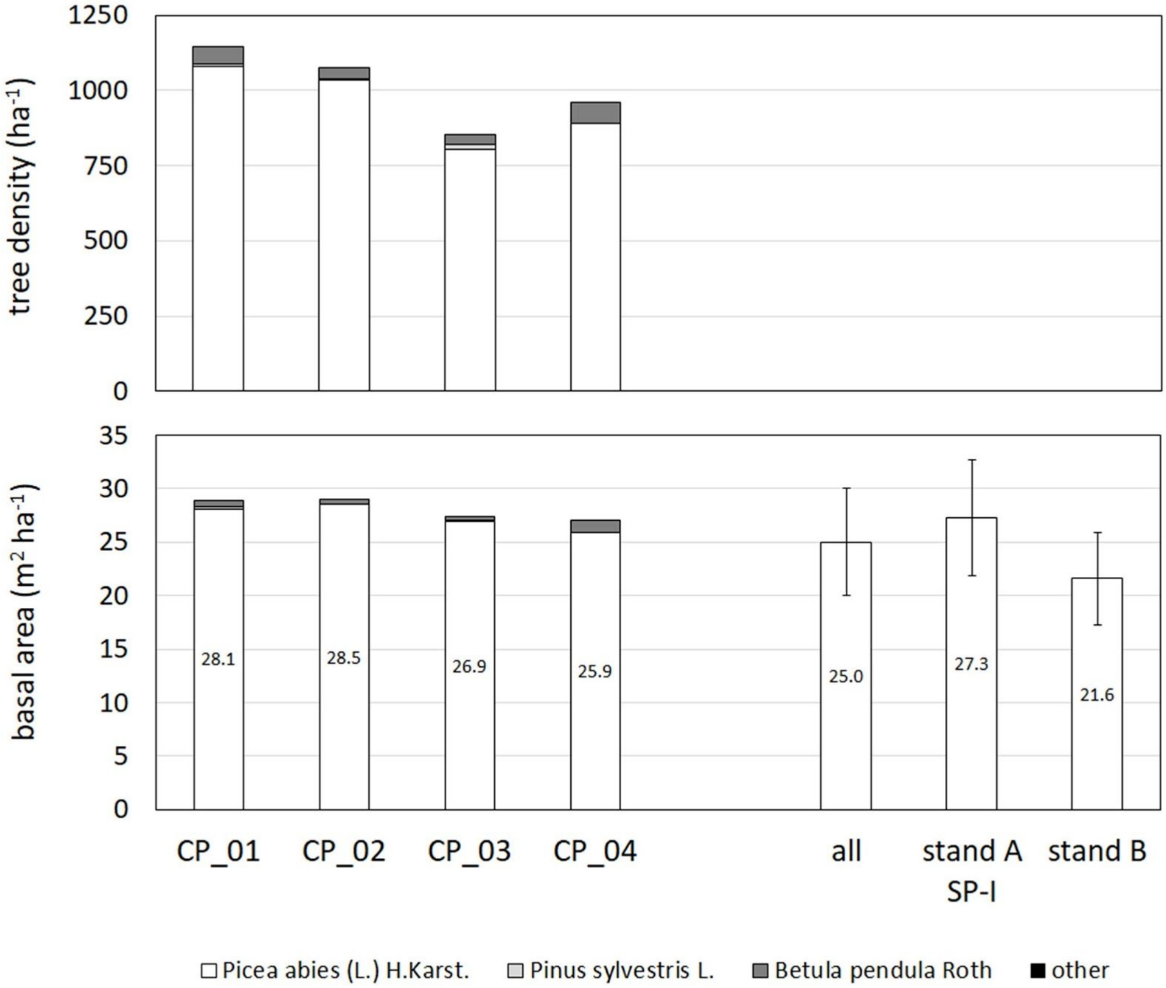

Figure 11: Tree density (upper panel) and basal area (lower panel) for each of the four CPs. Also shown is the average basal area of *Picea abies* of all 20 SP-I plots, the average of the SP-I plots located in each of the two stands that make up the target area. The numbers in the bars are the basal area values for *Picea abies*. The error bars indicate +/- 20% of the basal area value for *Picea*

abies for the SP-I plots. This info is added to the graph for the representativity test of the CPs, explained further in this report.

Green Area Index

The station team has carried out all the measurements required for the Green Area Index assessment in the step 2 labelling phase: they measured Green Area Index once in one of the CPs (in July 2017) and then later once more in all the CPs (during late Oct/early Nov 2017). The measurements were done by means of Digital Hemispherical Photography and, as prescribed in the Instructions, nine hemispherical images were taken in each CP. The ETC has quality checked and processed the images submitted by the station team. Figure 12 shows the plot results of the autumn measurements done in all CPs.

Note: At the request of the ETC, the station team had in June 2017 also measured Green Area Index with the linear ceptometer and this concomitantly with the collection of hemispherical images (data not shown).

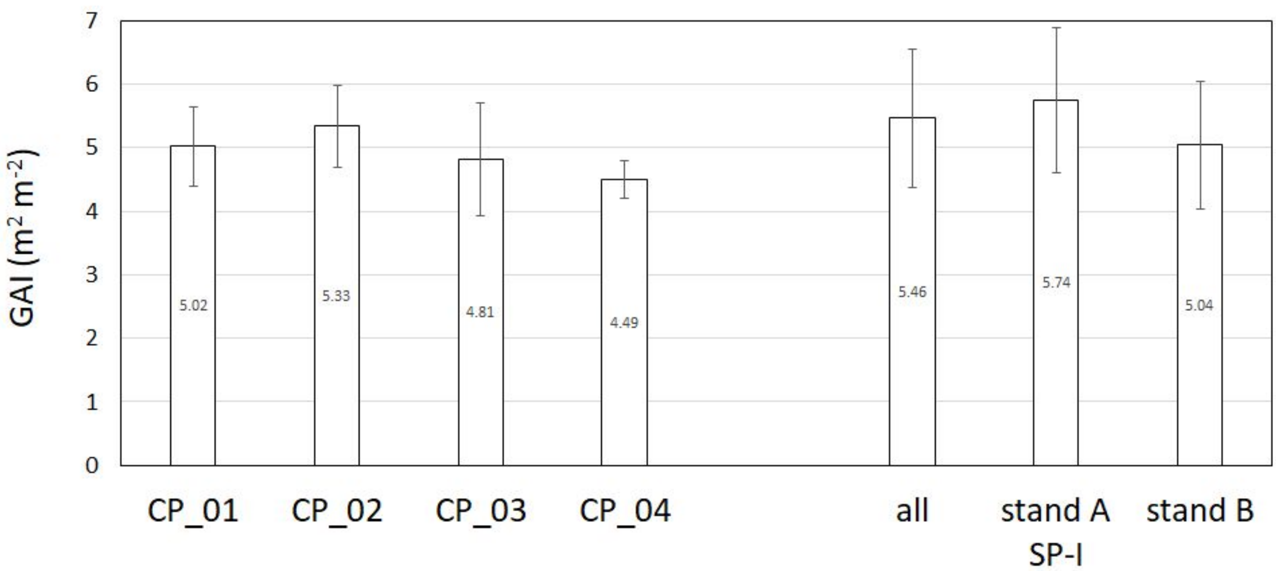

Figure 12: Green Area Index (GAI) for each of the CPs, with error bars indicating the standard deviation to the shown mean GAI. Also shown are the average GAI of all 20 SP-I plots, the average of the SP-I plots located in each of the two stands that make up the target area. Here, the error bars indicate +/-20% of the shown average. The numbers in the bars are the shown averages. This info is added to the graph for the representativity test of the CPs, explained further in this report.

Vegetation sampling and analysis

The foliar samples for the determination of the leaf mass-to-area ratio and the nutrient analysis were collected end of January 2018 and the related instructions for area and dry mass determinations as well as for leaf packaging were applied correctly. The quality control for these data consists in systematic comparison with (i) previous analysis results, irrelevant for the present labelling, and (ii) literature data and databases such as TRY. The results obtained in terms of average values and precision (Figure 13) are consistent with the current literature data and considered acceptable.

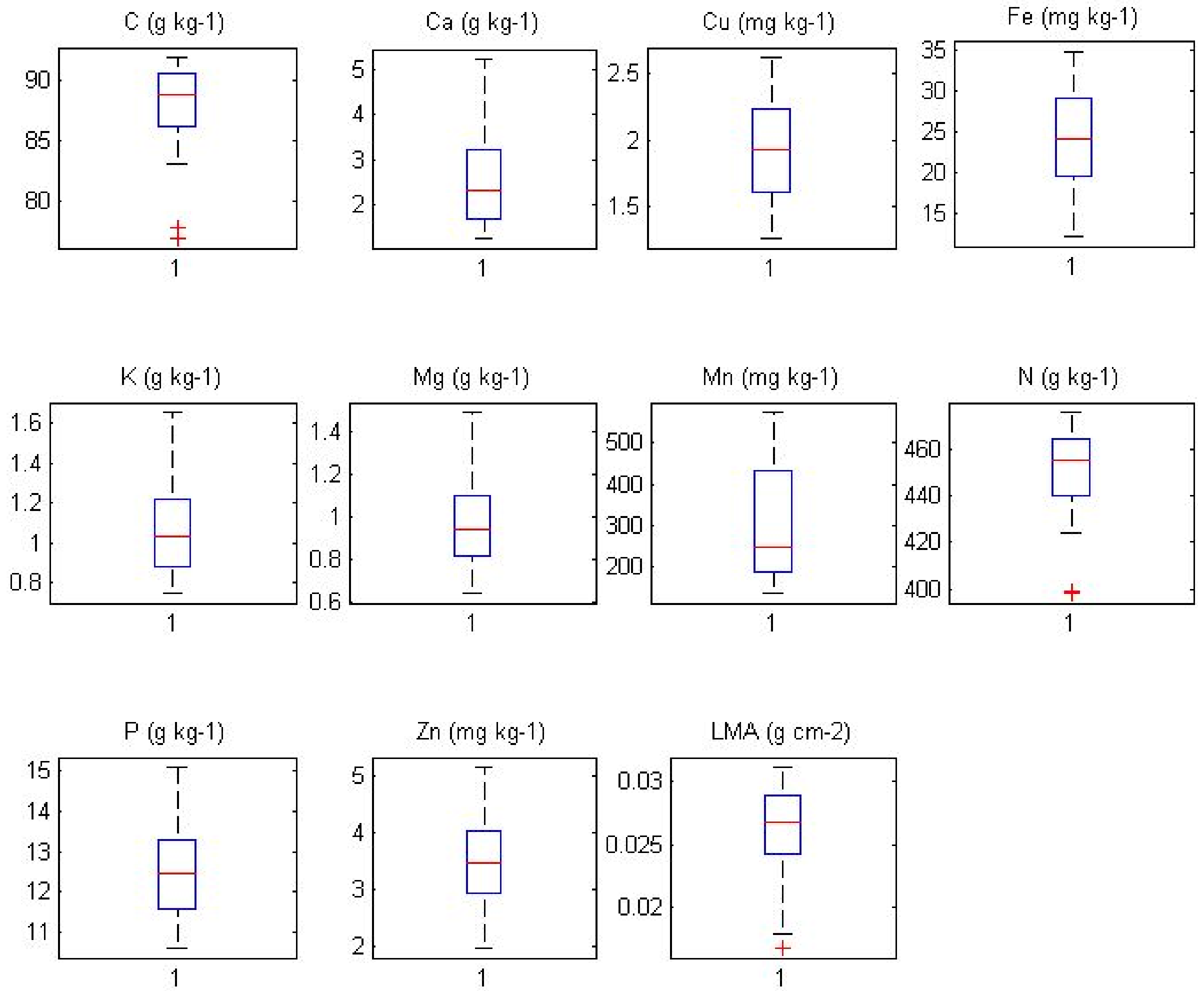

Figure 13: Boxplots of nutrient mass per g dry mass of leaves of *Picea abies* (L.) H.Karst. at the SE-Htm site and leaf mass-to-area ratio (LMA). Each plot gives the distribution and median value of n=30 values. Leaves samples were collected end of January 2018 using a sampling scheme compliant with the ICOS instructions.

Data check and test

Data quality analysis (Test 1)

On the basis of the current state of scientific knowledge, the quality control (QC) procedure aims to verify that at least 60% of half-hourly values in a given temporal window are of the highest quality possible. This means that the total percentage of missing data after the QC routines does not exceed the 40% threshold value.

The QC procedure involves a sequential removal of half-hourly flux data flagged by severe and moderate quality (Vitale et al, *in prep*). A severe quality flag is assigned when (i) flux originates from wind sectors to exclude or in case of instrument malfunction as provided by sonic anemometer (SA) and gas analyser (GA) diagnostics; (ii) when flux is out of its physical range; (iii) in case of anomalous values of the spectral correction factor; (iv) when well developed turbulence regimes (Foken and Wichura, 1996) or (v) stationarity conditions (Mahrt, 1998) and are not satisfied.

A moderate quality flag is assigned (i) when stationarity and (ii) integral turbulence conditions are only partly satisfied, and (iii) in case of failure of one of statistical tests proposed by Vickers and Mahrt (1997) to detect any instrument malfunction. Half-hourly flux values flagged with severe quality flag are directly discarded, whereas those with moderate quality flags are removed only if they are also identified as outlier.

Concerning SE-Htm site, the testing period involves raw data sampled in 2018 from February 2nd to April 6th. Of 3071 expected half-hourly files for NEE fluxes, 71.7% were retained after QC routines as illustrated in Figure 10. In particular, about 9.2% of raw-data files were missed, 27.4% of calculated half-hourly fluxes were discarded because flagged by severe quality, while an additional 0.9% of them were discarded because identified as outlier and flagged by moderate quality. Being the percentage of missing data equal to 28.3% and below the 40% threshold value, we conclude that SE-Htm 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

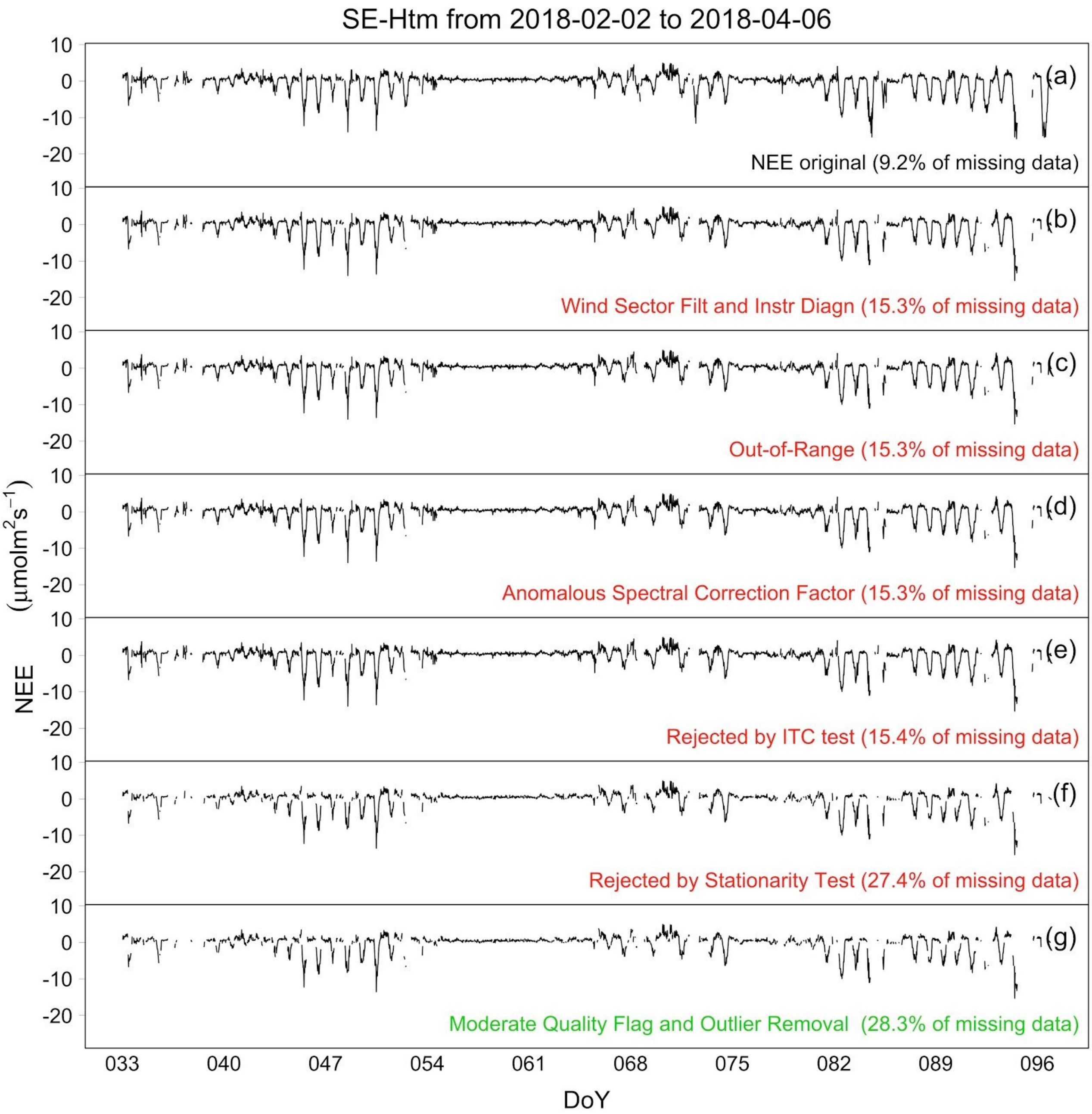

Figure 14: Summary of the quality control routines applied to Net Ecosystem Exchange (NEE) of CO_2 flux collected at SE-Htm from 2018/02/02 to 2018/04/06. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data with severe quality flags according to the following criteria: (b) wind sectors to exclude and diagnostics provided by sonic anemometer (SA) and gas analyser (GA); (c) out of plausible physical range check; (d) anomalous spectral correction factor check; (e) integral turbulence characteristic (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 data identified as outliers with at least a moderate quality flag.

Footprint analysis (Test 2)

The test aimed to evaluate if half-hourly flux values are effectively representative of the target area 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, having been georeferenced, was compared to the TA spatial extent. Results showed that basically the the very majority of the whole data have a cumulated contribution of at least 70 % from the Target Area, and this holds also for daytime and nighttime conditions (Fig. 15).

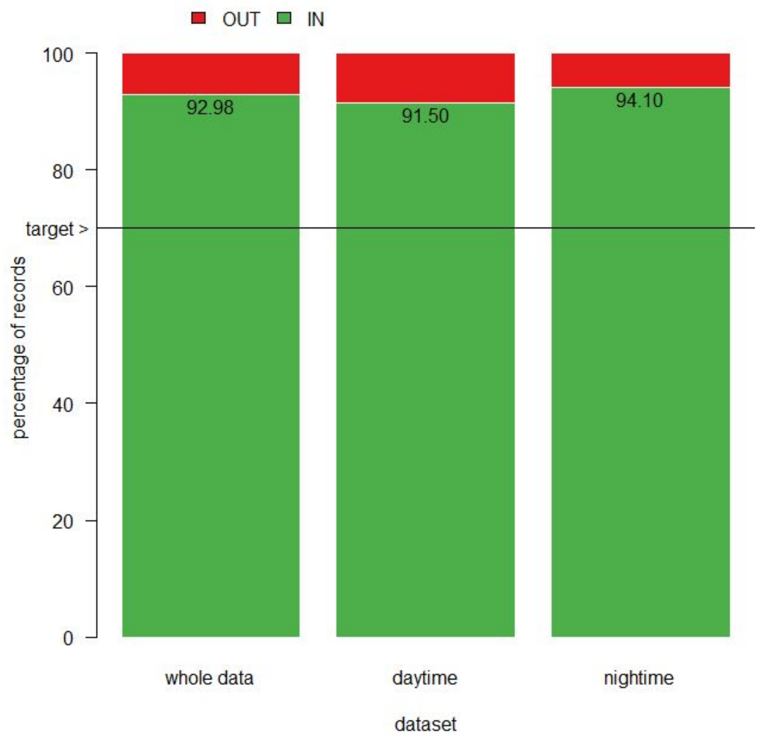

Figure 15: test results showing the percentage of half-hours with a footprint cumulated contribution of 70% from the target area. The target value is that the 70% of data must hold this condition.

Data representativeness analysis (Test 3)

At SE-Htm the spatial heterogeneity characterization revealed two main land cover typologies (LCT) defined according to the vegetation structure (see also Test 4), estimated comparing the vegetation map and the results from vegetation sampling at the SP-I plots. Given the specific species distribution (the TA does not contain sensible vegetation discontinuities), this empirical approach can be accepted. The two defined LCT are shown in Figure 16.

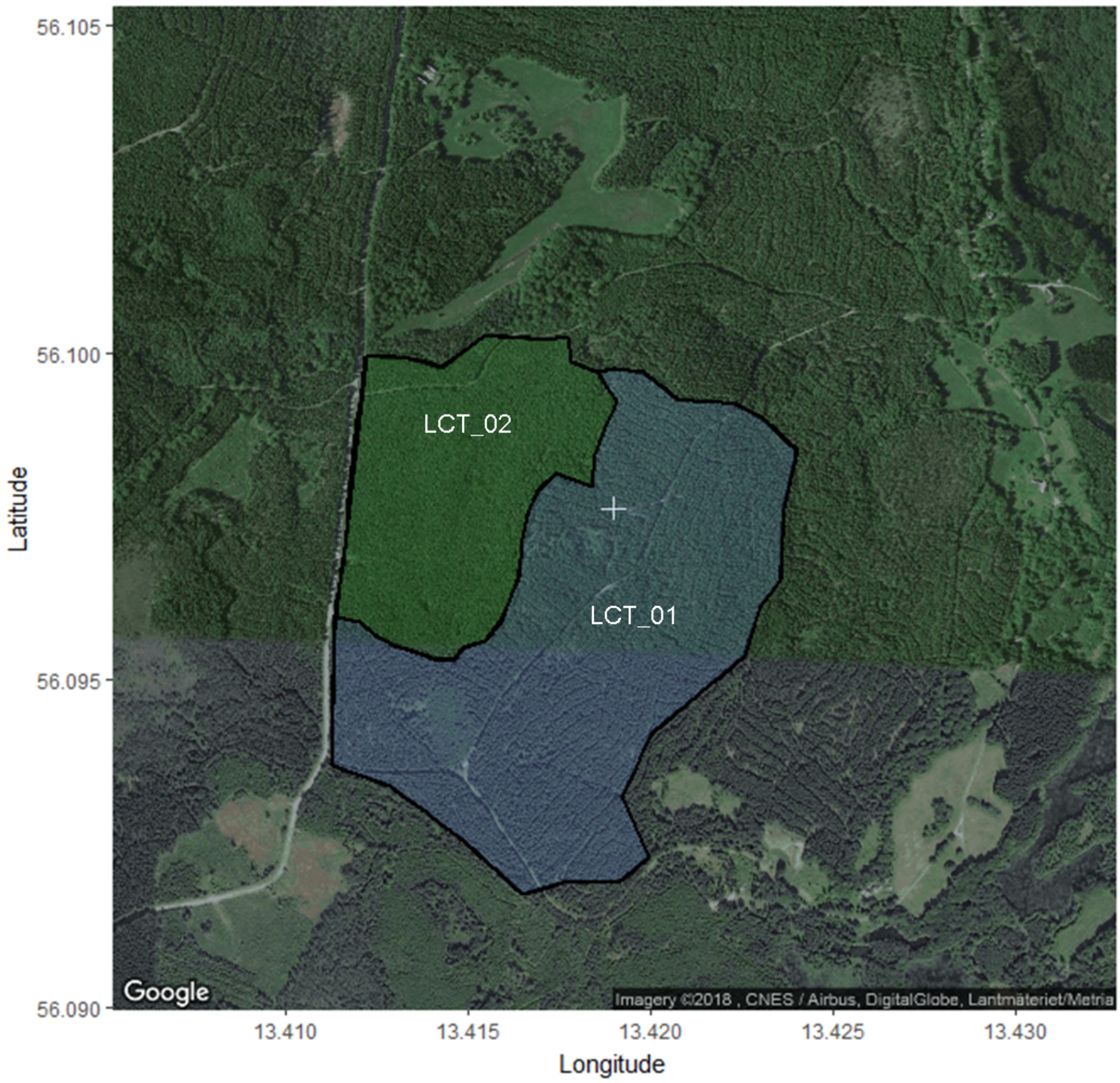

Figure 16: Spatial extent of the two land cover typologies (LCT) defined into the target area of SE-Htm.

The half-hourly 2-D footprint estimations were used to quantify the amount of records coming from the different LCT, checking their representativeness in terms of day-night conditions and in the whole analysed period. The target is to get for each representative LCT, at least 20% of the data during the whole period and considering day/night separately with 70% of cumulated contribution. The figure below (Figure 17) shows some exemplary results of the intersection between the half-hourly footprint and the LCT.

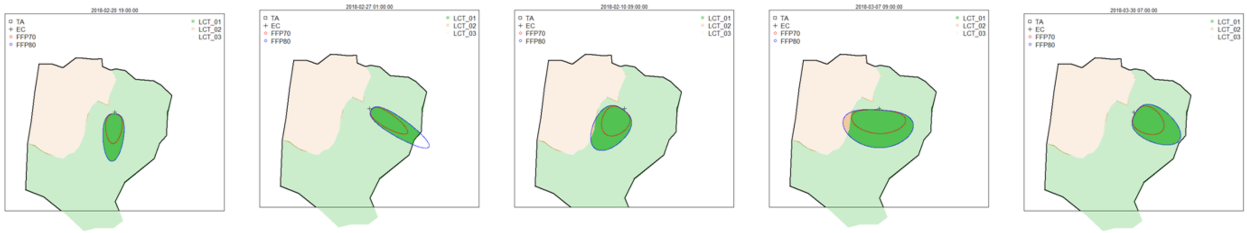

Figure 17: exemplary results of the intersection between half-hourly footprints and the LCT at SE-Htm.

The numerical analysis showed that the main contribution to fluxes is from the LCT_01 (i.e. more than 70% of the flux contribution in more than 20% of the data), while the average contribution of LCT_02 is only of the 10%. Thus, analysing the LCT_01 contribution in both in the whole period and during day and night separately, resulted that the minimum threshold of 20% of data is verified in each case (Figure 18).

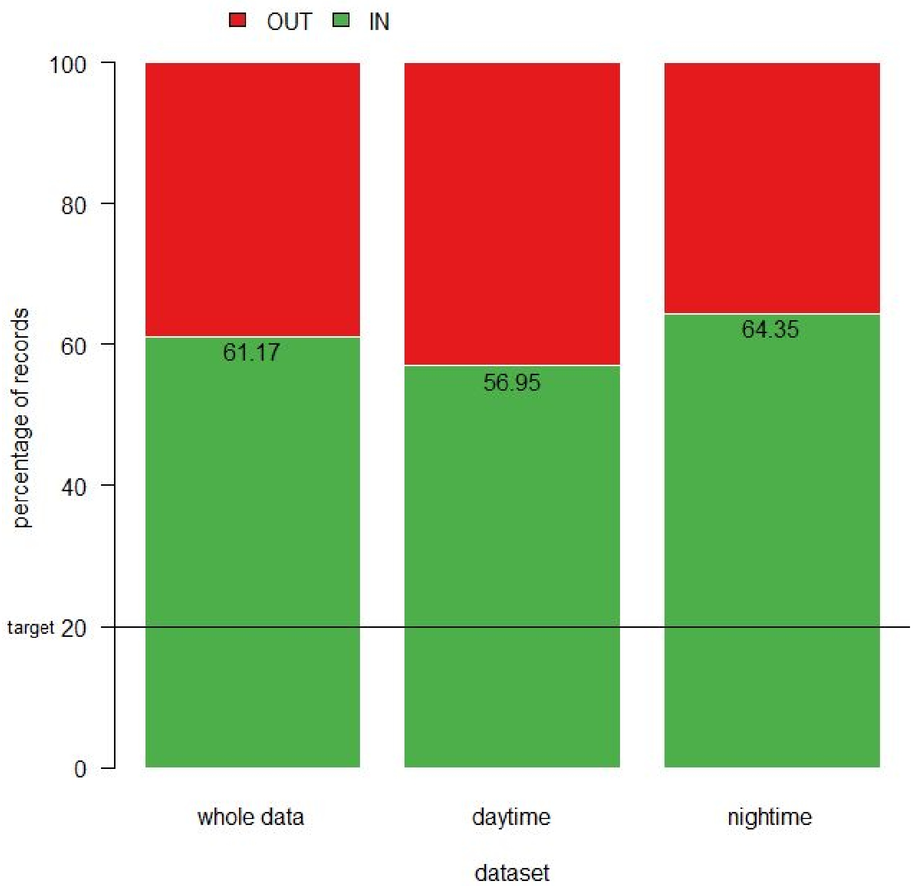

Figure 18: statistics for the spatial analysis of the representativeness of the two LCT defined for SE-Htm. The target is to get at least 20% of the data with at least 70% of contribution from each LCT. Note that only the LCT_01 effectively contributes to fluxes.

Ancillary plot representativeness (Test 4)

How well the CPs represent the target area is evaluated by comparing each CP with the SP-I plots and this in terms of (i) species composition, i.e the percentage basal area of the two main species, (ii) standing biomass, i.e. the basal area of the two 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 plots.

(i) species composition: As can been inferred from Figure 19 and from other figures earlier in this report, *Picea abies* is the single dominant species at the site. *Picea abies* accounts for between 96% and 99% of the total basal area in each CP and for 97% of the total basal area in the target area. It can hence be said that there is no difference between the CPs and the target area (nor is there between the two stands that make up the target area).

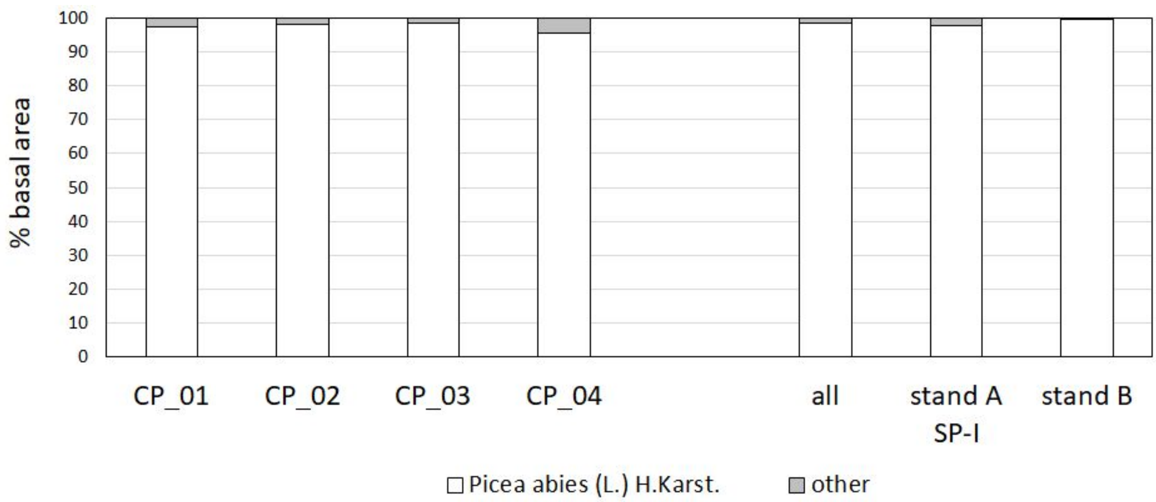

Figure 19: Percentage basal area of *Picea abies* in each CP. Also shown are the average of all 20 SP-I plots and the average of the SP-I plots located in each of the two stands that make up the target area.

(ii) standing biomass: As can be seen in Figure 19 in the section Aboveground biomass, the basal area of *Picea abies* in the CPs varies between 25.9 and 28.9 m^2 ha^{-1}, and each CP falls within the range of the target area's average +/- 20% (= 25.0 +/- 5.0 m^2 ha^{-1}). It should be noted that this is also true for the stand in which the CPs are located (= 27.3 +/- 5.4 m^2 ha^{-1}, stand A), but not for the other stand in the target area (21.6 +/- 4.3 m^2 ha^{-1}, stand B). Each CP contains at least 20% more basal area of *Picea abies* than does this stand.

(iii) Green Area Index: As can be seen in Figure 19 in the section Green Area Index, Green Area Index of the CPs varies between 4.49 and 5.33 m^2 m^{-2} and each CP falls within the range of the target area's average +/- 20% (= 5.46 +/- 1.09 m^2 m^{-2}). This is also true for both stands in the target area.

Even though the CPs are not fully representative of the smaller of the two stands that make up the target area, they are representative of the target area as a whole and of the stand in which they are located. This stand is the larger of the two stands in the target area and is also the main source area of sensed fluxes.

Near Real Time data transmission

The SE-Htm station is collecting EC, BM and ST files using Campbell Scientific dataloggers. The files are being submitted to the Carbon Portal since April 06th, i.e. 12 days from now (April 18th). Up to date, all of the expected files are present in the repository: 576 (=48 files * 12 days) zipped ASCII files of type EC, 120 (10 files * 12 days) uncompressed ASCII files BM and 12 ST files. The strict collaboration between the station team and the ETC led to solve all the inconsistencies with the ICOS format found in the several example files created at the SE-Htm station. An exception has been temporarily allowed for the name of the variable "TIMESTAMP", which cannot be created with the CS loggers, while looking for a solution. A test on the synchronisation of the time series will be performed in the upcoming weeks.

Plan for remaining variables

Soil sampling

The first soil sampling field survey is planned by Aug. 1st 2018. Some adaptation of the protocol is expected because of the soil stoniness (glacial deposit).

Other

The station team must not have the soil sensors installed to complete the labelling procedure, but may delay the installation. The sensors must however be installed before the summer 2018. The data acquisition system for EC must be verified for the synchronization and the format of the files checked and made fully compliant in particular regarding the timestamp label. Radiation sensors need to be calibrated as soon as it is clarified the possible agreement between ICOS and the sensors producer company.

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 Hyltemossa (SE-Htm) is labelled as ICOS CLASS 2 Ecosystem station.

Dario Papale, ETC Director

April 19th 2018