ICOS Ecosystem Station Labelling Report

Station: SE-Svb (Svartberget)

Viterbo (Italy), Antwerp (Belgium), Bordeaux (France), April 19th 2019

Description of the Labelling procedure

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

Preparation and start of the Step2

The station started the Step1 of the labelling on April 14th 2016 and got the official approval on August 28th 2016. The Step2 started officially on February 08th 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 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 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 Svartberget, with ICOS code SE-Svb, is located about 70 km west of the Gulf of Bothnia, NW of the city Umeå. The site in a northern Sweden boreal forest, with coordinates in WGS84 system: latitude 64.25611 °N, longitude 19.7745 °E, at the elevation above sea level of 267 m and having an offset respect to the Universal Time (UTC) equal to +01. The site is marked by the following climate characteristics: Mean Annual Temperature 1.8 °C, Mean Annual Precipitation 614 mm, Mean Annual Radiation 93.4 W m^{-2}. The landscape is characterized by the ridges, valleys and lakes stretching from northwest to southeast, and the station is located within the Svartberget Experimental forest, about 1520 hectare forest land with forest research activities since 1909.

Figure 1 - The SE-Svb tower

Team description

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

MEMBER_NAME	MEMBER_INSTITUTION	MEMBER_ROLE	MEMBER_MAIN_EXPERT
Matthias Peichl	PI	SLU	MICROMET
Mikaell Ottosson-Löfvenius	CO-PI	SLU	MICROMET

Mats Nilsson	CO-PI	SLU	MICROMET
Per Marklund	MANAGER	SLU	
Meelis Mölder	SCI-FLX	Lund University	MICROMET
Mats Öquist	SCI	SLU	SOIL
Jutta Holst	DATA	Lund University	DATAPROC
Kim Lindgren	DATA	SLU	DATAPROC
Pernilla Löfvenius	TEC-ANC	SLU	
Giuseppe De Simon	TEC	SLU	MICROMET
Holger Tülp	TEC	SLU	MICROMET
Rowan Dignam	TEC	SLU	
Tommy Andersson	TEC	SLU	
Paul Smith	TEC	SLU	

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

Spatial sampling design

For the spatial sampling design at SE-Svb, the Station Team (ST) proposed in addition to the Target Area (TA), 3 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). ETC noticed however, that two of the proposed CPs, CP_03 and CP_04, were not compliant because they were partially overlapping. While this is by *per-se* not an issue because as Class 2 site at SE-Svb 2 CP are enough, ETC asked the ST to provide an explanation and the sampling strategy they want to adopt, proposing the following options: 1) do not consider neither CP_03 or CP_04 for the analysis; 2) do not consider one of the two and keep the other; 3) change the position of one (possibly CP_04) of the two and keep booth. The PI confirmed the situation providing a reasonable motivation for the overlapping (severe difficulties to dig down the sensors at CP_04 in the ideal quadrant corner), and also stated that only CP_01 and CP_03 will be used at a first stage for the mandatory ICOS measurement, since the station is now a class 2 station and only requires a minimum of 2 CP’s.

Figure 2 shows the extent and position of SE-Svb 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.

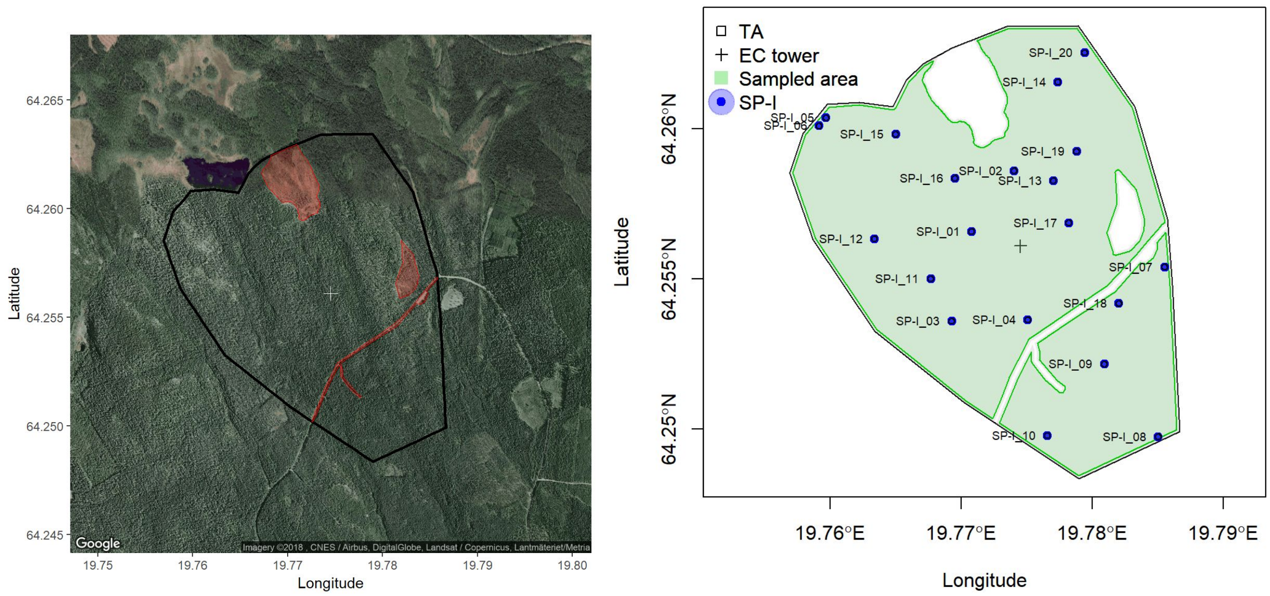


Figure 2: Aerial map of SE-Svb and proposed spatial features according to the reported target area, exclusion area and ICOS requirements. Note that the CP areas have not been excluded from the sampled area. The TA surface is 163.42 Ha, the total excluded area is of 10.43 Ha and the minimum distance between SP-I centers is 39.35 m.

The location of SP-I and SP-II points in the field was done in spring 2018 (after ground was snow free) but the check with the originally sampled coordinates revealed that some SPII points were too far from respective native location (including tolerance). The second check was repeated after new coordinates were submitted and all the points matched the respective sampled location within a tolerable distance. The sampling points locations are thus definitive.

Station implementation

Eddy covariance:

EC System		
MODEL	GA_CP-LI-COR LI-7200	SA-Gill HS-50
SN	72H-0345	H162507
HEIGHT (m)	34.5	34.5
EASTWARD_DIST (m)	0.76	-4.75
NORTHWARD_DIST (m)	-4.55	0.78
SAMPLING_INT	0.05	0.05
LOGGER	1	1
FILE	1	1
GA_FLOW_RATE		-
GA_LICOR_FM_SN	FM1-0323	-

GA_LICOR_AIU_SN	AIU-0729	-
SA_OFFSET_N	-	176
SA_WIND_FORMAT	-	U, V, W
SA_GILL_ALIGN	-	Axis
ECSYS_SEP_VERT	-0.05	
ECSYS_SEP_EASTWARD	-0.02	
ECSYS_SEP_NORTHWARD	0.2	
ECSYS_WIND_EXCL		
ECSYS_WIND_EXCL_RANGE		

The station is mounting the ICOS EC sensors from 2014 (IRGA) and 2016 (HS). 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. Next calibration of the IRGA has been planned. Also for the sonic, a plan for calibration exists (summer 2019): ETC accepted as there is a spare sonic for all the Swedish stations. The reference point of the station is the SAT, installed at 32.5 m above the surface as proposed and agreed in Step1. Due to ongoing projects, the orientation of the sonic at the beginning of the labelling was 236° from N instead of the orientation agreed during the Step1, i.e. 160-170° from N. The station was moved in a new position in July close to the agreed orientation (176°). The EC system was also moved 2 meters higher than proposed and accepted during the Step 1: this modification, despite not discussed with the ETC, is not expected to change the station evaluation, and is therefore accepted. See the quality tests section for more details on the quality and footprint analysis.

Storage: concerning the storage system, the PI proposed to use the sequential sampling scheme with a single gas analyser (Li-Cor LI-7200). Being appropriate for the concerning ecosystem the scheme was accepted. The system setup was agreed at the end of a discussion with the SCI-FLX team member which proposed the setup summarized in Tab. 3 and shown in Fig. 3. He proposed to modify the current (already operative) system by adding a level at 1 m and skip those at 70 and 100 m, and the proposal was accepted by the ETC. A requested exception was the use of additional sampling levels above the EC system (because already installed and operative), although without using them as ICOS variables. ETC decided to agreed in consideration of the scientific importance of such a rare setup. Then ETC raised some concerns with respect to 1) the actual number of the level dedicated to ICOS which was not compliant being 8 (7+1) while it should be 10 considering the default value of 2/3 for the exponent a in the relevant formula of the instructions; 2) their vertical distribution which was also not compliant, suggesting to rearrange the levels according to an exponent b = 1.8; 3) the ramification of the two lowermost levels that was not specified.

Table 3: characteristics of the proposed (by ST) storage sampling scheme for SE-Svb

Feature	*unit*	*value*
Tower height	(m)	150
Flux height	(m)	32.5
ICOS levels *	(m)	1, 4.2, 10, 15, 20, 25, 30, 35
Additional levels **	(m)	42, 50, 60, 70, 85, 100, 125, 150
Number of ICOS levels + 1		7+1+1
Number of additional levels		9(6)
Flow rate	(L/min)	4
95% response for H2O change	(s)	21
Presently switched in steps of	(s)	30
Time for ICOS levels	(min)	4.5
Time for all levels	(min)	7.5

* ST proposed to add a level at 1 m to the current profile setup
** ST proposed to skip the levels at 70 and 100 m from the current profile setup

After a discussion an agreement was found and the ETC conclusions were as follows:

1. in consideration of the already long cycle time and that it is not technically 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 proposed level configuration was also accepted;
3. given that the ramification of the lowest two levels at 1 and 4 m from the soil was also agreed, the air lines design was accepted. The lower inlets are shifted about 20 meters far from the tower given that the environment at the base of the tower is disturbed and not representative of the target ecosystem.

According to info in Tab. 3, the flow rate is 4 L/min and the switching between levels is done each 30 s. All levels sampling takes 7.5 minutes, while for the 'ICOS levels' (8+1 considering the addition of 1 level and the repetition of the lowermost level to allow for a good stabilization of concentration signals after switching from the highest to the lowest level) it takes 4.5 minutes.

This timing was accepted. The air system tubing is in high-density polyethylene, 4 mm inner diameter, ca 200 m long (tubes are of the same length and insulated).

Figure 3: Storage system structure at SE-Svb.

Radiations:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RAD-4C-KZCNR4	120872	50	0.768736547965091	-4.64651918038726	SW_IN_1_1_1
					SW_OUT_1_1_1
					LW_IN_1_1_1
					LW_OUT_1_1_1
LICOR LI-190	Q52448	50	0.768736547965091	-4.64651918038726	PPFD_IN_1_1_1
LICOR LI-190	Q52452	50	0.768736547965091	-4.64651918038726	PPFD_OUT_1_1_1
Delta-T BF5	4603	50	0.768736547965091	-4.64651918038726	PPFD_IN_1_1_2
					PPFD_DIF_1_1_1
Kipp&Zonen CMP21	120921	50	0.768736547965091	-4.64651918038726	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 *LI190-SL* (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 on the use of a *CMP21* (Kipp & Zonen) pyranometer close to the BF5 to use as reference for the direct radiation.

Precipitation:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
Geonor T200BM	29812	2.52	289.209253607958	-156.729455000721	P_1_1_1
Campbell SR50	4714	2.01	290.382500360953	-159.792253809981	D_SNOW_1_1_1

For total precipitation SE-Svb 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 *SR50* (Campbell) sonic range sensor.

Air temperature, relative humidity and air pressure

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
Rotronic HC2-S3	60999804	32.5	-2.59034783102106	-1.12444444000721	TA_1_1_1
					RH_1_1_1
					TA_1_1_2
Vaisala PTB210	H2220006	2	10.6169619769789	12.8545646499842	PA_1_1_1
Campbell Scientific 105E	TA_2_1_1	150	-4.0529205740313	-1.97057831007987	TA_2_1_1
Campbell Scientific 105E	TA_2_2_1	125	-4.0529205740313	-1.97057831007987	TA_2_2_1
Campbell Scientific 105E	TA_2_3_1	100	-4.0529205740313	-1.97057831007987	TA_2_3_1
Campbell Scientific 105E	TA_2_4_1	85	-4.0529205740313	-1.97057831007987	TA_2_4_1
Campbell Scientific 105E	TA_2_5_1	70	-4.0529205740313	-1.97057831007987	TA_2_5_1
Campbell Scientific 105E	TA_2_6_1	60	-4.0529205740313	-1.97057831007987	TA_2_6_1
Campbell Scientific 105E	TA_2_7_1	50	-4.0529205740313	-1.97057831007987	TA_2_7_1
Campbell Scientific 105E	TA_2_8_1	42	-4.0529205740313	-1.97057831007987	TA_2_8_1
Campbell	TA_2_9_1	35	-4.0529205740313	-1.97057831007987	TA_2_9_1

Scientific 105E					
Campbell Scientific 105E	TA_2_10_1	30	-4.0529205740313	-1.97057831007987	TA_2_10_1
Campbell Scientific 105E	TA_2_11_1	25	-4.0529205740313	-1.97057831007987	TA_2_11_1
Campbell Scientific 105E	TA_2_12_1	20	-4.0529205740313	-1.97057831007987	TA_2_12_1
Campbell Scientific 105E	TA_2_13_1	15	-4.0529205740313	-1.97057831007987	TA_2_13_1
Campbell Scientific 105E	TA_2_14_1	10	-4.0529205740313	-1.97057831007987	TA_2_14_1
Campbell Scientific 105E	TA_2_15_1	4.2	-4.0529205740313	-1.97057831007987	TA_2_15_1

The sensor models proposed by the station for measuring TA, RH and PA at the station are ICOS compliant. Their calibration however is expired: the ETC agrees on the plan of the station of calibrating them in summer 2019, as the station team has a calibrated spare sensor available to be used as replacement during the calibration time. On the calibration of the PA sensor, it was agreed with the ETC for all the Swedish stations to have a spare sensor, factory calibrated every two years, to be sent from one station to the next for about a month every year. This will be used as a reference station to check the calibration of the main PA sensor: in case of important un-calibration, the main sensor will have to be sent to the factory for re-calibration. The PI asked as exception to keep their historical time resolution, i.e. 5 seconds, and the exception was agreed by the ETC. The station has also installed a profile of TS sensor to be used as auxiliary measurements for the storage flux calculation. The sensor reported are CS105E (type E) thermocouples. After a discussion on their accuracy, the ETC decided to accept them for the profile. A detailed document on the error expected from this type of sensors was provided, showing how in the worst case scenario the total error, considering also the one due to the reference PT100, sums up to 0.19K.

Backup meteorological station

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
PT100/3	36124	1.7	-362.15	-1371.2	TA_5_1_1
MP103A-T4-W4W	61683627	1.7	-362.15	-1371.62	RH_2_1_1
ARG100	86838	0.3	-362.15	-1371.2	P_2_1_1
Kipp&Zonen CMP21	140438	3	-362.15	-1371.62	SW_IN_2_1_1

The PI proposed to use a compliant pyranometer and a non-compliant commercial station for the remainder variables. After discussion, the PI and the ETC agreed to use data from a close-by meteorological station (Svartberget station). This station is however 1.4 km, i.e. further away than the 1 km maximum distance of ICOS standards. However, this station has ICOS compliant sensor, is powered and logged independently as requested, and furthermore is measuring since 1979 following the WMO climate standards. The final agreement is that data from the backup station will be tested again the main sensors, and in case of inconsistencies a different solution will be agreed between ETC and Station Team.

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

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-001_1	-0.02	97.42695968	19.85118999	TS_1_1_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-001_2	-0.05	97.42695968	19.85118999	TS_1_2_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-001_3	-0.1	97.42695968	19.85118999	TS_1_3_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-001_4	-0.15	97.42695968	19.85118999	TS_1_4_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-001_5	-0.3	97.42695968	19.85118999	TS_1_5_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-001_6	-0.5	97.42695968	19.85118999	TS_1_6_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-002_1	-0.02	122.0776562	-26.6597186	TS_3_1_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-002_2	-0.05	122.0776562	-26.6597186	TS_3_2_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-002_3	-0.1	122.0776562	-26.6597186	TS_3_3_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-002_4	-0.15	122.0776562	-27.9597186	TS_3_4_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-002_5	-0.3	122.0776562	-27.9597186	TS_3_5_1
MicroStep-MIS TPPSDI PT100	TPPSDI-3.0-1809-6-002_6	-0.5	122.0776562	-27.9597186	TS_3_6_1
Delta-T ML2x	387/069	-0.025	97.4269596799859	20.4511899901553	SWC_1_1_1
Delta-T ML2x	387/068	-0.05	97.4269596799859	20.4511899901553	SWC_1_2_1
Delta-T ML2x	387/067	-0.1	97.4269596799859	20.4511899901553	SWC_1_3_1

Delta-T ML2x	387/066	-0.3	97.4269596799859	20.4511899901553	SWC_1_4_1
Delta-T ML2x	387/065	-0.5	97.4269596799859	20.4511899901553	SWC_1_5_1
Delta-T ML2x	387/019	-0.025	49.3364065599744	-5.03682509064674	SWC_2_1_1
Delta-T ML2x	387/064	-0.05	49.3364065599744	-5.03682509064674	SWC_2_2_1
Delta-T ML2x	387/062	-0.1	49.3364065599744	-5.03682509064674	SWC_2_3_1
Delta-T ML2x	387/061	-0.3	49.3364065599744	-5.03682509064674	SWC_2_4_1
Delta-T ML2x	387/060	-0.5	49.3364065599744	-5.03682509064674	SWC_2_5_1
Delta-T ML2x	387/025	-0.025	122.077656194975	-26.0597186004743	SWC_3_1_1
Delta-T ML2x	385/09	-0.05	122.077656194975	-26.0597186004743	SWC_3_2_1
Delta-T ML2x	385/08	-0.1	122.077656194975	-26.0597186004743	SWC_3_3_1
Delta-T ML2x	385/07	-0.3	122.077656194975	-26.0597186004743	SWC_3_4_1
Delta-T ML2x	384/066	-0.5	122.077656194975	-26.0597186004743	SWC_3_5_1
Delta-T ML2x	384/057	-0.025	92.0900522239972	-49.8144000601023	SWC_4_1_1
Delta-T ML2x	387/057	-0.05	92.0900522239972	-49.8144000601023	SWC_4_2_1
Delta-T ML2x	387/056	-0.1	92.0900522239972	-49.8144000601023	SWC_4_3_1
Delta-T ML2x	387/053	-0.3	92.0900522239972	-49.8144000601023	SWC_4_4_1
Delta-T ML2x	387/052	-0.5	92.0900522239972	-49.8144000601023	SWC_4_5_1
Hukseflux HFP01SC	2826	-0.05	97.4269596799859	20.4511899901553	G_1_1_1
Hukseflux HFP01SC	2810	-0.05	49.3364065599744	-5.03682509064674	G_2_1_1
Hukseflux HFP01SC	2803	-0.05	122.077656194975	-26.0597186004743	G_3_1_1
Hukseflux HFP01SC	2804	-0.05	92.0900522239972	-49.8144000601023	G_4_1_1
Campbell CS451	14011593	-2.89	95.13	20.45	WTD_1_1_1
Campbell CS451	14011592	-1.26	118.08	-26.06	WTD_2_1_1

The station team has installed the full set of soil meteo sensors required for a Class 2 forest station (see Table above), except the four soil temperature sensors for the additional heat flux plates. The ETC and the station team have however agreed that these will be installed in spring/summer 2019 after the snow melt. The soil meteo sensors have been installed at locations in the target area that comply with the ICOS Instructions: two fully equipped soil plots each in the vicinity of the center of the two Continuous Measurements plots (CPs), plus two additional soil heat flux plates elsewhere in the target area (see Figure 4). The set-up of each soil plot and each additional soil heat flux plate, 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.

Regarding the soil temperature sensors, the ETC and the station team have agreed that the three deepest sensors in the soil plots could be installed 1 m away from the plate. This is to limit disturbance of the soil near the plate and near existing TS profiles that would occur when digging a 50 cm deep pit very near the plate in the stony soil. The three upper sensors were installed at the standard distance from the plate.

Furthermore, the station team has indicated that "an automatic calibration [of the heat flux plates] is not possible due to small fluxes and long "recovery periods" after a calibration". Time series of plate data collected early April 2019 under snow-covered soil near freezing point showed indeed that with the default generated flux of 300 w m-2 the recovery times after each self-calibration are unacceptably long, i.e. up to +3 hours. The ETC and the station team have agreed to further test in spring 2019 whether applying lower generated fluxes may reduce recovery times to an acceptable length, before definitively ruling out the possibility of (daily) self-calibration.

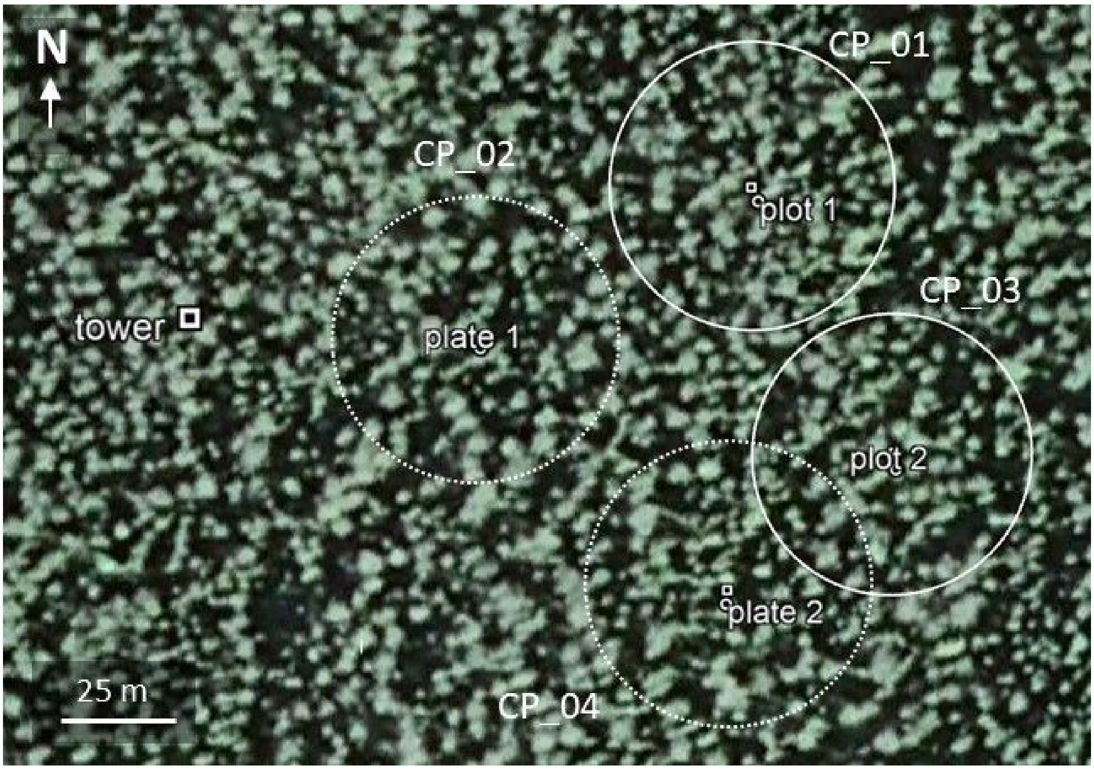


Figure 4: Location of the two soil plots and two extra heat flux plates around the EC tower. CP = Continuous Measurements plot. Note: only CP_01 and CP_03 are official ICOS CPs.

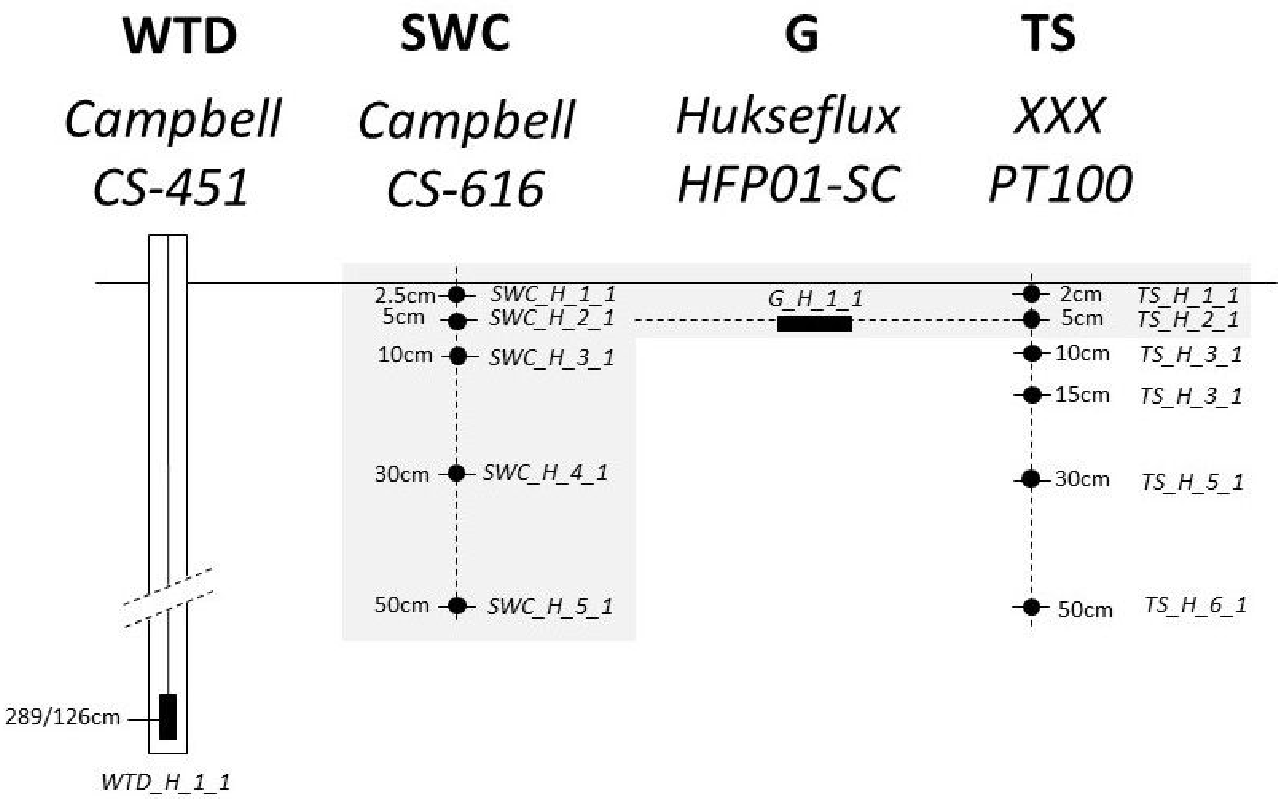


Figure 5: Set-up of the two soil plots (all sensors) and the two extra heat flux plates with accessory sensors (grey sensors). WTD = water table depth, SWC = soil water content, G = soil heat flux density, TS = soil temperature.

Above Ground Biomass

The station team has collected 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 (spring 2018) and 2 CP (spring 2017) 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 Norway Spruce (*Picea abies (L.) H. Karst.*) and Scots pine (*Pinus sylvestris L.)*, with sparse presence of silver birch (*Betula pendula Roth*), goat willow (*Salix caprea L.*), and mountain ash (*Sorbus aucuparia L.*).

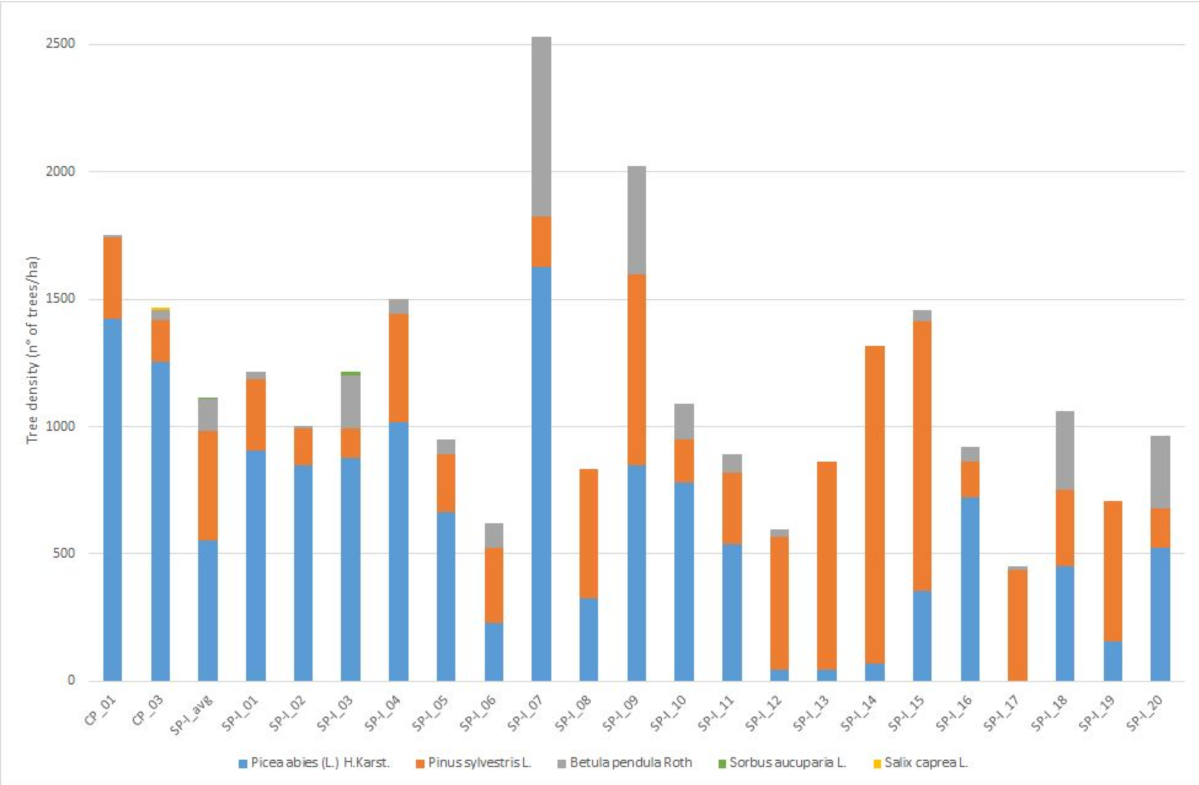


Figure 6: Tree density per species, shown for the twenty SP-I plots and the two CPs installed in the target area.

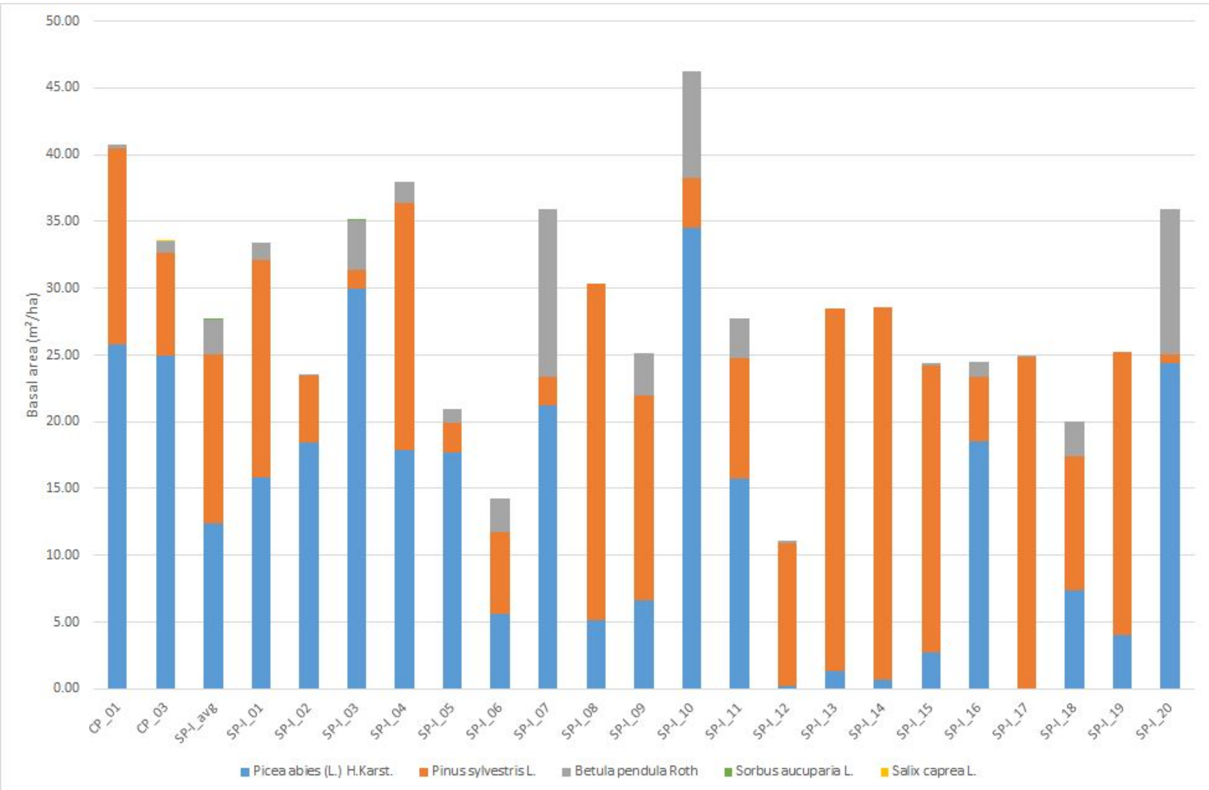


Figure 7: Basal Area per species, shown for the twenty SP-I plots and the two CPs installed in the target area.

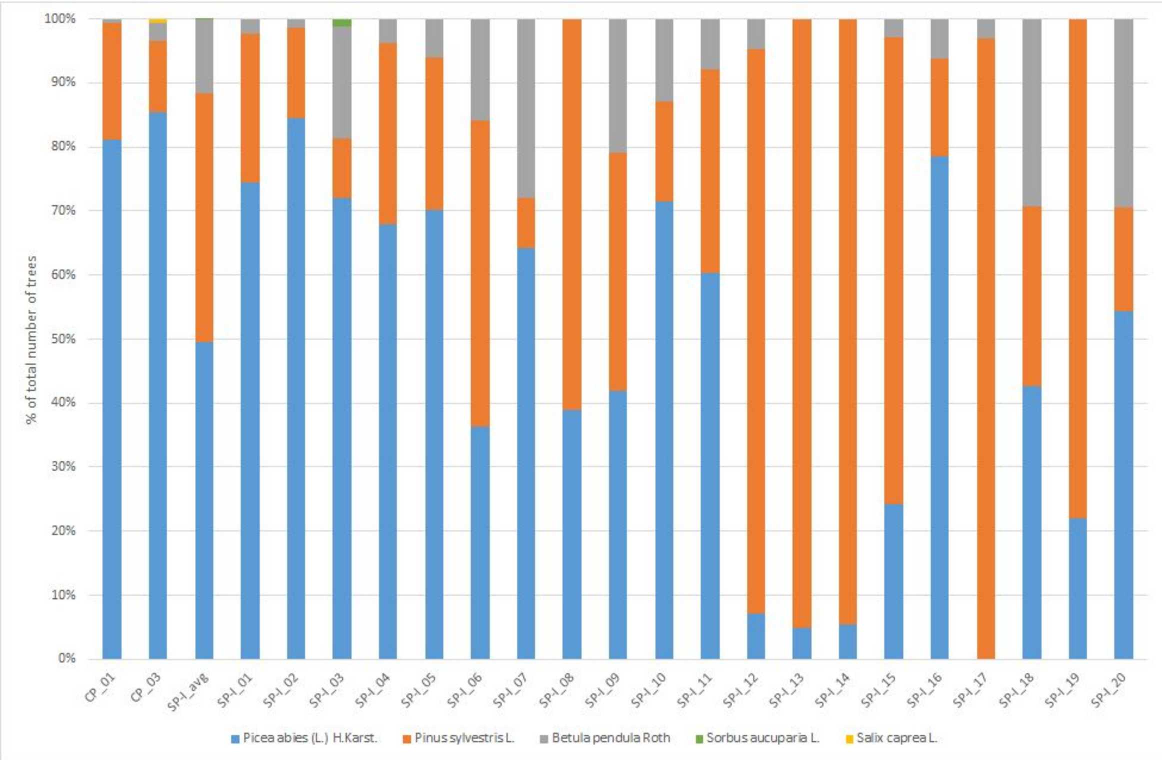


Figure 8: Percentage-wise contribution of each species to the total basal area of the plot, shown for the twenty SP-I plots and the two CPs installed in the target area.

Green Area Index

The station team has taken hemispherical images twice (in june 2018) in the two mandatory CPs (CP_01 and CP_03), and submitted the set of images to ETC. In addition DHP have been taken at all 20 SPs during the peak of the growing season in 2018. 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. The results are presented below in Figure 9.

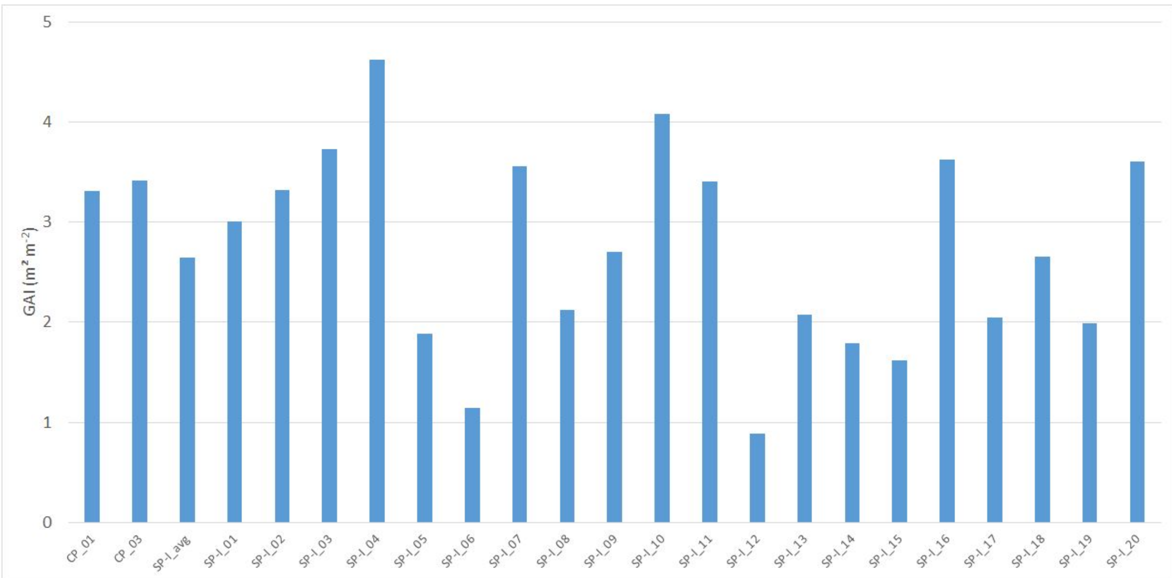


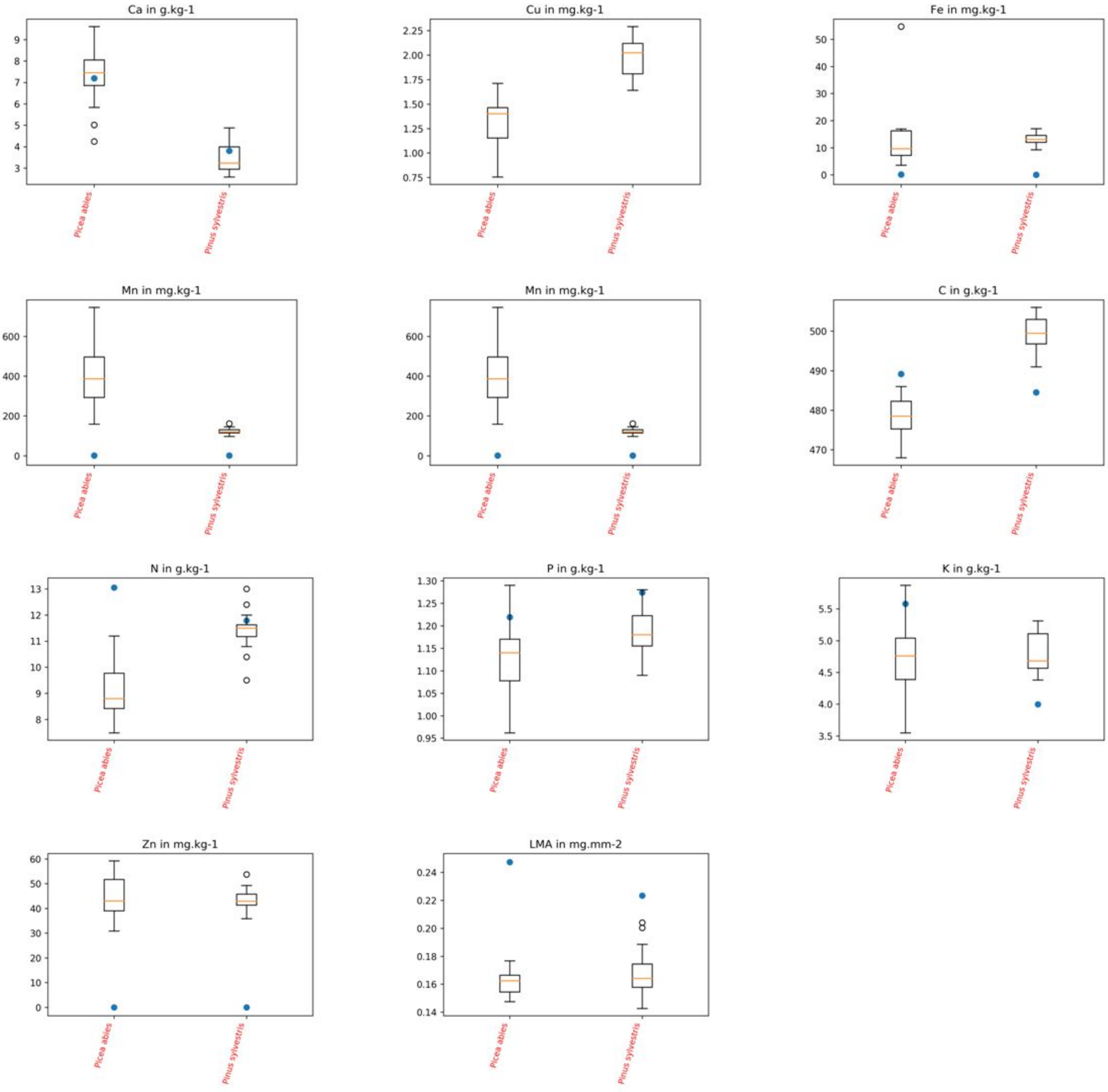
Figure 9: Green Area Index (GAI) for the twenty SP-I plots and the four CPs installed in the target area. All measurements were performed during the peak of the 2018 growing season.

The variability that can be seen in the results of the GAI measurements is in line with what can be expected from the biomass measurements at the plots, where plots with a higher representation of Scots pine hold lower values of GAI compared to plots dominated by Norway spruce.

Vegetation sampling and analysis

The first set of foliar samples has been collected and received at ETC by 2017, Dec. 12th. The chemical analysis have been carried out and metadata have been processed. We did not detect departure from the expected range of values of foliar nutrient mass ratio or LMA. The 2nd set of samples was collected by 8th October 2018 and received at the Laboratory analysis by 22nd Nov., after metadata were checked. Analysis results show no anomaly but the LMA values and N content are very low in the *Picea abies* needles.

Foliar Analyses for station SE-Svb, 2017-10-23



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

Data check and test

Data quality analysis (Test 1)

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 labelling is that the total percentage of missing and removed data after the QC filtering does not exceed the 40% threshold value.

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) inappropriateness of the spectral correction method as provided by anomalous values of the spectral correction factor; (iv) lack of well developed turbulence regimes (Foken and Wichura, 1996); (v) 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 SE-Svb site, the testing period involves raw data sampled from October, 15th 2018 to March, 24th 2019. Of the 7728 expected half-hourly NEE fluxes, 66% were retained after QC routines as illustrated in Figure 8. In particular, 7.9% of raw-data was missed, 33.4% of calculated half-hourly fluxes was discarded because affected by SevEr, while an additional 0.6% was discarded because identified as outliers and affected by ModEr. Being the percentage of missing data equal to 34%, we conclude that SE-Svb 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

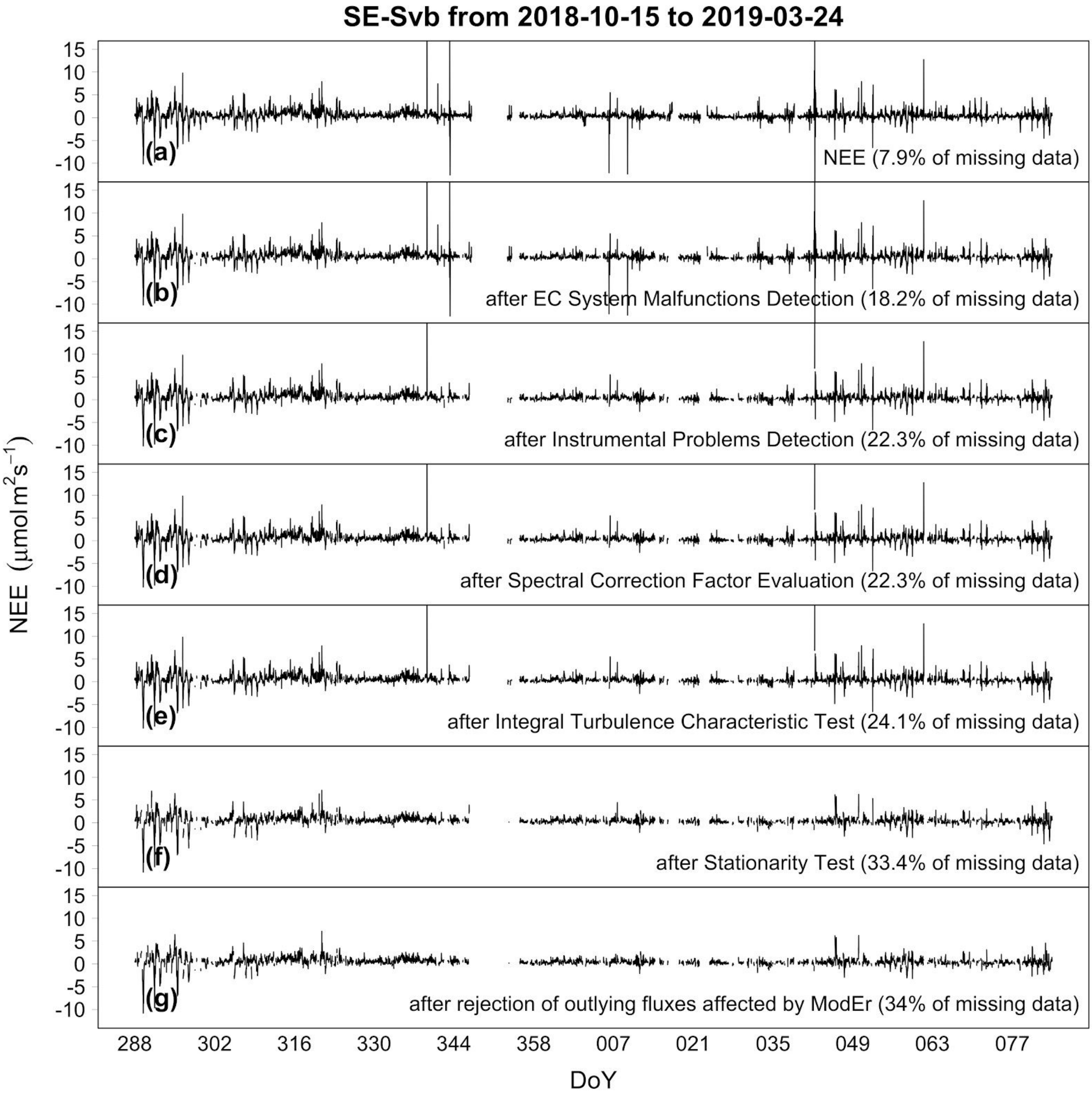


Figure 10: Summary of the data cleaning procedure applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at SE-Svb site from 2018/10/15 to 2019/03/24. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe 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 about 5 months of data, after QC filtering procedure (previous Section) has been achieved. The model by 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 QC procedure and additional filtering according to footprint model requirements, the 58.6 % of the data was used for the test.

Results showed that almost the 100% of the whole period data have a cumulative contribution of at least 70 % from the TA (Fig. 11, first bar on the left), and this holds for daytime and nighttime periods too (Fig. 11, left panel).

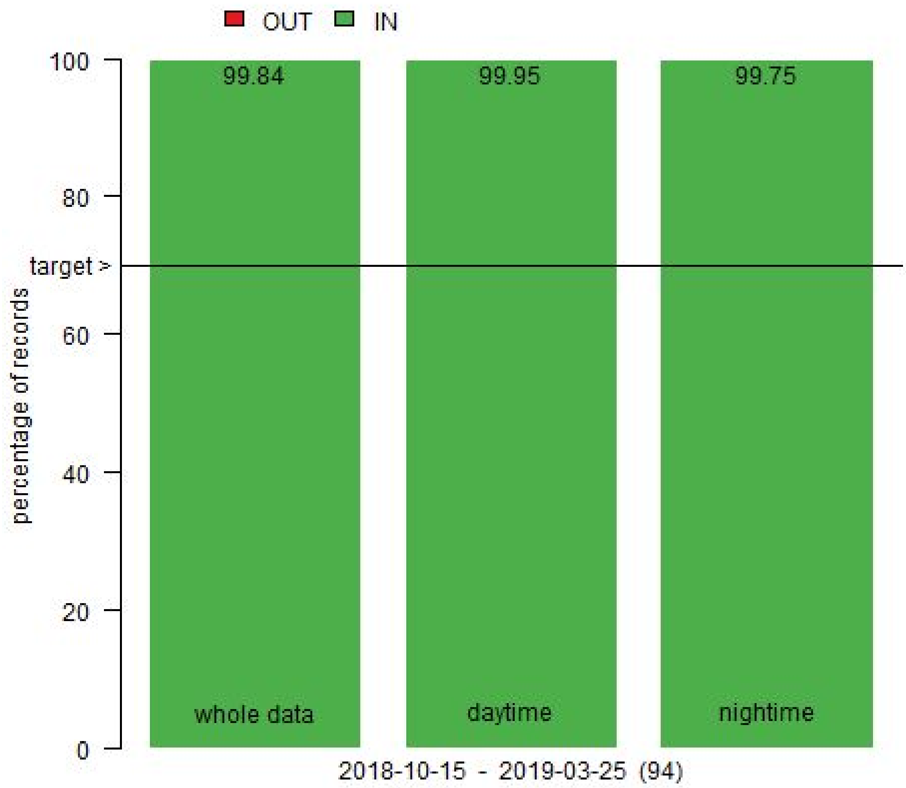


Figure 11: Test results over the whole analyzed period showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value is that the 70% of data (half-hourly fluxes) must hold this condition.

In addition, the test was performed on 6 sub-periods and results confirm the previous founding: the footprint can reasonably be considered representative of the ecosystem, in all the atmospheric conditions (Fig. 12). According to these results, the test is passed.

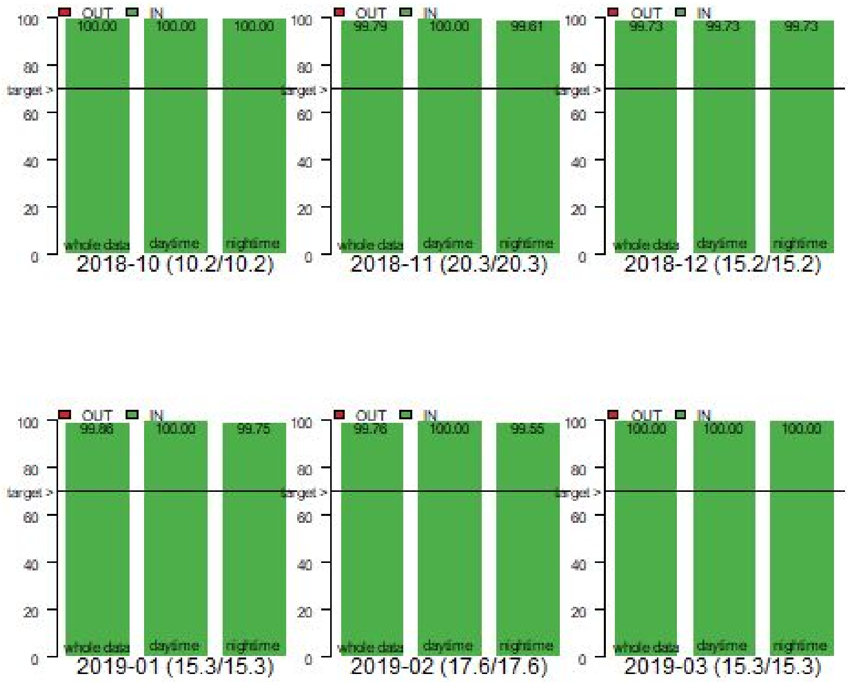


Figure 12: Test results over monthly sub-periods showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value is that the 70% of data (half-hourly fluxes) must hold this condition.

The footprint climatology for SE-Svb, for the period under consideration is reported in Fig. 13, by which it is possible to noticed that the footprint 80% contribution is completely included in the TA.

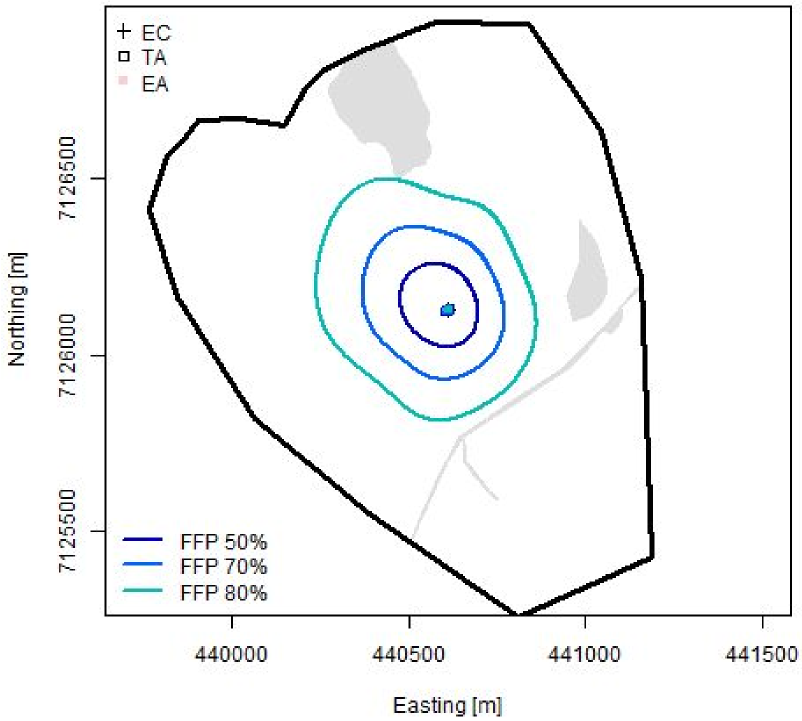


Figure 13: Footprint climatology at SE-Svb in relation to the TA, the different land cover typologies (LCT), the EC tower (EC), and the excluded areas (EA, see the spatial sampling Section). The 50, 70 and 80 % cumulative distribution isopleths are reported.

Data representativeness analysis (Test 3)

This test aimed to evaluate the representativeness of the possible different land cover tipologies inside the Target area (TA). At SE-Svb the analysis on vegetation (Test 4, Section below) revealed a single vegetation typology. As a consequence, the entire TA can be considered as homogeneous in terms of vegetation and the Test 3 became unnecessary.

Ancillary plot representativeness (Test 4)

The vegetation composition within the target area shows quite some variability. It can be seen that SP plots hold lower basal area values compared to the average of the CP's, 37 m² ha^{-1} compared to 27 m² ha^{-1} respectively. In general, the target area is dominated by Norway spruce and Scots Pine. However, when comparing the species contribution between CPs and SPs we observe a higher contribution of Norway spruce in the CPs compared to the SPs, 83% and 50% respectively. This is especially because some SP plots (SP-I_08, SP-I_12, SP-I_13, SP-I_14, SP-I_15, SP-I_17 and SP-I_19) are almost fully covered by Scots pine. The ETC proposed to expand one of these SP-I plots to a CPs so that the continuous measurements of the ancillary data are also performed in a plot dominated by Scots pine.

The station team agreed with this solution and will convert one SP-I plot which is dominated by Scots pine into an additional CP. This action will be complete before the summer break in 2019.

The station team confirmed that the variability in species composition and tree density is due to natural variability and can not be linked to management practices. The species variability is also heterogeneous throughout the target area and can not be stratified into different areas.

Near Real Time data transmission

Example files for EC, SAHEAT and BM were submitted and after some modifications applied to solve some inconsistencies, some BM files got the green light and the submission to the Carbon Portal started on October 24th 2018. Other files got the green light on February 15th 2019.

Plan for remaining variables

Soil sampling

The station team has carried out a detailed soil characterization in the target area. The area around the tower is primarily on gneis with till moraine till soils and therefore the underlying bedrock is shallow and the stoniness of the soil is high. This makes it impossible at many places to reach the required depth of 100cm. The station team has carried out an initial test using a metal soil probe stick which suggested that at 50% of SP locations the maximum depth is limited to 20cm. The large and highly variable stone content in the soil would also add considerable uncertainty into the determination of the bulk density and subsequently the carbon stock estimates.

The ICOS protocol recommend to sample and to evaluate the soil carbon stock to a maximum depth of 100 cm whenever it is possible. I has been agreed to try to sample as deep as possible on each point till you reach the gneiss and then you can constitute the composite with the available samples regarding the depths indicated in the protocol. On each point, you can document the reached depth. Concerning the bulk density, in stony soils the instructions recommend to use an excavation method with water or sand to measure the volume, even if I know that it’s a hard job, and that the incertitude associated to bulk density estimation in stony soils is rather high.

Using available soil chemistry data, a rough estimate of the potential soil C change over the next 20 years indicates that such change would likely be within the uncertainty due to spatial variability of the soil carbon concentration. However, from a statistical point of view, we think it is worth getting estimates of C stock and their uncertainty using harmonized sampling protocol for all ICOS sites. It seems that the future of the soil carbon stock at the SE-Svb site cannot be assumed negligible or undetectable. Even if the total carbon content of the soil could not be estimated accurately, a change in the carbon areal density in the only upper horizons might still be detected and it would provide a reliable and appropriate information to ICOS users.

Other

The station team have agreed that (1) the four accessory soil temperature sensors for the two extra soil heat flux plates shall be installed in spring/summer 2019 after the snow melt, and (2) further tests with the heat flux plates to reduce recovery times after self-calibrations will be conducted in spring 2019.

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 Svartberget (SE-Svb) is labelled as ICOS Class 2 Ecosystem station.

Dario Papale, ETC Director

April 29th 2019