ICOS Ecosystem Station Labelling Report

Station: SE-Deg (Degerö)

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

Description of the Labelling procedure

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

Preparation and start of the Step2

The station started the Step1 of the labelling on April 15th 2016 and got the official approval on November 15th 2016. The Step2 started officially on February 8th 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 quality tests and some of them will lead to data exclusion and gaps. It is calculated the number of half hours removed by these QAQC filters and the target value is to have less than 40% of data removed. If the test fails, an in depth analysis of the reasons is performed in order to find solutions and alternatives.

Test 2 – Footprint and Target Area

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

Test 3 – Data Representativeness in the Target Area

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

Test 4 – CP Representativeness in the Target Area

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

Station Description

The statin Degerö, with ICOS code SE-Deg, is located in the northern Sweden boreal region, about 70 km west of the Gulf of Bothnia, NW of the city Umeå, situated on highland between the major rivers, Ume and Vindeln River. The site is an oligotrophic mire consisting of a rather complex system of interconnected smaller mires, divided by islets and ridges of glacial till. The coordinates in WS84 system are: Latitude 64.182029 °N, Longitude 19.556539 °E, at an elevation above sea level of 270 m, and having an offset respect to the Coordinated Universal Time (UTC) equal to +01. The site is marked by the following climate characteristics: Mean Annual Temperature 1.2 °C, Mean Annual Precipitation 523 mm and Mean Annual Radiation 93.4 W m^{-2}. The area around the Eddy Covariance tower is dominated by flat lawn plants communities with bog moss dominating the bottom layer.

Figure 1: the SE-Deg tower

Team description

The staff of the site has been defined and communicated in December 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.

MEMBER_NAME	MEMBER_INSTITUTION	MEMBER_ROLE	MEMBER_MAIN_EXPERT
Mats Nilsson	Swedish University of agricultural sciences	PI	
Mikaell Ottosson Löfvenius	Swedish University of agricultural sciences	CO-PI	
Giuseppe De Simon	Swedish University of agricultural sciences	MANAGER	
Matthias Peichl	Swedish University of agricultural sciences	SCI	
Meelis Mölder	Lund University	SCI-FLX	
Jutta Holst	Lund University	DATA	
Kim Lindgren	Swedish University of agricultural sciences	DATA	
Per Marklund	Swedish University of agricultural sciences	TEC	
Holger Tülp	Swedish University of agricultural sciences	TEC	
Rowan Dignam	Swedish University of agricultural sciences	TEC	
Tommy Andersson	Swedish University of agricultural sciences	TEC	
Paul Smith	Swedish University of agricultural sciences	TEC	
Pernilla Löfvenius	Swedish University of agricultural sciences	TEC-ANC	
Eric Larmanou	Swedish University of agricultural sciences	AFFILIATED	

Spatial sampling design

For the spatial sampling design at SE-Deg, the Station Team (ST) proposed, in addition to the Target Area (TA), 10 areas to be excluded from sampling (EA) and 16 continuous measurement points (CP). These spatial features can be seen in Figure 2 (left panel). After the spatial sampling results were sent on to the Station Team (ST) they realized that it was impossible to reach some of the SPI.

After a discussion with ETC they submitted the boardwalk paths along which at least 100 CP sampling points must be positioned in a systematic design (according to Site Characterization Measurements in Mires and Ancillary Vegetation Measurements in Mires instructions).

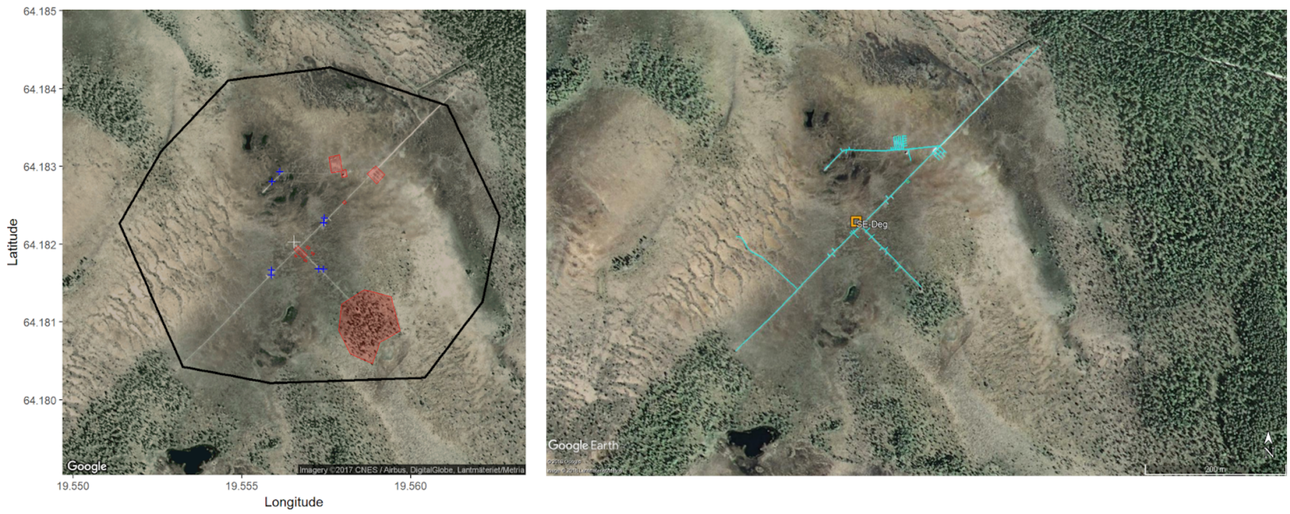


Figure 2: *Left panel:* aerial map of SE-Deg and proposed target area (TA, black), exclusion areas (EA, red), and continuous plots (CP, blue crosses). *Right panel*: PI proposal for boardwalk paths along which CP points must be systematically placed.

Station implementation

<u>*Eddy covariance:*</u>

The eddy covariance system is running at the station with two compliant sensors. The LI7200 was calibrated on 20180223, then the calibration is valid until 2020. Even if the Gill HS was not calibrated after purchase (20160621), it was installed in the field only on 21070919, and the station planned to send it for calibration in autumn 2019: this plan is accepted by the ETC. During Step1 the ETC recommended to increase the EC system height to 2 m from 1.75 m. The height selected was 2.12 m, compliant. The execution of the footprint tests revealed that the location chosen is appropriate, and then the relocation considered in Step1 is not needed. In addition, the footprint appeared to include a very small part of the target area: for that reason the ETC suggested to the station to further increase the measurement height to 3 m, which was accepted (3 m current height). The orientation, 312 degrees from N, is compliant with the changes asked by the ETC in Step1 (from 350° to 315°). All the northern stations reported issues 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, which will not prevent the labelling of the station.

EC System

MODEL	GA_CP-LI-COR LI-7200	SA-Gill HS-50
SN	72H-0342	H162506
HEIGHT (m)	3.07	3
EASTWARD_DIST (m)	-0.404	-1.136
NORTHWARD_DIST (m)	0.454	1.022
SAMPLING_INT	0.05	0.05
LOGGER	1	1
FILE	1	1
GA_FLOW_RATE	12	-
GA_LICOR_FM_SN	FM1-0328	-
GA_LICOR_AIU_SN	AIU-0726	-
SA_OFFSET_N	-	312
SA_WIND_FORMAT	-	U, V, W
SA_GILL_ALIGN	-	Axis
ECSYS_SEP_VERT	-0.04	
ECSYS_SEP_EASTWARD	0.142	
ECSYS_SEP_NORTHWARD	-0.148	
ECSYS_WIND_EXCL		
ECSYS_WIND_EXCL_RANGE		

Storage: Although not mandatory given the EC measurement height, the PI proposed to use a profile system for the storage measurement and proposed to use the sequential sampling scheme with a single gas analyser and five measurement levels. A ventilation pump is used to maintain a continuous flow through all the lines. A sketch of the system is reported in Figure 3 while a picture of the system in place is in Figure 4.

The gas analyser is a Los Gatos Greenhouse Gas Analyser (CO2, CH4, H2O; Model 911-0011-0004), the air temperatures along the profile are measured with Campbell Scientific 105E type E thermocouples while relative humidity is provided by the gas analyser. The line flow is controlled by rotameters and PFM710-F01-E (SMC pneumatics) flow meter. In addition to the GA pump, a Gast DAA-P501-GD pump is used for ventilation.

The sampling is carried out along an ad-hoc mast, 12 m in S-E direction apart to the EC mast. The profile levels distribution was agreed after a discussion on both the original station team proposal and the definitive EC measurement height that was set to 3 m. The inlets are a 0.43, 1, 1.63, 2.3 and 3 meters above ground.

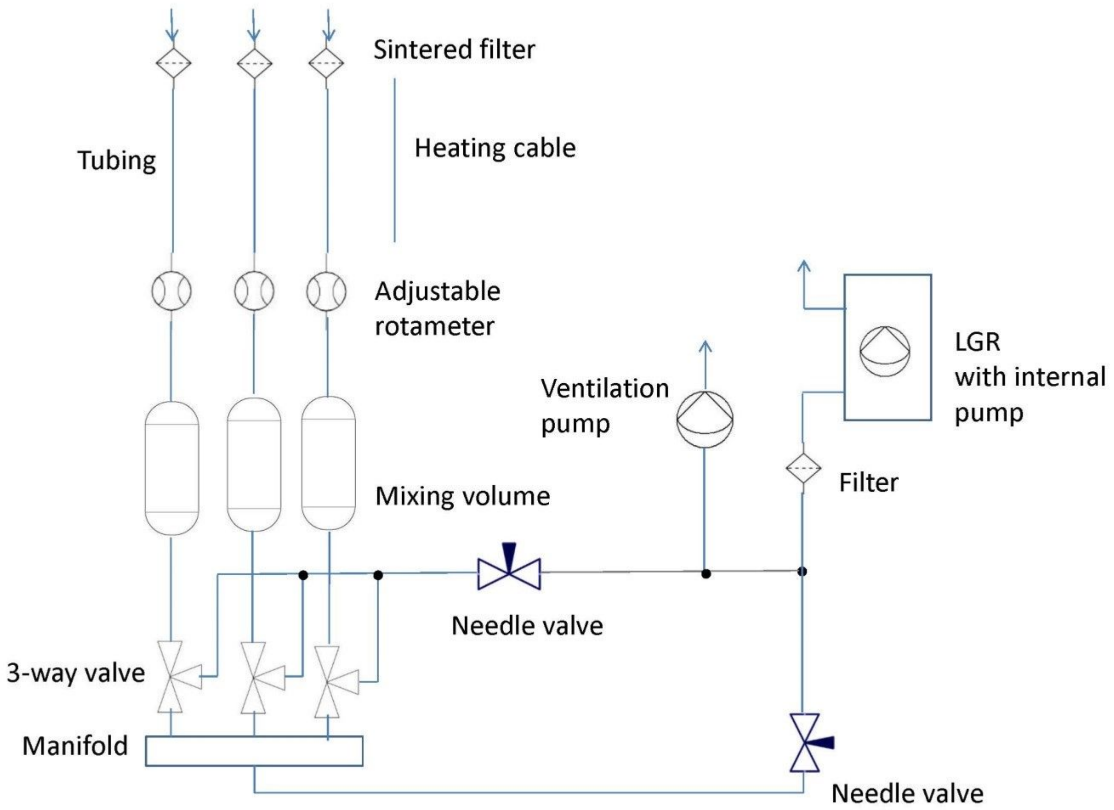


Figure 3: Sketch of the storage sampling system at SE-Deg.

Figure 4: Winter image of the profile mast (lowest level covered by snow)

All lines are made of high-density polyethylene. Outer diameter is 6 mm, inner diameter is 4 mm and all lines have the same length (ca 20 m). Systems fittings are either Swagelok metal tube fittings (6mm) or quick connect fittings (6mm). Tube length from the inlet to the buffer volumes is ca 20 m, buffer volumes are very close to the manifold (<50 cm). Tube length from the lines switch to the analyser is ca 1.6 m. Levels are switched in 1 minute steps. All 5 levels take 5 minutes to measure. Data are provided in 1 s steps. Flow rate (measured at intake) is 4.5 L/min. Buffer volumes are placed between intakes and manifold and have a volume of 8 L. The under-pressure in the buffer volumes is 50 mb.

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 Device*) sensor, which is not fully ICOS compliant. ETC agreed the exception if the sensor will be used in parallel with another sensor acquiring the absolute value (CMP21, *Kipp & Zonen*) and BF5 used for the ratio diffuse/total.

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RAD_4C-K&Z CNR4	120869	4	0.768	1.649	SW_IN_1_1_1
					SW_OUT_1_1_1
					LW_IN_1_1_1
					LW_OUT_1_1_1
RAD_PAR-LI-COR LI190R	Q104924	4	0.351	0.853	PPFD_IN_1_1_1
RAD_PAR-LI-COR LI190R	Q104925	4	0.351	0.853	PPFD_OUT_1_1_1
RAD_PAR-DeltaT BF5	24 08	4	53.229	-69.611	PPFD_IN_2_1_1
					PPFD_DIF_1_1_1

Precipitation:

For total precipitation at SE-Deg will be used the T200BM (*Genor*) weighing gauge in combination with the Geonor Alter type windshield and an intake heating ring. Snow depth will be measured (in two positions) by the *SR50* (*Campbell*) sonic range sensor.

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
PREC-Geonor T200x	29912	2	55.048	-67.725	P_1_1_1
SNOW-Campbell SR50x	4713	2.03	52.203	-69.764	D_SNOW_1_1_1
SNOW-Campbell SR50x	4712	2.03	-15.536	97.88	D_SNOW_2_1_1

Air temperature, relative humidity and air pressure

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
TEMP-Rotronic MPX02H	60999805	2.03	53.523	-70.876	TA_1_1_1
RHTEMP-Rotronic HC2(A)-S	60956401	2.03	53.523	-70.876	RH_1_1_1
PRES-Vaisala PTB210	H2220002	1.2	12.63	-17.026	PA_1_1_1

TEMP-Campbell 105E	105E_3_1_1	3	3.791	-11.712	TA_3_1_1
TEMP-Campbell 105E	105E_3_2_1	2	3.791	-11.712	TA_3_2_1
TEMP-Campbell 105E	105E_3_3_1	1.28	3.791	-11.712	TA_3_3_1
TEMP-Campbell 105E	105E_3_4_1	0.7	3.791	-11.712	TA_3_4_1
TEMP-Campbell 105E	105E_3_5_1	0.31	3.791	-11.712	TA_3_5_1
TEMP-Campbell SR50 AT	4713	2.03	52.203	-69.764	TA_4_1_1
TEMP-Campbell SR50 AT	4712	2.03	-15.536	97.88	TA_5_1_1

The selected sensors for TA, RH and PA are ICOS compliant, but the calibrations are expired for all of them. However, the station team provided to the ETC a plan for calibration: the thermo-hygrometer will be sent for calibration as soon as the spare sensor shared among the Swedish stations will be available (expected date: November). The ETC accepted this plan. Similar situation for the barometer: as agreed with the ETC for all the Swedish stations, a spare, calibrated sensor will be run in parallel to the one at the station for one month, and the data compared to check its need for calibration.

The station also has a profile of air temperature sensors installed, i.e. thermocouples CS 105E. A detailed document was provided by the station team on their accuracy, and this type is then accepted by the ETC for profile measurements.

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. Also, two sensors for TA related to two snow-depths sensors are reported.

Backup meteorological station

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
TEMP-Rotronic MPX02H	61461161	2.16	53.077	-70.381	TA_2_1_1
RHTEMP-Rotronic HC2(A)-S	20 199472	2.16	53.077	-70.381	RH_2_1_1
PREC-EML ARG100	ARG100_exFOMAS	1.23	57.027	-68.107	P_2_1_1
RAD_SW-K&Z CMP21	111320	4	53.779	-69.805	SW_IN_2_1_1

As the sensor initially proposed by the station team for TA and RH (Vaisala Weather Transmitter WXT520, part of the WeatherHawk integrated met station) was not compliant for TA, the station team installed a different, compliant sensor (Rotronic MP102H). Also the sensors for P and SW_IN measurements at the backup station are ICOS compliant.

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

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-003_1	-0.02	42.796	-39.117	TS_1_1_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-003_2	-0.05	42.796	-39.117	TS_1_2_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-003_3	-0.1	42.796	-39.117	TS_1_3_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-003_4	-0.15	42.796	-39.117	TS_1_4_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-003_5	-0.3	42.796	-39.117	TS_1_5_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-003_6	-0.5	42.796	-39.117	TS_1_6_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-004_1	-0.02	45.492	34.315	TS_2_1_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-004_2	-0.05	45.492	34.315	TS_2_2_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-004_3	-0.1	45.492	34.315	TS_2_3_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-004_4	-0.15	45.492	34.315	TS_2_4_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-004_5	-0.3	45.492	34.315	TS_2_5_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-004_6	-0.5	45.492	34.315	TS_2_6_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-005_1	-0.02	-12.743	98.764	TS_3_1_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-005_2	-0.05	-12.743	98.764	TS_3_2_1
TEMP-MicroStep	3.0-1809-6-005_3	-0.1	-12.743	98.764	TS_3_3_1

TPS Class 1/5 DIN					
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-005_4	-0.15	-12.743	98.764	TS_3_4_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-005_5	-0.3	-12.743	98.764	TS_3_5_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-005_6	-0.5	-12.743	98.764	TS_3_6_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-006_1	-0.02	-33.828	-46.873	TS_4_1_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-006_2	-0.05	-33.828	-46.873	TS_4_2_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-006_3	-0.1	-33.828	-46.873	TS_4_3_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-006_4	-0.15	-33.828	-46.873	TS_4_4_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-006_5	-0.3	-33.828	-46.873	TS_4_5_1
TEMP-MicroStep TPS Class 1/5 DIN	3.0-1809-6-006_6	-0.5	-33.828	-46.873	TS_4_6_1
SWC-DeltaT MLx	M008428	-0.02	42.596	-38.987	SWC_1_1_1
SWC-DeltaT MLx	M008071	-0.05	42.596	-38.987	SWC_1_2_1
SWC-DeltaT MLx	M008060	-0.1	42.596	-38.987	SWC_1_3_1
SWC-DeltaT MLx	M008062	-0.15	42.596	-38.987	SWC_1_4_1
SWC-DeltaT MLx	M008061	-0.3	42.596	-38.987	SWC_1_5_1
SWC-DeltaT MLx	M008429	-0.02	45.592	34.575	SWC_2_1_1
SWC-DeltaT MLx	M008064	-0.05	45.592	34.575	SWC_2_2_1
SWC-DeltaT MLx	M008065	-0.1	45.592	34.575	SWC_2_3_1
SWC-DeltaT MLx	M008066	-0.15	45.592	34.575	SWC_2_4_1
SWC-DeltaT MLx	M008063	-0.3	45.592	34.575	SWC_2_5_1
SWC-DeltaT MLx	M008430	-0.02	-13.023	98.724	SWC_3_1_1
SWC-DeltaT MLx	M008070	-0.05	-13.023	98.724	SWC_3_2_1
SWC-DeltaT MLx	M008067	-0.1	-13.023	98.724	SWC_3_3_1
SWC-DeltaT MLx	M008069	-0.15	-13.023	98.724	SWC_3_4_1
SWC-DeltaT MLx	M008068	-0.3	-13.023	98.724	SWC_3_5_1
SWC-DeltaT MLx	M008058	-0.02	-34.068	-46.813	SWC_4_1_1
SWC-DeltaT MLx	M008075	-0.05	-34.068	-46.813	SWC_4_2_1
SWC-DeltaT MLx	M008074	-0.1	-34.068	-46.813	SWC_4_3_1

SWC-DeltaT MLx	M008073	-0.15	-34.068	-46.813	SWC_4_4_1
SWC-DeltaT MLx	M008072	-0.3	-34.068	-46.813	SWC_4_5_1
SOIL_H-Hukseflux HFP01SC	2811	-0.05	43.833	-37.132	G_1_1_1
SOIL_H-Hukseflux HFP01SC	2827	-0.05	42.347	36.331	G_2_1_1
SOIL_H-Hukseflux HFP01SC	2825	-0.05	-12.388	96.606	G_3_1_1
SOIL_H-Hukseflux HFP01SC	2824	-0.05	-31.412	-47.968	G_4_1_1
WTD-Campbell CS45X	70010941	-1.16	42.896	-38.487	WTD_1_1_1
WTD-Campbell CS45X	70010942	-1.07	44.892	34.595	WTD_2_1_1
WTD-Campbell CS45X	70010946	-1.04	-12.533	98.414	WTD_3_1_1
WTD-Campbell CS45X	70010943	-1.083	-33.168	-46.893	WTD_4_1_1

The station team has installed the full set of soil meteo sensors required for their Class 2 mire station: four soil plots have been installed at representative locations in the target area (see Figure 5). The set-up of each soil plot is compliant with the ICOS Instructions in terms of sensor models, number of sensors, and sensor depths (see Figure 6). The station team has furthermore submitted all requested metadata on the installed sensors. The station team has agreed with ETC to set up a calibration function for peat for their SWC sensors. *Note: The station team has purchased sensors for a fifth soil plot which is to be installed in the dry part of the target area, approximately 140 m WSW from the tower.*

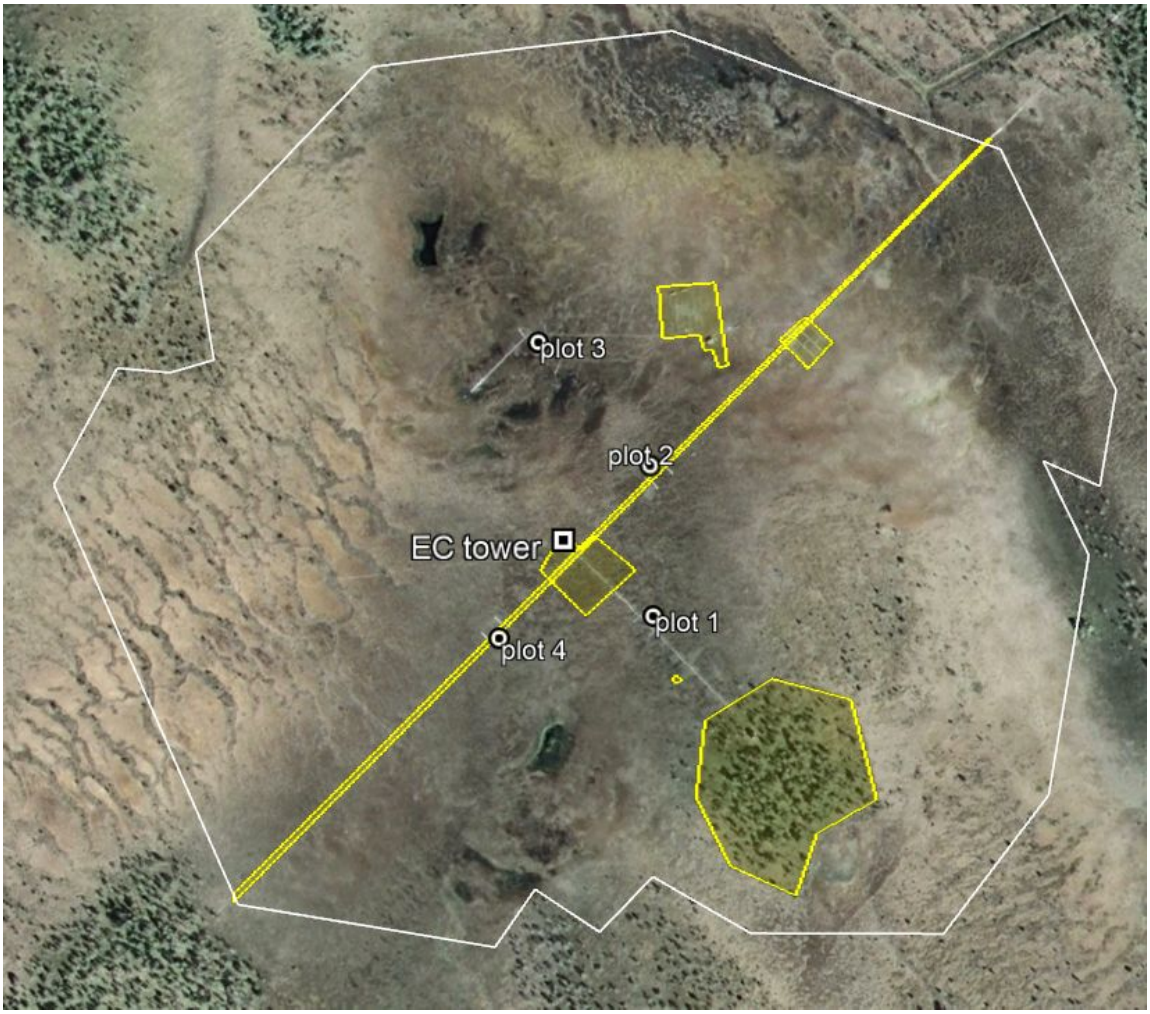


Figure 5: Location of soil plots in the target area (plot 1 to 4). Yellow = exclusion areas.

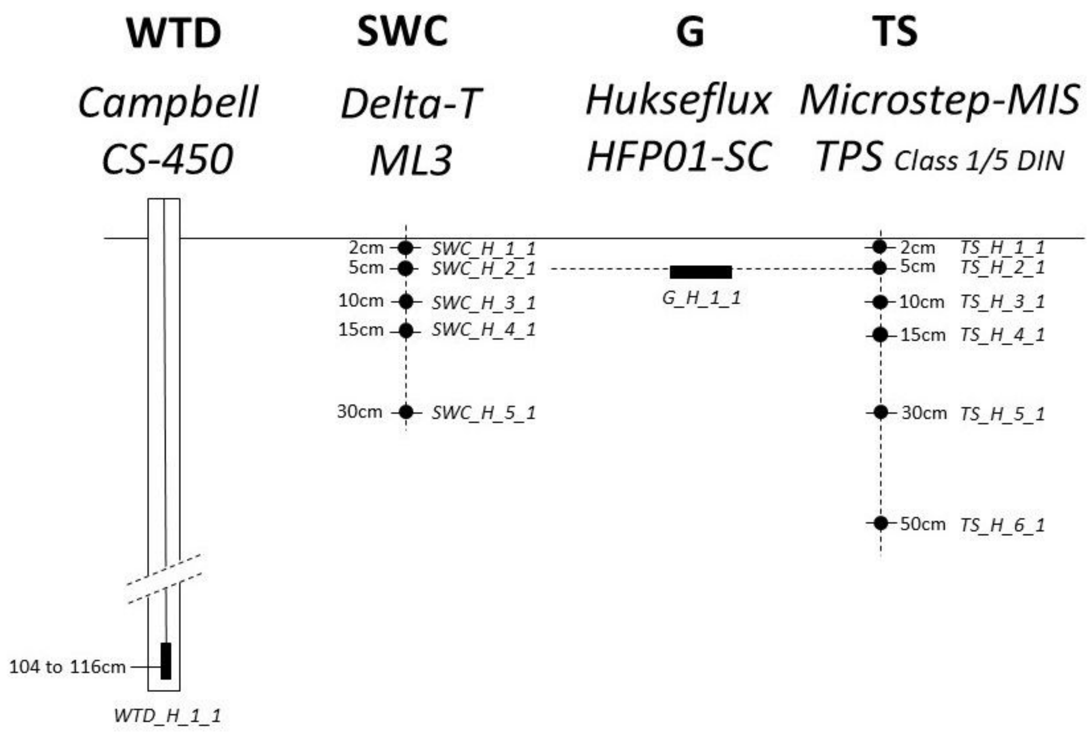


Figure 6: Set-up of each soil plot. WTD = water table depth, SWC = soil water content, G = soil heat flux density, and TS = soil temperature.

Spatial heterogeneity characterization

The station team has collected in summer and autumn 2018 all the measurements required for the characterization of the spatial heterogeneity of the target area vegetation. These measurements comprise records of species cover at 100 plots located along the set of boardwalks installed in the target area and at 87 additional plots located in a radial pattern around the EC tower. It has also measured the species cover in the 16 candidate CPs. The ETC has quality-checked the cover data and has subsequently carried out a TWINSPAN cluster analysis of the dataset in order to classify the 187 plots into groups that correspond with the Plant Community Types (PCTs) that can be distinguished in the target area. The station team agreed to distinguish between four groups, which are named group 1 to 4 until a PCT terminology for the groups is suggested. These groups reflect PCTs along a moisture gradient from dry to wet (*hummock -> lawn -> hollow/carpet*). Figure 7 hows the average species composition per group and the number of plots assigned to each group. Figure 8 shows the distribution of the 187 survey plots in the target area.

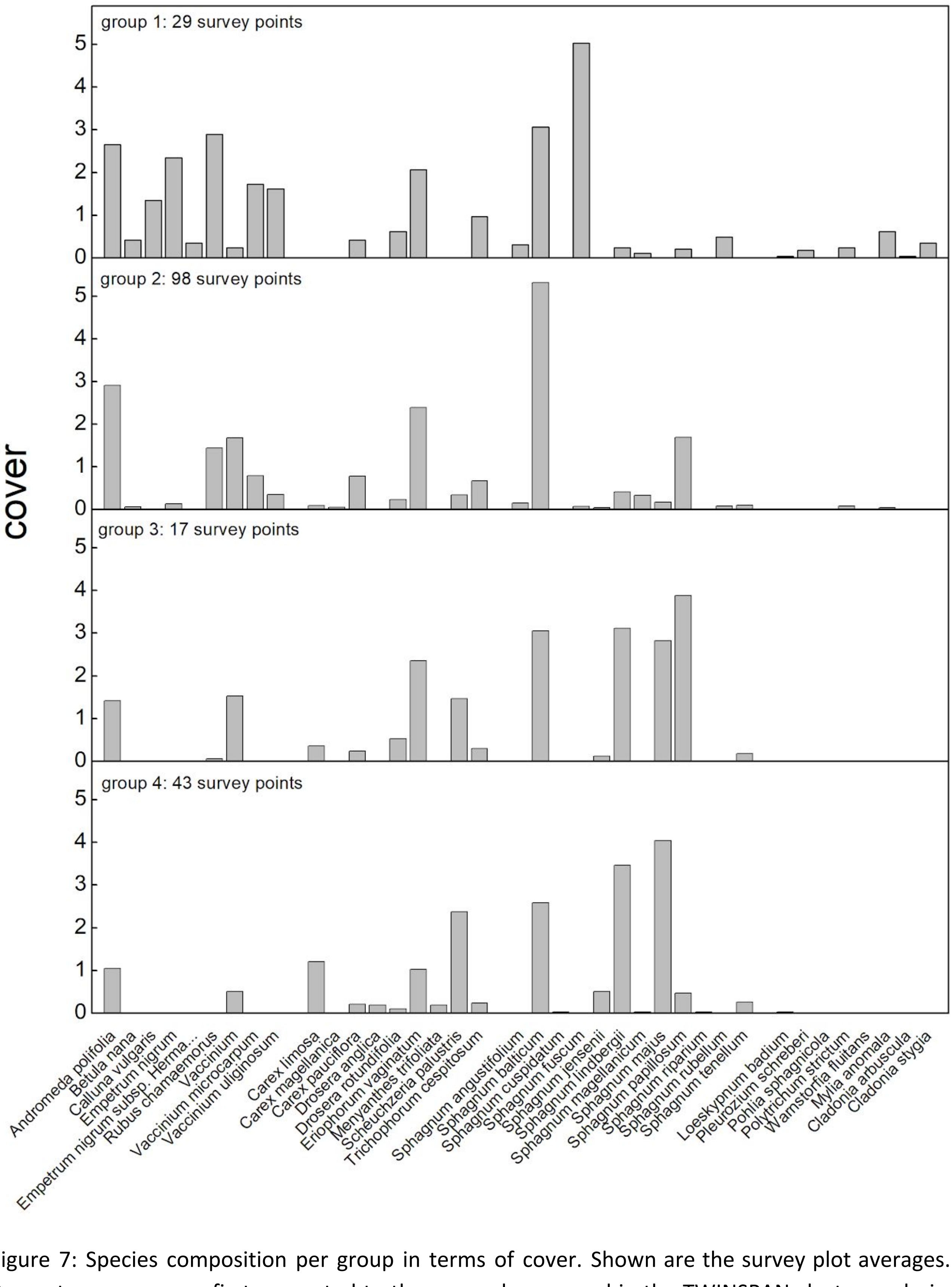


Figure 7: Species composition per group in terms of cover. Shown are the survey plot averages. Percentage cover was first converted to the cover classes used in the TWINSPAN cluster analysis: <1% = not present, 1 = 1 - 2%, 2 = 2-5%, 3 = 5-10%, 4 = 10-20%, 5 = 20-50%, and 6 = 50-100% .

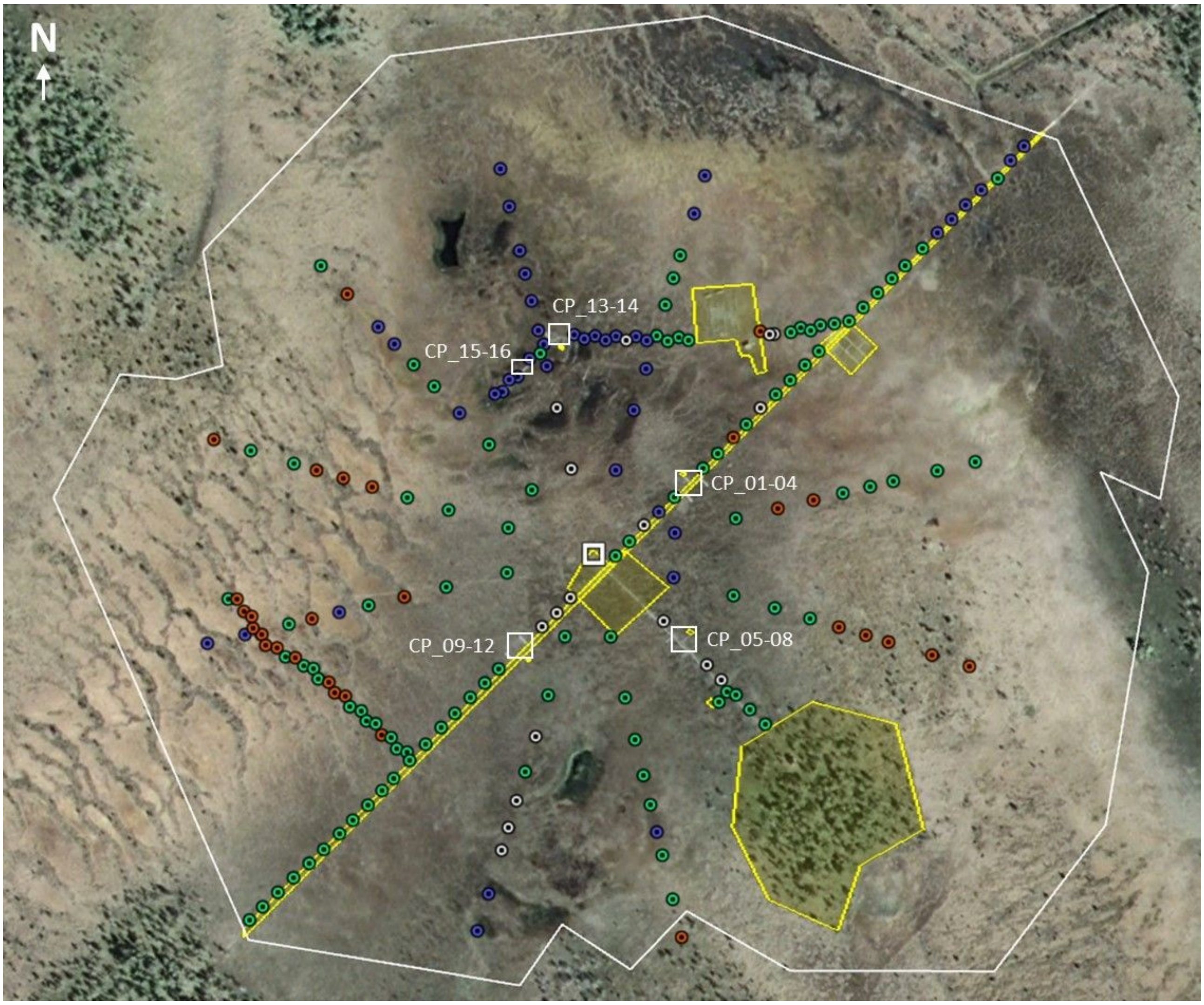


Figure 8: Distribution of the 187 points for the characterization of the spatial heterogeneity (dots) and the 16 CPs (squares) in the target area. red= group 1, green = group 2, white = group 3, blue = group 4. The thick square indicates the location of the EC tower. Yellow areas = exclusion areas.

Green Area Index

The station team has collected and submitted the minimum number of two GAI datasets that are requested as part of the step 2 labelling requirements. It has in fact collected GAI (and AGB) measurements in all 16 candidate CPs during the growing seasons 2017 and 2018 as if the station were already labelled. All these data have been submitted to ETC and quality-checked. As an example, Figure 9 shows the GAI measurements collected in 2018 on the vascular species in CP_02.

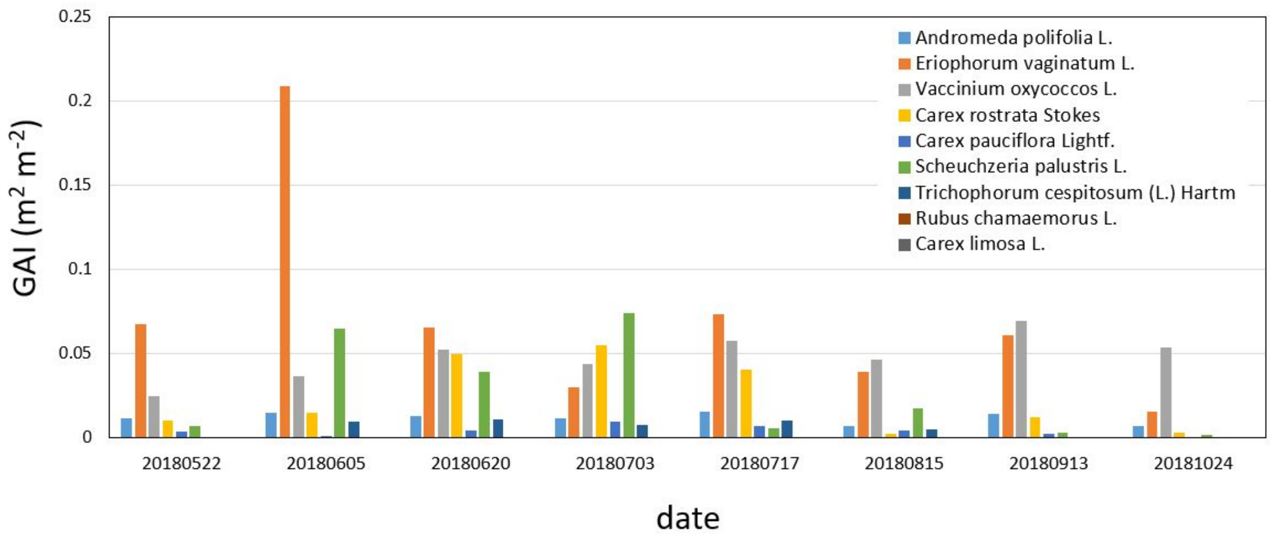
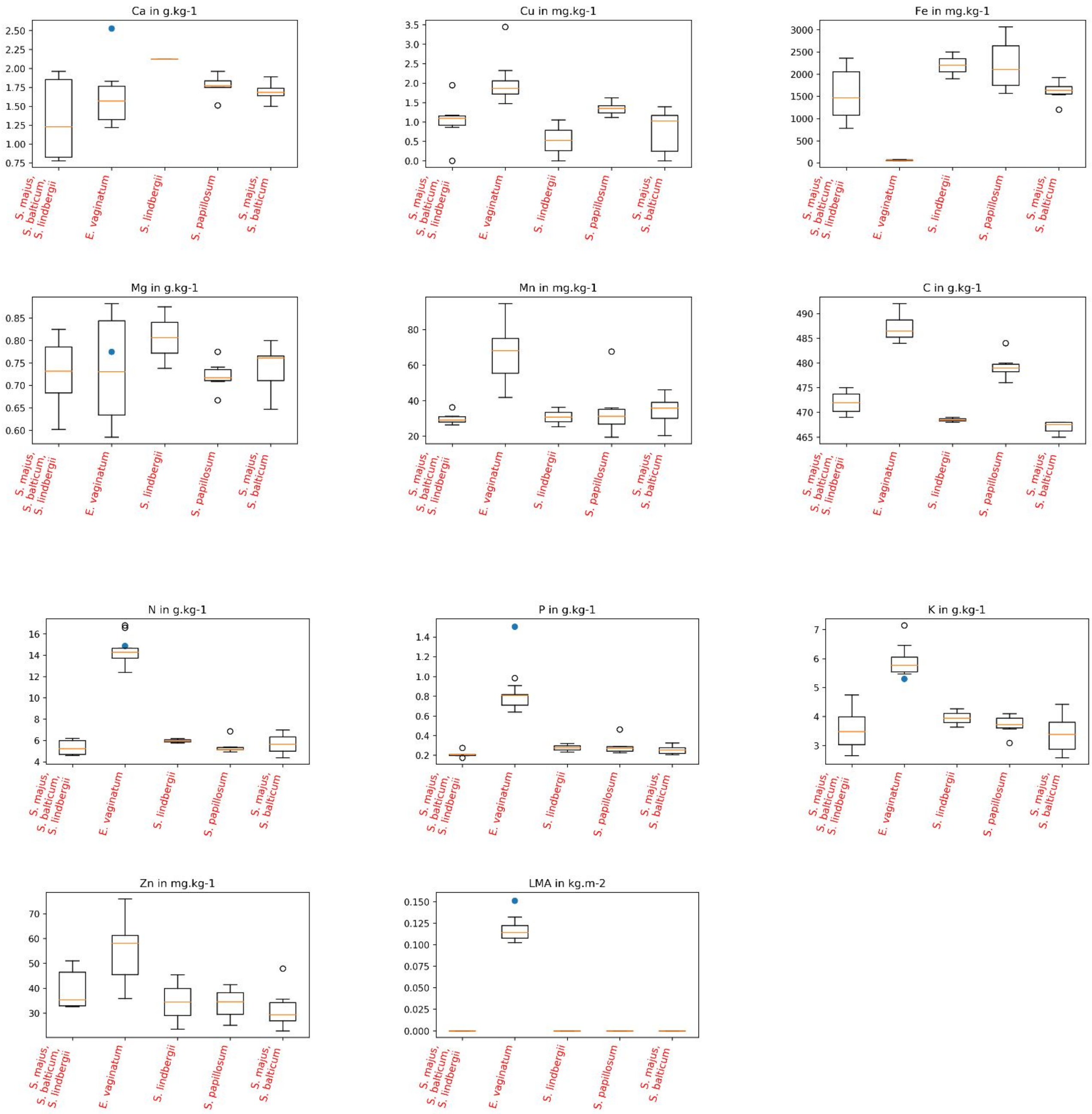


Figure 9: GAI measured in 2018 on all vascular species in CP_02.

Vegetation sampling and analysis

The sampling strategy have been agreed, sample collected received by September 20th 2018, the metadata are correct and the chemical analysis were achieved by November 23rd, the results are shown below. We observe that nutrient ratio values are in the range expected for Eriophorum and Sphagnum in oligotrophic conditions and that the site seems very poor in phosphorus.

Foliar Analyses for station SE-Deg, 2018-08-29



● *Mean value of the **Eriophorum vaginafum L.** 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); instruments malfunction detected by (ii) low signal resolution and (iii) structural changes tests as described in Vitale et al (2019); (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 (for more details see Vitale et al., 2019): 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-Deg site, the testing period involves raw data sampled in 2019 from 1st July to 30th September. Of 4416 expected half-hourly files for NEE fluxes, 71.8% were retained after QC routines as illustrated in Figure 10. In particular, about 0.2% of raw-data was missed, 26.3% of calculated half-hourly fluxes was discarded because affected by SevEr, while an additional 1.9% was discarded because identified as outliers and affected by ModEr. Being the percentage of missing data equal to 30%, we conclude that SE-Deg 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
Vitale D, Fratini G, Bilancia M, Nicolini G, Sabbatini S, Papale D (2019) A robust data cleaning procedure for eddy covariance flux measurements, Biogeosciences Discussion, 1-36, doi = 10.5194/bg-2019-270, https://www.biogeosciences-discuss.net/bg-2019-270/.

Softwares

LI-COR Biosciences: EddyPro 7.0.4: Help and User's Guide, LI-COR Biosciences, Lincoln, Nebraska USA, www.licor.com/EddyPro, 2019.
Fratini, G., & Mauder, M. (2014). Towards a consistent eddy-covariance processing: an intercomparison of EddyPro and TK3. Atmospheric Measurement Techniques, 7(7), 2273-2281.
Vitale D (2019). RFlux: Eddy Covariance Flux Data Processing. R package v 1.0.1, https://github.com/icos-etc/RFlux

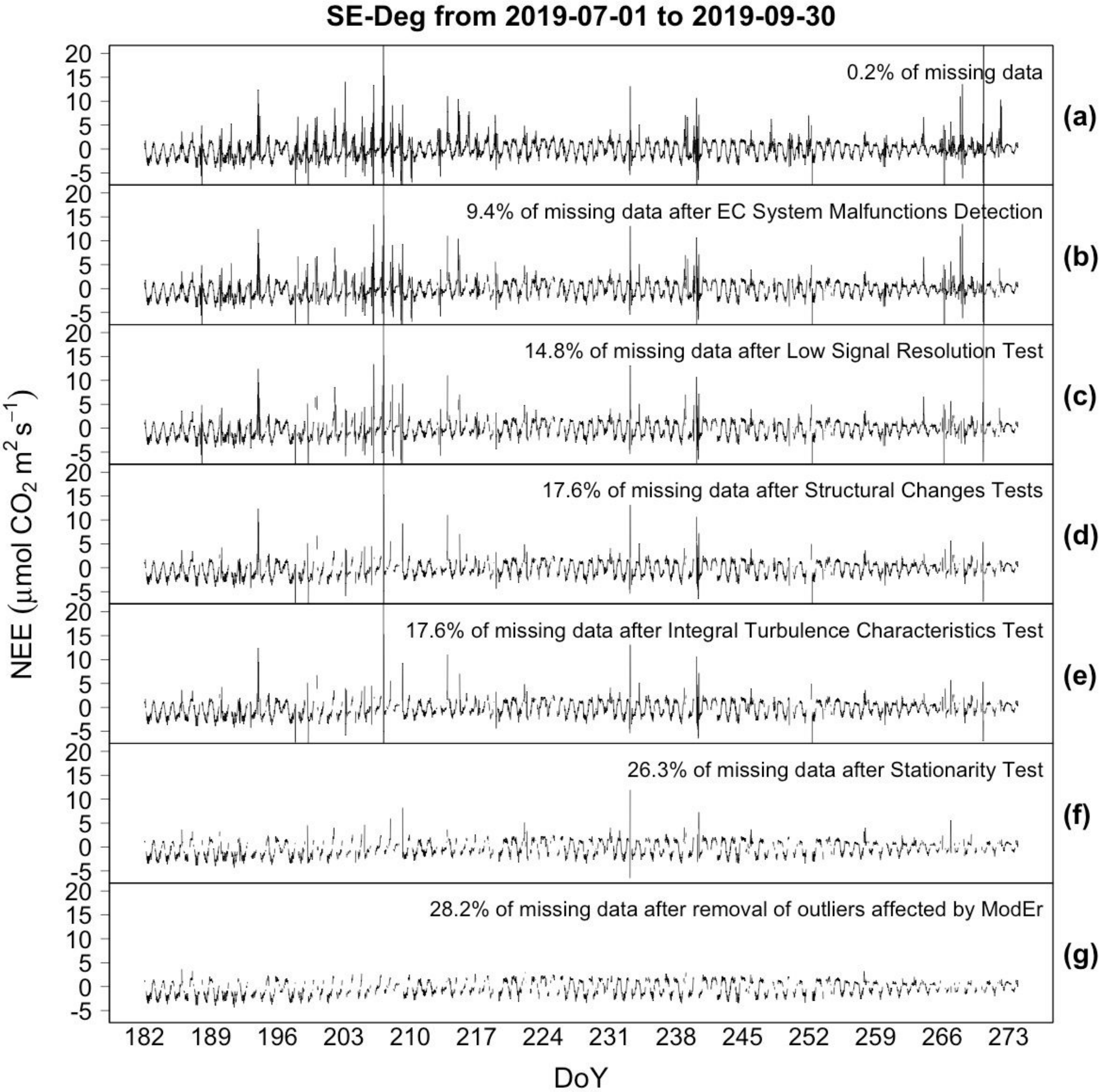


Figure 10 Summary of the data cleaning procedure applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at SE-Deg site from 2019/07/01 to 2019/09/30. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe 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-d) instrumental problems detection (Vitale et al, 2019); (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 3 months (93 days) of QC filtered data (see previous Section). The model by Klijun et al. (2015) were used to obtain the 2-dimensional flux footprint for each half-hour, which was compared to the TA spatial extent. After the QC procedure and additional filtering according to footprint model requirements, the 41% of the data was used for the test.

Results showed that the whole data, each half-hourly flux, have a cumulative contribution of at least 70% from the TA (Figure 11, leftmost bars block), and this holds for daytime and nighttime periods too. The test was performed on 4 sub-periods of similar length and results confirmed the percentages obtained on the whole dataset (Figure 11).

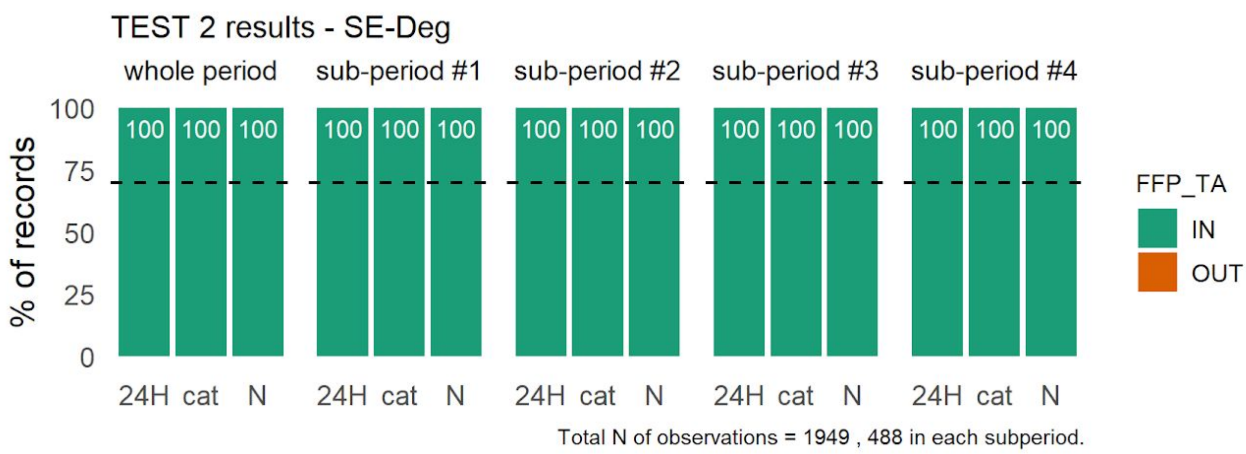


Figure 11: Test 2 results obtained over the whole period (leftmost block) and sub-periods, showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value (dashed horizontal line) is that 70% of data (half-hourly fluxes) must hold this condition. The analysis was done considering both the whole day ('24H') and daytime and nighttime separately ('D' and 'N' respectively).

The footprint climatology for SE-Deg, estimated over the period under consideration is reported in Figure 12, by which it is possible to notice that the 70% footprint cumulative contribution (even 80% actually) is always included in the TA. According to these results, the test is passed.

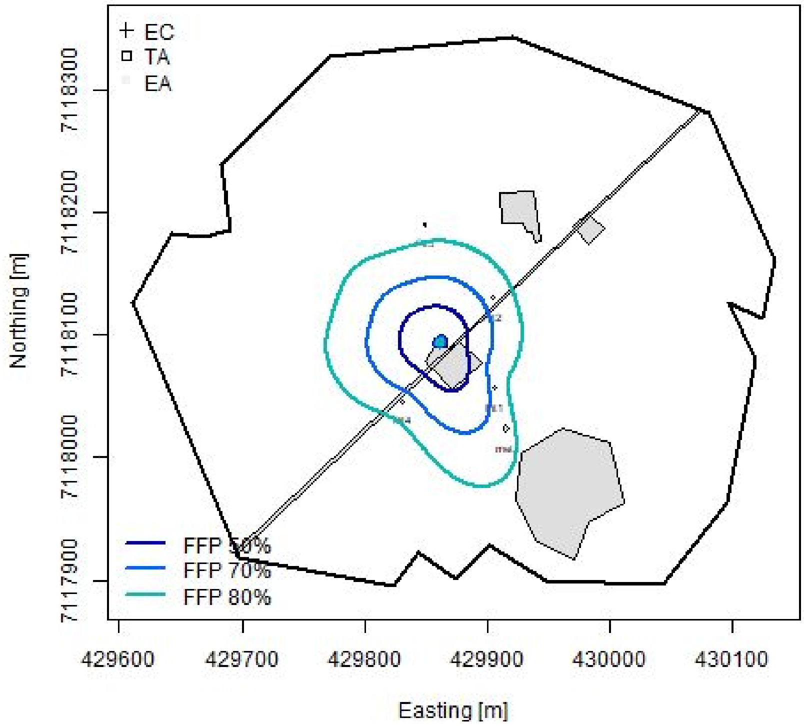


Figure 12: Footprint climatology at SE-Deg in relation to the TA, the EC tower (EC), and the excluded areas (EA, see the spatial sampling Section). The 50, 70 and 80 % cumulative contribution isopleths are reported.

Data representativeness analysis (Test 3)

This test aims to evaluate the representativeness of the possible different land cover tipologies inside the Target area (TA).

At SE-Deg, according to the spatial heterogeneity characterization and the ancillary plot representativeness (Test 4 Section below), the entire TA was considered as homogeneous in terms of vegetation/soil contribution to fluxes, and the Test 3 became then unnecessary.

Ancillary plot representativeness (Test 4)

The station team has collected in summer and autumn 2018 all the measurements needed for the representativity tests. For mire stations such as SE-Deg, it is not the standard test described in the Introductory section of the report that is applied. Instead, each candidate CP is checked by running the same TWINSPAN cluster analysis as ran for the classification of site characterization plots into groups, but with that candidate CP included in the input data set. It is then checked to which group the CP is assigned by the TWINSPAN algorithm and whether this group corresponds with the target group for that CP, if such target group was defined. This is the outcome of the test for the 16 candidate CPs installed in the SE-Deg target area (groups are named group 1 to 4 until a PCT terminology for the groups is suggested by the station team):

- group 1: no CPs
- group 2: CP_01, CP_03, CP_04, CP_07, CP_09, CP_12
- group 3: CP_02, CP_05, CP_06, CP_08

- group 4: CP_02, CP_10, CP_11, CP_13, CP_14, CP_15, CP_16

Based on this classification, the ETC accepts the 16 candidate CPs even though none of the candidate CPs was assigned to group 1. This group represents the plant community type associated with the driest zones in the target area. These zones are not found in the central and generally wetter part of the target area where the EC tower is located (see Figure 8), and it can therefore be expected that their contribution to the sensed EC fluxes will be limited. For this reason, the ETC accepts the set of candidate CPs while group 1 is not represented. If further flux analyses reveal that the contribution if the dry zones is significant, it must however be discussed later to add CPs that represent the driest PCT.

Near Real Time data transmission

The station is sending EC files to the CP since the end of September 2018 using a Campbell Scientific CR6 logger. The EC files were made compliant after correcting some inconsistencies and removing the internal header. The ETC accepted the exception of having one variable (sonic diagnostic) between double quotes. Also the SAHEAT files are compliant. BM and ST files were also sent for the format check, and after correcting few inconsistencies they all got the green light for the submission to the Carbon Portal, with the exception of some soil files, received for the check on October 2019: they got some out-of-range errors for SWC and WTD, and the reason for that is the presence of free water. ETC accepted this for SWC sensors, but found out WTD measurements are bad due to an error in the logger program. The ETC and the station team agreed that the green light will be given even with out-of-range values for SWC, but only after the WTD will be corrected. The station planned this correction for the week 28th Oct - 1st Nov 2019, and the ETC accepted. The station started indeed the submission of compliant BM and ST files to the CP on Sep. 5th, and of EC files on Sep. 29.

The daily checks made by the ETC highlighted few issues that were solved by the station, like some missing values in the raw data and the merging of two consecutive EC files leading to a big file one hour long.

All the Swedish stations collect EC files using a Campbell CR6. The ETC acknowledged that the sync test for all the Swedish stations can be done once at one station: SE-Htm was selected, and the results apply then also for SE-Deg. The sync test checks the synchronisation between the sonic and the IRGA time series by sending the analog signals of one (or both) the instruments to the other one. In that way, the analog and the digital version of the set of variables coming from one (or both) the sensors are in the same data stream and the lag can be easily found by maximising the covariance between each couple of homologous (digital and analog) variables sent. The ETC asked to do the test on a series of half-hourly files (for 1 or 2 day), as those created for ICOS, and on a single, 2 or 3-day long file, to check if the drift is present on a longer period and not evident in the half-hourly files. The program of the logger/PC has to be the same used in the normal data acquisition, except for the changes needed in order to have the analog variables and to have the desired length of the files. The interest is uniquely on the drift between the timeseries, as an offset is expected due to the electronics involved, and will be easily corrected during the processing. The tests are based on the paper Fratini et al., 2018.

Test results on the half-hourly files

144 half-hourly, 20-Hz consecutive files (three days) were available for the test, containing the SAT analog values. The results of the sync test were positive, even if an offset was evident in all of the files sent: the SAT analogue variables, traveling together with the GA digital values, had a delay of about 1.2 seconds in respect of the digital ones. This offset was constant though, except for some fluctuations on the order of +-0.05 s. 2 to 4 exceptions for file are present, mostly due to the impossibility of the script to find the extremum of the covariance in the selected window, likely due to noisy data. This constant offset however will be easily corrected during the processing, then it does not constitute an issue. Overall, the program of the logger was able to contain the occurrence of the expected drifts between the clocks of the IRGA and the SAT within the range of 2 step (+-50 ms). Figure 13 shows the lag for the first 35 files.

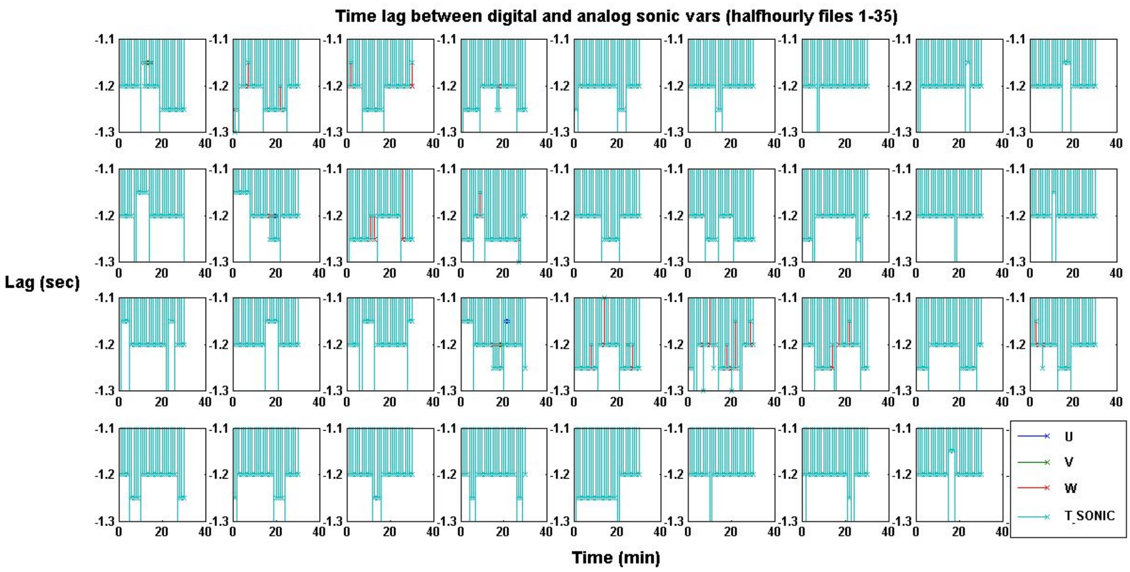


Figure 13 - Time lag between analog and digital signals from the sonic anemometer. File 1-35

The same applies considering the 3-day-long file: after synchronising the beginning of the timeseries, the lag found was constant between -0.05 and 0.05 seconds (Figure 14)

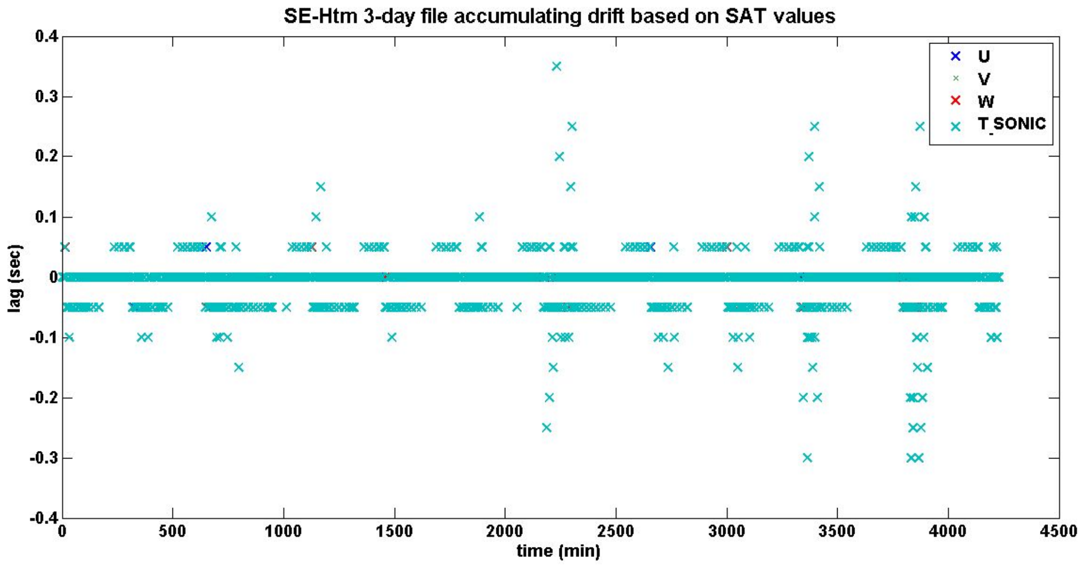


Figure 14 - Accumulating time drift between analog and digital signals from the sonic anemometer.

A discussion with the station team was also taken to understand how the code works. For each sensor, a buffer is present. Every 50 ms, dictated by the logger clock, the buffer is opened and the “older” data present there are taken. If the clocks of the instruments are synced, the buffer will always be filled and the data synced. If one of the clocks is faster, its buffer will empty faster: when below a threshold, the data are not taken and NaN recorded in file. As jitter is present, to check if the threshold is reached the median over 2 seconds is used. This results in logger skipping one measurement every 30 minutes approx from the IRGA. Also, if the buffer is full, the extra measurements will not be recorded. The results of the test are compliant with the strategy described. Overall, potential drifts seem to be corrected, and the test is considered passed for the labelling. However, due to the complexity of the code and the presence of some points with higher lag, the ETC reserves the right to ask in the future further clarifications and modifications.

References

Fratini, G., Sabbatini, S., Ediger, K., Riensche, B., Burba, G., Nicolini, G., ... & Papale, D. (2018). Eddy covariance flux errors due to random and systematic timing errors during data acquisition. Biogeosciences, 15(17), 5473-5487.

Plan for remaining variables

<u>Soil sampling</u>

It seems not feasible to monitor the soil organic matter changes in such a station because the entire area targeted is not accessible and pile of organic matter accumulated in the mire peat is huge (see figure below). ETC has proposed to simplify the soil characterisation and give up the assessment of putative changes in the stock of soil organic Carbon and Nitrogen in this site.

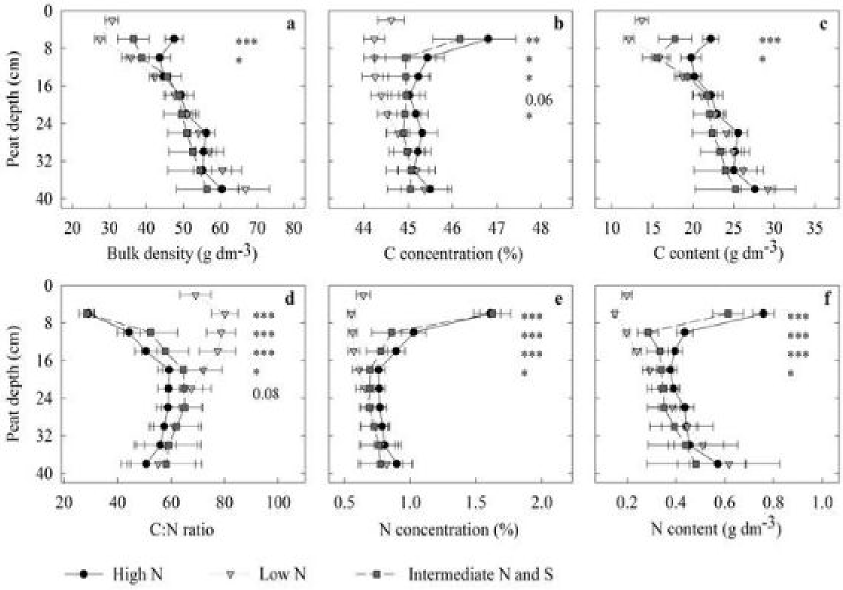


Figure 15. Examples on the vertical (0-40 cm) depth profiles of C, 13C, N and 15N from surface peat cores after 10 years of field manipulations. The figures are from a field manipulation experiment at SE-Deg just a few 100 m away from the ICOS mast. The lower panels are So this kind of vertical high resolution surface peat cores might provide useful information within the ICOS life time. This will give information on potential changes in the C and N input to the long-term mire peat, i.e. from the acrotelm into the catotelm, though not information on changes in the total C and N stocks, which will not at all be possible to detect over 10-20 years time. Below are also some profiles based on eight peat cores collected ~50 m away from the ICOS mast.

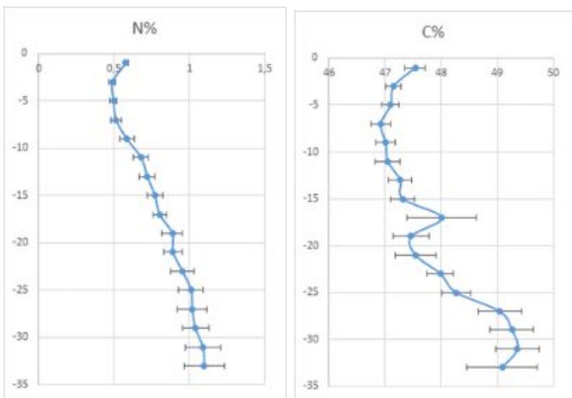


Figure 16. Examples on the vertical depth profiles (n=8) of C, N, 13C and 15N down to 35cm collected adjacent to the SE_Deg CP point

The station team proposed to collect peat cores at 10-15 of the locations used for vegetation inventory. Cores will be taken with a sampler giving high accuracy in sample volume determination, i.e. minimal compaction due to the sampling, the peat sampler proposed being specifically developed for very soft surface peats (Clymo et al. 1988).

At each location , the peat profile will be subsampled for vertical high resolution C- and N-profiles. The peat cores are sliced into four cm sections down to 60 cm, i.e. well into the permanently water saturated, anoxic zone. This will give 15 samples per core for C- and N-analyses and in total 150-225 samples depending on the number of peat cores. This sampling scheme once agreed with soils and laboratory experts would be conducted by summer 2019. It will not allow to determine the organic C and N stocks with sufficient accuracy for monitoring stock changes but will provide relevant information on element ratio and basic density that ICOS may use to contribute to understanding the carbon and nitrogen cycles and related impacts on GHG atmospheric exchanges.

Clymo, R. S. 1988 A high-resolution sampler of surface peat FUNCTIONAL ECOLOGY 2:425-431

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 Degero (SE-Deg is labelled as ICOS CLASS 2 Ecosystem station.

October 28th 2019

Dario Papale, ETC Director