ICOS Ecosystem Station Labelling Report

Station: CH-Dav (Davos)

Viterbo (Italy), Antwerp (Belgium), Bordeaux (France), November 18th 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 February 20th 2016 and got the official approval on April 27th 2016. The Step2 started officially on November 16th 2016 with a specific WebEx between the ETC members and the station team members where the overall procedure was discussed and explained.

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

<u>Data evaluation</u>

Stations entering Step2 have been already analyzed during Step1 of the labelling but the optimal configuration and the possible presence of issues can be checked only looking to the first data measured. For this reason a number of tests will be performed on the data collected during the Step2 (NRT submissions, that can be integrated if needed by existing data) and the results discussed with the PI in order to find the best solution to ensure the maximum quality that is expected by ICOS stations. Four tests are performed:

Test 1 - Percentage of data removed

During the fluxes calculation the raw data are checked by a number of checks 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 Davos, with ICOS code CH-Dav, is located in the eastern part of the Swiss Alps, in the Canton of Graubünden. The site is a evergreen needleleaf forest in sub-alpine ecosystem with coordinates in WGS84 system: Latitude 46.81533 °N, Longitude 9.85591 °E. The elevation is 1689 m above sea level and the offset respect to the Coordinated Universal Time (UTC) is equal to +01. The site is marked by the following climate characteristics: Mean Annual Temperature 4.1 °C, Mean annual Precipitation 833 mm, Mean Annual Radiation 151 W m^{-2}. The coniferous forest is dominated by Norway spruce (*Picea abies* (L.) Karst.) with a maximum canopy height of 27 m, and a leaf area index of about 3.9 m^2 m^{-2}. Tree age of the dominant trees ranges between 250 and 400 years. The understorey vegetation is rather patchy, covering roughly 30% of the forest floor, and is mainly composed of dwarf shrubs, primarily *Vaccinium myrtillus* L. as well as mosses.

Figure 1: the CH-Dav tower.

Team description

The staff of the site has been defined and communicated in August 2017 and updated at a later date. It includes in addition to the PI, one CO-PI, one Manager, the technical-scientific staff and administrative person. Below the summary table of the Team members is reported.

MEMBER_NAME	MEMBER_INSTITUTION	MEMBER_ROLE	MEMBER_MAIN_EXPERT
Lukas Hörtnagl	ETH Zurich	PI	DATAPROC
Roman Zweifel	WSL Birmensdorf	CO-PI	LOGISTIC
Mana Gharun	ETH Zurich	MANAGER	DATAPROC
Werner Eugster	ETH Zurich	SCI	MICROMET
Arthur Gessler	WSL Birmensdorf	SCI	LOGISTIC
Christian Ginzler	WSL Birmensdorf	SCI	DATAPROC
Maria Schmitt Oehler	WSL Birmensdorf	SCI	BIOMASS
Anne Thimonier Rickenmann	WSL Birmensdorf	SCI	PLANT
Sophia Etzold	WSL Birmensdorf	SCI-ANC	DATAPROC
Käthi Liechti	WSL Birmensdorf	SCI-ANC	BIOMASS
Peter Waldner	WSL Birmensdorf	SCI-ANC	PLANT
Stephan Zimmermann	WSL Birmensdorf	SCI-ANC	SOIL
Thomas Baur	ETH Zurich	TEC	LOGISTIC
Alexandra Glauser	WSL Birmensdorf	TEC-ANC	BIOMASS
Mattias Häni	WSL Birmensdorf	TEC-ANC	DATAPROC
Christian Hug	WSL Birmensdorf	TEC-ANC	BIOMASS
Roger Köchli	WSL Birmensdorf	TEC-ANC	SOIL
Simpal Kumar	WSL Birmensdorf	TEC-ANC	DATAPROC
Stefan Peter	WSL Birmensdorf	TEC-ANC	SOIL
Tanja Stutz	WSL Birmensdorf	TEC-ANC	SOIL
Flurin Sutter	WSL Birmensdorf	TEC-ANC	DATAPROC
Marco Walser	WSL Birmensdorf	TEC-ANC	SOIL

Philip Meier	ETH Zurich	TEC-FLX	MICROMET
Nina Buchmann	ETH Zurich	ADMIN	LOGISTIC
Susanne Burri	ETH Zurich	ADMIN	SOIL

Table 2 - Description of team members roles at CH-Dav

Spatial sampling design

The spatial sampling design at CH-Dav went through several discussion steps because some site characteristics prevented the standard implementation of the ICOS protocol. Mostly resulting from permission restrictions, they can be summarized as follows:

1. constraints on permanently mark the points in the field
2. constraint on the target area
3. constraint on CP positioning

1. This point was resolved by permanently mark the points and the centre of each SP-I plot with a metal pole completely digged in the soil and not visible above ground. By combining the use of a metal detector, the GPS and the panoramic images, the exact SP-I centre points would easily be found.

2. The sampling activity outside a certain area around the tower (see Fig. 3) is not allowed by forest owners, so the station team originally proposed a TA which was too small (less than 1 Ha) to extract the points locations according to ICOS requirements. The PI and ETC agreed to consider a wider TA (see Fig. 2, grey area), and then ask for exceptions on sample in certain locations. This was agreed by the ETC responsible for soil sampling too.

3. The station team originally proposed 4 CPs, but were not compliant with ICOS requirements (some overlapped, one of them was too close to the EC tower). In a first stage it was agreed to move the centers of 4 CPs and avoid the overlap, but still include respective pre-existing forest floor measurements. In a second stage the station team reported that, given that parts of the CP areas extended over the allowed area, it was impossible to perform regular inventories (because *i.* the trees cannot be marked visibly making regular assessment of specific trees extremely uncertain, *ii.* the slopes at the site are steep and under these very difficult conditions field releves without reliable tree identification will cause extremely high errors, and *iii.* they do not have an official permission from the forest owners to do any assessments in that particular part of the forest, which might prevent any long-term inventory outside the core site).

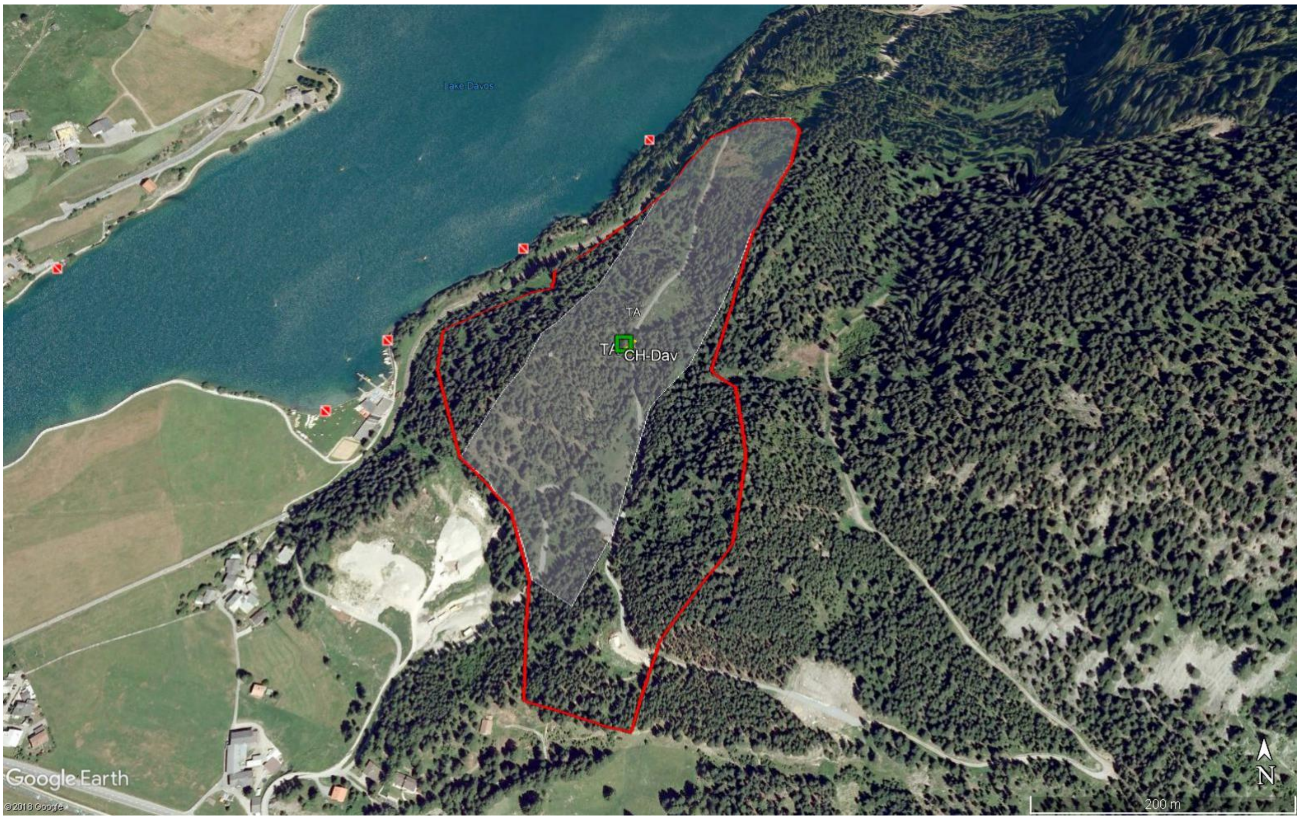


Figure 2: Aerial map of CH-Dav and proposed spatial features. The grey area represents the originally agreed TA (surface is 8.88 Ha, with a total excluded area is of 0.79 Ha. In a later stage, the TA was extended and agreed in order to better envelop the footprints in all the atmospheric conditions.

Considering the issues above and the required exceptions, it has been agreed that (Fig. 3 and 4):

- divide the area on the west side of the road in 4 plots of 2000 m² (the surface of a standard CP in ICOS) to use as CP (in light blue in the figures).
- DHP locations must be displaced according to systematic grid with 15 m distance between points (in yellow CPx_DHP-yy, in Fig. 3 left panel). The rules to set the points were: i) point on a 15 m grid, ii) point >5 m away from road, iii) point not in an area which should not be entered, iv) using existing DHP points (in red) when close to the new grid. The requested number of points (9) have been placed into each CP plot by moving some of the points slightly off the grid.
- litter trap locations locations must be displaced according to systematic grid with 20 m distance between points (in green triangles in Fig. 3). The requested number of 5 traps was placed within each plot.

With these exceptions the station will measure the needed ICOS ancillary information but will not be fully coherent with the remaining part of the network and this must be considered in the data use, in particular in relation with Remote Sensing activities.

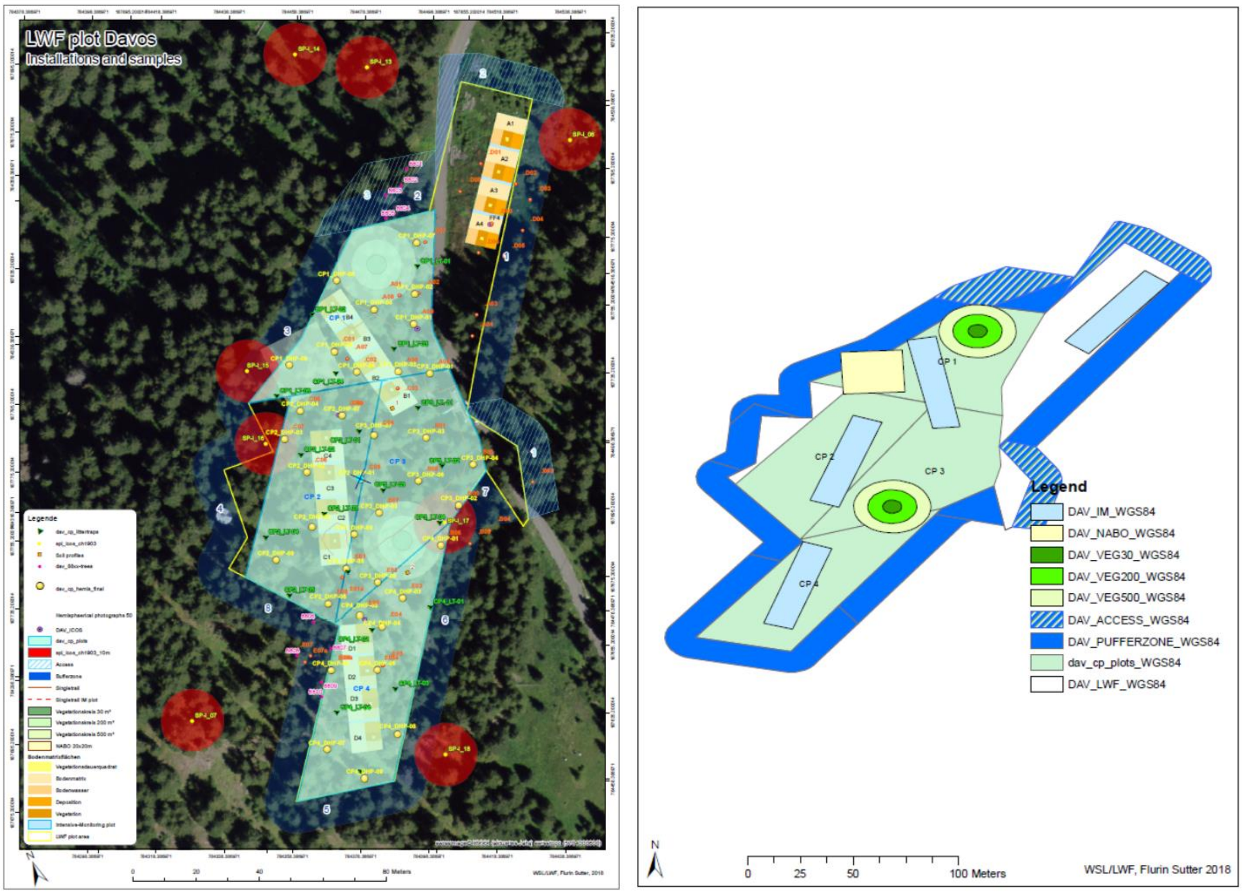


Figure 3: *left panel*: CH-Dav proposal for exceptional CP shape, buffer zone, pre-existing measurements points and some of the SP-I locations sampled by ETC. *right panel*: map zoom on the buffer zone area (where measurements are allowed), pre-existing plots (rectangular and cIrcular areas) were considered as exclusion areas, along with some zone of the buffer area (shaded areas).

In addition, concerning the impossibility to achieve any sampling activity into the CP areas, ETC exceptionally located the points on which to perform the understory biomass measurements, within an accessible buffer zone (blue area in Fig. 3 right panel). Such points have been extracted randomly into areas in correspondence with the 4 CP (Fig. 4). The respective polar coordinates and N/E distances were calculated using the CP centers as reference, on turn computed as the centre-of-mass of the CP polygons.

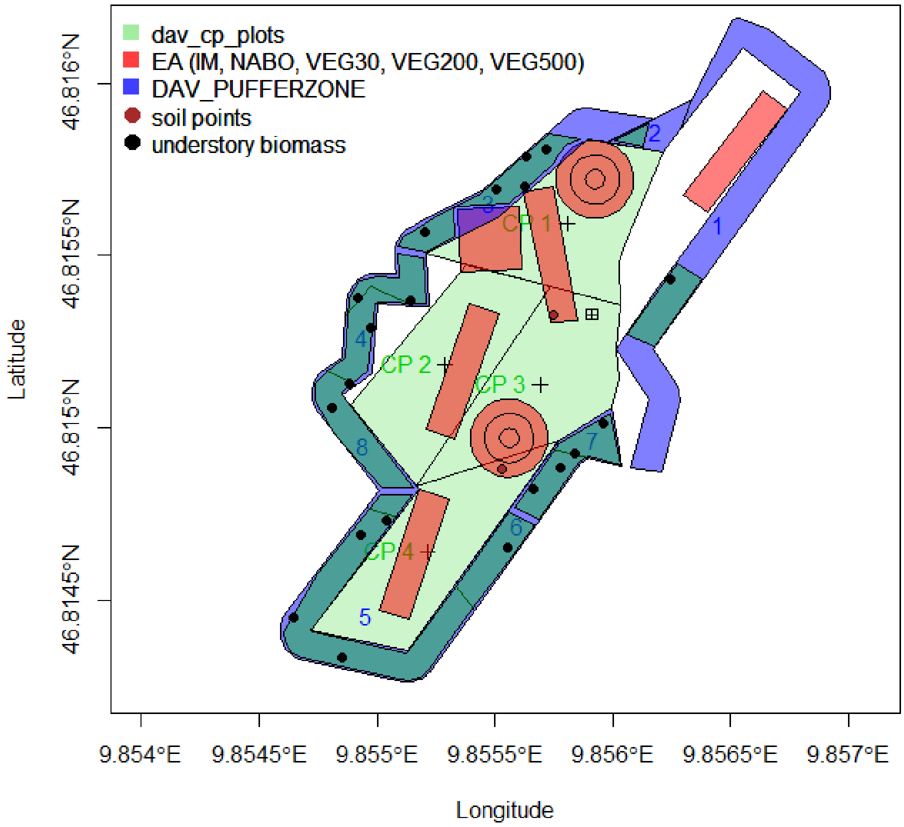


Fig. 4: understory biomass points (5+5 in correspondence of each CP) sampled by ETC within the buffer area, according to CH-Dav constraints.

All the agreed exceptions will be re-evaluated by ETC in terms of their actual representativeness and compliance with the ICOS sampling strategy.

After having mapped the originally sampled SP-I and SP-II (agreed to use 3 out of 5 SP-II at each SP-I), the SP-I radius requirement was updated from 10 to 15 m. As a consequence 8 SP-I became partially overlapped. In a first stage it has been agreed that one of the overlapping SP couples must be moved along the axis of the two centre points (SP-I_4, SP-I_14, SP-I_15, SP-I_20) until it is 31 m far from the neighbor's centre point. However, the test on footprints (see the Data check and test Section) failed considering the proposed TA (grey area in Fig. 2). Hence, it was agreed to enlarge again the TA toward S-E and W, and to move the 4 SP-I overlapping into these new 2 areas (Fig.5). The points were again mapped in the field and are now definitive.

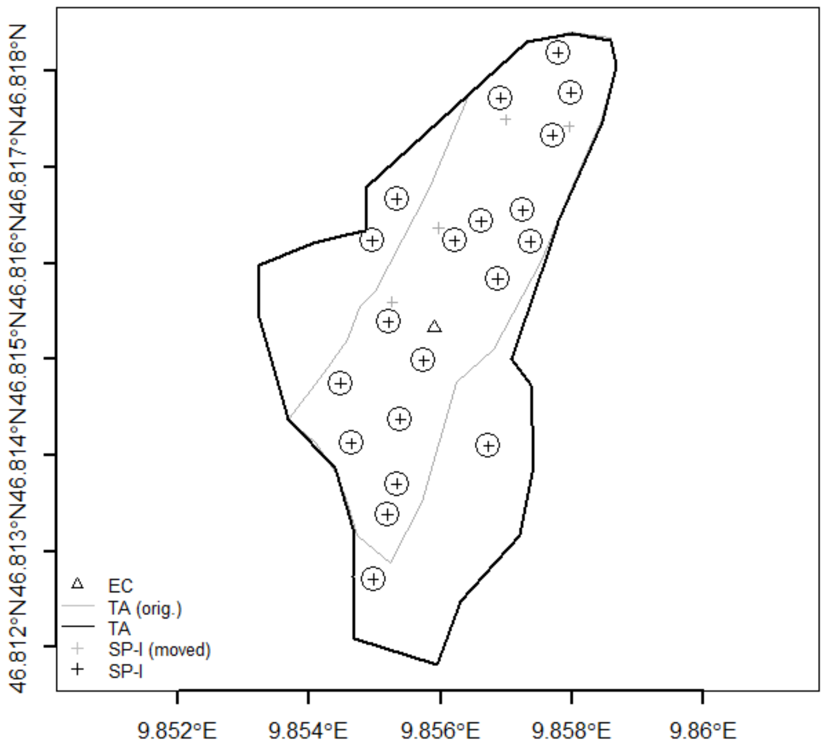


Fig. 5: CH-Dav map with the further enlarged TA and definitive SP-I points.

Station implementation

Eddy covariance:

EC System		
MODEL	GA_CP-LI-COR LI-7200	SA-Gill HS-50
SN	72H-0215	H140505
HEIGHT (m)	35	35
EASTWARD_DIST (m)	0	0
NORTHWARD_DIST (m)	0	0
SAMPLING_INT	0.05	0.05
LOGGER	1	1
FILE	5	5
GA_FLOW_RATE	12	-
GA_LICOR_FM_SN		-
GA_LICOR_AIU_SN	AIU-0419	-
SA_OFFSET_N	-	270
SA_WIND_FORMAT	-	U, V, W

SA_GILL_ALIGN	-	Axis
ECSYS_SEP_VERT	-0.012	
ECSYS_SEP_EASTWARD	0.142	
ECSYS_SEP_NORTHWARD	0.01	
ECSYS_WIND_EXCL		
ECSYS_WIND_EXCL_RANGE		

The EC sensor models required in ICOS (ultrasonic anemometer Gill HS and infrared gas analyser LICOR LI-7200) are present at CH-Dav station since July 2014. IRGA was calibrated on April 2018, and the ETC accepted the plan of the PI to calibrate the sonic during winter 2019-2020, or as soon as a new agreement is found between the Gill and the ETC. The PI also communicated the possibility of installing an additional sonic near the main one for the summer time in case of downtime of the main one. The ETC accepted provided that the new sonic is not disturbing the main one. Also, the ETC will not process these data as they are not easily usable in the place of the main one in short periods/insulated half hours. The ICOS system is installed at 35 m height, as agreed in Step1. After the first period of data submission, ETC found an error in the wind direction due to a bad configuration of the sonic: after a long period of discussion which included a test on a HS-50 made by the ETC, the correct settings were agreed (sonic configuration: Axis, north offset: 270°), even if slightly different from what agreed during the Step1. The PI upgraded the firmware of the IRGA, and will update the BADM soon. The EC system is considered the reference point of the station.

Storage: The storage system is mandatory at CH-Dav and it has been agreed and approved after a very useful discussion between the Station Team and the ETC. The instrumentation is ICOS compliant and mainly consist of a gas analyzer (LI-840, *Li-Cor*), air temperature and relative humidity sensors (*Rotronic* HygroClip2 S3), line pressure sensor (*Keller* PAA X33), 2 line flow meters (*Voegtlin* red-y GSM-C9SA-C00 before the analyser and a custom made digital flow meter for each inlet line using *Sensirion* SDP800). Sampling lines are made by aluminum cored synflex tubing with a PE-foil as the innermost layer. All inlet tubes have the same length of about 56 m. Overlength tubing is reeled up in a temperature controlled cabinet to avoid condensation inside the tubes. All inlets are equipped with a custom made rain cup containing a stainless steel bug screen and a 0.5 micron PTFE filter membrane. Tubes connections are made by stainless steel Swagelok-fittings. Switching between levels (valves channels) is done by *Valco* VICI 16-fold selectors, solenoid valves (*Parker* Series 9) and Swagelok PTFE-sealed ball-valves. The sampling pump is an *EBARA* EV-A06 dry-pump.

Concerning the sampling scheme, the PI originally proposed to use the 'sequential' scheme with a single analyzer to be used in sharing for soil chamber fluxes and EC fluxes (also measuring methane and nitrous oxide). Although the scheme is appropriate for the ecosystem and has been agreed, the sampling approach was rejected by the ETC. At the end of the discussion it has been agreed that the IRGA will be used to sample both the storage profile and soil chambers, optimizing the timing according to the scheme below (Figure 6). Currently, only CO_2 is of concern, N_2O and CH_4 measurements are possibly postponed (a dedicated sampling system has been designed already and will be further discussed before approval). The system is in place and ready to start the sampling.

1 half-hour, minutes	5	10	15	20	25	30
storage measurement	yes	yes	no	no	yes	yes
1 chamber measurement	no	no	yes	yes	no	no

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
00:00	C1	C4	C2	C5	C3	C1
00:30	C2	C5	C3	C1	C4	C2
01:00	C3	C1	C4	C2	C5	C3
01:30	C4	C2	C5	C3	C1	C4
02:00	C5	C3	C1	C4	C2	C5
02:30	C1	C4	C2	C5	C3	C1
03:00	C2	C5	C3	C1	C4	C2
03:30	C3	C1	C4	C2	C5	C3
04:00	C4	C2	C5	C3	C1	C4
04:30	C5	C3	C1	C4	C2	C5
…	…	…	…	…	…	…
20:00	C1	C4	C2	C5	C3	C1
20:30	C2	C5	C3	C1	C4	C2
21:00	C3	C1	C4	C2	C5	C3
21:30	C4	C2	C5	C3	C1	C4
22:00	C5	C3	C1	C4	C2	C5
22:30	C1	C4	C2	C5	C3	C1
23:00	C2	C5	C3	C1	C4	C2
23:30	C3	C1	C4	C2	C5	C3

Figure 6: agreed timing for storage and chamber flux measurement at CH-Dav. The 5 chambers would be measured sequentially each day (C=chamber).

The PI proposed a profile configuration based on 9 levels (according to an exponent *a* of 0.618), with the lowest 2 levels sampling from 4 ramified points. According to the EC measurement height, and considering *a* = 2/3 as recommended, the proper number of points should be 10 (or 11 even better). However, also in consideration of technical constraints, ETC agreed that 9 heights can be sufficient at the site, and have thus been accepted. Concerning their vertical distribution, after evaluating pro and cons of other design in agreement with the PI, ETC agreed to use the original (adjusted after *b*=2) vertical design because of its balanced distribution of sampling points. The definitive heights are then: 0.43, 1.73, 3.89, 6.91, 10.80, 15.56, 21.17, 27.65 and 35.00 m for levels from 9 to 1.

Air will be sampled with a flow of 1 slpm for each line. The buffers volumes (4.75 L) will be in a cabinet at ~20 °C. The median integral time scale at the site is around 21 s, therefore the station team proposed a buffer constant of 210 s, which has been agreed by ETC. For the lowest inlet heights which are 4 inlets in a ramified setup, the total flow and thus the buffer scales with 4 leading to 19 L. Buffer volumes are stainless steel cylinders, each equipped with a Bosch BME280 p-T-rH sensor for monitoring purposes.

Radiations:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R

RAD_4C-K&Z CNR4	160819	35	0	0	SW_IN_1_1_1
					LW_IN_1_1_1
					SW_OUT_1_1_1
					LW_OUT_1_1_1
RAD_PAR-K&Z PARLITE	050602	35	0	0	PPFD_IN_1_1_1
RAD_PAR-K&Z PARLITE	050611	35	0	0	PPFD_OUT_1_1_1
RAD_PAR-DeltaT BF5	81/02	35	0	0	PPFD_DIF_1_1_1

For SW-LW radiations the CNR-4 (*Kipp & Zonen*) pyranometer will be used in combination with the CNF4 ventilation and heating unit. For PPFD, the PI proposed to use the PAR Lite (*Kipp & Zonen*) quantum sensor, a discontinued product. While ETC encouraged to install the upgraded version of the sensor (e.g. PQS1 model), decided to accept the use of PAR Lite as exception. A further exception has been agreed for what it concerns the diffuse PPFD: the PI proposed to use the *BF5* (Delta-T), a not fully-compliant sensor, in combination with the main PPFD sensor *PAR Lite* mounted close to each other. ETC accepted this approach.

The CNR-4 was bought in Mar/Apr 2017, the BF-5 in Oct/Nov 2017, so at the moment there is no need to calibrate them. The PAR LITE were bought in 2015, and has been agreed that the factory calibration will be done in Fall/Winter 2018.

Precipitation:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
PREC-Lambrecht 1518x	empa_5708330001	20	0	0	P_1_1_1

For total precipitation CH-Dav will use the rain[e]H3 (*Lambrecht*) weighing gauge. The PI proposed to perform precipitation measurement at an height of 25 m, along a tower. Originally the PI proposed to avoid the use of the windshield because of the natural protection of the surrounding trees. Given that there is no alternative location to perform the precipitation measurements elsewhere, it has been agreed that the gauge would be installed along the tower, though shielded by an Alter type windshield. The Station Team built and mounted an Alter type windshield in aluminium (Fig. 7)

Figure 7: Pictures of the aluminium windshield installed at Davos.

For snow depth measurement the PI originally proposed to use digital cameras images only. Given the importance of snow at the site (continuous snow cover from Nov/Dec until April), ETC suggested to use the cameras pointing the snow-rods in addition to a sonic/laser sensor. PI agreed with this solution and decided to use, the laser sensor model SHM30 (*Campbell Sci.*), mounted on a turnable head (measuring the snow height around the location where it is mounted, i.e. it rotates from left to right, pointing downwards). However, after discussion with ETC and a measuring test period, the Station Team discovered a malfunctioning in the mechanical part of the device. Consequently, the PI decided to remove the laser sensor and install a compliant sonic sensor in agreement with the ICOS standards (the model must be communicated to ETC when the sensor will be installed).

<u>Air temperature, relative humidity and air pressure</u>

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RHTEMP-Rotronic HC2(A)-S	60953556	1	0	0	TA_1_1_1
					RH_1_1_1
RHTEMP-Rotronic HC2(A)-S	60953557	2	0	0	TA_1_2_1
					RH_1_2_1
RHTEMP-Rotronic HC2(A)-S	60953554	10	0	0	TA_1_3_1
					RH_1_3_1
RHTEMP-Rotronic HC2(A)-S	60953552	20	0	0	TA_1_4_1
					RH_1_4_1

RHTEMP-Rotronic HC2(A)-S	60953553	25	0	0	TA_1_5_1
					RH_1_5_1
RHTEMP-Rotronic HC2(A)-S	61184540	35	0	0	TA_1_6_1
					RH_1_6_1
PRES-Keller PAA33x	615700	*NA*	0	0	PA_1_1_1
WDWS-Gill WindsonicX	8390024	1	0	0	WD_1_1_1
					WS_1_1_1
WDWS-Gill WindsonicX	8390025	2	0	0	WD_1_2_1
					WS_1_2_1
WDWS-Gill WindsonicX	10170053	10	0	0	WD_1_3_1
					WS_1_3_1
WDWS-Gill WindsonicX	10170054	20	0	0	WD_1_4_1
					WS_1_4_1
WDWS-Gill WindsonicX	8390023	25	0	0	WD_1_5_1
					WS_1_5_1

The sensors proposed and installed for TA, RH and PA (Rotronic HC2(A)-S and Keller PAA33x) are compliant with ICOS, including the profile used for the calculation of the storage (all Rotronic HC2(A)-S). According to the BADM group INST, the instruments for TA and RH have been purchased more than 2 years ago, and no factory calibration has occurred since then. The station team is planning to perform the calibration during winter 2019-2020, and the ETC accepted. The PA sensor is brand new and then there is no need for calibration. The PI agreed with the ETC to move the PA sensor closer to the EC system, and/or to install a pressure head on it, however the sensor height has not been reported yet and will be done before the end of 2019. The station has also a wind profile installed, composed of all ICOS-compliant sensors, whose calibration expired in 2015: the ETC recommended to the PI to plan their calibration; however, these variables are not requested to complete the Labelling procedure.

Backup meteorological station

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RHTEMP-	MeteoSwiss_Backup	2	-245	-960	TA_3_1_1

Meteolabor Thygan VTP	Meteo_92				RH_3_1_1
PREC-Lambrecht 1518x	MeteoSwiss_Backup Meteo_730221.0007	2	-245	-960	P_3_1_1
RHTEMP-Rotronic HC2(A)-S	empa_20257222	35	0	0	TA_1_6_2
					RH_1_6_2
RAD_SW-K&Z CM21	MeteoSwiss_Backup Meteo_51429	2	-245	-960	SW_IN_3_1_1
RAD_SW-K&Z SMP21	180032_NABEL	35	0	0	SW_IN_4_1_1

The PI argued that they cannot build an independent station, and proposed to use data from a station closeby held by the local meteorological station (MeteoSwiss, independently powered and logged). An agreement with the meteorological company has been found by the PI so that these data can be shared as ICOS data. Despite the sensors were ICOS compliant (all but the temperature sensor, but exception was accepted), the format of the files would have been different from ICOS requirements: the ETC accepted the proposal of the PI to post-edit the files to make them compliant. However, the time resolution of these files is much lower (10 minutes) than ICOS standards (20 to 60 seconds). The ETC proposed as a trade off to use these data only in case of a blackout, and to have additional sensors at the station at least for TA, RH and SW_IN, sharing the power grid with the main sensors but logged independently: these additional data will be used in case of main sensors and loggers failures. The PI agreed, but in order to have them collected in a separate PC he proposed to use the data from their partner EMPA making measurements of air pollution. The sensors are mounted close to ICOS devices, and are ICOS compliant. The ETC accepted this plan. Also in that case, however, an issue in the file format was present, solved on summer 2019 for TA and RH. For SW_IN, even if a sensor accepted by the ETC was installed by the EMPA, later removed, the station team installed an additional sensor (CNR1, not compliant, but OK for backup), and the ETC accepted that this can become the definitive backup sensor. This was also removed later on, and backup SW_IN sensor became an SMP21 from Kipp & Zonen. As the preparation of this solution took some months, the ETC and the PI agreed to have a commercial station mounted at the tower, with non-compliant TA and RH sensors, as a temporary solution only. As agreed with the ETC, the commercial station was discontinued when the EMPA data became compliant (20190829). The sampling interval of the sensor for SW_IN from EMPA was set to 60 seconds as agreed with the ETC (exception accepted). For all of the above, the current backup “station” is actually made of several sensors: three from MeteoSwiss, one from EMPA and one installed by the station.

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

The station team has installed the full set of soil meteo sensors required for their Class 1 forest station. The station team has requested the ETC to be exempt from the mandatory water table depth measurements, because these measurements are not relevant at the station. Based on measurement data provided by the station team that indicate a very deep water table, the ETC has accepted this request for an exception to the ICOS Instructions: water table depth does not have to be measured at CH-Dav.

The station team installed five fully equipped soil plots around the EC tower (Figure 8). The plot locations comply with the ICOS standards, as each of the four Continuous Measurements Plots (CPs) includes a soil plot. The set-up of each soil plot, shown in Figure 9, is compliant with the ICOS Instructions in terms of sensor models, number of sensors installed and sensor depths. The station team has furthermore correctly submitted all requested metadata on the sensors, except that currently all sensors in a soil plot have been given the same spatial coordinates. The sensors of the soil water content profile, the sensors of the soil temperature profile, and the heat flux plate that are installed in the same soil plot must be given distinct coordinates, even if they are only a distance of few cm apart. The station team will submit the correct coordinates by the end of the year.

Three of the installed SWC sensors are currently defective and the ETC and the station team have agreed that these must be replaced only as soon as the snow has gone (mail 20190423). These sensors are indicated in red in the table below.

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
TEMP-Campbell CS10X	107_00020ETH	-0.03	-0.6	33.5	TS_1_1_1
TEMP-Campbell CS10X	107_00021ETH	-0.05	-0.6	33.5	TS_1_2_1
TEMP-Campbell CS10X	107_00026ETH	-0.05	-0.6	33.5	TS_1_2_2
TEMP-Campbell CS10X	107_00022ETH	-0.11	-0.6	33.5	TS_1_3_1
TEMP-Campbell CS10X	107_00023ETH	-0.21	-0.6	33.5	TS_1_4_1
TEMP-Campbell CS10X	107_00024ETH	-0.5	-0.6	33.5	TS_1_5_1
TEMP-Campbell CS10X	107_00025ETH	-0.8	-0.6	33.5	TS_1_6_1
TEMP-Campbell CS10X	107_00027ETH	-0.03	-9.2	-24.5	TS_2_1_1
TEMP-Campbell CS10X	107_00028ETH	-0.05	-9.2	-24.5	TS_2_2_1
TEMP-Campbell CS10X	107_00033ETH	-0.06	-9.2	-24.5	TS_2_2_2

TEMP-Campbell CS10X	107_00029ETH	-0.11	-9.2	-24.5	TS_2_3_1
TEMP-Campbell CS10X	107_00030ETH	-0.21	-9.2	-24.5	TS_2_4_1
TEMP-Campbell CS10X	107_00031ETH	-0.53	-9.2	-24.5	TS_2_5_1
TEMP-Campbell CS10X	107_00032ETH	-0.8	-9.2	-24.5	TS_2_6_1
TEMP-Campbell CS10X	107_00042ETH	-0.03	-34.6	17.8	TS_3_1_1
TEMP-Campbell CS10X	107_00043ETH	-0.05	-34.6	17.8	TS_3_2_1
TEMP-Campbell CS10X	107_00044ETH	-0.05	-34.6	17.8	TS_3_2_2
TEMP-Campbell CS10X	107_00045ETH	-0.11	-34.6	17.8	TS_3_3_1
TEMP-Campbell CS10X	107_00046ETH	-0.2	-34.6	17.8	TS_3_4_1
TEMP-Campbell CS10X	107_00047ETH	-0.5	-34.6	17.8	TS_3_5_1
TEMP-Campbell CS10X	107_00048ETH	-0.6	-34.6	17.8	TS_3_6_1
TEMP-Campbell CS10X	107_00049ETH	-0.02	33.5	52.9	TS_4_1_1
TEMP-Campbell CS10X	107_00050ETH	-0.06	33.5	52.9	TS_4_2_1
TEMP-Campbell CS10X	107_00055ETH	-0.05	33.5	52.9	TS_4_2_2
TEMP-Campbell CS10X	107_00051ETH	-0.11	33.5	52.9	TS_4_3_1
TEMP-Campbell CS10X	107_00052ETH	-0.21	33.5	52.9	TS_4_4_1
TEMP-Campbell CS10X	107_00053ETH	-0.51	33.5	52.9	TS_4_5_1
TEMP-Campbell CS10X	107_00054ETH	-0.66	33.5	52.9	TS_4_6_1

TEMP-Campbell CS10X	107_00129ETH	-0.02	-58	-48.8	TS_5_1_1
TEMP-Campbell CS10X	107_00130ETH	-0.05	-58	-48.8	TS_5_2_1
TEMP-Campbell CS10X	107_00135ETH	-0.05	-58	-48.8	TS_5_2_2
TEMP-Campbell CS10X	107_00131ETH	-0.1	-58	-48.8	TS_5_3_1
TEMP-Campbell CS10X	107_00132ETH	-0.21	-58	-48.8	TS_5_4_1
TEMP-Campbell CS10X	107_00133ETH	-0.5	-58	-48.8	TS_5_5_1
TEMP-Campbell CS10X	107_00134ETH	-0.75	-58	-48.8	TS_5_6_1
SWC-Meter ECH2O	00014ETH	-0.05	-0.6	33.5	SWC_1_1_1
SWC-Meter ECH2O	00015ETH	-0.05	-0.6	33.5	SWC_1_1_2
SWC-Meter ECH2O	00016ETH	-0.1	-0.6	33.5	SWC_1_2_1
SWC-Meter ECH2O	00017ETH	-0.24	-0.6	33.5	SWC_1_3_1
SWC-Meter ECH2O	00018ETH	-0.5	-0.6	33.5	SWC_1_4_1
SWC-Meter ECH2O	00019ETH	-0.84	-0.6	33.5	SWC_1_5_1
SWC-Meter ECH2O	00142ETH	-0.05	-9.2	-24.5	SWC_2_1_1
SWC-Meter ECH2O	00147ETH	-0.04	-9.2	-24.5	SWC_2_1_2
SWC-Meter ECH2O	00143ETH	-0.1	-9.2	-24.5	SWC_2_2_1
SWC-Meter ECH2O	00144ETH	-0.21	-9.2	-24.5	SWC_2_3_1
SWC-Meter ECH2O	00145ETH	-0.5	-9.2	-24.5	SWC_2_4_1

SWC-Meter ECH2O	00146ETH	-0.8	-9.2	-24.5	SWC_2_5_1
SWC-Meter ECH2O	00036ETH	-0.05	-34.6	17.8	SWC_3_1_1
SWC-Meter ECH2O	00037ETH	-0.05	-34.6	17.8	SWC_3_1_2
SWC-Meter ECH2O	00038ETH	-0.1	-34.6	17.8	SWC_3_2_1
SWC-Meter ECH2O	00039ETH	-0.21	-34.6	17.8	SWC_3_3_1
SWC-Meter ECH2O	00040ETH	-0.52	-34.6	17.8	SWC_3_4_1
SWC-Meter ECH2O	00041ETH	-0.68	-34.6	17.8	SWC_3_5_1
SWC-Meter ECH2O	00056ETH	-0.05	33.5	52.9	SWC_4_1_1
SWC-Meter ECH2O	00061ETH	-0.06	33.5	52.9	SWC_4_1_2
SWC-Meter ECH2O	00057ETH	-0.1	33.5	52.9	SWC_4_2_1
SWC-Meter ECH2O	00058ETH	-0.2	33.5	52.9	SWC_4_3_1
SWC-Meter ECH2O	00059ETH	-0.49	33.5	52.9	SWC_4_4_1
SWC-Meter ECH2O	00060ETH	-0.69	33.5	52.9	SWC_4_5_1
SWC-Meter ECH2O	00136ETH	-0.06	-58	-48.8	SWC_5_1_1
SWC-Meter ECH2O	00141ETH	-0.06	-58	-48.8	SWC_5_1_2
SWC-Meter ECH2O	00137ETH	-0.1	-58	-48.8	SWC_5_2_1
SWC-Meter ECH2O	00138ETH	-0.22	-58	-48.8	SWC_5_3_1
SWC-Meter ECH2O	00139ETH	-0.5	-58	-48.8	SWC_5_4_1

SWC-Meter ECH2O	00140ETH	-0.79	-58	-48.8	SWC_5_5_1
SOIL_H-Hukseflux HFP01SC	3860	-0.06	-0.6	33.5	G_1_1_1
SOIL_H-Hukseflux HFP01SC	3863	-0.06	-9.2	-24.5	G_2_1_1
SOIL_H-Hukseflux HFP01SC	3862	-0.05	-34.6	17.8	G_3_1_1
SOIL_H-Hukseflux HFP01SC	3864	-0.05	33.5	52.9	G_4_1_1
SOIL_H-Hukseflux HFP01SC	3861	-0.05	-58	-48.8	G_5_1_1

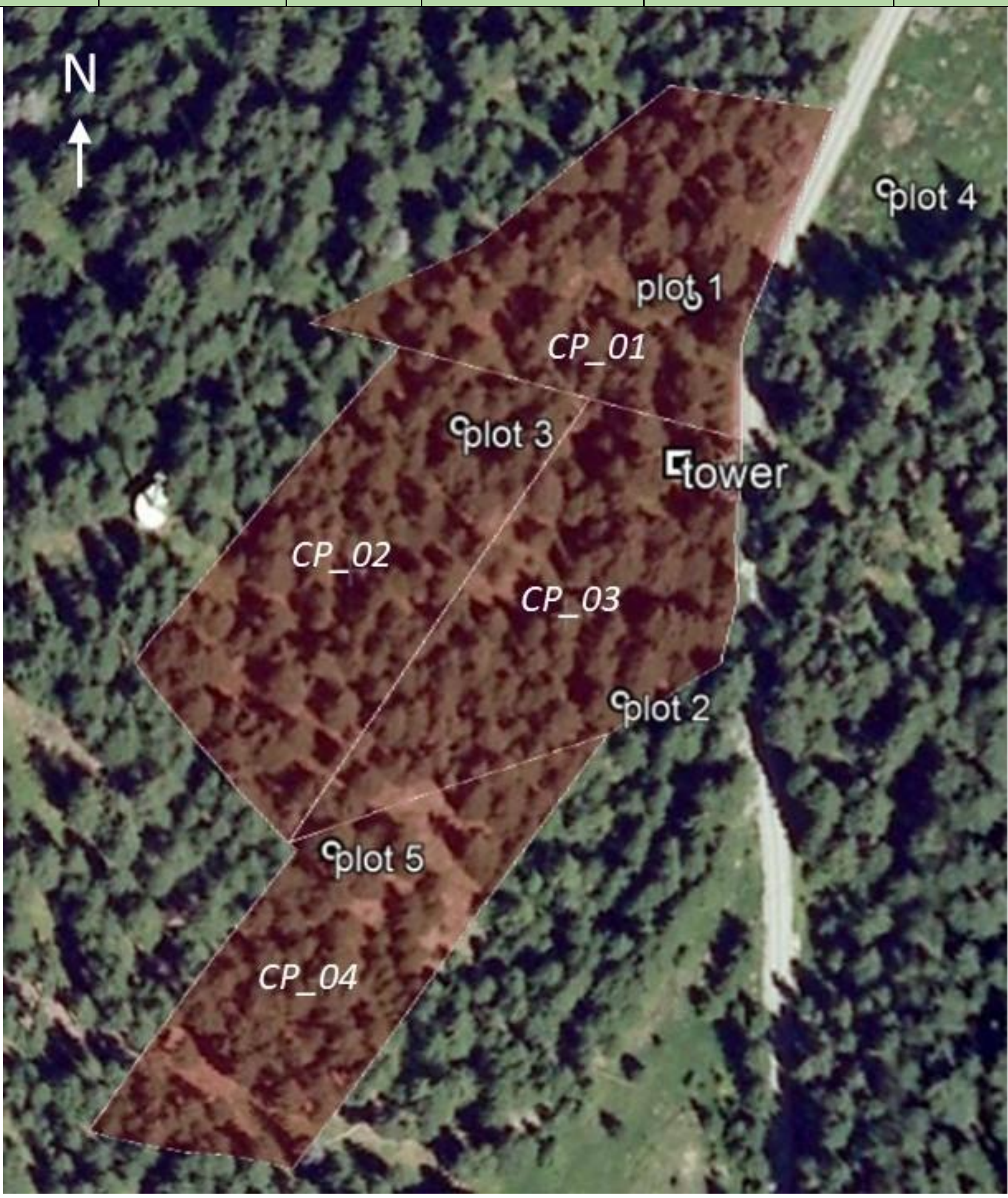


Figure 8: Location of the soil plots around the EC tower (plots 1 to 5). The four CP areas are shown in red.

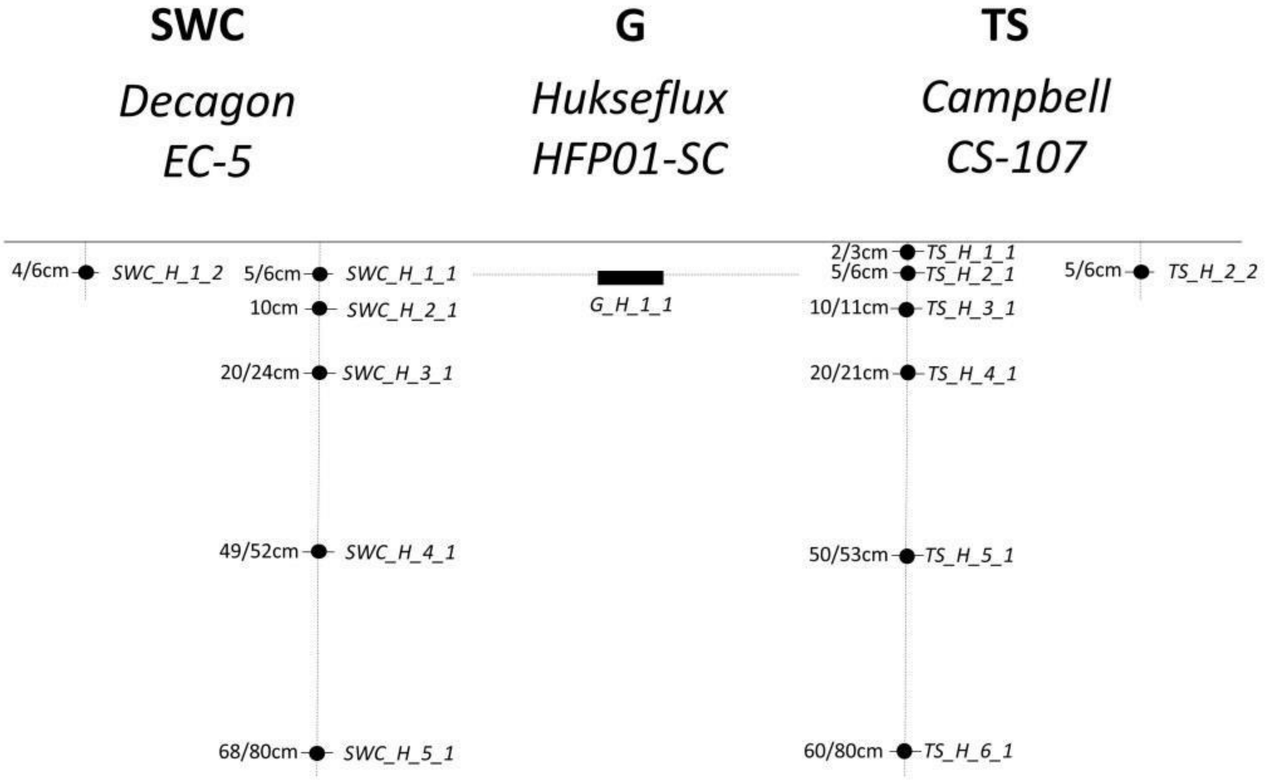


Figure 9: Set-up of the five soil plots (H = 1 to 5). SWC = volumetric soil water content, G = soil heat flux density, TS = soil temperature. X/Ycm indicates per sensor the variation in installation depth between the five plots.

Spatial heterogeneity characterization

Aboveground biomass:

The station team has collected in the spring 2018 the full set of tree data that is requested for the characterization of the target area and its spatial heterogeneity. This dataset comprises the species, DBH, height, and health status of all trees above the stem diameter threshold of 5 cm that are growing inside the 20 SP-I plots and four CP plots installed in the target area. The ETC has quality-checked and processed these data. However it was noted that the SP-I plot had a radius of 10m while 15m is required. Moreover during the labelling it was agreed to expand the target area and move four SP-I plots into the extended area (SP-I_04, SP-I_14, SP-I_15, SP-I_20). The station team prepared to perform the measurements in the field related to these four SP-I plots. This was done in November 2019 for SP-I_14 and SP-I_15 already with the compliant radius of 15m and the station team confirmed to submit the data for SP-I_04 and SP-I_20 by the end of 2019. It has been also agreed to perform the required measurements with the expanded radius for the remaining 16 SP-I plots in spring 2020. The hereby presented data are thus preliminary data until the final data set has been submitted. Figures 5, 6 and 7 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 here as a proxy for Aboveground biomass. As can be seen in the figures, the target area is dominated by Norway spruce (Picea abies (L.) H Karst.) with sparse presence of mountain-ash (*Sorbus aucuparia L.*), silver fir (*Abies alba Mill.*), and barberry (*Berberis vulgaris L.*), mountain pine (*Pinus mugo Turra*) and European larch (*Larix decidua Mill.*).

Green Area Index:

The station team has carried out all the Green Area Index measurements in the 20 SP-I plots that are requested for the characterization of the target area and its spatial heterogeneity. The measurements have been done in May 2018 by means of Digital Hemispherical Photography. The two sets of measurements for the four CP plots were carried out in July and October 2019. 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. Given the large time gap between the measurements in the SP_I plots and the CP plots and the decision to move four SP-I plots into the extended target area it was decided together with the station team to perform a new campaign as soon as the weather conditions improve (spring 2020).

Green Area Index

The station team has collected the minimum of two sets of GAI measurements that are requested for the step 2 labelling. As prescribed in the ICOS Instructions, GAI was measured by means of Digital Hemispherical Photography and at each measurement date nine hemispherical images were taken in each CP. The first set of measurements was collected in July 2019 in four CPs. The ETC quality-checked and processed the images. Some pictures did not meet the criteria. The second set of measurements was collected in October 2019 in four CPs. All pictures from the SP-I plots were taken in August 2018. The ETC quality-checked and processed the images, some pictures need to be retaken, however since four SP-I plots were moved due to the expansion of the target area it was agreed with the station team to perform a new campaign according to the requirements in the instructions for all SP-I and CP plots in spring 2020 (as soon as weather conditions allow).

Above Ground Biomass

The station team has collected a partial data set of tree data which 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 and four CP plots installed in the target area.

The ETC has quality checked and processed these data and performed a preliminary analysis on the available data. Figures 10 -13 summarizes the dataset, showing for each plot respectively the species composition, the density and the basal area per species. Basal area is used as proxy for Aboveground biomass.

Please note the following deviations from the instructions:

- CPs have an irregular shape with an area of 2000m². Due to this irregular shape, location of the trees could not be tested to lie within the CP boundaries.
- The requested radius of 15m of the SP-I plots was not respected initially. Instead a radius of 10m was applied. For 2 plots (SP-I_14 and SP-I_15) the center was moved and the measurements were done in a 15m radius around the new center. The analysis presented below is therefore done based on a plot surface of 314 m² for the 18 SP-I plots measured in 2017 and based on a plot surface of 707 m² for plots SP-I_14 and SP-I_15 measured in 2019.

- The measurements were spread over 3 years and 2 growing seasons: September 2017 (all SP-I-plots), September 2018 (CPs) and October 2019 (SP-I_14 and SP-I_15 which were moved and expanded.
- Two plots (SP-I_4 and SP-I_20) were moved to expand the target area and still have to be remeasured.

The ETC accepted the current data set for the preliminary analysis during the station labelling, however we request the station team to expand the remaining plots to a radius of 15m by spring 2020.

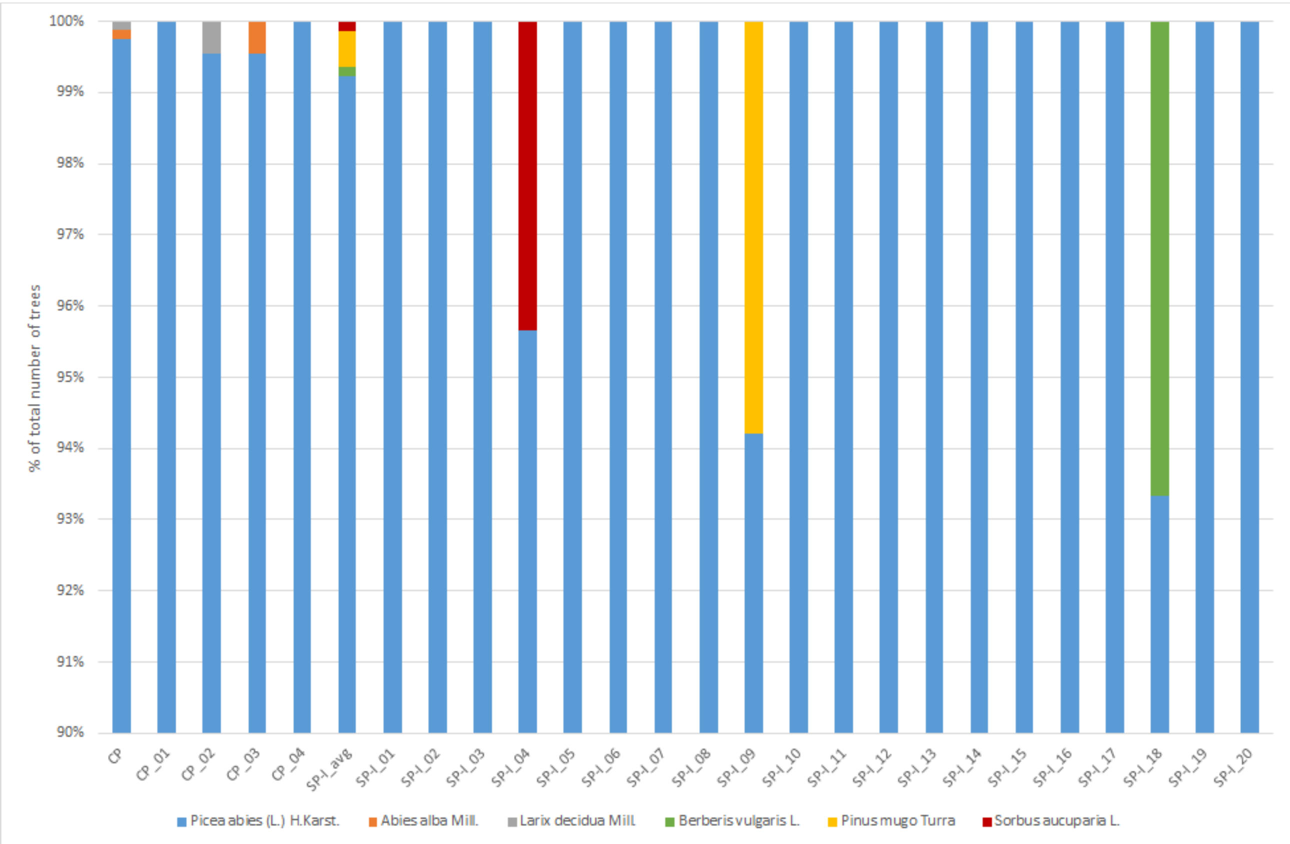


Figure 10: Relative species composition (number of trees per species divided by total number of trees per plot) shown for the twenty SP-I plots and the four CPs installed in the target area. Note that all plots contain over 93% *Picea abies*, which allows to consider this site as a mono-culture.

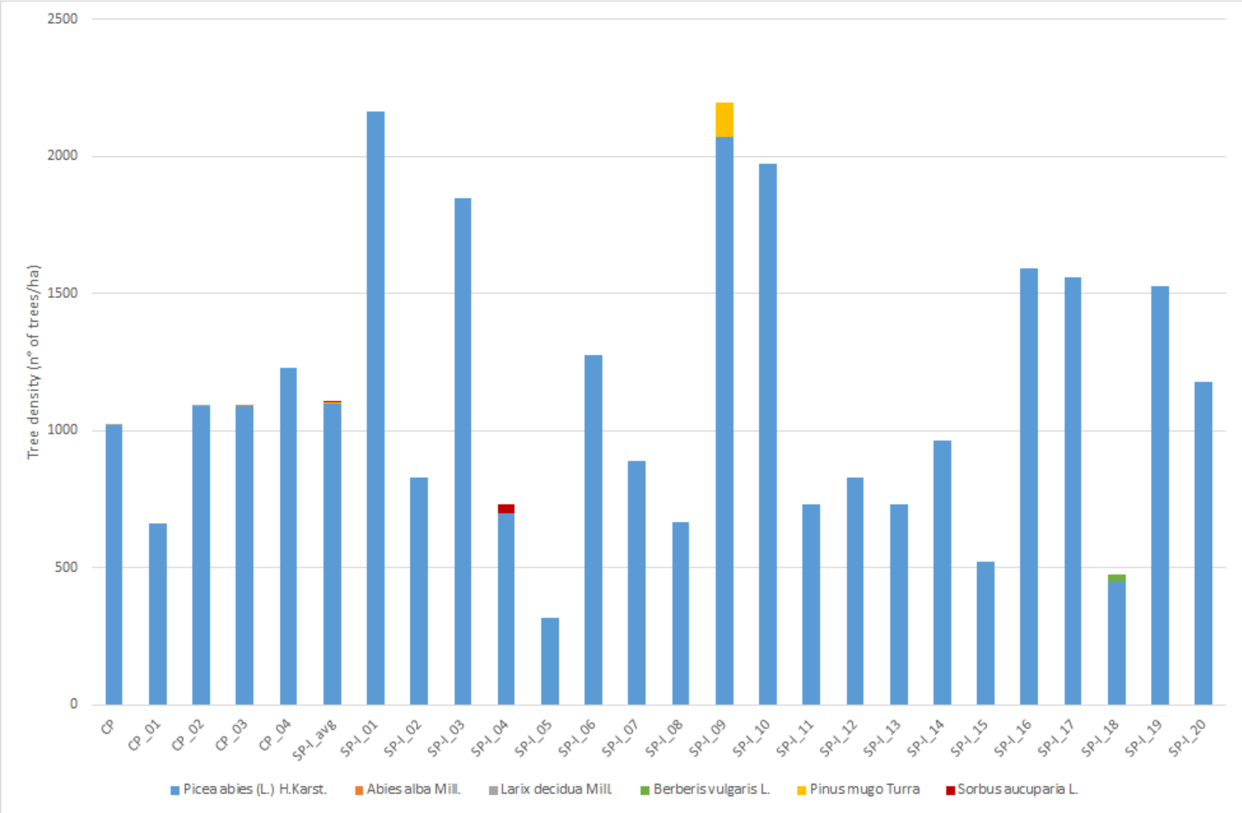


Figure 11: Tree density (number of trees in each plot upscaled per hectare) shown for the twenty SP-I plots and the four CPs installed in the target area.

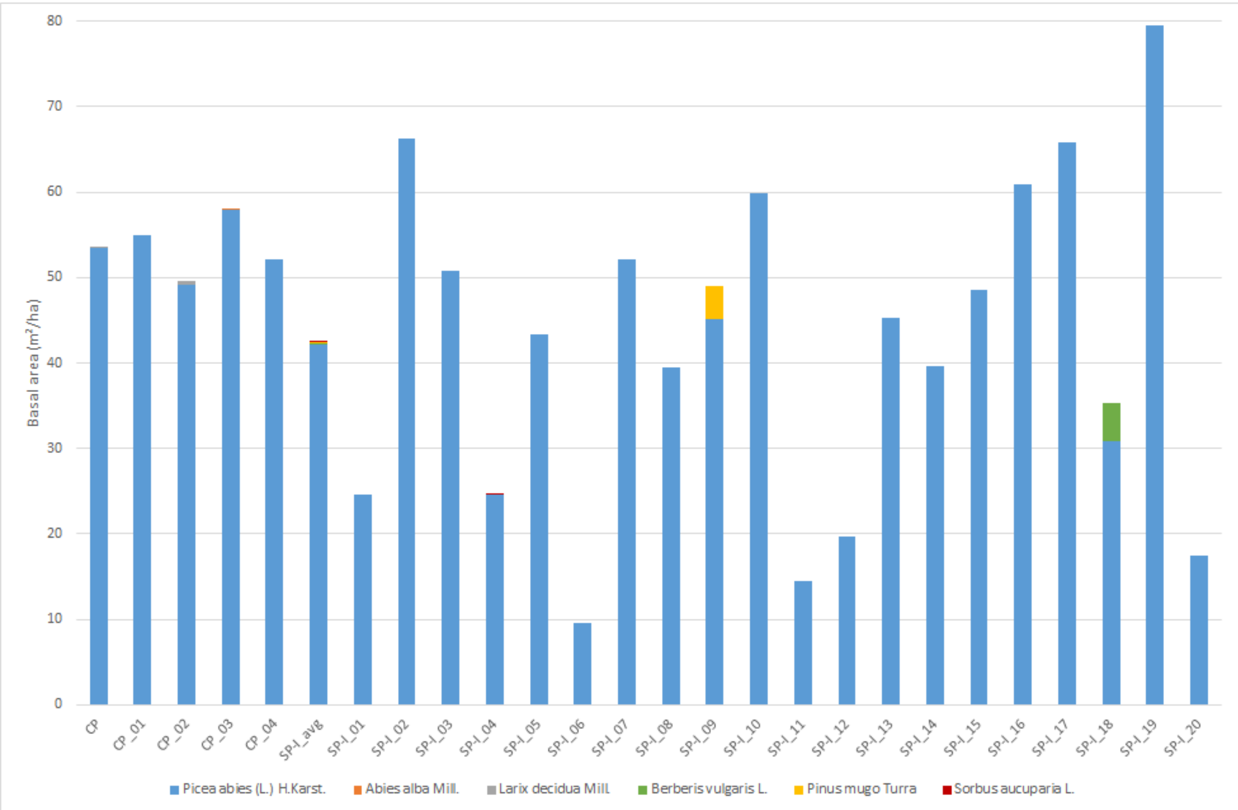
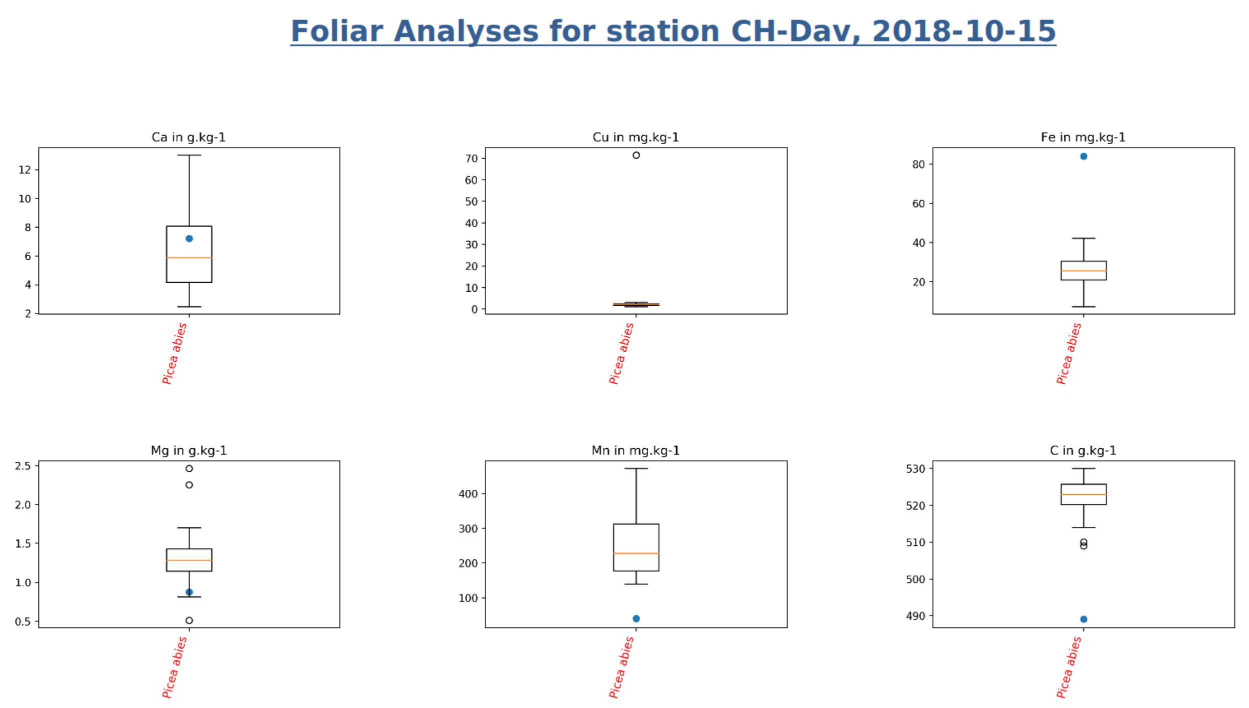


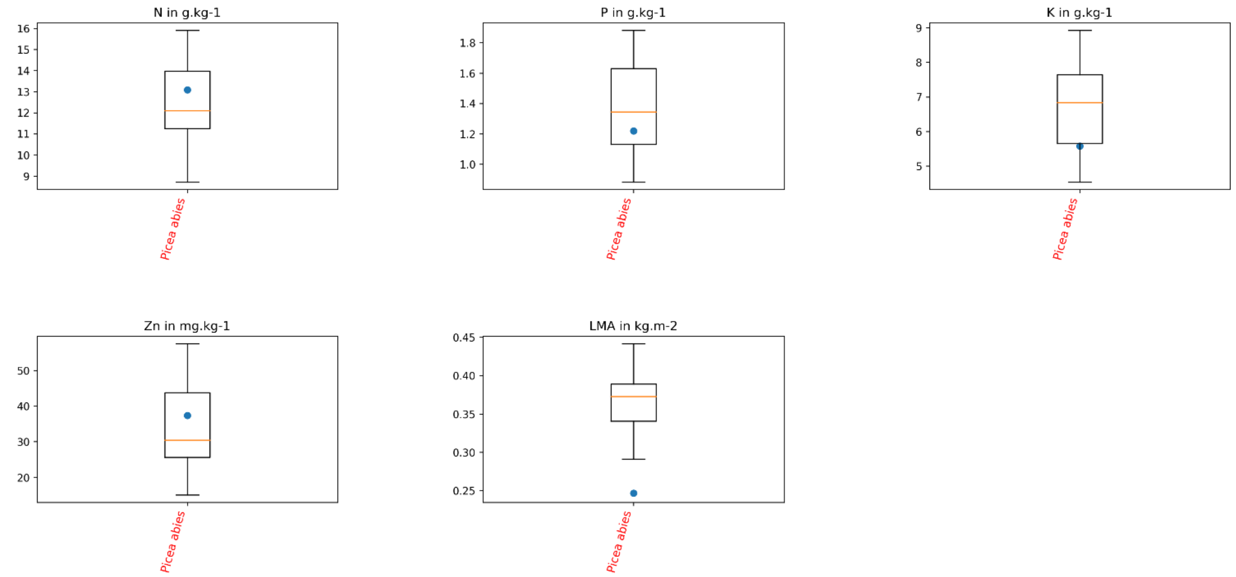
Figure 12: Basal Area per species per plot, shown for the twenty SP-I plots and the four CPs installed in the target area.

Vegetation sampling and analysis

The station team sent three set of samples from 2016 to 2018. For 2018 the site specific protocol was agreed. The foliar BADM file has been filled in correctly. Samples have been forwarded to the ETC laboratory by Nov. 12th 2018. Results are show in the figure below.

The nutrient values are for most of them in the range of the TRAIT data base and values reported in the 2018 ICP-Forest about European forest conditions. However, I suspect a mistake in the LMA values (BADM) that are on average twice the values expected. To be checked by station team. (see e.g. Homolová, L., Lukeš, P., Malenovský, Z., Lhotáková, Z., Kaplan, V., and Hanuš, J.: Measurement methods and variability assessment of the Norway spruce total leaf area: implications for remote sensing, Trees, 27, 111-121, 10.1007/s00468-012-0774-8, 2013.)





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

Data check and test

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

The test aims at quantifying the availability of NEE half-hourly data after the application of Quality Control (QC) procedures. The requirement expected for the Step 2 of 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 CH-Dav site, the testing period involves raw data sampled in 2019 from May 1st to September 1st. Of 5952 expected half-hourly files for NEE fluxes, 56.6% were retained after QC routines as illustrated in Figure 11. In particular, about 1.1% of raw-data was missed, 42.9% of calculated half-hourly fluxes was discarded because affected by SevEr (mainly caused by violation of stationary conditions), while an additional 0.5% was discarded because identified as outliers and affected by ModEr.

Although the percentage of missing data slightly exceed the 40% threshold, in consideration of the 1% of original missing data and of the allowed tolerance around the threshold, ETC agreed to consider the test as passed.

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

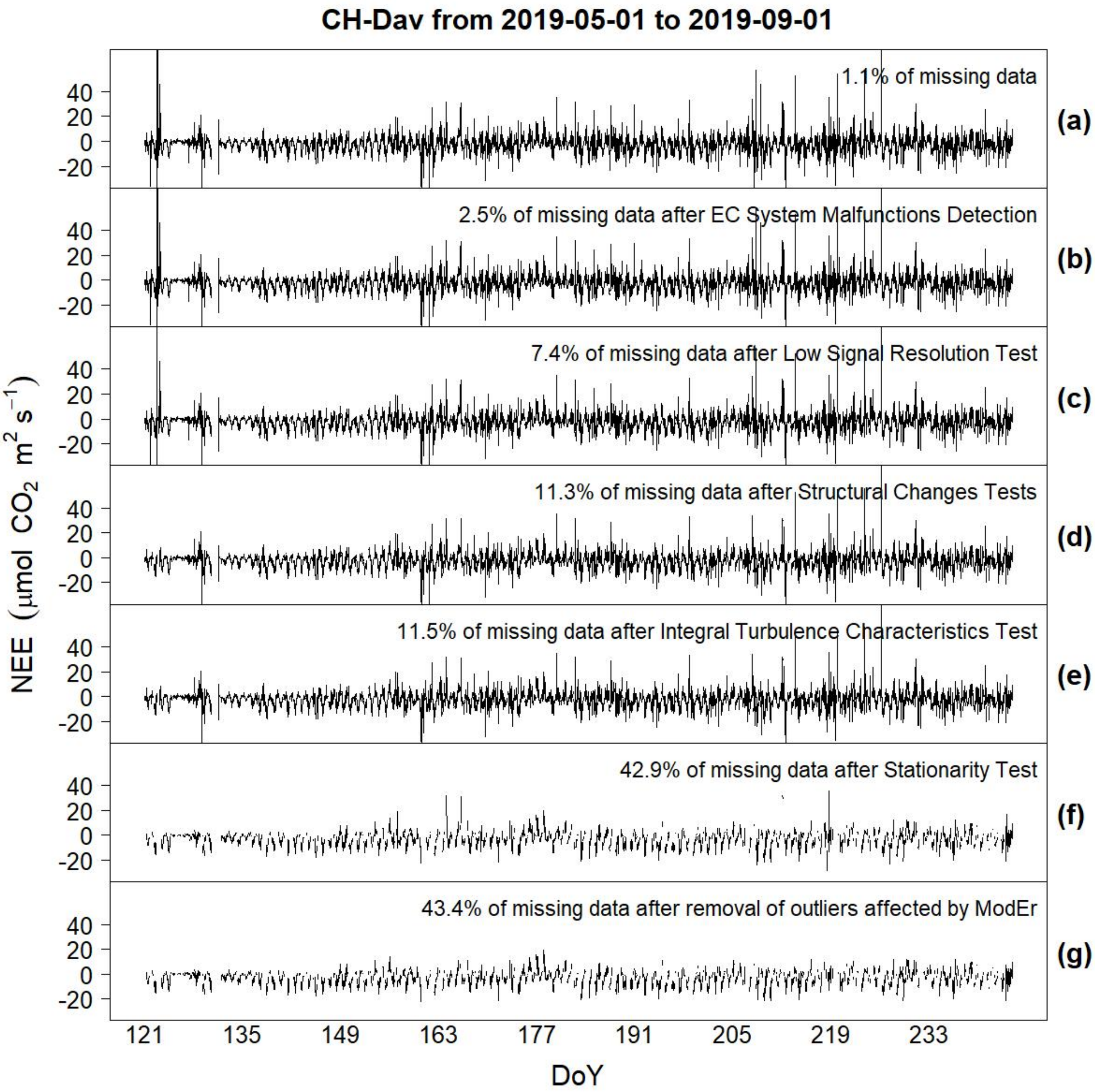


Figure 11: Summary of the data cleaning procedure applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at CH-Dav site from 2019/05/01 to 2019/09/01. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe evidences of error according to the following criteria: (b) wind sectors to exclude and diagnostics provided by sonic anemometer (SA) and gas analyser (GA); (c) instrumental problems detection; (d) integral turbulence characteristics test (ITC, Foken and Wichura, 1996); (e) stationarity test by Mahrt (1998). Bottom panel displays the time series of retained high-quality NEE after the additional removal of outlying fluxes affected by moderate evidences of error.

However, in order to better investigate the reasons for the high percentage of data removed by the Stationarity test (30%) an analysis of single halfhours has been performed and discussed with the station management. In figure 12 it is possible to see three examples of halfhours, the first that pass the stationarity test and the other two where the stationarity is not present and that are flagged by the Mahrt (1998) test (only one by the Foken and Wichura, 1996). The conclusion after the discussion with the station team and PI was that this is typical of the site when the wind blows from specific direction (city, lake). This is a characteristic that affect the quality of the measurements and that must be considered in future during the ICOS products preparation.

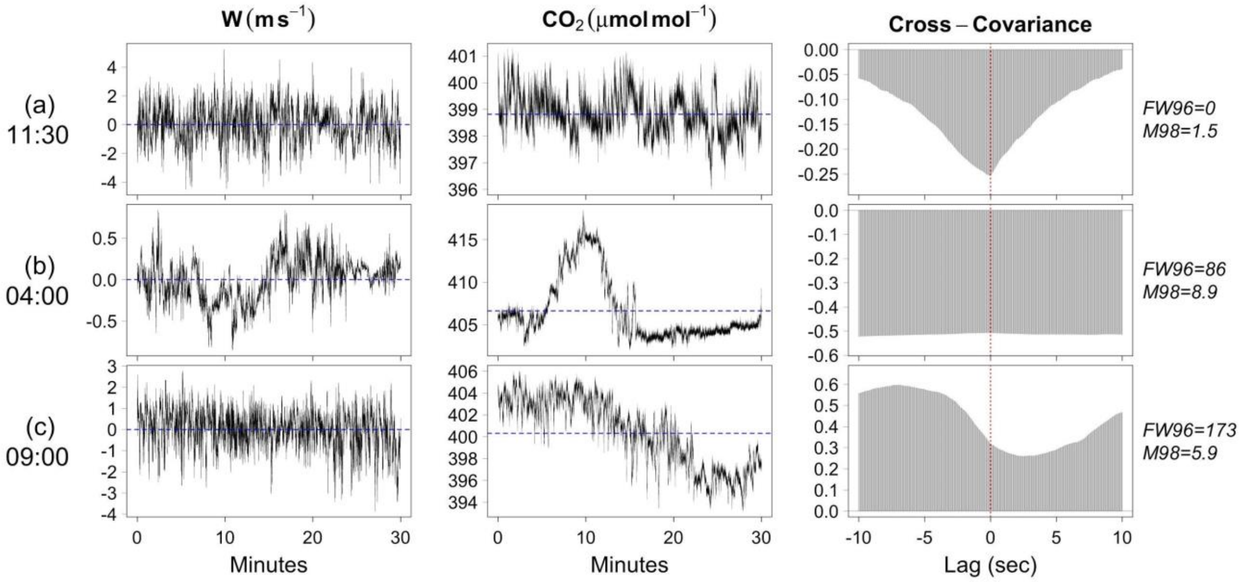


Figure 12: Raw high frequency time series of vertical wind speed (W, ms^{-1}, left panels), carbon dioxide atmospheric concentrations (CO_2, $\mu mol mol^{-1}$, middle panels) and estimated cross-covariance function (right panels) sampled under stationary (a) and non-stationary (b-c) conditions. For fluxes of high magnitude, when stationary conditions are fulfilled the cross covariance function between W and CO_2 exhibits a clear peak at lag 0 (red dotted line on right plots).

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 (143 days) after QC filtering procedure (previous Section) were achieved. The model by Klijun et al. (2015) were used to obtain the 2-dimensional flux footprint for each half-hour, which was compared to the TA spatial extent.

After the QC procedure and additional filtering according to footprint model requirements, 43.4 % of the data was used for the test.

Results showed that about 89 % of the data have a cumulative contribution of at least 70% from the TA (Figure 13, leftmost bars block), with a certain difference in the contributions during daytime and nighttime periods (97.4 % and 75.9 % respectively).

In addition, the test was performed on 4 sub-periods of analogous length (same number of observations) and results confirmed the percentages obtained on the whole period (Figure 13).

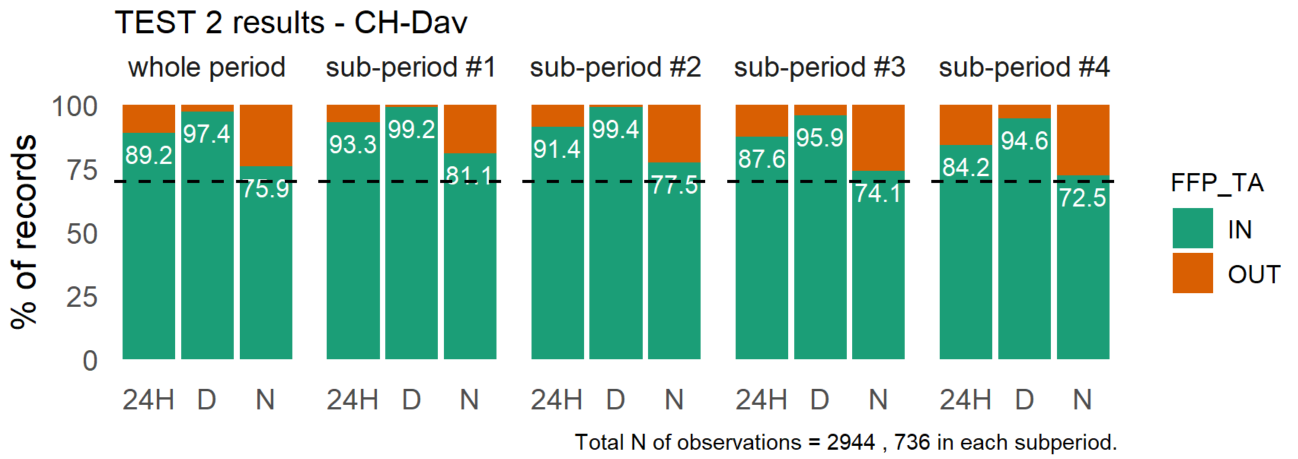


Figure 13: Test 2 results obtained over the whole period (leftmost block) and sub-periods, showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value (dashed horizontal line) is that 70% of data (half-hourly fluxes) must hold this condition. The analysis was done considering the whole day ('24H') and daytime and nighttime separately ('D' and 'N' respectively).

The footprint climatology for Ch-Dav, estimated over the period under consideration is reported in Figure 14, by which it is possible to notice that the 70% footprint cumulative contribution (even 80% actually) is on average always included in the TA. According to these results, the test is passed.

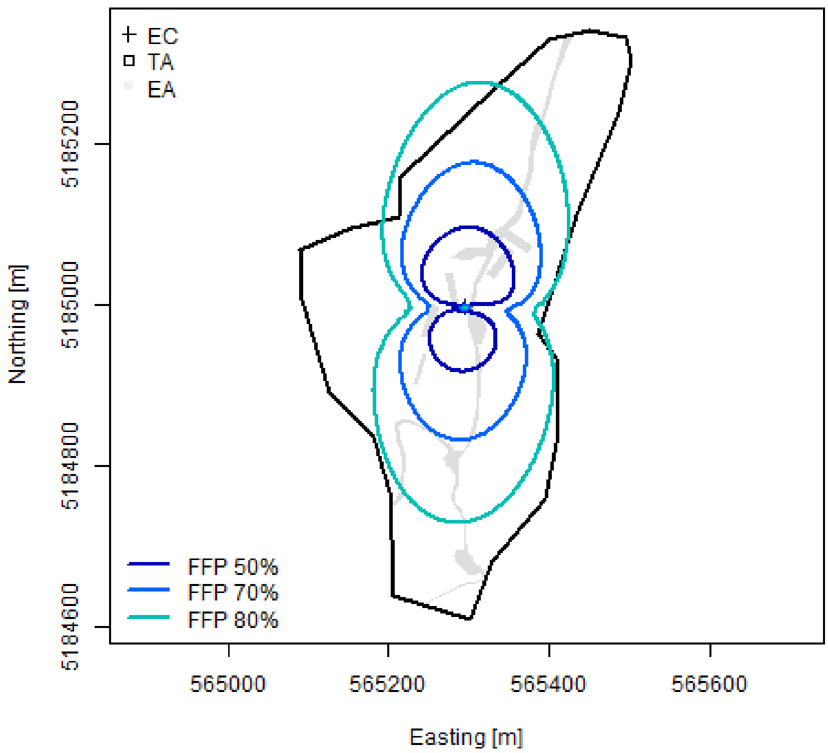


Figure 14: Footprint climatology at CH-Dav in relation to the TA, the EC tower (EC), and the excluded areas (EA, see the spatial sampling Section). The 50, 70 and 80 % cumulative contribution isopleths are reported.

References

Kljun, N., Calanc
a, P., Rotach, M. W., and Schmid, H. P.: A simple two-dimensional parameterisation for Flux Footprint Prediction (FFP), Geosci. Model Dev., 8, 3695-3713, 2015.

<u>*Data representativeness analysis (Test 3)*</u>

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

<u>*Ancillary plot representativeness (Test 4)*</u>

A preliminary representativity analysis, based on SP-I plot that do not have the required 15m radius and two SP-I plots that need to be moved due to the target area expansion, it reveals that only CP_02 falls just within the anticipated range of 20% of the average of the basal area measured in the SP-I's. CP_01, CP_03 and CP_04 have a basal area above the tolerance limit of 20%, with deviation of 28%, 37% and 23% respectively. However, some of the SP's are located at the forest edge, and thus part of the area is covered by grassland or roads (SP-I_06, SP-I_11, SP-I_12, - SP-I_14, SP-I_20) and therefore hold lower values of BA. If these SP's are omitted from the analysis, all CP's fall within the 20% range.

A second test reveals that the vegetation within the target area is dominated by Picea abies, which is perfectly reflected in the CP's with an average of 99% of the trees belonging to this species.

Based on the preliminary test, we would conclude that the CP's are representative for the target area (SP-I plots).

Near Real Time data transmission

After discussing with ETC, all of the data files (EC, SAHEAT, BM and ST) of CH-Dav were compliant between August and November 2018: EC files got the green light on August 29th; SAHEAT file on September 13th; BM files between September and November; ST file on September 6th. However, the station was submitting SAHEAT files in wrong format up to 20190422, and another format error due to the Carbon Portal was also corrected.

The station has its own acquisition system issuing a property binary file and an uncompressed ASCII ICOS file. The ST files will be shorter than expected because the analyser is used also for chamber measurements (agreed with the ETC). After the collection of three months of data, some inconsistencies arose with the metadata submitted, in particular for the settings of the sonic, that were corrected accordingly.

The BM files containing G_SF are giving errors for that variables: the units is wrong, ETC asked the PI to correct, that was done on 20191021.

An error of out-of-range values is present in one PA variable: the PI is aware of the issue and is working to fix it.

The station team performed the synchronization test as requested by the ETC. The ETC checked the data and the results are encouraging. 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.

<u>Test results on the half-hourly files</u>

CH-Dav provided 109 half-hourly, 20-Hz consecutive files (a bit more than two days). They contained both the IRGA and the SAT analog values: for that reason the data could be analysed considering both the corresponding set of digital variables (form SAT and IRGA) as reference. An offset was evident in all of the files sent: the SAT analogue variables, traveling together the GA digital values, had a delay alternating between 22 and 23 steps (1.1-1.15 seconds) in respect of the digital ones. Despite a short drift at the beginning and the end of the timeseries, due to the initial and final filling and emptying of the buffer used, in total the offset was constant. The situation is reversed considering the digital vs analogue signals of the IRGA: the digital signals of CO2 and H2O are late between 0.9 and 0.95 seconds as compared to the analog ones.

<u>Test results on the long file</u>

Considering the long file, CH-Dav sent a 2-days file. In this case, the short drift observed previously was not present at all, and after synchronising the beginning of the timeseries, the lag found was constant between 0 and 0.05 seconds.

Considering the whole situation, any potential drift seems to be corrected in the data acquisition process, and the test is for that considered passed.

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

Soil sampling

The site specific protocol was submitted to the ETC (Oct. 2017) and properly reviewed and accepted (Feb. 2018). This protocol accounts for the site constraints in terms of ownership and accessibility. Soil samples have been collected and are being sent to the ETC laboratory for analysis and archiving (update_2018/11/23.)

The site CH-DAV is located in a subalpine forest with multiple private owners and a history full of complicated cases between land owners, forest management and researchers in the last 20 years. For our core research site (CP plots) we have established contracts with land owners and the local forestry management. The core site is in a buffer zone (additional 5 m stripe of forest around the core site). The core area including the buffer zone is indicated as 'Main area' in the map attached. The core site is not available for any type of destructive sampling, whereas the buffer zone can be used for such sampling. Outside of this main area we are not allowed to leave any type of traces with our research activities.

Our suggestion to use the buffer zone as sampling area was not accepted with the argument of offering a too low number of replications. After discussing this topic with experts of the long-term monitoring team (LWF/ICP-forest) responsible for the site CH-DAV, we came to the conclusion that it is neither useful nor possible to increase the number of soil pits within this buffer zone, since the structure of soil asks for digging large sized holes to reach the necessary depth of 1 m as requested by the protocol. Coring is not possible due to the soil structure with large stones in it. Touching the core site for the digging work is also not acceptable since we do not want to risk destroying the monitoring work lasting now for more than 20 years. The only (hopefully) feasible way to go is to get additional permissions in the area of the SP-I plots (as suggested by the protocol).

In order to increase the chance of getting these permissions and to reduce the destructive work to a minimum, the following soil sampling procedure has been submitted to ETC experts and accepted:

- Digging soil pits with 1 m of depth (whenever possible) at the second SP-II location within 18 of the 20 SP-I plots and sampling them according the protocol (excavation method in stony soils)
- The second and third soil pits in each SP-I plots are dug with smaller dimensions most likely reaching only about 30-50 cm in depth and sampling them according to the protocol (excavation method).
- The two SP-I plots located in our core area (SP-I 16 and SPI-I 17) are suggested to be substituted with two existing soil pits used for the ICP-forest measurements (within the core site). No further soil pits are allowed in this area.

In total, this sampling concept suggests 20 soil pits of 1 m in depth and 2x 18 soil pits with a reduced sampling depth spread over the total SP-I area. In total 56 soil profiles. The sampling scheme is cross-checked with a C-N quantification study of the very same area in 2008 (Jörg, 2008, Böden im Seehornwald bei Davos und deren Vorrat an Kohlenstoff und Stickstoff, Msc-Thesis, Zürcher Hochschule für angewandte Wissenschaften, 79 p.) and should be able to cover the main characteristics of the soil including the changes of C and N over 10 years.

Soil samples have been collected and should reach ETC laboratory and Conservatory within days.

However, when checking the related BADM, we realised that the soil sampling instructions may not have been applied strictly and this point has been discussed with the station team.

- The mineral soil sampling should have been done at 5 depths : 0-5, 5-15, 15-30, 30-60, 60-100, but the submitted BADM contains samples in excess (the last 2 horizons have been split in two) : 0-5,-5-15, 15-30, 30-45, 45-60, 60-80, 80-100. As the total number of samples remains manageable, the analysis has been maintained, but this will complicate the processing of the result.
- The processing of the metadata and of the analysis is undergoing.

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 propose the station Davos (CH-Dav) for the labelling as Class 1 station.

The issues in some of the data will be still present, potentially impacting the quality and uncertainty in the calculation of the carbon balance, which is the main objective of ICOS. The station is however interesting for its unicity and would be crucial to better develop methods and techniques in complex sites like this. A similar issue is present for the ancillary data that are collected following a design not compliant with the other ICOS station and for this reason not easy to compare or to communicate to the users. This will probably preclude the selection of the site for a number of activities by the users.

The conditions of the weather and some delay in specific in-situ activities didn’t allow to complete all the labelling activities in the optimal way but a clear timeline has been agreed with the ETC with part of the actions to be completed by the end of 2019 (correct metadata on meteo sensors, complete the submission of the additional SP-I plots data) and part by the 2020 growing season (expand the SP-I). The ETC will strictly monitor the respect of the timeline.

November 18th 2019

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