



ICOS SWEDEN

Annual Report 2022

ICOS |  National
Network
Sweden



The Steering Committee of ICOS Sweden endorsed this Annual Report 2022 on 15 March 2023. The report is complemented by other documents from ICOS Sweden, including the Operational Plan for 2023, the Strategic Plan 2023-2028, and the ICOS Sweden keynumbers for 2022.

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1. Introduction to ICOS Sweden

ICOS - Integrated Carbon Observation System - is a European research infrastructure for quantifying and understanding the greenhouse gas balance of the European continent and of adjacent regions. The infrastructure is built up as a collaboration of nationally operated measurement stations in, at present, 16 European countries. ICOS Sweden is the Swedish contribution to this European effort. The ERIC (European Research Infrastructure Consortium) 'ICOS ERIC' has been established as a legal entity for ICOS data release as well as the coordination and integration of the whole research and measurement infrastructure, ICOS Research Infrastructure (RI), that includes the national networks, the monitoring station assemblies and the central facilities (Fig. 1).

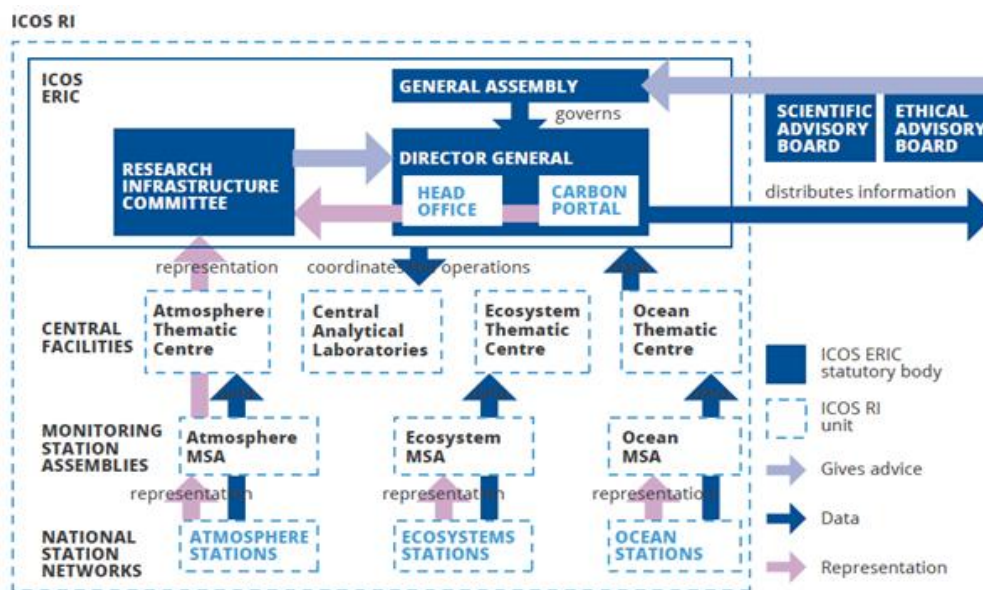


Figure 1. Outline of the ICOS RI organization. Sweden is a member of ICOS ERIC and ICOS Sweden is the national station network in Sweden (<https://www.icos-cp.eu/about/organisation-governance/structure>).

High-precision, standardized observations of the exchange of greenhouse gases and heat between the Earth's surface and its atmosphere form an essential basis for understanding not only our planet's present climate, but also past and future developments. It has also become clear that these studies must be secured beyond the lifetime of a typical research project. The aim of ICOS is therefore to construct, equip, and operate a network of standardized, long-term, high precision integrated monitoring stations for atmospheric greenhouse gas concentrations and fluxes. In 2022, the ICOS Research Infrastructure has more than 150 stations in the member countries. The current ICOS measurement networks include 46 Atmosphere stations, 96 Ecosystem stations and 27 Ocean Observation Systems, including Voluntary Observatory Ships, so called Ships of Opportunity (SOOP), fixed stations and research vessels located across Europe and covering the North Atlantic and European marginal seas. ICOS RI stations are separated into 3 different classifications:

- **Class 1 station:** ICOS Ocean, Ecosystem or Atmosphere Station with a complete equipment setup for measuring the full set of ICOS core variables.
- **Class 2 station:** ICOS Ocean, Ecosystem or Atmosphere Station with a complete equipment setup for measuring ICOS core variables. Less variables are measured compared to the Class 1 station and ancillary data are determined less frequently.

- **Associated station:** The network of ecosystem sites in ICOS is enlarged to a set of Associated stations where the requirements in terms of variables collected and standards to follow are different from the Class 1 and Class 2 ICOS stations. Ecosystem fluxes calculated by the station principal investigator and data at final time resolution are submitted to the Thematic Center.

The national station network ICOS Sweden is fully integrated with and plays an important role in the European ICOS (ICOS RI). ICOS Sweden has been providing data that help to compile information on greenhouse gas exchange of typical northern ecosystems to the research community as well as Swedish stakeholders. ICOS Sweden furthermore provides test sites for national inventory systems and sites and databases for advanced research. ICOS is funded by the Swedish Research Council and the consortium partners as research infrastructure of national interest.

2. Status of ICOS Sweden at the end of 2022

ICOS Sweden maintains stations distributed across Sweden, from Abisko-Stordalen in the north to Hyltemossa in the south (Fig. 2). The RI comprises three Class 1 Atmosphere Stations (AS) for measurement of concentrations of GHGs in the well-mixed boundary layer, six Class 2 Ecosystem Stations (ES) for measurements of exchanges of GHGs between ecosystems and the atmosphere, one Class 1 fixed Ocean Station (FOS) for observations of the coastal Baltic Sea, and one Class 1 Ocean Station based on the ship of opportunity (SOOP) Tavastland, travelling between the northern and southern basins of the Baltic sea, for measurements of the ocean surface. The measurement stations are operated by six consortium partners together providing the broad experience needed to successfully operate such a complex, distributed RI. Each consortium partner is assigned full technical and scientific responsibility for their measurement station(s). The partners jointly provide the expertise to operate and develop ICOS Sweden.

Lund University (LU) is the host organisation with overall responsibility for the coordination of ICOS Sweden, and for the operation of four ICOS stations: forest Ecosystem and Atmosphere stations Norunda and forest Ecosystem and Atmosphere stations Hyltemossa.

Swedish University of Agricultural Sciences (SLU) operates three ICOS stations: forest Ecosystem and Atmosphere stations Svartberget and the mire Ecosystem station Degerö.

University of Gothenburg (GU) is responsible for the operation of the mire Ecosystem station Mycklemossen.

Uppsala University (UU) operates the Ocean station Östergarnsholm.

Swedish Polar Research Secretariat (PFS) runs the mire Ecosystem station Abisko-Stordalen Palsa Bog.

Swedish Meteorological and Hydrological Institute (SMHI) is responsible for the marine station aboard SOOP Tavastland.

Some of the stations have been managed by the partner organisations for >2 decades (e.g. Norunda - LU; Östergarnsholm - UU; Degerö - SLU; Abisko-Stordalen - PFS).



Figure 2. Map of the site locations of the observation network of ICOS Sweden.

ICOS Sweden data

All three Atmosphere Stations (Svartberget, Norunda, Hyltemossa) were labelled as Class 1 ICOS RI Atmosphere Stations in spring 2018. Measurements and calibrations following the schedule of the Atmosphere Thematic Centre (ATC) and the Central Analytical Laboratory (CAL) are ongoing; data is transferred automatically to the ATC each night. The last release by the ATC of finally calibrated and quality-controlled data products (Level 2 data) including data from ICOS Sweden stations was in summer 2022 and included data until end of February 2022. These data as well as near real time data (Level 1 data) from the Atmosphere Stations are available for users via access through the ICOS Carbon Portal (CP)¹.

All three forest Ecosystem Stations Hyltemossa, Norunda and Svartberget as well as the mire Ecosystem Station Degerö were labelled as ICOS RI Class 2 Ecosystem Stations by the ICOS ERIC General Assembly (in 2018 and 2019). The mire station Abisko-Stordalen Palsa Bog (SE-Sto) received the label as Class 2 Ecosystem station in May 2022. Measurements (automatic data sampling and manual for ancillary vegetation data) are ongoing following the instructions of the Ecosystem Thematic Centre (ETC), which are based on the elaborated protocols for Ecosystem Station measurements². Data is automatically transferred to the ETC via the ICOS Carbon Portal each night. The ETC released interim Level 2 data including data from the labelled ICOS Sweden stations until the end of August 2022 in the end of 2022. L2 data from the newly labelled station SE-Sto will be first released in spring 2023 together with the full L2 data release covering the full year 2022. The ETC data products are available through the ICOS Carbon Portal.

Data from the Ocean stations have been submitted to the Surface Ocean CO₂ Atlas (SOCAT³) from where they will be available for FAIR use after thorough quality control.

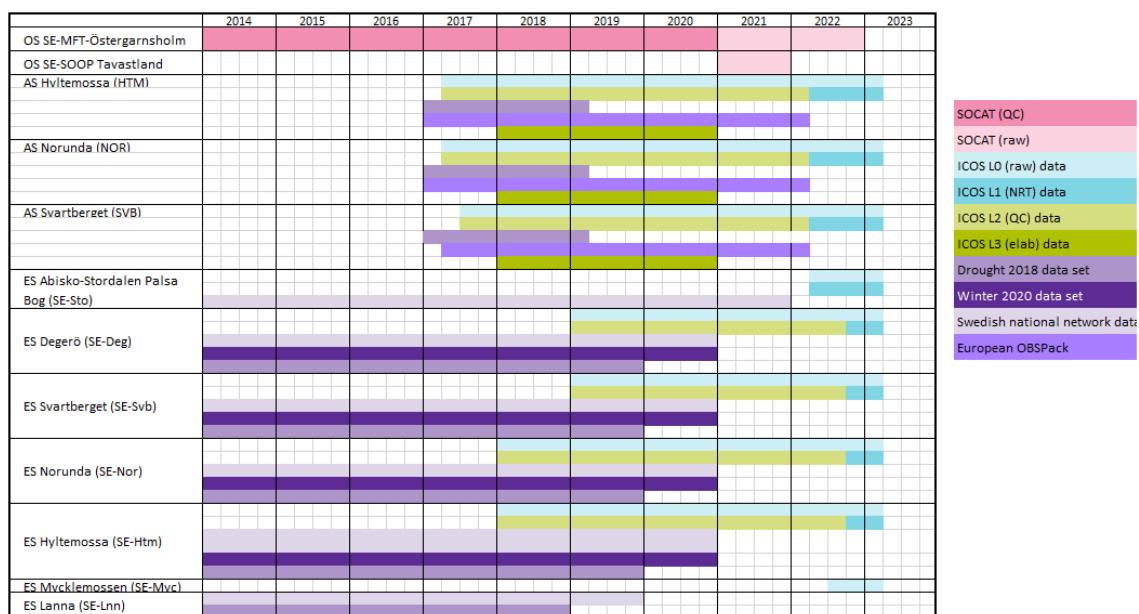


Figure 3. Graphical overview on data from ICOS Sweden stations from 2014 onwards on SOCAT and the Carbon Portal.

¹ data.icos-cp.eu/portal

² www.international-agrophysics.org/infopage/articles/y/2018/pub/1/issue/4

³ www.socat.info

Most data from the ICOS Sweden ecosystem network (start in 2014, resp. 2015) has been made available and searchable as Swedish national network data on the ICOS Carbon Portal (Fig. 3). ICOS Sweden contributed to several data collections initiated by the ICOS network. These aimed for (i) fast analyses of consequences of the hot and dry weather during 2018 (Drought 2018), (ii) effects of the warm weather conditions during winter 2019/20, and (iii) consequences of the shutdown due to the covid-19 pandemic in spring 2020. Data from these initiatives are available through the ICOS Carbon Portal (Drought 2018⁴, Winter 2019/20-Covid19⁵). No process can be reported so far from the uploaded pre-labelling data as Associated Station data; these data have not been further processed by the ETC so far.

3. Highlights in science and management during 2022

To be able to follow up the progress of the RI, Table 1 shows a commented version of the time table which was part of the proposal to the ongoing funding period. In the middle of the current funding phase, ICOS Sweden is in phase with most of the planned work. Details about the usage of the infrastructure are included in this report and the key number files provided to the Swedish Research Council.

3.1 Management

- The mandate period of Jutta Holst as Director of ICOS Sweden which was originally fixed to one year was prolonged.
- The ICOS Sweden Steering Committee visited the research station Norunda during the face-2-face meeting in October 2022. Norunda hosts both an ICOS Atmosphere station, an ICOS Ecosystem station, an ACTRIS station, spectral measurements for the SITES affiliated network NordSpec and was recently clear-cut.



Figure 4. ICOS Sweden Steering Committee incl ICOS Sweden's Director at Norunda research station in October 2022.

⁴ www.icos-cp.eu/data-products/YVR0-4898; www.icos-cp.eu/data-products/ERE9-9D85

⁵ www.icos-cp.eu/data-products/2G60-ZHAK

Table 1: Commented timetable for ICOS Sweden milestones during 2021-2024. Legend: n/y - n times per year, cont – continuously; accomplished (green), partly accomplished (blue); not yet accomplished (pink)

		2021	2022	2023	2024
Milestones	1. Management of the organization (module 1)				
	Management				
	Production and revision of steering documents	1 / y	1 / y	1 / y	1 / y
	Board meetings, revisions and endorsements	3 / y	3 / y	3 / y	3 / y
	Collaboration with other RIs	cont	cont	cont	cont
	Joint SAC and Board meetings	1 / y	1 / y	1 / y	1 / y
	Management team meetings	2-4 /y	2-4 /y	2-4 /y	2-4 /y
	Preparation of reports				
	Annual reporting, incl. financial status and key numbers	1 / y	1 / y	1 / y	1 / y
	Self-evaluation	1 / y		1 / y	1 / y
	Conduction of outreach activities and dissemination				
	Homepage, media activities, reports, info material, papers	cont	cont	cont	cont
	Courses and field visits	cont	cont	cont	cont
	Activities to stimulate scientific use of the RI	cont	cont	cont	cont
	2. Management of sites, systems and measurements (modules 2-6)				
	Operate measurement sites	cont	cont	cont	cont
	Station labelling: SE-Sto	x			
	Station labelling: SE-MFT-Östergarnsholm	x			
	Station labelling: SE-SOOP Tavastland				x
	Station labelling: SE-Myc				x
	Quality check data from thematic centres	cont	cont	cont	cont
	Service, system maintenance and update, work routines and protocols	cont	cont	cont	cont
	Staff training and station safety routines	1 / y	1 / y	1 / y	1 / y
Service to ancillary project and data users	cont	cont	cont	cont	
Research engineer meetings (distant and face-2-face)	monthly	monthly	monthly	monthly	
3. Evaluation and renewal application (module 1)					
Preparation of midterm evaluation	cont				
Preparation for application for next period		cont	cont		
Deliverables	4. Reports (module 1)				
	Annual and financial reports incl. key numbers, operational plan, revision of strategic plan	1 / y	1 / y	1 / y	1 / y
	5. Dissemination (module 1-6)				
	ICOS conferences (ICOS RI, Nordic ICOS Symposium)	1 / y	1 / y	1 / y	1 / y
	6. Data (module 2-6)				
Delivering data to ICOS RI	cont	cont	cont	cont	
Open data available in Carbon Portal	cont	cont	cont	cont	

- In the end of 2022, the ICOS Sweden reference group started to work on the application for the next funding period 2025-28, which was successfully handed in to the SRC in February 2023. The current structure of the RI was kept even for the next funding period. To minimize the effects of increased costs for electricity, salaries and drift material, only the most important investments have been taken up in the proposal.
- The project 'ICOS – resource for school' ended at the end of 2022. The aim of the project was to produce material which can be used in school to stimulate interest of children at high school age in STEM subjects. The project was carried out in collaboration with Vattenhallen, the Lund University's Science Center. In total 12 pupils got the possibility to spend a day at the ICOS station Hyltemossa, meet scientists and technicians, learn about measurements and aim of such a research stations and perform simple own measurements. Programming material and lab exercises were tested during visits of school classes at Vattenhallen in autumn 2022. During their half days at the Science Center, the students even had the possibility to meet a climate science and learn more and discuss about the climate system, climate change and the roll of ecosystems in the climate system.

3.2 Measurement stations

3.2.1 Station certification

The ecosystem station Abisko-Stordalen Palsa Bog received the ICOS label during the ICOS General Assembly meeting in May 2022. The status of the not yet labelled ICOS Sweden stations is as follows:

The new ES mire station Mycklemossen started transmitting data to the ETC and is in the quality assurance phase for station labelling. The Ocean stations are both in the process of station labelling. The labelling of the fixed ocean station Östergarnsholm has been delayed several times. The problem relates to the pCO₂ sensor in the water (which is the key parameter for Ocean station). This can be explained by a combination of factors which can be summarised as: a) the methodology suggested by the OTC to take and analyse water samples for verification of the sea surface pCO₂ is less accurate for the low salinity, highly variable Baltic Sea conditions; b) the problem of accessing the mooring to take the water samples limits the possibility to collect data used for validation. c) We do not have remote access to the waterside sensor, and do not know when there are sensor failures (which has happened during several occasions when water samples were collected).

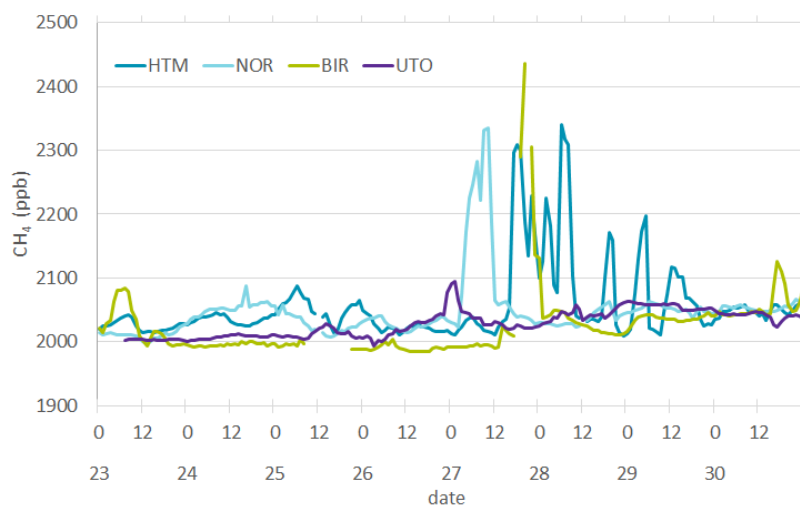
The station team has a continuous discussion with OTC on how to solve the problem, plans include: 1. Collaboration with SMHI and R/V Svea for assistance in collecting the water samples which will hopefully improve the sampling. 2. Quality control of the station's pCO₂ sensor within an intercomparison project organised by OTC (together with other sensors). 3. For a slightly longer time perspective, OTC plans to purchase a portable calibration system to check the quality of the station data. 4. Possible purchase of a complementary pCO₂ sensor (different to the present).

3.2.2 Station highlights

Nord Stream gas pipeline leakage

In September 2022, large amounts of methane were released into the atmosphere, when the Nord Stream gas pipelines in the Baltic Sea were damaged. The increased gas concentrations were captured by ICOS stations in around the Baltic (Sweden, Finland, Norway), but also further away (UK). Data from the stations were used by scientists to both quantify the amount of leaked gas and

validate atmospheric transport models. The event draw high attention from media both nationally and internationally (see App. 2).



Methane concentrations at selected nordic ICOS Atmosphere stations from 23 to 30 September 2022. Data: [Heliasz et al., 2023](#) (HTM); [Lehner et al., 2023](#) (NOR); [Lund Myhre et al., 2023](#) (BIR); [Hatakka et al., 2023](#) (UTO).

Norunda clear cut

On November, 24 2022, the clear-cutting at the combined ICOS Atmosphere and forest Ecosystem Station Norunda was finalized. ICOS Sweden measurements will continue to collect data about the carbon and energy budget of the site as before. The coordination with the ICOS ETC has been finalized regarding the adjusted placement of the main instrumentation (GHG flux system). Additional instrumentation connected to research projects running on the site such as the [CORE project](#) (PI Natascha Kljun, LU) will give further insight into what is happening.



3.3 Dissemination: Conferences and Meetings

SPIs and station team members took actively part in the MSA meetings of all three domains, Atmosphere, Ecosystem and Ocean which were mostly held online during 2022 to reduce travel needs and travel connected emissions. However, in December 2022, the OTC organized a workshop on data quality assurance for data from the Ocean stations which was attended by ICOS Sweden Ocean station staff.

ICOS Sweden scientists and research engineers ICOS Sweden attended the 5th ICOS Science Conference, which was held as hybrid event in Utrecht/NL on 13-15 September 2022. Data from the ICOS Sweden stations were subject of several presentations at this conference, but also at other conferences (e.g. EGU, AGU, Baltic Earth Conference).



Figure 5. Impressions from the ICOS Science Conference in Utrecht and the field excursion to the Dutch ICOS Ecosystem station Loobos.

4. User statistics

The users of ICOS infrastructure divide into two partially overlapping classes, data users and users of the physical station infrastructure. Again, the data and the sites will be available to all.

The academic users of ICOS data can be divided into three main groups. 1) Modelers working with both bottom-up and top-down type models from different disciplines, e.g., soil science, ecophysiology, biogeochemistry, hydrology, meteorology, climate science, atmospheric science. 2) Remote sensing (RS) community that is interested in ground truth data for validation of different RS products. 3) Researchers synthesizing empirical data from different types of ecosystems and climatic regions to understand the processes regulating exchange of matter and energy between ecosystems and the climate system.

Users taking advantage of the physical access to the measurement stations benefit from station infrastructure, including laboratory space, technical support, power supply, internet and other services, and high-quality auxiliary data provided by ICOS Sweden. These users perform on site research consisting of measurement programs that are in addition to the ongoing ICOS measurement program. They, in turn, benefit directly from the context of the long term ICOS measurements. The users use and process ICOS data while integrating it into their own scientific research topics. They publish scientific papers in high-impact journals, make presentations at international workshops and conferences, and develop novel measurement methods that may become operational within ICOS in future. During 2022, users visiting the site from the consortium member institutions and from outside the consortium member institutions balanced out. However, data from the stations were widely used and downloads from the ICOS Carbon Portal data repository increased again compared to previous years. Downloads from users within Sweden further decreased compared to earlier years.

Table 1 comprises the summary of the key numbers since the start of the 2nd ICOS Sweden funding

period 2016. The results are analyzed in more detail below. ICOS Sweden defined targets for the keynumbers in its most recent Strategic Plan. These are included in the last row of Table 2. It is obvious that both, the scientific output in terms of peer-reviewed publications and the data usage by users from Sweden are below expectations in 2022.

Table 2. Summary of the key numbers for the annual reporting of the infrastructure activities. Data downloads include all levels of data products (Level 0: raw data to level 3: elaborated products).

year	general key numbers	Project Pis		Number of site days	Data repository downloads	
		Inter-national	national		national	international
	number of peer-reviewed publications					
2016	44	17	52	-	--	--
2017	64	15	39	-	2	752
2018	60	28	26	-	3728	1397
2019	26	16	82	-	10483	2776
2020	87	13	76	-	50467	2296
2021	71	24	75	7928	44978	2111
2022	49	18	63	14819	52026	1752
target	>60	>15	>50	>5000	>40000	>2000

4.1 Physical Users of the infrastructure

The motivation for users that come in person to the ICOS Sweden RI facilities is broad. ICOS Sweden facilities are used for education at university level during excursions and field courses. National and international scientists use ICOS Sweden stations for their own research project related field work. Table 3 includes the updated numbers for each group of physical users. In 2022 on-site excursions were taken up again which reflexes in the large increase of both scientific and general public visitors at the ICOS Sweden stations.

The number of research projects at the stations was comparable to the previous years with a slight increase compared to the pandemic influenced years. Note, that the number of research projects purely using data are not part of this statistic. Even if researchers are asked to inform the station PIs about the usage of data the number is highly unsure due to the open data policy following. Projects at the sites were mostly related to the respective host of the station used for the research (Fig. 6a). Other Swedish Universities which are not part of the ICOS consortium represent only a small share of the projects as PIs. However, they are involved as project partners (Fig. 6b).

Table 3. User numbers for project PIs, Scientific visitors (site visitors through field courses and excursions) and General public visitors (general public and school children).

year	Project PIs		Scientific visitors		General public visitors
	male	female	male	female	not divided by gender
2016	50	19	355	277	245
2017	40	14	166	227	21
2018	42	12	72	67	32

2019	63	25	163	94	14
2020	49	35	129	64	10
2021	40	30	134	92	10
2022	68	35	407	208	128

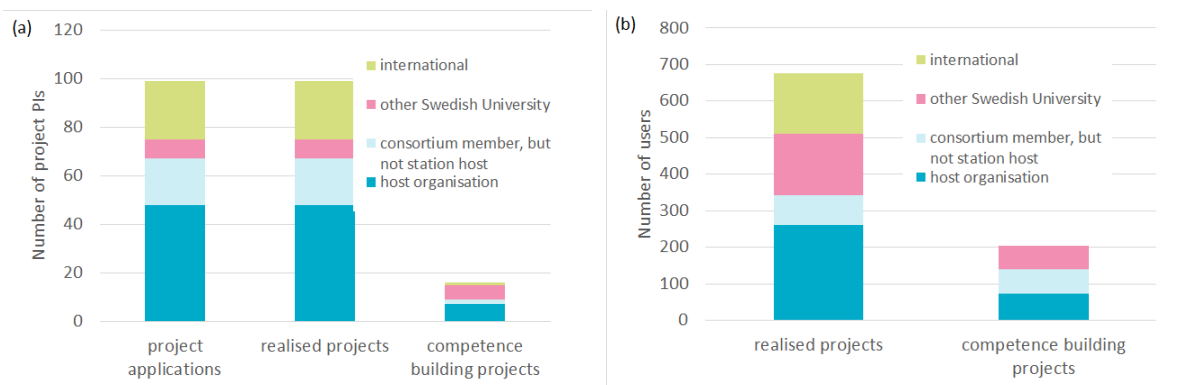


Figure 6. Number of (a) academic projects and (b) academic users divided into their respective academic residence. Host organisations refers to the host of the respective station.

4.2 Users of the data produced by the infrastructure

Data produced at ICOS Sweden facilities is of interest for scientists nationally and internationally. During 2022, the amount of data requests from the ICOS Carbon portal, where all data are available under a Creative Commons Attribution 4.0 International License increased to more than 52000. No personal data is gathered from users downloading data via the Carbon Portal, however, the country of origin is derived from the users IP number (Fig 7). As before, no statistics on gender distribution was evaluated for 2022.

The data flow from the stations through the ICOS Atmosphere Thematic Centre to the Carbon Portal been fully established. The data flow from the stations to the Ecosystem Thematic Centre has been fully established for the labelled Ecosystem stations (all but one ICOS Sweden station). Data requests directly to ICOS Sweden were often connected with detailed questions on how to use the data or where to find specific data products. Data downloads from stations from which official ICOS data releases are available on the Carbon Portal (labelled, resp. labelled before 2022) are higher than from the other stations (Table 4). In general, data downloads from the Atmosphere Stations are higher than from the Ecosystem stations. This can be explained by the structure of the data products (single variables in Atmosphere station data vs. collection of parameters in Ecosystem station data). Also the user behaviour is different for the different communities: whereas the Atmosphere station community often accesses the data by demand during model runs which results in multiple downloads for multiple model runs, the typical Ecosystem station data user downloads a dataset and works offline with the data (single data download).

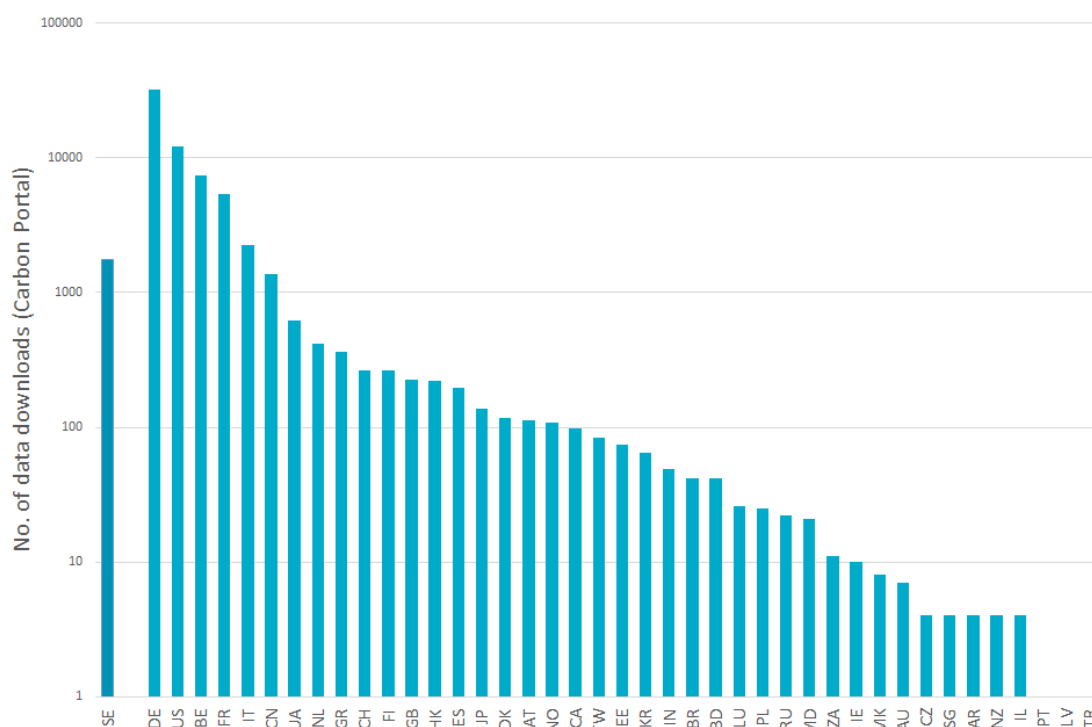


Figure 7. Origin of international data users of the ICOS Sweden data products in 2022 (level 0 to 3); data downloads from the ICOS Carbon Portal.

Table 4. Downloads of data (Level 1 to 3) from the ICOS Carbon Portal since 2018 per station. The Ocean stations are not yet listed as data from the Swedish Ocean stations are not yet available from the Carbon Portal.

station / year	Ecosystem Stations						Atmosphere Stations		
	SE-Sto	SE-Svb	SE-Deg	SE-Nor	SE-Lnn	SE-Htm	SVB	NOR	HTM
2018	0	1046	25	560	124	1012	204	241	273
2019	5	2337	133	1381	451	1775	1902	1915	2560
2020	15	1071	378	613	289	838	2068	2309	2569
2021	366	2627	668	1547	595	2146	11423	11358	11344
2022	663	3172	1274	2048	673	2883	14132	13540	13671

4.3 Citation statistics for peer-reviewed publications related ICOS Sweden stations

The full list of peer-reviewed scientific publications published in 2022 that the ICOS Sweden infrastructure has contributed to through data measured at the stations or support of field research at the stations is included in Appendix A. Google scholar was used to compile the citations related to publications since 2018. The full publication list of included papers is available on the RI’s webpage (www.icos-sweden.se). The first authors’ home institutions are evenly distributed between international universities (25 publications) and Swedish universities (24 publications). Publications with Swedish first authors originated mainly from partner universities within the consortium, but not necessarily from within the working group directly working within ICOS. An analysis of publications naming “ICOS Sweden” showed that most papers are connected to environmental science or meteorology/atmospheric science; other research areas are ecology, forestry and agronomy as well as multidisciplinary approaches in geosciences and sciences in general (Web of Science, 15 March 2023).

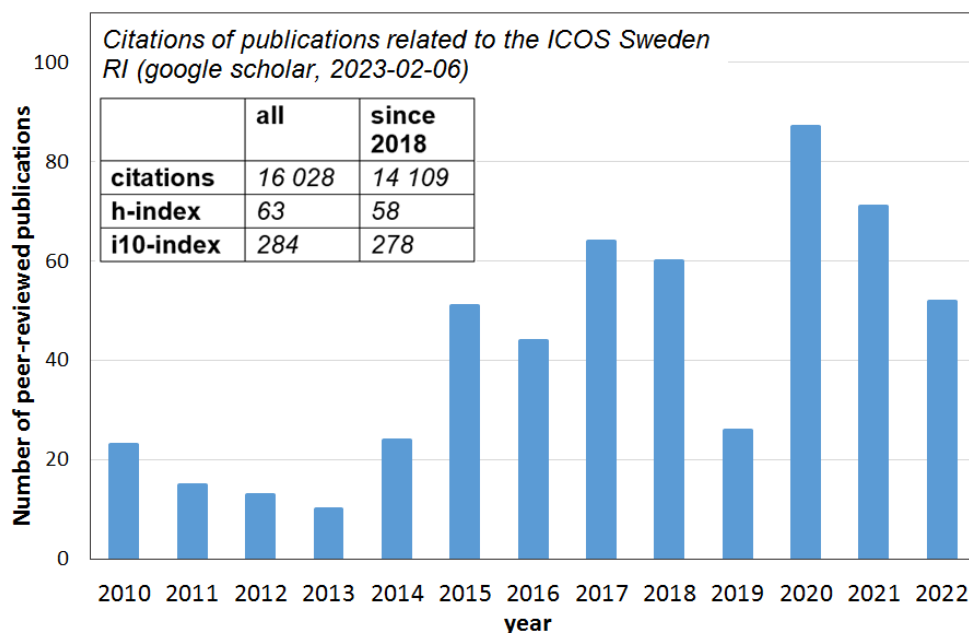


Figure 8. Number of publications and citation statistics (google citations, 2023-02-06) of publications related to ICOS Sweden stations and ICOS Sweden activities. The full publication list of included papers is available the RI’s webpage (www.icos-sweden.se).

5. Financial outcomes 2022

A summary of the financial outcome at the end of 2022 for the grant ICOS Sweden Operations 2021-24 (DNo. 2019-00205) is given in Tables 5. Column 1 identifies the specific budget item; columns 2 and 11 give the remaining balances at the beginning, resp. at the end of the year 2022; columns 3 to 8 list the incomes and costs for each consortium partner; column 12 summarizes the remaining balance at the end of 2022 in % from the incomes, resp. budgeted costs at the beginning of the funding period. The costs for the Coordination Office and Technical Support were listed as salary costs including overhead in the financial outcome for 2021, but they had not been invoiced in 2021 due to changes in the ICOS Sweden leadership; these costs have been included in the costs for 2022. When invoicing the consortium partners, the costs are accounted as “Operating other costs”. To balance the accounting correctly, the costs for 2021 appear as negative costs in the 2022 reporting (column 9). Column 10 (Total outcome 2022) summarizes the individual budgets and outcomes of column 3 to 9. The negative outcome in the remaining balance is balanced by a positive outcome in the previous years (2021+22).

Table 5. ICOS Sweden Operations 2021-24 grant (DNo. 2019-00205) financial outcomes 2022 for each partner and in total (kSEK). For acronyms, see Appendix 3.

	1	2	3	4	5	6	7	8	9	10	11	12
		Remainin g balance 2022-2024	LU	GU	PFS	SLU	SMHI	UU	ICOS SE	Total outcome 2022	Remaining balance 2023-2024	Remaining %
in	partner	43,498.2	5,850.8	1,169.1	1,601.5	3,232.0	544.5	1,654.2	0.0	14,052.1	29,446.1	55%
	SRC	29,999.5	3,681.8	859.0	1,084.5	2,770.0	333.5	1,271.2	0.0	10,000.0	19,999.5	50%
	total income	73,497.7	9,532.6	2,028.1	2,686.0	6,002.0	878.0	2,925.4	0.0	24,052.1	49,445.6	
costs	Staff/salaries	24,979.4	4,152.4	753.3	1,229.7	2,574.9	312.1	960.6	-1,476.8	8,506.2	16,473.2	43%
	Premises	1,454.5	541.8	149.8	0.0	11.0	0.0	116.6	-50.4	768.8	685.7	33%
	Operating other costs	26,019.0	1,902.2	617.9	675.8	1,989.6	331.8	1,257.4	-8.0	6,766.7	19,252.3	67%
	Overhead	12,374.5	2,040.5	290.9	437.2	764.5	234.1	590.8	-485.1	3,872.9	8,501.6	50%
	Investments	5,488.6	601.0	111.6	118.4	0.0	0.0	0.0	0.0	831.0	4,657.6	64%
	total costs	70,316.0	9,237.9	1,923.5	2,461.1	5,340.0	878.0	2,925.4	-2,020.3	20,745.6	49,570.4	
in-out	3,181.8	294.7	104.6	224.9	662.0	0.0	0.0	2,020.3	3,306.5	-124.7		

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All partners contributed with more than 50% to the costs for 2022 for operating the RI; this is in accordance to the contract with the SRC and the consortium agreement. After half of the funding period's time (2021-24 grant), approximately half of the budgeted costs and incomes are left for the remaining two years (Table 5, column 12).

The ICOS Sweden Upgrade and Renewal grant (DNo. 2021-00244) does not require any co-funding from the consortium partners (Table 6). Column 1 defines the budget item, column 4 to 9 lists the incomes and costs for all consortium partners for 2022; this is summarized in column 10. Column 11 summarizes incomes and spent costs for 2021 and 2022; the surplus in the balance in column 11 balances the negative balance in column 12. Column 2 includes the total available budget at the beginning of the grant period, whereas column 3 shows the remaining balance at the beginning of the second year (2022), and column 12 the remaining balance at the end of 2022.

Table 6. ICOS Sweden Upgrade and Renewal grant (DNo. 2021-00244) financial outcomes 2022 for each partner and in total (kSEK). For acronyms, see Appendix 3.

1		2	3	4	5	6	7	8	9	10	11	12
		Total Budget 2021-2025	Remaining balance 2022-2025	LU	GU	PFS	SLU	SMHI	UU	Total outcome 2022	Accumulated result 2021+2022	Remaining balance 2023-2025
in	SRC	16,833.0	10,941.0	1,779.4	680.6	668.1	2,059.3	236.2	468.4	5,892.0	11,784.0	5,049.1
	total income	16,833.0	10,941.0	1,779.4	680.6	668.1	2,059.3	236.2	468.4	5,892.0	11,784.0	5,049.1
costs	Investments	16,833.0	16,347.1	494.2	1,103.6	1.0	1,457.6	428.5	43.6	3,528.5	4,014.4	12,818.7
	total costs	16,833.0	16,347.1	494.2	1,103.6	1.0	1,457.6	428.5	43.6	3,528.5	4,014.4	12,818.7
	in-out	0.0	-5,406.1	1,285.2	-423.0	667.1	601.8	-192.3	424.8	2,363.5	7,769.6	-7,769.6

At the end of 2022, most budgeted investments still have to be done (76% of investments left). The reasons are manifold:

- The delay in the clear-cut at Norunda delayed the investments connected to the adjustment of the installations.
- A specific eddy-covariance system (Campbell CPEC310) was included in the Upgrade and Renewal Grant which was intended to be tested as a promising alternative to obtain more reliable data in harsh winter conditions than from the current ICOS set-up. Unfortunately, this specific system is no longer available as the manufacturer found serious technical issues which they want to solve first before continue selling the system again. The manufacturer of the originally thought system could not tell when their system will be available again. Discussions with the SRC whether we can deviate from the original plans to an alternative are ongoing.
- The delivery times for the N₂O analyzers for the atmosphere stations and CH₄ analyzers for the ecosystem stations were extremely long, delaying the invoices to 2023.

It is expected that the investments will be done at the end of 2023, thus following the available budget.

Appendices

Appendix 1: List of peer-reviewed publications

- Ahlberg, Erik, Ausmeel, Stina, Nilsson, Lovisa, Spanne, Mårten, Pauraite, Julija, Klenø Nøjgaard, Jacob, Bertò, Michele, Skov, Henrik, Roldin, Pontus, Kristensson, Adam. 2022. Measurement Report: Small effect of regional sources on black carbon properties and concentrations in Southern Sweden background air. *Atmospheric Chemistry and Physics Discussions* 44946.
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Coupling plant litter quantity to a novel metric for litter quality explains C storage changes in a thawing permafrost peatland. *Global Change Biology* 28, 950-968.

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Appendix 2: list of selected appearances of ICOS Sweden in media in 2022

TV:

- 2022-11-17, TV4: [Därför ändrar stressade träd doft.](#)
- 2022-09-28: Misstänkt gas från Nord Stream upptäckt på forskningsstation i Perstorp <https://www.svt.se/nyheter/lokalt/helsingborg/misstankt-gas-fran-nord-stream-upptackt-pa-forskningsstation-i-perstorp>
- 2022-09-29: <https://www.svt.se/nyheter/lokalt/uppsala/har-ger-matstationen-i-bjorklinge-utslag-efter-gaslackan-i-ostersjon>
- 2022-09-30: <https://www.svt.se/nyheter/inrikes/metanforskarna-mangden-metan-forsvinnande-liten-globalt>
- 2022-09-30: <https://www.tv2bornholm.dk/artikel/sverige-maaler-en-oeget-maengde-metangas-i-luften>
- <https://tvn24.pl/tvnmeteo/swiat/szwedzka-stacja-badawcza-observerujemy-wzrost-stezenia-metanu-w-powietrzu-6136708>
- 2022-08-18, SVT: <https://www.svt.se/nyheter/lokalt/uppsala/unik-matning-ska-ge-ny-kunskap-om-skogens-klimatpaverkan>

Radio broadcast:

- 2022-09-28: <https://sverigesradio.se/artikel/nord-streamgasen-drar-in-over-skane-matt-valdigt-hoga-koncentrationer>
- 2022-09-29: <https://sverigesradio.se/artikel/metangas-uppmatt-langt-fran-nordstream-klimatpaverkan-oroande>
- 2022-09-29: Med Erik Blix - P4 Extra <https://sverigesradio.se/avsnitt/2010548> (4:30-11:00)
- 2022-09-30: P4 Kristianstad <https://sverigesradio.se/avsnitt/2011260> (2:32:00-2:39:00)
- 2022-08-01: Sveriges Radio: <https://sverigesradio.se/artikel/avverkning-blir-till-ovanligt-experiment-om-skog-och-vaxthusgaser>

Newspapers and online media:

- 2022-10-14, Land Lantbruk: Kalhygget är guld värd för forskarna.
- 2022-09-29, LUNews: [Kolsänkorna inte klimaträddarna vi hoppats på](#)
- 2022-09-29: <https://www.svd.se/a/15OkEq/misstankt-gas-upptackt-pa-forskningsstationer>
- 2022-09-29: <https://www.aktuellhallbarhet.se/miljo/klimat/gaslackan-ger-redan-stora-utslag-i-matningar-kommer-inte-belasta-svenska-utslappsstatistiken>
- 2022-09-28: <https://www.sydsvenskan.se/2022-09-28/efter-gaslackorna--forhojda-metannivaer-i-skane>
- Uppsala Nya Tidning, 2022-09-29: Misstänkt gas upptäckt på forskningsstationer (unt.se)
- 2022-09-29: <https://www.dn.se/varlden/senaste-nytt-om-gaslackorna-pa-nord-stream/>
- Uppsala Nya Tidning, 2022-09-30: Metan från Nord Stream har nått Uppsala (unt.se)
- 2022-09-28: <https://www.washingtonpost.com/world/2022/09/28/nord-stream-russia-methane-leak-baltic-sea>
- 2022-09-29: <https://www.washingtonpost.com/world/2022/09/29/nord-stream-gas-leak-methane-russia>
- <https://www.dn.se/sverige/krismote-i-ystad-efter-nord-stream-lackorna/>

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- 2022-09-30: <https://www.nilu.com/2022/09/methane-leaks-from-nord-stream-a-serious-pollution-event/>
- 2022-09-30: <https://omni.se/nivan-av-metangas-over-skandinavien-pa-rekordniva-aldrig-sett-nagot-liknande/a/q1WWv0>
- 2022-09-30: <https://www.spiegel.de/wissenschaft/natur/datenauswertung-zeigt-riesige-methanwolke-ueber-nord-stream-lecks-a-98e01ac3-a96d-4fb1-902a-4a76c274ce50>
- 2022-09-30: <https://video.repubblica.it/dossier/crisi-in-ucraina-la-russia-il-donbass-i-video/la-grande-nuvola-di-metano-su-norvegia-e-svezia-il-video-del-rilievo-elettronico-del-flusso-del-gas/427682/428633?ref=RHTP-BS-I353012196-P23-S1-T1>
- 2022-09-30: <https://www.gp.se/nyheter/sverige/moln-av-metan-fr%C3%A5n-brustna-gasledning-1.82221324>
- 2022-09-30: <https://www.dn.se/sverige/sa-rorde-sig-metangasmolnet-efter-explosionen-av-nord-stream/>
- <https://wydarzenia.interia.pl/raporty/raport-kryzys-energetyczny/aktualnosci/news-nord-stream-dania-i-szwecja-pisza-o-setkach-kilogramow-mater,nld,6318840>
- <https://www.nature.com/articles/d41586-022-03111-x>
- <https://www.nytimes.com/live/2022/09/30/world/russia-ukraine-war-news/scientists-are-tracking-the-path-of-the-plume-of-methane-gas-from-the-pipeline-leaks-caused-by-explosions?smid=url-share>

Appendix 3: Documentation of personnel during 2022

Total amount of FTEs: 14.64

Employees at the ICOS Sweden stations in 2022

year	individuals		Fulltime equivalents
	male	female	
Coordination office	0	3	0.9
Technical and Scientific Support	2	1	1.0
Abisko-Stordalen	3	1	1.8
Svartberget	3	1	2.35
Degerö	2	1	1.35
Norunda	2	2	2.33
Östergarnsholm	2	1	1.2
Mycklemossen	3	0	1.05
Hyltemossa	4	2	2.35
M/S Tavastland	0	1	0.31

Appendix 4: List of abbreviations and acronyms

ICOS RI (European level)

ATC – Atmosphere Thematic Center

AS – Atmosphere stations

CAL – Central Analytical Laboratories

CFs – Central facilities (ETC, ATC, OTC and CAL)

CP – Carbon Portal

ES –Ecosystem station

ETC – Ecosystem Thematic Center

ERIC – European Research Infrastructure Consortium

ICOS RI – Integrated Carbon Observation System Research Infrastructure

MSA – Monitoring Station Assembly

OS – Ocean station

OTC – Ocean Thematic Center

SOOP – ship of opportunity

SPI – Station Principal Investigator

ICOS Sweden partners

LU – Lund University

GU – Gothenburg University

PFS - Swedish Polar Research Secretariat

SMHI –Swedish Meteorological and Hydrological Institute

SLU – Swedish University of Agricultural Sciences

UU – Uppsala University

Other

FTE – full-time equivalent

GHG – greenhouse gas

SRC –Swedish Research Council (in Swedish VR – Vetenskapsrådet)

STEM – Science, technology, engineering, and mathematics

TNA – transnational access