ICOS SWEDEN Annual Report 2021

ICOS National Network Sweden

Lunds Universitet · Göteborgs Universitet · Uppsala Universitet · SLU · Polarforskningssekretariatet · SMHI · Swedish Research Council

The Steering Committee of ICOS Sweden endorsed this Annual Report 2021 on February, 28 2022. The report is complemented by other documents from ICOS Sweden, including the Operational Plan for 2022, the Strategic Plan 2021-2024, and the ICOS Sweden User Statistics for 2021.

This document was prepared by the ICOS Sweden Coordination Office.

Innehåll

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, 14 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).

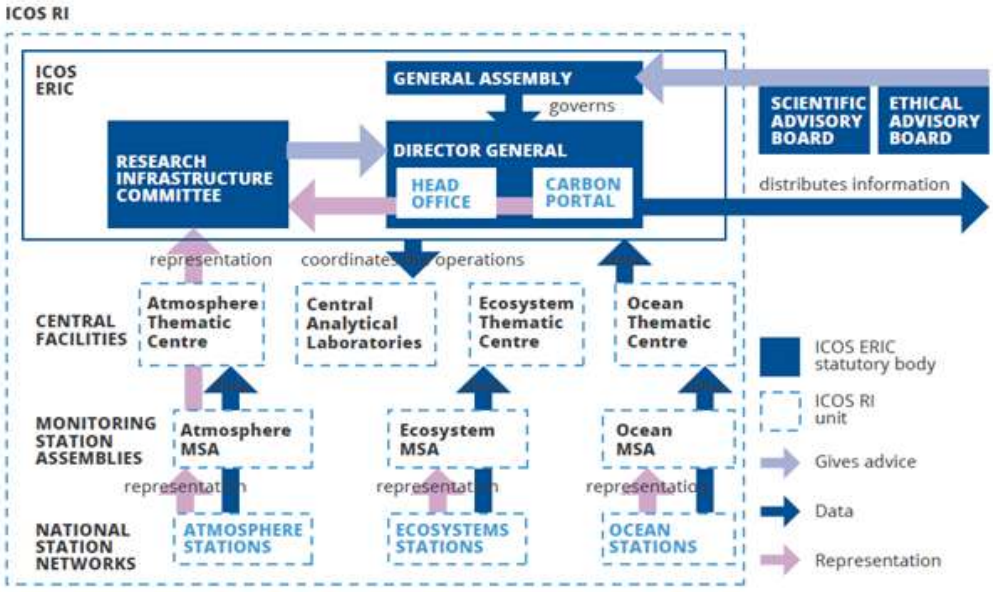

Figure 1. *Outline of the ICOS RI organization. Sweden is a member of ICOS ERIC and ICOS Sweden is the national station network in Sweden (https://www.icos-cp.eu/about/organisation-governance/structure).*

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 140 stations in 14 European countries. The current ICOS Atmosphere and Ecosystem Networks include more than 30 atmospheric and around 70 ecosystem stations located across Europe. The ICOS Ocean Network covers the North Atlantic and European marginal seas. The Ocean Observation System will consist of more than 20 facilities: Voluntary Observatory Ships, so called Ships of Opportunity (SOOP), fixed stations and research vessels.

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 will furthermore provide 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 national research infrastructure.

2. Status of ICOS Sweden at the end of 2021

ICOS Sweden makes measurements at stations distributed across Sweden, from Abisko-Stordalen in the north to Hyltemossa in the south (Fig. 2). There are three Atmosphere Stations for measurement of concentrations of GHGs in the well-mixed boundary layer, six Ecosystem Stations for measurements of exchanges of GHGs between ecosystems and the atmosphere, one fixed Ocean Station for observations of the coastal Baltic Sea, and one Ocean Station based on a SOOP, for measurements of the surface ocean traveling between the Netherlands and Finland. The measurement stations are run by the consortium partners. The framing of the cooperation is set by a formal agreement, the consortium agreement.

- **Lund University (LU)** is the host organization with overall responsibility for the coordination of ICOS Sweden, and for the operations of four ICOS stations: Norunda forest Ecosystem and Atmosphere stations and Hyltemossa forest Ecosystem and Atmosphere stations.
- **Swedish University of Agricultural Sciences (SLU)** operates three ICOS stations: Svartberget forest Ecosystem and Atmosphere stations, and the Degerö mire Ecosystem station.
- **University of Gothenburg (GU)** is responsible for the operations of the Mycklemossen mire Ecosystem station.
- **Uppsala University (UU)** operates the Östergarnsholm fixed Ocean station incl. a marine flux tower.
- **Swedish Polar Research Secretariat (PFS)** runs the Abisko-Stordalen mire Ecosystem station.
- **Swedish Meteorological and Hydrological Institute (SMHI)** operates the Ocean station measurements onboard the SOOP M/S Tavastland.

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

The status of all measurement stations at the end of 2021 is summarized in Fig. 3. ICOS Sweden became, for most of the measurement systems, fully operational during 2014. In 2016, the station labelling process procedures and the criteria for the different types of stations were specified by ICOS RI.

In spring 2018, all three Atmosphere Stations (Svartberget, Norunda, Hyltemossa) were labelled as Class 1 ICOS RI Atmosphere Stations. 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 May 2021 and included data until January 2021. 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). 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 measurements[2]. Data is automatically transferred to the ETC via the ICOS Carbon Portal each night. The ETC released Level 2 data including data from the labelled ICOS Sweden stations until the end of 2020 in spring 2021. In 2021, ETC agreed on releasing interim Level 2 products to enable faster access to the data. A first set of interim Level 2 data was released for selected stations, including the labelled ICOS Sweden sites, in late 2021. The processing of more station data is ongoing. The ETC data products are available through the ICOS Carbon Portal.

The status of the not yet labelled ICOS Sweden stations is at follows:

- Östergarnsholm is expected to become labelled by ICOS ERIC General Assembly in spring 2022. The labelling has been delayed several times due to staff changes at the Ocean Thematic Centre (OTC) and new rules for the labelling process.
- Abisko-Stordalen has taken up the labelling process in 2021 and is expected to be certified by ICOS ERIC General Assembly in spring 2022.
- The new stations, the Ecosystem Station Mycklemossen and the Ocean Station SOOP M/S Tavastland, passed the first step of the labelling process in 2021 and are now in step 2.

[1] data.icos-cp.eu/portal

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

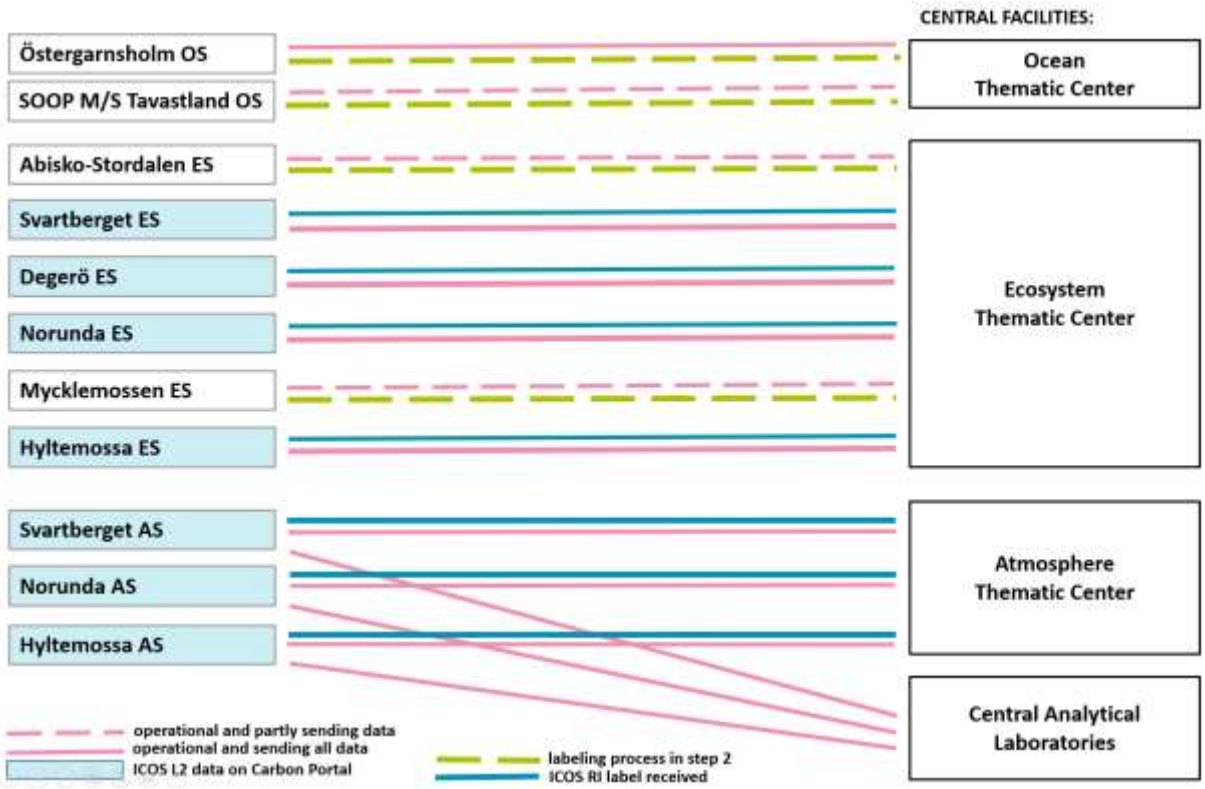

Figure 3. *The development status for the delivery of data and information from the ICOS Sweden measurement stations to the ICOS Central Facilities (status February 2022). Coloured lines – status ICOS labelling. AS – Atmosphere station, ES – Ecosystem station, OS – Ocean station.*

ICOS Sweden data

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. ICOS Sweden is continuously working on updating the files from all Swedish ICOS Ecosystem Stations in the repository (Table 1). 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 is (Drought 2018[3]), resp. will be (Winter 2019/20-Covid19) available through the ICOS Carbon Portal. Furthermore, ETC has opened the possibility to upload data from before the date of ICOS labelling as Associated Station data: Data and the full set of metadata for Svartberget (SE-Svb, 2014-2019), Degerö (SE-Deg, 2014-2019), and Hyltemossa (SE-Htm, 2015-2018) has already been uploaded to the ICOS Carbon Portal; the upload of (meta)data for Norunda (SE-Nor, 2014-2018) has been started. The status of all data from ICOS Sweden stations is summarized in Fig. 4.

[3] www.icos-cp.eu/data-products/YVR0-4898

Table 1. *Status of the Swedish National Network data on the ICOS Carbon Portal on 2021-12-01. The table includes even the agricultural site Lanna (SE-Lnn) which was part of ICOS Sweden until the end of 2020.*

	Fluxes (annual files)	Meteo variables (annual files)	Gas and temperature profile variables (annual files)	Eco variables (annual files)	Metadata on instruments and variables
SE-Htm	2015-2020	2015-2020	2015-09/2020	2015-2020	On landing page at CP (variables and heights), resp on icos-Sweden.se
SE-Lnn	2014-2019	2014-2019	–	2014-2018	On landing page at CP (variables and heights), resp on icos-Sweden.se
SE-Nor	2014-2020	2014-2020		2014-2020	On landing page at CP (variables and heights), resp on icos-Sweden.se
SE-Deg	2014-2020	2014-2020	–	2014-2020	On landing page at CP (variables and heights), resp on icos-Sweden.se
SE-Svb	2014-2020 (not: 2017)	2014-2020	2014-07/2020 (not: 2018)	2014-2020	On landing page at CP (variables and heights), resp on icos-Sweden.se
SE-Sto	2014-2019	2014- Oct 2021	–	2014-Oct 2021	On landing page at CP (variables and partly heights), resp on icos-Sweden.se

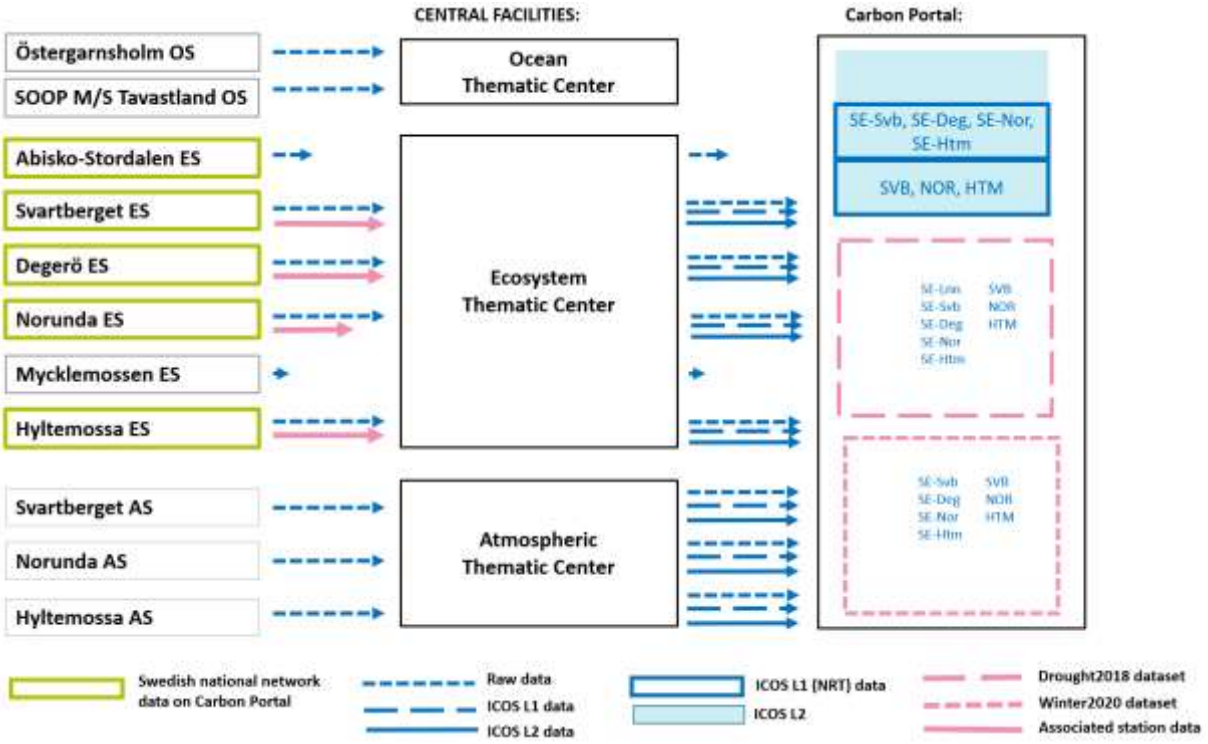

Figure 4. *Status of ICOS Sweden data products on the ICOS Carbon Portal on 2022-02-01. The length of the arrows reflects symbolically the percentage of total data that is being transferred.*

3. Highlights in science and management during 2021

3.1 Management

- At the end of 2020, the Lund University vice rector announced Janne Rinne as interim director of ICOS Sweden from the 1st of January 2021. Rinne took over after Maj-Lena Linderson who decided to step down as director. From 1 July 2021, Jutta Holst was asked by the vice rector of Lund University to take over the directorship, since J. Rinne had to step down from the task due to personal reasons. The

directorship was given to J. Holst for an initial one-year period. The change in the leadership was done in agreement with the consortium partners, represented by the *stämma,* and the Swedish Research Council (SRC).

- The consortium agreement for the 3rd funding period which formally defines the rights and obligations between the partners was finalized and signed all partners in July 2021.

- The mandate period of the ICOS Sweden Steering Committee had ended. Thus, the reference group suggested eight candidates to the consortium partners who agreed on the suggested list. The new ICOS Sweden Steering Committee was appointed by LU in agreement with the SRC for the period 2021-12-16 to 2024-12-31. The new Steering Committee members are Dr Eija Juurola (chair), Finnish Meteorological Institute, Dr Lars Arneborg, SMHI, Professor Hjalmar Laudon, SLU, Dr Heather Reese, GU, Professor Isaac Rodriges Dos Santos, GU, Dr Linda Marie Kanders, IVL, Dr Marko Scholze, LU, and Professor Lars Tranvik, UU.

- In early 2021, ICOS Sweden handed in the application "ICOS Sweden infrastructure upgrade and renewal" to the SRC call for Grants for investments in research infrastructures 2021. The positive decision on the outcome came in July 2021. The project includes investments regarding renewal of instruments and upgrading of measuring equipment at the ICOS Sweden infrastructure and complements previously granted resources regarding ICOS Sweden's operations for the period 2021 to 2024. Resources for operation, maintenance, user support and data management are covered by ICOS Sweden's operations for the period 2021 to 2024.

- The progress within the project 'ICOS – resource for school' that was approved by the SRC in summer 2020 is delayed. The aim of the project is to stimulate interest of children at high school age in STEM subjects. This will be done by using ICOS data for example calculations as well as description videos and texts within the ICOS measurement context related to multiple topics of the school curriculum. The project is done in collaboration with the Swedish Science Centers. While the programming tasks and teachers' material has been mainly finalized, other tasks like the production of the introduction movies, the pilot tests in the schools, and the visit of school kids (PRAO) at the stations have been delayed due to covid-19 restrictions.

- Even though no longer being SPI of any of the measurement stations the Ecosystem MSA asked Janne Rinne to continue as chair for the MSA in 2021; Rinne acted as chair until the middle of 2021. The chair of the MSA is an important leadership link between ICOS Sweden and ICOS RI.

3.2 Measurement stations

3.2.1 Station certification

All three certified Atmosphere stations delivered data for the mandatory variables to the ATC throughout 2021; the certified Ecosystem stations delivered data for the mandatory variables to the ETC throughout 2021. The mire Ecosystem station Mycklemossen passed the first step of the labeling procedure and started with the tasks necessary for step 2. Even SOOP M/S Tavastland, started collecting data for the 2nd step in the labelling procedure. The finalization of the second step in the

labelling of the fixed Ocean station Östergarnsholm was delayed again; new requested samples were delivered to OTC in mid-2021.

3.2.2 Station highlights

At the stations, the maintenance work to ensure high quality, continuous data had high priority. The risk assessments and detailed workplace strategies have been updated following the Swedish Government's and Public Health Authority's recommendations regarding measures to reduce the spread of the coronavirus (Covid-19). As in 2020, most study visits from courses have been transferred to digital visits as far as possible. Restrictions concerning visits by master students and interns to the stations have been eased compared to 2020. At most stations, however, despite the restrictions, users could come and perform their fieldwork. The access to SOOP M/S Tavastland which has been operating between Finland and Germany was still limited. To ensure the continuation of the measurements despite these difficulties, maintenance work on board was supported by the GEOMAR Helmholtz Centre for Ocean Research Kiel (Germany). Thanks to this, measurements could be carried out throughout 2021 except for a 4-week period in early 2021 when the ship was in the dockyard for service.

In December 2021, the first call for the ATMO-ACCESS project opened which enables international researchers to visit research facilities which are part of the project through transnational access (TNA). From the Swedish ICOS sites this relates to Hyltemossa. ATMO-ACCESS will deliver a series of recommendations for establishing a comprehensive and sustainable framework for access to distributed atmospheric RIs, ensuring integrated access to and optimized use of the services they provide.

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 held online during 2021 due to covid-19 pandemic restrictions.

The 3rd Nordic ICOS Symposium was held from 23rd to 25th November. Like most other conferences during 2021 the symposium was held online due to the pandemic. More than 150 registered participants joined the conference that was jointly prepared by the Nordic national ICOS networks and hosted by ICOS Finland. Data from the ICOS Sweden stations were subject of several presentations at the conferences.

4. Financial outcomes 2021

A summary of the financial outcomes for 2021 for all sites are given in Table 2 below. Costs for the Coordination Office and Technical Support was not invoiced in 2021 due to changes in the ICOS Sweden leadership. The costs will be invoiced in 2022 together with the costs for 2022. At SLU higher personal costs than originally estimated were caused by temporary staff due to parental leave of the ordinary staff. Part of the co-funding (585 kSEK) at GU was not accounted during 2021 and will be added retroactive in 2022.

Table 2. *Financial outcomes 2021 for each partner and in total (kSEK). For acronyms, see Appendix 3.*

all in kSEK			Outcome 2021									
		Total Budget 2021-2024	LU	GU	PFS	SLU	SMHI	UU	ICOS SE	*total*	Remaining balance 2022-2024	%
income 2021	ICOS SE 2021-2024 partner	53 240.0	4 455.2	282.1	243.5	3 125.0	190.5	1 445.5	0.0	***9 741.8***	*43 498.2*	82%
	ICOS SE 2021-2024 SRC	40 000.0	3 681.8	859.0	1 085.0	2 770.0	333.5	1 271.2	0.0	***10 000.5***	*29 999.5*	75%
	total income	***93 240.0***	***8 137.0***	***1 141.1***	***1 328.5***	***5 895.0***	***524.0***	***2 716.7***	***0.0***	***19 742.3***	***73 497.7***	
costs 2021	Staff/salaries	45 213.8	3 839.9	840.3	1 125.4	4 597.1	202.6	1 018.6	1 476.8	***13 100.7***	*32 113.1*	71%
	Premises	2 394.2	419.3	170.5	0.0	10.8	0.0	0.0	50.4	***651.0***	*1 743.2*	73%
	Operating other costs	18 425.4	603.2	69.7	70.0	961.2	116.1	860.2	8.0	***2 688.4***	*15 737.1*	85%
	Overhead	19 982.8	1 469.8	299.1	274.9	1 402.4	152.0	665.5	485.1	***4 748.8***	*15 234.0*	76%
	Investments 2021	7 223.8	1 509.5	0.0	0.0	0.0	53.3	172.4	0.0	***1 735.2***	*5 488.6*	76%
	total costs	***93 240.0***	***7 841.7***	***1 379.6***	***1 470.3***	***6 971.5***	***524.0***	***2 716.7***	***2 020.3***	***22 924.1***	***70 316.0***	
result	***in-out***	***0.0***	***295.3***	***-238.5***	***-141.8***	***-1 076.5***	***0.0***	***0.0***	***-2 020.3***	***-3 181.8***	***3 181.7***	

all in kSEK			Outcome 2021									
		Total Budget 2021-2024	LU	GU	PFS	SLU	SMHI	UU	ICOS SE	*total*	Remaining balance 2022-2024	%
income 2021	ICOS Equipm. renewal 2021-2024	16 835.0	1 779.4	680.6	668.1	2 059.3	236.2	468.4		***5 892.0***	*10 943.0*	65%
	total income	***16 835.0***	***1 779.4***	***680.6***	***668.1***	***2 059.3***	***236.2***	***468.4***	***0.0***	***5 892.0***	***10 943.0***	
costs 2021	Investments 2021, renewal	16 835.0	0.0	0.0	165.8	320.1	0.0	0.0	0.0	***485.9***	*16 349.1*	97%
	total costs	***16 835.0***	***0.0***	***0.0***	***165.8***	***320.1***	***0.0***	***0.0***	***0.0***	***485.9***	***16 349.1***	
result	***in-out***	***0.0***	***1 779.4***	***680.6***	***502.3***	***1 739.2***	***236.2***	***468.4***	***0.0***	***5 406.1***	***-5 406.1***	

all in kSEK			Outcome 2021									
		Total Budget 2021-2024	LU	GU	PFS	SLU	SMHI	UU	ICOS SE	*total*	Remaining balance 2022-2024	%
TOTAL INCOME		*110 075.0*	*9 916.4*	*1 821.7*	*1 996.6*	*7 954.3*	*760.2*	*3 185.1*	*0.0*	*25 634.3*	*84 440.7*	77%
TOTAL COSTS		*110 075.0*	*7 841.7*	*1 379.6*	*1 636.1*	*7 291.6*	*524.0*	*2 716.7*	*2 020.3*	*23 410.0*	*86 665.1*	79%
RESULT	*in-out*	*0.0*	*2 074.7*	*442.2*	*360.5*	*662.7*	*236.2*	*468.4*	*-2 020.3*	*2 224.3*	*-2 224.4*	

Appendices

Appendix 1: List of personnel during 2021

Total amount of FTEs: 14.5

Coordination Office:

Janne Rinne, director, 20% (Jan-Jun)
Jutta Holst, scientific secretary, 43% (Jan-Jun); director, 50% (Jul-Dec)
Yvonne Kedström, secretary, 5%
Irene Lehner, scientific secretary, 5% (Nov-Dec)
Helene Holmström, economist, 25% (Nov-Dec)
Meelis Mölder, scientific and technical station support, 40%
Jutta Holst, scientific and technical station support, 40%
Michal Heliasz, scientific and technical station support, 20%

Measurement stations:

M/S Tavastland:
Anna Willstrand Wranne, OS PI, 20%

Abisko-Stordalen:
160% split into
Erik Lundin, ES PI, research engineer
Alexander Meire, research engineer
Niklas Rakos, research engineer

Svartberget:
Paul Smith, AS PI, research engineer, 100%
Matthias Peichl, ES PI, 10%
Guiseppe de Simon, research engineer, 10%
Per Marklund, research engineer, 25%
Pernilla Löfvenius, experiment technician, 25%
Rowan Dignam, research engineer, 10%
Craig King, research engineer, 50%

Degerö
Per Marklund, research engineer, 50%
Rowan Messmer, research engineer, 50%
Pernilla Löfvenius, experiment technician, 25%
Mats Nilsson, ES PI, 10%

Norunda:

Irene Lehner, research engineer, 95% (Jan-Oct), 90% (Nov-Dec)
Anders Båth, research engineer, 85%
Meelis Mölder, AS PI, 10%; ES PI, 2.5%; research engineer, 32.5%
Natascha Kljun, Co-PI, 7.5%
student helpers, 7.5%

Östergarnsholm:

130% split into
Anna Rutgersson, OS PI
Erik Nilsson, research engineer
Panagiotis Stagianos, research engineer

Mycklemossen:

Per Weslien, ES PI, research engineer, 75%
Bengt Liljeblad, research engineer, 15%
Leif Klemedtsson, research engineer, 10%

Hyltemossa:

Tobias Biermann, research engineer, 100%
Michal Heliasz, AS PI, 10%; ES PI 2.5%; research engineer, 67.5%
Thomas Holst, research engineer, 20%
Meelis Mölder, research engineer, 5%
Natascha Kljun, Co-PI, 7.5%
Student helpers, 22.5%

Appendix 2: List of measurement variables and instruments/systems

Table 2.1 ICOS Sweden Ecosystem station parameters

Ecosystem stations		Hyltemossa (SE-Htm)	Norunda (SE-Nor)	Svartberget (SE-Svb)	Mycklemossen (SE-Myc)	Degerö (SE-Deg)	Abisko-Stordalen (SE-Sto)
PI; Co-PI		Michal Heliasz, LU; Natascha Kljun, LU	Meelis Mölder, LU; Natascha Kljun, LU	Matthias Peichl, SLU	Per Weslien, GU	Mats Nilsson, SLU	Erik Lundin, PFS
ecosystem type		forest	forest	forest	mire	mire	palsa mire
Latitude		56°06'N	60°05'N	64°10'N	58°35'N	64°11'N	68°21'N
Longitude		13°25'E	17°29'E	19°47'E	12°06'E	19°33'E	19°03'E
Height a.s.l.		115 m	46 m	270 m	81 m	270 m	360 m
climate zone (Köppen classification)		marine west-coast (Cfb)	humid continental (Dfb)	sub-arctic (Dfc)	marine west-coast (Cfb)	sub-arctic (Dfc)	sub-arctic (Dfc)
biome		temperate	hemi-boreal	boreal	hemi-boreal	boreal	tundra
Dominating species		Picea abies	Picea abies, Pinus sylvestris	Pinus sylvestris, Picea abies	Sphagnum rebellum, Sphagnum fallax, Sphagnum austinii	bog mosses: Sphagnum papillosum Lindb., Sphagnum lindbergii Schimp., Sphagnum balticum (Russow) C.E.O. Jensen	Sphagnum spp. Eriophorum spp. Carex spp, ericacious shrubs
Mean tree height/ age		19 m	25 m	20 m	-	-	-
Mean stand age		35 yrs	120 yrs	100 yrs	-	-	-
Understorey and ground vegetation		mosses	Vaccinium myrtillus L., Vaccinium oxycoccos, mosses, flowers	Vaccinium vitis-idaea L., Vaccinium myrtillus L.		Eriophorum, dwarf-shrubs: Vaccinium oxycoccos, Andromeda polifolia, Trichophorum cespitosum	Empetrum nigrum, Vaccinium vitis-idaea L., Rubus chamaemorus; Cyperaceae, Eriophorum
mean annual temperature		7.0 °C	5.6 °C	1.8 °C	7.0 °C	1.2 °C	-0.1 °C
mean annual precipitation		830 mm	544 mm	614 mm	1052 mm	523 mm	332 mm
Continuous measurements							
Turbulent fluxes	CO_2	27 m	36 m	34.5 m	2.2 m	2.1 m	CO_2
	H_2O	27 m	36 m	34.5 m	2.2 m	2.1 m	2.2 m
	CH_4	-	-	-	2.2 m	2.1 m	2.2 m
	Momentum	27 m	36 m	34.5 m	2.2 m	2.1 m	2.2 m
	Sensible heat	27 m	36 m	34.5 m	2.2 m	2.1 m	2.2 m
	Latent heat	27 m	36 m	34.5 m	2.2 m	2.1 m	2.2 m
Radiative fluxes	Incoming short-wave	150 m, 50 m	101.5 m, 55 m	2 x 50 m	4 m	4 m	2.2 m

	Outgoing short-wave	50 m	55 m	50 m	4 m	4 m	5 m
	Incoming long-wave	50 m	55 m	50 m	4 m	4 m	5 m
	Outgoing long-wave	50 m	55 m	50 m	4 m	4 m	5 m
	Net radiation (from 4 components)	50 m	55 m	50 m	4 m	4 m	5 m
	Incoming PAR	150 m, 50 m	55 m	50 m	4 m	4 m	5 m
	Diffuse incoming PAR	150 m	-	50 m	4 m	4 m	5 m
	Outgoing PAR	50 m	55 m	50 m	4 m	4 m	5 m
	PAR below canopy	4 x 4 transects	4 x 4 transects	4 x 4 transects	-	-	5 m
Soil fluxes	Soil heat flux	4 x -0.05 m	4 x -0.05 m	4 x -0.05 m	4 x -0.05 m	4 x -0.05 m	5 m
State variables	Air temperature profile	14 levels	14 levels	14 levels	5 levels	5 levels	4 x -0.05 m
	CO2 profile	14 levels1	14 levels1	14 levels1	5 levels	5 levels	5 levels
	H2O profile	14 levels	14 levels	14 levels	5 levels	5 levels	5 levels
	CH4 profile	-	-	-	5 levels	-	5 levels
	Relative humidity	24 m, 27 m	37 m, 29 m	32.5 m	2.2 m	2.0 m, 2.2 m	2.5 m
	Wind speed/direction (sonic)	30 m	36 m	34.5 m	2.2 m	2.1 m	2.2 m
	Air pressure	3.5 m	1.5 m	2 m	1 m	1.2 m	1.7 m
	Soil temperature profile	4 x 5	4 x 5	4 x 5	4 x 5	4 x 5	4 x 5
	Soil moisture profile	4 x 5	2 x 5	4 x 5	4	4	4
	Ground water level	4	2	4	4	4	4
	Snow depth	1	1	1	1	2	1
	Precipitation	2	2	2	2	2	2
	Tree trunk surface temperature	4 x 4 x 3	4 x 4 x 3	4 x 4 x 3	-	-	-
	Canopy IR temperature	50 m	55 m	50 m	4 m	4 m	5 m
	Ground height	-	-	-	2 m	2 m	1.5 m
Periodic measurements							
soil	soil carbon stocks	1 / 10 years	1 / 10 years	1 / 10 years	1 / 10 years	1 / 10 years	1 / 10 years

trees	GAI (hemispherical pictures)	6/year	6/year	6/year	-	-	-
	above ground biomass (AGB)	1/ 3 years	1/ 3 years	1/ 3 years			
	Nutrient analysis and Leaf Mass Area (foliar sampling)	1/year	1/year	1/year			
	Woody debris	1/year	1/year	1/year			
mosses	GA (percentage cover)	2/year			2/year	2/year	2/year
	NPP (yearly net change in biomass)	1/year			1/year	1/year	1/year

Table 2.2 ICOS Sweden Atmosphere station parameters

Atmospheric stations	**Hyltemossa**	**Norunda**	**Svartberget**
coordinates	56°06'N, 13°25'E	60°05'N, 17°29'E	64°10'N, 19°47'E
PI	Michal Heliasz, LU	Meelis Mölder, LU	Per Marklund, SLU
Continuous Measurements			
gas concentrations: CO, CO_2, CH_4, H_2O	30 m, 70 m, 150 m	32 m, 58 m, 100 m	35 m, 85 m, 150 m
PBL/cloud base height	1	1	1
Wind speed/direction, air temperature/humidity	30 m, 70 m, 150 m	32 m, 58 m, 100 m	35 m, 85 m, 150 m
Turbulent fluxes	Ecosystem station	Ecosystem station	Ecosystem station
Periodic sampling			
Flask sampling; CO, CO_2, CH_4, H_2O, SF_6, H_2, $^{12/13}CO_2$, $^{12/13}CH_4$	150 m	100 m	150 m
Sampling of radiocarbon ^{14}C	150 m	100 m	150 m

Table 2.3 ICOS Sweden Ocean station parameters

Marine stations		**Östergarnsholm**	**SOOP-Tavastland**
PI		Anna Rutgersson, UU	Anna Willstrand Wranne, SMHI
Continuous measurements			
Turbulent fluxes	CO_2	1	
	H_2O	1	
	Momentum	3	
	Sensible heat	3	

Radiative fluxes	Global radiation	2	
Water measurements	Temperature profile	4	
	Salinity profile	4	
	Surface CO_2	1	1
	Surface Oxygen	1	1
	Surface Temperature		1
	Chlorophyll fluorescence		1
	Turbidity		1
	Phycocyanin fluorescence		1
	CDOM fluorescence		1
	Surface salinity		1
State variables	Air temperature profile	5	
	CO_2 profile	4	
	H_2O profile	4	
	Wind profile	5	
	Relative humidity	1	
	Precipitation	1	
Periodic sampling			
Water sampling	Nitrogen	x	
	Phosphorous	x	
	Silica	x	
	Salinity		x
	Alkalinity		x

Appendix 3: 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