ICOS SWEDEN Operational Plan 2024

ICOS National Network Sweden

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

ICOS Sweden Operational Plan 2024

ICOS Sweden Operational Plan 2024

> *The ICOS Sweden Steering Committee endorsed this Operational Plan on 2023-11-01 (DNr. STYR-*STYR 2023/2315*). The plan is complemented by other documents from ICOS Sweden, including the Strategic Plan (2024-2029) and the Annual Report (2023).*

ICOS Sweden Operational Plan 2024

Table of Contents

1. Introduction to ICOS RI

ICOS - Integrated Carbon Observation System - is a European research infrastructure (RI) for quantifying and understanding the greenhouse gas balance of the European continent and of adjacent regions.

High-precision, standardized observations of the exchange of greenhouse gases and heat between the Earth's surface and the 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 therefore, is to construct, equip, and operate a network of standardized, long-term, high precision integrated monitoring stations for atmospheric greenhouse gas concentrations and fluxes. The infrastructure is founded in two pillars: 1) research and measurement infrastructure and 2) ICOS ERIC (European Research Infrastructure Consortium), a legal entity for ICOS data release, coordination, and integration of the whole system. A full description of the ICOS RI organization is included in Appendix A.

As of 2022, ICOS RI has more than 140 stations in 14 European countries. The current ICOS Atmosphere and Ecosystem Networks include more than 30 atmosphere and around 70 ecosystem stations located across Europe. The ICOS Ocean Network covers the North Atlantic and European marginal seas. The ocean observation system consists of more than 20 facilities: voluntary observatory ships, so called Ships Of Opportunity (SOOP), fixed stations and research vessels.

Stations within ICOS RI separate into three different classifications:

- Class 1 Station: ICOS Ecosystem, Ocean, or Atmosphere Station with a complete equipment setup for measuring the full set of ICOS core variables.
- Class 2 Station: ICOS Ecosystem, Ocean, or Atmosphere Station with a complete equipment setup for measuring ICOS core variables. Less variables are measured compared to a Class 1 station and ancillary data are determined less frequently.
- Associated Station: The network of ecosystem sites in ICOS is enlarged with 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. In contrast to Class 1 and Class 2 Stations, only calculated fluxes and processed data must be submitted.

To assure that stations fulfil the requirements set by the ICOS RI measurement protocols, all stations need to pass a three-step labelling process[1] (two steps for Associated Stations). During this process, the stations prove the suitability of the facility and its surrounding, the correctness of the instrumentation, installation as well as functioning of the data transmission. Once the stations have passed this process, they are promoted to the General Assembly to receive label as an ICOS station.

[1] https://www.icos-cp.eu/about/join-icos/process-stations

2. Status of ICOS Sweden

The national network ICOS Sweden is the Swedish contribution to this European effort. ICOS Sweden is integrated with, and plays an important role in the European ICOS RI. ICOS Sweden has been providing data and helping to compile information on greenhouse gas exchange of typical northern ecosystems to the research community and Swedish stakeholders. Furthermore, ICOS Sweden provides test sites for national inventory systems and databases for advanced research. ICOS Sweden's current operations are funded as a national research infrastructure by the Swedish Research Council (SRC, DNo. F2020-11498) and the partner institutions of the consortium: Lund University (LU, host of ICOS Sweden), Swedish University of Agricultural Sciences (SLU), University of Gothenburg (GU), Uppsala University (UU), Swedish Polar Research Secretariat (PFS) and Swedish Meteorological and Hydrological Institute (SMHI). In September 2023, the RI was informed by the SRC about the decision on the coming funding period (2025-28, DNo. F2023-00172). The funding will mainly follow the proposal which was handed in buy the RI in February 2023. The costs for the marine station Östergarnsholm are excluded from this preliminary decision; in case the station will have passed the labelling process before the end of 2028, the RI can apply to cover the costs for the station for the remaining funding period (2025-28). The decision on the final amount will be made after a dialogue meeting including the host of the RI (Lund University), the director of the RI and the SRC in November 2023. More information about the organization of the national research infrastructure ICOS Sweden can be found in Appendix B.

Station labelling

ICOS Sweden became fully operational during 2014. In 2016, the station labelling process 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 every 24 hrs. The lastest release by the ATC of quality-controlled data products (Level 2 data) including data from ICOS Sweden stations was in July 2023 and included data until April 2023. These data as well as near real time data (Level 1 data) from the Atmosphere Stations are available for users via the ICOS Carbon Portal (CP)[2].

All Swedish Ecosystem stations, except the mire station Mycklemossen, have passed the labelling process before 2023. Measurements (automatic data sampling and 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[3]. Data is automatically transferred to the ETC via the ICOS Carbon Portal. The ETC released the latest Level 2 dataset including data until the end of 2022 in July 2022. The next interim L2 dataset covering the data until the end of the summer 2023 is in preparation. The ETC data products are available through the ICOS Carbon Portal.

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

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

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

- The labelling process of the fixed ocean station Östergarnsholm has been delayed due to difficulties with the sensor quality assurance. Various attempts have been made to get around the problem which is caused by the low salinity of the Baltic Sea without success. Limited access to the buoy further prolongs the process. Currently, OTC is developing a sampling system which will be deployed at Östergarnsholm for long-term parallel measurements. The system is expected to be ready for the field in spring 2024. The installation time will depend on the weather situation and the resulting accessibility of the station.
- During 2023, the Ecosystem Station Mycklemossen has been concentrating on preparing the instrumentation and the automatic data transfer to the ETC which has now been fully established. The vegetation sampling which is also mandatory for the labelling is planned for summer 2024, resulting in the earliest possible labelling in autumn 2024.
- The Ocean Station SOOP M/S Tavastland has collected several months of data which will be sent to OTC as part of the labelling process. Tavastland had an extended stay in the port during 2023 due to reorganization on the part of the shipping company. At the moment, the boat is travelling between Belgium and the Mediterranean Sea.

The status of all measurement stations in October 2023 are summarized in Fig. 1.

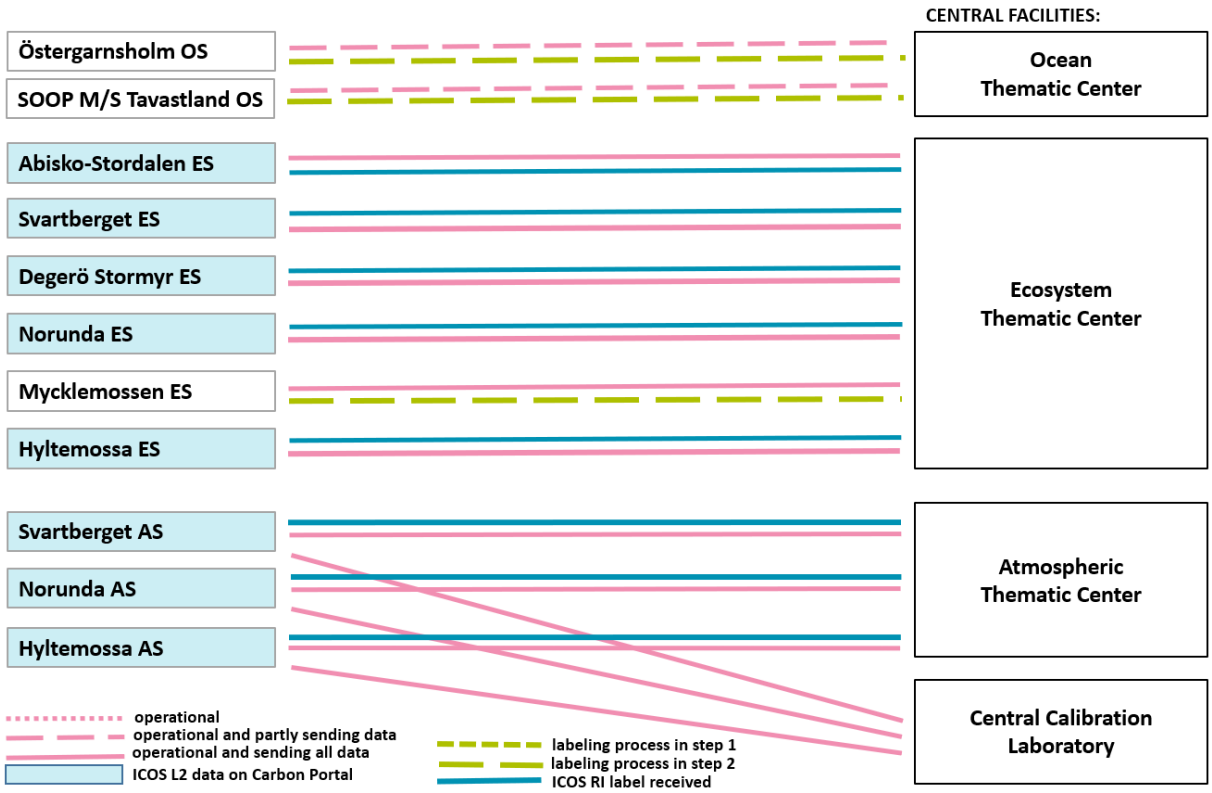

Figure 1. *The development status for the delivery of data and information from the ICOS Sweden measurement stations to the ICOS Central Facilities (status October 2023). Coloured lines – status ICOS labelling. AS – Atmosphere station, ES – Ecosystem station, OS – Ocean station.*

ICOS Sweden data

Most data from the ICOS Sweden ecosystem network are available and searchable as Swedish National Network data on the ICOS Carbon Portal. 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[4]), 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 put on hold while waiting for feedback from ETC. The status of all data from ICOS Sweden stations are summarized in Fig. 2.

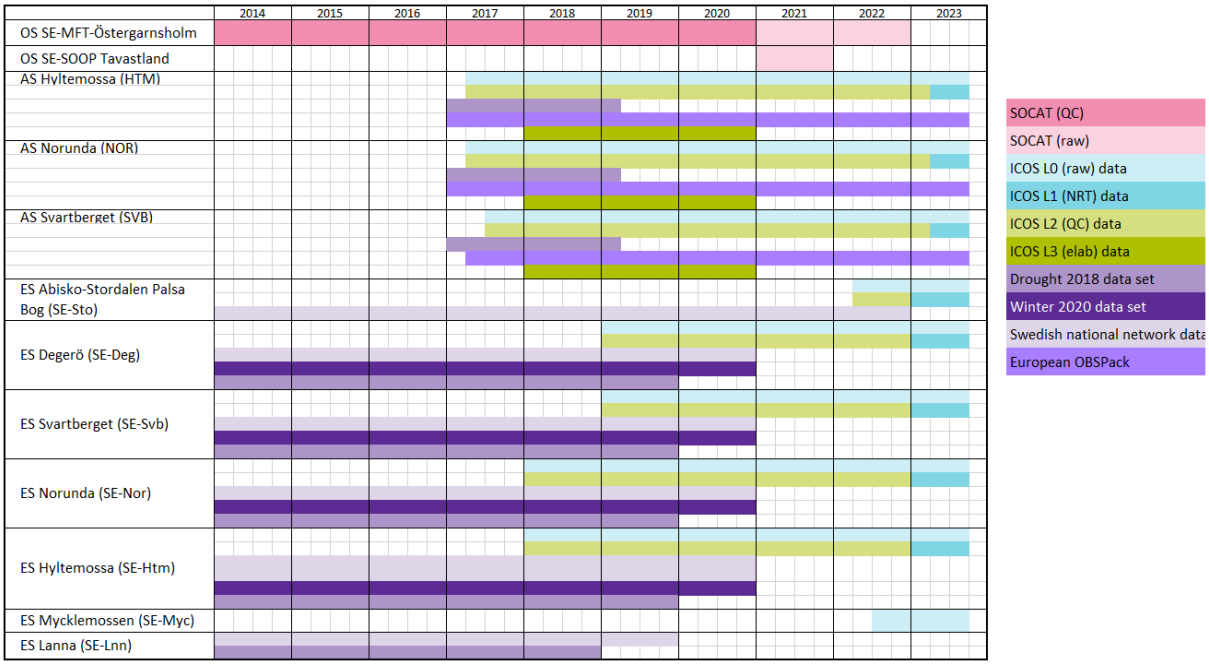

Fig 2. *Status of ICOS Sweden data products on the ICOS Carbon Portal on 2023-10-04.*

3. Planned activities during 2024

General

At the stations, fulfilling the commitments to ICOS RI is of highest priority.

During 2023, the aim is to continue with the labelling process for the remaining stations and, receive the ICOS label. This will also include commencing delivery of all data to ICOS RI in the operational mode.

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

During autumn/winter 2023/24, the preparations for the implementation of the result of the proposal for the period 2025-28 will be the main focus of the reference group.

The main emphasis of outreach activities in 2024 will again be on attracting scientific users to ICOS Sweden data and facilities. The primary goal is to show the benefit of ICOS data for scientific questions. Alongside other initiatives, this will be done by actively contributing to joint efforts by the ICOS community regarding current research questions, and by actively following and contributing to developments in larger European scientific proposals and projects (e.g. PAUL[5], ATMO-ACCESS[6]). The co-location of the ICOS sites with other national research infrastructures (SITES[7] and ACTRIS Sweden[8]) opens up a wide field of research questions, which will be defined in dialogues between the RI representatives. The report on possible synergies between the three Swedish environmental RIs is due in spring 2024. As in previous years, the deep involvement in education from school to higher education levels will continue alongside information provision to stakeholders and the general public.

Summary of planned activities

Planned activites divide into 1) measurement stations, systems, and data, 2) management of the organization, and 3) collaboration and outreach activities. Acronyms are explained in Appendix D.

1) Measurements stations, systems, and data

- At the Atmosphere Stations, teams will continue with the necessary tasks defined in the ICOS RI protocols for atmospheric stations, including regular system tests (more detail in Fig. 3).
- Gas analysers for measuring N_2O concentrations at the Atmosphere Stations have been purchased in 2023. Once they have been delivered, they will be implemented in the existing measurement system.
- Hyltemossa and Norunda Atmosphere Station will continue sending near real time ceilometer data to the EUMETNET project E-PROFILE[9]. In addition, Norunda data is part of a PROBE COST action in collaboration with E-PROFILE.
- We will continue to follow the sampling strategy for the automatic flask sampler with one flask every third day. These flasks are analysed at the CAL; one flask per month being analysed for carbon isotopes. Hyltemossa has already and Svartberget and Norunda will implement additional sampling every day for a potential isotope analysis if the atmospheric conditions are given following the ICOS RI protocol.
- The ecosystem stations will follow the strict schedule to fulfil all tasks defined in the ICOS RI protocols and instructions (Fig. 4). These tasks include regular vegetation sampling and the

[5] www.icos-cp.eu/event/1064
[6] www.atmo-access.eu/
[7] www.fieldsites.se/en-GB
[8] www.actris.se/
[9] https://www.eumetnet.eu/activities/observations-programme/current-activities/e-profile/

acquisition of hemispherical pictures for calculating green area index. Connected to these tasks, ICOS Sweden will continue the delivery of manual ancillary data from all ecosystem stations.

- The methane analysers will be replaced at the ecosystem mire sites; long lead times prevented this in 2022 and 2023.
- The ocean stations Östergarnsholm and SOOP M/S Tavastland, will follow the schedule to fulfil all tasks defined in the ICOS RI protocols (Fig. 5). The station teams will continue the discussion on the implementation of the coastal-based flux measurements into ICOS RI.
- If SRC approves the request for deviation from the special terms, Östergarnsholm will renew instrumentation of the existing buoy (instead of buying a new buoy) to meet the requirements of the OTC.
- The stations that do not receive the ICOS label in the general assembly meeting in November 2023 will continue the labelling process during 2024.
- In addition to the tasks for stations that are in the preparation to become labelled, ICOS Sweden will continue the automatic delivery of data from the atmosphere stations to ATC, from Östergarnsholm and M/S Tavastland to OTC and from the Ecosystem Stations to the ETC.
- We will continue following the development and updates of ETC instructions for all types of measurements, continuous automatic as well as manual, and we will continue working on adapting our routines to ensure they fulfil ICOS requirements.
- Continuous below-canopy photosynthetically active radiation measurements will be used to estimate green area index at the forest sites; the difficult task of taking hemispherical pictures (difficult in terms of matching right season, light and weather conditions) will thus be reduced to twice per year.
- The routines for litter sampling have been adjusted to meet both ICOS RI requirements and possibilities at the stations. Litter includes coarse woody litter, fine woody litter and non-woody litter. Non-woody litter has been sampled in litter traps. The sorting into different compounds which is not mandatory for class 2 stations but very time consuming will not be continued. Instead, only the total non-woody litter mass will be recorded. Coarse and fine woody litter will be sampled according to the ICOS protocol in late summer.
- the clear-cut at Norunda was finalized in November 2022. An additional mast has been set up during 2023. The data transfer from this mast to ETC will be established in 2024.
- At Svartberget an additional eddy-covariance system has been deployed to be able to deliver reliable data during winter. Since the system done not comply with the ICOS protocols, data processing will have to be done in house. The discussions with ETC on how to best make the data available to users have been started and the process will be continued in 2024.
- Station staff will continue to participate in training and working with the standardized measurement protocols and recommended data practices, arranged by ICOS RI and/or ICOS Sweden. Staff will continue to follow up on health and security checks necessary for their working environment.

- The descriptions of all non-ICOS research activities ongoing inside the domains will be updated continuously and we will continue to provide service and support to projects at the stations if time allows.
- The ICOS Sweden personnel will participate in workshops and meetings organized by the ICOS ERIC Head Office and Central Facilities as long as funding is available. The SPI will also participate in the ICOS RI MSA meetings.
- There will be ongoing monitoring of the measurements and service, maintenance and update of systems and follow up of safety rules at the stations.
- Monthly meetings of the research engineers will continue, to ensure active information flow about best practices and problems at the stations. An in-person technician meeting is planned for early 2024.

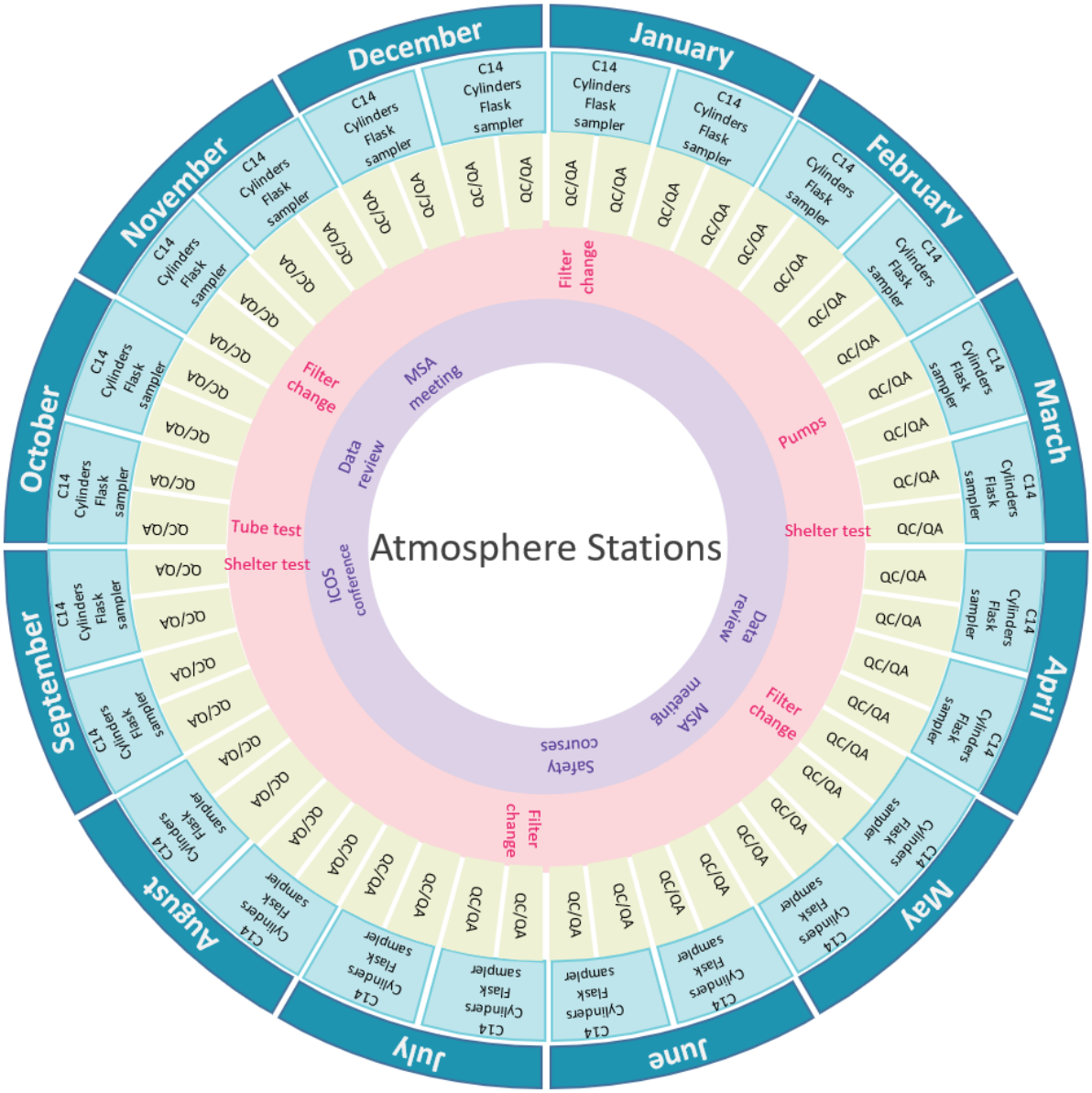

Figure 3: Scheduled regular *tasks at the Atmosphere stations within ICOS RI/ICOS Sweden.*

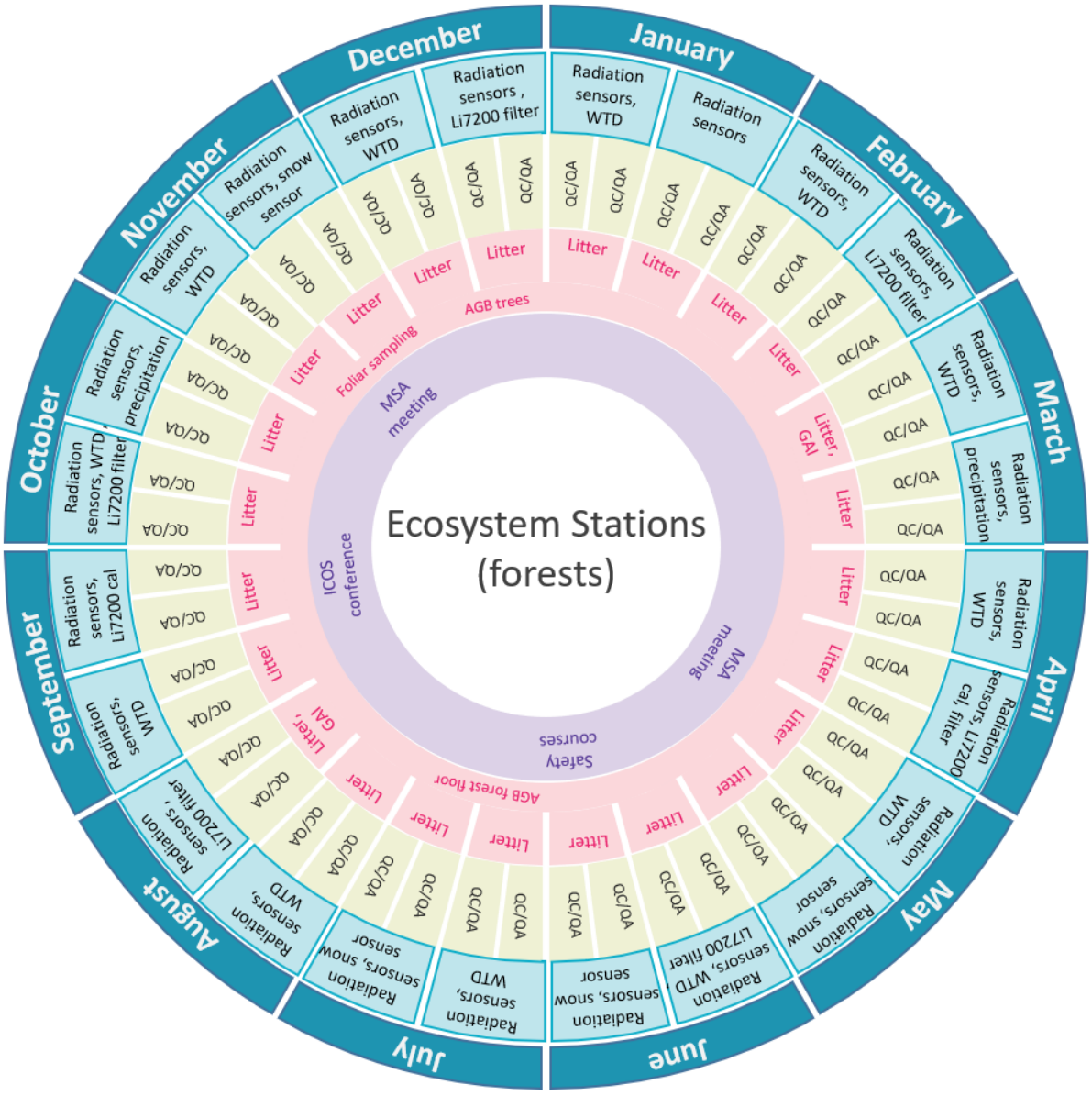

Figure 4: Scheduled regular *tasks* at the Ecosystem stations within ICOS RI/ICOS Sweden.

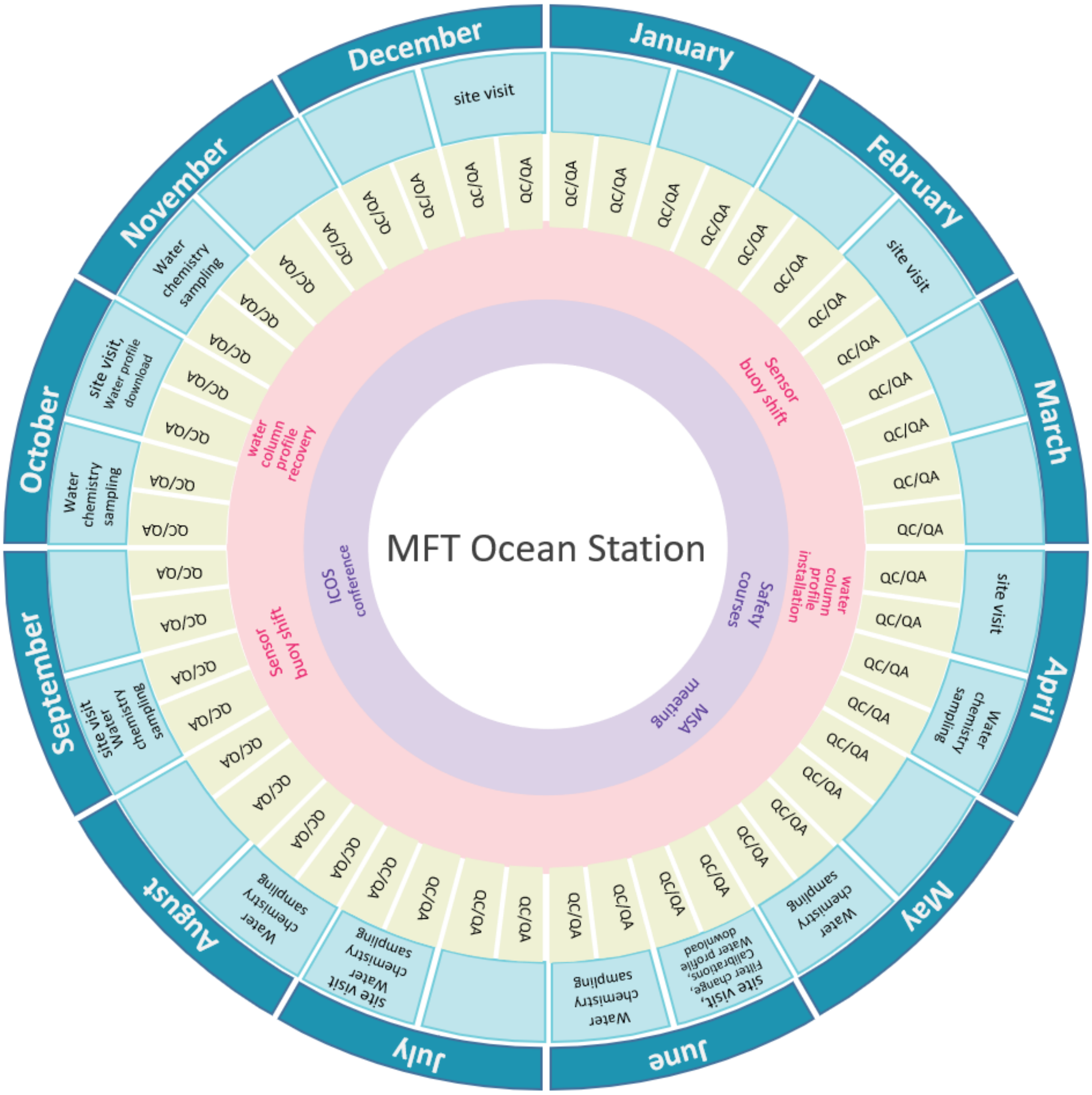

Figure 5: Scheduled regular *tasks at the Ocean station SE-MFT-Östergarnsholm within ICOS RI/ICOS Sweden. Tasks for SOOP M/V Tavastland will be added during 2024.*

2) Management of the organization

- The management team will implement the result of the proposal for the funding period 2025-28. This includes the update of the consortium agreement. Since it will not be clear until the end of 2024 whether Uppsala University will continue as consortium partner, the agreement will be prepared for either solution.
- The management team will coordinate the contributions to ICOS RI initiated proposals. The management team will also prepare the documents for endorsement by the Steering Committee.

- The Steering Committee will revise the ICOS Sweden strategy and follow up on the ICOS Sweden goals and achievements.
- For internal communication, we will continue to arrange online meetings via video every two months for the whole consortium. We will also arrange at least two management team meetings per year, where possible face to face or via internet.
- The new lecturer with the responsibility of director for ICOS Sweden will start working in 2024 at Lund University. The change of the director of the RI needs to be approved by both, the host of the RI (LU) in consultation with the consortium partners and the SRC. The coordination office (current director) will assist the new director with his/her tasks.

3) Collaborations and outreach activities

- ICOS Sweden will continue disseminating information and support education efforts though courses, field visits, media contacts, and through social media (ICOS Sweden homepage[10], twitter, ResearchGate and LinkedIn).
- ICOS Sweden will continue to take initiatives on deepening the collaboration between ICOS Sweden and other Nordic infrastructures such as SITES, ACTRIS Sweden and NordSpec[11].
- ICOS Sweden will continue to encourage applications from researchers looking to set up new projects at the stations.
- ICOS Sweden will support and encourage scientists and stakeholders to make use of data measured at the stations.
- ICOS Sweden will also continue to support ongoing activities at all the sites.
- ICOS Sweden will take part in the upcoming ICOS Science Conference in Versailles on 10-12 September 2024.

4. Planned budget 2024

ICOS Sweden is entering the last year of the current funding period (SRC Diary No 2019-00205). At the end of the funding periods, the numbers for the remaining balance (last column) are expected to be close to zero to avoid having to give money back to the SRC. Furthermore, since the funding from the SRC is limited to 40 Mkr, adjustments in the co-funding need to be done to match the final financial outcome. The respective partners have been informed about this. A detailed list of the preliminary numbers for the financial outcome for 2023 and the planned budget for 2024 is available in the document ICOSSwedenSCMeeting_20231101_appC_financialOutcomeBudget.xlsx.

According to the special terms of the contract between the SRC and ICOS Sweden of the ICOS Sweden Infrastructure Upgrade and Renewal grant (*SRC Diary No 2021-00244*), the acquisition phase should have been finalized at the end of 2022. However, the stations are still waiting for open deliveries of expensive instrumentations; some of these orders have been placed in early 2022, others late 2022 or early 2023. The long delivery time and the development of the currency made the final price to be paid

[10] www.icos-sweden.se
[11] nordspec.nateko.lu.se/home

uncertain. It was thus decided, to pause additional purchases to see if the costs can be covered completely. In summer 2023, the SRC put ICOS Sweden on hold with any further expenses on this grant and asked for an explanation of the delay and an official request for extension of deadline to spend the granted money and report the expenses. This was handed in immediately. The request was approved and the new deadline for the financial reporting is together with the annual reporting in spring 2024.

Appendix A: The ICOS RI organization

ICOS is a European research infrastructure founded in 2008, which provides data on greenhouse gas concentrations. ICOS RI is part of the European Environmental Research Infrastructure landscape. ICOS RI organization consists of two pillars: research and measurement infrastructure and ICOS ERIC[12] , a legal entity for ICOS data release, coordination, and integration of the whole system.

ICOS RI (Fig. A1) is coordinated ICOS ERIC. ICOS is one of 18 ERICs. The legal entity of ICOS ERIC has held a Landmark status in the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap[13] since March 2016. The ESFRI Roadmap identifies new RIs of European interest corresponding to the long-term needs of the European research communities, covering all scientific areas, regardless of possible location.

ICOS RI receives funding from member and observer countries through annual membership contributions, and through host contributions towards specific facilities in ICOS RI. The station networks being funded by different national agencies.

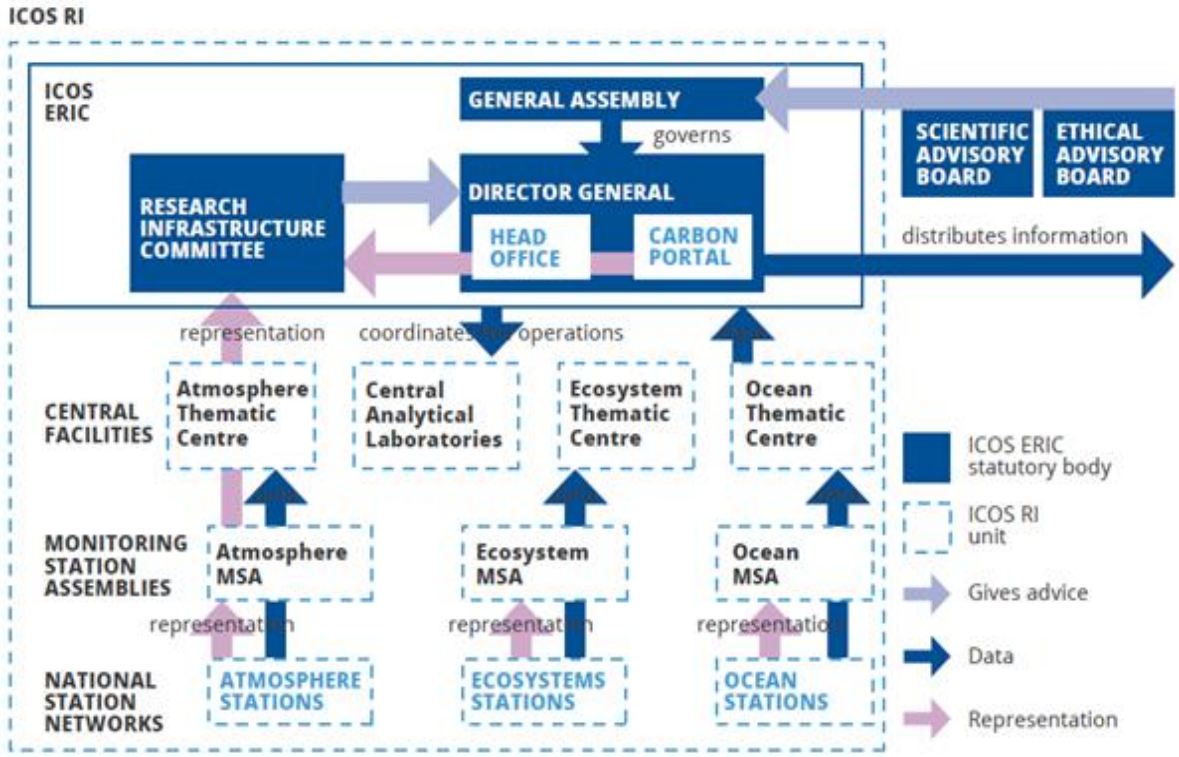

Figure A1. *Outline of the ICOS RI organization (ICOS RI, 2021).*

[12] https://ec.europa.eu/info/research-and-innovation/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures/eric_en
[13] https://roadmap2021.esfri.eu/projects-and-landmarks/

ICOS National Station Networks

ICOS RI has more than 170 measurement stations in 16 European countries. These stations measure greenhouse gas concentrations in the atmosphere and fluxes over the terrestrial and marine ecosystems. The ICOS stations are run and funded by national funding agencies, institutes, and universities, demonstrating an impressive joint effort to enable climate change research.

The current ICOS Atmosphere and Ecosystem Networks include 46 atmospheric and around 98 ecosystem stations located across Europe. The ICOS Ocean Network covers the North Atlantic and European marginal seas. The ICOS Ocean Observation System includes 29 facilities: voluntary observatory ships, fixed stations, and research vessels.

Monitoring Station Assemblies (MSA)

Monitoring Station Assemblies (MSAs) for the Atmosphere, Ecosystem and Ocean Station Networks consist of SPIs. The MSAs monitor, develop and improve the scientific and technical basis of the ICOS RI. The MSAs usually meet twice a year and they work closely with the ICOS Central Facilities (CF).

Central Facilities (CF)

All measurement raw data from each atmosphere, ecosystem, and ocean station within the ICOS Station Network is transferred to and processed in the ICOS CFs: The Atmosphere, Ecosystem and Ocean Thematic Centres (ATC, ETC and OTC). The CFs ensure that highly standardized and coordinated data is maintained and respected. The CFs ensure that all data are treated, and quality controlled with the same algorithms and properly archived for the long term.

ICOS ERIC

ICOS RI are coordinated by the legal entity of ICOS ERIC. ICOS ERIC was established by the decision of the European Commission on 23 November 2015, with the statutory seat in Finland. The principal task of ICOS ERIC is to coordinate the operations of ICOS RI, distribute information from ICOS RI to user communities and to provide integrated data and analysis from greenhouse gas observation systems.

ICOS ERIC Head Office

ICOS ERIC Head Office, located in Helsinki, Finland, manages the legal entity of ICOS ERIC. The Head Office promotes network extension to new countries in cooperation with the ICOS CFs and Focal Points of the ICOS National Networks. ICOS ERIC Head Office supports the scientific and technological developments in ICOS RI and facilitates the outreach, training, and mobility of participants.

ICOS ERIC General Assembly

The ICOS ERIC General Assembly is the governing and decision-making body of ICOS ERIC. It is composed of representatives of the member and observer countries of ICOS ERIC. It is led by the chair Christian Plass-Duelmer from the German Weather Service (DWD).

ICOS ERIC Director General

The Director General, appointed by the ICOS ERIC General Assembly, is the legal representative of ICOS ERIC. The Director General carries out the day-to-day management of ICOS ERIC and is responsible for the implementation of the decisions by the ICOS ERIC General Assembly, as well as overseeing and

coordinating the activities of ICOS RI. Werner Kutsch is the current Director General of ICOS ERIC; Alex Vermeulen, Director of the ICOS Carbon Portal, was elected as deputy director.

ICOS ERIC Research Infrastructure Committee

The ICOS ERIC Research Infrastructure Committee is a key advisory body in ICOS RI that supports the Director General in all matters relevant to the coordination and management of ICOS RI. ICOS Research Infrastructure Committee consists of representatives from the Head Office, ICOS Carbon Portal, each ICOS CF and each MSA. The Director General chairs the committee.

ICOS Scientific Advisory Board

The ICOS Scientific Advisory Board is an external body and monitors the scientific quality of ICOS RI, gives feedback on and makes recommendations for the development of ICOS RI activities, and advises ICOS ERIC with the objective of achieving the scientific goals of ICOS RI. It also provides programmatic support by commenting on the overall science plans and directions and analyses the output of ICOS RI.

ICOS Ethical Advisory Board

The second external body, the ICOS Ethical Advisory Board giving advice to the ICOS ERIC based on periodical reports on ethical issues related to science, data, discrimination, or any kind of conflict of interest.

ICOS ERIC Carbon Portal

The ICOS Carbon Portal, an operative unit of ICOS ERIC, offers free access to ICOS RI data on greenhouse gases observations from the ICOS Station Networks, as well as easily accessible and understandable science and education products. The system design for the ICOS Carbon Portal management, databases, web services, and elaborated products is carried out by the system architect in dialogue with both internal and external scientists. Dedicated researchers from all over the world will contribute to the elaborated products catalogue.

Appendix B: The ICOS Sweden organization

Consortium partners

ICOS Sweden performs measurements at stations in a transect across Sweden, from Abisko-Stordalen in the north to Hyltemossa in the south (Fig. A2). There are three Atmosphere Stations for measurement of GHGs in the well-mixed boundary layer, six Ecosystem Stations for measurements of GHG exchange 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 four universities and two institutes. The framing of the cooperation is set by formal agreement. The consortium partners of ICOS Sweden are the following:

- Lund University (LU) is the host organization with overall responsibility for the coordination of ICOS Sweden. LU also operates four ICOS stations: the Norunda forest Ecosystem and Atmosphere stations and the 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) is responsible for the Ocean station aboard the SOOP M/S Tavastland.

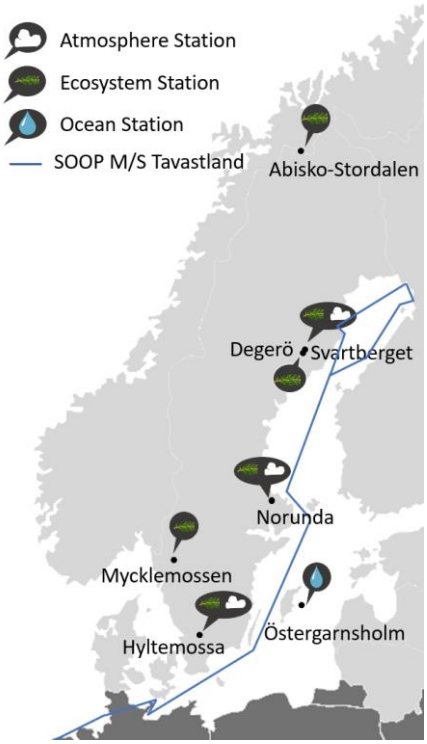

Fig A2. *Map of the site locations of the observation network of ICOS Sweden.*

The organization of ICOS Sweden (Fig. A3) are structured according to the directions given in the original agreement with the Swedish Research Council (SRC) for the funding period 2021-2024.

Lund University, as host for ICOS Sweden, is responsible for the financial resources and reporting to the donors. The host is the director's employer and formally appoints the director and the assistant director after consultation with the so-called partners' council (PC). The PC is a forum for consultation and agreement between all participating parties: all consortium partners are represented in the PCil thatdecides on matters concerning the activities within the infrastructure but has no mandate in addition. The host also formally appoints the Steering Committee (SC) in consultation with the SRC.

Each partner has employer's liability for the personnel at its station(s) and is represented in the ICOS Sweden Reference Group (RG) and in the ICOS RI Monitoring Station Assembly (MSA) by the Station Principal Investigator (SPI).

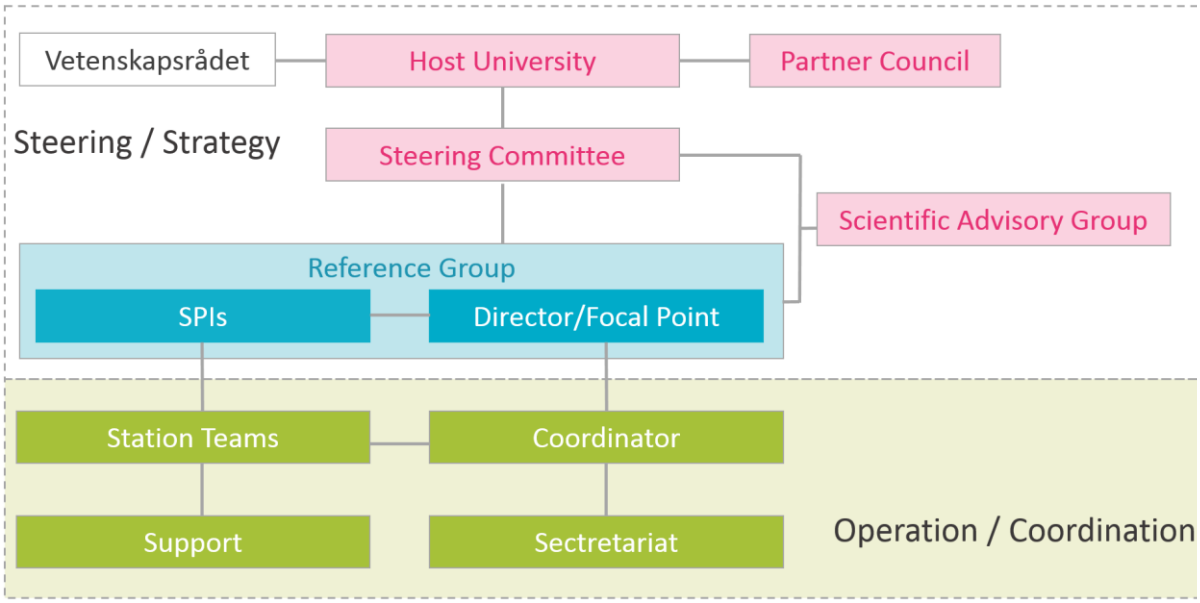

Fig. A3. *The organization structure of ICOS Sweden.*

ICOS Sweden Steering Committee (SC)

The SC has a broad composition with expertise that covers both the management of research infrastructure and qualified research in the area. The task of the SC is, independently of the parties and within the given frames by the PC, to work for optimal development, operation, and management of ICOS Sweden as a national research infrastructure. The SC is responsible for overall strategic and financial monitoring and shall promote development, operation, and management. The SC also decides on the focus and objectives for the collaboration between the different partner organizations that constitute ICOS Sweden.

The present SC members appointed on 16 December 2021 until the end of 2024, are Eija Juurola (Chair; Finnish Meteorological Institute), Lars Arneborg (SMHI), Hjalmar Laudon (SLU), Heather Reese (GU), Isaac R Dos Santos (GU), Linda Kanders (Swedish Environmental Research Institute), Marko Scholze (LU), and Lars Tranvik (UU).

Scientific Advisory Group (SAG)

The SAG consists of four leading international scientists, appointed by the SC. The SAG is independent and contributes with scientific advice, establishes external contacts, and acts as ambassadors to the wider community. SAG participates in the annual workshop and, in conjunction to the workshop, meets the SC to discuss strategic issues.

The most recent members of the SAG were Inez Fung (University of California, Berkeley, USA), Yiqi Luo (Northern Arizona University, Flagstaff, USA), Monique Leclerc (University of Georgia, Georgia, USA), and Peter Rayner (University of Melbourne, Australia).

Reference Group (RG)

The RG consists of the director and scientifically merited and active representatives from each partner (SPIs). The RG shall provide the director with advice on strategic plans and budgets. Furthermore, the RG shall promote the use of research at ICOS Sweden at each partner institution and work on the outreach in Sweden in accordance with the strategic plan. The director is responsible for the management of the research infrastructure. The role as director of ICOS Sweden was given to Jutta Holst for the period 2021-07-01 to 2023-06-30. The director's tasks include planning, leading, and prioritization of ICOS Sweden's operations within the framework of its business plan and budget with the support of the SPIs, while the operational management can be delegated to the assistant director according to the consortium agreement. As contact point between RG and the SC, the director prepares the reporting documents for the SC and the PC.

Operational Management

The operational management oversees the daily business at the stations with the main goal of delivering high quality data to ICOS RI. This comprises the main task for the SRC funded national infrastructure. For this, the stations are to a large part directed by ICOS RI. The operational management group is led by the director who is supported by administrative staff: a part time (5%) scientific secretary (Irene Lehner), a part time (25%) economist (Heléne Holmström), and part time (5%) administrative support (Yvonne Kedström). The SPIs are responsible for the daily management, data quality control, data reporting and coordination of scientific issues at the site level. The SPIs are also members of the respective ICOS MSAs (Atmosphere, Ecosystem, Ocean). During 2016, a Scientific and Technical Station Support Module for technical and data support of the stations and users was added. 1 FTE is divided into three part time personnel: Michal Heliasz (20%), Meelis Mölder (40%), and Jutta Holst (40%). The costs for the module have been shared between the ecosystem and atmosphere station hosts.

Appendix C: The ICOS Sweden measurement stations

ICOS Sweden operates eleven measurement stations in total: six ecosystem stations, three atmospheric stations, and two ocean stations. The three atmospheric stations are co-located with three of the ecosystem stations. The locations of the measurement stations chosen with the aim to cover typical Swedish conditions, while at the same time considering a broader Nordic context as well as the European perspective.

Abisko-Stordalen Ecosystem Station

The Abisko-Stordalen subarctic mire, consisting of a palsa/bog/fen complex, is of great interest to many national and international researchers and there are a number of ongoing activities including flux measurements by different groups. The mire area is located very close to the 0°C isotherm and represents a very dynamic part of the sub-arctic region. The station operated by the PFS at the Abisko Scientific Research Station and is located about 10 km east of Abisko. Personnel resources correspond to 1.2 FTE involving the research engineers Niklas Rakos, Alexander Meire, Erik Lundin, and Annika Kristoffersson. SPI is Erik Lundin.

Degerö Ecosystem Station

The Degerö station is situated on a minerogenic oligotrophic boreal mire covering 6.5 km² in the Kulbäcksliden research park at Vindeln Experimental Forests, located in a cold temperate humid climate, about 60 km west of Umeå. The station is run by SLU. Personnel resources correspond to 1.25 FTE involving the research engineers Per Marklund, Pernilla Löfvenius, and the SPI Matthias Peichl and Co-SPI Mats B. Nilsson.

Svartberget combined Ecosystem and Atmosphere Station

The Svartberget site is located in a mixed boreal pine/spruce forest within the Vindeln Experimental Forests situated in Vindeln, 60 km west of Umeå. The ICOS Atmosphere and Ecosystem stations are operated by SLU. Personnel resources correspond to 2.35 FTE involving the research engineers Eric Larmanou, who also is SPI for the Atmosphere Station, Pernilla Löfvenius, Nataliia Kozii, and the ecosystem SPI Matthias Peichl.

Norunda combined Ecosystem and Atmosphere Station

Norunda is located in a mixed boreal pine/spruce forest about 30 km north of Uppsala. The research station is the oldest flux site in Sweden, established in 1994. The ICOS Atmosphere (SPI: Meelis Mölder) and Ecosystem (SPI: Meelis Mölder, Co-SPI: Natascha Kljun) stations are operated by LU. Personnel resources correspond to 2.35 FTE involving the SPIs and the research engineers Anders Båth, Irene Lehner, and Meelis Mölder as permanent staff.

Östergarnsholm Fixed Ocean Station with Marine Flux Tower

This site is located on the small island Östergarnsholm situated 4 km east of Gotland in the Baltic Sea. The island is very flat and for selected wind sectors representing well the open sea, i.e., marine conditions. The site has been running since 1995 and has been included as an ICOS Sweden station since 1 January 2015. The station is run by UU and personnel resources correspond to 0.95 FTE involving a research engineer (John Trytherch) and the SPI Anna Rutgersson. Hans Bergström, Erik Sahlée, and Erik Nilsson are also involved in the operational work.

Mycklemossen Ecosystem Station

Mycklemossen mire station is located within the Skogaryd Research Catchment which is situated in a part of the country with high levels of nitrogen deposition, about 15km north-west of Trollhättan. The measurements enable determination of the net ecosystem carbon balance. The station is operated by GU. SPI is Per Weslien.

Hyltemossa combined Ecosystem and Atmosphere Station

The Hyltemossa site is located in southernmost Sweden, about 60 km north-east of Lund, in a young temperate spruce forest around 30 years old. The ICOS Atmosphere (SPI: Michal Heliasz) and Ecosystem (PI: Michal Heliasz, Co-PI: Natascha Kljun) stations are operated by LU. Personnel resources correspond to 2.35 FTE involving the SPIs as well as the research engineers Michal Heliasz, Tobias Biermann, and Thomas Holst as permanent staff.

M/S Tavastland: SOOP Ocean Station

SMHI runs a ferrybox on the SOOP M/S Tavastland, that cruises the Baltic Sea one week (Lubeck-Oulu-Kemi-Lubeck) and the North Sea (Lubeck-Zeebrugge-Tilbury-Lubeck) one week on a constant schedule. Measurements on M/S Tavastland are operated by SMHI. The SPI is Madeleine Nilsson, who also runs the station as research engineer together with Irena Draca (total 0.6 FTE).

Appendix D: List of abbreviations and acronyms

ACTRIS Sweden – Aerosols, Clouds, and Trace gases Research Infrastructure network
ATC – ICOS Atmosphere Thematic Center
AS – Atmosphere station
CAL – Central Analytical Laboratory
CF – Central facilities (ETC, ATC, OTC and CAL)
CP – Carbon Portal
ES –Ecosystem station
ETC – ICOS Ecosystem Thematic Center
ERIC – European Research Infrastructure Consortium
ESFRI - European Strategy Forum on Research Infrastructures
EUMETNET – Network of European Meteorological Services
FTE – full-time equivalent
GHG – greenhouse gas
GU – Gothenburg University
ICOS – Integrated Carbon Observation System
LU – Lund University
MSA – Monitoring Station Assembly
NordSpec – research network for spectral data collection
OS – Ocean station
OTC – ICOS Oceani Thematic Center
PFS – Swedish Polar Research Secretariat
RG – ICOS Sweden Reference Group
RI – Research Infrastructure
SAG – ICOS Sweden Scientific Advisory Group
SC – ICOS Sweden Steering Committee
SITES – Swedish Infrastructure for Ecosystem Research
SLU – Swedish University of Agricultural Sciences
SMHI – Swedish Meteorological and Hydrological Institute
SOOP – Ship of Opportunity
SRC –Swedish Research Council (in Swedish VR – Vetenskapsrådet)
UU – Uppsala University