ICOS SWEDEN Annual Report 2017

ICOS National Network Sweden

Lunds universitet

Göteborgs universitet

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SLU

Polarforskningssekretariatet
Swedish Polar Research Secretariat

Vetenskapsrådet

The Board of ICOS Sweden endorsed this Annual Report 2017 on 8 March 2018. The report is complemented by other documents from ICOS Sweden, including the Operational Plan for 2018, and the Strategic plan 2016-2020.

This document was prepared by the ICOS Sweden Coordination Office.

Contents

Summary

ICOS - Integrated Carbon Observation System - is a new European research infrastructure for quantifying and understanding the greenhouse gas balance of the European continent and of adjacent regions. The aim of ICOS 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 built up as a collaboration of over 100 nationally operated measurement stations in twelve European countries. ICOS Sweden is the Swedish contribution to this European effort.

ICOS Sweden started its build up in mid-2010, funded by the Swedish Research Council and the ICOS Sweden consortium partners. ICOS Sweden operates, until the reporting date, ten measurement stations in total, of which six are ecosystem stations, three are atmospheric stations and one is an ocean station. During 2017, most of the ICOS RI protocols and working instructions got finalized. Due to changes in the protocols, some of the ICOS Sweden instrumentation and the sampling design need to be discussed with the Central Facilities or adjusted to the final requirements. To make data from the ICOS Sweden stations more visible and easier available, ICOS Sweden started during 2017 to upload quality-controlled datasets using the ICOS Carbon Portal (CP) services. These datasets are, however, not classified as ICOS data, but treated in the same way in terms of metadata terminology and will thus be searchable and findable through the CP. The buildup of the ICOS Sweden organization and its functions is finished except for the full implementation of the User's Group and that our stations are not yet ICOS labeled.

In late 2016, the former Director retired and the mandate for the Board ended, which lead to new appointments in 2017. Due to the difficult financial situation for the Abisko-Stordalen station, the organization has put a lot of effort into finding a possibility to continue with the station. During the year, it became clear that Polar will take on the task to continue the station as an associated site.

The main outreach activities during 2017 were focused on the Nordic ICOS Symposium, collaboration with other research infrastructures and on information campaigns. The work with enrolling members to the User's Group and to further define its objectives and work procedures has not yet started due to the intensive work on adapting to the new funding situation. A startup discussion meeting between the Chair of the User's group and the Coordination Office took place in late 2017.

The key number follow up shows that there is an overall increasing trend of research interest within this topic with 69 peer-reviewed publications, where data from ICOS Sweden was used. 30 national and 7 international projects are ongoing at the sites. Number of data users in total is 164 (not counting data downloads of data compilations including global datasets) and 464 researchers, course and excursion participants visited the sites in 2017.

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 over 100 nationally operated measurement stations in twelve European countries. ICOS Sweden is the Swedish contribution to this European effort. An 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 measurement station assemblies and the central facilities.

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.

ICOS Sweden will be fully integrated with and play an important role in the pan-European ICOS (ICOS RI). ICOS Sweden will also provide data, and 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.

A description of ICOS RI status and progress can be found at the website http://www.ICOS-ri.eu/. A list of ICOS Sweden personnel can be found in Appendix 1. In Appendix 2, the measurement variables and instruments/systems used in ICOS Sweden are listed. Appendix 3 contains a list of the acronyms and abbreviations mentioned in the report.

2. Status of ICOS Sweden at the end of 2017

ICOS Sweden became, for most of the measurement systems, fully operational during 2015. In 2016, the labeling process was set by ICOS ERIC. During 2017, all ICOS Sweden stations successfully completed step 1 of the labeling process and entered step 2 of the labeling. The installation and deployment of equipment and control systems at the ecosystem stations are finalized. During step 2, we are waiting for approval of the installed systems by the Central Facilities (CFs). At the same time, the spatial and temporal frame for the ancillary and site characterization measurements are set up in dialogue with the CF and the metadata database at the CF is filled with required information before the automatic transfer of data files can be started. The atmospheric systems are fully operational for most parts and the 14C samples are being sent in to the Central Analytical Laboratory. However, the dryer for the flask sampling systems are not yet available from the Central Facilities. We also purchased and installed Ceilometers at all three atmospheric stations. During the ongoing step 2 of the labeling process, data is being sent to the CF and calibration and target gas routines are adapted according to the requests of the CF. The ocean station is running, and has been updated to the ICOS RI

requirements. There is presently an ongoing discussion at the Ocean Thematic Center (OTC) on the labeling process of the ocean stations and the handling of eddy-covariance data from fixed ocean stations.

During 2017, most of the ICOS RI protocols and working instructions got finalized. Due to changes in the protocols, some of the ICOS Sweden instrumentation and the sampling design need to be discussed with the CF or adjusted to the final requirements. To make data from the ICOS Sweden stations more visible and easier available, ICOS Sweden started during 2017 to upload quality controlled datasets using the ICOS Carbon Portal (CP) services. These datasets are, however, not classified as ICOS data, but treated in the same way in terms of metadata terminology and will thus be searchable and findable through the CP.

The buildup of the ICOS Sweden organization and its functions is finished except for the full implementation of the User's Group and that our stations are not yet ICOS labeled. The coordination office is working on outreach tasks and on finding sustainable solutions for the Abisko-Stordalen station. It is now clear that Polar will continue the station as an associated site.

During 2017, Swedish research Infrastructures have been evaluated by the Council for Research Infrastructure (RFI) in order to make sure that resources set aside to provide Swedish researchers with access to state of the art research infrastructures are sufficient and have been used efficiently. The status of ICOS Sweden was judged positively.

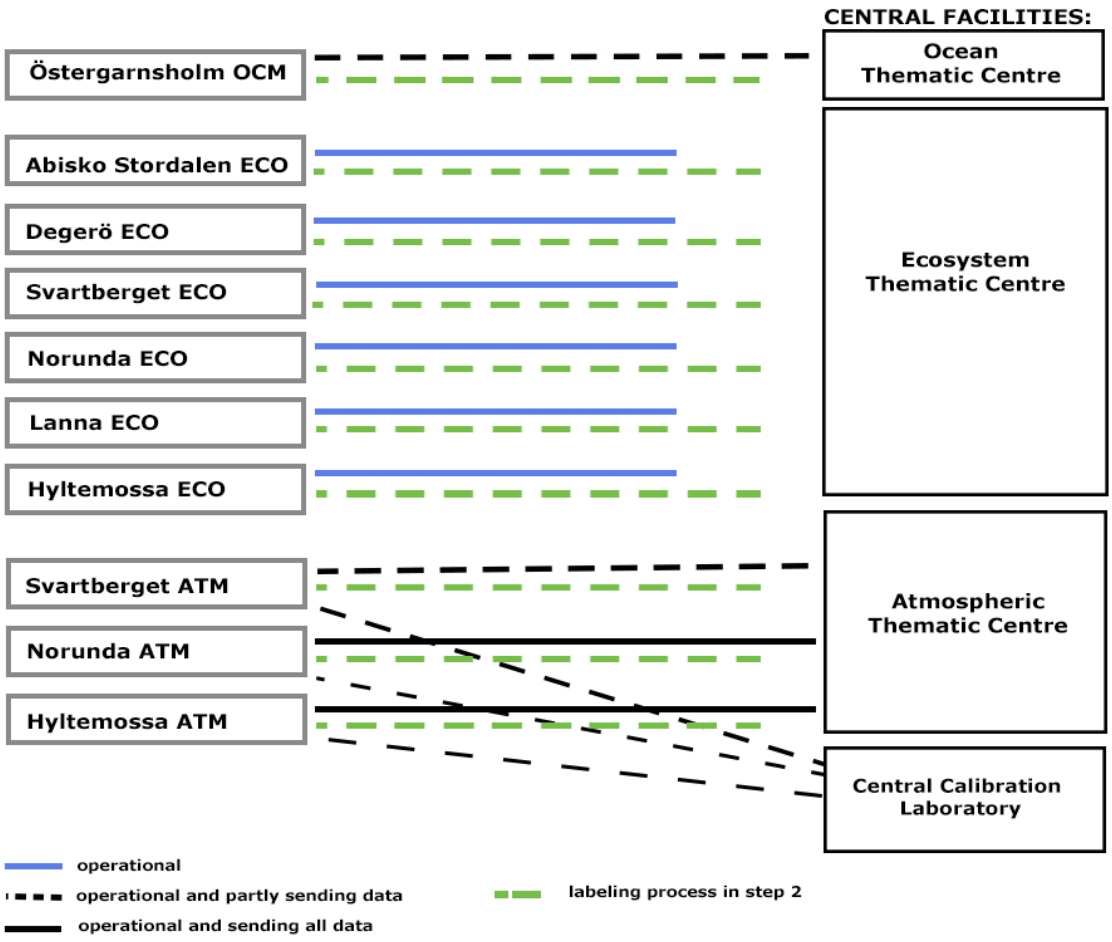


Figure 1. *The development status for the delivery of data and information to the Central Facilities from the ICOS Sweden measurement stations. Upper lines at all stations – development status for data delivery. Lower lines – status for getting ICOS labeled.*

3. Building up and management of the measurement stations and systems

ICOS Sweden operate, until the reporting date, ten measurement stations in total, of which six are ecosystem stations, three are atmospheric stations and one is an ocean station (Fig. 2). The atmospheric stations are co-located with three of the ecosystem stations.

The locations of the measurement stations have been chosen with the main aim to cover typical Swedish conditions, while at the same time considering a broader Nordic context as well as the European perspective. The stations are run by the consortium partners Lund University, University of Gothenburg, Swedish University of Agricultural Sciences, Uppsala University, Stockholm University, and the Swedish Polar Research Secretariat. Each partner has employer's liability for the personnel at its station(s) and is represented by a Station Principal Investigator (SPI) in the Station Coordination Group (SCG) of ICOS Sweden and in the ICOS RI Measurement Station Assembly (MSA) (see Chap. 4.1).

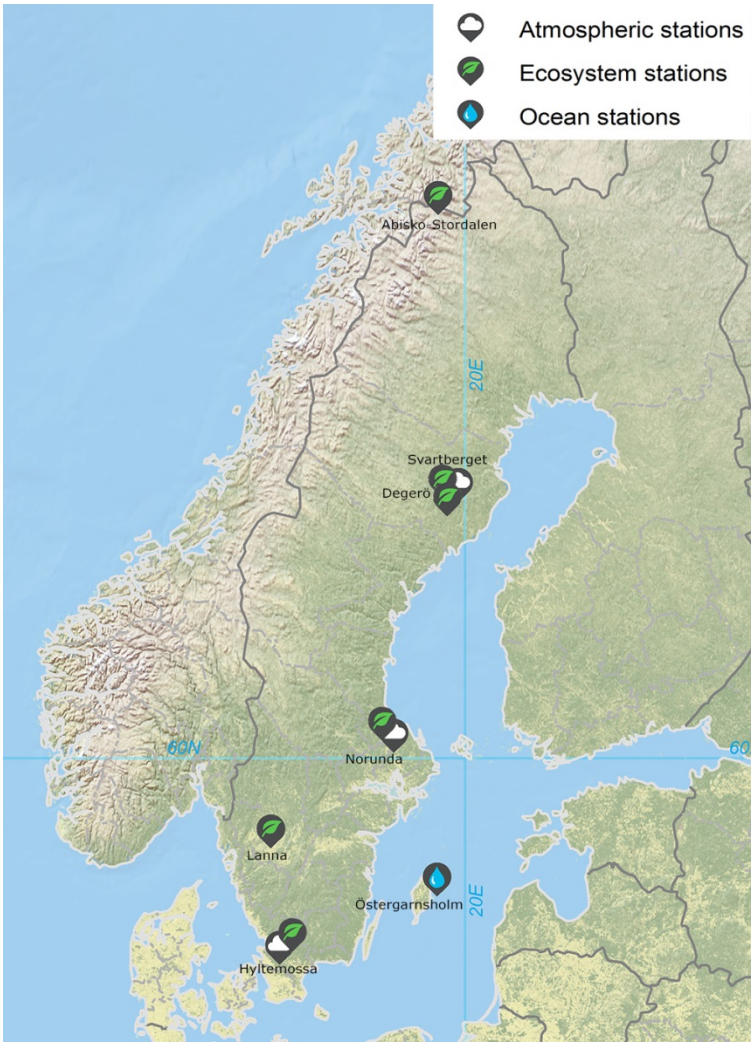


***Figure 2**. Location of the ICOS Sweden measurement stations.*

With the goal of optimization of resource usage, common collaborations between ICOS Sweden and other (infrastructure) projects have been started. These are:

ACTRIS – a European Research Infrastructure for the observation of aerosols, clouds, and trace gases. Measurements at Hyltemossa and Norunda will replace measurements at Vavihill, resp. Aspvreten.

SITES – a nationally co-ordinated infrastructure for terrestrial and limnological field research. Abisko-Stordalen and Svartberget are located within the area of the SITES field research stations Abisko and Svartberget.

NordSpec – an infrastructure for collecting spectral data for ecosystem monitoring. The spectral measurements are conducted year-round using robust equipment in order to capture seasonal signals from vegetation. ICOS Sweden sites included in the network are Hyltemossa, Norunda, Degerö and Abisko-Stordalen.

3.1 The measurement stations

The measurement stations are described below followed by a summarized description of the progress during 2017, where the focus was on gathering all information needed for getting the ICOS RI label. Personnel employed at the stations are listed in Appendix 1.

3.1.1 Abisko-Stordalen ecosystem station

The Stordalen subarctic wetland, consists of a fen/palsa/lake complex. The site is a protected natural wetland (unmanaged) which for the last 30 years has served as a study area for a large number of national and international researchers as well as a favorite location for field courses and students. The location in Stordalen is well suited for studies of climate change effects in the Arctic and sub-Arctic region because a mean annual temperature of 0°C in the Abisko region makes the permafrost and associated ecosystems highly responsive to any changes in temperature. Being the northernmost of all ICOS ecosystem stations, it represents an extreme site both within ICOS and Europe.

The station is operated by the Swedish Polar Research Secretariat at the Abisko Scientific Research Station. Station PIs are Patrick Crill and Janne Rinne, who replaced Thomas Friborg in mid-2017. The station has been operational since spring 2013.

Especially during summer season, a large number of researchers are using Stordalen for field experiments, and ICOS has provided data and logistic assistance to three national and two international projects in the past year. Courses and excursions have visited the site during longer or shorter periods in 2017. As in previous years, groups from local gymnasiums as well as Umeå and Lund Universities visited the site.

Methane flux reaches its maximum in the end of the summer (August), just after the maximum soil temperatures were measured.

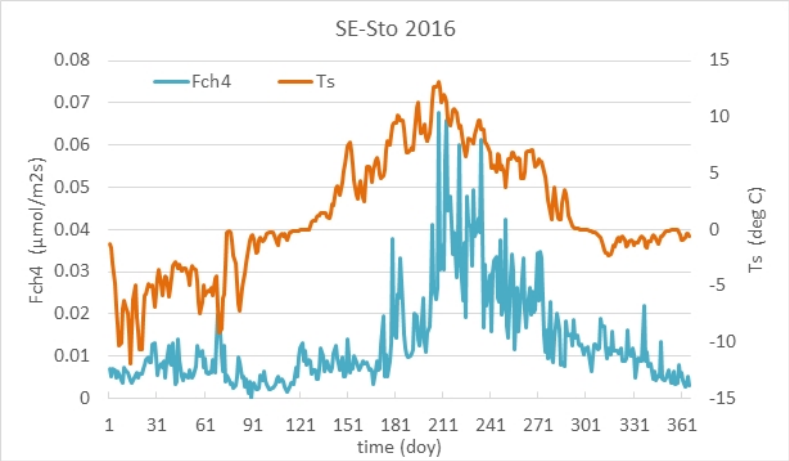


Figure 3. *Daily averages of CH_4 flux and soil temperature at Abisko-Stordalen in 2016.*

3.1.2 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. The site is located in a cold temperate humid climate. The station is run by the Swedish University of Agricultural Sciences in their role as a consortium partner of ICOS Sweden. The station is operated by SLU, Umeå; station PI is Mats Nilsson.

There is a constant interest from researchers all over the world in data from Degerö resulting in numerous scientific publications. Degerö has been a small, distinct and relatively constant carbon sink since the start of the measurements (Fig. 4).

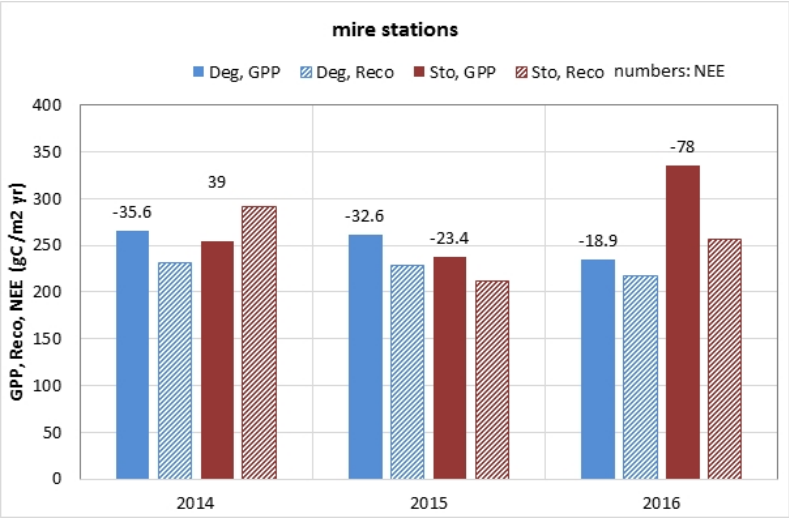


Figure 4. *Annual totals of gross primary production (GPP), ecosystem respiration (Reco) and net ecosystem exchange (NEE, numbers above columns) at Degerö Stormyr (blue) and Abisko Stordalen (red) from 2014 to 2016.*

3.1.3 Svartberget combined ecosystem and atmospheric station

ICOS-Svartberget is located in the Svartberget Experimental Forest, Vindeln. It is run by SLU, Umeå; station PI is Mikaell Ottosson Löfvenius. The experimental forest covers 1076 hectares of boreal forest land and governs a manifold of research activities since 1923. A reference monitoring program of climate and water is active since 1980. ICOS-Svartberget site is situated on a moraine slope covered mainly by Scots pine (60%) and Norway spruce (40%), in the center of a well-investigated sub-catchment with long-term hydrological measurement. The sub-catchment is part of the larger Krycklan catchment area. A wide range of ancillary data is available at ICOS-Svartberget and invites to collaborative research in field.

The forest is about 110 years old with a mean height around 20 m. Some cleaning was done in 1962, otherwise the stand is undisturbed except for unavoidable influences by installation of research infrastructures and instruments. The ICOS ecosystem instrumentation was in place during 2013, most of the measurements started in June 2013.

In the end of January 2017, highly polluted air masses from Central Europe was transported to Scandinavia and caused high CO concentrations at all atmospheric ICOS Sweden sites (Fig. 5). The time delay in enhanced concentrations are caused by the delay in when the weather system reached the stations.

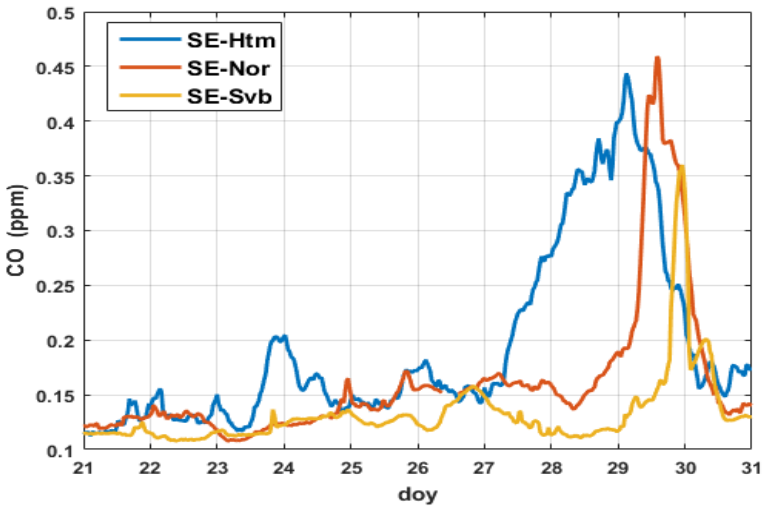


Figure 5. *CO concentrations at the atmospheric stations Hyltemossa, Norunda and Svartberget from 21st to 31rd of January 2017.*

3.1.4 Norunda combined ecosystem and atmospheric station

The Norunda is located in a mixed boreal pine/spruce forest, about 30 km north of Uppsala. The mean air temperature is 5.6°C and the mean annual precipitation sums up to 544 mm (data period 1961-1990, SMHI station Uppsala). Southwest is the prevailing wind direction. The station is operated by Lund University, as part of its commitments as a partner of ICOS Sweden; the Station PI is Meelis Mölder.

The station is the oldest flux site in Sweden, established in 1994. Parts of the forest are older than 110 years. In 2021-22, the area ca 500 m around the main tower will be turned into a clear cut. The ICOS Sweden equipment at the station is operational since 2013. Core measurements for the atmospheric system (GHG concentrations) are operational since 2015.

Ground water tables were already low in the beginning of 2017 and continued to sink due to very low precipitation: each month from January to October reached only max. 80% of the long term average monthly precipitation totals. Only during June, the climate precipitation values were reached. However, while respiration was even higher than in previous years, GPP did not seem to be influenced by the dry conditions (Fig. 6).

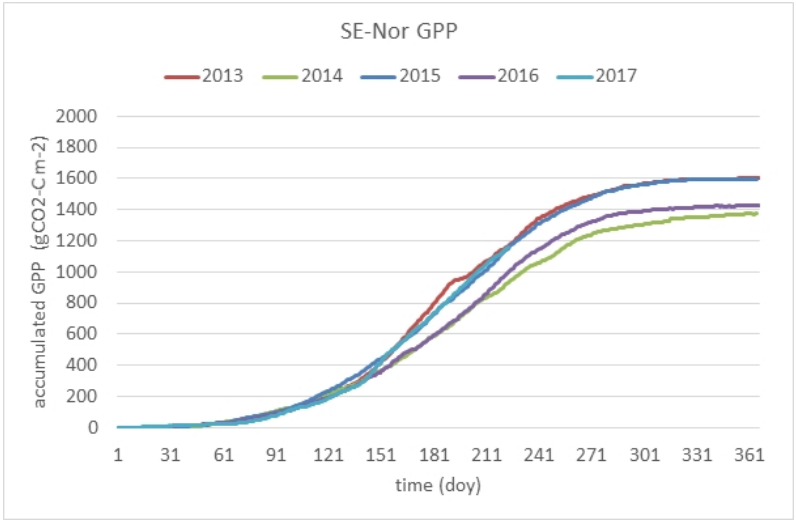


Figure 6. A*nnual cumulated sum of gross primary production at Norunda from 2013 to 2017.*

3.1.5 Östergarnsholm ocean station

The Östergarnholm ocean station is located in the Baltic Sea, about 4 km east of Gotland. The measuring site at Östergarnsholm has been running since 1995 by Uppsala University, station PI is Anna Rutgersson. It is a land-based 30 m tower situated on the southern tip of a very small, flat island. In addition to the tower measurements several buoys in the water continuously measure temperature, pCO_2 salinity and oxygen.

The cold water in spring and summer gives dominantly stable atmospheric stratification during April to July. Despite low winter temperatures, the sea surrounding Östergarnsholm has ice free conditions throughout the year. Higher rates of cyclonic activity in winter result generally in higher wind speeds in winter than in summer.

Data from the Östergarnsholm site has been used to develop algorithms to use remote sensing data for water-side pCO_2 and air-sea flux calculations. The purpose is to derive tools for evaluating the net emissions/uptake of CO_2 for the Baltic Sea as well as variability in time and space. There is a shift in the seasonal cycle over time using the remote sensing data (Fig. 7).

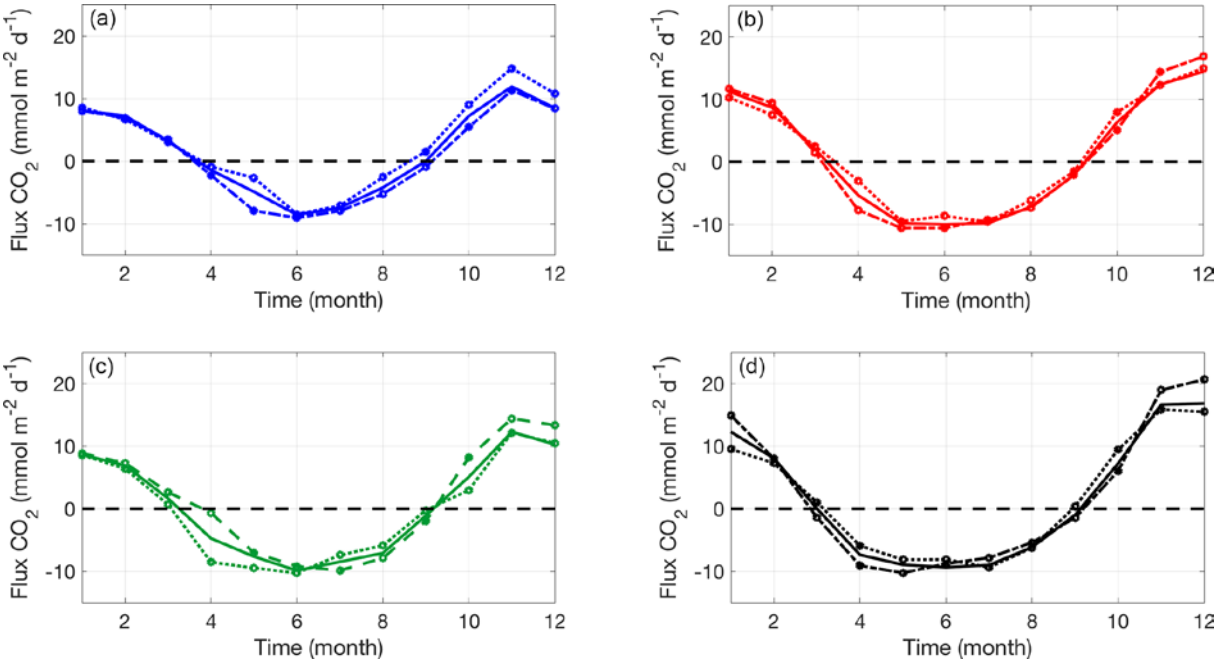


Figure 7. Seasonal cycle of air–sea CO_2 flux for the (a) Gulf of Bothnia, (b) Central Basin, (c) Gulf of Finland, and (d) South Basin. Solid lines represent the average for the period (1998 to 2011), dotted lines with markers are for the first 5 years (1998–2002), and dashed lines are for the last 5 years (2007 to 2011).

3.1.6 Lanna ecosystem station

Lanna is the most northern agricultural site within ICOS-Europe (58°20.43'N 13°6.14'E). It is operated by GU (station PI Per Weslien) and is located on the SLU research station which has been in operation since 1929. ICOS Lanna is thus operated in close cooperation with SLU. Part of this collaboration was the event "Lanna day", where research facilities at Lanna from SLU and ICOS Sweden were open for the general public. Approx. 100 people used the possibility to have a look at the installations and to get insight into climate research.

The station is set on clay soil and representative for the most dominate cereal production in Sweden. The 1961-1990 average annual precipitation at the site was 560 mm and annual

temperature 6.1°C. With 7.4°C mean annual temperature and 508 mm precipitation, 2017 was warmer and drier than the long-term average.

Besides regular ceptometer measurements for leaf area index measurement, taking 100 soil samples down to 0.8 m depth (Fig. 8) for monitoring soil carbon and nitrogen was one of the tasks which has been fulfilled for the ICOS labeling at Lanna. The samples have been dried and sieved to obtain fine earth, stones and root mass values.

Figure 8. *Taking soil sampling down to 0.8 m depth at Lanna*.

3.1.7 Hyltemossa combined ecosystem and atmospheric station

Hyltemossa is a combined ecosystem and atmospheric station located in Skåne, southern Sweden, operated by Lund University and station PI Michal Heliasz. The site is placed in a temperate, maritime climate with monthly average temperatures of around 0°C for January and 20°C for July. Annual average temperature is around 8°C. Spring months are the driest while summer months are the wettest, with a total annual precipitation of around 800 mm.

The ICOS activities are centered on a 150 m tall tower. The site around the tower is dominated by Norway spruce (Picea abies) with a small fraction of birch trees (Betula sp.) and single occurrence of Scots pine (Pinus sylvestris). Understory vegetation is sparse. The forest floor is mainly covered by mosses.

The forest is owned and managed by Gustafsborg Säteri AB (www.gustafsborg.se). The management turnover rate is 50 years, with an estimated growth of 34 m within 100 years. After clear cut, the site was replanted in 1983 with 3300 trees per hectare. At the present time the forest stand is 19 m tall and holds around 190 m^3 per hectare (excluding branches, stumps and roots).

The ICOS site was established in 2014 and started high quality ecosystem measurements in January 2015.

From the three forest sites within ICOS Sweden, Hyltemossa forest has the longest net carbon uptake period per year (approx. 180 days with negative NEE). In 2017, the net carbon uptake period started already in January (day 20) as a result of low ecosystem respiration and rather large gross primary production in the second half of January.

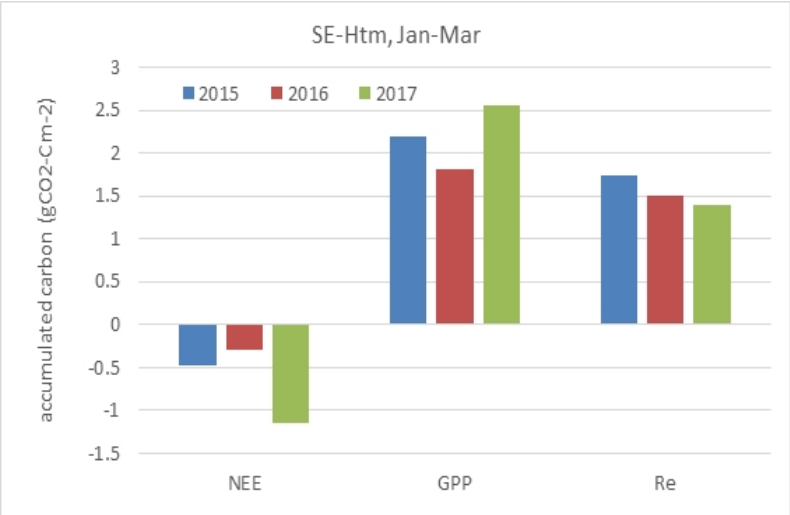


***Figure 9**. Total sum of net CO_2 exchange NEE, gross primary production GPP and ecosystem respiration Re at Hyltemossa in spring 2015 to 2017.*

3.2 Development phase of the measurement stations and systems

The buildup of measurement stations and systems was finalized at the end of 2015 and ICOS Sweden has, for most of the measurements systems, been fully operational since then.

During 2017, we have been working on getting ICOS labeled. The atmospheric stations have furthermore been working on the remaining installations and the testing and quality control of these. We have contributed to the revision of instructions that will be the base for the labeling process and are continuously adapting our routines and stations to these.

Delivery of test data from the Norunda ecosystem station to the ETC has been ongoing since 2015 and we have started submitting from all our stations using the database structure from the Carbon Portal. The aim is to provide easy access to non-ICOS labeled data from the ICOS Sweden infrastructure to potential users. This will include all ICOS Sweden data since start of the operational phase. Following the ICOS RI data provision rules, the continuous submission of ICOS labeled data may start after the labeling process has been finalized.

The dialogue on how to handle flux data from the ocean station with the Central Facilities (CFs) is ongoing and has not yet been solved. Both, OTC and ETC are involved into the discussion. All data for CO_2, water temperature and salinity in the water is being delivered to the SOCAT database with an ICOS label.

3.2.1 Actions taken 2017

- All ecosystem stations entered step two of the labeling where the installation of all sensors will be finalized in order to get the ICOS label. Step 2 is also a test period that shall facilitate the station compliance to the defined protocols for measurements.
- ICOS Sweden has started automatic data delivery of data from the atmospheric stations to Atmospheric Thematic Centre (ATC) and from Östergarnsholm to Ocean Thematic Centre (OTC) and has also started manual data delivery of ancillary data from all ecosystem stations to the ETC.
- All atmospheric stations have entered step two of the labeling and have been sending gas concentration data and meteorological data to the ATC since summer 2017.
- Ceilometers have been bought for the AS and installed at the Hyltemossa and Norunda forest sites. The automatic flask samplers are partly in place at the AS, but since some of the parts are still in production at MPG, they are not yet operational.
- We purchased spare instruments, as the budget for the new five-year period does not include any investments.

- At the Östergarnsholm station, the water-sampling program was continued. Changes in collaboration between SMHI and FMI required new exploratory talks to find a solution on the future buoy handling.
- ETC has summarized the measurement protocol contents into so called instructions that will be the base for the evaluation of the stations in the labeling process. We have provided thorough input to these instructions. We have also continued to adjust our procedures in order to fulfil the ICOS requirements.
- The staff has participated in training on site routines and working practices as well as on the standardized measurement protocols and recommended data practices, arranged by ICOS RI and/or ICOS Sweden.
- The ICOS Sweden personnel have participated in workshops and other types of meetings organized by the ICOS RI Head Office and Thematic Centers. The Station PIs have participated in the ICOS RI Measurement Station Assembly meetings.
- The compilation of descriptions of all non-ICOS research activities that are ongoing inside the domains have been continuously updated and we have provided service and support to projects at the stations.
- We have continued data archiving of raw data from the stations.
- Monitoring of the measurements and service, maintenance and update of systems as well as follow up of safety and rules at the stations have been continuously ongoing.
- Until the ICOS RI Carbon Portal is operational, we have continued to make data available upon request.
- We have started to produce a quality controlled dataset of ecosystem fluxes and their drivers. These datasets have been published using ICOS Carbon portal services. So far data from the three forest sites and Lanna are available through the ICOS Carbon Portal. The aim is to deliver data from all stations from 2014 onwards.
- Since 2014, continuous data from Norunda, with its metadata, has been submitted as an evaluation data set for ETC to standardize its procedures.
- The Svartberget and the Hyltemossa stations applied for participating in a collaboration project with NEON and San Diego State University that would include setting up a NEON tower in connection to the ICOS tower and collaboration opportunities for the station host university.

4. Building up and management of the ICOS Sweden organization

4.1 The ICOS Sweden Organization

During the last seven years, the ICOS Sweden management structure has been built up and now consists of a Board, a Scientific Advisory Committee, and a management group. The management group is led by the Coordinating Director and includes the Science Director, the Station PIs and the Scientific Experts. In 2016, a Scientific and Technical Station Support Module as well as a Communication Officer was added to the Coordination office. The support module is a resource for the stations and the costs for the module are shared between the partners. Below, the different bodies and their duties are described.

4.1.1 The ICOS Sweden Board

The present ICOS Sweden Board members have been selected by the Lund University Vice-Chancellor in agreement with the Swedish Research Council and the Consortium Partners. The members in 2017 were Leif Anderson (Chair; University of Gothenburg), Hannele Hakola, (Finnish Meteorological Institute), Joakim Langner, (Swedish Meteorological and Hydrological Institute), Ulf

Gärdenfors (SLU), Benjamin Smith (Lund University), Birgitta Resvik (FORTUM) and Hillevi Eriksson (Skogsstyrelsen). The Board is responsible for overall strategic and financial monitoring and shall promote development, operation, and management. The Board also decides on the focus and objectives for the collaboration between the different partner organizations that constitute ICOS Sweden. The Board meets the Scientific Advisory Committee (SAC) annually to discuss strategic issues.

4.1.2 The Scientific Advisory Committee (SAC)

The members of the Scientific Advisory Board are Professor Beverly Law (Oregon State University, USA), Professor John Moncrieff (School of Geosciences, University of Edinburgh, UK), Professor Monique Leclerc (University of Georgia, Georgia, USA) and Professor Ernst-Detlef Schulze (Max Planck Institute for Biogeochemistry, Jena, Germany). The SAC contributes with scientific advice, establishes external links, and acts as ambassadors in general. SAC participates in the annual workshop and, in conjunction to the workshop, meets the Board to discuss strategic issues.

4.1.3 Coordination Office (CO)

The ICOS Sweden Coordination Office is hosted by Lund University. It consists of a Coordinating Director (Maj-Lena Linderson), a Science Director (Janne Rinne), a scientific secretary (Jutta Holst), a communication officer (Susanna Olsson/Ylva van Meeningen), a project assistant (Eva Andersson) and the personnel of the scientific and technical expertise module. This module includes three part time personnel (Meelis Mölder, Jutta Holst and Björn Eriksson). The Coordinating Director decides on all day-to-day scientific, technical, and administrative issues of the research infrastructure. The Coordinating Director also serves as Sweden's national Focal Point to ICOS RI. The Science Director promotes external collaborations and research activities and assists the Coordinating Director in scientific and strategic planning. The CO supervises the activities at the stations and acts as an intermediary between the Board and the rest of the organization. The CO assists the Board in organizing meetings, taking minutes and compiling documents for progress follow up, revisions, and endorsements. Furthermore, the CO coordinates the renewal of applications and agreements as well as the internal communication and common information and outreach activities. The scientific and technical support module delivers support on instrumentation and computer systems, and on data storage and delivery. The modules are resources for the stations and the costs are shared between the partners.

4.1.4 Consortium partners, partner Scientific Experts (SE) and Station Principal Investigators (SPIs)

A Station Principal Investigator (SPI) is appointed for each of the operative ICOS Sweden stations. Responsibilities, tasks, and duties for the SPIs include organizing and managing the activities at their respective measurement station and to be responsible for the data quality checks in conjunction to the data submission to the Thematic Centers. The SPIs participate in the ICOS RI MSAs as representatives of ICOS Sweden and are part of a Station Coordination Group (SCG). The SPIs also promote outreach activities specific for their site e.g. courses and field visits. Each partner also provides ICOS Sweden with a scientific expert (SE) that act as a contact person between the respective partner and the CO. These experts participate in Management Team meetings in order to be well acquainted with the activities of ICOS Sweden, contribute to application writing, scientific meetings, and to other matters of strategic importance for development of the infrastructure. A partner may appoint the SPI of the measurement station to be its SE. The list of SPIs includes Mats B. Nilsson (Degerö), Mikaell Ottosson Löfvenius (Svartberget), Meelis Mölder (Norunda), Per Weslien (Lanna), Michal Heliasz (Hyltemossa), and Tomas Friborg and Patrick Crill (Abisko-Stordalen). Thomas Friborg ended his work as PI in the end of 2017 and was replaced by Janne Rinne. The SPIs are at the moment the same persons as

the SEs except for Gothenburg University (the Lanna station) for which Leif Klemedtsson is the SE and for Lund University (the Norunda and Hyltemossa stations) for which Janne Rinne is the SE.

4.1.5 The management team

The Management Team is made up of the Station Principal Investigators (SPIs) and the scientific experts (SE), as representatives for their respective measurement station and consortium partner. The team coordinates the activities at the different sites, resolves various technical and practical issues, and is a forum for discussions on the management and development of the research infrastructure. The team has regular phone/internet meetings that are complemented by occasional site visits, when needed. They also contribute to applications and reporting, including the strategic development of ICOS Sweden, and act as intermediary between their respective partner and the CO.

4.1.6 Users' Groups

In the early stage of the buildup of ICOS Sweden, the plan was to set up a Users' Group and a Stakeholder's group. The Users' Group should promote contacts with members of the scientific user community, who are tentatively interested in using research sites and measurement data of the national RI. The Stakeholders' Group aimed at promoting contact with representatives of authorities and organizations that are potentially interested in using the synthesized data products of ICOS RI. Because ICOS RI is not yet fully operational, and ICOS Sweden's activities are just starting, it was decided to join the two contact groups into one single user group open to stakeholders as well as site and data users. Guy Schurgers, University of Copenhagen, is appointed as chair with the aim of leading the work with identifying and enrolling members to the group and further defining its objectives and work procedures. At first, the enrollment will be concentrated on scientific users of the data and of the sites. The stakeholder community will be approached once ICOS Sweden is operational and there are data products to display to illustrate the usefulness of the data.

4.2 Development phase of the organization and its management

In late 2016, the former Director retired and the mandate for the Board ended, which lead to new appointments in 2017. Due to the difficult financial situation for the Abisko-Stordalen station, the organization has put a lot of effort into finding a possibility to continue with the station. During the year, it became clear that Polar will take on the task to continue the station as an associated site. The main outreach activities during 2017 were focused on the Nordic ICOS Symposium, collaboration with other infrastructures and projects. The work with enrolling members to the User's Group and to further define its objectives and work procedures has not yet started due to the intensive work on adapting to the new funding situation. A startup discussion meeting between the Chair of the User's group and the Coordination Office took place in late 2017.

4.2.1 Actions taken 2017

- To have time to explore a sustainable solution for the Abisko-Stordalen station, extra funding from remaining assets from the first funding period were set off to support the station during 2017. After some negotiation with Polar and the other consortium partners, it is now clear that Polar will continue running the station as associated site. Discussions on involving other financers will continue during 2018.
- To strengthen the position of ICOS Sweden as a national resource, we submitted a suggestion of upgrading ICOS Sweden with ACTRIS to the SRC inventory of infrastructure needs.

- During a first meeting with the head of the User's Group plans on how to continue were discussed. It was decided that the current focus of the user group will be young and more experienced researchers in order to investigate their research needs in terms of what ICOS Sweden could provide.
- We arranged monthly internal information meetings via internet as well as field visits to stations. We also arranged face-to-face SCG meetings.
- ICOS Sweden hosted the ecosystem and atmosphere MSA meetings during spring.
- ICOS Sweden has continued disseminating information and support education efforts through seminars, courses, field visits, media contacts, and through the ICOS Sweden homepage.
- The CO personnel have collaborated with ICOS RI through focal point meetings and communication meetings and participated in the ICOS ERIC General Assembly meetings. ICOS Sweden personnel have also attended the RINGO project meetings and are involved in collaboration within the WP on lateral fluxes.
- ICOS Sweden co-organized the first Nordic ICOS workshop in Denmark. The Advisory Committee and Board was invited and had a strategy meeting in connection to the workshop.
- We have participated in the Research Infrastructure Network for Nordic Atmospheric and Earth System Science Nordic ENVRI and contributed to the strategic recommendations for future Nordic research infrastructures to NordForsk.
- A newsletter has been started with the intention to be sent out every fourth month, both within the ICOS Sweden community and to possible future stakeholders. The newsletter has so far been well received.
- The coordination office enhanced the advertisement of the use of ICOS Sweden stations and data within the universities and relevant target groups. We developed information material like folders, posters, stickers, roll-up, calendars and bags.
- We worked on elaborated data products to be used for teaching in schools and education of teachers. Furthermore, there was a large demand on data to be used in graduate schools and undergraduate courses during 2017.
- ICOS Sweden has, through Carbon Portal contacts, collaborated with ENVRI+ and EUDAT regarding data management.
- We have continued to encourage applications from ICOS-external researchers aiming at setting up new projects at the stations and to support already ongoing activities.

5. Financial outcomes 2017

A summary of the financial outcomes for 2017 for all sites are given in Table 2 below. It should be noted that this is a liquidity budget, using incomes and expenses and no depreciation costs, which means that the difference between the total incomes and total expenses represent the amounts available. The closing balance corresponds to the accumulated amount available since 2010, following the contributions by SRC and the partners in the consortium agreement.

Table 1. *Financial outcomes 2016 for each partner and in total (kSEK). For acronyms, see Appendix 3.*

	LU	SLU	GU	UU	Polar	SU	Sum
Initial balance	**7,951**	**1,719**	**657**	**164**	**1,707**	**38**	**12,236**
Incomes	0	0	0	0	0	0	0
Incomes SRC	3,314	1,896	970	770	0	60	7,011
Co-financing	4,565	3,330	1,309	1,301	450	179	11,135
Sum	**7,879**	**5,226**	**2,279**	**2,071**	**450**	**240**	**18,145**
Costs							
Salaries	4,768	2,774	1,005	1,012	835	130	10,525
Consumables	716	936	280	11	312	0	2,254
Travels	232	102	66	2	0	30	431
OH	2,067	815	677	361	282	80	4,281
Technical Support	625	400	236	0	0	0	1,261
Investments	379	293	0	0	80	0	753
Sum	**8,788**	**5,320**	**2,263**	**1,385**	**1,509**	**240**	**19,505**
Difference	-908	-94	16	686	-1,059	0	-1,360
Closing balance	**7,043**	**1,626**	**673**	**850**	**648**	**38**	**10,877**

The preliminary outcome for 2017 follows the budget well, taking into account that the initial balance is used to cover the annual negative difference. This was expected already from the start of the second financing period, 2016-2020. The remaining assets in the closing balance are reserved to cover such deficit in the annual balances 2018-2020 (65%). Polar does take part of the distributed funding from SRC during 2017.

The rest of the remaining assets are reserved for coming investments (around 35%). The delayed investments are due to late decisions on the requirements by the Central Facilities in ICOS RI, and that the production of some of the items has been delayed (e.g. the air sample flasks and drier produced by MPG Jena). As soon as the stations have undergone the evaluation for becoming labeled, these items will be purchased.

The running costs for the stations were slightly lower than expected for most of the stations. This was due to that the stations are not yet running as labeled stations with the corresponding duties and full costs that we estimated in early 2017. The salary cost for some of the partners are higher than expected due to an increase in personnel to help out with various tasks for the stations.

6. Key numbers

ICOS Sweden documents the performance and usefulness of the infrastructure by evaluating certain key numbers. The list of key numbers which had been identified at the startup of ICOS Sweden has been expanded to a documentation of physical users and data users divided in scientific and geographic background to be reported to the SRC. The report to the SRC with numbers for 2017 is available at the infrastructure's website (www.icos-sweden.se). The statistics presented here include data requests/usages of specific ICOS Sweden data by single persons. As

can be seen from Table 2 (development number of data users) and Figure 10 (development of peer-reviewed and popular science publications referring to ICOS-related data measured at sites that now belong to ICOS Sweden), there is an overall increasing trend of research interest within this topic. However, in contrast to 2016, the statistics do not include downloads of data compilation (e.g. the NOAA obsPack global CO_2 dataset compilation); thus, the number of data users decreased in 2017 compared to the previous year.

In 2017, ICOS Sweden also provided processed data sets to be used in undergraduate and graduate courses and material for a high school education on behalf of the Swedish National Agency for Education. This will open up the usage of the infrastructure's output to a larger number of users, which will not be registered by any statistics. Excursions in connection with undergraduate courses are a large part of the physical users at the ICOS Sweden stations.

The uptime statistics for the backup systems for meteorological variables and the key variables continued to be high (Figure 11 and 12). No statistics for the backup system can be provided for Östergarnsholm, as it is not foreseen to be installed at this site. The eddy covariance data coverage at the ecosystem sites where higher than 80% at all sites.

Table 2. *Number of academic users of data, measured at sites within ICOS Sweden since 2005. Numbers include (i) data requests from sites that now belong to ICOS Sweden via the European Fluxes Database Cluster, (ii) projects which are in direct relation to ICOS, (iii) data requests addressed to ICOS Sweden directly, and (iv) data downloads from the ICIS RI Carbon portal.*

Year	Number of Data Users			
	international	national	unspecified	total
2005	3	0		3
2006	19	0		19
2007	4	0		4
2008	14	9		23
2009	38	2		40
2010	45	6		51
2011	21	1		22
2012	36	2		38
2013	64	1		65
2014	51	17		68
2015	75	45		120
2016	211	77		288
2017	9	28	127	164

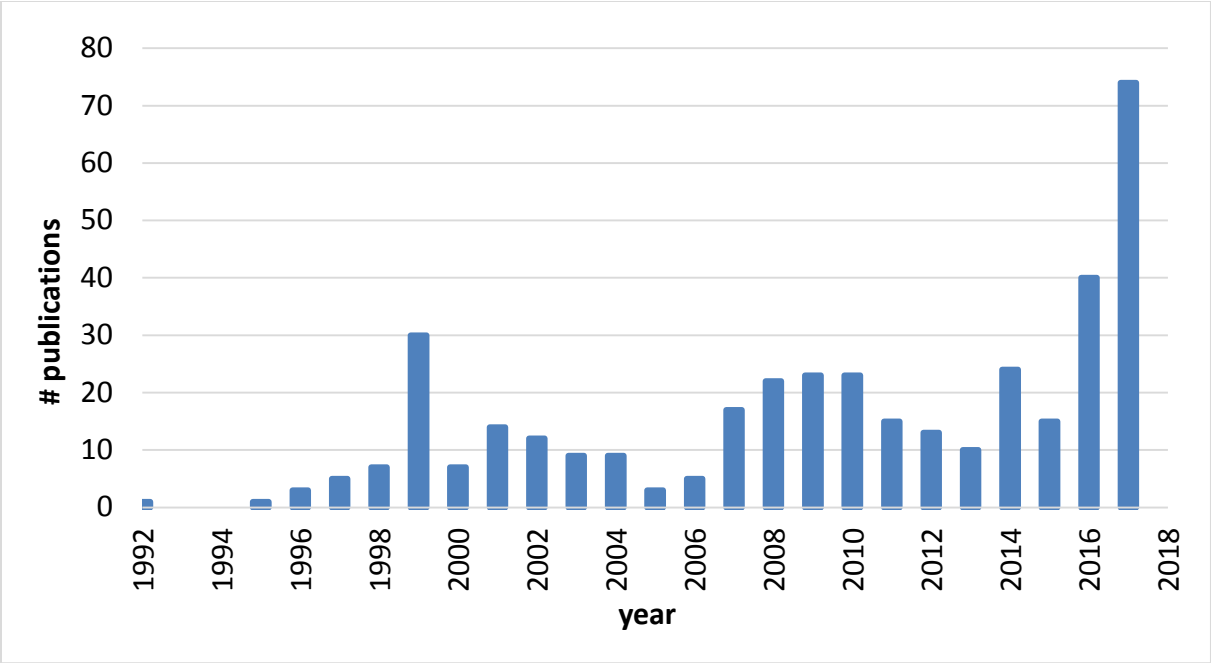


Figure 10. *Number of peer-reviewed and popular science publications referring to ICOS-related data measured at sites that now belong to ICOS Sweden.*

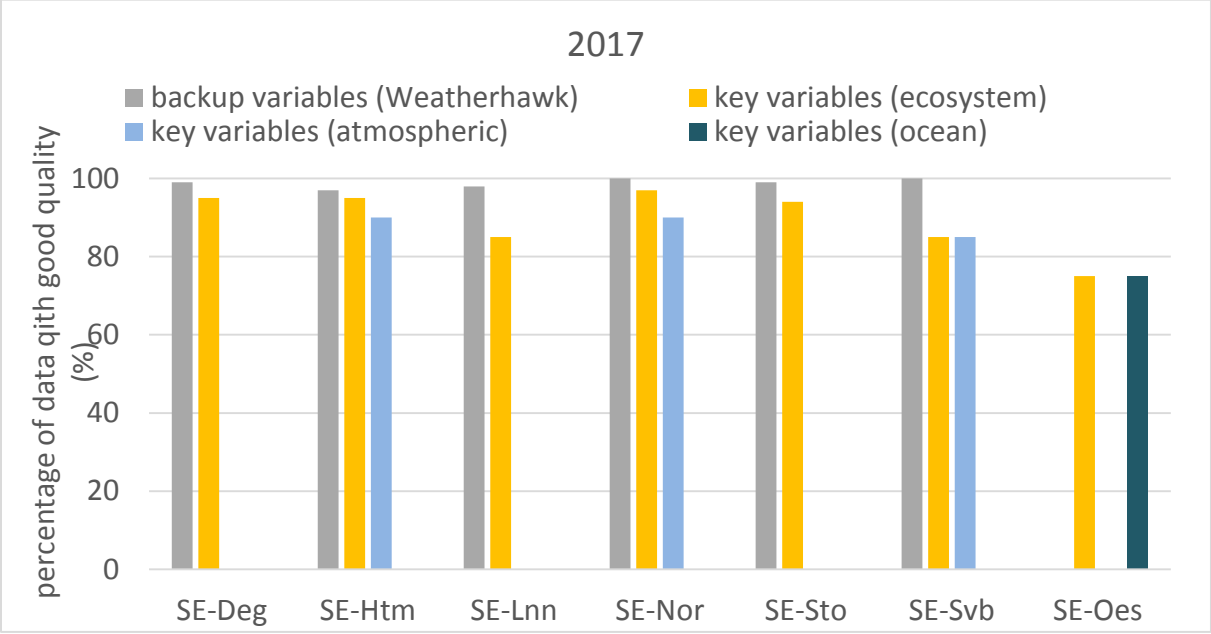
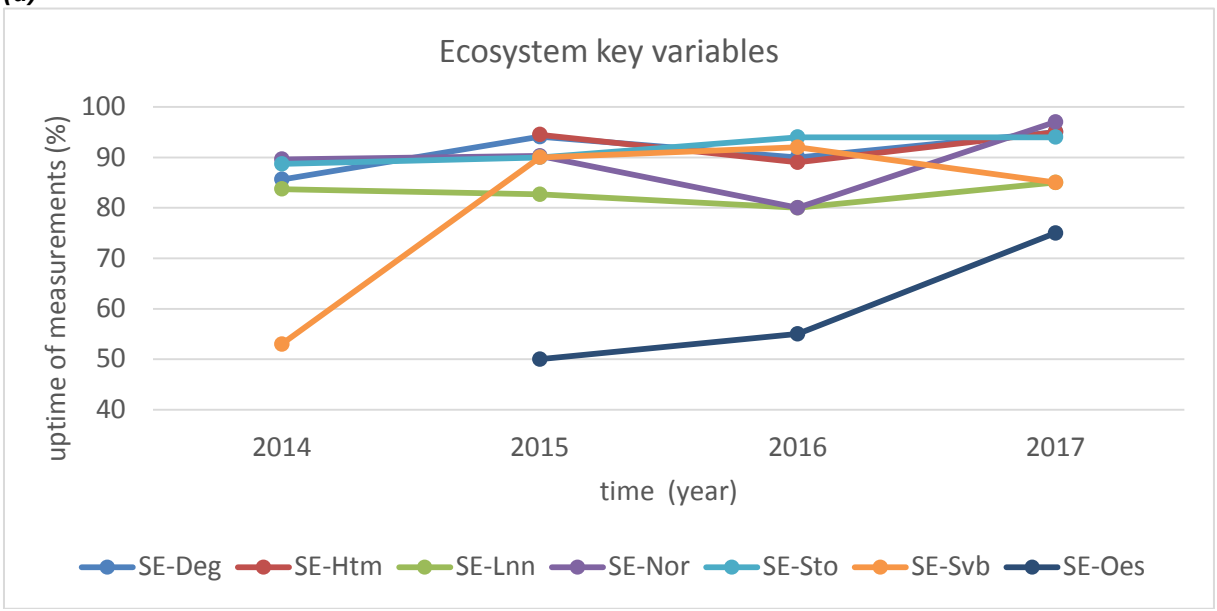


Figure 11. *Bar plot showing the percentage of days with high data quality for backup meteorological variables and for key variables for the ecosystem, atmospheric and ocean stations. Key variable for the ecosystem stations are turbulent fluxes from the eddy covariance systems. Key variables for the atmospheric stations are concentrations of GHG at three levels, Key variables for the ocean station is pCO_2 (CO_2 concentration). All stations in ICOS Sweden are shortened with the prefix SE. Deg: Degerö, Htm: Hyltemossa, Lnn: Lanna, Nor: Norunda, Sto: Abisko-Stordalen, Svb: Svartberget and Oes: Östergarnsholm.*

(a)



(b)

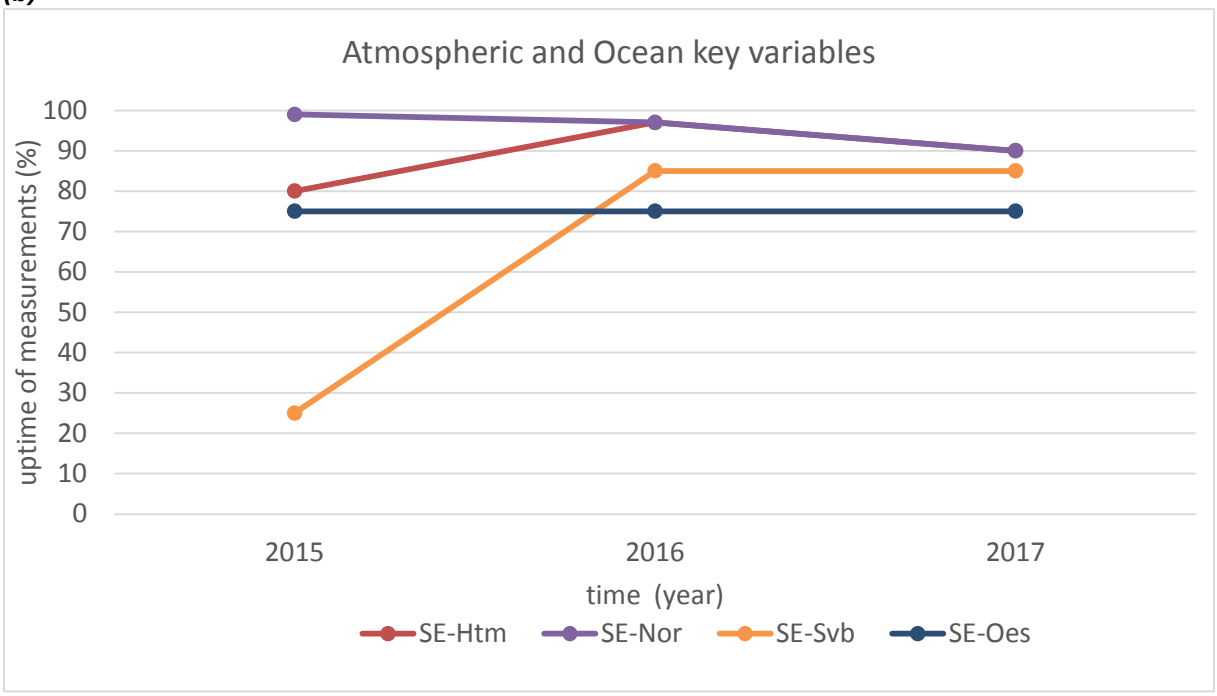


Figure 12. *Temporal development of high quality data availability for Ecosystem station key variables (a), atmospheric station and ocean key variables (b). All stations in ICOS Sweden are shortened with the prefix SE. Deg: Degerö, Htm: Hyltemossa, Lnn: Lanna, Nor: Norunda, Sto: Abisko-Stordalen, Svb: Svartberget and Oes: Östergarnsholm.*

Appendices

Appendix 1: List of personnel during 2017

Total amount of FTEs: 14

Coordination Office:

Maj-Lena Linderson, coordinating director, 50%
Janne Rinne, science director and ICOS Sweden SE for Lund university, 20%
Jutta Holst, scientific secretary 20%, scientific and technical station support, 80%
Meelis Mölder, scientific and technical station support, 70%
Susanna Olsson, communication officer until Aug, then
Ylva van Meeningen, 50%
Björn Eriksson, scientific and technical station support, 20%
Eva Andersson, project assistant, 10%

Measurement stations:

Abisko-Stordalen:

Per Marklund, research engineer until spring then
Robert Holden, 100%
Niklas Rakos, research engineer, 50%
Thomas Friborg, station PI and SE, 20%, replaced in late 2017 by
Janne Rinne, 10%
Patrick Crill, station PI and SE, 10%

Degerö and Svartberget:

Holger Tülp, research engineer until autumn then
Per Marklund, 100%
Eric Larmanou, research engineer, 100%
Pernilla Löfvenius, research engineer, 50%
Guiseppe de Simon, research engineer, 50%
Mikaell Ottosson Löfvenius, station PI and SE, 20 %
Mats Nilsson, station PI and SE, 10%

Norunda:

Irene Lehner, research engineer, 100%
Anders Båth, research engineer, 90%
Meelis Mölder, station PI, research engineer, 30%

Östergarnsholm:

Anna Rutgersson, station PI and SE, 35%
Marcus Wallin, research engineer, 50%
Erik Nilsson, research engineer, 45%
Hans Bergström, research engineer, 5%

Lanna:

Per Weslien, Station PI, research engineer, 75%
Bengt Liljeblad, research engineer, 25%
Leif Klemedtsson, SE, 35%

Hyltemossa:

Tobias Biermann, research engineer, 100%
Michal Heliasz, station PI, research engineer, 100%
Thomas Holst, research engineer, 20%

Appendix 2: List of measurement variables and instruments/systems

Ecosystem stations (Hyltemossa[1], Lanna[3], Norunda[1], Degerö[2], Svartberget[1], Stordalen[2])				
Continuous measurements		Forest[(1)]	Wetland[(2)]	Agriculture[(3)]
Turbulent fluxes	CO_2	1	1	1
	H_2O	1	1	1
	CH_4	-	1	-
	N_2O	-	-	1
	Momentum	1	1	1
	Sensible heat	1	1	1
Radiative fluxes	Incoming short-wave	2	2	2
	Outgoing short-wave	1	1	1
	Incoming long-wave	1	1	1
	Outgoing long-wave	1	1	1
	Net Radiation	Combination of 4 components	Combination of 4 components	Combination of 4 components
	Incoming PAR	2	2	2
	Diffuse incoming PAR	1	1	1
	Outgoing PAR	1	1	1
	PAR below canopy	16	-	-
	Spectral reflectance	1	1	1
Soil fluxes	Soil heat flux	4	4	4
	Soil CO_2 efflux	6	-	-
State variables	Air temperature profile	14-15	5	5
	CO_2 profile	14-15	5	5
	CH_4 profile	0	0	0
	Relative humidity	1	1	1
	Wind speed/direction	Flux sonic, SE-Nor: 14	Flux sonic	Flux sonic
	Soil temperature profile	4x5	4x5	4x5
	Soil moisture profile	4x5	4x5	4x5
	Ground water level	1-4	4	-
	Ground height	-	1	-
	Snow depth	1	1	1
	Precipitation	1	1	1
	Tree trunk surface temperature	48	-	-
	Canopy IR temperature	1	1	1
	Backup meteorological station	1	1	1
Imaging	Above canopy phenological cam	1	1	1
	Below canopy phenological cam	1	0	0
Periodic measurements	Green area index	x	x	x
	Aboveground biomass	x	x	x
	Leaf chemical analysis	x	x	x
	Litterfall	x		
	C and N export/import	x		x

Atmospheric stations				
		Svartberget	Norunda	Hyltemossa
Continuous measurements	CO_2, CH_4, H_2O, CO	3	3	3
	Wind speed/direction	3	3	3
	PBL height	1	1	1
	Meteorological parameters	3	3	3
Periodic measurements	Sampling for radio carbon ^{14}C	1	1	1
	Flask sampling: SF_6, N_2O, O_2, N_2, C-14, Rn-222 + other isotopes	1	1	1

Ocean station		
Continuous measurements		Östergarnsholm
Turbulent fluxes	CO_2	1
	H_2O	1
	CH_4	-
	N_2O	-
	Momentum	1
	Sensible heat	1
Radiative fluxes	Incoming short-wave	2
Water measurements	Temperature profile	4
	Salinity profile	4
	Surface CO_2	1
	Surface Oxygen	1
State variables	Air temperature profile	5
	CO_2 profile	4
	H_2O profile	4
	Wind profile	5
	Relative humidity	1
	Precipitation	1
Periodic Water sampling	Nitrogen	x
	Phosphorous	x
	Silica	x

Appendix 3: Publication list 2017

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Appendix 4: List of abbreviations and acronyms

ICOS RI (European level)

ATC – Atmospheric Thematic Center
AS – Atmospheric stations
CAL – Central Analytical Laboratory
CFs – Central facilities (ETC, ATC, OTC and CAL)
CP – Carbon Portal
ES –Ecosystem station
ETC – Ecosystem Thematic Center
ERIC – European Research Infrastructure Consortium
ESFRI - European Strategy Forum on Research Infrastructures
HO – Head office
ICOS RI – Integrated Carbon Observation System Research Infrastructure
ICOS PP – ICOS Planning Project (sometimes also Preparatory Phase)
ISIC – ICOS Stakeholder Interim Council
OS – Ocean station
OTC – Oceanic Thematic Center

ICOS Sweden

CO – ICOS Sweden's Coordination Office
SAC – ICOS Sweden's Scientific Advisory Committee
SCG – ICOS Sweden's Station Coordination Group
SPI – ICOS Sweden Station Principal Investigator

ICOS Sweden partners

LU – Lund University
GU – Gothenburg University
SU – Stockholm University
SLU – Swedish University of Agricultural Sciences
PFS - Swedish Polar Research Secretariat

Other infrastructures and organizations

ACTRIS - Aerosols, Clouds, and Trace gases Research Infrastructure network (http://www.actris.net)
ANAEE – Analysis and Experimentation on Ecosystems (www.anaee.com)

GMES - Global Monitoring for Environment and Security (now called Copernicus, http://www.copernicus.eu)

DEFROST – A Nordic Centre of Excellence with the aim to understand how climate change induced changes in the cryosphere influence the ecosystem/geosphere processes which directly affect climate (http://www.ncoe-defrost.org)

INTERACT – International Network for Research and Monitoring in the Arctic (http://www.eu-interact.org)

NORDFROST - A Nordic researcher network supporting the study of greenhouse gas and energy exchange in sub-arctic and arctic ecosystems (http://www.nateko.lu.se/nordfrost)

WCRP – World Climate Research Programme (http://www.wcrp-climate.org)

SITES – Swedish Infrastructure for Ecosystem Research (http://www.fieldsites.se/)

Other

CWG – contract working group

GHG – greenhouse gas

NORA – The Marie Sklodowska Curie Initial Training Network ”Nitrous Oxide Research Alliance”

SMHI –Swedish Meteorological and Hydrological Institute

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