ICOS SWEDEN Annual Report 2014

ICOS INTEGRATED CARBON OBSERVATION SYSTEM SWEDEN

LUNDS UNIVERSITET

GÖTEBORGS UNIVERSITET

Stockholms universitet

SLU

POLARFORSKNINGS SEKRETARIATET
SWEDISH POLAR RESEARCH SECRETARIAT

Vetenskapsrådet

This Annual Report was endorsed by the Board of ICOS Sweden on 26 February, 2015. The plan is complemented by other documents from ICOS Sweden, including the Operational Plans for 2014 and 2015, and the Strategic plan 2012-2014 (from 2012) and Strategic plan 2016-2020 (from 2015).

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1. Introduction to ICOS Sweden

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 infrastructure is built up as a collaboration of nationally operated measurement stations in 15+ European countries. ICOS Sweden is the Swedish contribution to this European effort.

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 of CO_2, CH_4, CO and radiocarbon-CO_2.

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 homepage http://www.icos-infrastructure.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 2014

The building up of the organization and management as well as of the measurement stations and systems is about to be finalized. ICOS Sweden has, at the end of 2014, entered its testing phase for most of the measurement systems, and expects to become fully operational during 2015.

The installation and deployment of equipment and control systems at the ecosystem stations are finalized. Delivery of data from the Norunda ecosystem station to the ETC has started and will soon be followed by delivery from all the other ecosystem stations. The installations and deployment of the atmospheric systems have been delayed, as some parts for the systems are not yet available from the Central Facilities. However, we expect the atmospheric systems for continuous concentration measurements to be installed and running in early 2015. Figure 1 illustrates the development status of the ICOS Sweden measurement stations when it comes to delivery of data and information to the Central Facilities.

The buildup of the ICOS Sweden organization and its functions is finished except for the full implementation of the User's Group and continued establishment of links to the Central Facilities. The funding application for the next financing period was postponed to 2015 due to SRC's reorganization of their infrastructure management and has thus not been in focus during 2014.

The coordination office has, together with the Board, SAC and the SCG-group, however started updating the Strategic Plan.

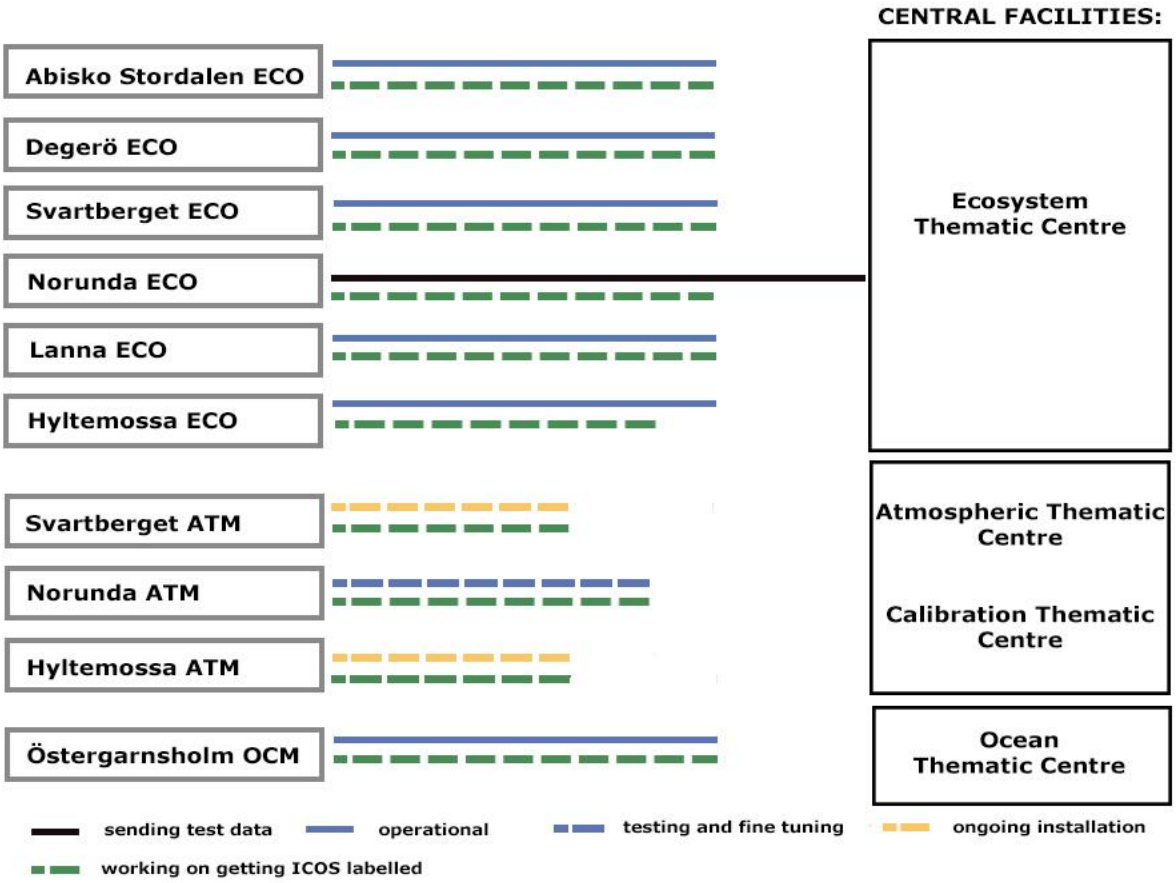


Figure 1. *The development status for the delivery of data and information to the Central Facilities from the ICOS Sweden measurement stations. Upper lines at all stations – development status for data delivery. Lower green lines – status on getting ICOS labelled.*

The activities for ICOS Sweden during 2014 are related to the milestones (Tab. 1) in order to identify actions needed and to reveal the progress of the infrastructure. Compared to what was planned in the Operational plan for 2014 (endorsed by the board in late 2013) the following milestones have not been reached:

- 2.1.2 and 2.2.2: Follow up of measurement routines and fine tuning of the atmospheric installations. This is because the atmospheric instruments are not installed at all the atmospheric measurement stations.
- 2.3: Becoming ICOS labelled stations. The ICOS RI and Central Facilities are not ready to verify the stations yet as the common ICOS RI protocols are not finalized.

Table 1. *ICOS Sweden milestones for the building up and management of the research infrastructure. Dotted lines mark the years when the milestone is active. The pink color shows start year and the blue color identifies the year when the milestone is finalized. In-between years are marked with yellow color. Table continues on the next page .*

				PHASE	2010	2011	2012	2013	2014	2015	2016-ff
1.				**Initiation phase**							
	1.1.			***Building up of ICOS Sweden organization:***	====	=======	=======	=======	=======	=======	
		1.1.1		*Establishing the ICOS Sweden management structure*	-----	----------	----------	----------	----------	----------	
			1.1.1.1.	Establishing the Coordination Office	-----						
			1.1.1.2.	Appointing the Board		----------					
			1.1.1.3.	Establishing the ICOS Sweden consortium and verifying the measurement stations	-----	----------					
			1.1.1.4.	Establishing the Station Coordination		----------					
			1.1.1.5.	Appointing the SAC			----------				
			1.1.1.6	Establishing the User Group				----------	----------	----------	
			1.1.1.7.	Establishing links to ICOS RI	-----	----------	----------	----------	----------		
		1.1.2.		*Development of the strategy and planning*	-----	----------	----------				
			1.1.2.1.	Strategic plan development and formalizing the operational plans	-----	----------	----------				
		1.1.3.		*Formalizing the reporting and*	-----	----------	----------				
			1.1.3.1.	Formalizing the annual reporting incl key numbers and economic outcomes		----------	----------				
			1.1.3.2.	Creating an outreach strategy	-----	----------					
	1.2.			***Building up of the field sites and measurement systems:***	====	=======	=======	=======	=======	=======	
		1.2.1.		*Building masts and labs*	-----	----------	----------	----------	----------		
		1.2.2.		*Employing staff and appointing Station Pis*	-----	----------	----------	----------	----------		
		1.2.3.		*Installing the instrumentation at the sites: ecosystem, atmospheric and ocean measurement systems*	-----	----------	----------	----------	----------	----------	
		1.2.4.		*Forming the routines at the measurement stations*	-----	----------	----------	----------	----------	----------	
			1.2.4.1.	Routines for the measurements and measurement protocols				----------	----------	----------	
			1.2.4.2.	Safety and rules at the stations	-----	----------	----------	----------	----------	----------	
			1.2.4.3.	Routines for access to stations and identification of the ICOS domain			----------	----------	----------	----------	
2.				**Testing phase**							
	2.1.			***Follow up of measurement routines and fine tuning***				=======	=======	=======	
		2.1.1.		Ecosystem measurement data				----------	----------	----------	
		2.1.2.		Atmospheric measurement data						----------	
		2.1.3.		Ocean measurement data						----------	
	2.2.			***Startup sending data to the thematic centres***					----------	----------	
		2.2.1.		Ecosystem measurement data					----------	----------	
		2.2.2.		Atmospheric measurement data						----------	
		2.2.3.		Ocean measurement data						----------	
	2.3.			***Becoming ICOS labelled stations***						=======	
		2.3.1.		Ecosystem sites						----------	
		2.3.2.		Atmospheric sites						----------	
		2.3.3.		Ocean sites							----------

Table 1 (continued). *ICOS Sweden milestones. Continued from previous page.*

				PHASE	2010	2011	2012	2013	2014	2015	2016-ff
3.				**Operational phase**							
	3.1.			***Management of the organisation***		=======	=======	=======	=======	=======	=======
		3.1.1.		*Reoccuring revision of the strategy and planning*				----------	----------	----------	----------
			3.1.1.1.	Production and revision of steering documents		----------	----------	----------	----------	----------	----------
			3.1.1.2.	Board revision and endorsements		----------	----------	----------	----------	----------	----------
			3.1.1.3.	SAC supevision and advice				----------	----------	----------	----------
		3.1.2.		*Reporting*			----------	----------	----------	----------	----------
			3.1.2.1.	Biannual follow up of key numbers					----------	----------	----------
			3.1.2.2.	Annual reporting			----------	----------	----------	----------	----------
			3.1.2.3.	SRC evaluations and renewed applications			----------			----------	----------
		3.1.3.		*Conduction of outreach activities and dissemination*			----------	----------	----------	----------	----------
			3.1.3.1.	Annual workshop				----------	----------	----------	----------
			3.1.3.2.	Seminars, homepage, media activities		----------	----------	----------	----------	----------	----------
			3.1.3.3.	Courses and field visits		----------	----------	----------	----------	----------	----------
			3.1.3.4.	User group interaction						----------	----------
			3.1.3.5.	Dissemination - reports and papers						----------	----------
		3.1.4.		*Consortium agreement revision and renewal*					----------	----------	----------
		3.1.5.		*Cooperation activities*				----------	----------	----------	----------
	3.2.			***Management of sites, systems and measurements***				=======	=======	=======	=======
		3.2.1.		*Monitoring measurements at the sites*					----------	----------	----------
		3.2.2.		*Service, maintenance and update of systems, work routines and protocols*					----------	----------	----------
		3.2.3.		*Storing and long-time archiving of data and metadata*						----------	----------
		3.2.4.		*Delivery of data to CFs including quality verification*						----------	----------
		3.2.5.		*HR strategy and development*				----------	----------	----------	----------
		3.2.6.		*Service to ancillary project and data users*					----------	----------	----------

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

ICOS Sweden operates, up to the end of 2014, nine measurement stations in total, of which six are ecosystem stations and three are atmospheric stations (Fig. 2). The three atmospheric stations are co-located with three of the ecosystem stations. The ecosystem and marine station, Östergarnsholm, run by Uppsala University, will be included in ICOS Sweden in 2015 and is thus not described here.

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, 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 PI (SPI) in the Station Coordination Group (SCG) of ICOS Sweden and in the ICOS RI Measurement Station Assembly (MSA) (see Chap. 4.1.4).

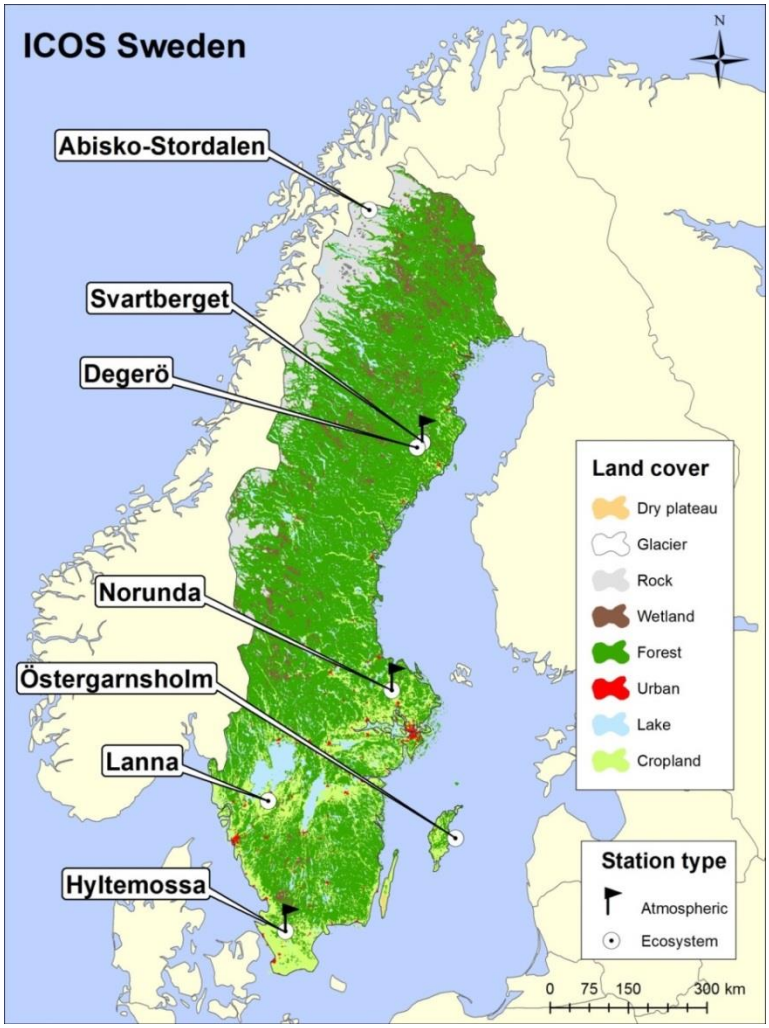


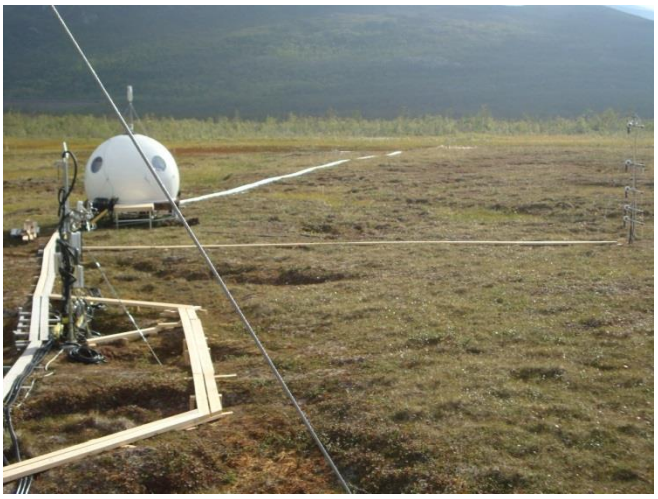
Figure 2. *The locations of the ICOS Sweden measurement stations. The colors indicate the dominant land cover: forest (dark green), wetlands (brown), agricultural land (light green), water bodies (light blue), barren/alpine vegetation (gray) and built-up areas (red).*

3.1 The measurement stations

Below, the measurement stations are described, followed by a summarized description of the progress during 2014 and a list of actions taken during this time.

3.1.1 Abisko-Stordalen ecosystem station

The Stordalen subarctic wetland, consisting of a fen/palsa/lake complex, is of large interest to many national and international researchers and there are 15 ongoing projects there including flux measurements by different groups. The wetland area is located very close to the 0°C isotherm and represents a very dynamic part of the sub-arctic region.



The station has been equipped since 2012, including the construction of an instrument shed ("igloo"), but during 2013 a number of improvements were made in order to prepare the station for the uninterrupted measurements from new year 2014. Though the station has been measuring since early 2013 improvements have gradually been made since experience has been accumulated during the startup phase. As part of this, profile measurements have been moved to a slightly different location, the interior of the instrument shed has been reorganized, and proper air conditioning is now in place. Since the beginning of the year, the quality control of the data has been intensified, in order to avoid long periods with poor quality data. Routines are presently being introduced make sure that errors in the data stream are identified and corrected with the shortest possible delay. Regardless of these efforts, the station has experienced instrumental problems during the year, which mostly in the early part of the year caused loss of some data. Calibration routines are being introduced as a routine and standards for this will be adjusted to follow ICOS RI protocols, once these are finalized. During the year, the installation in Abisko-Stordalen has been documented in terms of metadata for the instrumentation and protocols for various parts of the instrumentation under development.

Under 2014, 9 papers have been published from this side. The site has been demonstrated several times for students, small groups or individuals that might become possible future users.

Station PIs are Thomas Friborg and Patrick Crill; research engineers, 1.5 FTE, are Robert Holden and Niklas Rakos. The station is operated by the Swedish Polar Research Secretariat at the Abisko Scientific Research Station.

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.

Final inspection by InSitu was undertaken and the deviations from the specifications were noted and will be further evaluated and if necessary changed accordingly. The ICOS instrumentation at Degerö survived a lightning strike with only minor damages. Major problems have occurred mainly with the Los Gatos (LGR) eddy covariance fast greenhouse gas analyzer, being shipped to LGR Inc. in November for repair. A first preliminary evaluation of eddy-covariance CH_4 flux has been undertaken by Georg Jocher, Post-Doc, SLU, Umeå. Data looks very promising and compare surprisingly well with manual chamber data.

About 15 projects have been active in utilizing the ICOS Degerö infrastructure. In addition, numerous projects are utilizing data from Degerö through the FLUXNET/European Eddy Covariance database. The projects focuses e.g. on partitioning of the ecosystem respiration within the eddy covariance footprint between mosses and vascular plants, revealing the importance of phenology to the GHG fluxes, tracing of the origin of water borne CO_2 and dissolved Inorganic carbon, and relating precipitation to the mire net ecosystem exchange. More than 8 papers have been published 2014 from the site. The personnel at the station has served these projects with routine maintenance and expert support. The station PI and personnel at Degerö ICOS site were responsible and actively involved in the 2nd annual ICOS Sweden workshop, SLU Umeå, with visits both to Degeö and Svartberget ICOS sites.

The station is run by the Swedish University of Agricultural Sciences in their role as a consortium partner of ICOS Sweden. Personnel resources correspond to 1.5 FTE involving the research engineers Jörgen Sagerfors, Tomas Hörnlund, Pernilla Löfvenius and the Station PI Mats Nilsson.

3.1.3 Svartberget combined ecosystem and atmospheric station

The Svartberget site is located in a mixed boreal pine/spruce forest within the Vindeln Research Forests which are situated in Vindeln 60 km west of Umeå in the Province of Västerbotten.

A final inspection of the instrumentation was done in April and most remaining issues were done some time afterwards, although some remaining issues were postponed until next spring. A warranty inspection of the tower construction was done in May and concluded that the tower is in good and stable conditions.

The back-up weather station (WeatherHawk) was moved from a nearby clearing to the precipitation measurement site in July. The tower was exposed to several icing events during the

winter, due to unusual mild and humid weather conditions. The effects on the heated sensors (the Metec 3D-sonic and the solarimeter) were small while the unheated sensors (such as the Gill 3D-sonic) did not function at all during those conditions. The elevator was damaged during an icing event and installation of an improved elevator system is ongoing. Lightning caused severe damages in Aug 7, where several analyzers, sensors and the server were damaged, as well as a manifold of surge protectors and fuses. Most of the soil and tree measurements, the below-canopy PAR sensors and the gas and temperature profile measurements were almost unaffected, while the flux and radiation measurements were halted several weeks. Substantial efforts have been put into replacement and repair of the lightning damages, investigation of weak points in the system and to improve the over-all lightning protection at the site. In late October, installation of a mobile flux system in the tower began as part of ICOS-INWIRE project.

A new research engineer was recruited during the spring and started in June. Two persons attended a repetition-climbing course and three persons attended the basic climbing course. ICOS-personnel attended a flux workshop in Vienna, MSA workshops, the ICOS Conference in Brussels and ICOS Sweden internal workshops during the year. The station PI and personnel at Svartberget ICOS site were responsible and actively involved in the 2nd annual ICOS Sweden workshop, SLU, Umeå with visits both to the Degerö and the Svartberget ICOS sites.The Svartberget ICOS facilities have been demonstrated several times for students, small groups or individuals that might become possible future users. More than 20 projects have been running at the Svartberget ICOS facilities under 2014. The projects address both hydrological and atmospheric questions in biogeochemistry.

Personnel resources correspond to 2 FTEs involving research engineers Holger Tülp, Pernilla Löfvenius and Tomas Hörnlund, as well as the Station PI Mikaell Ottoson Löfvenius.

3.1.4 Norunda combined ecosystem and atmospheric station

The Norunda station is located in a mixed boreal pine/spruce forest, about 30 km north of Uppsala. The station is the oldest flux site in Sweden, established in 1994, with an existing infrastructure in terms of tower, electricity, buildings etc. All the equipment, except the new data logger, was installed by In Situ in 2012.

In 2014, the installed ecosystem equipment has been in routine operation. The instruments and sensors have been checked daily by the personnel. Problematic periods with the LI-7200 gas analyser have luckily been backed up by an old system that is still running in parallel. Anemometers for wind profile measurements that were purchased with support of Lund University were all installed before the start of growing season. The preliminary results show the occurrence of low level jets at Norunda site. This might have implications on how the CO_2 flux data shall be interpreted.

The equipment for the Atmospheric station was installed in the beginning of July and is running well.

We are evaluating the stability of the system and finding out an optimal calibration procedure. Some minor improvements to the system are still needed and new calibration gases are on the way. Measurements of CO_2, CH_4, CO and H_2O are made at three levels. In moderately turbulent conditions we can calculate even fluxes of CH_4. During the forest fires in Sweden this summer we could monitor a considerable enhancement of CO concentration in the air. The system in Norunda will be a prototype for all other Atmospheric Stations in Sweden.

There have been eight ancillary projects in operation in Norunda. Two of them are mentioned here. The Norunda personnel have been conducting CH_4 flux measurements from soil with a portable chamber and a portable CH_4 gas analyser in a large number of points within the main footprint area of the tower. The data will be used to improve footprint models and to improve interpretation of existing and new CH_4/CO_2 flux data. This autumn also measurements of BVOC concentrations started at several heights in the tower. For this purpose, an equipment shed, an advanced mass spectrometer and tubing have been installed. These concentrations in combination with turbulence measurements will allow the flux of BVOCs to be estimated. Eight papers relating to the Norunda site have been published during 2014.

The station is operated by Lund University, as part of its commitments as a partner of ICOS Sweden. Personnel resources correspond to 2 FTEs involving research engineers Anders Båth and Irene Lehner, as well as the Station PI Meelis Mölder.

3.1.5 Lanna ecosystem station

Lanna is the agricultural site in ICOS Sweden and is located at the long-term research station Lanna that belongs to the Swedish University of Agricultural Sciences. The station is more than 80 years old and has a large number of ongoing agricultural field trials, both long-term and short-term, that can be utilized by visiting scientists. Cereal crops as winter wheat, spring barley and spring oats, and oil seed rape (winter or spring) are common crops in the area. The ICOS Sweden Lanna station consists of the eddy-covariance tower site as for all the other stations, and also has additional six one-hectare field plots equipped with gradient flux technique instrumentation. The main site will be operated under “conventional” farming practices and is not open for management experiments, but four of the smaller plots can be used for other management practices than the main field (different fertilizers, tillage practice etc.).

Final inspection of the ecosystem installations was made in May. Minor deviations from specifications were noted which have been corrected during the year. There were instrumentation problems at the site with the both the flux LICOR 7200 and the Aerodyne QCL which were sent in for repair, resulting in major data gaps in the flux data sets. Per Weslien went to Aerodyne Inc, Boston for training in changing and installing new lasers, which will result in much shorter stop-time in case of further laser problems. There were problems with the snow depth sensor and one of the soil thermocouples. The snow depth sensor will be sent in for repair after the winter season.

Two projects have been active in utilizing the ICOS Lanna infrastructure. The ICOS Sweden personnel attended a flux workshop in Vienna, MSA workshops, the ICOS Conference in Brussels, ICOS Sweden internal workshops and the ICOS Sweden annual workshop in Umeå/Vindeln in September. The Lanna facilities have been demonstrated several times for students, small groups or individuals that might become possible future users.

The station is operated by University of Gothenburg, a consortium partner in ICOS Sweden. Personnel resources correspond to 1.5 FTEs involving research engineers Per Weslien and Bengt Liljeblad, as well as Station PI Leif Klemedtsson.

3.1.6 Hyltemossa combined ecosystem and atmospheric station

Hyltemossa is combined ecosystem and atmospheric station located in Skåne, southern Sweden. The site is placed in a temperate, maritime climate. The ICOS activities are centered around a 150 m tall tower, located in a 30-year old managed spruce forest.

The build-up of the station was delayed until 2014, due to building permission problems, but is now coming in phase with the other stations. The tower and the laboratory building were built in the spring and the installation of electricity and most of the installations connected with the ecosystem measurements took place in June-July. The office building was finalized in October. The Hyltemossa station appeared in local and national news by SVT1 in connection to the ecosystem systems installations. The station was visited by school pupils from Lund, research groups, a PhD course from Lund University and the ICOS Sweden Board.

During the summer the tower experienced some lightning strikes which damaged the top three fans of the profile ventilation system. The fans were replaced and a surge protection was added to solve this problem for the future. A broken charger for the backup battery pack was replaced by one more resistant to weather conditions. Water started to enter into the tubin system of the profile system for CO_2 and H_2O. The cause of the problem has been identified and In Situ is preparing for a modification. Also the Rotronic was damaged because of water entering the radiation shield. The ISDL logger (flux system) caused a lot of problems resulting in large data gaps. Hyltemossa was chosen to test the final version of firmware for the ISDL logger. The number of software bugs in this final version, which have not been solved yet, have been causing further loses of data

The station is operated by Lund University, being a partner of ICOS Sweden. Personnel resources correspond to 2 FTEs involving research engineers Michal Heliasz, who is also the Station PI, and Tobias Biermann.

3.2 Development phase of the measurement stations and systems

The building up of the measurement stations and systems is about to be finalized at the end of 2014 and ICOS Sweden has, for most of the measurements systems, entered the testing phase with expectations to become fully operational during 2015. All ecosystem stations are instrumented according to the ICOS RI requirements and the systems are now fine-tuned and in operation. Delivery of data from the Norunda ecosystem station to the ETC has started and will soon be followed by delivery from all the other ecosystem stations. The chamber systems for the forest sites are however delayed due to the need for special design in Nordic climates. A workshop on chamber designs will take place in January 2015 and the production of the chambers will take place thereafter.

The atmospheric instrumentation is installed at Norunda and will be installed at the other forest sites in early 2015. The flask sampling systems and sampler for $^{14}CO_2$ are however not yet in place due to delays from the ICOS RI Central Facilities. The purchase of the spectroradiomenters is also delayed as the requirements form ICOS RI is not yet delivered. The procurement of the LIDARs (laser based distance measurements of boundary layer height) for the atmospheric sites is ongoing and the purchase and installation will be performed during early 2015. The delay is due to the need of clarification on the requirements from ICOS RI and the possibilities to enable expansion of the systems in order to suite other projects including aerosol measurements. After different options had been evaluated, ICOS Sweden decided on installing the more advanced LIDARs that are expandable.

ICOS Sweden has, concerning building up and management of the measurement stations and systems, in principle concluded the initiation phase and entered the testing and operational phases. The timing for entering the operational phase is now highly dependent on the development of ICOS RI and the Thematic Centres as we now are awaiting finalized protocols for data and metadata acquisition and for instructions and procedures to submit data operationally to the TCs.

3.2.1 Actions taken 2014

Numbers within [ ] indicate milestones, as defined in Table 1.

- The tower, the laboratory building and personnel building at the combined ecosystem and atmospheric station Hyltemossa has been built and is in use. Electricity and internet has been installed and the ecosystem systems are now running at the station. [1.2.1, 2.1.1, 1.2.3]
- ICOS Sweden has worked on the consolidation and quality control of the installed and finally inspected sensors and measurements systems at the ecosystem stations and the measurements are now running operationally at all stations. [2.1.1]
- Systems for data delivery to the Ecosystem Thematic Center has been designed but may need to be adjusted according to the final ETC protocols. Metadata for all sensors and systems has been provided to ETC. Submission of the complete ecosystem dataset from Norunda to ETC started in autumn 2014. Delivery of the ecosystem data from the other stations will start as soon as ETC is prepared for this. [2.1.1, 2.2.1]
- The instruments to be used for the high precision atmospheric concentration measurements in the high tower at Norunda have been installed and integrated with the 3-level profile and the measurements are now running. The installations of the concentration measurements at Hyltemossa and Svartberget are ongoing. The procurement of the LIDAR systems for all the atmospheric stations has been upstarted. [2.1.1]

- We have had severe problems with one of the key instruments for ecosystem flux measurements, namely the LI-7200 gas analyzer. It has been broken at all sites and at some sites even three times during about one year of operation. A report on this problem will be produced and sent to the manufacturer.
- The official protocols for ICOS RI are not yet finalized. Meanwhile, ICOS Sweden has started developing own measurement routines for all type of measurements, continuous automatic as well as manual, that are applied at all stations. As the official protocols from ICOS RI are not in place, approval by the Thematic Centers for being ICOS labelled is delayed [1.2.4, 2.3]
- The work on documenting the "ICOS domain" for all sites has continue, including the compilation of descriptions of all non-ICOS research activities that have been performed or are ongoing inside these domains. The SCG group has decided on using footprint analyses as a base for identifying the ICOS domain. Such analysis is available for Norunda and will be performed for the other sites in early 2015. [1.2.4]
- The ICOS Sweden personnel have participated in ICOS SE internal workshops, in the ICOS RI scientific conference in Brussels in September and in workshops organized by the ICOS RI Head Office and Thematic Centers. The Station PIs also participated in ICOS RI Measurement Station Assembly meetings. [3.1.3, 3.2.1]
- The personnel at the sites have provided service and support to ancillary projects at the station and to data users. [3.2.6]
- ICOS SE continued providing users with measurement data upon request. [3.2.6]

4. Building up and management of the ICOS Sweden organization

4.1 The ICOS Sweden Organization

During the last five years, the ICOS Sweden management structure has been built up and now consists of a Board and Scientific Advisory Committee, a Coordination Office and Director, the consortium partners and a Station Coordination group. Below, the different bodies and their duties are described, followed by a summarized description of the progress up to the end of 2014 and a list of actions taken during the year.

4.1.1 The ICOS Sweden Board

The ICOS Sweden Board members are Sanna Sorvari (Chair; Finnish Meteorological Institute (FMI), Marianne Lillieskold (Swedish Environmental Protection Agency), Joakim Langner (Swedish Meteorological and Hydrological Institute SMHI), Gunilla Svensson (Stockholm University) Benjamin Smith (Lund University), and Hans Winsa (Sveaskog). The Board is responsible for the overall strategic and financial monitoring and shall promote development, operation and management. The Board has also to decide 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) at the annual workshop 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 David Fowler (Center for Ecology and Hydrology, 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 Director (Anders Lindroth), two part time Scientific Coordinators (Jutta Holst (50%) and Maj-Lena Linderson (50%) and a Measurement System Coordinator (Meelis Mölder, 25%)). The Director decides on all day-to-day scientific, technical and administrative issues of the research infrastructure. The Director also serves as Sweden's national Focal Point to ICOS RI. The CO supervises the activities at the stations as well as the instruments and systems functioning. It acts as an intermediary between the Board and the rest of the organization and also assists the Board in organizing meetings, taking minutes and compiling documents for progress follow up, revisions and endorsements. The CO coordinates the renewal of applications and agreements as well as the internal communication and common outreach activities.

4.1.4 Consortium partners and Station Principal Investigators (SPIs)

A Station Principal Investigator 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 perform 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. 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. The SPIs promote outreach activities specific for their site e.g. courses and field visits. The list of SPIs includes Tomas Friborg and Patrick Crill (Abisko-Stordalen), Mats B. Nilsson (Degerö), Mikaell Ottosson Löfvenius (Svartberget), Meelis Mölder (Norunda), Leif Klemedtsson (Lanna), and Michal Heliasz (Hyltemossa).

4.1.5 Station Coordination Group (SCG)

The Station Coordination Group is made up of the Station Principal Investigators, as representatives for their respective consortium partner, and is headed by Prof. em. Sune Linder. The group coordinates the activities at the different sites and resolves various technical and practical issues and is a forum for discussions on the management and development of the research infrastructure. The SCG has regular phone/internet meetings, which are complemented by occasional site visits, when needed.

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. To start with, 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

The buildup of the ICOS Sweden organization and its functions is finished except for the full implementation of the User's Group and the continued establishment of links to the Central Facilities. The ICOS RI MSA has started and the ICOS Sweden representatives are appointed (Director and SPIs). Further development of the links to ICOS RI will take place when the ICOS RI and the ERIC (European Research Infrastructure Consortium) is in place. 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 finalizing the buildup of the measurement stations. This will be a task for the coming year.

The funding application for the next five year period that was due in spring 2014 was postponed to 2015 as the Swedish Research Council (SRC) is planning a reorganization of their infrastructure management. The application for funding will thus be submitted to SRC in spring 2015. The consortium agreement has been extended to cover 2015 and to include Uppsala University.

4.2.1 Actions taken 2014

Numbers within [] indicate milestones, as defined in Table 1.

- As the renewed application to the Swedish Research Council was postponed, the present consortium agreement (2012-2014) was prolonged for one year. [3.1.4]
- The Coordination office made continuous follow up of the planned activities during the year, and produced the annual reporting and plans. [3.1.1]
- The Coordination office worked on the Strategic plan, around the future aims and strategy of ICOS Sweden, in interaction with the SCG, the Board and the SAC. [3.1.2]
- The internal communication was continued through phone and skype information meeting including all personnel and the SCG had extra meetings focusing on the future strategy and management of ICOS Sweden. [3.2.1, 3.2.2]
- The ICOS Sweden personnel participated in ICOS SE internal workshops, in the ICOS RI scientific conference in Brussels in September and in workshops organized by the ICOS RI Head Office and Thematic Centers. The Station PIs also participated in ICOS RI Measurement Station Assembly meetings. [3.1.3, 3.2.1]
- The Coordination Office continued the work on the development and interaction with the User's Group and has started planning for its structure and the enrollment of members. [1.1.1]
- The annual ICOS Sweden workshop was organized by the Swedish University of Agricultural Sciences at Umeå. The meeting focused on interactions between water and carbon in boreal ecosystems, and included field visits to the Degerö and Svartberget measurement stations.

The Advisory Committee and Board was invited to the workshop and also had a separate meeting to discuss strategic issues. [3.1.3]

- ICOS Sweden continued the interaction and collaboration with the Arctic infrastructure network INTERACT and continued the strong Nordic collaboration on greenhouse gas studies, involving networks like NORDFROST and the Nordic DEFROST project. ICOS Sweden became member of the newly started Research Infrastructure Network for Nordic Atmospheric and Earth System Science. [3.1.5]
- Furthermore, we supported the aerosol group in their plans for moving the monitoring measurements to Hyltemossa. [3.1.5]
- We have continued to support the initiatives aimed at integrating a new European infrastructure for aerosol measurements with ICOS. [3.1.5]
- The homepage that was rebuilt and updated following the new ICOS RI layout and information was added. Posters of the infrastructure and the stations were presented at the ICOS RI scientific conference in Brussels in September. Information material was sent out in conjunction to the ICOS Sweden annual workshop. [3.1.3]
- A number of courses, field visits and seminars has been held at the stations (see also Key numbers, chapter 6). [3.1.3]
- The planned setting up of a strategy for community building and investigation funding and collaboration opportunities mentioned in the operational plan for 2014 has mainly been discussed in connection to the revision of the strategy so far. [3.1.3]

5. Comments on economy and the deviation from the budget for 2014

A summary of the financial outcomes for 2014 for all sites and the common equipment investments is 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 accumulated assets correspond to the accumulated amount available since 2010 following the contributions by SRC and the partners in the consortium agreement.

The preliminary outcome for 2014 follows well the budgets for each partner except for the less than expected infrastructure investments. This is because the purchase of some of the instruments has been postponed to 2015. These postponed purchases are also the reason for the large total accumulated asset of ICOS Sweden. The transfer of the SRC funding from Lund University to the Polar Research Secretariat is reduced to zero for 2014. As the Secretariat is prohibited to invest in expensive instrumentation, the laser analyzer for the station will be bought from Lund University through the Common equipment account.

The partner Stockholm University (SU) did not yet contribute according to the specified annual contribution in the consortium agreement (300 kSEK each year 2011-2014) which explains the outcome for SU. The question on how the contribution can be used for a station run by another partner (Abisko-Stordalen) must be solved first. In 2015, SU will contribute fully according to the consortium agreement.

Table 2. *Financial outcomes 2014 for each partner and in total (kSEK). For acronyms, see Appendix 4.*

	LU	GU	SLU	PFS	SU	Common equipment	Total
Incomes							
Incomes SRC	6,853	1,079	2,568	0		7,000	**17,500**
Co-financing	3,000	1,051	1,400	480			**5,931**
Sum	9,853	2,130	3,968	480	0	7,000	**23,431**
Expences							
Salaries	3,704	963	2,001	1,000			**7,668**
Consumables	948	398	599	159			**2,104**
Travel	346	65	184	20			**615**
Infrastructure	10,319	148	403	69		1,188	**12.127**
OH	1,512	596	965	417		0	**3,491**
Sum	16,828	2,172	4,152	1,665	0	1,188	**26,005**
Total outcomes 2013	-6,975	-42	-184	-1,185	0	5,812	**-2,574**
Accumulated assets	**3,588**	**1,105**	**2,463**	**986**	**0**	**10,847**	**18,989**

6. Key numbers

ICOS Sweden has identified a list of key numbers that should be reported annually and used to evaluate the performance and usefulness of the infrastructure, see Table 3 next page. The key numbers are explained in the Table or described in the following text. Targets for the key numbers have not yet been established. For key number 1 and 2, the targets will be set once the ICOS RI requirements are ready. For the other key numbers, the goals will be developed during 2015.

Table 3. *Key numbers for evaluation of the ICOS Sweden infrastructure.*

Key No	Performance	Key number description
1.	86	Percentage of uptime of measurements for key variables such as fluxes and concentrations flagged with the highest quality.
2.	96	Percentage of uptime of backup meteorological variables to be used for gap filling.
3.	36	Number of national research projects at the different sites.
4.	15	Number of international research projects (projects with a foreign PI) at the different sites.
5.	Not compiled	Volume (amount of funding) of research projects.
6.	6	Number of users of ICOS Sweden data.
7.	Not applicable	Volume of data retrieval of ICOS data products (provided by ICOS Carbon Portal) from ICOS Sweden sites.
8.	22	Number of peer review publications (in preparation and/or published) where data from ICOS Sweden sites are used.
9.	Not applicable	Number of citations for all peer review publications where data from ICOS Sweden sites are used.
10.	Not applicable	Number of other scientific publications where data from ICOS Sweden are used.
11.	0	Number of popular science publications related to ICOS Sweden.
12.	2	Number of appearances in public media.
13.	3 /108	Number of undergraduate courses and number of participants.
14.	5 / 70	Number of graduate courses and number of participants.
15.	18	Number of course days at the different sites.
16.	1	Number of undergraduate theses using data or sites.
17.	5	Number of graduate theses using data or sites.
18.	7	Number of meetings/conferences/workshops organized by ICOS Sweden.
19.	See text	No of stakeholders.
20.	See text	Impact on society and industry.

Number of non-scientific visitors to the sites: 19

Key number 1 and 2, the percentages of uptime of measurements of key variables and backup meteorological variables are important measures connected to data accessibility and each key variable should be presented separately. These are illustrated in Figure 3. So far, only the ecosystem measurements are included as key variable (the eddy covariance flux measurements) as the atmospheric station installations are not yet operational.

Key number 7, volume of data retrieval of ICOS RI data products (provided by ICOS Carbon Portal) from ICOS Sweden sites, is not applicable this year as the Carbon Portal has not yet started delivering data.

Key number 18 will be an indicator of how well ICOS Sweden can interact with the wider scientific and stakeholder communities.

Key numbers 19 and 20 relates to the required reporting in the SRC agreement: "Infrastructure importance for direct societal interests" and "Infrastructure importance for trade and industry and commercial use". As ICOS Sweden has not fully entered the operational phase, this can only be described in general terms, without specification of actual number of users outside the scientific community. More information about potential impact on society and industry can be found in the strategic plan.

Other issues required in the annual reporting according to the agreement with SRC that not included here: number of patents and scientific breakthroughs as they are not applicable for the infrastructure.

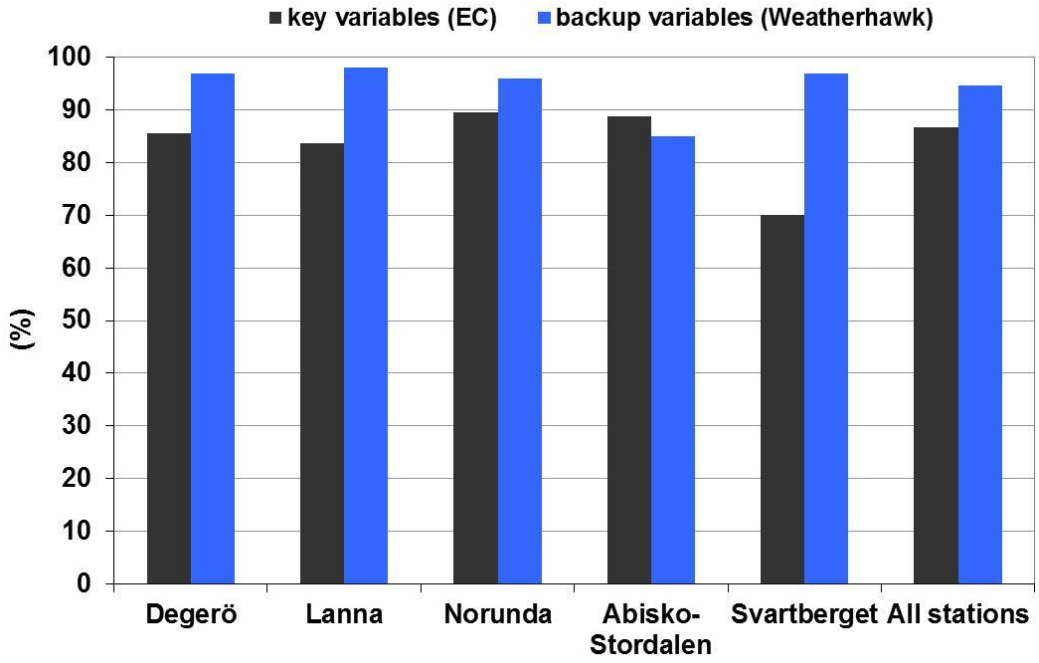


Figure 3. *Bar plot showing the percentage of days with high data quality for key variables and backup meteorological variables for the ecosystem stations.*

The mast at Svartberget was hit by severe lightning during the summer which lead to server and instrument damages and data loss. This in combination with subsequent problems with the LICOR 7200 is the reason for the large number of days with missing data (Fig. 3). The backup station was expected to be stable and capture most of the days but as can be seen in the figure, there are a number of missing days, especially at Abisko-Stordalen. The system has not been working as expected and is under evaluation. The Hyltemossa measurement station has been in a startup phase during the year and is thus not included in the uptime statistics.

Appendices

Appendix 1: List of personnel during 2014

Total amount of FTEs: 12.1

Coordination Office:

Anders Lindroth, director, 50%
Maj-Lena Linderson, scientific coordinator, 50%
Jutta Holst, scientific coordinator, 50%
Margareta Hellström, scientific coordinator, 40%
Meelis Mölder, measurement system coordinator 25%

Measurement stations:

Abisko-Stordalen:

Robert Holden, research engineer, 100%
Niklas Rakos, research engineer, 50%
Thomas Friborg, station PI, 20%
Patrick Crill, station PI, 0%

Degerö and Svartberget:

Jörgen Sagerfors, research engineer, 80%
Holger Tülp, research engineer, 100%
Pernilla Löfvenius, research engineer, 40%
Tomas Hörnlund, research engineer, 20%
Mikaell Ottosson Löfvenius, station PI, 50 %
Mats Nilsson, station PI, 20%

Norunda:

Irene Lehner, research engineer, 100%
Anders Båth, research engineer, 75%
Meelis Mölder, station PI, 25%

Lanna:

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

Hyltemossa:

Tobias Biermann, research engineer, 100%
Michal Heliasz, station PI, research engineer, 100%

Appendix 2: List of measured variables and instruments/systems

Ecosystem stations

Continuous measurements		Forest	Wetland	Agriculture
Mass fluxes [mol $m^{-2} s^{-1}$]	CO_2	1	1	1
	H_2O	1	1	1
	N_2O	-	-;1	1
	CH_4	-	1	-
Momentum flux [$m^2 s^{-2}$]	τ	min 5	1	1
Energy fluxes [Wm^{-2}]	Sensible heat	1	1	1
	Latent heat	1	1	1
	Incoming short-wave	1	1	1
	Outgoing short-wave	1	1	1
	Incoming long-wave	1	1	1
	Outgoing long-wave	1	1	1
	Incoming PAR	1	1	1
	Outgoing PAR	1	1	1
	Diffuse PAR	1	1	1
	PAR below canopy	15	-	-
	Spectral reflectance	1	1	1
Soil fluxes	Soil heat flux	2	2	2
State variables	Soil CO_2 efflux	6	-	-
	Air temp profile [K]	15	5	5
	H_2O profile [mol H_2O mol^{-1}]	15	5	5
	CO_2 profile [mol CO_2 mol^{-1}]	15	5	5
	CH_4 profile [mol CH_4 mol^{-1}]	-	5	-
	Relative humidity [%]	1	1	1
	Dew point temp [K]	1	1	1
	Wind speed [m s^{-1}]	5	1	1
	Wind direction [°]	5	1	1
	Turbulent statistics	5	1	1
	Soil temp profile [K]	4x5	4x5	4x5
	Soil moisture profile [Θ]	4x5	4x5	4x5
	Ground water level [m]	1	1	1
	Ground height [m]	-	1	-
	Snow depth [m]	1	1	1
	Precipitation [mm s^{-1}]	1	1	1
	Tree trunk surface temp [K]	12	-	-
	Tree diameter [m]	6	-	-
	Canopy temp [K]	1	1	1

Appendix 2, continued: List of measured variables and instruments/systems

Ecosystem stations, continued

Periodic measurements		Forest	Wetland	Agriculture
	Leaf area index	1	-	1
	Above ground biomass	1	1	1
	Soil carbon content	1	1	1
	Litter fall	1	-	-
	Leaf N concentration	1	1	1
	Soil N concentration	1	1	1
	Soil water N conc.	-	-	1
	Soil water DOC	1	1	1
	C/N export/import	1	1	1

Atmospheric stations

Continuous measurements		Svartberget	Norunda	Hyltemossa
State variables	CO_2, CH_4, H_2O, CO	3	3	3
	SF_6, N_2O, O_2, N_2, C-14, Rn-222 + other isotopes	1	1	1
	PBL height	1	1	1
Periodic measurements				
	Flask sampling			

Appendix 3: List of abbreviations and acronyms

ICOS RI (European level)

ATC – Atmospheric Thematic Center
CAL – Central Analytical Laboratory
CP – Carbon Portal
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
OTC – Oceanic Thematic Center

ICOS Sweden

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

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)

Other

SMHI –Swedish Meteorological and Hydrological Institute
SRC –Swedish Research Council (in Swedish VR – Vetenskapsrådet)