ICOS SWEDEN - user statistics 2024

ICOS National Network Sweden

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

Key numbers for the annual reporting of the infrastructure activities

"Special conditions for contributions to the national infrastructure - ICOS Sweden", The Swedish Research Council's (SRC's) Director General, April 06, 2020.

The Integrated Carbon Observation System Sweden, ICOS Sweden[1] is a part of the pan-European distributed research infrastructure ICOS[2] that promotes fundamental understanding of carbon cycle, greenhouse gas (GHG) budgets and perturbations and their underlying processes by providing consistent and persistent measurement data from *in situ* networks. The overall aim of ICOS Sweden is to produce harmonized, high-quality data on GHG exchanges, atmospheric GHG concentrations and their defining state variables within typical Swedish ecosystems (both terrestrial and marine) and regions. These activities are critical to enable quantification of the Swedish GHG balance and the feed backs of these ecosystems to a changing climate. Swedish ICOS stations contribute data that are critical for a continental scale understanding of the GHG balance of Europe.

ICOS Sweden and its data products is an infrastructure which is open to everyone. As research infrastructure, it is meant to be used by scientists to address different research questions. By organizing open door events or preparing easy to understand teaching material, it can even reach out to the general public to arouse interest and enlarge knowledge on ecosystem related climate issues. Elaborated products will be available for all the interested social stakeholders such as citizens, decision makers and media.

Scientific users of the infrastructure are researchers using the data produced by the measurement stations to address their research question. More than 23700 datasets of near real time (level 1), final quality-controlled data sets (level 2), or elaborated products (level 3) have been downloaded via the Carbon Portal.

Scientific users of the ICOS Sweden infrastructure are also researchers coming to the stations for field experiments to answer their specific research question. During 2024, 92 unique research projects were active at the ICOS Sweden stations, many of them using several stations for their studies.

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

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

[1] www.icos-sweden.se
[2] www.icos-ri.eu

Users taking advantage of the physical access to the measurement stations benefit from station infrastructure, including laboratory space, technical support, power supply, internet and other services, and high-quality auxiliary data provided by ICOS Sweden. These users perform on site research consisting of measurement programs that are in addition to the ongoing ICOS measurement program. They, in turn, benefit directly from the context of the long term ICOS measurements. The users use and process ICOS data while integrating it into their own scientific research topics. They publish scientific papers in high-impact journals, make presentations at international workshops and conferences, and develop novel measurement methods that may become operational within ICOS in future.

Table 1 comprises the summary of the key numbers since the start of the 2nd ICOS Sweden funding period 2016. The results are analyzed in more detail below. ICOS Sweden defined targets for the keynumbers in its most recent Strategic Plan. These are included in the last row of Table 1. The number of peer-reviewed publications increased and is now closer to the target than in 2022. Data usage by users from Sweden increased above the target number.

*Table 1. Summary of the key numbers for the annual reporting of the infrastructure activities. Data downloads include all levels of data products (Level 0: raw data to level 3: elaborated products without excluding whitelisted IP addresses).*courses visiting the sites are no longer counted as site days*

year	**general key numbers**	**Project Pis**		**Number of site days**	**Data repository downloads**	
	number of peer-reviewed publications	Inter-national	national	national	international	national
2016	44	17	52	-	--	--
2017	64	15	39	-	2	752
2018	60	28	26	-	3728	1397
2019	26	16	82	-	10483	2776
2020	87	13	76	-	50467	2296
2021	71	24	75	7928	44978	2111
2022	55	18	63	14819	52026	1752
2023	63	21	89	11264	45051	2822
2024	64	29	60	8310*	56026	3561
target	>60	>15	>50	>5000	>40000	>2000

Physical Users of the infrastructure

The motivation for users that come in person to the ICOS Sweden RI facilities is broad. ICOS Sweden facilities are used for education at university level during excursions and field courses. National and international scientists use ICOS Sweden stations for their own research project related field work. Table 2 includes the updated numbers for each group of physical users. The number of visitors/users from the general public have not been registered for 2024. However, there were several events targeted to the general public, e.g. open doors at Hyltemossa Research station at the Worlds Environmental Day and in connection to the district championship in orienteering. Several activities

were targeted to schools, e.g. SciFest Science Festival in Uppsala, launch of the webside "ICOS resurs för skolor" as result of the ICOS-MINT project, presentation at information days of the partner universities. Furthermore, pupils get the possibility to spend a day at selected ICOS stations as part of their intership.

Table 2. User numbers for project PIs, Scientific visitors (site visitors through field courses and excursions) and General public visitors (general public and school children). *excursions during conferences no longer counted as scientific visitors; +courses no longer counted as projects

year	Project PIs		Scientific visitors		General public visitors
	male	female	male	female	not divided by gender
2016	50	19	355	277	245
2017	40	14	166	227	21
2018	42	12	72	67	32
2019	63	25	163	94	14
2020	49	35	129	64	10
2021	40	30	134	92	10
2022	68	35	407	208	128
2023	78	38	323	245	n/a
2024	59+	33+	229*	144*	n/a

The number of projects making physical use of the stations decreased again compared to the previous year. Research projects purely using data are not part of this statistic; even if researchers are asked to inform the station PIs about the usage of data the number is highly unsure due to the open data policy following. Unlike previous years, half of the projects at the sites were related to the respective host of the station used for the research, whereas the other half were related to PIs from other research institutions (Fig. 1a). Other Swedish Universities which are not part of the ICOS consortium still represent only a small share of the projects as PIs. However, they are involved as project partners (Fig. 1b). The station Abisko-Stordalen in particular stands out due to its high proportion of international projects (22 out of 25 total registered projects).

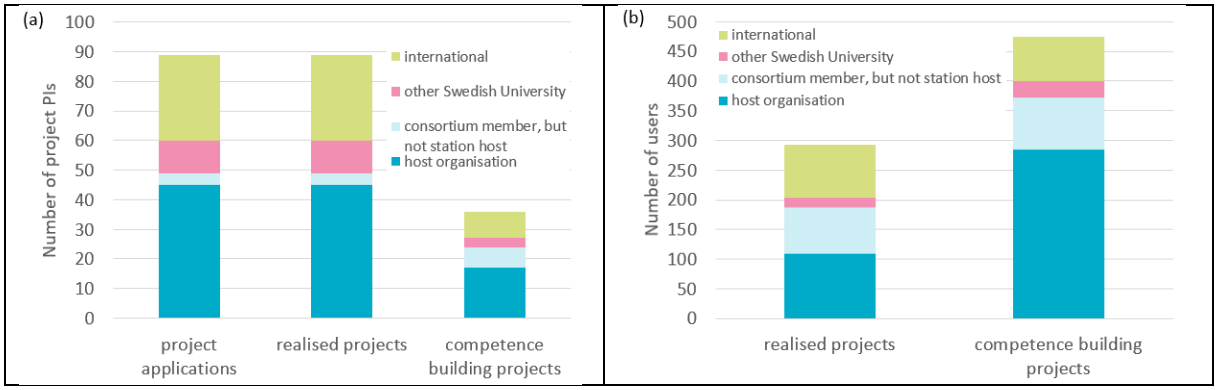

Fig. 1: Number of (a) academic projects and (b) academic users in 2024 divided into their respective academic residence. Host organisations refers to the host of the respective station.

Users of the data produced by the infrastructure

No personal data is gathered from users downloading data via the Carbon Portal, however, the country of origin is derived from the users IP number (Fig 2). As before, no statistics on gender distribution was

evaluated for 2024. Data produced at ICOS Sweden facilities is of interest for scientists nationally and internationally. During 2024, the number of data downloads from the ICOS Carbon portal, where all data are available under a Creative Commons Attribution 4.0 International License was 60294 (data level 1 to 3, whitelisted IP addresses excluded) which is a distinct increase compared to the download numbers from previous years which is mainly caused by a strong increase in data downloads from the Ecosystem stations (Table 3).

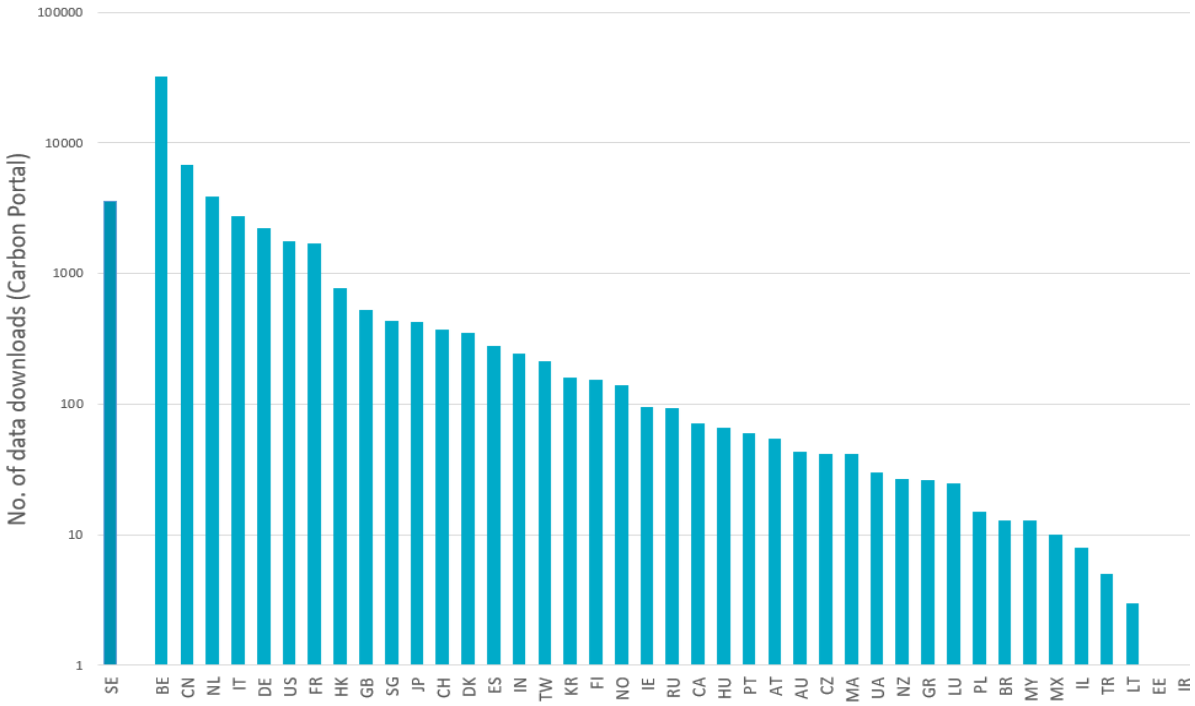

Fig. 2: Origin of international data users of the ICOS Sweden data products in 2024 (level 0 to 3); data downloads from the ICOS Carbon Portal (white listed IPs included due to technical reasons).

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

station/ year	Ecosystem Stations						Atmosphere Stations			Total
	SE-Sto	SE-Svb	SE-Deg	SE-Nor	SE-Lnn	SE-Htm	SVB	NOR	HTM	
2018	0	1046	25	590	124	1012	153	185	218	3 323
2019	5	2337	133	1381	451	1775	1294	1280	1901	10 557
2020	15	1071	378	613	289	838	1622	1618	1811	8 255
2021	249	899	378	580	167	657	2877	2902	3086	11 795
2022	538	1212	629	791	280	1023	4084	3792	3983	16 332
2023	470	876	679	626	137	695	7953	7833	8005	27 274
2024	1581	1831	1554	1631	191	1731	4656	5496	5075	23 746

The data flow from the stations through the ICOS Atmosphere Thematic Centre to the Carbon Portal been fully established. The data flow from the stations to the Ecosystem Thematic Centre has been fully established for all Ecosystem stations. Data requests directly to ICOS Sweden were often connected with detailed questions on how to use the data or where to find specific data products. Data downloads are more or less equally distributed among the Ecosystem stations and among the Atmosphere stations (Table 3). In general, data downloads from the Atmosphere Stations are higher

than from the Ecosystem stations. This can be explained by the structure of the data products (single variables in Atmosphere station data vs. collection of parameters in Ecosystem station data). Also, the user behaviour is different for the different communities: whereas the Atmosphere station community often accesses the data by demand during model runs which results in multiple downloads for multiple model runs, the typical Ecosystem station data user downloads a dataset and works offline with the data (single data download).

Publication and Citation statistics for peer-reviewed publications related ICOS Sweden stations

The full list of peer-reviewed scientific publications published in 2024 that the ICOS Sweden infrastructure has contributed to through data measured at the stations or support of field research at the stations is included in Appendix A and available on http://www.icos-sweden.se/publications. Google scholar was used to compile the citations related to publications over the last five years. Theses we are aware of on graduate and undergraduate level using data from ICOS Sweden stations are listed in Appendix B.

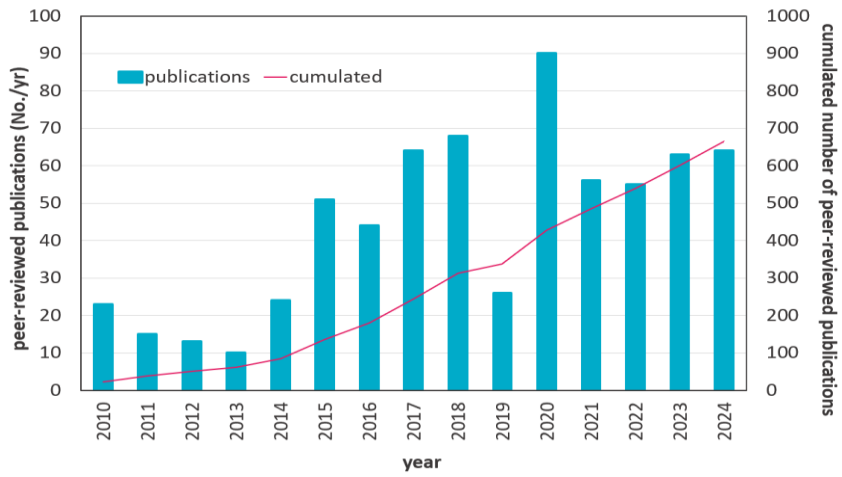

Fig. 3. Number of publications and citation statistics (google citations, 2025-02-14) of publications related to ICOS Sweden stations and ICOS Sweden activities. The full publication list of included papers is available on www.icos-sweden.se.

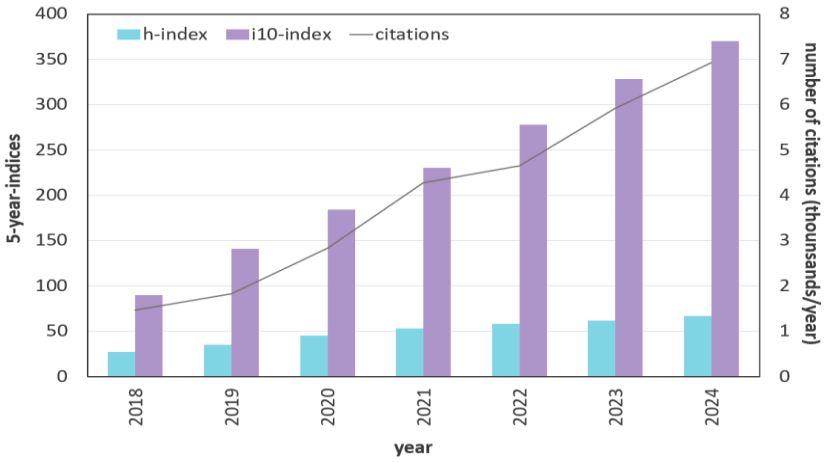

Fig. 4. Time series of citation indices (google citations, 2025-02-14) and number of citations per year derived from publications related to ICOS Sweden stations and ICOS Sweden activities.

Appendix A: List of peer-reviewed publications

Anav, A., Sorrentino, B., Collalti, A., Paoletti, E., Sicard, P., Coulibaly, F., ... & De Marco, A. (2024). Meteorological, chemical and biological evaluation of the coupled chemistry-climate WRF-Chem model from regional to urban scale. An impact-oriented application for human health. Environmental Research, 119401. doi:10.1016/j.envres.2024.119401

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Barczok, M., Smith, C., Kinsman-Costello, L., Patzner, M., Bryce, C., Kappler, A., ... & Herndon, E. (2024). Iron transformation mediates phosphate retention across a permafrost thaw gradient. Communications Earth & Environment, 5(1), 635. doi:10.1038/s43247-024-01810-z

Barrios, J.M., Arboleda, A., Dutra, E., Trigo, I., Gellens-Meulenberghs, F. 2024. Evapotranspiration and surface energy fluxes across Europe, Africa and Eastern South America throughout the operational life of the Meteosat second generation satellite. Geoscience Data Journal doi:10.1002/gdj3.235

Bayat, B., Raj, R., Graf, A., Vereecken, H. & Montzka, C. 2024. Comprehensive accuracy assessment of long-term geostationary SEVIRI-MSG evapotranspiration estimates across Europe. Remote Sensing of Environment 301, 113875. doi:10.1016/j.rse.2023.113875

Bolek, A., Heimann, M., and Göckede, M. 2024. UAV-based in situ measurements of CO2 and CH4 fluxes over complex natural ecosystems, Atmos. Meas. Tech., 17, 5619–5636, doi:10.5194/amt-17-5619-2024

Chauhan, A., Patzner, M.S., Bhattacharyya, A., Borch, T.,Fischer, S., Obst, M., ThomasArrigo, L.K., Kretzschmar, R., Mansor, M., Bryce, C., Kappler, A. & Joshi, P. 2024. Interactions between iron and carbon in permafrost thaw ponds. Science of The Total Environment, 946, 174321. doi:10.1016/j.scitotenv.2024.174321

Deng, Z., Ciais, P., Hu, L., Martinez, A., Saunois, M., Thompson, R. L., ... & Chevallier, F. (2024). Global greenhouse gas reconciliation 2022. Earth System Science Data Discussions, 2024, 1-47. doi:10.5194/essd-2024-103 [***revised version accepted***]

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Forsmark, B., Bizjak, T., Nordin, A., Rosenstock, N. P., Wallander, H., & Gundale, M. J. 2024. Shifts in microbial community composition and metabolism correspond with rapid soil carbon accumulation in response to 20 years of simulated nitrogen deposition. Science of the Total Environment, 918, 170741. doi:10.1016/j.scitotenv.2024.170741

Freire-Zapata, V., Holland-Moritz, H., Cronin, D. R., Aroney, S., Smith, D. A., Wilson, R. M., ... & Tfaily, M. M. (2024). Microbiome–metabolite linkages drive greenhouse gas dynamics over a permafrost thaw gradient. Nature Microbiology, 9(11), 2892-2908. doi:10.1038/s41564-024-01800-z

Guo, Z., Martínez-García, E., Chi, J., Nilsson, M. B., Jia, X., & Peichl, M. 2024. Divergent apparent temperature sensitivity of forest-floor respiration across a managed boreal forest landscape. Science of the Total Environment, 955, 176950. doi:10.1016/j.scitotenv.2024.176950

Holmgaard, S. B., & Burlingame, K. (2024). Monitoring materialities: Anthropocene landscapes of environing technologies in the High North. Landscape Research, 1-17. doi:10.1080/01426397.2024.2416409

Islam, M.R., A.M. Jönsson, J. Bergkvist, F. Lagergren, M. Lindeskog, M. Mölder, M. Scholze, N. Kljun, 2024: Projected effects of climate change and forest management on carbon fluxes and biomass of a boreal forest. Agricultural and Forest Meteorology, 349}, 109959. doi:10.1016/j.agrformet.2024.109959

Jaakkola, E., Hellén, H., Olin, S., Pleijel, H., Tykkä, T., & Holst, T. (2024). Ozone stress response of leaf BVOC emission and photosynthesis in mountain birch (Betula ***pubescens spp. czerepanovii***) depends on leaf age. Plant-Environment Interactions, 5(1), e10134. doi:10.1002/pei3.10134

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McGivern, B. B., Cronin, D. R., Ellenbogen, J. B., Borton, M. A., Knutson, E. L., Freire-Zapata, V., ... & Wrighton, K. C. (2024). Microbial polyphenol metabolism is part of the thawing permafrost carbon cycle. Nat. Microbiol. 9, 1454-1466. doi:10.1038/s41564-024-01691-0

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Appendix B: List of published theses

PhD Theses

Jaakkola, E. (2024). Stress-induced BVOC emissions from forests in Sweden. Lunds Universitet/Lunds Tekniska Högskola. *phd thesis*

Karimi, S. (2024). Peatland hydrology in boreal Sweden: Modelling, long-term data analysis, and experimental rewetting. Acta Universitatis Agriculturae Sueciae, (2024: 28). *phd thesis*

Zhu, X. (2024). Mechanisms behind aquatic browning in boreal catchments. Publications of the University of Eastern Finland/FI. Dissertations in Science, Forestry and Technology, 41. phd thesis

MSc theses

Arnsteg, A. (2024). Long term ecosystem fluxes of BVOCs over a Norway spruce (Picea abies) forest in southern Sweden. Lund University, Department of Physical Geography and Ecosystem Science.

Kandrotaité, K. (2924). Submicrometer aerosol particles dynamics in ambient air. Vilnius University/Lithuania

Karisma, K. (2024). A Machine Learning Approach for Estimating Gross Primary Productivity Using Sentinel-2 Data. University of Twente/NL

Kuru, S. (2024). Evaluating the accuracy of NEWA, ERA5 and NORA3 in predicting onshore wind conditions: a comparative study using ICOS meteorological mast data in Sweden. Uppsala University Department of Earth Sciences, Campus Gotland.

Pardo, J. (2024). Investigating the Relationship Between Sediment Methane Production and Ebullition in Sub-Arctic Lakes. University of New Hampshire/US

BSc theses

Arasaki, K. (2024). Validation of low-cost sensors in field tests at Hyltemossa research station. Lunds Tekniska Högskola.

Nagatomi, H. (2024). Is dust an important source of aerosol particles in northern Europe? Lunds Tekniska Högskola.

Noack, N. (2024). Applying BROOK90 to model the Water Balance of the spruce forest in Hyltemossa, Sweden. Lund University, Department of Physical Geography and Ecosystem Science.

Sarno, F. (2024). Long-Term Particulate Matter Measurements in Southern Sweden. Lund University, Department of Physics.

Weibull, M. (2024). Dendrometer analysis of tree water dynamics and radial stem growth of Norway spruce in Hyltemossa. Lund University, Department of Physical Geography and Ecosystem Science.

Wulff, E. (2024). Kvicksilver I ett svenskt landskap. SLU Uppsala, Dept. of Aquatic Sciences and Assessment.

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