ICOS Integrated Carbon Observation System

2025

ICOS Annual Report 2024

For approval

21-22 May 2025
ICOS/GA24/14

Summary

This document contains the annual report of the entire RI: ICOS ERIC consisting of the Head Office and Carbon Portal, as well as all Central Facilities and national networks. In annexes, we have included input material for KPIs, the report of Co-operation between ICOS and ACTRIS Head Offices as well as a list of all ICOS stations and their co-location with other RIs.

All KPIs, totals and tables are missing contribution from Greece which did not arrive by deadline.

Contents

2024 Highlights of ICOS Research Infrastructure

ICOS Science Conference 2024

Conference in Versailles and online received record high number of abstracts (462).

Atmosphere FastTrack and European ObsPack data releases

ICOS Atmosphere released in October 2024 its first FastTrack 2024.3 release for CO2, CH4, N2O and CO. This is an important step in operationally producing high-quality greenhouse gas data at a higher frequency than the current annual final quality-controlled releases (level 2) around mid-summer. The ICOS Carbon Portal also produced updated European Obspack products for the ICOS stations that combines historical data (going back to as far as 1972), ICOS Level 2, ICOS FastTrack and ICOS near-real-time data for all the gases.

Third issue of European Greenhouse Gas Bulletin FLUXES

FLUXES, the European Greenhouse Gas Bulletin is an annual publication by ICOS, which aims at highlighting climate issues to an audience of policymakers, policy advisors, and climate journalists.

The third volume of FLUXES which was published just before SBSTA meeting, focused on Monitoring, Reporting and Verification (MRV) systems.

Ten new stations joined the network

In beginning of 2024, ICOS gained 10 new stations in the network. Among them are the northernmost crop site in the network in Maaninka, Finland, an experimental carbon farming station in Westmalle, Belgium, and the first station in the ICOS network that measures greenhouse gases in all three ICOS domains, Lampedusa Italy.

KPI summary

An updated list of KPIs is discussed in May GA meeting. Infographic below shows a summary of such KPIs which are suitable for following progress every year.

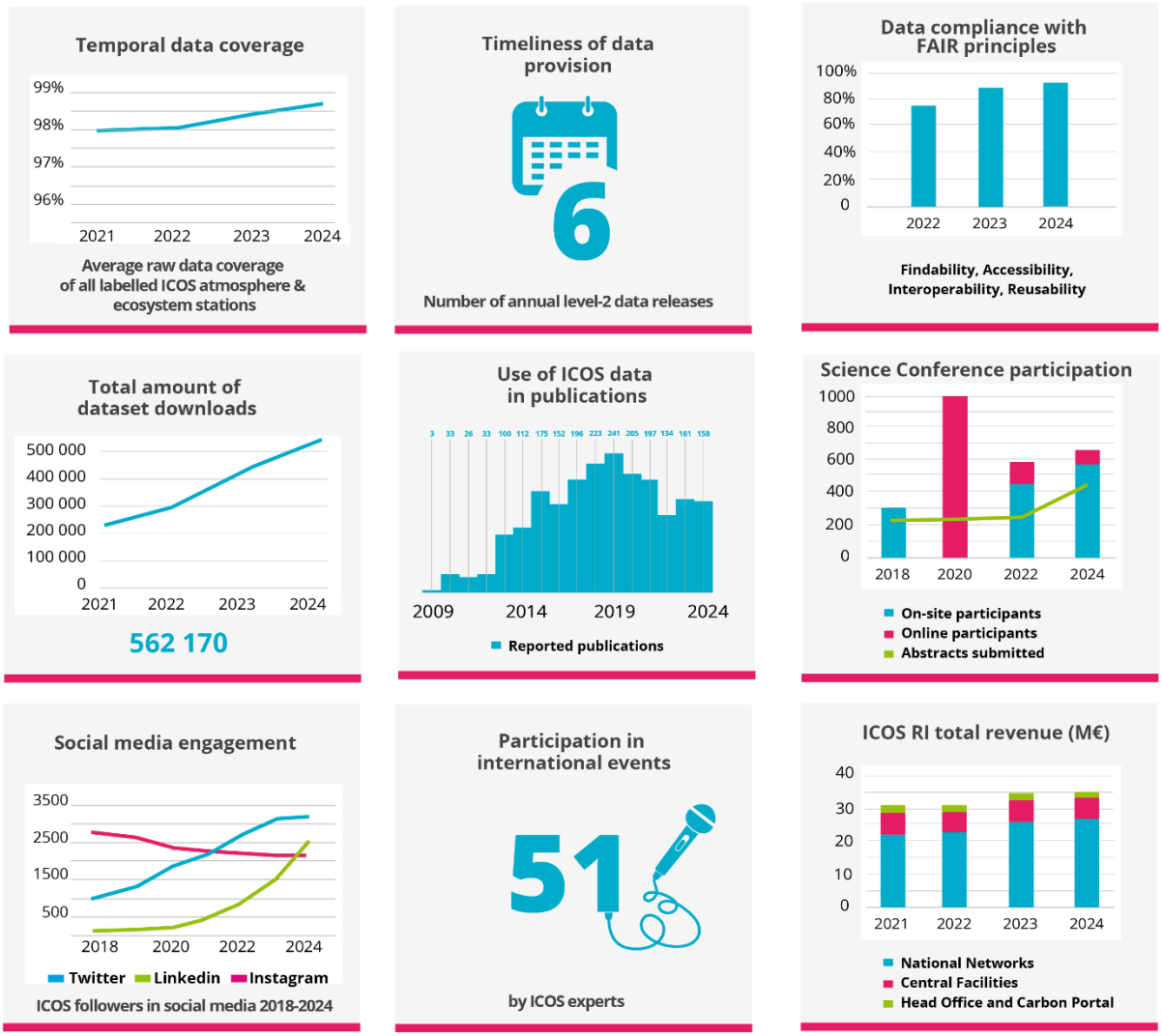


Figure 1 The essential ICOS Key Performance Indicators

Co-operation with other infrastructures

The most important co-operation between infrastructure happens on station level. Having stations of two different networks at same location or near to each other can lead to significant savings in electricity and data connections and especially in travel arrangements of maintenance technicians and other staff. However, there are risks of having certain types of instruments too close to each other, e.g. the radiocarbon analysis at ICOS Class 1 Atmosphere stations can be disturbed by certain types of ACTRIS instrumentation. The co-located stations are listed in Annex 2.

A working group between the ICOS and ACTRIS Head Office teams and has been tasked by Academy of Finland to annually report co-operation. Their report is in Annex 3.

Director General and Head Office

Progress in the regular tasks

General Assembly coordination

Coming back to normal rhythm, ICOS had two General Assembly meetings in 2024. November meeting was held in Budapest, Hungary, and an Info Day in Debrecen was preceding it. The topic of the Info Day was "Foresight Day" and coordinated by the Science Integration Officer working groups of members of wider ICOS Community. The May meeting was held online.

RI Committee management

The RI Committee, formed by representatives from the Head Office, Carbon Portal, Central Facilities and Monitoring Station Assemblies, had a-three-day face to face meeting in Venice, and a set of longer online meeting in in October. The RICOM also had monthly online-meetings. In addition to normal topics like GA paper preparation, the RICOM discussed extensively the Risk plan and its relationship to KPIs.

Support for Scientific and Ethical Advisory Boards

The Scientific Advisory Board meeting with RICOM in November was held online and split over two days to accommodate all the various time zones from Finland to West coast USA. An important topic was the Foresight Day themes.

The Ethical Advisory Board has not had any emerging issues to solve during 2024. Members for new term were selected, and the new board is starting in 2025.

Financial management of ICOS ERIC

The Annual Contributions of the member countries were paid before the Autumn General Assembly meeting. Participation and coordination of Horizon Europe projects added the load in administration. Accounts were audited before May meeting.

The Financial Committee continues to collaborate with the Head Office on the financial management of ICOS ERIC, serving as an advisory and strategic working group that reports directly to the General Assembly. In 2024, the committee convened for two virtual meetings. The Financial Committee currently has four members. At the end of the year, one member stepped down and was subsequently replaced by a new member.

Instrument register

No new instruments were bought 2024. ICOS ERIC still owns a PICARRO (in use onboard Tavastland, operated by IOW) and a MIRO (in use in ICOS Cities project).

Human resources management for ICOS ERIC

A Workplace Survey was conducted in the autumn of 2024. The Head Office continues to implement improvements, and to organise trainings based on the feedback received. For instance, a Diversity, Equity, and Inclusion training and workshops were held for all employees in the first quarter of 2024. Additionally, the Head Office personnel attended AI workshops organised by ACTRIS ERIC in the last quarter of 2024.

ICOS ERIC Salary and Career Paths policy continues to guide career path progression and salary increases. Development of an International Remote Work Policy to clearly define guidelines and procedures was initiated in 2024 and is to be concluded at the start of 2025.

Early in the year 2024, the tasks of Unit Administration were reorganised internally. The HO recruited a Financial Assistant (Leysan Karimova) in March 2024 and a Service Designer (Mariana Salgado) in April 2024, to work in EU-projects. Another new recruit, Digital Communications Specialist (Annina Bergman), joined ICOS in January, but left ICOS due to family reasons in October 2024. Additionally, ICOS ERIC employed two summer trainees to assist with the Science Conference for period of four months May-September 2024. The total number of staff consistently averages around 20 on an annual basis.

The following personnel were employed by ICOS ERIC during the year 2024.

- Director General (Werner Kutsch)
- Director of Carbon Portal (Alex Vermeulen), leading the Carbon Portal at Lund University. Deputy of the Director General during unforeseen absences.
- Head of Unit 'Operations' (Elena Saltikoff), coordination and development of the operations of the whole ICOS research infrastructure.
- Head of Unit 'Strategy & International Cooperation' (Emmanuel Salmon), coordination and development of the strategic and international cooperation of whole ICOS RI.
- Head of Unit 'Communications' (Katri Ahlgren) Responsibility for ICOS RI communication and outreach strategy, activities and ICOS brand and visual outlook.
- Science Integration Officer (Sindu Parampil), facilitation of the initiatives of the ICOS academic community, contributing to projects and proposals, supporting the work of the ICOS Scientific Advisory Board.
- Operations Officer (Evi-Carita Riikonen), supporting the coordination of the operations, especially the RI Committee work, supporting the planning and reporting of the RI activities, operational development tasks and project management and impact analysis tasks.
- Science Officer (Janne-Markus Rintala), ICOS Science conference, contributing to projects and proposals especially related to ocean observations' technological and scientific research & development
- HR & Administration Officer (Inka Hellä), Human Resources and general administration and providing personal assistant duties for Director General.
- Senior Officer, Data Analyst, (Ville Kasurinen), HO contact for elaborated data products development, contributing to projects and proposals (ICOS Cities, KADI)

- Observation Network Officer (Maiju Tiiri), support with the coordination of the station network, ICOS Science Conference.
- Project Officer (Liisa Ikonen) contributes to participating and preparing for externally funded projects (ICOS Cities), and ICOS stakeholder analysis.
- Communications Officer (Charlotta Henry), tasks and responsibilities related ICOS RI internal as well as to ICOS RI external communications, and selected EU projects ICOS participates in (such as ICOS Cities).
- Communications Officer (Maria Luhtaniemi), communications tasks and responsibilities related ICOS RI internal as well as to ICOS RI external communications and to selected EU projects ICOS participates in (such as GEORGE and RItrainPlus).
- Communications Officer, (Karlina Ozolina), tasks and responsibilities related ICOS RI internal as well as to external communications and selected EU projects ICOS participated in (such as ENVRI-HUB-NEXT and KADI).
- Communications Assistant (Peter Taggart), communications tasks and responsibilities related ICOS RI internal as well as to external communications, and to selected EU projects ICOS participates in (such as NUBICOS).
- Service Designer (Mariana Salgado), contributes to EU projects ICOS participates in (IRISCC, ENVRINNOV), employed since 3.4.2024
- Junior Controller; (Tommi Pesonen), travel and cost claims, assisting with the financial tasks.
- EU Project Assistant (Emilie Hachem), assisting with the tasks related Horizon2020 and Horizon Europe projects.
- KADI Project Manager (Theresia Bilola), tasks related to KADI project management.
- Financial assistant (Leysan Karimova), assisting with the tasks related Horizon2020 and Horizon Europe projects. Karimova started in 5.3.2024.

Employed in 2024 (No Longer with ICOS ERIC):

- Communications Officer (Laurent Chmiel), communications tasks and responsibilities related ICOS RI internal as well as to ICOS RI external communications activities and selected EU projects ICOS participates in (such as ENVRI-FAIR and KADI), left 15.1.2024.
- Digital Communications Officer, (Annina Bergman), online platform development tasks related to ICOS RI and to EU projects ICOS participates in (e.g. ERIC FORUM). Employment duration, 8.1.2024 - 11.10.2024
- Summer trainee, (Emma de Carvalho), Science Conference support, 27.5.2024-20.9.2024
- Summer trainee, (Maikki Roiha), Science Conference support, 27.5.2024-20.9.2024

In 2024, of the 25 persons employed 15 of the employment contracts were until further notice and 10 were fixed term. Two employees work part-time upon their own request.

Each ICOS employee had 2-4 confidential *development discussions* with their supervisor. In these events, employee and supervisor discuss tasks of the current year, performance and potential need of new skills. These skills can be achieved by independent learning, from colleagues or by participating in formal training. There is also space for feedback in both directions, and a discussion of motivation and well-being. Such discussions are a standard procedure in working life in Finland since 1970s. In many other countries, a similar event is called *performance review*, but in Finland tradition is to have more focus in being prepared for future tasks than in assessing the past performance.

Contract management.

Contracts were similar to previous years: IT support was bought from Atea, legal service from Fondia and the Audit company was KPMG, accounting company AZETS and recruitment partner Accountor.

Operational management of ICOS ERIC and RI

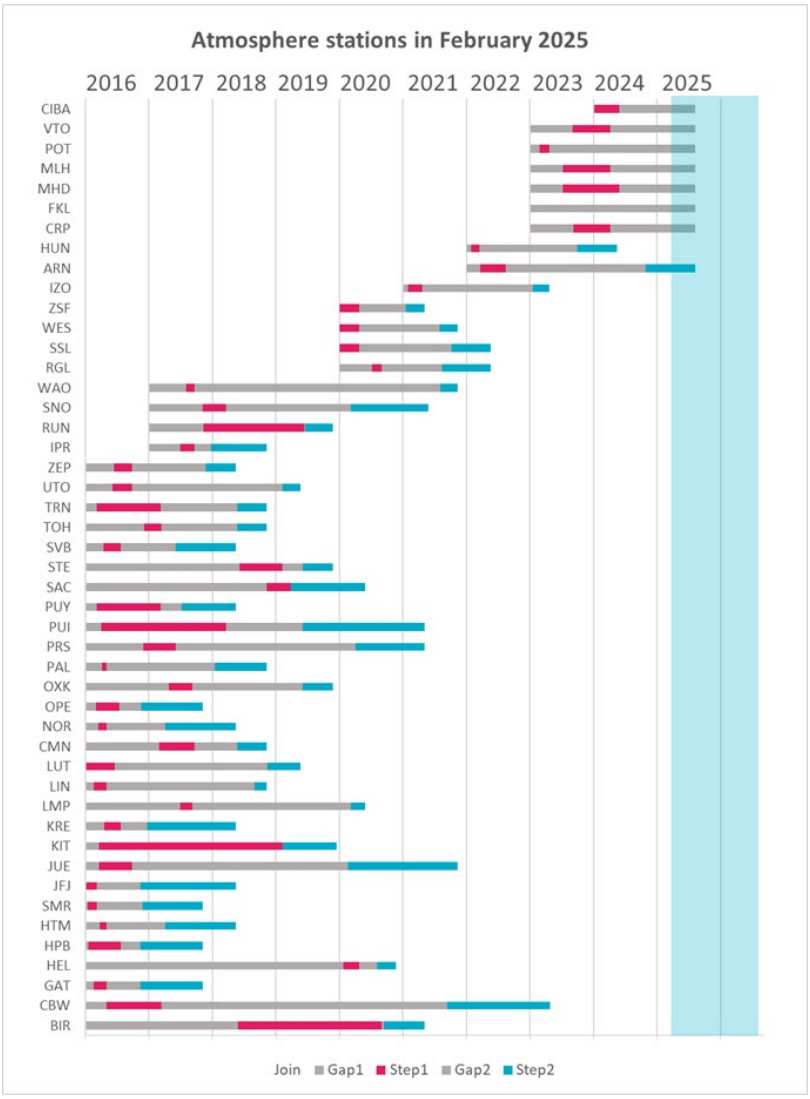
Several new PIs were introduced to ICOS activities. Online meetings were organized for all Focal Points of National Networks, and new focal points were invited to one-to-one meetings in early 2024.
The members of Operations unit participated in the face-to-face meeting of Atmosphere Monitoring Station assembly (MSA) as well as the online meetings of the other two MSAs.

A total of 12 stations received an official ICOS label in 2024. Of these stations one was an atmospheric station, 10 were ecosystem stations and one was an ocean station. Station contracts were prepared between the ICOS ERIC and the host organisations of labelled stations. Progress of the labelling is illustrated in Table 1 and figure 1, figure 2 and figure 3. The GA stakeholders have been encouraged to be in contact with stations, where progress is slow, and where appropriate even consider removing those stations from ICOS network.

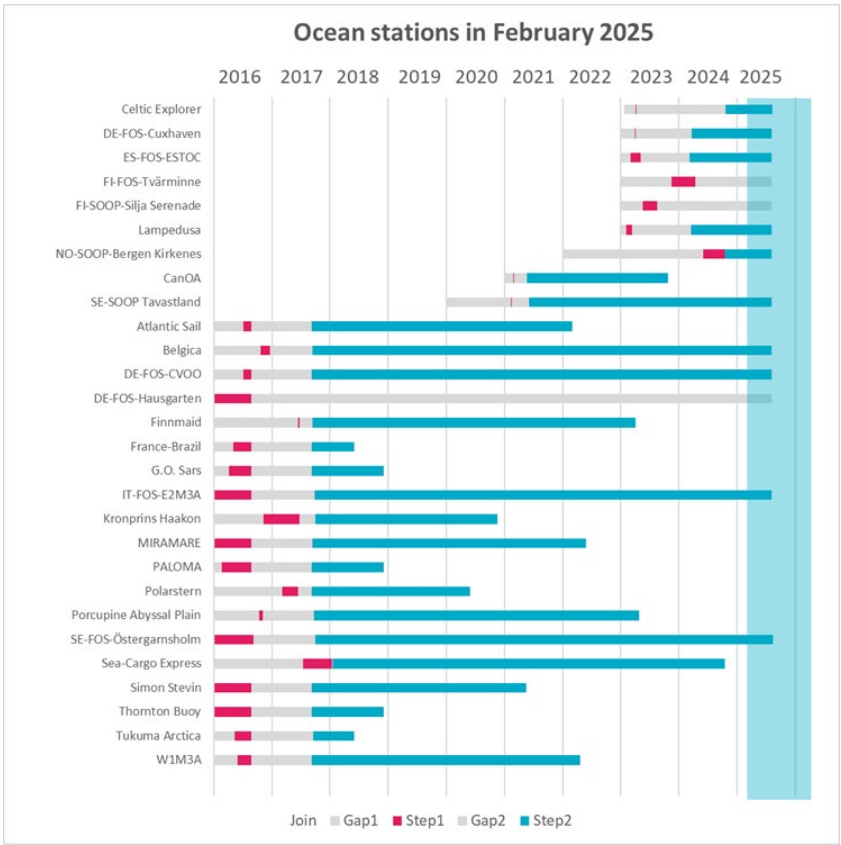
Status of the ICOS Station Labelling in February 2025

Member/ Observer countries	Stations total	Labelled stations total	Number and type of stations														% Labelled per country
			Ecosystem stations						Atmospheric stations				Ocean stations				
			C1	C1 labelled	C2	C2 labelled	Assoc.	Asso. labelled	C1	C1 labelled	C2	C2 labelled	C1	C1 labelled	C2	C2 labelled	
Belgium	12	9	1	1	4	4	3	0	0	0	1	1	3	2	0	0	75 %
Czech Rep.	4	4	1	1	1	1	1	1	1	1	0	0	0	0	0	0	100 %
Denmark	7	7	1	1	1	1	4	4	0	0	1	1	0	0	0	0	100 %
Finland	18	14	2	2	3	2	7	6	2	2	2	2	0	0	2	0	78 %
France	21	20	2	2	6	6	8	7	2	2	2	2	1	1	0	0	95 %
Germany	39	31	5	4	0	0	16	12	6	6	6	6	3	2	3	1	79 %
Greece	4	2	0	0	1	0	2	2	0	0	1	0	0	0	0	0	50 %
Hungary	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	100 %
Ireland	10	0	0	0	2	0	3	0	0	0	4	0	0	0	1	0	0 %
Italy	24	18	2	2	2	2	11	8	1	0	3	3	2	1	3	2	75 %
Netherlands	3	3	0	0	1	1	0	0	1	1	1	1	0	0	0	0	100 %
Norway	8	7	0	0	1	1	0	0	1	1	1	1	3	2	2	2	88 %
Spain	6	3	0	0	0	0	1	1	0	0	3	1	2	1	0	0	50 %
Sweden	12	9	0	0	6	6	1	0	3	3	0	0	2	0	0	0	75 %
Switzerland	3	3	1	1	0	0	1	1	1	1	0	0	0	0	0	0	100 %
UK	4	4	1	1	0	0	1	0	0	0	2	2	0	0	1	1	100 %
JRC	2	2	0	0	1	1	0	0	0	0	1	1	0	0	0	0	100 %
Total	178	137	16	15	29	25	59	42	18	17	29	22	16	9	12	6	
% Labelled per domain and class:			94 %		86 %		71 %		94 %		76 %		56 %		50 %		

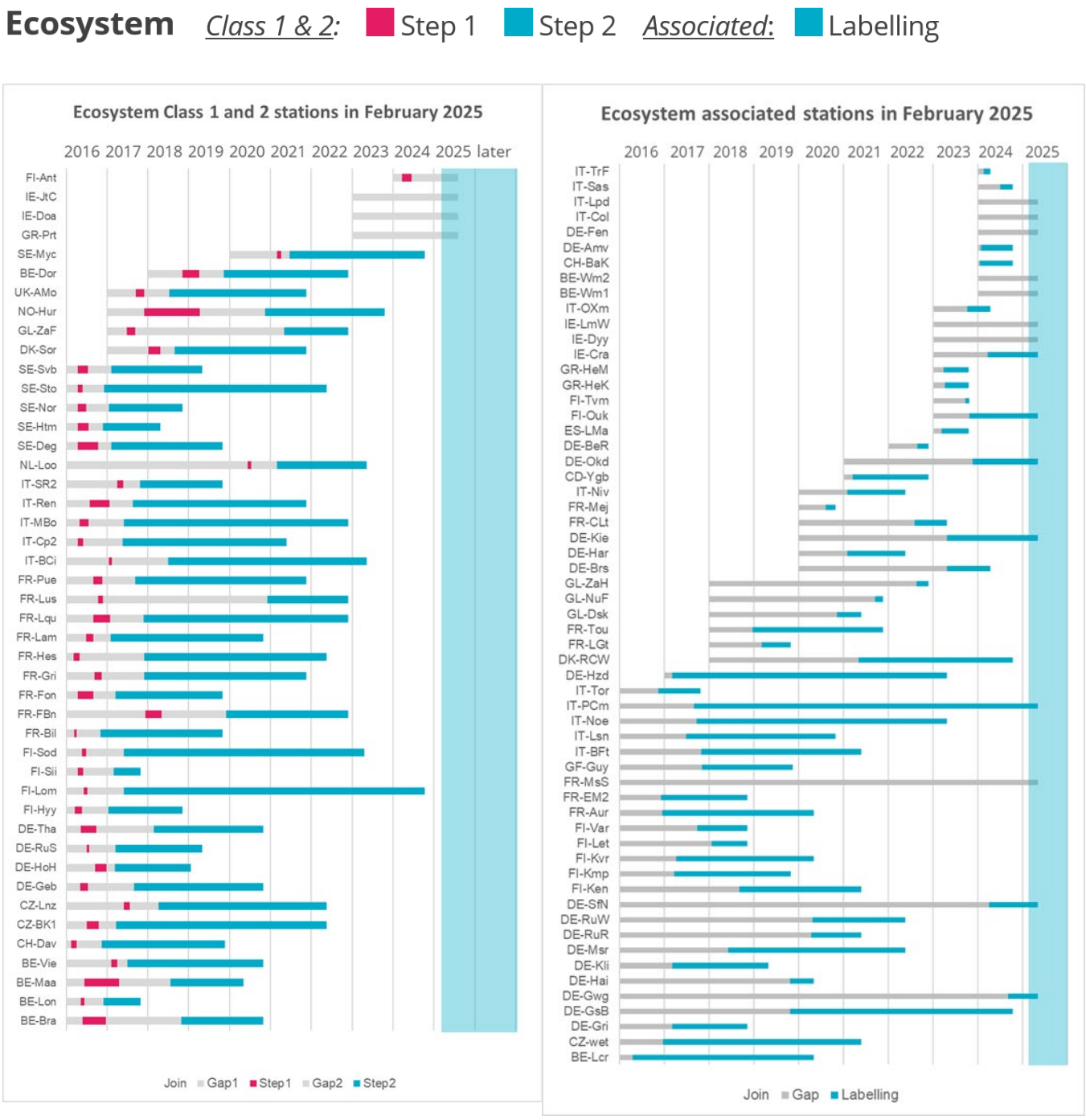
Table 1. Labelled ICOS stations per country, domain and class by the end of February 2025. Note: One ocean station from Germany (DE-SOOP-Polarstern) was labelled as class 2 but has now been changed to class 1.


Atmosphere stations in February 2025
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
CIBA
VTO
POT
MLH
MHD
FKL
CRP
HUN
ARN
IZO
ZSF
WES
SSL
RGL
WAO
SNO
RUN
IPR
ZEP
UTO
TRN
TOH
SVB
STE
SAC
PUY
PUI
PRS
PAL
OXK
OPE
NOR
CMN
LUT
LIN
LMP
KRE
KIT
JUE
JFJ
SMR
HTM
HPB
HEL
GAT
CBW
BIR
Join Gap1 Step1 Gap2 Step2


Atmosphere
Step 1
Step 2


Ocean stations in February 2025
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
Celtic Explorer
DE-FOS-Cuxhaven
ES-FOS-ESTOC
FI-FOS-Tvärminne
FI-SOOP-Silja Serenade
Lampedusa
NO-SOOP-Bergen Kirkenes
CanOA
SE-SOOP Tavastland
Atlantic Sail
Belgica
DE-FOS-CVOO
DE-FOS-Hausgarten
Finnmaid
France-Brazil
G.O. Sars
IT-FOS-E2M3A
Kronprins Haakon
MIRAMARE
PALOMA
Polarstern
Porcupine Abyssal Plain
SE-FOS-Östergarnsholm
Sea-Cargo Express
Simon Stevin
Thornton Buoy
Tukuma Arctica
W1M3A
Join Gap1 Step1 Gap2 Step2


Ocean
Step 1
Step 2



Ecosystem *Class 1 & 2:* Step 1 Step 2 *Associated:* Labelling

Figure 2-3. Progress of station labelling in each domain in February 2025.

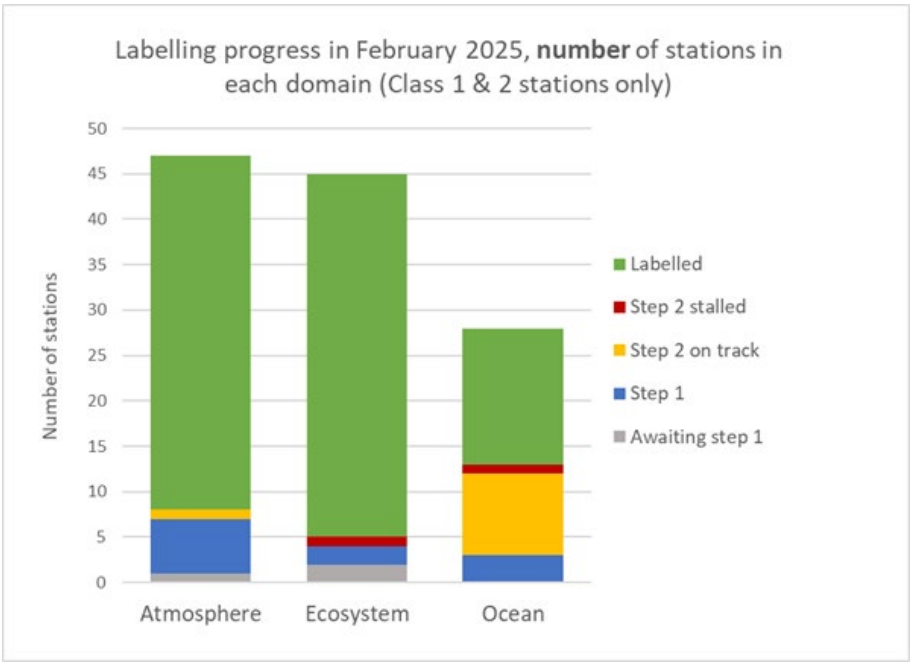


Figure 4. Labelling process, per cent of stations (Class 1 and class 2) in each labelling step by domain.

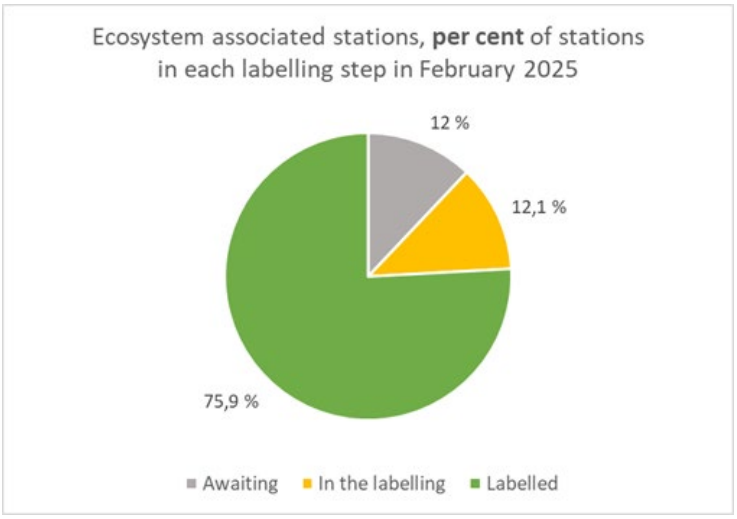


Figure 5. Labelling process of associated ecosystem stations in February 2025.

The station level progress of labelling can be followed from https://meta.icos-cp.eu/labeling/

Currently, 5 stations are with a status “Step 2 delayed” and 2 stations are in status “stalled”.

Stations where labelling was stalled as of 28th February 2025			
Domain	Station		Notes
ECO	Fendt	DE	No real activities in the labelling process, ETC is waiting metadata and data (Step1 approved 2018-08-06 and Step2 started 2018-10-17). Nothing happened until November 2022
OCE	R/V Belgica	BE	2022 January: The new R/V Belgica is operational. 2024 October: The pCO2 and pH instrumentation was up and running during the first two months of 2024. In June, the operator of the RV Belgica unilaterally stopped the contract, and since then the ship has been at quayside. Hopefully, this will be solved soon. In the meantime no data collection is possible

Support for ICOS-related science

Science facilitation focused much in preparing for ICOS Science Conference which took place in Paris, September 2024.

Other conferences were on national level, see details in the reports of national networks. In addition, several project proposals were written, and Head Office provided letters of support describing the importance of nationally funded research projects for the entire GHG community.

The FLUXES bulletin was a visible effort in facilitating impact of research made in the ICOS Scientific community and making research visible in eyes of policymakers.

See also summary of ongoing projects at end of this report.

Communication and community integration

ICOS uses communications and outreach to considerably increase its impact to the society.

External communications and outreach

The ICOS Head Office continued to promote ICOS mission and its services to a wide range of stakeholders.

The third volume of ICOS’s FLUXES, the European Greenhouse Gas Bulletin was published in June 2024. The publication highlights climate issues to an audience consisting particularly of policymakers, policy advisors, and climate journalists.

The volume focused on monitoring, reporting and verification of greenhouse gas emissions, the challenges such systems have, and how ICOS can support these efforts with its high-quality data, large measurement network and the research community. The 2024 magazine also featured articles about the Global Stocktake effort and the Global Greenhouse Gas Watch to be established by WMO, discussing the role of ICOS in these endeavours. The volume three reached over 2000 people in the target audience. Same topics were also raised up in high-level meetings organised and participated by ICOS during autumn 2024. More about those in International Cooperation section of this report.

ICOS ERIC continued to highlight stations in the Explore ICOS video campaign. In 2024, the HO visited 5 stations in **Germany, Hungary and Italy,** producing videos, photos, articles etc. about each station**.** HO also visited the Atmosphere Thematic Centre in France, the video will be published in 2025.

ICOS materials, website, media and social media

ICOS' external communication include production and dissemination of a wide range of engaging content across a variety of channels. ICOS HO published 60 (52) pieces of news on the website, and a monthly newsletter reaching 1976 (1500) readers.

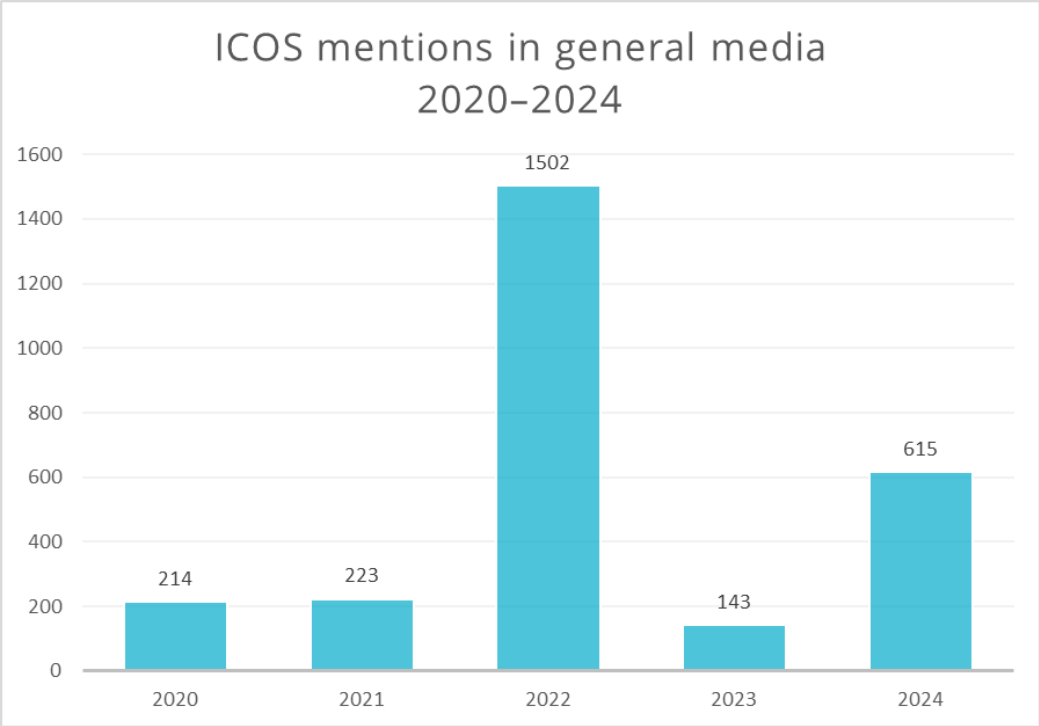


Figure 6: ICOS mentions in global online media 2020-2024. Year 2022 has exceptionally high number of media hits because of the high interest in North Stream leak.

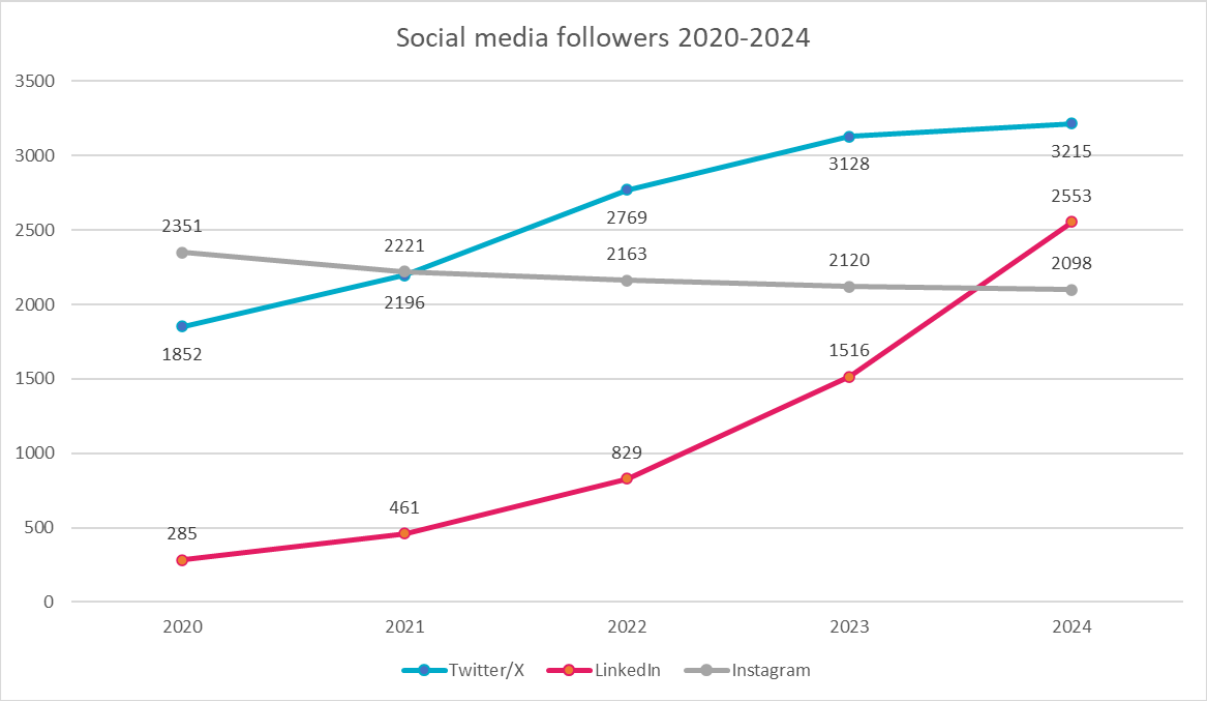


Figure 7. The number of followers in the most important ICOS social media channels. X (ex-Twitter) has seen many unexpected changes during 2024, and many of ICOS's followers have left X. While the ICOS's trend in X is still positive for the full year, it was in slight decline in the last weeks of the year. In the early days of 2025, ICOS opened a new account in Bluesky. The use of LinkedIn has grown considerably in the world, and ICOS followership reflects that trend.

Community integration

Community integration refers to the participation of different parts of the RI into activities and the ability to improve activities and respond in an agile way to new opportunities or challenges.

ICOS community organised several trainings and workshops to develop things together. Most took place in online format.

Besides activities, communication is an important glue fitting the community together. To that end, the Head Office and Carbon Portal regularly support internal communication across the ICOS RI. HO continued to publish a monthly community newsletter, while the ICOS Carbon Portal maintained internal document management system and email-lists. The HO also continued the good cooperation with the RI Communications Network - consisting of National Network coordinators or Focal Points - in order to align messaging and to share information and best practises.

International Cooperation

No new country joined ICOS ERIC in 2024 but the work towards Portugal, Poland and, to a lesser extent, Austria continued. Portugal remains a highly strategic country as its geographical position, including its vast maritime domain, would significantly increase the coverage of the ICOS network. Thanks to an active contact in the country, a first meeting of the Portuguese scientific community was held in July 2024. The participants identified national opportunities to strengthen their collaboration and contact was maintained between the HO and the Portuguese authorities who will decide on a future membership.

In Poland, the HO restarted activities with a different contact person who is willing to advance the integration of their country into ICOS. It is foreseen that a gathering of the Polish scientists involved in ICOS-related activities will be organized in 2025.

Similarly, a meeting of the Austrian scientific community was organized during the EGU week to identify the local actors and start discussions on common activities. The DG attended an event organized in Vienna in June where discussions could be continued and the Austrian representative of the ministry of research was present. This event also opened the door for an ICOS-related session at the future International Mountain Conference in Innsbruck in 2025.

ICOS initiated a major strategic event of the Board of European Environmental Research Infrastructures, BEERi. The retreat-type event was held in Belgium and led to the renaming of BEERi into ENVRI Board and a redefinition of its mission. The role and working processes were also renewed. The ICOS DG was the chair of the BEERi/ENVRI Board until the end of 2024.

Outside of Europe, the activities in the Knowledge and Services from an African Observation and Data Infrastructure (KADI) project in Africa took speed with several key events where the project and ICOS were prominently showcased: AfriGEO, the annual meeting of the project that included a very successful stakeholder event…

The Global Ecosystem Research Infrastructure (GERI), a consortium between ICOS and 5 other world-class RIs in Africa, Australia, China, Europe and the US, was also a visible activity at the International Conference on Research Infrastructures (ICRI) in Brisbane, Australia.

As an observer to the UN Framework Convention on Climate Change (UNFCCC), ICOS was also present at COP29 in Baku this year, but only virtually. The ICOS DG spoke on a panel of a side-event entitled *"Carbon Dioxide Removal: Policy Considerations for Responsible Deployment on Land and in the Ocean"* that was co-organized with two American NGOs, the Climate Center and the World Ocean Council.

Green Team

ICOS ERIC Head Office personnel have reported their business travel and commuting emissions monthly since 2019. In 2023 the UNFCCC pledge of compensation by offsetting ended, and the new practices that were developed in return were still in place in 2024.

First of all, the ICOS ERIC Travel Rules were extended to cover slow travel in 2023, which means that a supervisor can accept a longer travel time and reasonable additional travel costs if an employee selects a low-emission method such as the train or the bus. In addition, if an employee has several work-related journeys close to each other, they may choose to combine travelling to different destinations. As an example, the Head Office team travelled to Versailles for the ICOS Science Conference and two team members decided to take advantage of the slow travel option: trains and ferries. One of them flew back, the other one continued by train to visit Carbon Portal in Lund on her way home.

Second of all, it is encouraged to think more carefully if there is an actual need to travel – or could the same result be achieved by arranging a virtual meeting or by other method. At the same time, it is seen important to provide proper reasoning for travel – why or when to fly, and who should fly.

In 2020, the Head Office business travel emissions dropped dramatically from more than 100 000 kg eCO2 per year to about 6500 kg eCO2 due to the corona lock down. After the lock down ended, they have increased steadily, exceeding 78 000 kg eCO2, but not yet reaching the 2019 level. However, there are factors that affect the development of the curves (see figure 8). In 2019 the HO staff included 15 members, in 2024 we were already 20. We also coordinated 4 projects in 2024, while in 2019 there were only 2. Additionally, ICOS ERIC staff has flown longer distances to Africa and Australia during 2024 due to entering the KADI project and the ICRI meeting. All of this results in more travels and potentially more emissions.

Figure 8. Years 2020 and 2021 show a dramatic decrease in emissions due to the Covid19 . After the lock down ended, business travel emissions have increased steadily.

Carbon Portal

General

In 2024 Carbon Portal experienced many changes due to a transition into a more operational phase, with tasks shifting from pure development into more maintenance, time-consuming routine operations, interactions with users and incremental improvements. The large number and diversity of tasks and small number of people in combination with many and more time-pressed European projects has led to a challenging year.

In 2024 the Carbon Portal also celebrated its 10th anniversary. Because of this and the challenges highlighted above, a retreat with all personnel was organised May-June 2024. Discussions sessions and workshops were organised on working climate, motivation, long term strategy and organisation of the work. Overall conclusion was that the current more and more operational phase of the Carbon Portal would benefit from a more open structure, with better integration of core development and elaborated (scientific integration) products in combination with better organised workflows. The retreat was followed up by several sessions after the summer to monitor progress and refine details on the agreed direction. One major change implemented was the introduction of the Asana agile management tool, that has proven to be very useful in planning and making visible to all the work at hand and planned. Another strong conclusion was that the team should be enforced with a user support engineer, a data steward and a developer to be able to better support our main customers in curating contributed data and use of our services.

In the midst of all the turbulence many small to major improvements and achievements have been reached in 2024 at Carbon Portal. In this report we will highlight the most relevant and striking improvements and achievements.

Data Statistics

Data availability

In 2024 CP received in total 504 864 data objects (Table 1), of which 420 277 are considered ICOS data. Of these 211 715 came from the atmosphere, 204 141 from the ecosystem and 4 409 from the ocean domain. 12 ICOS data objects were of the mixed data theme, mainly CTE-HR data results. The biggest share of ICOS data is raw data (L0, 226 016), but also the daily growing NRT data files (L1, 192 795) form a considerable part of the total number of files. A total of 1 406 data objects were received as Level 2, final quality controlled, ICOS data. At the end of 2024, the Carbon Portal held in total more than 2.24 million data objects.

Total		504 864
ICOS data objects		420 277
	Atmosphere	211 715
	Ecosystem	204 141
	Ocean	4 409
	Mixed theme	12
	L0	226 016
	L1	192 795
	L2	1 406
Other data objects		84 587

Table 1 Statistics on number of data objects received in 2024.

Figure 1 and 2 show the percentage per month of raw data received for the individual stations of the ecosystem and atmosphere domain respectively. Clearly one can see that the number of stations sending data increases because of the growing number of labelled stations. For all years and over the whole period all stations show a data availability of better than 95%. Table 2 summarises the data per year and over the whole period for the two networks. No significant upward or downward trend can be seen over the period 2020-2024 which means the overall network behaves consistently and reliably, despite the growing number of stations that got labelled over the years.

Table 2 Percentage of raw data received for the domains of atmosphere and ecosystem for the years 2020, 2021, 2022, 2023, 2024 and for the whole period 2020-2024

		2020	2021	2022	2023	2024	2020-2024
Atmosphere	AVERAGE	95.7%	96.6%	96.3%	97.6%	98.1%	97.0%
	MEDIAN	96.1%	96.7%	96.9%	97.9%	98.4%	97.6%
Ecosystem	AVERAGE	98.3%	98.2%	97.5%	98.3%	98.4%	98.1%
	MEDIAN	99.7%	99.6%	99.4%	99.2%	99.4%	99.0%

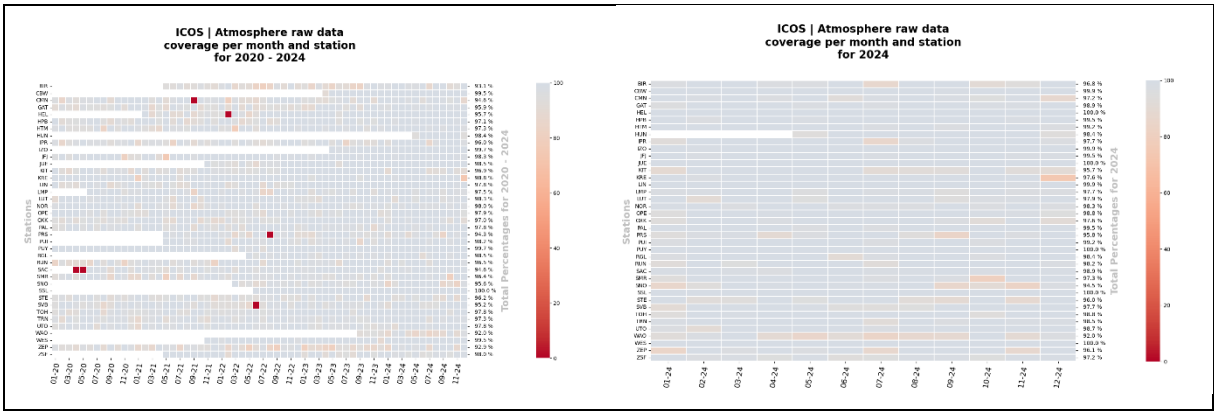


Figure 1 Percentage of raw data coverage for Atmosphere stations. Left: for the period 2020-2024. Right: for the year 2024 .

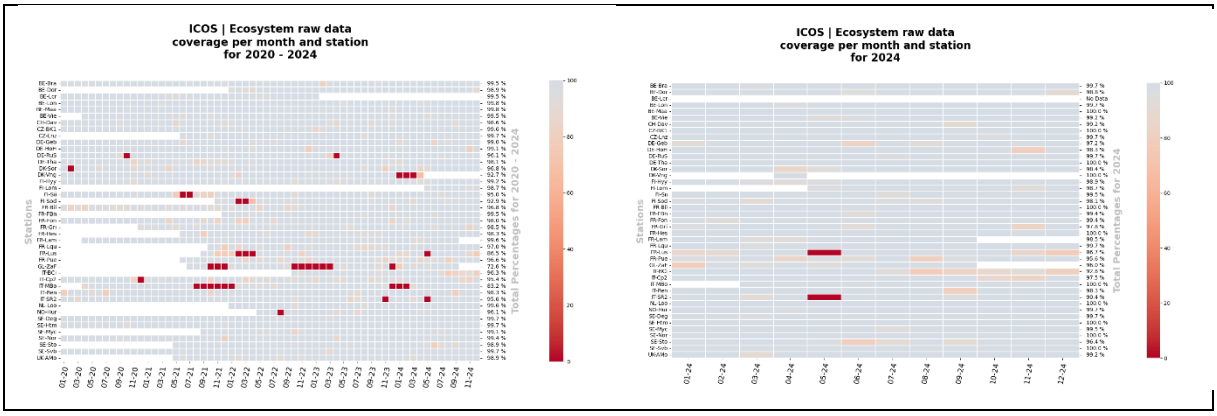


Figure 2 Percentage of raw data coverage for ecosystem stations. Left: for the period 2020-2024. Right: for the year 2024.

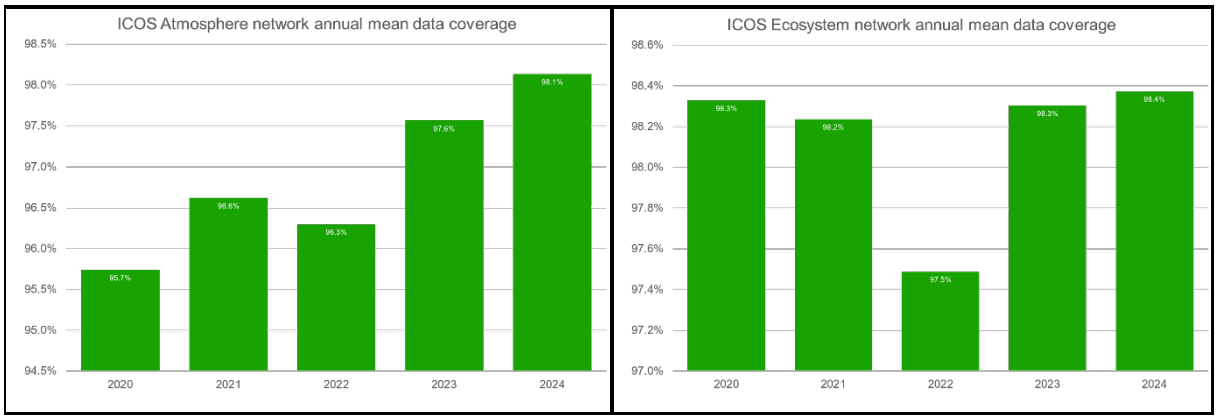


Figure 3 Annual average percentage of raw data coverage over the ICOS atmosphere (left) and ecosystem (right) networks over the period 2020-2024.

Data releases

All domains delivered at least one release of level 2 final quality data. Ocean L2 release for 2024 was on 24 Feb 2025, Ecosystem L2 release 2024-1 on 22 May 2024 and Atmosphere L2 release 2024-1 on 28 June 2024. The end of growing season interim L2 dataset of Ecosystem data was released 20 Dec 2024.

The 2024 European Obspack data release product (GVeu v10) was prepared and released 29 July 2024. The first so-called FastTrack (2024-3) quarterly release of ICOS Obspack data was published on 10 October 2024. FastTrack releases are intermediate NRT releases (could be seen as data level 1.5) where the PIs performed manual quality control and flagging to the NRT data and ATC produced a minimal processing update.

Table 3 Release dates of 2024 level 2 data for the different domains

Domain	Release	Date
Ocean	L2 2024-1	24 Feb 2025
Atmosphere	L2 2024-1	28 June 2024
	Obspack EU	29 July 2024
	Obspack FT	10 October 2024
Ecosystem	L2 2024-1	22 May 2024
	L2 2024-2	20 December 2024

Data usage by download count and user number

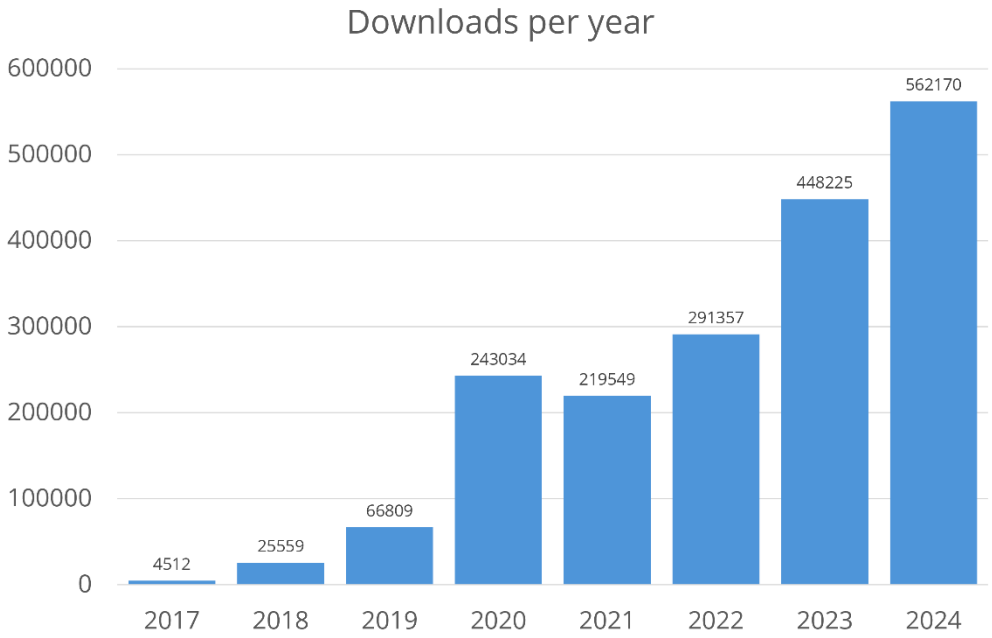


Figure 4. Total number of data downloads from Carbon Portal from 2017 to 2023. In 2024 the number of downloads of ICOS Level 1 and 2 data was: 256 693. Total number of downloads was 562 180.

We can further zoom in on specific data uses and for example for the number of timeseries previews we can clearly identify a spike in interest corresponding with the ICOS Science Conference in September 2024 on top of an increasing trend (Figure 5).

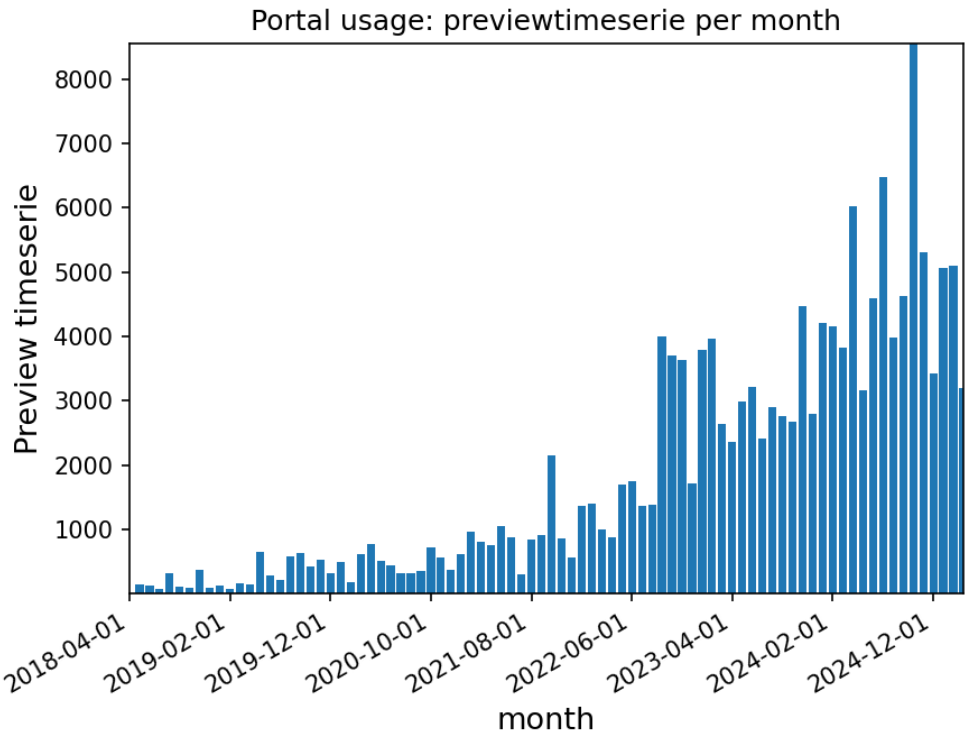


Figure 5. Monthly number of time series previews at Carbon Portal

Next to download through the portal we offer the for example the users of the ICOS python library the option to directly access previewable time series through a very efficient binary API. The number of monthly API calls to this download function is shown in figure 6.

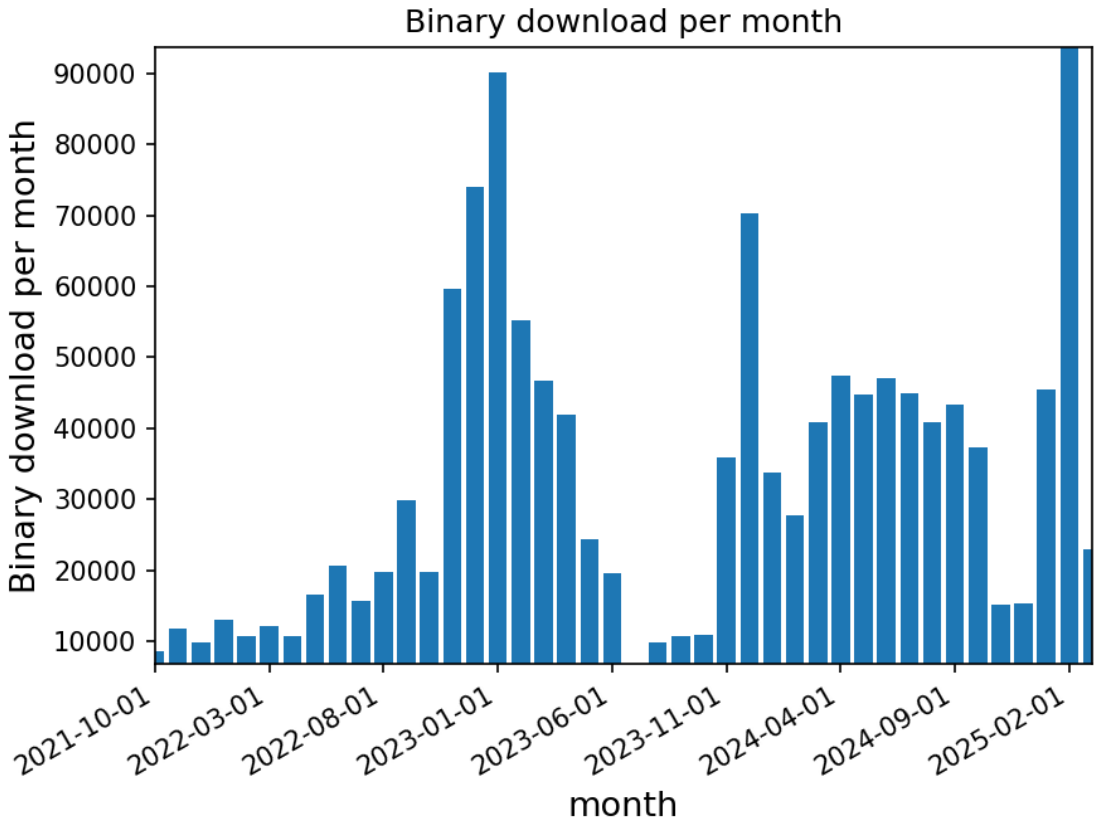


Figure 6 Two-monthly number of API calls to the binary interface to previewable time series data. The gap in the middle of 2023 is due to a bug after an update of the python library.

Total amount of unique users of web pages and web services

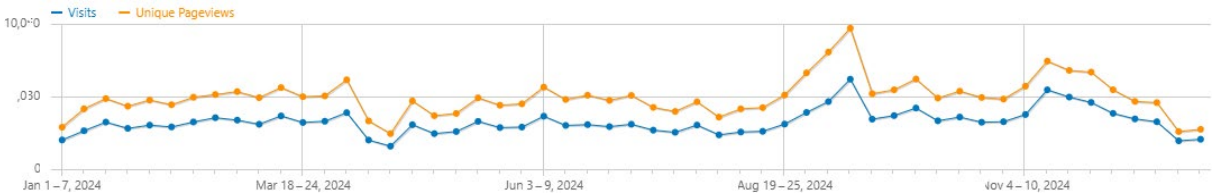


Figure 7 Number of unique users and pageviews per week over 2024 of the ICOS web site plus Carbon Portal. The total numbers of unique users over 2024 was over 171 832 users.

Figure 8 Number of unique users and pageviews per month in the period Jan 2020 until Jan 2025, showing a quite stable average of 10 000 users per month since 2020 with a clear peak in September 2022 (Nordstream pipe line blow-up event). Results before 2020 are not shown here because of transfer of web statistics from Google Analytics to Matomo due to GDPR concerns.

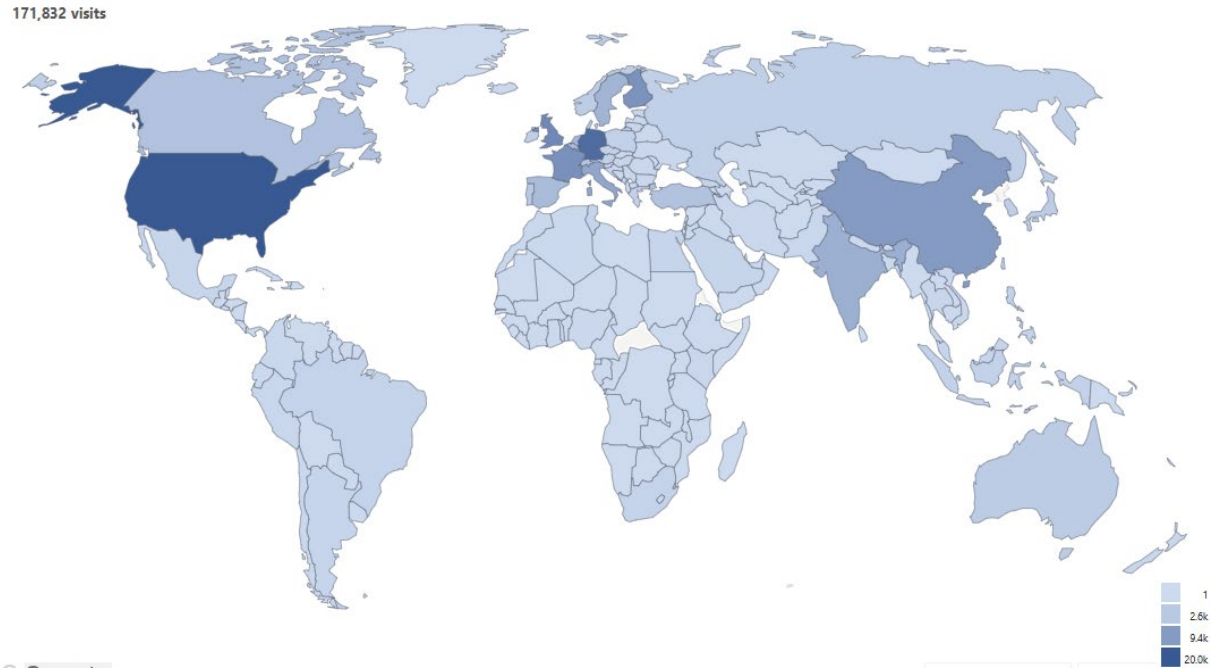


Figure 9 Number of visitors of the ICOS web sites per country for the year 2024.

Impact

Impact through articles and citations

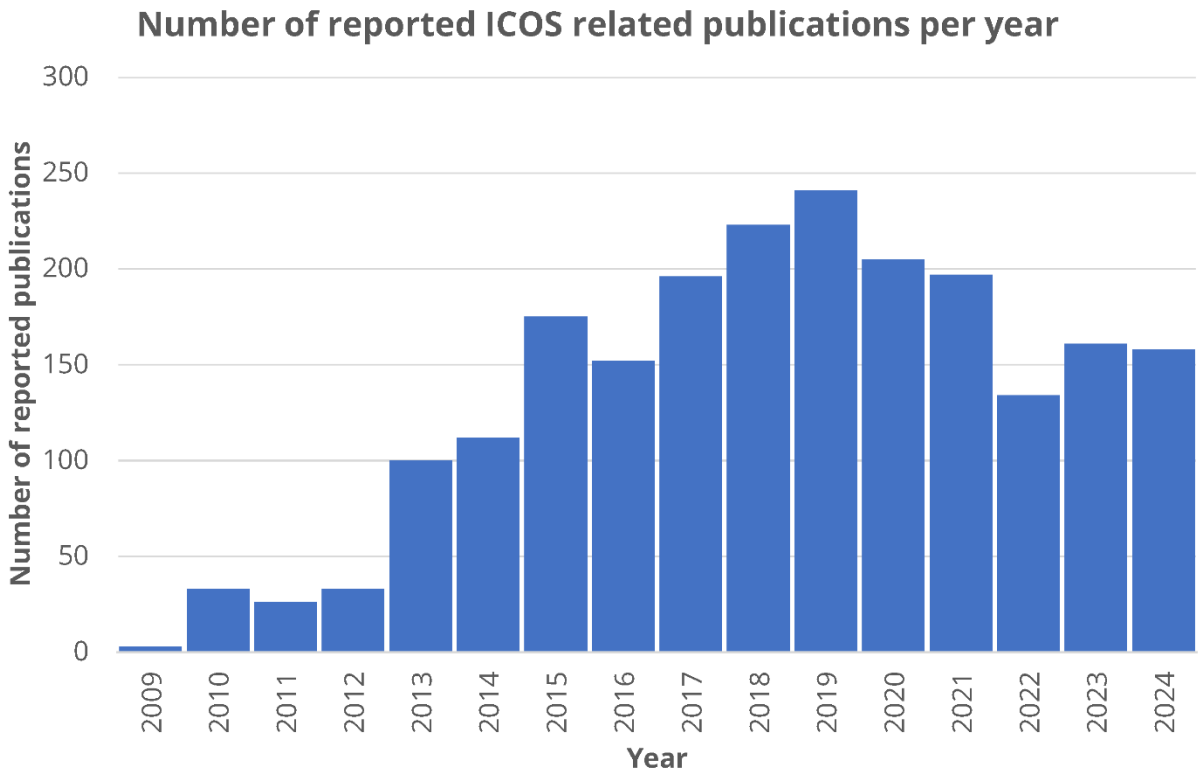


*Figure 10a Number of ICOS related **publications** per year (as reported by the community via national focal points). Reporting publications has a lag of a few months to more than a year due to the review process, so that next year the numbers for 2023 and even more 2024 will still increase.*

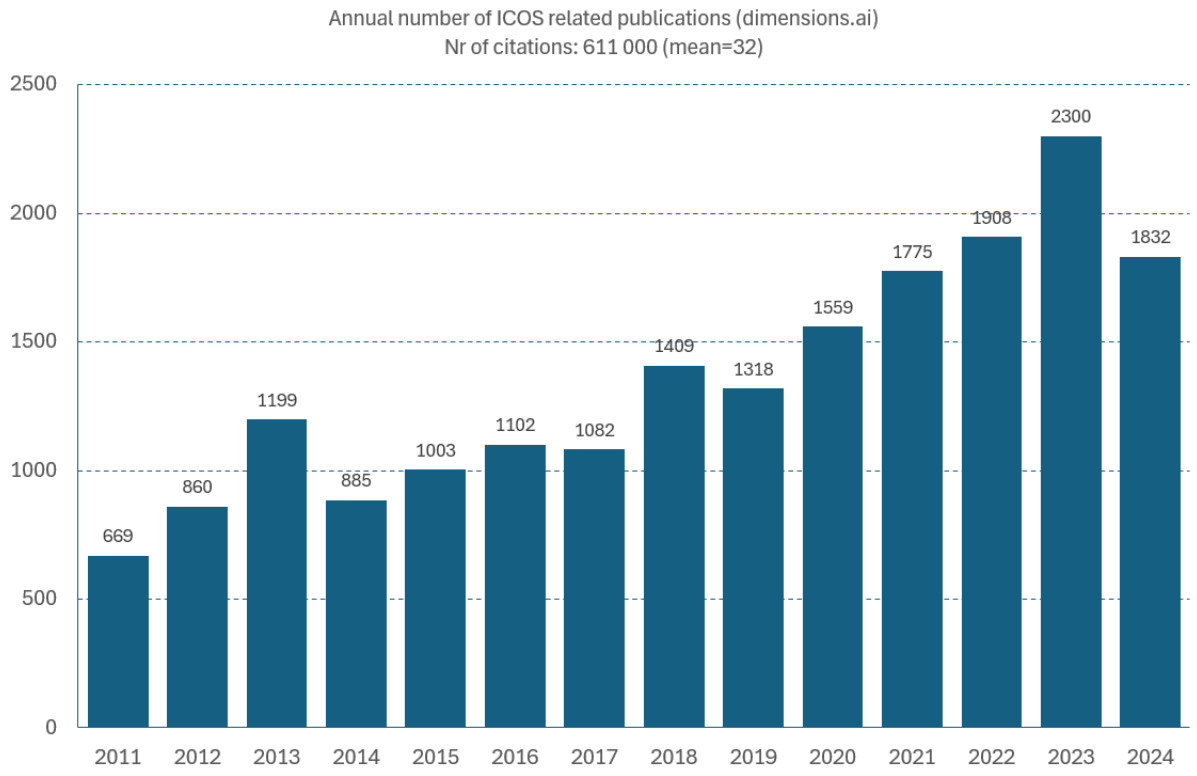


*Figure 10b Number of ICOS related **publications** per year (extracted through dimensions.ai). Reporting publications has a lag of a few months to more than a year due to the review process, so that next year the numbers for 2023 and even more 2024 will still increase.*

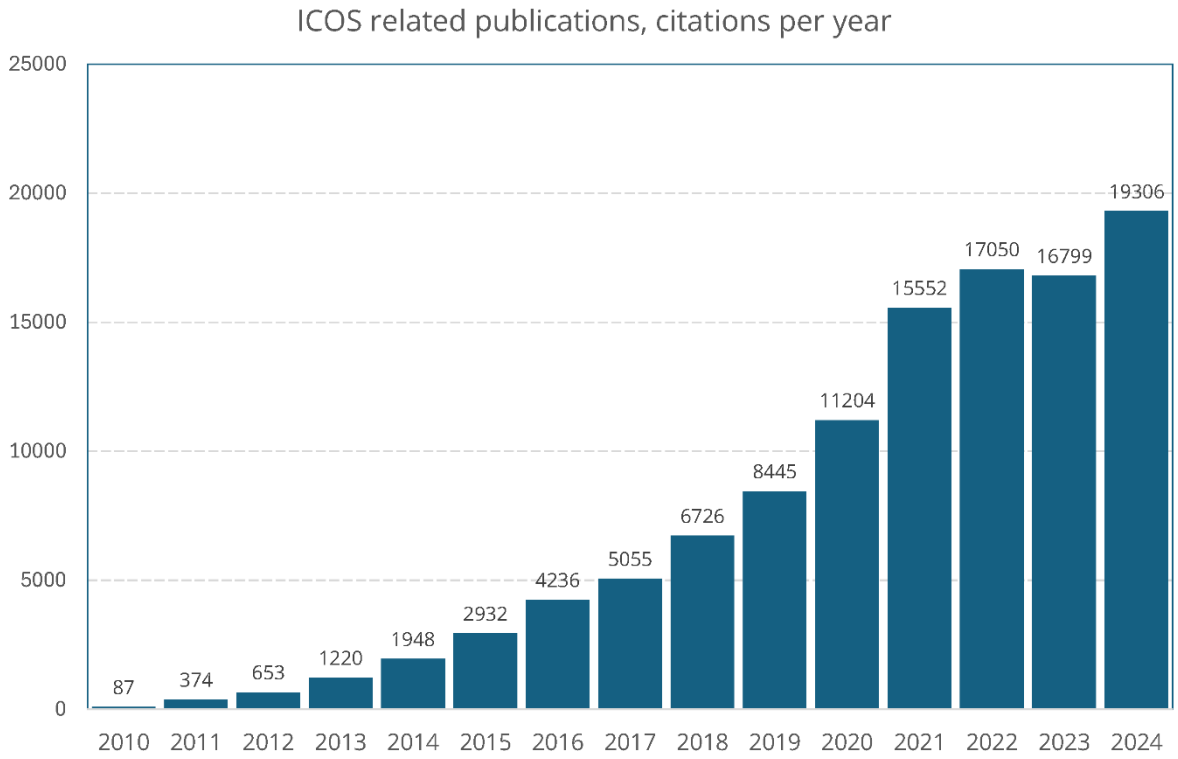


*Figure 11 Number of **citations** to ICOS related publications per year (based on analysis of articles reported by national netwwroks, ie, fig 10a.). In the Dimensions ai. Analysis, each article has in average 32 citations.*

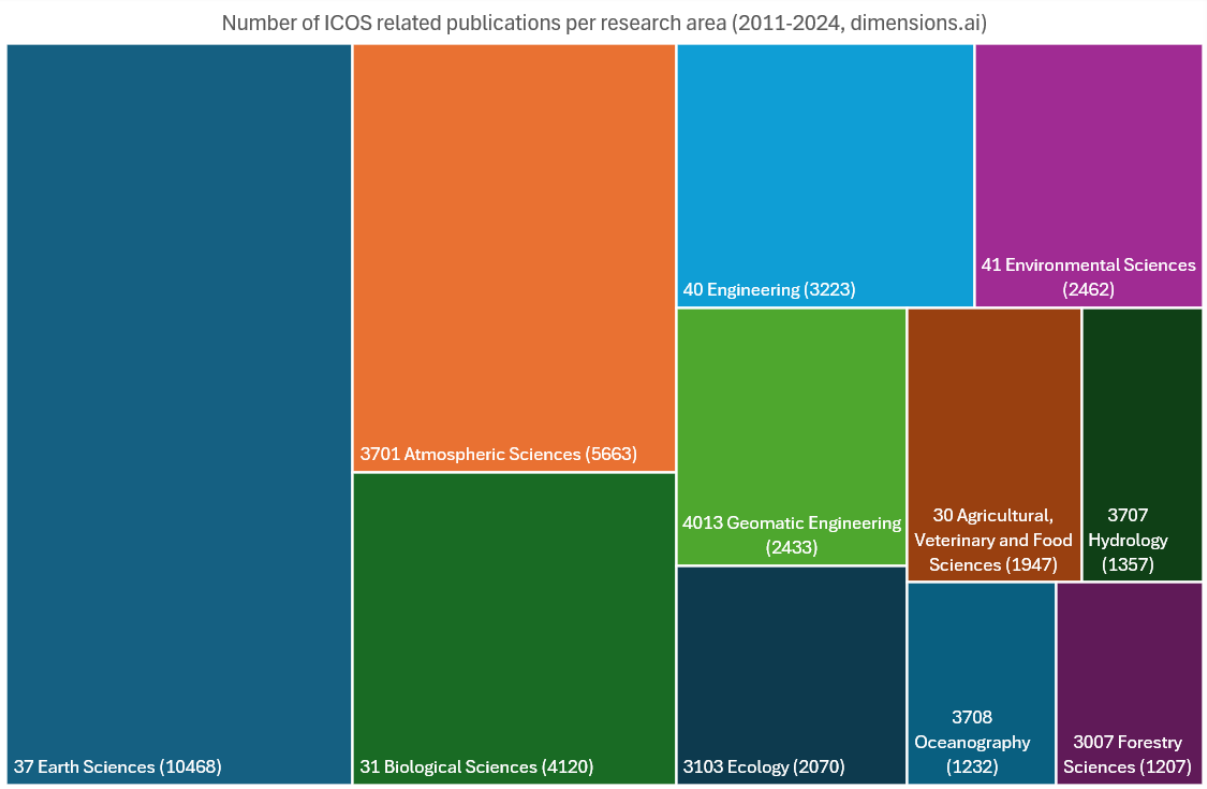


Figure 12. Categories of ICOS publications over the period 2010-2024 (extracted through dimensions.ai). The six largest categories of ICOS publications were Earth Sciences, Atmospheric Sciences, Biological Sciences, Geomatic Engineering, Ecology, Environmental Sciences and Agricultural Sciences.

Two methods have been used to estimate the scientific articles related to ICOS. Firstly, the national networks and central facilities are asked to list published papers in their area. The definition of ICOS-related articles has been discussed in RICOM 20172019 and it is stated on the website*. ICOS related publications are publications that used ICOS data or knowledge based on ICOS data or is based on science that is relevant for ICOS and to which persons from the large ICOS community have contributed.*

Number of these papers has been increasing steadily. An additional peak can be seen in 2017-2020, when, as encouraged by ESFRI evaluation board, extra effort was made to identify papers published outside of ICOS members countries (which are not under responsibility of any national network to report, but still emphasis the global value of ICOS Data).

The second method is using an artificial intelligence tool *Dimensions.ai*. When using prompt ICOS, FLUXNET, SOCAT, ObsPack it returns ten times as much hits than the manual method. The ratio is apparently constant over years, so the trend has same shape.

As ICOS does not yet have an policy for use of AI tools, we publish here both numbers.

Science and integration

Jupyter notebooks

The Jupyter Notebook services at CP continued to be a popular service for scientists and students to explore ICOS data and products on our public service exploredata.icos-cp.eu or to work on their own scientific analysis and code development in collaboration with colleagues on our collaborative Jupyter Hub, which currently has more than 270 registered users. In particular the advanced options of the collaborative Jupyter Hub are actively used in several EU projects (e.g. Avengers, Paris, ICOS-Cities) but also in smaller project groups (with a total of more than 40 project groups). These advanced options are sharing notebooks and data between users in collaborative projects including associated disk space on

the ICOS Fileshare, allow upload of own data for analysis together with ICOS data, and provide permanent storage of notebooks and data . These Jupyter services are regularly updated to provide users with a versatile python (also R, Julia) programming environment and are continuously expanded in close consultation with our users to support their scientific analysis and interpretation of ICOS data and products.

The ICOS-specific python libraries for an easy and user-friendly access to ICOS data and metadata as well as to results of the STILT footprint tool have been continuously updated to reflect the developments in the data portal. Improved performance of the access to the core data and metadata services of the data portal is provided by the new icos_core library that now forms the foundation of the existing user-friendly icoscp python library but can also be used stand-alone by more proficient scientific programmers. All example notebooks that CP provides to showcase the data access have been updated and adapted to the icoscp_core functionalities.

The development of Jupyter notebook-based tools has been continued. A tool to characterize and cluster European cities with respect to key aspects relevant for CO_2 monitoring and modelling strategies was developed as part of a scientific study. The tool and its application are described in detail in a scientific manuscript and the respective Jupyter notebook is available to users for further analysis.

The Jupyter services and the data access using the ICOS-specific python libraries were showcased in interactive presentations at the EGU2024 and the ICOS Science Conference, inviting the users to follow along on their own computer.

Data products and scientific services

FLUXCOM-X, an extensive dataset of global, high resolution estimates of CO_2 net ecosystem exchange (NEE), gross primary productivity (GPP) as well as evapotranspiration (ET) and transpiration (ETT), generated by combining in-situ eddy covariance measurements of terrestrial land-atmosphere fluxes with e.g. satellite data through machine learning models, is disseminated through CP in several temporal and spatial resolutions to ease data handling for common use cases and has become the most downloaded external product in 2024.

The High-Resolution, near real-time CO_2 fluxes over Europe from the Carbon Tracker Europe system (CTE-HR) are extended on a monthly basis with a delay of 2-3 months depending on the availability of the input data. The CTE-HR system offers results from a dynamic anthropogenic emission model, net ecosystem productivity (NEP) calculated by SiB4, as well as fire emissions and ocean fluxes at high spatial and temporal resolution.

Other products for use in atmospheric transport models and inversions, which have been available at CP for many years, continue to be regularly updated. These include regional biosphere model results (VPRM and LPJ-GUESS), anthropogenic CO_2 emissions, and radon exhalation from soils, all with high spatial and temporal resolution. Anthropogenic CH_4 emissions, consistently derived using the same approach and input datasets as CO_2 emissions, are now also available. Meanwhile, LPJ-GUESS simulations of natural CH_4 fluxes remain in an experimental phase and will undergo further evaluation before publication.

The harmonized dataset of global CO_2 flux fields from the atmospheric inversion model systems that participated in the Global Carbon Budget 2024 is disseminated through CP, allowing users to inspect the individual results in more detail. The annual update includes results from 14 different inversion systems.

CP assisted in the collection of historic and non-ICOS atmospheric N_2O data for the use in the EU projects AVENGERS, PARIS and EYE-CLIMA.

Upload and curation of elaborated products and project-based measurement data, including DOI minting, has seen an increasing demand in the last years and is since November 2024 handled by our data steward. A semi-automated workflow for recurring datasets is being established and will be further

operationalized. However, the diverse content of these products still requires specific solutions and is handled in close contact with product providers.

The STILT footprint tool and the tool for computing daily updated forecasts of back-trajectories are frequently used by scientists. The number of STILT simulations for ICOS and other existing atmospheric stations as well as for hypothetical station locations is steadily increasing. The STILT footprint tool was extended by implementing the modelling of CH_4 concentrations, also split into different source contributions from the main source categories like fossil fuel, landfills, enteric fermentation etc. This required rerunning the model to include CH_4 concentrations in all existing simulation result files. A download option for STILT results was added to allow users to directly download the displayed concentration and footprint time series.

FLEXPART model simulations to estimate the influence of radiocarbon emitted from nuclear facilities are now implemented as an operational service to the ICOS CRL to support sampling strategies for $^{14}CO_2$ (radiocarbon) and to directly inform the flask sampling devices at the ICOS stations whether or not to preserve samples depending on the prognosed amount of contamination of the radiocarbon content due to emissions from nuclear facilities.

An interactive user interface for graphical representations of key ICOS datasets, such as those presented in the annual FLUXES publication, was implemented using a Platform-as-a-Service (PaaS) solution. Paas enables easy prototyping of services, e.g. based on code developed by users on the Jupyter Hub.

Data portal

Improvements in functions and usability

Our data services have been under development for many years and a lot of effort goes into their maintenance and keeping the code up to date and improved by minor and medium size user interface and operational improvements. One of the main feature releases of 2024 was enabling to query for spatial coverages. While one could get data from a station or location in the past, one now can get data linked to specific geographic areas. This is especially useful because many datasets are sampled from areas further away from a station or covering a larger area. This gives us the possibility to further improve the map search available on the data portal in the future by showing the exact locations where data was sampled. Our data collections also get special coverage metadata properties generated based on the data it contains. Of course, this special metadata is available for machine to machine communication, supporting the FAIR principles.

We used to replicate our data to the B2SAFE trusted repository hosted by CSC in Finland, and unfortunately, they decided to discontinue this service. We worked with IT4I in the Czech Republic, also part of the EUDAT CDI consortium, to move our data from B2SAFE to their services, and updated the data portal to replicate new data uploads.

We migrated to a updated version of the triple store database engine to ensure that we could keep growing the number of datasets we host for at least 10 years to come, and to make sure that our user interface will stay performant.

Other changes include an upgrade from Java 11 to 21, improved station pages with links to extra content (eg. https://meta.icos-cp.eu/resources/stations/ES_GL-ZaF), the possibility to preview more types of NetCDF files, the automatic upload of atmospheric data to WDCGG, and many other smaller improvements and bug fixes.

On the server infrastructure side, two of our servers were relocated to Lund's University IT Division. Our two remaining servers should also be moved there in the future. A new monitoring tool was set up to show the availability of our main services and make sure we get alerts if one of them does not respond anymore (https://uptime.icos-cp.eu/status/core).

The independent instance of the Carbon portal used for the ICOS Cities project at https://citydata.icos-cp.eu/portal/ was further extended and is now in full use for the project, so that it now is filled with 13 000 data objects of 17 different data types, next to high precision ICOS tall tower GHG data also including data from urban CO2 flux, low- and midcost GHG sensors, total column GHG observations, model and emission inventory data.

FAIRness improvements

F.A.I.R. is a fairly recently minted concept (Wilkinson et al., 2016; see also https://www.go-fair.org/fair-principles/fairification-process/), that has been formulated as principles, without making reference to specific implementations, although it is stated that using the approach (as applied in Carbon Portal) of using Linked Open Data (LOD) and semantic web technology comes quite natural to build FAIR data systems. Measuring compliance to the FAIR principles is not straightforward, as the concept is purposely defined loosely, but there is a clear need to be able to track progress and compare different systems on the way to achieving more FAIR data systems. In the framework of the GoFAIR project work has started to use so called FAIR Implementation Profiles (FIP) to document better the choices repositories and communities have made to achieve their FAIR(er) data systems.

In the projects ENVRIHUBnext and IRISCC (for more details on these projects please see the project sections later in this report) we follow up on the recently finished ENVRIFAIR and EOSC-Future to further work on the interoperability of our data services with the other European environmental research infrastructures and common data and service catalogs using FAIR principles.

An interesting and advanced way of 'scoring' FAIRness has been developed by the FAIRsFAIR project (https://www.fairsfair.eu/) using the F-UJI tool (https://www.f-uji.net/), that provides a numerical score from 0 to 100% on how FAIR a certain data set is provided, the score is based on the FAIRsFAIR Data Object Assessment Metrics. In Figure 8 the F-UJI score is shown for an ICOS Level 2 data object. The resulting score early 2024 is 91%, which is graded as Advanced level. In a study performed by the European Commission (2022), where the same tool was used to evaluate FAIRness, ICOS Carbon Portal ranked 8th on the 26 tested repositories (see Figure 9). This result was achieved in 2020 with a score of 65%, now CP would rank 2nd with the score of 91%.

Figure 13 F-UJI score for the FAIRness score of an ICOS Level 2 data product for the atmosphere domain at the end 2024

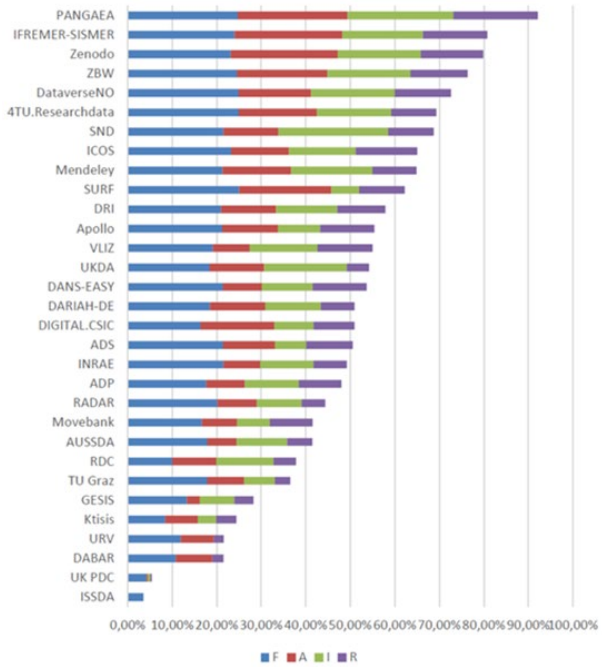


Figure 14 Comparison of the FAIRness scores of 31 data repositories using the F-UJI tool according to European Commission (2022), the comparison was performed in 2020.

Data science

Through the engagement of Carbon Portal staff, ICOS is involved in various initiatives that seek to develop research data management (RDM) concepts and associated technologies that can support and sustain Open Science and FAIRness – both for human and "machines". In part this work is carried out in the framework of European research and infrastructure development projects, like ENVRI-FAIR and EOSC Future, where the CP has contributed to discussions and scientific use cases that both identify gaps in understanding and interoperability, and then develop technological ICOS solutions to these issues. Of special interest has been investigating how ICOS can streamline the use of persistent identifiers (PIDs)

In parallel to these efforts, ICOS is also represented in working and interest groups of international initiatives like the Research Data Alliance (RDA)[1[1]], the FAIR Digital Object Forum[2[2]], the EOSC Association's. Opportunity Area 1 Expert Group on Persistent Identifiers[3[3]] and the Synchronisation Force initiative from FAIR-IMPACT[4[4]]. In these fora, we have contributed to discussions and other activities (surveys, recommendations) with insights from a "research infrastructure as end user" perspective.

RDA:

• FAIR DO Fabric IG[5[5]]: M. Hellström (appointed co-chair in August 2022) is a contributing member, coordinating activities on FDO-related training and awareness-raising.

• InteroperAble Descriptions of Observable Property Terminology (I-ADOPT) WG[6[6]]: M. Hellström monitors developments, as this group is now in maintenance mode.

1[1] https://rd-alliance.org/

2[2] https://fairdo.org/

3[3] https://eosc.eu/opportunity-area-exp/oa1-persistent-identifiers/

4[4] https://fair-impact.eu/synchronisation-force

5[5] https://www.rd-alliance.org/groups/group-fair-digital-object-fabric-ig-1942598258/activity/

6[6]https://www.rd-alliance.org/groups/interoperable-descriptions-observable-property-terminology-wg-i-adopt-wg/activity/

FDO Forum: M. Hellström is a contributing member of the working groups on Technical Specification & Implementation (TSIG) and Basic Infrastructure and has in this role co-authored several reports, including the FAIR DO Specifications draft. She also co-chaired the Forum's Technical Advisory Committee (until its disbanding in mid-2024).

Open Science Champions at Lund University: A. Adamaki represents ICOS in the group of Open Science experts who are appointed by the Lund University Research Board to act as Open Science ambassadors and raise awareness within the academic communities. The champions organised in November 2024 the LU Open Science Days, a mini conference where several LU groups and infrastructures (ICOS CP among them) presented their work with Open and FAIR practices in Science.

Training on Open Science, RDM and FAIR

ICOS Summer School 2024

Carbon Portal organises the bi-annual ICOS Summer Schools in Hyytiälä, where about 35 students get introduced in the fine art of science around greenhouse gas measurements and modelling. The next regular summer school will be in May 2025. In the framework of the Global Greenhouse Gas Watch initiative the idea came up to organise together with WMO/IG3IS another instance of this ICOS Summer School directed at capacity building for interested scientists from the Global South. WMO therefore organised a call for participants and selected 25 persons from 12 countries (Armenia, Costa Rica, Ecuador, Egypt, India, Indonesia, Moldova, Morocco, Panama, Peru, South Africa). Sponsors of this special summer school were WMO, WMO IG3IS (through a NASA grant) and the NUBICOS project. Through an intense and condensed program (6 instead of 10 days compared to the regular summer school) students received an in-depth overview of all aspects of carbon cycle measurements and modelling. The course was given August 2024 in Wageningen, The Netherlands. Figure 13 gives an overview of the program. Three excursions were part of the program to see how the measurements take place in reality at ICOS facilities at Cabauw, Loobos and an agricultural peat meadow flux site. Practice sessions were provided on atmospheric transport modelling and data assimilation. Many ICOS related scientists and lecturers contributed to the course.

From	to	Sun 18-8	Mon 19-8	Tue 20-8	Wed 21-8	Thu 22-8	Fri 23-8	Sat 24-8	Sun 25-8
7:00	8:00		Breakfast						
8:00	8:30		Break						
8:30	9:15		Elevator pitches		Getting in the bus	Group work preparation	Remote sensing - De Mazière	The global budget top down vs bottom up - Peters	
9:15	9:30		Break						
9:30	10:15		Intro to ICOS and GGGW - Vermeulen	Ecosystem measurements I - Mammarella	Excursion	Fires and discturbances - Guido van der Werf	Data assimilation- Peters	The global budget top down vs bottom up - Peters	
10:15	10:30		Break						
10:30	11:15		Climate system - Heimann	Ecosystem measurements II - Mammarella	Excursion	GHG fluxes in the tropics - Merbold	Data assimilation practical - Luijkx/Peters	Group work	
11:15	11:30		Break						
11:30	12:15		Measurement principles - Gerbig	Wetland and acquatic emissions - Treat	Excursion	Ocean obs and fluxes I- Ingunn Skjelvan	Data assimilation practical - Luijkx/Peters	Group work	
12:15	13:15	Arrival	Lunch						
13:15	14:00		Carbon cycle I - Heimann	Urban fluxes - Järvi	Excursion	Ocean obs and fluxes II - Ingunn Skjelvan	Excursion	Group work	Departure
14:00	14:15		Break						
14:15	15:00		Carbon cycle II - Heimann	Atmospheric transport modelling - Peters	Excursion	Isotopes, O2 and the carbon cycle - Luijkx	Excursion	Presentations	
15:00	15:15		Break						
15:15	16:00		Chamber measurements - Treat	Atmospheric modelling practical I - Peters	Excursion	Ecosystem modelling I - Bastos	Excursion	Presentations	
16:00	16:15		Break						
16:15	17:00		Open science - data management - Adamaki	Atmospheric modelling practical II - Peters	Excursion	Ecosystem modelling II - Bastos	Excursion	Discussion	
17:00	18:00		Break						
18:00	20:00	Dinner at own expense	Dinner						

Figure 15 Overview of the WMO/ICOS/IG3IS/NUBICOS Summer School 2024 program.

The students appreciated the school very positively, with an overall score of 8.9 on a scale of 1-10, with a main critique on the length of the course, that should have been less condensed and longer.

14

Figure 16 Some impressions of the WMO/IG3IS/ICOS Summer school 2024

Other education and training

During the ICOS Science Conference 2024 Ida Storm presented on September 12 an interactive lecture on how to use Jupyter to analyse ICOS and related data with the title “Tools for Easy Analysis of ICOS data”.

All interactive Jupyter notebooks used in the WMO/ICOS Summer School were hosted at the ICOS Carbon Portal Jupyter Hub.

Together with the Department of Physical geography and Ecosystem Science and the LU Science Faculty Library, the course ‘Introduction to practical data management’ was given during April-May with 9 PhD students finishing the course. The course was this year updated with more hand-on exercises on how write a data management plan and how to publish data following the FAIR principles, as was requested by students from previous years. The course received very positive responses and at the moment it is considered to make the course part of the core of the PhD research school at the Lund University Science Faculty

The CP contributed to the PhD course ‘From CO2 in situ measurements to carbon balance maps as a tool to support national carbon accounting’, which is part of the ClimBEco research school at Lund University. The course, with 9 PhD students from Lund university, took place in the period from 19th of August to the 11 of September, with an intensive campus period from 2-6 September. Staff from the CP contributed with lectures, development and supervision of exercises and use of the Jupyter Hub for the applications.

Management

Human resources

As mentioned the conclusions of the retreat in May 2024 lead to a re orienteering of some positions and redistributions of tasks. Due to one of the developers leaving to industry in September, this led to the definition of four new positions, two developers, a data steward and a user support engineer.

Maggie Hellström was selected as the new data steward, transitioning from her position as (data) scientist. The other positions were filled by the end of 2024. However in an unfortunate coming together of unrelated events, in the last quarter of 2024 yet another four persons decided to terminate their position, including our lead developer/system architect and our operations engineer, who both had been instrumental in setting up the Carbon Portal from the start. These positions will need be filled in the first half of 2025, making use of the improved strategy and orientation of CP.

Starting January 2025 Jonathan Thiry has taken over the role of lead developer, as he has the right experience and skills, for example by being responsible for setting up, building and running the SITES data portal, built on the CP technology stack.

International cooperation at the Carbon Portal

Global Greenhouse Gas Watch

The WMO initiative Global Greenhouse Gas Watch (hereafter G3W) aims at providing global products of monthly net fluxes of CO_2, CH_4, and N_2O with 1x1 degree resolution, aiming to reduce uncertainties and increasing the reliability of the GHGs monitoring systems.

In 2023, the 19th World Meteorological Congress (Cg-19, Resolution 5) approved a concept note for the G3W, which aims to support WMO Members' decision-making in mitigation actions to implement the Paris Agreement by providing more accurate information.

This concept has been developed in a close collaboration between WMO and partner organizations like ICOS in dealing with greenhouse gases and carbon cycle. In 2024, WMO INFCOM-3 approved the G3W Implementation Plan (IP), and the 78th Executive Council (EC-78) endorsed the plan to officially commence its Pre-Operational Phase (IPP) for the period 2024-2027.

G3W will create a technical framework for member countries to cooperate on production of the Greenhouse Gas (GHG) data products that would help to understand and access the impact of mitigation actions taken by the Parties to the UNFCCC and the Paris Agreement on the state of climate. Such information will be produced in a timely manner and will consider both human and natural influences on the levels of greenhouse gases in the atmosphere.

Initial focus will be on the three most important GHGs influenced by human activities, namely carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Increasing abundances of these gases in the atmosphere are the dominant cause of the observed climate change and related impacts according to the Intergovernmental Panel on Climate Change. Recent increases in atmospheric concentrations of CO_2, CH_4 and N_2O have been documented to be driven by human activities.

It is anticipated that ongoing and new research to develop capabilities to further separate these net fluxes into source-apportioned emissions will lead to additional operational products in the future. Per WMO's data policy and in the interest of maintaining transparency as required under the Paris

Agreement, the data are expected to be made available to all users worldwide on a free and unrestricted basis.

CPD was selected to advise WMO in two of the three task teams that will guide the further development of the G3W: Task Team on Networks and Task Team on Data. Both task Teams and the previous advisory committee on G3W have two monthly meetings and will organise 1-2 face to face meetings or workshops per year, usually to be held in Geneva.

WMO Scientific Advisory Group for Greenhouse Gases

2024 was the last year of the 8 year term for CPD as chair of the WMO Scientific Advisory group for Greenhouse Gases. Starting 2025 CPD will represent ICOS as ex-officio member in this committee. As in the years before CPD acted as chief editor of the WMO bulletin for Greenhouse Gases 2024, that received a lot of attention in the worldwide press. Also CPD was co-organiser and session chair of the 25th WMO GGMT meeting, this time held in Brazil.

Atmosphere Thematic Centre

Highlights

- New version (rackmount) of FTIR Spectronous on the ICOS list of compliant instruments.
- Publication of the first L1 Fast Track release
- Publication Eddy covariance with slow-response greenhouse gas analysers on tall towers

Task 1. General management

ATC Data Processing unit and Mlab meet on a weekly basis; ATC as a whole on a monthly basis.

ATC director attended all RICOM meetings and ICOS GAs and performed the required reporting. ATC is also largely involved in the MSA Atmosphere that take place twice a year.

Task 2. Data management / production

Task 2.1 Level 0 data transfer

New instrument registrations took place and new data transfers have started. The Spanish El Arenosillo should be proposed for labelling at the spring GA

Maintenance

- IT maintenance of the network data. Manage multiple instrument movements on different sites as well as change of processing parameters.
- The new interpolation of the water vapor correction factors has been applied to 22 couples station/instrument with 12 couples having timeseries over 2 years.
- Reprocessing of all the Ansto radon data to apply the new normalization.
- Reprocessing of all the N2O data to consider the new CAL internal N2O scale and the new short term working standard correction method.

Developments

- New short term working standard correction method which uses the CAL assigned N2O values.
- Evolutions of the new processing chain for the EM27 instruments in the frame of the PAUL project. In particular the possibility to generate files containing all species together.
- New processing chain for NOx data in the frame of the PAUL project.
- New black box processing chain for Black Carbon data in the frame of the PAUL project.
- Evolutions of the chain processing the CAL tank data. Handling of changes of the tank species content behavior over time.
- Evolutions of the chain processing the flask data, additions of several comparisons between flask and in-situ data.
- Evolution of the Ansto radon processing chain with the addition of activity normalization using temperature and pressure.
- Evolutions of the blackbox of Heidelberg radon data.
- The weekly GHG data reports for the Pis have been enhanced, addition of a section providing the list of data inconsistencies. A dedicated report for inconsistencies has been developped to list all the inconsistencies to help the PIs before data releases.
- The first version of web-based form, included in WebObs, allowing Pis to request the creation of new ICOS instruments is online.

- Evolutions for the preparation and generation of the ICOS releases, Obspack data releases including now N2O data, L1 Fast Track data releases and the PAUL project data releases.
- Evolution of the graphical applications:
    - Updates of the ATCQc to display and qualify EM27 data.

New data servers have been installed, more powerfull and with more storage. At the same time the database has been updated to a new version.

Task 2.2 NRT data production

A total of 43 stations are connected to ATC, sending their data and processed in NRT mode. This represents 24023 (nearly equal to 2023) raw archive files (~165Go) processed for an availability rate of ~0.99 stations which transmit their data over the complete 2024 year.

Task 2.3 NRT data visualization and distribution.

NRT data visualisation can be accessed on ICOS ATC website [https://icos-atc.lsce.ipsl.fr/dp], through the page of the NRT data products generated at ICOS ATC, and/or, depending on the product, directly on the panel board of the concerned station (accessible via its trigram code).

In 2024, 15741 products files of graphical NRT Data Products are produced daily from NRT measurements (total volume of 1.72Go 1.39Go (+23%/2023) and freely available on the ATC website for station monitoring and diagnosis.

Those Data Products are for PIs to verify the status of their stations. In total, for the year 2024, nearly ~ 4600 users have interacted with ATC's website, for ~ 56900 page views. These usage statistics are of the same order of magnitude as for 2023.

Task 2.4 Level 2 data production.

The new Level 2 (2024-1 release final quality controlled) data from the atmospheric network has been released on July 2024 by the ICOS Atmosphere Thematic Centre. This is the 2024-1 release containing data from the atmospheric network of ICOS Research Infrastructure for 39 stations and atmospheric composition at all available vertical levels at stations Birkenes, Cabauw, Gartow, Hegyhátsál, Helgoland, Hohenpeißenberg, Hyltemossa, Ispra, Izaña, Jungfraujoch, Jülich, Karlsruhe, Křešín u Pacova, La Réunion, Lampedusa, Lindenberg, Lutjewad, Monte Cimone, Norunda, OPE, Ochsenkopf, Pallas, Plateau Rosa, Puijo, Puy de Dôme, La Réunion, Ridge Hill, Saclay, SMEAR-II Hyytiälä, Station Nord, Schauinsland, Steinkimmen, Svartberget, Torfhaus, Trainou, Utö - Baltic Sea, Westerland, Weybourne, Zeppelin Observatory and Zugspitze. This collection contains the final quality controlled hourly averaged data for the mole fractions of CO2, CH4, N2O, CO and meteorological observations measured at the relevant vertical levels of the measurements stations; 14C in CO2 in two-weekly integrated samples (17 stations); and analysed flask data for CO2, CH4, CO, N2O, SF6 and H2 (17 stations), for the period September 2015 to April 2024. All stations follow the ICOS Atmospheric Station specification V2.0 (https://doi.org/10.18160/GK28-2188) and are certified as ICOS atmospheric stations Class I or II. Data processing has been performed as described in Hazan et al., 2016 (doi:10.5194/amt-9-4719-2016).

An update of the official release of the European Obspack project compiling atomospheric CO_2, CH_4 and N_2O from ICOS an non-ICOS European stations for the period 1972-2024 has been issued.This data package contains high accuracy CO_2/CH_4/N_2O dry air mole fractions from 69/69/32 ICOS and non-ICOS European observatories at in total 152/148/73 observation levels, collected by the ICOS Atmosphere Thematic Centre (ATC) and provided by the station contributors. The package is part of the Globalview

EU data product, released in 2024 and is intended for use in carbon cycle inverse modeling, model evaluation, and satellite validation studies.

European CO_2 ObsPack, packaged by ICOS Carbon Portal - https://doi.org/10.18160/X450-GTAY, European CH_4 ObsPack, packaged by ICOS Carbon Portal - https://doi.org/10.18160/PAWA-B2Y4 and European N_2O ObsPack, packaged by ICOS Carbon Portal - https://doi.org/10.18160/6ZXD-BAAZ

Publication of historic DWD Radon Data. https://doi.org/10.18160/q2m8-b1hj

Task 3.1 Perform instrument testing

In 2024, ATC MLab has performed all the instrument testing required for the station labelling or quality check after repair. It includes: leakage rate, instrument precision, linearity and drift, short term and long-term repeatability, sensitivity to inlet pressure, atmospheric pressure and temperature, H_2O correction. ATC MLab has provided a test report and a certificate of compliance to all the instruments tested. Moreover ATC MLab has performed technology watch activities with new analyzer testings. This was the case for the new Picarro N_2O analyzer, PI5310, which is supposed to offer better robustness (weakness of the previous version, G5310) and performance. ATC tested the ability of this analyzer to measure the $^{13}CO_2$ in order to potentially improve the N_2O measurement performance (crosstalk) and consider CO_2 isotopic ratio measurement by combining a PI5310 with a CO_2 analyzer (G2301 or G2401) Picarro which measure $^{12}CO_2$ (performance assessment in progress at MLab) In addition, ATC Mlab has test new analyzer from AERIS measuring the differents species targeted by ICOS : CO_2, CH_4, CO, N_2O, H_2O and a new version QCL spectrometers from MIRO able to measure GHG (CO_2, CH_4, N_2O, H_2O) and Air Quality compounds (NO, NO_2, O_3, CO, NH_3) at high frequency in order to potentially open the field of application to the flux measurement (by eddycovariance) in addition to the accurate and precise concentration measurement. The performance for flux measurement has been demonstrated in the framework of the ICOS-Cities project (intercomparison of the fluxes retrieved from MIRO and Campbell Irgason). The test of the new version of the MIRO was aiming to better characterize the analyzer response, in particular with water vapor, in order to improve the performance for the concentration measurement (not flux which require different specifications), especially the stability during tank measurement. Indeed, if MIRO analyzers have demonstrated interesting performance for flux measurement, it has shown significant limitation for atmospheric background GHG mole fraction measurement. Thanks to the test conducted at ATC, MIRO is improving the performance of its QCL analyzer for atmospheric concentration measurement.

ATC has tested different strategies for the correction of N_2O short term variability. Indeed, the original strategy based on a regular calibration in the field of the working standard to correct the instrument intrinsic variability, has shown limitation, especially with very unstable analyzer, by introducing significant bias between consecutive calibrations (every month typically). The strategy finally tested and implemented on the ICOS server, consist in considering the CAL FCL assigned value as the reference value of the working standard (instead of the regular calibration in the field) to characterize and then correct the instrument variability. If this approach has provided a significant improvement for many N2O analyzer, it has also highlited issues which are under investigation.

ATC is also still working on performance testing and characterization of several mid and low-mid cost sensors for CO2 and CH4 like MirSense MultiSense photoacoustic sensor, Senseair HPP and K96, Vaisala GMP343, Figaro CH4 Metal Oxide sensor, Alpha Sense CO sensor, Axetris LGD CH4, Cubic CH4, ABB HoverGuard… This prospective work takes place for new domain of application (mobile measurement, dense low-cost sensor network for urban area or industrial site…). This work also feeds in ATMOACCESS to provide a testing platform for manufacturer and training (Nov 2024 in Zurich) and ICOS-Cities-PAUL focusing on CO2 emission in 3 urban areas: Paris, Munich and Zurich.

Task 3.2 Perform atmospheric station audit

ICOS Mobile Laboratory is one of the subunits of the ICOS RI Atmosphere Thematic Centre (ATC). It is physically located in the Finnish Meteorological Institute and mainly funded by the Ministry of Transport and Communication in Finland. The main task is to conduct quality control (QC) by parallel greenhouse gas measurements at ICOS atmosphere stations (AS). Aim is to improve measurement compatibility and development of quality assurance (QA) of the ICOS AS network that ensures credibility of the measurements. The instrumentation of the Mobile Laboratory includes three greenhouse gas analysers: Picarro G2401 (CO_2, CH_4, CO), Picarro G5310 (CO & N_2O) and Ecotech FTIR (CO_2, CH_4, CO, N_2O). The Mobile Laboratory also carries dedicated standard gases to calibrate its measurements and validate the standard gases of ASs.

During the year 2024, the Mobile Laboratory performed three audit visits. The continental class 2 station Juelich (JUE) in the west of Germany, close to the Netherlands was audited at the beginning of the year. Then the coastal class 2 station Lutjewad (LUT) in the Netherlands was hosting the Mobile Laboratory in spring/early summer and finally the coastal class 2 station Westerland (WES) on the island of Sylt in the very north of Germany was audited in autumn. The audit reports of the class 1 station Svartberget (SVB, Sweden), audited in the spring 2023, and of the class 2 station Monte Cimone (CMN, Italy), audited in autumn 2023, were finalised during the year 2024.

As a part of QC procedures of the Mobile Laboratory, it monitors calibration scales between ICOS CAL and Mobile Laboratory, using travelling cylinders prepared by WMO/GAW Central Calibration Laboratory.

Task 3.3 Perform training activities for ICOS atmospheric measurements

ATC has organized one in-person training. The attendees of this training were PIs/Staff from Hungary, Ireland, Italy and Germany. It lasted over 3.5 days.

All the initial training requested for new ICOS incomers and step 2 labelling have been provided by ATC.

ATC will continue to offer standard training at ATC in order to answer the demand of new incomers and also to deal with the technical staff turnover. These standard trainings can be online and face-to-face meeting at LSCE (more suitable for experimental practical work).

Task 3.4 Station Labelling

The ATC workplan, reports and associated budgets were provided to ICOS HO. Labelling of 1 new ICOS Atmosphere stations in 2024:Hegyhátsál. Also one new station has gone through step 1

Task 4. Projects and international cooperation

ATC was involved in 2024 in the following EU projects: ENVRI-FAIR, IsoMet, Atmo-Access, PAUL/ICOS cities.

Task 5. Other activities

Webobs is a web application for monitoring and managing atmospheric measurement stations, developed at ATC. It provides support to station managers of the ICOS network and other networks to assist them in the maintenance of their stations. With Webobs user-friendly interface, the station manager can easily manage inventory, track equipments and tanks, add station events, and collaborative tools such as troubleshootings and tests performed on the instruments on stations. In the framework of the ICOS Cities project, ATC has developped a web application tool, based on the existing

Webobs development, in order to manage the metadata related to the midcost sensors. It offers an interface to declare all the metadata which is then easily queried for automatic data processing.

ATC has negotiated with Picarro a price harmonization within Europe and an ICOS discount.

ATC is pursuing its activity to get accredited with the ISO norm 17025 for the instrument testing activity of the Mlab

ATC has put in place a new compressor facility based on resato technology to fill in high pressure tanks.

Ecosystem Thematic Centre (ETC)

Highlights of the year 2024

- labeling proceeding toward the end
- Level2 and Level2 Interim routinely processed and shared
- Increased international visibility in FLUXNET and CalVal activities

Task 1. General management

Task 1.1 Management and provision of the ETC and the related It- and data management

ETC participated in the spring and fall GAs presenting the results obtained and the situation of the activities, to the Scientific Advisory Board meeting of and the Evaluation process meetings. ETC participated in the RICom meetings and teleconferences. A series of meetings have been organized in order to develop solutions for the specific financial situation of the ETC, including the preparation of different scenarios. Meetings have been both internal (with the stakeholders of the three countries) and external, with the HO and GA representatives.

Task 1.2 Reporting

The activity and financial plan for 2025 and the report of the 2023 activities (including the financial report) have been prepared and submitted to the DG and HO using the agreed template and guidelines approved by the GA.

Task 2. Data Management / Data production

The data collection continued in a systematic and robust way, including new stations and involving both ETC and Carbon Portal. All the labelled stations and the stations under the labelling procedure submitted data and metadata. Vegetation samples and soil samples have been shipped by 30and 8 stations respectively to the ETC labs in France for analysis.

Level2 data have been produced and distributed through the CP, including the Interim version released after the growing season. Near Real Time data production and release continued operationally and the data release covers the period from the last Level2 release to the current day.

Subtask 2.1: Raw data collection and transfer, including their metadata

The raw data flow from the station to the Carbon portal continued regularly under the supervision of the ETC. The metadata needed to interpret and then accept the files submitted are transferred regularly to the Carbon Portal in a machine to machine procedure. Also, the ancillary raw data, particularly the DHP and ceptometer files have been regularly submitted to the ETC portal and transferred to the Carbon Portal where they are archived and assigned a PID. There have been 1338 vegetation samples shipped to the ETC (they were 671 in 2018, 934 in 2019, 989 in 2020 and 1242 in 2021, 1322 in 2022, 1218 in 2023) for the analysis and all the samples have already been analysed and imported into the database. In addition, 734 soil samples have been shipped for analysis in 2024 and are under processing. The soil samples are stored in the long-term facility for a total of 23 sites.

Subtask 2.2: From raw data to Level 1 data

Near Real Time data are produced every day and transferred to the Carbon Portal. The processing, scheduled every morning at 7 AM, after the check of raw data completeness and coherence with the metadata (that generates alert messages to the Station Teams for rapid intervention), produces several results that are uploaded to the Carbon portal. The NRT data also include the auxiliary data provided by the eddy covariance sensors that can be important for the early detection of issues with the different sensors. The NRT results are cumulative, with the addition of 48 half hours every day, and they start the day after the release of the Level2 data.

Subtask 2.3: Level 2 data production

The Level 2 data production and upload to the Carbon portal happened twice in the year, as has been common since 2022. The first release of the official Level2 is performed by the end of April and covers until the end of December of the previous year. The second processing period has been defined at the end of the growing season for both the continuous (fluxes and meteorological) and ancillary data. The product, named Level2 Interim, deprecates the official Level2 released in spring, and it is deprecated by the new official Level2 released the year after in spring.

The new metadata system with persistent identifiers of single sensors has been extended to almost all the variables and the results are distributed by the Carbon Portal that accesses the data through an API. Also in 2024 a special emphasis and investment has been done on the meteorological data quality control and processing, with a person full time dedicated to this and in continuous contact with the PIs and station teams. In addition, new developments in raw data processing, after discussions with the ecosystem MSA, have been implemented and are currently under test in the new Level2 production.

Task 3. Network coordination, training, and network / RI development

Subtask 3.1: Support and training for a correct implementation of the ICOS protocols

Four Instruction documents and six templates for metadata and ancillary data have been revised, clarified and updated in 2024. The sensors listed in the ETC with a unique identifier arrived at 384 models. Continuous support has been provided to the stations' teams to optimize the data and metadata submission. Feedback time on specific requests is generally less than 36 hours and commonly within 24 hours.

Subtask 3.2 Evaluation, optimization, evolution and development of the methods used to measure the ICOS Ecosystem variables are crucial to ensure data quality and consistency

A new Instruction on eddy covariance measurements of non-CO2 gases (in particular CH4 and N2O) have been released and will be implemented and tested, including the processing pipeline, in 2025.

An improvement in the data processing has been added in the continuous data, with a new way to treat the noise in the spectral corrections. This improvement, discussed in the MSA, is under test and it is implemented in the ICOS ETC data processing pipeline for the Level2 preparation beginning in 2025, where it will be finally tested.

A large effort to create a FAIR vocabulary for the sensors used in the ecosystem stations has been started, using the VocBench system. This is expected to have a large impact on the FAIRness of the data and cross-RIs relations.

The processing pipeline for the phenocam pictures has been finalized at the ETC servers and is now ready to process the pictures from the network. This has been done in close collaboration with the phenocam network in the US in order to ensure intercomparable Level 2 data products.

Subtask 3.3 Station Labelling

The activities on the labelling continued in 2024with stations that entered the process and stations proposed for labelling. In particular:

- Eight stations started the labelling procedure (CH-BaK, DE-Amv, DE-Gwg, DE-SfN, FI-Ant, IE-Cra, IE-JtC, IT-Sas,), and all completed the Step1
- Fifteen stations completed the labelling in 2024: 2 Class2 (FI-Lom, SE-Myc) and 7 Associated (CH-BaK, DE-Amv, DE-Brs, DE-GsB, DK-RWC, IT-OXm, IT-Sas, IT-Trf)
- Currently there are no Class1 and Class2 stations entered before 2023 that are not yet labelled.
- Unfortunately, five labelled stations quit ICOS in 2024, one Class 1 (DK-Vng), one class 2 (FR-Lam) and three Associated (BE-Lcr, DK-Gds, DK-Skj)

Subtask 3.4 Support on ecosystem data interpretation and use

No specific activities on this subtask performed in 2024 except a basic support by email to specific questions about the ICOS products.

ICOS ETC supported PIs to compute and analyse the difference in soil carbon stock between a pre-ICOS sampling take and an ICOS sampling take (BE-Lon, FR-Fon, FR-Gri).

Task 4. Projects and international cooperation

A large initiative started in 2024 to develop a new FLUXNET system, where Regional Networks have a central role in the data distribution, keeping full control of the data processing and sharing and full visibility. The new system is planned to be operational at the end of 2025 but the construction started.

ICOS ETC will play a central role, with the cooperation of ICOS Carbon Portal, ensuring the participation and full visibility of all the ICOS stations and collaborating with the European Database to optimize the process and confirm the central role of Europe in the initiative.

Increased efforts have been made towards the remote sensing community and the use of ICOS data for cal/val activities.

Task 5. Other activities

ICOS ETC started gathering pre-ICOS soil sampling information to identify sites where soil carbon stock difference could be computed.

Ocean Thematic Centre OTC

Highlights of the year 2024

Station calibration system trialled successfully (previously known as lowered sampler)

Engagement of ICOS staff in WMO planning process

Successful submission of SOCONET to GOOS as emerging network

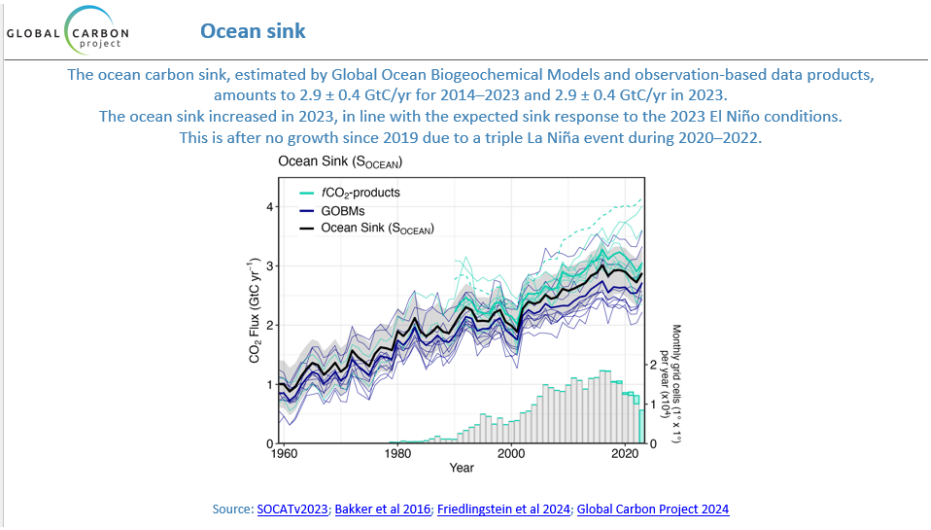
Submission and funding of TRICUSO

Oostende declaration on Operationalising Surface Ocean Carbon Value Chain

Task 1. General management

Information flow within the network, tracking impact and use of the outputs supplied by the network

The major output of information supplied by the ICOS Oceans Network is the set of observations which enter the Surface CO2 Atlas, which are then used by multiple groups in the Global Carbon project to estimate surface ocean uptake which is then reported to the COP. This process continued as normal in 2024 with multiple groups from ICOS represented in the final Global carbon budget reported in late 2024 (ESSDD - Global Carbon Budget 2024). ICOS Oceans authors included: Peter Landschützer, Are Olsen, Meike Becker, Henry C. Bittig,Thanos Gkritzalis, Siv K. Lauvset, Nathalie Lefèvre, Tobias Steinhoff. The data continued to show that an offset exists between measured and modelled estimates of ocean C uptake, with measurement based estimates Green lines in Figure below) being significantly larger than those based on models (blue lines in Figure below). The reason for this offset us unknown, and is currently stimulating a great deal of effort within both the global and ICOS Socnece communities. The OTC is leading a grant with a significant work package focused on understanding this discrepancy and a further grant aimed at improving the quantity of data available to address this issue, focussing on key undersampled regions of the ocean in the southern hemisphere.



Attend MSA meetings twice per year to report on previous years actions and present next year's workplan, plus other meetings as requested

We attended the MSA in spring 2024 (online) and in fall 204, (in person), combined with MSA training course in Villefranche.

Produce workplan for 2025 in Autumn in discussion with MSA and submit to head office

The 2025 Workplan was submitted assuming full funding for the Norwegian research Council submission which was made in spring 2024. The reduced level of support allocated meant that the workplan had to be rewritten over Christmas 2024/2025. We are able to maintain a slightly reduced level of service to the stations going forward.

Monitor delivery of workplan via quarterly reviews

In addition to the ongoing review of activity that takes place at the weekly meetings we also held an OTC awayday to mark the end of phase II of ICOS and to plan phase III. This was held in Bergen in fall 2024 and was attended by OTC staff from Exeter, Southampton and Bergen, MSA chairs, Dorothee Bakker from the ICOS SAB, Alex Vermeulen from the CP and Werner Kutsch from HO. This discussed the future strategy of the Ocean element including its relationship to other key initiatives such as those supporting the WMO Greenhouse Gas watch, the role ICOS can play in supporting SOCAT, the relationship between ICOS and GOOS and its multiple networks, the forthcoming relocation of some OTC staff from UiB to VLIZ to deal with data management and the forthcoming loss of Tobias Steinhoff from OTC activities as he returns to his parent workplace in GEOMAR Kiel.

Produce Budget for 2025 in autumn.

The OTC budget was produced. In the final event it had to be restructured to accommodate the reduced level of award from the Norwegian Research Council

Produce report on 2023 actions and expenditure in spring for submission to GA

Both these reports were produced

Organise weekly OTC meetings

The weekly OTC meetings, with minutes and actions lodged on the Fileshare

Produce newsletter and maintain website, plus social media presence

The OTC website was maintained, with significant activity towards refreshing it.

To welcome new stations and to liaise informally with potential new countries including Ned, Den, Iceland and Portugal

We maintained contact with multiple countries in the framework of the JPI Oceans Ocean carbon Capacities initiative and recently have been liasing with the Netherlands (NIOZ) who have expressed a desire to enrol an Ocean station into ICOS

To run townhalls and similar events to publicise OTC actions

We ran a townhall at the EGU meeting in Vienna in 2024 to inform potential new stations around ICOS benefits *(*Session TM16*)*

To support station funding renewals via e.g. letters of support or appearing at panels/ interviews

We provided letters of support for the following activities

1. ICOS Belgium funding renewal, emphasising the importance of their observations in the Scheldt Estuary and Southern N Sea which give important insights into the C cycle in a major N European industrialised estuary and the continental Shelf pump respectively
2. A proposal to produce a European supply of deep ocean CO2 reference materials.

Task 2. Data management / Data production

Task 2.1 Data availability and quality

New stations continue to be integrated into the OTC data flow as they pass through labelling, with PIs and OTC staff using the QuinCe software for quality control and publication to the Carbon Portal.

We have begun work on streamlining the dissemination of ICOS OTC data to external databases (i.e. SOCAT) and also set up an ERDDAP server to allow other Data Assembly Centres to integrate ICOS OTC data into their systems. This is in preparation for the creation of the global SOCONET network of surface ocean carbon observations, which will become an official GOOS (Global Ocean Observing System) network, which intends for all affiliated network to share their data via ERDDAP, as well as providing federated access to other projects that make use of OTC data.

Task 2.2 Maintain metadata records

The data structure for metadata completed its overhaul during 2024 and is now ready to be expanded to include all the metadata required both for ICOS and downstream networks. We are actively involved in ongoing global level discussions on the required metadata for these networks and will ensure that ICOS provides everything needed. The recent restructuring of the OCOS data team includes the services of a metadata expert at the British Oceanographic Data Centre to assist in this process.

Task 2.3 Raw (Level 0) data transfer

All Level 0 data uploaded to QuinCe as the basis for data reduction and quality control are automatically submitted to the Carbon Portal for archiving.

Task 2.4: Ingest and Process Near Real Time (Level 1) data delivered to the OTC from stations

We have set up NRT data flow for three new stations this year, with implementation of a new data pathway via Google Drive and automated rationalisation of data formats into more useful forms for archiving.

Task 2.5: Produce and transmit of publication quality (Level 2) data

L2 data from labelled stations continue to be processed and published at the ICOS data portal. We are also receiving backdated data whose processing has been delayed for various reasons.

Summary of published L2 observations for 2024:

Station	Observations
BE-FOS-Thornton Buoy	1,766
BE-SOOP-Simon Stevin	119,493
DE-SOOP-Finnmaid	315,571
DE-SOOP-Polarstern	349,225
FR-SOOP-France-Brazil	37,294
IT-FOS-MIRAMARE	9,942
IT-FOS-PALOMA	26,639
IT-FOS-W1M3A	808
NO-SOOP-G O Sars	159,947
NO-SOOP-Sea-Cargo Express	77,899
NO-SOOP-Tukuma Arctica	151,600
UK-FOS-Porcupine Abyssal Plain	2,442

Task 2.6: Software development and maintenance

The QuinCe software has been maintained with much work focusing on keeping dependencies up to date and integrating the data from new stations. Work continues on adding support for SubCTech sensors in communication with the manufacturer; this should be complete in early 2025. Where time has allowed features have been added and adjusted to reduce 'pain points' where the software is difficult or inefficient to use, along with improving general performance.

Task 3. Network coordination, training and development

Task 3.1 Training to optimize and standardize performance of the network.

ICOS stations tend to use one of two basic technologies to measure surface ocean CO_2 levels, systems directly calibrated to gas standards from the ICOS Calibration Laboratory and membrane based systems which rely on pre and post deployment calibrations plus any opportunistic comparisons made during station visits. We work hard to support both communities including via the provision of technical solutions to allow better calibration of buoy mounted systems and the provision of bespoke Software known as Quince to allow data processing of both data streams (see figure below).

Several tutorial videos have been created for the QuinCe software allowing new users to learn how to use it with less reliance on direct support from OTC staff. These have been published publicly on Vimeo.

Workshop: In autumn 2024 OTC organized an in-person 4 day workshop in Villefranche, France. The workshop provided practical training on 4 instruments that were on site : OTC pCO2 validation system (based on GO system), Contros HydroC (submersible and FT), Vegas (Hagan GenX) and a HydroFIA TA. In addition there were plenary discussions regarding uncertainties and the creation of an ICOS-Oceans knowledge base.

In May 2024 OTC participated in the GEORGE technical forum I, presenting the different platforms used in ICOS-Oceans.

MSA Meetings: We organised a virtual MSA meeting in spring and an in person MSA meeting at the end of the training workshop held in Villefranche. All station a are given an opportunity to provide station updates, whether labelled or not. Various topics were discussed this included updates from the OTC, Data Updates, SOCAT, WMO, Station Labelling and Future Projects.

Station Ringarounds: Between July 2024 and September 2024 we aimed to conduct the annual station ring around where all PIs are asked to participate. The response from Station PIs this year was poor. The results previously have helped us provide give a good overview over the network condition (in terms of funding and technical problems). A more detailed overview could not be created this year.

Lowered Sampler / Station validation System: The OTC pCO2 validation system was built and tested in 2024. The system is a General Oceanics pCO2 system 8050 which was upgraded to be used with the laser-based LI-7815 . In addition, a submersible sea water pump can supply water to the pCO2 system from the depth of interest (max 20 m). The equipment was used for the first time in the Baltic Sea at SE-FOS Östergarnsholm in April 2024. There, a comparison was performed between a SAMI-CO2 sensor, a Hagan-GENx pCO2 sensor, and the OTC pCO2 validation system. There was a good agreement particularly between the OTC pCO2 validation system and Hagan-GENx pCO2 system, which also uses reference gases during regular measurements. This piece of work has lead directly to the labelling work undertaken at Östergarnsholm which will be reported in 2025.

Labelling

In 2024, the ICOS ocean network encompassed 29 stations, of which 12 were of the category FOS (Fixed Ocean Stations), 16 were SOOP (Ship Of Opportunity), and 1 was MFT (Marine Flux Tower). In 2024, the ES-SOOP CanOA moved from being a Class 2 station to becoming a Class 1 station and the NO-SOOP

Sea Cargo Express was labelled a Class 2 station. This means that slightly more than 50% of the ocean stations are labelled.

By the end of 2024, one station left the ICOS community (UK-FOS WCO) and one station moved from being a MFT to becoming a FOS (SE-FOS Östergarnsholm).

The labelling is an continuous activity where we help the stations achieving data of highest possible quality, give advices regarding instruments and installation, and help trouble shooting when things don't work as they should.

Inspired by the outcomes from the Intercomparison experiment i Ostende in 2021, we are in the process of revisiting the labelling scheme for the oceanic stations. There is no conclusion from this work, yet.

Task 4. Projects and international cooperation

International collaboration and standardization are key activities to increase ICOS's visibility and ensure cross-RIs data interoperability. The OTC organizes continuous exchange with other similar RIs globally and participates in national and international projects that strengthen ICOS's role in the scientific community. This task ensures a proper flow of information, development, results and connections between the research projects and the ICOS OTC activities. Project work in 2024 included the following:

1. **OceanICU.** 15.7 M Eu Grant lead by NORCE. This large grant focusses on understanding industrial and fishing impacts on C cycle. Key for ICOS is the inclusion of a ca. 2M component focussed on understanding the model data mismatch in the Global C project estimates of Ocean C uptake which exploits ICOS and other data. This is lead by OTC partners at the University of Exeter. Steady progress was made including estimating Ocean C uptake by multiple methods. Leading to a synthesis and review exercise planned for 2025. There are other elements supporting network design and the International ocean Carbon coordination project which Jones and Sanders on the Steering Committee of.
2. **EuroGOSHIP.** 3M EU lead by NORCE with heavy OTC and ICOS head office involvement. Aims towards integrating Hydrographic Sections into Research Infrastructure landscape. Actions relevant to ICOS include ones around system design and standards as well as funding agency liaison. This wrapped up all its interim reporting in 2024 leading to a draft set of requierments /specification for a new RI service. The work continues in 2024
3. **MARCO BOLO**: EMBRC lead EU proposal on coastal biodiversity including element on Ocean C cycle (OTC element is ca 150K Euros). This is focussed on blue carbon and therefore plays an important role in our thinking around how this can be integrated into future ICOS activities such as the LOAC activity planned within the Foresight exercise
4. **GEORGE**: Head Office / OTC lead technology proposal focussed on building next generation snsosrs and integrating them into existing workflow. OTC element includes data and platform trials, plus international leadership. Multiple stations involved as demonstration platforms.
5. **LandSeaLot.** This is a recently awarded grant lead by Deltares. The OTC component is apilot study involving using carbon isotopes to track the disintegration of terrestrial organic matter in the N Baltic. Again this activity is a prelude to the work proposed in the LOAC under the foresight activity
6. **NUBICOS.** This is a head office lead activity that includes elements on software engineering for QUINCE
7. **Aquarius** and **AMRIT**. These are two small grant lead by others in the RI landscape that consider the integration of RI activity.
8. We submitted a successful Horizon Europe grant to integrate activity within ICOS, EMBRC and Argo in support of a comprehensive Southern Ocean observing system. Details are available here (Three Research Infrastructures together: Carbon Uptake Southern Ocean | TRICUSO |

Project | Fact sheet | HORIZON | CORDIS | European Commission) and the abstract is reproduced below

The ocean is key in the global C cycle, taking up ca. 25% of the CO2 we emit, slowing climate change and giving us more time to mitigate and adapt to climate change. The Ocean C Value Chain (VC) of observations, data QC & analysis delivers key information around this to decision makers such as the Conference of the Parties. The RIs play a pivotal role in the VC via their ability to operate at scale & pool resources to ensure common data standards and operational practices. The urgency of the climate crisis drives us to put this VC on a much more robust footing with the World Meteorological Organisation leading the planning of a Global Greenhouse Gas Watch (G3W) covering all components of the Earth System.
Unfortunately, the VC currently delivers estimates of Ocean C uptake much larger than those from models, leading to a damaged ability to manage climate change. However further work suggests that observations at a much higher density in the Southern Ocean (SO) would substantially resolve this issue. Our ability to deliver these via ships is limited by the small number that enter the SO and we therefore need many more observations from research vessels, citizen science platforms, autonomous robotic floats & surface platforms. This step change requires substantial technological innovation and complex data synthesis.
TRICUSO will address these needs by a) improving the sensing technologies on floats and small uncrewed surface vessels, b) supporting citizen science on yachts and potentially cruise and expedition vessels, c) integrating biological observations into the work flow, d) improving data flows to scientists, e) evaluating the density of observations needed & f) proposing fit for purpose governance structures that allow the RIs to operate within the G3W. These actions will enable us to have a much firmer grip of how and why Ocean Carbon uptake varies and thus a much firmer evidence base on which to make decisions around managing climate change impacts.

Task 5. Other activities

1. Planning phase 3 of ICOS (2025-2029) including budget discussions and extension scenarios

   We submitted a proposal to the RCN in spring 2024 requesting further support which was partially supported. We also engaged strongly in the Foresight exercise and lead one activity on the LOAC

2. To contribute to ongoing actions around sustainability of the (Surface) Ocean CO_2 observing system including the JPI Oceans Ocean Carbon Capacities programme, the UN Decade Exemplar, the IOCCP/ G7 FSOI Surface pCO2 task team and the WMO GHG observing system initiative.

   Work in this area was extensive. The JPI Oceans action is now reaching out to multiple research organisations in Europe around their possible contributions, The Exemplar activity is likely to underpin a future (2025) grant submission to address requirements for ocean C observing in support of carbon dioxide removal activities. The IOCCP activity is mow mainly concentration on the establishment of SOCONET building on the 2023 workshop we organised in Ostend and the associated declaration as a contribution to the G3W.

Central Radiocarbon Laboratory (CRL)

Highlights of the year 2024

- The number of ICOS $^{14}CO_2$ flask measurements has more than doubled.
- ΔNO_x observations prove to be a reliable fossil fuel proxy, comparable to ΔCO observations
- The risk of nuclear ^{14}C contributions in ICOS flasks has been significantly reduced due to optimised sampling strategies.

Use of resources per task in 2024

Task	1 General management	2 Data Management / production	3. Network coordination, training and development	4 Projects and international co-operation	5 Other
Total CRL	171	272 (+150)	79	50	36

Share of ICOS CRL resources in per cent; 100 = one full-time person. Worktime shares from Projects are listed in red and given for completeness but not included in the ICOS CRL financial report.

Task 1. General management

This task encompasses the tasks described below, along with risk management in accordance with the host institution's guidelines, RICOM activities following the RICOM Rules of Procedure, general communication and dissemination of ICOS Science, participation in the GA Info Days, meetings with the SAB, and other organizational activities.

Task 1.1 Management and provision of general Central Radiocarbon Laboratory capacity and related data management at the CRL

CRL services and the capacity for sample analysis were fully provided in 2024. After 5 years of operation, the CRL IT infrastructure no longer met current security requirements. To ensure uninterrupted laboratory operation, new server hardware was purchased, and the CRL IT infrastructure was transferred to the new hardware and updated to meet current security standards. After a successful upgrade, the new IT infrastructure was put into operational use.

Following last year's re-evaluation of the ^{12}C-current dependence in calculating AMS results, a CRL internal AMS evaluation and calibration software was developed in 2024. The new CRL internal AMS evaluation software relies solely on AMS raw data and enhances comparability among measurements taken on different dates and from various calibrations. The software objectifies the flagging criteria and ensures complete traceability of the data evaluation, as operators are no longer required to make subjective decisions. Currently, to ensure consistency and validate results, the data flags and evaluation correction factors obtained with the internal CRL software routine are transferred to the manual AMS evaluation software routine used by the external AMS operator (CEZA). We plan to publish the CRL internal evaluation soon. Subsequently, it is anticipated that the CRL internal evaluation software will become the default evaluation software for future ICOS AMS measurements.

Due to the ageing of the existing laboratory equipment, the CO_2 extraction process from sodium hydroxide samples was modified in 2024. Previously, moisture produced during the extraction was

removed using a dry ice trap. This year, we implemented a new CO_2 extraction line featuring a cryostat, eliminating the necessity for dry ice. Up to now, dry ice typically accounted for roughly 15% of the consumable costs. We anticipate the new extraction line will pay for itself within 4 to 5 years.

Deliverable 1: Provision of the Central Radiocarbon Laboratory capacity and the local database.

Deliverable has been fulfilled.

Person-months spent on Task 1.1: 17.2 PM

Task 1.2 Reporting

The general report, which encompasses the financial and activity report for 2023, was submitted to the HO in April 2024. CRL contributed to the ICOS RI five-year work plan for 2025 – 2029. The budget and work plan for 2025 were provided in October 2024 (Deliverable 2). CRL activity updates were presented during the General Assemblies in May and November 2024 and in online meetings with the SAB.

Deliverable 2: CRL general report. The report includes the Annual Activity Report and the financial report, the Annual Work Plan and the Annual Budget for the following year and 5-years Financial Plan. It is based on templates provided by the HO and submitted to the General Assembly and RI Committee.

Deliverable has been fulfilled.

Person-months spent on Task 1.2: 3.4 PM

Task 2. Data management/production

Task 2.1 Radiocarbon analysis of up to 1000 two-weekly integrated CO2 samples per year from the ICOS RI atmospheric station network

In 2024, 17 atmospheric ICOS Class 1 stations and two ICOS Class 2 stations, Izana and Schauinsland, along with the ICOS CRL pilot station, provided integrated CO2 samples to the ICOS CRL. Mace Head did not provide samples in 2024 due to the collapse of the sampling mast. In total, 355 European samples were analysed using low-level counting. Additionally, 32 integrated samples from ICOS stations were analysed by accelerator mass spectrometry (AMS). We analysed 29 non-European integrated $^{14}CO_2$ samples from the polar stations Neumayer (Antarctica) and Alert (Arctic), as well as the ATTO (Amazon Tall Tower Observatory) and Cape Grim (Tasmania). The samples collected at these global background stations facilitate the comparison of various global measurement networks.

Deliverable 3: Continuous reporting of preliminary integrated $^{14}CO_2$ analysis L1 data for all atmospheric class-1 stations

Deliverable 4: 1 Revision of L1 integrated $^{14}CO_2$ analysis data to L2 for each atmospheric data release

Both deliverables have been fulfilled.

Person-months spent on Task 2.1: 21.9 PM

Task 2.2 Radiocarbon analysis of CO2 from up to 1000 flask samples per year

In 2024, the number of ICOS flask analyses rose to 1,087, up from 487 the previous year. This represents an increase of approximately 120%, driven by the additional $^{14}CO_2$ analysis for CORSO. In addition to covering the AMS costs for the extra CORSO analysis, the project funds 12 PM technicians, whose costs are not detailed in the ICOS budget going forward.

For the PAUL project, an additional 403 flasks - about a 70% increase compared to 2023- were processed and analysed for $^{14}CO_2$. The funds from the PAUL project fully covered the expenses for four additional PM technicians and the AMS analysis costs.

Deliverable 5: Continuous reporting of flask sample $^{14}CO_2$ analysis L1 data for all atmospheric class-1 stations

Deliverable 6: Revision of L1 flask sample $^{14}CO_2$ analysis data to L2 data for each atmospheric data release

Both deliverables have been fulfilled.

Person-months spent on Task 2.2: 10.7 PM (+18 PM funded by projects)

Task 3. Network coordination, training and development

Task 3.1: Interaction with station PIs

CRL scientists participated in the ICOS Atmosphere MSA meetings in April and November 2024. The $^{14}CO_2$ results from the integrated and flask sampling were presented to the MSA participants. The CRL and the stations regularly exchange emails regarding sample supplies, spare parts, and other issues. The regular transfer of samples between the stations and the CRL is going smoothly.

In 2024, the CRL executed a new flask sampling selection strategy to minimise the risk of nuclear $^{14}CO_2$ contributions for CORSO-related ICOS stations. Based on this experience, an extended and generalised ICOS flask sampling selection was developed, which the ATC will implement throughout the ICOS network in 2025 with support from the CP and CRL.

Deliverable 7: Meeting and continuous interaction with station PIs. Annual meeting and ongoing exchange with station PIs to discuss CRL-related issues (together with MSA)

Deliverable 8: Supporting PIs in the $^{14}CO_2$ flask sample selection.

Both deliverables have been fulfilled.

Person-months spent on Task 3.1: 4.0 PM

Task 3.2 Production of integrated CO2 samplers

No integrated CO_2 sampler was requested from the network in 2024

Deliverable 9: $^{14}CO_2$ integrated sampler production. Production of up to 6 integrated samplers per year for new ICOS class-1 atmospheric stations

Deliverable in 2024 not applicable.

Person-months spent on Task 3.2: 0.0 PM

Task 3.3: Operation of the ICOS Pilot station, development and evaluation of ffCO2 monitoring strategies

In 2024, the CRL operated the ICOS CRL pilot station, including:

- continuous in-situ measurements with ICOS-compliant CRDS and FTIR analysers
- continuous in-situ NO and NO_2 measurements
- semi-continuous in-situ ^{222}Rn measurements
- integrated CO_2 sampling for $^{14}CO_2$ analysis

Deliverable 10 was completed through continuous operation, the transmission of in-situ GHG data to the ATC, and the submission of the $^{14}CO_2$ results to the CAL-FCL database.

No additional flasks were sampled at the ICOS-CRL pilot station in 2024. During this year, Hannes Juchem completed his MA Thesis titled: *Using NO_x as a Fossil Fuel Proxy at the ICOS CRL pilot station: Challenges and Benefits.* A subset of the results has been presented to the ICOS MSA in April 2024. While NOx poses a more significant challenge for calibration with $^{14}CO_2$ due to its much shorter chemical lifetime, the estimates of $ffCO_2$ based on ^{14}C-calibrated NOx yield uncertainties comparable to those based on CO. The results of the MA thesis will also be presented at the IG^{3}IS/ICOS meeting in Geneva in April 2025, and a publication is being prepared.

Penelope Pickers has presented the results of using APO as $ffCO_2$ proxy at the ICOS science conference in Versailles and is working on publishing those results.

Deliverable 10: Operation of the CRL pilot station. Continuous operation of ICOS standard instrumentation at the CRL pilot station and provision of in-situ and flask data to the ATC.

Deliverable has been fulfilled.

Person-months spent on Task 3.3: 5.4 PM

Task 4. Projects and international cooperation

The analysis of the second pure CO_2 intercomparison (ICP) samples concluded in 2024. It compared sample preparation and AMS measurement among the four leading laboratories conducting global atmospheric $^{14}CO_2$ background measurements: ICOS-CRL, NOAA-INSTAAR, SIO-IRVINE, and GNS. The ICP results were presented at the WMO-GGMT conference in Brazil and indicate that the mean deviations of ICOS-CRL, SCRIPPS, and GNS are within ±0.5‰ of the consensus value. The mean deviation of NOAA from the consensus value is slightly larger at -0.98‰. ICOS-CRL plans to lead a joint publication of the results in 2025.

The CRL participates in the PAUL project, coordinated by ICOS ERIC, and contributes to WP3. In 2024, the CRL analysed 403 $^{14}CO_2$ samples for the PAUL project. The project provides the flask analysis costs, consumables, and a dedicated part-time technician in the CRL.

The EU-Horizon project CORSO (CO2MVS Research on Supplementary Observations), coordinated by ECMWF, began in 2023. This project provides resources and additional workforce to analyse all ICOS flask samples from ten western European ICOS class 1 stations for $^{14}CO_2$ collected in the calendar year 2024. It covers the costs of flask analysis and consumables and includes a dedicated technician for sample preparation. As part of the CORSO project, ETH Zurich was tasked with developing a specialised graphitisation system for ICOS flasks. The project funded a developer position at ETH Zurich, as well as

part of the hardware costs for the CRL. Due to administrative reasons, the funds allocated for hardware costs were redirected to personnel resources for the CRL. By the end of 2024, the new system was completed. However, it is not yet operational, as it still awaits further modifications from Zurich.

For the ATTO+ (Amazon Tall Tower Observatory, Coordinator MPI-BGC) project, funded by the German BMBF, the CRL analysed three integrated samples in 2023. The ATTO+ project pays € 250 per sample plus overhead costs. All results will be available to ICOS RI.

Deliverable 11: Report on Projects and International and extra-ICOS collaborations. It reports, in the context of the Annual activities report, the activities performed and the results obtained from the participation in research projects and other collaboration activities.

Deliverable has been fulfilled.

Person-months spent on Task 4: 0.0 PM (all PM spent on these tasks are funded and accounted in the individual projects)

Task 5. Other activities

The CRL is leading an MSA Atmosphere working group to refine the $^{14}CO_2$ flask sampling strategy. Based on forecasted footprints, the group developed a $^{14}CO_2$ sampling strategy that minimises the impact of nuclear ^{14}C emissions in ICOS flasks. In 2024, this approach was tested at 10 ICOS stations in central-western Europe, which are part of the CORSO project. An ICOS-CRL scientist reviewed the contamination estimates and determined whether samples should be retained. The strategy proved feasible and demonstrated the ability to avoid flask collection during significant contamination events. Following the presentation of the performance of the new sampling strategy at the MSA in November 2024, the working group was tasked with extending the sampling strategy to all ICOS stations, which is planned for 2025.

Max Gachivsky, in collaboration with the MPI-BGC in Jena, is working on $ffCO_2$ modelling at European scales using the CarboScope TM3/STILT inversion system. In 2024, Max focused on utilizing ^{14}C-calibrated CO-based $ffCO_2$ estimates in the inverse models. To achieve this, the $^{14}CO_2$ flask measurements at all ICOS C1 stations were used to calculate station-specific $\Delta CO/\Delta ffCO_2$ ratios, subsequently determining continuous CO-based $ffCO_2$ time series. It was found that not all ICOS stations have sufficient fossil CO_2 signals to establish meaningful $\Delta CO/\Delta ffCO_2$ ratios. Focusing on the stations with adequate signals, preliminary tests indicate that the inversion can estimate fossil CO_2 emissions for the observed area with ±20%, even without prior information provided to the inversion. These preliminary tests suggest that combining CO-based $ffCO_2$ with actual prior information may lead to a valuable validation of CO_2 emissions. Max's PhD thesis will document these findings and discuss recommendations for a modified $^{14}CO_2$ sampling strategy.

Person-months spent on Task 5: 4.4 PM

Flask and Calibration Laboratory (FCL)

Highlights of the year 2024

- Flask sample QC confirms high level of accuracy of ICOS atmosphere station network CO_2 and CH_4 observations through 2024
- All atmosphere class 1 stations equipped with ICOS flask sampler
- First flask O_2/N_2 data release

Task 1. General management

Task 1.1 Management and provision of Flask and Calibration Laboratory capacity and related IT- and data management at FCL

FCL services and the capacity for sample analysis and data management were fully provided in 2024. Routine maintenance of the laboratory technical infrastructure was performed. The UPS (uninterrupted power supply) unit, the CRDS analyser used for CO_2 and CH_4 calibration and the Pulsed Discharge Detector for gas chromatographic hydrogen analysis had to be replaced to maintain the operational capacity.

A. Jordan was participating at the Foresight Day in Debrecen and the General Assembly in November 2024 in Budapest. He also joined both RI COM face-to-face meetings in 2024 (online and in presence in Venice) and the regular monthly RI COM webconferences.

Task 1.2 Reporting

The general report, which encompassed the financial and activity report for 2023, was submitted to the Head Office in April 2024. The budget and work plan for 2025 were provided in September 2024 (Deliverable 2). FCL activity updates were presented to the SAB.

Task 2. Data management / production

Task 2.1: Trace gas analysis

There have been 2292 flask samples from the 17 ICOS class 1 stations with active flask sampling programme that have been analysed (Deliverable 3). The Flask data transfer to the ATC went smoothly. Trace gas data from flask samples including their respective uncertainty estimates were provided for the ICOS Atmosphere 2024 data release in June. The reported CO_2 data result from mass spectrometric analysis using the IRMS that simultaneously measures O_2/N_2 ratios. Those data have proven to be of superior quality. They have been used successfully for quality control of continuous measurements at ICOS Atmosphere observatories resulting in stable median monthly CO_2 offsets (all ICOS stations of 0.03 ± 0.03 ppm for the period 2020 – 2024). The respective long term insitu - flask offset for CH_4 is also low (0.4 ± 0.3 ppb). A flask sample pressure dependent bias of N_2O resulting from a GC valve problem was identified, quantitatively assessed and an approach to correct this effect was developed that will reduce the currently observed bias of 0.2 ± 0.1 ppb.

Task 2.2: Analysis of supplement parameters (CO_2 stable isotopes and O_2/N_2 ratios)

All station air flask samples mentioned in Task 1 have been analysed for CO_2 stable isotopes and O_2/N_2 ratios (Deliverable 4). The O_2/N_2 measurement results have likewise been part of the annual release of ICOS Atmosphere data. For the CO_2 stable isotope results the data processing chain and QC had not been finalised at the submission deadline. This has been completed by end of 2024 and the data set was made available to ATC for the 2025 fast track release.

Task 2.3: Support to maintain ICOS network flasks fit for purpose

All flasks purchased by ICOS stations first received a standardised specification check at FCL before being pre-conditioned for usage. All flasks were reconditioned before being sent to the ICOS stations. Following sample pressure loss the respective flasks underwent a sensitive leak test and were repaired where necessary.

Task 2.4: Production of real air high pressure standard gases within specified composition ranges for the ICOS continuous-core parameters

In 2024, 150 new standard gases have been filled for ICOS atmosphere monitoring and QC activities, 26 standards for ocean observations.

Task 2.5: Calibration and re-calibration of above-mentioned standard gases every third year relative to the current WMO calibration scales at any one time

251 high pressure standard gases have been calibrated and recalibrated for atmospheric stations, 41 for Thematic Centers and 39 for ocean monitoring activities.

A data revision of N_2O calibration data has been conducted that is based on revised assignments of FCL standard gases, a re-assessment of the stability of N_2O mole fractions throughout the service life of standard gases at ICOS stations and the identification of small biases of a specific analyser unit that was in use between August 2022 and February 2023. The revised data have been made available to ATC for reprocessing the continuous atmospheric observations.

A data revision of CO_2 calibration has been prepared that is likewise based on revised assignments of FCL standard gases and that also addresses small systematic biases that arise from differences in the CO_2 isotopologue composition of standard gases that are composed of modified real air relative to true atmospheric air. There had not been a standardized approach for this problem in the international community so the new procedure first had been discussed with colleagues from BIPM and NOAA and was presented at the WMO Expert's meeting (GGMT 2024).

Task 3. Network coordination, training and development

Task 3.1 Interaction with station PIs

FCL scientists participated in the ICOS Atmosphere MSA meetings in April and November 2024 and the MSA QA/QC Working Group Meeting. The FCL and the station PIs routinely interact concerning standard gas requests, flask shipments, and flask sampler questions. The regular transfer of samples between the stations and the FCL is going smoothly.

Task 3.2 Organisation of and participation in international QC activities to link ICOS to other global networks

The ongoing QC programme for flask analysis has been continued. Three sets of "sausage" flasks were prepared, distributed to the participating international partner laboratories, and analysed. New high pressure cylinder samples for the round robin programme ("MENI") were prepared, calibrated and forwarded to the involved partner laboratories. The respective measurement results of those two exercises are submitted to a NOAA-GML ftp site and plotted using their ICP2 software tool. Results of all QA/QC activities have been compiled and evaluated in an updated QC Report.

Task 3.3: Flask sampler support, development and implementation of new flask sampler capabilities for additional applications needed to enable upcoming flask sampling strategies

Three new flask samplers were delivered to ICOS stations: the two class 1 stations of Trainou and Schauinsland started their sampling programmes and a replacement sampler was brought to the Jungfraujoch site.

The flask sampler design has been optimised. A stronger pump provides more sample for $^{14}CO_2$ analysis, an additional valve and digital mass flow meter allow automated inlet line and system leak tests, and a revised arrangement of the installed components increases the ease of maintenance. The flasksamplers taking part in the CORSO project have been enabled for automated interactions with footprint model predictions calculated at the Carbon Portal and the selection process at the ICOS CAL CRL.

Support was provided to field stations in the operation of their flask sampling programmes.

Task 4. Projects and international cooperation

PAUL / ICOS Cities project: The Relaxed Eddy Accumulation system was relocated from the Paris site to Munich as scheduled. Before commissioning the system at the Munich tower in June 2024 technical improvements were implemented to the sample collection unit. For its contributions to tasks 3.1 and 3.4 FCL analysed 465 samples in 2024.

CORSO: The participation of the CAL-CRL in the CORSO project has been supported by covering the additional flask logistics and analysis of additional 93 samples.

NUBICOS: A flask sampler for the NUBICOS comparison activities at the Irish Mace Head ICOS station was built and tested. Arrangements for the sampling were discussed with the international partners. The start of the comparison activity was delayed to early 2025 because of problems with the building infrastructure at the Mace Head site.

IM4CA: FCL contributed to the successful proposal for the “Investigating Methane for Climate Action” project. This will allow to set up an analytical system to analyse methane stable isotopes from ICOS flask samples. An additional flask sampler has been manufactured to be used by a project partner.

BIPM / CCQM - GAWG (Consultative Committee for Amount of Substance - Gas Analysis Working Group) Task Group on GHG calibration scale comparisons: FCL remains involved in discussions taking place between representatives of metrology institutes (BIPM and NMIs) and atmospheric scientists (NOAA, ICOS represented by FCL, Scripps, CSIRO, NIES) at online meetings. The Task Group aims to implement a process that ensures that the relationship between different calibrations scales can solidly be established.

Monitoring Station Assemblies

Ocean MSA

MSA Meetings: We organised a virtual MSA meeting in spring and an in person MSA meeting at the end of the training workshop held in Villefranche. All station a are given an opportunity to provide station updates, whether labelled or not. Various topics were discussed this included updates from the OTC, Data Updates, SOCAT, WMO, Station Labelling and Future Projects.

Ecosystem MSA

Meeting in-person at Antwerp University hosted by Marilyn Roland and the station BE-Bra and Maa station teams, Belgium, 2024 May 21-24.
There were 64 participants. Due to a following meeting of ETC nearby there was a large participation of ETC members in the meeting fertilizing discussion between ETC and MSA.
Online meeting, 2024 November 18 (09:00-12:00), 26 (08:00-12:00), 27 (09:00-12:00), 77 participants
A few selected highlights from both meetings and working group activities in between:

- Discussion about ICOS data in FLUXNET – strategy and steps needed.
- A new wavelet-based-direct-partitioning eddy covariance CO2 fluxes workflow evaluated in ICOS.
- Discussion if is it possible to measure Eddy Covariance fluxes at ICOS atmospheric tall towers with minimal setup changes ?
- GGGW and discussion what ecosystem domain can contribute.
- Cosmic Rays Neutron sensors & continuous soil moisture monitoring in the root zone at the hectare-scale.
- Below canopy comparison experiment (Focus on decoupling of above and below canopy decoupling that can lead to underestimation of the signal from below-canopy space).
- Combination of multiple methods (tower, airplane / fluxes, concentration) to study effect of coupling ecosystems to boundary layer meteorology.
- Update on work on crop dataset - CROP2021 database. Now much more auxiliary data and metadata available for crop sites. Work trying to utilize the newest data and prove that it is worth to do this additional effort.
- Ecosystem stations as virtual tall tower (Project FeaViTa)
- Iconic graph Working Group - focus on a very strong graph to show the merit of the ecosystem data.

Atmosphere MSA

A face-to face meeting was organized 20 – 22 April 2024 in Utrecht, netherlands. Virtual meeting in November was split to several days.

Projects

This year, all the projects are in one table and participation of ICOS ERIC and thematic centres is indicated.

AMRIT - Advance Marine Research Infrastructures Together)	**HO, CP, OTC**
AMRIT will provide a catalyst for the development and consolidation of marine research infrastructures throughout Europe, including coordination of planning, operations and data management. The project will contribute significantly to the development of the European Ocean Observing System (EOOS), including the design and implementation an Technical Support Center (EOOS TSC) that will sustain the tools and services developed by AMRIT into the future. AMRIT aims to be a cornerstone in establishing and maintaining the EOOS, upon which European ocean observing can be strengthened in the coming decades. AMRIT is one of those projects where HO has a small role to support participation of other elements of the distributed infrastructure.	
Aquarius	**OTC**
This MI lead grant is a large programme that will support transnational access to facilities around Europe, we have a small component in it relevant to data access.	
ATMO-ACCESS - Solutions for Sustainable Access to Atmospheric Research Facilities (HO and CP as ERIC and Lund)	**HO, CP, ATC, several PIs**
In ATMO-ACCESS the atmospheric RIs ACTRIS (coordinator), IAGOS and the atmospheric component of ICOS join forces. The ambition of ATMO-ACCESS is to address the needs for developing sustainable solutions based on the principles of open access and to develop guidelines and recommendations for governance, management and funding for efficient and effective access provision suited to distributed atmospheric RIs. This project investigates the most suitable mechanisms that could lead to the sustainable provision of access to atmospheric research infrastructures. Main involvement from ICOS is the ICOS Carbon Portal leading the work package 5, and Head Office participating in work package 2, Communications and Engagement. The WP5 aims at developing and optimally integrating on-line data and computing services, which aims at developing and testing new cross-RI interoperable cloud services in response to specific user needs for innovative tools for data analysis and data management.	
AVENGERS	**CP**
The project started in 2023. Follow up of VERIFY with strong modelling focus. Carbon Portal takes up the data management of this project, for example for datasets gathered and created by the project, not only observational but also elaborated and prior datasets such as emission inventories and inversion model results. The project will use CP Jupyter resources to work on model intercomparisons and model benchmarking. The inversion demonstrator developed by CP in the DICE project will be deployed and extended in this project.	

University of Lund delivered a Data set on observations on M12, and dissemination plan. ICOS ERIC – in form of CPD, made the data management plan.	
CORSO - CO2MVS Research on Supplementary Observations	**CRL**
The CORSO project directly contributes to the implementation of the new European anthropogenic CO2 emissions Monitoring and Verification Support capacity (CO2MVS) in the Copernicus Atmosphere Monitoring Service (CAMS).	
ENVRI Hub NEXT	**HO, CP**
ENVRI-Hub NEXT consolidates and advances the robust conceptual and technical structure established by the ENVRI-Hub to empower the ENVRI Science Cluster to provide interdisciplinary data-driven services. ENVironmental Research Infrastructures delivering an open access Hub and NEXT-level interdisciplinary research framework providing services for advancing science and society. ICOS contributes to data and services catalogue, and the Carbon Portal Director is leading WP8 and tasks in WP7.	
ENVRINNOV	**HO, ATC**
ENVRIINNOV is one of those projects where HO has a small role to support participation of other elements of the distributed infrastructure. ENVRINNOV will co-design, test, and validate a common Innovation Roadmap for the ENVRI community. This Roadmap will set a credible pathway for the ENVRI community to establish and operate an ENVRI Innovation Hub (EIH), for the future development of new state-of-the-art technologies and services. The project will also develop the tools, policies, and community necessary for the Roadmap's successful implementation. In 2024, HO contributed to a survey on technology innovation needs	
EOSC Enhance - Connecting Thematic Communities to Advance Open Science	**CP**
CPD represents the ENVRI-FAIR project to follow the further development and specification of the EOSC (European Open Science Cloud) Portal together with representation of the other ESFRI science cluster projects. This project is an intermediate and short-term project to fill the gap to the start of the EOSC Future project that is supposed to begin mid 2021 and that will further operationalise the EOSC system. Important developments, specifications and requirements, for example on the on-boarding process for services into the EOSC Portal and the development of metadata standards for describing services and data are fed back into ENVRI-FAIR through its WP5.	
EOSC Future - Advancing European research through Open Science	**CP**
ICOS CP had the leading role at the Science Project 2 (SP2) of the EOSC Future, the Dashboard for the State of the Environment. The ENVRIs participating in this project built analytical workflows that give access to their data and services and provide environmental indicators that populate the environmental Dashboard, a new service that was developed by the ENVRIs on the EOSC platform. ICOS CP had the responsibility of coordinating the development tasks to deliver the Dashboard and took initiatives for the engagement plan and for promoting the Dashboard using the existing ENVRI channels and strengthening the links between the ENVRIs and the EOSC. ICOS CP	

demonstrated of the Dashboard in several occasions, provided the first prototype of the new service which was further developed by EMSO, worked on the workflows that bring the ICOS indicators to the Dashboard and give the EOSC users the possibility to access the ICOS data, products and services. Several ICOS services were onboarded on the EOSC platform during the project, aiming at increasing ICOS visibility. ICOS CP was also active in WP9 and WP10, working on training activities (webinars, guidelines etc.), coordinating the development of training material for the ENVRI Dashboard in SP2 (which resulted in a tutorial on how to use the Dashboard in the form of a course on the OpenAIRE platform OpenPlato) and contributing to the user engagement tasks with demonstrations and by collecting the outreach/communication material and feedback required by the project. The project officially ended in September 2023, with an extension of 6 months (until March 2024) that would cover some of the SP, training and communication tasks.	
ERIC Forum 2	**HO**
In the earlier ERIC FORUM project ICOS ERIC provided the project website and email lists, and continued to develop an online toolbox which will gather the results of the project to a user-friendly format: the purpose is to allow RIs to benefit from the joint knowledge gathered there, and to facilitate the process of becoming an ERIC. In the follow-up project started 2024, ICOS ERIC has helped to get the requirements for the EIRC FORUM portal and prepared the procurement process to be started in early 20245.	
EuroGOSHIP	**HO, OTC**
The project aims to support a programme to address ocean observation gaps within the context of the European RI landscape. In 2024 ICOS ERIC participated in annual meeting and a workshop for key RIs to better understand the gaps in RI landscape which the potential new RI could fill. We also started preparations for the annual meeting 2025 which will be hosted in Helsinki.	
EYE-CLIMA	**CP**
The project shall address this need for independent verification by developing observation-based methods using both satellite remote sensing and ground-based observations.	
GEORGE – Next GEneration multiplatform Ocean obseRving technoloGiEs for research infrastructures (HO)	**HO, OTC**
ICOS ERIC is coordinating the GEORGE project. Here, the three ocean observing RIs, (EMSO, ICOS, Euro-Argo) work together with sensor manufacturers. In 2024, several types of sensors sensors were evaluated in pressure tanks. T first field trials were carried out at at the Ligurian Sea and the deep sea deployment at the Norwegian Sea . The 1st hands-on training for ca 30 RI technicians and RI-staff to use future technologies. took place in Villefranche-Sur-Mer. Two deliverables were due at the end of 2024: Updated Dissemination, communication & exploitation plan, and updated data management plan. The latter was delayed by one month, both were led by ICOS ERIC.	

IM4CA - Investigating Methane for Climate Action	**CP, FCL**
(Project starts 1.1. 2025) Specific objectives are to: 1) Strengthen methane mitigation policy world-wide with actionable information on local methane emissions and key driving processes, 2) Provide the EU with the measurement and modeling capacity needed to monitor its methane emissions and assess its progress towards the 30% emission reduction target of the European methane strategy and the global methane pledge, 3) Explore and understand climate feedbacks on natural methane sources and sinks, and 4) Improve the accuracy of climate scenarios by resolving the controversy about the causes for the recent growth rate variations in global methane.	
KADI - Knowledge and climate services from an African observation and Data research Infrastructure (HO)	**HO, OTC**
Knowledge and climate services from an African observation and Data research Infrastructure (KADI) aims to provide concepts for developing the best available science and science-based services in Africa. These are needed to sharpen a common action on climate change as outlined in the Paris Agreement and the UN Sustainable Development Goals (SDGs), in particular SDG 13 to enable urgent action to combat climate change and its impacts In 2024, KADI hosted a coastal carbon training course and the first meeting of collaborative networks in Nairobi in October. It provided first policy documents to inform the AU-EU cooperation, recommendations for innovative funding. The second reporting period ended in a succesful review.	
LandSeaLOT	**OTC**
This Danibius lead proposal will allow us to address carbon cycling in the coastal zone and LOAC. It aims to bring together the fragmented land-sea interface area observation communities across various scientific domains to co-design and develop an integrated, optimal, and robust observation of the land-sea interface area.	
MarcoBOLO.	**OTC**
This grant, lead by EMBRC, is providing resource to allow us to explore the usage of satellite imagery for Blue Carbon Accounting, and thus bridging us through to important policy and other RI stakeholders	
NUBICOS – New Users for Better ICOS	**HO, CP, ATC, ETC, OTC, CRL, FCL**
During the first year of project, the usual tools and documents (document templates, data management plan, website) were developed. An all-staff meeting with motto “minimum powerpoint, maximum discussion” was convened in Paris. Work packages lead by ICOS partners were proceeding well and created contacts with important stakeholders in WMO and satellite organizations.	
Ocean Improved Carbon Understanding (ICU).	**OTC**
ICU project seeks to gain a new understanding of the biological carbon pump and its processes in order to provide fundamental knowledge and tools to help policy makers, regulators and Ocean industry–fishing and mining, along with	

the wider blue economy–manage and understand the impact of their actions on Ocean carbon. This will ultimately lead to a better approach for addressing climate change in alignment with the EU Green Deal to reduce the net emissions of greenhouse gases to Zero by 2050.	
PARIS - PRocess Attribution of Regional EmISsions	**CP-NL**
This project aims to improve GHG inventory reports. It will develop new methods for detecting and measuring a countries' greenhouse gas emissions, such as carbon dioxide, methane, and nitrous oxide from atmospheric observations. PARIS will also make new emission estimates for F-gases, and organic matter aerosols, and black carbon, both important climate forcers. PARIS is together with EYE-CLIMA and AVENGERS one of the three sister projects selected from the same H2020 call. Compared to the other two project here more emphasis is on extending observational capacities like fluorinated gases measurements at more European stations. ICOS CP is mainly involved in data management and data publishing of the project results.	
PAUL (ICOS Cities) - Pilot Application in Urban Landscapes towards integrated city observatories for greenhouse gases (HO, CP)	**HO, CP, ATC, ETC, CRL**
The EU HORIZON 2020 project, coordinated by ICOS ERIC, develops and tests comprehensive green-house gas measurement observatories and technologies in urban environments, to produce reliable data for cities. The project conducts pilot studies in a large, medium and small city, and later aims to share the same methods in multiple European cities. The project also services and tools based on the needs of cities, for pro-cessing and analysing the observation data, while raising awareness and engaging citizens SUPPORTING THE EUROPEAN AMBITION Provide the future backbone of an urban GHG monitoring system in Europe and contribute to the Euro-pean ambitious climate strategy to meet the targets of the Paris Agreement.	
RItrainPlus - The Research Infrastructure Training Plus	**HO**
RItrainPlus project aims at improving the skills-base of European Research Infrastructures and Core Facilities. In 2024, ICOS ERIC contributed to the RItrain Plus by giving a webinar of KPIs, module of impact assessment and a three-part knowledge exchange workshop of project portfolio management, as well as in communication and outreach (where ICOS ERIC is leading the workpackage).'	
SITES - Swedish Infrastructure for Ecosystem Science	**CP**
Already since 2017 the national measurement infrastructure SITES in Sweden makes use of the Carbon Portal concept through their own instance of the Carbon Portal software (see https://data.fieldsites.se/portal/) . The SITES project funds 0.6 FTE at CP and through this co-development both SITES and ICOS profit from joint developments and experiences, through the extended user base and use cases of this combination. SITES applied for an extension of their operation through the Swedish national road map and has now secured funding until the end of the year 2028. SITES and ICOS CP have now agreed to extend the existing agreement on the cooperation over this period.	

traceRadon - Radon metrology for use in climate change observation and radiation protection at the environmental level	**CP, ATC**
A process-based radon exhalation map for Europe based on state-of-the-art soil moisture reanalyses and the latest version of the European soil uranium content map was developed for the use in atmospheric transport models and application in radiation protection. The map is available as elaborated product in CP and will be regularly updated even after the project is completed.	

Projects in member countries with national funding using ICOS Infrastructure

Country	**Project**	**Total budget**	**When**
CH	**NFI** Swiss National Forest Inventory NFI		1983-
CH	**NABEL**- National Air Pollution Monitoring Network		1990-
CH	**HACLIM** Measurements and modelling of halogenated GHG at JFJ		2000-
CH	**LWF** Long-term Forest Ecosystem Research		2007-
CH	**TreeNet** The biological drought and growth indicator network		2011-
CH	**Fluo4Eco** Combining Fluorescence Spectroscopy and Mechanistic Modelling for Advanced Assessment of Ecosystem Photosynthesis		2021-2025
CH	**COCO** COS and below-canopy CO2 fluxes of two Swiss forests: understanding land-atmosphere ecosystem exchange		2021-2025
CH	**EcoDrive** Unravel the changing contributions of abiotic vs. biotic drivers of ecosystem gas exchange under weather extremes		2021-2024
CH	**SwissPhenocam** Country-scale automated phenology tracking from imagery		2023-2027
CH	**UrbaNature** Feedbacks between vegetation, carbon, energy, and water cycles in the urban environment	1,1 MCHF	2023-2027
CH	**National Drought program** Long-term national in situ soil moisture network in the scope of the national drought program		2024
CH	**CERES** Impacts of Air Pollution and Climate Extremes on the Resilience of European Forests		2024-2026
CZ	**CzeCOS - Czech Carbon Observation System** The main goal of the large research infrastructure (LRI) CzeCOS is to enable open access to the entire scientific community, to provide research services to external users, and to facilitate knowledge transfer (training and education of students, PhD students, postdocs, researchers and other experts) in the field of long-term sophisticated research on global change (GC) impacts on terrestrial ecosystems in the Czech Republic and Central Europe. Particular aims are (1) to form a national complement to the existing ESFRI infrastructures ICOS ERIC, AnaEE ERIC, DANUBIUS-RI, eLTER RI, and EUFAR AISBL, (2) to provide unique facilities for (i) long-term impact studies on effects of environmental factors on plants/ecosystems, (ii) operation of atmospheric and ecosystem stations for observational research and quantification of greenhouse gas	6,83 M€	2023-2026

	fluxes, (iii) measuring physiological responses to GC in ecosystems, (iv) metabolomic, isotope, and genomic investigation, and (v) remote sensing laboratory; (3) to significantly contribute to the global network of GC research; (4) to represent a unique platform for a broad national and international interdisciplinary collaboration. LRI comprises a unique set of facilities for the research of GC impacts on ecosystems, study of adaptation mechanisms and the development of mitigation measures		
CZ	**AdAgriF - Advanced methods of greenhouse gases (GHG) emission reduction and sequestration in agriculture and forest landscape for climate change mitigation** https://adagrif.cz/ International AdAgriF scientific team aims to turn agriculture and forestry into long-term sinks and stocks of carbon and prevent avoidable emissions of CO2, N2O, and CH4. This will be achieved by greatly modernized infrastructure and three transdisciplinary research WPs spanning from molecules to landscape and society. The research will be imbedded in extensive network of excellent collaborating institutes fostering the growth of all participating scientists and reducing the research risk.	16 M€	07/2023 - 06/2028
CZ	**CzeCOS-BOOST: Modernisation and Boosting of LRI CzeCOS** The aim of the CzeCOS-BOOST project is to upgrade and strengthen four key elements of the RI CzeCOS aimed at standardising methods and procedures, introducing new measurements resulting from the updated ESFRI infrastructure criteria, upgrading instrumentation to ensure higher sensitivity and accuracy, increasing attractiveness and capacity for top research teams, and providing open access to data with an expected 2600 remote user accesses. The implementation of the project in the period 2024 - 2026 will contribute to the fulfilment of the international commitments of the Czech Republic in the field of research, adaptation and mitigation of GC impacts.	2,35 M€	01/2024 - 12/2026
DE	**ITMS Integrated Greenhouse Gas Monitoring System for Germany** The ITMS project aims on the development and implementation of a system capable of combining and using atmospheric observations from ground, air, and from space, high spatiotemporal resolution bottom-up flux modelling, and high resolution atmospheric (inverse) modelling for monitoring and documenting GHG sources and sinks. Such information will match user requirements and allow the implementation of an independent Monitoring, Reporting, and Verification (MRV) system for GHG emissions from diffuse sources like agricultural and industrial activities. Embedded within European research context like the European Copernicus activities on CO2 monitoring, in particular ICOS, Copernicus, and H2020 projects, the ITMS will in the long term deliver sector-specific high		

	spatially and temporally resolved information on GHG sources and sinks which would be tailored to the requirements of German stakeholders (industry, policy), EU programs, and the broad scientific community.		
IT	**ITINERIS**. To achieve an integrated approach to the Earth system and its changes, the 22 participating RIs agreed to jointly prepare and build the thematic network called ITINERIS. The primary objective of ITINERIS is to establish the italian integrated system of the Research Infrastructures in the environmental scientific domain, facilitating observation and study of processes in the atmosphere, marine domain, terrestrial biosphere, and geosphere. Such a broad-scale and long-term vision of environmental research, sustained by the main Italian scientists currently involved in European RIs, is truly innovative and it will support Italy in taking a leading role in European environmental research activities, designing the framework for the next decades.	€ 155.208.808,81	2022-2025

ICOS National Networks

Belgium

Highlights

More than ever **ICOS Belgium is an active partner in different research projects**. Some projects allow us to extent ongoing research beyond standard ICOS measurements (e.g. UAV equipped with a set of validation sensors) while in other projects ICOS Belgium support development and operations of new flux sites around the world.

UGhent Rector and Director Research and Director General INERA visited the CongoFlux site in Yangambi (January 2024)

Securing new funding allowing to continue ICOS Flanders research for 4 more years.

Two ICOS PhD theses were defended and multiple papers, including first research papers using data from the Yangambi site, were published

Collaborations with ICOS RI with organisation of the Ecosystem MSA and contribution of the ICOS foresight days.

Changes in station network

No new stations were added to the Belgium national network in 2024.

Co-operation with other RIs

1. The ICOS Belgium network collaborates with multiple RIs including eLTER, ACTRIS and ANAEE.

   Detailed overview of the ongoing collaborations per site:

   - **Brasschaat**: co-location as eLTER, ICP Forest site
   - **La Réunion**: co-location as ACTRIS station
   - **Maasmechelen**: Providing for baseline for temperature control of the nearby ANAEE infrastructure
   - **Simon Stevin** and **Thornton Buoy**: co-location as LifeWatch site
   - **Vielsalm**: co-location as ACTRIS station
   - **Network collaborations**: collaboration with ACTRIS RI (road map ESFRI 2016); "*Aerosols, clouds and trace gazes European research Infrastructure*" with BIRA, KMI, IsseP, ULiège.

2. In addition to collaborations with other RIs, ICOS Belgium is also an active partner in multiple research projects or long-term partner in monitoring projects :

   - **Brasschaat**
     - **Flanders Forest Living Lab** realizes a specific breakthrough in the assessment of crucial ecosystem functions using a UAV and a set of linked validation sensors.
     - **NUBICOS** aims to strengthen ICOS by intensifying the connection to the Copernicus services and the Global Greenhouse Gas Monitoring System recently initiated by the World Meteorological Organization (WMO).

- **Dorinne**
    - Project **MRV4SOC**: It aims at designing a Tier 3 approach to estimate GHG and C budgets and assess the results of traditional management and C farming.
- **La Réunion**
    - Member of SSC and STVB in ATMO-ACCESS
- **Lonzée**
    - **BRAIN 2.0 AGROFLUX** (UCLouvain,ULiège,KULeuven, IRM): Improvement of agrosystems greenhouse gas balance by assimilation of surface flux data.
    - **Project MRV4SOC**: It aims at designing aTier 3 approach to estimate GHG and C budgets and assess the results of traditional management and C farming.
    - **Project CROP2021**: European initiative, largely led by ICOS, to synthesize the carbon balances of crop stations and extrapolate the results to the continental scale using satellite data.
    - **Project ICLS-DesMod**: FNRS project (PhD fellowship) that aims among else to improve the calibration of the model STICS on the greenhouse gases emissions
    - **Project D-NESS**: The main objective is to quantify denitrification processes in a wide range of soils
- **Maasmechelen**
    - Long-term collaboration with VMM (Flemish Environmental Agency) and ISSeP (Wallonne Environmental Agency) in Maasmechelen for assessment of air pollutants and N deposition

- **Simon Stevin** and **Thornton Buoy**
    - Kick off of **BERNARDO** project which is based on data from ICOS BE Ocean stations (March 2024)
    - Joined **Consortium for TRICUSO**, proposal under HE 2024 call
- **Vielsalm**
    - **BRAIN 2.0VERBE** (BISA, UAntwerp,ULiège, LSCE (France), DLR (Allemagne) :Towards a greenhouse gas emission monitoring and VERification system for Belgium.
    - **BRAIN 2.0AGROFLUX** (UCLouvain, ULiège, KULeuven, IRM): Improvement of agrosystems greenhouse gas balance by assimilation of surface flux data.
    - **FED-tWINpostdoc** (2021): B. Verreyken, BERTRAC, "Investigation of bidirectional surface/atmosphere exchange of reactive trace compounds in terrestrial ecosystems through measurements and modelling" (BISA,ULiège)
    - **ERC Starting Grant** "The plant water pump" (V. Couvreur, UCLouvain)
    - **PQRVF (DGO3, SPW)**, A.Doat: «Assessment of water stress in the Walloon forest soils: best estimate of extractable water in 11 Ardennes soils» (C. Vincke, UCLouvain)
    - **CDR J.0101.24** (2024-2025) SAERF (“Surface-Atmosphere Exchange of Reactive trace compounds in a Forest ecosystem”; B. Heinesch, ULiège)
    - **BELAIR** (Silva): Vielsalm site is part of the BELAIR SILVA site (forestry and grasslands,since campaign 2017, areas are close to Liège, Vielsalm and Eupen)
- **Westmalle**

- Project **MRV4SOC**: It aims at designing a Tier 3 approach to estimate GHG and C budgets and assess the results of traditional management and C farming.

- **Yangambi**
  - **CLARIAH-VL+**: interaction with Christophe Verbruggen on digitalisation of historical climate data in Congo
  - **CAFRINAT 2.0** by Global Minds and BOF UGent (Prof. P. Boeckx, Prof. M. Bauters, Prof. H. Verbeeck, Prof. W. Hubau)
  - FWO post doc proposal to measure BVOC concentrations from CongoFlux site (Dr. Paula A. Lamprea Pineda)
  - Proposal to **Schmidt Foundation**, where UGent is a partner. "The tropical carbon and nutrients project". The overarching aim is to investigate the degree to which soil nutrients constrain the tropical forest carbon cycle. (Cary Institute of Ecosystem Studies)
  - Proposal to **Schmidt Foundation**, where UGent is a partner. "Congo Basin Carbon Flux Experiment, CBC-FLEX".If funded, this proposal aims to provide a first robust estimate of the net CO2 flux of central Africa, and partition this net flux across deforestation, degradation, regrowth and land carbon sink fluxes.
  - **FWO** Historical climate data rescue (precipitation) for 36 INERA stations in DRC
  - For the **VLIR UOS** IUC project of the University of Lubumbashi 'Challenges and opportunities for a sustainable socio-ecology in the Katangese Copperbelt Area', UGent (led by P. Boeckx) is the leading Belgian partner in the subproject 'Biodiversity and Climate Change'.

- **Network**:
  - Use of data in the **BRAIN VERBE** project
  - **LPTV** (remote sensing product validation)
  - **NEC** (Agence wallonne de l'air et du climat): Assess the impact of air pollution on ecosystems / habitats (acidification, ozone damage, …)
  - **Ongoing collaborations with multiple projects in which ICOS teams** support the project development by providing expertise
    - **WETCOAST** (VLAIO, DBC-project), Developing new scientific knowledge to optimize the creation and C storage of tidal marshes and mangroves in estuaries and coastal areas.
    - For the **VLIR UOS IUC** '*Management of Lake Victoria Basin Natural Resources*' with Jaramogi Oginga Odinga University of Science and Technology (JOOUST) in Bondo (Kenya) and University of Leuven (Belgium); UAntwerp provides support for one of the 5 project components focusing on land use in the Lake Victoria watershed and sediment, carbon and nutrient fluxes.
    - **PANGEA,** FONAREDD, JICA (Japan International Cooperation Support in DRC) and OFVi (One Forest Vision Initiative, France)f or a **CAFI proposal**

Czech Republic

Highlights

On 4th April 2024, the Czech ecosystem station had the honour of hosting Minister of the Environment, Petr Hladík. During his visit, Minister Hladík, accompanied by CzechGlobe scientists, explored the ICOS-CZ Trebon wetland station in South Bohemia. The visit highlighted the station's advanced methods for measuring carbon dioxide and methane fluxes, which are crucial for assessing the impacts of climate change on the landscape and soil. This event underscored the importance of CzechGlobe's research in providing valuable data to help municipalities and farmers make informed decisions about environmental management.

Changes in station network

No change

All Czech stations are labelled since 16th GA May 2022 session.

Co-operation with other RIs

ICOS CZ host institute research infrastructure is also part of: ESFRI ACTRIS, DANUBIUS-RI, AnaEE ERIC and eLTER RI and it is founding member of EUFAR AISBL and these interlinks are used for interdisciplinary research.

Collocation stations:

- Křešín u Pacova atmospheric station (ICOS/ACTRIS).
- Bílý Kříž ecosystem station (ICOS/AnaEE/eLTER)
- Trebon wetland station (ICOS/eLTER)
- Lanžhot ecosystem station (ICOS/DANUBIUS-RI)

Denmark

Highlights

Acknowledging the work and capacity required to obtain it, the most important highlight is that the activities stations worked as far as we know as planned.

The DK-Sor team battled with malfunctioning of the IRGA of the EC system (LI-7200), which took way too long to be repaired by LI-COR Europe. Use of a surplus old LI-7200 system helped to avoid larger gaps. Same with the LI-7200 at DK-RCW, which will be sent to factory, soon.

The number of downloads from our stations increased exponentially to a record high. Users are mainly international but include now also new users from Danish national administrations.

Station data from Disko has been collected almost unbroken. Improved robustness has been implemented in Kobbefjord with installation of open path CH_4 sensor and new power supply.

There is no information from the other Greenlandic stations available.

Changes in station network

DK-RCW was labelled as associated site, all other stations kept their status.

We have a new station PI for associated station Nuuk.

Co-operation with other RIs

DK-Sor is part of the Danish contribution/preparation to LTER. Cooperation between the two LTER beech forest sites Suserup and Sorø in preparation

ICOS DK participated in a proposal (SITES Denmark) to the Danish National Board of Research Infrastructure under the Danish Ministry for Higher Education and Research

Finland

Highlights

At the Siikaneva mire station (FI-Sii), automatic chambers have been installed and started their operation in summer 2024. Vegetation inventory of the site was done in August. Moreover, Siikaneva webpage (Siikaneva - Exploring the boreal wilderness) was launched in November 2024 at Univ. of Eastern Finland.

A new flux site "Kilpisjärvi" has been established and started its operation in August 2024 in Northern Finland, being the first to represent mountain tundra in the continental Europe. This site is preparing to step in to ICOS and start the labelling process towards an ecosystem associate site. The site is operated with solar and fuel cell power.

Pallas ATM station's methane concentration measurements reached the 20-year anniversary in 2024

Changes in station network

Lompolojänkkä mire (FI-Lom) was labelled as a Class II Ecosystem station in May.

Oulanka station (FI-Ouk), a pristine mire, run by the University of Oulu and the Anttila station (FI-Ant), an agricultural field, are currently going through the labelling process for an ecosystem associate and Ecosystem Class 2 station, respectively. FI-Ant is so far the only ICOS station on agricultural field.

Co-operation with other RIs

ICOS Finland organizations have applied and received common infrastructure funding from the Research Council of Finland for the years 2025-2029. The project is run under an umbrella research infrastucture INAR, and brings together several institutes, researchers and network of sites contributing to ICOS, ACTRIS, AnaEE and eLTER.

The Finnish umbrella for four European RI's (ICOS, ACTRIS, AnaEE and eLTER), INAR RI Ecosystem board, has met three times in 2024 to discuss the common funding application and other coordination topics.

The same INAR umbrella is organizing a Finnish research infrastructure science meeting in April 7-10, 2025, in Vuokatti, Sotkamo.

Finnish ICOS researchers (Risto Taipale, Henriikka Vekuri, Pasi Kolari) have participated in developing the eLTER Standard Observation protocols in themes with links to ICOS.

France

Highlights

- Co-organisation of the ICOS Science Conference
- North-South pCO_2 gradient near the coast of Brazil around 8ºS observed by the France-Brazil SOOP line (Guimarães et al., 2024).
- AtmoBox development and deployment, Lian et al.(2024). Development and deployment of a mid-cost CO2 sensor monitoring network to support atmospheric inverse modeling for quantifying urban CO2 emissions in Paris. Atmospheric Measurement Techniques. 17. 5821-5839. 10.5194/amt-17-5821-2024.
- Highlight paper of Atmospheric Measurement Techniques: "Eddy covariance with slow-response greenhouse gas analysers on tall towers: bridging atmospheric and ecosystem greenhouse gas networks". Coimbra et al. 2024
- Global change biology paper: "High heat tolerance, evaporative cooling, and stomatal decoupling regulate canopy temperature and their safety margins in three European oak species". Gauthey et al. 2024

Changes in station network

FR-Lam (ECO Class1) stopped operating in 2024 due to manpower difficulties

Co-operation with other RIs

In coll with ACTRIS, three NH3 OFFCEAS analysers received and evaluated at INRAE

Germany

Highlights

- GEOMAR, DE-SOOP-Atlantic Sail: Complete overhaul of installations onboard merchant vessel. Upgrade of pCO_2 system with new generation of laser-based LI-7815 CO_2 Trace Gas Analyzer (OF-CEAS)
- AWI: First deployment of a mooring with sensors as part of DE-FOS HAUSGARTEN to comply with ICOS requirements, following a new observation strategy at this Arctic site
- HEREON, CUXHAVEN:
    - Acquired new FerryBox to replace old system (>10 years old)
    - Acquired a new methane sensor to integrate continuous measurements into ITMS-GEM project, and support land-sea GHG measurements
- IOW, DE-SOOP Finnmaid:
    - Publication of a pCO_2 climatology for pCO_2 over the Baltic Sea published by Bittig et al. (2024). The paper uses data from DE-SOOP Finnmaid and other pCO_2 data sources in

the Baltic Sea in combination with variability patterns from a 3-D biogeochemical model to derive a monthly climatology of pCO_2 in the Baltic Sea using an EOF smart extrapolation approach, and also provides fields of uncertainty.

    - pCH_4 data of DE-SOOP Finnmaid are used for three publications addressing the Nord Stream methane leakage of 2022; all manuscripts are accepted and will be published in January 2025.
    - Gregor Rehder, PI of DE SOOP Finnmaid, was elected MSA Ocean chair in October 2024.
- University of Göttingen: Successful start of the project **FoResLab** (coordinator: Alexander Knohl)
    - Th future Lab towards Forests Resilient to climate change (FoResLab) will investigate the central question of how forests can be made resilient to climate change under current and future conditions. FoResLab will bring together experts from three universities, a university of applied sciences and arts, two state research institutions with a network of international partners and five practice partners, thus ensuring a close link between science, business and civil society. FoResLab is one out of so far four future labs in Lower Saxony, funded by the *zukunft.niedersachsen* program of the Lower Saxony Ministry of Science and Culture and the Volkswagen Foundation. Climate Future Labs bring together partners throughout Lower Saxony from the worlds of politics, the economy and civil society to engage in topic-specific research on the climatic challenges and impacts that will shape our future. Climate future labs are coordinated and connected under the roof of the Lower Saxony Center for Climate Research (ZKfN). FoResLab is funded with 5 Mio Euro for a duration of six years (11/2024-10/2030). The ICOS site Hainich is one of six central research sites.
- TU Dresden: New reference paper for the ICOS cluster Saxony submitted:
    - Grünwald, T. et al., 2025. Carbon Fluxes Controlled by Land Management and Disturbances at a Cluster of Long-Term Ecosystem Monitoring Sites in Central Europe. http://dx.doi.org/10.2139/ssrn.4987803
    - Airborne and terrestrial laser scans at DE-Tha by GFZ Potsdam
- UFZ is part of two projects working on the ICOS infrastructure:
    - MW3 (national project) Standardized monitoring of growth responses of important forest tree species to climatic extreme events funded by the German Ministry of Food and Agriculture. The project shall capture the most important key parameters for a cross-scale growth analysis in forests. It will identify the growth responses of tree species and uses already existing dendrometer and sap flux measurements in addition to the canopy exchange data.
    - CLIMBFOREST (EU funded) - CLImate Mitigation and Bioeconomy pathways for sustainable FORESTry, an EU HORIZON project. This project aims to make recommendations for sustainable forest management. It uses ICOS data as well as information from ancillary data to improve prediction models.

Changes in station network

Stations that completed labelling in GA meetings in 2024:

- Associated Ecosystem Station Braunschweig (DE-Brs)
    - Responsible institution: Deutscher Wetterdienst (DWD); Station PI: Lennart Böske
- Associated Ecosystem Station Amtsvenn (DE-Amv)

    - Responsible institution: University of Münster; Station PI: Mana Gharun
- Associated Ecosystem Station Großen Bruch (DE-GsB)
    - Responsible institution: Helmholtz Centre for Environmental Research (UFZ); Station PI: Anke Hildebrandt

New Principal Investigator and technician of DE-FOS Hausgarten: Sinhué Torres-Valdes and Daniel Scholz, both of AWI.

Co-operation with other RIs

- Granting and start of two paludiculture research projects ('Living Lab Teufelsmoor' and RoNNi') including seven new eddy-covariance sites funded by the Federal Ministry of Agriculture over a period of ten years. The consortia intend a close collaboration and application of harmonized methodology using ICOS standards.
- DFG Research Unit joint application by University of Münster, "Aquatic Methane Cycling in the Anthropocene (AMCA)", Coordinator: Frank Keppler, Heidelberg University (project was not funded, currently preparing to submit for the second time)
- Cooperation with GFZ Potsdam in the project ESA Digital Twin Earth Components using the DE-HoH site for GNSS testing and providing ancillary data
- Cooperation with ACRI-ST and Ground-Based Observations for Validation (GBOV) of Copernicus Global Land Products - exchange of measurements and analysis results
- Cooperation with University of Leicester within the Advanced Surface Temperature Radiometer Network (ASTeRN) for the validation of land surface temperature measurements
- Cooperation with the global network for automated vegetation structure monitoring StrucNet
- DE-SOOP Polarstern was part of the EU project SO-CHIC (Southern Ocean Carbon and Heat Impact on Climate), where pCO_2 data from the Weddell Sea were used for analyses
- GEOMAR participation, EU project "GEORGE – Next Generation Multiplatform Ocean Observing Technologies for Research Infrastructures ", together with Euro-Argo and EMSO
- GEOMAR participation, EU proposal (unsuccessful) "Mooring-A – Multidisciplinary Ocean Observation Networking in Western and Southern Africa" (EMSO)
- LandSeaLOT HE project, (2024-2028) ongoing, Cuxhaven Station will contribute integration data for in-situ measurements and model integration
- AQUARIUS HE project, EU infrastructure (2024-2028) ongoing
- TESA cooperation agreement with *Elbe River Basin Community* to study oxygen dynamics and carbon sequestration in the Elbe River Estuary and upstream regions
- IOW is partner in the EU INFRADEV project GEORGE. Here in particular synergies and integrated use of data from ICOS, Euro-ARGO and ENSO are being developed. Moreover, an additional line on DE-SOOP Finnmaid is under construction to facilitate sensor testing for GHGs and pH, which benefits all 3 RIs.

Greece

(Report Missing)

Hungary

Highlights

Production of #ExploreICOS video on Hegyhátsál (HUN) ICOS station in early July 2024.

ICOS GA23 in Hungary, November 2024

Changes in station network

Hegyhátsál tall tower atmospheric station (HUN) was labelled as Class 2 monitoring site by ICOS GA in May 2024.

Ireland

Highlights

  - European funding was secured to provide additional measurement of radon and isotopic analysis, compliant with Class 1, at Mace Head atmospheric station. This facilitates better definition of sectoral emissions and boundary layer height.
- ICOS-compliant equipment was installed at multiple stations to progress the labelling process.
  - Instruments from two atmosphere stations were certified at ICOS-laboratory
  - Towers were erected at Doory and Leam West stations, and acquisition of measurements was commenced
  - Documents for Ireland's Ecosystem Associated Station at Clara Raised Bog were submitted

Changes in station network

- The Doory grassland site (organic soil) was proposed to replace the previously nominated Gurteen Farm glassland site (organic soil), and a blanket bog station was installed at Leam West.
- Ireland's four atmospheric stations completed step 1 of labelling process to become Class 2 stations.

Co-operation with other RIs

- ACTRIS-relevant atmospheric measurements are being carried out at Mace Head atmospheric station
- The data from the RV Celtic Explorer will be provided to SOCAT for use in international analysis
- The grassland ecosystem stations at Johnstown Castle and Doory form part of the larger National Agricultural Soil Carbon Observatory (NASCO) network
- The blanket bog ecosystem station at Leam West forms part of an expanding National Parks and Wildlife Services network
- The Dooary Forest Ecosystem Station forms part of two funded projects (AdaptForRes & PeatFor) by the Department of Agriculture

Italy

Highlights

2024 has been an important year for ICOS Italy. **Four new stations** have been added to the network: Collelongo, Torgnon Forest, Lampedusa Ecosystem and Sassari. The **University of Chieti-Pescara** joined as a new member of the Joint Research Unit and is finalizing the realization of a new atmospheric station, Trabocchi.

ICOS Italy was one of the key topics in an episode of **Futuro24**, a national television program that, in its first broadcast, in January, reached an audience of approximately 530,000 viewers.

The Italian Ministry of Universities and Research, **Anna Maria Bernini**, visited CNR-IRET in Porano in November 2024. During this occasion, ICOS Italy was at the heart of the discussions, presented as one of the key Research Infrastructures in which the institute is actively involved.

The sampling system in the shelter at the base of the tall tower for POT site has been completed and the first test measurements with the **Picarro G2401** for ICOS POT have been carried out

The **Torgnon-LD forest** (IT-TrF) received the labelling as Associated site on 14th May 2024. Available data start from 2012.

As part of the ATMO-ACCESS project, CMN-IT has provided access to **Utrecht University** to carry out an experiment dedicated to the observation of CH4 and CO isotopologues.

In March, ICOS Italy hosted the **RICOM Meeting**, in Venice.

During October, **Capodimonte** station has been enhanced, thanks to the acquisition and installation of equipment for continuous monitoring using the eddy covariance technique.

Changes in station network

New stations:

- Torgnon Forest (Larch forest)
- Sassari (Urban station)
- Collelongo (Beech Forest)
- Lampedusa Ecosystem (Part of the Integrated Observatory)

Change of class:

- Lampedusa Atmosphere (LMP-ATM) is now class 1

Labelling

- Torgnon-LD forest (IT-TrF) received the labelling as Associated site on 14th May 2024;
- Lampedusa Ocean and Ecosystem (LMP-OCE, LMP-ECO) in labelling phase;

Co-operation with other RIs

- Many Italian stations (Potenza, Paloma, Monte Cimone, to name just a few) are involved in **ITINERIS** project, an Italian project aiming to the integration of the RIs working in the environment domain operating over Italy. As part of the project, PALOMA station is currently

being upgraded through a joint effort by three research infrastructures: ICOS, DANUBIUS, and JERICO.

- ICOS Italy co-operates with **ACTRIS**.
- ICOS Italy participates in the national network of **EMSO**.
- IT-Tor and IT-TrF co-operate with the **NBFC** - (National Biodiversity Future Center) Network for eDNA monitoring.
- Bosco Fontana is involved with the participation to the "Dry deposition group" of the **TOAR II initiative** (Tropospheric Ozone Assessment Report) of the GAW (Global Atmospheric Watch)
- Bosco Fontana participates to the Task Force of the **ICP Vegetation** (International cooperative project) of the UN/ECE for ozone deposition, carbon sequestration, ecophysiology and effects of atmospheric pollutants on vegetation.
- Bosco Fontana Co-operates with Centre for Ecological Research and Forestry Applications (CREAF), Spain in the project "**STOIKOS** - Elemental Ecology: towards an element-based functional ecology" (coordination by the Autonomous University of Barcelona).
- Bosco Fontana Co-operates with the University of Bologna in the project "**NEXTRES**. Effects of nitrogen deposition and climate extremes on European forests: combining stable isotopes in tree rings and ecosystem fluxes".
- ICOS POT station is included in **ATMO ACCESS** and IRISCC project in conjunction with ACTRIS as a TNA facility. CMN-IT station is included in the H2020 ATMO ACCESS project in conjunction with ACTRIS-RI as part of the CMN-PV facility.
- In January 2024, the **LanSeaLot** – "Land-Sea Interface: Let's Observe Together!" project was launched (https://landsealot.eu/). This HORIZON-CL6 governance project aims to strengthen collaboration between Earth Observation initiatives, local communities, and the research infrastructures DANUBIUS, JERICO, and ICOS in coastal area studies. At the PALOMA station, EO, ICOS, and DANUBIUS will collaborate on this theme.

Netherlands

Highlights

- Hosted conferences, meetings and visits

  7th ICOS Summer school held in Wageningen 19-24 August 2024, this time in collaboration with WMO's Global Greenhouse gas Watch and NUBICOS (https://www.icos-cp.eu/news-and-events/news/wmo-and-nubicos-hold-successful-summer-school) with >20 students in majority from the global South. It included a visit to the Loobos ecosystem site, Cabauw atmospheric station and a peatland site in the Dutch Peat Meadows Observatory (NOBV).

  - Seminar Eva Pfannenstil (Juelich) 7 November 2024 about BVOC flux measurements
  - Seminar Simon Besnard (Helmholz Center Potsdam) Coupling forest dynamics with the net carbon balance 11 June 2024
  - Visit RIVM Air Quality modelling group to Loobos (5 June 2024)
  - Visit University of Braunschweig to Loobos (12 August 2024)

    - ICOS Atmospheric station MSA held in Utrecht 22-24 April 2024
- Carbon Portal
- Cabauw
    - CINDI3 campaign (https://ruisdael-observatory.nl/cindi-3-campaign/)
    - Multicomponent (N2O, CO, NO, NO2, CO2, CH4) flux measurement campaigns June 2024 and November 2024 - February 2025 using Miro closed path analyser and Gill Windmaster Sonic at 60m
    - Testing Aeris N2O-CO analyser
    - FTO Proposal for multi-year funding and expansion of the Cabauw site has been granted (Medusa-GCMS becoming part of AGAGE, H2, refurbish the spectronus and backup equipment as well as becoming Actris trace gas NF apart from Actris Aerosol NF)
- Loobos
    - O_3 flux sensor installed and tested (December 2024)
    - Developed software to routinely calculating VOC and O_3 fluxes according to ICOS instructions as far as possible
    - Experimental NH_3 flux measurements performed (TNO, WUR, RIVM)
    - Installed Profile of 8 leaf wetness sensors along the tower
    - GNSS network installed (TU Delft, U Potsdam, U Enschede) to study vegetation water content detection
    - Proposal to include N fluxes (well received, not granted)
    - Development of a N-oriented network (WU, UU, RIVM, TNO)
    - Participated in the HyPlant campaign (ground, airplane, satellite SiF retrieval verification experiment)
- Lutjewad
    - Installation of an Agilent 8890 Gas Chromatograph equipped with a Pulse Discharge Helium Ionization Detector (GC-PDHID) for semi-continuous observations of H_2 and SF_6 in ambient air.
    - Installation of an Aerodyne dual-laser absorption spectrometer (“BraSICAS”) for semi-continuous observations stable isotope composition measurements of atmospheric CO_2, including the triple oxygen isotope composition or $D^{17}O$.

Changes in station network

No changes in the station network have been made in 2024. Cabauw is still a ICOS class 1 atmosphere station, Lutjewad a class 2 atmosphere station and Loobos a class 2 ecosystem station. However, extra instrumentation has been installed (see above).

Co-operation with other RIs

- The ICOS Netherlands activities are part of the Dutch Ruisdael-Observatory.nl infrastructure, in which we collaborate with Actris Netherlands.

- Launch of the Ruisdael Data Catalogue (https://ruisdael-catalog.citg.tudelft.nl/index.php?title=Main_Page)
- Loobos is involved in the Veluwe network of LTER-LIFE-NL (https://lter-life.nl/en)
- Submitted proposal Ruisdael Northsea (in review)
- Submitted proposal LT-Aerial (not granted)

Norway

Highlights

In 2024 NO-SOOP *Sea Cargo Express* was labelled as a class 2 ICOS station at the ICOS general assembly in Budapest, Hungary. Sea Cargo Express is the successor to the previous ocean station *Trans Carrier*. Equipment was transferred to the new station after the parent company sold the Trans Carrier. ICOS Ocean measurements on Sea Cargo Express will cover an area of the North Sea between the UK and Norway and the south coast of Norway up to Central Norway (Trondheim). Meanwhile, instrumentation on the *Richard With*, the vessel operating on NO-SOOP-Bergen Kirkenes route, was overhauled and upgraded with new a pCO2 system which became fully operational in December 2024. In combination, these vessels cover the entire length of Norway's unique coastline. This area is a disproportionately large sinks relative to its surface area, and thus of key importance in global ocean carbon uptake.

In 2024 ICOS Norway successfully negotiated for a limited continuation of Research Council of Norway funding for 2025-2027. This funding will enable continuation of ICOS Norway measurements in the atmosphere and terrestrial domains and cover most operations of the ocean domain, as well as allow Norway to continue hosting the OTC. ICOS Norway continues to engage with national stakeholders to secure long term funding of Norway's ICOS membership.

Changes in station network

ICOS Norway ocean station *NO-SOOP Sea Cargo Express* received ICOS Class 2 labelled status.

Co-operation with other RIs

NO-Hur is one of the demonstration sites of the EU Horizon project "Monitoring, Reporting, and Verification of Soil Organic Carbon and Greenhouse Gas Balance" (MRV4SOC, https://mrv4soc.eu/, 2023-2026) and is feeding the data obtained into that project with a focus on carbon farming. The site at Hurdal is also contributing to the EU Horizon project CLIMB-FOREST (https://www.climbforest.eu/, 2022-2027) where the biophysical implications of forest management will be investigated and site-level runs of an Earth System Model (LPJ-GUESS) will be performed.

The Norwegian atmospheric sites Zeppelin (ICOS class 1) and Birkenes (ICOS class 2) are both part of the ACTRIS network. In addition, the Zeppelin Observatory is a key station in many research infrastructures including the European Monitoring and Evaluation Programme (EMEP); the Arctic Monitoring and Assessment Programme (AMAP); the Global Atmosphere Watch (GAW); and the Advanced Global Atmospheric Gases Experiment (AGAGE) network.

Spain

Highlights

ICOS-Spain continues its consolidation process. In 2024, 50% of our stations have successfully completed the labelling process, thus strengthening the representation of the national node in ICOS-ERIC. Additionally, the El Arenosillo, CIBA and ESTOC stations have concluded the first phase of the labelling process.

At the El Arenosillo Atmospheric Station, the ICOS calibration tanks, which arrived from Jena (Germany) in November 2023, were connected at the end of February 2024. The ICOS measurement protocol was initiated in March 2024. The drying system was adapted and the first ARN data were sent to ATC in October 2024.

In addition, work to adapt the current infrastructure to the technical requirements of ICOS has begun at the CIBA Atmospheric station.

ES-SOOP CanOA move from Class 2 to Class 1 station. Data from CanOA are daily stored in the lab server and accessed directly by the ICOS Carbon Portal.

Changes in station network

El Arenosillo Atmospheric Station

- At the end of February, the Picarro sampling system was adapted to connect the ICOS calibration tanks that arrived at the station in November 2023.
- In early March, measurements and calibrations started according to the protocol defined by ICOS.
- In September 2024, modifications were carried out on the ATCConfig and ATC QC of the ARN station. At the end of October 2024, the drying system was modified by replacing the desiccant and adapting it to ICOS recommendations.
- In October 2024, data from both the Picarro and meteorological measurements began to be sent to the ICOS ATC. At the end of December, ARN data validation began at the ATC.

CIBA Atmospheric Station

- Dr. Abel Calle has joined the national node as a principal investigator.
- Dr. Ramiro González has joined the national node as a technician.
- A new P&ID has been designed for the station.

Izaña Atmospheric Station

- A new Picarro has been acquired as a backup for the current one.

CanOA Oceanic Station

- The ICOS General Assembly, held on 13-14 of May 2024, unanimously agreed to move the CanOA Oceanic Sation from Class 2 (previous incorporated in GA November 2023) to a fully-fledged class 1 station in its network.

Co-operation with other RIs

Izaña Observatory is part of the following research networks:

- Actris (AEROSOLS, CLOUDS, AND TRACE GASES RESEARCH INFRASTRUCTURE)

- GCOS (Global Climate Observing System)
- WMO-GAW (Global Atmospheric Watch)
- NDACC (Network for Detection of Atmospheric Composition Change)
- TCCON (Total Carbon Column Observing Network)
- COCCON (Collaborative Carbon column observing network)
- BSRN (Baseline Surface Radiation Network)
- AERONET (AErosol RObotic NETwork)
- MPLNET (Micropulse Lidar NETwork)
- E-GVAP (EUMETNET EIG GNSS water vapour programme)
- PANDORA-PANDONIA

El Arenosillo station is part of the following research networks:

- Actris (AEROSOLS, CLOUDS, AND TRACE GASES RESEARCH INFRASTRUCTURE).
- WMO-GAW (Global Atmospheric Watch).
- AERONET (AErosol RObotic NETwork).
- MPLNET (Micropulse Lidar NETwork).
- WRC (World Radiation Center)
- WDCA (World Data Center of Aerosols).
- NOAA-ESARL Collaborative Aerosol Network

The QUIMA group of the ULPGC is one of the working groups of the GEORGE project. The GEORGE project brings together 28 leading partners from academia and industry, including three research infrastructures: EMSO-ERIC, Euro-Argo-ERIC and ICOS-ERIC. Together, these three ERICs cover the full extent of European marine waters, from the coasts to the open ocean and from the seafloor to the interior and the ocean surface. The project is coordinated by ICOS-ERIC and EMSO-ERIC.

Sweden

Highlights

Norunda Research Station (ICOS ES, AS station and ACTRIS station) celebrated its 30-year anniversary which was highlighted with a get together at the stations with scientists from different periods of the station's life cycle (very first beginning, long term and recent station staff), forest owners and local support companies.

In 2024, 65 peer-reviewed publications using data from Swedish ICOS sites were published (full list available on www.icos-sweden.se/publications). The stations themselves were used by 60 national and 29 international research projects with a total of 8310 site days; the number of data only using projects was not determined. In total, 229 male and 144 female scientists related to research projects using the stations physically and course participants (undergraduate and graduate education) visited the stations.

Changes in station network

Mycklemossen (Ecosystem Class 2; SE-Myc) labeled in November 2024

Co-operation with other RIs

ICOS Sweden together with the two other Swedish Research Infrastructures of national interest SITES (www.fieldsites.se) and ACTRIS Sweden elaborated together a strategy for closer collaboration setting short-term goals and defining long-term vision to maximise the scientific gains that can be made possible. The progress and results from this strategy will monitored by the SRC.

Funded research projects using ICOS and ACTRIS: Carl Tryggers Stiftelse: Forest management effects on forest resilience and carbon sink strength, ~242 000 SEK

Switzerland

Highlights

In February 2024, near-real time CO_2 data from Jungfraujoch station (ICOS Class 1 Atmosphere station) became available on the webpage of the Swiss Radio and Television group (SRF), which is one of the most visited webpages in Switzerland. SRF's 'Klimamonitor' (climate monitor) shows facts and figures on climate change and displays current data.

In June 2024, after a long and detailed data analysis lead by Roman Zweifel (ICOS PI at WSL), a new site description for the Davos station (ICOS Class 1 Ecosystem station) was published on EnviDat. The material offers new information on the biomass and growth of trees at the Davos station.

In August 2024, the Secretary General of the World Meteorological Organization (WMO), Celeste Saulo, visited the Jungfraujoch station.

On 2 October 2024, ICOS-CH received great news from the Swiss National Science Foundation: The next project phase for ICOS-CH (Phase 4, 2025-2029) is funded.

In November 2024, the Basel station was labeled as ICOS Associated Ecosystem station and became the third station of the ICOS-CH network. Basel station (264 m a.s.l.) is an urban station located in the city center of Basel and has one of the longest urban CO_2 flux records worldwide (permanently operated since 2004).

Changes in station network

New ICOS station (labelled in November 2024): CH-BaK Basel-Klingelbergstrasse (Associated Ecosystem Station, urban station)

Co-operation with other RIs

Davos station is part of the international networks eLTER, ICP forest level 2 and FLUXNET. The site also participates in the CLEANFOREST and the NextGenCarbon project. COST Action and. Davos is part of the national networks Swiss FluxNet (Swiss network of active eddy covariance flux sites), Long-term Forest Ecosystem Research (LWF), National Air Pollution Monitoring Network (NABEL), the biological drought and growth indicator network (TreeNet).

Jungfraujoch station is part of ACTRIS and the national networks National Air Pollution Monitoring Network (NABEL), CLIMGAS, SwissMetNet, Permafrost Monitoring Switzerland (PERMOS), Swiss Glacier

Monitoring Network (GLAMOS), GAW Swiss Alpine Climate Radiation Monitoring program (SACRaM). In November, ACTRIS Centre for Reactive Trace Gases In Situ Measurements (CiGas) audited the VOC and Nox measurements at Jungfraujoch. The audit is one of the steps in the evaluation process towards the station labelling.

Basel station is part of the national network Swiss FluxNet (Swiss network of active eddy covariance flux sites) and part of the extended ICOS-Cities city network.

The World Meteorological Organization (WMO) works towards a Global Greenhouse Gas Watch (G3W) initiative. In 2024, the planning of the implementation of the pre-operational phase was launched and task teams and an advisory group were established. Martin Steinbacher was appointed as member of the Advisory Group on Global Greenhouse Gas Watch (AG-G3W).

The WMO Integrated Global Greenhouse Gas Information System (IG3IS) is updating the "Urban Greenhouse Gas Emission Observation and Monitoring Good Research Practice Guidelines", first published in 2022. Stavros Stagakis is a contributing author in the chapters related to the eddy covariance fluxes. The document is currently available online for public comment. The guidelines draft will be discussed and finalized at the Urban Greenhouse Gas Conference in Geneva, April 7-9 2025, which is co-organized by IG3IS and ICOS-Cities project.

United Kingdom.

Highlights

Ridge Hill data was used in a publication in conjunction with satellite data to estimate emissions from an active gas leak in the UK: https://doi.org/10.5194/amt-17-1599-2024

Ridge Hill is involved with the UK GEMMA programme (https://www.npl.co.uk/greenhouse-gas-emissions-measurement-modelling).

Ridge Hill is involved in the EU-funded PARIS (Process Attribution of Regional Emissions) project: https://horizoneurope-paris.eu/partners/.

Jodrell Bank was established as a new atmospheric measurement site as part of the UK GEMMA programme.

Duplicate CO2 Prooceanus membrane sensors were deployed at PAP-SO for year-round measurements (on the MO/NOC Mobilis buoy). The deployment was in May 2024 on the JC263 cruise, and we delivered NRT data to the carbon portal (Hartman, S., Flohr, A. (2024). ICOS OTC FOS NRT Product, Porcupine Abyssal Plain, 2024-05-31–2024-11-26, ICOS RI, https://hdl.handle.net/11676/g_Ehfd0rclK_TDR1wkpXtUiE)

PAP-SO collaboration with EU MINKE – sponsored attendance at the Versailles ICOS conference where a number of presentations were made including the poster 'The Porcupine Abyssal Plain Sustained Observatory: Towards a Multi-Platform Open-Ocean Observatory'.

Weybourne has received funding for a solar array that will provide approximately 25 percent of the running power. Looking to have this installed in summer 2025.

New instrumentation installed at Weybourne to measure ethane to aid source apportionment.

Installed a new instrument to improve the measurements of hydrogen at Weybourne

Changes in station network

Western Channel Observatory withdrew from the ICOS network at the end of 2024.

Co-operation with other RIs

Working with EMSO as part of the EU GEORGE project. PAP-SO is a demonstrator site for them in June 2025. Various platforms and sensors will be tested at the site for comparison with the PAP-SO data.

Tables of material contributing to KPIs

Use of ICOS data in educational tools and activities

Type: Thesis, class, …	Topic	Place / university	Notes
Belgium			
PhD thesis, S. Callewaert	Application of the WRF-GHG model for the interpretation of ground-based observations of atmospheric greenhouse gas concentrations	Université de Liège	
PhD thesis, Q. Beauclaire	Stomatal and non-stomatal responses of typical temperate C3 crops to soil water stress	Université de Liège	
MSc thesis, Sarah Lamotte	Impact of air temperature on the leaf-level photosynthetic capacity of tropical tree species of the Congo Basin	Ghent University	
MSc thesis, Warre Demuynck	Comparison of leaf-level photosynthetic capacity of tropical lowland forests from the Congo and Amazon Basin	Ghent University	
MSc thesis, Lien Ceulemans	Chamber measurements of CO2, N2O, and CH4 fluxes from tropical forest soil of the Congo Basin	Ghent University	
MSc thesis, Helena Verbruggen	Greenhouse Gas Fluxes from Tree Trunks of different Plant Functional Types in the central Congo Basin	Ghent University	
MSc thesis, J.Dartevelle	Numerical modeling of flow and transport in inter-row agrivoltaic power plants	Université de Liège	Data from BE-Dor
Course	Exchanges Ecosystems-Atmosphere Site visit BE-Lon (November 2024)	Université de Liège	
Course	Nature based Solution for Climate Change and on Climate Change	Université de Liège	

Course	Meteorology and Eco-climatology	Ghent University	
Site visits by University students		Ghent University (Yangambi station) University of Antwerp (Brasschaat station)	
MSc thesis, Eveline Rypens	Standing biomass evaluation Brasschaat site	University of Antwerp	
Czechia			
BSc, Masters and PhD study programmes	Programmes e.g. Forest Ecology, Methods of Ecosystem Studies, Forest Stands Microclimate	Mendel University in Brno	
PHD thesis	Dynamics of fine roots carbon storage on the example of Norway spruce (Picea abies [L.] Karst.) stand in Ecosystem station Bílý Kříž	Mendel University, Brno, Czechia	Completed by Tereza Uchytilová
PHD thesis	Growth of woody plants at the cellular level	Mendel University, Brno, Czechia	Completed by Dimitrios Tsalagkas
PHD thesis	Ecophysiological response of Norway spruce and sessile oak saplings to stress conditions	Mendel University, Brno, Czechia	Completed by Janko Arsić
Denmark			
MSc.	Agricultural productivity from three ICOS sites	Copenhagen / Copenhagen University	Wicke / Friborg
MSc	Forest floor plant phenology at DK-Sor	Kgs Lyngby DTU	Lam eau/ Ibrom
MSc	Willow sensitivity to draught at DK-RCW	Kgs Lyngby and Gif Sur Yvette / DTU and Agro Paris Tech	Jaujay / Ibrom Gabrielle
BSc	Beech phenolology based on repeated web cam imagery at DK-Soro	Kgs Lyngby / DTU	Thorleifsson / Ibrom
BSc (team if three)	Willow carbon balance at DK-RCW	Kgs Lyngby / DTU	Kastberg, Wentzel Sørensen, Damm / Ibrom
MSc course Hydrology	Hydrology	Univ. of Copenhagen	
MSc course	12145 Terrestrial Ecology for Engineers	Kgs Lyngby / DTU	Excursion to DK-Sor
BSc course	2515 Ecology	Kgs Lyngby / DTU	Excursion to DK-Sor

Finland			
MSc thesis by Eeva Järvi-Laturi	Dependence of methane flux on plant community composition in a north boreal rich fen	Univ. of Eastern Finland	
PhD thesis by Nicola Kokkonen	The impact of drying on the structure and photosynthesis of a boreal peatland vegetation	Joensuu, University of Eastern Finland	
PhD thesis, Laura Heimsch	Greenhouse gas fluxes and carbon balance in Finnish agroecosystems that utilize regenerative farming practices	Univ. of Helsinki, Finnish Meteorological Institute	
Eddy Covariance Intensive course, February 5-9, 2024	Ivan Mammarella, Aki Vähä	Course at University of Helsinki	ca. 30 participants
Lecture in a course Climate change mitigation and adaptation in forestry	Annalea Lohila	Lecture for university students: IPCC AR6 and forests. Univ. of Helsinki	ca. 50 participants
Educating climate experts,	Timo Vesala	Lecture: carbon cycle and CO2 emissions	
Systemschange.now course	Timo Vesala	Forest as system - Climate perspectives – lecture in Climate University	
Global biogeochemical cycles, January-March 2024, Univ. Helsinki	Annalea Lohila	Univ. Helsinki	10 participants
France			
Practical work on greenhouse gases integrated into the PEPS Master .	GHG	University Paris-Saclay	
Field internship for master students, visit to the ICOS tower in Trainou, the ICOS Atmospheric Thematic Center in Saclay, participation in an AIRCORE launch, and a visit to the SNO Tourbières in Orléans	GHG Tall tower	Univ.Paris Saclay - UVSQ	

The TCCON-Paris station welcomed students from the M2 master's degree "Physical Methods in Remote Sensing" in practical work to train them in large scientific instruments and greenhouse gas monitoring; and to raise their awareness of global warming	TCCON instrumentation	Sorbonne University	
Earth System course, Master ACTE	Lecture	Ecole Centrale Supelec	
Discovery internship for two weeks from 5 middle schools		Middle school	
One day educational session during the ICOS Science conference in Versailles		ICOS Science Conference	30 students
PhD Pedro Coimbra	wavelet based Eddy Covariance coupled to bayesian inversion spatial flux computation	Univ Paris Saclay	
PhD Taeken Wijmer	Estimating the components of crop carbon and water budgets: a high-resolution approach using optical data assimilation in a crop model	Univ Toulouse	
Master thesis Hadrien Cadiou	Study of the spatiotemporal variability of leaf functional leaf traits and relationships with associated carbon fluxes in the ICOS observation network	U. Bordeaux	
Study visit : 21 students visits @ FR-Lqu	carbon cycle	U Clermont Ferrand	
Study visit : 45 master 2 studens visit to FR-Hes	carbon cycle	U Gembloux (Be) & U Nancy	
Study visit : 32 students visit to the FR-Bil site	carbon cycle	Bordeaux Science Agro	
Study visit : 15 students visit to the FR-Gri site	Climate and land Use change	U Paris Saclay	
Study visit : 18 students visit to the FR-Pue site	Ecosystem functioning	U Montpellier	
Study visit : 21 students visit to the FR-Pue site	Forest ecology and functioning	Agro Dijon	

PhD Thesis	Guimarães L.M (2024). Variabilidade interanual da pCO_2 na interface oceano-atmosfera do Atlântico tropical entre as latitudes 3ºS e 14ºS		
MasterThesis	Verheyde T. (2024). Quantification of the seasonal and interannual air-sea flux of CO_2 in the tropical Atlantic using neural network techniques and in situ CO_2 observations. LOCEAN,	Sorbonne Université	
Germany			
BSc Thesis Landscape Ecology	Understanding the cooling effect of peatland ecosystems through measured energy fluxes	University of Münster	Using data from DE-Amv
BSc Thesis Landscape Ecology	Tracking peatland vegetation phenology using digital repeat photography	University of Münster	Using data from DE-Amv
MSc. Thesis by Gerrit Sassor	Climate impact (radiative forcing) of land use changes	TU Dresden	M.Sc. Thesis in Hydrology
Class	'Bioclimatology', 'Ecosystem-Atmosphere Processes', 'Experimental Bioclimatology', 'Global Change', 'Klima- und Bodenschutz', 'Chemistry/Physics', 'Physik für Forstwissenschaftler'	Bioclimatology, Georg-August-Universität Göttingen	Usage and discussion of data in the lectures and seminars (Alexander Knohl, Christian Markwitz, Anne Klosterhalfen)
Master thesis	Ayesha Saddiqa, Plasticity in foliar drought tolerance of European beech and European ash in mature old-growth stands over a growing season	Bioclimatology, Georg-August-Universität Göttingen	Supervisor: Anne Klosterhalfen
Bachelor thesis	Lykka Gering, Betrachtung der Wechselwirkung zwischen Phänologie und Brutto-Primärproduktivität mittels dreier Bestimmungsmethoden im Gebiet des Nationalparks Hainich	Bioclimatology, Georg-August-Universität Göttingen	Supervisor: Christian Markwitz
Bachelor thesis	Annika Heuss, Drought tolerance assessment of European beech and	Bioclimatology, Georg-August-Universität Göttingen	Supervisor: Anne Klosterhalfen

	European ash trees in Hainich National Park and Leinefelde: Investigating plasticity in midday water potential and pressure-volume curves		
Bachelor thesis	Sören Schwekendiek, Evaluation of gap-filling vertical concentration profile data using an LSTM Network	Bioclimatology, Georg-August-Universität Göttingen	Supervisor: Anne Klosterhalfen
Bachelor thesis	Finn Westermann, Analyse des Leaf Area Index (LAI) unter Anwendung von verschiedenen indirekten Messmethoden im Nationalpark Hainich	Bioclimatology, Georg-August-Universität Göttingen	Supervisor: Anne Klosterhalfen
Lecture, BioGeo-Kolloquium	25 years of climate science in National Park Hainich	Friedrich Schiller University Jena, 29. Oct 2024	Anne Klosterhalfen
PhD thesis	Nico-Maurice Lange, 2024: Beyond FAIR: Manifesting marine data synthesis products within the ocean observing system – A biogeochemical essential ocean variables perspective (Betreuer: A. Körtzinger)	University of Kiel, Germany	
Summer School	Hackathon with DE-FOS-CVOO data during Helmholtz MarData summer school (B. Fiedler)	Ocean Science Centre Mindelo (OSCM), Cabo Verde	
M.Sc. course	International WASCAL M.Sc. Programme “Climate Change and Marine Sciences”, Teaching Module CC-02 “Chemical oceanography” (A. Körtzinger)	Universidade Tecnica do Atlantico, Mindelo, Cabo Verde	
Master thesis	Integrierung und Evaluierung eines HydroC- Messgerätes im autonomen Messbetrieb im subpolaren Nordatlantik (SOOP) und Vergleich der Parameter des maritimen CO_2 Systems (Tobias Spreitz)	University of Kiel, Germany	
B.Sc. course	B.Sc Course, Teaching Module MNF-chem 0406D “Introduction to Oceanography and Marine	University of Kiel, Germany	Specific lectures on marine carbon cycle and CO_2 system

	Chemistry", summer semester 2024, winter semester 2024 (A. Körtzinger)		
M.Sc. course	M.Sc. Course, Teaching Module MNF-bioc 231 "Current Topics in Marine Biogeochemistry"	University of Kiel, Germany	Specific focus on marine carbon cycle and CO_2 system
M.Sc. Course Land-atmosphere interactions	Excursion to DE-Har station	University of Freiburg	18.04.2024 (10 Students)
B.Sc. Course "Bioclimatology"	Excursion to DE-Har station	University of Freiburg	12.01.2024 (50 Students)
M.Sc. Thesis	Ecophysiological response of competing Pinus sylvestris L. and Carpinus betulus L. after years of recurrent severe droughts.	University of Freiburg	Used data from ICOS Station DE-Har
University Course "Atmosphere and Hydrosphere"	Used data from DE-Har to illustrate basic role of land surface in climate system	University of Freiburg	270 Students
University Course "Bioclimatology"	Used data from DE-Har to illustrate basic biometeorology	University of Freiburg	60 Students
University Course "Land-atmosphere interactions"	Used data from DE-Har for student projects	University of Freiburg	6 Students
Lecture to University of Oldenburg students in Operational Oceanography	Carbonate system and FerryBox Measurements	Hereon, March, 2024	This is an annual event, and we introduce students (around 20) to our approaches for studying biogeochemical dynamics at the land-sea interface
PhD thesis	Felix Pohl: Towards unified drought analysis: Detecting direct and legacy effects on forest carbon cycling in eddy covariance data	UFZ, Leipzig, April, 2024	
M.Sc. study course "Nature conservation and landscape ecology" of University of Bonn	Excursion to DE-HoH, soil sampling, tower visit	UFZ, Leipzig, May, 2024	

M.Sc. Thesis	Gombodshaw-Johann Boß (2024): ”Towards sustainable traffic: High-resolution modelling of urban CO_2 flux variability and the impact of COVID-19 lockdown on traffic emissions in Berlin”.	M.Sc. Thesis in Urban Ecosystem Science TU Berlin, 2024	
PhD thesis	Louise Rewrie: “Carbon Cycling in the Elbe Estuary”	University of Kiel, Germany, supervision by HEREON	
Ireland			
Teagasc – lectures	Soil Carbon	University of Galway	Lecture given by Dr Rachael Murphy
Undergraduate lecture & fieldtrip	Forest carbon balances	UCD	Part of a module entitled Forest Climate & Carbon led by Dr Brian Tobin
Lecture to UCD Sustainability module SUST40050	Forest carbon sequestration opportunities	UCD	Lecture by Dr Brian Tobin
Italy			
Lectures and university classes:	“*INAUGURAZIONE PANCHINA VERDE panchina tematica per la tutela dell’ambiente e non solo…*” I.I.S ”Quinto Orazio Flacco”, Venosa – Seminar “La tutela del patrimonio in un clima che cambia” 05/04/2024		100 participants
lecture	“*Rilevazione dei Dati Atmosferici e cambiamenti climatici*” Liceo Scientifico e Linguistico Statale “Federico II di Svevia”, Altamura, 13/03/2024		60 participants
Lecture	"Carbon cycle in forest ecosystems: from measurements to climate change impacts" - Lecture to the Ormea forest school - 2024		
Summer school	“ATMospheric Observations and Soil Organic Carbon (ATMO-SOC)” training course		22 participants

	in the framework of the "International summer school "High mountain ecosystems by soil survey and GIS–based mapping " (https://eventi.unibo.it/scuola-estiva-alfonsa-2024, 22 participants).		
Lecture	"ICOS: L'INFRASTRUTTURA DI RICERCA EUROPEA PER LO STUDIO DEL CICLO DEL CARBONIO"", Sestola, 7 June 2024 (59 participants)		59 participants
Lecture	"Cambiamenti climatici, inquinamento atmosferico e "Planetary Health"",	Liceo Scientifico "A.Tassoni" Modena, 21 November 2024	
MSc course	Micrometeorology. MSc Course for the Physics Master degree	Catholic University of the S.H., Brescia (BoscoFontana)	
MSc course	Ecologia. MSc Course for the Physics Master degree	Catholic University of the S.H., Brescia	
BSc course	Controllo dell'inquinamento. BSc Course for the Mathematics degree	Catholic University of the S.H., Brescia	
MSc course	Fisica dell'Atmosfera. MSc Course for the Physics Master degree	Catholic University of the S.H., Brescia	
BSc course	Analisi di dati sperimentali e statistica applicata. BSc Course for the Mathematics degree	Catholic University of the S.H., Brescia	
MSc course	Environmental chemistry.	Universidad de Navarra, Pamplona (Spain)	
Lecture	(Integration of satellite and in situ data to measure CO_2 fluxes in the Mediterranean Sea)	M. Pecci, Univ. of Rome Sapienza	
Lecture	Giani M. CO_2 absorption by the ocean and the acidification process, Advanced master in sustainable Blue Growth, Giambiagi Lecture Hall, Adriatico Guesthouse Trieste, 14 March 2024 (Miramare)		

Seminar	Anthropic activities and planetary radiative budget: the climate crisis, March 5, 2024, seminar during "Giornate formative AEROBIOLOGIA, CAMBIAMENTO CLIMATICO E CO-FATTORI DI ORIGINE ANTROPICA E NATURALE", Lamezia Terme (Italy)		
Seminar	10th September 2024 (Sestola, Italy) - "Role and activities of the Italian Climate Observatory Ottavio Vittori"		
Field trip	11th Field trip at Mount Cimone: visiting to the Italian Climate Observatory "Ottavio Vittori", soil profiles description and methodologies for pedofauna surveying	Mount Cimone	
Seminar	Seminar at Royal Holloway University of London by Giulia Zazzeri: 23rd Febrauary 2024. Title: "The rapid growth of atmospheric methane: a puzzle still to be resolved"		
Seminar	Seminar on eddy covariance measurements at the Torgnon ICOS sites - University of Milano (Forest Lab)		
Study visits	22 study visits in Italy		
The Netherlands			
BSc thesis Janne Graumans	Local influences on the groundwater table	Wageningen University	
BSc thesis Marc Lobregt	Transforming the Loobos into a sand drift area A comparative study for the consequences for the water balance and groundwater level	Wageningen University	
MSc thesis Ruizhe Li	Gapfilling NEE measurements study in Loobos in situations of missing storage flux measurements	Wageningen University	

MSc thesis Federico Battistig	IMPACT OF DROUGHT ON CARBON AND WATER FLUXES IN A TEMPERATE SCOTS PINE FOREST: A BI-DECENNIAL ANALYSIS	Wageningen University	
MSc Thesis Lena Sakalak	Quantifying carbon storage from atmospheric and LiDAR measurements	Wageningen University	
MSc thesis Maxine Luger	Partitioning Forest Evaporation	TU Delft	
Spain			
Master's Thesis.	To explore the levels and behavior of CO_2 at El Arenosillo.	El Arenosillo Atmospheric Station	
Student external practices	To investigate GHG atmospheric concentration in the Canary islands region.	Izaña Atmospheric Station	
Master	Master in Oceanography ULPGC: CO2 and Ocean Acidification	Universidad de Las Palmas de Gran Canaria	
Sweden			
BSc theses	Sarno, F. (2024). Long-Term Particulate Matter Measurements in Southern Sweden.	Lund University, Department of Physics.	
BSc theses	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.	
BSc theses	Wulff, E. (2024). Kvicksilver I ett svenskt landskap.	SLU Uppsala, Dept. of Aquatic Sciences and Assessment.	
BSc theses	Zhong, Y. (2024). Impact of wind on litterfall in a coniferous forest of southern Sweden.	Lund University, Department of Physical Geography and Ecosystem Science.	
Course	Environmental monitoring course	LTH/Lund, SE	Field visit
Course	Aerosol Technology Project Course	LTH/Lund, SE	Field visit
Course	Climbecco Summer School	LU/GU, Sweden	Field visit
Course	Greenhouse gases and biogeochemical cycles	LU, Sweden	Field work
Course	Trädekofysilogi	Linné universitet, Sweden	Field work

Course	5 courses	GU/Sweden	Field visit
Course	NN	Franklin Univ/CH	Field visit
Course	European Forestry Field School	University of British Colombia/CA	Field visit
Course	Soil biology and biogeochemical cycles	SLU / SE	Field visit
Course	Forest Management Course	Linneuniversitetet/SE	Field visit
Course	Watershed Ecology and Biogeochemistry	SLU / SE	Field visit
Course	Environmental field studies	Stockholm Univ/SE	Field visit
Course	Greenhouse gas exchange across the sub-Arctic; simultaneous hands-on measurements and scaling at different sites	LU/SE	Field work
Course	Artic & Alpine ecology	GU/SE	Field work
Course	Greenhouse Gases and the Carbon Cycle	LU/SE	Field work
Course	universities associated with the ELLS network (Euroleague for Life Sciences)		Field visit
Course	Excursion with students from Alnarp	SLU/SE	Field visit
Talk at EcoHydrology Summer School 2024 (19.6.2024, Nina Buchmann)	Ecosystem carbon and water vapor fluxes	ETH Zurich and EPFL	28 international students
Master thesis, Ziyu Guo	Response of net ecosystem productivity of forests to short-term temperature changes	ETH Zurich	
Lecture 'Air pollutants and air quality' (21 November 2024, Martin Steinbacher)	Variability and trends in atmospheric trace gases, measurement techniques	Zurich University of Applied Sciences, Waedenswil	60 students from the program 'Environment and Natural Resources'
Lecture 'Luft als Resource' (06 Dezember 2024, Martin Steinbacher)	Air pollution and greenhouse gases	Zurich University of Applied Sciences, Winterthur	40 students from the 'School of Architecture, Design and Civil Engineering'

International BMKG - WMO Training on Greenhouse Gas Monitoring and Data Analysis (25 June to 11 July 2024, Martin Steinbacher)	Greenhouse gases and climate change, measurement techniques	Online part of the blended greenhouse gas training (see below)	60 participants from the Asia and Southwest Pacific Region
Hands-on Training on Greenhouse Gas Measurements (30 September to 04 October 2024, Martin Steinbacher)	Operation and quality control of in-situ atmospheric greenhouse gas measurements	Bukit Koto Tabang Global Atmosphere Watch Station, Indonesia	28 participants from 14 countries of the Asia and Southwest Pacific Region
Lecture "Urban Climatology" , fall semester 2024 (Lecturers: Stavros Stagakis, Nicolas Bukowiecki)	Impacts of urbanization on atmospheric processes and climate	University of Basel	10 MSc level students
Lecture "Biogechemistry and Sustainable Management", fall semester 2024 (Nina Buchmann, Kukka-Maaria Kohonen, Iris Feigenwinter)	Greenhouse gas fluxes from agricultural ecosystems	ETH Zurich	25 MSc students
Lectures, ETH Zurich, 701-1616-00L, Growth of Trees and Forests – from Germination to Tree Death. (A. Gessler, A. Rigling, Roman Zweifel et al.)	Growth of Trees and Forests	ETH Zurich	30 Msc students
Head office and central facilities			

Course	ICOS Summer school	CP, OTC, Wageningen	
Lectures	Visiting lectures in course “Sustainable future” for high school	HO / Helsinki High School of Natural Sciences	
Seminar	Master Seminar Environmental Physics	CRL, Heidelberg University	
Course	Organization of the next FLUXCOURSE events in Colorado	ETC Papale	
Master course	Monitoring Terrestrial Carbon Cycle in Viterbo (Italy)	ETC Papale	
Bachelor course	Global Carbon Cycle in Antwerp	ETC Gielen	
PhD Pedro Coimbra:	Wavelet based Eddy Covariance coupled to bayesian inversion spatial flux computation	ATC	
Master Class	Master STEP: class given on Metrology for GHG	ATC	
Master	internship in ATC	ATC	

List of Main ICOS National Network Meetings

(Events inside of ICOS community)

Meeting / Seminar	Time	Place	Nr. of participants
CzechGlobe Working Meetings and Seminars	Several times a month	Brno CzechGlobe seat and ICOS CZ sites	5-10
Gas Workshop Middelfart organized by Aarhus University	29/05/2024, 10:00 - 16:30	Middelfahrt	25
ICOS DK steering group meetings	11/06/2024 11/11/2024	Virtual and UoC	5
ICOS Finland annual meeting	11.-12.1.2024	FMI, Helsinki	55
ICOS Finland board	March 2024	Remote meeting	10
ICOS Finland board	October 2024	Remote meeting	12
ICOS Finland coffees	Weekly	Cafe Arktis	5-10
ICOS France annual meeting	27-29 november 2024	Rennes	50 people
ICOS Germany Annual Meeting	20.-22.11.2024	Staats- und Universitätsbibliothek Göttingen	25 (+15 online)
Annual ICOS-Hungary consortium meeting	8 February 2024	Gödöllő, Hungary	13
ICOS Ireland National Meeting	14:00-15:30 10th April 2024	Dublin, Ireland	
ICOS Ireland National Meeting	14:00-15:00 7th May 2024	Dublin, Ireland	
ICOS Ireland National Meeting	10:30-15:00 22nd October 2024	Dublin, Ireland	
Ruisdael Science Day	30 September 2024	Utrecht, The Netherlands	60
ICOS Norway Annual Meeting 2024	03.12.2024-04.12.2024	Bergen, Norway	20
Meeting Izaña observatory (AEMET) with the National Institute of Aerospace Technology (INTA) to exchange experiences and define measurement strategies for ICOS-Spain	8/02/24 16/04/24 24/09/24 11/10/24 13/12/24	On-line	Sergio Leon (Izaña station), Pedro Pablo Rivas (PI of Izaña station) and Jose A. Adame (PI of El

station of El Arenosillo.			Arenosillo station).
ICOS-Spain: Meeting stations of the national network	5 June	On-line	Focal point and PI of spanish station
Coordination meeting before ICOS General Assembly (4-6 November 2024)	30-31 October	On-line	Carlos Torres (Focal Point), Maria Vallejo, Melchor González and Arnaud Carrara.
Preparation of funding proposal for all ICOS stations	13-20 June	On-line	Focal point and PI of spanish station
Technician Meeting	1/month	digital	Between 5 and 12
ICOS SE meeting	every 2 months	digital	Between 10 and 20
ICOS SE steering committee meetings	Mar+Nov	digital	9
ICOS Davos Spring Meeting	15 May 2024	Zurich, Switzerland	11
HFSJG (Jungfraujoch) user meeting	24 May 2024	Bern, Switzerland	18
ICOS Switzerland Annual Meeting	3 September 2024	Bern, Switzerland	25

List of Main Events Organised or Co-organised by ICOS National Network

(Events including people outside of ICOS community)

	Event	**Time**	**Place**	**Nr. of partici pants**
BE	UGhent rectoral visit of all Congoflux-sites in Yangambi	14-20 January 2024	Yangambi, DRC	15
BE	BE-Dor site visit during a workshop organized as part of the European MRV4SOC project	26 March 2024	Dorinne, Belgium	25
BE	Lecture at ICOS/WMO summer school	18 – 25 August 2024	Wageningen, the Netherlands	20
BE	Ecosystem MSA	21 – 23 May 2024	Antwerp, Belgium	100
BE	ETC Teambuilding and meeting	23 – 24 May 2024	Antwerp, Belgium	20

BE	ICOS Wallonia annual meeting	08 October 2024	Gembloux, Belgium	50
CH	22nd Swiss Geoscience Meeting – Session 16 "Atmospheric Composition and Biosphere-Atmosphere Interactions"	9 November 2024	Basel, Switzerland	40
CH	22nd Swiss Geoscience Meeting – Session 17 "Urban environments and climate change"	9 November 2024	Basel, Switzerland	50
CH	TreeNet Annual Meeting	12 November 2024	Birmensdorf, Switzerland	60
CZ	Visit of the Minister of the Environment, Petr Hladík of the ICOS-CZ Trebon wetland station	4th April 2024	ICOS-CZ Trebon wetland station, Třeboň, Czechia	6
DK	EGU 2024 BG8.13 Long-Term Flux Observation and Ecosystem Research Networks - Benefits for Science and Society	18.04.2024	Vienna	200
FI	ACCC-FASN Science Conference 2024, bringing together researchers working with the data from ICOS, ACTRIC, AnaEE and eLTER infrastructures. ACCC stands for the "Atmospheric and climate change competence center" and is a flagship program funded by the Research Council of Finland. FASN stands for "Finnish Atmospheric Science Network".	November 2024	Finnish Met. Institute and Univ. of Helsinki	150
FI	ACCC impact week 2024 in April in Helsinki: "From deep understanding to implementation of practical, sustainable solutions - Climate change and green transition as global challenges for science and society"	April 8-12, 2024	Cultural center Sofia, Helsinki, Finland	200
FR	ICOS cities annual meeting	March 2024	Université Paris-Saclay (Lumen)	80 people
	ICOS International Science Conference (n°6)	10-12 September 2024	Versailles	540 people (on site and remote)
DE	PaludiNetz Kick-off	10.-12.06.2024	Braunschweig	200 (~25 for GHG part)

DE	PaludiNetz GHG workshop on method harmonization	08.-09.10.2024	Braunschweig	18
DE	EGU General Assembly, Session BG3.33 on ”Understanding carbon, energy, and water fluxes from leaf to continental scales”	15.-19.04.2024	Vienna, Austria	~100
DE	EGU General Assembly, Session BG3.35 on ”Exchange of GHG and reactive gases in agricultural ecosystems”	15.-19.04.2024	Vienna, Austria	~50
DE	EGU General Assembly, Session AS2.4 on ” Air-Land Interactions (General Session, co-sponsored by ICOS)”	15.-19.04.2024	Vienna, Austria	~100
DE	ICOS Science Conference, Session ”Impact of Climate Extremes on GHG fluxes”	10.-12.09.2024	Versailles	~150
DE	ICOS Science Conference, Session ”Exchange of reactive gases and aerosols between the land surface and the atmosphere in natural and managed ecosystems”	10.-12.09.2024	Versailles	~80
DE	iPSC- Peatlands and Ecosystem Functions	18-21.09.2024	Freising	300
FR	ICOS OTC workshop	07. – 10.10.2024	Villefranche, France	30

List of Main Events Attended by ICOS Consortium

Note: Some national networks have reported e.g. Project meetings. Those have been excluded from this event summary.

Member(s)	**Event**	**Time**	**Place**
CH	GAW/GCOS Switzerland National Coordination Meeting	1 February 2024	Bern, Switzerland
DE	Ocean Sciences Meeting	18. – 24.02.2024	New Orleans, USA
BE	Belgian Science for Climate Action Conference	19 – 20 February 2024	Brussels, Belgium
BE	Participation of P. Boecx at PANGEA workshop	21 – 22 February 2024	Yaoundé, Cameroon
BE	VLIZ Marine Science Day	06 March 2024	Ostend, Belgium
DE	Workshop ”Microclimatic processes and natural hazards under climate change”	04. – 05.03.2024	Berchtesgarden, Germany
BE	Aavos spring event: Process and Environmental Analyser solutions		
CH	VAO Board meeting	19 March 2024	Innsbruck/online

HU	XIX. Carpathian Basin Environmental Science Conference	3-5 April 2024	Debrecen, Hungary
CH	Symposium 'Jungfraujoch and beyond. High Altitude Physiology and Medicine'	4 April 2024	Bern, Switzerland
BE	Congo Biogeochemical Observaotry meeting		
BE, CH, DK, HU, NO, SV, FR, D, IE, OTC, HO, ETC	EGU 2024	14-19 April 2024	Vienna, Austria
	ATM MSA meeting	20 – 22 April 2024	Utrecht, Netherlands
CH	CLEO 2024: Conference on Lasers and Electro-Optics	05 -10 May 2024	Charlotte, United States
CH, DE	14th International Conference on Air Quality	13-17 May 2024	Helsinki, Finland
SE	https://swedishclimatesymposium.com/	May 2024	Norrköping/Sweden
CH	FORECOMON Conference	9 – 10 June 2024	Prague, Czech Republic
CH	ICP Forests Scientific Conference	10-12 June 2024	Prague, Czech Republic
BE	Biosphere-Atmosphere Interactions and Impacts in the Anthropocene	9 – 14 June 2024	Barcelona, Spain
IT, SE	IUFRO World Conference https://iufro2024.com/	23-29 June 2024	Stockholm/Sweden
IT	ESA ATMOS 2024	1-5 July 2024	Bologna, Italy
FI	PPNW2024	1-5.7.2024	Girona, Spain
NO	SIOS-Methane In Svalbard workshop	03-04.07.2024	Longyearbyen, Svalbard
CRL, CP	International Carbon Dioxide Conference ICDC	July	Manaus, Brazil
FI, OTC, CRL, FCL, CP	22nd WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Tracers Measurement Techniques (GGMT-2024)	5.-8.8.2024	Sao José dos Campos, Brazil
FI	Microclimate Ecology & Biogeography Conference	26-27.8.2024	Helsinki, Finland
IT	EMS Annual Meeting	1-6 September	Barcelona, Spain
ETC	AMERIFLUX annual meeting	4.-6. September	USA
BE, CH, CZ, FI, FR, NO,	ICOS Science conference	10 – 12 September 2024	Versailles, France

SP, SV, UK, DE, IE			
CH	"Beating the Heat" Conference 2024	11 September 2024	Bern, Switzerland
CH	Seminar series of the "ReClean consortium"	17 September 2024	Online, Switzerland
DE	XXVI Union of European Foresters Governing Council Meeting 2024	20. – 21.09.2024	Luxemburg
HU	4th International Radiocarbon in the Environment Conference	22-27 September 2024	Lecce, Italy
DE	ITMS General Assembly	24. – 26.09.2024	Karlsruhe, Germany
IT	WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2024)	24-26 September 2024	Vienna, Austria
FI, DE	12th FerryBox Workshop	1.-2.10.2024	Helsinki, Finland
	OTC MSA meeting	10 – 11 October 2024	Laboratoire d'Océanographie de Villefranche Villefranche-sur-Mer, France
BE, DE, FR	OTC workshop	7-10 October 2024	Laboratoire d'Océanographie de Villefranche Villefranche-sur-Mer, France
IT	Eurogeo Workshop 2024, ,	8–10 Oct 2024	Cracow (PL)
HU	XII. Environmental Chemistry Symposium	11 October 2024	Siófok, Hungary
FI	LiWeFor seminar at Sarawak Tropical Peat Research Institute	15.10.2024	Kuching, Malaysia
OTC	G7 FSOI	15.10.2024	
NO	AMAP workshop on Coupled Terrestrial Monitoring:	15-16.10.2024	Reykjavik, Iceland
FCL	CCQM-GAWG Workshop on Global and National Greenhouse Gas Monitoring Initiatives	October	Daejon / Online
OTC	IOCCP	5.-7.11.2024	Paris
IE	UNFCCC COP29 & SB	11-11.11.2024	Baku, Azerbaijan
CH	22nd Swiss Geoscience Meeting	8-9 November 2024	Basel, Switzerland

CH	TreeNet Annual Meeting 2024	12 November 2024	Birmensdorf, Switzerland
	Ecosystem MSA	18, 26, 27 November 2024	Virtual
ETC	FLUXNET CH4 meeting	21-23 October 2024	Virtual
	ATM MSA meeting	25 – 27 November 2024	Virtual
BE	ICOS AST (ICOS France Scientific and Technical Assembly)	27 - 29 November 2024	Rennes, France
DE	METTOOLS XII (DMG)	26. – 28.11.2024	Dresden, Germany
FI	Ginkgo Network Meeting	27.-29.11.2024	Jena, Germany
BE	GAPSYM17	28 – 29 November 2024	Ghent, Belgium
CZ	International Conference on Research Infrastructures - ICRI	3.-5. December 2024	Brisbane, Australia
BE, FI, ETC	AGU	9 -13 December 2024	Washington D.C., USA

List of outreach events

Member	**Event**	**Person**	**Media**	**Note**
BE	Newspaper article	P. Boeckx	Le Monde	Les scientifiques appelés au chevet des forêts du bassin du Congo
BE	Site visits	P. Boeckx	Research visit of P. Boeckx and UGENT rector to AmazoneFace and INPA in Manaus, Brazil;	Aim is to tighten relationship with FWO-IRI activities in the Congo basin and the INPA activities in the Amazon
BE	CNO Brasschaat (05 March 2024)	Fran Lauriks		
BE	Oostende voor Anker (23 – 26 May 2024)	Fran Lauriks	Science booths in harbor festival	
BE	BE-Lon site presentation to the partners of the European	Bernard Heinesch Bernard Longdoz	Site visit	

	MRV4SOC project, (07 May 2024)			
BE	Meeting with Flemish enivronmental policy organisations - presentation of the Flemish IRI's (10 October)	Fran Lauriks		
BE	Belgian Science Day (24 November 2024)	Thanos Gkritzalis (VLIZ) Marilyn Roland (Uantwerp)	Science festival	
BE	Exursion bosgebruiksplatform (19 December)			
CH	Waldschutzüberblick 2023	WSL, treenet	Report	Link
CH	Article in SCNAT ProClim Flash nr. 79	ETHZ and University of Basel in collaboration with the Swiss GAW/GCOS-Office	Wie urbanes Grün die Hitze reduziert	Link
CH	Grosser Rat diskutiert Sofortmassnahmen gegen Stadthitze	Christian Feigenwinter	Radio (SRF Regional Journal Basel Baselland, 10 April 2024)	Link
CH	Visit of Japanese journalists at Jungfraujoch	Markus Leuenberger and HFSJG Team	Station visit, 18 April 2024	
CH	'Swiss Youth in Science' at Jungfraujoch	Urs Baltensperger and HFSJG Team	Station visit, 5 July 2024	Link
CH	Visit of ECOSENSE project participants at Davos	Iris Feigenwinter	Station visit, 31 July 2024	19 participants

CH	Visit of WMO's Secretary General, Celeste Saulo, at Jungfraujoch station	Markus Leuenberger and Martin Steinbacher	Station visit, 21 August 2024	
CH	Visit of members of the Swiss Society for Meteorology at Jungfraujoch	Martin Steinbacher	Station visit, 23 August 2024	Link
CH	Invited talk at the ITES Montagskolloquium für die Praxis: Langfristige Beobachtung und Experimente im Wald: Was nützt das der Praxis?	Nina Buchmann, Iris Feigenwinter	Oral presentation, 30 September 2024	
CH	Interview for BBC documentary	Martin Steinbacher	BBC panorama, 18 November 2024	Link
CH	Visit of President of the National Council	Markus Leuenberger and HFSJG Team	Station visit, 28 November 2024	Link
CH	Waldschutzüberblick 2023	WSL, treenet	Report	Link
CZ	Article: Zalesňování není všelék na změnu klimatu, upozorňuje vědec z Akademie věd. Uhlík se v lesích neudrží navždy. (Afforestation is not a panacea for climate change, warns a scientist from the Academy of Sciences. Carbon will not be stored in forests forever)	Ladislav Šigut	Websites Czech National TV24 (www.ceskatelevize.cz)	Statements supported by the Czech Carbon Observation System (CzeCOS) ecosystem sites network that are part of ICOS
DK	Naturmødet	Ibrom / Scheutz	Presentation	Meeting for the Danish public intersted in Nature In Hirtshals
DK	Science Picnic at DTU Sustain	Ibrom, Pilegaard, Kissas, Wang, Ricci, Rønn	Excursion to forest	Internal communication of ICOS to colleagues

		Lange, Møller, Skaarup Sørensen		
FI	Flux site visit	Hannu Autto/Mikko Sipilä	Environmental science course high school students (ca. 30 persons) visiting the Kilpisjärvi eddy covariance site in October 2024	
FI	Journalist visit by Helsingin Sanomat 3.12.2024	Timo Vesala	Presentation: What do we know about the methane emissions from northern regions?	
FI	Naarasneva open doors day 31.10.2024	Annalea Lohila, Alex Buzacott	Local people and entrepreneurs (ca. 25 participants), two newspapers	
FI	Art exhibition opening 18.5.2024	Timo Vesala	Treebound – puuhunsidotut presentation using movies	
FI	Interview during the CoastClim outreach event on June 6th, 2024 held at the University of Helsinki main building	Ivan Mammarella	The researchers of Stockholm University and University of Helsinki presented their results to the stakeholders and university officials.	
FI	Kumpula-Viikki Day 14.5.2024	Timo Vesala	Being the go-between: From 3-D stomata to nanobubbles - lecture	
FI	Kilpisjärvi hosts research on the effects of climate change on ecosystems, locally and globally	Anna Virkkala	University website	Link
FI	Cooperative bodies between the University of Helsinki and Lapland meeting and visiting the	Hannu Autto	Meetings	

	Kilpisjärvi eddy covariance site, September 2024			
FI	CLEHE RC Seminar Days, 25-26.3.2024, Joensuu, 87 participants	Eeva-Stiina Tuittila	Seminar	
FR	One planet Webinar for African scientists: Measuring and monitoring greenhouse gas concentrations in the atmosphere: Why? How?	M. Delmotte	Webinar	
FR	Visitors at LSCE all year long, high school students, decision-makers, media	M. Delmotte	Seminars, round tables, science festival	
FR	Visit of the Swedish Minister of Climate to the LSCE in the fall of 2024 with a visit to the ICOS ATC and SNO labs		Visit	
FR	Inauguration of CO2 measurements on the Generali balloon in Paris as part of the European ICOS-Cities project in April 2024		Event	
FR	Public Visit from the European Society of Agronomy Congress, Rennes, August 2024 @ FR-Mej	20	no media	
FR	You tube visit of @FR-Fbn Class 2 ecosystem site by Léa Veuillen (PhD	651 views		Link

	student now Scientist @ INRAE)			
FR	TV Interview of JM Limousin in FR-Pue for the show "Sur le front, La face cachée des forêts françaises"		French National Television: France 5	
DE	Newspaper article	Mana Gharun	Unizeitung wissen|leben Nr. 8, 11. Dezember 2024.	Link to digital article
DE	Essay, **"**Klimafor-schung im Nationalpark Hainich - Erkenntnisse zu Kohlen-stoffbilanz und Energieflüs-sen."	Anne Klosterhal-fen	*Mühlhäuser Beiträge* 47, edited by Mühlhäuser Geschichts- und Denkmalpflegeverein in cooperation with Mühlhäuser Museen, and Stadtarchiv, Mühlhausen, 61-73.	
DE	Public talk, Soil, trees, climate - the forest system	Alexander Knohl	Online-event for high school students organised by VBIO and DV Geo	ca. 1200 participants
DE	Exhibition „Digital Forest – A virtual journey into climate research"	Alexander Knohl, Anne Klosterhal-fen	Exhibition at the National Park center Hainich, 03/2024-06/2024	
DE	Inauguration of new GEOMAR building	Bettina Stark-Watzinger (former minister for education and research)	Reception, poster	presentation of DE-FOS-CVOO
DE	Climate change	General public	Tagesschau news web article & radio report	Long-term Observations from CVOO used to explain regional impact by climate change (B. Fiedler)
DE	Climate change	General Public	RBB radio interview	Long-term Observations from CVOO used to explain regional impact by climate change (B. Fiedler)

DE	Exhibition for 70 years anniversary of Deutscher Wetterdienst	Jennifer Müller-Williams	Public talk from 6 July 2024 entitled "Klimagase messen und verstehen" = Measuring and understanding climate gases	Travelling exhibition at Deutsches Museum Flugwerft Link
DE	Deutschland-funk radio interview on the day of publication of the WMO GAW Greenhouse Gas Bulletin	Jennifer Müller-Williams	Radiointerview on 28 October 2024	Link
DE	Visit of delegation from Agricultural Research Council of South Africa at Thünen Institute and DWD-ZAMF	Christian Brümmer, Lennart Böske	Reception, talks, field site visits including DE-Brs tower on 28 October, 2024	
DE	Visit of eLTER Head Office	Anke Hil-debrandt	Field visit at DE-HoH tower (also an eLTER site) on August 26, 2024	
DE	Talk to regional foresters on data collected at De-HoH	Anke Hil-debrandt	Talk with specific focus on drought effects following the 2018-2022 droughts, November 13, 2024	
IT	Conference: Gerosa Giacomo, "La stazione di misura dei flussi di carbonio al Bosco della Fontana: una risorsa per monitorare le forzanti del cambiamento climatico", Un osservatorio giovane 200 anni, Mantova (I), 4 May 2024	Giacomo Gerosa	La Gazzetta di Mantova	Event for students of High Schools. (Ca 200 participants)
IT	MeetMeTonight 27 September 2024, Brescia.	Giacomo Gerosa	In presence event	Event for the wide public. (Ca 150 participants)

	Marzuoli R., Giacomo G., "Alberi e CO_2. Come le piante possono aiutarci a mitigare il cambiamento climatico e il riscaldamento globale"			
IT	"La necessità aguzza l'ingegno. Le competenze per affrontare il cambiamento climatico"	Lucia Mona	YouTube link Reporter: Vito Verrastro	Conference (ca 80 participants) Link
IT	"Il *CNR incontra le scuole: lezioni aperte*" 9 -11 April 2024	Lucia Mona	CNR-IMAA Link	(Ca 263 participants)
IT	"Il CNR-IMAA alla giornata dello studente 2024" 25th May - Potenza	Lucia Mona	Public event Link	Event, organized and promoted by the Provincial Student Council of Potenza (more than 300 participants)
IT	Lampedusa, monitoring greenhouse gases in the ocean, atmosphere, and ecosystem	Tatiana Di Iorio, Alcide di Sarra, Damiano Sferlazzo	video	#ExploreICOS campaign
IT	Activity with Lampedusa high school on CO_2, climate, and energy	Tatiana Di Iorio, Alcide di Sarra, Damiano Sferlazzo	Lampedusa high school, visit to the Atmospheric Observatory	April 15-16, 2024. Approx. 50 students
IT	ECOMED 2024; stand with description of the Lampedusa Observatory	Tatiana Di Iorio, Alcide di Sarra, Damiano Sferlazzo	ECOMED 24, Catania	April 17, 2024
IT	Visit to the Lampedusa Observatories within the Workshop:	Tatiana Di Iorio, Alcide di Sarra,	Lampedusa	October 25-26, 2024. Approximately 30

	”Restoring Lampedusa Island: A Pilot Action for the EU Mission Restore our Ocean and Waters”	Damiano Sferlazzo		
IT	TV programme ”SOSTENIBILITA’ - PROGETTIAMO IL FUTURO” – episode 18 ”FORESTE”	Damiano Gianelle, Luca Belelli Marchesini	Trentino TV	Broadcasted on 19-23 August 2024 (3 replicates) and available on streaming on broadcaster website Link
IT	Futuro 24, ICOS Italy among the topics	Gabriele Guidolotti	National broadcast, more than 350.000 viewers	Link
IT	*"Scienza e Montagna"- August 2024 - Gressoney*	Marta Galvagno	outreach activity to general public	Link
IT	Climate change and the Alps from a European perspective	Marta Galvagno	European Committee of the Regions (CoR) - Saint-Vincent June 12, 2024	Link
IT	Conference ”Il Sentiero dell’Atmosfera: tra scienza, conoscenza e turismo”	Paolo Cristofanelli	Public event. (CA 45 participants)	Link
IT	“Press tour” to the Climate Observatory “Monte Cimone”,12 - 13 June 2024	Paolo Cristofanelli		Public event (Ca 13 participants) Link
NO	Popular science article	Stephen Platt	Forskning.no	Article in Norwegian *Derfor er det så mye metan i atmosfæren nå* (English: why there is so much methane in the atmosphere now).
NO	Interview	Jose A. Adame	Radio	Link
ES	News	Jose A. Adame	Newspapers	Link

ES	News	Jose A. Adame	Internet	Link
ES	Public visits	Jose A. Adame	In person	Student visits have been organized at the El Arenosillo station (University of Huelva, University of Sevilla, University of Córdoba, high schools, etc.).
ES	Public visits	Sergio León and Pedro Pablo	In person	Student visits have been organized at Izaña station (University of Manchester, high schools, etc.)
ES	News	Sergio León	Internet	3 information notes related to the activities and measurements made at the ICOS Link
ES	Récord histórico de concentración atmosférica de CO2 en la estación de Izaña		El Dia Tenerife	Link
ES	FIMAR 2024	QUIMA group	Public event	https://feriainternacionaldelmar.com/
SE	Field visit	Representatives from ICOS SE and ACTRIS SE (coordination and station staff)	Site visit	Visit of LU Working Group for infrastructure visit at HTM/SE-Htm
SE	Interview for newspaper article	Jutta Holst	Dagens ETC, 2024-10-21	Larm-Naturens klimathjältar är akut sjuka
SE	Interview for newspaper article	Erik Lundin	"Turist", 2024-10-25	Link
SE	Public lecture	Jutta Holst, LU	2024-03-11	Om att mäta ekosystemets andningar; NMT dagarna Lund (public talks within the faculties of Science, Medicin and Technology at Lund University)
SE	Blogg on open science	Jutta Holst, LU; Erik Swietlicki LU	2024-10-28	Link

SE	Skogen & Människan	SLU: Björn Ferry, Hjalmar Laudon and more	2024-03-06	Link
SE	interview with Swedish TV; field visit	SLU	2024-03-25	People from SLU are frequently asked about forest related questions; main person here is Hjalmar Laudon who is part of the ICOS Sweden Steering Committee, but who is not involved directly in ICOS otherwise.
SE	interview with Swedish radio broadcast; field visit	SLU	2024-04-26	People from SLU are frequently asked about forest related questions; main person here is Hjalmar Laudon who is part of the ICOS Sweden Steering Committee, but who is not involved directly in ICOS otherwise.
SE	Field visit	SLU	2024-05-02	Wallenberg Foundations Sara Mazur and Carina Dahlberg
SE	Field visit	SLU	2024-06-27	Public excursion with forestry and ecology interest
SE	Field visit	SLU, PFS	2024-07-02	Excursion with team from the IUFRO conference International researchers
SE	Field visit	SLU	2024-09-26	Excursion with Krycklan symposium
SE	Field visit	SLU	2024-10-17	Faculty board and head of departments
SE	Field visit			Several visits of smaller research groups, phd committees etc
SE	Field visit			Several visits of school children
OTC	'The science we need to bridge ocean carbon policy development and concrete action'.	Sanders	Webinar in COP virtual ocean Pavilion: OceanICU	Link
OTC	Will the ocean uptake of anthropogenic carbon dioxide (CO_2) continue	Sanders	Webinar in COP virtual ocean Pavilion: OceanICU	Link

	primarily as an abiotic process?			
OTC	Contribution to "Unlock Ocean-Based Solutions to Climate Change."	Sanders	Ocean Decade Vision 2030 White Papers, UNESCO	Link
OTC	first draft of the Ostend declaration resulting from Ostend meeting in 2023 Declaration_on_Operationalising_the_Surface_Ocean_Carbon_Value_Chain.pdf. This was published in early 2024	Sanders		
FCL	Laboratory tours at the ICOS FCL facility and public lecture on "Knowledge through observations: Greenhouse gas measurements in the ocean, on land and in the air"		Long Night of Science in Jena (22.11.2024):	

Name	Domain	Class	Location	Member	Notes	eLTER	ACTRIS	Other
La Reunion	Atmospheric Station	2	FR	BE+FR		x	x	
Brasschaat	Ecosystem Station	1	BE	BE		x		
Dorinne	Ecosystem Station	2	BE	BE				
Lonzee	Ecosystem Station	2	BE	BE		x		
Maasmechelen	Ecosystem Station	2	BE	BE		x		x
Vielsalm	Ecosystem Station	2	BE	BE		x	x	
Yangambi	Ecosystem Station	Associated	CD	BE				
BE-FOS-Thornton Buoy	Ocean Station	1	BE	BE	LifeWatch	x		x
BE-SOOP-Belgica	Ocean Station	1	BE	BE				
BE-SOOP-Simon-Stevin	Ocean Station	1	BE	BE	LifeWatch			x
Westmalle1	Ecosystem Station	Associated	BE	BE				
Westmalle2	Ecosystem Station	Associated	BE	BE				
Jungfraujoch	Atmospheric Station	1	CH	CH			x	
Davos	Ecosystem Station	1	CH	CH		x		
Basel Klingelbergstrasse	Ecosystem Station	Associated	CH	CH				
Křešín u Pacova	Atmospheric Station	1	CZ	CZ			x	
Lanzhot	Ecosystem Station	1	CZ	CZ	Danubius			x
Bily Kriz forest	Ecosystem Station	2	CZ	CZ	AnaEE	x		x
Trebon	Ecosystem Station	Associated	CZ	CZ		x		
Gartow	Atmospheric Station	1	DE	DE				
Hohenpeissenberg	Atmospheric Station	1	DE	DE			x	
Karlsruhe	Atmospheric Station	1	DE	DE				
Lindenberg	Atmospheric Station	1	DE	DE			x	
Ochsenkopf	Atmospheric Station	1	DE	DE				
Schauinsland	Atmospheric Station	1	DE	DE				
Steinkimmen	Atmospheric Station	1	DE	DE				
Helgoland	Atmospheric Station	2	DE	DE				
Jülich	Atmospheric Station	2	DE	DE	IAGOS		x	x
Torfhaus	Atmospheric Station	2	DE	DE				
Westerland	Atmospheric Station	2	DE	DE				
Zugspitze	Atmospheric Station	2	DE	DE			x	
Amtsvenn	Ecosystem Station	Associated	DE	DE				

Name	Domain	Class	Location	Member	Notes	eLTER	ACTRIS	Other
Fendt	Ecosystem Station	1	DE	DE				
Gebesee	Ecosystem Station	1	DE	DE				
Hohes Holz	Ecosystem Station	1	DE	DE		x		
Selhausen Juelich	Ecosystem Station	1	DE	DE		x		
Tharandt	Ecosystem Station	1	DE	DE				
Berlin-Rothenburgstrasse	Ecosystem Station	Associated	DE	DE				
Braunschweig	Ecosystem Station	Associated	DE	DE				
Graswang	Ecosystem Station	Associated	DE	DE				
Grillenburg	Ecosystem Station	Associated	DE	DE				
Grosses Bruch	Ecosystem Station	Associated	DE	DE		x		
Hainich	Ecosystem Station	Associated	DE	DE				
Hartheim	Ecosystem Station	Associated	DE	DE				
Hetzdorf	Ecosystem Station	Associated	DE	DE				
Kienhorst	Ecosystem Station	Associated	DE	DE				
Klingenberg	Ecosystem Station	Associated	DE	DE				
Mooseurach	Ecosystem Station	Associated	DE	DE				
Oberklenkendorf	Ecosystem Station	Associated	DE	DE				
Rollesbroich	Ecosystem Station	Associated	DE	DE		x		
Schechenfilz Nord	Ecosystem Station	Associated	DE	DE				
Wustebach	Ecosystem Station	Associated	DE	DE		x		
Cuxhaven	Ocean Station	2	DE	DE	JERICO			x
DE-FOS-CVOO	Ocean Station	1	DE	DE				
DE-FOS-Hausgarten	Ocean Station	1	DE	DE		x		
DE-SOOP-Atlantic Sail	Ocean Station	1	DE	DE				
DE-SOOP-Finnmaid	Ocean Station	1	DE	DE				
DE-SOOP-Polarstern	Ocean Station	1	DE	DE				
Station Nord	Atmospheric Station	2	DK	DK			x	
Soroe	Ecosystem Station	1	DK	DK		x		
Zackenberg Fen	Ecosystem Station	2	GL	DK				
Disko	Ecosystem Station	Associated	GL	DK				
Nuuk Fen	Ecosystem Station	Associated	GL	DK				
Risoe	Ecosystem Station	Associated	DK	DK				

Name	Domain	Class	Location	Member	Notes	eLTER	ACTRIS	Other
Zackenberg Gras	Ecosystem Station	Associated	GL	DK				
CIBA	Atmospheric Station	2	ES	ES				
El Arenosillo	Atmospheric Station	2	ES	ES			x	x
Izana	Atmospheric Station	2	ES	ES			x	x
Majadas de Tiétar	Ecosystem Station	Associated	ES	ES				
CanOA VOS-line	Ocean Station	1	ES	ES				x
ESTOC	Ocean Station	1	ES	ES				
Hyytiälä	Atmospheric Station	1	FI	FI	AnaEE	x	x	x
Pallas	Atmospheric Station	1	FI	FI	AnaEE	x	x	x
Puijo	Atmospheric Station	2	FI	FI			x	
Utö - Baltic sea	Atmospheric Station	2	FI	FI	Jerico		x	x
Anttila	Ecosystem Station	2	FI	FI				
Oulanka	Ecosystem Station	Associated	FI	FI				
Hyytiälä	Ecosystem Station	1	FI	FI				
Sodankyla	Ecosystem Station	1	FI	FI				
Lompolojankka	Ecosystem Station	2	FI	FI	AnaEE	x	x	x
Siikaneva	Ecosystem Station	2	FI	FI		x		
Kenttarova	Ecosystem Station	Associated	FI	FI		x	x	
Kuivajarvi	Ecosystem Station	Associated	FI	FI		x		
Kumpula	Ecosystem Station	Associated	FI	FI				
Lettosuo	Ecosystem Station	Associated	FI	FI				
Tvärminne	Ecosystem Station	Associated	FI	FI				
Varrio	Ecosystem Station	Associated	FI	FI	AnaEE	x	x	x
FI-SOOP-Silja Serenade	Ocean Station	2	FI	FI				
FI-FOS-Tvärminne	Ocean Station	2	FI	FI				
Observatoire pérenne de l'environnement	Atmospheric Station	1	FR	FR	Station also known as Bure			
Saclay	Atmospheric Station	1	FR	FR				
Trainou	Atmospheric Station	1	FR	FR				
Puy de Dôme	Atmospheric Station	2	FR	FR			x	
Fontainebleau-Barbeau	Ecosystem Station	1	FR	FR				
Hesse	Ecosystem Station	1	FR	FR				

Name	Domain	Class	Location	Member	Notes	eLTER	ACTRIS	Other
Lamasquere	Ecosystem Station	1	FR	FR	Removed in 2025, reported still for 2024			
Bilos	Ecosystem Station	2	FR	FR				
Font-Blanche	Ecosystem Station	2	FR	FR	AnaEE			x
Grignon	Ecosystem Station	2	FR	FR				
Laqueuille	Ecosystem Station	2	FR	FR	AnaEE			x
Lusignan	Ecosystem Station	2	FR	FR	AnaEE			x
Puechabon	Ecosystem Station	2	FR	FR	AnaEE			x
Aurade	Ecosystem Station	Associated	FR	FR		x		
Col du Lautaret	Ecosystem Station	Associated	FR	FR	AnaEE	x		x
Estrees-Mons A28	Ecosystem Station	Associated	FR	FR				
Guyaflux	Ecosystem Station	Associated	GF	FR				
La Guette	Ecosystem Station	Associated	FR	FR				
Mejusseaume	Ecosystem Station	Associated	FR	FR				
Montiers sur Saulx	Ecosystem Station	Associated	FR	FR	AnaEE			x
Toulouse	Ecosystem Station	Associated	FR	FR			x	
FR-SOOP-France-Brazil	Ocean Station	1	FR	FR				
Ridge Hill tower	Atmospheric Station	2	GB	GB				
Weybourne Atmospheric Observatory	Atmospheric Station	2	GB	GB				
Auchencorth Moss	Ecosystem Station	1	GB	GB				
UK-FOS-PAP	Ocean Station	1	GB	GB	EMSO			x
UK-FOS-Western Channel Observatory	Ocean Station	1	GB	GB	Removed in 2025, reported still for 2024			
Finokalia	Atmospheric Station	2	GR	GR				
HECKOR - Heraklion Kornarou	Ecosystem Station	Associated	GR	GR				
HECMAS - Heraklion Mastabas	Ecosystem Station	Associated	GR	GR				
Pertouli	Ecosystem Station	2	GR	GR				
Hegyhátsál	Atmospheric Station	2	HU	HU				
Carnsore Point	Atmospheric Station	2	IE	IE				

Name	Domain	Class	Location	Member	Notes	eLTER	ACTRIS	Other
Mace Head	Atmospheric Station	2	IE	IE				
Malin Head	Atmospheric Station	2	IE	IE				
Valentia Island	Atmospheric Station	2	IE	IE				
Clara Raised Bog	Ecosystem Station	Associated	IE	IE				
Dooary	Ecosystem Station	2	IE	IE				
Leam West	Ecosystem Station	Associated	IE	IE				
Doory	Ecosystem Station	Associated	IE	IE				
Johnstown Castle	Ecosystem Station	2	IE	IE				
RV Celtic Explorer	Ocean Station	2	IE	IE				
Lampedusa	Atmospheric Station	2	IT	IT			x	
Monte Cimone	Atmospheric Station	2	IT	IT			x	
Potenza	Atmospheric Station	1	IT	IT			x	
Plateau Rosa	Atmospheric Station	2	IT	IT				
Borgo Cioffi	Ecosystem Station	1	IT	IT				
Castelporziano2	Ecosystem Station	1	IT	IT		x		
Monte Bondone	Ecosystem Station	2	IT	IT				
Renon	Ecosystem Station	2	IT	IT		x		
Arca di Noe - Le Prigionette	Ecosystem Station	Associated	IT	IT				
Bosco Fontana	Ecosystem Station	Associated	IT	IT		x		
Lison	Ecosystem Station	Associated	IT	IT				
Nivolet	Ecosystem Station	Associated	IT	IT		x		
Osservatorio Ximeniano Firenze	Ecosystem Station	Associated	IT	IT				
Parco Urbano di Capodimonte	Ecosystem Station	Associated	IT	IT				
Torgnon	Ecosystem Station	Associated	IT	IT		x		
Torgnon-LD	Ecosystem Station	Associated	IT	IT				x
Collelongo	Ecosystem Station	Associated	IT	IT		x		
Lampedusa Ecosystem Observatory	Ecosystem Station	Associated	IT	IT				x
Sassari	Ecosystem Station	Associated	IT	IT				
IT-FOS-PALOMA	Ocean Station	1	IT	IT				
IT-FOS-E2M3A	Ocean Station	2	IT	IT				
Lampedusa	Ocean Station	2	IT	IT				
IT-FOS-Miramare	Ocean Station	2	IT	IT				

Name	Domain	Class	Location	Member	Notes	eLTER	ACTRIS	Other
IT-FOS-W1M3A	Ocean Station	2	IT	IT	EMSO			x
Ispra	Atmospheric Station	2	IT	JRC				
San Rossore 2	Ecosystem Station	2	IT	JRC				
Cabauw	Atmospheric Station	1	NL	NL			x	
Lutjewad	Atmospheric Station	2	NL	NL				
Loobos	Ecosystem Station	2	NL	NL				
Zeppelin Observatory	Atmospheric Station	1	NO	NO	AGAGE, EMEP, AMAP,GAW, NOAA		x	
Birkenes Observatory	Atmospheric Station	2	NO	NO			x	
Hurdal	Ecosystem Station	2	NO	NO				
NO-SOOP-G.O.Sars	Ocean Station	1	NO	NO				
NO-SOOP-Tukuma Arctica	Ocean Station	1	NO	NO				
NO-SOOP Bergen-Kirkenes	Ocean Station	2	NO	NO				
NO-SOOP-Kronsprins Haakon	Ocean Station	2	NO	NO				
NO-SOOP-Trans Carrier	Ocean Station	2	NO	NO				
Hyltemossa	Atmospheric Station	1	SE	SE		x	x	
Norunda	Atmospheric Station	1	SE	SE		x	x	
Svartberget	Atmospheric Station	1	SE	SE		x	x	
Abisko-Stordalen Palsa Bog	Ecosystem Station	2	SE	SE		x		
Degero	Ecosystem Station	2	SE	SE	SITES	x		x
Hyltemossa	Ecosystem Station	2	SE	SE	NordSpec			x
Mycklemossen	Ecosystem Station	2	SE	SE	SITES	x		x
Norunda	Ecosystem Station	2	SE	SE	NordSpec			x
Svartberget	Ecosystem Station	2	SE	SE	SITES	x	x	x
SE-MFT-Östergarnsholm	Ocean Station	1	SE	SE			x	
Östergarnsholm	Ecosystem Station	Associated	SE	SE	Added in 2025, not reported for 2024			
SE-SOOP Tavastland	Ocean Station	1	SE	SE				
					total	**38**	**31**	**30**

Total
99

21.11.2024

Report to the Finnish Research Infrastructure Committee

ACTRIS ERIC and ICOS ERIC synergies at Head Offices

Introduction

The research infrastructure committee has included a requirement on the synergies between the ACTRIS and ICOS Head Offices (HO) in their decisions in recent years, including the latest funding decisions for both HOs. This is the third report on such synergies.

The activities of each ERIC are defined by its respective Statutes, confirmed by the European Commission and member countries. The statutes are available online, links to ICOS and ACTRIS. Each ERIC is directed by the respective General Assembly (GA), which defines the tasks and activities of the ERIC. In both ICOS and ACTRIS the ERIC includes the Head Office and part of the Data Centre.

It is important to note that the European research infrastructures (RI) cooperate, exchange experiences and commonly develop best practices as part of their regular operations. This cooperation takes place internationally (eg. within the ENVRI cluster and in the ERIC Forum), but more on the practical level, information is shared between research infrastructures hosted in the same country. There has been active cooperation and knowledge sharing from the beginning between the HOs of the three RIs with statutory seat hosted by Finland; ICOS, ACTRIS and Euro-Bioimaging.

Thus, a lot of added know-how is gained in Finland through the establishment process of ICOS, Euro-Bioimaging and ACTRIS HOs. Sharing experiences and best practices also in future strengthens the HOs, and the position of Finland in the European RI landscape.

In the process of establishing ACTRIS ERIC and writing its essential documents the respective ICOS ERIC documents have often been the starting point and have then been adapted to the needs of ACTRIS ERIC. Members of ICOS HO have also reviewed and commented on several essential deliverables of the ACTRIS IMP project supporting the implementation of ACTRIS ERIC.

Financial framework

The financial framework of the two ERICs and the respective HOs is determined by the statutes and the decisions of the GA of the respective ERICs. Both ERICs receive 70-80% of their funding from the hosting countries and the remaining 20-30% from all Member counties of the ERIC through membership contributions. Both ERICs have a similar cost structure, in which the personnel costs form 60-75% of the annual budget with the annual funding and personnel resources explained below. A substantial part of this goes for the Director General (DG), who is the legal representative of the ERIC and the leader of the whole Research Infrastructure. This sum is defined in a contract between the DG and the respective ERIC's GA.

The annual funding for the core activities is for ICOS ERIC currently about 1.3 million € per year, including so-called common contributions from all member countries, and host contributions from Finland and France. In ICOS HO, which is solely located in Finland, the current total staff is 20 persons, approximately 10 full-time equivalents (FTE) with core funding and 10 FTE with project funding. To

ensure resilience of the HO (a lesson learned during the COVID-19 pandemic), individuals are not usually working 100% in core work or 100% in projects - instead, most HO staff have a dual role to safeguard against any unexpected loss of skills or knowledge.

For ACTRIS ERIC the annual core funding in Finland is 1.0 million €, including membership contributions and host premium contributions from Finland. In ACTRIS HO in Finland the current personnel is equivalent to 10 FTEs, of which 8 are working with the core funding. The amount of project funding and number of people working on it may increase in the future. It is also to be noted that one unit of ACTRIS HO is located in (and funded by) Italy, and that this unit is not included in the figures above, nor in the funding by Research Council of Finland.

External project funding is welcome to gain more resources for the development of the RIs and for allowing the HOs to perform tasks that would be difficult to complete otherwise. However, the core activities of the HOs are performed with the core funding.

Both ICOS and ACTRIS have a system of distributed Central Facilities (CFs), each of them mainly supported directly by its respective hosting countries. There is a mutual expectation between the countries that the host contributions to the ERIC facilities (Head Offices and Data Portals) and to the CFs are sustained to ensure the core functionalities of the research infrastructures.

Realized and planned synergy-increasing activities

A working group between the ICOS HO and ACTRIS HO was established in 2021. The group has investigated several synergy topics such as the possibility to use common service providers (e.g. for ICT support, accounting, or auditing), the use of common facilities (e.g. meeting rooms, printers) and even the sharing of personnel with specific expertise (e.g. on finances). The realized synergies by 2024 and some planned synergy actions in 2025 include the following aspects:

1. Synergies on premises

Co-locating Head Offices, negotiations with FMI

No progress during 2024. The process is currently in the hands of FMI. The primary aim of ACTRIS ERIC and ICOS ERIC is still to have ACTRIS and ICOS HOs close to each other to gain synergies on premises, e.g. by sharing meeting rooms.

ACTRIS HO is currently using the premises (eg. meeting rooms) of Finnish Meteorological Institute, but that has sometimes been problematic. ICOS HO has welcomed ACTRIS to use its meeting room, if needed.

2. Cooperation and shared personnel resources

Financial management

ICOS and ACTRIS HO both manage in their ERICs the collection of membership contributions and their internal redistribution to the CFs as well as the monitoring and reporting of the work and performance of networks and CFs. Experiences have been exchanged. ACTRIS has also with an external service provider developed a new online tool for annual planning and reporting of the finances and activities of the CFs of the RI. As ICOS has very similar structure and reporting needs, the know-how and lessons learned in developing the tool can be utilized if ICOS decides to develop a similar tool for their planning and reporting.

Organization of Innovation in Atmospheric Measurement Techniques workshop

ICOS and ACTRIS (and IAGOS) jointly organized a one day free-of-charge Innovation workshop held online 9th June 2024, with the respective Hos being the responsible organizers. Prominent representatives of both RIs gave keynote talks and chaired sessions. The audience consisted of e.g research performing organizations (RPOs), RIs, industrial companies and air-quality networks. The event was advertised on both organizations' websites, newsletters, and X (formerly Twitter) accounts.

Funding proposals and contracts

The Heads of Operations in both organizations shared insights and lessons learned when writing proposals to FIRI Funding call and co-operation agreement with EUs Joint Research Center JRC. Insights have also been shared in applying for and coordinating Horizon Europe funded projects.

Conference organizations

ACTRIS and ICOS both organized their respective science conferences in France in 2024. The conferences were organized by the respective HO together with the national RI node of France, consisting partially of the same RPOs. The main French partner hired the same person to help in organizing both conferences, and lessons learned were carried from the ACTRIS science conference organization to that of the ICOS science conference.

3. Collaboration in project planning and coordination in European RI landscape

Trilogue between the Finnish ERICs

ACTRIS, ICOS and Euro-Bioimaging **–** the three ERICs with statutory seat in Finland – have started regular meetings to discuss both strategic approaches and challenges in everyday work, and towards increasing the visibility of the ERICs in Finland. So far, useful hints of opportunities for societal impact have been exchanged, but more concrete co-operation is being planned for 2025 onwards.

Collaboration within EU-funded projects

Currently, ACTRIS and ICOS are working together in several RI projects funded by the EC such as KADI, ATMO-ACCESS, IRISCC, ENVRINNOV, and ENVRI-Hub Next. These projects are based on collaboration of several RIs, increasing further the participation of both HOs in RI projects.

For 2024, RI-URBANS (coordinated by an ACTRIS partner, ACTRIS ERIC as a beneficiary) and ICOS Cities (coordinated by ICOS ERIC) projects have demonstrated close co-operation. The most important synergies are the development of a common framework to integrate urban observations and services to cities into the portfolio of European Environmental Research Infrastructures, common data approaches and joint communication efforts, especially in outreach to city representatives and European-level policymakers.

The cooperation within the IRISCC project has revealed a specific strength of what we call 'the Helsinki Cluster for EU Project Coordination'. Besides ICOS ERIC and ACTRIS ERIC also FMI, University of Helsinki, LUKE, CSC and Aalto University have recently been involved in several EU projects with a coordinating or other key role either together or separately. This hub of know-how shows a unique leadership capacity for EU consortia and will most probably ensure a high flow of EU resources to Finland.

ERIC Forum is an initiative by the European Commission, and also a joint Horizon-funded project between European ERICs. ACTRIS ERIC has been a full member of ERIC Forum since June 2024 but is not part of the project. In the ongoing project, ICOS ERIC is responsible for creating an online platform for ERICs and their stakeholders. The platform will gather key information about the ERICs: finances, KPIs, sizes and formats of the organizations, etc., enhancing collaboration and synergies between all ERICs.

4. Collaboration in training and event organisation

ICOS, ACTRIS and eLTER hosted a joint session at the ICOS Science Conference in September 2024, focusing on co-location of measurement sites and best practices in operating an RI. The session was targeted to all RIs related to ICOS science and was convened by ICOS ERIC and ACTRIS ERIC together. ACTRIS, ICOS and eLTER had a joint oral presentation on co-location in this session.

ACTRIS and ICOS have organized training for utilizing AI tools in managerial processes, provided by external experts for the personnel of the HOs. The training package consists of a total of 10 hours of training and is ongoing at the time of writing this report. The number of personnel participating in the training was 15-20, roughly 2/3 from ACTRIS and 1/3 from ICOS. This training has also shown a need to review some of the ACTRIS ERIC and ICOS ERIC policies, and this work would benefit from being partially done together.

ICOS and ACTRIS planned and hosted together a series of online Knowledge Exchange Workshops with the theme "Project portfolio management" in the framework of EU project RITRAIN+. The first workshops were a great success with more than 30 participants all over Europe.

Note: As requested by the Academy of Finland, this document is prepared in collaboration between ICOS and ACTRIS HOs. In addition to the above-mentioned actions, we anticipate that informal cooperation between staff continues as usual.

This report will be attached as an annex to the annual reports of the two ERICs as information to their General Assemblies.

Sincerely yours,

Niku Kivekäs

PI of the Research Council of Finland (former Finnish Academy) project for ACTRIS Central Facilities

Senior officer, operations, ACTRIS ERIC

Elena Saltikoff

PI of the Research Council of Finland (former Finnish Academy) project for ICOS ERIC Head Office

Head of Operations, ICOS ERIC