ICOS RI Annual Report 2023

Approved 14 May 2024
ICOS/GA22/13

ICOS
Integrated
Carbon
Observation
System

Contents

2023 Highlights of ICOS Research Infrastructure

ICOS hosted an event at the European Parliament in Brussels

"Science should be at the heart of the European carbon credit system."

On 21 September 2023, the Baltic Sea Action Group, the European Parliament Intergroup for Climate Change, Biodiversity and Sustainable Development and ICOS co-organised "Nature-based solutions to increase carbon sinks on land", an event held at the European Parliament and online, hosted by MEP Elsi Katainen. In front of a combined audience of 200 participants, scientific experts, European policymakers, and stakeholders could debate the crucial role of natural carbon sinks in the context of the upcoming European legislation. Among the topics discussed, a unified, science-based Monitoring, Reporting and Verification (MRV) system emerged as a crucial step to sustain the Carbon Removal Certification Framework and the Soil Monitoring Law**.**

ICOS strongly visible at COP28

As ICOS has the status of an observer intergovernmental organization to the UNFCCC, it took part in the 2023 United Nations Climate Change Conference, also known as COP28, in Dubai, United Arab Emirates, 30 November 12 December 2023. The goal was to highlight the need for a global observation network to have a scientific base for decisions, and to remind of the need for more drastic climate action.

ICOS hosted a side event: "Transformative climate services for decision-makers based on observational data". This side-event was the opportunity to showcase the activities performed in the PAUL (ICOS Cities) and KADI projects.

In addition of hosting its own side event, ICOS was featured in six other side events.

CO_2 module, a pedagogical tool for educators to explain the effects of CO_2 concentrations, developed in ICOS Cities project, was featured at COP28 during the RewirED Summit as one part of the 100 outstanding climate education solutions.

Second 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 second volume of FLUXES which was published just before FLUXNET meeting, focused on potential and limitations of nature-based solutions for carbon -removals from a scientific perspective.

Cross-RI co-operation in a record number of accepted Horizon Europe proposals

ICOS ERIC coordinated successfully Horizon Europe funding proposal "NUBICOS – New Users for Better ICOS" and contributed to six other accepted proposals. Several of these projects start between January and April 2024, see more in Projects section (p.20).

ESFRI Evaluation passed with flying colours

ICOS was in the first batch of monitored research infrastructures and dedicated a lot of time and effort in the early part of 2023 to developing a renewed set of 20 key performance indicators (KPIs) and delivering detailed responses to the ESFRI Monitoring questionnaire. The panel concluded: "The

standardised and scientifically interpreted measurement data provided by ICOS RI play an essential role as a rationale for European climate policy, significantly contributing to global policy action."

SAB visited Heidelberg and ICOS Cities locations in Munich

After the November GA meeting, ICOS Scientific Advisory Board visited the Central Radiocarbon Laboratory in Heidelberg and the urban s flux tower in Munich. The tour included presentations on ICOS instrumentation, urban greenhouse gas measurements, and new advancements in estimating fossil fuel carbon dioxide (ffCO2) emissions from atmospheric observations.

Stakeholders agreed of funding structure for next 5-year period

ICOS funding organizations gathered in two extra meetings, totalling in 4 GA meetings, to agree on funding structure for the third funding period 20252029.

KPI summary

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

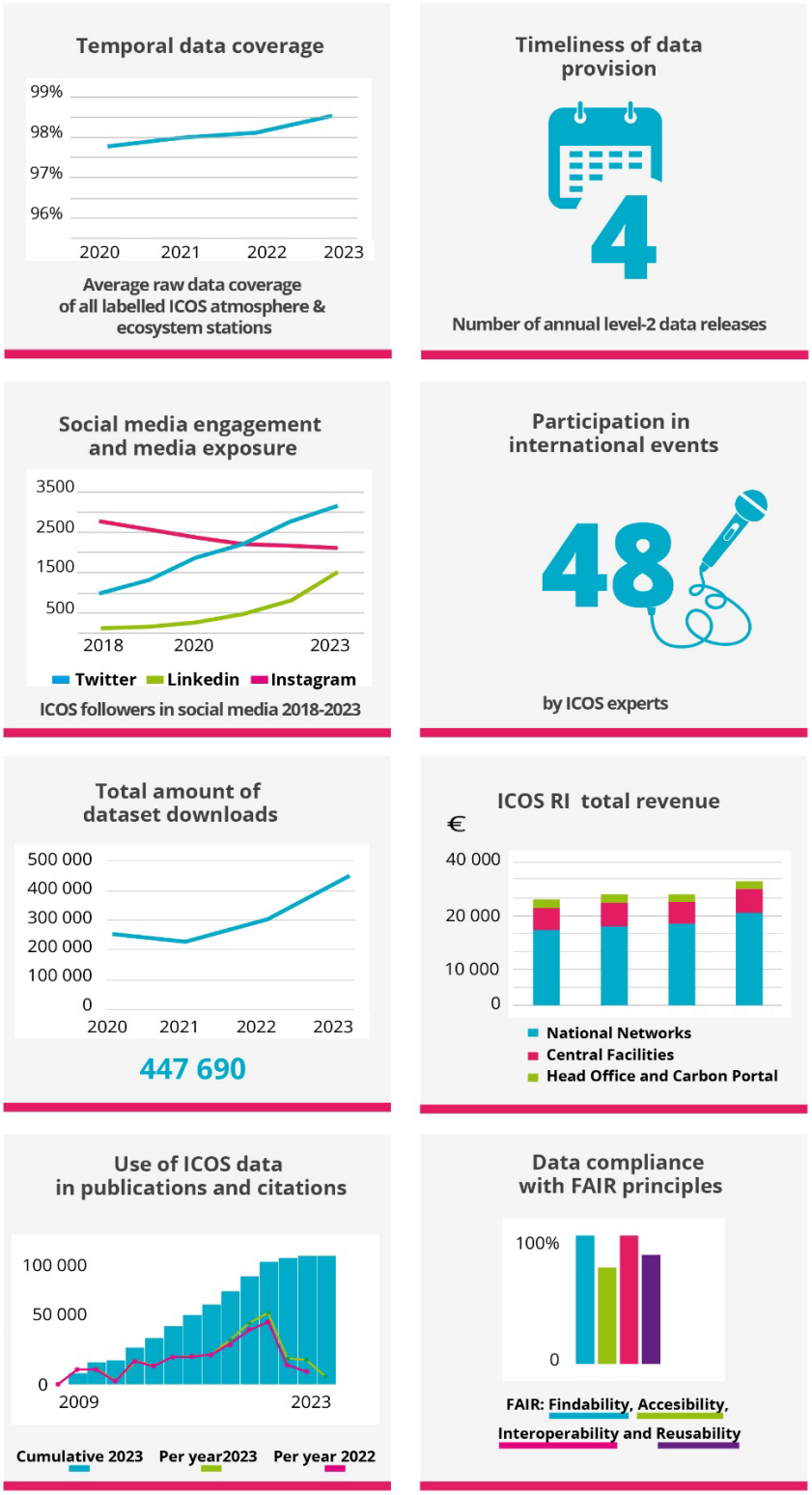


Figure 1 The essential ICOS Key Performance Indicators.

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

To discuss the five-year financial plan 2025-2029, 2023 ICOS had two extraordinary General Assembly meetings in 2023, in addition to the two usual ones. November meeting was held in Offenbach, and an Info day was preceding it. The other meetings were 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 Antwerpen, and a set of longer online meeting in in October. The RICOM also had monthly online-meetings.

Topics discussed in the RICOM included preparations for the five-year plan and draft versions of all documents prepared for GA or for general management, including first version of KPIs.

Support for Scientific and Ethical Advisory Boards

In their report delivered in February, the SAB finds that overall ICOS is growing, and serving as a benchmark for other greenhouse gas research infrastructures around the world. Examples of ICOS's reach are exemplary, such as the rapid turnaround of data for the 2022 drought, demonstrating the value of ICOS to supporting "real-time" science in a rapidly changing climate. ICOS also has growing roles in UNFCCC and WMO Global Greenhouse Gas Watch (G3W). In terms of Monitoring Reporting and Verification also, ICOS is positioned as a critical RI for Europe. For G3W in particular, ICOS has been recognized as a potential model for implementation and operation of coordinated atmospheric and oceanic networks. SAB is glad to see continue cooperation across member nations in supporting a healthy and sustainable operating budget that also preserves capability for innovation and expansion.

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.

Three members of the SAB (Ankur Desai, John Miller and Eric Kort) attended the Info Day in-person GA in Offenbach, and then continued to an introductory tour to ICOS lab facilities in Heidelberg and to Munich. The tours were very well received by the attending members of the ICOS SAB. The first leg of the tour was to the Central Radiocarbon Laboratory in Heidelberg. The SAB was given a comprehensive tour of the ICOS – CRL Karl Otto Münnich 14C Laboratory by Head of CRL, Samuel Hammer, and (late) Dr. Ingeborg Levin and research conducted there. Second part of the tour was to Munich, one of the pilot cities in the ICOS Cities project. The board mainly met with two research groups working in the project: those of Prof Dr. Jia Chen and Prof Dr. Miranda Schreurs.

The Ethical Advisory Board has not had any emerging issues to solve during 2023. Their term comes to an end. No candidates were nominated for 2024. Hence, the HO has been tasked to discuss with ACTRIS and wider ERIC community about roles and members of the EABs.

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. (UPDATE COMING)

Overall financial management of ICOS RI

Financial committee selected a new chair and two new members. (UPDATE COMING) .

Instrument register

No new instruments were bought 2023. 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 Work Place Survey was conducted in Spring 2023, followed by a Focused Workplace Survey in the early Autumn. The Head Office continues to work with the employees in analysing the results of employee surveys to implement improvements, and to organise trainings based on the feedback received. A key action derived from these surveys is the organisation of workshops on Diversity, Equity, and Inclusion, which will be held for all employees in the first quarter of 2024. A new workplace survey will be conducted latest in 2025 by the occupational healthcare company Terveystalo. ICOS ERIC Salary and Career Paths policy continues to guide career path progression and salary increases.

ICOS ERIC Travel Rules were updated to include a low-emission travel policy in March. The policy takes into account the employer's obligations concerning employee health and well-being during travel.

The Head of Unit Administration left ICOS ERIC at the end of the year. The tasks of Unit Administration were reorganised internally and as a result, there are no plans for a replacement recruitment to be made in 2024. Two new recruits, a KADI Project Manager and a Communications Assistant, started in March and June, respectively. Recruitment for Digital Communications specialist was opened in December 2023, to replace the Communications Officer leaving at the start of the year 2024.

The following personnel was employed by ICOS ERIC during the year 2023.

- 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 'Administration' (Anne Malm), responsible for finance, human resources and general administration, until 23.12.2023.
- 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
- Executive Assistant (Inka Hellä), back office and operational support for the Head Office and providing personal assistant duties for Director General.
- 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-FAIR and KADI).
- 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 in 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 activities and selected EU projects ICOS participates in (such as ICOS Cities).
- 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), until 15.1.2024.
- Communication Officer (Maria Luhtaniemi), 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 ERIC Forum and RItrainPlus).
- 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. Since 13.3.2023
- Communications Assistant, (Peter Taggart), Communications supporting tasks. Since 5.6.2023

In 2023, 11 of the employment contracts were until further notice and 8 were fixed-terms contracts ending at the end of year 2024. During the year, two persons had reduced working time on to their own request.

Each ICOS employee had 2-4 confidential *development discussions* with his/her 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.

Gender balance and equality

The staff consisted of 8 men and 13 women, out of which 3 men and 3 women were in managerial positions. A gender equality plan (GEP), as required by European Commission in Horizon Europe

projects, is published on the ICOS website. The GEP covers ICOS ERIC's processes related to general inclusivity and equality in the workplace and includes details about how ICOS ERIC monitors these processes.

Contract management.

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

Operational management of ICOS ERIC and RI

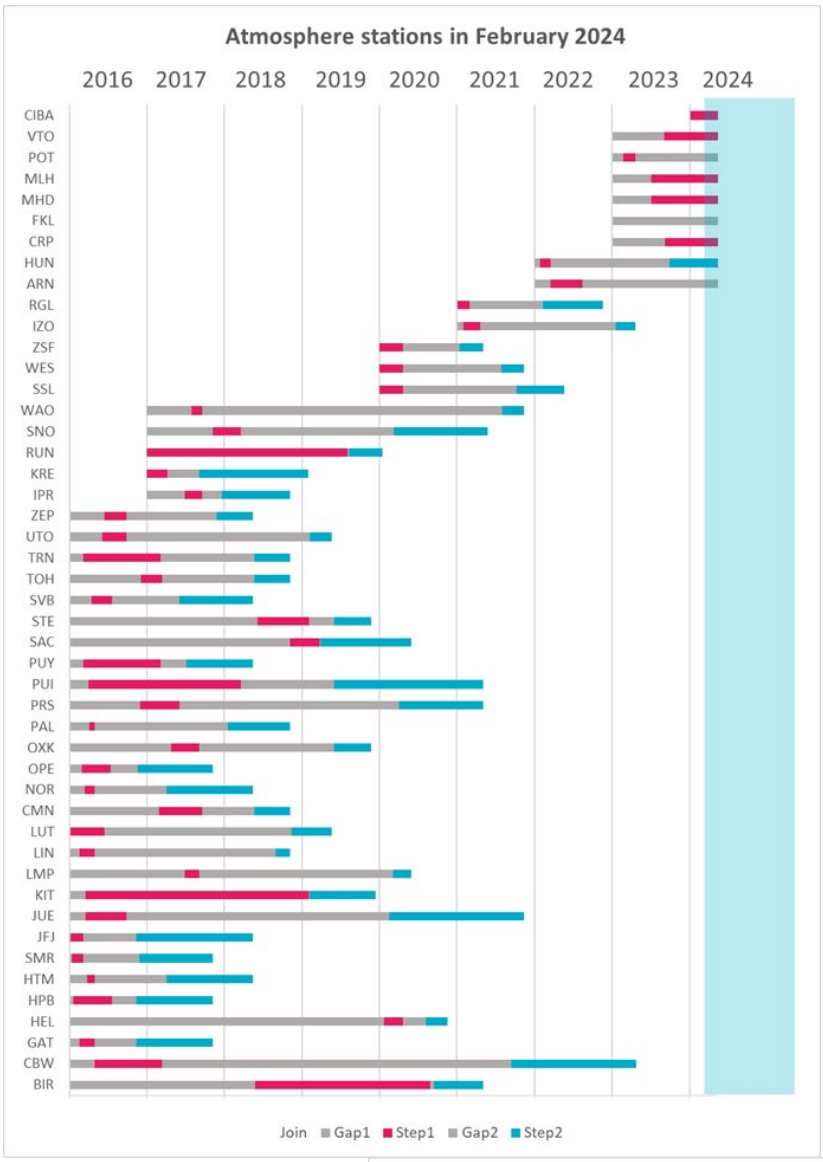
Several new PIs were introduced to ICOS activities. Online meetings were organized for all Focal Points of National Networks, and new focal points were invited to one-to-one meetings in early 2024.
The members of Operations unit participated in the face-to-face meeting of Atmosphere Monitoring Station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

A total of 16 stations received an official ICOS label in 2023. Of these stations two were atmospheric stations, 11 were ecosystem stations and three were ocean stations. 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.

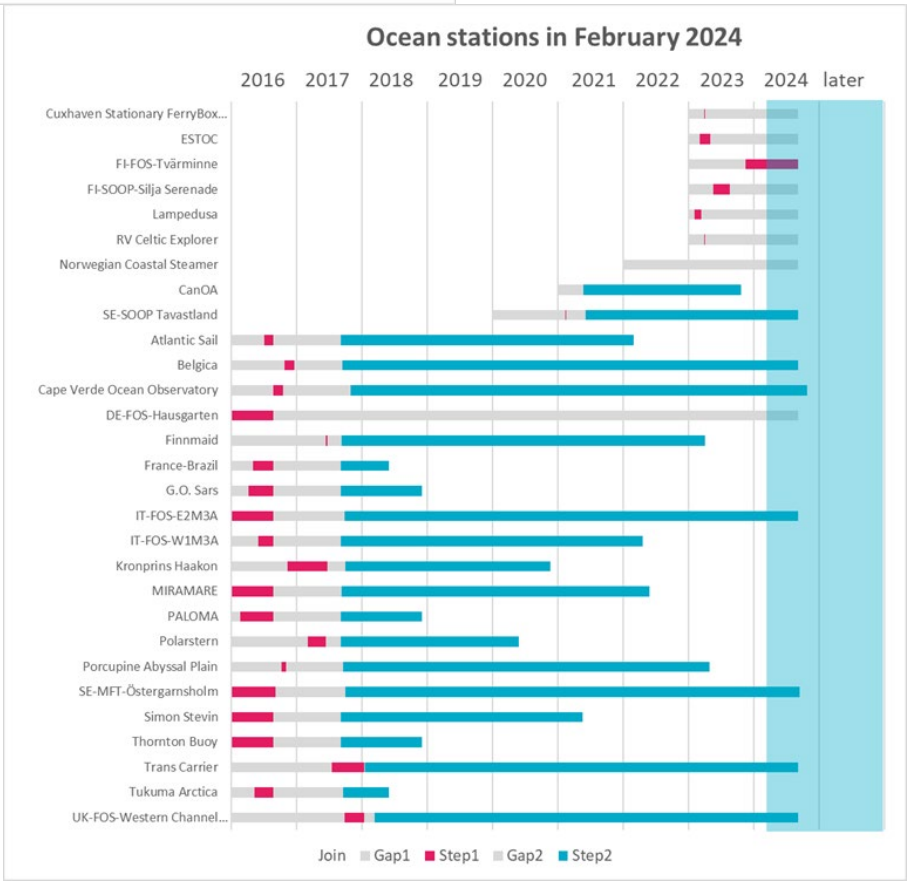
Status of the ICOS Station Labelling by the end of February 2024

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	6	1	1	1	1	4	3	0	0	1	1	0	0	0	0	86 %
Finland	18	13	2	2	3	1	7	6	2	2	2	2	0	0	2	0	72 %
France	22	21	3	3	6	6	8	7	2	2	2	2	1	1	0	0	95 %
Germany	39	28	5	4	0	0	16	9	6	6	6	6	3	2	3	1	72 %
Greece	4	2	0	0	1	0	2	2	0	0	1	0	0	0	0	0	50 %
Hungary	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0 %
Ireland	10	0	0	0	5	0	0	0	0	0	4	0	0	0	1	0	0 %
Italy	24	15	2	2	2	2	11	5	1	0	3	3	1	1	4	2	63 %
Netherlands	3	3	0	0	1	1	0	0	1	1	1	1	0	0	0	0	100 %
Norway	8	6	0	0	1	1	0	0	1	1	1	1	3	2	2	1	75 %
Spain	6	3	0	0	0	0	1	1	0	0	3	1	2	1	0	0	50 %
Sweden	11	8	0	0	6	5	0	0	3	3	0	0	2	0	0	0	73 %
Switzerland	3	2	1	1	0	0	1	0	1	1	0	0	0	0	0	0	67 %
UK	5	4	1	1	0	0	1	0	0	0	2	2	1	0	1	1	80 %
JRC	2	2	0	0	1	1	0	0	0	0	1	1	0	0	0	0	100 %
Total	**179**	**126**	**17**	**16**	**32**	**23**	**55**	**34**	**18**	**17**	**29**	**21**	**16**	**9**	**13**	**5**	
% Labelled per domain and class:			94 %		72 %		62 %		94 %		72 %		56 %		38 %		

Table 1. Labelled ICOS stations per country, domain and class by the end of February 2024. 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 2024
2016 2017 2018 2019 2020 2021 2022 2023 2024
CIBA
VTO
POT
MLH
MHD
FKL
CRP
HUN
ARN
RGL
IZO
ZSF
WES
SSL
WAO
SNO
RUN
KRE
IPR
ZEP
UTO
TRN
TOH
SVB
STE
SAC
PUY
PUI
PRS
PAL
OXK
OPE
NOR
CMN
LUT
LIN
LMP
KIT
JUE
JFJ
SMR
HTM
HPB
HEL
GAT
CBW
BIR
Join Gap1 Step1 Gap2 Step2


Atmosphere
Step 1
Step 2


Ocean stations in February 2024
2016 2017 2018 2019 2020 2021 2022 2023 2024 later
Cuxhaven Stationary FerryBox...
ESTOC
FI-FOS-Tvärminne
FI-SOOP-Silja Serenade
Lampedusa
RV Celtic Explorer
Norwegian Coastal Steamer
CanOA
SE-SOOP Tavastland
Atlantic Sail
Belgica
Cape Verde Ocean Observatory
DE-FOS-Hausgarten
Finnmaid
France-Brazil
G.O. Sars
IT-FOS-E2M3A
IT-FOS-W1M3A
Kronprins Haakon
MIRAMARE
PALOMA
Polarstern
Porcupine Abyssal Plain
SE-MFT-Östergarnsholm
Simon Stevin
Thornton Buoy
Trans Carrier
Tukuma Arctica
UK-FOS-Western Channel...
Join Gap1 Step1 Gap2 Step2


Ocean
Step 1
Step 2

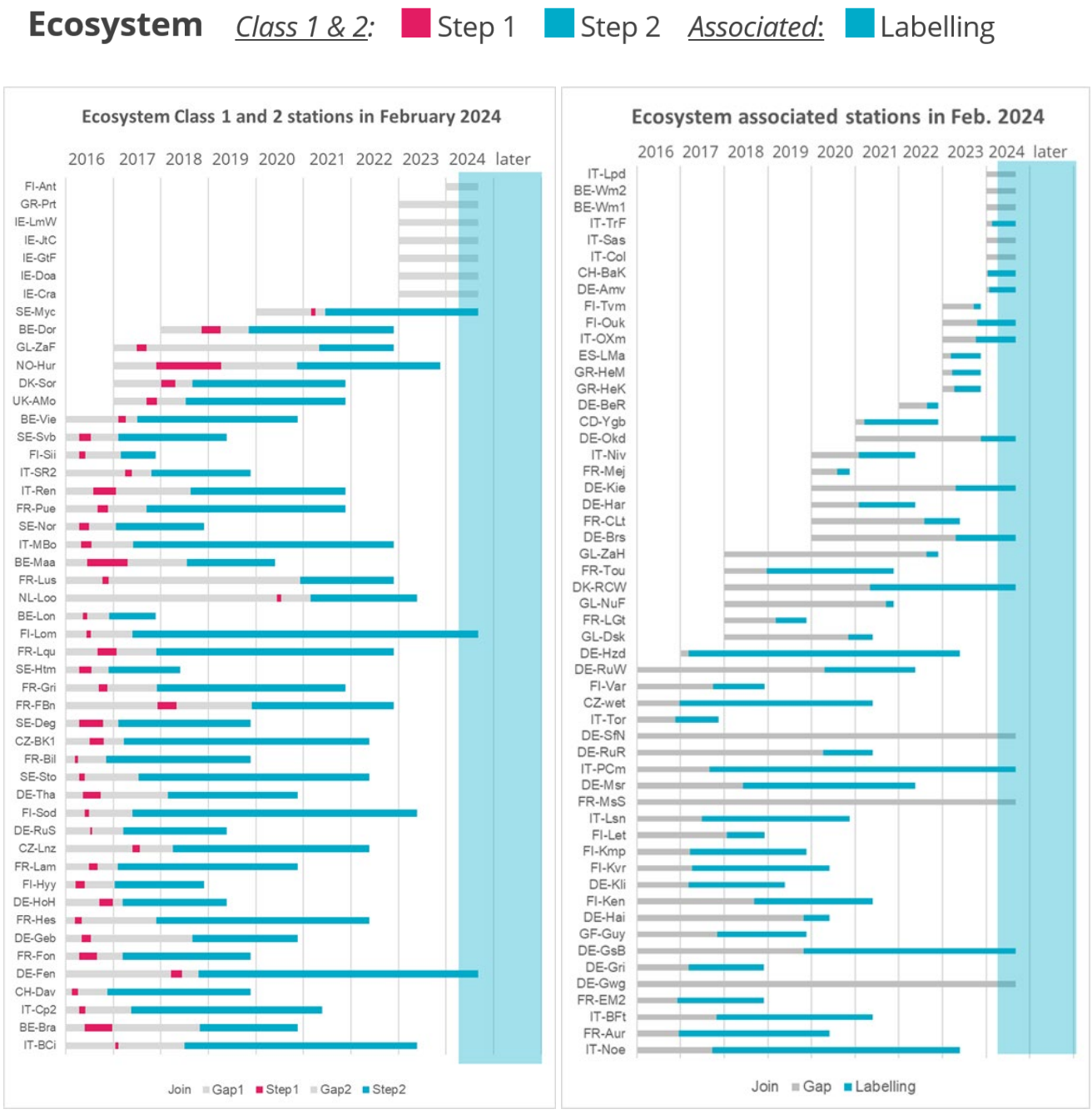


Figure 2-3. Progress of station labelling in each domain in February 2024.

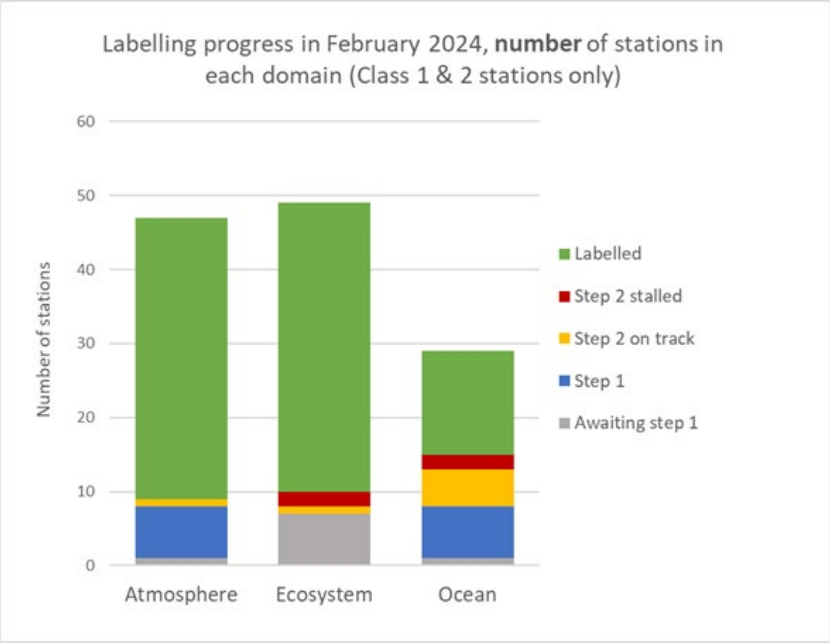


Figure 4. Labelling process, per cent of stations (Class 1 and class 2) in each labelling step by domain.

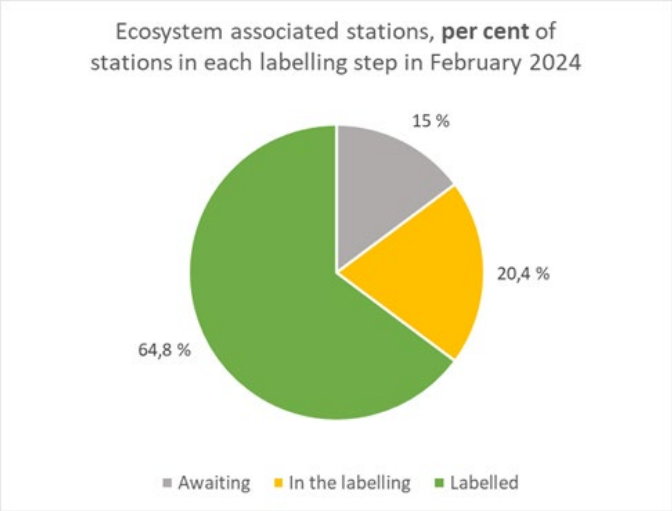


Figure 5. Labelling process of associated ecosystem stations in February 2024.

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

Currently, 7 stations are “Step 2 delayed” and 5 stations are in status “stalled”.

Stations where labelling was stalled as of 8 March 2024			
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

ECO	Risoe	DK	Associate station. Completed first step June 2021. No activities in the last 2 years for the labelling of the station
ECO	Lompolojänkkä	FI	No data submission started. Step1 approved 2016-08-28 and Step2 started 2017-05-29
OCE	R/V Belgica	BE	The new R/V Belgica is operational from January 2022. pCO2 data is available and will be submitted early 2023
OCE	Western Channel Observatory	UK	No response from PI. The station has decided to withdraw from the ICOS network from 2025..

Support for ICOS-related science

Science facilitation in 2023 focused much in preparing for ICOS Science Conference which will take 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 bulleting 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. During the year, the Head Office made significant efforts towards that end.

External communications and outreach

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

The second volume of ICOS's FLUXES, the European Greenhouse Gas Bulletin was published in June 2023. The publication highlights climate issues to an audience consisting particularly of policymakers, policy advisors, and climate journalists.

The second volume focused on carbon sinks in over land and ocean areas, pointing out their vulnerability and warning against trusting their capability to continue fixing carbon year after year in the changing climate. The publication was promoted widely, and it reached more than 2000 people in the target audience. Same topics were also raised up in high-level meetings organised and participated by ICOS during autumn 2023. More about those in International Cooperation section of this report.

ICOS ERIC also initiated a new video campaign, Explore ICOS, in which we showcase recently labelled stations, as well as station in new member countries. In 2023, the Head Office communications coordinated and visited altogether nine stations interviewing the Principal Investigators, and other station crew in **Germany, Greece, the Netherlands, Italy, Spain and UK.** ICOS Atmosphere Thematic Centre in France was also visited. As a result, six longer videos with respective stories were published in 2023, with five videos to be published in 2024. All videos were published together with shorter social media videos, still photographs and other materials. All the materials are available for use both for the stations, the scientists and of course for the host institutions in their communications about ICOS work.

ICOS materials, website, media and social media

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

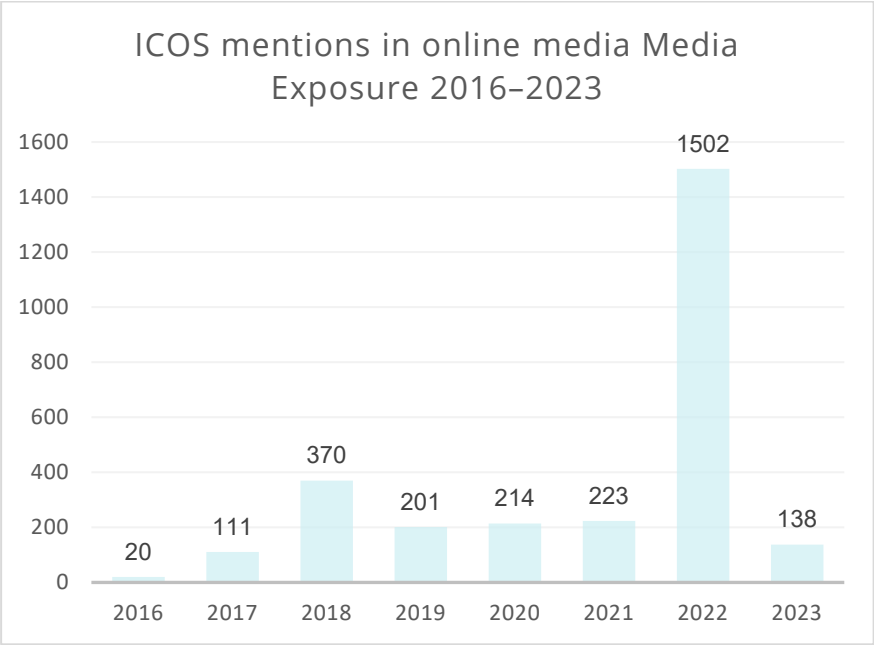


Figure 6: ICOS mentions in global online media 2016-2023.

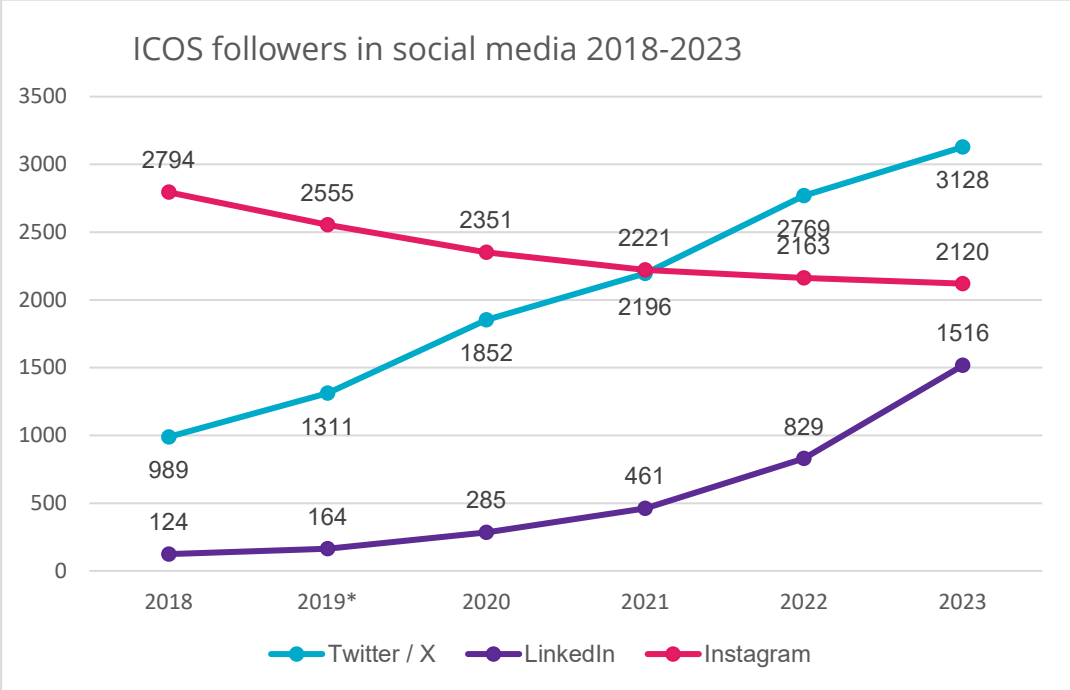


Figure 7. The number of followers in the most important ICOS social media channels. In recent years, the X (ex-Twitter), has seen many sudden changes, thus the future of the channel remains somewhat unsure. Majority of the ICOS Instagram followers were gained through a campaign done with a famous photographer, thus since the end of the campaign in 2018, the number has slightly decreased.

Community integration

Community integration refers to the participation of different parts of the RI into activities, the ability to improve activities and respond in an agile way to new opportunities or challenges, and the potential for improving the RI's structure.

ICOS community organised several trainings and workshops to develop things together. Most of those took place in online format. For more information, please refer to 'Use of ICOS data in educational tools and activities' on page 85.

Besides activities, communication is an important glue fitting the community together. To that end, the Head Office and Carbon Portal regularly supports internal communication activities across the ICOS RI. To enhance cooperation and timely communication across the RI, the HO continued to publish a monthly community newsletter, while the ICOS Carbon Portal maintained internal document management system, email-lists, as well as continued to host an internal discussion forum at Discord platform. 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 2023 but Switzerland, an observer since the installation of ICOS ERIC, upgraded its statute to a full member. Thanks to a change in the national legislation, it had become possible for the country to join ERICs and allow Swiss universities and research institutions to exploit the full potential of international cooperation. ICOS was one of the six ERICs Switzerland decided to strengthen its position in.

The HO also started intense discussions with the Portuguese scientific communities to open the path to a future membership in ICOS ERIC. Portugal has been a target country since the RINGO project, most notably because of its geographical location "at the western edge" of the continent and its vast maritime domain that offer scientific opportunities for the ICOS network. A patient work to identify, connect and mobilize the different researchers involved in all ICOS three domains has started and will be pursued. The aim is to strengthen the national consortium and convey a consistent message to the Portuguese authorities who will decide a future membership.

Other activities at the European level include the final occurrence of the ENVRI FAIR project that gave the opportunity to plan a networking event on the margin of the RI Conference organized by the Swedish Presidency of the Council of the European Union in Lund. The aim was to present the main results and the added-value of the collaborative work performed by the community of environmental RIs in Europe, ENVRI.

More specific to ICOS was the event organized at the European Parliament on Nature-based solutions to increase carbon sinks on land. The opportunity was given by the discussions on the European Certification Framework for Carbon Removals that the Parliament was examining. With scientific presentations and a panel discussion including Members of the European Parliament and the Commission, the event gave the opportunity to discuss the most relevant research results likely to inform the European decision-makers.

Outside of Europe, the activities in the Knowledge and Services from an African Observation and Data Infrastructure (KADI) project in Africa took speed with the recruitment of a project manager. KADI was prominently presented at several events on the continent (AfriGEO, GEO Week, World Climate Research Programme Conference) as well as globally (COP28, see below).

New developments occurred in the Global Ecosystem Research Infrastructure (GERI), a consortium between ICOS and 5 other world-class RIs in Africa, Australia, China, Europe and the US. The US partner was awarded a three-year 1.6 M$ grant from the US National Science Foundation through their

Accelerating Research through International Network-to-Network Collaborations program (AccelNet). The grant will support efforts to harmonize international, drought-related ecological data across the networks of GERI to address droughts as a global issue and not only nationally or regionally.

As an observer to the UN Framework Convention on Climate Change (UNFCCC), ICOS was again present at COP28 in Dubai. A side-event based on the activities in KADI was organized, entitled "Transformative climate services for decision-makers based on observational data". It insisted on the importance of co-designing these services with their users at every stage of the process and stressed the valuable information received, that can allow in turn to improve observational networks. Pilot examples (e.g. in cities like Nairobi or Dar Es-Salam) were presented by the KADI partners (Kenya Meteorological Department, Universities of Turku and Helsinki, Resilience Academy of Tanzania…).

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, so some new practices were developed in return.

#1: In 2023 the ICOS ERIC Travel Rules were extended to cover slow travel, 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.

#2: 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 communications. At the same time, it is seen important to provide proper reasoning for travel – why or when to fly, and who should fly.

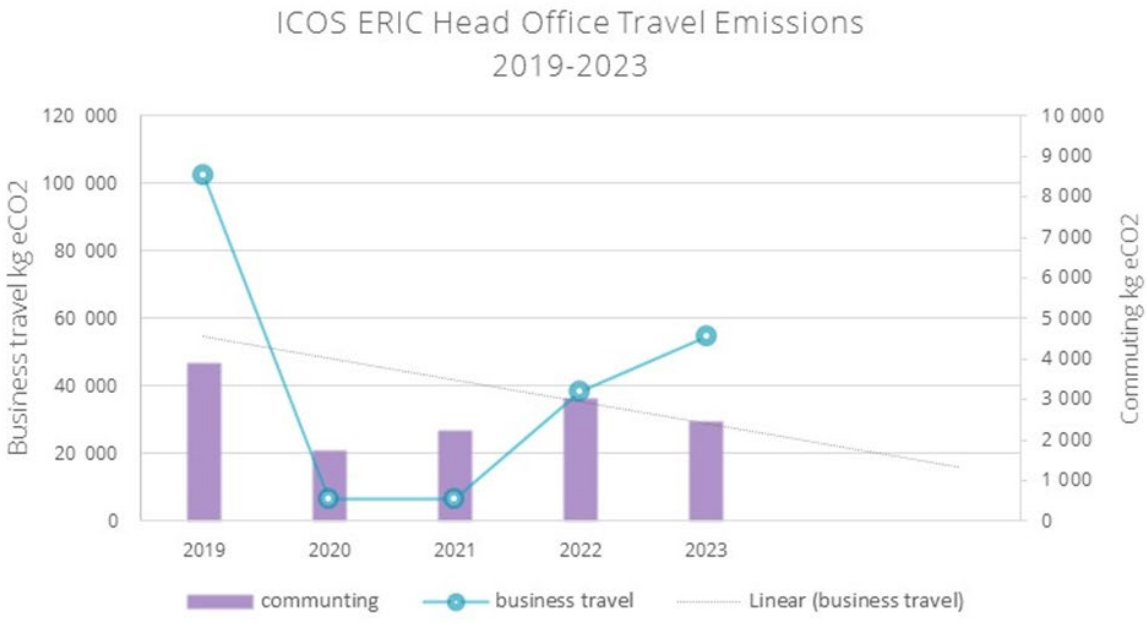


Figure X. Years 2020 and 2021 show a dramatic decrease in emissions due to the Covid19 , however, the emissions have not returned to the 2019 level in the following years. .

Carbon Portal

General

After large changes in working mode during and just after the COVID period, the work situation stabilised in 2023. However, the number of online meetings is still larger and only partly replaces in-person meetings, not causing significantly reduced travel but leading to even fuller agendas. ICOS data streams are still fully operational, and more and more stations have become labelled, leading to them sending more and more data. This again has put significant pressure on the operational side of business and induced the need for continued development in robustness and performance of the services. To keep all services up and running and up to date is therefore taking most of the effort in the core infrastructure work at Carbon Portal. Nevertheless, the availability of the CP services in 2023 was better than 99.8%. One major instance causing disruption was a failure in the metadata system in November 2023 due to a combination of factors, including an error in metadata transferred from one of the central facilities and a high load on the system. This vulnerability has been traced and corrected, by refactoring an important low-level part of the back-end code. Improved resilience of the core services remains one of the main targets for 2024.

Data Statistics

Data availability

In 2023 CP received in total 471 831 data objects (Table 1), of which 394 118 are considered ICOS data. Of these 202 397 came from the atmosphere, 189 296 from the ecosystem and 2 413 from the ocean domain. 12 ICOS data objects were of the mixed data theme, mainly CTE-HR data results. In total 79 mixed data theme data objects were received as non-ICOS data. The big share of ICOS data is raw data (L0, 213 419), but also the daily growing NRT data files (L1, 179 035) form a considerable part of the total number of files. A total of 1 448 data objects were received as Level 2, final quality controlled, ICOS data. At the end of 2023, the Carbon Portal held in total more than 1.8 million data objects.

Table 1 Statistics on number of data objects received in 2023.

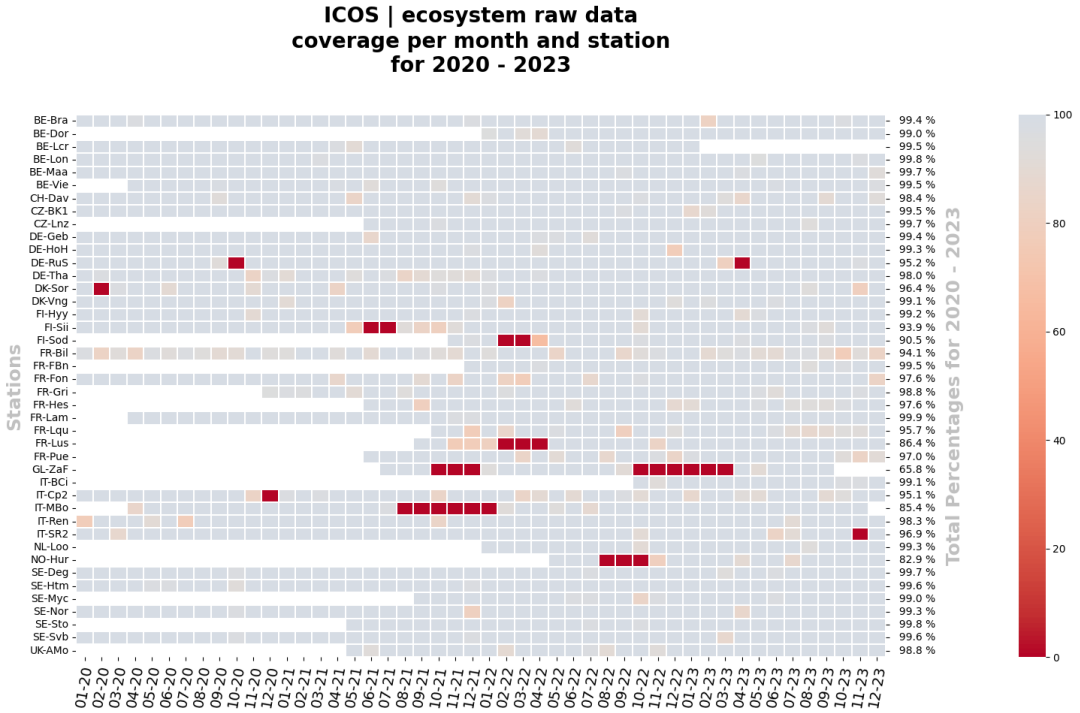
Total		471 831
ICOS data objects		394 118
	Atmosphere	202 397
	Ecosystem	189 296
	Ocean	2 413
	Mixed theme	12
	L0	213 419
	L1	179 035
	L2	1448
Other data objects		77 713

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 2020-2023 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 and 2023, and for the whole period 2020-2023

	Year	2020	2021	2022	2023	2020-2023
Atmosphere	**average**	95,7%	96,6%	96,3%	97.6%	96,6%
	median	96,1%	96,6%	97,0%	97.9%	96,9%
Ecosystem	**average**	98,3%	98,2%	97,9%	98.4%	97.9%
	median	99,7%	99,6%	99,4%	99.2%	99.4%



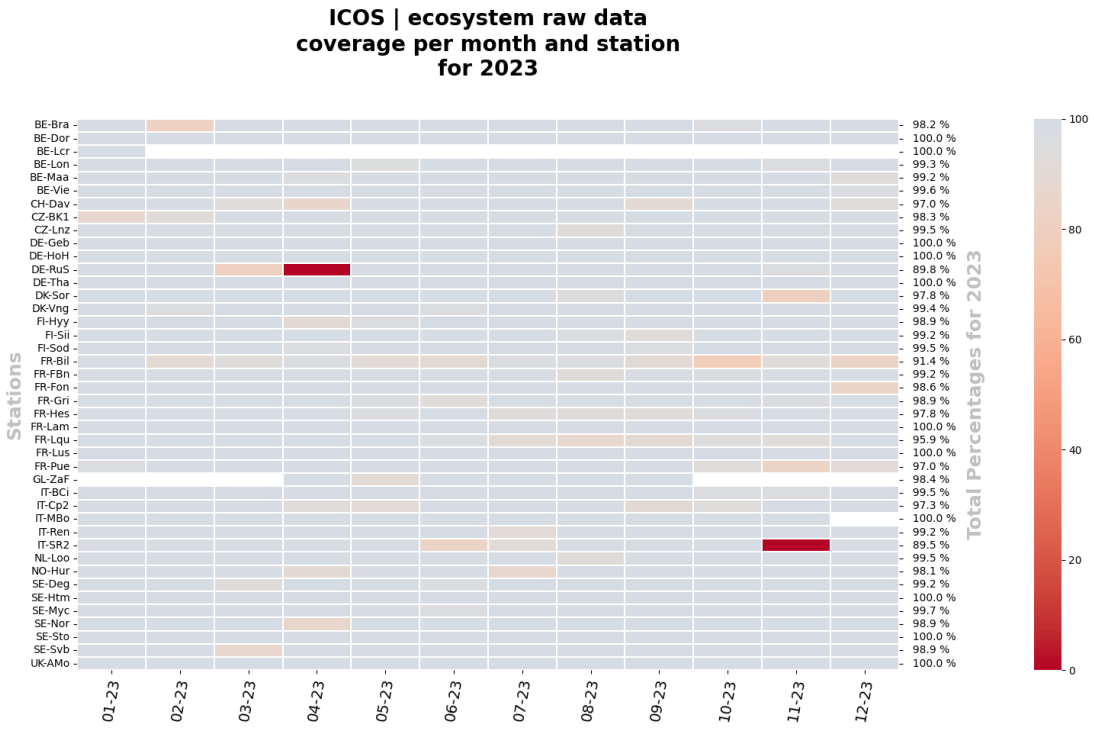
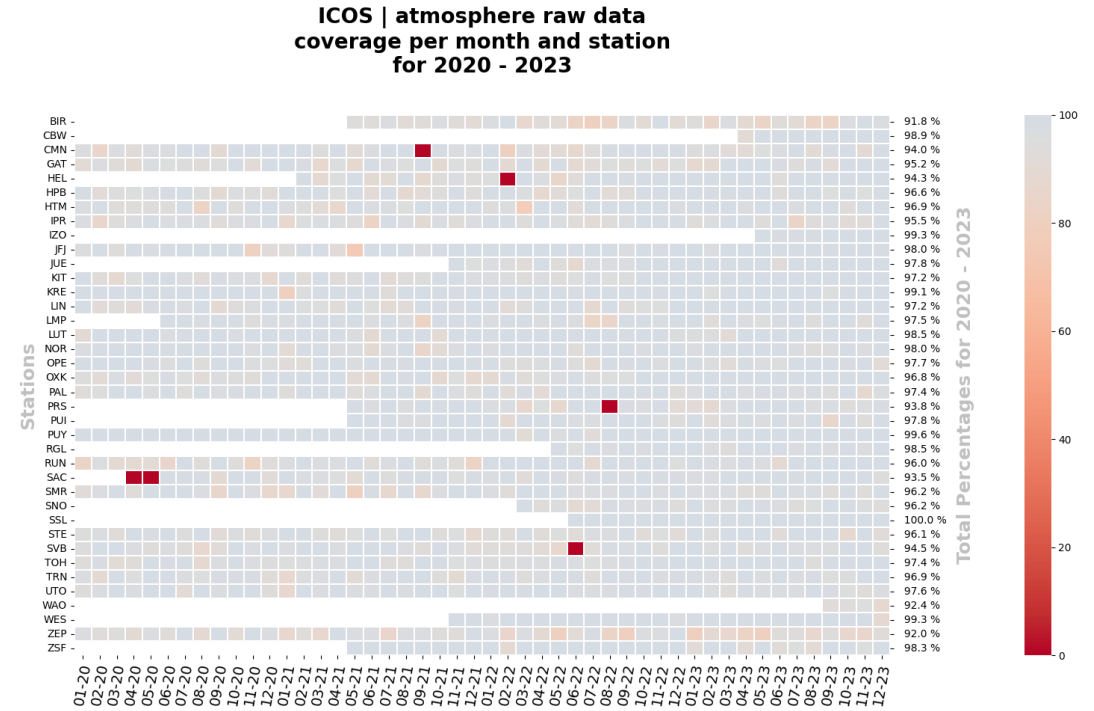


Figure 1 Percentage of raw data coverage for ecosystem stations. Left: for the period 2020-2023. Right: for the year 2023 .



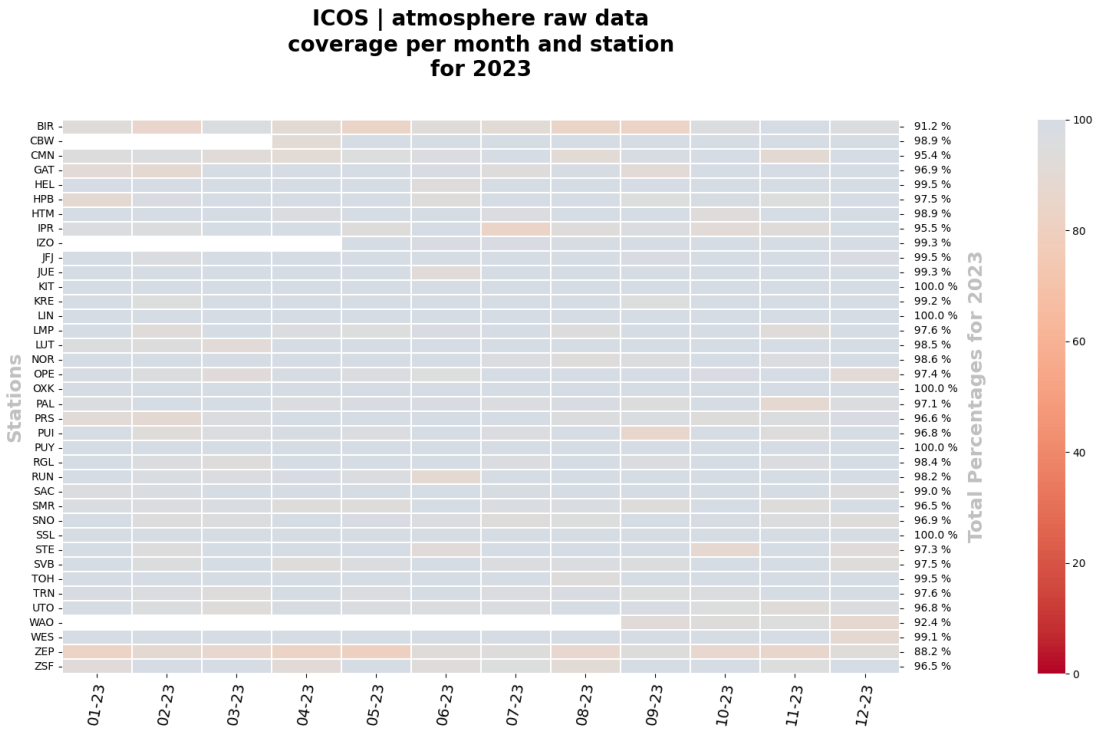


Figure 2 Percentage of raw data coverage for atmospheric stations. Left: for the period 2020-2023. Right: for the year 2023.

Data releases

All domains delivered at least one release of level 2 final quality data. Ocean date release was on 13 Feb 2024, Ecosystem 8 July 2023 and Atmosphere 6 July 2023. The end of growing season interim L2 dataset of Ecosystem data was released 20 Dec 2023.

The 2023 Obspack data product was prepared and released in September 2023.

Data usage by download count and user number

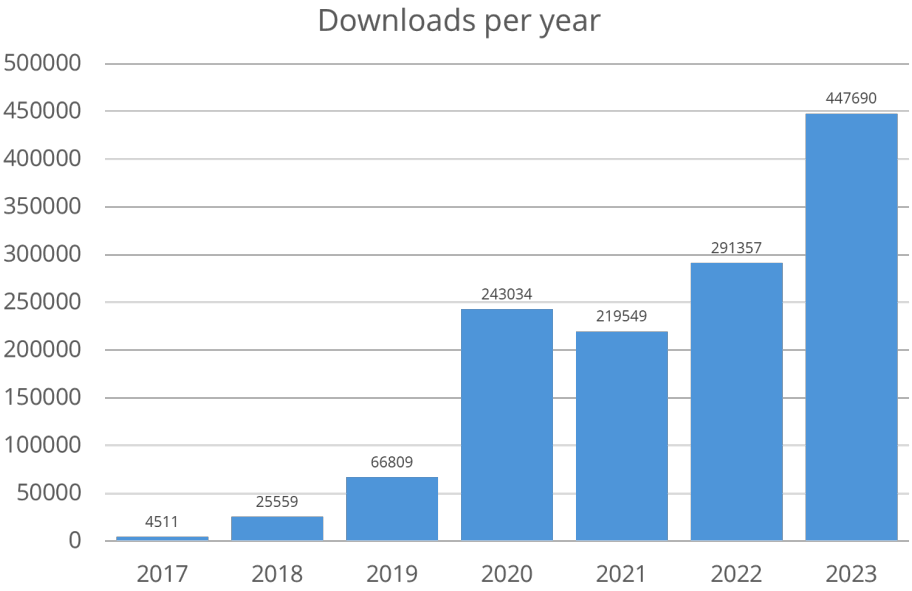


Figure 3. Total number of data downloads from Carbon Portal from 2017 to 2023. In 2023 the number of downloads of ICOS Level 1 and 2 data: 272 375000. Total number of downloads was 447 690.

Another statistic relevant to the use of ICOS CP data is the number of data use through the apps of Carbon Portal, for example the data preview, the Dashboard and the python library. Total number of access per month is shown in figure 4.

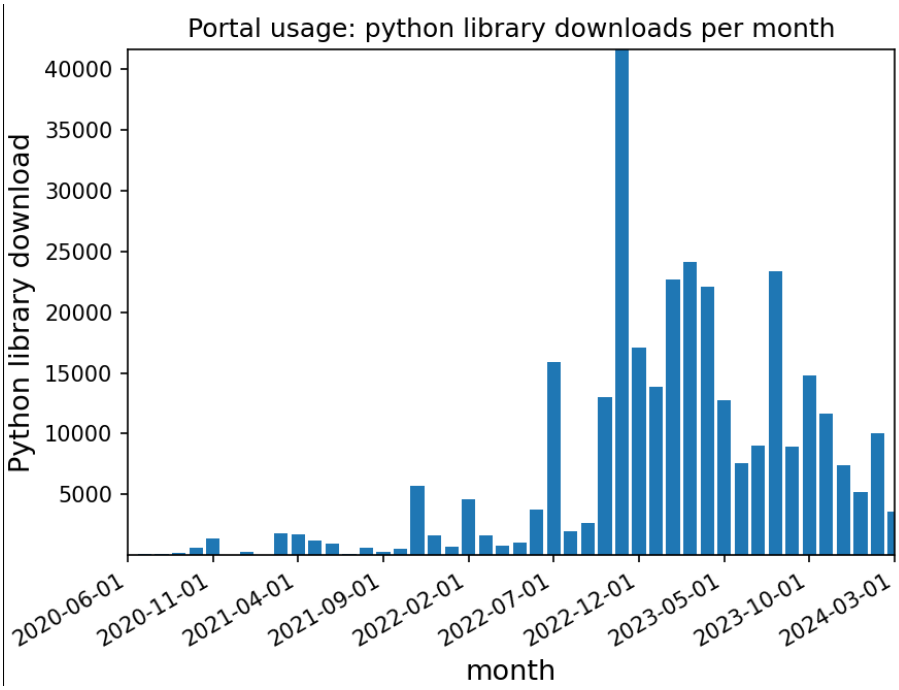


Figure 4. Number of access of ICOS CP data through the python library

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 time of the Nordstream I+II methane leaks that were detected in the ICOS network, which caused a lot of interest for a prolonged period (Figure 5).

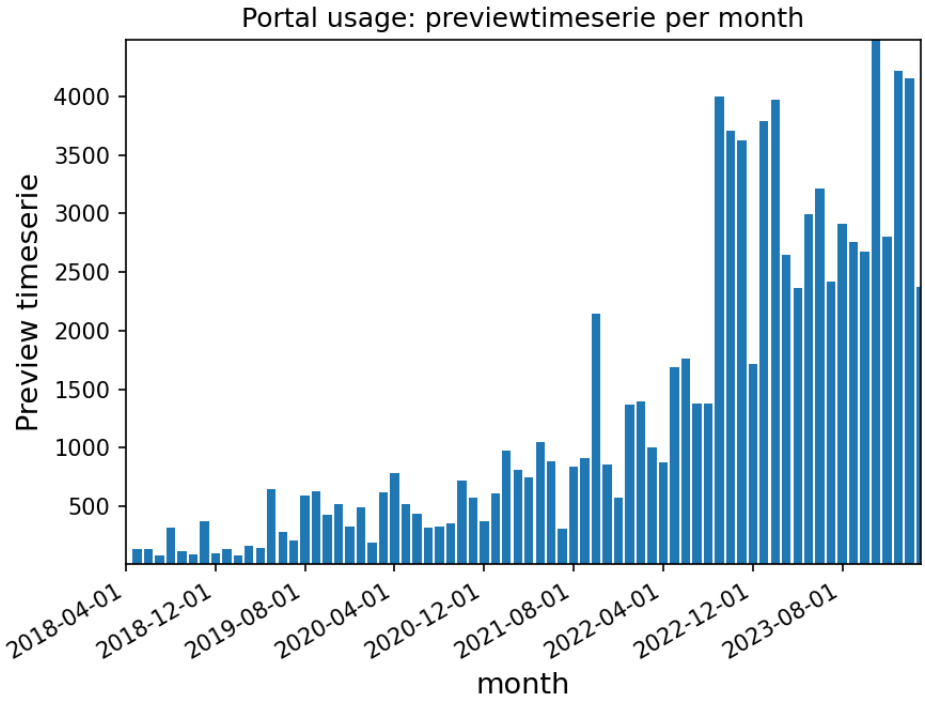


Figure 5. Number of timeseries previews at Carbon Portal

Total amount of unique users of web pages and web services

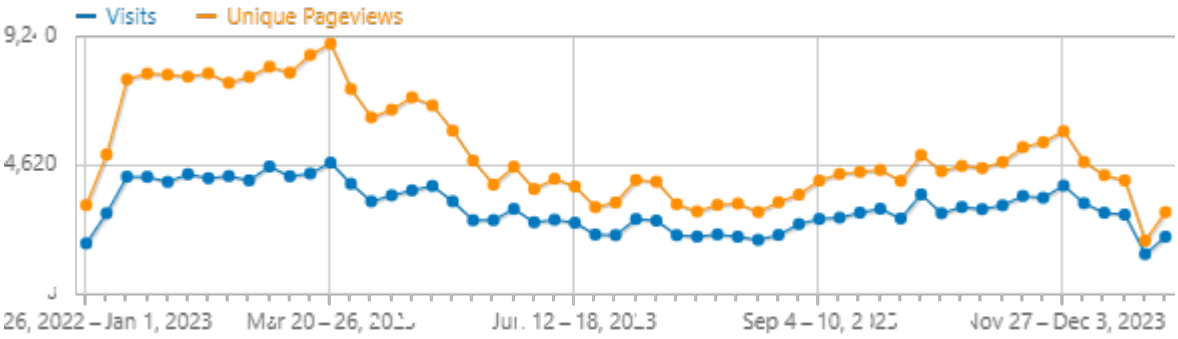


Figure 6 Number of unique users and pageviews per week of the ICOS web site plus Carbon Portal. The total numbers of unique users over 2023 was over 159 900 users.

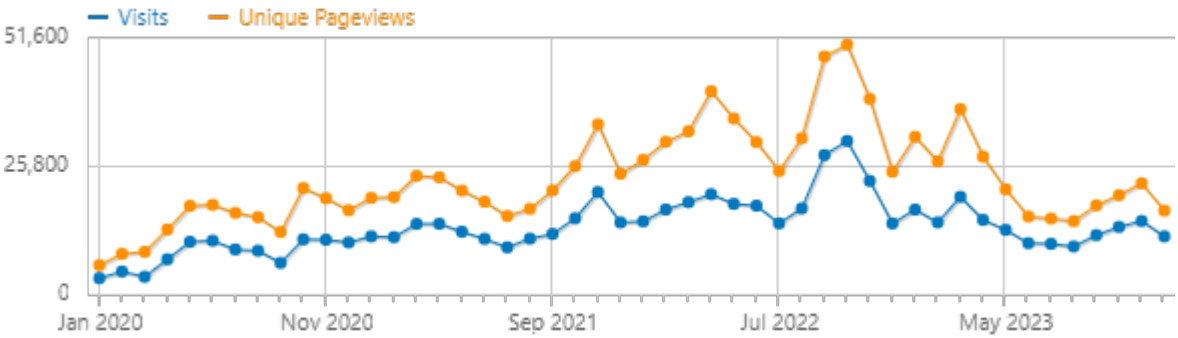


Figure 7 Number of unique users and pageviews per month in the period Jan 2020 until Jan 2023, showing a quite stable average of 10 000 users per month since 2020 with a clear peak in September 2022. Results from before 2020 are not shown here because of transfer of web statistics from Google Analytics to Matomo due to GDPR concerns.

Impact

Impact through articles and citations

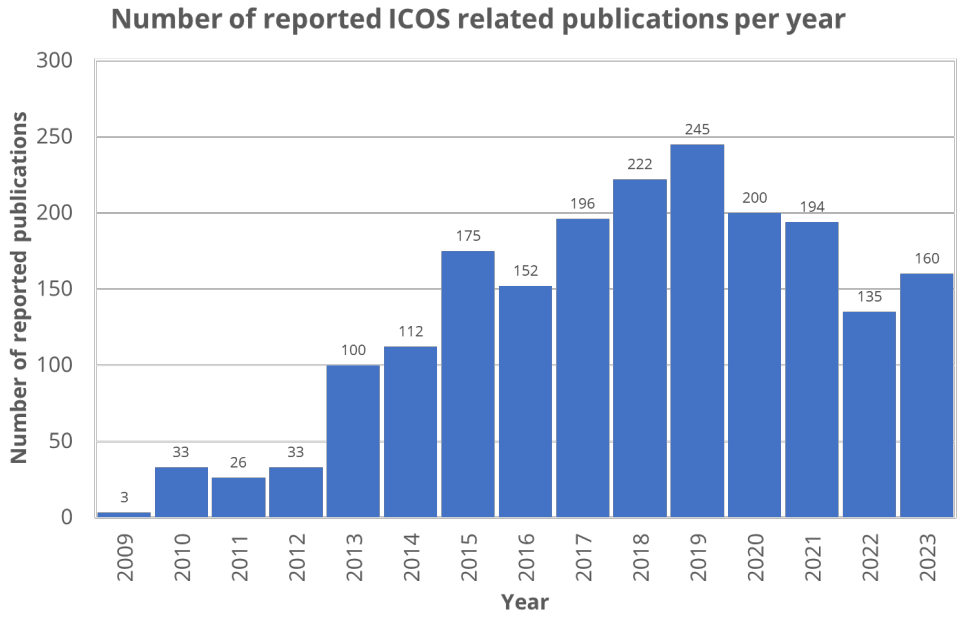


*Figure 8 Number of ICOS related **publications** per year (reported)*

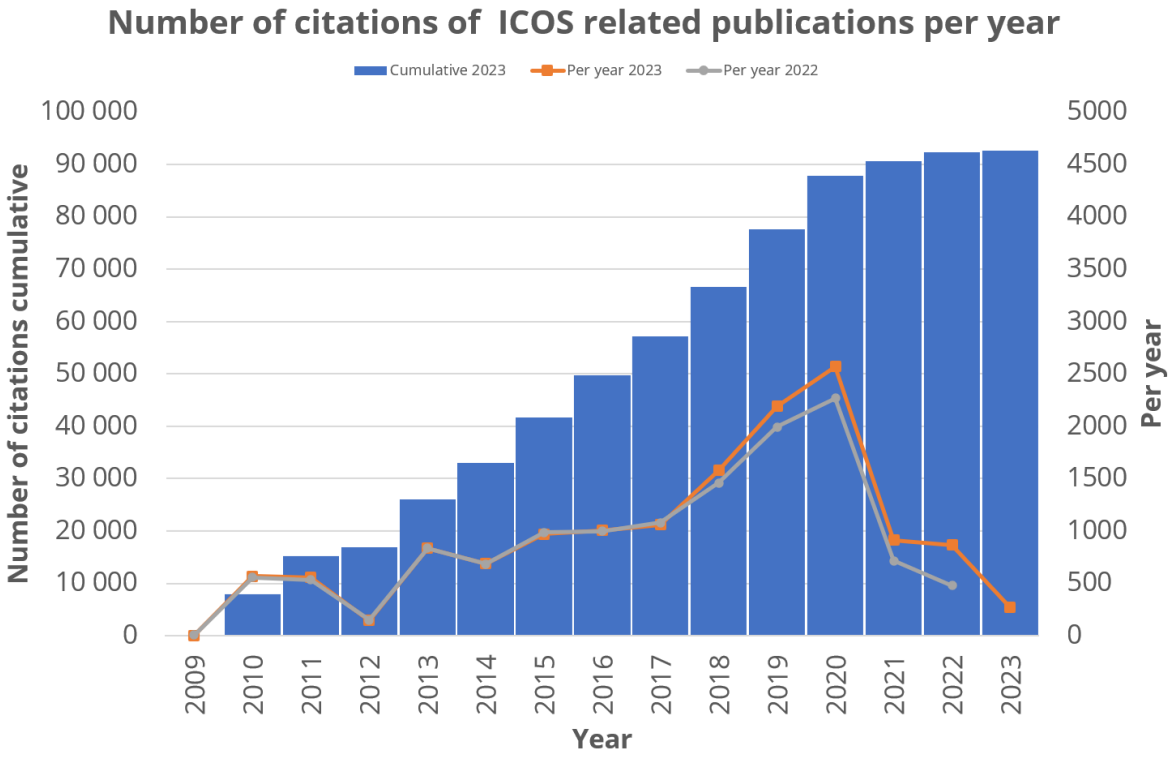


*Figure 9. Number of **citations** of ICOS related publications per year*

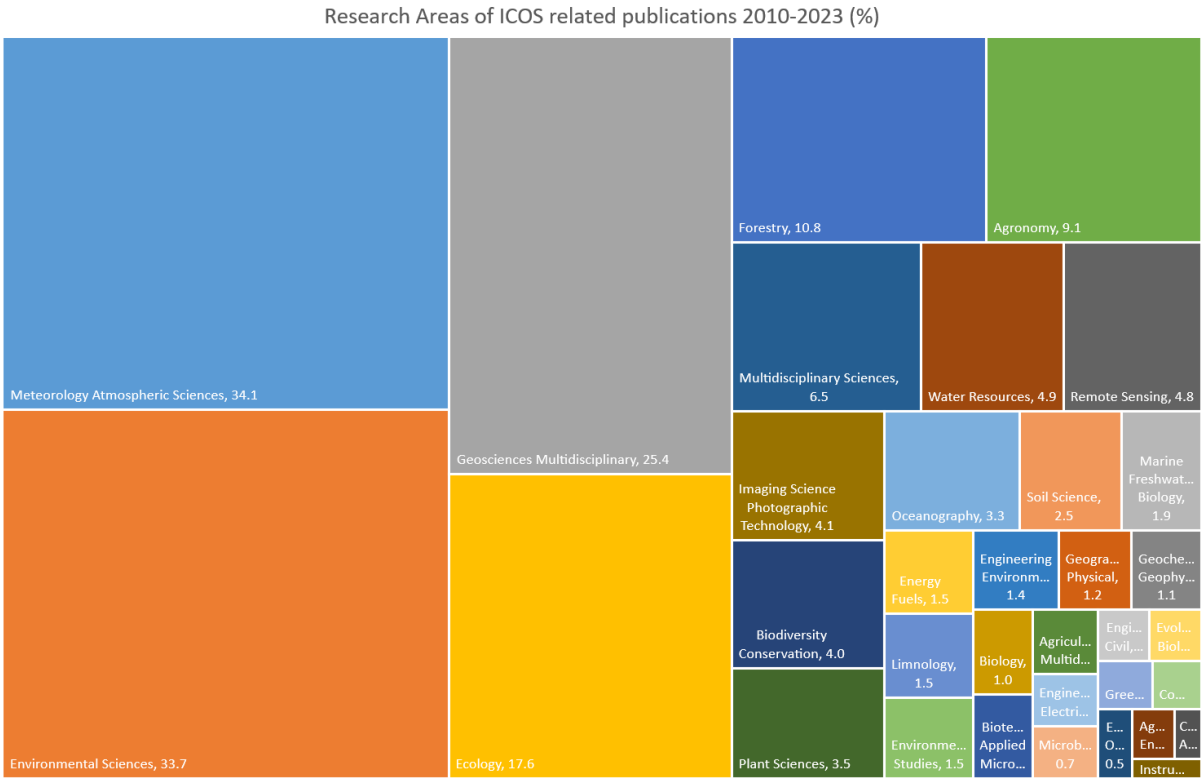


Figure 10. Categories of ICOS publications. The six largest categories of ICOS publications were Meteorology Atmospheric Sciences, Environmental Sciences, Geosciences Multidisciplinary, Ecology, Forestry and Agronomy.

Impact through citations of data and referring articles

In the Dimensions citation system (https://dimensions.ai) we can find 20 990 publications (1120 datasets and 19 870 articles) related to ICOS (about 2000 publications are produced per year). These received in total 747 000 citations, on average 37.6 citations per publication. "Note that on our website we have roughly 1900 publications from our own community, listed with help of Focal Points. So much of the data use seems to be outside of our circles. It is also likely, that the Dimensions also includes references related to cryptocurrencies or neurobiology.

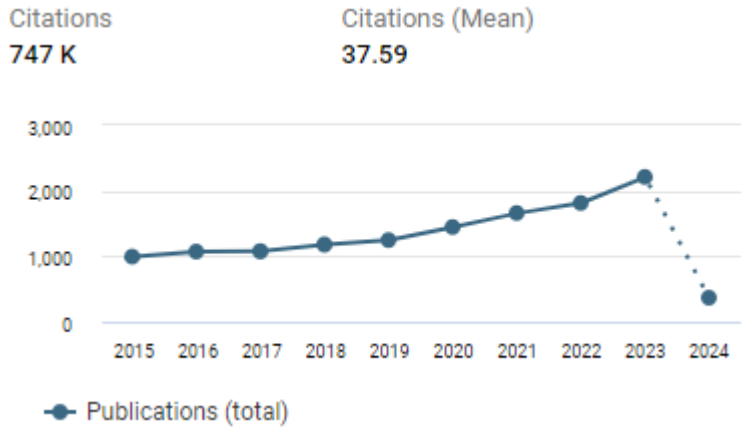


Figure 11 ICOS-related articles in Dimensions.ai

Elaborated products

Jupyter notebooks

The Jupyter Notebook services at CP have again seen an increasing number of users in 2023, both in the collaborative Jupyter Hub, with currently more than 200 registered users, and in the semi-public service exploredata.icos-cp.eu. Many of the new users are participant of EU projects (e.g. Avengers, PARIS, ICOS-Cities) who are using the advanced options of the collaborative Jupyter Hub, like sharing notebooks and data between users in collaborative projects including associated disk space on the ICOS Fileshare allowing upload of own data for analysis together with ICOS data and providing permanent storage of notebooks and data. These 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 library for an easy and user-friendly access to ICOS data and metadata as well as to results of the STILT footprint tool has been continuously updated to reflect the developments in the data portal. Access to the core data and metadata services of the data portal will be provided by the new icoscp-core library in future releases, while maintaining the user-friendly interface.

Jupyter notebooks showcasing tools for analysing the monitoring potential of atmosphere station networks and visualizing anomalies in ecosystem variables were presented in webinars and are available for all interested users on the Jupyter Notebook services.

Data products and services

FLUXCOM-X, an extensive dataset of global, high resolution estimates of CO2 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 now disseminated through CP in several temporal and spatial resolutions to ease data handling for common use cases.

High-Resolution, near real-time CO2 fluxes over Europe from the Carbon Tracker Europe system (CTE-HR) were updated 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 available at CP since many years, have continued to be updated. These include regional biosphere model results (VPRM and LPJ-GUESS), anthropogenic CO_2emissions and radon exhalation from soils, all with high spatial and temporal resolution.

The harmonized dataset of global CO2 flux fields from the atmospheric inversion model systems that participated in the Global Carbon Budget 2023 is disseminated through CP, allowing users to inspect the individual results in more detail. The annual update includes now results from 14 different inversion systems.

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. FLEXPART model simulations to estimate the influence of radiocarbon emitted from nuclear facilities are provided as a service to the ICOS CRL to support sampling strategies for 14CO2 (radiocarbon).

Upload and curation of these elaborated products, possibly including DOI minting, is handled by CP personnel in close contact with product providers. A semi-automated workflow for recurring

datasets is established. However, the diverse content of these products still requires specific solutions.

Data portal

The lists of improvements are provided in a roughly chronological order of when the corresponding work had started.

Improvements in functions and usability

- Document object downloads are now also logged to users' profiles, if the user is logged in
- Content of data objects who are ZIP files can be listed and accessed on the landing page
- Phenocam image packages became previewable, with possibility to view each image
- Spatial NetCDF data preview app has been enhanced with new colormaps ported from Python's matplotlib library
- UploadGUI app for data/doc object upload and collection creation got a video tutorial, access to which is embedded in the app, and gained ability to create draft DOIs with pre-filled metadata based on CP metadata export to the DataCite metadata model.
- Collection landing pages enhanced with DataCite metadata, whenever DOI is attached to the collection
- Spatial NetCDF support improved by allowing an additional discrete labelled data dimension (e.g. simulation model used to produce the data)
- CP authentication token update to make it cross-platform (to support Python and other languages)
- Differentiation of data objects into two kinds (spatiotemporal and station-specific time series) made more explicit and consistent, and independent of ICOS data level
- Latest-version link added to the landing pages (in addition to the next/previous versions)
- Geo-coverage metadata support improvements
- Enriched landing pages for ICOS stations (enhanced with extra multimedia content backed by Web elements metadata)
- New exotic temporal-axis format supported: year/month (without date or time)
- Many-to-one deprecations: possibility for multiple data objects together to deprecate one
- Dashboard web app (co2/co/ch4 concentration widgets) improved
- (Large addition!) CP added a new "customer" — a meta/data repository for ICOS Cities. The work implied large overhaul in the code of the services, some architectural changes, and a big work on deployment configuration. ICOS Cities is deployed separately from the co-located ICOS and SITES
- STILT web service has been integrated with ATMO-ACCESS (authentication, visual web page style, and service usage reporting to ATMO-ACCESS). Possibility to package the results and download the packages added.
- The server side of the data object downloads statistics service has been heavily overhauled, making it responsive and fast again, despite a sharp increase in the number of download events in the last years
- (Large addition!) New Python library *icoscp_core* for access to the core data- and metadata services across three supported repositories (ICOS, SITES, ICOS Cities) has been released. It is also meant to be a solid foundation for future releases of the (now legacy) *icoscp* library
- Overhaul of metadata flow machinery (thematic centers to CP) in order to support metadata import for low- and mid-cost sensor networks in ICOS Cities
- Operations improvements in backup recovery automation and in development machine provisioning automation
- Serious internal overhaul of server-side reading of metadata from RDF into programming-language data structures. The improvements have made the meta service much more

robust in the case of broken or inconsistent metadata, and added error handling information to the landing pages and JSON metadata.
- Numerous various smaller improvements and bugfixes (throughout the whole year).

FAIRness improvements

- ICOS/CP ontology has been published on Linked Open Vocabularies (LOV) registry with standard prefix *cpmeta*.
- Schema.org metadata has been added to document and collection landing pages (in addition to data object landing pages)
- DataCite metadata added to CP JSON metadata of data/doc objects and collections.
- Support for sensor deployment metadata (time interval, geo coordinates, variable assosiation), including the data object landing pages

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 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 FAIRer 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 ENVRI-FAIR (See chapter 9) the Environmental RIs have worked together with GoFAIR as one of the pioneering communities to test out and co-develop the FIP framework. For what it is worth, in 2022 from all participating repositories and communities the Carbon Portal scored highest in number of implemented elements of the profile and showed high cross-domain convergence with other RIs.

Another 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 87%, which is graded as Advanced level. In a study performed by the European Commission (2022), 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 87%.

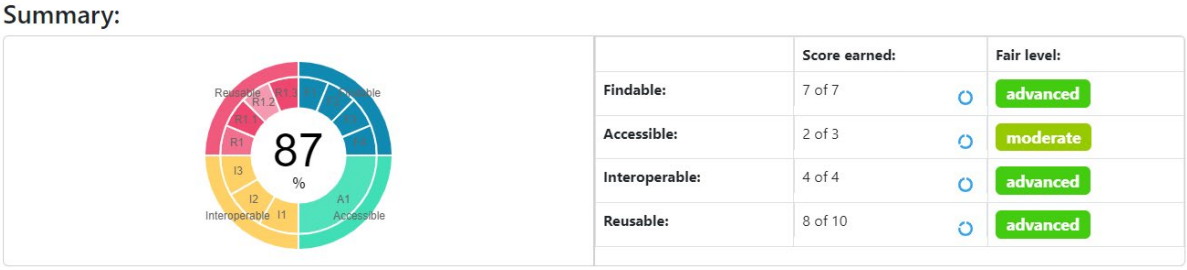


Figure 11 F-UJI score for the FAIRness score of an ICOS Level 2 data product et at the end 2023

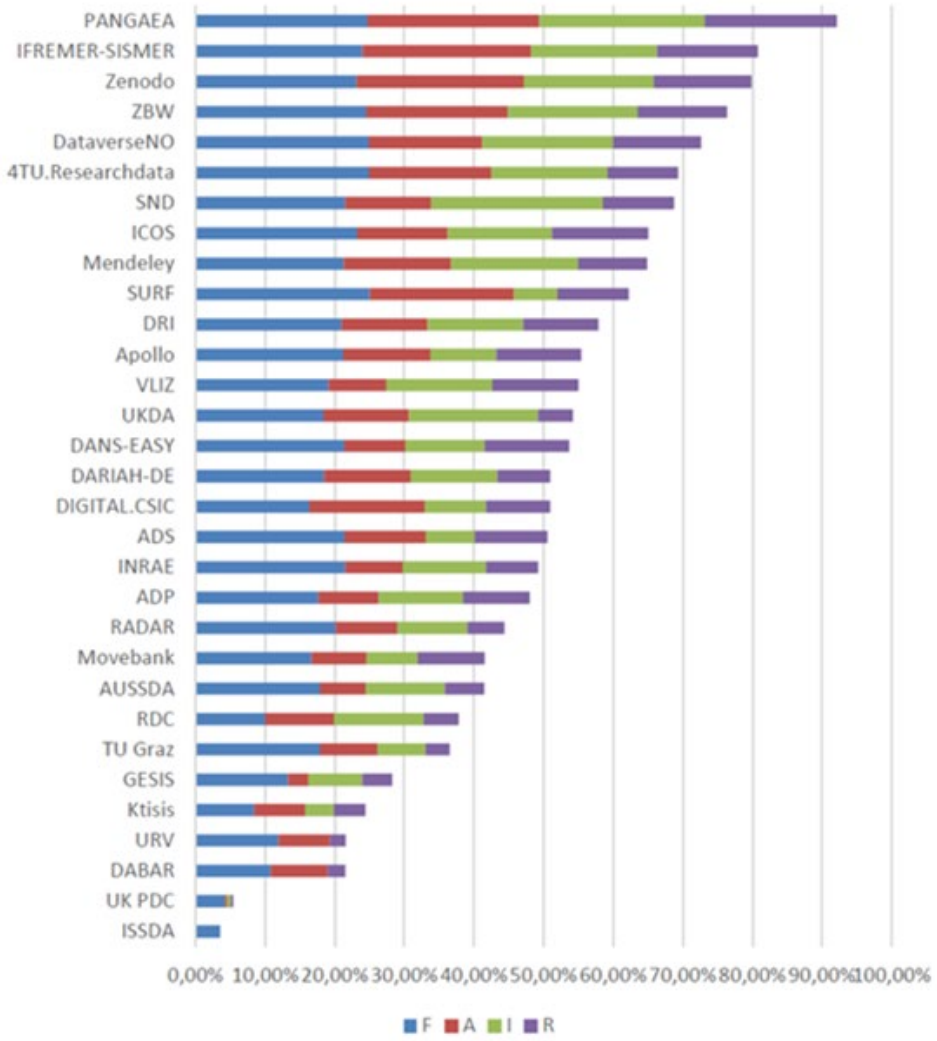


Figure 12 Comparison of the FAIRness scores of 31 data repositories using the F-UJI tool according to European Commission (2022), the comparison was performed in 2020.

CoreTrustSeal certification

The CoreTrustSeal certification, supported by the FAIRsFAIR project, has been a slow process, due to delays partly caused by the COVID periods and slow response by both Carbon Portal and the reviewers. We submitted the final version (after receiving the initial review by the reviewers) early 2022 and received the result end of 2022. We improved the application according to the reviewer comments concerning a formal written and approved contingency plan in case the Carbon Portal would cease to exist. Resubmission will have to wait for the contract to be settled with CSC on the B2SAFE service (important for the contingency plan), to cover for the period after the DICE project that funded the service thus far. However CSC is making its mind up on whether and how to continue this service provision.

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

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], the FAIR Digital Object Forum[2] and others, as well as the EOSC Association's Task Force on Persistent Identifier Policy and Implementation. 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[3]: 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[4]: M. Hellström monitors developments, as this group is now in maintenance mode.
- Education and Training on Handling of Research Data IG: contributions to the development of the specification on a minimal metadata set for learning resources, as well as the development (in progress) of DCAT application profiles for learning resource metadata.

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 is also co-chairing the Forum's Technical Advisory Committee.

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 2023 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 Carbon Portal is actively engaged in developing and delivering training based on ICOS services, knowledge and experiences.

- ICOS Summer School 2023
  First regular Summer School after the COVID period with 38 students. A 10 day intensive course at Hyytiälä field station. The course starts with a general overview over the Climate System and the Global Carbon Cycle, and offers furthermore detailed lectures on the science of all domains of ICOS, the ICOS history and organisation, data management, modelling and observational techniques, excursions to measurement sites, and practical exercises on modelling, including data assimilation and actual atmospheric inversions.

[1] Research Data Alliance (RDA), https://rd-alliance.org/

[2] FAIR Digital Object Forum, https://fairdo.org

[3] RDA FAIR Digital Object Fabric IG, https://www.rd-alliance.org/group/FAIR-digital-object-fabric-ig.html

[4] RDA I-ADOPT WG, https://www.rd-alliance.org/groups/interoperable-descriptions-observable-property-terminology-wg-i-adopt-wg

Figure 22 ICOS Summer school 2023

- ENVRI-FAIR
  - During the ENVRI-FAIR project, M. Hellström (lead), H. Lankreijer and A. Adamaki actively contributed to the WP on Training and Capacity building. Training modules were designed and delivered (as webinars and Summer/winter school sessions) on a wide variety of topics, including Jupyter Notebooks for research, Data Portal design, technology readiness level (TRL) assessment, service validation and service evaluation
- EOSC Future
  - Active participation in WP9 on Training, contributing to building up the EOSC knowledge hub portal (metadata catalogue design, web portal configuration) as well as designing, reviewing and delivering educational content (M. Hellström)
  - Designing and delivering the course "AG2.7 Service documentation for providers", work in progress (M.Hellström, H. Lankreijer)
- Academic settings
  - Delivering NNG006F: Introduction to research data management", a post-graduate-level course for Lund University Faculty of Science (M. Hellström, H. Lankreijer). Throughout this course, the Carbon Portal and selected examples of ICOS data are extensively used as good examples of Research Data Management best practices
  - Contributing lecture on FAIR & Open Earth science data to the post-graduate level course "Spatial Data Infrastructure, 5p" organised by the Lund University Centre for Geographical Information Systems (GIS) (M. Hellström)
  - Contributions to RDM activities at Lund University Dept of Physical Geography and Ecosystem Science (M. Hellström, H. Lankreijer)
  - Research Data Management course for PhD students, ICOS Summer School 2023 (A. Adamaki)

Management

Human resources

During 2023 the average work force at CP was 16.8 full time equivalents divided over 18 persons. In early May 2023 we expanded the development team with Jonathan Schenk as programmer. A job opening for a data steward as approved by GA and SAB has received bureaucratic delays at Lund University and is expected now end of Q1 2024.

International cooperation in the Carbon Portal

WMO GAW, GGGW

Also during 2023 CPD served as chair of the WMO GAW Scientific Advisory Group (SAG) for greenhouse gases, and from this function also member of the WMO GAW Scientific Steering Committee (SSC). He was also member of the WMO GAW SAG for applications (SAG-App) and the WMO Expert Team for Atmospheric Composition Data Management (ET-ACDM). The GHG SAG coordinates the greenhouse gas activities in the WMO GAW network, approves new stations, coordinates the GGMT meetings and the annual WMO Greenhouse Gas Bulletin. This year's 19th WMO GHG bulletin (WMO, 2023) focused on the uncertainties in reaching the Paris agreement goals due to changes in natural greenhouse gas emissions and uptake because of ongoing climate change and the recent WMO initiative for the Global Greenhouse Gas Watch in its role to reduce these uncertainties.

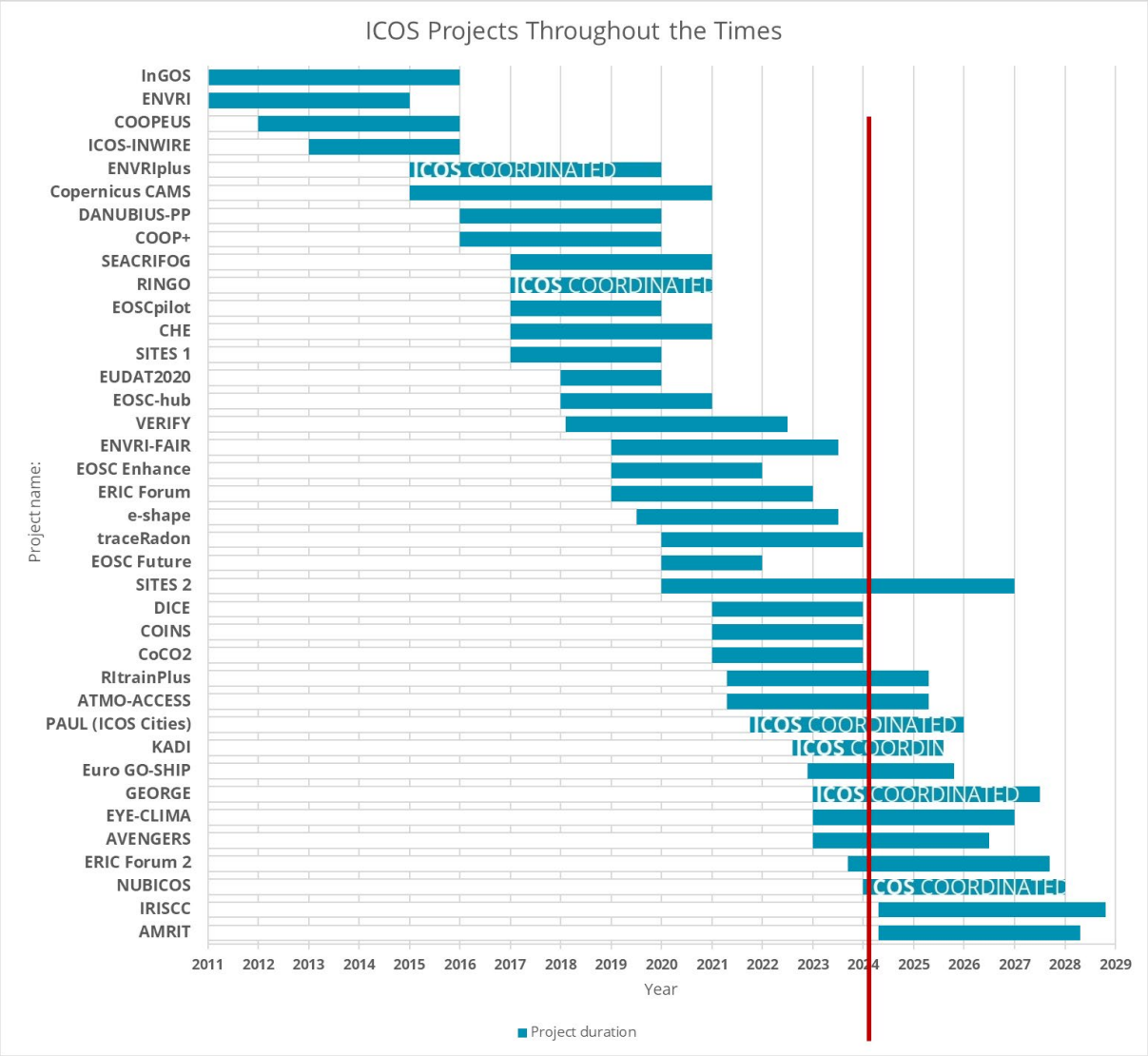
This recent development by WMO is to coordinate an operational global Greenhouse Gas Monitoring Infrastructure. In March 2023 WMO organised a meeting in Geneva that resulted in a white paper and a resolution to the WMO Congress, that was accepted in June. In September 2023 WMO organised in Bonn and Geneva two workshops to discuss this with the global observations and modelling community. The Bonn meeting was by invitation only and was attended by representants from NOAA, ICOS (CPD), space agencies and the foreseen data analysis centres (like Copernicus, NASA, CES and NIES). Both workshops were well attended and the open workshop on observations received a lot of contributions through talks, posters and input at the discussions from numerous ICOS colleagues.

The Study group of experts, appointed by WMO INFCOM, in which ICOS is also well represented (e.g. by CPD), met during the year to steer the process and produced by the end of 2022 on the basis of all received input an Implementation Plan, that should be approved by WMO in April 2024. The GGGW initiative was welcomed by the SBSTA at the most recent COP in Dubai.

ICOS is seen as a blueprint and role model for how the in situ component of this GGGW should be organised through regional centres. ICOS is the only organisation world-wide that delivers operational and near-real time greenhouse gas observation information, and does this integrated over the three relevant domains, for atmosphere within the compatibility goal of WMO GAW and through free and open (FAIR) data access. Next to serving as part of the reference (Tier 1) in situ observations network, ICOS could play a role in capacity building for setting up networks in new countries that want to participate in the GGGW.

Projects

In the following, the progress of projects where ICOS ERIC participates is described briefly. Participation of different elements of ERIC is indicated (HO = Head Office, CP = Carbon portal).



ATMO-ACCESS - Solutions for Sustainable Access to Atmospheric Research Facilities (CP as ERIC and Lund)

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 the ICOS Carbon Portal is in work package 5, lead by CP: 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. The work package is divided into three tasks in order to investigate services for different groups, namely:

- 5.1 Homeless data, for long term storage in a FAIR environment, with persistent identification for download, visualisation, and aggregation.
- 5.2 Footprint service, to calculate on demand footprints with the Flexpart and STILT transport-models, where the results can be retrieved and visualised.
- 5.3 Time series data, provide access to long-term time series from the ACTRIS, IAGOS and ICOS Research Infrastructures with tools for filtering, statistical analysis and interactive visualisations.

Current output of the project consists of a user survey for all three Tasks which was the basis for the deliverable D5.1: Detailed requirements and (non-) technical specifications for all services based on the user consultations. Which contains a detailed system requirement specification and a mock-up for the service implementation.

A second output (Deliverable D5.2) is a first version of Data management plan for data from Trans National Access (TNA) activities.

In 2023 the STILT transport model view and calculation tools were implemented as an ATMO-ACCESS service.

AVENGERS (CP as ERIC and Lund)

Starting 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.

CoCO2 - Prototype system for a Copernicus CO2 Service (HO and CP)

The CoCO2 project, coordinated by ECMWF and spanning from 2021 to 2023, delivered the prototype systems for a new European anthropogenic CO2 emissions monitoring and verification support capacity that can be implemented within the Copernicus programme. ICOS ERIC was leading WP7 about in-situ measurements, and participating in several others. In 2023, the remaining deliverables Report on data providers and long-term data availability, Gap analysis report of the current in situ measurement capacity and Demonstrator of data pipeline were completed. These included the important note, that modelers are able to use in some cases only 10% of existing in situ data, due for gaps in timeliness and FAIRness and disparate post processing. ICOS CP was also supporting the model evaluation and benchmarking activities in WP4 and WP5 with a collaborative space on the Jupyter Hub and storage capacity on ICOS fileshare.

ENVRI-FAIR - ENVironmental Research Infrastructures building Fair services Accessible for society, Innovation and Research (HO and CP as ERIC and Lund)

ICOS CP had the leading role in the ENVRI-FAIR WP5 and WP6 and the CP representatives were involved in all WP5-WP6 tasks, both at cluster and subdomain level, as well as in technical tasks in WP7 and subdomain tasks in WP(8-11). A lot of effort was invested on the six (6) cross-domain thematic groups (Task Forces, TFs) formed in 2020 (corresponding to commonly identified targets within the ENVRI cluster) to offer recommendations to the participating RIs and help the project managers with several tasks. ICOS, having the leading role of WP5, had the responsibility for managing the TFs, following their progress, reporting back to the community and contributing to the harmonization of the different tasks and decision making wherever required. The CP participated in most of the TF virtual meetings representing ICOS, sharing experience (in the TF working groups or in surveys distributed by the TFs

that investigated the ENVRI landscape) and taking actions for developments that were required by the project (leading the PID TF, working closely with the TF on the citations and licences, working on the mapping of the ICOS services metadata into DCAT-AP standards, delivering the ICOS FIPs). Additionally, ICOS CP having the leading role in WP6 had the responsibility of coordinating the training activities that were required to help the ENVRI partners complete their tasks (e.g. workshops on FIPs) and the organisation and execution of the ENVRI International Summer Schools, together with the WP6 co-leads from LifeWatch. ICOS CP worked closely with the ENVRI-Hub developers for the design of the ENVRI-Hub (concept and demonstrator), coordinating discussions and activities on the Hub components, demonstration of usability, design of the front-end and general architecture and taking the lead for the better integration of the training resources into the Hub by coordinating the developments on the "training gateway", in collaboration with the training catalogue metadata team in LifeWatch. ICOS CP finally contributed to 3 out of 4 subdomain WPs by providing the ICOS FIPs for the subdomain tasks on FAIRness, as well as the necessary metadata and services for the development of the subdomain use cases (scientific demonstrators). The project concluded in June 2023, with many deliverables and other reports (including white papers) published in the ENVRI Zenodo repository[5] where the ICOS CP members were leading or contributing authors.

Some of the ENVRI events where the ICOS CP participated in 2023 include the ENVRI week (organising TF-WP5 sessions and contributing to the subdomain sessions), the EGU23 GA (convening a session in the division ESSI (Earth and Space Science Informatics) and contributing to the ENVRI exhibition booth), , the RDA ENVRI event co-located with the RDA plenary in Göteborg (co-organising and moderating event, representing the TFs and providing content to the event and panel discussion), the ENVRI policy event (hosting and co-organising the event as part of the ENVRI-FAIR final event series, and demonstrating live the ENVRI-Hub demo for policy making), etc. .

EOSC Enhance - Connecting Thematic Communities to Advance Open Science (CP as ERIC)

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 in to 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 as ERIC)

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

[5] ENVRI Zenodo Repository (last accessed March 5, 2024): https://zenodo.org/communities/envri

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.

During 2023 ICOS CP represented the ENVRI Dashboard in several ENVRI and EOSC meetings, including the ENVRI week (organised by ENVRI-FAIR, see above), the EOSC Future meetings where the SP2 was presented and demonstrated, the EOSC Symposium (invited talk and ICOS bo)), training activities on service description etc. An important task in the EOSC Future project was the integration of the service providers in the EOSC. ICOS CPplayed an important role in this task, taking the initiative (together with MARIS) to compile the ENVRI integration matrix and motivate the ENVRIs to strengthen their links with the EOSC. Workshops with the core services and the ENVRIs were organised with help from ICOS CP.

ERIC Forum (HO)

In the ERIC Forum project, ICOS ERIC led a task in a work package about the ways to measure and convey the socio-economic impact of ERICs. Furthermore, 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. ICOS ERIC also participated in discussions and planning related to a follow-up project that aims to further strengthen the position and voice of ERICs as a united body and continue to harmonise managerial processes across the ERICS.

e_SHAPE (HO)

e-shape (EuroGEOSS Showcases: Applications Powered by Europe, (2019-2023) brought together a pan-European team composed of more than 50 partners from the academia, industry, institutions and user communities, fully aligned with the strategic directions of GEO and EuroGEO, to create a conducive environment whereby the strengths of Europe are exploited towards addressing societal challenges, fostering entrepreneurship and supporting sustainable development. ICOS coordinated a Global Greenhousese Gases pilot in Climate showcase.

During 2023 E-shape global carbon and ghg emission climate show case pilots were implemented in Jupyter notebooks in ICOS Carbon Portal. Fluxcom x product made available in CP.

EuroGOSHIP (HO and CP as ERIC)

Started 1.12.2022 The project aims to support a programme to address ocean observation gaps within the context of the European RI landscape. In 2023 ICOS ERIC had a milestone of reviewing the original scope of the planned RI.

EYE-CLIMA (CP as ERIC)

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)

GEORGE Grant Agreement (GA) preparations started immediately after the summer vacations. First GA-meeting was organized via the zoom with all of the WP and ERIC leaders at August 19th, 2022 and the

first interim EB meeting composed from WP and ERIC leader meeting was held in August 31st, 2022. After which, the HO project management team (Janne-M. Rintala and Emilie Hachem) carried out independently throughout the autumn and successfully executed the Grant Agreement. Necessary changes made since the submission of the proposal included addition of ethical self-assessment and adding of a new work package 8 for Ethics. Major changes made to consortium structure was that all of the UK beneficiaries were changed into associated partners according to the instructions received from the EC Research Executive Agency, Project Officer, Emilino Carrozza. In the beginning of 2023 Deliverable 8.1 "Appointing an external Ethical Advisor" was written and submitted in a timely manner to the EC. Management team also drafted two big documents, an Consortium Agreement and an NDA for External Expert Advisory Board members were prepared. The project has had five WP and ERIC leader meetings in 2023: Jan. 12th, Jan. 19th, Feb. 2nd, Feb. 16th and March 2nd respectively to discuss ongoing project matters and to plan the Project Kick-off meeting, which will be held virtually via the Zoom in March 15th and 16th. Work package 5 has organized one planning meeting in March 7th to plan future demo-missions and work-packages 2-4+6 organized a separate workshop in March 8th at Southampton to plan and synchronize all of the future activities. This meeting also had a remote participation.

GEORGE started in January 2023 and it has funding for 54 months and a total budget of ca. 10Milj.€.

Highlights of the first year: Sponsored international landmark event, The Oostende Surface Ocean pCO2 mtg and got the project invited to the COP at GOOS side event. Organized hybrid Annual Meeting in Villefranche sur mer, October 2023 incl. GA and EB D5.1 Technology validation and prototyping, agreeing on standard operational practices and trials project plan (M12), submitted end of Dec. 2023.

Other HO activities: Establishing of the coordination team inside the head office 1/2023. Nominating external ethical advisor 1/2023, approved 3/2023 (Deliverables 8.1 and 8.2) Setting up email lists and confluence pages and organizing teaching for all partners how to use it. Virtual Kick-off meeting 3/2023, incl. GA and EB Submitted Data Management Plan (Del 1.1 End of June) D7.1 Dissemination, communication and exploitation plan (submitted 9days late June 9th, DL 31st of May)Held monthly EB meetings and followed the progress of the Project. Preps of project review.

KADI - Knowledge and climate services from an African observation and Data research Infrastructure (HO)

The KADI project started on September 1st 2022 and had its kick-off meeting in October in Johannesburg (South Africa). The 16 partners (5 from Africa) were all represented at the meeting that defined the work program for the first year of the project. The project was also presented at the following 36th annual meeting of the South African Society for Atmospheric Sciences hosted by the Global Change Institute of the University of the Witwatersrand.

In 2023, KADI completed and submitted six deliverables, one milestone and its first periodic report. KADI held its second project meeting and organized side events at the GEO Week and Ministerial Summit and COP28. KADI actively participated in different international events, contributing through presentations, posters, and keynotes at events such as the 7th AfriGEO Symposium, the EGU 2023 General Assembly, and the WCRP Open Science Conference.

PARIS - PRocess Attribution of Regional EmISsions (CP)

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)

All observational sites are now operational. Including Frog sensors in Zurich which were installed for comparison and calibration for low cost CO2 sensors

NRT flux measurements, from ETC (they take the raw measurements and calculate the fluxes). Misbehaviour of the Miro instrument was observed - it was running in Paris, but the measurements seemed off, multitracer measurements were not working and it had to be sent back to Zurich for maintenance. The device was fixed and sent back.

By the end of 2023 we had set up the city data portal way ahead of schedule, and NRT data flows through it. the modelling WP is up and running as well.

Successful annual meeting was held in Zurich, follow up promotional video which was launched 2024, based on the interviews from Zurich. Tour and press conference in Zurich before the annual meeting. Which got attention of the Swiss national newspapers.

ICOS SAB visited in November in Munich city observatory including EM27, total column measurements. This was in preparation for WP6 and the final recommendations, if and how the city observatories could be integrated in ICOS. PAUL has also its own SAB: chair changed, it's working actively, they give useful comments. The full SAB was invited to the Zurich annual meeting.

ESS, task 1.3, sent out the second wave of questionnaires mapping citizen's climate attitude in Paris and Munich ahead of time. Climate Plan mapper was published as a deliverable and an interview.

There was a successful outreach activity from Astrid Huegli going to the schools and doing the classes in Zurich and she started taking it to Munich too – the work was presented in COP28, see highlights.

We put in a new kind of session at the proposed for the EGU 2024 to bring social sciences and the urban measurements together. We have continued the ICOS Cities Talks, ending up in a panel discussion including city stakeholders from Zurich - International expert panel with city stakeholders - produced from the annual meeting.

RItrainPlus - The Research Infrastructure Training Plus (HO)

Building on heritage of earlier project RItrain, RItrainPlus project will transform the skills-base to drive the professionalisation, efficiency and long-term value creation of European Research Infrastructures and Core Facilities. This Project brings together, for the first time, research infrastructures, core facilities, business management Schools and European universities, in a new innovative concept to transform the access and empowerment of human resources for national and international scientific facilities in Europe.

ICOS ERIC contributes to the RItrain Plus -project by participating in work packages that focus on the development of common European policies and learning tracks for curricula enrichment and development, course development and delivery (where ICOS ERIC is involved in developing a module relate to the socio-economic impact of RIs) , staff and knowledge exchange programme within European RIs, CFs and abroad, design study of a European School for Management of RIs, and 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)

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.

Atmosphere Thematic Centre (ATC)

Highlights

New version (rackmount) of FTIR Spectronous on the ICOS list of compliant instruments.

Publication of Obspack Europe with the CP

Use of resources per unit and task in 2023

Task ATC Units	1 General management	2 Data Management and production	3. Network coordination, training and development	4 Projects and international co-operation	5 Other
Data center	60	420		140	
Metrology lab	60		380	140	
Mobile lab			170		
Total ATC	120	420	550	280	

Share of resources in per cent, 100 = one full-time person

Task 1. General management

ATC Data Processing unit and Malb 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 station and instrument registrations took place and new data transfers have started. The Hungarian Hegyhátsál station has started to transfer GHG data and meteorological data. It 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 7 stations.

Developments

Set up and automatic process for the data from the 2 super sites Meudon and Romainville.

Evolutions of the new chain to process the CAL flask data. Handling of two data streams, NRT data and L1 data to be used to generate the L2 release. Compute the difference between in-situ data and flask data. Developed the generation of a Continuous Time Series of flask data in order for the coming releases to use CO2 flask data from the CAL MS when available.

Processing of the O2/N2 and Ar/N2 ratios.

Development of a new chain to process EM27 data as a grey box. Basic automatic quality control is applied, the possibility to apply a calibration factor has been developed and the PIs are given the possibility to apply manual quality control.

The weekly GHG data reports for the Pis have been enhanced, addition of a section providing the list of reprocessing done by the ATC staff.

Development of a first version of web-based form for Pis to request the creation of new ICOS instruments. The form is included in WebObs.

Add events in the database upon receiving emails from camera located at stations.

Discussions with the CAL to allow the tank assigned values system to evolve, laying the foundations for new developments to come.

Evolutions for the preparation and generation of the data releases.

Addition to the Java and libraries migration of all the processing chains, second step migration of the logging libraries.

Evolution of the graphical applications:

Updates of the ATCConfig like handling the new spare location or computing tank assigned value using the given algorithm for display.

Updates and new functionalities added to the ATCQc related to the flask data, display the difference between in-situ data and flask data.

Task 2.2 NRT data production

A total of 43 (+2 compared to 2022) stations are connected to ATC, sending their data and processed in NRT mode. This represents 24139 (+27% compared to 2022) raw archive files (~165Go) processed for an availability rate of ~0.99 stations which transmit their data over the complete 2023 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 2023, 10418 products files of graphical NRT Data Products, (an increase of ~139%/2022, for ICOS network stations) are produced daily from NRT measurements (total volume of 1.39Go (+0.18Go/2022) and freely available on the ATC website for station monitoring and diagnosis. This increase is mainly due to new products related to the QA panelboard available on ICOS ATC website.

Those Data Products are for PIs to verify the status of their stations. In total, for the year 2023, nearly ~ 5200 (+18%/2022) users have interacted with ATC's website, for ~ 61697 (+7%/2022) page views.

Task 2.4 Level 2 data production.

The new Level 2 (2023-1 release final quality controlled observational) data from the atmospheric network has been released on July 2023 by the ICOS Atmosphere Thematic Centre. This 2023-1 release contains data from the atmospheric network of ICOS Research Infrastructure for 38 stations with atmospheric composition data at all available vertical levels at stations Birkenes, Cabauw, Gartow, 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 measurement stations; 14C in CO2 in two-weekly integrated samples (16 stations); and analysed flask data for CO2, CH4, CO, N2O, SF6 and H2 (14 stations), for the period September 2015-1 April 2023. 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).

https://doi.org/10.18160/VXCS-95EV

An update of the official release of the European Obspack project compiling atmospheric CO2 and CH4 from ICOS an non-ICOS European stations for the period 1972-2023 have been issued. This data package contains high accuracy CO2(CH4) dry air mole fractions from 65(66) ICOS and non-ICOS European observatories at in total 146(143) 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 2023 and is intended for use in carbon cycle inverse modelling, model evaluation, and satellite validation studies. European CO2 ObsPack, packaged by ICOS Carbon Portal - https://doi.org/10.18160/PEKQ-M4T1and European CH4 ObsPack, packaged by ICOS Carbon Portal - https://doi.org/10.18160/9CQ4-W69K

Task 3.1 Perform instrument testing

In 2023, ATC MLab has performed all the instrument testing required for the station labelling, including: 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 analyser testings. Indeed, the MLab has tested several analysers and models from AERIS measuring the different species targeted by ICOS : CO_2, CH_4, CO, N_2O, H_2O and a new version (Air Plus) of the NIR spectrometer (CO_2, CH_4, N_2O, H_2O) from the european manufacturer, Durag AP2E. ATC has finalized in 2023 the assessment of the new version (rackmount) of FTIR Spectronous and which is still part of the ICOS compliant instrument list like the initial version. ATC MLab has also continued the assessment of 5 multispecies 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 eddy covariance) in addition to the accurate and precise concentration measurement. The performance for flux measurement is still on going in the framework of the ICOS-Cities project.

ATC has studied the overall CO2 bias observed on the short- and long-term target (quality control gas) measured in the whole ICOS network in order to check the representativeness of such information and detect possible related issue such as Nafion artifact. In 2023, this study has been extended to the other species measured continuously in the ICOS network: CH4, CO and N2O. For all the species including CO2, the test did not show systematic issue related to the tank assignment. However, it highlighted the small residual bias related to dryness of the gas and Nafion membrane if installed. However, thanks to

an operating procedure described in the ICOS specifications document (version 2.0), ATC is able to estimate this bias, it will be part for the overall uncertainty (still in progress).

Once the stations are labelled, ATC carries on controlling the quality of the data provided by the station by checking the corresponding ATC data products in interaction with the station PIs.

ATC is also still working on performance testing and characterization of several mid and low-mid cost sensors for CO_2 and CH_4 like MirSense MultiSense photoacoustic sensor, Senseair HPP and K96, Vaisala GMP343, Figaro CH_4 Metal Oxide sensor, Alpha Sense CO sensor, Axetris LGD CH4… 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 ICOS-Cities-PAUL focusing on CO_2 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 2023, the Mobile Laboratory performed two audit visits. Continental class 1 station Svartberget (SVB) in Northern-Sweden was audited in spring and mountain class 2 station Monte Cimone (CMN) in Central-Italy in autumn. Audit report of the class 2 station Reunion (RUN, Belgium); audited in the autumn 2022; was finalised during the year 2023.

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 Spain, Italy, Germany and Finland. It lasted over 3 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 2 new ICOS Atmosphere stations in 2023: Cabauw and Izana. Also five new stations have gone through step 1.

Task 4. Projects and international cooperation

ATC was involved in 2023 in the following EU projects: ENVRI-FAIR, TraceRadon, Atmo-Access, PAUL/ICOS cities.

Task 5. Other activities

Webobs is a web application for monitoring and managing atmospheric measurement stations, deeloped y AC. 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 equipment and tanks, add station events, and collaborative tools such as troubleshooting and tests performed on the instruments on stations. In the framework of the ICOS Cities project, ATC has developed web application tool, based on the existing Webobs development, in order to manage the metadata related to the midcost sensors. It offer 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 2023

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

Use of resources per unit and task in 2023

Task	1 General management	2 Data Management and production	3. Network coordination, training and development	4 Projects and international co-operation	5 Other
ETC Executive committee unit	66.7	0.0	8.3	25	0.0
Italy	33.3	0.0	8.3	8.3	0.0
Belgium	16.7	0.0	8.3	16.7	0.0
France	16.7	0.0	0.0	0.0	0.0
Data Unit	0.0	500.0	33.3	0.0	0.0
Italy	0.0	300.0	0.0	0.0	0.0
Belgium	0.0	200.0	0.0	0.0	0.0
France	0.0	0.0	33.3	0.0	0.0
Test unit	0.0	150.0	83.3	50.0	0.0
Italy	0.0	100.0	33.3	50.0	0.0
Belgium	0.0	50.0	25.0	25.0	0.0
France	0.0	0.0	0.0	0.0	0.0
Network Unit	0.0	166.7	100.0	0.0	0.0
Italy	0.0	50.0	50.0	0.0	0.0
Belgium	0.0	50.0	50.0	0.0	0.0
France	0.0	66.7	0.0	0.0	0.0
Support team	0.0	0.0	0.0	0.0	0.0
Italy	0.0	0.0	0.0	0.0	0.0
Belgium	0.0	0.0	0.0	0.0	0.0

France	0.0	0.0	0.0	0.0	0.0
Total	66.7	816.7	225	75	0.0

Share of resources in per cent, 100 = one full-time person

Task 1. General management

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

ETC participated to 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 to 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 2024 and the report of the 2022 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 34 and 8 stations respectively to the ETC labs in France for analysis, a number increasing every year with the new stations labelled.

Level2 data have been produced and distributed through the CP, including the Interim version released after the growing season and introduced last year. Near Real Time data production and release continued operationally and the data release cover 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 1218 vegetation samples shipped to the ETC (they were 671 in 2018, 934 in 2019, 989 in 2020 and 1242 in 2021, 1322 in 2022) for the analysis and all the samples have already been analysed and imported into the database. In addition, more than 800 soil samples have been shipped for analysis in 2023 and are under processing. The soil samples are stored in the long-term facility for a total of 23 sites. The reduction of vegetation samples shipped respect to the previous year is under analysis with the PIs of the stations that didn't' submit the expected number of samples in order to understand the reasons and solve the difficulties.

Subtask 2.2: From raw data to Level 1 data

Near Real Time 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 Level2 data production and upload to the Carbon portal happened time twice in the year, as common since 2022. The first release of the official Level2 in performed by end of April and covers until 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 identifier of single sensors has been extended to additional variables and the results are distributed by the Carbon Portal that access the data through an API. In 2023 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.

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

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

Five Instruction documents have been revised, clarified and updated in 2023. The sensors listed in the ETC with a unique identifier arrived at 367 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 document on Automatic Dentrometers has been finalised and released. The document describes how to add this new important data stream to the ICOS Ecosystem portfolio of measurements following a clear and well described protocol. A major effort was also dedicated to the preparation of the protocols and Instruction for non-CO2 eddy covariance measurements that is expected to be published in spring 2024.

An improvement in the data processing has been added in the continuous data, with the possibility to compensate possible fixes shifts in the timeseries of the high frequency data. This improvement, discussed and tested with the teams of the stations affected by this possible problem, has been tested and implemented in the ICOS ETC data processing pipeline.

Subtask 3.3 Station Labelling

The activities on the labelling continued in 2023 with stations that entered the process and stations proposed for labelling. In particular:

- Nine stations started the labelling procedure (DE-Brs, DE-Kie, DE-Okd, ES-LMa, FI-Ouk, FI-Tvm, GR-HeK, GR-HeM, IT-Oxm), and all except DE-Kie completed the Step1
- Fifteen stations completed the labelling in 2022: 2 Class1 (FI-Sod, IT-BCi,), 2 Class2 (NL-Loo, NO-Hur) and 7 Associated (DE-Hzd, ES-LMa, FI-Tvm, FR-CLt, GR-HeK, GR-HeM, IT-Noe)
- Currently only two Class1 and Class2 stations entered before 2023 are not yet labelled: FI-Lom and SE-Myc. Both stations are currently in contact with the ETC to complete the labelling in 2024.

Subtask 3.4 Support on ecosystem data interpretation and use

No specific activities on this subtask performed in 2023 except a basic support by email to specific questions about the ICOS products.

Task 4. Projects and international cooperation

The ETC Director (Dario Papale) continued his participation in the FLUXNET Co-Op, a US initiative to coordinate the activities in the context of the regional ecosystem fluxes networks. In addition a parallel initiative of coordination with the most stable and robust networks (AmeriFlux, NEON and OzFlux) continues.

A presentation of the ICOS Ecosystem metadata system (BADM) has been done to ACTRIS (invited by the ACTRIS management team)

In the context of the activities in increase the use of ICOS ecosystem network in CalVal Remote Sensing activities, an activity to implement in an ICOS station (FR-Fon) a standard GBOV setup in order to compare it with the ICOS setup has been started. This will help to clarify the steps needed to make ICOS Ecosystem Network a reference in the FAPAR and GAI validation.

Task 5. Other activities

Nothing to report here.

2.1 Ocean Thematic Centre

Highlights of the year 2023

- In 2023 We engaged strongly in the WMO G3W process including attending 2 key workshops in Geneva and authoring the summery of the first conference and the G3W implementation plan.
- In 2023 we co convened a workshop in Ostend alongside SOCAT, IOCCP and the Global Carbon project to bring together the surface pCO2 community post COVID to discuss the formation of a Global Reference Network for surface pCO2 observations which ICOS would be a core European contribution to.

Use of resources per unit and task in 2023

Task	1 General management	2 Data Management and production	3. Network coordination, training and development	4 Projects and international co-operation	5 Other
Leadership					
Norway	22			20	
UK	40			10	
VOS and SOCAT					
Norway			25		
UK			87.5		
Repeat sections and link to GLODAP					
Norway					
UK					
Fixed stations					
Norway			25		
UK			87.5		
Data Centre					
Norway		220			
UK					
Total	62	220	225	30	

Progress in core tasks of the Ocean Thematic Centre (OTC)

Task 1. General management

In addition to the tasks described below, this task also includes the risk management according to the host institution, RICOM activities according to the RICOM Rules of Procedure, general communication and dissemination of ICOS Science, involvement in the GA Info Days, meetings with the SAB and other organisational activities.

Task 1.1: Management and provision of the OTC capacity and related IT- and data management

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

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

Produce workplan for next year in autumn in discussion with MSA and submit to head office.

Monitor delivery of workplan via quarterly reviews

Produce budget for next year in autumn.

Produce annual report in spring for submission to GA.

Report on previous years expenditure in spring each year.

Organise weekly OTC meetings.

Produce newsletter and maintain website, plus social media presence.

To welcome new stations to the Ocean domain of ICOS and to liaise informally with potential new countries including the Netherlands, Denmark, Iceland and Portugal.

To run townhalls and similar events to publicise OTC actions.

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

Task 1.2 Reporting

This task includes the preparation of the Annual Activity Report, the Annual Financial Report, the Annual Work Plan and the Annual Budget Plan.

Deliverable 1: OTC Annual report. This includes the Annual Activity Report submitted to the GA in spring and the financial report, the Annual Work Plan and the Annual Budget for the following year submitted to the GA in autumn and the 5-years Financial Plan, it is based on templates provided by the HO and it is submitted to the General Assembly and RI Committee.

In 2023 we reported on activities in 2022.

We continued the weekly OTC meetings where possible, varying the agenda between day-to-day updates and more formal reviews of progress.

We produced the budget and workplan for 2024.

We convened an OTC awayday in Southampton to plan for phase 3.

We submitted a renewal request to the Norwegian research Council for further funding in autumn 2023.

We attended MSA meetings online (spring 2023) and in person (in Ostend, fall 2023). This involved general updates in all areas with the key decision at the 2023 MSA being to develop a forward look for EU proposal submissions to address key issues. We are now waiting for the 2025 calls to be released so that we can map our ambitions into available calls.

We embarked on a major revamp of the OTC website and produced OTC newsletters.

We successfully requested an OTC townhall in Vienna in 2024.

Task 2. Data management / Data production

Task 2.1 Data availability and quality

Track the data collection, flow, processing, quality and availability for all ocean stations. Ensure that data are contributed to relevant global data collections and national data centres where required. Also, to ensure prompt actions in order to solve potential critical situations.

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 providing data from UK stations (currently only the Porcupine Abyssal Plain mooring) to the British Oceanographic Data Centre and understanding how PIDs must be shared between them and the ICOS Carbon Portal. The general principles have been agreed, and we are ready to move on to the technical implementation.

Task 2.2 Maintain metadata records

Ensure that station metadata is kept up to date in the Carbon Portal in response to updates provided by station PIs.

We have been working with the Carbon Portal to overhaul the metadata structures implemented for OTC. The new structures are in place, and we are working on migrating the existing metadata to the new structure. Once this is complete we will have a much stronger overview of what metadata is in place and what is still missing for each station. We have also started to identify which additional metadata should be added to the CP system in order to meet the needs of major downstream products such as SOCAT.

Task 2.3 Raw (Level 0) data transfer

Ensure that all raw data from sensors deployed at ocean stations are archived in the Carbon Portal.

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

Automatically ingest, process and publish near real time data from those stations that provide it. Apply automatic quality control routines to give an initial quality assessment. Publish the data for community use through the Carbon Portal. Provide quick looks for station PIs to enable instrument monitoring using property-property plots. Monitor NRT data rates and quality to identify possible critical issues and raise them with the station PIs to determine any required actions.

New methods of data retrieval through NRT transmission channels have been added for two new stations, together with the creation of automated data correction routines for stations with frequent, predictable transmission errors. The Level 1 processing system is more robust to transmissions errors that cannot be automatically fixed, reducing the amount of data rejected due to individual errors.

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

Station PIs perform manual quality control on received data using the QuinCe tool developed for this purpose. Upon submission by the PI, final quality checks are performed by OTC staff before being published at the Carbon Portal. Transfer published datasets to global data collections (e.g. SOCAT) automatically where possible, or by OTC staff if automatic submissions are not available.

We have worked with 4H-JENA to develop a definitive processing algorithm for their sensors. The algorithm will be published freely as a Jupyter Notebook and integration into QuinCe is complete pending final adjustments to the algorithm. Discussions along similar lines have started with SubCTech as the Belgica station has started producing testing data which can be used as a basis for developing the required algorithms.

Task 2.6: Software development and maintenance

Continuous development of the QuinCe tool used for data ingestion and quality control to improve usability for the station PIs, including support for new sensors, improved automated quality control (to improve L1 data quality), improved manual quality control tools, and reduce total time-to-publication of data from ocean stations.

QuinCe development has continued, fixing some issues that prevented certain users from processing their data due to limitations in the data processing and QC interfaces. Support has been added to automatically detect and handle fixed stations that only take measurements every few hours, which must be processed differently from stations that measure continuously. Updates to underlying dependencies (libraries, frameworks etc.) have been incorporated, with code adjustments to fix incompatibilities and make use of new features. User interface and other quality of life changes continue to be added between the development of major functionality.

Summary of published L2 observations for 2023:

Station	***Observations***
BE-FOS-Thornton Buoy	*22,342*
BE-SOOP-Simon Stevin	*113,152*
DE-SOOP-Finnmaid	*327,946*
FR-SOOP-France-Brazil	*23,190*
NO-SOOP-G O Sars	*126,482*
NO-SOOP-Tukuma Arctica	*86,731*

Task 3. Network coordination, training and development

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

To run one in person event per year in collaboration with the MSA on a subject of the MSAs choice (2023 likely to be hands on training).

Ongoing training in Quince as required.

Support externally funded and organised events (SOLAS; IOCCP; ICOS).

Report on the pCO2 Intercomparison from 2021.

Task 3.2 Station support

Provide guidance and technical support for new installations at individual stations.

Monitor Gas standard distribution and supply.

Conduct station ringarounds.

Undertake station visits Station Visits.

Deliverable 3 Report on network training and station support activities within main report (annually):

In 2023 the major training event was the MSA component of the Ostend workshop, which focussed on surface ocean pCO2 observations, data synthesis, and data products. This encompassed Global Carbon Budget, SOCONET, and SOCAT. We supported externally funded workshops lead by IOCCP and SOLAS in summer 2023 and maintained progress on writing up the 2021 pCO2 Intercomparison event, sharing key results at the 2023 MSA meeting. We maintained an overview of the gas calibration scheme and conducted the station ringaround programme.

Task 3.3 Labelling

To assist stations with labelling process. New stations entering ICOS through the labelling process in three steps which allows them to demonstrate that their methodologies and data quality are consistent with ICOS standards. The OTC assists with this process including quality check of data and metadata and producing a report which recommends to the GA that a station should be labelled.

Deliverable 4: station labelling reports (continuous, summary in annual report)

Task 3.4: New technology and new platforms

To present the existing portfolio of work funded via external grants to the Monitoring Station Assembly, inviting collaborators as early adopters of the new technology/partners in future research grants for its exploration. Key current projects include the UK National programme, CLASS, the EU funded Programme George and the saildrone mission.

To lead on any internally funded technology projects.

To assist MSA members with developing proposals for integrating new technology into their observing programmes.

Deliverable 5 Report detailing current status and activities of technology workstream.

We presented the technology programnme in several venues including the MSA meetings and coffee mornings. We made progress with the lowered sampler which we plan to bring onstream, for station usage in 2024.

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 will ensure a proper flow of information, development, results and connections between the research projects and the ICOS OTC activities.

In 2023 Priorities are as follows:

To deliver relevant parts of EU grants as follows:

Ocean Improved Carbon Understanding (ICU). This 15MEu OTC lead grant involves a significant work element lead by OTC host institutions Exeter and NORCE focused on using ICOS (and other) data to evaluate the current state of the Ocean C Cycle.

GEORGE, Large (10MEu) technology grant lead by ICOS head office and OTC in collaboration with EMSO and Argo aimed at supporting the transition to autonomous observing.

KADI, Capacity building grant lead by ICOS head office aimed at supporting the development of a GHG observing system in Southern Africa with significant ocean element.

EuroGOSHIP. EU Infrastructure development grant aimed at supporting network of sections that make inter alia observations of vertical ocean CO2 profiles.

If funded the CarboAdvance training network due for resubmission at the end of 2022.

To support or lead proposals in any areas identified by as being key expansion areas, or where ICOS is identified as a key contributor.

Deliverable 6 Report on Projects and International and extra-ICOS collaborations as part of the Annual activities report,

Projects

In 2023 we participated in four EU projects as follows:

EuroGOSHIP: This is providing resource to address the issue as to hew to integrate Long Hydrographic Sections into the RI concept and framework. These are key platforms involved in measuring interior carbon concentrations and also have surface pCO2 measurements as a core variable.

OceanICU: This is providing resource to address the causes of the data mode mismatch in the strength of the Ocean C sink documented by the Global C Project.

GEORGE: This is providing resource to develop a range of technologies in OTC institutions aimed at better measuring the Ocean C cycle. These include small equlibrator based systems on the sailbouy autonomous platform and a range of lab on a chip measuring devices.

MarcoBOLO. 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.

KADI. This head office lead programme is allowing us to develop links to African Scientists working in this field and to integrate African Efforts into global planning actions.

In 2023 We submitted four further successful grant proposals as follows:

NUBICOS. This head office lead proposal will allow us to innovate labelling and data handling methods.

LandSeaLOT. This Danibius lead proposal will allow us to address carbon cycling in the coastal zone.

AMRIT. This proposal (All Marine Research Infrastructures Together) will allow us to develop links to other marine RIs and to make progress on equipment passports and tracking.

Aquarius. 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.

International Cooperation

In 2023 we were active in the WMO G3W programme as described above and also sat on the IOCCP Steering Committee. The IOCCP (International Ocean Carbon Coordination Project) is the Global Ocean Observing System Biogeochemistry Biogeochemistry panel and is the key fora where international linkages between ICOS and the IOCC UNESCO global coordination system can occur. Sanders and Jones both sit on the IOCCP SSC.

Task 5. Other activities

In addition to activities mentioned above, OTC may perform other activities that align with the processes in the ICOS RI Management Plan.

In 2023 these include:

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

To contribute to the ICOS Fluxes document as required.

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.

To organize a 14-day international training course on the use of marine biogeochemical sensors together with IOCCP. 5-18 June 2023, Kristineberg, Sweden.

Deliverable 7. Brief report on other activities included within overall report.

We fully engaged with ICOS phase 3 planning including negotiating station contributions and OTC actions in phase III.

We supplied information on Blue Carbon for fluxes.

We engaged in multiple discussions around SOCAT in the IOCCP /G7 arena leading to the formation of the SOCAT funders forum. Activities in the G3W are dealt with earlier in this report.

Flask and Calibration Laboratory (FCL)

Highlights of the year 2023

- first flask data release
- comparison difference medians show very good agreement between continuous measurements at ICOS stations and flask samples taken in parallel and analysed later at FCL
- new mass spectrometric technique for CO_2 measurements established with precision superior to gas chromatographic method
- successful use of the ICOS flask sampler combined with a new Relaxed Eddy Accumulation module that has been developed at FCL within the PAUL / ICOS Cities project
- 2 flask sampler workshops for ICOS users

Use of resources per task in 2023

Task	1 General management	2 Data Management and production	3. Network coordination, training and development	4 Projects and international co-operation	5 Other
		Analyses, standards, flasks	Sampler activities (workshop,	PAUL, WMO-BIPM, ICP	
Total FCL	108	860	200	8	

Share of resources in per cent, 100 = one full-time person

Progress in the core tasks of the Flask and Calibration Laboratory (FCL) as part of the Central Analytical Laboratories (CAL)

The main functions of the ICOS RI Central Analytical Laboratories (CAL: Flask and Calibration Laboratory - FCL, and Central Radiocarbon Laboratory - CRL) are to provide calibrated reference air standards to the (atmospheric) stations, analyse grab samples (flasks) collected by the individual network stations for trace gases and stable isotopes (FCL), and to perform 14CO2 analysis on integrated and spot samples collected at the atmospheric stations (CRL).

Task 1. General management

In addition to the tasks described below, this task also includes the risk management according to the host institution's guidelines, RICOM activities according to the RICOM Rules of Procedure, general communication and dissemination of ICOS Science, involvement in the GA Info Days, meetings with the SAB and other organizational activities.

. A. Jordan was participating at the General Assembly in November 2023 providing updates on FCL activities. He also joined both RI COM face-to-face meetings in 2023 (online and in presence in Antwerp), the regular monthly RI COM webconferences and online-meetings with the SAB.

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

Deliverable 1: Provision of the Flask and Calibration Laboratory capacity and the database

A new storage room was rented to cover the growing space need with more cylinders being in use within ICOS.

Task 1.2 Reporting

Deliverable 2: FCL general report. The general 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 it is submitted to the DG, RI Committee and General Assembly.

The general report including the financial and activity report 2022 has been submitted to the Head Office in March 2023, the budget and work plan for 2024 were provided in September 2023.

Task 2. Data management / production

Task 2.1: Trace gas analysis (CO2, CH4, CO, N2O, SF6, H2) of flask samples for ICOS RI atmospheric monitoring.

Deliverable 3. Flask Sample Trace Gas Analysis. Trace gas analysis of flask samples from atmospheric class 1 stations.

There have been 1532 flask samples from the 15 ICOS class 1 stations with active flask sampling programme that have been analysed and 212 samples from the ICOS Cities project. The Flask data transfer to the ATC has been operative, a first flask data release has been made and flask data been used for quality control of continuous measurements. A sample pressure dependent small bias of CO_2 results has been identified, quantitatively assessed and a procedure to correct this effect developed. This took benefit on the newly implemented mass-spectrometric measurement of CO_2 that appears more robust and accurate than the GC method.

Task 2.2: Analysis of supplement parameters (CO2 stable isotopes and O2/N2 ratios)

Deliverable 4. Flask Sample Isotope, O2/N2 Analysis. CO2 stable isotope and O2/N2 ratio analysis of weekly flask samples from atmospheric class 1 stations

All station air flask samples mentioned in Task 1 have been analysed for CO2 stable isotopes and O_2/N_2 ratios (Deliverable 2). The standardisation of the O_2/N_2 measurements has been changed. It is now directly to the actual Scripps Institution of Oceanography scale through three standard gases calibrated by the Keeling Atmospheric Oxygen Lab. The data processing had not been completed at the time of the scale release so the data set was not yet included in the 2023 flask data release. Similarly, the CO_2 stable isotope standardisation and data processing scheme had not been finalised so the data were not yet included in the 2023 data release.

Task 2.3: Support to maintain ICOS network flasks fit for purpose (flask specification check, flask leak check, flask conditioning).

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 for diagnostics 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.

Deliverable 5: Standard Production for Atmospheric Observations. Filling of high-pressure cylinders with real ambient air, depletion / spiking of relevant tracers to produce targeted composition of standard gas for CO2, CH4, CO, N2O atmospheric monitoring activities of the ICOS RI.

Deliverable 6: Standard Production for Ocean Observations. Filling of high-pressure cylinders with real ambient air, depletion / spiking of CO2 to produce targeted composition of standard gas for CO2 monitoring activities of the ICOS Ocean Network.

130 new standard gases have been filled in 2023 for ICOS monitoring activities.

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.

Deliverable 7: Standard Calibration for Atmospheric Observations. Analysis of high pressure cylinder standard gases for ICOS continuous core parameter according to WMO compatibility target accuracy.

Deliverable 8: Standard Calibration for Ocean Observations. Analysis of high pressure cylinder standard gases for ICOS stations linked to NOAA-ESRL gravimetric standards.

More than 200 high pressure standard gases have been calibrated and recalibrated for atmospheric and ocean monitoring activities.

Deliverable 9*:* Replacement Standard Provision. Provision of replacement calibration standards to ICOS atmosphere stations during periods when stations return individual standards for recalibration.

The number of replacement sets that are needed for periods when stations return their standard gases for recalibration has further increased to 14. Special sets have been made for regional ICOS stations where the calibrated range needs a larger span. In 2023 replacement sets have been used by the stations DE-SIL, NO-ZEP, DE-DWD, BE-RUN, IT-PRS, IT-IPR, SE-SVB, FR-PUY, UK-WAO.

Task 3. Network coordination, training and development

Task 3.1 Interaction with station PIs

Deliverable 10: Meeting with station PIs. Annual meeting with station PIs to discuss CAL-related issues (as part of the MSA)

FCL staff was present at the Atmosphere MSA in Brussels and the online MSA in December. Markus Eritt chairs the MSA flask sampler working group, Fadwa Damak and Armin Jordan contributed to the N_2O Working Group.

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

Deliverable 11: QC samples. Preparation, distribution to international partner laboratories and analysis of comparison samples for international quality control program (flasks, cylinders). Participation in global round robin exercises (e.g. WMO round robin).

Deliverable 12: QC Report. Performance report on QC activities.

The ongoing QC programs for greenhouse gas mole fraction and stable istotope intercomparisons of flask sample analysis (3 sets of “sausage” flasks prepared and distributed to the participating international partner laboratories) and high pressure cylinder measurements (new set of “MENI” tanks

shipped to NOAA) have been continued. The FCL joined the international oxygen intercomparison program GOLLUM. Results of all QA/QC activities have been compiled 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.

Deliverable 13: Report to MSA on new ICOS flask sampler developments.

Two flask sampler user workshops were organised for ICOS station PIs in March and April 2023 at FCL in Jena. Support to field stations with flask sampler problems was provided.

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 FCL 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 will ensure a proper flow of information, development, results and connections between the research projects and the ICOS FCL activities.

Deliverable 14: 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.

1. PAUL / ICOS Cities project: FCL developed, tested and put into operation the instrumentation for the sample collection of the Relaxed Eddy Accumulation system together with CRL colleagues and other project partners. This system has been placed on project sites first in Zürich, then in Paris and allows to collect sample air separately depending on its vertical wind direction (i.e. upwind air from the city vs. downwind air from the atmosphere). It has operated very well and has yielded samples where the $^{14}CO_2$ measurement results by CRL permitted statements on the fossil vs. natural fluxes of CO_2 from the urban catchment.

2. BIPM / CCQM - GAWG (Consultative Committee for Amount of Substance - Gas Analysis Working Group) Working Group on GHG calibration scale comparisons:

An intensive discussion process between representatives of metrology institutes (BIPM and NMIs) and atmospheric scientists (NOAA, ICOS represented by FCL, Scripps, CSIRO, NIES) has taken place in several online meetings to draft a protocol for a calibration scale comparison process which ensures that the relationships between different calibrations scales can solidly be established.

Task 5. Other activities

In addition to activities mentioned above, FCL may perform other activities that align with the processes in the ICOS RI Management Plan

FCL has constructed a batch of new ICOS flask samplers that shall allow to equip also those ICOS class 1 stations that by now have no such sampler.

Central Radiocarbon Laboratory (CRL)

Highlights of the year 2023

- ICOS internal release of all ICOS $^{14}CO_2$ flask measurement results.
- An excellent agreement was found between the four global ^{14}C laboratories that perform atmospheric background measurements. This was demonstrated through current laboratory intercomparison activities as well as archived sample comparisons.
- Together with the ICOS CP, an NRT estimation of the nuclear ^{14}C contribution during flask sampling periods was established.

Use of resources per task in 2023

Task	1 General management	2 Data Management / production	3. Network coordination, training and development	4 Projects and international co-operation	5 Other
Total CRL	113	337	83	45	64

Share of ICOS CRL resources in per cent; 100 = one full-time person. Worktime shares for "Projects and international co-operation" and "Other" are listed for completeness but not included in ICOS CRL report and are paid by project funds.

Progress in core tasks of the Central Radiocarbon Laboratory (CRL) as part of the Central Analytical Laboratories (CAL)

The main functions of the ICOS RI Central Analytical Laboratories (CAL: Flask and Calibration Laboratory - FCL, and Central Radiocarbon Laboratory - CRL) are to provide calibrated reference air standards to the (atmospheric) stations, analyse grab samples (flasks) collected by the individual network stations for trace gases and stable isotopes (FCL), and to perform $^{14}CO_2$ analysis on integrated and spot samples collected at the atmospheric stations (CRL).

Task 1. General management

In addition to the tasks described below, this task also includes risk management according to the host institution's guidelines, RICOM activities according to the RICOM Rules of Procedure, general communication and dissemination of ICOS Science, involvement 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

The capacity and services of the CRL have been fully provided in 2023. Starting this year, Dr. Susanne Preunkert has become a full-time employee of CRL. Over the past few years, Dr. Preunkert has been managing the CRL database as part of a collaboration contract between Heidelberg University and IGE (UMR 5001) in Grenoble. With Dr. Preunkert joining the core staff of the

laboratory, the database developer position has been successfully filled. Apart from managing the database, Dr. Preunkert is also the deputy head of the laboratory. In addition, in 2023, a new technician was hired on a temporary basis for the work related to the CORSO project, see Task 4.

The automated transmission of the $^{14}CO_2$ AMS L1 measurement results of the flask samples to the CAL-FCL database was made operational in 2023. This final data processing step was activated once the standardised quantification of the additional ^{12}C-current-dependent measurement errors was implemented in the CRL database (see Task 2.2).

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

Deliverable has been fulfilled.

Person-months spent on Task 1.1: 10.4 PM

Task 1.2 Reporting

The general report, including the financial and activity report for 2022, was submitted to the HO in March 2023, and the budget and work plan for 2024 were provided in September 2023 (Deliverable 2). CRL activity updates were reported at the General Assemblies in May and November 2023, as well as 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 it is submitted to the General Assembly and RI Committee.

Deliverable has been fulfilled.

Person-months spent on Task 1.2: 3.2 PM

Task 2. Data management / production

Task 2.1 Radiocarbon analysis of up to 1000 two-weekly integrated CO_2 samples per year from the ICOS RI atmospheric station network

In 2023, 16 atmospheric ICOS Class 1 stations and four ICOS Class 2 stations, including Izana, Mace Head, Schauinsland, and the ICOS CRL pilot station, provided integrated CO_2 samples to the ICOS CRL. Mace Head and Izana are important monitoring stations that help determine the European $^{14}CO_2$ background concentration. In total, 374 European samples were analysed by low-level counting. In addition, 110 integrated samples from ICOS stations were analysed by accelerator mass spectrometry (AMS). We analysed 46 non-European integrated $^{14}CO_2$ samples from the polar stations Neumayer (Antarctica) and Alert (Arctic), the ATTO (Amazon Tall Tower Observatory) and Cape Grim (Tasmania). The samples collected at these global background stations enable the comparison of different global measurement networks. As part of the CORSO project, the global $^{14}CO_2$ background data sets from ICOS, UHEI, NOAA, SCRIPPS and GNS have been compiled and intercompared in a joint global $^{14}CO_2$ background data set. The CORSO deliverable report for this activity can be found here. Recently, Alert flasks from the SCRIPPS observation network have been analysed and compared to the two-week integrated Alert samples, which have been concurrently collected using standard ICOS $^{14}CO_2$ sampling equipment. Based on nine comparisons covering the time range from 2017 to 2022, a mean $\Delta^{14}CO_2$ difference of -0.25‰ with a standard error of ±0.58‰ was found. This highlights the excellent agreement between the SCRIPPS and ICOS CRL

observational program and underpins the importance of concurrent $^{14}CO_2$ background measurements to link different observational 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: 23.6 PM

Task 2.2 Radiocarbon analysis of CO_2 from up to 1000 flask samples per year

In 2023, the number of ICOS flask analyses increased to 487 compared to 378 in the previous year. This is an increase of about 30%.

In the course of the PAUL project, 239 additional flasks were processed and analysed for $^{14}CO_2$. The cost of labour, as well as the expenses for consumables and AMS analysis, were fully covered by the funds from the PAUL project.

The additional ^{12}C-current-dependent uncertainty calculation for the $^{14}CO_2$ AMS results was implemented in the CRL database, and the entire $^{14}CO_2$ flask data set was re-evaluated. Thereafter, the automatic transfer of $^{14}CO_2$ AMS results to the FCL database was set to operational, syncing the L1 results in near real-time after the AMS analysis. All L1 flask sample $^{14}CO_2$ results have been quality-controlled, raised to the L2 level, and subsequently submitted to the CAL-FCL database.

The analysis of the pure-CO_2 intercomparison (ICP) samples also began in 2023. This ICP compares the sample preparation and the AMS measurement in the four world-leading laboratories performing atmospheric $^{14}CO_2$ background measurements (ICOS-CRL, NOAA-INSTAAR, SIO-IRVINE and GNS). By the end of 2023, 12 of the 48 samples from each laboratory had been analysed. The results of all laboratories agree well within the typical AMS uncertainties. A detailed evaluation of the results will take place in 2024 after all ICP samples have been analysed.

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: 16.9 PM

Task 3. Network coordination, training and development

Task 3.1: Interaction with station PIs

CRL scientists participated in the ICOS Atmosphere MSA meetings in May and November 2023. The $^{14}CO_2$ results from both the integrated and flask sampling were presented to the MSA participants. The CRL and the stations regularly exchange emails concerning sample supply, spare parts, and other issues. The regular transfer of samples between the stations and the CRL works smoothly.

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: 3.7 PM

Task 3.2 Production of integrated CO_2 samplers

No integrated CO_2 sampler was requested from the network in 2023. The 2023 work plan foresaw a sampler for the Potenza station, which could be delivered by the end of 2022 already.

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 2023 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 $ffCO_2$ monitoring strategies

In 2023 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 fulfilled with continuous operation, the transmission of the 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 2023. During this year, we focused on publishing and further evaluating the samples collected in the past years. This is reflected by the two publications of Maier et al. (2023a and 2023b) that were submitted in 2023. The two companion papers deal with the investigation of CO as a proxy for $ffCO_2$ at the ICOS CRL pilot station. In 2023, we worked on the use of NO_x as a $ffCO_2$ proxy. Even if the basic idea of the proxy is the same for NO_x and CO, the determination of a suitable NO_x background is much more challenging due to the short and variable NO_x lifetime. The results of the master's thesis of Hannes Juchem are expected in summer 2024 and will be presented to the ICOS PIs for the first time at the MSA in April 2024. We have also resumed work on analysing the APO measurements as a further $ffCO_2$ proxy together with Penelope Pickers. All this together creates a unique comparison of the three most promising $ffCO_2$ proxies, CO, NO_x and APO, at the ICOS pilot station. All three proxies will be compared and benchmarked against $^{14}CO_2$.

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

Deliverable has been fulfilled.

Person-months spent on Task 3.3: 6.2 PM

Task 4. Projects and international cooperation

The CRL is participating in the PAUL project coordinated by the ICOS ERIC and contributing to WP3. In 2023, the CRL analysed 239 $^{14}CO_2$ samples for the PAUL project. The project provides the flask analysis costs, consumables, and a dedicated part-time technician in the CRL. Ann-Kristin Kunz completed her master's thesis on using the Relaxed Eddy Accumulation (REA) technique to apportion CO_2 flux using $^{14}CO_2$. In the framework of a joint PhD thesis between Heidelberg and Freiburg University, Mrs Kunz is continuing this work for the next three years.

For the ATTO+ (Amazon Tall Tower Observatory, Coordinator MPI-BGC) project, funded by the German BMBF, the CRL analysed 15 integrated samples in 2023. The ATTO+ project pays 250 €/sample plus OH costs. All results will be available to ICOS RI.
The EU-Horizon project CORSO (CO2MVS Research on Supplementary Observations) coordinated by ECWMF started in 2023. This project provides the resources and the additional workforce to analyse all ICOS flask samples from ten western European ICOS class 1 stations for $^{14}CO_2$ in the calendar year 2024. For this, an additional technician was hired in 2023 on a temporary contract. To process the largely increased number of samples, a second graphitisation system for the CRL should have been built by ETH Zurich. Unfortunately, ETH Zurich experienced significant delays in building the new graphitisation system for more than six months. The new system will thus become available to the CRL only by the summer of 2024. This delay causes a high load on the existing CRL graphitisation system in the first month of 2024.
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. The working group's task is to develop a $^{14}CO_2$ sampling strategy that minimizes the effect of nuclear ^{14}C emissions in ICOS flasks. Together with the ICOS CP, an NRT estimation of the nuclear ^{14}C contribution during flask collection time could be established in 2023. This approach uses NRT meteorological fields provided by ECWMF in combination with the FLEXPART footprint model. During 2024, we are testing this approach for the 10 ICOS stations in central-western Europe, which are part of the CORSO project, and thus get five times more $^{14}CO_2$ analysis compared to the standard ICOS analysis protocol. 48 hours after sampling, the estimated nuclear contamination is available. An ICOS-CRL scientist reviews the contamination estimates and decides if samples should be retained or if the flask can be resampled. The result of this nuclear preselection is automatically transmitted to the ICOS flask sampler, no action is required from the station PIs.

Max Gachivsky, in cooperation with the MPI-BGC in Jena, is working on $ffCO_2$ modelling on European scales using the CarboScope TM3/STILT inversion system. Despite intensive efforts, we have not yet been able to achieve a satisfactory representation of the 14-day integrated samples in the model. The diurnal cycle of the atmospheric boundary layer causes a varying sensitivity of the integrated samples to surface fluxes. The inappropriate representation of the diurnal cycle in the model has so far prevented a meaningful inversion of the continental, integrated $^{14}CO_2$ data. The PhD thesis will document these findings and discuss the resulting recommendations for a modified $^{14}CO_2$ sampling strategy for the integrated samples.

Person-months spent on Task 5: 7.7 PM

ICOS National Networks

Belgium

Highlights

After over 10 years; we concluded our research at the bio-energy plantation with short coppice poplar and willow trees in Lochristi.

Changes in station network

In the summer of 2023 the Lochristi site (BE-Lcr), a short-rotation coppice plantation of poplar trees, operated by the University of Antwerp was closed. Measurements were concluded since the farmer was switching from poplar trees to traditional crops. With the closure of the Lochristi site, it was decided to move the flux station elsewhere.

Today the University of Antwerp is involved in the start-up of two new ICOS associated sites: BE-Wm1 and BE-Wm2. These sites will be located at the same crop field in Westmalle. After a control period farming practices in the footprint surrounding one of the stations will be adjusted. This setup will allow evaluation of farming practices on field carbon fluxes and results will give important insights to the possible contribution of carbon farming practices as carbon sequestration technique. Westmalle stations will be officially added to the ICOS network in 2024.

Czech Republic

Highlights

On July 11-14, 2023, the annual FLUXNET conference was held in Brno, co-hosted by CzechGlobe and the Mendel University in Brno. FLUXNET is a global network formed by regional networks (ICOS from Europe, Ameriflux, OzFLUX, SAEON, MexFLUX and AsiaFLUX) bringing together organisations that deal with the measurement of greenhouse gas fluxes using the eddy-covariance method.

Changes in station network

No changes - 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.

Denmark

Highlights

Increasing robustness in the maintenance of the ecosystem stations in Greenland including established internet connection at Zackenberg.

Continued funding for the Greenlandic stations, but a depressing lack of support to the Danish part of the network.

Changes in station network

The stations DK-VNG, DK-SKJ and DK-GDS have sadly been discontinued from the end of the year , due to lack of funding.

Co-operation with other Ris

Continued Collaboration between ICOS and ACTRIS at Station Nord, Collaboration at all Greenlandic ecosystem sites between ICOS and Greenland Ecosystem monitoring program (https://g-e-m.dk/)

Finland

Highlights

New partner in the ICOS Finland network: University of Oulu, Welcome!

Ecosystem Class 1 station Sodankylä (FI-Sod), a pine forest in Northern Finland, received the label in spring 2023 in ICOS general assembly. Tvärminne coastal station received the label in autumn 2023 GA meeting.

Highly relevant publication regarding the gap-filling of flux data, including a critical review of the method currently used in ICOS by Henriikka Vekuri et al (https://doi.org/10.1038/s41598-023-28827-2)

Large delegation of Finnish partners participated in ICOS Nordic meeting in November in Bergen.

Changes in station network

New stations:

- FI-SOOP-Silja Serenade (OCEAN Class 2; FI-SER)
- FI-FOS-Tvärminne (ECO Associate; FI-Tvm + OCEAN Class 2; FI_TVA)
- Oulanka (ECO associate; FI-Ouk), pristine mire

New institute to join ICOS Finland network: University of Oulu (with a station FI-Ouk)

Co-operation with other RIs

The Finnish umbrella for four European RI's (ICOS, ACTRIC, AnaEE and eLTER), INAR RI Ecosystem board, has met four times in 2023 to discuss the common funding application and other coordination topics.

ACCC-FASN Science Conference 2023, bringing together researchers working with the data from ICOS, ACTRIC, AnaEE and eLTER infrastructures, was held in Kuopio in November 2023, hosted by the University of Easter Finland. 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".

ACCC impact week 2023 in April in Helsinki: "Climate change and green transition as global challenges for science and society. "Climate change and green transition as global challenges for science and society",

The 2nd Atmosphere and Climate Competence Center (ACCC) Impact Week was organized on April 11-14, 2023 in Helsinki by the ACCC partners; Institute for Atmospheric and Earth System Research (INAR)/University of Helsinki, Finnish Meteorological Institute, Tampere University and University of Eastern Finland. During the four day event there were 360 participants in Vuosaari or on-line. Daily participation in Vuosaari, at the Sofia Cultural Center, varied from 80 – 120 people**.** As an audience we invited researchers and experts, businesses, civil society organizations, climate policy makers, educational professionals, research infrastructure experts and all ACCC members and stakeholders to join us in discussing pathways to climate neutrality. This year's thematic focus is in climate change as a global challenge for civil society and decision-makers and in financing the green transition. The aim of the event was to further develop existing and new collaborations with key ACCC stakeholders from global organisations, countries, businesses, civil society organizations and others. The presented topics represented themes related to ICOS, ACTRIS, AnaEE and eLTER. For example, prof. Annalea Lohila gave a presentation "Greenhouse gases and methane" in the session "Biosphere-atmosphere interactions – scientific results and knowledge gaps", and prof. Katrianne Lehtipalo talked about Aerosols and trace gases in the same session. In another session, prof. Leena Järvi gave a presentation "Potential for carbon sinks in urban environments".

France

Highlights

- Ecosystem + Atmosphere network: Major summer drought in the south of Europe. Temperature extremes of 2022 reduced carbon uptake by forests in Europe. van der Woude, A. M., et al., 10.1038/s41467-023-41851-0
- Soil smoldering in temperate forests: A neglected contributor to fire carbon emissions revealed by atmospheric mixing ratios; Vallet et al.
- Detection and attribution of an anomaly in terrestrial photosynthesis in Europe during the COVID-19 lockdown Tang, A. C. I., et al., 10.1016/j.scitotenv.2023.166149
- First Eddy-covariance data coming out from Paris: Romainville tall-tower, Jussieu short tower and Saclay tall-tower. Romainville showing similar CO2 emissions per unit surface as in Zurich and Munich.

Co-operation with other RIs

The French ICOS community is actively involved in the FairCarboN PEPR (Priority Research Programmes and Equipments) that aims at studying Carbon cycles in terrestrial ecosystems. In particular, the forest Ecosystem stations are all participating to the Drought ForC project that studies drought impacts on carbon fluxes and stocks in forest ecosystems, jointly with the rainfall manipulation experiments of

AnaEE RI. Soil carbon measurements led by ETC Soil will also contribute to the ALAMOD project that aims at benchmarking ecosystem carbon stock models with data from RI ICOS, AnaEE and IN-Sylva.

Obs4Clim national project, collaboration with ACTRIS and IAGOS: INRAE Purchase and test of 3 MIRO instruments (2*6 species and 1*9 species). Measurement of methane, N_2O and NO emissions following digestate and compost application near Paris. 1 MIRO instrument installed in Saclay.

Germany

Highlights

- Addition of the peatland site **Amtsvenn (DE-Amv)** in the ecosystem domain. The site was drained in the past, but is now part of a Nature Conservation Area. With peatlands being highly underrepresented in the network, organic soils contribute significantly to ecosystem greenhouse gas exchange at national level. The biosphere-atmosphere fluxes are driven by water table dynamics, vegetation composition, and land management.
- Successful start of the ITMS project **FeaViTa** (coordinator: Alexander Graf)
- This project aims to enhance the accuracy and spatial resolution of greenhouse gas (GHG) flux estimates between the land surface and atmosphere by integrating data from ecosystem and atmospheric measurement stations. It focuses on validating and potentially combining two innovative approaches: Virtual Tall Towers (VTT) and a statistical method based on the turbulent probability density function, to estimate vertical GHG concentrations. By leveraging existing adjacent ecosystem and atmospheric stations, the project seeks to improve the validity of atmospheric GHG measurements and reduce uncertainties in global GHG budgets. This endeavor could significantly contribute to more precise climate modeling and improved strategies for mitigating climate change impacts.
- Successful start of the ITMS project **ISOMONEAE** (coordinator: Nicolas Brüggemann)
- This project aims to monitor the exchange of H_2O, CO_2, CH_4, and N_2O between ecosystems and the atmosphere with high temporal resolution at an agricultural site in Selhausen, Germany, and a forest site in Leinefelde, Germany, using cutting-edge isotope-specific laser analyzers and eddy-covariance methods. It will enhance understanding of ecosystem dynamics by partitioning fluxes into their source and sink components, such as distinguishing between evaporation and transpiration for water vapor, and photosynthesis and respiration for CO_2. By developing an automated flask sampling system for detailed CH_4 and N_2O analysis, the project seeks to identify seasonal and event-driven variations in gas fluxes, aiming for long-term integration into an Integrative Greenhouse Gas Monitoring System (ITMS).
- Successful start of the BMBF project „Standardisiertes Monitoring von Wachstumsreaktionen wichtiger Waldbaumarten auf klimatische Extremereignisse (**MW³**)“ (Coordinator: Michael Leuchner (RWTH Aachen), PIs: Heye Bogena (FZ Jülich), Harrie-Jan Hendricks-Franssen (FZ Jülich), Theresa Blume (GFZ), Corinna Rebmann (UFZ) etc., 01.10.2022-31.09.2027
- This project is financed by the Waldklimafond call of the Federal Ministries of Food and Agriculture and Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The main objective of the MW³ project is the development of a standardised monitoring system and protocol to record and analyse growth responses of important Central European forest tree species with a focus on climatic extremes. The system will be based on the existing TERENO

monitoring platforms and will record the most important key parameters for a cross-scale growth analysis through a close coupling of ground-based measurement data, satellite-based remote sensing and tree modelling.

- Successful project application within the German project ITMS together with KIT/IMK-IFU on the topic of modeling greenhouse gas emissions from peatlands (**MODELPEAT**). In the project, data from the ICOS station DE-Msr are used.
- ITMS proposal (**GEMS**, led by Hereon (K. Dähnke, Y.G. Voynova, T. Sanders) and AWI (I. Bussmann) as PIs), focused on estimating GHG emissions at the Land-Sea Interface, expected to be funded and starting in April 2024; a parallel project to ITMS proposal for coastal regions by IOW (Gregor Rehder). Cuxhaven ICOS Station is central in this proposal.
- Start of the operational measurements at the agriculture site **Braunschweig (DE-Brs)** in the ecosystem domain. Agricultural sites have previously been underrepresented in the German ecosystem network, given that about half of Germany's land surface is used for agriculture. DE-Brs is located on the Braunschweig research campus with a large variety of complementary scientific activities, covering agriculture, biology, soil science, hydrology and meteorology. Management activities at the site are well documented.
- At **Hartheim forest (DE-Har)**, a new Vertical Profile System for CO_2 according to ICOS Protocols plus Sap Flow Sensors were installed.
- Research Projects at University of Freiburg:
- Laurin Osterholt: Does wind-induced pressure-pumping facilitate methane oxidation in upland soils? (DFG, MA 5826/2-2)
- Prof. Martin Maier (Göttingen): Waldklimafonds Projekt "Wald, Wasser und Transpiration"
- 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.
- Official handover of the ICOS station label onboard ICOS station DE-SOOP-Atlantic Sail. The label will be displayed together with a poster describing the ICOS activities onboard in the mess room of the vessel.

Changes in station network

New stations:

- Cuxhaven station – Pilot Estuarine Station for ICOS-D Ocean Stations since 2023
- Responsible Institution: Helmholtz-Zentrum Hereon; Station PI: Yoana Voynova

Stations that completed labelling in GA meetings in 2023:

- Class 2 Ocean Station M/S Finnmaid (DE-SOOP Finnmaid)

- Responsible institution: Leibniz Institute for Baltic Sea Research, Warnemünde (IOW); Vessel owner: Finnlines; Station PIs: Michael Glockzin, Gregor Rehder and Henry Bittig
- Associated Ecosystem Station Hetzdorf (DE-Hzd)
- Responsible institution: TU Dresden; Station PI: Matthias Mauder

The classification of the Ecosystem Station Fendt (DE-Fen) has been changed to 'Associated'.

Co-operation with other RIs

- Cooperation with ACRI-ST and Ground-Based Observations for Validation (GBOV) of Copernicus Global Land Products - exchange of measurements and analysis results
- GEOMAR participation in EU project GEORGE (together with EuroArgo and EMSO)
- Jerico-S3 TNA CABS project, November 2023, capacity transfer to colleagues from Bulgarian Academy of Science focused on use of membrane-based sensors for pCO2 measurements at Cuxhaven station, and automated nutrient analyses, as well as autonomous biogeochemical observations
- LandSeaLot EU Horizon project, funded August 2023, starting February 2024. Cooperation between ICOS-ERIC, DANUBIUS-RI and JERICO-RI. Cuxhaven Timeseries station is part of Elbe Estuary-Wadden Sea LandSeaLot Integration Labs
- AQUARIUS Horizon EU project, funded August 2023 and starting in March 2023 focuses on the availability and use of infrastructures, where Cuxhaven Station is one station which Hereon is providing within the Elbe Estuary-North Sea region and DANUBIUS-RI
- Hereon collaboration with ICOS researcher Natalie Lefevre and 4H Jena Engineering on testing the newest membrane based pCO2 sensor and comparing it to GO
- Hereon participation on an inter-comparison experiment with pH and dissolved oxygen within MINKE project in 2023
- IOW is involved with station DE-SOOP Finnmaid in the Horizon Europe project GEORGE (coordinated by ICOS HO); cooperation project ICOS, EMSO, ARGO

Greece

Highlights

In 2023, Greece became an ICOS member. So for the year 2023, 3 of our 4 stations are already labelled, and we were actively working to address the ownership issues with the Pertouli University Forest site. While these minor developments mark our highlights for 2023, we are committed to striving for greater progress in 2024!

Changes in station network

Heraklion's Ecosystem stations, in City Center (HECKOR) and in Residential Area, Mastabas, (HECMAS) established in November 2016 and April 2021, respectively both were labelled as Associated Stations in the recent ICOS General Assembly.

Finokalia atmospheric monitoring station operates by the University of Crete at Finokalia, Lasithi, Crete since 1993, flasks measurements of GreenHouse Gases started in 2002 in collaboration with LSCE,

France, and since June 2014 a PICARRO instrument is running at the station. The station joined ICOS in 2023.

Co-operation with other RIs

- AERONET (https://aeronet.gsfc.nasa.gov)
- Urbisphere (https://urbisphere.eu/campaign_berlin.html)
- ACTRIS (https://www.actris.eu)

Hungary

Highlights

The refurbishing of the 30-year-old Hegyhátsál tall-tower atmospheric GHG monitoring station (HUN) was finished by the middle of the year, and the regular data reporting to ICOS ATC was started.

Changes in station network

Labelling of Hegyhátsál monitoring station (HUN) as a Class 2 atmospheric site is in progress.

Co-operation with other RIs

HUN also provides flask air samples for NOAA Cooperative Global Flask Air Sampling Network.

Ireland

Highlights

Ireland became a full member of ICOS-ERIC in January 2023.

The national network for ICOS (ICOS Ireland) has been established.

Changes in station network

The Ecosystem site at Gurteen station has been replaced by a site at Doorey. This is an Ecosystem grassland site and is classed as Associated.

Co-operation with other RIs

ACTRIS relevant atmospheric measurements are being carried out at Mace Head and that there is an ongoing discussion of the ACTRIS RI

Italy

Highlights

ICOS Italy has accomplished many important results regarding the funding programme. Overall, the network has empowered sites and stations, including instruments and measurement capacity. Three new stations have joined the network.

On September – October 2023, the IT-CMN class-2 atmospheric site hosted a combined audit by the ICOS Mobile Lab and the World Calibration Centre (WCC-Empa) for Surface Ozone, Carbon Monoxide, Methane and Carbon Dioxide.

The Lampedusa station (IT-Lmp), already part of the ICOS network as an atmospheric observatory, has completed the installation of marine and ecosystem instrumentation for measuring air-sea-ecosystem exchanges. The installation was carried out within the PRO-ICOS-MED project, coordinated by the National Research Council (Cnr) in collaboration with the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and the Council for Agricultural Research and Analysis of the Agricultural Economy (CREA). Lampedusa has become the only example of an integrated observatory between all ICOS components among the whole ICOS sites network. To emphasize this accomplishment, ICOS Italy has organized the conference "ICOS Italy meets in Lampedusa", on June 6-7th. The conference reunited almost 50 national and international scientists and stakeholders. Physical attendees had the chance to visit the integrated observatory, which is not only the southernmost in Europe, but also the first and only site capable of monitor a vast spectrum of parameters, collecting a whole picture among all three ICOS components: atmosphere, ocean and ecosystem. The ecosystem observatory is already functional, but will officially join the network during 2024, while the ocean observatory has joined the network as a class II site.

The new station of Potenza has received a vast mediatic attention. Inaugurated on July, the atmospheric tower has an overall height of 104 m and is equipped for air sampling at 10, 50 and 100 m. These instruments, alongside with the laboratory for data acquisition, make the site unique due to its geographical location, allowing the scientific community to study large cities pollution with a new and accurate perspective.

Changes in station network

ICOS Italy had three new stations joining the network: Osservatorio Ximeniano Firenze (IT-OXm), an Associated Ecosystem Station in an urban environment; Lampedusa ocean observatory (IT-Lmp), a class II site with a 74m depth buoy; and Potenza (IT-POT), a class I Atmosphere Station with a 100m tall tower.

Stations completing labelling in GA meetings of 2023:

Class I Ecosystem Station: Borgo Cioffi (IT-BCi);

Associated Ecosystem Station: Arca di Noe - Le Prigionette (IT-Noe)

Co-operation with other RIs

ICOS is part of ITINERIS (Italian Integrated Environmental Research Infrastructures System), a cross-environmental RIs project which comprehends 22 RIs. This important co-operation has led to a profitable scientific and funding relationship.

Strong interaction with ACTRIS-RI (Aerosol, Clouds and Trace Gases Research Infrastructure) under the trans-national access activities at the atmospheric site IT-CMN within the H2020 ATMO-ACCESS project. At national scale, interactions with 21 RIs (16 from the environmental domain, 3 from agri-food with strong link with the environment and 2 from the PSE domain, supporting services for the marine domain) within the project ITINERIS.

Furthermore, the Torgnon site has joined eLTER network.

The Potenza ICOS Atmosphere site is part of the CNR IMAA Atmospheric Observatory (CIAO), hosted and managed by the Institute of Methodologies for Environmental Analysis of the National Research Council of Italy. CIAO also includes a site which is part of ACTRIS. The co-location of the two sites of these two European infrastructures makes their co-operation and integration natural.

Among the joint project proposals approved during 2023 and involving both ICOS and ACTRIS infrastructures, the following are listed:

ITINERIS - Italian Integrated Environmental Research Infrastructures System (https://itineris.cnr.it), a National project - financed by the PNRR and coordinated by the Institute of Methodologies for Environmental Analysis - with the aim of building the Italian Hub of Research Infrastructures in the environmental scientific domain for the observation and study of environmental processes in the atmosphere, marine domain, terrestrial biosphere, and geosphere, providing access to data and services and supporting the Country in addressing current and expected environmental challenges.

ATMO-ACCESS - Sustainable Access to Atmospheric Research Facilities (https://www.atmo-access.eu/), a Horizon Europe project which provides physical, virtual and remote access services to more than 50 atmospheric facilities' data and instruments worldwide through periodic calls.

It should be underlined that CIAO is involved, in addition to ICOS, also in other ground observation networks: EARLINET, ACTRIS, CloudNet, AERONET, NDACC, GRUAN, GALION, and it is among the fifteen backbone stations involved in the operations of GRUAN (GCOS Upper-Air Reference Network).

Netherlands

Highlights

- **Hosted conferences and meetings**
- ***ICOS Ecosystem MSA April 23-28, 2023:***
  In April 2023, Wageningen hosted the ICOS ETC Member State Assembly, where site PI's and ETC staff meet, to discuss recent developments (below canopy fluxes, spectral reflectance and fluoresence, 2022 drought study) and future plans (non-CO2 fluxes, historical data processing, dendrometer networks, flux stations in the North sea). The meeting was attended by 60 people and included a presentation about MAQ-WUR activities and a site visit to the Loobos site.

- ***NCGG9 June 21-23, 2023:*** Non-CO_2 greenhouse gases, such as methane, nitrous oxide and fluorocarbons, significantly contribute to climate forcing. To find a way to address the reduction of these species, the Ninth International Symposium on Non-CO_2 Greenhouse Gases (NCGG9) took place in Amsterdam, The Netherlands and was hosted by VMM and the ICOS-NL community. The conference emphasized identifying game changers and evaluating their impact on reducing these emissions, with a focus on distinguishing realistic solutions from impractical ideas. Contributions encompassed scientific and policy perspectives on causes, effects, and solutions to environmental challenges associated with non-CO_2 greenhouse gases.

- **Labelling for Cabauw and Loobos stations (see below),**

- **Progress on instrumentation and important visits**

- ***Carbon Portal:*** The Dutch contribution of the ICOS-CP in 2023 focused on the provision of high-resolution near real-time fluxes for Europe. This product, of which the details were published in a journal article (van der Woude et al 2023), is updated each month and contains all European carbon fluxes at 0.2x0.1 degrees resolution. They immediately found use in a second publication (van der Woude et al 2023b) that analysed the 2022 summer drought in Europe, appearing in Nature Communications. This paper, and its underlying product, is drawing wide attention and was featured in national news, international media, an ICOS communique, and in a recent report on climate risks commissioned by the European Commission.

- ***Cabauw:*** The Cabauw site has been labelled as an ICOS class 1 Atmospheric site. Shortly after the labelling, the N_2O measurements resumed (after a year absence of the Picarro G5310 for repair). An Aeris Miro Ultra for N_2O and CO is being tested for performance and possible candidate as replacement. Flask sampling at Cabauw continued after the Medusa experiment in 2022 for halocarbon analysis at Bristol University. This is part of the cooperation in the EU project Paris. End of 2023 additional flask sampling for $14CO_2$ analysis started as part of the CORSO project. Autumn 2023 Cabauw ICOS instrumentation was shown on television as part of an educational youth program 'Klokhuis' about GHG.

- ***Loobos:*** The Loobos site is equipped with instrumentation in agreement with the ICOS-ETC instructions since April 2023. Shortly afterwards the station was labelled as an official ICOS class 2 Ecosystem site. All instruments have been working properly, apart from regular maintenance. In addition to the fully automatic continuous measurements were/will be conducted:
- Digital Hemispheric Pictures of the canopy are taken every second month
- A soil inventory is being carried out in the winter of 2024 to determine soil properties, carbon and nitrogen content. This analysis is to be repeated in a 10-year cycle.
- Foliar samples are being collected for leaf mass : area measurements and nutrient analysis. These samples are collected in a 1-year return cycle.
- A below canopy species and biomass analysis.
  Besides the ICOS instrumentation, an O_3 flux instrument has been ordered and will be installed in the summer of 2024. Additionally, measurements are collected of H_2O isotope concentrations, VOC concentrations, GNSS radiation density, DTS temperatures. Plans are made to collect O_2/N_2 concentration measurements starting in May 2024.
  The Loobos site was visited by the members of ICOS ETC MSA, the director of the Ruisdael Observatory, the Rector of Wageningen University, the Director of the Environmental Sciences group of Wageningen University, and representatives of the Water Board Vallei and Veluwe.

- ***Lutjewad:*** In May of 2018 Lutjewad station was labelled as ICOS Class II station to provide continuous data for CO_2, CH_4 and CO. In March of 2023 our Picarro G5310 for N_2O and CO, in operation since late 2019, was added as official ICOS instrument (ID 890) to deliver data to the ICOS data portal. Furthermore, in April of 2023 we registered our ANSTO radon as official ICOS instrument with ID 1573. The Lutjewad Radon data time series from 2017 onwards are available as ICOS data product from the data portal. As such, Lutjewad station is now a Class II Plus station. Other data products such as bi-weekly 14C-CO_2 are on the list to become ICOS data products as well.

Changes in station network

On May 23, the Cabauw and Loobos stations received their official ICOS label at the ICOS General Assembly meeting in Malmö. Cabauw is now an official class 1 Atmospheric station and Loobos is an official class 2 ecosystem station.
The road to get there was like a pilgrimage for the last few years: always the end-goal in mind, but a trip full of setbacks. ICOS-NL thanks the PI's of these stations, Arnoud Frumau and Michiel van der Molen, and everyone who contributed to this remarkable milestone. Now all ICOS stations in the Netherlands (Cabauw, Loobos and Lutjewad) are officially labelled and their data are sent to the ICOS Carbon Portal on a daily basis, where they are made publicly available (ICOS Carbon Portal | ICOS (icos-cp.eu)).

Co-operation with other Ris

Cabauw is co-located ICOS and ACTRIS facility. It is the only ACTRIS station so far that is able to measure 5 out of all 6 ACTRIS components: in-situ aerosols and reactive trace gases and remote sensing aerosols, clouds and reactive trace gases.

On national level, The Dutch National Research Programme on Greenhouse Gases in Peatlands (**NOBV**) has been building up an increasing number of GHG exchange monitoring sites on peat soils, mostly managed and some natural, aimed at building a monitoring network as well as a system to validate mitigation measures. One site has been equipped according to ICOS standards. These and other sites also run automated chamber measurements and a host of other soil observations. On top of this, almost weekly Skyarrow EC flux flights are carried out in three peat regions of the Netherlands. By 2023, the NOBV network consisted of and reported on 20 EC measurement sites on peat soils (meadows and natural wetlands), along with many chamber-based observation sites, soil chemical and physical observations and modelling activities. The airborne EC fluxes are also being extensively analysed, mainly in a machine-learning context, to deliver relationships with groundwater tables and land use/peat types. A peat-focused national reporting framework, called SOMERS, has seen its first version made available while version 2 is on its way.

Norway

Highlights

The ecosystem station at Hurdal (NO-Hur) received class 2 labelled status on November 15th at the 2023 ICOS general assembly. The station is operated by the Norwegian Institute of Bioeconomy Research (NIBIO) and is located in a mature Norway spruce forest stand ca. 50 km north of Oslo. As part of the ICOS Norway phase 2 infrastructure project and under the labelling process, a new 42 m high tower was installed for the eddy flux covariance and all auxiliary measurements required for a label 2 station. NO-Hur has a footprint of approximately 63 ha. As the stand within that footprint is rather typical for Norwegian forests of medium productivity, the station is ideally placed to assess the impact of forest management practices on fluxes and ecosystem processes in Norway, which has a large, forested area (37% or 119 000 km^2 of the Norwegian mainland) and is thus an important European carbon reservoir. The tower was built with suitable foundations for a possible extension in future and co-location with an ICOS atmospheric station.

ICOS Norway (represented by NORCE and University of Bergen) organised and hosted the 2023 ICOS Nordic conference, in Bergen on 21-22 November. At the conference were 85 participants, mainly from the Nordic countries, representing all ICOS domains. The event was also streamed for on-line participants. In addition to scientific presentations and posters the event included a panel debate on

the societal relevance of carbon data with representatives from ICOS HO, local management authorities, and non-governmental organizations working with industry to improve sustainability.

Changes in station network

Hurdal ecosystem station (NO-Hur) received Class 2 label at the November 2023 ICOS GA.

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 the three relevant domains. In 2023, the Izaña, CanOA-SOOP, and Majadas de Tiétar stations successfully completed the labelling process, thus strengthening the representation of the national node in ICOS-ERIC. Additionally, the El Arenosillo and ESTOC stations concluded the first phase of the labelling process. Finally, the necessary procedures were completed to incorporate a new atmospheric station, El CIBA, in 2024.

The Izaña atmospheric station has completed its first year of observation in the context of ICOS-ERIC and its data have been integrated in the observation packages (Obspack) elaborated by this network. Both the principal investigator (PI) and a technician attended the last Monitoring Station Assembly (MSA) held in Brussels (Belgium) on 15-17 May 2023.

The El Arenosillo atmospheric station sent the Picarro instrument to the Atmospheric Thematic Center (ATC) on 16 January 2023, and it returned on 8 June 2023. The instrument was certified by the ATC for the three gases (CO_2, CH_4, and CO). The PI of El Arenosillo attended the training course hosted by ATC in an online format from 19-22 September 2023. The calibration tanks from the laboratory in Jena arrived at El Arenosillo on November 24.

Changes in station network

- Carlos Torres (AEMET) replaced Emilio Cuevas (AEMET-retired) as national Focal Point of ICOS-Spain.
- Dr. Arnaud Carrara (CEAM) has joined the national node as a scientific advisor.
- The "ICOS-Spain Activity Report 2021-2022" was published by AEMET. This public document will be issued every two years.

Izaña Atmospheric Station

- Pedro Pablo (PI) and Sergio León (technician) attended to the MSA held in Brussels (Belgium) on 15-17 May 2023.
- The ICOS General Assembly, held on 22-23 May 2023 in Malmö (Sweden), unanimously agreed to incorporate the Izaña Observatory as a fully-fledged class 2 station in its network.

El Arenosillo Atmospheric Station

- The Picarro (Id 1513) was certified by the ATC on 2 June 2023.
- The calibration tanks from the CAL-ICOS in Jena arrived at El Arenosillo on 24 November 2023. Its installation and connection to the rotary valve and Picarro was carried out in December together with the first tests.

CanOA VOS Oceanic Station

- The ICOS General Assembly, held on 14-15 November 2023, in Offenbach am Main (Germany) unanimously agreed to incorporate the CanOA Oceanic Sation as a fully-fledged class 2 station in its network.
- During September 2023, an oxygen optode sensor has been installed in order to be able to obtain class-1 in the next future.

ESTOC Oceanic Station

- ESTOC station has concluded the first phase of the labelling process.

Majadas de Tiétar

- The ecosystem station finalized its labelling process in October 2023 and has been officially awarded the status of Associated ICOS station on 14-15 November 2023.
- The Majadas de Tiétar station delivered 3 years of data (2020-2022) to ICOS database.

Co-operation with other RIs

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

The Swedish national network succeeded in the competitive national call for funding of research infrastructures of national interest. The next funding period will start in January 2025. The weather in Sweden was characterised by very little precipitation in the first six months of 2023, whereas the second half of the year was characterised by heavy precipitation. While September to November were very warm, winter started early in all parts of the country at the end of November and reached very low temperatures especially in the northern part of the country. These special weather conditions influenced the carbon uptake at the stations, resulting e.g. in a positive total net ecosystem exchange at Hyltemossa.

Changes in station network

No changes to the network in 2023.

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 has been intensively working on designing a strategy for future collaboration between the three environmental RIs SITES, ICOS and ACTRIS in Sweden. The strategy will be sent to the Swedish Research Council in the end of March 2024.

Switzerland

Highlights

The Jungfraujoch station was awarded the EuChemS Historical Landmark Award. To celebrate, a one-day symposium was held on 16 February 2023 in Bern, followed by the unveiling of the Historical Landmark plaque at Jungfraujoch on the next day.

After 10 years as an Observer, Switzerland has finally become a full Member of ICOS! The membership required first a decision by the Swiss parliament followed by the acceptance of the Swiss application at the ICOS General Assembly in May 2023.

The Davos excursion guide, a booklet containing a nice overview of the Davos station for excursions, was updated and released in August 2023. The figures in the guide are based on the long-term station dataset, which includes ecosystem fluxes and meteorological data from 26 years (1997-2022), released at the beginning of 2023.

Installation of a new 360° roundshot camera on the top of the Davos tower.

Collaboration with the GCOS financed project 'SwissPhenoCam: country-scale automated phenology tracking from imagery', WSL, MeteoSwiss, Uni Zurich.

Successful negotiations with Swiss Federal administration to define Swiss national science foundation (SNSF) to be the application receiver for the ICOS Phase 4 proposal (2025-2028).

Changes in station network

The Basel urban flux tower site (CH-BaK) was approved by the ICOS General Assembly in November 2023 to enter the labelling process by January 2024. Current status is "Step 1 submitted" (11.01.2024).

Co-operation with other RIs

Davos station is part of the international networks eLTER and ICP forest level 2. The site also participates in the CLEANFOREST COST action. 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).

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.

United Kingdom

Highlights

Funding for the UK DECC network of atmospheric monitoring stations (including the Ridge Hill ICOS station) was secured until 2029 through the award of a contract from the UK Government Department for Energy Security and Net Zero

The Porcupine Abyssal Plain Sustained Observatory (PAP-SO) ocean station became an ICOS labelled station

Weybourne Atmospheric Observatory is involved with the UK GEMMA programme (https://www.npl.co.uk/greenhouse-gas-emissions-measurement-modelling) and represents an important link between European and UK measurements.

Weybourne Atmospheric Observatory was showcased in the #ExploreICOS outreach programme: https://www.icos-cp.eu/exploreicos-weybourne-atmospheric-observations-all-directions

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

Changes in station network

The Porcupine Abyssal Plain Sustained Observatory (PAP-SO) ocean station became an ICOS labelled station

New CO2/CH4 instrument (Picarro G2301) installed at Weybourne. This was funded by the UEA in 2022.

Co-operation with other RIs

Planning a 2025 demonstrator mission at PAP-SO with ICOS, EMSO and ARGO to test new open ocean technologies alongside established techniques as the part of the 'GEORGE' demonstrator site in 2025.

Led a team including EMSO and other RIs in preparation of a Frontiers paper on synergies between oceanography and metrology (see Hartman et al., 2023)

Annex 1 input for KPIs and other tables

Use of ICOS data in educational tools and activities

	Activity
BE	Ma. thesis of V. Authelet (ULiège - Gembloux Agro-Bio Tech), Influence de la circulation d'air au sein des chambres de l'écotron sur les conductances convectives. Ma. thesis D. Tzvetkov (ULiège - Gembloux Agro-Bio Tech), Analysis of turbulent fluxes with the means of the continuous wavelet transform on the Belgian ICOS sites of Lonzée and Vielsalm. Ma. thesis of A. Marinet (ULiège - Gembloux Agro-Bio Tech), Contribution of soil organic carbon variations to the life cycle analysis of a farm: case study in Belgium and methodological recommendations. Ma. thesis of T. Asnong (UGhent - Faculty of Bioscience Engineering), Setting up data post-processing for eddy flux measurements in the Congo Basin. Ma. thesis of S. Huylebroeck (UAntwerp – Environmeltal technology), Impact van klimaatverandering en droogte op de groei van bomen.Analyse van dendrometrische data voor Pinus sylvestris L. in de gematigde zone.
BE	Course on Exchanges Ecosystems-Atmosphere (ULiège) Course on Bio-Climatology (ULiège) Course 'Multidisciplinary Analysis of Climate Change' (UGent) Course on Remote Sensing of Environment (KMI / RMI) Presentation of ICOS by T. Manise : colleagues of Earth and Life Institute at UCLouvain Student site visit (ULiège
CZ	Daniel Lhotský - BSc thesis, *Vývoj koncentrací vybraných skleníkových plynů na území ČR jako téma do výuky na základních školách* (*Development of selected greenhouse gas concentrations in the Czech Republic as a topic for teaching at primary schools),* Masaryk University, Faculty of Education, 2023.
CZ	Mendel University in Brno – BSc, Masters and PhD study programmes e.g. Forest Ecology, Methods of Ecosystem Studies, Forest Stands Microclimate Study visits organised within above mentioned Mendel University in Brno – BSc, Masters and PhD study programmes e.g. Forest Ecology, Methods of Ecosystem Studies, Forest Stands Microclimate
DK	NRT data used for geography bachelor projects
DK	MSc thesis in Geography on CO2 dynamics based on the DK-VGN flux measurements
DK	.Many other student and course input from ICOS data.
FI	PHD Theses: Heiskanen L. (2023), Environmental responses of carbon dioxide and methane fluxes of subarctic ecosystems in Northern Finland

	Linkosalmi M. (2023), Insights into the above- and belowground CO2 fluxes on pristine and managed peatlands: tools for examining ecosystem carbon cycle
FI	Master theses: Karvonen A. (2023), Variability in carbon dioxide and heat fluxes in Minneapolis determined using land surface modelling, Master Thesis, University of Helsinki Soininen J. (2023), Estimating urban carbon uptake using carbonyl sulfide fluxes as a tracer, Master Thesis, University of Helsinki Master university course, Univ. Helsinki, "Water, carbon, and nitrogen cycles in terrestrial ecosystems" in spring 2023, included exercises related to ICOS data.
FR	Master students, University of Montpellier, 14 students, Nov 20, 2023 Master training course on carbon cycle, M. Delmotte PHd summer school, Bordeaux Sciences Agro PhD Lucas Medeiros. Interannual variability of the air-sea CO_2 flux in the tropical Atlantic from 3°S to 14°S. Ongoing PhD Luís H. B. Alves. Response of CO2 Fluxes to the Ocean-Atmosphere Interaction Processes in the Fernando de Noronha Island. Dec. 2023. Hamadou BALDE. PhD 2023, Sorbonne-Université. Télédétection de la Fluorescence Induite par Laser (LIF) et par le Soleil (SIF) pour l'étude du Fonctionnement Hydrique et Carboné des Écosystèmes Terrestres.
DE	**Lectures and visits** B.Sc. Program in Environmental Sciences, "Bioklimatologie" (University of Freiburg) - Excursion to Ecosystem Station DE-Har (about 30 Participants). M.Sc. Program in Environmental Sciences "Global Change Biology" (University of Freiburg) - Excursion to Ecosystem Station DE-Har (about 20 Participants). Use of DE-Har data in courses "Atmosphäre und Hydrosphäre" (300 Students), "Introduction to Meteorology" (100 Students), "Bioclimatology (30 Students). Lecture on Agrometeorology at Leibniz University Hannover (using ICOS data to explain GHG exchange of agroecosystems). University of Oldenburg Winter school: Masters students visiting Hereon, and learning about autonomous biogeochemical sampling at Hereon Research stations in Tesperhude and Cuxhaven (February, 2023). Usage and discussion of data in the following lectures and seminars of Bioclimatology Group, University of Göttingen: 'Bioclimatology', 'Ecosystem-Atmosphere Processes', 'Experimental Bioclimatology', 'Global Change', 'Klima- und Bodenschutz', 'Chemistry/Physics', 'Physik für Forstwissenschaftler'. Excursion to Hainich flux tower site with Master students of the study track 'Sustainable Forest and Nature Management (SUFONAMA)' of University of Göttingen. WASCAL lecture on Chemical oceanography (A. Körtzinger).

	Internship Doris Vertegaal (Wageningen University), April – August 2023, “Internal consistency of marine carbonate observations across the North Atlantic”. Dagmar Kubistin et al: Integrated Carbon Observation System (ICOS): Tall tower greenhouse gas monitoring in Germany, Invited lecture at 7th WCC-SF6 Training and Education Course, 2023.
DE	**3 PhD:s:** On 03.08.2023 Oliver Reitz defended his dissertation "Assessment and Prediction of Carbon Dioxide Fluxes with Eddy Covariance and Machine Learning Techniques" with distinction. E.S. Droste, The role of sea ice in the carbon uptake by polar oceans. PhD thesis, University of East Anglia, Norwich, U.K., 2023 (M. Hoppema co-advisor). Felix Pohl (UFZ) handed in his dissertation (defense will be in 2024) with main advisor Corinna Rebmann and a focus on standardized drought assessment, which includes work on the ICOS site DE-HoH, although the dataset predates the labelling. It also develops drought indices for the ICOS locations and a general analysis of factors driving GPP resonses.
DE	**Masters:** MSc. Thesis by Fabio Scarpa (2023) „Ecophysiological response of competing Pinus sylvestris and Carpinus betulus after years of recurrent severe droughts". M.Sc. Thesis in Environmental Sciences. MSc. Thesis by Fabian Rees (2023) „Analysis of long-term changes in evapotranspiration of a pine tree forest suffering from drought using the Bowen ratio energy balance and eddy covariance approach“. M.Sc. Thesis in Environmental Sciences. Elena Zwerschke: Influences on atmospheric nitrous oxide based on continuous measurements at German ICOS stations, Masterthesis, Ruprecht-Karls-Universität Heidelberg, 2023. Felix Rietz: About the Impact of Wind Turbine Induced Turbulence on (Trace Gas) Reference-Mast Measurements, Masterthesis, University of Bremen, 2023.
GR	Attendees of the JURSE2023 conference visited Gr-HeM (HECMAS), where they received a comprehensive explanation of the physics underlying Eddy Covariance and the strategic significance of the site, given its location in an urban residential area, by Matthias Roth
GR	Dr. Chrysoulakis in the context of course *Principles and Applications of Satellite Remote Sensing* during summers semesters, in department of Physics, University of Crete, in summer semesters with semester-long workshops Analysis of time series of measurements from the ground-based remote sensing networks AEROSOLS, AERONET (AErosol RObotic NETwork), created by NASA and their correlation with carbon dioxide (CO2) emissions from the micro-meteorological towers of the Remote Sensing Laboratory in Heraklion (2022-2023
GR	Secondary school teachers are using CO2 and CH4 data from Finokalia together meteorological data to introduce pupils in climate change science (https://edu4clima.gr ; https://climademy.eu). Actions led by Prof. M. Kanakidou and Dr. N.Kalivitis.
IE	Finished PhD thesis using ICOS data: Ruchita Ingle (2023). Impacts of land use and climate change on carbon and greenhouse gas dynamics of Irish peatland ecosystems. PhD Thesis, TCD.

IE	Lectures and university classes: Guest Lecture at UoG entitled “Greenhouse Gases and Carbon in Grasslands and Agricultural Soils”. Johnstown Castle data presented. 24.01.23 Series of lectures to UoG MsC on AgriFood Sustainability & Technology on ICOS activities
IT	Finished PhD thesis using ICOS data Laura Bignotti, 2023. Size-resolved aerosol particle deposition to European broadleaved forests. International PhD on Science, Catholic University of the S.H. Brescia (I) & Katholeike Universiteit Leuven (B)
IT	Masters and BSc working at the station Davide Plebani, 2023. Messa a punto e applicazione di un sistema per la misura dei flussi di NOx, O3 e CO2 dal soprassuolo forestale. MSc at Università Cattolica del S.C., Brescia (I) Nicole Manza, 2023. Indagini sulla relazione tra flussi stomatici di ozono e assorbimenti di carbonio in una foresta planiziale. MSc at Università Cattolica del S.C., Brescia (I) Lorenzo Rossi, 2023. Valutazione della rimozione di polveri sottili da parte della vegetazione di un bosco periurbano. MSc at Università Cattolica del S.C., Brescia (I) Claudia Marasco, 2023. Profili verticali di ozono, ossidi di azoto ed anidride carbonica in una foresta planiziale. BSc at Università Cattolica del S.C., Brescia (I)
IT	Lectures and university classes Micrometeorology. MSc Course for the Physics Master degree at Catholic University of the S.H., Brescia (I) Ecologia. MSc Course for the Physics Master degree at Catholic University of the S.H., Brescia (I) Controllo dell’inquinamento. BSc Course for the Mathematics degree at Catholic University of the S.H., Brescia (I) Analisi di dati sperimentali e statistica applicata. BSc Course for the Mathematics degree at Catholic University of the S.H., Brescia (I) Gerosa, Vendrame, 2023. “Fluxes between ecosystems and the atmosphere”. Short course for the PhD course Sustainable Development and Climate Change, IUSS-Scuola Universitaria Superiore Pavia, Padua (I) Lecture: Paolo Cristofanelli, Atmospheric variability of greenhouse gases, Dept. Of Physics, Bologna University, 17 March 2023.
IT	Study visits Visit of the students of the Micrometeorology course for the Physics Master degree at Catholic University of the S.H., Brescia (I) Visit of the students of the Ecology course for the Mathematics degree at Catholic University of the S.H., Brescia (I) Visit of dr. Diamiano Gianelle of the Edmund Mach Foundation, S. Michele all’Adige (TN) for a possible joint research project to be held at the station ItBft

IT	A PhD was activated in December 2023 (three-year duration). The topic is focused on the research activities conducted in the ICOS infrastructure, and specifically at the Potenza site. The PhD student will work at the Potenza station and will use the ICOS data in the PhD thesis. During 2023, two school visits (a primary middle school and a secondary school) to the CIAO observatory also involved the ICOS station. In particular, the set-up of the site (tall tower and installed equipment) and the measurements that will be carried out at this station was illustrated. A total of around 80 students were involved in these activities. Additionally, lectures were given to secondary schools about climate change and relevance of ground-based observations, explain among other topics the CIAO observatory capability including the ICOS station. In particular, the set-up of the site (tall tower and installed equipment) and the measurements that will be carried out at this station was illustrated. A total of around 120 students were involved in these activities.
NL	**PhD Thesis Farilde Steur (RUG):** Using laser absorption spectroscopy for the measurement of d13C, d18O and D17O of atmospheric CO_2 **PhD thesis Katarina Vinkovic (RUG):** Quantifying methane emissions from the energy and agriculture sectors using vehicle and UAV-based atmospheric observations **PhD thesis Femke Jansen (WUR):** The potential of actual evaporation
NO	University class: Course in Time Series Analysis, February 2023, at the University of Bayreuth, Germany, for master students of "Geoecology" and "Global Change Ecology". The course used the ICOS time series obtained at the tower in Hurdal 2021-2022.
CH	Student excursion to Davos station, 25 July 2023, 10 participants
CH	Student excursion to Basel station, 18 December 2023, 20 participants
CH	Visits and guided tours of several school classes at Jungfraujoch station.
CH	Master Thesis of Quirin Beck: Evaluation of SUEWS (Surface Urban Energy and Water Balance Scheme) for Basel flux towers' energy and CO_2 fluxes. University of Basel
CH	Doctoral thesis of Ankit Shekhar: Forest vulnerability to extreme dryness stress. DISS. ETH NO. 29410. ETH Zurich, https://doi.org/10.3929/ethz-b-000634638
CH	Lecture "Urban Climatology", Autumn Semester, University of Basel
CH	Practical Course "Measurement methods for fine dust and trace gases" (Praktikum: Messmethoden für Spurengase und Feinstaub), University of Basel
SE	Finished PhD thesis using ICOS data Hallgren, Christoffer. Charaterization and forecasting of wind conditions over the Baltic sea. UU, PhD. Junttila, Sofia. Modelling carbon uptake in Nordic forest landscapes using remote sensing. LU, PhD White, Joel. The functional potential of methane producing and consuming microorgansims in a changing world. LU, PhD. Zinke, Julia. Factors influencing emission fluxes and bacterial enrichment in sea spray aerosols, SU, PhD.
SE	(Masters and BSc only if really working at the station)

	Mastepanov, Ilia, 2023. Seasonal variation of LAI in Swedish coniferous forest. LU, BSc Carlsen, Mads, 2023. The Effects of Clear-Cutting a Hemiboreal Forest on Local CO2 Fluxes in Norunda, Sweden. LU, MSc Forsmalm, Malin, 2023. Investigation of Ice Nucleating Particles (INPs) in southern Sweden - With a special focus on their origin, possible connection to meteorological parameters and aerosol properties. LU, MSc Ellen Soroka, 2023. Testing aerosol vertical profiling methods with portable instruments on unmanned and manned aircraft. LU, MSc Kabir, Tamina, 2023. Seasonal Variability of Ice Nucleating Particles (INP) in Southern Sweden. LU, MSc Szetela, Jessica, 2023. Into the mire: a floristic and ecology informed field guide of Stordalen mire. US, MSc Requardt, Anna Valeria, 2023. Climate Effects of Managed Boreal Forests. SLU, MSc Havertz, Nils Helge, 2023. GIS and remote sensing based mapping of microtopography and vegetation composition in a boreal mire complex. SLU, MSc
SE	Lectures* and university classes Tobias Rütting, GV1410 – Geovetenskap: grundkurs, GU, SE, BSc Andreas Johnsson, GVN400 – Geovetenskaplig metodik, GU, SE, BSc Tobias Rütting, GVK460 – Biogeochemistry, GU, SE, MSc Johan Uddling, BIO506 – Plant ecophysiology in a global change perspective, GU, SE, MSc Dan Hammarlund, GEON09 – Globala miljöförändringar i ett geologiskt perspektiv, GU, SE, MSc Bethanie Carney Almroth, ES1201 - Miljövetenskaplig baskurs, GU, SE, BSc Magnus Hellqvist- Regional miljögeovetenskap (GV2001), GU, SE, BSc Harry Lankreijer– Greenhouse Gases and the Biochemical Cycles (NGEN14), LU, SE, MSc Paul Mann - Masters in Environmental Monitoring, Modelling and Reconstruction, Northumbria University, UK, MSc Reiner Giesler - Terrestrial Biogeochemistry, Umeå University, SE, MSc Ruth Varner - Emergent ecosystem response, University of New Hampshire, US, MSc Thomas Holst – Theory and Methods of Physical Geography (NGEA07), LU, SE, BSc Thomas Holst – The Climate System (NGEA21), LU, SE, BSc Thomas Holst – Hydrology (NGEA22), LU, SE, BSc Thomas Holst – Technology, Soil and Climate for Horticultural Production, SLU, SE, BSc Thomas Holst - Climate change & biogeochemical cycles (NBIK14001U), Copenhagen Univ, DK, MSc Axel Eriksson - Aerosol Technology (TFRG11), LTH, SE, BSc Erik Nilsson - Geovetenskap - planeten jorden/meteorolgy course, UU, SE, BSc

	Per-Ola Olsson – Programming for applications in GIS and remote sensing (NGEN20), LU, SE, MSc Karolina Pantazatou - Programming for Applications in GIS and Remote Sensing (NGEN20), LU, SE, MSc Adam Kristensson - Miljöövervakning (MVES04), LU, SE, MSc Eveline Krabb - Soil biology and biogeochemical cycles, SLU, SE, MSc Sofi Jonsson - Environmental Field Studies, SU, SE, MSc Margareta Hellström/Harry Lankreijer - How to take care of your data: Introduction to practical data management, LU, SE, PhD
UK	Leigh S. Fleming (UEA) successfully defended PhD Thesis in July 2023. Analyses of multi-species greenhouse gases and related tracers using novel measurements at Weybourne Atmospheric Observatory, Norfolk, UK
UK	Andrew Manning taught 10 weeks on a final-year undergraduate class titled "The Carbon Cycle and Climate Change"; heavily related to ICOS themes, and also presents Weybourne station data.
ETC	Teaching at the FLUXCOURSE2023 (Papale)
ETC	Master course on Monitoring Terrestrial Carbon Cycle in Viterbo (Italy) (Papale)
CRL	PhD Thesis: Fabian Maier
CRL	Master Seminar Environmental Physics - Summer term 2023/24 Master Seminar Environmental Physics - Winter term 2023/24 50th Heidelberg Physics Graduate Days: S. Hammer: The Current State of the Global Carbon Cycle: Insights from Observations, Isotope Studies and Modelling

List of Main ICOS National Network Meetings

	Meeting / Seminar	**Time**	**Place**	**Nr. of participants**
BE	ICOS Belgium annual progress meeting	28 February 2023	Brussels	NA
BE	ICOS Atmospheric MSA meeting	15 – 17 April 2023	Brussels	NA
BE	ICOS Belgium Science Conference	20 April 2023	Brussels	60
BE	ICOS Wallonia annual meeting	11 September 2023	Gembloux	10
CZ	CzechGlobe Working Meetings and Seminars	Several times a month	Brno CzechGlobe seat and ICOS CZ sites	5-10
DK	DK ICOS partner meeting	June	Zoom	

DK	Several meetings involving Cop. Uni and DTU with ministries of education and research + min of Climate	Spring/Summer/Autumn	Zoom/Physical	
FI	ICOS Finland board	March 2023	Teams	10
FI	ICOS Finland board	October 2023	Hybrid, FMI Helsinki and Teams	12
Fi	ICOS Annual meeting 2023	January 2024	FMI building Helsinki	50
FI	ICOS Finland board	March 2023	Teams	10
FR	Journées ICOS France meeting 2023	8-10 Nov 2023	Montpellier	61
FR	Obs4clim General assembly	27-28 Nov 2023	Paris	
DE	ICOS Germany Annual Meeting	24.-26.10.2023	Max Planck Institute for Biogeochemistry, CAL-FCL, Jena	25 (+15 online)
IE	ICOS Ireland National Meeting	10:00-15:00 2nd March	Dublin, Ireland	14
IE	ICOS Ireland National Meeting	10:00-17:00 17th May	Dublin, Ireland	18
IE	ICOS Ireland National Meeting	09:00-17:00 8th November	Dublin, Ireland	15
IT	Meeting ICOS-Italy Atmosphere	22/2/2023	Virtual	22
IT	Visit of OTC representative Tobia Steinhoff at the MIRAMARE, and PALOMA	8-10/05/2023	OGS Chemical and Biological Laboratories, Trieste	10
IT	Presentation of E2M3A	8-10/05/2023	OGS (headquarters)	6
IT	ICOS ITALY JRU	08/06/2023	Lampedusa and online	Almost 30
IT	Meeting ICOS-Italy Atmosphere	20/11/2023	Virtual	16
IT	Meeting ICOS-Italy Atmosphere	21/12/2023	Virtual	20
NL	ICOS National Assembly	Feb 8, 2023	Utrecht	12
NL	Ruisdael Science day	Sept 28, 2023	Cabauw	± 50
CH	ICOS Davos Spring Meeting	18 April	Birmensdorf, WSL	13

CH	HFSJG (Jungfraujoch) user meeting	12 May	Bern	18
CH	ICOS Switzerland Annual Meeting	12 September	Dübendorf, Empa	26
SE	Technician Meeting	1/month	digital	Between 5 and 12
SE	ICOS SE meeting	31 March	Digital	
SE	PI & coordinator meeting	3 May	Digital	
SE	PI & coordinator meeting	29 sep	Digital	

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

	Event	**Time**	**Place**	**Nr. of participants**
BE	ICOS Belgium Science Conference	20 April 2023	Brussels	60
CZ	FLUXNET Meeting – 2023 conference	July 11-14, 2023	Brno	90
DK, NO	ICOS Nordic meeting	Nov	Bergen	85
FI	Seminar on GHG inventory – how flux measurements and GHG modelling can be utilized?	September 2023	FMI, Helsinki	70
FI	ICOS Summer school (Timo Vesala and UH co-organizing)	May 2023	Hyytiälä Forestry station	38 students
DE	Information Day ICOS & Peatlands	26.10.2023	Max Planck Institute for Biogeochemistry, CAL-FCL, Jena	20
DE	Series of surface ocean pCO2 workshops (SOSOM, SOCONET, SOCAT)	06. – 09. November 2023	VLIZ Flanders Marine Institute, Oostende/Belgium	100
IT	PRO-ICOS_MED results presentation event "ICOS Italy meets in Lampedusa"	6-7 th June 2023	Lampedusa	Almost 50
IT	"Center for experiences on the Atmosphere, Climate and Environment" project presentation event	10th July 2023	Sestola	Almost 50

IT	Potenza ICOS Station presentation event	26th July 2023	Potenza	Almost 70
NL	NCGG9 Conference on Non-CO_2 greenhouse gases	June 21-23, 2023	Amsterdam	± 120
NL	Celebration of 50th Cabauw anniversary	Sept 29, 2023	Cabauw	± 70
CH	PAUL ICOS cities project Meeting	28 - 30 March	Dübendorf, Switzerland	60
CH	6th VAO Symposium	21 - 23 March	Grainau, Germany	90
CH	21st Swiss Geoscience Meeting – Session "Atmospheric Composition and Biosphere-Atmosphere Interactions"	18 November	Mendrisio, Switzerland	40

List of Main Events Attended by ICOS staff

Member	Workshops and conferences attended	Time	Place
All	EGU General Assembly	23-28 April	Vienna
Many	WMO GGGW	Oct, Dec	Geneve
All	MSA meetings		
Many	ENVRI Week	30 Jan – 3 Feb	Leipzig
Many	Global Earth Observations Workshop	8-10 May	Hyytiälä
HO	2nd Forum of the Mission on Adaptation to Climate Change	12-13 June	Ronneby
HO	Swedish Presidency Conference on Research Infrastructures	19-20 June	Lund
Many	ENVRI Policy Event	21 June	Lund
HO	Hybrid Event: Nature-based solutions to increase carbon sinks on land	21 Sept	Brussels
HO	World Climate Research Programme Conference	23-27 October	Kigali
BE, FR	ICOS France Science conference	9-10 Nov	Montpellier
CZ, IE, ETC	FLUXNET	July	Brno
CZ, IE, HO	UNFCCC COP28 & SB meetings	November	Abu Dhabi
FI,IE	AGU	11-15 Dec	San Francisco

FI	Nordic-Baltic Workshop on Greenhouse Gas Exchanges and Carbon Cycling in Managed Peatlands,		Vidal, Sweden
FR, HO	1st Northern Europe "4 per 1000" Regional Meeting	June 2023	Helsinki
GR	ACCC Impact Week	April	Helsinki
GR	Symposium Chair of the Joint Urban and Remote Sensing Event (JURSE) 2023		Heraklion
GR	IGARSS		Pasadena
FI, GR	ICUC11 - 11th International Conference on Urban Climate		Sydney
GR	SPIE Sensors + Imaging Symposium, Amsterdam	September	Amsterdam
GR	EuroGEO Workshop, chairing the EuroGEO Urban Action Group	October	Bolzano
GR,HO	GEO Week and Ministerial Summit	November	Cape Town
HU	NOAA 51st Global Monitoring Annual Conference		Boulder, USA
IT	109th Congress of the National Society of Physics, Fisciano, Italy (11 – 15 September 2023)		
IT	ITINERIS Project WP4 meeting, Potenza, 3-4 July 2023		
IT	NCGG9 2023 (9th International Symposium on Non-CO2 Greenhouse Gases	June	Amsterdam
IT	. iLEAPS – OzFlux Joint Conference 2023	January 30 – February 4, 2023	Auckland, New Zealand
IT	36th Task Force meeting of the ICP Vegetation,		Online
NL	NCCG9	June	Vienna, Austria
NL	Ruisdael Science Day	September	
NO	Ninth Joint Session of the EMEP Steering Body and Working Group on Effects	September	Geneva, Switzerland
CH	GAW DACH Meeting	23 January	Munich
CH	Colloquium of the Institute for Landscape Ecology, University of Münster	24 January	Münster
CH	International GHG Monitoring Symposium	30 January to 01 February	Geneva
CH	6th VAO Symposium	21-23 March	Grainau
CH	Joint National GAW/GCOS coordination meeting	23 March	Bern
CH	ANAKON 2023	11-14 April	Vienna

CH	EuroAnalysis 2023	27-31 August	Geneva
CH	International Workshop on High-Altitude Atmospheric Measurements	28 August	Jungfraujoch
CH	ICUC-11 International Conference on Urban Climate	28 August to 01 September	Sydney
CH	Umwelt 2023	13 September	Muttenz
CH	21st Swiss Geoscience meeting	18 November	Mendrisio
SE	New Horizons in Environmental Mechanics, NCAR	July	Boulder, USA
UK	SOCAT, SOCONET worldwide meeting on Surface Ocean pCO2 workshop	6-9 October	Ostend
UK	OceanSITES Virtual workshop		virtual
UK, FCL	Fourth International Workshop on Atmospheric Oxygen,	23- 25 Aug 2023	Brunswick, Maine, USA,

List of outreach events

BE	Event	Person	Media	Note
BE	XIII Seminar for users of STICS, Bordeaux, France, 15 November 2023	M. Delandmeter	Seminar	
BE	TERRA innovation day	Team ULiège	Visiting day	
BE	Carbon storage in the soil, a co-benefit of improving soil quality ? -	B. Heinesch	Newspaper story, CELAGRI	https://www.celagri.be/compte-rendu-de-la-journee-celagri-2024-face-au-changement-climatique-comment-lagriculture-fait-partie-des-solutions/
BE	Importance of precipitation measurements on forest resilience	C. Vincke	Newspaper story, Le Vif	
BE	De klimaat en energietransitie, waar staan we?	H. Verbeeck	Keynote lecture, VENECO (Flemish intermunicipal organization)	
BE	We are not on track to net zero, but there is hope.	H. Verbeeck	Keynote lecture, VOKA, release charter on sustainable	VOKA is the Flemish Employers' organization

			entrepreneurship	
BE	Sense of urgency inzake klimaat. Key-note lezing. VOKA Academy Duurzaam ondernemen.	H. Verbeeck	Keynote lecture, VOKA - Academy sustainable entrepreneurship	VOKA is the Flemish Employers' organization
BE	Vranckx en de Nomaden: Yangambi een klimaat van spanning.	Thomas Sibret (PhD) and Fabrice Kimbesa (technician)	National television (Flanders), interview/ documentary	Vranckx & de Nomaden - zaterdag 25 november 2023 om 20:10 | VRT MAX
BE	2nd Biodiversity conference (Kisangani, DRC)	P. Boeckx	Conference, Keynote lecture	
BE	Conference on emission monitoring in harbors entrepreneurship	B Gielen	Conference, lecture	
BE	Oostende voor Anker	F Lauriks	Day of Science	
BE	Dag van de Wetenschap	M. Roland	Science village, at Ostend city festival	
BE	Ellsworth D, Verbeeck H, Soudzolovskaia N, Baeten L, Hubau W, Van Coillie F, Verheyen K et al. 2023. Our natural capital, research needs and priorities for the future.	H. Verbeek	White paper	Our natural capital: research needs and priorities for the future (ugent.be)
CZ	Article: Tiší strážci krajiny Silent guardians of the landscape - interview by Marian Pavelka for the magazine "A" (published by the Academy of	Marian Pavelka	The magazine "A" (published by the Academy of Sciences of the Czech Republic, 2023) https://pdf.avcr.cz/A/2023-02/#page=47	Interview on topic – ecosystem stations

	Sciences of the Czech Republic, 2023)			
CZ	Interview – Marian Pavelka – TV – ČT24 (Czech national TV) Studio 6 (20. 6. 2023)	Marian Pavelka	TV ČT24 (Czech TV) Studio 6 (20. 6. 2023) https://www.czechglobe.cz/cs/marian-pavelka-pro-studio-6-ct24/	Interview on topic – ICOS CZ ecosystem station Bily Kriz, climate change and forests)
CZ	Popularization lecture for general public during the event Academy of Sciences Week – prof. Michal V. Marek - The importance of forests for mitigating global climate change, 8.11.2023	Marian Pavelka	Popularization lecture for general public, event invitation: https://www.czechglobe.cz/cs/media-a-pr/tyden-akademie-ved-2023/	
CZ	Article: Tiší strážci krajiny Silent guardians of the landscape - interview by Marian Pavelka for the magazine "A" (published by the Academy of Sciences of the Czech Republic, 2023)	Marian Pavelka	The magazine "A" (published by the Academy of Sciences of the Czech Republic, 2023) https://pdf.avcr.cz/A/2023-02/#page=47	Interview on topic – ecosystem stations
FI	Webinar "Climate and water quality impacts of afforested cutover peatlands and rewetted forestry-drained peatlands", 22.9.2023	Annalea Lohila, Tuula Aalto	Intended for the experts and public authorities; the Finnish broadcasting company YLE showed our results and made a video clip from an open-door day held in the same occasion	Presented GHG flux data from e.g. a new flux station covering both ICOS and ACTRIS type of measurements

			in the local news, 70 attendees	
FI	Webinar "Climate and water quality impacts of afforested cutover peatlands and rewetted forestry-drained peatlands", 14.11.2023	Annalea Lohila, Tuula Aalto	Intended for landowners and public audience, 80 attendees	Presented GHG flux data from e.g. a new flux station covering both ICOS and ACTRIS type of measurements
FI	Presentation Kaupunkivihreän mallintamisella tukea päätöksentekoon (Modeling urban green to support decision making) 12.12.2023	Leena Järvi	The Smart City Talks by Sitowise company, online	
FI	Presentation Nature-based solutions in carbon- and climate-smart cities, 23.3.2023	Leena Järvi	European Parliament Seminar directed for selected MEP's and EU Directorates-General representatives ,23.3.2023, Brussels, Belgium	
FI	Presentation "Kaupunkialueiden hiilensidonta" (Carbon sequestration by urban areas)	Leena Järvi	Hiilineutraalius ja kestävät hankinnat viheralueilla by the City of Joensuu, 17.8.2023, online	
FI	Interview: Kaupunkipuiden istuttaminen luokin uuden päästölähteen hiilinielun sijaan	Leena Järvi	Newspaper Helsingin Sanomat https://www.hs.fi/kaupunki/art-	

	(Planting urban trees creates a new emission source instead of carbon sequestration), 15.1.2023		2000009234616.html	
FI	Participation in panel discussion on *More nature to cities*	Leena Järvi	Climate Change and Biodiversity Now event series, 1.10.2023, Helsinki, Finland	
FI	Presentation *Metsien hiilinielujen laskenta päivittyy - Mitä muutos merkitsee Suomen metsien käytölle*	Timo Vesala	Päättäjien metsäakatemia event, 18.4.2023, Kirkkonummi	
FI	Presentation B*enefits of open data for the scientist who opens*	Timo Vesala	FAIR opening of research data seminar, 22.8.2023, Helsinki	
FI	Presentation Lehmuskallio ja turvemaat	Timo Vesala	Lehmuskallio seminaari in Kino Regina, Oodi, Helsinki, 9.12.2023	
FR	ATC Visits at least 10 in the year (including journalists from France TV, AFP and E5)		Visit	Over 200 visitors total
FR	Fete de la science at OVSQ	M. Delmotte ; M. Ramonet	Public event	
FR	Seminars with mention of ICOS	M. Delmotte	Seminar	
FR	High school	M.Delmotte	Student internship	

	student internship (40 in 2023)			
FR	Fresque du climat	M.Delmotte	Workshop	
FR	Visit France Nature Environnement in FR-Pue	23	Environmental NGO	Nov 28, 2023
FR	Visit RDI ONF in FR-Fon	60	National Forest Office	
FR	Exhibition in Cité des Sciences, Paris with on-line data from FR-Fon		National Museum	Since May 16, 2023
FR	Visit "oeuvre d'eau" association in FR-Pue	16	Environmental Association	May 14, 2023
DE	CVOO visit by German president F.-W. Steinmeier		Visit	
DE	The Ocean Race – Stopover Cabo Verde (science fair and summit) with Antonio Guterres (UN secretary general)		Science fair and summit	
DE	Exhibition 70 years DWD, incl. ICOS-DWD, at German Parliament (Kubistin, Müller-Williams, Lindauer, Plass-Dülmer) – Outreach to German politics, 20.4.-12.5.23. with Poster ICOS-D at DWD		Exhibition	
DE	Deutscher Bundestag - Ausstellung „70 Jahre zwischen Natur & Gesellschaft",		Exhibition	https://www.bundestag.de/ausstellung-dwd

DE	Exhibition 70 years DWD, incl. ICOS-DWD, at Klimahaus in Bremerhaven (Kubistin, Müller-Williams, Lindauer, Plass-Dülmer) – Public Exhibition from 21.9.2023-Spring 2024 with Poster ICOS-D at DWD		Exhibition	
DE	Klimahaus Bremerhaven | Hier geht's rund. Um die Welt.			https://www.klimahaus-bremerhaven.de/
DE	Days of Open Doors, Observatory Hohenpeissenberg, 1.-2.7.2023 (Kubistin, Müller-Williams, Lindauer, Plass-Dülmer), Presentation ICOS, Poster ICOS, some 5000 visitors		Visit	
DE	German TV ZDF documentary on drought stress: „Die Welt im Dürrestress: Trocknet Deutschland aus?“ (15.08.2023):		Television	https://www.zdf.de/dokumentation/zdfzeit/zdfzeit-trocknet-deutschland-aus-100.html
DE	#ExploreICOS video campaign at Gebesee site, 17.-19.07.2023			
DE	#ExploreICOS media campaign (video and article) at ICOS associated station Berlin-Rothenburgstrasse (ecosystem station) from 20.07.-21-07.2023			

DE	UFZ: Discussion with the federal states Ministry of the Environment regarding the renaturation of peatlands, including the site DE-GsB.		Participation in a first planning meeting and interactions to prepare a common proposal with the European Union.	
DE	Web app showing the : main data collected at the field sites:		Data dashboards for stakeholders	Example: DE-GsB The interest is currently high, due to the recent floods in the area.
DE	Always in the flow Highly polluted estuaries sometimes take decades to recover.		Press release for the Rewrie et al. (2023) paper	https://www.hereon.de/innovation_transfer/communication_media/news/111464/index.php.en
DE	Significant shifts in inorganic carbon and ecosystem state in a temperate estuary (1985–2018)		Radio interview with Deutschlandfunk in October, 2023 & 2 newspaper articles:	https://wiley.altmetric.com/details/151008727/news
DE	Press release for Schultz et al. (2023) paper:			https://hereon.de/innovation_transfer/communication_media/news/111506/index.php.en https://www.altmetric.com/details/152611997/news
DE	Talk for visitor guides of the National Park Hainich	Anne Klosterhalfen	Talk	
DE	Digital Forest. A virtual journey into climate research	Alexander Knohl, Franziska Koebsch	Exhibition in the Forum Wissen (Museum of Knowledge in Göttingen)	26. October 2023 - 04. February 2024, including many collateral events, such as interviews, guided tours, podium discussions, symposia, children workshop, excursions
DE	Guided tour with experts, 03. November 2023, 05. November	Alexander Knohl	Visit	

	2023, 14. January 2024,			
DE	Chalk Talk: „Wald und Klima: Eine Beziehung im Stress?“, 08. December 2023,	Alexander Knohl	Talk	
DE	Discussion: “Digitaler Wald: Behind the Science – The Science Behind”, 25. January 2024,	Alexander Knohl, Franziska Koebsch, Frank Tiedemann	Discussion	
DE	Scientific Conference 2023 (SciCon 2023): “Forest under Pressure”	Anne Klosterhalfen	Workshop	
DE	Lecture for Saturday Morning Science at University of Göttingen, 18. November 2023 -	Anne Klosterhalfen	Lecture	
DE	Talk for Gesellschaft für Nachhaltige Entwicklung (GNE) Witzenhausen, 06. December 2023	Anne Klosterhalfen	Lecture	
DE	Excursion to Hainich flux tower site with group of the German Soil Science Society (DBG)		Visit	
GR	2nd Symposium of the Association of Physicists of Crete "Physics in Action" 19/3/2023. Invited Talk on: "Exploitation of Earth Observation in the domains of Urban Climate and Urban Resilience"		Talk	

	(Heraklion, Greece).			
GR	Interviewed by "Skai Kritis" radio regarding the Joint Urban and Remote Sensing Event (JURSE) 2023		Radio	
GR	Presentation by the Athens-Macedonian News Agency of the activities of the Remote Sensing Laboratory related to monitoring the impact of interventions, aiming at both mitigation and adaptation to climate change in the city of Heraklion (September 2023			
GR	Public presentation of Finokalia observations including ICOS GHG data, trends and explanation of the implications for climate change during the celebration of 30 years operation of Finokalia monitoring station, Agios Nikolaos, Lasithi (June 2023)		Talk	
HU	Presentation of ICOS-Hungary activities to the National Research, Development and Innovation Office		lecture	Budapest, Hungary 20 participants

IT	A national broadcast has included ICOS in a special episode of FUTURO24, a national TV show. The programme registered almost 530 000 share.		Television	530 000 shares
IT	109th Congress of the National Society of Physics	Paolo Cristofanelli	Invited Lecture on trace gas measurements at the Global WMO-GAW station Mt. Cimone	Promotion of ICOS data
IT	"Sentiero dell'atmosfera" (open days at IT-CMN)	Paolo Cristofanelli	Visit of citizens to the Mt. Cimone observatory	Public visits on 26 July 2023
IT	"Futuro24"	Gabriele Guidolotti	Rai news broadcast	530 000 share
IT	Quante storie sulla CO2 di origine antropica: il clima è già cambiato anche in passato e non per colpa dell'uomo! … Oppure no? Due parole su alcuni miti dei negazionisti del cambiamento climatico. ISISS ValleSeriana, Gazzaniga (BG)	Gerosa Giacomo	Conference	200 attendees
IT	InSilva. Alberi e boschi raccontano il cambiamento climatico. Evento divulgativo tenutosi presso la RNO di Bosco della Fontana. Marmirolo (MN)	Angelo Finco	Conference	150 attendees

IT	Benefits of planting trees: what science can tell us		Information meeting at the Sarezzo library	
IT	SIR (agenzia di informazione AVVENIRE) – Intervista su Alluvione in Emilia Romagna			Related to floods
IT	Il Giorno – Intervista su Alluvione in Emilia Romagna			Related to floods
IT	SkyNews24 (TV) – Passaggio Intervista sul telegiornale delle 13:30 sull'Alluvione in Emilia Romagna		television	Related to floods
IT	RaiNews – Passaggio Intervista sul telegiornale delle 14:40 sull'Alluvione in Emilia Romagna		television	Related to floods
IT	2023 Giornale di Brescia – Articolo su Alluvione in Emilia Romagna			Related to floods
IT	Intervista radiofonica su InBLU2000 per l'Alluvione in Emilia Romano		Radio interview	Related to floods
IT	EspansioneTV (emittente di Como) – Passaggio Intervista sul telegiornale delle ore 11:00 sull'Alluvione in Emilia Romagna		Television	Related to floods
IT	Cattolica News – Articolo in occasione della Giornata mondiale			

	prevenzione disastri naturali			
IT	2023 OGS team (Michele Giani, Alessandro Laudicella, Martina Kralj) with the help of the Marine Protected Area staff (Carlo Franzosini) helped the organization of video & photoshoots carried out by Charlotte Henry of ICOS Communication in Trieste Italy			
NL	Celebration Cabauw anniversary including several media posts	Caroline Kohlmann-van Noord	News items on the websites of KNMI, TNO and Ruisdael, LinkedIn posts	Attended and received very well. Good attendance by Dutch ministries.
NL	National Newspaper article (NRC) about carbon sequestration in forests	Michiel van der Molen, Wouter Peters		Attracted a lot of attention and reactions.
NO	NAUTILOS summer school	Nick Roden	talk about surface water CO2 observations and sensors	
NO	Viking Expeditions cruise	Andrew King	talk to expedition guests about "How scientists study oceans and lakes"	
NO	Data Day 2023	Meike Becker	Data and AI in climate and environment	
NO	ICOS summer school	Meike Becker	Quantifying the ocean carbon cycle	

CH	Release of the " Research Site Davos-Seehornwald — Excursion guide"	Susanne Burri (ed.)	ETH Zurich research collection	35 pp, https://doi.org/10.3929/ethz-b-000609359
CH	"Schwitzen Wiesen und Wälder so wie wir?"	Nina Buchmann	Invited talk of the Senioren-Kolleg Liechtenstein in Mauren (FL)	30 March 2023
CH	"Wärmeinseln in Basel – Eine kurze Einführung in die Stadtklimatologie»	Christian Feigenwinter	Invited talk of the Seniorenuni Volkshochschule beider Basel in Basel (CH)	29/30 November 2023
CH	Wälder leiden unter jahrelangem Wasserdefizit	Roman Zweifel	Radio interview (Swiss radio and television SRF)	https://www.srf.ch/news/schweiz/schweizer-wald-waelder-leiden-unter-jahrelangem-wasserdefizit
CH	Siccità sotto la lente 2022, l'anno più caldo e asciutto mai registrato dal 1864 in Ticino	Roman Zweifel	Reportage in Swiss Italian TV RSI	https://www.rsi.ch/la1/programmi/cultura/il-giardino-di-albert/Siccità-sotto-la-lente-16289809.html
CH	Sprechende Bäume, die sich vor Feinden warnen, und Pilze, die ihnen dabei helfen: Gibt es das wirklich?	Roman Zweifel	Article in a Swiss newspaper, NZZ	https://www.nzz.ch/wissenschaft/sprechende-baeume-die-sich-vor-feinden-warnen-und-pilze-die-ihnen-dabei-helfen-immer-mehr-forscher-sprechen-vom-wood-wide-web-gibt-es-das-wirklich-ld.1735116?reduced=true
CH	"Hoch hinaus – Spitzenforschung zu KI, Nachhaltigkeit und Hochgebirge"	Martin Steinbacher	Report of the WPK Recherche reise in die Schweiz, 7 to 13 May 2023	https://wpk.org/was-wir-bieten/recherchereisen/berichte-der-recherchereise-hoch-hinaus-in-die-schweiz/
CH	Waldschutzüberblick 2022. Witterung und ihre Auswirkung auf Schweizer Waldbäume.	WSL, TreeNet	Report	https://www.wsl.ch/de/publikationen/waldschutzueberblick-2022/
CH	Visit of a delegation of the Global Change Research Institute	Martin Steinbacher	Training as part of the trans-national training	16 October 2023

	(CzechGlobe) from the Czech Republic to the Empa laboratories		services in the frame of ATMO-ACCESS	
CH	Visit of the Directors of the Swiss Federal Office for the Environment and Empa at Jungfraujoch	Markus Leuenberger, Lukas Emmenegger	Station visit	3 March 2023
CH	Visit and guided tour for MeteoSwiss management (62 persons) at Jungfraujoch	Markus Leuenberger	Station visit	16 May 2023
CH	Visit and guided tour of 78 ambassadors at Jungfraujoch organized by the State secretary Livia Leu	Markus Leuenberger	Station visit	2 June 2023
CH	Visit of the ambassador of Chile, Information about research projects at Jungfraujoch	Markus Leuenberger	Station visit	8 June 2023
CH	Visit of the ambassador of Pakistan, Information about research projects at Jungfraujoch	Markus Leuenberger	Station visit	21 June 2023
CH	Visit of the PhD Summer School Mont-Soleil at Jungfraujoch (Presentation by Prof. Silvio Decurtins)	Markus Leuenberger	Station visit	12 August 2023
CH	Visit of a delegation from Beijing University at Jungfraujoch	Markus Leuenberger, Martin Steibacher	Station visit	28 August 2023

CH	Visit of a delegation from Pakistan organized by the embassy of Pakistan in Switzerland, Jungfraujoch	Markus Leuenberger	Station visit	29 November 2023
SE	Här mäts kalhyggets utsläpp	Cheng Wu, Stockhom University	Sveriges Radio, 2023-08-10	Radio broadcasting
SE	Torkan minskar skogens koldioxidupptag - forskare följer utvecklingen i Hyltemossa	Anders Lindroth, Lund University	SVT Skåne, 2023-06-12	TV
SE	Jubilée excursion Kulbäcksliden and Svartberget 100 years	SLU Unit for field-based forest research, NFI & Skogshistoriska sällskapet	excursion	Site visit
SE	Nordic-Baltic workshop on GHG fluxes from managed/restored peatlands	Mats Nilsson, SLU	Workshop with stakeholders	
SE	20th Annual Krycklan Symposium	Hjalmar Laudon, SLU	symposium	
SE	Research Conference on Sustainable Development 2023	Jutta Holst, LU	2023-09-08	Introducery talk about ICOS
SE	Vattenhallen, Lund	Jutta Holst and other staff from Hyltemossa, LU	3 times in 2023	Interns from highschool to Hyltemossa
SE	NMT dagarna Lund (public talks within	Jutta Holst, LU	2023-03-17	Om att mäta ekosystemets andningar

	the faculties of Science, Medicin and Technology at Lund University)			
SE	ICOS - kunspap om kolbalanser genom observationer	Jutta Holst, LU/ Matthias peichl, SLU / Mats Nilsson, SLU / Marko Sch olze, LU	Presentation about carbon uptake measurements within ICOS at the workshop on climate reporting organised by SLU Uppsala and Naturvårdsverk et; 2023-03-02	presentation
SE	Open doors at Hyltemossa research station in connection with the district championship 2023 in orienteering	Hyltemoss a ICOS and ACTRIS staff, Jutta, LU	2023-09-24	General public event
SE	Nordic Ozone Group Meeting 3-4 May 2023	Pernilla Löf venius and Svb staff, SLU	2023-05-03	Excursion to ICOS Svb
SE	En månad kortare vinter i Svartberget (https://www.svt.s e/nyheter/lokalt/v asterbotten/en-manad-kortare-vinter-vid-svartberget)	Hjalmar Laudon, Svb staff, SLU	SVT Västerbotten, 2023-03-03	TV
SE	Liljaskolan Vännäs (upper secondary school)	Per Marklund, SLU		Intern working at Degerö
SE	Kalix Skogsbruksgymna sium (upper secondary school)	Per Marklund, SLU		Excursion to Deg
SE	Polar Insynsråd/Regerin	Katarina Gårdfeldt,	Government of fice	Site visit

	gskansliet 2023-05-23	Polar Research Secretariat, Abisko		
SE	CIRC höstsymposium 2023-10-03	Polar Research Secretariat, Abisko		presentation
SE	Luleå Upper Secondary School, Luleå	Elin Eriksson, Polar Research Secretariat, Abisko		Site visit
SE	Göteborg Higher coeducating school	Lisa Gulve, Polar Research Secretariat, Abisko		Site visit
SE	Norra Reals Upper Secondary School, Stockholm	Göran Dessen, Polar Research Secretariat, Abisko		Site visit
SE	Sint-Janslyceum upper secodary school, NL	Elina Lioukchina, Polar Research Secretariat, Abisko		Site visit
SE	ICOS – resurs för skolor (https://www.icos-sweden.se/icos_mint)	Jutta Holst	website	Collection of material to be used in schools
SE	Extremväder i ett föränderligt klimat	Anna Rutgersson	Kungl Vetenskapsakademien	presentation
SE	Sci-Fest 2023, koldioxid I vatten, Uppsala	UU, NTA (Naturvetenskap och Teknik för alla)		Science festival, Fyrishov, ca. 90 pupils (11 years)

Annex 2: List of Stations and their co-location with other RIs

Annex 3 Report of co-operation of ICOS and ACTRIS Head Offices

(As requested by the Academy of Finland / Finnish Research Infrastructure Committee)

Name	Domain	Class	Mr	Notes	eLTER	ACTRIS	Other
La Reunion	ATM	2	BE+FR	in FR	x	x	
Brasschaat	ECO	1	BE	ICP Forests	x		X
Dorinne	ECO	2	BE				
Lochristi	ECO	Associated	BE				
Lonzee	ECO	2	BE		x		
Maasmechelen	ECO	2	BE	ANAEE	x		X
Vielsalm	ECO	2	BE		x	x	
Yangambi	ECO	Associated	BE	in CD			
BE-FOS-Thornton Buoy	OCE	1	BE	LifeWatch	x		x
BE-SOOP-Belgica	OCE	1	BE				
BE-SOOP-Simon-Stevin	OCE	1	BE	LifeWatch			X
Jungfraujoch	ATM	1	CH			x	
Davos	ECO	1	CH		x		
Křešín u Pacova	ATM	1	CZ			x	
Lanzhot	ECO	1	CZ	Danubius			x
Bily Kriz forest	ECO	2	CZ	AnaEE	x		x
Trebon	ECO	Associated	CZ		x		
Gartow	ATM	1	DE				
Hohenpeissenberg	ATM	1	DE			x	
Karlsruhe	ATM	1	DE				
Lindenberg	ATM	1	DE			x	
Ochsenkopf	ATM	1	DE				
Schauinsland	ATM	1	DE				
Steinkimmen	ATM	1	DE				
Helgoland	ATM	2	DE				
Jülich	ATM	2	DE	IAGOS		x	x
Torfhaus	ATM	2	DE				
Westerland	ATM	2	DE				
Zugspitze	ATM	2	DE			x	
Fendt	ECO	Associated	DE				
Gebesee	ECO	1	DE				
Hohes Holz	ECO	1	DE		x		
Selhausen Juelich	ECO	1	DE	TERENO	x		
Tharandt	ECO	1	DE				
Berlin-Rothenburgstrasse	ECO	Associated	DE	PhenoCam			
Braunschweig	ECO	Associated	DE				
Graswang	ECO	Associated	DE				
Grillenburg	ECO	Associated	DE				
Grosses Bruch	ECO	Associated	DE		x		
Hainich	ECO	Associated	DE		x		
Hartheim	ECO	Associated	DE				
Hetzdorf	ECO	Associated	DE				
Kienhorst	ECO	Associated	DE				
Klingenberg	ECO	Associated	DE				
Mooseurach	ECO	Associated	DE				
Oberklenkendorf	ECO	Associated	DE				
Rollesbroich	ECO	Associated	DE	TERENO	x		
Schechenfilz Nord	ECO	Associated	DE				
Wustebach	ECO	Associated	DE	TERENO	x		

Cuxhaven St. FerryBox Pl.	OCE	2	DE	Danubius, Jericho			x
DE-FOS-CVOO	OCE	1	DE				
DE-FOS-Hausgarten	OCE	1	DE		x		
DE-SOOP-Atlantic Sail	OCE	1	DE				
DE-SOOP-Finnmaid	OCE	1	DE				
DE-SOOP-Polarstern	OCE	1	DE	MOSAIC			
Station Nord	ATM	2	DK			x	
Soroe	ECO	1	DK		x		
Zackenberg Fen	ECO	2	DK	in GL			
Disko	ECO	Associated	DK	in GL			
Nuuk Fen	ECO	Associated	DK	in GL			
Risoe	ECO	Associated	DK				
Zackenberg Gras	ECO	Associated	DK	in GL			
Gludsted Plantage	ECO	Associated	DK				
Skjern	ECO	Associated	DK				
Voulundgaard	ECO	1	DK				
El Arenosillo	ATM	2	ES			x	x
Izana	ATM	2	ES			x	x
Majadas de Tiétar	ECO	Associated	ES				
CanOA VOS-line	OCE	1	ES				x
ESTOC	OCE	1	ES				
Hyytiälä	ATM	1	FI		x	x	
Pallas	ATM	1	FI			x	x
Puijo	ATM	2	FI			x	
Utö - Baltic sea	ATM	2	FI	Jerico		x	x
Oulanka	ECO	Associated	FI	AnaEE	x	x	
Hyytiälä	ECO	1	FI	AnaEE	x	x	x
Sodankyla	ECO	1	FI		x		
Lompolojankka	ECO	2	FI		x	x	
Siikaneva	ECO	2	FI		x		
Kenttarova	ECO	Associated	FI		x	x	
Kuivajarvi	ECO	Associated	FI		x		
Kumpula	ECO	Associated	FI				
Lettosuo	ECO	Associated	FI				
Tvärminne	ECO	Associated	FI				
Varrio	ECO	Associated	FI	AnaEE	x	x	x
FI-SOOP-Silja Serenade	OCE	2	FI				
FI-FOS-Tvärminne	OCE	2	FI				
Observatoire pérenne de l'env.	ATM	1	FR	a.k.a Bure			
Saclay	ATM	1	FR				
Trainou	ATM	1	FR				
Puy de Dôme	ATM	2	FR			x	
Fontainebleau-Barbeau	ECO	1	FR				
Hesse	ECO	1	FR				
Lamasquere	ECO	1	FR				
Bilos	ECO	2	FR				
Font-Blanche	ECO	2	FR	AnaEE			x
Grignon	ECO	2	FR				
Laqueuille	ECO	2	FR	AnaEE			x
Lusignan	ECO	2	FR	AnaEE			x

Puechabon	ECO	2	FR	AnaEE			x
Aurade	ECO	Associated	FR		x		
Col du Lautaret	ECO	Associated	FR	AnaEE	x		x
Estrees-Mons A28	ECO	Associated	FR				
Guyaflux	ECO	Associated	FR				
La Guette	ECO	Associated	FR				
Mejusseaume	ECO	Associated	FR				
Montiers sur Saulx	ECO	Associated	FR	AnaEE			x
Toulouse	ECO	Associated	FR			x	
FR-SOOP-France-Brazil	OCE	1	FR				
Ridge Hill tower	ATM	2	GB				
Weybourne Atmospheric Observat	ATM	2	GB				
Auchencorth Moss	ECO	1	GB				
UK-FOS-PAP	OCE	1	GB	EMSO			X
UK-FOS-Western Channel Observa	OCE	1	GB				
Finokalia	ATM	2	GR				
HECKOR - Heraklion Kornarou	ECO	Associated	GR				
HECMAS - Heraklion Mastabas	ECO	Associated	GR				
Pertouli	ECO	2	GR				
Hegyhátsál	ATM	2	HU				
Carnsore Point	ATM	2	IE				
Mace Head	ATM	2	IE			x	
Malin Head	ATM	2	IE				
Valentia Island	ATM	2	IE				
Clara Raised Bog	ECO	Associated	IE				
Dooary	ECO	2	IE				
Leam West	ECO	Associated	IE				
Gurteen Farm	ECO	Associated	IE				
Johnstown Castle	ECO	2	IE				
RV Celtic Explorer	OCE	2	IE				
Lampedusa	ATM	2	IT			x	
Monte Cimone	ATM	2	IT			x	
Potenza	ATM	1	IT				
Plateau Rosa	ATM	2	IT				
Borgo Cioffi	ECO	1	IT				
Castelporziano2	ECO	1	IT		x		
Monte Bondone	ECO	2	IT				
Renon	ECO	2	IT		x		
Arca di Noe - Le Prigionette	ECO	Associated	IT				
Bosco Fontana	ECO	Associated	IT		x		
Lison	ECO	Associated	IT				
Nivolet	ECO	Associated	IT		x		
Osservatorio Ximeniano Firenze	ECO	Associated	IT				
Parco Urbano di Capodimonte	ECO	Associated	IT				
Torgnon	ECO	Associated	IT		x		
IT-FOS-PALOMA	OCE	1	IT		x		
IT-FOS-E2M3A	OCE	2	IT				
Lampedusa	OCE	2	IT				
IT-FOS-Miramare	OCE	2	IT				
IT-FOS-W1M3A	OCE	2	IT	EMSO			x

Ispra	ATM	2	JRC				
San Rossore 2	ECO	2	JRC				
Cabauw	ATM	1	NL			x	
Lutjewad	ATM	2	NL				
Loobos	ECO	2	NL				
Zeppelin Observatory	ATM	1	NO			x	
Birkenes Observatory	ATM	2	NO			x	
Hurdal	ECO	2	NO				
NO-SOOP-G.O.Sars	OCE	1	NO				
NO-SOOP-Tukuma Arctica	OCE	1	NO				
NO-SOOP Bergen-Kirkenes	OCE	2	NO				
NO-SOOP-Kronsprins Haakon	OCE	2	NO				
NO-SOOP-Trans Carrier	OCE	2	NO				
Hyltemossa	ATM	1	SE			x	(x)
Norunda	ATM	1	SE		(x)	x	
Svartberget	ATM	1	SE			x	(x)
Abisko-Stordalen Palsa Bog	ECO	2	SE	INTERACT	x		x
Degero	ECO	2	SE	INTERACT	x		x
Hyltemossa	ECO	2	SE	NordSpec		(x)	x
Mycklemossen	ECO	2	SE		x		
Norunda	ECO	2	SE	NordSpec		(x)	x
Svartberget	ECO	2	SE	INTERACT	x	(x)	x
SE-MFT-Östergarnsholm	OCE	1	SE			x	
SE-SOOP Tavastland	OCE	1	SE				
				sum	39	36	35
				total 110			

22.11.2023

Report to the Finnish Research Infrastructure Committee

ACTRIS and ICOS ERIC synergies at Head Offices

Introduction

The research infrastructure committee has included a requirement on the synergies between the ACTRIS ERIC and ICOS ERIC Head Offices in their decisions in recent years, including the latest funding decisions for both Head Offices. This is the second report of the plans and activities, following the report of 2022 activities submitted in January 2023.

The activities of each ERIC are defined by its respective Statutes, confirmed by the European Commission and member countries. The statutes are now available online, links to ICOS and ACTRIS. Each ERIC is directed by the respective General Assembly, 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 cooperate, exchange experiences and commonly develop best practices as part of their regular operations. This is especially true for research infrastructures hosted in the same country, and there has been cooperation and knowledge sharing between the ICOS ERIC HO, ACTRIS ERIC HO and Euro-Bioimaging Head Office from the beginning.

Thus, a lot of added know-how is gained in Finland through the establishment process of ICOS, Euro-Bioimaging and ACTRIS Head Offices. By 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 ERIC Head Office 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 offices is determined by the statutes and the decisions of the General Assemblies (GA) of the respective ERICs. Bothe 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 not negotiable, as it is defined in a contract between the DG and the respective ERICs GA.

The annual funding for the core activities is for ICOS ERIC currently about 1.25 million € per year, including so-called common contributions from all member and observer countries, and host contributions from Finland and France. It will be increased to about 1.32 million € in the third financial five-year period, an increase by 4,6 % of which 4.4% are realised through an increase in the common contributions. Finland intends to increase the host contributions by 18.000 € (1.4 % of the total Head Office budget), while France declared it will reduce its host contribution by 15.000 € (-1.2% of the total Head Office budget. The required number of personnel working on the core tasks is 9 full-time equivalents for ICOS ERIC (as documented to the 18th ICOS General Assembly meeting, document ICOS/GA18/2023/1). However, in the last application of funding to the Finnish Academy less funding was received. For ICOS ERIC it is clear that the required personnel costs will not be achieved by the foreseen financial contributions.

For ACTRIS ERIC the core funding is 1.0 million € for the first financial period, ending in 2025, including membership contributions and host premium contributions from Finland. It is to be noted that ACTRIS ERIC has one part (Services Access Management Unit, SAMU) of the ACTRIS Head Office in Italy. That part is not included in the Finnish research infrastructure committee funding decisions but receives its host premium contribution from Italy. Therefore that part not included in the synergies listed in this report. In ACTRIS Head Office in Finland the planned personnel is 7 persons as full-time equivalents.

With the constrained funding in respect to the personnel needs it is evident that the two Head Offices and the two General Assemblies deciding on their tasks need to aim for wise use of resources. In this context, the two Head Offices will discuss synergies with their General Assemblies which are the statuary bodies to decide on their tasks and activities.

Both ICOS and ACTRIS have a system of distributed Central Facilities, each of them mainly supported directly by its respective hosting countries. The detailed tasks and names of the Central Facilities are slightly different in ICOS and ACTRIS but the structure and funding model

are the same. For each Central Facility the host country contributes the major part of the costs. It is a matter of trust among the ERIC member countries that these host contributions are sustainable. According to Financial Rules of ICOS ERIC, the host contribution should not exceed 80% of the total costs. In fact, it is already closer to a 75% - 25% ratio in the next funding period (2025-2029) and might be further reduced in the future. In ACTRIS the sharing of the costs for the first five-year period is agreed to be 70% by the host country and 30% through membership contributions. In Finland the Host contributions of both Head Offices are shared equally between FMI and Academy of Finland.

External project funding is welcome to gain more resources for the development of the RIs and for allowing to perform tasks that would be difficult to complete otherwise. They are not available to fix budgetary holes in the core funding. ICOS ERIC has been successful in gaining external funding and this is visible in their international visibility and strong position in the European landscape. Currently ACTRIS is participating in several projects through the hosting institutes in different countries but starting from 2024 a some of that will be moved to ACTRIS ERIC as a coordinator or beneficiary in the RI-related projects.

ICOS ERIC participated in 6 project proposals submitted in March 2023, leading to 5 projects. ACTRIS participated in 7 project proposals submitted in March 2023 through its key RPOs, also leading to 5 projects. Some of the ACTRIS related activities and funding will be transferred to ACTRIS ERIC already in 2024. See details in Chapter 4.

Realised and planned synergy-increasing activities

A working group between the ICOS ERIC Head Office and ACTRIS Head Office preparation team was established in 2021. The group has investigated a list of 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 realised synergies by 2023 and the planned synergy actions in 2024 include the following aspects:

1. **Synergies on premises**

Realised & Planned: Co-locating Head Offices, negotiations with FMI

In 2022, the two HOs have agreed on locating the premises close to each other if this was possible from the FMI side. The meeting rooms and multi-workspaces of the HOs could be shared and used jointly. The negotiations with the FMI are still ongoing and more concrete plans can be developed jointly once the FMI has concluded their new internal strategy on the arrangements of the works spaces. This was originally due at the end of 2022, but the premises renewal project of FMI has been delayed from the original plan and now the estimated time for the detailed negotiations appears to be during 2024. In case the negotiations will not be successful for some reason, the two ERICs may look for alternative solutions jointly. In the long run, sharing facilities is expected to result in efficient use of the premises and savings in rental costs, or at least not increasing costs for both organisations.

Both organisations had discussions in their planning days about hybrid working modes and needs of the staff. This will be the basis for space planning jointly together by the two organisations. ACTRIS is currently located within the FMI premises, working within the

government rules for the office space. The plan is to continue the working mode in the open space office, with proper facilities for meetings and quiet working. As the staff will continue to work remotely to some extent, the office space is planned so that there would be no dedicated seats, thus empty spaces, but at the same time taking into account the needs for likely expansion during the next 5 years.

For ICOS, the plans are still very preliminary and tied to the timeline of changes. In 2023 ICOS ERIC was coordinator of 3 and beneficiary in 9 EU-funded projects. The projects have a significant impact of Head Office finance, but they also affect the need for space for project-related staff and remote meeting facilities.

Consideration: As the discussions with FMI / Senaattikiinteistöt are still ongoing, it is not possible to provide exact numbers, but the order of magnitude can be estimated. ICOS is currently paying for 104 m^2 of meeting rooms, corridors and lobby / multifunctional area, which are used sporadically. If ACTRIS ERIC HO was not collocated with ICOS, it would need roughly the same area of such spaces. By collocating the Head Offices, the same spaces can be used by both organisations, resulting in a 104 m2 area saving compared to the non-collocated HOs scenario. Assuming the current rent level ICOS is paying this means an annual saving of 25 000 - 30 000 € for the two ERICs combined.

2. Synergies on procuring third-party services

Realised: The two HOs have shared experiences in building the ICT solutions necessary for day-to-day operations. ICT systems can be combined only in some specific cases, as the two RIs have different approaches. ICOS ICT is run locally, in-house, at the Carbon Portal at Lund, Sweden, whereas ACTRIS is hosting all its ICT services in Helsinki and is looking for a fully cloud-based system. ICOS ERIC HO has participated in the general level negotiations on the ICT services for ACTRIS ERIC to see whether joint activities or procurements would be possible. The economic benefit here is, however, limited.

ICOS and ACTRIS purchased together in May 2023 a joint lecture of data security from computer service provider ATEA.

Both organisations currently use ATEA as main IT provider and have been discussing possible synergies that could be gained through joint services. As explained above, these possibilities are somewhat limited due to the different structure in organising the services, and the fact that the two ERICs are separate legal entities. A common project for developing the software for annual planning and reporting of the Central Facilities activities and finances to the ERICs has started in 2023. Even though the two organisations will have different versions of the system fine-tuned to their respective needs the high similarity of the systems allows joint development work at the ATEA side. This is a good example of the synergy at the practical level. The cost saving from this individual example is not yet estimated, but it is likely to be measured in thousands of euros.

Planned: Cooperation in procuring third-party services

Selecting the right outsourced web-based services from third parties related to, for example, ICT, HR or Communications (teleconferencing, discussion boards, conference-organising) is

consuming resources and requires that the users understand the activities. The synergies can be found in the benchmarking phase, even if the two ERICs end up making different decisions in the end. Sharing and learning from experiences saves time and money, but the amount is difficult to estimate.

If the two HOs are working in collocated premises, it is technically possible to provide a shared firewall, shared printing system and shared wireless network. The amount of potential saving depends on the level of data security needed between the organisations and the type of juridical contract between ICOS ERIC and ACTRIS ERIC considering that they are two separate legal entities. For software licences etc. no cost savings are foreseen as the contracts need to be organisation specific and licenses are usually invoiced per user. The estimated potential savings are some thousands of Euros annually. It is important to note that this work is still ongoing as the ACTRIS ERIC HO has not yet been set up physically. More detailed information on potential monetary benefits only after this work and the question on the location of the premises is concluded.

Consideration: The potential economic benefit through common tendering and common outsourcing of other services is limited. ACTRIS ERIC and ICOS ERIC are two different legal entities, so they need to be treated separately by the service providers. The same limitation applies to other contracted services. The goal of the two ERICs is to seek synergies and financial benefits wherever it is possible, through bilateral agreements.

3. Cooperation and shared personnel resources

Realised: Communications cooperation

ACTRIS and ICOS communication teams have cooperated actively for several years, and this cooperation has continued in 2023. ACTRIS and ICOS communication offices have actively shared each other's news and announcements through different channels to engage common stakeholders such as policy makers and industry. ACTRIS and ICOS are also co-leading communication activities in EU projects, e.g. ATMO-ACCESS, and had a joined booth at the EGU conference. ACTRIS and ICOS ERIC HO communications staff are meeting regularly to share best practices, together with FMI and the other main actors in the Kumpula campus.

Realised: Organisation of Innovation in Atmospheric Measurement Techniques workshop

ICOS and ACTRIS Head Offices (and IAGOS) cooperated in connection with organising an one-day free-of-charge Innovation workshop held online 8th June 2023. Prominent representatives of both ERICs gave keynote talks and chaired sessions. The audience consisted of e.g of RPO's, RIs, industrial companies and air-quality networks. The event was advertised on both organisations' websites, newsletters, and Twitter accounts.

Planned: Co-recruitments

The two HOs have been discussing together on possibilities for co-recruiting for non-core activities of the RIs especially when the position for one RI would be only part time. For instance, the aforementioned ICT expertise or part of the HR or communication support could be

a joint employment. Since the funding available from the projects varies from year to year, a common pool of experienced project officers may be an efficient way to keep experienced staff. Progress can be expected later, within 3-5 years, when both HOs are established fully.

ICOS has hired project related staff with fixed-term contracts stating . "... fixed-term until 31.12.2024, to be filled as soon as possible. There is a possibility for an extension depending on project funding." This "extension" may well take place fully or partially in ACTRIS, if the project funding situation supports that.

Consideration: It is important to realise that even though the two organisations fully agree on resource wise use of funding and personnel, co-recruitment is not necessarily easy for several reasons. First, especially for project management, the needed number of personnel fluctuates strongly annually and inter-annually. During the first years of operation ACTRIS ERIC may have less projects to be managed than ICOS ERIC. How then to divide the resources and costs so that it is fair for both organisations from year to year? Secondly, it has been seen during the last years that the recruitment of administrative personnel is not necessarily easy, and proposing a contract and work time under two different supervisors and that would be part time for both organisations is not necessarily increasing attractivity of the positions. However, both ERICs are doing their best in searching for best opportunities for joint recruitment in positions that allow the sharing of the work time without problems in loyalty or responsibilities.

Even though the co-recruitment appears to be challenging, there is a lot of potential in cooperation between the existing / planned personnel of the ERICs. Sharing of expertise and best practices leads to more effective and efficient work and use of resources. In such small organisations this does lead to cost savings due to reduction of workforce as the specific expertise of personnel but it will decrease the pressure to increase the workforce. Once ACTRIS ERIC is fully established and the tasks are properly running the type of cooperation currently practised between the communication teams is planned to extend also to other units of the ERICs.

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

Realised: Collaboration within ENVRI-field infra-projects
Currently ACTRIS and ICOS are working together in ENVRI-field infra-RI projects such as ENVRI-FAIR, ATMO-ACCESS and KADI. In March 2023, Horizon Europe proposals were submitted with remarkable success rate, with funding of IRISCC, ENVRI-INNOV, ENVRI-HubNext, NUBICOS, AMRIT, POLARIN, CARGO-ACT and EOSC Future. Most of these projects are based on collaboration of several RIs, including ICOS and ACTRIS, increasing further the participation of both HOs in infra-RI projects.

The reviewers commenced the level of cooperation in the IRISCC proposal. Quote from Evaluation report of IRICC proposal: "T*he state-of-the-art is sufficiently described and suggests that the IRISCC approach is novel and ambitious as it transcends traditional single-RI service provisions and R&I activities. The foreseen provision of challenge-driven RI services is focused on*

cross-RI service integration. This represents an advance as the interconnections and dependencies between various social and natural components leading to climate change, are not fully explored yet. The proposed service integration, which includes harmonization of access policies and access management processes for a wide range of climate change risk services, is ambitious and has the potential to allow for the development and launching of RI services and access calls addressing long-term needs for academic and societal users."

It is to be noted that at the time of proposal submission in March 2023 ACTRIS ERIC was not yet established, and therefore the ACTRIS participation is via other beneficiaries. In many projects it has been agreed that a significant fraction of the ACTRIS-related funding will be transferred to ACTRIS ERIC via amendments in the projects. For the 2024 report, it should be possible to summarize the financing in euros to a table.

Planned: Collaboration within EU-projects

For 2023, RI-URBANS (coordinated by an ACTRIS partner) and ICOS Cities (coordinated by ICOS ERIC) projects have demonstrated close cooperation that involves ACTRIS, ICOS and IAGOS. 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.

As a practical example of cooperation between the projects coordinated by ACTRIS and ICOS, ICOS Cities is running a now well-established webinar series on topics that are relevant also to other projects such as RI-URBANS, and CoCO2 projects. ACTRIS in involved in planning and contributing in these webinars.

ERIC Forum is an initiative by the European Commission, and also a joint Horizon-funded project between European ERICs. Not being an ERIC earlier ACTRIS has so far been participating as an associated partner in the initiative. ICOS has been leading the communications WP in the previous ERIC Forum project culminating in ERIC Toolkit providing support for most practical questions relevant to ERICs, including financing, administration, human resources, communication, impact and evaluation. https://www.eric-forum.eu/toolkit/

In ICOS Science Conference 2024 ICOS ERIC and ACTRIS ERIC have proposed a joint session on best practices in operating an RI. The session is targeted to all RIs related to ICOS science and is to be convened by ICOS ERIC and ACTRIS ERIC together.

Considerations: As per their statutes ICOS ERIC and future ACTRIS ERIC implement the strategic decisions of their General Assemblies. The General Assemblies direct the way how the two organisations operate and cooperate within the European landscape including more than 20 research infrastructures. The cooperation among all the relevant RIs is essential and crucial for the success of both RIs.

5. Collaboration in training and event organisation

Realised 2023: ICOS has organised a Science conference five times. The biannual ICOS Science conference is the main European event in the area of Greenhouse Gases, and the largest activity in ICOS facilitating science by providing researchers opportunities to present their work, learn and network. For the 2022 edition, 2000 working hours from permanent staff as well as work of 2 summer trainees were used to create an event of 400 participants. ACTRIS organised its first science conference virtually in spring 2022 with more than 300 participants and is organising the first physical ACTRIS Science Conference in May 2024 with a plan to continue organising the conference biannually. In 2024 both ICOS Science Conference and ACTRIS Science Conference are organized in France, and the local organizers cooperate in planning and organizing the events, to the extent of recruiting a person for supporting both organization committees. Lessons learned in all steps of preparing a fully hybrid major event are openly shared between the two ERICs and ACTRIS project management officer and ICOS team organised information and "lessons learned" sharing meetings in 2023 in order to facilitate the planning of the ACTRIS Science conference. Organising large conferences is a huge and expensive work, and knowledge sharing increases the efficiency of the organisational work, and choosing the best technologies etc., bringing cost efficiencies in the resourcing of the personnel.

Planned: Training that is not specific to the field of an individual RI can be obtained together. Already in 2023 the Head Offices have collected the need for training needs related to developing the necessary skills and competencies of their personnel. In cases where the needs meet, the HOs may procure common training. Examples of this could be hybrid meeting facilitation and project management.

Furthermore, sharing best practices e.g. in event organisation can reduce the workload, costs, and lead to added value. However, it needs to be kept in mind that the two RIs and their scientific fields are different.

Note: As requested by the Academy of Finland, this document is prepared in collaboration between ICOS and ACTRIS Head Offices. 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 in 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