2018

ICOS | INTEGRATED CARBON OBSERVATION SYSTEM

ICOS RI Annual Report 2017

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Foreword from Director General

In its second official operational year, in 2017, ICOS has made huge steps towards further implementation. This is visible in the approval of the first official ICOS stations by the General Assembly (GA), as an outcome of the station labelling process. It's the result of hard work done by the whole ICOS community that has been enthusiastic and motivated as always. The standardisation of ICOS stations and data processing has been concluded by preparing publications on the ICOS protocols. Through its high standardisation and its cross-domain integration, ICOS is becoming a global landmark for greenhouse gas research and is recognized as such by global organizations such as the World Meteorological Organization, the Group on Earth Observation and even the United Nations Framework Convention on Climate Change.

While the National Networks and Central Facilities worked hard on the final implementation, ICOS ERIC as a legal entity coordinating the research infrastructure has consolidated operations and established RI-wide routines for data management and for internal reporting and management.

An important recognition of our work is that the European Strategic Forum for Research Infrastructures (ESFRI) and the European Commission are seeing ICOS as a mature infrastructure and suggested us for a pilot evaluation for Landmark Research Infrastructures.

However, the journey continues: while ICOS is becoming operational, new requirements have been formulated at the science/policy interface and we have to respond to these. Therefore, we have set up a process to formulate our future strategy. ICOS wants to be ready for the next phase, as science and technology are advancing and the societal requirements for a greenhouse gas observation system are changing. Several supportive actions to facilitate the ICOS strategical planning were started in 2017. They resulted in a first draft of a strategy, which was based on an 'updated mission statement', having been presented to the spring GA in 2018.

Executive Summary

The final lap towards an operational infrastructure

The final implementation of the observational networks continued also in 2017 to be the most important activity of the whole infrastructure. At the end of 2017 the ICOS station network consisted of 131 registered stations of which 34 were atmosphere, 76 ecosystem and 21 ocean stations.

Twenty atmosphere stations were sending data to ATC in by the end of 2017. Greenhouse gas data files from 10 stations, on 'Level 0', are being sent to the Carbon Portal. They correspond to the subset of stations that have entered Step 2 in the labelling process; all of them have either been approved by the GA in autumn 2017 or will be approved by the spring GA 2018. Four new Near Real Time internal data products have been developed and the ATC website had over 34 000 page-views. The first 'Level 2 data' release will take place during the first half of 2018.

23 ecosystem stations completed the Step 1 in the labelling process and 24 started Step 2 in 2017. ETC steered the overall procedure in close communication with the site Principal Investigators (PIs) of the stations. For 21 stations, ETC performed the analysis and design of the spatial sampling scheme, which the station teams implemented. 15 stations proposed a timeline and a detailed procedure for implementation of the Instructions: this included also the list of all

sensors, that have been checked for the compliance. Three ecosystem stations ended the labelling process by approval of the autumn GA 2017 and one will be labelled in the spring GA 2018.

By the end of year 2017, altogether 19 of 21 of marine stations have passed Step 1 and are ready for Step 2 in the labelling process. In 2017, a document describing core parameters, criteria, metadata, and quality control, was finalised and agreed upon by the marine MSA. 10 marine stations started Step 2 labelling process, and the submitted station data and metadata were quality controlled and evaluated. A template for Step 2 quality control report was developed; it contained results, evaluation and recommendation for the quality control process. Step 2 will continue throughout 2018.

The Flask and Calibration Lab (FCL) and the Central Radiocarbon Lab (CRL) have been in transition from development and implementation mode to an operational mode in 2017. Web tools for meta-data, using the ICOS-CAL database application, have been set up and tested for the two labs. Also, the production and performance testing of flask samplers has been continued. For the ICOS Atmospheric station network, a total of 100 reference standards in high pressure cylinders have been produced. This was done to equip new stations and maintain the supply of operating stations by refilling empty cylinders. By the end of 2017, in total 15 ICOS atmospheric stations have been equipped with new $^{14}CO_2$ samplers: 10 of these stations delivered integrated samples to the ICOS CRL for analysis.

Data life cycle and elaborated data products

In the 2016 report, the executive summary about the data life cycle was headlined 'Defining the pulse of ICOS'. Continuing in that line, the veins are now filling with data and the heart of ICOS is pumping first data: complete basic functionality for ingesting and publishing the ICOS data while implementing the full ICOS Data Policy, including the checking of the licence and the usage tracking, has been finalised. This system has been in operational use since summer 2017. The first data released under the ICOS license will be performed during 2018.

At this moment, the Carbon Portal holds just under 10 000 data objects, of which 3900 are labelled as ICOS data objects. All thematic centres are connected to the Carbon Portal data ingestion engine and use it operationally.

Data citation based on Digital Object Identifiers (DOIs) has been implemented. A user-friendly interface at Carbon Portal supports editing metadata for new and existing DOIs. This interface will be extended to allow for ingestion of 'Level 3' products from external parties.

Carbon Portal has started to provide higher-level products and services for the inverse modelling community. It is the central data hub for an EUROCOM regional inversion model intercomparison, providing access to all prior data and collecting the model results. One of the important prior input datasets is a large, high space and time resolution dataset of fossil fuel emissions of CO_2 by source category. It is based on the EDGAR V4.2 database from JRC and has been produced by and published at Carbon Portal.

Research and Innovation within ICOS

New EU-funded projects have provided resources for research and innovation within ICOS. In particular the projects ENVRIplus, RINGO and VERIFY will have important impact on the scientific development and future role of ICOS. All levels of the ICOS research infrastructure participate:

Many expert scientists from the National Networks contribute to scientific tasks is RINGO, e.g. on the measurements of vertical greenhouse gas concentration profiles with air cores, flux measurements of methane and nitrous oxide or surface ocean carbon dioxide concentration measurements with unmanned automated vehicles. CRL has a leading scientific role on

"Assessment of atmospheric proxy/ffCO_2 ratios and independent $^{14}CO_2$-based ffCO_2 emission estimates" in VERIFY. The task will help improving methodologies to measure fossil fuel carbon dioxide in highly polluted areas.

ICOS ERIC is coordinating ENVRIplus and RINGO and uses the resources to further develop the ICOS data life cycle (Carbon Portal), to global co-operation (Head Office) and to attract new countries to ICOS.

New ways in communicating ICOS

To use social media more efficiently to communicate greenhouse gas measurements and climate change towards a general audience, ICOS hired a professional nature photographer and launched 'ICOScapes' a photo campaign that tours 12 selected stations – one in each member country. The campaign produces and publishes videos including station crew interviews, as well as beautiful pictures from the stations and their surroundings. The campaign has been very successful in attracting visitors and transporting the ICOS messages. It will be finalized in an exhibition opened during the third ICOS Science Conference at Prague in September 2018 and will tour to all ICOS countries thereafter.

Many other communication efforts helped establishing ICOS as reliable partner and data provider and promoted the ICOS mission and its services to a wide range of stakeholders. ICOS was present at a number of major international scientific conferences and events including UN COP23 in Bonn, Germany in November, and XIV GEO Plenary in Washington, USA in October. Presentations were held towards ESFRI, European Commission and in many national events on greenhouse gas observations and climate science.

External cooperation

From its very clear position in the European research area, ICOS ERIC actively cooperates with other European research infrastructures both bilaterally and within the ENVRIplus project. The goal is to develop common solutions e.g. for interoperability in data management and synergies e.g. via co-location of sites.

ICOS aims to co-operate globally with other regional research infrastructures to carry on domain-wise global networks such as FLUXNET, SOCAt and GAW. The ICOS community has been active in fostering this co-operation. In order to support the global scientific co-operation ICOS ERIC has been active in major global initiatives: the GEO-Carbon and Greenhouse Gas Initiative (GEO-C) where ICOS ERIC is hosting the GEO-C Secretariat and the Integrated Global Greenhouse Gases Information System (IG3IS) by the WMO. Furthermore, ICOS ERIC has applied the status of Observer Organisation in the United Nations Framework Convention on Climate Change (UNFCCC) in August 2017. The decision is expected in spring 2018.

Administrative and financial management of ICOS ERIC and ICOS RI

Head Office further developed both the administration of ICOS ERIC and the research infrastructure as a whole. Financial management included developing the final process for financial reporting and auditing of ERIC, and a format for financial reporting of the Central Facilities and National Networks. With the financial report for the year 2017, a first overall view on the ICOS finances can be given. The result shows a healthy distribution of the financial resources within the research infrastructure (70% of the resources are going towards the National Networks, 22% to the Central Facilities, 8% to ICOS ERIC).

The operations of the ICOS are co-ordinated according to an annual clock to establish some routines already in the second year of the ERIC. The position of the meetings of General Assembly, Research Infrastructure Committee, Monitoring Station Assemblies, and Scientific Advisory

Board on this annual clock have been proved to facilitate the internal communication between all bodies of the research infrastructure.

Selected highlights of 2017 at a glance

- ICOS has made huge progress in the standardization and labelling of the sites. The station labelling – an integrated process for final implementation of ICOS standards and compliance check for the stations – has been the main activity for National Networks and Thematic Centres.
- During the autumn General Assembly 2017, the first sites were officially approved after passing the Step 2 in the labelling procedure.
- Carbon Portal developed full functionality of data ingestion, PID minting, persistent storage, data search, data retrieval, and data preview. License checking and usage tracking have been implemented and are operational.
- ICOS ATC has started to provide improved access to Near Real Time ICOS atmospheric data for the purposes of the validation of global and regional forecasts to ECMWF to further develop Copernicus Atmosphere Monitoring Services (CAMS).
- ICOS ERIC has started a participation in Horizon 2020 projects and took the coordination of the projects RINGO and ENVRIplus. In the two coordinated projects, many resources are also going towards Central Facilities and National Networks.
- ICOS was presented at international scientific conferences as well as the UNFCCC Conference of Parties (Fidji/Bonn) and the Group on Earth Observation Summit (Washington).
- The ICOScapes campaign with a professional nature photographer visiting ICOS sites in all countries was launched, and 5 sites were visited. It has been multiplying the ICOS social media coverage and connected non-scientific audience to ICOS.

ICOS ERIC

Introduction

ICOS ERIC has been established as a legal entity to coordinate the operations of ICOS RI, distribute information from ICOS RI to user communities and to establish integrated data and analysis from GHG observation systems. ICOS ERIC provides effective access to coherent and precise data to facilitate research into multi-scale analysis of GHG emissions, sinks and their driving forces by making available measurement protocols long-term data and data products. The statutory seat of ICOS ERIC is in Helsinki, Finland. ICOS ERIC has governance bodies such as General Assembly (GA), Director General (DG), ICOS Research Infrastructure Committee (RI Com), Scientific Advisory Board (SAB), and Ethical Advisory Board (EAB).

ICOS ERIC General Assembly is the decision-making body of ICOS RI and acts as a high-level council for Member and Observer representatives. General Assembly discusses and approves strategic issues as well as any legal, governance of financial issues, approves the official ICOS stations into the network and location of the facilities.

Director General is responsible for implementing the decisions adopted by the General Assembly and is the legal representative of the ICOS ERIC. The Director General carries out the day-to-day management of the ICOS ERIC and is responsible for managing staff and activities of the Head Office and the Carbon Portal in accordance with the ICOS ERIC budget. The Head Office supports the work of all ICOS ERIC governance bodies and day-to-day operations.

Carbon Portal (CP) is the one stop for all ICOS data and is part of ICOS ERIC. It is led by the CP Director who is employed by the ERIC. All other personnel are employed by either Lund University in Sweden, the main host and location of the CP, or Wageningen University in The Netherlands.

Director General and Head Office

Administrative and financial management of ICOS ERIC and ICOS RI

Human resource administration for ICOS ERIC

The new Head Office structure, as per approval of the General Assembly in November 2016, was implemented during the first quarter of 2017, and new project personnel was recruited.

ICOS ERIC had the following permanent and temporary personnel by the end of the 2017:

- Director General (Werner Kutsch)
- Director of Carbon Portal (Alex Vermeulen)
- Head of Unit I “Administration” (Johanna Pasilkar neé Lätti until November 2017)
- Head of Unit II “Operations” (Eija Juurola)
- Head of Unit III “Communications” (Gorana Jerkovic, until July 2017; Katri Ahlgren November 2017-)
- Scientific Integration and Liaison Officer, Unit II (Jošt Lavrič, until February 2017, Jouni Heiskanen, March 2017-)

- Operations Assistant, Unit II, (Evi-Carita Riikonen)
- Communications Assistant, Unit III, (Mari Keski-Nisula)
- International Cooperation Officer, DG Unit (Emmanuel Salmon April 2017-)
- Junior Officer, Operations, Unit II (Janne-Markus Rintala October 2017-)
- Junior Officer, Communications (ENVRIplus), Unit III (Magdalena Brus, November 2017-)

In addition, two assistants (Inka Hellä, Shawnie Kruskopf), were employed through a company (Staff Point) and Pirjo Kontkanen continued as a legal counsellor.

One of the focus areas for 2017 was to finalise and improve the HR-processes in ICOS ERIC. In September a HR specialist (Nelli Matikainen) started as a consult in the Head Office. During the process the recruitment processes were improved, staff and travel rules updated and job descriptions clarified. The process will be finalised in spring 2018.

Head Office supports the professional training and development if its personnel. In 2017 the staff participated e.g. in several EU project management trainings and in a specific training programme EMMRI, designed for RI personnel. Communications team members also participated in PARI2017 Workshop on Public Awareness of Research Infrastructures in Garching, Germany, in May 2017 to further improve our knowledge in communicating science to society.

Financial Management of the ICOS ERIC

When ICOS ERIC went through its first audit in spring 2017 the financial management and the roles of the Director General and the General Assembly had to be defined in the light of EU ERIC regulation and Finnish law. While the latter could be interpreted.

Based on the experiences of the first reporting, the annual clock of financial processes and planning and reporting cycles were presented in the GA meeting in May 2017. Clear process for announcing changes in stations as well as entering of new member or observer countries were agreed to establish routines and improve the financial forecasts.

Furthermore, payroll, time reporting and accounting services which are outsourced to the accounting company Azets Oy had to be adapted to the management of EU projects since ICOS ERIC entered several H2020 projects as coordinator or beneficiary.

The mid-term reporting to the Academy of Finland of the Host Contribution by Finland, was one of the key tasks for the first half of the year. The report consisted of the progress of ICOS ERIC during first funding period (2014-2018) and a first plan for next funding period.

The ICOS Financial Committee, founded in May 2016, supported the financial management of ICOS ERIC as well as ICOS RI. It is a five-member committee consisting of General Assembly delegates and nominated experts: Marc de Jonge (Chair), Salah Dib, Gelsomina Pappalardo, Sirpa Nummila and Sara Moa. The Financial Committee had a face-to-face meeting in Rome to prepare the 4th General Assembly and three virtual meetings to support strategic financial management actions. The Committee was actively involved in development of the reporting and budgeting process and templates of the RI.

Support to the contract management, procurement and coordination of the service providers for the Head Office

An agreement with the Joint Research Centre (JRC) was concluded in the first half of 2017. JRC operates one atmosphere and one ecosystem stations that are now officially a part of the ICOS Station Network.

Procurement Rules of ICOS ERIC were drafted and presented to the General Assembly in November 2017. The General Assembly requested some minor changes in the rules, and final approval of the document will be made in the spring 2018 General Assembly.

Supporting the Financial Management for the ICOS RI

As a major activity, the rules and templates for financial reporting of ICOS RI activities were revised in cooperation with the Central Facilities and supported by the Financial Committee. The templates were approved in spring 2017. Furthermore, the annual clock of the planning and reporting was improved and presented to the General Assembly in spring 2017.

General Assembly

General Assembly had two face-to-face meetings and on written procedure in 2017. The two-day spring meeting of General Assembly was held in Rome, Italy on 3-4 May 2017. RI Committee representatives as well as SAB Chair participated in the information day preceding the decisive meeting on 4 May. During the discussion day the activity and financial reports were extensively discussed, as well as the annual clock of the planning and reporting cycles in ICOS RI. In the decisive meeting, e.g. the annual report 2016 was approved, ICOS RI Cooperation Rules were approved as well as the financial reporting templates for the Central Facilities. Petteri Kauppinen (Finland) was selected unanimously as the Vice-Chair of the General Assembly.

The second General Assembly meeting was held in Brussels on 17 November 2017, where Jean-Marie Flaud (France) was selected unanimously to the second term as the Chair of the General Assembly. In the meeting the ICOS ERIC and RI plans for 2018, Membership contributions and the instructions on Observer and Member Admittance process were approved. Importantly, first 7 ICOS stations were approved as labelled ICOS stations marking a significant step towards becoming an operational observation system.

Scientific Advisory Board and Ethical Advisory Board

ICOS Scientific Advisory Board (SAB) was nominated in May 2016. For the term 2016-2018 the members of the SAB are Anna Michalak (Chair), Beverly Law (Vice-Chair), James Butler, Marcus Reichstein and Rik Wanninkhof.

SAB provided its first report to the General Assembly in spring 2017. This report was discussed by the General Assembly which asked the Director General to formulate a response together with the Research Infrastructure Committee and the Head Office. This process introduced a reflection on the mid-term strategy of the Research Infrastructure that will last through the year 2018 and be finalized in a strategic plan to be provided by the end of 2018. An update of the strategy has become necessary since new requirements to greenhouse gas observations have been developed after the Paris Agreement in 2016.

SAB held a face-to-face meeting back-to-back with the autumn General Assembly together with the RI Committee, and participated in October in a dedicated webex to discuss the strategic developments of ICOS RI.

The Ethical Advisory Board was nominated in November 2016, consisting of three members for the first two-year term: Silvia Peppoloni, Meri Vannas and Per Sandin. Ethical Advisory Board had no meetings in 2017.

Support for the operations and development of the RI (Task 2)

Coordination and support for the Central Facilities

Head Office supported the Central Facilities in the station labelling process by communicating with the CFs and station PIs and steering the formal approval process in Step 1 and 2. In Step 1

The Director General discusses possible open questions with the RI Committee and approves the Step 1 station reviews provided by the Thematic Centers. In Step 2 the final evaluation reports prepared by the Thematic Centres are discussed in the RI Committee after which the Director General makes the proposal for approval or rejection of the evaluated station to the General Assembly.

Head Office visited all Central Facilities and held teleconferences when seen necessary. A dedicated face-to-face meeting of the Central Facilities was held on 23-24 February in Heidelberg in connection with RINGO project kick off, to develop and agree on the format and content of the activity and financial reporting of ICOS RI.

Research Infrastructure Committee

In 2017 members of RI Committee 2017 were:
HO: Eija Juurola, Johanna Lätti
CAL: Ingeborg Levin, substitute Armin Jordan
ETC: Dario Papale, substitute Bert Gielen
ATC: Leonard Rivier, substitute Michel Ramonet
CP: Alex Vermeulen, substitute Harry Lankreijer
OTC: Truls Johannessen, substitute Benjamin Pfeil
MSA atmosphere: Huilin Chen, substitute Martin Steinbacher
MSA ecosystem: Corinna Rebmann, substitute Mathias Herbst
MSA ocean: Dorothee Bakker (stepped down on 2 March 2017), Tobias Steinhoff (substitute until 2 March 2017) substitute Thanos Gkritzalis (from 3 April 2017 onwards)

RI Committee held one face-to-face meeting, on 27-29 September in Groningen. RI Committee plays a key role in strategic planning of ICOS activities. The focus of the meeting was to discuss the strategic development of ICOS RI, finalise the station labelling process and respond to the strategic recommendations made by the SAB report presented in the GA meeting in May. Furthermore, station labelling process, RI Committee met virtually in monthly videoconferences. Extraordinary meetings were arranged when seen necessary.

RI Committee participated in preparation for the General Assembly meetings, attended the discussion day event on 3 May 2017, as well as the SAB meeting on 16 November. RI Committee members were also active in planning the ICOS project participation.

Supporting the MSAs and National Networks

ICOS ERIC supported financially the MSA activities and participated in all meetings organized in the three domains. These are important events for following the progress of the implementation of ICOS RI as well as scientific and technical developments in the ICOS research community. Head Office participated also several national ICOS events.

Head Office supported the publication of the ecosystem protocols, an important and laborious activity of ICOS scientific community to standardise the measurements at ICOS ecosystem stations. 14 articles are now in the review process in International Agrophysics and planned to be published as a Special Issue in summer 2018.

Management of external cooperation

Cooperation in European landscape

ICOS ERIC actively cooperates with other European research infrastructures both bilaterally and within the framework of the H2020 cluster project ENVRIplus, with the European Strategic

Forum for Research Infrastructures (ESFRI) and the European Commission. ICOS has agreed in January 2017 to participate in a pilot evaluation for Landmark Research Infrastructures by the ESFRI. DG Werner Kutsch presented ICOS and discussed the evaluation procedure with the respective ESFRI group during the 2nd ESFRI Exchange of Experience workshop in January 2017 at Malaga (DG), the RICH symposium in May 2017 at Lisbon and the ERIC Network meeting held in Helsinki in May 2017. The latter was hosted by ICOS ERIC with more than 80 research infrastructure representatives gathering together to discuss the major management issues in ERICs and to develop the best practices. In the meeting, a Memorandum of Understanding for the establishment of the ICOS ERIC Forum, was signed, aimed to further intensify collaboration between ERICs. During the ENVRI week in November 2017 at Malaga, DG Werner Kutsch presented the "State of the European Environmental Research Infrastructures" to the ESFRI strategic working group on environmental research infrastructures.

To foster the planning of the actions supporting innovation related to ICOS, Head Office participated in an Innovation framework meeting for ERICs, organised by the European Spallation Source in Denmark.

In many of these meetings, socio-economic impact of environmental research infrastructures was discussed and ICOS took a clear role in sharpening the discussion in the mentioned presentations by focusing on the value of conservation. Environmental Research Infrastructures in general, and ICOS in particular, generate important knowledge on our ecological life support systems that provide priceless services. This is particularly evident in the field of GHG: not reaching our safe climate change target level by inadequate mitigation will lead to extremely large societal costs for adaptation, loss and damage. Compared to the values at risk, the investments and running costs needed for a GHG monitoring and analysis network are marginal and could be easily compensated due to improved effectiveness of the mitigation strategies.

In 2017 Head Office participated also in the events of Nordic ENVRI, an infrastructure network of Nordic Atmospheric and Earth system science and in the event organised by JPI Climate.

International collaboration

ICOS ERIC worked together with many International Organisations towards a global Carbon and Greenhouse Gas Observation System where ICOS aims to be the European Pillar. ICOS ERIC has applied the status of Observer Organisation in the United Nations Framework Convention on Climate Change (UNFCCC) in August 2017. The decision will be made in spring 2018. The Director General participated in informal strategy meeting between the Chair of the Subsidiary Body for Scientific and Technical Advice and the Earth observation community during COP 23 in Bonn. We cooperated within the World Meteorological Organisation (WMO) and the Group on Earth Observation (GEO) where ICOS ERIC supported major global initiatives.

Specifically, GEO-Carbon and Greenhouse Gas Initiative (GEO-C), accepted into the GEO 2017-2019 Work Plan in autumn 2016, was the major international activity for Head Office in 2017. ICOS ERIC was selected as the host of the GEO-C Secretariat in the project kick-off meeting at Rome in July 2017. The coordination of the initiative is shared between ICOS ERIC and CMCC. An important milestone was reached when the 12-member Scientific Steering Committee was established. The main focus areas of 2017 were strengthening the relationships with other regional and global actors in the field and increasing the number of participants. GEO-C website was launched in autumn 2017 (https://www.icos-ri.eu/geo-c).

To support these activities Head Office participated in ISRSE Symposium and GEO Work Programme Symposium in Tshwane, South-Africa in May 2017 and in a side event in 10th International Carbon Dioxide Conference (ICD10) in Interlaken, Switzerland August 2017. In the

GEO Plenary 2017 ICOS ERIC co-organized a side-event "GEO-C: Toward policy-relevant global carbon and GHG observations".

ICOS aims to cooperate globally with other regional research infrastructures to carry-on domain-wise global networks such as FLUXNET, SOCAt and GAW). ICOS community has been active in fostering this cooperation and Director General has participated in several meetings to support these efforts and to develop formal, active relations between different networks; such as Flux discussion workshop in Stubaital, Austria; FLUXNET conference in San Fransisco, USA and EuroGOOS meeting in Bergen, Norway.

Management of ICOS ERIC participation in externally funded projects

Horizon 2020 Projects and new Proposals

Director General and Head Office coordinate the ICOS ERIC and ICOS RI participation in different proposals and funded projects. ICOS ERIC seeks funding opportunities that support the development of the ICOS RI and enhances European and global integration of greenhouse gas observations. ICOS ERIC follows the guidelines on ICOS participation in proposals, approved by General Assembly.

ENVRIplus coordination was transferred from University of Helsinki to ICOS ERIC starting from the beginning of 2017. The respective amendment process of ICOS ERIC becoming beneficiary and coordinator was completed in January 2018 but is retroactively in force already from 1 January 2017. In ENVRIplus, the communication and dissemination strategy sets an objective to raise awareness of the project and of the wider Environmental Research Infrastructures community within identified target groups, and to encourage them to use the products and solutions developed by the project while engaging them in discussions. ENVRIplus communication activities also support the visibility of the Environmental RIs (such as ICOS). ICOS ERIC as the coordinator of the project has been responsible for the development and day-to-day management of the ENVRIplus communications. This includes e.g. visual identity management, regular content updates to website and social media with consecutive analytics follow-up, production of a regular newsletter, as well as distribution of printed dissemination material such as brochures and the colouring book, which was updated in early 2017 and distributed together with a set of pencils with ENVRIplus logo on box at several events. A preparation of new communications material promoting the tools, services and solutions developed in ENVRIplus has also been started, with plans to finalize these in the first half of 2018.

ICOS ERIC also participated in promoting the ENVRIplus project in several conference abstracts. Very important dissemination activity was a publication of the article: Asmi, A., Brus, M., Sorvari S. (2017). Community-Driven Efforts for Joint Development of Environmental Research Infrastructures, In Terrestrial Ecosystem Research Infrastructures: Challenges, New developments and Perspectives, edited by Chabbi A., Loescher H. W. CRC press.

An important result from ENVRIplus is a report on "Further integration of research infrastructures related to terrestrial ecosystem research" that was coordinated by ICOS ERIC.

'Readiness of ICOS for Necessities of integrated Global Observations' (RINGO) is coordinated by the Director General and was kicked off in February 2017, leading to a planning and publication of a RINGO-specific section under ICOS website, as well as production of a specific RINGO logo. 2017 was active year in establishing the coordination of RINGO (ID 730944), which included minor modifications via amendment process, the initialisation of internal project management system EMDESK, reporting and planning framework for Work Package and Task Leaders, and the general governance of the project. A lot of effort was put in the production of an Initial Project Dissemination Strategy for the project, submitted to the European Commission in June. Among

the first publications were also the Deliverables which outlined the and risk management plans. The HO prepared and released two procurements, one for the impact analysis of ICOS RI and one for novel instrumentation in ship lines. Within HO related Tasks, progress was made in acquiring new countries to ICOS and linking ICOS to global initiatives. Also, the arrangements started for the annual meeting in March 2018.

2017 was the first year of the RISCAPE project. As the leader of WP3 dedicated to environmental sciences, ICOS performed a survey of the European Research Infrastructures (RIs) in the field. They covered all four traditional scientific domains in environmental sciences (atmosphere, biosphere, geosphere, and hydrosphere). All members of the Board of European Research Infrastructures (BEERi) established in the ENVRIplus project were interviewed in order to identify their international partners (present or possible), their counterparts outside of Europe, or the global initiatives and networks they contribute to. A total of 100 organizations was listed, and will form the basis for the second part of the project: an analysis of complementarities and cooperation opportunities with the ones that will fulfil the criteria defined in RISCAPE for a Research Infrastructure.

The SEACRIFOG project also started in 2017, but its full execution was slightly hindered by the absence of a coordinator until September 2017. As one of the initiators of the project, ICOS took the lead for the organization of the kick-off in Kenya in May 2017. The general objective of the project was clarified, as the original scope needed to be made more specific. The emphasis of SEACRIFOG was refocused on the design of a concept for a pan-African greenhouse gas (GHG) observational system, with a special attention put on land-use, land-use change and climate-smart agriculture. ICOS participated in the realization of two stakeholder engagement workshops in Kenya and Ghana.

In addition, ICOS ERIC is a beneficiary in EOSCpilot project supporting the development of the European Open Science Cloud (EOSC) and DANUBIUS-PP, a preparatory phase project to build DANUBIUS-RI (International Centre for Advanced Studies on River-Sea Systems).

The project funds contribute significantly to the budget of ICOS ERIC (increase of 25 % in HO and 30 % in CP) for the years 2017 – 2019. To successfully manage the project portfolio, the practices and procedures established at the Head Office were adjusted to be compliant with the European Commission H2020 funding rules and principles.

Outreach and media communication

Bi-annual ICOS Science Conference

Program planning and even concrete actions for the 3rd ICOS Science Conference, to be held in Prague in September 2018, started already in 2017. The nine-member scientific programme committee was established in autumn 2017. The committee held its first Webex-meeting on 27 November 2017 to discuss the themes of the conference and develop scientific programme. The first communications activities included social media messaging, emails, disseminating printed invitation cards, as well as the planning and publication of the conference website. These activities took place during the fourth quarter of the year. The majority of the communications actions will happen in 2018, closer to the opening of the registration and the conference.

External outreach and networking

In its second operational year, the Head Office was concentrating on further establishing ICOS as a reliable partner and data provider, as well as promoting ICOS mission and its services to a wide range of stakeholders. For that end, ICOS Head Office organised and attended a number of major international conferences and events including UN COP23 in Berlin, Germany in November, and XIV GEO Plenary in Washington, USA in October.

For the EGU17 held in April, ICOS suggested that all the ENVRI community RIs pool resources to present themselves jointly as one community. The organisation of the joint booth required an extensive use of manhours from ICOS ERIC to ensure a successful presence. The activity was considered as most important communication activity within many RIs. The ENVRI cluster and ICOS were also well presented at AGU 2017 organised in December.

ICOS also coordinated two ENVRI weeks during the year as part of ENVRIplus project. The weeks gathered on average of 140 participants from 26 RIs to cooperate on joint solutions and services for the RIs as well as to further integrate the complex RI landscape. The first Industry Forum was organized in Grenoble, France, as part of the ENVRI week. The forum gave us a very good opportunity to present ICOS to the potential industrial partners throughout the week.

International communications networks

ICOS ERIC maintains a communications network for the RI communication officers from the Environmental RI's. The aim is to share the knowledge and best practices and in the same time, promotion of the project's results within the RIs themselves. ICOS also initiated a similar network for other RI clusters (CORBEL, EMBRIC, PARENTHOS, ASTRICS, SINE2020) to regularly share the best practices in promoting the cluster projects and improving the exploitation of results. In addition to the virtual meetings, the group has set up a joint virtual space to improve collaboration and sharing of information.

ICOS materials and presence in web, media and social media

ICOS' day-to-day external communication activities included production and dissemination of a wide range of engaging content such as news and media kits on the website, as well as other outreach products. For example, a new ICOS Science Brochure was produced and printed to present the operation of the infrastructure in relatively short format.

The most important social media channels for ICOS are Twitter, Instagram, YouTube and LinkedIn. During 2017, our presence in all these channels has grown much stronger, mainly thanks to ICOScapes photo and video campaign. The number of Instagram followers grew from 7 to 844 (12 000%) from July to December 31st, and also the number of Twitter followers increased by 59%, and LinkedIn by 1.8%.

Additionally, ICOS was mentioned in at least eight traditional or scientific media outlets in 2017, for example, in relation to the station labelling.

ICOScapes photo campaign

In July 2017, ICOS decided to use social media more efficiently to gain the visibility for greenhouse gas measurements and climate change within the general audience. For that purpose, ICOScapes campaign tours 12 selected stations – one in each member country – and produces videos including station crew interviews, as well as has beautiful pictures taken of the stations and their surroundings. For still photos, a professional, well-known nature photographer was enlisted. In 2017, three countries were covered: Castelporziano 2 station in Italy, Zackenberg Fen in Denmark, and Zeppelin Observatory in Norway.

The campaign has been very successful in several aspects. In addition to multiplying the ICOS social media coverage, it has also connected the audience to ICOS, which is shown by the likes and positive comments received by the Instagram posts (138–505 likes per photo).

Three YouTube videos produced in the campaign during 2017 have been viewed in total 1550 times. Videos were also shown e.g. in the ICOS Nordic Symposium, GEO Week 2017 and at COP23, where they received positive comments. Furthermore, on the photographer Konsta Punkka's Instagram account, #ICOScapes photos have gained between 35 500 to 91 000 likes each, as well as positive comments.

Internal RI communication

The Head Office regularly supported internal communication activities across the ICOS RI network in 2017. That included further increasing the cooperation within the RI Communications Network in order to align messaging and to share information and best practices. The second face-to-face ICOS Communications Network Meeting was organized Garching, Germany.

Head Office has also produced and distributed regular quarterly ICOS RI Newsletters which included highlights and latest ICOS related news from members and observer countries and institutions, as well as information on the ICOS community related events.

Strategic developments

Developing the long-term strategy for ICOS RI

While ICOS has become operational, the world continued to turn. Science and technology advanced as well as the societal requirements for a greenhouse gas observation system changed. We have, therefore, to provide a strategy for the further development of ICOS. Several mutually supportive actions to facilitate the ICOS strategical planning were started in 2017. They have resulted in a first draft of a strategy based on an 'updated mission statement' which has been presented to the spring GA in 2018.

The process of conducting an Impact Analysis of ICOS was started at the end of 2017, to be carried out in the first part of 2018. The analysis will be executed in conjunction with the RINGO project and will consist of four steps: defining a framework for describing the impact of environmental research infrastructures in general to science, society and economy; developing a set of KPIs; describing the current impact of ICOS RI; and developing a strategy to improve it.

An investigation into the user landscape of ICOS was also started in 2017, aiming at exploring the internal and external user groups that are expected to be using ICOS data products (related to both scientific and informative data).

To facilitate community engagement and further development of the RI, it is vital to establish an idea how the internal ICOS members perceive the infrastructure. For this purpose, it was decided to launch a study called 'ICOS Identity Study'. It aims at exploring how the internal members see ICOS' purpose, what motivates them to be part of ICOS and what they expect from ICOS in the future. The planning work for this study was carried out in late 2017 and the study will be concluded during 2018.

To facilitate the management of the processes needed for performing the ICOS core operations, work was started on compiling a Management Plan out of the collection of managerial documents that have been elaborated through the course of time. A single consistent management plan will correspond to the evolving requirements related to an RI that is now in its operational phase.

Head Office was actively in contact with new potential Member countries. The participation of potential new countries was supported by the RINGO project, where nine countries that are planning in joining in ICOS ERIC are partners. These countries include Estonia, Greece, Hungary, Ireland, Poland, Portugal, Romania, South-Africa and Spain. Portugal and Romania attended also as guests at the autumn General Assembly meeting. Furthermore, ICOS ERIC supports the national process and funding proposals in new countries e.g. by providing support letters and advocating ICOS in national events.

Highlights

- Participation in Horizon 2020 projects and took the coordination of the projects RINGO and ENVRIplus.
- ICOS was presented at the UNFCCC Conference of Parties (Fidji/Bonn) and the Group on Earth Observation Summit (Washington).
- ICOScapes photo-campaign was launched, multiplying the ICOS social media coverage and connected non-scientific audience to ICOS.
- New recruitments in the Head Office

ICOS Carbon Portal

Data service development (Task 1)

In 2017 the complete basic functionality for ingesting and publishing the ICOS data implementing the full ICOS Data Policy, including the checking of the licence and the usage tracking, has been finalised. This system has been in operational use since summer 2017.

Through the use of open linked data technology all data and metadata is published dynamically and instantly. All data and metadata can be retrieved through the persistent identifiers (PID), that are minted at ingestion. Metadata can also be queried through the open SPARQL endpoint. ICOS data is in fact published on universal virtual 'disk' that can be accessed through the web using the PID as part of the handle link, that is just a normal web link. Accessing this link triggers the license check and every download is registered for the usage tracking. Any portal or website can query the CP endpoint and use the results to give transparent access to the ICOS data through these links. In fact the CP uses these techniques itself to create the frontends for the users in the different apps.

Furthermore an 'expert' data search and download app has been launched that allows to find, preview and download all ICOS and related data that is stored through the Carbon Portal. The app allows previews for time series and spatial (time series) data. The download takes place through a data cart that always includes a short version of the ICOS data licence together with the files and the list of persistent identifiers.

At this moment the Carbon Portal holds just under 10 000 data objects, of which 3900 are labelled as ICOS data objects. All thematic centres have connected successfully to the Carbon Portal data ingestion engine and now make use of it operationally.

Downloads are registered for each data object in a separate database. Through a dedicated app users can easily retrieve reports on the number of downloads per data object, filtered by

station(s), data provider(s), contributor(s), data level(s), country and so on. In 2018 this information will be extended with a report on the history of number of downloads with time and the geographical distribution of the downloaders for a certain selection of data objects based on the mentioned selection criteria.

Since summer 2017 the raw data from Picarro and Los Gatos instruments is automatically ingested from the Atmosphere Thematic Center for the 10 stations that thus far made it to step 2 of the labelling process. These ICOS level 0 products make up 3200 of the 3900 ICOS data objects in the data object store. First test versions of L1 and L2 data products from ATC have been submitted as well, but these are not yet visible publicly. However we are ready to mint PIDs (and DOIs) for NRT data products from ATC for submission to Copernicus.

In May 2017 the Ocean Thematic Center ingested automatically 941 data objects of Level 2 type products from ship cruise data. This data is part of the latest SOCAT product and originates from the data sources that will be included in ICOS. This data is labelled in the data store as pre-ICOS (and thus non-ICOS) data.

In May 2017 a simplified 'façade' interface, adapted to be used by dataloggers as routinely used by stations in the field, was developed to accommodate the ingestion of raw data directly from the Ecosystem field stations. Successful tests of this façade connected to Licor dataloggers were completed in Spring 2017. The Ecosystem Thematic Center itself connects to the data ingestion since the end of 2017. Operational data flow to CP from ETC commenced January 2018. The first ecosystem stations now submit raw data directly through the façade interface. The façade interface collects all files per station on an hourly or half-hourly basis, and on a daily basis stages the raw data automatically through the normal ingestion procedure. This data will then be processed in the cloud by ETC and the resulting L1 products are then ingested through CP for publication in a completely automated workflow.

Another important development is the user-friendly interface at Carbon Portal to edit Datacite metadata for new and existing DOIs. New DOIs have to be staged by an admin. These functions requiring an account at Carbon Portal and admin rights respectively. This interface will be extended to allow for ingestion of Level 3 products from external parties.

The mapping service has been extended to enable different projections, so that now the interactive station maps or other spatial information can also be shown for example in the projection prescribed by the EU for European maps or any other common projection.

The data portal concept of Carbon Portal with its strong emphasis on data identification, long-term preservation and flexibility will be also used by the Swedish national infrastructure SITES. For joint further development the team has been enhanced with an additional developer, allowing to make the portal even more versatile.

Agreement has been reached with CSC in Finland to provide Carbon Portal with Grid Computing facilities and access to B2SAFE for persistent storage of the ICOS data.

Downtime of the CP server was limited to one day due to a power failure of the Lund city power grid and subsequent failure of some network switches at the Lunarc computing centre. This limited the availability of the CP services over 2017 to 99.7%. Lunarc has now taken measures to limit downtime to the actual power shortage periods by protecting the switches with UPS systems.

Support for management of data collections has started and will be coupled to the optional minting of DOIs for these collections, and automatic generation of data citation strings.

Google Analytics statistics data collection about the visitors of the CP website has started in July 2017, also including results from visitors to the (meta)data services. Some of the results are shown in the next two figures.

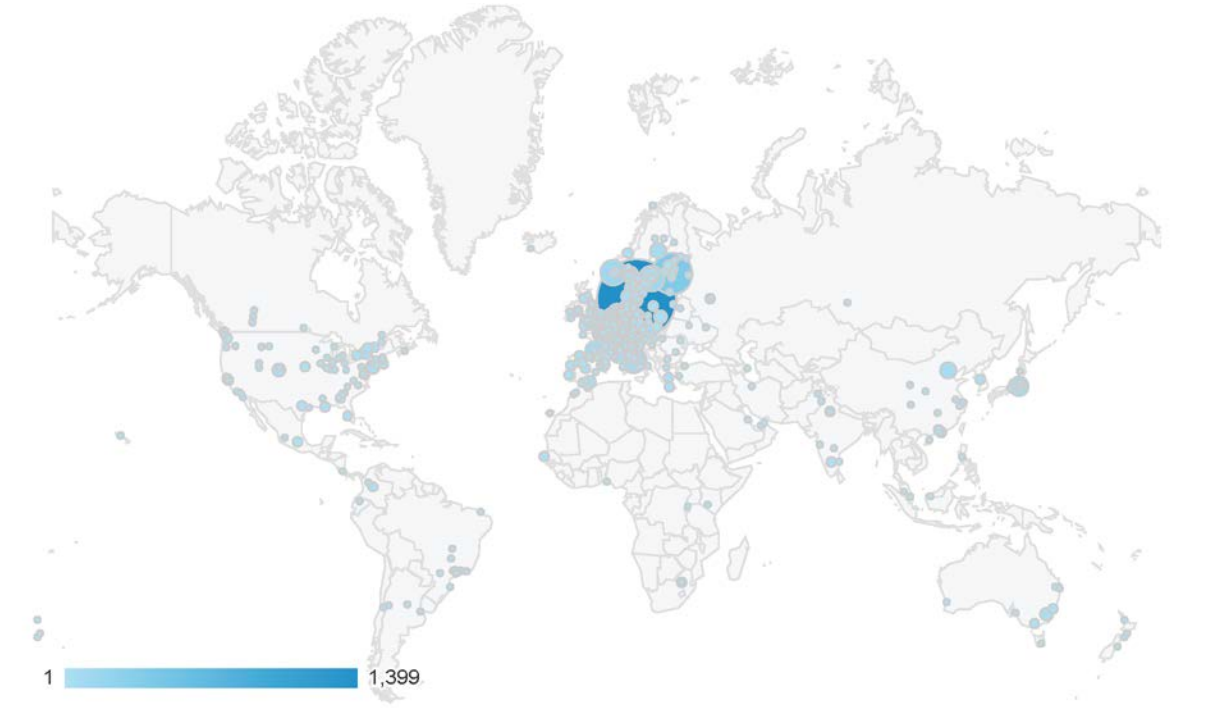

Figure 1 Number of sessions on Carbon Portal website between 1 September 2017 and 1 January 2018 per city. Average session duration is 5 minutes. The global coverage is reasonable, but as expected there is a strong emphasis on sessions from Europe.

Figure 2 Number of sessions per week in the period September 2017-February 2018. This shows sustained growth since November from about 200 to 350 sessions (except for Holiday season) per week. CP received a total 2578

unique users in the period of which 58% is returning visitor, viewing 4 pages on average. The Novmber peak is due to the publication of the GCP 2017 product.

ERIC IT Infrastructure support (Task 2)

A new data server has been purchased. It was installed at the Lund University Lunarc computing centre in November 2017. The new machine offers considerably more storage (from 30 to 110 TB) and roughly 50% more processing power (from 12 to 20 cores and similar single thread performance). In the course of 2018 all operational services will be moved to the new server. The old server will remain in service as development machine where services are tested before being staged and deployed in production. The old server also can be used to provide additional computing resources for the modelling services like the STILT footprint service or ETC eddy flux data processing.

The web services that CP provides include the web sites from the Head Office, the Carbon Portal itself, ICOS Norway, OTC and since the end of 2017 also ICOS Finland. ICOS Sweden announced their intention to move their website to CP. Furthermore CP now also hosts the website for the ERIC Forum project.

The Alfresco document management server was further optimised to the needs of the ICOS community. A system update is planned for 2018. Public documents are now published automatically through the CMIS link between Alfresco and the ICOS website.

The ICOS discussion forum was setup using the phpBB software but turned out to be not used at all, so this service will be deprecated. A phpList server was set up to support mailing lists but this has been superseded by use of the Mailchimp service for ICOS newsletters and all other email distribution lists through the Exchange email service at CP. In 2018 this phpList server will be replaced by the mailman list server that is more flexible and manageable, and will be used for example in project related mail lists.

The ICOS ERIC Exchange email service has been transferred from a UK based provider to a Swedish provider. Use of email is an important, if not the main, communication tool that is extensively used by all people involved in the RI. The conversion to the new provider was far from smooth and still causes some (though now only minor) problems.

Data management and elaborated products (Task 3)

CP and LU co-organised the 2nd EUROCOM workshop in November in Paris where the first results of the regional inversion model intercomparison for CO_2 were presented. Carbon Portal is the central data hub for this intercomparison, by providing access to all the prior data and through collection of the model results. CP provides a Jupyter Notebook virtual research environment to analyse the data collaboratively. One of the important prior input datasets is a large, high space and time resolution dataset of fossil fuel emissions of CO_2 by source category. It is based on the EDGAR V4.2 database from JRC, and has been produced by and published at Carbon Portal.

CP published and minted DOIs for the methane observation and modelling results of the InGOS projects. The remaining InGOS results will be published early 2018. In November 2017 CP published and minted a DOI for the results of the Global Carbon Project 2017. Publication of the latter caused a huge spike in the number of visits to Carbon Portal and contributed to a persistent increase in the number of visitors since then.

We organised two meetings of the User Consultation Group that delivered valuable feedback on the user interfaces of the Carbon Portal. This feedback loop will be intensified in 2018, as the services expand and the amount of content is starting to grow.

With the help of resources from the EUDAT2020 and ENVRIplus projects, CP developed the STILT Footprint tool further to also allow for on demand calculation of footprints and forward concentrations at user-defined coordinates in Europe. This will be a helpful tool for new ICOS member states or expansion of existing members in designing their atmospheric network. The footprint and modelled concentration data generated in this app will be staged to the portal and then immediately available in the STILT footprint viewer app.

The STILT footprint tool is also used in the framework of the RINGO project to assist in developing measurement strategies for the ICOS flask sampler and $^{14}CO_2$ measurements.

The work on the synchronisation of community metadata between TC's and CP has been moved to lower priority in order to put more available resources on getting the observational data flows operational. The community metadata issue will be picked up in 2018 with the help of the RINGO project and the recently filled position of a dedicated post-doc for this work at CP.

Training and user support (Task 4)

CP organised together with the University of Helsinki in the period 24 May-2 June the 4th ICOS Summer School in Hyytiälä. The overall theme of the summer course was "Challenges in greenhouse gas observations and modelling". The school targeted mainly PhD students, but also Postdocs, and master students preparing to start doctorate studies, were accepted to participate in the school. The summer school gathered altogether 37 students. From the participants, 8 were from ICOS candidate countries and 4 were from non-ICOS countries. The course was carried out in collaboration with the related H2020 projects ENVRI+, COOP+ and RINGO.

The course addressed a wide range of the most crucial topics and methods of Carbon Cycle science in the context of global climate change. The topics covered ecosystem fluxes and measurements, atmospheric composition using in-situ and remote sensing measurements, global climate modelling and carbon cycle, and atmospheric transport and chemistry. Also data management and 'big data' methods were tackled during the course. To fulfill the learning process on these themes in practice, the course was divided into lectures and practical work at the Hyytiälä Forestry Field station.

Lectures were oriented across domains and covered sessions on Atmosphere, Ecosystems, Oceans and Boreal and Arctic domains. Within and in addition to domain centered themes, climate system and global carbon cycle, metadata practices (eScience), atmospheric measurements with the help of aircrafts, emissions and remote sensing topics were tackled during the lectures. The lectures were given by several experts in the field of greenhouse gas science, including: Martin Heimann, Anders Lindroth, Greet Maenhout, Christoph Gerbig, Maarten Krol, Kadmiel Maseyk, Wouter Peters, Alex Vermeulen and Timo Vesala.

The overall evaluation by the students on a scale of 1-6 was 4.9 (+/- 0.5), on a scale of 1-10 this would be mark 8.1, which is very positive and slightly higher than evaluations of previous editions of the summer school.

All the course presentations and materials are available at the ICOS Summer School website: http://2017.icos-summerschool.eu.

The PhD course on eScience was cancelled due to lack of registered participants. It is now scheduled for autumn 2018.

Management (Task 5)

The Carbon Portal involves a team of 14 contributing persons, delivering in 2017 a total of 9 fte, including the external projects (3 fte). All CP personnel except the director is employed by either Lund University or Wageningen University. The overall management, including HR and project management (including acquisition), is performed by the Carbon Portal director, who is employed by ICOS ERIC. In regular group meetings, every two weeks, progress is discussed with all CP team members. The CP director also takes part in weekly telco's with ICOS Head-Office and two-weekly ICOS Head of Units telco's. ICOS RIcom meets with a telco's in a monthly schedule. Next to this there are the half yearly face to face meetings with ICOS RIcom. In principal, the CP director visits Head Office every two months.

Telco's with the thematic centers have been irregular in 2017, with the schedule based on emerging needs. Furthermore CP director and representatives from CP have been attending the MSA meetings from all ICOS Themes, presenting there the progress at CP and receiving feedback on the developments. CP was also invited to several ICOS national meetings to present the progress.

The CP project portfolio in 2017 consisted of 4 H2020 projects (EUDAT2020, ENVRIplus, SEACRIFOG, RINGO), 1 national project (SITES) and 1 international project (COPERNICUS in-situ). The H2020 EOSC-Hub project where CP applied in 2017 for a Competence Centre together with eLTER will start on 1 January 2018. Of course all plenary project meetings from the CP project portfolio projects have been attended by representatives of CP.

CP itself also hosted several meetings related to these H2020 projects, like an ENVRIplus workshop on data identification and citation, on which CP leads a work-package, and an ENVRIplus site visit to ICOS where also the Thematic Centers participated.

Extensive work is carried out in the H2020 projects that are beneficial to ICOS with regards to data management and eScience, and links to EUDAT (CDI) and the other e-infrastructures that will play important roles in the upcoming European Open Science Cloud. Maggie Hellström is very active in representing ICOS in the GEDE (Group of European Data Experts) RDA working group.

The CP director is active as chair of the WMO GAW scientific advisory board for greenhouse gases, member of the executive steering group of WMO IG3IS, member of the expert group of the H2020 CHE project and member of the advisory board of the MEMO2 project. CP is also acting as representative of ICOS in the Copernicus in-situ project lead by EEA.

CP hired two new employees in Lund, one project assistant/communicator (Ulrika Jönsson-Belyazid; 0.6 fte) and one full-time developer (Jonathan Thiry; 0.8 fte SITES, 0.2 fte ICOS). One developer left and was lost to the commercial sector (Paul Hedberg). This position will be filled Q2 2018. One post-doc for the RINGO project was hired to start Q1 2018 (Claudio D'Onofrio). At the CP in the Netherlands our co-worker Ingrid van der Laan was granted a prestigious personal grant which unfortunately for CP resulted in her leaving early 2017. She has been replaced with Naomi Smith in September who picked up the work with great speed.

Highlights

- Full functionality of data ingestion, PID minting, persistent storage, data search, data retrieval, data preview, license checking and usage tracking implemented and operational
- Operational atmospheric footprint calculation and visualisation tools through virtual research environments in the cloud
- 4th ICOS Summer School in Hyytiälä

ICOS INTEGRATED CARBON OBSERVATION SYSTEM

ICOS RI

Atmosphere Thematic Centre (ATC)

Data collection and availability (Task 1)

Twenty European stations were connected and sending data to ATC in 2017. The GHG Level 0 data files of 10 stations are being sent to the Carbon Portal. They correspond to the subset of station that have entered Step 2 of the labelling process. Four new NRT internal data products have been developed and the ATC website had over 34000 page-views. First Level 2 data release will take place first half of 2018.

61 PM allocated for this task

Level 0 data transfer (Task 1.1)

As new atmospheric stations come into the ICOS Network, they are registered as well as all their instruments along with their metadata. The data stream is set up and data and metadata start flowing in.

In 2017, the following new data transfers have started:

- CO data from the Gartow and Hohenpeissenberg German stations
- GHG data, meteorological data and station data from the three Swedish stations Norunda, Hyltemossa and Svartberget
- GHG data, meteorological data and station data from the European station Ispra
- GHG data, meteorological data and station data from the Finnish station Pallas
- GHG data and station data from the German station Karlsruhe
- GHG data from the Norwegian station Zeppelin
- meteorological data and station data from the French station Puy de Dôme
- meteorological data from the four levels of the tower of the French station Trainou
- meteorological data from the Belgium station La Réunion station

Important developments were made to better and more easily track the data transfer by station and instrument.

Metadata and format needed for transfer of the Level 0 data to the Carbon Portal have been defined. Everyday data files are automatically minted and sent to the Carbon Portal.

The system has been secured to cope with network or minting failures. If after several attempts, a file could not be minted a given day, the system automatically retries the next day.

The entire process is traced, the PIDs are stored as well as the files waiting for minting. In case of failure, the date and the error are also stored. If a station sends an updated version of a Level 0 data file, the new version is also minted.

Upon minting, the Carbon Portal automatically generates a landing page for the file (i.e. https://meta.icos-cp.eu/objects/-HEfreSBjlR3N8tO7_wyGuSH). The design of the landing will evolve this year to add more metadata.

The GHG files of 10 stations are currently sent to the Carbon Portal. When a station enters the Step 2 of the labelling process, its Level 0 data files start to be sent to the Carbon Portal.

NRT data production (Task 1.2)

NRT data flow is operational for stations in the labelling process. The NRT data production at ICOS ATC is an automatic daily process based on shell scripting, Java and MySQL for the ICOS database. It is documented by ICOS ATC in a joint paper with others ICOS TCs in [Hellström et al., 10.5281/zenodo.204817]. Of the 34 atmospheric ICOS stations involved in the labelling process in order to become official ICOS stations, 20 stations are connected to ATC in 2017, sending their data to ATC and, consequently, are able to be processed in NRT mode. This represents 6522 raw archive files (~51Go, for a mean of 7.6Mo/station/day) processed for an availability rate of ~0.97 for 14 stations which transmit their data over a complete 2017 year. Once NRT data are generated, they are stored in ICOS database and are never changed anymore.

NRT data visualization and distribution (Task 1.3)

In 2017 NRT data visualization can be done on ICOS ATC website [https://icos-atc.lsce.ipsl.fr/dp], through the access page of the NRT data products generated at ICOS ATC. In 2017, 47 families of graphical NRT DataProducts, (~ 3400 products in total, for ICOS network stations) are produced daily from NRT measurements and freely available on the ATC website. Among new 2017 NRT data products, one can find: P0003.10 which compares the variation of target's molar fraction and the variation of GHG Analyzer temperature, P0004.6 which shows various NOAA's CCGCRV fitting for in-situ GHG data, P0035.6 which shows the air time series and target's uncertainties, for each site/instrument/sampling height/species and P0060.1 which shows the time series of site's tanks pressure. In total, for the year 2017, nearly ~ 1800 users have interacted with ATC's website, for ~ 34000 page-views, with a visitor return rate of around 75%, and an interest for NRT data of 77.6%. Distribution is not completely operational in 2017, since some technical aspects need to be tuned and are in discussion with ICOS CP (Pids and DOIs for data citation and contributor identification).

Level 2 data production (Task 1.4)

The Level 2 atmospheric data release scenario was proposed and agreed at the November atmospheric MSA. The station PI has 1 month after MSA meeting to make latest adjustment before the actual data release. The first four atmospheric stations were labelled at the ICOS ERIC GA on Nov 17 and therefore the first level 2 data release will take place first half of 2018.

Network coordination, training and development (Task 2)

Twenty-four instruments have gone intensive testing at ATC before being deployed in the ICOS network. In 2017, ATC is processing in situ droplet tests to follow the water vapor correction in time. The Mobile Lab audited stations in Finland, Sweden and the Czech Republic. Thirteen station PIs were trained on how to use ATC software tools with practical courses. Ten stations have passed step 1 in 2017, six entered Step 2 and four were labelled in November 2017.

27 PM allocated for this task

Instrument testing (Task 2.1)

In 2017, 18 Picarros CO_2/CH_4(/CO) were tested at the ATC before deployment in the ICOS network. These instruments are for stations in Switzerland, Germany, European Commission (ISPRA), Finland, France, Italy, The Netherlands, Norway and Sweden. In addition, 6 Los Gatos N_2O/CO were also tested for stations in Germany and France. Tests are standardized in ICOS and

last 3 to 4 weeks each. These tests have become a benchmark and are now taken into account by industrials like Picarro and LGR to guaranty they are in conformity with ICOS specifications.

In terms of technology watch several instruments, not qualified so far in ICOS, were tested using the same benchmark to allow comparison: Picarro N_2O/CO, LGR MGGA (microportable) $CH_4/CO_2/H_2O$, LGR GGA CO_2/CH_4, several Senseair HPP CO_2. The HPP sensors were tested against a reference Picarro analyser during several weeks. This period allows for a learning process to determine calibration coefficient for the Sensair instrument which has otherwise important drift in time. All test reports have been finalized with an updated version of the ATC analysis software.

An in-situ droplet test was put in place to verify the water vapor correction in time. The data treatment for these droplet tests is done at the ATC.

A measurement bias was put into evidence by ATC when performing very dry air measurements of CO_2 and CH_4 on Picarro analysers. This was shown when measuring a quality control target gas just after calibration sequences that flow really dry air during the 8 hours of the calibration. Analysis done in collaboration with the Picarro company concluded that the bias was due to a biased cavity pressure measurement with the Picarro's pressure piezo sensor when a residual H_2O layer is coating the sensor surface. Picarro is currently working on a solution to correct this effect (e.g. spectral pressure measurement).

Atmospheric station audit (Task 2.2)

A new optical cell for FTIR instrument of the Mobile Lab was installed successfully at the beginning of the year and performance tests showed clear improvements in temperature and pressure stabilization. MobileLab also started the routine determinations of the station analysers' water vapour correction factors as a part of an audit, with a dedicated water vapour bench.

In early 2017, Finnish station Smear (SMR) was re-audited due some quality control issues discovered during data management. Czech tall tower site Křešín (KRE) was audited in spring and the Swedish station Hyltemossa (HTM) in autumn of 2017. After HTM visit the field calibration gas cylinders were sent to CAL for determining the mole fractions the MobileLab will use to calculate audits results. Thus, audit reports of these stations are in preparation.

To improve ICOS atmospheric stations quality control, MobileLab started to organise blind-cylinder measurements, for a start between five stations; MobileLab and ICOS central analytical laboratory (CAL); to collect experiences and improve measurement protocols for this kind of QC-tool. The MobileLab also got involved with a separate, but similar kind of a QC-operation between CAL and NOAA laboratories.

Training activities for ICOS atmospheric measurements (Task 2.3)

According to the need of the ICOS atmosphere network (email survey and during the MSAs), two training sessions have been organized by the IOCS ATC in 2017 at LSCE, France.

A first training session took place in June 2017 during 3 days. It mainly focused on the data processing and Quality Control with practical works on the use of the ATC software tools (ICOS Station configuration and data quality control). This session trained 6 station PI/staff of the European atmospheric network (Norway, Germany, Finland and Belgium).

A second training session, lasting 4 days in October 2017, dealt with the data processing and Quality Control like during the first session in June (same program) but also with the theory and practical work on the ICOS compliant analyzers and the sampling system.

This second training session was attended by 7 station PI/staff from 4 different countries of the European network (Italy, Germany, Denmark and Belgium).

Extensive documentation was prepared for these training. More than 30 documents are available on the ICOS ATC website (https://icos-atc.lsce.ipsl.fr/training).

According to the answers to the attendee satisfaction questionnaire (anonymous online survey), the ICOS ATC training meet the expectation and needs of the station PI. The overall evaluation is very satisfactory.

Activities reported to the DG, RI Com and General Assembly (Task 2.4)

The ATC workplan and associated budgets for 2018 were provided to ICOS HO in October of 2017 and later accepted by ICOS ERIC in November 2017.

The ATC had the two days visit of Eija Juurola and Gorana Jerkovic from the Head Office end of January 2017. The meeting was centred on how the ATC works in practice and communication activities.

The ATC attended the Scientific Advisory Board meeting that took place on November 16 alongside the GA meeting of ICOS ERIC. The Atmosphere Labelling process was presented extensively and we participated to the strategic discussions.

Station labelling process, Steps 1 and 2 (Task 2.5)

In 2017, ICOS ATC has continued to accompany stations through the labelling process. Ten stations have filled up their Step1 documents that have been reviewed, completed and evaluated by ATC before sending them for validation to the Head Office. The new stations accepted in Step1 are Cabauw (Netherlands), Monte Cimone, Plateau Rosa and Lampedusa (Italy), Ispra (European Comission), Puy de Dôme and Trainou (France), Ochsenkopf and Torfhaus (Germany) and Weybourne Atmospheric Observatory (United Kingdom).

Six stations, Hyltemossa, Norunda and Svartberget (Sweden), Puy de Dôme (France), Ispra (European Comission) and Zeppelin (Norway), have begun the Step 2 initial test period. At the end of the year 2017, of the 6 stations that were in Step2 since end of 2016, four are now ICOS labelled (Gartow and Hohenpeissenberg (Germany), Observatoire Pérenne de l'Environnement (France) and Hyytiälä (Finland)). Two are still in Step 2 (Jungfraujoch (Switzerland) and Křešín u Pacova (Czech Republic). The work in Step 2 has involved organizing 8 teleconferences in 2017 to review the data and the station progress. Minutes have been written for each session. For the labelled four stations, a full report as well as an executive summary have been produced and send to the Head Office for validation. Several data products have been developed to help the data assessment for ATC and the PIs. Numerous emails have been exchanged to assist PIs when necessary. For example, thanks to common quality control, faulty material leading to biases has been identified and removed from the Swedish stations. At the Swiss station, a better quality of the data has been reached after removing the nafion system following ATC MobileLab advices.

Highlights

During 2017, ICOS ATC engaged with ECMWF and the Copernicus Atmosphere Monitoring Service (CAMS) into a project "For the Provision of improved Access to NRT ICOS atmospheric data for the purposes of the validation of global and regional forecasts", under the acronym "CAMS26". The work plan aims to consolidate and improve the outline and reliable preparation, transmission and quality control of NRT atmospheric ICOS data for use by CAMS and other potential users. It is grouped into four work packages (WP), including coordination and

management in WP0. In WP1, the rapid delivery data flow from actual observation to availability to CAMS will be improved for CO_2 and CH_4 species. In particular, to achieve this goal, a workflow engine software will be implemented in order to orchestrate the complex distributed suite of interdependent tasks in ATC to have full control and information on NRT data workflow. In WP2, a new set of rapid delivery data products and indicators that enables rapid detection of signal anomalies will be developed and implemented at ICOS ATC. New diagnostic software to handle data treatment configuration errors will be deployed. The WP3 Evolution of service increases the data provision of NRT atmospheric data by adding measurement of CO and Radon.

ATC participates in the RINGO project, it attended the kick-off meeting in February 2017. ATC is responsible for subtask 1 "Integrating TCCON into ICOS" of Task 1.5 Enhancing the bridge between ICOS RI and satellite observations. A session to develop the concept of integration between ICOS and TCCON communities took place during ICOS MSA (21-23 November / Groningen) with presentations from TCCON colleagues T. Warneke, M. Zhou, and M. Sha.

In ENVRIPlus, the ATC is in charge of a task on Metrology. The aim is to share good practices in metrology in environment in between the different European research infrastructures (RI) participating in ENVRIplus. In doing so, one can also identify gaps where standards for measurements are lacking. On the subject, a consultation of more than 13 Research Infrastructures has been performed in 2017. Also, a joint meeting between RI scientists and people from the national metrology institutes in various countries were organized. A first gap analysis showed four parameters for which standards were missing or could be improved: Black carbon, GHG gas analysis, PH measurements in water and eddy covariance measurements.

ATC attended with several presentations made each time, the atmospheric MSAs in March and November 2017.

ATC attended and presented at the GAW symposium in April 2017 and the WMO meeting in August 2017.

ATC was presented at the Inversion workshop organized by JRC in June 2017. It gave oral presentation at the EGU (Laurent et al.)

ATC participated in an inter-comparison exercise FTIR vs Picarro at Cabauw in the Netherlands, end of 2017. Results are to be produced in 2018.

Ecosystem Thematic Centre (ETC)

Data collection and availability (Task 1)

Data collection started end of 2017 with the first labelled stations. This contributed to identify the bottlenecks and to simplify the step where possible, keeping high level of tractability and robustness. The different data types that are submitted are very heterogeneous, ranging from continuous high frequency measurements, to results from campaigns of data collection, metadata, physical samples and digital hemispherical pictures. For all these data type a standard procedure for submission has been developed and tested with operational sites. The data are submitted through the ETC portal (except of the continuous data, described below) and then archived in the Carbon Portal. The overall procedure to link ETC and CP (with the PID assignment and data retrieval by ETC for processing) has been successfully implemented and is working.

20 PM in this task (impossible to split in subtasks)

Raw data transfer (Task 1.1)

Continuous data (eddy covariance and meteorology): the labelled stations are submitting NRT data directly to the Carbon Portal or to the ETC portal because of few issues with the file format. The other five stations did all the necessary steps to prepare ICOS compliant data files and will be ready to submit raw data beginning of 2018. Ancillary data and metadata: large number of metadata describing the sensors and setup have been submitted by the stations during the Step 2 of the station labelling. All the data are archived in the ETC database and will be synthesized and transferred to the CP as soon as they are ready together with the Level 2 data production. Ancillary data on ecosystem characteristics (species composition, biomass, Green Area Index, trees position etc.) have been submitted by stations in Step2 and quality checked by ETC. Five of the forest sites used the FieldMap instrument provided by the ETC. Digital Hemispherical Pictures and ceptometer files: DHP and ceptometer files have been submitted by stations in Step2. For the DHP the routine and tool to upload them in the CP system and retrieve the PID has been implemented and tested. This tool will then be used for all the other data and files that ETC will transfer to CP. Vegetation samples: ten ecosystem stations collected and submitted a total of 318 samples to the ETC labs. All these samples are labelled and archived.

NRT data production (Task 1.2)

The NRT data production will start in 2018 with the labelled stations. For the eddy covariance fluxes the implementation of NRT data production progressed due to the ENVRI+ project, and currently the tools are working correctly. It is needed to define and select the infrastructure where the processing will happen and different options are being tested and under evaluation: a European e-infrastructure, an ICOS cloud or a commercial solution. Waiting for the final selection the routines are for the moment running on the ETC system where also the NRT processing of meteorological data is performed and all the codes for the data aggregation are prepared.

NRT data visualization and distribution (Task 1.3)

No new activities have been performed in this task but the tool is ready for the visualization. The NRT data will be produced and then submitted to the CP using the same tool prepared and tested for the DHP.

Level 2 data production (Task 1.4)

The Level2 data production started with some of the variables submitted by the two labelled stations and the stations in the Step2 of the labelling process. The results are however only produced as test because in the case of the labelled sites the time series is still very short (labelled end of 2017) while for the stations under labelling they are not always compliant and of sufficient quality (this is the goal of the labelling). However, the activity has been used to check the tools with real data. Eddy covariance and meteorological data: the processing has been tested during the labelling using three months of test data. For the postprocessing the feedbacks received from the FLUXNET community helped us to implement and optimize some of the steps that are under recoding and will be ready for the 2018 Level2 data production. DHP and ceptometer: the tools ready since 2016 have been tested in the different stations and confirmed the high quality. The Green Area Index data will be mainly collected in 2018 and will be provided as Level2 data to the CP together with all the other ancillary data. Vegetation samples analysis: all the 318 vegetation samples have been analysed and the chemical content uploaded in the ETC database. All this information will be aggregated and processed to produce the best possible quality controlled Level2 dataset which will be transferred to the CP together with the other data.

Network coordination, training and development (Task 2)

As planned the largest part of the activities in 2017 have been dedicated to this Task. The urgency to define all the Instruction documents needed to setup the sites and the respective data and metadata structure, template and system was a key objective of 2017 because this is directly linked to the possibility to conclude the labelling of the proposed stations. This involved not only the preparation, discussion with the MSA and finalization of all the documents and templates but also a continuous assistance to the station teams and the development of the Step2 labelling procedure and report. This is better described and specified in the subtasks report here below.

99 PM in this task

Training and information of the ICOS ecosystem network (Task 2.1)

A total of 25 Instruction documents for the data collection, instrument setup and measurements submission have been prepared or revised in 2017 and shared with the MSA. ETC has been providing the stations team with a continuous technical "hotline" support mainly organised through e-mail exchanges and tracked through the ETC-information system. A special condition for the ICOS stations has been agreed with LICOR for the calibration of the ICOS sensors and with GILL where also a special price is offered to the ICOS ecosystem stations. ETC also contacted Campbell to get support to the network for the data logger programming and Kipp&Zonen to discuss special conditions for the radiometer calibration. The preparation of ICOS APP to collect and submit metadata directly in the field has been started and the first version is under test. The first release is expected before the Ecosystem MSA of 2018. ETC members participated to the MSA where discussion of the different activities took place and training on specific points have been provided. ETC prepared standard plastic bags that are provided to all the stations ready for the soil sampling.

35 PM in this sub-task

Activities reported to the DG, RI Com and General Assembly (Task 2.2)

The activity and financial plan for the 2018 and the report of the 2016 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. ETC participated to the spring GA presenting the results obtained and situation of the activities. ETC participated to the RICom meetings and teleconferences.

4 PM in this sub-task

Station labelling process, Steps 1 and 2 (Task 2.3)

The station labelling has been the main activity for ETC in 2017. For the year 2017, a total of 23 stations completed the Step1 of the labelling and 24 started Step2. For each of them a specific WebEx has been organized between the station team and the ETC in order to explain the overall procedure. For 21 sites ETC performed the analysis and design of the spatial sampling scheme that the station teams implemented. 15 stations proposed a timeline and detailed procedure of implementation of the Instructions, including the list of all sensors, that have been checked for the compliance. Three stations ended the labelling process and final reports have been submitted to the GA. Test of example files have been performed for all the stations that installed the equipment in order to check format and possibility to process and instruction for the upload (to the ETC and to the CP directly) have been provided. FieldMap have been borrowed and full support given for the forest stations characterization. In general, the exchange with the station

team during the labelling is very intensive, with continuous exchange of emails and sharing of documents online. All the staff of the ETC is involved in the process.

60 PM in this sub-task

Highlights

By April 1st, 2017, Mrs Christelle Aluome, expert in database management was recruited at INRA, UMR ISPA, and has been working since as responsible of the foliar analyses data flow and database.
S. Lafont and D. Loustau have been invited for ICOS-ETC presentations at the Annual ICOS-France assembly (16-19th Nov. Orléans) and ICOS-France steering committee meetings. Alessandro Ciaccia has been recruited at CMCC as database and IT system expert for the evaluation of the best technical solution for the final ETC database and web portal implementation.
In February 2017 the ETC had a retreat in Italy where all the ETC members got in contact and discussed the strategy of interaction in the different activities. Among other issues, the meeting allowed to cross-validate the workflows that are under the ETC responsibility.

Ocean Thematic Centre (OTC)

Data collection and availability (Task 1.)

In order to implement the OTC data lifecycle -with the various levels of quality control performed at each step- a dedicated software needs to be written. The software has been under development since the software engineer was hired in mid-2016 and in the last quarter a second software engineer was hired to work on this task. The software is on the highest priority within the OTC data management group since it is essential for the station labelling and for becoming operational in respect to data delivery to the Carbon Portal. The software, called QuinCe, is an automated system and online tool for data submission, data processing, and quality control and is being established for the automated data streams from the ICOS ocean network.

16 PM in this task

Raw and Level 0 data transfer (Task 1.1)

We have been receiving raw and Level 0 data from ICOS OTC stations for assessment in the station labelling process. These data are in a wide variety of non-standard formats; prior to ICOS the station PIs performed all processing themselves, so no centralised system for handling marine data of this kind existed.

Software routines have been written to facilitate the standardisation and processing of Level 0 data submitted to OTC for station labelling, although some manual processing has still been required. The new software system, QuinCe, will handle the complete workflow of ICOS marine data from submission, through processing and quality control, and submission of Level 2 data to the Carbon Portal. This system is currently in the Alpha testing phase and is scheduled for release during the summer of 2018.

Data from stations that pass the labelling process and submit data before the QuinCe processing tools are ready will be published through the Carbon Portal as pre-ICOS data (see Task 1.3).

Near Real Time data visualization and distribution (Task 1.2)

Near Real Time data is not available from the majority of ICOS OTC stations due to lack of data transmissions. Near Real Time data, as soon as data can be received, are either collected on a daily basis via satellite or as soon as the platforms ships visit port and those from moorings are collected during maintenance visits (typically semi-annual or annual).

We are currently focusing efforts on processing data retrieved manually, which will allow data from all stations to be processed and published according to ICOS standards (which is not currently possible – see Tasks 1.1 and 1.3). Once this is complete we will begin developing tools to handle NRT data sent via satellite. We hope to be able to draw on the expertise of the other Thematic Centres which have more experience of this activity.

Production and transmission of L2 data (Task 1.3)

As mentioned in Task 1.1, we are developing a software system (QuinCe) to allow station PIs to submit their raw/Level 0 data to ICOS OTC for processing and quality control. This software will allow PIs to QC their own Level 1 data directly within the OTC framework. Once this is complete, the data will be checked by OTC experts before Level 2 data is sent to the Carbon Portal for publication.

Some OTC stations will pass the station labelling process before QuinCe is ready in mid-2018. In this case, we will ask station PIs to follow the procedure currently used by the SOCAT project, which is the main global destination for surface ocean CO_2 data. In this scenario, station PIs process and quality control the data themselves, and submit that data to SOCAT. This is the equivalent of Level 2 data in ICOS. In our case, we will ask station PIs to submit their raw data (Level 0) and the Level 2 equivalent data to ICOS for publication through the Carbon Portal. We will label this to indicate that we believe it to be of high quality (based on the expertise of the SOCAT project), but that it has not been processed using ICOS methods.

Some ICOS OTC stations have had 'historic' data published through the Carbon Portal. This consists of all data from the station submitted to the SOCAT database, but without the accompanying L0 and L1 data. This allows the Carbon Portal to publish a complete time series of data from those stations even though not all the data was processed using ICOS standards, and the original Level 0 data is not available. Historic data will be added to the Carbon Portal up until the point that a station passes labelling, at which point ICOS OTC will require that L0 data is submitted as described above.

Task 2. Network coordination, training and development

We supported the ICOS RI, which is the arena for communication, future strategies, development, to quality assure the labelling process, and to fulfil the requirements of the ICOS General Assembly (GA). Two annual face-to-face meeting and monthly video conferences were organised. The general reporting for ICOS GA was done during the spring meeting and the communication with ICOS SAB to improve the performance of ICOS RI was done at the fall meeting.

In 2017, we organized one MSA-OTC meeting, planned one technical workshop, presented the OTC work in conferences, processed three more ocean stations that passed Step 1 labelling, and produced the 2018 OTC work and financial plans. These activities are detailed below.

45 PM in this task of which 18 PM toward the labeling process

Meetings, training and interactive discussion groups (Task 2.1)

In March 1-2, 2017, we organised the fourth joint meeting for the ICOS Monitoring Station Assembly (MSA) and OTC in Bergen, Norway. Delegates from 8 European countries, ICOS ERIC Head Office, and SCOR/UNESCO's International Ocean Carbon Coordination Project (IOCCP) participated. During the meeting, OTC services, ICOS data policy, ICOS OTC software and station labelling were discussed.

In May 9-10, 2017, OTC staff participated at an ICOS Norway meeting, co-organised by NILU (Norwegian Institute for Air Research) and Uni Research, where the OTC services, data life cycle, data policy and stepwise labelling process were presented.

Additionally, OTC have had extensive contact with station PIs in 2017, both via telephone/video calls and e-mail communication, and the aim has been to exchange knowledge and prepare for data QC and labelling of stations.

Locally, the OTC has weekly meetings to discuss the daily operation and to ensure continuous progress of the OTC with special focus on station labelling, data quality control procedures and internal communication.

Also, OTC had extensive contact with station PIs and MSA Chairs and has also contacted a sensor supplier with the aim to provide additional information to the sensor users.

Training and information of the ICOS ocean network (Task 2.2)

In an effort to improve communication between instrument vendors and PIs, a workshop has been planned for March 2018. Organisation, communications between interested parties, and set up for this workshop has primarily occurred during the second half of 2017. The workshop includes representatives from: the OTC, MSA, ICOS station PIs, the University of Miami, the European Multidisciplinary Seafloor and water-column Observatory (EMSO), and International Ocean Carbon Coordination Project (IOCCP).

Uncertainty analyses to improve data quality of underway instruments (used for VOS stations) has been performed. Furthermore, discussions between MSA Chairs, OTC personnel, and the FCL stemmed from these analyses to provide adequate gas standards for underway pCO_2 instruments. These gas standards are important to calibrate the underway instruments and are one of the requirements set forth by the OTC to produce high quality data. These discussions are still ongoing.

A searchable web database for Frequently Asked Questions related to the most used instrumentation within the marine ICOS community has been designed, and the system will be launched in 2018.

Preparations of the ICOS lab occurred in 2017.

Activities reported to the DG, RI Com and General Assembly (Task 2.3)

The OTC Work Plan and the financial plan for 2018 were produced and submitted based on templates provided by the Head Office (HO). These documents are available to the ICOS OTC network through the internal information sharing space (Alfresco).

Station labelling process, steps 1 and 2 (Task 2.4)

OTC is responsible for both Step1 and Step 2 of the station labelling procedure. In 2017, three additional stations (Polarstern (Germany), Finnmaid (Germany), Lance (Norway)) passed the

Step 1 labelling, and thus 19 of 21 of the marine stations are ready for Step 2 of the labelling procedure. In 2017, a document describing core parameters, criteria, metadata, and QC, was finalised and agreed upon by the marine MSA. Step 2 labelling was started for 10 of the marine stations, and the submitted station data and metadata were quality controlled and evaluated. A template for Step 2 QC report was developed, and this contained results, evaluation and recommendation of the QC process.

Highlights

New recruits: Erik Sandquist (admin Director) and Jill Johannessen (Communication).

- Other training: On the 11th and 12th of September, 2017, Charles Battisti (Chief Engineer) participated in a DuraFET workshop held in Nice, France. The purpose of attending the workshop was to better understand the instrument and evaluate its use in the marine ICOS sector. On the 3rd of February and 22-26, June, 2017 Charles Battisti participated in a mooring deployment cruise and a mooring recovery cruise (respectively). This was to improve his knowledge of mooring deployment and recovery and begin developing short informational videos to help explain the deployment/recovery process for interested users.

Central Analytical Laboratories - Flask and Calibration Laboratory (CAL-FCL)

Trace gas analysis (CO_2, CH_4, CO, N_2O, SF_6, H_2) of flask samples (Task 1)

As anticipated in the 2017 work plan there were not yet many requests for trace gas analysis with only one ICOS class 1 station (OPE) providing flask samples in 2017. Therefore, the GC capacity was mainly used for the following purposes:

- support of the development of the flask sampler and quality control of the production by testing the performance of manufactured sampler specimen before delivery to the ICOS stations
- maintain the ongoing quality control activities of ICOS external comparisons and the internal check of the calibration measurements made with optical analysers.

The web tools for the input of sampling or container meta-data using the ICOS-CAL database application have been set up. Tests have started involving the CRL and will in future allow to register sample collection at the stations.

The approach of using a laser spectrometric method for CO and N_2O analysis in flask samples to improve the flask CO data reliability could not be addressed due to an issue with the new LGR instrument. This analyser was delivered in spring of 2017 but failed the initial specification check. Communication with the manufacturer were tedious before they finally performed a remote maintenance that only solved some of the problems like the unstable water signal and moderately improved the signal to noise ratio. Yet, further test campaigns revealed that the stability of the detector response remained unsatisfactory such that the instrument had to be returned to the manufacturer Los Gatos Inc. end of 2017.

24 PM in this task

Analysis of supplement parameters (CO_2 stable isotopes and O_2/N_2 ratios) (Task 2)

As foreseen in the workplan also the task of analysis of additional parameters was not exploited by the ICOS network as samples were not collected due to the lack of sampling equipment. Big efforts were undertaken to achieve progress towards a failure-proof process of sample collection. This included the following main activities:

- development of a new automated drying unit for the flask sampler, including its performance characterization, an endurance term test (4 months already), and its integration into the flask sampler software
- development of a test bench for long-term tests of the faultless operation of the sampler, its mechanical and electrical components and the achieved sample quality
- improvement of the robustness of the glass flasks in collaboration with the manufacturing company defining specifications and improving their quality control in the production process to ensure the adherence of quality standards (e.g. developing a moulding tool for the caps that are crucial for the automated opening and closing process, quality control gauges for ensuring the compliance with specifications)
- development of a new automated testing device for regularly assuring the leak tightness of flasks before shipment to the ICOS stations
- production or upgrade of several flask sampler units that have been provided to five ICOS partners
- extending the software of the sampler in close cooperation with ICOS users concerning sampling schemes, trigger possibilities, individual tests by the operators and recording and utilization of sampling meta-data
- considering ICOS user feedback-initiated hardware changes on the flask sampler (e.g. the introduction of a possibility for integrated sampling, increased attention to leak issues and the possibility for on board leak tests)
- The FCL flask sampler facility was further furnished to reduce assembly times and allow additional quality tests of the instruments before they are deployed to the field.

48 PM in this task

Production of real air high pressure standard gases (CO_2, CH_4, CO) (Task 3)

For the ICOS Atmospheric station network a total of 100 reference standards in high pressure cylinders have been produced to equip new stations and maintain the supply of operating stations by refilling empty cylinders. Occasional events of urgent replacement needs by some stations could be addressed. Some of the standard gases that were filled for the ICOS atmosphere network are replacement sets for stations to bridge the periods when their reference gases are absent for the purpose of re-calibration at the FCL. An additional 15 gases were produced for FCL laboratory operations.

Many stations have implemented continuous N_2O measurements. To allow for a future extension of N_2O as core parameter for in-situ observations ALL reference gases have already been prepared with targeted N_2O concentrations.

After long-term storage tests of new type of T-PED and DOT certificated, 10 L cylinders (Milestone 4) these cylinders seemed to exhibit excellent properties regarding the stability of CO_2 concentrations and similar properties with regard to CO compared to larger volume cylinders of the types that commonly have been used up to now. Therefore ,they are a good choice for the purpose of the new ICOS round robin exercises (see Task 5).

The gas filling facility has been upgraded to improve occupational safety by using pre-configured large diameter compression fittings that are certified by the manufacturer. The installation of a new zero air purifier has improved the filling efficiency for standards with methane concentrations at sub-ambient levels.

17 PM in this task

Calibration and re-calibration of standard gases (Task 4)

More than 150 reference standard calibrations were made.

A second subset of the FCL primary standards was recalibrated by the Central Calibration Laboratory (CCL).

Reference gases with unstable CO are a big limitation for the accuracy. 40 L cylinders of the new type that has been tested have been purchased to be used for additional CO primary standards. Based on the performance of the small cylinders it is expected that potential CO growth should be reduced in the larger gas volume. The double EU and US certification of these cylinders allows the preparation by the FCL and shipping them to the CCL in the USA.

The idea of using the FTIR as a backup analyser for atmospheric reference gases has not been followed up as plans were changed to explore the option to accommodate requests by OTC aiming for a future FCL supply of reference gases. A clarification of the needs of the ocean community regarding precision and calibrated range requirements has been achieved and an agreement made with the CCL that such concentrations beyond the WMO scales can be calibrated by them. Respective gas mixtures were then prepared and sent to the CCL. To ensure that this activity is not interfering with the ongoing calibration activities the FTIR had to be relocated to another laboratory room.

The automated data QC for CO and N_2O calibrations has been implemented. Data transfer to the ATC is in place. Discussions were made concerning a data revision of FCL results based on CCL re-assignments. This would entail the reprocessing of all ICOS Atmospheric Monitoring data by the ATC. It was agreed to postpone such a revision given that the update is insignificant for CH_4 and N_2O, there is a major CO_2 calibration scale revision upcoming and CO data is still inconclusive.

33 PM in this task

Organisation of and participation in international QC activities (Task 5)

The FCL contributed to several international QC activities.

- As a result of discussions at the MSA in Lund a round robin program was begun with several stations in the labelling process. FCL provided the respective sample for this exercise.
- To improve the link with the CCL the implementation of a routine exchange of comparison cylinders has been negotiated with NOAA. This serves to provide a frequent high precision check of the agreement of FCL and NOAA measurement data to assess the compatibility and to get an early alert when problems might evolve. It will also involve the ATC

MobileLab unit and will offer an ongoing control by an independent agency to raise confidence in ICOS data. The data submission mechanism has been set up and the first samples sent to the CCL.

- FCL took part in the WMO round robin for SF_6 (SICE), coordinated by the World Calibration Center. The report was published in Dec 2017 with FCL results showing no mean offset to the reference (0.00 ± 0.03 ppt).
- FCL submitted its data and uncertainty budged on schedule to the BIPM for the pilot study CCQM-P188 that accompanies the Key Comparison CCQM-K120a (Feb 2017). Re-analysis back at FCL in summer 2017 showed stable and reproducible gas mixtures for contribution. The draft A report is pending (initially announced for 2017).
- FCL has continued to organize and participate in the so-called Sausage Inter-comparison Experiment that links the major flask laboratories from Europe, USA, Canada, Australia and Japan. As planned this was performed four times in 2017.

A comprehensive evaluation of the QC activities (internal and external) has been made to result in an assessment of the uncertainty of calibration measurements by the FCL in the Quality Control report.

3 PM in this task

Activities reported to the DG, RI Com and General Assembly (Task 6)

The general report including the financial and activity report 2016 has been submitted to the HO in Feb 2017, the budget and work plan 2018 were provided in September 2017.

2 PM in this task

Interaction with station PIs (Task 7)

The FCL team was present at the ICOS Atmosphere MSA in Lund and Groningen. The reports on FCL activities were put up for discussion. Daily communication of specific topics (e.g. reference gases, flask samples, flask sampler) between individual station PIs and FCL is facilitated by dedicated mailing lists and named contact persons. Topics concerning the entire atmospheric domain have been brought up for discussion with the MSA chairs and colleagues from ATC and CRL.

2 PM in this task

Highlights

The collaboration with Ken Masarie (formerly NOAA-ESRL, now SkyData Solutions LLC) has been continued and contributed to the successful continuation of the development of the ICOS CAL database application after the loss of the former database developer team and handing over to a new database developer end of 2017.

FCL is participating as linked third party in the RINGO project contributing to the Work Packages 1 and 3.

Poster contributions to promote ICOS were made at two meetings. At the 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques (GGMT-2017) in Duebendorf, Switzerland in August 2017 4 posters were presented.

Central Analytical Laboratories -Central Radiocarbon Laboratory (CAL-CRL)

Radiocarbon analysis of two-weekly integrated CO_2 samples (Task 1)

By the end of 2017, in total 15 ICOS atmospheric stations have been equipped with new $^{14}CO_2$ samplers and 10 of these stations delivered integrated samples to the ICOS CRL for analysis. In addition, samples were analysed from the ICOS stations Jungfraujoch, Cabauw, and Heidelberg, which had already been part of the ICOS DEMO experiment, as well as from the non-ICOS sites Mace Head and Schauinsland, which serve, together with Jungfraujoch as reference sites to estimate regional fossil fuel CO_2 concentrations. All delivered samples from the European and ICOS atmospheric network have been analysed (or are in preparation for analysis if they arrived only recently). In total, more than 360 European samples were analysed by low level counting. Analysis of samples from Hyytiälä station (FI) turned out to be highly contaminated in ^{14}C, possibly due to earlier biological ^{14}C radioactive labelling experiments at the site. Handling of ICOS samples at Hyytiälä has now been dislocated from the potentially contaminated laboratory and only future samples will show if this intervention was successful to avoid further problems. Due to the rather cold winter 2016/2017, a number of ICOS stations showed lower winter ^{14}C values than during the preceding year, indicating higher fossil CO_2 levels than before. All Level 1 results have been transferred to the CAL database in Jena. The Level 2 data product for 2017 is finalized at the CRL and will be transferred to the CAL database in Jena once the respective communication channels are established.

28.1 PM in this task

Radiocarbon analysis of CO_2 from flask samples (Task 2)

The ICOS flask sampler has been delivered to Heidelberg in October 2017 for testing. The flask-valve design had problems with automatic closing, which are solved now. However, 50% of the delivered flasks need refurbishment by the manufacturer. This also caused some delay in testing of the flask sampler in Heidelberg. The CRL has built two prototypes for integrated flask sampling (starting from vacuum to over-pressure over one week's time) for ^{14}C AMS analysis. For testing of these systems 63 samples have been collected over the course of 2017 in parallel to the routine integrated high-volume samples for low-level counting (Task 1). A subset of these samples was analysed for ^{14}C via AMS and the results were in good agreement with the routine samples, showing a mean difference (AMS-LLC) of (0.9±1.4) ‰ (N=11). All flask samples were processed with the new semi-automatic extraction and graphitization line, which had been rigorously tested and optimized in its procedures in 2017. We also processed and analysed by AMS 13 pure CO_2 aliquots from the large-volume low-level counting samples (see Task 1) yielding a mean difference of 1.2 and a mean error of 1.4 ‰ between the two different analytical methods. This difference is larger than the difference, which we obtained in the past with the old sample preparation system. Based on more parallel samples we will investigate the reasons for this larger deviation between LLC and AMS in 2018. In total, we analysed 266 atmospheric as well as quality control samples by AMS in 2017. The majority of these samples were analysed in the course of parameter testing and optimization of the CO_2 extraction and graphitization line. The requirements for transfer of results to the CAL database have been fully established, but no Level 1 or Level 2 data have been transferred yet.

24 PM in this task

Production of integrated CO_2 samplers (Task 3)

Two integrated $^{14}CO_2$ samplers have been built in 2017 and delivered to the stations Zeppelin (NO) and Pallas (FI). No more requests for new samplers for the ICOS class-1 station network have been received in 2017 and no extension of the network was announced for 2018.

2.5 PM in this task

Interaction with station PIs (Task 4)

CRL scientists have participated at both atmospheric MSAs, in Lund (SE) in spring and in Groningen (NL) in autumn 2017. All available $^{14}CO_2$ results from integrated sampling had been presented to the participants and were discussed with the station PIs. There is regular email exchange between the CRL and the stations, concerning supply of sampling bottles, spare parts and other issues. The regular transfer of samples to the CRL works smoothly and analysis is on track.

2.2 PM in this task

Activities reported to the DG, RI Com and General Assembly (Task 5)

Reporting of activities and finances in 2016 as well as of the 2018 Work Plan and Financial Plan have been submitted to the HO in time. At both GA meetings, in Rome in May and in Brussels in November 2017, one CRL representative has participated and discussed CAL issues either with the GA directly (I. Levin) or with the Scientific Advisory Board (S. Hammer). The CRL has hosted one RIC face-to-face meeting in Heidelberg in February and, with very few exceptions, either I. Levin or S. Hammer or both have participated at the regular monthly teleconferences of the RI Committee.

3.0 PM in this task

Highlights

In 2017 ICOS-CRL recruited two new members: Caterina Trimarchi-Keller works since May on a 50% position as administration secretary helping also with sample logistics for the network. Dr. Susanne Preunkert, works since July 2017 as external IT support on a 30% position. CRL pilot station: The CRL pilot station was running smoothly in 2017. We installed a G2401 Picarro at the station and established its data transfer to ATC.

In September 2017 the ICOS flask sampler was delivered to Heidelberg and was set up at the CRL pilot station. Beta testing of the sampler began immediately after delivery. The testing of the flask sampler comprised quantification of potential concentration artefacts and the sampling/averaging properties of the sampler. With the flask sampler and the Picarro the CRL pilot station is now equipped with standard ICOS instrumentation and can test different sampling strategies in the field (in connection with RINGO WP1).

7.1 PM in this task

Participation in VERIFY: The CRL will be part of the new EU-funded project VERIFY, leading task 2.3 on "Assessment of atmospheric proxy/$ffCO_2$ ratios and independent $^{14}CO_2$-based $ffCO_2$ emission estimates", which will help improving methodologies to measure fossil fuel CO_2 in highly polluted areas. The CRL will analyse 170 ^{14}C samples for this project. The AMS analysis costs are covered by the VERIFY project, whereas the sample preparation of these samples will be done on the extraction and graphitization line during idle times. This in-kind contribution of ICOS-CRL to the VERIFY project has been agreed by the DG.

0.5 PM in this task

O_2/N_2 collaboration: CAL-CRL has started a collaboration with UEA, Bristol, on joint measurements of precise continuous O_2/N_2 ratios and flask sample $^{14}CO_2$ to investigate the potential of O_2/N_2 observations as surrogate tracer for continuous fossil fuel CO_2 estimation. UEA is an expert of O_2/N_2 measurements and we jointly selected the ICOS pilot station in Heidelberg as an ideal site to test this methodology. Spare financial resources (i.e. 25 kEuro in 2017, left-overs from the year 2016) from the CRL went into this new project, which will start in autumn 2018 and help developing new methodologies to "measure" fossil fuel CO_2 continuously.

0.5 PM in this task

Evaluation of ICOS data: We installed three Heidelberg Radon Monitors at the German tall tower station Karlsruhe at 30, 100 and 200 m a.g.l. in June 2017. Julian Della Coletta performed first evaluations of these data together with the continuous CO_2 and CH_4 measurements from the Picarro instrument in the framework of a BA thesis. Besides the well-known Radon Tracer Method (RTM) estimating trace gas fluxes from co-located night-time measurements, he also investigated the radon and CO_2 gradients. He estimated, for the first time, CO_2 fluxes using this new so-called Radon-Gradient-Method; his preliminary results are in good agreement with the RTM flux estimates. This project was presented at the atmospheric station MSA in Groningen in November 2017.

RINGO: In the course of RINGO Task 1.3, together with the Carbon Portal we started work on developing a flask sampling strategy for Class 1 atmospheric stations that shall serve two purposes: (1) Ongoing independent quality control of in situ observations and (2) monitor and characterize isotopically important source regions in the catchment area of the station. First preliminary results from this RINGO activity had been presented at the Groningen MSA. This presentation initiated a discussion on the general strategy of air sampling at ICOS tall tower sites, which must have the aim of being most valuable for current (and future!) modelling purposes. This important discussion, to be further conducted with the European modelling community, will be pursued in an ICOS task force that is led by the Heidelberg CRL.

3 PM in this task

First $^{14}CO_2$ results from the ICOS station network have been presented at:

- 2nd International Radiocarbon in the Environment Conference in Debrecen, Hungary, July 2017
- 10th International CO2 Conference in Interlaken, Switzerland, September 2017
- WMO GGMT conference in Dübendorf, Switzerland, September 2017 I. Levin was invited in the Heidelberg Physics faculty colloquium to present results from its 14CO2 monitoring and its role as CRL in ICOS RI. S. Hammer was invited to and participated at the IG3IS lead author meeting in Geneva and to represent ICOS-CRL.

Monitoring Station Assemblies

Atmosphere MSA

Two Atmosphere MSA meetings, one in Lund, Sweden, and one in Groningen, the Netherlands were organized in March and November 2017, respectively. The meetings, attended by approximately 60 participants, specifically focused on issues related to the operation of the

stations and the station labelling process, on the elaborated data processing at the ATC as well as the recent development of new atmospheric measurement techniques and strategies, especially those are being developed within the ICOS-related RINGO project. The assembly also updated the atmospheric specification document which defines the technical requirements for ICOS-compliant atmospheric observations. During the Groningen meeting in November 2017, the current chair and vice-chair, Huilin Chen and Martin Steinbacher were re-elected for two more years.

4 atmosphere stations (Gartow, Hohenpeissenberg, Hyytiälä, Observatoire Pérenne de l'Environnement) successfully completed the station labelling process.

Ecosystem MSA

Ecosystem MSA meeting was organised in May 2017 in Lund, Sweden with almost 50 participants. The meeting discussed e.g. about the publication of the ICOS ecosystem measurement protocols, Step 2 data evaluation process for ecosystem stations and Step 2 situation and procedure in general, protocol on CH_4/N_2O fluxes, data transfer through Carbon Portal and on potential additional ETC services and new technical solutions.

Publication of 14 ICOS protocols in International Agrophysics, was one of the main activities. Most of the manuscripts were submitted early 2018. This required close cooperation between authors, MSA and ETC and was supported by Daniela Franz.

3 ecosystem stations (Lonzée, Siikaneva, Torgnon) successfully completed the station labelling process.

Ocean MSA

The Ocean MSA and OTC organised a joint meeting in Bergen, Norway in March 2017. The meeting focused on the station labelling criteria for different marine stations and data transfer and quality control. Within 2016 - 2017 all ocean ICOS stations finalized their setup and started their ICOS operational mandate. Outreach activities included e.g. the ICOS Norway Facebook page and contribution to the annual Ginger Bread City in Bergen, Norway.

First ocean stations are expected to be labelled in spring 2018.

Highlights and milestones in ICOS National Networks

This part is based on the activity reports given by the National Focal Points, that not covered all the ICOS National Networks.

Funding obtained and evaluations held

In ICOS Belgium, in the recent Policy Note of Federal Minister of Science Zuhal Demir, ICOS was mentioned as an example of international collaboration and of specialised research infrastructures. In the same note the investment into a new research vessel that will replace RV Belgica (Belgian's third ocean observation station) was also mentioned.

ICOS Czechia, hosted by CzeCOS successfully passed international evaluation organised by the Czech Ministry of Education (that is responsible for national roadmap of RIs). All Czech national

RIs where evaluated (including new RIs applying for national roadmap membership). International peer review panel evaluated CzeCOS RI very positively.

ICOS Finland reports of several new ICOS related projects, such as UPFORMET, (Kangasmaametsät alueellisen metaanitaseen säätelijänä: valuma-alueelta globaaliin mittakaavaan, 2017-2021), Finnish Meteorological Institute, Natural Resources Institute Finland, University of Helsinki, funded by Academy of Finland; MEMETRE, (From processes to modelling of methane emissions from trees, 2018-2023), University of Helsinki, funded by ERC Starting Grant; and a project "Uncovering the belowground sink – The significance of Scots pine root system dynamics for intra- and inter-annual variation of whole-tree carbon balance" (2018-2020), funded by the University of Helsinki.

ICOS Germany reports multiple participations of partners in the H2020 projects RINGO, SEACRIFOG, and VERIFY. Many other ICOS National Networks are also partners in these projects.

In ICOS Sweden, 30 national and 7 international projects are ongoing at the sites. The Svartberget and Hyltemossa stations applied for participating in a collaboration project with NEON and San Diego State University that would include setting up a NEON tower in connection to the ICOS tower and collaboration opportunities for the station host university.

ICOS Switzerland received funding for the next project phase (2017-2021) in April 2017.

Labelled stations

In 2017 following stations received the official ICOS label:

- *Class 1 Atmosphere Station Gartow (GAT) Location:* Gartow, Germany; *Responsible institution:* Deutscher Wetterdienst, Hohenpeißenberg Meteorological Observatory;
- *Class 1 Atmosphere Station Hohenpeissenberg (HPB)Location:* Hohenpeißenberg, Germany; *Responsible institution:* Deutscher Wetterdienst, Hohenpeißenberg Meteorological Observatory;
- *Class 1 Atmosphere Station Hyytiälä (SMR) Location:* Ruovesi, Finland; *Responsible institution:* Division of Atmospheric Sciences, Department of Physics, University of Helsinki;
- *Class 1 Atmosphere Station Observatoire Pérenne de l'Environnement (OPE) Location:* Houdelaincourt, France; *Responsible institution:* Arda -French National Radioactive Management Agency;
- *Class 2 Ecosystem Station Siikaneva (FI-Sii) Location:* Juupajoki, Finland; *Responsible institution:* Division of Atmospheric Sciences, Department of Physics, University of Helsinki;
- *Class 2 Ecosystem Station Lonzée (BE-Lon) Location:* Gembloux, Belgium; *Responsible institution:* Gembloux Agro-Bio Tech - Université de Liège;
- *Associated Ecosystem Station Torgnon (IT-Tor) Location:* Torgnon, Italy; *Responsible institution:* Environmental Protection Agency of Aosta Valley (ARPA VdA)

Other reported network activities

In ICOS Sweden, implementation of most of the ICOS RI protocols and working instructions got finalized during 2017 and uploading of the data using the ICOS Carbon Portal (CP) services was started. The atmospheric systems are fully operational for most parts and the ^{14}C samples are being sent in to the Central Analytical Laboratory. The ICOS Sweden ocean station is running, and

has been updated to the ICOS RI requirements. 179 course and excursion participants visited the ICOS Sweden sites in 2017.

In ICOS Belgium, the mission statement of the ICOS Belgium Consortium was signed by all by Belgian partners of ICOS on 26 July 2017. Furthermore, ICOS Belgium has good collaboration with AnAEE (a.o. the collaboration between the ICOS ecosystem station of Maasmechelen, PI and the AnaEE Ecotron (UHasselt)). Contacts with other RI's such as ACTRIS and eLTER are ongoing. Maasmechelen is an example of a master site jointly operated within ICOS and AnaEE.

In ICOS Germany, The Junior Research Group NITROSPHERE at Thünen Institute of Climate-Smart Agriculture in Braunschweig developed and tested devices for micrometeorological measurement setups for the long-term feasibility and determination of reactive nitrogen compounds to complement with routine ICOS measurements of non-reactive greenhouse gases. A year-round campaign at a Bavarian National Park forest site has been conducted where the field applicability of a quantum cascade laser spectrometer for the determination of ammonia and a custom-built converter for total reactive atmospheric nitrogen was established.

In ICOS France, several new recruitments were made. Technical and logistic support is provided to French ecosystem station team for soil and foliar sampling and processing: protocols, instructions, email assistance for the network. Furthermore, technical and logistic support to French atmospheric station team, such as weekly meetings, email assistance, spare parts management, instrument maintenance services.

ICOS Finland was co-organising the 4th ICOS Summer School - Challenges in GHG measurements and modelling, 24 May – 2 June 2017, Hyytiälä, Finland. 36 students participated the course. ICOS Finland assisted on course organization, implementation and practicalities.

Reported outreach activities and media appearances

ICOS France organized a Scientific workshop 14th Nov. on "The greenhouse gases cycles: fluxes, regional budgets, scenarios and instrumentation". New updated website www.icos-france.fr was launched. ICOS France participated also in National Science Festival (11-15 oct. 2017), "Greenhouse gases measurements", at University Versailles St Quentin. First labelling of ICOS Ecosystem and atmospheric Stations in France was marked by a press release in December 2017.

ICOS Czechia organized a conference “Quo vaditis agriculture, forestry and society under global change?”, in Velké Karlovice, in October 2017. The conference had very good media coverage including live Czech National TV interview with the RI CzeCOS director prof. Michal V. Marek. There were plenty of TV and media interviews throughout the year - topics dedicated mainly to climate extremes, Paris agreement, climate adaptations, international scientific collaboration.

A virtual reality tour was created for the ecosystem site Davos of ICOS Switzerland, and was shown during various outreach activities: Scientifica Zürcher Wissenschaftstage, science fair for the Zurich public (September 2017), ETH Science City (November 2017), ETH unterwegs (November 2017)

ICOS Sweden has continued disseminating information and support education efforts though seminars, courses, field visits, media contacts, and through the ICOS Sweden homepage, and participated in the Research Infrastructure Network for Nordic Atmospheric and Earth System Science Nordic ENVRI and contributed to the strategic recommendations for future Nordic research infrastructures to NordForsk. A newsletter has been started with the intention is to be sent out every four months.

ICOS Belgium organized the first ICOS Belgium Science Conference in October 2017 in Gembloux with ca. 75 participants. Furthermore, an open house day was organized at the ecosystem station of Brasschaat in November 2017, consisting of guided tours around the ICOS tower and in the surrounding forest and a workshop with climate change experiments for children (more than 120 visitors). Workshop on global changes and ICOS is being further developed by ICOS Belgium into a travelling concept and will be visiting (high)schools in Flanders in March 2018 as a first trial. ICOS Belgium highlights of 2017 are available on the ICOS Belgium website: http://www.icos-belgium.be/

In 2017 eight of twelve National Networks prepared a media-kit available at ICOS RI website.

Events attended and results presented

ICOS National Networks representatives and scientists participated numerous national and international meetings in 2017, listed in the end of the report for the whole ICOS RI.

List of ICOS training and workshops

Three days training session organized by the ICOS ATC in June 2017 at LSCE, France. It mainly focused on the data processing and Quality Control with practical works on the use of the ATC software tools (ICOS Station configuration and data quality control). 6 station PI/staff of the European atmospheric network (Norway, Germany, Finland and Belgium) have been trained.

Four days training session organized by the ICOS ATC in October 2017 at LSCE, France. Focused on Data processing and Quality Control like during the first session in June (same program) but also with the theory and practical work on the ICOS compliant analyzers and the sampling system. 7 station PI/staff from 4 different countries of the European network (Italy, Germany, Denmark and Belgium have been trained.

4th ICOS Summer School - Challenges in GHG measurements and modelling, 24 May – 2 June 2017, Hyytiälä, Finland, organised by Carbo Portal and University of Helsinki.

Full technical and logistic support to Ecosystem station team for soil and foliar sampling and processing: protocols, instructions, email assistance, France

Full technical and logistic support to Atmospheric station team: weekly meetings, email assistance, spare parts management, instrument maintenance services, France

Stable Isotopes in CO_2 and H_2O fluxes, Goettingen, Germany 20.-21- April 2017

179 course and excursion participants visited the ICOS Sweden sites in 2017

Workshop on global changes and ICOS is being further developed by ICOS Belgium into a travelling concept and will be visiting (high)schools in Flanders in March 2018 as a first trial

List of Main Internal Meetings

- Carbon Portal executive board meeting, Lund, Sweden 23-24 January 2017)

- ENVRIplus Executive Board face-to-face meeting, (6 February 2017) Amsterdam, The Netherlands
- RINGO kick-off meeting, (21-23 February 2017), Kirchhoff Institute for Physics, Heidelberg, Germany.
- ETC teambuilding (February 2017), Italy
- Ocean MSA and OTC meeting in Bergen, Norway (1-2.03.2017)
- ICOS Atmosphere MSA, 14-16.03.2017 Lund, Sweden.
- 4th General Assembly Meeting of ICOS ERIC (3-4.05.2017), Rome, Italy.
- Ecosystem MSA meeting (9-11 May 2017), Lund, Sweden.
- ICOS ERIC Planning day, 23 May 2017, Kirkkonummi, Finland.
- ATC WMO meeting in August 2017
- RI Committee face-to-face meeting (25-28 September 2017), Groningen, The Netherlands.
- 5th General Assembly Meeting of ICOS ERIC (17.11.2017), Brussel, Belgium.
- Atmosphere MSA in Groningen (21-23.11.2017)

List of Main ICOS National Network meetings

- ICOS Denmark kick-off (22 – 23 January 2017), Lyngby, Denmark.
- ICOS Germany meeting (23-24 March 2017), Offenbach, Germany.
- ICOS-Norway Spring Seminar (9-10 May 2017), Kjeller, Norway.
- Conference on greenhouse gases (CO_2, CH_4) space mission validation, (11 May 2017) CNES, Paris, France
- The First Nordic ICOS Symposium (29-31 August 2017), DTU, Copenhagen, Denmark
- 5th annual “Global Change: A Complex Challenge” conference, entitled “Quo vaditis agriculture, forestry and society under global change?”, (2–4 October 2017) Velké Karlovice, Czech Republic
- National Science Festival (11-15 October 2017), "Greenhouse gases measurements", University Versailles St Quentin, France
- ICOS Belgium Science Conference (20 October 2017) Gembloux, Belgium
- Annual ICOS-France assembly and ICOS-France steering committee meetings (16-19. November 2017), Orléans, France.
- Swiss Geoscience Meeting (17-18 November 2017), dedicated session “Atmospheric Processes and Interactions with the Biosphere” was co-organized by ICOS members
- Scientific workshop on "The greenhouse gases cycles: fluxes, regional budgets, scenarios and instrumentation", (14 November 2017) France
- Meeting of the French National delegates of Environment Infrastructure (December 2017), Paris, France
- ICOS-CH Annual Meeting (November 2017), Switzerland
- Annual ICOS BE Consortium meeting

List of Main Events Organised or Co-organised by ICOS

- EGU 2017 session (23-28.04.2017), Vienna, Austria
- ENVRI week, (14-19 May 2017), Grenoble, France
- Geo-C Kick-off, (6-8 July 2017), Rome, Italy
- ENVRI week (5-8 November 2017), Malaga, Spain
- GEO-C Side Event at the 10th International Carbon Dioxide Conference (ICDC10), 21-25 August 2017, Interlaken, Switzerland
- GEO-C Side Event "GEO-C: Toward policy-relevant global carbon and GHG observations", (24 October 2017), Washington DC, USA.

List of Main Events Attended by ICOS

- E-infra meeting, (19 January 2017) Stockholm, Sweden
- 2nd ESFRI Exchange of Experience Workshop, (17 – 19 January 2017) Malaga, Spain.
- Wissenschaftsrat Meeting, (25-26 January 2017), Cologne and Bonn, Germany.
- EUDAT User Forum,: status of ICOS EUDAT service uptake, (25 January 2017) Helsinki, Finland
- Verify core team meeting, 26-27 January 2017, Paris, France.
- RISCAPE Project kick-off meeting (30-31 January 2017), Helsinki, Finland.
- Wissenschaftsrat German Roadmap, (5-7 March 2017), Cologne, Germany.
- ENVRIplus eLTER site visit, (March 9 2017) Vienna, Austria
- Meeting at DWD on future of ICOS Germany and communication and data usage, (16 March 2017), Offenbach, Germany.
- ORCID Integration meeting, (28 March 2017) Espoo, Finland
- EUDAT workshop (29 March 2017), Garching, Germany
- 3 April, Bluebridge workshop @ RDA plenary P9, Barcelona
- GAW 2017 Symposium (10-13 April 2017), WMO Secretariat, Geneva, Switzerland.
- EEA Copernicus meeting, (20 April 2017), Copenhagen, Denmark
- Flux discussion workshop, (21 – 23 April 2017), Stubaital, Austria
- EGU Conference, (23-29 April 2017), Vienna, Austria
- GOA-ON Steering Committee meeting (25.-27 April 2017), France.
- II RICH -Research Infrastructures Symposium meeting (7-9 May 2017), Lisbon, Portugal
- The 6th European Research Infrastructure Consortium (ERIC) Network Meeting (9 – 10 May 2017), Helsinki, Finland.
- EGI Conference, (9-11 May 2017) Bari, Italy
- 37th ISRSE Symposium, (8-12 May 2017) Tshwane, South Africa
- LU research data working group, (12 May 2017) Lund, Sweden
- GEO Work Programme Symposium, (12-13 May 2017), Tshwane, South Africa

- COMPUTE-REACH seminar, (30 May 2017), Lund Sweden
- SEACRIFOG kick-off (28 May- 4 June 2017), Nairobi, Kenya.
- FLUXNET Conference 2017 (6-12 June 2017), San Francisco, USA
- Top/down and bottom/meeting inverse modelling, (21 June 2017) Ispra, Italy
- WMO WIGOS data expert meeting, (26-27 June 2017) Geneva, Switzerland
- 2nd International Radiocarbon in the Environment Conference (3-7 July 2017), Debrecen, Hungary.
- The 10th International Carbon Dioxide Conference (21-25 August 2017) – Interlaken, Switzerland
- 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques (GGMT-2017) (27-31 August 2017), Duebendorf, Switzerland.
- Nordic ENVRI (5 September 2017) – Helsinki, Finland
- EuroGOOS conference, (2-4 October 2017), Bergen, Norway
- WMO data taskgroup, (3-5 October 2017) Kjeller, Norway
- The Climate Conference of the German Meteorological Service (DWD) (4-6 October 2017), Offenbach, Germany
- EMSO ERIC all regions workshop (9-11 October 2017), Rome, Italy.
- Innovation Framework meeting, (11 October 2017), organised by ESS, Lyngby, Denmark
- ENVRIplus AnaEE site visit, (12 October 2017) Paris, France
- SEACRIFOG Session at HLDF Brussels (18-19 October 2017), Brussels, Belgium
- ENVRIplus workshop, (18 October 2017), Hamburg, Germany
- EGI-Engage review meeting, (24 October) Brussels, Germany
- GEO XIV Plenary, (21-29 October 2017), Washington, USA
- 3rd GPC Workshop on the future of Joint Programming, (7 November 2017), Brussels, Belgium
- UN COP 23, (8-12 November 2017) Bonn, Germany
- Workshop on Developing Arctic Observing Systems – the role of Norwegian institutions (9 November 2017), Norwegian Research Council, Lysaker, Oslo
- SND annual meeting, (14 November 2017) Göteborg, Sweden
- Atlantos General assembly (20-24.11.2017), Grand Canary, Spain
- Danubius General Assembly meeting, (21-22 November 2017) Berlin, Germany
- EUROCOM meeting, (21-22 November 2017) Paris, France
- EOSC Stakeholder event, (28 November 2017) Brussels, Belgium
- IG3IS implementation meeting, (30 November-1 December 2017) Geneva, Switzerland
- DI4R-2017, (1 December 2017) Brussels, Belgium
- ENVRI+ Theme 2 meeting, (6-7 December 2017), Lund, Sweden

List of Main Publications

Full list of ICOS RI publications, including the National Networks is available at: https://www.icos-cp.eu/node/101

Arriga, N., Rannik, Ü., Aubinet, M., Carrara A., Vesala, T., & Papale, D. (2017). Experimental validation of footprint models for eddy covariance CO2 flux measurements above

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Graven, H., Allison, C. E., Etheridge, D. M., Hammer, S., Keeling, R. F., Levin, I., Meijer, H. A. J., Rubino, M., Tans, P. P., Trudinger, C. M., Vaughn, B. H., & White, J. W. C., 2017. Compiled records of carbon isotopes in atmospheric CO_2 for historical simulations in CMIP6. *Geoscientific Model Development*, 10(12): 4405-4417. https://doi.org/10.5194/gmd-10-4405-2017

Ibánhez, J. S. P., Flores, M. & Lefèvre, N., 2017. Collapse of the tropical and subtropical North Atlantic CO2 sink in boreal spring of 2010. *Scientific Reports*, 7, 41694. doi:10.1038/srep41694

Ingrosso G., Bensi, M., Cardin V., & Giani M., 2017. Anthropogenic CO2 in a dense water formation area of the Mediterranean Sea. *Deep-Sea Research Part I: Oceanographic Research Papers* 123: 118-128. https://doi.org/10.1016/j.dsr.2017.04.004

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Van Asperen, H., Warneke, T., Sabbatini S., Höpker, M., Nicolini, G., Tommaso, C., Papale, D., Böhm, M., & Notholt, J., 2017. Diel variation in isotopic composition of soil respiratory CO_2 fluxes: The role of non-steady state conditions. *Agricultural and Forest Meteorology* 234-235: 95-105. https://doi.org/10.1016/j.agrformet.2016.12.014

List of other materials

- Hammer, S. and Levin, I., 2017. Monthly mean atmospheric $^{14}CO_2$ at Jungfraujoch and Schauinsland from 1986 to 2016 [Dataset], doi:10.11588/data/10100.
- Internal ICOS procedure on water vapor correction. The developed procedure allows the PI and the ATC Mlab to perform this check.
- Internal ICOS procedure for the sampling line integrity test. The procedure has been tested at Trainou station several times to improve it and is now shared with the PIs.
- OTC Data to the Global Carbon Budget 2017 and to the 5th and 6th version of the Surface Ocean CO_2 Atlas (SOCAT). (https://www.earth-syst-sci-data-discuss.net/essd-2017-123/).
- Brochure and a video about OTC. Available via the outreach section on the OTC website (https://otc.icos-cp.eu/outreach).
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