

# ICOS

● ● ●  
INTEGRATED  
CARBON  
OBSERVATION  
SYSTEM

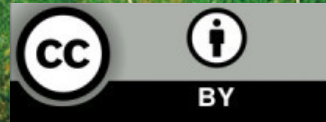
## ICOS Carbon Portal

Karolina Pantazatou & Maggie Hellström

*ICOS Carbon Portal*

“Working together on large datasets”

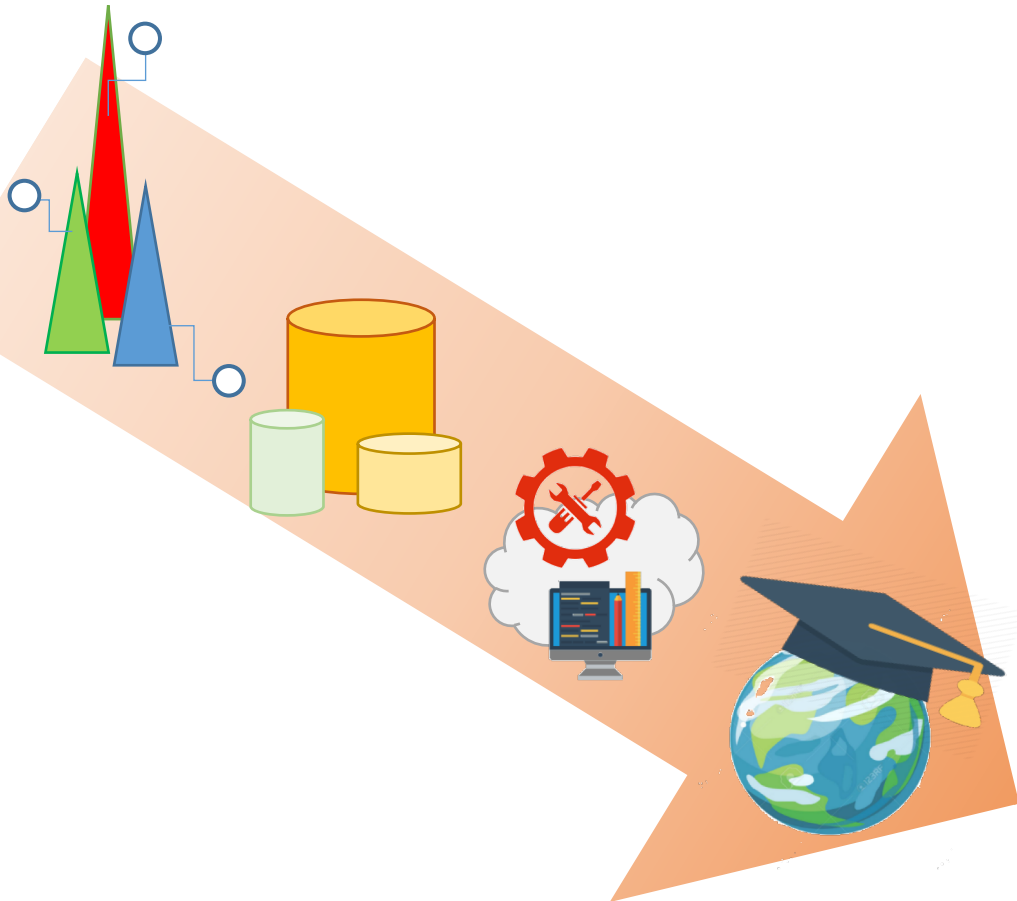
MAX IV workshop @Lund, December 9, 2019



# What is ICOS?

# ICOS

• • •  
INTEGRATED  
CARBON  
OBSERVATION  
SYSTEM

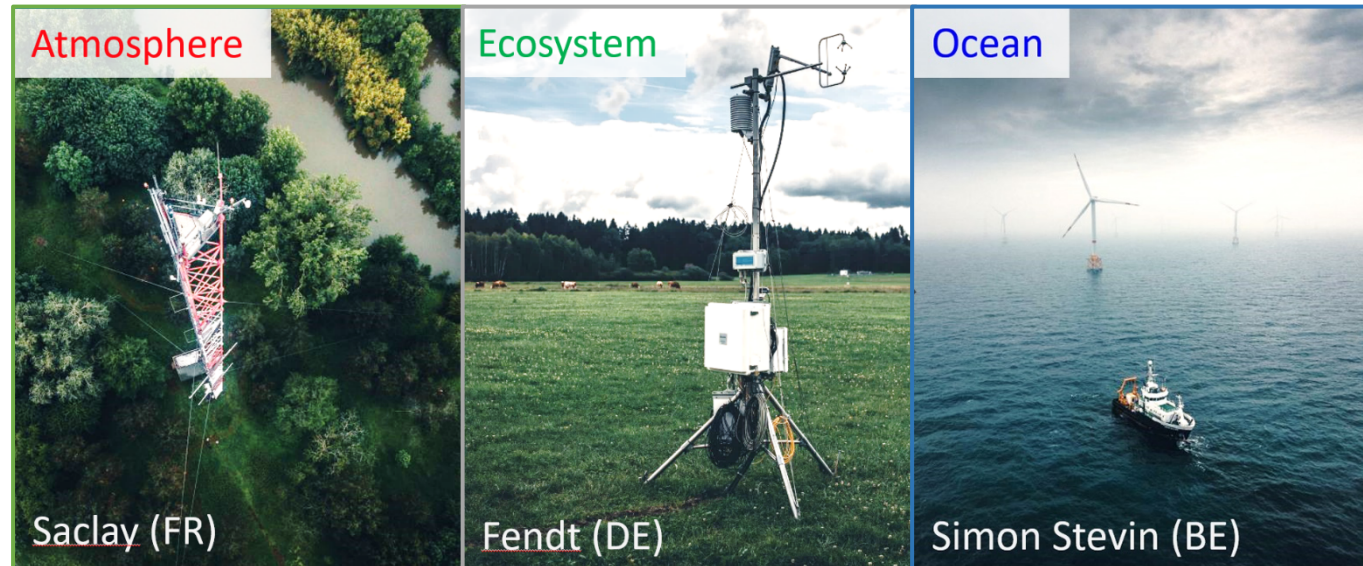


- Integrated Carbon Observation System (ICOS) is a European Research Infrastructure in the environmental & climate domain
- ERIC in 2015, ESFRI flagship in 2018
- ICOS missions are to
  - collect high-quality, standardised observational data & share this with anyone who wants to use it
  - provide services that support end-users to make the best possible science based on ICOS data
  - inform stakeholders, policy makers and the public about ongoing trends in greenhouse gas concentrations and fluxes

# Our observation networks



- ICOS has 12 member countries
- We operate three observation station networks:
  - Atmosphere – 33 stations (●)
  - Ecosystem – 80 stations (●)
  - Ocean – 21 stations & ships (● and ---)
- Each domain has a dedicated Thematic Centre



# Producers of ICOS data

- **National Measurement Networks**
  - Atmospheric, Ecosystem and Marine observation stations
  - Produce raw time series data, often at “high frequency” (10-20 Hz)
- **Thematic Centers**
  - One each for Atmospheric, Ecosystem and Marine observation networks
  - QA/QC: Quality Control and Assurance
  - Calculate fluxes of energy and greenhouse gases (GHGs)
  - Produce aggregated time series of half-hourly or hourly averages
- **GHG research community**
  - Apply models that use ICOS observational data
  - Produce elaborate products, such as “flux maps”

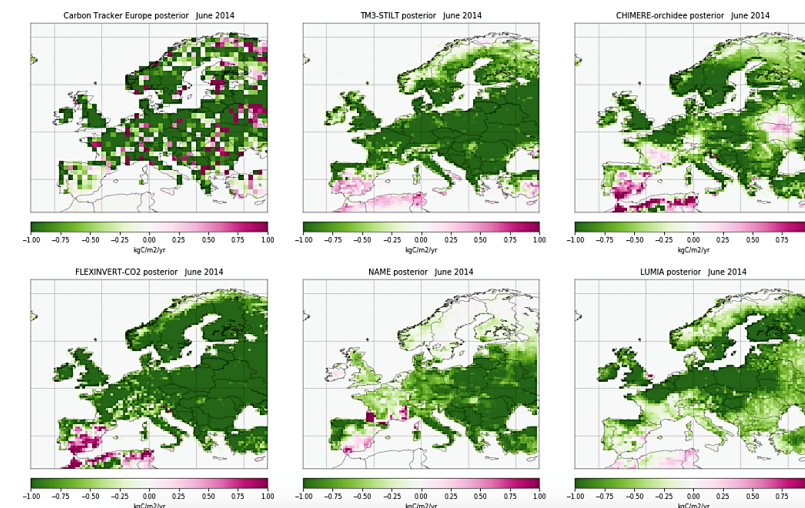
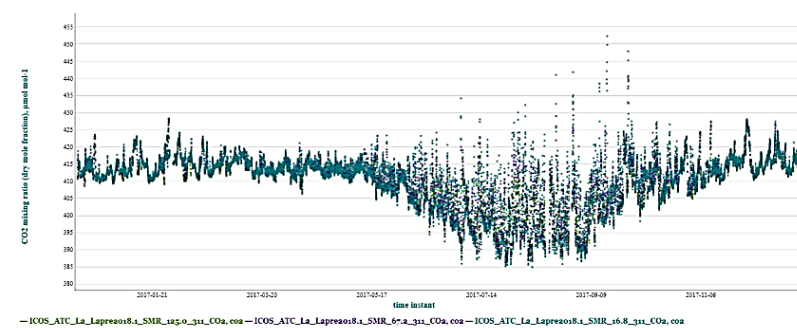


# ICOS data products

- **Quality-controlled observational data**
  - Greenhouse gas concentrations – CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O
  - Other trace gases & isotopes (CO, C-14, ...)
  - Greenhouse gas and energy fluxes
  - Meteorological parameters & ecosystem variables

- **Elaborated (model) products**

- Advanced visualisations
- Flux maps in time & space (inverse modelling)
- Other model output (ecosystem, vegetation,...)
- Station “footprints” (spatial & temporal origin of measured GHG concentrations)

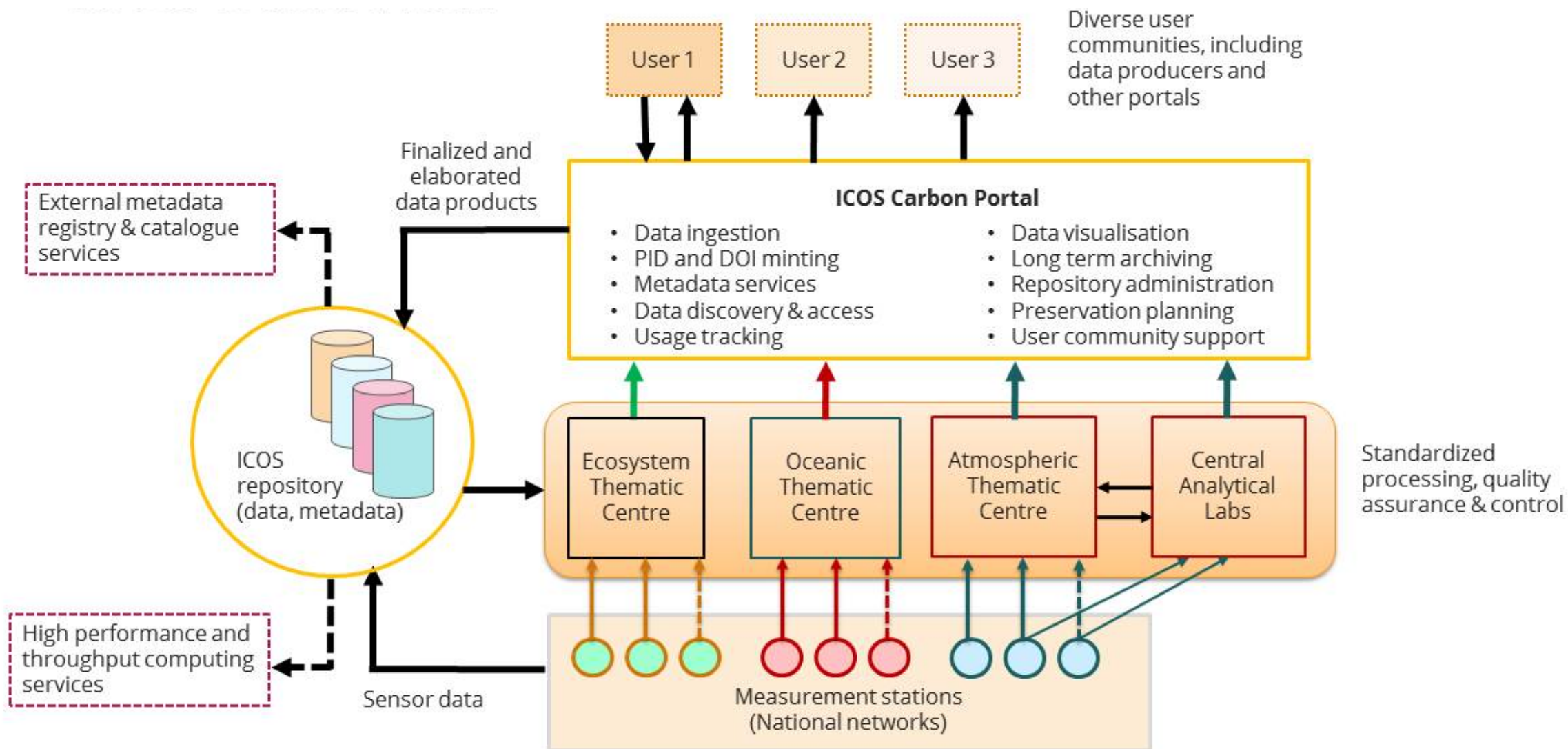


# Users of ICOS data

- Our data producers (station PIs & staff)
- **International and national Operational Centres assimilating atmospheric composition data (Copernicus)**
- **Research communities (atmosphere, ecology, biogeochemistry, biogeophysics, climatology, ...)**
- Commercial users
- The general public interested in greenhouse gas emissions and global climate change



# ICOS data flow



# ICOS data storage

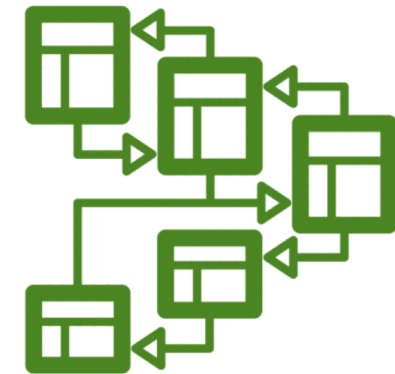
- **Data**

- Data stored in two places: locally & external trusted repository
- Data stored as a sequence of bytes (Blob) on the disk
- File name based on encrypted hash sum (SHA256)
- Hash sum-based unique persistent identifier (PID) for every file



- **Metadata**

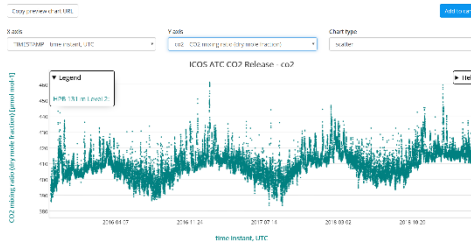
- Stored in an RDF triplestore (Linked Open Data)
- Metadata acquisition through SPARQL endpoint
- ICOS Search Interface runs with SPARQL queries



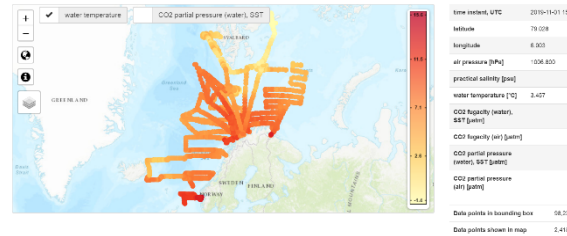


# ICOS services: some examples

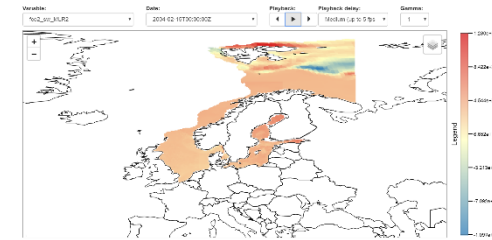
- **Carbon Portal for data discovery**
- **Data Preview**



Time Series

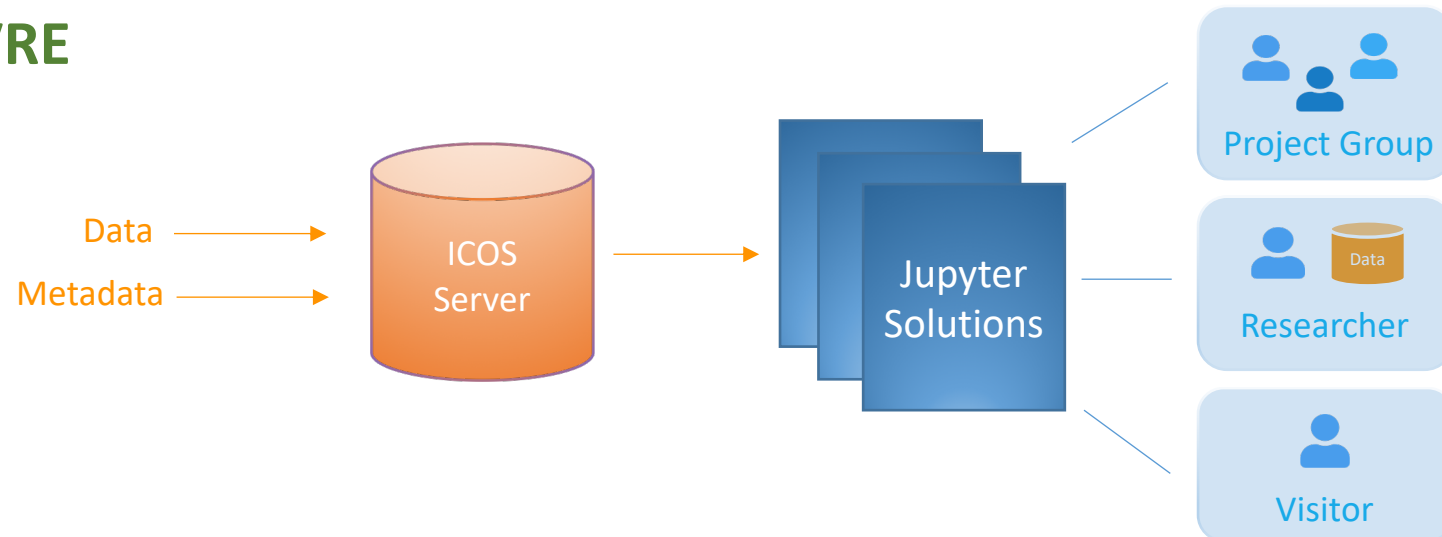


Time Series



NetCDF

- **Jupyter VRE**



# ICOS Carbon Portal

<https://www.icos-cp.eu/>

icos-cp.eu

ICOS Carbon Portal

Home Data Other services About Help Log in

## Welcome to ICOS Carbon Portal

Here you can discover, visualize and download European greenhouse gas data!

[Discover our data](#)

ICOS is the Integrated Carbon Observation System, a European Research Infrastructure. ICOS is the European measurement system for high quality and high precision greenhouse gas observations. The ICOS Carbon Portal provides free and open access to all ICOS data.

ICOS data supports climate science that informs scientists and society on natural and human emissions and uptake of these greenhouse gases from ocean, land ecosystems and atmosphere. Climate change is recognized by the United Nations and the European Union as the biggest environmental threat to human civilisation. Greenhouse gas emissions by humans are recognized as the most important contribution to the global

### News

#### New data releases

2019-08-06

ICOS atmosphere Level 2 final quality data, release 2019-1, meteorological data and atmospheric conc...

[Read more...](#)

#### ICOS CP Summer 2019 Newsletter

2019-07-30

Read the latest news from ICOS Carbon Portal, exciting new data has arrived. And please consider...

[Read more...](#)

### Events

# Search interface

Facetted search interface, dynamically updated by SPARQL calls to metadata triple store

ICOS + Atmospheric data + HTM (Hyltemossa) + ICOS ATC CO2 Release

## ICOS data portal Search, preview, download data objects

View data cart 1 item

Filters **Advanced**

[Clear filters](#)

Data origin ▾

Data types ▾

Value types ▾

Temporal filters ▾

Search results

Compact view

Data objects 1 to 3 of 3



Data object ↓↑	Size ↓↑	Submission time (UTC) ↓↑	From time (UTC) ↓↑	To time (UTC) ↓↑
<a href="#">ICOS_ATC_L2_L2-2019.1_HTM_70.0_CTS_CO2</a>	345 KB	2019-07-31 15:44	2017-04-17	2019-04-30 23:00
<a href="#">ICOS_ATC_L2_L2-2019.1_HTM_30.0_CTS_CO2</a>	347 KB	2019-07-31 15:44	2017-04-17	2019-04-30 23:00
<a href="#">ICOS_ATC_L2_L2-2019.1_HTM_150.0_CTS_CO2</a>	345 KB	2019-07-31 15:44	2017-04-17	2019-04-30 23:00

<https://data.icos-cp.eu/portal/>

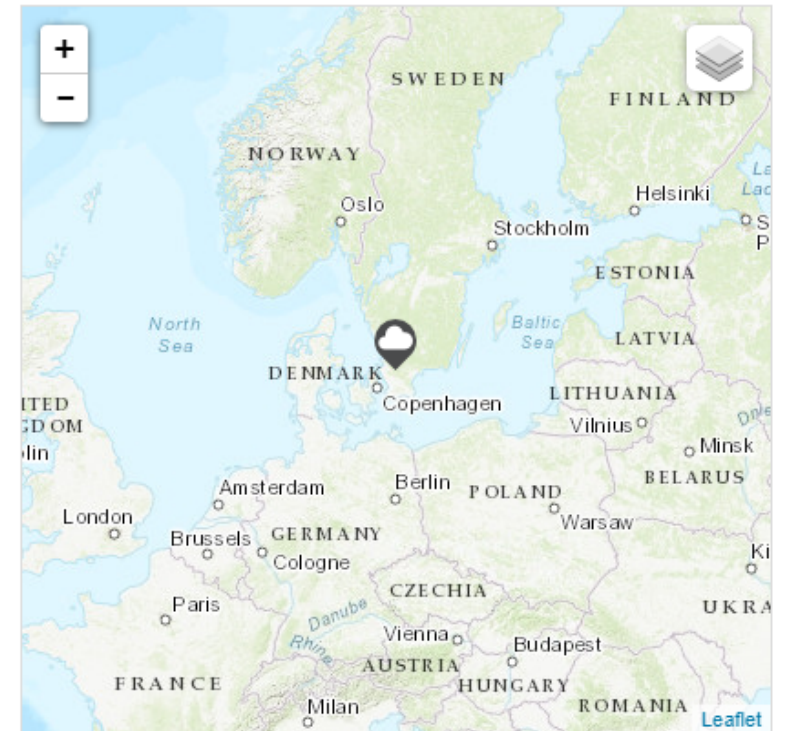
# Dataset landing page

## ICOS ATC CO2 Release from Hyltemossa

View data cart **1 item**

2017-04-17 – 2019-04-30

<b>PID</b>	<a href="#">11676/I0ysHf3ENUx1MlouesbfFAnG</a>
<b>Affiliation</b>	ICOS
<b>Type</b>	ICOS ATC CO2 Release
<b>Level</b>	2
<b>File name</b>	ICOS_ATC_L2_L2-2019.1_HTM_150.0_CTS_CO2.zip
<b>Size</b>	345 KB
<b>Station</b>	<a href="#">Hyltemossa</a>
<b>Time coverage</b>	2017-04-17 00:00:00 – 2019-04-30 23:00:00
<b>Instruments</b>	<a href="#">ATC_463</a> , <a href="#">ATC_461</a>
<b>Sampling height</b>	150 m
<b>Citation</b>	ICOS RI, 2019. ICOS ATC CO2 Release, Hyltemossa (150.0 m), 2017-04-17-2019-04-30, <a href="https://hdl.handle.net/11676/I0ysHf3ENUx1MlouesbfFAnG">https://hdl.handle.net/11676/I0ysHf3ENUx1MlouesbfFAnG</a>
<b>Previous version</b>	<a href="#">View previous version</a>
<b>Previous version</b>	<a href="#">View previous version</a>
<b>Made by</b>	<a href="#">Atmosphere thematic center</a>
<b>Host organization</b>	<a href="#">Atmosphere thematic center</a>
<b>Creation date</b>	2019-07-31 15:44:27



### Metadata

[HTML landing page](#) • [JSON](#) • [RDF/XML](#) • [RDF/TURTLE](#)

# Dataset preview

ICOS\_ATC\_L2\_L2-2019.1\_HTM\_150.0\_CTS\_CO2 ⓘ

Copy preview chart URL

Remove from cart

X axis

TIMESTAMP—time instant, UTC

Y axis

co2—CO2 mixing ratio (dry mole fraction)

Chart type

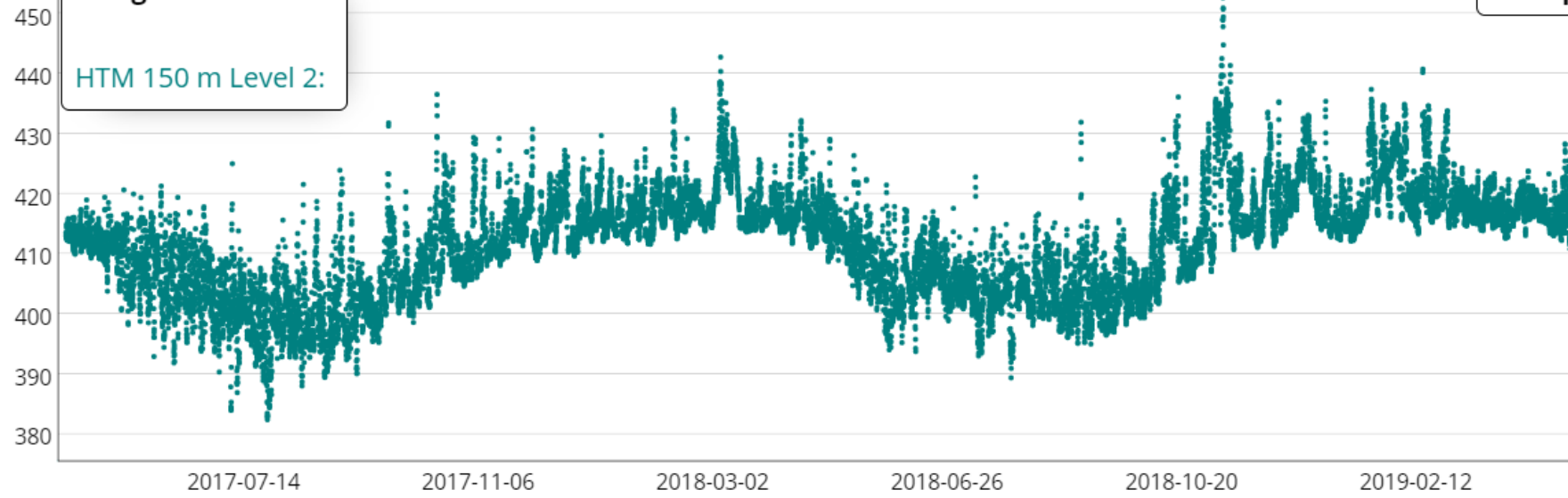
scatter

## ICOS ATC CO2 Release - co2

CO2 mixing ratio (dry mole fraction)  
[ $\mu\text{mol mol}^{-1}$ ]

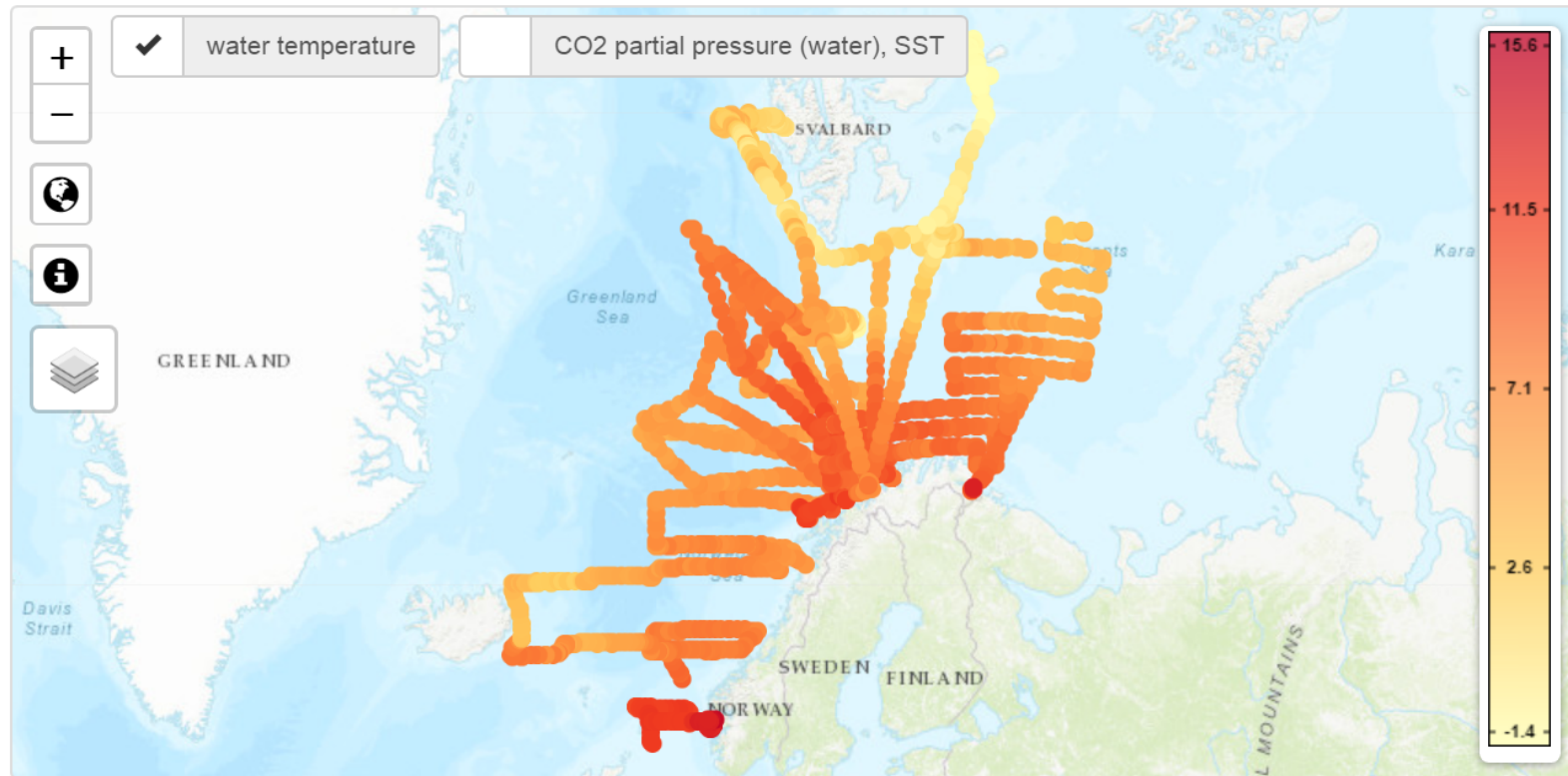
▼ Legend  
HTM 150 m Level 2:

► Help



# ICOS preview – time series (cont.)

- Water temperature – ocean station

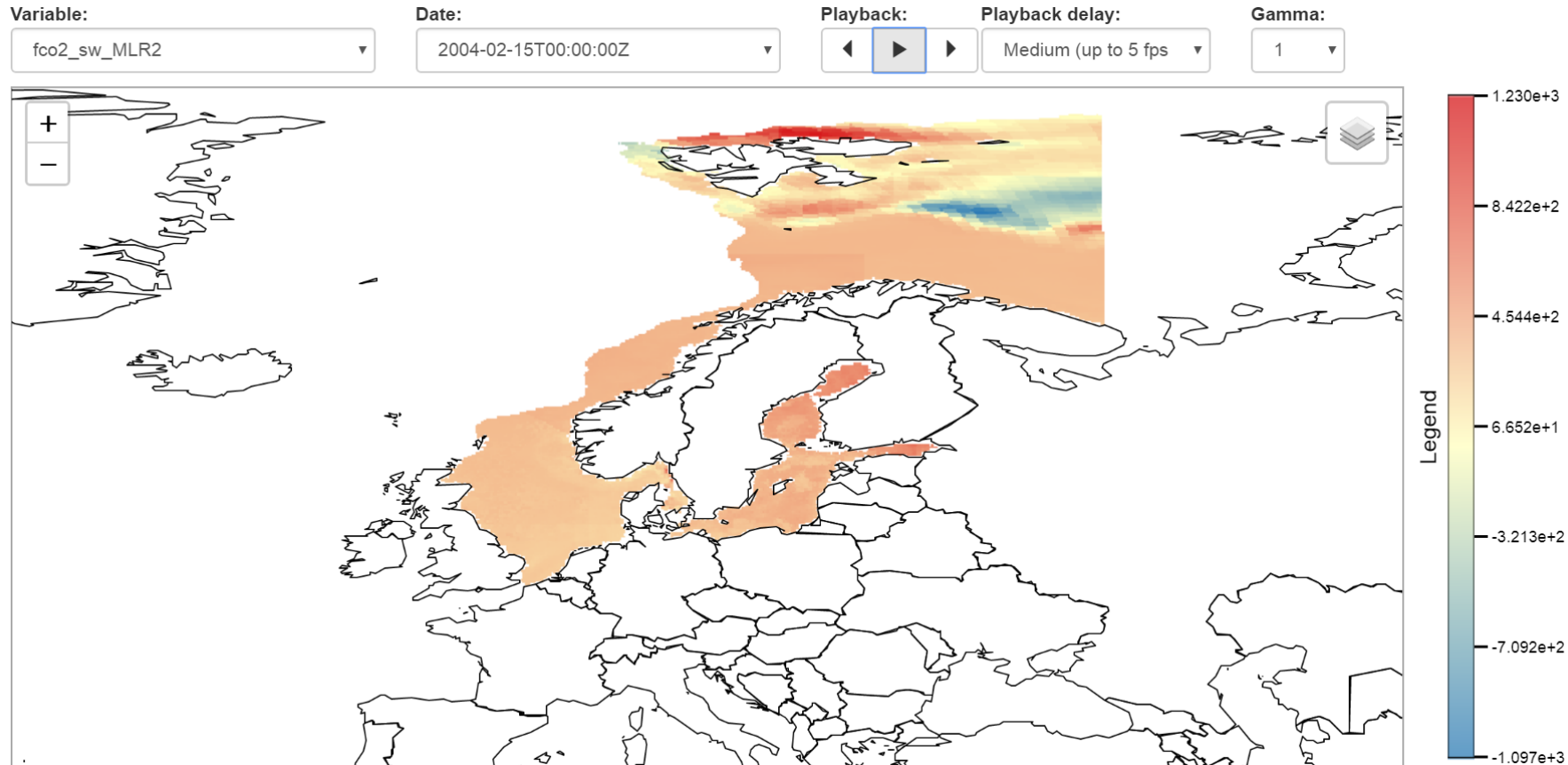


time instant, UTC	2019-11-01 15:11
latitude	79.028
longitude	6.003
air pressure [hPa]	1006.800
practical salinity [psu]	
water temperature [°C]	3.457
CO2 fugacity (water), SST [µatm]	
CO2 fugacity (air) [µatm]	
CO2 partial pressure (water), SST [µatm]	
CO2 partial pressure (air) [µatm]	
Data points in bounding box	98,229
Data points shown in map	2,418

[https://data.icos-cp.eu/map-graph/3UoSdkoud7jWMGeH8M4YcPNL#{"objId":"3UoSdkoud7jWMGeH8M4YcPNL","y1":7,"y2":13,"map":7,"center":{"lat":72.82248019446818,"lng":14.315499999999998},"zoom":3}](https://data.icos-cp.eu/map-graph/3UoSdkoud7jWMGeH8M4YcPNL#{)

# ICOS Preview – NetCDF


- Monthly coastal CO<sub>2</sub>-fluxes (1997 - 2016)



<https://data.icos-cp.eu/portal/#%7B%22route%22%3A%22preview%22%2C%22preview%22%3A%5B%22n7cB5kS4U1E5A3mXKtEUCF9s%22%5D%7D>



# Data cart

[← Back to search](#)

 My data cart

[Preview](#) [Remove from cart](#)

[ICOS ATC CO2 Release from Hyltemossa, 2017-04-17 – 2019-04-30](#)

 Atmospheric data  150 meters

Accept license and download cart content

[Download](#)

Total size: 344.67 KB (uncompressed)

ICOS data is licensed under a [Creative Commons Attribution 4.0 international licence](#)



# ICOS Jupyter

- **Jupyter Hub**

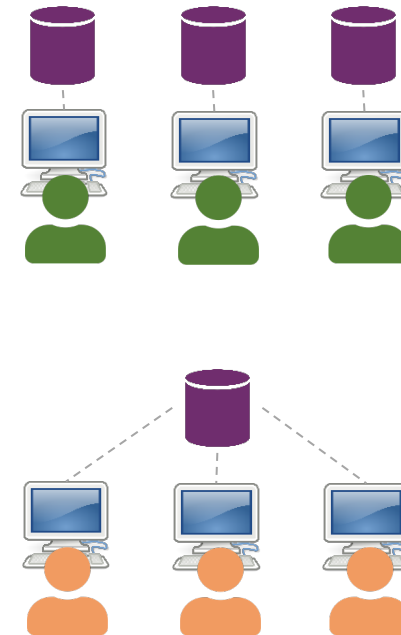
- User accounts for registered users
- Collaboration between users with shared directories (access to directories on server)
- Users may upload data (all work is saved)
- One docker container

- **Exploredata – “Anonymous” Jupyter Service**

- Testing platform for conferences & “hands-on” sessions
- Content deleted after log-out or after 15 min of inactivity
- One docker container per user

- **Voilà (upcoming service)**

- Displaying notebooks “live” on portal (no code visible)
- Interaction with plots using widgets



# ICOS Jupyter Notebooks

- **Project Specific Jupyter Notebooks** *(not yet openly available to the public)*
  - Analysis of simulated fossil fuel CO2 time series (RINGO)
  - Evaluation of sampling strategies (RINGO)
  - inversion intercomparison (EUROCOM)
- **Open Access Jupyter Notebooks** *(openly available to the public)*
  - Explore ICOS Atmospheric Data
  - Compare atmospheric model results (STILT) to ICOS Atmospheric Data
- **Educational Jupyter Notebooks** *(openly available to the public)*
  - Introduction to Carbon Cycle & Python Programming *(Swedish Science Centres)*
  - Drought 2018 & Python Programming *(Highschool pupils & BSc students)*



# Examples of ICOS Jupyter Notebooks

The image displays three Jupyter Notebook interfaces. The left notebook, titled 'ICOS\_stations\_obs\_v.1.11', shows a widget for selecting a station (Gartow) and a plot of CO2 concentration over time from 2016 to 2020. The middle notebook shows two maps of Europe, labeled 'CHIMERE-orchidee posterior June 2014' and 'LUMIA posterior June 2014', with a color scale for log(Cm2)/yr. The right notebook, titled '07 (autosaved)', shows a plot of CO2 concentration for the station AM-TIMAN - CHAD (alt. 60m) from 2012 to 2013, with a legend for 'nep', 'anthropogenic', 'back ground', and 'total\_co2\_conc'. A chemical structure of methane (CH4) is shown in the top right corner of the right notebook.

**ICOS - Continuous air (Gartow, Germany, 30.0 m. a. g. l.)**

CO<sub>2</sub> (µmol mol<sup>-1</sup>)

Time (UTC)

Level 1 - GAT (30.0) Level 2 - GAT (30.0)

**CHIMERE-orchidee posterior June 2014**

LUMIA posterior June 2014

lgCm2/yr

**CO<sub>2</sub> Concentration (ppm)**

Time (UTC)

Legend: nep, anthropogenic, back ground, total\_co2\_conc

**CO<sub>2</sub> in Africa (SEACRIFOG)**

Map showing CO<sub>2</sub> concentrations in Africa (SEACRIFOG) with country labels: BELARUS, UKRAINE, ROMANIA, BULGARIA, GREECE, TURKEY, SYRIA, JORDAN, SAUDI ARABIA, EGYPT, SAUDI ARABIA, UNITED ARAB EMIRATES, IRAQ, TURKMENISTAN, IRAN, AFGHAN, PAKISTAN, YEMEN, ETHIOPIA, SOUTH SUDAN, SUDAN, KENYA, DEMOCRATIC REPUBLIC OF THE CONGO.

metan

isstag i beräkningarna. Programmering  
rövningar är att få erfarenhet över hur  
eskriva enklare principer inom Python-  
s upp eller släpps ut mellan delar av ett

ar av koncentrationer och upptag av

# Access to ICOS Jupyter Notebooks

- **ICOS Carbon Portal Jupyter Hub**

Send an email to [exploredata@icos-cp.eu](mailto:exploredata@icos-cp.eu) with a request for an account

- **Open Access Jupyter Notebooks**

<https://exploredata.icos-cp.eu>

- **GitHub**

<https://github.com/ICOS-Carbon-Portal/jupyter>



# ICOS in numbers

- **Data**

- Data file size: 22 bytes - 3 GB !
- Number of files: 136,324
- Total size: 1.3 TB

- **Services**

- Jupyter Hub: 35 user accounts
- Jupyter Hub docker container: 35 GB RAM allocated (out of 128 GB available on the server)
- Exploredata: support for max 25 users at the same time

# Thanks for listening!

## Questions or comments?

### Ask now, or get in touch later:

- send an e-mail
  - [karolina.pantazatou@nateko.lu.se](mailto:karolina.pantazatou@nateko.lu.se)
  - [margareta.hellstrom@nateko.lu.se](mailto:margareta.hellstrom@nateko.lu.se)
- visit the ICOS Carbon Portal
  - virtually: <https://www.icos-cp.eu>
  - IRL: Geocentrum II (2<sup>nd</sup> floor)

