



**GEO-ACADEMY**

GEO-Hub for teachers in Europe

**Innovative digital GEO-Tools for  
enhancing teachers' digital, green and  
spatial skills towards an effective STEAM  
Education for Sustainability Development**

Geo-Academy Summer School 2025

**ICOS**

# **Integrated Carbon Observation System**

## **understanding carbon exchanges, sources and sinks**

Rolf Niemann  
Lund University



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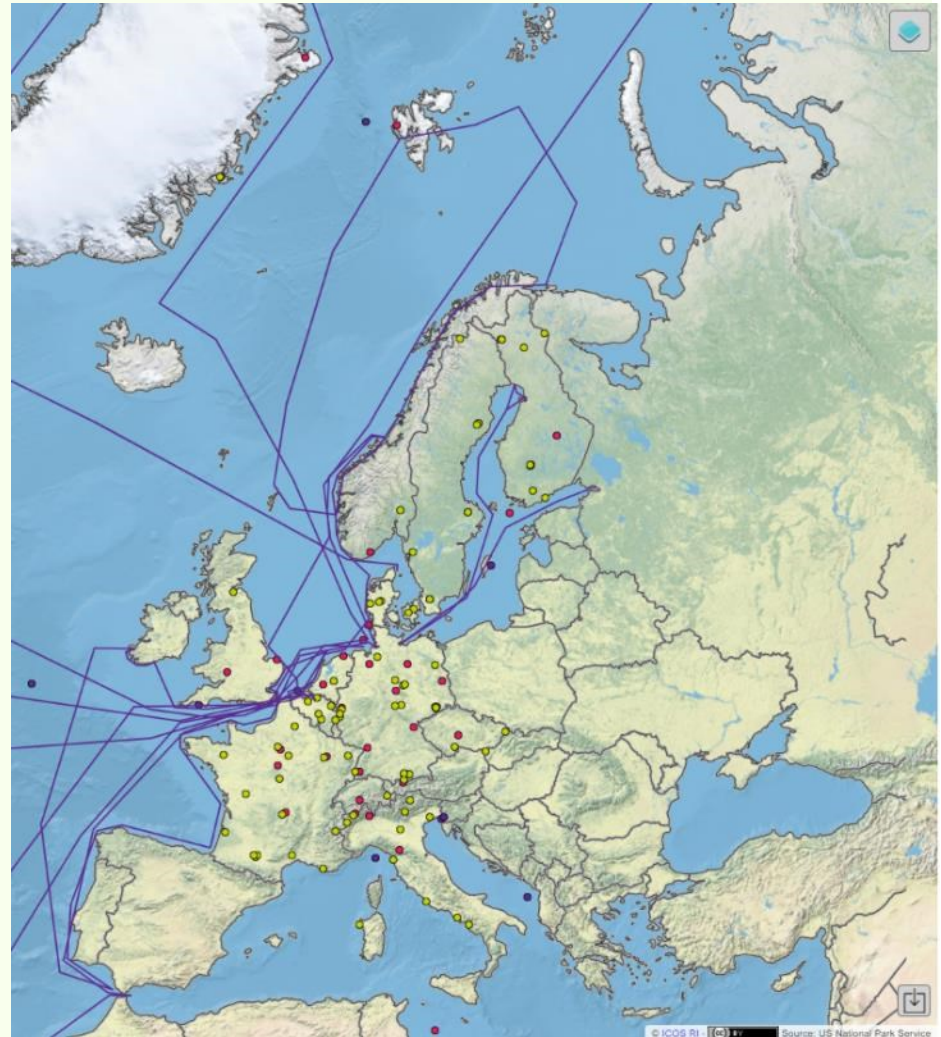


# What is ICOS ?

## Aim:

Comparable measurement data related to the carbon cycle to enable better science and give reliable information to decision makers.

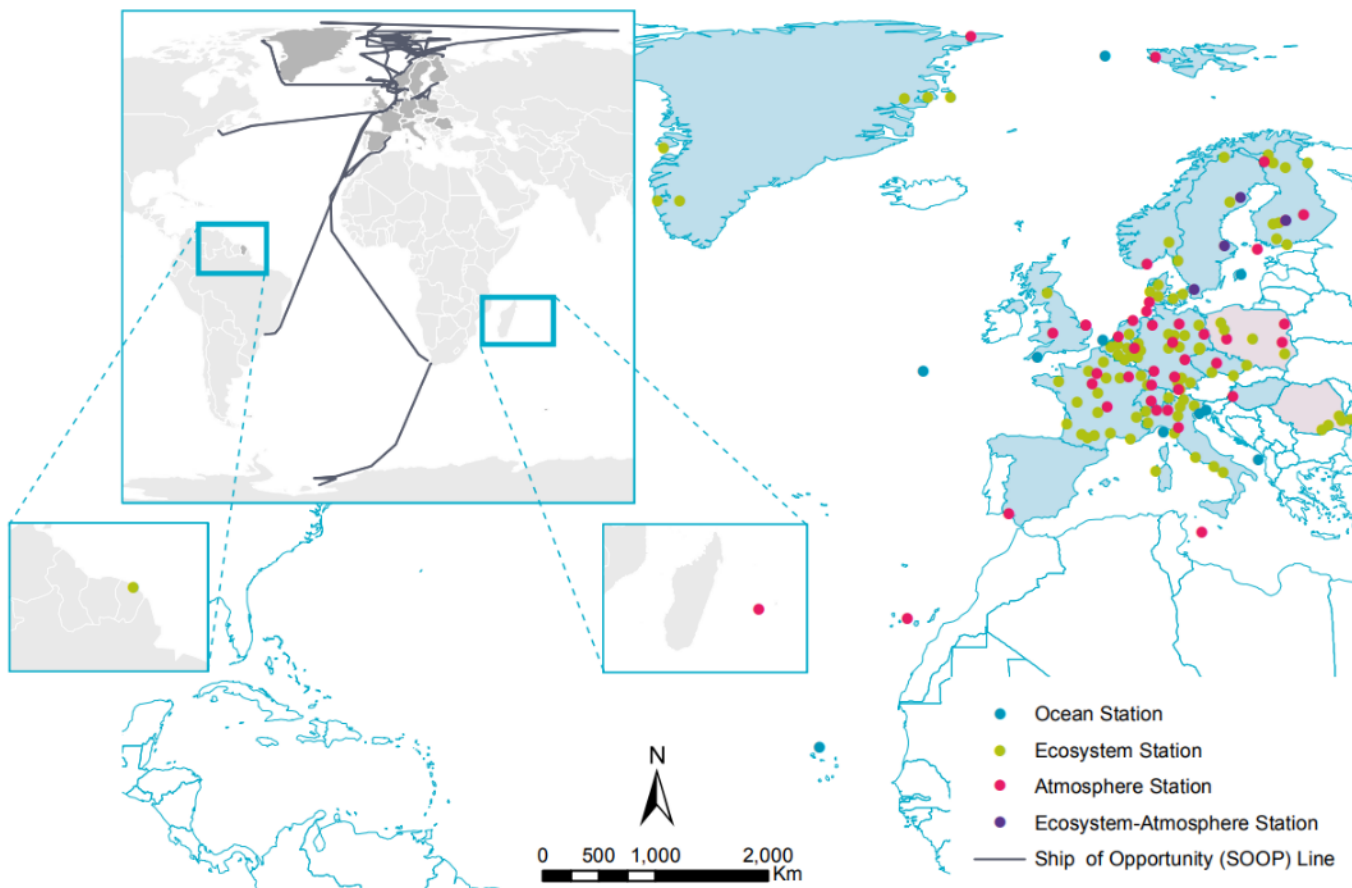
- ICOS provides harmonized high-quality measurements of variables linked to the carbon cycle.
- Three scientific areas: atmosphere, ecosystem, ocean
- ICOS ERIC (since 2015)



# ICOS Station Network

In the map, light blue indicates current ICOS countries and light pink indicates prospective countries joining ICOS in 2023.

>170 stations in  
16 member  
countries





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# ICOS



Atmosphere Station



Ecosystem Station



Ocean Station



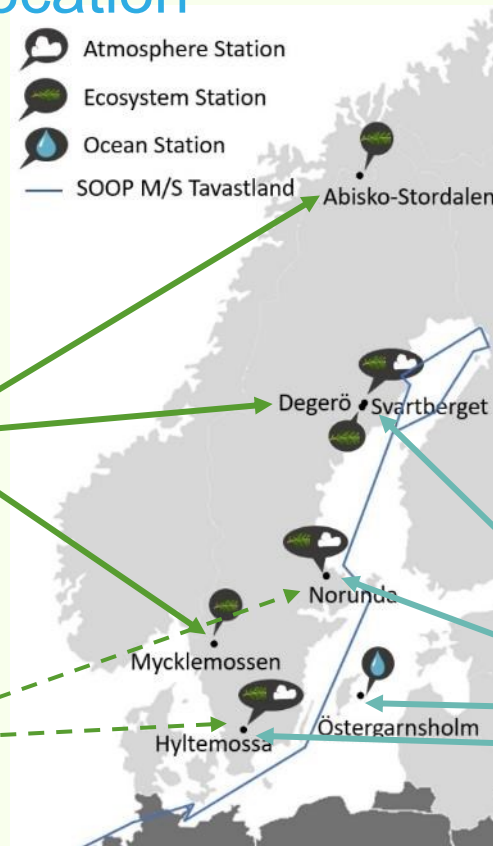
SOOP M/S Tavastland



# Maximize information and applicability and optimize resources through co-location

**SITES**

Field sites to promote high quality research through long-term field measurements and field experiments



Measurements of aerosols, particles and short-lived trace gases

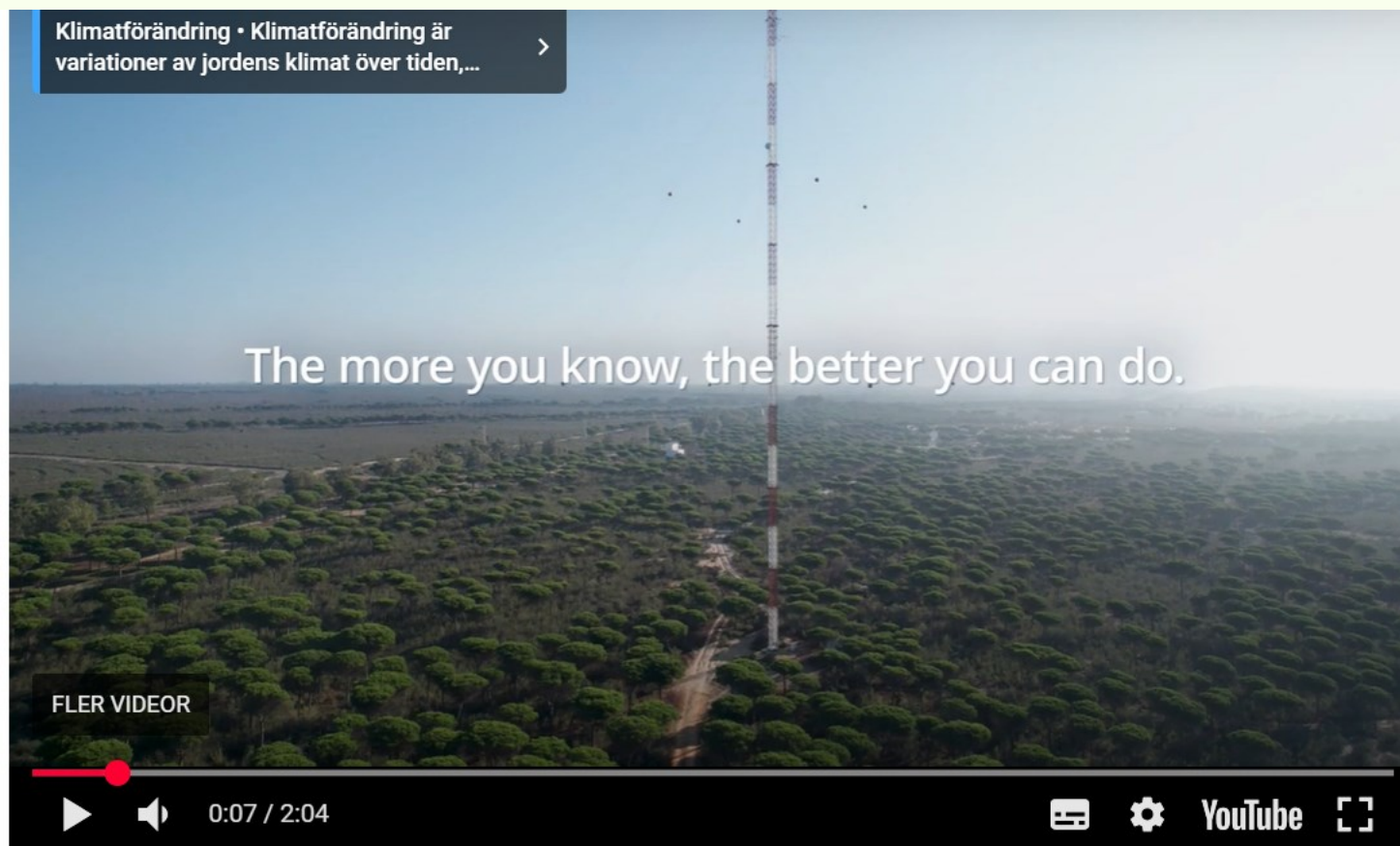


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## film about ICOS



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Ocean stations measure sea surface  $p\text{CO}_2$ , sea surface temperature, salinity and related variables.

The goal is to quantify the exchange of  $\text{CO}_2$  between the atmosphere and the ocean and to assess its variability.



# Short experiment

## CO<sub>2</sub> uptake in warm and cold water

1 glass filled with warm water

1 glass filled with cold water

2 straws

BTB (pH- indicator)

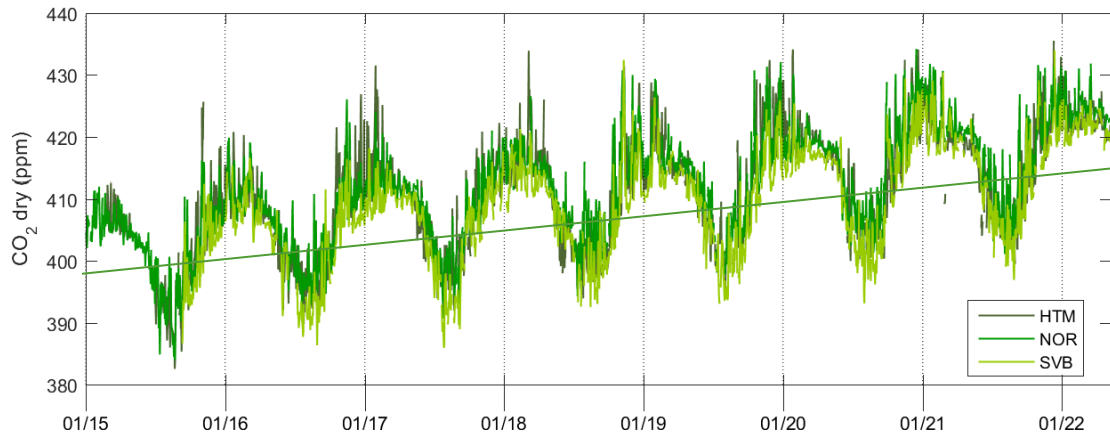


# Atmosphere data

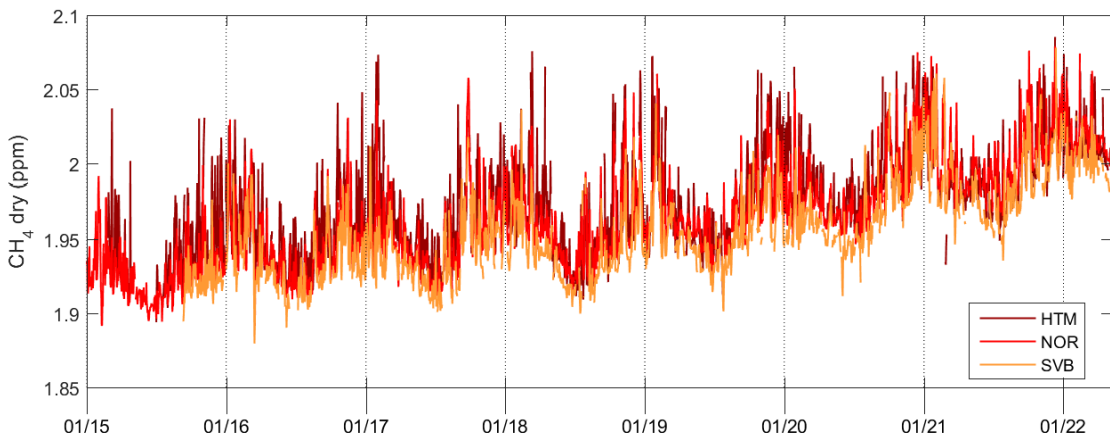
Atmospheric stations continuously measure concentrations of greenhouse gases (e.g.  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ ), other trace gases (e.g.  $\text{CO}$ , radiocarbon- $\text{CO}_2$ ) and basic meteorological parameters.

These gas concentrations are the result of the regional and global net exchange between the Earth's surface and atmosphere and complex atmospheric transport mechanisms.

# Atmosphere data from the Swedish stations



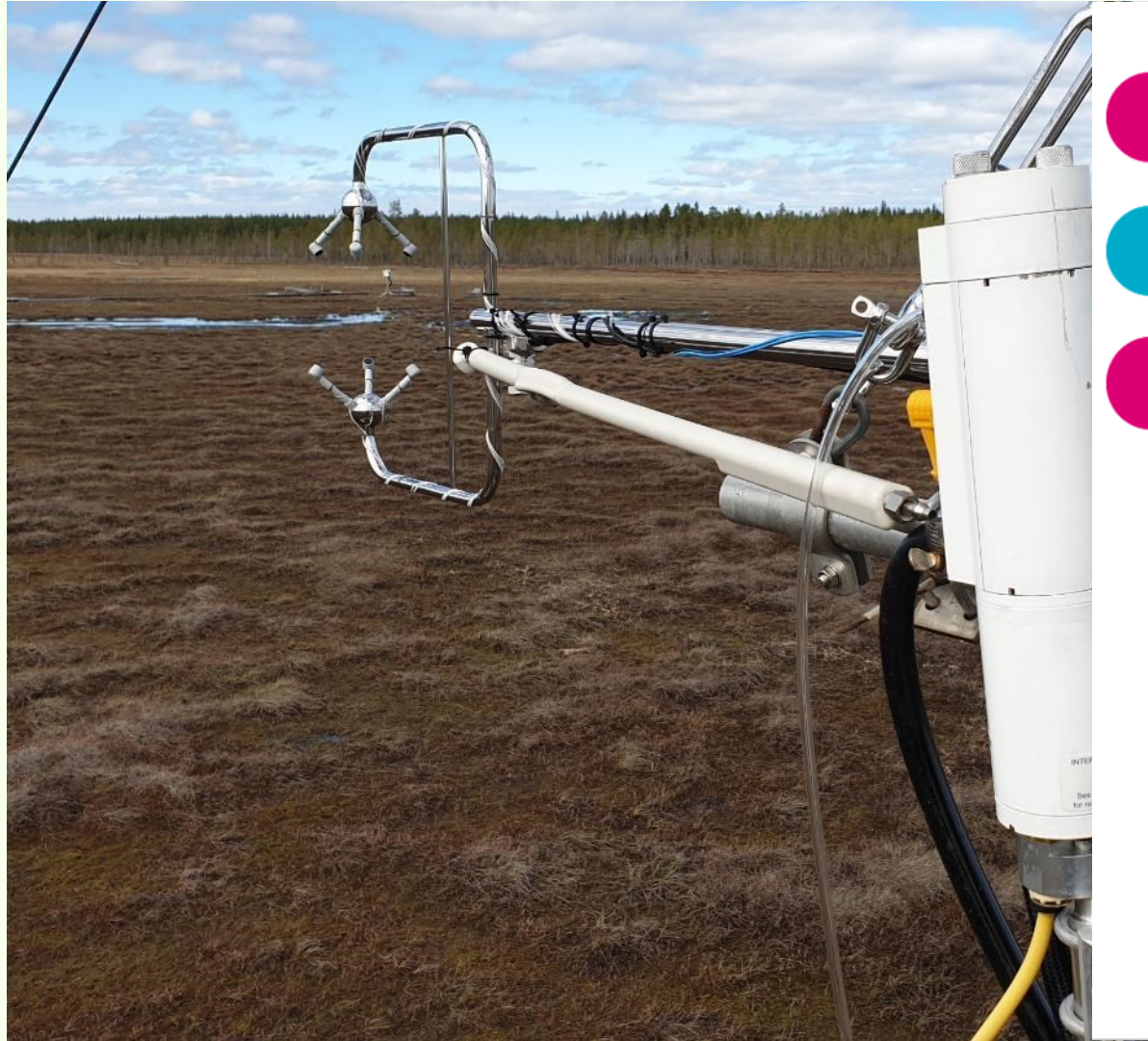
The data reflect the state of the atmosphere.



The measurements make it possible to track the effects of human activity on greenhouse gas concentrations.

# Ecosystemdata

Ecosystem stations continuously measure the exchange of relevant greenhouse gases across their respective ecosystems.





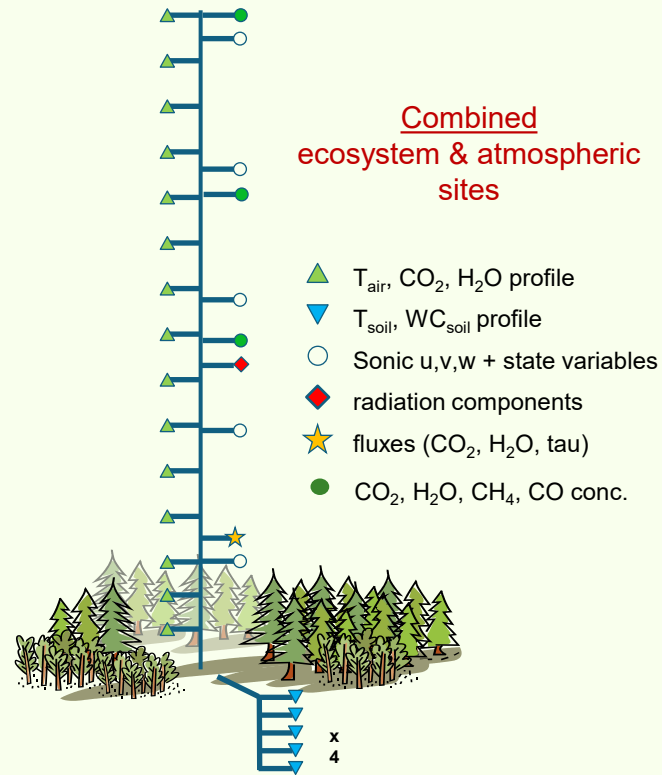


**Many more variables:**

Leaf area  
Biomass growth  
Litterfall  
Soil chemistry  
Meteorological

...

## Tower instrumentation



# Ecosystem data

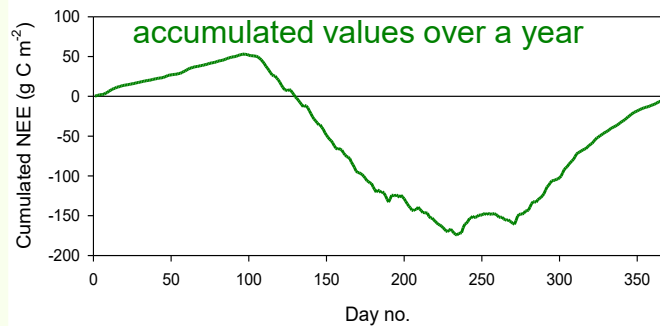
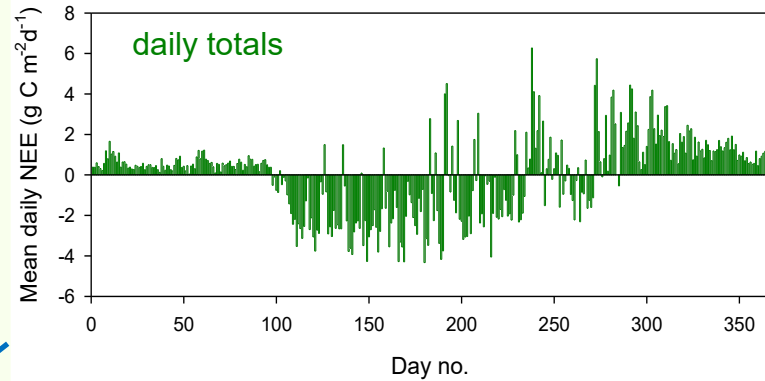
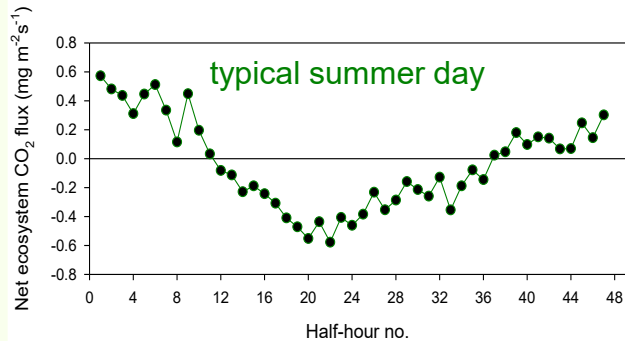
- documentation management activities
- vegetation characteristics
- soil properties

## aim:

- support data interpretation
- spatial upscaling
- modeling of observed ecosystem carbon and greenhouse gas dynamics



## Greenhouse gas net uptake



continuous  
measurements  
become one  
number per  
year





**ICOS** Integrated Carbon Observation System

Home > Data & Services >

## ICOS Data Portal

ICOS Data Portal provides observational data and [elaborated products](#) on greenhouse gases.

**> Data Products**

The major data products offered by ICOS. These datasets are offered as collections of data and are released under the ICOS CC4BY licence.

**> Search in Data Portal**

Search greenhouse gas data on Data Portal.

**ICOS** National Network Sweden

Data from the ICOS stations is open according to the CC4BY license terms:

Anyone can download and use ICOS data, but must reference and cite correctly (doi or pid).

[www.icos-cp-eu](http://www.icos-cp-eu)





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## ICOS – knowledge through observations

### Thanks to:

**Jutta Holst ([www.icos-sweden.se](http://www.icos-sweden.se))**

Department for Physical Geography and Ecosystem Science  
Lund University



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[www.icos-sweden.se](http://www.icos-sweden.se)

Picture credits:

Tobias Biermann, Anders Båth, Leonie Esters, Michal Heliasz, Thomas Holst, Jutta Holst, Irene Lehner, Per Marklund, Erik Nilsson, Stefan Osterwalder, Niklas Rakos, Paul Smith, Patrik Vestin, Per Weslien, Anna Willstrand Wranne

# The carbon cycle – exercise with carbon data from ICOS Hyltemossa

Link to the activity:

[https://colab.research.google.com/drive/1CvRLeXLRoy5nNL\\_x5p6j3eu\\_XQG9UYk7?usp=sharing](https://colab.research.google.com/drive/1CvRLeXLRoy5nNL_x5p6j3eu_XQG9UYk7?usp=sharing)



A screenshot of a Google Colab notebook. The top bar shows the Colab logo, the file name 'carbon\_Hyltemossa\_htm.ipynb', and various icons for chat, settings, sharing ('Dela'), Gemini, and a user profile. Below the top bar is a menu bar with 'Arkiv', 'Redigera', 'Vy', 'Infoga', 'Körning', 'Verktyg', and 'Hjälp'. A search bar labeled 'Kommandon' is on the left, and a status bar on the right shows 'RAM' and 'Disk' usage. The notebook content area has a title 'The carbon cycle - exercise with carbon data from ICOS-Hyltemossa research station' and a description: 'In this interactive exercise, we will explore problems related to the carbon cycle, i.e., the circulation of how carbon is absorbed and released within an ecosystem. We will focus on how the concentration of carbon dioxide in the air changes over the course of a day and throughout the year.' Below this, it states 'The exercise consists of the following parts:' followed by a numbered list: 1. What is carbon dioxide, 2. The carbon cycle, 3. A Year in the Life of Carbon on Earth (NASA video), and 4. Quiz – How much do you know about carbon?. The bottom of the interface shows 'Variabler' and 'Terminal' tabs, and a 'Python 3' label on the right.

# Investigate more about ICOS:

Learn about ICOS stations in Europe!

- Find some locations and discuss
- Can you find some interesting results?
- Are there a station in your country? Make contact for visiting the station

Greece:

<https://www.youtube.com/watch?v=ol5O6L9Mc5Y>

Italy:

<https://www.youtube.com/watch?v=9qVpK189eLw>





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You can find the presentation and the links to the activities on our homepage:

[GeoAcademy -  
Vattenhallen  
Science Center](#)



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# Thanks!

- Time for coffee break



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## global carbon project

**GLOBAL CARBON PROJECT**

HOME | CARBON ATLAS | CARBON BUDGET | CH<sub>4</sub> BUDGET | N<sub>2</sub>O BUDGET | RECCAP | URBANIZATION | SEARCH

Translate this site

- About GCP
- Activities
- Meetings
- Publications
- Science
- Research Programs
- Carbon Neutral
- Internet Resources
- Site Map
- Contact Us

## The Global Carbon Project

The Global Carbon Project (GCP) integrates knowledge of greenhouse gases for human activities and the Earth system. Our projects include global budgets for three dominant greenhouse gases — carbon dioxide, methane, and nitrous oxide — and complementary efforts in urban, regional, cumulative, and negative emissions.

**The GHG budget of the permafrost region**

research papers

**GCP Boston Office Job Opportunities**

jobs

**Global Carbon Atlas**

website

**Science Highlights**

- Carbon Budget 2024**  
[Carbon Budget 2024](#)
- N<sub>2</sub>O Budget 2024**  
[N<sub>2</sub>O Budget 2024](#)
- Methane Budget 2024**  
[Methane Budget 2024](#)



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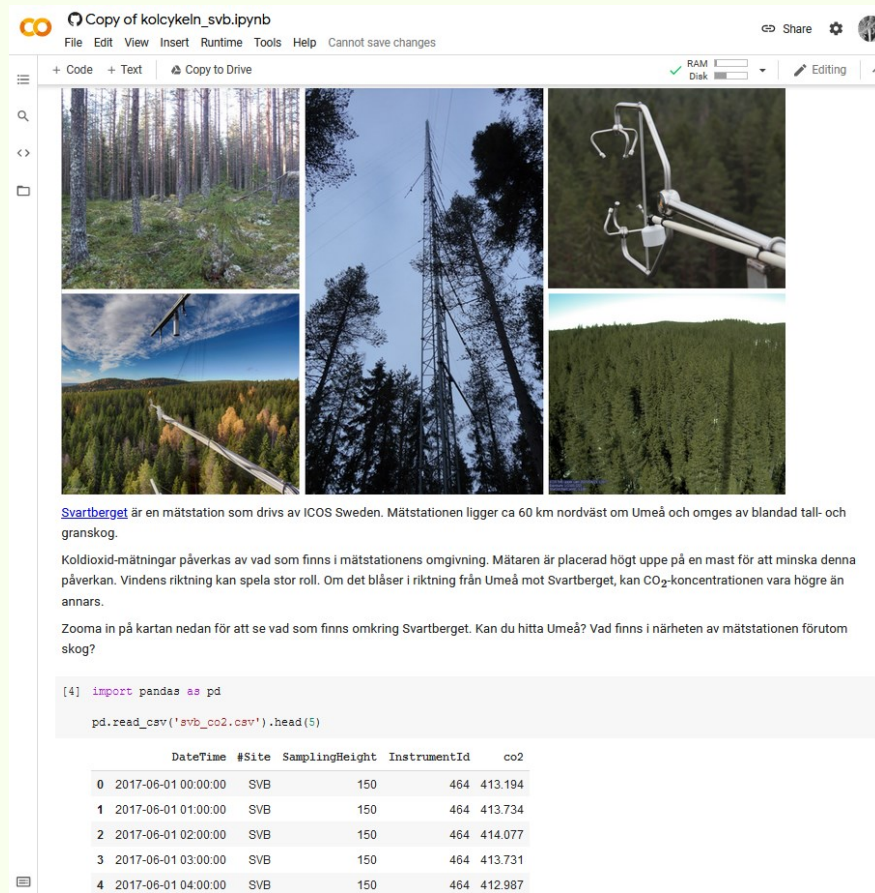


# What is a notebook?

Text cell

Kod cell

Output



The screenshot shows a Jupyter Notebook titled "Copy of kolcykeln\_svb.ipynb". The interface includes a menu bar (File, Edit, View, Insert, Runtime, Tools, Help), a toolbar (+ Code, + Text, Copy to Drive), and status indicators (RAM, Disk, Editing). The notebook content is divided into three cells:

- Text cell:** Contains five images of a forest landscape and a tall measurement tower. Below the images is text in Swedish describing the Svartberget measurement station, its location, and the data it collects.
- Kod cell:** Contains Python code using pandas to read a CSV file and display the first five rows.
- Output:** Displays the result of the code execution as a table with five rows of data.

	DateTime	#Site	SamplingHeight	InstrumentId	co2
0	2017-06-01 00:00:00	SVB	150	464	413.194
1	2017-06-01 01:00:00	SVB	150	464	413.734
2	2017-06-01 02:00:00	SVB	150	464	414.077
3	2017-06-01 03:00:00	SVB	150	464	413.731
4	2017-06-01 04:00:00	SVB	150	464	412.987

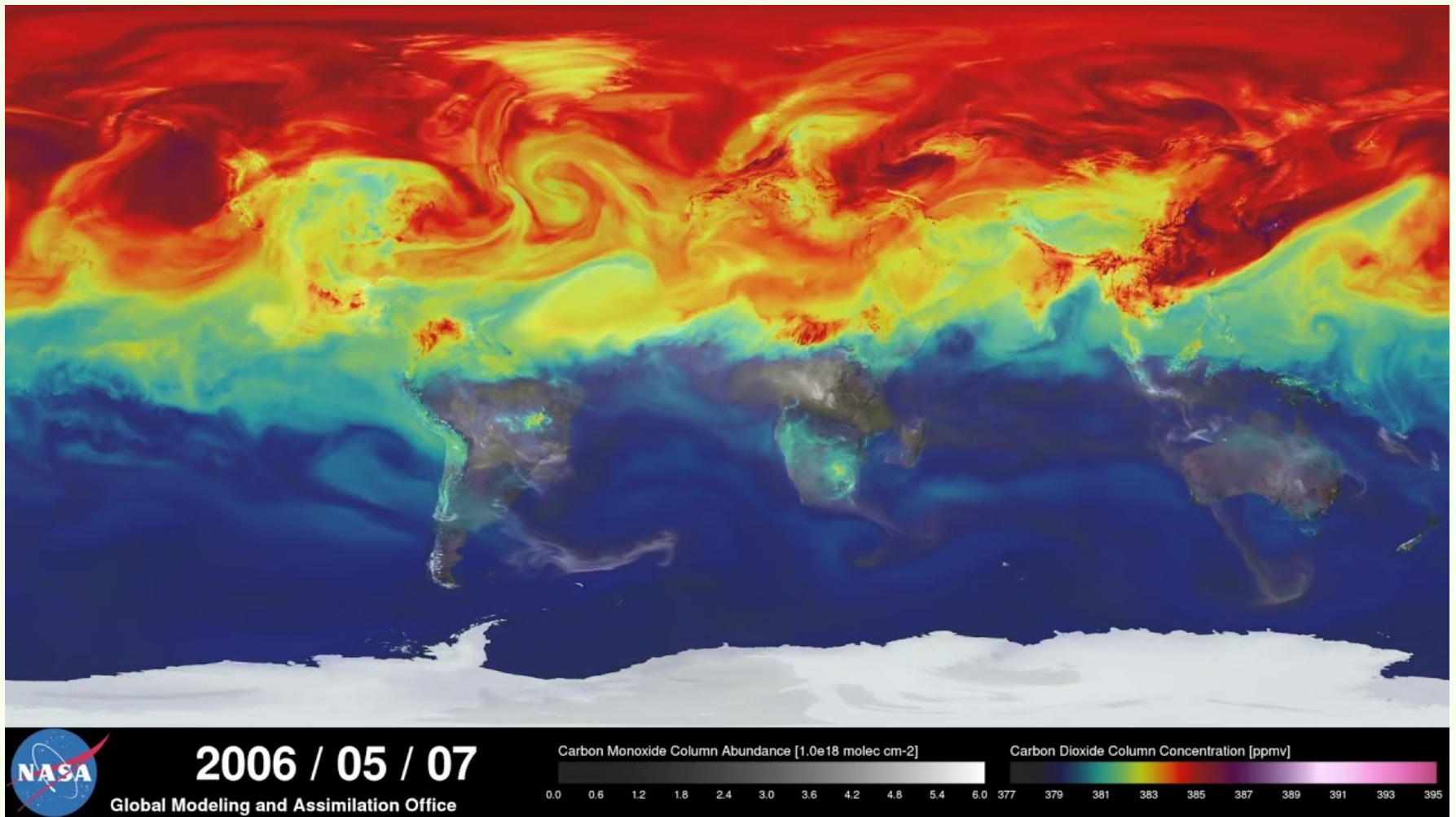
Dokumentation

- ✓ Text  
(vanlig text, HTML, Latex, ...)
- ✓ Bilder  
(PNG, JPEG, ...)
- ✓ Länkar  
(interna och externa)

Python kod

vektorer, tabeller, strängar,  
diagram, kartor, animeringar





NASA, A Year in the Life of Earth's CO<sub>2</sub>

<https://www.youtube.com/watch?v=x1SgmFa0r04>

# Carbon cycle

