

The background of the slide is a landscape photograph. In the foreground, a wide, braided river delta flows through a green, vegetated area. In the middle ground, a large body of water reflects the sky and the surrounding terrain. In the background, a range of rugged, brown mountains with some snow patches stretches across the horizon under a clear sky.

# ICOS

INTEGRATED  
CARBON  
OBSERVATION  
SYSTEM

## ENVRI-FAIR WEBINAR INTRODUCTION TO JUPYTER

Claudio D'Onofrio & Karolina Pantazatou

# Topics

- **Intro (5)**
- Technical aspects (10)
- Access to data (5)
  - Hands-on exploredata & break (15)
- Q&A (10)
- ICOS Jupyter solutions, services, target groups (10)
- Use cases for different notebook types (10)
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- Q/A (10 min)
- Panel discussion (15 min)



# Integrated Carbon Observation System

ICOS IN SHORT

**12** countries

**140** stations

**500** researchers

**80** renowned  
universities or institutes

Research Infrastructure  
for standardised  
greenhouse gas observations

Read the ICOS Handbook @  
<https://www.icos-cp.eu/>



# ICOS Mission

## ICOS IN SHORT

**12** countries

**140** stations

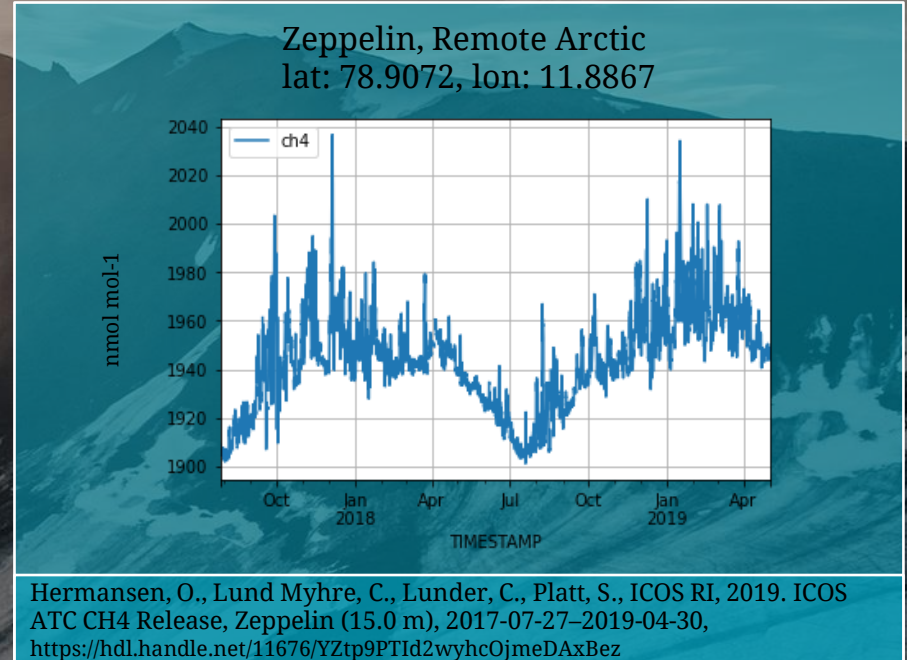
**500** researchers

**80** renowned  
universities or institutes

- High-quality, high-precision and long-term observation
- Free & FAIR
- Outreach to the public, science, policy-makers & education

# ICOS Python Library

- Access to ICOS data
- Make it as easy as possible
- Five lines of code to have a reproducible, high quality graph

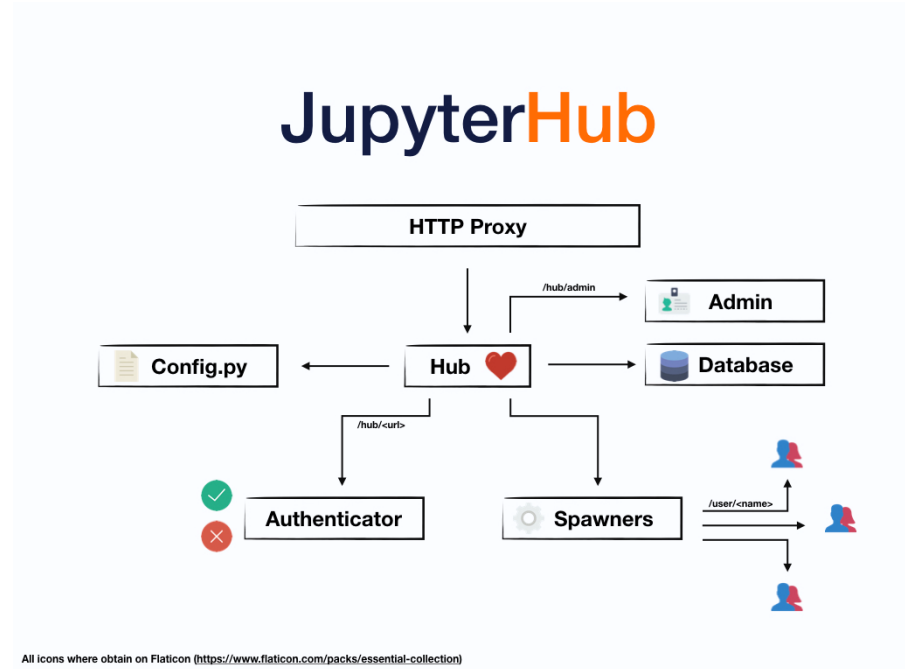


# What is Jupyter

The Jupyter Notebook is a **web application** that allows you to create and share documents that contain **live code**, **equations**, **visualizations** and **narrative text**.

There are many kernels available.

**Julia + Python + R = jupyter**

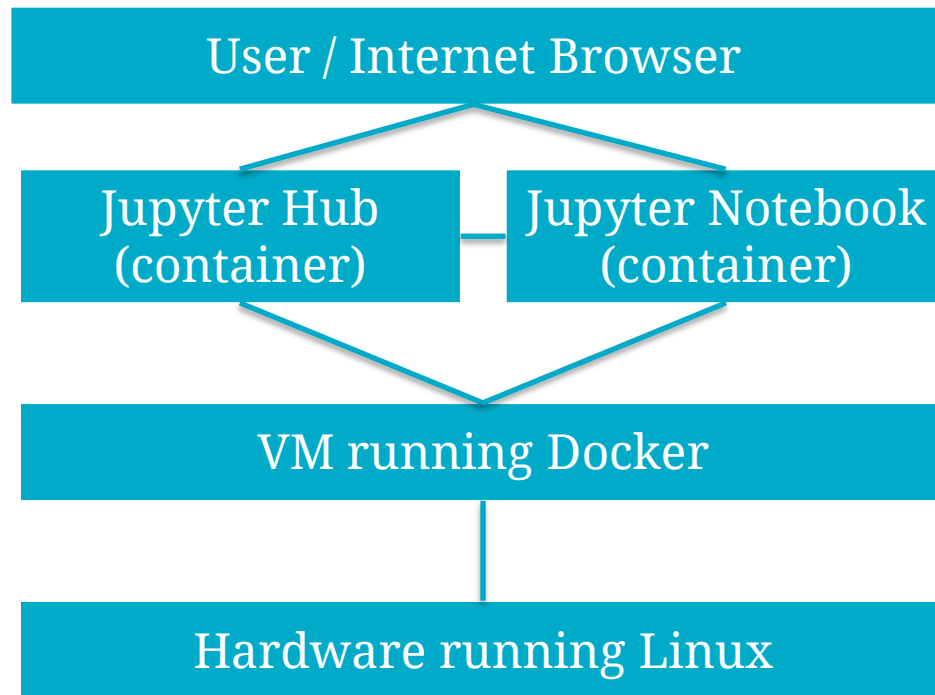


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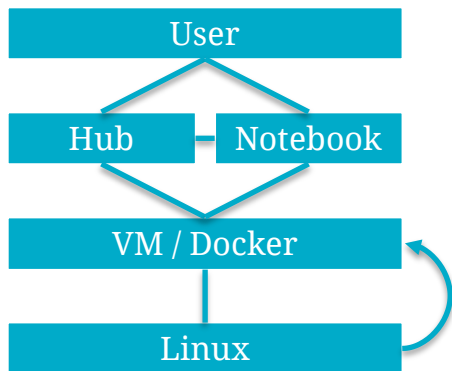


# Tech Overview



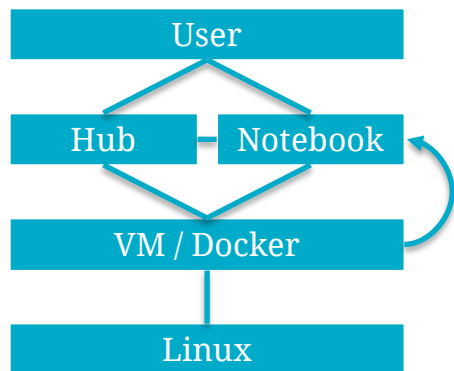


# Tech Overview



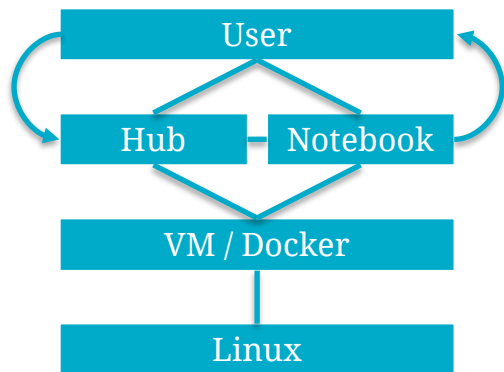
- Using LXD to create VMs
- Create user & groups (standard linux)
- Ansible Playbook

# Tech Overview



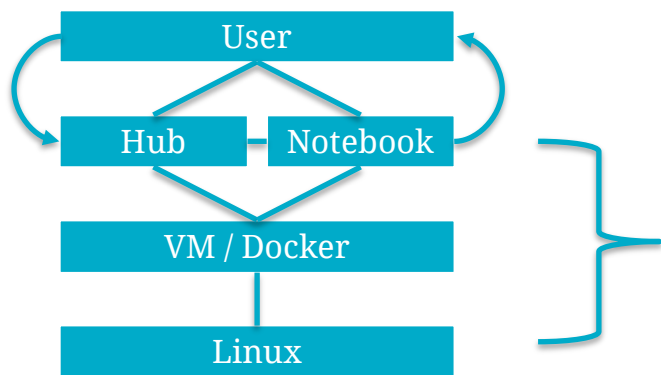
- Create Docker images
- Link data repositories
- Clone Github repository
- Start the 'Hub'

# Tech Overview



- Internet browser to access the ‘Hub’
- Select an image
- Create a ‘Notebook Container’

# Tech Overview

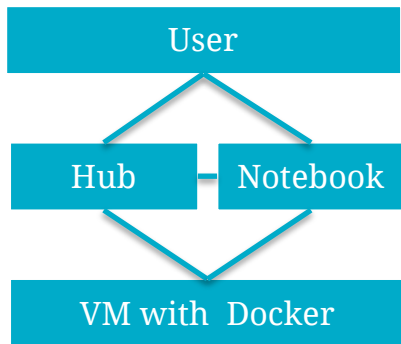


- Automated with Ansible Playbooks and Makefiles, admin friendly
- container-in-container
  1. Crash-barrier, if we mess up one docker instance, the other ones will survive
  2. Security - breaking out of an LXD container is much harder than breaking out of docker.
  3. Co-administration. Many of our VMs will have people logging in via ssh and it's much easier to contain any damage they make
  4. Flexibility
  5. Scalability

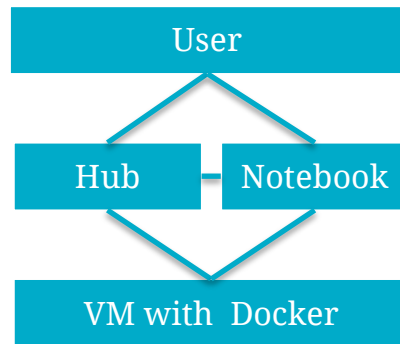


# Tech Overview

exploredata.icos-cp.eu



jupyter.icos-cp.eu



...

Hardware running Linux

# Tech Overview

exploredata.icos-cp.eu

- Public
- Password: msa
- Loss of changes on logout
- Playground

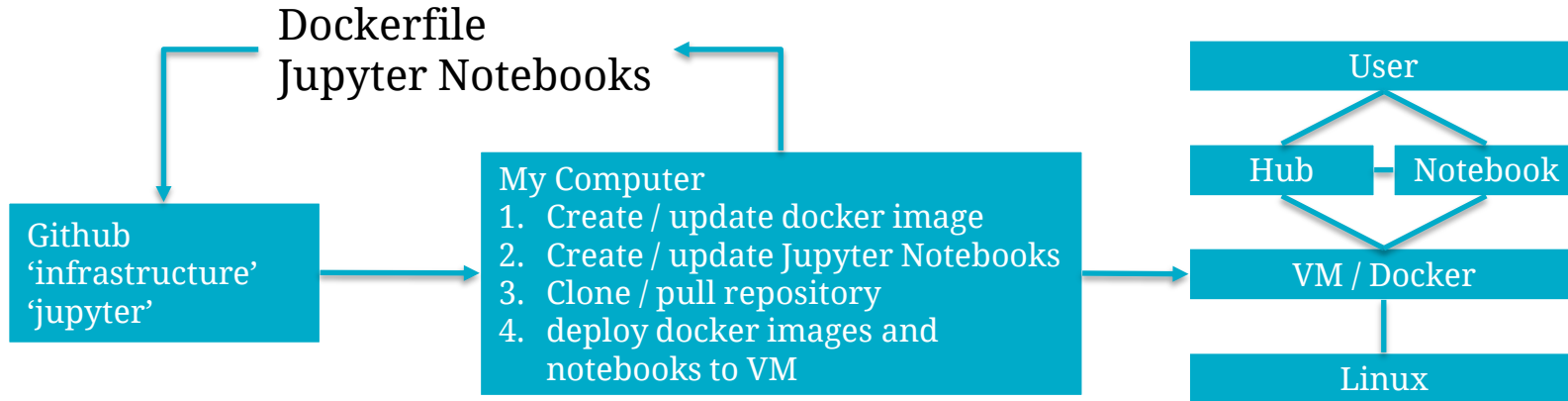
jupyter.icos-cp.eu

- Registered Users
- Group collaboration
- Linux users & groups
- Virtual Research Environment

Hardware running Linux

# Tech Overview

How does it look like in the real world



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

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

# Tech Overview

Live example, publish exploredata

As a side note,

..... “my computer” is actually a virtual machine running on our server



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# An example

- Find a PID by searching the ICOS Data Portal  
<https://data.icos-cp.eu>
- Go to <https://exploredata.icos-cp.eu> and play around.

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# Hands on & Break

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

user: whatever password: msa

Open the notebook “pylib\_examples/EnvriFairWebinar

Try to add data from another ship to the map





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# Recap

We have used open source software to create our own ‘stack’ to make an admin friendly python programming environment

Don’t forget, Jupyter Hub is MORE than just python.  
Many kernels available...(the name comes from Julia, Python & R)

Our goal is to have an easy access to ICOS data  
inside a collaboration & sharing platform

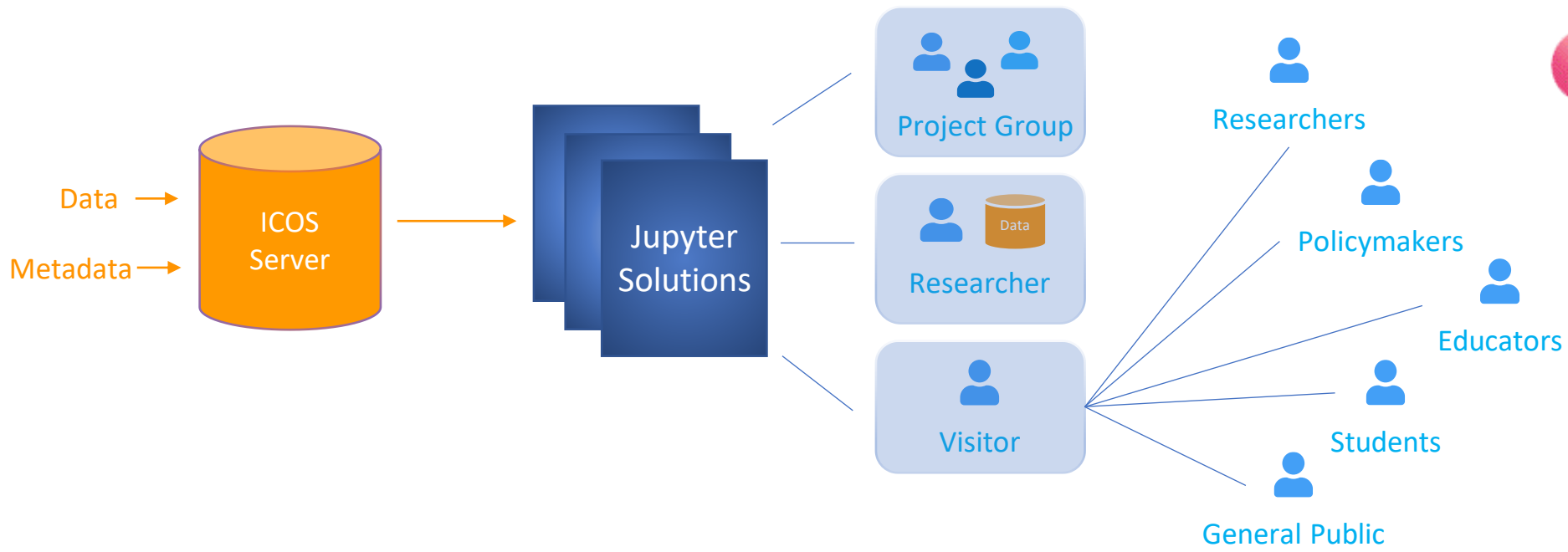
The Open Infrastructure Summit 2020  
<https://www.openstack.org/summit/2020/>

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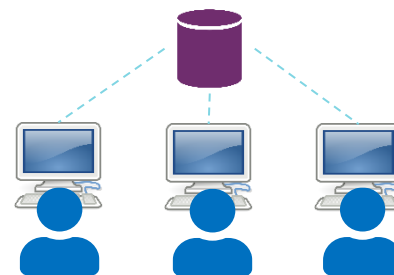
# ICOS Jupyter Solutions – Target user groups





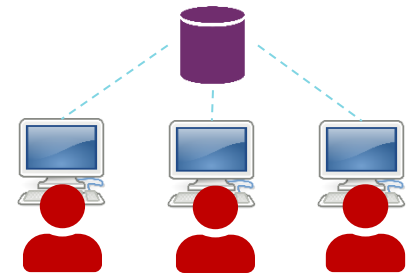
# ICOS Jupyter Solutions – Jupyter Hub

- User accounts for registered users
- Users may upload data & create own directories  
(all work is saved)
- Collaboration between users with shared directories  
(access to directories on server)
- Runs in a VM with docker containers  
(automated setup)



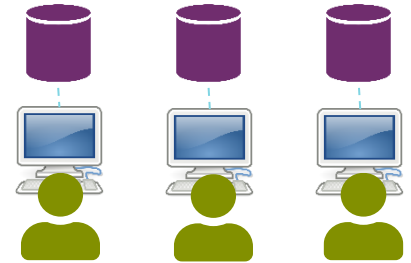
# ICOS Jupyter Solutions – Temporary Jupyter Instances

- One Jupyter instance with multiple user accounts for registered users that take part in a course, workshop or seminar
- Collaboration between users with shared directories (access to directories on server)
- Users may upload data (all work is saved as long as the instance exists)
- One docker container for all users (automated setup)
- The Jupyter instance is deleted after the course, workshop or seminar has ended



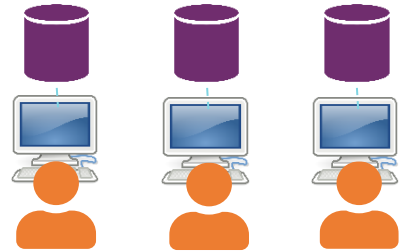
# ICOS Jupyter Solutions – Exploredata

- Multiple purpose testing platform
- Used in presentations & short seminars
- Requires log in
- Includes IPython notebooks that are open to the public
- Content deleted after log-out or after 15 min of inactivity
- One docker container per user (automated setup)



# ICOS Jupyter Solutions – Open service

- Displaying notebooks “live” on portal
  - ✓ no code visible
  - ✓ code visible (no editing)
- Interaction with plots using widgets (no coding-skills required)
- Upcoming service (under development)

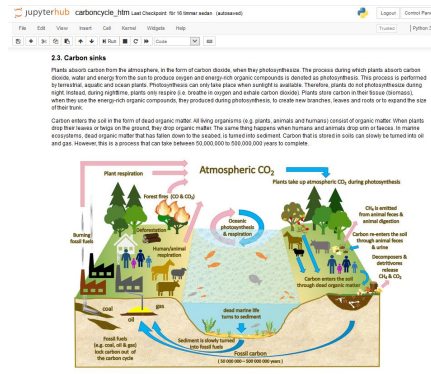
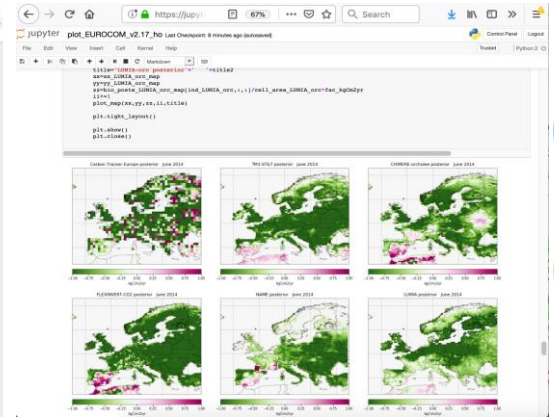
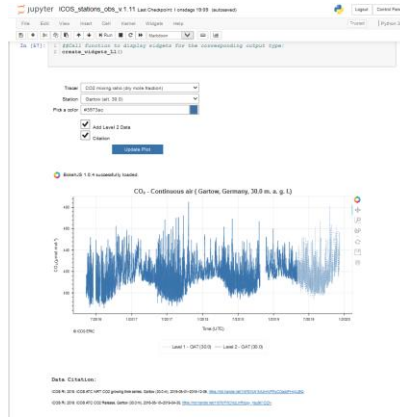


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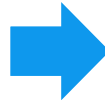
# Notebook types

- Introduction to Python (open access)
- Exploring ICOS data (open access)
- Scientific notebooks (private / open access)
- Educational notebooks (open access)



# Introductory Notebooks

- Introduction to Python
- Tailored examples with use cases from the ICOS environment
- No programming skills required
- Easy transition for people with prior experience in programming in another programming language



jupyter QuickstartToPythonENG (unsaved changes) Logout Control Panel

File Edit View Insert Cell Kernel Widgets Help Not Trusted Python 3

ICOS INTEGRATED CARBON OBSERVATION SYSTEM python™

### Quickstart to Python

This notebook contains a short introduction of basic principles of coding in Python. It is aimed for people who have no prior knowledge in programming but also for people who wish to brush up their memory in programming with Python or are already familiar with programming in another programming language and want to become acquainted with Python. The notebook is organized in a series of chapters where the main principles of programming are introduced. There is an emphasis on providing brief descriptions of the coding principles in conjunction with simple and self-explanatory coding examples. People who are new to programming are advised to follow this manual step by step. For people that are already familiar with Python or programming in general, it is possible to use the links to navigate to specific chapters.

Observe that this tutorial was developed using **Python 3.6.7**.

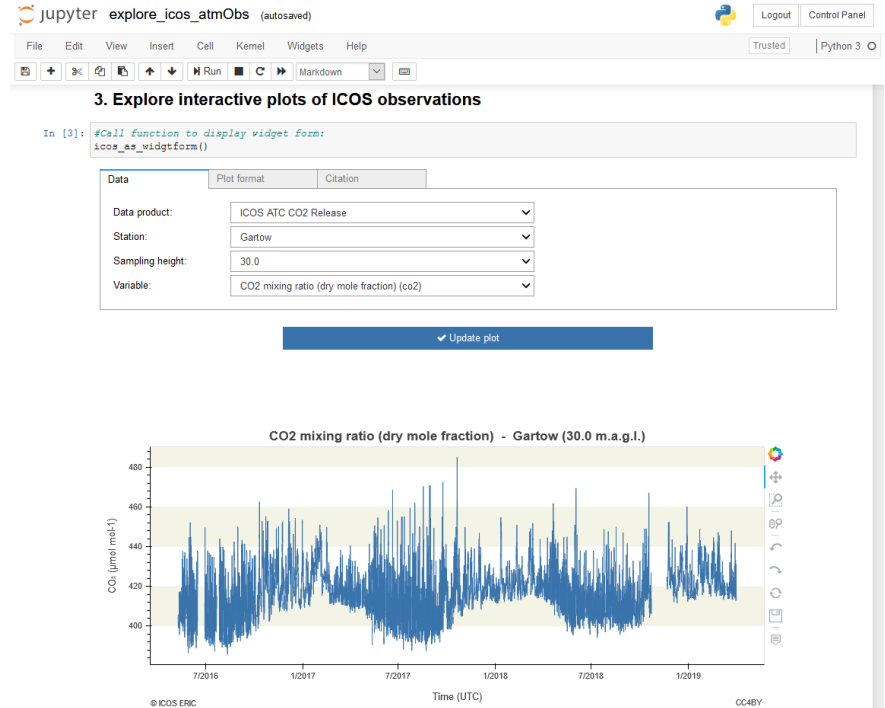
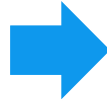
### Table of Contents

- [introduction](#)
- [1. import Python modules](#)
- [2. Variables and data types in Python](#)
  - [2.1. Variables](#)
  - [2.2. Data types](#)
  - [2.3. Python conventions](#)
  - [2.4. Comments](#)



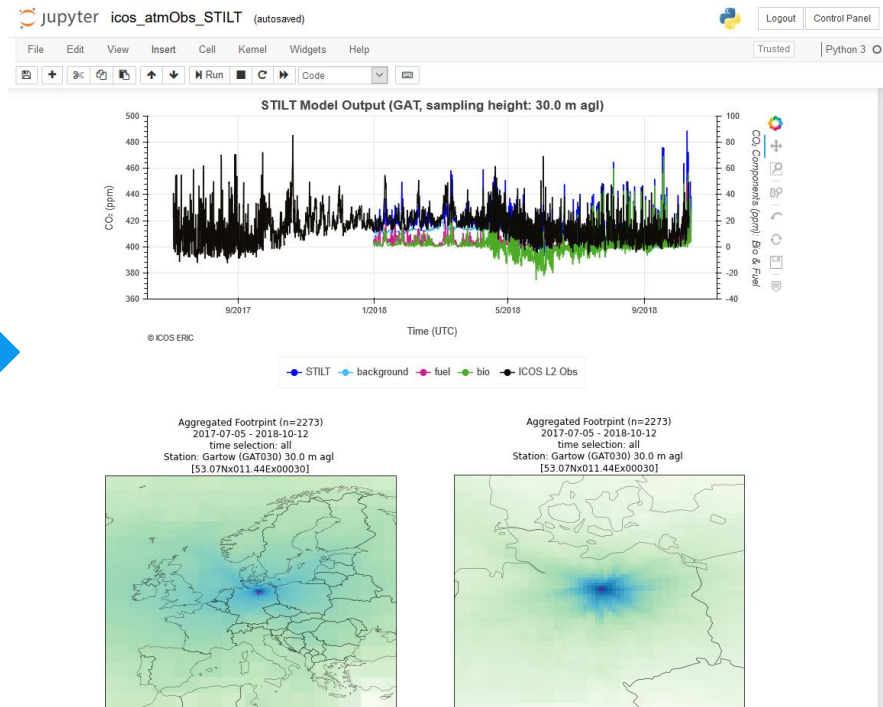
# Notebooks – Exploring ICOS Data

- Explore ICOS data products per domain
- Availability of data
- Metadata on data quality
- Statistics
- Compare measurements between different stations
- Interactive visualizations
- Metadata on data citation



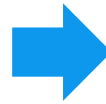
# Scientific Notebooks

- Apply scientific methods to:
  - ✓ ICOS data
  - ✓ Combination of ICOS data and data from other sources
- Well documented application of methods
- Interactive elements for selection of output
- Interactive visualizations



# Educational Notebooks

- Introduction to environmental science and programming
- Increase awareness regarding problems related to climate change
- Promotes the important role of ICOS in the fight against climate change
- No programming skills required
- Suitable for students, educators & the general public



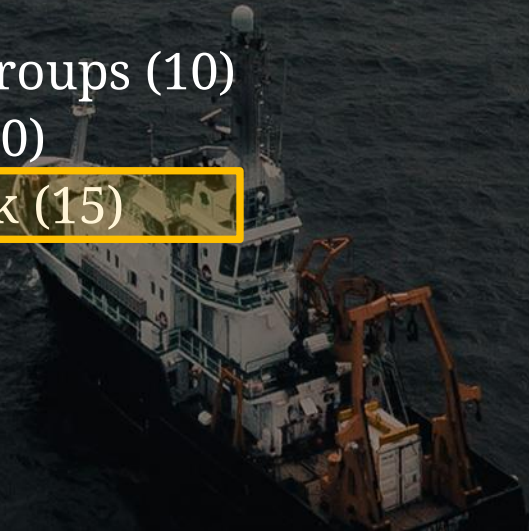
**2.3. Carbon sinks**

Plants absorb carbon from the atmosphere, in the form of carbon dioxide, when they photosynthesize. The process during which plants absorb carbon dioxide, water and energy from the sun to produce oxygen and energy-rich organic compounds is denoted as photosynthesis. This process is performed by terrestrial, aquatic and ocean plants. Photosynthesis can only take place when sunlight is available. Therefore, plants do not photosynthesize during night. Instead, during nighttime, plants only respire (i.e. breathe in oxygen and exhale carbon dioxide). Plants store carbon in their tissue (biomass), when they use the energy-rich organic compounds, they produced during photosynthesis, to create new branches, leaves and roots or to expand the size of their trunk.

Carbon enters the soil in the form of dead organic matter. All living organisms (e.g. plants, animals and humans) consist of organic matter. When plants drop their leaves or twigs on the ground, they drop organic matter. The same thing happens when humans and animals drop urine or faeces. In marine ecosystems, dead organic matter that has fallen down to the seabed, is turned into sediment. Carbon that is stored in soils can slowly be turned into oil and gas. However, this is a process that can take between 50,000,000 to 500,000,000 years to complete.

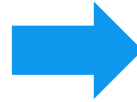
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# Hands-on “Carbon Cycle” Notebook

- Open your browser and go to:  
[exploredata.icos-cp.eu](https://exploredata.icos-cp.eu)
- Enter login details:  
Username: *free of choice*  
Password: *msa*
- Navigate to (*simple version*):  
**education** --- > **General**  
[carboncycle\\_htm.ipynb](#)
- Navigate to (*advanced version*):  
**education** --- > **General**  
[carbon\\_cycle\\_drought.ipynb](#)



Jupyterhub carboncycle\_htm Last Checkpoint: för 16 timmar sedan (autosaved)

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3.0

### Carbon Cycle

Examples using ICOS CO<sub>2</sub>-data

This Jupyter Notebook is dedicated to explaining the carbon cycle and focuses on topics regarding daily and yearly fluctuations in the concentration of carbon dioxide. It contains definitions, short descriptions, figures and animations that describe the following terms: **carbon dioxide**, **carbon cycle**, **carbon sinks** and **carbon sources**. You will be able to test your knowledge on carbon by taking the **Carbon Challenge Quiz**. In order to better comprehend the carbon cycle, the notebook also includes exercises using ICOS data from Hyytiemossa station in Sweden. The exercises are based on topics related to the uptake and release of carbon dioxide amongst different parts of an ecosystem.

The notebook is divided into the following parts:

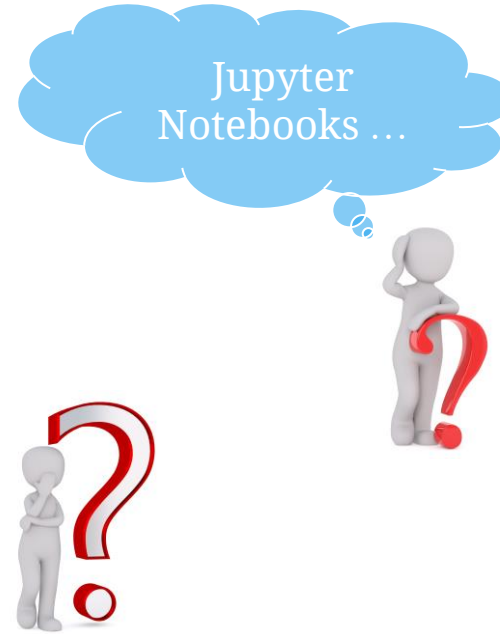
- [1. What is carbon dioxide \(CO<sub>2</sub>\)](#)
- [2. Carbon cycle](#)
- [3. A year in the life of Earth's CO<sub>2</sub>](#)
- [4. Quiz: Carbon challenge - How well do you know carbon?](#)
- [5. Exercises with CO<sub>2</sub>-data from Hyytiemossa ICOS station](#)
- [6. References](#)



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# Q / A - Jupyter Solutions & Notebooks





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# Questions

- Are you working with Jupyter in your data center?  
What is your experience?
- What are the pros working with Jupyter?
- What are the cons working with Jupyter?
- What do you think are the most interesting features  
of working with Jupyter?
- Would you consider start using Jupyter?  
Yes/No? Why?



