



# ENVRI Community International Winter School on DATA FAIRness

<https://www.lifewatch.eu/envri-iws-data-fairness-2020>

Elaborated Products @ ICOS

Ute Karstens, Karolina Pantazatou, Ida Storm, Claudio D'Onofrio, ICOS Carbon Portal  
11-22 January 2021



ENVRI-FAIR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824068



# Integrated Carbon Observation System

Research Infrastructure  
for standardised  
greenhouse gas observations

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

## ICOS IN SHORT

**12** countries

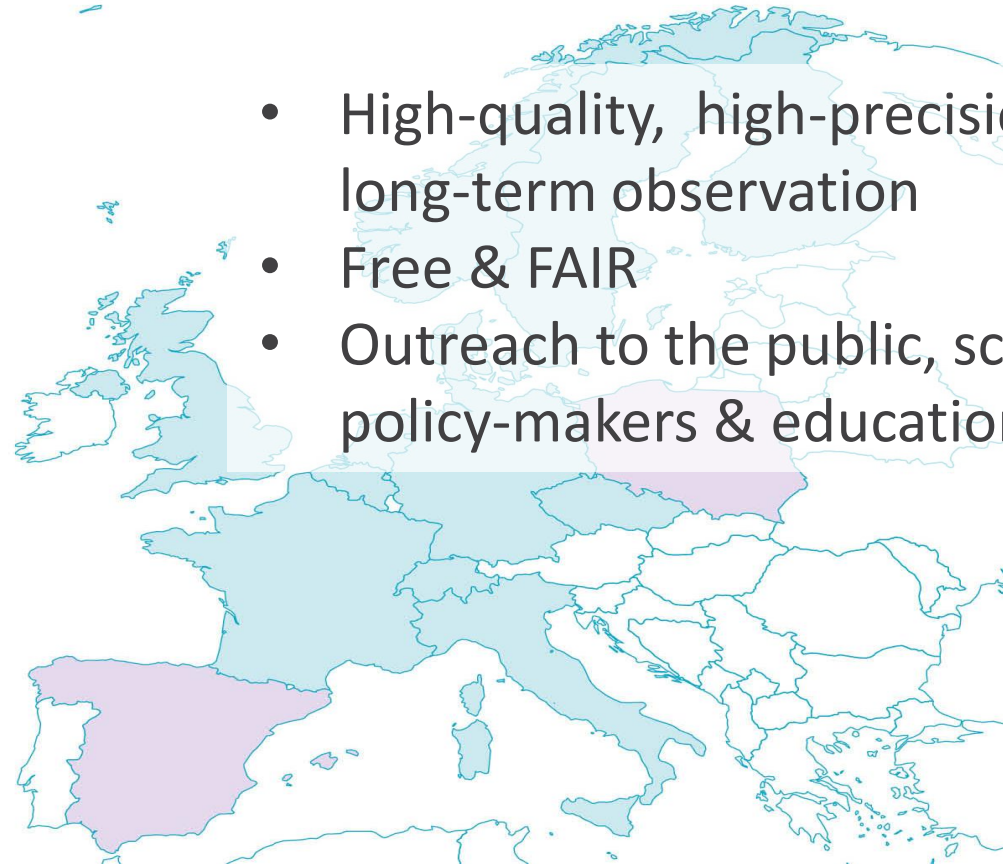
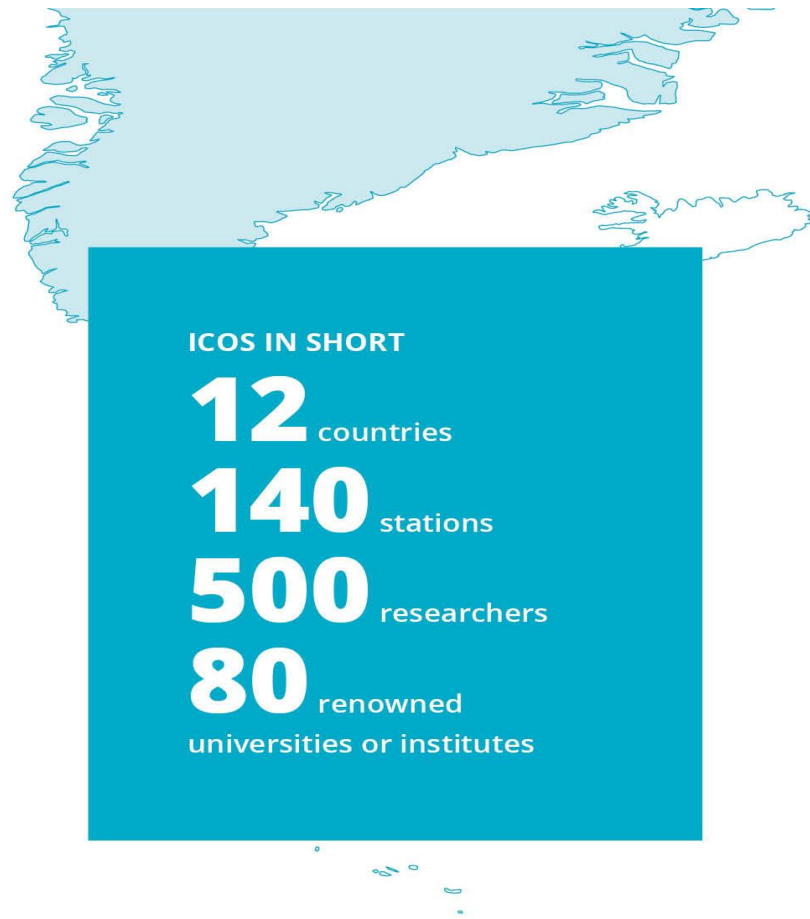
**140** stations

**500** researchers

**80** renowned  
universities or institutes



# ICOS Mission



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

# Since this is virtual.....



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# ICOS

● ● ●  
INTEGRATED  
CARBON  
OBSERVATION  
SYSTEM

## GOAL FOR THIS WORKSHOP

Showcase the STILT web application @ ICOS CarbonPortal

Hands on (Jupyter Notebooks) compare STILT result with measurements

- Create a time series plot

- Create an interactive map for the station

Exercise:

- Create a timeseries plot (model output vs. observation)

- Create a Jupyter notebook with a map (show the station location)

  - Yes**, the same as we do in the workshop

  - No**, you can't use the 'workshop station', you **MUST** use a different station

# Workshop Schedule

🌀 STILT <ul style="list-style-type: none"><li>🌀 On demand calculation</li><li>🌀 Result visualization</li></ul>	Ute	15 min
🌀 Station characterization <ul style="list-style-type: none"><li>🌀 Create a new “data product” based on STILT results</li></ul>	Ida	5 min
🌀 Login to VRE	Karolina	5 min
🌀 Break		5 min
🌀 Hands on – create an interactive map	Claudio	30 min
🌀 Break		10 min
🌀 Hands on – create a timeseries plot	Karolina	45 min
🌀 Conclusion and exercise	Claudio	5 min



# STILT Footprint Tool @ ICOS CarbonPortal

**STILT** is an atmospheric transport model that is used to compute **footprints** and greenhouse gas (GHG) **concentrations** at ICOS atmospheric stations

*What is the “footprint” of an atmospheric station?*

- *Source area that influences the GHG concentration at a station location*

*Why do we need to model the footprint?*

- *Analysis of potential impacts of natural and anthropogenic emissions on the atmospheric GHG concentration*

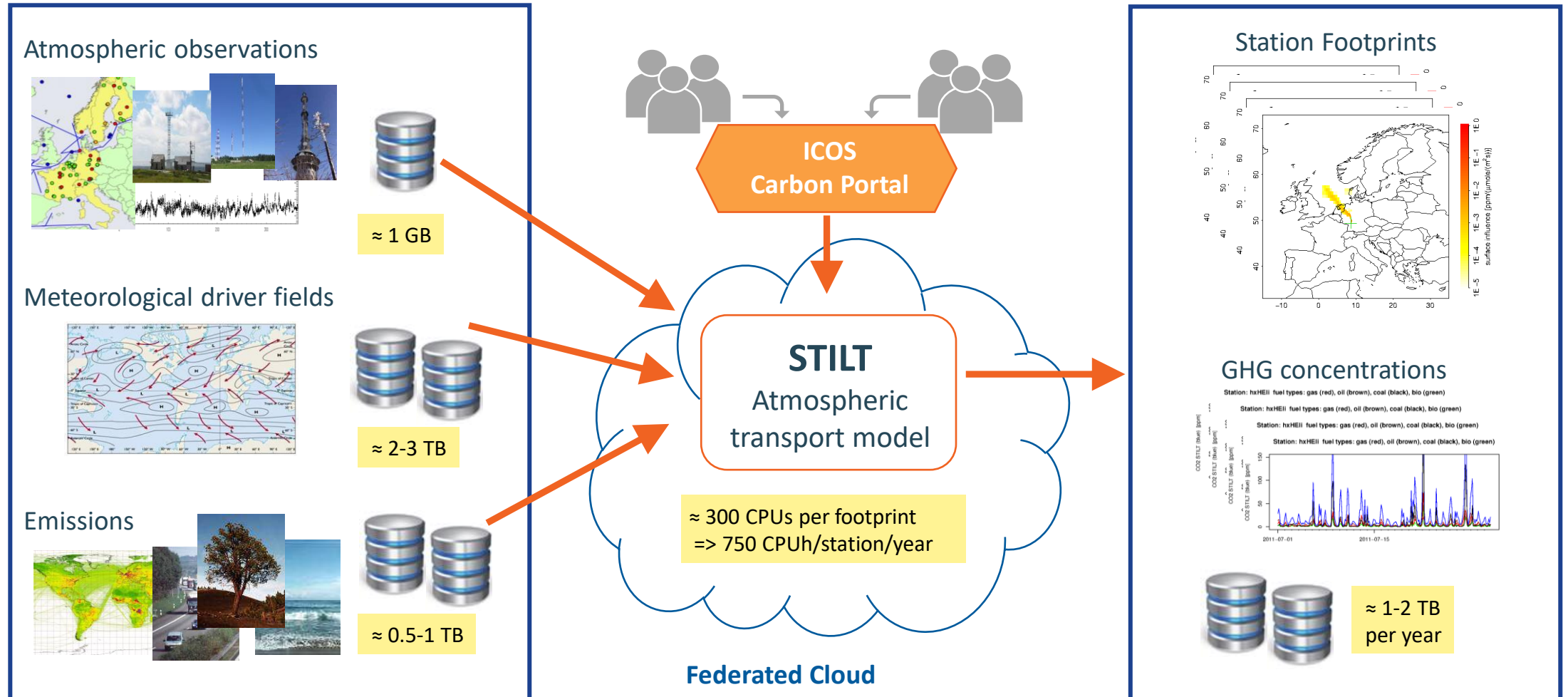


# STILT Footprint Tool @ ICOS CarbonPortal

- Web-based service at ICOS Carbon Portal
  - On-demand STILT model calculations
    - Model implemented in Virtual Machine to be scalable and transferable
    - Combination of computing resources at ICOS CP and in the cloud
    - Computationally intensive:  $\approx 300$  CPUs per single footprint
    - ICOS authentication required
- <https://stilt.icos-cp.eu/worker/>
- Open-access STILT viewer displaying all available computation results
- <https://stilt.icos-cp.eu/viewer/>

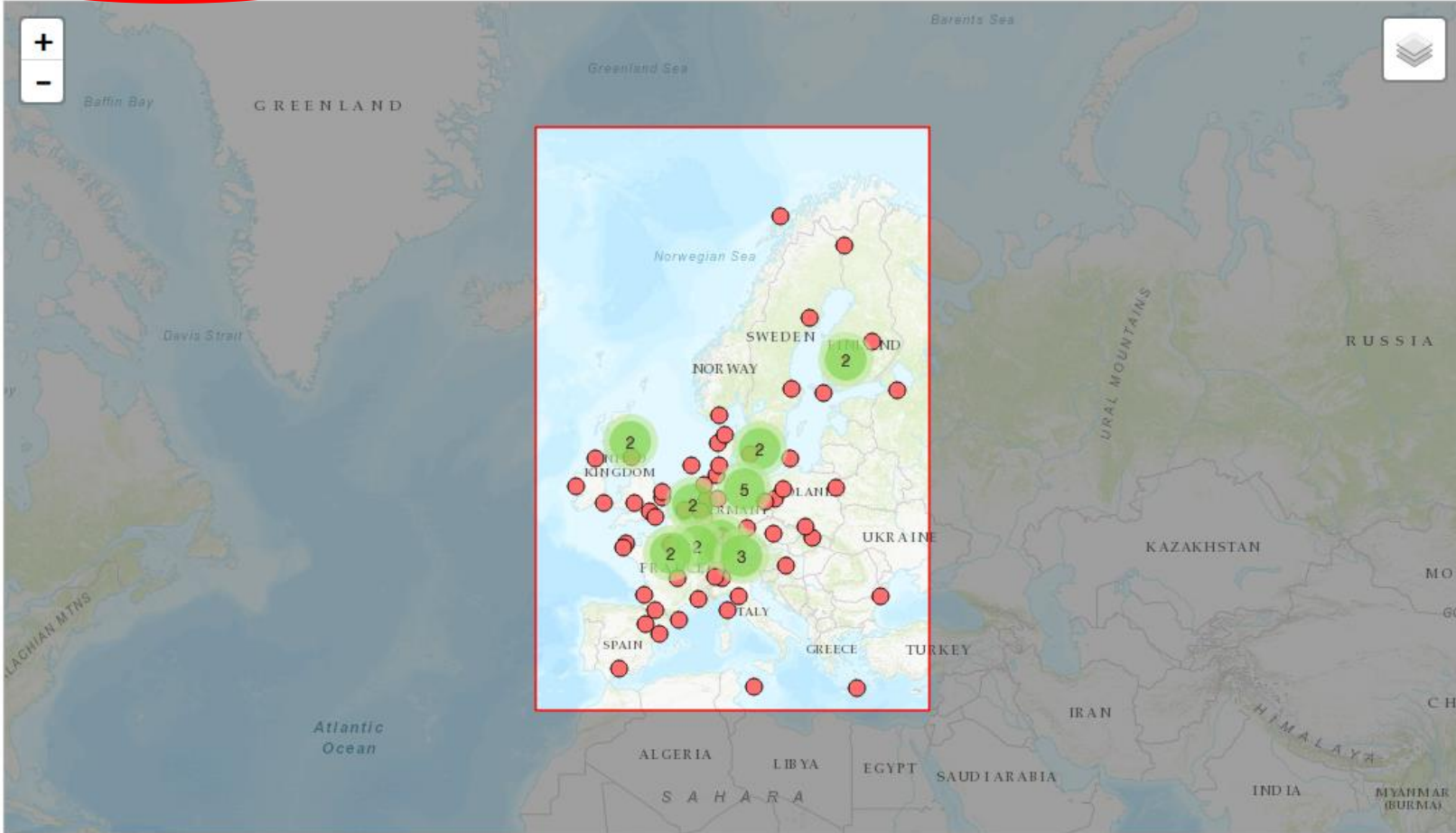


# STILT Footprint Tool @ ICOS CarbonPortal



## Existing STILT footprints

Select station here or on the map



## Create new STILT footprint

Latitude (decimal degree)

Longitude (decimal degree)

Altitude above ground (meters)

Site id (usually a 3 letter code)  
 [Load data](#)

Start date (YYYY-MM-DD)

End date (YYYY-MM-DD)

[Submit STILT job](#)

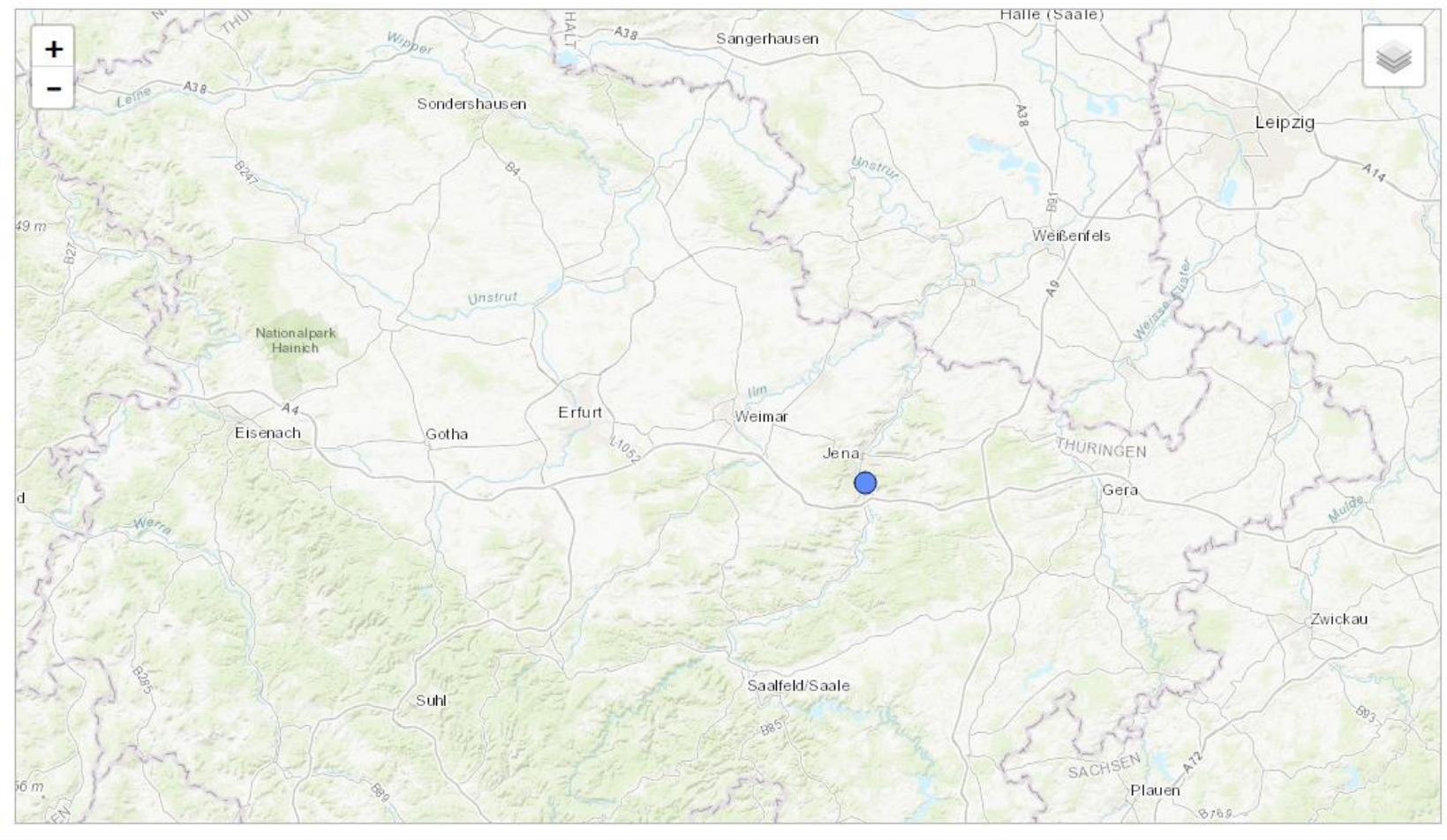
## Submitted STILT jobs

[Show details](#)

No jobs have been submitted

## Existing STILT footprints

Select station here or on the map




## Create new STILT footprint


**Latitude (decimal degree)**

**Longitude (decimal degree)**

**Altitude above ground (meters)**

**Site id (usually a 3 letter code)**  
 [Load data](#)

**Start date (YYYY-MM-DD)**  
 

**End date (YYYY-MM-DD)**  
 

[Submit STILT job](#)

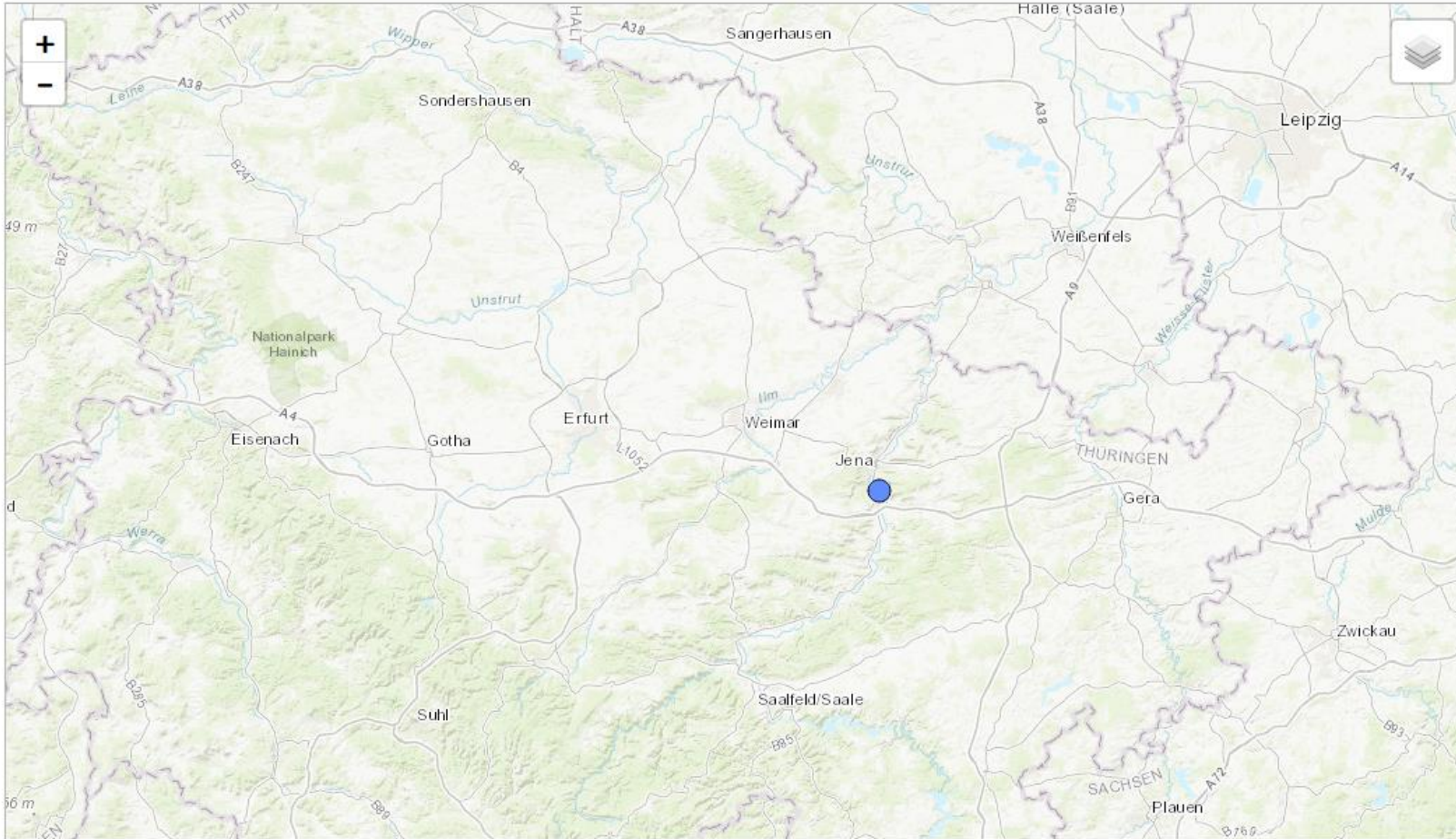
## Submitted STILT jobs

[Show details](#)

No jobs have been submitted

## Existing STILT footprints

Select station here or on the map



## Create new STILT footprint

Latitude (decimal degree)

50.9

Longitude (decimal degree)

11.6

Altitude above ground (meters)

100

Site id (usually a 3 letter code)

JENA

Load data

Start date (YYYY-MM-DD)



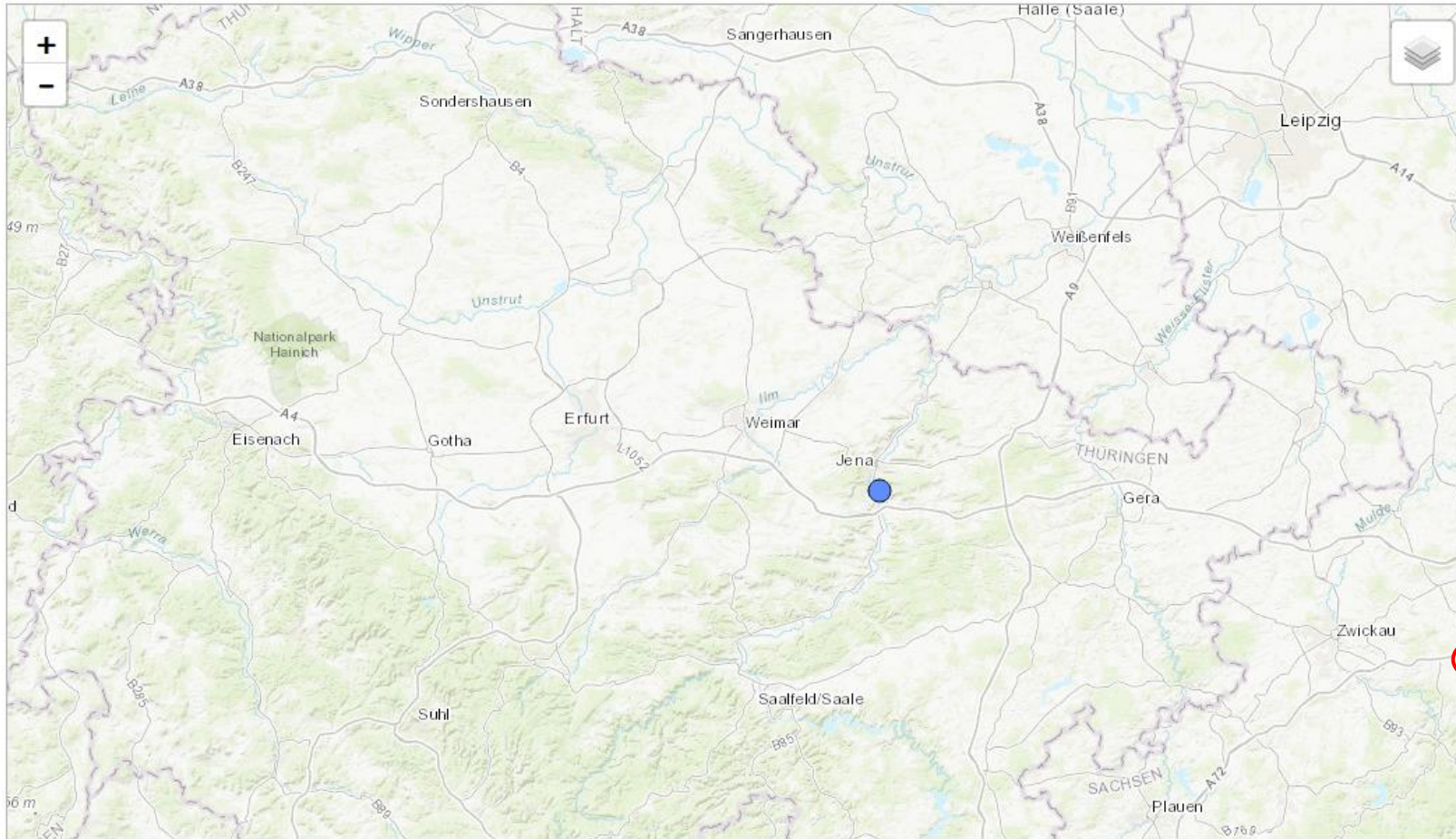
January 2006						
Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
SU	29	30	31	1	2	3
4	5	6	7	8	9	10
11						

Show details

No jobs have been submitted

## Existing STILT footprints

Select station here or on the map



## Create new STILT footprint

Latitude (decimal degree)

Longitude (decimal degree)

Altitude above ground (meters)

Site id (usually a 3 letter code)

Load data

Start date (YYYY-MM-DD)

End date (YYYY-MM-DD)

Submit STILT job

## Submitted STILT jobs

Show details

No jobs have been submitted

### Existing STILT footprints

Select station here or on the map

The map displays STILT footprints across Europe. A red rectangular box highlights a specific region in Western and Central Europe. Within this region, several green circles are overlaid on red dots, each containing a number: '2' is visible in the UK, France, Germany, and the Baltic states; '5' is visible in Poland; and '3' is visible in the Balkans. Other red dots representing existing footprints are scattered across the rest of Europe. The map includes labels for major geographical features like the Atlantic Ocean, Mediterranean Sea, and various countries.

### Create new STILT footprint

**Latitude (decimal degree)**

**Longitude (decimal degree)**

**Altitude above ground (meters)**

**Site id (usually a 3 letter code)**  
 [Load data](#)

**Start date (YYYY-MM-DD)**

**End date (YYYY-MM-DD)**

[Submit STILT job](#)

### Submitted STILT jobs

[Show details](#)

Running computations

★ Site 'JENA'

## Computational resources

Node	Free CPUs	Total CPUs
akka.tcp://StiltCluster@localhost:2561	0	40

## Running computations

[Cancel job](#) Site id: **JENA** (lat: 50.9, lon: 11.6), alt: 100, start: 2016-06-01, stop: 2016-06-07, done: 1 of 56 - submitted by ute.karstens@nateko.lu.se

[To the job starter](#)

## Computational resources

Node	Free CPUs	Total CPUs
akka.tcp://StiltCluster@localhost:2561	31	40

## Running computations

 [Cancel job](#) Site id: **JENA** (lat: 50.9, lon: 11.6), alt: 100, start: 2016-06-01, stop: 2016-06-07, done: 47 of 56 - submitted by ute.karstens@nateko.lu.se

[To the job starter](#)

## Computational resources

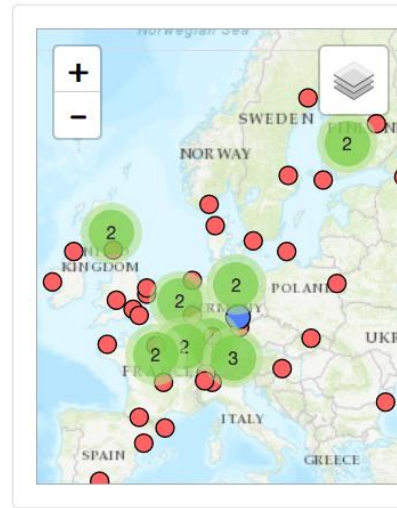
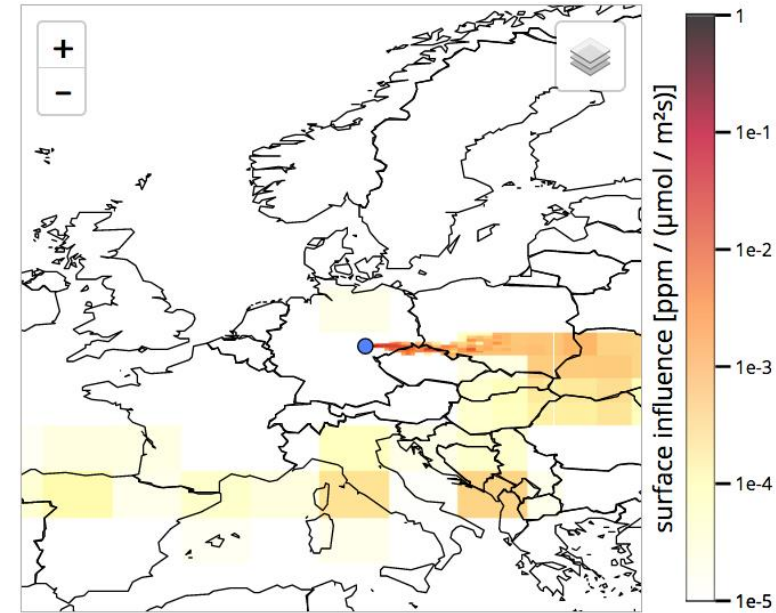
Node	Free CPUs	Total CPUs
akka.tcp://StiltCluster@localhost:2561	40	40

## Finished computations

[View results](#) Site id: *JENA* (lat: 50.9, lon: 11.6), alt: 100, start: 2016-06-01, stop: 2016-06-06, done: 48 of 48 - submitted by ute.karstens@nateko.lu.se

[To the job starter](#)

# STILT single-site scoped viewer



Pre-selected site: JENA

Start date: 2016-06-01

End date: 2016-06-06

Footprint: 2016-06-03 21:00

Primary Y-axis:  co2.stilt  co2.background

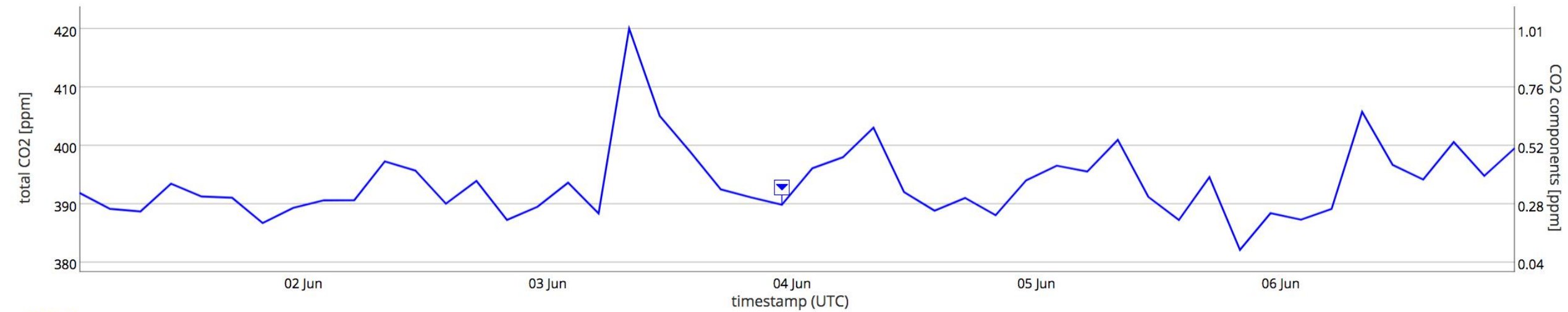
Secondary Y-axis:  co2.bio  co2.bio.gee  co2.bio.resp  co2.fuel  co2.fuel.oil  co2.fuel.coal  co2.fuel.gas  co2.fuel.bio  co2.energy  co2.transport  co2.industry  co2.others

Playback

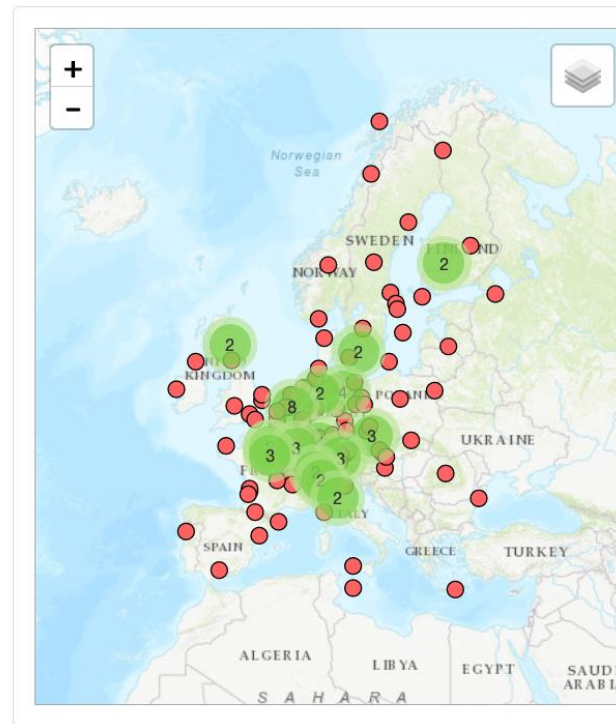
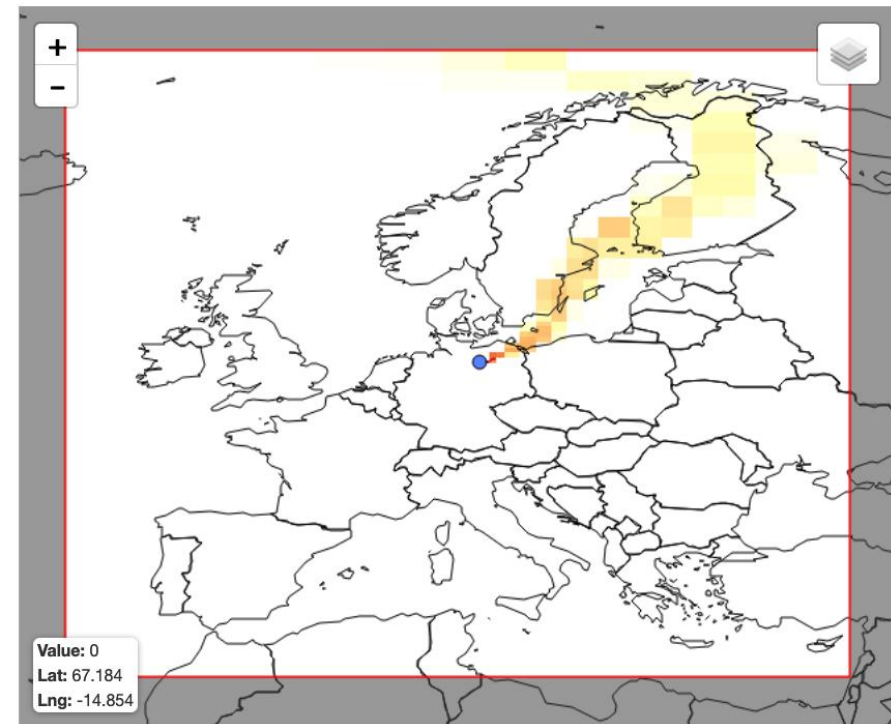


Playback speed

Fast (up to 10 fps)



— co2.stilt



GAT344 (Gartow 344m, 344 m) 2018

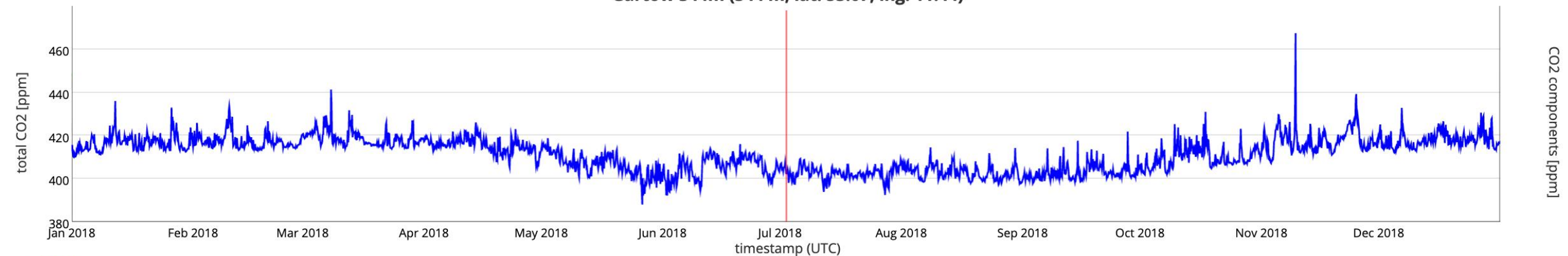
**Footprint:** 2018-07-02 09:00

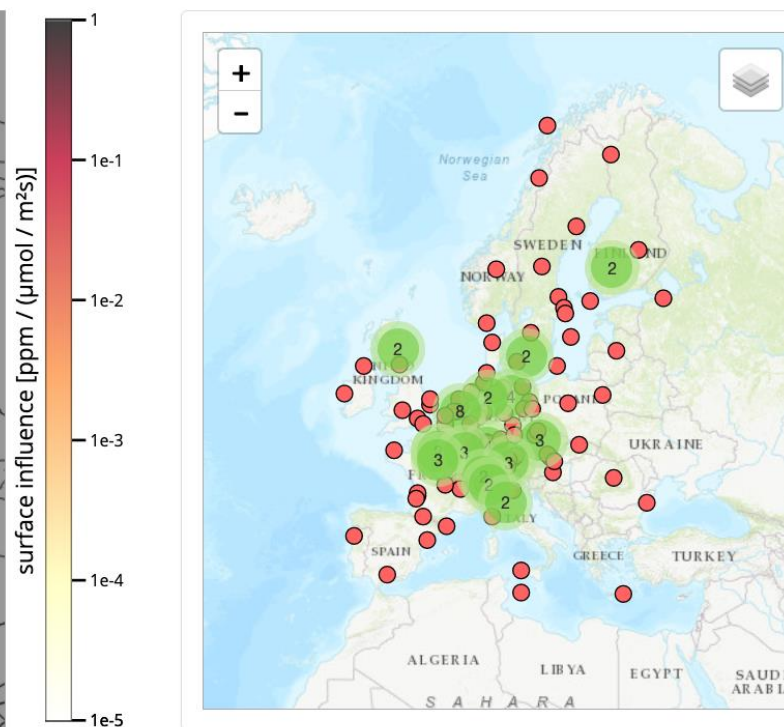
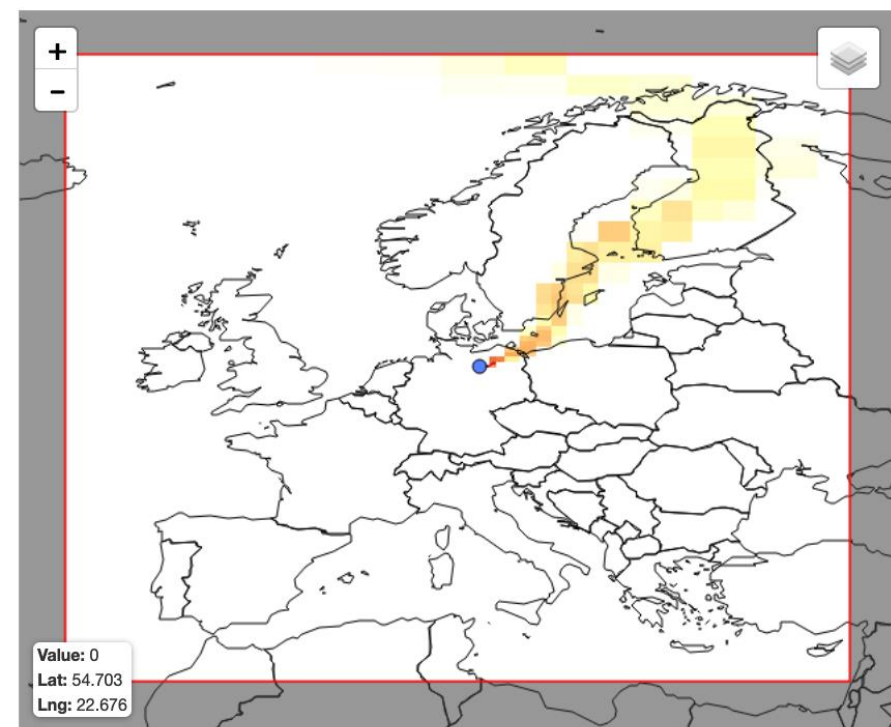
**Primary Y-axis:**  
 co2.observed  co2.stilt  co2.background

**Secondary Y-axis:**  
Biosperic CO2  
 co2.bio  
Biosperic CO2 split into Photosynthetic uptake and respiration  
 co2.bio.gee  co2.bio.resp  
Anthropogenic CO2  
 co2.fuel  
Anthropogenic CO2 split into Fuel types  
 co2.fuel.coal  co2.fuel.oil  co2.fuel.gas  co2.fuel.bio  
Anthropogenic CO2 split into Source categories  
 co2.energy  co2.transport  co2.industry  co2.others

**Playback** [Navigation icons] **Playback speed** Fast (up to 10 fps)

**Gartow 344m (344 m, lat: 53.07, lng: 11.44)**





GAT344 (Gartow 344m, 344 m) 2018

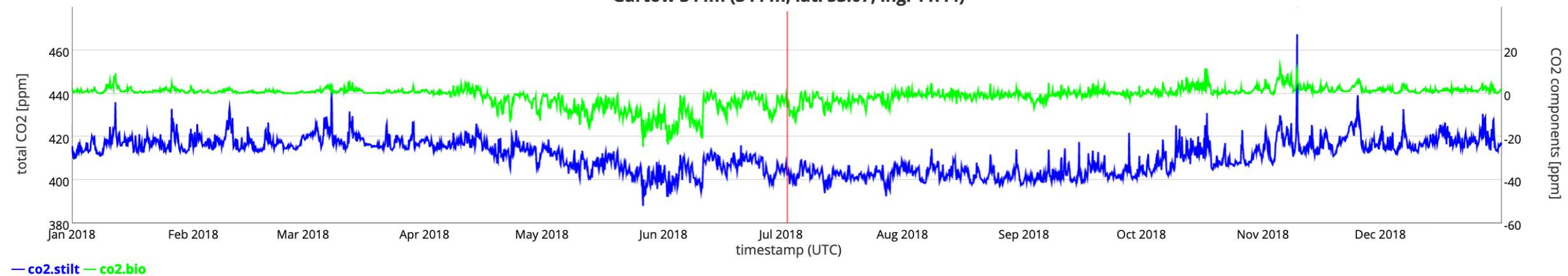
**Footprint:** 2018-07-02 09:00

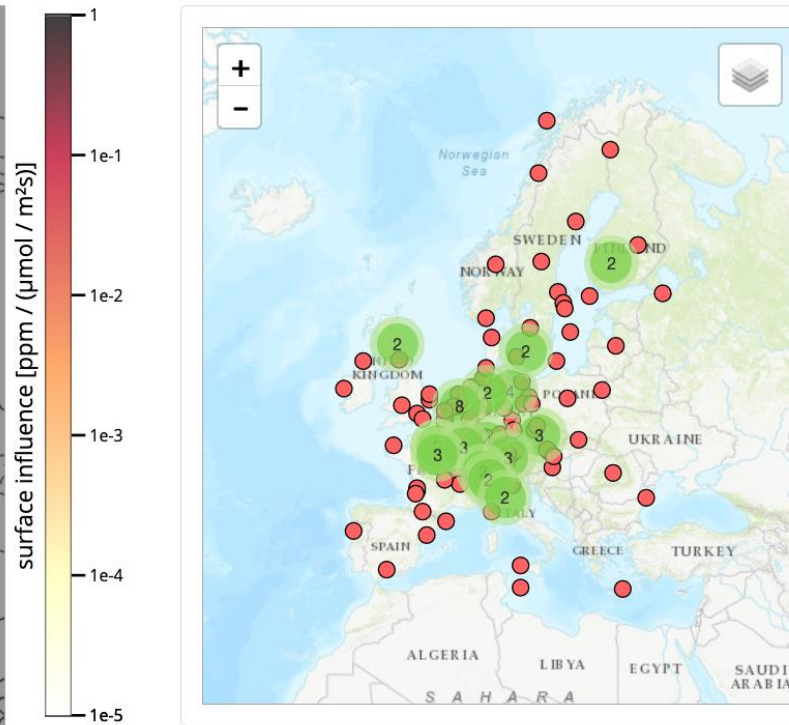
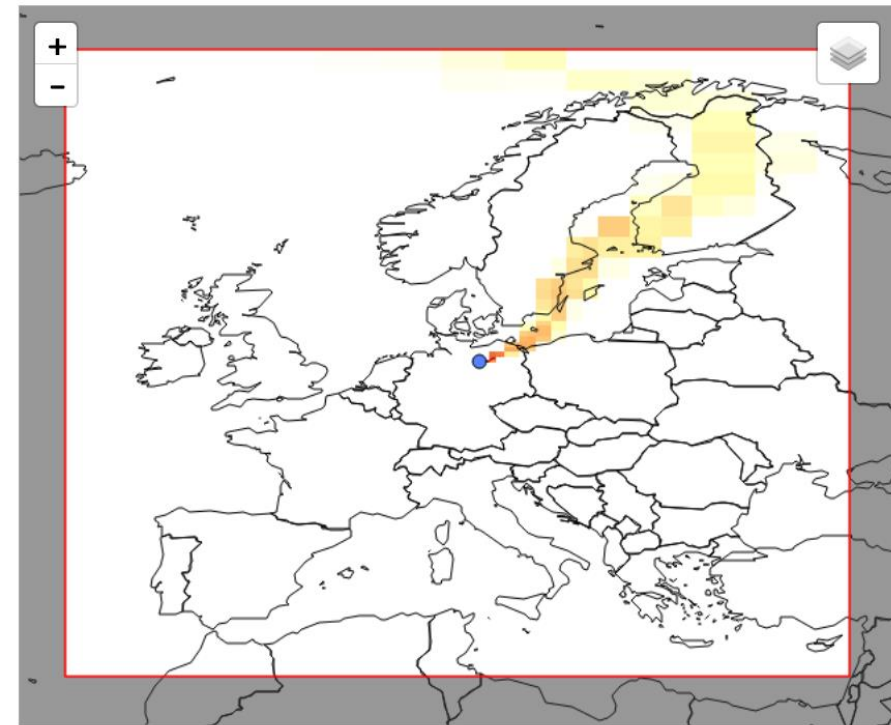
**Primary Y-axis:**  
 co2.observed  co2.stilt  co2.background

**Secondary Y-axis:**  
Biosperic CO2  
 co2.bio  
 Biosperic CO2 split into Photosynthetic uptake and respiration  
 co2.bio.gee  co2.bio.resp  
Anthropogenic CO2  
 co2.fuel  
 Anthropogenic CO2 split into Fuel types  
 co2.fuel.coal  co2.fuel.oil  co2.fuel.gas  co2.fuel.bio  
 Anthropogenic CO2 split into Source categories  
 co2.energy  co2.transport  co2.industry  co2.others

**Playback** [Left Arrow] [Right Arrow] [Fast Arrow] **Playback speed** Fast (up to 10 fps)

Gartow 344m (344 m, lat: 53.07, lng: 11.44)





GAT344 (Gartow 344m, 344 m) 2018

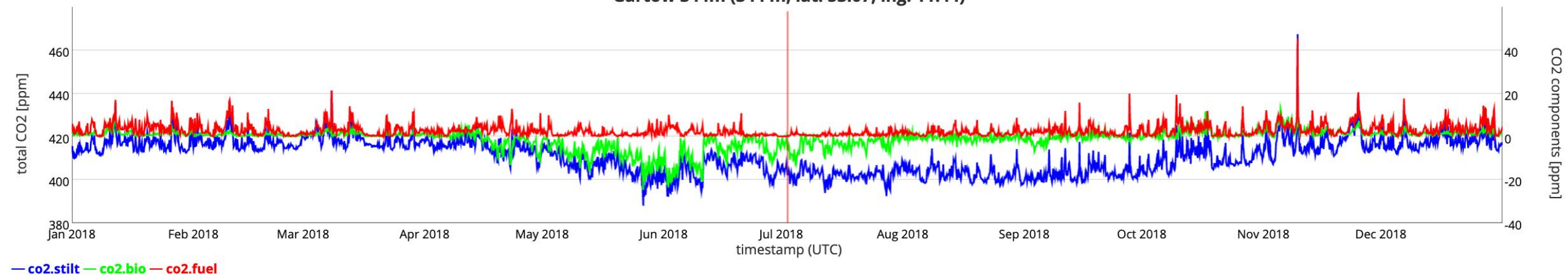
**Footprint:** 2018-07-02 09:00

**Primary Y-axis:**  
 co2.observed  co2.stilt  co2.background

**Secondary Y-axis:**  
Biospheric CO2  
 co2.bio  
Biospheric CO2 split into Photosynthetic uptake and respiration  
 co2.bio.gee  co2.bio.resp  
Anthropogenic CO2  
 co2.fuel  
Anthropogenic CO2 split into Fuel types  
 co2.fuel.coal  co2.fuel.oil  co2.fuel.gas  co2.fuel.bio  
Anthropogenic CO2 split into Source categories  
 co2.energy  co2.transport  co2.industry  co2.others

**Playback** [Navigation buttons] **Playback speed** Fast (up to 10 fps)

Gartow 344m (344 m, lat: 53.07, lng: 11.44)





# STILT Footprint Tool @ ICOS CarbonPortal

All footprints and concentration results from the on-demand calculations are

- instantly available at ICOS CP
- directly accessible in Jupyter notebooks for further analysis, e.g.
  - combination with additional datasets
  - comparison with ICOS observations



# Workshop Schedule

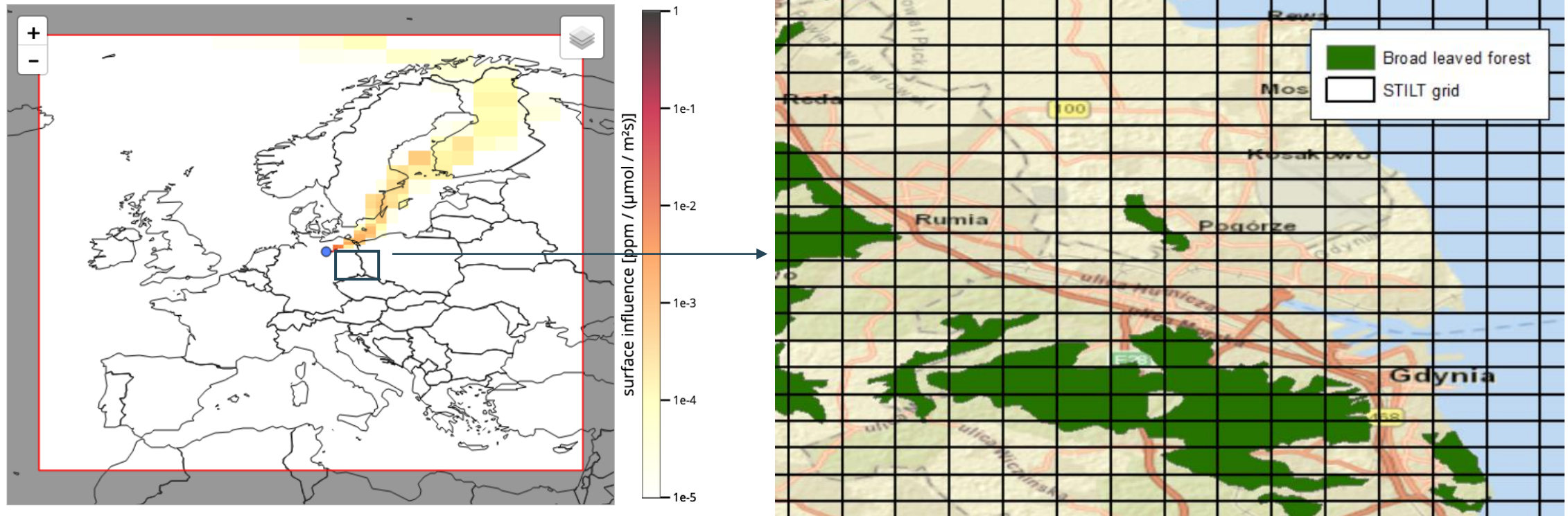
🌀 STILT	Ute	15 min
🌀 On demand calculation		
🌀 Result visualization		
🌀 Station characterization	Ida	5 min
🌀 Create a new “data product” based on STILT results		
🌀 Login to VRE	Karolina	5 min
🌀 Break		5 min
🌀 Hands on – create an interactive map	Claudio	30 min
🌀 Break		10 min
🌀 Hands on – create a timeseries plot	Karolina	45 min
🌀 Conclusion and exercise	Claudio	5 min



# Station Characterization

Characteristics of Gartow's footprint area from combination with additional datasets such as land cover (e.g. broad leaved forests):

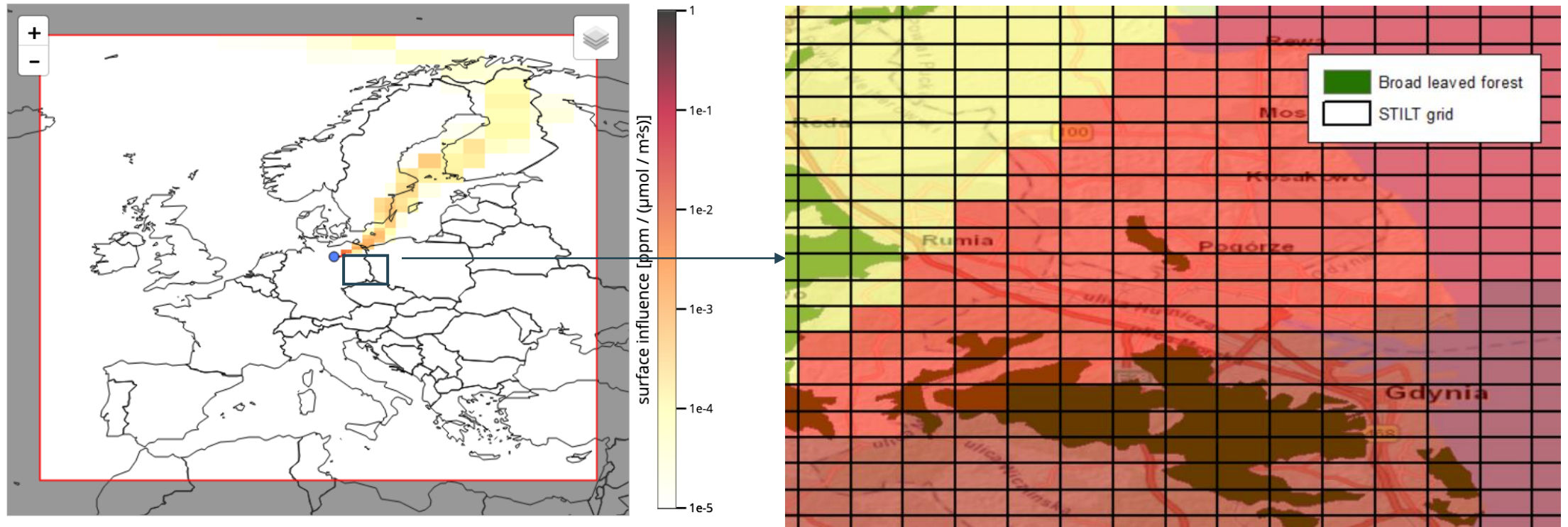
*What is "seen" by the station?*





# Station Characterization

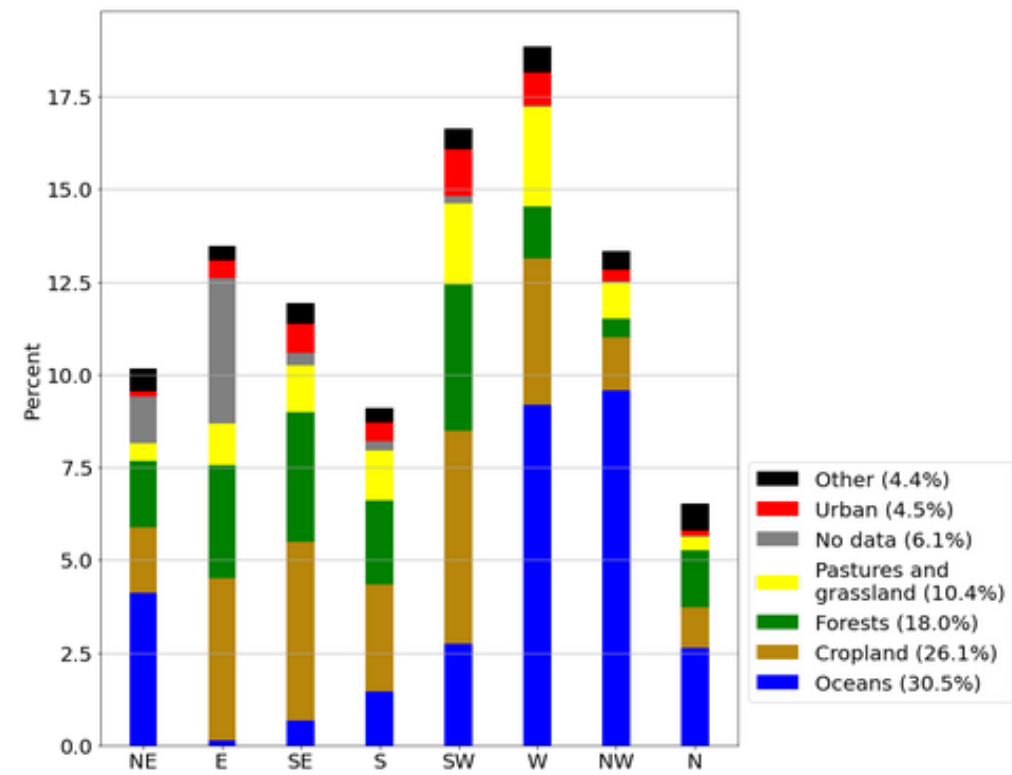
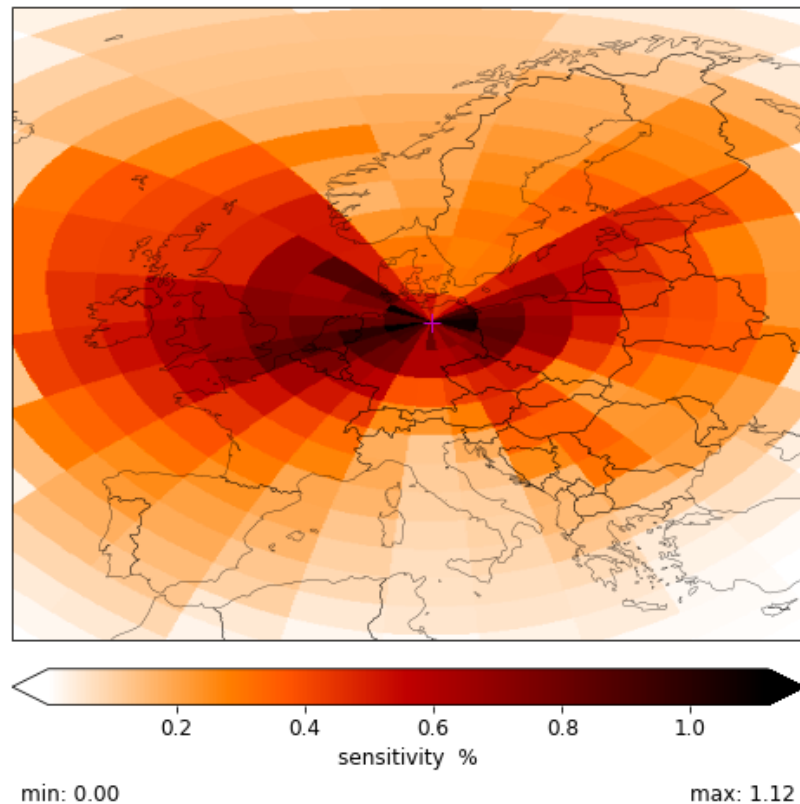
The color of each footprint "cell" indicate how "seen" it is by the station. Its value is multiplied by underlying data (e.g. area of broad leaved forest within the cell).





# Station Characterization

Average footprint calculated from all 2018 footprints (every three hours)  
Average footprint multiplied by all underlying different types of land cover.





# Station Characterization Tool

It is possible to combine other data layers with the footprints. Visit [exploredata.icos-cp.eu](https://exploredata.icos-cp.eu) to see more examples of this and to characterize different stations!

- Footprints directly accessed in a user-friendly notebook
- Output in accordance with user-specified parameters
- Option to generate a PDF with the results

How to get there:

- [https://exploredata.icos-cp.eu/user/jupyter/notebooks/icos\\_jupyter\\_notebooks/station\\_characterization/station\\_characterization\\_one\\_cell.ipynb](https://exploredata.icos-cp.eu/user/jupyter/notebooks/icos_jupyter_notebooks/station_characterization/station_characterization_one_cell.ipynb)

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# Login to VRE

Enter the following  
URL in your browser:

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

Sign in to  
Exploredata

Username:

Password:

← Enter your own email address

← Enter password: **msa**



# Access working folder

The image displays two screenshots of the JupyterHub interface, illustrating how to access a working folder.

**Left Screenshot:** Shows the JupyterHub home page at <https://exploredata.icos-cp.eu/>. The "Files" tab is active, showing a directory listing. The folder `project_jupyter_notebooks` is highlighted with a yellow box.

**Right Screenshot:** Shows the JupyterHub interface for the `project_jupyter_notebooks` directory. The "Files" tab is active, showing a directory listing. The folder `envrifair_winterschool` is highlighted with a yellow box. A dashed orange arrow points from the highlighted folder in the left screenshot to the highlighted folder in the right screenshot.

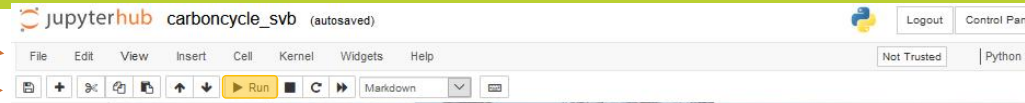
The right screenshot also displays a table of files and folders within the `project_jupyter_notebooks` directory:

	Name	Last Modified	File size
<input type="checkbox"/>	..	seconds ago	
<input type="checkbox"/>	envrifair_winterschool	3 minutes ago	
<input type="checkbox"/>	OTC Data Reduction Workshop	12 days ago	
<input type="checkbox"/>	RINGO_T1.3	2 months ago	
<input type="checkbox"/>	README.md	2 months ago	833 B



# Jupyter Notebook

Menu Bar  
Tool Bar



Markdown Cell



Figure 3: Photos from ICOS Svartberget research station [\[credits\]](#)

Svartberget research station is part of the ICOS Sweden station network. The station is located about 60 km northwest of the city of Umeå, in northern Sweden, and is surrounded by a 100 years old mixed forest with 60% Scots pine *Pinus sylvestris* and 40% Norway spruce *Picea abies*. The tree height close to the tower is about 20 m.

Measurements of carbon dioxide can be influenced by what is near the broader vasinity of a station. To minimize this effect, measuring instruments are placed high up on towers (see photo in the middle). Measurements can also be influenced by the wind speed and wind direction. For instance, if the wind blows in direction from a city with high industrial activity, then the measured CO<sub>2</sub>-concentration might be higher.

Zoom in in the map below to view what is near Svartberget research station. Can you find the city of Umeå? What else is close to the station besides forest?

Code Cell

```
In [3]: #Importera csv-fil med CO2-data till tabell:
co2_df = pd.read_csv('data/carboncycle/co2_concentration/svb_co2.csv',
                    header=0,
                    sep=',',
                    parse_dates=['DateTime'])

#Sätt kolumnen "DateTime" som index i tabellen:
co2_df_ind = co2_df.set_index('DateTime')
co2_df_ind.head()
```

Output

```
Out[3]:
```

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

Documentation

- ✓ Text  
(regular text, HTML, LaTeX, etc.)
- ✓ Images  
(png, jpeg, etc.)
- ✓ Links  
(internal & external)

Python Code

Dataframes, lists, arrays,  
strings, plots, maps, videos...



# Please fill out the form

Could we please ask you to fill in your details. If you don't feel comfortable giving us this information, you can create a 'fake' one (with sensible values)

Open this link, and add your information

<https://fileshare.icos-cp.eu/apps/onlyoffice/s/ByCDKPH8LC5Jqz4>

If you don't know your location, checkout this site: <https://mylocation.org/>

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back in 5



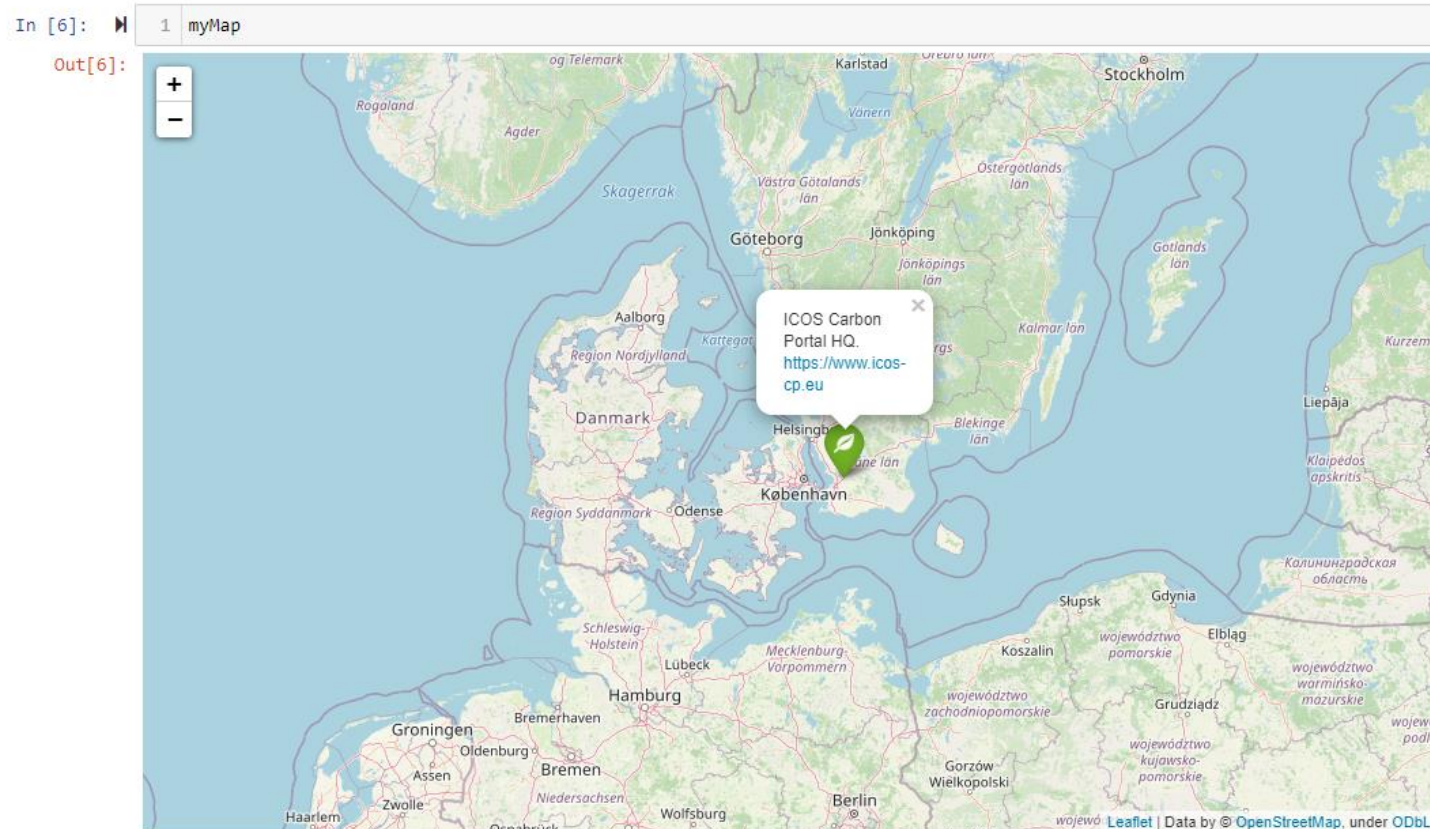
# Workshop Schedule

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# Interactive Map

Show map



# Workshop Schedule

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back in 10



# Workshop Schedule

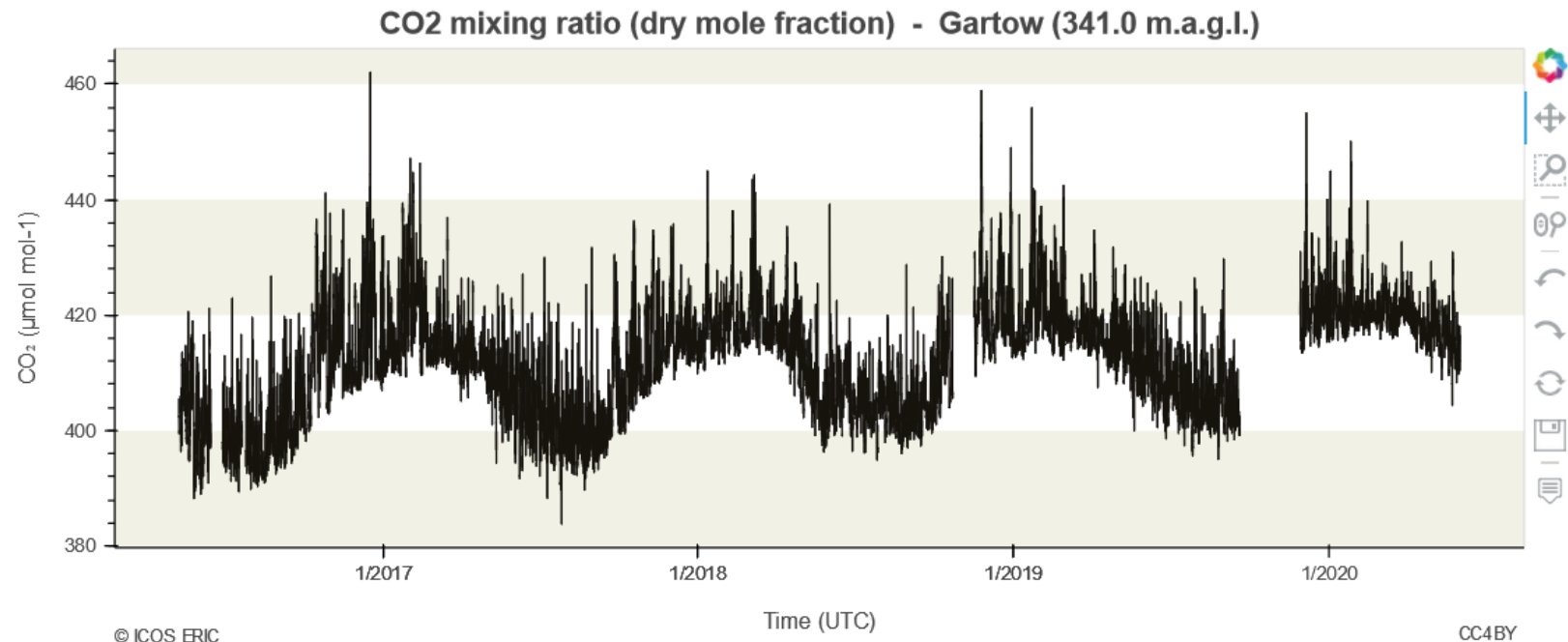
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# Timeseries Plot

## 4.5. Interactive plot - using ICOS tools

```
In [16]: 1 #Call function to get plot object:  
2 p = plot_icos_single_station_binary(dobj, 'co2', 'line', color='#0F0C08') #line/point  
3  
4 #Show interactive plot:  
5 show(p)
```



# Workshop Schedule

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🌀 Hands on – create an interactive map	Claudio	30 min
🌀 Break		10 min
🌀 Hands on – create a timeseries plot	Karolina	45 min
🌀 Conclusion and exercise	Claudio	5 min



# Exercise



Create a new notebook to include your solutions to the following tasks:

- I. Write code to produce an interactive map with a marker for a station of your choice. Add functionality so that a pop-up message displaying station metadata appears, when the marker is clicked.  
(select a station from the station list included in the “1. Explore ICOS atmosphere stations” part of the *time series* notebook).
- II. Repeat all steps in the *time series* notebook for the station you selected in *task I*. Note that you are meant to pick a different station than the one used in the notebook example!



# Submit exercise

- Remember to enter your **name** and **affiliation** in the bottom part of the notebook.
- Export your notebook as a **ipynb**, **pdf** or **html** file and change the filename to include your name.  
(e.g. *filename\_kim\_andersson.ipynb*)
- Please send your answers to: [jupyter-info@icos-cp.eu](mailto:jupyter-info@icos-cp.eu)
- Observe that exploredata **deletes** your instance after **15 min of inactivity**, so make sure to download your notebook if you do not plan to complete the exercise in one go.



# Conclusion

ICOS has opted for Jupyter Hub and Python Notebooks because ...:

- userfriendly
- easy to learn
- easy to share
- enable and empower users to interact and explore data
- write interactive documentation
- create transparency

We think that all of the above are essential building blocks for the users to pave the way for FAIR content



# Conclusion

ICOS has opted for Jupyter Hub and Python Notebooks because ...:

- easy to deploy
- out of the box
- customize and adjust
- low maintenance



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