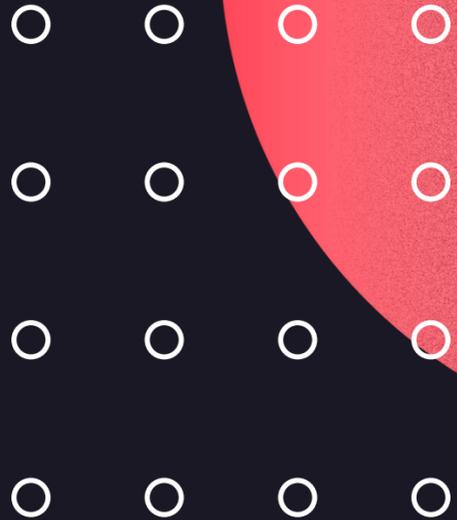


# Crossing pedagogical boundaries with open data

Santeri Koivula, Peitsa Veteli  
and Veera Juntunen  
Helsinki Institute of Physics HIP

# The agenda

- What is this about?
- Exercise: What is the Jupyter Notebook?
- Going through an advanced example
- Website
- Feedback



Open data is everywhere — CERN, NASA, The World Bank, etc.

Our mission is to help teachers to create research-based exercises for their courses using open data. Multidisciplinarity; curiosity; and skills for data analysis are at the heart of what we do.

We have created study materials, organized workshops for teachers, and helped teachers to use open data in their classes.



# WHAT IS THIS ABOUT?

**WHY?**

# WHY?

Future citizenship -  
understanding, analyzing  
information and  
assessing its credibility

The amount of data is  
rising

Communication skills

Getting acquainted with  
the tools of science

Understanding large  
phenomena and  
different contexts

Multidisciplinary  
learning

Ability to understand  
and question

# THE PERSPECTIVE OF A STUDENT

In its simplest form, the student is provided with a link of an exercise that uses open data. An exercise can be saved either as a notebook or a PDF file.

The exercises can also work as a tool for a student to reflect on their learning, in which case other programs or platforms are not even needed.

Easy!

VISUALIZING DATA

INFORMATIVE  
COMMUNICATION

UNDERSTANDING DATA

ASSESSING  
CREDIBILITY

PROGRAMMING

SEARCHING FOR  
DATA

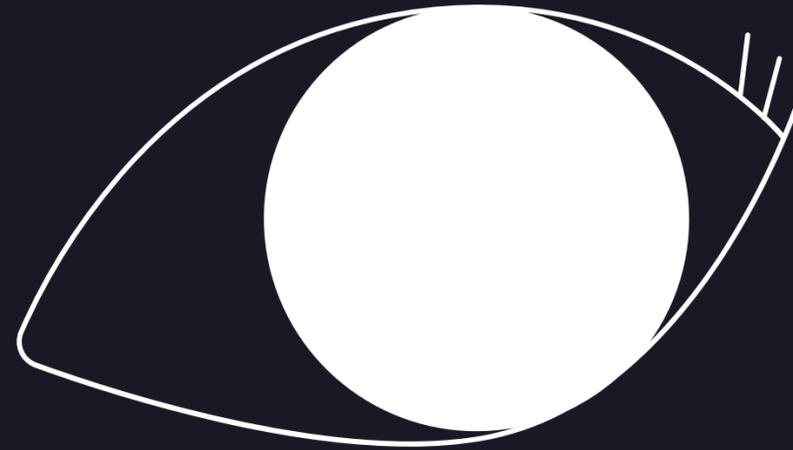
FINDING  
REPEATING  
PATTERNS



What kind of materials?

Do you want to make materials  
by yourself?

How much coding?



What is the group size?

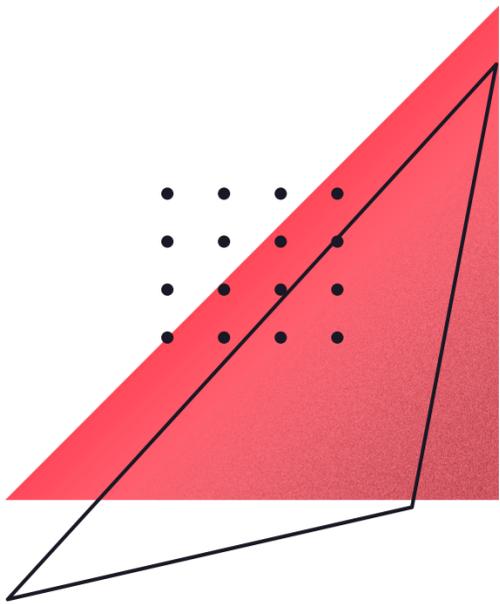
How much can students influence  
on the exercises?

Returning the exercises?

# HOW MUCH WORK FOR TEACHERS?

BEGINNER – INTERMEDIATE – EXPERT

# WHAT OUR EXERCISES LOOK LIKE



☰
🔍 🔄 📄 📥

## Plotting the invariant mass histogram

In this exercise, we learn how to plot the histogram of invariant masses with Python. Let us use the data collected by the CMS detector in 2011 [1]. Events with specific criteria [2] have been selected in the CSV file `Ymumu_Run2011A.csv`, which we are using.

Explore the different code cells below and run the code. Note that normally the code would not be commented as much as this. Here, the reason for these comments is to explain in detail what the code is doing.

[1] CMS collaboration (2016). DoubleMu primary dataset in AOD format from RunA of 2011 (/DoubleMu/Run2011A-12Oct2013-v1/AOD). CERN Open Data Portal. DOI: [10.7483/OPENDATA.CMS.RZ34.QR6N](https://doi.org/10.7483/OPENDATA.CMS.RZ34.QR6N).

[2] Thomas McCauley (2016). Ymumu. Jupyter Notebook file. <https://github.com/tpmccauley/cmsopendata-jupyter/blob/hst-0.1/Ymumu.ipynb>.

### 1) Start

```
# Import the needed modules. Pandas is for the data-analysis
# and matplotlib.pyplot for making plots. Modules are named as pd and plt.
import pandas as pd
import matplotlib.pyplot as plt

# Jupyter Notebook uses "magic functions". With this function it is possible to plot
# the histogram straight to notebook.
%matplotlib inline
```

### 2) Getting the data

```
# Create a new DataFrame structure from the file "Ymumu_Run2011A.csv"
dataset = pd.read_csv('../Data/Ymumu_Run2011A.csv')

# Create a Series structure (basically a list) and name it "invariant_mass".
# Save the column "M" from the "dataset" to the variable "invariant_mass".
invariant_mass = dataset['M']
```

## 3) Plotting the histogram

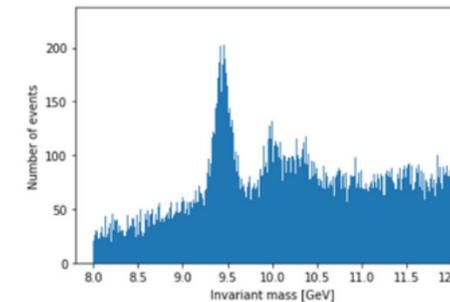
Now we can create and plot the histogram of the values of the invariant masses. The histogram shows for how many events the invariant mass of the muon pair is in a certain value range. Note that we will use total 500 bins in the histogram, so you will not spot the separate bins because there are so many of them.

```
# Plot the histogram with the function hist() of the matplotlib.pyplot module:
# (http://matplotlib.org/api/pyplot_api.html?highlight=matplotlib.pyplot.hist#matplotlib.pyplot.hist)
# 'bins' determines the number of bins used.
plt.hist(invariant_mass, bins=500)

# Name the axes and give a title.
plt.xlabel('Invariant mass [GeV]')
plt.ylabel('Number of events')
plt.title('The histogram of the invariant masses of two muons \n') # \n creates a new line for

# Show the plot.
plt.show()
```

The histogram of the invariant masses of two muons



## 4) Analysis

- What does the histogram tell us?
- What happens around the mass 9.5 GeV?

← Previous  
Calculating the invariant mass

Next  
Advanced →

By HIP Education and Open Data Team

Development of this material is made possible by a grant from Finnish National Agency of Education

The material on this website is licenced under CC-BY 4.0. licence.

# DIFFERENT SUBJECTS

Open data can be used in many different subjects.

In Finnish we have materials on physics, biology, text analysis, geography, and mathematics.

Similar exercises could be used in other fields as well, such as history, economics, and psychology.

## Pumput - saastumislähteet ja terveystiete

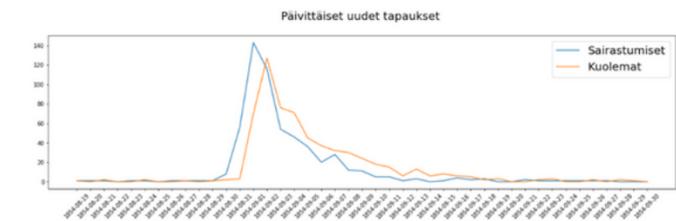
Tässä osiossa käytetään autenttisia tietoja tapahtumista elokuussa 1854.

John Snow kuoli asiasta 4.9. ja käytti seuraavat kolme päivää juosten ympärillä keräämässä aineistoa, piirtäen karttoja ja vakuuttaen paikallishallintoa tarpeellisista vastatoimista. Jokainen tuhlatu hetki tarkoitti lisää tartuntoja ja kuolleita.

```
# AJA NÄMÄ PAKETIT ENSIN, JOLLE AJANUT EDELLISTÄ OSIOTA
import pandas as pd
import matplotlib.pyplot as plt
import random as rnd
import numpy as np

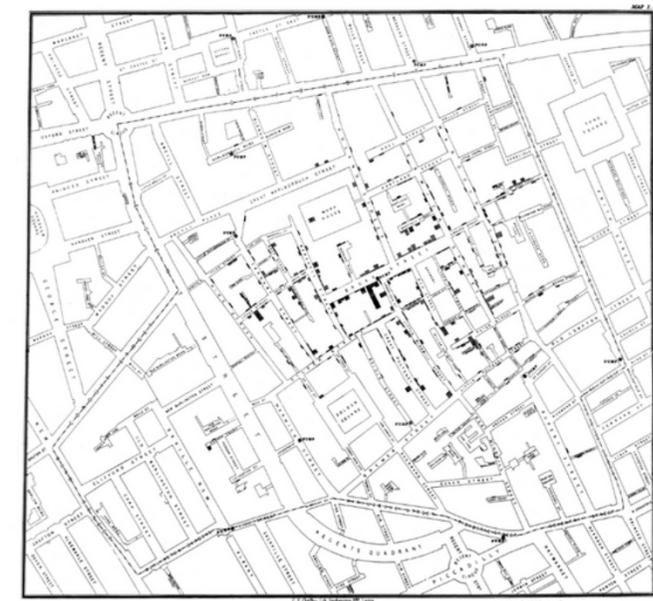
# Historiallinen data, joka on kerätty Robin Wilsonin julkaisemista paketeista
# täältä http://blog.rtwilson.com/john-snows-cholera-data-in-more-formats/
ajat = pd.read_csv("../data/johnsnow_dataset_dates_all.csv")
kuolinluvut = pd.read_csv("../data/johnsnow_dataset_deaths.csv")
pumput = pd.read_csv("../data/johnsnow_dataset_pumps_names.csv")

# Tästä nähdään tapahtumien aikakehitys.
plt.figure(figsize=(20,5))
plt.plot(ajat["date"], ajat["attacks"], label = 'Sairastumiset')
plt.plot(ajat["date"], ajat["deaths"], label = 'Kuolemat')
plt.xticks(rotation=45)
plt.legend(fontsize=20)
plt.title('Päivittäiset uudet tapaukset \n', fontsize = 20)
plt.show()
```



Yllä olevasta kuvaajasta nähdään naapuruston sairastapausten räjähtävän käsiin kuun taitteessa. Myöhemmissä arvioissa Snow on uskonut taudin olleen jo luonnostaan laskussa toimiensa aikaan (esimerkiksi ihmisten karattua paikalta), mutta jotain ratkaisevaa tapahtuu 8.9., mikä katkaisee isomman leviämisen lähes samantien.

Snow kiersi paikanpäällä aikansa, mutta yhden ihmisen tiedonkeruuoperaatio kuolevien ihmisten, paetessa hylättyjen talojen ja yleisen kaoksen keskellä olisi tullut liian hitaaksi. Sen sijaan tohtorimme kääntyi tehokkaampaan suuntaan ja marssi paikallisen tilastokeskuksen, Office of Register Generalin, puheille ja vaati käyttöönsä kaikkien kuolemantapausten ajat ja osoitteet. Alla on alueen kartta, mihin hän merkkasi kuolleet mustina vaakaviivoina kuin vierekkäiset hauta-arkut piholle.



### Tehtävä 2:

Katsomalla yllä olevaa karttaa, mitä voit sanoa kuolintapausten asettumisesta kartalle?

```

# Valmistellaan kuva, tehdään kuvasta suuri ja asetetaan taustaväriksi sininen
fig, ax = plt.subplots(1, figsize=(50,20), facecolor='lightblue')

# Piirretään taustaksi kaikki maat ja täytetään ne viivoilla.
# Tällöin ne maat, joista ei ole dataa, erottuvat helpommin.
world.plot(ax=ax, color='darkgrey', alpha=0.8, hatch= "////")

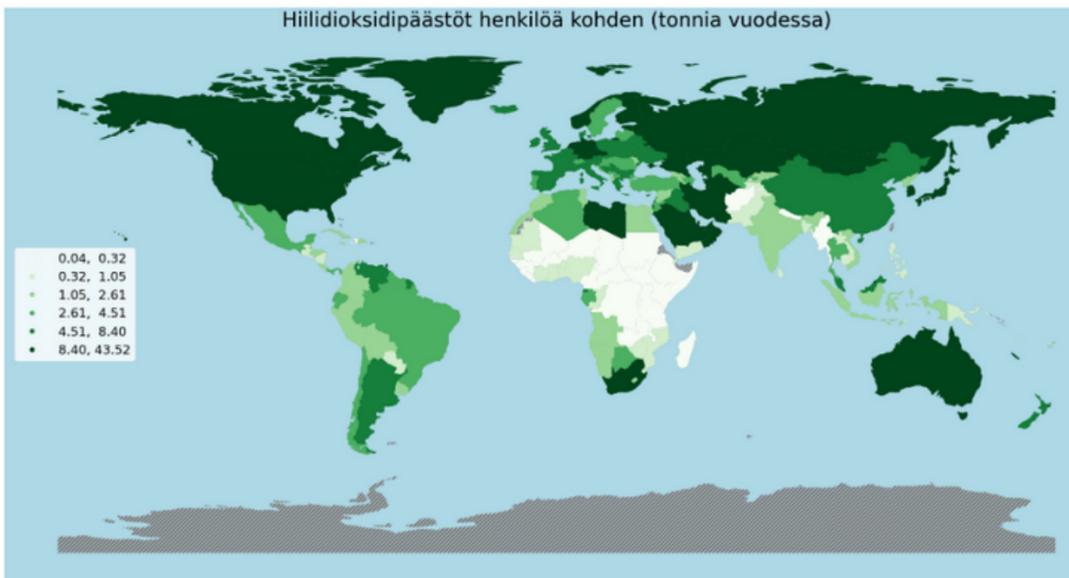
# Piirretään data taustan päälle
data.plot(
    column='2014 [YR2014]', # Määritetään piirrettävä sarake
    ax=ax, # Piirretään kuva samalle akselille kuin tausta
    cmap='Greens', # Käytetään vihreää värikarttaa
    legend=True, # Lisätään selite
    legend_kwds={ #
        'fontsize': 25, # Asetetaan selitteen fonttikoko
        'loc':'center left' # Asetetaan selitteen sijainti
    }, #
    scheme='quantiles', # Jaetaan datan värit samankokoisiin osiin
    k=6 # Valitaan osien lukumääräksi 6
)

# Lisätään kuvalle otsikko
plt.title('Hiilidioksidipäästöt henkilöä kohden (tonnia vuodessa)', fontsize = 40)

# Poistetaan akselit kuvan reunoilta
ax.axis('off')

# Näytetään kuva
plt.show()

```



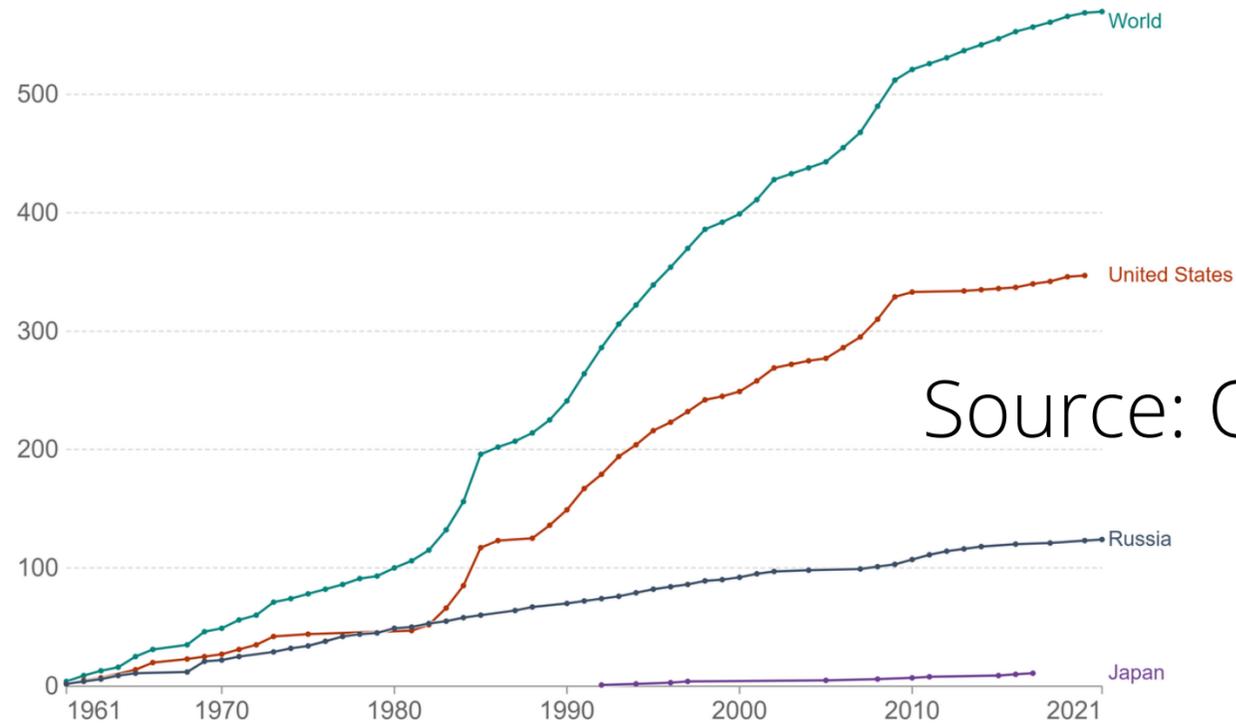
Nyt kartasta erottaa jo huomattavasti paremmin eri alueet ja niitä vastaavat hiilidioksidipäästöt. Voit kokeilla piirtää datan myös jakamalla datan useampaan tai vähempään kuin kuuteen osaan. Miltä data tällöin näyttää? Muokkaa kuvaa haluamallasi tavalla.

Etsi itse jokin toinen valtiokohtainen data ja piirrä se samaan tapaan. Valtiokohtaista dataa löytää googlaamalla tai esimerkiksi osoitteesta <https://databank.worldbank.org/source/world-development-indicators#>. Maailmanpankin sivuilta pystyy myös tarkastelemaan dataa kartalla, mutta kokeile piirtää se itse!

## Cumulative number of people who have been to space, 1961 to 2021

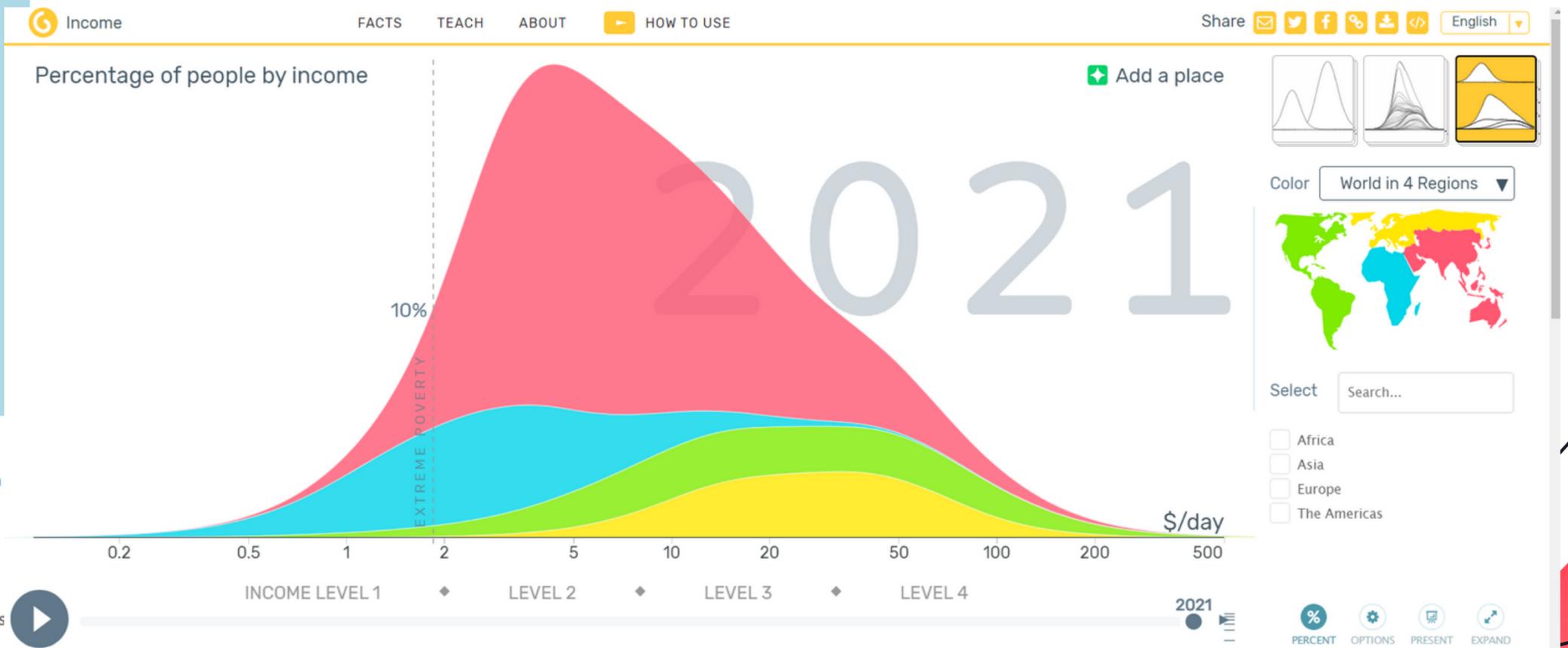


For individuals who have been to space multiple times, only the date of their first visit is shown.



Source: Our World In Data

Source: CSIS Aerospace Security Project (2022) OurWorldInData.org/space-exploration-satellites • CC BY



Source: Gapminder

# PROJECTS

2021

HEALTH EDUCATION

Autumn 2021

PROGRAMMING

Autumn 2021

BIOLOGY

Autumn 2021

Spring 2022

SCIENCE COURSE

Spring 2022

Autumn 2022

SCIENCE COURSE

Autumn 2022

CLIMATE THEME DAY

Autumn 2022

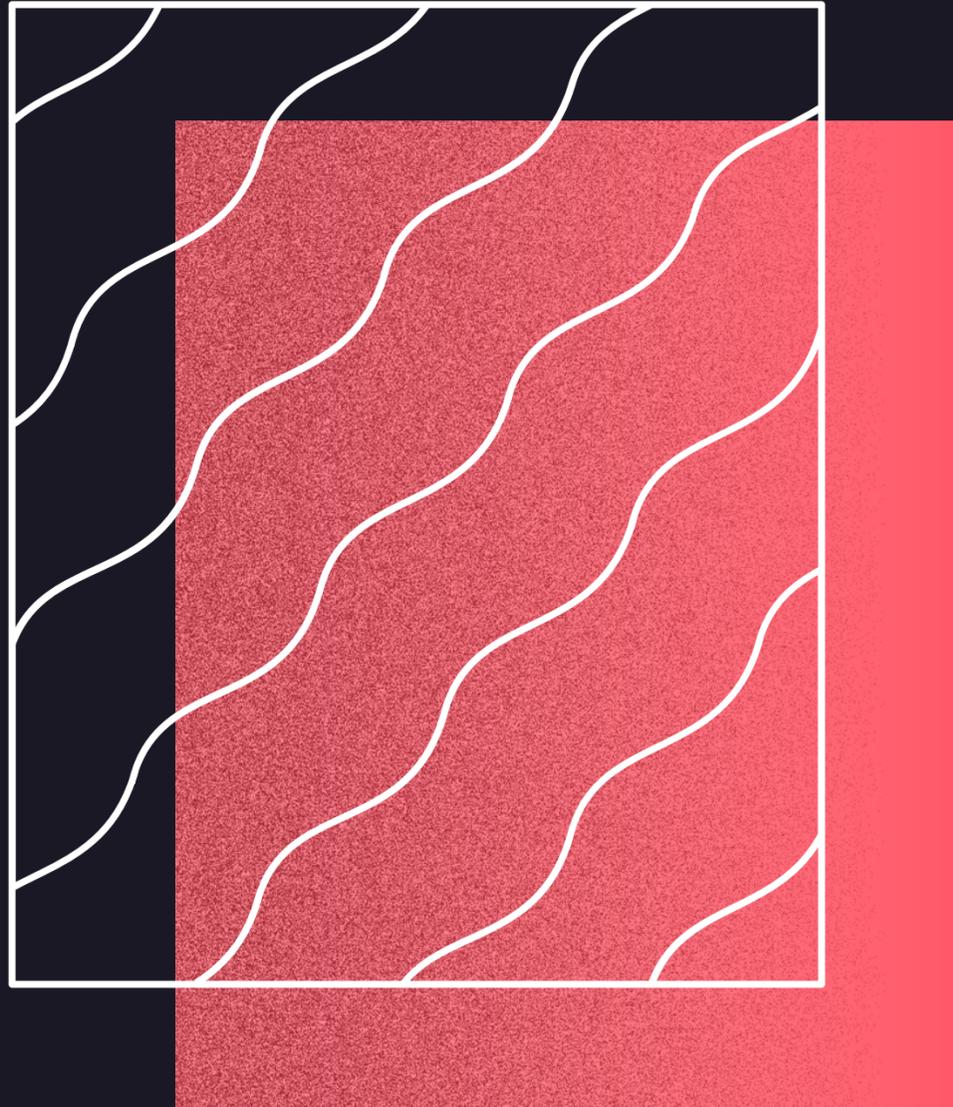
Teacher training

Workshops

Classes

Theme days

individual work – groupwork – laboratory work – essays – analyses – research work



Versatility - text, code,  
images, videos, animations

Students can return one  
document only

... What about Excel?

## WHY LEARN A NEW PLATFORM?

Everything from instructions  
to exercises are in the  
same place

Teacher can easily run the  
commands again while  
going over the results



# NEXT

1. Jupyter Notebook -exercise
2. Going through an advanced example
3. Our website

# CONTACT US

Peitsa Veteli

[peitsa.veteli@helsinki.fi](mailto:peitsa.veteli@helsinki.fi)

Veera Juntunen

[veera.juntunen@helsinki.fi](mailto:veera.juntunen@helsinki.fi)

Santeri Koivula

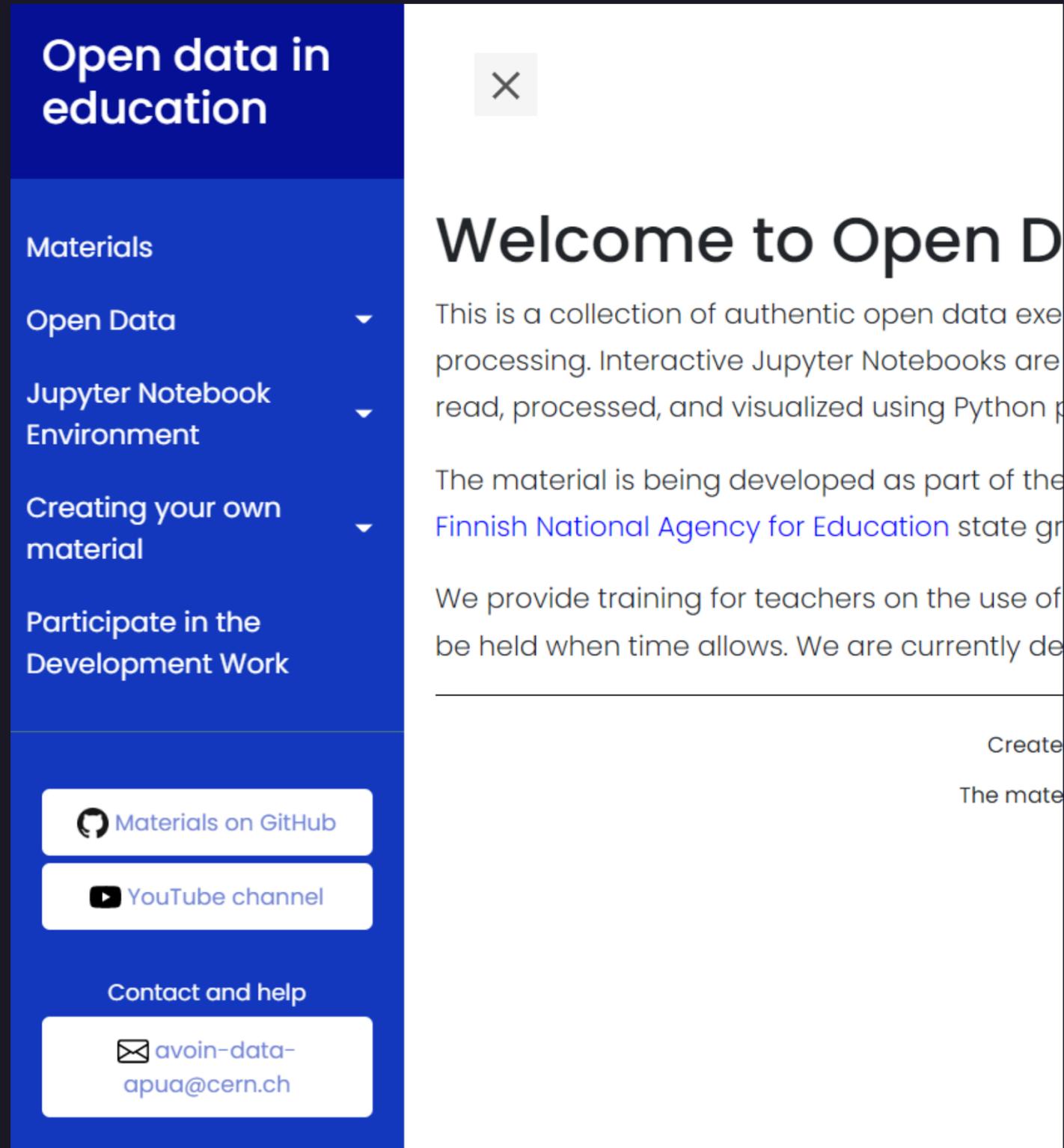
[santeri.jan.viliam.koivula@cern.ch](mailto:santeri.jan.viliam.koivula@cern.ch)

# WEBSITE

## and materials

<https://opendata-education.github.io/en/>

You can find everything you need to get started from our website, such as materials that are ready to use or to modify, and links to websites that publish open data. Currently we have materials in English on particle physics and text analysis.



**Open data in education**

- Materials
- Open Data
- Jupyter Notebook Environment
- Creating your own material
- Participate in the Development Work

Materials on GitHub

YouTube channel

Contact and help

✉ avoin-data-apua@cern.ch

×

## Welcome to Open D

This is a collection of authentic open data ex... processing. Interactive Jupyter Notebooks are... read, processed, and visualized using Python p...

The material is being developed as part of the... [Finnish National Agency for Education](#) state gr...

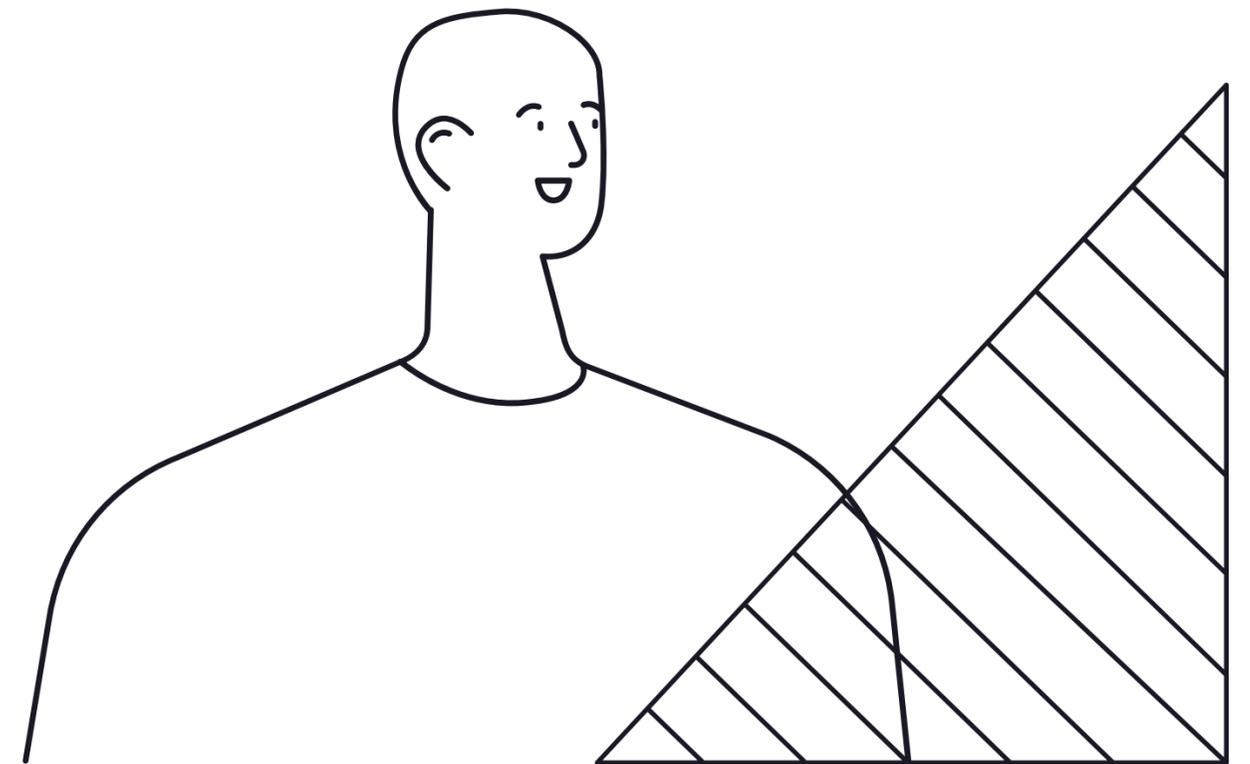
We provide training for teachers on the use of... be held when time allows. We are currently de...

Create...  
The mate...

WEBSITE

ANACONDA

# LINKS AND MATERIALS



# DATA RESOURCES

- [CERN Open Data Portal](#)
- [Our World In Data](#)
- [Figshare](#)
- [Zenodo](#)
- [World Bank](#)
- [WHO: Global Health Observatory](#)

