VOIS library:

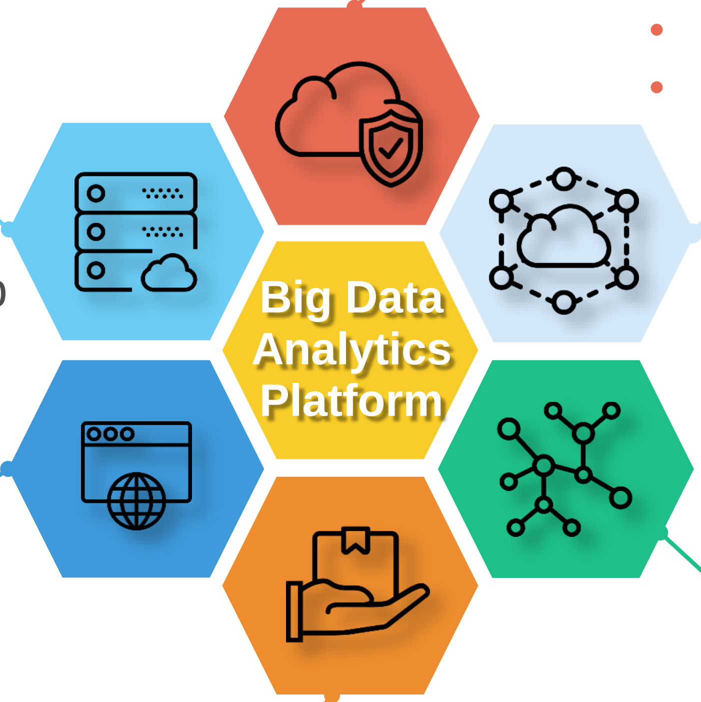
Pushing data science dashboards to the limits

Davide De Marchi – European Commission - Joint Research Centre

CS3 Conference - Barcelona, 6th March 2023

European Commission

JRC Big Data Analytics Platform



Security

- Encrypted protocol (https)
- Multi-factor authentication

Hardware

- Petabyte scale data hub
- Co-located with computing cluster

Web-based access

- JupyterLab
- Remote data science desktop
- Distributed computing
- Development environments

Interactivity

- Novel interactive data analysis
- Exploratory visualisation tools

Machine Learning

- Specialized hardware
- Artificial Intelligence and Deep Learning modelling

Dissemination

- Web-based data dissemination
- Visualisation services
- Secure file transfer (ftps)

VOIS library

- **VOI**là **S**implification library
- Its goal is to make life easier for the creation of impactful Voilà dashboards
- Partially developed in the context of the CS3MESH4EOSC Horizon2020 project lead by CERN
- Currently in IP clearance and security checks phase for the publication as open source on the https://code.europa.eu following European Commission Decision of 8 December 2021 on the open source licensing and reuse of Commission software 2021/C 495 I/01.

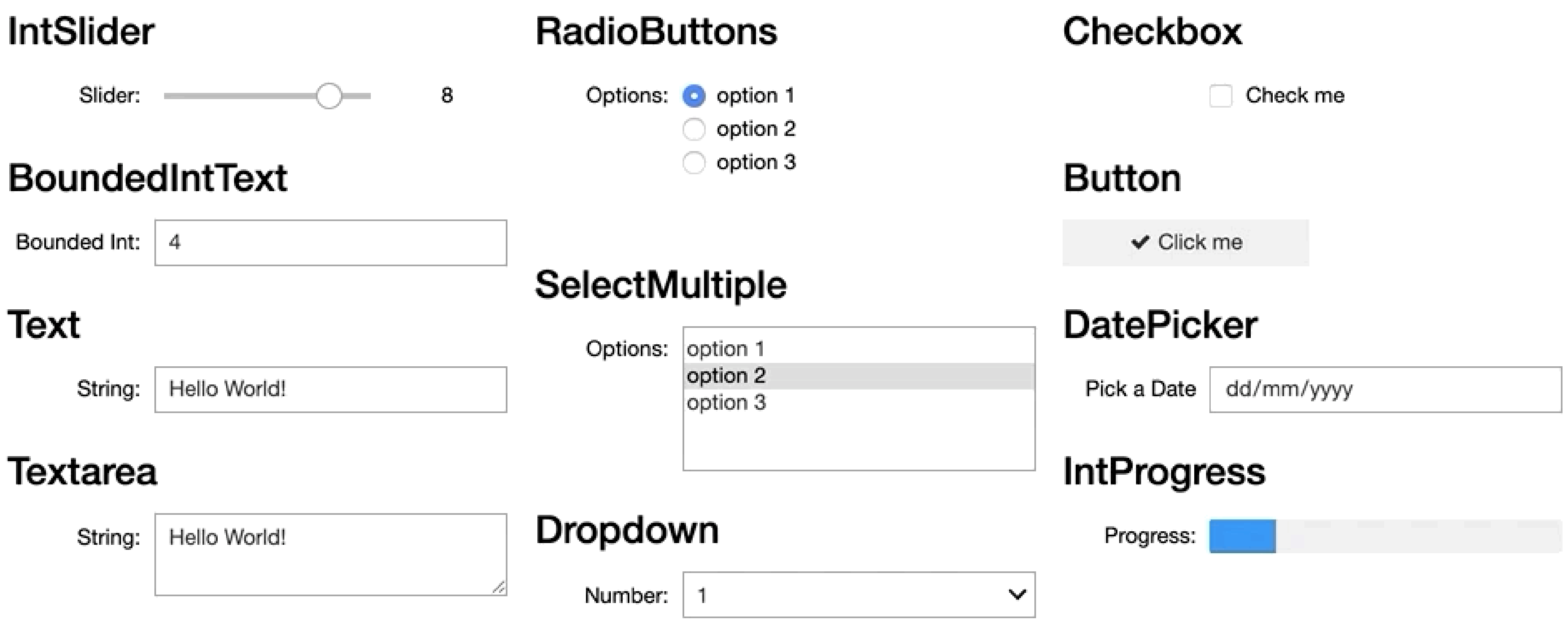
Voilà

- A Jupyter notebook extension to automatically create standalone applications and dashboards.
- Notebooks are rendered by showing only the output of the cells, while the code is hidden.
- Suitable for non-technical experts for communicating insights and foresight to a wider audience.
- Single environment for full data analytics workflows from research and innovation to outreach engaging policy makers and citizens.

Widgets

- Widgets are the part of a GUI that allows the user to interface with the application.
- Widgets can make Jupyter notebooks look lively and interactive, by using elements like buttons, drop-down lists, sliders, etc.
- They allow users to interact with the notebook, manipulate output according to the selection of widget and controlling events. Can be used to record user's input and implemented easily in a Jupyter notebook.
- ipywidgets is the standard open-source python library used to create many types of widgets. It is easy to use and the first choice for dashboards creation.

ipywidgets



IntSlider

Slider: 8

BoundedIntText

Bounded Int: 4

Text

String: Hello World!

Textarea

String: Hello World!

RadioButtons

Options: ● option 1
○ option 2
○ option 3

SelectMultiple

Options: option 1
option 2
option 3

Dropdown

Number: 1

Checkbox

□ Check me

Button

✓ Click me

DatePicker

Pick a Date dd/mm/yyyy

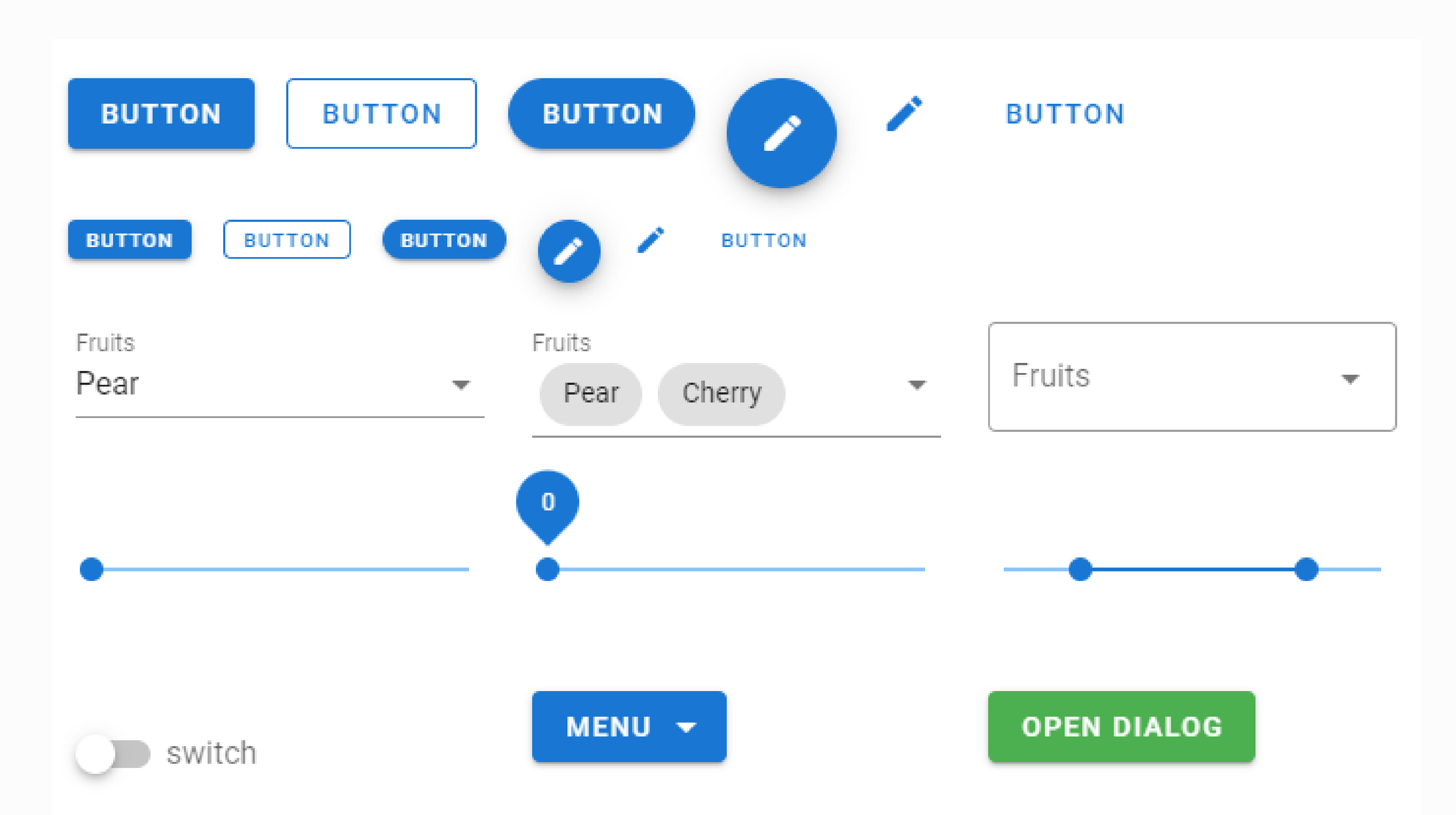
IntProgress

Progress:

Widgets

- The look&feel of the ipywidgets, cannot be customized, and when there is the need to create fancy looking applications in Jupyter or Voilà, more modern widgets library come to play their role.
- ipyvuetify is a widget library for making modern looking GUI's in Jupyter notebooks and Voilà dashboards. It's based on the Google material design philosophy. It is a porting of the vuetifyjs JavaScript library.
- A large set of widgets is provided with many widgets having multiple variants. Widgets are "**composable**" (any widget can contain a list of other widgets) allowing for the creation of rich and engaging user experiences.

ipyvuetify


BUTTON
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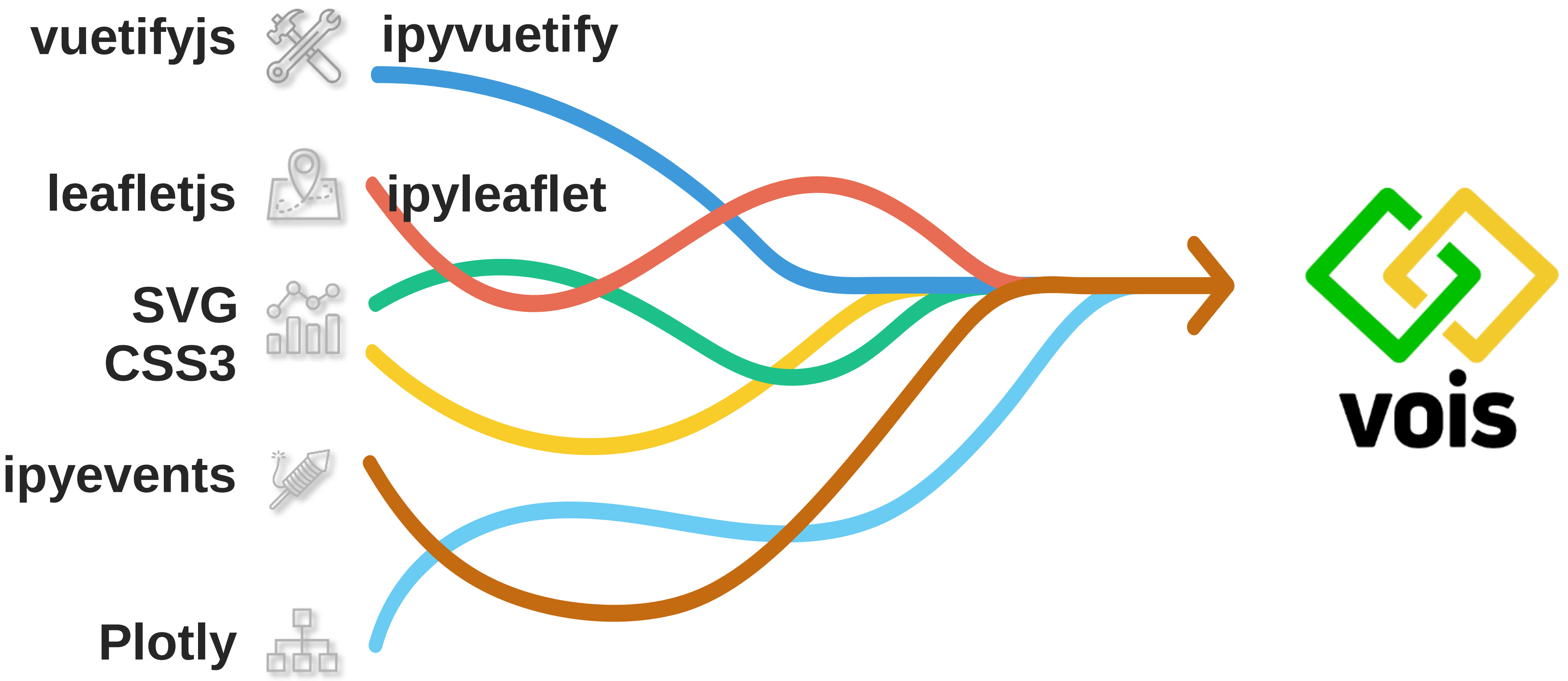
BUTTON
Fruits
Pear
Fruits
Pear
Cherry
Fruits
0
switch
MENU
OPEN DIALOG

Components



vuetifyjs

ipyvuetify

leafletjs

ipyleaflet

SVG

CSS3

ipyevents

Plotly

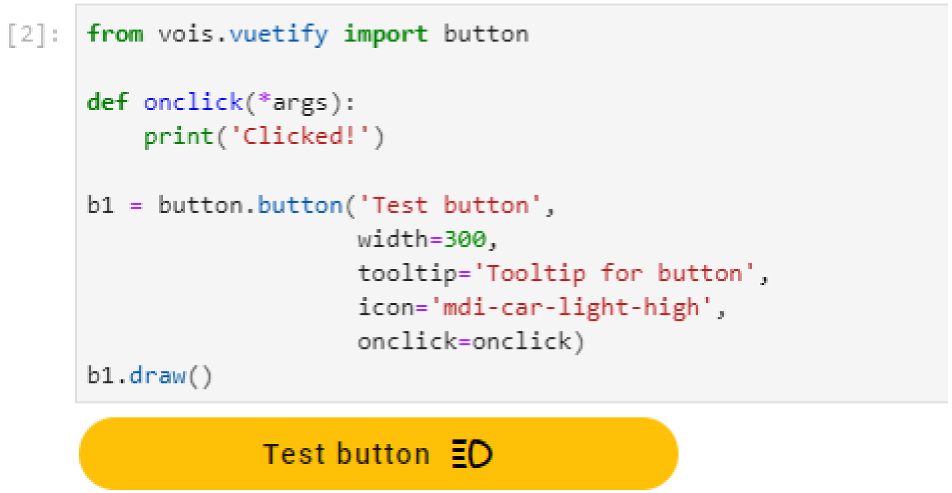
Objectives

- **Facilitate** full exploitation of ipyvuetify/vuetify.js components with less code
- **Consistent** usage of widgets variants/colors/themes
- Allows for **fullscreen** applications (possibly avoiding scrollbars)
- Support multiple screen resolutions: **responsiveness**
- **Compound elements** created from groups of widgets
- **Layered** components (popup-menus, dialog-boxes, etc.)
- **Multipage** applications
- Advanced **geo-spatial** visualizations
- Custom interactive **charts**
- **Cloud ←→ local system** data exchange

Facilitate

ipyvuetify

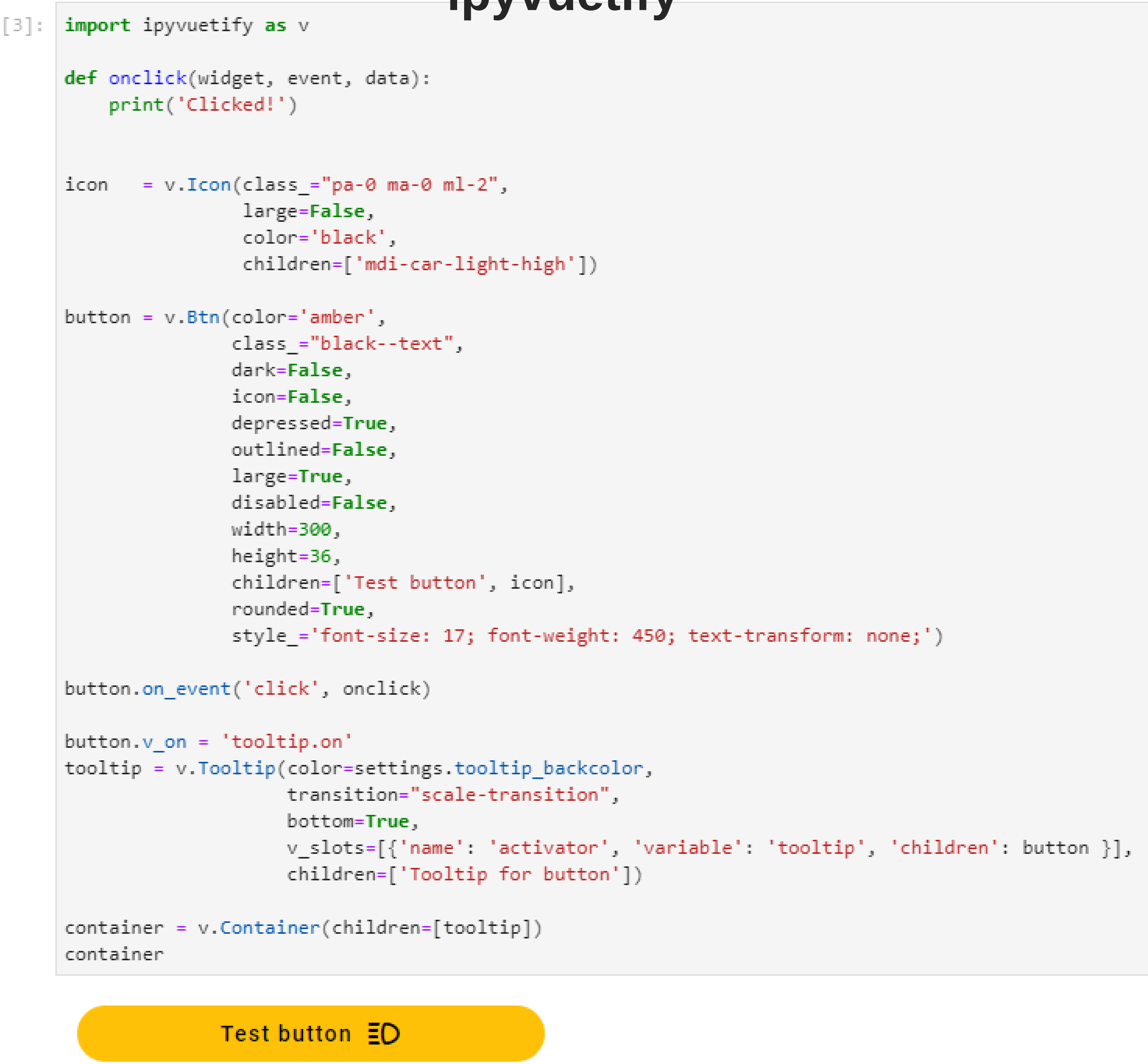
vois library



```
[2]: from vois.vuetify import button

def onclick(*args):
    print('Clicked!')

b1 = button.button('Test button',
                   width=300,
                   tooltip='Tooltip for button',
                   icon='mdi-car-light-high',
                   onclick=onclick)
b1.draw()
```



```
[3]: import ipyvuetify as v

def onclick(widget, event, data):
    print('Clicked!')


icon   = v.Icon(class_="pa-0 ma-0 ml-2",
                large=False,
                color='black',
                children=['mdi-car-light-high'])

button = v.Btn(color='amber',
               class_="black--text",
               dark=False,
               icon=False,
               depressed=True,
               outlined=False,
               large=True,
               disabled=False,
               width=300,
               height=36,
               children=['Test button', icon],
               rounded=True,
               style_='font-size: 17; font-weight: 450; text-transform: none;')

button.on_event('click', onclick)

button.v_on = 'tooltip.on'
tooltip = v.Tooltip(color=settings.tooltip_backcolor,
                    transition="scale-transition",
                    bottom=True,
                    v_slots=[{'name': 'activator', 'variable': 'tooltip', 'children': button }],
                    children=['Tooltip for button'])

container = v.Container(children=[tooltip])
container
```

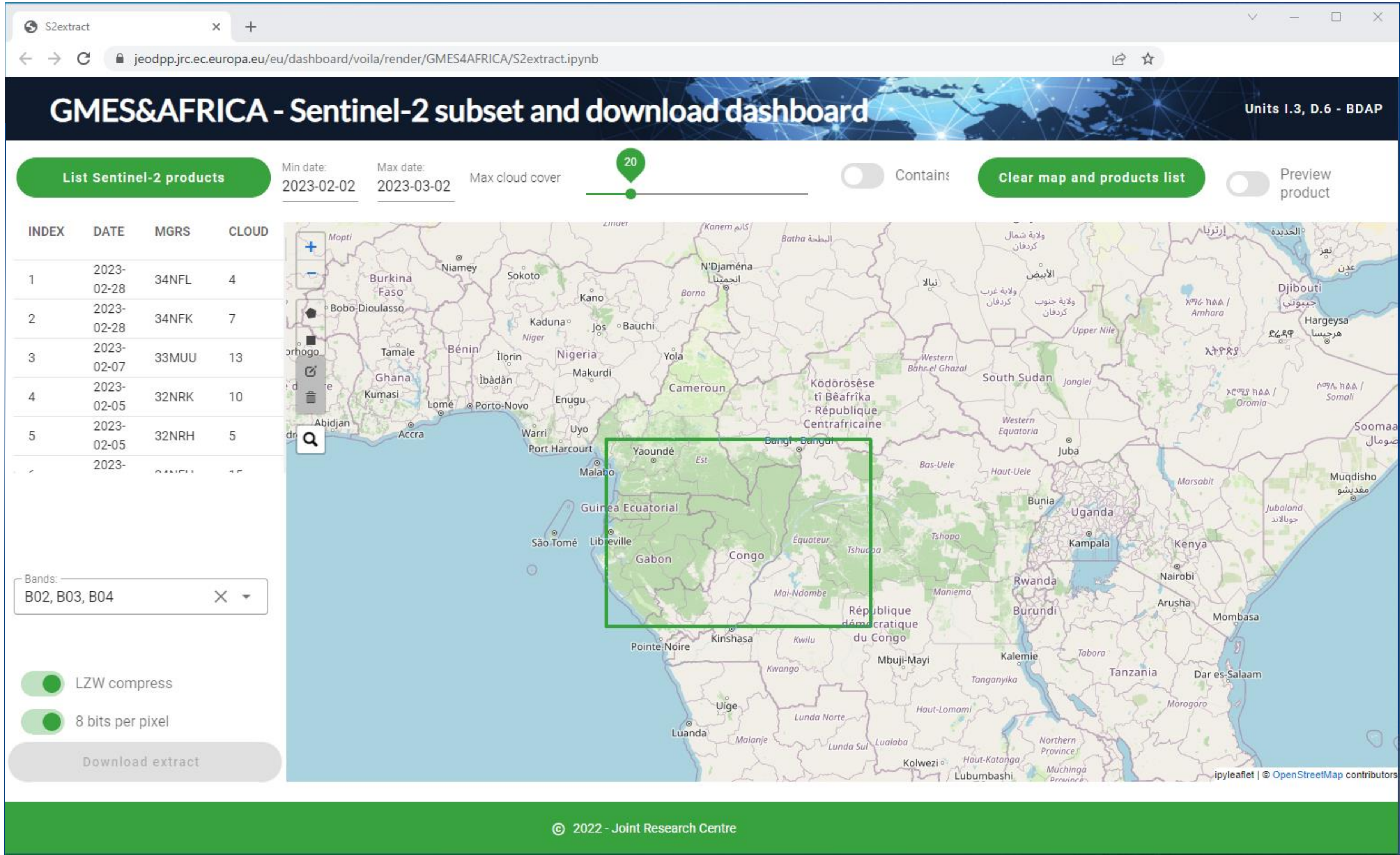
Consistency

```
from vois.vuetify import settings

settings.dark_mode      = False
settings.color_first    = '#81bae6'
settings.button_rounded = False
```

```
from vois.vuetify import settings

settings.dark_mode      = True
settings.color_first    = '#38a23f'
settings.button_rounded = True
```



S2extract
jeodpp.jrc.ec.europa.eu/eu/dashboard/voila/render/GMES4AFRICA/S2extract.ipynb
GMES&AFRICA - Sentinel-2 subset and download dashboard
Units I.3, D.6 - BDAP
List Sentinel-2 products
Max cloud cover
20
Contains
Clear map and products list
Preview product
LZW compress
8 bits per pixel
Download extract
ipyleaflet | © OpenStreetMap contributors
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Min date: 2023-02-02

Max date: 2023-03-02

INDEX	DATE	MGRS	CLOUD
1	2023-02-28	34NFL	4
2	2023-02-28	34NFK	7
3	2023-02-07	33MUU	13
4	2023-02-05	32NRK	10
5	2023-02-05	32NRH	5
	2023-		

Bands: B02, B03, B04

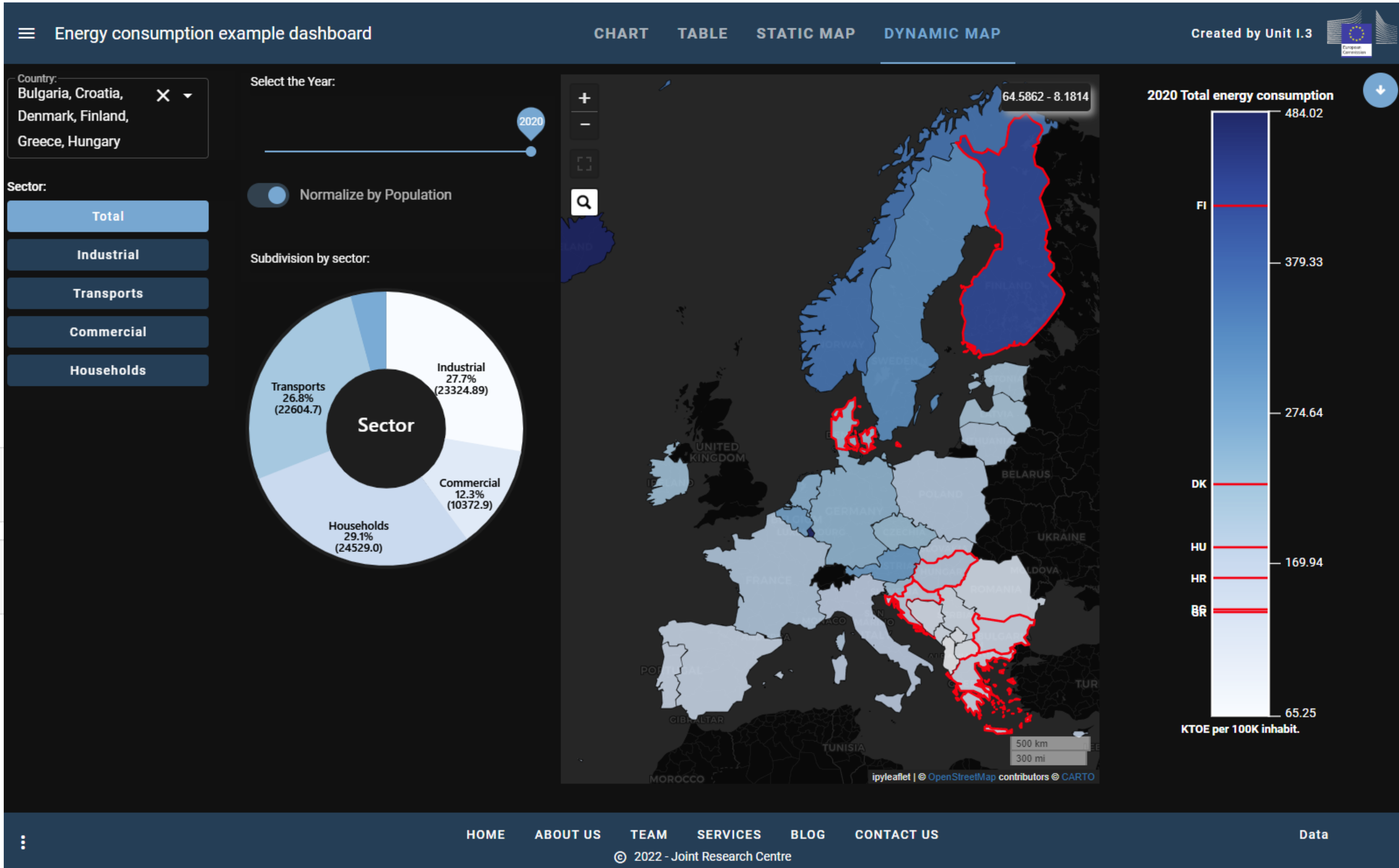
Consistency: themes

VOIS library manages the light and dark theme for all the widgets

With a single setting a dashboard theme can be changed

```
[1]: from vois.vuetify import settings
     settings.dark_mode = False
```

```
[2]: from vois.vuetify import settings
     settings.dark_mode = True
```



Energy consumption example dashboard

Country: Bulgaria, Croatia, Denmark, Finland, Greece, Hungary

Select the Year: 2020

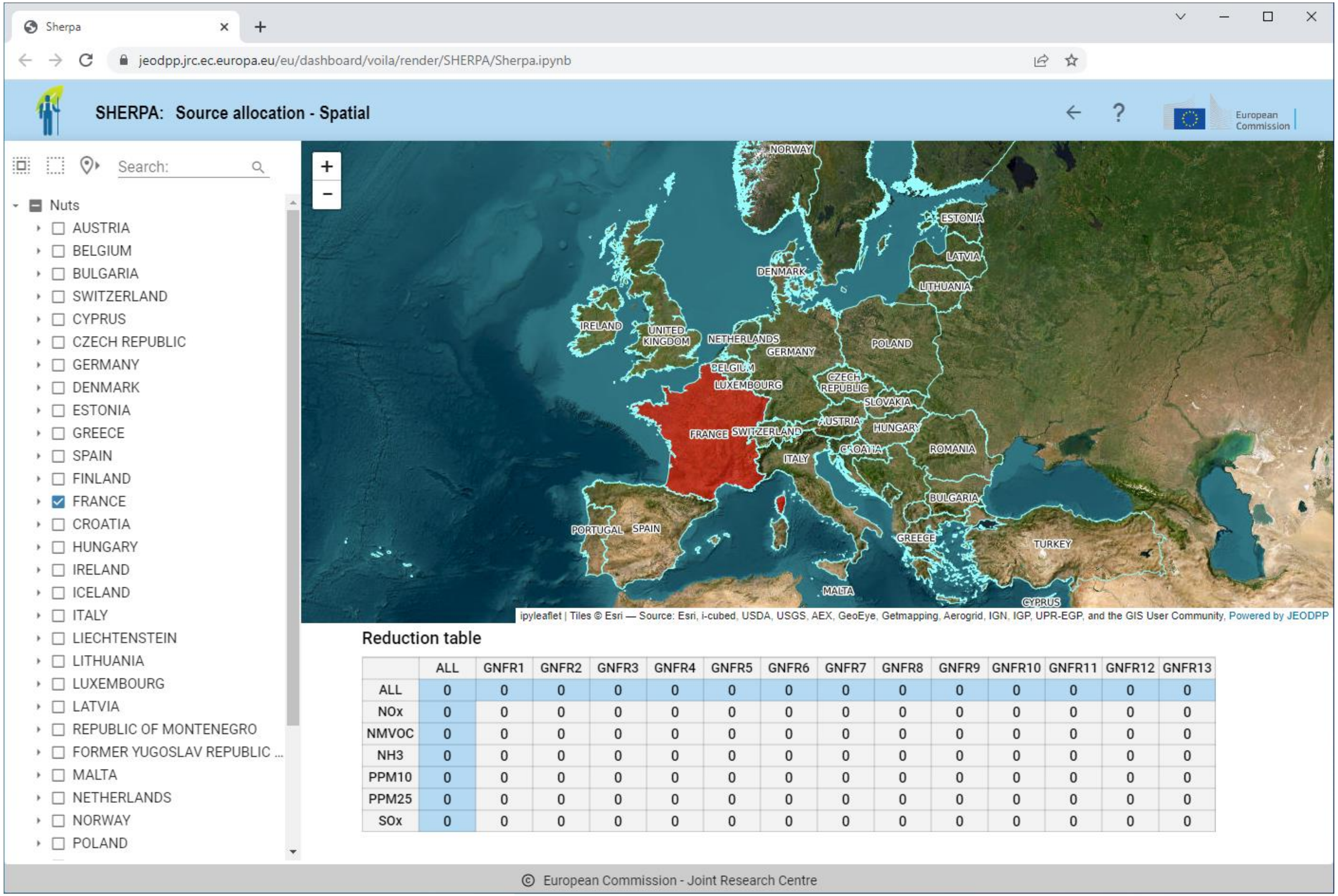
Normalize by Population

Sector: Total

Subdivision by sector:

Fullscreen

- Dashboard can occupy the full space of the page
- A main bar with title, buttons, icons is displayed on top
- A footer bar with some copyright information is displayed on the bottom



SHERPA: Source allocation - Spatial

- Nuts
  - □ AUSTRIA
  - □ BELGIUM
  - □ BULGARIA
  - □ SWITZERLAND
  - □ CYPRUS
  - □ CZECH REPUBLIC
  - □ GERMANY
  - □ DENMARK
  - □ ESTONIA
  - □ GREECE
  - □ SPAIN
  - □ FINLAND
  - ☑ FRANCE
  - □ CROATIA
  - □ HUNGARY
  - □ IRELAND
  - □ ICELAND
  - □ ITALY
  - □ LIECHTENSTEIN
  - □ LITHUANIA
  - □ LUXEMBOURG
  - □ LATVIA
  - □ REPUBLIC OF MONTENEGRO
  - □ FORMER YUGOSLAV REPUBLIC ...
  - □ MALTA
  - □ NETHERLANDS
  - □ NORWAY
  - □ POLAND

ipyleaflet | Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community, Powered by JEODPP

Reduction table

	ALL	GNFR1	GNFR2	GNFR3	GNFR4	GNFR5	GNFR6	GNFR7	GNFR8	GNFR9	GNFR10	GNFR11	GNFR12	GNFR13
ALL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOx	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NMVOC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PPM10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PPM25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOx	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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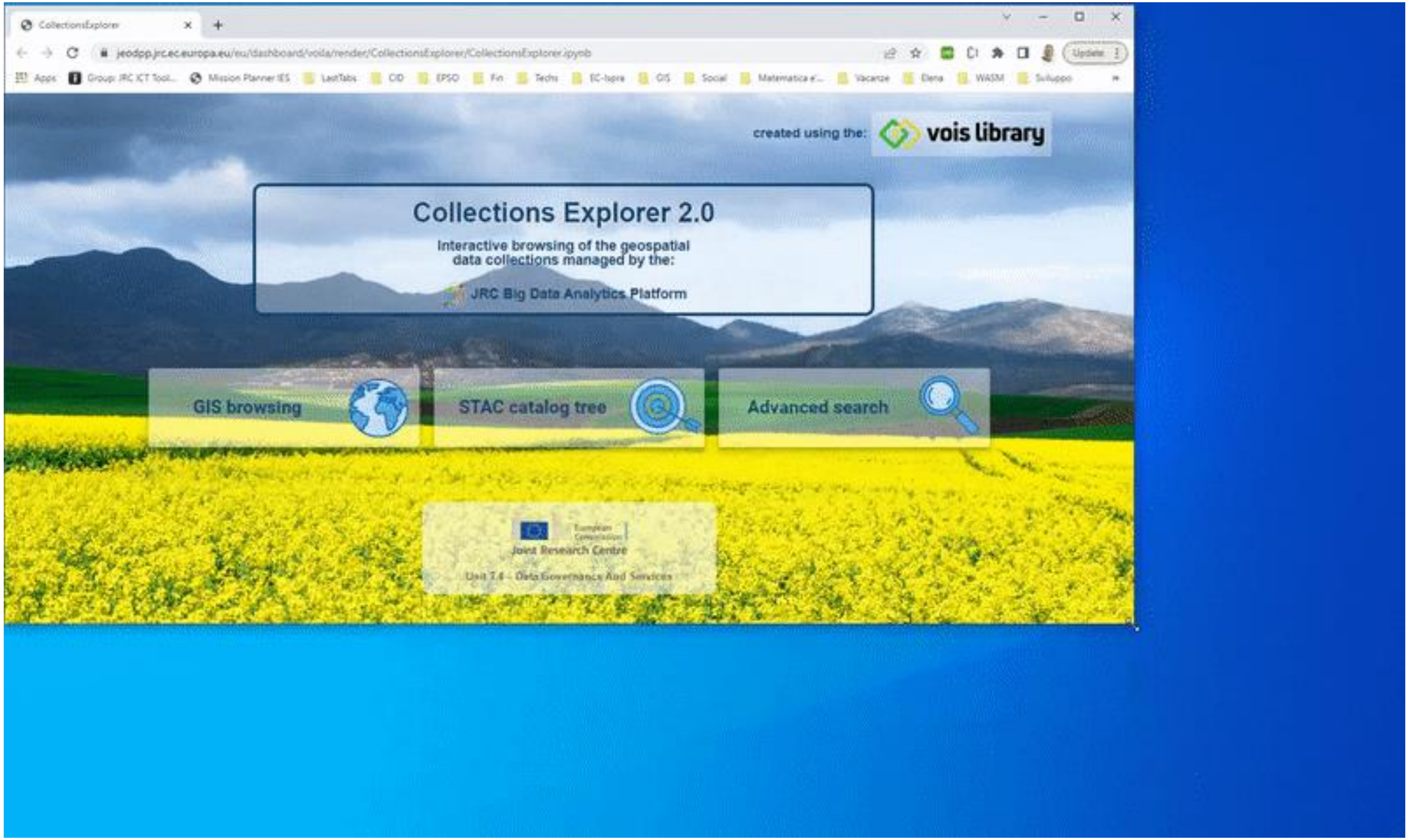
Responsive

- Dashboards can be made responsive to change in the browser page size

- Graphical elements and font sizes con adapt to different page sizes



CollectionsExplorer
jeodpp.jrc.ec.europa.eu/eu/dashboard/voila/render/CollectionsExplorer/CollectionsExplorer.ipynb
created using the: vois library
GIS browsing
STAC catalog tree
Advanced search
European Commission
Joint Research Centre
Unit T.4 - Data Governance And Services

Collections Explorer 2.0

Interactive browsing of the geospatial data collections managed by the:

JRC Big Data Analytics Platform

Fullscreen & responsive: how to?

VOIS library makes extensive use of these **CSS3** «tricks» and JavaScript resources to dynamically resize interface elements and text sizes:

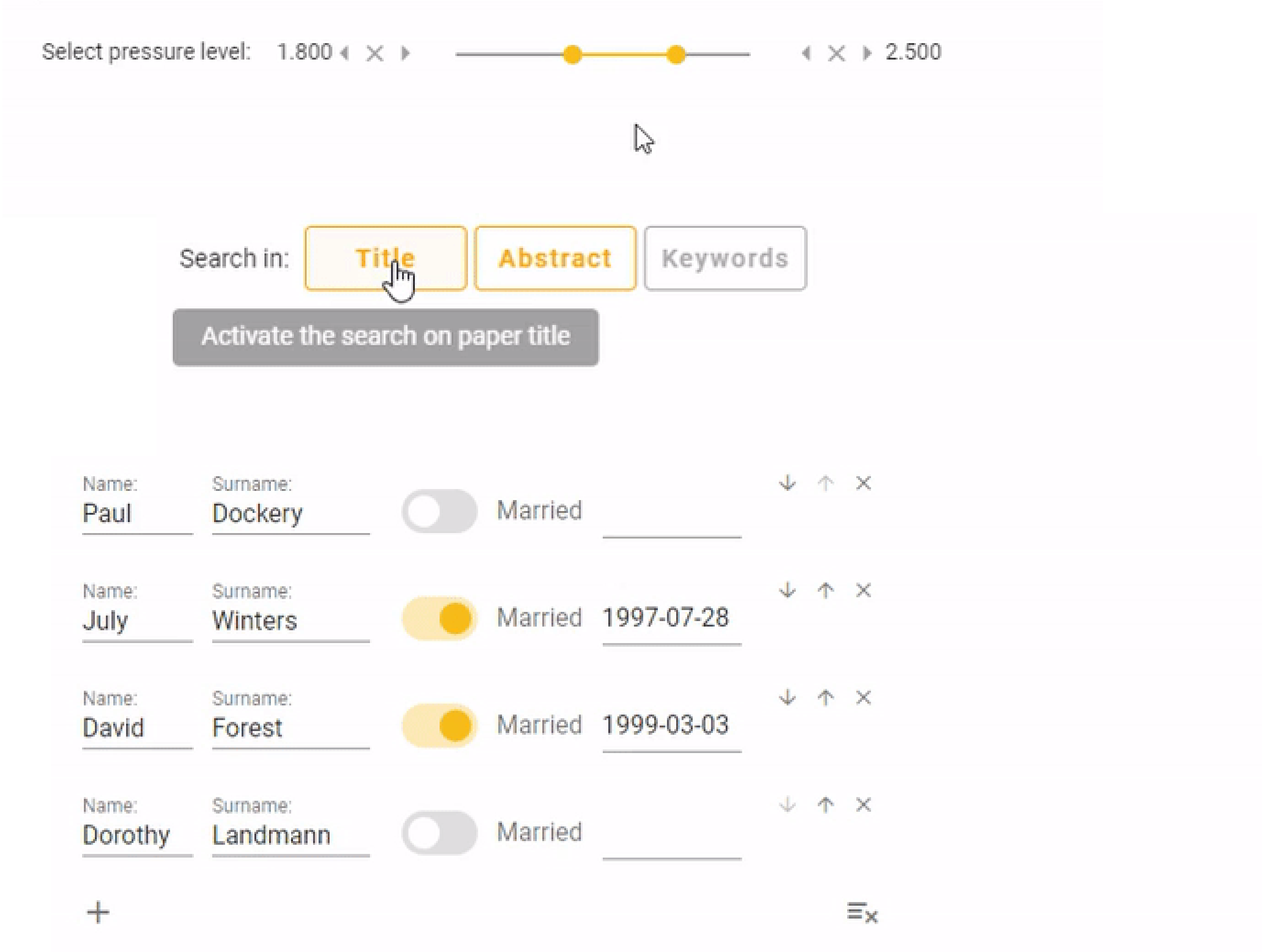
- **Fullscreen dialogs:** https://vuetifyjs.com/en/api/v-dialog/
- CSS **vw** and **vh** units: https://css-tricks.com/fun-viewport-units/
- CSS **calc**(), **min**(), ...: https://css-tricks.com/a-complete-guide-to-calc-in-css/
- CSS **Media queries:** https://css-tricks.com/a-complete-guide-to-css-media-queries/
- Vuetifyjs **breakpoints**: https://vuetifyjs.com/en/features/display-and-platform/

Composition

The VOIS library defines composite widgets that containg multiple ipyvuetify widgets to solve complex tasks

Examples:

- a float range slider managing default values
- a multi-switch widget for collecting multiple boolean options
- a sortable list of complex items



Select pressure level: 1.800 … 2.500

Search in:

Activate the search on paper title

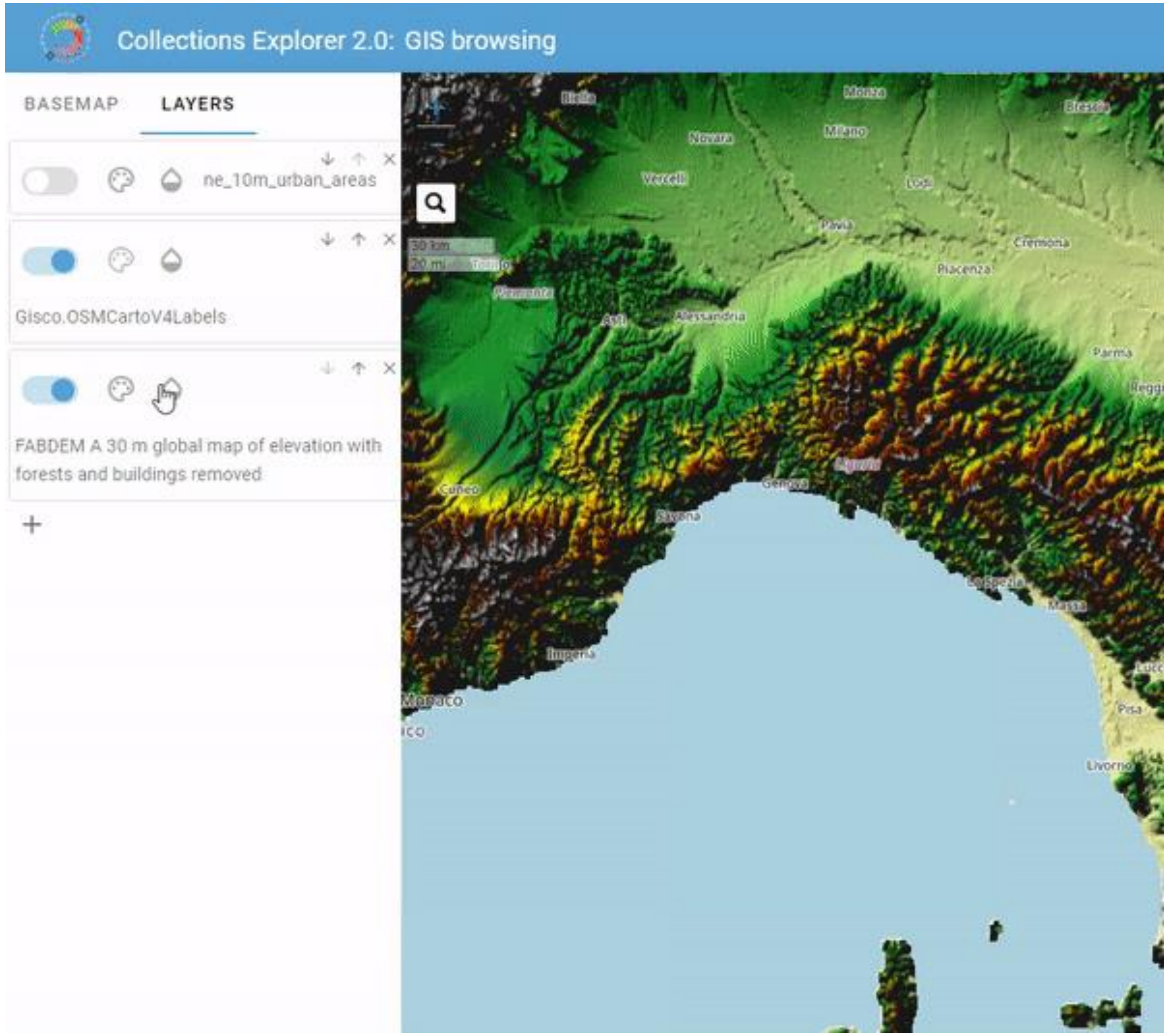
Name:	Surname:		
Paul	Dockery	Married	
July	Winters	Married	1997-07-28
David	Forest	Married	1999-03-03
Dorothy	Landmann	Married	

Layered widgets: pop-ups

Using ipyvuetify and the VOIS library it is possible to easily create widgets that pops-out of the screen:

- Pop-up menus
- Pop-up windows for capturing user interaction without changing what is displayed on the screen

This is not possible using the standard ipywidgets library



Collections Explorer 2.0: GIS browsing

BASEMAP LAYERS

ne_10m_urban_areas

Gisco.OSMCartoV4Labels

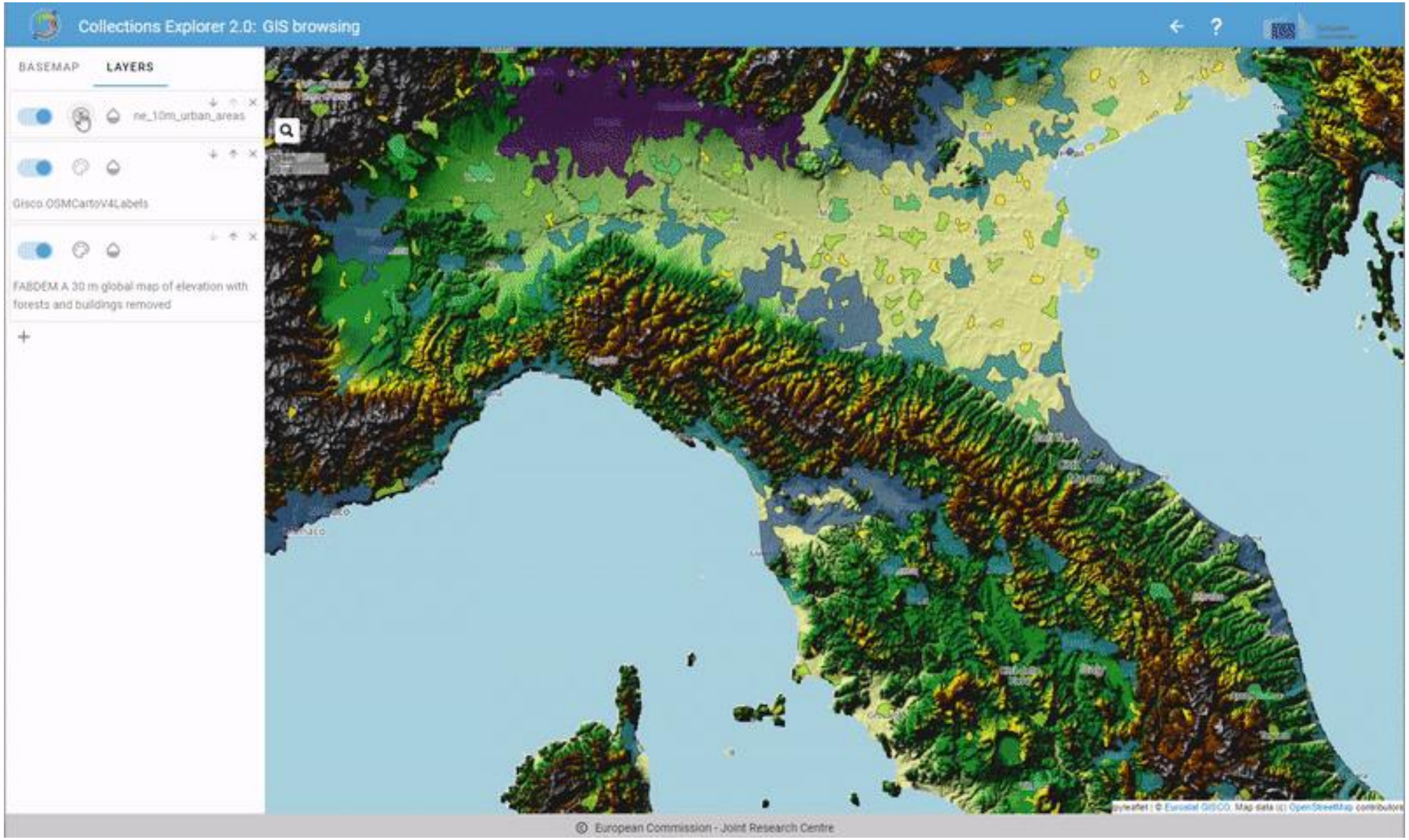
FABDEM A 30 m global map of elevation with forests and buildings removed

Layered widgets: dialog-boxes

Modal dialog-boxes can be opened to request user input

Any widget can be added to the dialog content

On the right an example of some overlapping dialog-boxes that implement a legend editor for geospatial vector dataset thematization


Collections Explorer 2.0: GIS browsing

ne_10m_urban_areas

Gisco.OSMCartoV4Labels

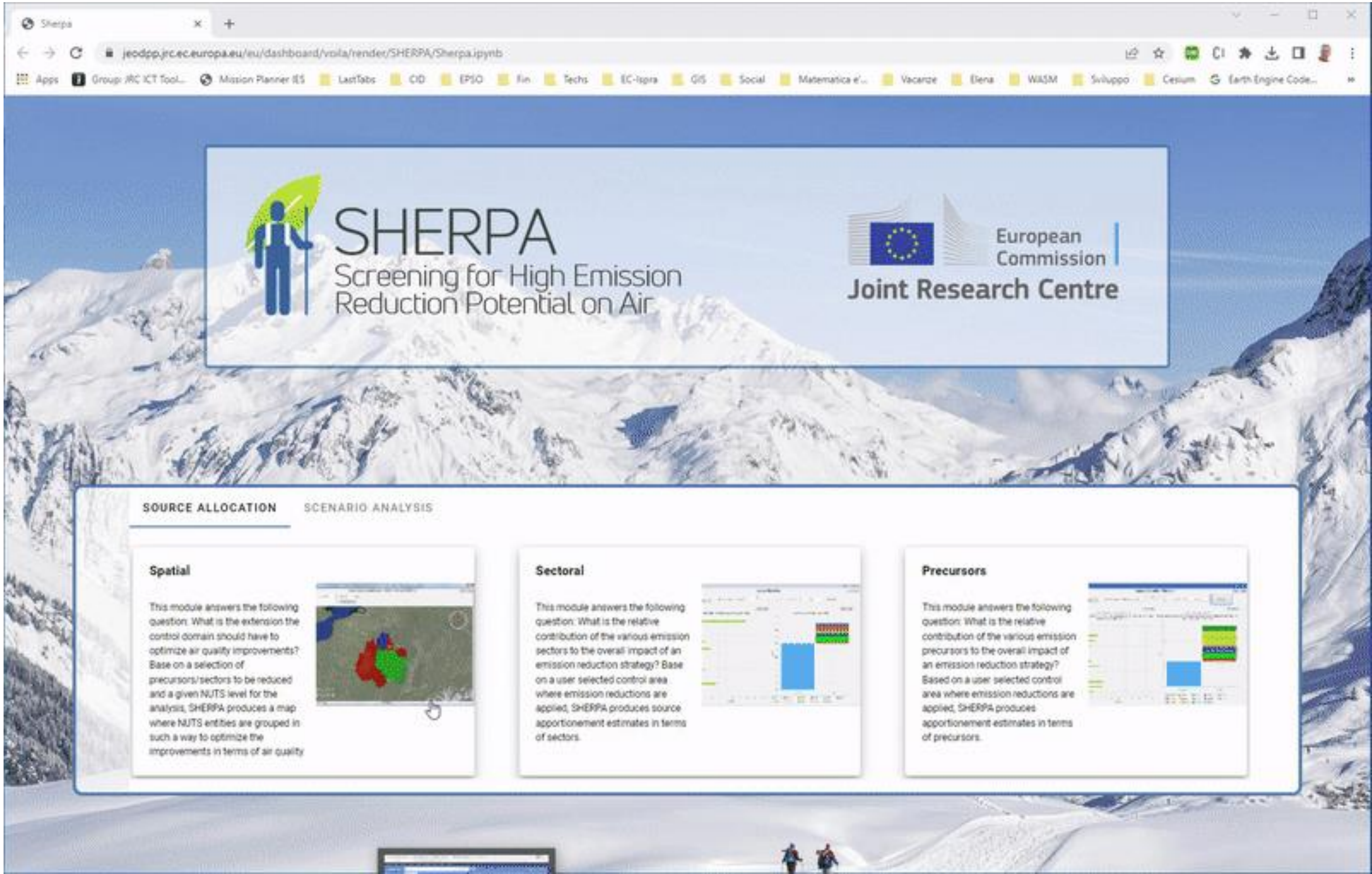
FABDEM A 30 m global map of elevation with forests and buildings removed

European Commission - Joint Research Centre

Multipage applications

Support for multi-pages application development

On the right an example of the Sherpa application for Air Quality monitoring



SHERPA
Screening for High Emission Reduction Potential on Air

European Commission
Joint Research Centre

SOURCE ALLOCATION | SCENARIO ANALYSIS

Spatial

This module answers the following question: What is the extension the control domain should have to optimize air quality improvements? Base on a selection of precursors/sectors to be reduced and a given NUTS level for the analysis, SHERPA produces a map where NUTS entities are grouped in such a way to optimize the improvements in terms of air quality

Sectoral

This module answers the following question: What is the relative contribution of the various emission sectors to the overall impact of an emission reduction strategy? Base on a user selected control area where emission reductions are applied, SHERPA produces source apportionement estimates in terms of sectors.

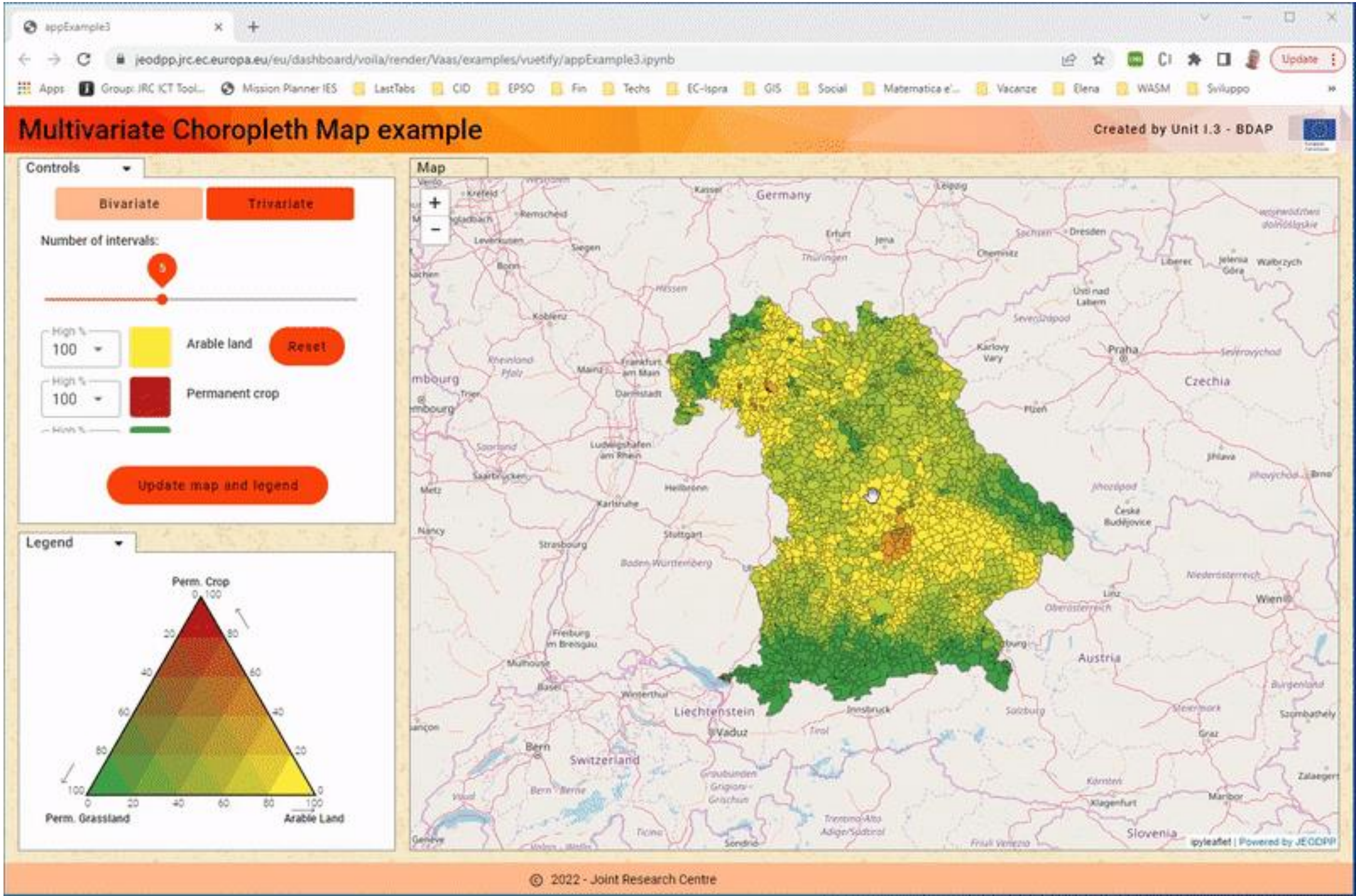
Precursors

This module answers the following question: What is the relative contribution of the various emission precursors to the overall impact of an emission reduction strategy? Based on a user selected control area where emission reductions are applied, SHERPA produces apportionement estimates in terms of precursors.

Geo spatial

The VOIS library has some modules dedicated to geospatial data visualization

On the right an example dashboard to interactively create a bi-variate or tri-variate choropleth map, i.e. a map representation where the colors of the polygons depend on two or three data attributes



Multivariate Choropleth Map example

Created by Unit I.3 - BDAP

Controls

Number of intervals: 5

High % 100 Arable land

High % 100 Permanent crop

Legend

Map

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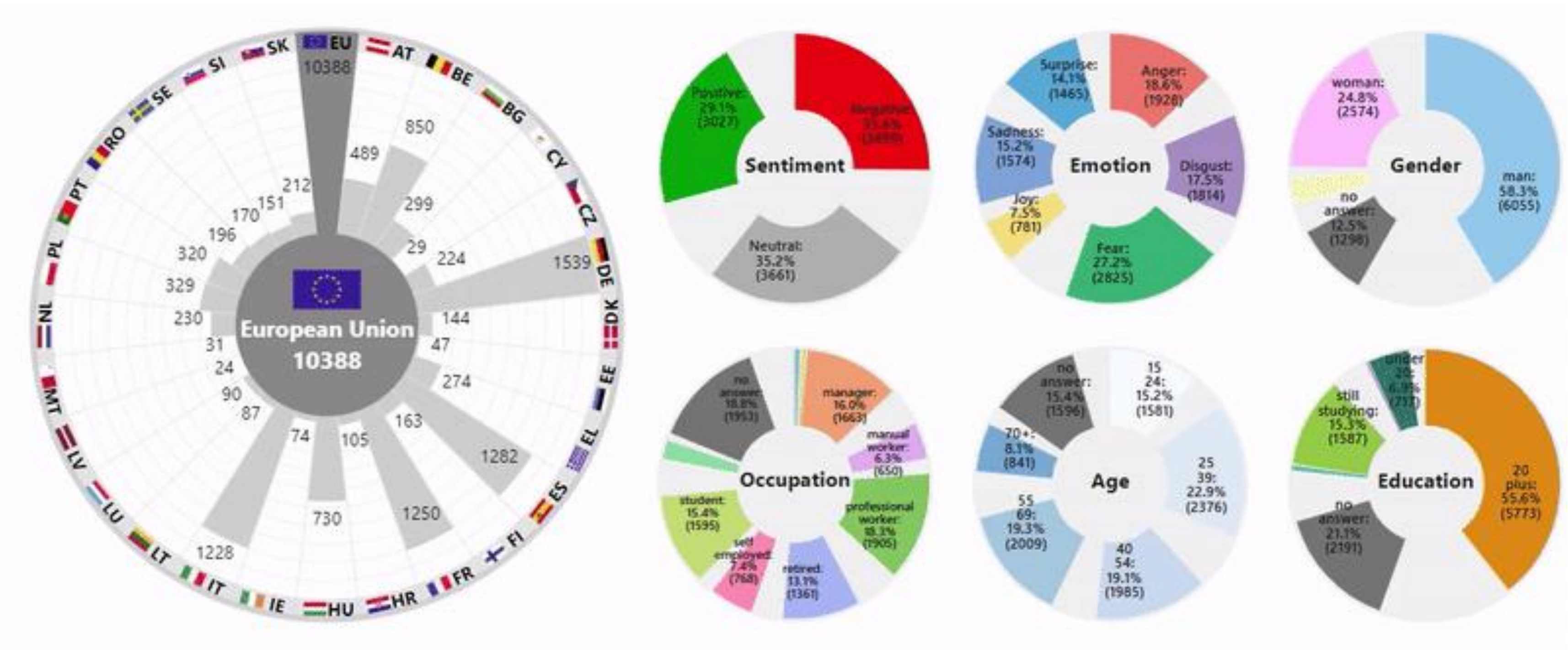
Custom charts: SVG + ipyevents

Some time the chart you want is not available in Plotly/Bokeh/Matplotlib:

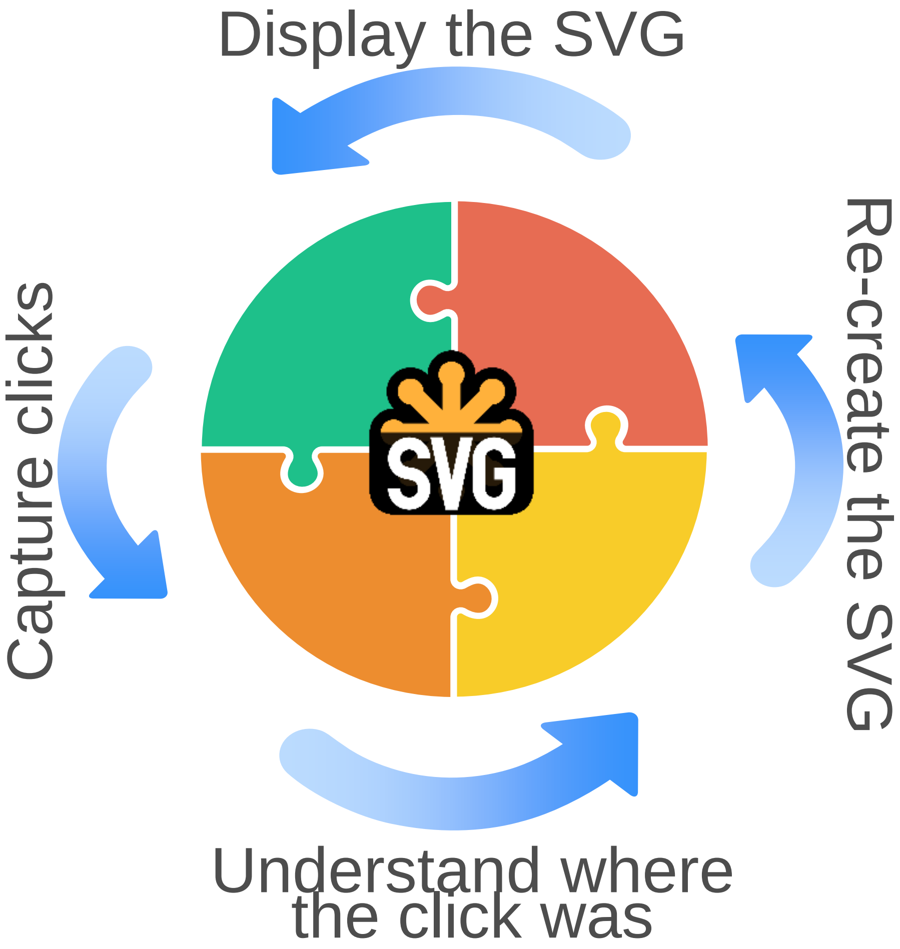
→ SVG!

Tooltip and highlighting of elements while the mouse is moved are done by SVG/CSS instructions

Click events (that cause an update of the drawings) are managed by ipyevents



Custom charts: SVG + ipyevents



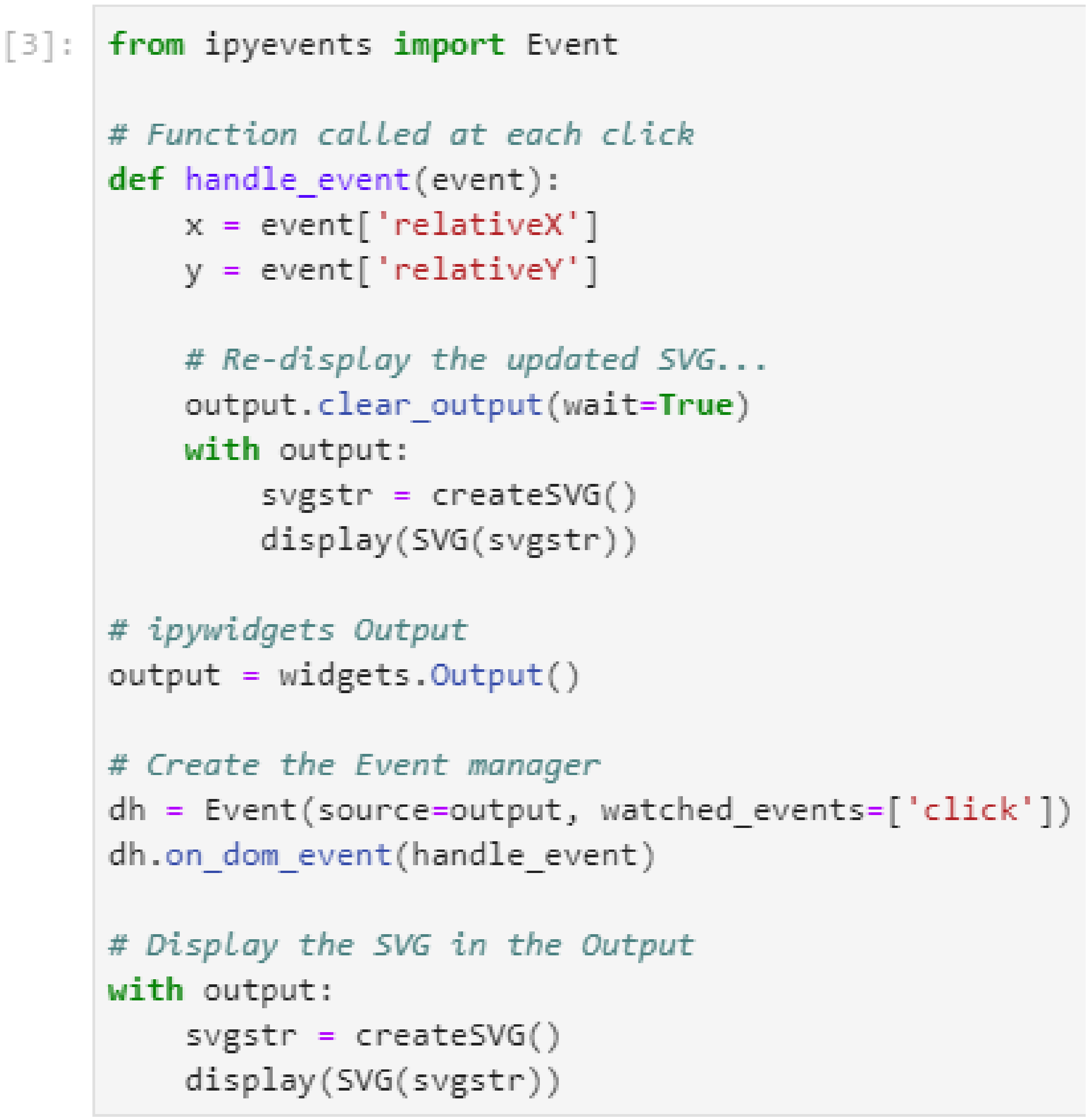
Display the SVG

Re-create the SVG

Understand where the click was

Capture clicks

Pseudocode used by the VOIS library:

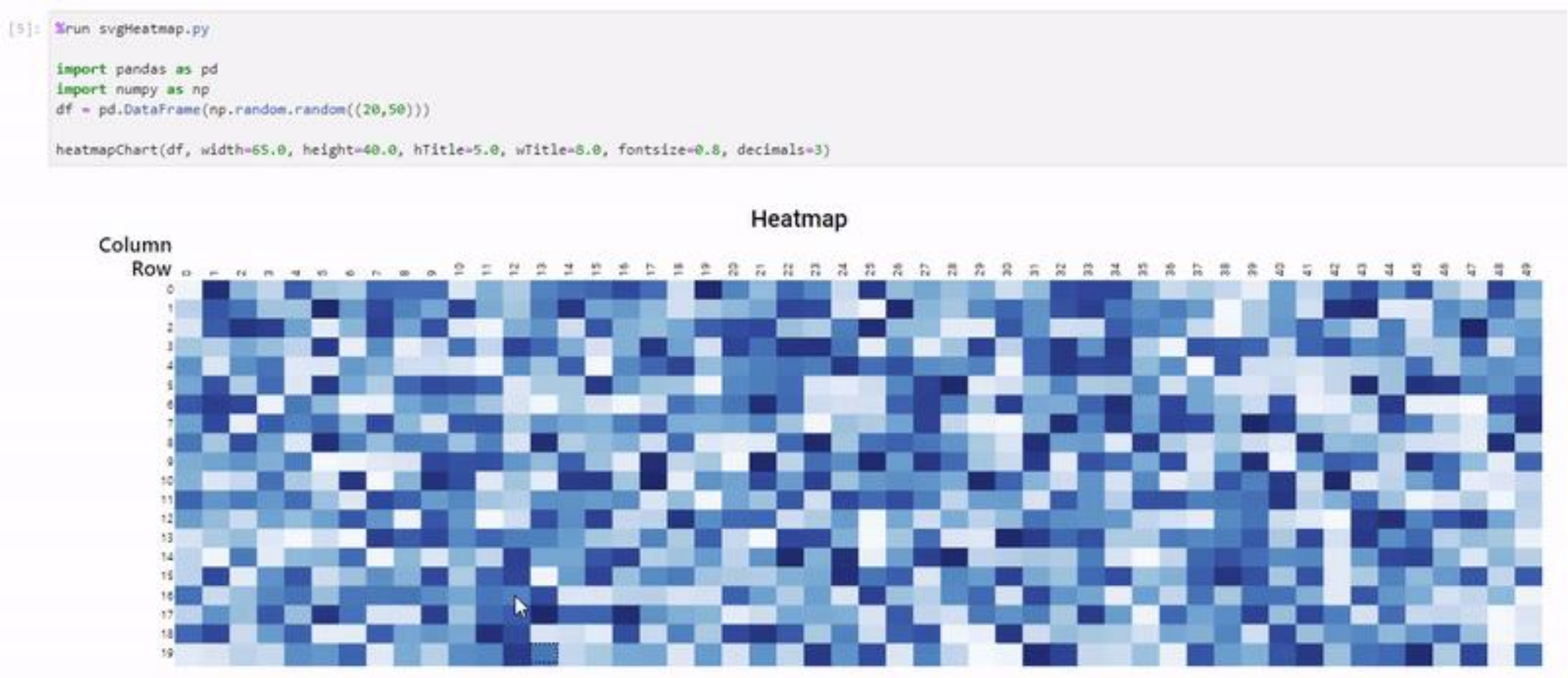


```
from ipyevents import Event

# Function called at each click
def handle_event(event):
    x = event['relativeX']
    y = event['relativeY']

    # Re-display the updated SVG...
    output.clear_output(wait=True)
    with output:
        svgstr = createSVG()
        display(SVG(svgstr))

# ipywidgets Output
output = widgets.Output()

# Create the Event manager
dh = Event(source=output, watched_events=['click'])
dh.on_dom_event(handle_event)

# Display the SVG in the Output
with output:
    svgstr = createSVG()
    display(SVG(svgstr))
```

Custom charts: SVG + ipyevents

Similar example: vois.**svgHeatmap**.py module

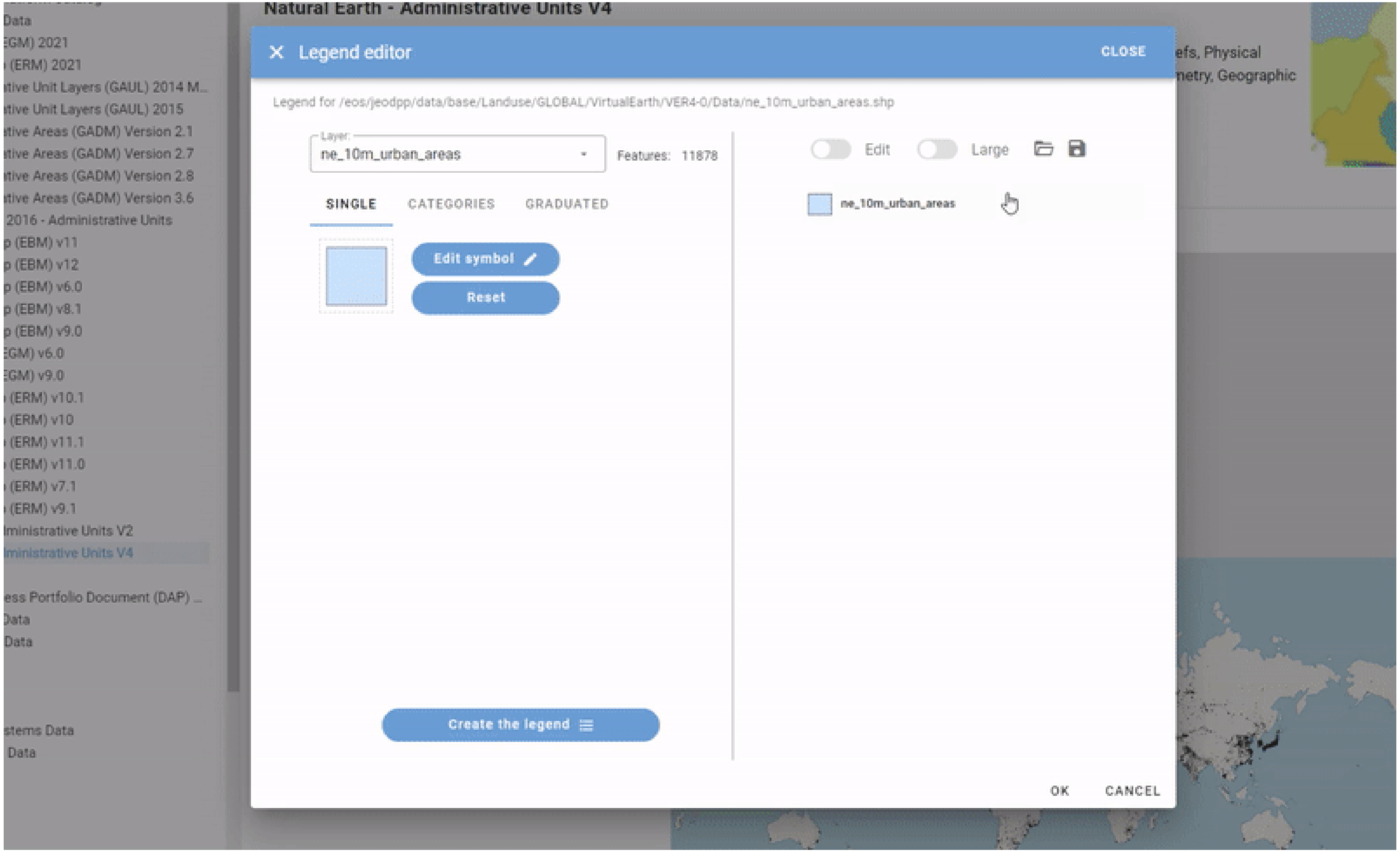
Tooltips and highlight of cells is managed by **CSS**, the click events are managed by **ipyevents**



```
[5]: %run svgHeatmap.py

     import pandas as pd
     import numpy as np
     df = pd.DataFrame(np.random.random((20,50)))

     heatmapChart(df, width=65.0, height=40.0, hTitle=5.0, wTitle=8.0, fontsize=0.8, decimals=3)
```

Cloud ←→local data exchange

Upload and download of data is possible with a dedicated widget:



Natural Earth - Administrative Units V4

Data
EGM) 2021
(ERM) 2021
ative Unit Layers (GAUL) 2014 M...
ative Unit Layers (GAUL) 2015
ative Areas (GADM) Version 2.1
ative Areas (GADM) Version 2.7
ative Areas (GADM) Version 2.8
ative Areas (GADM) Version 3.6
2016 - Administrative Units
p (EBM) v11
p (EBM) v12
p (EBM) v6.0
p (EBM) v8.1
p (EBM) v9.0
EGM) v6.0
EGM) v9.0
(ERM) v10.1
(ERM) v10
(ERM) v11.1
(ERM) v11.0
(ERM) v7.1
(ERM) v9.1
ministrative Units V2
ministrative Units V4
ess Portfolio Document (DAP) ...
Data
Data
stems Data
Data

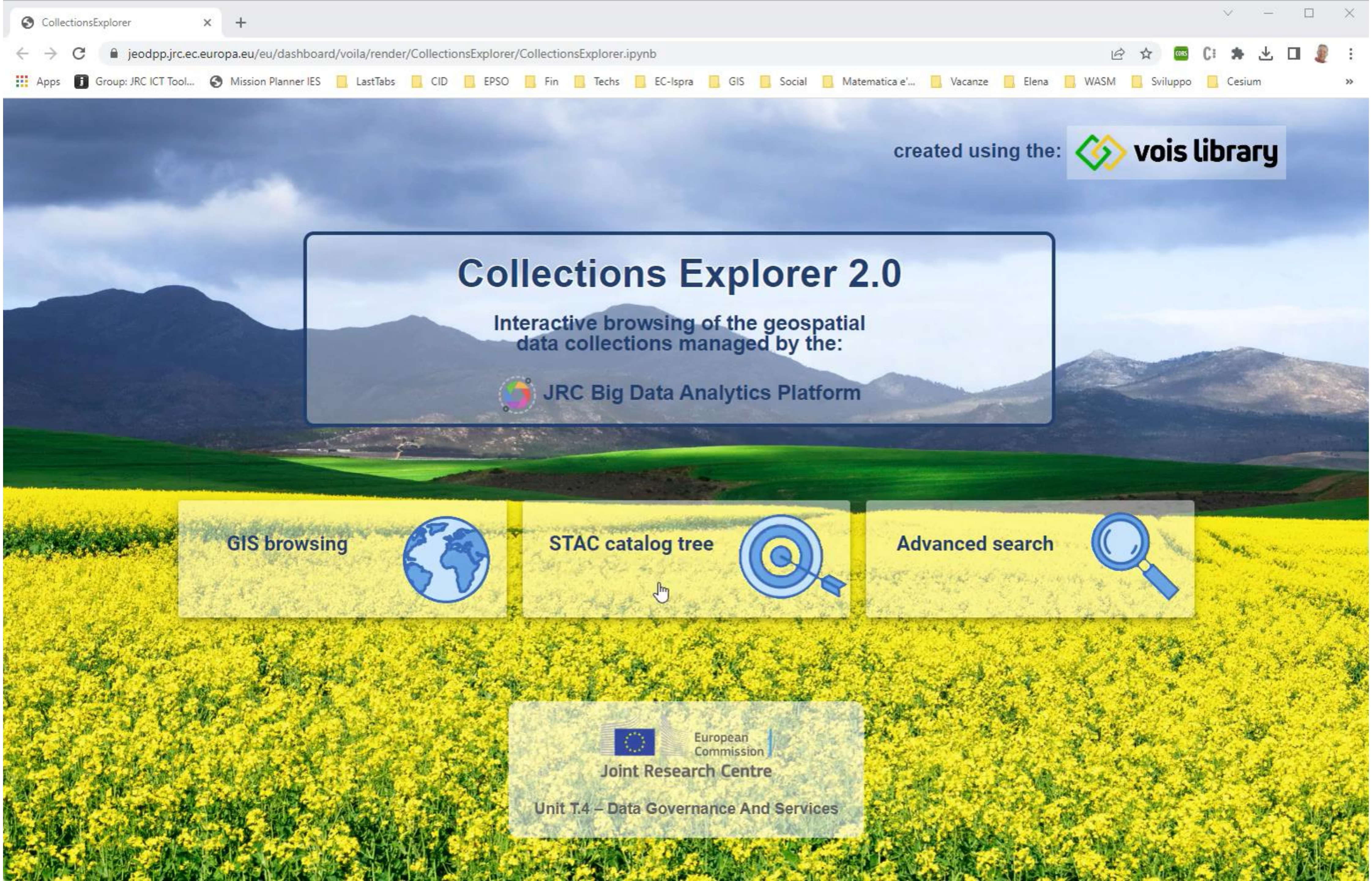
efs, Physical
metry, Geographic

Legend editor

Legend for /eos/jeodpp/data/base/Landuse/GLOBAL/VirtualEarth/VER4-0/Data/ne_10m_urban_areas.shp

Layer: ne_10m_urban_areas

Features: 11878



Collections Explorer 2.0

Interactive browsing of the geospatial data collections managed by the:

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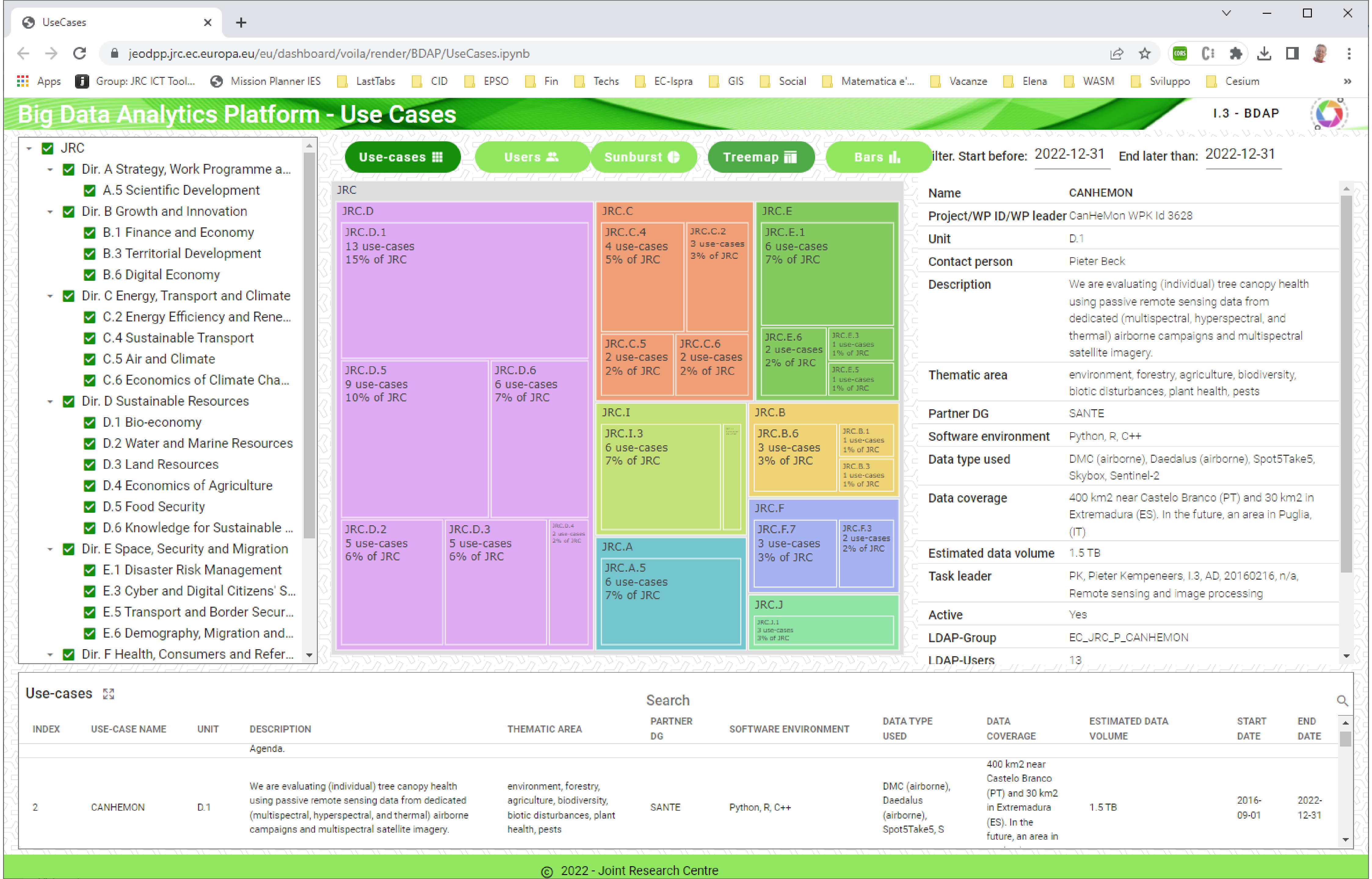
Unit T.4 – Data Governance And Services



Big Data Analytics Platform - Use Cases

ilter. Start before: 2022-12-31 End later than: 2022-12-31

- ☑ JRC
  - ☑ Dir. A Strategy, Work Programme a...
    - ☑ A.5 Scientific Development
  - ☑ Dir. B Growth and Innovation
    - ☑ B.1 Finance and Economy
    - ☑ B.3 Territorial Development
    - ☑ B.6 Digital Economy
  - ☑ Dir. C Energy, Transport and Climate
    - ☑ C.2 Energy Efficiency and Rene...
    - ☑ C.4 Sustainable Transport
    - ☑ C.5 Air and Climate
    - ☑ C.6 Economics of Climate Cha...
  - ☑ Dir. D Sustainable Resources
    - ☑ D.1 Bio-economy
    - ☑ D.2 Water and Marine Resources
    - ☑ D.3 Land Resources
    - ☑ D.4 Economics of Agriculture
    - ☑ D.5 Food Security
    - ☑ D.6 Knowledge for Sustainable ...
  - ☑ Dir. E Space, Security and Migration
    - ☑ E.1 Disaster Risk Management
    - ☑ E.3 Cyber and Digital Citizens' S...
    - ☑ E.5 Transport and Border Secur...
    - ☑ E.6 Demography, Migration and...
  - ☑ Dir. F Health, Consumers and Refer...

Name	CANHEMON
Project/WP ID/WP leader	CanHeMon WPK Id 3628
Unit	D.1
Contact person	Pieter Beck
Description	We are evaluating (individual) tree canopy health using passive remote sensing data from dedicated (multispectral, hyperspectral, and thermal) airborne campaigns and multispectral satellite imagery.
Thematic area	environment, forestry, agriculture, biodiversity, biotic disturbances, plant health, pests
Partner DG	SANTE
Software environment	Python, R, C++
Data type used	DMC (airborne), Daedalus (airborne), Spot5Take5, Skybox, Sentinel-2
Data coverage	400 km2 near Castelo Branco (PT) and 30 km2 in Extremadura (ES). In the future, an area in Puglia, (IT)
Estimated data volume	1.5 TB
Task leader	PK, Pieter Kempeneers, I.3, AD, 20160216, n/a, Remote sensing and image processing
Active	Yes
LDAP-Group	EC_JRC_P_CANHEMON
LDAP-Users	13

Use-cases

Search

INDEX	USE-CASE NAME	UNIT	DESCRIPTION	THEMATIC AREA	PARTNER DG	SOFTWARE ENVIRONMENT	DATA TYPE USED	DATA COVERAGE	ESTIMATED DATA VOLUME	START DATE	END DATE
			Agenda.								
2	CANHEMON	D.1	We are evaluating (individual) tree canopy health using passive remote sensing data from dedicated (multispectral, hyperspectral, and thermal) airborne campaigns and multispectral satellite imagery.	environment, forestry, agriculture, biodiversity, biotic disturbances, plant health, pests	SANTE	Python, R, C++	DMC (airborne), Daedalus (airborne), Spot5Take5, S	400 km2 near Castelo Branco (PT) and 30 km2 in Extremadura (ES). In the future, an area in	1.5 TB	2016-09-01	2022-12-31

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Takeaway

- Voila’ demonstrated its versatility in both allowing for quick&dirty notebook conversion and in creating fully fledged web applications
- VOIS library is used inside the European Commission BDAP Cloud Platform to communicate scientific results to a wider audience
- It greatly expands the capacity of Voilà and of the standard widgets library to visually present and interact with complex datasets
- It favors code reuse and sharing amont data scientist/devevopers
- It will be soon available as an open source library on the https://code.europa.eu EC gitlab repository

Thank you

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