CCI KNOWLEDGE EXCHANGE & CATE TOOLBOX DEMO

Carsten Brockmann & Sophie Hebden

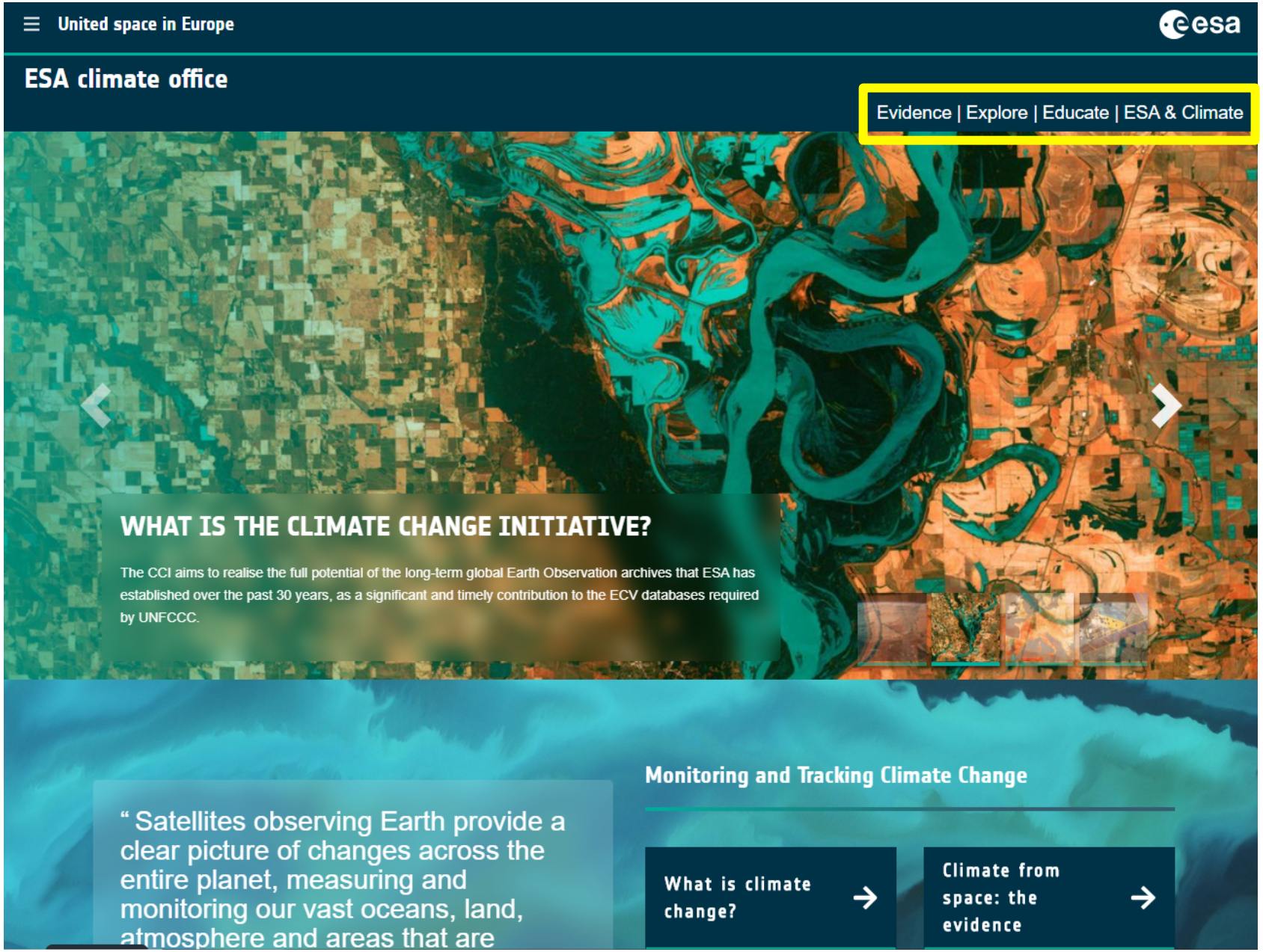
25/03/2021

CCI Knowledge Exchange

Aims to maximise awareness, access, use & understanding of satellite data for climate research

- **Addresses new audiences**: the general public and educational audience
- Increases **visibility of the CCI programme**
- **Showcases** role of ESA satellite data in **climate science**

  - Website
  - Education
  - Climate from Space web-app
  - Open Data Portal
  - CCI Toolbox (Cate)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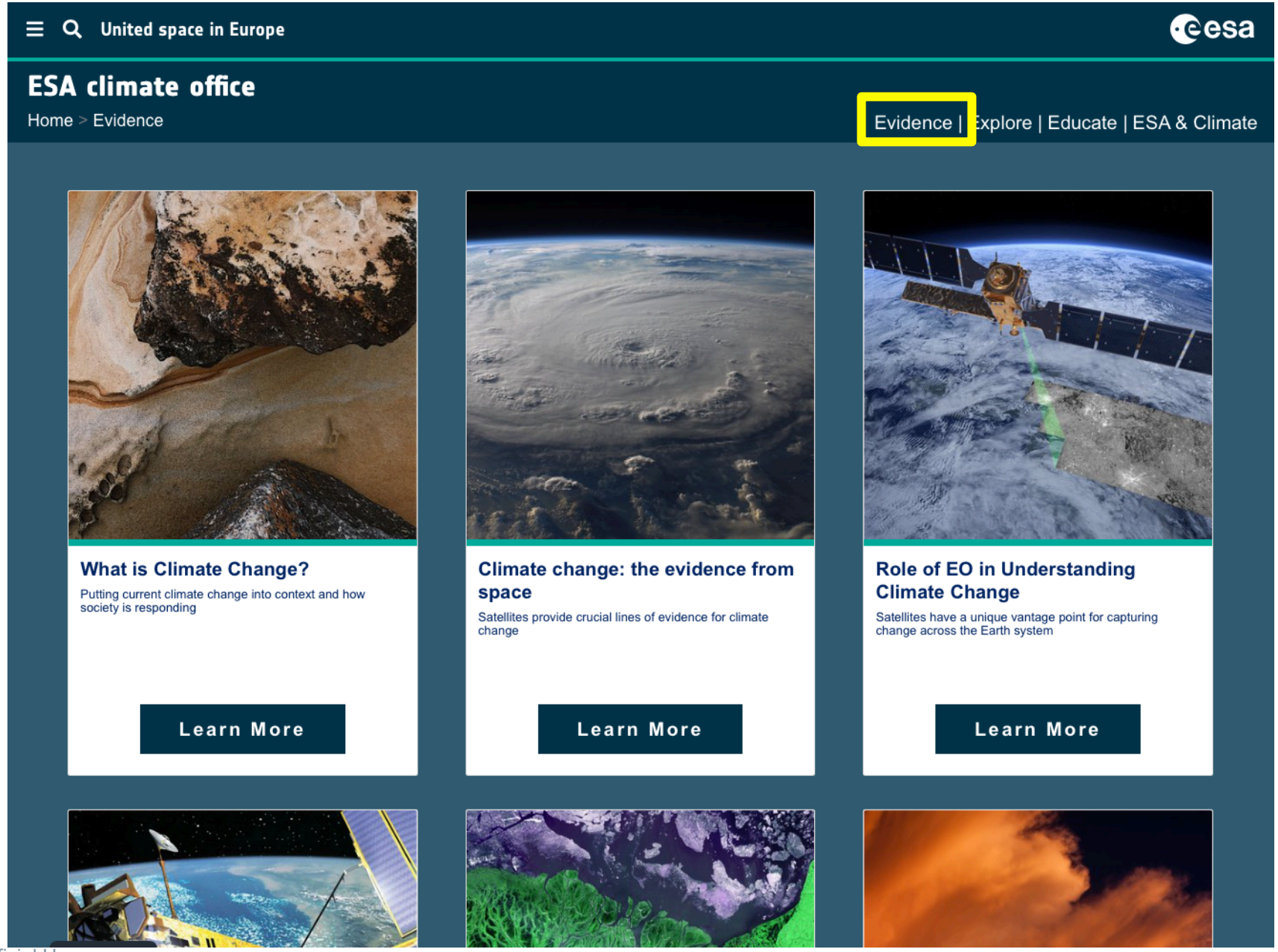
esa
ESA climate office
Evidence | Explore | Educate | ESA & Climate
WHAT IS THE CLIMATE CHANGE INITIATIVE?
The CCI aims to realise the full potential of the long-term global Earth Observation archives that ESA has established over the past 30 years, as a significant and timely contribution to the ECV databases required by UNFCCC.
“ Satellites observing Earth provide a clear picture of changes across the entire planet, measuring and monitoring our vast oceans, land, atmosphere and areas that are
Monitoring and Tracking Climate Change
What is climate change?
Climate from space: the evidence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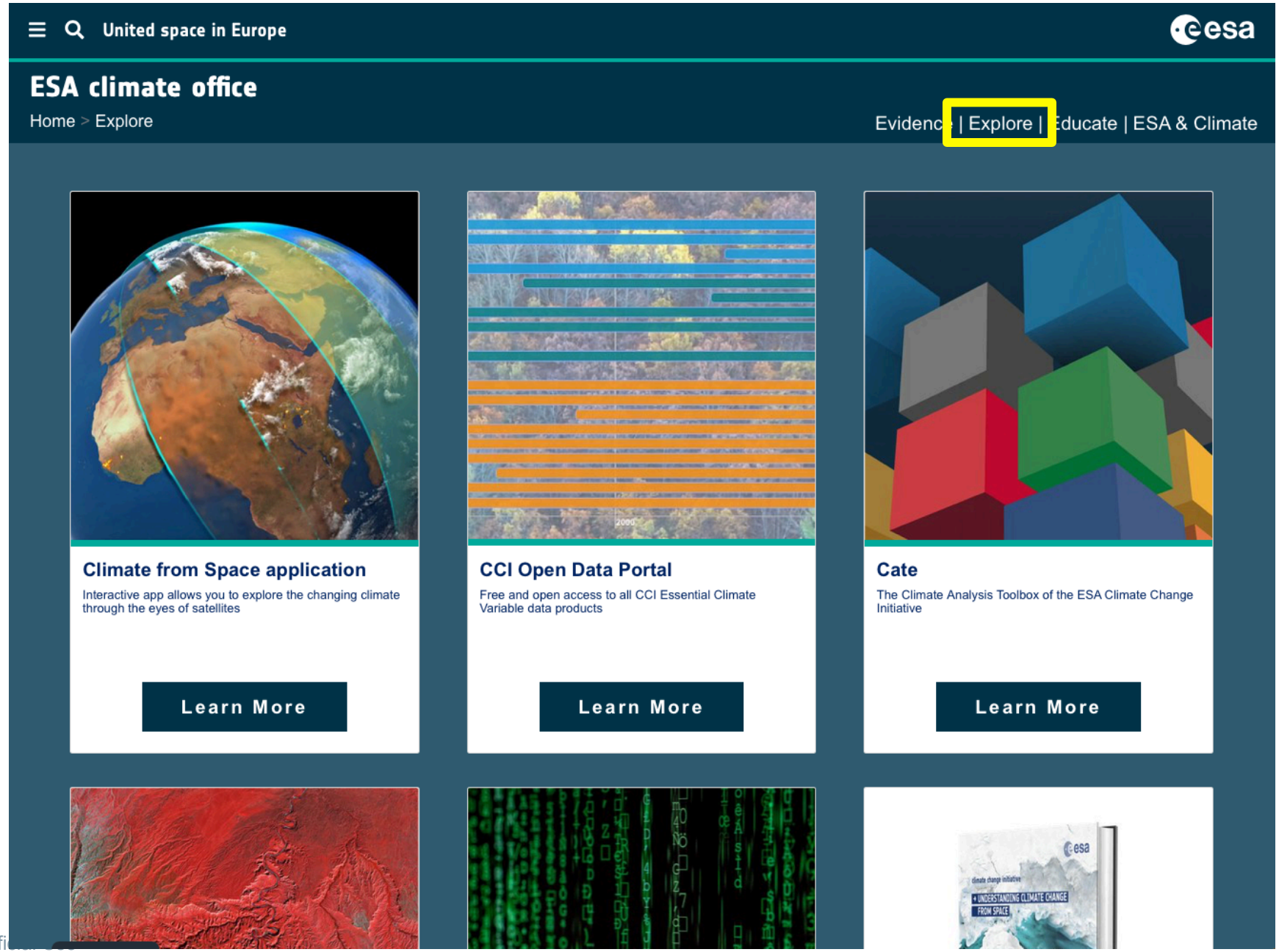
What is Climate Change?
Putting current climate change into context and how society is responding
Learn More
Climate change: the evidence from space
Satellites provide crucial lines of evidence for climate change
Learn More
Role of EO in Understanding Climate Change
Satellites have a unique vantage point for capturing change across the Earth system
Learn More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Climate from Space application
Interactive app allows you to explore the changing climate through the eyes of satellites
Learn More
CCI Open Data Portal
Free and open access to all CCI Essential Climate Variable data products
Learn More
Cate
The Climate Analysis Toolbox of the ESA Climate Change Initiative
Learn More

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Home > Educate

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Climate for Schools

Teaching resource packs from the Climate Change Initiative

Learn More

Climate for Science Excellence

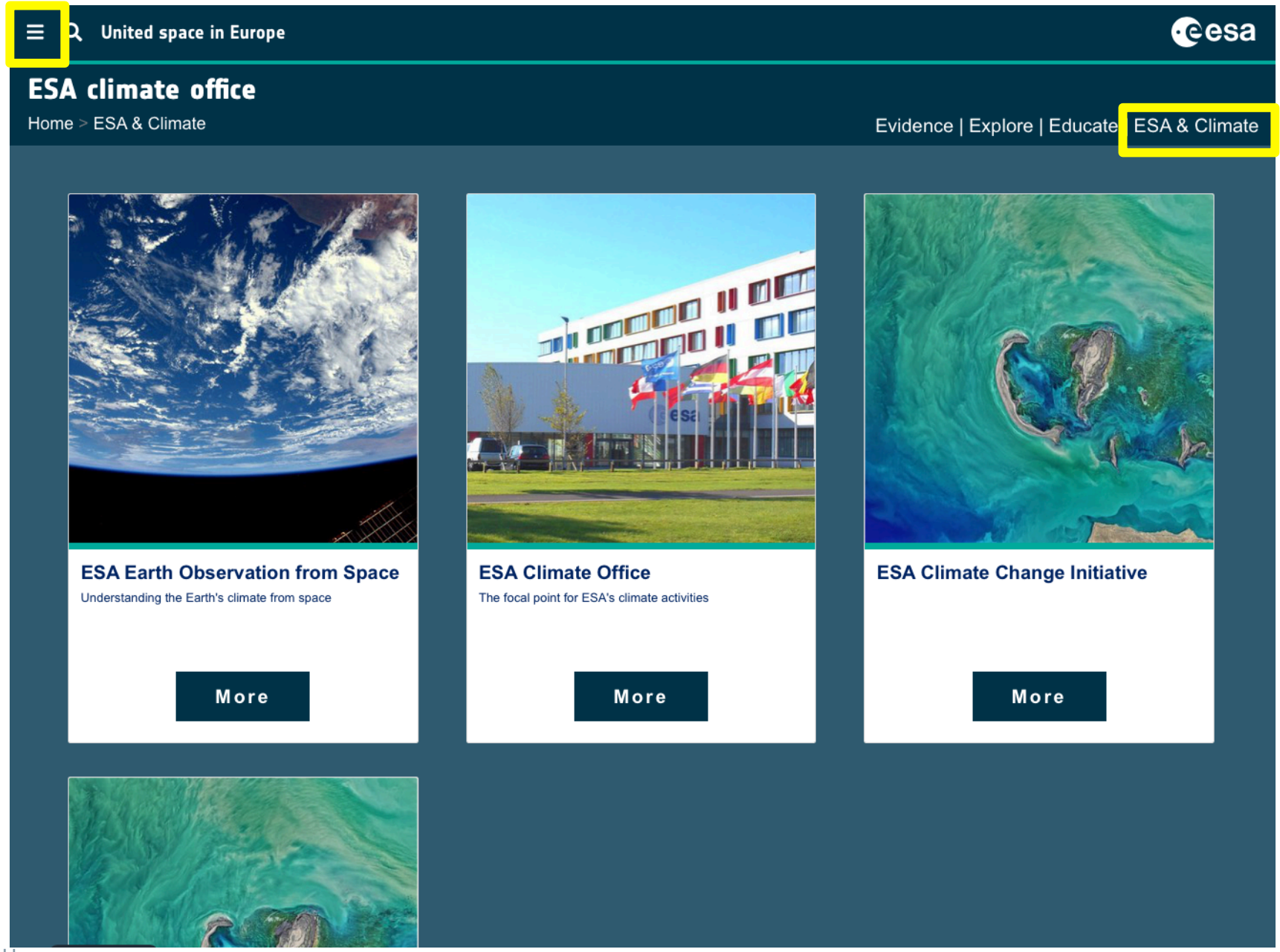
Massive Online Open Courses, Summer Schools & Training for learners at MSc & BSc levels

Learn More

Climate For The Public

Playful games to understand climate change and the role of satellite data in monitoring it

Learn More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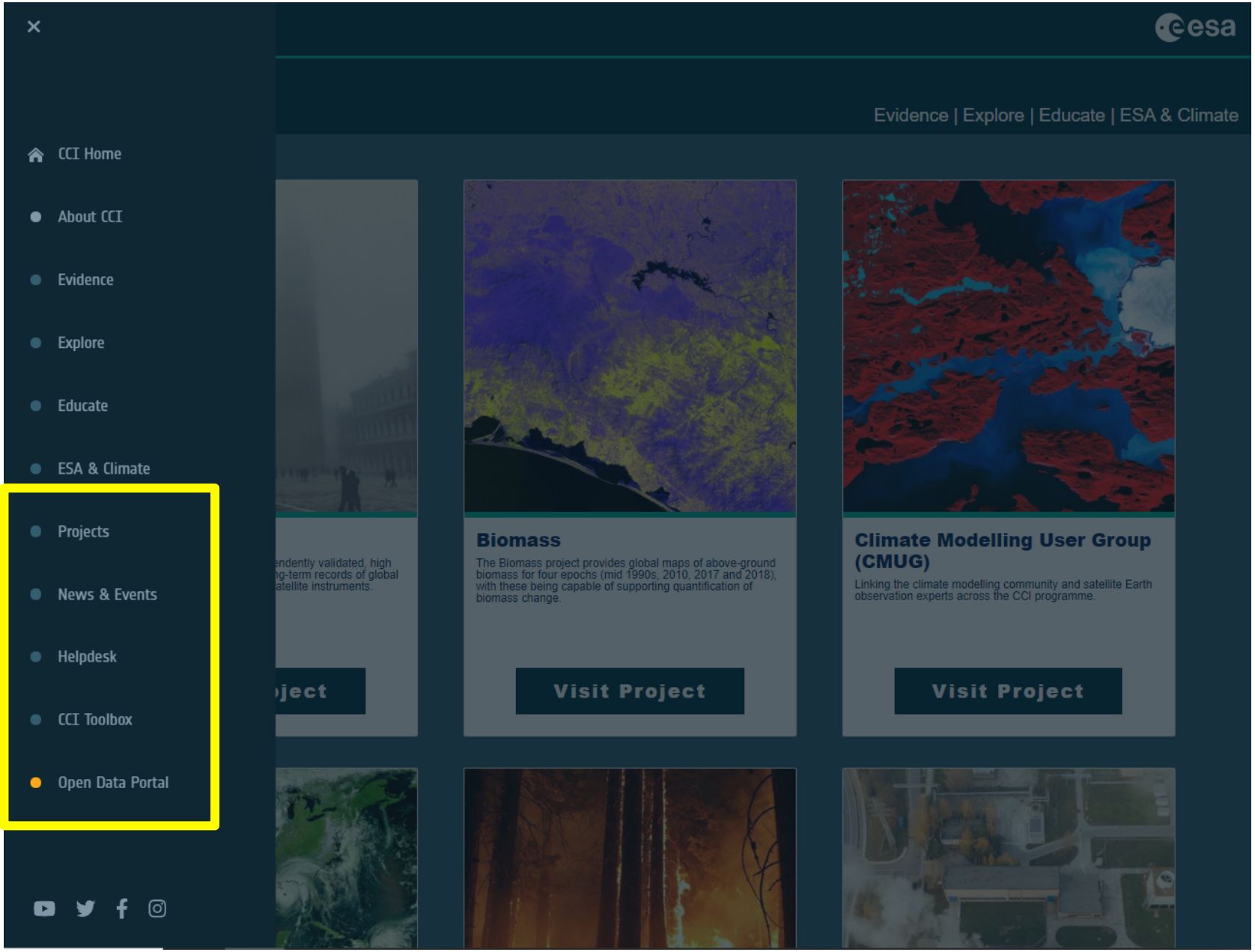
ESA & Climate
ESA Earth Observation from Space
Understanding the Earth's climate from space
More
ESA Climate Office
The focal point for ESA's climate activities
More
ESA Climate Change Initiative
More


CCI Home
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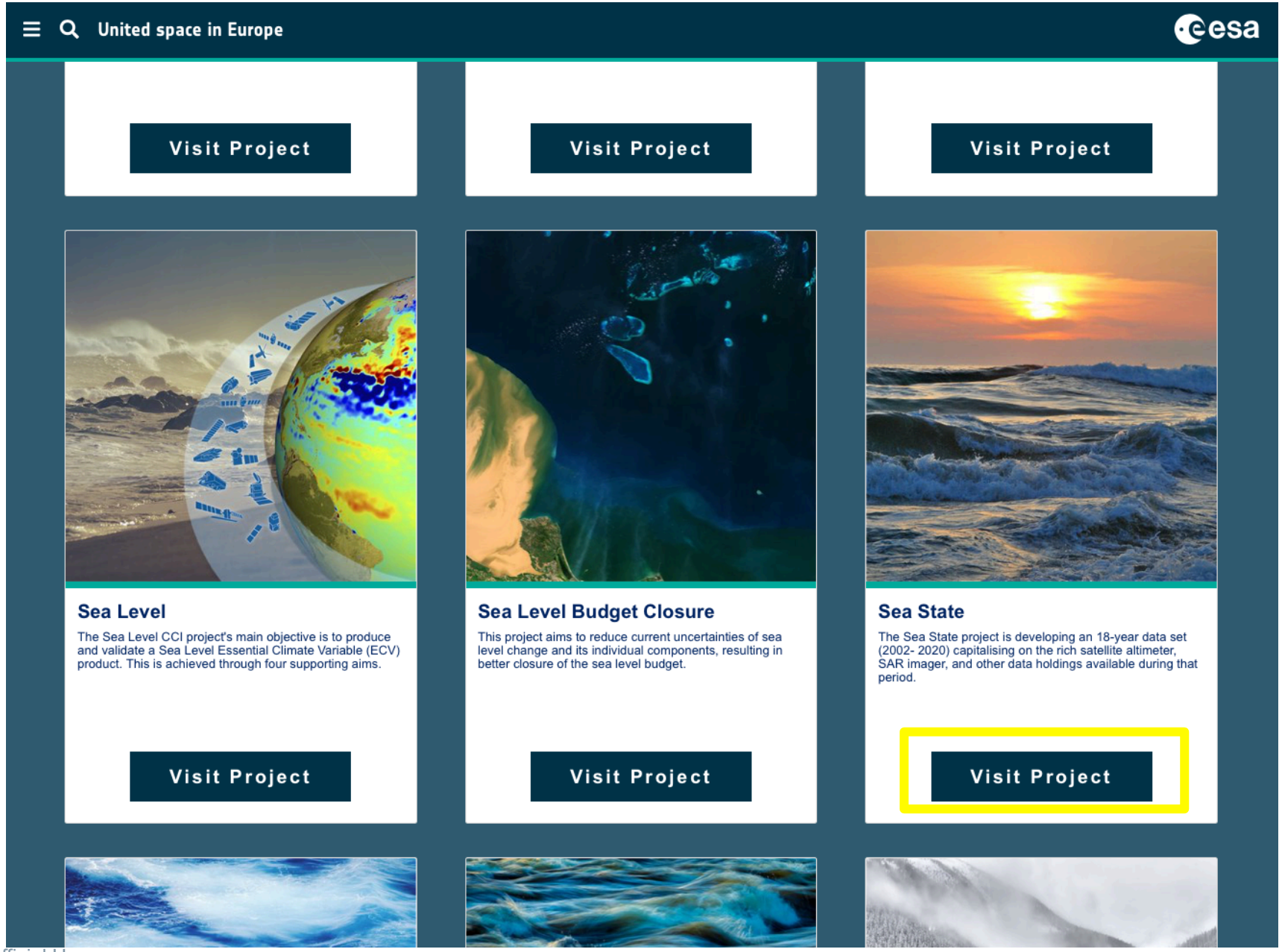
Educate
ESA & Climate
Projects
News & Events
Helpdesk
CCI Toolbox
Open Data Portal
Evidence | Explore | Educate | ESA & Climate
Biomass
The Biomass project provides global maps of above-ground biomass for four epochs (mid 1990s, 2010, 2017 and 2018), with these being capable of supporting quantification of biomass change.
Visit Project
Climate Modelling User Group (CMUG)
Linking the climate modelling community and satellite Earth observation experts across the CCI programme.
Visit Project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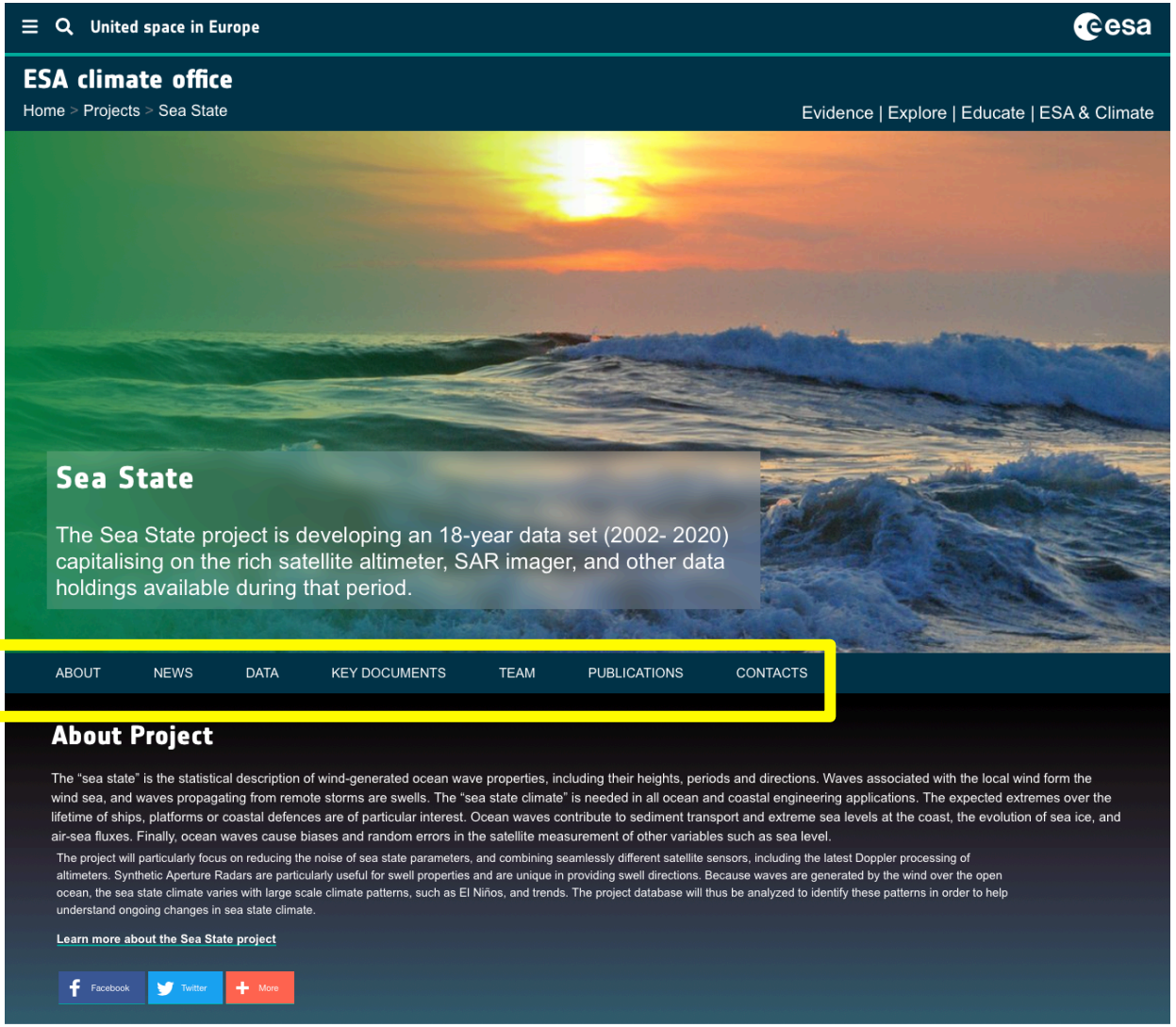
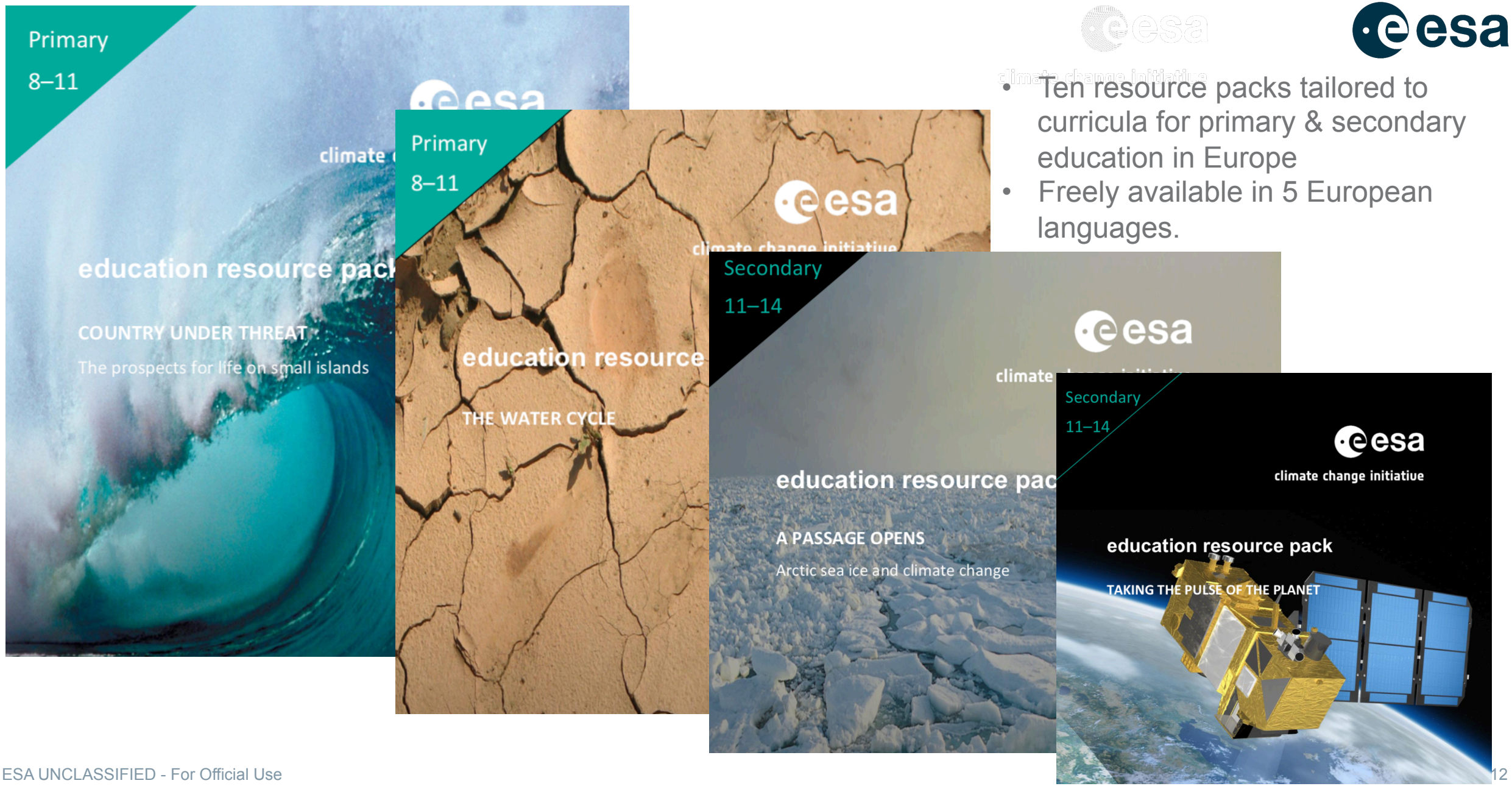
esa
Visit Project
Visit Project
Visit Project
Sea Level
The Sea Level CCI project's main objective is to produce and validate a Sea Level Essential Climate Variable (ECV) product. This is achieved through four supporting aims.
Visit Project
Sea Level Budget Closure
This project aims to reduce current uncertainties of sea level change and its individual components, resulting in better closure of the sea level budget.
Visit Project
Sea State
The Sea State project is developing an 18-year data set (2002- 2020) capitalising on the rich satellite altimeter, SAR imager, and other data holdings available during that period.
Visit Project


United space in Europe
esa
ESA climate office
Home > Projects > Sea State
Evidence | Explore | Educate | ESA & Climate
Sea State
The Sea State project is developing an 18-year data set (2002- 2020) capitalising on the rich satellite altimeter, SAR imager, and other data holdings available during that period.
ABOUT
NEWS
DATA
KEY DOCUMENTS
TEAM
PUBLICATIONS
CONTACTS
About Project
The "sea state" is the statistical description of wind-generated ocean wave properties, including their heights, periods and directions. Waves associated with the local wind form the wind sea, and waves propagating from remote storms are swells. The "sea state climate" is needed in all ocean and coastal engineering applications. The expected extremes over the lifetime of ships, platforms or coastal defences are of particular interest. Ocean waves contribute to sediment transport and extreme sea levels at the coast, the evolution of sea ice, and air-sea fluxes. Finally, ocean waves cause biases and random errors in the satellite measurement of other variables such as sea level.
The project will particularly focus on reducing the noise of sea state parameters, and combining seamlessly different satellite sensors, including the latest Doppler processing of altimeters. Synthetic Aperture Radars are particularly useful for swell properties and are unique in providing swell directions. Because waves are generated by the wind over the open ocean, the sea state climate varies with large scale climate patterns, such as El Niños, and trends. The project database will thus be analyzed to identify these patterns in order to help understand ongoing changes in sea state climate.
Learn more about the Sea State project
Facebook
Twitter
More
Sea State latest news & events

New CCI Educational Material

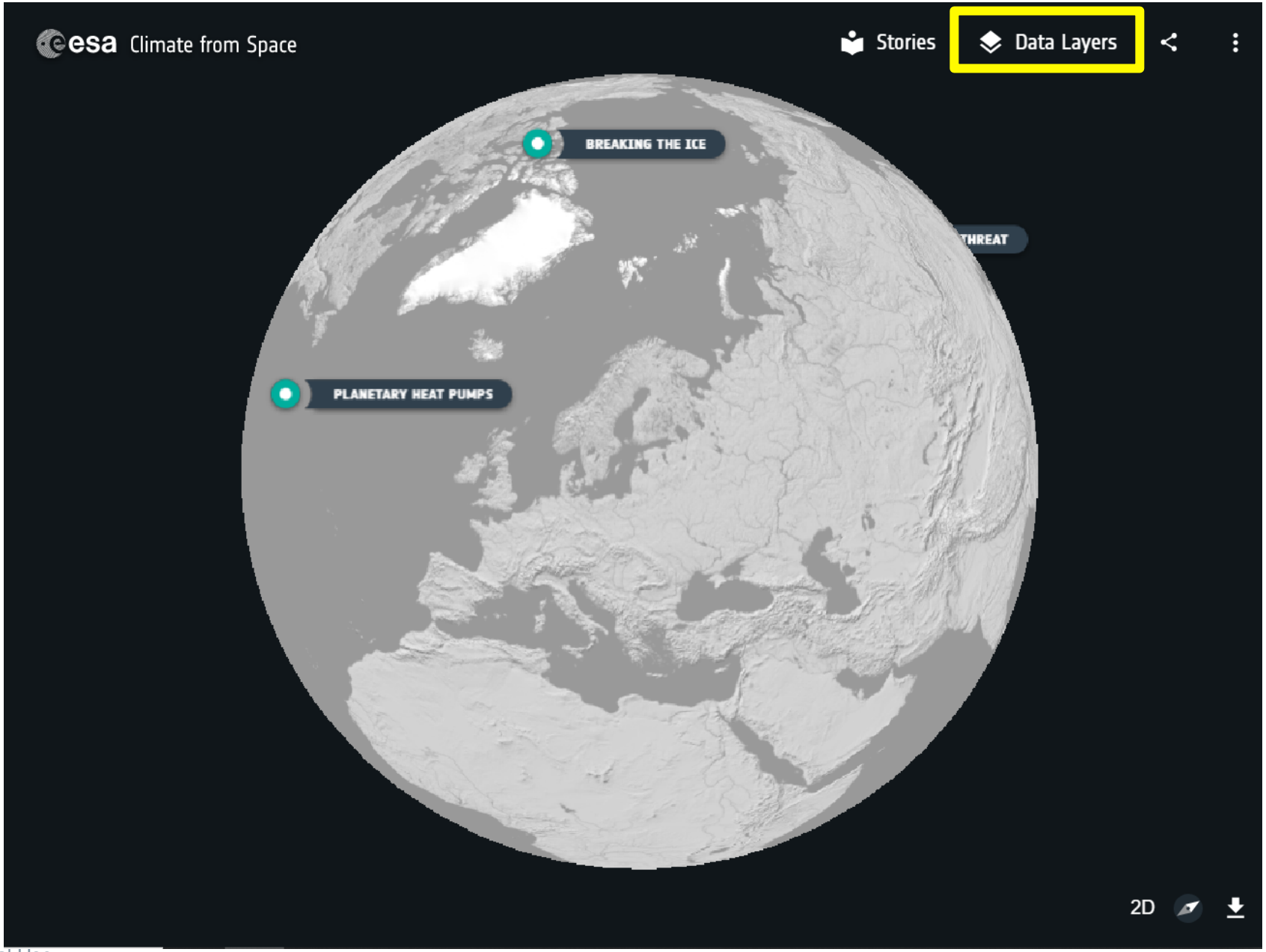
https://climate.esa.int/en/educate/climate-for-schools/

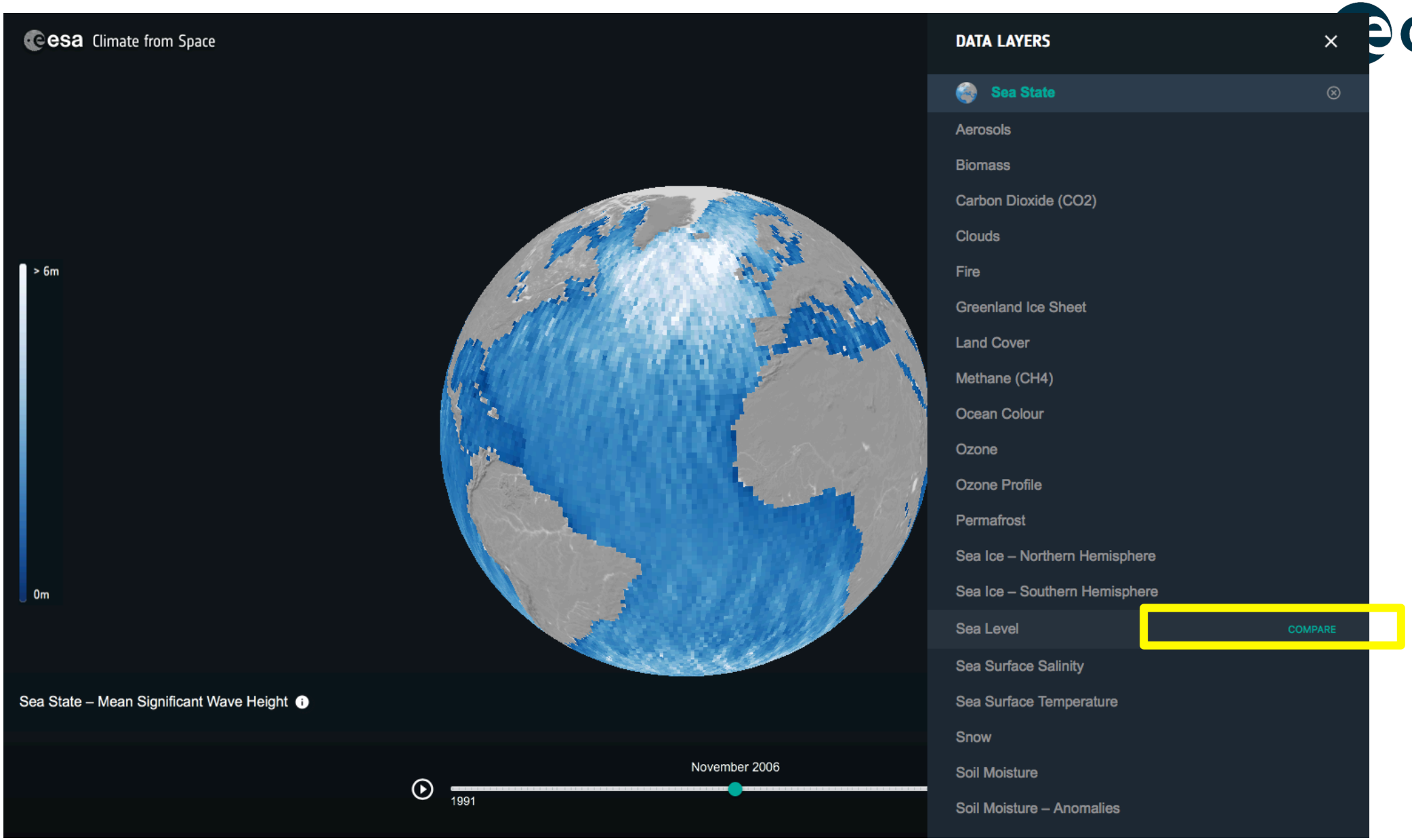


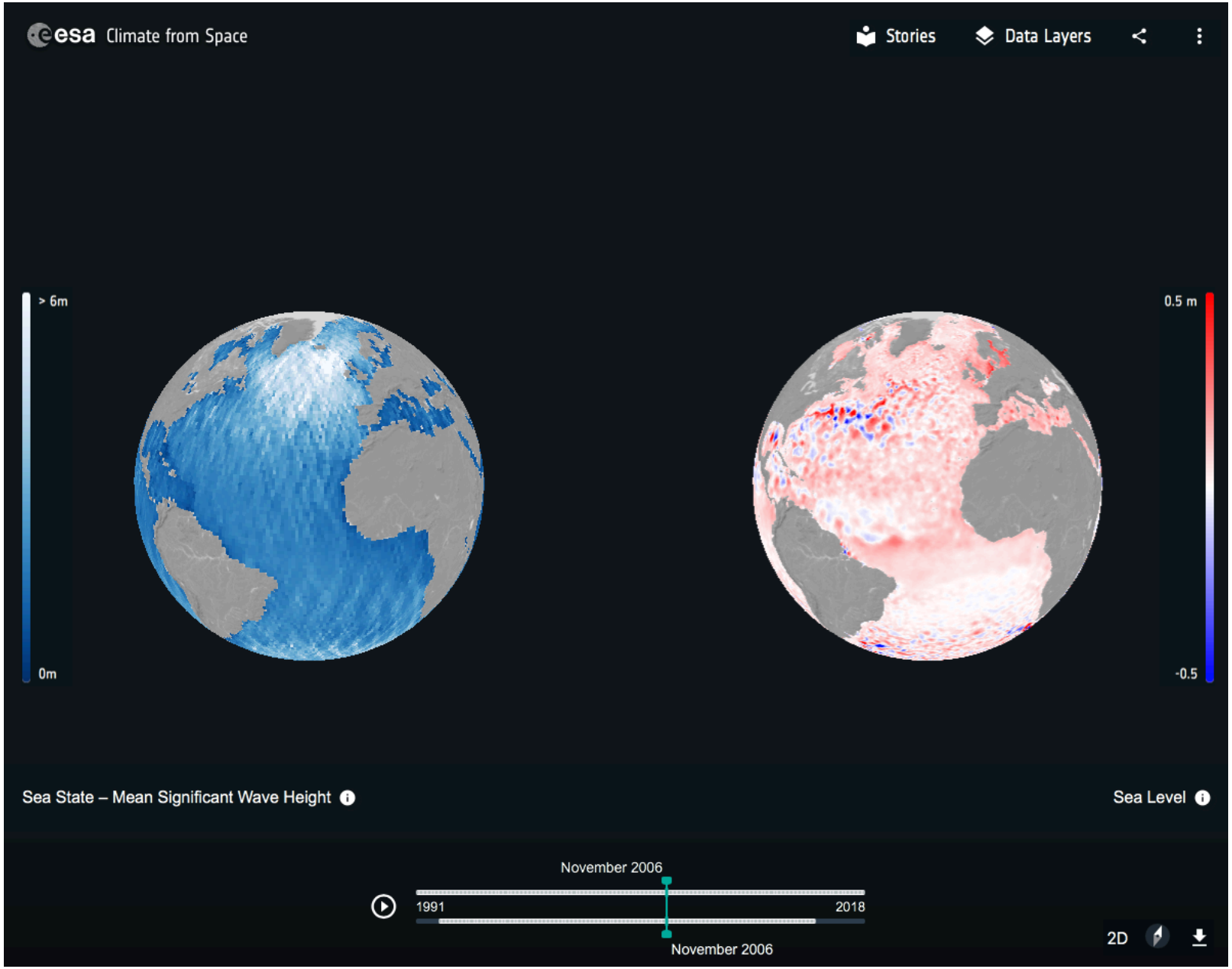
- Ten resource packs tailored to curricula for primary & secondary education in Europe
- Freely available in 5 European languages.

Climate from Space web-app

https://cfs.climate.esa.int/


esa Climate from Space
Stories
Data Layers
BREAKING THE ICE
THREAT
PLANETARY HEAT PUMPS
2D


esa Climate from Space
DATA LAYERS
Sea State
Aerosols
Biomass
Carbon Dioxide (CO2)
Clouds
Fire
Greenland Ice Sheet
Land Cover
Methane (CH4)
Ocean Colour
Ozone
Ozone Profile
Permafrost
Sea Ice – Northern Hemisphere
Sea Ice – Southern Hemisphere
Sea Level
COMPARE
Sea Surface Salinity
Sea Surface Temperature
Snow
Soil Moisture
Soil Moisture – Anomalies
> 6m
0m
Sea State – Mean Significant Wave Height
November 2006
1991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Stories
Data Layers
> 6m
0m
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-0.5
Sea State – Mean Significant Wave Height
Sea Level
November 2006
1991
2018
November 2006
2D


esa Climate from Space
Stories
Data Layers
BREAKING THE ICE
THREAT
PLANETARY HEAT PUMPS
2D

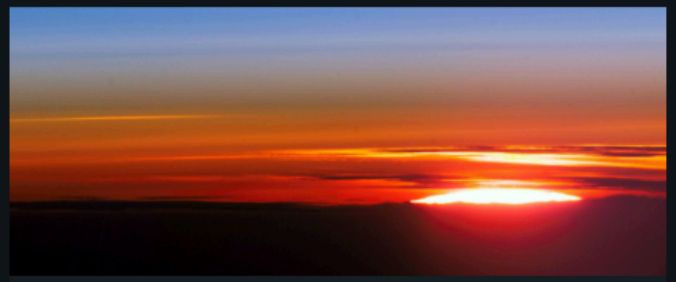
← Back to Data Mode

STORIES

LAND SURFACE TEMPERATURE | SOIL MOISTURE | FIRE | SATELLITE ORBITS | SENSORS | ELECTROMAGNETIC SPECTRUM | CLIMATE MODELLING | GEOSTATIONAR | Reset Filters

Planetary Heat Pumps

SEA SURFACE TEMPERATURE | SEA ICE | OCEAN COLOUR | +1



Is Ozone Good or Bad?

OZONE | AEROSOL

Breaking the Ice

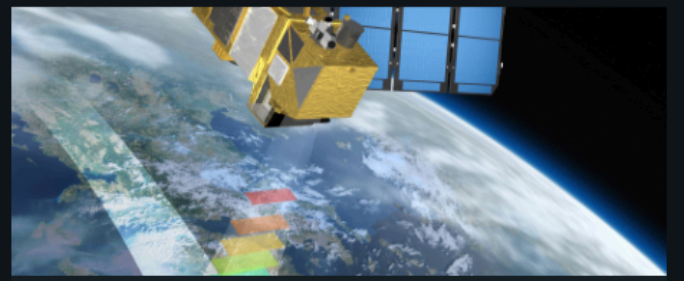
SEA ICE | SEA SURFACE TEMPERATURE | SEA SURFACE SALINITY | +2

Coasts Under Threat

SEA LEVEL | SEA SURFACE TEMPERATURE | GLACIERS | +1

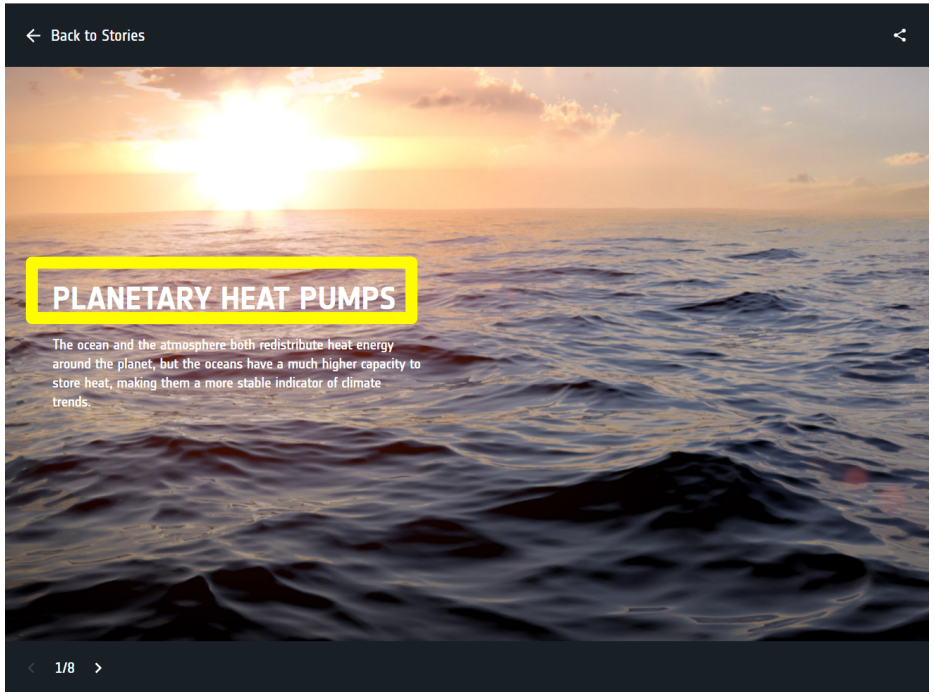
Biodiversity and Habitat Loss

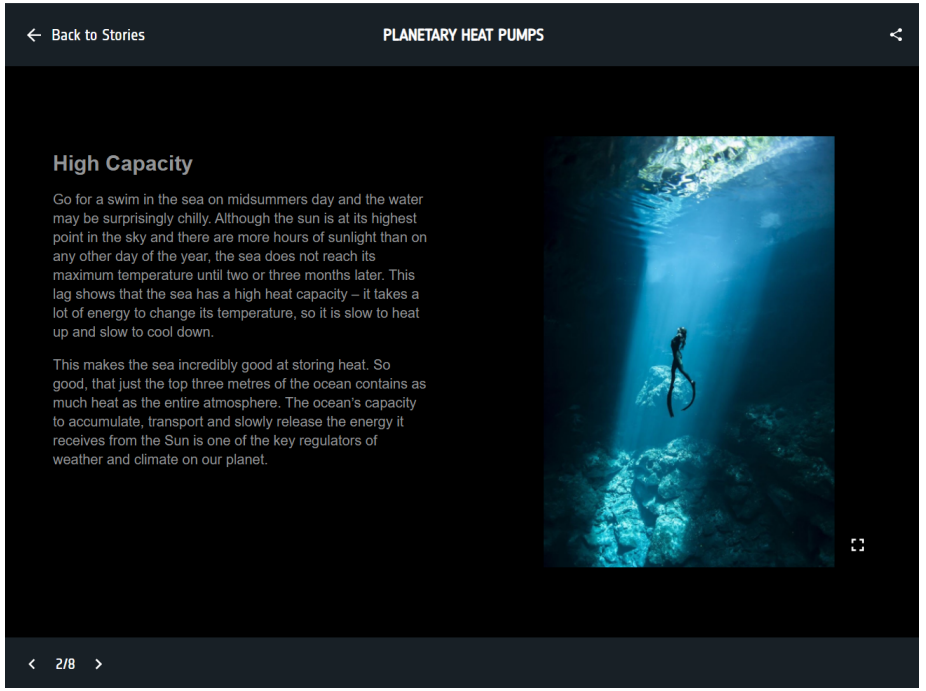
LANDCOVER | HR LANDCOVER | LAND SURFACE TEMPERATURE | +3



Taking the Pulse of the Planet

SATELLITE ORBITS | SENSORS | ELECTROMAGNETIC SPECTRUM | +2


Back to Stories
PLANETARY HEAT PUMPS
The ocean and the atmosphere both redistribute heat energy around the planet, but the oceans have a much higher capacity to store heat, making them a more stable indicator of climate trends.
1/8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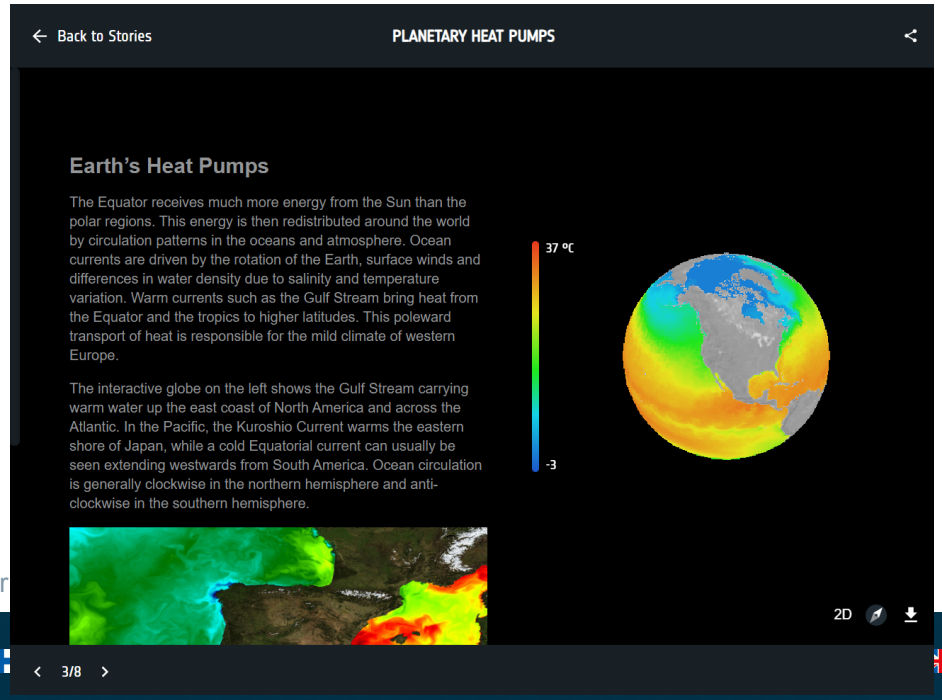
PLANETARY HEAT PUMPS
High Capacity
Go for a swim in the sea on midsummers day and the water may be surprisingly chilly. Although the sun is at its highest point in the sky and there are more hours of sunlight than on any other day of the year, the sea does not reach its maximum temperature until two or three months later. This lag shows that the sea has a high heat capacity – it takes a lot of energy to change its temperature, so it is slow to heat up and slow to cool down.
This makes the sea incredibly good at storing heat. So good, that just the top three metres of the ocean contains as much heat as the entire atmosphere. The ocean's capacity to accumulate, transport and slowly release the energy it receives from the Sun is one of the key regulators of weather and climate on our planet.
2/8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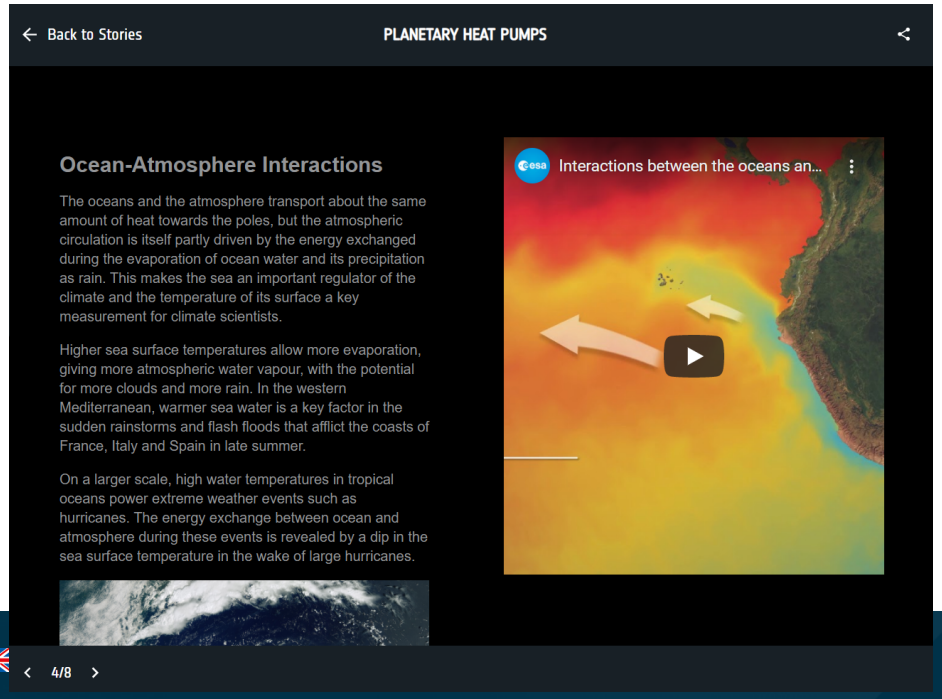
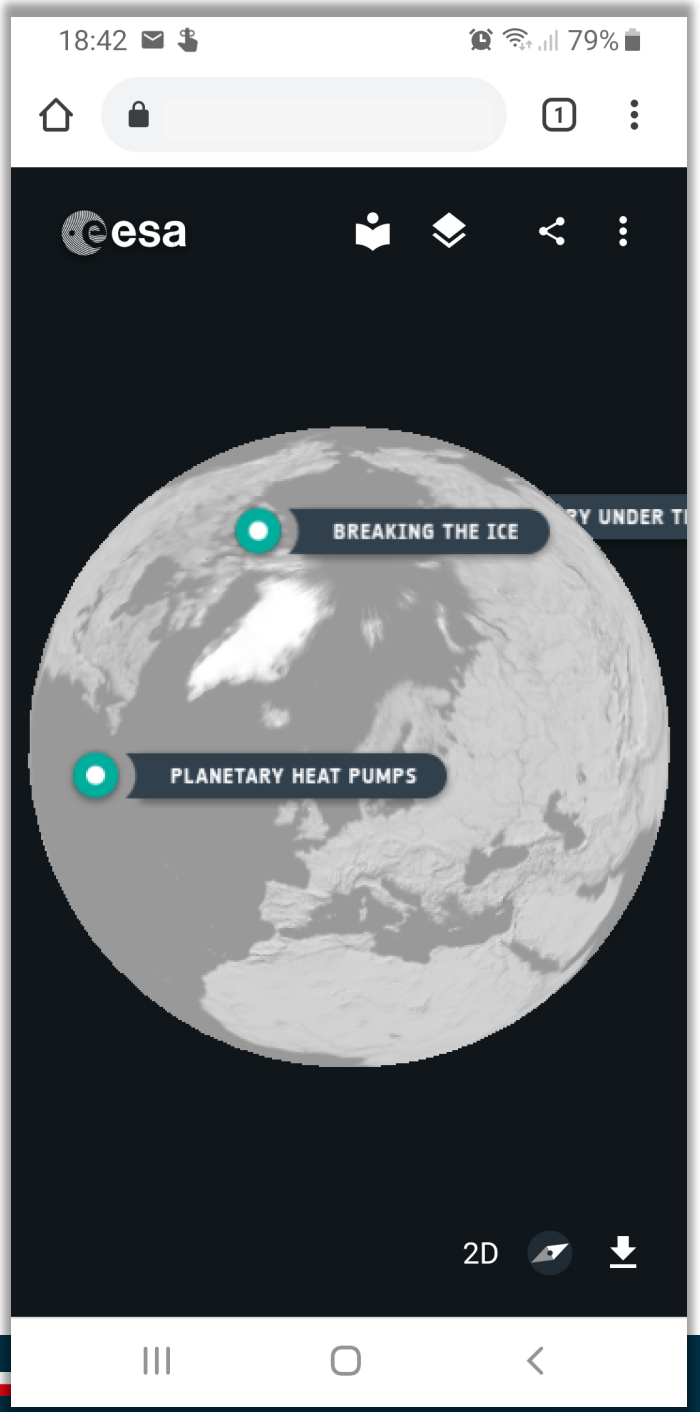
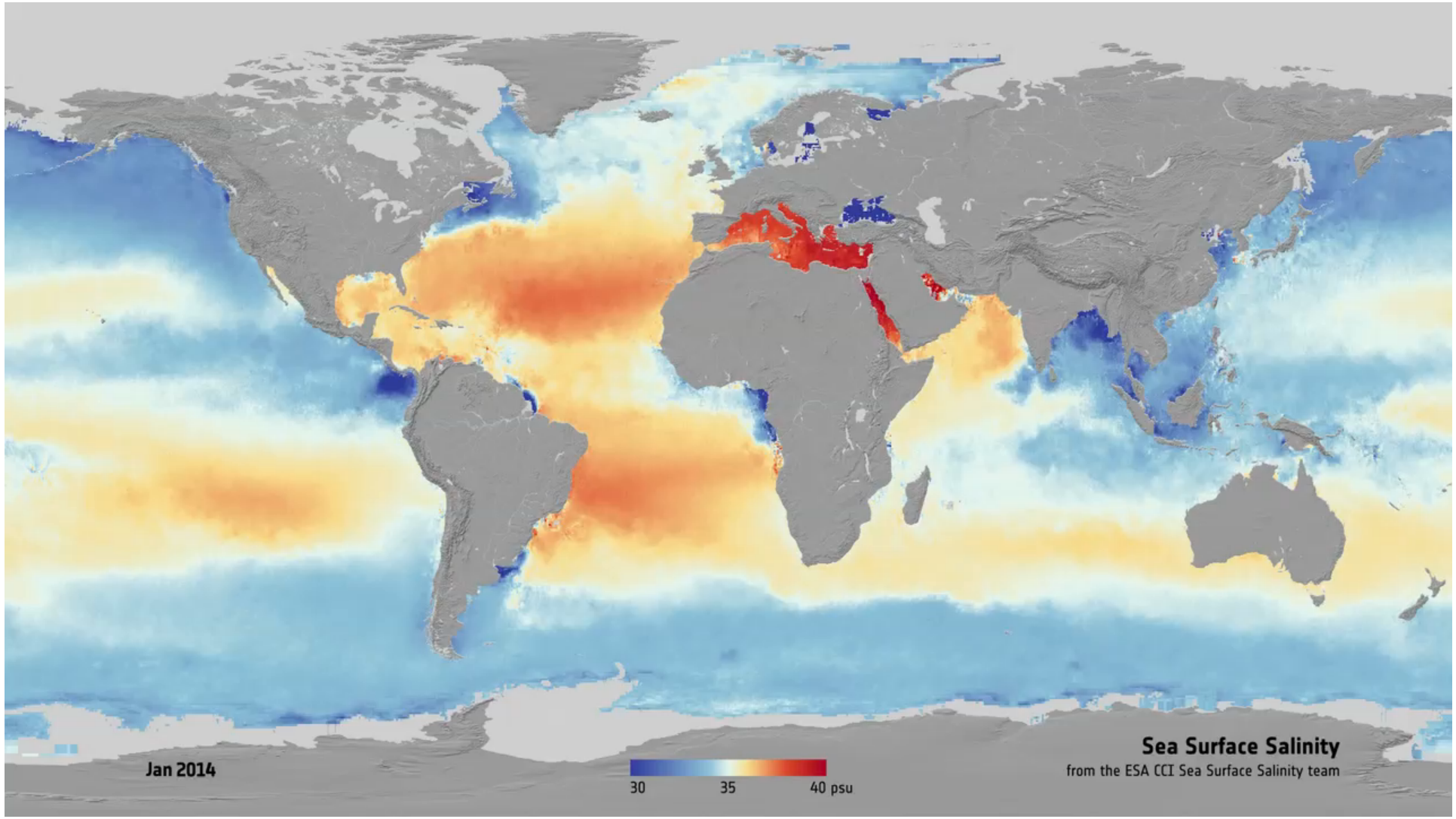
PLANETARY HEAT PUMPS
Earth's Heat Pumps
The Equator receives much more energy from the Sun than the polar regions. This energy is then redistributed around the world by circulation patterns in the oceans and atmosphere. Ocean currents are driven by the rotation of the Earth, surface winds and differences in water density due to salinity and temperature variation. Warm currents such as the Gulf Stream bring heat from the Equator and the tropics to higher latitudes. This poleward transport of heat is responsible for the mild climate of western Europe.
The interactive globe on the left shows the Gulf Stream carrying warm water up the east coast of North America and across the Atlantic. In the Pacific, the Kuroshio Current warms the eastern shore of Japan, while a cold Equatorial current can usually be seen extending westwards from South America. Ocean circulation is generally clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere.
37 °C
-3
2D
3/8


Back to Stories
PLANETARY HEAT PUMPS
Ocean-Atmosphere Interactions
The oceans and the atmosphere transport about the same amount of heat towards the poles, but the atmospheric circulation is itself partly driven by the energy exchanged during the evaporation of ocean water and its precipitation as rain. This makes the sea an important regulator of the climate and the temperature of its surface a key measurement for climate scientists.
Higher sea surface temperatures allow more evaporation, giving more atmospheric water vapour, with the potential for more clouds and more rain. In the western Mediterranean, warmer sea water is a key factor in the sudden rainstorms and flash floods that afflict the coasts of France, Italy and Spain in late summer.
On a larger scale, high water temperatures in tropical oceans power extreme weather events such as hurricanes. The energy exchange between ocean and atmosphere during these events is revealed by a dip in the sea surface temperature in the wake of large hurricanes.
Interactions between the oceans an...
4/8



Fit for mobile devices

Graphics & Animations


Jan 2014
30
35
40 psu
Sea Surface Salinity
from the ESA CCI Sea Surface Salinity team

Animation topics

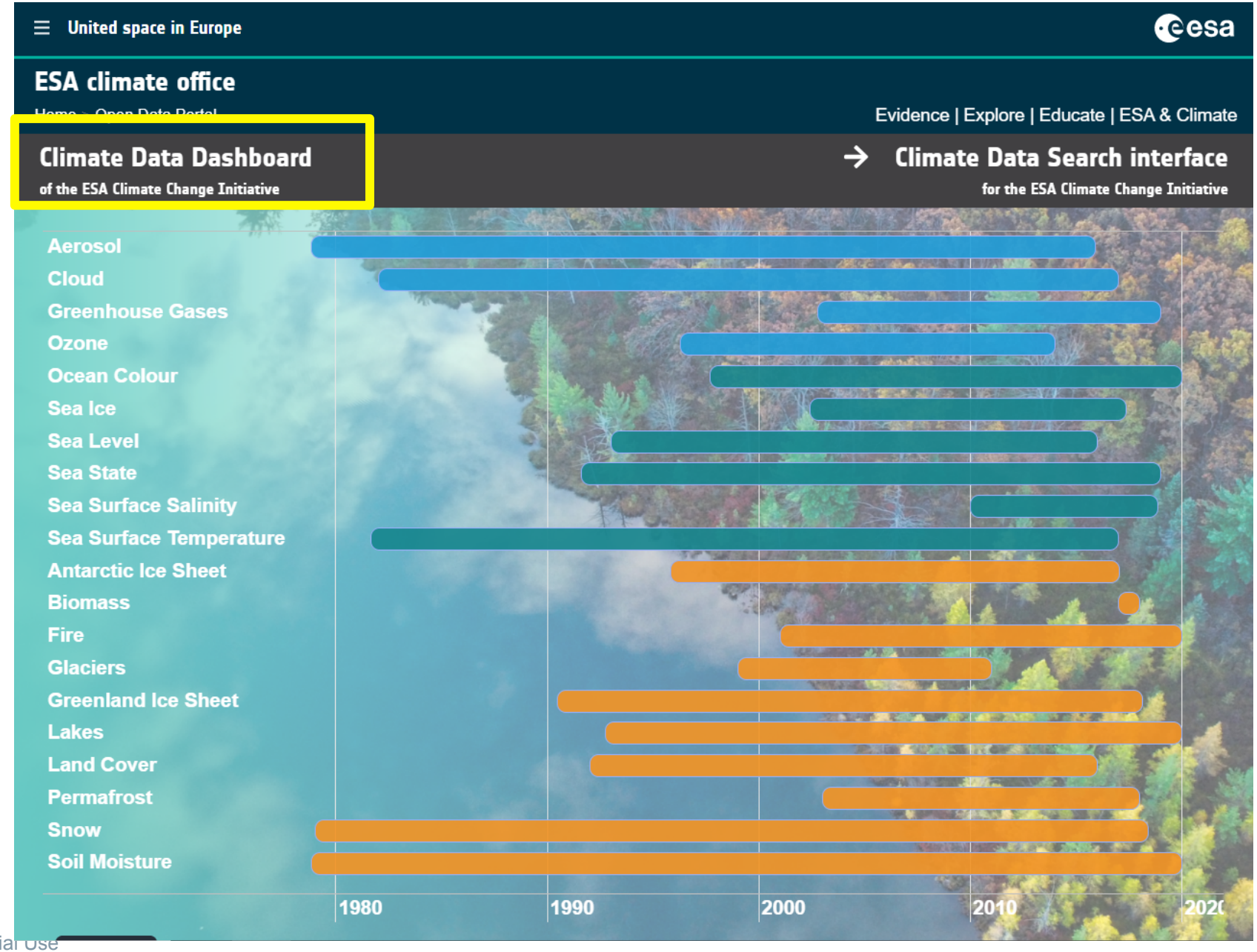
- In support of CfS stories
- In support of Educational activities
- To support outreach generally and cover gaps not previously covered

1. **Electromagnetic Spectrum** – a look at Earth in different wavelengths
2. **Change in the Arctic** – tour of change, how we measure sea ice & ice sheet thickness & extent as slab view
3. **Coasts under threat** – DTMs & satellite imagery of coasts, includes sea state use at coasts (flood defence)
4. **Water Cycle** – follows a water drop, includes energy exchanges with computer graphics
5. **Land Ice Dynamics** – glacier flow with moving ice flow vectors and ice sheet thinning in 3D
6. **Measuring Vegetation** – includes spectral-temporal classification of vegetation for land cover, and biomass
7. **Ocean Currents** – includes sea state – a tour of the main ocean currents, their role in heat and nutrient transport.
8. **Greenhouse effect** – Graphics sequence showing how GHG warm the atmosphere, cycles and budgets.
9. **Counting Carbon** – covers ECVs for carbon stocks and atmospheric concentrations
10. **Taking the Pulse of the Planet** – how we make ECVs and why

New Open Data Portal user interface (UI)

https://climate.esa.int/en/odp/#/dashboard/

https://climate.esa.int/en/odp/#/search/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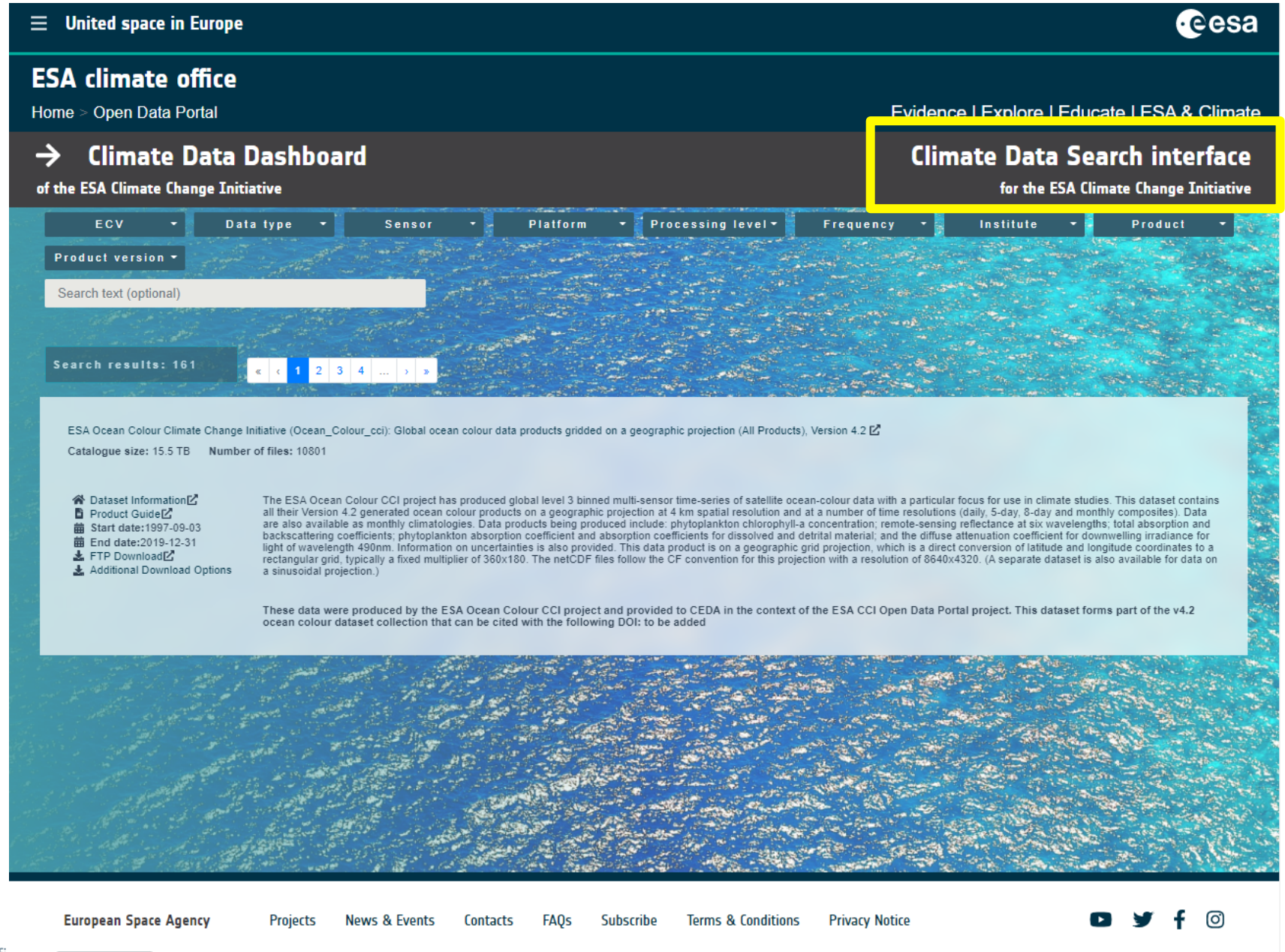
Climate Data Dashboard
of the ESA Climate Change Initiative
Climate Data Search interface
for the ESA Climate Change Initiative
Aerosol
Cloud
Greenhouse Gases
Ozone
Ocean Colour
Sea Ice
Sea Level
Sea State
Sea Surface Salinity
Sea Surface Temperature
Antarctic Ice Sheet
Biomass
Fire
Glaciers
Greenland Ice Sheet
Lakes
Land Cover
Permafrost
Snow
Soil Moisture
1980
1990
2000
2010
2020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Climate Data Dashboard
of the ESA Climate Change Initiative
Climate Data Search interface
for the ESA Climate Change Initiative
ECV
Data type
Sensor
Platform
Processing level
Frequency
Institute
Product
Product version
Search text (optional)
Search results: 161
« ‹ 1 2 3 4 ... › »
ESA Ocean Colour Climate Change Initiative (Ocean_Colour_cci): Global ocean colour data products gridded on a geographic projection (All Products), Version 4.2
Catalogue size: 15.5 TB
Number of files: 10801
Dataset Information
Product Guide
Start date:1997-09-03
End date:2019-12-31
FTP Download
Additional Download Options
The ESA Ocean Colour CCI project has produced global level 3 binned multi-sensor time-series of satellite ocean-colour data with a particular focus for use in climate studies. This dataset contains all their Version 4.2 generated ocean colour products on a geographic projection at 4 km spatial resolution and at a number of time resolutions (daily, 5-day, 8-day and monthly composites). Data are also available as monthly climatologies. Data products being produced include: phytoplankton chlorophyll-a concentration; remote-sensing reflectance at six wavelengths; total absorption and backscattering coefficients; phytoplankton absorption coefficient and absorption coefficients for dissolved and detrital material; and the diffuse attenuation coefficient for downwelling irradiance for light of wavelength 490nm. Information on uncertainties is also provided. This data product is on a geographic grid projection, which is a direct conversion of latitude and longitude coordinates to a rectangular grid, typically a fixed multiplier of 360x180. The netCDF files follow the CF convention for this projection with a resolution of 8640x4320. (A separate dataset is also available for data on a sinusoidal projection.)
These data were produced by the ESA Ocean Colour CCI project and provided to CEDA in the context of the ESA CCI Open Data Portal project. This dataset forms part of the v4.2 ocean colour dataset collection that can be cited with the following DOI: to be added
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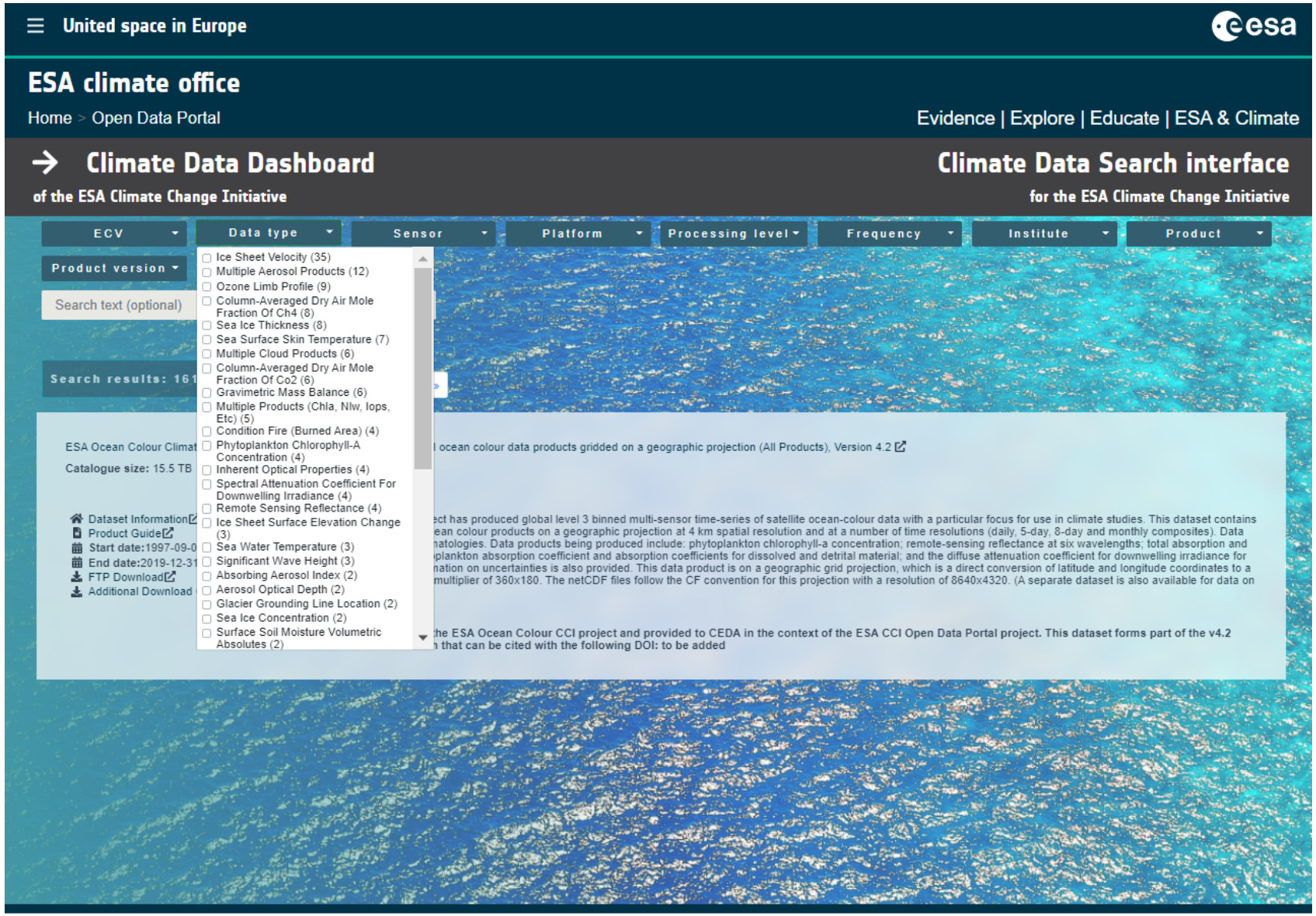
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of the ESA Climate Change Initiative
Climate Data Search interface
for the ESA Climate Change Initiative
ECV
Data type
Sensor
Platform
Processing level
Frequency
Institute
Product
Product version
Search text (optional)
Search results: 161
Ice Sheet Velocity (35)
Multiple Aerosol Products (12)
Ozone Limb Profile (9)
Column-Averaged Dry Air Mole Fraction Of Ch4 (8)
Sea Ice Thickness (8)
Sea Surface Skin Temperature (7)
Multiple Cloud Products (6)
Column-Averaged Dry Air Mole Fraction Of Co2 (6)
Gravimetric Mass Balance (6)
Multiple Products (Chla, Nlw, Iops, Etc) (5)
Condition Fire (Burned Area) (4)
Phytoplankton Chlorophyll-A Concentration (4)
Inherent Optical Properties (4)
Spectral Attenuation Coefficient For Downwelling Irradiance (4)
Remote Sensing Reflectance (4)
Ice Sheet Surface Elevation Change (3)
Sea Water Temperature (3)
Significant Wave Height (3)
Absorbing Aerosol Index (2)
Aerosol Optical Depth (2)
Glacier Grounding Line Location (2)
Sea Ice Concentration (2)
Surface Soil Moisture Volumetric Absolutes (2)
ESA Ocean Colour Climat
Catalogue size: 15.5 TB
Dataset Information
Product Guide
Start date:1997-09-0
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FTP Download
Additional Download
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Cate Toolbox

https://cate.climate.esa.int/

A cloud-enabled computing environment to analyse, process and visualise climate data

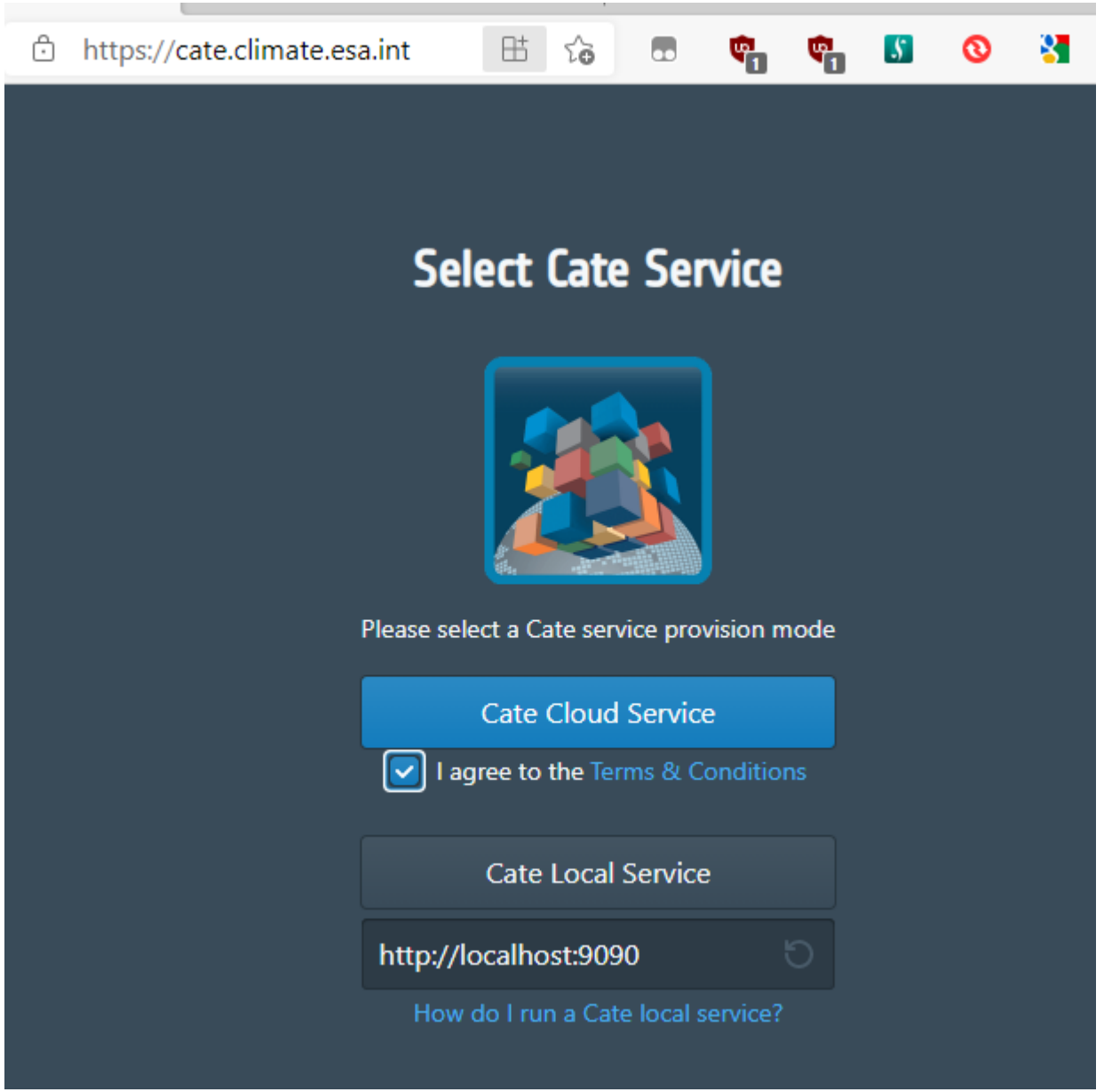
Highlights

- Easy **access** to ESA CCI and other Climate data
- Emphasis on **cross-ECV** work
- **Interactive**: Cate GUI
- **Programmatic**: pure Python, scritable & extendible
- **Embedding**: Jupyter Notebook
- Work in the **cloud**, next to CCI data, **or local** at your computing environment

Cate Demo

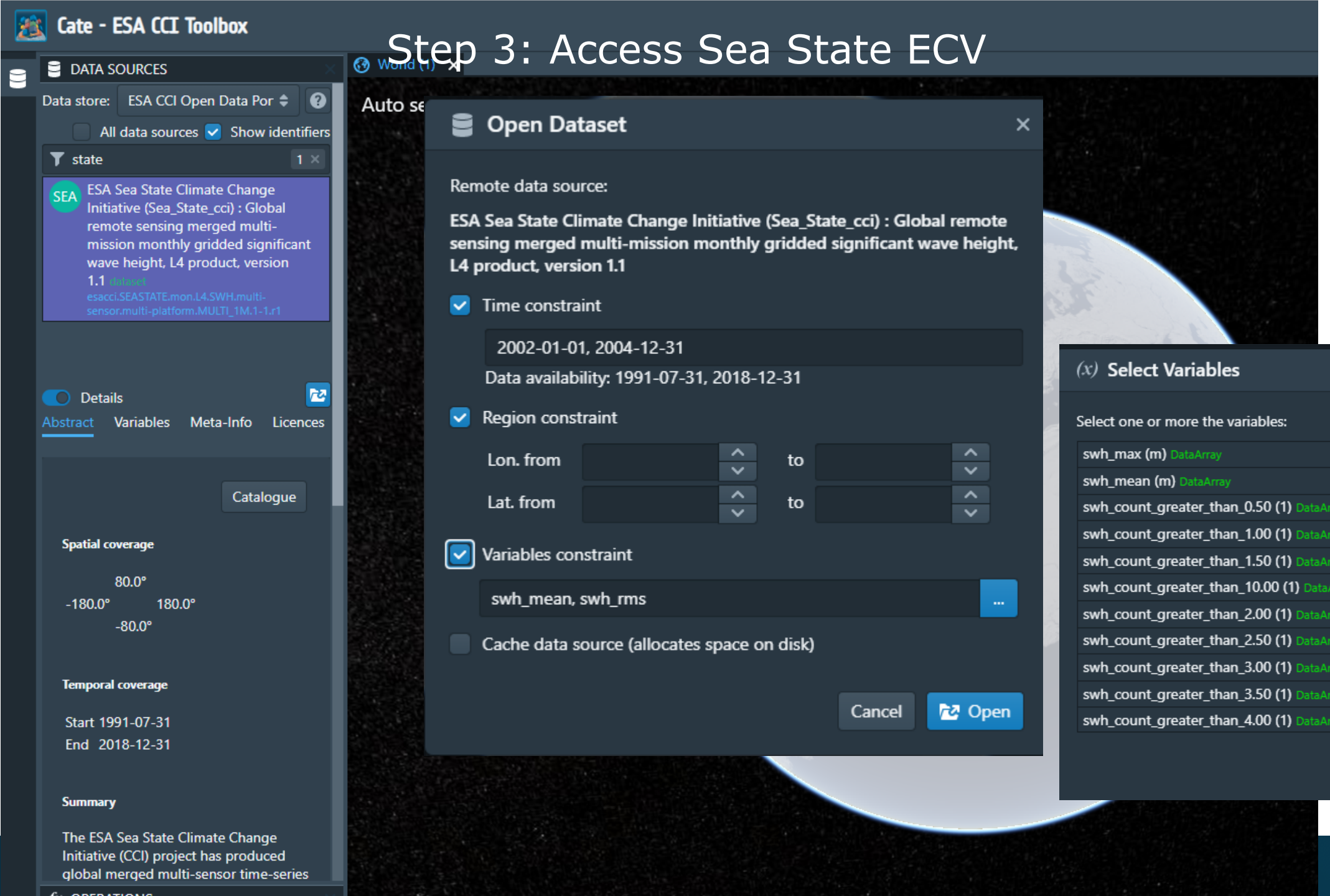
1. Start Cate WebGUI
2. Explore ESA Climate Store from Cate
3. Access Sea State ECV
4. Visualise global maps and time series
5. Manipulate data (arithmetic operation)
6. Calculate and plot stastical distribution of significant wave height and corresponding rms
7. Repeat workflow in a JupyterNB

Step 1: Start Cate



Step 2: Explore CCI Data directly from Cate

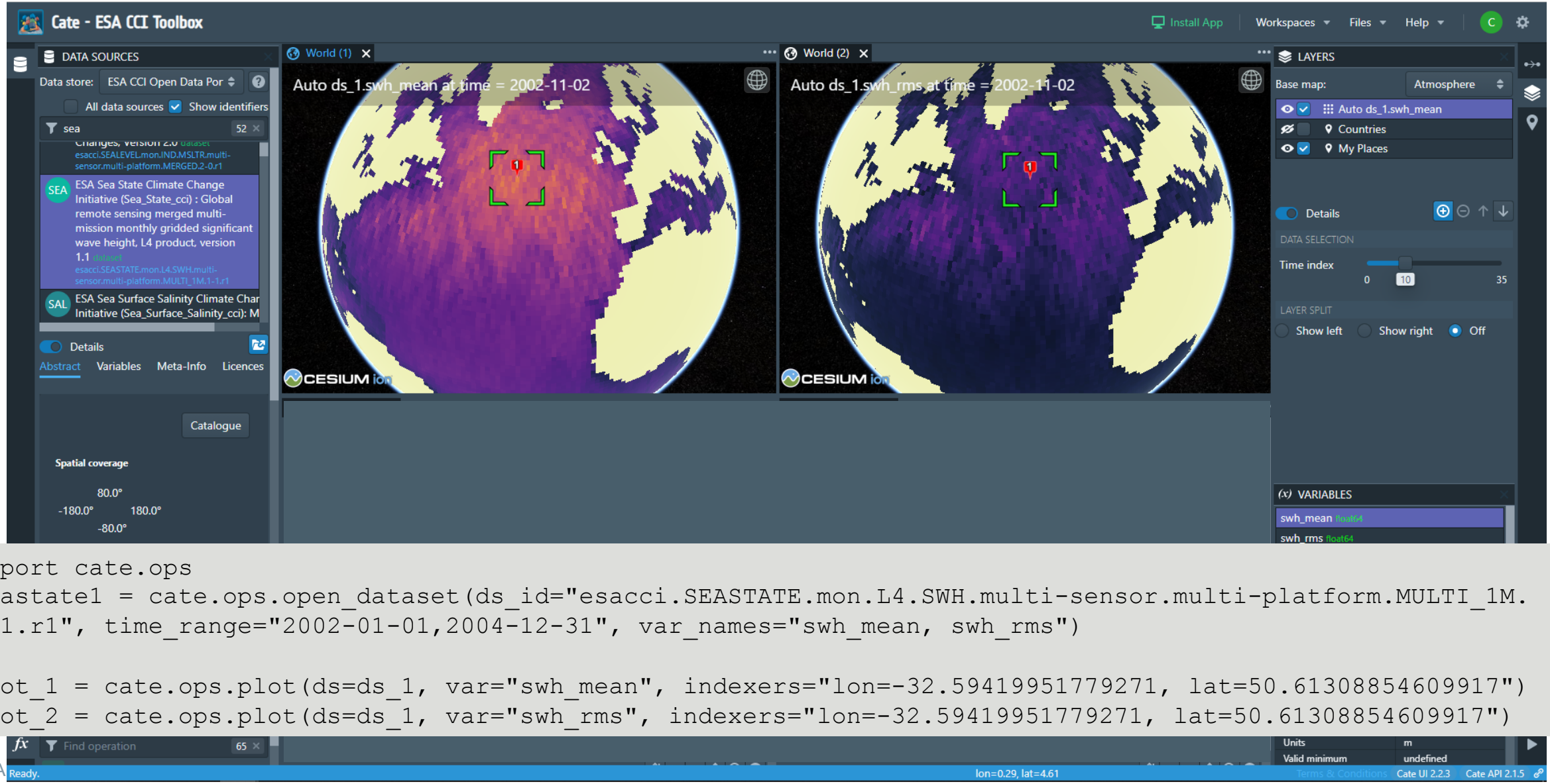
Step 3: Access Sea State ECV



Step 3: Access Sea State ECV


```
import cate.ops
seastate1 = cate.ops.open_dataset(ds_id="esacci.SEASTATE.mon.L4.SWH.multi-sensor.multi-platform.MULTI_1M.1-1.r1", time_range="2002-01-01,2004-12-31", var_names="swh_mean, swh_rms")
```

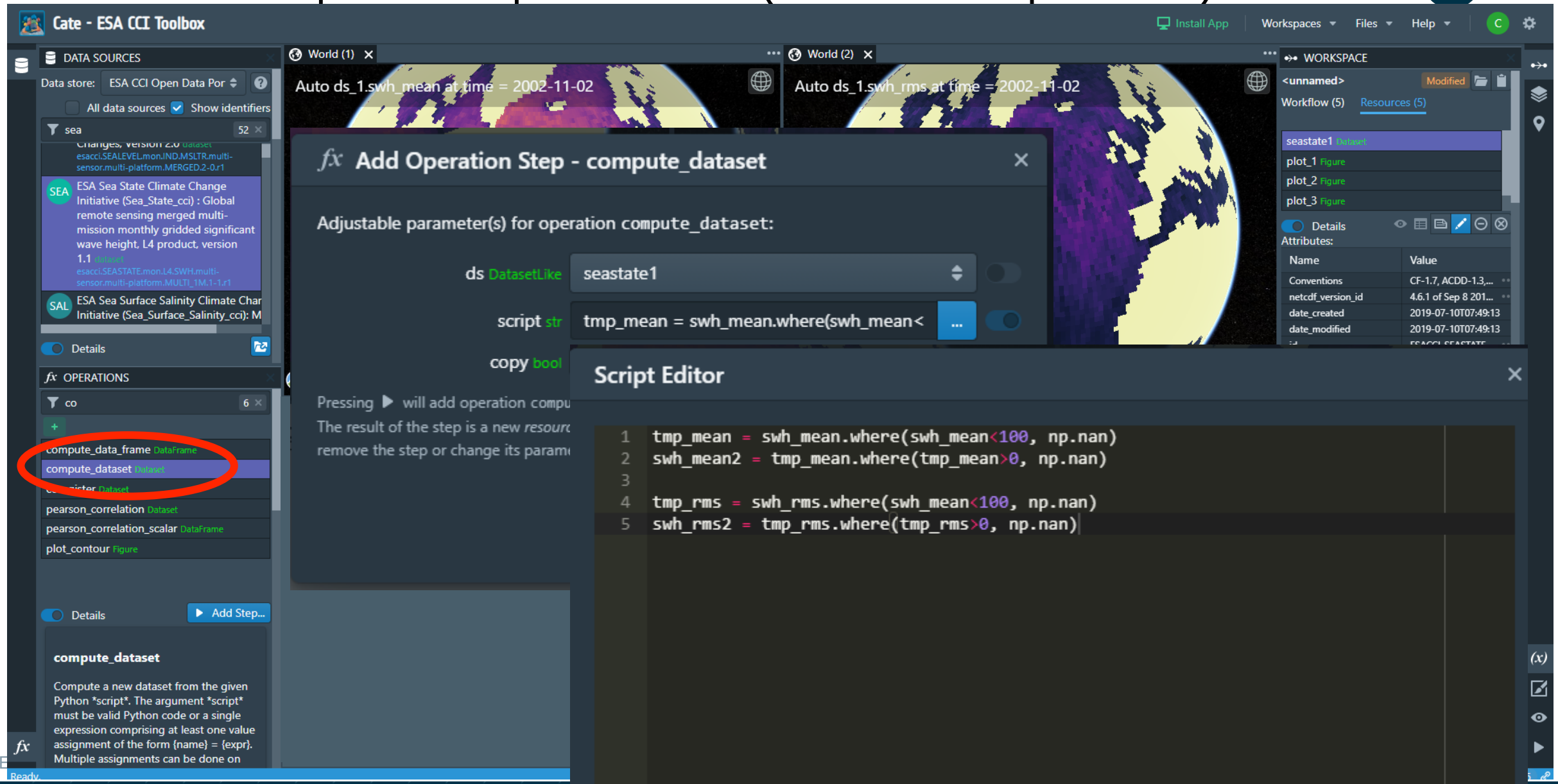
Step 4: Visualise global maps and time series



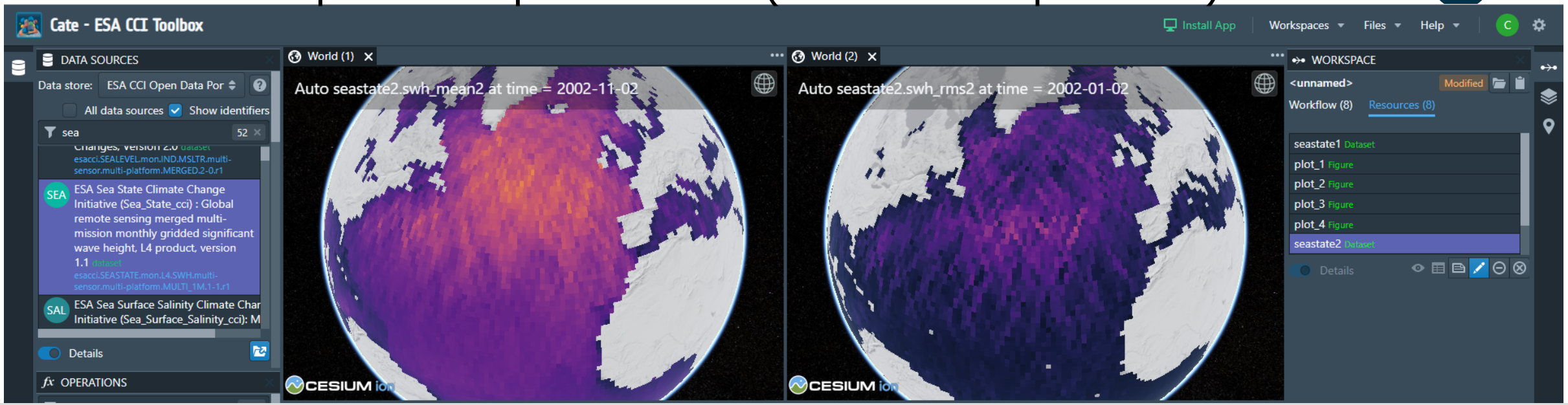

```
import cate.ops
seastate1 = cate.ops.open_dataset(ds_id="esacci.SEASTATE.mon.L4.SWH.multi-sensor.multi-platform.MULTI_1M.
1-1.r1", time_range="2002-01-01,2004-12-31", var_names="swh_mean, swh_rms")

plot_1 = cate.ops.plot(ds=ds_1, var="swh_mean", indexers="lon=-32.59419951779271, lat=50.61308854609917")
plot_2 = cate.ops.plot(ds=ds_1, var="swh_rms", indexers="lon=-32.59419951779271, lat=50.61308854609917")
```

Step 5: Manipulate data (arithmetic operation)



Step 5: Manipulate data (arithmetic operation)

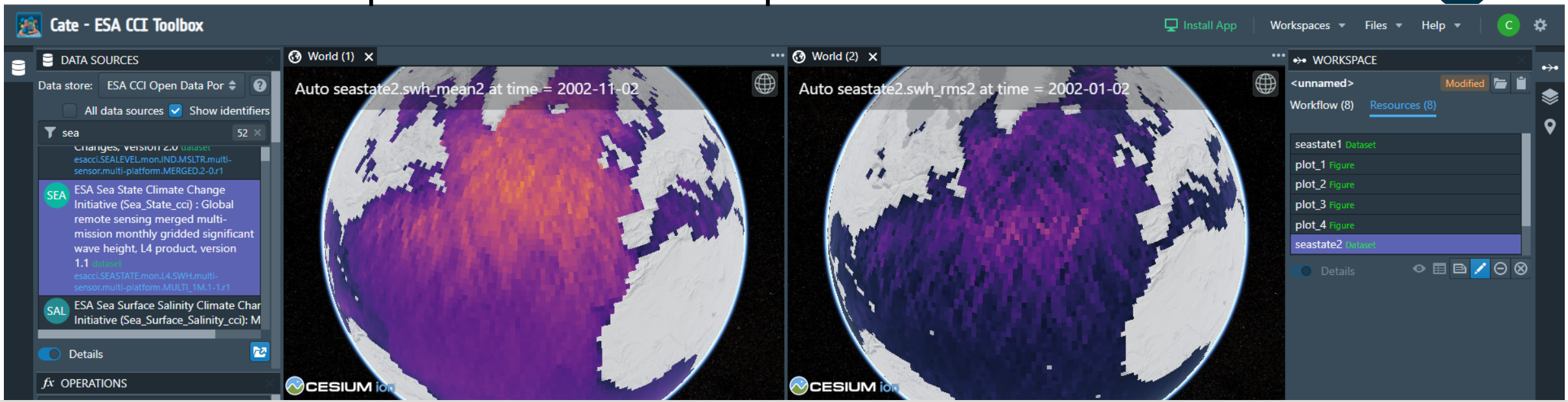



```
import cate.ops
seastate1 = cate.ops.open_dataset(ds_id="esacci.SEASTATE.mon.L4.SWH.multi-sensor.multi-platform.MULTI_1M.
1-1.r1", time_range="2002-01-01,2004-12-31", var_names="swh_mean, swh_rms")

plot_1 = cate.ops.plot(ds=ds_1, var="swh_mean", indexers="lon=-32.59419951779271, lat=50.61308854609917")
plot_2 = cate.ops.plot(ds=ds_1, var="swh_rms", indexers="lon=-32.59419951779271, lat=50.61308854609917")

seastate2 = cate.ops.compute_dataset(ds=seastate1, script=
                "tmp_mean = swh_mean.where(swh_mean<100, np.nan)
                swh_mean2 = tmp_mean.where(tmp_mean>0, np.nan)
                  tmp_rms = swh_rms.where(swh_mean<100, np.nan)
                 swh_rms2 = tmp_rms.where(tmp_rms>0, np.nan)")
```

Step 6: Calculate and plot stastical distributions

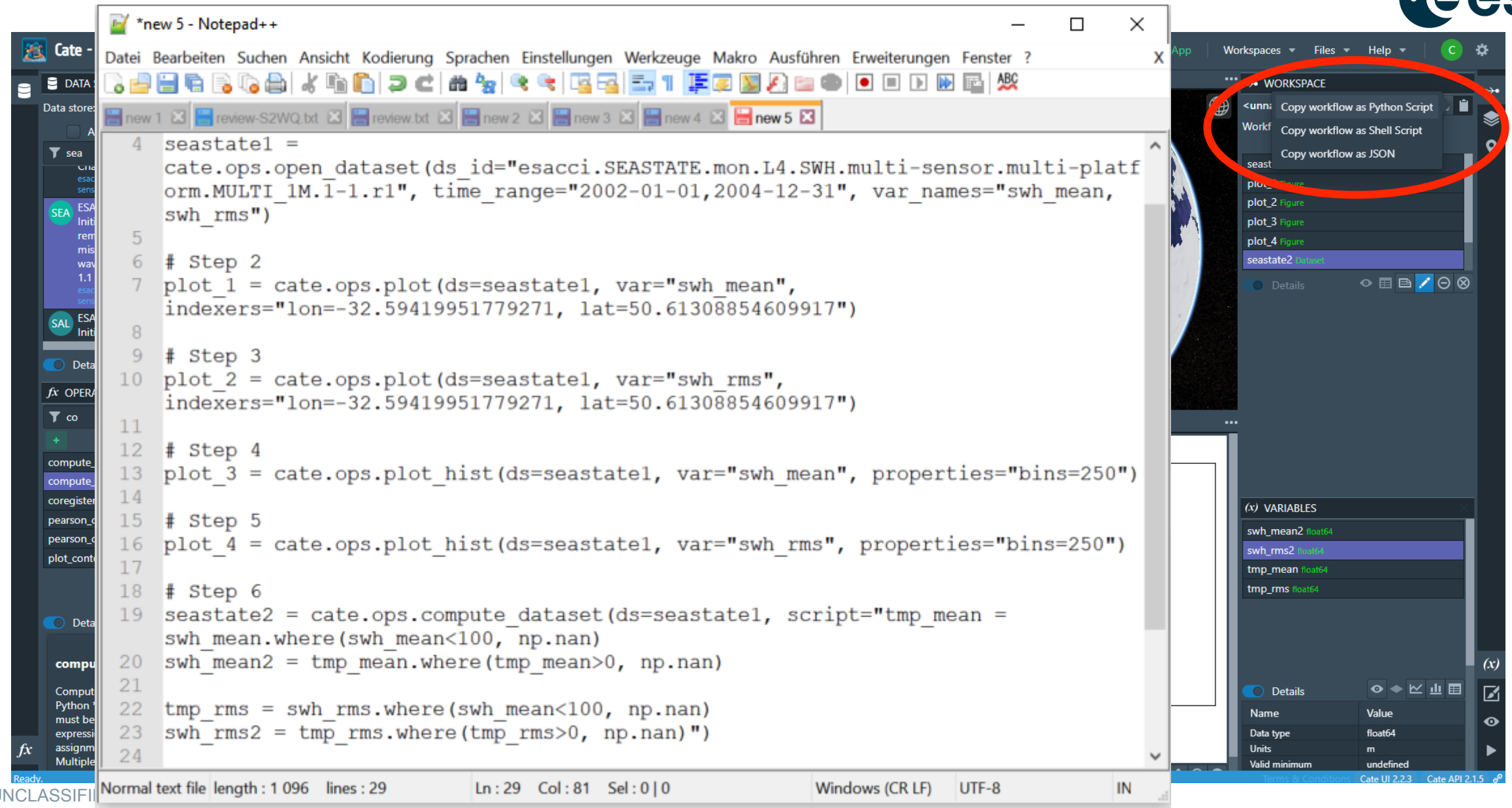



```
import cate.ops
seastate1 = cate.ops.open_dataset(ds_id="esacci.SEASTATE.mon.L4.SWH.multi-sensor.multi-platform.MULTI_1M.
1-1.r1", time_range="2002-01-01,2004-12-31", var_names="swh_mean, swh_rms")

plot_1 = cate.ops.plot(ds=ds_1, var="swh_mean", indexers="lon=-32.59419951779271, lat=50.61308854609917")
plot_2 = cate.ops.plot(ds=ds_1, var="swh_rms", indexers="lon=-32.59419951779271, lat=50.61308854609917")

seastate2 = cate.ops.compute_dataset(ds=seastate1, script=
                "tmp_mean = swh_mean.where(swh_mean<100, np.nan)
                swh_mean2 = tmp_mean.where(tmp_mean>0, np.nan)
                  tmp_rms = swh_rms.where(swh_mean<100, np.nan)
                 swh_rms2 = tmp_rms.where(tmp_rms>0, np.nan)")

plot_5 = cate.ops.plot_hist(ds=seastate2, var="swh_mean2", properties="bins=250")
plot_6 = cate.ops.plot_hist(ds=seastate2, var="swh_rms2", properties="bins=250")
```


*new 5 - Notepad++
Datei Bearbeiten Suchen Ansicht Kodierung Sprachen Einstellungen Werkzeuge Makro Ausführen Erweiterungen Fenster ?
new 1
review-S2WQ.txt
review.txt
new 2
new 3
new 4
new 5
4 seastate1 = cate.ops.open_dataset(ds_id="esacci.SEASTATE.mon.L4.SWH.multi-sensor.multi-platform.MULTI_1M.1-1.r1", time_range="2002-01-01,2004-12-31", var_names="swh_mean, swh_rms")
5
6 # Step 2
7 plot_1 = cate.ops.plot(ds=seastate1, var="swh_mean", indexers="lon=-32.59419951779271, lat=50.61308854609917")
8
9 # Step 3
10 plot_2 = cate.ops.plot(ds=seastate1, var="swh_rms", indexers="lon=-32.59419951779271, lat=50.61308854609917")
11
12 # Step 4
13 plot_3 = cate.ops.plot_hist(ds=seastate1, var="swh_mean", properties="bins=250")
14
15 # Step 5
16 plot_4 = cate.ops.plot_hist(ds=seastate1, var="swh_rms", properties="bins=250")
17
18 # Step 6
19 seastate2 = cate.ops.compute_dataset(ds=seastate1, script="tmp_mean = swh_mean.where(swh_mean<100, np.nan)
20 swh_mean2 = tmp_mean.where(tmp_mean>0, np.nan)
21
22 tmp_rms = swh_rms.where(swh_mean<100, np.nan)
23 swh_rms2 = tmp_rms.where(tmp_rms>0, np.nan)")
24
Normal text file length : 1 096 lines : 29 Ln : 29 Col : 81 Sel : 0 | 0 Windows (CR LF) UTF-8 IN
Workspaces Files Help
WORKSPACE
Copy workflow as Python Script
Copy workflow as Shell Script
Copy workflow as JSON
plot_2 Figure
plot_3 Figure
plot_4 Figure
seastate2 Dataset
Details
VARIABLES
swh_mean2 float64
swh_rms2 float64
tmp_mean float64
tmp_rms float64
Details
Name Value
Data type float64
Units m
Valid minimum undefined
Cate UI 2.2.3 Cate API 2.1.5

Step 7: Repeat workflow in a JupyterNB

cate-uc09.ipynb | cate-uc11.ipynb | cate-uc06.ipynb

Markdown

Start Cate

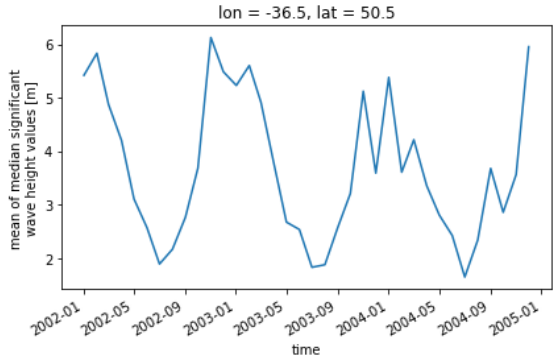
```
[8]: %matplotlib inline
import cate.ops
import numpy as np
import matplotlib.pyplot as plt
from pandas.plotting import register_matplotlib_converters
register_matplotlib_converters()
import nest_asyncio
nest_asyncio.apply()
```

Access Sea State ECV

```
[10]: seastate1 = cate.ops.open_dataset(ds_id="esacci.SEASTATE.mon.L4.SWH.multi-se
```

Visualise time series

```
[11]: plot_1 = cate.ops.plot(ds=seastate1, var="swh_mean", indexers="lon=-36.62280
plot_2 = cate.ops.plot(ds=seastate1, var="swh_rms", indexers="lon=-36.622800
```



cate-uc09.ipynb | cate-uc11.ipynb | cate-uc06.ipynb

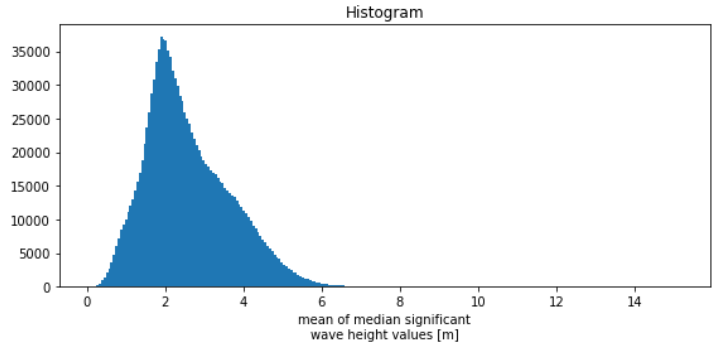
Markdown

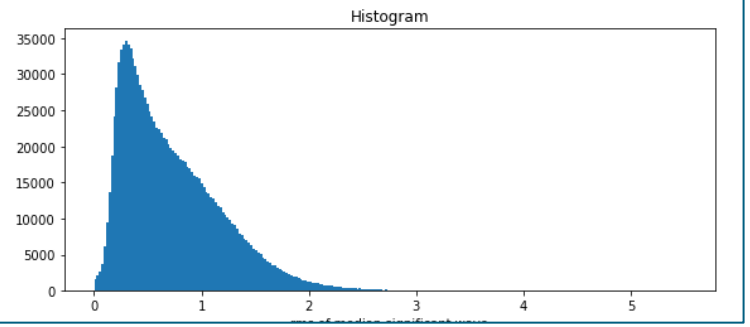
Manipulate data (arithmetic operation)

```
[31]: seastate2 = seastate1
tmp_mean = seastate1.swh_mean.where(seastate1.swh_mean<100, np.nan)
seastate2['swh_mean2'] = tmp_mean.where(tmp_mean>0, np.nan)
tmp_rms = seastate1.swh_rms.where(seastate1.swh_rms<100, np.nan)
seastate2['swh_rms2'] = tmp_rms.where(tmp_rms>0, np.nan)
```

Calculate and plot stastical distributions

```
[32]: plot_4 = cate.ops.plot_hist(ds=seastate2, var="swh_mean2", properties="bins=250")
plot_4 = cate.ops.plot_hist(ds=seastate2, var="swh_rms2", properties="bins=250")
```





Cate's various user interfaces

Cate App	Cate command-line tool	Cate Python API
… is Cate's graphical user interface that runs in all modern internet browsers.	…is used to access and process ESA climate data through a command shell. Use it to write your own batch scripts.	…allows you to use Cate in your own Python programmes and make up new functions for the toolbox too.

Questions?

www.esa.int