



- 1.Basics of Remote Sensing: The Electromagnetic Spectrum, Radiation and Temperature, Atmospheric Interference, Passive Sensors& Active sensors
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Slide 2



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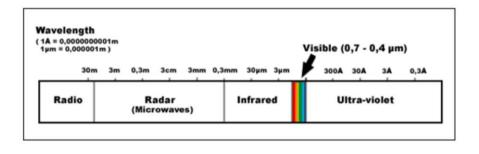
Side 3

1. Basics of Remote Sensing: The Electromagnetic Spectrum



- Collecting and analysing data about an object without direct contact with it.
- 4 elements:
 - Platform (satellite, airplane)

- Sensor (using ≠ parts of the electromagnetic spectrum)
- Object to be observed (land surface, etc)
- Information obtained
- Objects can reflect part of the light they receive & can emit radiation due to their temperature → electromagnetic radiation
- Electromagnetic spectrum



Remote Sensing = collecting and analysing data about an object with an instrument that is not in direct contact with the object.

4 elements:

- 1- A platform to hold the instrument (planes or satellites)
- 2- A target object to be observed (the Earth: its land surface, the oceans, the atmosphere, its dynamics)
- 3- An instrument or sensor (cameras, scanners, radars, etc)
- 4- The information obtained, and how it is used and stored (e.g, cloud cover over Europe, evolution of ozone hole, etc)

In Remote Sensing, sensors are able to acquire information that the human eye cannot see, using different parts of the electromagnetic spectrum besides the visible part (e.g. the infrared part)

Objects normally reflect part of the light that reaches them (hence their colour) and can also emit radiation due to their temperature. This cannot always be seen by the human eye (e.g. infrared)

Light is emitted and reflected in the form of radiation = a wave propagating in space with magnetic and electric components = electromagnetic radiation.

Electromagnetic waves have different wavelengths, and their energy at different wavelengths can be measured, to quantify how much radiation is emitted or reflected by a certain object.

The collection of all possible wavelengths is called the electromagnetic spectrum, shown in the graph. Note that humans have designed objects to emit at certain wavelengths (e.g. microwaves)

More information at in Eduspace / Remote Sensing Principles / What is remote sensing?: http://www.esa.int/SPECIALS/Eduspace EN/SEMF9R3Z2OF 0.html

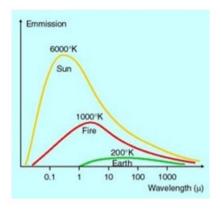
1. Basics of Remote Sensing: Radiation and Temperature



Objects on Earth emit radiation in proportion to their temperature

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- Emission depends on the surface temperature
- Therefore, by remotely sensing the emission we can calculate the temperature of the surface
- · Surfaces with different temperatures have maximum emission at different wavelengths



n Snara Ananry

European Space Agency

Thermodynamics indicates that a body at a temperature different from 0 Kelvin, i.e. an object on Earth, emits radiation proportionally to its

Surface temperature is a key factor for emission. The surface temperature and the degree of emission at a certain wavelength are directly correlated.

Therefore the surface temperature can be calculated on the basis of remote sensing of the thermal infrared emission.

Surfaces with different temperatures have maximum emission at different wavelengths.

temperature.

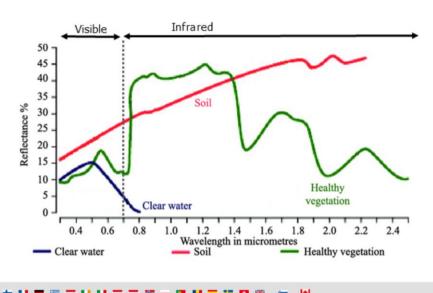
More information in Eduspace

http://www.esa.int/SPECIALS/Eduspace EN/SEM7IQ3Z2OF 0.html

1. Basics of Remote Sensing: Spectral Signatures



- Different surfaces reflect radiation differently in the various parts of the Electromagnetic Spectrum → Spectral signatures
- Therefore different surface types can be distinguished



The radiation reflected as function of the wavelength is called the spectral signature of the surface.

For example, vegetation can be distinguished from the bare ground because it has a high reflection in the Near Infrared (around 0.8 micrometers) and a low one in the Visible Red (around 7 micrometers)

Water only reflects in the visible light range (0 to 7 micrometers), and it has almost no reflection in the Near Infrared part. Therefore it is easy to distinguish water bodies, they will appear as clearly delimited dark areas with low pixel values, when looking at images recorded in the Near Infrared range.

More information in Eduspace

http://www.esa.int/SPECIALS/Eduspace EN/SEM7IQ3Z2OF 0.html

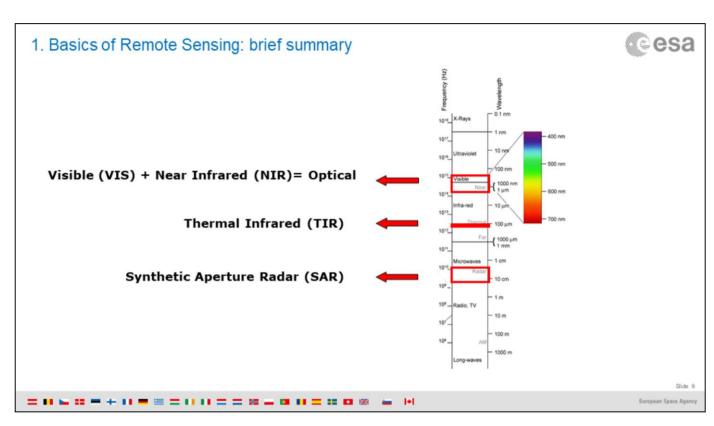
Image modified from https://www.researchgate.net/figure/Spectral-reflectance-curves-of-different-land-cover-types-Modified-from fig4 245538996

esa 1. Basics of Remote Sensing: Atmospheric interference Sun radiation & its reflection from Earth's surface pass through the atmosphere before reaching the satellite sensor. Greenhouse gases absorb part of the radiation from Earth: ozone, water vapour, carbon dioxide. This **reduces** the amount of radiation the atmosphere can **transmit** in those specific wavelengths. Wavelengths where most of the radiation can pass through = atmospheric windows In this part of the spectrum, H₂O and CO2 absorb most of the radiation coming from the Earth. Very little O₂ reaches the satellite sensor! Atmospheric transmission (%) H₂O CO₂ Even in atmospheric windows, atmosphere 03 uses and absorbs → data STILL need to be adjusted via processing 0.5 1.0 2.0 5.0 10.0 Wavelength (µm) Visible European Space Age

More information about atmospheric windows in Eduspace http://www.esa.int/SPECIALS/Eduspace EN/SEMUYP3Z2OF 0.html

Original image from

Kääb, A.; Winsvold, S.H.; Altena, B.; Nuth, C.; Nagler, T.; Wuite, J. Glacier Remote Sensing Using Sentinel-2. Part I: Radiometric and Geometric Performance, and Application to Ice Velocity. *Remote Sens.* **2016**, *8*, 598, available at https://www.mdpi.com/2072-4292/8/7/598/pdf/1



This graph highlights some of the parts of the Electromagnetic Spectrum used in Remote Sensing for the Earth.

Visible and NIR → e.g. agriculture

Thermal Infrared \rightarrow e.g. vegetation stress, evapotranspiraton

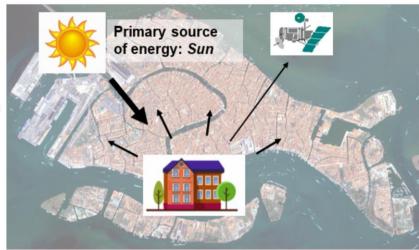
Synthetic Aperture Radar → e.g. ground subsidence

1. Basics of Remote Sensing: Passive sensors



Two types of sensors:

- Passive (use external energy sources)
 Problem of clouds!
 e.g. infrared viewers
- Active (uses its own source of energy to 'illuminate' objects and measures the part that is reflected and returned to the sensor)
 - e.g. radar



Slide 10

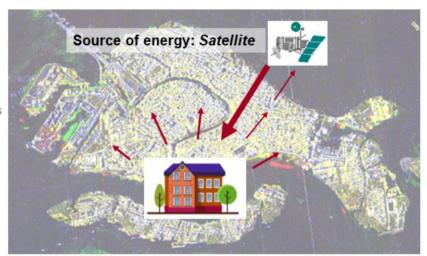
1. Basics of Remote Sensing: Active sensors



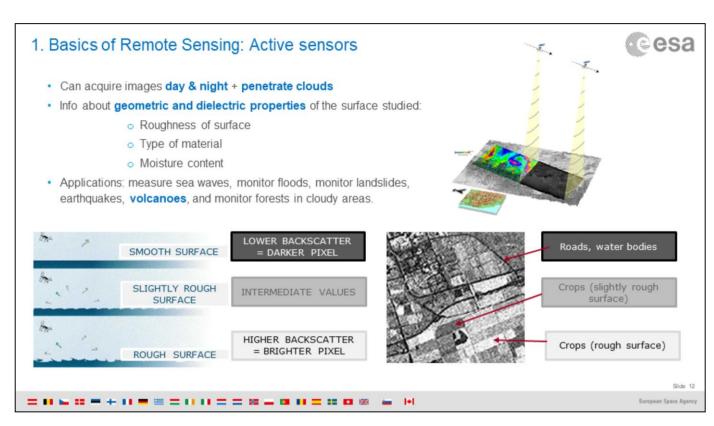
Two types of sensors:

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 Problem of clouds!
 e.g. infrared viewers
- Active (uses its own source of energy to 'illuminate' objects and measures the part that is reflected and returned to the sensor)

 e.g. radar



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Colour radar images can be produced by combining three single images from different dates (e.g. 35 days apart) to produce a multi-temporal composite. Each individual date/image is displayed in one of the three colours used to form any colour picture, that is Red, Green and Blue (RGB). The different amounts of colour from each date combine to produce other colours that can be interpreted by experienced image processors. (More information about RGB displays in the EO Browser exercise on Etna lava flow from Sentinel-2)

For example, in the case of water bodies, for the radar sensor, the rougher the surface, the greater the reflection of the microwave energy that will reach the sensor and be recorded, therefore the pixel will have higher values and show brighter (whiter).

More info on how to interpret radar images in Eduspace http://www.esa.int/SPECIALS/Eduspace EN/SEMHUESTGOF 0.html



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2. ESA & ESA's Earth Observation Programmes





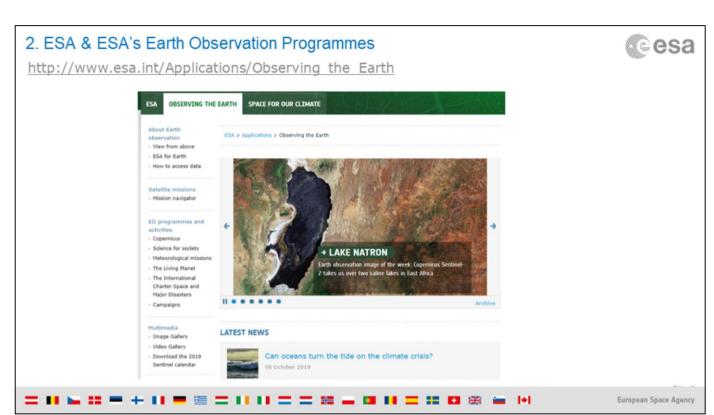
 Established in 1975 "To provide for and promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications." (Article 2 of the ESA Convention)

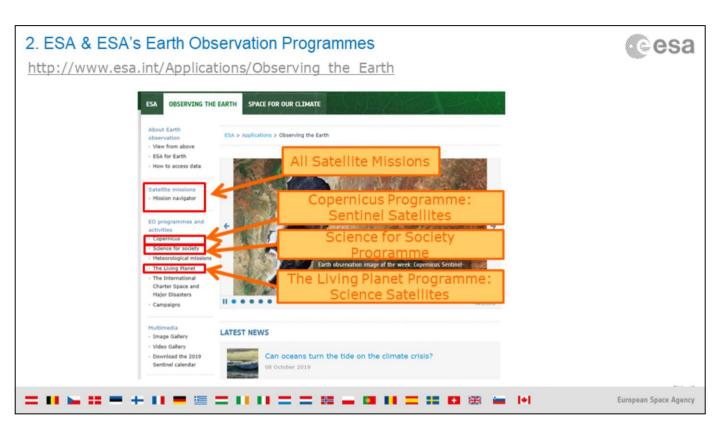
- · Over 50 years of experience
- · 22 Member States
- · 8 sites/facilities in Europe
- · Over 80 satellites designed, tested and operated in flight
- 5.6 billion Euro budget (2018)
- ESA Directorate of Earth Observation Programmes:

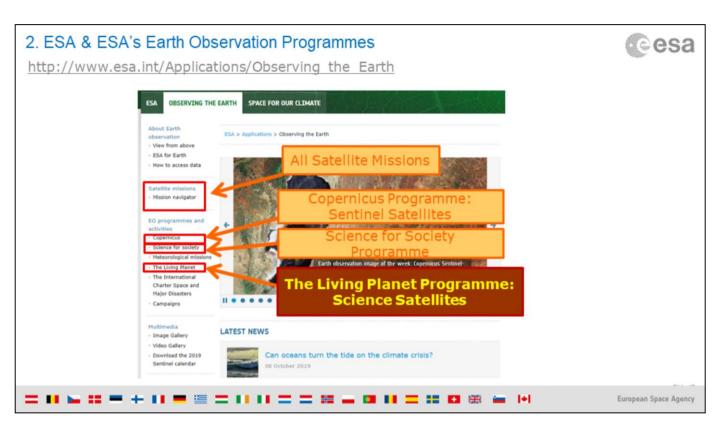
Develop world-class Earth Observation systems addressing scientific & societal challenges with European and global partners







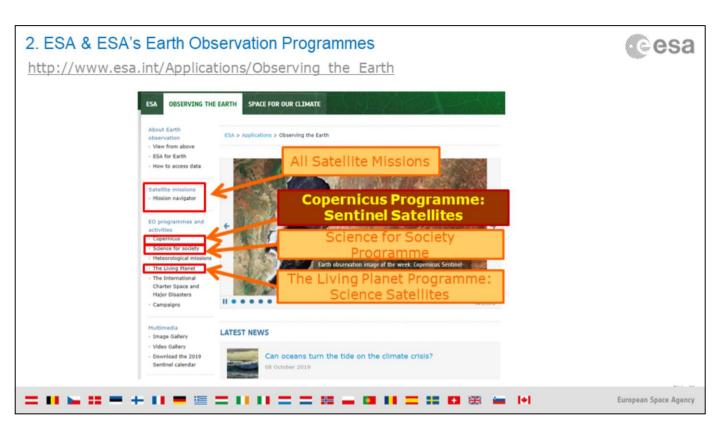




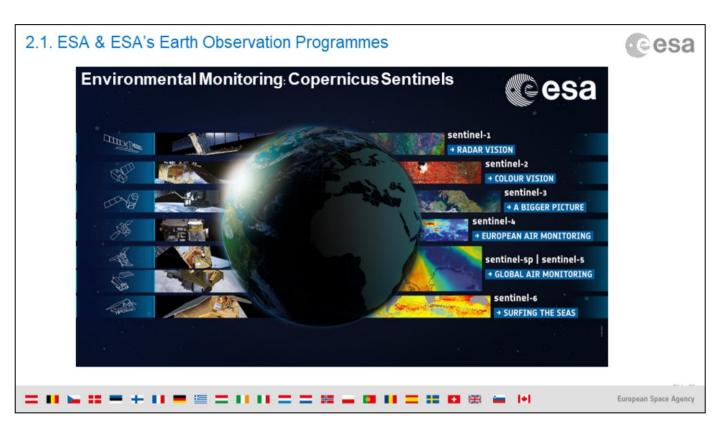


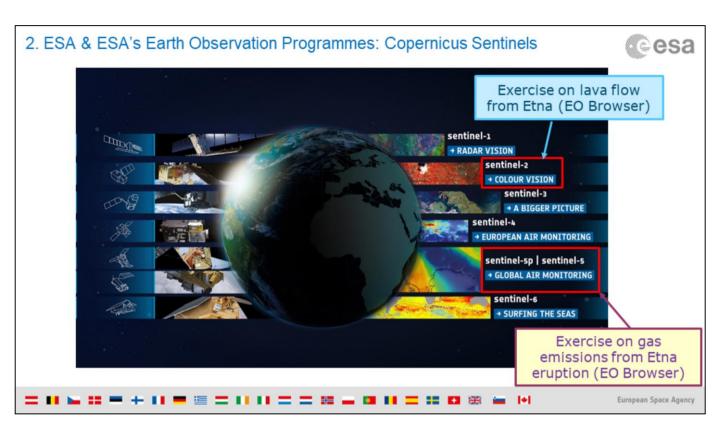


The Earth science missions "Earth Explorers" allow us to understand the Earth System and its diverse aspects in more and more detail.

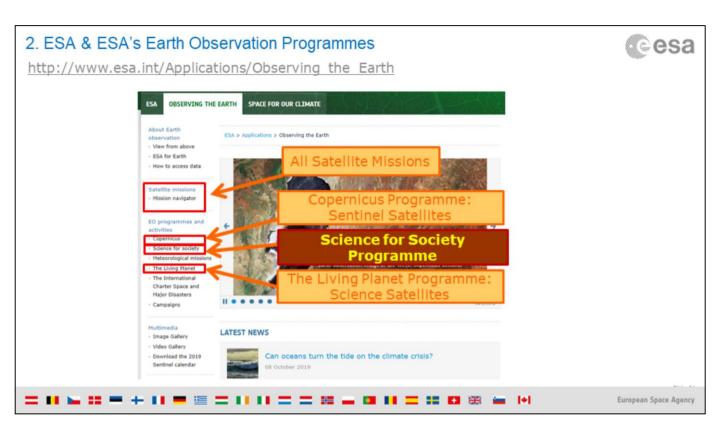


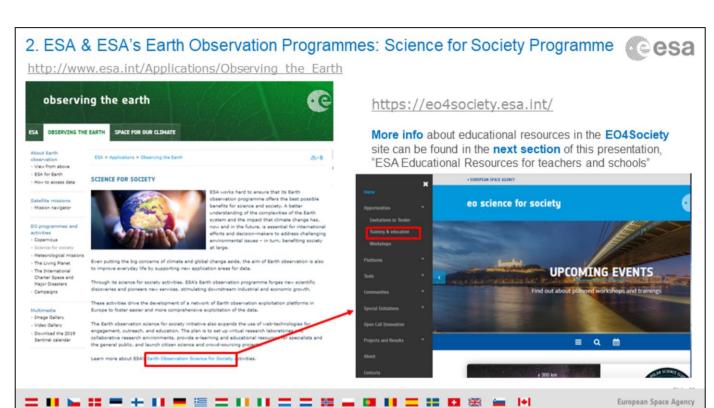






In the exercises we will work with data from Sentinel-2 and Sentinel-5P







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European Space Agency

3.1. ESA Education Office

https://www.esa.int/Education





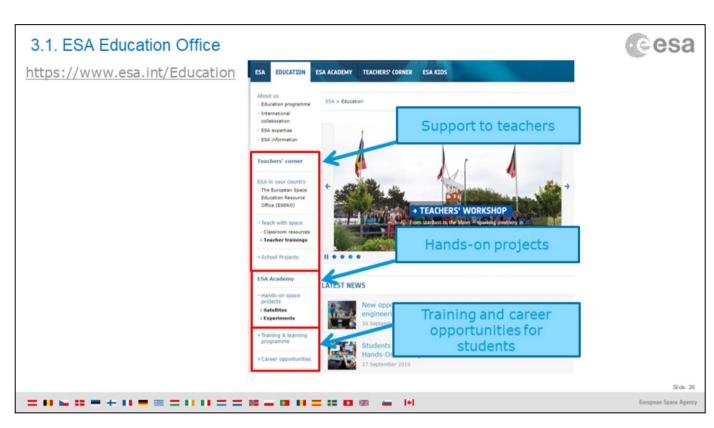
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ESA's Education Office aims to help **young Europeans** (from 6 to 28 years old) gain and maintain interest in science and technology.

- 1. Hands-on projects
- 2. Support to teachers
- 3. International Cooperation activities
- 4. Opportunities for students
- 5. Outreach initiatives

The resources and projects from ESA's Education Office are related to **more than Earth Observation**: interplanetary exploration, satellite simulations, astronaut training....

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3.1. ESA Education Office: Teacher's corner: ESERO project for secondary schools https://m.esa.int/Education/Teachers Corner/European Space Education Resource Office ESERO (European Space Education Resource Offices in ESA Member States) offers an annual series of national or regional training sessions for both primary and secondary school teachers, offered in collaboration with national partners 15 ESERO offices: Austria, Belgium, Czech Republic, Denmark, Germany, Ireland, Italy, Luxembourg, Netherlands, Nordic ESERO, Poland, Portugal, Romania, Spain, UK.



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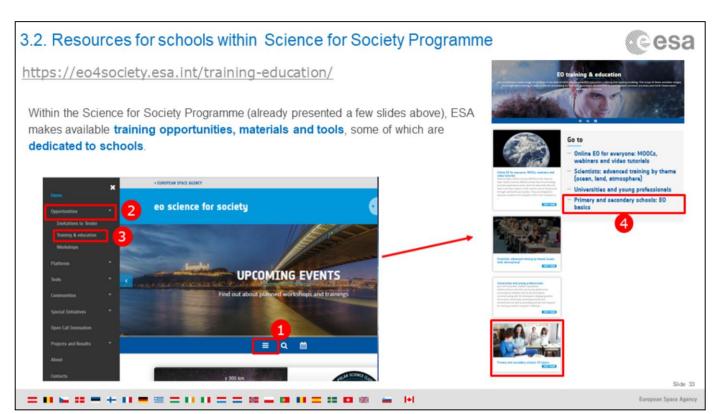


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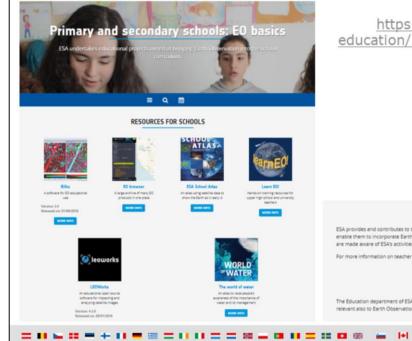
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3.2. Resources for schools within Science for Society Programme





https://eo4society.esa.int/trainingeducation/primary-and-secondary-schools-eobasics/

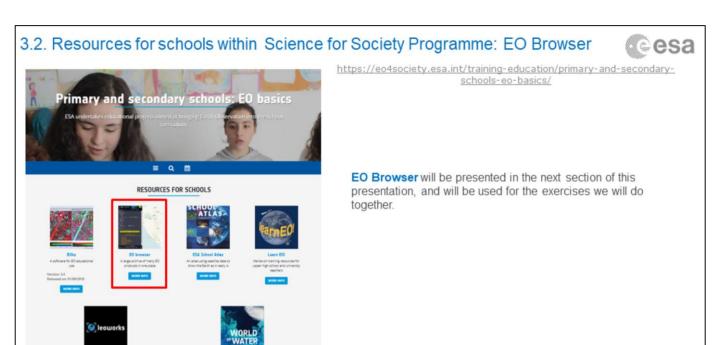
TRAINING COURSES FOR TEACHERS

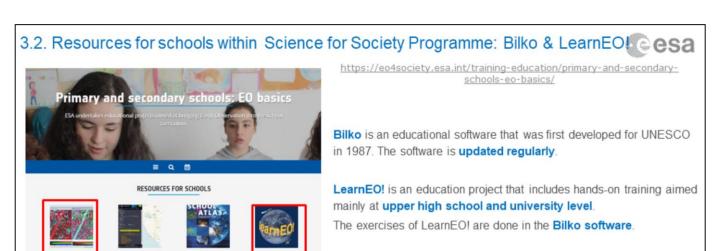
ESA provides and contributes to training courses, workshops and other events where teachers are given instruction in the use of tools that will enable them to incorporate Earth Observation into the curricula of their subject. ESA also organises outreach events where students and teachers are made aware of ESA's activities in Earth Observation.

For more information on teacher training and outreach events for exercises and presentations, look at EGU GIFT Workshop

MORE GENERAL ESA SPACE EDUCATION

The Education department of ESA develops educational material and undertakes many activities in space education for children. Some of this is relevant also to Earth Observation. For more information, visit the ESA Education and ESERO website.



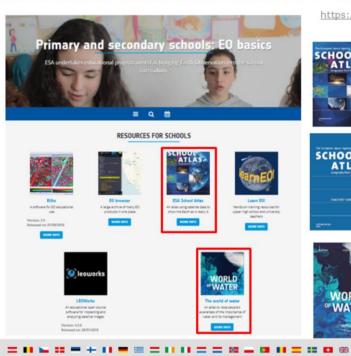




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3.2. Resources for schools within Science for Society Programme: Atlases





https://eo4society.esa.int/training-education/primary-and-secondaryschools-eo-basics/



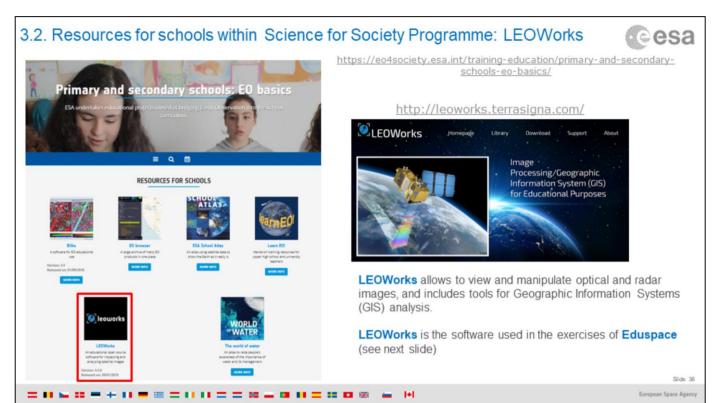
- Introduction to ESA
- Earth Observation
- Global Overview
- Continental Overview
- The Natural and Cultural Sphere



- Teachers' Handbook
- DVD-ROMs with the original bands of the satellite data
- Handbook content and exercises, connected to Eduspace and its software Leoworks (see next slides)



- Describes the major issues related to water on Earth
- Presents water as a natural resource, focusing on global water, the oceans, seas, lakes and rivers of the Earth



3.2. Resources for schools within Science for Society Programme: Eduspace

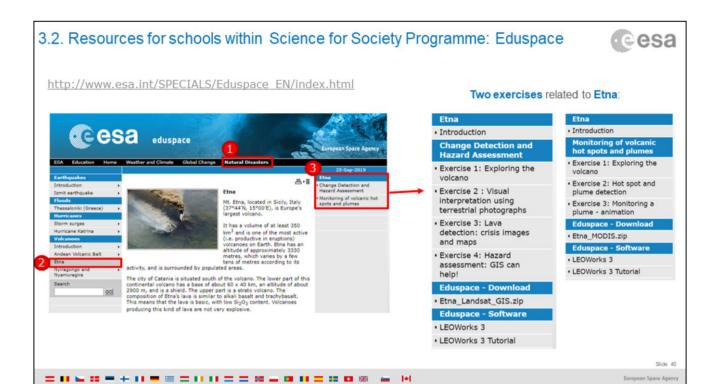


http://www.esa.int/SPECIALS/Eduspace EN/index.html



- Educational website aimed at secondary school students and teachers
- Entry point for Earth Observation applications, education and training
- Ready-made projects
- · Didactical material with local and global data
 - Source of ideas for classroom activities

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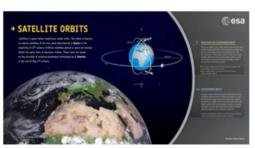
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In addition, another tool for secondary schools is educational posters

Posters can be ordered by emailing: education@esa.int or eohelp@esa.int





Posters available in: English, German, Spanish, Czech, Greek:

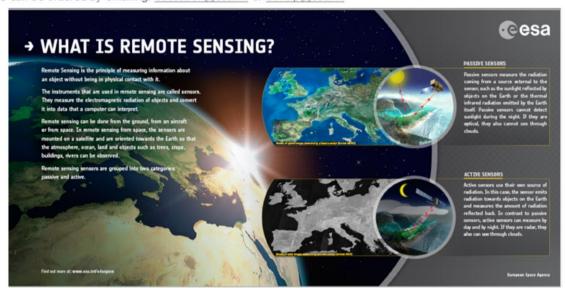
- · What is Remote Sensing?
- Satellite orbits
- · Ocean applications
- · Land applications
- · Ice applications
- Atmosphere applications

Slide 4



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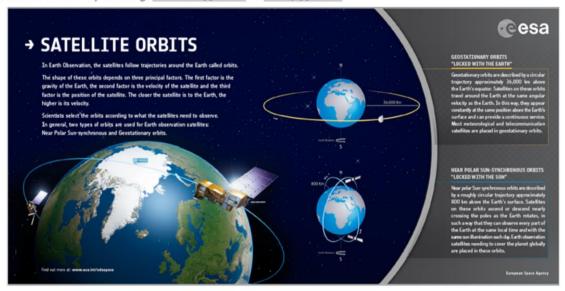


Slide 4



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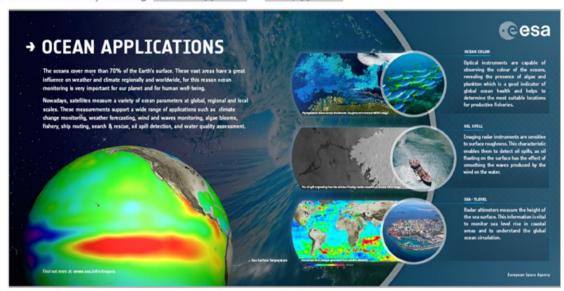
Slide 4



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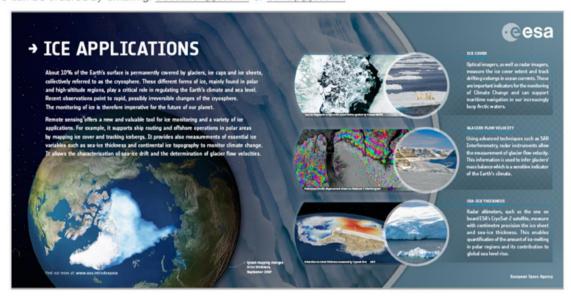
Slide 45



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Overview



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3.3. Tools for general outreach: CryoSat App (VIDEO)



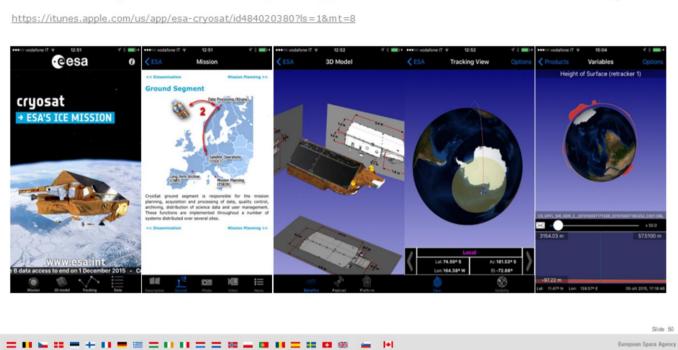


http://www.esa.int/spaceinvideos/Videos/2012/12/Earth from Space the Living Beauty

Slide 4

3.3. Tools for general outreach: CryoSat App





3.3. Tools for general outreach: Sentinels App







- See the last and next time they have been and will be over your location; Move them to the time of the last data transmission and smoothly move them back to their current location over the 3D globe
- Get information and news about the Copernicus Programme
- Set Notifications to be warned when satellites are flying by



esa





3.3. Tools for general outreach: Proba-V App

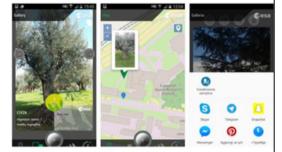








- Take a picture of a landscape
- Associate the vegetation status derived from Proba-V NDVI products in your area to the picture
- See graphics of the vegetation status evolution during the last 6 months (tap on picture icon or on map)
- Build your picture gallery and see all your pictures on the map
- Share the pictures on social media
- Learn about Proba-V, get news and image of the week
- UI available in several languages: English, Italian, Portuguese. Dutch. Spanish. German. etc.
- And much more!





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http://cci.esa.int/content/tablet-app





Climate from Space:

ESA's iPad App for visualization of climate data being produced through the European Space Agency's Climate Change Initiative (CCI)

Allows to visualize temporal changes of the 13 general categories of the Essential Climate Variables:

- Sea surface temperature, Sea level, Sea ice
- Glaciers, Ice sheets
- Ocean colour
- Land cover
- Soil moisture
- Greenhouse gases, Ozone, Cloud, Aerosols
- Fires



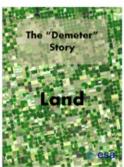
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3.3. Tools for general outreach: Educational "Stories" / exercises on Climate Change

- Set of successive thematic stories and hands-on exercises based on the CCI Visualisation Tool (Climate from Space) - CCI App
- · Dedicated to secondary school students

- · Tutorials for teachers
- · Not online, still under review









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3.3. Tools for general outreach: Video courses (MOOCs)



https://eo4society.esa.int/training-education/online-eo-for-everyone-moocs-webinars-and-video-tutorials/

ESA recently started to create **educational MOOCs** for EO techniques & Applications, starting with Climate Change

What is a MOOC?

Massive: no limitation on the number of participants. The record is 440,000!

Open: free and accessible for anyone with an Internet connection

Online: all activities are made online

Course: it has a **specific topic**, prepared by specialists, offering theoretical and practical content





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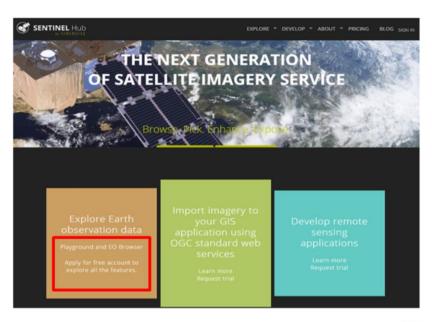
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4. Overview of Sentinel Hub



European Space Agency

Sentinel Hub is a Copernicus Award winning service for archiving, processing and distributing Sentinel data. http://www.sentinel-hub.com

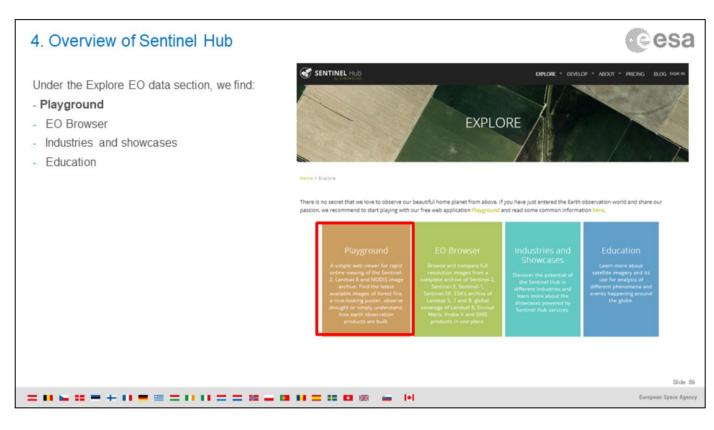


Sentinel Hub is a Copernicus Award (http://www.copernicus-masters.com/index.php?anzeige=press-2016-03.html) winning service for archiving, processing and distribution of Sentinel data.

Users can look closely into the global archive of all the Sentinels and explore this rich archive to monitor changes in the land. They can:

- Observe imagery all over the globe

- Create statistical analysis and compare different sensors
- Export results as a raster for further processing



Under the Explore EO data section, we find:

- Playground,
- EO Browser
- Industries and showcases
- Education

We will use EO Browser, but first let's have a quick overview of what those sections contain.

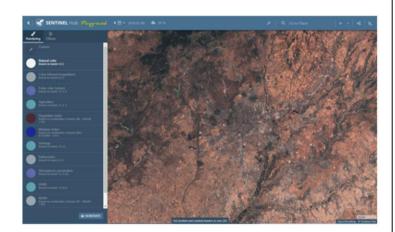
First the Sentinel Playground section.

4. Overview of Sentinel Hub



http://apps.sentinel-hub.com/sentinel-playground/

Sentinel Playground is a simple web viewer for rapid exploring of Sentinel-2, Landsat-8 and MODIS, along with access to data products (NDWI, etc)



Slide 60

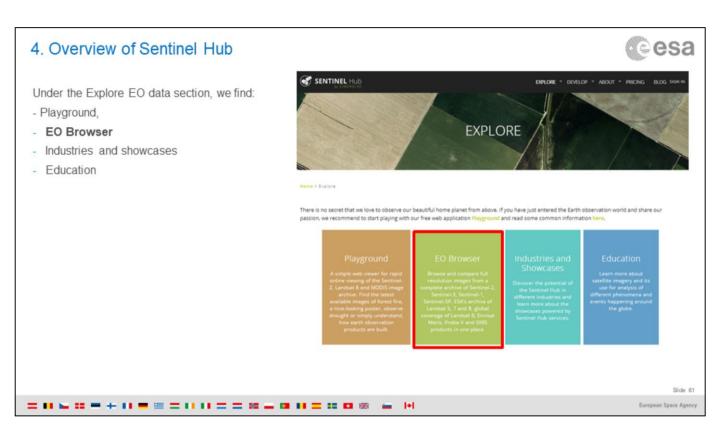
Consessor Conses Assessor

The Sentinel Playground is a web application that is publicly available and allows users to query for Sentinel data all over the world.

It is a graphical interface to a complete and daily updated **Sentinel-2** archive, a massive resource for anyone interested in Earth's changing surface, natural or manmade.

It is perfect for someone who wants to find the latest available images of forest fire, or create a nice looking poster, observe drought or simply understand how EO products are built.

Access it at: http://apps.sentinel-hub.com/sentinel-playground/



Next let's have a closer look at the EO Browser.

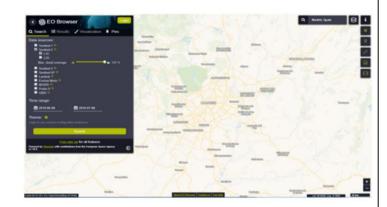
4. Overview of Sentinel Hub



https://www.sentinel-hub.com/explore/eobrowser

EO Browser is a tool to compare the complete archives of all the Sentinels, as well as Landsat, Envisat Meris, Prova-V and GIBS.

It allows instant access to browse through petabytes of newest and archive data.



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EO Browser allows instant access to browse through petabytes of newest and archive data and chronological comparison of full resolution images.

Their cloud infrastructure can produce results in a few seconds, and the user does not need to download, archive and process the data.



Expert users, who would like to get earth observation data in their own GIS environment, can make use of Sentinel Hub Open Geospatial Consortium (OGC) services.

The front-end application is open source so anyone can take it and build added value services on top of Sentinel Hub OGC services.

For more general information about OGC start here: https://www.sentinel-hub.com/develop/documentation/api/ogc_api

Step-by-step guidelines for integration of Sentinel Hub OGC with ArcMap and QGIS: https://sentinel-hub.com/develop/documentation/integration-guide Tutorial for the Sentinel-Hub QGIS plug-in: https://medium.com/sentinel-hub-from-within-qgis-2a83eb7f13db

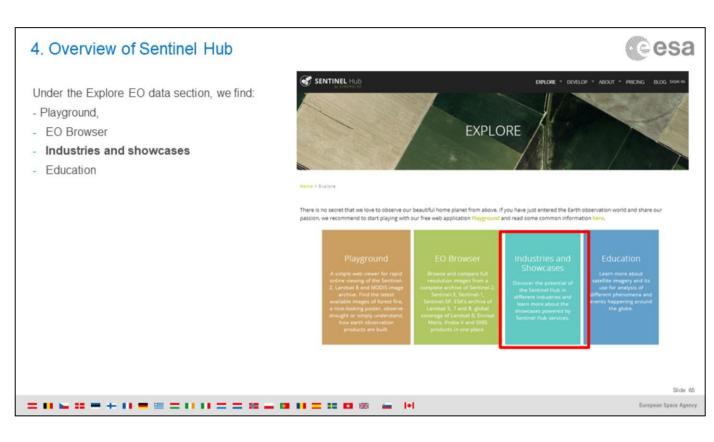
4. Overview of Sentinel Hub



Demo video: https://www.youtube.com/embed/m3pron0C0kE



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Next let's have a quick look at the "Industries and showcases" section.

4. Overview of Sentinel Hub

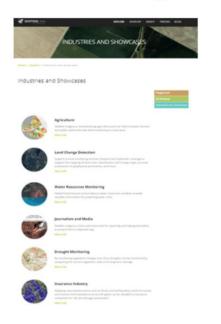


European Space Agency

https://www.sentinel-hub.com/explore/industries-and-showcases

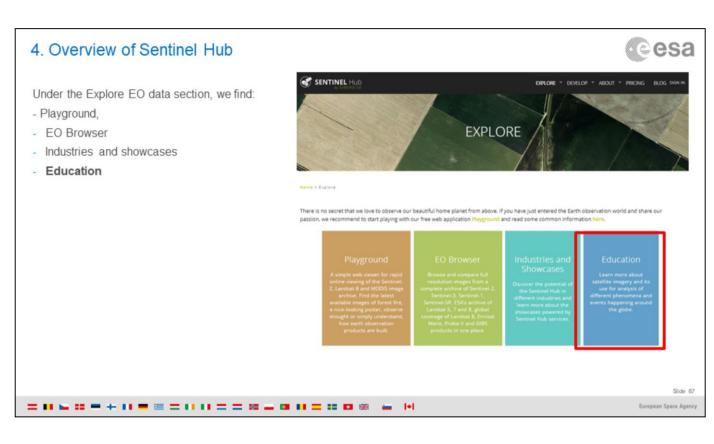
Several case studies based on the Sentinel Hub are presented, to demonstrate the potential of the Hub for:

- Agriculture
- Land Change Detection
- Water Resources Monitoring
- Drought Monitoring
- Insurance Industry
- Journalism and Media

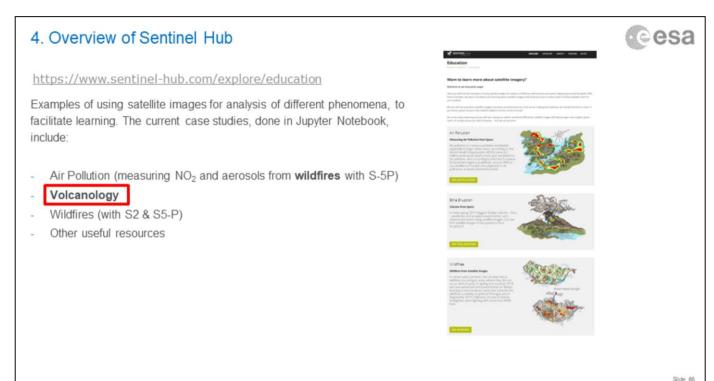


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Finally let's have a look at the Education section



With new technologies like machine learning and educational software the traditional educational methods as well as the role of educators are evolving. And so is the role of EO Browser. This free web application for browsing, comparing and analysing various satellite data sources is a very useful tool for experts in remote sensing field. But it is becoming more and more popular in teaching and engaging students with practical learning in Earth Observation. The EO Browser is being introduced to many teachers, during workshops and presentations at universities. Such activities inspired the creation of a landing page with educational materials.

Case studies are done with Jupyter Notebook, and are a mixture of code, text, figures, links, equations, etc.

Case studies inspire the definition of the so-called "Themes", where the user can find different features related to the case study (e.g. pins).

Overview



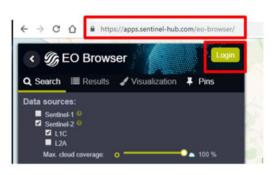
- 1.Basics of Remote Sensing: The Electromagnetic Spectrum, Radiation and Temperature, Atmospheric Interference, Passive Sensors& Active sensors
- 2.The European Space Agency & ESA Earth Observation Programmes: Science Satellites, Copernicus Sentinels, Science for Society Programme
- 3.ESA Educational resources for teachers and schools
 - 1.ESA Education Office: Teacher's corner (including ESERO project), ESA Academy
 - 2.Resources for schools within EO4Society (including Eduspace exercise on the Etna)
 - 3. Tools for general outreach (i-books, apps, MOOCs)
- 4. Earth Observation Browser (EO Browser): Overview of Sentinel Hub, Sentinel Playground, EO Browser, Industries and Showcases, Education
 - 1.Exercise: Sentinel-2 for Etna lava flow
 - 2.Exercise: Sentinel-5P for Etna atmospheric emissions

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4.1. Sentinel-2 EO Browser exercise



http://apps.sentinel-hub.com/eo-browser/



Register for free with an email address, to have full access to all the tools

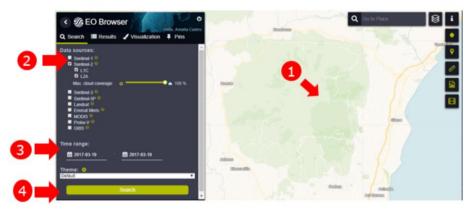


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4.1. Sentinel-2 EO Browser exercise



- 1. Where to search? Navigate to Etna area (simply use your mouse to move the display in order to show the volcano, as seen below. There is no need to upload polygons or enter coordinates)
- 2. What sensor? Select Sentinel-2 (both L1C and L2A) * See Note 1 in next slide
- 3. When to search? Define Time frame: 2017-03-19 to 2017-03-19 (yes, the same day for both!)
- Click Search



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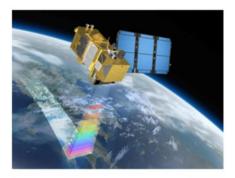
We need to define three things:

- 1- WHERE: This is the geographical area where we want to search for images
- 2- WHEN: This is the time frame, the date of the images we want to find
- 3 WHAT SENSOR: Given that we want to see the lava flow, it has to be an Optical sensor with bands in the Short Wave Infrared part of the spectrum. Sentinel-2 is used in this case

4.1. Sentinel-2 EO Browser exercise - NOTE 1



When the satellite acquires the image, it sends it to a **ground station**. But the image is **not yet ready to be used** because its quality is not yet good enough!





A simple explanation of this is that the image has **geometric distortions** (e.g. due to the rotation of the earth) and the values recorded are influenced by the fact that the **atmosphere absorbs** part of the radiation.

Slide 72

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But what does L1C and L2A mean?

A satellite acquires an image over a certain area, and then sends it to a ground station in Earth. This image is called Level 0, because no corrections have been applied to it yet so the image still presents distortions that affect its geometry and the values recorded. Everytime a correction is applied, we say the level of the image increases.

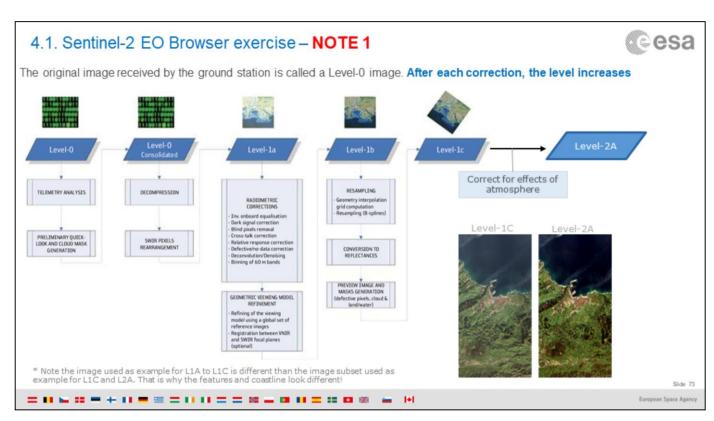
Level 1C images have had all the corrections done, except for the atmospheric correction: the distortion of the atmosphere is still present. The values represent what the satellite measures at the top of the atmosphere (not at the bottom of the atmosphere!).

After the algorithm that makes this last correction is applied, the outcome is called a Level-2A product (L2A). L2A products therefore represent the measurement at the BOTTOM of the atmosphere, i.e. at the level of the ground.

Ideally we would only use L2A products, but when Sentinel-2 started acquiring images, the algorithm was not applied to L1C images in an automatic way. Only later on it started being applied automatically, and then L2A products

became available as routine. This is the reason why we prefer to select L1C AND L2A, to be sure that whenever we search for an image, we will be able to find one. Otherwise, if we only selected L2A and we were looking, for example, for dates in the end of 2015, we may not find L2A results...because there would only be L1C.

More info at https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/processing-levels and https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/product-types/level-2a





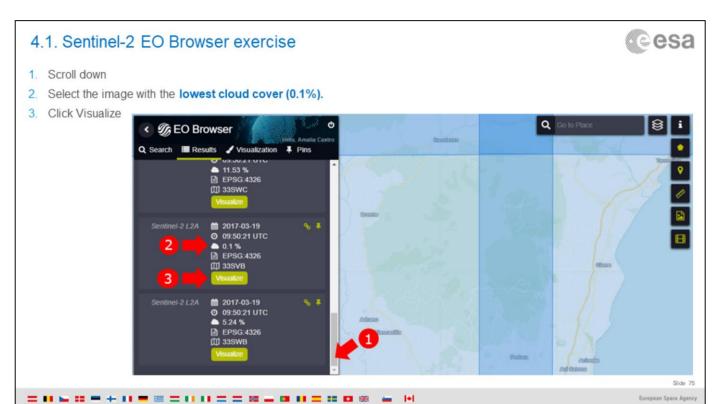
Subset of a Level-1C image (before correcting for the effects of the atmosphere)

Subset of a Level-2A image(**after** correcting for the effects of the atmosphere)





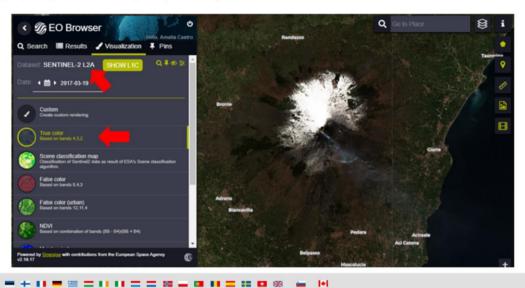
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- Note this image is a Level-2A product (the distortions due to the atmosphere have been removed)
- Try seeing the lava flow with the visualizations that are available by default (**True Colour**, False colour, False colour (urban)) or in the maps (NDVI, Soil Moisture...). Do you manage to see it?



True Colour is a way of combining the bands of the satellite that creates an image which resembles what our eyes naturally see. This is useful because it is easier to interpret!

However, remember that satellite images are different from pictures because they record the radiation that our eyes cannot see! Therefore other visualizations (other combinations of bands) can give us additional information, even if they look "strange".

For example, the False Colour visualization is a way of displaying bands that creates an image where any areas with vegetation appear very clearly and in colour red. This is handy when you need to know where there is vegetation, because it is clearly visible.

The False Colour (urban) and the SWIR visualizations allow you to see the lava flow.



- But how are band combinations created? What does "Based on bands 4.3.2" mean?
- When we ask the software to display an image, the computer gives a colour for each pixel, and **that colour is a combination** of **different proportions** of red, green and blue.
- The computer decides the proportions for each colour based on the value of the pixel in the band that is assigned to the
 colour.



RED = Band 4

GREEN = Band 3

BLUE = Band 2

For example:

Pixel shows green → higher values in the band that we assigned to colour **GREEN** (Band 3 in this example) (e.g. vegetation)

Pixel shows brown → combination in some proportions of the values in **RED**, **GREEN** and **BLUE** that creates brown colour (e.g. bare soil areas)

The fact that those different proportions exist is what allows for a wide range of colours in the display!

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"Based on Bands 4,3,2" means the band 4 was assigned to colour RED, band 3 was assigned to colour GREEN, and band 2 was assigned to colour BLUE.

The pixels that show green had higher values in Band 3 than in the other two bands.

But remember that a wide range of colours is created by combining these 3 in different proportions, as you can see in the True Colour image.

Let's look at an easier example, with False Colour.

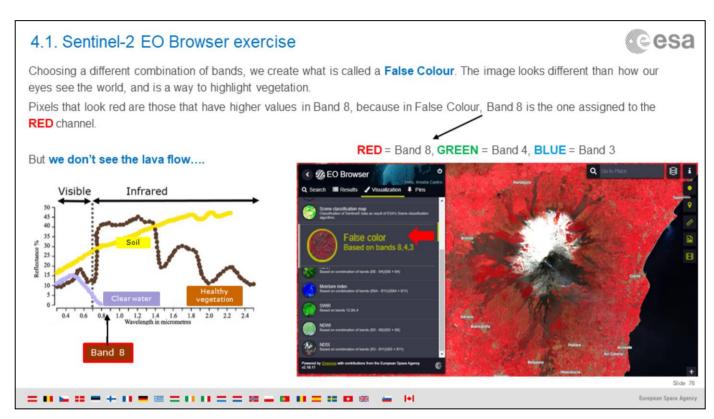


Image modified from https://www.researchgate.net/figure/Spectral-reflectance-curves-of-different-land-cover-types-Modified-from fig4 245538996

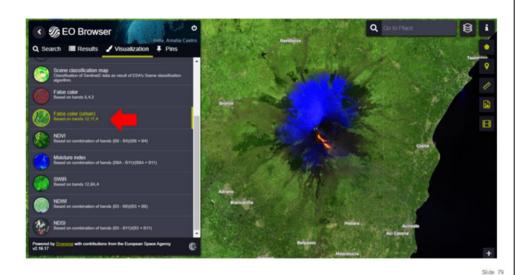


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• The visualization called **False Color (urban)** shows the lava flow nicely in red/orange. Why? Because the pixels in the area of the lava flow had higher values in Band 12, which is the one assigned to **RED**.



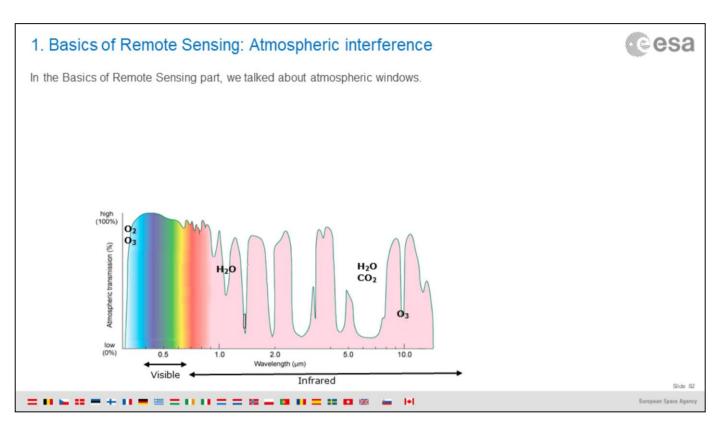
But why Band 12?





- When first ejected from a volcano, the temperature of lava can vary between 700 and 1200° C
- At these temperatures, the **main radiant emissions** are in the Thermal Infrared (TIR), middle Infrared (MIR) and Short Wave Infrared (SWIR) parts of the Electromagnetic spectrum.
- · SWIR is only emitted in detectable quantities from very hot surfaces (e.g. incandescent lava)
- Lava shows red thanks to R=B12 (Short Wave Infrared part of the Electromagnetic spectrum, 2.190 μm) when hotter than 500 $^{\circ}$ C

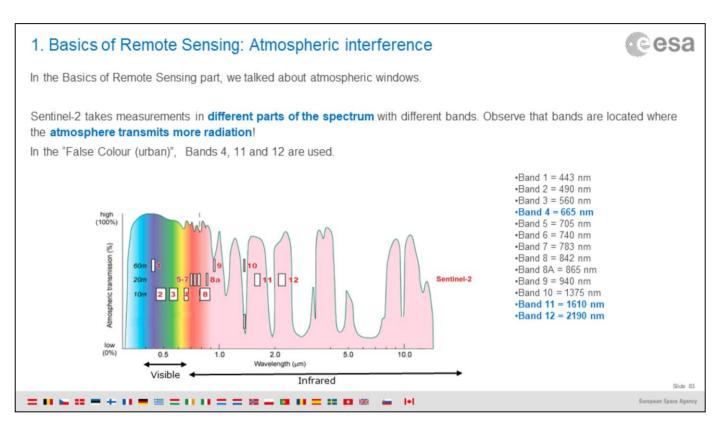
Slide 80



More information about atmospheric windows in Eduspace http://www.esa.int/SPECIALS/Eduspace EN/SEMUYP3Z2OF 0.html

Original image from

Kääb, A.; Winsvold, S.H.; Altena, B.; Nuth, C.; Nagler, T.; Wuite, J. Glacier Remote Sensing Using Sentinel-2. Part I: Radiometric and Geometric Performance, and Application to Ice Velocity. *Remote Sens.* **2016**, *8*, 598, available at https://www.mdpi.com/2072-4292/8/7/598/pdf/1



More information about atmospheric windows in Eduspace http://www.esa.int/SPECIALS/Eduspace EN/SEMUYP3Z2OF 0.html

Original image from

Kääb, A.; Winsvold, S.H.; Altena, B.; Nuth, C.; Nagler, T.; Wuite, J. Glacier Remote Sensing Using Sentinel-2. Part I: Radiometric and Geometric Performance, and Application to Ice Velocity. *Remote Sens.* **2016**, *8*, 598, available at https://www.mdpi.com/2072-4292/8/7/598/pdf/1



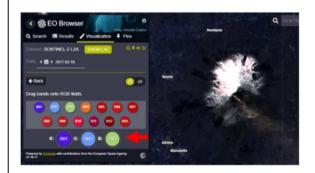
• The visualization False Color (urban) gives you this pre-defined combination of bands. But you can also re-create it manually, or even explore by creating your own combinations!



Slide 8



- Select Custom rendering. You will see the default selection of bands (R=B01, G=B02, B=B03), which does not look very useful in our case.
- We want to have R=B12, G=B11, B=B04
- · Click on the circles containing each band (B12, B11 and B04), and drag them to the R, G or B circles correspondingly





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- You can explore using other bands combinations, to make sure you understand how RGB displays work.
- For example, if you use this combination, why does the snow look red and the lava blue? R=B04, G=B11, B=B12



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- You can explore using other bands combinations, to make sure you understand how RGB displays work.
- For example, if you use this combination, why does the snow look red and the lava blue? R=B04, G=B11, B=B12



Answer: because the lava has higher values in B12, and B12 is assigned to the **BLUE** colour.

Sinde 88



 IMPORTANT TO KNOW: when you want to visualize hot lava flows, you should always use the bands in the Short Wave Infrared part of the Electromagnetic spectrum (like B12).

But you **do not need to assign it to the RED colour** of the display if you don't want to! For us, fire or hot lava is usually thought of as red, that is why a display with red lava is **more intuitively understood**. But it is **not wrong** to show it in a different colour, as long as you **understand** the mechanism behind!

A small game: Can you try to recreate those beautiful displays?





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Answer:





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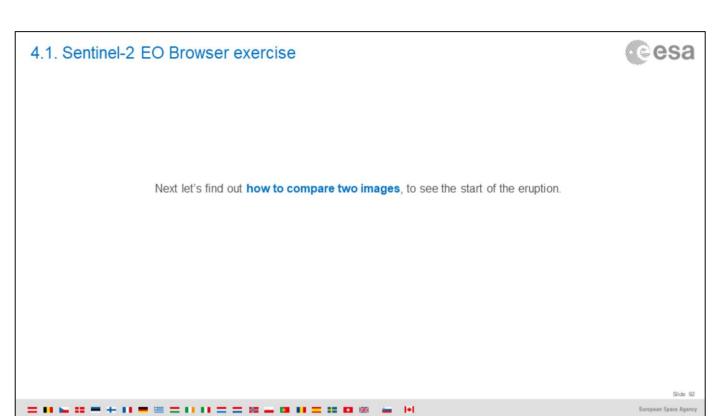


In EO Browser you can also **export** images. When you have a **display that you like** and understand, export it by clicking on the **Save icon** (right side of the screen). Then select the **format and resolution** you want (in Basic, Analytical or High-res print).

Note you will need to be logged in EO Browser to have this functionality! Otherwise it will not appear.









This is a shortcut to search for images:

- 1. Click the calendar next to "Date" (You don't need to go back to Search like we did to find the image from 2017-03-19 and repeat all the steps)
- 2. Select the 2017-03-09 and the image will display with the same band combination.
- 3. Notice the clouds and...the absence of lava flow. The eruption had not started yet that day.





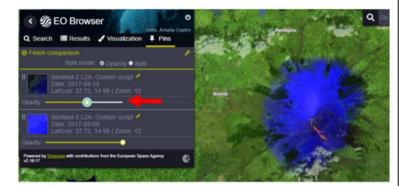
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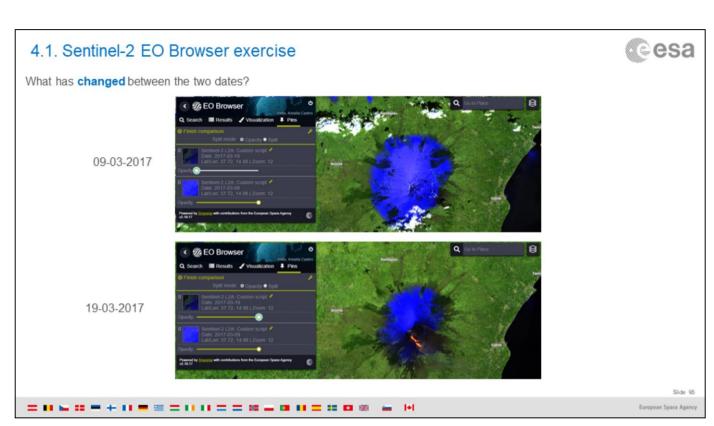


- . To compare them, we will overlay them (put one on top of the other) and play with the transparency to visualize the change:
- 1. Pin this image from 2017-03-09
- 2. Go to Pins. The images you have saved by "pinning" them earlier are stored here
- 3. Click Compare
- 4. Play with the transparency sliders

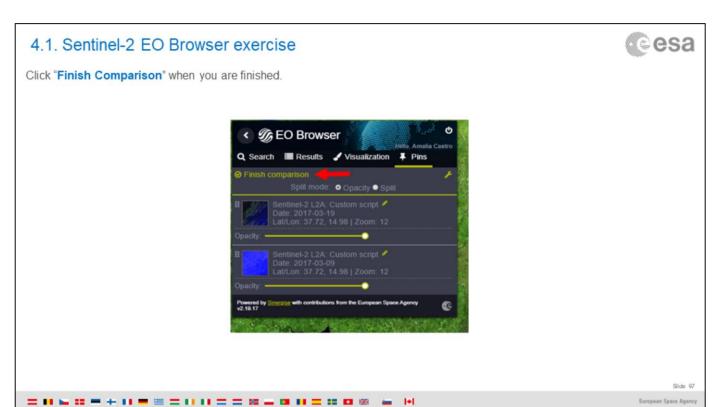














A nice way to visualize the evolution of the volcano is by doing a Timelapse gif.

(Make sure you have a band combination or other products displayed

- 1. Put the start date and end date of the period of time you are interested in. For example 2017-02-09 to 2017-05-08
- 2. Search for the images. The small visualizations on the left side will be updated
- 3. Adjust the percent of clouds you accept in your images (e.g. 73%)

- 4. Scroll down the images, and leave ticked the ones you like
- 5. Click play to preview your gif
- 6. Adjust the speed to make it slower or faster
- 7. Download it Sentinel-2_L2A-timelapse
- 8. You can show it to your friends and family!







Did you notice some of the images do not show the whole area?

The video below (right) will give you a hint....





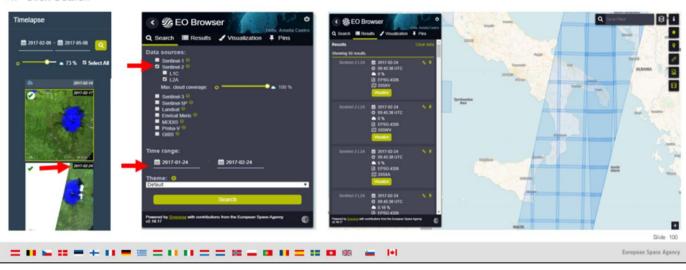
http://www.esa.int/spaceinvideos/Videos/2016/08/Sentinel-2_global_coverage?source=post_page

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Another hint.....

- 1. Go back to search and zoom out to see the whole south of Italy
- 2. Select Sentinel-2 (L2A only, for simplicity)
- 3. Keep a single day in the Time range: 2017-02-24 (same date as the image in the Timelapse that appears "cut")
- 4. Click Search





Note that sometimes, there are **more data** than the Results tab of the EO Browser **shows by default**. It could be that you see an image like the one below.

In that case, scroll down, click Load more, and all the results should be displayed.





Answer: the image is not cut, it is simply that the Etna volcano was **on the edge of the image** that was acquired that day. Every day the satellite Sentinel-2 orbits over a **different area** of the world, it does **not cover the same areas every day!**

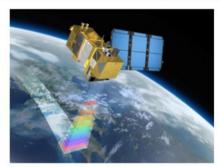


Game: can you find other days when the Etna volcano appears on the edge of the image?

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We have now finished the exercise with Sentinel-2



We will now have a look at what Sentinel-5P can offer



Overview



- 1.Basics of Remote Sensing: The Electromagnetic Spectrum, Radiation and Temperature, Atmospheric Interference, Passive Sensors& Active sensors
- 2.The European Space Agency & ESA Earth Observation Programmes: Science Satellites, Copernicus Sentinels, Science for Society Programme
- 3.ESA Educational resources for teachers and schools
 - 1.ESA Education Office: Teacher's corner (including ESERO project), ESA Academy
 - 2. Resources for schools within EO4Society (including Eduspace exercise on the Etna)
 - 3. Tools for general outreach (i-books, apps, MOOCs)
- 4. Earth Observation Browser (EO Browser): Overview of Sentinel Hub, Sentinel Playground, EO Browser, Industries and Showcases, Education
 - 1. Exercise: Sentinel-2 for Etna lava flow
 - 2.Exercise: Sentinel-5P for Etna atmospheric emissions

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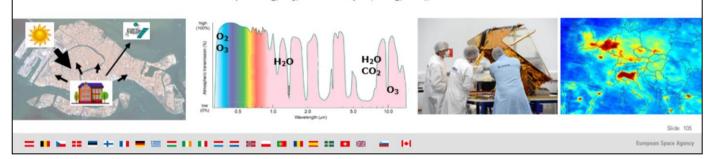
http://www.tropomi.eu

Sentinel-5P is a satellite launched in preparation for the Sentinel-5 satellite that will be launched in the future: P means "Precursor". It carries only **one sensor**, called **TROPOMI**. TROPOMI is the most advanced **multispectral imaging spectrometer** to date.

It observes the **sunlight that is scattered** back to space by the surface of the Earth and by the atmosphere, and it detects the **unique fingerprints of gases** in **different parts of the electromagnetic spectrum**.

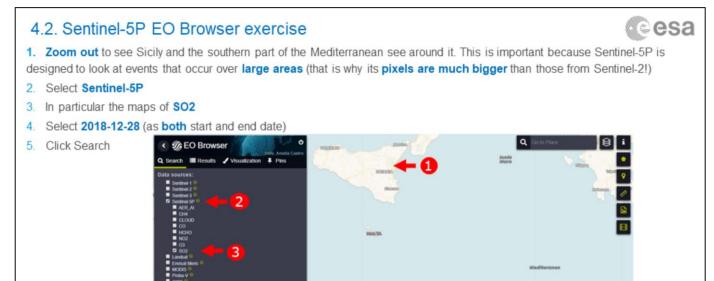
It can detect a wide range of pollutants, because it measures in the Ultra Violet, Visible, Near Infrared and Short Wave Infrared parts of the electromagnetic spectrum.

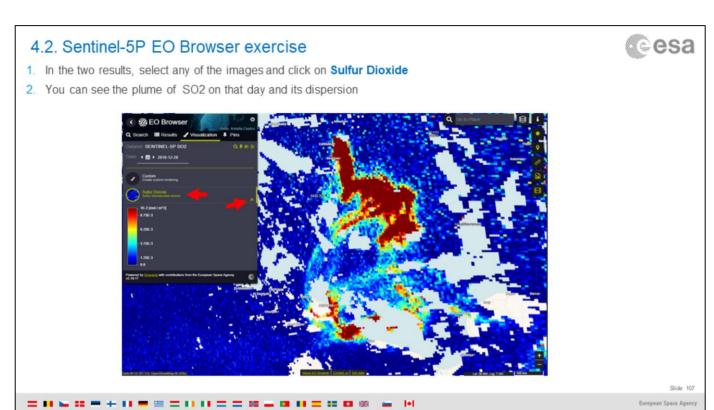
For example NO2, O3, formaldehyde, SO2, CH4, CO can be measured

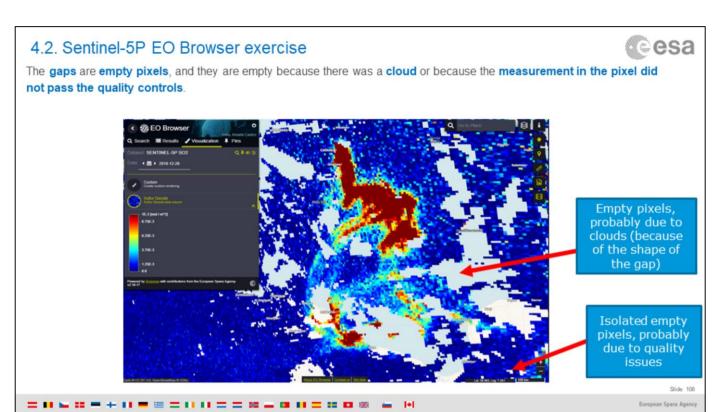


Additional info about TROPOMI at

https://m.esa.int/Applications/Observing the Earth/Copernicus/Sentinel-5P/Tropomi







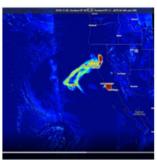


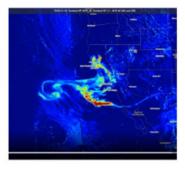
https://www.sentinel-hub.com/explore/education

Additional material:

The **EO** Browser case study on Air Pollution uses Sentinel-5P and has beautiful visualizations of the spread of aerosols from wildfires, for example. We invite you to have a look at it as well!







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3. Useful Addresses



- > ESA education portal: www.esa.int/education
- > Eduspace: http://www.esa.int/SPECIALS/Eduspace EN/
- > ESA EO Education web page: https://eo4society.esa.int/training-education/
- > Climate Change Initiative: http://cci.esa.int/
- Leoworks 4.3: http://leoworks.terrasigna.com/
- > i-Books, Apps: http://www.esa.int/spaceinvideos/Videos/2012/12/ Earth from Space the Living Beauty
- ESERO: http://www.esa.int/Education/Teachers_Corner/ European_Space_Education_Resource_Office
- > to order EO material: education@esa.int or eohelp@esa.int
- Santorini, Nea Kammeni Inflating: http://www.esa.int/spaceinimages/
 Images/2012/09/Santorini inflating
- > Water Currents: http://globcurrent.oceandatalab.com/
- Institute for the study and monitoring of the Santorini Volcano (ISMOSAV): http://www.santorini.net/ismosav/

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