



## CESAR Scientific Challenge

# A 3D Earth

*Research on topographic maps with data from the Copernicus Programme and Google Earth*

### Student guide





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# Your Scientific Challenge



## Decoding the 3D scientific information from satellites

Scientists of the COPERNICUS Space Programme analyse the scientific data from Earth collected by the ESA satellites "Sentinel". Their main goal is to protect our planet, Earth.

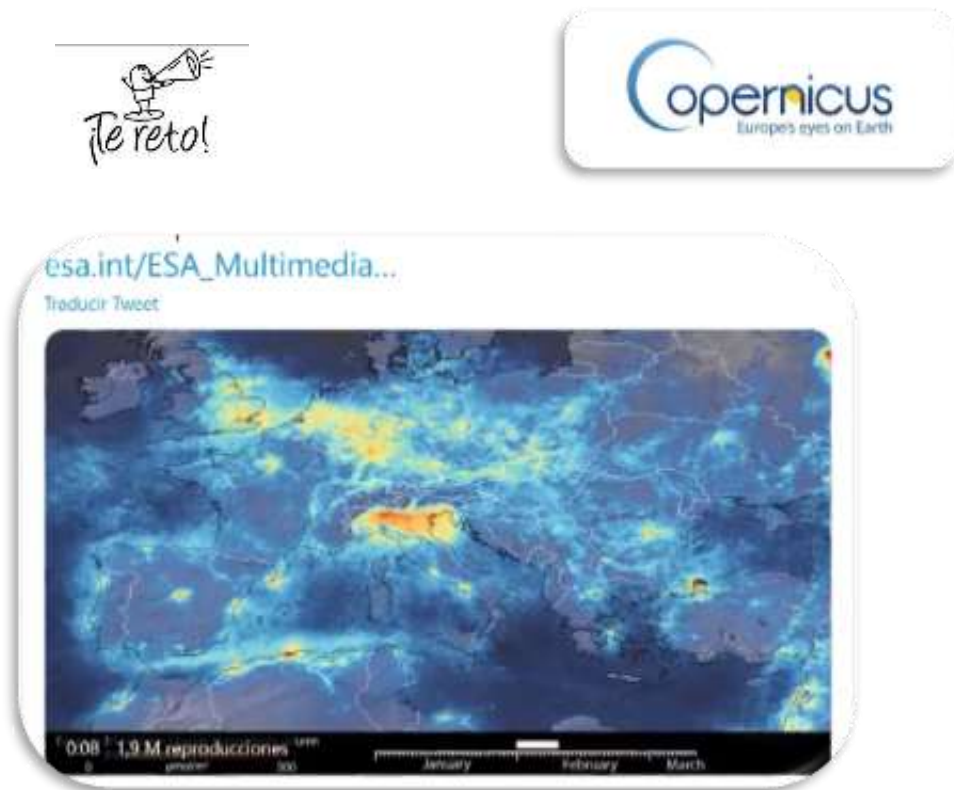


Figure 1: Image of Copernicus programme (Credits: ESA)

The first thing that we are going to do is to explore the terrain in 2-Dimensions (2D) and to identify patterns in it. We will be able to create our own 2D maps, with scales, references and level curves.

From that moment on, we will jump into the 3D, by testing our space vision and studying changes in the terrain along the years and will be able to create our own path.

**Could we count on you to help our scientist?**



# Phase 0



To understand the situation, start watching these **videos**:

- [Images of Earth from the ISS](#)
- [Sound \(and vision\) of Silence](#)
- [ESAC: ESA window to the Universe](#)
- [This is ESA](#)

### Work in teams

**Work in teams of (4-6) students.** Each member of the Team will have a specific role in the investigation.

- Ask the teacher for the Challenge ID and your Team number to fill out Table 0.
- Write down your names according to the agreed tasks.

| Challenge ID   |  | Number of your Team |  |
|--|--|---------------------|--|
| <p>Writer:<br/>_____</p> <p>Responsible of the material:<br/>_____</p> <p>Reader:<br/>_____</p> <p>Speaker:<br/>_____</p> <p>Drawer:<br/>_____</p> |  |                     |  |



# Phase 1





## Activity 1: Refresh concepts

Fill in each sentence with the words or concepts given below:

**maps, scale, planes, two-dimensional, physical maps, deltas, sketches, cartography, mountains, earth globes, legend, topographical, geographical features and landforms**

\_\_\_\_\_ is the science in charge of the study and the creation of maps.

The \_\_\_\_\_ and \_\_\_\_\_ are forms of representation of the surroundings or geographical areas.

The planes are \_\_\_\_\_ representations of a village, city or a house.

There are two ways of representing, in a reduced size and on a plane, the Earth surface, through \_\_\_\_\_ and maps.

The \_\_\_\_\_ contain a large amount of information such as dots, lines and polygons, besides a measured scale and a legend.

The \_\_\_\_\_ is the numerical expression of equivalence between the drawing on the map and the real size of the represented surface.

The \_\_\_\_\_ in a map explains the used symbols on it and gives necessary information to understand it.

There are two big groups of maps: the \_\_\_\_\_ and the thematic maps.



The physical or \_\_\_\_\_ maps try to represent the exact and detailed surface of the Earth, considering mainly the relief and altitude.

Topographical maps try to represent show elements such as mountains, valleys, rivers and other \_\_\_\_\_.


There are fluvial landforms such as river \_\_\_\_\_, islands or lagoons.

River deltas appear at the mouth, but the source of the rivers themselves are in the \_\_\_\_\_.

- If you want to know more about the **Scales of the Universe** [click here](#)

## Activity 2: How to draw a map?

Choose between Option A or B and answer the following questions in Teams:

|   |          |
|---|----------|
|   | <p>A</p> |
|  | <p>B</p> |

*Figure 2 Images of places in Spain (Credits: Google Maps)*

Imagine the next situation...you suddenly wake up in the next place and only see this image (A or B) in front of you:

1. Where do you think you are?

|                 |  |
|-----------------|--|
| <p>Option :</p> |  |
|-----------------|--|



2. Is this a slope to the sea, or an island or a lake...?

3. How to find where you are?

4. Could you draw a map of the place? Suggest means, machines, and tools that you will need and how to do it.

5. Present your results and share them with the other groups.

Planes and aerial photography helped us to know better our country, our continent and our planet. Thanks to satellites we can see everything with a glance: [Space for Kids - A view of Earth.](#)

### Activity 3: Identify the relief and hydrography in a physical map.

Let's remember the elements that appear on a **physical map**. Consult on the Internet the information that is asked for if it is necessary.

#### Activity 3.1: Islands

1. Locate and circle the Cíes islands.



Figure 3: Edited image from the physical map of Spain from Ed. Anaya (Credit: [Blaq Aula de línqua galega](#))

2. Write down the name of the river that appears on the map and its tributary.

3. Where are their sources and where do they flow into?

### Activity 3.2: Lakes

1. Locate and circle the Lake of Sanabria.



Figure 4: Edited image from the physical map of Spain from Ed. Anaya (Credit: Blog Aula de língua galega)

2. Write down the name of the river input and output to the lake.



3. How was the lake formed?

4. To which mountain system does it belong?

All this data can be analyzed through maps or images that satellites capture nowadays. (See an example: [Earth from Space: Barcelona](#))



## Activity 4: Where to draw something on our map?

### Material required:

- Pencil, paper and crayons.
- Smartphone to take a picture and upload it to this document.
- Measuring tape or ruler.
- Cord or wool.

### Experiment:

Imagine that your team have been left alone on an unknown island.

#### 1. **Draw a map** of how you imagine your **island**.

- You must include as many details as possible
- You must think carefully about the distance between them
- And where to draw, for instance, their mountains, their rivers, lagoons, cascades, trees, forests, etc.







## 2. Calculate Distances:

### 2.1 On the Map:

- Locate a **reference point (A) on the map**. (Hint: It can be a mountain, a tree, the mouth of a river, etc.)
- Choose another point (B) on the island near it.
- Take a string and connect point A and B. Make a mark on the string for each of these points.
- Put the string on the ruler and measure the length (in centimeters). This will be the **distance in your plane**. Write this data here (in cm).

Measurement 1 (**distance in plane**)

### 2.2 In class: Imagine that your class is the island and you are going to measure distances on it by counting steps.

- Stand up and take where you are as a reference point (A).
- Choose another point (B) from the class
- Put one foot in front of the other (feet together) to measure. Move around (guided by the teacher) to get used to calculating distances in feet.
- The number of steps between points A and B will be the actual distance** (if your class was an island)
- Write the number of feet of the measurement (N):**



- Measure** with a ruler **foot in centimeters (cm)**

- Therefore, the **actual distance** will be the number of feet (N) **multiplied** by the measurement of the foot (in cm):

Measure 2 (**actual distance**)

N x (measure of your foot in cm)

### 3. Calculate scales (or proportions)

- Divide the actual distance (**Measurement 1**) by the distance in the plane (**Measurement 2**) to obtain the **proportionality constant, k**

$$k = \frac{(\text{Measurement 1})}{(\text{Measurement 2})}$$

- We usually write the scale of a plane as [1: K]. What is the scale of your map?**

[1:    ]



## Activity 4.1: Self-evaluation of your map

**On the same map you just drew:**

1. **Measure** the distance between two other points on the map with the string (Note: Use the ruler to see how many centimeters (cm) the string measures)

2. Do you remember the value of the proportionality constant of your map,  $K$ ? **Multiply your distance from the plane (in centimeters) by  $K$  and you will get the real distance.**

3. Does this measure make sense in reality?

4. What if we measure the distance to the highest peak of a drawn mountain? Will the distance between your drawings in the plane be the same as the real one?



It is not only important to be able to draw a map of a place but also to have a distance reference to locate mountains, rivers or paths. **We need to add coordinates, distances and a reference system.** We also have to reflect the **altitudes** in them.

The satellites help us to know and find those data.

For instance, navigation satellites like the [Galileo](#) system help us to know where we are, how far are the places we want to go, or how long it takes to take a tour. They can also guide us on hiking routes or walks by the rivers, seas, and oceans.



*Figure 5: Image from the video in the article "Galileo signal team wins European Inventor award" (Credits: [ESA](#))*

## Activity 5: What types of maps are there?

Maps are representations of a reality that we see in 3D. Besides representing distances we need to be able to identify altitude or depth in the terrain, which we call relief.

In order to be able to understand this relief on the plane we must:

- Place our points in a 3D reference system.
- Think about how to transform these drawings into a map.

We are going to create a topographic map with modelling clay ([Activity 5.1](#)) and/or with an application that makes **graphics**, called **Geogebra**. The latter needs the use of a computer or Tablet

### Activity 5.1: Topographic maps (plasticine, sheet and colours)

1. Make a 3D topographic map with plasticine (Figure 6)
2. Think about what heights you would make the cuts (planes that cut horizontally across the mountain) and give each cut a colour.
3. Paint on a sheet the shape of these cuts with different colours for different heights (as shown in Figure 6).

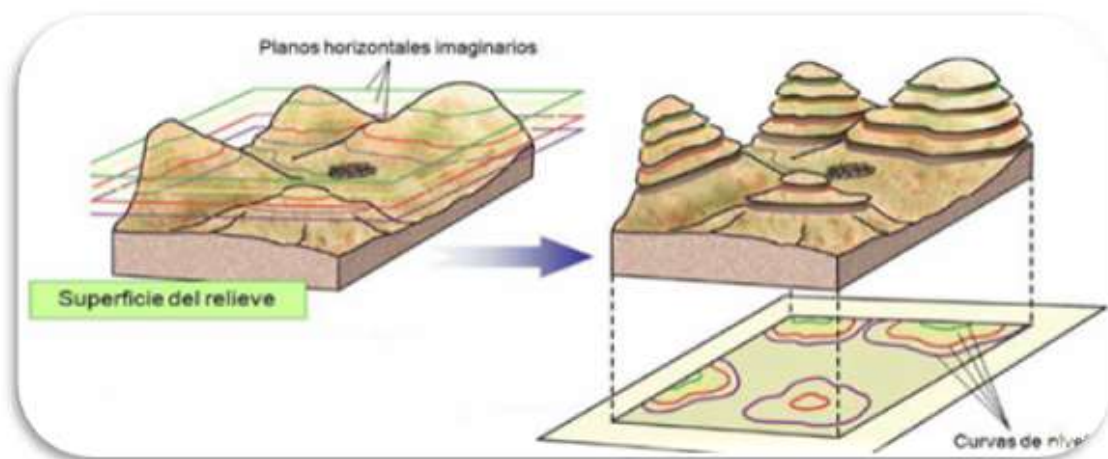


Figure 6: Image Edited (Credits: Planet Science)



## Activity 5.2: Topographic maps (with Geogebra)

### Activity 5.2.1: Get familiar with Geogebra 3D Graphics

Follow the steps of the following **procedure**:

1. Click on the link (or download the app) [Geogebra, 3D Graphing](#). You will see something like Figure 7, where three axes are shown that are used to draw our figures in 3D.

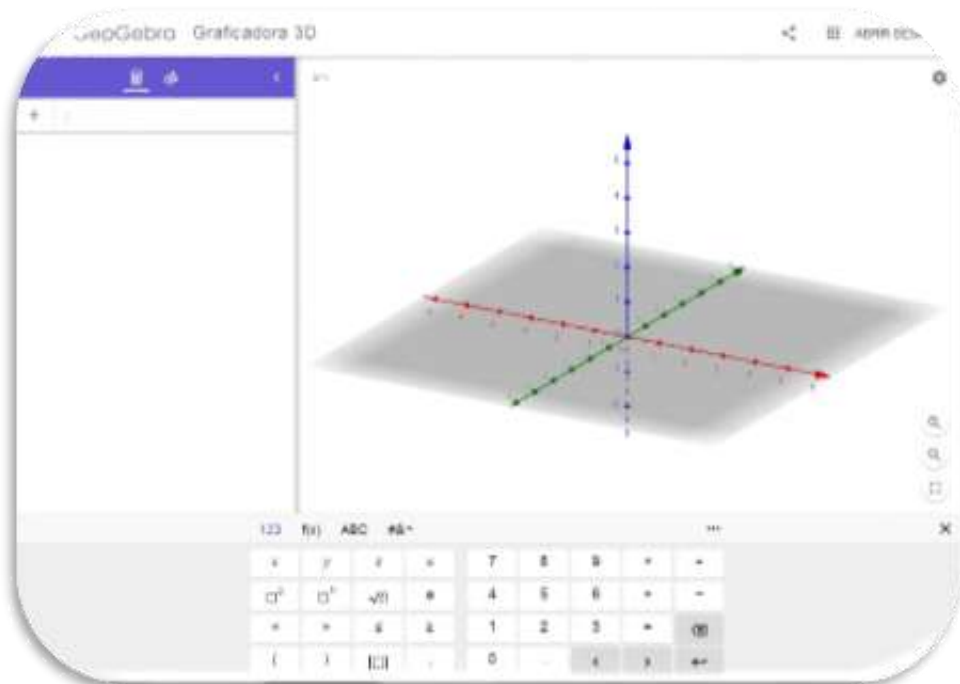
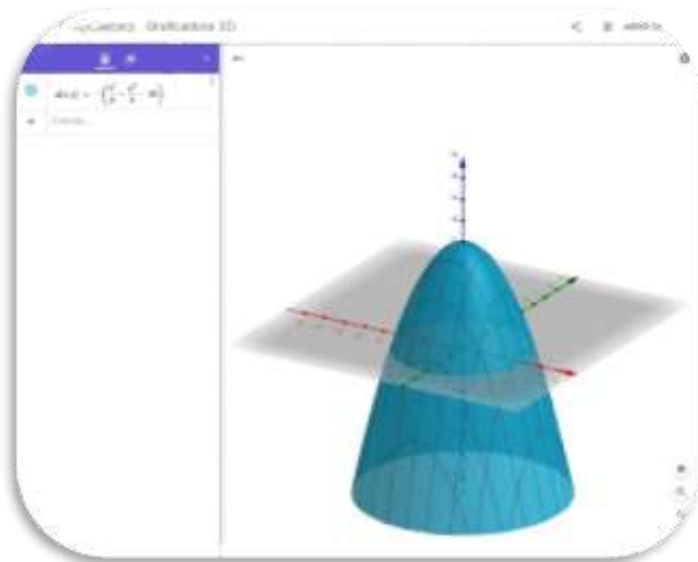


Figure 7 Image of the starting screen (Credit: [Geogebra, 3D](#))

### Activity 5.2.2: Create a mountain with Geogebra

1. Repeat [Activity 5.2.1](#) if you have not already done so
2. To reproduce a mountain, Figure 8 on the Tablet



- 1.1. Using the keys on the 3D Calculator, type in the following *Figure 8 Image of the mountain (Credits: Geogebra, 3D Graphics)* and press enter:

$$(x [ ]^2 > \div 4 > + y [ ]^2 > \div 4 > - 10 > \leftarrow$$



- 1.2. Click on the magnifying glass with a minus to see the whole.

## Define contour lines

We are going to cut a mountain into slices (horizontal planes) at different heights. Imagine that your mountain is 1000 m high, cut it into planes that are 200 m high from each other (Figure 9)

To do so, follow this **Procedure**:

1. We start from the mountain drawn in [Activity 5.2.2](#). If you have not done this activity, do it
2. Write the following in calculator mode:

$$z=2 \leftarrow z=4 \leftarrow z=6 \leftarrow z=8 \leftarrow$$

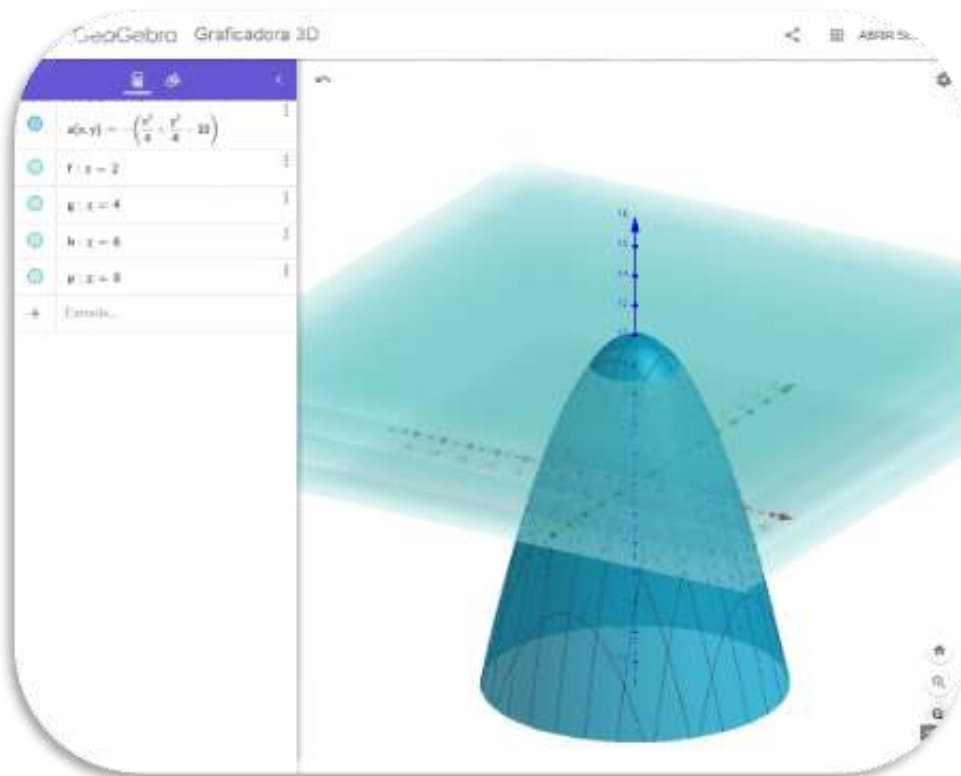


Figure 9. Example image of cutting planes (Credits: Geogebra, 3D Graphics)

You will see in the application an image like the one in Figure 9, where the planes come out in the same colour by default.



### 3. Colour the plans.

Select the plane and assign it a colour, as shown in **Figure 10**.

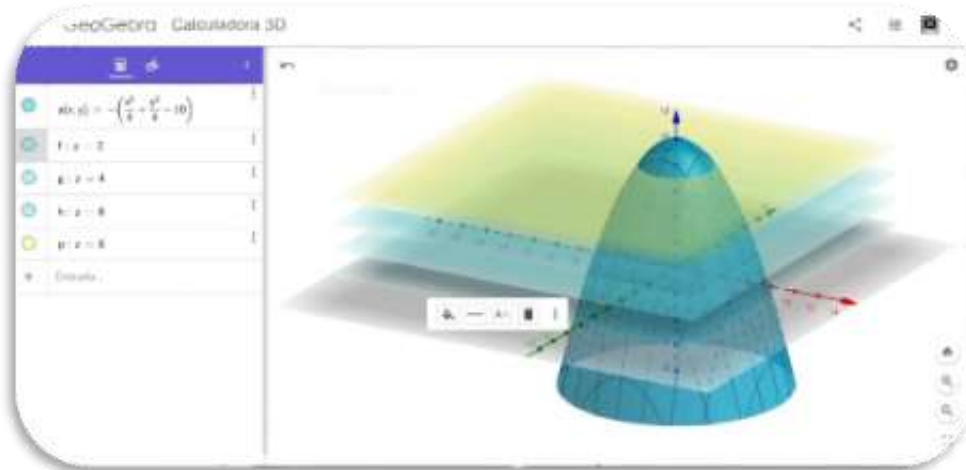


Figure 10-A: Colouring cutting planes (Credits: Geogebra, 3D Graphics)

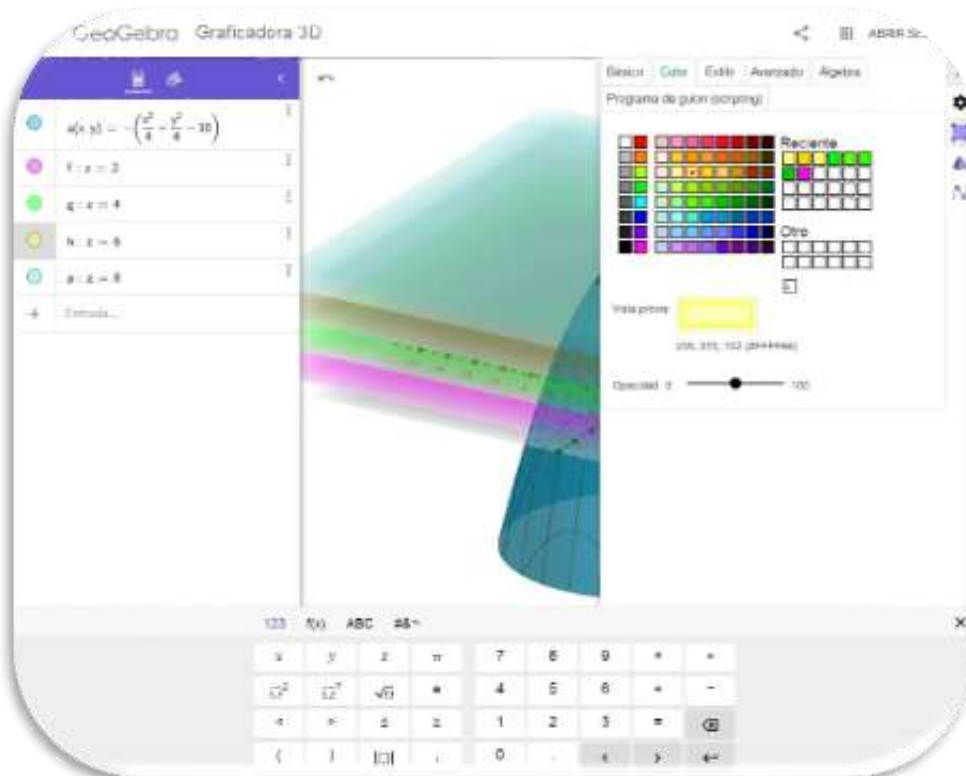


Figure 10-B Explanatory image (Credits: Geogebra, 3D Graphics)

Move Figure 11 to see the mountain and its slices from different points of view (perspectives).

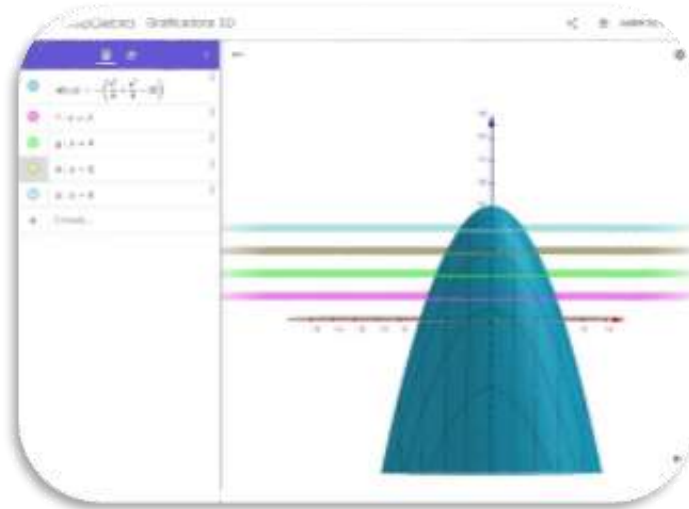


Figure 11 Explanatory image (Credits: Geogebra, 3D Graphics)

4. Identify the **contour lines**.

We call the regions that create the cutting planes on our mountain "contour lines" (see Figure 12)

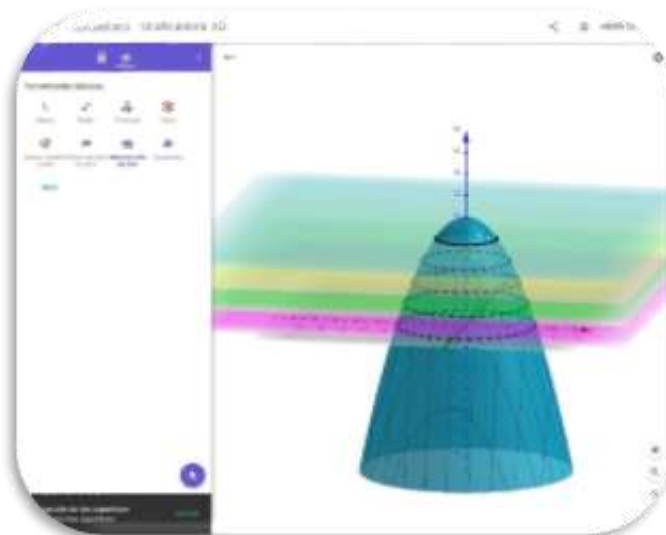


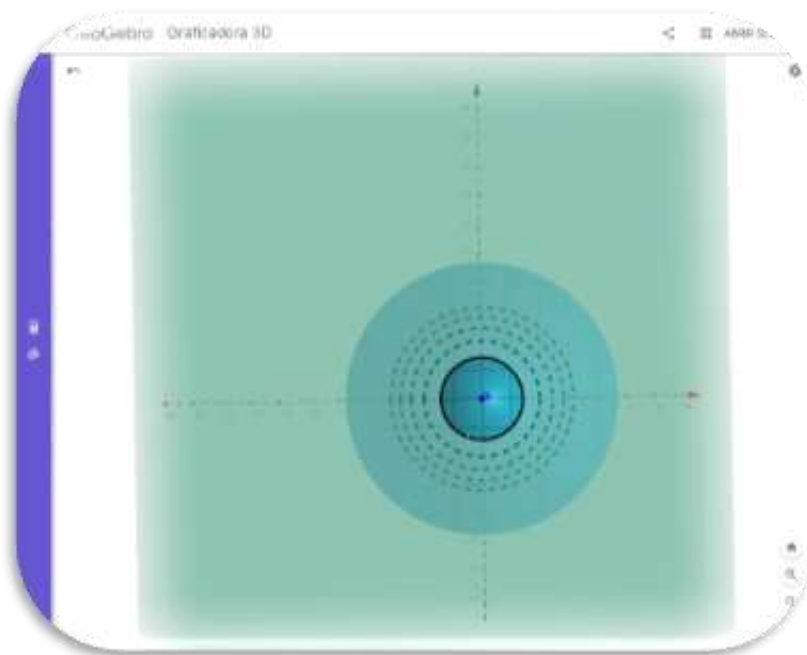
Figure 12 Explanatory image (Credits: Geogebra, 3D Graphics)

### Create your own topographic map.

1. Change the viewpoint of Figure 12 and look at it from above.
2. Check that you see **concentric curves (or contour lines)** as in Figure 13.

This is a topographic map, in which each contour line represents a height.

Try to draw the contour lines on the map of your island.



*Figure 13 Example of a topographic map (Credits: Geogebra, 3D Graphics)*

### Activity 5.2.3: Create a valley with Geogebra

You will create a 3D figure representing a valley (Figure 14).

#### Preparation:

- If you have done [Activity 5.2.2](#), clear the screen. To do this, go to the menu on the top left (three small strips) and click on "Clear all". Then start the procedure.
- If you have not done [Activity 5.2.2](#), follow the procedure below

#### Procedure:

- Type the following in the 3D Calculator and press enter:

$$x [ ]^2 \div 10 > - y [ ]^2 \div 5 > \leftarrow$$

- Add the maps  $z=-2$  y  $z=-4$
- Click on the magnifying glass with a minus to see the whole.

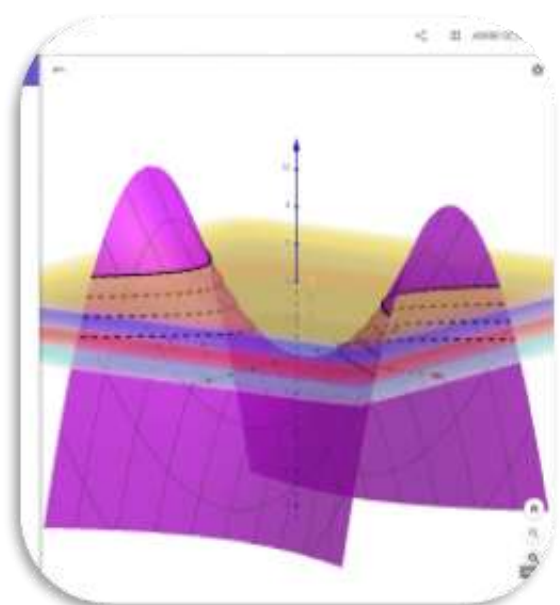
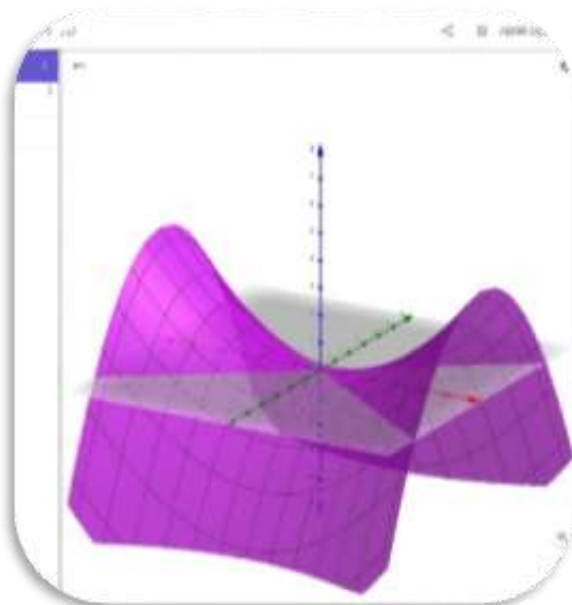
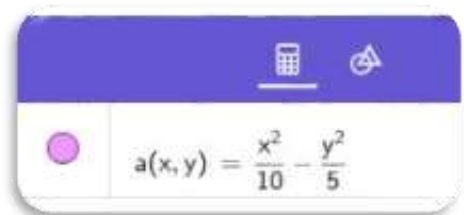


Figure 14 A & B Representation of a valley (Credits: Geogebra, 3D Graphics)

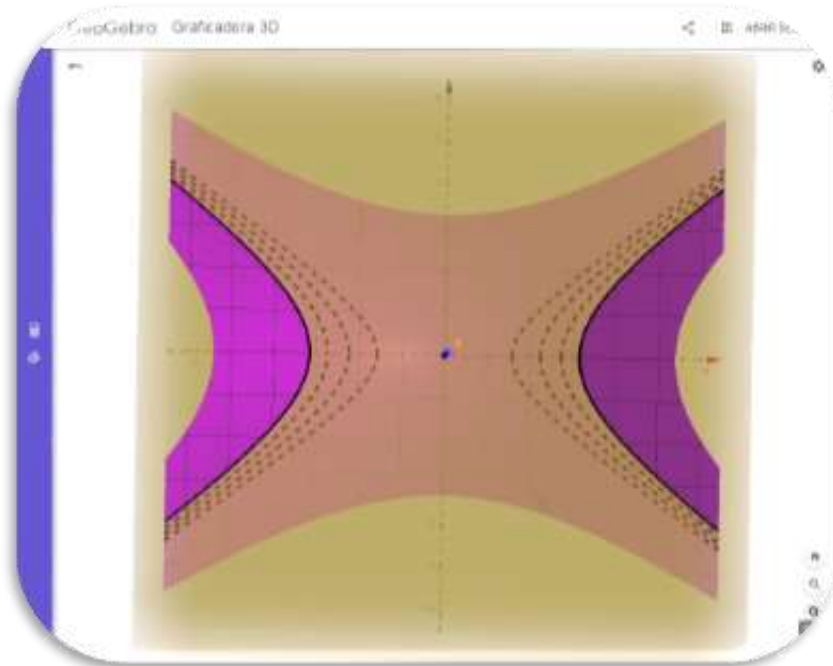


Figure 14C: View from above of the same figure (Credits: Geogebra, 3D Graphics)

If we enlarge or reduce our topographic map with the magnifying glass, we can simulate how we would see on a map if the mountain has a greater or lesser slope depending on whether the lines are closer together or further apart respectively.

You can see an example of a satellite topographic map [ESA - Pine Island retreat](#) where you can see the different heights or layers of our contour lines in various colours

### Activity 5.2.4: Create an island with Geogebra

You will create a 3D figure representing a valley (Figure 14).

#### Preparation:

- If you have done [Activity 5.2.2](#) or [Activity 5.2.3](#), clear the screen. To do this go to the menu on the top left (three small strips) and click on "Clear all". Then start the procedure.
- If you have not done [Activity 5.2.2](#) or [Activity 5.2.3](#), follow the procedure below

#### Procedure:

- Type the following in **the 3D Calculator** and press enter:

$$x [ ]^2 \div 4 > + y [ ]^2 \div 4 > - 10 \downarrow$$

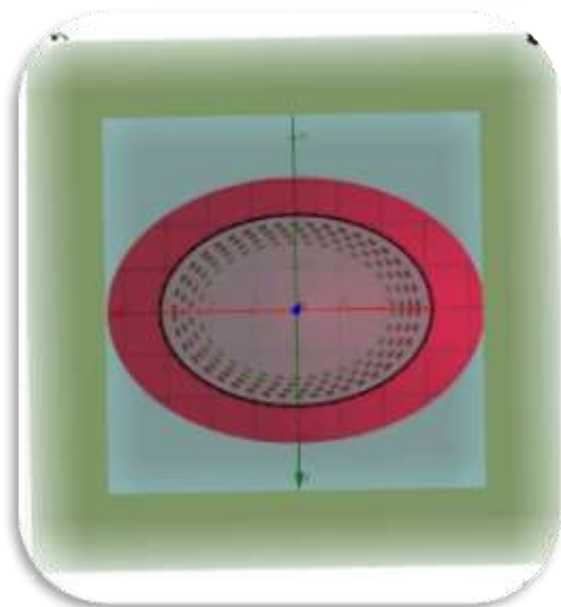
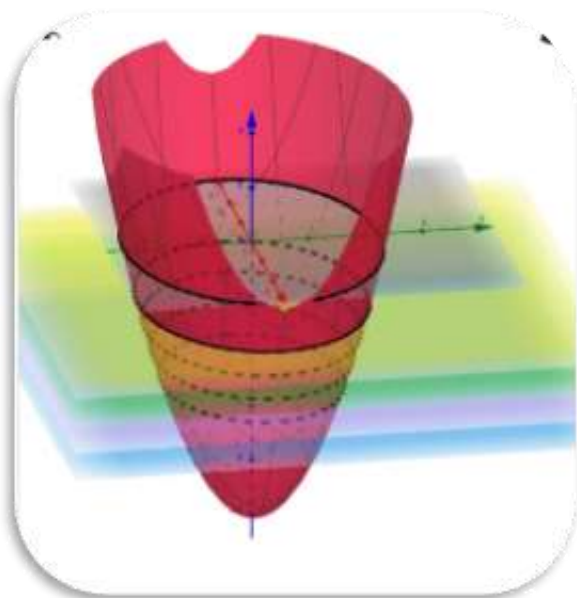


Figure 15 Different perspectives of the same figure (Credit: Geogebra, 3D Graphics)

We must only write to section the figures by underground planes or cutting planes with heights  $z=-1$ ,  $z=-2$ , etc.

In the case of repeating the figure from [Activity 5.2.3](#), it would be:

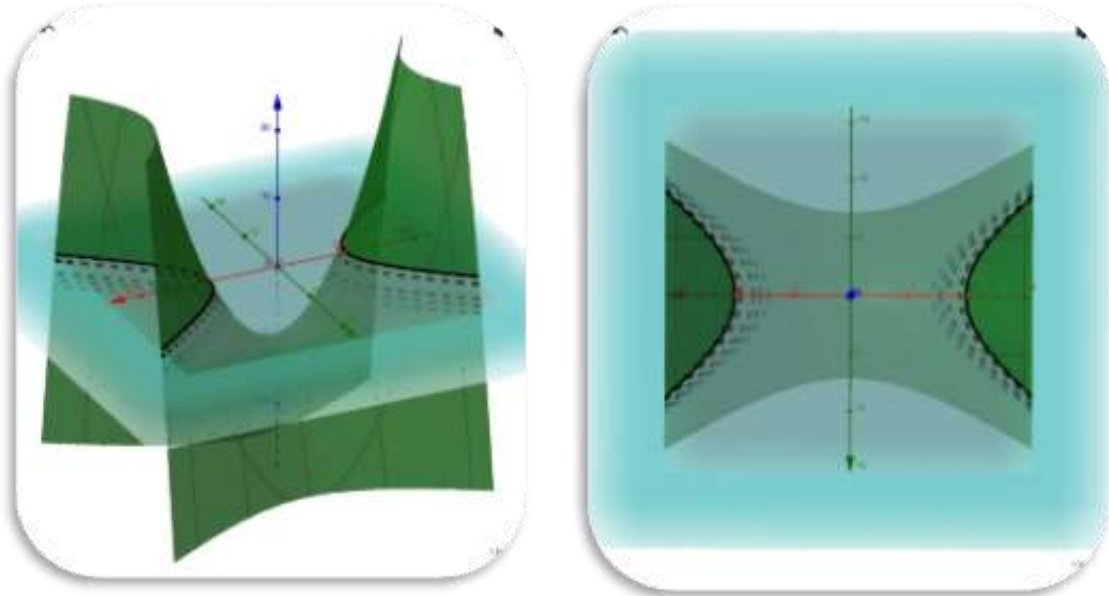


Figure 16 Different perspectives of the same figure (Credit: Geogebra, 3D Graphics)

Do you think that Figure 16 could contain a reservoir or be the link between islands?



## Activity 6: Does my island have water, reservoirs or rivers?

1. Watch this [video](#) before starting this activity on the water cycle.
2. Analyze the hydrography (distribution of the water or water bodies) of your map of the island by answering the following questions:

- How have the bodies of water within the island been created?

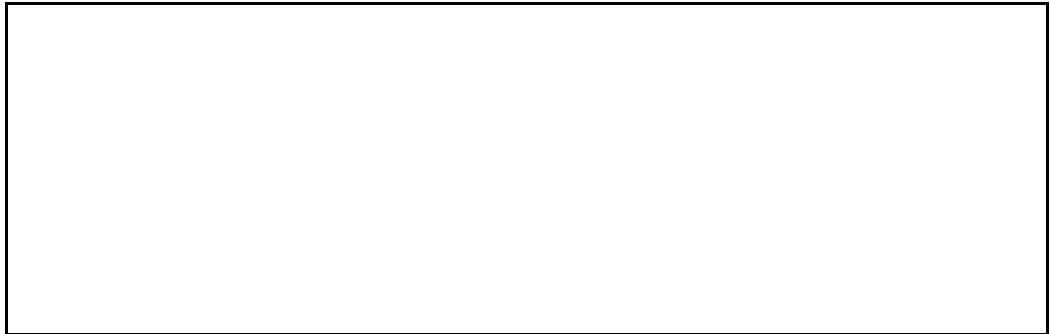
- If we imagine a body of water crossing our island, dividing it into two parts, would it be a river?

- Would it make sense to draw a river on a flat surface? (Hint: Think about the path the water follows in the course of a river)





- Could we draw a lake on a flat surface? And how would you draw its depth?



### Activity 6.1: How to use that water?

Water is essential for living beings and for survival on our island. If we stay a long time on an island, we must analyze how to collect it, if it will be drinkable or if we will need a reservoir to dispose of it in times of drought.

Thanks to the satellites, all this information usually comes from images or similar data to those analyzed in the previous activities.

Each group will read one of the following news and must expose to the others what they have read.

- [ESA - Space for Kids](#) - ESA satellites help us tap into the Earth's precious water
- [Space for Kids](#) - Water-saving satellite navigation technology
- [Space for Kids](#) – The rives

## Activity 7: Study of climate change with maps

Figure 17 shows us a map of the Earth, and above it, colors. These colors instead of showing heights (contour lines) as in **the topographic map** give us **information about the temperature of the Earth or the oceans.**

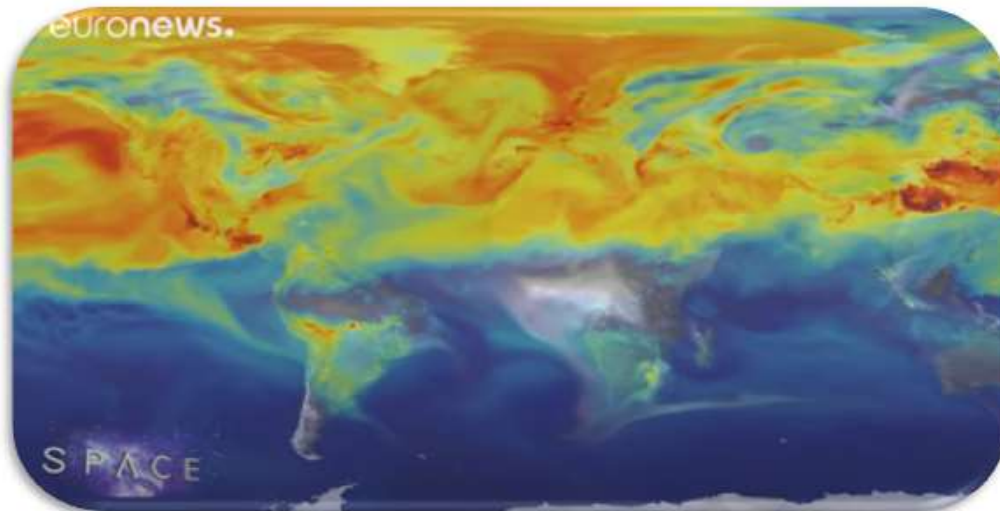


Figure 17 Image capture of the animation (Credits: ESA Euronews)

1. Watch the video: [ESA Euronews: Studying climate threats with Sentinel](#)
2. Explain how scientists use satellites to better understand what is happening in places like this, and around the planet.

3. What measures do you propose in the video to improve the environmental conditions of our planet?

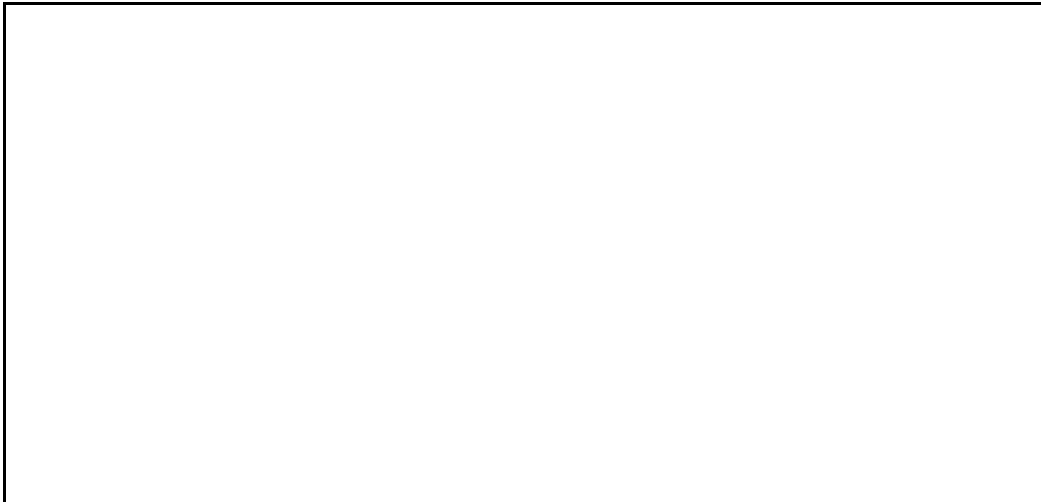


Figure 18 Layers of the Earth's atmosphere (Credits: geologyweb)



## Activity 8: Earth exploration by the European Space Agency missions

**The Copernicus program** is a project led by the European Space Agency and by the European Union through the Environment Agency. The aim is to provide accurate information for environmental management, minimize the effects of climate change and generate civil security.

ESA is the main sponsor and designs, supervises and co-finances the development of **Sentinel missions**. The Copernicus program also has **Meteosat and MetOp-SG** instruments that form the basis of EUMETSAT. **ESA and EUMETSAT are working together** to collect information from about 30 satellites, such as Landsat.

Let's learn a little more about the **Sentinel family of satellites**, or space sentinels

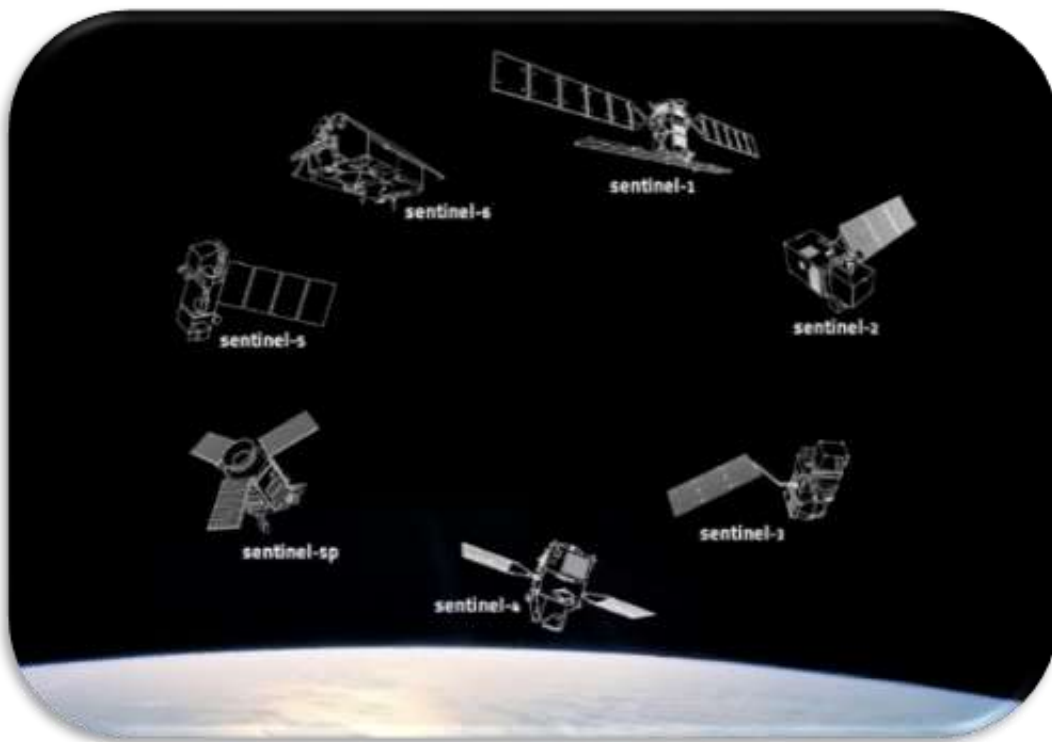


Figure 19. Representation of the different Sentinel missions (Credits: ESA)



- [Sentinel-1](#) (satellites 2A and 2B) take images by radar, day and night and in all weather conditions.
- [Sentinel-2](#) (satellites 2A and 2B) take very detailed color (optical) images.
- [Sentinel-3](#) (satellites 3A, 3B and 3C) measure sea surface altitude, soil and sea surface temperature, and ocean color.
- [Sentinel-4](#) has several instruments that measure air quality in the atmosphere and are on board two third generation Meteosat satellites.
- [Sentinel-5P](#) will be used to examine pollution in the earth's atmosphere, detecting gases such as carbon monoxide and aerosols.
- [Sentinel-6](#) will be launched in November 2020 (and Sentinel-6B in 2025) to study the composition of the Earth and the topography of the seas, respectively.

Figure 20 shows the lifetime of satellites.

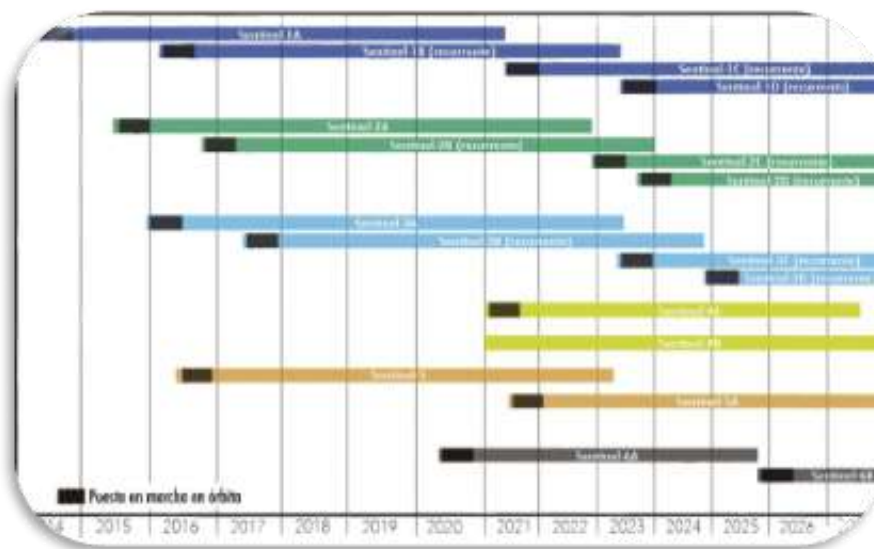
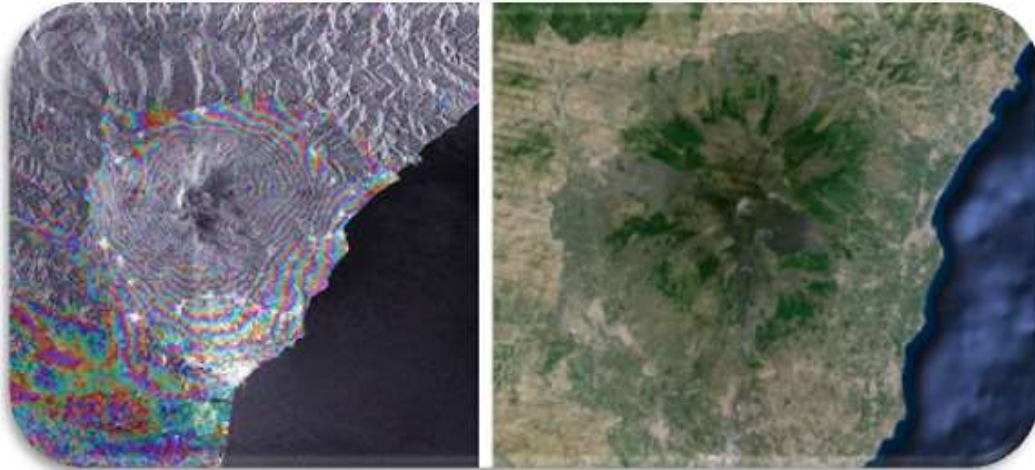


Figure 20 Sentinel mission lifetime (Credits: researchgate)

**Sentinel satellites also allow us to make topographic maps in 3D. Observe, by clicking on the [link](#), the animation created with the colored contours thanks to the images taken by Sentinel 1A of a group of Norwegian islands in the Lyngen Alps**



*Figure 21 Aerial image of Etna volcano, Italy (Credits: left ESA - Etna slopes and right Google Maps)*

1. Write the Sentinel mission number (1-5P) and its objective :

|           |  |
|-----------|--|
| Sentinel- | Discover which living beings inhabit the surface of the ocean, knowing their color |
| Sentinel- | Study the air pollution that affects Paris.  |
| Sentinel- | Study changes in the vegetation, soil or water surface of a natural park .         |
| Sentinel- | Monitoring Arctic sea ice during storm periods .                                   |
| Sentinel- | Study changes in the hole in the ozone layer .                                     |

*Table 1: Sentinel missions objectives*



## Activity 9: What have you learnt so far?

To find out what you have learned so far play the following [questionnaire](#)



# Phase 2





*Figure 22: Sentinel 6, Copernicus. (Credits: ESA)*

<https://twitter.com/esa/status/1321786108187832321>



# Phase 3

## Activity 11: Identify the course of a river on a topographical map

Develop a hypothesis<sup>1</sup>:

1. Draw on the image which path you think the water would follow after a heavy rain.



*Figure 2 Tindaya Mountain, Fuerteventura (Credit: Google Images)*

---

<sup>1</sup> A hypothesis is the initial idea about how you think something happens. Therefore, it should not be considered correct or incorrect, but will serve as a basis for your investigation.



2. Explain in the box why you think it is like this:

3. Now try to draw the mountain with the river on a plane:

Once you have made your drawing, compare it to this Figure 24.

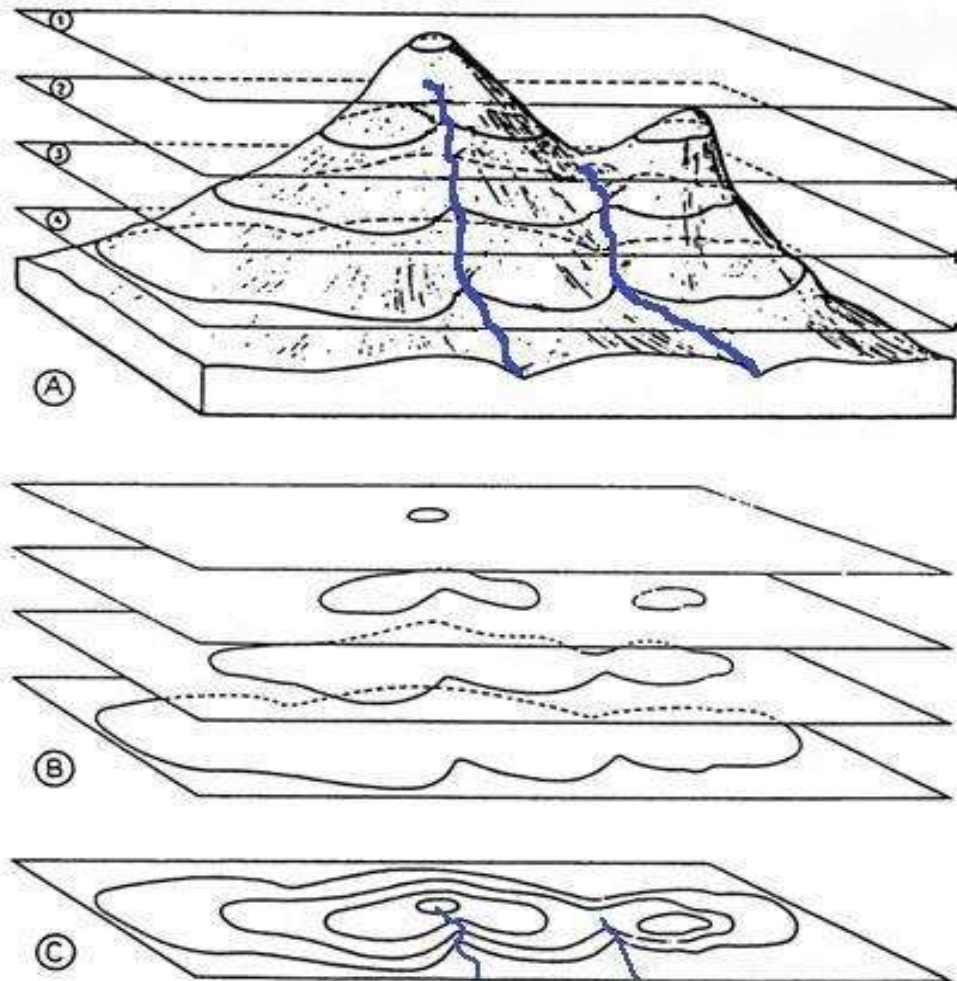
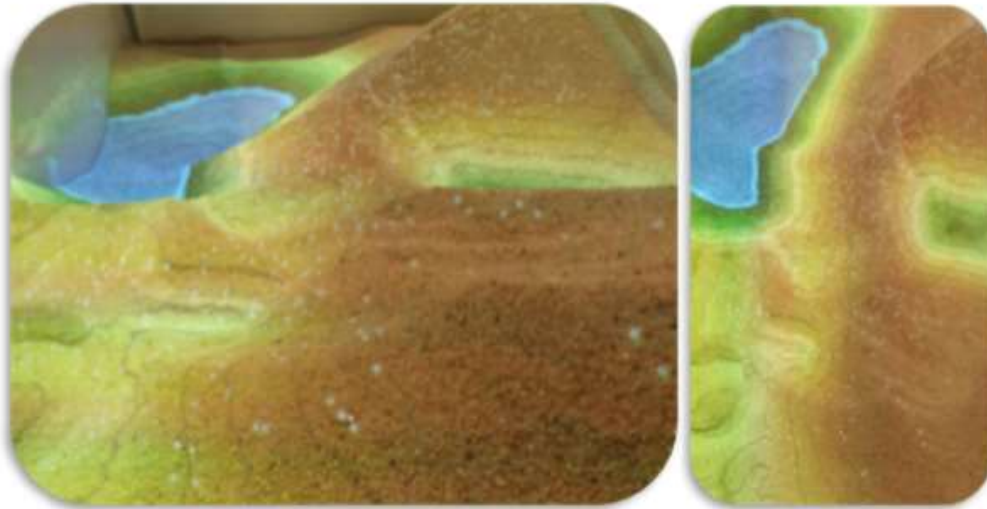


Figura 24 Imagen de recurso web (Créditos: Topografía del relieve)

## Activity 12: Topography in augmented reality: Sandbox

**Note:** This Activity can only be done complete with the Sandbox. The CESAR Team offers it in the Type I Experiences.



*Figura 25 Líneas de contorno como las producidas por la Caja de Arena  
(Crédito: CESAR-ESAC)*

### **You are going to reproduce a topographic map with augmented reality**

#### **Materials:**

- Computer with access to google maps
- Sandbox

#### **Procedure** (by teams):

1. Choose one of the landscapes in Table X
2. Search in google maps how is this landscape
3. Go to the sandbox and reproduce the chosen landscape.
4. Write down what you see (colors) and try to draw your map with **contour lines**.

| <b>Areas of Spain</b>   |
|---|
| A snowy mountain like the peak <a href="#">Mulhacén</a> (Sierra Nevada)       |
| A glacial lake like the one in <a href="#">Sanabria</a> .                     |
| A river at sea level, like <a href="#">the Ulla River</a> in the Rias Baixas. |
| A beach like " <a href="#">El palmar</a> ", Cádiz.                            |
| A volcano like " <a href="#">El Teide</a> ", Tenerife.                        |

*Table 2: Areas of Spain*

Draw your contour map here and explain your experience in this activity.

| Landscape : |
|-------------|
|             |



## Activity 13: What can you see in a topographical map?

### Activity 13.1: Identify the geographical features

Figure 26 is the topographic map you will be working with.

#### **Procedure:**

1. Observe the data on the map and look for the highest mountain or mountains.
2. Trace the course of one or more rivers, from these highest points, to where you think the river reaches.
3. Answer the following questions:
  - Is it possible that there is a lake on the map? Why?

- Do you think that in the previous image there are tributaries or more than one river? Why?





- Where would these tributaries start from?

- Do you think that the river water will always go down at the same speed? Why?

- What do you think it means when the contour lines are very close? And further apart?



*Figura 26 Este mapa muestra la topografía que rodea el embalse de la Pinilla en Madrid. La escala altimétrica del embalse ha sido diseñada para el ejercicio, no es real.*

### Activity 13.2: Where would you place an artificial dam?



*Figure 27 Hoover Dam in Colorado, USA (Credit: Google)*

**Dams** are walls built to stop the course of rivers and form reservoirs.

For this study you will use the map in Figure 26.

#### **Procedure:**

Analyze Figure 26 and indicate:

1. Where do you think a natural reservoir could be formed
2. Where would you put a dam to increase the size of the reservoir
3. Redraw the reservoir

## Activity 14: Study topographical maps with Google Earth

### Activity 14.1: Get used to Google Earth Software

To learn how to use Google Earth we indicate the steps to follow, using the indicated material:

#### Material:

- Computer or device with touch screen.
- Installing [Google Earth Pro](#) software.

#### Procedure:

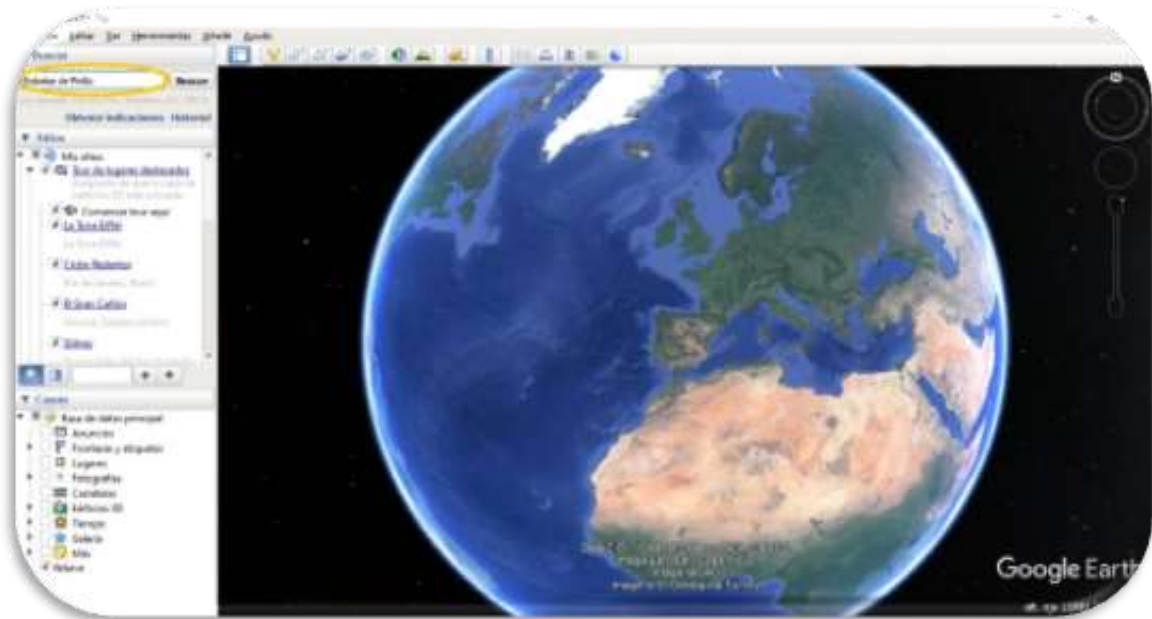
1. Open the Google Earth Pro program and you will see an image as Figure 28
2. With the mouse wheel you can zoom in or out to get a better view of the whole Earth. This is the image that we observe.



*Figure 28 Google Earth Pro Software image (Credits: Google Earth)*



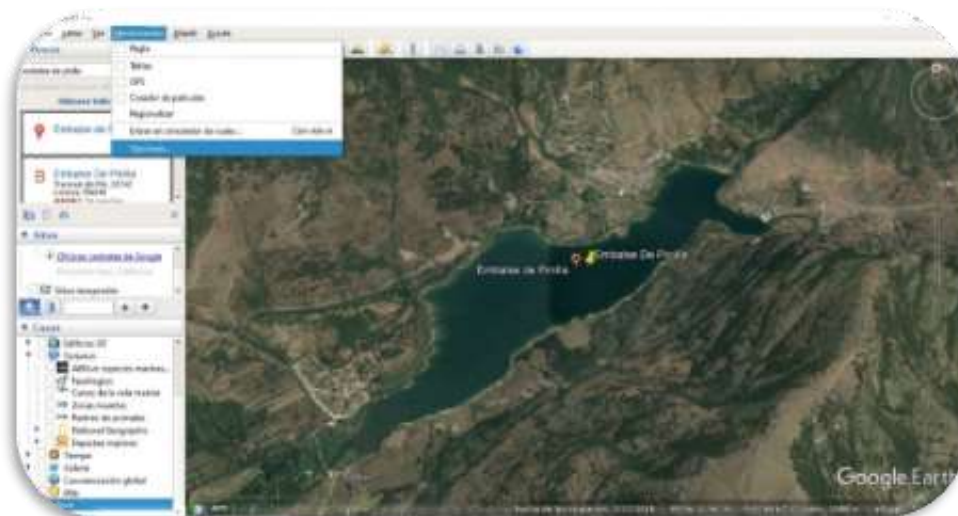
3. In the search engine, type “Reservoir of Pinilla” (yellow oval in *Figure 28*) and go there by clicking on the button “Search”.



*Figure 3b Google Earth Pro Software image (Credits: Google Earth)*

4. To better distinguish the irregularities, go to:

**Tools-> Options -> Elevation Exaggeration**



*Figure 4 Image from Google Earth Pro Software (Credit: Google Earth)*

Write a 3 (marked with an orange oval and a 1 in the next image), click on Apply (green oval and a 2) and then click on OK (blue oval and a 3).

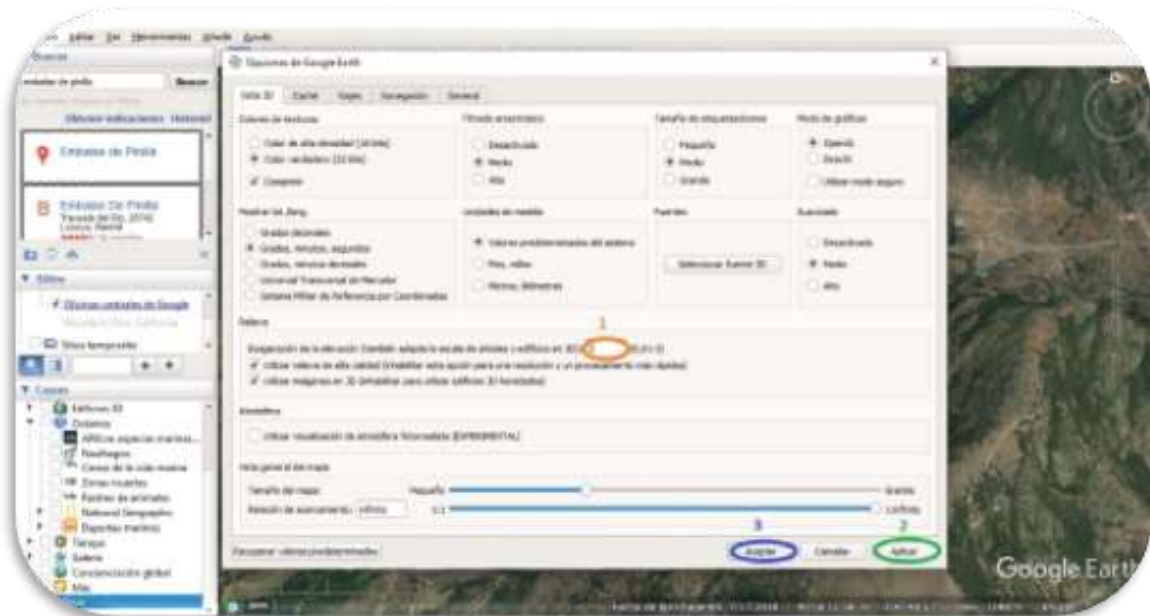


Figure 5 Imagen del Software Google Earth Pro (Créditos: Google Earth)

- Click on the icon of a person on the right (under the compass) and drag it to the center of the reservoir (where we release it and you can see the landscape as if you were there and not in class).



Figure 31 Google Earth Pro Software image (Credits: Google Earth)



6. Try to distinguish the different peaks that you saw on the topographic map in Activity 12. (Note: It is important that the Relief layer is active, otherwise you will see a flat image.)

7. Did you imagine that the 3D map of the 2D map of the Pinilla reservoir was as you have seen it here?

Tell us what differences you see (details) between the two views (2D and 3D) of La Pinilla reservoir

A large, empty rectangular box with a black border, intended for the student to write their observations and differences between the 2D and 3D views of the La Pinilla reservoir.

8. Repeat this Activity (see a detailed 3D map) for your favorite place.

## Activity 14.2: Time travel with Google Earth.

Google Earth allows you to analyze a terrain on various dates. In this way we can identify if there are temporal changes (with time) in that terrain. Let's travel in time!

1. Follow the procedure for **the Pinilla reservoir** and then for **As Encrobas Lake** (also known as Meirama Lake) in Galicia.

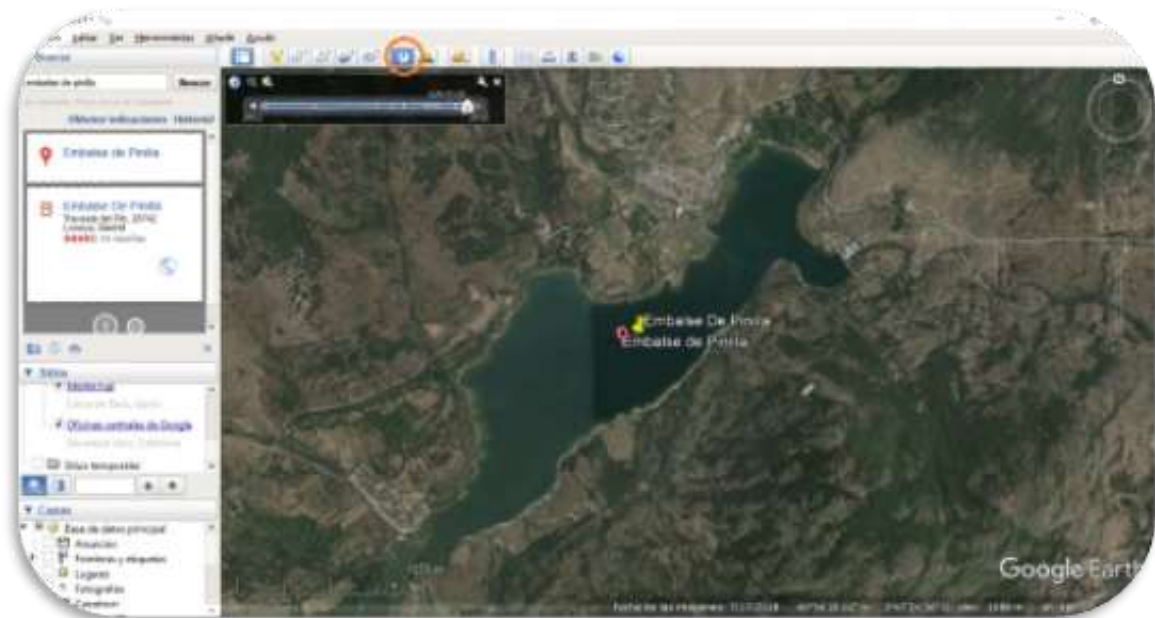


Figure 6 Image from Google Earth Pro Software (Credit: Google Earth)

### Procedure:

1. Write in the search engine the land to be studied (for example: "Pinilla reservoir")
2. Activate the tab that shows historical images, (see Figure 33) and a timeline will be displayed (top left)





3. taken from the land on various dates (date on bottom menu)
4. **See** when the reservoir has more or less water and if we have spent some period of drought.
5. Write here what you have found in your temporary study

**Repeat the procedure for the As Encrobas Lake** (also known as Meirama Lake) in Galicia and solve this investigation

Observe the surroundings of the lake, do you see any mountains or high areas that justify that a lake has been formed here? Does any river reach there?



**Travel back in time and unravel the next mystery:**

**"How can there be water?"**

1. Write in Table 3 what you see on the following dates:

| Date<br>(month/day/year) | Describe what you see | Which satellite took the picture? | Paste a screenshot of what you see |
|--------------------------|-----------------------|-----------------------------------|------------------------------------|
| 10/7/2017                |                       |                                   |                                    |
| 9/26/2015                |                       |                                   |                                    |
| 5/16/2014                |                       |                                   |                                    |
| 3/13/2012                |                       |                                   |                                    |
| 4/5/2011                 |                       |                                   |                                    |
| 4/10/2010                |                       |                                   |                                    |
| 7/22/2005                |                       |                                   |                                    |

*Table 3: Travel back in time and unravel the mystery*



2. Has there been any modification of the relief?

3. Studying the images, what do you think has happened?

4. Share it with your colleagues to see if you can get an answer.

**Note:**

You can also observe the passage of time with the following address in a browser: <https://earthengine.google.com/timelapse/>

Look at the menu on the left and share what differences in time between the different zones:

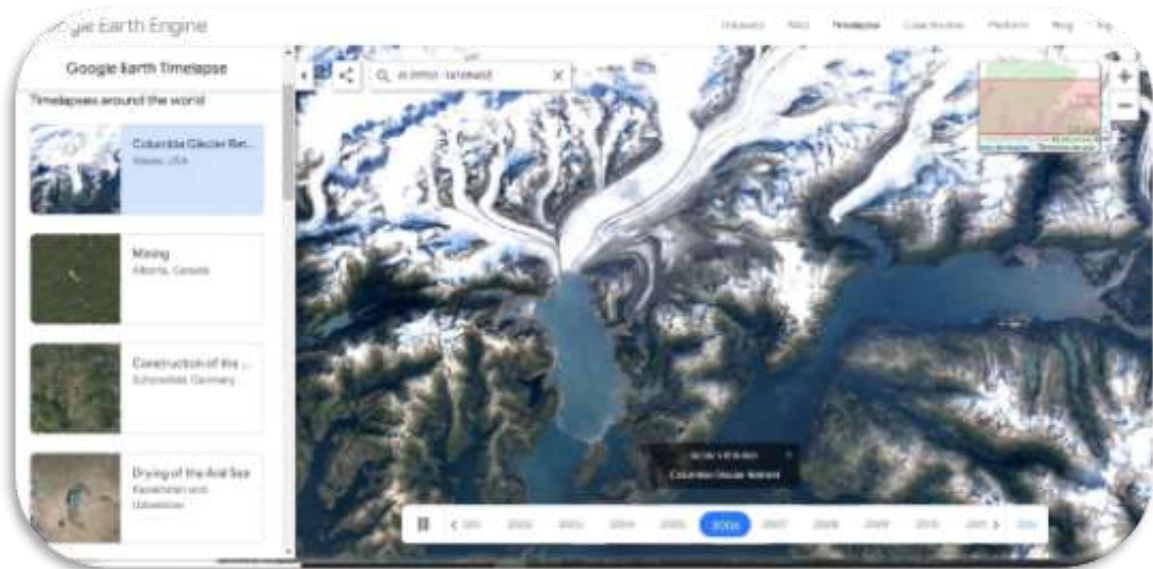


Figure 33 Timelapses from Google Maps (Credits: Google maps)

| Areas                   | Time variation |
|-------------------------|----------------|
| Alaska, USA             |                |
| Alberta, Canada         |                |
| Schonfeld, Germany      |                |
| Kazakhstan y Uzbekistan |                |
| Dalian, Liaoning, China |                |
| Bahía, California, USA  |                |
| Las Vegas               |                |
| Dubai                   |                |
|                         |                |
|                         |                |
|                         |                |

## Activity 15: Create your topographic map with Google Earth

Now we will focus on the mountains of Spain to build topographic contour maps (Hint: review Figures 6 and 24 to remember how contour maps and/or Activity 5 are built)

Do you know some of the highest peaks in Spain? Write down the ones you remember.

### Activity 15.1: How to know the height of your terrain?

1. Choose a piece of land (for example, El Teide).
2. By clicking with the right mouse on the red indicator you will see in the lower right menu the meters of height

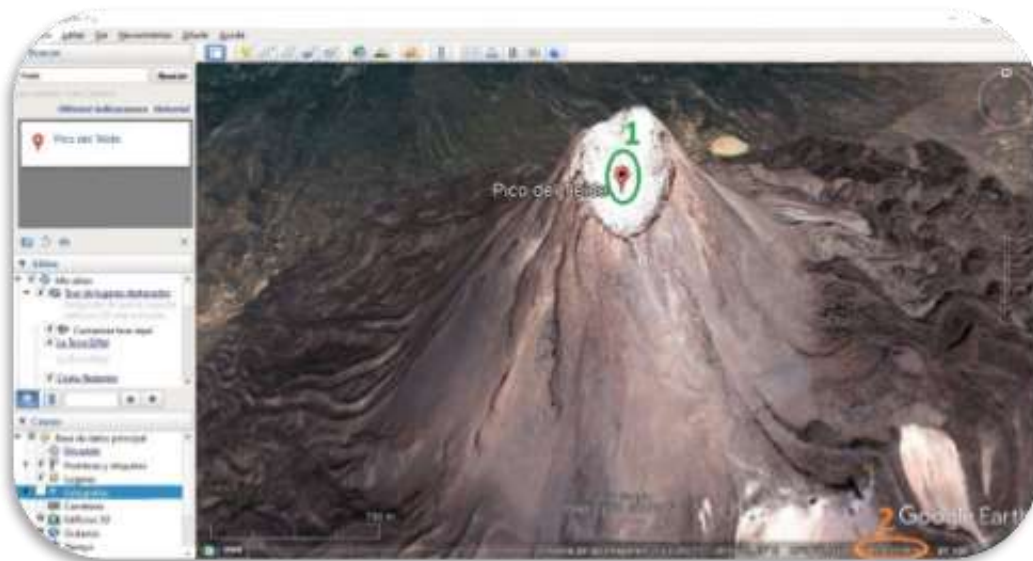
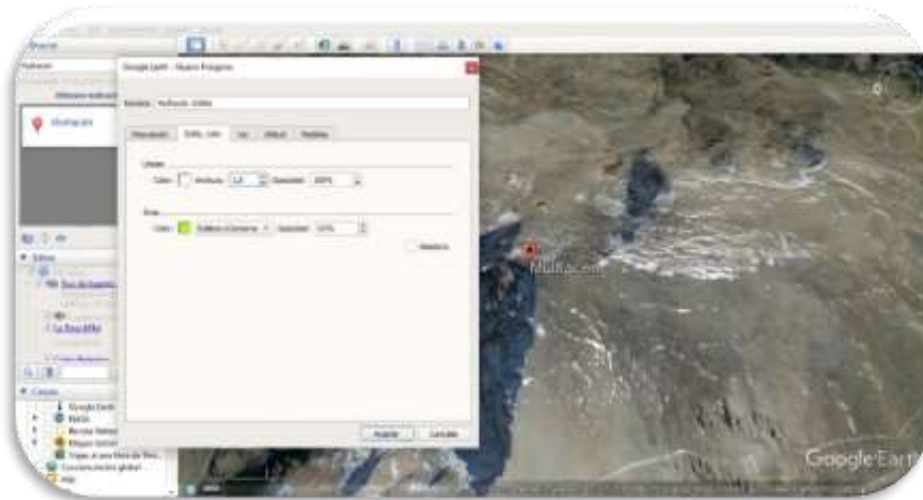


Figure 34 Image from Google Earth Pro Software (Credit: Google Earth)

### Activity 15.2: How to create contour lines in your terrain?

1. Write on the browser Mulhacén.
2. Click on the peak of the mountain and select the option “Add a polygon”. It will open a window as in the *Figure 35*.



*Figure 35 Image from Google Earth Pro Software (Credit: Google Earth)*

3. Go to the menu tab that says "Style, color" and for a particular height (contour).
  - Choose the color of the line that borders the polygon
  - Choose the one in your own polygon.
4. Look at the elevation value (bottom right) and every time you have the same height click left.
5. Always go in the same direction and add points. Keep in mind that the more points you add, the more accurate the contour line will be, but for our research a few points will be enough. In our case we have chosen 3250m as the lowest height for the Mulhacén contour lines..

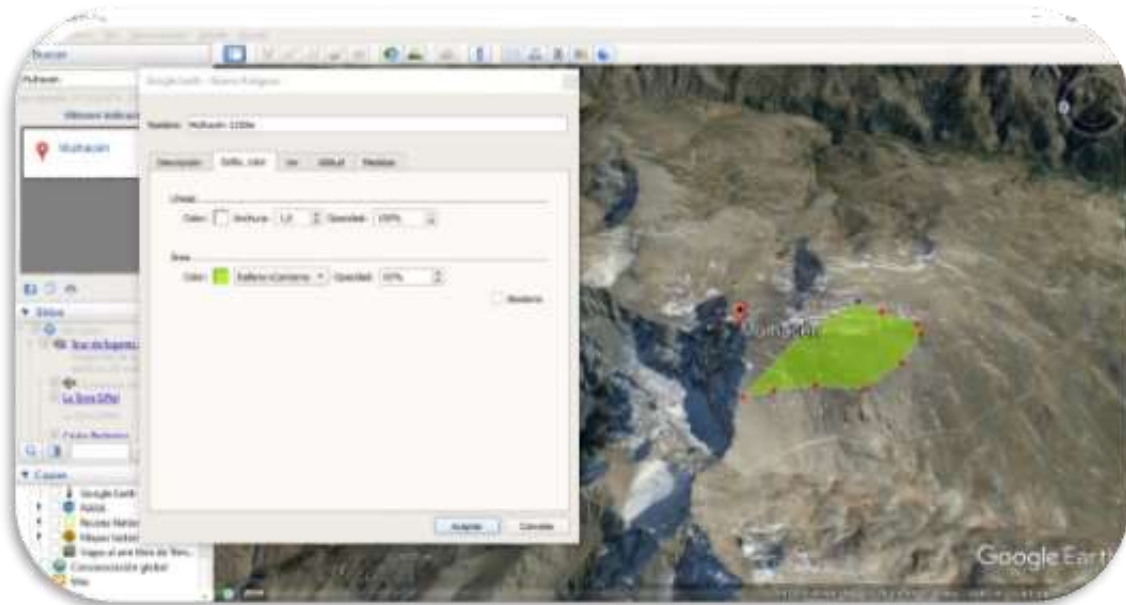


Figure 36 Google Earth Pro Software image (Credits: Google Earth)

6. When you finish selecting all the points you want for your curve, click "OK" in the window you had open and you will have something like this:



Figure 37 Google Earth Pro Software image (Credits: Google Earth)



7. Create a second contour line (repeat steps 3-6, for another color). In Figure 39, the selected height is at 3300 m.



Figure 38 Google Earth Pro Software image (Credits: Google Earth)

8. Add at least two more contours, needed for research. In Figure 37 and 38 these are at heights of 3300 m, 3350 m, 3400 m and 3450 m.

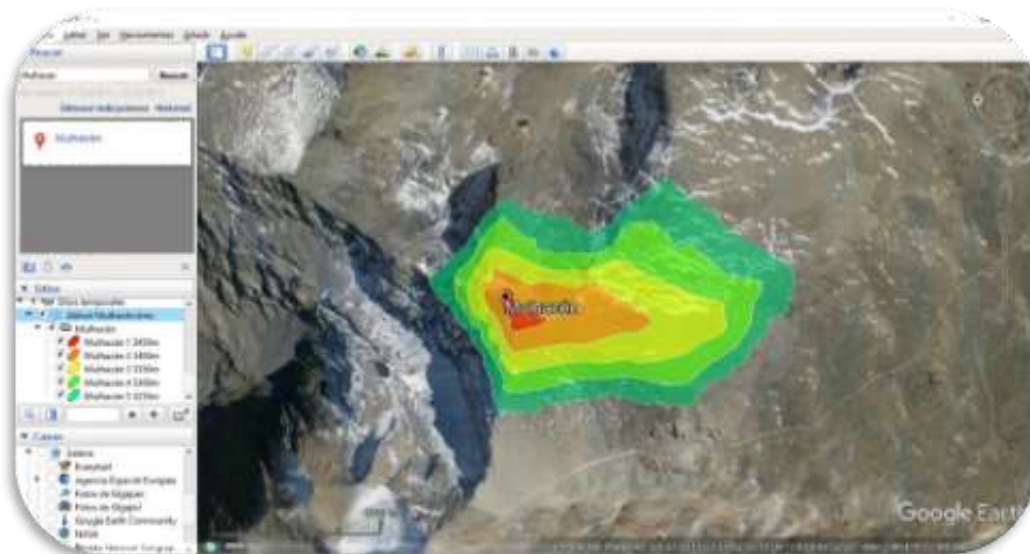


Figure 39 Google Earth Pro Software image (Credits: Google Earth)



9. Change the map view by dragging the person's icon to the area where you are

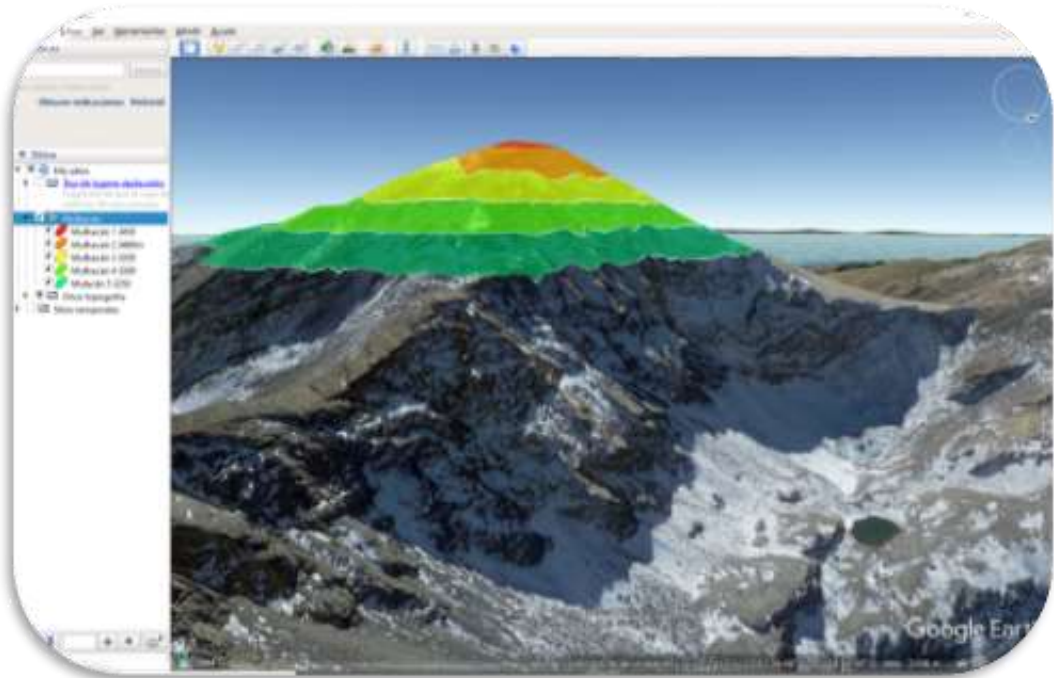


Figure 40 Google Earth Pro Software image (Credits: Google Earth)

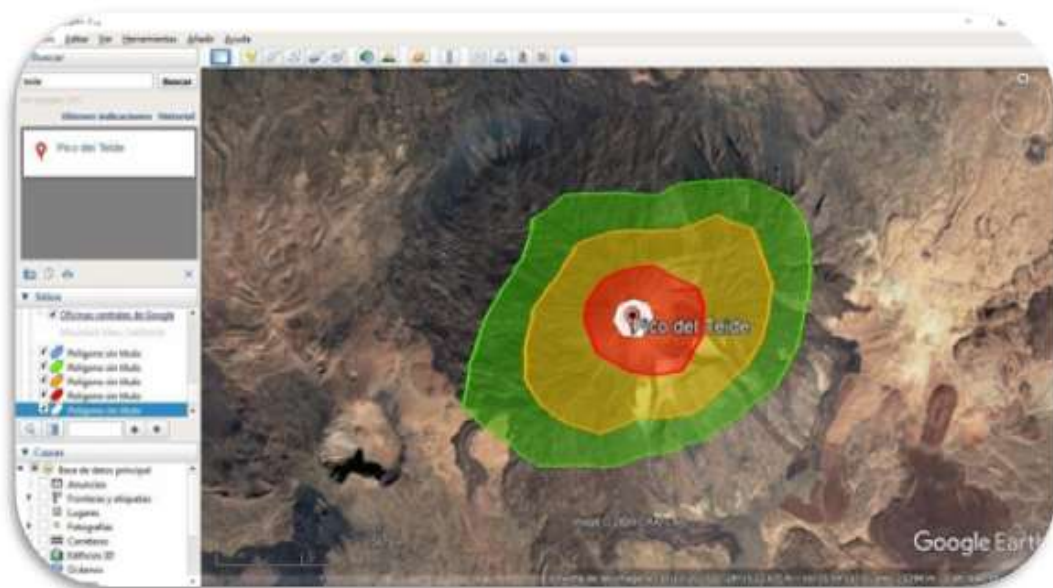


Figure 41 Google Earth Pro Software image (Credits: Google Earth)

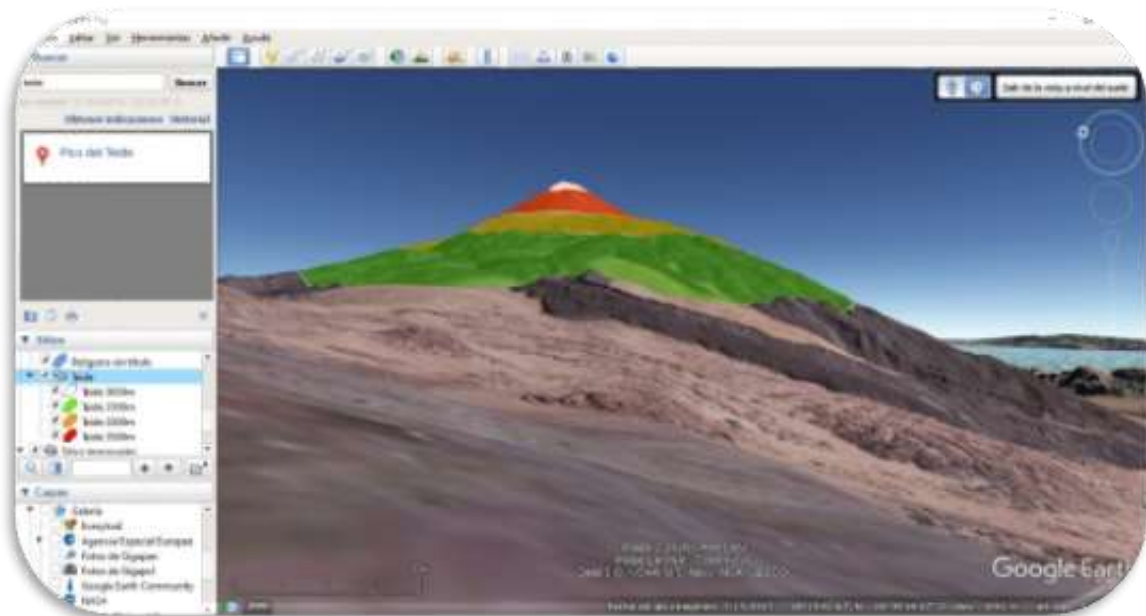


Figure 42 Google Earth Pro Software image (Credits: Google Earth)

### Activity 15.3. How to plan your mountain route

You are going to use this wonderful tool to try to discover which would be the best mountain route if you had to climb a mountain.



Figure 43 Image of young people on a mountain route (Credits: Pixabay)

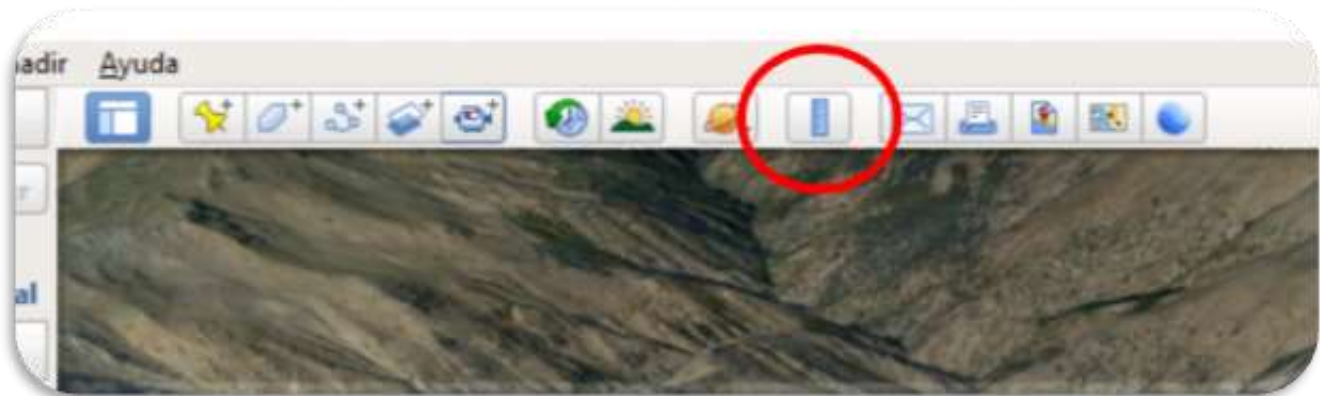


The Mulhacén is shown below as an example.

You will work as a team following this procedure:

- Each Team will be assigned a slope of the mountain (North, South, East and West)
- Each of them must create a route of descent from the highest point of the Mulhacén to an altitude of 3250 meters.
- The route you choose should be as straight as possible and should be 1.5 kilometers long.
- Go ahead and good luck!

1. Activate the "ruler" tool in the main menu..



*Figure 44 Google Earth Pro Software image (Credits: Google Earth)*

2. Select the "route" tab and leave the "show elevation profile" box checked

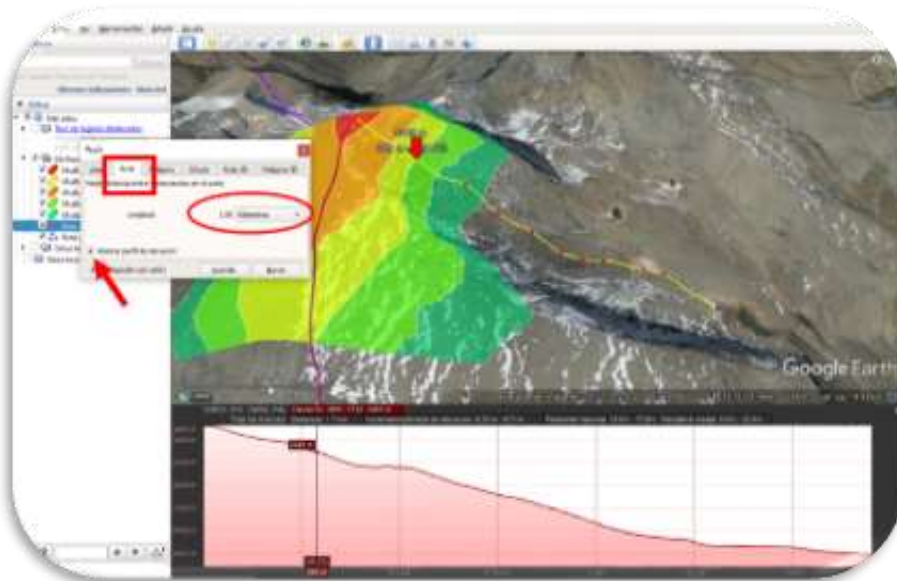


Figure 45 Google Earth Pro Software image (Credits: Google Earth)

3. Mark with the mouse on the map the points of the route, in the same way you did to form the polygons in [Activity 15.2](#)
4. Double click.

Now you will study the slope data and the elevation profile provided by the program itself.

- Make a screenshot like the one in the figure, and paste it here:



What is your average slope?

And the maximum?

Do you think it is a viable route without using climbing and/or mountaineering equipment?

Now put together all the routes and discuss what you think would be the most appropriate route of descent.

**Important note:** High mountain routes can be extremely dangerous. The topographical study of mountain routes is essential to be able to carry out them safely. In addition, it is very important to always be accompanied and to make sure that we have the necessary technical knowledge and we are in the physical conditions for the chosen route.



# Phase 4





## **Congratulations!**

### **You have completed your Science Challenge!**

### **Tell us your story!**

Stop to think about the Experience with your Team and teacher and complete these Activities.

#### Activity 16: Evaluation

- **Teams:** Fill in this [questionnaire](#) so that you can check what you have learned in the Challenge.
- **With your teacher:** Give us your feedback

#### Activity 17: Present your results

Students will have to create a final product (an A0 poster in pdf format, using power point, for example) showing what they have learned in the different phases of the Scientific Challenge.

This poster is the ticket to participate in the CESAR international adventure competition.



# Links





## Phase 0

- [Images of Earth from the ISS](#)
- [Sound \(and vision\) of Silence](#)
- [ESAC: ESA window to the Universe](#)
- [This is ESA](#)

## Phase 1

- [Space for Kids - A view of Earth](https://www.esa.int/kids/es/Multimedia/Videos/Paxi_en_la_ISS/A_view_of_Earth)  
[https://www.esa.int/kids/es/Multimedia/Videos/Paxi en la ISS/A view of Earth](https://www.esa.int/kids/es/Multimedia/Videos/Paxi_en_la_ISS/A_view_of_Earth)
- [Earth from Space: Barcelona](https://www.esa.int/ESA_Multimedia/Videos/2020/06/Earth_from_Space_Barcelona)  
[https://www.esa.int/ESA Multimedia/Videos/2020/06/Earth from Space Barcelona](https://www.esa.int/ESA_Multimedia/Videos/2020/06/Earth_from_Space_Barcelona)
- [Galileo](http://www.esa.int/ESA_Multimedia/Videos/2016/12/Galileo_Initial_Services)  
[http://www.esa.int/ESA Multimedia/Videos/2016/12/Galileo Initial Services](http://www.esa.int/ESA_Multimedia/Videos/2016/12/Galileo_Initial_Services)
- [Maps](https://en.wikipedia.org/wiki/Map) <https://en.wikipedia.org/wiki/Map>
- [Geogebra, 3D Graphing](https://www.geogebra.org/3d?lang=es) <https://www.geogebra.org/3d?lang=es>
- [ESA - Pine Island retreat](http://www.esa.int/ESA_Multimedia/Videos/2014/03/Pine_Island_retreat)  
[http://www.esa.int/ESA Multimedia/Videos/2014/03/Pine Island retreat](http://www.esa.int/ESA_Multimedia/Videos/2014/03/Pine_Island_retreat)
- [Video about the water cycle](https://www.esa.int/kids/en/Multimedia/Paxi_animations/English/The_water_cycle)  
[https://www.esa.int/kids/en/Multimedia/Paxi animations/English/The water cycle](https://www.esa.int/kids/en/Multimedia/Paxi_animations/English/The_water_cycle)
- [ESA - Space for Kids - ESA satellites help us to make the most of Earth](https://www.esa.int/kids/es/Noticias/Los_satelites_de_la_ESA_nos_ayudan_a_aprovechar_la_valiosa_agua_de_la_Tierra)  
[https://www.esa.int/kids/es/Noticias/Los satelites de la ESA nos ayudan a aprovechar la valiosa agua de la Tierra](https://www.esa.int/kids/es/Noticias/Los_satelites_de_la_ESA_nos_ayudan_a_aprovechar_la_valiosa_agua_de_la_Tierra)
- [Space for Kids 1](#)
- [Space for Kids – 2](#)
- <http://cesar.esa.int/form.php?Id=15&k=HkTe1EM22b&ChangeLang=en>

## Phase 2

## Phase 3

- [Google Earth Pro](https://www.google.es/earth/download/gep/agree.html) <https://www.google.es/earth/download/gep/agree.html>
- [Timelapse app](https://earthengine.google.com/timelapse/) <https://earthengine.google.com/timelapse/>



## Phase 4

- <http://cesar.esa.int/form.php?ld=15&k=HkTe1EM22b&ChangeLang=en>
- [Bases of the SSE contest  
http://cesar.esa.int/upload/202001/bases\\_concurso\\_sse\\_final.pdf](http://cesar.esa.int/upload/202001/bases_concurso_sse_final.pdf)

## Credits:

This Scientific Challenge contains part of the material of the educational activities [Asociación Planeta Ciencias](#) and CESAR Team. The CESAR Team is fulfilled in occasions with trainees thanks to the [Young Graduate trainees program offered by ESA](#).

- [Young Graduate trainees program offered by ESA.  
https://www.esa.int/About\\_Us/Careers\\_at\\_ESA/Graduates\\_Young\\_Graduate\\_Trainees](https://www.esa.int/About_Us/Careers_at_ESA/Graduates_Young_Graduate_Trainees)
- [Asociación Planeta Ciencias http://planetaciencias.es/](http://planetaciencias.es/)