teach with space

→ INVESTIGATING GREENHOUSE GASES

Mini Case Study for Climate Detectives

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FAST FACTS

Subject: Science; Technology

Age range: 12-17 years old

Type: Project activity

Keywords: Climate; Climate Change; Earth Observation; Greenhouse Gases; Science; Technology

LEARNING OBJECTIVES

- Be able to work scientifically by collecting data, making careful observations, looking for patterns and relationships
- Understand the relation between greenhouse gases and climate change
- Identify the main greenhouse gases
- Understand how Earth observation satellites can be used to monitor greenhouse gases

Brief description

The Mini Case Studies for Climate Detectives are intended to help teachers identify the topic that their Climate Detectives team will investigate and to guide them during the different phases of the project. In the template, teachers will find suggestions of different types of data that students could collect and analyse. The suggestions are not exhaustive, and the teachers may decide on their own specific focus within a given research area. The mini case study should be used in conjunction with the teacher guide and not as a stand-alone document.

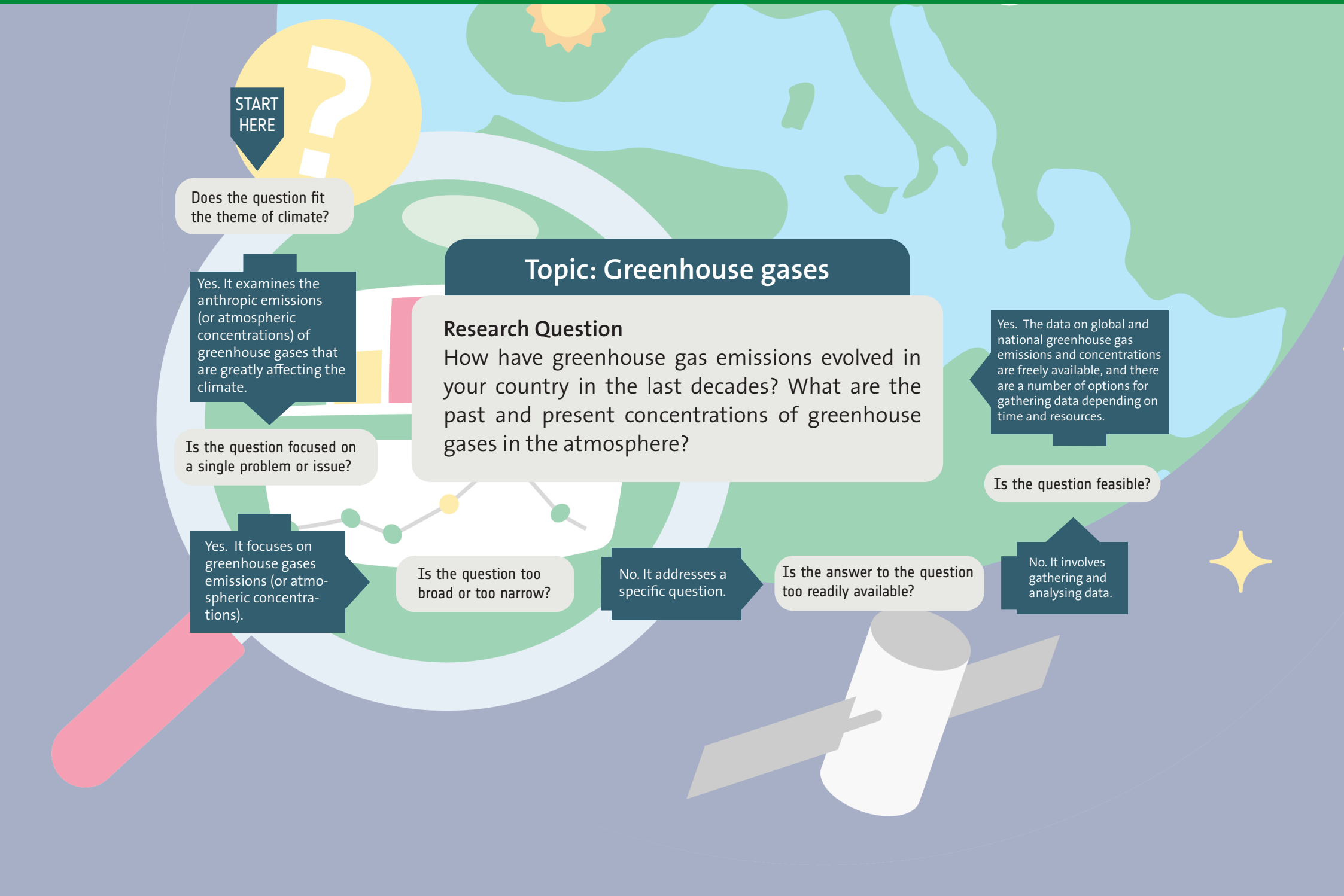
This case study is dedicated to the topic of climate change and greenhouse gases and students will investigate how greenhouse gas emissions and concentrations in the atmosphere evolved in their country in the last decades.

About Climate detectives

Climate Detectives is a school project for school students run by the European Space Agency (ESA) in collaboration with the national European Space Education Resource Offices (ESEROs) throughout Europe.

In this project students will embrace the role of Climate Detectives while learning about Earth's environment. For that they will identify a local climate problem (Phase 1), investigate it by using real satellite images or their own ground measurements (Phase 2), and finally propose actions to help reduce or monitor the problem (Phase 3).

RESEARCH QUESTION PLANNER



A – Introduction to the topic (PHASE 1)

Background information

Greenhouse gases are a natural part of the Earth's atmosphere that allow us to hold on to some of the Sun's energy in the form of heat. Without the greenhouse effect, the mean temperature of the Earth's surface would be around -18°C, making our planet too cold to support life as we know it. Since the industrial revolution, human activities such as burning fossil fuels have increased the levels of greenhouse gases in the atmosphere to unprecedented levels. The Kyoto Protocol named the six greenhouse gases most increased by human activities. The top three are carbon dioxide (CO_2); methane (CH_4) and nitrous oxide (N_2O). The Earth's climate is changing and generally warming due to increasing concentrations of carbon dioxide and other greenhouse gases in the atmosphere with adverse consequences such as global sea level rise. While carbon dioxide is more abundant in the atmosphere and therefore more associated with global warming, methane is around 30 times more potent as a heat-trapping gas.

Different economic sectors contribute to the emission of greenhouse gases: the energy industry, fuel combustion by energy users, transport, agriculture and livestock management, industrial processes and product use, and waste.

Greenhouse gases emitted in excess by humans modify the natural characteristics of the atmosphere, which in turn affects the environment. In this case, greenhouse gases can then also be considered air pollutants.

The following classroom resources can be used to teach students about the greenhouse effect:

- Earth under the lid: Understanding the greenhouse effect (Primary education)
- The greenhouse effect and its consequences: Investigating global warming (Secondary education)
- The carbon cycle (Secondary education)

Additional resources to learn more about:

- Weather vs climate
- Atmospheric CO_2 and CH_4 concentrations
- The carbon cycle
- The methane cycle
- The latest climate science information
- Climate Change: The evidence from space

Investigation plan

Now that your team have decided on the topic and research question, it is time to plan which data your team need to collect. The final step in Phase 1 of Climate Detectives is the submission of an investigation plan. Teachers can find ideas for data collection in section B, which may help you with submitting your Team's investigation plan.

TIP

To do their research, different groups of the class could focus on a particular sector emitting greenhouse gases or on a particular greenhouse gas.

B – Data collection and analysis (PHASE 2)

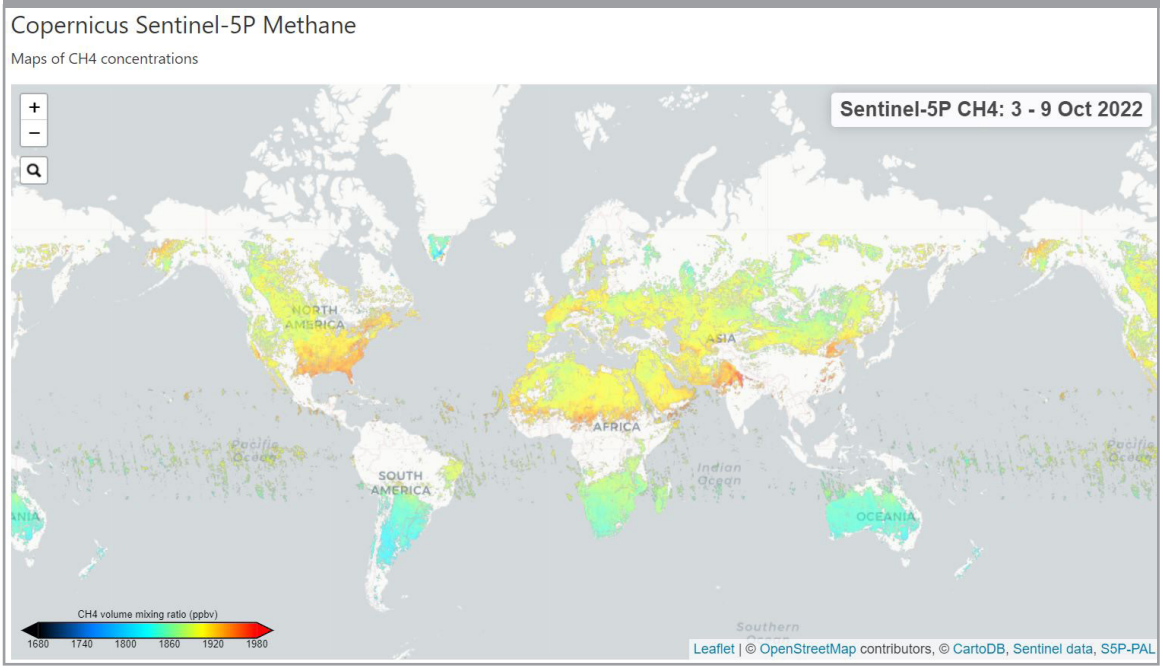
Data to be analysed

Depending on time availability and the data offered by different countries, teams can choose from one or more data sources listed below to conduct their research. There are two types of methods to monitor the atmosphere: "in situ" measurements and remote sensing observations, as for example from satellites. In-situ means "situated in the original place". These measurements are provided by institutions and agencies at the regional, national and global level. Teams can also make their own observations and collect data from their own measurements. We will call this primary data.

Satellite data - Greenhouse gas concentrations

- Climate from Space - interactive website (esa.int) - The Climate from Space app provides a graphical visualisation of archived satellite data and offers an overview of the different climate variables that scientists use to study climate change. It is possible to see the evolution of carbon dioxide (CO_2) and methane (CH_4) levels in the atmosphere over time (2003-2018).
- Students can use the EO browser to find data obtained from Copernicus Sentinel 5P, the first Copernicus mission dedicated to monitoring our atmosphere. Using the Education Mode, students can choose the theme 'Atmosphere and Air Pollution' and try to find data on CH_4 concentration.
- Copernicus Sentinel-5P Mapping Portal - This online platform visualises worldwide data from the Copernicus Sentinel-5P satellite.

Figure 1



↑ On the Copernicus Sentinel-5P Mapping Portal is possible to find the averaged global methane concentrations as measured by the Tropomi instrument.

Local/national data - Greenhouse gas concentrations

Teams are also encouraged to find and analyse data from national and international agencies and institutions relative to their countries/area of investigation.

- The Global Monitoring Laboratory (GML) of the National Oceanic and Atmospheric Administration (NOAA) provides data files for different types of greenhouse gases.
  Check here to locate measuring stations near to your local area of investigation.

  Below we propose data measured in a station situated in the Azores. We chose this station as it is close to Continental Europe and because it has been measuring parameters since 1979:

  - Carbone dioxide (CO_2) monthly average from 1979 to 2020
  - Methane (CH_4) monthly average from 1983 to 2020
  - Nitrous oxide (N_2O) monthly average from 1997 to 2020

- View CO2 concentrations measured threw ice-cores – Such data enables to go back further in time. Here we give one example of the many available.

Emissions per country and sector

Teams can search online for data provided by their home country showing the emissions of greenhouse gases per country and per sector. Below you can find some examples of publications and online platforms with worldwide data.

- Global Carbon Atlas is an online platform to explore and visualize global and regional carbon data arising from both human activities and natural processes. It's possible to find geographical emissions of different countries over time.
- EDGAR - Emissions Database for Global Atmospheric Research is a global database of man-made emissions of greenhouse gases and air pollution on Earth. It provides a country fact sheet organized by sector and substance.
- This interactive publication developed by Eurostat presents EU data on greenhouse gas emissions per sector and country.

TIP

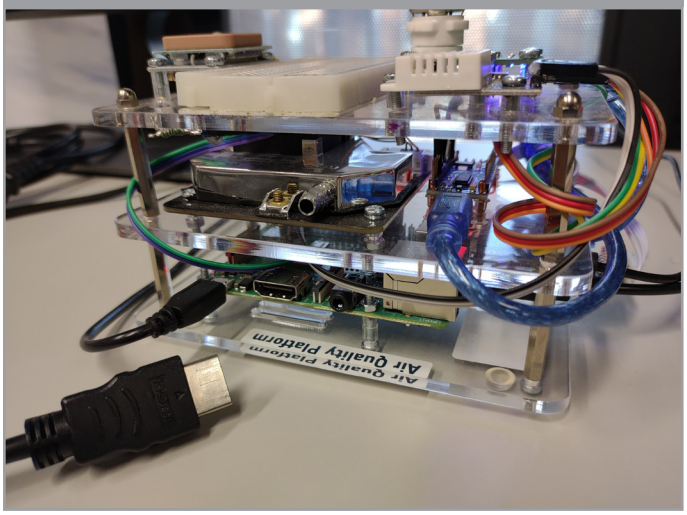
The first step in organising the data is to compile it into a form that is easy to interpret and where relationships between variables can be readily observed. The data can be sorted into data tables. These can then be used to create different types of graphs to show patterns, trends, and similarities/differences more clearly.

Primary Data

Sensors

ESA has developed an Air Quality Platform (AQP) based on the Raspberry Pi 3B+ computer and equipped with a set of sensors that measure different characteristics, to be used for educational purposes. ESERO offices in each country have AQPs that can be lent out to schools to measure, for example, CO_2 concentrations on a daily basis. However, it must be noted that because of sensors' accuracies, CO_2 values should not be compared to short- and long-term data issued by national agencies. Nonetheless, ESA AQP is a pedagogic tool to monitor, for example, the effect of daily traffic on CO2 levels. For more information visit https://aqp.eo.esa.int/.

Figure 2



↑ESA's Air Quality Platform (AQP)

Surveys and measuring carbon footprint

For teams who want more active investigations, it is possible to conduct surveys on specific topics related with greenhouse gas-emitting sectors. Students can submit the survey to their families, to another class, the school board, etc.

- Many kinds of surveys are possible:
  - Students can, for example, do a survey about cloth shopping habits and investigate sustainable clothing.
    - Example of what can be included in a survey about cloth shopping habits:
      - How old is Mr/s X?
      - How many new t-shirts were bought by Mr/s X. this year?
      - Did Mr/s X tend to buy more/less new t-shirts per year in the past?
      - In which countries were these t-shirts made?
      - Do these t-shirts have labels? E.g., proof of sustainability labels?
  - Students can also do a survey about their eating behaviour regarding the consumption of meat or products coming from all over the world. Food systems activities, as for example, livestock production, produce greenhouse gas emissions and are therefore strongly related to climate change. As an example, to produce 100 gr of beef, 7.6 kg of CO2 are released. Teams can find here more information: Food and Climate Change: Healthy diets for a healthier planet | United Nations

For every survey, students can calculate the carbon footprint. The products and services that we use and many of our daily activities cause greenhouse gas emissions. Together these emissions make up our carbon footprint. We even produce a digital carbon footprint! Students can calculate individual carbon footprints or their school's carbon footprint. To include the carbon footprint, see the following tips:

- Start by discussing what is a carbon footprint and how to measure it. This is one example of the many carbon footprint calculators available online.
  Teams can search for the footprint calculator that best suit their needs. Teams can also try to develop their own calculator. See this example from a previous Climate Detectives project.

- It could be interesting to calculate carbon footprint before the project and after 'making a difference' (Phase 3).

C - Time to MAKE A DIFFERENCE! (PHASE 3)

What actions could students take as individuals or as a community to make a difference regarding the topic of their investigation? Actions can be introduced in many areas of everyday life. Even small changes help to reduce greenhouse gas emissions per person.

Actions do not need to be limited to school time; for example, students could take home ideas and involve their families to put them into practice in their everyday lives or give a presentation or host a campaign at their school or local community to raise awareness

CLIMATE DETECTIVES

→ TASKS AS CLIMATE DETECTIVES

Student Worksheet

A – Introduction to the topic (PHASE 1)

- *What is a greenhouse gas? What is the greenhouse effect?*
- *What is the difference between gas emissions and the atmospheric concentration of a gas?*
- *What are the main sources of emissions of the greenhouse gases you plan to investigate?*
- *How does the topic that you selected affect/relate to you, your community or local environment?*
- *Describe how you plan to investigate the climate problem and which data you plan to analyse. (For the Investigation Plan)*

B – Data collection and analysis (PHASE 2)

- *Draw a graph of the evolution of a greenhouse gas emission over time.*
  - *What does the data show?*
- *Draw a graph of the atmospheric concentration of a greenhouse gas from the 1980's to nowadays.*
  - *What does the data show?*
- *Compare the evolution of the greenhouse gas emissions against their atmospheric concentration. What conclusions can you draw?*
- *Draw a graph showing the contribution of different sectors to greenhouse gas emissions over time.*
  - *What does the data show?*
- *Conduct surveys of your choice that give insight into a sector or a habit that contributes to greenhouse gas emissions.*

C – Time to make a difference! (PHASE 3)

Your Climate Detective work is now complete. What actions could you propose, as individuals and as a community, to make a difference regarding the topic of your investigation?

→ Links

ESA resources

Climate Detectives Teacher Guide
https://climatedetectives.esa.int/teacher-guide/

Climate Detectives classroom resources
https://climatedetectives.esa.int/classroom-resources

Climate for schools – Resources from the Climate Change Initiative
https://climate.esa.int/en/educate/climate-for-schools/

Background information

What is Climate and Climate Change?
https://climate.esa.int/en/evidence/what-is-climate-and-climate-change/

Weather vs climate – what are the differences
https://www.esa.int/Applications/Observing_the_Earth/Space_for_our_climate/Weather_vs_climate_What_s_the_difference

European Environment Agency - Greenhouse gas emissions in Europe
https://www.eea.europa.eu/themes/climate/eu-greenhouse-gas-inventory

Data collection and analysis

Climate from Space app
https://climate.esa.int/en/explore/climate-from-space/

EO Browser
https://apps.sentinel-hub.com/eo-browser

Copernicus Sentinel-5P Mapping Portal
https://maps.s5p-pal.com/

EDGAR - Emissions Database for Global Atmospheric Research
https://edgar.jrc.ec.europa.eu/

ESA Air Quality Platform
https://aqp.eo.esa.int/

Global Monitoring Laboratory
https://gml.noaa.gov/dv/site/

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