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→ INVESTIGATING AIR POLLUTION

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: Air Pollution; Climate; 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 Air Pollution and Climate Change
- Identify the main Air Pollutants
- Understand how Earth observation satellites can be used to monitor Air Quality

Brief description

The mini case Studies for Climate Detectives are intended to help teachers identifying 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 standalone document.

This case study is dedicated to the topic of **Air Pollution and Climate** and students will investigate the links betweens local travel related air pollution and climate change.

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

START HERE

Topic: Air Pollution and Climate

Research Question

How does travel in our school community contribute to global climate change? What are the links between local travel related air pollution and global climate change?

Does the question fit the theme of climate?

Yes. It examines the school's travel related contribution to climate change.

Is the question focused on a single problem or issue?

Yes. It examines the school's travel related contribution to climate change.

Is the question too broad or too narrow?

No. It identifies a local scale problem but establishes links to a wider global issue. Students can look at just greenhouse gas emissions from school travel or can expand it out to study links with air pollution.

Is the answer to the questions too readily available?

Yes. The data on global and national greenhouse gas emissions and air pollutants are freely available and there are a number of options for gathering primary data depending on time and resources.

Is the question feasible?

No. It identifies a local scale problem but establishes links to a wider global issue. Students can look at just greenhouse gas emissions from school travel or can expand it out to study links with air pollution.

A – Introdution to the topic (PHASE 1)

Before we investigate the links between travel and climate change, we need to understand what we mean by climate change. This article from the ESA Climate Office can help:

What is Climate and Climate Change?

Travel is a source of both air pollutants and greenhouse gases. Many air pollutants, although not classed as greenhouse gases can contribute to climate change (World Health Organization, 2022). The video below, from the World Meteorological Organization can be a starting point to introduce the topic:

Connections between air quality and climate

Greenhouse Gases

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 at the earth's surface would be around -18°C and our planet would be too cold to support life as we know it. Since the industrial revolution, human activities such as the burning of fossil fuels have increased the levels of greenhouse gases in the atmosphere to unprecedented levels. There are 6 greenhouse gases named in the Kyoto Protocol, levels of which have all been increased by human activities. The top three are Carbon Dioxide (CO_2); Methane (CH_4) and Nitrous Oxide (N_2O). Water vapour is also an important natural Greenhouse gas, which increases the effect of the other gases. 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.

The following classroom resources can be used to learn more about the Greenhouse effect and natural and human sources of CO_2:

- 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)

Air Pollutants

The World Health Organization defined air pollution as: "contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution".

There are many different air pollutants from transport. Two of the main ones are summarized below.

Particulate Matter

Particulate Matter (PM) describes microscopic particles of solid or liquid suspended in the air. They are categorized according to their size.

- PM10 between 2.5 and 10 micrometers (µm)
- PM2.5 are less than 2.5 micrometers (µm)

These particles may include dust, dirt, smoke, drops of liquid, and soot. PM comes from construction sites, landfill, agriculture, roads and vehicle tyres. PM is a serious Air Pollutant and can seriously affect health as we breathe in these tiny particles that cannot always be seen with the naked eye.

Complete combustion (100% burning) would turn all carbon in a fuel into CO_2. but combustion is never totally efficient. Burning of fossil fuels not only produces CO_2, but it also produces particulate matter called soot or Black Carbon (BC). Different components of PM can have either warming or cooling effects on the climate. Black carbon contributes to the warming of Earth. When BC deposits on ice and snow it causes local warming and increases melting as the 'dark' patches on the snow absorb more heat from the sun. BC is estimated to be responsible for 15% of the current excessive warming of global temperatures.

Nitrogen Dioxide

Nitrogen Oxides are compounds of Nitrogen and Oxygen. They are formed by man in industrial and domestic combustion processes and from motor vehicles as a result of burning fossil fuels. The exhaust emissions from traffic produces Nitrogen Dioxide (NO_2). Nitrogen Dioxide is a primary pollutant of the air but is not listed as a greenhouse gas as it doesn't trap the sun's rays however as a result of complex reactions in the atmosphere, NO_2 does contribute to global warming and therefore climate change.

Nitrogen Dioxide (NO_2) is not the same as Nitrous Oxide (N_2O). N_2O is a greenhouse gas and is mostly produced from the use of artificial fertilisers in agriculture although minor amounts are also produced from car exhausts.

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.

B – Data collection and analysis (PHASE 2)

To connect the local issue of transport to the global issue of climate change, students can collect and analyse data from a number of sources.

Global Satellite Data

Global data on air pollutants and greenhouse emissions can give an overall picture of global problems and how both air pollution levels, and greenhouse gas emissions have changed over time. From above, satellites can collect data from sites all around the world, including places too remote to visit in person.

The following links can help teams finding satellite data on gas emissions:

- 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 overtime of the levels of carbon dioxide and methane in the atmosphere (2003-2018).
- EO Browser - 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 find data on NO_2 emissions as well as data on other air pollutants. More information about how to use EO browser to investigate air pollution from space can be found here.
- Copernicus Sentinel-5P Mapping Portal – An online platform that allows for the tracking of air pollution worldwide. The maps, which use data from the Copernicus Sentinel-5P satellite, show concentrations of greenhouse gases as CH_4 and air pollutants (NO_2 and SO_2) around the world.
- Air quality – The Copernicus service monitors and forecasts European air quality and worldwide long-range transport of pollutants.

Figure 1

↑ Copernicus Sentinel-5P carries the state-of-the-art Tropomi instrument that maps a multitude of trace gases such as nitrogen dioxide, methane, carbon monoxide and aerosols – all of which affect the air we breathe and therefore our health and climate

National Data

National data can help to look at the problem on a national scale or to look at emissions from a particular area or a particular sector.

The European Air Quality Index combines information for five different air pollutants (particulate matter (PM10); fine particulate matter (PM2.5); ozone (O_3); nitrogen dioxide (NO_2); and sulphur dioxide (SO_2) for different European Countries.

Teams are also encouraged to find data from their national environment/ air quality agencies.

Local/Primary Data

This is information that the students measure or calculate for themselves. Primary data on greenhouse gases and air pollutants can be gathered in a number of ways.

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. The ESERO office in each country has a set of these sensors that can be lent out to schools to measure, for example, CO2 concentrations and a variety of air pollutants in the school environment. For more information visit https://aqp.eo.esa.int/

Traffic Surveys

As an alternative to using sensor technology students can conduct a survey of the traffic entering and leaving the school grounds and the kilometres travelled over a time period. They can calculate the CO_2 emissions using websites that give this data. Here teams can find some information about CO_2 emissions from cars.

Average carbon dioxide emissions can be used so as to not individualise emissions from different car types

- How does the school community travel to school (teachers, students and school staff)
- How many petrol cars, diesel cars, busses arrive each morning for drop off (school start time)
- How many petrol cars, diesel cars, busses arrive each afternoon for pick up (school finish time)
- What is the distance in km travelled by each car in those tasks each day.
- What are the average carbon dioxide emissions per day, per week per school year.

Before starting on their data collection teams should decide on their timeframe. You might want to collect data at different times of the day or at different times of the year. For example, if you wanted to investigate if air pollution levels vary throughout the school day, you might gather data at a number of set times per day over a period of a few weeks. If you wanted to investigate seasonal changes in the amount of air pollution, you would need to gather data over a longer time period.

Dust particles investigation

Particulate matter, being so small, is very difficult to measure. It is still a good indicator of air pollution to also measure the number of larger particles such as dust, dirt, smoke that can be potentially seen. It is possible to find online many experiments using the sticky tape method to visualise air pollution. Following this example students can collect their own qualitative and quantitative observations on air pollution.

Analysing data

After collecting data it's important to analyse findings. Students may use the following questions to evaluate whether their findings answer their research question:

- What does the data show? Are there obvious trends/patterns?
- Are there any readings that don't seem to make sense? Can they be explained?
- Can any conclusions be drawn from the findings?
- Is further research required?

C - It is time to MAKE A DIFFERENCE! (PHASE 3)

What actions could teams take as individuals or as a community, to reduce transport related greenhouse gas emissions and air pollutants and 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 air pollutant 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.

Other subjects of investigation

Also on the topic of Climate and Air Pollution teams can investigate different subjects:

- Climate and air pollution from agricultural activities
- Climate and air pollution from burning of fossil fuels for domestic heating
- Climate and air pollution from waste disposal

→ 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/

Video from the World Meteorological Organization about air pollution and climate
https://youtu.be/s4ly6o-VT9o

European Environment Agency
https://www.eea.europa.eu/themes/air

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/

Copernicus Atmosphere Monitoring Service (CAMS)
https://atmosphere.copernicus.eu/air-quality

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

European Air Quality Index
https://airindex.eea.europa.eu/Map/AQI/Viewer/

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