



SPACE[◉] awareness

EDUCATIONAL KIT: THE CLIMATE BOX

This kit contains a suite of activities related to the Earth's climate, its change we are witnessing and measuring techniques.

MARKUS NIELBOCK

MARCO TÜRK

Curriculum topics:

Composition and structure
Orbit and rotation
Habitability
Climate change
Surface
Interior
Oceans
Atmosphere
Biodiversity
Seasons
Satellites
The environmental awareness and care

Big idea of Science:

Earth is a very small part of the universe.

Keywords:

absorption, acidification, air, altimetry, angles, Antarctic, Archimedes, Arctic, atmosphere, atmospheric windows, average, balloons, Black Body, buoyancy, carbon dioxide, chemistry, climate change, climate chart, convection, Copernicus, Earth, earth observation, energy, equator, exoplanets, exoskeletons, expansion, extrasolar, gas, glaciers, global warming, Greenhouse Effect, greenhouse gases, Habitable Zone, heat, heat capacity, heat storage, ice, insolation, lakes, Landsat, latitude, life, light, light spectrum, limestone, marine life, methane, model, oceans, orbit, pH value, photovoltaic cell, planets, poles, radar, radar altimetry, radiation, real data, remote sensing, satellite imagery, sea levels, seasons, Sentinel, simple mean, solar constant, solar energy, solar radiation, solstice, spectral index, stars, Stefan Boltzmann Law, Sun, surface layers, temperature, thermal expansion, thermic radiation, thermocline, thermometer, updraft, vegetation, water, weather, winds

Education level:

Secondary

Language:

English

Core Skills:

Asking questions
Developing and using models
Planning and carrying out investigations
Analysing and interpreting data
Constructing explanations
Engaging in argument from evidence
Communicating information

Type of learning activity:

Full enquiry

INTRODUCTION

The space segment of the European Earth observing programme “Copernicus” consists of satellite measurements. One of the purposes is the monitoring of the Earth’s climate and its change. With this in mind, this educational kit addresses the current knowledge and



scientific evidence for the climate change and its consequences. The Climate Box is a concept of a set of activities that break down the complex phenomena into simple exercises and experiments to highlight specific aspects in detail. The individual experimental settings are designed in a way that their components are either inexpensive or at least easy to obtain. The topics covered with this kit comprise basic physical processes that govern the global climatic system as well as phenomena and consequences that everyone can relate to. Cross correlations between the activities support the notion of a complex and intertwined nature of the Earth's climate.

RESOURCES TABLE

Theme Category	Title	Topic	Short description
Our Fragile Planet	The Engine of Life	The Habitable Zone	The students simulate the relation between the flux density of stellar radiation received at a revolving planet and their distance using a lamp and a photovoltaic cell that drives a motor. The voltage produced by the cell to drive the motor is high enough only for distances not too far away from the lamp.
Our Fragile Planet	Water is a heat sink	Energy balance	The students experience the ability of water to effectively absorb and store heat as compared to air. This is done with a simple experiment in which two balloons, one filled with air and the other filled with water, are heated with a flame.
Our Fragile Planet	Oceans as a heat reservoir	Energy balance	This activity is a quantitative extension to the previous one that demonstrates its global relevance for the oceans that store lots of heat which the atmosphere and the continents cannot do. The students measure the temperature increase of solid and water illuminated by a strong lamp.
Our Fragile Planet	Greenhouse Effect	Greenhouse Effect	Flanked by scientific background on the causes of the Greenhouse Effect, the students carry out an experiment that mimics its consequences for the global climate. The heating of air enclosed in a container is compared with freely circulating air by temperature measurements.
Our Fragile Planet	Global Warming of the Atmosphere	Global Warming	This activity demonstrates the basic processes that heat the atmosphere. It is mostly driven by indirect infrared heating emitted from the illuminated ground. The



			experiment uses a simple model of a PET bottle blackened at the bottom. When illuminated, the air above the ground is heated up and a temperature stratification is measured at higher altitudes.
Our Fragile Planet	The Intertropical Convergence Zone	Global wind system	This activity demonstrates one of the effects of irradiating surfaces like the equator region of the Earth. Heated air produces an updraft which is the cause of a global wind system. The students build a model updraft tower. When irradiated, the upper propeller is driven by the rising air.
Our Fragile Planet	The Climate in Numbers and Graphs	Climate zones	This activity demonstrates that climate is a long term average of weather phenomena. Real weather data of temperatures and precipitation measured on a daily basis are provided from which the students derive climate charts. Those are very indicative for evaluating the climate of a given location.
Our Fragile Planet	Climate Zones	Climate zones	This activity demonstrates that the climate zones are generated by the changing incident angles of solar irradiation along the latitudes. A lamp illuminates a photovoltaic cell that drives a motor. The voltage produced by the cell to drive the motor depends on the angle or its irradiated cross section. The same set-up also explains the origin of the seasons.
Our Fragile Planet	The thermal layers of oceans	The oceans	Based on the activities related to the oceans' ability to store heat, this unit demonstrates that in fact only the upper layers of a water body react by raising the temperature. The vertical temperature distribution of the oceans is stratified. The students carry out an experiment that simulates this effect. A cup with water is illuminated from above. After some time, the students probe the vertical temperature distribution with a thermometer.
Our Fragile Planet	Transforming water into acid ... and back	Carbon cycle	This activity demonstrates the temperature dependent ability of water to solve carbon dioxide by forming carbonic acid. The students use exhaled air to pump carbon dioxide into distilled water and monitor the change of pH with an indicator. Afterwards, the carbon dioxide is driven out again by heating the solution. The students learn that acidification is a serious threat to marine life.
Our Fragile Planet	Ocean acidification	Carbon cycle	After having explored the acidification of water by carbon dioxide, this activity approaches the problem of ocean acidification by catching atmospheric



			carbon dioxide in a slightly more realistic way. An experiment demonstrates that carbonic acid is formed only in the upper layers of the oceans, where the water touches the atmosphere.
Our Fragile Planet	Oceans on the rise	Rising sea levels	The students learn that one of the consequences of climate change, the rising sea levels, can already be witnessed now. A simple experiment with water heated by a lamp shows that water expands with rising temperature. Within a confined container, this leads to a rise of water levels. This is one component of the global rise of the oceans.
Our Fragile Planet	The big meltdown	Rising sea levels	This activity demonstrates with a simple experiment that melting ice can lead to an increase of global ocean levels. The students learn that floating ice does not contribute, while melting continental ice indeed adds to the rise of the oceans.
Our Fragile Planet	Valleys deep and mountains high	Radar altimetry	The students learn how radar altimetry via satellites leads to the construction of altitude maps. They probe a landscape model that is hidden inside a box with a skewer that is lowered through the lid of the box. A grid of measuring points results in a table of heights that can be translated into various versions of maps.
Our Fragile Planet	A View from Above	Earth observation	A software tool specially designed for educational purposes (LEO Works) is used to analyse real satellite data. The students learn basic analysis procedures and apply them to imagery data. They follow the steps professionals employ to derive geophysical information like the grade of vegetation and the spatial distribution of open waters.



This resource was developed by Space Awareness. Space Awareness is funded by the European Commission's Horizon 2020 Programme under grant agreement n° 638653.

