PLANET CHANGE

Monitoring the health of the oceans

Teachers manual

Co-funded by the
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of the European Union

Planet change is the short name of an EU Erasmus+ project aimed at VET teachers and their students. With small activities, the idea is to create awareness about sustainability and acquire 21st century skills. All this is done in a technical context, mostly from space technology.

www.planetchange.eu

Contents:

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1. General information

Duration: 2 x 45 minutes

Target group: 16-20 y.o.

European qualifications framework level: 3-4

Materials: Computer with internet connection

Teacher preparation: study background information, materials listed with the activity
Students will actively use internet resources to identify and monitor sea currents and changes in sea ice. It would be convenient for them to read beforehand the introduction in this task to have a better understanding of the goals behind the analysis and the images they will be working with. The activity is much based on analyses of satellite data. Therefore, it is also recommended to see this video to review the basic principles about how satellites images are built.

Topic

Themes: climate change

Keywords: Climate change, sustainability, satellite images, ocean currents, sea ice, data analysis, earth observations, weather, 21st century skills

Activity

Goals

The goal of this activity is to use satellite data to monitor and understand how global warming is decreasing the amount of sea ice, and how this may be changing important ocean currents, such as the Gulf Stream. The consequences can be significant, not only accelerating global warming itself, but also affecting weather patterns in large areas of the world, especially Europe.

Learning Objectives

The student will get better knowledge and training about

1. The importance of using space:
    a. How space helps to monitor climate change
    b. How to use satellites to obtain information on important ocean parameters, such as sea surface temperature.
    c. How to use satellite data to identify and monitor sea currents and changes in the sea ice
2. What are the sea currents

3. How the Gulf Stream current works and why it important for Europe.
4. Use of online tools to analyse how satellite imagery provides information about currents, their evolution in time, the sea ice and its evolution through decades.
5. The correlation between global warming and the evolution of sea ice, and the possible implications in the weakening of the Gulf Stream.
6. Consequences in Europe if the Gulf Stream weakens or is interrupted.
7. Training of 21st Century skills including:
    a. Problem solving
    b. Critical thinking
    c. Technology skills and digital literacy
    d. Collaboration and communication skills
8. How the abilities learned in the school can help to a future career in the space sector.

Summary

Ocean currents are very important to Earth's climate. The Gulf Stream is crucial to Europe, as it carries warm water from the Gulf of Mexico and along the entire western coast of Europe. This additional heat produces a relative milder climate in several areas of Europe. This activity will focus on the use of satellite data to identify the current of the Gulf Stream and monitor its relatively warmer temperature. Students will also investigate Arctic sea ice and its evolution over decades, which may be strongly related to global warming. Students will understand how shrinking sea ice can affect the Gulf Stream by weakening it and explore the consequences for Europe.

2. Introduction

Ocean currents:

Covering 71% of the planet, the oceans are intrinsically linked to our weather and climate. They are also essential for global transport and provide a wealth of resources. What happens far out to sea has a direct impact on societies all over the world! Ocean currents are driven by surface winds, differences in water density due to salinity and temperature variation, and by Earth's rotation. Ocean circulation and the ocean's capacity to accumulate and slowly release the energy it receives from the Sun play a crucial role in moderating the climate.

The oceans directly absorb most of the solar heat, retaining it for much longer periods of time than either the land or the atmosphere. The equator receives much more energy from the Sun than the polar regions. The major ocean currents, together with the wind, help redistribute this energy around the world.

Satellites in combination with in-situ instruments provide important information to understand and monitor the oceans. Through Earth observation, scientists have been able to model and monitor global sea surface temperatures in unprecedented detail over the last decades. Considering that oceans are vast reservoirs of heat, measuring the sea surface temperature can improve our understanding of global warming and climate change.

Gulf Stream:

As part of this group of ocean currents, the Gulf Stream is important for Europe. It works like a giant conveyor belt. It starts in the tropics, where high temperatures not only warm up the seawater but also increase its proportion of salt by boosting evaporation. This warm, salty water flows northeast from the US coastline toward Europe — creating the current known as the Gulf Stream. The Gulf Stream carries warm surface water from the equator up north to Greenland, where it cools, becomes denser, and sinks, allowing the North Atlantic Current to send the water back down south. The Gulf Stream System moves over 700 million cubic feet of water per second, almost a hundred times the Amazon flow!

Sea ice:

About 12% of the world's oceans are covered by sea ice. Even though sea ice occurs primarily in the polar regions, it influences our global climate. Sea ice changes the reflectivity of the ocean and acts as a barrier to the exchange of heat and moisture between the ocean and the atmosphere. Sea ice also has a significant role in global ocean circulation. Changes in sea ice are one of the biggest challenges for scientists trying to predict Earth's changing climate.

Since 1979 satellites have been monitoring sea ice. Satellites give us a unique overview of the polar regions, providing measurements that were previously impossible to acquire in such hostile and remote areas. Different types of sensors, from optical to passive microwave or infrared sensors, can be used to observe and monitor sea ice. Several European Space Agency (ESA) missions have studied or are studying sea ice on Earth. Among them are ESA's CryoSat satellite, an Earth Explorer mission, and the Copernicus Sentinels, a family of satellites developed to monitor our fragile planet.

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Sea ice changes and implications to the Gulf Stream

Changes in Arctic Sea ice as well as ice sheets and glaciers in Antarctica and Greenland may produce climate change impacts. These changes contribute to sea level rise, play critical roles in global weather formation, and are a pivotal force in determining ocean currents.

Changes to the Gulf Stream System is one example of the risks of sea ice melt. It is very likely that the Gulf Stream System is slowing down due to human-caused warming, which has led to an influx of freshwater into the North Atlantic.

The Gulf Stream System is self-sustaining as long as the necessary temperature and salinity gradients exist. But climate change has shifted the balance. Higher temperatures make ocean waters warmer and lighter. An influx of freshwater from melting sea and continental ice and glaciers dilutes North Atlantic's saltiness, reducing its density. If these waters aren't heavy enough to sink, the entire Gulf Stream became weaker and eventually may shut down.

Consequences of shutting down the Gulf Stream

The Gulf Stream brings warm water to Northwest Europe. Without it, Europe gets a lot colder. Scientists have calculated a possible collapse of the current from 2030-2050. They focused their studies on UK where they calculated that temperatures would drop by an average of 3.4° C, with Scotland cooling the most. In a period where global warming is very important, northern areas of Europe will cool down dramatically! Further studies conclude negative impacts on land use and economic outcomes for agriculture in these areas.

Other consequences predicted include rapid sea-level rise on the east coast of North America, the Amazon Rainforest receiving less water, an impact on Asian monsoons. In addition, the ocean could end up its capacity to retain CO2, which would leave more heat-trapping CO2 in the atmosphere and trigger faster warming elsewhere.

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3. Part 1 Preparations

Work in groups. Before starting with the analysis of satellite information, let's discuss the subject together. Work in groups as indicated by the teacher (3 persons recommended). Do **not** look for answers in the introduction or other resources, just concentrate on what you think. Discuss the following questions with your peers. Designate one person in the group to take notes of your discussion and final conclusions.

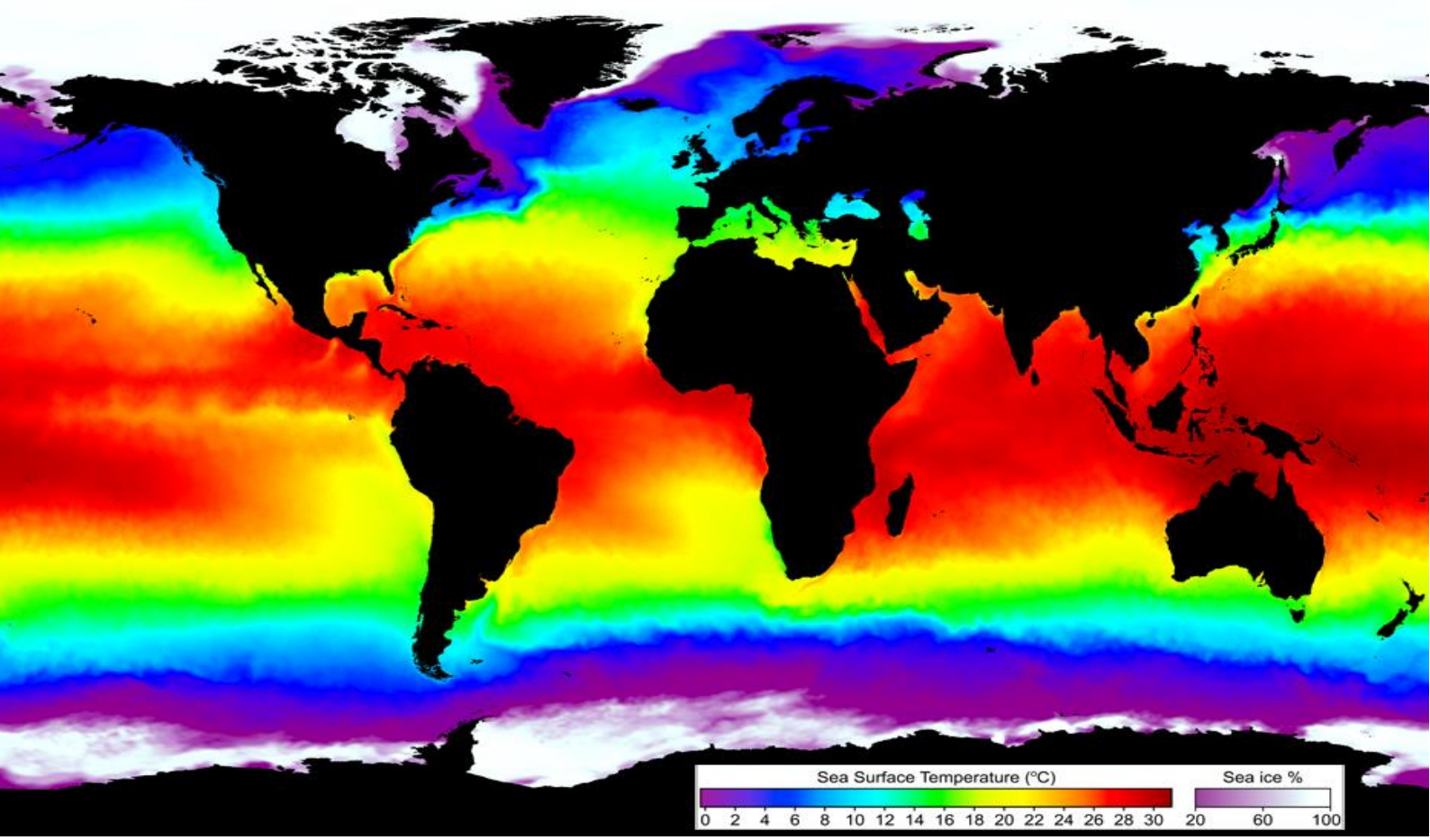
i. Think about currents. Imagine that you are in Florida, USA, marked with a in the figure below, and want to send a message inside a bottle. Where do you expect this message can go? Consider that there can be more than one possible destination.

In the figure above, focus on the areas 2, 4, 5, 6, 7. Can you order them from higher to lower sea water temperature. Explain why and discuss your expectations with your peers. Remember to take notes.

4. Part 2 Feeling the heat

Monitoring ocean currents from satellites

Meteorological Earth Observation Satellites have for decades been equipped with radiometers that measure in the thermal infrared part of the spectrum. Such measurements of the thermal radiation from the ground surface are used to map the surface temperature of the seawater. Measurements of the surface temperature of the water are made from a variety of satellite systems. This type of surface temperature image is called SST (Sea Surface Temperature). They provide detailed information about sea currents.



Activity 1:

The weather satellite NOAA provides a basis for both global and regional sea surface Temperature images (SST). Study the global SST images offered by the *SSEC* (Space Science and Engineering Centre, University of Wisconsin-Madison) at http://www.ssec.wisc.edu/data/sst/ . Select today's image from the link below: "Latest Sea Surface Temperature image".

i. Describe the distribution of the SST. What do you think are the main mechanisms responsible for the distribution of the sea surface temperature?

ii. Identify signatures of **ocean currents** based on the SST satellite image. Can you identify the Gulf Stream current? Explain.

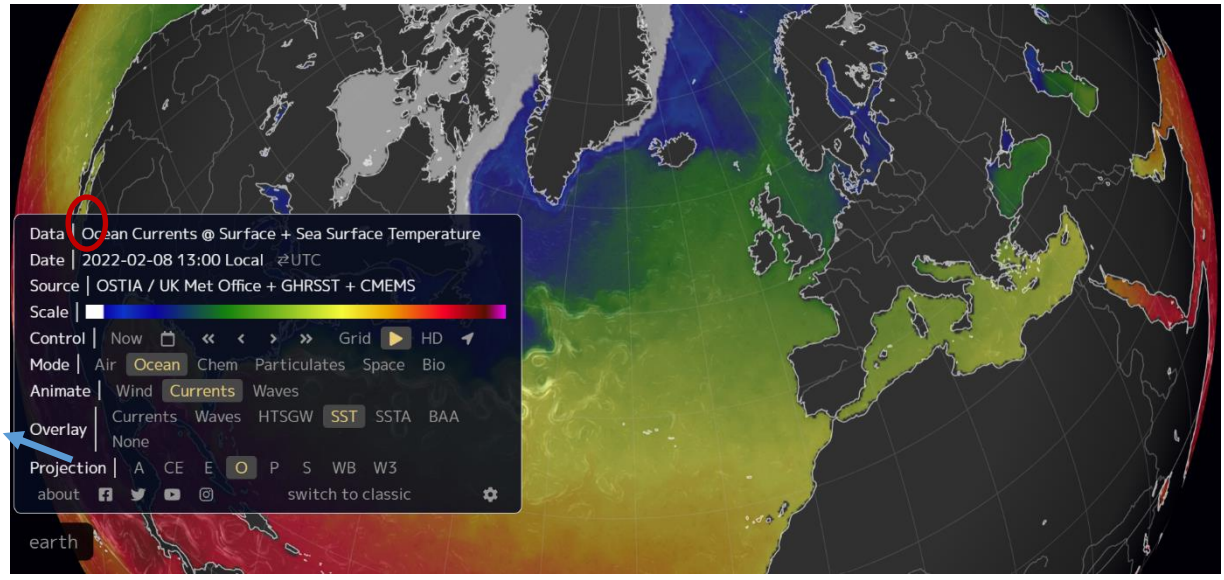
Activity 2:

Let's focus on the Gulf Stream current and analyse the impact on the sea temperatures.

i. Open the link:
https://earth.nullschool.net/#2022/02/08/1300Z/ocean/surface/currents/overlay=sea_surface_temp/orthographic=-32.36,52.90,629
This will show the sea surface temperature in the Atlantic, focusing on the northern hemisphere. The image is from **8th February 2022**. We also see the currents overplotted.

ii. Can you see the Gulf Stream current? Describe and explain.

iii. Select another date and repeat the analysis. The first image is from winter. We compare with an image from summer. Click over the icon "earth" that appears towards the lower-left corner. A window showing options will open up:



Click over the date selection (red circle above) and select **8th July 2022**. Repeat the previous analysis. You can click over the button "earth" again to make disappear the selection box.

a. Let's compare the sea temperature of some areas of the coast of Europe to other areas of the coast of Greenland and north Canada that are at the same latitude so, in principle, without the presence of currents, should have around the same temperature.

b. Select again the date **8th February 2022**.

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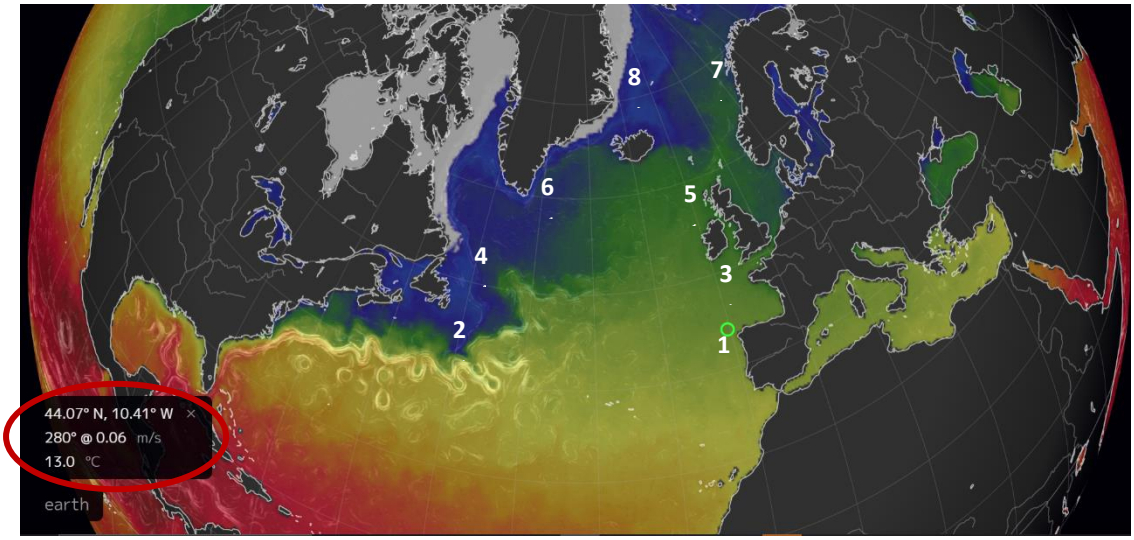
c. Check the sea temperatures of the 8 areas displayed below: click over each area. A small box with information including the temperature will open (see red oval):



d. Make a table with the values comparing the areas at the same latitude. Explain the results.

e. Will you expect regional variations in the climate in Europe if the Gulf Stream current shut down? Explain.

5. Part 3 Sea Ice

ESA's CryoSat satellite monitoring sea ice

In the previous section we have seen the importance of the Gulf Stream for Europe. We indicated in the introduction that this current is self-sustaining if the necessary temperature and salinity gradients exist. However, an influx of freshwater from melting sea and continental ice and glaciers can dilutes North Atlantic's saltiness, reducing its density. If these waters aren't heavy enough to sink, the entire Gulf Stream became weaker and eventually may shut down.

In this part, we will learn where in the world you can find sea ice and its evolution. We will analyse up-to-date satellite data about sea ice concentration in the Arctic.

Activity 1:

Lets check the sea ice today:

i. Click https://seaice.uni-bremen.de/sea-ice-concentration/ (University of Bremen) to study today's arctic sea ice concentration. Click to enlarge the image to the right. After opening the image, you can zoom to see better details. The different colours indicate different concentrations (see explanation box in the image). Describe today's concentration.

ii. Identify areas around the same distance from the North Pole where there are and there are not Sea Ice. What may be the reason for this distribution?

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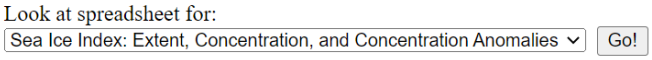
Activity 2:

Let's check the sea ice changes through the seasons and years. Open the link:

i. Study the seasonal changes of Sea Ice by comparing the sea Ice extent in February and September of 2019. Use http://nsidc.org/data/seaice_index/bist from NSIDC.

ii. Below "BIST: Browser Image Subset Tool", after the first paragraph, you will find a menu box with different possibilities (see image below). Open it and select *"Sea Ice Index: Extent, Concentration, and Concentration Anomalies", and click "go"*



iii. A panel with some images will appear. In the "Control Panel" select <Scale: 75%>, <Columns: 2>, <Rows: 1>. Click "Refresh". You will have 2 images. For the first image select <Month: Feb>, <Map: Sea Ice Conc> (for sea ice concentration), and <Month: Sep>, <Map: Sea Ice Conc> for the second. Finally select <year 2022> in the second row of the first column. Click again "Refresh" in the "Control Panel" to see the new selection.

   a. Analyse the seasonal differences. What do you think are the main mechanism(s) responsible for these changes?

iv. Study the prevalence of the Northern Hemisphere by comparing data for September 1988, 1998, 2006, and 2007. Use again http://nsidc.org/data/seaice_index/bist from NSIDC. Now, proceed configuring the "Control Panel" as follows: select <Scale: 100%>, <Columns: 1>, <Rows: 4>. Click "Refresh". You will have 4 images in the second row. Select <Month: Sep>, <Map: Sea Ice Conc> (for sea ice concentration). Finally, towards the left of each image, select the corresponding <Year>. Click again "Refresh" in the "Control Panel" to see the new selection.

   a. Describe your observations. Note that you can read the total area covered below each graph. Consider that the sea ice concentration is an important parameter. The prevalence of sea ice depends strongly on the concentration. Low sea ice concentration can spread easily, but it tends to disappear quickly.

   b. 2007 was reported as a peculiar year. Do you find this in your data?

   c. Make a comparison of the sea-ice data from 15th September 2007 with the same date for the years 2010, 2015 and 2020. Give a brief description of your findings.

v. The ex-president of the USA Donald Trump used the data for September for period 2016, 2017, and 2018 to claim that the sea ice was not diminishing anymore. Select <Rows: 3> and repeat the comparison for these 3 years. Note that you can read the total area covered below each graph. Do you agree with Trump conclusion? Explain and write your thoughts.

6. Reflection

Work in groups. Use the same groups as in the Part 1. Discuss the following questions. Design one person of the group to take notes of your discussion and final conclusions.

i. Think again together about the answers of the part 1 (preparations), about the destination of the message in the bottle, and the temperatures of the areas 2, 4, 5, 6, 7. Do you agree with your previous expectations? Explain if you want to change something from the answers of the part 1 and discuss the reasons behind

ii. Discuss together your findings about the evolution of the sea ice. What do you think it may happen the future?

iii. Look in the introduction and search in internet consequences for Europe if the Gulf Stream shut down. Discuss together your findings.

iv. Discuss together about Trump conclusion (part 3, activity 2.v).

v. Discuss in the group: why do you think we have several climate deniers even though over 90 % of the scientists consider that global warming is happening and can have dramatic consequences soon, and presenting a lot of data and evidence?

A possible future in the space sector

Work in groups. Use the same groups as in the previous sections. Discuss the following questions. Designate one person of the group to take notes of your discussion and final conclusions.

The skills learned in several VET schools are valuable for using space to monitor the health of the oceans and possible consequences for Europe due to changes in the Gulf Stream. An important tool is satellite information. Therefore, we need satellites and all the infrastructure around for designing, building, launching, operating, analysing data, and making it available for the users.

Example: The Norwegian VET school system has 10 different paths. Some of them provides skills valuable for completing these projects. For example, the education program “building and construction” provide good skills to work in the development and specially maintenance of space ports and other infrastructures needed for satellites. The education program “electrical engineer and computer technology” is adequate to work with the maintenance of networks, electrical components, computers systems and software needed in these infrastructures, and in some cases for the satellites themselves. The education program “agriculture, fishing and forestry” is valuable, since it can provide unique information to complement satellite data, like the location and evolution of fisheries…

i. Identify and discuss about how different VET schools in your country can help to the space sector for monitoring the health of the oceans.

ii. Discuss the skills learned at your VET schools that are valuable to work in the space industry.