Primary
8-11

education resource pack

COUNTRY UNDER THREAT

The prospects for life on small islands

Teacher guide and student worksheets

climate change initiative education resource pack – COUNTRY UNDER THREAT
https://climate.esa.int/en/educate/

Activity concepts developed by University of Twente (NL) and
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The ESA Climate Office welcomes feedback and comments
https://climate.esa.int/helpdesk/

Produced by the ESA Climate office

COUNTRY UNDER THREAT: Overview

The prospects for life on small islands

Fast facts

Subject(s): Geography, Science, Earth Science

Age range: 8–11 years old

Type: reading and practical activities

Complexity: easy to medium

Lesson time required: 2½ –4 hours

Cost: low (5–20 euro)

Location: indoors

Includes the use of: ice, water, various containers, food colouring, standard software, Internet

Keywords: sea level, temperature, glaciers, ice sheets, expansion, satellite, observation

Brief description

In this set of activities pupils will learn about the causes and potential impacts of sea-level rise while developing core scientific skills.

The first activity introduces the context by considering the potential future of Kiribati and is linked to an exercise to develop instructional writing skills.

Practical activities exploring two of the main contributors to sea-level rise give opportunities to discuss how models are used in science.

In the final activity, pupils use real satellite data to explore sea surface temperature, changes in average sea level and the relationship between them.

Intended learning outcomes

Having worked through these activities, pupils will be able to:

List some of the ways in which global warming is leading to sea-level rise.

Create a set of instructions others can use to carry out an experiment.

Relate the different parts of an experimental model to the real world.

Analyse images to obtain data on the melting of ice.

Carry out an experiment to demonstrate that water expands when it is heated.

Explain why this happens using ideas about particles.

Identify some problems that sea-level rise may cause.

Use the Climate from Space web application to explore and compare sea surface temperature and changes to sea level.

Explain the relationship between variables using scientific knowledge.

Summary of activities

	Title	Description	Outcome	Prior learning	Time
1	Country under threat	Story on the effect of sea-level rise on low-lying island nations as a basis for a comprehension exercise and a literacy activity. Optional discussion on local impacts of rising sea levels.	List some of the ways in which global warming is leading to sea-level rise. Create a set of instructions others can use to carry out an experiment.	None	45–60 minutes
2	Melting ice	Monitoring and mapping the melting of ice.	Relate the different parts of an experimental model to the things they represent in the real world. Analyse images to obtain data on the melting of ice.	None	30 minutes (simple version) 1–1½ hours (with analysis)
3	Warming water	Practical activities demonstrating and explaining the thermal expansion of water.	Carry out an experiment to demonstrate that water expands when it is heated. Explain why this happens using ideas about particles. Identify problems that sea-level rise may cause.	None	30–45 minutes
4	Warm and cold seas	Research activity using Climate from Space web application. Optional additional research on El Niño.	Use the Climate from Space web application to explore and compare sea surface temperature and changes to sea level. Explain the relationship between variables using scientific knowledge.	Understanding of thermal expansion, e.g. through Activity 3	30 minutes

Times given are for the main exercises, assuming full IT access or/and distribution of repetitive calculations and plots around the class. They include time for sharing results, but not presentation of outcomes as this will vary depending on the size of the class and groups. Alternative approaches may take longer.

Practical notes for teachers

The **material required** for each activity is listed at the start of the relevant section, together with notes about any preparation that may be required beyond copying worksheets and information sheets.

Worksheets are designed for single use and can be copied in black and white.

Information sheets may contain larger images for you to insert into your classroom presentations, additional information for students, or data for them to work with. These resources are best printed or copied in colour but may be reused.

Any **additional spreadsheets, datasets or documents** required for the activity may be downloaded by following the links to this pack from https://climate.esa.int/en/educate/climate-for-schools/

Extension ideas and suggestions for **differentiation** are included at appropriate points in the description of each activity.

Worksheet answers and sample results for practical activities are included to support **assessment**. Opportunities for you to use local criteria to assess core skills such as communication or data handling are indicated in the relevant part of the activity description.

Health and safety

In all activities, we have assumed you will continue to follow your usual procedures relating to the use of common equipment (including electrical devices such as computers), movement within the learning environment, trips and spills, first aid, and so on. Since the need for these is universal but the details of their implementation vary considerably, we have not itemised them every time. Instead, we have highlighted hazards particular to a given practical activity to inform your risk assessment.

Some of these activities use the Climate from Space online resource. It is possible to navigate from here to other parts of the ESA Climate Change Initiative website and thence to external websites. If you are not able – or do not wish – to limit the pages students can view, do remind them of your local Internet safety rules.

Climate from Space

ESA satellites play an important role in monitoring climate change. Climate from Space (cfs.climate.esa.int) is an online resource that uses illustrated stories to summarise some of the ways in which our planet is changing and highlight the work of ESA scientists.

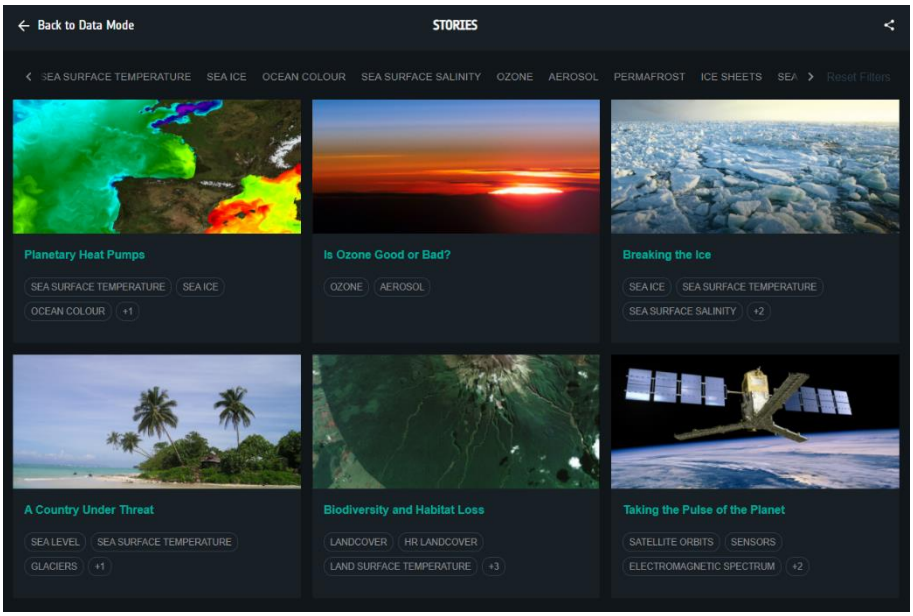


Figure 1: Stories in Climate from Space (Source: ESA CCI)

ESA's Climate Change Initiative programme produces reliable global records of some key aspects of the climate known as essential climate variables (ECVs). The Climate from Space web application allows you to find out more about the impacts of climate change by exploring this data for yourself.

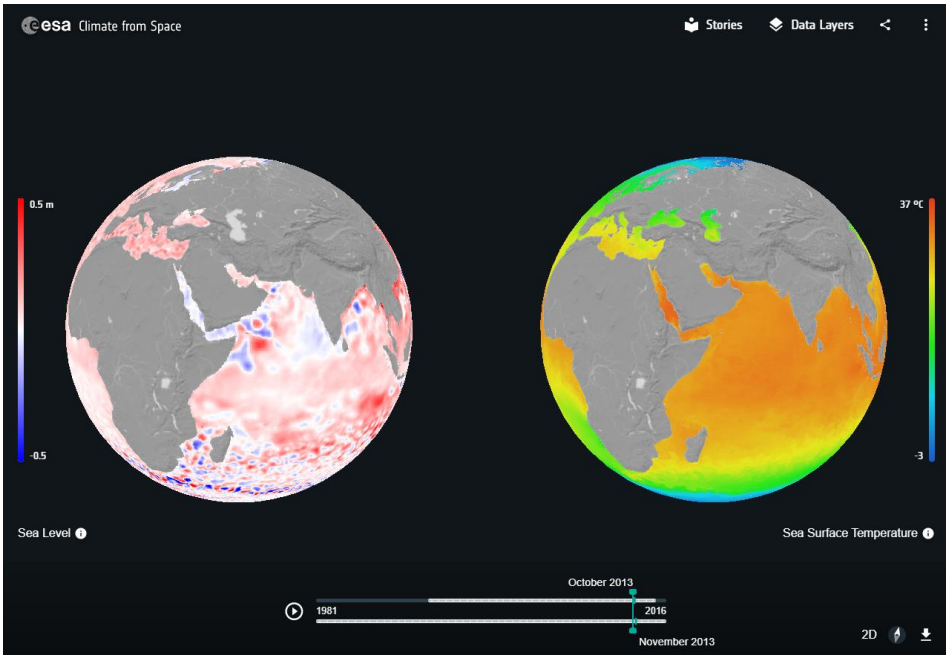


Figure 2: Comparing sea level and sea surface temperature in the Climate from Space web application (Source: ESA CCI)

Climate and sea level: background information

Global warming and our oceans

Global warming has a number of effects on the enormous amount of water in the oceans – and the ocean has a huge impact on the climate of the Earth because of the vast amounts of energy it stores and the proportion of the planet it covers.

Sea levels are rising because of thermal expansion (warmer water takes up more space), faster melting of ice on land (mountain glaciers in many parts of the world and the massive ice sheets of Antarctica and Greenland) and changes to how we use water which means more water from lakes and underground is making its way to the oceans.

The impact of sea-level rise

The potential consequences of rising seas for coral island nations such as Kiribati are dramatic and the people of these countries are working to protect their homes. But governments in other places are also spending on projects to defend their own coastline or adapt it to the changes they expect to see. Across the world, 680 million people live in coastal zones and many of them are already feeling the effects of increased flooding or higher storm surges. More and more people are moving to cities, many of which are low-lying: every centimetre of sea-level rise means 3 million more people live in a place where they may experience floods every year.

Monitoring changing seas

We can now use satellite sensors, such as those carried by the satellite shown in Figure 3, to measure sea level, along with many of the factors that are causing it to rise, including the thickness and extent of ice sheets, and the temperature of the ocean surface. Satellites can take frequent measurements across the whole world rather than periodic measurements in a few selected places. However, instruments on buoys, research ships and planes are still needed – scientists use readings from them to calibrate the satellite sensors and check that the data from them is reliable.

Figure 3: Sentinel-6 – a satellite that monitors sea level (Source: ESA/ATG Medialab)

Activity 1: COUNTRY UNDER THREAT

This activity uses the story of two children in Kiribati to introduce the reasons why global sea levels are rising globally. Confident readers may be able to read the story themselves, perhaps in preparation for the lesson. In the classroom, you can use material from the related Climate from Space story to supplement the text.
The story describes experiments carried out by the characters. Rewriting the descriptions as instructions provides an opportunity to develop literacy skills related to science and reinforce some aspects of the scientific method.

Equipment

- Information sheet 1 (2 pages)
- Student worksheet 1 (2 pages)
- Climate from Space online resource: *Coasts under threat* story (optional)

Exercise

1. Read the story on Information sheet 1 to or with the class, pausing to check understanding at appropriate places.
   You could illustrate the text with material from the Climate from Space story *Coasts under threat* as follows:
   - There are more pictures of Kiribati in the gallery displayed on slide 2, along with the image of New York used on the information sheet.
   - The first part of the video on slide 3 (up to 1:33 minutes) gives more details about the various contributions to sea-level rise (including figures which students could note and use to create a graph or/and a pie chart).
   - Another area already heavily affected by rising seas, the Mississippi delta, is shown in the gallery on slide 5 which also contains the other two images used on the information sheet.
2. Ask students to complete question 1 on the worksheet to summarise the causes of sea-level rise.
   If your country has a coastline, you could follow this with a discussion of possible local effects of rising sea levels or/and things that are being done to reduce the impact of, or adapt to, potential changes.
3. Explain that scientists repeat experiments that other scientists have done in order to check the results are reliable. (The oldest national scientific institution in the world, The Royal Society (UK), founded in 1660, has as its motto *Nullius in verba* which is usually translated as ‘Take nobody’s word for it’.)
   This is easier to do if we have a list of the equipment needed, step-by-step instructions and, perhaps, a diagram of how to set the equipment up.
4. Ask students to change the descriptions of the experiments in the story to instructions, working individually or in pairs and using the outline on the worksheet.
   Some students may need support to make sure there is a single action in each step or/and to appreciate that the description in the story also includes the results (what happened).

More able students may want to include additional detail – for example, the story does not explain how to tell if the water level has changed.

5. Students could peer assess their instructions by considering exactly what they would do if they only had the instructions created by another pair to follow.

Note: If students were to do the experiment following their instructions or those of another pair you would need a lot of buckets and quite a lot of ice, so we are not suggesting this, although you might want to follow Miss Bauro's lead and do it as a demonstration. There are instructions for a version of the activity using cups of water and only two ice cubes per group in the ESA Climate Detectives pack *The ice is melting* (see Links).

Worksheet answers

1. The four factors mentioned in the story are melting glaciers, melting ice sheets, groundwater ending up in the ocean, water expanding as temperature rises.
2. Items in brackets are not specifically mentioned in the story.

Experiment 1 **What you need**: bucket, water, ice.

What to do:

Step 1: Put water in the bucket (and mark or note the water level).
Step 2: Add ice to the bucket.
Step 3: Leave the bucket in a warm place.
Step 4: Look at the water level after a few hours/when the ice has melted (and mark or note the new level).

Experiment 2 **What you need:** bucket, water, ice, sand.

What to do

Step 1: Use the sand to make an 'island' in the bucket.
Step 2: Put water in the bucket, leaving some of the island sticking out (and mark or note the water level).
Step 3: Put ice on the island.
Step 4: Leave the bucket in a warm place.
Step 5: Look at the water level after a few hours/when the ice has melted (and mark or note the new level).

Activity 2: MELTING ICE

In this activity, students monitor the melting of ice. It provides an opportunity for them to make close observations which may include scale drawing or/and using squared paper to measure irregular areas. They may use a smartphone to model a satellite taking observations from orbit, or you may set this up as a parallel demonstration.

Equipment

- A plate with a rim or edge, or a small tray or bowl for each group
- Three or four buttons or counters of different colours for each group
- Play dough to fix the markers in place
- An ice cube or lump of ice for each group
- Classroom clock
- A copy of Student worksheet 2 for each student with spares in case of spills
- Smartphone or tablet (optional)
- A stack of books or block of wood to support the phone if it is being used
- Squared or/and graph paper (optional)
- Acetate sheets printed with a grid (optional if using camera)
- Access to presentation, image- or/and word-processing software with which students are familiar (optional, if using camera)
- Towels for wet hands and to deal with any spills

Note: The worksheet suggests various ways of recording the results: choose the one appropriate to the age and ability of your students, the equipment available and the skills you wish to develop. The first option is to describe close observations, but you may wish younger children to simply draw what they see. If students are to measure the area of the ice, analysing photographs is easier than making drawings that are roughly to scale. A compromise may be to have students work in groups, writing descriptions of what they see, in parallel with the phone version of the experiment being run as a demonstration. The images from this activity can then be shared and analysed by the whole class.

Preparation

You may want to try this out beforehand to find out the best height and position for a phone (if relevant) or/and how long it takes ice cubes of the size you plan to use melt to a noticeable extent in the environment of your classroom.

Health and safety

Make sure that the plates (and books/blocks if you are using them) are in stable positions and not overhanging the edge of tables. They will need to stay in position for some time and there is a risk of spills if they are dislodged.

Instruct students not to put anything – including their fingers! – in their mouths.

Ensure there is material available to deal with spills.

Exercise

1. Refer back to the story of the previous activity. The newsreader said that the ice was melting. How do we know how much ice is there and how it is changing when there is so much of it? The story said we use satellites. Explain to students that these go around the Earth and can take images of it from above that scientists can use to monitor and map the ice.
2. Tell students that they are going to monitor or/and map some melting ice. Take them through the set-up described on Student worksheet 2.
   Ask students to identify how the set-up in the pictures models the global situation: the plate is a part of the Earth, the ice cube is an ice sheet or glacier, the buttons are things that stay in one place and can easily be seen from space such as cities or headlands (or GPS reference points), the camera is the sensor on the satellite which passes over the same part of the Earth every so often.
3. Get students to set up the equipment and note results at an appropriate interval – say every five minutes for half an hour.
   - If they are writing descriptions or taking photos for later analysis, the intervals could be used to discuss predictions and comparisons. Are there differences in what different groups are seeing? Why? What do we expect to see next time? How long do we think it well be before all the ice has melted?
   - If they have been making drawings on squared paper they could use the intervals to measure and record the area of the ice and perhaps plot their latest data point on a graph with axes set up in advance.
4. If the class has made only descriptive observations (in words or pictures), discuss what happened to the ice and how students would expect this to change if the air was warmer. Ask them to discuss in groups how they could test this idea. Can they think of a way that does not involve turning the heating up in the classroom (e.g. setting it up in a different part of the classroom, outside in the sun, or in a box to cut out draughts).
5. If you or the students have taken photographs of the melting ice, import these into a document or presentation making sure that all the images are the same size. (As they will be if the camera stayed in position. If it moved, you may need to use the reference points to help you resize the photographs.)
   Students can then measure the area of the ice at each interval using a transparent grid overlaid on the screen or a printout, or trace the outlines of the ice from a printout on to squared paper. If you have worked as a class, you may want to distribute this task around the class.
6. Ask students to plot a graph of the area of ice against time and discuss what it shows. How would the graph change if the ice was melting faster? Does the rate at which the ice melts change as the amount of ice changes? What does this suggest about how the Antarctic and Greenland ice sheets may melt in the future?

Sample results

The results shown in Figure 4 and the table were collected working outdoors on a warm sunny day in August.

Figure 5 shows a sequence of images from a second run that have been cropped and resized so a grid can be used to compare the area of the ice in each case.

Figure 4: Melting ice observations at 13:30 and 13:50 (Source: ESA CCI)

Time	Time since start (minutes)	Observations
13:30	0	A large block of ice.
13:35	5	The edges of the block have melted. It has moved to a different place.
13:40	10	The ice block has moved, maybe it has slid on the water below it or someone has nudged the table.
13:45	15	The ice block is smaller.
13:50	20	The ice block has almost completely melted.

Figure 5: Melting ice images resized and cropped so areas can be measured using an overlay (Source: ESA CCI)

Activity 3: WARMING WATER

An experiment illustrating the thermal expansion of water. This being a major cause of rising seas is mentioned in the story in Activity 1 and explored further in Activity 3.

Equipment

- 2 identical bottles with plastic lids for each group – small bottles will give faster results; 500 ml PET water bottles work well
- 2 transparent straws for each group – narrower ones are better
- Food colouring or ink
- A jug or large beaker for each group
- Play dough or similar material – each group will need a piece about the size of a walnut
- Heat source – this could be, for example, a sunny windowsill, a reading lamp with a filament bulb, a bowl of hot water to use as a water bath, a heat pad of the sort used for home winemaking, a hairdryer or a fan heater
- Cloths to deal with spills
- A tray for each group to work in (optional)
- Marker pen and ruler (optional)
- Student worksheet 3 – one copy per student with spares in case of spills
- Chalk or tape to mark a box on the ground

Preparation

- Make a hole for the straw in the lid of each bottle using a bradawl or pointed scissors. If the bottles have nipple tops, remove the lid and cut away any plastic inside the nipple so the straw can go in.
- You may want to prepare jugs of coloured water rather than allowing children to colour the water themselves.
- If laboratory equipment is available, you can use boiling tubes, capilliary tubing and a holed bung. The tubing needs to fit tightly into the hole in the bung so it is advised to insert it in advance to reduce the risk of injury from broken glass.
- The time taken to obtain measurable results varys widely depending on the equipment and heat source used. It is, therefore, important to try this out in advance and structure the session accordingly.

Health and safety

Instruct students not to put anything – including their fingers! – in their mouths.

If mains electrical equipment is to be used, make sure it has been safety tested, that students do not to touch it with wet hands and that leads do not pose a trip hazard.

Warn students if the heat source is likely to become hot to the touch (although the use of such devices is not recommended).

Ensure there is material available to deal with spills.

Exercise

1. Refer back to the story in Activity 1. Miss Bauro tells Joena and Afa that warm water takes up more space than cold water but she does not show them this is so. Explain this is called expansion, and discuss whether or not we see water expanding at home. If we take a bottle of water from the fridge, does it get fuller? (You may need to point out that something different is going on when a pot boils over!) Is Miss Bauro wrong? Maybe not.
2. Discuss the idea that the change of volume of a liquid is much more visible if we put it in a narrow container. (You could perhaps use a straw as a pipette to pick up some coloured water and transfer it to a beaker – the water shows up in the straw but barely covers the bottom of the larger container.) So if the only place water has to go when it expands is into a narrow place, we'll be able to see the change.
3. Get students to set up the equipment as described on Student worksheet 3. You will need to tell them where to leave each bottle and how long for.
   With younger students, transferring the water with all the equipment on a tray (such as a shallow storage tray) may help to contain spills.
   If the sensitivity of the set-up you are using allows, you may want older or more able students to produce a graph showing how the level changes over time. They may find it easier to make a mark on the straw where it meets the bottle and then mark the water level at intervals, they can make the measurements when the equipment has been disassembled.
4. This next step can be done while students wait for the water to warm or after they have noted the results, as appropriate.
   Remind or explain to students that everything is made up of particles and the hotter something is, the faster the particles in it move. Get a group of students (anything from four to a whole class) to stand close together and mark a box around them on the floor using chalk or tape. Ask the students to start wiggling and then moving faster – they will soon find it difficult to stay in the box. When particles move faster, they take up more space.
5. Ask students to use these ideas to explain what they saw happening in their experiment, noting their ideas on the worksheet.
6. The seas are huge, not narrow like the straw, so it may seem they will not rise that much. Discuss this with students bringing out the following points:
   - Water is very good at storing heat (think about how long a bath of water stays warm compared to how quickly the air in a room cools).
   - The oceans cover 70% of our planet and are very deep – that's a lot of water.
   - Many of the world's major cities – and therefore lots of the world's population, are coastal so will be affected by relatively small rises. (Students could use maps and population data to explore this further.)
   - Flooding and land disappearing are not the only problem. Think about the effects of seawater seeping into ground it does not normally reach – parts of many cities are underground, wetter ground may not support buildings so well, we pull fresh water from the ground and plants depend on it too.

- Scientists, therefore, keep a close eye on sea temperatures and sea levels and we will look at some of their data in the next activity.

Sample results

As noted above, results depend on the equipment used and the environment, but water should move into the straw of the bottle left in a warm place. The bottle shown in Figure 6 had been sitting in the bowl of hot tap water for about five minutes.

There may be a slight change in level for the bottle left in a cool place if the water used was cooler than the surroundings.

Figure 6: Warming water activity result (Source: ESA CCI)

Worksheet answer

The heat makes the water particles move around more. When they are moving more, they take take up more space. So the water expanded into the straw because there was no more room in the bottle.

Activity 4: WARM AND COLD SEAS

In this activity, students use the Climate from Space web application to explore sea surface temperatures and sea level changes across the globe. Looking at both datasets together gives the students an opportunity to relate satellite data to experimental work on thermal expansion.

Equipment

- Internet access
- Climate from Space web application
- Student worksheet 4 (2 pages)
- Coloured pencils

Exercise

1. Ask students to open the Climate from Space web application and navigate to the sea surface temperature data layer.
   Ensure students understand the colour scale (blue is cool, red is hot).
   It would be worth discussing why the lowest temperature is just below freezing (sea water freezes at a lower temperature than fresh water) and what the hottest temperature on the scale would feel like (swimming pools are often heated to 28–29°C, a hot bath will be 40–45°C).
2. Give students time to explore the data before asking them to answer the first two questions on Student worksheet 4.1.
   You may want to encourage students to draw a number line to help them answer the second question if they are not familiar with operations involving negative numbers.
3. Demonstrate how to switch to the sea level dataset and again discuss the colour scale. This step may not be necessary for older students who may be able to continue by following the instructions on the worksheet.
4. Ask students to answer questions 3 and 4 from the worksheet. They will probably need to refer to an online map or atlas to find the locations.
   Students working more quickly could spend some time investigating how sea levels at a single location vary. Is there a regular pattern over a year? Is there a longer-term trend?
5. Show students how to bring up two globes side by side, if necessary, before asking them to continue with the questions on Student worksheet 4.2.
   Students might want to look for interesting patterns in other years, explore how the location and path of currents of cooler water vary from year to year, or carry out some independent research on El Niño.

Worksheet answers

Sea temperatures

1. The South Pole.
2. About 40°C: 37°C – (–3°C) = 40°C

Sea levels

3.

4.

Place	Date	Sea level
Red Sea	August 1994	much lower than usual
Baltic Sea	January 2000	much higher than usual
Mediterranean Sea	April 2004	a little lower than usual
North Sea	February 2009	about the same as usual/ a little lower than usual
Gulf of Guinea	May 2015	a little higher than usual

Comparing sea levels and temperatures

5. Students' pictures should be simplified versions of the data shown in Figure 7.

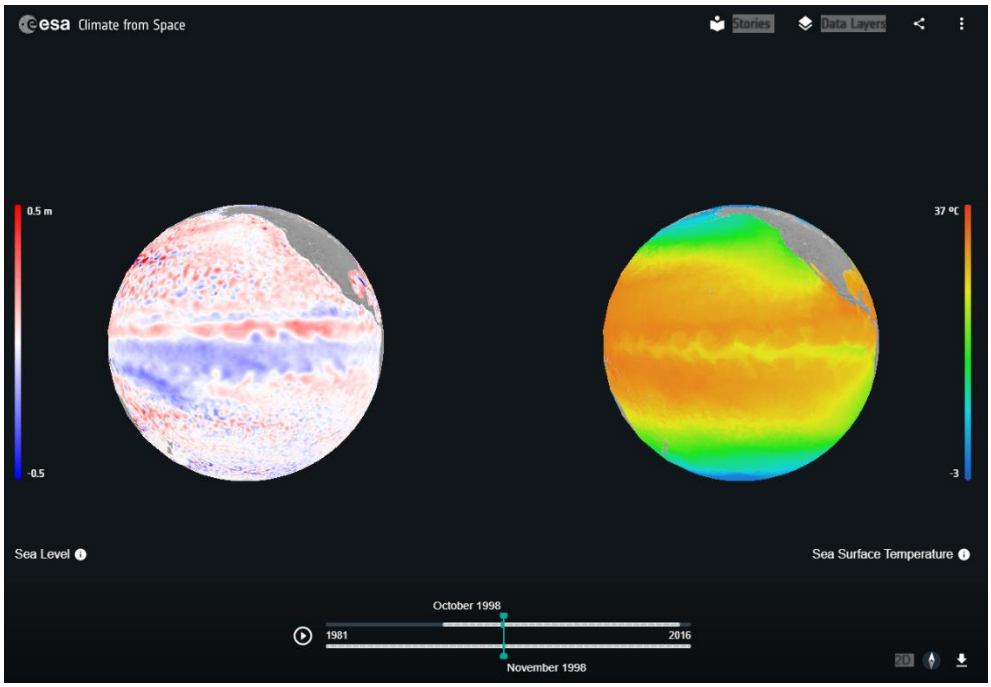


Figure 7: Sea level and sea surface temperature for October 1998 in the Climate from Space web application (Source: ESA CCI)

Note: There was a strong La Niña in 1998–1999. The opposite pattern – El Niño – shows clearly in the sea level data (see, for example, October to December 2015) but less so in the temperature data as this looks at absolute values rather than differences.

6. a. Lower than usual.

b. Cooler water takes up less space than warmer water (over this temperature range).

Worksheet 1: COUNTRY UNDER THREAT

1. Why are sea levels rising?
   (There are four reasons mentioned in the story – can you find them all?)

_____

_____

_____

_____

2. Miss Bauro, Joena and Afa do two experiments.
   Write step-by-step instructions to help someone repeat these experiments.
   List the equipment they will need and draw diagrams to show how to set up the equipment. (You might not need to use every line.)

Experiment 1

What you need

_____ _____

_____ _____

Diagram

What to do

Step 1 _____

_____

Step 2 _____

_____

Step 3 _____

_____

Step 4 _____

_____

Step 5 _____

_____

Experiment 2

What you need

_____ _____

_____ _____

Diagram

What to do

Step 1 _____

_____

Step 2 _____

_____

Step 3 _____

_____

Step 4 _____

_____

Step 5 _____

_____

Worksheet 2: MELTING ICE

What you need

- Plate
- Three or four buttons (different colours)
- Some play dough
- A large ice cube
- A clock

You might also want

- A pile of books
- A smartphone
- Squared paper or graph paper

Health and safety

- Make sure your equipment does not stick out over the edge of the table.
- Mop up any spills quickly.
- Do not taste anything. Keep your hands away from your mouth.

What to do

1. Use the play dough to stick the buttons to the plate near the edge. Space them out equally. These will be reference points to help you see if the ice has moved.
2. If you are going to use a phone to take pictures, put it on top of a pile of books as shown in the pictures.
3. Put your block of ice in the middle of the plate.
4. Note the time and draw or take a picture or describe what you see. These are your initial observations.
5. Now and again (your teacher will tell you how often), look closely at the ice.

Using a smartphone to monitor melting ice. The top picture is a side view, and the bottom picture is a bird's-eye view. (Source: ESA CCI)

Results

Each time you look at your ice, record the time and what you see. The key questions in the box below will help you look closely.

You could make a table and write what you see, take pictures, or make drawings – maybe even to scale on squared paper.

Discussion

How long did it take the ice to melt?

_____

How would you expect this to change in a warmer classroom?

_____

With your group, plan how you could test this idea.

Key questions

1. Is the ice a different size?
2. Has the ice changed shape?
3. Has the ice moved? How? Where to?
4. Has anything else happened to the ice?

Worksheet 3: WARMING WATER

What you need

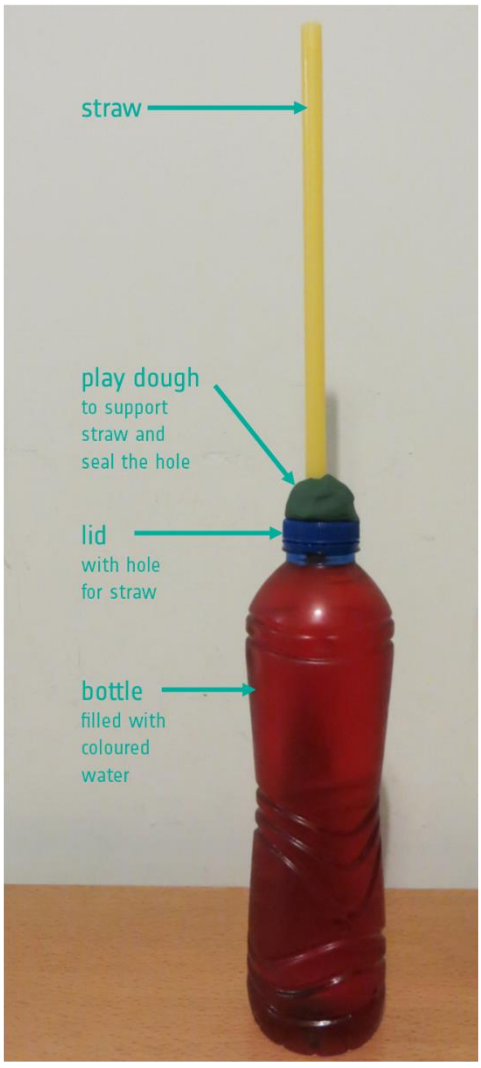
- 2 plastic bottles with holes in the lids
- Coloured water
- 2 straws
- Play dough

Health and safety

- Pour coloured water carefully so you don't stain your skin or anything else.
- Mop up any spills quickly.
- Do not taste anything. Keep your hands away from your mouth.
- Make sure your hands are dry before you touch any electrical equipment.
- Be careful near hot objects.

What to do

1. Set up your bottles as in the picture:
   a. Pour coloured water into the bottle right up to the top, then put the lid on the bottle.
   b. Put a straw through the hole in the lid. Leave about three quarters of the straw sticking out of the the bottle.
   c. Wrap play dough around the straw to keep it in place and make sure no air can get into the bottle through the lid.
2. Put one of your bottles in a cool place.
3. Put the other bottle in a warm place.
4. Leave both bottles alone for a while.



(Source: ESA CCI)

What happened

Write or draw what happened in these boxes.

Bottle in a cool place	Bottle in a warm place

Explanation

Use ideas about particles to explain what happened.

_____

_____

_____

Worksheet 4: WARM AND COLD SEAS

Sea temperatures

Open the Climate from Space web application (cfs.climate.esa.int).

Click on the Data Layers symbol (top right) and pick Sea Surface Temperature.

Check you understand the colours and how the controls on the screen help you to look more closely at particular places or times.

1. Move the globe so you can see the Arctic, and then the Antarctic.
   Which pole has colder water surrounding it?

   _____

2. Work out the temperature difference between the ocean near the equator and the ocean near the poles.

   _____

Sea levels

Open the Data Layers list.

Pick Sea Level.

This map shows the average sea level compared to the usual value for the time of year. Shades of blue mean the sea is lower than usual, shades of red mean the sea is higher than usual. The darker the colour, the bigger the difference.

3. Move the globe and the timeline dot so you see the Red Sea in August 1994.
   Was the level of the sea much higher than usual, a little higher than usual, the same as usual, a little lower than usual or a lot lower than usual?
   Write your answer in the third column of the table below.

4. Now do the same for the other times and places in the table.

Place	Date	Sea level
Red Sea	August 1994	
Baltic Sea	January 2000	
Mediterranean Sea	April 2004	
North Sea	February 2009	
Gulf of Guinea	May 2015	

Comparing sea levels and temperatures

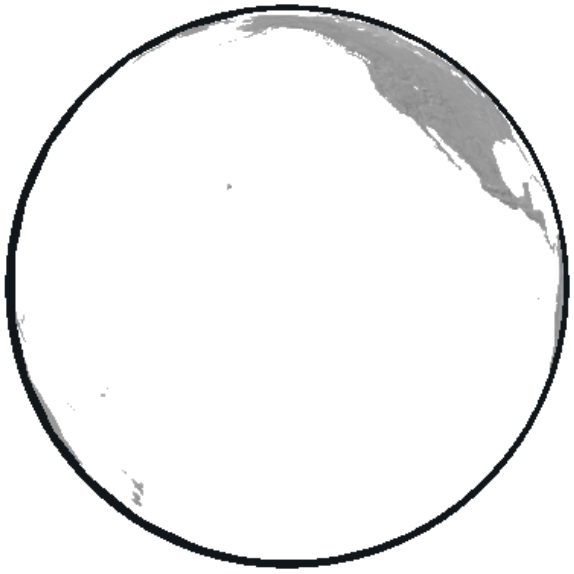
Open the Data Layers list again.

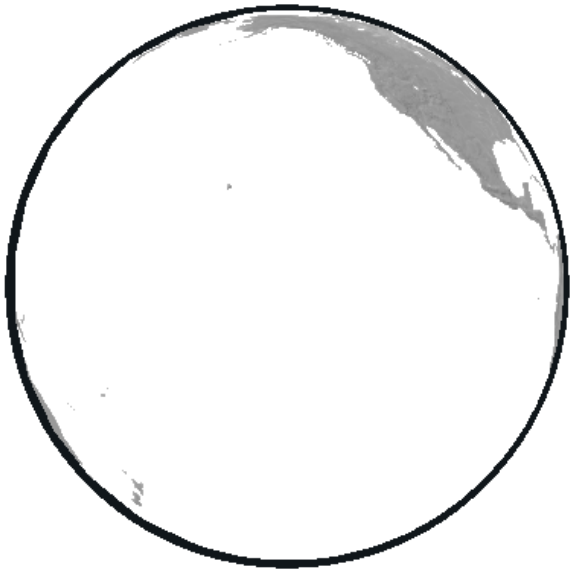
Click COMPARE next to Sea Surface Temperature.

You should now see two globes side by side on your screen.

5. Rotate the globes so you see the Pacific Ocean with some of America showing at the top and New Zealand just visible at the bottom (as in the diagrams below).
   Move the timeline bar to October 1998.
   Colour in the pictures to show the main patterns you see on each globe.
   Add a key to your diagrams.

Sea Level | **Sea Surface Temperature**





lower than usual → higher than usual

cold → hot

6. Look on the temperature globe for a band of cooler water near the equator.
   Now look at the same place on the sea level globe.
   a. What is the sea level like in the places where the temperature is lower?

   _____

   b. Why? _____

   _____

Information sheet 1: COUNTRY UNDER THREAT

(Source: Diederik Veerman, Museon The Hague)

Kiribati (you say it 'ki-ri-bas') is a group of small tropical islands in the Pacific Ocean. Joena lives on one of these islands with her mum, dad and little brother in a beautiful house close to the beach. Many, many generations of her ancestors lived on the same island. Her father is a fisherman, her mum is a nurse. Afa is Joena's best friend. Together they play on the beach, swim in the lagoon and try to climb the palm trees. Life in Kiribati is good.

After a day outdoors, Joena loves to sit on the sofa with a cup of chocolate. Sometimes she watches the news with her mum. Usually this helps Joena to fall asleep, but today she heard something that shocked her. The newsreader was talking about global warming, saying the temperature of the Earth is increasing. Because it is warmer, all the seas and oceans around the world are rising. The newsreader said scientists expect the islands of Kiribati will be completely drowned by the year 2100.

Joena can't sleep because she is afraid that her family will have to move one day. She would like to know why the level of the ocean is rising. Even though it is now the middle of the night, she calls Afa. He doesn't know either, so they decide to talk to their teacher in the morning.

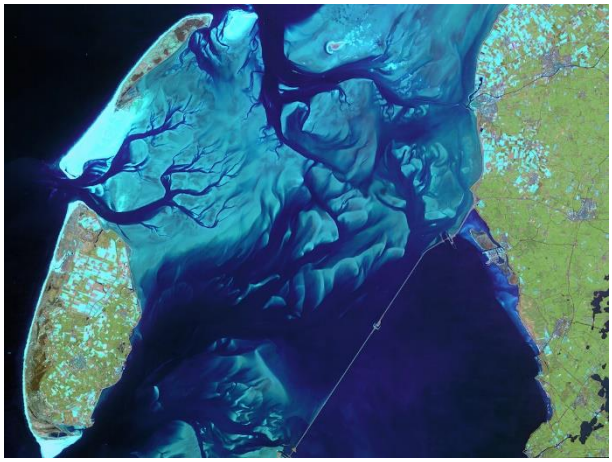
Joena and Afa are first into class the next day. They ask their teacher, Miss Bauro, if she has a minute. When they tell her what it said on the news, she is shocked, too.

'But why is it happening?' Joena asks. 'Is it because the ice where the polar bears live is melting?'

Miss Bauro stands up. 'Wait a minute', she says and walks away.

Five minutes later, she comes back with a bucket of water and a bag of ice cubes. They throw the ice cubes into the bucket and put it on a sunny windowsill. When they look in the bucket an hour later, they see that the floating ice cubes have all gone but nothing has happened to the water level. Now they are even more puzzled. If the ice floating in the sea doesn't make the water rise, what does?

The next day, Miss Bauro, Joena and Afa do another experiment with the bucket of water and a new bag of ice cubes. Miss Bauro has made an island of sand in the middle of the bucket and this time they put the ice cubes on the island. 'We'll come back in a few hours and see what has happened,' the teacher says. When they come back, they see that all the ice cubes have disappeared and that the island is covered by water.



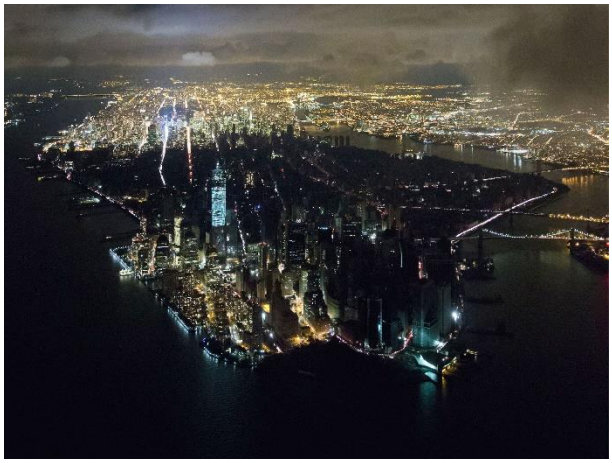
Protecting countries from sea-level rise.
This picture, from a satellite circling the Earth, shows the long Afsluitdijk that protects the Dutch coast from the North Sea. (Source: CNES/Spot Image)

Miss Bauro explains that there is water everywhere all around the world. There is groundwater deep in the Earth, rivers of ice called glaciers in high mountains, ice floating in cold seas around the poles, and ice sheets covering most of the land in Antarctica and Greenland. When the glaciers and ice sheets melt, the water goes into the oceans. When people pump up groundwater to drink or use in factories to make things, the water will eventually go into the ocean. So melting ice on land and using up water from the ground are both things that make sea levels rise.

But there is another reason. The sea itself is getting warmer, and warm water takes up more space than cold water. With so much water in the oceans, nearly a third of sea-level rise is due to the oceans expanding rather than ice melting.

Kiribati is not the only place where rising seas are causing problems. In Great Britain, people are leaving a town on the Welsh coast because there is no way to protect it as the sea gets higher. Many of the world's largest cities are near a coast. People living in those places also have to defend themselves against the rising sea or move to higher ground.

We can use satellites to measure some of the changes that lead to sea level rise including the size of glaciers, the thickness of ice sheets, and the temperature of the ocean. We can even measure the sea level itself. Scientists have been tracking these things for a long time. Looking at them all together gives us a better picture of current sea levels and helps us work out how it is likely to rise in the future so we know which places will be most affected. If we know what might happen, people around the world can plan how to protect their cities and countries.



Even where land still rises above the sea, higher sea levels can cause problems.
When Hurricane Sandy reached New York in October 2012, there was a 'storm surge. Tunnels, subways and power stations were flooded, and almost two million people were left without power. (Source: Iwan Baan/Getty Images)

Links

ESA resources

Climate from Space online resource
https://cfs.climate.esa.int

Climate for schools
https://climate.esa.int/en/educate/climate-for-schools/

Teach with space
http://www.esa.int/Education/Teachers_Corner/Teach_with_space3

Climate Detectives: *The ice is melting*
https://www.esa.int/Education/Teachers_Corner/The_ice_is_melting_How_can_we_investigate_the_effects_of_melting_ice_Teach_with_space_PR13

ESA space projects

ESA Climate Office
https://climate.esa.int/en/

Space for our climate
http://www.esa.int/Applications/Observing_the_Earth/Space_for_our_climate

ESA's Earth Observation missions
www.esa.int/Our_Activities/Observing_the_Earth/ESA_for_Earth

Earth Explorers
http://www.esa.int/Applications/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers

Copernicus Sentinels
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Overview4

Copernicus Sentinel-6
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-6_overview

Extra information

Tarawa, Kiribati
https://www.esa.int/ESA_Multimedia/Videos/2020/09/Earth_from_Space_Tarawa_Kiribati

Earth from Space videos
http://www.esa.int/ESA_Multimedia/Sets/Earth_from_Space_programme

ESA Kids
https://www.esa.int/kids/en/learn/Earth/Climate_change/Climate_change