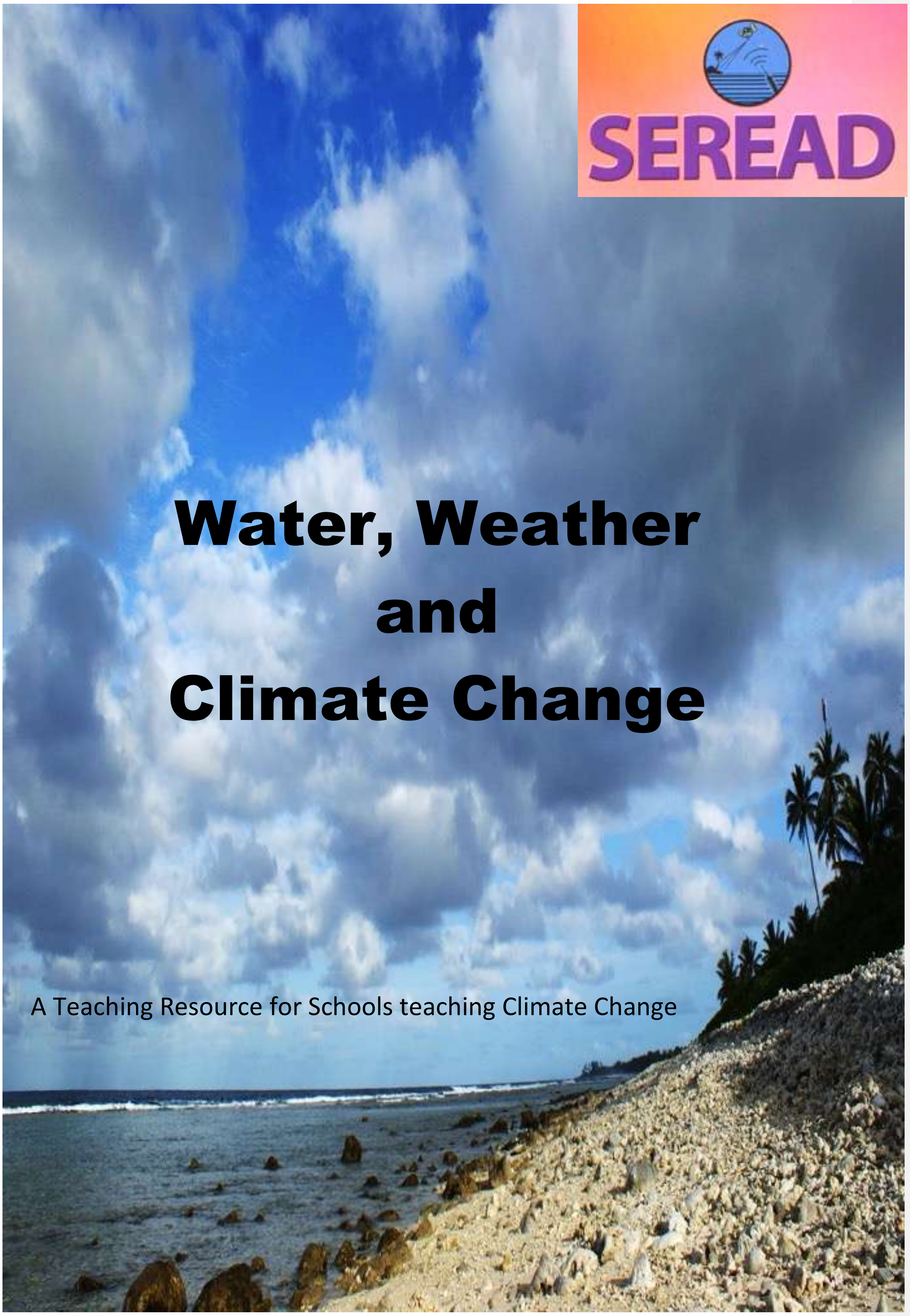
SEREAD



Water, Weather and Climate Change

A Teaching Resource for Schools teaching Climate Change

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WELCOME TO SEREAD

What is SEREAD?

SEREAD is an educational programme linked to current teaching programmes in Pacific Island schools.
SEREAD stands for Scientific Educational Resources and Experience Associated with the Deployment of Argo. The Argo Project is a series floats that move up and down vertically through the water and the information they provide is used to help understand the changes taking place in today's climate.

This workshop and the SEREAD programme are sponsored by:

- The International Oceanographic Institute, University of the South Pacific (IOI)
- UNESCO Office Apia
- Argo Science Team
- Partnership of Observation for the Global Ocean
- National Oceanic and Atmospheric Administration. U.S.A.
- South Pacific Applied Geoscience Commission
- International Oceanographic Commission, Perth Regional Office
- National Institute for Water and Atmosphere, New Zealand.

The Goal of SEREAD

The goal is to help generate awareness, discussion and an understanding of the ocean's role in the climate system. Climate changes can take place over months or years. The key to understanding change involves the role of the water and energy cycles in the tropical marine climate of the Pacific Islands.

SEREAD's objectives are to:

- Provide teaching resources that complement current teaching curriculum and demonstrate the value of scientific knowledge through realistic and locally relevant applications.
- Teach students about the fundamental measurements that are used to describe and measure changes in climate.
- Help teachers and students to understand how scientists use data.
- Provide opportunities for interaction between scientists and teachers.

Goals of the SEREAD workshops:

- To provide teachers with practical classroom materials and resources that they can take away with them for use in their classrooms.
- Develop teacher's knowledge of climate change and the role of the ocean.

Reference websites

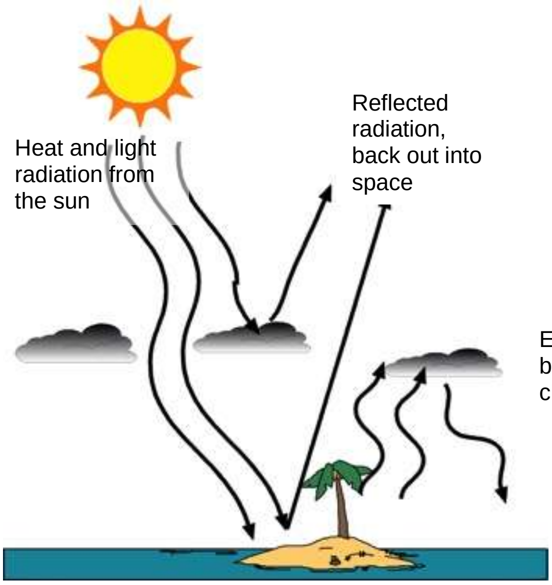
The Intergovernmental Panel for Climate Change: www.ipcc.ch
Pacific Climate Change Science Program: www.pacificclimatechangescience.org
NIWA (Resources on climate and Island Climate Update): www.niwa.co.nz
NOAA Climate Service. (Information and resources): www.climate.gov./#climateWatch
NASA (Huge resource site): www.nasa.gov
Hadley Centre: www.metoffice.gov.uk/climate-change
Samoa Meteorology Division: www.mnre.gov.ws
Wikipedia (huge resource site): www.wikipedia.org
Penguin's View of Climate Change: www.tiki.oneworld.net

This booklet has been specially prepared for a workshop in Kiribati, 2013. It combines What is Weather – a booklet for junior primary students, What is Climate, a booklet for senior primary, and Oceans Rising, a rewrite of the junior secondary booklet. It takes into account that a new resource will be coming out in 2014. This resource – *Educating for Climate Change the Pacific Way – Kiribati*, will have a lot of information that is complementary to the Seread books so has not been repeated.
Each section of information for the teacher is followed by some activities for students. More activities that help students understand these concepts can be found in the Seread Teaching and Learning Strategies book.

Is climate change happening?
Our foot is stuck on the accelerator and we are heading for an abyss. (UN

The Driving Force for our Weather

The driving force of this planet is the sun. The energy that radiates from the sun is responsible for many things that happen on our planet. Light energy is needed for plant photosynthesis and this is the key to the survival of all living things. Heat energy warms our planet, enabling life to survive, and creates the weather that we are familiar with.



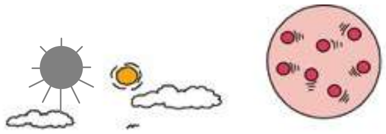
The sun actually gives out or radiates many different types of energy. Some of the types of energy are very strong and but do not reach earth through the protection by the upper atmosphere. Other forms of energy including light and heat do reach the surface of the earth. Some of the radiated heat energy is reflected by, or absorbed by the clouds. Some of the heat energy can be trapped inside the earth's atmosphere and this is what warms up the air, and everything on the surface of the earth including small rocks on the ground and the oceans .

How do we know how warm it is getting? We can sense a warm object or how warm the water is by touch or feel on our skin. A more accurate way is to measure temperature.

What is temperature? What does temperature actually measure?

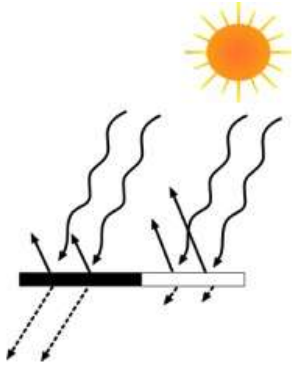
Heat from the sun warms up Earth's surface through absorption of the solar radiation. The heat energy has to go somewhere and in fact the energy goes into making the particles, that all matter is made up of, move around faster.

Temperature is a measure then of the amount of movement of these particles and so relates to the amount of heat energy.



The particles in warm air move around faster.
They occupy more space, so warm air is less dense.

Particles in cool air move more slowly and are closer together. Cooler air is more dense for this reason.



Objects such as rocks and black sand on the beach, and bare soil, absorb large amounts of solar energy quickly. They feel warm, and have a high temperature. White surfaces reflect heat energy, so they absorb less energy and feel cooler.

The temperature of the air around us depends on the amount of heat that is absorbed into the land below.

Recycling Water

Water is recycled by the sun's energy. When the sun shines on a puddle of water, the puddle disappears, but the water doesn't simply vanish; it changes from one from form into another.

Water can be found in nature in three different forms or states:

- The solid from is ice;
- the liquid form is water (confusing!)
- and the gas form is water vapour. (Not steam - we'll see why later).

Heat energy is involved when changing these states.

What makes water evaporate at different rates?

- Higher daily temperatures.
- When air pressure is low.
- Surface area. Large shallow areas of water compared to deep puddles.
- Wind. This helps moves the water particles away form the surface.

- Air Humidity: On hot sweaty days water evaporates only slowly, as there is already a lot of water vapour in the air.

ACTIVITY 1

WHAT IDEAS DO CHILDREN HAVE ABOUT WATER?

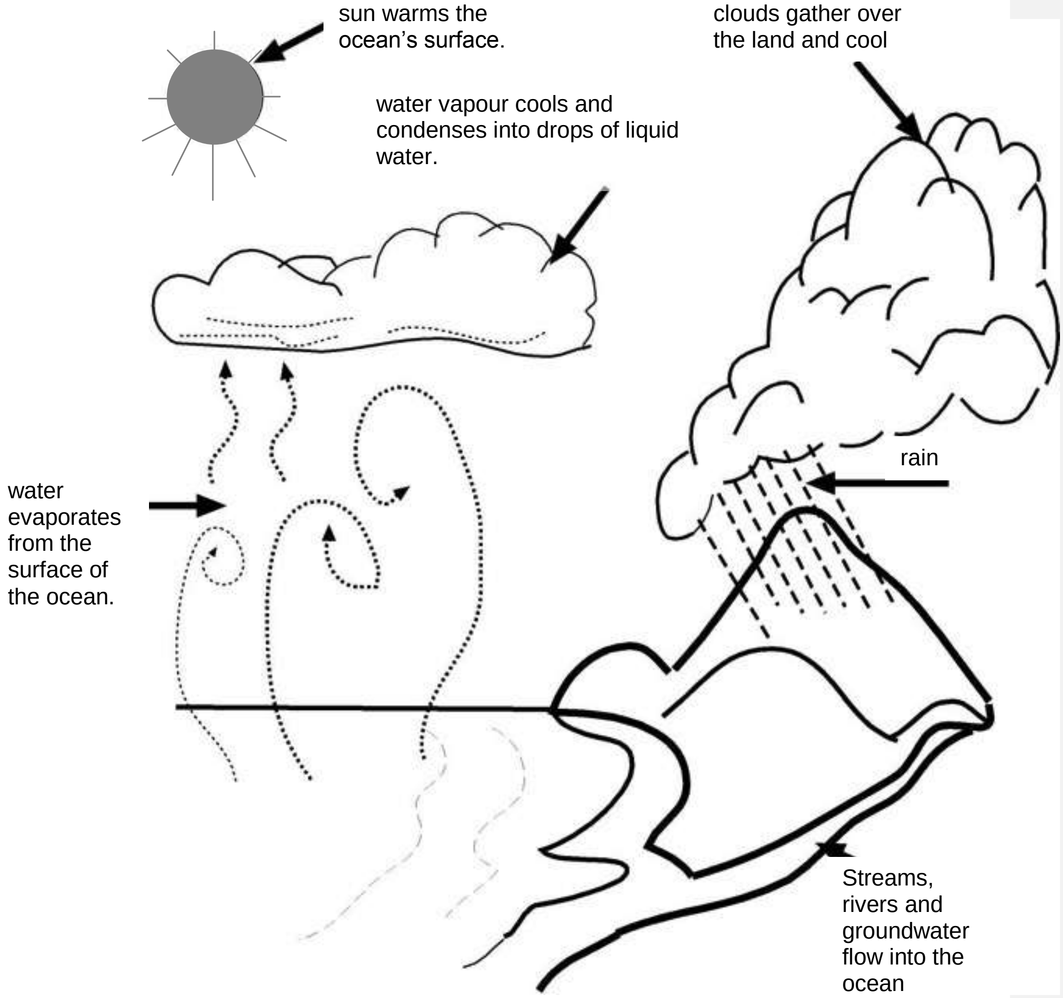
Starter: What are all the things we can think of about water?

Purpose: To get children thinking about the importance of water in our daily lives. It is just a general discussion starter. Use drawings, Children can work in groups to draw pictures of their associations with water.

Some ideas:
What does it feel like?
What does it look like?
What does it taste like?
Where do we get it?
Where does it come from?
Where does it exist?
Who needs water?
What do we do with it?

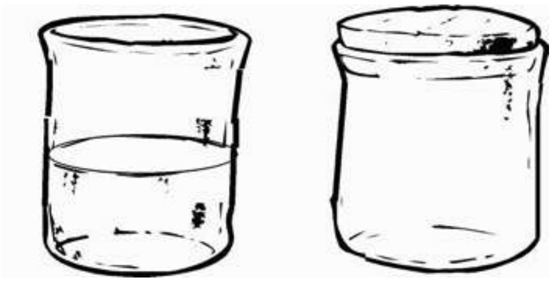
For the teacher: What to look for?
Children recognise how important water is to our existence and the sources of water eg sea, river, well, rain………….

The diagram is a representation of nature's water cycle. It shows us how the sun warms the oceans causing the process of evaporation.
As the water vapour cools it condenses to form clouds and eventually rain.

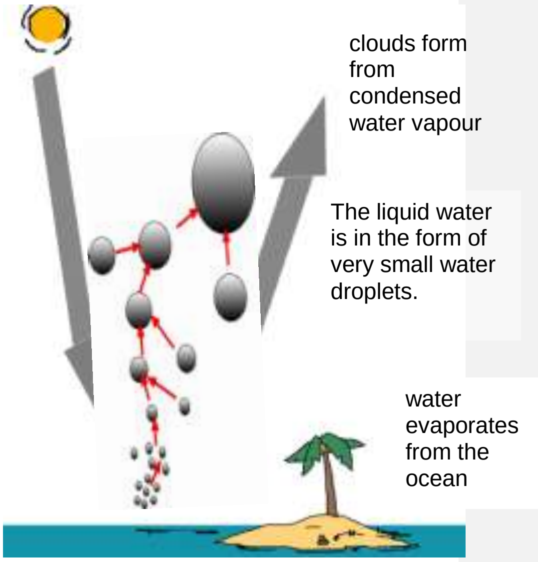


The Science of the Water Cycle

When the water is heated by heat energy the water particles absorb this energy and start to move around. Some have enough energy to escape the surface of the liquid water and become a gas, water vapour.
We can see this if we put a sealed container of water out in the sun alongside another one, which is open to the air. Water evaporates in both of them, but the water vapour in the in the sealed jar cannot escape to the open atmosphere.



When water evaporates from the earth's surface the vapour has to go somewhere!



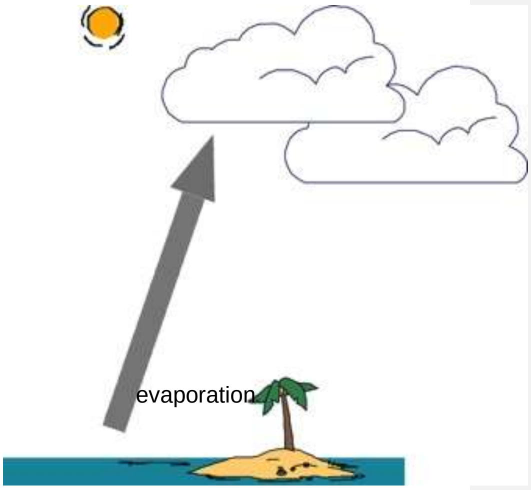
The water vapour is an invisible gas. The water particles rise with the warm air. Eventually high up in the earth's atmosphere they have lost most of their energy as the air cools. When water vapour cools, the water particles loose their energy and move closer together.

They gather around microscopic bits of dust that exist in the air, and change back into liquid water. This process of water vapour turning back into liquid water is called condensation.

The tiny water droplets get moved around by the air and end up bumping into one another. They end up joining together to form larger droplets and eventually form a cloud.

Remember that steam is not water vapour! When water is boiling the liquid water is turning into water vapour. Then as the water vapour cools we see clouds of what we call steam. Steam is condensing water vapour and what we are seeing are clouds of water droplets. (Rather warm ones at that!

Most of the water that evaporates to form clouds and eventually rain comes from the ocean. This is nature's big recycling machine.



The amount of evaporation depends on the amount of solar energy reaching the earth's surface. This we recognise as air temperature. The temperature varies depending on what time of day it is and the angle of the sun in the sky. A sun that is overhead appears to put out more energy into the land and sea than when it is just coming over the horizon. The amount of heat that is arriving onto the earth's surface also depends on the amount of cloud cover. Cloud cover acts as a barrier reflecting the sun's radiation back up into space. So naturally down below the cloud cover where the sun is not getting through, it remains cooler.

Also the temperature depends on the time of year, and the seasons.

The water droplets collect in the clouds getting bigger and bigger. The process of forming these drops is called coalescence. (In cooler regions of the world the water droplets freeze as the air temperature drops below freezing point to form ice crystals as well.) These large droplets remain up in the clouds until they become too heavy for the air currents to keep them there, and gravity pulls them back to earth as raindrops.

Sometimes the clouds reach the surface of the earth. This we call fog or mist. These 'surface clouds' form when the cold air lying directly on top of the cold surface of the earth cools the moist raising air. This could be either land or sea. The only real difference between mist and fog is the thickness of the cloud. A more dense surface cloud is called fog.

ACTIVITIES 2

1. PUDDLES.

What I need: Water, a concrete surface. (or somewhere where water will not soak through).

What to do.
Create a puddle of water.
Draw a chalk line around it.

Predict: Make some predictions from what the children think might happen.

Observe: Observe what happens over a period of time. Each time the puddle is checked, draw a new chalk line around it.

Explain: Get children to draw pictures of what happened and write their explanations about what they think happened.

What we want the children to learn:
They can use the words liquid and gas or vapour.
They use the word evaporation for the change from liquid to gas.

Extend to different conditions: e.g. cloudy, windy.
Does the speed the water disappears at, ever change?
What do the children think happens out in the ocean?
Where does the rain come from that makes the puddle?

2: **WHAT DO YOU UNDERSTAND ABOUT EVAPORATION?**

What I need: Water, Paper towels, or Cotton material, Pen.

What to do:
Get the children to draw a line around their hand to make a handprint on the paper towel or cloth.
Wet the hand.
Place the wet hand on the towel (or cloth) inside the outline.

Observe: What do they see on the paper towel (or cloth).
How do they think the handprint was formed?

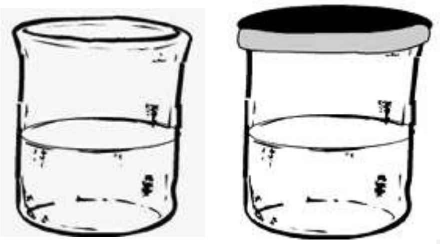
Predict: What do they think will happen to it? Write down all the possibilities.

Observe: Leave the handprint for a period of time.

Explain: What happens to the handprint? Write down all the possibilities.
Why is the towel no longer wet? Where did the water go?

What we want the children to learn:
Children understood that the water has changed into gas form.
The process is called **evaporation**.

3: WHERE DOES THE WATER GO?



What I need: 2 glass jars, (one with a lid,) some water, and a marker pen.

What to do:
Put the glass jars in a sunny place. Put the same amount of water in each. Put the lid on one of the containers.

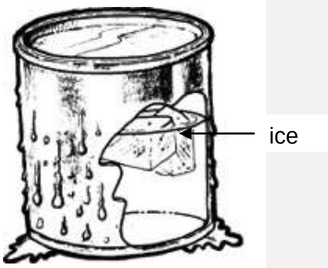
Predict: What do the children think will happen over the next few days? What effect will the lid have, if any?

Observe: Get the children to mark on the sides off the jars the level of the water.

Explain: Get the children to answer the question: Where has the water in the open jar gone? Where has the water in the closed jar gone? Why is there a difference?

What we want the children to learn:
The children draw out pictures to explain, "Where does all the water go when evaporation happens."

4: WHAT DO YOU UNDERSTAND ABOUT CONDENSATION?



What I need: A metal can with lid, cold water and ice cubes.

What to do:
Get the children to feel the outside of the can. It should be dry.
Put some cold water and ice cubes into the can. Put the lid on the can.

Predict: What do they think will happen to the outside of the can? Give reasons.

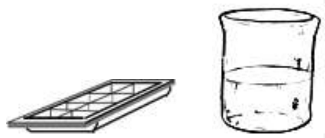
Observe: Leave the can for a while at room temperature. Get the children to have a look at the outside of the can. Is it wet or dry?

Explain: Compare the results with predictions. How can they explain what has happened.
Draw a wall chart to share ideas.
Where did the water come from?
Where was it before it appeared on the surface of the can?

What we want the children to learn:

That the water was in a gaseous form in the air around them.
It is often called water vapour.
Cooling turns the gas into liquid water.
This is called **condensation.**

5. WHAT DO YOU UNDERSTAND ABOUT FREEZING?



What I need: Water, Ice Block Tray, and Freezer.

What to do:
Put water in an ice tray.
Get children to write down their observations about the water.
Get children to write down their predictions about what will happen to the water if placed in the freezer overnight.
(What will it look like? What will it feel like? Does it become larger or smaller?……….)
Next day write down all their observations.
Compare these with their predictions.

Write up a wall chart with their predictions and observations.

What we want the children to learn:
That water changing into ice is called **freezing.**
That the process is reversible.
Ice warmed up turns into liquid water.
This process is **melting.**

Question: Does it matter how many times this is done? Will the water become any different other than ice or liquid water?

6: **DOES ICE LOOSE WEIGHT WHEN IT MELTS?**

What I need: A large block of ice or several ice cubes, a large jar and lid to hold the block of ice, a set of kitchen scales.

What to do:
Place a block of ice in the jar, put the lid on it. Put the jar on the scales. Weigh it.

Predict: Write down what the children think will happen? What do they think they will see happen to the ice block? What will happen to the weight measurement on the scales?

Observe: Allow the ice to melt. What happens? What is the reading on the scales?

Explain: Compare the observations with the predictions. What explanations can they give?

What we want the children to learn:
We do not loose water when it changes from one form to another.

7. **WATER IN NATURE.**

This is attempt to put together the ideas of water existing as a solid, liquid or vapour, and utilise the terms evaporation and condensation.

Review ideas about evaporation and condensation.
Where does rain come from?
What is the effect of the sun on puddle of water?
What would be the effect of the sun's heat on the ocean?

Making Clouds

What I need: Ice cubes, metal tray, large glass jar, and warm water.

What to do:

Pour about 2 cm of warm water into the glass jar. (Do not use boiling water, as this will crack the glass jar.)
Put some ice cubes on the metal tray and put this on top of the jar of warm water.

Predict: Get the children to predict what is likely to happen.

Observe: Watch what happens as the moist warm air in the glass jar rises and reaches the cold metal tray.

Explain: Get the children to draw their observations and write an explanation.

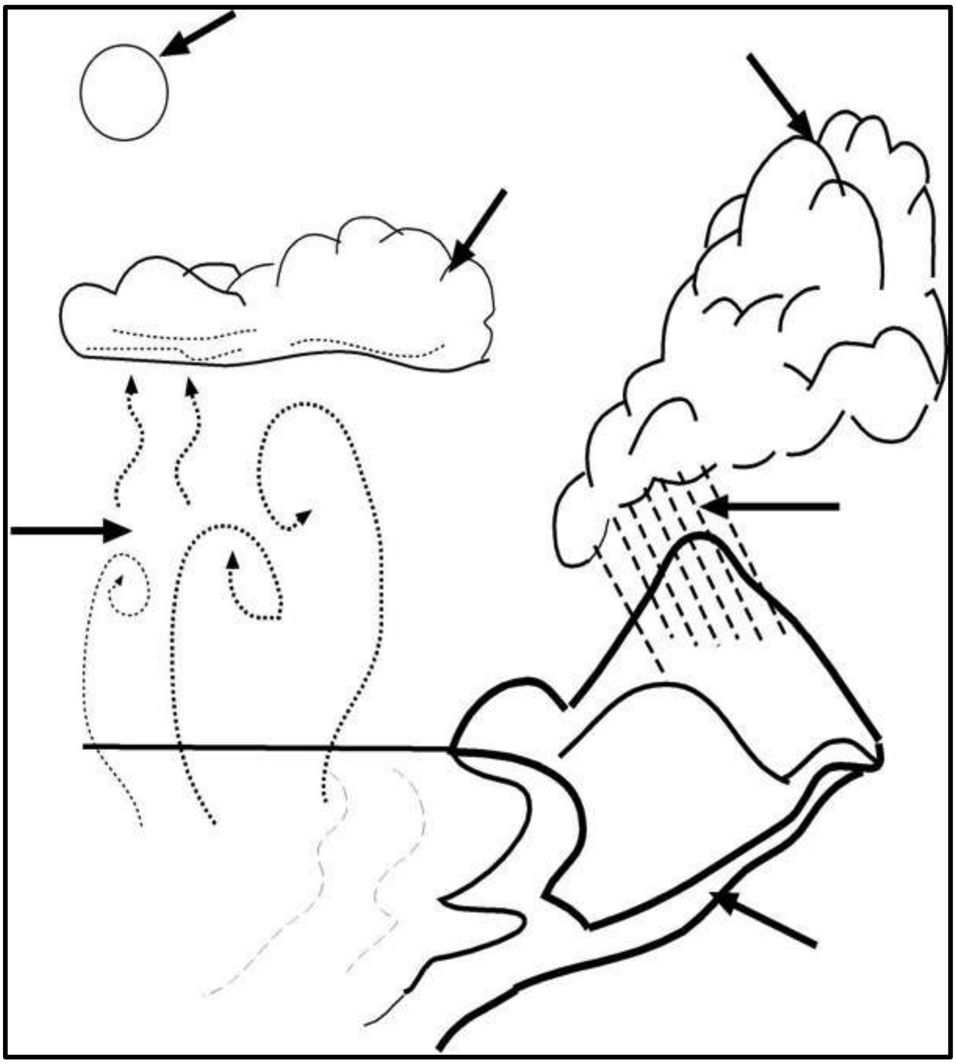
What we want the children to learn: Use the words evaporation and condensation.
This activity can be linked to water evaporating off the sea and cooling high in the atmosphere.
When the water vapour cools, small drops of liquid water form. These collect together to form clouds.

8. **THE WATER CYCLE.**

What I need: Large sheets of paper and plenty of colouring pencils, pens etc.

What to do: Relate this as a story or even get the children to write a story of a water drop, after they have been through ideas about the water cycle, and become familiar with the terms.

Step 1: Sun provides heat heat energy	Step 2: water evaporates from the surface of the ocean	Step 3: water vapour condenses into droplets to form clouds
Step 4: clouds rise and cool	Step 5: water drops combine and fall as rain	Step 6: water soaks into the ground, flow into streams and rivers



The Story:
The story of the water cycle is all about how water is being dried up by the heat of the sun. It is happening all the time, and just keeps on going on.

STEP 1.
Heat from the sun dries up the liquid water that is on the earth's surface. The water can be in rivers, lakes, puddles, streams, plants and the ocean.
The sun dries up a lot of water from the oceans, because they are so large. Two thirds of the earth is covered in ocean.
The liquid water is turned into an invisible gas, which we call water vapour.

STEP 2
The water vapour rises into the air. As it gets higher the water vapour cools. It changes back into tiny drops of liquid water.

STEP 3
Slowly the tiny droplets of liquid water start to crowd together. This is when they form a cloud.

STEP 4
The clouds are blown over the ocean by wind. When they reach land they are forced higher into the sky. The higher the clouds go the colder it gets.

STEP 5
As the cloud gets colder the tiny droplets of water join together. They become so heavy that they cannot stay up there. They fall down to the ground as rain.

STEP 6
When the water reaches the ground, it soaks into the soil. Plants get some of the water. Some of the water ends up in puddles. A lot of the water ends up in streams, which flow into rivers. The rivers then flow into the oceans.

STEP 7
The sun warms up the water in the oceans again. It changes into water vapour and floats up to make a cloud.

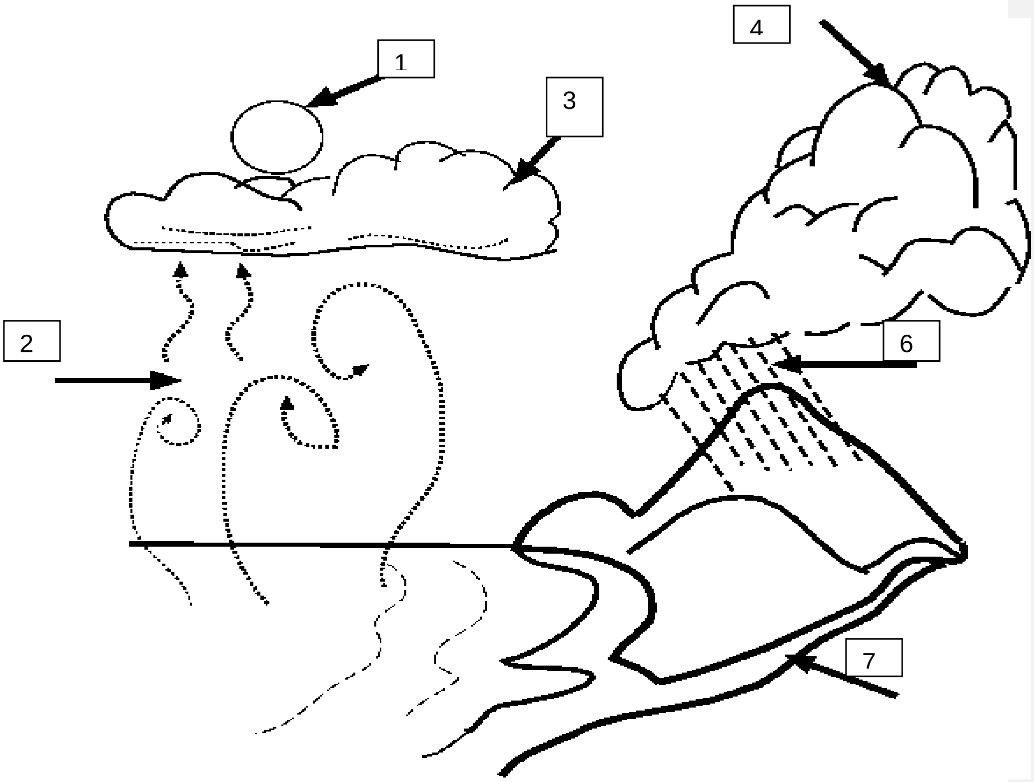
And so the cycle repeats itself.

9. **EXTRA ACTIVITY SHEET**

Fill in the words to tell the story of the water cycle.

1. Heat from the ………… dries up …………… from the oceans.
2. The invisible …………… vapour rises into the air.
3. The cool air changes the water vapour into tiny droplets of floating …………
4. The tiny droplets join together to form a ………………….
5. The wind blows the …………… towards the land.
6. The rain soaks into the ground and …………….
7. The rivers flow into the ………………….
8. The water ………… has started all over again.
9. It never …….

Use the information to complete the diagram of the water cycle.



Question: What do they think will happen to the amount of evaporation if the seas are warmed up by global warming?
What effect could this have our weather?

10. DO PLANTS GIVE US WATER?

What I need: Plastic drink bottle, pot plant.

What to do:
Water the plant in its pot and tie a plastic bag over the pot and around the base of the plant to stop water evaporating from the pot soil.
Carefully cut the bottom off a large drink bottle. Keep the lid on the top of the drink bottle.
Put the plant on a flat plate. Put the drink bottle over the plant and seal around where the bottom of the bottle and plate meet. (Use something like Blu-Tack).

Predict: Have the children write about what they think will happen.

Observe: Leave the plant for three days and look at the inside of the drink bottle.

Explain: Where has the water come from?

What we want the children to learn:
Children can draw the plant experiment and write their explanations. They can use the words evaporation and condensation.

CHECKPOINT: WHAT DO THE CHILDREN THINK NOW?

Do the children now recognise the meaning of the words:

Melting, Freezing, Evaporation, Condensation.

Can they recognise that water exists in three states: solid, called ice, liquid water and water vapour (a gas)?

Can they draw pictures and use the correct words to show the changes between each state?

Can they draw pictures to show examples of the process of evaporation or condensation happening in everyday life?

For example: Clothes drying in the sun, hair drying, water on the outside of cold cans of drink…

Lets talk Heat Energy.

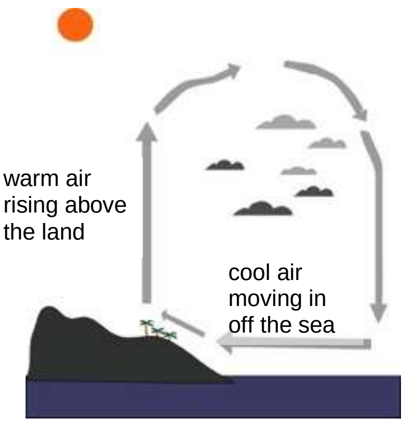
Water and land do not treat heat energy the same way. Down on the beach, we know that the sand and coral on the beach heat up a lot faster than the water during the day, it feels warmer! That means it is at a higher temperature than the water even though both of them are being exposed to the same amount of the sun's radiation.

Why does this happen? The temperature of the land falls and rises much more quickly because the sun's energy is trapped within the first few centimetres of material. Down on the beach, the top five centimetres are the hottest. Once we dig down further the sand cools down considerably.

In the oceans the sun's energy can be carried lower as the water is mixed up by the action of the winds like the trade winds stirring up the water's surface. This creates waves. The mixing carries the heat energy deeper and it is distributed more evenly through ocean waters.

When evaporation from the sea takes place, heat energy is removed from the sea. This is similar to the process as when our sweat evaporates from our skin. We cool down as the heat is removed form our bodies.

When the water vapour formed, by the evaporation of the ocean, condenses back into water droplets, the heat energy used to create the water vapour is released back into the atmosphere.



This process is obeying one of the fundamental laws of nature, Conservation of Energy. That is : that energy can neither be created nor destroyed. In other words, what goes in must come out. The winds are not only carrying water but also heat energy from evaporation from the sea. This way water and heat are distributed around the planet.

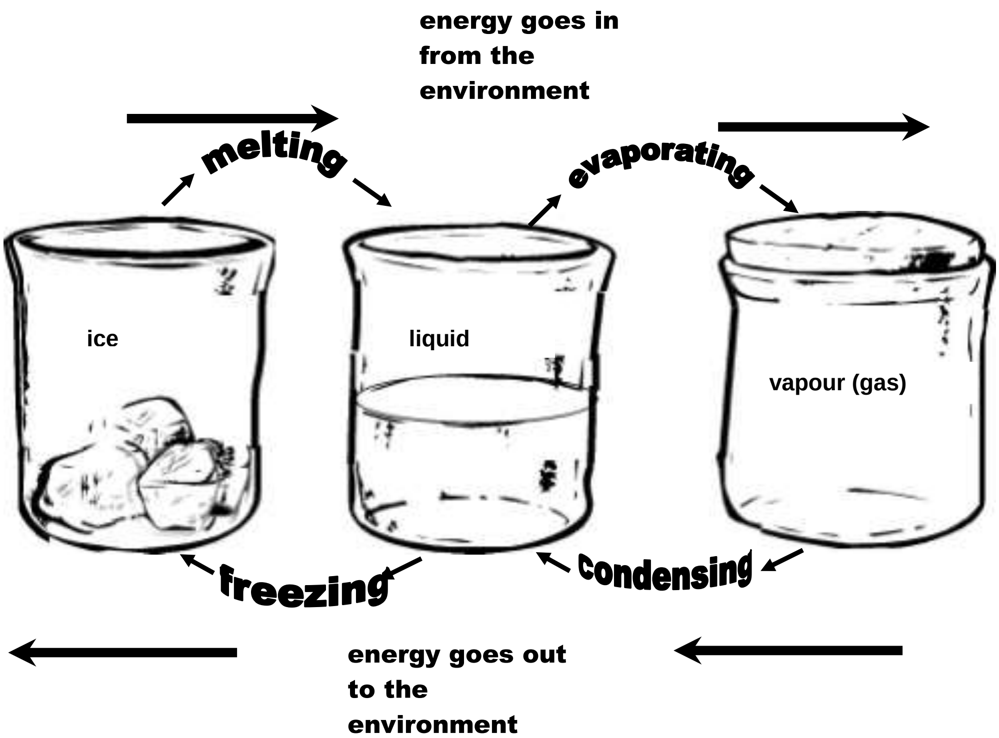
Perhaps one of the most obvious effects of the way the land and sea behave in absorbing the heat's energy, besides those afternoon showers, are the formation of daytime sea breezes.

During the day the top few centimetres of land absorbs heat energy. This is transferred into the air sitting above it. The warm air rises up into the atmosphere. That air has to be replaced. The cooler air that exists above the sea moves in to replace this air. The result is the cool sea breeze that blows in from the ocean.

By night the situation is reversed. Since the land cools quickly the air over the land starts to sink and is pushed out to sea.

Water, the energy storehouse.

If we go back to the behaviour of water we can link this to heat energy. What we are looking at are the physical states that water naturally exists as and relating to this the amount of heat energy required to change each state.



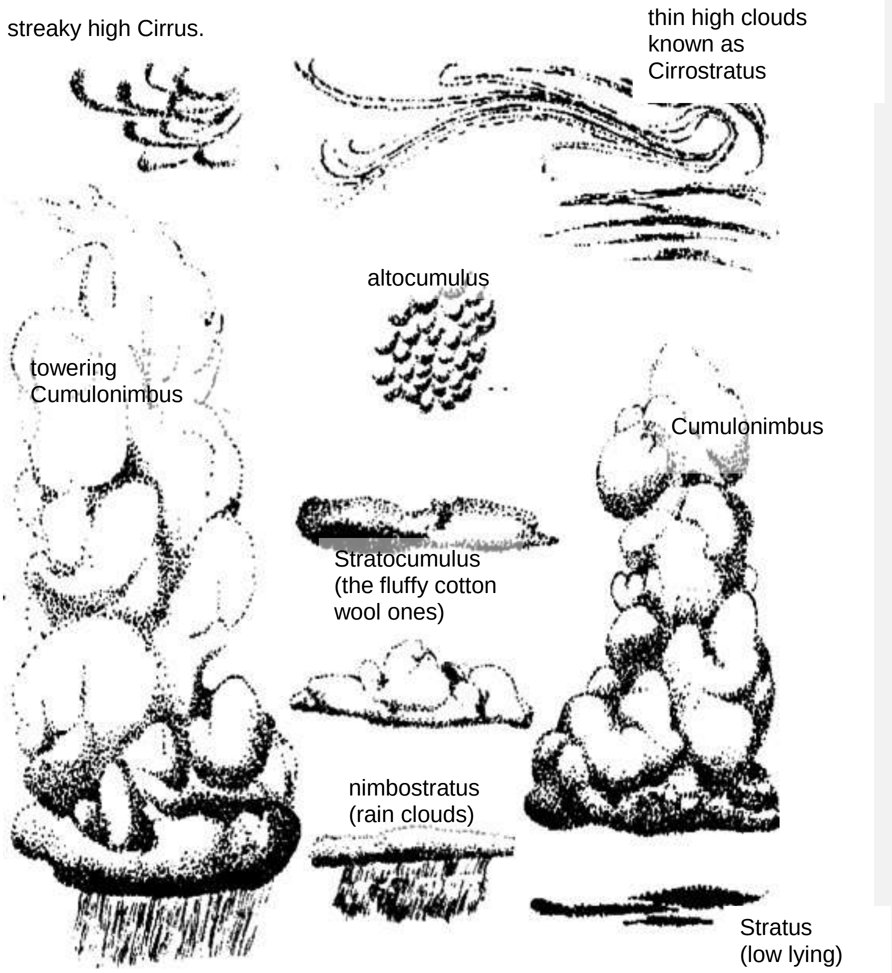
Energy has to go into changing the state (form) that the water is in and then that same energy is released when the water changes back
Water can act as an energy storehouse. When you consider the amount of ocean on the planet, there is a lot of heat energy that can be stored and then released into the atmosphere.

This is one of the reasons why monitoring is being carried out to measure the ocean's temperatures. Keeping a track of ocean temperatures indicates the changes in energy taking place and the effect this will have on the atmosphere above.

Think of the ocean as a big heat energy sink. This energy passes into the atmosphere as evaporation from the surface of the ocean. Both the sun's radiation and the sea control our weather and in the long-term climate.

Clouds.

With the breezes come clouds. These clouds are made up of water droplets, which could lead to rain. Some of these clouds form very high up in the atmosphere, others much lower. Some form quickly while others build up slowly. It all depends on the conditions at the time. Clouds can tell us what weather to expect. Cloud observations are another important and very practical tool in understanding the weather conditions and changes taking place.



What information do we gather about the weather and why?

The most obvious data we can collect would be:
Air temperature
Wind speed and direction
Rain
Cloud cover
Cloud type

Scientists will also gather data on air pressure as changes in air pressure indicate changes in weather.

Students can make a variety of instruments to measure aspects of weather, and use this information for maths and language activities, make their own predictions and talk to local farmers and fishermen about other indications of weather patterns that they use. The presence of the Frigate bird over land is an indication of stormy weather to come in many pacific countries. What other indicators are there for *i-Kiribati*?

ACTIVITY: WEATHER WATCH Junior

STARTER: WHAT MAKES WEATHER?

An activity that children can do in groups and then come together as a class. Make up a wall chart of their opinions.

Give five reasons why weather is so important.
Name and explain four things that make up weather.

Some information for the children:
The weather can change from day to day. We go through wet seasons and dry seasons.
The weather changes because the air is moving, we call this wind.
To get an idea of the weather patterns we build up observations of day to day weather. We can use this information about weather and make measurements.

Question: What sort of things do you think we need to record? Write down your ideas.

Teacher notes:
Hopefully the children will come up with some of the following ideas;
Sun
Cloud
Showers

Rain
Wind
Thunderstorms
Hot or Cold
Amount of rain

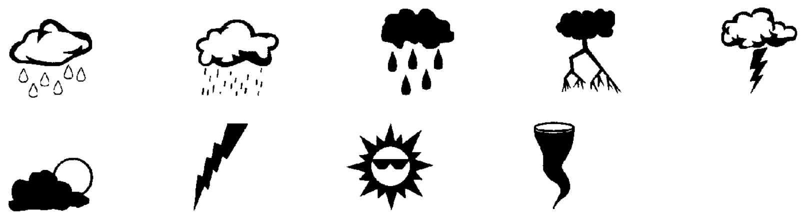
Do they need to consider what time of day they make their observations?
Does it have to be the same each day?

Allow the children to design their own wall chart to record their observations. Have the children design their own pictures for each of the things they want to measure.

What we want the children to learn;
That building up a picture of the weather requires regular observations.
This information can help tell us if the weather is changing on a year to year basis.
Scientists use this information along with information from satellites and Argo to help explain why the changes are happening.

Some suggestions for the weather monitoring:

Some symbols that are used:



WEATHER WATCH - Senior

The purpose of this activity is to make up a daily of record of information regarding the weather, and from this possibility work out weather patterns.

This activity will also fit in with various mathematics activities, such as graphing and averages.

The activity requires the students to put together their own measuring instruments for recording weather details. These include rain gauges and wind vanes. A thermometer is the only specialised piece of equipment needed. (It may be possible to obtain a maximum and minimum thermometer.)

To start with: **Introduction to Weather Watch**

Some Questions to think about:

Why is important to study weather?
What are some of things that you would like to know about the weather every day?
What kinds of information is it important to collect?
Is there a better way to study (or monitor) weather than just describing it in words and pictures?
What kinds of instruments could you use to collect information about weather each day?

(Their answers don't have to be specific; They may have responses such as: "something to tell where the wind is coming from".)

What things should these instruments measure?

Some focus questions: (these can be asked after the above introductory questions)

How can we tell which direction the wind is blowing from?
How can we tell how fast the wind is blowing?
What kind of container would be good for collecting rain?
How could rain be measured?

Step One: Choose the site and the time.

The best place for a weather station is out in the open. A garden is a suitable place. Buildings and tall tress can cause problems, so keep away from these. It would help if there was a suitable shady place out of direct sunlight for the thermometer.

The best time to record this information is around midday. It does not have to be exact as an hour either side is fine.

Step Two; Measuring Temperature.

What you will need: Thermometers, a Maximum and Minimum Thermometer.

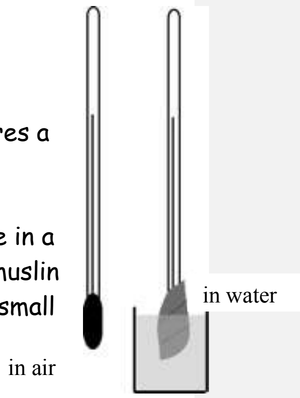
The thermometer is best placed about 1.2 to 1.5m off the ground. It should be partly in the shade. Hang the thermometer off a fence.

You may be able to use a maximum and minimum thermometer, which is even better. The maximum and minimum temperature for the previous 24 hours as well as the current temperature can be recorded.

Step Three: Measuring Humidity.

Humidity is a measure of the amount of water in the air. It requires a wet and dry bulb thermometer.

A simple version of this is to place two thermometers side by side in a shady place. One of the thermometers has some cotton wool or muslin wrapped around it. The end of the cotton wool is dipped in a tub (small yoghurt pot) of water.



The diagram shows how this is set up.

To find the humidity, read the temperature of the dry thermometer. Work out the temperature difference between the dry and wet thermometers.
The humidity (as a percentage) can be found by reading the temperature difference against the dry temperature on the table on the next page.

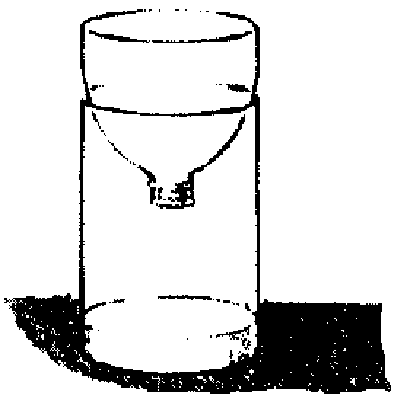
Difference between the wet and dry thermometers

Temperature of the dry thermometer	1°C	2°C	3°C	4°C	5°C	6°C	7°C	8°C	9°C	10°C
10 – 14°C	85	75	60	50	40	30	15	5	0	0
15 –19°C	90	80	65	60	50	40	30	20	10	5
20 –24°C	90	80	70	65	55	45	40	30	25	20
25 –29°C	90	85	75	70	65	55	45	40	30	25
30 –34°C	95	85	80	75	70	60	55	50	45	40
35 -40°C	95	90	80	75	70	65	60	55	50	45

Step Four: Measuring Rainfall

What you need: A large plastic drink bottle. Craft knife. Ruler or measuring cylinder.

What you do:



Cut the top off the bottle just below the shoulder. Turn the top upside down to make a funnel. Push this back inside the cut off rim of the bottle.

Find a clear area of ground. Dig a small hole in the ground to fix the rain gauge in position. This will stop it getting moved around. (Sand helps keeps it in place and it is easy to take the bottle out and put it back in place again.)

Use a ruler to mark a scale on the side of the bottle. The scale can be in cm or in mls of water.

At the same time each day: Measure the amount of water in the container by either tipping it out into a measuring cylinder or measuring the height of the water in the bottle.

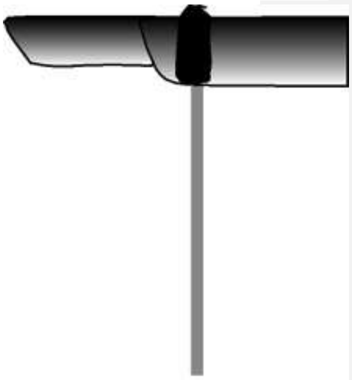
Remember tip out the water each day.

Step Five: Measuring Wind

Measuring wind direction.

What you need: Craft knife, Shoe box, Card, Protractor, A piece of 5 mm dowel (1m long), Strong tape, marker pen, Book covering plastic (if available). Pen cap or the end of a broken biro. (It needs to be big enough to fit over the dowelling.)

Completed wind vane

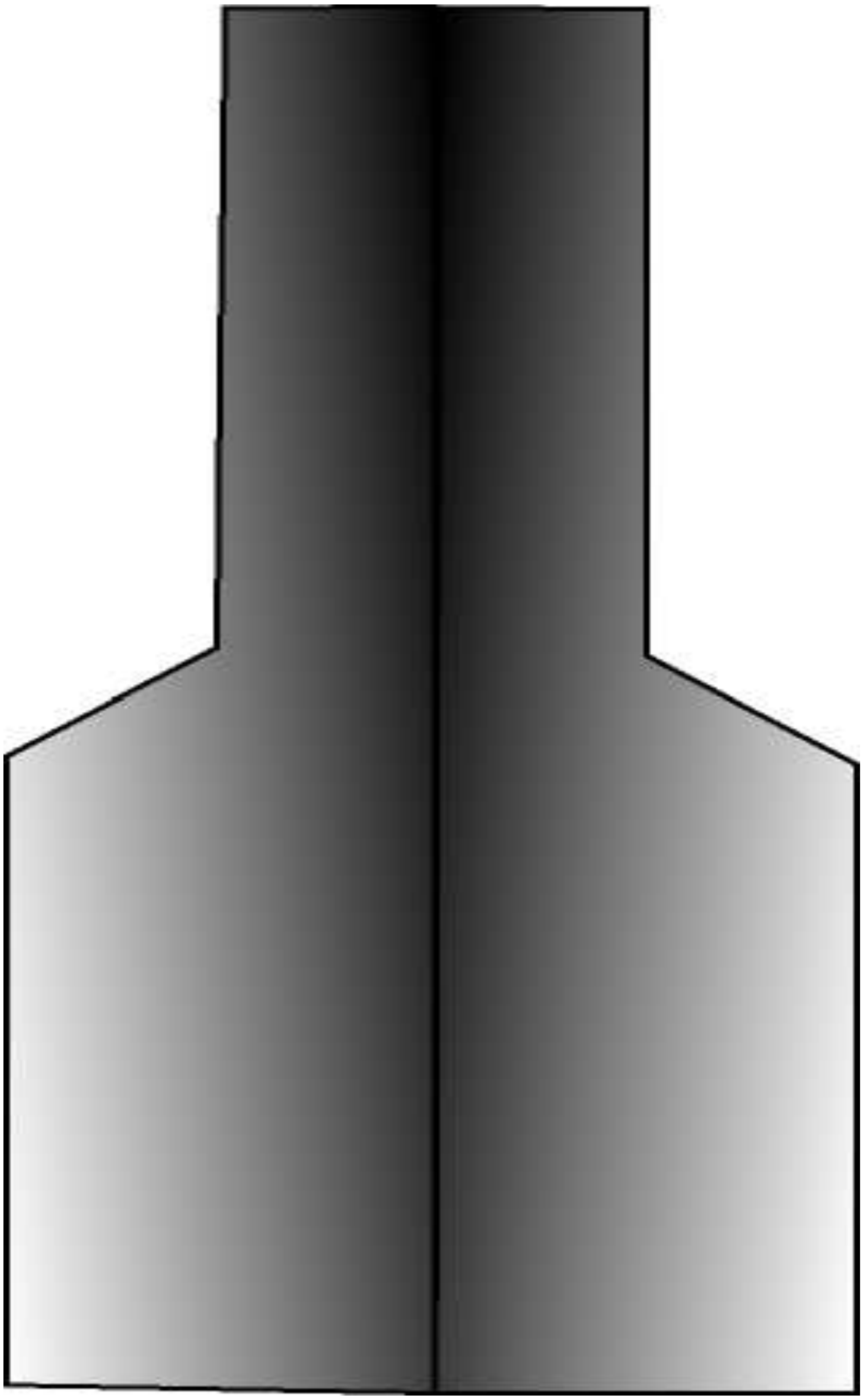


What to do:
Use the plan on the next page to draw out the wind vane.
Cut it out.
Score a line down the centre and fold in half.
Stick the folded halves together.
Cover one side of the wind vane with the protective plastic then fold the plastic over the other side.

Stick the pen cap to the vane.

Find a post or fence that is out in the open.
Fix the piece of dowel to the post or fence. (Use clips if possible) Make sure it is vertical and the weather vane spins freely when put on top.

Let the vane spin in the wind. It will spin in the wind and point to the direction the wind is coming from.
You will need to mark out the directions north, south, east and west. Use a compass or better still a map. (This will give you true north.)
Use landmarks to give you a reference point for the directions.

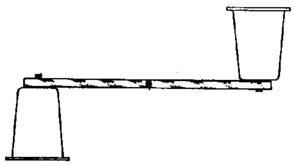


12 cm

Measuring Wind Speed;

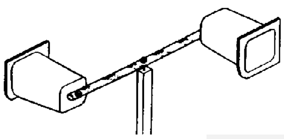
There are two ways to measure the wind speed. Firstly there is an anemometer.

Making an anemometer.
What you will need:
Two yoghurt pots, drinking straw, pins, a post, tape.



What to do:
Fix the pots to the straw using the pins.
Place the wind speed machine on a suitable post so that it spins.

Observe: Record the number of turns in 10 seconds.
Do this four times and work out the average wind speed.
Other things to try:
Try comparing the wind speed at different heights.
Try making an anemometer with four cups instead of two.



Make up a record of the average number of turns for different wind speeds.

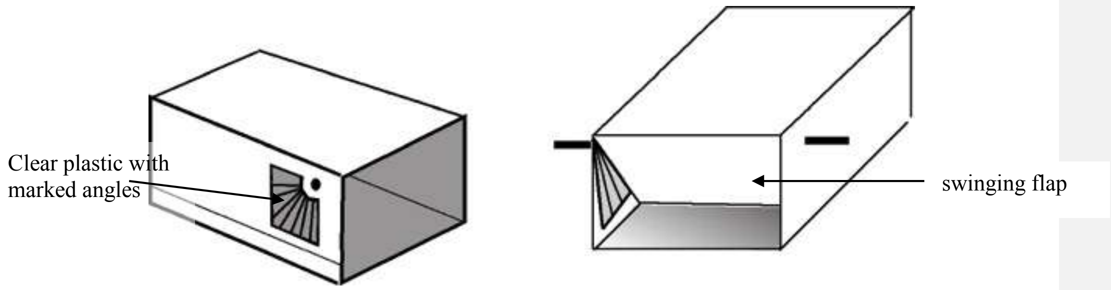
Wind Speed box.

What you will need: Craft knife, Shoe box, Card, Protractor, A piece of 5 mm dowel (wider than the box.) or metal rod, Clear plastic sheet, Strong tape, Marker pen.

What to do:
On the clear plastic sheet and using the protractor and marker pen, mark off 5 degree intervals between the angles of 0 and 90 degrees.
Cut the ends off the show box and lid you have a wind tunnel.
Cut a hole near one end like the one shown in the diagram.
Stick the clear plastic film with the scale on the inside. It should be clearly seen through the hole in the side of the box.
Using the cardboard from one of the end you cut out earlier, cut it so it slightly smaller than the end of the box. Fix it to the rod. Check that the flap you have made swings freely.

Make a hole in the side of the box above the scale and directly on the opposite side.

Push the rod through the holes. Move it around to make sure it can rotate freely.



Observe: Hold the box so it faces into the wind. Measure the angle of the flap. Use the table to work out the wind speed

Angle (degrees)	Speed (km/hr)	Angle (degrees)	Speed (km/hr)
90	0	50	28-30
85	8-11	45	31-33
80	12-14	40	34-36
75	15-17	35	37-39
70	18-20	30	40-43
65	21-23	25	44-48
60	24-25	20	49-54
55	26-27		

Wind Speed and the Beaufort Scale

Observations of the sea and trees can be used to give an idea of the wind speed. The scale that is used for these is called the Beaufort Scale and is used to represent wind strength.

The table below represents some observations related to wind speed:

Beaufort Wind Force Number	Name	Average Wind Speed (km/hr)	Land observation.	Sea observation.
0	Calm	0	Leaves don't move	Sea like a mirror
1	Light Air	1-5	Smoke drifts slowly Leaves don't move	Sea is slightly rippled
2	Slight Breeze	6-11	Smoke shows direction. Leaves rustle	Small wavelets which don't break
3	Gentle Breeze	12 -19	Twigs and large palm leaves move. Small flags extended.	Large wavelets. The crests just begin to break
4	Moderate Breeze	20 -29	Small branches move Flags flap	Waves with whitecaps
5	Fresh Breeze	30-38	Small trees sway. Flags flap and ripple	Moderate waves with many whitecaps
6	Strong Breeze	39-50	Large branches sway Flags beat and pop	Larger waves with regular whitecaps
7	Moderate Gale	51-61	Whole trees sway.	Large waves Sea heaps up. White foam streaks
8	Fresh Gale	62-75	Twigs break off trees	Moderately high sea with foam blowing off the tops
9	Strong Gale	75-86	Branches break of trees	High crested waves
10	Whole Gale	87-101	Trees blown down. Building damage	High waves. Churning white seas.
11	Storm	102-120	Widespread damage to trees and buildings	Mountainous seas, covered in white foam
12	Cyclone	120+	A lot of damage	Air is filled with spray. Sea is completely white.

A mix and match activity: The boxes are all jumbled up. The wind speeds do not match the descriptions. Cut the sheet up to match the wind speeds to what you think are the correct descriptions. (The boxes in bold are correct!)

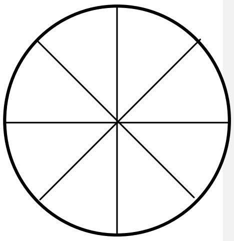
Beaufort Wind Force Number	**Name**	**Average Wind Speed (km/hr)**	**Land observation**	**Sea observation**
0	**Calm**	**0**	Branches break of trees	Moderately high sea with foam blowing off the tops
5	**Light Air**	**1-5**	**Smoke drifts slowly. Leaves don't move**	Mountainous seas, covered in white foam
1	**Slight Breeze**	**6-11**	Small branches move. Flags flap	Small wavelets which don't break
8	**Gentle Breeze**	**12 -19**	A lot of damage	**Large wavelets. The crests just begin to break**
11	**Moderate Breeze**	**20 -29**	Leaves don't move	Sea like a mirror
2	**Fresh Breeze**	**30-38**	Small trees sway. Flags flap and ripple	Large waves Sea heaps up. White foam streaks
10	**Strong Breeze**	**39-50**	Trees blown down. Building damage	Air is filled with spray. Sea is completely white
9	**Moderate Gale**	**51-61**	**Whole trees sway**	High crested waves
3	**Fresh Gale**	**62-75**	Twigs break off trees	Larger waves with regular whitecaps
12	**Strong Gale**	**75-86**	Twigs and large palm leaves move. Small flags extended	Moderate waves with many whitecaps
6	**Whole Gale**	**87-101**	Widespread damage to trees and buildings	**High waves. Churning white seas.**
4	**Storm**	**102-120**	Smoke shows direction. Leaves rustle	Sea is slightly rippled
7	**Cyclone**	**120+**	Large branches sway Flags beat and pop	Waves with whitecaps

Note for Teacher: the last two activities can be matched together. The wind speed from the wind box can be linked to the Beaufort Scale above.

Step Six: Measuring Cloud Cover

There are two things to look for with clouds. One is the amount of cloud cover; the other is the type of cloud.

Cloud cover.



What you need: A clear space and open-mindedness.
A piece of clear plastic with a circle on it. The circle is split up in eight segments.

What to do: Lie on the ground or stand and look around you.
Hold the clear piece of plastic in front of you.
Estimate the amount of cloud cover, out of a factor of 8.
Use the chart below.
Check your value out with 3 others. Do you all agree?
Decide amongst yourselves what is the best value. (No answer is wrong!)

Cloud Cover Scale

0 out of 8	no cloud
1 out of 8	very little cloud
2 out of 8	about a quarter of the sky is covered
3 out of 8	
4 out of 8	about half of the sky is covered
5 out of 8	
6 out of 8	about three quarters of the sky is covered
7 out of 8	nearly all the sky is covered. Very few blue patches
8 out of 8	total cloud cover

Step Seven: Cloud Types:

What you need: a clear space

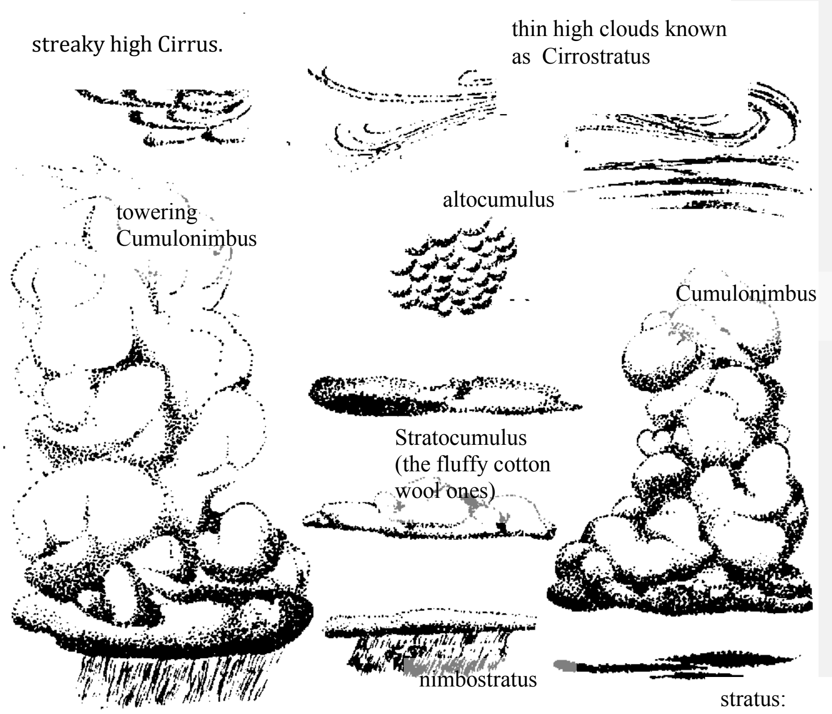
What to do:
Guessing the type of cloud is not easy.
There are four main types:

Cumulus: the fluffy cotton wool clouds.

Cirrus: high streaky clouds.

Stratus: sheet or layer cloud.

Nimbus: Rain clouds.



Take a look at the clouds and compare them to the pictures.
There are nine cloud types shown in the picture.
Decide on the type of cloud you see.

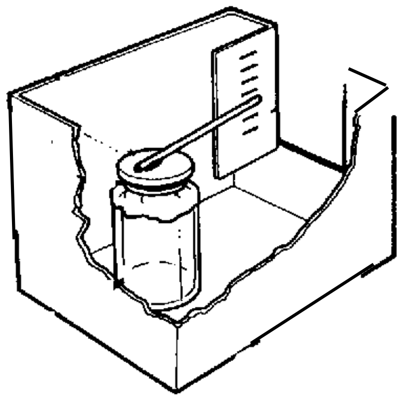
Something to think about:
Do all clouds bring rain?
What kind of clouds do you see on sunny days?
Have you ever seen clouds that look like feathers, animals, cotton wool, etc.?

Step Eight: A "do it yourself" barometer

What you will need: Jam jar. Balloon. Elastic Band. Drinking straw. Cardboard Box. (a shoe box will do). Clingfilm. Blu-tack or sticky tape. Fish tank.

What to do:

Warm the jar in hot water.
Cut off the neck of the balloon and stretch it over the jar.
Fasten it with the elastic band to make sure it is airtight.
Glue or tape one end of the straw to the middle of the balloon.
Place the jar in the cardboard box and mark the box behind the straw with a scale marked in centimetres. (Tape a ruler to the box)



To test the barometer.

Put the barometer in an empty fish tank. Cover the fish tank with the cling film. Press down gently on the cling film. What do you notice happen to the end of the straw? Does it move up or down? Is this high or low pressure?

Using the barometer:
At the same time each day record the weather and the pressure on the barometer.

What pattern do you notice between the measurements you made on the barometer and the weather each day?

What do we want children to learn:
- Air pressure changes over of days.
- Changes in air pressure can relate to changes in weather.

Recording all the information.

The reason for recording all this information is not only to see what is happening now but also to look for patterns and predict future weather patterns from observations.

Recording is important and should be methodical so that anyone can understand what you have done.

Written out is just one idea and it assumes that you have recorded all of the measurements indicated in the activities above. You can even use our forecasts to see how accurate the local weather forecast was.
Don't forget to record the names of the people in your group.

Day and Date	**Time**	**Air Pressure**	**Wind**		**Cloud**		**Temp**	**Humidity**	**Rain gauge**	**General Weather**
		Raising Or Falling	Speed	Direction	Cover	Type				
Mon 21 Feb	11.30	↘	4	SE	3/8	Cu	24	65	0	Clear, windy

Suggested follow-up activities

Work with your partners to compose three questions about the data you have collected, for example: What was the coldest day? The day with the most rain? The windiest day?
Swap questions with another group.
Use the charts to compose word problems to practice. (This helps their numeracy skills.) For example: What was the difference between the temperature of the coldest day and the warmest day?
Make bar or circle graphs showing the number of sunny, cloudy and rainy days.
Make line or bar graphs to show the temperature of each day.
Make a chart showing the temperature of each day. Illustrate each day with a picture.

Something extra to do with this information.

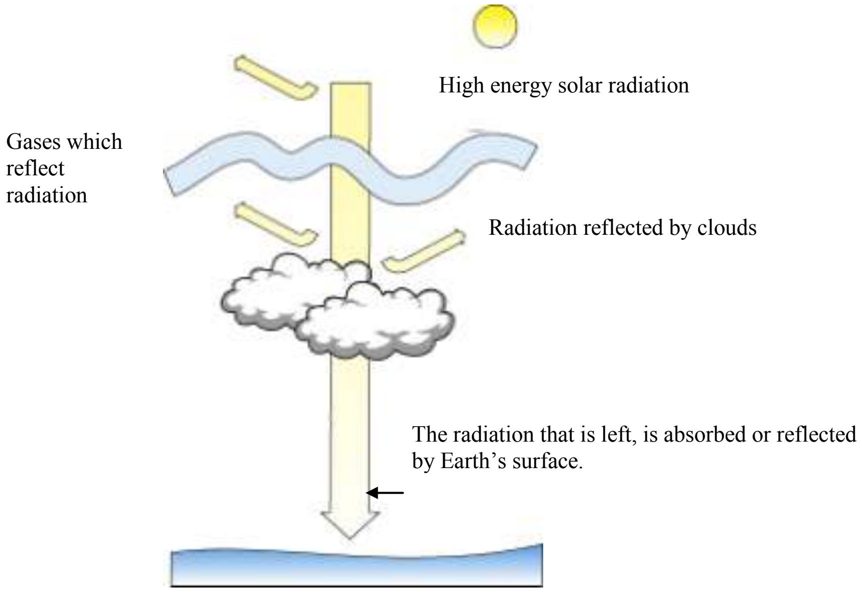
Compare your recorded weather with the predicted forecasts.
Contact a school a few kilometres away and see how their weather records compare with yours.
Contact another school on another island or country and see how the weather records compare.

Something to think about:
When does the weather become important? Write down all the times when weather has become important to you or your family. Try and find stories to back up your ideas.

What we want children to learn:
Collecting weather information takes practice and time.
Collecting weather information requires us to make careful observations.
Looking back over the weather information that has been collected over a long period of time tells us if the climate is changing.

Sun, radiation and atmosphere.

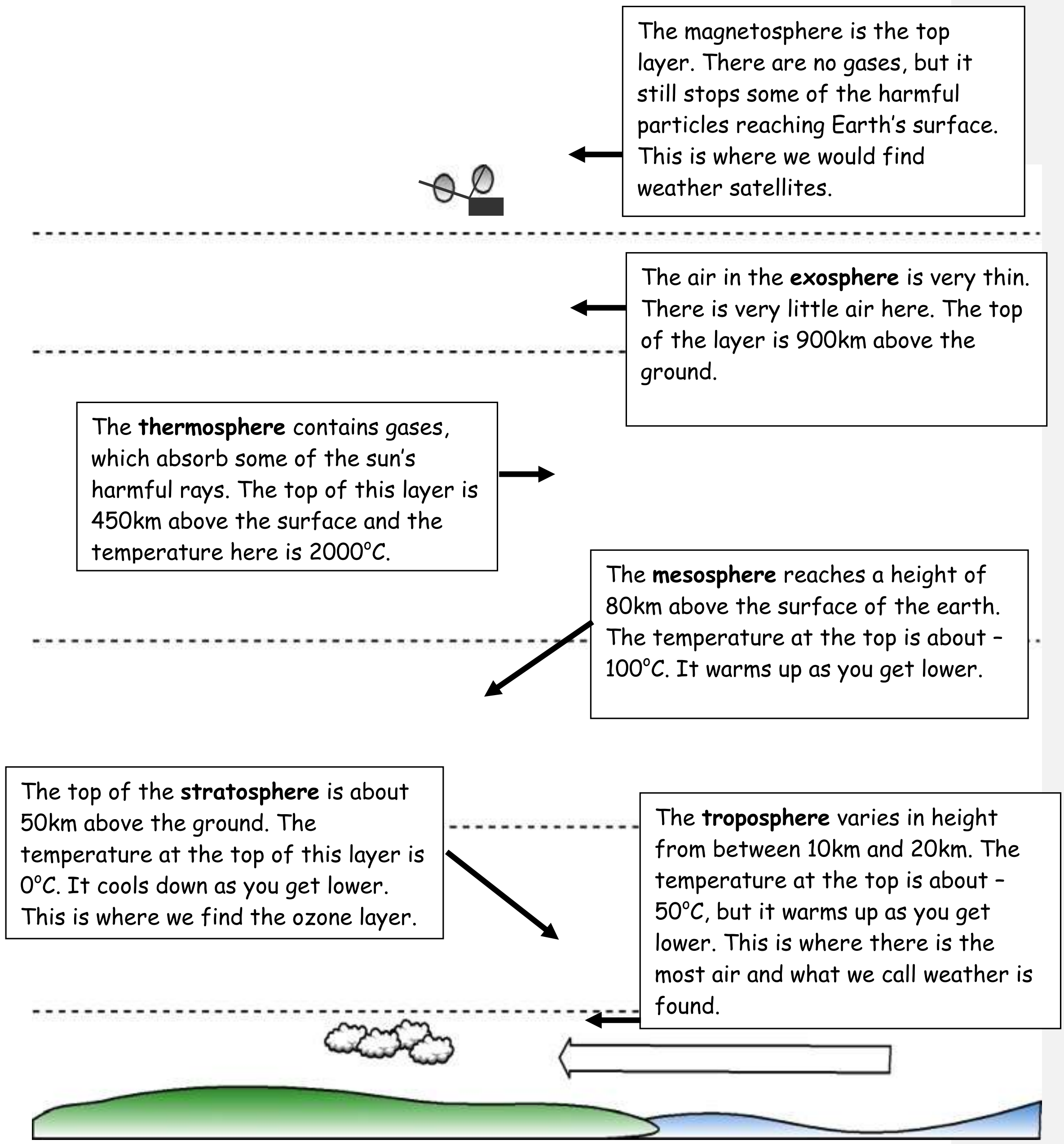
The energy that radiates from the sun is responsible for many things that happen on our planet. Light energy is needed for plant photosynthesis and this is the key to the survival of all living things on the planet. Heat energy warms our planet, enabling life to survive, and creates the weather that we are familiar with. Not all the heat reaches the earth's surface. Some of the radiated heat energy is reflected by, or absorbed by the clouds. This all counts towards influencing the climate.



There is also a lot of harmful radiation that comes from the sun; this radiation would annihilate all life on the planet if it weren't for the atmosphere.

The atmosphere is made of layers that are divided by temperature. Each of these layers influence the radiation that reaches the surface.

Is climate change happening?
Some experts point out that natural cycles in Earth's orbit can alter the planet's exposure to sunlight, which may explain what is happening now. Earth has experienced warming and cooling cycles roughly every thousand years due to orbital shifts., but these changes have occurred over the span of several centuries.

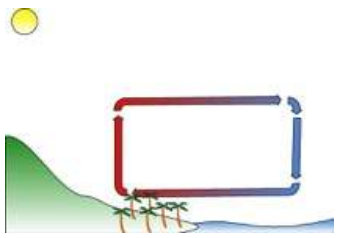


The Troposphere is the region that concerns most of us! That's where the weather happens.

What happens as the Sun heats the Earth's surface.

One of the most obvious effects we observe from the heating effect of the sun is the air temperature. The surface of our earth is heated by absorbing the sun's radiation. When the air above the surface of the earth is cool, the land beneath it warms it. The warm air rises.

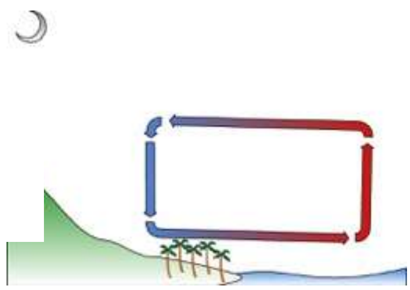
This helps to create localized weather conditions. For instance, sea breezes cool the land near the sea, whereas further inland there is no cooling and it is considerably warmer or the wind is blowing from another direction.



Cool air moves in off the sea to replace warm air rising over the rapidly warming land.

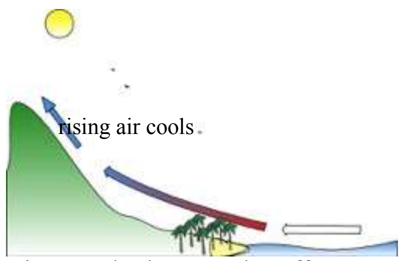
At night the breeze is reversed.

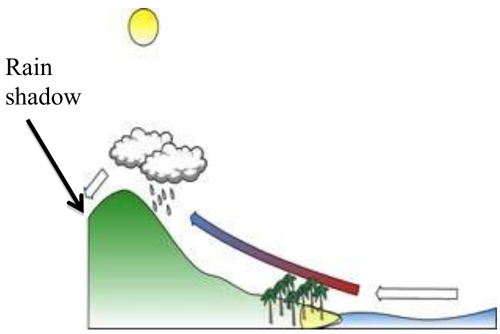
Air sinks, as the land as cools rapidly at night and forces its way out to sea.



However, if you go round the coast and it is cloudy, there is little radiation to heat up the land. There will be a similar temperature between land and sea and there will be no breeze.

If we move inland and climb the mountain, we also notice the air temperature gets lower the higher we climb.



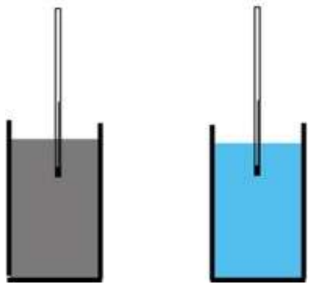


Mountains can also have another effect. Some countries have their winds come mainly from one direction. This is called the prevailing wind and is often associated with different types of weather. Consider what happens when a wind that usually brings rain comes up to a mountain. As the warm air rises the clouds are forced upwards and it rains, but once the wind has passed over the top of the mountain there is little rain left, and the land lies in a 'rain shadow.'

ACTIVITY

HEATING LAND AND SEA

What do I need: A jar three quarter full of sand, a jar three quarter full of water, two thermometers, a sunny spot



What to do:

Set up the jars with water and sand.
Put one thermometer into the sand and the other thermometer into the water.
Place in a sunny spot sheltered from the wind.

Predict: Which jar will heat up the fastest? Which jar will cool down the quickest?

Observe: Which jar heats up the fastest over a period of 60 minutes?

Explain: Ask the children if they can explain why this has happened? Get them to write down their ideas and compare with others.

What we want the children to learn: The land heats up quicker in the sun than the water.

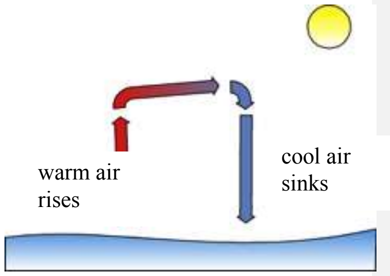
Extension:
Put an umbrella over the jars. Take the temperature every 15 minutes.
Can you think of an explanation for what you have seen happen.

Is climate change happening?
Our climate is changing rapidly, and at a rate faster than what we have experienced in all of human history.

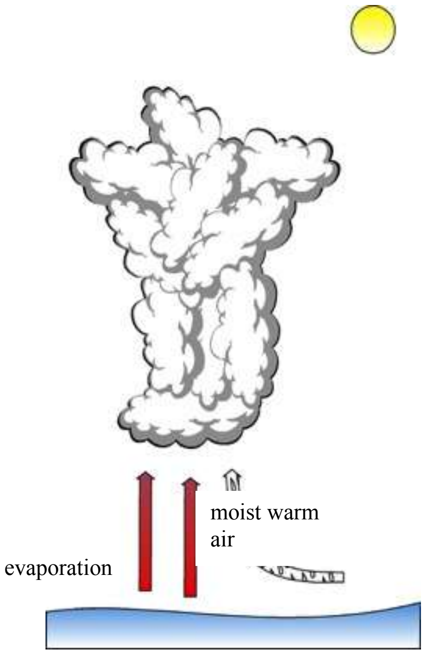
What is driving the Weather?

What appears to drive our weather is air being heated over both land and ocean by the sun. The sun's heat is absorbed by the land and ocean. If air above the land or ocean is cooler, heat energy is transferred to warm this air.

The warm air expands and becomes less dense (heavy), which means it will rise. This rising air has to be replaced, so the surrounding cool air moves in. As the warm air rises, it cools. This causes it to become more dense and stop rising. Eventually it sinks back to the Earth's surface where it becomes warmed up again.



This cycle of moving air can carry water vapour.



Those tropical afternoon showers are formed when the moist warm air above the sea rises into cold air. As the water vapour rises to great heights it condenses to form large clouds. These large tall clouds are pushed higher over the land and heavy tropical showers result. Sometimes water droplets become charged with static electricity and thunderstorms result.

This circulation of warm and cold air is called a Convection Current.

Convection currents can cause changes in weather over small distances e.g. the seashore or valleys. These currents also can range over large areas where huge amounts of air are moved. These large movements of air create the weather patterns.

What information do we gather about the weather and why?
The most obvious data we can collect would be:
Air temperature
Wind speed and direction
Rain
Cloud cover
Ocean Temperatures

Is climate change happening?
Cylcones are increasing in severity.

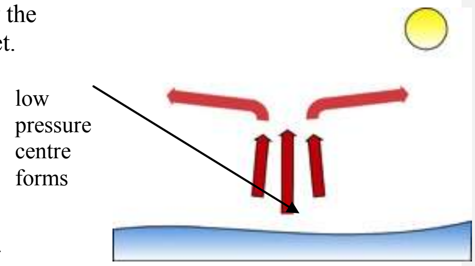
All of these measurements are useful and can be combined, along with other measurements such as air pressure and humidity, to predict weather patterns over a period of time. The historical weather data is combined to give the information that we refer to as climate. It is basically a summary of the patterns of weather data over the long term. Scientists define 30 year patterns as climate.

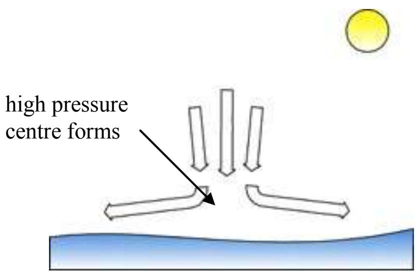
Air Pressure is important in our understanding of weather and climate. Air is all around us and because it is matter, it consists of particles that are bouncing off other objects and us all the time. We don't notice this because we are used to it. However these particles bouncing off us, creates a force. If we take the size of this force over a certain area, this is called pressure. At sea level air pressure is about 1 kilogram per square centimetre. Meterologists measure air pressure in hectopascals using a barometer. 1016 Hectopascals is normal atmospheric pressure.

Now if air is to move, which we call wind, it has to have energy to flow. Just as the water in a stream or river moves from somewhere high to somewhere low, air has to do the same. Only the difference is, that air moves from areas of high pressure to areas of low pressure.

The areas of high and low pressure are created by the effect of the sun's heating the surface of the planet.

When air is warmed, it rises creating an area of low pressure on Earth's surface. Surrounding air moves in to replace this rising air. This air has come from areas where the pressure is higher.





When the air rises sufficiently, it cools and falls back to the earth's surface. This air movement replaces the surface air that has moved away and creates an area of high pressure above the surface.

This also gives us air movement (wind) from areas of high pressure to low pressure.

Where the air rises it creates large areas of low pressure. One of these areas is a low pressure band that exists around the equator.

For more information on the ITCZ and weather and climate patterns in the Pacific, refer to the *Climate Change education the Pacific Way – Kiribati* resource, SPC/GIZ

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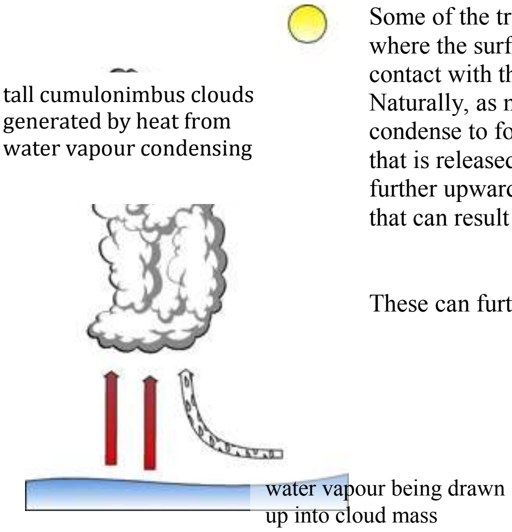
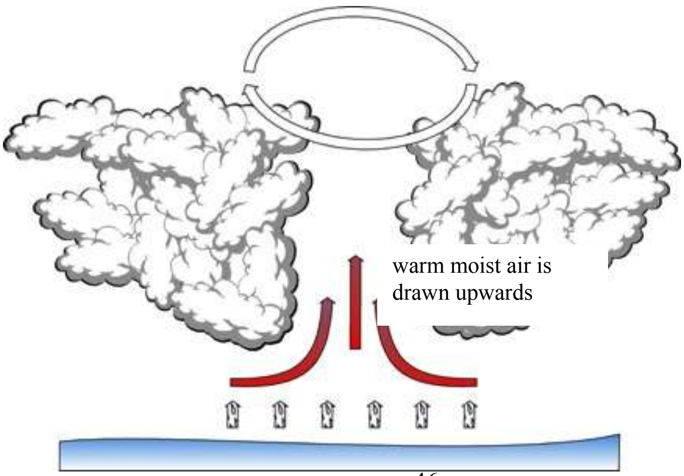


Some of the trade winds may encounter areas of the ocean where the surface temperature is quite high. The air in contact with the ocean is warmed and starts to rise. Naturally, as moist air rises the water vapour starts to condense to form droplets of liquid water. The heat energy that is released when water vapour condenses, pushes the air further upward. The result is very tall cumulonimbus clouds that can result in very heavy rainfall.

These can further develop into cyclones .

Cyclones.

There are times when the air rising over the warm regions of ocean can form areas of extreme low pressure. This happens when the sea temperatures are above 29^{0}C.The convection currents start spiralling around this low pressure centre, causing rotation. The winds spiral clockwise in towards the centre of the low pressure area picking up more moisture from the sea. At the centre, the air rises upwards, with the water vapour condensing to give high cloud formations and heavy rainfall. As long as the low pressure centre remains over the warm ocean, there will always be energy to continue feeding the system.
The amount of water in the system builds up and wind and rain intensify. The system becomes a tropical cyclone.

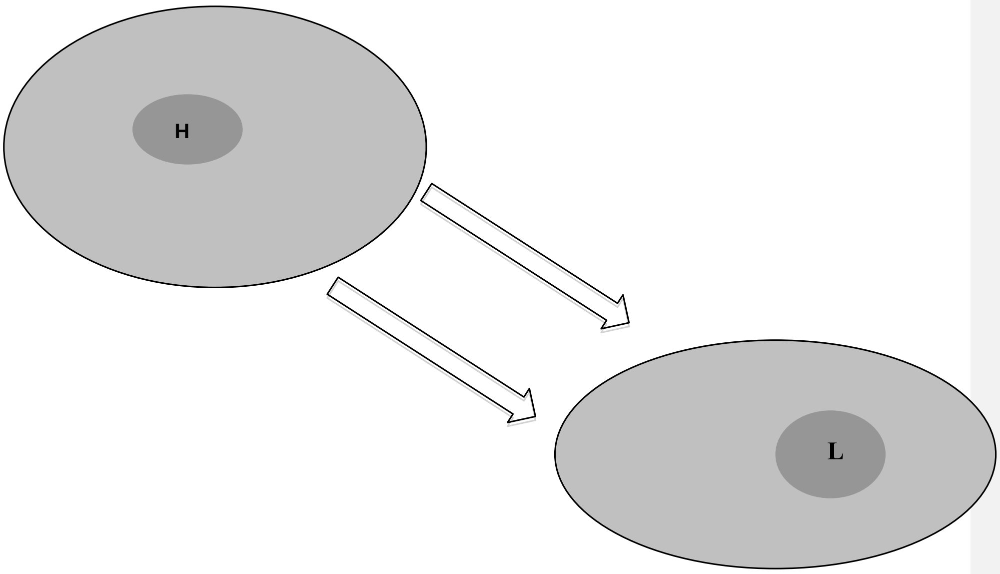


When the tropical cyclone has moved over land or cooler water, there is no energy to feed the system and the cyclone will die away. In the meantime the amount of energy and rain can do a great deal of damage.

Is climate change happening?
Disease carrying insects are moving into new areas as temperature increases. Global warming will expose millions of people to new health risks

surface, air moves from the high pressure areas to the low pressure areas. But very high up in the troposphere there are high level winds that move these pressure centres. These winds are called jetstreams.

As the pressure centres move they will influence one another. If a high pressure centre moves towards a low pressure centre, air will flow from the high pressure centre towards the low pressure centre. If there is a large pressure difference between the two, the air will move faster and give strong surface winds. Conversely when there is little pressure difference we experience only the light breezes as the air moves out slowly from the high pressure centre.



ACTIVITY. THE HEATING EFFECT OF THE SUN ON EARTH'S SURFACE

These activities will hopefully show you what air pressure is and how weather scientists measure air pressure.

1. DOES AIR WEIGH ANYTHING?

What you will need: 2 balloons. A stick or length of bamboo about 45cm long. String. Piece of Sellotape. Measuring cylinder. Tubing

What to do:
Blow up the balloons so they are about the same size.
Suspend the stick from the piece of string.
Put a piece of Sellotape on each balloon.
Tie the balloons onto the stick. Move the balloons so they balance each other.
Prick one of the balloons carefully through the Sellotape.

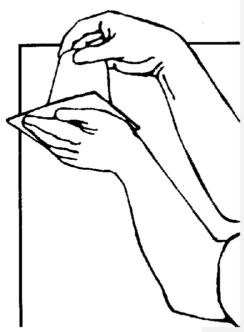
Observe: What has changed?

Explain: Why has this happened?
What does this tell you about the particles in air?

Extension: Can you use the other gear to work out the volume of air in the balloon?

For the Teacher: as the air moves out of the balloon, it gets lighter so the other balloon goes down, Air particles have mass (weight).

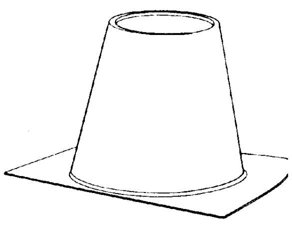
2. A SIMPLE DEMONSTRATION OF THE EFFECT OF AIR PRESSURE.



What you will need: a glass or paper cup. A stiff piece of cardboard big enough to completely cover the glass. A jug of Water.

What to do:
Fill up both glasses to the brim with water.
Slide the piece of card over one of the glasses of water.
Make sure there is no air between the water and the card.

Gently turn the glass with no card upside down.



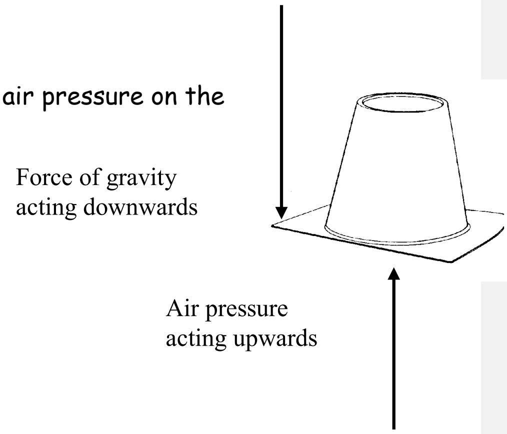
Gently turn the glass with the card upside down, whilst holding the card in place.
When the glass is upside down, take your hand off the card.

Observe: What happens when the glass are turned upside down?

Explain: Can you explain what has happened? What is holding the card in place?

For the teacher:

The explanation can be put simply as the air pressure on the underside of the cardboard balances the force of gravity acting on the water above the card.



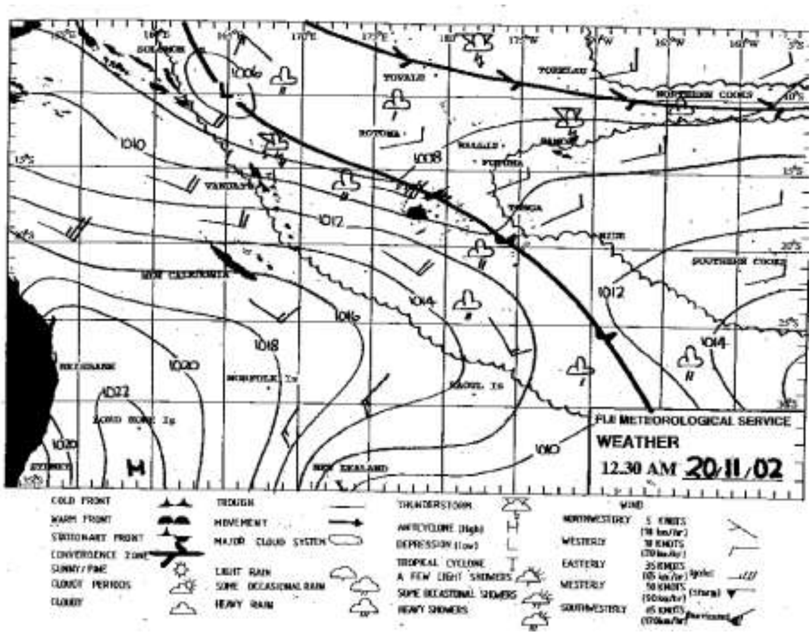
What we want children to learn:

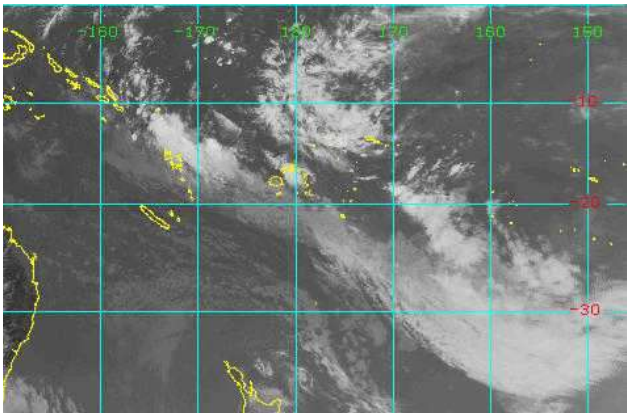
- Air has weight.
- The air exerts a force on us even though we don't realise it.
- The force is spread over the surface of the earth.
- The size of the force is measured as air pressure.

Is climate change happening?
Strong hurricanes, droughts, heat waves, wildfires and other natural disasters may become common place in many parts of the world.

Weather Map

A weather map shows a series of lines called isobars. Each isobar represents a particular value of air pressure at sea level.





Satellite picture that corresponds to the weather map above

The air spirals around the high and low pressure areas. In the South Pacific the air spirals anticlockwise around the high pressure areas and clockwise around the low pressure regions. The surface winds do not blow directly from the high to low pressure centres, but spiral outwards and flow more or less in a direction parallel to the isobars.

Is climate change happening?

Glaciers around the world are starting to melt, causing sea levels to rise while creating water shortages in regions dependent on runoff for fresh water.

When the lines are widely spaced the winds are gentle, but when the lines are squeezed close together we are looking at big differences in air pressure over small distances and this means strong winds.

Given this information the weather map can be used to predict wind direction and strength. Often this wind direction and strength will give us an indication what weather that may be coming, that's one reason why recording weather conditions can be useful.

If this is weather, what is climate?

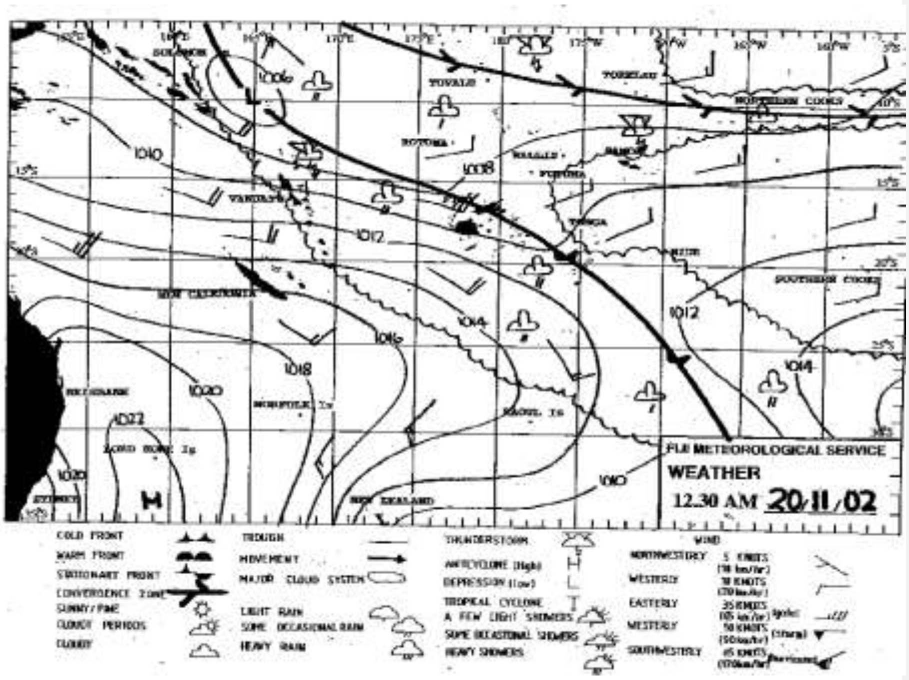
Compiling all of this information helps establish long term weather patterns. These patterns we call climate.

Looking back on these patterns helps to establish whether changes are occurring and what type of change it may be. The scientific data collected by Argo and other sensors as well as human observations helps to make models about possible changes and make predictions on future weather patterns.

ACTIVITY. WHAT'S ON THE WEATHER MAP?

NOTE: for the Teacher: This exercise could be used as a starter activity before beginning the topic and then at the end as a summative exercise.

What you will need: Weather maps sourced from newspapers or meteorological office.



What to do:
Look at the weather map. Identify the following if they are on the weather map:

Isobars, Low Pressure centre, High Pressure Centre, Warm Front, Cold Front.

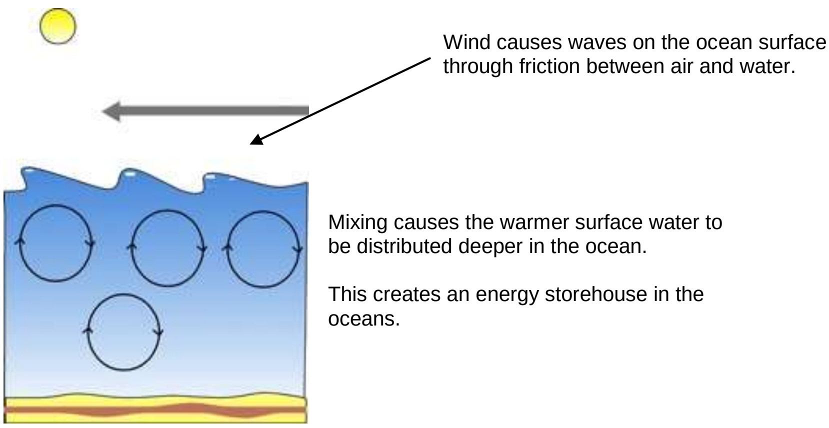
Questions:
Where do you think the air is rising on the map?
Where do you think the air is sinking on the map?
Where do you think the winds will be strongest?
Draw an arrow to show the direction of the wind.
Where do you think the winds will be lightest?
Draw an arrow to show the direction of the wind.

Extension Activity: Find some weather maps.
Your job is to predict the weather for the TV or radio.
Use the maps to write your forecast from the maps and read it to the class.

What we want children to learn:
- Weather maps provide details for predicting weather in various localities.
- Weather maps show us the movement of weather patterns.
- The lines on a weather map represent air pressure and are called isobars. (Lines showing equal pressure.)

Where does Argo fit into this?

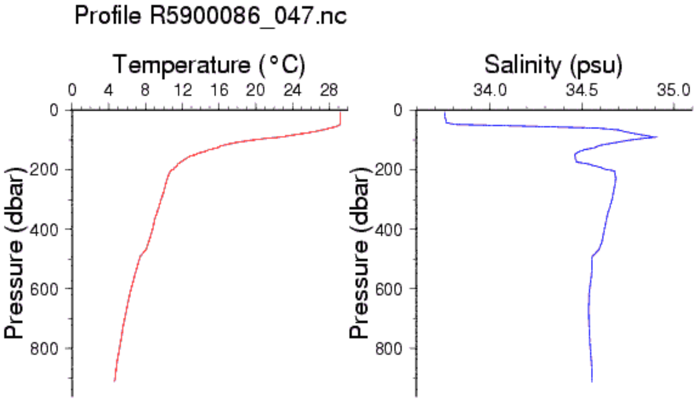
Argo floats take on an important role in helping to assess the amount of heat energy being transferred from the ocean to the air. Sea temperatures change more slowly than the air temperature and heat energy is stored through warming of the lowers layers of water.



An Argo float is dropped into the ocean, where it sinks up to depths of 2 kilometres. It then travels for a period of 10 days in the ocean currents at these depths, before it rises to the surface. On its way up it measures the temperature and salinity of the water. The temperatures and the temperature depth profile indicate how much heating has been occurring due to the sun, while the salinity measurements also indicate the amount of evaporation that has taken place. High salinity on the surface means salty water due to high rates of evaporation. We would expect to find this over the equatorial regions of the Pacific, and we are familiar with the moist, warm tropical air, which results from this evaporation.

The information helps scientists link the weather we experience on the earth's surface with what is happening in the oceans.

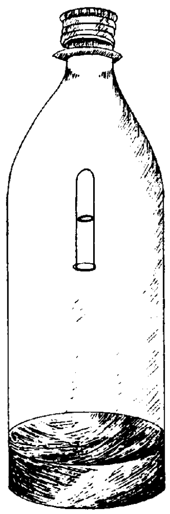
An Argo Float



Temperature and Salinity Profile from Tropical Waters

ACTIVITY. ARGO FLOATS.

The idea of this activity is to show how an Argo float can work. The principle is based on internal pressure in the buoyancy chamber. In this case the buoyancy chamber is a small tube part filled with air.



What you need: Large plastic lemonade or coke bottle, Small tube that will fit inside, this can be a small testtube or clear pen lid,

What to do:

Set up the bottle as shown in the picture.
Part fill the small tube with water so it floats with air trapped inside it.

Carefully change the amount of air in the test tube so that it just floats to the top of the bottle.

Screw on the top and gently squeeze the bottle.

Observe: What happens when you squeeze the bottle?
What happens when you stop squeezing?
Draw what you see happening in the diver, when the bottle is squeezed and released.

Explain: How do you think what you have seen might explain the way the diver behaves?
How do you think this might explain how fish can go up and down in the water?
How do you think this works in an Argo float?

Prediction:
What will happen if you were to stand the experiment out in the sun where the water will get warm?

Try it and see.

Is climate change happening?
A follow up report released by the IPCC released in April 2007 warned that global warming could lead to large scale food and water shortages and have catastrophic effects on wildlife.

The earth, oceans and the climate, what does science tell us?

The ocean covers 70% of the Earth's surface and has a major control on climate by dominating Earth's energy and water cycles. It has the capacity to absorb large amounts of solar energy. Heat and water vapour are redistributed globally through the ocean currents and atmospheric circulation.

Changes in ocean circulation caused by tectonic movements or large influxes of fresh water from melting polar ice off the land can lead to significant and even abrupt changes in climate, both locally and on global scales

adapted from; *Climate Literacy. The essential principles of Climate sciences*. March 2009, visit www.climate.noaa.gov/education.

ACTIVITY: TO DEMONSTRATE HOW MUCH EXTRA WATER IS PRODUCED WHEN ICE MELTS.

What you will need: A paper/ polystyrene cup or glass : Some ice cubes

What to do:
Fill the container full with water.
Add 10 –12 ice cubes.
Dry the side of the container after the water has spilled over.
Now let the ice cubes melt.

Prediction: What do you think will happen?

Measure: Has the height of the water changed once the ice cubes have melted.

Explain: Was there as much change as you expected? Can you explain what has happened?

Question: We know that the Greenhouse Effect is warming the oceans and melting the floating ice caps.
Which one do you think will have the greatest effect in your lifetime on sea levels?
What evidence do you have to support your answer?

What we want students to learn:
When water warms it expands. Reason being that the water particles have more energy so need to occupy more space as they move around more.

When icebergs melt they will not increase the amount of water in the oceans as the water that has originated from the ice merely takes up the volume originally occupied by the ice.

Extension:

Fill a container three quarter full of water.
In the container place a large block e.g. a rock that will represent a land mass.
On the block place a large number of ice cubes. (This represents an ice sheet such as the one that covers Antarctica)
Let the ice melt.
Does the water level rise?

What effect would this have on the oceans if all of the ice on the Antarctic continent melts?

One of the most effective means of measuring ocean temperature below the surface is by using the Argo floats. They aim to tell us what is going on from deep water to the surface.

Question: Does water temperature remain constant to the bottom, gradually get colder or are there layers?

The answer depends naturally on ocean depth, but there are characteristics that firstly indicate a decline in temperature with depth with some evidence of layering.

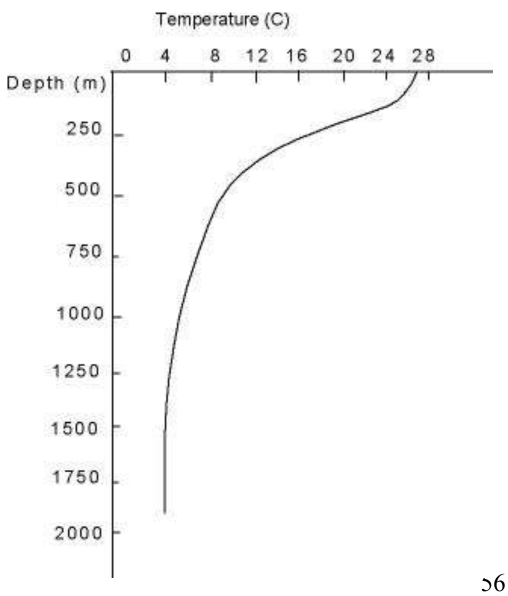


Diagram showing a typical temperature profile from an argo float

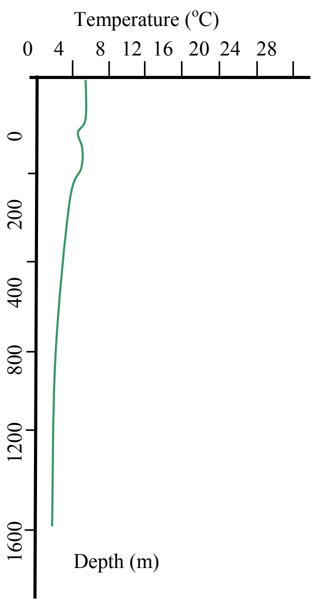
This is known as a **thermocline**.

The part showing the temperature change (above roughly 300m) is known as the mixed layer.

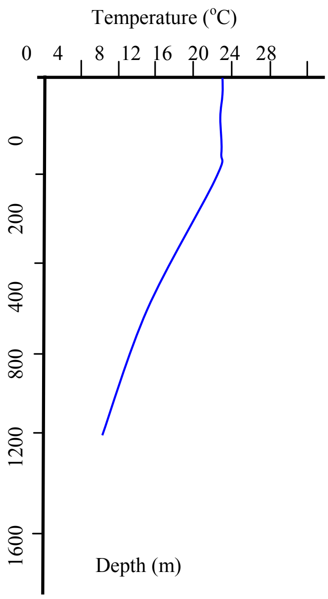
The main method of distributing the heat energy in the ocean comes through the action of wind. The turbulence created by the wind carries the heat energy deeper. But below 1000m the profiles are fairly constant and cold with temperatures in the range of 0 to 5°C.

Different locations have different characteristics, like finger-prints!

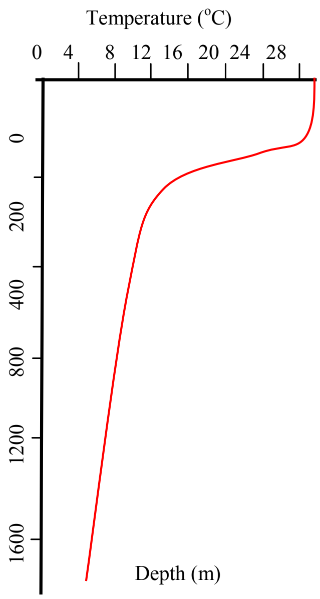
These profiles show thermoclines for equatorial, mid and polar regions.
(The longitudes were in the region of 170 – 180°E)



Profile from latitude around 60°S in the Southern Ocean.



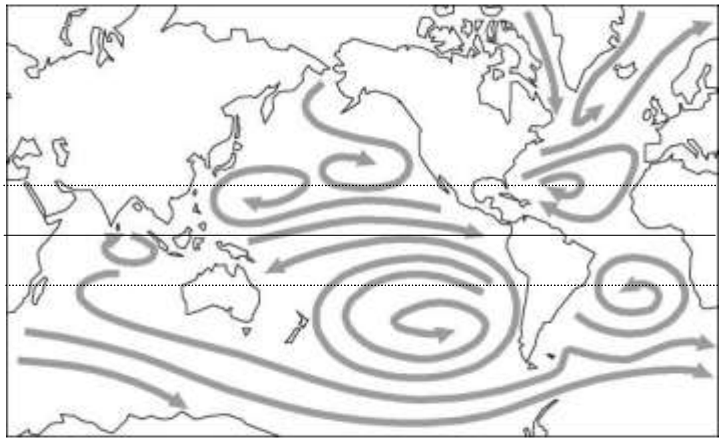
Profile from a latitude around 35°S in the region of the Kermadec Trench



Profile from a latitude close to the equator in the region of theTokelau Islands

Ocean currents can also be seasonal. Mid latitudes in particular will show variations due to the seasons such as summer heating, winter cooling.

Diagram showing some of the main surface currents that are partly wind driven.



This gives an indication of the direction heat energy will be carried

Wind speeds and directions will have their effect on the temperature levels in the upper layers of the ocean, and the extent to which the heat is distributed to the lower layers.

Very low temperatures are maintained at depths throughout Earth's oceans. It is the cold water sinking in the Polar Regions that causes this.

The question is why does this happen?

Cold water is denser and sinks. As it sinks it moves slowly along the ocean floor towards the equator, driving the deep ocean currents. These deep ocean currents will eventually reach the surface as they follow the sea bed. The movement up to the surface is called upwelling.

There is one such current that has a major effect on the climate in the Pacific. This upwelling exists off the coast of South America.

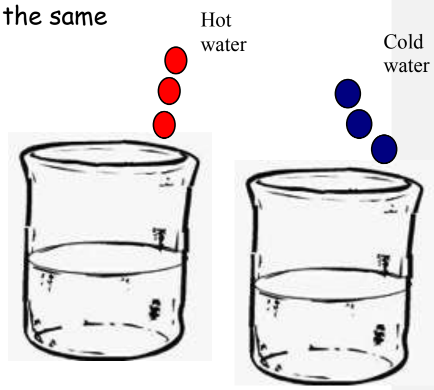
ACTIVITY: COMPARING THE BEHAVIOUR OF WARM WATER TO COLD WATER.

The temperature of sea water varies all over the world. The ocean waters near the Arctic and Antarctic will be considerably colder than the water near the Equator.
The temperature of the water affects its density. This in turn affects how the water moves in the ocean, and the way deep ocean currents move.

Prediction: What do you think will happen when warm and cold water meet each other?

What you will need: Iced water: Very hot water: 2 large clear containers (at least 250ml or 500 ml beaker): 2 small containers (30 ml beakers): Red and Blue food colouring: 2 droppers or straws

What to do:
Fill the large containers 3/4 full with tap water and place on a table to allow the water to settle. This allows it to reach the same temperature as the room.



Pour some hot water into one of the small containers so that it is half full.
Put some drops of RED food colouring into the hot water to make it dark red.
Pour some iced water into the other container.
Put some drops of BLUE food colouring into the iced water to make it dark blue.
Using the dropper (or straw as a pipette) gently add some drops of hot red water to the water in one large container. Then add drops of blue iced water to the other large container of water.

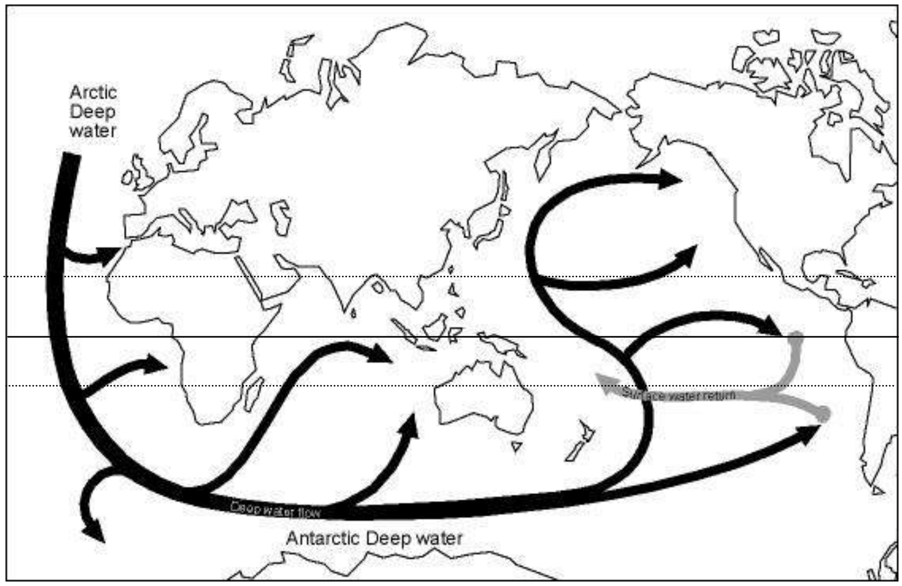
Observe: What happens to the hot and cold water. Do they mix?

Draw pictures using Red and Blue colouring pencils to show what happens to the water. You may need to do several pictures over a period of time.

Explain: What happens to the cold water? Why do you think this happens?
What happens to the warm water? Why do you think this happens?
What do you think will happen when cold water from the Polar Regions meets up with warmer water from the equator?
Extension: Hold a straw at the edge of the top of the beaker so that it is parallel to the water surface. Blow gently through the straw. What happens to the water?

What we want children to learn:
Cold water sinks below warm water. It is more dense.
Warm water will sit on top of cold water.
Wind will mix up the layers of warm and cold water.

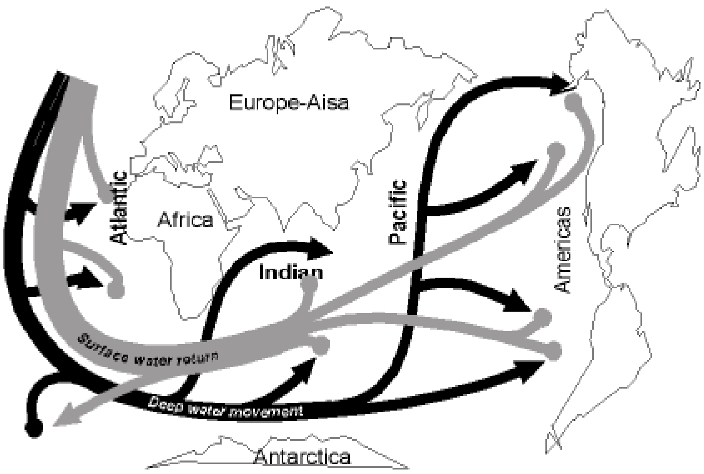
This map shows the main deep ocean currents that affect the pacific with the equatorial surface current and the upwelling off the west coast of South America



These ocean currents move very large masses of water, and can be identified by their temperature and salinity profiles. This is in part what ARGO measures and helps to provide information about where these currents are, where they are rising and mixing with upper water layers.

The average temperature profiles do not seem to change particularly from year to year for particular locations, indicating that the temperature distribution around Earth's oceans should be pretty stable. It is the continuous motion and interaction of the ocean currents through the different depths that is responsible for this stability.

This is a representation of the deep water currents and the returning surface currents that travel the world's oceans.



You can imagine this as a giant conveyor belt that drives the oceans, the heat the water carries and consequently our weather. This giant conveyor current is not fast. It takes over a thousand years for the water in the Arctic ocean to reach the Pacific ocean.

What is known, is that climate changes result not only from changes in the surface temperatures but also in the changes in temperature of the waters below the surface, what is known as the thermocline. The thermocline shows these changes below the surface. It is known that now the Antarctic ice sheet is melting at a faster rate and how this might change this deep ocean current no-one is really sure!

It is important to remember that the top 3 metres of ocean carries as much heat energy as there is in the whole of the atmosphere. That means that the ocean has a tremendous capacity to store heat and given the nature of the ocean currents, carry this heat energy from one location to another.

Is climate change happening?
Human's are pouring carbon dioxide into the atmosphere faster than plants and oceans can absorb it.

SOME BACKGROUND SCIENCE: WHAT IS SEA WATER?

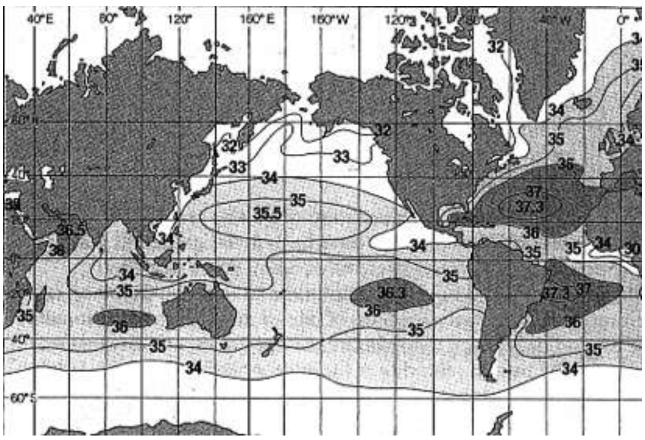
Most people would distinguish between seawater and fresh water by the fact that one of them tastes salty. That's true but there is more to it than that!

There are many materials dissolved in Seawater. Most of these materials are ions, which have originated from salts. The non-metal ions involved are chloride, sulfate; bicarbonate; bromide; fluoride and borate, whilst the metal ions generally found are sodium; magnesium; calcium; potassium and strontium. These are all soluble ions. Other materials such as silicon, aluminium and iron are there but only in very small quantities since they are not very soluble.

The average concentration of these dissolved salts is about 3.5% by weight. That's 3.5g of salts per 100 grams of water (or 35g per litre of water). The actual amount can vary depending on the where in the ocean, or if close to shore or estuary.

Out in the ocean the driving force for salinity depends on the balance between evaporation, precipitation (rain), on the surface and the amount of mixing that has taken place between the upper and lower layers of ocean.

At the surface the salinity level depends on the rate of evaporation, (which increases salinity,) or rainfall (which decreases salinity.)

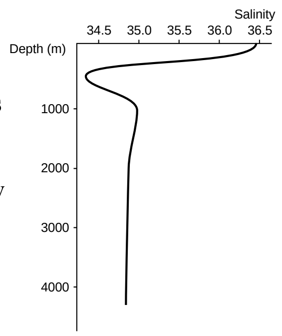


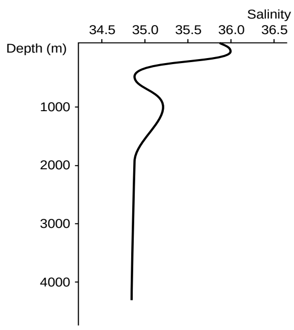
The map shows surface salinity profiles across the Pacific Ocean

Key: Each number represents the weight of salts per litre of water

Argo floats provide a picture of the salinity changes with depth. The salinity is measured by using conductivity. Increase in salinity levels bring about an increase in conductivity.

These diagrams are graphical representations showing salinity changing with depth

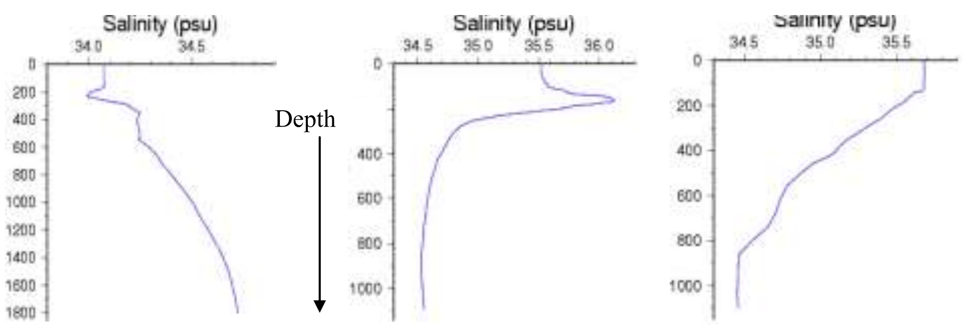




Above about 1000m, salinities can vary depending on what is happening in the atmosphere above and the location of seawater. The mixing takes place as the ocean is disturbed by wind, distributing the heat energy and any fresh water layers down to deeper depths. (This is called the mixed layer). Below 1000 m, the effects of the surface changes are very small and the salinities are consistently between 34.5 and 35.0.

The zone on the salinity profile that varies is called a halocline. What is important is that it is like a fingerprint. Different locations show hardly any change in salinity levels from year to year even though the water is changing as evaporation or precipitation takes place. Changes that do occur in the ocean's weather are reflected in these profiles and this information can be used as part of the assessment of what is happening as climate change occurs.

Three examples of profiles taken from Argo floats with a similar longitude range and timeframe but widely differing latitudes. (The longitudes were in the region of 170 – 180°E)



Profile from latitude around 60°S in the Southern Ocean

Profile from a latitude around 35°S in the region of the Kermadec Trench

Profile from a latitude close to the equator in the region of the Tokelau Islands

Seawater is more dense than freshwater. Some people recognise it is easier to float in seawater than freshwater. If you look carefully at the three profiles above, the further south you go, the salinity reading on and near the surface is considerably lower than the readings for further north. This means less dense freshwater must be on the surface (lower conductivity). This could have originated from melting ice or rain.

Comparing profiles in the tropics gives a good indication of high rates of evaporation or rainfall.

NOTE: Density is a measure of mass per unit volume of water. More particles packed in the same amount of space means an increase in density. When salt is dissolved in water, the volume does not appear to change. Yet the density is increased. The higher the salinity, the greater the density will be.

ACTIVITY. AN INTRODUCTION TO SOME OF THE PROPERTIES OF SEAWATER

Explain: Why is Sea Water salty? Where does the salt come from? Discuss your ideas as a group and draw or write out your final ideas on a large sheet of paper for class discussion.

1. WHERE DOES THE SALT GO?

Prediction: Does adding salt to the water change the volume occupied by the water?

What you will need: A large jar (or a large measuring cylinder): Marker pen: Salt: A tablespoon: Water.

What to do: Fill the large container 3/4 full with water.
Mark the level of the water in the container.

Add a tablespoon of salt. Stir and wait until it has dissolved.
Keep doing this until there is just a little bit of salt left on the bottom of the container.

Check the water level on the side of the container.

Observe: What happens to the water level before and after adding salt?

Explain: If the water and salt are made up of particles how can what has happened be explained? (Use pictures to help you explain what has happened if you wish).

Teacher: Use pebbles in a measuring cylinder and then add sand to show how the salt particles can take up the spaces between water molecules without increasing the volume).

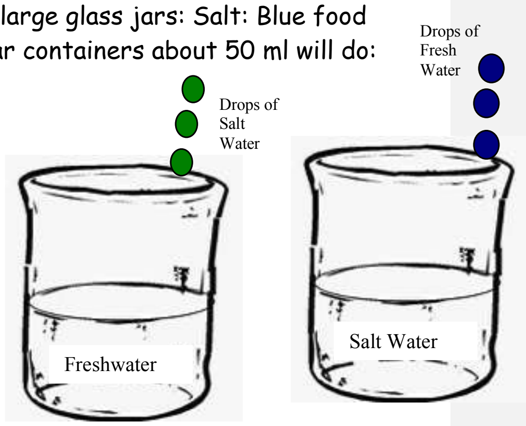
Question: Density is a measure of how tightly the particles of something are packed in the same amount of space. For instance a kilogram of salt occupies more space than a kilogram of lead.
Would one litre of Sea Water weigh **more**/ **the same**/ **or less**/ then one litre of Freshwater?
Can you explain why?
What do you think the density of Sea Water would be like compared to Fresh Water?

What we want children to learn:
Salt has come from the land – runoff and sedimentation
Salt dissolves in water.
The dissolved salt does not change the volume of the water.
Since the volume of the water does not change, the density of the water has increased.

2. WHAT MAKES SEAWATER DIFFERENT?

Prediction: Will seawater and freshwater mix?

What you will need: 2 x 250ml beakers or large glass jars: Salt: Blue food colouring: Green food colouring: 2 small clear containers about 50 ml will do: 2 droppers: Tablespoon: Marker pen.



What to do:
Pour enough water into the large glass containers so they are half full.
Put a tablespoon of salt into one of the containers and stir until the salt has dissolved.
Write salt water on this container.
Write fresh water on the other container.
Pour some of the salty water into one of the small containers so it is 3/4 full.

Add green colouring to this salty water until it is dark green.
Label the small container "Salt Water."

Pour some freshwater into the other small container until it is 3/4 full.
Add the Blue food colouring so that the water turns light blue.
Label it "Fresh Water."

Use a dropper and gently add some drops of the "green" salt water to the large container of clear fresh water.

Observe: Draw what happens to the green seawater? Does it mix with the fresh water? Does it float or sink? Use colours in your drawing to show what is happening?

Now use a clean dropper and add some drops of blue freshwater to the clear seawater in the large container.

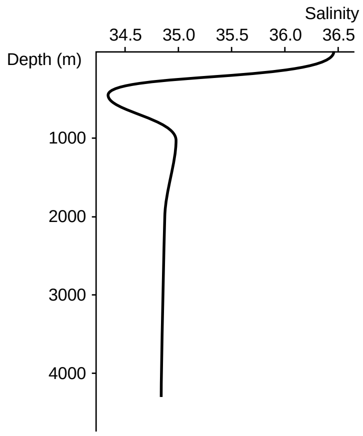
Observe: Draw what happens to the blue fresh water? Does it mix with the seawater? Does it float or sink? Use colours in your drawing to show what is happening?

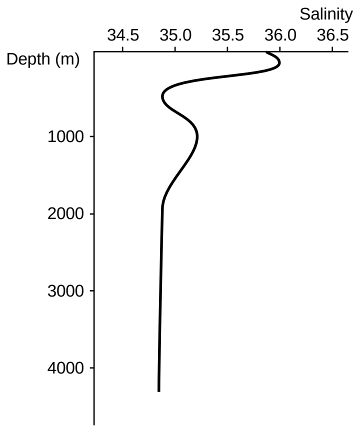
Explain: Can you think of a reason for what you see happening when freshwater and seawater come together?

Questions:
What do you think happens when it rains out at sea? Does the rainwater and sea water mix straight away?

What we want children to learn:
Seawater is denser than freshwater.
When it rains the freshwater reduces the salinity of the saltwater on the surface.

Something Extra:
An Argo float looks at the amount of salt (salinity) of the water as it comes to the surface. The profiles below come from the data from two floats that were close to each other in the equatorial regions. How could you explain the difference in the salinity levels of the water? (Hint: before and after a heavy rainstorm)





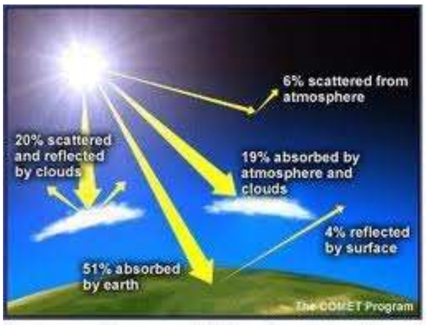
Why could this be important information?

What would cause the rainwater and sea water to eventually mix?

The interrelationship between the land, the sea and the atmosphere

Earth's climate is influenced by interactions involving the Sun, ocean, atmosphere, clouds, ice, land, and all life. Climate varies by region as a result of local differences in these interactions. Energy from the sun reaches the Earth and heats the land, ocean, and atmosphere. Some of that heat is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet. When Earth reflects the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.

Adapted from; *Climate Literacy. The essential principles of Climate sciences.* March 2009, visit www.climate.noaa.gov/education.



Ref: http://www.nc-climate.ncsu.edu/

Green House effect

What is it?

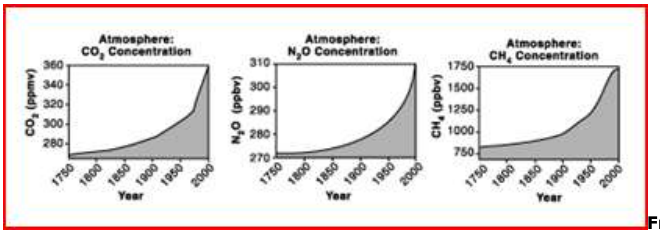
The greenhouse effect is a natural phenomenon whereby gases in the atmosphere, primarily water vapour, carbon dioxide and methane, trap the heat like a green house and keep the Earth's surface warm. Human activities, primarily burning **fossil fuels** (coal, oil and natural gas)and changing land cover patterns eg. deforestation, are increasing the concentrations of some of these gases, amplifying the natural greenhouse effect, trapping more heat in the atmosphere which means that the temperature is getting warmer called global warming.

The Greenhouse gases which occur naturally in small amounts and absorb and release heat energy. Small increases in carbon dioxide concentration have a large effect on the climate system

Adapted from; *Climate Literacy. The essential principles of Climate sciences*. March 2009, visit www.climate.noaa.gov/education.

For more information on the Greenhouse Effect, Causes and consequences for climate patterns in the Pacific, refer to the *Climate Change education the Pacific Way – Kiribati* resource, SPC/GIZ

Scientific evidence of the green house effect and climate change



From: Steffen et al. 2004

The interconnectedness of Earth's systems means that a significant change in any one component of the climate system can influence the equilibrium of the entire Earth system.

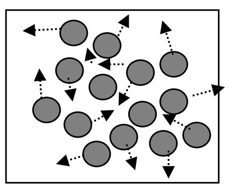
Positive feedback loops can amplify these effects and trigger abrupt changes in the climate system. The amplification of the greenhouse effect has an effect on climate

Human activities related to the green house affect Life—including microbes, plants, and animals and humans—which is a major driver of the global carbon cycle and can influence global climate by modifying the chemical makeup of the atmosphere. The geologic record shows that life has significantly altered the atmosphere during Earth's history

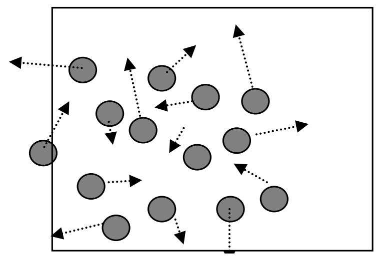
Natural processes driving Earth's long-term climate variability do not explain the rapid climate change observed in recent decades. The only explanation that is consistent with all available evidence is that human impacts are playing an increasing role in climate change.

Future changes in climate may be rapid compared to historical changes. Human activities have affected the land, oceans, and atmosphere, and these changes have altered global climate patterns. Burning fossil fuels for industry and transport, releasing chemicals into the atmosphere, reducing the amount of forest cover, and rapid expansion of farming, development, and industrial activities are releasing carbon dioxide into the atmosphere and changing the balance of the climate system.
Adapted from; *Climate Literacy. The essential principles of Climate sciences*. March 2009, visit www.climate.noaa.gov/education

What about long term events: how does heat affect the oceans?
The Greenhouse effect or global warming is not just having an effect on our atmospheric conditions e.g. air temperature and weather, but also ocean temperature. Just as the sun's energy is absorbed by the atmosphere, so it is also by the oceans. Water warms up more slowly than the air, the reason being water's much higher heat capacity or ability to store more heat energy. This means that global warming is going to be seen over the long term in the oceans.
The question is then, how is this heat energy held in the ocean?
Heat energy is transformed into kinetic energy of water molecules, that is movement. The more heat energy that is transformed into kinetic energy the faster the water molecules will move around. Therefore, the heat energy is held internally by the water molecules. This is what we measure as temperature.



Particles moving around at a low temperature



The same particles moving around at higher temperatures. Notice they also occupy more space.

Besides the observed increase in temperature, the increased movement of the water molecules means that they need more space to move around in. This we see as expansion.

The next question is, how much heat energy can the oceans hold and what changes are taking place as a result?

Heated water expands. If there was to be a one degree temperature rise spread throughout the whole ocean to its full depth, this would correspond to sea levels rising approximately 80cm. Just think, could that happen? What would it mean?

We need to develop a picture to see what is going on, and work out what changes are going on in sea levels. Satellites provide one part of the story. The satellites look down from above and measure the surface temperature of the ocean, and sea level changes through the year. This helps establish a pattern that relates to the seasons.

These can be found on associated N.A.S.A web sites. By continuous monitoring over a period of time it is possible to assess what long term changes are taking place in surface ocean temperature.

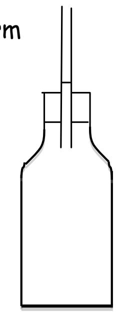
The problem is that satellites may show what happens on the surface, but what happens beneath?

Knowing what happens below the surface is important if we are to understand how the heat energy is distributed and the changes in sea levels that will result.

ACTIVITY WHAT HAPPENS TO WATER WHEN IT IS HEATED?

Prediction: What do you think? Discuss your ideas with your and write down your group explanation.

These two experiments may help you answer this question and confirm your ideas.



Experiment:

What you will need: A Flask or clear plastic drink bottle: Stopper: Glass tube or straw, Food colouring, blue tac

What to do:
Fill the flask almost to the brim with water and a drop of colouring.
Put in the stopper and tube/ straw. Seal carefully with blue tac or plasticine.
Press down firmly. Water should rise up the tube.
When it has stopped rising mark the tube with a marker pen.
Put the flask out in the sun.

After 10, minutes take a look at the flask.

Measure: How far up the tube is the water level now?

Explain: Why has the water moved in this way?

Something to think about: Can you redesign the experiment to measure the how far the water travels for every 2°C?

Something more to think about:
For each 1 degree centigrade that the temperature of the water increases, it increases in volume by a factor of 0.00021 or 0.021%.

What would be the effect on the volume of water in the ocean of a 1 degree temperature rise?

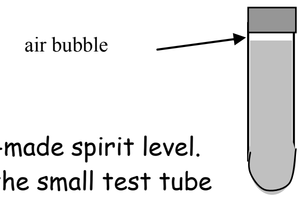
Well let's assume that the average depth of the ocean is 3.7 km. If the area that the oceans cover remains pretty much unchanged, then the change in depth will be:
3700 m x 0.00021 = 0.78 m
That means that a 1 degree temperature increase in the oceans will give an almost 80 cm increase in sea level.

Measure 80cm on a wall up from the ground. Look around you, how much of the area you are standing would be flooded? How much would be clear above the new water level?
This is the worst case scenario for 2100, the turn of the next century!

HOW DO WE FIND OUT THE MEAN SEA LEVEL?

What you will need: Long length of string, tape measure, meter ruler, sellotape, a marker, a level marker, small weight. Students will need to work in threes

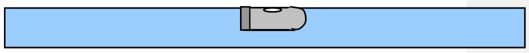
Note to the teacher. If the beach has only a small slope you may want to tie two rulers together before putting the level in place.



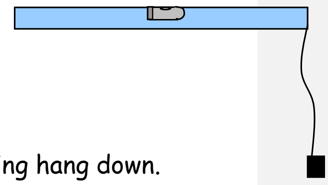
What to do: Getting the gear together.

First thing to do is to make a level. This is a home-made spirit level. Find a small plastic test tube with a screw lid. Fill the small test tube so that it is almost full with water (or cooking oil). Leave a small air bubble. Screw on the lid. The air bubble should move freely in the test tube.

Secure the test tube to the middle of a metre ruler. Sellotape will do



At one end of the ruler tie a one metre length of string.



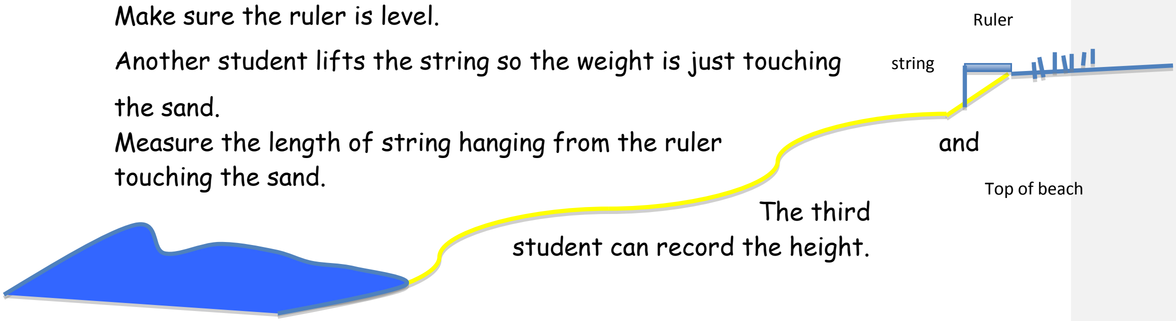
Finding the profile: Do this at low tide.

At the top of the beach, hold the ruler level and let the string hang down.

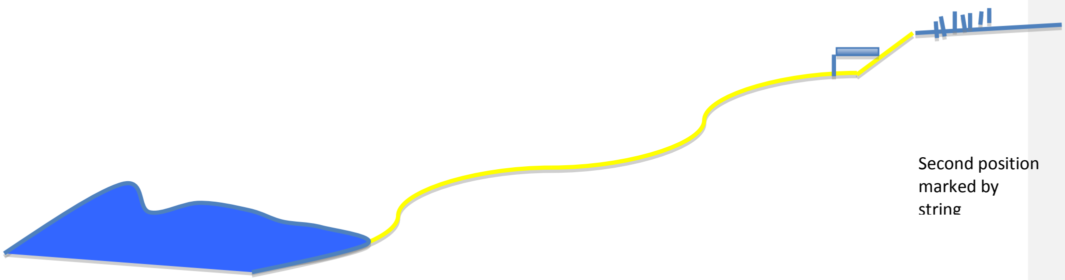
Make sure the ruler is level.

Another student lifts the string so the weight is just touching the sand.

Measure the length of string hanging from the ruler and touching the sand. The third student can record the height.



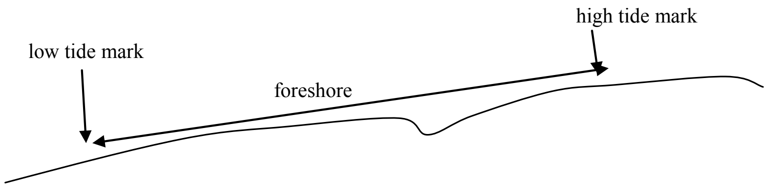
Move the end of the ruler to the place in the sand where the string reached and do the same thing again.



Continue this until you reach the low tide mark.

Now use graph paper and use these measurements to draw a profile.

Mark the high tide mark and the low tide points.
This is an example



Now draw a line between the two marks, high water and low water. This is called the foreshore.

Mark a point on the fore shore halfway between the low tide and high tide marks. This is the mean (average) point for the sea level.

What to do next:
You have measured the distance between high and low tides. If possible take this measurement over the period of a month and record the state of the moon and weather.

Can you explain:
What could be altering the height of the sea?
How large an effect is it having?
What is the change in the heights of the high and the low tide marks over the month?
How does the mean (average) sea height change over the month?

Can you estimate:
How will the water level marks change if the oceans start to rise?
Will the water levels at high tide start to affect the land behind the beach?
How high will the sea level have to rise, allowing for everything else staying the same?

What we want children to learn;
Data is information gathering.
Gathering data over time provides evidence for what could be happening.
Scientific knowledge needs the assistance of mathematical tools.
The mean sea level (height up the foreshore) changes naturally with the monthly cycle of the tides. This is caused by the gravitational attraction of the moon.
The height changes over the year too as the oceans warm so the water expands.

Weather events such as El Nino and La Nina will cause the mean height of the sea to alter as they effect they warm or cool the water.

In the long term as the oceans warm, the mean sea height will rise. This will mean the high tide mark and low tide marks will change too. Will the sea start to move onto the land above the current high tide mark?
How far will it reach?

ACTIVITY: SEA LEVELS, PAST, PRESENT AND FUTURE!

What you will need: Graph paper, Ruler: Pencil.

What to do:

The sea has never been always at the same level. For a variety of reasons ranging from climate to geological the sea levels have changed.

Using a technique known as Thorium/Uranium dating, sea level has been estimated off the coral reefs of Papua New Guinea for the last 250 thousand years.

Thousand years before today	Metres below present sea level	Thousand years before today	Metres below present sea level
0 (Today)	0	130	5
10	23	140	16
20	119	150	123
30	54	160	11
40	44	170	30
50	72	180	57
60	55	190	87
70	71	200	46
80	22	210	32
90	59	220	7
100	20	230	25
110	48	240	12
120	27	250	32

Plot a graph showing how the sea level has changed over the last 250 thousand years.

Start with the x-axis on 250 thousand and work up to 0 (today).
On the y-axis start at 0 and go downward to a maximum of 140m

Question: How has the sea level varied over this period of time?
That was the past.

Now what do scientists predict for the future?

The data is based on models that scientists use to predict the changes in sea level as the oceans increase in temperature. These figures were dated from 1990.

Comment [n1]: Update?

Year	Change in average sea level		
	Lowest Estimate (cm)	Best Guess Estimate (cm)	Worst Case Estimate (cm)
1990	0	0	0
2000	1	4	10
2010	2	8	20
2020	3	14	30
2030	4	20	41
2040	4.5	25	52
2050	5	30	63

Draw a graph of the possible changes in sea level over the sixty years from 1990.
Put the years along the x-axis. The average sea level should be on the y-axis.
You will have a line for each estimate.

Something to think about:
30cm may not seem like a lot! Imagine 30cm above the high tide mark, and that's 30cm in a vertical direction, (straight up!) .The Brun rule estimates that for most beaches, a 1cm rise in sea level translates to a 1m movement inland of the high tide mark. A 30cm rise in sea level would mean that the high tide mark would move inland 30m!

What effect do you think the sea level change will have in your area?
(You could do this for each of the estimates).

Something extra:
Can you predict how badly the coastal areas will be affected and to what extent? If you can, get hold of a map of your area or nearest coastal area showing the heights of the land above sea level. (These are shown by contours).
Make a rough copy of the map, showing towns, villages, rivers, hills and valleys.
See if you can shade in the areas that will be most affected by a 30 cm increase in sea level.
Go down to the beach. Work out where the low and high tide marks would be.
How much higher would the high tide mark be?
Could this affect any areas inland on your island?

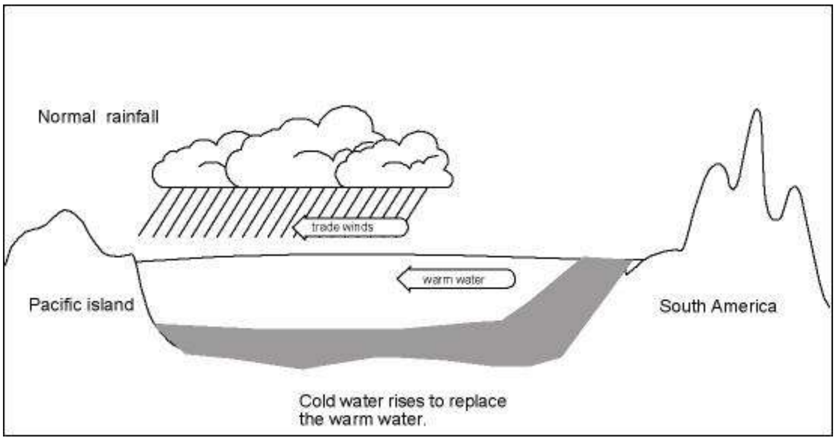
The Brun Rule states that on most beaches, each rise in sea level of 1cm will result in the high tide mark moving inland 1m. This would mean that a 30cm rise in sea level would result in the high tide mark moving 30m inland all around an island. Obviously this does not happen with cliffs or steep sea walls.

For more information on sea level rise in the Pacific, refer to the *Climate Change Education the Pacific Way* – Kiribati resource, SPC/GIZ

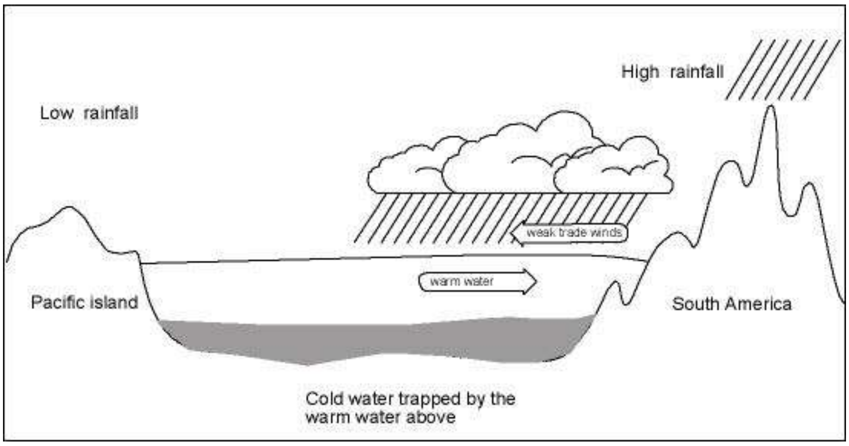
Climate change – what has happened?

EL Nino and La Nina as part of ENSO – EL Nino Southern Oscillation, have had an impact on weather in the Pacific and Kiribati in particular for thousands of years, The ENSO patterns used to be regular but now they have changed.

Under normal conditions what we would see is:

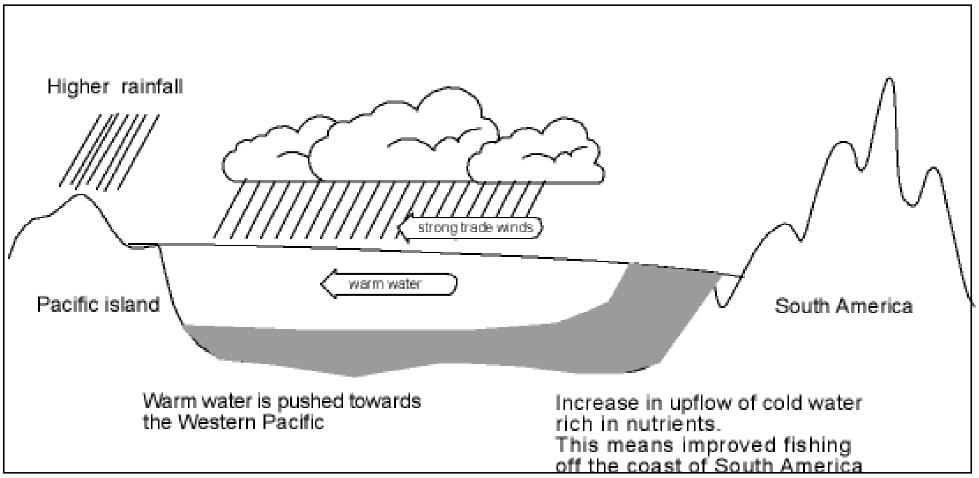


Is climate change happening?
Disease carrying insects are moving into new areas as temperature increases. Global warming will expose millions of people to new health risks.



The event more commonly know as a La Nina is the opposite of an El Nino. The trade winds are stronger and blow more warm water into the Western Pacific. This results in more cyclones and bad weather for the Pacific Islands and New Zealand, along with an increase in the mean height of sea levels on their shores.

For the fisherman of South America this means bumper fishing!



Salinity measurements also predict the oncoming of an El Nino event. What has been noticed is that before an El Nino event, salinity levels in the waters of the Western Pacific are low six months before the event occurs. This is followed by increased salinity 12 months later in warmer waters close to the equator. It is thought that the sinking of cold, salty water around the equator allows the warmer less salty surface water to spread eastward and helps to create the changing weather pattern.
There is still more left unexplained!

For more information on the effects of El Nino and La Nina in Kiribati, refer to the *Climate Change education the Pacific Way – Kiribati* resource, SPC/GIZ

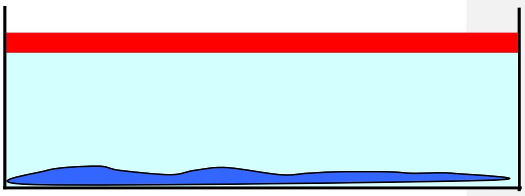
ACTIVITY: EL NINO A TEACHER DEMONSTRATION

Purpose: This is a way of demonstrating to students of what happens to the trade winds in an EL Nino cycle and the effect it has on ocean "upwelling".

Materials:
Clear plastic oblong container (approx. 45cm x 10cm x 10cm) or glass aquarium (If not available clear plastic food containers will do),
Water,
Cooking oil
Blue food colouring, (put in the fridge overnight or in a bowl of ice for 30 mins if you can)
Hair dryer

A map of the Pacific Ocean

Setting this up:



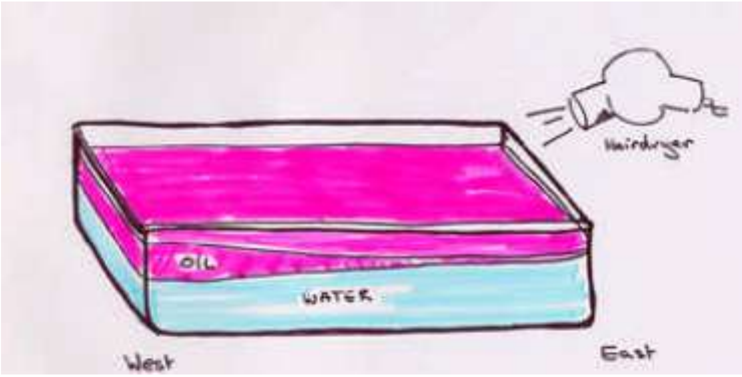
Fill the tray with water to within 4-5cm of the top.
Gently pour the oil over the surface of the water. Allow to settle, so that you have two layers.
Mark one end of the container west (Indonesia) and the other end east (South America.)
Plug in hair dryer. **Note keep it away from any water spills.**

What does the model represent?
The liquids in the plastic container represent a slice across the equatorial Southern Pacific Ocean.
The oil represents the warm layer of surface water that has been heated by the sun.
The water represents the colder water below the surface warm layer which has traveled through from the colder southern regions.
The hairdryer is about to represent the trade winds.

What to do:
Place some cold food colouring on the bottom of the tank on the South American side. Use a straw as a pipette to get it to the bottom. Try and disturb the water as little as possible.

Turn on the hairdryer so giving a strong blast of air (no heat needed) and direct the 'wind' it across the surface of the oil-topped water from the East (South America) to the West (Indonesia).

Note:
After the wind has been blowing for a period of time you may want to add a few more drops of food colouring to the "west" end of the tank. (It should sink to the bottom.)



Keep the wind blowing.
Ask the class to describe what effect this has on the "warm" and "cold" water.
Have the class draw what they see happening. (It should be possible show the upwelling of cold water to the surface.)

Have the class predict what would happen if the "Trade Winds" do not blow or are not as strong:

Turn off the "trade winds" and ask the class to describe what happened when the trade winds stop.

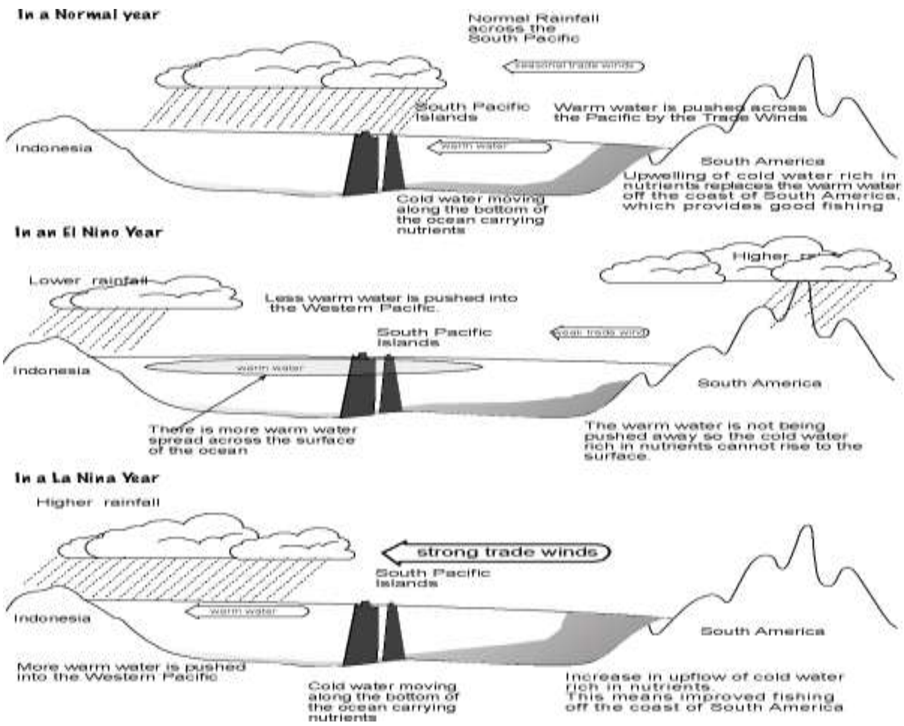
Repeat this by turning down the speed of the hairdryer or moving it further away from the surface of the "ocean" to represent weaker winds. Ask the class to describe what happened when the trade winds are not as strong.

Do the observations fit the predictions?

Explanation:

The “warm” water is pushed across the Pacific and piles up in the West (Indonesia) as it is blown by the “trade winds” (hair dryer). This is what we would normally expect to happen in the equatorial Pacific Ocean.

The blue food represents the cold water and you may notice that the bottom moves upwards towards the surface at the eastern end (South America). This is upwelling which, in the Pacific Ocean, brings nutrient-rich bottom waters to the surface. Plankton feed on the nutrients, and in turn fish feed on the plankton, so these areas tend to be rich in fish and other sea life. **This is a normal year in the first diagram.**



In an El Nino Year.

When the trade winds do not happen or are weaker. The “warm” water moves back across the “ocean” from the west (Indonesia) to the east (South America). This movement warm water that is the oceans part of the El Nino condition. (You may need to do this several times to observe the movement)This stops the upwelling and prevents the nutrients flowing to the plankton. The result is poor fishing.

There is also a larger area of warm water that builds up around the central South Pacific. What will be the impact of this on the weather patterns?

Note: The warm water also deflects up and down the coastline of South and North America, and this creates other problems.

Sometimes the seasonal trade winds blow stronger than normal. This is a La Nina. The effects are the opposite that that of an El Nino.
This is shown in the third of the three diagrams on the previous page.

La Nina: EL Nino's twin!

What do you think will be the effects of a La Nina on the fishing and weather patterns. Discuss the location of the warm water on the globe.

Discuss what will happen to the air above the warm water in terms of how much moisture the air can hold. (The air warms and holds more moisture from the evaporation of seawater – the water cycle)

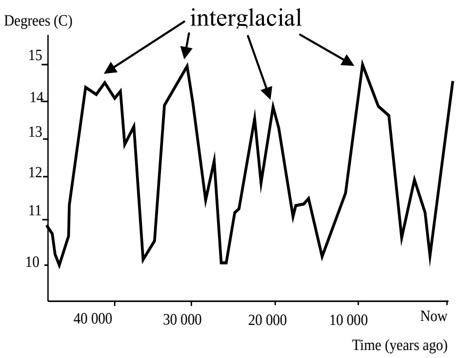
Extension:
Draw up a table to compare the three conditions on the effect on the weather patterns across the Pacific.
If the body of warm water expands what will happen to possible occurrence of cyclones in the South Pacific?

The Global Impact of Climate Change.

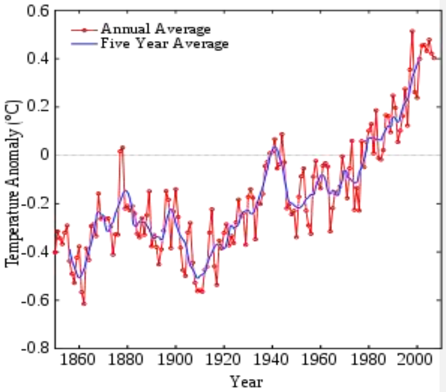
Measurements indicate the planet is getting warmer. It has happened in the past, but these temperature variations were more than likely part of the natural cycles related to volcanic activity or ice ages.

Comparison of the graphs below show that global warming may be nothing new but the reasons behind it in recent times do differ.

This graph shows the average temperature variations over the last Forty thousand years. Change has always happened.



This graph shows average temperature trends within recent times. It is getting warmer! But at a very fast rate Almost half of a degree per year!



Current indications show that there will a rapid increase in temperature due human activities, taking the average temperature two degrees higher on current trends by the end of this century. This is only an estimate based on a model, some say it will be only half a degree, others as much as six degrees. The only agreement is that it will go up!

This temperature increase will mean an increase in stored energy in the atmosphere and oceans. This will mean not only weather changes but also sea level changes due to the subsequent expansion.

One thing is for sure, it will impact on the way we live. Some of the effects we might well experience are:

- underground water supplies may become contaminated with seawater,
- disasters such as severe storms, flooding and drought may become more common,
- coral reefs will become damaged more frequently by the severe storms,
- increased sea level heights will damage the life inside the coral reef,
- warmer waters inside the reef will create conditions that cause increase in algae growth,
- increased acidity inside the reef areas due to dissolved CO_2 will damage coral and plankton with possible severe affects to marine ecosystems
- diseases once associated with only tropical regions may become more widespread,
- agriculture will change as plants no longer grow in altered climates with warmer soils
- many plants and animals will be under stress as habitats change.
- water stored on land in natural lakes, reservoirs, rivers will evaporate faster.

For more information on possible and probable changes in the Pacific, refer to the *Climate Change education the Pacific Way – Kiribat*i resource, SPC/GIZ

What the scientists think could happen

One in ten year weather events such as El Nino patterns, or even one in one hundred year events will become more frequent. Weather extremes will become common place.

Important coastal regions, coral atolls and fertile estuaries will be under direct threat from rising sea levels. The sea level increase will come about predominately from increased expansion of the water mass of the oceans,

Sea levels already change with seasonal temperature changes and in response to natural climatic events such as El Nino. But with a permanent temperature increase, the ice on the land mass will melt and that will increase the body of water in the oceans.

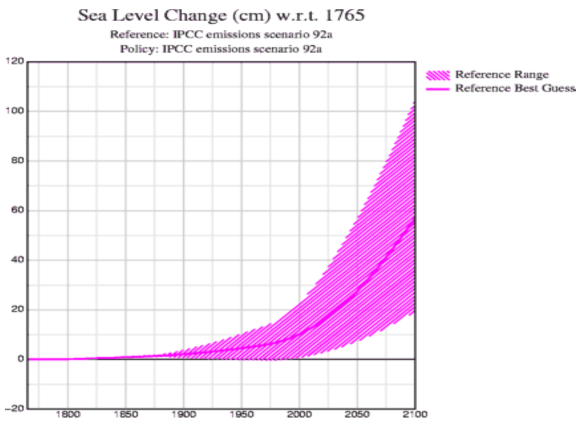
The idea that the floating ice cap and icebergs will effect the volume of water in the ocean is not correct. This is because they already occupy the same amount of space as they would if they were liquid water.

Is climate change happening?
Sea level could rise between 18 and 60 centimetres by the end of this century. A rise of just 10 centimetres could flood many South Sea islands. (IPCC)

Check the PACCSAP report on predicted changes to Kiribati climate.
http://www.pacificclimatechangescience.org/wp-content/uploads/2013/09/Kiribati.pdf

Sea Level rise

This graph gives an idea of the predicted sea level changes



All of these changes need to be considered as they impact on our environment.

The question is what will the impact be and how will things be altered?

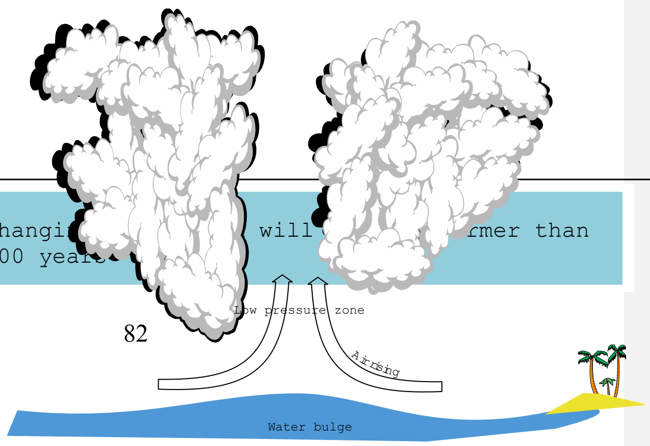
For more information on the predictions for sea level rise in Kiribati refer to the PACCSAP report.

Irregular and short term events

Storm Surge:

Weather can affect sea level and produce tides that are out of the ordinary. If a deep low-pressure zone such as a Tropical Cyclone is passing over, at the same time as a high tide, it can severely increase the height of the tide. Once again this is due to water's fluid behaviour and the ocean effectively expands (occupies more space) under less air pressure.

Diagram showing the ocean water bulging under a low pressure zone.



Is cl… ng?
At the rate our climate is changi… will … rmer than at any time in the last 10,000 years…

Combine this with the effect of storm driven waves and the result is islands being swamped far inland by seawater, as was seen in Niue 2004

Effect on biodiversity

Individual organisms survive within specific ranges of temperature, precipitation, humidity, and sunlight.If the climate changes in different regions and becomes drier and hotter or colder and wetter this will affect the speices living in that area Organisms exposed to climate conditions outside their
normal range must adapt or migrate, or they will perish. Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change. Animals, plants, bacteria, and viruses will migrate to new areas with favourable climate conditions Infectious diseases and certain species will be able to invade areas that they did not previously inhabit. . Adapted from; *Climate Literacy. The essential principles of Climate sciences*. March 2009, visit www.climate.noaa.gov/education.

For the Pacific Islands, coral reefs in particular are under threat. As sea levels rise so the water over the coral reefs becomes deeper and the plant algae die through being unable to cope with less light and higher temperatures. The relationship between the algae and animal life that make up the coral reefs is no longer in balance. Already noticeable effects such as coral bleaching have been seen to be on the increase where the croal becomes white a, brittle and easily broken. As the ocean absorbs more CO2 it becomes acidic which effects coral, zooplankton and other sea animals with exoskeletons

Comment [n2]: Shell and acid ext rates of reaction

Fish will also migrate if their food source is changed, the temperature or water quality changes or they will die. This will affect the whole food chain including humans relying on fish for food.

For more information on the effects on biodiversity and the effects of acidification in the Pacific, refer to the *Climate Change education the Pacific Way – Kiribati* resource, SPC/GIZ

Is climate change happening?
Strong hurricanes, droughts, heat waves, wildfires and other natural disasters may become common place in many parts of the world.

Ocean Acidification

The chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere Increasing carbon dioxide levels in the atmosphere are causing ocean water to become more acidic, threatening the survival of shell-building marine species and the entire food web of which they are a part. Visit www.climate.noaa.gov/education.

ACTIVITY. OCEAN ACIDIFICATION EXERCISE

The effects of ocean acidification can be shown easily if students collect small pieces of shell or coral and wash them carefully. Tell your students to do the following.

1. Wrap a piece of Sellotape closely around part of the shell.
2. Make a 50% solution of vinegar and water or squeeze some lemon or lime juice into the water – make sure it tastes 'sour'. (Students could also make carbonic acid in water by blowing into the water through a straw, but this will take a while.)
3. Place the wrapped shell in the acid solution and leave it overnight.
4. Unwrap the shell – it should look white and smooth on the part that was not covered and, under the Sellotape, it should be the original colour and roughness.

You may need to experiment beforehand to get the right strength that will erode the shell or coral. Shells vary in their hardness. If you want to make it very effective use eggshell – it may disappear altogether! This is what can happen to plankton skeletons in acidic water.

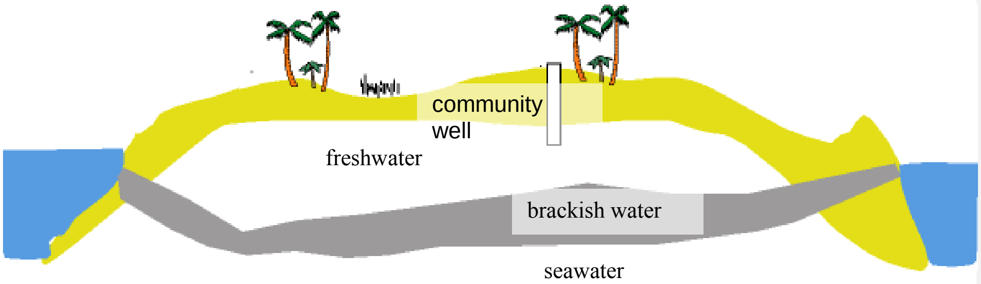
If you have the sheets of plastic covering used for covering exercise books and shelves, students can cut themselves a piece and then cut out their initial inside the square. When they put their plastic over a shell and leave it in the acidic water overnight, their initial will appear on the surface of the shell, etched by the acid

Erosion

With a rise in sea level and more frequent storm surges and cyclones, coastal land will be washed away. All this is on top of the effects of sedimentation being washed out to sea through Man's activities including deforestation, and pollution (eg sewage). The result will see the coral reefs crumble and the coastline become unprotected from the wave action.

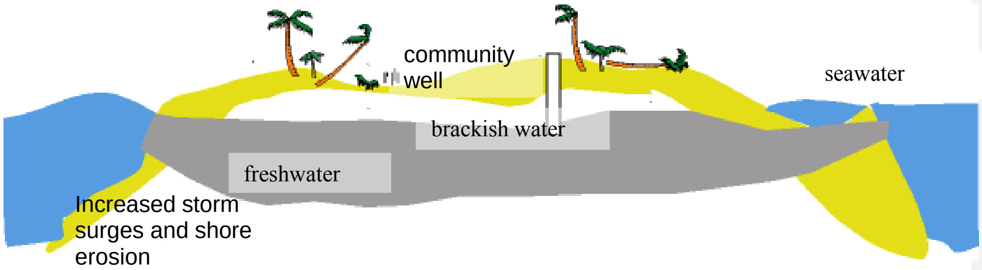
Water Quality

The land that makes up the island's landmass is usually porous. That means freshwater can filter through them. This is a natural way for water to be stored. The layer of freshwater stored this way is called an aquifer. Communities use this aquifer to provide for freshwater, often in the form of wells.



Since the rock is porous, seawater can also seep into the rock strata. Seawater is more dense, and combined with the effect of sea level, the saltwater sits deep in the rock. Where the two layers of water meet, the water becomes brackish.

As sea levels rise, there is a likelihood of the freshwater layer becoming thinner. The saltwater will be naturally higher in the rocks. This contaminates the well with brackish water, damages the soil and reduces food crop production. What could make matters worse, is a decline in rainfall, even droughts.



Changing Weather patterns
Incidents of extreme weather are projected to increase as a result of climate change. Many locations will see a substantial increase in the number of heat waves they experience per year and a likely decrease in episodes of severe cold. Precipitation events are expected to become less frequent but more intense in many areas, and droughts maybe more frequent . Check PACCSAP for specific detail for Kiribati and Climate Change the Pacific Way – Kiribati.

Is climate change happening?
Arctic sea ice cover has shrunk from 7.9 million sq kilometres to 4.7 million sq kilometres in 28 years.t

So what?

Climate information can be used to reduce vulnerabilities or enhance the resilience of communities and ecosystems affected by climate change. Continuing to improve scientific understanding of the climate system and the quality of reports to policy and decision-makers is crucial. Observations, experiments, and theory are used to construct and refine computer models that represent the climate system and make predictions about its future behaviour. Results from these models lead to better understanding of the linkages between the atmosphere-ocean system and climate conditions and inspire more observations and experiments. Over **time, this iterative process will result in more reliable projections of future climate conditions**

Actions

A combination of strategies is needed to reduce greenhouse gas emissions. The most immediate strategy is conservation of oil, gas, and coal, which we rely on as fuels for most of our transportation, heating, cooling, agriculture, and electricity. Short-term strategies involve switching from carbon-intensive to renewable energy sources, which also requires building new infrastructure for alternative energy sources. Long-term strategies involve innovative research and a fundamental change in the way humans use energy.

Actions taken by individuals, communities, states, and countries all influence climate. Practices and policies followed in homes, schools, businesses, and governments can affect climate. Climate-related decisions made by one generation can provide opportunities as well as limit the range of possibilities open to the next generation. Steps toward reducing the impact of climate change may influence the present generation by providing other benefits such as improved public health infrastructure and sustainable built environments.

Action can be defined in 2 ways;

Mitigation Humans may be able to mitigate climate change or lessen its severity by reducing
greenhouse gas concentrations through processes that move carbon out of the atmosphere or reduce greenhouse gas emissions

and.

Adaptation; Humans may be able to change behaviour to help them cope with climate change in three main areas – food security and production, coastal zone management and water resource management.

For more information on mitigation and adaptation definitions and activities in the Pacific, refer to the *Climate Change education the Pacific Way – Kiribati* resource, SPC/GIZ

Is climate change happening?
Glaciers around the world could melt, causing sea levels to rise while creating water shortages in regions dependent on runoff for fresh water.

Stories.

Example One; Wind Power in Vanuatu.

Vanuatu is one of the participating PICs in the PIGGAREP and one of the activities in its 2011/2012 Work Plan and Budget is a Wind Power Monitoring Development Project. The project involved the installation of six complete wind monitoring systems at 'hot spot' sites on all provinces of Vanuatu in the following island locations: Vanua Lava, Pentecost, Santo, Malekula, Tongoa and Tanna. The sites were identified during a scoping mission carried out between June and September 2009 by the Vanuatu Energy Unit.

Example Two; UC installing solar panels providing power to Tongan schools.

The University of Canterbury has just installed photo-voltaic solar panel systems on five Tongan high schools, in a project funded by government through Rotary NZ Worldwide Community Services and led by EcoCARE Pacific Trust. The ultimate goal will be to install solar power system in all 36 Tongan schools on 21 different islands.
``The aim of the project was to design and install PV solar power systems in five Tongan high schools to help reduce their electricity consumption and reduce their hefty diesel-fuelled power bills; enabling the savings to be spent on other educational requirements'' Professor Bodger said

Adaptation: Humans can adapt to climate change byreducing their vulnerability to its impacts. Actions such as moving to higher ground to avoid rising sea levels, planting new crops that will thrive under new climate conditions, or using new building technologies represent adaptation strategies. Adaptation often requires financial investment in new or enhanced research, technology, and infrastructure.

Example Three; Kiribati.

The Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP) had commissioned a feasibility study in late 2011 and early 2012 into the use of coconut oil to substitute fossil fuel in Kiritimati Island (Line Islands in the far east of Kiribati) for power generation and transportation.

This feasibility study, conducted by Gehard Zieroth, concluded that CNO is technically, economically, socially, institutionally and environmentally feasible, hence could address the energy security issues of Kiritimati Island and the whole of Kiribati.

Example Four; Tuvalu.

According to Natano, available freshwater in urban areas such as Funafuti will be under additional strain from climate change and population growth, and people are likely to face water scarcity to the point where the nations' social and economic development is threatened.

"Like any developing nation, this challenge is much too large for Tuvalu to address alone. We need to work and leverage the efforts of our nation, the international community, and partners in the non-profit and private sectors.

"We have had increasing success with simple solutions such as water tanks and large storage concrete tanks, and these simple solutions continue with the introduction of Falevatie or Composting Toilets."

Tausi said that the Falivatie was introduced to the people of Tuvalu as an adaptation option to assist them in their water problems.

"Literally translated means 'house that doesn't use water and is good for the environment' capturing the whole idea of water conservation.

The Composting Toilets is a water conservation measure jointly coordinated by the PACC Project of the Secretariat of the Pacific Regional Environment Programme (SPREP), and the IWRM Project of the Pacific Islands Geosciences Commission (SOPAC).

Example 3; SALT RESISTANT food crops will be put on trial for the first time as a step towards adapting to climate change impacts for people living in our low lying islands.

This will be made possible under the current adaptation to climate change project that is currently in process on its first phase at Ontong Java.

Pacific Adaption to Climate Change (PACC) Project National Coordinator Casper Supa told Island Sun in an exclusive interview that the initial idea was to find a new farming system that is suitable for the low lying islands within the country. Food crops will have to be salt resistant, so they survive the changing infertility of the available soil.

"Currently the idea is working with the relevant Ministries responsible in finding possible means and avenue to identify and test hybrid food crops" said Supa.

He added, if the outcome is positive it will then be implemented on a medium term, while the government deliberate on further strategies.

This will have a profound impact on the availability of balanced diet, especially to those who depend very much on marine resources for food.

Example Five: Nauru solar water purifiers

Fredrick Cook, a father of nine would go a long way in ensuring there is quality water for him and his family.

Like other small islands in the Pacific, Cook's island home Nauru faces water problems and has many water safety and conservation concerns.

Under the Pacific Adaptation to Climate Change Project newly installed solar purifiers have helped address these concerns and for Cook, this has helped supply more quality drinking water for him and his family.

"We're very happy with the results of the Solar Water Purifiers, we use the water for drinking and cooking and we are looking forward to having the water outlet directed to our water tank."

He added they now collect at least 30 to 40 litres of drinkable water daily.

Taken from; http://www.sprep.org/Pacific-Adaptation-to-Climate-Change/Success-Stories/

ACTIVITY : WHAT IS HAPPENING AND WHAT CAN WE DO?

A lot of work is being done by scientists to understand the role of the oceans, atmosphere and how they affect the weather.

One thing is definitely known: The Greenhouse Effect is changing our climate.
The changes include:
Warming of the earth's atmosphere,
Sea levels rising,
Change in weather patterns e.g. more droughts or more rainfall in some areas,
Change in agriculture practices,
New health threats caused by unfamiliar diseases,
Lack of drinking water,
Threats to wildlife and coral reefs,

Survey: What do people think is happening?

What you will need: Pen and large sheets of paper. Groups of 3-4 people.

What to do:
In your group decide on a series of questions that you think might tell you something about what people think about climate change.
They can be simple questions like:
Do we seem to be getting more rain? Is our rainfall changing?
Are we getting more storms?
Is the fishing as good as it used to be?
How has the reef near the village changed?
Is the sea coming up the beach further?

There are many more, but decide on the five best ones.
Now decide who you are going to ask. Who would be the best people to get your information from? Who has lived in your village for a long time? Each group member should ask at least 3 people.

When you have the information:
Draw up a table to record people's comments. Think of ways that you can group their answers.

It could be something like this:

NAMES	More rain	More storms	More cloud	Less rain
Joe				
Mary				

Look for any common statements recorded by people in your group.
Is there anything in common about what the people you surveyed think is happening to the climate?

Could you rewrite any of these as **issues.**

ACTIVITY: LOOKING FOR SOLUTIONS

What you will need: Pen and large sheets of paper. Groups of 3-4 people.

What to do: The sheet below is called an Environmental Action Planner.

Divide up your large sheet of paper into the sections shown on the template.

Pick one of the issues from your survey above.

Write this into the box: "What is the Issue?"

Work your way through the rest of the boxes. You don't have to do them in any particular order.
You may find that there are a lot of things to consider and you have to cut down on these in order to make it workable.

Remember: Your solutions need to be workable for you.

Environmental Action Planner