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To Use:
1. Students can form small groups of 3-4
2. Students read each card in turn, starting with the key question
3. Each student in the group has a chance to explain which comment they think answers the question best, and give their reasons why.
4. The group comes to a consensus together about which comment they can all agree with, or there may be more than one, and they record it underneath each written question.
5. After all of the groups have finished, the whole class comes together to discuss each question.
6. Each group can get up in turn to present a question each, stating their selected answer. Other students can question from the floor.
7. “Scientist says” slides are available for the teacher to sum up after each card. At this point further questions can be asked.
Are humans responsible for climate change?

The climate is always changing, and it has changed many times in the past.

It has not really been long enough to know if the climate is changing or not.

Waste created from Human activity is the main reason for climate change today.

What the scientists say:

We have been able to collect evidence, and use models, to tell the difference between natural sources and human sources of climate change. Evidence also shows that human made CO₂ is the main cause of climate change.

(Center for climate and energy solutions)

Are humans responsible for climate change?
Do scientists agree that human activity has caused climate change?

There are scientists on both sides who agree and don’t agree.

Scientists can’t tell yet. We need more time, and observations, to see if climate change has been caused by human activity.

Nearly all scientists agree that recent climate change has been caused by human activity.

What the scientists say:

Over 97% of climate scientists agree that human activity is the main cause of recent climate change. Scientists publish their research in journals, that is checked by other scientists. Large scientific organisations around the world have also made public statements that agree with climate scientists. (NASA)

Do scientists agree that human activity has caused climate change?
Has human activity affected the carbon cycle?

It makes no difference to climate change where the carbon is found – as the total amount never changes.

By burning fossil fuels, we move the carbon into the atmosphere.

We can’t affect the carbon cycle, as it is a natural process.

What the scientists say:

Humans increase the shift of carbon, locked up in fossils fuels, into the atmosphere, by using them as fuels. This also increases the amount of CO₂ moving into the ocean. Due to human activity, the CO₂ levels in the atmosphere are higher than at any time in the last 800,000 years, and the influence on the climate system is clear. (IPCC)

Has human activity affected the carbon cycle?
What causes the Greenhouse effect?

More heat energy is getting into the atmosphere than getting out.

It is caused by Humans heating up the Earth.

Maybe the heat travels to Earth in another form of energy, and some stays once it is here.

What the scientists say:
The Greenhouse Effect allows heat to remain 'trapped' in the atmosphere around Earth. This is important, so that it is warm enough for life to survive. Energy from the Sun travels to the Earth mostly as light. Light passes through the atmosphere easily to reach the Earth's surface, and then it is absorbed. Energy is then 'emitted' from the cooler earth mostly as heat. Heat energy is absorbed by greenhouse gases such as CO₂, and prevented from escaping from the atmosphere. This is called the Greenhouse Effect. (IPCC)
All gases in the atmosphere are greenhouse gases.

Which gases are Greenhouse gases?

I think carbon dioxide is the main greenhouse gas.

I think smog, caused by pollution, is the worse greenhouse gas.

What the scientists say:

Carbon dioxide ($CO_2$) is naturally found in the atmosphere, and it is able to absorb heat emitted from Earth (transformed from Sun light) to keep the Earth warm, so it is called a Greenhouse gas. Methane and water vapour also act as greenhouse gases, but they disappear from the atmosphere quicker, so have less effect than $CO_2$. Pollution and smog are not greenhouse gases. Human activity is increasing the amount of greenhouse gases in the atmosphere, especially $CO_2$, so the Earth is becoming warmer. (IPCC). The more $CO_2$ in the atmosphere, the more heat is absorbed. The Earth’s atmosphere heats up as more energy enters than released, changing the Earth’s ‘energy budget’.
Do colder years mean climate change is slowing down?

What the scientists say:
Short time periods (less than 10 years), can show some cooling, which lead some people to think climate change is not true. Climate refers to longer term patterns of over 30 years, and this shows that the average surface temperature of the Earth has increased. Powerful computers, based on observations, can help scientists predict, with much confidence, that the Earth will continue to warm, due to human created climate change.

(Center for climate and energy solutions)
I think the ozone hole causes global warming

I think the ozone hole lets another type of energy from the Sun through, but not enough to cause global warming.

If there is more ozone in the atmosphere, it would mean more warming.

Does the hole in the ozone layer contribute to global warming?

What the scientists say:

The ozone hole does not cause global warming. The ozone hole, which forms in spring over Antarctica, is a thin patch of ozone (O₃) gas. It was caused by pollutants like CFC, found in refrigerators and spray cans, but they are banded now. Ozone blocks UV light only (less than 8% of all energy from the Sun), and the hole allows an even smaller amount through. This additional amount of energy is too small to have any impact on global warming, and therefore, climate change. (climate.gov)

Does the hole in the ozone layer contribute to global warming?
Does melting sea ice from the Arctic sea cause the sea level to rise?

Only land ice, like that on Antarctica and in glaciers, cause the sea level to rise.

As the iceberg melts, the sea level rises by the same amount.

All melting ice and snow around the world makes the sea level rise.

What the scientists say:

Sea level rise is a consequence of climate change. Warming temperatures are causing the melting of the cryosphere (ice and snow on Earth), and much of this is travelling into the oceans as water, causing the sea-level to rise. However, sea ice, such as that floating in the Arctic, is already in the water, and will not change the volume of water added to the ocean. Climate change also causing the oceans to get warmer, as the water absorbs heat. This causes heat expansion of the water and also adds to sea level rise. (NASA)

Does melting sea ice from the Arctic sea cause the sea level to rise?
Can animals adapt to climate change?

We can just move animals to cooler areas ourselves.

Animals can adapt, they just need to move to cooler areas.

Climate change is happening too quickly for most species to adapt or move to cooler areas.

What the scientists say:

Some animals can move higher up, or closer to the poles, to escape warming temperatures, but different food and competition may mean it is difficult for them to survive. Some animals are at the farthest extent of their range, and there is nowhere left to go. Man-made structures may also prevent movement to cooler areas. Human-created climate change is occurring quicker than natural climate change, and may be too quick for most species to adapt to. (Earth Institute)
Renewable energy is just about saving the environment from pollution.

Does switching to renewable energy stop climate change?

Using renewable energy, rather than burning coal and oil, is one way we can slow down climate change.

Climate change can be stopped, if we only use renewable energy.

Mitigation solutions reduce or remove greenhouse gas emissions of CO2, to slow further climate change. Most CO2 comes from humans’ burning fossil fuels for energy to generate electricity, transport, and industry. Renewable energy does not use fossil fuels. Energy generation produces over two thirds of global greenhouse emissions. Mitigation occurs when we produce electricity using renewable resources, such as hydro, wind or solar energy, instead of burning fossil fuels, and is an important way we can reduce the impact of global warming.
<table>
<thead>
<tr>
<th>Statement</th>
<th>Weather, or climate?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. January 2018 (New Zealand mean temperature 20.3°C; 3.1°C higher than the 1981-2010 January average) was New Zealand’s hottest month on record, which of course means it was additionally the country’s hottest January on record <a href="https://www.niwa.co.nz/climate/monthly/climate-summary-for-january-2018">https://www.niwa.co.nz/climate/monthly/climate-summary-for-january-2018</a></td>
<td>Both</td>
</tr>
<tr>
<td>2. With a mean annual rainfall of 6,412 mm each year, a high level even for the West Coast, Milford Sound is known as the wettest inhabited place in New Zealand and one of the wettest in the world. Rainfall can reach 250 mm (10 in) during a span of 24 hours. <a href="https://en.wikipedia.org/wiki/Milford_Sound">https://en.wikipedia.org/wiki/Milford_Sound</a></td>
<td>Both</td>
</tr>
<tr>
<td>3. On 23rd September, 2018, the temperature in Cambridge reached a high of 16°C <a href="https://www.windy.com">https://www.windy.com</a></td>
<td>Weather</td>
</tr>
<tr>
<td>4. Snow is more common inland in both main islands of New Zealand, though snow to sea level does occur on average once or twice per year in the central and southern South Island. <a href="https://en.wikipedia.org">https://en.wikipedia.org</a></td>
<td>Climate</td>
</tr>
<tr>
<td>6. In New Zealand generally there are relatively small variations between summer and winter temperatures, although inland and to the east of the ranges the variation is greater (up to 14°C) <a href="https://www.niwa.co.nz">https://www.niwa.co.nz</a></td>
<td>Both</td>
</tr>
<tr>
<td>7. NEW ZEALAND HERALD “Severe rain warnings after flooding overnight” 9 Jul, 2018 <a href="https://www.nzherald.co.nz">https://www.nzherald.co.nz</a></td>
<td>Weather</td>
</tr>
<tr>
<td>8. 25 July and 14 August 2011 New Zealand snowstorms: The first severe winter storm brought the coldest winter snap in fifteen years. During August snow fell consistently down to sea level in Wellington for the first time since 1976, and snowflakes even fell for a brief time in Auckland for the first time in 80 years. <a href="https://en.wikipedia.org">https://en.wikipedia.org</a></td>
<td>Climate</td>
</tr>
<tr>
<td>9. Antarctica is the coldest, windiest and driest continent. Scott Base is New Zealand’s permanent Antarctic base. Sited on the coast, temperatures, although very low, are higher than those recorded inland. <a href="https://www.niwa.co.nz">https://www.niwa.co.nz</a></td>
<td>Both</td>
</tr>
<tr>
<td>10. Future High and low temperature extremes in New Zealand: “Increasing temperatures result in more “hot days” and fewer frosts. New Zealand does not experience the extreme high temperatures that occur in many other parts of the world. A daily maximum temperature threshold of 25°C has therefore been chosen to mark a “hot day” <a href="https://www.niwa.co.nz">https://www.niwa.co.nz</a></td>
<td>Both</td>
</tr>
</tbody>
</table>
Weather or Climate?
<table>
<thead>
<tr>
<th>Date</th>
<th>Rain Gauge reading mL</th>
<th>Air Temperature °C at 1.30pm</th>
<th>Weather description (see above)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
The climate system is an interactive system consisting of five major components: the **atmosphere**, the **hydrosphere**, the **cryosphere**, the **land surface** and the **biosphere**, influenced by various **forcing mechanisms**, the most important of which is the Sun. Any change, whether natural or human caused, in the components of the climate system and their interactions, may result in climate changes. (IPCC)

1. Label the five components above.
2. Use information from the diagram, and the word bank, to label some interactions between components.

- **Word Bank:** weathering, evaporating, freezing, photosynthesis, respiration, plant/leaf litter, precipitation, combustion, melting, volcanic eruptions, transpiration, plant water uptake, permafrost melting

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1.2.3. digital poster of climate features

Adapted from [http://www.gisacclimate.org/node/2418](http://www.gisacclimate.org/node/2418)
The climate system is an interactive system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, forced or influenced by various forcing mechanisms, the most important of which is the Sun. (IPCC). Use information from the diagram to complete chart below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Comprised of:</th>
<th>How can Human Activity influence this component?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>N₂, O₂, Ar, H₂O, CO₂, CH₄, N₂O, O₃, aerosols</td>
<td></td>
</tr>
<tr>
<td>Hydrosphere</td>
<td>Rivers, lakes, oceans</td>
<td></td>
</tr>
<tr>
<td>Cryosphere</td>
<td>Sea ice, ice sheets, glaciers, and permafrost</td>
<td></td>
</tr>
<tr>
<td>Land surface</td>
<td>The top layer of the Earth, exposed to the atmosphere</td>
<td></td>
</tr>
<tr>
<td>Biosphere</td>
<td>All living organisms found below, above and on the land</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Formula</td>
<td>Model</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>carbon (graphite / diamond)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>carbon dioxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>methane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>CaCO₃</td>
<td></td>
</tr>
<tr>
<td>glucose</td>
<td>C₆H₁₂O₆</td>
<td></td>
</tr>
<tr>
<td>carbonic acid</td>
<td>H₂CO₃</td>
<td></td>
</tr>
<tr>
<td>oil</td>
<td>Carbon and hydrogen molecules</td>
<td></td>
</tr>
<tr>
<td>coal</td>
<td>Mostly carbon</td>
<td></td>
</tr>
</tbody>
</table>
1. Write in correct processes and carbon store (reservoir) terms from word bank.

2. Colour in the processes that you think human activity could influence.

Possible stores (reservoirs):
- Atmosphere
- Ocean
- Lithosphere
- Biosphere
- Fossil fuel
- CO₂ (atmosphere)
- Soil organic matter
- Aquatic biomass
- Limestone & Dolomite
- Coal, Oil & Gas
- Marine deposits

Possible processes:
- Diffusion
- Decomposition
- Respiration & emissions
- Fossil fuel
1. Write in correct process and carbon reservoir terms from word bank.

2. Colour in the arrows that you think human activity could influence.

Possible reservoirs:
- Atmosphere
- Plants
- Soil
- Sedimentary rocks
- Coal
- Oil
- Gas
- Ocean floor
- Rocks
- Deep ocean
- Benthic layer
- Phytoplankton
- Ocean surface
- Rocks
- Sedimentary rocks
- Coal
- Oil
- Gas

Possible processes:
- Photosynthesis
- Respiration
- Soil respiration
- Decomposition
- Volcano eruption
- Burning fossil fuels
- Weathering and erosion
- Diffusion
- Sinking
- Rock cycle
- Weathering and erosion
- Diffusion
- Sinking

Adapted from https://serc.carleton.edu/download/images/5694/4/global_carbon_cycle_1427132279.jpg
3.1.4 Earth’s Energy Budget

Adapted from http://www.ces.fau.edu/nasa/
Earth’s Energy Budget

1. Add the values to the correct labels on the diagram

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Energy (Watts/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL Incoming solar energy</td>
<td>340</td>
</tr>
<tr>
<td>TOTAL Reflected Solar energy</td>
<td>100</td>
</tr>
<tr>
<td>Solar energy absorbed by atmosphere</td>
<td>79</td>
</tr>
<tr>
<td>Solar energy down to surface</td>
<td>185</td>
</tr>
<tr>
<td>Solar energy reflected by surface</td>
<td>24</td>
</tr>
<tr>
<td>Solar energy absorbed by surface</td>
<td>161</td>
</tr>
<tr>
<td>Heat from Evaporation</td>
<td>84</td>
</tr>
<tr>
<td>Sensible heat</td>
<td>20</td>
</tr>
<tr>
<td>TOTAL Outgoing heat (thermal) energy</td>
<td>239</td>
</tr>
<tr>
<td>Heat (Thermal) energy up from surface</td>
<td>398</td>
</tr>
<tr>
<td>Heat (Thermal) energy down from surface</td>
<td>342</td>
</tr>
</tbody>
</table>

2. Calculating Earth’s Energy Budget

<table>
<thead>
<tr>
<th>Total of all Solar (light) energy into Earth’s atmosphere</th>
<th>Total of all outgoing solar (light) energy from Earth’s atmosphere</th>
<th>Total of all heat (thermal) energy leaving Earth’s atmosphere</th>
<th>TOTAL of all energy reaching Earth’s atmosphere</th>
<th>TOTAL of all energy leaving Earth’s surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

3. Difference in energy IN and energy OUT _______________w/m² in the atmosphere

4. What effect will this difference have on Earth’s overall energy, and therefore temperature?

________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________

5. Discuss what might happen to the Earth’s energy budget in these two following scenarios
a. Increase of Carbon dioxide emissions (Greenhouse gas)
b. Decrease of land ice from increasing warming, reducing light reflected by surface (Albedo effect)

________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________

O 3.14. Earth’s Energy Budget

Energy budget values based on IPCC AR5
Earth’s Energy Budget

1. Add the values to the correct labels on the diagram

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Energy (Watts/m²)</th>
</tr>
</thead>
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<tr>
<td>TOTAL Incoming solar energy</td>
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<td>Heat (Thermal) energy up from surface</td>
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<td>Heat (Thermal) energy down from surface</td>
<td>342</td>
</tr>
</tbody>
</table>

2. Calculating Earth’s Energy Budget

<table>
<thead>
<tr>
<th>Total of all Solar (light) energy down to Earth’s surface</th>
<th>Total of all solar (light) energy reflected from Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of all heat (thermal) energy to Earth’s surface</td>
<td>Total of all heat (thermal) energy leaving Earth</td>
</tr>
<tr>
<td>TOTAL of all energy reaching Earth’s surface</td>
<td>TOTAL of all energy leaving Earth’s surface</td>
</tr>
</tbody>
</table>

3. Difference in energy IN and energy OUT _______________ w/m² onto Earth’s surface

4. What effect will this difference have on Earth’s overall energy, and therefore temperature?

________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________

5. Discuss what might happen to the Earth’s energy budget in these two following scenarios
   a. Increase of Carbon dioxide emissions (Greenhouse gas)
   b. Decrease of land ice from increasing warming, reducing light reflected by surface (Albedo effect)

________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
1. Use the following data to continue plotting a line graph of CO₂ concentration in the atmosphere over time. Use a ruler to find correct concentration reading.

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ data collected</th>
<th>CO₂ concentration in the atmosphere (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>317</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>325</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>331</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>339</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>346</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>354</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>361</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>370</td>
<td></td>
</tr>
</tbody>
</table>

Year CO₂ data collected | CO₂ concentration in the atmosphere (ppm)
2002 | 373
2004 | 377
2006 | 382
2008 | 385
2010 | 389
2012 | 394
2014 | 399
2016 | 403
2018 | 407 (currently)

data collected from Mauna Loa, Hawaii observatory
For each of the cards

1. As a group, look at each card.
2. Talk about what you think it represents prior to looking at the questions for this station.
3. Feel free to ask each other questions about parts of the graph that you don’t understand or point out parts of the graph that you think are important. It is helpful to start by identifying what each axis represents.
4. After looking at the graph, read the questions for this station that appear below. Discuss each question as a group.
5. After you are finished discussing the questions, individually answer the questions for each station.

Cards

1. Temperature
2. Temperature Predictions
3. Sea Level Rise
4. Sea Level Rise Predictions
5. Rainfall Predictions
6. Extreme Temperatures
7. Melting Glacier
8. Extreme Weather Events
Card 1. Temperature

Use the following information to make an evidence supported claim.

1. What is the difference between the blue dots and the red line?

2. How much has temperature, in degrees Celsius, changed since 1880?

3. Now make an evidence supported claim about mean surface temperature in New Zealand.

Graph attributed to: MrFebruary - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=46210465
Card 2. Temperature predictions

Use the following information to make an evidence supported claim.

Predicted increase in average temperature (°C) by 2090, relative to 1986-2005. (for highest CO₂ emissions prediction)

Graph attributed to: https://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios

1. Which season will experience the most impact from the temperature increase, created from climate change?

2. Why do you think some areas of New Zealand experience a difference in temperature increase??

3. Now make an evidence supported claim about the 2090 predicted mean surface temperature in New Zealand.
Card 3. Sea Level Rise

Use the following information to make an evidence supported claim.

1. What are the two main processes that are contributing to sea level rise?

2. What ‘melting’ does not contribute to sea level rise, and why?

3. What is the total sea level rise from

Card 4. Sea Level Rise Predictions

Use the following information to make an evidence supported claim.

1. Why does the most recent instrumental recording have the narrowest range of sea level rise?

2. Why does the range for the projections of the future sea level rise get larger as time goes by?

3. Now make an evidence supported claim about the global sea level rise.

Sourced from: http://thebritishgeographer.weebly.com/sea-level-change.html
Card 5. Rainfall Predictions

Use the following information to make an evidence supported claim

Predicted increase in precipitation (rainfall) (%) by 2090, relative to 1986-2005. (for highest CO₂ emissions prediction)

Sourced from: https://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios

Card 5

1. What areas of New Zealand are projected to get drier by 2090, due to Climate change?

2. What areas of New Zealand are projected to get wetter by 2090, due to Climate change?

3. Now make an evidence supported claim about the predicted changing precipitation rates in New Zealand.
Card 6. Extreme temperatures

Use the following information to make an evidence supported claim

Predicted change in number of extreme temperature days by 2090, relative to 1986-2005. (for highest CO₂ emissions prediction)

Number of days change from 1986-2005 average time period

Sourced from: https://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios

Card 6

1. What areas of New Zealand are projected to have more hot days by 2090, due to Climate change?

2. What areas of New Zealand are projected to have fewer frosts by 2090, due to Climate change?

3. Now make an evidence supported claim about the predicted changing extreme hot AND cold days in New Zealand.
Card 7. Melting Glaciers

Use the following information to make an evidence supported claim.

Change in Fox Glacier, West Coast, New Zealand from 2008 to 2014

![Change in Fox Glacier, West Coast, New Zealand from 2008 to 2014](http://glacierhub.org/2016/07/26/as-glaciers-melt-tourists-keep-on-coming-in-new-zealand/)

Change in Franz Joseph Glacier, West Coast, New Zealand from 2009 to 2013

![Change in Franz Joseph Glacier, West Coast, New Zealand from 2009 to 2013](http://glacierhub.org/2016/07/26/as-glaciers-melt-tourists-keep-on-coming-in-new-zealand/)

Card 7

1. Where do you think the ice/snow from the glaciers is going?

2. What do you think is eventually going to happen to the glaciers?

3. Now make an evidence supported claim about the change in size of the Glaciers in New Zealand.
Card 8. Extreme Weather Events

Use the following information to make an evidence supported claim.

Numbers of Extreme Weather event from 1980 to 2014

1. What type of events have increased the most from 1980 to 2014?
2. Which events are not attributed to Climate change?
3. Now make an evidence supported claim about the change in Extreme weather Events in New Zealand.
The Albedo Effect is the result of different coloured surfaces reflecting, and absorbing different wavelengths (colours) of visible light. White surfaces reflect all wavelengths of visible light, and black surfaces absorb all wavelengths. Different colours have different energy waves, with red at a lower energy than green and violet.

1. Place a digital thermometer probe through the top of a polystyrene cup, so the probe nearly touches the bottom.
2. On a sunny day move around to several ground surfaces such as grass, concrete, dirt, and a white board left out in the sun for at least 30mins.
3. Place the cup down firmly on the surface, and once the temperature stabilises, record the surface type, colour and temperature.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Colour of surface</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. What coloured surface had the highest temperature reading? ________________________________
2. What explanation can you give for this?
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

3. What coloured surface had the lowest temperature reading? ________________________________
4. What explanation can you give for this?
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

5. If ice and snow melt, caused by raising global temperatures, caused darker rock or earth underneath to be exposed, how do you think this might effect the temperature of the surrounding area?
   ___________________________________________________________________________________
   ___________________________________________________________________________________
Climate change is causing the world to heat up. All of the frozen ice and snow around the world, together called the cryosphere, is melting because of the temperature increase. Some ice sits on top of land, such as the Antarctica and Greenland ice shelves, as well as the Glaciers around the world. Other ice floats on the sea, such as the Artic ice. Melting ice is causing the Sea level to rise—but what melting ice? This investigation helps us to understand what is causing sea level rise.

What conclusion can you make about the results of this investigation? And how does this relate to whether sea ice or land ice contributes to sea level rise?

________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________

Using your science ideas, why do you think you got the results you did?

________________________________________________________________________________________________________
________________________________________________________________________________________________________
________________________________________________________________________________________________________

1. Set up 2 large beakers, with an inverted smaller beaker in each. Place 3 ice cubes around the bottom of Beaker A, and on Beaker B place the 3 ice cubes on top of the inverted beaker.
2. Fill each with the same volume of water (but not above the inverted beaker – where the ice cubes sit in Beaker B).
3. Place a heat source (lamp) close to each and record volume in each beaker every 2 minutes until all the ice melts.

<table>
<thead>
<tr>
<th>Time</th>
<th>Volume of Sea ice (A) in mL</th>
<th>Volume of land ice (B) in mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting time (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2mins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4mins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6mins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final time (when all of the ice is melted)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Our homes are changing

<table>
<thead>
<tr>
<th>Our stories</th>
<th>Who am I?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I eat tiny crustaceans called krill, which live on the undersides of Antarctic ice sheets. The ice sheets are melting, and I have to go further and further to find food. I now have less energy to raise my young.</td>
<td></td>
</tr>
<tr>
<td>I can grow in dry and hot conditions, but climate change is making my home drier and hotter than I can handle. I can't grow and spread quick enough to keep up with a fast-changing climate.</td>
<td></td>
</tr>
<tr>
<td>I need ice sea, so I can sneak up and hunt for seals in spring and summer, when my young are coming out into the world for the first time. I can't swim fast enough to catch the seals in the water, and I am going hungry.</td>
<td></td>
</tr>
<tr>
<td>I am very important to my ecosystem, and many other species rely on me for homes and protection. The algae, which lives inside me, and gives me a lovely colour, does not like any increase in temperature, so the warmer water is causing the algae to leave me!! I am starting to turn white.</td>
<td></td>
</tr>
<tr>
<td>I have to move to a new place to live, so I can find cooler areas to eat and breed. But when I move the food around me is different to what I like. If all the sea ice disappears, I may not have anywhere else to move to.</td>
<td></td>
</tr>
<tr>
<td>I lived in misty mountaintop cloud forests. Climate change has increased the amount of droughts around my home, making it too dry for me, and I have no where else to live. Nobody has seen me for over 30 years.</td>
<td></td>
</tr>
<tr>
<td>I have a very special diet and only eat one type of food. My food grows in dry places, but if climate change causes my home to be even drier it may not continue to grow here. I will need human help to move around and find more food.</td>
<td></td>
</tr>
<tr>
<td>I am quite rare already, and I have adapted to live in mountain areas away from humans. Climate change is causing humans to spread out into my home area, looking for new places to live. If I am chased away too many times I may have no where else to live.</td>
<td></td>
</tr>
</tbody>
</table>
Impacts to New Zealand Species due to Climate Change

Select a species card, use the chart to determine what threats a species may face, then discuss what adaptation solutions might help, and how.

- Changes in range and altitude
- Changes in mating and flowering
- Changes in local population numbers
- Changes in food availability
- Loss of habitat
- Increased range and population of pests
- New diseases introduced
- Increased range and numbers of pests
- Increased fire risk
- Increased water use by humans
- Changes in land use
- Use of land for renewable energy
- Coastal development

Changing Climate

Direct impacts

Biological threats

Indirect impacts

Human threats

Modified from: Adapting to a changing climate. DoC.
| **Shore plover** | This small, wading bird lives by the coast. It lays its eggs in rocks and grass close to the beach. The birds eat shoreline food found at low tide. Climate change may cause the nesting area to be covered with water due to sea level rise. |
| **Southern rock hopper penguin** | The penguin breeds in large colonies, on subantarctic islands to the south of New Zealand. The rockhopper penguin eats krill, squid, octopus, and fish, from the ocean, but climate change may shift where their food can be found, and this will affect survival of their chicks. |
| **Wrybill** | The wrybill lives in the ‘braided’ stony rivers of Otago and Canterbury. It lays camouflaged eggs amongst the stones, on mid river island to avoid pests. Climate change may increase spring flooding, covering the eggs which will then not hatch. |
| **Kakapo** | Adult kakapos are camouflaged with mossy green feathers. Breeding is timed with the ‘mast fruiting’ of the ‘rimu’ tree, which only occurs every two to five years. Climate change may affect when and how often this mast year occurs. |
Shore plover

This small, stocky wader is one of the world's most threatened coastal birds. During the breeding season from November to February, pairs will defend small territories containing their nest. The nests of the shore plover are well hidden amongst vegetation or between boulders, and both the male and female will take part in incubating the two to three eggs that are laid. Outside of the breeding season birds flock together but do not migrate. Their diet is made up of shoreline crustaceans, spiders, molluscs and insects, which are foraged from the sea-shore at low tide. Climate change may cause the nesting area to be covered with water due to sea level rise.

Southern rock hopper penguin

The southern rockhopper penguin breeds in large colonies, which is found on several subantarctic islands to the south of New Zealand, that may comprise over a hundred thousand nests. Breeding pairs are monogamous, and usually return to the same nest every year. The diet of the southern rockhopper penguin is composed of a variety of oceanic species, such as krill and other crustaceans, squid, octopus and fish. Groups of southern rockhopper penguins may often feed together, diving to depths of up to 100 metres in pursuit of prey. Climate change may shift where their food can be found, and this will affect survival of their chicks.

Wrybill

The wrybill is a distinctive wading bird, which possesses a uniquely bent bill. The laying season runs between September and October; a clutch of two eggs is laid into a slight depression amongst the gravel of braided rivers in Otago and Canterbury. Both parents take it in turn to incubate the eggs that are well camouflaged against the shingle, resembling the stones around them. Birds are forced to nest on islands in the middle of braided rivers as a result of predator pressure and river-edge habitat modification. Climate change may increase spring flooding, covering the eggs which will then not hatch.

Kakapo

Adult kakapos have beautiful mossy green plumage mottled with brown and yellow, which provides excellent camouflage against the forest floor. The kakapo is the only parrot to have a lek mating system. Breeding is erratic and slow, occurring every two to five years, and is dictated by the infrequent availability of super-abundant food supplies. One such event is the ‘mast fruiting’ of the 'rimu' tree (Dacrydium cupressinum), which only occurs every two to five years. The kakapo feeds on a variety of fruits, seeds, roots, stems, leaves, nectar and fungi. Climate change may affect when and how often this mast year occurs.
Tuatara

The ‘living fossil’ lives in burrows, where the female tuatara also lays her eggs. The sex of the tuatara is determined by the temperature at which the eggs are incubated, with higher temperatures producing males and lower temperatures producing females. Climate change is causing a temperature increase.

Takahe

This flightless bird prefer alpine tussock grasslands, and feeds mainly on the leaf bases and seeds of tussocks and other grasses. Habitat changes and the introduction of predators, such as stoats, can harm these birds. Climate change can impact survival of this species.

Lesser short-tailed Bat

This bat is more at home on the forest floor than flying through the treetops, and active in winter. Warmer winters, caused by climate change, makes bats need more insects for food when there may not be that many. The bats are important pollinator of the endangered woodrose, a parasitic plant of roots on the forest floor.

Archey’s frog

This small frog (3-4 cm) lives in damp forest habitats, in only a few small locations. Archey’s frogs make a tasty meal for rats, pigs, stoats, hedgehogs, possums, cats and introduced frogs. These rare frogs are at risk from Climate change effects.
Tuatara

An unusual and unique reptile found only in New Zealand, the tuatara (Sphenodon punctatus) has been dubbed a ‘living fossil’ as it is the only surviving member of an ancient group of reptiles that flourished during the time of the dinosaurs. The tuatara lives in burrows, either digging one itself or sharing the burrow of a nesting seabird. The female tuatara lays her eggs in spring, covered up by dirt, which do not hatch until 11-16 months later. The sex of the tuatara is determined by the temperature at which the eggs are incubated, with higher temperatures producing males and lower temperatures producing females. Climate change is causing a temperature increase.

Takahe

This unique flightless bird is roughly the size of a hen, making it the world’s largest rail. Once thought to be extinct, the birds are still very rare. Mainland populations prefer alpine tussock grasslands although they are also found in forest and sub-alpine shrublands. Island populations are found mainly on modified grassland habitat. The takahe feeds mainly on the leaf bases and seeds of tussocks and other grasses. Habitat changes and the introduction of predators, such as stoats, can harm these birds. Climate change causes an increase in Extreme weather events that can impact survival of young.

Lesser short-tailed Bat

The New Zealand lesser short-tailed bat is remarkable for the fact that it is the most terrestrial bat in the world; more at home on the forest floor than flying through the treetops. New Zealand bats are unusually active in winter compared with other temperate bats, and are therefore sensitive to warmer winters, caused by climate change, becoming more active and thus experiencing an increased demand for insect food at a time when it may be scarce. This species is an important pollinator of the endangered woodrose, a parasitic plant of roots on the forest floor.

Archeys frog

Archeys frog is our smallest native frog, growing up to 37 mm long. It occupies damp forest habitats above 400 m, but has been found as low as 100-200 m above sea level in the Coromandel. Mottled colours of red, green and brown make up the colour of the Archeys skin. Archeys frogs are modern-day dinosaurs. Almost unchanged from their 150 million-year old fossilised relatives, these little battlers are among the world’s oldest frogs and in desperate need of help. Archeys frogs make a tasty meal for rats, pigs, stoats, hedgehogs, possums, cats and introduced frogs. These rare frogs are at risk from Climate change effects.
Climate Change Adaptation solutions

- Supplementary feeding of species
- Changing their environment with plantings and building
- Translocation – moving species to another area
- Captive breeding programmes
- Increased Pest control in their habitat
- Design and make new pest proof protected areas
- Manage and restore ecosystem areas
- Keep human roads and buildings away from their habitat
The climate system is an interactive system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, forced or influenced by various forcing mechanisms, the most important of which is the Sun. (IPCC)

Use information from the diagram to complete chart below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Comprised of:</th>
<th>How can Human Activity influence this component?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>N\textsubscript{2}, O\textsubscript{2}, Ar, H\textsubscript{2}O, CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}O, O\textsubscript{3}, aerosols</td>
<td>More CO\textsubscript{2} and methane emissions into the atmosphere – increase greenhouse effect. Adding aerosols</td>
</tr>
<tr>
<td>hydrosphere</td>
<td>Rivers, lakes, oceans</td>
<td>Oceans act as heat reservoir. Heating oceans, due to climate change – more evaporation of water into atmosphere, increasing greenhouse effect. Also Sea level rise</td>
</tr>
<tr>
<td>cryosphere</td>
<td>Sea ice, ice sheets, glaciers, and permafrost</td>
<td>Increasing average temperature is melting cryosphere. Reduced surface ice is decreasing albedo effect (reflecting from ice) so more heat absorbed than reflected. Sea level rise</td>
</tr>
<tr>
<td>Land surface</td>
<td>The top layer of the Earth, exposed to the atmosphere</td>
<td>Changing land use, like agriculture/building/roads, can increase the amount of heat absorbed.</td>
</tr>
<tr>
<td>biosphere</td>
<td>All living organisms found below, above and on the land</td>
<td>Cutting down trees (for fuel) can add CO\textsubscript{2} to atmosphere. Trees remove CO\textsubscript{2} from atmosphere. Carbon stored in biosphere. Forests retain moisture/water</td>
</tr>
<tr>
<td>Name</td>
<td>Formula</td>
<td>Model</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Carbon (graphite/diamond)</td>
<td>C</td>
<td><img src="diamond.png" alt="Diamond" /></td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>CO₂</td>
<td><img src="carbon_dioxide.png" alt="Carbon Dioxide" /></td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>CaCO₃</td>
<td><img src="calcium_carbonate.png" alt="Calcium Carbonate" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>methane</td>
<td>CH₄</td>
<td><img src="methane.png" alt="Methane" /></td>
</tr>
<tr>
<td>glucose</td>
<td>C₆H₁₂O₆</td>
<td><img src="glucose.png" alt="Glucose" /></td>
</tr>
<tr>
<td>carbonic acid</td>
<td>H₂CO₃</td>
<td><img src="carbonic_acid.png" alt="Carbonic Acid" /></td>
</tr>
<tr>
<td>oil</td>
<td>Carbon and</td>
<td><img src="oil.png" alt="Oil" /></td>
</tr>
</tbody>
</table>
1. Write in correct processes and carbon store (reservoir) terms from word bank.

2. Colour in the processes that you think human activity could influence.
1. Write in correct processes and carbon reservoir terms from word bank.

2. Colour in the arrows that you think human activity could influence.
1. Calculating Earth’s Energy Budget

<table>
<thead>
<tr>
<th>Energy Flux (W/m²)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>340</td>
<td>Total of all solar (light) energy into Earth’s atmosphere</td>
</tr>
<tr>
<td>100</td>
<td>Total of all outgoing solar (light) energy from Earth’s atmosphere</td>
</tr>
<tr>
<td>239</td>
<td>Total of all heat (thermal) energy leaving Earth’s atmosphere</td>
</tr>
<tr>
<td>340</td>
<td>TOTAL of all energy reaching Earth’s atmosphere</td>
</tr>
<tr>
<td>339</td>
<td>TOTAL of all energy leaving Earth’s surface</td>
</tr>
</tbody>
</table>

2. Difference in energy IN and energy OUT 1 w/m² into Earth’s atmosphere

**Incoming solar TOA** (at the top of the atmosphere) = average solar radiation impinging on top of Earth’s atmosphere

**Solar reflected TOA** = solar radiation reflected by Earth’s atmosphere

**Solar down surface** = solar radiation hitting Earth’s surface

**Solar absorption surface** = solar radiation absorbed by Earth’s surface

**Solar reflected surface** = solar radiation reflected by Earth’s surface

**Thermal up surface** = heat radiated by Earth’s surface to atmosphere

**Sensible heat** = heat exchanged between Earth’s surface and atmosphere due to convection

**Thermal outgoing TOA** = heat radiated from Earth’s atmosphere to space

**Greenhouse gas effect** = back radiation to the surface from heat retained on Earth’s surface by greenhouse gases (CO₂, CH₄, N₂O)

**Evaporation** = heat conveyed from Earth’s surface to atmosphere by evaporation of water
### Earth’s Energy Budget

**1. Calculating Earth’s Energy Budget**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of all Solar (light) energy down to Earth’s surface</td>
<td>185</td>
<td>Total of all solar (light) energy reflected from Earth</td>
</tr>
<tr>
<td>Total of all heat (thermal) energy to Earth’s surface</td>
<td>342</td>
<td>Total of all heat (thermal) energy leaving Earth</td>
</tr>
<tr>
<td>TOTAL of all energy reaching Earth's surface</td>
<td>527</td>
<td>TOTAL of all energy leaving Earth’s surface</td>
</tr>
</tbody>
</table>

**2. Difference in energy IN and energy OUT**

- **Incoming solar TOA** (at the top of the atmosphere) = average solar radiation impinging on top of Earth’s atmosphere
- **Solar reflected TOA** = solar radiation reflected by Earth's atmosphere
- **Solar down surface** = solar radiation hitting Earth’s surface
- **Solar absorption surface** = solar radiation absorbed by Earth's surface
- **Solar reflected surface** = solar radiation reflected by Earth's surface
- **Thermal up surface** = heat radiated by Earth's surface to atmosphere
- **Sensible heat** = heat exchanged between Earth’s surface and atmosphere due to convection
- **Thermal outgoing TOA** = heat radiated from Earth's atmosphere to space
- **Greenhouse gas effect** = back radiation to the surface from heat retained on Earth's surface by greenhouse gases (CO₂, CH₄, N₂O)
- **Evaporation** = heat conveyed from Earth’s surface to atmosphere by evaporation of water

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![Diagram of Earth’s Energy Budget](image-url)