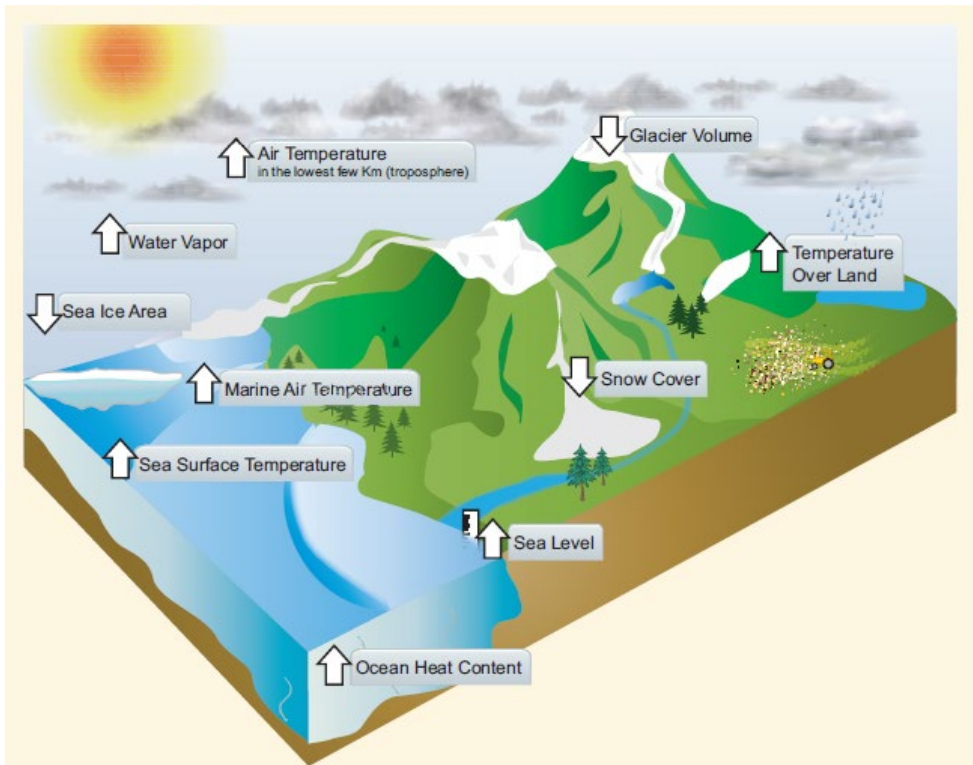




Climate signals

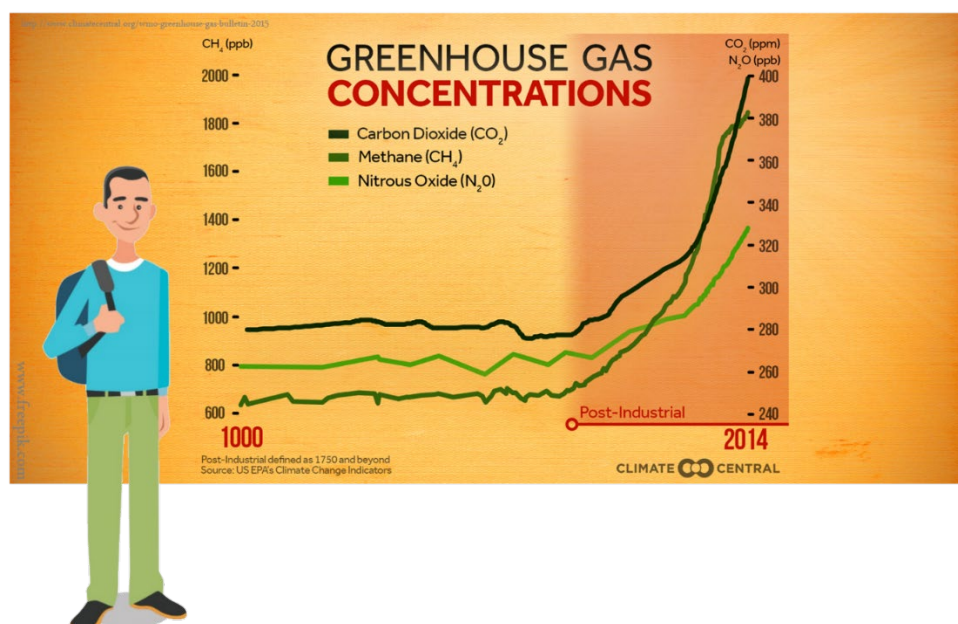


Climate Signals are long-term trends, including temperature, sea level, glaciation, and rainfall patterns, and allow us to tell if there has been any significant movement from naturally expected climate trends

Features of the climate system (climate signals) affected by climate change. The arrows show the direction of change. (IPCC, 2013)

Comparing pre-industrial climate signals to post-industrial climate signals

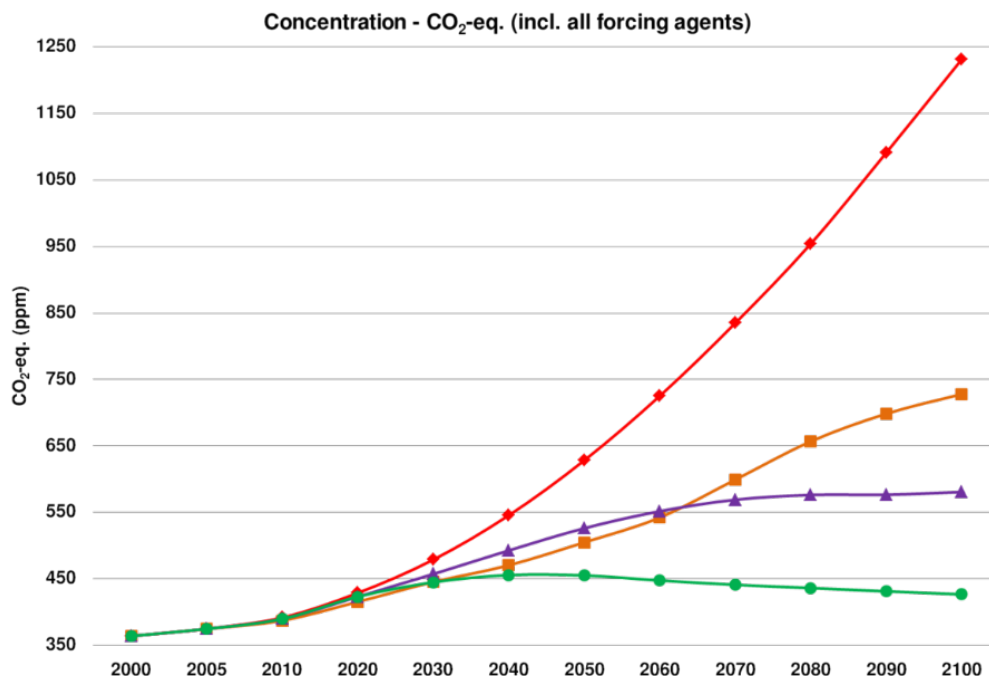
Naturally fluctuating (moving) temperature and carbon dioxide signals, prior to human activity, can be compared to post-industrial signals. Using observations and projections, scientists can now state that it is “extremely likely”, with a confidence of 95-100%, that Climate Change is due to anthropogenic (human) influence.



How much CO₂ will humans produce in the future?

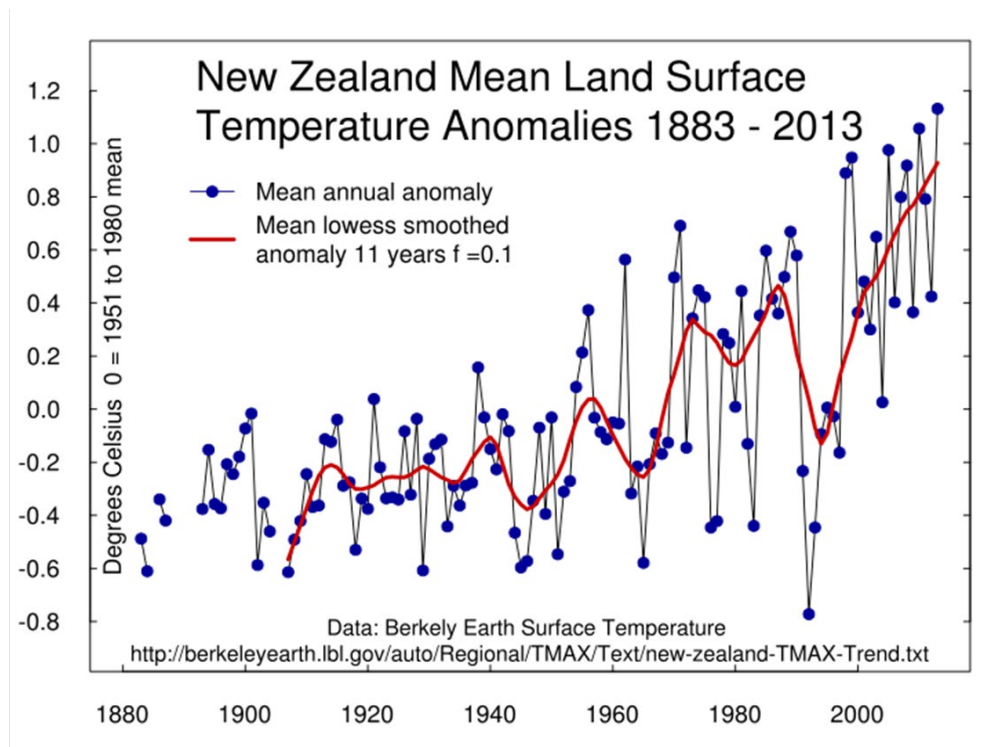
We can measure how much CO₂ we are producing at the moment and releasing into the atmosphere. Predicting the future amounts of CO₂ becomes more difficult, as we look further into the future. By making big changes to how we live and finding ways to remove current CO₂ in the atmosphere, we may be able to limit the projected rise of the earth to under 2°C. (green line).

At the other extreme, if we do nothing, and even increase the amount of CO₂ we release, the temperature rise (and sea level) could reach levels that completely change the Earth. (red line). It is more likely that we will end up somewhere between these two predictions.



Temperature changes

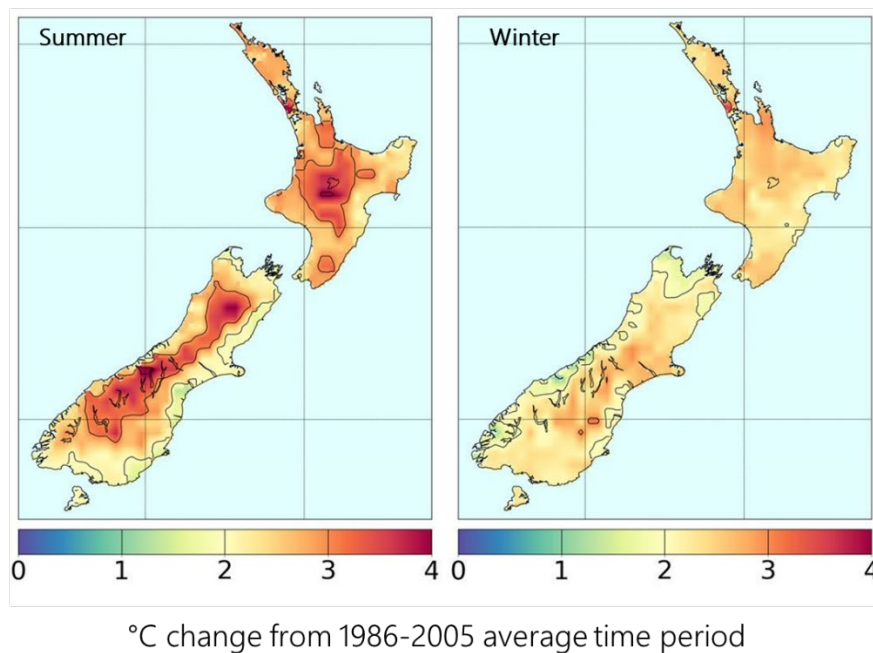
The past three decades have been hotter than all decades since temperature observations were recorded in the 19th Century, and the warmest has been the most recent decade.



Graph attributed to: Mifebruary - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=46210465>

Temperature rise predictions

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>

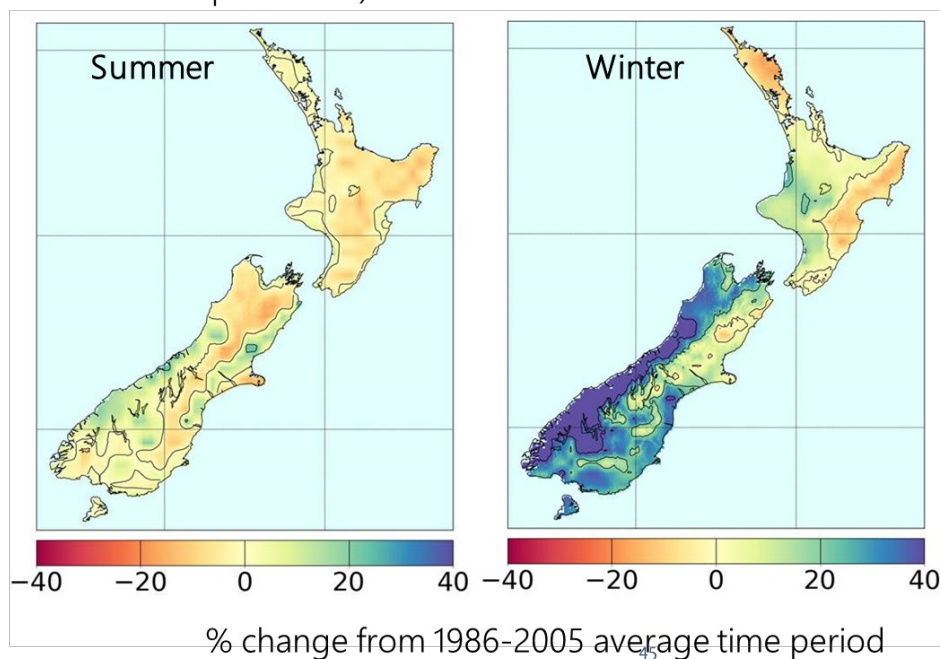
Using climate models generated from the NIWA supercomputer, for a **medium CO₂ emissions scenario**, NZ may experience a temperature increase of:

0.8°C by 2040, 1.4°C by 2090, and 1.6°C by 2110, relative to the 1986–2005 period” with a maximum of 5.0°C in 2110, using **the highest emission scenario**.

Rainfall predictions

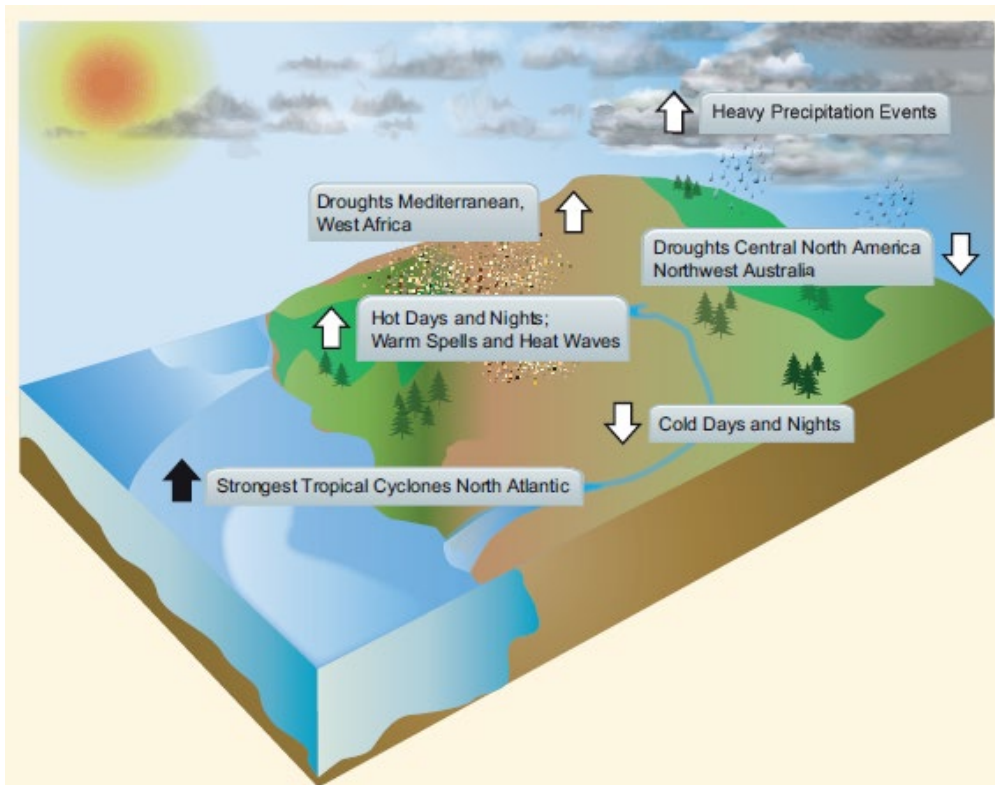
Changing rainfall patterns can also be predicted using CC models, and in NZ it is projected that the west of both Islands will become gradually wetter and the north and east will become drier in climate. In future, it is also predicted that NZ will have “more “hot days” and fewer frosts”. Temperature and precipitation extremes have increased and become more frequent around the world.

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>

Extreme Weather Events



Extreme weather events are stronger, and occur less often than typical weather. Extreme weather events are induced by both natural and human-activity causes

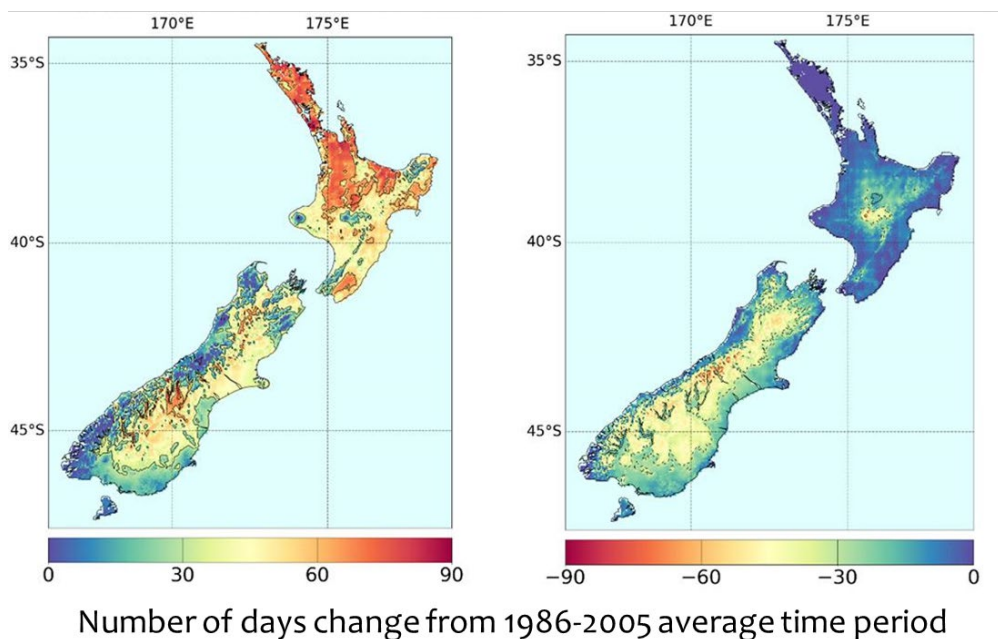
These cause a shift in the balance of Earth's energy, which powers the climate system. Extreme weather events include droughts, storms, deluges, heat waves, and tornados, and have increased in frequency since the 1950's.

Extreme temperatures

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

Days above 25°C

Days below 0°C



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

Extreme weather events in NZ are predicted to increase in frequency, and include both extreme rainfall events and drought across the country.

Melting of the Cryosphere and sea level rise

Multiple lines of evidence show that global warming, because of climate change, has caused the reduction of the *cryosphere*, consisting of sea and land ice, glaciers, and permafrost, in the past 30 years. Paleo (pre-history) records show that previous episodes of naturally induced global warming, around 2°C warmer than current temperatures, had produced a sea level rise (SLR) of more than 5m above present levels.

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



Sourced from: <http://glacierhub.org/2016/07/26/as-glaciers-melt-tourists-keep-on-coming-in-new-zealand/>

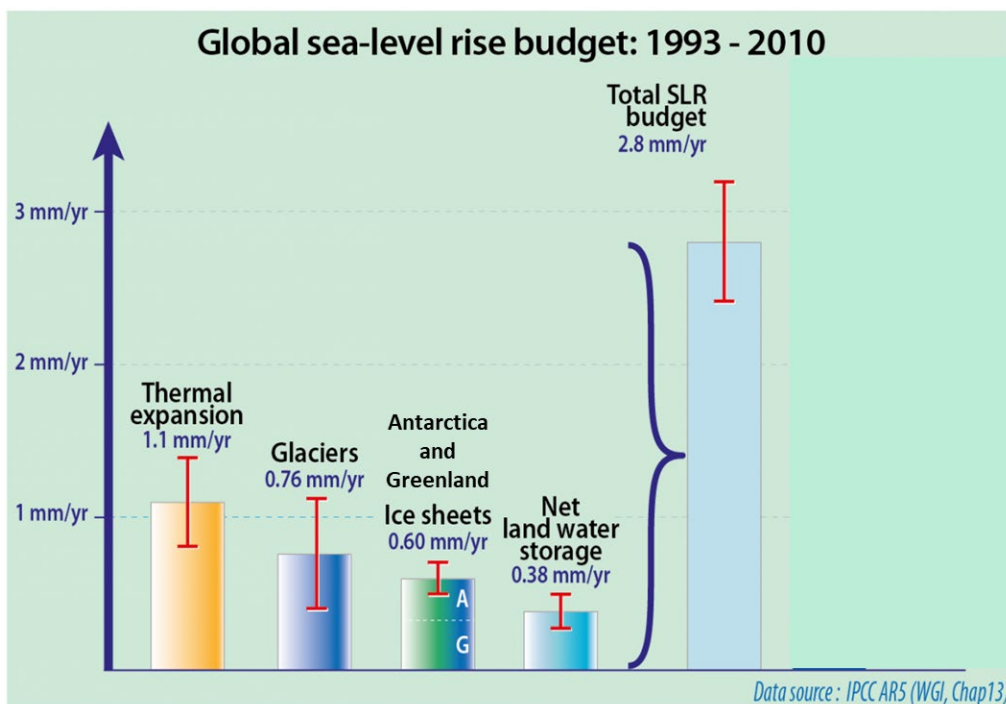
Change in Franz Joseph Glacier, West Coast, New Zealand from 2009 to 2013



Sourced from: <http://glacierhub.org/2016/07/26/as-glaciers-melt-tourists-keep-on-coming-in-new-zealand/>

Disappearing ice.

Observations now show that the Arctic sea ice is becoming thinner and smaller with each passing year. Continued warming of the planet could cause some large ice sheets, such as Greenland, to totally disappear, adding nearly 7m to long-term sea level rise.

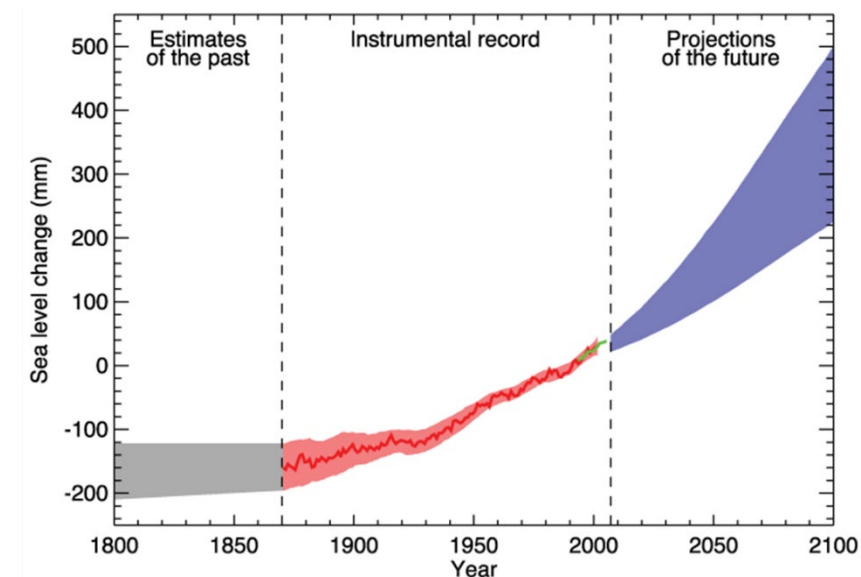


The main contributors (75%) to sea level rise have been the melting of glaciers, predicted to continue shrinking even if the temperature stabilises and more recently the Antarctic and Greenland ice sheets. Calving glaciers make up 90% of the continental ice loss.

Sea level rise predictions

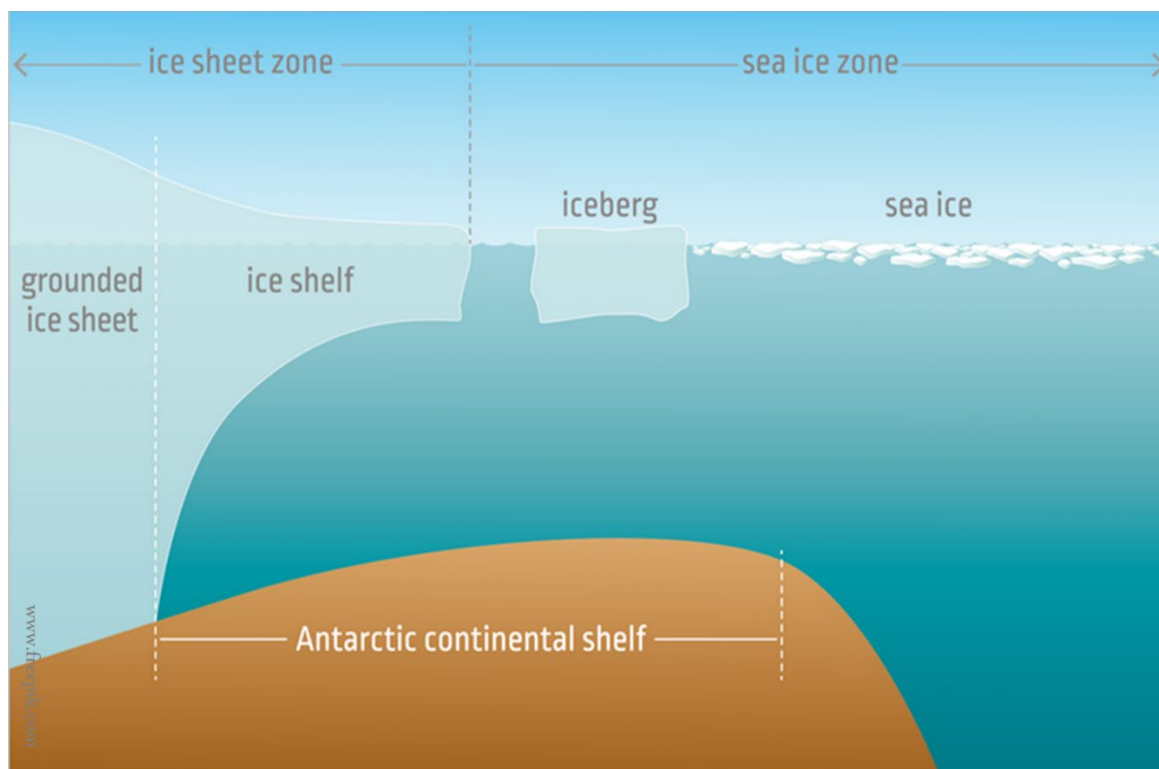
Predicted ranges for sea level rise by 2100 are from 0.26 to 0.98 m, depending upon future emission levels. In the last decade the rate of sea level rise is double that compared to the previous century, with small islands most exposed to risk.

NZ is particularly susceptible to sea level rise, due to the long coastline, and the position of many communities, and major cities, in low-lying areas near to the coast. The rising sea levels will cause coastal land erosion and flooding and result in reduced land area.



Why does only land ice contribute to sea level rise (and not sea ice)?

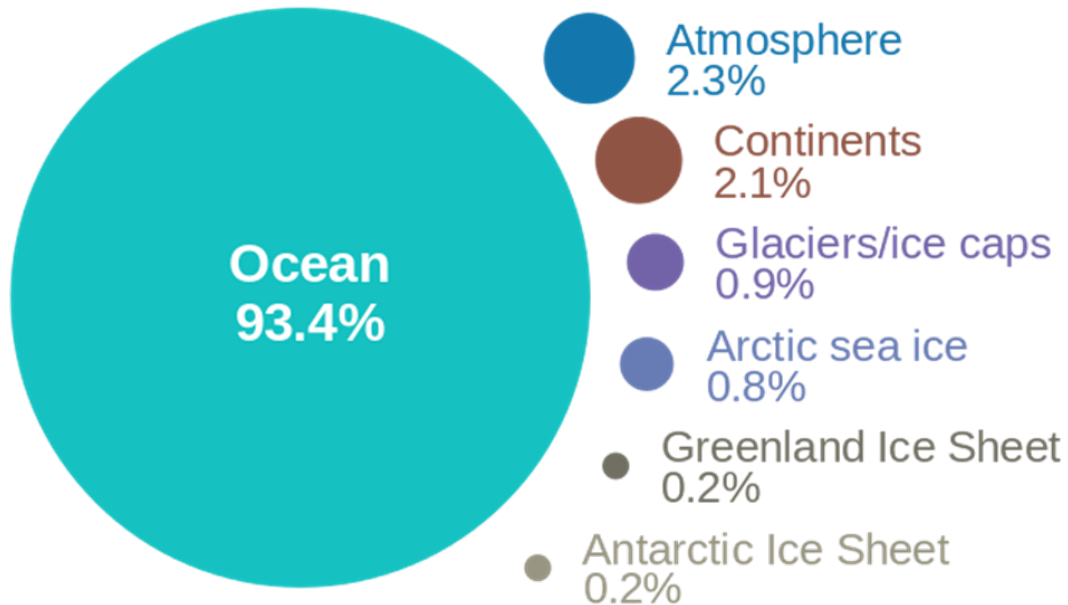
Ice that is floating in the sea (like in the Arctic) is mostly displacing (taking up space in) water already, so when it melts there will not be much sea level rise. Land ice (like in Greenland or the Antarctica) melting displaces much more water.



Heating Oceans

Most of the extra heat created by the additional greenhouse gases is being absorbed by the oceans. The oceans are huge so they are taking a long time to heat, but the extra warmth is causing problems for the living things that call it home, and changing the water moves around

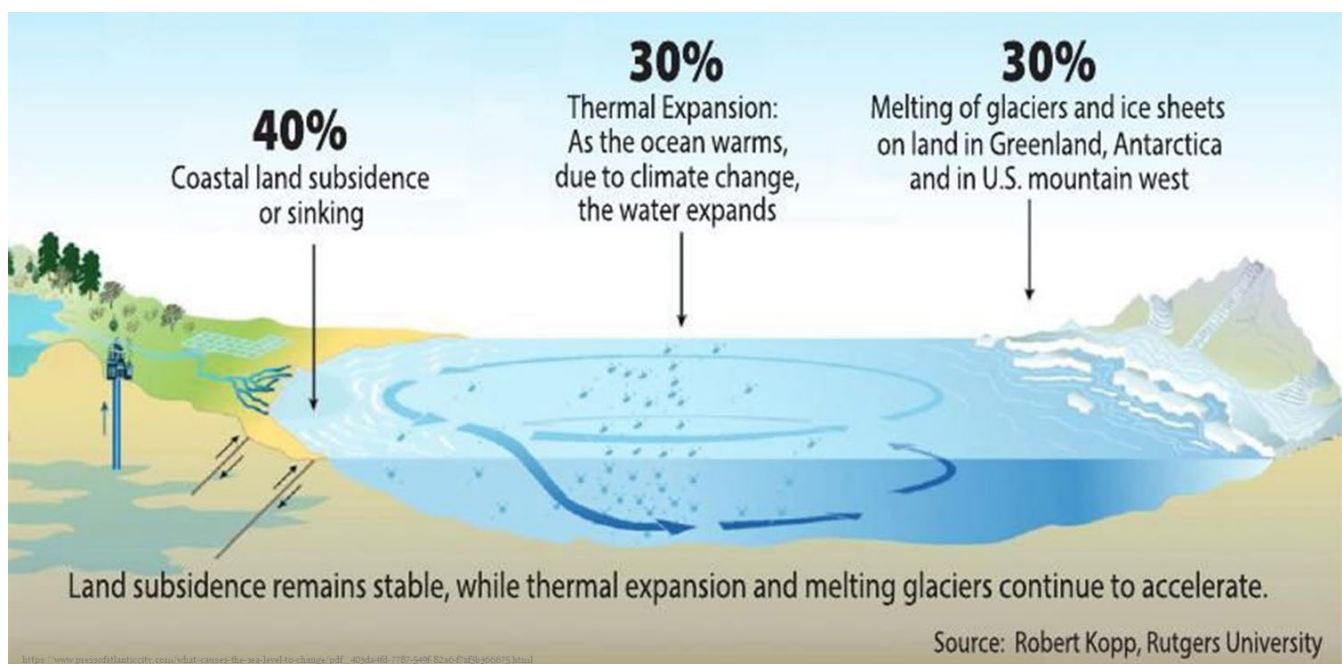
Where is global warming going?



<https://www.skepticalscience.com/Ocean-Heat-Content-And-The-Importance-Of-The-Deep-Ocean.html>

What else causes the sea level to rise?

Thermal expansion from heating oceans also contributes to sea level rise, as the average temperature of the ocean risen 0.17°C in the past 40 years. The ocean water has a high capacity to absorb energy and, therefore, shows a slower increase in temperature than on land.





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

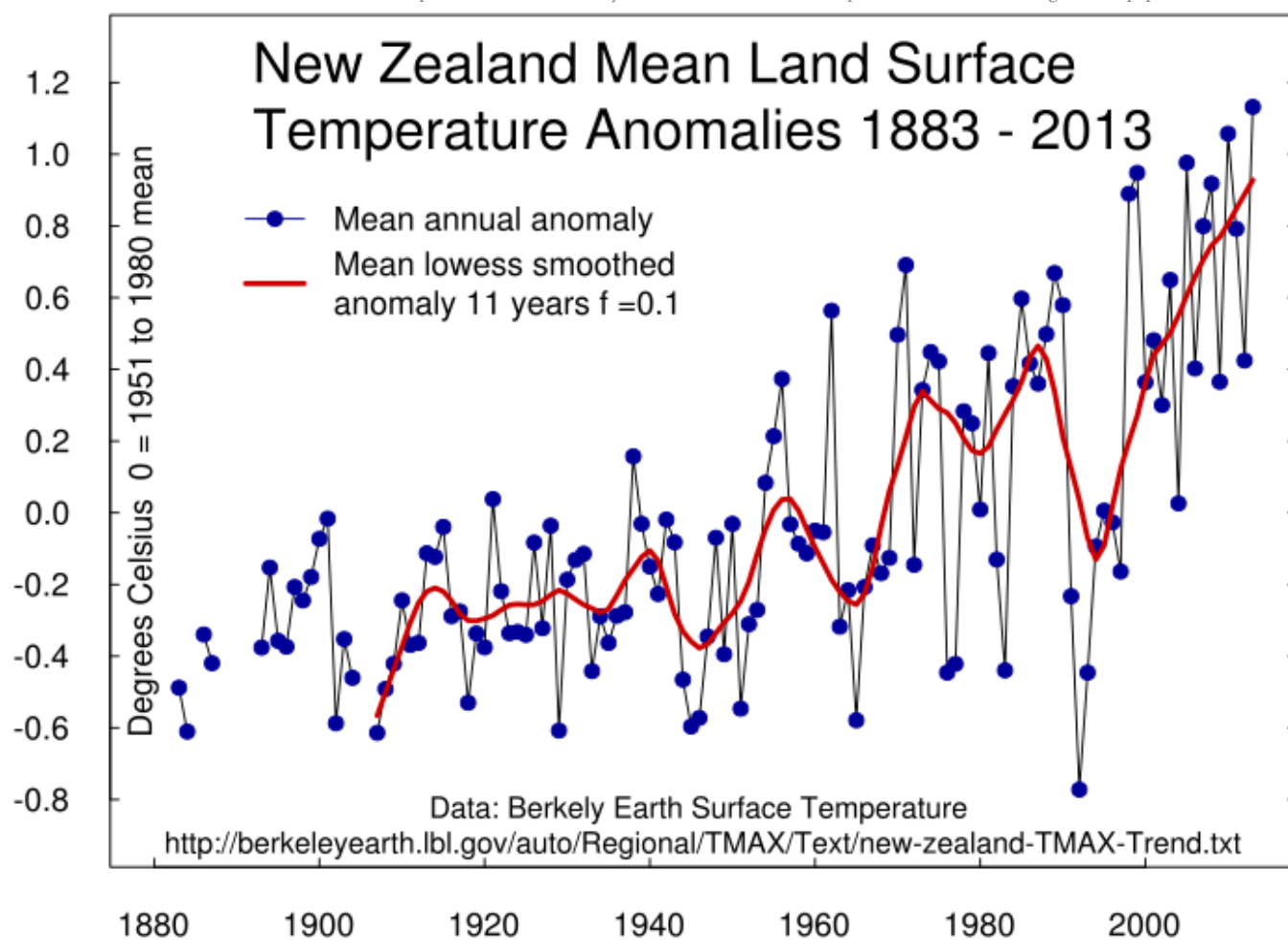
- | | |
|--------------------------|-------------------------------|
| 1. Temperature | 2. Temperature Predictions |
| 3. Sea Level Rise | 4. Sea Level Rise Predictions |
| 5. Rain fall Predictions | 6. Extreme Temperatures |
| 7. Melting Glacier | 8. Extreme Weather Events |



Card 1. Temperature

Use the following information to make an **evidence supported** claim

Graph attributed to: Mrfebruary - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=46210465>



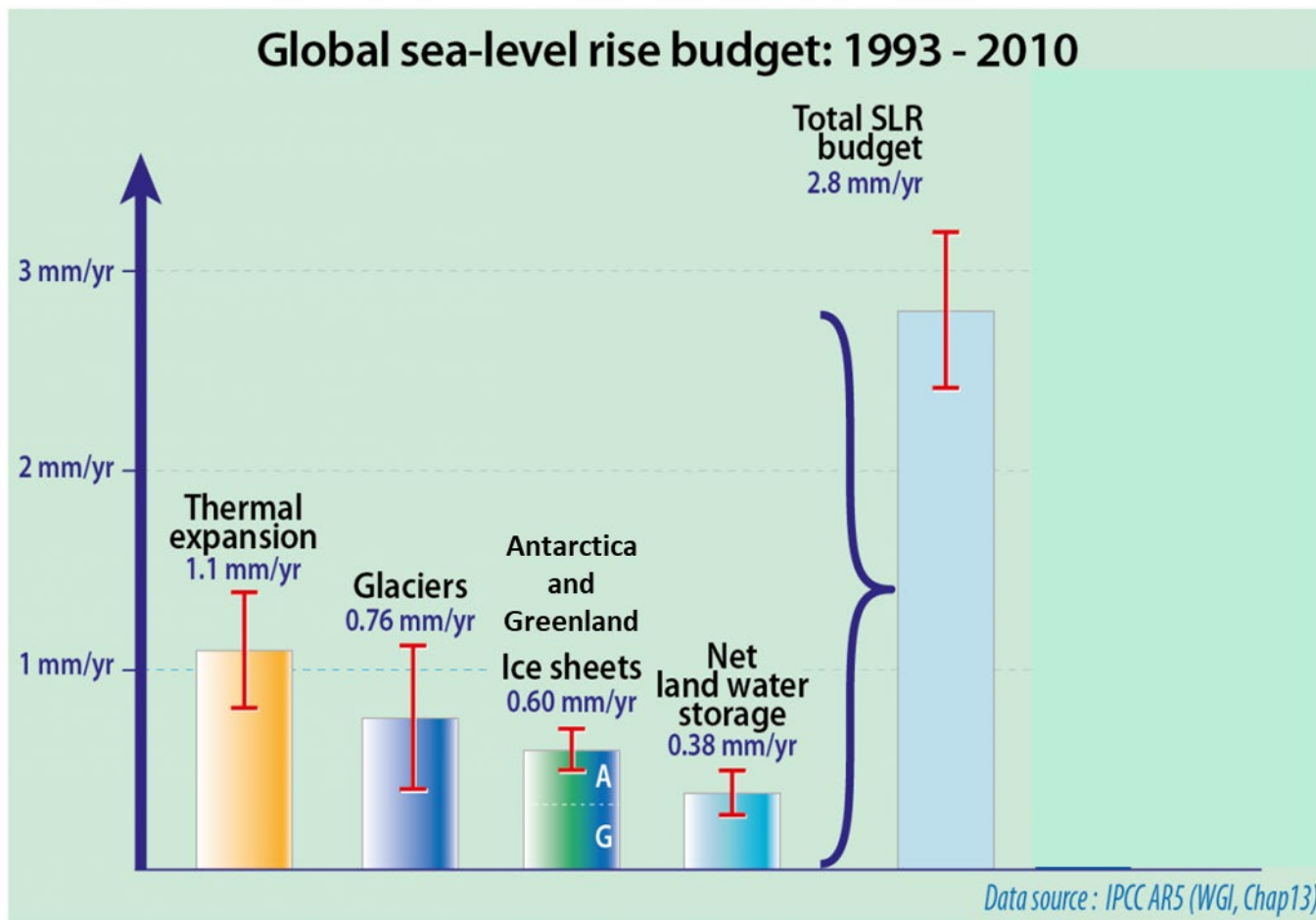
1. What is the difference between the blue dots and the red line?

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.

Card 2. 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?

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

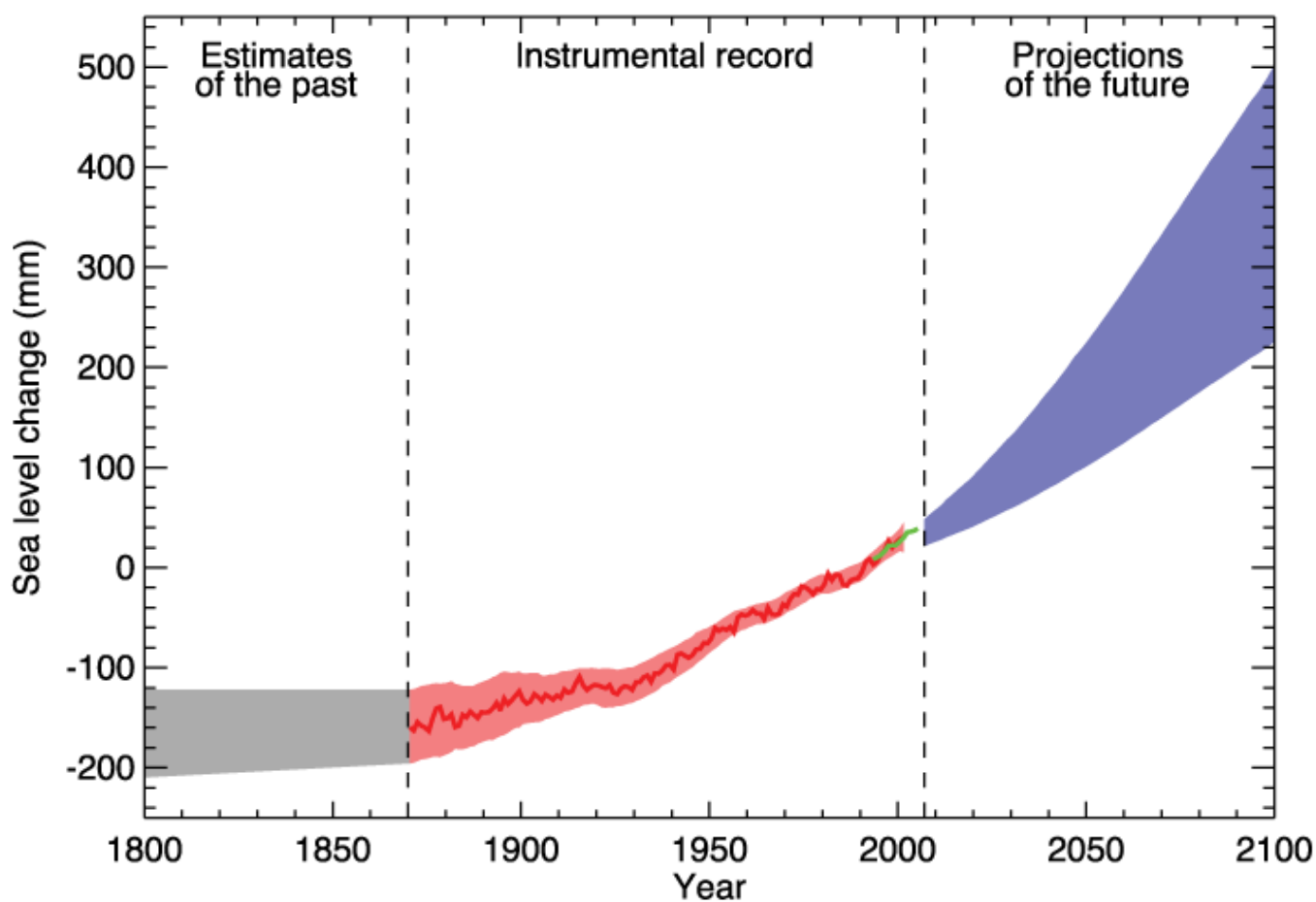
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3. Now make an **evidence supported** claim about the 1993 – 2010 global sea level rise.

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Card 3. 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.

Card 4. Melting Glaciers

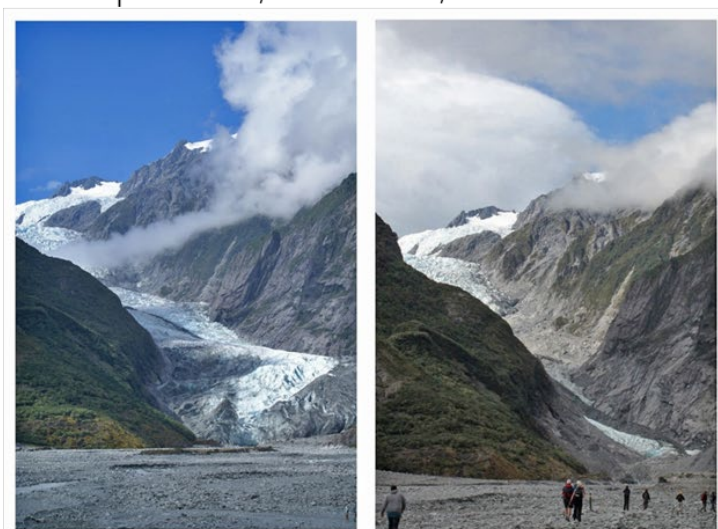
Use the following information to make an **evidence supported** claim

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



Sourced from: <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



Sourced from: <http://glacierhub.org/2016/07/26/as-glaciers-melt-tourists-keep-on-coming-in-new-zealand/>

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

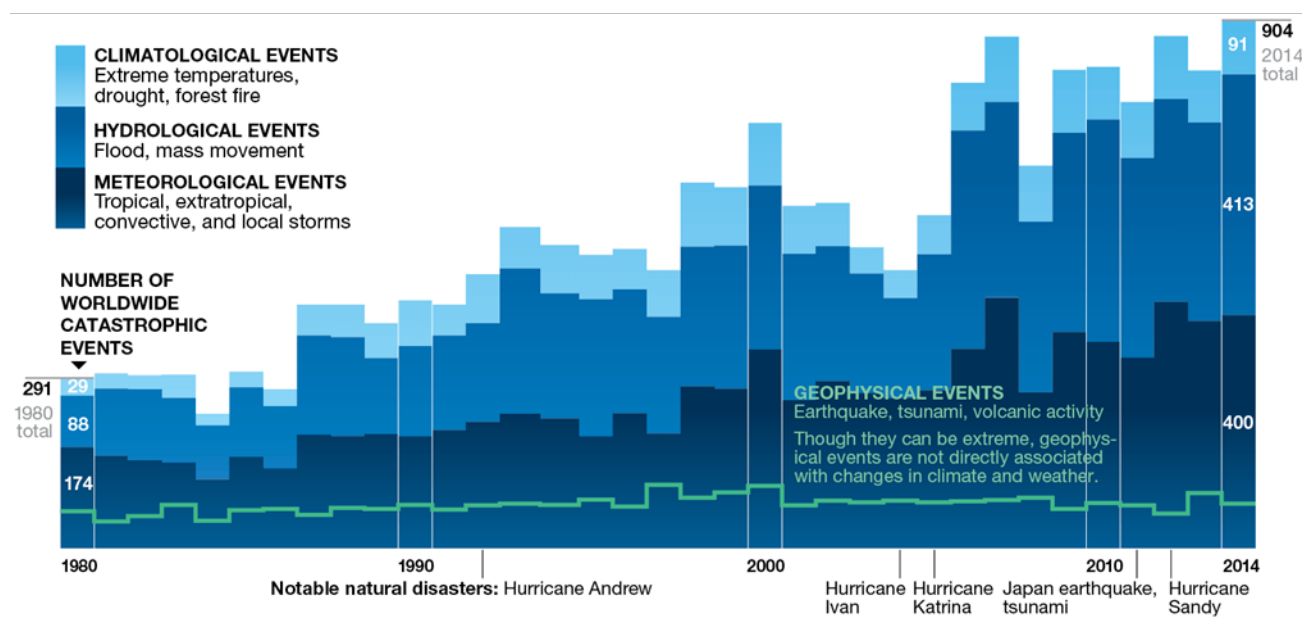
2. What do you think is eventually going to happen to the glaciers?

3. Now make an **evidence supported** claim about the change in size of the Glaciers in New Zealand.

Card 5. Extreme Weather Events

Use the following information to make an **evidence supported** claim

Numbers of Extreme Weather event from 1980 to 2014



Sourced from: <https://www.nationalgeographic.com/climate-change/how-to-live-with-it/weather.html>

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.