**PCAS 18 (2015/2016)**

**Supervised Project Report**

**(ANTA604)**

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# *Inside Ice – Antarctica and climate change*

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Word count: 4,200

Abstract/executive summary:

This project is a focused study on Antarctica and climate change for the purposes of developing communications materials for use in a Museum setting. Specifically, the content is structured as a shooting script for a planetarium show. The visuals described include both filmed content and animated sequences.

Focusing on climate change science in Antarctica, the content will cover why Antarctica's geological setting makes certain parts of the continent more vulnerable to warming. It will give an explanation of how scientists derive past climate information from ice cores, and explore current research into ice shelf dynamics.

## Project aims:

This project aims to shed light on how Antarctic glaciological research contributes to our understanding of climate change, from past climate reconstructions to future climate predictions. There is a plethora of contemporary communication about climate change, in practically every medium imaginable. What gives this project a point of distinction is its commitment to showing the processes behind our understanding of climate change, not just its implications. While the general public may have a sound understanding that Antarctic ice cores are used to develop climate models, the way in which ice cores are interpreted by scientists is often not well covered.

The content is science heavy, deliberately so. In order to properly communicate the pivotal role Antarctica plays in our climate system, and our knowledge of it, science communicators need to help their audiences understand *how* scientists' draw their conclusions.

This concept was developed over a series of meeting with external parties, specifically Jeanine Begg (Communications Manager, Antarctica New Zealand) and Anthony Powell (Documentary filmmaker), and internal parties, specifically Emma Burns (Curator, Natural Science), Robert Morris (Director, Collections, Research and Education), Craig Grant (Director, Science Engagement), Oana Jones (Full-Dome Producer) and Nathalie Wierdak (Outreach Coordinator).

This project's focus on climate change in Antarctica is in line with the goals of the Deep South National Science Challenge currently funded by the Ministry of Business, Innovation and Employment (MBIE). The goals of this Science Challenge are to increase knowledge and observations of climate in the Antarctica and the Southern Ocean, and to engage with New Zealanders in sharing this knowledge.

## Format of the Shooting Script:

The following shooting script gives a simple introduction to Antarctica, its underlying geology, its ice-sheets and shelves, and the glaciological research methods that are shedding light both on past climate conditions and on the projected future of the Antarctic ice sheet. While this content has been written and structured as a script for a planetarium show, the narrative order of this content would lend itself to other mediums. This information will feed into gallery content in *Southern Land Southern People*, where a greater emphasis on Antarctica and the Southern Ocean will contextualise discussion of climate change.

The script of broken into scenes with accompanying voiceover text. The ‘Action’ column describes the components of each individual shot or section. The ‘Narration’ column reads the voiceover narration that will accompany this action. The ‘Time’ column is left blank, and as the script is workshopped can be filled in to give an approximate pacing for each shot or section.

The images provided in the left-hand ‘Concept’ column are not intended for use in any resultant work. They are provided for context and inspiration, for visually communicating written concepts, and for conveying a possible aesthetic for the planetarium show or panel content. While some have a Creative Commons lisence others are Copyrighted, so are not intended for any form of publication. None of the images are my own work. Image credits are provided below each image.

## Working title: *Inside Ice – Antarctica and climate change*

| Action | Narration | Time | Concept |
|---|---|---|---|
| Atmospheric landscapes, mists, snow, blizzards, ice shelves, icebergs, etc. | *Before it was ever discovered, Antarctica existed in the human imagination.* | | <br>Ian Parker (2013) parkerlab.bio.uci.edu |
| | *The Ancient Greeks imagined an icy, Southern land, equal and opposite to the Arctic.* | | <br>Anthony Powell (2013) |
| | *Writers dreamed up its wretched seas and inaccessible shores.* | | <br>Anthony Powell (2013) |
| Early explorers huts, historic footage, Heroic era expedition images. | *And when humans first reached mainland Antarctica in the early 1800s, they found it impenetrable, inhospitable, forbidding.* | | <br>© brittanica.com |

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|---|---|---|---|
| | *It wasn't until 1899 that the first building was erected in Antarctica…* | | <br>© Antarctic Heritage Trust (2016) |
| | *…and it took decades, and many lives, for explorers to span the continent.* | | <br>© Royal Geographical Society |
| | *Antarctica pushed the boundaries of human endurance. At its extremes, it pushes the boundaries of our planet.* | | <br>Creative Commons image: wikimedia.org |
| Extreme weather, wind, snow, blizzard. | *It's often called the highest, driest, coldest and windiest place on earth, but Antarctica's tests don't stop there.* | | |

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|---|---|---|---|
| Time-lapse of aurora or night sky. | *Huge seasonal change plunges Antarctica into winter darkness, the sun not rising for months on end.* | |  Anthony Powell (2013) |
| Time-lapse of sun circling in the sky. | *In summer, there is constant daylight, the sun above the horizon, circling in the sky.* | |  © Ben Adkinson (2016) terrain.org |
| Confusing perspective, distance and visibility. | *The seemingly endless white of the ice can make it difficult to judge distance and size in the landscape…* | |  Anthony Powell (2013) |
| | *…which can disorient and bewilder.* | |  Anthony Powell (2013) |

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|---|---|---|---|
| | *And the continent's inaccessibility means that making our way to Antarctica is expensive, time-consuming, and hazardous.* | | <br>Anthony Powell (2013) |
| Animals adapted to the Antarctic environment. | *But this land of ice is a place of adaptation…* | | <br>Anthony Powell (2013) |
| | *…and just like the animals who live at these extreme margins of the planet…* | | <br>Anthony Powell (2013) |

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|---|---|---|---|
| Aerial Scott Base. | *…we humans have learned to survive in Antarctica.* | |  Anthony Powell (2013) |
| Scott Pole Station. | *Today, we have an increasingly sturdy foothold on the continent. More than 30 countries send scientists to Antarctica, and permanent research bases operate year-round.* | |  Anthony Powell (2013) |
| Plane landing at Willy's Field. | *Yet despite thousands of people arriving on the continent each year, nobody lives in Antarctica permanently.* | |  Anthony Powell (2013) |
| Ivan the Terra Bus. | *Some people might return year after year…* | |  Anthony Powell (2013) |

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|---|---|---|---|
| Flight departing. | *…but all visits are temporary. Those who travel South will eventually travel back North.* | |  Anthony Powell (2013) |
| Harsh working conditions. | *So in the face of Antarctica's hostile environment and inaccessibility, why do scientists go there?* | |  Anthony Powell (2013) |
| Scientists conducting experiments on ice. | *While people might not be able to build their lives there, Antarctica is a vital part of the global climate system.* | |  Anthony Powell (2013) |

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|---|---|---|---|
| Weather patterns, cloud formation and dissipation, etc. | *Driving weather patterns, ocean currents, and winds around the globe.* | |  Anthony Powell (2013) |
| Humans dwarfed by the scale of Antarctica. | *While scientists have been visiting Antarctica for over a century, there is still so much we don't understand about how this frozen pole interacts with the rest of the planet.* | |  Anthony Powell (2013) |
| Scientific expeditions. | *So scientists continue to head South…* | |  Anthony Powell (2013) |
| Ice core sampling. | *…delving deep into the ice to expose earth's past, and predict its future.* | |  © nsidc.org |

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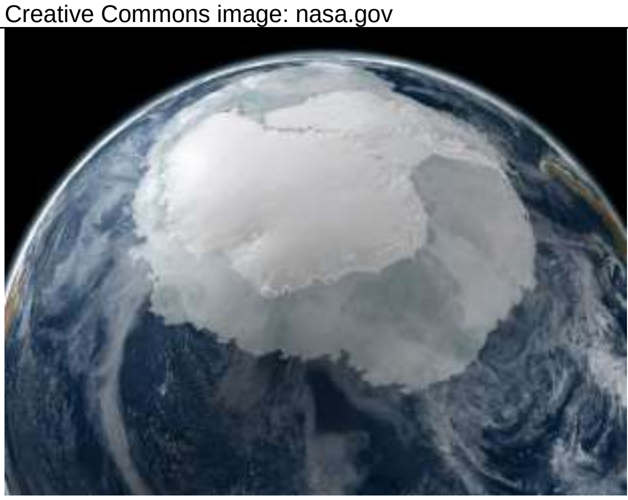
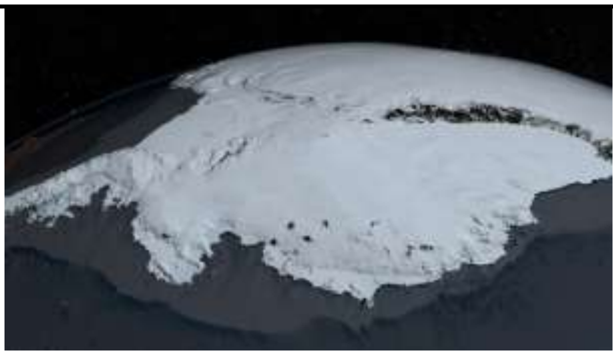
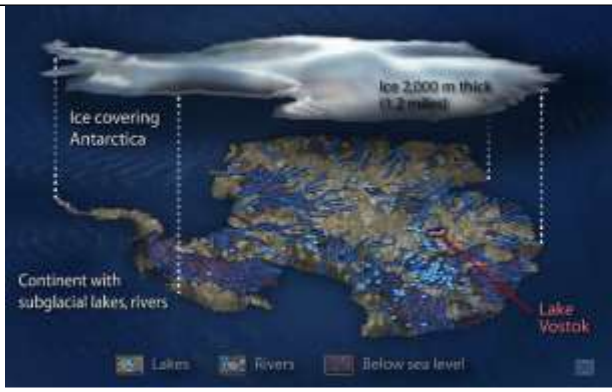
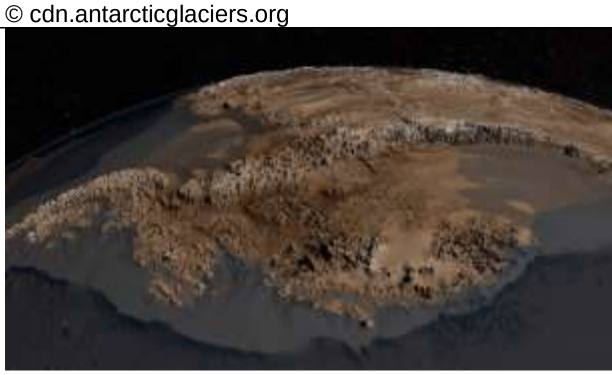
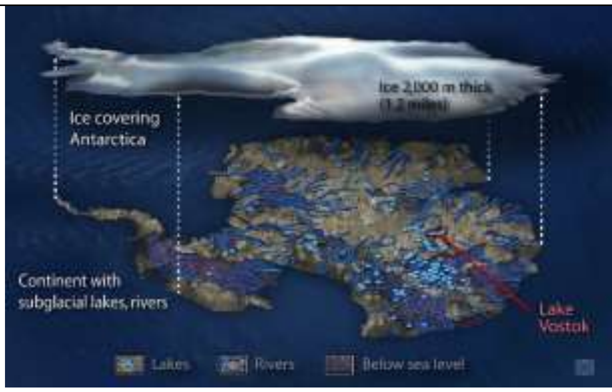
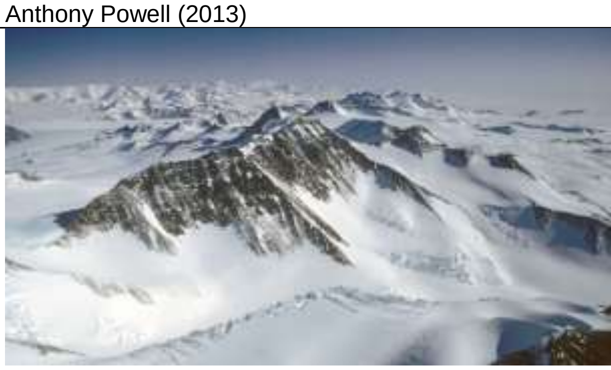
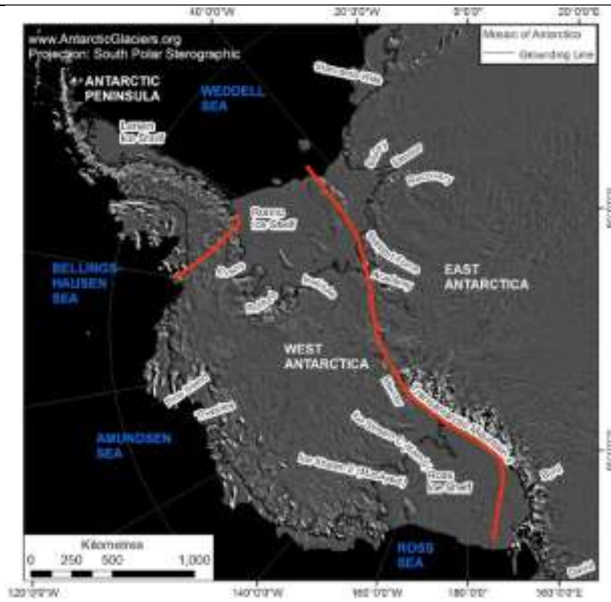
|---|---|---|---|
| Aerial Antarctica. | *Because what happens to Antarctica in a what is now a warming world…* | |  Creative Commons image: nasa.gov |
| Aerial earth. | *…will be felt across the globe.* | |  Creative Commons image: nasa.gov |
| **LITHOSPHERE** | | | |
| Forward zoom to Antarctica. | *From above, Antarctica might seem like it's made of floating ice, its surface smooth and white.* | |  Creative Commons image: nasa.gov |

<table>
<tr><td>Lift ice off continent.</td><td>But if we could lift the ice off the continent…</td><td></td><td>

© cdn.antarcticglaciers.org</td></tr>
<tr><td>Antarctic land mass. Zoom along mountain ranges, ocean basins, and along areas of active volcanism, showing lava.</td><td>…we would see that it's grounded on rock. This is the base of the world's 5th largest continent. It's a land of rising mountains with craggy, jagged peaks, of deep ocean basins, and active volcanoes.</td><td></td><td>
Creative Commons image: nasa.gov</td></tr>
<tr><td rowspan="2">Put ice back on continent.</td><td>But getting to any of this land presents challenges for geologists.</td><td></td><td>

© cdn.antarcticglaciers.org</td></tr>
<tr><td>Less than 1% of Antarctica is ice-free, which means there is very little exposed land.</td><td></td><td>
Creative Commons image: nasa.gov</td></tr>
</table>

<table>
<tr>
<td rowspan="2">Mountains emerging from the ice. Shots of the trans-Antarctic mountains.</td>
<td>But some rocky features are unmistakable. The trans-Antarctic mountains stretch 3,500km across Antarctica, one of the longest mountain ranges in the world.</td>
<td></td>
<td><br>Anthony Powell (2013)</td>
</tr>
<tr>
<td>While much of the range is buried, some peaks jut up above the snow and ice, reaching as high as 4,500m.</td>
<td></td>
<td><br></td>
</tr>
<tr>
<td>Aerial view of trans-Antarctic mountains spanning the continent.</td>
<td>These mountains cross the continent, a dividing line between East and West Antarctica.</td>
<td></td>
<td>
<br></td>
</tr>
</table>

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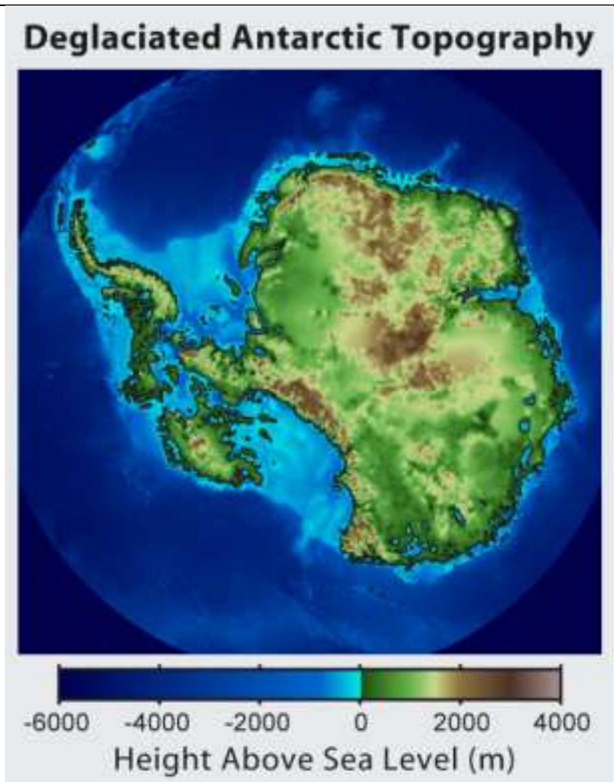
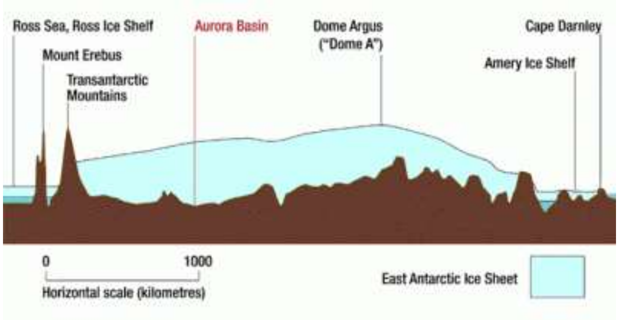
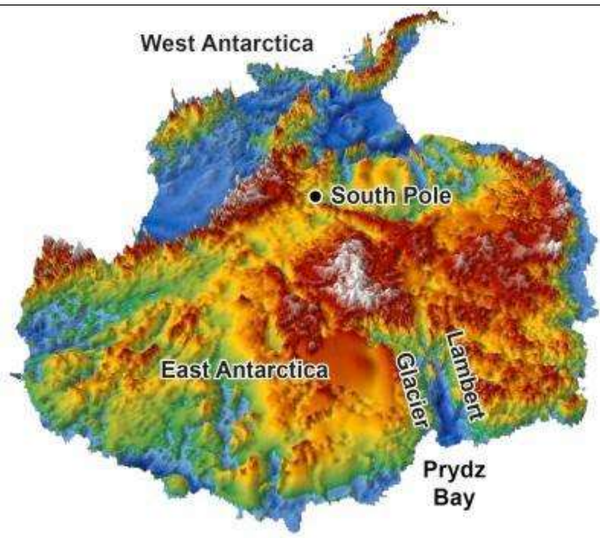
| Ice melts away to reveal how the continent would look deglaciated. | *While it's invisible from above, below the ice, these two regions have vastly different geologies.* | | <br><br>© cdn.antarcticglaciers.org |
| Cut through the East Antarctic landmass. | *The East Antarctic landmass is a thick and fairly continuous crust.* | | <br><br>© southwind.com.au |
| Water around edges shows minimal encroachment, even when deglaciated. | *In most places it rises above sea level, which means the East Antarctic ice sheet generally sits higher than the ocean surface.* | | <br><br>© livescience.com |

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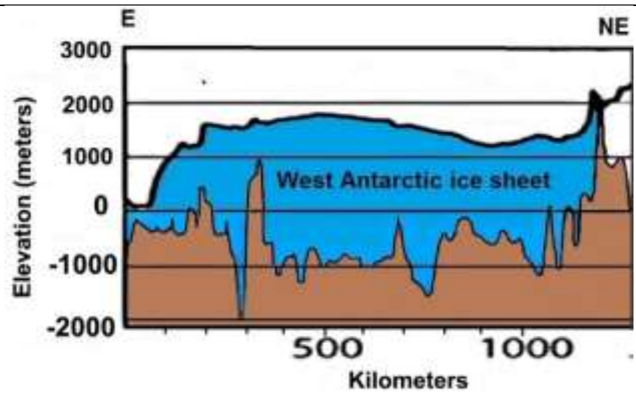
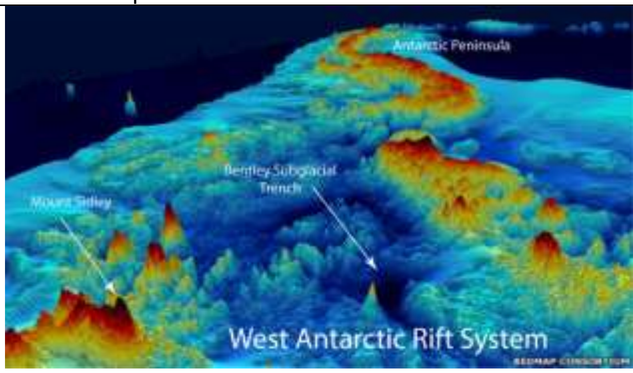
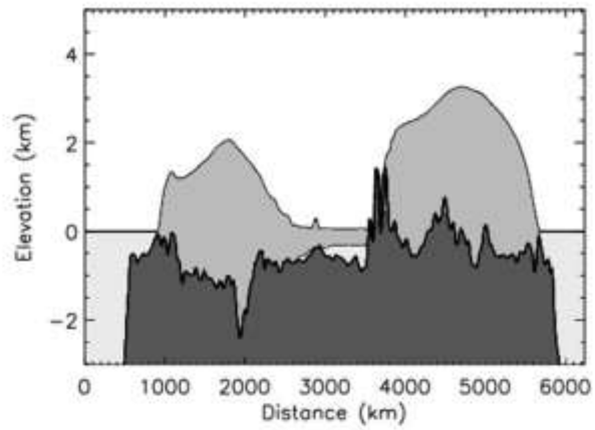
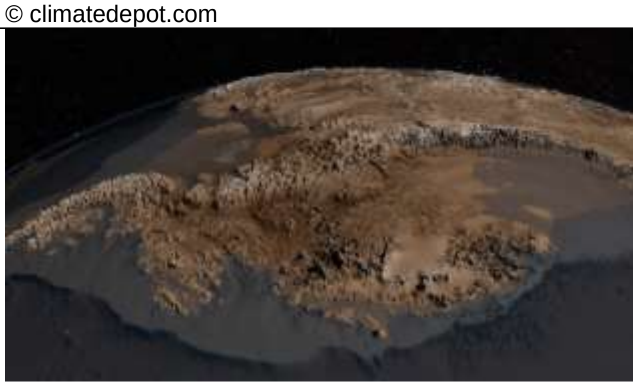
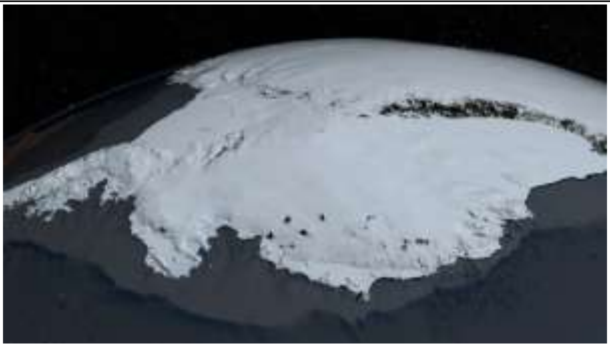
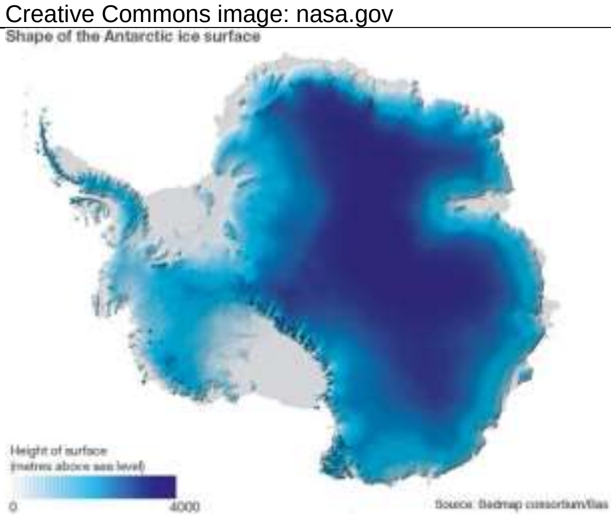
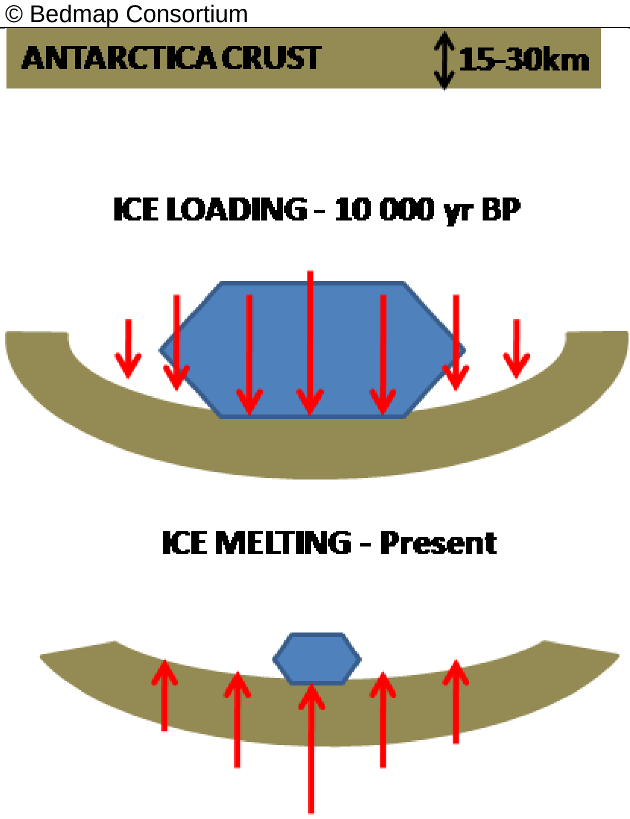
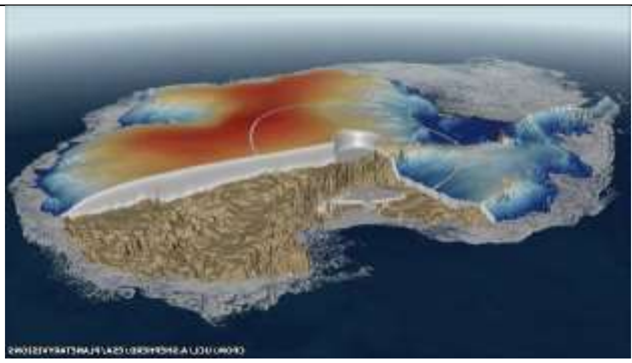
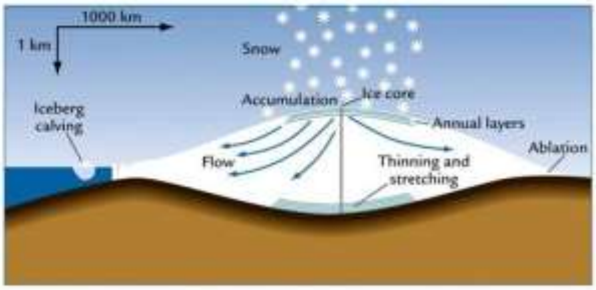
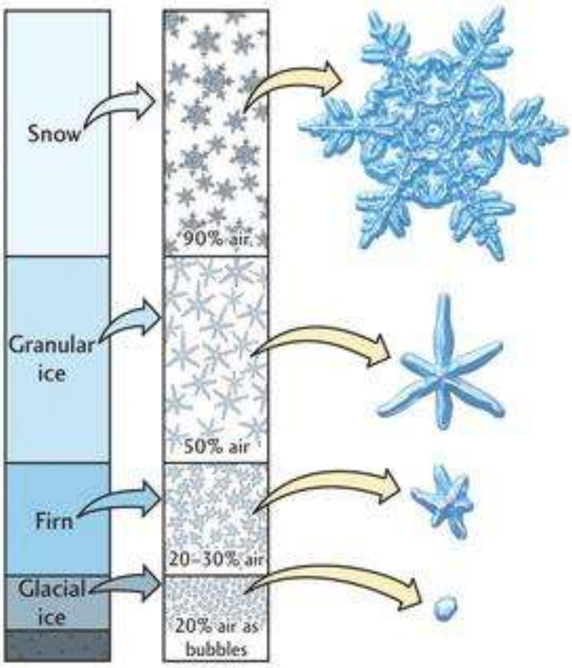
|---|---|---|---|
| Cut through West Antarctic landmass. | *West Antarctica is very different. It has a thinner crust, with large sections lying below sea level.* | | <br>© climatedepot.com |
| Significant water encroachment present, with much of the landmass under the ocean. | *If the ice were removed, West Antarctica would look like a chain of islands and archipelagos from above the ocean surface.* | | <br>© livescience.com |
| Cut through East and West Antarctica, showing distinction between the two. | *These differences in the underlying geology of East and West Antarctica are largely hidden beneath huge sheets of ice.* | | <br>© climatedepot.com |
| Antarctic land mass. | *But even though we can't see the rocky surface of the Antarctic continent, these differences are important. Because what the ice is sitting on has a huge impact on how it behaves.* | | <br>Creative Commons image: nasa.gov |

# CRYOSPHERE

| | | | |
|---|---|---|---|
| Aerial Antarctic ice sheet. | *And it's a lot of ice. Ice covers 99.6% of Antarctica, making an ice cap that is the single largest solid object on the surface of the Earth.* | | <br>Creative Commons image: nasa.gov |
| Figure communicating the height or thickness of the Antarctic ice sheet. | *~90% of the world's ice, and ~80% of the world's freshwater are locked up in Antarctic snow and ice, which has grown up to 4800m thick in places.* | | <br>© Bedmap Consortium |
| Earth's crust deforming below the weight of the Antarctic ice sheet. | *It's so heavy, that the weight of the ice sheet is enough to deform Earth's crust below.* | | <br>© gnss.be |

| | | | |
|---|---|---|---|
| Cut through ice, showing height and extent. | *But how did all this ice get here, piled up kilometres above the Antarctic landmass?* | |  © planetaryvisions |
| Snowfall. | *Snow. Year after year, snow falls over the Antarctic continent…* | |  © kimballstock.com |
| Snow accumulation process. | *… building up, layer upon layer …* | |   © globalchange.umich.edu |
| Snow compression into ice. | *…until it eventually compresses to form ice.* | |   © glaciers1011 |

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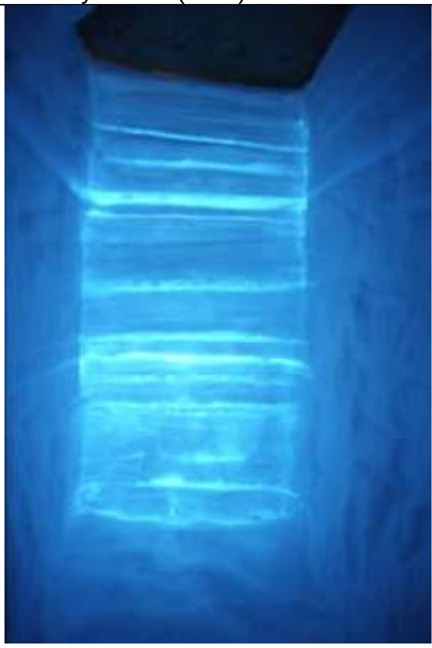
| Shots from South Pole station. | *While Antarctica might be the driest continent on earth (at South Pole, just 2-5cm falls per year, equivalent to the amount of rainfall in the Sahara)…* | | <br>Anthony Powell (2013) |
| Snow pit, showing annual accumulation layers. | *…this precipitation doesn't quickly run away like liquid water does.* | | <br>© jerome-chappellaz.com |
| Glaciers and ice streams. | *It runs away very slowly. Because while Antarctic ice might look stationary, it's actually inconstant motion…* | | <br>Anthony Powell (2013) |
| Ice moving from inland towards the sea. | *… moving from the interior of the continent out towards the coast, channelled by glaciers and ice streams.* | | <br>© antarcticglaciers.org |

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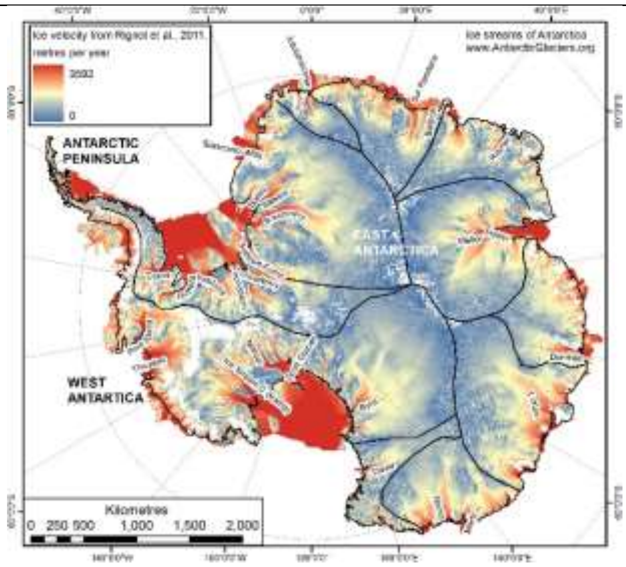
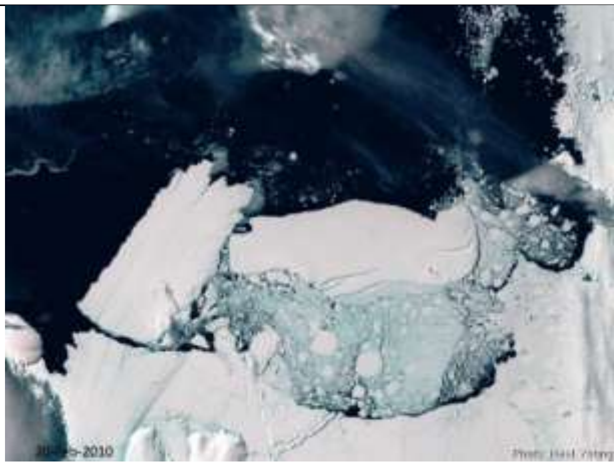
|---|---|---|---|
| Ice moving from interior of continent to exterior of continent. | *Each year, this icy conveyor belt carries 200 billion tonnes of ice to the edges of the continent…* | | <br>© antarcticglaciers.org |
| Ice sheet flowing onto ice shelf. | *…where it flows onto ice shelves…* | | <br>© ice2sea.eu |
| Icebergs calving, aerial or landscape. | *…and eventually calves off into the sea.* | | <br>Creative Commons image: nasa.gov |

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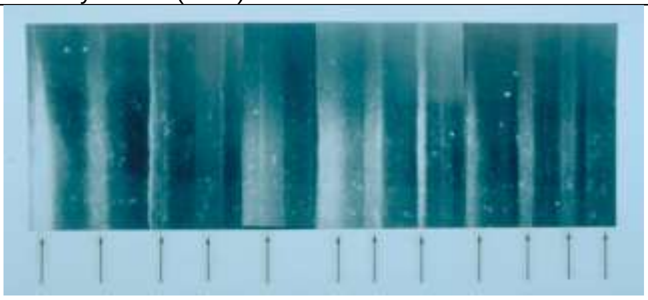
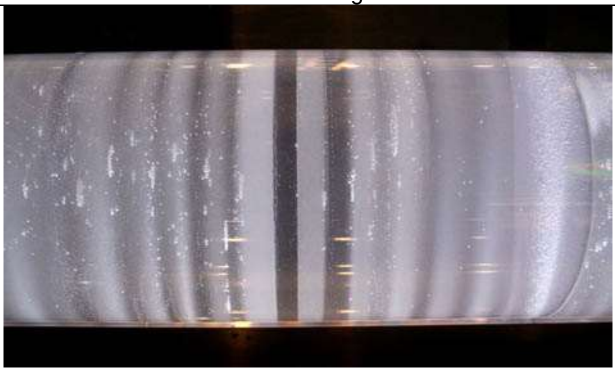
| Ice layers, high ice masses. | *These slow moving layers of ice, built up over millions of years of snowfall, are more than just frozen water. They are a record of earth's ancient environment.* | | <br>Anthony Powell (2013) |
| Profile of ice cores, showing annual growth. | *Just like the fossil record can tell us about prehistoric lifeforms, Antarctic ice can help scientists paint a picture the earth's past climate.* | | <br>Creative commons: wikimedia.org |
| | *Because when snowfall compresses to ice in Antarctica, the layers building up year after year, it traps, frozen water…* | | <br>© naturalhistoria |

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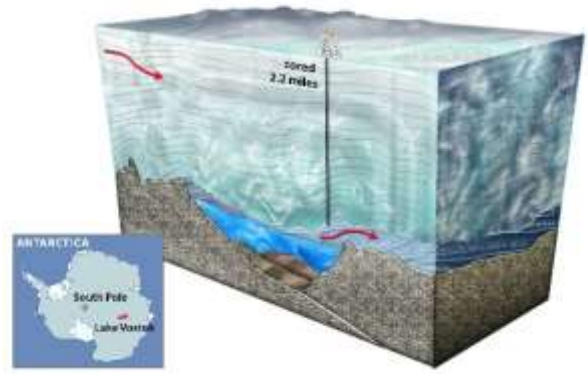
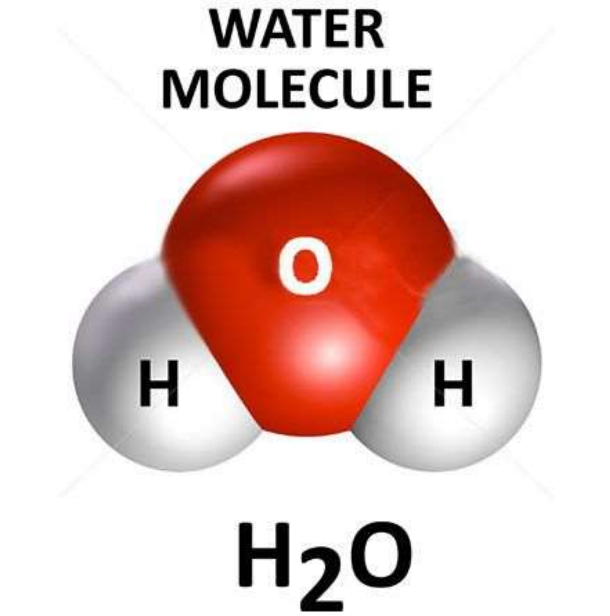
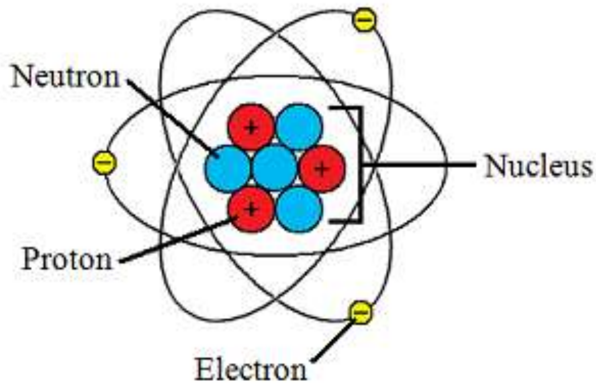
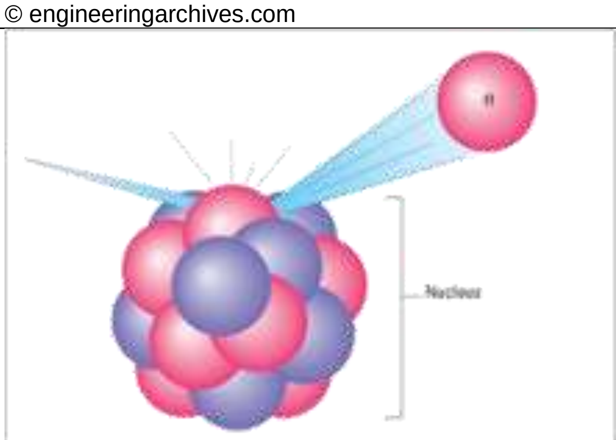
|---|---|---|---|
| Section of ice core showing air bubbles. | *…and tiny bubbles of air.* | | <br>© oregonstate.edu |
| Drilling and extracting ice cores. | *By drilling deep down into the Antarctic ice sheet…* | | <br>© icecores.org |
| Depth of drilling through the Antarctic ice sheet. | *… scientists can dig up ice deposited hundreds of thousands of years ago.* | | <br>© lakescientist.com |
| Analysing cores in the lab. | *Studying these remnants from an ancient world can help shed light on earth's climate history. But if ice cores are a record of the past, how do we read them?* | | <br>© washington.edu |

## OXYGEN ISOTOPES and PAST AIR TEMPERATURES

| | | | |
|---|---|---|---|
| Zoom into the ice core. Zoom into water molecule. | *First, the water. Let's start small. You might have heard of water being called "H2O". This is because it's made of two hydrogen atoms, the H2, and one oxygen atom, the O.* | |  <br>© pinimg.com |
| Separate hydrogen atoms from oxygen atom. Zoom into atomic structure of oxygen atom. | *But while all water molecules are made up of these basic ingredients, not all oxygen atoms are created equal. They come in different types, and these types are called isotopes.* | |  <br>© engineeringarchives.com |
| Zoom into the neutrons. | *And isotopes have everything to do with these parts of the atom: the neutrons.* | | <br>© glossary.oilfield.slb.com |

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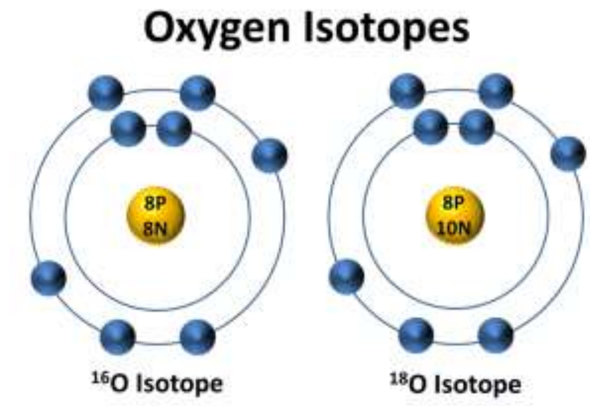
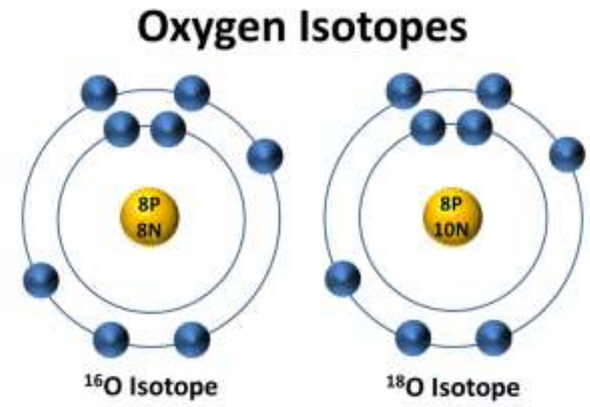
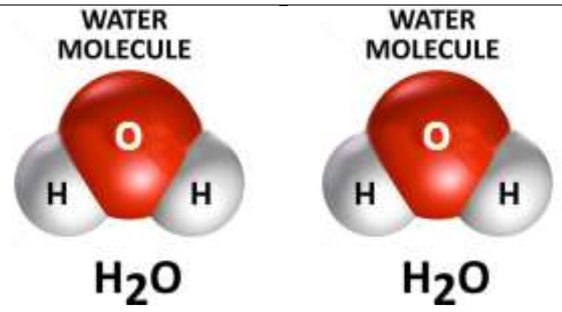
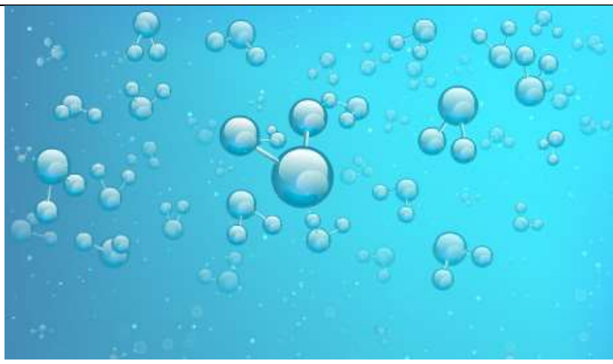
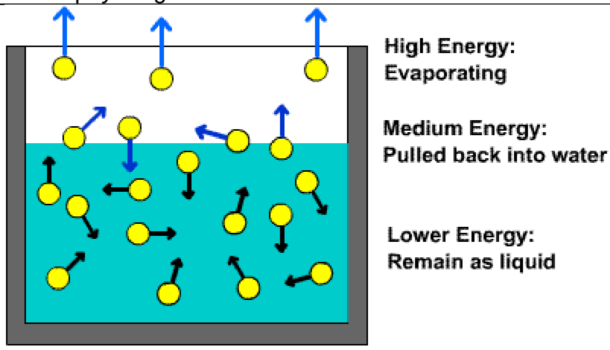
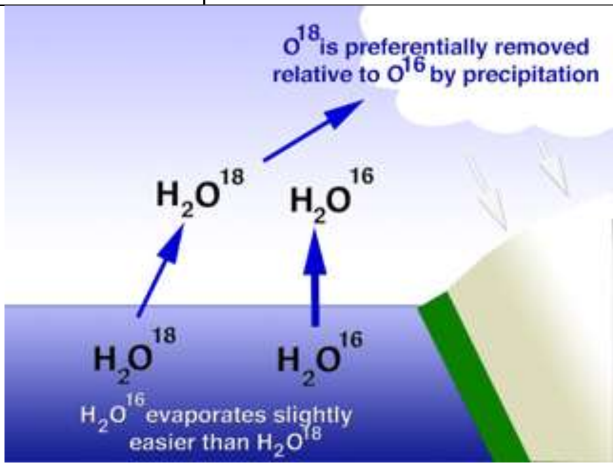
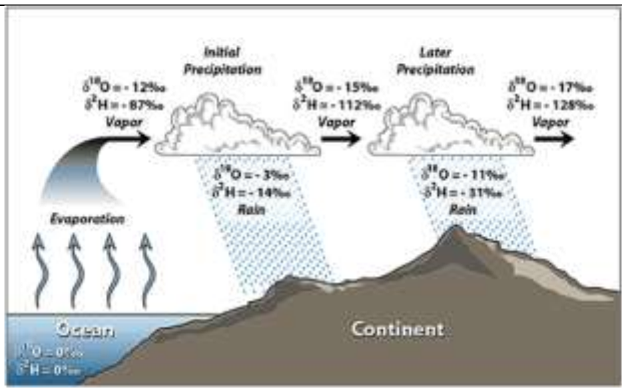
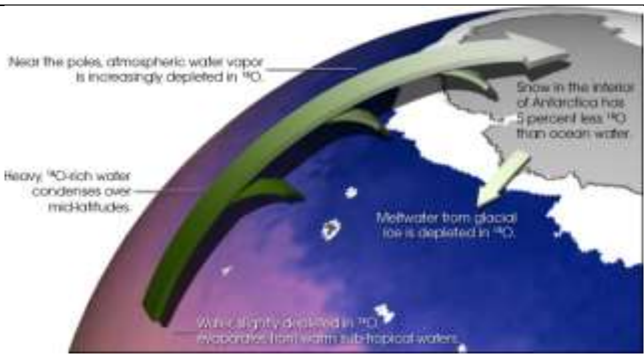
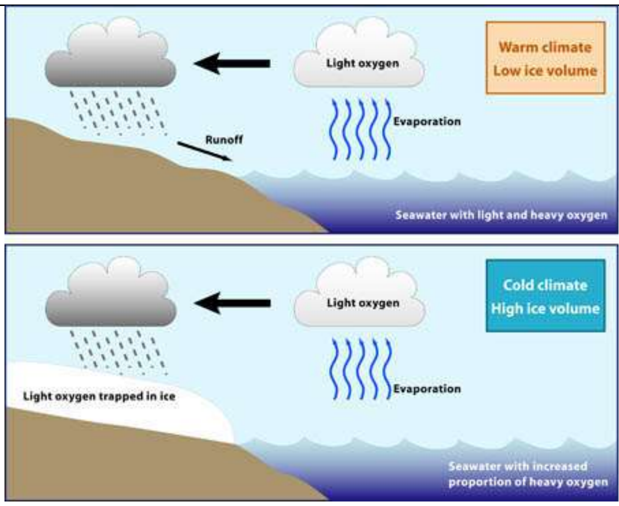
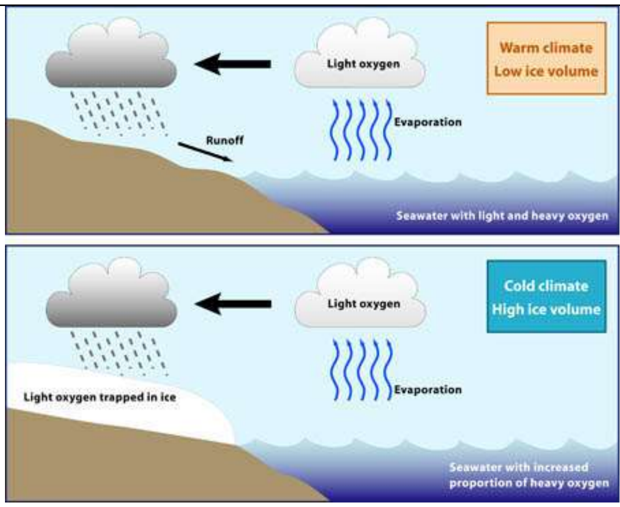
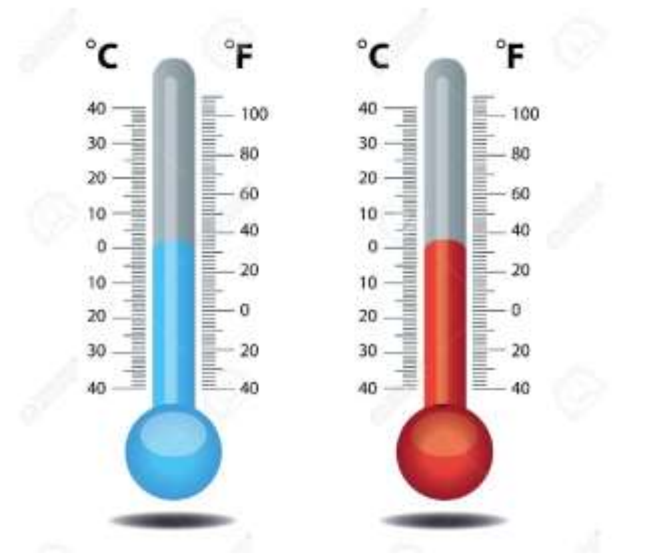
| 8 neutrons and 8 protons of O16. | *In water, by far the most common isotope of Oxygen has 8 neutrons and 8 protons. So, with these two 8s together, it's called Oxygen 16.* | | <br>© ces.fau.edu |
| 2 neutrons being added to O16 to make O18. | *But there's another type, much less common, called Oxygen 18. It has 10 neutrons, which is 2 more neutrons than Oxygen 16. These two extra neutrons means that Oxygen 18 is slightly heavier.* | | <br>© ces.fau.edu |
| O16 and O18 joined by 2 hydrogen atoms each to make water molecules. | *These two isotopes, O16 and O18, do the same basic job, combining with two hydrogen atoms to form water molecules.* | | <br>© pinimg.com |
| Each water molecule on a scale, H2O18 heavier than H2O16. | *But because O18 heavier than O16, these two types of water molecule behave in slightly different ways in earth's environment.* | | <br>© clipartbest.com |

| | | | |
|---|---|---|---|
| Ocean water containing H2O16 and H2O18. | *At the ocean surface, water molecules …* | | <br>© cdn.phys.org |
| Water molecules evaporating. | *… are constantly evaporating, forming vapour and clouds.* | | <br>© school-for-champions.com |
| H2O16 molecules evaporating more than H2O18 molecules. Clouds with relatively more H2O16. | *Because H2O16 (let's call this 'light water') weighs less than H2O18 (and let's call that 'heavy water'), it evaporates more readily out of the oceans. This means that clouds have lower concentrations of the heavy water than the ocean does.* | | <br>© uoregon.edu |
| Water cooling in clouds then precipitating from clouds. | *As water vapour cools, by moving upwards in the atmosphere, or moving towards the cold poles, the water condenses and precipitates. This means that it falls down as rain, sleet, hail or snow.* | | <br>© gordonton |

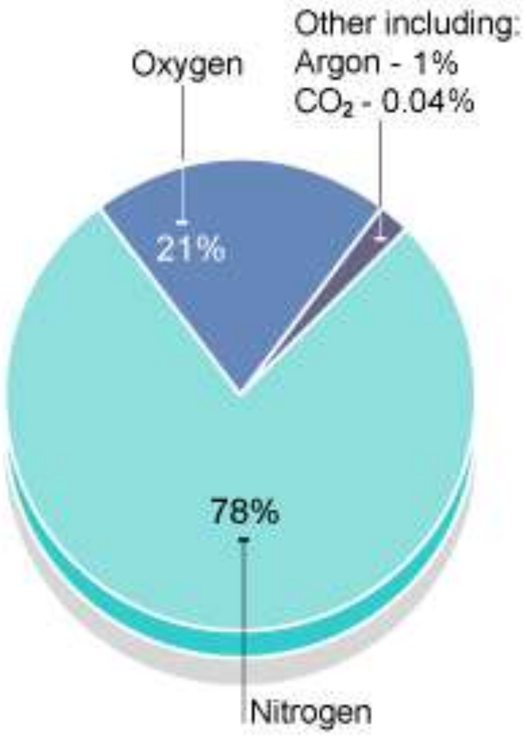
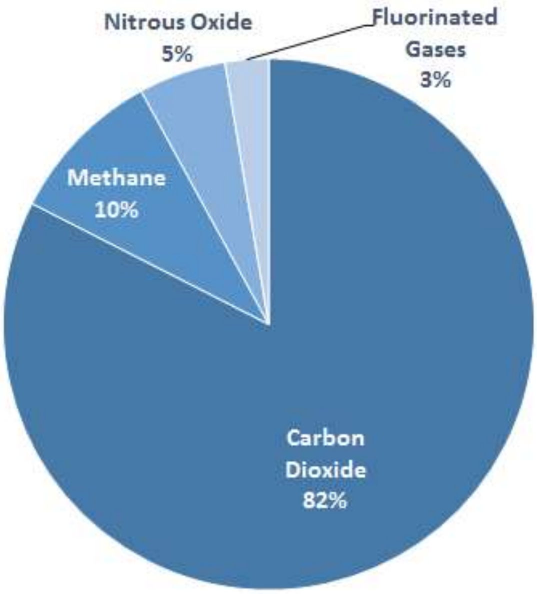
| | | | |
|---|---|---|---|
| More H2O18 precipitating than H2O16. H2O18 evaporating with difficulty, and precipitating with ease. | *In the clouds, heavy water precipitates out more readily than light water, again because it weighs more. So basically, the heavier water has a harder time getting up into the clouds, and an easier time falling out of them.* | |  © iso-net.atlassian.net |
| Water vapour moving towards Antarctica, precipitating out H2O18 on the way. H2O16 trapped in ice sheet. | *By the time water vapour reaches Antarctica and is precipitated out as snow, it has preferentially lost heavy water along the way. This means that snow from the interior of Antarctica has 5% less heavy water than the ocean. Light water gets trapped in ice, frozen at the cold poles. So analysing the water frozen at the poles can that tell us about temperature in earth's past.* | |  © earthobservatory.nasa.gov |
| Cold climate scenario, in which H2O16 is trapped at the poles. | *During cold climate periods, more O16 is trapped at the poles in ice sheets, which means there's a higher ratio of O18 in the oceans.* | |  © geography.hunter.cuny.edu |

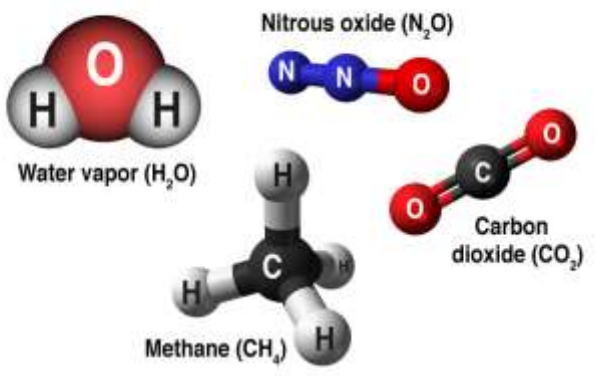
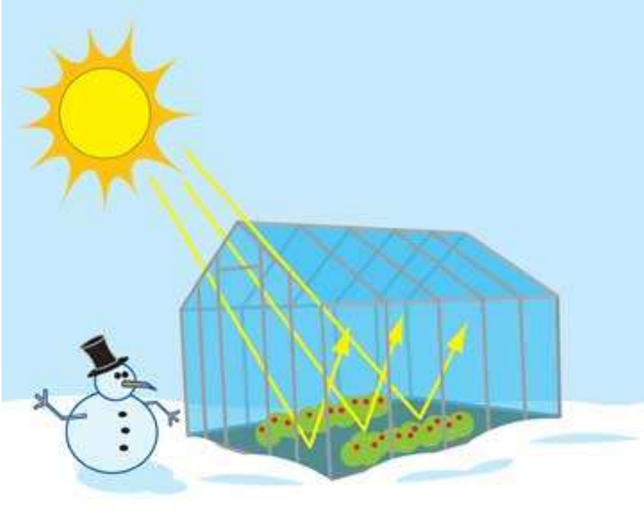
<table>
<tr>
<td>Warm climate scienario, in which H2O16 melts into the ocean water.</td>
<td>When it warms up and the ice sheets melt, this O16 returns to the ocean, which evens out this ratio.</td>
<td></td>
<td>

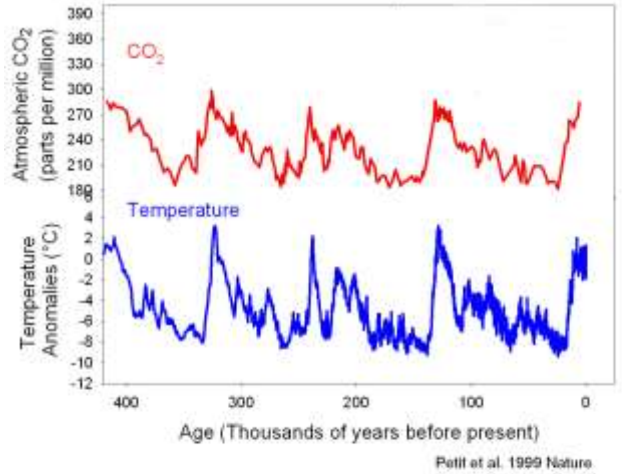
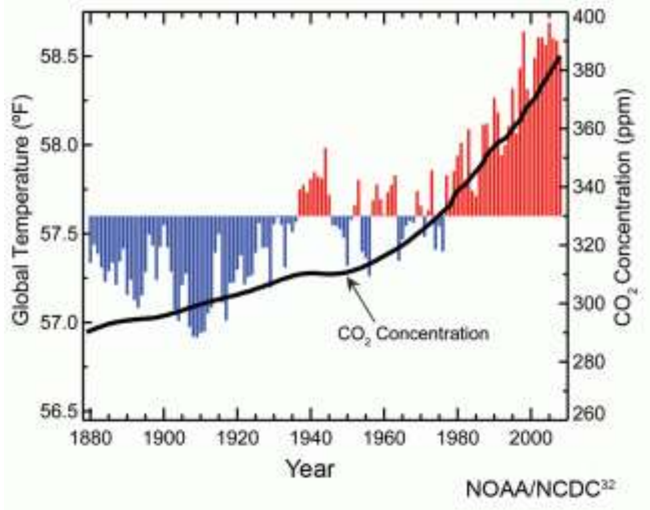
© geography.hunter.cuny.edu</td>
</tr>
<tr>
<td>Thermometer going up and down with changing ratios of H2O16 in the ice sheet and ocean.</td>
<td>So by analysing the ratio of O16 to O18 isotopes in ice core layers, scientists can uncover what the temperature was when each layer of snow fell.</td>
<td></td>
<td>

© 123rtf.com</td>
</tr>
<tr>
<td>Mock-up weather forecast, 800,000 years in the past.</td>
<td>This means that Antarctic ice cores can be used to check the weather, over 800,000 years ago!</td>
<td></td>
<td>

© australiaresorts.us</td>
</tr>
<tr>
<td>Zoom into ice core, between water molecules, to bubbles of air.</td>
<td>Isotope analysis on ice core water can tell us so much about the earth's past. And so can what's between the water, tiny bubbles of trapped air.</td>
<td></td>
<td></td>
</tr>
</table>

| **FOSSIL AIR and PAST ATMOSPHERIC GAS CONCENTRATIONS** | | | |
|---|---|---|---|
| Nitrogen and oxygen atoms floating through the air. | *The air around us is mostly made up of two gases: it's 78% nitrogen and 21% oxygen.* | | |
| Atoms zoom into pie chart. | *Together, nitrogen and oxygen make up 99% of the air. This leaves just 1% for all the other gases, floating but of dust and particles, and water vapour.* | | <br>© bbc.co.uk |
| Zoom into 1% of pie chart to show break-down of greenhouse gases. | *In this remaining 1%, we'll find what are called the 'greenhouse gases'.* | | <br>© epa.gov |

| | | | |
|---|---|---|---|
| Atoms zoom out of pie chart to float freely. | *In the greenhouse gases, the main players are carbon dioxide, methane, and nitrous oxide.* | | <br>© climate.nasa.gov |
| Simple animation of the greenhouse effect. | *These molecules are called greenhouse gases because they trap heat in earth's atmosphere, like the glass in a greenhouse traps heat inside. An oversupply of these gases to our atmosphere, caused by humans burning fossil fuels, is causing our world to warm up.* | | <br>© climatekids.nasa.gov |
| Zoom into ice core, showing atoms and molecules of past atmosphere trapped in the bubbles. | *Studying the tiny bubbles of air in Antarctic ice cores can help scientists understand how much of these greenhouse gases were in earth's ancient atmosphere, and how this amount has changed over time.* | | <br>© oregonstate.edu |

| | | | |
|---|---|---|---|
| Zoom out of the ice core, onto a graph mapping greenhouse gases and temperature. | *And when past temperature records are compared to these greenhouse gases, a very clear trend emerges.* | | <br>© Nature |
| Animated graph showing the relationship between temperature rise and atmospheric greenhouse gas concentrations. | *As temperatures rise, so does the amount of greenhouse gas in our atmosphere. They fall, and rise, together.* | | <br>Creative commons image: Wikimedia.org |

| GLACIOLOGY and PRECICTING WHAT'S COMING | | | |
|---|---|---|---|
| Ice layers. Ice sheet. | *Antarctic ice is a frozen record of earth's history, able to show us how our climate has naturally varied over time...* | |  © Anthony Powell |
| Icebergs calving, ice melting, or similar. | *… and how human induced climate change is moving our planet outside of these usual boundaries.* | |  © Anthony Powell |

| | | | |
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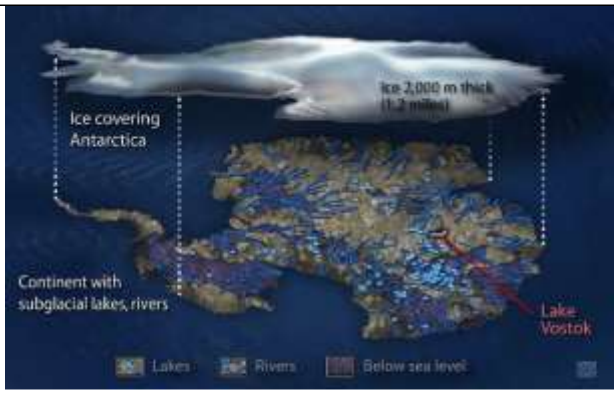
| Glaciers, ice streams, ice calving, surface melting, ice shelf fracturing. | *But Antarctic ice isn't just a window to the past. Today, glaciologists are studying how ice builds, moves, breaks and melts to make predictions about the future.* | |  © Anthony Powell |
| | *In a warming world, sea level rise will be one of the greatest challenges we face. How much the Antarctic ice caps will melt, and how quickly, are some of the biggest questions for today's scientists.* | |  © Anthony Powell |
| Ice either lifting off the Antarctic landmass, or slowly melting away. | *To understand how vulnerable the Antarctic ice sheet is to melting, we need to look back underneath the ice to the continent's rocky base below.* | |   © cdn.antarcticglaciers.org |

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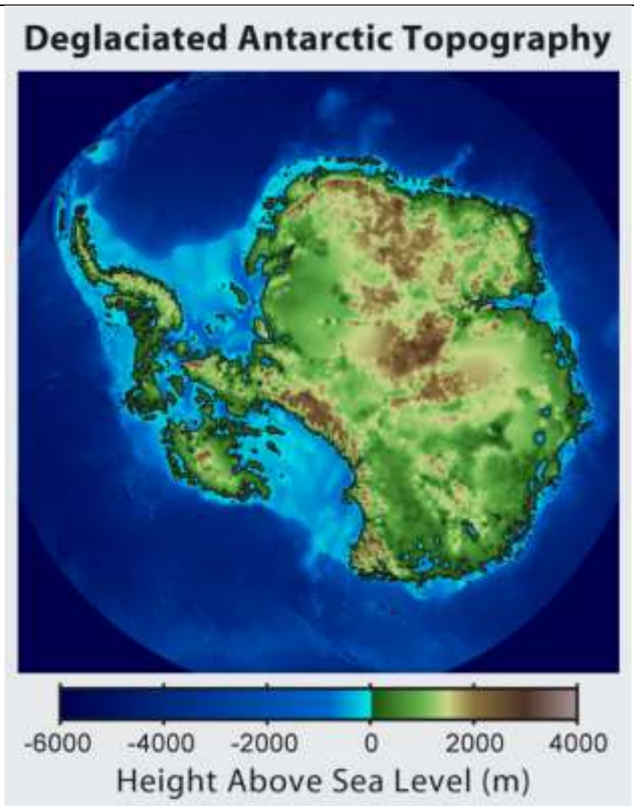
|---|---|---|---|
| Show sea level differences between EAIS and WAIS. | *An important difference between the East Antarctic and West Antarctic landmasses is how high they sit above sea level. Because ice in water and ice in air melt very differently.* | | <br>© cdn.antarcticglaciers.org |
| Either film or animate two clear ups, each containing a cube of ice. One contains water, the other contains air. | *Imagine you had two ice cubes, and two cups. One cup contains room-temperature water, while the other contains just air.* | | <br>© middleschoolchemistry.com |
| Ice cube in water melting more quickly than ice cube in air. | *If you put one ice cube in each cup, which cube would melt the fastest?* | | <br>© aquapro.in.ua |

| | | | |
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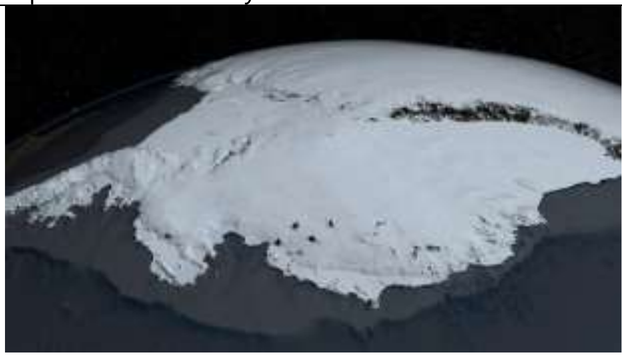
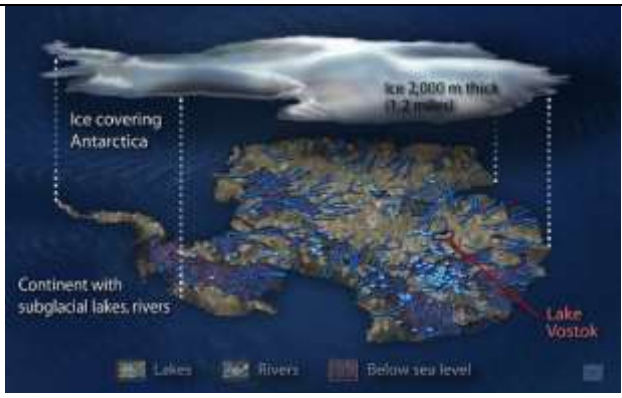
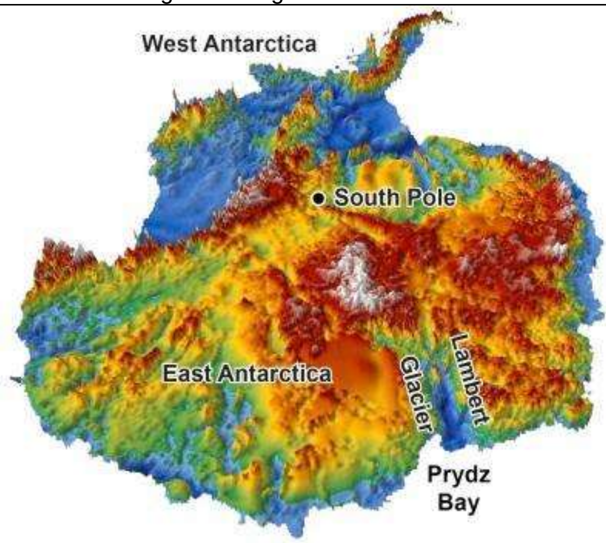
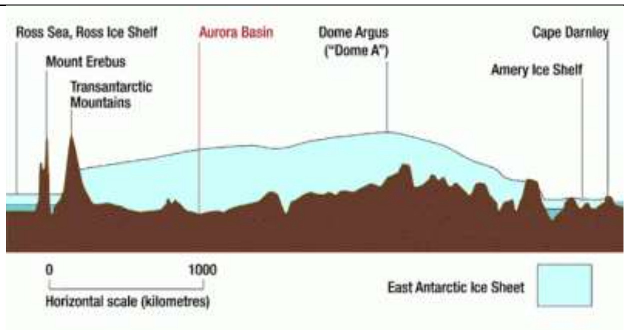
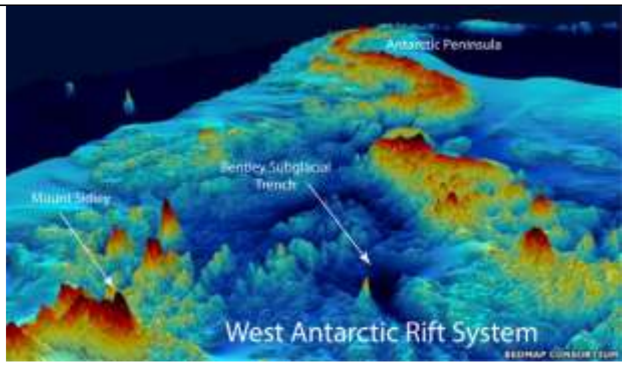
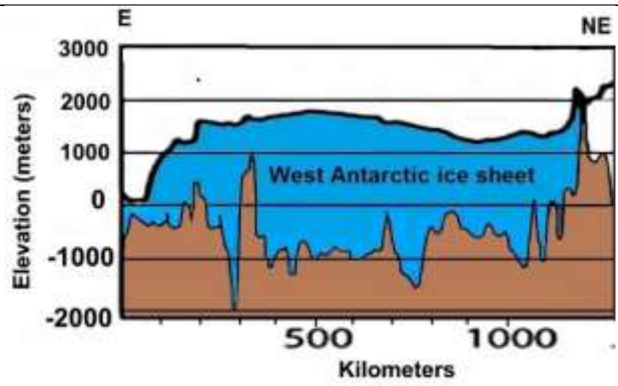
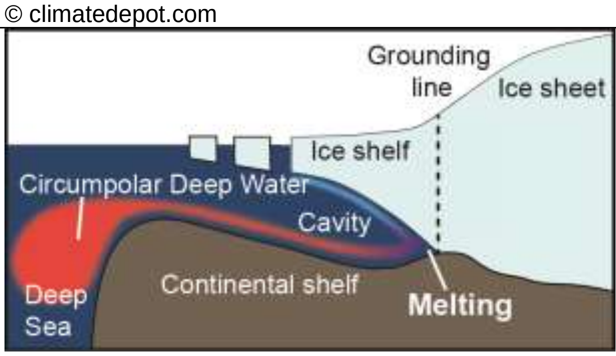
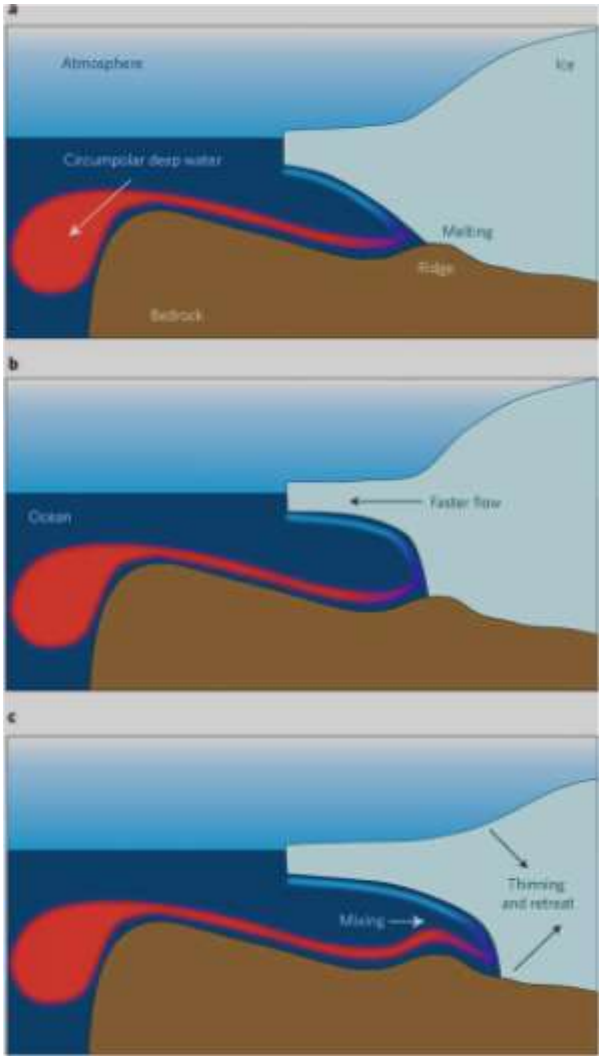
| Moving red waves (or similar) indicating heat transfer from medium into ice cube. In water, more and faster red waves. | *The water transfers heat energy to ice more efficiently than air does. This means that ice will melt more quickly in water than in air at the same temperatures.* | | <br>© processtechacademy.com |
| Grow ice cubes, change substrate to landmass. Keep growing ice until the piece in air is shaped like the EAIS and the piece in water is shaped like the WAIS. | *Now, if we expand this idea out to Antarctic ice sheet proportions…* | | <br>Creative Commons image: nasa.gov |
| Lift the icesheet off Antarctica, then break it in half into the EAIS and the WAIS. | *…we can see how what Antarctic ice is sitting on, or in, can have a big impact on how it might melt.* | | <br><br>© cdn.antarcticglaciers.org |
| Place the EAIS onto the East Antarctic landmass. | *The East Antarctic Ice Sheet is more like the ice cube exposed to the air…* | | <br><br>© livescience.com |

| | | | |
|---|---|---|---|
| Profile view of ice sitting on landmass. | *…as it's grounded on land that's mostly above sea level.* | | <br>© southwind.com.au |
| Place the WAIS onto the West Antarctic landmass. | *But the West Antarctic Ice Sheet is closer to the ice cube in the water…* | | <br>© livescience.com |
| Profile view of ice sitting on landmass, with sections below sea level. | *…as it's grounded on land that's largely below sea level.* | | <br>© climatedepot.com |
| Ice sheet, grounding line and ice shelf distinctions, with water moving below ice shelf. | *Where the West Antarctic ice sheet is grounded on land, it's protected from melting by ocean water…* | | <br>© bas.ac.uk |

<table>
<tr>
<td>Grounding line retreat, ocean water access to underside of ice sheet, melting, thinning.</td>
<td>…but as the ice thins and floats, it comes into contact with the sea. And this contact will cause it to melt.</td>
<td></td>
<td>


© Nature Geoscience (2010)
</td>
</tr>
<tr>
<td>West Antarctic Ice Sheet melting off the continent.</td>
<td>The West Antarctic Ice sheet is accessible to encroaching ocean water, making it vulnerable to melting in our warming world. And if West Antarctica were to melt, it would contribute nearly 5 metres of sea level rise around the world.</td>
<td></td>
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© cdn.antarcticglaciers.org
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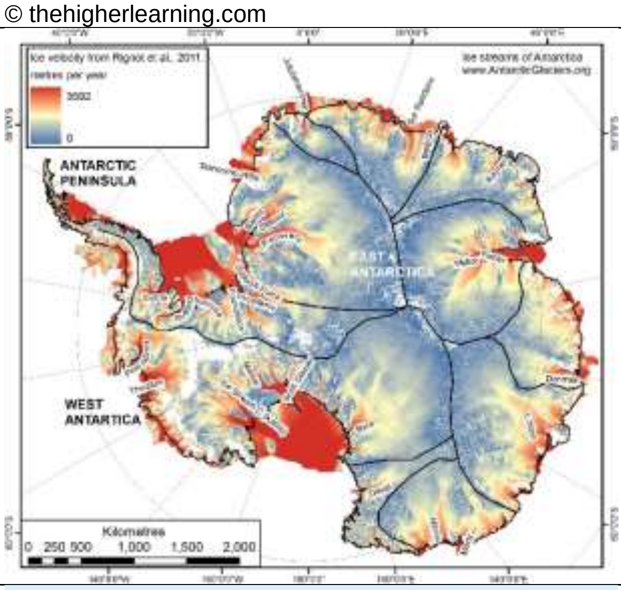
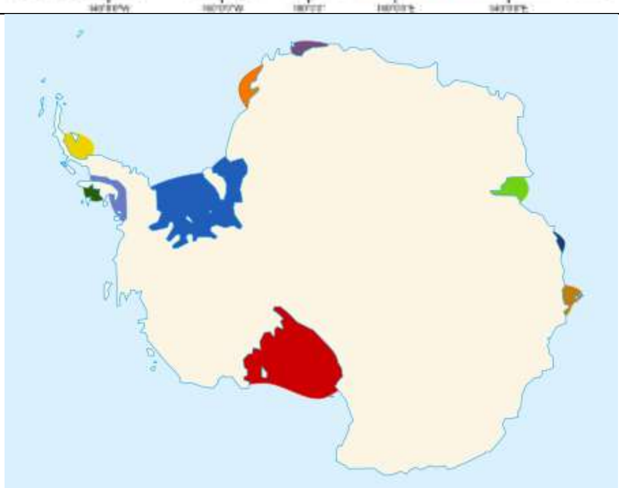
</tr>
</table>

# ICE SHELVES AS BUFFERS TO ICE LOSS

| | | | |
|---|---|---|---|
| Ice shelf shots. | *But, there are some forces helping keep this ice sheet together: Antarctica's ice shelves.* | | <br>© thehigherlearning.com |
| Ice flowing from the interior of Antarctica onto the ice shelves. | *Ice shelves are thick platforms of ice. They are attached to the ice sheet, but floating on the ocean.* | |  |
| Map showing location of ice shelves around the Antarctica continent. | *Fed by ice flowing from inland Antarctica, and by ocean water freezing from below, they can grow more than a kilometre thick, reaching deep down towards the ocean floor.* | | <br>Creative Commons image: Wikimedia.org |

| | | | |
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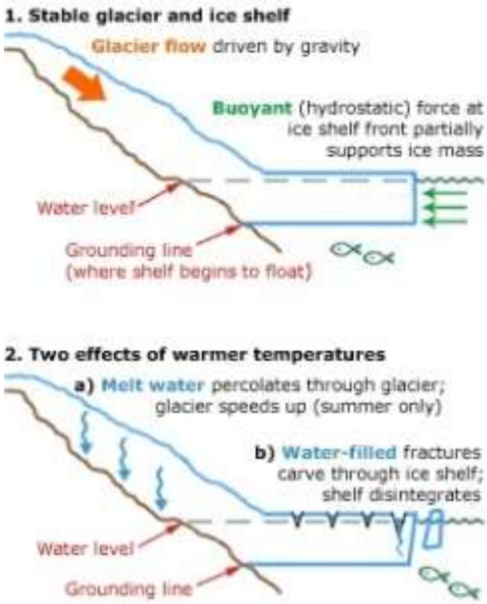
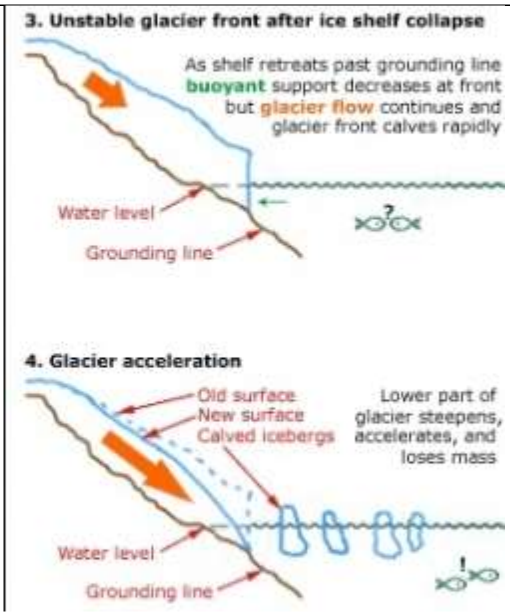
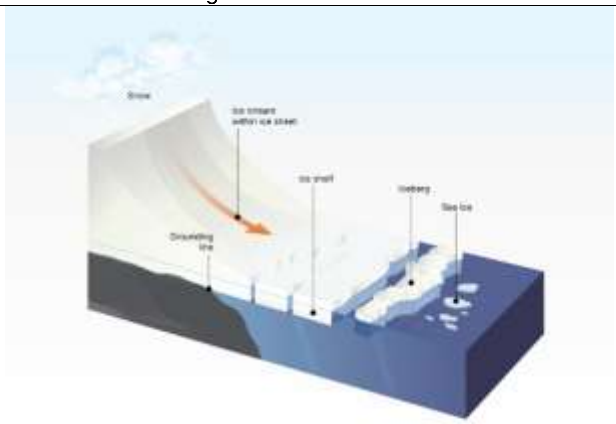
| | *They can cover massive areas. The Ross Ice Shelf is Antarctica's largest, and is nearly 800km across.* | | <br>© eoearth.org |
| Slow, steady movement of ice sheet ice to ice shelf to calving front. | *And for the ice sheets they're attached to, they act like dams on rivers, slowing the flow of continental ice into the ocean.* | | <br>© climatecentral.org |

| | | | |
|---|---|---|---|
| Accelerated rate of ice sheet loss to the ocean. | *If an ice shelf collapses into the ocean, the dam is removed, and the ice sheet flows more quickly and readily into the ocean. So in order for scientists to predict how ice sheets will respond to our changing climate, they must understand how ice shelves are built, how they move, and how they melt.* | | <br>© climatecentral.org |
| Ice moving from ice sheet to ice shelf out to the ocean. | *Ice shelves are in constant motion moving inland ice to the ocean, sometimes at rates of several kilometres a year. They lose this ice when it calves off at the edge of the ice shelf, making floating icebergs. But with global warming, ice shelves are melting, from above and below.* | | <br>© ulb.ac.be |
| Footage of surface melt on ice shelf. | *On the surface of the ice shelf, above freezing temperatures and sunshine cause melt pools to form. Liquid water flows into cracks and fractures, weakening the ice shelf until it breaks into fragments.* | | <br>© planetmattersandmore.com |

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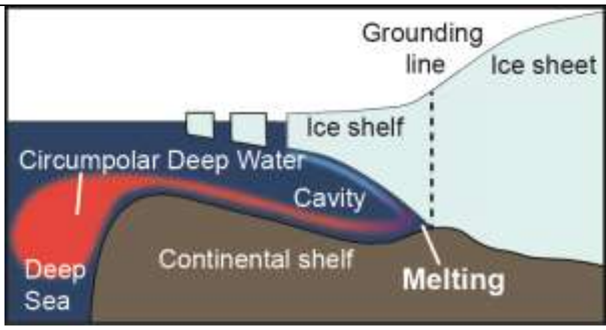
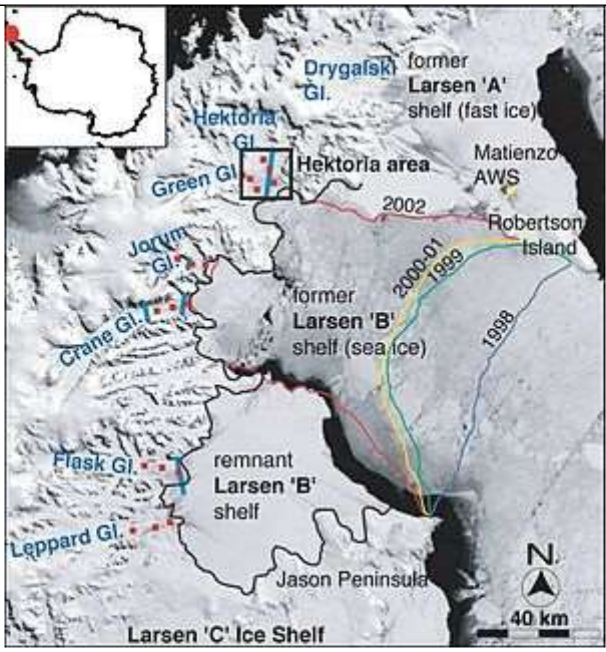
| Animation of below ice shelf melt. | *From below, the ice shelf will melt wherever it comes into contact with the relatively warm ocean water.* | |   © bas.ac.uk |
| Footage of the loss of the Larsen B ice shelf. | *Losing ice shelves could have a huge impact on sea level rise, as it could greatly increase ice flow from the ice sheets to the ocean.* | |   Creative commons image: Wikimedia.org |
| Zoom out to aerial view of Antarctica and the globe. | *But for now, scientists still have more questions than answers about how these floating, icy platforms will react to a warming world.* | |  Creative Commons image: nasa.gov |

## LOOKING TO THE FUTURE

Action: Various glamour shots of Antarctica.

Narration: *The extent of melting of both the vulnerable West Antarctic Ice Sheet and the East Antarctic Ice Sheet depend a lot on our actions today. How humans choose to combat climate change in the coming decades will have implications for ice sheet stability for centuries, even millennia, to come.*

*For scientists, the goal is to know with more certainty how much of the icesheets will go, and how quickly. But for now, these remain the big questions. Each year, researchers are heading down, drilling down, trying to better understand how ice builds, moves and melts, and how this will impact the rest of the world into the future.*

*It's difficult information to get. While we are able to delve ever deeper into the ice, Antarctica remains a wild, harsh, and challenging place to work. But the more we understand Antarctica, bringing its icy layers into sharper focus, the more prepared we'll be for what's to come.*