From Pole to Pole: Investigating Polar Climate Change

The Scholars Programme

Dr Marks

Student Name:

The Scholars Programme – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to a standard of first year undergraduate level
2:1	60-69	Performing to a standard of A Level
2:2	50-59	Performing to an excellent standard at GCSE level
3rd	40-49	Performing to a good standard at GCSE level
Workings towards a pass	0-39	Workings towards a pass
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor			
Title of Assignment			
Name of Pupil			
Name of School			
ORIGINAL MARK / 100		**FINAL MARK / 100**	
DEDUCTED MARKS		**FINAL GRADE**	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 - *Communication*	
What you did in relation to this Key Learning Priority	**How you could improve in the future**
Learning Feedback Comment 2 – *Research skills*	
What you did in relation to this Key Learning Priority	**How you could improve in the future**
Learning Feedback Comment 3 – *Subject knowledge*	
What you did in relation to this Key Learning Priority	**How you could improve in the future**
Resilience Comment	
How you showed learning resilience during the course	**How you could build learning resilience in the future**

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Course Rationale

There is extensive evidence that the Earth's climate is changing, although the degree to which humans are causing climate change and the effects this may have on the planet, are still extensively debated by scientists. Polar Regions, particularly the Arctic, are, arguably, being most affected; sea ice extent in the Arctic has decreased by over 7% a decade since 1979 with the most abrupt changes observed since 2002. Understanding climate change in Polar regions is essential as not only does sea ice decline have negative consequences for the Arctic ecosystem, but these regions play a crucial cooling role on the whole of the planet's climate system. How to best tackle present day climate change is one of the major challenges facing the 21st century world.

This course is aimed at students who would like to know more about the Science of Climate change with a particular focus on the causes and effects of Polar climate change both in the northern Arctic and southern Antarctic. In later stages, the course will move onto how the challenges posed by climate change can be best addressed. This multi-disciplinary course will include elements of Physics, Chemistry and Geography and apply these subjects to understand all aspects of Polar climate change.

A final assessment will give students the chance to write a report on why Polar Regions are being so greatly affected by climate change using knowledge acquired throughout the course and by independent study. The course will encourage independent subject knowledge development, critical thinking, research skills and effective communication. All of which are essential skills for university level study.

Mark Scheme

Key Skill	1st	2.2
Communication	☐ Writing/presentation is coherent and organised following a logical sequence. ☐ Almost faultless spelling, punctuation and grammar. ☐ Writing is of a scientific essay style ☐ Forms a clear and balanced argument	☐ Generally well written but occasionally the writing/presentation is poorly organised with a lack of coherent structure. ☐ The spelling, punctuation and grammar are generally good but with a few errors in places. ☐ Some inconsistent use of style throughout the essay which may result in a lack of clarity in places. ☐ Infrequent use of scientific terminology or terminology is sometimes incorrectly applied ☐ Argument is slightly one sided or poorly balanced
Research skills	☐ All the outside sources are correctly referenced in the agreed format, which is appropriate for the scientific style. ☐ Uses a purposeful but imaginative range of sources; reliable, relevant, and balanced in their choice. ☐ Comprehensive research is evidenced; sources of information go beyond the obvious choices and those suggested throughout the course ☐ Additional scientific content not covered in the course is included in the essay	☐ Sources are mostly but not always referenced correctly. ☐ A limited range of sources outside of the course reading has been used. ☐ Some sources that have been found outside of the course reading may be unreliable; inappropriate for the subject; or heavily biased. ☐ Little scientific content that is not covered in the course is included
Subject knowledge	☐ Extensive knowledge of the issues surrounding Polar Climate change is outlined. ☐ Explains clearly why Polar climate change is significant and worthy of discussion. ☐ The significance is explored through comprehensive use of current literature.	☐ Some reference is made to current knowledge of the issues surrounding Polar climate change beyond what has been discussed throughout the course. ☐ Discussion of why the topic is significant and worthy of discussion.

Glossary of Keywords and Acronyms

Albedo- The ratio of reflected light from a surface to incident light upon it. It is a unitless quantity expressed as a percentage or on a scale from 0 to 1 where 0 represents no reflection of light from a surface (a perfectly black surface) and a value of 1 represents perfect reflection of a white surface.

Anthropogenic- Originating from human activity

Black carbon- A distinct type of carbonaceous material, formed only in flames during combustion of carbon-based fuels, it is highly absorbent of solar radiation.

Carbon footprint- The amount of greenhouse gases released into the atmosphere as a result of the activities of a particular individual, organization, or community.

Climate- The description of the long-term pattern of weather in a particular area

Climate change- A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.
It refers to any change in climate over time, whether due to natural variability or as a result of human activity

Greenhouse effect- The process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be in the absence of its atmosphere.

IPCC- Intergovernmental Panel on Climate Change. The IPCC is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts

Kyoto protocol- An international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. Emission targets differ by country although they originally averaged out as a 5.2% reduction from 1990 to 2012.

Radiative forcing- The net change in the energy balance of the Earth system due to some imposed perturbation. It is expressed in watts per square meter (Wm^{-2}) averaged over a particular period of time and quantifies the energy imbalance that occurs when the imposed change takes place. A positive value represents a net increase in energy (warming), while a negative value represents a net decrease in energy (cooling).

Solar radiation- Radiant energy emitted by the sun.

Solar irradiance - The power per unit area produced by the Sun in the form of electromagnetic radiation.

Weather- The state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc.

Tutorial 1 – An introduction to Climate Change

What is the Purpose of Tutorial 1?

- Be able to define "climate change"
- Examine evidence for present day climate change
- Provide an overview of the causes of climate change

What is "climate change"?

What does "climate change" mean to you?
Write down any key words or phrases you relate to climate change, e.g. causes, effects, solutions

The intergovernmental panel on climate change (IPCC) defines climate change as:

"A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity"

Evidence of present day climate change

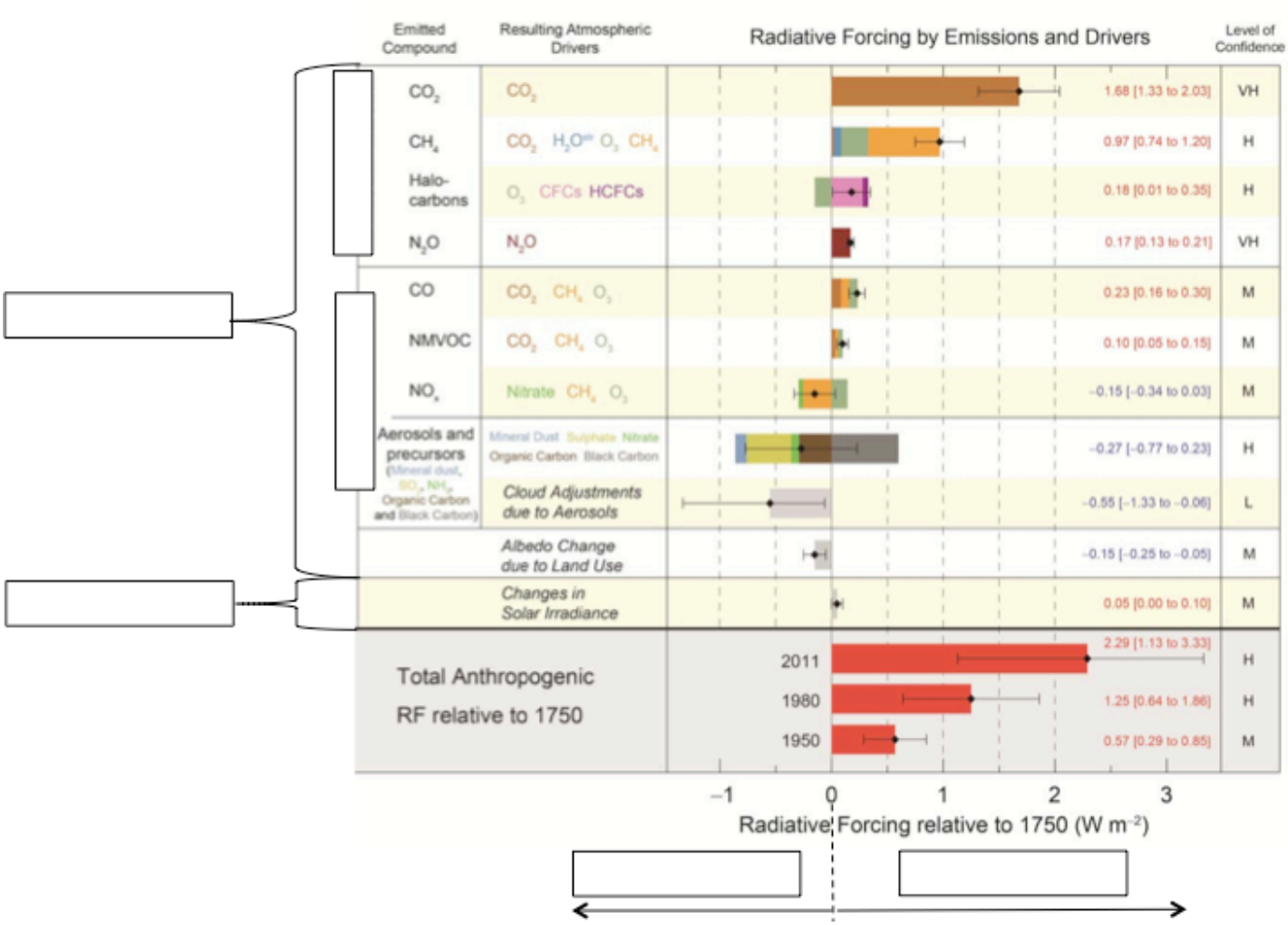
The table below gives seven key indicators for present day climate change. You will each be given an article about one of these indicators of climate change. You will need to read through the article and select three pieces of evidence of climate change for that indicator.

Indicator of climate change	Evidence
Higher temperatures	1. 2. 3.
Changing rainfall	1. 2. 3.
Changes in nature	1. 2. 3.

Sea level rises 	1. 2. 3.
Retreating glaciers 	1. 2. 3.
Sea ice 	1. 2. 3.
Ice sheets 	1. 2. 3.

Causes of present day climate change

The below figure, from the Intergovernmental Panel on Climate Change, shows factors that are contributing to climate change. Fill in the blank boxes on the figure with the words below. Then answer the question beneath the diagram. Remember to use the glossary on page 6 to look up unknown words.



Complete the blanks with the following words:

- Warming
- Cooling
- Natural causes
- Anthropogenic causes
- Greenhouse gases
- Short lived gases and aerosols

From the above figure what is the largest contributor (atmospheric driver) to climate change (radiative forcing)? What are the sources of this gas?

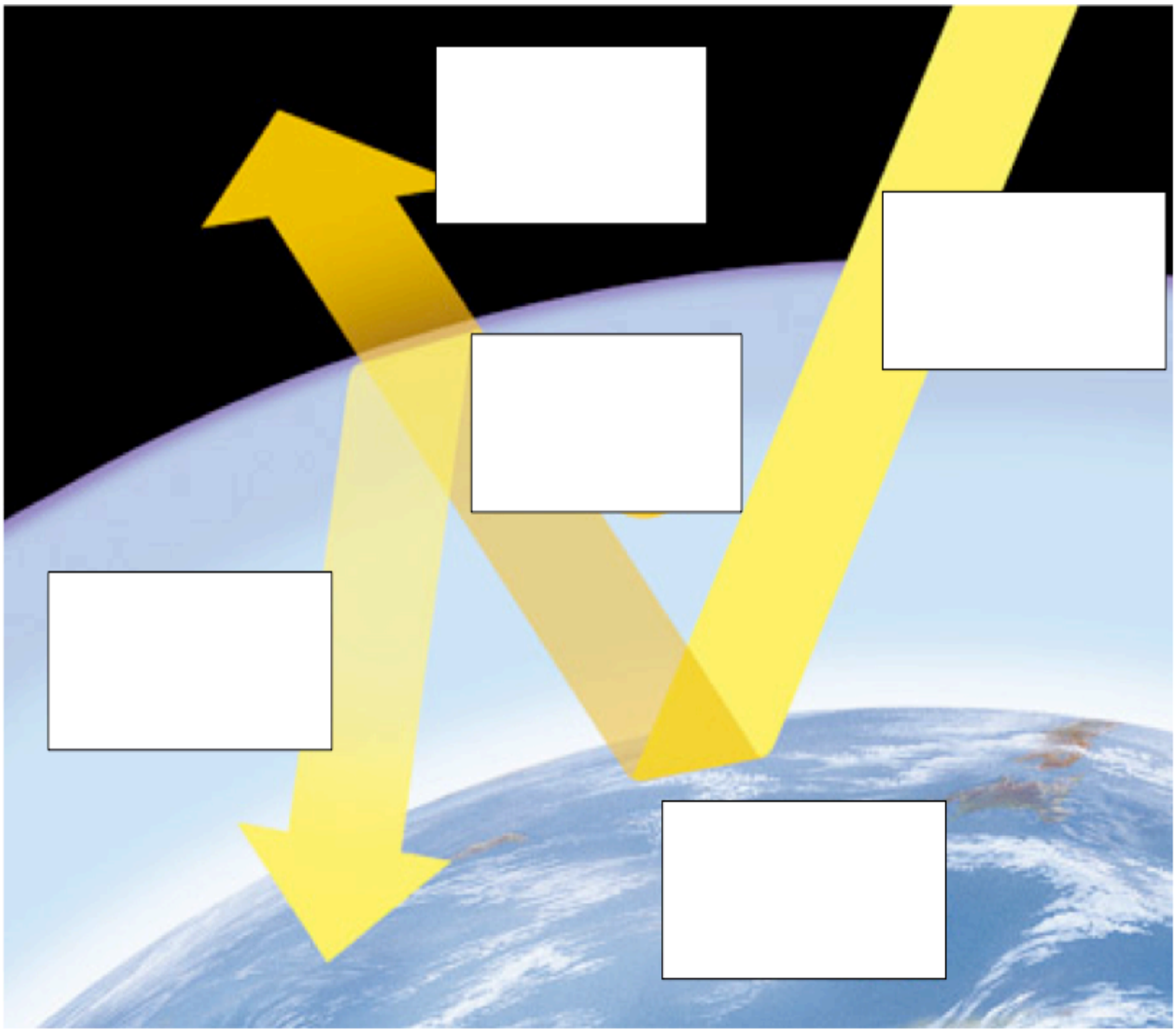
Tutorial 1 – Baseline Test on The Greenhouse Effect

The homework assignment for the first tutorial is a baseline test to see your initial level of attainment in this subject area. The assignment will test for some or all of the subject specific skills that are required later in the final assignment. However, it is shorter than the final assignment and is will be an introduction to the subject as well as a challenge!

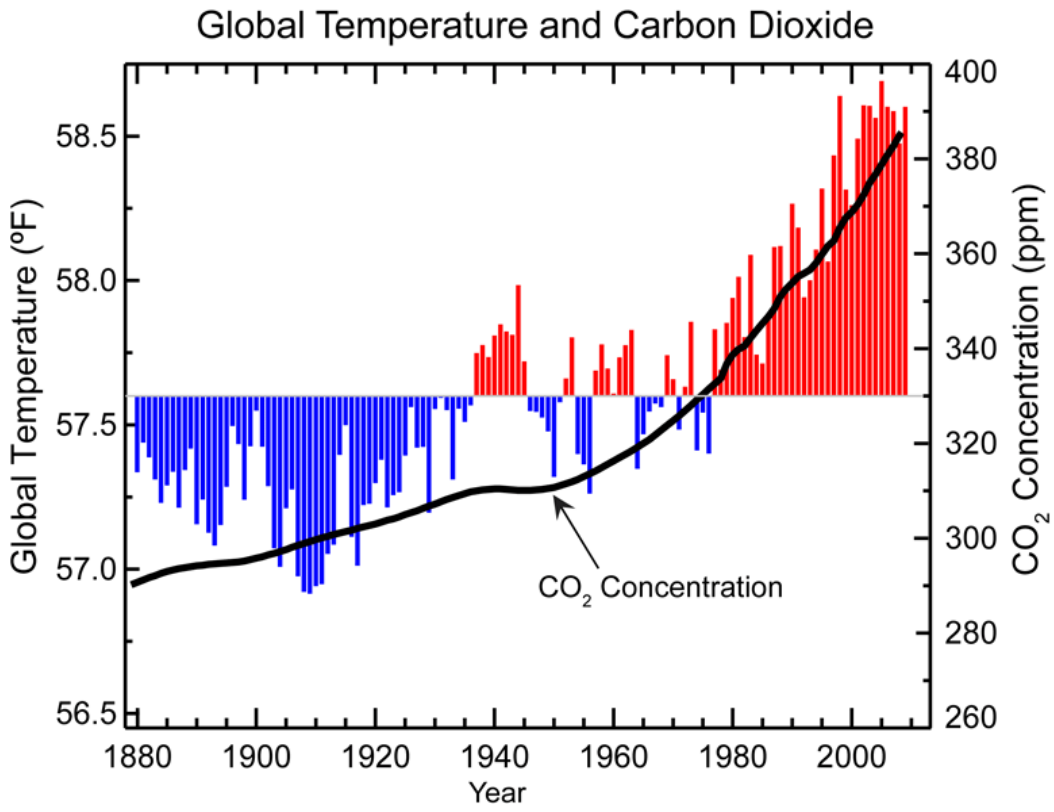
Do not worry too much about doing 'well' or 'badly' on the baseline test, it takes into account the fact that you may not be familiar with the subject area. It is designed to help you identify where you are at the start of the programme and to help you measure your progress along the way.

1. The below box provides a summary of the greenhouse effect. Use this information and prior knowledge to fill in the blank boxes on the diagram summarising the different stages in the greenhouse effect.

> The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be in the absence of its atmosphere. If a planet's atmosphere contains greenhouse gases the atmosphere radiates energy in all directions. Part of this radiation is directed towards the surface, warming it. On Earth, solar radiation at the frequencies of visible light largely passes through the atmosphere to warm the planetary surface. The surface itself emits energy at the lower frequencies of infrared thermal radiation. Infrared radiation is absorbed by greenhouse gases in the atmosphere, these gases also radiate energy, some of which is directed to the surface and lower atmosphere.



2. The below figure shows a graph of concentration of the greenhouse gas, carbon dioxide, in the atmosphere from 1880 to the present day and global temperatures over the same time period. Examine the graph and answer the questions below.

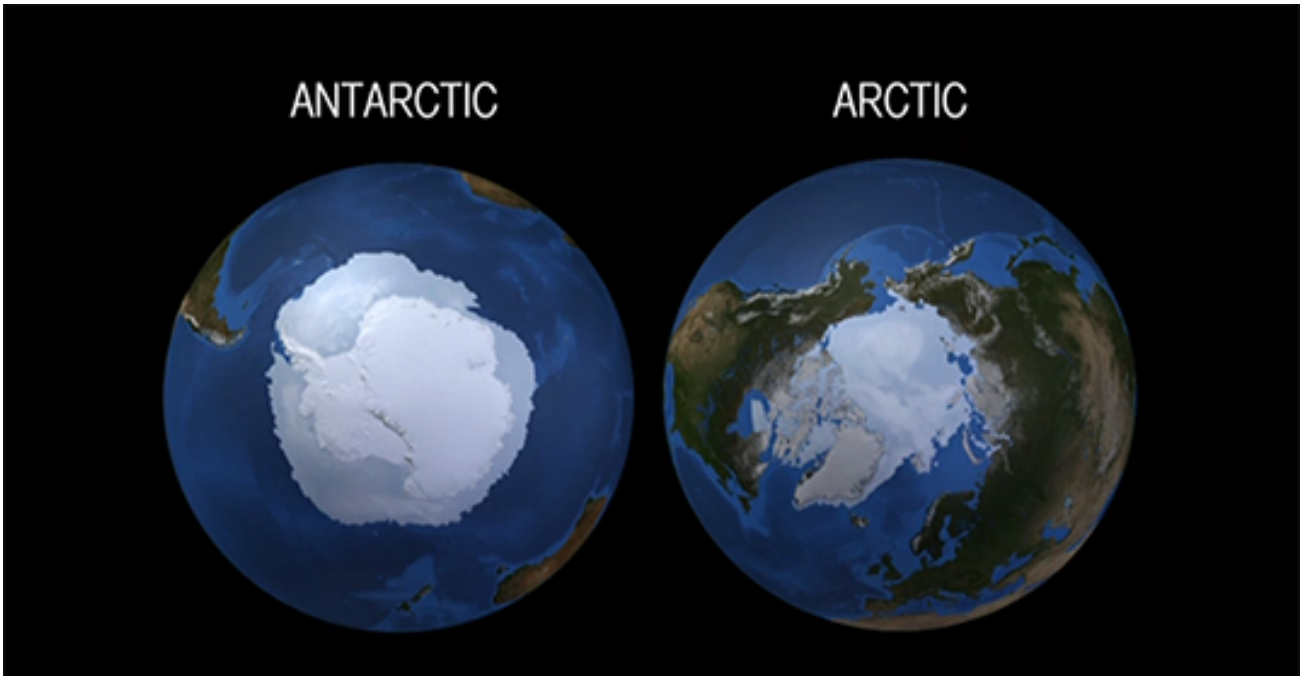


By what percentage has carbon dioxide in the atmosphere increased from 1880 to 2010?

How have global temperatures changed over time, has the change been steady?

Explain in terms of the greenhouse effect how an increase in carbon dioxide concentrations in the atmosphere can lead to an increase in global temperatures

Tutorial 2 – The role of Polar Regions in Global Climate

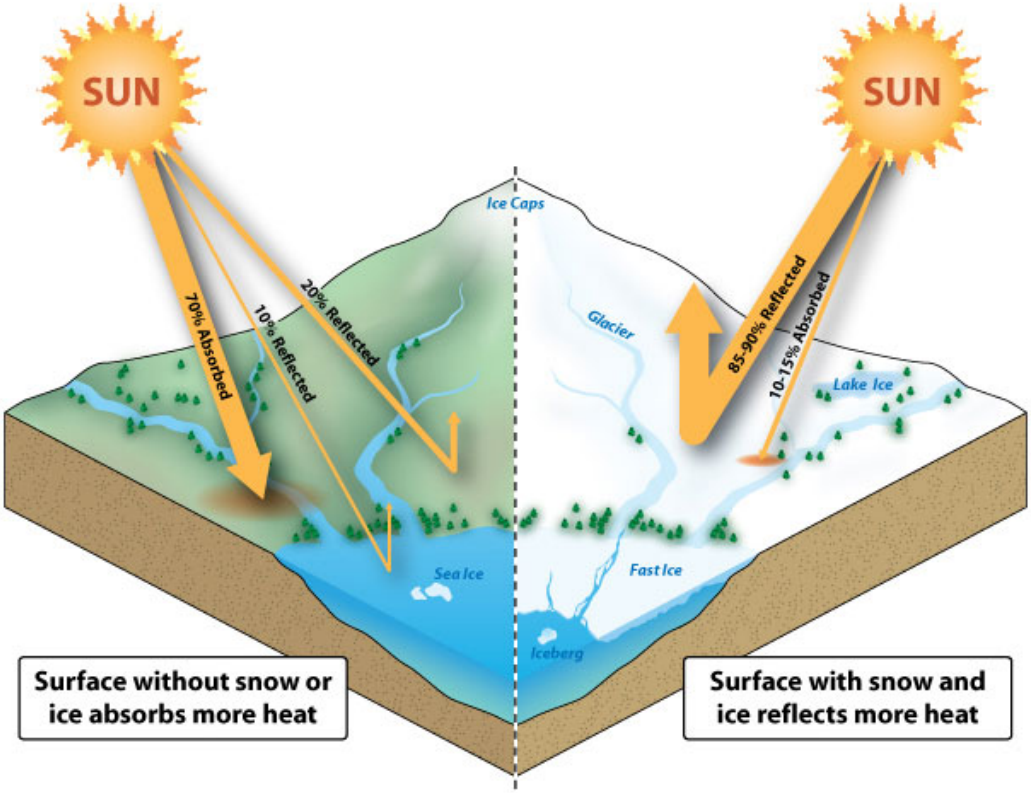


What is the Purpose of Tutorial 2?

- Understand why Polar Regions are important for the global climate
- Understand the Polar albedo feedback effect
- Examine the effects of black carbon on albedo of snow and sea ice

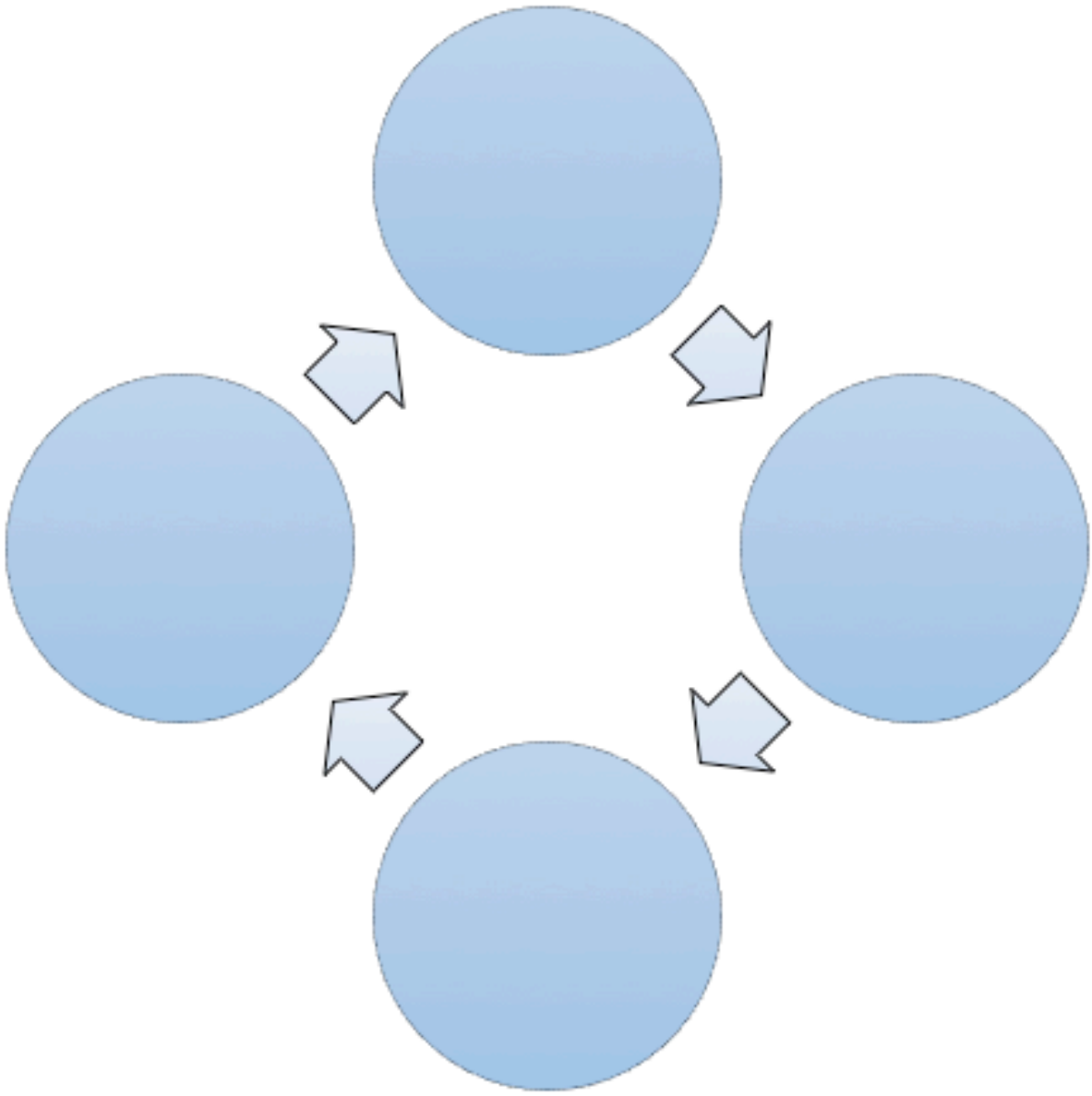
The Polar Regions and global climate

The Northern Arctic and Southern Antarctica make up Earth's frozen Polar Regions, covering up to one third of the Earth's surface. Snow and sea ice is highly reflective of sunlight (solar radiation) compared to bare land or ocean, as demonstrated in the diagram below. This means polar regions have a natural cooling effect on the planet.



Polar albedo feedback effect

You will be given four statements which form part of a feedback loop to show how decreasing snow and sea ice can itself cause increased snow and sea ice melting via the albedo effect. You need to place these statements in the right place in the loop, when you are happy you have the right order fill in the diagram below.



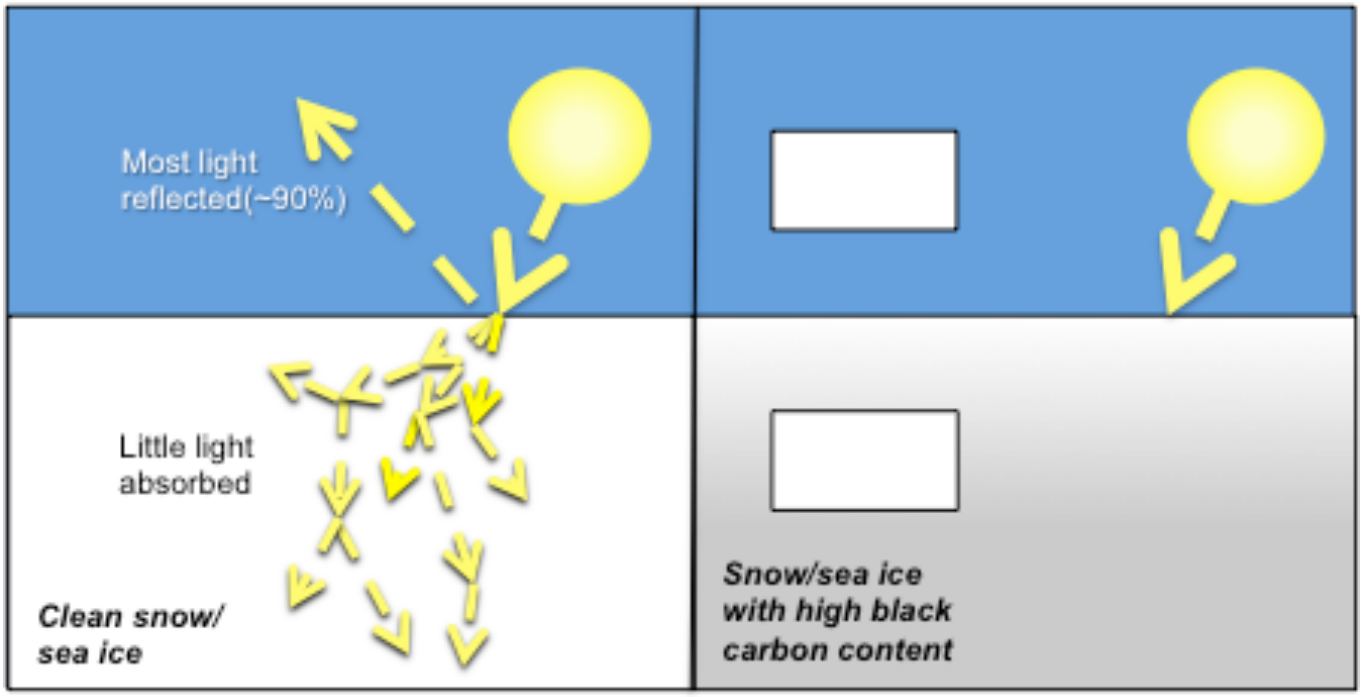
Black carbon effects on snow and sea ice albedo

In the last tutorial we looked at the IPCC's diagram of factors contributing to global warming. Black carbon has the third largest radiative forcing aside from the greenhouse gases carbon dioxide and methane.

Black carbon is a distinct type of carbonaceous material, formed only in flames during combustion of carbon-based fuels. Sources include industry, vehicle and ship emissions and agriculture burning. Black carbon is important for climate as it is highly absorbent of solar radiation.

Black carbon is deposited from the atmosphere on to snow and sea ice where it causes a reduction in albedo. Complete the right-hand diagram below with phrases and arrows for sunlight absorption and reflection to show how increasing black carbon content can reduce albedo relative to the left-hand image.

- Is more or less light reflected from the snow/sea ice surface?
- Is more or less light absorbed as light travels through the snow/sea ice?



Homework assignment

Using information from today's tutorial explain how the Polar Regions regulate global climate and why Polar regions may be especially prone to the effects of climate change, in no more than 500 words.

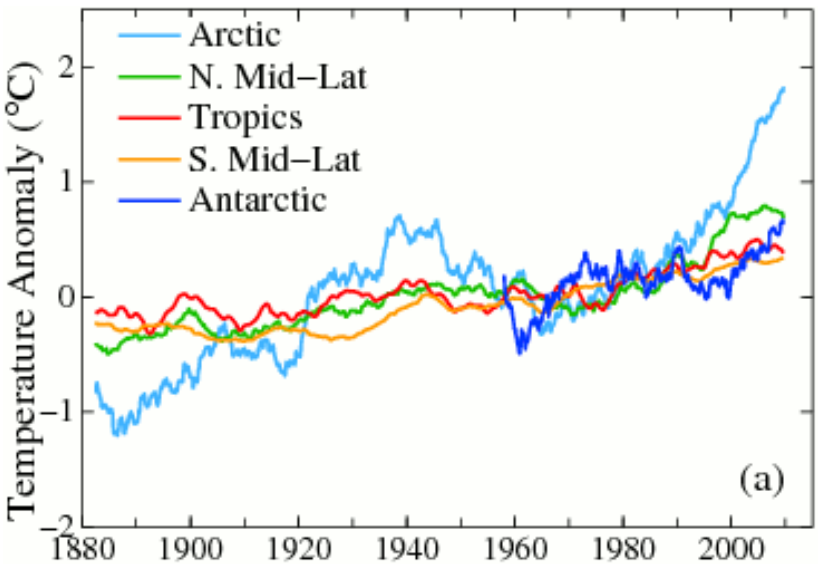
Tutorial 3 – The changing Arctic

What is the Purpose of Tutorial 3?

- Look in detail at climate changes that are occurring in the Arctic
- Examine the difference between noise in data sets and long term trends (and a note on using reliable sources)
- Look at projections for future Arctic climate change and assess issues due to uncertainties in climate models

Present day Arctic climate change

The below graph shows the deviations in Arctic temperature from the average between 1880 to 2015 compared to other regions on Earth. Examine the graph and answer the questions below.



How does the variation in Arctic temperature between 1880 and 1980 compare to variations between 1980 and 2015?

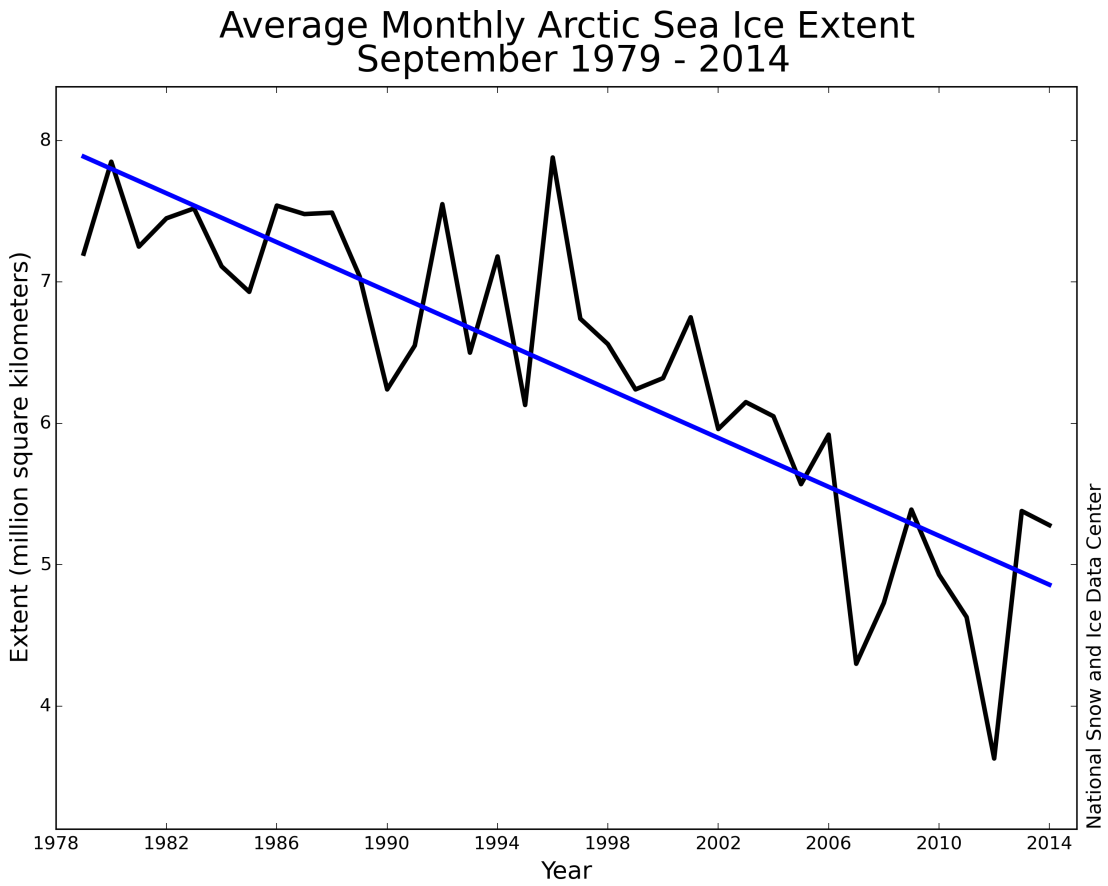
How do Arctic temperature increases compare to other regions on Earth?

Watch the video from 2012 on Arctic climate change and answer the questions below.

How does the average Arctic sea ice extent from 1979 to 2000 compare to the extent in 2012?

What are the potential global consequences of warming in the Arctic?

Noise versus trends in data sets



The below text is an exert from a Daily Mail article published on 8th September **2013**, the full article can be found here: www.dailymail.co.uk/news/article-2415191/And-global-COOLING-Return-Arctic-ice-cap-grows-29-year.html. Read through the article and compare this to the above graph showing trends in Arctic sea ice from 1978 to 2014. Make any notes in the box beneath.

And now it's global COOLING! Return of Arctic ice cap as it grows by 29% in a year

- **533,000 more square miles of ocean covered with ice than in 2012**
- **BBC reported in 2007 global warming would leave Arctic ice-free in summer by 2013**
- **Publication of UN climate change report suggesting global warming caused by humans pushed back to later this month**

By David Rose for The Mail on Sunday

Published: 00:37, 8 September 2013 | Updated: 15:58, 11 October 2014

A chilly Arctic summer has left 533,000 more square miles of ocean covered with ice than at the same time last year – an increase of 29 per cent.

The rebound from 2012's record low comes six years after the BBC reported that global warming would leave the Arctic ice-free in summer by 2013.

Instead, days before the annual autumn re-freeze is due to begin, an unbroken ice sheet more than half the size of Europe already stretches from the Canadian islands to Russia's northern shores.

CONTRACTION: This Nasa satellite image shows the ice at the smallest extent on record, with much of the Arctic Ocean uncovered

RECOVERY: Contrary to predictions that the ice would have vanished by this summer, it has actually increased by 29 per cent from last year

Make notes on how this article may be misleading on Arctic climate change?

Using reliable sources of information

As the above article shows some newspaper articles may be misleading and politically biased. It is therefore best not to use these as references. Likewise many websites will be biased and poorly represent scientific evidence; use these with caution. Useful sources of information on polar climate change include:

British Antarctic Survey- www.bas.ac.uk

BBC- www.bbc.co.uk

Intergovernmental panel on climate change- www.ipcc.ch

Met Office- www.metoffice.gov.uk

NASA climate change- climate.nasa.gov

National snow and ice data centre- nsidc.org

New Scientist environment- www.newscientist.com/subject/earth

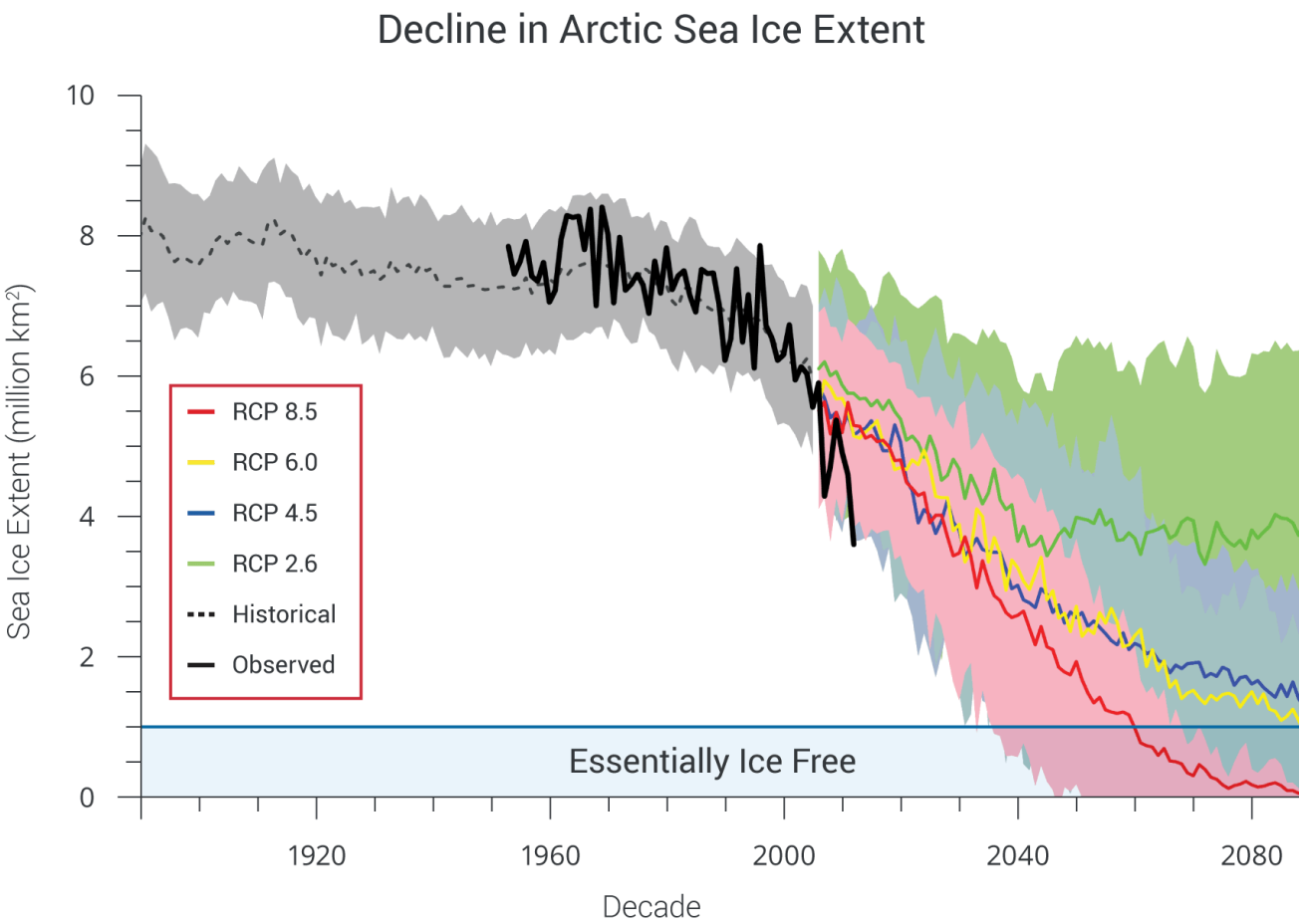
Nature Climate change- www.nature.com/nclimate

United Nations World Meteorological Organisation- www.wmo.int

World Wildlife Fund- www.panda.org/climate

Future Arctic climate change projections

Predictions on future Arctic sea ice extent vary significantly, although observed decline in previous years has been faster than most predictions, as the below graph shows. Different colours represent different predictions by climate models, with the line representing the mean and the shaded area representing the range of predictions from the model. Answer the questions below on when an "ice free" Arctic may occur.



According to the models on the graph, when is the earliest the Arctic would be ice free?

Draw your own best fit line for the observed data (either a line or a curve), extrapolate the line out to when the Arctic would be ice free, when would that be from your line?

Homework assignment

Read the following adapted NASA article on the role of aerosols in Arctic climate change (full, original article available here: www.giss.nasa.gov/research/news/20090408/). Look particularly at the figure showing Arctic, Antarctic and Global temperature changes. Consider, given the information in the article, why Antarctic temperatures have not increased as dramatically as Arctic temperatures. We will discuss this at the start of the next tutorial.

Aerosols are suspensions of particles dispersed in the atmosphere. They can influence climate directly by either reflecting or absorbing the sun's radiation as it moves through the atmosphere. The tiny airborne particles enter the atmosphere from sources such as industrial pollution, volcanoes and residential cooking stoves.

Aerosols May Drive a Significant Portion of Arctic Warming

Apr. 8, 2009

Though greenhouse gases are invariably at the centre of discussions about global climate change, new NASA research suggests that much of the atmospheric warming observed in the Arctic since 1976 may be due to changes in tiny airborne particles called aerosols.

Emitted by natural and human sources, aerosols can directly influence climate by reflecting or absorbing the sun's radiation. The small particles also affect climate indirectly by seeding clouds and changing cloud properties, such as reflectivity.

Researchers found that the mid and high latitudes are especially responsive to changes in the level of aerosols; aerosols are likely to account for 45 percent or more of the warming that has occurred in the Arctic during the last three decades.

Two types of aerosols — sulfates and black carbon — play an especially critical role in regulating climate change. Both are products of human activity.

Sulfates, which come primarily from the burning of coal and oil, scatter incoming solar radiation (light) and have a *net cooling effect on climate*. Over the past three decades, the United States and European countries have passed a series of laws that have reduced sulfate emissions by 50 percent. While improving air quality and aiding public health, the result has been less atmospheric cooling from sulfates.

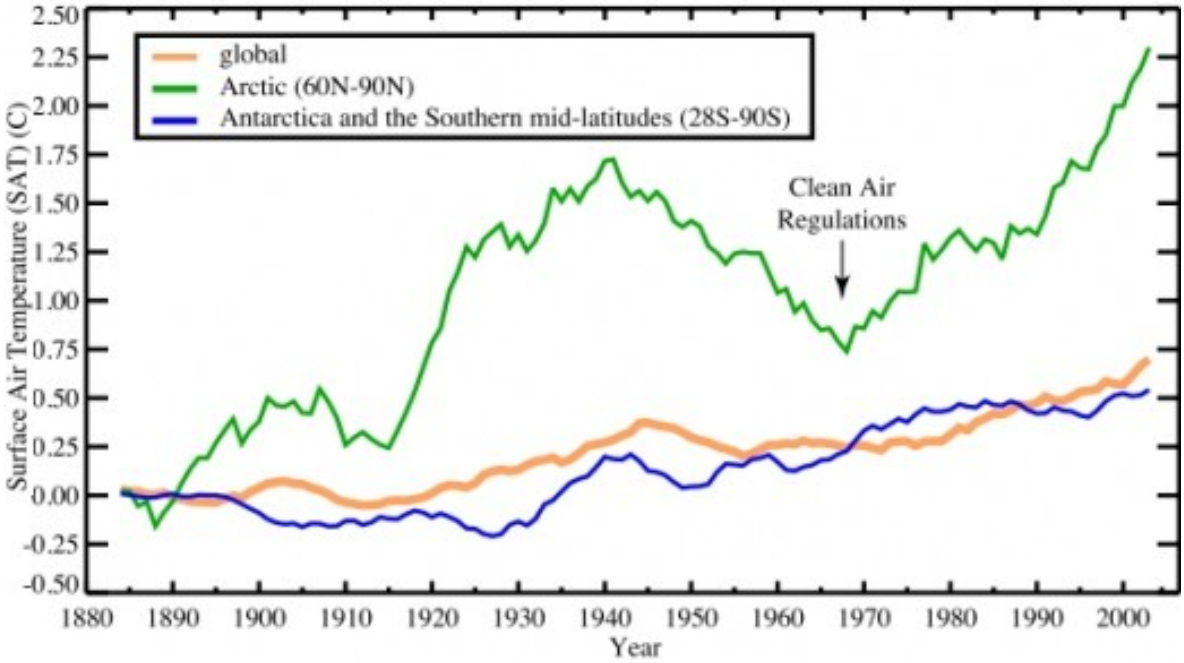
At the same time, black carbon emissions have steadily risen, largely because of increasing emissions from Asia. Black carbon — small, soot-like particles produced by industrial processes and the combustion of diesel and biofuels — absorb incoming solar radiation and have a *strong warming influence on the atmosphere*.

The regions of Earth that have the largest amounts of aerosol in the atmosphere are the same regions that have shown the greatest temperature increases since 1976. The Arctic region has seen its surface air temperatures increase by 1.5°C since the mid-1970s. In the Antarctic, where aerosols play less of a role, the surface air temperature has increased about 0.35°C.

The Arctic is close to North America and Europe. These two highly industrialized regions have produced most of the world's aerosol emissions over the last century, and some of those aerosols drift northward and collect in the Arctic.

Since decreasing amounts of sulfates and increasing amounts of black carbon both encourage warming, temperature increases can be especially rapid. The build-up of aerosols also triggers positive feedback cycles that further accelerate warming as snow and ice cover retreat.

In the Antarctic, in contrast, the impact of sulfates and black carbon is minimized because of the continent's isolation from major population centres and the emissions they produce.



Since the 1890s, surface temperatures have risen faster in the Arctic than in other regions of the world. In part, these rapid changes could be due to changes in aerosol levels. Clean air regulations passed in the 1970s, for example, have likely accelerated warming by diminishing the cooling effect of sulfates. ***Credit:*** *Drew Shindell, Goddard Institute for Space Studies*

Write your thoughts on why Antarctic temperatures have not increased as dramatically as Arctic temperatures here.

Tutorial 4 – Antarctic climate change

What is the Purpose of Tutorial 4?

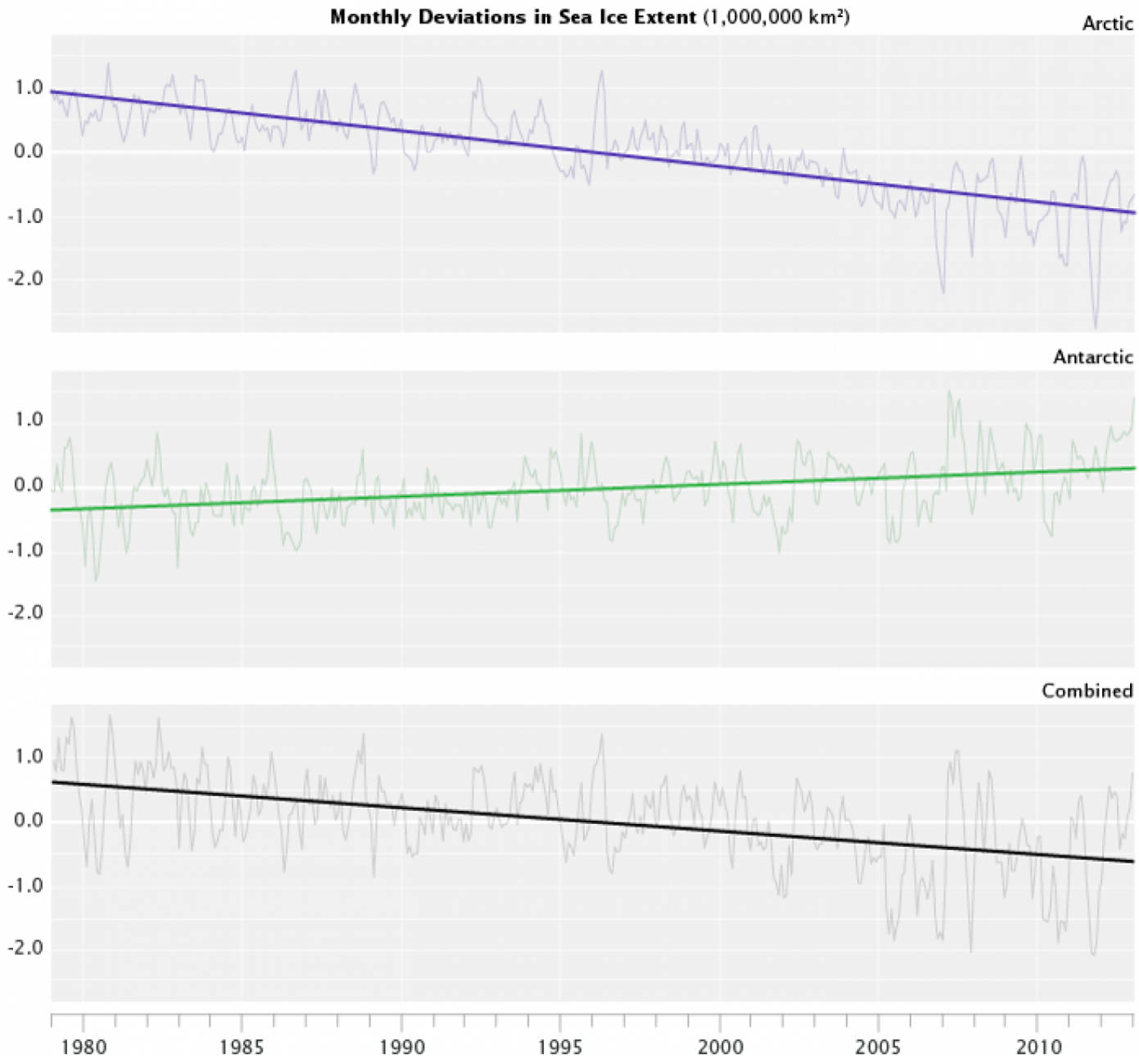
- Examine the difference between changes in sea ice in the Antarctic and Arctic
- Look at the reasons why Antarctic sea ice is increasing
- Examine other climate changes in Antarctica

Sea ice changes in Antarctica

Watch the video on Polar climate change, this will provide a recap of what we have learnt so far and an introduction to Antarctic climate change. Once finished, answer the below question.

How does Antarctic sea ice change compare to the Arctic, what does this suggest about Climate Change?

The following graphs show variations in Arctic and Antarctic sea ice extent from the average between 1979 to 2013, and the combined global variation. Examine the graphs and answer the questions below.



By what percentage has Antarctic sea ice increased from 1979 to 2013 (Use the green trend line)?

By what percentage has overall sea ice decreased from 1979 to 2013 (use the black trend line)?

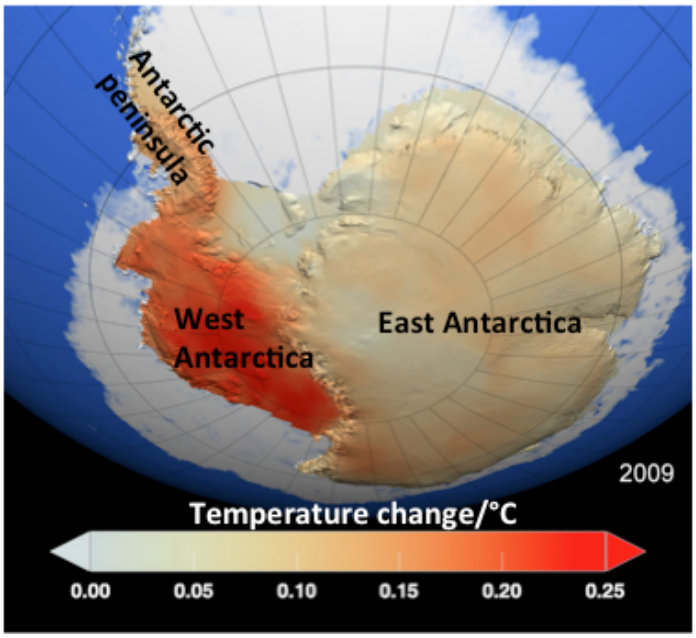
Why is Antarctic sea ice growing?

Scientists still heavily debate the exact reason why Antarctic sea ice is growing. Although there are three prominent theories, outlined in the table below. You will be divided into groups and each given an article on one of the three theories to read through. You will need to summarise the theory in the corresponding part of the table and then report your findings back to the rest of the group.

Theory	**Summary and evidence**
Changes in winds circulating around Antarctica	
Changes in heat exchange between the ocean, sea ice and the atmosphere	
Changes in ozone levels	

Other climate change in Antarctica

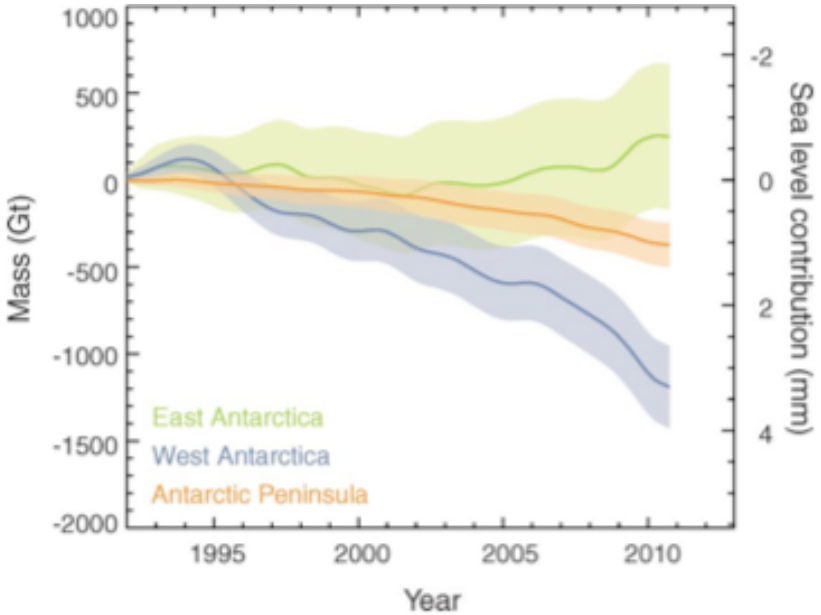
Although sea ice has been observed to increase around Antarctica, other climate change indicators are still indicative of a global warming trend. The image below shows temperature change in Antarctica between 1957 and 2008. Examine the image and answer the questions below.



Is the overall trend in Antarctic temperatures warming or cooling?

What area has seen the greatest temperature change?

The below graph shows the changes in mass of Antarctic *land* ice from 1992 to 2011 (remember that Antarctic is a land mass surrounded by water contrarily to the Arctic), examine the graph and answer the questions below.



Where in Antarctica is land ice declining quickest?

How does this compare to the previous image showing temperature changes?

Tutorial 4 – Homework: Draft Assignment

For the final assessment (to be completed after next weeks tutorial) you will need to write 1500 words (±100 words) on the question:

To what extent do you agree/disagree with the following statement:
"*Climate change in Polar Regions is more important than other regions of Earth* "?

List initials ideas of what to include here:

Get together the references you will use and start to put together a reference list, suggested reading as a start point is below. For the draft assignment complete your essay introduction, which you will then get feedback on before completing the assignment.

Please note the following points for the final assignment:

- Go over the mark scheme on page 5 to see how you can get a 1st for you final assignment
- Use your subject knowledge you have acquired over these tutorials and expand on this through independent reading for the higher marks
- Suggested starting points for reading are below but for the higher marks you will need to complete extra reading not listed below
- You will need to present a balanced argument in your essay based on referenced science facts.
- Remember to correctly reference all material both in the text and in a references list at the end of the essay. Include dates accessed for websites.

Some suggested reading:

climate.nasa.gov/resources/education/pbs_modules/lesson2Engage/

www.wwf.org.uk/what_we_do/tackling_climate_change/impacts_of_climate_change/climate_change_and_polar_regions/

noc.ac.uk/science-technology/climate-sea-level/polar-regions

news.bbc.co.uk/1/hi/in_depth/629/629/6528979.stm

www.climatehotmap.org/

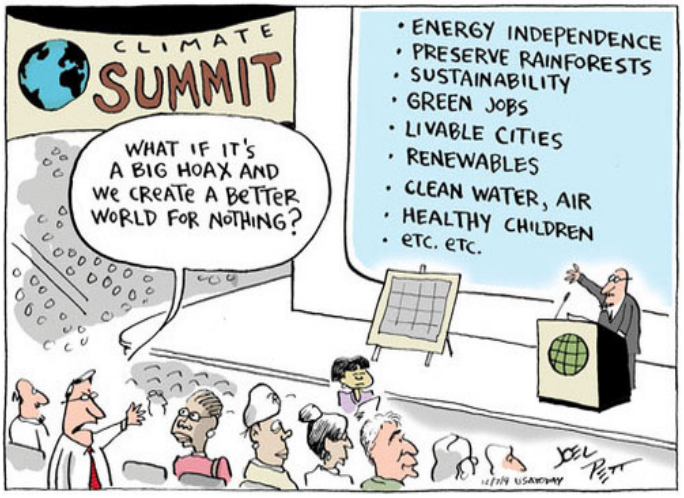
www.wwf.org.uk/what_we_do/tackling_climate_change/impacts_of_climate_change/

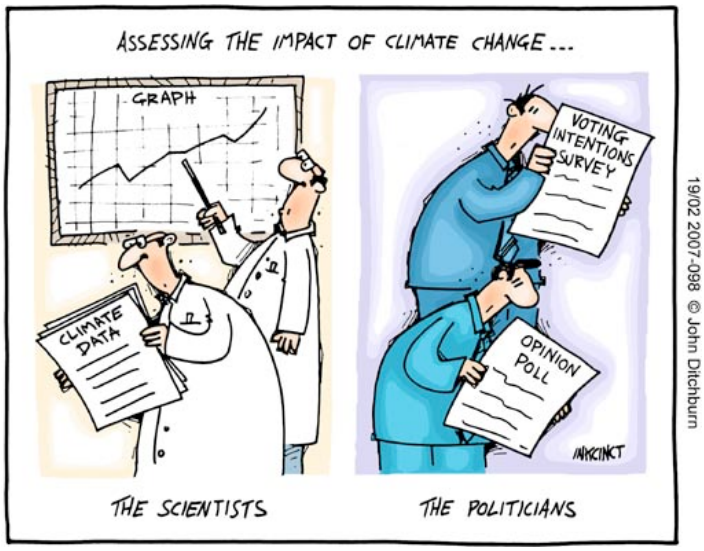
www.bbc.co.uk/news/science-environment-26817593

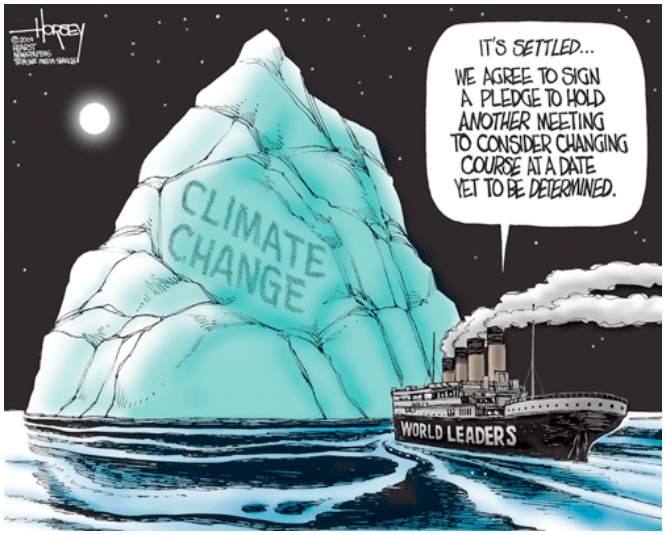
www.greenfacts.org/en/arctic-climate-change/

www.discoveringantarctica.org.uk/alevel_5_1.html

Tutorial 5 – What can be done to tackle climate change?







What is the Purpose of Tutorial 5?

- An overview of global climate change policies
- Taking individual responsibility for climate change
- Debate what can be done about climate change

Global climate change policies

Global climate policy has centred around the "Kyoto Protocol". First established in 1979, it was originally due to end in 2012 but is now extended until 2020.

> The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. Emission targets differ by country although they originally averaged out as a 5.2% reduction from 1990 to 2012.

Read the below article exerts published in The Guardian on the 26th November 2012 on how successful the Kyoto Protocol initially was. Then answer the question in the following box.

Has the Kyoto protocol made any difference to carbon emissions?

The first phase of Kyoto, the only international binding treaty on emissions cuts, has failed to slow global carbon emissions

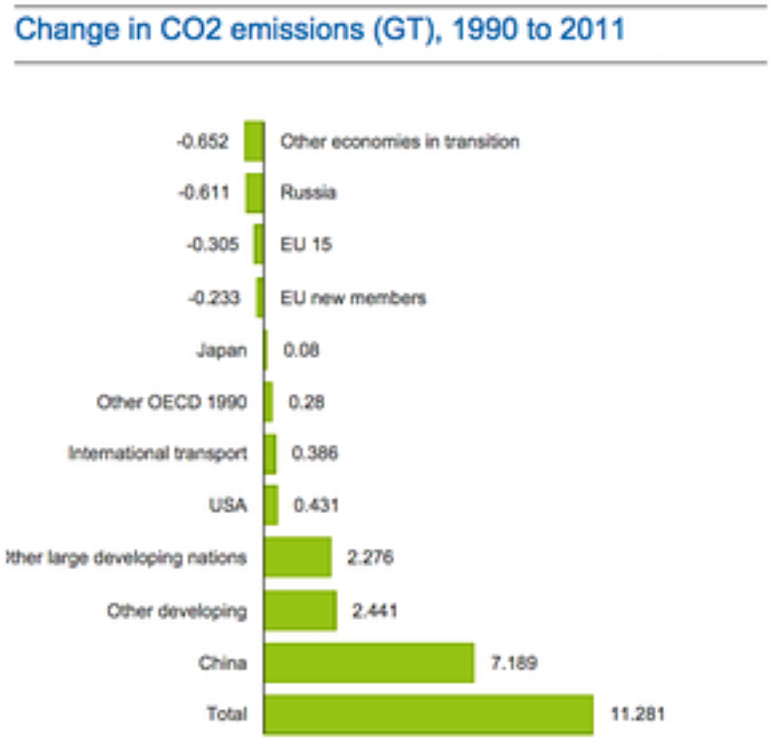
Duncan Clark

Monday 26 November 2012 10.39 GMT Last modified on Friday 30 January 2015 13.35 GMT

Under the Kyoto protocol most developed nations other than the US committed themselves to targets for cutting or slowing their emissions of the key greenhouse gases that cause climate change. The targets varied between nations. Some were allowed to increase their emissions by a certain amount; others were required to make significant cuts. The average target was a cut of around 5% relative to 1990 levels by 2012 (or more accurately 2008–12).

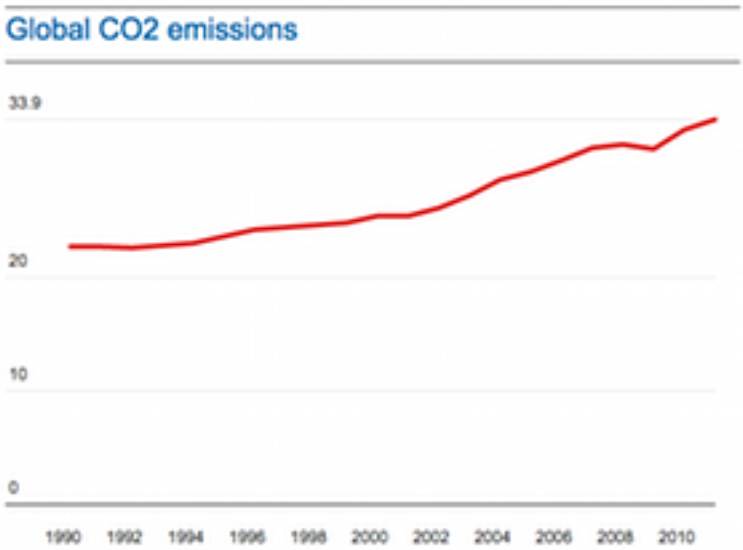
To give a sense of how countries have performed against their targets, in the charts below we've plotted the gap between each nation's percentage target and its actual percentage change between 1990 and 2010. So for example if a nation had a -10% target but its emissions increased by 10% it scores -20, of if it had a 5% target but cut by 15% it scores 10.

Overall, there are more successes than failures and the sum of emissions from nations with Kyoto targets have fallen significantly. In the meantime, however, emissions in the rest of the world have increased sharply – especially in China and other emerging economies, as the chart below makes clear.



This blurs the success of the nations with Kyoto targets because much of the growth in China and other emerging economies has been driven by the production of goods and services exported to developed nations. According to one study I reported on last year, when you look at total carbon footprint of each nation (including imports and excluding exports), the progress made under Kyoto looks extremely poor, with Europe's savings reduced to just 1% from 1990 to 2008 and the developed world as a whole seeing its emissions rise by 7% in the same period.

Overall, the result is that global emissions have showed no sign of slowing down, as the chart below shows. In that sense, the Kyoto protocol has been a failure. But it was unquestionably an important first step in global climate diplomacy. The question is whether a more ambitious second step will follow in time to avoid unacceptable risks of devastating climate change.



How successful was the Kyoto Protocol in your opinion, do you think this article is fair?

Individual responsibility for climate change

A way to help individually reduce your carbon dioxide emissions and help stop climate change is to reduce your "carbon footprint".

A carbon footprint is the amount of greenhouse gases released into the atmosphere as a result of the activities of a particular individual, organization, or community.

Each of the following activities add 1 kg of CO_2 to your personal carbon footprint:

- Travel by public transportation (train or bus) a distance of 10 to 12 km (6.5 to 7 miles)
- Travel in a car a distance of 6 km or 3.75 miles (assuming 7.3 litres petrol per 100 km or 39 mpg)
- Fly in a plane a distance of 2.2 km or 1.375 miles.
- Operate your computer for 32 hours (60 Watt consumption assumed)
- Production of 5 plastic bags
- Production of 2 plastic bottles
- Production of 1/3 of an American cheeseburger (yes, the production of each cheeseburger emits 3.1 kg of CO_2!)

What can be done about climate change?

We are going to have a group "silent debate" about issues regarding helping combat climate change. On the piece of paper in front of you there is a question, write down on the paper any thoughts or further questions you have prompted by the initial question on the paper. Then reply to other people's comments and questions.

Tutorial 5 – Homework: Final Assignment

Write a 1500 words (±100 words) essay on the following question:

To what extent do you agree/disagree with the following statement:
"*Climate change in Polar Regions is more important than other regions of Earth*"?

Remember to use your feedback on the introduction completed for your draft assignment and use the mark scheme on page 5.

Tutorial 6 – Feedback

What is the Purpose of Tutorial 6?

- Reflect on skills learned on the programme with a view to encouraging resilience
- Receive feedback on final assignment

What are the key questions?

- What strengths have I demonstrated in my work and what areas of development are there left for me to address?
- What steps do I need to take to improve my academic output?

Marking your own

Using the mark scheme, identify three things you did well and three things you could improve.

What went well?

1.

2.

3.

What could be improved?

1.

2.

3.

Responding to feedback

Read through your feedback sheet and highlight on your assignment where you received positive feedback (one colour) and areas for improvement (different colour). You might find it helpful to annotate this with a brief comment or two.

University Applications and Careers Guidance

For course choices and careers information:	www.brightknowledge.org.uk
For information and statistics on universities and course:	www.unistats.direct.gov.uk
For comprehensive information on universities, including rankings:	www.thecompleteuniversityguide.co.uk

PLEASE NOTE – The Scholars Programme is designed to support the university applications process at your school. The work you complete for the programme should add to your schoolwork rather than detract from it. Please be aware of deadlines and try to manage your workload appropriately. If you are worried about the Scholars Programme interfering with your schoolwork then please speak to your teacher.

The following websites have useful information on potential careers in climate change, from research to implementing new climate policies:

The Met Office: careers.metoffice.gov.uk

The British Antarctic Survey: www.bas.ac.uk/jobs

The Government Energy and Climate Change department: www.gov.uk/government/organisations/department-of-energy-climate-change/about/recruitment

University of East Anglia, Climate Research Unit: www.cru.uea.ac.uk

The Walker Institute for Climate Change: www.walker-institute.ac.uk

The Tyndall Centre for Climate Change Research: www.tyndall.ac.uk

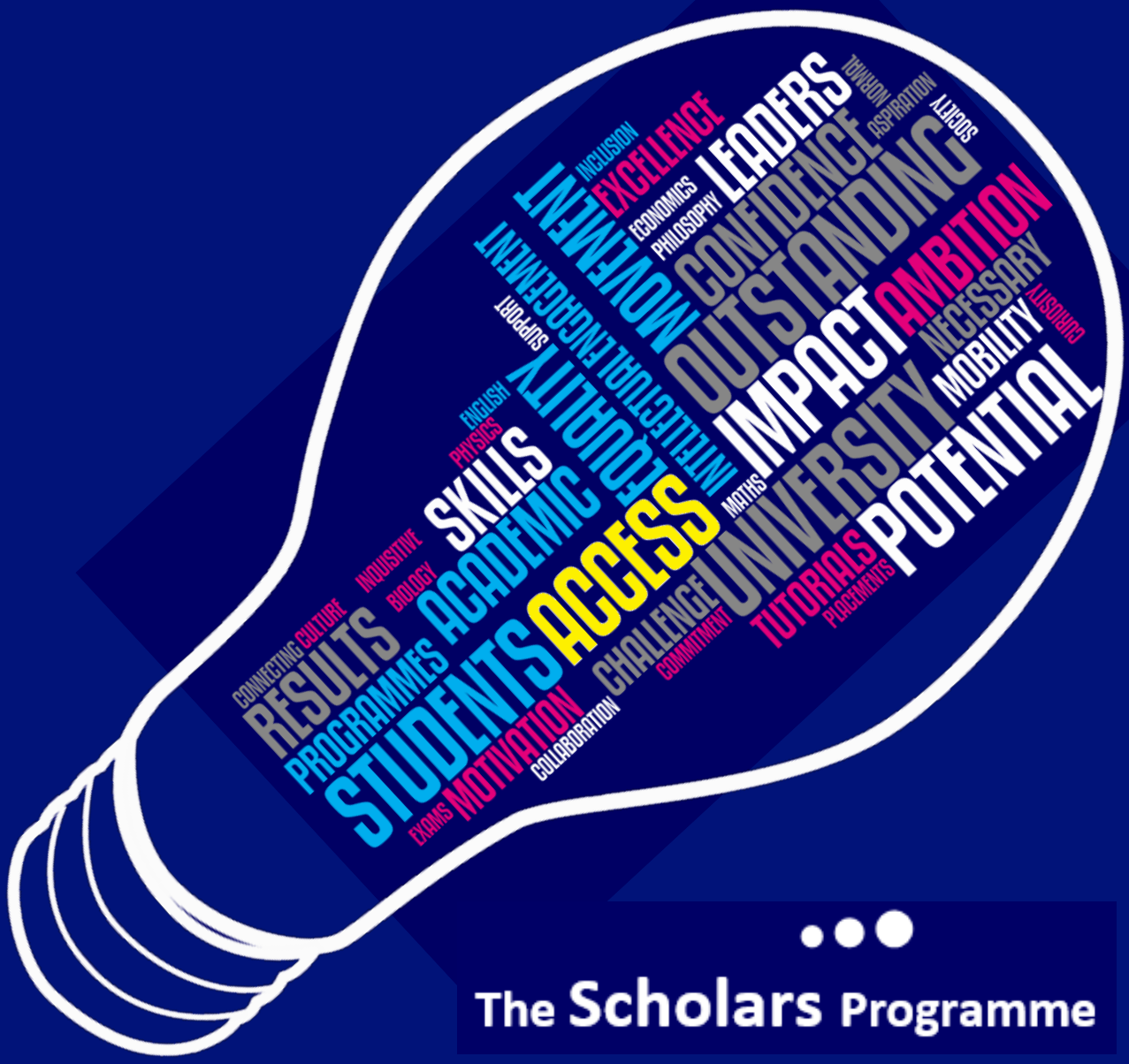
The Environmental Change Institute: www.eci.ox.ac.uk

The Cambridge Centre for Climate Change Mitigation Research: www.4cmr.group.cam.ac.uk

The Scott Polar Research Institute: www.spri.cam.ac.uk

Institute of Physics careers advice: www.iop.org/careers/index.html

Additional notes



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