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THE °CLIMATE GROUP

This is part of THE CLEAN REVOLUTION

CLIMATE SCIENCE

PART II: OBSERVED CLIMATIC IMPACTS

Insight Briefing | Analyzing the issues that matter to the Clean Revolution

ABOUT

This briefing is the second in a series of non-technical papers on key climate science issues. Along with its companion briefings, it aims to increase awareness of climate science in advance of the publication of the Fifth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC), from September 2013. This briefing looks at the observed climatic impacts already being recorded by climate scientists. Other briefings in the series cover the 'fundamentals' of climate science, future climatic impacts, short-lived climate pollutants and the IPCC report production process.

KEY POINTS

- The average global surface temperature has increased 0.8ºC over the last 100 years
- The 12 warmest years on the instrumental record have occurred in the last 15 years
- The observed plateau in temperatures in the past 14 years masks an unequivocal warming trend once natural variability is accounted for
- Nearly 90% of the extra heat generated since the 1960s has gone into the oceans, which have continued to warm uninterrupted
- Sea level rise has accelerated in the last two decades rising from 1.7mm to 3.2mm a year since 1990, driven by increased ice loss and thermal expansion
- Antarctica and Greenland are experiencing net ice loss of 600 billion tons per year
- Summer Arctic sea ice has reduced dramatically, falling 13% per decade since 1979
- Increased atmospheric CO_2 absorbed by the oceans has raised the acidity of the oceans by 30%
- Ecosystems are moving poleward and to higher altitudes in response to warming

INTRODUCTION

Over the last three decades the depth and breadth of climate science research has grown significantly. No scientist however, would claim our understanding is complete—uncertainty remains and new evidence is always emerging—this is the nature of science. Yet, despite the complexity of the earth's climate system and the difficulty in specifying exact impacts in the future, the basic mechanics and causal relationships are well understood (see our previous briefing).

We know that increasing greenhouse gas (GHG) emissions are raising atmospheric concentrations of these gases, leading to a rise in global temperature. And we know that this rise in temperature will have consequences for our climate as more energy is fed into this system. The body of scientific evidence accumulated in recent decades and analyzed—and then re-analyzed—provides us with a high degree of certainty about the causes, direction and impacts of climate change that is impossible to ignore.

This briefing looks at some of the observed changes in the climate system to date. Three important indicators of a warming world: increased temperatures; sea level rise; and ice-loss from the planet's polar regions, are examined below. Ocean acidification and ecosystem changes are also briefly reviewed.

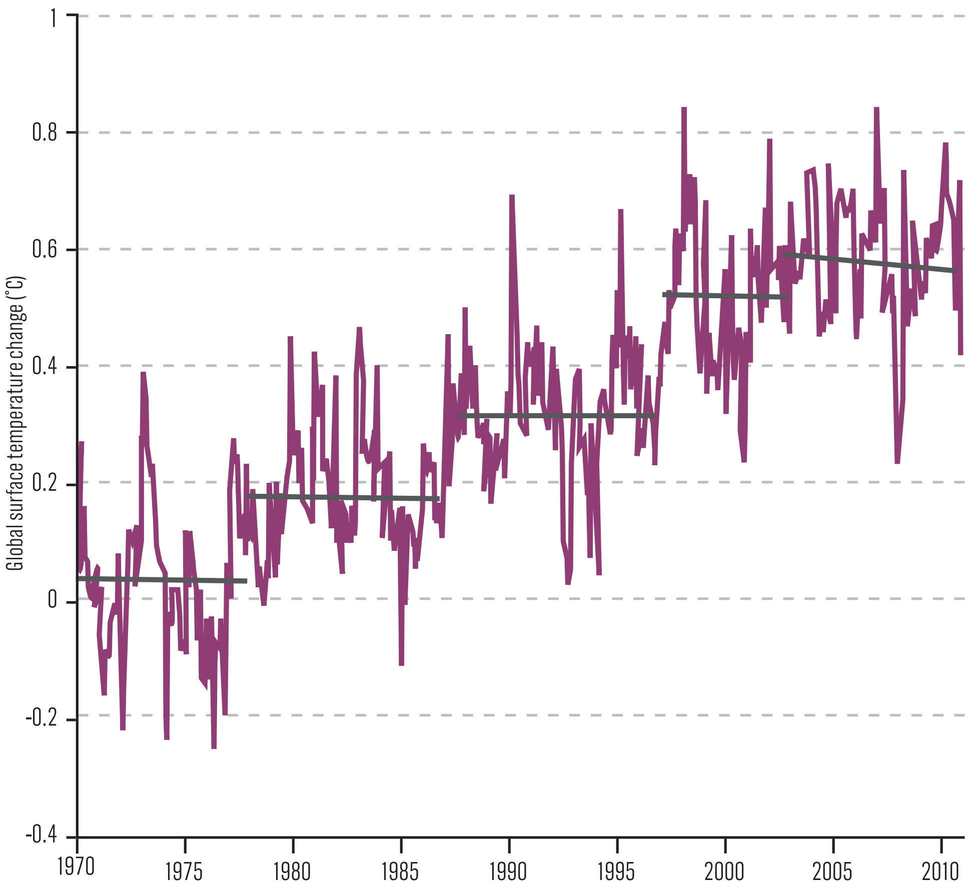
TEMPERATURE

Rising average global surface temperature is obviously the key indicator of global warming and hence for climate change. The unequivocal direction over the past century has been an upward trend (see Figure 1b). The overall increase in average global surface temperature across the period has been approximately 0.8ºC[1], with the 12 warmest years on record having occurred in the last 15 years[2].

The increase in temperature has not been uniform across the planet. The Arctic, for example, has seen average temperature increase at twice the global rate over the last 100 years. And land area temperatures have increased faster than ocean temperatures[3]. It is very likely (i.e. more than a 90% probability) that the frequency of extreme high temperatures has also increased, while the number of cold days and nights has fallen[4]. Record-breaking high temperatures in the US, Australia and Russia in recent years are indicative of the kind of change predicted.

Recently, however, much has been made of the fact that the average global surface temperature has not risen since 1998. This temperature plateau, while an observed fact, is not proof that climate change has stopped—as some have been quick to claim[5] (although it may suggest a need to reassess climate sensitivity, see Box 1). There are several reasons for this. First, the 15-year period in question is simply too short to provide an accurate assessment of a warming, cooling or stable trend. Figures 1a and 1b below neatly illustrate how very different interpretations of the same temperature data can be made depending on the time scales used for assessment.

FIGURE 1A The cherry-picked view of global warming



NB: Horizontal lines indicate short-term trends in temperature.

[1]NASA, Earth Observatory. http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php Accessed 11 July 2013

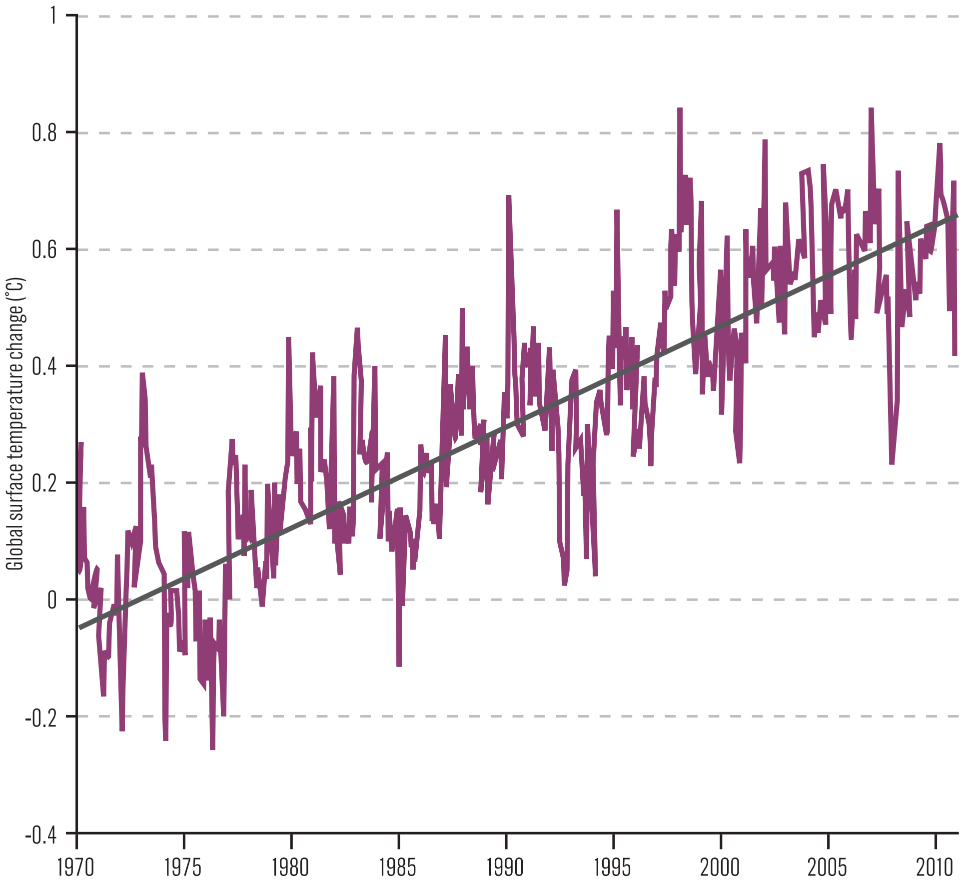
[2]NOAA, National Climatic Data Center.
http://www.ncdc.noaa.gov/news/2012-global-temperatures-10th-highest-record. Accessed 12 July 2013

[3]IPCC (2007) Fourth Assessment Report, Synthesis Report.
http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html

[4]Ibid

[5]See for example The Guardian's 2012 article on misreporting of global warming in the media
http://www.guardian.co.uk/environment/2012/oct/16/daily-mail-global-warming-stopped-wrong

FIGURE 1B The scientific view of global warming



Source: http://skepticalscience.com/still-going-down-the-up-escalator.html

NB: Straight line indicates long-term warming trend.

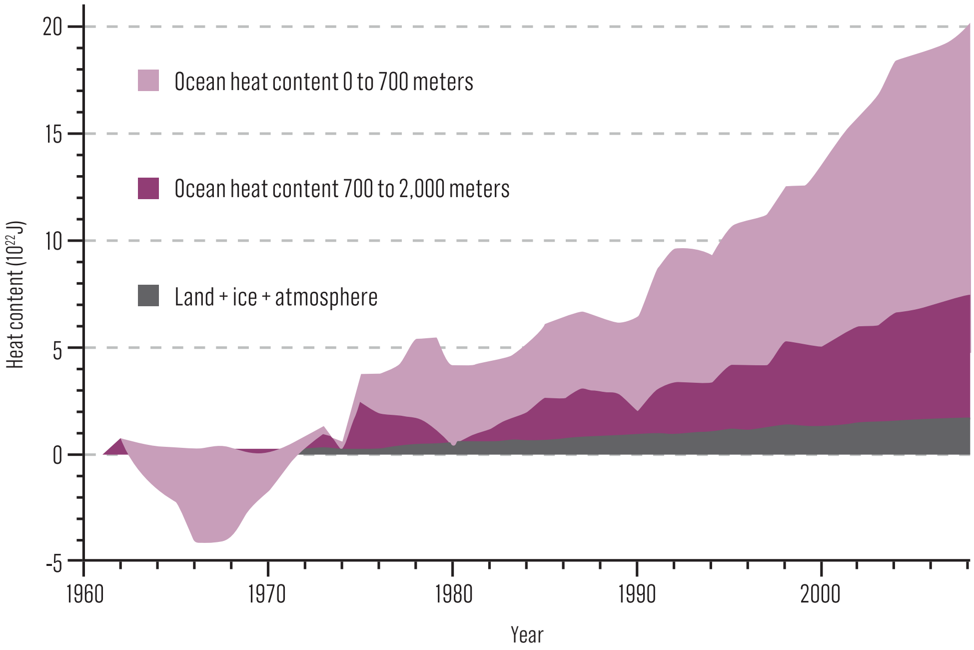
There is also the impact of natural variability on temperature. Factors such as solar intensity, volcanic eruptions and significant regional weather patterns, including the El Nino - La Nina phenomena in the Pacific Ocean, can all have positive and negative effects on measured temperature. Recent research, however, has shown a clear warming trend continuing in global surface temperatures over the last 30 years, once these natural variability factors have been accounted for.[6]

A final reason that the current plateau in surface temperatures needs to be treated with caution is that the atmosphere represents only a part of Earth's climate system. Oceans, which cover two-thirds of the planet's surface, play a much larger role in how our climate functions because of their capacity to absorb enormous quantities of heat. In the oceans, the global temperature trend shows no plateau, but rather a steady and increasing upward march as illustrated in Figure 2 on the next page. Since the 1960s, oceans have absorbed nearly 90% of the extra heat created by the enhanced greenhouse effect.[7]

[6]Foster & Rahmstorf, 2011. Global Temperature Evolution 1979-2010. Environmental Research Letters. http://iopscience.iop.org/1748-9326/6/4/044022. Accessed 12 July 2013.

[7]Australian Climate Commission. The Critical Decade. http://climatecommission.gov.au/wp-content/uploads/The-Critical-Decade-2013_Website.pdf. Accessed 5 June 2013.

FIGURE 2 Changes in heat content for ocean, land, ice and atmosphere



Source: http://skepticalscience.com/global-warming-stopped-in-1998-intermediate.htm

BOX 1. REASSESSING CLIMATE SENSITIVITY?

Although the plateau in atmospheric temperature is not evidence that global warming and climate change has stopped, some scientists are investigating whether it may show that the climate is less sensitive to changes in CO_2 than previously thought. In layman's terms, 'climate sensitivity' is the temperature change expected from a doubling of CO_2 concentration from the pre-industrial level (i.e. increasing from 280 ppm to 560 ppm). The current best estimate is that climate sensitivity is between 2-4.5°C, but with a range that extends from 1.1 to 6.4°C.[8] The extent of the range matters a lot, since scientists agree that there is a significant difference between a world that warms by 2°C or 4°C. It also matters in policy terms, since a reduction in sensitivity might extend the window of time for decarbonizing economies. A small number of recent papers have suggested that the planet's climate system may indeed be less sensitive than previously thought – a fact picked up notably by The Economist recently.[9] In no way are the findings a get-out-of-jail-free-card, however. While they suggest that the upper extremes of change are less likely, the direction of travel remains upward and still within a range (i.e. 2-4.5°C or more) that demands prudent and urgent action.

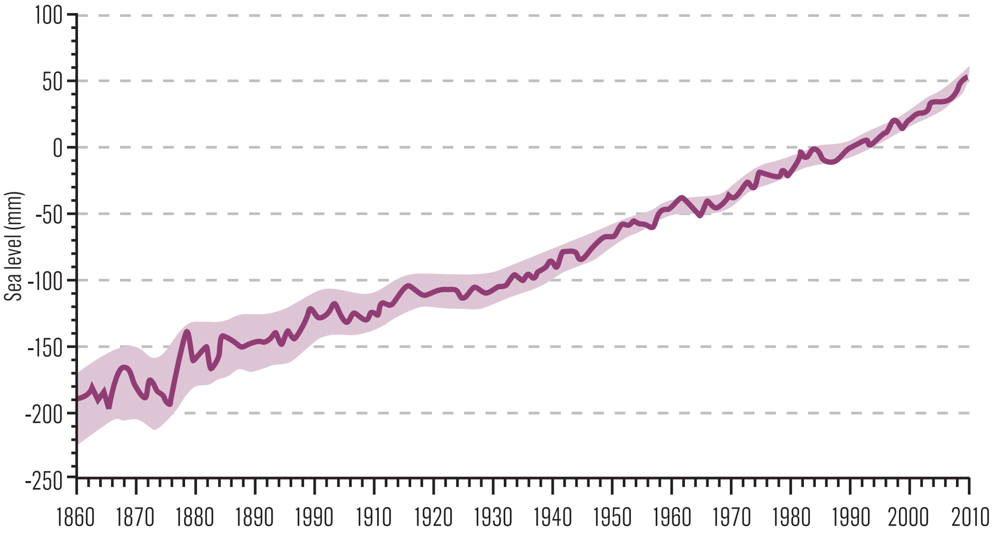
[8] IPCC Fourth Assessment Report. http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains3-2-1.html. Accessed July 12 2013.

[9] The Economist. http://www.economist.com/news/science-and-technology/21574461-climate-may-be-heating-up-less-response-greenhouse-gas-emissions. Accessed July 12 2013.

SEA-LEVEL RISE

Global mean sea-level is estimated to have risen by more than 20cm between the mid-18th century and 2009.[10] Most of the rise has been due to the thermal expansion of the ocean as temperatures have increased. During the 20th century, sea levels rose at a rate of around 1.7mm per year. However, from 1990 onwards the rate has increased to 3.2mm per year, which has been attributed to increased melting from glaciers and other land ice.[11]

FIGURE 3 Global mean sea-level rise



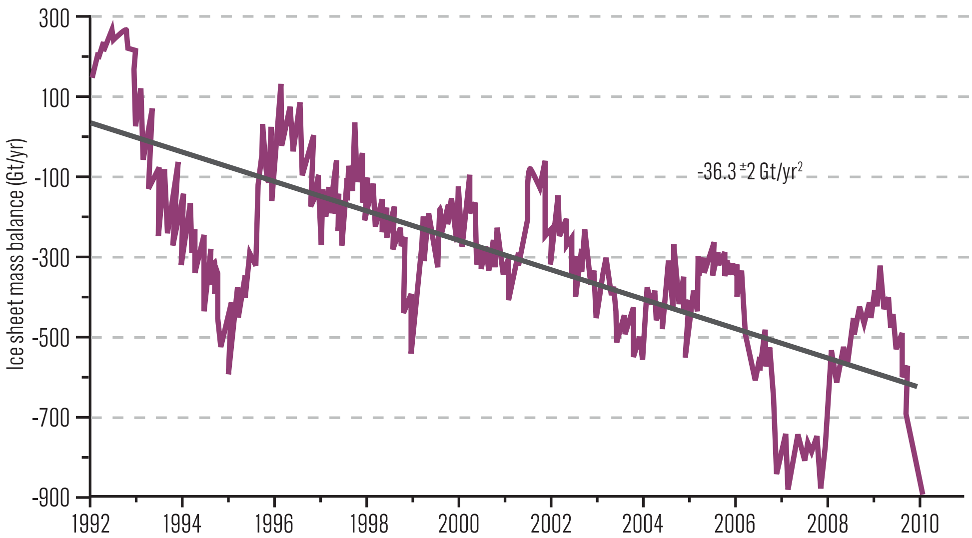
Source: http://climatecommission.gov.au/wp-content/uploads/The-Critical-Decade-2013_Website.pdf

NB: The graph is based on both reconstructed and direct measurements (including from satellites). The width of the shaded area indicates the degree of uncertainty in the data.

ICE LOSS

Observations over the last few decades show a net loss of ice from the Arctic, Greenland and Antarctica. The Antarctic and Greenland ice sheets have moved from being in balance in the early 1990s, to an average net-loss of 600 billion tons of ice per year, with the loss accelerating[12] (see Figure 4).

FIGURE 4 Combined Antarctica and Greenland ice-loss trend



Source:http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

[10] Potsdam Institute for Climate Impact Research and Climate Analytics. 'Turn down the Heat' http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf. Accessed 11 July 2013.

[11] Ibid

[12] Australian Climate Commission. The Critical Decade. http://climatecommission.gov.au/wp-content/uploads/The-Critical-Decade-2013_Website.pdf. Accessed 5 June 2013.

The declining trend in Arctic sea ice coverage has been more alarming, with summer sea ice coverage falling 13% per decade since 1979.[13] A new record low was set in the summer of 2012, when coverage dropped to around half of what it had been three decades earlier.[14] Figure 5 below shows the 2012 ice range in white, with the grey line indicating the longer-term summer average. Unlike land ice, the loss of sea ice does not have an effect on sea-levels, since there is no actual addition of water to the ocean – merely a transformation of form.

FIGURE 5 Arctic sea ice extent in 2012 compared to 1979-2000 average

Source: http://nsidc.org/arcticseaicenews/2012/08/arctic-sea-ice-breaks-2007-record-extent/

The loss of ice cover from the earth's surface has important implications. Less snow and ice means that there is less reflection of incoming radiation and more absorption. Oceans and land therefore absorb more heat, further accelerating the loss of ice – a classic feedback mechanism. Scientists are now investigating the impact this is having on the weather. Researchers believe that the loss of Arctic sea ice, for example, is disrupting the jet stream over Europe, which in turn is shifting weather patterns (including polar air) resulting in recent colder winters in Europe.[15]

OTHER INDICATORS OF CHANGE

Although not a climate change indicator, the increasing acidification of the world's oceans is a direct result of rising atmospheric CO_2 levels, with important consequences for other natural systems. The oceans have always acted as an essential sink for CO_2 and are estimated to have absorbed approximately 30% of all CO_2 released since the mid-18th century.[16] The oceans have thus kept atmospheric CO_2 levels (and hence warming) considerably lower than they would otherwise have been. The downside to this is that when dissolved in water, CO_2 forms carbonic acid, which increases the ocean's acidity. The level of acidity has already increased by 30% since pre-industrial times, which has implications for many organisms that form the base of marine food chains.[17] Changes in acidity affect the process of calcification, which is critical to the lifecycles of zooplankton, corals and small molluscs. Research on zooplankton in the Antarctic Ocean has found that shell weights are already 30-35% lighter compared to pre-industrial times.[18]

[13] National Potsdam Institute for Climate Impact Research and Climate Analytics. 'Turn down the Heat' http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf. Accessed 11 July 2013.

[14] Ibid

[15] National Geographic. http://news.nationalgeographic.co.uk/news/2013/03/130326-arctic-sea-ice-global-warming-science-environment-spring/. Accessed 12 July 2013

[16] Shrink That Footprint. 'The Importance of Carbon Sinks'. http://shrinkthatfootprint.com/carbon-emissions-and-sinks. . Accessed 12 July 2013.

[17] Australian Climate Commission. The Critical Decade. http://climatecommission.gov.au/wp-content/uploads/The-Critical-Decade-2013_Website.pdf. Accessed 5 June 2013.

[18] Ibid

Ecosystems – evidenced through changes in animal and plant behavior and location - provide the other main indicators for a changing climate. The IPCC's Fourth Assessment Report, for example, noted that an "overwhelming majority" of studies looking at terrestrial species showed poleward and elevational range shifts by both animals and plants in response to warming.[19] Similar kinds of movements are evident in the oceans, with Northern Hemisphere plankton, for example, now found 1000 kilometers further north than it was forty years ago.[20]

CONCLUSION

The evidence for global warming is now unequivocal. This is not a new conclusion but one made six years ago in the IPCC's last Assessment Report. As this briefing has shown the evidence has only strengthened since then. Changes to various natural systems are now underway. Climate change is no longer a future threat but something which is happening today. Although the impacts have so far been manageable, it is clear that tremendous shifts are occurring which could have profound consequences for food chains, coastal communities and areas already subject to high temperatures. Failure of decision-makers in business and government to appreciate the magnitude of what has already happened, and the implications these changes have for the future, are putting the long term sustainability (and indeed survival) of natural systems, communities and companies at risk.

FURTHER READING

IN THIS SERIES OF CLIMATE SCIENCE BRIEFINGS:

Part I: The fundamentals

Part III: Future climatic impacts

Part IV: The IPCC and its work

Part V: Short-lived climate pollutants (available from September 2013)

(Freely available to The Climate Group partners and otherwise on request – see contact details below.)

USEFUL AND AUTHORITATIVE SOURCES ON THE WEB INCLUDE:

Skeptical Science http://skepticalscience.com

A very accessible source of information and explanations on climate science issues for non-experts

Real Climate http://www.realclimate.org

In-depth, technical information and discussion on climate science from climate scientists

Met Office (UK) http://www.metoffice.gov.uk/climate-change

The UK's leading public institution engaged in climate change research and communication

NOAA http://www.noaa.gov/climate.html

One of the key US government agencies engaged in climate science research, especially with respect to the ocean

NASA http://climate.nasa.gov

One of the key US government agencies engaged in climate science research, especially with respect to satellite observation

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[19] IPCC Fourth Assessment Report. WGII Report. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch1s1-es.html

[20] Australian Climate Commission. The Critical Decade. http://climatecommission.gov.au/wp-content/uploads/The-Critical-Decade-2013_Website.pdf. Accessed 5 June 2013.