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This document has been compiled by the Australian Climate Change Science Program in order to provide a succinct update of recently published climate change science.

The document aims to provide a reliable and concise summary of climate change science useful for a wide audience. Information is aimed at the needs of policy makers, government agencies, scientists, science communicators and media.

The information presented comes from research within the Australian Climate Change Science Program, Australian universities and international research agencies. The update provides a summary of relevant climate change science with further references cited.

Recent research has shown that:

- Concentrations of greenhouse gases are on the rise, with an unexpected increase in methane.
- Carbon sinks remove considerable amounts of anthropogenic carbon dioxide, but they are becoming less efficient.
- Sea levels are rising, with current projections of up to 80 cm by the end of the century.
- Southern Ocean acidity has increased, while salinity has decreased.
- Rainfall in southern Australia has declined over a 30-year period, caused by changes in climate systems over the region.

These findings indicate stronger than expected and sooner than expected forcing of climate change.

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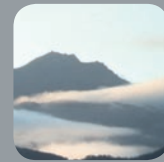
Summary of recent climate change science



1 Greenhouse gas concentrations

- Anthropogenic carbon dioxide emissions are currently tracking above the worst case scenario of the Intergovernmental Panel on Climate Change: Special Report on Emissions Scenarios.
- In 2007 the atmospheric carbon dioxide concentration was 383 parts per million, 37% above the concentration at the start of the industrial revolution.
- Global emissions from the combustion of fossil fuel and land use change reached 10 billion tonnes of carbon in 2007, up from about 2 billion tonnes in 1950.
- Australia is increasing output of greenhouse gases (by two per cent per year).
- Atmospheric methane concentrations have increased significantly (by more than 25.4 million tonnes from June 2006 to October 2007).

2 Carbon sinks and sources

- Oceans and land currently absorb 29% and 26% respectively of anthropogenic emissions.
- The efficiency of natural carbon sinks has decreased over the past 50 years.

3 Sea level

- There has been a global average sea-level rise of 0.17 m during the 20th century.
- Sea levels are projected to rise up to 80 cm by the end of the century.
- Melting of the Greenland and West Antarctic ice sheets could be hastened by lubrication of bedrock and collapse of buttressing ice shelves.

4 Oceanic processes

- The acidity of oceans has increased significantly due to greater quantities of dissolved carbon dioxide.
- The freshening of Antarctic Bottom Water from melting ice sheets has increased and is likely to affect ocean circulation.

5 Climate systems

- In the Australian region tropical cyclones may increase in intensity.
- Reduced rainfall in Southern Australia is linked to changes in climate systems patterns over the past 30 years.

1 Greenhouse gas concentrations

2000-2007 trends in greenhouse gas emissions were higher than the worst case Intergovernmental Panel on Climate Change: Special Report on Emissions Scenarios[1].

In 2007 the atmospheric CO_2 concentration was 383 parts per million, 37% above the concentration at the start of the industrial revolution (about 280 parts per million in 1750)[2]. The present concentration is the highest during the last 800,000 years and probably during the last 20 million years[3].

Global emissions from the combustion of fossil fuel and land use change almost reached 10 billion tonnes of carbon in 2007[1]. Australia's fossil-fuel emissions have grown by two per cent per year since 2000[1].

Methane concentrations are influenced by human activity. Atmospheric methane levels started rising in 2006 jumping by more than 25.4 million tonnes from June 2006 to October 2007[4]. Based on the amount of warming it causes and levels in the atmosphere, methane is considered the second worst greenhouse gas.

The amount of frozen organic carbon in the world's permafrost regions is double previous estimates. The release of a small fraction of this vast frozen reservoir of carbon would significantly accelerate climate change[1,5].

2 Carbon sinks and sources

Natural land and ocean carbon dioxide sinks have removed 54% of all carbon dioxide emitted from human activities during 2000-2007[6]. The size of the natural sinks has grown in proportion to increasing atmospheric carbon dioxide. However, the efficiency of these sinks has decreased by 5% over the last 50 years, and will continue to do so in future[1]. Atmospheric carbon dioxide has been outstripping the growth of natural carbon dioxide sinks such as forests and oceans[7].

Oceans and land are taking up 26% and 29% respectively of all anthropogenic carbon emissions[1]. Clearing of tropical forest accounts for 16% of anthropogenic carbon emissions and destroys globally significant carbon sinks[8]. Preventing further decreases of natural carbon sinks will be vital in any mitigation effort.

3 Sea Level

Global atmospheric temperature rise has resulted in warming of the oceans and melting of ice on land. The sea level rose significantly during the 20th century at a rate faster than for the previous several centuries[9].

There has been a global average rise of 0.17m during the 20th century[6]. Ocean warming and thermal expansion trends are about 50% larger than earlier estimates, and account for about 33% of the total sea level rise over the past 50 years[10].

IPCC 2007 projections of a 0.2-0.8m sea-level rise by the end of this century may be underestimated[11]. Larger values can not be excluded[12]. Global sea levels are likely to rise by 0.03 m in the next decade[12].

Stabilisation of atmospheric greenhouse gas concentrations at 550 ppm CO_2 equivalent is likely to result in a high (greater than 78%) likelihood of initiating irreversible melting of the Greenland ice sheet[13]. Although starting this century, this process is likely to occur over at least several hundreds of years[6,13].

Surface ice melt may lubricate the base of ice sheets at the bedrock to increase the flow of ice sheets into the sea. Disintegration of ice shelves also results in faster flow of glaciers to the sea[12]. Our understanding of these processes is limited.

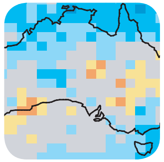
The average rate of sea-level rise from 1961 to 2003 was 1.8mm/year and increased to 3.1 mm/year from 1993 to 2003. Whether this latter rate indicates decadal variability or an increase in the long-term trend over time remains unclear[12].

4 Ocean Processes

Global oceans removed 26% of all carbon dioxide emissions from 2000-2007[1]. Ocean sinks have grown more slowly than expected over the last 20 years.

The increased concentration of carbon dioxide from anthropogenic emissions has increased ocean acidity[14]. Data from the Great Barrier Reef and the Southern ocean is being used to examine effects of increased acidity on marine organisms. Carbonate chemistry drives acidification, with consequences for marine organisms that form calcium carbonate shells, such as molluscs, corals, crustaceans and some plankton species[15]. Changes to species composition and populations at the bottom of the food chain will affect other marine life as well as reducing the capacity of the ocean to store carbon dioxide.

Changes in temperature, salinity and density have been quantified in the Southern Ocean. Salinity of the Southern ocean has decreased since the 1970s resulting in fresher and lighter water above the sea floor[16]. Ocean circulation is driven by different densities of water in the ocean. Fresh water from melting glaciers has increased in polar regions, changing the density of the water, indicating climate change is already having an effect on ocean transport and circulation[17].



5 Climate systems

A number of large-scale climate systems in our region determine rainfall patterns over Australia. In the past 30 years there has been a dramatic shift in the climate, affecting storm tracks in southern Australia, with a 30% reduction in storm growth rate[18]. With the chance of storms dropping significantly, reduced rainfall has occurred across southern Australia.

The sub-tropical pressure ridge, a large belt of high pressure situated about 30°S in latitude, has moved further south over the past 30 years. A poleward movement of the pressure system may be contributing to the reduced winter rainfall over southern Australia[19].

The largest reduction is in the autumn season, in part driven by a lack of La Niña events[20].

The drying trend in south-west Western Australia has been attributed to a combination of natural variability, an increase in greenhouse gas concentrations, and land-use change[21]. The human-induced component accounts for approximately 50% of the reduction[22].

The south-east of Australia is affected by several climate systems including the El Niño – Southern Oscillation and the Southern Annular Mode. There is a consensus that in response to global warming, the IOD[23] and the SAM will contribute to rainfall reduction in the region. The atmospheric response is similar to that of an El Niño state[23] also unfavourable to Australian rainfall.

There is currently no evidence of significant change in the number of tropical cyclones in the Australian region although there is some evidence to suggest that the more intense cyclones will increase in intensity[24].

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