CSIRO FREEDOM OF INFORMATION OFFICE
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This document was created in response to a Freedom of Information request made to CSIRO.

FOI Number: FOI2019/35

Date: 23 July 2019

Request: In relation to the physics of the atmosphere, please provide all documents in which CSIRO staff have made recommendations to the Chief Scientist and/or the Federal Minister under which the CSIRO served and/or the Federal Government pertaining to claims that an increase in carbon dioxide concentration in the atmosphere would cause Earth's global mean surface temperature to increase

Document(s): 1-16

For more information, please refer to CSIRO's FOI disclosure log at www.csiro.au/FOILog

KC AR RS

Minister
Innovation, Industry, Science and Research

B08/3777
Document 1

CSIRO No. C2008/8181

For Information and response by noon 25 August 2008

CSIRO Requested

PROVISION OF INFORMATION ON CLIMATE SCIENCE TO THE HON MALCOLM TURNBULL MP

Purpose:

- To inform you that CSIRO has received a request for information about climate science from the Shadow Treasurer (and former Minister for the Environment), the Hon Malcolm Turnbull MP (Lib, Wentworth), and to provide you with an advance copy of CSIRO's response.

s22 [redacted]

- CSIRO is often asked to provide information to members of Parliament. CSIRO provides information based on peer reviewed scientific literature in the public domain, and in accordance with its standard procedures for communicating with members of parliament. CSIRO's policy on such communications is currently being updated along with other policy updates, but the proposed revisions are not substantially different from current practice.

- CSIRO's response to the request from Mr Turnbull is attached for your information.

Communication: Nil

[redacted]

Attachments: Letter from the CSIRO Environment Group Executive, Dr Andrew Johnson, to the Hon Mr Turnbull MP, for your information. ***Slipstream Version 19 August 2008***

Andrew Johnson s22 [redacted]
Group Executive, Environment
CSIRO
19 August 2008

Jenny Baxter s22 [redacted]

Consultation: MPLO, CSIRO Board Office

NOTED/PLEASE DISCUSS
s22 [redacted]
20/8/08

Kim Carr

Dr Andrew Johnson
CSIRO Group Executive - Environment,
s22
Telephone s22 Facsimile s22 ABN 41 687 119 230
CSIRO

The Hon Mr Malcolm Turnbull MP
Member for Wentworth
PO Box 6022
House of Representatives
Parliament House
CANBERRA ACT 2600

August 2008

Dear Mr Turnbull

I am advised that you recently requested of the Chief of CSIRO Marine and Atmospheric Research (CMAR), Dr Greg Ayers, some information about climate change science.

Please find attached some information compiled by CSIRO scientists.

I trust that this information responds to your queries and helps to address your concerns.

Best regards

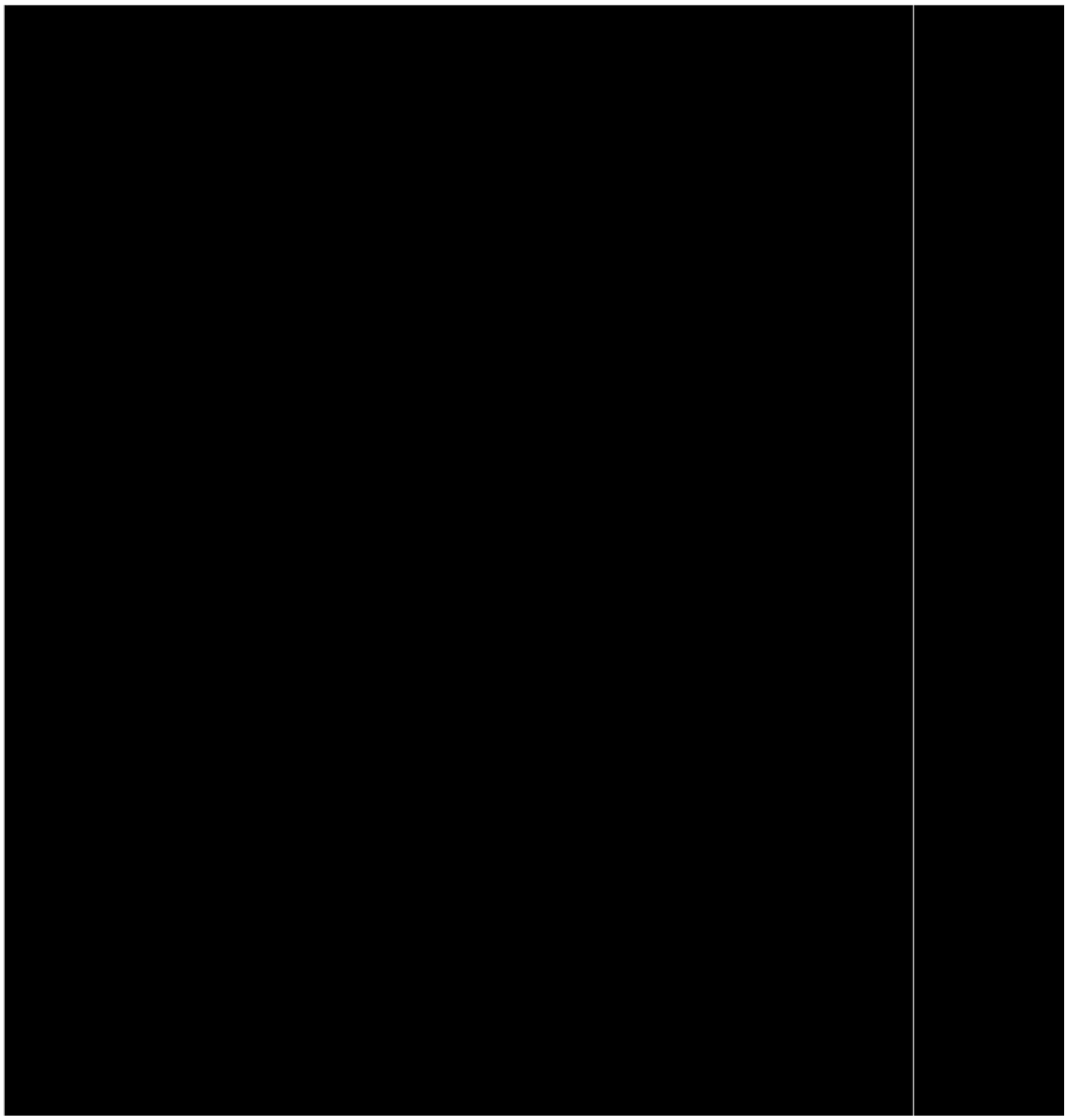
Andrew Johnson
Group Executive
Environment

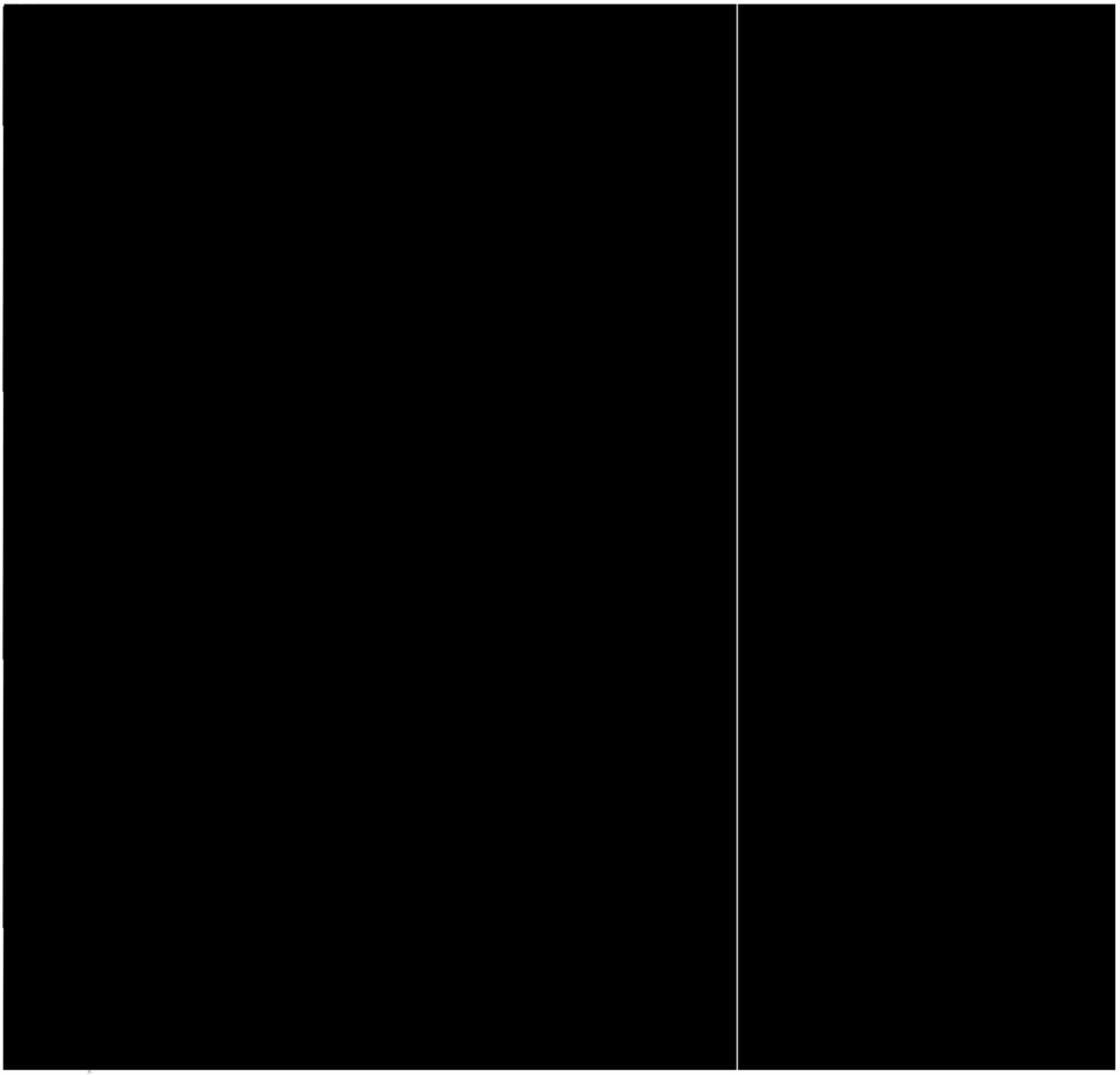
Response to some queries raised recently regarding climate change

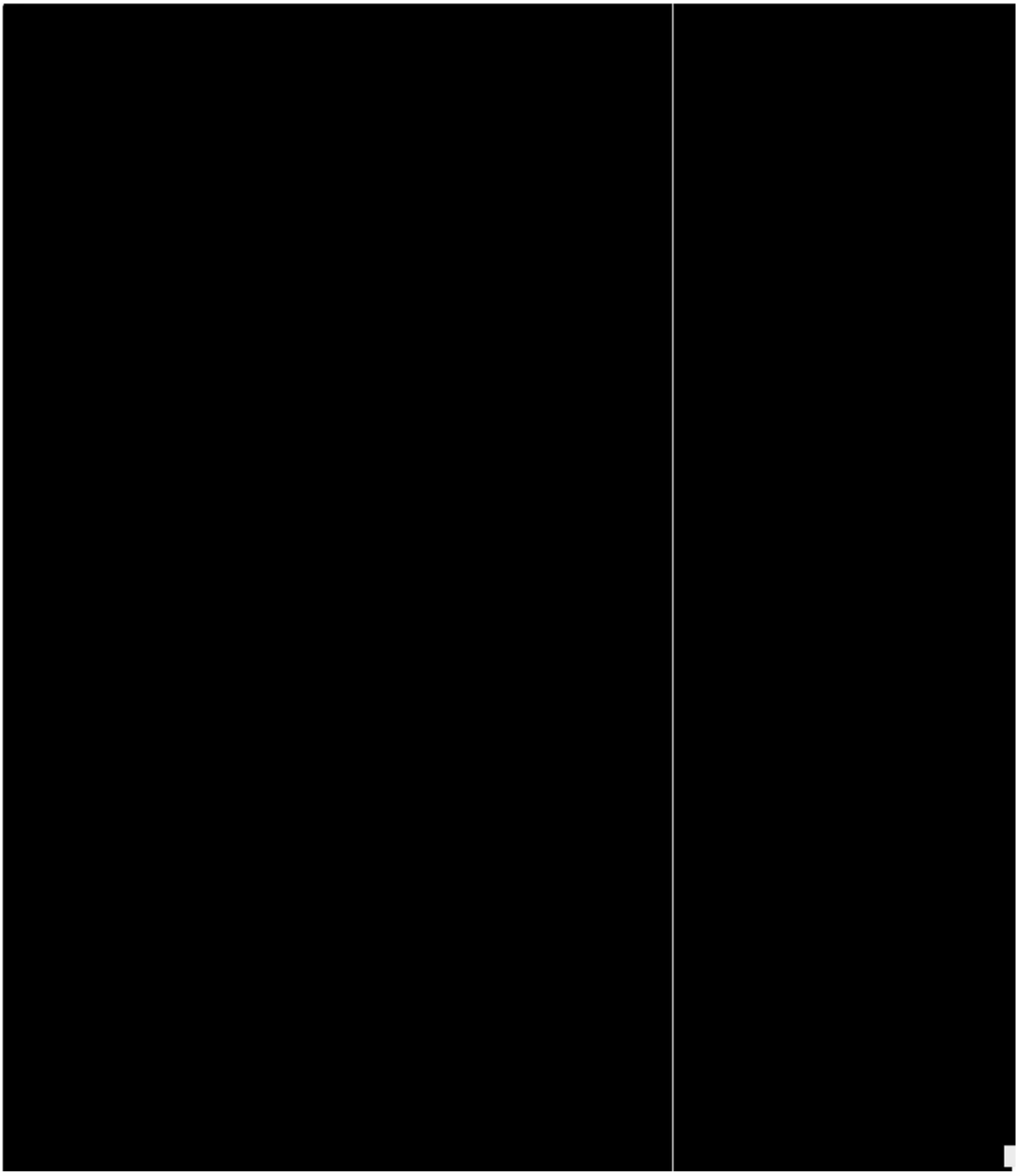
K.J. Hennessy, R. Colman, P. Whetton and R. Jones
CAWCR

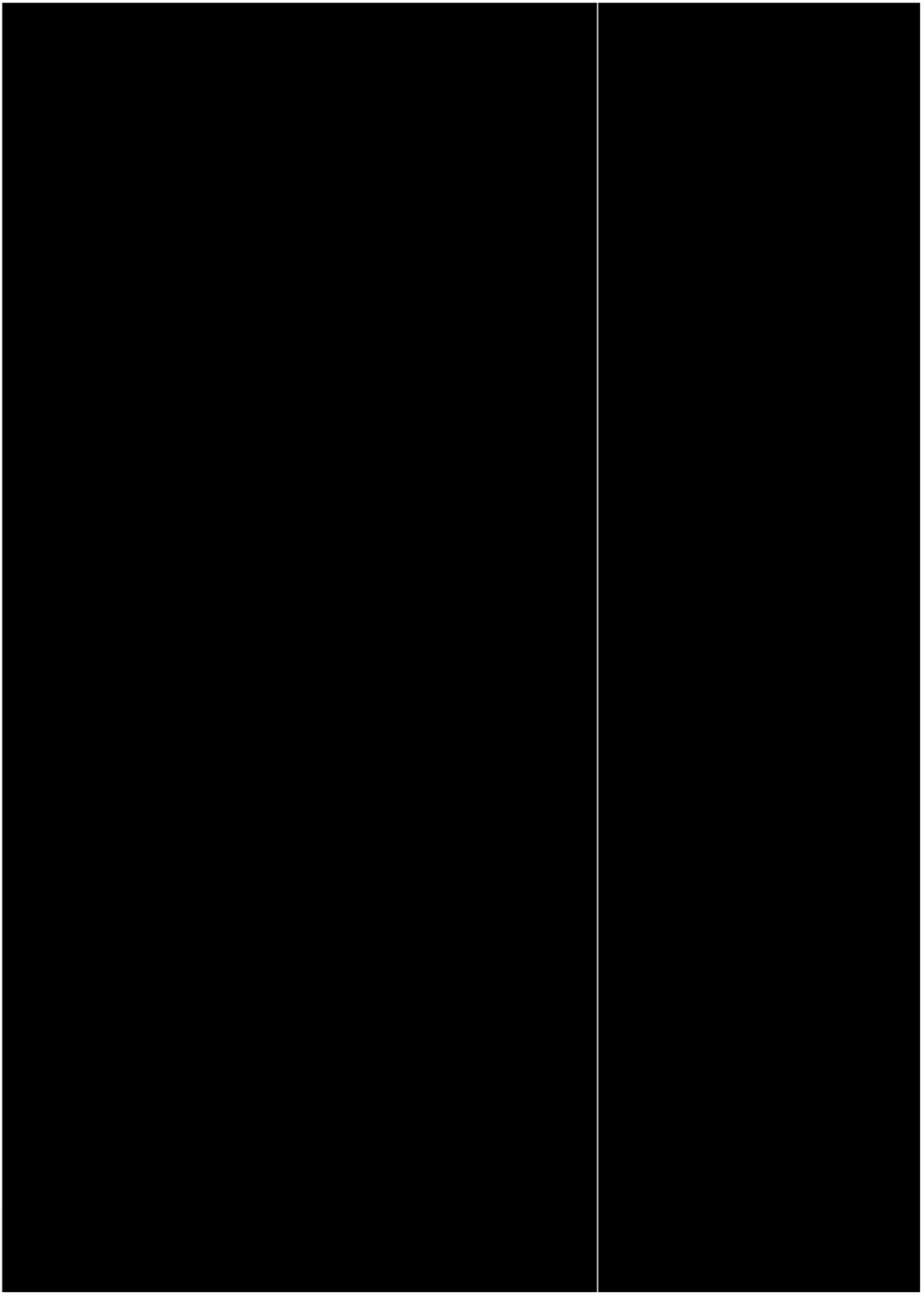
14 August 2008

Claim: The world isn't warming, it's been cooling since 1998.









Roy Spencer's testimony to US Congress:
"Despite decades of persistent uncertainty over how sensitive the climate system is to increasing concentrations of carbon dioxide from the burning of fossil fuels, we now have new satellite evidence which strongly suggests that the climate system is much less sensitive than is claimed by the U.N.'s Intergovernmental Panel on Climate Change (IPCC).

If true, an insensitive climate system would mean that we have little to worry about in the way of man made global warming and associated climate change. And, as we will see, it would also mean that the warming we have experienced in the last 100 years is mostly natural. Of course, if climate change is mostly natural then it is largely out of our control, and is likely to end — if it has not ended already, since satellite-measured global temperatures have not warmed for at least seven years now."

Full testimony at:
http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=e12b56cb-4c7b-4c21-bd4a-7afbc4ee72f3

Response

Spencer's testimony is based in part on a Journal of Climate article by R. Spencer and W. Braswell ("Potential biases in feedback diagnosis from observational data: a simple model demonstration", J. Clim., 2008, in press). This paper deals with a narrow scientific point and does not contain (nor support) Spencer's conclusion that recent satellite data indicate that the climate system is much less sensitive than IPCC concluded. The reminder of his testimony comprises non-peer reviewed scientific results and Spencer's interpretation of them.

In our assessment, Spencer's results are of some scientific interest, but they do not materially alter current scientific understanding of climate change. Spencer's testimony exaggerated the implications of his work.

Specific points:

- Spencer notes that diagnosing cloud feedback from atmospheric observations may lead to estimates biased toward a more positive feedback (higher climate sensitivity) than really applies. This is interesting, but climate modelling does not depend on this diagnosis. Feedbacks that apply in climate models are a consequence of model representations of more fundamental, and better observed, climate processes. Spencer's result is of little relevance to climate change modelling.
- Spencer's argument focuses just on cloud feedback. It does not address water vapour feedback which is a far more important feedback process for the climate change issue.
- In a non peer-reviewed study Spencer also presents estimates of (aspects of) cloud feedback based on satellite observations of natural climatic variability. He compares this to model-derived feedback and notes that the observed feedback is more negative (representing a less sensitive climate system) than any of the models. This is comparing apples and oranges. There are many factors that confound our ability to diagnose feedbacks that would apply under secular warming from those that may appear to operate with natural variability. This is why climate change feedback is not usually assessed in this way.

- Spencer also uses a simple model to demonstrate that there may be an explanation for much of the warming observed over the past century based on natural variability. Although Spencer says otherwise, this issue has been extensively assessed by climate scientists using a variety of techniques that appropriately address the complexity of the issue. This work led to IPCC's conclusion that most of warming since 1950 is very likely due to enhanced greenhouse conditions. Spencer's simplistic calculation neglects key issues and does not have implications for IPCC's conclusion.

KC AR CJ RS

Minister
Innovation, Industry, Science and Research

B08/4543

Document 2

For Advanced Notification CSIRO Initiated **CSIRO No. C2008/9785**

GLOBAL CARBON EMISSIONS – 2007 SUMMARY

[redacted]

Background:

- The GCP was formed in 2001 to assist the international science community to establish a common, mutually agreed knowledge base supporting policy debate and action to slow the rate of increase of greenhouse gases in the atmosphere.
- GCP is a shared partnership between the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP), the World Climate Research Programme (WCRP) and Diversitas. This partnership constitutes the Earth Systems Science Partnership (ESSP).
- CSIRO scientists currently hold senior positions within the GCP. Dr Pep Canadell is Executive-Director and Dr Mike Raupach is co-Chair.
- The GCP will release its 2007 global carbon emission summary in Washington and Paris on Friday 26 September 2008.

[redacted]

Attachments: A) Text of CSIRO media release.

Slipstream Version 25 September 20(
Dr Andrew As s22
A/g Group Executive, Environment
CSIRO
24 September 2008
Contact: Jenny Baxter s22

Consultation:

NOTED/PLEASE DISCUSS
s22
30/9/07
Kim Carr

ATTACHMENT A

CSIRO MEDIA RELEASE

Media Release

EMBARGOED TO 11pm 25 September 2008

Ref

Emissions rising faster this decade than last

The latest figures on the global carbon budget to be released in Washington and Paris today indicate a four-fold increase in growth rate of human-generated carbon dioxide emissions since 2000.

"This is a concerning trend in light of global efforts to curb emissions," says Global Carbon Project (GCP) Executive-Director, Dr Pep Canadell, a carbon specialist based at CSIRO in Canberra.

Releasing the 2007 data, Dr Canadell said emissions from the combustion of fossil fuel and land use change almost reached the mark of 10 billion tonnes of carbon in 2007.

Using research findings published last year in peer-reviewed journals such as *Proceedings of the National Academy of Sciences*, *Nature* and *Science*, Dr Canadell said atmospheric carbon dioxide growth has been outstripping the growth of natural carbon dioxide sinks such as forests and oceans.

The new results were released simultaneously in Washington by Dr Canadell and in Paris by Dr Michael Raupach, GCP co-Chair and a CSIRO scientist.

Dr Raupach said Australia's position remains unique as a developed country with rapidly growing emissions.

"Since 2000, Australian fossil-fuel emissions have grown by two per cent per year. For Australia to achieve a 2020 fossil-fuel emissions target 10 per cent lower than 2000 levels, the target referred to by Professor Garnaut this month, we would require a reduction in emissions from where they are now by 1.5 per cent per year. Every year of continuing growth makes the future reduction requirement even steeper."

The Global Carbon Project (GCP) is a joint international project on the global carbon cycle sponsored by the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Research (IHDP), and the World Climate Research Program.

The research team included Corinne Le Quéré (University of East Anglia/British Antarctic Survey, UK), Philippe Ciais (Commissariat a L'Energie Atomique, France), Thomas Conway (NOAA, USA), Chris Field (Carnegie Institution of Washington, USA), Skee Houghton (Woods Hole Research Center, USA), Gregg Marland (Carbon Dioxide Information Analysis Center, USA), and Drs Canadell and Raupach.

Image available at:

Further information:
Dr Pep Canadell, CSIRO Marine and Atmospheric Research
Dr Michael Raupach, CSIRO Marine and Atmospheric Research
Dr Paul Fraser, CSIRO Marine and Atmospheric Research

s22

Global Carbon Project
http://www.globalcarbonproject.org

Media Assistance:
Simon Torok, CSIRO Marine and Atmospheric Research

s22

www.csiro.au

Background

Key figures released today include –

Atmospheric CO_2 growth

Annual mean growth rate of atmospheric CO_2 was 2.2 ppm per year in 2007 (up from 1.8 ppm in 2006), and above the 2.0 ppm average for the period 2000-2007. The average annual mean growth rate for the previous 20 years was about 1.5 ppm per year. This increase brought the atmospheric CO_2 concentration to 383 ppm in 2007, 37% above the concentration at the start of the industrial revolution (about 280 ppm in 1750). The present concentration is the highest during the last 650,000 years and probably during the last 20 million years. [ppm = parts per million].

Emissions from land use change

Land use change was responsible for estimated net emissions of 1.5 PgC per year to the atmosphere. This is largely the difference between CO_2 emissions from deforestation and CO_2 uptake by reforestation. Emissions for 2006 and 2007 were extrapolated from the previous 25-year trend of 1.5 PgC per year. Land use change emissions come almost exclusively from deforestation in tropical countries with an estimated 41% from South and Central America, 43% from South and Southeast Asia, and 17% from Africa. An estimated 160 PgC were emitted to the atmosphere from land use change during the period 1850-2007 [1 Pg = 1 billion tons or 1000 x million tons].

Emissions from fossil fuel and cement

Emissions increased from 6.2 PgC per year in 1990 to 8.5 PgC in 2007, a 38% increase from the Kyoto reference year 1990. The growth rate of emissions was 3.5% per year for the period of 2000-2007, an almost four fold increase from 0.9% per year in 1990-1999. The actual emissions growth rate for 2000-2007 exceeded the highest forecast growth rates for the decade 2000-2010 in the emissions scenarios of the Intergovermental Panel on Climate Change, Special Report on Emissions Scenarios (IPCC-SRES). This makes current trends in emissions higher than the worst case IPCC-SRES scenario. Fossil fuel and cement emissions released approximately 348 PgC to the atmosphere from 1850 to 2007.

Regional fossil fuel emissions

The biggest increase in emissions has taken place in developing countries, largely in China and India, while developed countries have been growing slowly. The largest regional shift was that China passed the U.S. in 2006 to become the largest CO_2 emitter, and India will soon overtake Russia to become the third largest emitter. Currently, more than half of the global emissions come from less developed countries. From a historical perspective, developing countries with 80% of the world's population still account for only 20% of the cumulative emissions since 1751; the poorest countries in the world, with 800 million people, have contributed less than 1% of these cumulative emissions.

Carbon Intensity of the economy

After decades of improvements, the carbon intensity of the global economy, the carbon emitted per unit of Gross Domestic Product (GDP), was stalled during the period 2003-2005. This change was largely caused by China's rapidly growing share in economic output and carbon emissions. Since 2005 China's energy intensity (which underpins carbon intensity) has decreased (improved) by 1.2% in 2006 and 3.7% in 2007 compared to 2005 levels (according to the National Energy Administration in China).

CO_2 removal by natural sinks

Natural land and ocean CO_2 sinks have removed 54% (or 4.8 PgC per year) of all CO_2 emitted from human activities during the period 2000-2007. The size of the natural sinks has grown in proportion to increasing atmospheric CO_2. However, the efficiency of these sinks in removing CO_2 has decreased by 5% over the last 50 years, and will continue to do so in the future. That is, 50 years ago, for every ton of CO_2 emitted to the atmosphere, natural sinks removed 600 kg. Currently, the sinks are removing only 550 kg for every ton of CO_2 emitted, and this amount is falling.

Natural Ocean CO_2 sinks

The global oceanic CO_2 sink removed 25% of all CO_2 emissions for the period 2000-2007, equivalent to an average of 2.3 PgC per year. The size of the CO_2 sink in 2007 was similar to that in the previous year but lower by 0.1 PgC compared to its expected increase from atmospheric CO_2 growth. This was due to the presence of a La Nina event in the equatorial Pacific. The Southern Ocean CO_2 sink was higher in 2007 compared to 2006, consistent with the relatively weak winds and the low Southern Annular Mode (a circumpolar pressure oscillation between Antarctica and southern mid-latitudes). An analysis of the long term trend of the ocean sink shows a slower growth than expected of the CO_2 sink over the last 20 years.

Natural Land CO_2 sinks

Terrestrial CO_2 sinks removed 29% of all anthropogenic emissions for the period 2000-2007, equivalent to an average of 2.6 PgC per year. Terrestrial ecosystems removed 2.9 PgC in 2007, down from 3.6 Pg in 2006, largely showing the high year-to-year variability of the sink. An analysis of the long term trend of the terrestrial sink shows a growing size of the CO_2 sink over the last 50 years.

Conclusions. Anthropogenic CO_2 emissions have been growing about four times faster since 2000 than during the previous decade, and despite efforts to curb emissions in a number of countries which are signatories of the Kyoto Protocol. Emissions from the combustion of fossil fuel and land use change reached the mark of 10 billion tones of carbon in 2007. Natural CO_2 sinks are growing, but more slowly than atmospheric CO_2, which has been growing at 2 ppm per year since 2000. This is 33% faster than during the previous 20 years. All of these changes characterize a carbon cycle that is generating stronger climate forcing and sooner than expected

Minister
Innovation, Industry, Science and Research

B08/5022

KC AR CJ RS

For Advanced Notification CSIRO Initiated

C2008/10716

Document 3

ATMOSPHERIC METHANE LEVELS RISING

Purpose: To inform you of the current availability, on-line, and the publication in print in early 2009, of the paper "Renewed growth of atmospheric methane" in *Geophysical Research Letters*. This research may relate to Australian Government policies or programmes.

Background:

- Methane is the second most important greenhouse gas in the atmosphere, after carbon dioxide.
- Methane accounts for nearly 20 per cent of global warming since the industrial revolution.
- Methane is emitted to the atmosphere from various sources including: coal mines, natural gas leakage and use, rice fields, livestock, forest and grassland fires, and wetlands.

Issues:

- A scientific publication in press with *Geophysical Research Letters* for publication in early 2009, and currently accessible at http://www.agu.org/journals/pip/gl/2008GL036037-pip.pdf, suggests that after eight years of near-zero growth in atmospheric methane concentrations, levels have again started to rise. This is attributed to an imbalance between methane-emitting sources and methane sinks, and in part, to methane releases in the high latitudes of the northern hemisphere.
- The paper raises concerns that global warming will accelerate.
- The paper was co-authored by Commonwealth Scientific and Industrial Research Organisation (CSIRO) scientists and researchers in the University of Bristol in the United Kingdom, and the Massachusetts Institute of Technology (MIT) and the University of California, in the United States.
- The bulk of Australian methane emissions come from the agricultural sector, totalling 12.5 per cent of all Australian emissions. Livestock production contributes around 11 per cent of these emissions. The remainder of methane agricultural emissions derive from biomass burning and rice cultivation.
- In light of these findings you may wish to inform the Minister for Climate Change and Water, Senator the Hon Penny Wong, of the subject matter of the paper.

Communication:

- The paper was accepted by the journal on 16 October 2008 and an 'in press' copy became available on the publisher's website (American Geological Union (AGU)) on 18 October 2008. Distribution of the printed copy of the journal is scheduled for early 2009.
- CSIRO intends to issue a joint media release with AGU during the week of 3 November 2008 **(Attachment A)**. A fact sheet explaining methane's contribution to greenhouse gases and its sources has also been prepared **(Attachment B)**.

Slipstream Version 21 October 2008

Dr Andrew Johnso, s22
Group Executive, Environment
CSIRO
21 October 2008
Contact Simon Torok s22

Consultation: CSIRO colleagues in DC will be alerted informally to the website providing the paper.

NOTED/PLEASE DISCUSS

s22

Kim 22/10/08

ATTACHMENT A

DRAFT MEDIA RELEASE

Global methane levels on the rise again

After eight years of near-zero growth in atmospheric methane concentrations, levels have again started to rise; fuelling concerns that global warming will accelerate.

Dr Paul Fraser, from CSIRO Marine and Atmospheric Research, says that atmospheric methane concentrations are now rising rapidly.

'This is not good news for future global warming,' says Dr Fraser, who co-authored a paper to be published in *Geophysical Research Letters*, a journal of the American Geophysical Union. 'Over recent years, the growth of important greenhouse gases, namely methane and the CFCs, had slowed. This tended to offset the increasing growth rate of carbon dioxide that results mainly from large increases in the consumption of fossil fuels, particularly in the developing world.'

'Now that methane levels have resumed their growth, global warming will accelerate.'

Methane is the second most important greenhouse gas in the atmosphere after carbon dioxide, accounting for nearly 20 per cent of global warming since the industrial revolution.

Methane is emitted to the atmosphere from natural wetlands, rice fields, cattle, forest and grassland fires, coal mines, and natural gas leakage and use.

'Over the past decade these methane sources have been close to balancing the absorption of methane through atmospheric oxidation and into dry soil,' says Dr Fraser. 'This fragile balance has resulted in little growth of methane in the atmosphere. Apparently some sources have been increasing, such as from fossil fuel use, cattle, and rice, while others have been decreasing, particularly natural tropical wetlands. However, over the past year, the total sources have overwhelmed the total sinks, and methane has again started to rise.'

Dr Fraser says that recent analyses of global data by CSIRO and collaborators at MIT, the University of California and the University of Bristol suggest that the methane increase is, at least in part, due to methane releases in the high latitudes of the Northern Hemisphere. 'Such increases have been predicted as rapid Arctic ice melting creates more high latitude wetland sources,' says Dr Fraser. 'A possible additional cause of the methane increase is that atmospheric oxidation may be weakening, for reasons as yet unknown, although recovery from ozone depletion, which is predicted to have commenced, may be involved.'

The Intergovernmental Panel on Climate Change (IPCC) has identified the need to understand causes of the variations of methane growth rates as a priority area of research. 'The reality is that scientists have only a very basic understanding of these methane variations,' says Dr Fraser. 'In order to predict the future contribution of methane to climate change, continuing high-quality observations, in particular in tropical and boreal locations, are required as input to, and verification of, sophisticated climate models.'

Research paper available at: http://www.agu.org/journals/pip/gl/2008GL036037-pip.pdf

Further Information:
Dr Paul Fraser, CSIRO Marine and Atmospheric Research s22

Media Assistance:
Simon Torok, CSIRO Marine and Atmospheric Research s22
www.csiro.au

ATTACHMENT B

INFORMATION FACT SHEET – METHANE AND LIVESTOCK

Methane – and its contribution to Australian greenhouse gases

Rising concentrations of greenhouse gases are resulting in global warming because these gases trap heat in the atmosphere rather than allowing radiant heat from the earth's surface to be lost to space. Carbon dioxide (CO_2) is the most well known greenhouse gas. Because of the very large quantities of CO_2 that human activities have released to the atmosphere, CO_2 has had the greatest impact on climate change.

Methane increases have had the second highest impact on climate change, accounting for about 20 per cent of the warming from all greenhouse gases over the past 250 years. The effect of methane concentrations on climate change has been considerable because methane is more than 20 times as effective at trapping heat in the atmosphere as CO_2.

CSIRO's Dr Paul Fraser says that methane concentrations have more than doubled in the atmosphere in the past 250 years. The increase was due to agricultural sources, leakage during fossil fuel use, and other human sources, as well as the burning of trees and other vegetation. Dr Fraser has analysed figures from Australia's National Greenhouse Accounts, National Inventory Report 2005, Volume 1, Feb 2008, Department of Climate Change, to provide a breakdown of Australia's methane emissions. These data are derived from the Intergovernmental Panel on Climate Change (IPCC) emissions factors.

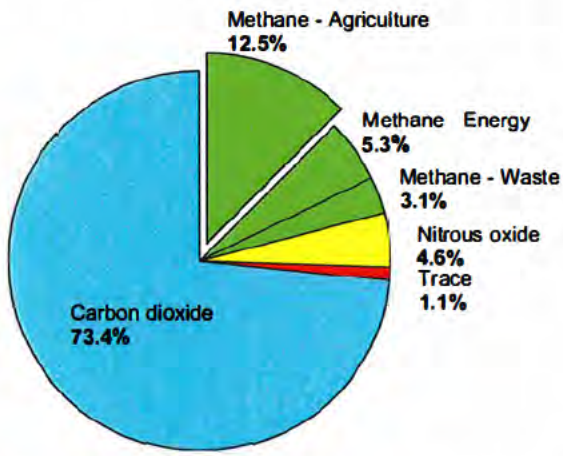


Figure 1: Australian greenhouse gas emissions by global warming potential

Figure 1 shows a breakdown of Australia's greenhouse gas emissions, by global warming potential. Carbon dioxide, produced largely from the energy sector accounts for nearly 75 per cent; methane comprises just over 20 per cent of Australian emissions, and the remainder are nitrous oxide and other trace gases.

The bulk of Australian methane emissions come from the agricultural sector, totalling 12.5 per cent of all Australian emissions. Figure 2 breaks this category down further. It shows that around 90 per cent of agricultural methane emissions are from livestock production. Ruminant animals, like cattle and sheep produce methane in their gut during digestion (enteric fermentation), animal manure also makes a small contribution to emissions. Livestock production therefore contributes around 11 per cent of Australia's total greenhouse gas emissions. The remainder of methane agricultural emissions derive from biomass burning and rice cultivation.

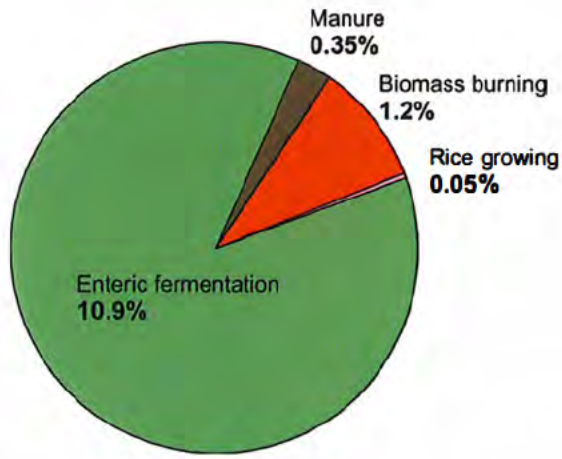


Figure 2: Methane emissions from agriculture as a percentage of Australia's total greenhouse gas emissions (12.5 per cent of total)

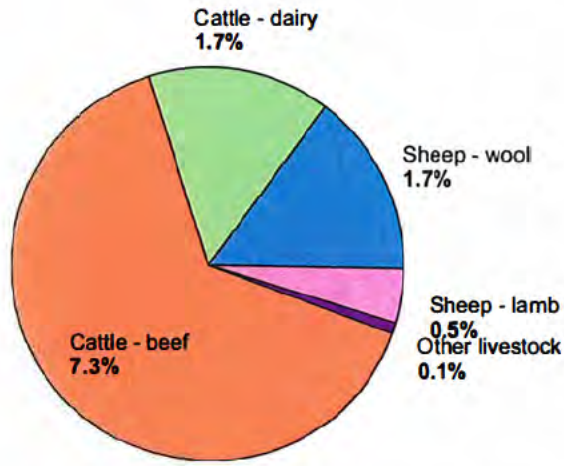


Figure 3: Methane emissions from livestock as a percentage of Australia's total greenhouse gas emissions (11 per cent of total)

Figure 3 shows the proportion of Australia's total greenhouse gas emissions that derive from different livestock industries. As methane emission factors from animals have an uncertainty of about ±35 per cent, these figures are approximate. However, around 9 per cent of Australian greenhouse gas emissions are from cattle, split between beef farming and the dairy industry. Sheep farming for wool and lamb contributes around 2 per cent of total emissions and a small fraction come from other animals such as horses, goats and pigs.

More information: Explaining the methane mystery - http://www.csiro.au/news/ps2bf.html

Dr Zoë Loh
Postdoctoral Fellow
CSIRO Marine & Atmospheric Research (Sept, 2008)

CSIRO

Minister
Innovation, Industry, Science and Research

B09/755

Document 4

CSIRO No. C2009/1397

For Information **CSIRO Initiated**

CLIMATE CHANGE AND SEVERE WEATHER EVENTS

[redacted]

Further background is at **Attachment A.**

[redacted]

Andrew Johnson s22
Group Executive Environment
CSIRO
19 February 2009
Jenny Baxter s22

Consultation

NOTED/PLEASE DISCUSS

s22

23/2/09

Kim Carr

ATTACHMENT A

FURTHER BACKGROUND

BACKGROUND:

Fire

- There is over 90 per cent certainty that most of the warming observed over the past 50 years is due to human-induced increases in greenhouse gas emissions.

KC. RS. AR.

Minister
Innovation, Industry, Science and Research

B09/983

Document 5

For Event

CSIRO No. C2008/8438

CSIRO BRIEFING AT PARLIAMENT HOUSE

CLIMATE CHANGE – THE LATEST SCIENCE

[redacted]

- **Attachment C:** Background information
- **Attachment D:** Speech notes

Slipstream Version 11 March 2009

Dr Andrew Johnson s22 [redacted]
Group Executive, Environment
CSIRO
11 March 2009
Dr Katherine Harle s22 [redacted]

NOTED/PLEASE DISCUSS

s22 [redacted]

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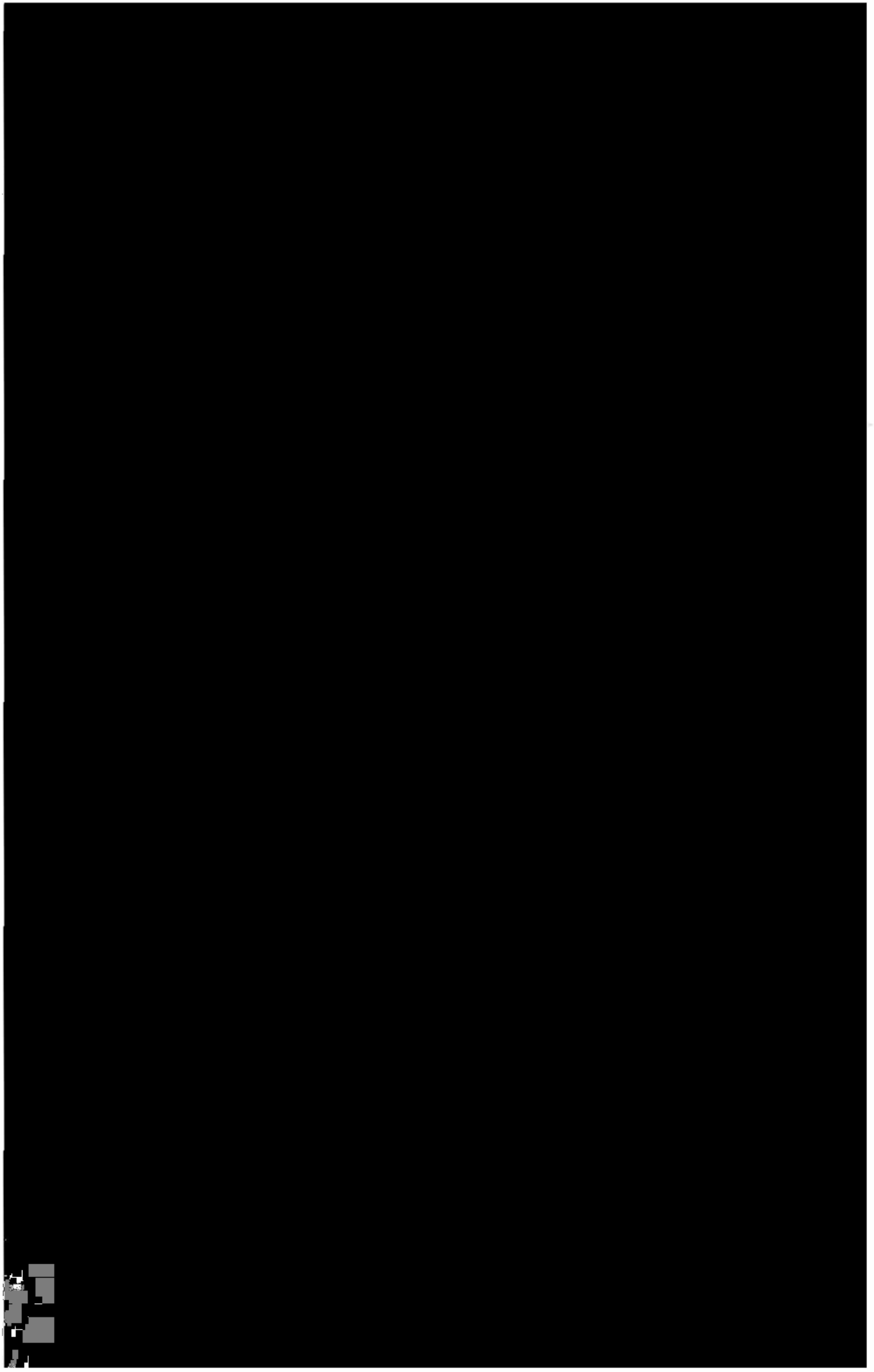


[redacted]

[redacted]

Dr Penny Whetton has led the Climate Impacts and Risk research stream at CSIRO Marine and Atmospheric Research since July 2005. A major component of Dr Whetton's research has been analysing the regional output of enhanced greenhouse general circulation model (GCM) experiments, and using this information to construct regional scenarios of future climate change. She also works on regional climate change impact assessment. She was the main contributor to, and editor of, the Climate Impact Group's Australian climate change projections released in November 1992, November 1996, and May 2001, as well as contributing to projections released in late 2007

Mr Kevin Hennessy leads CSIRO's Climate Impacts and Risks group. He is an expert in analysing observed climatic trends and future greenhouse simulations, developing Australian climate change projections, assessing potential impacts and communicating climate science. With over 130 publications dealing with climate variability and climate change issues, Kevin's work has been widely disseminated. He has managed or co-authored a number of consultancy projects for State and Territory departments, the former Australian Greenhouse Office (AGO) and private industry. Kevin represents CSIRO on the Impacts and Adaptation Working Group of the COAG High Level Greenhouse Group, and is a member of the NSW Greenhouse Advisory Panel reporting to the NSW Premier and the NSW Greenhouse Office.

[redacted]

ATTACHMENT D

SPEECH NOTES

SENATOR THE HON KIM CARR

MINISTER FOR INNNOVATION INDUSTRY SCIENCE & RESEARCH

CSIRO SCIENCE FOR POLICY BRIEFING AT PARLIAMENT HOUSE

"CLIMATE CHANGE – THE LATEST SCIENCE"

MONDAY 16 MARCH 2009 AT 11.00 AM

TALKING POINTS:

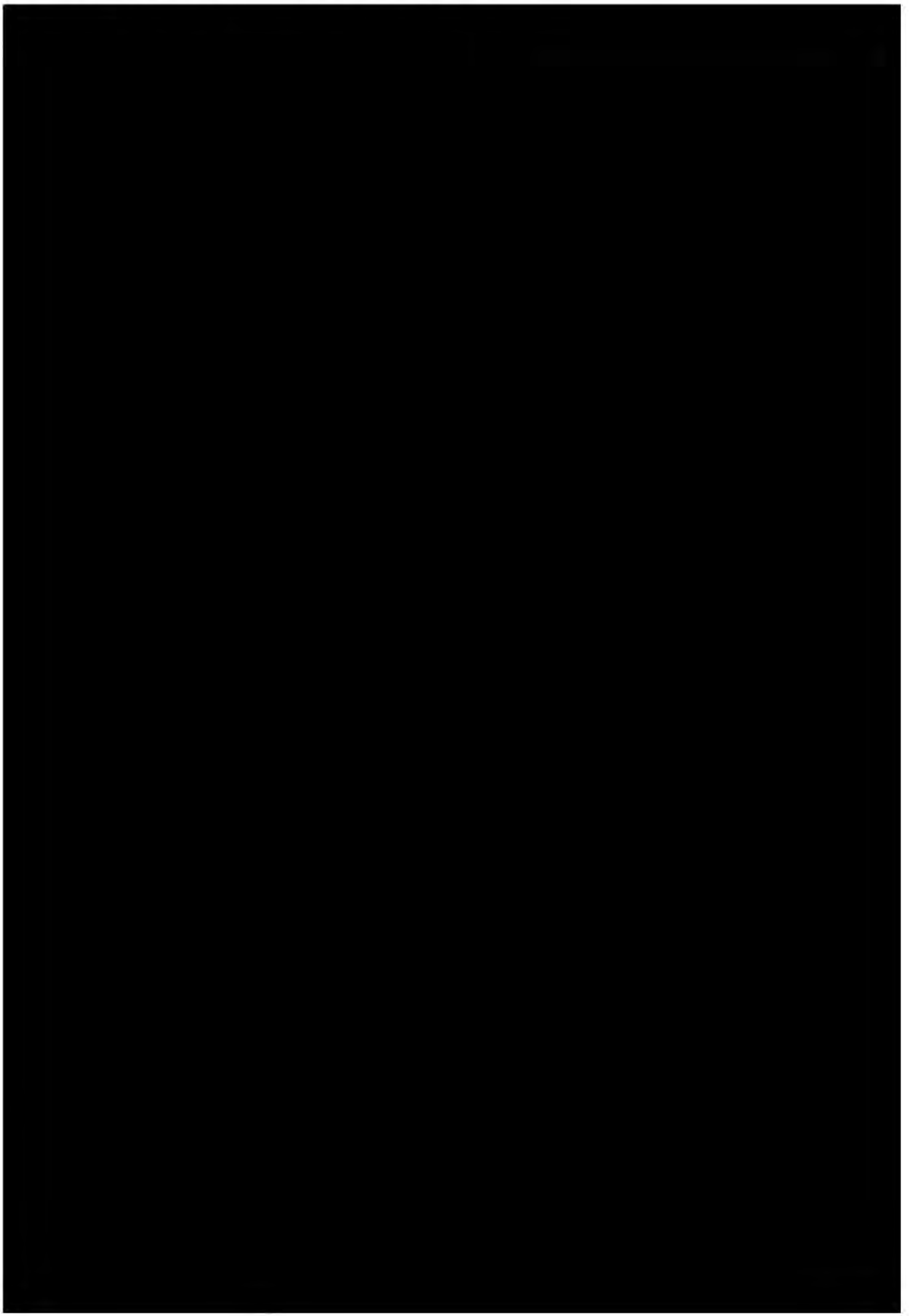
[redacted]

- Climate change is one of the most pressing issues facing Australia, and indeed the world. Rising greenhouse gas emissions as a result of human activity, and their consequent impact on global climate systems are not something we can ignore.

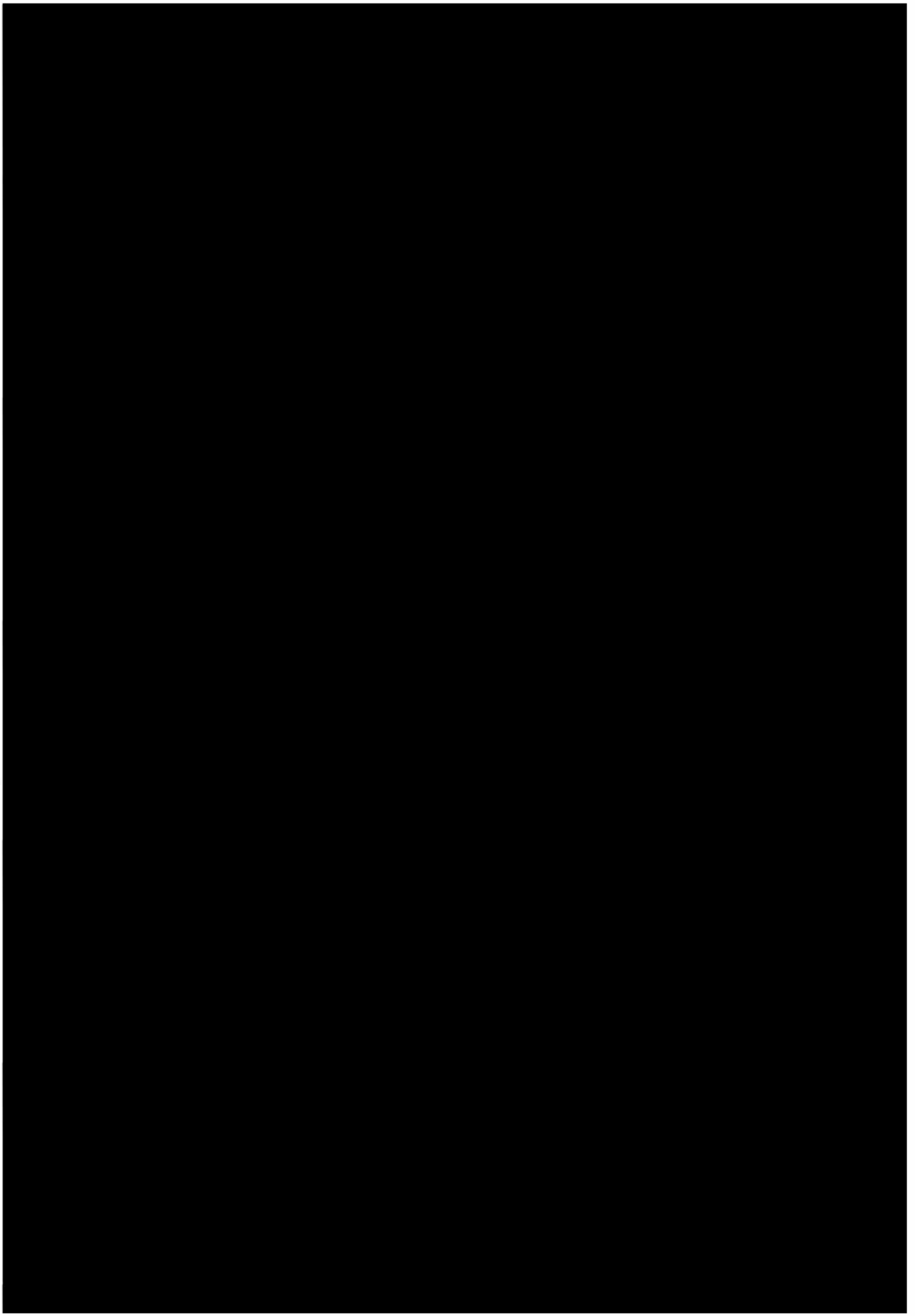
[redacted]

- As noted by Dr Clark, CSIRO has a strong, world class track record in climate research. CSIRO scientists have been major contributors in the development of a global understanding of the earth's climate systems and the impact humans have had on them. They have had a significant presence in the international efforts to understand and document climate change, including being major contributors to the

International Panel on Climate Change, the Global Carbon Project and the World Climate Research Program.



[redacted]



CSIRO Parliamentary Briefing on Climate Change – the Latest Science

16 March 2006 at Parliament House

Speech notes for Dr Megan Clark

The CSIRO Energy Transformed Flagship is playing an important national and international role in developing technologies for mitigating the degree of climate change through reducing greenhouse gas emissions.

KC LS AR

Minister
Innovation, Industry, Science and Research

B09/2942

Document 6

CSIRO No. C2009/5766

For Information **CSIRO Initiated**

RESEARCH INTO CARBON SINKS AND CLIMATE CHANGE

Purpose: To inform you of the upcoming release of research regarding the vulnerability of carbon in arctic permafrost, and clarify how this science relates to recently released CSIRO carbon sink research.

Background:

- Carbon, in its many forms, cycles between the biosphere (the global sum of all ecosystems), the atmosphere, oceans, and geosphere (the densest parts of the Earth, consisting mostly of rock and the loose material covering it). Within this cycle there are various sinks (fluxes in), sources (fluxes out) and stores, of carbon.
- Increasing carbon levels in the atmosphere, due to anthropogenic sources of carbon, have been implicated in causing global warming and climate change.
- Predicting climate change requires an understanding of the various sources, natural or anthropogenic, of carbon in the atmosphere. One area of current research is the stability of various carbon sinks particularly under different projected climate change conditions. In a warming climate, if the ability of carbon sinks to store carbon is reduced the rate of climate change could accelerate rapidly.

Issues:

- In late April 2009, *Science* published a paper on the stability of methane clathrates (a carbon store largely found in the deep ocean), to which CSIRO scientists contributed. At the time of publication CSIRO issued a 'good news' media release outlining the paper's findings that indicated this carbon sink was more stable in a warming world, and less likely to accelerate climate change, than previously thought (see **Attachment A**).
- A CSIRO scientist, Dr Pep Canadell, is publishing a paper on 27 June 2009 in *Global Biogeochemical Cycles* that reports on findings indicating that another carbon store, organic carbon stored in frozen soils around the North Pole, has been greatly underestimated. As global warming occurs most intensely around the circumpolar region, these soils are vulnerable to degradation and the release of carbon into the atmosphere with a predicted negative impact on carbon-climate feedbacks resulting.
- As science makes incremental progress in understanding the interactions between carbon the carbon cycle and climate change, the nature of the research findings may appear contradictory. This is to be expected as there are many carbon stores with different sensitivities to global warming. It will be the composite of the effects on all carbon stores that will determine whether, and by how much, carbon released in its various forms will accelerate climate change.
- The vulnerability of permafrost is a key issue of climate change science and media and policy makers are likely to be interested in new research on this issue. CSIRO will continue, through you, to keep the Government abreast of important advances in climate change science as our knowledge evolves.

Communication: A media release on permafrost vulnerability is due for release in conjunction with the publication of the paper (see **Attachment B**).

Sensitivity: No

Slipstream Version 25 June 2009

Dr Andrew Johnson s22
Group Executive, Environment
CSIRO
25 June 2009
Contact: Imogen Jubb s22

Consultation:BOM

s22

NOTE: PLEASE DISCUSS

809

Kim Carr / /

ATTACHMENT A

METHANE CLATHRATES MEDIA RELEASE

24 April 2009
Ref 09/62

Greenland's 'good news' methane finding

Ice core research has revealed that a vast, potential source of the potent greenhouse gas, methane, is more stable in a warming world than previously thought.

Based on international research published today in *Science,* the finding includes Australian contributions from CSIRO and the Australian Nuclear Science and Technology Organisation (ANSTO)

Wetlands in the tropics and emerging from under receding Northern Hemisphere glaciers have been considered the primary source of rising atmospheric methane in a warming world. But scientists have known of another potential source.

Massive quantities of methane are locked away in permafrost and in the ocean floors as methane clathrate an ice-like material which can return to gas if temperatures increase or pressures drop. Just a 10 per cent release of methane would have the equivalent impact on global warming of a ten-fold increase in carbon dioxide concentration.

So began a US, New Zealand and Australian research project to understand ice core records spanning hundreds of thousands of years, profiling periods of high-methane increase and focusing on the Younger Dryas period. The cause of the large increase in methane 12,000 years ago as the Earth warmed and the Younger Dryas ended has been a source of much debate among scientists.

"The result is a good news outcome for climate scientists monitoring greenhouse gases and investigating the likely sources of methane in a warming world," says CSIRO's Dr David Etheridge, from the Centre for Australian Weather and Climate Research who helped show how the air could be extracted from polar ice to measure past methane changes and identify their causes.

"There are vast stores of methane clathrates beneath the ocean and in permafrost and there is evidence that millions of years ago release from these storages caused significant climate change, although none in more recent times.

"The objective of the research was to determine how stable the clathrate methane stores were as the Earth warmed rapidly from its last glacial state and whether clathrates might be a source of future climate change as global temperatures rise."

Dr Andrew Smith, from ANSTO, studied the source of methane by using a technique called accelerator mass spectrometry to detect individual radiocarbon atoms from ancient atmospheric methane samples over the Younger Dryas period.

"Radiocarbon provided the key insight to decide whether the extra methane was derived from clathrates or from wetlands," Dr Smith says.

"A multi-disciplinary team of scientists from the US Scripps Institution of Oceanography, New Zealand's National Institute of Water and Atmosphere, and from Australia's ANSTO and CSIRO combined their resources to tackle this challenging project."

The project involved years of field-work in West Greenland where scientists accessed samples located in 'outcropping' ice, a cross-section of ice formed over tens of thousands of years that is exposed at the surface. A tonne of ice was excavated to provide sufficient air from trapped bubbles for each measurement of the methane carbon isotopes.

Extremely sensitive analysis was required because of the low concentration of methane in air and because only about one trillionth of that methane contains radiocarbon – the carbon-14 isotope that is the key indicator of clathrate emissions. The analysis was undertaken at ANSTO in southern Sydney.

The methane isotope change accompanying the jump in concentration confirmed that the emission was not from clathrates, but from ecological sources such as wetlands.

"We know that emissions of methane are increasing now and that some sources might emit even more with warming, causing a positive climate feedback, or amplification. But this finding suggests that the clathrate source is less susceptible than recently feared," Dr Smith says.

The Centre for Australian Weather and Climate Research is a partnership between CSIRO and the Bureau of Meteorology.

Image available at: http://www.scienceimage.csiro.au/mediarelease/mr09-62.html

Further Information:

Dr David Etheridge, Centre for Australian Weather & Climate Research s22
Dr Andrew Smith, Australian Nuclear Science and Technology Organisation

Media Contact:

Craig Macaulay, CSIRO Marine and Atmospheric Research s22

Sharon Kelly, ANSTO Media and Community Relations Manager

ATTACHMENT B

EMBARGOED PERMAFROST MEDIA RELEASE

? Jun 2009
Ref 09/?

Permafrost melt poses major climate change threat

New research shows that the amount of carbon stored in frozen soils at high latitudes is double previous estimates and could, if emitted as carbon dioxide and methane, lead to a significant increase in global temperatures by the end of this century.

"Massive amounts of carbon stored in frozen soils at high latitudes are increasingly vulnerable to exposure to the atmosphere," says the Executive Director of the Global Carbon Project at CSIRO, Dr Pep Canadell.

"The research shows that the amount of carbon stored in soils surrounding the North Pole has been hugely underestimated."

In a paper published in the latest edition of *Global Biogeochemical Cycles*, Dr Canadell says frozen high latitude soils have the potential to release vast quantities of carbon and methane into the atmosphere and subsequently influence carbon climate feedbacks.

"Warmer temperatures at high latitudes are already resulting in unprecedented permafrost degradation," he says. "Projections show that almost all near surface permafrost will disappear by the end of this century exposing large carbon stores to decomposition and release of greenhouse gases."

Models developed in collaboration with Dr Canadell show that global warming could trigger an irreversible process of thawing.

"A number of feedbacks increase the vulnerability of these soils. For example, heat generated from increased microbial activity could lead to sustained and long term chronic emissions of carbon dioxide and methane."

In addition, 'thermokast lakes' formed as permafrost thaws, would draw heat to deeper layers and bring methane to the surface.

Increased fire frequency will also trigger permafrost degradation and thermokast collapse.

"Using the new carbon pool estimates from this research, permafrost degradation could account for the entire upper range of carbon climate feedbacks currently estimated by climate models," Dr Canadell says.

"The potential for significant feedbacks from permafrost carbon could be realised with only a small fraction of currently frozen carbon released to the atmosphere. For example if only 10 per cent of the permafrost melts, the resultant feedback could result in an additional 80 ppm carbon dioxide equivalent released into the atmosphere, equating to about 0.7°C of global warming."

Embargoed until 27 June 2009

The Centre for Australian Weather & Climate Research is a partnership between CSIRO and the Bureau of Meteorology.

Image available at:
Further Information:

Dr Pep Canadell, Global Carbon Project, CSIRO Marine & Atmospheric Research
Mb: + s22
E: s22
Visit the Global Carbon Project website at: www.globalcarbonproject.org

Media Assistance:
Imogen Jubb, Australian Climate Change Science Program Ph: s22
Mb:
E: s22

www.csiro.au;

KC GM ABAC

Minister
Innovation, Industry, Science and Research

Min ID: B10/1087

Document 7

CSIRO No. C2010/3406

For Information **CSIRO Initiated**

CSIRO CLIMATE COMMUNICATION STRATEGY

[redacted]

- CSIRO is proposing to release a joint media statement with BoM in order to put on the public record a statement regarding the underpinning science and documented observations of climate over the last 50 years.

[redacted]

Communication: Refer above

Sensitivity: No.

Attachments: A) Overview of the CSIRO Carbon Strategy

[redacted]

Slipstream version: 11 March 2010

Dr Andrew Johnson 07 3214 2383
Group Executive Environment
CSIRO
11 March 2010
Contact: Dr Peter Stone [redacted]
[redacted]

Consultation

BoM

Kim Carr 14/03/10

ATTACHMENT A

OVERVIEW OF THE CSIRO CLIMATE STRATEGY

Pages 3 and 4 removed under s 22 - Irrelevant

C11/538

CSIRO

OFFICE OF
SENATOR THE HON KIM CARR

Document 8

MINISTER FOR INNOVATION, INDUSTRY,
SCIENCE AND RESEARCH

s22 [redacted]

06 APR 2011

Dear [redacted]

Thank you for your letter of 1 March 2011 to the Minister for Innovation, Industry, Science and Research, Senator the Hon Kim Carr, concerning [redacted] and evidence of climate change. The Minister has asked me to reply on his behalf.

In reference to your statement that average yearly global temperatures have not increased, the World Meteorological Organization noted that last year ranked as one of the warmest years on record, together with 2005 and 1998 (see the WMO statement at <<www.wmo.int/pages/mediacentre/press_releases/pr_906_en.html>>. There is evidence that the Earth's climate has warmed over the last century, as is apparent in a range of climate indicators including increasing temperatures over land and in the oceans and increases in sea level. Furthermore, all measurements of the climate system indicate the long-term global warming trend is continuing. Please see the CSIRO's summary (with supporting references) at <<www.csiro.au/news/Has-Global-Warming-Stopped.html>> for more information on how average annual global temperatures have increased. CSIRO and the Bureau of Meteorology last year released a snapshot of the state of the climate in Australia, which similarly illustrates a warming trend <<see http://www.csiro.au/resources/State-of-the-Climate.html>>.

[redacted]

Telephone s22 [redacted] PO Box 6022, Parliament House, Canberra ACT 2600 Facsimile s22 [redacted]

[redacted]

Yours sincerely

s22 [redacted]

Dr John Byron
Senior Adviser Science and Research

KC19MAY2011

Minister
Innovation, Industry, Science and Research

Min ID: B11/2320

For Information **CSIRO Initiated**

CSIRO No. C2011/5401

Document 9

NEW GREENHOUSE GASES (GHG) GRAPHS WEBSITE

Purpose:

To inform you of a new website about atmospheric GHG levels that will be launched by CSIRO on Monday, 20 June 2011.

Background:

- In June 2009, CSIRO established the Carbon Strategy, a cross organisational initiative to deliver a systematic approach to assisting Australia to respond to climate change. The release of 'State of the Climate', a joint CSIRO-Bureau of Meteorology statement of our understanding of climate science in March 2010 (refer **B10/1087**) was an early activity under the Strategy.
- As part of the Carbon Strategy communication plan, CSIRO is launching a website to enable access to historical recorded levels of GHG concentrations measured for the Southern Hemisphere atmosphere at the Cape Grim Baseline Air Pollution Station (Cape Grim) since 1976.
- Cape Grim is an internationally recognised meteorological station located on Tasmania's north-west coast. It is one of three Baseline Air Pollution Stations in the World Meteorological Organization-Global Atmosphere Watch (WMO-GAW) network and is managed by the Bureau of Meteorology (BoM) in a joint program led by CSIRO and BoM.
- The Southern Hemispheric air samples collected at Cape Grim are analysed to determine concentrations of GHG, ozone-depleting gases, other air pollutants including aerosols and reactive gases, and radon. Also measured are weather and climate indicators such as wind speed and direction, rainfall, temperature, humidity, and solar radiation.

Issues:

- CSIRO's new GHG website will provide data collected over the past 1000 years that graphically traces the rise in carbon dioxide levels from about 280 parts per million (ppm) before the start of the industrial era around the year 1800, to 388 ppm in 2010. This is an increase of almost 40 per cent, largely due to human activities.
- The measurements testify to a steady rise in carbon dioxide concentrations in the Earth's atmosphere, as has been reported in the peer-reviewed literature. This can be attributed (through isotopic analysis) mainly to the burning of fossil fuels and deforestation.
- The new website will make observed GHG concentrations more accessible and more easily explored by members of the public.
- The website employs a user-friendly dynamic interface to allow users to analyse the behaviour of the three important GHG influenced directly by human activities and natural variability: carbon dioxide, methane and nitrous oxide. In addition, data for the synthetic GHG and ozone depleting gases, such as chlorofluorocarbons, are available.

s22 [redacted]

Sensitivity: Nil

Attachments: Nil

Slipstream version: 17 June 2011

Andrew Johnson [redacted]
Group Executive, Environment
CSIRO
17 June 2011
Contact: Jenny Baxter
[redacted]

Consultation
Nil

NOTED/PLEASE DISCUSS
[redacted]
Kim Carr 20/6/11

Minister for Information
By 3 March 2014 Release of report on 4 March 2014

B14/428
CSIRO Ref: C2013/1333

STATE OF THE CLIMATE 2014

Document 10

Recommendation: That you note the release of the State of the Climate 2014 report by CSIRO and the Bureau of Meteorology (BoM) on 4 March 2014.

Key Points:

[redacted]

- Atmospheric greenhouse gas concentrations continue to rise.

[redacted]

[redacted]

Attachments:

Attachment A Copy of *State of the Climate 2014* draft and embargoed report.

Slipstream Version 27 February 2014

Clearance Officer Dr Andrew Johnson [redacted]
Group Executive, Environment
CSIRO
27 February 2014

Consultation: BoM

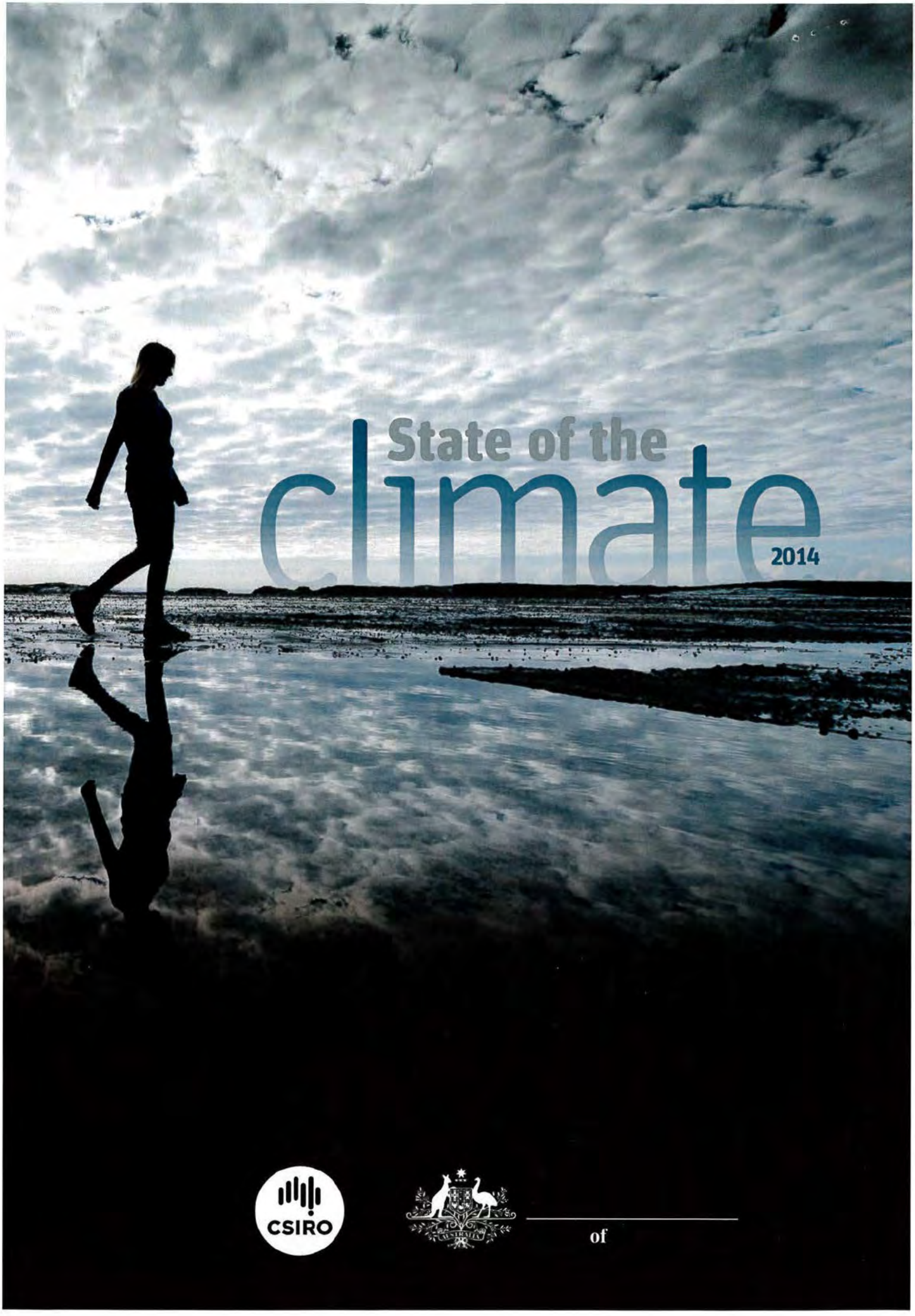
NOTED/PLEASE DISCUSS

[redacted]

Contact: Jen Baxter [redacted]

Activity:

Ian Macfarlane 4/3/14


State of the
climate
2014
CSIRO
of

s22

[redacted]

FURTHER INFORMATION

The Bureau of Meteorology:
www.bom.gov.au/climate

CSIRO: www.csiro.au/climate

Telephone 1300 363 400 or
email enquiries@csiro.au

A list of peer-reviewed references underpinning State of the Climate 2014 can be found at www.csiro.au/State-of-the-Climate-2014 and www.bom.gov.au/

Future Climate Scenarios for Australia

Key points

[redacted]

[redacted] Warming by 2070, compared to 1980 to 1999, is projected to be 1.0 to 2.5°C for low greenhouse gas emissions and 2.2 to 5.0°C for high emissions. The high emissions scenario assumes a continuation into the future of the global CO_2 emissions growth seen over the past decade, whereas the low-emissions scenario assumes a significant reduction in global emissions after 2020.

[redacted]

s22

[redacted]

Ocean-acidity levels will continue to increase as the ocean absorbs anthropogenic carbon-dioxide emissions.

[redacted]

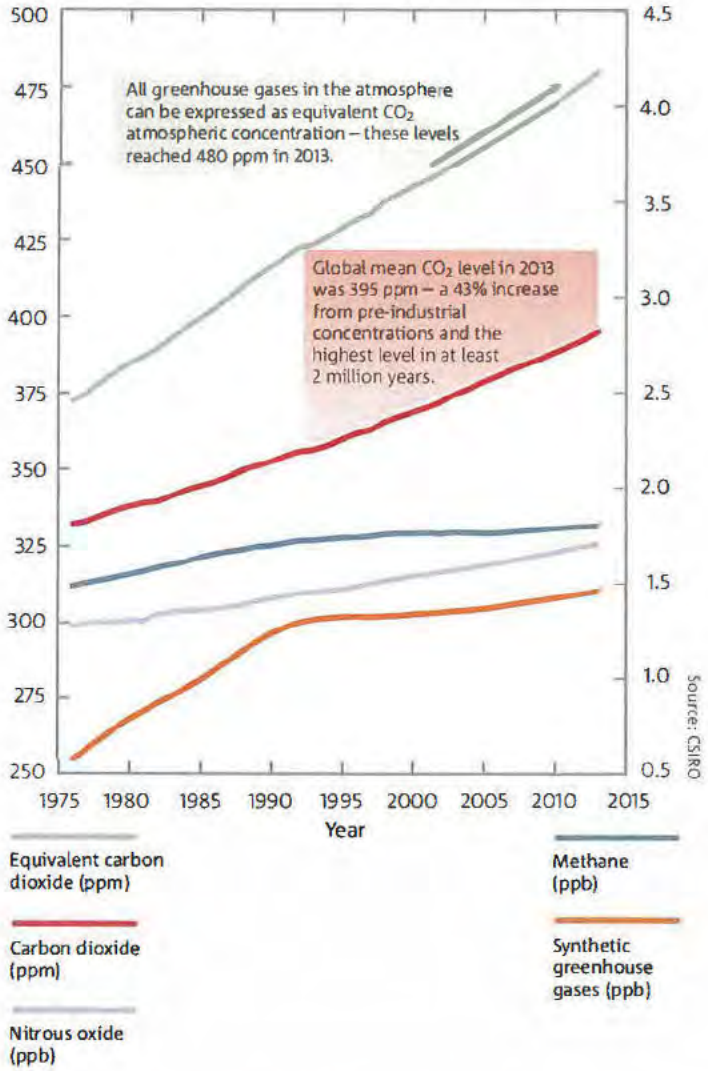
Greenhouse gas concentrations

Atmospheric concentrations of major greenhouse gases, including CO_2, methane (CH_4), nitrous oxide (N_2O), and a group of synthetic greenhouse gases (SGG), are increasing.

Greenhouse gas levels have exceeded the record levels reported in the 2012 *State of the Climate* report, continuing the increase observed over the past century. The global mean CO_2 level in 2013 was 395 parts per million (ppm) a 43 per cent increase from pre-industrial (1750) concentrations, and likely the highest level in at least 2 million years.

The global CO_2 annual increase from 2012 to 2013 was 2.5 ppm, and the increase of 5.1 ppm since 2011 is the largest two-year increase observed in the historical record. Global atmospheric CH_4 concentrations are 151 per cent higher, and N_2O 21 per cent higher than in 1750, and are at their highest levels for at least 800,000 years.

The impact of all greenhouse gases in the atmosphere combined can be expressed as an 'equivalent CO_2' atmospheric concentration, which reached 480 ppm in 2013.



Global mean greenhouse gas concentrations ('ppm' is parts per million, while 'ppb' is parts per billion) determined from continuous monitoring by CSIRO, the Bureau of Meteorology and the CSIRO/ Advanced Global Atmospheric Gases Experiment at Cape Grim since 1976, in Antarctic firn air samples since the mid 1970s, and globally by CSIRO since the mid-1980s.

Greenhouse gases

Key points

- Atmospheric greenhouse gas concentrations continue to increase due to emissions from human activities, with global mean CO_2 levels reaching 395 ppm in 2013.
- Global CO_2 emissions from the use of fossil fuel increased in 2013 by 2.1 per cent compared to 3.1 per cent per year since 2000.
- The increase in atmospheric CO_2 concentrations from 2011 to 2013 is the largest two-year increase ever observed.

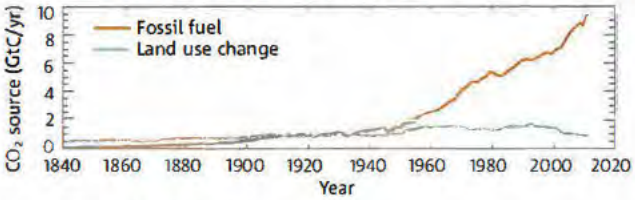
Carbon dioxide emissions

Global anthropogenic CO_2 emissions into the atmosphere in 2013 are estimated to be 38.8 billion tonnes of CO_2 (10.6 billion tonnes of carbon), the highest in history and about 46 per cent higher than in 1990. Global CO_2 emissions from the use of fossil fuel are estimated to have increased in 2013 by 2.1 per cent compared with the average of 3.1 per cent per year from 2000 to 2012.

Since the industrial revolution more than two centuries ago, about 30 per cent of the anthropogenic CO_2 emissions have been taken up by the ocean and about 30 per cent by land vegetation. The remaining 40 per cent of emissions have led to an increase in the concentration of CO_2 in the atmosphere.

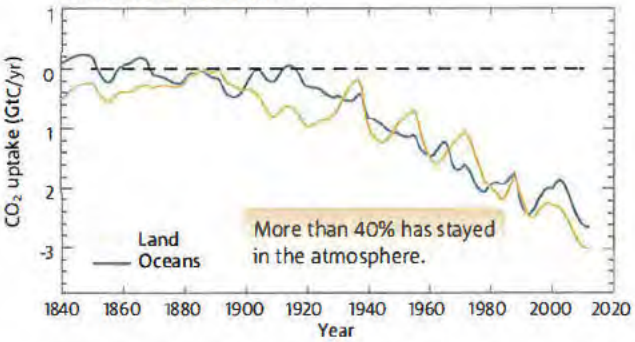
The origin of CO_2 in the atmosphere can be determined by examining the different types (isotopes) of carbon in air samples. This identifies the additional CO_2 as coming from human activities, mainly the burning of fossil fuels, and not from natural sources.

Sources of increased atmospheric carbon dioxide concentrations



CO_2 emissions continue to rise and are mainly from fossil fuel burning.

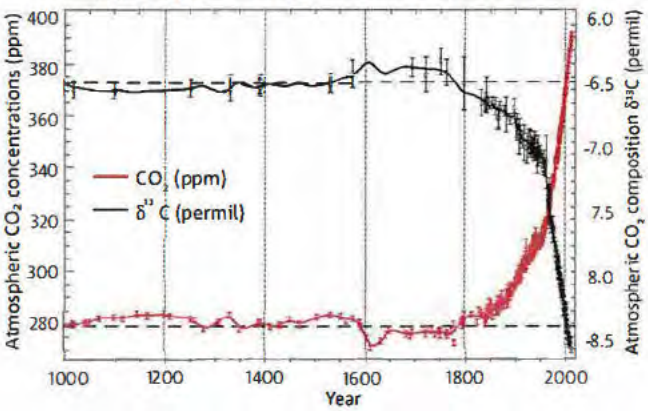
Sinks of carbon dioxide



About 30% of CO_2 has been taken up by the ocean

About 30% has been taken up by land vegetation.

Isotopic signature of accumulated carbon dioxide



The decrease in the ratio of the carbon 13 isotope ($\delta^{13}C$) that accompanies increasing CO_2 trends show that the sources are fossil fuel and land use change.

Most of the CO_2 emissions from human activities are from fossil fuel combustion and land-use change (top graph, in gigatonnes of carbon per year – a gigatonne is equal to 1 billion tonnes). CO_2 emissions from human activities have been taken up by the ocean (middle graph, in blue), by land vegetation (middle graph, in green), or remain in the atmosphere. This has led to an increase in the atmospheric concentration of CO_2 (bottom graph, in red), as identified by the trend in the ratio of different types (isotopes) of carbon in atmospheric CO_2 (bottom graph, in black, from the year 1000). CO_2 and the carbon 13 isotope ratio in CO_2 ($\delta^{13}C$) are measured from air in Antarctic ice and firn (compacted snow) samples from the Australian Antarctic Science Program, and at Cape Grim (northwest Tasmania).

Ocean acidification

Ocean acidification is caused by the ocean absorbing higher levels of carbon dioxide (CO_2) from the atmosphere, and is therefore another consequence of the accumulation of anthropogenic CO_2 in the Earth's climate system. Ocean acidity is measured in units of 'pH'. A lowering pH means increasing acidity. The pH of surface waters in the open ocean has decreased by about 0.1 since 1750, equivalent to a 26 per cent increase in the activity of hydrogen ions (a measure of ocean acidity).

Oceans

[redacted]

Ocean acidity levels have increased since the 1800s due to absorption of higher CO_2 concentrations from the atmosphere.

[redacted]

Global atmosphere and cryosphere

Key points

[redacted]

- It is extremely likely that the dominant cause of recent warming is human-induced greenhouse gas emissions and not natural climate variability.

[redacted]

[redacted]

[redacted]

The report at a glance

[redacted]

Atmospheric greenhouse gas concentrations continue to rise and continued emissions will cause further warming over this century. Limiting the magnitude of future climate change requires large and sustained cuts to global emissions of anthropogenic greenhouse gases.

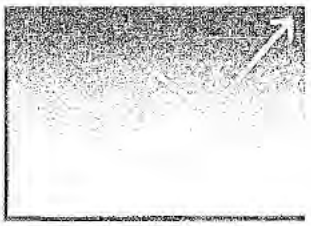
key points

s22

[redacted]

[redacted]

> Annual average global atmospheric carbon dioxide concentrations reached 395 parts per million (ppm) in 2013 and concentrations of the other major greenhouse gases are at their highest levels for at least 800,000 years.

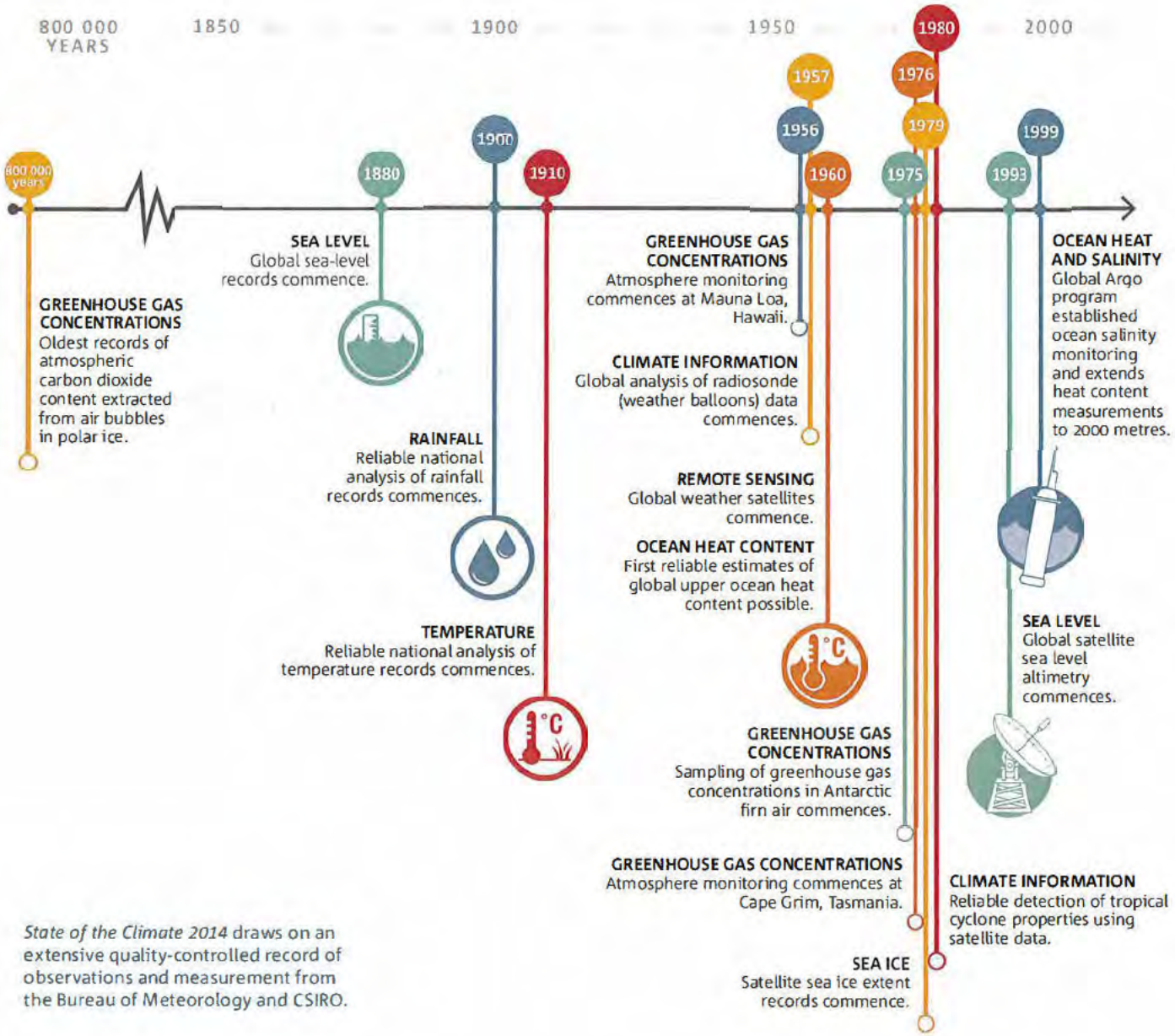


[redacted]

The State of the Climate report

Weather and climate touches all Australians and all of Australia every day. What we experience here at home is part of the global climate system. The Bureau of Meteorology and CSIRO contribute significantly to the international effort of climate and weather monitoring, forecasting and research. In *State of the Climate*, we discuss the long-term trends in Australia's climate.

This is our third biennial *State of the Climate* report. As with our earlier reports, we focus primarily on climate observations and monitoring carried out by the Bureau of Meteorology and CSIRO in the Australian region, as well as future climate scenarios.



State of the Climate 2014 draws on an extensive quality-controlled record of observations and measurement from the Bureau of Meteorology and CSIRO.

Source: Bureau of Meteorology

Minister for Information
Routine

Min ID: MS14-000141
CSIRO Ref: C2014/1965

Document 11

CSIRO AND THE RELEASE OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE'S FIFTH ASSESSMENT REPORT (AR5) FROM WORKING GROUP II (WGII)

[redacted]

Key Points:

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Dr Andrew Johnson
[redacted]
Group Executive Environment
CSIRO
25 March 2014

Contact: Jenny Baxter
[redacted]

Consultation:

Activity:

NOTED/PLEASE DISCUSS
Noted in the
Minister's Office
29 APR 2014
Ian Macfarlane / /

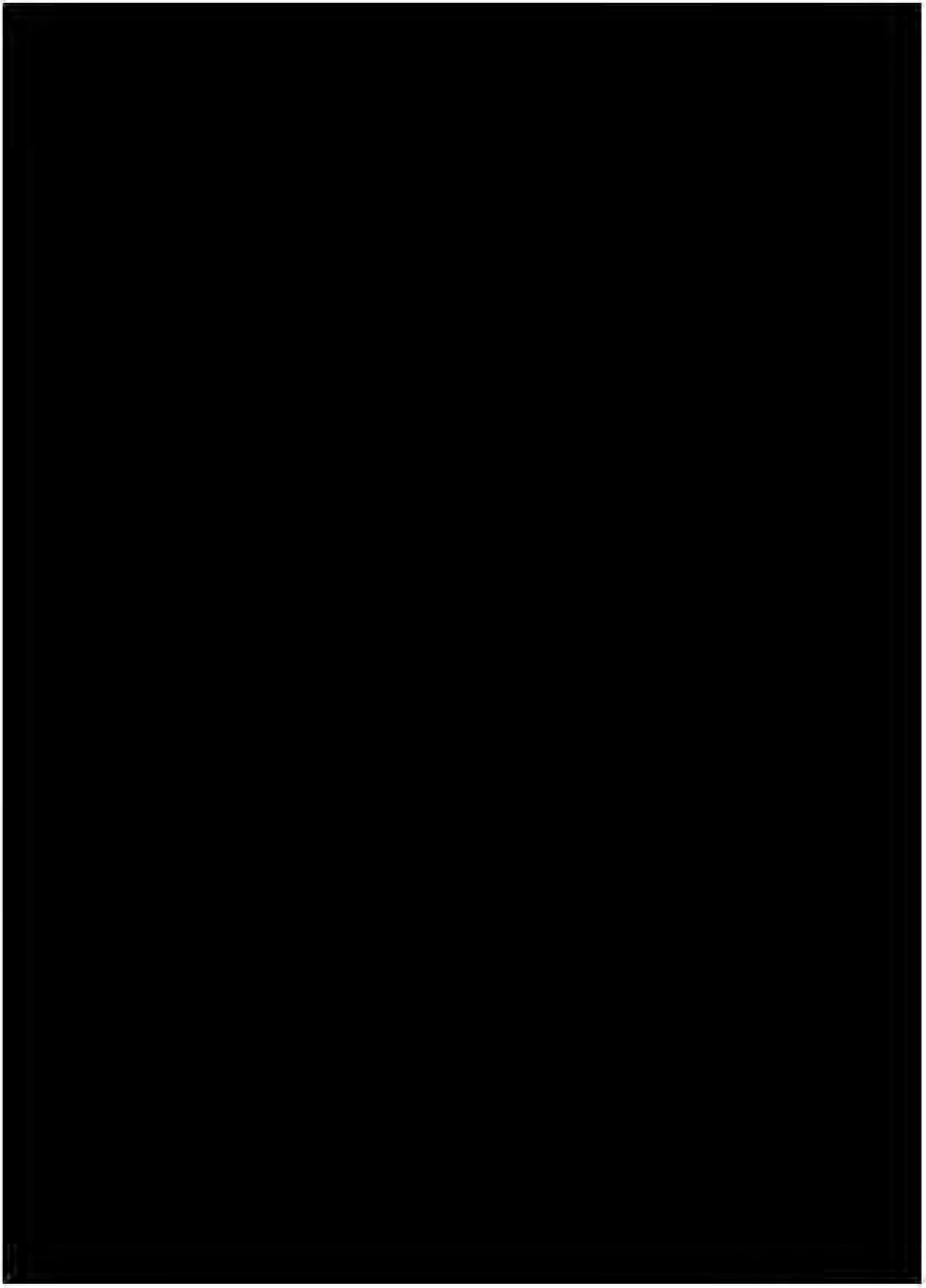
Slipstream version – 25 March 2014

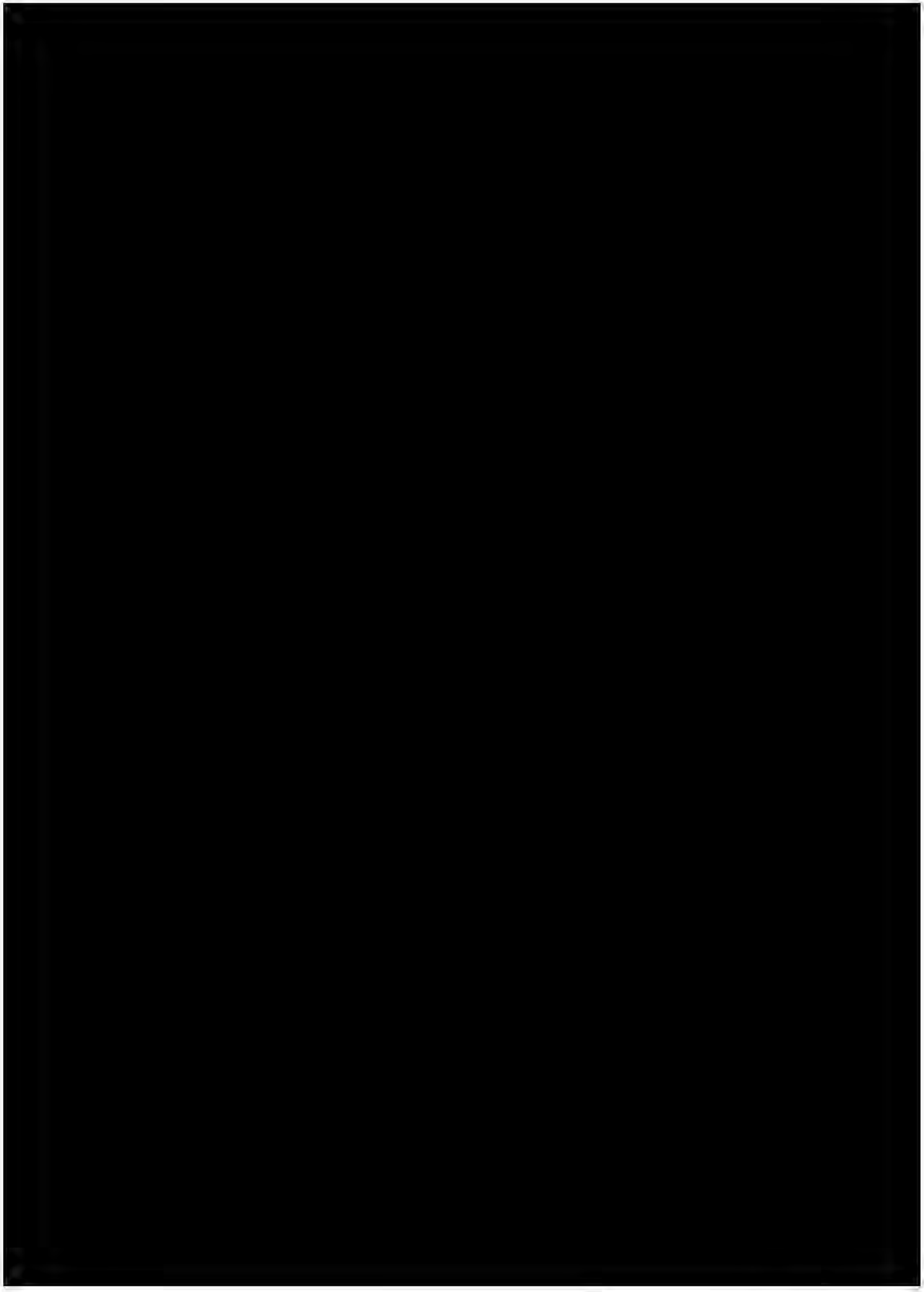
[redacted]

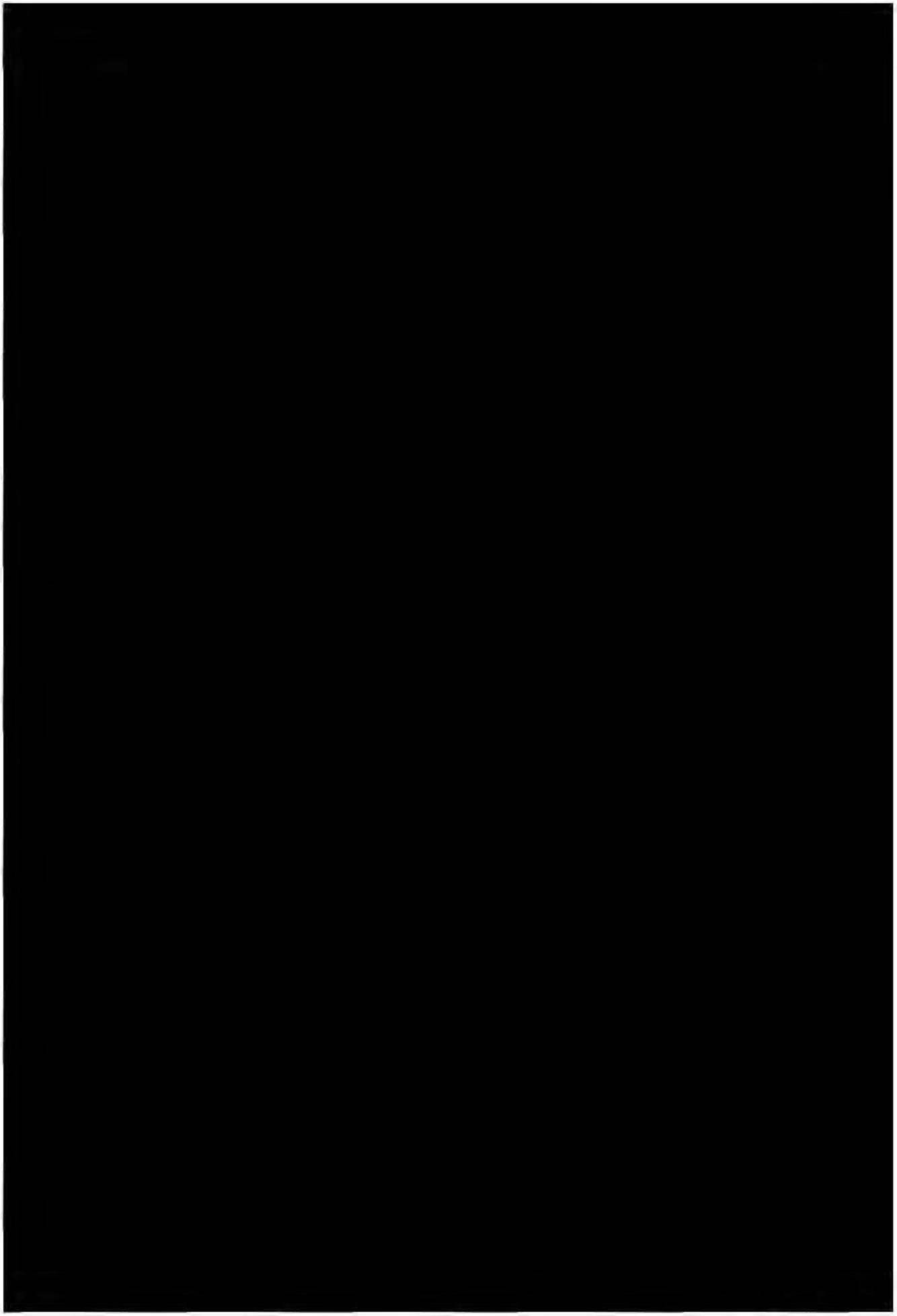
[redacted]

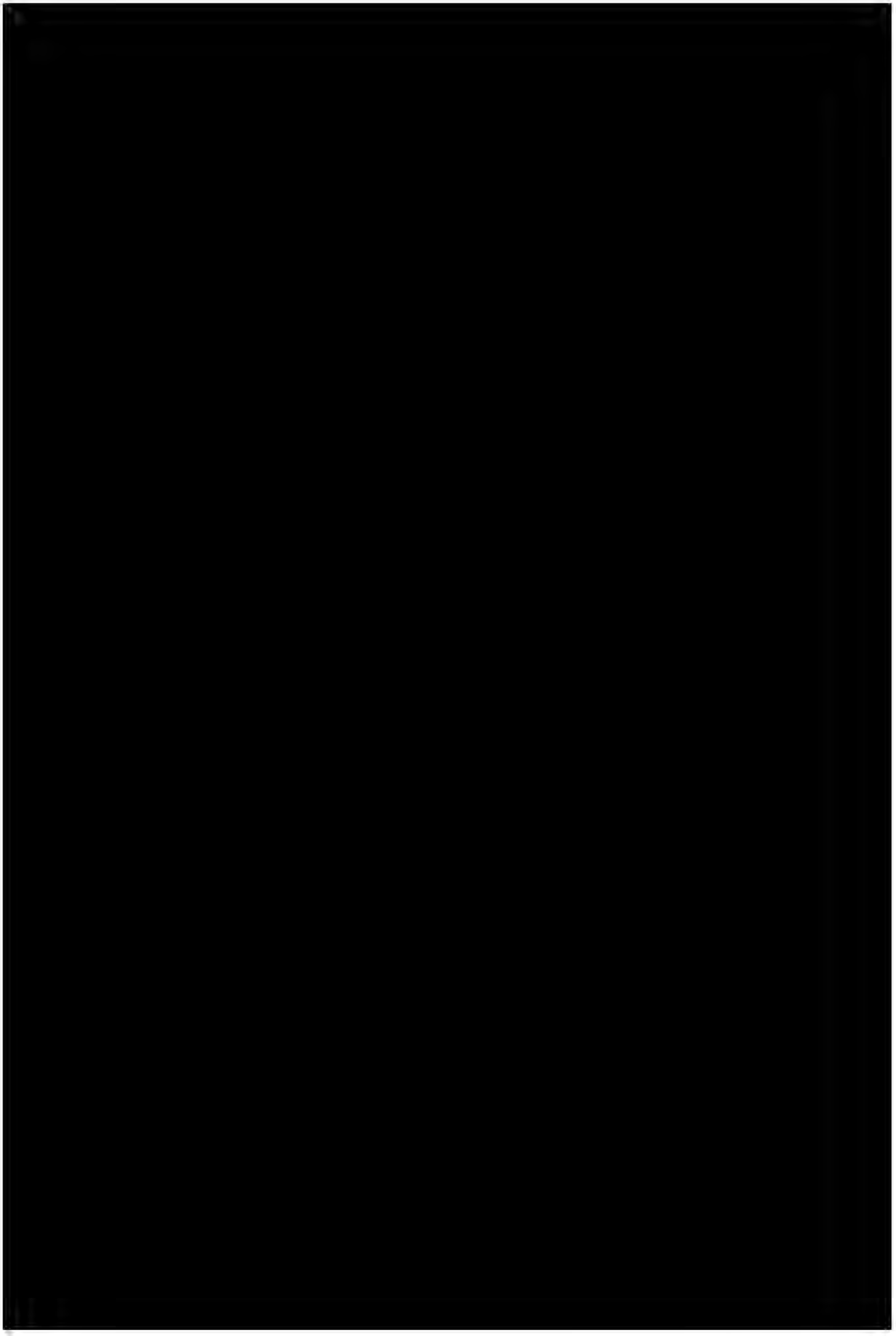
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

[redacted]

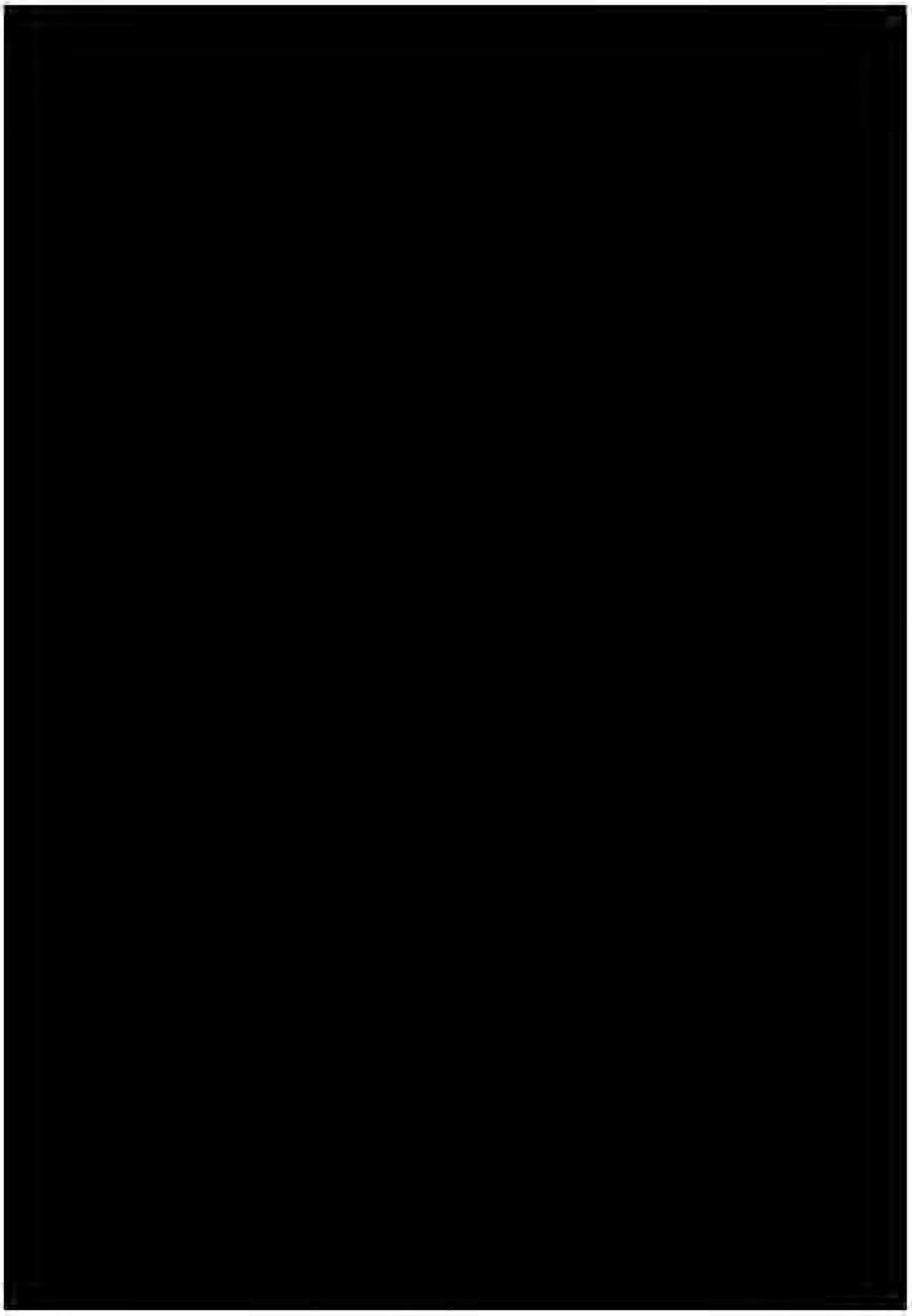








- The Ocean plays a central role in Earth's climate and has absorbed 93% of the extra energy from the enhanced greenhouse effect and approximately 30% of anthropogenic carbon dioxide from the atmosphere.



Minister for Industry, Innovation and Science
For Information

Min ID: MS16-001866
CSIRO Ref: C2016/5661
24 August 2016

Subject: RELEASE OF STATE OF THE CLIMATE 2016

Document 12

Timing: Routine

Recommendation:

That you **note** the information in ~~this~~ brief

Noted / Please discuss

s22 [redacted]

Greg Hunt … **Date:** 29/8/2016

Comments:

[redacted]

2. First published in 2010, the State of ~~the Climate Report~~ provides a biennial update on climate change, including the latest observations, trends, future scenarios and scientific developments. The reports differ from similar international synthesis reports by providing an Australian focus and context.

[redacted]

Alex Wonhas
Executive Director, Environment, Energy and Resources
CSIRO
[redacted]

Kimberley Shrives
Ministerial and Parliamentary Liaison
[redacted]

PS Version: 25/08/2016

ATTACHMENT
A: Key findings and background

ATTACHMENT A

Key Findings State of the Climate 2016 and Background

Minister for Industry, Innovation and Science

Min ID: MB16-000859
CSIRO Ref: C2016/6379
13 October 2016

Document 13

Subject: BRIEFING ON STATE OF THE CLIMATE 2016 REPORT

Recommendation:

That you **note** the contents of this brief.

Noted / Please discuss

Greg Hunt [redacted] **Date:** 17/10/**2016**

Comments:

Meeting Details:

Date:	Monday, 17 October 2016
Time:	4.30 pm 5.00 pm
Venue:	Room M1.40, Parliament House
Attendees:	Alex Wonhas (CSIRO), Helen Cleugh (CSIRO), Karl Braganza (BoM), Graham Hawke (BoM)

Key Points:

1. The Bureau of Meteorology (BoM) and CSIRO will jointly publish the fourth State of the Climate report on 27 October 2016.

[redacted]

Clearance Officer:
Alex Wonhas
Executive Director, Environment, Energy and Resources
CSIRO
[redacted]

Contact Officer:
Kimberley Shrives
Ministerial and Parliamentary Liaison
[redacted]

PS Version: 13/10/2016

ATTACHMENTS

A. Key Findings

ATTACHMENT A

Key Findings

Background

- First published in 2010, the State of the Climate Report Series provides a biennial update on climate change, including the latest observations, trends, future scenarios and scientific developments.

[redacted]

[redacted]

- Global average annual carbon dioxide (CO_2) levels are steadily increasing; they reached 399 parts per million (ppm) in 2015, and the annual value for 2016 is almost certain to be higher than 400 ppm. Current levels are likely the highest in the past two million years.

[redacted]

Minister for Industry, Innovation and Science
For Information

Min ID: MS16-002619
CSIRO Ref: C2016/6608
16 November 2016

Subject: AUSTRALIAN CLIMATE CHANGE SCIENCE PROGRAMME COLLATERAL

Timing: Routine

Recommendation:

That you **note** the following

Noted / Please discuss

s22 [redacted]

Greg Hunt .

Date: 21 / 11 /2016

Comments:

[redacted]

Key Points:

1. s22 [redacted]
2. [redacted]
3. Australia's Changing Climate, developed by CSIRO and the BoM, summarises climate change projections information for Australia (refer Attachment A).

[redacted]

6. The three reports will be made available on the ACCSP website and be provided to stakeholders electronically and at events and conferences. Attachment D provides additional background on the documents.

[redacted]

Clearance Officer:
Alex Wonhas
Executive Director, Environment, Energy and Resources
CSIRO
s22 [redacted]

Contact Officer:
Kimberley Shrives
Ministerial and Parliamentary Liaison
s22 [redacted]

MLO Version: 16/11/2016

ATTACHMENTS

A: Australia's Changing Climate Brochure

s22 [redacted]

D: Background

ATTACHMENT D

Background

s22 [redacted]

The *Australia's Changing Climate* Brochure

This brochure is a deliverable under the ACCSP Project 6.1 'Regional Climate Projections Science'. It was requested by the Department to provide an accessible summary of national level climate change projections information produced by CSIRO and the Bureau in 2015 and funded under the Government's *Regional Natural Resource Management Planning for Climate Change Fund.*

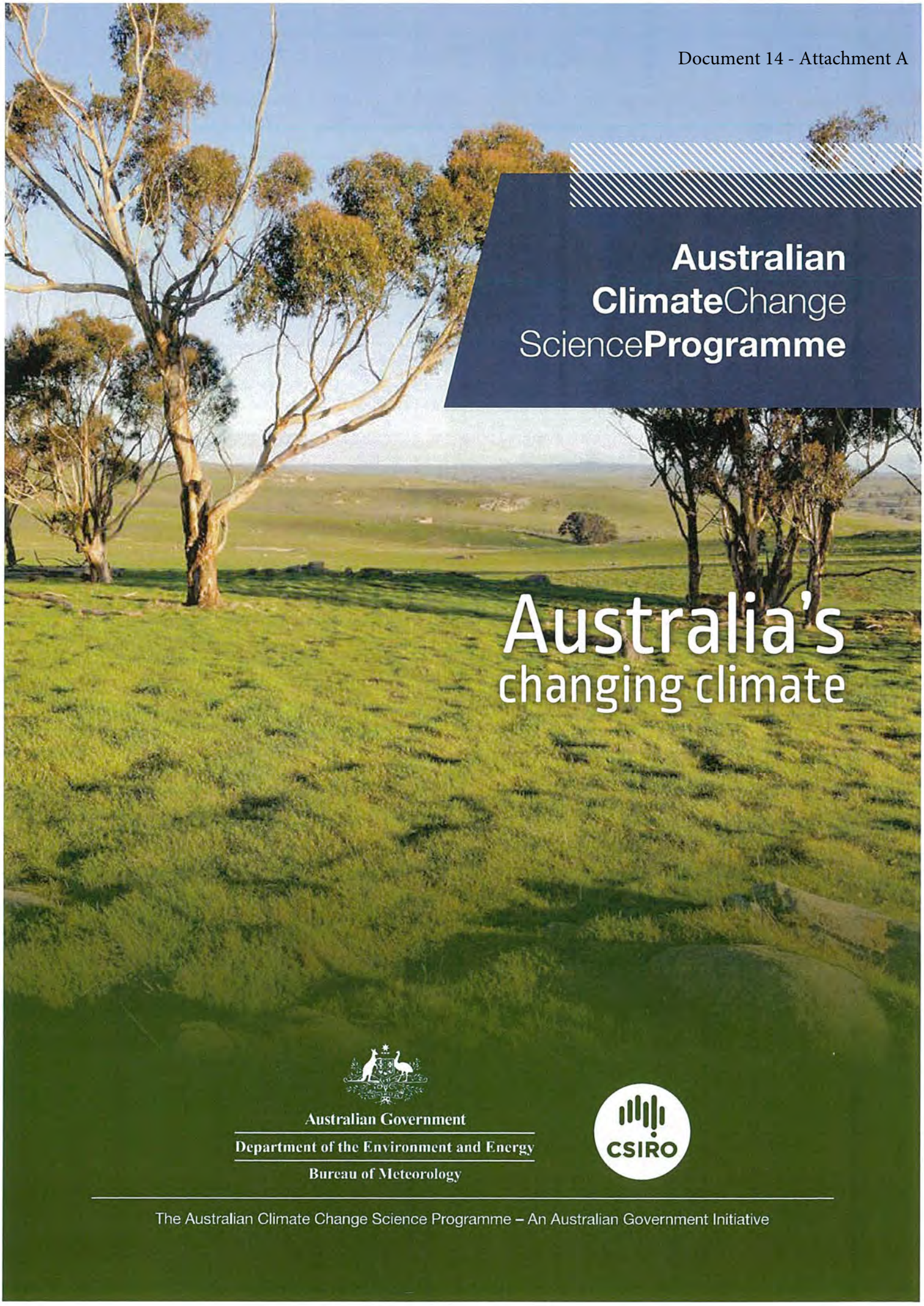
The projections information summarised in the brochure is based on the most recent data produced by climate models. Confidence in the projections is based on multiple lines of evidence including (i) degree of model agreement, (ii) physical understanding, (iii) ability of models to represent current climate, (iv) consistency with observed changes.

The brochure supports the conclusions of the IPCC Fifth Assessment Report, and other national and international climate science reports, which state that human influence has been the dominant cause of the observed global warming over the last five or more decades.

The brochure summarises:

- The state of the science in global and Australian variability and change
- Climate projections science
- Main results from climate projections released in 2015
- Using and interpreting climate projections
- Climate impacts in Australia
- How to use climate projections for adaptation research.

[redacted]



Australian
ClimateChange
ScienceProgramme

Australia's changing climate

Australian Government
Department of the Environment and Energy
Bureau of Meteorology

CSIRO

The Australian Climate Change Science Programme – An Australian Government Initiative

Our climate is changing and this will affect most of us in some way during our lifetimes.

Changes that are currently occurring include rising temperatures, changing rainfall patterns, sea level rise and ocean acidification.

Further climate change is expected due to increases in greenhouse gas emissions.

Climate research is essential in our efforts to quantify future risks and opportunities, slow the continuing emissions and adapt to the impacts associated with a warmer world.

Changes to the climate will have substantial impacts on water resources, coasts, infrastructure, health, agriculture, fisheries and biodiversity.

Effective emissions reduction efforts and climate change adaptation together will bring important benefits: social, environmental and economic risks will be lower; new opportunities can be exploited; and fresh thinking about climate resilience will stimulate innovation.

Global climate change

OBSERVED CLIMATE CHANGE

We have a good understanding of the climate system and what drives change. Climate variability and change are influenced by natural factors such as the El Niño Southern Oscillation, volcanic eruptions and solar output, as well as human factors that have increased atmospheric concentrations of greenhouse gases and aerosols and changed the land-surface. Key points from the latest global assessment[1] of observed and future climate change include:

- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.
- The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen and the concentrations of greenhouse gases have increased.
- The surface global warming was 0.85 °C in the period 1880–2012 (Figures 1 and 2), and 2015 was the warmest in the instrumental record.
- During 1901–2010, global average sea level rose by 190 mm. Since the early 1970s, glacier mass loss and ocean thermal expansion from warming together explain about 75% of the observed sea level rise.
- It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale.
- It is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia.
- There are likely more land regions where the number of heavy precipitation events has increased than where it has decreased.

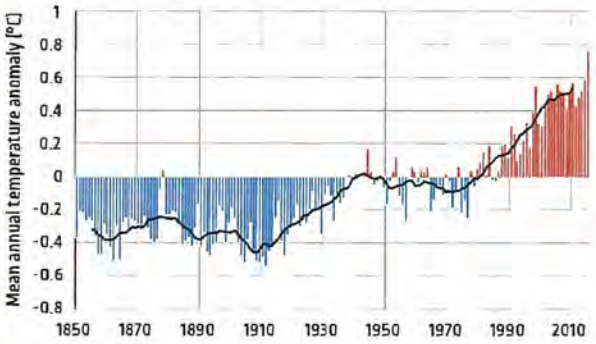


FIGURE 1 Global mean surface air temperature 1850 to 2015 (bars), shown as the anomaly relative to the 1961-1990 average, with an 11-year running average (black line) showing variability about an upward overall trend (source: UK HadCRUT4)[4].

- Changes in greenhouse gas and aerosol concentrations have been caused by human activities.
- It is extremely likely that human influence has been the dominant cause of the observed global warming since the mid-20th century.
- Human influence has also been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes.

PROJECTED CLIMATE CHANGE

- Continued net emissions of greenhouse gases will cause further warming and changes in all components of the climate system. For the period 2081–2100, relative to 1986–2005, expected changes include:
  - Global warming of 0.3 °C –1.7 °C under a low emissions scenario[2] through to 2.6 °C –4.8 °C under a high emissions scenario[3].
  - Sea level rise of 0.26 to 0.55 m under a low emissions scenario through to 0.45 to 0.82 m under a high emissions scenario.
  - More and longer heat waves.
  - More intense and more frequent extreme rainfall over most of the mid-latitude land masses and over wet tropical regions.

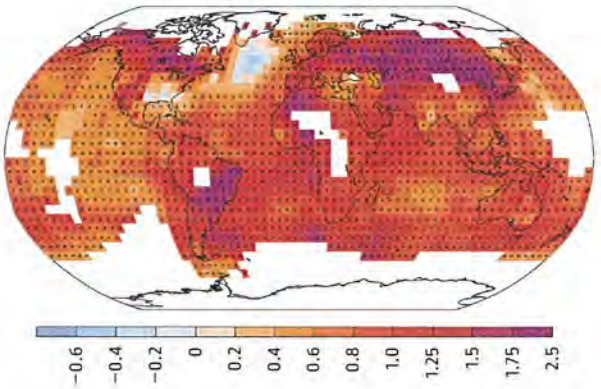


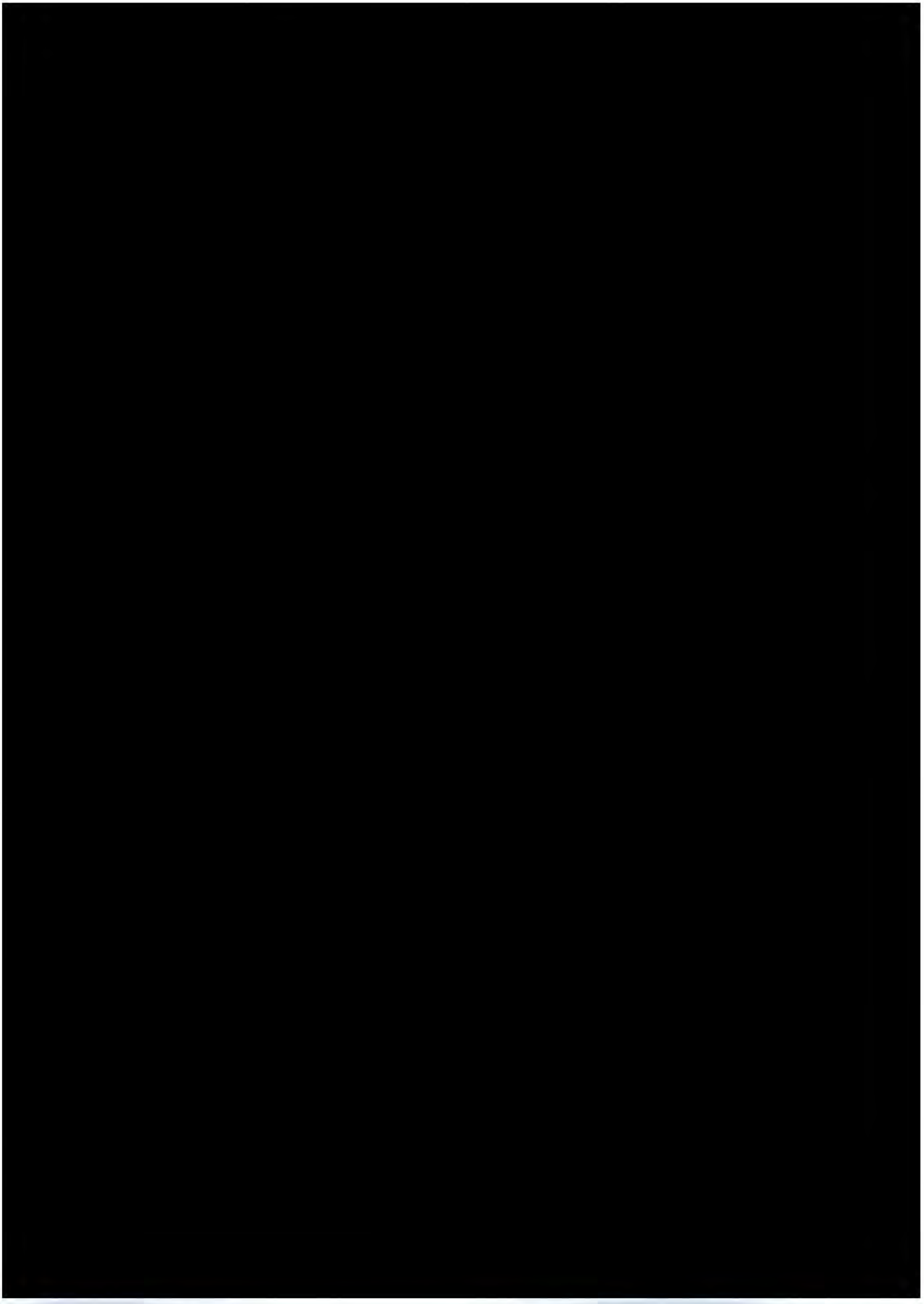
FIGURE 2 Change in mean annual surface temperature between 1901 and 2012, showing warming over almost all regions. Trends significant at the 10% level are shown by plus symbol, areas with insufficient data are white (source: IPCC 2013)[4].

[1] The Intergovernmental Panel on Climate Change (IPCC), Working Group 1 Fifth Assessment Report, 2013

[2] RCP2.6 – see page 3

[3] RCP8.5 – see page 3

[4] Figure 1 and 2 use the UK Hadley Centre and Climate Research Unit Temperature series version 4 (UK HadCRUT4) dataset, plus symbols in Figure 2 show where changes are statistically significant



Australian climate projections for the 21st century

ABOUT CLIMATE PROJECTIONS

[redacted]

The climate we experience for a given future period depends on three main factors:

[redacted]

2. Greenhouse gas and aerosol emissions – explored using Representative Concentration Pathways (RCPs). The RCP number refers to the amount of extra radiative impact on the climate system by the end of the century. All the RCPs are quite similar up to 2030, but grow increasingly different after that (Figure 6):

- RCP8.5 (high) – little global action to reduce greenhouse gas emissions
- RCP4.5 (medium) – strong global action to reduce emissions towards end of century
- RCP2.6 (low) – ambitious global action to reduce emissions

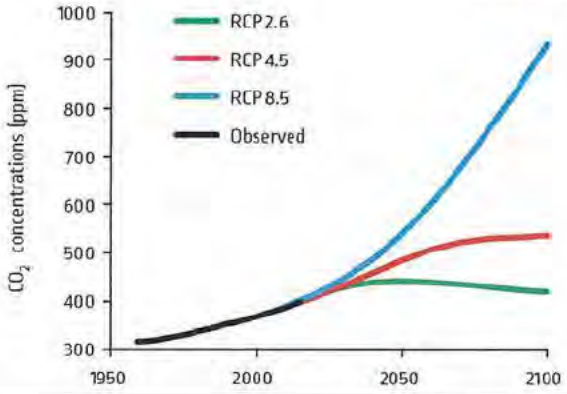
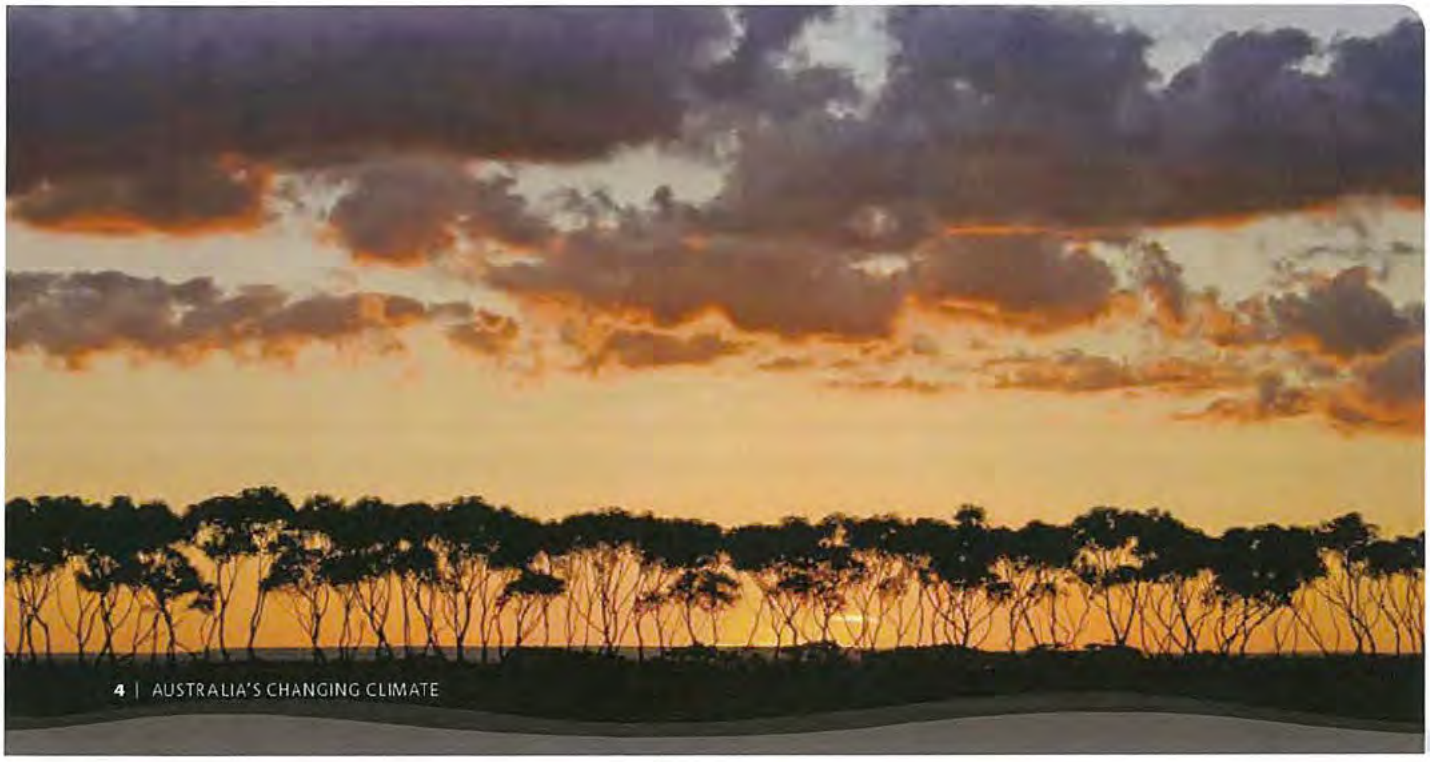


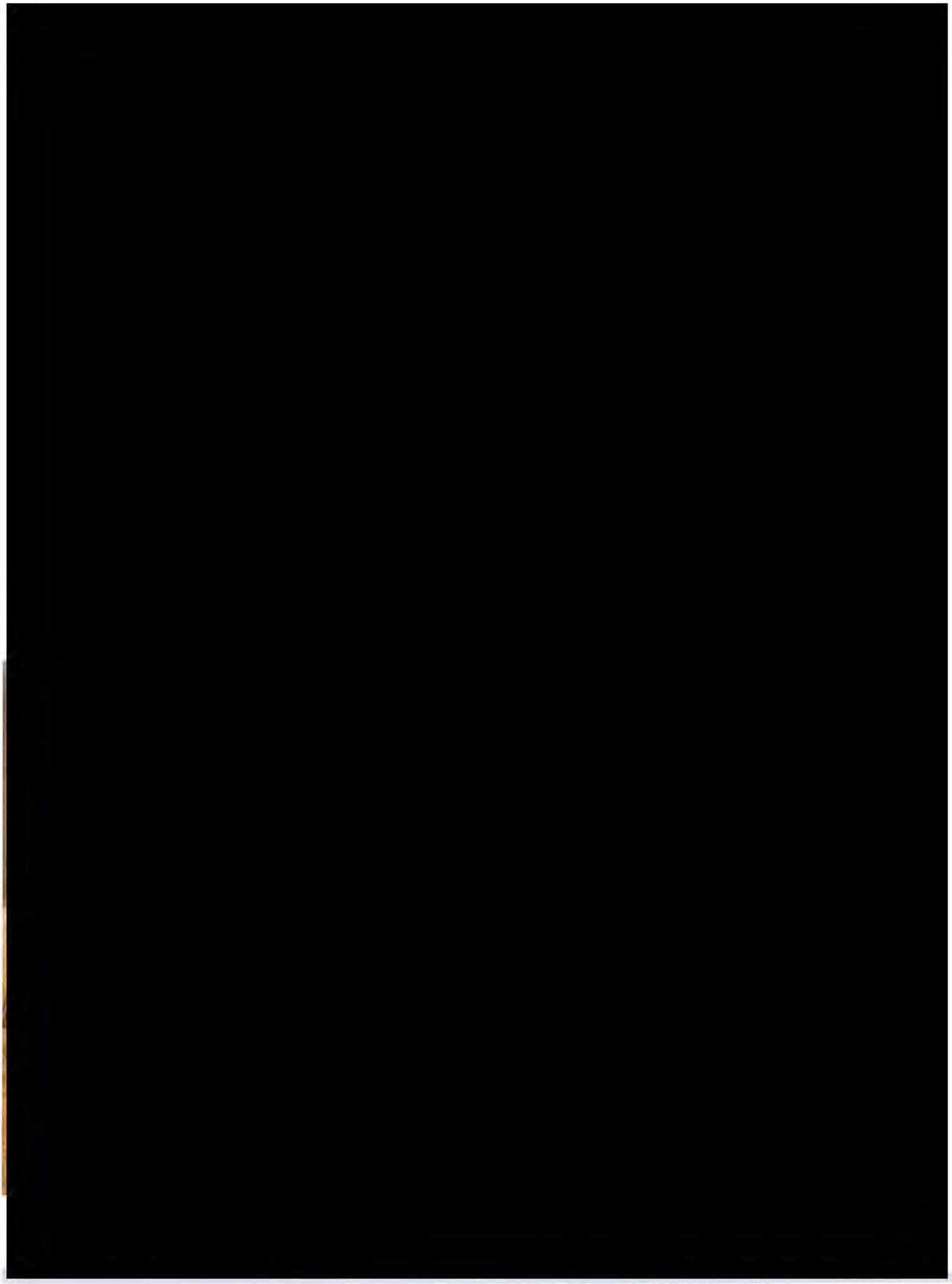
FIGURE 6 Carbon dioxide concentrations from global observations and for three RCPs in the 21st century, showing an increase proportional to human emissions[7].

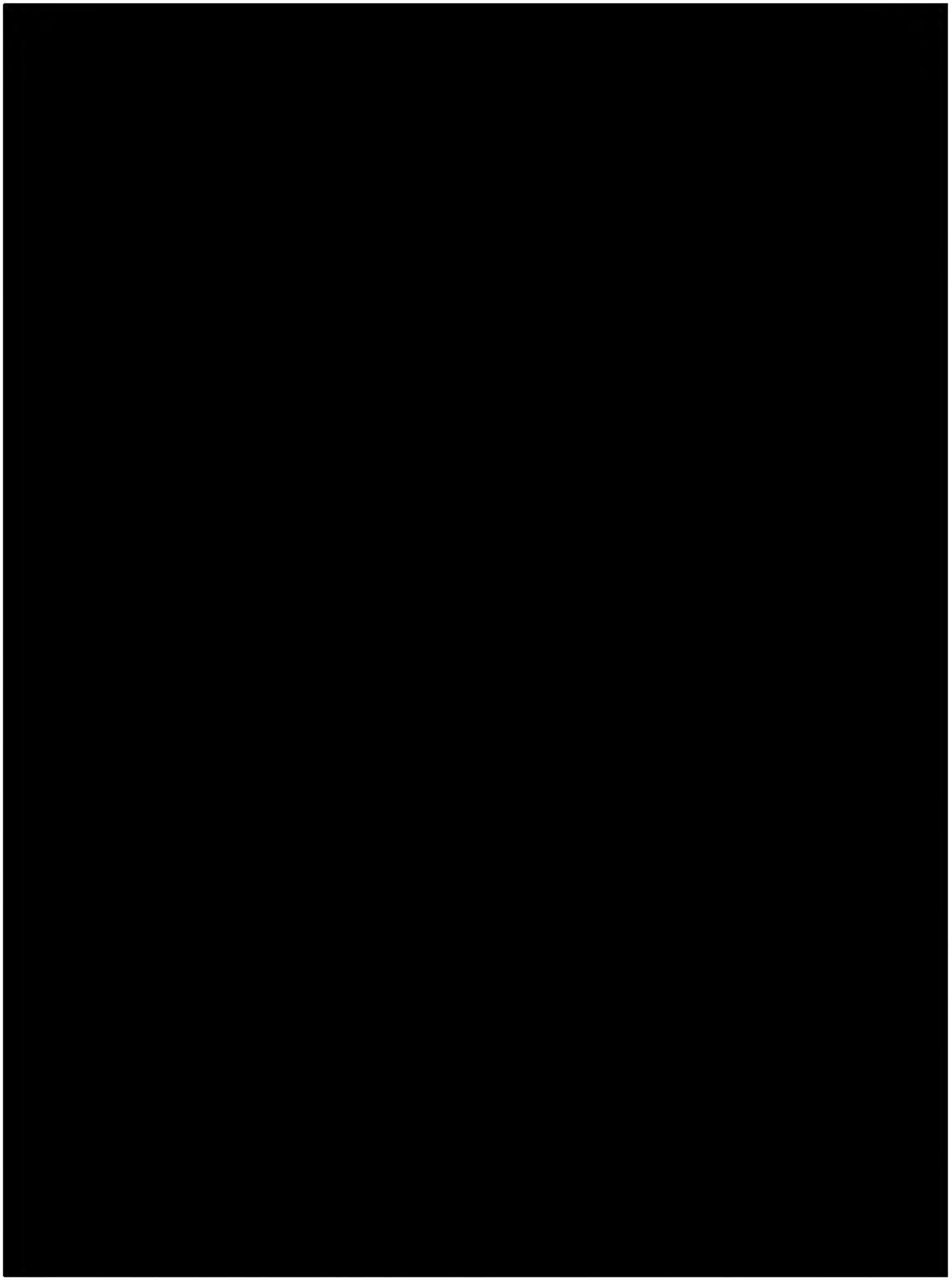
s22

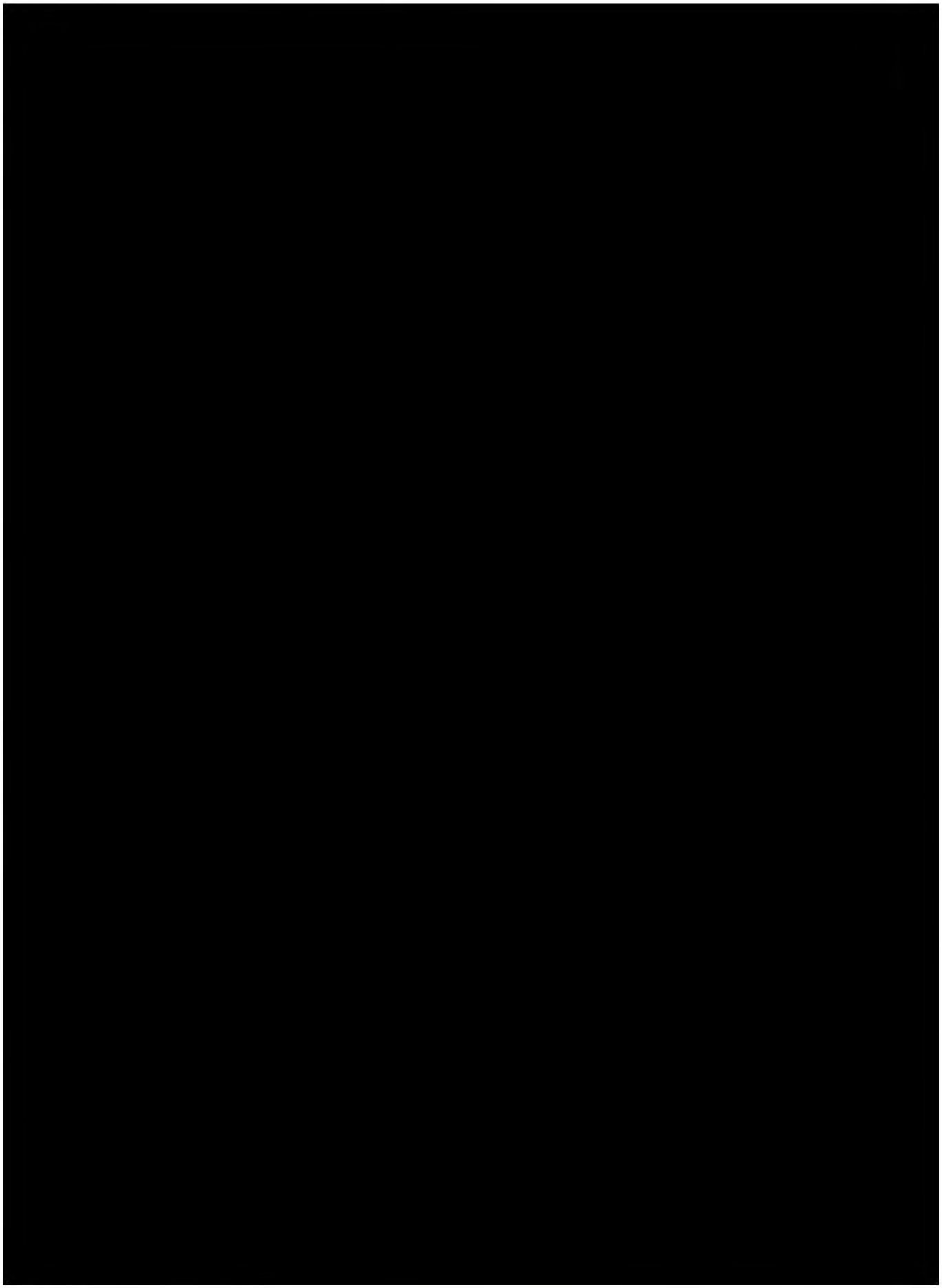
[redacted]

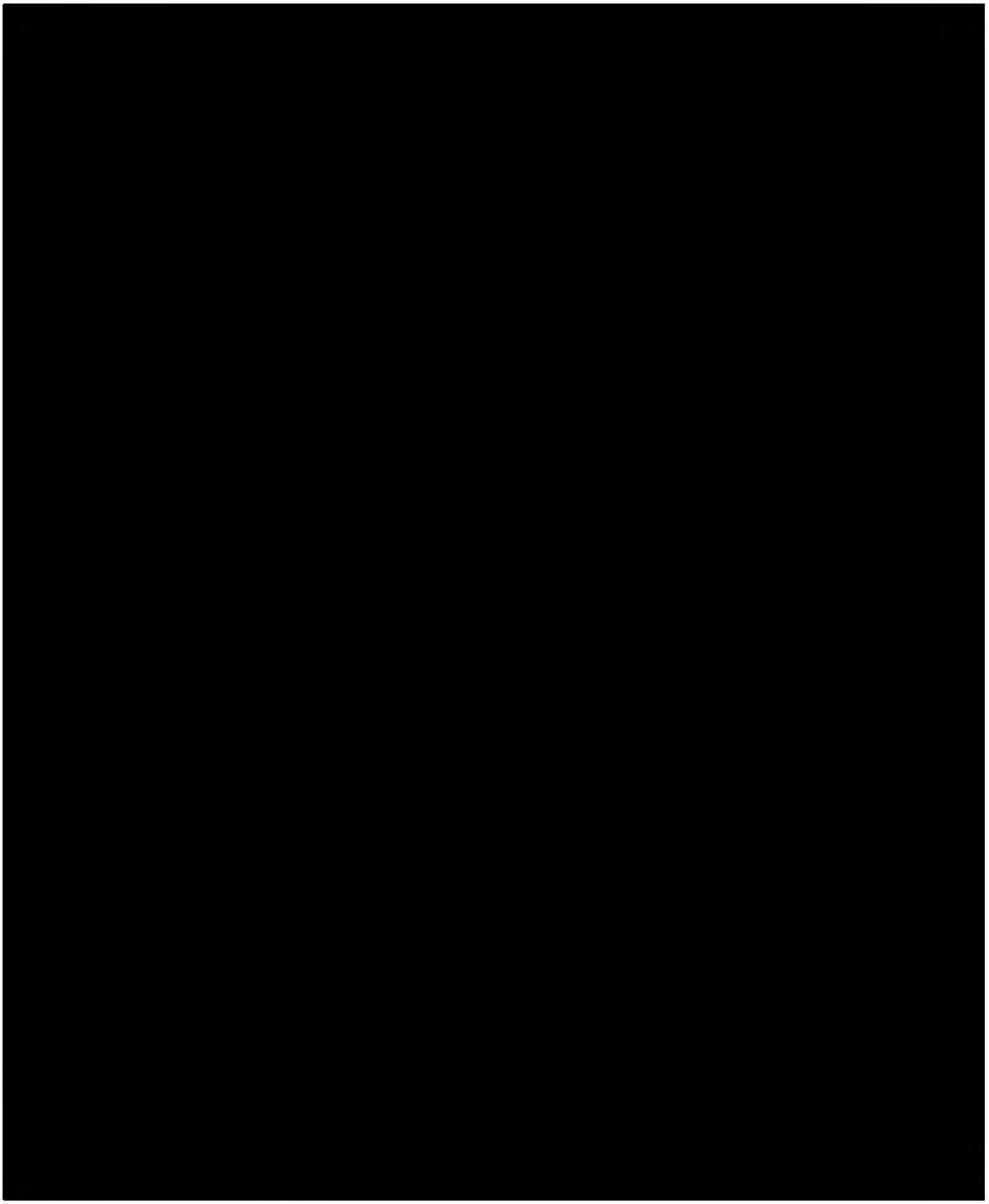


Australian climate projections at a glance







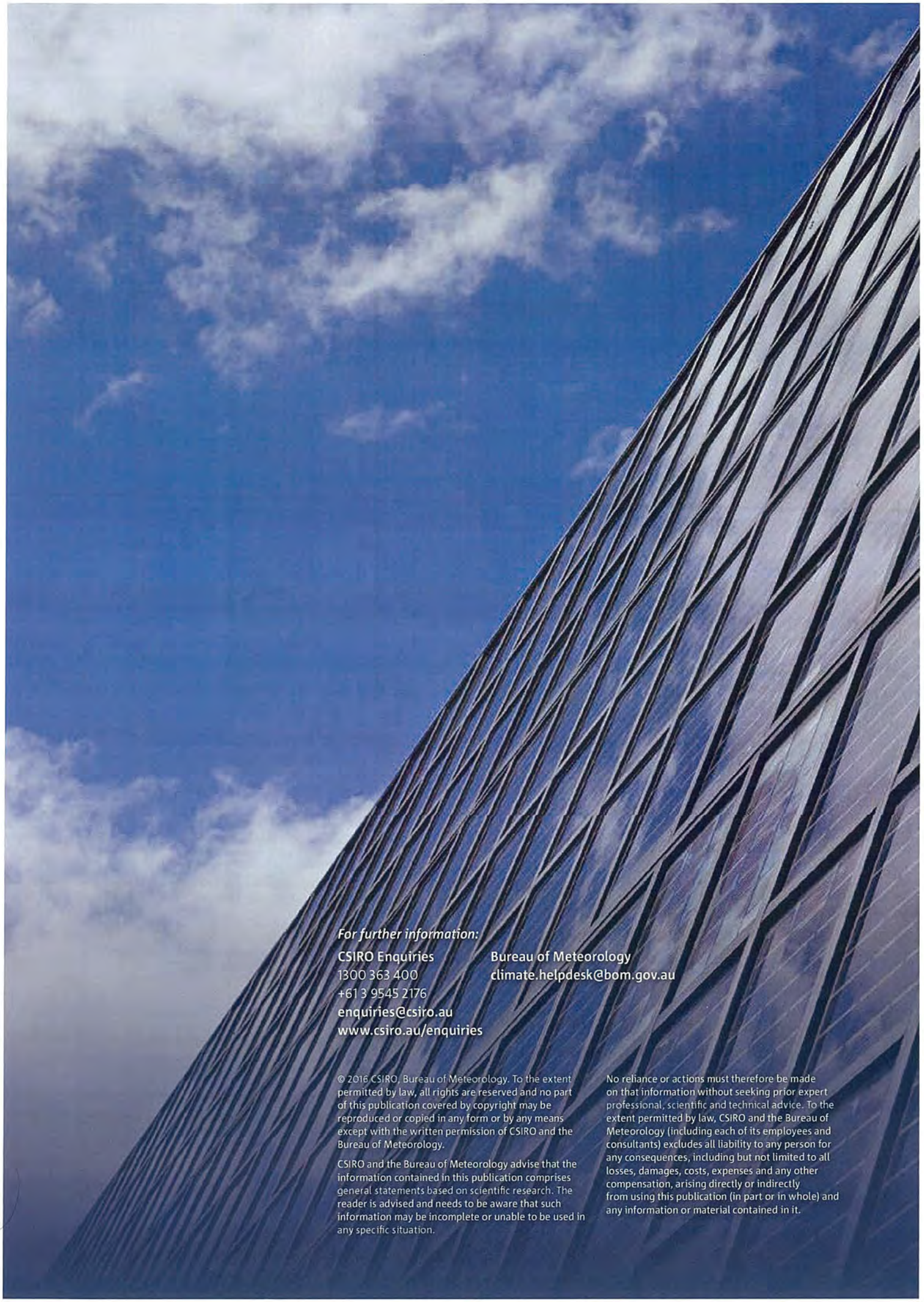


[17] https://www.nccarf.edu.au/content/coastal-tool-overview

[18] http://adaptnrm.csiro.au/

[19] https://www.nccarf.edu.au/localgov/case-study/adaptwater%E2%84%A2-online-climate-change-analysis-tool

[20] https://www.environment.gov.au/climate-change/adaptation/strategy



For further information:

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Document 15

Senator the Hon Arthur Sinodinos AO
Minister for Industry, Innovation and Science
PO Box 6100
Senate
Parliament House
Canberra ACT 2600

9 August 2017

Dear Minister,

I am writing to provide you with additional information as requested regarding a number of questions raised by Senator Roberts in a meeting between his office, your advisers and CSIRO scientists on 26 July 2017.

Specifically, the Senator and his team raised three questions relating to three specific research papers. My team have provided further information outlining our position on those matters which I have attached to this letter.

I affirm that the information attached has been prepared in accordance with the Government's expectations that CSIRO conduct its activities with integrity and impartiality and maintain high standards of scientific practice.

Thank you for the continued support we have received from your office during our engagement with the Senator on this important field of study.

Yours sincerely,

[redacted]

Dr Larry Marshall
Chief Executive, CSIRO

Att

Response to issues raised with references at the 26 July 2017 briefing

This document responds to questions raised by Senator Roberts and his team in relation to references presented by CSIRO at the Climate briefing on 26 July 2017.

1. Marcott et al. (Science, 2013)

2. Harries et al. (Nature, 2001)

CSIRO reaffirms its conclusion that changes in radiative spectra provide direct empirical evidence of an enhanced greenhouse effect.

Studies published since 2001 confirm that less energy is leaving the top of the atmosphere in the wavelengths absorbed by carbon dioxide and other greenhouse gases [e.g. 6-8], and more energy is reaching the surface in these wavelengths [e.g. 9-10]. These measurements provide further direct empirical evidence of the enhanced greenhouse effect.

The more recent studies confirm and extend the conclusion reached by Harries et al. (2001). These studies use new data sets and methods that are not subject to limitations noted by the original Harries et al. study. Specifically, the new studies use improved instruments and satellites, span the spectral range of the main CO_2 absorption band, and most are based on continuous measurements from single instruments (satellite or ground-based), which avoids introducing uncertainties or errors that might potentially arise as a result of intercalibrations between different sensors/satellites.

[redacted]

References:

[redacted]

6. Chapman, D.; Nguyen, P.; Halem, M., 2013. A decade of measured greenhouse forcings from AIRS. Proc. SPIE, 8743, 874313.
7. Griggs, J. A.; Harries, J. E., 2007. Comparison of spectrally resolved outgoing longwave radiation over the tropical Pacific between 1970 and 2003 using IRIS, IMG, and AIRS. Journal of Climate, 20, 3982-4001.
8. Worden, H. M.; Bowman, K. W.; Worden, J. R.; et al., 2008. Satellite measurements of the clear-sky greenhouse effect from tropospheric ozone. Nature Geoscience, 1, 305-308.
9. Philipona, R; Durr, B; Marty, C; et al., 2004. Radiative forcing - measured at Earth's surface - corroborate the increasing greenhouse effect. Geophysical Research Letters, 31, L03202.
10. Feldman, D. R., W. D. Collins, P. J. Gero, M. S. Torn, E. J. Mlawer & T. R. Shippert , 2015. Observational determination of surface radiative forcing by CO2 from 2000 to 2010. Nature, 519, 339–343, doi:10.1038/nature14240.

References and abstracts

[redacted]

6. Chapman, D.; Nguyen, P.; Halem, M., 2013. A decade of measured greenhouse forcings from AIRS. Proc. SPIE, 8743, 874313.

   Increased greenhouse gasses reduce the transmission of Outgoing Longwave Radiation (OLR) to space along spectral absorption lines eventually causing the Earth's temperature to rise in order to preserve energy equilibrium. This greenhouse forcing effect can be directly observed in the Outgoing Longwave Spectra (OLS) from space-borne infrared instruments with sufficiently high resolving power [3, 8]. In 2001, Harries et. al observed significant increases in greenhouse forcings by direct inter-comparison of the IRIS spectra 1970 and the IMG spectra 1997[8]. We have extended this effort by measuring the annual rate of change of AIRS all-sky Outgoing Longwave Spectra (OLS) with respect to greenhouse forcings. Our calculations make use of a 2°x2° degree monthly gridded Brightness Temperature (BT) product. Decadal trends for AIRS spectra from 2002-2012 indicate continued decrease of -0.06 K/yr in the trend of CO2 BT (700cm^{-1} and 2250cm^{-1}), a decrease of -0.04 K/yr of O3 BT (1050 cm^{-1}), and a decrease of -0.03 K/yr of the CH4 BT (1300cm^{-1}). Observed decreases in BT trends are expected due to ten years of increased greenhouse gasses even though global surface temperatures have not risen substantially over the last decade.

7. Griggs, J. A.; Harries, J. E., 2007. Comparison of spectrally resolved outgoing longwave radiation over the tropical Pacific between 1970 and 2003 using IRIS, IMG, and AIRS. Journal of Climate, 20, 3982-4001.

The observation of changes in the earth's spectrally resolved outgoing longwave radiation (OLR) provides a direct method of determining changes in the radiative forcing of the climate system. An earlier study showed that satellite-observed changes in the clear-sky outgoing longwave spectrum between 1997 and 1970 from the Infrared Interferometer Spectrometer (IRIS) and Interferometic Monitor of Greenhouse Gases (IMG) instruments could be related to changes in greenhouse gas composition. The authors present a new study that extends this to 2003, through the first use of a new, independent source of global atmospheric infrared spectra, from the Atmospheric Infrared Sounder (AIRS) experiment. AIRS is a dispersion grating spectrometer, while the other two were Fourier transform spectrometers, and this is taken into account in the analysis. The observed difference spectrum between the years 2003 and 1970 generally shows the signatures of greenhouse gas forcing, and also shows the sensitivity of the signatures to interannual variations in temperature. The new 2003 data support the conclusions found in the earlier work, though, interestingly, the methane (CH_4) Q branch centered at 1304 cm^{-1} exhibits more complex behavior, showing a decrease in intensity in the difference spectrum between 1997 and 2003. Sensitivity analysis indicates that this is due to changes in temperature structure, superposed on an underlying increase in CH_4. Radiative transfer calculations based on reanalysis data are used to simulate the changes in the OLR spectrum; limitations in such data and possible variations that could account for several observed effects are discussed.

8. Worden, H. M.; Bowman, K. W.; Worden, J. R.; et al., 2008. Satellite measurements of the clear-sky greenhouse effect from tropospheric ozone. Nature Geoscience, 1, 305-308.

   Radiative forcing from anthropogenic ozone in the troposphere is an important factor in climate change[1], with an average value of 0.35 W m^{-2} according to the Intergovernmental Panel for Climate Change[1] (IPCC). IPCC model results range from 0.25 to 0.65 W m^{-2}, owing to uncertainties in the estimates of pre-industrial concentrations of tropospheric ozone[1, 2, 3], and in the present spatial and temporal distributions of tropospheric ozone[4, 5, 6, 7, 8], which are much more variable than those of longer-lived greenhouse gases such as carbon dioxide. Here, we analyse spectrally resolved measurements of infrared radiance from the Tropospheric Emission Spectrometer[9] on board the NASA Aura satellite, as well as corresponding estimates of atmospheric ozone and water vapour, to obtain the reduction in clear-sky outgoing long-wave radiation due to ozone in the upper troposphere over the oceans. Accounting for sea surface temperature, we calculate an average reduction in clear-sky outgoing long-wave radiation for the year 2006 of 0.48±0.14 W m^{-2} between 45° S and 45° N. This estimate of the clear-sky greenhouse effect from tropospheric ozone provides a critical observational constraint for ozone radiative forcing used in climate model predictions.

9. Philipona, R; Durr, B; Marty, C; et al., 2004. Radiative forcing - measured at Earth's surface - corroborate the increasing greenhouse effect. Geophysical Research Letters, 31, L03202.

   The Intergovernmental Panel for Climate Change (IPCC) confirmed concentrations of atmospheric greenhouse gases and radiative forcing to increase as a result of human activities. Nevertheless, changes in radiative forcing related to increasing greenhouse gas concentrations could not be experimentally detected at Earth's surface so far. Here we show that atmospheric longwave downward radiation significantly increased (+5.2(2.2) Wm^{-2}) partly due to increased cloud amount (+1.0(2.8) Wm^{-2}) over eight years of measurements at eight radiation stations distributed over the central Alps. Model calculations show the cloud-free longwave flux increase (+4.2(1.9) Wm^{-2}) to be in due proportion with temperature (+0.82(0.41) °C) and absolute humidity (+0.21(0.10) g m^{-3}) increases, but three times larger than expected from anthropogenic greenhouse gases. However, after subtracting for two thirds of temperature and humidity rises, the increase of cloud-free longwave downward radiation (+1.8(0.8) Wm^{-2}) remains statistically significant and demonstrates radiative forcing due to an enhanced greenhouse effect.

10. Feldman, D. R., W. D. Collins, P. J. Gero, M. S. Torn, E. J. Mlawer & T. R. Shippert, 2015. Observational determination of surface radiative forcing by CO2 from 2000 to 2010. Nature, 519, 339–343, doi:10.1038/nature14240.

    The climatic impact of CO_2 and other greenhouse gases is usually quantified in terms of radiative forcing[1], calculated as the difference between estimates of the Earth's radiation field from pre-industrial and present day concentrations of these gases. Radiative transfer models calculate that the increase in CO_2 since 1750 corresponds to a global annual mean radiative forcing at the tropopause of 1.8 ± 0.19 W m^{-2} (ref. 2). However, despite widespread scientific discussion and modelling of the climate impacts of well-mixed greenhouse gases, there is little direct observational evidence of the radiative impact of increasing atmospheric CO_2. Here we present observationally based evidence of clear-sky CO_2 surface radiative forcing that is directly attributable to the increase, between 2000 and 2010, of 22 parts per million atmospheric CO_2. The time series of this forcing at the two locations—the Southern Great Plains and the North Slope of Alaska—are derived from Atmospheric Emitted Radiance Interferometer spectra[3] together with ancillary measurements and thoroughly corroborated radiative transfer calculations[4]. The time series both show statistically significant trends of 0.2 W m^{-2} per decade (with respective uncertainties of ±0.06 W m^{-2} per decade and ±0.07 W m^{-2} per decade) and have seasonal ranges of 0.1–0.2 W m^{-2}. This is approximately ten per cent of the trend in downwelling longwave radiation[5–7]. These results confirm theoretical predictions of the atmospheric greenhouse effect due to anthropogenic emissions, and provide empirical evidence of how rising CO_2 levels, mediated by temporal variations due to photosynthesis and respiration, are affecting the surface energy balance.

Minister for Industry, Science and Technology
For Information

RECEIVED 2 1 NOV 2018

Pdr No:MS18-002441
CSIRO Ref:C2018/5637
21 November 2018

Document 16

Subject: STATE OF THE CLIMATE 2018 REPORT

Timing: Routine by 5 December 2018

Recommendation:

That you **note** the State of the Climate 2018 report will be published on 12 Decem

Noted / Please discuss

Karen Andrews [redacted] **Date:** 6 / 12 /2018

Comments:

Key Points:

1. On Wednesday, 12 December 2018, CSIRO and the Bureau of Meteorology (the Bureau) will jointly publish the *State of the Climate 2018.*
2. *State of the Climate 2018* draws on the best available peer reviewed information to document the long-term changes to Australia's climate. It has been issued biennially since 2010, and was initiated as part of a comprehensive response from the Bureau and CSIRO to requests from Australian Governments for the communication of trusted climate science.
3. *State of the Climate 2018* is the fifth in the series and focuses on climate observations and monitoring carried out by the Bureau and CSIRO in the Australian region. The key findings are provided at Attachment A.

[redacted]

Consultation: Bureau of Meteorology.

Clearance Officer:
Peter Mayfield
Executive Director
Environment, Energy and Resources
CSIRO
[redacted]

Contact Officer:
Hannah Scott
Ministerial and Parliamentary Liaison
[redacted]

MLO Version: 21/11/2018

ATTACHMENTS
A: Key Findings
[redacted]

Document 16 - Attachment A

ATTACHMENT A

Key Findings

The *State of the Climate 2018* finds that climate change in Australia continues. Its findings support the warming trend outlined in prior reports with new insights and evidence. Key findings in the include:

s22 [redacted]

g. Carbon dioxide (CO_2) concentrations in the atmosphere are above 400 parts per million (ppm) and the CO_2 equivalent of all greenhouse gas has reached 500 ppm.

h. Emissions from fossil fuels are the main contributor to the observed growth in atmospheric CO_2.

[redacted]

ATTACHMENT B

Talking Points

s22 [redacted]

What does the State of the Climate 2018 say?

- There's a range of different aspects of Australia's climate covered in the report including information on temperature, rainfall and oceans; changing greenhouse gases and sea levels.
- Among some of the key findings are that Australia's climate has warmed by more than 1°C since 1910, with similar warming in our oceans since 1900.

[redacted]

[redacted]