Date req'd	**16 Feb '05**
Action	**For Info**
Sub #	**05/0288**
BoM File #	

Australian Government
Bureau of Meteorology

Minister for Foreign Affairs
cc Minister
Parliamentary Secretary
Secretary

CLIMATE CHANGE SCIENCE BRIEFING

MEDIA IMPLICATIONS: NO **PUBLIC AFFAIRS CONSULTED:** NO

ACTION SOUGHT:
To provide you with background briefing prior to the proposed meeting on climate change issues now scheduled for 11am on Thursday, 17 February 2005 in your Parliament House office.

CURRENT SITUATION:
The Parliamentary Secretary to the Minister for the Environment and Heritage, Mr Greg Hunt, has asked (Attachment A) the Bureau of Meteorology and the Australian Greenhouse Office (AGO) to prepare a background paper on the current status of climate change science as input to the 17 February meeting to brief you, and respond to your questions, on this area of research.

The paper at Attachment B was prepared by the Bureau of Meteorology, with input from the AGO. It aims to distil the core questions currently surrounding climate change science and provide a summary response, drawing on the current state of the science.

The questions were also framed to address, although not always directly, questions forwarded by your office and related to criticisms of climate change science by Prof Illarionov, the economics adviser to the President of Russia.

The briefing will be provided by Dr Geoff Love (Director of Meteorology), Mr Howard Bamsey (CEO AGO) and Mr Steve Morton (CSIRO Group Executive).

RECOMMENDATION:
It is recommended that you note this information. **Noted/Please discuss**

Geoff Love

(G LOVE)
DIRECTOR OF METEOROLOGY
14/2/2005

.....
MINISTER FOR FOREIGN AFFAIRS
/ /2005

CONTACT OFFICER: Dr Geoff Love S22 - Irrelevant

PORTFOLIO CONSULTATION:

AAD	AWD	CSD	HD	LWCD	NRMPD	PAD	PCEPD	SSD	GBRMP	SHFT	ORER	AGO	NOO	BoM
												√		

W-O-G CONSULTATION: NO

ATTACHMENT
A: Briefing Request 05/34
B: Paper on climate change science issues

ATTACHMENT A

Australian Government

Department of the Environment and Heritage

BRIEFING AND SPEECH/SPEAKING NOTES REQUEST 05/34

Brief No. H 147 Submission No.

Date Referred [illegible] *Due COB am/pm 31/1/05

Subject: [illegible]

Name: Hunt to be represented by Downer

Date: [illegible] Time: [illegible]

Place: [illegible]

☑ BRIEF ☐ SPEAKING NOTES ☐ SPEECH

REFERRED TO:

☑ AAD	☑ BM	☐ HD	☐ PAD
☑ AGO	☐ CSD	☐ LWCD	☐ PCEPD
☐ AWD	☐ GBRMPA	☐ NOO	☐ SSD
		☐ NRMPD	

Copy for information/appropriate action to

Purpose of meeting/speech; subjects to be covered:

1. Bureau of Met/AGO (AM Thursday) to meet with Alexander Downer [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5.
6.

Relevant correspondence: ☐ Attached ☐ Not Attached

Action area already contacted by the Parliamentary Secretary's Office: ☑ Yes ☐ No

If yes, whom? [illegible]

Departmental officer required to attend? ☑ Yes ☐ No ☐ TBA

Parliamentary Secretary's Office contact for meeting/speech [illegible]

For further information please see over

ATTACHMENT B

Summary of Recent Issues in Climate Change Science

Purpose

This paper outlines the background to a number of issues that have been recently raised about the science of climate change. Debate about some aspects of climate change science is typical of a healthy scientific process. The substance of this debate does not cast serious doubt on any of the conclusions reached by a majority of climate scientists – that the earth's climate is changing. The conclusions presented in this paper are based on several independent streams of evidence thereby giving the scientific community a high degree of confidence in their validity.

Scientific consensus

The key conclusions of the majority of climate change scientists, as reflected in the peer reviewed IPCC Third Assessment Report, are:

1. The atmospheric concentration of greenhouse gases (carbon dioxide (CO_2), methane, HFCs, CFCs) is higher today than at any other time in the last 420,000 years and continues to rise.
2. The rise in greenhouse gas concentrations is due to human activities.
3. The earth's climate is changing. In particular, global average surface temperatures have risen by 0.6 C over the last 100 years.
4. Increased greenhouse gas concentrations are a key driver of recent changes in global climate and further changes can be expected as greenhouse gas concentrations continue to rise.
5. Climate change will have both positive and negative effects, but on balance the negative impacts will substantially outweigh the benefits, particularly if global warming rises above about 2°C.

QUESTIONS ABOUT ASPECTS OF CLIMATE CHANGE SCIENCE

In recent times there have been a number of well-publicised criticisms of the science behind the policy development associated with climate change. Examples are the ten questions raised by Andrei Illarionov at the Moscow World Climate Change Conference in 2003, and the novel, "State of Fear", by Michael Crichton.

In order to explain the issues raised by such critics, the following questions are considered in this paper:

A. Has the surface temperature increased over the last century?
B. Do satellite data show that the free atmosphere is cooling rather than warming?
C. How are ice-covered areas changing?
D. How much has surface temperature changed in the past 1000 years?
E. How do we know that the present changes are different from past climate changes?
F. Is air pollution the reason for global climate change?
G. How do we know that greenhouse gases are associated with climate change?

A brief answer is given to each question, but more detailed information and data are available in the scientific literature to support the statements made below.

A. Has the surface temperature increased over the last century?

SUMMARY

Yes.

There is clear evidence that the surface of the earth (over both the land and ocean) has warmed over the last century. The average global surface temperature has increased by 0.6 °C. Temperatures have risen a little faster over the land than over the ocean because of the higher heat absorbing capacity of water.

It is sometimes suggested that observed temperature increases are due to the 'urban heat island effect', but measurements taken in rural areas and over the ocean prove that this is not the case. Further, measurements taken from the vicinity of urban areas are excluded from analyses.

SUPPORTING SCIENCE

There have now been at least five independent analyses of the land-surface temperature measured from *in situ* thermometers (e.g. see Figure 1). The long-term trend is about 0.7 °C /century.

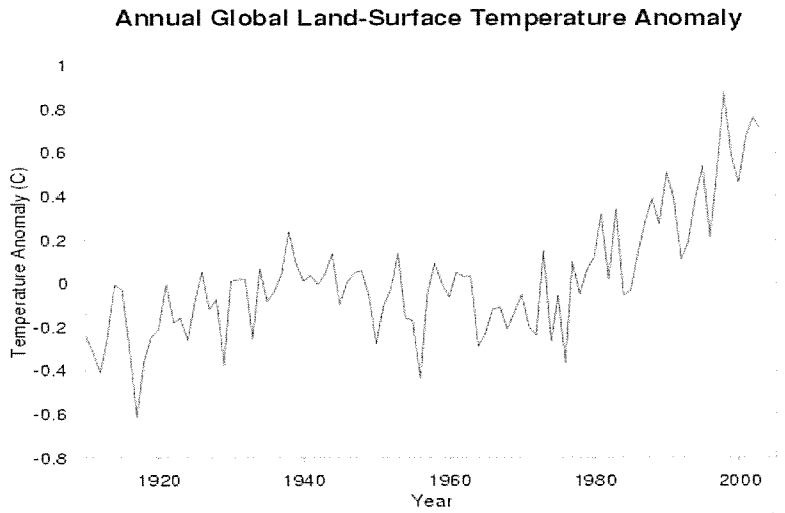

Figure 1. Increase in annual global land-surface temperature over 20th Century.

Analyses with only rural sites indicate that the results are not significantly affected by urban heat-island effects, mainly because the trends in urban areas are similar to those in rural areas. The strongest evidence that the observed warming over the land is not contaminated by urban effects is that similar results are found over the world oceans (Figure 2). The ocean tends to respond more slowly than the land and so the net trend in overall global surface temperature is about 0.6 °C /century over the 20th Century.

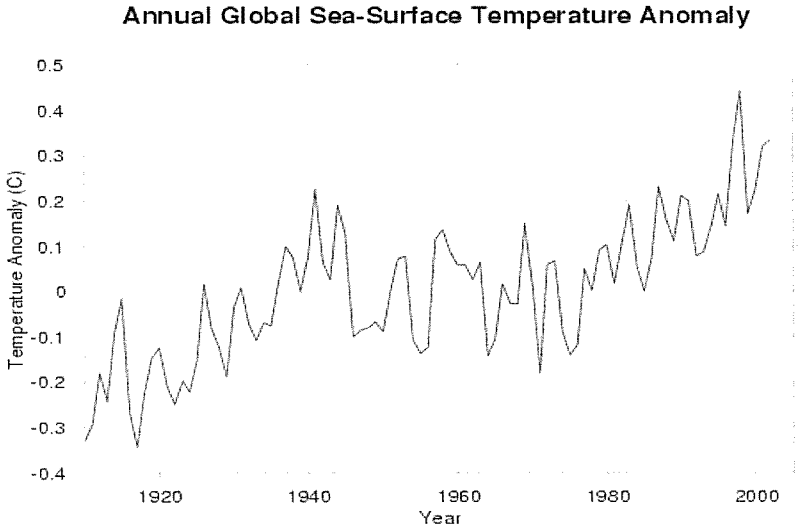

Figure 2. Increase in annual global sea-surface temperature during 20th Century.

Noting the warming trend averaged over the whole globe, it is interesting to ask whether the trend is regionally consistent. In particular, we find that the warming trend over Australia for the 20th Century is about 0.9 °C /century. This trend is calculated from non-urban sites, which should not be contaminated by heat island effects. The robustness of the trend is confirmed by considering the trend in sea-surface temperature in the ocean around Australia: a similar trend is found in the sea-surface temperature to that found over the continent.

The warming trend is also observed over the whole Asia – Pacific region. Over the last six years, Australian scientists have led a cooperative analysis of climate trends across fifteen countries in our region. The analysis has focused on trends in extreme events, such as hot days and cool nights. A consistent result has been an upward trend over the last 40 years in the frequency of warm days and downward trend in the frequency of cool nights.

In summary, there is clear evidence that the surface of the earth has warmed over the last century.

A question frequently posed by Mr Illarionov at the recent Exeter "Avoiding Dangerous Climate Change" science conference was: "why has temperature only risen 0.6 °C when we see the concentration of CO_2 in the atmosphere has risen from around 278ppm to over 360 ppm over the same time interval"? The implication contained in the question that a greater warming should have been observed. The answer to his question has essentially two components:

(a) While the concentration of greenhouse gases has increased so too has the concentration of aerosols that have had a cooling effect on the atmosphere. The success of EPA's in the developed world in reducing the aerosol (pollutant) load in the atmosphere is now leading to a reduction in this cooling effect;

(b) The ocean-atmosphere system has a certain "inertia", most particularly the thermal capacity of the ocean means that it is slow to warm – but this is only a delay in the systems reaction, the warming is not avoided.

Finally, in relation to this issue, simulations of climate with the observed greenhouse concentrations, and including a variety of other known effects on the radiative forcing of the atmosphere closely model known observations (discussed in more detail later in this paper).

B. Do satellite data show that the lower atmosphere is cooling rather than warming?

SUMMARY

No.
The temperature increase measured by satellites is virtually identical to that measured using instruments at the surface. Those who suggest otherwise are relying on outdated studies that did not correct satellite measurements for systematic errors such as change in the orbit of satellites as they age.

SUPPORTING SCIENCE

Over the last 25 years, satellites have provided invaluable data to support numerical weather prediction models. In particular, the microwave sounding unit (MSU) on USA satellites measures energy at wavelengths around 10 micrometres radiating from the atmosphere below the satellite. From such data it is possible to infer the temperature of layers of the atmosphere, and this information is used routinely to specify the current state of the atmosphere for numerical models that predict the future weather up to ten days ahead.

Some years ago it was recognised that these MSU data could be treated as part of the climate record to infer changes in the lower atmosphere over the last couple of decades. However, because the MSU instruments were designed for weather applications, they were good at estimating differences in

temperature on a day-to-day basis, but they were not good at providing unbiased estimates of the absolute temperature of the atmosphere for climate purposes. The early analyses of the MSU data did not account for all the sources of bias (such as differences in instruments on different satellites, decay in the quality of instruments as they age, changes in the orbits of satellites as they age), and they suggested that the lower atmosphere (in particular, the layer known as the troposphere) was cooling rather than warming.

Since that time, the data have been reprocessed several times in attempts to recover a useful climate record. The scientists (Christy and Spencer) who did the original analyses now find that the free atmosphere has warmed over the last 20 years by about 0.8 °C /century, which is much more consistent with trends in surface temperature (0.6 °C /century). Moreover, the MSU data have now been analysed by two other independent groups, who find at least as much warming as Christy and Spencer.

Some recent work in USA shows that, because the MSU measurements apply to layers of the atmosphere (rather than to a specific height above the surface), they are affected by the temperature of the stratosphere (the layer above the troposphere). A physical consequence of the greenhouse effect is that the stratosphere cools as the troposphere warms. Thus, the contamination of the MSU data by stratospheric temperatures means that they under-estimate tropospheric warming.

The work of Christy and colleagues has led to a significant international effort to improve our ability to observe and understand variations in the free atmosphere, and Australian scientists (along with Christy and Spencer) are involved in this collaboration. Our ability to detect trends from satellite data will continue to increase simply as the length of the measurement record increases.

C. How are ice-covered areas changing?

Summary

Globally, the area covered by ice is decreasing. Arctic sea ice has decreased by 7.4 % in the last 25 years and many glaciers are retreating. However, local variations in climate, such as increased precipitation, mean that the trend is not uniform and a few glaciers are advancing.

In Australia, snow depth is decreasing in Alpine areas (notwithstanding its year-to-year variability). Warming has also affected Antarctic ice shelves. The Larsen B ice shelf collapsed completely in 2002 when an area of 3500 square kilometres of ice up to 100 m thick broke up totally in 3 weeks. This is the largest single event in a series of retreats by ice shelves in the Antarctic Peninsula over the last 30 years.

Supporting science

The extent of the sea ice in the Arctic has been monitored by satellite instruments for about 25 years. Averaged over this period, the extent of the ice has decreased by 7.4% or 340,000 square km per decade. The same satellite data are used to monitor the area of the Greenland ice sheet that melts each summer. It is found that the area of ice that melts has gradually increased by 16% over the last 25 years. The reduction in sea ice extent and increase in melt area can both be related to warming that has been observed over the Arctic.

An authoritative international study on the impact of climate change and variability on the Arctic was recently completed. In testimony to the USA Senate Committee on Commerce, Science and Transportation the chair of the Arctic Climate Impact Assessment stated: "The Arctic is now experiencing some of the most rapid and severe climate change on Earth. Over the next 100 years, climate change is expected to accelerate, contributing to major physical, ecological, social, and economic changes, many of which have already begun. Changes in Arctic climate will also affect the rest of the world through increased global warming and rising sea levels."

The meteorology of Antarctica has been complicated in recent decades by the effects of ozone-depleting substances on the polar vortex in the atmosphere above the continent. Reduction in ozone has led to cooling in the stratosphere, which appears to have suppressed warming in parts of Antarctica. Consequently, there has been little change (or even a slight increase) in sea ice extent around Antarctica over the last 25 years. On the other hand, Australian scientists have found both anecdotal evidence from the logs of whaling ships and quantitative but proxy evidence from ice cores that suggests there was a rapid decrease in Antarctic sea ice between the 1950s and 1970s.

In Australia it has been found that the depth of our snow in springtime has been decreasing steadily for the last fifty years (Figure 3). Comparison of these data with the precipitation and temperature records shows the decrease in snow depth is best explained by the increasing temperature rather than any variation in precipitation. The higher temperatures in spring mean that the accumulated snow now melts more quickly than it used to do.

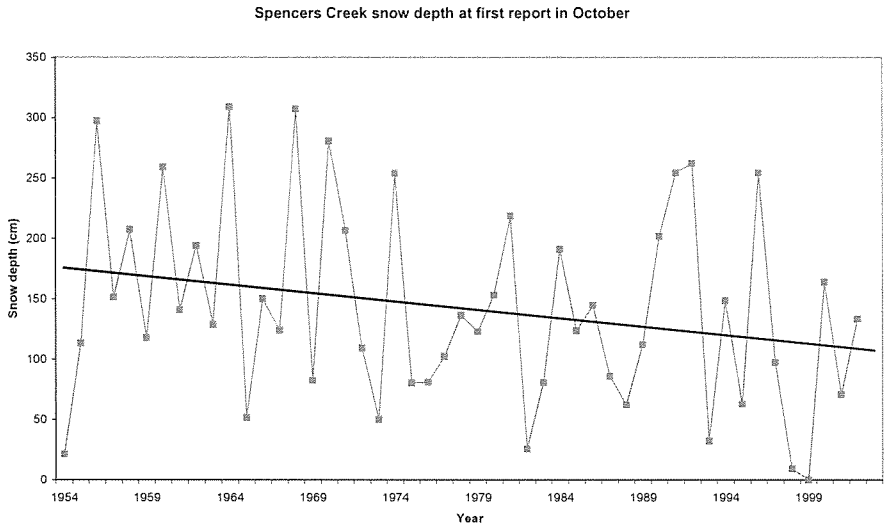

Figure 3. Decrease in snow depth in Australia in spring over the last 50 years.

Observations of the retreat of glaciers across the world provides supporting evidence of sustained global-scale warming. The World Glacier Inventory contains information on over 67,000 glaciers. While only a small fraction of the total number of glaciers are routinely monitored, such glaciers are distributed around the world and so they provide a global sample of glacier behaviour. It is found that especially over the last few decades glaciers in many parts of the world are retreating at an increasing rate. The discovery of the 5000-year-old Oetzal ice man in the Italian Alps in 1991 suggests that the current retreat is unprecedented for millennia.

A few glaciers are advancing; for example, in western Norway and New Zealand glaciers are advancing probably because of local increases in precipitation. These observations demonstrate that regional and local influences can dominate any global-scale influence. For example, it is found that Mt Kilimanjaro has lost much of its snow cover over the last fifty years. However, the snow loss started before global warming was significant, and so in the earlier period the snow loss is believed to have been associated with a local influence, such as a reduction in precipitation.

D. How much has surface temperature changed in the past 1000 years?

SUMMARY

Yes.
Independent studies conclude that, based on proxy data on the temperature of the northern hemisphere, the 20th Century was the warmest period over the last 1000 years.

Recent research has extended this conclusion: late 20th century warming in the northern hemisphere is likely to have been the largest of any century during at least the past 1800 years. These conclusions have been questioned in two well-publicised studies, however both these studies are considered by the majority of climate change scientists to be scientifically flawed and that the conclusions above remain valid.

SUPPORTING SCIENCE

Using proxy data (such as tree rings, lake-sediment cores and bore-hole temperatures) several groups have independently estimated the annual temperature record for the last millennium in the northern hemisphere (Figure 4); this is the "hockey stick" curve. (There are insufficient data available in the southern hemisphere to extend the estimates to a global scale.) Sophisticated statistical methods are used to relate the proxy data to the observed climate over the last century when there is overlap between instrumental and proxy data. These statistical relationships are then used to infer the climate in past times. Using largely independent data and quite different techniques, the groups agree it is likely that the 1990s was the warmest decade and 1998 was the warmest year in the last millennium.

This view has been questioned by well-publicised work of Soon and Baliunas and of McIntyre and McKitrick. Both of these analyses have been reviewed in the mainstream scientific literature and found to have fatal flaws. Moreover, the results of the two analyses are inconsistent; in particular, McIntyre and McKitrick suggest there was a warm period during the 15th Century at a time when Soon and Baliunas have the Little Ice Age.

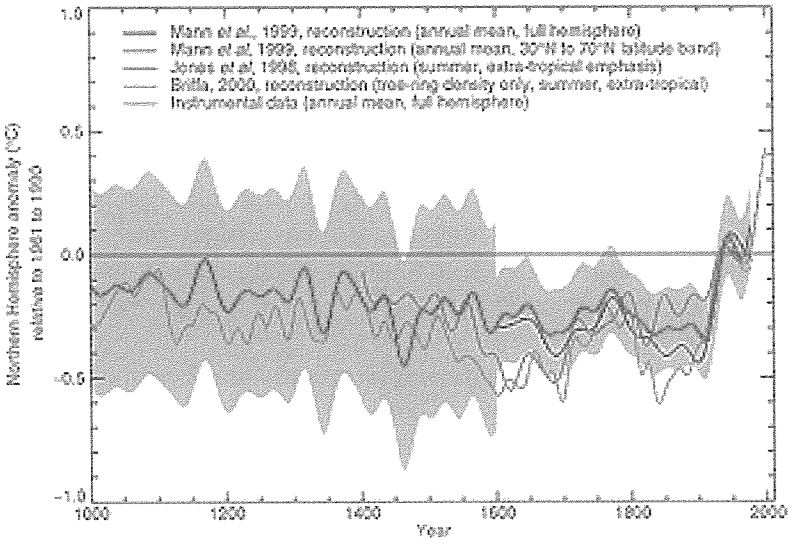

Figure 4. Different estimates of the northern hemisphere temperature over the last 1000 years. The shaded region is an estimate of the uncertainty in the mean temperature.

A recent modelling study by a German scientist (von Storch) has suggested that the inter-decadal and inter-centennial variability of the "hockey stick" curve has been under-estimated. Such under-estimation of extreme values is a known feature of the statistical methods used to derive the "hockey

stick". However, the possibility of greater variability in the mean is accounted for in the large error bars (the grey area) of Figure 4. Moreover, von Storch does not query the general shape of the "hockey stick" nor the inferences that the 20th Century was warmer than any other period in the last millennium.

E. How do we know that the present changes are different from past climate changes?

SUMMARY

The earth has fluctuated naturally between cold and warm periods over millions of years. These natural fluctuations are still affecting the earth's surface temperature and other climate variables over long timescales.
However, the present atmospheric concentration of carbon dioxide is 30% higher than at any time in the past 400,000 years. Furthermore, the current rate of temperature change is on human timescales (i.e. years to decades) rather than over geological timescales (i.e. thousands to millions of years). While the magnitude of warming is comparable to past changes at the end of a glacial period, this pace of temperature change would be unprecedented in human history.

SUPPORTING SCIENCE

Geologists tell us that climate has always changed on geological time scales under natural forces, and so we need to adapt to such variability. Indeed, over the last 2 million years there has been a series of glacial-interglacial cycles, forced by the varying geometry of earth around the sun. During these Milankovitch cycles the amount of solar radiation reaching different parts of the earth varies, leading to changes in the atmospheric circulation and in the distribution of ice over tens of thousands of years. It is worth noting that modern civilisation has arisen only since our emergence from the last glacial about 10,000 years ago.

Ice cores from Antarctica now provide information on the variation in CO_2 in the atmosphere over the last 400,000 years, corresponding to more than three of the 120-year major Milankovitch cycles. Over that period, the concentration of CO_2 varied between about 180 parts per million (ppm) during glacials to about 280 ppm during the inter-glacials. The present level of over 360 ppm is 30% greater than at any time during the last 400,000 years. Moreover, the changes associated with the enhanced greenhouse effect are occurring over a period of decades, rather than the tens of thousands of years associated with Milankovitch cycles.

There is evidence from ice cores that, during the last glacial and the transition to the present inter-glacial, there were rapid climate variations on hemispheric and perhaps global scales. Changes of several degrees Centigrade appear to have occurred over a few decades. It is thought that these rapid changes may have been associated with changes in ocean circulation, and research is continuing on clarifying these past events and evaluating the possibility of their occurrence in the future. Such changes are not alternatives to climate change due to greenhouse gases, rather they could be a source of further uncertainty in the estimation of future climate. However, it appears that these rapid changes have not occurred over the last few millennia during which a stable climate has promoted the evolution of civilisation.

F. Is air pollution the reason for global climate change?

SUMMARY

Air pollution is considered to have had a slight global cooling effect in the post-industrial era.
That is, air pollutants offset some of the warming until the 1980s when major efforts by developed countries, especially in the northern hemisphere, to reduce air pollution commenced.

Scientists are now monitoring the effects of the rise in pollutants from the rapidly developing economies such as those of China and India, and from the large scale land clearing in Brazil, however their net impact on the global climate is still unclear. It is expected that localised impacts from these pollution "hot spots" (eg change in precipitation patterns) will be observed before their global impacts are clear.

Supporting science

During the industrial growth of the 20th Century, human activities led to a substantial emission of pollutants into the atmosphere in the form of particles (or aerosols). An effect of aerosols is to reflect solar radiation back to space and so to cool the surface of the earth. Because of the distribution of economic activity across the earth, the main impact of aerosols has been felt in the northern hemisphere. Indeed both modelling studies and analyses of observations suggest that up till about the 1980s aerosols were offsetting some of the effects of greenhouse gases in the northern hemisphere ("global dimming"). Such effects are no longer substantial as air pollution is reducing in most developed countries and as greenhouse forcing is increasing.

In Australia it has been suggested that air pollutants are causing our rainfall to decline. However, both modelling and observations imply that our rainfall is essentially controlled by large-scale forces, such as the El Nino phenomenon which is associated with our major droughts. Some current research suggests that the rainfall decline in recent years across southern Australia may be linked to changes in the circulation around Antarctica where ozone-depleting substances have caused cooling of the stratospheric polar vortex. Because of the pervading effects of such large-scale phenomena, the effect of air pollution tends to be localised and will at best be an additional factor.

G. How do we know that greenhouse gases are associated with climate change?

Summary

The theory of the enhanced greenhouse effect – an increase in greenhouse gases in the atmosphere leading to global warming - has been understood for over a century. As well as greenhouse gases, there are several other forces that affect our climate – e.g. solar radiation and volcanic activity. However, global climate models demonstrate that greenhouse forcing is needed to explain the observed climate change in recent decades.

Supporting science

A Swedish scientist, Arrhenius, first pointed out in 1896 that industrialisation was likely to lead to increases in the concentration of CO_2 in the atmosphere and hence to global warming. Thus the basic theory of the enhanced greenhouse effect has been well understood for a century, and the prediction of Arrhenius on the global impact of CO_2 emissions is now being verified. A Study of Critical Environmental Problems at MIT in 1970 used a simple atmospheric model to predict that global surface temperature would rise by about 0.5 °C by the year 2000. A reason for their (small) over-estimation of the warming (the observed warming is 0.45 °C) is that they over-estimated the emissions of CO_2 from fossil fuels (this was before the first oil shock in 1973).

Using global climate models, we are able to simulate different climate regimes under different forcing conditions. The major external forces affecting our climate are variations in solar radiation (e.g. sunspots), volcanoes (which cool the earth due to the shielding effect of volcanic aerosols), industrial aerosols, and greenhouse gases. Several studies have now found that the observed climate can be simulated with these models only if the enhanced greenhouse effect is included. For example, Figure 5 shows the simulations from a USA model. Because of the chaotic nature of the climate system, an ensemble of simulations is run to estimate the uncertainty in the results of each run. The shaded areas in

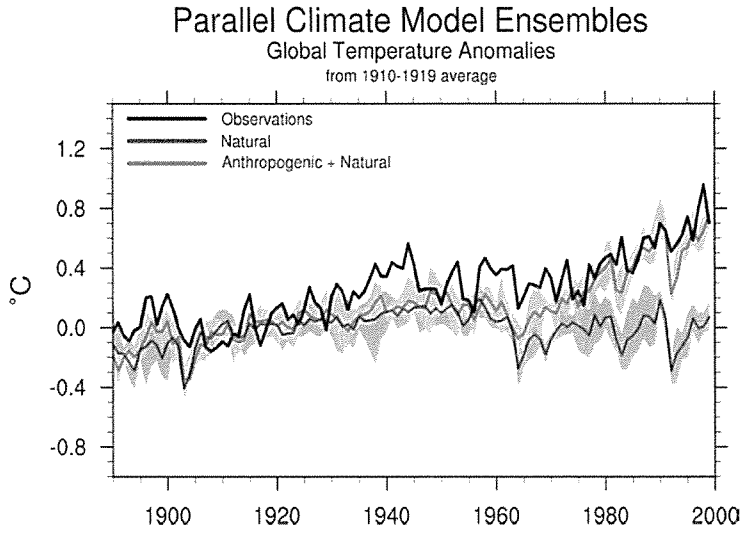

Figure 5. Model simulations of climate of 20th Century under different forcing assumptions. Shading indicates variability across the ensemble of simulations.

Figure 5 indicate this uncertainty. It is seen that for the early part of the century the shaded areas overlap, and so the greenhouse forcing is not discernible from the natural forcings. However, by the end of the century the paths associated with greenhouse forcing are quite separate from those due to natural forcing alone. Moreover, the observed temperature aligns well with the simulations that include the enhanced greenhouse effect. It is clear that when the enhanced greenhouse effect is omitted from the model, the simulated temperature significantly under-estimates the observed temperatures over the last 25 years.

CLIMATE CHANGE UPDATE

GLOBAL

The headline finding of IPCC Fourth Assessment Working Group I report on the science of climate change is that warming of the climate system is *unequivocal*, and is evident in the observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level. There is very high confidence that much of the warming can be attributed to human activities.

Global average air temperature

- Updated 100-year linear trend of 0.74 [0.56 to 0.92] °C for 1906-2005
- Larger than corresponding trend of 0.6 [0.4 to 0.8] °C for 1901-2000 given in the third assessment report
- Average ocean temperature increased to depths of at least 3000 m – ocean has absorbed 80% of heat added leading to seawater expansion and sea level rise

At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include:

- Large increases in Arctic temperatures and rapid decrease in sea ice extent and thickness
- Widespread changes in precipitation amounts, ocean salinity, wind patterns
- and aspects of extreme weather including droughts, heavy precipitation, heatwaves and the intensity of tropical cyclones

AUSTRALIA

Australia is already experiencing impacts of recent climate change, predominantly due to warming, but probably due to changes in rainfall patterns as well, to which some adaptation has occurred in sectors such as water, natural ecosystems and agriculture. However, significant vulnerability remains to droughts and extreme weather events.

The chapter in the IPCC WG-II Report dealing with Australia and New Zealand concluded that the climate of the 21st century is virtually certain to be warmer with significant changes in some extreme events, for example:

- The risk of increased heatwaves and fires are virtually certain to increase
- Floods, landslides, droughts and storm surges are very likely to become more frequent and intense, and snow and frost are very likely to become less frequent
- The main findings about potential impacts were:
    - As a result of reduced precipitation and increasing evaporation, water security problems are projected to intensify in southern and eastern parts of Australia
    - Loss of biodiversity is projected to occur by 2030 in ecologically rich sites including the Great Barrier Reef, Kakadu wetlands, the Queensland Wet Tropics, southwest Australia, subantarctic islands and alpine areas

- Ongoing coastal development and population growth, in areas such as Cairns and southeast Queensland, are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding by 2050
- Production from agriculture and forestry by 2030/2050 is projected to decline over much of southern and eastern Australia due to increased aridity and fire

The CSIRO and the Bureau of Meteorology have recently updated their assessment of past climate change and future projections for the Australian Climate Change Science Program. Their technical report is publicly available at http://www.climatechangeinaustralia.gov.au/resources.php.

A/ADC
S47F
February 2008

CLIMATE CHANGE UPDATE

GLOBAL

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AUSTRALIA

Australia is already tracking evidence of climate change that can be attributed in part to greenhouse-induced warming, including changes in rainfall patterns as well general warming trends. Some stress and adaptive responses to these changes can also be observed in sectors such as water, natural ecosystems and agriculture. There are significant ongoing vulnerabilities to drought, increasing aridity and extreme weather events.

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The CSIRO and the Bureau of Meteorology assessment report on past climate change and future projections for the Australian Climate Change Science Program is publicly available at http://www.climatechangeinaustralia.gov.au/resources.php.

It is anticipated that the IPCC will publish its Fifth Assessment Report around 2013.

A/ADC
S47F
May 2008

CLIMATE CHANGE UPDATE

GLOBAL

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- Larger than corresponding trend of 0.6 [0.4 to 0.8] °C for 1901-2000 given in the third assessment report
- Average ocean temperature increased to depths of at least 3000 m – ocean has absorbed 80% of heat added leading to seawater expansion and sea level rise
- Despite an apparent lack of warming since 1998 due to the dominance of short-term natural variability over long-term trends at the annual to decadal time scale, global mean temperatures are expected to continue to increase.

At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include:

- Large increases in Arctic temperatures and rapid decrease in sea ice extent and thickness. The minimum in Arctic sea ice extent in 2007 was a record-low at 39% less than the long-term average and in 2008 was second lowest on record at 34% below average.
- Widespread changes in precipitation amounts, ocean salinity, wind patterns
- and aspects of extreme weather including droughts, heavy precipitation, heatwaves and the intensity of tropical cyclones

AUSTRALIA

Australia is already tracking evidence of climate change that can be attributed in part to greenhouse-induced warming, including changes in rainfall patterns as well general warming trends. Some stress and adaptive responses to these changes can also be observed in sectors such as water, natural ecosystems and agriculture. There are significant ongoing vulnerabilities to drought, increasing aridity and extreme weather events. Another year of below average rainfall and above-average temperatures in 2008 have meant yet another poor year for inflows into the Murray Darling system.

The chapter in the IPCC WG-II Report dealing with Australia and New Zealand concluded that the climate of the 21st century is virtually certain to be warmer with significant changes in some extreme events, for example:

- The risk of increased heatwaves and fires are virtually certain to increase
- Floods, landslides, droughts and storm surges are very likely to become more frequent and intense, and snow and frost are very likely to become less frequent

- The main findings about potential impacts were:
    - As a result of reduced precipitation and increasing evaporation, water security problems are projected to intensify in southern and eastern parts of Australia
    - Loss of biodiversity is projected to occur by 2030 in ecologically rich sites including the Great Barrier Reef, Kakadu wetlands, the Queensland Wet Tropics, southwest Australia, subantarctic islands and alpine areas
    - Ongoing coastal development and population growth, in areas such as Cairns and southeast Queensland, are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding by 2050
    - Production from agriculture and forestry by 2030/2050 is projected to decline over much of southern and eastern Australia due to increased aridity and fire

It is anticipated that the IPCC will publish its Fifth Assessment Report around 2013

BUREAU OF METEOROLOGY CONTRIBUTIONS

The CSIRO and the Bureau of Meteorology assessment report on past climate change and future projections for the Australian Climate Change Science Program is publicly available at http://www.climatechangeinaustralia.gov.au/resources.php.

The Bureau of Meteorology is involved in many critical aspects of the climate change issue: making systematic observations of the climate; managing Australia's climate record; analysing and monitoring climate change; conducting research into climate change processes, modelling and projections; developing significant international collaboration; communicating climate change science; and providing input to policy.

SENATE (BUDGET) ESTIMATES BRIEFING
27 MAY 2009

CLIMATE CHANGE UPDATE

Issues

- Ongoing media and public misunderstanding about aspects of climate change and the role of human activity.
- Confounding signals from climate variability (e.g., the global cooling from El Niño to La Niña) affecting the longer term signals associated with climate change.
- Ongoing unusual climatic conditions over Australia; notably severe meteorological and hydrological drought across the southeast and southwest and unusually warm conditions.
- Confusion about recent shorter term climatic trends in the Antarctic and their relevance to climate change.

Key Points

- IPCC Fourth Assessment Report (Working Group 1) found that warming of the climate system is unequivocal.
- Global average surface temperature has increased by 0.74 [0.56 to 0.92] °C for 1906-2005 period. The highest annual temperature averaged over the globe occurred in 1998, with 2002 and 2005 only slightly cooler.
- The underlying global warming signal over recent years has been partially offset by natural variability; most notably with the onset of La Niña conditions across the Pacific. With the La Niña now passed and the Pacific moving into neutral to possible El Niño conditions this masking could very well fade.
- Some aspects of observed changes in Australian climate can be attributed in part to greenhouse-induced warming. These changes include the general warming that has occurred across the continent and reduced rainfall over parts of southern Australia.
- Australia continues to experience highly unusual meteorological drought across the southwest and the southeast (including the lower Murray-Darling Basin). These low rainfall conditions have been exacerbated by above average temperatures.
- Recent temperature data, particularly in the continental interior of the Antarctic, appear to show slight cooling. This cooling has been linked to changes in the intensity and tracks of weather systems around Antarctic, which are attributable at least in part to ozone depletion.
- To further understand changes about the Antarctic the Bureau has recently commenced a rehabilitation and analysis of station data. Preliminary results from this work show general warming in the longer term but some short term cooling trends more recently.

Written by: S47F
Cleared by (DDS):
Date Updated: 18 May 2009

Political sensitivities / issues / implications

- Recent weeks have seen significant media coverage of climate change issues, with a strong emphasis from a number of writers sceptical of mainstream climate science. The associated media coverage has tended to be both confusing and confused.
- In some cases the media coverage has conflated climate science issues with policy responses, and has highlighted debate and disagreement when in many cases little exists. Such coverage has recently been evident in discussion of the Antarctic where local short-term climate trends unrelated to the greenhouse effect have been interpreted by sections of the media as (further) evidence against global warming.
- The Bureau of Meteorology is involved in many critical, scientific aspects of the climate change issue:
    - making systematic observations of meteorological and related variables that are used to compose the climate record;
    - managing Australia's climate record;
    - analysing and publishing the climate record;
    - conducting research into climate processes, modelling and shorter term climate predictions;
    - contributing to national and international collaboration on climate science, including the National Framework for Climate Change Science, the Pacific Climate Change Science Program and the World Climate Research Programme.
    - communicating climate science to industry decision makers, the media and the community at large; and
    - providing scientific advice to inform government policy.

Written by: S47F
Cleared by (DDS):
Date Updated: 18 May 2009

SENATE (SUPPLEMENTARY) ESTIMATES BRIEFING
20 OCTOBER 2009

CLIMATE CHANGE UPDATE

Issues

- Ongoing media and public misunderstanding about aspects of climate change and the role of human activity.
- Signals from climate conditions and variability (for example, the global warming from La Niña to El Niño) beginning to align with the longer term signals associated with climate change.
- Based on current early observations (to September), 2009 is likely to be one of the warmest years on record for both the globe and Australia.
- Ongoing unusual climatic conditions over Australia; notably record breaking warm conditions over large parts of Australia. Largest anomalies across northern South Australia, southern Northern Territory, southern Queensland and NSW. Severe protracted meteorological and hydrological drought across the southeast and southwest.

Key Points

- IPCC Fourth Assessment Report (Working Group 1) found that warming of the climate system is unequivocal.
- Global average surface temperature has increased by 0.74 [0.56 to 0.92] °C for 1906-2005 period. The highest annual temperature averaged over the globe occurred in 1998 and 2005.
- The underlying global warming signal over recent years has been partially offset by natural variability; most notably the La Niña conditions across the Pacific. With the La Niña now passed global temperatures have returned to above trend values with recent months showing record to near record high temperatures (globally, August 2009 was the second warmest on record and the warmest August on record for Australia).
- Some aspects of observed changes in Australian climate can be attributed in part to greenhouse-induced warming. These changes include the general warming that has occurred across the continent and reduced rainfall over parts of southern Australia.
- Australia continues to experience highly unusual meteorological drought across the southwest and the southeast (including the lower Murray-Darling Basin). These low rainfall conditions have been exacerbated by above average temperatures.
- Winter and early spring has seen a large number of high temperature records broken. Whilst this has been associated with persistent high pressure systems over the Australian interior, with very little rain and no penetration of cold outbreaks, it must also be considered in terms of the background warming trend of approximately 1 degree over the past 50 years.

Written by: S47F
Cleared by (DDS): 2 October 2009
Date Updated: 24 September 2009

Political sensitivities / issues / implications

- There continues to be a mix in the media coverage of climate change issues, between those reporting on the mainstream scientific findings and those giving coverage to the view of a minority sceptical group. This has resulted in substantial public confusion.
- The Bureau of Meteorology is involved in many critical, scientific aspects of the climate change issue:
    - making systematic observations of meteorological and related variables that are used to compose the climate record;
    - managing Australia's climate record;
    - analysing and publishing the climate record;
    - conducting research into climate processes, modelling and shorter term climate predictions;
    - contributing to national and international collaboration on climate science, including the National Framework for Climate Change Science, the Pacific Climate Change Science Program and the World Climate Research Programme;
    - communicating climate science to industry decision makers, the media and the community at large; and
    - providing scientific advice to inform government policy.

Written by: S47F
Cleared by (DDS): 2 October 2009
Date Updated: 24 September 2009

SENATE (ADDITIONAL) ESTIMATES BRIEFING
9 FEBRUARY 2010

CLIMATE CHANGE UPDATE

Issues

- Ongoing media and public misunderstanding about aspects of climate change and the role of human activity.
- 2009 was Australia's second warmest year on record, with a mean temperature anomaly of +0.90°C compared to the 1961-1990 normal. 2009 also ends Australia's warmest decade on record (+0.48°C above the 1961-1990 normal).
- High temperatures were particularly notable during the second half of 2009, with Australia, Victoria, South Australia and NSW all recording their warmest July to December periods on record.

Key Points

- IPCC Fourth Assessment Report (Working Group 1) found that warming of the climate system is unequivocal.
- Global average surface temperature has increased by 0.74 [0.56 to 0.92] °C for the1906-2005 period. The highest annual temperature averaged over the globe occurred in 1998 and 2005.
- The global mean temperature for 2009 has been estimated at 0.44°C above the 1961-1990 normal (5th warmest year on record), with the last decade being the globe's warmest on record.
- Some aspects of observed changes in Australian climate can be attributed in part to greenhouse-induced climate change. These changes include the general warming that has occurred across the continent and reduced rainfall over parts of southern Australia.
- 2009 was marked by 3 extreme heatwave events: (1) A late January/early February heatwave in south-eastern Australia culminated in the Black Saturday bushfires. (2) An unusual winter-time heatwave occurred during August over large parts of inland Australia. (3) A prolonged heatwave occurred during November across central and southeast Australia leading to numerous new records at individual observation stations.
- A prolonged meteorological/hydrological drought continues to affect south-eastern Australia, including the southern half of the Murray-Darling Basin. Some regions have now been dry for the past 13 years, making the current dry spell the longest on record.

Provided by: ADC S47F
Cleared by a/DDS S47F
Date Updated: 14 January 2010

Political sensitivities / issues / implications

- There continues to be a mix in the media coverage of climate change issues, between those reporting on the mainstream scientific findings and those giving coverage to the view of a minority sceptical group. This has resulted in substantial public confusion.
- During a period when recurring and persistent drought has been prominent across large areas of Australia, and there is heightened media interest in the Carbon Pollution Reduction Scheme, any significant weather related events are likely to prompt some media interest in climate change.
- The Bureau of Meteorology is involved in many critical, scientific aspects of the climate change issue:
    - making systematic observations of meteorological and related variables that are used to compose the climate record;
    - managing Australia's climate record;
    - analysing and publishing the climate record;
    - conducting research into climate processes, modelling and shorter term climate predictions;
    - contributing to national and international collaboration on climate science, including the National Framework for Climate Change Science, the Pacific Climate Change Science Program and the World Climate Research Programme;
    - communicating climate science to industry decision makers, the media and the community at large; and
    - providing scientific advice to inform government policy.
- In late 2009 there was some discussion in the media on the topic of Australia being the hottest/driest continent. The facts are:

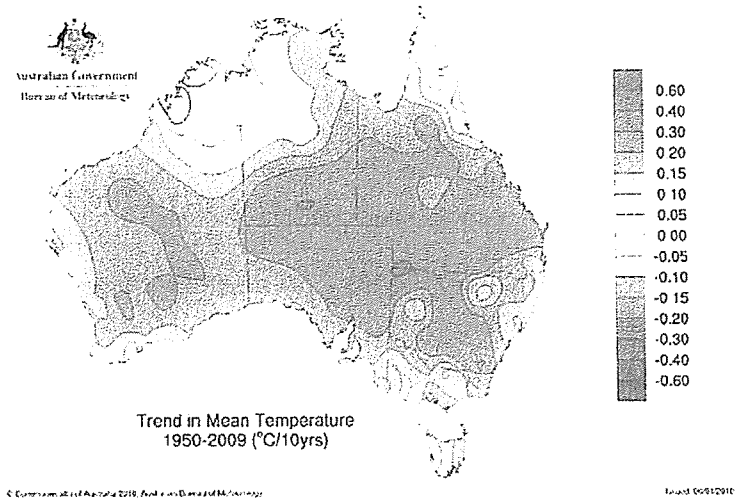
  Treating rainfall and temperature separately:
    - Australia is the second driest continent after Antarctica, and could reasonably be said to be the driest inhabited continent.
    - Australia is the second hottest continent after Africa.
    - A simple combined ranking of dryness and high temperature taken together would put Australia first, e.g. 2+2 = 4, next would be Africa (5+1 = 6).
    - Australia by a long way is neither the hottest nor the driest country on Earth. Most likely both would lie within the Saharan region of North Africa, e.g. Libya.

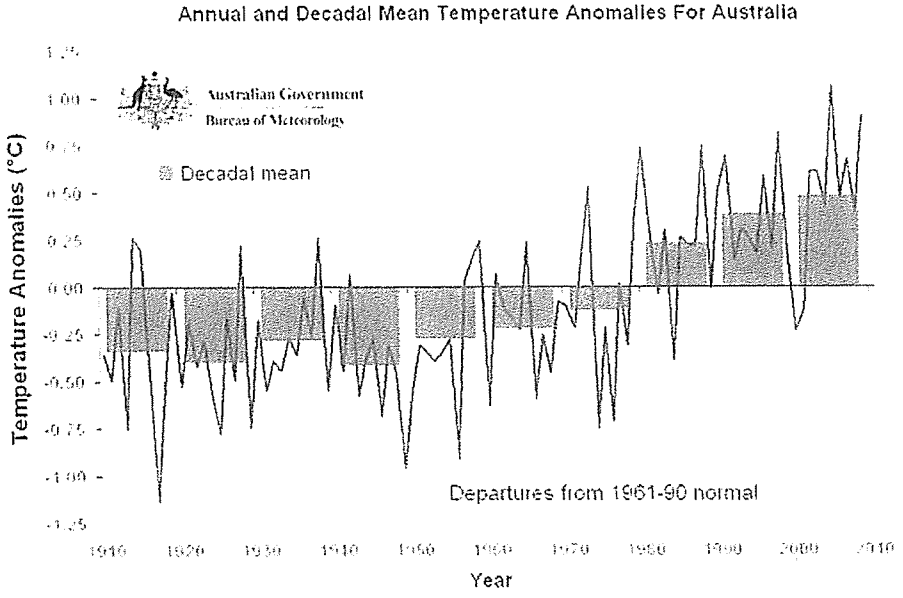
Provided by: ADC S47F
Cleared by a/DDS S47F
Date Updated: 14 January 2010

SENATE (ADDITIONAL) ESTIMATES BRIEFING
9 FEBRUARY 2010

Variations and Trends in Australian Rainfall and Temperature over the last 50-100 years.

Australia has experienced increases in temperature of about 1°C since the start of the 20th century. Most of this warming has occurred over the last 60 years with a nearly monotonic increase in temperature on the decadal time scale. The trends are reasonably uniform across space, but are largest in eastern and central parts of the continent.

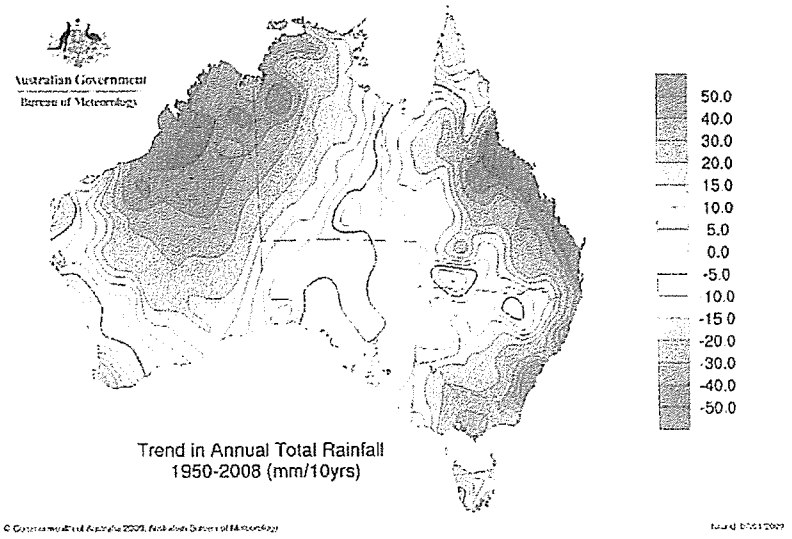




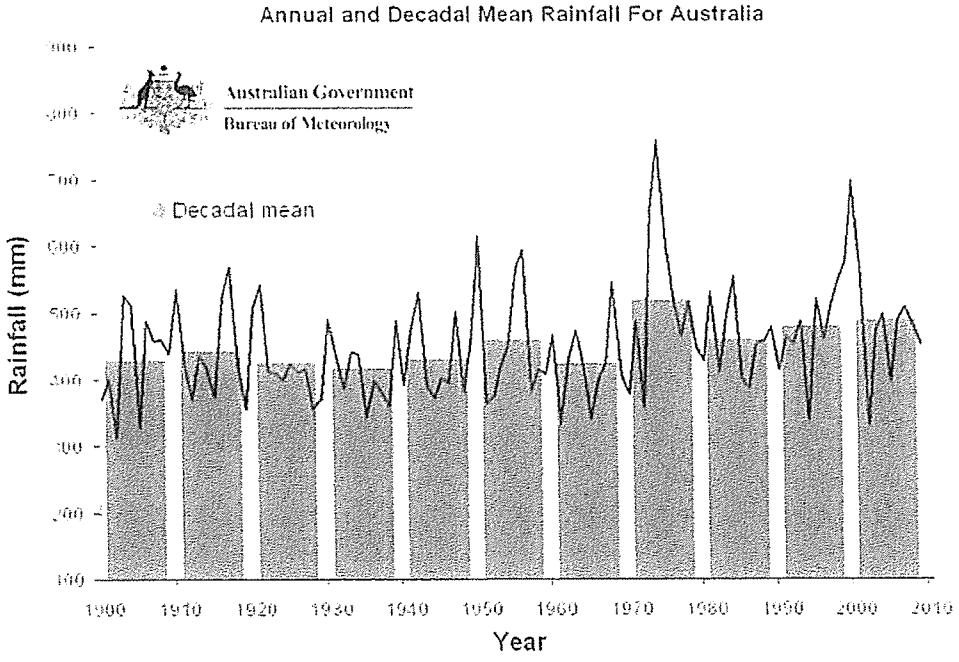
Rainfall changes have been mush less uniform in time and space. In general, the most notable feature of Australian rainfall is large seasonal and decadal variability. In the monsoonal climate of northern Australia, rainfall has

Provided by: ADC S47F
Cleared by a/DDS S47F
Date Updated: 14 January 2010

increased. The eastern third of Australia and the far south-west corner has experienced substantial decline in rainfall over the last 60 years.



Note update for 2009 is not yet available – data still being processed. (2009 was an average year for rainfall)



Data for the most recent year (2009) continue the broad trends in Australia's climate. The year was the second warmest on record with a mean temperature anomaly of +0.9°C above the 1961-1990 average. Rainfall was below average across most southern areas, and tended to be above average in the north.

Provided by: ADC S47F
Cleared by a/DDS S47F
Date Updated: 14 January 2010

SENATE (BUDGET) ESTIMATES BRIEFING
26 May 2010

CLIMATE CHANGE UPDATE

Issues

- Ongoing media and public misunderstanding about aspects of climate change and the role of human activity.
- 2009 was Australia's second warmest year on record, with a mean temperature anomaly of +0.90°C compared to the 1961-1990 normal. 2009 also ends Australia's warmest decade on record (+0.48°C above the 1961-1990 normal). Warm conditions have continued into early 2010 with the January-April period being the fourth-warmest on record (provisionally 0.75°C above the 1961-1990 normal).
- High temperatures were particularly notable during the second half of 2009, with Australia, Victoria, South Australia and NSW all recording their warmest July to December periods on record. These high temperatures have continued into the early months of 2010 in particular in Victoria and Tasmania.

Key Points

- IPCC Fourth Assessment Report (Working Group 1) found that warming of the climate system is unequivocal.
- Global average surface temperature has increased by 0.74 [0.56 to 0.92] °C for the1906-2005 period. The highest annual temperature averaged over the globe occurred in 1998 and 2005.
- The global mean temperature for 2009 has been estimated at 0.44°C above the 1961-1990 normal (5th warmest year on record), with the last decade being the globe's warmest on record. Despite an unusually cold winter in some mid-latitude Northern Hemisphere regions, including western Europe, the southern United States and parts of north-east Asia, globally January-March 2010 has been the fourth warmest on record, with the Southern Hemisphere warmest on record.
- Some aspects of observed changes in Australian climate can be attributed in part to greenhouse-induced climate change. These changes include the general warming that has occurred across the continent and reduced rainfall over parts of southern Australia.
- 2009 was marked by 3 extreme heatwave events: (1) A late January/early February heatwave in south-eastern Australia culminated in the Black Saturday bushfires. (2) An unusual winter-time heatwave occurred during August over large parts of inland Australia. (3) A prolonged heatwave occurred during November across central and southeast Australia leading to numerous new records at individual observation stations.
- A prolonged meteorological/hydrological drought continues to affect south-eastern Australia, including the southern half of the Murray-Darling Basin. Some regions have now been dry for the past 13 years, making the current dry spell the longest on record. Heavy rains in some areas in the early months of 2010 have alleviated short-term drought but have had only a limited impact on long-term rainfall deficiencies.

Provided by: ADC S47F
Cleared by: DDS S47F
Date Updated: 3 May 2010

- Both Victoria and Tasmania have just recorded their warmest 12 month period since records began. Victoria's mean temperature during the 12 months to the end of April was 15.36°C, passing the previous record of 15.25°C set between February 2007 and January 2008. Likewise, Tasmania recorded a mean temperature from May 2009 to April 2010 of 11.43°C, passing its previous record of 11.34°C set between May 1988 and April 1989.

Political sensitivities / issues / implications

- There continues to be a mix in the media coverage of climate change issues, between those reporting on the mainstream scientific findings and those giving coverage to the view of a minority sceptical group. This has resulted in substantial public confusion.
- During a period when recurring and persistent drought has been prominent across large areas of Australia, and there is heightened media interest in the Carbon Pollution Reduction Scheme, any significant weather related events are likely to prompt some media interest in climate change.
- The Bureau of Meteorology is involved in many critical, scientific aspects of the climate change issue:
    - making systematic observations of meteorological and related variables that are used to compose the climate record;
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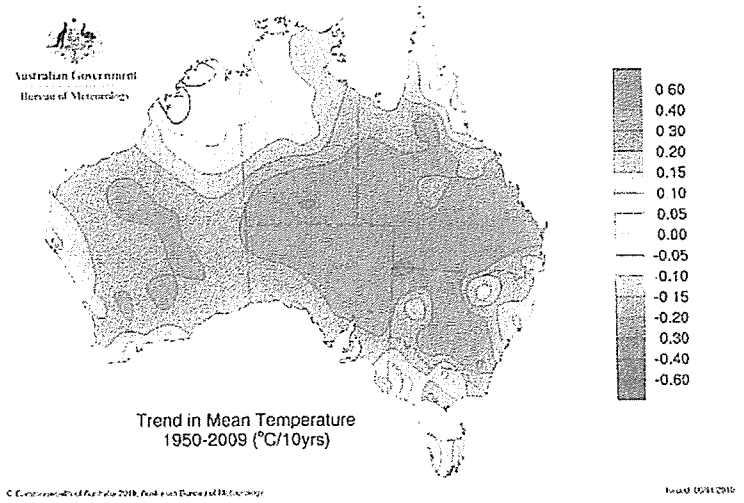
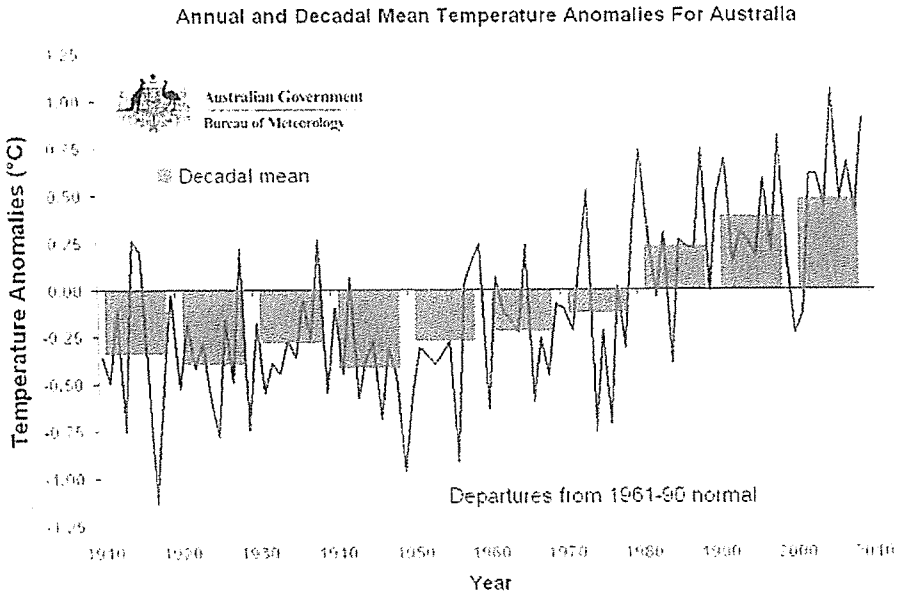
    - conducting research into climate processes, modelling and shorter term climate predictions;
    - contributing to national and international collaboration on climate science, including the National Framework for Climate Change Science, the Pacific Climate Change Science Program and the World Climate Research Programme;
    - communicating climate science to industry decision makers, the media and the community at large; and
    - providing scientific advice to inform government policy.

SENATE (BUDGET) ESTIMATES BRIEFING
26 MAY 2010

Variations and Trends in Australian Rainfall and Temperature over the last 50-100 years.

Australia has experienced increases in temperature of about 1°C since the start of the 20th century. Most of this warming has occurred over the last 60 years with a nearly monotonic increase in temperature on the decadal time scale. The trends are reasonably uniform across space, but are largest in eastern and central parts of the continent.

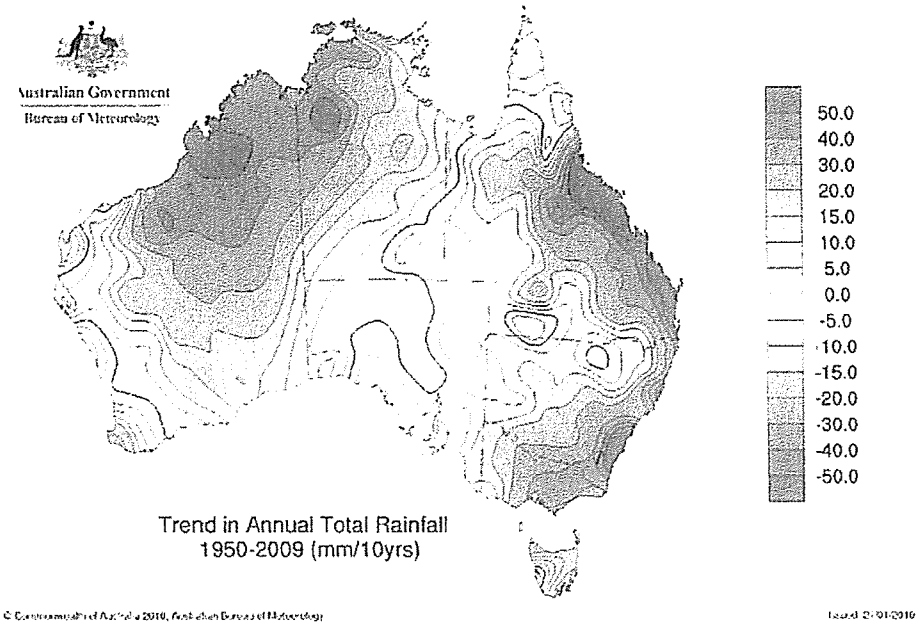


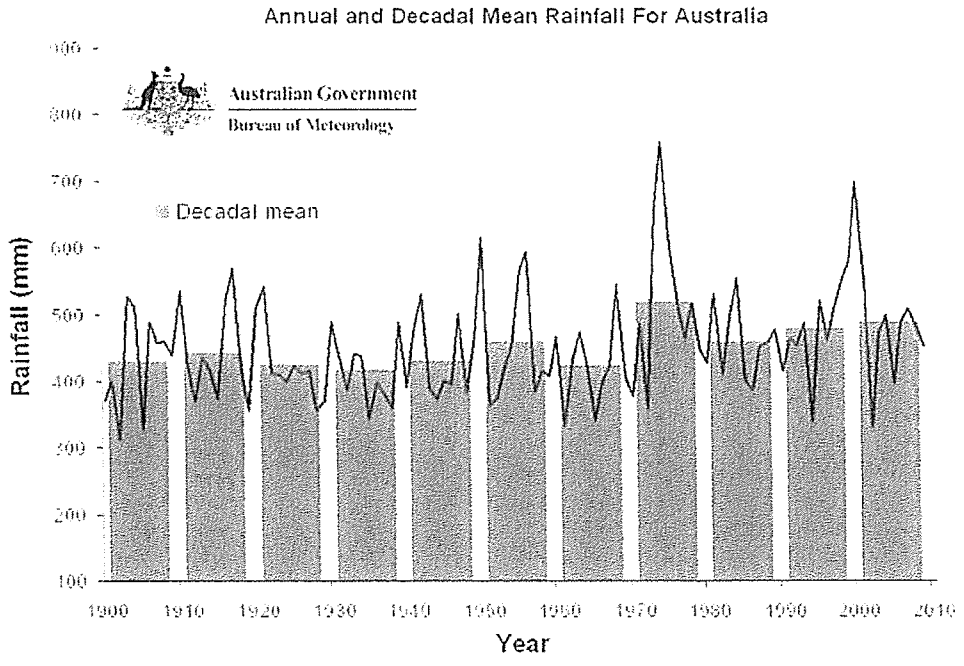


Rainfall changes have been mush less uniform in time and space. In general, the most notable feature of Australian rainfall is large seasonal and decadal variability. In the monsoonal climate of northern Australia, rainfall has

Provided by: ADC S47F
Cleared by : DDS S47F
Date Updated: 3 May 2010

increased. The eastern third of Australia and the far south-west corner has experienced substantial decline in rainfall over the last 60 years.





Data for the most recent year (2009) continue the broad trends in Australia's climate. The year was the second warmest on record with a mean temperature anomaly of +0.9°C above the 1961-1990 average. Rainfall was below average across most southern areas, and tended to be above average in the north.

Provided by: ADC S47F
Cleared by : DDS S47F
Date Updated: 3 May 2010

SENATE (SUPPLEMENTARY) ESTIMATES BRIEFING
18 OCTOBER 2010

CLIMATE CHANGE UPDATE

Issues

- Ongoing media and public misunderstanding about aspects of climate change and the role of human activity.
- 2009 was Australia's second warmest year on record, with a mean temperature anomaly of +0.90°C compared to the 1961-1990 normal. 2009 also ends Australia's warmest decade on record (+0.48°C above the 1961-1990 normal).).
- While 3 months remain in 2010, the year is now likely to be one of Australia's wettest years on record (probably in the top 10). The wet condition are associated with a La Niña event.
- Temperatures during 2010 have continued to be above average for Australia, though somewhat cooler than 2009. The year-to-date mean temperature anomaly is currently +0.4°C above the 1961-90 average.

Key Points

- IPCC Fourth Assessment Report (Working Group 1) found that warming of the climate system is unequivocal.
- Global average surface temperature has increased by 0.74 [0.56 to 0.92]°C for the1906-2005 period. The highest annual temperature averaged over the globe occurred in 1998 and 2005.
- The global mean temperature for 2009 has been estimated at 0.44°C above the 1961-1990 normal (5th warmest year on record), with the last decade being the globe's warmest on record. It is likely that 2010 will be the warmest or second warmest year on record at the earth's surface, though the exact rank is uncertain with 3 months left in the year.
- Temperatures during 2010 have continued to be above average for Australia, though somewhat cooler than 2009. The year-to-date mean temperature anomaly is currently +0.4°C above the 1961-90 average meaning that the year is likely to come in between 10th to 15th warmest on record.
- Some aspects of observed changes in Australian climate can be attributed in part to greenhouse-induced climate change. These changes include the general warming that has occurred across the continent and reduced rainfall over parts of southern Australia.
- The 2010 La Nina event has been associated with heavy rainfall across most of northern and eastern Australia. This rainfall has provided some relief to long-term rainfall deficiencies in parts of the southeast including the Murray-Darling Basin. It is now likely that the year will be one of Australia's wettest years on record (possibly top 10).

Provided by: A/g ADC S47F
Cleared by (A/g DDW): S47F
Date Updated: 1 October 2010

Political sensitivities / issues / implications

- There continues to be a mix in the media coverage of climate change issues, between those reporting on the mainstream scientific findings and those giving coverage to the view of a minority sceptical group. This has resulted in substantial public confusion.
- The Bureau of Meteorology is involved in many critical, scientific aspects of the climate change issue:
    - making systematic observations of meteorological and related variables that are used to compose the climate record;
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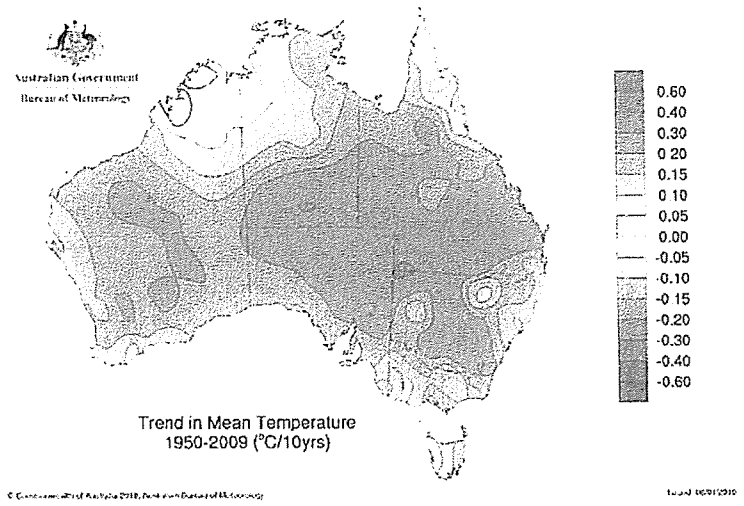
    - communicating climate science to industry decision makers, the media and the community at large; and
    - providing scientific advice to inform government policy.

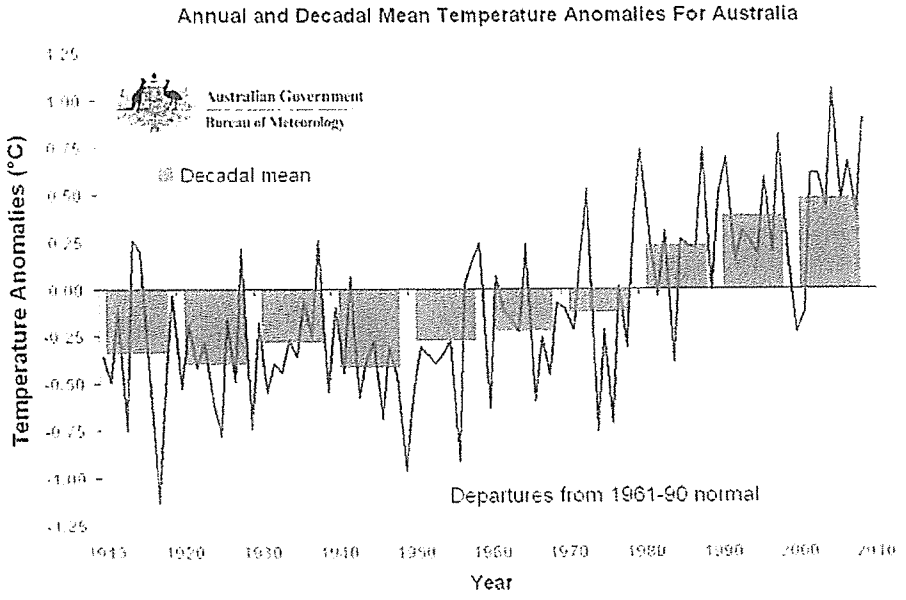
Provided by: A/g ADC S47F
Cleared by (A/g DDW): S47F
Date Updated: 1 October 2010

SENATE (SUPPLEMENTARY) ESTIMATES BRIEFING
18 OCTOBER 2010

Variations and Trends in Australian Rainfall and Temperature over the last 50-100 years.

Australia has experienced increases in temperature of about 1°C since the start of the 20th century. Most of this warming has occurred over the last 60 years with a nearly monotonic increase in temperature on the decadal time scale. The trends are reasonably uniform across space, but are largest in eastern and central parts of the continent.

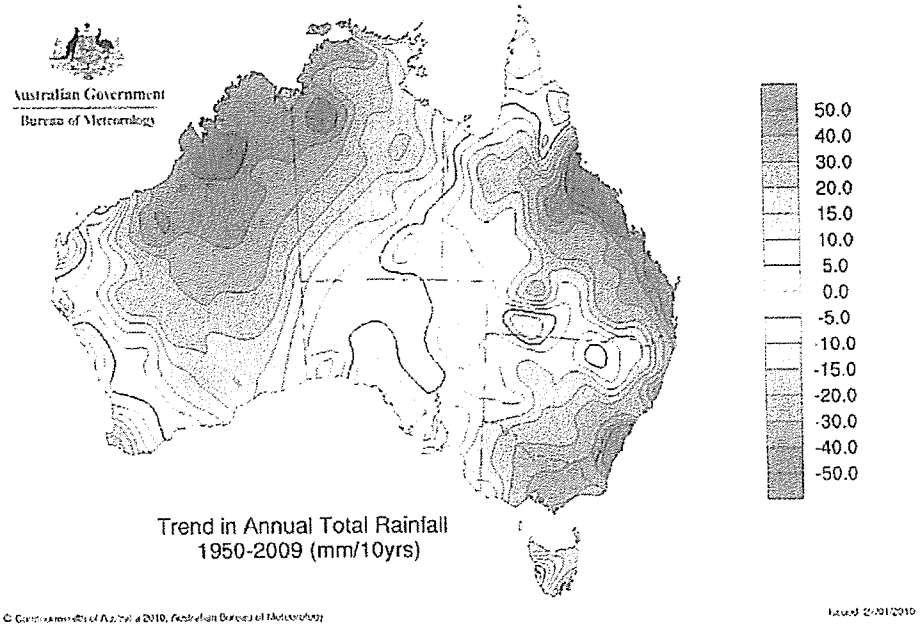


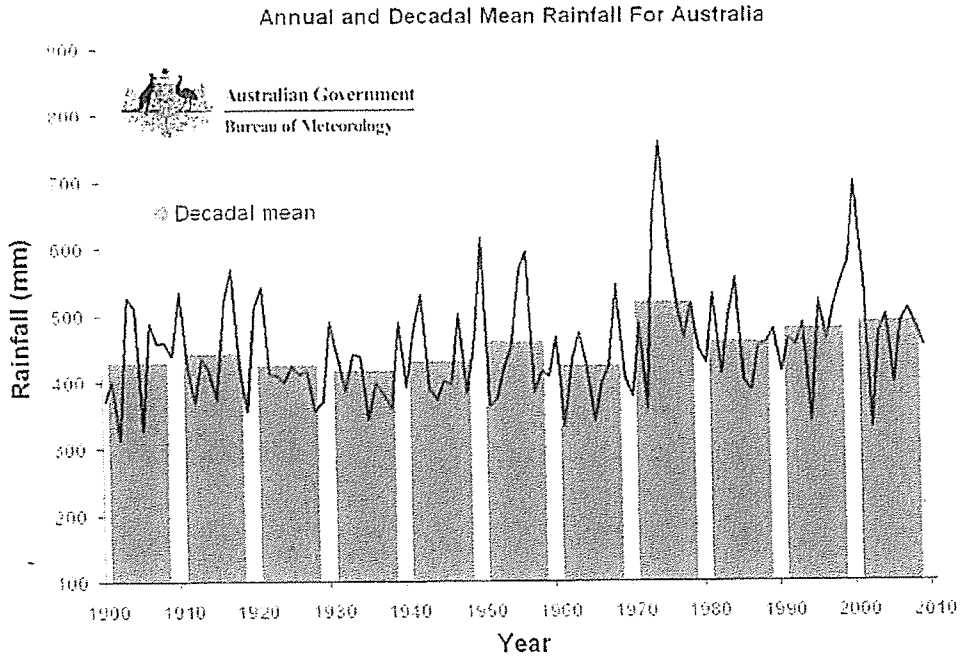


Rainfall changes have been mush less uniform in time and space. In general, the most notable feature of Australian rainfall is large seasonal and decadal variability. In the monsoonal climate of northern Australia, rainfall has

Provided by: A/g ADC
Cleared by (A/g DDW):
Date Updated: 1 October 2010

increased. The eastern third of Australia and the far south-west corner has experienced substantial decline in rainfall over the last 60 years.





Data for the most recent year (2009) continue the broad trends in Australia's climate. The year was the second warmest on record with a mean temperature anomaly of +0.9°C above the 1961-1990 average. Rainfall was below average across most southern areas, and tended to be above average in the north.

While there are three months remaining, the current indications are that 2010 will be one of Australia's wettest years on record (likely top 10) with above

Provided by: A/g ADC
Cleared by (A/g DDW):
Date Updated: 1 October 2010

average rainfall across most northern and eastern areas. In some contrast the southwest has experienced an exceptionally (record) dry year.

Provided by: A/g ADC
Cleared by (A/g DDW):
Date Updated: 1 October 2010

SENATE (ADDITIONAL) ESTIMATES BRIEFING
21 FEBRUARY 2011

CLIMATE CHANGE UPDATE

Issues

- Ongoing media and public misunderstanding about aspects of climate change and the role of human activity.
- 2010 was Australia's wettest year since 2000 and the second-wettest year on record (records commence in 1900). The extremely wet conditions are associated with one of the strongest La Niña events in recorded history.
- Mean temperatures in 2010 were cooler than those for the previous eight years but overall Australia's annual mean temperature for 2010 was +0.2°C above the 1961 to 1990 average.

Key Points

- IPCC Fourth Assessment Report (Working Group 1) found that warming of the climate system is unequivocal. Global average surface temperature has increased by 0.74°C ± 0.18°C for the 1906 - 2005 period.
- The global mean temperature for 2010 has been estimated at 0.53°C above the 1961-1990 normal making it the warmest year on record (though statistically the same as 2005 and 1998). The last decade was also the globe's warmest on record.
- Mean temperatures in 2010 were cooler than those for the previous eight years but overall Australia's annual mean temperature for 2010 was +0.2°C above the 1961 to 1990 average
- Some aspects of observed changes in Australian climate can be attributed in part to greenhouse-induced climate change. These changes include the general warming that has occurred across the continent and the oceans.
- Sea surface temperatures in the Australian region during 2010 were +0.54 °C above the 1961 to 1990 average. This is the warmest value on record for the Australian region. The most recent decade (2001–2010) was also the warmest decade on record for sea surface temperatures following the pattern observed over land.
- The current La Niña event has been associated with record rainfalls and widespread flooding across eastern Australia. The "long dry" which commenced in late 1996 in the far southeast of mainland Australia and late 2001 across much of the Murray-Darling Basin has effectively ended. In contrast, the southwest of Western Australia experienced a very dry year, continuing the long drying trend which extends back to the late 1960s.

Provided by: A/g ADC S47F
Cleared by DDW: 7 February 2011
Date Updated: 27 January 2011

Political sensitivities / issues / implications

- There continues to be a mix in the media coverage of climate change issues, between those reporting on the mainstream scientific findings and those giving coverage to the view of a minority "sceptical" group. This has resulted in substantial public confusion, and a failure by the public to recognise the significance of the climate change issue.
- The Bureau of Meteorology is involved in many critical, scientific aspects of the climate change issue:
    - making systematic observations of meteorological and related variables that are used to compose the climate record;
    - managing Australia's climate record;
    - analysing and publishing the climate record;
    - conducting research into climate processes, modelling and shorter term climate predictions;
    - contributing to national and international collaboration on climate science, including the National Framework for Climate Change Science, the Pacific Climate Change Science Program and the World Climate Research Programme;
    - communicating climate science to industry decision makers, the media and the community at large; and
    - providing scientific advice to inform government policy.

Background

Recent temperature observations for Australia and the globe show continued global warming, with 2010 the warmest year on record for global surface temperatures. Comparison with climate projections from the IPCC (for example) show that the ocean-atmosphere-cryosphere is behaving as predicted, with warming temperatures, rising sea levels, an accelerating hydorological cycle and the loss of snow and ice.

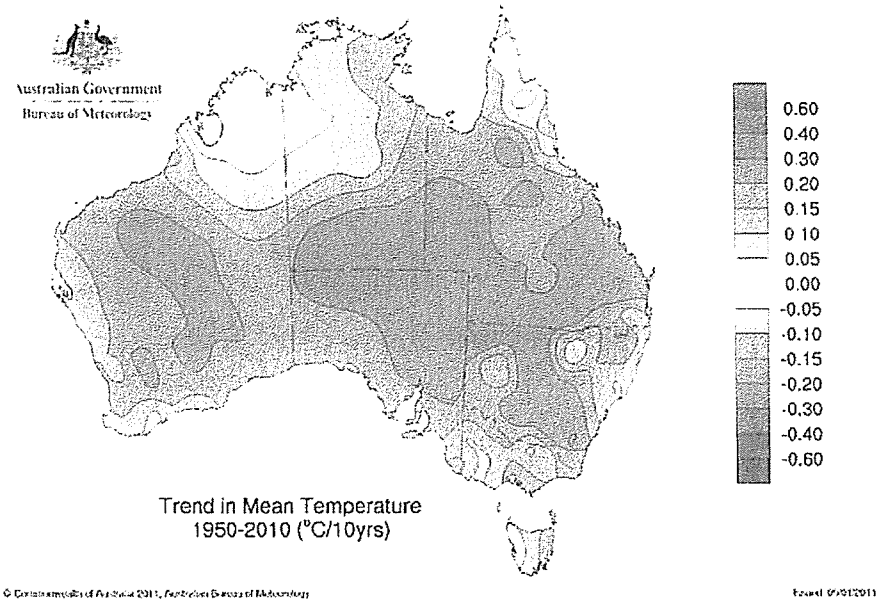
An important issue that the last year has highlighted is that climate variability remains important in determining the weather and climate in a particular year. The strong 2010/11 La Niña saw drought breaking rainfall across eastern Australia, despite the "presence" of a long drying trend in many areas. Communicating that very wet conditions in a particular year are not inconsistent with a drying climate, and do not mean that a trend has reversed will remain a challenge.

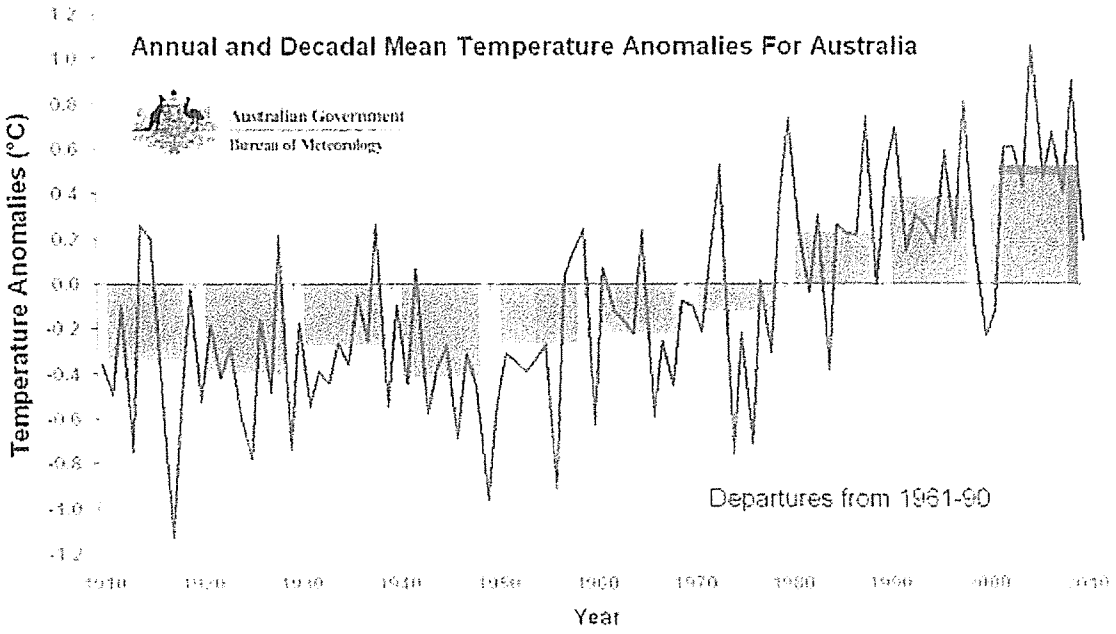
Provided by: A/g ADC S47F
Cleared by DDW: 7 February 2011
Date Updated: 27 January 2011

SENATE (ADDITIONAL) ESTIMATES BRIEFING
21 FEBRUARY 2011

Variations and Trends in Australian Rainfall and Temperature over the last 50-100 years.

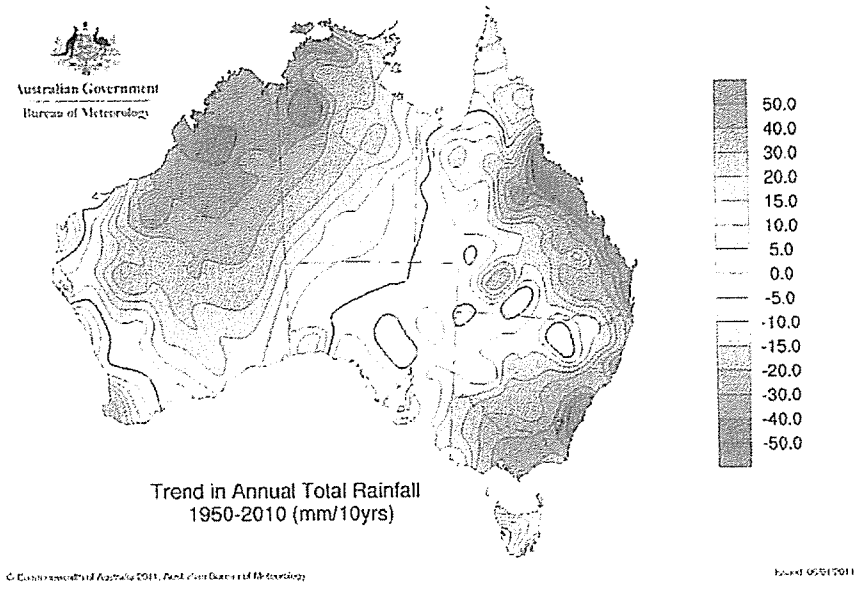
Australia has experienced increases in temperature of about 1°C since the start of the 20th century. Most of this warming has occurred over the last 60 years with a nearly monotonic increase in temperature on the decadal time scale. The trends are reasonably uniform across space, but are largest in subtropical parts of the continent.



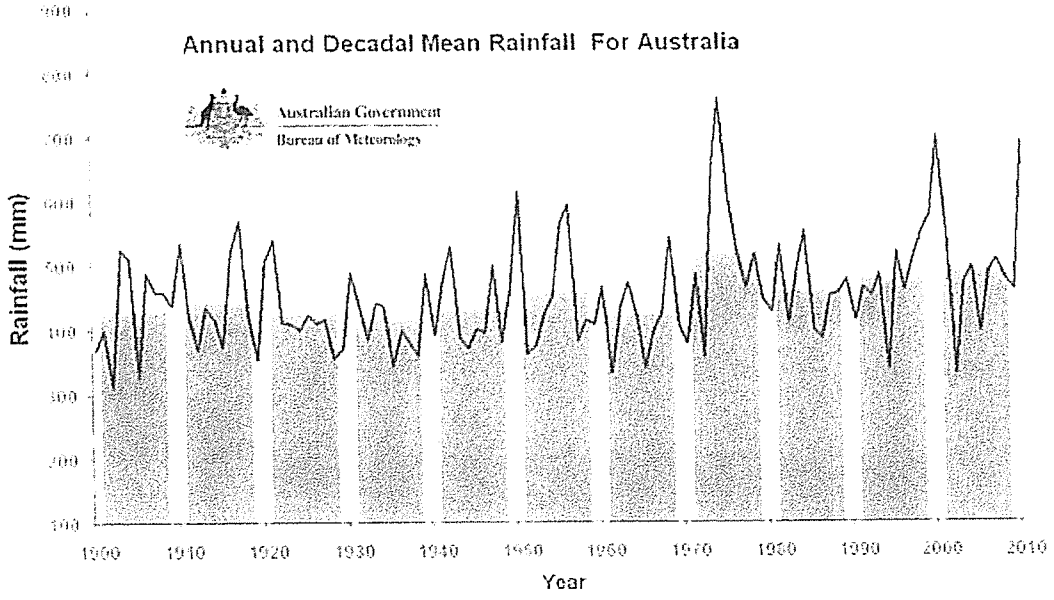


Provided by: A/g ADC S47F
Cleared by (DDW): 8 February 2011
Date Updated: 27 January 2011

Rainfall changes have been much less uniform in time and space. In general, the most notable feature of Australian rainfall is large seasonal and decadal variability. In the monsoonal climate of northern Australia, rainfall has increased. The eastern third of Australia and the far south-west corner has experienced substantial decline in rainfall over the last 60 years, not withstanding the wet conditions in many areas during 2010.



Trend in Annual Total Rainfall
1950-2010 (mm/10yrs)



2010 was Australia's wettest year since 2000 and the second-wettest year on record (records commence in 1900). The Australian mean rainfall total for 2010 was 690 mm, well above the long-term average of 465 mm. However, Southwest Western Australia had its driest year on record.

Provided by: A/g ADC S47F
Cleared by (DDW): 8 February 2011
Date Updated: 27 January 2011

Mean temperatures in 2010 were cooler than those for the previous eight years, but even so Australia's annual mean temperature for 2010 was +0.2 °C above the 1961 to 1990 average.

Provided by: A/g ADC S47F
Cleared by (DDW): 8 February 2011
Date Updated: 27 January 2011

3.11 CLIMATE CHANGE UPDATE

Issues

- Ongoing contention about aspects of climate change and the role of human activity.
- Likelihood that 2011 temperatures for Australia will average an anomaly of near 0.0 °C.

Key Points

- The global mean temperature for 2010 has been estimated at 0.53°C above the 1961 to 1990 normal, making it the warmest year on record (though statistically the same as 2005 and 1998). Global temperatures for 2011 are likely to be slightly cooler than in 2010.
- Australian mean temperatures in 2010 were cooler than those for the previous eight years, but overall Australia's annual mean temperature for 2010 was +0.2 °C above the 1961 to 1990 average.
- The 2010-11 La Niña (with very wet conditions) and anomalous southerly flow over eastern parts of Australia means that 2011 is likely to be Australia's coolest year since 2000 with an anomaly of near 0.0 °C expected.
- 2011 has been another very wet calendar year, with the average Australian rainfall total for January to September of 528mm being the second highest on record (behind 631mm in 1974).

Political sensitivities / issues / implications

- There continues to be confusion in the media coverage of climate change science and observations.
- The cooler temperature over Australia in 2011 may lead some commentators to suggest that global warming has ceased.
- The Bureau of Meteorology is involved in many critical, scientific and operational aspects of the climate change issue:
    - Making systematic observations of meteorological and related variables that are used to compose the climate record;
    - Analysing and publishing the climate record;
    - Conducting research into climate processes, modelling and shorter term climate predictions;
    - Contributing to national and international collaboration on climate science, including the National Framework for Climate Change Science, the Pacific Climate Change Science Program and the World Climate Research Programme;

Provided by: ADC. Lead author STCA
Cleared by DDW: 11 October 2011
Date Updated: 11 October 2011

- Communicating climate science to industry decision makers, the media and the community at large; and
- Providing scientific advice to inform government policy.

Background

Annual Mean Surface Temperature Anomaly

Australia			Global		
Year	Anomaly	Rank*	Year	Anomaly	Rank^
1990	0.5	12	1990	0.25	16
1991	0.69	6	1991	0.21	17
1992	0.14	35	1992	0.07	28
1993	0.31	16	1993	0.1	26
1994	0.25	24	1994	0.17	20
1995	0.17	33	1995	0.28	15
1996	0.59	10	1996	0.14	22
1997	0.2	29	1997	0.35	11
1998	0.81	3	1998	0.53	1
1999	0.18	32	1999	0.31	13
2000	-0.23	58	2000	0.28	14
2001	-0.13	50	2001	0.41	9
2002	0.61	9	2002	0.46	5
2003	0.61	8	2003	0.47	4
2004	0.43	14	2004	0.45	6
2005	1.06	1	2005	0.48	2
2006	0.47	13	2006	0.43	8
2007	0.68	7	2007	0.4	10
2008	0.41	15	2008	0.33	12
2009	0.9	2	2009	0.44	7
2010	0.19	31	2010	0.48	3

*since 1910

^since 1850

in comparison to the 1961-1990 average

Provided by: ADC. Lead author STCA
Cleared by DDW: 11 October 2011
Date Updated: 11 October 2011

3.8 CLIMATE CHANGE UPDATE INCLUDING ANNUAL CLIMATE STATEMENT 2011

ISSUES

Cooler Australian temperatures in 2011 may be interpreted as a slowing or reversal of post-1950 trends but are largely a consequence of wetter La Niña conditions.

KEY POINTS

- The global mean temperature for 2011 has been estimated at 0.41°C above the 1961 to 1990 normal, making the year the warmest La Niña year on record.
- The Australian mean temperature anomaly in 2011 was -0.14°C, being the first below average year since 2001.
- The 2010/11 and 2011/12 La Niña events (with very wet conditions) and anomalous southerly flow over eastern parts of Australia were responsible for the below average temperatures in 2011.
- Averaged across Australia, the 2011 rainfall was 705 mm, making the year the second wettest on record behind 1974 with 760mm, and ahead of 2010 (third place) with 703mm.

POSSIBLE QUESTIONS & SUGGESTED RESPONSES/ANSWERS

Do the cool temperatures for Australia in 2011 mean global warming has stopped?

The last decade was Australia's equal warmest decade on record (anomaly of +0.52°C). The cooler conditions in 2011 were mainly a result of two consecutive La Niña events and associated high rainfall which acted to cool Australian temperatures and offset the background warming trend. Australian temperatures will very likely continue to warm in the long term as a result of the enhanced greenhouse effect, and we expect a return to above average annual temperatures as the current La Niña event declines.

2010 was the warmest year on record for the earth, while the last decade has been the warmest decade on record, highlighting the continuation of the warming trend.

Written by: S47F (STCA). Reviewed by ADC S47F
Cleared by: S47F, a/DDW
Date Updated: 30 January 2012

Do the current wet conditions mean that concerns about global warming are wrong?

Australia has a history of flood and drought periods, largely as a result of El Niño and La Niña events. The last two very wet years are a result of consecutive significant La Niña events which are most likely unrelated to climate change (though noting the next para).

We expect in the long term that the cycle of droughts and floods over Australia will increase, and as a result exacerbate the cycling through droughts to floods. This is because a warmer planet experiences faster rates of evaporation so droughts tend to be hotter with higher evaporation, while heavy rainfall also increases as a hotter atmosphere can hold more moisture. Global data show an increase in both floods and drought events, and are consistent with projections. There is evidence that climate change has increased the severity of drought in parts of Australia, but the evidence is currently less clear with more intense rainfall.

FURTHER BACKGROUND INFORMATION

2011 commenced with a significant La Niña event which decayed in autumn 2011. The La Niña was record breaking in terms of the magnitude of the SOI, and was associated with record 2010 spring and summer rainfall.

A second La Niña then developed in spring 2011 and continued into summer 2011-12. This current La Niña has been weaker than that of 2010-11 in terms of the magnitude of the SOI and central Pacific sea surface temperature anomalies. Record warm conditions in the eastern Indian Ocean, combined with a positive SOI, have created favourable conditions for above average rainfall across Australia over the last few months.

Averaged across Australia, the 2011 rainfall was 705 mm, making the year the second wettest on record behind 1974 with 760mm, and ahead of 2010 (third place) with 703mm.

The affect of the back-to-back La Niña was such that the two year rainfall for 2010-2011 of 1408mm is the highest on recording, surpassing the old record of 1407mm set during 1973-1974. The record high rainfall total is composed of the second (2011) and third (2010) wettest years on record for Australia.

Preliminary annual temperatures were below average for Australia in 2011 with an all-Australian anomaly of -0.14°C. Preliminary maximum temperatures averaged -0.25 °C below normal across the country in 2011, while minima averaged -0.03 °C below normal. This is the first year that the continent has seen a negative anomaly since 2001, which was also a La Niña year with above average rainfall.

Seven of the last eight sustained La Niña years were associated with cooler than average temperatures.

Written by: S47F (STCA). Reviewed by ADC S47F
Cleared by: S47F a/DDW
Date Updated: 30 January 2012

The below average temperature for Australia largely reflects cooler than average conditions in tropical and subtropical Australia. In contrast, most of southern Australia experienced above average temperatures, while parts of west coast WA and southwest WA experienced their warmest year on record.

Despite the relatively cooler conditions in 2011, the 10-year average demonstrates the rising trend in temperatures, with 2002-2011 likely to be in the top 2 warmest (currently equal-warmest, with 2001-2010) such periods on record for Australia, with a preliminary temperature anomaly of 0.52 °C.

Using preliminary data, the global mean temperature for 2010 (January–October) has been estimated at 0.41 °C above the 1961-1990 climatological average. At present, 2011's nominal value ranks as the equal 10th highest on record, with the 13 warmest years having all occurred in the past 15 years.

Global temperatures in 2011 have not been as warm as the record-breaking values seen in 2010 but have been warmer than any previous La Niña year.

Written by: S47F (STCA). Reviewed by ADC S47F
Cleared by: S47F, a/DDW
Date Updated: 30 January 2012

SENATE (BUGDET) ESTIMATES BRIEFING
22 MAY 2012

3.4 STATE OF THE CLIMATE REPORT 2012

ISSUES

- The State of the Climate Report 2012 was released on World Meteorological Day, 14 March 2012.
- The 2012 State of the Climate Report provided a two year update to the 2010 report. The focus being mainly on observations of climate variability and change.
- The 2012 release was more comprehensive in terms of the range of scientific issues and observations that were summarised.
- There was extensive media coverage of the 2012 report.

KEY POINTS

- The Bureau's new ACORN-SAT temperature data base was used in the preparation of the report, which shows that Australia has warmed by around 1°C since 1910.
- The CSIRO have found that the heat content of the world's oceans has increased during recent decades, increasing the volume of ocean waters and contributing to rises in sea-level.
- The report also summarised the most recent science on the causes of observed warming. The warming trends observed around Australia are consistent with global-scale warming, despite 2010 and 2011 being the coolest years recorded in Australia since 2001. This warming is most likely due to increasing greenhouse gases.
- The relatively cool conditions experienced in the last two years are largely as a result of wet conditions caused by consecutive La Niña events.
- The concentration of CO_2 in the atmosphere in 2011 was 390 parts per million – higher than at any time for the past 800,000 years.
- The report provided a brief section on future projected climate change, outlining further warming of Australia and likely reductions in wintertime rainfall by mid century.

Written by: Lead author S47F Reviewed by ADC S47F
Cleared by: S47F, a/DDW
Date Updated: 11 May 2012

SENATE (BUGDET) ESTIMATES BRIEFING
22 MAY 2012

POSSIBLE QUESTIONS & SUGGESTED RESPONSES/ANSWERS

There has been two recent consecutive years of cooling. Is this the beginning of a reversal of the global warming trend?

The Bureau of Meteorology and CSIRO's *State of the Climate 2012* concludes that that the Australian long-term warming trend has not changed, with each decade having been warmer than the previous decade since the 1950s. During the past two years, Australia experienced record rainfalls and the coolest temperatures since 2001 due to a very strong La Niña event in 2010 and 2011. Such inter-annual variability (blips) are to be expected.

Why did the Bureau (and CSIRO) release a State of the Climate Report?

Through consultation with Bureau of Meteorology and CSIRO stakeholders, a need to provide digestible summaries of climate science and climate observations was identified prior to the 2010 report. Two years is considered an appropriate reporting frequency to update on the state of Australian and global climate in the context of climate change.

BACKGROUND

- The report is available from http://www.csiro.au/en/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx

Written by: Lead author S47F Reviewed by ADC S47F
Cleared by: S47F, a/DDW
Date Updated: 11 May 2012

4.2 VARIATIONS AND TRENDS IN AUSTRALIAN RAINFALL AND TEMPERATURE OVER THE LAST 50-100 YEARS

ISSUES

- Although the total Australian rainfall over the last 60 years is showing a positive trend, southern rainfall volumes have generally declined over the typical higher rainfall seasons autumn and winter. Total annual rainfall has also declined over much of eastern Australia since the 1950s.
- Monsoonal rainfall volumes have increased over Northern Australia since the 1970s.

KEY POINTS

- Analysis of long term trends in Australian temperature show a continuation of warming across the continent.
- There is an increase in warm weather records across Australia and a decrease in cold weather records.
- There are fewer individual cooler-than-average years in Australia, with 2011 (-0.12°C below the 1961-90 normal) being the only below average year in the last decade (2002 to 2011).
- There has been some relief from hydrological drought conditions in the southeast with heavy rainfall across the country influenced by two La Niña events during 2010 to 2012. This has led to a substantial improvement in water storage levels everywhere except for the south-west of Western Australia.
- The heavy rainfall has largely been in spring and summer, whereas declines in rainfall in southern areas (trends over the last one to two decades) have occurred in autumn and winter.

POSSIBLE QUESTIONS & SUGGESTED ESPONSES/ANSWERS

Q. Has the recent rainfall changed our understanding of climate change impacts on Australia?

No. The heavy rainfall of 2010 and 2011 is mostly due to natural variability. Climate projections indicate a drying (on average) over southern and eastern Australia during the cooler months of the year. However high rainfall events are expected to become heavier as the climate warms.

Written by: S47F (STCA), S47F
Reviewed by ADC Mobile: S47F
Cleared by: (DDW)
Last updated: 1 October 2012

Q. *Was too much concern raised over drought conditions prior to La Nina events in 2010 and 2011?*

Despite the record spring and summer rainfall during the last two years; rainfall drying trends remain during the key seasons of autumn and winter across southern Australia. The last drought brought severe hydrological impacts; any extension of those conditions will test some hydrological resources.

Q. *Why has it been cool in Australia recently?*

Australian temperature variability is closely related to rainfall, with years of high rainfall typically cooler than years of low rainfall. For this reason, the record rainfall of 2010 and 2011 was consistent with temperatures that were cooler than the past decade or more. However Australia was one of the few regions of the world to experience cooler temperatures during this period.

FURTHER BACKGROUND INFORMATION

- Australia has experienced increases in temperature of about 1°C since the start of the 20th century. Most of this warming has occurred over the last 60 years (i.e. since 1950) with a nearly monotonic increase in temperature on the decadal time scale. The trends are reasonably uniform across space, but are largest in subtropical parts of the continent and a little less near the coast.
- The last decade was the warmest on record for Australia, although 2011 was slightly cooler than average, in association with heavy rainfall across the continent. Above-average rainfall was also associated with generally below-average temperatures in the first quarter of 2012.
- The Bureau of Meteorology launched a new long-term temperature data set (ACORN-SAT) in March 2012. Values from the new data set are used in this document.
- Rainfall changes have been much less uniform in time and space. The most notable feature of Australian rainfall is large seasonal and interannual variability. Rainfall totalled over the entire continent has increased over the last 60 years. This is mostly due to increases in monsoonal rainfall over northern Australia since the mid 20th Century. The southeast of Australia and the far southwest corner have both experienced a decline in rainfall over the last 30 years, not withstanding the wet conditions in many areas from 2010 to 2011.
- The southern rainfall declines have been concentrated in the autumn and winter seasons. It should be noted that heavy rainfall in recent years has occurred in conjunction with La Niña events and been concentrated in spring and summer. Underlying rainfall deficiencies were still apparent in the winter of 2011, and this ongoing trend has possible implications for water resources and agriculture.
- The long-term average of Australian-mean rainfall is 465mm. 2010 (702mm) was Australia's third-wettest year on record while 2011 (704mm) was the second-wettest year on record (records commence in 1900). Above-average rainfall has continued into 2012 with the January-March 2012 total (279 mm) ranking as the ninth highest on record.

Written by: S47F (STCA), S47F
Reviewed by ADC Mobile: S47F
Cleared by: (DDW)
Last updated: 1 October 2012

4.2 VARIATIONS AND TRENDS IN AUSTRALIAN RAINFALL AND TEMPERATURE OVER THE LAST 50-100 YEARS

ISSUES

- Some elements of the media and public have a tendency to interpret recent weather and climate anomalies as being indicators of climate change (or lack of climate change).

KEY POINTS

- Australian land and ocean temperatures show approximately 1°C of warming since 1910, with all of the warming occurring since 1950.
- There is an increase in warm weather records across Australia and a decrease in cold weather records.
- There are fewer individual cooler-than-average years in Australia, with 2011 (-0.12°C below the 1961-90 normal) being the only below average year in the last decade (2003 to 2012).
- Rainfall over far eastern Australia has tended to decline since the 1950s, though shows large variability associated with La Niña and El Niño years.
- The heavy rainfall in recent years has largely been in spring and summer, whereas declines in rainfall in southern areas, over the last one to two decades, have occurred mainly in autumn and winter.
- Since the decline of the 2011/12 La Niña event in early 2012, rainfall in southern Australia has returned to the recurring pattern of below average totals during the winter half year.

POSSIBLE QUESTIONS & SUGGESTED RESPONSES/ANSWERS

Q. Has the recent rainfall during the summers of 2010/11 and 2011/12 changed our understanding of climate change impacts on Australia?

No. The heavy rainfall of 2010 and 2011 was mostly due to La Niña events. Climate projections indicate a drying (on average) over southern and eastern Australia during the winter half year.

Written by: S47F (STCA), S47F
Reviewed by ADC, Mobile: S47F
Cleared by: S47F (a/DDW)
Cleared by DIR: 29 January 2013
Last updated: 29 January 2013

However, high rainfall events are expected to become heavier as the climate warms.

Q. *Was too much concern raised over drought conditions prior to La Nina events in 2010 and 2011?*

No. Despite the record spring and summer rainfall between late 2010 and early 2012; drying trends remain during autumn and winter across southern Australia. The last drought brought severe hydrological ecological and economic impacts; any extension of those conditions will stress sectors dependent on water.

Recent months have seen a re-establishment of very dry conditions in southern Australia and future droughts are inevitable. It is likely that they will be more frequent and severe in the future.

FURTHER BACKGROUND INFORMATION

- Australia has experienced increases in temperature of about 1°C since the start of the 20th century. Most of this warming has occurred over the last 60 years (i.e. since 1950) with a nearly monotonic increase in temperature on the decadal time scale. The trends are reasonably uniform across space, but are largest in subtropical parts of the continent and a little less near the coast.

- Rainfall changes have been much less uniform in time and space. The most notable feature of Australian rainfall is large seasonal and interannual variability. Rainfall totalled over the entire continent has increased over the last 60 years. This is mostly due to increases in monsoonal rainfall over northern Australia. The southeast of Australia and the far southwest corner have both experienced a decline in rainfall over the last 30 years.

- Recent climate conditions reinforce our knowledge around Australian climate trends, including: a continuation of below average cool season rainfall across much of southern Australia; the establishment of well above average temperatures since the demise of the 2011/12 La Niña event; unusually heavy warm season/tropical rainfall; and recent record heatwaves.

Written by: S47F (STCA), S47F
Reviewed by ADC, Mobile: S47F
Cleared by: S47F (a/DDW)
Cleared by DIR: 29 January 2013
Last updated: 29 January 2013