Editorial

Welcome to the summer edition of the Bulletin of the Australian Meteorological and Oceanographic Society. With the year all but over as I write it seems apt (and almost a journalistic necessity) to look back at the year and see where we have come. And for meteorology and oceanography, it has been a long way. A change of Director for the Bureau of Meteorology, a major shake-up of CSIRO-Atmospheric Research, the launch of an operational ocean forecasting system, massive bushfires in the south east and the end to one of the worst droughts in Australia's recorded history. Not to mention (and in actual fact I don't know if anyone *did* mention) 30 years since the formation of the Royal Meteorological Society, Australian Branch, and 15 years since this branch metamorphosed into AMOS.

Thirty years may seem a long time, but AMOS has recently appointed Dr Tom Beer from CSIRO Atmospheric Research as the inaugural AMOS Fellow. Congratulations Tom from all those at AMOS – an honour well deserved, and a worthy first Fellow for AMOS.

Finally, as many of you will know, Prof Michael Reeder has been elected as the new President of AMOS. He follows the highly successful tenure of Andrew Forbes. We hope to hear more of Michael's vision in a future *BAMOS*.

Andrew B. Watkins

Further Information:
http://www.dar.csiro.au/profile/beer.html
http://www.amos.org.au/FAMOS_Guidelines.html

News

Geoff Love Addresses the Future of Australian Meteorology

The new Director of the Australian Bureau of Meteorology, Dr Geoff Love, presented an address to the AMOS Melbourne Centre on November 28 2003, titled: Possible Future Trends for Meteorology in Australia. In a wide-ranging lecture, Dr Love outlined his thoughts on not only the Bureau of Meteorology, but also the broader workings of meteorology in Australia.

Dr Love's talk opened with the general influence of `mega-trends'. These included the economy (a confident outlook, despite the noted low skill of economic forecasts!), globalisation (fewer met services needed; for example, European met services will reduce in number), convergence of scientific disciplines (for example, understanding climate change now requires atmospheric science, biology, IT, geology, and carries with it the subsequent clash of cultures), advancing technologies (the iterative improvement in IT is driving some countries out of the meteorology market; eg., by the IPCC 5th Assessment, will Australia have good enough models to contribute?) and the changing role of Government (whereas 20 years ago public and private organisations were clearly defined, today government has a view that smaller is better, and that the private sector can do it, putting pressures on the administration of the Bureau of Meteorology). Dr Love then shifted his focus to Meteorology in general, and the key focus areas of data collection, data management, research, service provision and international collaboration.

Data collection is highly unlikely to be privatised. However manual in-situ measurements will become increasingly priced out of the market, and automated observations (AWS, autosondes), remote sensing and radar will become more prevalent, though all still need to be used as efficiently as possible.

Data management is seen as an area currently undergoing big changes, primarily because of globalisation and politics. Key big players (eg NASA, NESDIS, ESA) are now driving how things are done rather than the WMO, with the satellite operators driving a lot of the agenda. This can be expensive if there are continued paradigm shifts in how data is managed.

Research was viewed as being fundamental to the Bureau of Meteorology and meteorology in Australia in general. However Dr Love noted that the only way we can genuinely be competitive on the world stage (e.g. for the IPCC 5th Assessment Report) is for wide collaboration amongst Australian institutions. These may include universities, CSIRO-AR, CSIRO-Marine, Land and Water, ABARE and others. Unfortunately, however, the federal government funding structure generally encourages competition rather than collaboration even within the CRC program. Similarly the politicisation of research was seen as a danger for future science. Dr Love again highlighted that the BMRC was fundamental to the Bureau of Meteorology, and that institutional collaboration was fundamental to the success of atmospheric research within Australia.

In service provision, the model for the Bureau of Meteorology suggested by some such as Roger Beale (Secretary of the Dept. of the Environment and Heritage), where a US-like weather service simply provides data and warnings, is seen as unworkable for Australia, given the small private sector and the expectations of the community. Furthermore, the present level of litigation will be a key deterrent for those entering the industry.

International collaboration was an area Dr Love examined in great detail and with much thought. As a small player in the big world, Australia benefits greatly from collaboration with other countries. A worrying trend, however, was seen to be the US's recent history of avoiding multilateral agreements and negotiating its own bilateral agreements with many countries. This has been particularly so post-Kyoto, with the US signing many bi-laterals, something that many see as virtually impossible to manage in the long run. This is seen as leaving the WMO in a transition phase, particularly given the impact of the US-led Earth Observation Summit (EOS), where satellite operators were driving the agenda quite forcefully, and with the change in secretary-general of the WMO and his assessment of the WMO direction. For global meteorology, this is a critical time.

Australia's influence on this world stage is also diminishing. Whilst John Zillman remains as Australia's Permanent Representative until at least the executive council meeting in May 2004, his relinquishing of the WMO president's role, as well as Dr Love himself leaving the secretary position of the IPCC and the government's reluctance for Dr Love to be involved in future WMO activities whilst he is Director of the Bureau of Meteorology, will cause a large loss of influence. Furthermore, and with CSIRO looking critically at the cost of its involvement in the IPCC 4th Assessment Report, it is conceivable that in the future there may be a reduced involvement by Australia in such activities.

The major hurdle facing Australia and others when it comes to international collaboration on a large scale is which model to follow; the US bilateral or the UN multilateral. As Dr Love mentioned in answering questions after his presentation, he has grave concerns for the bilateral approach, as it produces a world of haves and have-nots. For instance the US led EOS summit was attended by 30-40 nations, however this also meant some 140 countries missed out. The best solution would be for greater US involvement in the UN process; not necessarily letting them have everything their way, but equally not allowing them to be stifled to the extent with which they currently appear to be. How this could be achieved is a great problem.

The future as Dr Love sees it for the Australian Bureau of Meteorology is one of further declining staff numbers, but also of more advances and success if Australian meteorologists manage to work collaboratively. Dr Love noted that Australia collects data as effectively as anyone on the planet, and makes this data as accessible as anyone else. He especially noted that the Bureau of Meteorology's climate website is beyond compare. Whilst the Bureau of Meteorology is a very effective service with a genuine place on the world stage of meteorology, it needs to keep working hard and needs the support of the whole meteorological community in Australia to stay that way.

Further Information:
A video of Dr Love's talk is available from Pandora Hope: pxh@bom.gov.au

Australian Greenhouse Office Report released.

The Australian Greenhouse Office has released its official report, edited by Barrie Pittock, into the science of climate change in Australia and the Southern Hemisphere. The report aims to set out the main facts and uncertainties regarding climate change, and help provide Australians with policy-relevant, but not policy-prescriptive, advice and source material.

Releasing *Climate Change: An Australian Guide to the Science and Potential Impacts*, Minister for the Environment and Heritage, Dr David Kemp, said the Australian Government had commissioned this important new publication to help inform the global response to climate change. "Australian scientists are world leaders in climate change research in our region, research that is providing a vital southern hemisphere perspective to the global climate change scientific effort and becoming increasingly important in the global arena." Dr Kemp said.

Dr Kemp stated that the question was no longer 'Will the Climate Change?', but rather 'How will it change?' followed by 'What can we collectively do to reduce the threat?'

However despite this rhetoric, Dr Kemp's speech to the Renewable and Sustainable Energy Roundtable Side-event at the COP 9 meeting in Milan, at which the *Climate Change Guide* was released, outlined many of the reasons Australia is not a party to Kyoto. Primary reasons given were the uncertainty in the science and economics of the IPCC projections, and that unless all of the world's top 6 (or top 12 if Australia is to be included) greenhouse gas emitters are comfortable about the mutual consistency of their efforts, and trust that none is taking advantage of the others, then it will be impossible to stabilise greenhouse gas emissions at a level of 50-60% reduction from the IPCC "business as usual" scenarios by the end of the century. This level of reduction is thought to be what is needed to stabilise greenhouse warming at a manageable level.

The Climate Change Guide itself presents research to advance the understanding of global and regional climate change and its impacts on natural and managed systems and provides the foundation for international and domestic policy development and for adaptation strategies. Key scientific elements in the guide include:

- Australia plays a leading role in **Southern Hemisphere climate change science**.

- Australian research has resulted in a far greater understanding of the role the **Southern and Antarctic oceans** play in influencing climate change in Australia and the region.

- The **Antarctic Vortex** is a natural jetstream of 30km high; super cold, super fast winds spiralling around Antarctica. It is a natural phenomenon, but it is now spinning faster and tighter. Scientific data indicates the vortex is strengthening due to a combination of stratospheric ozone depletion and greenhouse gas emission, and this may be drawing rainfall away from southern Australia.

- One of the main achievements to date of Australia's Southern Ocean research has been in understanding the transport and variability of the **Antarctic Circumpolar Current** south of Australia. The circumpolar current is an important component of the global thermohaline ocean circulation and one of the major redistributors of heat in the climate system.

- Australia is a leader in understanding the many factors that impact on the **health of coral reefs**. Reef corals are very sensitive to sea temperatures outside their normal range. Scientists are investigating and gaining a better understanding of reef ecology and biodiversity, and the impacts of warmer sea surface temperatures and increasing carbon dioxide levels on corals.

- **Climate models**, developed by the CSIRO and the Bureau of Meteorology, are used by the Intergovernmental Panel on Climate Change (IPCC) in its assessment processes. **Economic models**, developed by the Australian Bureau Agricultural Resource Economics (ABARE), have also been used by the IPCC in its assessment processes.

Further Information:
http://www. greenhouse.gov.au/science
http://www.deh.gov.au/minister/env/2003/sp09dec03.html

Global Temperatures likely to be third warmest on record

The World Meteorological Organization (WMO) has reported that the year 2003 is expected to be around +0.45°C above the 1961-90 annual average, making 2003 the third warmest year just behind 2002 (+0.48°C). The warmest year remains 1998 (+0.55°C), like

2003 a post-El Niño year when the heat of the peak of the event (typically November/December) is dissipated.

Calculated separately for both hemispheres, the 2003 temperatures for the Northern Hemisphere (+0.57°C) and for the Southern Hemisphere (+0.33°C) are both likely to be the third warmest in the instrumental record from 1861 to present.

The WMO notes that the global surface temperature has increased since the beginning of the instrumental record in 1861, and that since 1900, the increase has been about 0.7°C. New analyses of proxy data for the Northern Hemisphere indicate that late 20th century warmth is unprecedented for at least roughly the past two millennia. In the Northern Hemisphere, the 1990s were the warmest decade and 1998 the warmest year in the past 2000 years. While the trend towards warmer globally averaged surface temperatures has been uneven over the course of the last century, the trend for the period since 1976 is roughly three times that for the past 100 years as a whole.

Major meteorological events of 2003 have included:
1) The heatwaves in Europe of June/July/August, where nationwide temperatures were warmest on record in Germany, Switzerland, France and Spain. In France, Italy, Netherlands, Portugal, the UK and Spain, over 21,000 additional deaths were attributed to the unseasonably hot conditions.
2) Temperature extremes in India and Pakistan; the pre-monsoon heat wave in May saw temperatures of between 45 and 49°C. 2003 was exceptionally hot, even by the normal standards of this period, the hottest time of the year.
3) Exceptionally cold conditions in northern India during January, with temperatures 4 to 5°C below normal. In the bordering countries of Pakistan, Nepal and Bangladesh, the combination of cold weather and persistent fog claimed hundreds of lives in January.
4) For the third year in a row Mongolia experienced a cycle of dry summer/cold winter with devastating effects on livestock.
5) Lingering effects of the drought in Australia.
6) Drought conditions continued to impact upon much of Botswana, Zimbabwe, parts of South Africa, and Mozambique. In the Greater Horn of Africa, the drought in northern parts of Ethiopia and Eritrea continued to hurt agriculture and food security.
7) In the United States, moderate to extreme drought affected much of the West, in some areas for the fourth or fifth year in a row, leading to water shortage. The most costly wildfires on record in the USA occurred in Southern California in late October.
8) The Asian summer monsoon, which typically lasts from June to September, brought heavy rain and flooding to parts of Pakistan, northern India, Nepal and Bangladesh. The Ganges River reached its highest level since 1975 causing hundreds of flood-related deaths.
9) In Africa, heavy seasonal rains in April led to flooding in Kenya and southern parts of Ethiopia and Somalia, with similar conditions in western Eritrea and northeast Sudan in July. Some areas experienced their wettest conditions in 70 years.
10) The Northern Hemisphere snow cover extent for 2003 was the second greatest on record.
11) This year's Atlantic hurricane season saw the development of 15 named storms, well above the 1944-96 average of 9.8, but consistent with a marked increase in the annual number of tropical systems since the mid 1990s. Hurricane Fabian was the most destructive hurricane to hit Bermuda in more than 75 years.
12) In Sri Lanka, heavy rainfalls in May from Tropical Cyclone 01B exacerbated already wet conditions, resulting in flooding and landslides and killing at least 250 people. The flooding is considered the worst to affect the region in 50 years.
13) The Antarctic ozone hole reached 28 million square kilometres in size in late September, matching the all-time record size reported in September 2000.
14) Northern Hemisphere sea ice extent reached a minimum of 5.4 million square kilometers in September 2003, which was just slightly more than the record low of 5.3 million square kilometres set in September 2002. The low sea ice extent observed in recent years is consistent with new analyses of satellite data, which show that the Arctic region warmed significantly in the 1990s compared to the 1980s.

More extensive, updated information will be made available in the annual WMO Statement on the Status of the Global Climate in 2003, to be published in early March 2004.

A summary of the Australian Climate of 2003 will appear in the next *BAMOS*.

Further Information:
http://www.wmo.int

ARGO Float Deployment reaches 1000

In November, ARGO reached an important milestone; its 1000th operating float. This is one third of the way towards ARGO's target of 3000 floats by 2006 (approximately one float every 3 degrees of latitude and longitude). Most of the northern hemisphere oceans have reached 50 percent of the planned float density. The present array delivers 3000 high quality temperature/salinity profiles each month. This should be compared with the typically less than 2000 temperature/salinity profiles to 2000m obtained each year from ships.

Australia has deployed 30 ARGO floats, mainly in the Indian Ocean and will deploy another 35 before the end of 2004. A summary of the ARGO system appeared in the June 2002 edition of *BAMOS*. At that time, only 446 floats were operational worldwide.

Already the benefits of the ARGO system of ocean observations are being seen by Australia, with data being used by both long range outlook climate models, such as POAMA, and short range ocean forecasting, such as BLUElink.

Most recently, The US Coast Guard icebreaker, Polar Star, has begun deploying ARGO floats in the Southern Ocean. During a five day stopover in Hobart en route from its home port in Seattle, Washington for its annual mission to the main US base in Antarctica at McMurdo Station, the 120-metre *Polar Star* took on five floats, deployed as part of Korea's contribution to the ARGO program, reinforcing the cooperative nature of the innovative ocean monitoring effort, the International ARGO Program.

The *Polar Star's* sister ship, *Polar Sea* will deploy another 15 ARGO floats in the Southern Ocean on its return to the US from McMurdo Station.

Further Information:
http://www.argo.ucsd.edu/
http://www.bom.gov.au/bmrc/ocean/JAFOOS/POAMA/
http://www.marine.csiro.au/bluelink/

The Priestley Cup 2003

On Monday 24 November the Priestley Cup, the soccer tournament associated with the CSIRO Priestley lecture was held at the University of Melbourne. The tournament was a round-robin affair with teams from the BMRC, CSIRO-AR, Monash University and the University of Melbourne.

First up was a clash of the titans - BMRC versus CSIRO. The determination of CSIRO to defend their trophy was evident from the start. Faced with a BMRC team depleted due to a brutal Friday evening training session, the CSIRO players were like the first scientists who studied fog - mystified. The game ended in a 1-1 tie but the highlight of the match was the strange, cardigan-wearing, bearded man who insisted on standing in the middle of the field. The referee even stopped the game and declared "CSIRO, you have too many on the pitch!". Maybe there is some truth to the rumour that CSIRO scientists are like fudge, mostly sweet with a few nuts...

Meanwhile, the battle between Monash and Melbourne ended sweetly for the home team with a 3-1 win. The game was a steep learning curve for the Monash players but they took the loss in good humour and proved that applied mathematicians are different to statisticians in that they don't say "mean" things!

Next, Monash started quickly taking a 2-0 lead against CSIRO before the defending champs attempted to be like old weatherman – trying to reign forever, by winning 4-3. Meanwhile, in the other match BMRC dominated the first half against Melbourne Uni taking in a 1-0 halftime lead. However, the second half showed that the Melbourne Uni players were younger, fitter, and better looking who tied up the game which finished all square at 1-1. This match is still undergoing an internal inquiry here at Melbourne Uni since one of its players (currently on leave from BMRC) should have won the game for the academics. However, he suspiciously (i.e., defying the laws of physics) missed an open goal with seconds to go...

The next clash was between Melbourne Uni and CSIRO, with the victor assured to win the prestigious cup (and, more importantly, bragging rights) (*BoM would have won if this game was drawn! – Ed*). For Bob Cechet, the CSIRO goalkeeper, this was no Cinderella story - he never missed the ball! In the end though, Melbourne Uni was finally able to break down the CSIRO defence and ran out 2-0 winners to win the trophy for the first time.

Q:What do you call a BMRC scientist in a game that determines the Priestley Cup? A: The referee! BMRC stayed true to form and finished runners-up again even though they beat Monash 4-2 thanks to a Kevin Tory hat-trick. Afterwards, some barbequed food, drinks and a little conversation (mostly about the strange guy invading the CSIRO-BMRC game) brought an end to a thoroughly enjoyable and tiring evening.

Richard Wardle,
Captain, Melbourne University Earth Sciences Soccer Team

The thinking man(s) pitch invader. Priestley Cup, 2003

Articles

Summary of Recent Reports on Climate Change Science

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Over the last few months there have been in Australia a number of reports in the media either querying the significance of climate change or suggesting new impacts of climate change. The purpose of this brief is to summarise the science associated with those reports.

Issues

- Two analyses of paleoclimate data have raised questions about earlier studies included in the IPCC Third Assessment Report (TAR) showing that the twentieth century was probably the warmest for at least 600 years
- Variations in sunspots (variations in solar radiation) have been suggested as an explanation of warming over the twentieth century
- Ozone depletion in the stratosphere over Antarctica has been suggested as a cause of rainfall decreases in southern Australia
- Urban pollution has been suggested as a cause of rainfall decrease in Australia
- Geologists Ian Plimer and Bob Carter have implied that the climate change in recent decades is part of the natural variability of the earth system
- Alan Oxley's Climate Change

Backgrounder suggests that scientists at the Russian Climate Change Conference in September were unable to answer basic questions on climate change science

Paleoclimate data

Perhaps the most significant finding of the TAR was the "hockey stick" curve showing a 600-year time series of annual surface temperature over the northern hemisphere. The result was based on paleoclimate data (eg corals, tree rings, ice cores) that were statistically related to the instrument-based measurements over the last century. The analysis of Mann, Bradley & Hughes (1998, Nature, 392, 779-787) is most widely quoted, but there have been several separate analyses and the record has been extended back at least 1000 years, as shown in Figure 1. The analysis has been restricted to the northern hemisphere owing to a lack of data for the southern hemisphere.

The paleoclimate data suggest that the northern hemisphere over the last century has been unusually warm, and the temperatures in the 1990s were greater than at any time in the last 600 years. Note that the estimated error bars for the analysis are shown in Figure 1, and that they increase as we go further back in time. This analysis has been one aspect of the evidence that the observed warming over the twentieth century is unlikely to be completely due to natural causes.

The Climate Change Backgrounder (Issues 5 and 6), edited by Alan Oxley, uses results from a paper by Soon and Baliunas to suggest that the Mann et al. analysis is incorrect. The Soon and Baliunas paper was published in the journal *Climate Research* in January 2003. The initial response of the mainstream research community was to ignore it; this is the traditional response to a poor piece of research because citations normally rank the importance of a paper. However, the media response to the paper was so great that it was agreed that a group of 14 scientists would provide a detailed criticism in EOS. Moreover, three of the editors (including the editor-in-chief) of *Climate Research* resigned their positions because of the way the paper was handled by one editor and the publisher.

The paper by Soon and Baliunas has been discredited, but it has recently been followed by a paper by McIntyre and McKitrick published in *Energy & Environment*. An article by Bob Carter (a geologist from James Cook University) in the *Financial Review* of 3 November suggests the paper implies that "global warming may turn out to be just hot air".

As the McIntyre and McKitrick paper is written as a criticism of Mann et al., the normal courtesy of the editor would be to send the paper to the authors of the criticised paper (as well as to independent reviewers). This courtesy was not extended by the editor of *Energy & Environment*. It is also normal practice to submit a criticism to the original journal. It is therefore apparent that McIntyre and McKitrick either had their paper rejected by *Nature* or they were not prepared to submit it to *Nature*.

It is worth noting that the editor of *Energy & Environment* is Sonja Boehmer-Christiansen who is regarded as a "greenhouse skeptic" and who has recently been involved in a dispute

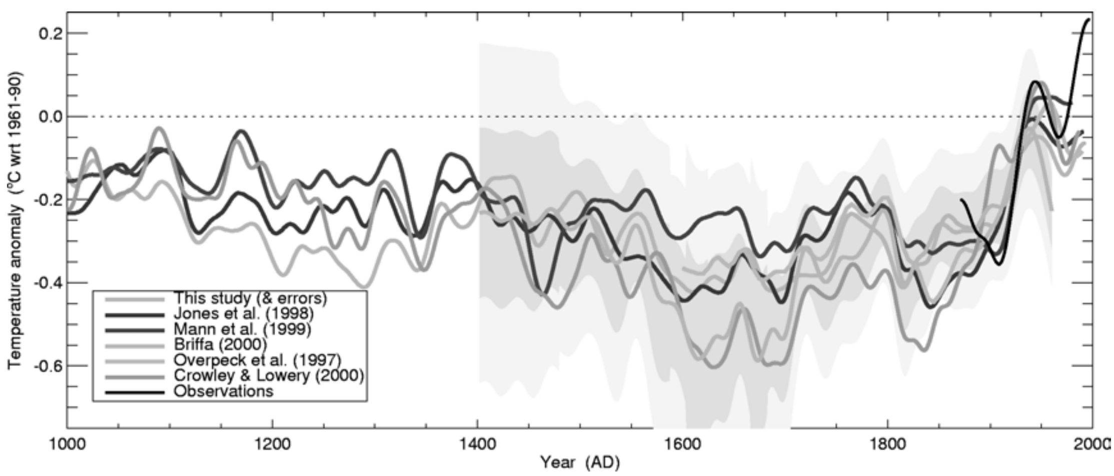

Figure 1. Comparison of several separate analyses of paleoclimate data used to estimate annual northern-hemisphere surface temperature. The instrument-based estimate is shown in black for the last century. (From Briffa et al., 2001, J. Geophys. Res., 106 D3, 2929-2941)

with John Zillman about the politics motivating the IPCC (*Australian Journal of Environmental Management*, 2003, 10, 192-194). A journalist David Appell (http://www.davidappell.com) comments that "The problem with *Energy & Environment*, of course, is that it makes it difficult, if not impossible, to determine if its papers are published because of their scientific worth or because they agree with the political motivations of its editor, and McIntyre and McKitrick's paper carries that burden along with it as soon as it gets out of the gate".

Mann has published on the web (see http://www.cru.uea.ac.uk) an initial response to the McIntyre & McKitrick paper. In addition to noting a range of technical errors in the paper, Mann states that the paper does not use key proxy indicators from the original analysis for the period 1400-1600. These omissions lead to the resulting temperatures for that period being warmer than the estimates of Mann et al. or any of the other analyses (see Figure 1).

The data used by McIntyre & McKitrick finish in 1980, but global temperatures since 1980 have been much higher than in earlier decades of the last century. Thus, even for their reconstruction, the last decade appears to have been warmer than any other period for the last 600 years.

The analysis of McIntyre & McKitrick has its warm period during the 15th century. However, this period lies within the Little Ice Age suggested by Soon & Baliunas. Thus, these two papers, which are accepted by only the "greenhouse skeptics", appear to be inconsistent.

Sunspots and global surface temperature

For decades there has been continuing research to identify and explain the impact of fluctuations in solar radiation on global climate. Thomas Crowley (*Science*, 2000, 270-277) provides a detailed analysis of the relative contributions over the last 1000 years. Figure 2 shows estimates of both the forcing due to solar variations (top panel) and due to greenhouse gases (bottom panel). It is clear that over the last 50 years anthropogenic forcing has dominated the natural forcing from solar variability; the cumulative forcing due to greenhouse gases since 1850 is about five times greater than that due to solar variations. The top panel also gives some indication of the uncertainty in the magnitude of the forcing

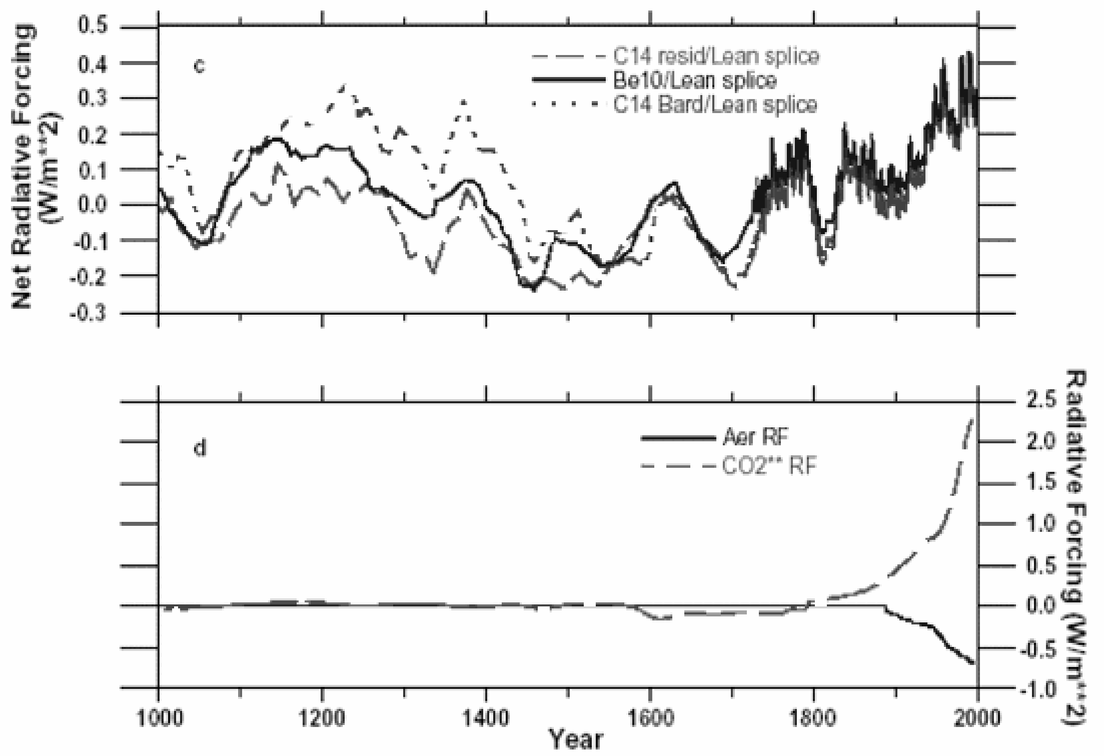

Figure 2. Top panel shows the radiative forcing due to solar variability over the last 1000 years estimated from different techniques. Bottom panel shows the radiative forcing due to greenhouse gases and aerosols over the last 1000 years; note the difference in scale between the two panels. (From Crowley (2000) Science, 270-277)

during the 1200s, when the solar activity may have been as great as it is now.

Confirmation of the validity of our understanding of the relative magnitudes and impacts of natural (solar radiation and volcanoes) and anthropogenic (greenhouse gases and aerosols) forcing was provided in the TAR. Models were forced with (1) natural sources, (2) anthropogenic sources, and (3) both natural and anthropogenic sources over the 20th century. It was found that forcing (3) provided the best comparison of the modelled global surface temperature with observations over the last century. This rather straightforward technique was supported in the TAR by the more arcane "fingerprint" tests in which specific patterns of variation associated with greenhouse forcing are found in the vertical and horizontal structure of the atmosphere.

Ilya Usoskin in *New Scientist* (2 November 2003) suggests that sunspot activity now is greater than at any time in the past 1000 years. *New Scientist* states that the "work will probably be seized upon by those who claim that temperature rises over the past century are the result of changes in the Sun's output". However, the results of Usoskin are based on beryllium-10 measurements as indicators of sunspot activity. As suggested by figure 2, there is uncertainty about the actual sunspot level in the 1200s and so it is not clear whether the current levels are unprecedented. Bearing in mind the uncertainties, Usoskin may be correct in asserting that the current level of sunspot activity is high in historical terms.

The historical record of sunspots is interesting and research will continue to determine its detailed variation over the long term. However, for the modern era, we have direct measurements of solar variability and sound estimates of the relative importance of natural and anthropogenic climate forcings. As noted above, it is clear that the cumulative forcing due to greenhouse gases is now many times more than that due to solar variability.

Ozone depletion and climate change

The depletion of stratospheric ozone and the enhanced greenhouse effect are distinct atmospheric phenomena; the former is driven by the release of ozone depleting substances (ODSs) such as CFCs while the latter is driven by the release of greenhouse gases such as CO2. However, the phenomena are linked. Most ODSs are also greenhouse gases, and so the selection of replacement gases for ODSs needs to be done carefully to ensure that the greenhouse effect is not exacerbated.

There are also dynamical links between the phenomena. One of the effects of the enhanced greenhouse effect is a cooling of the stratosphere, in addition to a warming of the troposphere (the lowest 10 km of the atmosphere to which storms and fronts tend to be confined). Ozone depletion is greatest when the stratospheric temperature is low enough to form polar stratospheric clouds (PSCs), which provide the catalytic surfaces for ODSs to act. Thus the enhanced greenhouse effect can exacerbate ozone depletion.

Susan Solomon and colleagues have recently suggested that ozone depletion in the southern hemisphere polar vortex has effects on the surface climate of Antarctica and may influence climate at lower latitudes (Thompson & Solomon, 2002, *Science*, 296, 895-899). (Solomon spoke on these issues in the Bureau's World Meteorological Day lecture in March 2002.) It is found that, while the Antarctic Peninsula has steadily warmed in recent decades, the interior of Antarctica has slightly cooled. It is suggested that the observed cooling can be explained by the stratospheric effects of ODSs extending down to the surface. This leads to changes in the pressure gradient between Antarctica and mid-latitudes. The Southern Annular Mode (SAM) is an indicator of the strength of this pressure gradient, and it has been found to be increasing in recent decades; ie high-latitude pressures have been decreasing and mid-latitude pressures increasing.

Modelling studies also show that an impact of the enhanced greenhouse effect in the southern hemisphere is an increase in the SAM, with sub-tropical pressures increasing and high-latitude pressures decreasing. There is continuing research on the relative importance of stratospheric ozone depletion and the enhanced greenhouse effect on the observed increase in SAM in recent decades. It is likely that both phenomena are affecting the climate of the southern hemisphere.

The increasing trend in the SAM has a significant impact on Australian climate. For more than two decades, there has been a substantial reduction in early winter rainfall in southwestern Western Australia. The joint BMRC-CSIRO-WA Government Indian Ocean Climate Initiative (IOCI) has found that the rainfall reduction is associated with changes in the large-scale pressure distribution in our region, as indicated by the SAM. However, the study was not able to be unambiguous on whether the change was due to natural variability or to anthropogenic effects.

The Bureau's National Climate Centre has shown that over the last few years there has been a sustained decline in early winter rainfall across all the southern coast of Australia correlated with increasing surface pressure. It is not clear why this phenomenon was apparent much earlier in the west than in the east of Australia. While it seems that rainfall in southern Australia is affected by large-scale pressure patterns, indicated by the SAM, there will be continuing research to clarify the relative roles of anthropogenic forcing and natural variability. Because the impacts of ozone depletion tend to be greatest in spring and summer, it is likely that the enhanced greenhouse effect is the main anthropogenic cause of the decline in Australian early winter rainfall.

Urban pollution and Australian rainfall

Over the last few years, Daniel Rosenfeld and his Australian agent, Aron Gingis, have been promoting the suggestion that rainfall across Australia is being reduced by urban pollution. Initial studies by BMRC and CSIRO, as well as an independent investigation by Neville Fletcher of ANU, did not support their suggestion. Indeed as more is understood about the influences on rainfall it is apparent that large-scale effects, such as the strength and location of the low-pressure systems that bring rain-bearing clouds, will dominate the level of annual rainfall. Weather modification, whether accidental or intended, will at best lead to incremental impacts on regional annual rainfall.

Anthropogenic climate change and natural variability

Professor Ian Plimer is a geologist and a very effective communicator. Recently he is being mimicked in the press by Bob Carter, a geologist from James Cook University. Prof. Pilmer appears in the media with the message that the planet has always been changing and it will continue to change; the implied but often unstated message is why worry about greenhouse in the great scheme of things. An example of his writing is from his presentation at the IPA Climate Change Conference in March 2003: "The messages written in stone show that the lithosphere, biosphere, atmosphere and biosphere are constantly interacting on our dynamic evolving planet. There is no evidence to suggest that the future of planet Earth will be significantly different from its past."

There are logical flaws in the arguments of Prof. Plimer and other geologists. First the geological time scales to which he refers are far longer than the years to decades associated with the enhanced greenhouse effect. As shown by the "hockey stick" curve of the TAR, we are facing an unprecedented rate of change of climate for at least 1000 years. Moreover, another significant finding of the TAR was that the current level of CO2 in the atmosphere is higher than at any time in the last 400,000 years.

The second point to make about the geological changes referred to by Prof. Plimer is that the changes he describes, such as the glacial-interglacial cycles, had a profound impact on life at the time. It is worth noting that modern civilisation has arisen only since the end of the last glaciation about 10,000 years ago.

An implication of Prof. Plimer's statements is that natural forcings have dominated any anthropogenic impacts on climate in the past and so humans will not affect climate in the future. This is clearly a false conclusion in logic, and the scientific evidence (see figure 2) shows that we are now in an unprecedented situation where anthropogenic forcing is far larger than natural forcings.

World Climate Change Conference

The Climate Change Backgrounder No. 9 of Alan Oxley has a summary of the World Climate Change Conference held in Russia in late September. He states that Bert Bolin and a group of colleagues were unable to answer ten questions on climate change posed by Andrei Illarionov, economic adviser to President Putin. The questions listed by Oxley, such as the impact of volcanoes and variations in CO_2 levels in the atmosphere, have been considered by the IPCC and discussed in each of the IPCC assessment reports. While it may be, as Oxley reports, that "Illarionov reported that the questions were not answered", the IPCC, which includes scientists and policymakers from Russia, would seem to be satisfied with the answers.

More relevant than a debate during the conference is the final statement from the conference, which would normally be decided through considered off-stage discussion. The summary report of the conference, which was endorsed at the concluding session, includes the following: "The Intergovernmental Panel on Climate Change (IPCC) has provided the basis for much of our present understanding of knowledge in this field in its Third Assessment Report (TAR) in 2001. A large majority of the international scientific community has accepted its general conclusions that climate change is occurring, is primarily a result of human emissions of greenhouse gases and aerosols, and that this represents a threat to people and ecosystems. Some divergent scientific interpretations were brought forward and discussed in the Conference." The implication of this statement is that the "divergent scientific interpretations" are accepted by only a small minority of the scientific community.

Further Information:
World Climate Change Conference
http://www.wccc2003.org/index_e.htm

Tropical Cyclone Activity in the Southern Hemisphere

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Introduction

Each year, a total of about 80 tropical cyclones (TCs) form around the globe, and about one-third of these occur in the southern hemisphere (Gray 1979). TCs dramatically affect maritime navigation and the lives of communities in coastal areas of Australia and islands of the South Pacific Ocean and the South Indian Ocean. Loss of life, destruction, as well as economical losses caused by TCs, can have a significant impact on the community. This was the case with, for example, TC *Tracy*, which devastated Darwin on Christmas Day 1974.

Records show that there is considerable inter-seasonal variability in the frequency and spatial distribution of TCs, and the relationship between ENSO (El Niño Southern Oscillation) and the inter-seasonal variability of TC activity has been investigated in a number of studies. For example, Gray (1988) demonstrated that during El Niño events, South Pacific TC activity tends to occur further eastward than normal with a general suppression of TC activity evident in the Coral Sea and north Australian region.

Nicholls (1979, 1985) produced evidence of a strong and stable relationship between inter-seasonal variations in TC numbers in the Australian region and Darwin pressure in the winter (June-August) preceding the TC season. Nicholls (1984) found that the years with a higher incidence of TCs were associated with abnormally high sea surface temperature (SST) in the North Australian region, especially just prior to the start of the cyclone season. He concluded that SSTs may be directly influencing cyclone generation. However, there are large-scale atmospheric anomalies in the region (e.g. abnormally low pressure) associated with such warm SSTs, and Nicholls alternatively suggested it was these anomalies, rather than the SSTs, which may directly influence the frequency of cyclone generation.

An archive of TCs for the southern hemisphere together with maps showing TC occurrences were developed by the Australian Bureau of Meteorology's National Climate Centre (NCC). The mapped information, which shows the average annual occurrence of TCs (climatology), as well as the average annual cyclone occurrence during El Niño, La Niña and neutral years can be found under the link 'Tropical cyclones' at:

http://www.bom.gov.au/climate/averages/

As part of this study, El Niño and La Niña years were selected from a list prepared by Wright (2001). In this article we present the NCC TC archive for the southern hemisphere and examine changes in TC activity in relation to the ocean and atmospheric circulation anomalies associated with ENSO.

Tropical cyclone archive

The southern hemisphere TC archive currently consists of cyclone best track data for the TC seasons from 1969/70 to 1998/99. The creation of a reasonably complete 30-year dataset for the whole southern hemisphere provided the basis for the generation of a set of climatological maps showing the frequency of TC occurrence.

In the Australian region, historical TC records go back to the late 1700s, however there are limitations associated with the older data. The introduction of routine satellite coverage in the late 1960s saw a significant increase in the quality of the TC records; particularly in the identification and positioning of TCs (Holland, 1981).

An examination of the more recent TC records showed that the majority of the TCs identified in the South Indian Ocean during the 1970s, did not contain central pressure estimates. There also appears to have been a tendency to over-identify TCs during this period, and it is suspected that some systems, which would now be classified as tropical depressions, were identified as cyclones (Nicholls et al 1998). Consequently, we believe that the most suitable use of this TC archive is for the analysis of TC tracks rather than for the analysis of TC intensity.

Quality control/validation procedures were applied as part of the TC archive generation process. For example, the data was cross-checked with archive TC data from the Joint Typhoon Warning Centre, Hawaii, USA. We believe that the NCC TC archive accurately represents cyclone best track data in the Southern Hemisphere.

Data analysis and mapping

The calculation of cyclone occurrence was similar to the analysis done by Lourensz (1981) for maps of average decadal incidence of tropical cyclones (in 5^o lat/long squares). However, the map-based TC climatology derived in this study shows annual occurrence rather than decadal incidence information, and the rectangular resolution used in this analysis (2^o lat/long squares) is finer and consequently provides for a more accurate areal representation of TC occurrence (Nicholls, Gill, Bate, Elliot, personal communications 2002).

For the 30-year period corresponding to the 1969/70 to 1998/99 TC seasons, cyclone tracks were analysed across the southern hemisphere at a resolution of 2^o x 2^o. The number of occurrences of cyclones in each 2^o x 2^o square was then calculated and the data converted to two-dimensional gridded format. A five point binomial box smoother was applied to the grids and a line-smoothing algorithm was applied as part of the mapping process.

ENSO

In terms of the ENSO, the core region for ocean-atmosphere interactions is the Indo-Pacific region. This region contains areas of the most pronounced changes in SST and convective activity across the Pacific Ocean and related responses in the Indian Ocean. It has been shown by Gray (1995) that favourable changes such as increased SSTs and the increase in convective activity are associated with enhanced TC genesis, whereas cooler ocean temperatures and the reduced convection lead to a reduction in TC activity. A detailed description of oceanic and atmospheric patterns during significant historical and contemporary ENSO events may be found, for example, in Allan, Lindesay and Parker (1996).

El Niño/La Niña refers to the anomalous warming/cooling of the central and eastern Pacific Ocean that leads to a significant shift in weather patterns across the Pacific. Changes to the atmosphere and ocean circulation during El Niño events include:

- Warmer than normal ocean temperatures across the central and eastern tropical Pacific Ocean.
- Higher than normal atmospheric pressure in the Australian region, and lower than normal atmospheric pressure in the eastern Pacific.
- Increased convection and cloudiness in the central tropical Pacific Ocean - the focus of convection migrates from the Australian/Indonesian region eastward towards the central tropical Pacific Ocean.

- Weaker than normal (easterly) trade winds.

ENSO and tropical cyclone activity

Comparison of the El Niño years and La Niña years TC maps *(see cover image of this BAMOS)* shows a number of significant features. The El Niño years map shows a reorganisation of the TC activity pattern, with what appears to be a northeastward displacement (to 165ºW-150ºW) of a number of areas of TC activity maxima. This shift in maxima is consistent with the anomalous warming and associated enhanced tropical convection in the central equatorial Pacific during El Niño events. In addition, an intensification of TC activity in the South Indian Ocean (between 55ºE and 85ºE) is also evident. This is consistent with the El Niño related (warmer) oceanic and atmospheric anomaly patterns in this region.

The La Niña years map shows that TC activity maxima in the western tropical Pacific are closer to Australia, with almost twice as many impacts on the northeast Australian coast (Callaghan, personal communication 2002). In the eastern Indian Ocean, an intensification of TC maxima is evident near the west coast of Australia (115ºE to 120ºE).

It is evident that there is a displacement of the TC activity maxima from 55ºE-85ºE (El Niño years) to 85ºE-105ºE (La Niña years). This is associated with suppressed/enhanced convection in the tropical Indian Ocean during El Niño/La Niña years.

The climatological information presented on the TC incidence maps has been used as a guide for the evaluation of TC activity. The information also forms part of the South Pacific Seasonal Outlook Reference Material, which the Australian Bureau of Meteorology provides to National Meteorological and Hydrological Services in the South Pacific to assist in the production of their climate outlooks.

We believe that it would be beneficial for the South Pacific and South Indian nations to initiate, under the WMO umbrella, a collaborative project on the revision and further improvement, including an annual update, of the southern hemisphere TC archive.

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Significant Weather

September 2003

Summary

Gale force winds were reported in New South Wales, Victoria, Tasmania and South Australia. In New South Wales gale force winds swept across parts of the southeast bringing down trees, damaging roofs and causing power failures. Strong winds brought down power lines across Tasmania and caused power cuts to thousands of people. In Queensland the combination of dry conditions, low rainfall, high temperature and strong wind exacerbated the effect of drought to produce an early start to the bushfire season.

Thunderstorms

New South Wales

On the 12th a severe thunderstorm with 3cm hail was reported between Batlow and Tumbarumba. A thunderstorm with 2cm hail was reported at Canberra Airport.

Wind

New South Wales

Gales in southeastern New South Wales on the 4th brought down power lines, damaged roofs and trees and ripped boats from moorings on Twofold Bay.

On the 22nd at Bowral (Illawarra) several people were injured by structures being blown over.

Victoria

On the 19th, damage occurred in southern and outer Melbourne. Widespread moderate tree damage was reported in the Knoxfield, Scoresby, and Ferntree Gully areas. The animal sanctuary at Healesville was damaged. A light aircraft at Moorabbin Airport was overturned due to the strong winds. Peak gusts included 126 km/h at Wilsons Promontory and 113 km/h at Mortlake.

Tasmania

Gale to storm force winds occurred a number of times during the month and many stations reported wind gusts in excess of 100 km/h. The highest gust recorded was 161 km/h at Tasman Island on the 3rd.

On the 3rd trees and powerlines were brought down causing scattered blackouts across the state, particularly in the south and northwest. Near Cygnet, in the south, a house was unroofed and there was other property damage. Elizabeth College in North Hobart had part of its roof removed.

On the 17th blackouts were experienced as trees and powerlines were brought down in various parts of the state. Worst affected was the east. A house and football club at Triabunna were unroofed, while a church at Falmouth was destroyed. Many boats slipped their moorings.

Flooding

Tasmania

Moderate flooding was reported on the lower reaches of the Derwent from the 17th to the 22nd, with peaks of 6.6 metres below Meadowbank on the 20th and 5.5 metres at Macquarie Plains.

Dust

New South Wales

Broken Hill reported widespread dust and visibility of 500 metres on the 22nd.

Bushfires

Queensland

On the 15th the worst fire of the season to date started on North Stradbroke Island. Seven homes were damaged on the 15th and by the 17th the fire was raging on an 8 kilometre front that destroyed over 1,200 hectares of bushland. Parts of the North Stradbroke Island golf course were destroyed with flames coming to within 100 metres of the clubhouse. Numerous spot fires broke out adding to the destruction. On the 18th a total fire ban for North Stradbroke Island was declared. The fire flared again and jumped containment lines on the 20th under the influence of 46-56 km/h south easterlies, threatening homes in Myora. Several cars were destroyed, but no homes. Over 3,000 hectares of bushland had been burned out.

New South Wales

On the 14th/15th about 45 bushfires in the northeast of the state were reported including 15 fires in Northern Rivers (Casino-Lismore area), 17 on the Northern Tablelands and 6 in the Hastings district with over 20,000 hectares burnt.

On the 25th 67 bushfires were reported in New South Wales along the entire coast from Kyogle (North Coast) to Bega (South Coast). Houses were evacuated on the Central Coast and some property destroyed.

October 2003

Summary

Thunderstorms, some with severe winds and damaging hail, were reported in five states, and a falling tree killed a person in the Blue Mountains.

Dust storms were recorded in Queensland and New South Wales.

Late snows fell in two States with road closures in Tasmania.

Thunderstorms

Queensland

On the 25th a severe multicell storm produced large hail along the Sunshine Coast hinterland. Golf ball to mandarin sized hail was reported from the Maleny area, while tennis ball sized hail smashed car windscreens at Mapleton and Witta. In the early evening a supercell produced 2cm to golf ball sized hail in the Toowoomba area, then proceeded to track through the Coominya, Lake Wivenhoe and Esk areas where hail up to cricket ball size destroyed house roofs, smashed windscreens, punctured rainwater tanks and stripped trees. In the Wide Bay and Burnett district, a severe storm produced very large hail and brought down trees across the road between Proston and Murgon. Hail 2-3cm in diameter was reported in the Biggenden area. Six hectares of zucchinis were destroyed by hail and a silo damaged near Cloyna.

On the 26th a tornado was reported at The Summit, near Stanthorpe where it shredded hail nets protecting a cherry crop, lifted a house off its stumps, and completely destroyed another house and a pumping shed. Two other suspected tornadoes occurred at Mt Nebo and Biggenden. A major hailstorm occurred on the Gold Coast with the worst affected areas being Currumbin, Palm Beach, and Coolangatta. Hail was golf ball to cricket ball sized. Many cars and 400 homes were damaged and many birds and animals at the Currumbin Wildlife Sanctuary were killed. A Qantas jet was damaged and forced to land shortly after taking off into the hailstorm.

Another major severe storm moved from the Samford/Mt Nebo area through Brisbane's northern suburbs and Redcliffe. This produced hail up to golf ball size and significant wind damage, particularly in the Samford/Mt Nebo area where 90 homes were damaged. At Biggenden a possible tornado caused a damage track 500 metres wide and a kilometre long. At Baralaba golf ball sized hail was reported. At Warwick hail to 5cm with a 100km/h wind gust and some flash flooding occurred. As far north as Rockhampton a 94km/h wind gust occurred. Insurance claims for the event totalled $15-20 million.

On the 31st a line of storms moved through southeast Queensland and produced damage chiefly in the Wide Bay and Burnett district. Houses were unroofed at Kingaroy, Wondai, and Mundubbera. A possible tornado occurred 12 kilometres south of Kilkivan, where a disjointed damage track 100 metres wide and several kilometres long was reported.

New South Wales

On the afternoon of the 1st a violent five-minute thunderstorm with golf ball sized hail caused some damage at White Cliffs. That evening a storm caused considerable damage to the Western Plains Zoo at Dubbo, and the following afternoon widespread storms caused damage in the Hunter Valley, Mid-North Coast and the Tamworth-Gunnedah area.

On the 2nd thunderstorms and strong winds in the northeast of the state caused structural damage to houses and brought down trees and power lines. Worst affected areas were Grafton, Lismore and Tamworth.

On the 25th violent hailstorms in the northern and western suburbs of Sydney, Central Tablelands, Australian Capital Territory and Southern Highlands caused roof damage and trees fell on power lines causing blackouts. At Berowra 75mm of rain was recorded in 1 hour. One man was killed by a falling tree in the Blue Mountains.

On the 26th thunderstorms and giant hail over 9cm in diameter were reported near Grafton on the North Coast.

Victoria

On the 15th severe thunderstorms occurred in the north of the state, in the greater Melbourne area and later in Gippsland. Hail up to 7cm in diameter was reported near Dookie and tennis ball sized hail was reported at St James. Trees were uprooted and fences, silos and haystacks damaged. Severe crop damage occurred over 2,000 hectares while 6,500 hectares of crop area suffered some damage. In the Melbourne area flash flooding was reported at Kew, Glen Waverley and Ferntree Gully.

South Australia

On the 19th severe thunderstorms brought damaging winds and large hailstones to many parts of central and eastern South Australia. Severe or damaging winds occurred at Marree (104km/h), Woomera (115km/h) and Yunta (106km/h), at many locations in the Mid North and Riverland, and in a wide swathe from near Beachport towards Kalangadoo in the Lower South East, where dozens of pine trees were uprooted or snapped, many other trees damaged, two semi-trailers tipped over, sheds and grain silos flattened and irrigation equipment wrecked. This storm also produced 4-6 cm hailstones. Other reports of large hail came from Dowlingville on northern Yorke Peninsula (4cm), Port Wakefield and Brinkworth in the Mid North and the southern Adelaide suburbs of Hallett Cove, Morphett Vale and Woodcroft (3cm).

Dust

Queensland

A trough extended across southwest Queensland from a deep low over South Australia on the 28th and the strong westerly winds caused a large scale dust storm across western New South Wales and southwest Queensland. The widespread dust and gusty westerlies across southeast Queensland on the 29th as the low moved to the Tasman Sea.

New South Wales

Dust storms and strong winds occurred in western New South Wales on the 28th at Broken Hill, Menindee, Cobar, Wilcannia, White Cliffs, Tibooburra, Wanaaring and Ivanhoe. Visibility was reduced to 100 metres at Tibooburra and was below 400 metres for over 6 hours with winds reaching 93km/h. At Ivanhoe and Wanaaring visibility fell to 200 metres and at Wilcannia 700 metres. The dust storms moved to northeast New South Wales overnight. At 9am on the 29th dust storms were reported at Tenterfield, Coffs Harbour, Inverell, Barraba and Smoky Cape.

Snow

Tasmania

Snowfalls on the 9th and 10th closed a number of elevated roads including the Murchison, Lake and Marlborough Highways.

Bushfires

Queensland

On the 29th wild winds drove a fire that destroyed two homes and a shed in the Upper Coomera/Willow Vale area in the Gold Coast Hinterland. The fire had been started by fallen power lines.

Northern Territory

On the 24th a resort at Uluru sustained extensive damage with an estimated cost of $4 million. A fire fighting crew had to flee their truck as a gust of wind pushed the fires suddenly towards them. The truck was destroyed in the fire.

On the 28th several houses at McMinns Lagoon (in the Darwin area) were threatened by a grassfire. A plantation of 136 mango trees was destroyed.

Records set – September 2003 (# - Australian record for September; * - state record for September; ^ - equal state record for September)

Station	State	Element	Value	Date	Previous record	Year	Years of record
Ayr DPI	QLD	High monthly max	29.8		29.1	2001	47
		High daily max	36.5	15	36.1	1982	49
Mackay MO	QLD	High monthly max	27.4		27.0	1992	43
		High daily max	32.9	15	32.3	1997	44
Longreach Aero	QLD	High monthly max	33.2		32.8	1983	36
		High daily min	26.0	25	23.5	1986	37
Rockhampton Aero	QLD	High monthly max	30.2		29.5	1991	64
Gladstone	QLD	High monthly max	27.8		27.7	1980	43
Cape Moreton	QLD	High monthly max	23.3		23.0	1915	90
Coffs Harbour	NSW	High monthly max	24.6		24.2	1983	60
		High daily min	20.5	23	19.7	2000	52
Birdsville	QLD	High monthly min	15.2		15.1	1965	47
		High daily max	42.4	22	42.2	1968	46
Townsville	QLD	High daily max	36.5	15	35.9	1986	62
White Cliffs	NSW	High daily max	39.5*	22	37.7	1973	41
Wilcannia	NSW	High daily max	39.4	22	37.2	1973	46
Broken Hill	NSW	High daily max	37.2	22	34.4	1919	95

Records set – September 2003 (# - Australian record for September; * - state record for September; ^ - equal state record for September)							
Station	State	Element	Value	Date	Previous record	Year	Years of record
Tibooburra	NSW	High daily max	39.3	22	37.2	1961	83
Menindee	NSW	High daily max	39.5*	22	37.2	1919	89
Brewarrina	NSW	High daily max	38.8	22	38.3	1948	92
		High daily min	22.7	24	22.1	2000	38
Cobar	NSW	High daily max	38.0	22	35.9	1980	41
Coonamble	NSW	High daily max	37.3	22	37.2	1919	95
		High daily min	22.3	23	19.5	1977	38
Yamba	NSW	High daily max	35.7	25	34.3	1981	59
Marree	SA	High daily max	39.5	22	39.4	1948	64
Alice Springs	NT	High daily max	38.8	22	37.7	1972	60
Mildura	VIC	High daily max	37.4*	22	35.6	1965	57
West Roebuck	WA	High daily max	43.1#	27	42.0	1998	5
Moomba Airport	SA	High daily max	41.5*	22	38.3	2001	9
Barcaldine	QLD	High daily min	23.4	25	22.3	1971	41
Cunnamulla	QLD	High daily min	25.5	23	22.3	2000	46
Bourke	NSW	High daily min	25.8	23	25.0	1928	96
Gunnedah SCS	NSW	High daily min	22.8	24	21.7	1965	55
Newcastle (Nobbys)	NSW	Low monthly rain	0.8		1.6	1980	122
Sydney	NSW	High daily min	22.0	24	21.9	1946	144
Darwin Airport	NT	Low daily min	15.1	5	16.7	1963	62
Victoria R. Downs	NT	Low daily min	6.0	4	7.0	1978	35
Liawenee	TAS	Low daily min	-10.7^	8	-7.7	1995	18
Glenorchy	TAS	High monthly rain	196.2		194.0	1983	105
Mangalore	TAS	High monthly rain	114.2		106.2	1983	102
Williamtown	NSW	Low monthly rain	0.4		3.6	1980	93
Glen Innes Ag	NSW	Low monthly rain	0.0		9.6	1917	122

Records set – October 2003							
Station	State	Element	Value	Date	Previous record	Year	Years of record
Hume Reservoir	NSW	Low monthly max	18.1		18.4	1976	81
Corowa	NSW	Low monthly max	18.2		18.9	1947	96
		Low monthly min	4.7		5.9	1941	96
Maatsuyker Island	TAS	Low monthly max	11.7		11.9	1998	65
St. Lawrence	QLD	High monthly min	19.8		19.7	1971	62
		High daily max	39.1	30	37.9	2001	46
Balranald	NSW	Low monthly min	6.9		7.2	1986	96
Bushy Park	TAS	Low monthly min	3.3		4.3	1972	68
Mount Isa AP	QLD	High daily max	42.5	28	42.3	1987	36
Mackay MO	QLD	High daily max	35.4	30	34.9	1971	44
Charters Towers	QLD	High daily max	41.5	28	40.6	1909	110
Clermont PO	QLD	High daily max	41.0	31	40.4	2002	41
		High daily min	26.5	29	24.2	1994	41
Urandangie	QLD	High daily max	43.3	27	43.1	1988	46
		High daily min	30.0	28	29.0	1980	45
Cape Moreton	QLD	High daily max	31.5	29	31.2	1958	46
Georgetown	QLD	High daily min	28.5	31	27.8	1928	107
Townsville Aero	QLD	High daily min	26.2	31	26.1	1987	63
Longreach Aero	QLD	High daily min	26.1	28	26.0	1987	37
Jervois	NT	High daily min	30.9*	28	29.4	1971	32
Mt. Hotham	VIC	Low daily min	-8.4*	9	-7.3	1998	14
Glenelg	QLD	High daily rain	73.6	2	66.3	1952	122
Wallangarra PO	QLD	High daily rain	109.6	2	91.4	1966	116
Glen Innes PO	NSW	High daily rain	85.8	2	82.8	1929	122
Deepwater	NSW	High daily rain	91.0	2	72.4	1954	114
Deeside	WA	High daily rain	52.2	27	43.7	1921	103

Charts from the Past by Blair Trewin

19 November, 1992

The late winter and spring of 1992 was a notably cool and wet period for southern Australia. The August-November period was the wettest on record for the southern Australian region as a whole, with regular and widespread flooding, particularly in South Australia and Victoria.

One of the most memorable events of the season resulted from a low-pressure system, with an associated cold front, which tracked south of the Australian mainland between the 19th and the 22nd.

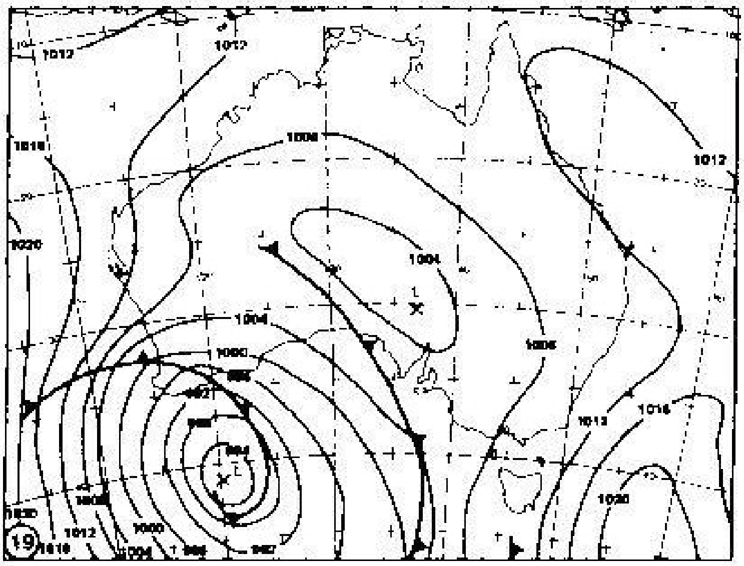
Perhaps the most exceptional event associated with the low occurred in the south-west of Western Australia on the 19th. Snow typically occurs on a few occasions each year on the highest peaks of the Stirling Ranges, but it is a rare event in any settled areas, even in the far south in mid-winter. The November 1992 event was extraordinary for its timing, less than two weeks before the start of summer. Snow fell as far north as Wagin and Narrogin, and was also reported at Manjimup, Kojonup, Boyup Brook and Mount Barker, all of them at elevations near 300 metres. It was one of the most significant snow events recorded in any month in Western Australia since June 1956.

Mount Barker's maximum of 7.7°C was the lowest daily maximum temperature ever recorded in spring in Western Australia, and numerous other locations, including Perth Airport (14.2), Albany (10.8) and Esperance (12.4), set records for November.

The system also brought severe winds on the west coast (115 km/h at Rottnest Island) and caused significant roof and tree damage in metropolitan Perth. There was substantial crop and fruit damage throughout the south-west, due to a combination of wind, hail and cold.

The temperatures associated with the system moderated as it moved east, but the severity of the weather did not. There were major severe thunderstorm outbreaks throughout south-eastern Australia between the 20th and the 22nd. Whilst individual incidents are too numerous to describe in detail, there were numerous reports of hail 4-7 centimetres in diameter in the northern agricultural regions of South Australia on the afternoon of the 20th, followed by severe winds on the morning of the 21st.

The system's parting shot came with a tornado near Smithton in northern Tasmania on the morning of the 22nd. This was one of the most notable tornadoes in recorded Tasmanian history, with a path 15 kilometres in length and numerous buildings destroyed or severely damaged.



Synoptic chart for 0000 UTC, 19 November 1992

Seasonal Climate Outlook

The Bureau of Meteorology's seasonal rainfall outlook for the March quarter shows no strong swings in the odds towards wetter or drier conditions. The chances of above average seasonal falls are generally close to a neutral 50%. This outlook is due to the fact that Pacific and Indian Ocean temperatures don't strongly influence Australian rainfall during mid-summer to early autumn.

Outlook confidence is related to the influence of Pacific and Indian Ocean temperatures on seasonal rainfall. During the March quarter, history shows this influence to be moderately consistent through eastern parts of NSW and Queensland, much of the NT and southern and western WA. Elsewhere the influence is only weakly or very weakly consistent .

Following a recent cooling trend, the tropical Indian Ocean warmed slightly during November, as did the tropical Pacific. The temperature patterns in the Indian and Pacific Oceans are not extreme enough to produce large swings in the outlook probabilities.

November's value of the Southern Oscillation Index (SOI) was –3, slightly below the –2 recorded in October.

The Bureau of Meteorology's seasonal temperature outlook for the March quarter, shows increased chances of above average daytime temperatures in parts of northern and eastern Australia. In contrast, in parts of southeastern Australia the first three months of 2004 are more likely to be cooler than average.

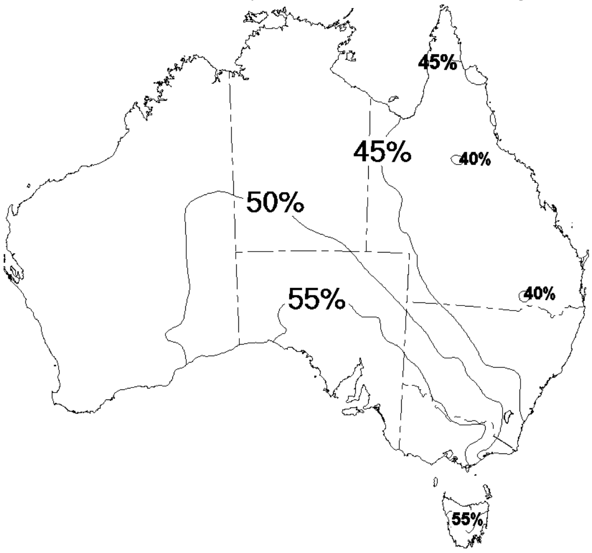
This outlook pattern is mainly the result of above average temperatures in the tropical Pacific Ocean, particularly the west. For the January to March period, the chances of above average seasonal daytime temperatures are over 60% northeast of a line from Derby in northwest WA to Sydney. Within this region, the chances peak in the 75 to 80% range in eastern Arnhem Land and in parts of northern and central Queensland (see map).

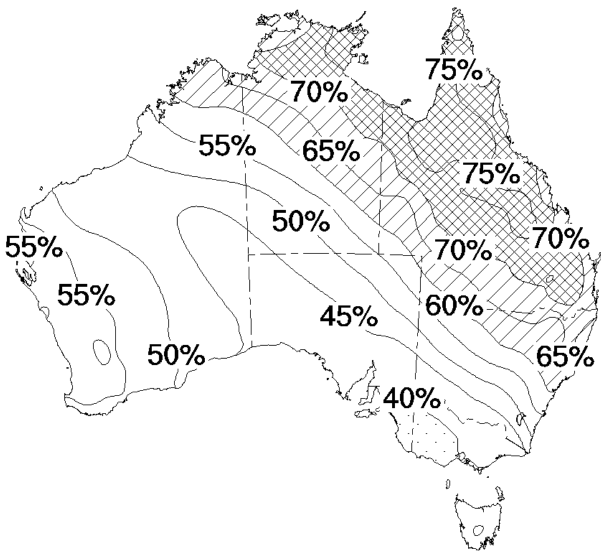
In southeast SA, western Victoria and a small part of central Tasmania, the chances of a warmer than average January to March are between 35 and 40%. This means that a cooler than average season has a 60 to 65% chance of occurring.

Warmer than average nights are favoured over most of the northern half of the continent, with probabilities above 60% across the NT, the northern three-quarters of Queensland and northeast WA. Elsewhere, the chances of above average overnight March quarter temperatures range between 40 and 60%. This outlook pattern is mostly due to above average temperatures in the Pacific Ocean.

History shows the oceans' influence on minimum temperatures in the March quarter to be moderately consistent over most of Queensland, the NT and northern WA. Elsewhere the influence shows weak to very weak consistency.

Further Information:
http://www.bom.gov.au/climate/ahead/





Probability of above-median rainfall (left) and mean max. temperature (right) for Jan-Mar 2004.

Calendar

January

11-15 84th AMS Annual Meeting, Washington State Convention and Trade Center, Seattle, Washington, USA

26-30 Conference on Hurricanes and Tropical Meteorology, Miami, Florida, USA

26-30 12th Ocean Sciences Meeting, Portland Oregon, USA
http://www.agu.org/meetings/os04/

May

10-15 Ocean Ops 04; Operational Metocean Products and Services in Support of Maritime Safety and Environmental Management, Centre International de Conferences, Meteo-France, Toulouse, France

24-28 9th International Meeting on Statistical Climatology, Cape Town, South Africa

June

20-25 ECSA 37 – ERF 2004, Estuaries and Change, Ballina NSW, Australia
hwww.scu.edu.au/esca37ecsa2004conference

July

5-9 AMOS Annual Conference, as part of the International Conference on Storms, Brisbane, Queensland, Australia.
http://www.amos.org.au/stormsconf

August

2-11 International Association of Meteorology and Atmospheric Sciences conference, Beijing, China

16-20 AGU Western Pacific Geophysics Meeting, Hawaii Convention Center, Honolulu, Hawaii, USA. (*Co-sponsored by AMOS*). http://www.agu.org/meetings/wp04/

IAPSO-IAG-IABO joint conference, Cairns, Australia (final August dates TBA). Input welcome to John Middleton & Chris Rizos, UNSW.

September

26-39 4th Annual European Meteorological Society (EMS) meeting, Nice, France.

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ARTICLES:

Tory, K.J., Cope, M.E., Hess, G.D., Lee, S. and Wong, N. The use of long-range transport simulations to verify the Australian Air Quality Forecasting System

Seaman R. and Hart, T. The history of PAOBS in the Australian Bureau of Meteorology

Lehmann, P. and Easson. J.R. A comparison of pump efficiency corrections for the Australian Brewer-Mast ozonesonde data record

Reeder, M.J., Lane, T.P., Guest, F.M., and Wratt, D. Two southerly changes observed during the New Zealand Southern Alps Experiment (SALPEX)

REGULAR FEATURES:

Reid, P.A., Seasonal climate summary southern hemisphere (2002/03): El Nino begins its decline.

BOOK REVIEWS:

Mitchell, R. Spectral imaging of the atmosphere by G. Shepherd;

Downey, W.K. Storm watchers by J. Cox;

Lindesay, J. Global-regional linkages in the Earth system by Tyson et al. (eds).

Further Information:
http://www.bom.gov.au/amm