Thematic findings

Atmosphere

Climate, weather and the state of the atmosphere are of prime importance in the economic, social and environmental health of our cities, regions, offshore territories and oceans. Australia, like other countries, spends a considerable effort on forecasting the weather nationwide, including warnings of extreme events, and in understanding and predicting the global climate and its changes. All Australians face major problems of living sustainably in a climate with extreme and highly variable weather, and a society in which agriculture and industry, population and the built environment all continue to grow.

Since 1996, Australian governments have introduced ways to improve the health and understanding of the atmosphere. This includes the establishment of the AGO, charged with managing a whole-of-government approach to greenhouse matters and ways to abate the greenhouse effect (see http://www.greenhouse.gov.au).

The quality of urban air has generally improved or remained constant for most years, but emission of pollutants in cities, mainly from vehicles, remains of concern.

The National Pollutant Inventory (NPI), established in 1998, is a major advance in environmental management (see http://www.npi.ea.gov.au). Before its establishment, data on emissions were sporadic and of poor quality, where data are now collected in a nationally consistent manner.

The 1997 Inquiry into Urban Air Pollution by the Australian Academy of Technological Sciences and Engineering (AATSE) was a major force behind introducing ways to improve or maintain urban and regional air quality. The AATSE was asked by the Commonwealth government to identify practical solutions to air quality problems that could be implemented by all levels of governments, industry and the community.

Recommendations of the Inquiry were used to inform Commonwealth government actions on air quality as part of the Air Pollution in Major Cities Program. This Program aims to:

- support the development of national air quality standards under the auspices of the National Environment Protection Council (NEPC) and other national cooperative forums
- improve the consistency of air quality monitoring across Australia to allow improved targeting of management strategies
- support air quality research and community education on air quality issues.

Source: CSIRO.

Table 1: The Air NEPM—Standards and goals for Australia set in 1998

Pollutant	Averaging period	Maximum concentration	Goal within 10 years[A]
Carbon monoxide	8 hours	9.0 ppm	1 day/year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day/year None
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day/year 1 day/year
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day/year 1 day/year None
Lead	1 year	0.50 $\mu g/m^3$	None
Particles as PM10	1 day	50 $\mu g/m^3$	5 days/year

[A] Maximum allowable exceedences.

Source: NEPC (1998).

Australia has an agreed set of national ambient (outdoor, as opposed to indoor) air quality standards for each of the major air pollutants listed in Table 1. These standards, made by the NEPC on 26 June 1998, are contained in the National Environment Protection Measure (NEPM) for Ambient Air Quality (Air NEPM) (Table 1) and http://www.nepc.gov.au.

Jurisdictions commenced reporting air quality data to NEPC under the Air NEPM in 2001, with the goal of meeting the standards within 10 years (by 2008). However, available air quality data indicate that the standards have been exceeded only a few times in most urban and regional areas since 1997. This can be attributed to the substantial efforts to reduce pollution from vehicles and major industrial sources.

Since 1996, many policy and regulatory structures have been put in place and a wide variety of other government, non-government and private industry initiatives have been developed to improve environmental performance.

In considering the state of the atmosphere, there were four key issues examined:

- climate variability and change
- stratospheric ozone
- urban air quality
- regional air quality.

A summary is presented in *Key findings* (page 5).

Key issues

Climate variability and change

Australia's climate is strongly influenced by the surrounding oceans, and weather systems such as the monsoon, tropical cyclones and cold fronts that give each region of the country its own characteristics. High year-to-year variability obscures any short-term background trends. Most of the year-to-year variations are linked to large-scale events such as the ENSO phenomenon. The Southern Oscillation is a two to five year sequence of differences in atmospheric pressure and changes in sea temperatures between the tropical central or eastern Pacific and the tropical eastern Indian Ocean or northern Australian region. El Niño (Figure 3) causes below-normal rainfall, and often drought, over much of Australia. The reverse effects occur during La Niña. These effects are additionally influenced by changes that occur in the Pacific over decades.

Australia's mean annual rainfall has increased slightly since 1910, mostly from the monsoonal north and west through to the south-east (Figure 4). A slight but cyclic increase in extreme wet conditions (Figure 5) has also occurred. Average and extreme amounts of rainfall have decreased in south-west Western Australia.

The total number of cyclones has decreased marginally since 1969–70, but their intensity may have increased slightly. The projected increased temperatures and reduced rainfall over some parts of Australia could lead to changes in agricultural patterns in marginal areas. Extreme events, including extensive flooding, will continue, with significant effects on agriculture, industry and infrastructure as well as on coastal habitat and coral reefs.

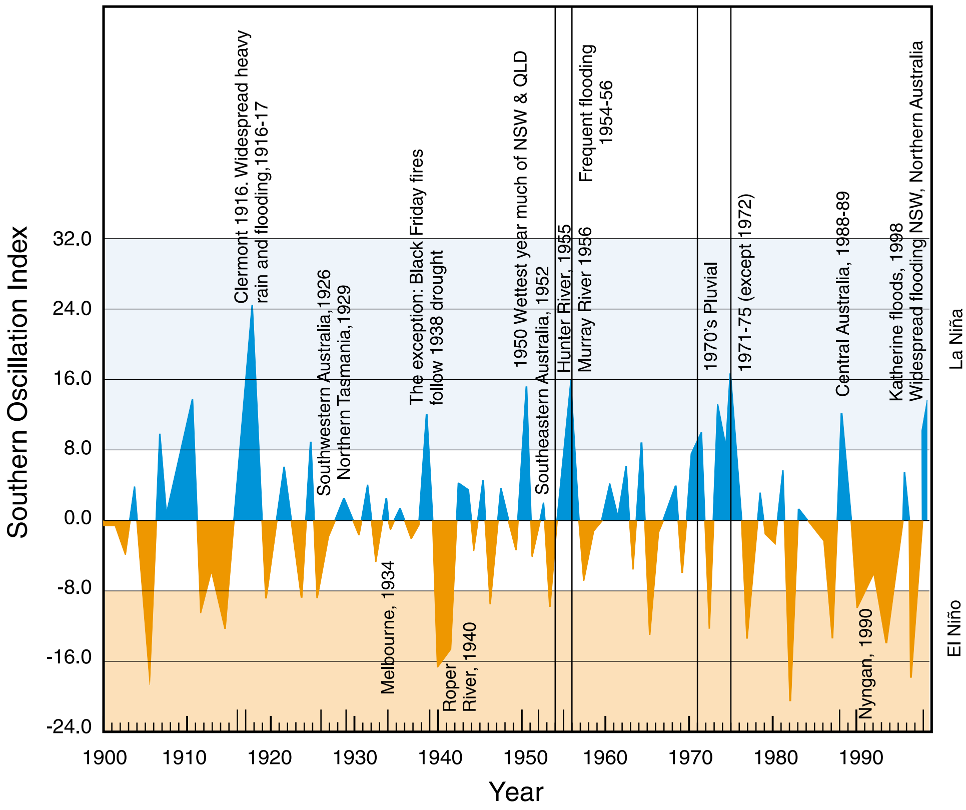

Figure 3: Annual variations in the Southern Oscillation Index.

Major floods associated with La Niña events since 1901 are also shown.

Source: BoM.

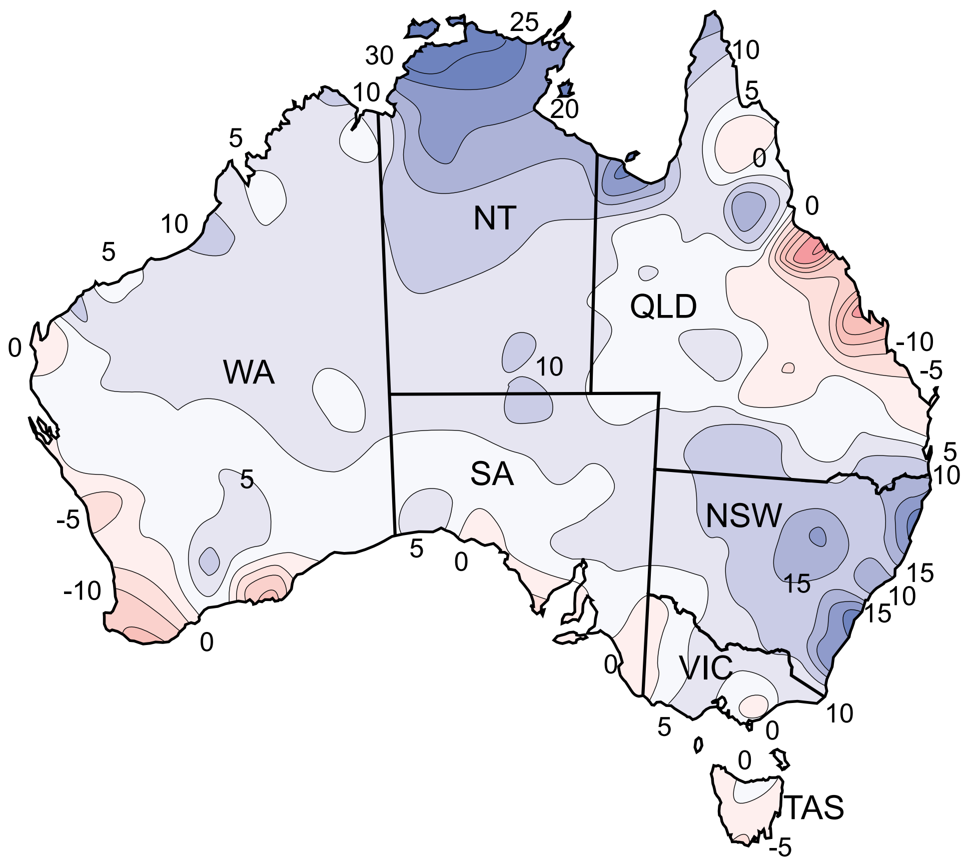

Figure 4: Rainfall trends in Australia from 1910 to 1999.

Trends are shown as millimetres per 10 years.

Source: BoM.

Australian average surface temperature follows global trends and has increased by 0.76°C since 1910 (Figure 6) with the minimum up by 0.96°C and the maximum by 0.56°C. The increase is largest over western and northern Australia. The number of extreme warm days and nights has increased while that of extreme cool days and nights has decreased, along with the annual number of frost days and the length of the frost season.

The sea around Australia appears to have risen an average of 12 to 16 cm over the last 100 years, compared with the IPCC estimated global average increase of 10 to 20 cm. However, tectonic action causes both falls and rises in local sea level observed around Australia. These changes, documented by the National Tidal Facility, Flinders University, confound the changes relative to the whole continent. Year-to-year variations around Australia also exist, strongly linked to ENSO. IPCC projects a global increase in sea level of 9 to 88 cm by 2100 (IPCC 2001).

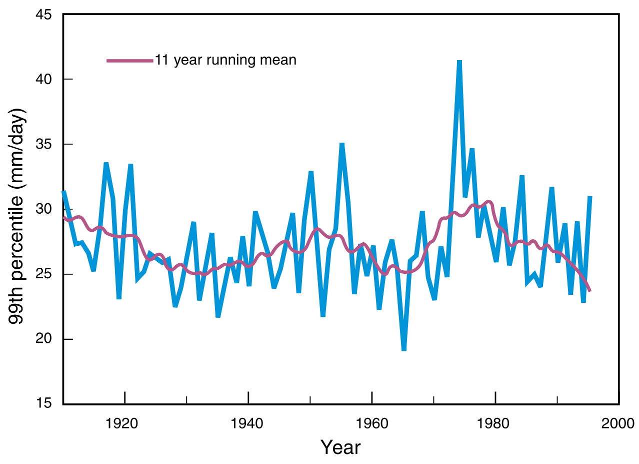

Figure 5: Interannual variations in the annual extreme rainfall (99th percentile of daily rainfall) for Australia.

Source: CSIRO Atmospheric Research.

Extreme weather causes considerable damage and losses. Tropical cyclones cause the most damage overall, with severe thunderstorms associated with hail and strong winds second. The largest cost for a single event, an estimated $1.6 billion, was the Sydney hailstorm of 1999.

Droughts result in fewer exports and lower tax receipts from primary production. Drought relief payments from 1992 to 1999 have averaged $100 million per year but the direct cost to government is only a part of the overall cost to the individual, communities and businesses. Coping with extreme events may require considerable changes in management practice to minimise cost and ensure sustainability, whether or not predicted long-term changes in climate occur.

Enhanced greenhouse effect

Carbon dioxide (CO_2), methane and water vapour in the atmosphere provide a natural greenhouse effect. These gases, together with clouds and aerosols in the stratosphere, maintain the earth's energy balance. Human activities and natural events can upset the balance by discharge of additional greenhouse gases into the atmosphere. Carbon dioxide is the most important greenhouse gas and its increase has accelerated since the mid-1800s. Methane shows a similar increase to carbon dioxide. Methane largely derives from the biosphere, particularly from livestock, rice cultivation, organic waste and landfills, as well as oil and gas production, gas distribution and coal mining.

Under the Kyoto Protocol developed countries are committed to reducing their greenhouse gas emissions by at least 5 per cent below 1990 levels by the first Kyoto commitment period (2008–12). However, at Kyoto, Australia negotiated an 8 per cent increase in emissions. According to the National Greenhouse Gas Inventory (NGGI) Australia's estimated emissions are already more than double this amount (although it should be noted that the NGGI methodology does not directly equate to the Kyoto Protocol accounting requirements).

Australia has very high greenhouse gas emissions per capita, although the total amount emitted is still small compared with other developed countries. Our total annual emissions, excluding land clearing, increased by 16.9% between 1990 and 1998 (Table 2) using the NGGI methodology. The increase of 16.9% compares unfavourably with Australia's target of an 8% increase above 1990 levels during the 2008–12 commitment period. Recent NGGI figures show that for 1999, total emissions increased by 17.4% from those in 1990.

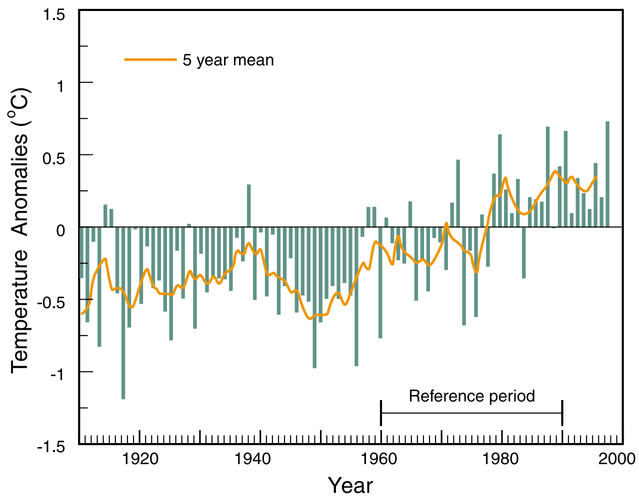

Figure 6: Annual mean temperature anomalies for Australia.

Source: BoM.

Table 2: Change in total carbon dioxide equivalent (CO_2-e) emissions by gas, 1990 to 1998
Totals and percentages may not correspond exactly due to rounding.

	1990 (Mt CO_2-e)	1998 (Mt CO_2-e)	Changes (Mt)[B]	Change in emissions (%)
Carbon dioxide	250.0	312.1	62.1	24.8
Methane	112.9	114.9	2.0	1.8
Nitrous oxide	22.1	27.5	5.4	24.3
Perfluorocarbons, etc.[A]	4.8	1.4	–3.4	–70.6
Total CO_2-e	389.8	455.9	66.1	16.9

[A]Includes sulfur hexafluoride (SF_6) from metal production; [B]Megatonnes.
Source: AGO (2000).

The main Australian sources of greenhouse gas emissions are:

- electricity and heat production, 56.8%
- agriculture, 20.2%
- transport, 15.9%
- fugitive emissions, 6.9%
- waste, 3.4%
- industrial process, 2.2%.

However, carbon dioxide removal relating to forestry and other subsectors reduced CO_2-e total by 5.4%. Therefore, any strategy that aims to reduce greenhouse gas emissions substantially should focus on energy production and use.

There is some evidence that Australia is being successful in decoupling its economic growth from its greenhouse emissions. The recent NGGI data showed greenhouse emissions increased by 1.1 % during 1999 while the economy grew by 5.4%.

The current best estimate of total gross emissions from the land use and forestry sector is 134.7 Mt of CO_2 or CO_2 equivalent (CO_2-e), while total removals (absorption of CO_2) in 1998 were estimated to be 95.2 Mt CO_2-e, a deficit of 39.5 Mt CO_2-e. The AGO reports that these estimates are unreliable because of uncertainty and gaps in the data.

Commonwealth and state governments, local councils and many businesses and industries have taken measures to respond to global warming by reducing greenhouse gas emissions. Measures include planting trees and managing land use to enhance greenhouse sinks, improving energy efficiencies, developing renewable energy and integrating transport systems.

Global models of climate are used to predict the potential effects of increasing concentrations of greenhouse gases. For Australia, the Commonwealth, Scientific and Industrial Research Organisation (CSIRO) has developed a range of temperature and rainfall projections that also take into account the uncertainties in such projections (Figures 7 and 8).

To the year 2030, most of Australia could warm by anywhere from 0.4 to 2.0°C. For 2070, the potential warming is about 1 to 6.0°C with regional and seasonal variations within both sets of projections.

In most locations, annual average rainfall relative to 1990 could either increase or decrease around the years 2030 and 2070. Changes are biased towards decrease in the south-

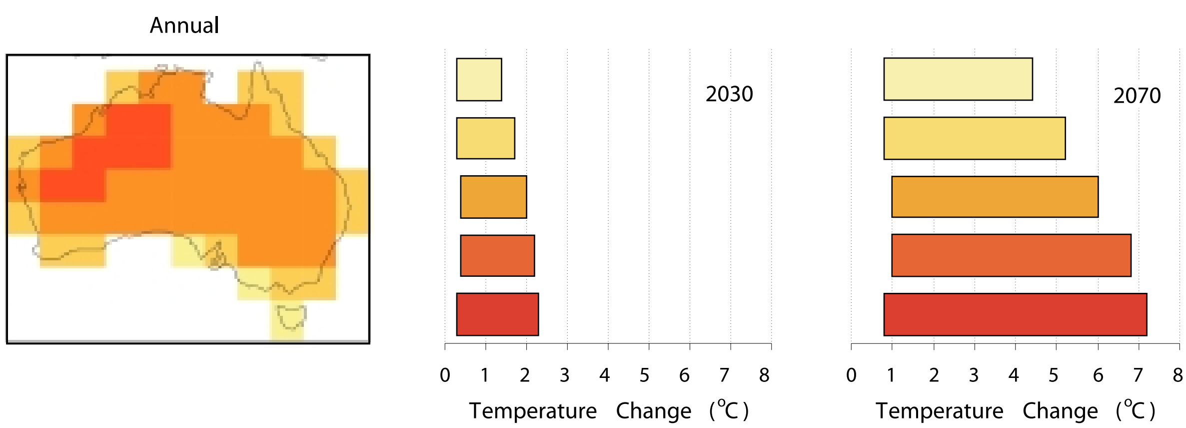

Figure 7: Projected mean annual temperature changes for 2030 and 2070.
Source: CSIRO Atmospheric Research.

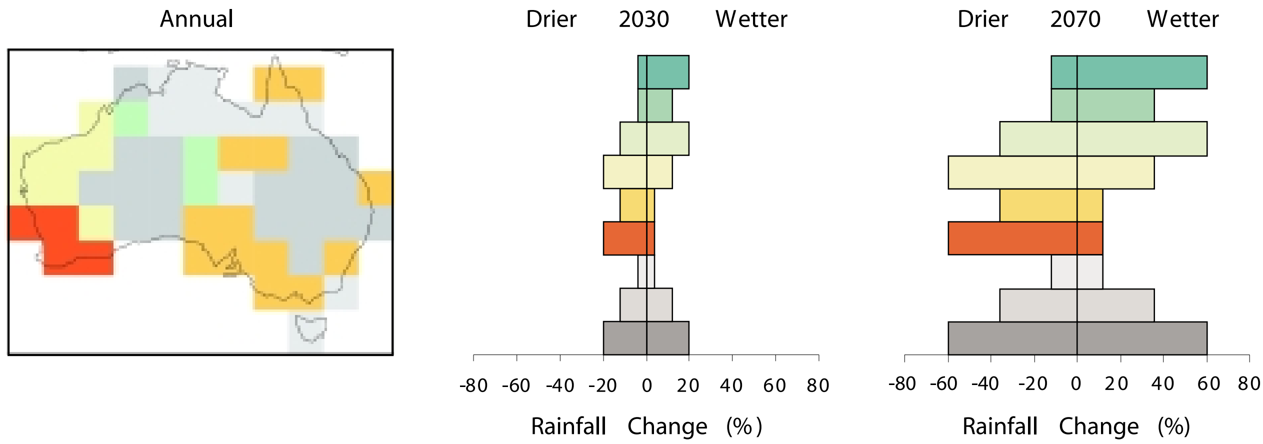

Figure 8: Projected rainfall changes for 2030 and 2070.

Source: CSIRO Atmospheric Research.

west and parts of the south-east and Queensland. For most other locations, predicted changes are around –10% to + 10% by 2030 and –35% to +35% by 2070. Despite their uncertainties, such models will continue to be an important means of anticipating the future (for details, see http://www.dar.csiro.au/publications/projections2001.pdf).

Stratospheric ozone

Ozone in the atmosphere prevents most of the sun's harmful ultraviolet (UV-B) radiation from reaching the earth's surface. It is produced in the stratosphere by the action of energetic UV radiation on molecular oxygen, and in turn destroyed by UV photolysis and by reaction with other oxygen species. Ozone destruction is assisted by trace levels of chlorine and bromine compounds released from the earth's surface.

The major ozone-depleting substances include chlorofluorocarbons (CFCs), halons and methyl bromide, used in many industries. Global consumption of these substances is now limited by the *Montreal Protocol on Substances that Deplete the Ozone Layer* to which Australia is a signatory. Accumulation of ozone-depleting substances is now declining slowly (Figure 9). This is a significant development since SoE (1996).

Ozone levels over Australia and New Zealand fell by 3 to 4% per decade from the 1960s, but may not decline much further. The largest ozone depletions, a drop of 60%, have occurred over Antarctica, where ozone removal has been enhanced by ice nuclei in polar stratospheric clouds and weak Antarctic sunlight.

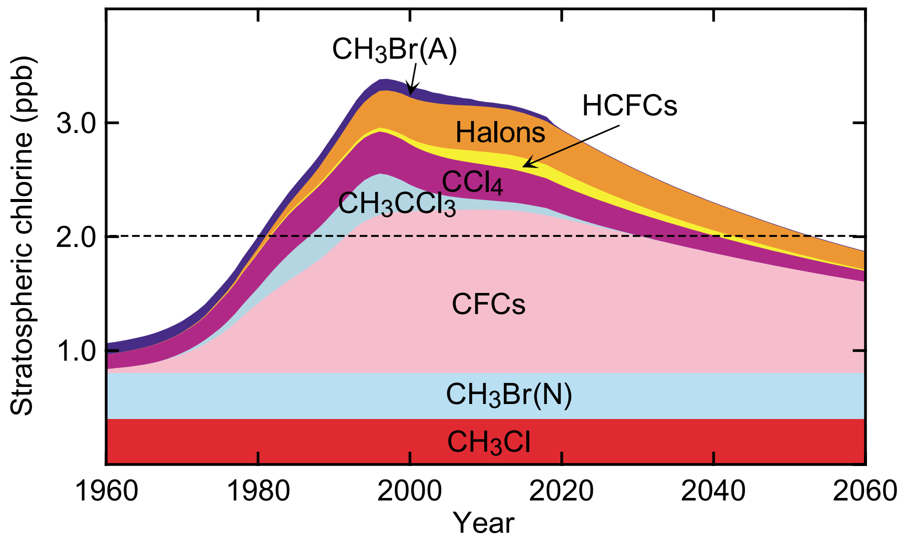

Figure 9: Stratospheric chlorine levels (ppb, cumulative) based on global atmospheric observations (1980–2000), historic (1960–1980) and projected emission data (2000–2050) of the major ozone-depleting substances.

The line at 2 ppb corresponds to when ozone depletion was first detected (about 1980) and when ozone recovery is anticipated (about 2050).

Source: Madronich & Velders (1999).

Australia has high levels of UV radiation and the highest per capita incidence of melanoma in the world, 28 per 100 000 persons in 1990. Since 1980, UV exposure in tropical regions of Australia has increased by 20% as a result of simultaneous depletion of ozone and decreases in cloud cover. At mid-latitudes, no significant net increases per year were found because of increasing levels of cloud cover but clear day levels of UV radiation rose. Human behaviour in avoiding excessive UV exposure is likely to have more than compensated for the increases in the UV levels. To assist the public the Bureau of Meteorology has recently added UV forecasting as one of its products (see http://www.bom.gov.au/weather).

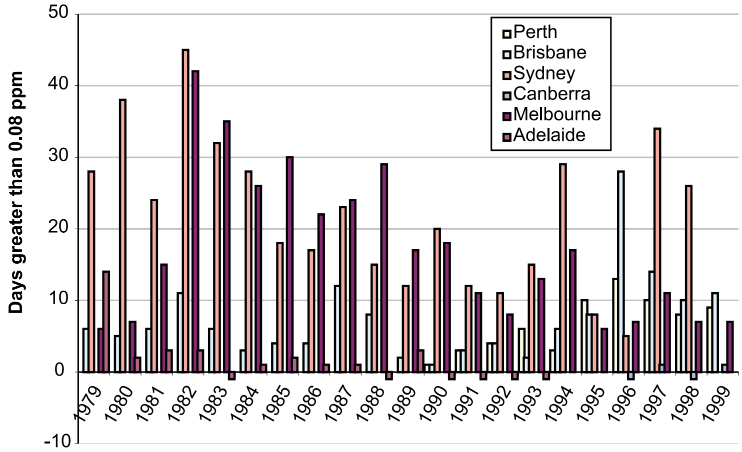

Figure 10: Maximum four-hour ozone concentrations in selected cities.

Source: Commonwealth, state and territory environment authorities.

Urban air quality

Over 60% of Australians live in coastal capital cities. High radiation levels, high summer temperatures and location in coastal basins surrounded by hills, make Australian urban areas susceptible to photochemical smog and to its recycling or concentration over areas of the airshed. Australian cities have air quality comparable with the better performing American, European and Asian cities.

Motor vehicles are the major emitters of air pollutants in urban Australia, contributing more than 75% of the carbon monoxide emissions and most of the oxides of nitrogen and organic compounds. Emissions include very fine particles that contribute to urban haze and adverse health. The phase-out of leaded petrol (complete by 2002) means that lead in air is no longer a concern for any major urban area. During 1980 to 1999, the eight-hour Air NEPM Standard for carbon monoxide has been exceeded in areas of high traffic density and low traffic flow, but the problem is not widespread. For nitrogen dioxide, only Sydney has shown exceedences and then on only one day per year.

In urban Australia, ambient sulfur dioxide concentrations rarely exceed Air NEPM values except near petroleum refineries, or petrochemical or chemical industries. Emissions of oxides of nitrogen and hydrocarbons react with sunlight to eventually form ozone, whose concentrations provide an estimate of photochemical smog. Since the 1980s, the maximum value of hourly ozone concentrations has declined steadily in the biggest cities. However, for the maximum amount averaged over four hours (Figure 10), there has been no decline, and hence no real drop in the level of photochemical smog. This indicates that the stricter vehicle emission limits proposed for the future will be needed to reach and maintain the Air NEPM standards.

Given that motor vehicles emit most of the pollution in capital cities (with power stations and heavy industry still a contributor in Perth and Brisbane), vehicle emission standards and their implementation are of major importance.

The present standard for new cars is Australian Design Rule 37/01 (ADR37/01). Starting in 2002, progressively tighter standards (ADR79, in harmony with European emissions standards Euro 2, 3 and 4) will be introduced and will become fully effective in 2005 (Tables 3 and 4).

The values for Melbourne in Table 3 reflect the 10-year average age of the Australian vehicle fleet. The 10% rate of replacement results in a long lag between the introduction of new standards and actual reductions in pollution.

Motor vehicle numbers and VKT continue to rise (Table 5). Fortunately, the stricter emission limits that will be introduced, together with the *National Fuel Quality Act 2000*, which will commence fully on 1 January 2002, should continue to maintain the quality of

Table 3: Comparison of Australian Design Rules for motor vehicle emissions and observed emissions for Melbourne

Emissions standard	Year first introduced	CO^A (g/km)	NO_x^B (g/km)	Hydrocarbons (g/km)	Evaporation (g/test)
ADR27	1974	24.2	1.9	2.1	6.0
ADR37/00	1986	9.3	1.93	0.93	2.0
ADR37/01	1997	2.1	0.63	0.26	2.0
Melbourne observations	1999	12.0	1.51	1.04	—

^{A}CO, carbon monoxide; ^{B}NO_x, nitrogen oxides.

Source: Beer (1995), FORS (1996); Melbourne observations from EPAV (1998, 1999a).

Table 4: Emission limits and timing for vehicles to meet Euro standards in Australia

	Fully in force	CO (g/km)	NO_x (g/km)	HC (g/km) [exhaust][A]	PM (g/km)
Passenger cars and light commercial					
ADR37/01 (petrol)	1997–99	2.1	0.63	0.26	NA[B]
ADR79/01 (Euro3) (passenger, light commercial: petrol, LPG[D], CNG[E])	2005–06	2.3	0.15	0.2	0.05[C]
ADR79/01 (Euro4) (light diesel)	2006–07	0.5	0.25	0.3 (NO_x + HC)	0.025
Heavy duty diesel					
ADR70/00	1995–96	4.5	8.0	1.1	0.36
ADR79/01 (Euro4)	2006–07	4.0	3.5	0.55	0.03

[A]HC [evaporative] 2 g/test, [B]NA, Not applicable; [C]Applicable to light diesels, [D]LPG, Liquid petroleum gas, [E]CNG, Compressed natural gas.

Source: http://www.dotrs.gov.au/land/Environment/emission-requirements.htm.

urban air. Modelling by the Bureau of Transport Economics estimates that, with the new standards, particulates in urban areas from diesel vehicles will be 26% less in 2015 than in 2000, even with an expected growth of 60% in VKT. If urban vehicle usage increases substantially beyond projected estimates, alternative transport systems and even stricter emission controls may be required.

Although photochemical or smoke haze occurs, visibility in all Australian cities is substantially greater than 20 km. Seasonal pollens and dust, however, make Australia the worst country in the world for hayfever, contributing to over 40% of young adults suffering allergic symptoms.

Despite the importance of pollen counts as a health indicator, little monitoring occurs outside Melbourne. This is in marked contrast to the United States of America where local pollen counts are available (see http://www.weather.com/health/allergies/).

Emissions of a pollutant and exposure to it are not always directly linked. Most benzene emissions come from automobile exhaust and industrial emissions but these contribute only modestly to people's exposure (for emissions in urban areas see Table 6). Benzene released by cigarettes, petrol fumes and consumer products poses a much greater threat. The exposure of Australian urban populations to air pollutants can be defined by a characteristic concentration to which 37% of the population is exposed at least once per year. Such data indicate that most urban Australians are not exposed to the maximum values that individual monitoring stations may record. Therefore, PM10 concentrations in Sydney can reach maximum values of 60 to 90 $\mu g/m^3$ but the characteristic concentration which typifies the exposure for most of the population is only 15 $\mu g/m^3$.

The main respiratory health risk for Australians arises from particulates and hydrocarbons. Since 1979, death as a result of respiratory diseases and respiratory cancers has been falling for males but rising for females, which mirrors cigarette smoking patterns. Peaks in death rates also arise from influenza outbreaks. Therefore, studies to relate air quality and health variables need to allow for these major effects before determining the more subtle effects induced by air pollution.

Most air pollution complaints to EPAs involve odours from a range of sources. Odours from diffuse sources are often difficult to identify and control. There is no consistent and

Table 5: Growth in Australian passenger car numbers and distance travelled

	Cars (thousands)	Cars per thousand people	VKT (billions of km)[C]
1979	5652[A]	389.3[B]	84.8
1982	6290[A]	415.6[B]	96.1
1985	6926[A]	438.6[B]	106.6
1988	7381[A]	446.8[B]	116.6
1991	8012[A]	463.6[B]	114.3
1995	8628[D]	478.8[D]	113.0
1998	9315[C]	496.8[E]	134.3

[A]BTCE (1996: Table I.1, p. 331); [B]BTCE (1996: Table II.5, p. 356); [C]ABS (2000b: Table A3, p. 24); [D]ABS (1997: Table 1.4, p. 9);
[E]ABS (2000c: p. 77).

Table 6: Peak values of urban benzene and toluene concentrations in Australia
Values given in µg/m^3 have been converted to ppb.

	Benzene (ppb)	Toluene (ppb)	Location and year	Benzene (ppb)	Toluene (ppb)	Location and year
Melbourne	14.9	20.2	CBD[A] 1990	7.9	13.0	CBD 1997
Sydney	2.6	8.9	1979–1980	2.5	6.9	1992–1993
Perth	5.0	9.1	Perth Traffic 1993–1994	1.44	2.56	1997–1998
Brisbane	5.3	10.7	1992	2.7	10.2	1998 Maximum
Adelaide	10.3	11.5	Hindley St 1989	8 .0	37 .0	North Tce 1994

[A] CBD, Central business district.

Source: EPAV (1998, 1999a, 1999b); DEPWA (1999a).

agreed objective method to measure and assess the strength and responses to odours. Odour criteria, if defined, vary among the states and territories but some states are now working on these issues and management approaches with the release of public discussion papers. No agency exists to coordinate a national approach to issues such as assessment methods, remedial measures and preventative strategies.

Regional air quality

In rural and regional Australia, levels of pollutants are generally well below actual or proposed standards. Carbon monoxide levels produced by vehicles, wood fires or other combustion sources can produce local effects but these are limited. Nitrogen dioxide and ozone are not of concern except for occasional transport from one region into another region. Benzene, where monitored, is well below any proposed standards. Airborne insecticides can be a local problem.

Airborne dust is often the only significant air quality issue in regional Australia. Strong winds influence levels of dust which can be attributed to natural sources as well as wind-blown erosion in cultivated or stocked areas and to mining. Particulates also arise from bushfires, burning off and domestic wood fires.

Maximum PM10 concentrations vary greatly. The Air NEPM allows five exceedences per year of the 24-hour average of 50 µg/m^3. Most regions comply, but wood burning in Launceston (Tas.) and Armidale (NSW) results in obvious exceptions. In Armidale, there were many days in 1997 and 1999 when 'local visual distance' was below 2 km (Armidale 2000).

The implementation of the Australian Minerals Industry Code for Environmental Management has helped reduce dust loads in mining areas. However, in New South Wales, a value of 4 g/m^2 per month of dust deposition is set for coal mining areas and until 1996, dust deposits in Wollongong remained close to or above this limit. In the Port Kembla area, deposition rates were generally higher.

In South Australia, dusty days are common, frequently due to wind erosion. As much as 20% of the state's asthma problems are possibly due to windborne dust.

With a 30% overall reduction in sulfur dioxide emissions since 1996, most of regional and rural Australia is now unaffected by sulfur dioxide pollution and there are only a few regional localities still of concern. In Port Pirie, maximum concentrations are presently unacceptable. Pollutants may be trapped close to the ground in atmospheric inversions at night, and mixing of plumes to the ground can occur during days with intense solar heating.

Mount Isa continues to meet its licence levels with the company's predictive control strategy in operation. However, the one-hour Air NEPM Standard is evidently a much bigger challenge (Figure 11) even with sulfur removal into the new sulfuric acid plant.

The copper smelter at Port Kembla used to have very high ground level concentrations of sulfur dioxide and of

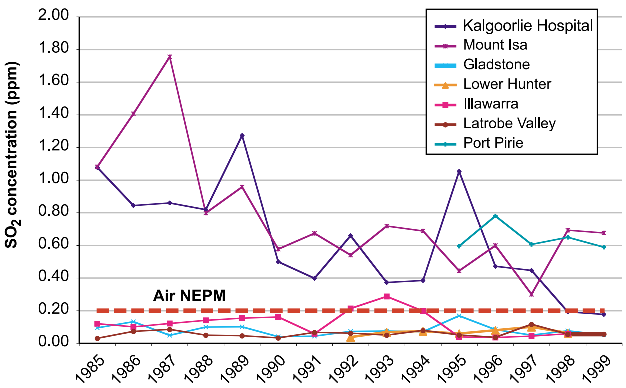

Figure 11: Highest one-hour averages of sulfur dioxide since 1985 in regional centres of Australia.

Lower Hunter from 1992; Port Pirie from July 1995.

Source: Data from State EPAs; DEPWA (1999b).

Table 7: ANZECC goals for ambient concentrations of fluoride
Values are presented in μg/m^3.

Goals	12 hour	24 hour	7 day	30 day	90 day
General land use	3.7	2.9	1.7	0.84	0.50
Special land use	1.8	1.5	0.80	0.40	0.25

Source: ANZECC (1990).

lead. After extensive community action and court appeals, the smelter was rebuilt in 2000 with a new sulfuric acid plant to remove much of the sulfur dioxide (see http://www.pkc.com.au/).

Mineral extraction and processing activities at Kalgoorlie have recently drastically reduced the one-hour and annual averages of sulfur dioxide and no exceedences of the Air NEPM have occurred in recent years for Gladstone, Lower Hunter and Latrobe Valley (power generation areas using coal).

Lead is of concern in rural or regional Australia only near smelters. At Mount Isa, ambient lead concentrations in the town are well below the Air NEPM Standard, even though stack emissions are large. Other significant industrial sources, notably Port Pirie and Cockle Creek, have committed to the Australian Minerals Industry Code for Environmental Management but substantial effort is still required in these locations before it can be said that all of Australia complies with the Air NEPM for lead.

Gaseous fluoride compounds cause damage to plants at concentrations about one thousand times lower than those that affect human health, and grapevines are particularly sensitive. The Australia and New Zealand Environment Conservation Council (ANZECC) has recommended ambient levels based on damage to plants (Table 7).

Fluoride concentrations are not a cause for concern around any of the aluminium smelter locations. At sensitive vineyard sites in the Hunter Valley (NSW), data from 1990 to 1995 show annual maximums of 0.1 to 0.3 μg/m^3, well below the guideline for sensitive vegetation of 0.8 μg/m^3, and there are consistently low atmospheric fluoride concentrations near the Alcoa smelters in Victoria. Major reductions in emissions of fluoride from smelters operated by Comalco Ltd have occurred over the past five years and these smelters are now comparable with new smelters at Tomago and Portland.

Gaseous fluorides are emitted in significant quantities from power station stacks, and investigative monitoring of these would be prudent.

Conclusion

Australia's climate is highly variable both in the short term and long term, and is dominated by major ocean and air circulation systems. Average temperatures have risen by 0.76°C since 1910, consistent with global increases. Rainfall averages have increased somewhat over most of the continent, although there have been decreases in some areas. Extreme events (drought, cyclones, floods and hailstorms) may have slightly increased in number or intensity, but also show cycles of decades in length.

Australia's greenhouse gas emissions per capita are high by world standards, and continue to increase, with energy production and use the greatest contributors.

Ozone loss from ozone-depleting chemicals has stabilised with reduction in their use, but ozone levels may not recover for many decades. Concomitant UV radiation levels have increased, but human behaviours to avoid excessive exposure have outweighed these increases.

Urban air quality has generally improved over the last two decades although episodes of high ozone levels still persist. Most other urban air pollutants—lead, sulfur dioxide, nitrogen dioxide, carbon monoxide and fine particles—are now less than set by the recent Air NEPM standards. Woodsmoke and pollens are a significant seasonal problem in some cities.

Motor vehicles remain the major source of urban air pollution. New emission standards, similar to those in Europe, and fuel standards should outweigh the projected increases in VKT.

Australia has the highest number of hayfever sufferers in the world attributed to pollen and other nasal allergens. There is insufficient regular, ongoing monitoring of pollen counts.

Most air pollution complaints to EPAs involve odours from a range of sources. There is no consistent and agreed objective method to measure and assess the strength and responses to odours.

Regional air quality is generally good. The exceptions are sulfur dioxide near some smelters, and in some locations, airborne dust or woodsmoke. Fluoride levels outside all Australian aluminium smelters are below the required limits, but may still be an issue for coal-fired power stations.

Coasts and oceans

Australia's marine area extends about 16 million square kilometres, from Antarctic to near equatorial latitudes. It includes one of the largest Exclusive Economic Zones in the world (11 million km^2), and the high degree of endemism (numbers of species found only in a particular region) in the south and the rich tropical diversity of the north create unique opportunities and challenges for Australia.

Australia is highly dependent on its marine resources in a range of ways such as the benefit of marine industries including shipping, tourism, fisheries and offshore oil and gas (see *Antarctica* box on page 37). The value of our marine resources has been appreciated by Indigenous Australians for thousands of years and their cultural associations remain strong. Many people cherish the clean beaches, the tourist destinations such as the Great Barrier Reef and the picturesque southern coastlines. Millions of Australians appreciate the pleasures of recreational fishing.

SoE (1996) raised the awareness of Australians to the state of their environment (as did *The State of the Marine Environment Report* in 1995). SoE (1996) found that coastal development had degraded near shore and estuarine habitats and water quality, particularly in the south-east and south-west. Many fisheries were fully or overexploited; and introduced marine pests were a threat to marine ecosystems. These findings are largely reinforced in SoE (2001).

In general, the states and territories have jurisdiction over marine areas to 3 nm from the baseline, and the Commonwealth has jurisdiction beyond those waters to the outer boundaries of the EEZ. The Offshore Constitutional Settlement established jurisdiction between the Commonwealth and the states over marine areas in 1983. Most of Australia's marine area is under sole Commonwealth jurisdiction.

In considering the condition of the coasts and oceans, there are eight key issues:

- degradation of habitats
- threats to marine species
- effects of increased coastal settlement
- coastal water quality
- fisheries and aquaculture
- introduced marine pests
- marine industry development
- marine resource management.

A summary is presented in *Key findings* (page 5).

Key issues

Continued degradation of habitats

Mangroves are our marine forests. Australia has 43 species representing 58% of global diversity. No mangrove species is considered threatened, and indeed, net mangrove area may be increasing. Reasons for the increases include growth in areas of accreting mud banks, and incursion into salt marsh systems. Mangrove forests are being destroyed locally through urban expansion, or through changes to drainage systems. Loss of mangroves represents loss of fish habitat and changes to the flows of nutrients and sediments. The consequences are lowered fish productivity and loss of water quality.

Seagrasses are not robust ocean 'weeds': they are flowering plants and represent productive, shallow marine pastures. They support nursery areas for fish, prawns and other species. They provide food for dugongs. Seagrasses are vulnerable to pollution from chemicals and smothering by mud.

Seagrasses populations may not recover after loss. In the tropics, many species are seasonal and regrow quickly. However, in temperate waters, the dominant *Posidonia* species may take many decades to regrow so their recovery is not practically achievable. The recent discovery of