Indian Ocean Climate Initiative

Climate Variability and Change in the South-West

*A partnership, formed by the Western Australian State Government to establish knowledge of **Climate Variability** and **Climate Change** as needed to support informed and effective climate adaptation.*

Executive Officer IOCI: c/- Dept. Environment Water & Catchment Protection, Plain St. East Perth, Western Australia **September 2002**

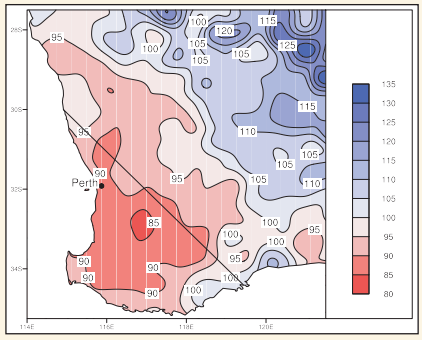
A Challenge to Planning

Over recent decades, the South-West has experienced unprecedented and mostly unpredictable climatic shifts. These have placed water systems under stress and have radically altered the basis for future planning of climate affected industries and challenged our approach to nature conservation.

Both natural variability change and human induced change are believed to be involved.

This pamphlet draws from the Indian Ocean Climate Initiative (IOCI), reports of the Inter-Governmental Panel on Climate Change (IPCC), and national projections by CSIRO.

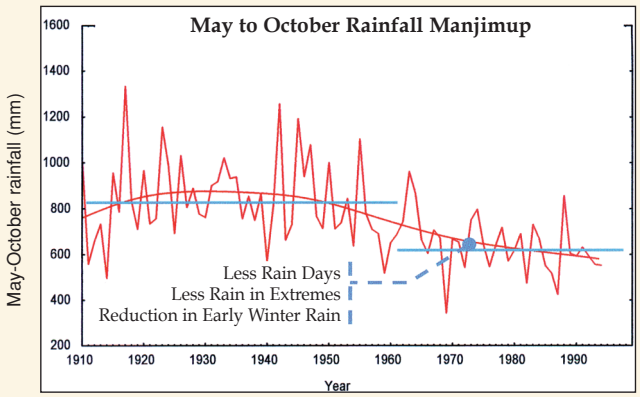
Adaptation to these changes is a key plank of the State Greenhouse Strategy, which is being developed, and IOCI is to provide an informed basis for such adaptation.



Last quarter century May-Oct rain as % of previous 50 years

Area of Abrupt Winter Rainfall Decrease (red) in the Last Quarter Century ***Source: IOCI, 2002***

Observed Rainfall Decrease



Source: IOCI, 1999

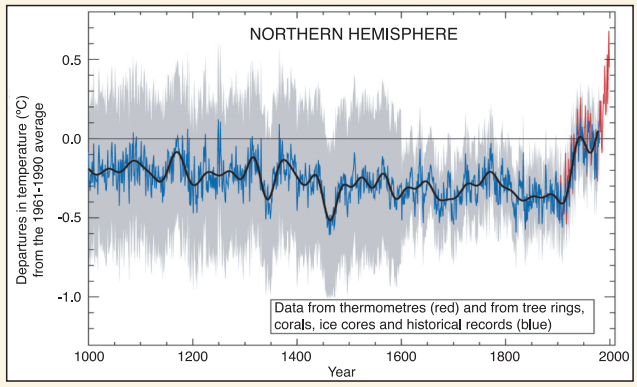
The area of the South-West shown above right has seen a 10-20% decrease of its winter rainfall over the last 30 years. The graph for Manjimup rainfalls above is typical.

The decrease is more of a step change to a drier state than a trend. The altered state has fewer rain days and less rain in extreme days than for previous decades.

The rain decrease is in early winter months, with a slight increase in late winter and spring.

Climate is not Constant

Reconstructions of millenial trends in temperature **IPCC, 2001**



After a millemium of cooling, last century warmed rapidly. Conditions now, are the warmest in 100,000 years or more.

Over geological time global climate has fluctuated widely. The IPCC has published reconstructions of temperature trends in the northern hemisphere over the last millennium. These are representative of global trends and show:

- Nine centuries of gradual temperature decline.
- An abrupt change, last century, to rapid warming.

The warming departs markedly from the millennial trend.

Contributing Partners

- Dept. Environment Water & Catchment Protection
- Dept. Conservation & Land Management
- Bureau of Meteorology WA Region
- Dept. of Premier & Cabinet
- Dept. of Agriculture
- Water Corporation
- Fire & Emergency Services

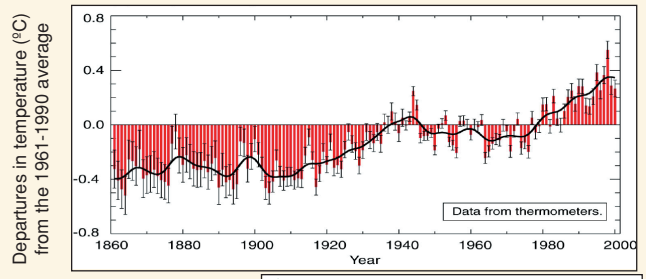
Core Research Team

- Bureau of Meteorology Research Centre
- CSIRO Atmospheric Research
- CSIRO Land and Water
- CSIRO Mathematical & Information Sciences

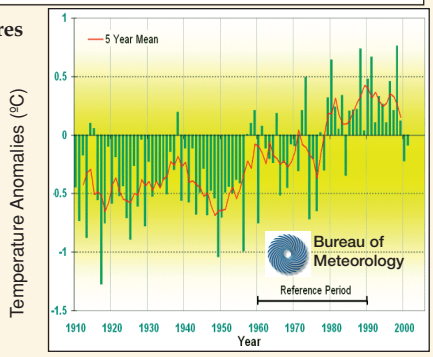
Global and Regional Warming

Global and Australian trends

Global Temperatures – IPCC



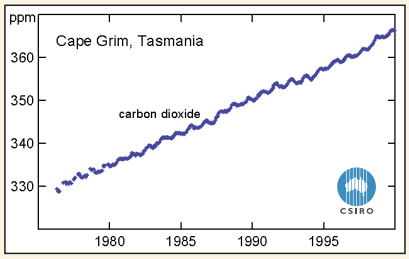
Australian Temperatures



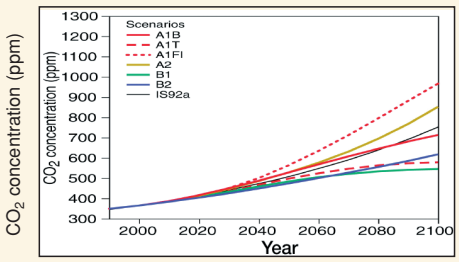
Water use by gardens, crops, native flora and wetlands is increased by this warming.

Global temperature increase is reflected in trends of annual temperatures for Australia (above graphs).
For the South-West a temperature increase of about 0.7°C in the last 50 years has occurred. Warming in this region has been greater in winter than summer and greater in daily minima than daily maxima.
Although these average increases may not seem large numerically, they are very significant climatically.
Such warming may assist plant growth where moisture is available, but also adds to evapo-transpiration and to moisture stress where soil moisture is limited.

Greenhouse Gases



Scenarios of alternative CO_2 concentration – IPCC



Records from Cape Grim show the steady rise in atmospheric CO_2, the main greenhouse gas associated with warming.

The IPCC predicts CO_2 concentrations will continue rising through this century.

There is a wide range in the IPCC's future projections of CO_2 because there are many possible scenarios for international behaviour in respect to emissions control.

- Change is already with us.
- There will be gains and losses.
- Informed adaptation is needed.

IPCC (2001) modelling of past temperature rises has shown that increasing greenhouse gas concentration in the atmosphere is the prime cause of the observed warming.

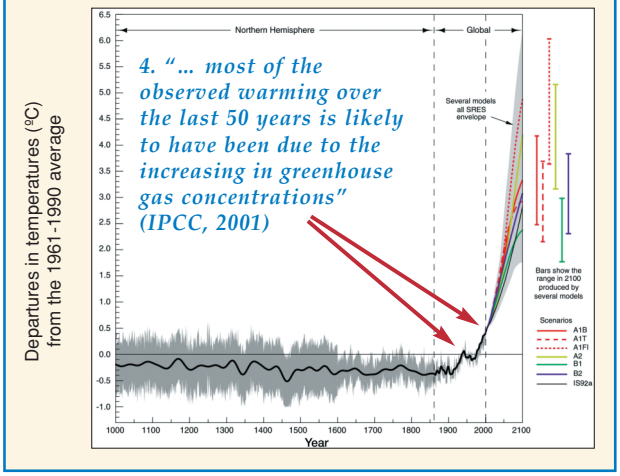
Future Warming – 21st Century

By 2100 the IPCC projects a further global warming of between 1.4 and 5.8°C based on several climate models and alternative scenarios of greenhouse emissions. The range of these projections reflects both scenario uncertainties and differences in model estimates.

Mid-range estimates suggest a global temperature rise of around 0.6 or 0.7°C over the next 30 years and that a rise of at least 2 or 2.5°C over the century is very probable.

CSIRO research indicates that, for Australia, the warming will be greater inland than for coastal areas and that changes in daily maxima and minima will be similar to change in average temperatures.

IPCC Temperature Projections

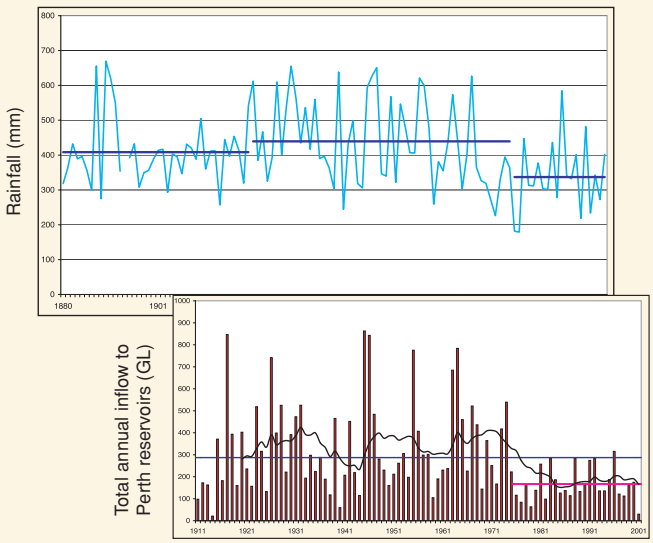


Rainfall Change, Recent and Future

One important outcome of IOCI work is recognition that South-West climate may shift naturally between wet and dry regimes over multi-decadal intervals.

Observed changes

Rottnest Island May-July Rainfalls



River flows of the last quarter century have been consistently low and have impacted the reliability of Perth's water supply. The State has recently completed a major programme of source development to recover this lost supply capacity.

IOCI has found evidence of altered climatic relationships and large scale atmospheric changes which explain or are associated with the rainfall decrease of the last quarter century.

The (above) Rottnest Island rainfall plot suggests that such changes may have occurred before. Experiments on global climate models indicate that long dry runs are more common than expected by simple chance.

The (above) plot of river flows shows how the rainfall decrease (and warming) is magnified in its effect on streamflows.

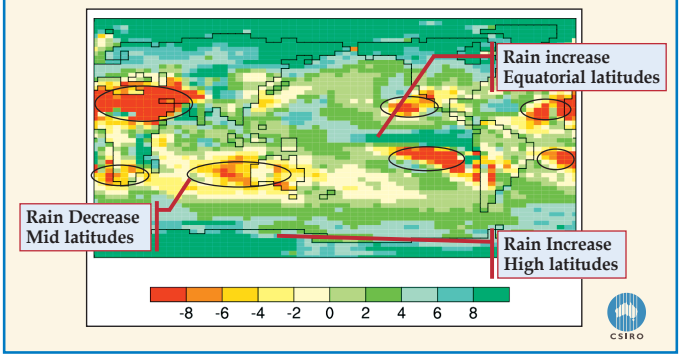
For more than a quarter of a century Perth's water reservoirs, designed to capture flood years, have gone without the replenishing inflows of 'wet' winters which occurred frequently in the middle of last century. Similar pressures have been imposed on groundwater, wetlands, and the soil profiles of native forests and woodlands.

Planners and decision-makers have now adjusted their climate baselines to accept that our rainfall may alternate between 'dry' and 'wet' regimes which might run for decades and which begin and end unpredictably. This is quite different from the normal assumptions on climate variability.

Most international models project a large decrease of winter/spring rainfall in the South West from the long-term climate.

Effects of Global Warming on Rainfall

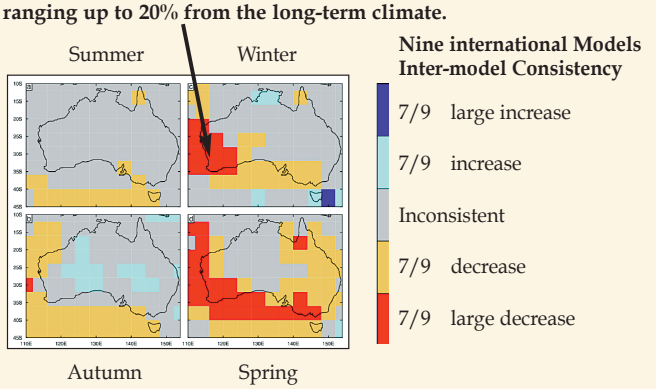
Simulated annual rainfall change % per global °C rise CSIRO Mk2



Global warming will affect rainfall. The above figure, adapted from CSIRO, typifies the patterns generated by international research on global climate models.
Broadly, such models predict an equatorial decrease in Sea Level Pressures and increased pressures at mid-latitudes. This leads models to predict rainfall decline at mid-latitudes, including the South-West of WA.
However, the observed decrease in the South-West rainfall since the mid 70s has occurred decades earlier than predicted for global warming. It could have developed naturally, but may include natural and enhanced greenhouse components.

Future projections

Most models project a S/W winter/spring rainfall decline by 2030, ranging up to 20% from the long-term climate.



Predicting the effects of global warming on rainfall is difficult and, at this stage, can only be seen as indicative.
CSIRO examined Australian rainfall projections from nine leading international models (see above).
For coming decades most models expect a declining trend in South-West rainfall from the long-term averages of the last century (see Table final page). This decline is expected to be significant by 2030 and large by 2070.

Summary

Has the climate of the South-west changed?

Winter rainfall in the South-West of WA has decreased substantially since the mid-20th century.

This has altered the previous interpretations of the climate of the region even though a similar, albeit less severe, dry sequence was experienced around the beginning of the 20th century.

Temperatures, both day-time and night-time, have increased gradually but substantially over the last 50 years, particularly in winter and autumn.

The rainfall decrease was in early winter (May-July) rainfall; late winter (August-October) rainfall has actually increased, although by a smaller amount.

The winter rainfall decreased sharply and suddenly in the mid-1970s by about 10-20%. It was not a gradual decline but more of a switching into an alternative rainfall regime.

The reduction in winter rainfall resulted in an even sharper fall in streamflow in the southwest.

Sustained multi-decadal shifts may be natural, but the current dry run is judged severe.

What caused this change?

Last century's warming in the southwest is believed to be largely due to the enhanced greenhouse effect.

The rainfall decrease accompanied, and apparently was associated with, documented change in large-scale global atmospheric circulation at the time.

The decrease in rainfall, and the associated circulation changes, bear some resemblance to changes most climate models project for an enhanced greenhouse effect.

However, the changes are not sufficiently similar to indicate that the enhanced greenhouse effect is responsible, beyond reasonable doubt, for the rainfall decrease. This decrease may simply reflect natural climate variability. Most likely, both natural variability and the enhanced greenhouse effect have contributed to the rainfall decrease.

Other local factors, such as land-use changes in the southwest, or increased local air pollution, seem unlikely to be major factors in the rainfall decrease, but may be secondary contributors.

Global land use changes and ozone depletion may also have played a role in the climate change experienced by the southwest.

Most likely, both natural variability and the enhanced greenhouse effect contributed to the rainfall decrease.

What should we assume about the future climate?

The climate of the South-West will continue to exhibit wetter and drier periods throughout the 21st century due to natural climate variability, overlaid by changes expected from enhanced greenhouse conditions. The latter include a continued warming coupled with the probability of a decrease in winter rainfall.

It is difficult, at this stage, to provide more definitive recommendations regarding what 'base-line' climatology, particularly for rainfall, should be used in decision-making. This is because of inherent scientific uncertainties and because different risk-structures will be associated with various sectors.

Decision makers will need to consider a range of more specific planning scenarios around these general expectations. These need to take into account alternative greenhouse gas emission scenarios recently published by the IPCC and the temperature and rainfall projections interpreted nationally by CSIRO.

A major scientific challenge for IOCI, if we are to provide more definitive projections of the climate of the South-West, is to determine the relative influences of natural variability and the enhanced greenhouse effect in causing the recent decrease in rainfall.

Future Climate – 21st Century

The South-West is expected to become increasingly warmer and drier than last century. The nature, scale, and timing of projected rainfall decline are more uncertain than temperature projections but indicative trends are available from CSIRO research.

Perth – Now and Future	Now #	2030	2070
Annual av. max. daily temp. (°C)	23.3	24.3 ± 0.7	26.3 ± 2.2
Dec-Feb days above 35°C	15	19 ± 3	29 ± 10
Annual rainfall (mm)	869	800 ± 105	660± 310
Annual moisture demand (mm)	-882	-960 ± 45	-1125 ± 155

represented by 1876 to 1992 averages

Source CSIRO, 2002

References

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