IOCI bulletin 6
IOCI reports key findings of recent research into south-western climate
Indian Ocean Climate Initiative
Informed Adaptation
August 2005 IOCI bulletin 6

Report of first phase of Stage 2 research, July 2003 – Dec 2004

A report, released in August 2005, presents results of the foundation phase of IOCI's Stage 2 research into south-west climate. The Stage 2 program has three themes of investigation – current climate regimes; climate change; and climate prediction.

A major report will follow in 18 months time. However, some key findings are now beginning to emerge, most particularly in respect to current climate and climate change. This bulletin summarises highlights from the research report and from early studies of the second phase.

The Phase 1 research report and associated material are available on the IOCI web site
www.ioci.org.au

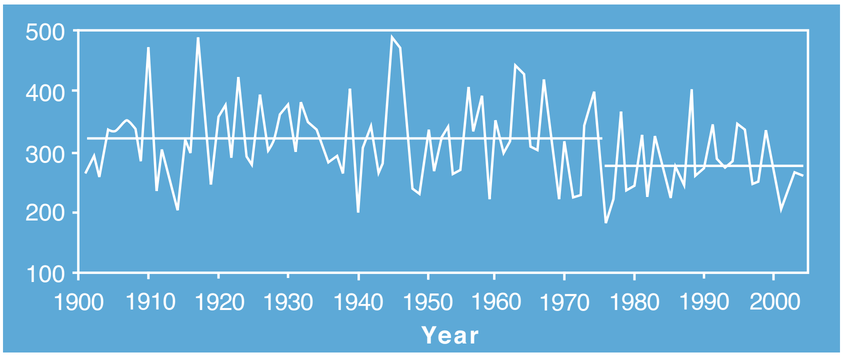

Figure 1 South-west WA May to July rainfall, 1901–2004.
Horizontal lines indicate the means for the periods 1901–1975 and 1976–2004.

Summary of key findings

In Stage 2 of its program IOCI is giving more emphasis to the study of large-scale changes in atmospheric circulation and the local implications of these changes.

There is now stronger evidence from this research that the observed rainfall decline over south-west WA is associated with such large-scale changes and that, at least partly, these are driven by human activity at the global scale, particularly the enhanced greenhouse effect.

The reported studies also support the statistical possibility that such changes in rainfall could occur through extremes of natural multi-decadal variability.

In the latest suite of climate change simulations, modelled results with greenhouse gas forcing do not fully explain the observed trend in rainfall.

IOCI therefore retains its earlier opinion that it is most likely both natural variability and the enhanced greenhouse effect that have contributed to the rainfall decrease.

Because of the geographic scale of the influences, IOCI has strengthened its view that other local anthropogenic factors, such as land-use change, are unlikely to be the primary cause of the observed change.

No conclusive position has been reached on whether ozone depletion has contributed to the rainfall decline.

The latest suite of climate change simulations also show that, even with the lowest greenhouse gas emission scenarios: south-west WA is projected to be drier and warmer later in this century, with increasing probability of 'dry everywhere' winter weather patterns and decreasing probability of 'wet west and central' weather patterns (see page 3).

Have there been recent changes in rainfall?

Recent winters in south-west WA, prior to 2005, have been particularly dry.

Coupling this situation with the past experience of a stepped decrease and the expectation of further rainfall decline, has given rise to legitimate local concerns that the region may be in the throes of another step decrease.

A representative time series of winter rainfall over south-west WA is shown in Figure 1. The four years prior to 2005 were particularly dry and the question has been asked as to whether this indicates another sharp drop in rainfall such as occurred in the mid-1970s. However, other four-year periods, (e.g. around 1970) have been similarly dry and 2005 has seen a particularly good start to the winter season.

Investigation has shown that it is too early to conclusively define any further change in the climate 'baseline'. This highlights the difficult judgements facing decision-makers.

Large-scale effects and the drying trend

This stage of IOCI research is placing a good deal of effort into investigating climate trends through studies of large-scale weather patterns. The studies are examining observed decadal trends in such patterns, their influence on south-west WA rainfall, and their likely changes under various forcings, such as increasing greenhouse gas concentrations.

These changes can involve large-scale temperature gradients, the strength and location of the sub-tropical jet stream, weather patterns which are associated with rainfall, and possibly even changes in Antarctic sea ice (see Figure 2).

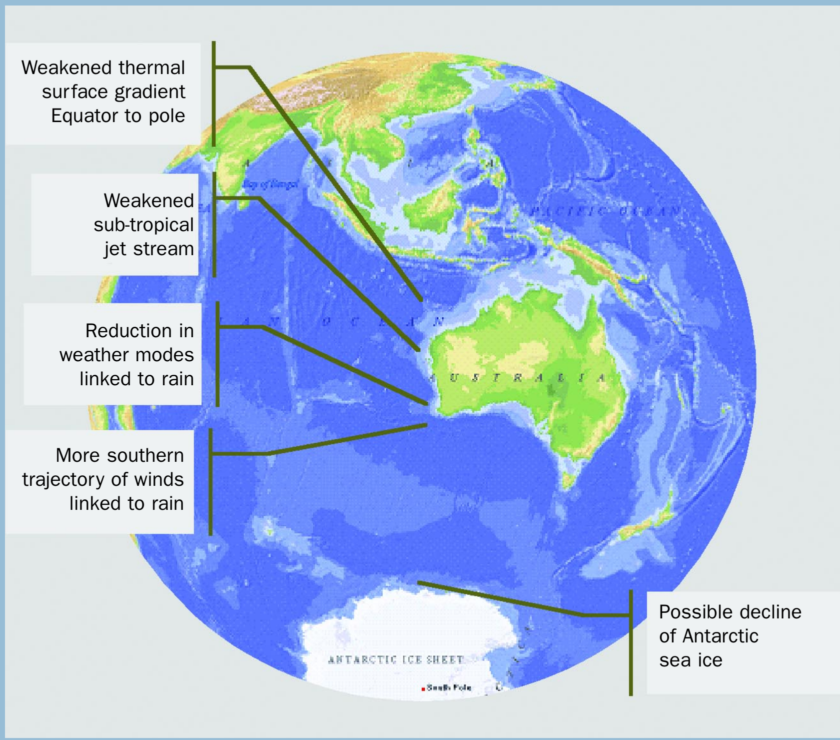

Figure 2 Large-scale changes related to south-west climate.

Changes in winter storm tracks

One such study considered changes to the large-scale patterns (or modes) of atmospheric stability that correspond to the preferred regions for storms to develop and move over southern Australia (see Figure 3).

For the 20-year period 1949–1968, the top panel of Figure 3 shows that the most preferred region (red shading) in winter was over south-western Australia.

By contrast, for the more recent period (1975–1994), the bottom panel shows that the most preferred region had effectively bypassed south-west WA and was located in the central south Pacific.

The large-scale atmospheric changes are also reflected by a reduction of 20% in the peak strength of the subtropical jet stream and an increased likelihood for it to be placed further south.

It is clear from this initial study that a shift in the storm track and a reduced potential for the development of storms has coincided with the observed rainfall decline over south-west WA.

Changes in other weather patterns that affect rainfall, such as north-west cloud bands, or the see saw in pressure between mid and high latitudes known as the Antarctic Oscillation, remain to be investigated. However, it is suspected that the changes in the nature of the winter storm tracks are probably the most important determinant.

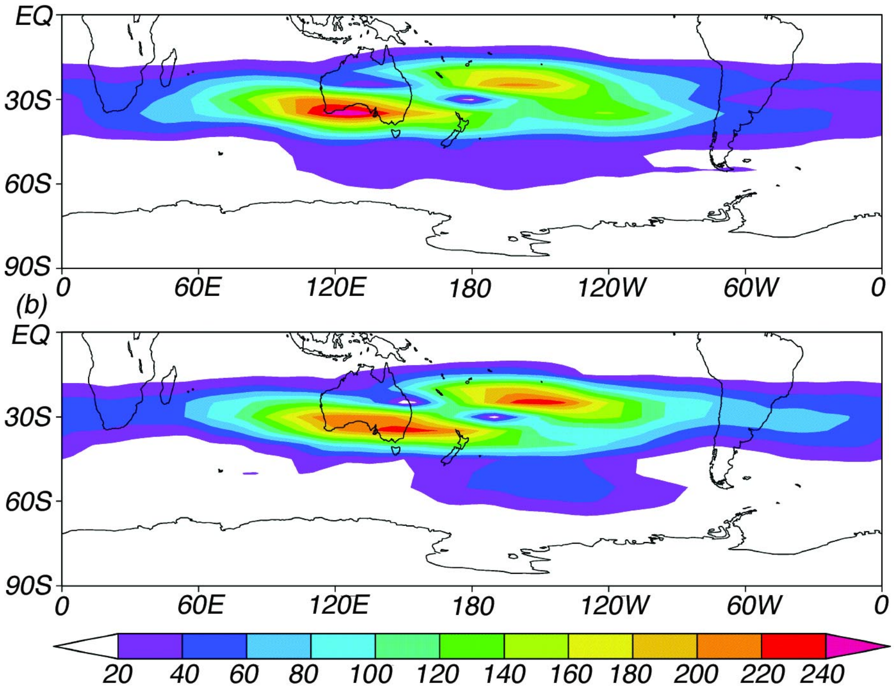

Figure 3 Preferred location of storm tracks over southern Australia.
The top panel shows the preferred locations 1949-1968. The lower panel shows the preferred locations 1975-1994. (Note: red shading indicates the most preferred locations.)

Cause of observed rainfall decrease

The winter rainfall over south-west WA from a 500-year simulation by CSIRO's Mark 3 coupled model shows that, with stable greenhouse gas conditions, the model can produce periods of rainfall decline similar to the decline since the 1970s (see Figure 4). This suggests the decline, though unusual, is not outside the range of natural long-term variability.

However, with observed and projected atmospheric greenhouse gas trends included, winter rainfall totals drop below the range of natural variations, reinforcing the concept that greenhouse gases will play a more prominent role in south-west WA winter rainfall reductions (see Figure 5). Research outside IOCI supports this finding.

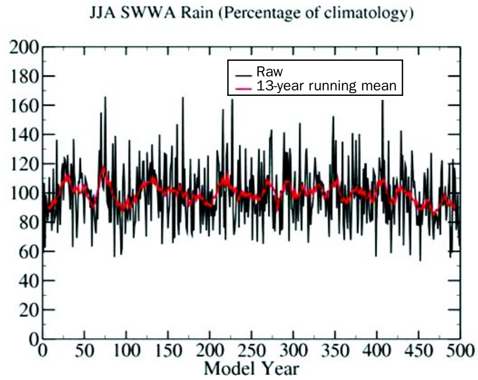

Figure 4 South-west winter rainfall from a long model simulation as a percentage of the average rainfall. A 13-year running mean is shown in red.

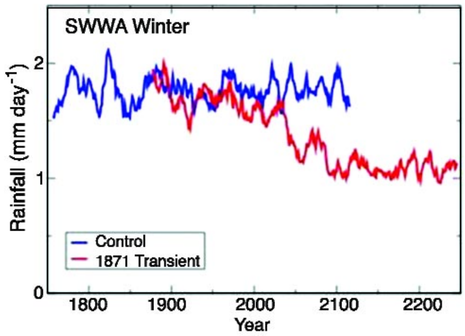

Figure 5 Modelled winter rainfall over the south-west from control simulation (blue) and climate change simulation (red).

Future trends

During Stage 1, key winter weather patterns (or modes) were identified that are linked to the occurrence or absence of rainfall.

More recent studies in Stage 2 of the IOCI program took this process a step further. Climate model experiments were carried out with CSIRO's Mark 3 model driven by historic and projected trends of greenhouse gas increases in the atmosphere.

The modelling (see Figure 6) indicated a steady decline in the frequency of the wet mode and an increase in the frequency of the dry mode. That is, the models indicated a continuing adverse change in winter weather patterns important to regional rainfall.

The scenario of future greenhouse gas increases used in this experiment was a severe one. Therefore it is likely that, in this experiment, the projected degree of change in rainfall pattern frequency beyond the middle of this century is pessimistic.

However, the experiment serves to illustrate the nature of studies being undertaken by IOCI.

This study is one of a number that have strengthened IOCI's opinion that the enhanced greenhouse effect has contributed to the past rainfall decline and will drive further decreases in coming years.

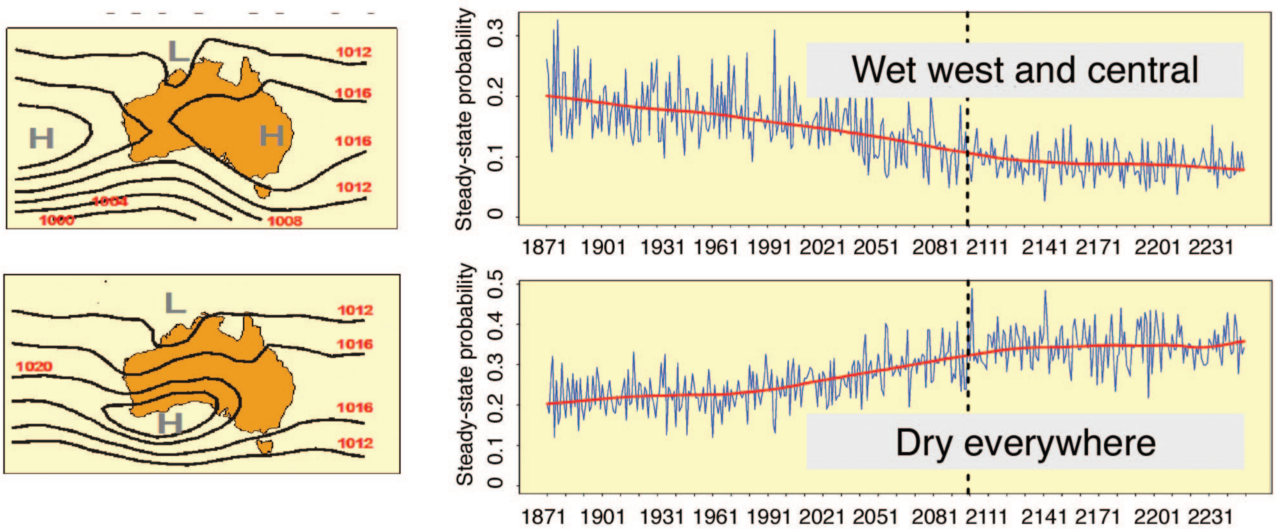

Figure 6 Pressure patterns (weather modes) associated with particular rainfall events over south-west WA. The top panel shows the pattern associated with wet conditions over the west and central regions and the time series shows how this becomes less frequent in a climate model simulation of the effect of enhanced greenhouse gases well into the future. The bottom panel shows the pattern associated with widespread dry conditions and the time series shows how this becomes more frequent in the simulation. The dashed line refers to the year 2099.

New suite of climate change simulations

During Phase 1, research partners updated climate projections for south-west WA under a range of emission scenarios by the Intergovernmental Panel on Climate Change, using nine international models that best reproduce Australian climatology.

The emission scenarios used included a representative range of possibilities (termed SRES here). These included a scenario without policies to reduce greenhouse gas emissions. The studies also included two scenarios stabilising CO_2, the first at 450 parts per million (ppm) by the year 2090 and the second at 550 ppm by 2150. It is notable that there is a wide and unavoidable uncertainty in the emission scenarios as it is impossible to predict future human behaviour globally. As an example, a stabilisation of CO_2 at 450 ppm would require immediate, major, reductions of global emissions. However, between all scenarios, the differences in projected increase of CO_2 concentrations in the atmosphere to 2030, or even 2050, is not very wide.

The range of results for rainfall, for the ‘wet’ (May to October) and ‘dry’ (November to April) seasons, from the nine selected models, is summarised graphically in Figure 7. This shows that, while there are regions where some models project a ‘dry season’ rainfall increase, the common projection for all south-west WA is for a ‘wet season’ rainfall decrease, with the magnitude of the decrease escalating later in the century.

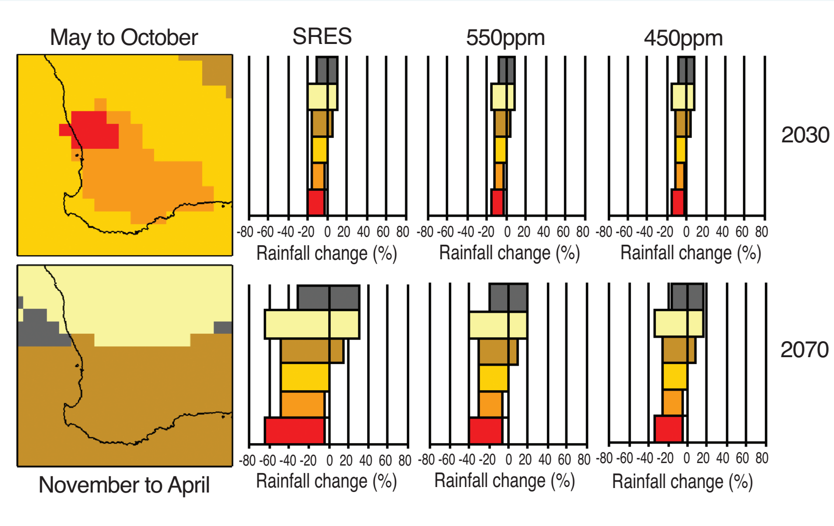

Figure 7 The range of projections for changes to rainfall over south-west WA from nine international models.

The top left hand panel refers to the winter (May to October) season.
The bottom left hand panel refers to the summer (November to April) season.
On the right hand panels for three different scenarios, and two distinct dates later this century, the bar diagrams show the range of model projected rainfall change.
The colours of the particular bars relate that projection geographically to areas on one of the two maps.

The significant drying trend in winter rainfalls is present in all scenarios. Table 1 presents a simple summary of the range of projected changes for inland south-west WA for temperatures and potential evaporation as well as for rainfall. The range of responses to the stabilisation scenarios is, in general, smaller than for the higher SRES emission scenario. All, however, show increases in temperature and potential evaporation. Smaller increases are seen in southern coastal regions.

Other parallel studies in Phase 1 used statistical downscaling of rainfall in models using complementary techniques developed by CSIRO and by the Bureau of Meteorology Research Centre. These parallel studies gave consistent climate change projections both from a high-resolution model (CCAM) and the CSIRO’s latest Mark 3 climate model (a 15% decrease by mid-century for the relatively extreme A2 scenario – see Figure 5).

Climate variable	2030	Mid-century
Mean summer temperature	+0.5° to +2.1°C	Continued increase
Mean winter temperature	+0.5° to +2.0 °C	Continued increase
Mean winter rainfall	-2% to -20%	Continued decrease
Winter potential evaporation	+0% to +10%	Continued increase

Table 1 The range of projected changes for inland areas of south-west WA from nine international models and a range of SRES emission scenarios.

Stabilisation scenarios to 450 and 550 ppm show relatively less warming, as do southern coastal regions.

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