Indian Ocean Climate Initiative

Towards Understanding Climate Variability in south western Australia -

Research reports on the First Phase of the Indian Ocean Climate Initiative

IOCI, October 1999

Towards Understanding
Climate Variability in south western Australia

Research reports on the First Phase
of the Indian Ocean Climate Initiative

Bureau of Meteorology Research Centre

CSIRO Atmospheric Research

CSIRO Land and Water

CSIRO Mathematical and Information Sciences

Dept of Commerce and Trade
Agriculture WA
Water and Rivers Commission
Water Corporation
Dept of Conservation and Land Management
WA Region of the Bureau of Meteorology
Dept of Environmental Protection
Fire & Emergency Services

A WA initiated partnership to foster -

- *research in climate variability; and*
- *developments in seasonal forecasting;*

for regions of western and southern Australia affected by the Indian and Southern Oceans; and particularly for south western Australia

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Abstract:

This report describes the research findings of Phase One of the Indian Ocean Climate Initiative (IOCI). IOCI is a five-year program of research into the effects of the Indian and Southern Oceans on interseasonal to interdecadal climate variability in the South West region of Western Australia, and the development of operational seasonal outlooks that have sufficient skill for effective decision making. IOCI was established through a partnership of federal and state government agencies. The findings include: (1) the observed run of dry years in the region over the last 20 years is unusual in a historical and a global context; (2) the rainfall decline has manifested itself through reductions in the number of rain days and the rainfall amounts in extreme events; (3) although climate model simulations for enhanced greenhouse conditions suggest reduced rainfall in the region, the reduction is not expected to take place until well into the next century; (4) the El Nino – Southern Oscillation phenomenon has a noticeable effect on the region's climate but current forecasting methods offer little practical skill; (5) 1000-year long climate simulations indicate that extended runs of dry years may not be unusual; (6) there is evidence of breaks in the climatic relationships for the region, and the timing of these breaks exhibits considerable spatial consistency; (7) stochastic downscaling of climate model runs produces credible simulations of observed daily and annual rainfall statistics at regional scales; and (8) preliminary results from a statistical-dynamical model for monthly rainfall are encouraging.

Foreword

The Indian Ocean Climate Initiative (IOCI) was announced by the Hon. Hendy Cowan MLA, Deputy Premier of Western Australia, on 12 November 1997. The Initiative was established through a partnership of government agencies to pursue the overlapping research and development interests of several economic sectors. The programme was stimulated by a desire to benefit from regional opportunities afforded by contemporary climate research and was given added impetus by the 20-year long sequence of low rainfall being experienced in south-west Western Australia.

The low rainfall sequence is of major concern to climate-dependent industries and to natural resources management in the region. These same sectors also believe that, for a variety of reasons, the products of past national climate research programs have been mostly of relevance to eastern and northern Australia. There is a perceived need to turn greater attention to the climatic phenomena of southern and western Australia, including the influences of the Indian and Southern Oceans.

IOCI is a five-year program of research into the effects of the Indian and Southern Oceans on climate variability in south-western Australia. The Western Australian partnership provides $300,000 per year for its core research program. These funds are a joint investment by a number of agencies which previously had worked semi-independently on climate research. The contributing partners are: Department of Commerce and Trade; Water and Rivers Commission; Agriculture WA; Water Corporation; Department of Conservation and Land Management; Western Australia Regional Office of the Bureau of Meteorology; Department of Environmental Protection; and State Emergency Services. The core research is conducted by the Bureau of Meteorology Research Centre, and the CSIRO Divisions of Atmospheric Research, Land and Water, and Mathematical and Information Sciences. The research institutions match the partnership inputs through in-kind contributions.

The objective of IOCI is to gainfully improve management decisions of climate-dependent industries, and environmental management, through:

- *improved understanding and definition of interannual and interdecadal climate variability; and*
- *enabling operational seasonal outlooks with sufficient skill for effective decision making.*

The research program has five phases:

Phase 1: *(January 1998 to June 1999) – review the state of knowledge, identify applications and observational gaps, and preliminary testing of predictive methods;*

Phase 2: *(January 1999 to June 1999) – review Phase 1, define research priorities and refine research program for Phase 3;*

Phase 3: *(June 1999 to December 2000) – pursue the knowledge gaps and develop the methods prioritised in Phase 2;*

Phase 4: *(July 2000 to December 2000) – review the IOCI contract and the associated research program before continuation to December 2002;*

Phase 5: *(December 2000 to December 2002) – continuation of the research program with testing of the new forecasting methods in application settings*

The potential beneficiaries from any increased understanding and predictability of interseasonal climate variability include: agriculture; water supply; forest fire control; wetlands management; fisheries production; offshore drilling; and tourism.

The IOCI Panel is now pleased to be distributing the underlying report from the first phase of its core research programme.

The Panel believes the report represents an important step in consolidating and developing an understanding of the variability of the climate in southern and western Australia.

The report also highlights elements of variability in the climate of south western Australia which are, as yet, unexplained. It provides an important platform for building the next phase of research and a base for scientific discussion on regional climate variability.

The insights provided by this first phase form a basis from which the development and refinement of specific applications to climate affected industries, such as water supply, agriculture, environment and fire management can be investigated.

As yet, it is too early to expect specific applications to be available from this work. However, the report is commended for study by those who have need to make plans or decisions which must consider the effects of climate variability.

Brian Sadler
Chair IOCIP
November 1999

Summary

This report marks the conclusion of IOCI Phase 1 and follows a two-day national seminar and workshop (IOCI98) held in Perth in November 1998 at which progress reports were presented by the research groups in draft form. Leaders in the science and application of interseasonal climate forecasts were invited to IOCI98, and a high level of national and international expertise was assembled. The seminar program provided an overview of the state of knowledge of climate variability in south-west Western Australia while the workshop provided a peer review of the research findings and the direction of the proposed research program. The workshop was productive and led to general agreement about the future research direction for the Initiative.

The following report is comprised of four parts, with one part contributed by each of the four research groups. The research outcomes support a number of broad conclusions that may be summarised as follows:

The drying trend:

- The observed run of dry years in south-west Western Australia over the last two decades is unusual in a historical and a global context. It has manifested itself through declines in the number of rain days and the rainfall amounts in extreme events. These declines have had a noticeable effect on the climate-dependent industries within the region.

- 1000-year long climate model simulations suggest that natural variability can give rise to decadal (or longer) dry spells over regions such as south-west Western Australia. While events comparable to the observed spell are relatively rare, the simulations suggest that they may occur without any obvious external factors. Further analysis is underway in order to better understand the mechanisms accompanying such naturally occurring events.

- Analyses of climate model simulations reveal that increased greenhouse gas concentrations can lead to global warming and regional-scale changes including reduced rainfall over south-west Western Australia. However, these simulated reductions are not predicted to occur until well into the next century.

- While natural climate variability may be the primary cause for the run of dry years, factors relating to human development have not been eliminated.

Seasonal predictions:

- The El Nino – Southern Oscillation phenomenon has a noticeable effect on the climate of south-west Western Australia but current forecasting methods offer little practical skill.

- There is evidence that breaks have occurred in the climatic relationships for south-west Western Australia. There are, for example, secular changes in the interannual relationship between rainfall in south-west Western Australia and the Southern Oscillation Index.

- The timing of the secular breaks shows considerable spatial consistency. This suggests that the breaks are a real phenomenon but the causative factors have yet to be fully identified. In the short to intermediate term, understanding the contributing factors to these breaks will be important to the development of new and more reliable forecasting methods.

- Away from the Pacific Ocean, there are links between both sea surface temperatures and mean sea level pressure patterns in the Indian Ocean. As yet these do not appear to provide useful skill for predictions of winter rainfall over south-west Western Australia.

- Climate model studies suggest that some of the relationships between anomalies in Indian Ocean sea surface temperatures and rainfall are not inherently useful for forecasting purposes, because changes in atmospheric circulation may be responsible for both. Thus the research focus has shifted towards looking for precursors other than in the tropics and mid-latitudes.

- At higher latitudes, anomalies in sea surface temperatures, mean sea level pressure, winds, and sea ice (e.g., the Antarctic Circumpolar Wave) have been identified. But the importance of these and related phenomena to the south-west of Western Australia are not yet quantified.

- There is a north-west influence from the Indian Ocean on south-west Western Australia, particularly in the northern and eastern agricultural zones which are affected by north-west cloudbands. However, many apparent Indian Ocean influences, particularly those identified in the lower south-west, may not be independent of the El Nino – Southern Oscillation phenomenon.

- There are a number of data deficiencies that will be a limiting factor in the development of improved interseasonal climate forecasting methods and our understanding of the contributing factors to multidecadal climate variability. In particular, the accuracy of observed sea surface temperature data prior to 1980 is poor, and there is a paucity of climatic and oceanographic data for latitudes greater than 40° south. The latter will remain a problem for decades.

- Although the observed synoptic characteristics associated with rainfall over south-west Western Australia are well-simulated by global climate models, rainfall predictions by such models have so far not demonstrated a great deal of skill. The effect of improved models and data sets are being evaluated.

- As an alternative to direct modelling of rainfall by global climate models statistical 'downscaling' from observed and modelled atmospheric circulation at the large scale has produced credible simulations of observed daily and annual rainfall statistics at the regional scale. This technique can potentially enhance the performance of climate model predictions and is being further refined.

- Downscaled simulations from global climate model runs forced by historical sea surface temperatures failed to reproduce the year-to-year variations in 'winter' precipitation for the period 1955 to the late 1960s. However, reasonable simulations were obtained for 1970 to 1991. A comparison of modelled and historical mean sea level pressure fields

suggested that the poor results for the 1950s to 1960s were due largely to errors in the historical sea surface temperature data rather than the presence of random effects or systematic error in either the global climate model or the downscaling technique.

- Preliminary results from a new statistical framework that has, as its foundation, a nonlinear dynamical statistical model of monthly rainfall are very encouraging. Fundamental properties of rainfall series are reproduced with some degree of success.

The first 18 months of the IOCI has been productive, and has heightened scientific attention on the region of Australia most likely to be influenced by the Indian Ocean and Southern Ocean. This first phase of research inspires optimism that it will lead to new knowledge and skills that will in turn provide valuable economic and social benefits for south-west Western Australia.

Bryson Bates
CSIRO Land and Water