PROJECT 3.1: STATISTICALLY DOWNSCALED CLIMATE CHANGE PROJECTIONS FOR THE SOUTH-WEST

Principal Investigator

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Objectives

- To complete an assessment of the ability of the GCMs used in the IPCC's Fourth Assessment Report (IPCC AR4) to simulate regional climate for present-day conditions.
- To identify the subset of IPCC GCMs that provide credible simulations of the predictors for the downscaling model under present-day conditions.
- To extend the existing downscaling model for the South-West by incorporating daily minimum and maximum temperatures as output variables.
- Using the above subset of GCMs, three IPCC SRES emission scenarios (B1, A1B and A2), and an existing downscaling model for the South-West, produce at-site climate change projections that can be used for impact and vulnerability assessments by either State agencies alone or in collaboration with IOCI's research providers

Key Research Findings

- Preliminary results from an intercomparison of GCMs show that those models that perform well on an annual, or even a seasonal, basis do not necessarily reproduce the month to month patterns seen in the observed record.
- Through collaboration with the International Research Institute for Climate and Society (Earth Institute, Columbia University), a new version of the computer code for the statistical downscaling model used by CSIRO Land and Water has been ported and is undergoing testing. Preliminary results are

encouraging. The new code provides much faster model calibration and the previous restriction on the number of rainfall sites that could be considered in a model run (31 sites) has been lifted. This means that additional sites of interest to State government agencies can be incorporated into the downscaling scheme.

- Through collaboration with the Department of Statistical Science, University College London, a statistical modelling approach that combines information from multiple GCMs to emulate the range of underlying uncertainty they represent has been developed. An exploratory application has been undertaken using six AR4 GCMs for the example of statistically downscaled projections of winter (May-July) rainfall for 30 sites in the South-West. Initial results indicate that the technique can account for GCM biases in atmospheric predictors and that the pooling GCM results in underestimates of the uncertainty in statistically-downscaled rainfall projections.

MILESTONE 3.1.1: REPORT ON THE PERFORMANCE OF IPCC AR4 GCMS FOR PRESENT-DAY CLIMATIC CONDITIONS IN THE SOUTH-WEST

Background

In order to have confidence in statistically downscaled projections there is a need to assess whether GCMs can adequately simulate the present-day atmospheric predictors required to drive the statistical downscaling models. With the aim of reducing uncertainty in statistically downscaled rainfall projections, we have commenced assessment of the ability of the AR4 GCMs to simulate SWWA regional climate.

Technical Details

Approach

We assess the performance of each historically-forced, 20th century GCM run (20C3M) against the NCEP/NCAR Reanalysis (NNR) observations for 1961–2000. If we can identify a subset of IPCC GCMs that provide credible simulations of the downscaling model predictors for present-day conditions, we will have more confidence in using these particular GCMs for generating statistically downscaled climate change projections for SWWA.

Results and Highlights

Preliminary results show that GCMs that perform well on an annual, or even a seasonal, basis do not necessarily reproduce the month to month patterns seen in the observed record. For example, monthly MSLP shown in Figure 3.1.1 for 25 AR4 GCMs indicated significant and frequent overall and monthly biases. As well as reproducing mean monthly MSLP, GCMs using historical forcing should reproduce long-term trends. In the case of SWWA, an increasing MSLP trend is known to be associated with the observed rainfall decline. Figure 3.1.2 shows that most AR4

GCMs produce an increasing trend, although Figure 3.1.3 indicates that the magnitude of the observed trend is not matched by any GCM. Other important metrics that have been assessed include spatial variability, assessed through EOF analysis and pattern correlation, and the reproduction of the probability distribution function (not shown). Investigations are on-going has to how best combine these sets of metrics in order to rank GCMs according to their present-day climate performance. MSLP is just one predictor, and we are extending the assessment to include the other predictors used by the statistical downscaling model.

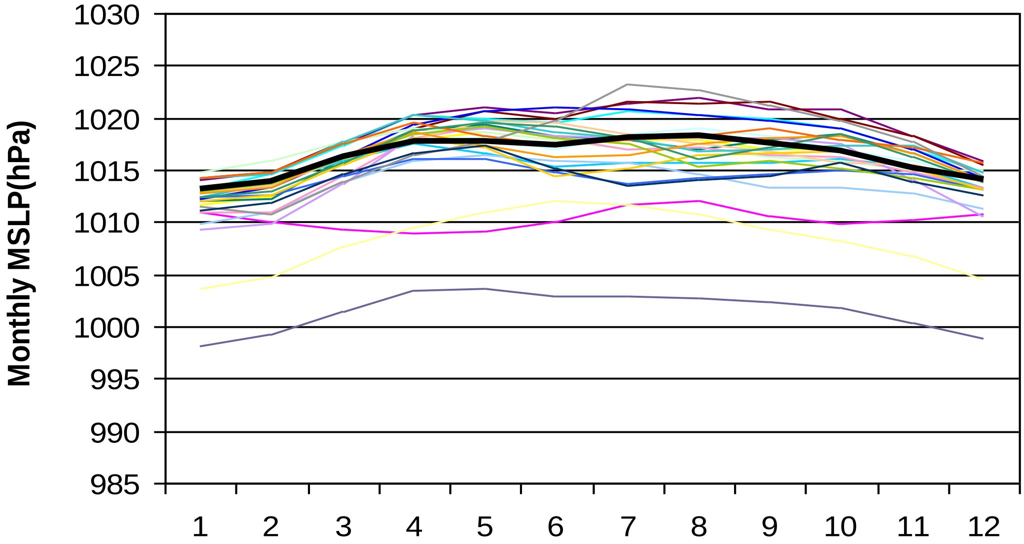

Figure 3.1.1 Mean monthly MSLP over SWWA observed (NCEP/NCAR Reanalysis, in black) and for 25 IPCC AR4 GCMs.

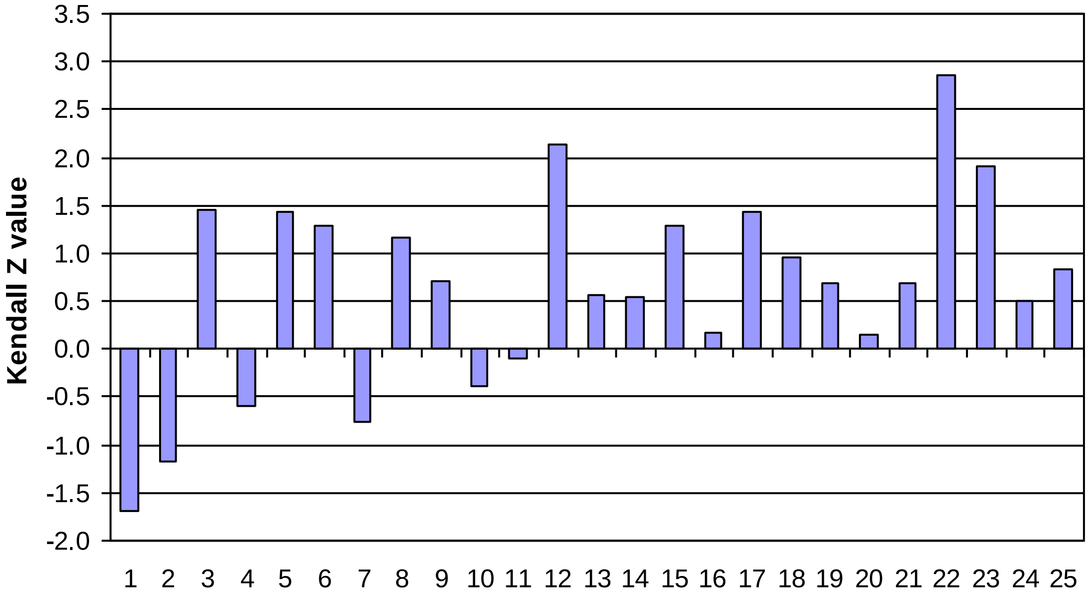

Figure 3.1.2 Testing for SWWA MSLP trend for 25 AR4 GCMs. Corresponding NNR value is 1.88.

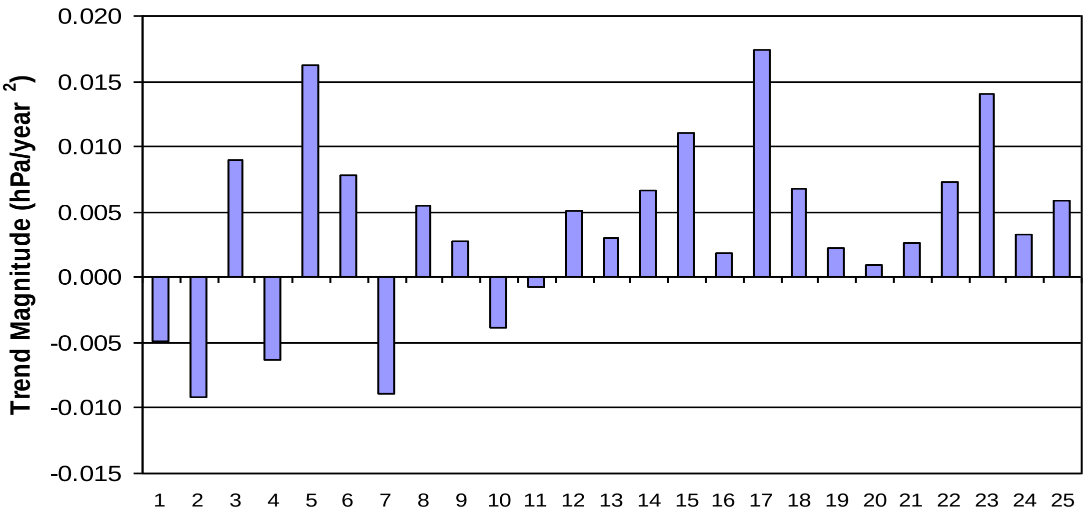

Figure 3.1.3 3SWWA MSLP trend magnitude for 25 AR4 GCMs. Corresponding NNR value is higher than all GCMs, at 0.0228 hPa/y^2.

IOCI-Related Presentations

Fu G, and Charles SP (2009) Assessing IPCC fourth assessment report GCMs for statistical downscaling in south-west Western Australia, Greenhouse2009.

MILESTONE 3.1.2: INTERIM REPORT ON DEVELOPMENT AND TESTING OF THE EXTENDED DOWNSCALING MODEL

Background

Through collaboration with the International Research Institute for Climate and Society (Earth Institute, Columbia University), a new version of the computer code for non-homogeneous hidden Markov model (NHMM) has been ported to and is being tested by CSIRO Land and Water. Preliminary results are encouraging. The new code provides much faster calibration and the previous restriction on the number of rainfall sites that could be considered in a model run (31 sites) has been lifted.

A full set of results will be presented in the Year 2 report. Meanwhile, we will seek advice from stakeholders on an expanded list of rainfall stations that are relevant to their research and operational activities.

A new research opportunity has arisen through collaboration with the Department of Statistical Science, University College London. A statistical modelling approach that combines information from multiple GCMs to emulate the range of underlying uncertainty they represent has been developed. The aim is to establish a distribution for parameters that describe the “population” of GCMs and hence characterises the uncertainty in their outputs. The modelling framework developed is based on a Bayesian hierarchical model to account for features such as inter-GCM differences, shared biases and outlying GCMs. An exploratory application has been undertaken using six AR4 GCMs for the example of statistically downscaled projections of winter (May-July) rainfall for 30 SWWA sites.

Technical Details

Promising initial results indicate that the technique can account for GCM biases in predictors (Figure 3.1.4) and that pooling GCM results underestimates statistically downscaled precipitation projection uncertainty, especially in lower extremes (Figure

3.1.5). Further development will extend the framework to incorporate information about which GCMs are best able to reproduce particular features of past climate (i.e. a deliverable of this project). This will reduce the uncertainty in future scenarios by down-weighting under-performing GCMs, while simultaneously accounting for the communal bias in all GCMs.

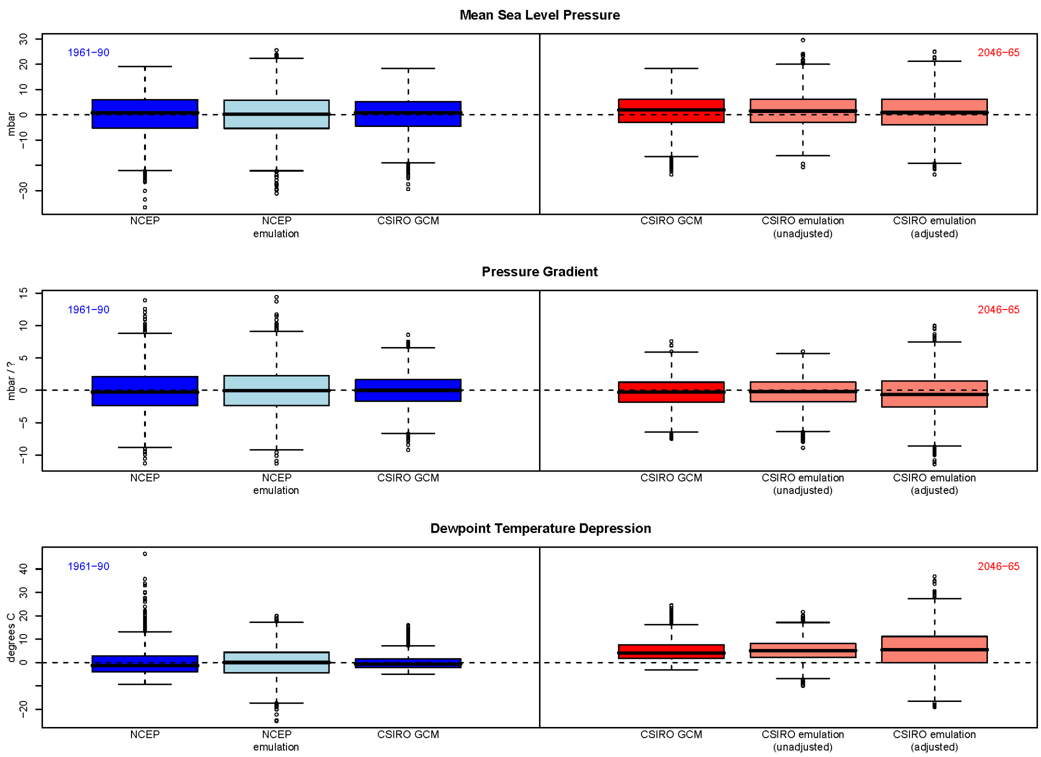

Figure 3.1.4 Distributions of predictors obtained from statistical emulator.

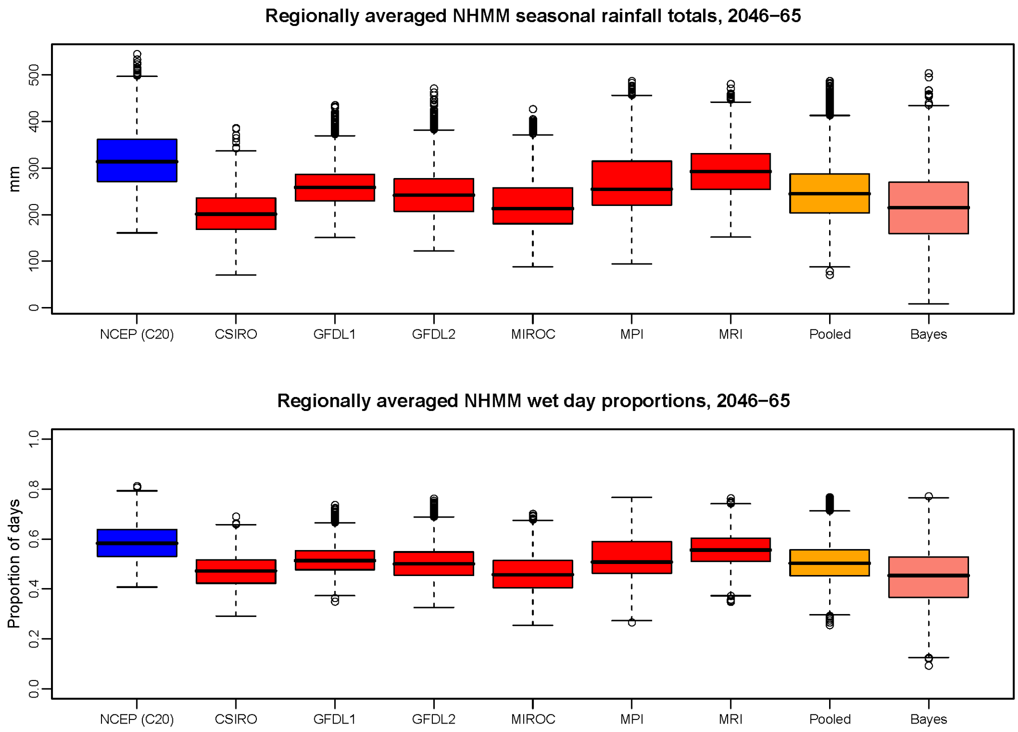

Figure 3.1.5 Range of statistically downscaled amounts and occurrence probabilities from hierarchical model.

Presentations

Bates BC, Chandler RE, Charles SP (2009) Trends in hydroclimatic series in south-west Australia: an integrated assessment, Greenhouse2009.

Chandler RE, Charles SP, Leith N, Bates BC, Phatak A (2009) Adapting to climate change – confronting model uncertainty in future projections, Greenhouse2009.

LIST OF FIGURES