PROJECT 2.3: STATISTICAL DOWNSCALING FOR THE NORTH-WEST

Principal Investigator

Steve Charles, CSIRO Land and Water, Private Bag No. 5, Wembley WA 6913 (Ph: 08 9333 6795; Email: Steve.Charles@csiro.au)

Senior Investigators

Guobin Fu, CSIRO Land and Water, Private Bag No. 5, Wembley WA 6913 (Ph: 08 9333 6342; Email: Guobin.Fu@csiro.au)

Objectives of Project 2.3

- To use statistical downscaling to link circulation drivers to the behaviour of historical rainfall and temperature at spatial and temporal scales suitable for management and planning.
- To compare observed weather state time series with those obtained from downscaling forced GCMs to assess the ability to reproduce the observed changes and trends.
- To assess the abilities of global and regional climate models to reproduce the atmospheric predictors required for statistical downscaling. (The climate models that perform adequately will be used to drive the downscaling model.)
- To produce high-resolution climate change scenarios 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

Milestone 2.3.5

1. GCM downscaled results for the Kimberley region summer half-year (Nov-Apr) do not reproduce the strong trends seen in the Reanalysis downscaled weather state and station rainfall time-series.
2. The GCM downscaled results for the Pilbara region winter half-year (May-Oct) better match the weather state and station rainfall trends seen in the downscaled Reanalysis results, although the observed trends are still not fully captured.
3. Reasons why the GCM downscaled results do not reproduce the strong trends seen in the observed records could include the dominant role of natural variability that is inadequately captured by GCM forcing, other 'missing' forcings such as Asian brown cloud aerosols, and the strongest observed trends occurring post-2000 (i.e. comparison of unequal length time-series emphasises an apparent mismatch).

Milestone 2.3.6

4. In addition to changes in mean temperatures, the shape of the distributions and lengths of the tails (i.e. extremes) are also projected to change.

5. Such distributional changes can result in, for example, projections that include lower than observed maximum and minimum temperatures whilst an overall warming trend is projected by all models for the future.
6. The downscaled projections will account for such changes in both the mean and variance of daily temperature series, as well as changes in temporal sequencing (i.e. runs of daily extremes) resulting from weather state sequence changes.

Milestone Reports:

Milestone 2.3.1 *Report on selection of high-quality daily rainfall gauge networks*

(Completed 30/06/2010)

This milestone was reported on in the IOCI3 Milestone Report 2.

Milestone 2.3.2 *Report on development and testing of downscaling models*

(Completed 30/06/2010)

This milestone was reported on in the IOCI3 Milestone Report 2.

Milestone 2.3.3 *Report on assessment of temporal trends in weather states and at-site rainfall statistics*

(Completed 30/06/2010)

This milestone was reported on in the IOCI3 milestone report 2.

Milestone 2.3.4 *Report on assessment of the ability of GCMs to simulate atmospheric predictors required for downscaling*

(Completed 30/06/2010)

This milestone was reported on in the IOCI3 milestone report 2.

Milestone 2.3.5 *Report on comparison of forced GCM downscaled time series of weather state sequences and at-site rainfall with the observed*

(Completed 31/12/2010)

The project has selected five GCMs on the basis of their reproduction of the atmospheric predictors required by the stochastic downscaling models (NHMMs, as previously reported) and the availability of corresponding CCAM dynamically downscaled results. CCAM is a global stretched-grid dynamical downscaling model run by CSIRO at a finer spatial scale over Australia (approximately 60 km grid resolution). The five GCMs are: GFDL 2.0 and 2.1, MIROC-medres, CSIRO Mk3.5, and MPI-ECHAM5.

The historical runs of these five GCMs (1961-2000) were downscaled to assess similarities between Reanalysis and GCM downscaled weather state and station rainfall trends. Only results for the Kimberley region summer and Pilbara winter half-year are presented, given space limitations. Equivalent analysis has also been undertaken for Kimberley winter and Pilbara summer half-years.

The Reanalysis downscaled weather states (Figure 1) and station rainfall (Figure 2) long-term trends for the Kimberley region summer half year (Nov-Apr) are not

reproduced in the GCM downscaled results for the overlapping 1961-2000 period. This could be evidence that the observed trends result from natural climate variability, rather than a response to enhanced global greenhouse gas concentrations. However, a caveat on this interpretation is the possibility that the GCM response is limited by inadequate representation of aerosols in regions further to the north (Rotstayn et al. 2007).

We do not expect GCM downscaled results to match the peaks and troughs of the Reanalysis downscaled results, because the GCMs produce their own year-to-year variability. However, a closer match of long term trends would add to the confidence in downscaled projected changes.

For the Pilbara region winter results, there is a better match between the Reanalysis and GCM downscaled weather state trends (Figure 3) and station rainfall trends (Figure 4), although the strong Reanalysis downscaled trends are not fully captured. Again, this emphasises the role of natural climate variability as well as possible GCM limitations.

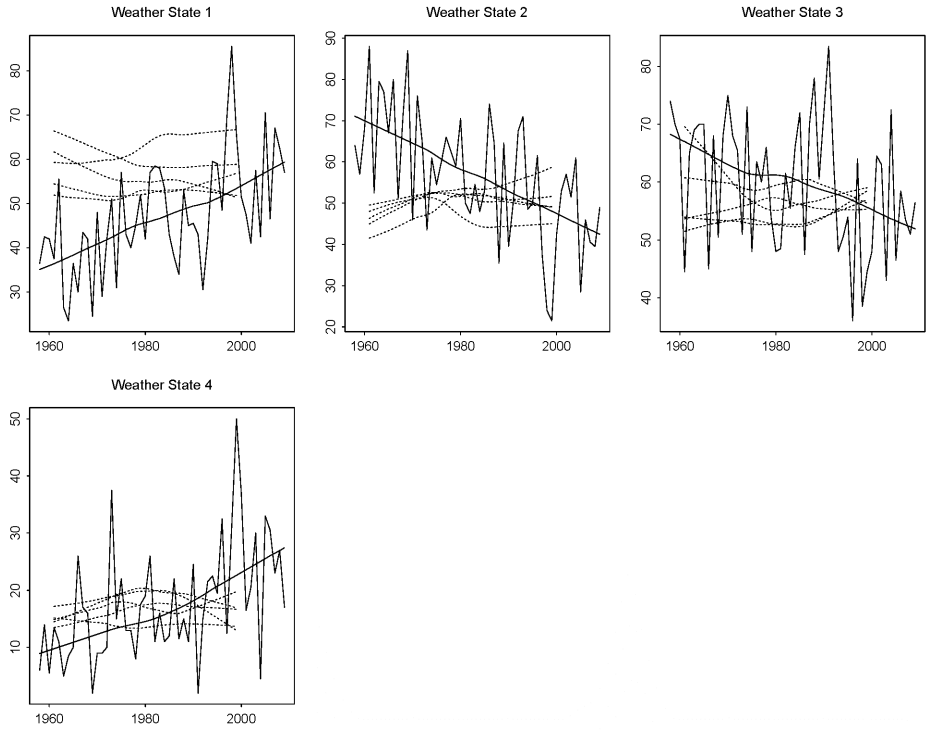

Figure 1: Weather state time-series for Kimberley Summer (Nov-Apr) season. Solid lines are annual and smoothed Reanalysis driven and dashed lines are smoothed GCM driven NHMM results.

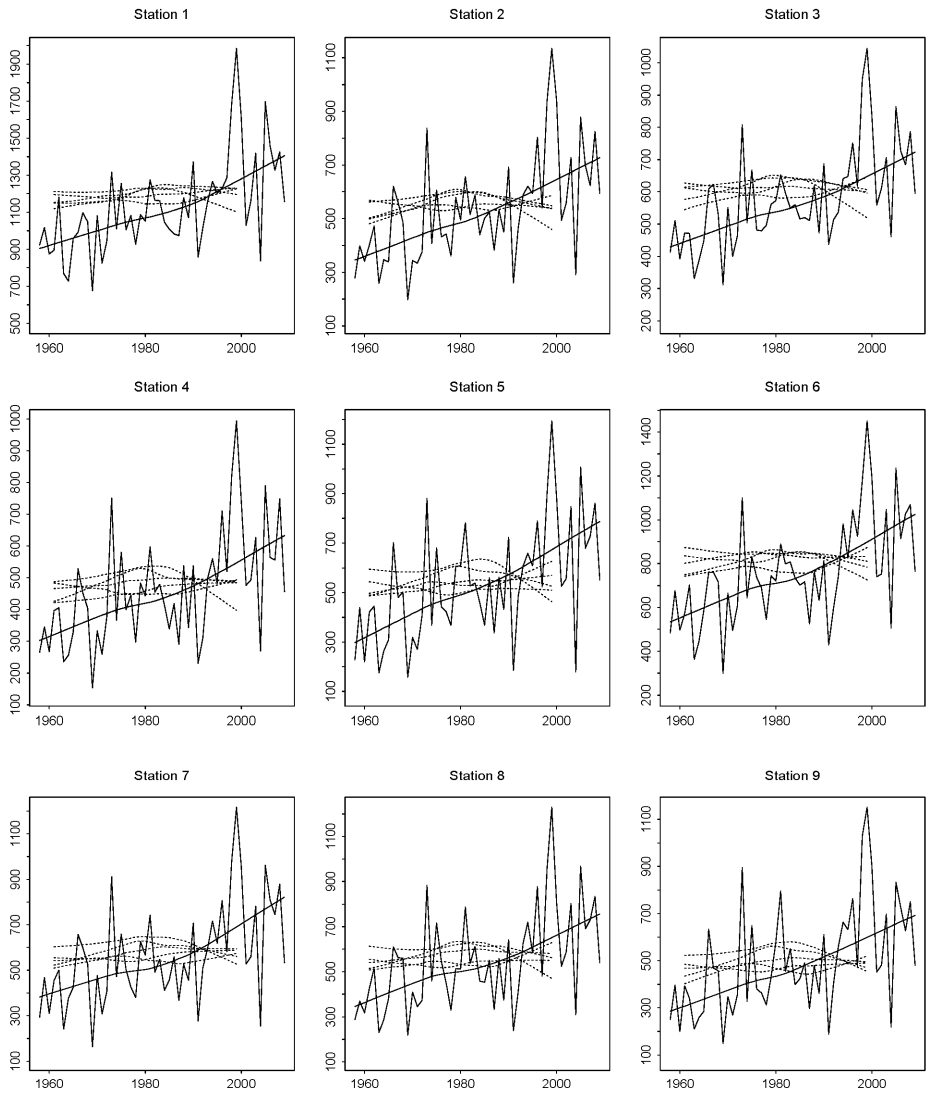

Figure 2: Station rainfall time-series for Kimberley Summer (Nov-Apr) season. Solid lines are annual and smoothed Reanalysis driven and dashed lines are smoothed GCM driven NHMM results.

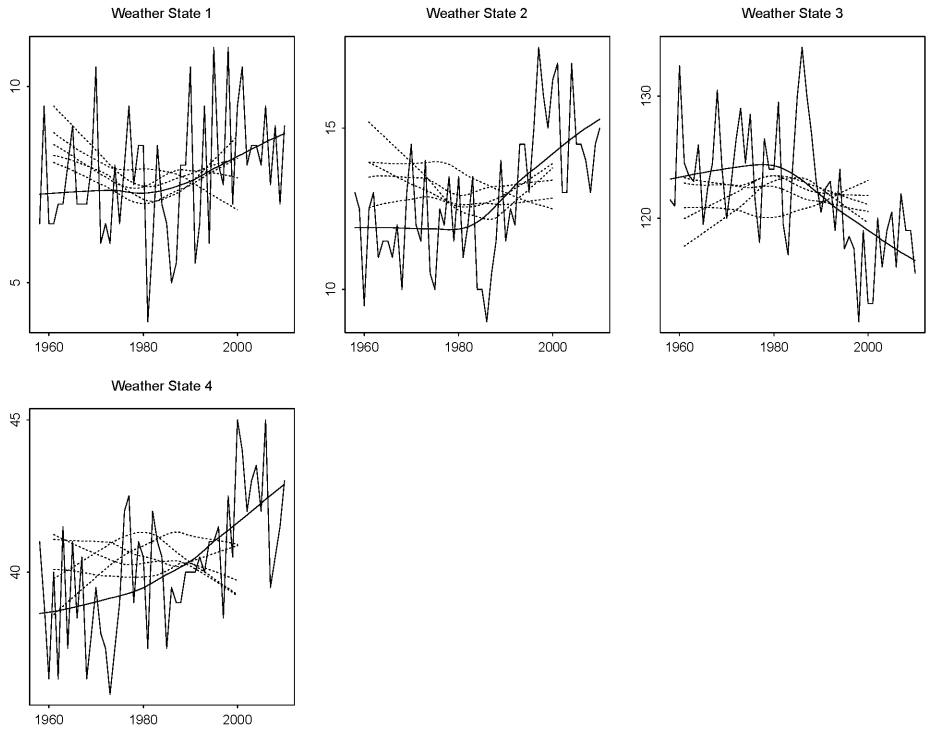

Figure 3: Weather state time-series for Pilbara Winter (May-Oct) season. Solid lines are annual and smoothed Reanalysis driven and dashed lines are smoothed GCM driven NHMM results.

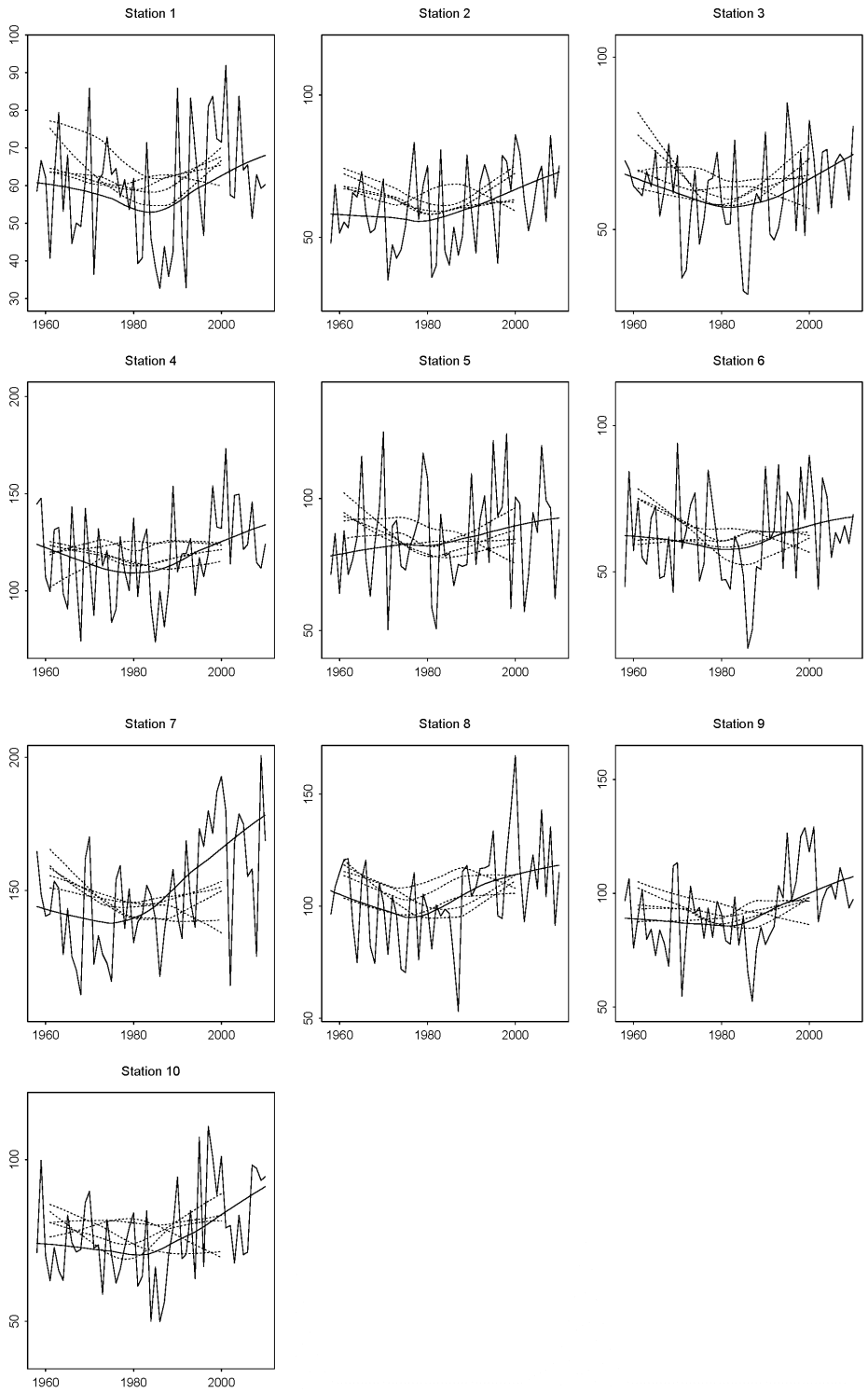

Figure 4: Station rainfall time-series for Pilbara Winter (May-Oct) season. Solid lines are annual and smoothed Reanalysis driven and dashed lines are smoothed GCM driven NHMM results.

Milestone 2.3.6 *Report on extension of statistical downscaling models to include temperature*

(Progress report – to be completed 31/12/2011)

Code has been implemented to combine the NHMM multi-site daily rainfall stochastic downscaling model with a stochastic weather generator to generate at-site daily maximum and minimum temperature conditional on NHMM simulated daily weather-state and wet/dry status sequences. An important advance afforded by this implementation, compared to previous approaches such as the scaling used by the CSIRO Sustainable Yields projects, is the ability to generate stochastic sequences of temperature reflecting the changes in distribution as indicated by the projections.

Figure 5 shows projected temperature changes for Mardie from CCAM simulations driven by four of the selected GCMs. It is evident that in addition to changes in the mean, the shape of the distributions and lengths of the tails (i.e. extremes) are also projected to change, for example lower than observed maximum and minimum temperatures possible in the future.

These distributional changes are not incorporated in scaling approaches, as scaling only applies the mean shift to the historical record. The stochastic weather generator will account for the projected changes in both the mean and variance of daily temperature series, as well as changes in temporal sequencing (i.e. runs of daily extremes) resulting from weather state sequence changes.

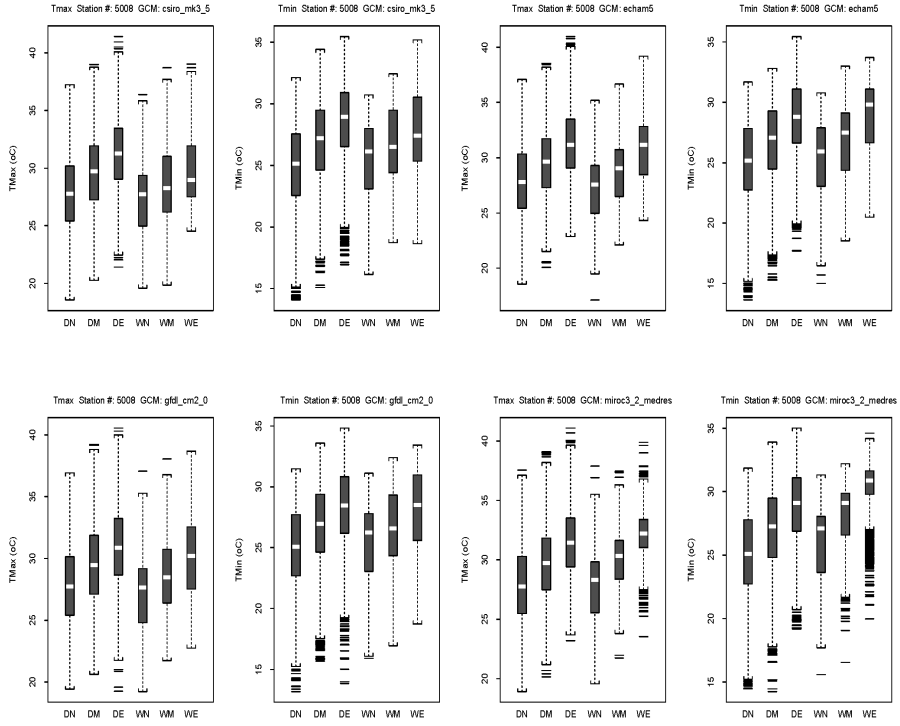

Figure 5: Maximum and minimum temperatures for the CCAM grid cell over Mardie for CCAM SRES-A2 scenarios for four GCMs. The first letter of the axis label, 'D' or 'W', refers to dry or wet days. The second letter refers to the period, 'Now' 1981-2000, 'Mid-century' 2046-2065, or 'End-of-century' 2081-2100.

Milestone 2.3.7 *Dissemination of climate change scenarios for daily rainfall and temperature at multiple sites*

(Progress report – to be completed 31/12/2011)

Extraction and processing of the large-scale predictor fields for the selected GCMs and corresponding CCAM future climate projections is being completed. The CCAM derived predictors provide continuous daily output from 1961 to 2100 for the SRES-A2 scenario. In contrast, the GCM daily output is limited to a current climate period (1961-2000) and two twenty-year future periods, mid-century (2046-2065) and end-of-century (2081-2100).

Milestone 2.3.6 and 2.3.7 will be completed by their target completion dates. This will result in the provision of 100 stochastic realisations of daily rainfall and maximum and minimum temperature for each of the five GCMs and corresponding CCAM runs selected, for the periods as noted above. These data-sets will be provided to State agencies (as files on DVD) for use in their respective climate assessments.

References

Rotstayn, L. D., et al. (2007), Have Australian rainfall and cloudiness increased due to the remote effects of Asian anthropogenic aerosols?, *Journal of Geophysical Research*, *112*(D09202), doi:10.1029/2006JD007712.

Summary of new linkages to other IOCI3 Projects

We have commenced extracting atmospheric predictors from the CSIRO Mk3.6 GCM runs being undertaken for Project 2.1: *Observed and Modelled Climate for the North-West*. These will be statistically downscaled to determine similarities between Reanalysis and Mk3.6 downscaled weather state and rainfall trends. Eventually AR5 projections will become available and could be downscaled if they can be processed in time.

Summary of any new research opportunities that have arisen

None

List of Publications Accepted and Submitted

None

List of IOCI-Related Presentations at National of International Conferences, Symposia and Workshops

None

Summary of Progress Status

All milestones are on track and at this stage will be completed on time.