PROJECT 2.4: PHYSICAL-STATISTICAL MODELLING OF EXTREME EVENTS

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Key research findings and highlights

Milestone 2.4.7 *Report documenting the likely changes in the frequency, intensity and region of occurrence of tropical cyclone-like vortices (TCLV) affecting WA*

This milestone uses the outputs from regional climate models to identify likely changes in the frequency and region of occurrence of TCLVs affecting WA. A report documenting these changes has been submitted. The development of projections of changes in intensity requires the high-resolution downscaling of TCLVs to resolve the TC structures (e.g. the eye wall) in which the extreme winds and high rainfall occur. Downscaling of TCLVs from one regional climate simulation is complete with results provided in a previously submitted report.

Milestone 2.4.9 Report documenting likely change in extreme rainfall events

Extreme rainfall events in NWWA are due to a number of synoptic systems, one of which is tropical cyclones (TC). In this milestone, we have downscaled extreme rainfall events for the current (1981-2000) and future (2081-2100) climates to provide high resolution projections of changes in extreme rainfall intensity. Changes in TC-related rainfall have been provided through analysis of downscaled simulations from Milestone 2.4.7.

Milestone 2.4.10 Provision of projections and modelled output (e.g. changes to ARIs, temporal rainfall patterns) in a format suitable for use by stakeholders

Milestone Reports

Milestone 2.4.7 Report documenting the likely changes in the frequency, intensity and region of occurrence of tropical cyclone-like vortices (TCLV) affecting WA.

Complete – report provided previously.

Milestone 2.4.9 Report documenting likely change in extreme rainfall events

The analysis of extreme rainfall from our 5 km downscaled TC simulations shows a 33% increase in average rainfall intensity for rainfall occurring within 300 km of the TC centre. Similar increases in maximum intensity are also found. These increases are higher than results previously reported as our analysis is centred on the 12 hours at which the TC was most intense, rather than the storm lifetime average reported previously and in other studies. In many cases, these changes in rainfall intensity are for TCs occurring over the ocean.

How may climate change affect the intensity of extreme rainfall events affecting northwest Western Australia (NWWA)? Outputs from a regional climate model have been examined to identify extreme rainfall events affecting this region. The regional climate model had a grid spacing of 65 km and thus the extreme rainfall events identified are of lower intensity than reality. These events have been downscaled to a grid spacing of 5 km so that the rainfall intensity simulated is more realistic.

The events to be downscaled were chosen by identifying the 2 highest rainfall days per year for each regional climate model grid point in the NWWA region. These rainfall days were deemed to be from independent synoptic systems by requiring them to be separated in time by 10 days or more. Results from all identified days for all grid points were then grouped to create a series of multi-day rainfall events that were downscaled for the entire region. This analysis was completed for the current (1981-2000) and future (2081-2100) climates, yielding over 300 distinct events covering almost 3100 days of simulation for each of the twenty year time slices.

The regional climate simulation that was downscaled was from the CSIRO Conformal Cubic Atmospheric Model (CCAM). CCAM is a global model that utilises a stretched grid in which the Earth is mapped onto a cube. The mapping is such that higher resolution is focussed over the region of interest and lower resolution is on the opposite side of the Earth, remote from the region of interest. To overcome the potential errors that could result from the poor resolution in the remote areas, the model solution in the lowest resolution areas is nudged heavily towards the solution of the parent Global Climate Model (GCM). The cubic conformal model simulation considered in this study had its highest resolution, of approximately 65 km, centred on Australia. In this region the CCAM winds above 500 hPa are nudged towards those of the parent GCM. This approach ensures that the CCAM storm tracks do not diverge from those of the parent GCM (i.e. the gross features of the atmospheric circulation are maintained) whilst allowing the model to form smaller scale atmospheric features that are not evident in the parent GCM. Below 500 hPa the model solution is allowed to evolve freely. The parent GCM was from CSIRO Mark 3.0 model using greenhouse gas forcing representative of the SRES A2 scenario. This CCAM simulation was chosen as earlier analysis of tropical cyclone characteristics had shown that this simulation had the best representation of the Australian region tropical cyclone climate of the eleven simulations considered: it best represented TC numbers in the region and when forced with reanalysis outputs was best able to capture the inter-annual variability of TCs in the Australian region.

The model used for the downscaling is the Regional Atmospheric Modeling System (RAMS). RAMS can be used with multiple, two-way interacting nests that are configured to produce high resolution results over the study regions; the nests used for the downscaling are shown in Figure 1. Four nests were used; the coarsest mesh had a grid spacing of 60 km, grid 2 a spacing of 15 km, while grids 3 and 4 both used a grid spacing of 5km. The results based on outputs from the two finest nests are described below.

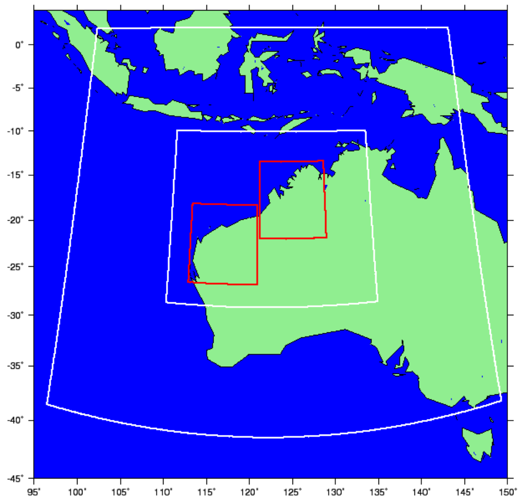

Figure 1: The 4 model domain used in the downscaled simulations. The two 5 km domains are shown by the red outlines.

Preliminary results were presented in an earlier version of this report in late-May 2012. Those results were based on interim downscaled results where approximately 80% of the simulations had been completed for each climate time slice. The current report is an update of that report based upon the completion of all simulations. Note that the addition of the extra simulations does not change the results presented in the earlier preliminary report.

Projected changes are shown in Figure 2 for 2-hour and 24-hour events; 72-hour events have been analysed but are not shown as the results are qualitatively similar to the 24-hour results.

These results show widespread increases in rainfall extremes for events occurring in the Hammersley Range region with less significant increases occurring in the Kimberley Plateau. Rainfall extremes are projected to decrease in a wide band along the coastline and in the Great Sandy Desert. Other features noted in an examination of these preliminary results are: (a) short duration events (e.g. 2-hour events) are projected to have larger increases in intensity than the longer duration events (e.g. 24-hour events), (b) more extreme rainfall events (e.g. 1-in-100 year events) are likely to increase in intensity more than the less extreme events (e.g. 1-in-2 year events), and (c) the projected pattern of change is similar for the 2-hour, 24-hour and 72-hour events.

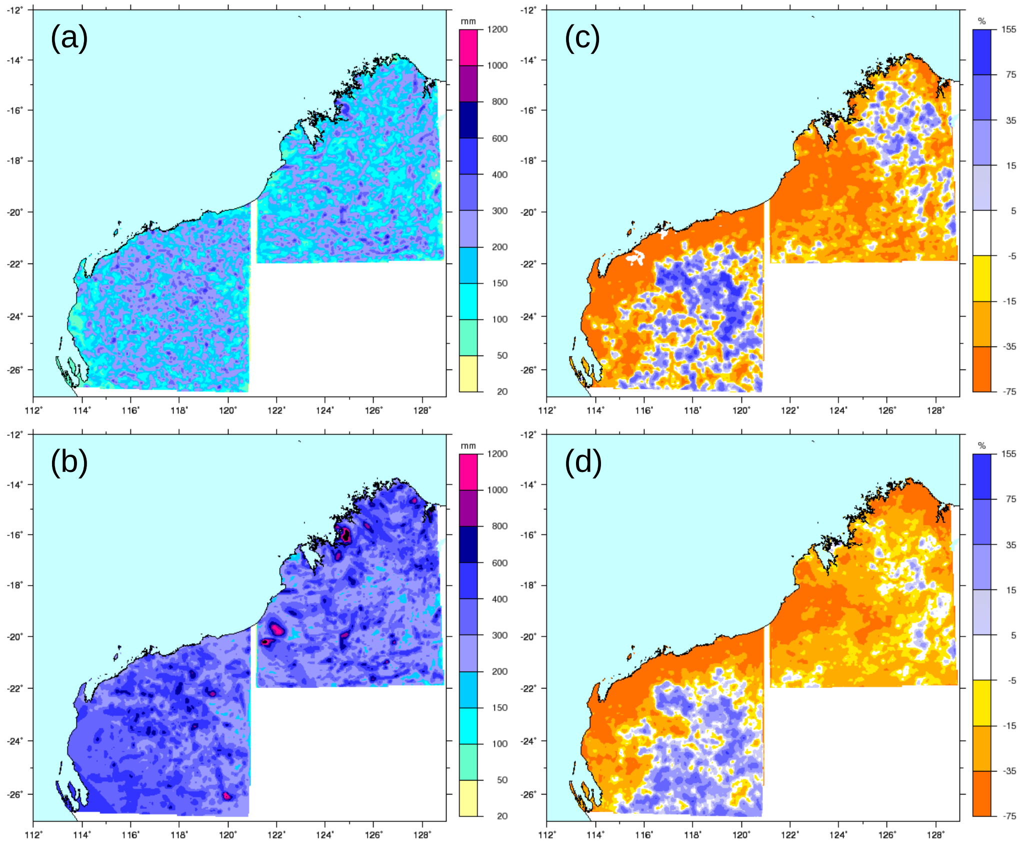

Figure 2 Most extreme (a) 2-hour and (b) 24-hour rainfall simulated in the 5 km downscaled simulations for the period 1981-2000. Also shown is the average projected change in the intensity of (c) 2-hour and (d) 24-hour rainfall accumulations for events with a recurrence interval of 1 year or longer for the period 2081-2100

An extreme value analysis of the outputs from these simulations will be completed once the remaining simulations have finished. These projected changes should be considered as indicative only. The outputs from only one GCM and one warming scenario have been considered and thus these results do not capture the range of change that would likely be projected if multiple GCMs were downscaled.

Milestone 2.4.10 Provision of projections and modelled output (e.g. changes to ARIs, temporal rainfall patterns) in a format suitable for use by stakeholders

Extreme value statistics have been applied to the modelled outputs from Milestone 2.4.9 to provide projected changes in Average Recurrence Intervals for extreme rainfall in the NWWA. Results will be provided in the format of maps and graphs and made available on the CSIRO web site.

List of publications accepted and submitted.

M. M. P. B. Fuentes and D. Abbs, 2010: Effects of projected changes in tropical cyclone frequency on sea turtles. Marine Ecology Progress Series, **412**, 283–292, doi: 10.3354/meps08678

Abbs, D., 2012: The Impact of Climate Change on the Climatology of Tropical Cyclones in the Australian Region. Climate Adaptation Flagship Working Paper 11. 16 pp.

http://www.csiro.au/en/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/WorkingPaper11_CAF_pub.aspx

Lavender, S. L. and D. J. Abbs, 2012: Trends in Australian Rainfall: Contribution of Tropical Cyclones and Closed Lows. Submitted to Climate Dynamics.

List of IOCI-related presentations at national or national and international conferences, symposia and workshops.

Rafter, A. and D. Abbs, High resolution dynamical downscaling of model-based tropical cyclones. Proc. Joint Conference of the New Zealand Meteorology Society and the Australian Meteorological and Oceanographic Society, 100. Wellington, New Zealand, 9-11 Feb, 2011.

Abbs, D: Tropical cyclones – methods to analyse changes In frequency and intensity for the Australia-Pacific region. Greenhouse 2011, Cairns. 4-8 April, 2011.

Rafter, A and D. Abbs: Tropical Cyclones - Methods To Analyse Changes In Frequency And Intensity For The Australia-Pacific Region. IUGG 2011, Melbourne. 28 June-7 July 2011.

S. L. Lavender , M. Chattopadhyay and D. J Abbs, Contribution of tropical cyclones to rainfall and extreme rainfall: Observations and GCMs. 3rd International Summit on Hurricanes and Climate Change. Rhodes, Greece. 27 June-1 July, 2011.

D. J. Abbs, S. L. Lavender, K.J.E. Walsh and A. S. Rafter: Dynamically downscaled simulations of Australian region tropical cyclones – a multi-model approach for the Australian region. 3rd International Summit on Hurricanes and Climate Change. Rhodes, Greece. 27 June-1 July, 2011. (Poster)

D. Abbs, S. Lavender, T. Rafter and K. Walsh, 2012: Dynamically downscaled simulations of Australian region tropical cyclones - a multi-model approach for the Australian region. 10th International Conference on Southern Hemisphere Meteorology and Oceanography, Noumea, New Caledonia. 23-27 April, 2011.

S. Lavender, D.Abbs, T. Rafter and K. Walsh, 2012: Dynamically downscaled simulations of Australian region tropical cyclones - a multi-model approach for the Australian region. 30th AMS Conference on Hurricanes and Tropical Meteorology, Ponte Vedra Beach, Florida, USA, 16-20 April 2012