OBSERVED AND PROJECTED CHANGES IN THE CLIMATE OF THE TROPICAL RAINFOREST REGION OF NORTHERN QUEENSLAND

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1. INTRODUCTION

Tropical rainforest covers less than 1% of Australia's landmass but contains a highly disproportionate amount of the biodiversity. About 900,000 hectares of rainforest lie between Townsville and Cooktown in northern Queensland in the Wet Tropics Bioregion. This region contains plant taxa representative of the earliest stages of the evolution of vascular plants and a very large number of regionally endemic plant and animal species. Extensive research on climate impacts on this biodiversity is being undertaken though a major research initiative, the Marine and Tropical Sciences Research Facility (MTSRF), coordinated by the Reef and Rainforest Research Centre (RRRC) in Cairns and Townsville.

Suppiah et al. (2008) developed climate change projections for the region using simulations from 23 global climate models (GCMs) performed for the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC). Temperature and rainfall projections for the tropical rainforest region were based on the probabilistic method described in Watterson (2008). This method was used by CSIRO and the Bureau of Meteorology (2007) to produce climate change projections for the Australian region. Firstly, a brief description on the new method and its related uncertainty is given. Secondly, projected changes in annual and seasonal average temperature and rainfall by 2030, 2050 and 2070 for three regions are discussed. Thirdly projected changes in maximum, minimum and potential evaporation are given. Projections were given for the 50^{th} percentile as the best estimate and low and high ranges are given as10^{th} and 90^{th} percentiles of temperature and rainfall changes. Lastly, conclusions derived from this study are given.

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2. METHOD USED TO GENERATE PROBABILISTIC CLIMATE CHANGE PROJECTIONS

This section provides a brief explanation of the generation of probabilistic projections for the tropical rainforest region. Changes in maximum, minimum, and average temperatures, rainfall potential evaporation for the years 2020, 2030, 2040, 2050, 2060, 2070 and 2080 were calculated relative to averages for the 20-year 1980-1999 period. Climate change projections are given for 30-year periods or decades, changes in any individual year will be strongly affected by natural climate variability (variability on interannual to decadal scales is not easily predicted and has not been accounted for). Three main sources of uncertainty are accounted for:

1) The uncertainty in the future evolution of greenhouse gases, sulphate aerosol emissions and other gases.
2) The uncertainty in how much the global average surface temperature will respond to increases in atmospheric greenhouse gas concentrations and changes in sulphate aerosol emissions.
3) The uncertainty in how the climate of Australia will respond to an increase in global average surface temperature.

The first uncertainty is addressed by considering six different scenarios for the future evolution of greenhouse gas and sulphate aerosol emissions described by the Special Report on Emissions Scenarios (SRES) (Nakićenović & Swart, 2000) of the Intergovernmental Panel on Climate Change (IPCC). Each of the scenarios, denoted A1B, A1FI, A1T, A2, B1 and B2 in Nakićenović & Swart, (2000) is based on a plausible storyline of future global demographic, economic and technological change in the 21^{st} Century.

The second uncertainty is addressed by considering information on the response of the global average surface temperature to the emissions scenarios from multiple climate models and the IPCC's Fourth Assessment Report (Meehl et al. 2007b). Meehl et al (2007b) reported warmings, between 0.5 and 1.6℃ by 2030 and between 1.1 and 6.4℃ by 2100 relative to the average temperature for the 1980-2000 period. Their study also suggested that simulated global average surface temperature anomalies for the 20th Century agree well with observed anomalies on the timescale of several decades, giving us some confidence in the ability of climate models to accurately simulate anomalies on such a timescale.

The third uncertainty is addressed by considering the response of the climate of Australia to global warming in 23 climate models. Model output from the Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset (see Meehl et al., 2007a) of the World Climate Research Programme (WCRP) was processed using the pattern scaling technique described by Mitchell et al. (1999), Mitchell (2003) and Whetton et al. (2005). From the simulations of the 21st century from each model, the trend in each variable and each model grid point was calculated, relative to the global mean warming. Projected regional changes in temperature are computed as degree of change per degree of global warming and rainfall changes are calculated as percentage change per degree of global warming. The results from the 23 models were then combined to form a probability distribution for local change per degree of warming. In this process, models were given differing weights, or emphasis, depending on their ability to simulate average patterns of temperature, precipitation and mean sea level pressure in the Australian region for the 30-year period, 1961-1990. An assessment of the simulations of mean sea level pressure, temperature and rainfall by 23 GCMs over the Australian region is given by Suppiah et al. (2007a).

3. OBSERVED TEMPERATURE AND RAINFALL TRENDS

Temperature in the tropical region of has increased steadily between 1950 and 2006, but shows strong decadal and interannual variations. Since 1950, the tropical rainforest region's average maximum temperature has increased by 0.8℃(0.14℃ per decade), the minimum by 0.91℃ (0.16℃ per decade) and the average by0.86℃ (0.15℃ per decade). Figure 1 shows strong interannual variations in mean annual temperature over the tropical rainforest region embedded with an increasing trend since 1950. Compared to national trends, the tropical rainforest region's temperatures show slower increases during the last five decades. However, similar to all-Australian records, 2005 was the warmest on record in the rainforest region.

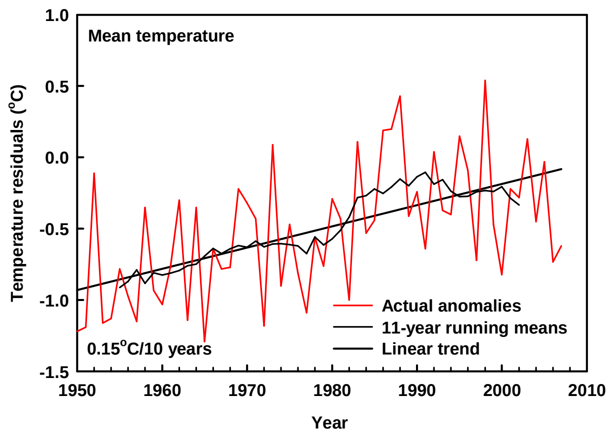

Figure 1. Long-term trend and variations in annual mean temperature anomalies over the tropical rainforest region from 1950 to 2006.

Variations in annual and seasonal rainfall in the rainforest region of North Queensland during the past century show no clear trend, but there are fluctuations on multi-decadal time scales as shown in Figure 2. In particular, the 1920s, 1960s and 1990s were dry decades and the 1970s was a wet period. Decadal fluctuations in annual rainfall are dominated by wet season (January to March) rainfall variations. Rainfall in the dry season (August to October) shows no clear trend and strong variability. Rainfall in transitional seasons (Transitional 1 – November and December; Transitional 2 – April to July) shows greater variability and also no clear trends. Rainfall decrease is stronger in the south of the region compared to the north (Suppiah et al., 2007b).

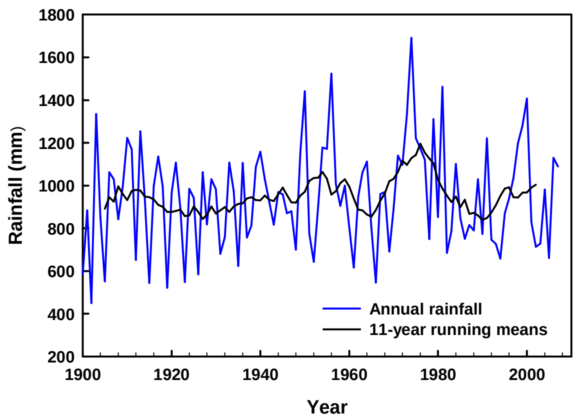

Figure 2. Interannual variations in annual rainfall in the tropical rainforest region.

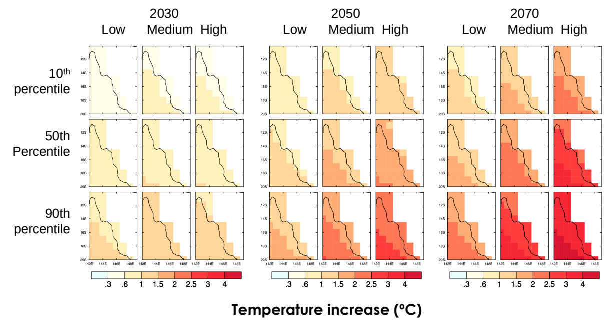

Figure 3. 10th, 50th and 90th percentile increases in annual average temperature (ºC) for low, medium and high emissions scenarios for 2030, 2050 and 2070.

4. TEMPERATURE, RAINFALL AND POTENTIAL EVAPORATION PROJECTIONS

4.1 Projected changes in temperature

Figure 3 shows the 10th, 50th and 90th percentiles of annual average temperature increase for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070. This figure shows that inland areas of the tropical rainforest region will warm faster than coastal areas. Temperature increases by 2030 do not differ greatly between low, medium and high emissions scenarios.

For a medium emissions scenario the best estimate (50th percentile) regional average temperature increase by 2030 is 0.8ºC with a range of uncertainty of 0.6 to 1.1ºC.

Temperature increases by 2050 and 2070 increasingly diverge dependent on emissions scenario. For 2050, the ranges of uncertainty for regional average temperature increase for the different scenarios and span the range 0.7 to 2.2ºC. The corresponding range for 2070 is 0.9 to 3.5ºC. Temperature increases for the different seasons are not greatly different from increases in annual average temperature. Projected changes in magnitudes of maximum and minimum temperature are very similar to those magnitudes for average temperature

4.2 Projected changes in rainfall

Projected changes in the 10th, 50th and 90th percentiles of annual average rainfall for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070 are shown in Figure 4. Rainfall changes are more complex than temperature changes, as their signs and magnitudes show strong spatial variations. Model to model variations in rainfall are also large. As for temperature, changes by 2030 do not differ greatly between low, medium and high emissions scenarios. For a medium emissions scenario the best estimate (50th percentile) regional average rainfall change for 2030 is -1% with a range of uncertainty of -8 to +6%. Changes by 2050 and 2070 are dependent on emissions scenario. For 2050, the ranges of uncertainty for regional average rainfall change for the different scenarios span the range -16 to +11%. The corresponding range for 2070 is -26 to +18%. As mentioned earlier, projected changes in rainfall are based on linear relationship between temperature and rainfall, and therefore, variations on inter-decadal scales are not easily predictable.

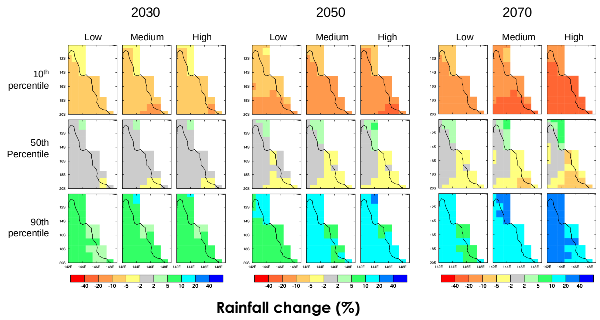

Figure 4. 10th, 50th and 90th percentile changes in annual average rainfall (%) for low, medium and high emissions scenarios for 2030, 2050 and 2070 in the region.

4.3. Changes in potential evaporation

Increases in temperature and overall decreases in rainfall show decreases in annual potential evaporation in the study domain. Figure 5 shows that southern and central parts of the area show strong increases in potential evaporation. Increases of 2 to 8% by 2030 and 4 to 18% by 2070 are projected between low and high emission scenarios.

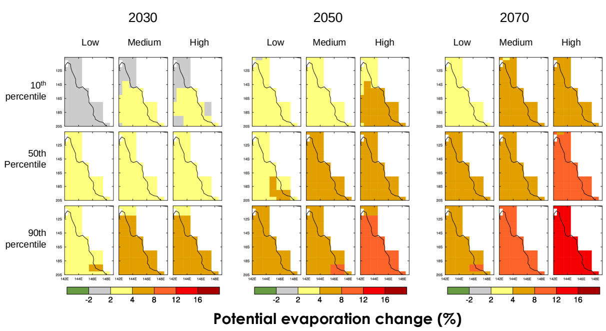

Figure 5. 10th, 50th and 90th percentile changes in annual average potential evaporation (%) for low, medium and high emissions scenarios for 2030, 2050 and 2070 in the region.

5. CONCLUSIONS

In this study, we have provided climate change projections for the tropical rainforest region of north Queensland. These climate change projections were derived from the output of the most recent generation of climate models by a probabilistic method in which each of 23 GCMs is assigned a weight based on its ability to simulate the observed climate averages for Australia for the 1961-1990 period. Projections were given for 10th, 50th and 90th percentiles of temperature and rainfall changes for low, medium and high emissions scenarios. Projections are given for annual maximum, minimum, and mean temperature, rainfall and potential evaporation for 2030, 2050 and 2070 for low, medium and high emissions scenarios, but projections for other decades from 2020 to 2080 are also available.

Projected temperatures show that the inland areas of the tropical rainforest region and it surroundings will warm faster than the coastal areas. For a medium emissions scenario the best estimate (50th percentile) regional average temperature increase by 2030 is 0.8ºC with a range of uncertainty of 0.6 to 1.1ºC. For 2050, the ranges of uncertainty for regional average temperature increase for the different scenarios and span the range 0.7 to 2.2ºC. The corresponding range for 2070 is 0.9 to 3.5ºC.

Rainfall changes are more complex than temperature changes and show increases and decreases. For a medium emissions scenario the best estimate (50th percentile) regional average rainfall change for 2030 is -1% with a range of uncertainty of -8 to +6%. Changes by 2050 and 2070 are dependent on emissions scenario. For 2050, the ranges of uncertainty for regional average rainfall change for the different scenarios span the range -16 to +11%. The corresponding range for 2070 is -26 to +18%. Percentage rainfall changes in Dry season and Transitional season 2 are greater than those for Wet season and Transitional season 1. Projected Increases in temperature and slight decreases lead to increases in potential evaporation. Potential evaporation. Increases of 2 to 8% by 2030 and 4 to 18% by 2070 are projected between low and high

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