Marine and Tropical Sciences Research Facility

Climate Change Projections
for the Tropical Rainforest Region of North Queensland: Final Report on MTSRF Activities, 2006-2010

R. Suppiah, I. G. Watterson,
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Australian Government
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CSIRO

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The Australian Government's Marine and Tropical Sciences Research Facility (MTSRF) supports world-class, public good research. The MTSRF is a major initiative of the Australian Government, designed to ensure that Australia's environmental challenges are addressed in an innovative, collaborative and sustainable way. The MTSRF investment is managed by the Department of Sustainability, Environment, Water, Population and Communities, and is supplemented by substantial cash and in-kind investments from research providers and interested third parties. The Reef and Rainforest Research Centre Limited (RRRC) is contracted by the Department to provide program management and communications services for the MTSRF.

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Reef & Rainforest
RESEARCH CENTRE

December 2010

Executive Summary

This is the final report from a four-year (2006-2010) program funded by the Marine and Tropical Sciences Research Facility (MTSRF) on regional climate change projections for the tropical rainforest region of North Queensland. It gives a descriptive assessment of observed climate variability during the past century, and provides general climate change projections for the region into the future. Recommendations for future research are also included at the end of this summary.

Climate change due to the likely increase in atmospheric greenhouse gas concentrations is now inevitable. Climate change will continue to increase until, and to a lesser known degree beyond, a stabilisation of greenhouse gas concentrations can be reached. We therefore need the best possible estimates of regional climate changes and of the sensitivity of various sectors to such changes.

During the four-year research period, we used several approaches for determining future changes in northeast Queensland, such as temperature, rainfall and potential evaporation patterns for various decades, the behaviour of the El Niño-Southern Oscillation phenomenon (ENSO), and tropical cyclones. These factors were investigated through simulations from global climate models (GCMs), theoretical considerations and the application of higher resolution regional climate models nested in a number of GCMs. Results of higher resolution simulations are given by Thatcher and others (2007, 2008).

Our climate change assessments are based on coupled-ocean-atmosphere GCMs. Although these are state-of-the-art models it is acknowledged that they are not fully realistic. In particular, the current generation of GCMs simulates ENSO inadequately. Furthermore, there is no consensus on the simulation of likely changes in ENSO characteristics. A major task in the near future is to refine coupled-ocean-atmosphere models to provide simulations of ENSO changes in which we can have confidence, and to use the models to investigate related effects including possible changes in the behaviour of tropical cyclones.

Model simulations indicate a range of plausible changes in temperature, mean rainfall and increased rainfall intensity, potential evaporation and possible changes in ENSO, and tropical cyclone behaviour. The practical implications of these climate change projections suggest possible widespread impacts across northeast Queensland, particularly in the rainforest and Great Barrier Reef regions. Such impacts can significantly affect coastal zones, ecosystems, agriculture, water resources, tourism, human health, fisheries, pests, diseases, mangroves, coral reefs and low lying islands.

The need for developing better methods to produce improved climate change projections under enhanced greenhouse conditions is widely recognised. Studies of the sensitivity of ecosystems and other sectors using climate change projections by colleagues at James Cook University, CSIRO Sustainable Ecosystems and others suggest that enhanced greenhouse conditions can have significant impacts on ecosystems of the tropical rainforest region, as well as economy and tourism, and human settlements. Within the next stage of post-MTSRF Australian Government funding, we look forward to a growing interaction and collaboration with research communities and application agencies in the region. Even in the absence of confident local projections of climate change, developing the ability to assess the impacts of climate change on particular activities and sectors is a valuable undertaking. It will enable rapid assessments to be made of potential impacts and adaptation strategies once uncertainties in the climate projections are reduced.

Present climate variability

Since 1950, the tropical rainforest region's average maximum temperature has increased by 0.12°C per decade, the minimum by 0.14°C per decade, and the average by 0.13°C per decade. Rainfall shows strong variations on inter-annual and inter-decadal time scales. The relationship between the Southern Oscillation Index and rainfall in this region is positive, but shows decadal-scale variations.

A distinct low pressure system forms over the Coral Sea during heavy rainfall events over Cape York and the rainforest region. Pressure, wind and out-going long wave radiation (OLR) anomalies indicate that they are part of large-scale circulation during the wet season. Higher temperatures are observed over southern Australia during the heavy rainfall events in northern Australia.

Climate change projections

Probabilistic climate change projections for temperature, rainfall and potential evaporation are given for the 50th percentile as the best estimate, and low and high ranges are given as 10th and 90th percentiles. The projections show that the inland areas of the MTSRF study region will warm faster than the coastal areas. For a medium emissions scenario the best estimate regional annual average temperature increase by the year 2030 is 0.8°C, with a range of uncertainty of 0.6 to 1.1°C. Larger increases are projected for 2050 and 2070. Projected rainfall changes include both increases and decreases. The best estimate of regional average annual rainfall change for 2030 is -1% with a range of uncertainty of between -8% and +6%. Larger ranges are projected for 2050 and 2070. Percentage changes in the Dry Season and Transitional Season 2 rainfall are greater than those for Wet Season and Transitional Season 1 rainfall.

El Niño-Southern Oscillation (ENSO) phenomenon

Both coarse and fine resolution models indicate that the ENSO cycle will continue to occur under simulated enhanced greenhouse conditions. However, while there has been a significant improvement in the ability of models to simulate ENSO, at present there is no clear consensus on how ENSO might change under enhanced greenhouse conditions. Since there is a strong observed relationship between tropical cyclone frequency and ENSO, uncertainty associated with ENSO under climate change conditions will also create uncertainty in future tropical cyclone behaviour in the region.

Extreme events including tropical cyclones

GCM simulations suggest an increase in heavy rainfall events in northeastern Australia under enhanced greenhouse conditions. Observations do show increases in heavy rainfall events in the region during the past century.

There is uncertainty about changes to tropical cyclone behaviour due to enhanced greenhouse conditions. However, a recent review of tropical cyclone characteristics simulated by models suggests an increase in globally averaged tropical cyclone intensity by 2-11% by the year 2100. This leads to an increase of the order of 20% in the precipitation rate within 100 km of the storm. These models also suggest a decrease in cyclone frequency in the southern hemisphere, with mixed changes in northern Australia. Further investigation is needed to establish the physical basis and statistical significance of these changes.

Potential climate change impacts in northeastern Queensland

Simulated changes in temperature, rainfall and potential evaporation under enhanced greenhouse conditions suggest little room for complacency about potential impacts on various sectors, despite large uncertainty. The sign of change in temperature is clear, but projections are indefinite about the sign of any rainfall change. A possible reduction in rainfall, higher temperatures and increased potential evaporation, and increase in rainfall intensities and possible change in ENSO and tropical cyclone behaviour suggest potential for widespread impacts in northeast Queensland, particularly in the tropical rainforest and Great Barrier Reef regions.

Conclusions and recommendations

Results obtained during the study period suggest that a certain degree of climatic change in northeast Queensland now seems inevitable, and is likely to become increasingly apparent over the next 30-100 years as atmospheric equivalent CO_2 concentrations exceed doubled pre-industrial concentrations. Changes are to be expected in both the mean values and in the magnitudes and frequency of extreme rainfall events. This means that long-term planning should not be made with the assumption that future climate and resources will be as they were over the past 100 years – significant adaptation to a changing climate will be necessary.

Characteristics of water quality, floods and drought frequency and severity, and the frequency and intensity of tropical cyclones and storm surges could change significantly. Anticipated changes have strong implications for the sustainable development of planned infrastructure including coastal development, ports, bridges and urban centres.

Higher temperatures and a changing frequency of droughts and fire could have increasing impacts on flora and fauna of the study region. These changes would affect farming practices, such as crop type, sawing and harvesting times. Significant changes in management may be required to minimise costs, maximise benefits, and ensure sustainability.

At this stage, it seems likely that the relationship between rainfall of the region and the Southern Oscillation Index will continue under enhanced greenhouse conditions. Thus seasonal rainfall predictions based on the Index may be a useful tool in climate change adaptation.

Decadal and century-scale climate change is expected to affect the present tropical ecosystems of the study region. Some animal and plant species may come under increasing stress, causing long-term change in species composition due to the combination of climate change and natural variability.

Coastal ecosystems will be affected by sea level rise and change in land-based and river runoff. Sea level rises are expected due to the thermal expansion of oceans and the melting of mid to low latitude glaciers.

Significant uncertainties remain in relation to the estimation of future climate. These might be lessened through, (1) improving the transient atmospheric and oceanic forcings input to transient experiments, (2) improving the ability of global climate models to simulate ENSO behaviour under present and enhanced greenhouse conditions, and (3) improving the high resolution modelling of the region to better incorporate the effects of topography and air-sea interaction processes. Some improvements are included in the IPCC AR5 simulations.

Climate impact and adaptation assessment methods should be improved by further development of versatile climate impact and adaptation models and methodologies for a number of key sectors and activities. These models should be developed and tested against observations initially. They can then be used to assess the impacts of more reliable climate change projections with reduced uncertainty when they become available. Priority should be given on the basis of potential sensitivity, impact model availability and stakeholder interest in sectors such as agriculture, water resources, coastal impacts, health, transport, land planning and emergency services.

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Acronyms and Abbreviations

CMIP3	Coupled Model Intercomparison Project phase 3
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ENSO	El Niño-Southern Oscillation
GCM(s)	Global climate model(s)
IPCC	Intergovernmental Panel on Climate Change
IPO	Inter-decadal Pacific Oscillation
MTSRF	Marine and Tropical Sciences Research Facility
OLR	Out-going long wave radiation
PCMDI	Program for Climate Model Diagnosis and Intercomparison
SOI	Southern Oscillation Index
SPCZ	South Pacific Convergence Zone
SRES	Special Report on Emissions Scenarios (see Nakićenović and Swart, 2000)
US	United States
WCRP	World Climate Research Programme

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1. Introduction

This is the final report from a four-year project on climate change projections for the tropical rainforest region of northeast Queensland. The first report on climate change projections by Suppiah and others (2007a) focused on temperature and rainfall projections based on a selected set of 15 models from the Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset. Following publication of the first report, the CSIRO developed new climate change projections for Australia using a probabilistic method that involves weighting the output of 23 Global Climate Models (GCMs) according to the ability of models to reproduce the observed climate averages (CSIRO, 2007). Therefore, a further report by Suppiah and others (2008) provided revised temperature and rainfall projections for Queensland's tropical rainforest region based on the new probabilistic method. Projected changes in annual average temperature and rainfall by 2030, 2050 and 2070 for the land area of three study regions were discussed. Seasonal average temperature and rainfall projections for 2020, 2030, 2040, 2050, 2060, 2070 and 2080 were also included in that report and those projections are included in this document. During the last two years, the CSIRO has developed storyline based climate change projections, also referred to as 'Climate Futures'. Using simulations from 24 GCMs, the CSIRO has developed Climate Futures for A1B, B1 and A1FI emission scenarios. Models have been classified based on 'slightly warmer', 'warmer', 'hotter' and 'much hotter', and 'much drier', 'drier', 'little change', 'wetter' and 'much wetter' conditions. The latest climate projections are at their early stage of development and will become available for end users in the future.

In this report, we first provide a brief description of observed climate trends and variability. Next, probabilistic based maximum, minimum and mean temperatures, rainfall and potential evaporation projections the three study regions (Figure 1) are given for various decades between 2020 and 2080. Changes in temperature, rainfall and potential evaporation are calculated only for the land area. Thirdly, projections based on a selected set of 15 models that were used by Suppiah and others (2007a) and all models are given. Sea level rise projections are included from published materials. Conclusions and recommendations are given last.

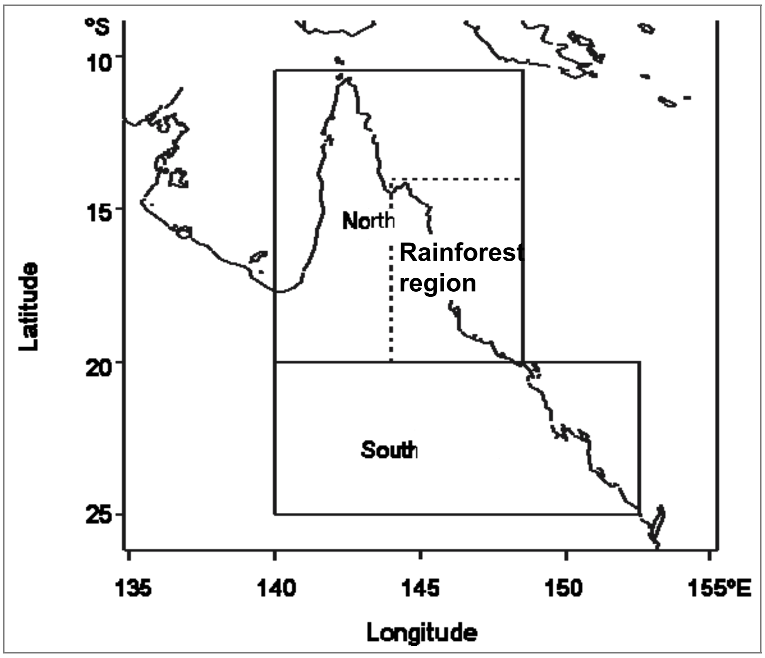


Figure 1: Map of the three study regions for which climate change projections are provided.

2. Observed climate trends and variability

2.1 Maximum, minimum and mean temperatures

Time series of annual maximum, minimum and average temperatures for the tropical rainforest study region (see Figure 1) of northern Queensland (14.5-19.5°S, 143.5-146.5°E) are shown in Figure 2. These figures reveal strong temporal variability on the inter-annual time scale embedded in a positive trend over the last six decades. Since 1950, the tropical rainforest region's average maximum temperature has increased by 0.12°C per decade, the minimum by 0.14°C per decade and the average by 0.13°C per decade. Thus, compared to national trends (Nicholls and Collins, 2006; Bureau of Meteorology, 2010) the region's temperatures show slightly higher increases over the last six decades.

A number of studies (e.g. Nicholls *et al.* 1996; Nicholls, 2003) have reported a strong negative relationship between Australian annual maximum temperature and rainfall. We investigated the relationship between rainfall and temperature for annual, as well as for four seasons, the study region. Table 1 shows that the relationship between rainfall and maximum temperature in the study region is strongly negative in the November to March period that covers Transitional Season 1 (November and December) and the wet season (January to March). It is weak during the dry season (August to October), when there is a positive correlation between rainfall and minimum temperature. These relationships lead to a strong negative correlation between diurnal temperature range and rainfall in all seasons as well as in annual values. If the influence of annual rainfall on annual mean temperature is removed by applying linear regression analysis, the trend in mean annual temperature is reduced by 0.01°C per decade (to 0.12°C per decade). The reduction in temperature trends indicates the influence of rainfall which will be discussed later. The negative relationship between rainfall and maximum temperature during the wet, Transitional 1 and Transitional 2 seasons is mainly due to increased evaporation and some effect of cloud cover on the reduction of maximum temperature (Karl *et al*. 1993; Dai *et al.* 1999). There is less available energy as convection to raise screen temperature (Deacon, 1969). During the dry season, low rainfall is associated with little or no cloud and relatively dry air. This leads to a high rate of radiative heat loss from the Earth's surface and hence low minimum temperature. Calm conditions are another factor that adds to heat loss during the night, but moderate or strong wind speed results in a relatively small fall in nighttime temperature. Rainfall during the dry season tends to suppress the radiative heat loss during the night, which in turn leads to increased minimum temperature.

Table 1 shows observed relationship between seasonal and annual rainfall and temperature in the tropical rainforest study region between 1950 and 2008. Climatic seasons shown in Table 1 are very specific to the tropical rainforest region.

Table 1: Relationship between seasonal and annual rainfall and temperature in the tropical rainforest study region, quantified by the correlation coefficient. Statistically significant levels for 95% and 99% are 0.25 and 0.325 respectively.

Temperature (°C)	**Wet Season** (Jan-Mar)	**Transitional Season 2** (Apr-Jul)	**Dry Season** (Aug-Oct)	**Transitional Season 1** (Nov-Dec)	**Annual**
Maximum	-0.83	-0.54	0.03	-0.73	-0.60
Minimum	-0.09	0.40	0.58	0.24	0.01
Mean	-0.66	-0.04	0.41	-0.36	-0.31
Diurnal Range	-0.87	-0.81	-0.73	-0.89	-0.61

Long-term fluctuations in maximum, minimum and mean temperatures in Figure 2 also show a steady increase from 1950 to the late 1990s and a slight decline after this period. Such a decline in temperature could be a part of natural variability.

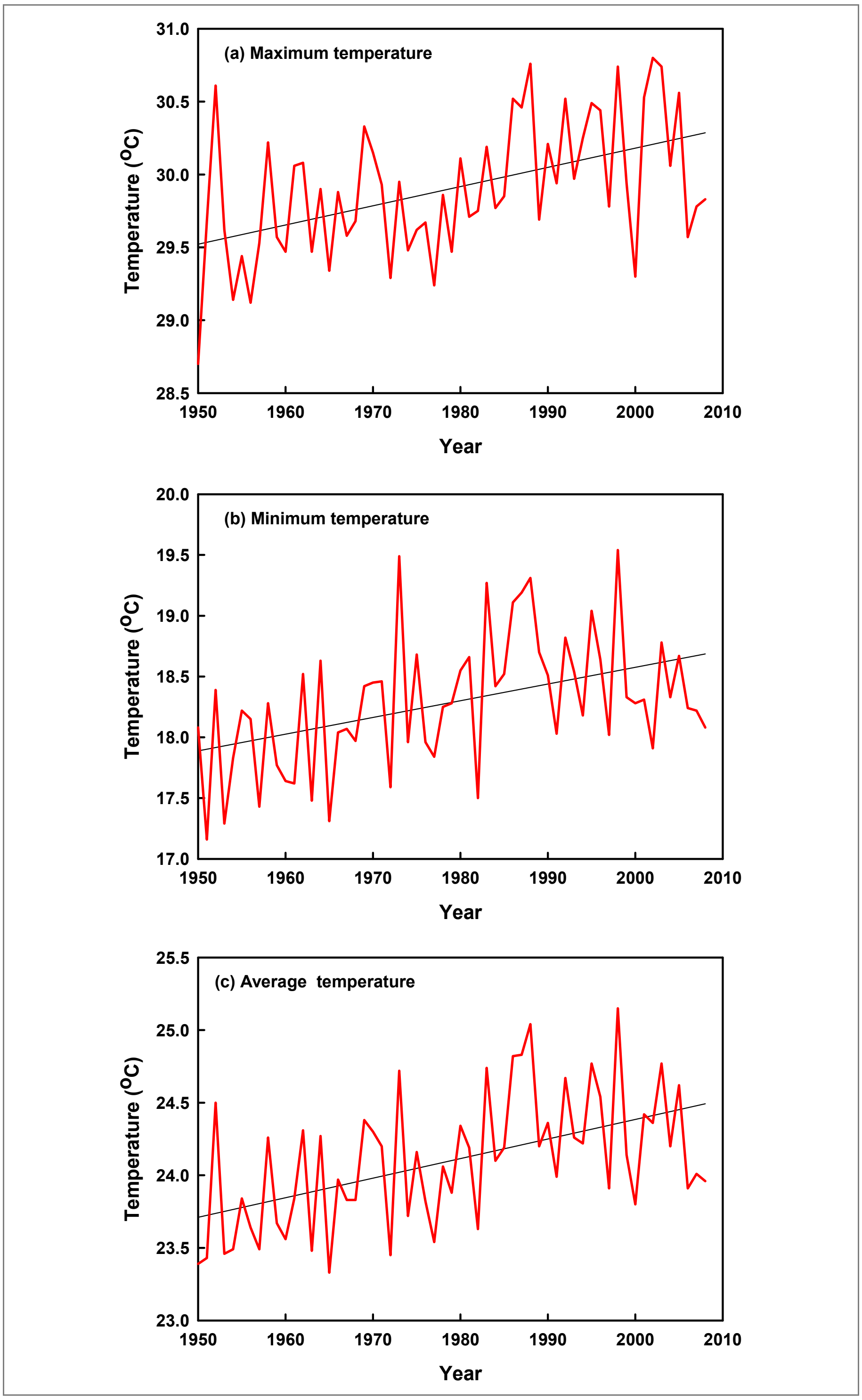


Figure 2: Trends and inter-annual variations in (a) maximum, (b) minimum and (c) average temperatures in the tropical rainforest study region of northeast Queensland. Source: Australian Bureau of Meteorology.

2.2 Rainfall trends and fluctuations

A number of studies (e.g. Nicholls and Lavery, 1992; Suppiah and Hennessy, 1996; Smith, 2004) have demonstrated a significant difference in spatial and temporal variations between mean rainfall and rainfall intensity for Australia. Increasing rainfall and intensity over northwestern Australia, but also a decline in both southwestern Western Australia and southeastern Australia have been documented in those studies. Tropical Australian rainfall and its intensity are strongly associated with variations in El Niño-Southern Oscillation (ENSO) on an inter-annual time scale. These studies also reported that no regular temporal pattern in the ENSO-rainfall link can be found during the past century. Variations in the ENSO-rainfall relationship in the rainforest region will be discussed in the next section. Figures 3 and 4 show fluctuations in annual and seasonal rainfall in the rainforest region of northeast Queensland between 1900 and 2007. Rainfall shows no clear trend during the past century, but shows fluctuations on multi-decadal time scales that could be linked to variations in ENSO and Inter-decadal Pacific Oscillation (IPO). In particular, the 1920s, 1960s and 1990s were relatively dry decades, while the 1970s was a wet period. Decadal fluctuations in the study region's annual rainfall are dominated by variations in wet season (January to March) rainfall. Rainfall in the dry season (August to October) shows strong variability with no clear trend. Rainfall in the transitional seasons (Transitional 1, November and December; Transitional 2, April to July) also shows variability without any clear trends. The decline in rainfall in recent years is stronger in the southern extent of the rainforest region compared to the northern extent (Suppiah *et al.* 2007a).

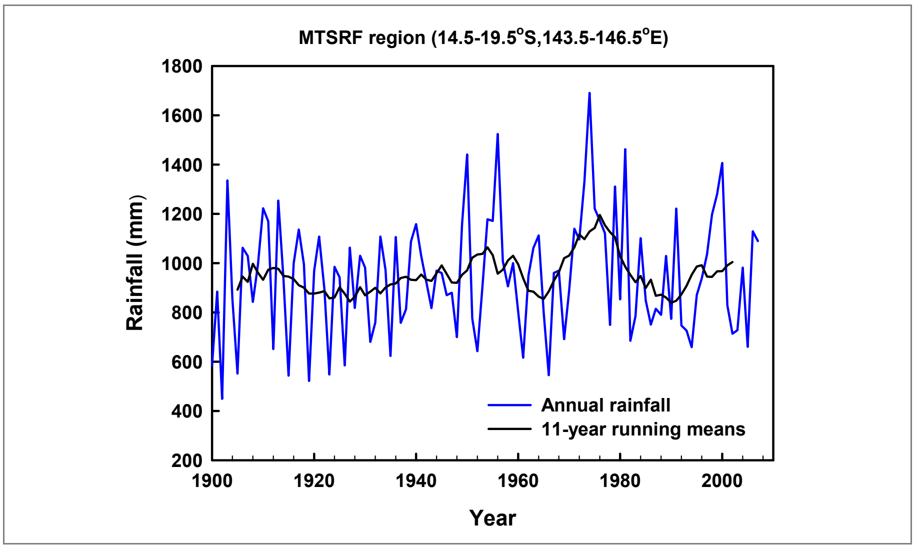


Figure 3: Annual rainfall variations in the tropical rainforest study region of northeast Queensland. The blue line indicates actual values; the black line depicts the 11 year running mean. Source: Australian Bureau of Meteorology.

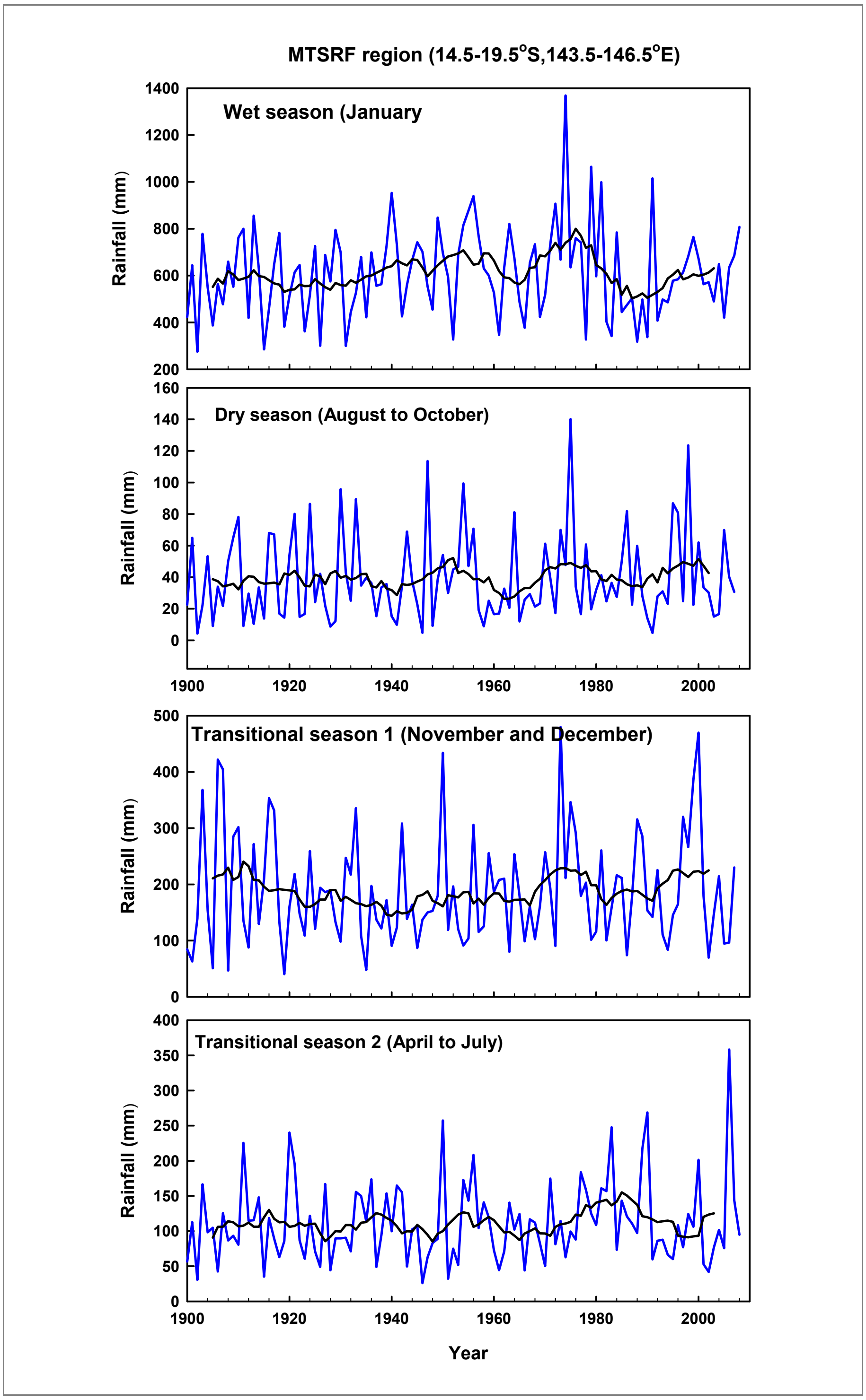


Figure 4: Seasonal rainfall fluctuations in the tropical rainforest study region of northeast Queensland during the Wet (January to March), Dry (August to October), Transitional 1 (November and December) and Transitional 2 (April to July) seasons. The blue line indicates actual values; the black line depicts the 11 year running mean. Source: Australian Bureau of Meteorology.

2.3 El Niño-Southern Oscillation and rainfall variations

The Southern Oscillation (SO) is characterised by seesaw variations of pressure difference between the north Australian-Indonesian low represented by Darwin, and the south Pacific sub-tropical high represented by Tahiti. El Niño events are associated with higher sea surface temperature in the central and eastern Pacific and weaker trade winds, and are often preceded by westerly wind bursts along the equator. El Niño events are associated with higher than normal pressure in the north Australian-Indonesian region and lower than normal pressure in the central-south Pacific region around Tahiti, hence negative SO. La Niña events have opposite characteristics to those associated with El Niño. El Niño and the SO together comprise a complex ocean-atmospheric system of climate variations termed the El Niño-Southern Oscillation (ENSO) phenomenon. Variations in ENSO are shown by various indices that include sea level pressure, sea surface temperature and rainfall.

The Southern Oscillation Index (SOI) is a measure of the seesaw pressure pattern and has been widely used to investigate teleconnection patterns between rainfall and atmospheric circulation in the tropics. Previous studies (e.g. McBride and Nicholls, 1983) have demonstrated a strong positive relationship between rainfall and the SOI. The relationship is particularly strong during spring. The relationship between the SOI and rainfall also shows variations on multi-decadal time-scales (Nicholls *et al.* 1996; Suppiah, 2004). The relationship was weak during the 1930s and again after the mid 1970s. Such a weakening of the SOI-rainfall relationship is due to increasing pressure over the Western Pacific represented by Darwin, as pressure records at Tahiti do not show clear trends (Suppiah, 2004). The weakening of the relationship between the SOI and rainfall has led to more rainfall for a given value of the SOI after the mid 1970s, compared to previous periods (Nicholls *et al.* 1996). We have repeated the analysis shown in Suppiah (2004) using area-average rainfall for the tropical rainforest study region of northeast Queensland. Correlations for the Wet, Dry, Transitional 2 and Transitional 1 seasons are 0.46, 0.52, 0.19 and 0.63, and they are statistically significant at the 95% confidence level, with the exception of the Transitional 2 season. The correlation between annual rainfall in this region and the annual SOI is 0.46, also statistically significant. However, the relationship appears to vary on decadal time scales as shown in Figure 5. In particular, the relationship was strong between 1900 and 1920 and between 1940 and the mid 1970s, and weak between 1920 and 1940 and also during the 1980s. The reason for the very weak/reversed correlation between 1920 and 1940 requires further investigation. In particular, there has been a tendency for a weakening relationship since the mid 1970s. Since the relationship between rainfall and SOI shows decadal variations, it is necessary that future GCMs adequately simulate the observed pattern of relationship and its low frequency variations that help to reduce uncertainty when producing regional scale climate change projections, including inter-annual and inter-decadal variability. At this stage, most GCMs do not adequately simulate various characteristics of ENSO, although there are significant improvements in the simulations of CMIP3 experiments (AchutaRao and Sperber, 2006; Lin, 2007). These models also suggest that in a warmer climate weakening occurs preferentially in the zonally asymmetric (i.e. Walker) rather than zonal-mean (i.e. Hadley) component of the tropical circulation and is shown to induce substantial changes to the thermal structure and circulation of the tropical oceans (Vecchi and Soden, 2007). They report that as the climate warms, changes in both the atmospheric and ocean circulation over the tropical Pacific Ocean resemble ‘El Niño-like’ conditions in some models; however, the mechanisms are shown to be distinct from those of El Niño and are reproduced in both mixed layer and full ocean dynamics coupled climate models.

In a recent review, Collins and others (2010) reported that under the influence of global warming, the mean climate of the Pacific region will probably undergo significant changes. The tropical Pacific easterly trade winds are expected to weaken; surface ocean temperatures are expected to warm fastest near the equator and more slowly further away; the equatorial thermocline that marks the transition between the wind-mixed Upper Ocean and deeper layers is expected to shoal (become shallower); and the temperature gradients across the thermocline are expected to become steeper. Year-to-year ENSO variability is controlled by a delicate balance of amplifying and damping feedbacks, and one or more of the physical processes that are responsible for determining the characteristics of ENSO will probably be modified by climate change. Therefore, despite considerable progress in our understanding of the impact of climate change on many of the processes that contribute to El Niño variability, it is not yet possible to say whether ENSO activity will be enhanced or damped, or if the frequency of events will change.

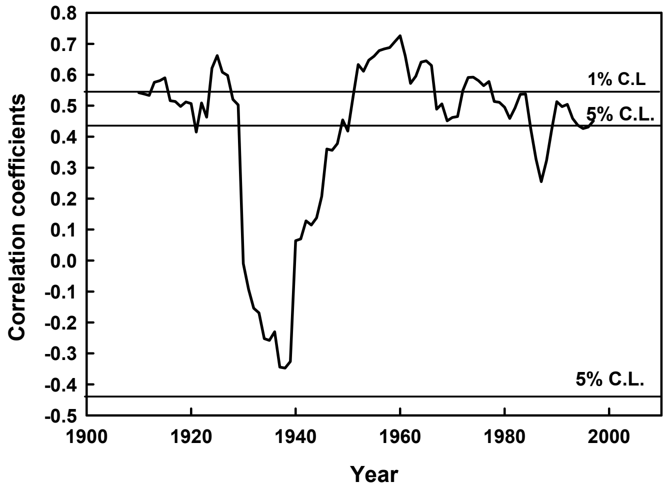


Figure 5: Variations in the relationship between the Southern Oscillation Index (SOI) and annual rainfall over the study area are shown by 31 year running correlations between rainfall and the SOI. Horizontal lines show the significance levels. CL = Confidence Levels.

2.4 Extreme rainfall events and their links to large-scale circulation variations

Extreme rainfall causes extensive damage to crops, infrastructure, wildlife, humans and industries in the study region. Heavy rainfall events during the Australian monsoon season are associated with the active phase of the monsoon, which is usually identified with intense depressions and tropical cyclones that form on the monsoon shear line or the monsoon trough. Low rainfall periods are usually associated with break and weak monsoon activities. Both the heavy and dry daytime rainfall extremes are dealt with in this study. We have used rainfall data from the Australian Bureau of Meteorology and atmospheric variables from the NCEP reanalysis (Kalnay *et al*. 1996). The atmospheric variables from the NCEP reanalysis include winds, humidity, temperature, sea level pressure and out-going longwave radiation (OLR). OLR is a proxy for large-scale convection and is measured by satellites.

The far northern region of Queensland was selected in order to study characteristics of extreme rainfall and their link to circulation patterns, as heavy rainfall events cause extensive damage to the community, infrastructure, industry, and so on. Extreme rainfall events are defined as thresholds of the top 5 and 10 percentiles (95th and 90th percentiles) and dry days as the 5th and 10th percentiles. These thresholds were calculated using daily rainfall and also pentads (5 day totals) from October to March. Results are shown as the difference between the composites of 90th and 10th percentiles of selected variables.

Figure 6 shows the region selected to calculate area-averaged rainfall. The selected area covers the tropical rainforest region of northern Queensland and the Torres Strait region. The selected region receives the majority of its rain during the Australian summer monsoon season. There were 202 events above the 90th percentile threshold and 204 events below the 10th percentile recorded during the period 1979 to 2007.

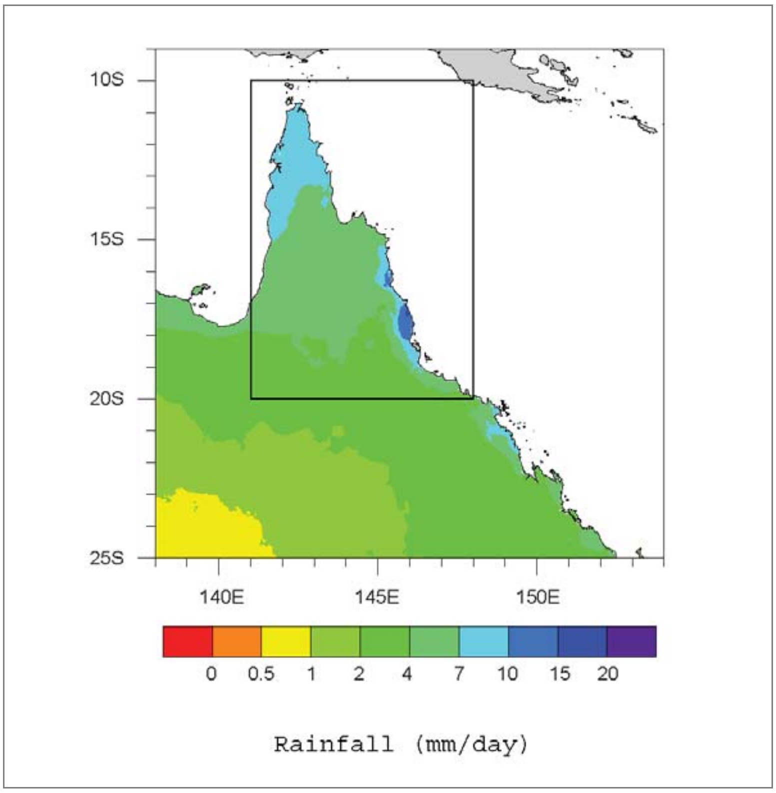


Figure 6: The domain used to calculate area-average rainfall. Land-only areas were used to calculate average rainfall. Colour scale represents rainfall in millimeters per day.

Figure 7 shows differences in OLR and winds between 90th and 10th percentiles for the period 1979 to 2007. During heavy rainfall events, an area of active convection is noticed over a broad region centered on Cape York Peninsula. This active convection area, which covers the Indonesia-north Australian region is shown by strong negative OLR values. The drier areas, indicated by positive OLR values, are found over southern Australia and also over southern China and the north Pacific as indicated by positive OLR values. Stronger north-easterlies over Southeast Asia, stronger westerlies over the Indonesian-north Australian region and a distinct cyclonic type circulation over the Coral Sea have also been noticed. The evolution of extreme events in winds and OLR values suggests a gradual strengthening of winds over Southeast Asia and the Indonesian-north Australian region. The large-scale convection also develops, associated with strengthening of winds. Winds associated with the large-scale convective system tend to become weaker after the peak event and dissipate after two weeks. At the same time, there is a tendency for an increase in surface pressure over the domain.

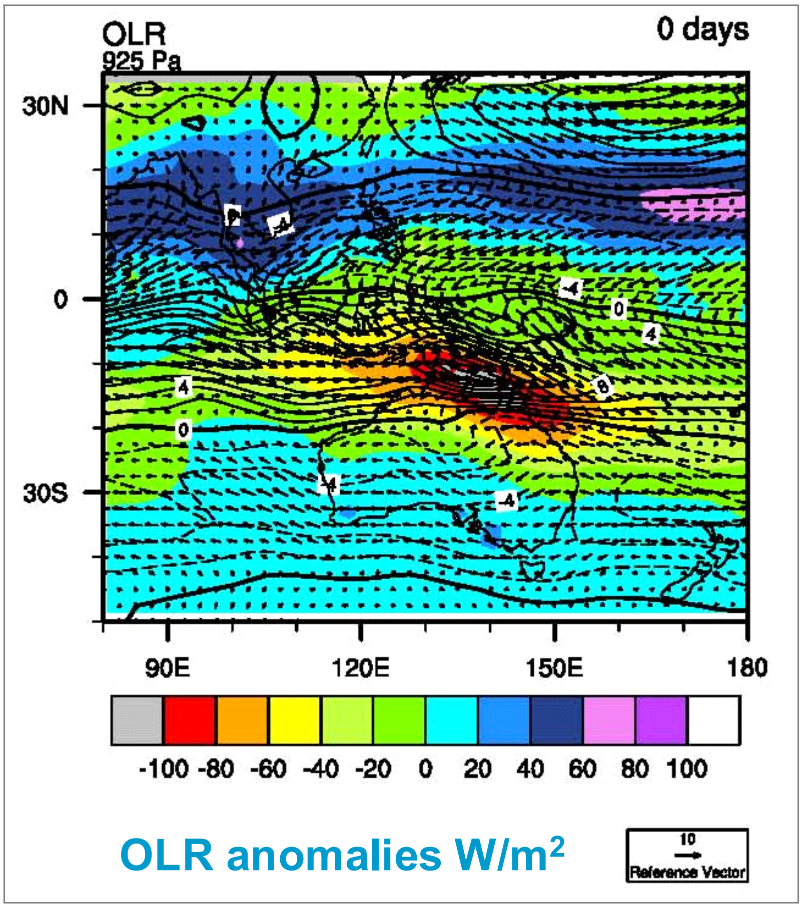
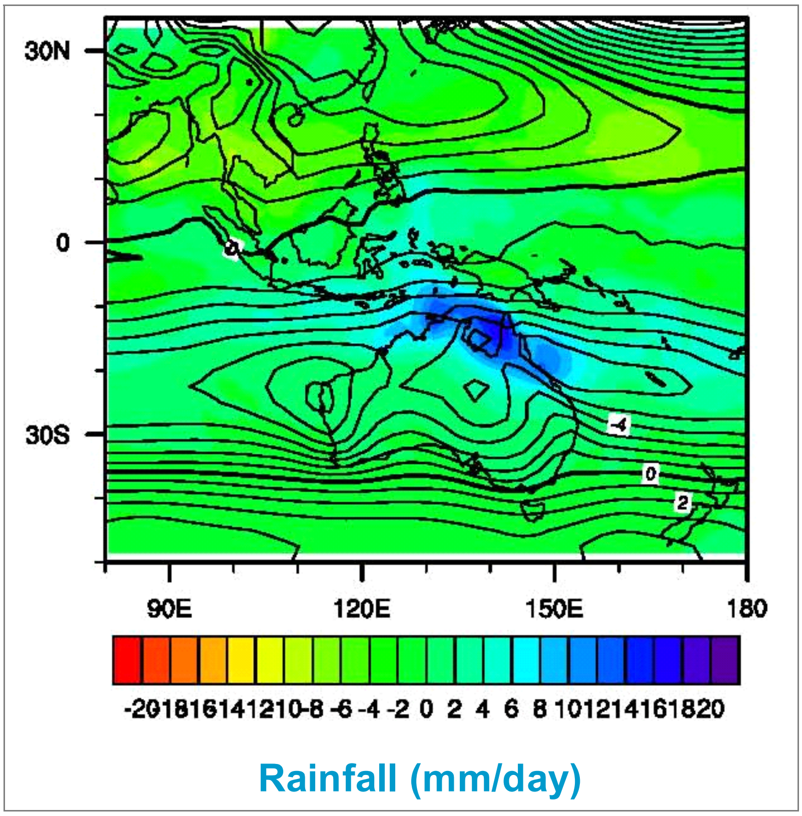


Figure 7: Differences in winds at the 925 hPa level and OLR values for the period 1979 to 2007.

Figure 8 shows rainfall and mean sea level pressure differences between the composites of 90th and 10th percentiles. These figures clearly show a low pressure system and heavy rainfall over northeastern Australia, centered on Cape York Peninsula and the rainforest region. Positive pressure values are observed over southern Australia and also over the north Pacific. Heavy rainfall anomalies and active convective system shown by strong negative OLR values and wind and pressure patterns suggest that these events are a part of large-scale circulation patterns.

Figure 8: Rainfall and pressure differences based on composites of 90th and 10th percentile events. Pressure values are shown by contour lines and colours depict rainfall anomalies for the period 1979 to 2007.



Vertical profiles of zonal wind (east-west wind), temperature and relative humidity averaged between 141°E and 148°E longitudes from 35°N to 50°S are shown in Figure 9(a)-(c). Low level westerly anomalies over northeastern Queensland and easterly anomalies over southern Australia in Figure 9(a) are two dominant features in terms of circulation characteristics over Australia.

The temperature profile shown in Figure 9(b) shows positive temperature values over the eastern part of southern Australia (New South Wales, Victoria and Tasmania) during heavy rainfall events over northeast Queensland. The relative humidity vertical profile shows increased relative humidity over the north and reduced relative humidity over southern Australia, a pattern consistent with the temperature pattern. Such a pattern of vertical profile is associated with an intense Hadley Circulation during extreme rainfall events in the tropics. During the intense Hadley Circulation period, a strong anti-cyclone circulation pattern dominates southern Australia and hence increases surface temperature and reduces relative humidity, leading to extreme hot conditions over the southern part of the continent.

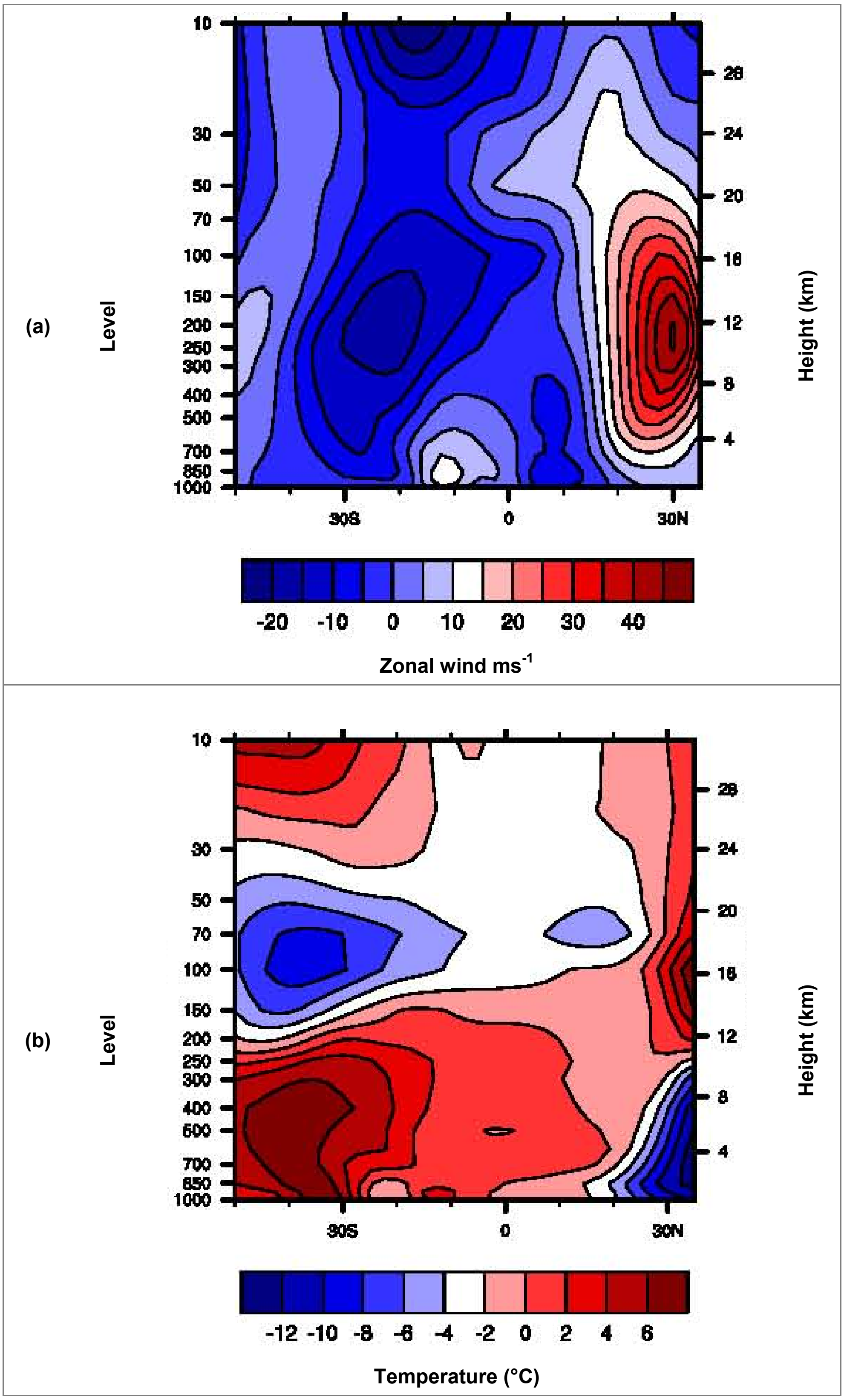


Figure 9: Differences in zonal (east-west) wind (a), temperature (b) and relative humidity (c – overleaf) between the composites of 90th and 10th percentiles along the north-south direction centered on the Cape York domain of far northern Queensland. Calculations are based on the period 1979 to 2007.

(c)

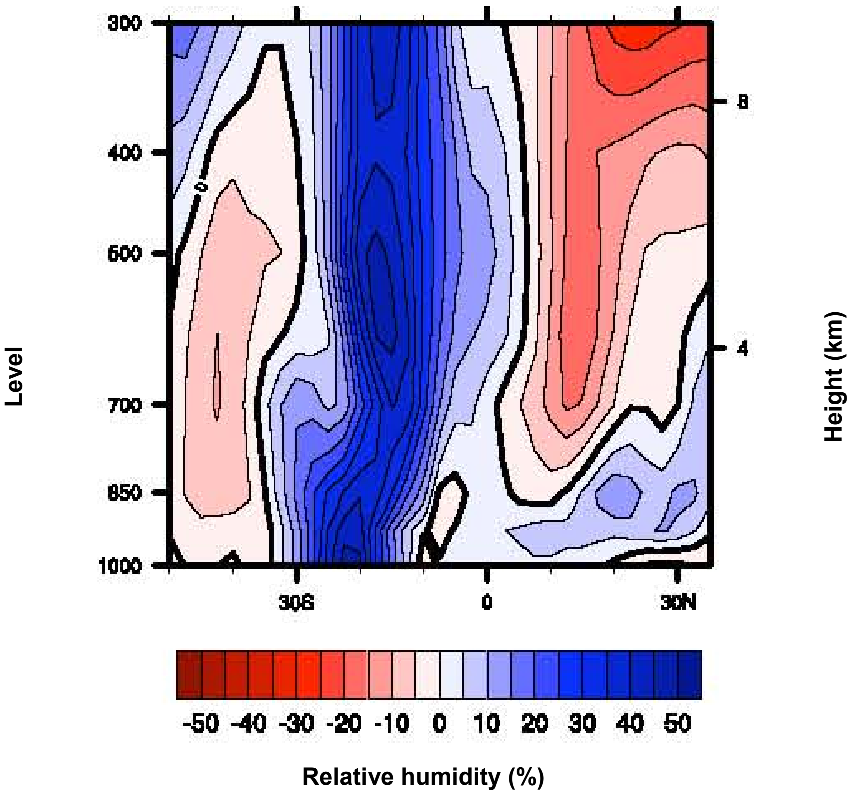


Figure 9 (continued): Differences in relative humidity (c) between the composites of 90th and 10th percentiles along the north-south direction centered on the Cape York domain of far northern Queensland. Calculations are based on the period 1979 to 2007.

2.5 Cloud base height and cloud stripping

Cloud base is an important meteorological variable for aviation safety, as it determines whether pilots may use Visual Flight Rules or must follow Instrument Flight Rules for take-off or landing. Furthermore, clouds are an important source of moisture in the tropical rainforest region, particularly during the dry season. Moisture for the rainforest comes from clouds by a phenomenon known as 'cloud stripping': as mist and clouds pass over valleys and peaks, moisture condenses on plants.

Low clouds have a base below two kilometres altitude, and are made of water droplets. They can be made of ice when the temperature is cold enough, for example at high latitudes in the winter time. Cloud types include stratocumulus, cumulus, stratus, cumulonimbus and nimbostratus. Fog can also be put in this class. Mid-level clouds are defined as those whose base is between two and six kilometres altitude. Cloud types are altostratus or altocumulus, and they are generally but not always water clouds, depending on the atmosphere's temperature and other conditions at the cloud altitude. High clouds are those whose base is above six kilometres. Types include cirrus, cirrocumulus and cirrostratus. These clouds can be either ice or water particles, but are more often ice. Water clouds tend to have definite edges, while ice clouds are wispier. This is not the case for the cloud tops[1], which can vary widely from cloud to cloud, as the depth of the cloud is determined by the strength of local convection[2]. Clouds greatly affect the transfer of radiation into the atmosphere. Hence clouds exchange thermal radiation between their bases and the underlying planetary surface (land or ocean) by absorbing and re-emitting this infrared radiation at the prevailing temperature: the lower the cloud base, the warmer the cloud particles and the higher the rate of emission. Variations of cloud base heights are given in Table 2.

Table 2: Variation of cloud base heights in the tropics.
Source: Galvin (2007).

Cloud type	Tropical regions
High	6,000-18,000 m
Middle	2,000-8,000 m
Low	0-3,000 m

In the study area, the occurrence of complex rugged topography close to the coast determines much of the spatial variations in climate, particularly in rainfall. Moisture-laden winds from the Pacific Ocean enhance rainfall amounts in the coastal lowlands and eastern slopes of the tropical rainforest region. In the rainforest mountain ranges southwest of Cairns, annual rainfall is in excess of 3,000 mm. Apart from rainfall, cloud stripping provides substantial moisture to rainforest plants. Recent studies by researchers from James Cook University and the CSIRO have suggested that this effect is much more significant than previously realised, particularly during the dry season. Cloud stripping may be collecting up to 40% more moisture than is measured by standard rain gauges. Any changes in the amount of cloud stripping during the dry season can have a profound effect on plants and animals.

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[1] http://en.wikipedia.org/wiki/Cloud_top

[2] http://en.wikipedia.org/wiki/Convection

3. Method for generating probabilistic climate change projections

This section provides a brief explanation of the generation of probabilistic projections for the rainforest region. Changes in average temperature and rainfall for the years 2020, 2030, 2040, 2050, 2060, 2070 and 2080 are calculated relative to averages for the 20-year 1980-2000 period. The changes pertain to climate conditions averaged over a number of decades. Conditions 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). Changes are derived from the output of the most recent generation of climate models using the method described in detail by Watterson (2008). Three main sources of uncertainty are accounted for:

- Uncertainty in the future evolution of greenhouse gas and sulphate aerosol emissions;
- Uncertainty in how much the global average surface temperature will respond to increases in atmospheric greenhouse gas concentrations and changes in sulphate aerosol emissions; and
- Uncertainty in how the climate of tropical rainforest region 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 and Swart, 2000) of the Intergovernmental Panel on Climate Change (IPCC). These emissions scenarios are illustrated in Figure 10. Each of the scenarios – denoted A1B, A1FI, A1T, A2, B1 and B2 – is based on a plausible storyline of future global demographic, economic and technological change in the 21st Century.

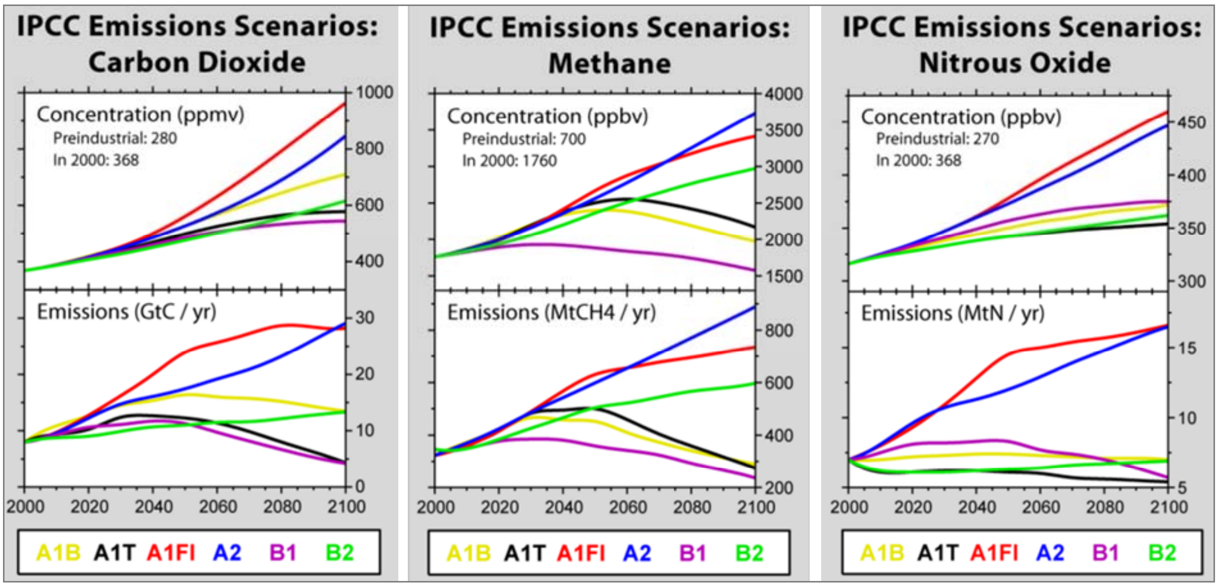


Figure 10: Atmospheric concentrations and emissions of carbon dioxide, methane and nitrous oxide for six SRES scenarios. Source: Nakićenović and Swart (2000).

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). This is summarised in Figure 11, which shows projected changes in global average surface temperature for the six scenarios. Warmings, relative to the average temperature for the 1980-2000 period, of between 0.5°C and 1.6°C by 2030 and between 1.1°C and 6.4°C by 2100 are suggested. Figure 11 also shows 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.

For each period of interest and each scenario, the range of warming is described using a probability distribution, which comprises a set of probabilities assigned to the numerous plausible values of change.

The third uncertainty is addressed by considering the response of the climate of Australia to global warming in 23 climate models in CMIP3. Model output 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. The 23 results 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.

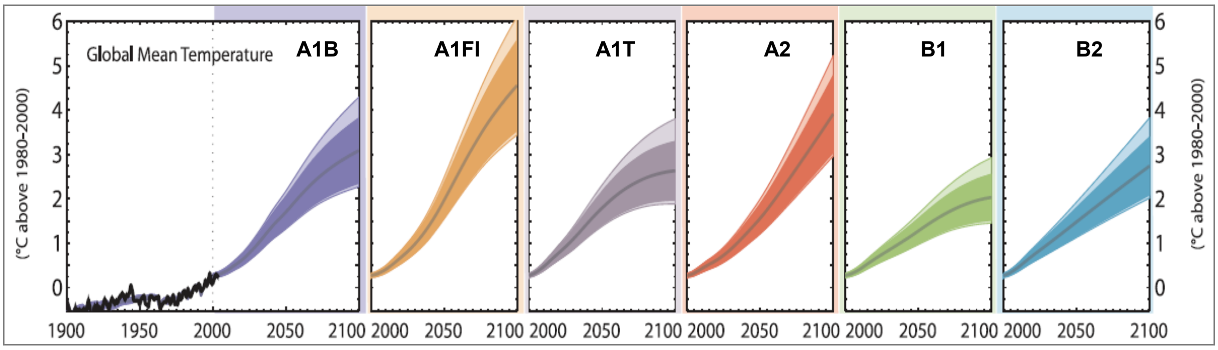
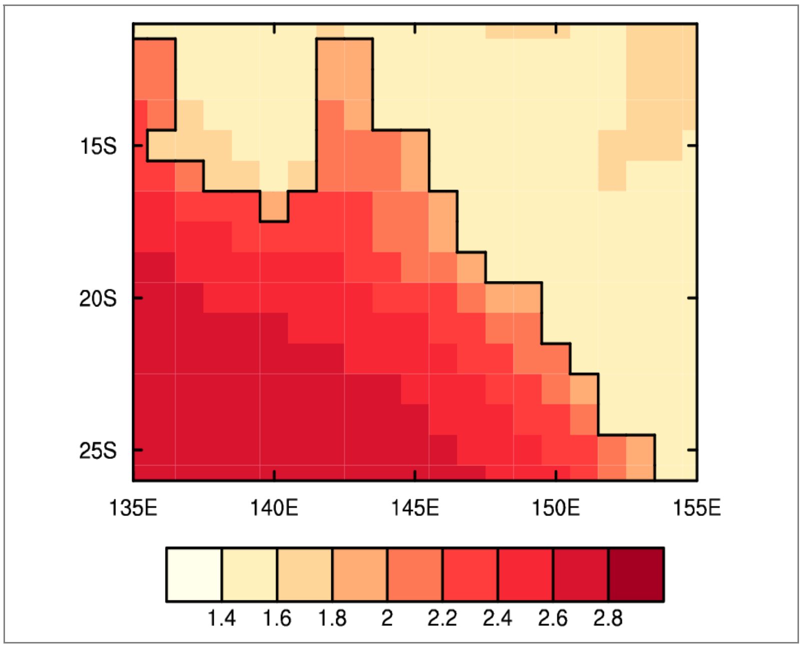


Figure 11: Changes, relative to the average for the period 1980-2000 in global average surface temperature for the 21st Century for the A1B, A1FI, A1T, A2, B1 and B2 SRES emissions scenarios. Dark shaded areas represent uncertainties in changes based on the consideration of the response of 19 climate models to the emissions scenarios. Light shaded areas represent uncertainties in changes based on the consideration of the response of the models to the emissions scenarios and uncertainty in carbon cycle feedbacks in the climate system. Coloured lines indicate changes based on the mean average response of the models and mid-range assumptions about carbon cycle feedbacks. The black line indicates changes recorded during the 20th Century. Source: Meehl *et al.* (2007).

The models use various grids, ranging 1-4 degrees in resolution. Before results could be combined, values were first interpolated to a common grid with one degree spacing in both latitude and longitude. This grid is illustrated for the full northeast Australian domain in Figure 12. An artificial coastline, which encloses grid squares that are centred on actual land, is shown. No greater detail than this can be inferred from the CMIP3 global models.

Figure 12: The northeast Australian region, as represented on the common one-degree data grid used in the probabilistic projections. The best estimate for annual average temperature change in degrees Celsius for the year 2070 under the A1B scenario is shown. Over land are surface temperatures, calculated separately from the sea surface temperatures (see text).



The product of the global warming and local change factors was calculated, as described by Watterson (2008), to produce probability distributions for the actual changes. The 10th and 90th percentile changes of the distributions provide ranges of uncertainty while the 50th percentile changes provide best estimate values of changes. The shading in Figure 12 illustrates the best estimate for annual average warming at 2070 under the A1B scenario, using results already included in the report for Australia. Over land the variable shown is the surface air temperature, at height of two metres above the surface. Over the ocean it is the 'sea surface temperature'. These were calculated separately to show the contrast between land and ocean warming that is simulated by the models. For surface air temperature, the interpolation to the common grid used only data from the model land. Results were derived only at points where at least half the models had land. In some models land extends a little beyond the true coastline. In Figure 12 any such results are excluded, in favour of sea surface temperatures.

The sea surface temperatures in the ocean near the Queensland coast in the Great Barrier Reef (GBR) zone warm typically 1.4°C to 1.6°C. This is some 20-30% less than the warming over land squares adjacent to the coast. Warming increases further inland. The actual warming pattern over the GBR zone may be influenced by shallow sea depths and by currents in ways not represented in the models. Likewise, the actual warming at coastal land locations may be further moderated by unresolved sea breezes. This report focuses on changes over land in the central MTSRF study region (Figure 1). Values are determined only from model land points. In the plots, these sometimes extend beyond the true coastline that is shown.

4. Projections

4.1 Projected changes in annual average temperature for the study region

The rainforest region is expected to warm in response to increases in global average surface temperature. In this section, we discuss projected increases in annual average temperature for the rainforest region only (see Figure 1) for 2030, 2050 and 2070. Projections for seasons of the year of particular relevance to the MTSRF study region for the years 2020, 2030, 2050, 2060, 2070 and 2080 and also for other regions in Figure 1 are given in the appendices to this report.

Figure 13 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. It shows that inland areas of the MTSRF study 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 0.8°C with a range of uncertainty of 0.6°C to 1.1°C. Temperature increases by 2050 and 2070 are 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°C to 2.2°C. The corresponding range for 2070 is 0.9°C to 3.5°C. Temperature increases for the different seasons are not greatly different from increases in annual average temperature.

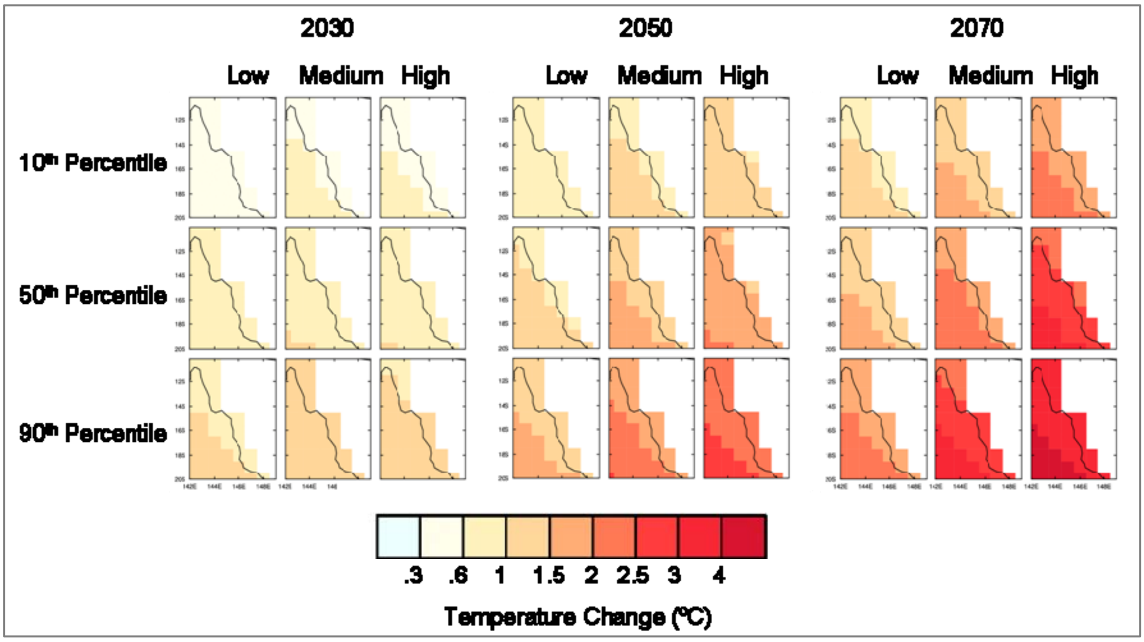


Figure 13: 10th, 50th and 90th percentile increases in annual average temperature (°C) for low, medium and high emissions scenarios for 2030, 2050 and 2070 in the study region.

4.2 Projected changes in annual average rainfall for the study region

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 14 (changes in seasonal average rainfall for the years 2020, 2030, 2050, 2060, 2070 and 2080 are given in appendices). Changes in rainfall 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%.

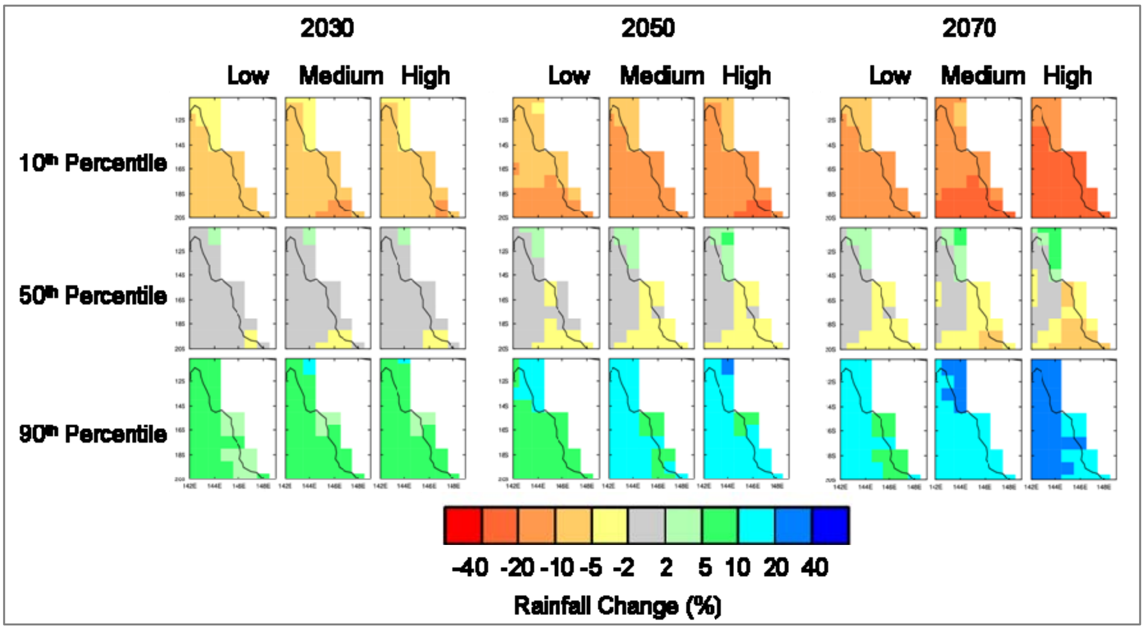
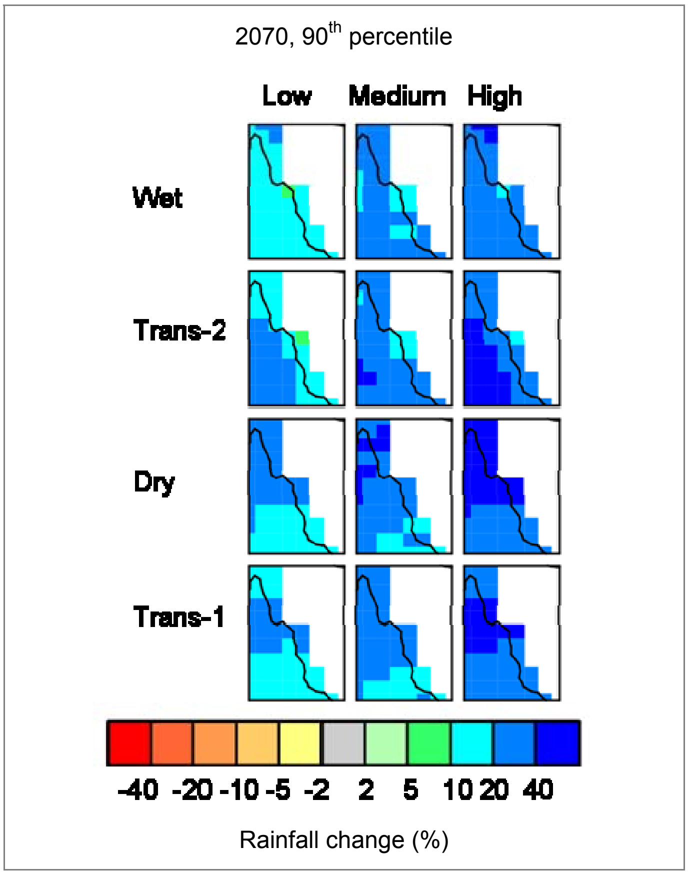


Figure 14: 10th, 50th and 90th percentile changes in annual average rainfall (%) for low, medium and high emissions scenarios for 2030, 2050 and 2070 in the study region.

Spatial patterns of projected rainfall changes show strong variations between seasons; particularly after 2070 (see appendices). For example, in Figure 15 the dry season (August to October) and Transitional Season 2 (April to July) rainfall shows larger percentage changes than the wet season (January to March) and Transitional Season 1 (November to December) rainfall.

Figure 15: 90th percentile changes in annual average rainfall (%) for high end of emissions scenarios for 2070 in the study region.



4.3 Projected changes in annual average potential evaporation for the study region

We had data available from only 11 GCMs to construct projected changes in potential evaporation over the domain. Increases in temperature and overall decreases in rainfall lead to an increase in annual potential evaporation in the tropical rainforest region. The potential evaporation was derived using offline calculations from simulated monthly time series of climate variables using the Morton method (Morton, 1983) Figure 16 shows increases in potential evaporation in southern and central parts of the region. Annual and seasonal increases in potential evaporation for 2030 range between 2% and 5%, and do not show significant difference between seasons and emission scenarios. However, annual and seasonal increases are large for medium and high emission scenarios by 2050 and 2070 (see appendices to this report).

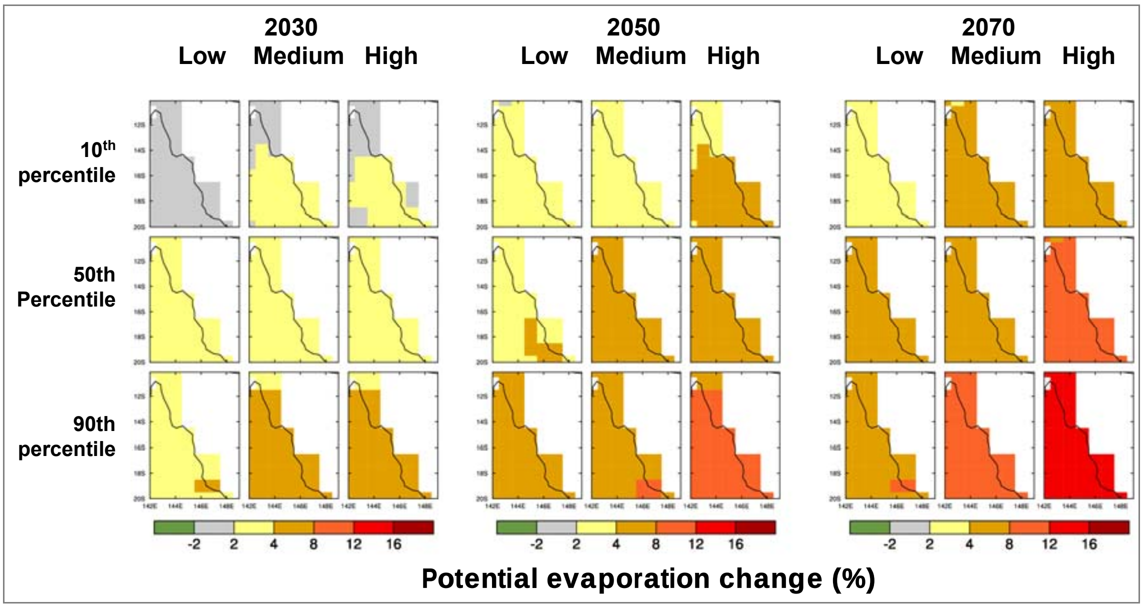


Figure 16: 10th, 50th and 90th percentile changes in annual average potential evaporation changes (%) for low, medium and high emissions scenarios for 2030, 2050 and 2070 in the study region.

4.4 Sea level rise

Sea level rise is one of the greatest threats to the region. Long-term mean sea level change and its variability is of considerable interest in the studies of global climate change, and is a potential threat to coastal regions and small islands in northeast Australia. Long-term sea level variations are primarily determined with two different methods. One is estimated from tide gauge measurement by long-term averaging and the other is from satellite measurements. Reliable estimates of global mean sea level rise from satellite altimetry first became possible with the launch of the TOPEX/Poseidon radar altimeter satellite in 1992. Regional and global estimates of mean sea level rise are given by Mitchum *et al.* (2010). Mean sea level of the region shows a strong annual cycle associated with summer monsoonal winds and winter south-easterlies. Changes in mean sea level is 6 mm per year between 1993 and 2010 for in the northern part of the region, which is twice the global average sea level change (3 mm per year) given by Mitchum *et al.* (2010). Apart from an increasing trend sea level shows strong inter-annual variability associated with ENSO. Sea levels were lower during El Niño years and higher during La Niña years. The El Niño years, such as 1997-1998, 2002-2003 and 2006-2007 show negative anomalies of sea level.

Sea level rise projected by IPCC (2007) is shown in Figure 17. Rises in sea level are expected due to thermal expansion of oceans and melting of mid-low and high latitude glaciers. Sliding ice sheets due to melting in Antarctica and Greenland can significantly contribute to further increases in sea level rise. However, extreme sea levels projected by the IPCC with combination of these factors and others can not be ignored.

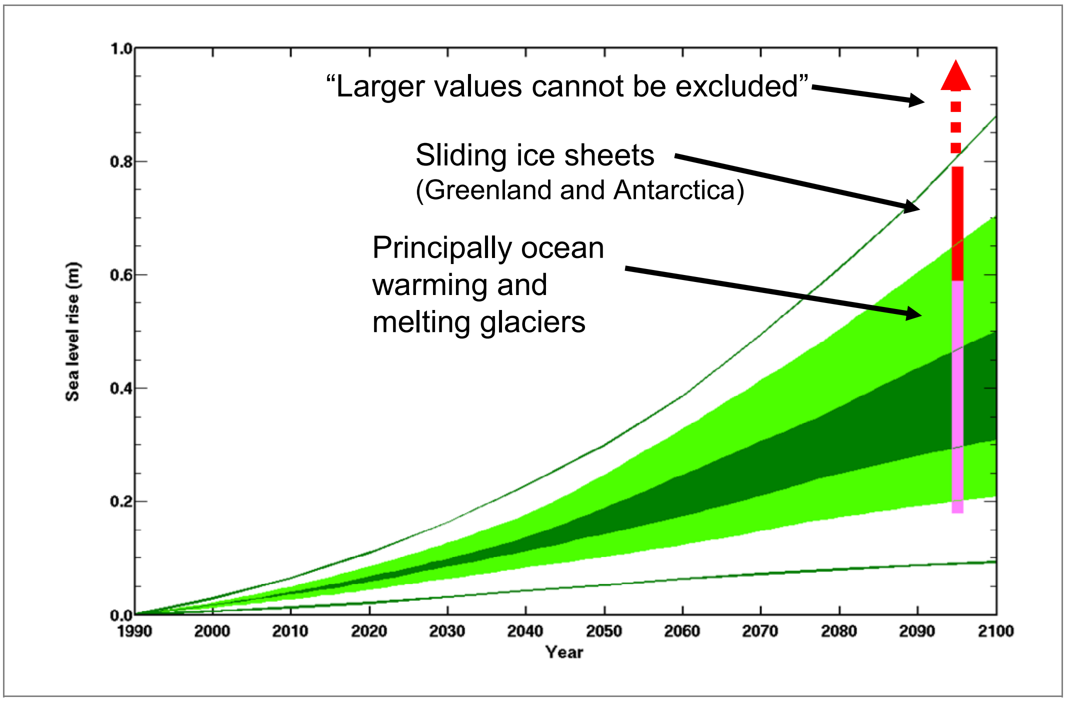


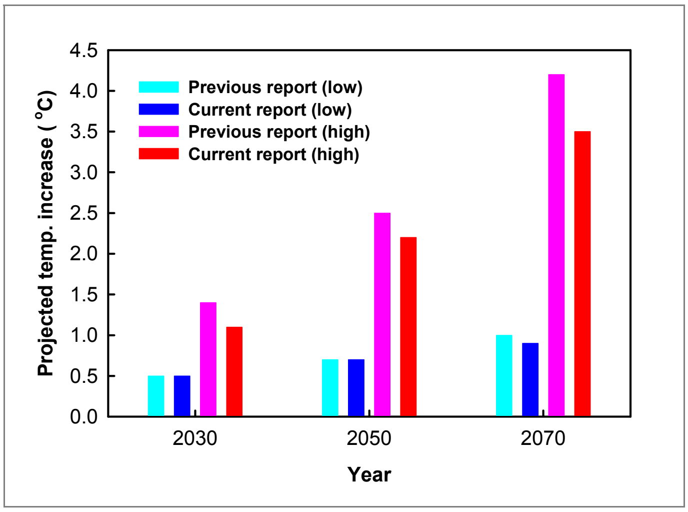
Figure 17: Projected mean sea level rise (m) for the 21st Century. Source: IPCC (2007).

5. Comparison of projections based on 15 models, and all 23 models

In this section, we compare the probabilistic projections of annual average temperature and rainfall for the rainforest region with those provided by Suppiah *et al.* (2007a) based on a selected set of models. The method used to construct climate change projections in that report was detailed in Suppiah *et al.* (2007b). In the previous study, projections were based on the results of a set of 15 GCMs, which exhibited high pattern correlation values and low root mean square error values when observed and simulated patterns of Australian temperature, rainfall and mean sea level pressure averages for the period 1961 to 1990 were compared over Queensland. Since publication of the projections outlined by Suppiah *et al.* (2007a), the CSIRO has developed probabilistic projections in which each of 23 models is assigned a weight based on its ability to simulate the present climate. In the latest method, results of 23 GCMs have been used to construct climate change projections for the region.

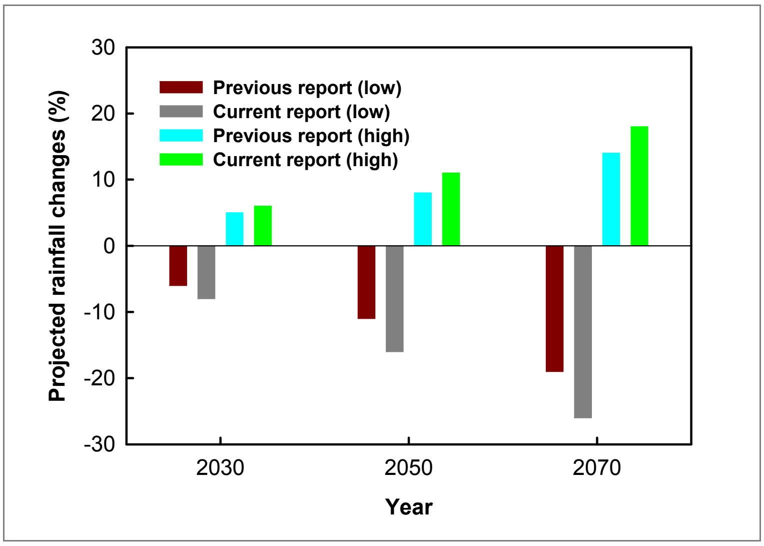
Spatial patterns of warming in both sets of projections are similar, indicating a strong inland warming and less warming along the coast. However, the revised projections show slightly less warming at the high end of the range of uncertainty than the previous projections. This leads to a slight narrowing of the range of warming in the current projections. For example, in the study by Suppiah *et al.* (2007a), ranges of uncertainty for increases in regional temperature for the rainforest region are 0.5-1.4°C for 2030, 0.7-2.5°C for 2050 and 1.0-4.2°C for 2070. However, in the present study the corresponding ranges are 0.5-1.1°C for 2030, 0.7-2.2°C for 2050 and from 0.9-3.5°C for 2070.

Figure 18: Projected low and high values of annual temperature change (°C) averaged over the rainforest region in the previous study by Suppiah *et al.* (2007a) and in the present study.



Both the present study and the previous study suggest the possibility of both increases and decreases in rainfall in the rainforest region. The ranges of rainfall change are larger in the present study than in that by Suppiah et al. (2007a), as shown in Figure 18. For example, the previous study indicated ranges of uncertainty for changes in regional annual average rainfall of -6% to +5% for 2030, -11% to +8% for 2050 and -19% to +14% for 2070. The corresponding ranges in the present study are -8% to +6% for 2030, -16% to +11% for 2050 and -26% to +18% by 2070 (Figure 19). Such an increase in the range could arise from the difference in the number of models used in the present and previous studies and also because of two different methods used in these studies. However, both models indicate that projected changes in rainfall are uncertain.

Figure 19: Projected low and high ranges of annual rainfall changes (%) in the previous study by Suppiah *et al.* (2007a) and in the present study.



6. Brief explanation of recent developments in climate change projections

In recent years, the CSIRO has developed climate change projections based on emission scenarios. The projections are based on storylines described by the IPCC. These storyline projections are called 'Climate Futures'.

We have access to monthly data for 12 climate variables, up to 24 global climate models (for some variables, but not all) from 1900-2100 for three emissions scenarios (A1B, A2 and B2). We can also scale some results for the highest emission scenario (A1FI). Typically, projections are created for individual climate variables for selected years and emissions scenarios. Projections from different climate models are often mixed together (an *ensemble*) and expressed as a range of values to represent the uncertainty, for example, a warming of 1-2°C and a rainfall decrease of 5-10% by 2030. Projections based on individual climate models have internal consistency. Since the models show internal consistency, impact researchers are willing to select models that give high and low sensitivities and also apply a number of climate variables from a single GCM in their impact models. Therefore, we have simplified by grouping the individual model projections into a set of 'climate futures', such as:

Warmer, wetter, windier (10 models);
Warmer, drier, windier (4 models);
Hotter, drier, calmer (5 models);
Hotter, much drier, calmer (1 model);
Warmer, much drier, much calmer (2 models); and
Hotter, much wetter, much windier (2 models).

Where,

'Slightly warmer' = between 0 and +0.5°C
'Warmer' = between +0.5 and +1.0°C
'Hotter' = between +1.0 and +2.0°C
'Much hotter' = >+2.0°C

and

'Much wetter' = >+5.0% rainfall
'Wetter' = between +1.0 and +5.0% rainfall
'Little change' = between -1.0 and +1.0% rainfall
'Drier' = between -5.0 and -1.0% rainfall
'Much drier' = <-5.0% rainfall

Climate variables

Tas	Air temperature
PR	Precipitation
Rsds	Downward solar radiation
Wsp	Wind speed
WVAP	Potential evaporation
P99	99th percentile daily rainfall intensity (heavy rainfall)
Pdays	Rain days

Likelihood terminology

This is consistent with the IPCC:

‘Very unlikely’	<10% of the 24 models
‘Unlikely’	10-33%
‘As likely as not’	33-66%
‘Likely’	67-90%
‘Very likely’	>90%

7. Potential climate change impacts for the rainforest region of northeast Queensland

Extreme rainfall and temperatures

Global climate model simulations suggest that the intensity of extreme rainfall events will increase. Such increases are even possible under slightly reduced average rainfall. Flow-on effects of increased rainfall intensity would include increased incidences of erosion, flash flooding, landslides and increased turbidity of rivers flowing into the Great Barrier Reef.

Simulations also suggest an increase in the number of hot days (beyond a threshold) and a reduction in the number of cool days. These observations support an increase in hot days and a reduction in cool days during the past century. Such changes to extreme temperature conditions can affect frost-sensitive vegetation and crops, but reduce energy demand for heating in urban areas, yet adversely affect crops that require winter chilling, such as fruits. An increase in the number of hot days would result in heat stress for vulnerable plants and animals, increasing human discomfort, fire potential and increased energy demand for air conditioning.

Tropical cyclones and their impacts

Tropical cyclones can cause severe impacts both environmentally and financially. Climate model simulations suggest an increase in the intensity of tropical cyclones globally, but a decrease in the frequency of cyclones in the southern hemisphere. Tropical cyclones are a significant threat to coastal zones, coastal development, tourism, the coastal area mining industry, port operations, fishing and offshore reef islands. A possible increase in storm intensity poses potential further damage to properties and is also a concern to the rapidly expanding tourism industry active along the coastal zone. Adaptation options include improved building codes for wind resistance, technologically advanced building materials to reduce deterioration in the ambient environment, and zoning and protection to defend against flooding and storm surge. Improved storm surge warning and evacuation procedures may also be appropriate in vulnerable areas, particularly along the densely built up and farmed regions between the coast and tropical rainforest region.

Changes to the magnitude of tropical storms would also affect both the structure and growth of coral reefs, since individual storms cause considerable damage to reefs, which take a long time to recover. Reefs may also suffer from increased bleaching as a result of increased ocean temperatures at various depths and other stresses. Increased sediment, nutrient and chemical pollution from riverine flooding due to tropical cyclones can negatively impact coastal areas and reef waters.

Tourism

Tourism is a key contributor to the North Queensland economy. The Great Barrier Reef and tropical rainforests are World Heritage areas in this region. Environmental quality, perceived heath risks due to disease, climate comfort (the impact of heat and humidity and the length of the wet season) and risks of extreme events such as tropical cyclones can have significant impacts on the tourism industry. Sea level rise, particularly when combined with storm surges may affect some low lying and unprotected coastal resorts. The tourism industry may be affected by increased risk of infectious disease, and more stringent and detailed quarantine precautions may need to be enforced.

Health

Risks to human health can be caused by increased temperature, changes in rainfall, cloudiness and humidity. Respiratory illness, water-borne diseases, heat stress, and infectious diseases, such as malaria, dengue fever, Japanese encephalitis, Australian encephalitis and Ross River fever are closely linked to anomalous climatic conditions.

The health and well being of Indigenous peoples living in northeast Queensland may face greater risk from climate change. Contributing factors include poor water quality and sanitation, below average living conditions and community structures, rendering populations more exposed to climate change impacts than the average Australian. Communities existing in low lying residential areas, islands, and coastal settlements are particularly vulnerable.

Water supply, floods, droughts and water quality

Runoff and river flow are sensitive to climate change. Changes to rainfall are amplified in runoff and stream flow, with small changes in rainfall leading to larger impacts on catchment hydrology. Even with a slight increase in mean rainfall (see Section 4 ‘Projections’), both mean soil moisture and mean runoff are likely to decrease. Climate change could result in increased water demand for settlements and cities, although is not a threatening issue at this stage. Other effects could include changes in water supply for irrigation and municipal water, decreased water quality, and changes to water table and salinity in coastal areas. Erosion and turbidity would increase with an increase in the number of extreme rainfall events.

Flooding of swamps used by birds for breeding might also be affected. Freshwater fluxes from rivers and nearby coastal areas, with associated increase in turbidity, nutrients and chemicals, could adversely affect coastal flora and fauna.

Ecosystems

The tropical rainforest ecosystem in northeast Queensland is highly sensitive to rainfall and temperature changes. Studies conducted by researchers from James Cook University show evidence for such impacts and changes. If rainfall declines with increasing temperature during the dry season or rainfall zones shift due to climate change there may be no suitable habitat within new areas with suitable rainfall, due to land-use changes having altered vegetation, or due to the lack of suitable soils. Ecosystems will not migrate *en masse* due to changes in temperature, rainfall, humidity, solar radiation and cloudiness, but will shift differently, perhaps leading to a degraded recombinant ecosystem. Sea level rise and coastal flooding can lead to saltwater intrusions which can irreversibly change the ecology of coastal wetland systems. However, to date, there is no clear evidence for a change in rainfall one way or another.

Pests, weeds and diseases

Tropical pests, weeds and diseases are all expected to be affected by climate change. Woody weeds which benefit from increased CO_2 could spread to other areas. Tropical diseases are expected to move south as the climate warms. A number of vector-borne diseases are dependent on wetlands where their vectors (arthropods) can breed, and are very sensitive to rainfall and temperature changes. Northern and northeastern Australia may be at increased risk from diseases originating from Southeast Asia, either through people or animal vectors due to their numerous entry points. Diseases present risk to native animals, livestock, fish population and people.

Fisheries

Northeastern Australian fisheries are dominated by prawn, northern rock lobster and tropical fisheries. All of these contribute to a large proportion of the total catch. Climate change could have significant impacts through heavy rain events and flooding affecting the size and distribution of fisheries, particularly Banana prawns in coastal waters. Nursery areas, such as mangroves, tidal flats and seagrass beds are an important contributor to fish stocks. Loss of these due to extreme rainfall events, flooding and sea level rise or as a result of other impacts may occur. For example, increased sediment deposition in seagrass areas may lead to declining catches.

Agriculture

Climate impacts on agriculture will have both positive and negative repercussions. Heat stress for crops will increase, while cold stress will decrease. Increased levels of CO_2 are expected to have an impact on the growth rates of all plants, affecting type C3 and C4 plants differently. Plants such as soy bean, wheat and cotton are C3 type, while plants such as maize, sugarcane and sorghum are C4 type. When compared with C4 plants, C3 plants indicate a greater increase in photosynthesis for a doubling of CO_2 concentration as well as greater increase in water-use efficiency. This direct CO_2 fertilisation effect will lead to increased growth, particularly during periods of reduced soil moisture. However, C4 plants are in general better adapted to higher temperatures. Sugarcane is one of the main crops grown in the region between the coast and the rainforest region. Although the crop benefits from higher temperatures, extreme events such as very hot days and heavy rainfall events can have significant adverse impacts on crop growth and harvest.

Adaptation and risk management

The primary strategy for coping with impacts of observed or expected climate change is to reduce greenhouse gas emissions (termed ‘mitigation’) and adapt to climate change. Adaptation strategies for dealing with climate variability are widely used in northeast Queensland and many of these are designed to cope with climate change. Adaptation strategies require much more sophisticated climate change scenarios which include realistic simulations of climate variability and better decision-making tools.

The OzClim[3] tool kit, a climate scenario generator specifically designed for the tropical rainforest region, may be used generate fine resolution climate change scenarios for the region. These scenarios can be used as inputs in impacts models. Some of these activities are already occurring in this region. In particular, sensitivity studies on impacts of climate change on species distribution under climate change conditions have been undertaken by other MTSRF funded researchers (Metcalfe and Lawson, 2010; Shoo, 2010; Williams *et al.* 2010).

The coastal zone between the rainforest region and the Great Barrier Reef would benefit from integrated studies aimed at assessing impacts at the catchment scale. Improved modelling is needed to simulate tropical storms and storm surge. River catchments should be modelled to take account of climate, land-use and land-cover changes to model peak outflow, turbidity, and nutrient and pollutant loadings. Comprehensive studies are needed to assess climate impacts on settlements and resorts along the coastal area and also near the rainforest region to assess vulnerability and ensure optimum siting, engineering design and evacuation procedures. There is great scope for future multi-disciplinary research on climate impacts and adaptation in northeast Queensland in collaboration with research groups in universities, the CSIRO and other stakeholders.

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[3] Climage Change Scenario Generator, http://www.csiro.au/ozclim/

8. Conclusions

Since 1950, the tropical rainforest study region's average maximum temperature has increased by 0.12°C per decade, the minimum by 0.14°C per decade and the average by 0.13°C per decade. Rainfall shows strong variations on inter-annual and inter-decadal time scales. The Southern Oscillation Index shows a declining trend since the mid 1970s. Such a decline can be linked to more El Niño events during the past three decades, although there were also La Niña events during this period. The relationship between the Southern Oscillation Index and rainfall over this region is positive, but shows decadal-scale variations.

We have provided probabilistic climate change projections for the Australian land area north of 25°S and east of 140°E and sub-regions. Projections of changes in annual average temperature, rainfall and potential evaporation for the years 2030, 2050 and 2070 for low, medium and high emissions scenarios were discussed in this report. Seasonal average maximum, minimum and mean temperatures, rainfall and potential projections for 2020, 2030, 2040, 2050, 2060, 2070 and 2080 are given in the appendices to this report.

Projections show that the inland areas of the rainforest region will warm faster than the coastal areas. Percentage changes in dry season and Transitional Season 2 rainfall are greater than those for wet season and Transitional Season 1 rainfall.

Changes in rainfall are likely to follow a global-scale pattern that suggests wet regions will become wetter and dry regions drier (IPCC, 2007).

There are large uncertainties associated with future climate projections, arising from strong model-to-model variation and uncertainties from emission scenarios. Apart from these, uncertainties related to climate viability are given in the appendices to this report.

Some significant changes are possible over the next 30-100 years as atmospheric equivalent CO_2 concentrations exceed doubled pre-industrial concentrations. Changes are to be expected in both the mean values and in the magnitudes and frequency of extremes. This means that long-term planning is needed to adapt to a changing climate.

9. Knowledge gaps

ENSO

There is no overarching consensus regarding changes in ENSO dynamics under enhanced greenhouse conditions. In particular, changes in the frequency and amplitude of ENSO are unclear. ENSO is linked to several large-scale climate drivers that influence both land and oceanic environments. Uncertainty associated with ENSO will also increase uncertainty in the dynamics of other climate drivers, such as Indian Ocean Dipole, tropical cyclones and natural and anthropogenic aerosols.

Tropical cyclones

There is large uncertainty about changes to tropical cyclone behaviour due to enhanced greenhouse conditions. Coarse resolution models fail to simulate tropical cyclones. Higher resolution models do simulate cyclones, but inherit many deficiencies from global climate models, as their boundary conditions are from global climate models. Further research is needed to establish the physical basis and statistical significance of tropical cyclones in the study region.

Climate change projections from GCMs

Global climate models capture primary and most secondary large-scale circulation patterns, but regional to local scale circulation and rainfall patterns are not adequately resolved. These models have too coarse a resolution to resolve circulation patterns where impacts are expected to be important. Large uncertainty is associated with simulations from these models as they do not capture important characteristics of climate drivers of northeast Queensland, such as ENSO, monsoon, circulation patterns that produce extreme rainfall events, etc.

High-resolution regional climate models

High-resolution grids are one of the best model characteristics likely to get reliable regional and local scale climate information. Simulations from high-resolution models are able to give detailed information in topographically complex terrain, such as the rainforest region of northeast Queensland. These simulations usually give higher temporal resolution data for the region. In particular, these simulations provide realistic day-to-day variability in climate parameters and extremes. In recent years, biases in sea surface temperatures simulated by GCMs are corrected and then used as boundary conditions to force high resolution modelling. However, deficiency in simulating some important climate drivers by GCMs, such as ENSO, the South Pacific Convergence Zone (SPCZ), and some important features of the monsoon still remains as a major concern. Higher resolution global climate models with improved physical parameterisations are one of the priorities for better climate change projections in the future. Changes in climate from high resolution modelling for the MTSRF study region are given by Thatcher and McGregor (2008) and simulated data are available in the OzClim Toolkit.

Air-sea interaction processes

Air-sea interraction processes between the Great Barrier Reef and the rainforest region are an important area of active research, as this is not well understood. Experimental, theoretical and high resolution modelling studies would help to understand the process under present and future climate conditions, as many developments occur in coastal regions.

10. References

AchutaRao, K., and Sperber, K. R. (2006) ENSO simulation in coupled ocean-atmosphere models: Are the current models better? *Climate Dynamics* 27: 1-15 [doi:10.1007/s00382-006-0119-7].

Bureau of Meteorology (2010) Australian climate change and variability. http://www.bom.gov.au/marine/averages-trends.shtml

Collins, M., An, S.-I., Cai, W., Ganachaud, A., Guilyardi, E., Jin, F.-F., Jochum, M., Lengaigne, M., Power, S., Timmermann, A., Vecchi, G. and Wittenberg, A. (2010) The impact of global warming on the tropical Pacific Ocean and El Niño. *Nature Geoscience* 3: 391-397 [doi:10.1038/NGEO868].

CSIRO (2007) *Climate change in Australia.* Technical report, 140pp. [http://www.climatechangeinaustralia.com.au/technical_report.php]

Dai, A., Trenberth, K. E and Karl, T. R. (1999) Effects of clouds, soil moisture, precipitation, and water vapour on diurnal temperature ranges. *Journal of Climate* 12: 2451-2473.

Deacon, E. L. (1969) *Physical processes near the surface of the Earth*. In: Flohn, H. (ed.) World Survey of Climatology, Vol. 2, pp. 39-104. Elsevier.

Galvin, J. F. P. (2007) The weather and climate of the tropics. Part 1: Setting the scene. *Weather* 62(9): 245-251.

IPCC (2007) *Climate Change 2007: The Physical Science Basis*. Summary for Policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 [http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spm.html]

Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, L., Iredell, M., Saha, S., White, G., Woollen, J., Zhu, Y., Chelliah, M., Ebisuzaki, W., Higgins, W., Janowiak, J., Mo, K. C., Ropelewski, C., Wang, J., Leetmaa, A., Reynolds, R., Jenne, R. and Joseph, D. (1996) The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society* 77: 437-471.

Karl, T. R., Jones, P. D., Knight, R. W., Kukla, G., Plummer, N., Razuvayev, V., Gallo, K. P., Lindseay, J., Charlson, R. J. and Petereson, T. C. (1993) A new perspective on recent global warming: Asymmetric trends of daily maximum and minimum temperature. *Bulletin of the American Meteorological Society* 74: 1007-1023.

Lin, J.-L. (2007) Interdecadal variability of ENSO in 21 IPCC AR4 coupled GCMs. *Geophysical Research Letters* 34: L12702 [doi:10.1029/2006GL028937].

McBride, J. and Nicholls, N. (1983) Seasonal relationships between Australian rainfall and the southern oscillation. *Monthly Weather Review* 111: 1998-2004

Meehl, G. A., Stocker, T. F., Collins, W. D., Friedlingstein, P., Gaye, A. T., Gregory, J. M., Kitoh, A., Knutti, R., Murphy, J. M., Noda, A., Raper, S. C. B., Watterson, I. G., Weaver, A. J. and Zhao, Z.-C. (2007) Global Climate Projections. In: *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm]

Metcalfe, D. J. and Lawson, T. J. (2010) *Determining species composition for restoration plantings using climate change scenarios*. Presentation to the 2010 Annual Conference of the Marine and Tropical Sciences Research Facility (MTSRF), 18-20 May 2010, Cairns.

Mitchell, T. D. (2003) Pattern scaling: An examination of the accuracy of the technique for describing future climates. *Climatic Change* 60: 217-242.

Mitchell, J. F. B., Johns, T. C., Eagles, M., Ingram, W. J., and Davis, R. A. (1999) Towards the construction of climate change scenarios. *Climatic Change* 41: 547-581.

Mitchum, G. T., Nerem, R. S., Merrifield, M. A. and Gehrels, W. R. (2010) Modeln sea level change estimates. In: *Understanding sea-level rise and variability*, Eds. J. A. Church, P. L. Woodworth, T. Aarup and W. S. Wilson, Wiley-Blackwell, Chichester, UK, 122-142.

Morton, F. I. (1983) Operational estimates of areal evapotranspiration and their significance to the science and practice of hydrology. *Journal of Hydrology* 66: 1-76.

Nakićenović, N., and Swart, R. (eds.) (2000) *Special Report on Emissions Scenarios*. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 599 pp. [http://www.grida.no/publications/other/ipcc_sr/]

Nicholls, N. (2003) Continued anomalous warming in Australia. *Geophysical Research Letters* 30(7): 1370 [doi:10.1029/2003GL017037].

Nicholls, N. and Collins, D. (2006) Observed changes in Australia over the past century. *Energy and Environment* 17: 1-12.

Nicholls, N and Lavery, B. (1992) Australian rainfall trends during the twentieth century. *International Journal of Climatology* 12: 153-163.

Nicholls, N., Lavery, B., Frederiksen, C., Drosdowsky, W. and Torok, S. (1996) Recent apparent changes in relationship between the El Niño-Southern Oscillation and Australian rainfall and temperature. *Geophysical Research Letters* 23(23): 3357-3360.

Shoo, L. P. (2010) *Targeted protection and restoration to conserve tropical biodiversity in a warming world*. Presentation to the 2010 Annual Conference of the Marine and Tropical Sciences Research Facility (MTSRF), 18-20 May 2010, Cairns.

Smith, I. N. (2004) An assessment of recent trends in Australian rainfall. *Australian Meteorological Magazine* 53: 163-173.

Suppiah, R. (2004) Trends in the Southern Oscillation phenomenon and Australian rainfall and changes in their relationship. *International Journal of Climatology* 24: 269-290.

Suppiah, R. and Hennessy, K. J. (1996) Trends in the intensity and frequency of heavy rainfall in tropical Australia and links with the Southern Oscillation. *Australian Meteorological Magazine* 45: 1-17.

Suppiah, R., Macadam, I and Whetton, P. H. (2007a) *Climate Change Projections for the Tropical Rainforest Region of North Queensland.* A CSIRO report to the Marine and Tropical Sciences Research Facility (MTSRF) (38 pp.) [http://www.rrrc.com.au/publications/downloads/25ii1-Climate-Projections.pdf].

Suppiah, R., Hennessy, K. J., Whetton, P. H., McInnes, K., Macadam, I., Bathols, J., Ricketts, J. and Page, C. M. (2007b) Australian climate change projections derived from simulations performed for the IPCC Fourth Assessment report. *Australian Meteorological Magazine* 56: 131-152.

Suppiah, R., Macadam, I. Watterson, I., Page, C., Bathols, J. and Whetton. P. H. (2008) *Probabilistic climate change projections for the MTSRF region*. A CSIRO report to the Marine and Tropical Sciences Research Facility (MTSRF).

Thatcher, M., McGregor, J. and Nguyen, K. (2007) *Regional climate downscaling for the Marine and Tropical Sciences Research Facility (MTSRF) between 1971-2000*. A CSIRO report to the Marine and Tropical Sciences Research Facility (MTSRF) (8 pp.) [http://www.rrrc.org.au/publications/downloads/25ii1-CSIRO-Thatcher-2007-Climate-Downscaling-1971-2000.pdf]

Thatcher, M. and McGregor, J. (2008) *Dynamically downscaled Mk3.0 climate projection for the Marine and Tropical Sciences Research Facility (MTSRF) from 2060-2090*. A CSIRO report to the Marine and Tropical Sciences Research Facility (MTSRF) (23 pp.).

Vecchi, G. A. and Soden, B. J. (2007) Global Warming and the Weakening of the Tropical Circulation. *Journal of Climate* 20: 4316-4340.

Watterson, I. G. (2008) Calculation of probability density functions for temperature and precipitation change under global warming. *Journal of Geophysical Research* 113: D12106 [doi:10.1029/2007JD009254].

Whetton, P. H., McInnes, K. L., Jones, R. N., Hennessy, K. J., Suppiah, R., Page, C. M., Bathols, J. and Durack, P. J. (2005) *Australian climate change projections for impact assessment and policy application: a review*. CSIRO Marine and Atmospheric Research Paper 001, Aspendale, (34 pp.) [http://www.cmar.csiro.au/e-print/open/whettonph_2005a.pdf]

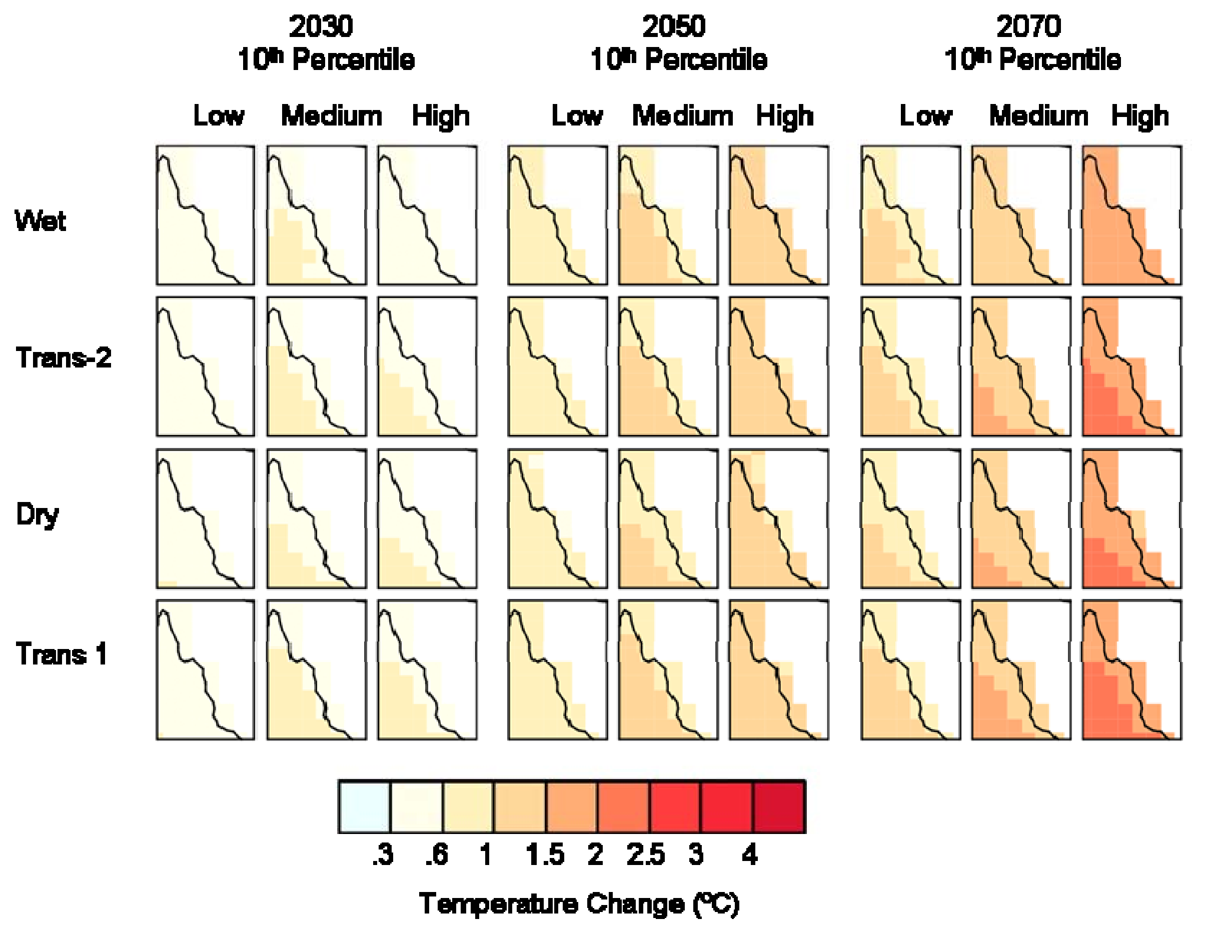
Williams, S. E., Shoo, L., VanDerWal, J. and Williams. Y. (2010) *Understanding and protecting rainforest biodiversity: adapting to global climate change*. Presentation to the 2010 Annual Conference of the Marine and Tropical Sciences Research Facility (MTSRF), 18-20 May 2010, Cairns.

11. Appendices

Appendix 1

Low-end (10th percentile) projected increases in seasonal average temperature (°C) for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070.

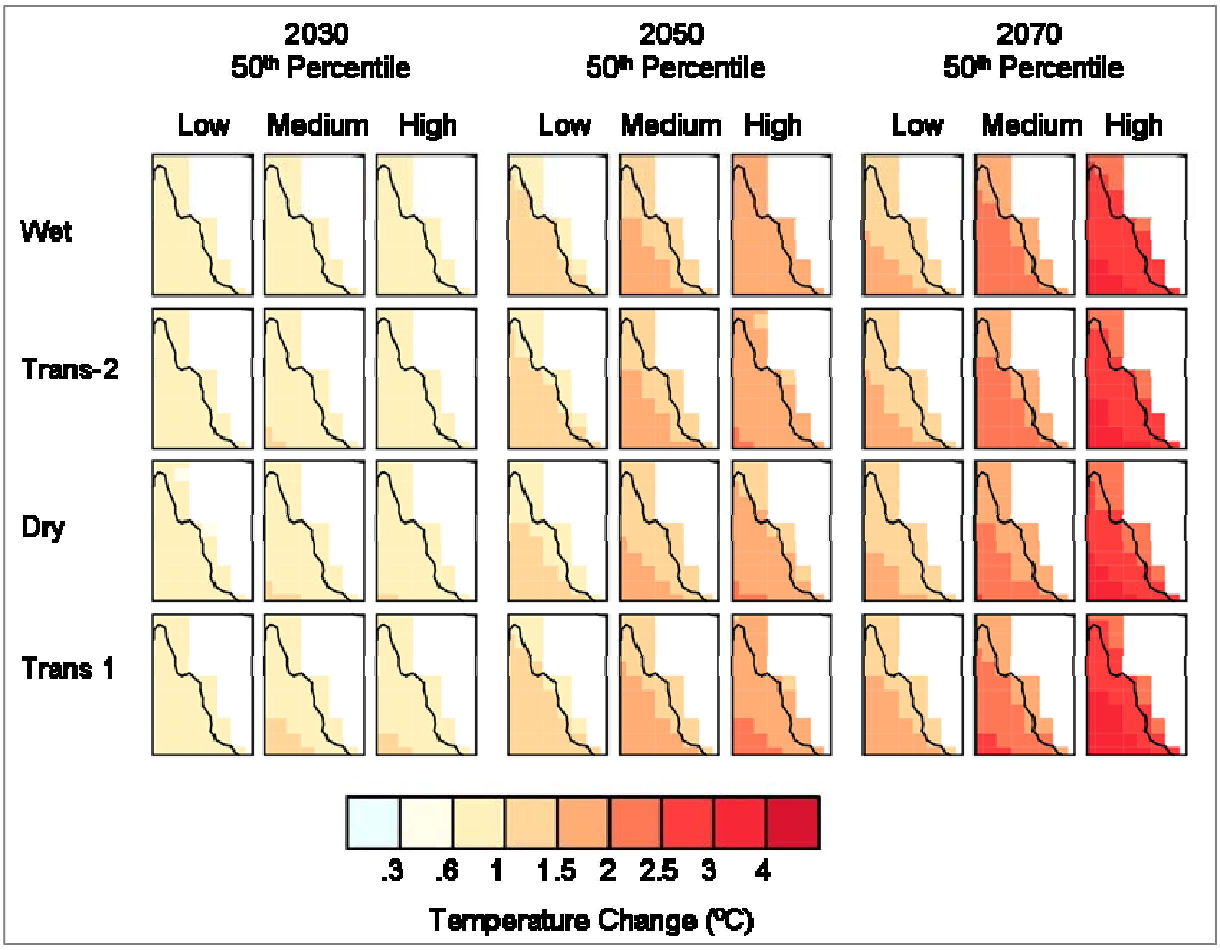
Key: 'Wet' = Wet season (January to March), 'Trans-2' = Transitional Season 2 (April to July), 'Dry' = Dry season (August to October), 'Trans-1' = Transitional Season 1 (November to December).



Appendix 2

Best estimate (50th percentile) projected increases in seasonal average temperature (°C) for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070.

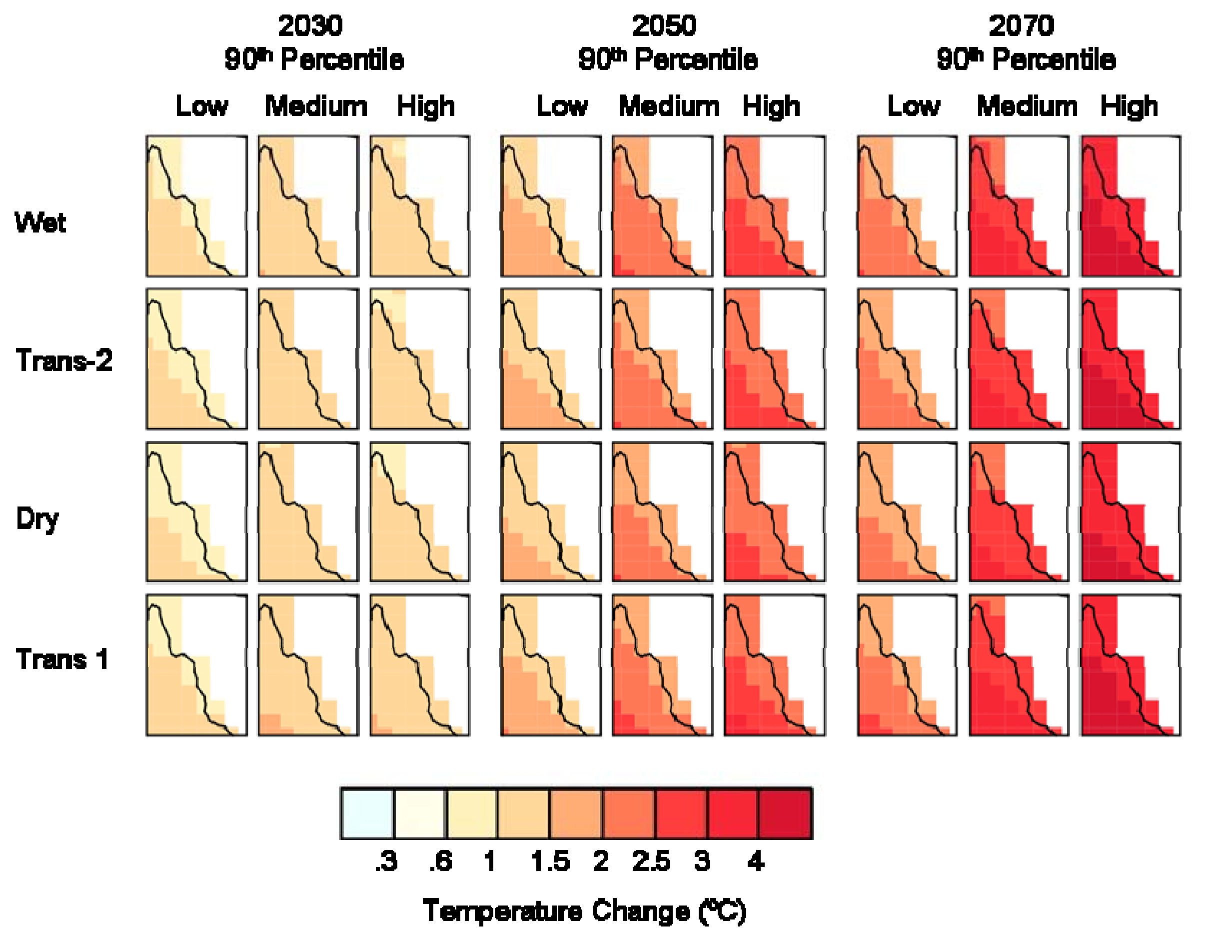
Key: 'Wet' = Wet season (January to March), 'Trans-2' = Transitional Season 2 (April to July), 'Dry' = Dry season (August to October), 'Trans-1' = Transitional Season 1 (November to December).



Appendix 3

High-end (90th percentile) projected increases in seasonal average temperature (°C) for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070.

Key: 'Wet' = Wet season (January to March), 'Trans-2' = Transitional Season 2 (April to July), 'Dry' = Dry season (August to October), 'Trans-1' = Transitional Season 1 (November to December).



Appendix 4

10th, 50th and 90th percentile increases in regional seasonal average temperatures (°C) for a low end SRES (B1) emissions scenario.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.4	0.6	0.9	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	1.0	1.4	2.0	1.1	1.6	2.2	1.2	1.8	2.5
Wet half-year	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	2.0	1.1	1.6	2.3	1.2	1.8	2.5
Dry half-year	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	1.0	1.4	2.0	1.1	1.6	2.2	1.2	1.8	2.5
Wet season	0.4	0.6	0.9	0.5	0.8	1.2	0.6	1.0	1.4	0.7	1.1	1.7	0.9	1.4	2.0	1.0	1.6	2.3	1.1	1.7	2.5
Trans. season 2	0.4	0.6	0.9	0.5	0.8	1.1	0.6	1.0	1.4	0.8	1.1	1.7	0.9	1.4	2.0	1.0	1.6	2.3	1.1	1.7	2.5
Dry season	0.4	0.6	0.9	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.7	1.0	1.4	2.0	1.1	1.6	2.3	1.2	1.8	2.5
Trans. season 1	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.8	1.0	1.5	2.2	1.1	1.7	2.5	1.2	1.9	2.7
Southern sub-region																					
Annual	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.8	1.0	1.5	2.1	1.1	1.7	2.4	1.3	1.9	2.6
Wet half-year	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.8	1.0	1.5	2.2	1.1	1.7	2.4	1.2	1.8	2.7
Dry half-year	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.1	1.5	0.9	1.2	1.7	1.0	1.5	2.1	1.2	1.7	2.4	1.3	1.9	2.6
Wet season	0.4	0.6	0.9	0.5	0.8	1.2	0.6	1.0	1.5	0.7	1.2	1.8	0.9	1.4	2.2	1.0	1.6	2.4	1.1	1.8	2.7
Trans. season 2	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.7	0.9	1.4	2.1	1.1	1.6	2.4	1.2	1.8	2.6
Dry season	0.4	0.7	0.9	0.6	0.9	1.2	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.1	1.2	1.7	2.4	1.3	1.9	2.7
Trans. season 1	0.4	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.9	1.0	1.6	2.3	1.2	1.8	2.6	1.3	2.0	2.9

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.8	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.0	1.1	1.6	2.2
Wet half-year	0.4	0.6	0.8	0.5	0.7	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.1	1.1	1.6	2.3
Dry half-year	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.0	1.1	1.6	2.2
Wet season	0.4	0.6	0.8	0.5	0.7	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.9	1.0	1.5	2.1	1.1	1.6	2.3
Trans. season 2	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.1	1.1	1.6	2.3
Dry season	0.4	0.5	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.4	2.0	1.1	1.6	2.2
Trans. season 1	0.4	0.6	0.8	0.5	0.8	1.1	0.6	1.0	1.3	0.8	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.2	1.2	1.7	2.4
Rainforest region																					
Annual	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.1	0.7	1.0	1.3	0.8	1.2	1.6	0.9	1.3	1.8	1.0	1.5	2.0
Wet half-year	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1
Dry half-year	0.3	0.5	0.7	0.4	0.6	0.9	0.6	0.8	1.1	0.7	1.0	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Wet season	0.3	0.5	0.7	0.4	0.7	0.9	0.5	0.8	1.2	0.6	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1
Trans. season 2	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.0
Dry season	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Trans. season 1	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Cairns																					
Annual	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.0
Wet half-year	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Dry half-year	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Wet season	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Trans. season 2	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1
Dry season	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.8	0.9	1.4	2.0
Trans. season 1	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1

Appendix 5

10th, 50th and 90th percentile increases in regional seasonal average temperatures (°C) for a medium case SRES (A1B) emissions scenario.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.5	0.7	0.9	0.7	1.0	1.3	0.9	1.3	1.8	1.1	1.6	2.3	1.3	2.0	2.8	1.6	2.3	3.2	1.8	2.6	3.6
Wet half-year	0.4	0.7	1.0	0.6	1.0	1.4	0.8	1.3	1.8	1.1	1.6	2.4	1.3	2.0	2.8	1.5	2.3	3.3	1.7	2.6	3.7
Dry half-year	0.5	0.7	0.9	0.7	1.0	1.3	0.9	1.3	1.8	1.1	1.6	2.3	1.4	2.0	2.7	1.6	2.3	3.2	1.8	2.6	3.6
Wet season	0.4	0.7	1.0	0.6	0.9	1.4	0.8	1.2	1.9	1.0	1.6	2.4	1.2	1.9	2.8	1.4	2.2	3.3	1.6	2.5	3.7
Trans. season 2	0.4	0.7	0.9	0.6	0.9	1.4	0.8	1.3	1.8	1.1	1.6	2.3	1.3	1.9	2.8	1.5	2.2	3.2	1.7	2.5	3.6
Dry season	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.3	1.3	2.0	2.8	1.5	2.3	3.2	1.8	2.6	3.6
Trans. season 1	0.5	0.7	1.0	0.7	1.0	1.5	0.9	1.3	2.0	1.1	1.7	2.5	1.4	2.1	3.0	1.6	2.4	3.5	1.8	2.7	3.9
Southern sub-region																					
Annual	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.9	1.2	1.7	2.4	1.4	2.1	2.9	1.6	2.4	3.4	1.8	2.7	3.8
Wet half-year	0.5	0.7	1.0	0.6	1.0	1.5	0.9	1.3	2.0	1.1	1.7	2.5	1.3	2.0	3.0	1.5	2.4	3.5	1.7	2.7	3.9
Dry half-year	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.4	1.9	1.2	1.7	2.4	1.4	2.1	2.9	1.7	2.4	3.4	1.9	2.7	3.8
Wet season	0.4	0.7	1.0	0.6	1.0	1.5	0.8	1.3	2.0	1.0	1.7	2.5	1.2	2.0	3.0	1.4	2.3	3.5	1.6	2.6	3.9
Trans. season 2	0.4	0.7	1.0	0.6	1.0	1.4	0.9	1.3	1.9	1.1	1.7	2.4	1.3	2.0	2.9	1.5	2.3	3.4	1.7	2.6	3.8
Dry season	0.5	0.7	1.0	0.7	1.0	1.5	0.9	1.4	2.0	1.2	1.7	2.5	1.4	2.1	3.0	1.6	2.4	3.5	1.9	2.8	3.9
Trans. season 1	0.5	0.8	1.1	0.7	1.1	1.6	0.9	1.4	2.1	1.2	1.8	2.7	1.4	2.2	3.2	1.6	2.5	3.8	1.9	2.9	4.3

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.3	1.8	2.5	1.5	2.1	2.9	1.7	2.4	3.3
Wet half-year	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.1	3.0	1.6	2.4	3.4
Dry half-year	0.4	0.6	0.8	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.2	1.8	2.5	1.4	2.1	2.9	1.6	2.3	3.2
Wet season	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.1	3.0	1.5	2.3	3.4
Trans. season 2	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.7	1.0	1.5	2.1	1.2	1.8	2.5	1.4	2.1	3.0	1.6	2.4	3.3
Dry season	0.4	0.6	0.8	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.2	1.8	2.5	1.4	2.0	2.9	1.6	2.3	3.2
Trans. season 1	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.1	1.6	2.2	1.3	1.9	2.7	1.5	2.2	3.1	1.7	2.5	3.5
Rainforest region																					
Annual	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.3	1.9	1.1	1.6	2.2	1.3	1.9	2.6	1.5	2.1	2.9
Wet half-year	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.5	2.2	3.0
Dry half-year	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.2	1.3	1.8	2.6	1.4	2.1	2.9
Wet season	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.1	1.5	0.9	1.3	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.4	2.1	3.0
Trans. season 2	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.1	1.5	0.9	1.3	1.9	1.1	1.6	2.3	1.3	1.9	2.6	1.5	2.1	3.0
Dry season	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.2	1.2	1.8	2.6	1.4	2.0	2.9
Trans. season 1	0.4	0.6	0.8	0.6	0.8	1.2	0.7	1.1	1.5	0.9	1.4	2.0	1.1	1.7	2.4	1.3	1.9	2.7	1.5	2.2	3.1
Cairns																					
Annual	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.6	1.5	2.1	3.0
Wet half-year	0.4	0.6	0.8	0.6	0.8	1.1	0.8	1.1	1.5	1.0	1.4	2.0	1.2	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.1
Dry half-year	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.5	0.9	1.3	1.9	1.1	1.6	2.2	1.3	1.8	2.6	1.4	2.1	2.9
Wet season	0.4	0.6	0.8	0.6	0.8	1.2	0.7	1.1	1.6	0.9	1.4	2.0	1.1	1.7	2.4	1.3	1.9	2.8	1.5	2.2	3.1
Trans. season 2	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.5	2.2	3.0
Dry season	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.5	0.9	1.3	1.9	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.0	2.9
Trans. season 1	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.0

Appendix 6

10th, 50th and 90th percentile increases in regional seasonal average temperatures (°C) fora high end SRES (A1FI) emissions scenario.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.7	1.7	2.5	3.5	2.1	3.1	4.3	2.5	3.6	5.1
Wet half-year	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	2.0	1.3	1.9	2.8	1.7	2.5	3.6	2.0	3.1	4.5	2.4	3.6	5.2
Dry half-year	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.7	1.7	2.5	3.5	2.1	3.1	4.3	2.5	3.6	5.0
Wet season	0.3	0.5	0.8	0.6	0.9	1.3	0.9	1.3	2.0	1.2	1.9	2.8	1.6	2.5	3.7	1.9	3.0	4.5	2.2	3.5	5.2
Trans. season 2	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.3	1.9	1.2	1.9	2.7	1.6	2.5	3.6	2.0	3.0	4.4	2.3	3.5	5.1
Dry season	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.7	1.7	2.5	3.6	2.1	3.1	4.4	2.5	3.6	5.1
Trans. season 1	0.4	0.6	0.9	0.6	1.0	1.4	1.0	1.4	2.1	1.3	2.0	2.9	1.8	2.7	3.9	2.1	3.3	4.7	2.5	3.8	5.5
Southern sub-region																					
Annual	0.4	0.6	0.8	0.7	1.0	1.4	1.0	1.4	2.1	1.4	2.0	2.9	1.8	2.7	3.8	2.2	3.3	4.6	2.6	3.8	5.4
Wet half-year	0.4	0.6	0.9	0.6	1.0	1.4	0.9	1.4	2.1	1.3	2.0	2.9	1.7	2.6	3.9	2.1	3.2	4.7	2.4	3.8	5.5
Dry half-year	0.4	0.6	0.8	0.7	1.0	1.4	1.0	1.5	2.0	1.4	2.0	2.9	1.8	2.7	3.8	2.3	3.3	4.6	2.6	3.8	5.4
Wet season	0.4	0.6	0.9	0.6	0.9	1.4	0.9	1.4	2.1	1.2	1.9	2.9	1.6	2.6	3.9	1.9	3.1	4.7	2.3	3.7	5.5
Trans. season 2	0.4	0.6	0.8	0.6	0.9	1.4	0.9	1.4	2.0	1.3	2.0	2.8	1.7	2.6	3.7	2.1	3.1	4.6	2.4	3.7	5.3
Dry season	0.4	0.6	0.9	0.7	1.0	1.4	1.0	1.5	2.1	1.4	2.1	2.9	1.8	2.7	3.9	2.2	3.3	4.7	2.6	3.9	5.5
Trans. season 1	0.4	0.6	0.9	0.7	1.0	1.5	1.0	1.5	2.3	1.4	2.2	3.2	1.8	2.8	4.2	2.2	3.5	5.1	2.6	4.0	6.0

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.5	1.6	2.3	3.2	2.0	2.9	4.0	2.3	3.3	4.6
Wet half-year	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.5	1.6	2.4	3.3	2.0	2.9	4.1	2.3	3.4	4.8
Dry half-year	0.4	0.5	0.7	0.6	0.8	1.2	0.9	1.3	1.7	1.2	1.7	2.4	1.6	2.3	3.2	2.0	2.8	3.9	2.3	3.3	4.5
Wet season	0.3	0.5	0.7	0.6	0.8	1.2	0.8	1.3	1.8	1.2	1.7	2.5	1.5	2.3	3.3	1.9	2.8	4.1	2.2	3.3	4.8
Trans. season 2	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.5	1.6	2.3	3.3	1.9	2.8	4.0	2.3	3.3	4.7
Dry season	0.4	0.5	0.7	0.6	0.8	1.2	0.9	1.2	1.7	1.2	1.7	2.4	1.6	2.3	3.2	1.9	2.8	3.9	2.2	3.2	4.5
Trans. season 1	0.4	0.5	0.8	0.6	0.9	1.3	0.9	1.3	1.9	1.3	1.8	2.6	1.7	2.4	3.4	2.0	3.0	4.2	2.4	3.5	4.9
Rainforest region																					
Annual	0.3	0.5	0.6	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.5	2.1	2.9	1.8	2.6	3.5	2.1	3.0	4.1
Wet half-year	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.3
Dry half-year	0.3	0.5	0.6	0.5	0.8	1.0	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.0	2.8	1.7	2.5	3.5	2.0	2.9	4.1
Wet season	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.3	1.4	2.1	3.0	1.7	2.6	3.7	2.0	3.0	4.3
Trans. season 2	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.1	2.9	1.7	2.6	3.6	2.0	3.0	4.2
Dry season	0.3	0.4	0.6	0.5	0.7	1.0	0.7	1.1	1.5	1.0	1.5	2.2	1.4	2.0	2.8	1.7	2.5	3.5	2.0	2.9	4.0
Trans. season 1	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.1	3.0	1.8	2.6	3.7	2.1	3.1	4.3
Cairns																					
Annual	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.5	2.1	2.9	1.8	2.6	3.6	2.1	3.0	4.2
Wet half-year	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.2	3.0	1.8	2.6	3.7	2.1	3.1	4.3
Dry half-year	0.3	0.5	0.6	0.5	0.7	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.0	2.9	1.7	2.5	3.5	2.0	2.9	4.1
Wet season	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.7	1.1	1.6	2.3	1.5	2.2	3.1	1.8	2.6	3.8	2.1	3.1	4.4
Trans. season 2	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.2
Dry season	0.3	0.4	0.6	0.5	0.7	1.1	0.7	1.1	1.6	1.0	1.5	2.2	1.3	2.0	2.9	1.6	2.4	3.5	1.9	2.8	4.1
Trans. season 1	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.1	3.0	1.8	2.6	3.7	2.1	3.0	4.3

Appendix 7

10th, 50th and 90th percentile increases in regional seasonal average maximum temperatures (°C) for a low end SRES (B1) emissions scenario.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.4	0.6	0.9	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	1.0	1.4	2.0	1.1	1.6	2.2	1.2	1.8	2.5
Wet half-year	0.4	0.6	0.9	0.5	0.8	1.1	0.6	1.0	1.4	0.8	1.2	1.7	0.9	1.4	2.0	1.0	1.6	2.3	1.1	1.7	2.5
Dry half-year	0.4	0.6	0.9	0.6	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	1.0	1.4	2.0	1.1	1.6	2.2	1.2	1.8	2.5
Wet season	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.4	0.7	1.1	1.7	0.9	1.3	2.0	1.0	1.5	2.3	1.1	1.7	2.5
Trans. season 2	0.4	0.6	0.8	0.5	0.8	1.1	0.6	1.0	1.4	0.8	1.1	1.6	0.9	1.4	2.0	1.0	1.5	2.2	1.1	1.7	2.4
Dry season	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	1.0	1.4	2.0	1.1	1.6	2.3	1.2	1.8	2.5
Trans. season 1	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.8	1.0	1.5	2.1	1.1	1.7	2.4	1.2	1.8	2.7
Southern sub-region																					
Annual	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.7	1.0	1.5	2.1	1.1	1.7	2.4	1.3	1.8	2.6
Wet half-year	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.7	0.9	1.4	2.1	1.1	1.6	2.4	1.2	1.8	2.6
Dry half-year	0.5	0.7	0.9	0.6	0.9	1.2	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.1	1.2	1.7	2.4	1.3	1.9	2.7
Wet season	0.4	0.6	0.9	0.5	0.8	1.2	0.6	1.0	1.5	0.7	1.2	1.7	0.9	1.4	2.1	1.0	1.6	2.4	1.1	1.7	2.6
Trans. season 2	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	2.1	1.1	1.6	2.3	1.2	1.8	2.6
Dry season	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.8	1.1	1.6	2.2	1.2	1.8	2.5	1.3	1.9	2.8
Trans. season 1	0.4	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.9	1.0	1.6	2.3	1.1	1.8	2.6	1.3	2.0	2.9

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.8	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.0	1.1	1.6	2.2
Wet half-year	0.4	0.6	0.8	0.5	0.7	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.1	1.1	1.6	2.3
Dry half-year	0.4	0.5	0.8	0.5	0.7	1.0	0.6	0.9	1.2	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.4	2.0	1.1	1.6	2.2
Wet season	0.4	0.6	0.8	0.5	0.7	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.1	1.1	1.6	2.3
Trans. season 2	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.0	1.1	1.6	2.3
Dry season	0.4	0.5	0.8	0.5	0.7	1.0	0.6	0.9	1.2	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.4	2.0	1.1	1.6	2.2
Trans. season 1	0.4	0.6	0.8	0.5	0.8	1.1	0.6	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.1	1.1	1.7	2.4
Rainforest region																					
Annual	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.8	1.0	1.5	2.0
Wet half-year	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Dry half-year	0.3	0.5	0.7	0.4	0.6	0.9	0.6	0.8	1.1	0.7	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Wet season	0.3	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1
Trans. season 2	0.3	0.5	0.7	0.4	0.7	0.9	0.6	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Dry season	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Trans. season 1	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.9	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Cairns																					
Annual	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.1
Wet half-year	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.9	1.2	0.7	1.0	1.4	0.9	1.2	1.7	1.0	1.4	2.0	1.1	1.5	2.2
Dry half-year	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Wet season	0.4	0.5	0.8	0.5	0.7	1.0	0.6	0.9	1.2	0.7	1.0	1.5	0.8	1.2	1.8	0.9	1.4	2.0	1.0	1.5	2.2
Trans. season 2	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.1
Dry season	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.8	0.9	1.4	2.0
Trans. season 1	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1

Appendix 8

10th, 50th and 90th percentile increases in regional seasonal average maximum temperatures (°C) for a medium case SRES (A1B) emissions scenario.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.5	0.7	0.9	0.7	1.0	1.3	0.9	1.3	1.8	1.1	1.6	2.3	1.3	2.0	2.7	1.6	2.3	3.2	1.8	2.6	3.6
Wet half-year	0.4	0.7	1.0	0.6	0.9	1.4	0.8	1.3	1.8	1.1	1.6	2.3	1.3	1.9	2.8	1.5	2.2	3.2	1.7	2.5	3.7
Dry half-year	0.5	0.7	0.9	0.7	1.0	1.3	0.9	1.3	1.8	1.1	1.6	2.3	1.4	2.0	2.8	1.6	2.3	3.2	1.8	2.6	3.6
Wet season	0.4	0.6	1.0	0.6	0.9	1.4	0.8	1.2	1.8	1.0	1.6	2.3	1.2	1.9	2.8	1.4	2.2	3.2	1.6	2.5	3.6
Trans. season 2	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.8	1.0	1.6	2.3	1.3	1.9	2.7	1.5	2.2	3.2	1.6	2.5	3.6
Dry season	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.9	1.1	1.7	2.4	1.4	2.0	2.8	1.6	2.3	3.3	1.8	2.6	3.7
Trans. season 1	0.5	0.7	1.0	0.7	1.0	1.5	0.9	1.3	1.9	1.1	1.7	2.5	1.4	2.0	3.0	1.6	2.4	3.4	1.8	2.7	3.9
Southern sub-region																					
Annual	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.9	1.2	1.7	2.4	1.4	2.1	2.9	1.6	2.4	3.4	1.8	2.7	3.8
Wet half-year	0.4	0.7	1.0	0.6	1.0	1.4	0.8	1.3	1.9	1.1	1.7	2.4	1.3	2.0	2.9	1.5	2.3	3.4	1.7	2.6	3.8
Dry half-year	0.5	0.7	1.0	0.7	1.0	1.5	1.0	1.4	1.9	1.2	1.8	2.5	1.5	2.1	3.0	1.7	2.5	3.4	1.9	2.8	3.9
Wet season	0.4	0.7	1.0	0.6	0.9	1.4	0.8	1.3	1.9	1.0	1.6	2.4	1.2	1.9	2.9	1.4	2.2	3.4	1.6	2.5	3.8
Trans. season 2	0.4	0.7	1.0	0.6	1.0	1.4	0.8	1.3	1.9	1.1	1.6	2.4	1.3	2.0	2.9	1.5	2.3	3.3	1.7	2.6	3.8
Dry season	0.5	0.7	1.1	0.7	1.1	1.5	1.0	1.4	2.0	1.2	1.8	2.6	1.5	2.2	3.1	1.7	2.5	3.6	1.9	2.8	4.1
Trans. season 1	0.5	0.7	1.1	0.7	1.1	1.6	0.9	1.4	2.1	1.2	1.8	2.7	1.4	2.2	3.2	1.6	2.5	3.7	1.8	2.9	4.2

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.3	1.8	2.5	1.5	2.1	2.9	1.6	2.4	3.3
Wet half-year	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.1	3.0	1.6	2.4	3.4
Dry half-year	0.4	0.6	0.8	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.0	1.2	1.8	2.4	1.4	2.0	2.8	1.6	2.3	3.2
Wet season	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.1	3.0	1.6	2.4	3.4
Trans. season 2	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.2	1.8	2.5	1.4	2.1	2.9	1.6	2.3	3.3
Dry season	0.4	0.6	0.8	0.6	0.9	1.2	0.8	1.1	1.6	1.0	1.5	2.1	1.2	1.8	2.5	1.4	2.0	2.9	1.6	2.3	3.2
Trans. season 1	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.1	1.5	2.2	1.3	1.9	2.6	1.5	2.2	3.0	1.7	2.4	3.4
Rainforest region																					
Annual	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.6	1.5	2.1	3.0
Wet half-year	0.4	0.6	0.8	0.6	0.8	1.2	0.7	1.1	1.5	1.0	1.4	2.0	1.1	1.7	2.4	1.3	1.9	2.7	1.5	2.2	3.1
Dry half-year	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.2	1.3	1.8	2.6	1.4	2.1	2.9
Wet season	0.4	0.6	0.8	0.5	0.8	1.2	0.7	1.1	1.6	0.9	1.4	2.0	1.1	1.7	2.4	1.3	1.9	2.8	1.4	2.2	3.1
Trans. season 2	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.0	1.5	0.9	1.3	1.9	1.1	1.6	2.3	1.3	1.9	2.6	1.4	2.1	3.0
Dry season	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.2	1.2	1.8	2.6	1.4	2.1	2.9
Trans. season 1	0.4	0.6	0.8	0.6	0.8	1.2	0.8	1.1	1.6	1.0	1.4	2.0	1.2	1.7	2.4	1.3	2.0	2.8	1.5	2.2	3.1
Cairns																					
Annual	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	1.0	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.5	2.2	3.0
Wet half-year	0.4	0.6	0.8	0.6	0.8	1.2	0.8	1.1	1.6	1.0	1.4	2.0	1.2	1.7	2.4	1.4	2.0	2.8	1.6	2.3	3.1
Dry half-year	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.2	1.2	1.8	2.6	1.4	2.1	2.9
Wet season	0.4	0.6	0.8	0.6	0.8	1.2	0.8	1.1	1.6	1.0	1.4	2.0	1.2	1.7	2.4	1.3	2.0	2.8	1.5	2.2	3.2
Trans. season 2	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.5	2.1	3.0
Dry season	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.5	0.9	1.3	1.9	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.0	2.9
Trans. season 1	0.4	0.6	0.8	0.6	0.8	1.2	0.7	1.1	1.5	1.0	1.4	2.0	1.1	1.7	2.4	1.3	1.9	2.7	1.5	2.2	3.1

Appendix 9

10th, 50th and 90th percentile increases in regional seasonal average maximum temperatures (°C) for a high end SRES (A1FI) emissions scenario.

Key: 'Wet half-year' = December to May, 'Dry half-year' = June to November, 'Wet season' = January to March, 'Trans. season 2' = April to July, 'Dry season' = August to October, 'Trans. season 1' = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.7	1.7	2.5	3.5	2.1	3.1	4.3	2.5	3.6	5.0
Wet half-year	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	2.0	1.2	1.9	2.7	1.6	2.5	3.6	2.0	3.0	4.4	2.3	3.6	5.1
Dry half-year	0.4	0.6	0.8	0.6	0.9	1.3	1.0	1.4	1.9	1.3	1.9	2.7	1.8	2.5	3.5	2.1	3.1	4.3	2.5	3.6	5.1
Wet season	0.3	0.5	0.8	0.6	0.9	1.3	0.8	1.3	2.0	1.2	1.8	2.7	1.5	2.4	3.6	1.9	3.0	4.4	2.2	3.4	5.1
Trans. season 2	0.4	0.5	0.8	0.6	0.9	1.3	0.9	1.3	1.9	1.2	1.9	2.7	1.6	2.4	3.5	2.0	3.0	4.3	2.3	3.5	5.0
Dry season	0.4	0.6	0.8	0.6	0.9	1.3	1.0	1.4	2.0	1.3	2.0	2.8	1.8	2.6	3.7	2.2	3.2	4.5	2.5	3.7	5.2
Trans. season 1	0.4	0.6	0.9	0.6	1.0	1.4	0.9	1.4	2.1	1.3	2.0	2.9	1.7	2.6	3.8	2.1	3.2	4.7	2.5	3.8	5.5
Southern sub-region																					
Annual	0.4	0.6	0.8	0.7	1.0	1.4	1.0	1.4	2.0	1.4	2.0	2.9	1.8	2.7	3.8	2.2	3.3	4.6	2.6	3.8	5.4
Wet half-year	0.4	0.6	0.8	0.6	0.9	1.4	0.9	1.4	2.1	1.3	2.0	2.9	1.7	2.6	3.8	2.0	3.2	4.6	2.4	3.7	5.4
Dry half-year	0.4	0.6	0.9	0.7	1.0	1.4	1.0	1.5	2.1	1.4	2.1	2.9	1.9	2.7	3.8	2.3	3.3	4.7	2.7	3.9	5.4
Wet season	0.3	0.6	0.8	0.6	0.9	1.4	0.8	1.4	2.0	1.2	1.9	2.8	1.5	2.5	3.7	1.9	3.0	4.6	2.2	3.5	5.3
Trans. season 2	0.4	0.6	0.8	0.6	0.9	1.4	0.9	1.4	2.0	1.3	1.9	2.8	1.7	2.5	3.7	2.0	3.1	4.5	2.4	3.6	5.3
Dry season	0.4	0.6	0.9	0.7	1.0	1.5	1.0	1.5	2.2	1.4	2.1	3.0	1.9	2.8	4.0	2.3	3.4	4.9	2.7	4.0	5.7
Trans. season 1	0.4	0.6	0.9	0.7	1.0	1.5	1.0	1.5	2.3	1.4	2.1	3.1	1.8	2.8	4.1	2.2	3.4	5.1	2.6	4.0	5.9

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.4	1.6	2.3	3.2	2.0	2.9	3.9	2.3	3.3	4.6
Wet half-year	0.4	0.5	0.8	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.6	1.6	2.4	3.4	2.0	2.9	4.1	2.3	3.4	4.8
Dry half-year	0.4	0.5	0.7	0.6	0.8	1.2	0.9	1.2	1.7	1.2	1.7	2.4	1.6	2.3	3.2	1.9	2.8	3.9	2.3	3.2	4.5
Wet season	0.3	0.5	0.8	0.6	0.8	1.2	0.8	1.3	1.8	1.2	1.8	2.6	1.5	2.3	3.4	1.9	2.8	4.1	2.2	3.3	4.8
Trans. season 2	0.3	0.5	0.7	0.6	0.8	1.2	0.9	1.2	1.8	1.2	1.7	2.5	1.6	2.3	3.2	1.9	2.8	4.0	2.2	3.3	4.6
Dry season	0.3	0.5	0.7	0.6	0.8	1.2	0.9	1.2	1.7	1.2	1.7	2.4	1.6	2.3	3.2	1.9	2.8	3.9	2.2	3.2	4.5
Trans. season 1	0.4	0.5	0.8	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.6	1.6	2.4	3.4	2.0	2.9	4.2	2.3	3.4	4.8
Rainforest region																					
Annual	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.5	2.1	2.9	1.8	2.6	3.6	2.1	3.0	4.2
Wet half-year	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.7	1.1	1.6	2.3	1.5	2.2	3.0	1.8	2.6	3.7	2.1	3.1	4.3
Dry half-year	0.3	0.5	0.6	0.5	0.7	1.0	0.8	1.1	1.5	1.1	1.6	2.2	1.4	2.0	2.8	1.7	2.5	3.5	2.0	2.9	4.1
Wet season	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.7	1.1	1.6	2.3	1.4	2.1	3.1	1.7	2.6	3.7	2.0	3.0	4.4
Trans. season 2	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.1	2.9	1.7	2.5	3.6	2.0	3.0	4.2
Dry season	0.3	0.5	0.6	0.5	0.7	1.0	0.8	1.1	1.6	1.1	1.5	2.2	1.4	2.0	2.9	1.7	2.5	3.5	2.0	2.9	4.1
Trans. season 1	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.7	1.1	1.6	2.3	1.5	2.2	3.1	1.8	2.7	3.7	2.1	3.1	4.4
Cairns																					
Annual	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.2	1.5	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.2
Wet half-year	0.3	0.5	0.7	0.6	0.8	1.1	0.8	1.2	1.7	1.2	1.7	2.4	1.5	2.2	3.1	1.9	2.7	3.8	2.2	3.2	4.4
Dry half-year	0.3	0.5	0.6	0.5	0.7	1.1	0.8	1.1	1.6	1.1	1.5	2.2	1.4	2.0	2.9	1.7	2.5	3.5	2.0	2.9	4.1
Wet season	0.3	0.5	0.7	0.5	0.8	1.2	0.8	1.2	1.7	1.1	1.7	2.4	1.5	2.2	3.2	1.8	2.7	3.9	2.1	3.2	4.5
Trans. season 2	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.5	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.2
Dry season	0.3	0.4	0.6	0.5	0.7	1.1	0.7	1.1	1.6	1.0	1.5	2.2	1.3	2.0	2.9	1.6	2.4	3.5	1.9	2.8	4.1
Trans. season 1	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.2	3.0	1.8	2.6	3.7	2.1	3.1	4.3

Appendix 10

10th, 50th and 90th percentile increases in regional seasonal average minimum temperatures (°C) for a low end SRES (B1) emissions scenario.

Key: 'Wet half-year' = December to May, 'Dry half-year' = June to November, 'Wet season' = January to March, 'Trans. season 2' = April to July, 'Dry season' = August to October, 'Trans. season 1' = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.4	0.6	0.9	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	1.0	1.4	2.0	1.1	1.6	2.2	1.2	1.8	2.5
Wet half-year	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.7	0.9	1.4	2.1	1.1	1.6	2.4	1.2	1.8	2.6
Dry half-year	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.2	1.6	1.0	1.4	1.9	1.1	1.6	2.2	1.2	1.7	2.4
Wet season	0.4	0.6	0.9	0.5	0.8	1.2	0.6	1.0	1.5	0.8	1.2	1.8	0.9	1.4	2.1	1.0	1.6	2.4	1.1	1.8	2.7
Trans. season 2	0.4	0.6	0.9	0.5	0.8	1.1	0.6	1.0	1.4	0.8	1.2	1.7	0.9	1.4	2.0	1.0	1.6	2.3	1.1	1.7	2.5
Dry season	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.1	1.6	0.9	1.4	1.9	1.1	1.6	2.2	1.2	1.7	2.4
Trans. season 1	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.1	1.5	0.8	1.2	1.8	1.0	1.5	2.2	1.1	1.7	2.5	1.2	1.9	2.7
Southern sub-region																					
Annual	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.7	1.0	1.5	2.1	1.1	1.7	2.4	1.3	1.8	2.6
Wet half-year	0.4	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.8	1.0	1.5	2.2	1.1	1.7	2.5	1.2	1.9	2.8
Dry half-year	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	1.0	1.4	2.0	1.1	1.6	2.3	1.2	1.8	2.5
Wet season	0.4	0.7	1.0	0.5	0.9	1.3	0.7	1.1	1.6	0.8	1.3	1.9	0.9	1.5	2.3	1.1	1.7	2.6	1.2	1.9	2.9
Trans. season 2	0.4	0.6	0.9	0.5	0.8	1.2	0.7	1.0	1.5	0.8	1.2	1.7	0.9	1.4	2.1	1.1	1.6	2.4	1.2	1.8	2.6
Dry season	0.4	0.6	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	1.0	1.4	2.0	1.1	1.6	2.3	1.2	1.8	2.6
Trans. season 1	0.4	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.9	1.0	1.6	2.3	1.2	1.8	2.7	1.3	2.0	2.9

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.8	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.1	1.1	1.6	2.3
Wet half-year	0.4	0.6	0.8	0.5	0.7	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.1	1.1	1.6	2.3
Dry half-year	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.8	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.0	1.1	1.6	2.3
Wet season	0.4	0.6	0.8	0.5	0.7	1.1	0.6	0.9	1.3	0.7	1.1	1.6	0.9	1.3	1.9	1.0	1.5	2.2	1.1	1.6	2.4
Trans. season 2	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.1	1.1	1.6	2.3
Dry season	0.4	0.6	0.8	0.5	0.7	1.0	0.6	0.9	1.3	0.7	1.1	1.5	0.9	1.3	1.8	1.0	1.5	2.0	1.1	1.6	2.2
Trans. season 1	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.8	1.1	1.6	0.9	1.4	1.9	1.1	1.6	2.2	1.2	1.7	2.4
Rainforest region																					
Annual	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.1	0.7	1.0	1.3	0.8	1.2	1.6	0.9	1.3	1.8	1.0	1.5	2.0
Wet half-year	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1
Dry half-year	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.1	0.7	1.0	1.3	0.8	1.2	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Wet season	0.3	0.5	0.7	0.4	0.7	1.0	0.5	0.8	1.2	0.6	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1
Trans. season 2	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.1
Dry season	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.1	0.6	0.9	1.3	0.8	1.1	1.6	0.9	1.3	1.8	1.0	1.4	2.0
Trans. season 1	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Cairns																					
Annual	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.1
Wet half-year	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Dry half-year	0.3	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.6	0.9	1.3	1.9	1.0	1.5	2.1
Wet season	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Trans. season 2	0.4	0.5	0.7	0.5	0.7	1.0	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.4	1.9	1.0	1.5	2.1
Dry season	0.3	0.5	0.7	0.4	0.6	0.9	0.5	0.8	1.2	0.6	0.9	1.4	0.8	1.1	1.6	0.9	1.3	1.9	1.0	1.4	2.0
Trans. season 1	0.4	0.5	0.7	0.5	0.7	0.9	0.6	0.8	1.2	0.7	1.0	1.4	0.8	1.2	1.7	0.9	1.3	1.9	1.0	1.5	2.1

Appendix 11

10th, 50th and 90th percentile increases in regional seasonal average minimum temperatures (°C) for a medium case SRES (A1B) emissions scenario.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.5	0.7	0.9	0.7	1.0	1.3	0.9	1.3	1.8	1.1	1.6	2.3	1.3	2.0	2.8	1.6	2.3	3.2	1.8	2.6	3.6
Wet half-year	0.5	0.7	1.0	0.6	1.0	1.4	0.9	1.3	1.9	1.1	1.7	2.4	1.3	2.0	2.9	1.5	2.3	3.3	1.7	2.6	3.8
Dry half-year	0.5	0.7	0.9	0.7	0.9	1.3	0.9	1.3	1.8	1.1	1.6	2.2	1.3	1.9	2.7	1.5	2.2	3.1	1.7	2.5	3.5
Wet season	0.4	0.7	1.0	0.6	1.0	1.5	0.8	1.3	1.9	1.1	1.7	2.5	1.3	2.0	3.0	1.5	2.3	3.4	1.7	2.6	3.9
Trans. season 2	0.4	0.7	0.9	0.6	0.9	1.4	0.8	1.3	1.8	1.1	1.6	2.3	1.3	1.9	2.8	1.5	2.2	3.2	1.7	2.5	3.6
Dry season	0.4	0.7	0.9	0.6	0.9	1.3	0.8	1.2	1.8	1.1	1.6	2.2	1.3	1.9	2.7	1.5	2.2	3.1	1.7	2.5	3.5
Trans. season 1	0.5	0.7	1.0	0.7	1.0	1.5	0.9	1.4	2.0	1.1	1.7	2.5	1.4	2.1	3.0	1.6	2.4	3.5	1.8	2.7	4.0
Southern sub-region																					
Annual	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.9	1.2	1.7	2.4	1.4	2.1	2.9	1.6	2.4	3.4	1.8	2.7	3.8
Wet half-year	0.5	0.7	1.1	0.7	1.0	1.5	0.9	1.4	2.0	1.1	1.8	2.6	1.4	2.1	3.1	1.6	2.4	3.6	1.8	2.8	4.0
Dry half-year	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.8	1.2	1.7	2.3	1.4	2.0	2.8	1.6	2.3	3.3	1.8	2.6	3.7
Wet season	0.4	0.7	1.1	0.6	1.0	1.6	0.9	1.4	2.1	1.1	1.8	2.6	1.3	2.1	3.2	1.5	2.4	3.7	1.7	2.8	4.2
Trans. season 2	0.4	0.7	1.0	0.6	1.0	1.4	0.9	1.3	1.9	1.1	1.7	2.4	1.3	2.0	2.9	1.5	2.3	3.4	1.7	2.6	3.8
Dry season	0.5	0.7	1.0	0.7	1.0	1.4	0.9	1.3	1.9	1.1	1.7	2.4	1.4	2.0	2.8	1.6	2.3	3.3	1.8	2.6	3.7
Trans. season 1	0.5	0.8	1.1	0.7	1.1	1.6	0.9	1.4	2.1	1.2	1.8	2.7	1.4	2.2	3.3	1.6	2.6	3.8	1.9	2.9	4.3

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.6	1.1	1.5	2.1	1.3	1.8	2.5	1.5	2.1	2.9	1.7	2.4	3.3
Wet half-year	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.2	1.2	1.8	2.6	1.4	2.1	3.0	1.6	2.4	3.4
Dry half-year	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.3	1.8	2.5	1.5	2.1	2.9	1.6	2.4	3.3
Wet season	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.2	1.2	1.8	2.7	1.4	2.1	3.1	1.6	2.4	3.5
Trans. season 2	0.4	0.6	0.9	0.6	0.9	1.3	0.8	1.2	1.7	1.0	1.5	2.1	1.2	1.8	2.6	1.4	2.1	3.0	1.6	2.4	3.4
Dry season	0.4	0.6	0.9	0.6	0.9	1.2	0.8	1.2	1.6	1.0	1.5	2.1	1.2	1.8	2.5	1.4	2.1	2.9	1.6	2.3	3.3
Trans. season 1	0.4	0.7	0.9	0.6	0.9	1.3	0.8	1.2	1.8	1.1	1.6	2.2	1.3	1.9	2.7	1.5	2.2	3.1	1.7	2.5	3.5
Rainforest region																					
Annual	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.2	1.3	1.9	2.6	1.5	2.1	2.9
Wet half-year	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.5	2.1	3.0
Dry half-year	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.5	0.9	1.3	1.9	1.1	1.6	2.2	1.3	1.9	2.6	1.5	2.1	2.9
Wet season	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.4	2.1	3.1
Trans. season 2	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.6	2.3	1.3	1.9	2.7	1.5	2.1	3.0
Dry season	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.4	0.9	1.3	1.8	1.1	1.6	2.2	1.2	1.8	2.6	1.4	2.1	2.9
Trans. season 1	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.1
Cairns																					
Annual	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	1.0	1.4	1.9	1.1	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.0
Wet half-year	0.4	0.6	0.8	0.6	0.8	1.1	0.8	1.1	1.5	1.0	1.4	1.9	1.2	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.1
Dry half-year	0.4	0.6	0.8	0.5	0.8	1.1	0.7	1.1	1.5	0.9	1.3	1.9	1.1	1.6	2.3	1.3	1.9	2.6	1.5	2.1	3.0
Wet season	0.4	0.6	0.8	0.6	0.8	1.2	0.7	1.1	1.6	0.9	1.4	2.0	1.1	1.7	2.4	1.3	1.9	2.8	1.5	2.2	3.1
Trans. season 2	0.4	0.6	0.8	0.6	0.8	1.1	0.8	1.1	1.5	1.0	1.4	2.0	1.2	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.1
Dry season	0.4	0.5	0.8	0.5	0.8	1.1	0.7	1.0	1.5	0.9	1.3	1.9	1.1	1.6	2.3	1.2	1.8	2.6	1.4	2.1	3.0
Trans. season 1	0.4	0.6	0.8	0.6	0.8	1.1	0.7	1.1	1.5	0.9	1.4	1.9	1.1	1.7	2.3	1.3	1.9	2.7	1.5	2.2	3.0

Appendix 12

10th, 50th and 90th percentile increases in regional seasonal average minimum temperatures (°C) for a high end SRES (A1FI) emissions scenario.

Key: 'Wet half-year' = December to May, 'Dry half-year' = June to November, 'Wet season' = January to March, 'Trans. season 2' = April to July, 'Dry season' = August to October, 'Trans. season 1' = November to December.

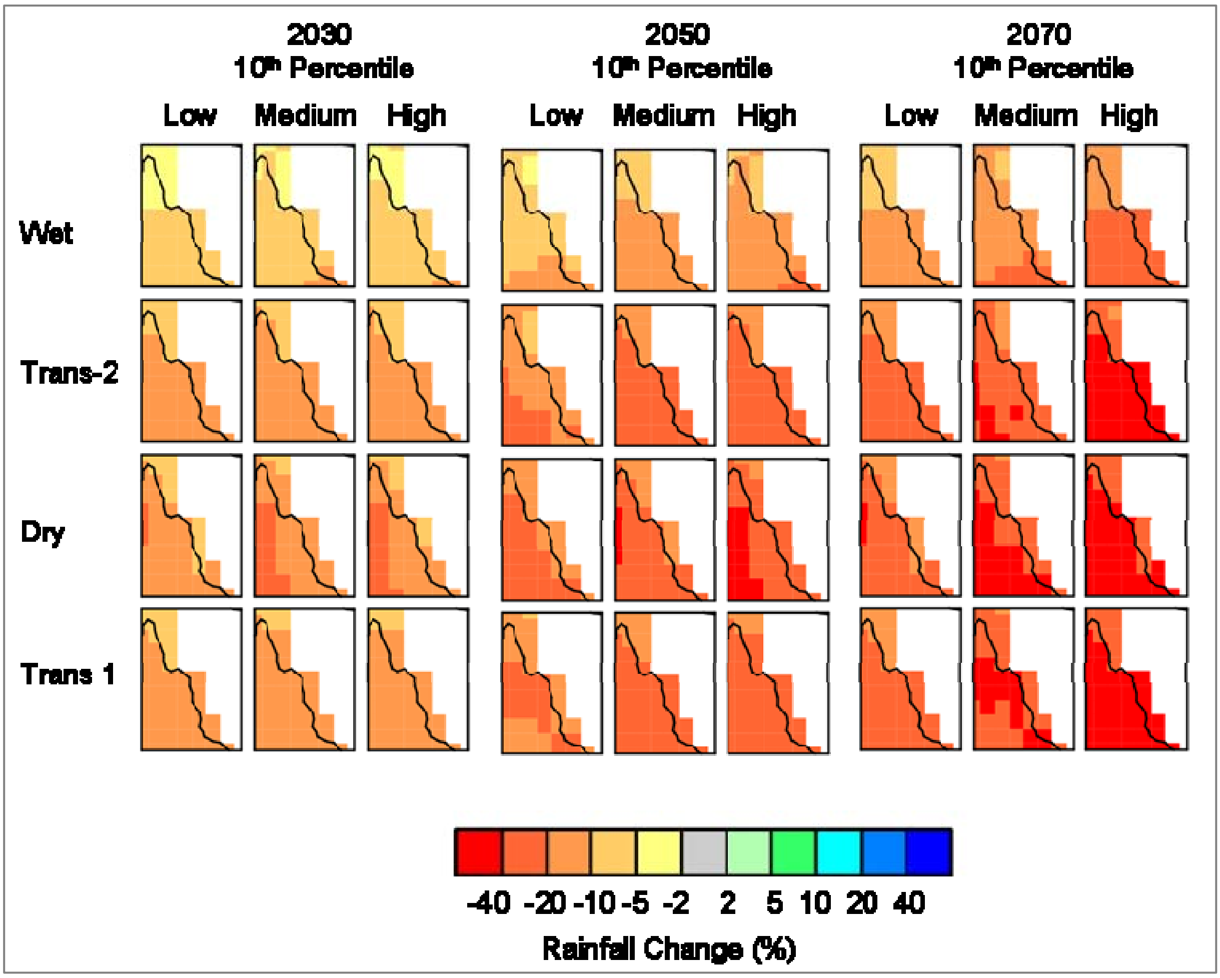
	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.7	1.7	2.5	3.6	2.1	3.1	4.3	2.5	3.6	5.1
Wet half-year	0.4	0.6	0.8	0.6	0.9	1.4	0.9	1.4	2.0	1.3	2.0	2.8	1.7	2.6	3.7	2.1	3.1	4.6	2.4	3.7	5.3
Dry half-year	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.6	1.7	2.5	3.5	2.1	3.0	4.2	2.5	3.5	5.0
Wet season	0.4	0.6	0.9	0.6	0.9	1.4	0.9	1.4	2.1	1.2	1.9	2.9	1.6	2.6	3.8	2.0	3.1	4.7	2.3	3.7	5.5
Trans. season 2	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	1.9	1.3	1.9	2.7	1.7	2.5	3.6	2.0	3.0	4.4	2.4	3.5	5.1
Dry season	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.3	1.9	1.3	1.9	2.6	1.7	2.5	3.5	2.1	3.0	4.3	2.4	3.5	5.0
Trans. season 1	0.4	0.6	0.9	0.6	1.0	1.4	1.0	1.5	2.1	1.3	2.0	3.0	1.8	2.7	3.9	2.2	3.3	4.8	2.5	3.8	5.6
Southern sub-region																					
Annual	0.4	0.6	0.8	0.7	1.0	1.4	1.0	1.4	2.0	1.4	2.0	2.9	1.8	2.7	3.8	2.2	3.2	4.6	2.6	3.8	5.4
Wet half-year	0.4	0.6	0.9	0.6	1.0	1.5	1.0	1.5	2.2	1.3	2.1	3.0	1.8	2.7	4.0	2.1	3.3	4.9	2.5	3.9	5.7
Dry half-year	0.4	0.6	0.8	0.7	1.0	1.3	1.0	1.4	2.0	1.4	2.0	2.8	1.8	2.6	3.6	2.2	3.2	4.4	2.6	3.7	5.2
Wet season	0.4	0.6	0.9	0.6	1.0	1.5	0.9	1.5	2.2	1.3	2.1	3.1	1.7	2.7	4.1	2.1	3.3	5.0	2.4	3.9	5.9
Trans. season 2	0.4	0.6	0.8	0.6	0.9	1.4	0.9	1.4	2.0	1.3	2.0	2.8	1.7	2.6	3.7	2.1	3.1	4.6	2.4	3.7	5.3
Dry season	0.4	0.6	0.8	0.6	0.9	1.3	0.9	1.4	2.0	1.3	2.0	2.8	1.7	2.6	3.7	2.1	3.2	4.5	2.5	3.7	5.2
Trans. season 1	0.4	0.6	0.9	0.7	1.0	1.5	1.0	1.5	2.3	1.4	2.2	3.2	1.8	2.8	4.2	2.2	3.5	5.1	2.6	4.1	6.0

	Year / Percentile / Temperature (°C)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.5	1.6	2.4	3.3	2.0	2.9	4.0	2.3	3.4	4.6
Wet half-year	0.4	0.5	0.8	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.6	1.6	2.4	3.4	2.0	2.9	4.1	2.3	3.4	4.8
Dry half-year	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.5	1.6	2.3	3.2	2.0	2.9	4.0	2.3	3.3	4.6
Wet season	0.3	0.5	0.8	0.6	0.9	1.3	0.8	1.3	1.9	1.2	1.8	2.6	1.5	2.3	3.4	1.9	2.9	4.2	2.2	3.3	4.9
Trans. season 2	0.4	0.5	0.7	0.6	0.9	1.2	0.9	1.3	1.8	1.2	1.8	2.5	1.6	2.3	3.3	2.0	2.9	4.1	2.3	3.4	4.7
Dry season	0.4	0.5	0.7	0.6	0.8	1.2	0.9	1.2	1.8	1.2	1.7	2.4	1.6	2.3	3.2	1.9	2.8	3.9	2.3	3.3	4.6
Trans. season 1	0.4	0.5	0.8	0.6	0.9	1.3	0.9	1.3	1.9	1.3	1.9	2.6	1.7	2.4	3.5	2.0	3.0	4.2	2.4	3.5	4.9
Rainforest region																					
Annual	0.3	0.5	0.6	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.5	2.1	2.9	1.8	2.6	3.5	2.1	3.0	4.1
Wet half-year	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.3	1.4	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.2
Dry half-year	0.3	0.5	0.6	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.1	2.9	1.8	2.5	3.5	2.0	3.0	4.1
Wet season	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.3	1.4	2.1	3.0	1.7	2.6	3.7	2.0	3.0	4.3
Trans. season 2	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.2
Dry season	0.3	0.5	0.6	0.5	0.7	1.1	0.8	1.1	1.6	1.1	1.5	2.2	1.4	2.0	2.9	1.7	2.5	3.5	2.0	2.9	4.1
Trans. season 1	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.1	3.0	1.8	2.6	3.7	2.1	3.1	4.3
Cairns																					
Annual	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.2	1.5	2.1	3.0	1.8	2.6	3.6	2.1	3.0	4.2
Wet half-year	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.2	3.0	1.8	2.6	3.7	2.1	3.1	4.3
Dry half-year	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.1	1.6	1.1	1.6	2.2	1.4	2.1	2.9	1.8	2.6	3.6	2.0	3.0	4.2
Wet season	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.7	1.1	1.6	2.3	1.5	2.2	3.1	1.8	2.6	3.8	2.1	3.1	4.4
Trans. season 2	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.2	3.0	1.8	2.6	3.7	2.1	3.1	4.3
Dry season	0.3	0.5	0.7	0.5	0.7	1.1	0.7	1.1	1.6	1.0	1.5	2.2	1.4	2.0	2.9	1.7	2.5	3.6	2.0	2.9	4.2
Trans. season 1	0.3	0.5	0.7	0.5	0.8	1.1	0.8	1.2	1.6	1.1	1.6	2.3	1.5	2.1	3.0	1.8	2.6	3.7	2.1	3.0	4.3

Appendix 13

Low-end (10th percentile) projected changes in seasonal average rainfall in percentage for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070.

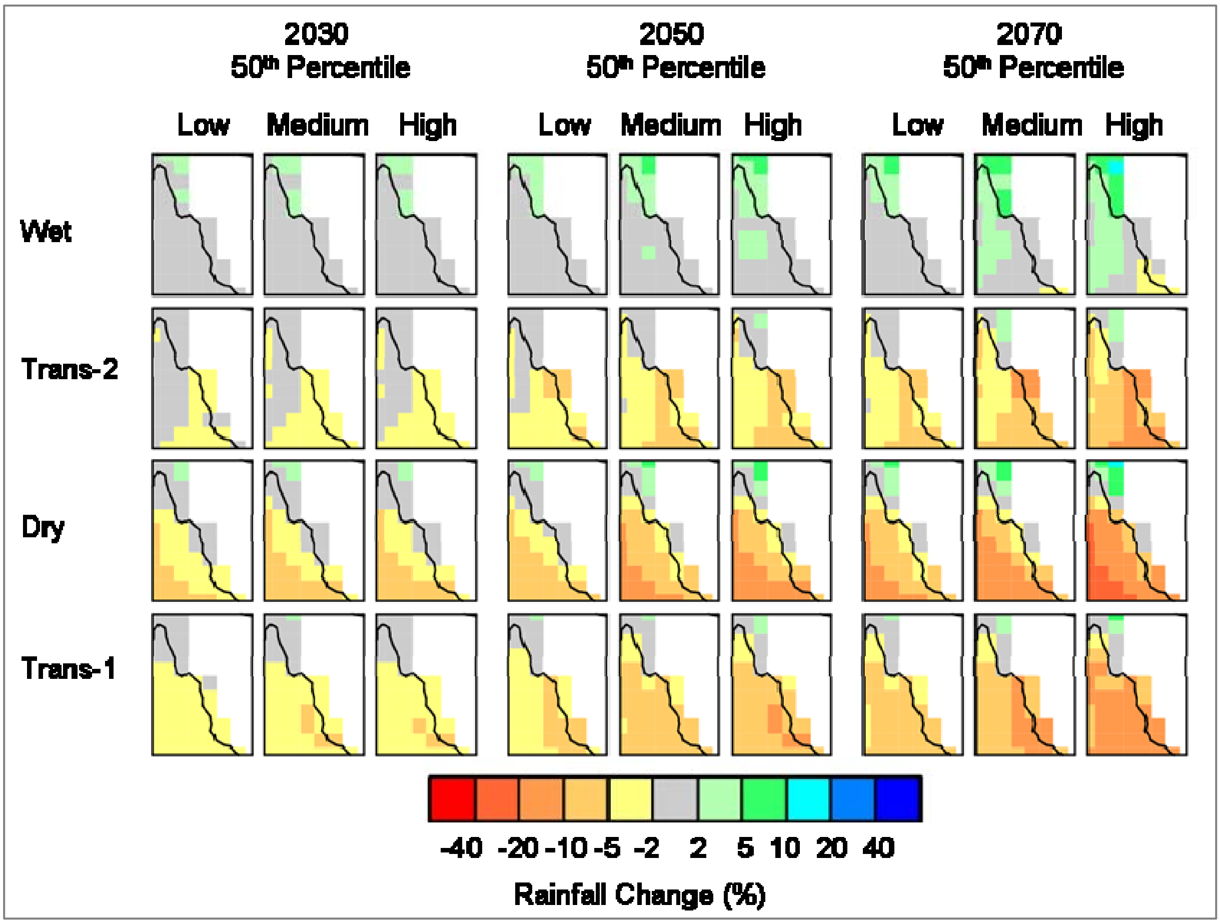
Key: 'Wet' = Wet season (January to March), 'Trans-2' = Transitional Season 2 (April to July), 'Dry' = Dry season (August to October), 'Trans-1' = Transitional Season 1 (November to December).



Appendix 14

Best estimate (50th percentile) projected changes in seasonal average rainfall in percentage for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070.

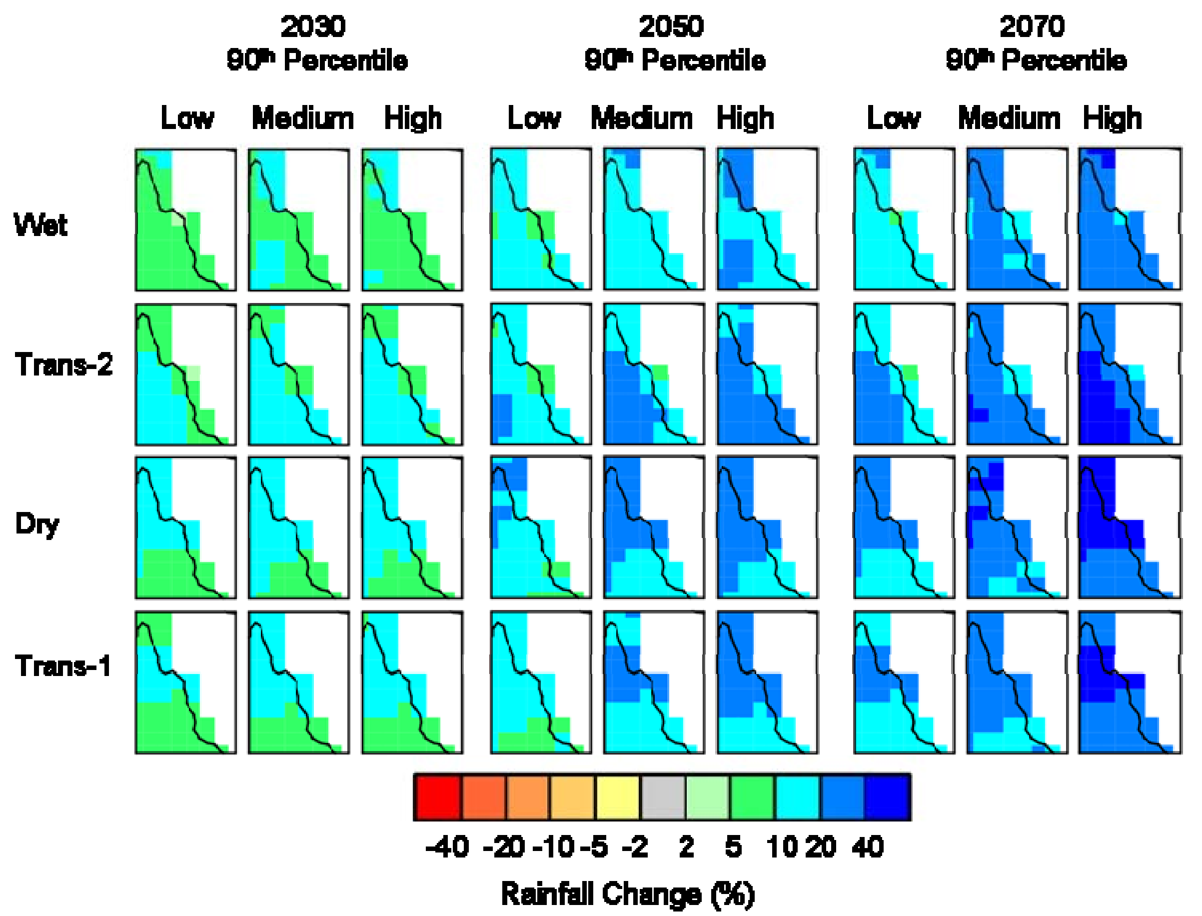
Key: 'Wet' = Wet season (January to March), 'Trans-2' = Transitional Season 2 (April to July), 'Dry' = Dry season (August to October), 'Trans-1' = Transitional Season 1 (November to December).



Appendix 15

High-end (90th percentile) projected changes seasonal average rainfall in percentage) for low (SRES B1), medium (SRES A1B) and high (SRES A1FI) emissions scenarios for 2030, 2050 and 2070.

Key: 'Wet' = Wet season (January to March), 'Trans-2' = Transitional Season 2 (April to July), 'Dry' = Dry season (August to October), 'Trans-1' = Transitional Season 1 (November to December).



Appendix 16

Projected annual and seasonal rainfall changes of 10th, 50th and 90th percentiles in percentage, relative to averages for the 20-year period (1980-1999) for the low end SRES (B1) emission scenario for the regions shown in Figure 1.

Key: 'Wet half-year' = December to May, 'Dry half-year' = June to November, 'Wet season' = January to March, 'Trans. season 2' = April to July, 'Dry season' = August to October, 'Trans. season 1' = November to December.

	Year / Percentile / Rainfall change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	-6	-1	4	-7	-1	5	-9	-2	7	-11	-2	8	-13	-2	9	-15	-3	10	-16	-3	12
Wet half-year	-6	-1	5	-7	-1	6	-9	-1	8	-11	-1	9	-13	-1	11	-15	-2	13	-16	-2	14
Dry half-year	-10	-3	4	-13	-4	6	-16	-4	7	-19	-5	9	-22	-6	10	-25	-7	12	-28	-8	13
Wet season	-5	0	6	-7	0	8	-8	0	9	-10	0	11	-12	0	13	-14	0	15	-15	0	17
Trans. Season 2	-9	-2	7	-12	-2	9	-15	-3	11	-18	-4	13	-21	-4	16	-24	-5	18	-26	-5	20
Dry season	-12	-4	5	-15	-5	6	-19	-6	8	-22	-8	9	-27	-9	11	-31	-10	12	-34	-11	14
Trans. season 1	-10	-2	6	-13	-3	8	-16	-3	10	-18	-4	11	-22	-5	14	-25	-6	15	-28	-6	17
Southern sub-region																					
Annual	-7	-2	3	-9	-2	5	-11	-3	6	-13	-3	7	-16	-4	8	-18	-5	9	-20	-5	10
Wet half-year	-7	-1	5	-9	-2	6	-11	-2	8	-13	-2	9	-16	-3	11	-18	-3	12	-19	-4	14
Dry half-year	-9	-3	3	-12	-4	4	-15	-5	5	-18	-6	6	-22	-7	8	-25	-8	9	-27	-9	9
Wet season	-7	-1	6	-9	-1	8	-11	-1	10	-13	-1	11	-16	-2	14	-18	-2	15	-20	-2	17
Trans. season 2	-9	-2	6	-12	-3	8	-15	-4	10	-18	-4	12	-22	-5	15	-24	-6	17	-27	-6	19
Dry season	-12	-4	4	-16	-6	5	-19	-7	6	-23	-9	7	-28	-10	8	-31	-12	10	-34	-13	11
Trans. Season 1	-9	-2	5	-12	-3	6	-15	-4	8	-18	-4	9	-21	-5	11	-24	-6	13	-27	-7	14

	Year / Percentile / Rainfall change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
North sub-region																					
Annual	-5	0	4	-6	-1	6	-8	-1	7	-9	-1	8	-11	-1	10	-13	-1	12	-14	-1	13
Wet half-year	-5	0	5	-6	0	7	-8	0	8	-9	0	10	-11	0	12	-13	0	13	-14	-1	14
Dry half-year	-10	-2	6	-13	-3	8	-16	-3	10	-19	-4	12	-23	-5	15	-26	-6	16	-29	-6	18
Wet season	-4	0	6	-6	1	7	-7	1	9	-8	1	11	-10	1	13	-11	1	15	-12	1	16
Trans. season 2	-9	-1	7	-12	-2	9	-14	-2	12	-17	-3	14	-20	-3	17	-23	-4	19	-26	-4	21
Dry season	-11	-3	7	-14	-3	9	-18	-4	12	-21	-5	14	-25	-6	16	-29	-7	19	-32	-8	20
Trans. season 1	-10	-2	7	-13	-3	9	-16	-3	11	-19	-4	13	-23	-5	16	-26	-5	18	-29	-6	19
Rainforest region																					
Annual	-5	-1	3	-6	-1	4	-8	-1	6	-10	-2	7	-11	-2	8	-13	-2	9	-14	-2	10
Wet half-year	-5	-1	4	-7	-1	5	-8	-1	6	-10	-1	7	-12	-2	9	-13	-2	10	-14	-2	11
Dry half-year	-8	-2	5	-11	-3	7	-14	-3	8	-16	-4	10	-19	-4	11	-22	-5	13	-24	-6	14
Wet season	-4	0	5	-6	0	6	-7	0	8	-9	0	9	-10	0	11	-12	0	13	-13	0	14
Trans. season 2	-9	-2	6	-11	-2	8	-14	-3	10	-16	-4	12	-20	-4	14	-22	-5	16	-25	-5	18
Dry season	-9	-2	6	-12	-3	8	-15	-4	9	-18	-4	11	-21	-5	13	-24	-6	15	-27	-6	17
Trans. season 1	-10	-3	5	-13	-3	7	-16	-4	9	-19	-5	10	-22	-6	12	-25	-7	14	-28	-7	15
Cairns																					
Annual	-5	-1	4	-7	-1	5	-8	-1	6	-10	-2	7	-12	-2	8	-13	-2	9	-14	-2	10
Wet half-year	-5	-1	4	-7	-1	5	-8	-1	6	-10	-1	7	-12	-2	9	-14	-2	10	-15	-2	11
Dry half-year	-8	-1	5	-10	-2	7	-12	-2	9	-15	-3	10	-17	-3	13	-20	-4	14	-22	-4	16
Wet season	-5	0	5	-6	0	6	-7	0	8	-9	0	9	-11	0	11	-12	0	13	-13	0	14
Trans. season 2	-9	-2	6	-11	-2	8	-14	-3	10	-17	-4	12	-20	-4	15	-23	-5	17	-25	-5	18
Dry season	-8	-2	6	-11	-2	8	-13	-2	10	-15	-3	12	-19	-4	14	-21	-4	16	-23	-4	17
Trans. season 1	-10	-3	6	-13	-4	7	-16	-4	9	-19	-5	11	-23	-6	13	-26	-7	15	-29	-8	16

Appendix 17

Projected annual and seasonal rainfall changes of 10th, 50th and 90th percentiles in percentage, relative to averages for the 20-year period (1980-1999) for the medium case SRES (A1B) emission scenario for the regions shown in Figure 1.

Key: 'Wet half-year' = December to May, 'Dry half-year' = June to November, 'Wet season' = January to March, 'Trans. season 2' = April to July, 'Dry season' = August to October, 'Trans. season 1' = November to December.

	Year / Percentile / Rainfall change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	-6	-1	4	-9	-2	6	-12	-2	8	-15	-3	11	-18	-3	13	-21	-4	15	-24	-4	17
Wet half-year	-6	-1	5	-9	-1	8	-12	-1	10	-15	-2	13	-18	-2	16	-21	-2	18	-24	-2	21
Dry half-year	-11	-3	5	-15	-4	7	-20	-6	9	-26	-7	12	-31	-9	14	-36	-10	17	-41	-12	19
Wet season	-6	0	6	-8	0	9	-11	0	12	-14	0	15	-17	0	19	-19	0	22	-22	0	24
Trans. season 2	-10	-2	7	-14	-3	11	-19	-4	14	-24	-5	18	-29	-6	22	-34	-7	25	-38	-8	28
Dry season	-13	-4	5	-18	-6	7	-24	-8	10	-31	-10	13	-37	-13	15	-43	-15	18	-49	-16	20
Trans. season 1	-11	-2	7	-15	-3	9	-20	-4	12	-26	-6	16	-31	-7	19	-36	-8	22	-40	-9	25
Southern sub-region																					
Annual	-7	-2	4	-11	-3	5	-14	-4	7	-18	-5	9	-22	-6	11	-25	-6	13	-29	-7	15
Wet half-year	-7	-1	5	-11	-2	7	-14	-3	10	-18	-3	13	-22	-4	15	-25	-5	18	-28	-5	20
Dry half-year	-10	-3	4	-15	-5	5	-20	-7	7	-25	-8	9	-31	-10	11	-35	-12	12	-40	-13	14
Wet season	-8	-1	6	-11	-1	9	-14	-1	12	-18	-2	16	-22	-2	19	-26	-3	22	-29	-3	25
Trans. season 2	-10	-2	7	-15	-3	10	-20	-5	13	-25	-6	17	-30	-7	21	-35	-8	24	-39	-9	27
Dry season	-13	-5	4	-19	-7	6	-25	-9	8	-32	-12	10	-38	-14	12	-44	-17	14	-50	-19	15
Trans. season 1	-10	-2	5	-15	-4	8	-19	-5	10	-25	-6	13	-30	-7	16	-34	-8	18	-39	-10	21

	Year / Percentile / Rainfall change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	-5	0	5	-8	-1	7	-10	-1	9	-13	-1	12	-16	-1	14	-18	-2	16	-21	-2	19
Wet half-year	-5	0	6	-8	0	8	-10	0	11	-13	0	13	-16	-1	16	-18	-1	19	-20	-1	21
Dry half-year	-11	-2	7	-16	-3	10	-21	-4	13	-27	-6	17	-32	-7	20	-37	-8	23	-42	-9	27
Wet season	-5	0	6	-7	1	9	-9	1	12	-11	1	15	-14	1	18	-16	1	21	-18	2	24
Trans. season 2	-10	-2	8	-14	-2	11	-19	-3	15	-24	-4	19	-28	-5	23	-33	-5	27	-37	-6	30
Dry season	-12	-3	8	-17	-4	11	-23	-5	15	-30	-7	19	-36	-8	23	-41	-10	26	-47	-11	30
Trans. season 1	-11	-2	7	-16	-3	11	-21	-4	14	-27	-5	18	-32	-7	22	-37	-8	25	-42	-9	28
Rainforest region																					
Annual	-5	-1	4	-8	-1	5	-10	-2	7	-13	-2	9	-16	-3	11	-18	-3	13	-21	-4	14
Wet half-year	-6	-1	4	-8	-1	6	-11	-1	8	-13	-2	10	-16	-2	12	-19	-3	14	-21	-3	16
Dry half-year	-9	-2	5	-13	-3	8	-18	-4	10	-22	-5	13	-27	-6	16	-31	-7	19	-35	-8	21
Wet season	-5	0	5	-7	0	8	-9	0	10	-12	0	13	-14	0	15	-17	0	18	-19	0	20
Trans. season 2	-9	-2	7	-13	-3	10	-18	-4	13	-23	-5	16	-28	-6	20	-32	-7	23	-36	-8	26
Dry season	-10	-2	6	-15	-3	9	-19	-5	12	-25	-6	15	-30	-7	18	-35	-8	21	-39	-9	24
Trans. season 1	-11	-3	6	-15	-4	8	-20	-5	11	-26	-7	14	-31	-8	17	-36	-9	20	-41	-11	22
Cairns																					
Annual	-6	-1	4	-8	-1	6	-11	-2	7	-13	-2	9	-16	-3	11	-19	-3	13	-21	-4	15
Wet half-year	-6	-1	4	-8	-1	6	-11	-2	8	-14	-2	10	-17	-3	12	-19	-3	14	-22	-3	16
Dry half-year	-8	-2	6	-12	-2	9	-16	-3	11	-20	-4	15	-24	-4	18	-28	-5	20	-32	-6	23
Wet season	-5	0	5	-7	0	8	-10	0	10	-12	0	13	-15	0	16	-17	0	18	-19	0	20
Trans. season 2	-10	-2	7	-14	-3	10	-18	-4	13	-23	-5	17	-28	-6	20	-32	-7	24	-37	-8	27
Dry season	-9	-2	7	-13	-2	9	-17	-3	13	-22	-4	16	-26	-5	19	-30	-6	22	-34	-6	25
Trans. season 1	-11	-3	6	-16	-4	9	-21	-6	12	-27	-7	15	-32	-9	18	-37	-10	21	-42	-11	24

Appendix 18

Projected annual and seasonal rainfall changes of 10th, 50th and 90th percentiles in percentage, relative to averages for the 20-year period (1980-1999) for the high end SRES (A1FI) emission scenario for the regions shown in Figure 1.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Rainfall change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	-5	-1	4	-9	-1	6	-13	-2	9	-18	-3	13	-24	-4	17	-29	-5	20	-34	-6	24
Wet half-year	-5	-1	5	-8	-1	7	-13	-1	11	-18	-2	15	-23	-2	20	-28	-3	25	-33	-3	29
Dry half-year	-9	-3	4	-15	-4	7	-22	-6	10	-30	-9	14	-40	-11	18	-49	-14	23	-57	-16	26
Wet season	-5	0	5	-8	0	9	-12	0	13	-16	0	18	-22	0	24	-26	0	29	-31	0	34
Trans. season 2	-8	-2	6	-14	-3	10	-21	-4	15	-29	-6	21	-38	-8	28	-46	-9	34	-54	-11	40
Dry season	-11	-4	4	-18	-6	7	-26	-9	11	-37	-12	15	-48	-16	20	-59	-20	24	-69	-23	28
Trans. season 1	-9	-2	5	-15	-3	9	-22	-5	13	-30	-7	19	-40	-9	24	-49	-11	30	-57	-13	35
Southern sub-region																					
Annual	-6	-2	3	-10	-3	5	-15	-4	8	-21	-5	11	-28	-7	14	-34	-9	17	-40	-10	20
Wet half-year	-6	-1	4	-10	-2	7	-15	-3	11	-21	-4	15	-28	-5	20	-34	-6	24	-40	-7	28
Dry half-year	-9	-3	3	-14	-5	5	-21	-7	7	-30	-10	10	-39	-13	14	-48	-16	17	-56	-19	19
Wet season	-6	-1	5	-10	-1	9	-16	-2	13	-22	-2	19	-29	-3	24	-35	-3	30	-41	-4	35
Trans. season 2	-9	-2	6	-14	-3	10	-21	-5	14	-29	-7	20	-39	-9	27	-47	-11	33	-55	-13	38
Dry season	-11	-4	3	-18	-7	6	-27	-10	8	-38	-14	12	-49	-19	15	-60	-23	19	-70	-27	22
Trans. season 1	-9	-2	5	-14	-3	7	-21	-5	11	-29	-7	15	-38	-9	20	-47	-11	25	-55	-13	29

	Year / Percentile / Rainfall change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub region																					
Annual	-5	0	4	-7	-1	7	-11	-1	10	-15	-1	14	-20	-2	18	-25	-2	22	-29	-3	26
Wet half-year	-4	0	5	-7	0	8	-11	0	11	-15	-1	16	-20	-1	21	-25	-1	25	-29	-1	30
Dry half-year	-9	-2	6	-15	-3	10	-22	-5	14	-31	-7	20	-41	-9	26	-50	-11	32	-59	-13	37
Wet season	-4	0	5	-6	1	9	-10	1	13	-13	1	18	-18	2	24	-22	2	29	-25	2	34
Trans. season 2	-8	-1	7	-13	-2	11	-20	-3	16	-28	-5	23	-37	-6	30	-45	-7	37	-52	-9	43
Dry season	-10	-2	7	-17	-4	11	-25	-6	16	-35	-8	22	-46	-11	29	-56	-13	36	-65	-15	42
Trans. season 1	-9	-2	6	-15	-3	10	-22	-5	15	-31	-6	21	-41	-8	28	-50	-10	34	-59	-12	40
Rainforest region																					
Annual	-5	-1	3	-8	-1	5	-11	-2	8	-16	-3	11	-21	-3	14	-25	-4	17	-29	-5	20
Wet half-year	-5	-1	4	-8	-1	6	-11	-2	9	-16	-2	12	-21	-3	16	-25	-3	20	-30	-4	23
Dry half-year	-8	-2	5	-13	-3	8	-19	-4	11	-26	-6	16	-35	-8	21	-42	-10	25	-49	-11	29
Wet season	-4	0	4	-7	0	7	-10	0	11	-14	0	15	-19	0	20	-23	0	24	-26	0	28
Trans. season 2	-8	-2	6	-13	-3	9	-19	-4	14	-27	-6	19	-35	-8	25	-43	-9	31	-51	-11	36
Dry season	-9	-2	5	-14	-3	9	-21	-5	13	-29	-7	18	-38	-9	24	-47	-11	29	-55	-13	34
Trans. season 1	-9	-2	5	-15	-4	8	-22	-6	12	-30	-8	17	-40	-10	22	-49	-13	27	-57	-15	31
Cairns																					
Annual	-5	-1	3	-8	-1	5	-11	-2	8	-16	-3	11	-21	-3	15	-25	-4	18	-30	-5	21
Wet half-year	-5	-1	4	-8	-1	6	-12	-2	9	-16	-2	12	-22	-3	16	-26	-4	20	-31	-5	23
Dry half-year	-7	-1	5	-12	-2	8	-17	-3	12	-24	-4	17	-31	-6	23	-38	-7	28	-45	-8	32
Wet season	-4	0	4	-7	0	7	-10	0	11	-14	0	15	-19	0	20	-23	0	25	-27	-1	29
Trans. season 2	-8	-2	6	-13	-3	10	-20	-4	14	-27	-6	20	-36	-8	26	-44	-9	32	-51	-11	38
Dry season	-7	-1	6	-12	-2	9	-18	-3	14	-25	-5	19	-33	-6	25	-41	-8	31	-48	-9	36
Trans. season 1	-9	-2	5	-15	-4	9	-22	-6	13	-31	-8	18	-41	-11	24	-50	-14	29	-59	-16	34

Appendix 19

Projected annual and seasonal potential evaporation changes of 10th, 50th and 90th percentiles in percentage, relative to averages for the 20-year period (1980-1999) for the low end SRES (B1) emission scenario for the regions shown in Figure 1.

Key: 'Wet half-year' = December to May, 'Dry half-year' = June to November, 'Wet season' = January to March, 'Trans. season 2' = April to July, 'Dry season' = August to October, 'Trans. season 1' = November to December.

	Year / Percentile / Potential evaporation change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	1	2	3	1	2	4	2	3	4	2	3	5	3	4	6	3	5	7	3	5	8
Wet half-year	1	2	3	1	2	4	2	3	4	2	3	5	3	4	6	3	5	7	3	5	8
Dry half-year	1	2	3	1	2	4	2	3	4	2	3	5	3	4	6	3	5	7	3	5	8
Wet season	1	2	3	1	2	4	1	3	5	2	3	6	2	4	7	2	5	8	2	5	9
Trans. Season 2	1	2	3	1	3	5	2	3	6	2	4	7	2	5	8	3	6	9	3	6	10
Dry season	1	2	3	1	2	4	1	3	5	1	3	5	2	4	6	2	4	7	2	5	8
Trans. season 1	1	2	3	1	2	3	1	3	4	2	3	5	2	4	6	2	4	7	2	5	8
Southern sub-region																					
Annual	1	2	3	1	2	4	2	3	4	2	3	5	2	4	6	3	5	7	3	5	8
Wet half-year	1	2	3	1	2	4	2	3	5	2	3	5	2	4	6	3	5	7	3	5	8
Dry half-year	1	2	3	1	2	4	2	3	4	2	3	5	2	4	6	3	5	7	3	5	8
Wet season	1	2	3	1	2	4	1	3	5	2	3	6	2	4	7	2	5	8	2	5	9
Trans. season 2	1	2	4	1	3	5	2	4	6	2	4	7	2	5	9	3	6	10	3	6	11
Dry season	1	2	3	1	2	4	1	3	5	1	3	6	1	4	7	1	4	8	2	5	9
Trans. Season1	1	2	3	1	2	4	1	3	4	1	3	5	2	4	6	2	4	7	2	5	8

	Year / Percentile / Potential evaporation change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
North sub-region																					
Annual	1	2	3	2	2	3	2	3	4	2	3	5	3	4	6	3	5	7	4	5	7
Wet half-year	1	2	3	2	2	3	2	3	4	2	3	5	3	4	6	3	5	7	4	5	8
Dry half-year	1	2	3	2	2	3	2	3	4	2	3	5	3	4	6	3	5	7	4	5	7
Wet season	1	2	3	1	2	4	1	3	5	2	4	6	2	4	7	2	5	8	2	5	9
Trans. season 2	1	2	3	2	3	4	2	3	5	2	4	6	3	5	7	3	5	8	3	6	9
Dry season	1	2	2	1	2	3	2	3	4	2	3	5	2	4	6	3	4	6	3	5	7
Trans. season 1	1	2	3	1	2	3	2	3	4	2	3	5	2	4	6	3	4	7	3	5	7
Rainforest region																					
Annual	1	2	2	2	2	3	2	3	4	2	3	5	3	4	6	3	4	6	3	5	7
Wet half-year	1	2	2	2	2	3	2	3	4	2	3	5	3	4	6	3	4	6	3	5	7
Dry half-year	1	2	2	2	2	3	2	3	4	2	3	5	3	4	6	3	4	6	3	5	7
Wet season	1	2	3	1	2	4	1	3	5	2	3	6	2	4	7	2	5	8	2	5	9
Trans. season 2	1	2	3	2	3	4	2	3	5	2	4	6	3	5	7	3	5	8	4	6	8
Dry season	1	1	2	1	2	3	2	2	4	2	3	4	2	3	5	3	4	6	3	4	6
Trans. season 1	1	2	2	1	2	3	2	2	4	2	3	4	2	4	5	2	4	6	3	4	7
Cairns																					
Annual	1	1	2	1	2	2	1	2	3	2	2	3	2	3	4	2	3	5	2	4	5
Wet half-year	1	1	2	1	2	2	1	2	3	2	2	3	2	3	4	2	3	5	2	4	5
Dry half-year	1	1	2	1	2	2	1	2	3	2	2	3	2	3	4	2	3	5	2	4	5
Wet season	1	1	2	1	2	3	1	2	4	1	3	4	1	3	5	2	4	6	2	4	7
Trans. season 2	1	1	2	1	2	3	2	2	3	2	3	4	2	3	5	2	4	5	3	4	6
Dry season	1	1	2	1	1	2	1	2	2	1	2	3	2	3	3	2	3	4	2	3	4
Trans. season 1	1	1	2	1	1	2	1	2	3	1	2	3	2	3	4	2	3	5	2	3	5

Appendix 20

Projected annual and seasonal potential evaporation changes of 10th, 50th and 90th percentiles in percentage, relative to averages for the 20-year period (1980-1999) for the medium case SRES (A1B) emission scenario for the regions shown in Figure 1.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Potential evaporation change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	1	2	3	2	3	4	2	4	6	3	5	7	4	6	9	4	7	10	5	8	11
Wet half-year	1	2	3	2	3	4	2	4	6	3	5	7	4	6	9	4	7	10	5	8	11
Dry half-year	1	2	3	2	3	4	2	4	6	3	5	7	4	6	9	4	7	10	5	8	11
Wet season	1	2	3	1	3	5	2	4	6	2	5	8	3	6	10	3	7	11	4	8	13
Trans. season 2	1	2	4	2	3	5	2	4	7	3	6	9	3	7	11	4	8	13	5	9	15
Dry season	1	2	3	1	3	4	2	3	6	2	4	7	2	5	9	3	6	10	3	7	12
Trans. season 1	1	2	3	1	3	4	2	3	6	2	4	7	3	5	9	3	6	10	3	7	11
Southern sub-region																					
Annual	1	2	3	2	3	4	2	4	6	3	5	7	3	6	9	4	7	10	4	8	12
Wet half-year	1	2	3	2	3	4	2	4	6	3	5	7	3	6	9	4	7	10	4	8	12
Dry half-year	1	2	3	2	3	4	2	4	6	3	5	7	3	6	9	4	7	10	4	8	12
Wet season	1	2	3	1	3	5	2	4	6	2	5	8	3	6	10	3	7	11	3	8	13
Trans. season 2	1	2	4	2	3	6	2	5	8	3	6	10	3	7	12	4	8	14	4	9	16
Dry season	1	2	3	1	3	5	1	3	6	1	4	8	2	5	10	2	6	11	2	7	13
Trans. season 1	1	2	3	1	3	4	1	3	6	2	4	7	2	5	9	2	6	10	3	7	12

	Year / Percentile / Potential evaporation change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub-region																					
Annual	1	2	3	2	3	4	3	4	5	3	5	7	4	6	8	5	7	10	5	8	11
Wet half-year	1	2	3	2	3	4	3	4	5	3	5	7	4	6	8	5	7	10	5	8	11
Dry half-year	1	2	3	2	3	4	3	4	5	3	5	7	4	6	8	5	7	10	5	8	11
Wet season	1	2	3	1	3	5	2	4	7	2	5	8	3	6	10	3	7	12	4	8	13
Trans. season 2	1	2	4	2	3	5	2	4	7	3	6	9	4	7	10	4	8	12	5	9	13
Dry season	1	2	3	2	3	4	2	3	5	3	4	7	3	5	8	4	6	9	4	7	10
Trans. season 1	1	2	3	2	3	4	2	3	5	3	4	7	3	5	8	4	6	9	4	7	11
Rainforest region																					
Annual	1	2	3	2	3	4	2	4	5	3	5	6	4	5	8	4	6	9	5	7	10
Wet half-year	1	2	3	2	3	4	2	4	5	3	5	6	4	5	8	4	6	9	5	7	10
Dry half-year	1	2	3	2	3	4	2	4	5	3	5	6	4	5	8	4	6	9	5	7	10
Wet season	1	2	3	1	3	5	2	4	6	2	5	8	3	6	10	3	7	11	4	7	13
Trans. season 2	1	2	3	2	3	5	3	4	6	3	5	8	4	6	9	5	7	11	5	8	12
Dry season	1	2	2	2	2	3	2	3	5	3	4	6	3	5	7	4	6	8	4	6	9
Trans. season 1	1	2	3	1	2	4	2	3	5	2	4	6	3	5	7	3	6	9	4	6	10
Cairns																					
Annual	1	1	2	1	2	3	2	3	4	2	3	5	3	4	6	3	5	7	4	5	8
Wet half-year	1	1	2	1	2	3	2	3	4	2	3	5	3	4	6	3	5	7	4	5	8
Dry half-year	1	1	2	1	2	3	2	3	4	2	3	5	3	4	6	3	5	7	4	5	7
Wet season	1	1	2	1	2	4	1	3	5	2	4	6	2	4	7	2	5	8	3	6	10
Trans. season 2	1	2	2	1	2	3	2	3	4	3	4	5	3	5	7	4	5	8	4	6	9
Dry season	1	1	2	1	2	2	2	2	3	2	3	4	2	3	5	3	4	6	3	5	6
Trans. season 1	1	1	2	1	2	3	1	2	4	2	3	5	2	4	6	3	4	7	3	5	7

Appendix 21

Projected annual and seasonal potential evaporation changes of 10th, 50th and 90th percentiles in percentage, relative to averages for the 20-year period (1980-1999) for the high end SRES (A1FI) emission scenario for the regions shown in Figure 1.

Key: ‘Wet half-year’ = December to May, ‘Dry half-year’ = June to November, ‘Wet season’ = January to March, ‘Trans. season 2’ = April to July, ‘Dry season’ = August to October, ‘Trans. season 1’ = November to December.

	Year / Percentile / Potential evaporation change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Entire region																					
Annual	1	2	3	2	3	4	2	4	6	3	6	9	5	7	11	6	9	14	7	11	16
Wet half-year	1	2	3	2	3	4	2	4	6	3	6	9	5	7	11	6	9	14	7	11	16
Dry half-year	1	2	2	2	3	4	3	4	6	4	6	8	5	7	11	6	9	14	7	11	16
Wet season	1	2	3	1	3	5	2	4	7	3	6	10	3	8	13	4	9	15	5	11	18
Trans. season 2	1	2	3	2	3	5	2	5	8	3	7	11	4	9	14	5	11	18	6	13	21
Dry season	1	2	3	1	3	4	2	4	6	2	5	9	3	7	11	4	8	14	4	10	16
Trans. season 1	1	2	2	1	2	4	2	4	6	2	5	8	3	7	11	4	8	14	5	10	16
Southern sub-region																					
Annual	1	2	3	2	3	4	2	4	6	3	6	9	4	7	11	5	9	14	6	11	16
Wet half-year	1	2	3	2	3	4	2	4	6	3	6	9	4	7	11	5	9	14	6	11	16
Dry half-year	1	2	3	2	3	4	2	4	6	3	6	9	4	7	11	5	9	14	6	11	16
Wet season	1	2	3	1	3	5	2	4	7	3	6	9	3	7	12	4	9	15	5	11	18
Trans. season 2	1	2	3	1	3	6	2	5	8	3	7	12	4	9	15	5	11	19	6	13	22
Dry season	1	2	3	1	3	5	1	4	7	2	5	9	2	7	12	3	8	15	3	10	18
Trans. season 1	1	1	3	1	2	4	1	4	6	2	5	9	3	7	11	3	8	14	4	10	16

	Year / Percentile / Potential evaporation change (%)																				
	2020			2030			2040			2050			2060			2070			2080		
Region	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Northern sub region																					
Annual	1	2	2	2	3	4	3	4	6	4	6	8	5	8	11	6	9	13	7	11	15
Wet half-year	1	2	2	2	3	4	3	4	6	4	6	8	5	8	11	6	9	13	7	11	15
Dry half-year	1	2	2	2	3	4	3	4	6	4	6	8	5	8	11	6	9	13	7	11	15
Wet season	1	2	3	1	3	5	2	4	7	3	6	10	3	8	13	4	9	16	5	11	19
Trans. season 2	1	2	3	2	3	5	3	5	7	4	6	10	5	9	13	6	10	16	7	12	19
Dry season	1	2	2	2	3	4	2	4	6	3	5	8	4	7	10	5	8	13	6	10	15
Trans. season 1	1	2	2	2	3	4	2	4	6	3	5	8	4	7	10	5	8	13	6	10	15
Rainforest region																					
Annual	1	2	2	2	3	4	3	4	5	4	5	8	5	7	10	6	9	12	7	10	14
Wet half-year	1	2	2	2	3	4	3	4	5	4	5	8	5	7	10	6	9	12	7	10	14
Dry half-year	1	2	2	2	3	4	3	4	5	4	5	8	5	7	10	6	9	12	7	10	14
Wet season	1	2	3	1	3	5	2	4	7	3	6	9	3	7	12	4	9	15	5	11	18
Trans. season 2	1	2	3	2	3	4	3	4	7	4	6	9	5	8	12	6	10	15	7	12	17
Dry season	1	1	2	2	2	3	2	3	5	3	5	7	4	6	9	5	8	11	6	9	13
Trans. season 1	1	1	2	1	2	3	2	3	5	3	5	7	4	6	10	5	8	12	5	9	14
Cairns																					
Annual	1	1	2	1	2	3	2	3	4	3	4	6	4	5	7	4	6	9	5	7	11
Wet half-year	1	1	2	1	2	3	2	3	4	3	4	6	4	5	8	4	6	9	5	8	11
Dry half-year	1	1	2	1	2	3	2	3	4	3	4	6	3	5	7	4	6	9	5	7	10
Wet season	1	1	2	1	2	3	1	3	5	2	4	7	3	6	9	3	7	12	4	8	13
Trans. season 2	1	1	2	1	2	3	2	3	5	3	4	6	4	6	8	5	7	10	6	8	12
Dry season	1	1	1	1	2	2	2	2	3	2	3	5	3	4	6	4	5	8	4	6	9
Trans. season 1	1	1	2	1	2	3	2	3	4	2	4	6	3	5	7	3	6	9	4	7	10