Extreme temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reaching on hot days, the frequency of hot days, and the duration of warm spells (very high confidence).

For Darwin and Broome, for example, days with temperatures over 35 °C could be experienced for around a third of the year under an intermediate emission scenario (RCP4.5) by late in the century (Table 3). Despite uncertainty in future projections these may occur (see Table 4 caption).

More hot days and warm spells are projected with very high confidence. More hot days and warm spells are projected with very high confidence.

A full report for the cluster can be found on the website for the Monsoonal North region (see Table 4 caption).

There is very high confidence in future sea-level rise. By 2050 the projected range of sea-level rise is 36 to 67 cm above the 1990–2000 level, with only minor differences between emission scenarios. The century progresses, projections are sensitive to concentration pathways. By 2050, the intermediate emissions case (RCP4.5) is associated with a rise of 0.8 to 1.1 m and the high case (RCP8.5) is a rise of 0.8 to 1.1 m. Under certain circumstances, sea-level rise higher than these may occur (see Table 4 caption). Mean sea level will continue to rise and height of extreme sea-level events will also increase (very high confidence).

Late in the century warming of the Monsoonal North coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundance, community structure, and enhanced coral bleaching risk. Sea surface temperature is projected to increase up to 4.1 °C by 2090 under a high scenario (RCP8.5). The sea will also become more acidic, with acidification proportional to emissions growth.

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CLIMATE CHANGE IN THE MONSOONAL NORTH

The International Scientific Community accepts that increases in greenhouse gases due to human activities have been the dominant cause of observed warming since the mid-20th century. Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system.

Australian changing climate represents a significant challenge to individuals, communities, governments, businesses and the environment. Australia has already experienced increases in average temperatures over the past 40 years, with more frequent hot weather, fewer cold days, shifting rainfall patterns, and rising sea levels.

To assist the planning and management of Natural Resource Management (NRM) regions, CSIRO and the Australian Bureau of Meteorology have prepared climate change projections for eight regions of Australia, termed NRM clusters. This brochure for the Monsoonal North cluster (Figure 5), comprising NRM regions in Western Australia, Northern Territory and Queensland, commonly known as the tropical 'top end'. This region experiences a pronounced wet and dry season, with differences in the timing between eastern and western parts. In this project, some analysis and reporting of climate change projections for the Monsoonal North is done for two sub-clusters: Monsoonal North-West (MN West) and Monsoonal North-East (MN East).

MN West covers tropical rainforests, wetlands and arid rangelands of the Northern Territory, and the steep mountain ranges of the Ord and Flinlock River catchments of the Kimberley. MN East covers relatively intact savannah woodland and important riparian areas as well as the Mitchell, Gilbert, Norman, Burdekin and Staaten River catchments, all of which flow into the Gulf of Carpentaria (except Budjerra).

FIGURE 1: MAP OF THE MONSOONAL NORTH CLUSTER

CLIMATE CHANGE PROJECTIONS

Projections for the Monsoonal North are based on the outputs of a set of 40 global climate models (GCMs), developed by Australian and international scientists. Climate models are based on established laws of physics and are rigorously tested for their ability to reproduce past climate. These projections draw on the full breadth of available data and peer-reviewed literature to provide a virtual assessment of the potential future climate. Projections for the Monsoonal North are based on four Representative Concentration Pathways (RCPs) underpinned by emission scenarios. More information on climate models and RCPs can be found inside this brochure.

PAST TEMPERATURE TRENDS

Temperatures have increased over the past century. Mean temperature increases between 1900 and 2010 by around 0.5°C. One area of north-west Australia has seen a decrease in mean temperature since 1910 and 2013 by around 0.9°C. One area of north-west Australia has seen this change over the past 40 years. One area of north-west Australia has seen this change over the past 40 years.

Temperature projections show substantial increases in projected mean, maximum and minimum temperatures in line with our understanding of the effects of further increases in greenhouse gas concentrations. For the near future (2040), the annually averaged warming across all emission scenarios is projected to be around 0.5°C above the climate of 1986–2005. By late in the century (2080), for a high emission scenario (RCP8.5), the projected range of warming is 2.3 to 5.1°C (Table 1; Figure 2). Under an intermediate scenario (RCP4.5), the projected warming is 1.3 to 2.7°C.

Table 1: Projected Temperature Change (°C) Compared to 1986–2005, for 20-Year Periods (Centre on 1986 and 2090) and Under Three Representative Concentration Pathways (RCPs) for the Monsoonal North Cluster.

<table>
<thead>
<tr>
<th>RCP</th>
<th>2030</th>
<th>2050</th>
<th>2090</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP2.5</td>
<td>-0.2</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>-0.4</td>
<td>0.4</td>
<td>1.2</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>-0.7</td>
<td>0.7</td>
<td>1.8</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>-1.0</td>
<td>1.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

EXPLANATION OF THE TEMPERATURE TIME-SERIES

1. The projected change in mean observed temperature during the century is the projected change. The change is shown as a line across the grid.
2. The change is the difference between the grid point in 1986–2005 and the grid point in the year specified.
3. The line is red to show that the grid point is above the climate of 1986–2005.
4. The line is blue to show that the grid point is below the climate of 1986–2005.
5. One climate model is shown to illustrate how the models compare to the grid for the temperature time-series. Median results are not shown here because models do not always agree on the direction of change.

PAST RAINFALL TRENDS

The Monsoonal North experienced an overall slight increase in rainfall during the 20th century, which includes prolonged periods of drying as well as above average rainfall. The strongest increases have been across north-western regions during recent decades. Year to year variability is strongly influenced by the El Niño Southern Oscillation.

Rainfall projections provide confident rainfall projections for the Monsoonal North cluster and are largely driven by climate models. Global climate models offer diverse results, and changes to rainfall are possible but not certain. For the near future, natural variability is projected to dominate any projected changes.

Table 2: Projected Rainfall Differences (per cent), Compared to 1986–2005, for 20-Year Periods (Centre on 1986 and 2090) and Under Three Representative Concentration Pathways (RCPs) for the Monsoonal North Cluster.

<table>
<thead>
<tr>
<th>RCP</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP2.5</td>
<td>5.0% to 10%</td>
<td>0.0% to 0%</td>
<td>-5.0% to -10%</td>
<td>-10% to -15%</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>-2.0% to 4.0%</td>
<td>0.0% to 0%</td>
<td>-10% to -15%</td>
<td>-15% to -20%</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>-3.0% to 6.0%</td>
<td>0.0% to 0%</td>
<td>-15% to -20%</td>
<td>-20% to -25%</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>-4.0% to 7.0%</td>
<td>0.0% to 0%</td>
<td>-20% to -25%</td>
<td>-25% to -30%</td>
</tr>
</tbody>
</table>

EXPLANATION OF THE RAINFALL TIME-SERIES

1. The projected change in mean observed rainfall during the century is the projected change. The change is shown as a line across the grid.
2. The change is the difference between the grid point in 1986–2005 and the grid point in the year specified.
3. The line is red to show that the grid point is above the climate of 1986–2005.
4. The line is blue to show that the grid point is below the climate of 1986–2005.
5. One climate model is shown to illustrate how the models compare to the grid for the rainfall time-series. Median results are not shown here because models do not always agree on the direction of change.

REPRESENTATIVE CONCENTRATION PATHWAYS

• Climate projections are available from model simulations using four RCPs (high emissions), RCP4.5 and RCP6.0 (intermediate scenarios resulting from moderate emissions reduction, with differing timing of peak emissions) and RCP2.5 (low emissions,ambitious and sustained global emissions reductions). RCPs are named in accordance with the level of influence these gases have on the Earth’s energy balance.

• Not every combination of RCP and climate variable is available for all GCMs in the projections presented here.

• Projections for RCP8.0 are not presented in this brochure, but are available on the website.
CLIMATE CHANGE IN THE MONSOONAL NORTH

The International Scientific Community accepts that increases in greenhouse gases due to human activities have been the dominant cause of observed warming since the pre-industrial period. Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system.

Australian changing climate represents a significant challenge to individuals, communities, governments, businesses and the environment. Australia has already experienced increases in average temperatures over the past 60 years, with more frequent hot weather, fewer cold days, shifting rainfall patterns, and rising sea levels.

To assist the planning and management of Natural Resource Management (NRM) regions, CSIRO and the Australian Bureau of Natural Resource Management (NRM) have prepared climate change projections for eight regions of Australia, termed NRM clusters. This brochure is for the Monsoonal North cluster (Figure 1), comprising NRM regions in Western Australia, Northern Territory and Queensland, commonly known as the tropical "top end". This region experiences a pronounced wet and dry season, with differences in the timing between eastern and western parts.

CLIMATE CHANGE PROJECTIONS

Projections for the Monsoonal North are based on the outputs of a set of 40 global climate models (GCM) developed by Australian and international scientists. Climate models are based on established laws of physics and are rigorously tested for their ability to reproduce past climate. These projections draw on the full breadth of available data and peer-reviewed literature to provide a robust assessment of the potential future climate.

Projections for the Monsoonal North are based on four Representative Concentration Pathways (RCPs) underpinned by emission scenarios. More information on climate models and RCPs can be found inside this brochure.

For more comprehensive information about the Monsoonal North, read the Cluster Report available on the Climate Change in Australia website: www.climatechangeinaustralia.gov.au

PAST TEMPERATURE TRENDS

Temperatures have increased over the past century. Mean temperature increases between 1900 and 2010 by around 1°C. One area of north-west Australia has seen a 0.5°C rise due to increases in rainfall and cloudiness. The eastern coast and central parts have had much more substantial increases than the western interior of the continent.

TEMPERATURE PROJECTIONS

Average temperatures will continue to increase in all seasons (very high confidence). There is very high confidence in continued substantial increases in projected mean, maximum and minimum temperatures in line with our understanding of the effects of further increases in greenhouse gas concentrations. For the near future (2030), the annually averaged warming across all emission scenarios is predicted to be around 0.5°C above the climate of 1986–2005. By late in the century (2100), for a high emission scenario (RCP8.5), the projected range of warming is 2.8 to 5.1°C (Table 1; Figure 2). Under an intermediate scenario (RCP4.5), the projected warming is 1.3 to 2.7°C.

Table 1: Projected temperature change (°C) compared to 1986–2005

<table>
<thead>
<tr>
<th>RCP</th>
<th>2030</th>
<th>2050</th>
<th>2090</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP2.6</td>
<td>0.5</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>1.3</td>
<td>1.8</td>
<td>2.7</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>2.8</td>
<td>4.5</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Table 2: Projected annual changes (°C) from 1986–2005 to 2030, 2050 and 2090 for the Monsoonal North cluster

<table>
<thead>
<tr>
<th>Season</th>
<th>2030</th>
<th>2050</th>
<th>2090</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>-1.7</td>
<td>-1.3</td>
<td>-0.9</td>
</tr>
<tr>
<td>Spring</td>
<td>0.9</td>
<td>1.4</td>
<td>1.9</td>
</tr>
<tr>
<td>Summer</td>
<td>1.0</td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Autumn</td>
<td>0.7</td>
<td>0.9</td>
<td>1.3</td>
</tr>
</tbody>
</table>

 climates. Results are not shown here because models do not always agree on the direction of change.

PAST RAINFALL TRENDS

The Monsoonal North experienced an overall slight increase in rainfall during the 20th century, which included prolonged periods of drying as well as above average rainfall. The strongest increases have been across north-western regions during recent decades. Year to year variability is strongly influenced by the El Niño Southern Oscillation.

RAINFALL PROJECTIONS

Providing confident rainfall projections for the Monsoonal North cluster is difficult because global climate models offer diverse results, and models have shortcomings in resolving some components of the climate. One area of north-west Australia has seen substantial increases in projected mean, maximum and minimum temperatures in line with our understanding of the effects of further increases in greenhouse gas concentrations. For the near future, rainfall changes are approximately 0.5 to +10 per cent under an intermediate emission scenario (RCP4.5) and approximately 25 to +20 per cent under a high scenario (RCP8.5). Rainfall changes are much larger in winter in some models, but these changes are less reliable because average winter rainfall is very low. Impact assessment in this region should consider the risk of both a drier and wetter climate.

Changes to rainfall are possible but unlikely. For the near-future natural variability is projected to dominate any projected changes.

Representative concentration pathways

- Future changes in greenhouse-gas, aerosol (suspended particles in the atmosphere) and land use depend on human behavior.
- The scientific community defined a set of four scenarios, called Representative Concentration Pathways (RCPs) for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- The RCPs reflect plausible trajectories of future greenhouse gas and aerosol concentrations to the year 2100 and represent a range of economic, technological, demographic, policy, and institutional futures.
- Climate projections are available from model simulations using four RCPs (RCPs 6 high emissions, RCP2.5 low emissions, and RCP8.5 intermediate scenarios resulting from moderate emissions reduction, with differing timing of peak emissions) and GCMs in the projections presented here.

Figures 3-5: Projected rainfall differences (per cent) for three RCPs for the Monsoonal North for 25 years (2070–2095) compared to 1986–2005, banding in the 10th to 90th percentile range of model results. The horizontal line indicates the median.
CLIMATE CHANGE IN THE MONSOONAL NORTH

THE INTERNATIONAL SCIENTIFIC COMMUNITY ACCEPTS THAT INCREASES IN GREENHOUSE GASES DUE TO HUMAN ACTIVITIES HAVE BEEN THE DOMINANT CAUSE OF OBSERVED WARMING SINCE THE PAST 60 YEARS. CONTINUED EMISSIONS OF GREENHOUSE GASES WILL CAUSE FURTHER WARMING AND CHANGES IN ALL COMPOSANTS OF THE CLIMATE SYSTEM.

Australians changing climate represents a significant challenge to individuals, communities, governments, businesses and the environment. Australia has already experienced increases in average temperatures over the past 40 years, with more frequent hot weather, fewer cold days, shifting rainfall patterns, and rising seawalls. To assist the planning and management of Natural Resource Management (NRM) regions, CSIRO and the Australian Bureau of Meteorology have prepared climate change projections for eight regions of Australia, termed NRM clusters.

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The Monsoonal North cluster is difficult because climate change in this region is caused by multiple factors, including internal variability associated with El Niño-Southern Oscillation. Recent decades. Year to year variability is likely to remain the major driver of rainfall changes in the near future. Rainfall projections in this region should consider the risk of both a drier and wetter climate.

PAST RAINFALL TRENDS

The Monsoonal North experienced an overall slight increase in rainfall during the 20th century, which includes prolonged periods of drying as well as above average rainfall. The strongest increases have been across north western regions during recent decades. Year to year variability is strongly influenced by the El Niño-Southern Oscillation. Changes to rainfall are possible and wetter years. For the near future (2020-2049), the rainfall system will remain the major driver of rainfall changes in the next few decades.

Impact assessment in this region should consider the risk of both a drier and wetter climate.

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MN West covers tropical rainforests, wetlands and arid rangelands of the Northern Territory, the steep mountains ranges of the Ord and Fitzroy River catchments of the Kimberley. MN East covers relatively intact areas as well as the Mitchell, Gilbert, Norman, Bodeker and Stuart River catchments, all of which flow into the Gulf of Carpentaria (except Bodeker).

Figure 1: Map of the Monsoonal North Cluster

CLIMATE CHANGE PROJECTIONS

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Projections for the Monsoonal North are based on four Representative Concentration Pathways (RCPs) underpinned by emission scenarios. More information on climate models and RCPs can be found inside this brochure.

PAST TEMPERATURE TRENDS

Temperatures have increased over the past century. Mean temperature increases between 1960 and 2030 would be around 1°C. One area of north-west Australia has seen a 1.6°C increase in temperature over the 1960-2030 period. This increase is due in part to increases in rainfall and cloudiness in the eastern sub-cluster. Daily minimum temperatures have increased more than daily maximums.

Average temperature projections for the next century are for increases of up to 1.3°C above the climate of 1966–2005. By late in the century (2046), for a high emission scenario (RCP8.5), the projected range of warming is 2.8 to 5.1°C (Table 1 and Figure 2). Under an intermediate scenario (RCP4.5) the projected warming is 1.3 to 2.7°C.

Table 1: Projected Temperature Change (%), Compared to 1986–2005

<table>
<thead>
<tr>
<th>RCP</th>
<th>Summer</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP4.5</td>
<td>0.8%</td>
<td>-0.4%</td>
<td>0.2%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>1.3%</td>
<td>-0.9%</td>
<td>0.6%</td>
<td>-0.4%</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>1.8%</td>
<td>-1.5%</td>
<td>1.1%</td>
<td>-0.9%</td>
</tr>
</tbody>
</table>

The Monsoonal North experienced an overall slight increase in rainfall during the 20th century, which includes extended periods of drying as well as above average rainfall. The strongest increases have been across north-western regions during recent decades. Year-to-year variability is strongly influenced by the El Niño-Southern Oscillation.

PAST RAINFALL TRENDS

The Monsoonal North cluster is affected because global climate models offer diverse results, and models have shortcomings in resolving some tropical processes. Natural climate variability is projected to remain the major driver of rainfall changes in the near future.

Changes to rainfall are possible but include, for the near future, multi-decadal variability that is projected to dominate any projected change.

Representative Concentration Pathways

- Future changes in greenhouse gases, aerosols (suspended particles in the atmosphere) and land use depend on human behavior.

- The scientific community defined a set of four scenarios, called Representative Concentration Pathways (RCPs) for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

- The RCPs reflect possible trajectories of future greenhouse gas and aerosol concentrations to the year 2100 and represent a range of economic, technological, demographic, policy, and institutional futures.

- Climate projections are available from model simulations using four RCPs: RCP2.5 (high emissions), RCP6.0 and RCP8.5 (intermediate scenarios resulting from moderate emissions reduction, with differing timing of peak emissions) and RCP4.5 (low emissions, ambitious and sustained global emissions reductions). RCPs are named in accordance with the level of influence these gases have on the Earth’s energy balance.

- Not every combination of RCP and future scenario is represented in the projections presented here.

- Projections for RCP2.5 are not presented in this brochure, but are available on the website.
EXTREME TEMPERATURE

Extreme-temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reached on hot days, the frequency of hot days, and the duration of warm spells (very high confidence).

For Darwin and Broome, for example, days with temperatures over 35 °C could be experienced for around a third of the year under an intermediate emission scenario (RCP4.5) by late in the century (Table 3).

More hot days and warm spells are projected with very high confidence.

### More hot days and warm spells are projected with very high confidence.

#### Figure 2: Modeled Temperature (°C) in annual average across the Monsoonal North

<table>
<thead>
<tr>
<th>Projected Year</th>
<th>2080</th>
<th>2090</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986–2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2030–2049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050–2069</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2070–2089</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2090–2099</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MARINE AND COASTAL PROJECTIONS**

For 1986 to 2005, the average rate of relative sea-level rise for Australia, from observations along the coast, was 1.4 mm/year. There is very high confidence in future sea-level rise. By 2050, the projected range of sea-level rise is 0.16 to 0.71 m above the 1986–2005 level, with only minor differences between emission scenarios. As the century progresses, projections are sensitive to concentration pathways. By 2080, the intermediate emissions case (RCP4.5) is associated with a rise of 0.28 to 0.65 m and the high case (RCP8.5) is a rise of 0.56 to 0.81 m. Under certain circumstances, sea-level rise higher than these may occur (see Table 4).

Mean sea level will continue to increase by late in the century. Late in the century warming of the Monsoonal North coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundance, community structure, and enhanced coral bleaching risk.

### Late in the century warming of the Monsoonal North coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundance, community structure, and enhanced coral bleaching risk.

Mean sea level is not expected to change the frequency of fire (medium confidence). In more southerly locations, changes to future rainfall will be the determining factor of change to fire frequency. When the fire does occur, there is little confidence that fire behaviour will become more extreme.

### Other variables

- **Wave height:** There is little change projected in relative humidity until later in the century under a high greenhouse scenario (RCP8.5), where a decrease in relative humidity is projected (medium confidence).
- **Evaporation:** Potential evapotranspiration is projected to increase in all seasons as warming progresses (high confidence).
**EXTREME TEMPERATURE**

Extreme temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reached on hot days, the frequency of hot days, and the duration of warm spells (very high confidence).

For Darwin and Broome, for example, days with temperatures over 38 °C could be experienced for around a third of the year under an intermediate emissions scenario (RCP4.5) by late in the century (Table 3).

**MARINE AND COASTAL PROJECTIONS**

For 1866 to 2005, the average rate of relative sea-level rise for Australia, from observations along the coast, was 4.4 mm/year. There is very high confidence in future sea-level rise. By 2030 the projected range of sea-level rise is 0.06 to 0.17 m above the 1986–2005 level, with only minor differences between emission scenarios. As the century progresses, projections are sensitive to concentration pathways. By 2050, the intermediate emissions case (RCP4.5) is associated with a rise in sea level of 0.28 to 0.65 m and the high case (RCP8.5) is a rise of 0.58 to 0.81 m. Under certain circumstances, sea-level rise higher than these may occur (see Table 4). A rise in mean sea level will continue to increase the height of extreme sea-level events and will also increase the frequency of flooding (very high confidence).

**EXTRREME RAINFALL & DROUGHT**

Despite uncertainty in future projections of total rainfall for the Monsoonal North cluster, an understanding of the physical processes that cause extreme rainfall become more important (Figure 4), indicate with high confidence a future increase in the intensity of extreme rainfall events. However, the magnitude of the increases cannot be confidently projected. Drought will continue to be a feature of the regional climate variability, but projected changes are uncertain.

Tropical cyclones are projected to become more intense, but the proportion of all intense storms is projected to increase (medium confidence).

**TROPICAL CYCLONES**

Late in the century warming of the Monsoonal North coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundances, community structure, and enhanced coral bleaching risk. Sea surface temperature is projected to increase by 2 to 3 °C by 2050 under a high scenario (RCP8.5). The sea will also become more acidic, with acidification proportional to emissions growth.

**OTHER VARIABLES**

**FIREFIRE WEATHER**

The primary determinant of bushfire in regions where abundant rain falls (Top End and the Kimberley), climate change is not expected to change the frequency of fire (high confidence). In more southerly locations, changes to future rainfall will be the determining factor of change to fire frequency. When the fires occur, there is medium confidence that fire behaviour will be more extreme.

**MONSOONAL NORTH**

**PROJECTIONS FOR AUSTRALIA’S NRM REGIONS**

**KEY MESSAGES FOR THE CLIMATE CHANGE IN AUSTRALIA**

- A full report for the cluster can be found on the website.
- A number of interactive tools allow exploration of a range of climate variables up to late in the 21st century.
- Communities, in particular the NRM sector, can adapt to these projected changes.
- This website provides comprehensive information on climate change in Australia.

**TABLE 3: AVERAGE ANNUAL NUMBER OF DAYS ABOVE 35 °C FOR DARWIN (NT) AND BROOME (WA) FOR THE 2-YEAR PERIOD CENTRED ON 1995 (1981-1985) AND FOR FUTURE 35-YEAR PERIODS CENTRED ON 2030 AND 2090.**

<table>
<thead>
<tr>
<th>THRESHOLD</th>
<th>1981-1985</th>
<th>2030</th>
<th>2090</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECADE</td>
<td>1990-1992</td>
<td>2030</td>
<td>2090</td>
</tr>
<tr>
<td>DECADE</td>
<td>2000-2001</td>
<td>2030</td>
<td>2090</td>
</tr>
<tr>
<td>OVER 35 °C</td>
<td>1981-1985</td>
<td>2030</td>
<td>2090</td>
</tr>
<tr>
<td>INC. HIGH</td>
<td>0.0 (0.0)</td>
<td>0.06 (0.06)</td>
<td>0.12 (0.12)</td>
</tr>
<tr>
<td>INC. LOW</td>
<td>0.0 (0.0)</td>
<td>0.04 (0.04)</td>
<td>0.08 (0.08)</td>
</tr>
<tr>
<td>DEC. HIGH</td>
<td>0.0 (0.0)</td>
<td>0.02 (0.02)</td>
<td>0.04 (0.04)</td>
</tr>
<tr>
<td>DEC. LOW</td>
<td>0.0 (0.0)</td>
<td>0.01 (0.01)</td>
<td>0.02 (0.02)</td>
</tr>
</tbody>
</table>

**TABLE 4: PROJECTED SEA-LEVEL CHANGE (METRES) FOR TWO MONSOONAL NORTH SITES, COMPARED TO 1986–2005, FOR 20-YEAR PERIODS (CENTRED ON 2030 AND 2090) AND THREE RCPs. THE MEDIAN PROJECTION ACROSS THE MODELS IS SHOWN, WITH THE RANGE OF MODEL RESULTS IN BRACKETS. THESE RANGES OF SEA LEVEL RISE ARE CONSIDERED ‘LIKELY’. HOWEVER, A COLAPSE IN THE MARINE BASED VECTORS OF THE ANARCTIC ICE SHEET WOULD INVALIDATE THESE PROJECTIONS COULD BE SEVERAL TENTHS OF A METRE HIGHER BY LATE IN THE CENTURY.**

<table>
<thead>
<tr>
<th>SITE</th>
<th>RCP8.5</th>
<th>RCP4.5</th>
<th>RCP8.5</th>
<th>RCP4.5</th>
<th>RCP8.5</th>
<th>RCP4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DARWIN (NT)</td>
<td>0.12 (0.08 to 0.17)</td>
<td>0.61 (0.40 to 0.84)</td>
<td>0.11 (0.07 to 0.16)</td>
<td>0.59 (0.38 to 0.81)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BROOME (WA)</td>
<td>0.12 (0.07 to 0.16)</td>
<td>0.46 (0.30 to 0.64)</td>
<td>0.11 (0.06 to 0.15)</td>
<td>0.35 (0.19 to 0.51)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 3: MODELLED EVAPOTRANSPIRATION (MM/SE) IN ANNUAL AVERAGE RAINFALL CRU (TOP) AND MAXIMUM DEW POINT AT 20 °C (BOTTOM) FOR THE WETTEST DAY IN 20 YEARS AND RAINFALL ON THE WETTEST DAY IN 10 YEARS FOR 1981-1985 (10 YEARS TO 2006–2025, 2006–2025 TO 2090).**
EXTREME TEMPERATURE

Extreme temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reached on hot days, the frequency of hot days, and the duration of warm spells (very high confidence).

For Darwin and Broome, for example, days with temperatures over 35 °C could be experienced for around a third of the year under an intermediate emission scenario (RCP4.5) by the year 2100, compared to about a fifth of the year under current forcing.

More hot days and warm spells are projected with very high confidence.

More extreme temperature thresholds on the website: “Threshold Calculator.”

EXTREME RAINFALL & DROUGHT

Despite uncertainties in future projections of total rainfall for the Monsoonal North cluster, an understanding of the physical processes that cause extreme rainfall coupled with modelled projections (Figure 4), indicate with high confidence a future increase in the intensity of extreme rainfall events. However, the magnitude of these increases cannot be confidently projected.

Drought will continue to be a feature of the regional climate variability, but projected changes are uncertain.

Late in the century warming of the Monsoonal North coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundances, community structure, and enhanced coral bleaching risk. Sea surface temperature is projected to increase by 1 to 2 °C by 2050 and to 3 to 4 °C by 2090 under a high greenhouse gas emissions scenario (RCP8.5). The sea will also become more acidic, with acidification proportional to emissions growth.

MARINE AND COASTAL PROJECTIONS

For 1860 to 2005, the average rate of relative sea-level rise for Australia, from observations along the coast, was 1.4 mm/year.

There is very high confidence in future sea-level rise. By 2030 the projected range of sea-level rise is 0.0 to 0.17 m above the 1860-2005 level, with only minor differences between emission scenarios. As the century progresses, projections are sensitive to concentration pathways. By 2050, the intermediate emissions case (RCP4.5) is associated with a rise of 0.28 to 0.65 m, the intermediate emissions case (RCP6.0) is associated with a rate of 0.65 to 0.81 m. Under certain circumstances, sea-level rise higher than these may occur (see Table 4).

There is medium confidence in future projections for 2030 and higher confidence for 2090, for sea-level rise for Australia, from observations along the coast, was 1.4 mm/year.

For Darwin and Broome, for example, days with temperatures over 35 °C could be experienced for around a third of the year under an intermediate emission scenario (RCP4.5) by the year 2100, compared to about a fifth of the year under current forcing.

More hot days and warm spells are projected with very high confidence.

More extreme temperature thresholds on the website: “Threshold Calculator.”

TROPICAL CYCLONES

Tropical cyclones are projected to become more frequent, and the proportion of the most intense storms is projected to increase (medium confidence).

OTHER VARIABLES

wavepower: There is little change projected in relative humidity until later in the century under a high greenhouse scenario (RCP8.5), where a decrease in relative humidity is projected (medium confidence).

evapotranspiration: Potential evapotranspiration is projected to increase in all seasons as warming progresses (high confidence).

FIRE WEATHER

The primary determinant of bushfire in the Monsoonal North is fuel availability, which varies widely with rainfall. In regions where abundant rain falls (Top End and the Kimberley), climate change is not expected to change the frequency of fire (high confidence). In more southerly locations, changes to future rainfall will be the determining factor of change to fire frequency. When the days are dry, there is a greater chance that fire behaviour will be more extreme.

Droghetti. Emissions growth謜

Before 2030, for 20-year periods (centred on 2016 and 2056) and three RCP, the median projection across the models is shown, with the range of model results in brackets. These ranges of sea-level rise are considered “likely.” However, if a collapse in the marine-based sectors of the Antarctic ice sheet were initiated, these projections could be several centimetres of a metre higher by the end of the century.