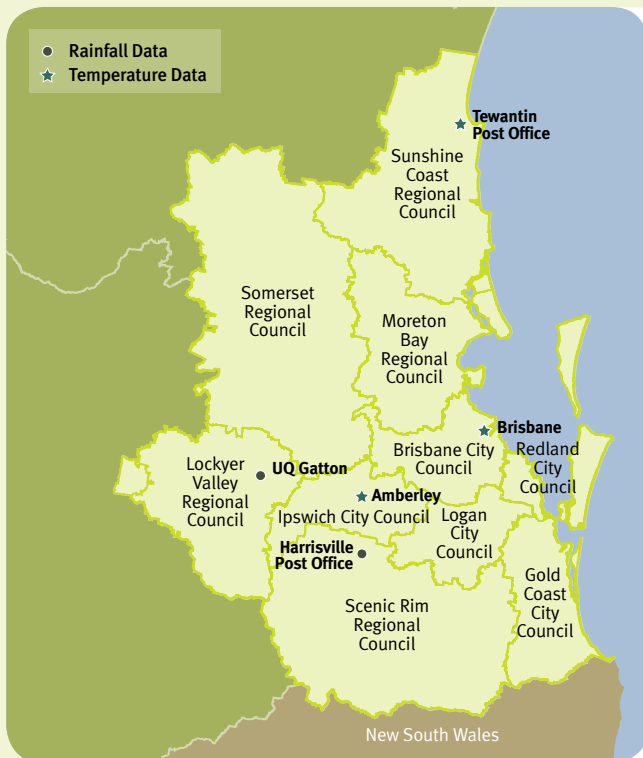




Photo: Tourism Queensland

# Climate change in the South East Queensland Region



This regional summary describes the projected climate change for the South East Queensland (SEQ) region.

Projected average temperature, rainfall and evaporation for 2030, 2050 and 2070 under low, medium and high greenhouse gas emissions scenarios are compared with historical climate records.



Photo: Tourism Queensland

## Key findings

### Temperature

- Average annual temperature in SEQ has increased 0.4 °C over the last decade (from 19.4 °C to 19.8 °C).
- Projections indicate an increase of up to 4 °C by 2070; leading to annual temperatures well beyond those experienced over the last 50 years.
- By 2070, Amberley may have more than three times the number of days over 35 °C (increasing from an average of 12 per year to 41 per year), Brisbane may have six times the number of hot days (increasing from an average of one per year to an average of six per year) and Tewantin may have nearly four times the number of days over 35 °C (increasing from an average of three per year to an average of 11 per year by 2070).

### Rainfall

- Average annual rainfall in the last decade fell nearly 16 per cent compared with the previous 30 years. This is generally consistent with natural variability experienced over the last 110 years, which makes it difficult to detect any influence of climate change at this stage.
- Models have projected a range of rainfall changes from an annual increase of 17 per cent to a decrease of 30 per cent by 2070. The 'best estimate' of projected rainfall change shows a decrease under all emissions scenarios.

### Evaporation

- Projections indicate annual potential evaporation could increase 6–16 per cent by 2070.

### Extreme events

- The 1-in-100-year storm tide event is projected to increase by 44 cm at Wellington Point, 42 cm in Noosa and 35 cm at Surfers Paradise if certain conditions eventuate. These conditions are a 30 cm sea-level rise, a 10 per cent increase in cyclone intensity and frequency, as well as a 130 km shift southwards in cyclone tracks.

## A regional profile

### Climate and landscape

South East Queensland is home to the state's capital, Brisbane, which has a sub-tropical climate. Rainfall in the region is influenced both by tropical systems from the north and fluctuations in the high pressure ridge to the south.

South East Queensland is Australia's fastest growing region. The population of SEQ is heavily urbanised and is generally concentrated along the coast between Noosa and Coolangatta. The metropolitan areas of the Brisbane Statistical Division, Gold Coast and Sunshine Coast Statistical Districts account for 90 per cent of the region's population.

The SEQ Regional Plan identifies around 80 per cent of the region as Regional Landscape and Rural Production Area. The coastline of this region supports diverse values and resources, including biodiversity, scenic amenity, outdoor recreation, economic activities and cultural heritage.

### Demographics

In 2007, the region's population was 2 922 832 and is projected to increase beyond 4 100 000 by 2026.

(OESR, 2007; DIP, 2008)

## Important industries of the region

Tourism in SEQ contributes more than \$3.7 billion to Queensland's growing economy and directly employs more than 61 000 people. The number of international visitors is growing by almost eight per cent a year. Protecting the ecologically rich wilderness and natural attractions of the region is therefore an important focus of sustainable tourism development.

Infrastructure needed to support the future development of the region has been identified in order to manage future growth patterns and inform the implementation and review of the SEQ Infrastructure Plan and Program. Across the region, water and energy will continue to be a key focus of sustainable management efforts.

The majority of the region's agricultural area is used for beef farming, with some dairy farming located on productive grazing land. The rich alluvial soils along the valleys in the west and south of the region—including the Brisbane, Lockyer, Fassifern and the Albert-Logan valleys—support a vast array of cropping industries. Closer to the coast, horticultural and cropping industries thrive in the Gold Coast, Redlands, Glass House Mountains and Sunshine Coast districts.

A range of industry sectors are represented in the SEQ region, for example, manufacturing, aviation and aerospace, biotechnology, professional and business services, information and communications technology, food and agribusiness, tourism, marine, mining technologies, and pharmaceuticals.

(Extracted from the South East Queensland Regional Plan)

## Understanding the climate and how it changes

Queensland's climate is naturally variable; however, climate change will lead to shifts beyond this natural variability. To assess the risk of human-induced climate change requires an understanding of the current climate using historical data and future climate scenarios. These future scenarios are prepared using data from Global Climate Models.

### Method

#### Historical climate data

Historical climate data collected by the Bureau of Meteorology (BoM) were aggregated across the SEQ region. The fluctuations and trends in the observed data are presented including extremes in temperature and the frequency of cyclones.

#### Greenhouse emission scenarios

The World Meteorological Organization (WMO) and the United Nations established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The IPCC assesses the latest scientific, technological and socio-economic literature on climate change.

To estimate the potential impacts of future climate change on Queensland, climate change projections were developed using the IPCC low (B1), medium (A1B) and high (A1FI) greenhouse gas emissions scenarios. The low-range scenario (B1) assumes a rapid shift to less fossil fuel intensive industries. The mid-range (A1B) scenario assumes a balanced use of different energy sources. The high (A1FI) scenario assumes continued dependence on fossil fuels.

Greenhouse gas emissions are currently tracking above the highest IPCC emissions scenario (A1FI). The low and medium scenarios are presented to show the potential benefits of action to reduce greenhouse gas emissions.

#### Climate change projections

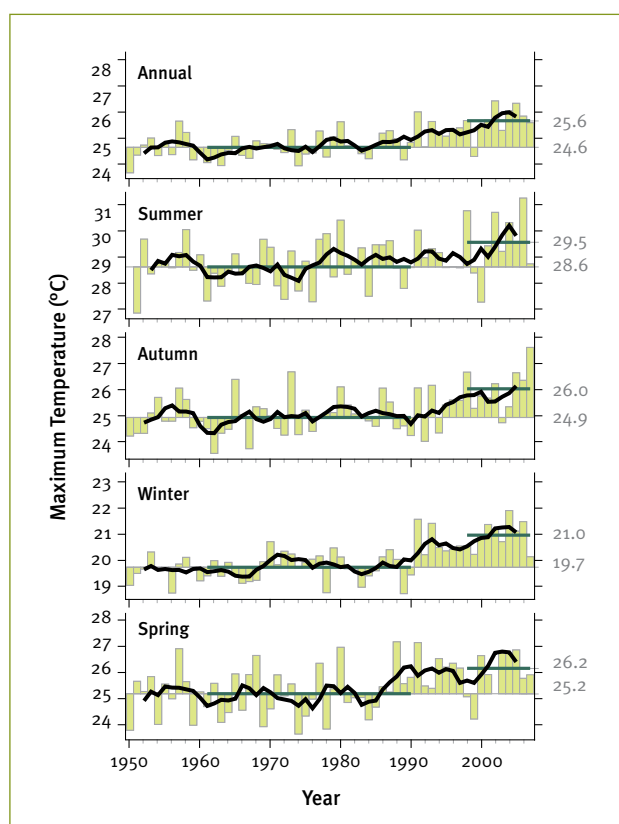
Queensland climate change projections were produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BoM) based on the results from 23 Global Climate Models. Projections were provided for 2030, 2050 and 2070. However, as the climate can vary significantly from one year to the next, these projections show changes in average climate for three future 30-year periods centered on 2030, 2050 and 2070. Sea-level rise is also considered.

## Current climate

### Temperature (BoM, 2008)

Historical temperature records indicate the average temperature in the SEQ region has risen, with this increase accelerating over the last decade (1998–2007). The average annual temperature was 19.4 °C in the 30 year period from 1971–2000, which is a 0.2 °C increase on the 1961–1990 average. However, over the last decade it has risen by a further 0.4 °C, suggesting an accelerated rise in temperature.

### Average maximum temperature has risen in the South East Queensland region



**Figure 1: Historical annual and seasonal maximum temperatures for the South East Queensland region for the period 1950–2007, compared to the base period 1961–1990**

The black line is a five-year running average. The mean for both the baseline of 1961–1990 and the last decade 1998–2007 are shown by the green lines and indicated numerically at the right of the graph.

Note: vertical scales may differ between graphs.

Data source: BoM, 2008

The increase in annual maximum temperature is presented in Figure 1. The trend over time is represented by the black line in each graph.

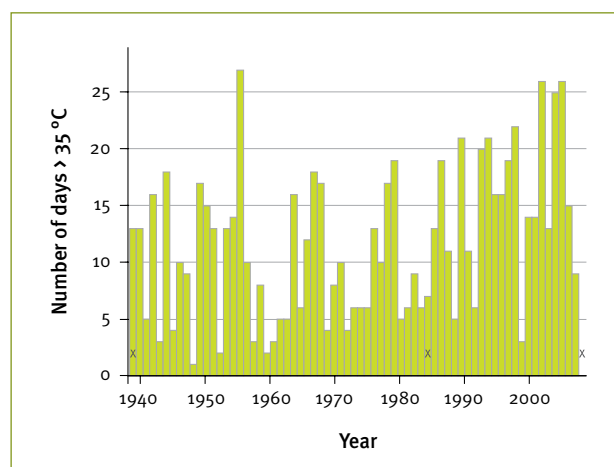
The change in maximum temperatures is greater in the winter, with the average over the last decade increasing by 1.3 °C averaged compared to the 1961–1990 average.

### Temperature extremes (BoM, 2008)

Extremes in temperature (such as a number of days exceeding 35 °C) are single events that usually do not extend past a couple of days. Due to the influence of regional topography, proximity to the ocean and prevailing winds, location-specific data are required when considering changes in these extreme events over time.

Due to its inland location, Amberley (Figure 2) currently experiences more extreme temperature days than coastal Tewantin (Figure 3).

### The number of days over 35 °C has risen in Amberley



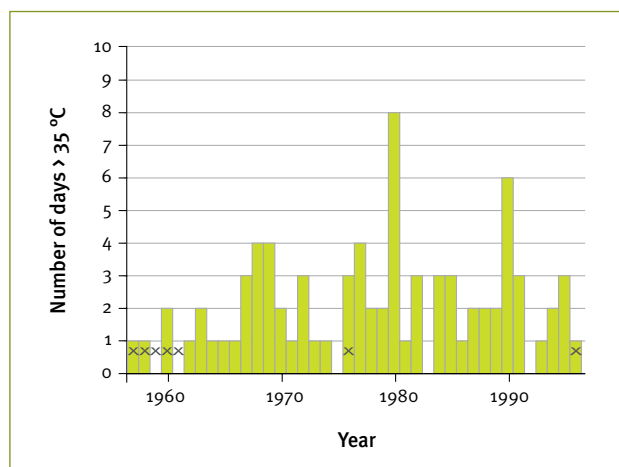
**Figure 2: Number of days where the temperature exceeded 35 °C for Amberley**

Blank spaces are those years where the maximum temperature did not exceed 35 °C.

'X' denotes year for which the full data set is not available (i.e. the actual values may in fact be greater than what is shown).

Data source: BoM, 2008

### No observable change in the number of days over 35 °C in Tewantin



**Figure 3: Number of days where the temperature exceeded 35 °C for Tewantin**

Blank spaces are those years where the maximum temperature did not exceed 35 °C.

'X' denotes the year for which the full data set is not available (i.e. the actual values may in fact be greater than what is shown).

Data source: BoM, 2008

Although there is insufficient evidence from the available records to categorically state there has been a rise in the number of extreme days at either location, there appears to be an increasing trend in Amberley since the single year in the mid-1950s when more than 25 days over 35 °C were experienced.

### Rainfall (BoM, 2008)

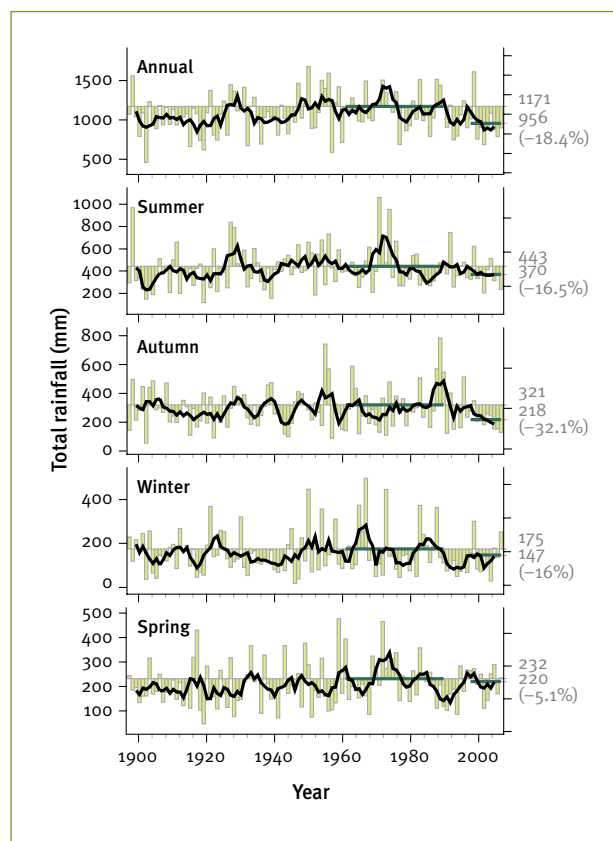
Annual and seasonal average rainfall is strongly influenced by natural variability, local factors such as topography and vegetation, and broader scale weather patterns, for example El Niño-Southern Oscillation (ENSO) events. To understand how this natural temporal variation changes rainfall patterns, long-term rainfall records are required. The BoM has been collecting rainfall data for the South East Queensland region since 1897.

The variability in annual and seasonal rainfall is outlined in Figure 4. The annual rainfall averaged over the last decade has decreased by 18 per cent compared to the 1961–1990 average. Since 1990, only three years have received rainfall greater than the 1961–1990 average. However, this situation also occurred at the beginning of the last century.

Figure 4 shows the dominant summer rainfall pattern, with a 1961–1990 average rainfall of around 440 mm, compared to an autumn average (the next most dominant rainfall period) of around 320 mm.

Over the most recent decade, there has been a 32 per cent decline in the average autumn rainfall compared to the 1961–1990 average. This appears to be the most consistent downward trend observed over the last 100 years. Summer average rainfall has only declined by 16 per cent. However, there has been a fairly consistent decrease since the 1980s, with only five summers in this period above the 1961–1990 average.

### Historical rainfall shows high variability



**Figure 4: Historical annual and seasonal total rainfall for the South East Queensland region for the period 1897–2007**

The black line is a five-year running average.

The mean for both the baseline 1961–1990 and the last decade 1998–2007 are shown by the green lines and indicated numerically at the right of the graph.

The difference in rainfall between the baseline and last decade is shown in per cent.

Note: vertical scales may differ between graphs.

Data source: BoM, 2008

## Evaporation

Potential evaporation is a measure of the evaporative (or drying) power of the atmosphere. The potential evaporation rate assumes that there is an unlimited supply of water to evaporate (either from the soil or from water bodies). Although potential evaporation can differ from actual evaporation, a change in potential evaporation gives a good indication of the change in the evaporative power of the atmosphere.

Networks to measure potential evaporation are not as well developed as those that measure temperature and rainfall and there are insufficient data available to indicate the changes over time.

Averaged over the SEQ region, the annual mean potential evaporation over the period 1971–2000 (1553 mm) is close to one and half times greater than the annual mean rainfall over the same period (1135 mm), which contributes to the depletion of soil moisture.

## Cyclones

Strong winds, intense rainfall and ocean effects such as extreme waves combine to make the total cyclone hazard. This hazard is greatest in Queensland between January and March, but tropical cyclones in Queensland can occur anytime over the period from November to April.

Although the South East Queensland region is further south than the main area of tropical cyclone

development and occurrence, tropical cyclones still have an impact on the region (Figure 5), either from those that do track further southwards or the heavy rain and strong easterly winds through the region that accompany cyclones to the north.

There is a relationship between the impact of cyclones on eastern Australia and the El Niño-Southern Oscillation (ENSO) phenomenon. This relationship is reflected in Figure 5 with very few cyclones in the last three decades (in fact there were none in the last decade) compared to the La Niña dominant decades commencing in the mid 1940s and mid 1960s. There is also a greater tendency for cyclones to track further southward in La Niña dominant decades.

## Projected climate change in South East Queensland

Global Climate Models simulate the earth's climate system using a complex set of mathematical rules that describe the physical processes of the atmosphere, ocean, land and ice. They are currently considered to be the best tools for projecting climate change. CSIRO has recently released climate change projections for Australia (CSIRO & BoM, 2007) based on the results from 23 Global Climate Models. Projections for the South East Queensland region have been extracted from this dataset for the Queensland Climate Change Centre of Excellence (QCCCE). The projections presented here are relative to the base period of 1980–1999.

The Global Climate Models show little difference under the low, medium and high emissions scenarios to 2030. Therefore, the 2030 climate change projections for South East Queensland have been presented on a mid-range emissions scenario.

However, the projections diverge at 2050 under different emissions scenarios. Therefore, the 2050 and 2070 projections are based on low and high emissions scenarios.

The full range of projected changes for temperature, rainfall and potential evaporation for the SEQ region in 2030, 2050 and 2070 are described in Table 2. The numbers shown in brackets indicate the range of the results from the Global Climate Models.

### Fewer cyclones have occurred over the last three decades under El Niño weather patterns

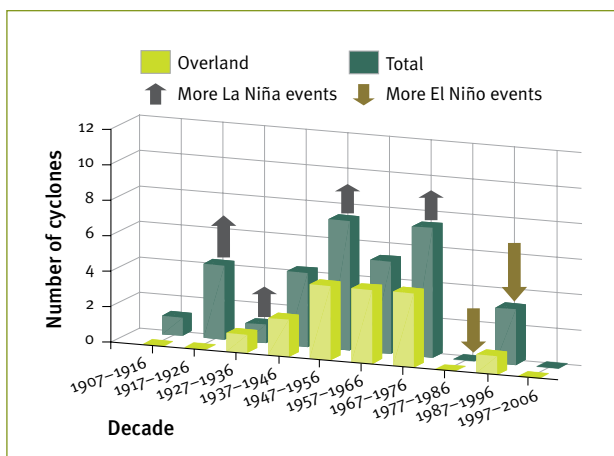


Figure 5: Total and overland number of tropical cyclones for the South East Queensland region for the period 1907–2006.

Adapted from BoM, 2008.

## Overview of climate projections

In summary, the ‘best estimate’ changes to temperature and rainfall under the three emissions scenarios are:

### 2030 (medium emissions scenario)

- **Annual and seasonal temperature:** annual mean temperature (the average of all daily temperatures within a given year) is projected to increase by 0.9 °C. There is little variation in projections across the seasons.
- **Annual and seasonal rainfall:** annual rainfall (the total rainfall received within a given year) is projected to decrease by three per cent (-34 mm). The largest decrease of five per cent is projected for spring (-11 mm) and winter (-7 mm).
- **Annual and seasonal potential evaporation:** across all seasons the annual ‘best estimate’ increase is projected to be around 3–4 per cent (47–62 mm), with some models projecting up to a six per cent increase in autumn (20 mm) and winter (14 mm).

### 2050 (low and high emissions scenarios)

- **Annual and seasonal temperature:** annual temperature is projected to increase by 1.1 °C and 1.8 °C under the low and high emissions scenarios, respectively. There is little variation in projections across the seasons.
- **Annual and seasonal rainfall:** annual rainfall is projected to decrease by three per cent (-34 mm) and five per cent (-57 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease of 10 per cent (-15 mm) is projected for winter under the high emissions scenario.
- **Annual and seasonal potential evaporation:** under a high emissions scenario an increase in annual potential evaporation of up to 10 per cent (155 mm) is projected with the best estimate being six per cent (93 mm). Autumn and winter are projected to have the greatest increases of up to 12 per cent (40 mm and 29 mm respectively).



Photo: Tourism Queensland

### 2070 (low and high emissions scenarios)

- **Annual and seasonal temperature:** annual temperature is projected to increase by 1.5 °C and 2.9 °C under the low and high emissions scenarios respectively. There is little variation in projections across the seasons.
- **Annual and seasonal rainfall:** annual rainfall is projected to decrease by four per cent (-45 mm) and eight per cent (-91 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease under a high emissions scenario of 15 per cent is projected for spring (-34 mm) and winter (-22 mm).
- **Annual and seasonal potential evaporation:** under a high emissions scenario, annual evaporation is projected to increase by as much as 16 per cent (248 mm). Autumn and winter are projected to be the seasons most impacted with increases up to 19 per cent (63 mm and 46 mm respectively) in some models.

## Temperature extremes

Global Climate Models indicate that increasing greenhouse gas concentrations in the atmosphere will increase the likelihood of record high temperatures in a given region. The Global Climate Models project a rise in extreme temperatures (CSIRO & BoM, 2007). Table 1 shows the projected number of days above 35 °C for three observation stations in the SEQ region with good historical records.

Under a high emissions scenario in 2070 for Amberley the number of hot days above 35 °C per year are projected to increase from 12 to 41 days and from one to six days in Brisbane. Under the same scenario for Tewantin, hot days above 35 °C are projected to increase from three to 11 days.

Station Name	Current	2030 Mid	2050 Low	2050 High	2070 Low	2070 High
Amberley	12	18 (15–21)	20 (16–24)	26 (20–36)	23 (19–31)	41 (28–65)
Brisbane Aero	1	2 (1–2)	2 (2–3)	3 (2–5)	3 (2–4)	6 (6–15)
Tewantin	3	4 (4–6)	5 (4–6)	7 (5–10)	6 (5–8)	11 (7–20)

**Table 1: Number of hot days per year above 35 °C projected for 2030 (mid emissions scenario) and 2050 and 2070 (low and high emissions scenarios)**

Current number of days calculated using a base period of 1971–2000.

## Cyclones and sea-level rise

Extreme weather events, such as cyclones, have a complex link to ocean surface temperatures, characteristics of a region and global climate patterns such as the ENSO, making it difficult to predict their frequency of occurrence. This results in discrepancies in cyclone frequencies between different climate models.

Recent studies have projected a slight decrease (nine per cent) in tropical cyclone frequency off the east coast of Australia by 2070 (Abbs et al, 2006). However, they also simulate an increase in the number of long-lived and severe (Category 3–5) eastern Australian tropical cyclones. Under three different studies the number of severe tropical cyclones is projected to increase by 56 per cent by 2050 (Walsh et al, 2004), 22 per cent by 2050 (Leslie et al, 2007) and 140 per cent by 2070 respectively (Abbs et al, 2006).

Projected southward shifts in the primary regions of cyclone development through the coming century (Abbs et al, 2006; Leslie et al, 2007) could result in a greater cyclone impact in the SEQ region. With projected increases in the intensity of future

cyclones and projected rise in mean sea levels (CSIRO & BoM, 2007), storm surges will be able to penetrate further inland greatly increasing the risk of damage to natural ecosystems, infrastructure and the risk of erosion in low-lying coastal regions.

The 1-in-100-year storm tide event is projected to increase by 44 cm at Wellington Point, 42 cm in Noosa and 35 cm at Surfers Paradise if certain conditions eventuate. These conditions are a 30 cm sea-level rise, a 10 per cent increase in cyclone intensity and frequency, as well as a 130 km shift southwards in cyclone tracks (Hardy et al, 2004).

According to the IPCC, global sea-level is projected to rise by 18 to 59 cm by 2100, with a possible additional contribution from melting ice sheets of 10 to 20 cm (IPCC, 2007).

These rises in sea levels will have serious implications for the coastal communities and ecological assets of the South East Queensland region, ranging from contaminated fresh water aquifers through to regular inundation of the critical infrastructure.



Photo: Tourism Queensland



Variable	Season	(1971–2000)  Current historical mean*	2030 <sup>†</sup>	2050 <sup>†</sup>			2070 <sup>†</sup>		
			Emissions Scenarios						
			medium	low	high	low	high		
			Projected Changes <sup>#</sup>						
Temperature °C	Annual	19.4 °C	<b>+0.9</b> [+0.6 to +1.3]	<b>+1.1</b> [+0.7 to +1.5]	<b>+1.8</b> [+1.2 to +2.5]	<b>+1.5</b> [+1.0 to +2.1]	<b>+2.9</b> [+1.9 to +4.0]		
	Summer	23.9 °C	<b>+0.9</b> [+0.6 to +1.3]	<b>+1.1</b> [+0.7 to +1.5]	<b>+1.7</b> [+1.2 to +2.5]	<b>+1.5</b> [+1.0 to +2.1]	<b>+2.8</b> [+1.9 to +4.0]		
	Autumn	20.1 °C	<b>+0.8</b> [+0.6 to +1.2]	<b>+1.0</b> [+0.7 to +1.5]	<b>+1.7</b> [+1.1 to +2.4]	<b>+1.4</b> [+0.9 to +2.0]	<b>+2.7</b> [+1.8 to +3.9]		
	Winter	14.0 °C	<b>+0.9</b> [+0.6 to +1.2]	<b>+1.1</b> [+0.7 to +1.5]	<b>+1.8</b> [+1.2 to +2.5]	<b>+1.5</b> [+1.0 to +2.1]	<b>+2.8</b> [+1.9 to +4.0]		
	Spring	19.6 °C	<b>+0.9</b> [+0.6 to +1.4]	<b>+1.1</b> [+0.7 to +1.7]	<b>+1.9</b> [+1.2 to +2.8]	<b>+1.6</b> [+1.0 to +2.3]	<b>+3.0</b> [+1.9 to +4.5]		
Rainfall %	Annual	1135 mm	<b>-3</b> [-11 to +5]	<b>-3</b> [-12 to +6]	<b>-5</b> [-20 to +10]	<b>-4</b> [-17 to +9]	<b>-8</b> [-30 to +17]		
	Summer	431 mm	<b>0</b> [-10 to +9]	<b>-1</b> [-12 to +11]	<b>-1</b> [-19 to +18]	<b>-1</b> [-16 to +15]	<b>-1</b> [-28 to +29]		
	Autumn	317 mm	<b>-3</b> [-14 to +10]	<b>-3</b> [-16 to +11]	<b>-5</b> [-25 to +19]	<b>-4</b> [-21 to +16]	<b>-8</b> [-37 to +30]		
	Winter	148 mm	<b>-5</b> [-15 to +4]	<b>-6</b> [-17 to +5]	<b>-10</b> [-27 to +8]	<b>-8</b> [-23 to +7]	<b>-15</b> [-39 to +13]		
	Spring	227 mm	<b>-5</b> [-15 to +6]	<b>-6</b> [-18 to +7]	<b>-9</b> [-28 to +11]	<b>-8</b> [-24 to +9]	<b>-15</b> [-41 to +17]		
Potential evaporation %	Annual	1553 mm	<b>+3</b> [+2 to +5]	<b>+3</b> [+2 to +5]	<b>+6</b> [+4 to +10]	<b>+5</b> [+3 to +8]	<b>+10</b> [+6 to +16]		
	Summer	522 mm	<b>+3</b> [+2 to +5]	<b>+2</b> [+2 to +4]	<b>+6</b> [+3 to +11]	<b>+5</b> [+3 to +9]	<b>+10</b> [+5 to +17]		
	Autumn	334 mm	<b>+4</b> [+2 to +6]	<b>+4</b> [+2 to +6]	<b>+7</b> [+4 to +12]	<b>+6</b> [+3 to +10]	<b>+11</b> [+6 to +19]		
	Winter	241 mm	<b>+4</b> [+2 to +6]	<b>+4</b> [+2 to +7]	<b>+7</b> [+4 to +12]	<b>+6</b> [+3 to +10]	<b>+12</b> [+6 to +19]		
	Spring	458 mm	<b>+3</b> [+2 to +4]	<b>+3</b> [+2 to +5]	<b>+6</b> [+3 to +9]	<b>+5</b> [+3 to +7]	<b>+9</b> [+5 to +14]		

**Table 2: Summary of projections for South East Queensland\***

\* To enable the projections for each of the regions to be referenced against historical climate, observational means have been calculated using a 30-year base period of 1971–2000.

<sup>#</sup> Projections represent the change in temperature, relative change in rainfall and potential evaporation relative to the model base period of 1980–1999. The numbers in brackets are the 10th and 90th percentiles and depict the range of uncertainty; the number outside the brackets is the 50th percentile (i.e. the best estimate). The changes are the average change over the region.

<sup>†</sup> These projections show changes in average climate for three future 30-year periods centred on 2030, 2050 and 2070.

Data source: CSIRO & BoM 2007. Regional summaries prepared by QCCCE.

## Impacts of climate change on the South East Queensland region

Projections for the SEQ region include a decline in rainfall, with increasing temperature and evaporation, in conjunction with more extreme climate events such as sea-level rise and cyclonic weather.

The temperature projections for inaction on climate change suggest a temperature increase well outside the range of temperatures ever experienced over the last 50 years. The projections for temperature and number of hot days are all in the same direction—increasing. These climate change projections will pose many challenges for South East Queensland:

- In the winter of 2050, under the high emissions scenario, the predicted decline in rainfall (-10 per cent), increasing high temperatures (+1.8 °C) and an increase in evaporation (+7 per cent) could result in heat damage to horticultural crops and challenges in supplying sufficient water to meet demand.
- The rapid population growth of South East Queensland combined with the projected reductions in rainfall will make ensuring the long-term adequacy of water supplies especially challenging.
- Warmer winters may reduce stone fruit yields, extreme temperatures may increase the stress on intensively managed livestock and overall conditions may become more favourable for an increase in plant diseases, weeds and pests. Lower rainfall and increasing evaporation will also result in more frequent depletion of soil moisture, reduced ground cover and lower livestock stock carrying capacity.
- Increased temperature would allow species such as the Queensland fruit fly and cattle tick to move southwards into areas from which they are currently excluded. This would affect interstate and international trade and, while damage from fruit flies is currently estimated at \$28.5 million per year, a southward spread in their population could add millions of dollars to this.
- In contrast to the overall rainfall declines, more intense extreme storm events are expected to cause increases in flooding impacts which could affect infrastructure such as water, sewerage, stormwater, transport and communications. The riskiest areas are those closest to the coast which can incur flash flooding, wind damage and considerable structural damage from falling trees, affecting industry, infrastructure and roads. This will increase the cost of insurance to business and the community.
- The projected higher temperatures and more hot days above 35°C can result in significant health impacts like heat exhaustion and increased mortality among vulnerable sectors of the community, such as the very young or old. It may be more difficult for locations that have not typically experienced these higher temperatures on a regular basis to adapt to these conditions.
- Electricity consumption is forecast to increase at approximately four per cent per year, and peak summer demand also by four per cent per year (twice the rate of the other states), over the next 10 years, as a result of the high growth rate expected over the timeframe of the SEQ Infrastructure Plan. Climate change will further add to the demand for air-conditioning and the subsequent cost to the electricity network of meeting this peak seasonal demand (DIP, 2007).



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