

■ Stage 1: Identification of key synoptic patterns

Data on key climate variables were obtained from the Bureau of Meteorology, including precipitation, temperature, humidity, evaporation, daily wind speed and wind gusts. Available data within the period 1948-2007 was used for this process to comply with data quality and duration standards established for the project.

In addition, a detailed climatic data set was obtained from the US National Oceanic and Atmospheric Administration. This contained daily and monthly data for the full range of climate parameters, from the surface through the atmosphere. Monthly sea level air pressure data was then used to define the variety of synoptic types that drive weather patterns, and therefore climatic variability, within the region.

The final twelve synoptic types were then identified using a pattern recognition technique known as 'self-organising mapping'. This technique clusters like features together to produce a resultant "map" which arranges the clusters by similarity (i.e. clusters with similar features will appear close together on the map). This process enabled those synoptic patterns most associated with key weather patterns in the region to be identified.

■ Stage 2: determining the relationship between synoptic types & climate variability

The 12 identified synoptic types generate a range of significant large-scale features that are known to influence the region's weather. They may induce clear seasonal trends in the location and intensity of features such as the subtropical anticyclone, the monsoonal trough, the circumpolar trough, the long wave trough, and ridge features in the Pacific and Indian Ocean. Data from Bureau of Meteorology recording stations within the region were related to each synoptic type to understand how these 12 patterns drive the region's climate variability.

This process confirmed that it is changes in the frequency of occurrence of these synoptic types between 1948 and 2007 that is responsible for the variability recorded in key climatic parameters during that period. Additionally, relationships between extreme events (high or low rainfall and temperature events) and synoptic types were also identified.

■ Stages 3 & 4: Determining potential impacts of climate change

Climate projections for the period 2020-2080 were assessed using data from the CSIRO Mk3.5 Global Climate Model (GCM). Because Global Climate Models generate coarse-scale outputs however, an additional process called Statistical Downscaling was employed. This allowed the data to be meaningfully interpreted at a much finer geographical scale suitable for projecting likely climatic changes at both regional and subregional levels.

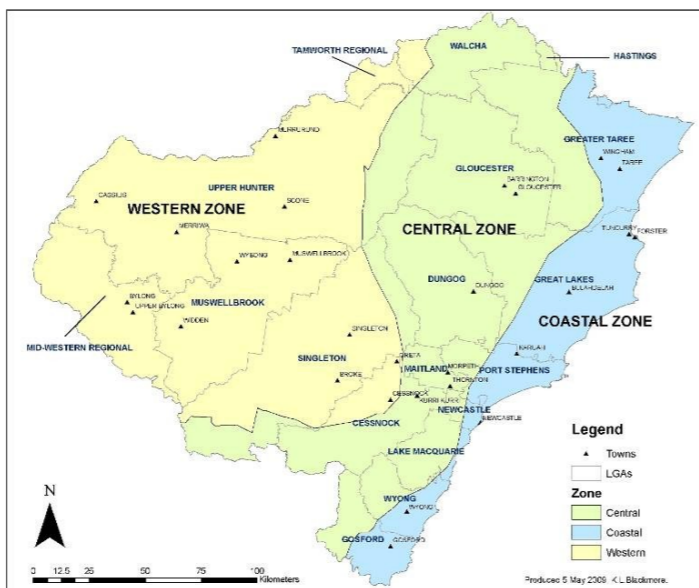
A weather typing approach to Statistical Downscaling was adopted for the research. This involved deriving the key synoptic types from the Global Climate Model output and identifying projected changes (to 2100AD) in the frequency of these synoptic types compared to their pattern of occurrence during the 1948-2007 time period. These changes in synoptic types were then combined with an understanding of how the region's weather is impacted by these types. This allowed the researchers to project the likely changes in climate variables across the region, such as temperature, rainfall and evaporation at both sub regional and seasonal scales.

The actual climate variables for which an analysis has been completed were identified through consultation with regional stakeholders including councils, government agencies and the agricultural sector. This aimed to ensure that the outputs of the research were directly relevant to regional stakeholders and could be readily applied to risk assessment and adaptation planning activities.

Climate Zones

To facilitate the sub regional analysis and interpretation of projected climate change impacts, three sub regional climate zones (coastal, central and western) have been established for the region. An analysis of both historic and projected climate change has been provided for each of these. These zones are shown in the Figure below.

These zones were identified through a process known as climate zonation, which divides a region into distinct sub-regions or zones where climatic similarity is maximised within zones and minimised between zones. This purely statistical process was based upon key seasonal climate variables including summer, autumn, winter and spring precipitation and average minimum and maximum temperature.



Climate zones within the Region

Results

The research outcomes project future changes in climate at both *seasonal* and *sub regional* scales. Projections are provided for the period 2020-2040, 2040 -2060 and 2060-2080. Where minimal change between these periods is identified, projections are provided for the entire 2020-2080 period.

Projections are provided for a range of climate variables including rainfall, temperature (minimum, maximum and average annual), humidity, pan evaporation, water balance, wind, sea level rise and extreme sea levels, wave climate and extreme events. Examples of the projections generated for some of these climate variables is shown below.

Projected changes: minimum temperature

Across the region minimum temperatures are projected to be generally warmer, particularly in the western zone. More detailed seasonal and zonal projections are summarised below.

Minimum temperature (2020-2080)				
<i>Projected changes are relative to the 1970-2007 period</i>				
Zone	Summer	Autumn	Winter	Spring
Coastal	Cooler: ~0.9°C decrease	Warmer: ~1.4°C increase	Warmer: ~1.3°C increase	Cooler: ~0.2°C decrease
Central	Cooler: ~0.8°C decrease	Warmer: ~1.5°C increase	Warmer: ~1.2°C increase	Cooler: ~0.2°C decrease
Western	Warmer: ~4.2°C increase	Warmer: ~4.8°C increase	Cooler: ~0.8°C decrease	Cooler: ~1.2°C decrease

Projected changes: maximum temperature

Maximum temperatures are also projected to increase in the region with the most significant changes projected to occur during autumn and winter. More detailed seasonal and zonal projections are summarised below.

Maximum temperature (2020-2080)				
<i>Projected changes are relative to the 1970-2007 period</i>				
Zone	Summer	Autumn	Winter	Spring
Coastal	Cooler: ~0.2°C decrease	Warmer: ~1.1°C increase	Warmer: ~1.3°C increase	Cooler: ~0.7°C decrease
Central	No significant change	Warmer: ~1.8°C increase	Warmer: ~1.6°C increase	Cooler: ~1.3°C decrease
Western	Cooler: ~0.2°C decrease	Warmer: ~2.0°C increase	Warmer: ~1.8°C increase	Cooler: ~1.3°C decrease

Projected changes: rainfall

No statistically significant change in overall average annual rainfall patterns are projected to occur. Overall rainfall extremes are also projected to stay within the limits of known natural variability.

Historically however, the region has been characterised by two distinct rainfall cycles that are directly linked to shifts in the Interdecadal Pacific Oscillation (IPO). These periods include 1948 -1976 (the wetter, more variable La Nina like negative phase) and 1977-2007 (drier, less variable El Nino like positive phase). It is projected that rainfall patterns during 2020 – 2080 will return to those higher and more variable rainfall patterns experienced during the 1948-76 La Nina like period. Projected seasonal and zonal changes are summarised below.

Rainfall (2020 – 2080)				
<i>Projected changes are relative to the 1948-1976 period</i>				
Zone	Summer	Autumn	Winter	Spring
Coastal	No significant change	No significant change	Drier: ~13% decrease	Wetter: ~15% increase
Central	No significant change	No significant change	Drier: ~12% decrease	Wetter: ~11% increase
Western	No significant change	Sig. wetter: ~33% increase	No significant change	No significant change

Projected changes: water balance

Water balance refers to the excess of precipitation over evaporation. It is affected by both the level of precipitation and prevailing temperature conditions.

A decrease in water balance is projected for the Western Zone. Seasonal shifts in the Coastal and Central Zones balance out to produce no projected change on an annual basis. Projected seasonal shifts in water balance during the period 2020-2080 for each Climate Zone are summarised below.

Water Balance (2020-2080)		
<i>Changes are reported in average mm per day relative to 1970-2007.</i>		
Season	Decrease	Increase
Summer		~1.3 mm Central Zone ~0.5 mm Western Zone
Autumn	~1.9 mm Central Zone ~0.9 mm Coastal Zone ~0.3 mm Western Zone	
Winter	~0.5 mm Central Zone	~0.7 mm Coastal Zone; ~0.2 mm Western Zone
Spring		~1.8 mm Coastal Zone ~1.3 mm Central Zone ~1.4 mm Western Zone