The Bureau of Meteorology

Implementation of climate classification maps

Introduction

This file documents the updated methodology and classification specifications for the climatological plots provided on the Bureau of Meteorology public website.

These maps have multiple applications in planning, development, agriculture, and research. The updates were necessary to include the most recent observational data and to implement a new and consistent data foundation for all climatological products.

The updated suite of maps has two benefits:

- The most recent observed climatic period is included.
- The maps create a visual sequence of Australia's changing climate, which allows customers to examine how the climate has changed between 1951 and 2020, complementing the descriptions provided in the State of the Climate reports (Bureau of Meteorology, CSIRO, 2024). Seeing the shifts through the lens of various climate classifications can help customers to understand the implications of those changes to their sectors.

Method

Climate is often colloquially considered as the "average weather" of a region, which can be more rigorously described as the mean and variability of certain elements (including the temperature, rainfall, and wind) over a period of time. It is generally accepted that 30 years of data is an appropriate length of time to describe the climate of a region. The World Meteorological Organisation recognises 30 years as the minimum length to calculate the average (referred to as *climate normals*) as this window of time sufficiently captures climate variability. The WMO climate normals are updated at the end of every decade (WMO, 2025). The maps show Australia's climate based on current and past climate normals from 1951, or from 1971 for maps which require humidity data for calculations.

Each map is based on either annual or monthly average values, or a combination of both, for rainfall and/or temperature. Annual averages are created by examining all values over the years from the relevant period and then dividing by the number of years. Monthly averages are calculated by adding monthly values and dividing by the number of years in the specified period.

The maps provided are based on the Australian Gridded Climate Data (AGCD) data set (Jones, Wang, & Fawcett, 2009; Evans, Jones, Smalley, & Lellyett, 2020).

Classifications

This section describes the three separate classification systems used for the plots provided on the web page. The classifications described in this documentation are:

- Köppen Classes
- Seasonal rainfall zones
- Climate zones based on temperature and humidity

Köppen classes

- The Köppen classes as depicted in the plots are based on an updated and adapted version of the originally described Köppen-Geiger classification system (Köppen, Klimakarte der Erde, 1931; Köppen & Geiger, Handbuch der Klimatologie, 1930-1939) which has 30 classes globally. The modified version, described in (Stern, de Hoedt, & Ernst, 2000) has 6 foundational classes in Australia (example shown in Figure 1) and 28 detailed sub-classes in Australia (example shown in Figure 2). The reader is directed to the paper which fully describes the details of the classification system. (Note that neither polar nor cold climates are found in Australia.)

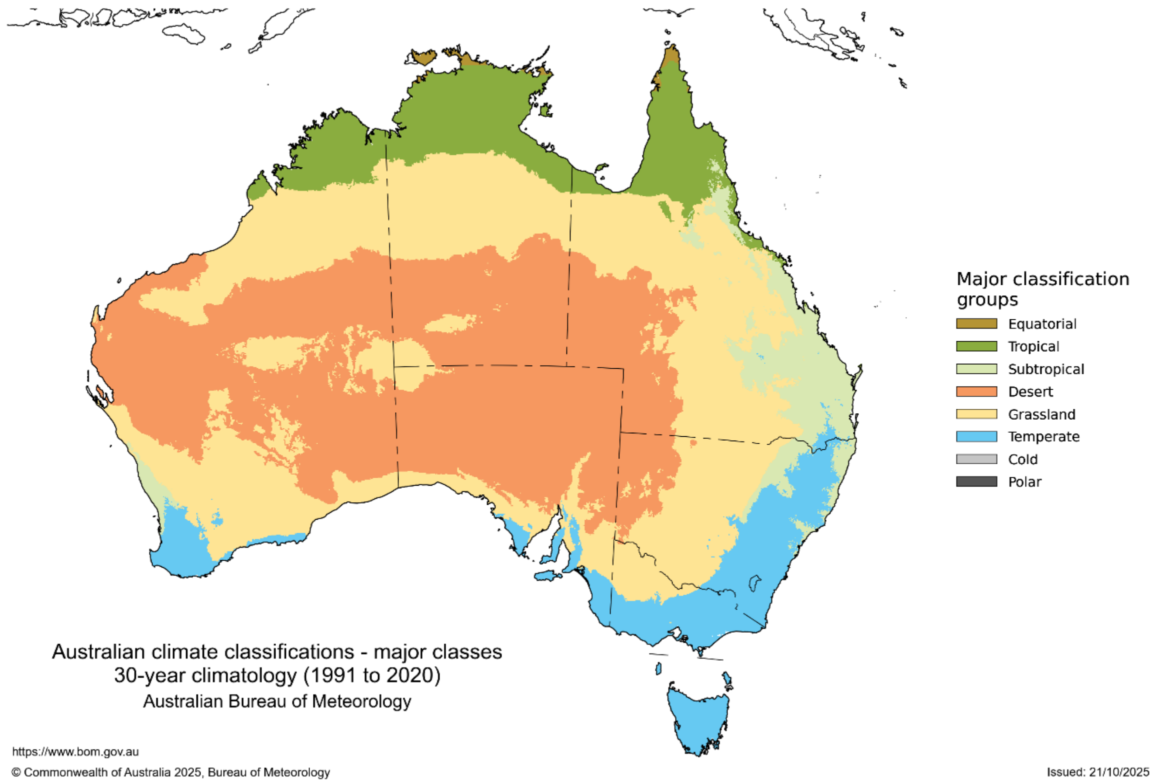

Figure 1 Stern-de Hoedt major classes computed using observational temperature and rainfall data from the years 1991 – 2020 inclusive.

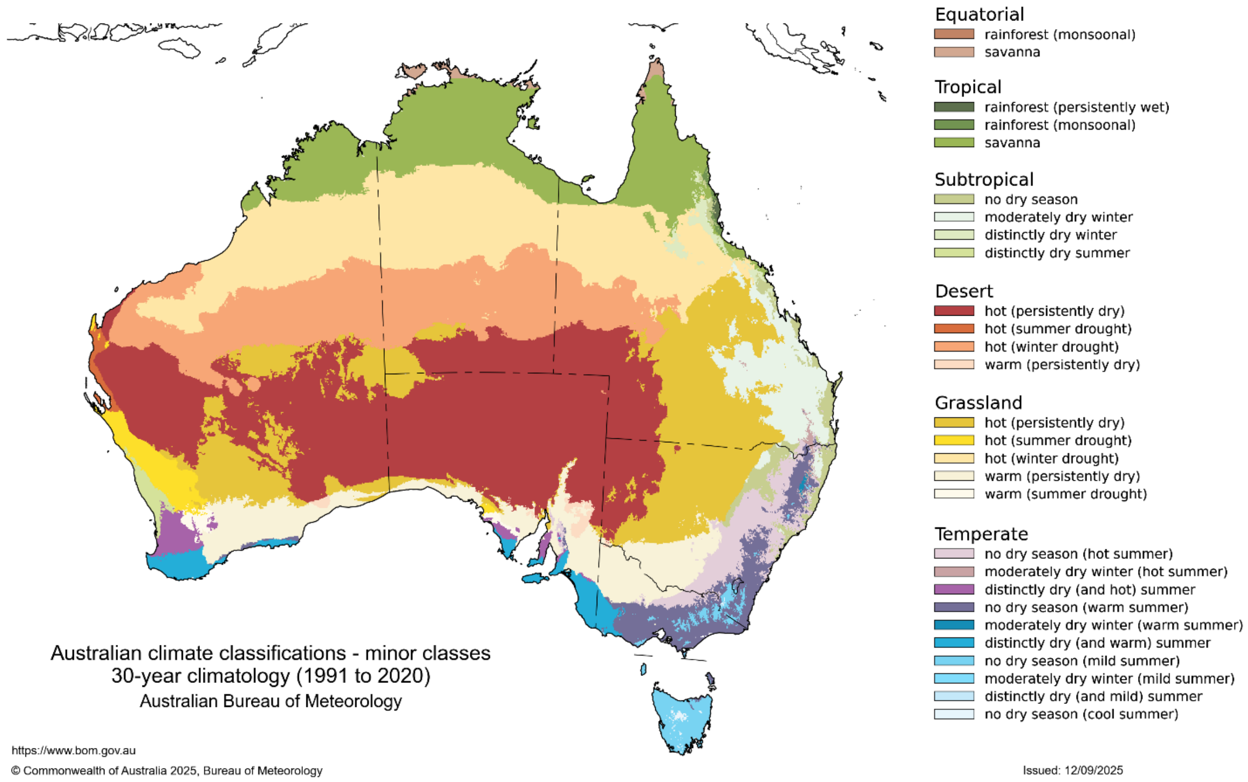

Figure 2 Stern-de Hoedt minor classes computed using observational temperature and rainfall data from the years 1991 – 2020 inclusive.

Seasonal rainfall zones

The Australian seasonal rainfall zones were originally described by Gaffney (1971). They argued that the application of various vegetation classification systems developed internationally for various purposes, including vegetation and cropping estimates, were not well suited for Australia. The seasonal rainfall zones classification system focusses on the seasonal incidence of Australian rainfall and its relationship to the seasonal atmospheric circulation with an aim to take more account of the climatic requirements of individual plants. Seasonal rainfall zones in Australia are defined based on median annual rainfall, seasonal incidence, and altitude. Seasonal rainfall is systematised as the chief determinant of climatic zones in Australia, and the classification provides an objective basis for making broad regional comparisons for development purposes.

Modifications have been made to the originally described zones to produce these maps. Firstly, the conversion from rainfall thresholds measured in inches, as it was at the time of publication, to the contemporary millimetres, with some rounding of values for ease of interpretation. Secondly, the limits used for altitude levels[1] have not been used in this implementation. Since the late 1950s snow depth, cover, and number of snow days have decreased in alpine regions (Bureau of Meteorology, CSIRO, 2024). With climate projections data indicating snowfall is likely to further decrease, limiting altitude levels would also prevent comparison of the past distribution of these rainfall zones with future scenarios. Thus, 16 of the 21 originally described rainfall zones are shown, with the arid zone corresponding approximately to the region of highest evaporation from a water free surface.

Seasonal incidence is determined from the ratio of the median rainfalls:

$$seasonal\ ratio = \frac{warm\ season\ median\ rainfall}{cool\ season\ median\ rainfall}$$

where the warm season is November to April, and the cool season May to October.

Table 1 Seasonal rainfall zones with adapted rainfall thresholds in millimetres from the originally described inches (Gaffney, 1971)

Seasonal maximum	Seasonal ratio	Median annual rainfall (mm)	Symbol
Summer-dominant (*SS*)	> 3.0	>1300	SS_h
		635-1300	SS_m
		380-635	SS_l
Summer (*S*)	1.3 < x ≤ 3.0	>1300	S_h
		635-1300	S_m
		380-635	S_l
Uniform (*U*)	≤ 1.3	> 890	U_h
		510 – 890	U_m
		255 - 510	U_l

[1] average altitude at which snow normally persists on the ground for at least 20 days during the year (this is the lower limit for the alpine regions for NSW, Vic, Tas).

Winter dominant (*WW*)	> 3.0	> 890	WW_h
		510 – 890	WW_m
		255 - 510	WW_l
Winter (*W*)	1.3 < x ≤ 3.0	> 890	W_h
		510 – 890	W_m
		255 - 510	W_l
Arid (*AZ*)	> 3.0	<380	*AZSS*
		<255	*AZWW*
	1.3 < x ≤ 3.0	<380	*ASS*
		<255	*AZW*
	≤ 1.3	<255	AZU
		Altitude minima	
Alpine (*A*)	NSW	1500m	*A*
	Vic	1250m	
	Tas	1050m	

Table 2 Adapted implementation of seasonal rainfall zones as published on www.bom.gov.au

Seasonal maximum	Seasonal ratio	Median annual rainfall	Symbol
Summer-dominant (*SS*)	> 3.0	>1200	SS_h
		650-1200	SS_m
		350-650	SS_l
Summer (*S*)	1.3 < x ≤ 3.0	>1200	S_h
		650-1200	S_m
		350-650	S_l
Uniform (*U*)	1/1.3 < x ≤ 1.3	> 800	U_h
		500 – 800	U_m

		250 - 500	U_l
Winter (*W*)	1/3 ≤ x < 1/1.3	> 800	W_h
		500 – 800	W_m
		250 - 500	W_l
Winter dominant (*WW*)	< 1/3	> 800	WW_h
		500 – 800	WW_m
		250 - 500	WW_l
Arid (*A*)	1.3 ≤ x	<350	*A (S)*
	x < 1.3	<250	*A (U and W)*

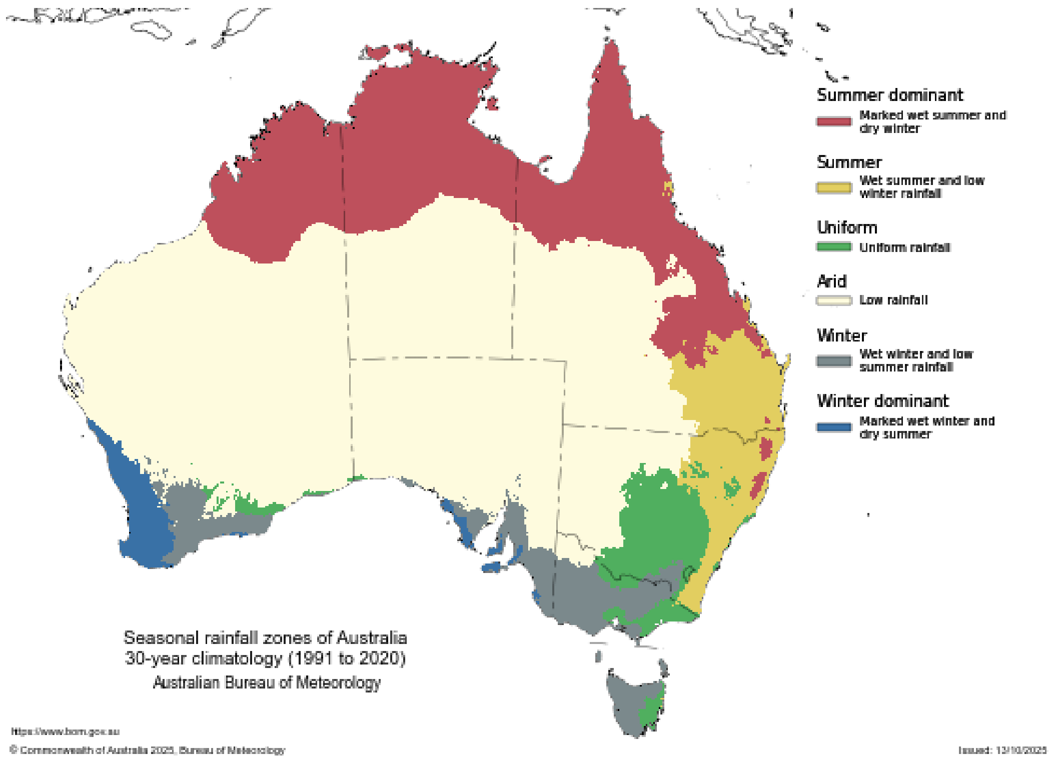

Figure 3 Seasonal rainfall zones (major) computed using observational temperature and rainfall data from the years 1991 – 2020 inclusive.

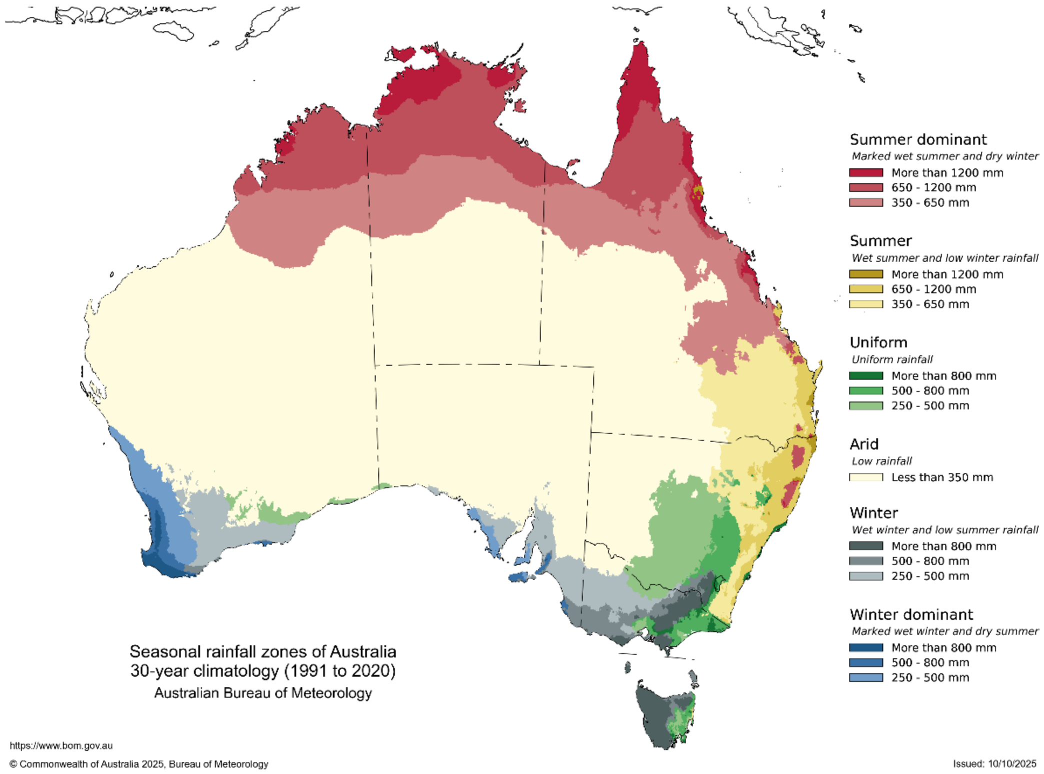

Figure 4 Seasonal rainfall zones (minor) computed using observational temperature and rainfall data from the years 1991 – 2020 inclusive.

Climate zones based on temperature and humidity

This map was originally created in 2005 using the ANUDEM software package developed by the Centre for Resource and Environmental Studies at the Australian National University (Hutchinson, 2011), to estimate climatic conditions where climate data are not available. The classification is provided in Table 3.

Table 3 Temperature and humidity climate zones

Climate zone	Temperature conditions	Vapour pressure conditions
hot humid summer, warm winter zone	average January max temp >= 30 °C	average 3 pm January water vapour pressure >= 2.1 kPa
warm humid summer, mild winter zone	average January max temp <= 30 °C	average 3 pm January water vapour pressure >= 2.1 kPa
hot, dry summer, warm winter zone	average January max temp > 30 °C average July mean temperature > = 14 °C	average 3 pm January water vapour pressure < = 2.1 kPa
hot, dry zone with cool winter	average January max temp > 30 °C average July mean temperature < = 14 °C	average 3 pm January water vapour pressure <= 2.1 kPa
warm summer, cool winter (temperate zone)	average January max temp <= 30 °C average annual heating degree days (definition supplied for Glossary) <= 2000, using base 18 °C	average 3 pm January water vapour pressure <= 2.1 kPa
mild to warm summer, cold winter (cool temperate zone)	average January max temp <= 30 °C average annual heating degree days >= 2000, using base 18 °C (this is the threshold where edge insulation of concrete slabs becomes cost effective.)	average 3 pm January water vapour pressure <= 2.1 kPa

2.1 kPa is about the upper humidity limit for comfort. The American Society of Heating, Refrigeration and Airconditioning Engineers uses 1.87 kPa. It also coincides most closely with the 24°C wet-bulb isotherm, above which evaporative cooling starts to have limited effect.

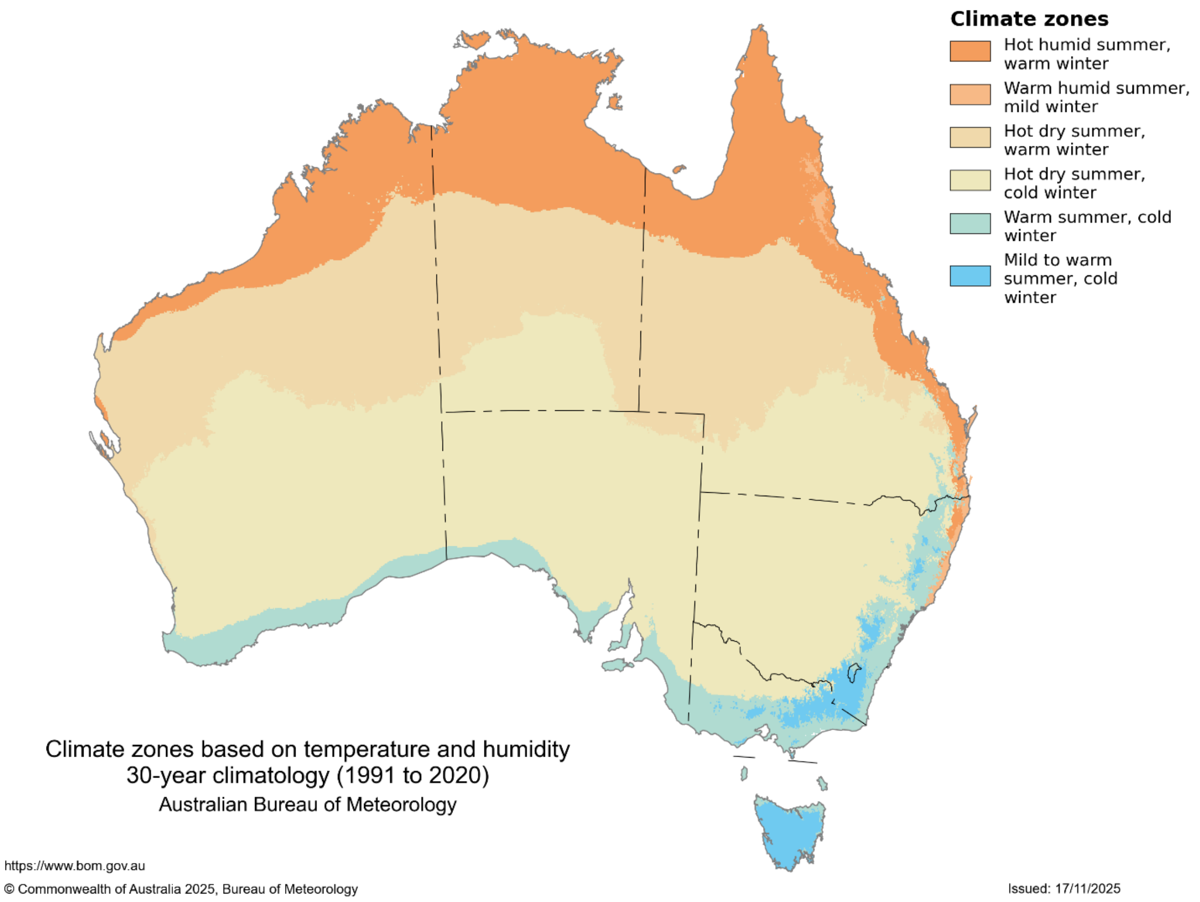

Figure 5 Climate zones based on temperature and humidity computed using observational temperature and humidity data from the years 1991 – 2020 inclusive.

Heating/cooling degree days

Heating and cooling degree days are based on the *average daily temperature*, computed by

$$average\ daily\ temperature = \frac{daily\ maximum\ temperature + daily\ minimum\ temperature}{2}$$

A threshold is chosen for a *comfort level*. If the average daily temperature falls below the comfort level, heating is required; and if it goes above the comfort level, cooling is required.

The *heating degree days* or *cooling degree days* are determined by the difference between the average daily temperature and the comfort level temperature.

Examples:

Heating degree days: if the comfort level is 18 °C, and the average daily temperature for a particular location was 14 °C, then heating equivalent to 4 °C (4 heating degree days) would be required to maintain a temperature of 18 °C for that day. If the average daily temperature was 20 °C, then no heating would be required, so the number of heating degree days for that day would be zero.

Cooling degree days: if the comfort level is 24 °C, and the average temperature for a day was 27 °C, then cooling equivalent to 3 °C (3 cooling degree days) would be required to maintain a temperature of 24 °C for that day. If the average temperature was 21 °C, then no cooling would be required, so the number of cooling degree days for that day would be zero.

The comfort level values used in the plots provided here are 12 °C and 18 °C for heating and 18 °C and 24 °C for cooling.

Average annual heating and cooling degree days are calculated by adding heating and cooling degree days totals over the years specified and dividing the total by the number of years in that period (30 years in this case). Similarly, average monthly heating and cooling degree days are calculated by adding monthly totals and dividing by the number of years in the specified period.

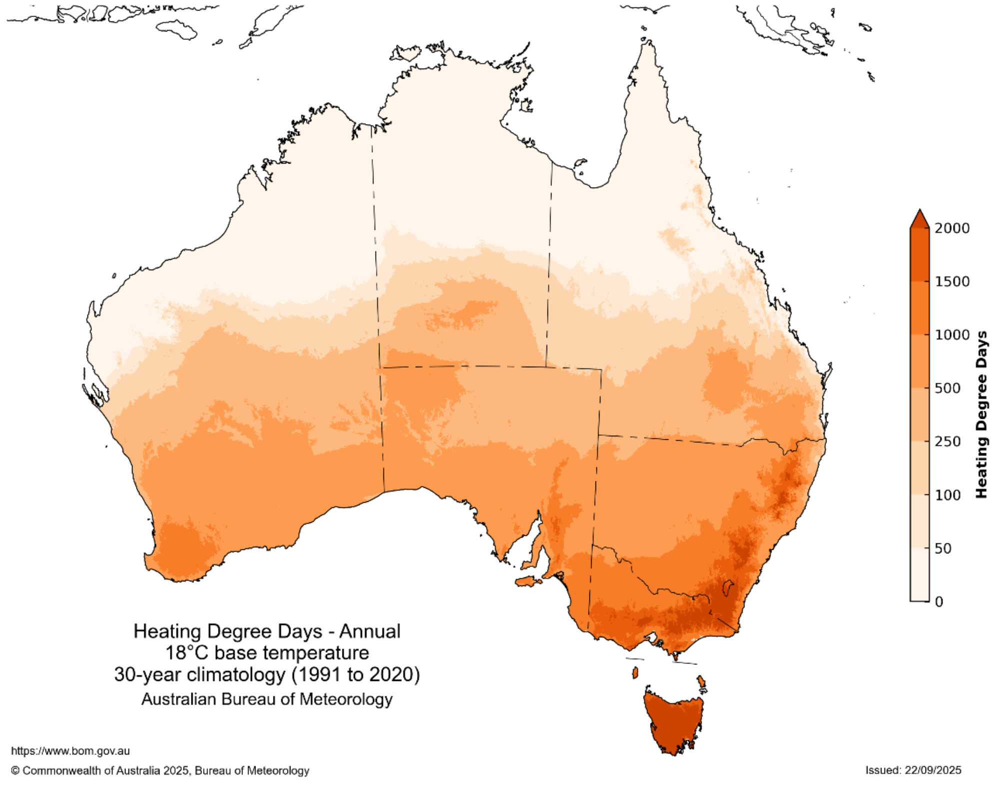

Figure 6 Annual heating degree days based on 18 °C threshold computed using observational temperature data from the years 1991 – 2020 inclusive.

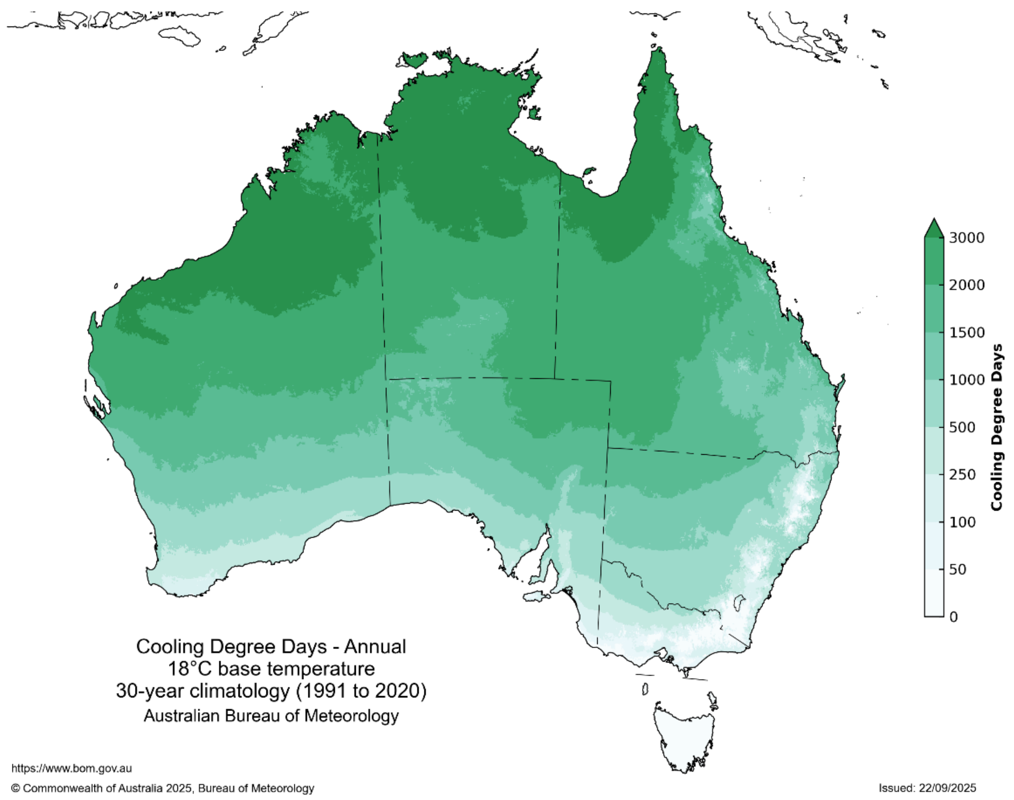

Figure 7 Annual cooling degree days based on 18 °C threshold computed using observational temperature data from the years 1991 – 2020 inclusive.

Copyright details

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