Technical information supporting the 2023 Temperature environmental trend and condition report card

Department for Environment and Water
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DEW Technical note 2023/47

Government of South Australia
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Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

Acknowledgements

This document was prepared by Graham Green (DEW) and technically reviewed by Dan Rogers (DEW). Brady Stead (DEW) provided mapping support. Improvements were made to this report and associated report card based on reviews by Amy Ide (DEW), Di Favier (DEW) and Fi Taylor (DEW).

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Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Temperature report card. The reliability of information sources used in the report card is also described.

The Temperature report card sits within the report card Climate theme sub-theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

1 Introduction

1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the *Landscape South Australia Act 2019* is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the *Environment Protection Act 1993*. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- include a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the *River Murray Act 2003* (112(3(ab))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

1.3 Climate change in Australia

Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline.

According to the Australian Academy of Science (2015), "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."

The Bureau of Meteorology (the Bureau) and other science agencies employ a range of air, land and marine sensors to track climatic trends across Australia. The Bureau's Australian Climate Observations Reference Network – Surface Air Temperature dataset is based on a network of over 100 stations.

The Bureau's biennial State of the Climate report draws on the latest monitoring, science and projection information to describe variability and changes in Australia's climate (including temperature) and how it is likely to change in the future (Bureau of Meteorology 2022).

1.4 Temperature

The Climate: Temperature report card reports on the decadal timescale trends in temperature change observed in South Australia over the past approximately 52 years. The information presented is based on Bureau observed trend data representing 1970 to the present.

The report card provides textual comments on the trends in observed temperature in two figures presented in the card. These figures show 1) a colour-coded contour map of changes in mean annual temperature across South Australia, and 2) a graph of the annual mean temperature anomaly for South Australia from 1900 to 2022.

2 Methods

2.1 Indicator

The indicator used for the Temperature report card is the spatially averaged annual average temperature, recorded at monitoring stations distributed across South Australia.

2.2 Data sources, collection and analysis

The content of the Temperature report card includes a combination of elements of textual information, graphical figures, trend and condition ratings, and summary statements about the observed temperature trends in South Australia. The information sources and analyses applied to derive each element of the report card content are summarised in Table 2.1. The method of selection of the trend, condition and information reliability ratings is described in Section 2.3.

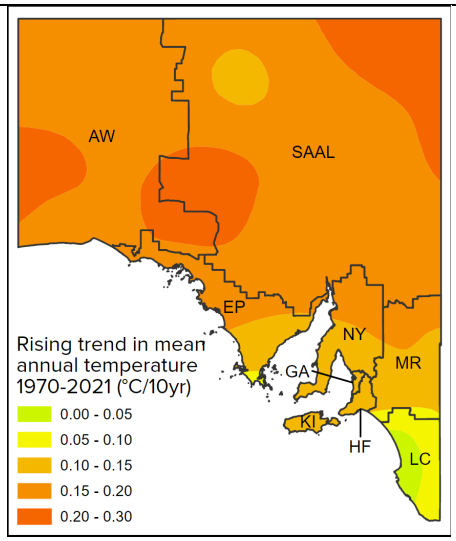
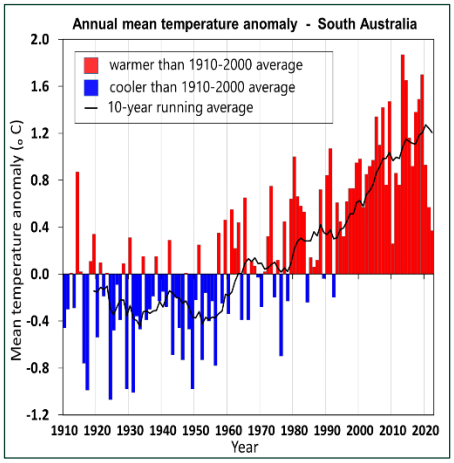
The temperature trend contour map, showing zones of decadal temperature trends covering the whole of South Australia, was provided by the Bureau of Meteorology's Business Solutions Group (Figure 2.1). The temperature trends in the map are calculated from a homogeneous temperature dataset (known as the Australian Climate Observations Reference Network - Surface Air Temperature, or ACORN-SAT, dataset) developed for monitoring climate variability and change in Australia (Bureau of Meteorology 2023a). The dataset employs the latest analysis techniques and takes advantage of newly digitised observational data to provide a national daily temperature record since 1910. The boundaries and identifying initials of each of the landscape regions were added to the map by the Department for Environment and Water (DEW) and a new legend panel inserted. The base temperature trend contour map can be downloaded directly from the Bureau's Australian variability and change trend tracker website (Bureau of Meteorology 2023b).

The graph of the statewide annual mean temperature anomaly shows the difference (anomaly) between statewide mean annual temperature for each year from 1910 to 2022, compared to the mean annual statewide temperature during the period 1961 to 1990 (Figure 2.2). Data for the annual temperature anomaly graph were downloaded directly from the Bureau of Meteorology's Australian variability and change trend tracker website (Bureau of Meteorology 2023b).

Table 2.1. Summary of information sources and analysis

Report card element	Content	Information sources / analysis
Trend quote	Average annual temperatures across South Australia have been increasing since the 1970s, with the highest rates of increase in the north of the state.	This statement is based on observation of the regional temperature trend map in the top figure of the report card, which shows a rising trend in temperature from 1970–2021 in all of the state's landscape regions, and the graph in the bottom figure, which shows a marked trend of increase in annual mean temperature anomalies (compared to a 1961–1990 baseline period) for South Australia.

Report card element	Content	Information sources / analysis
Trend text	This assessment uses Bureau of Meteorology Australian variability and change trend maps. These are based on observed temperature data from Bureau monitoring stations distributed across Australia. Mean annual temperature, averaged across South Australia is now approximately 1.1 degree Celsius (°C) warmer than in the 1970s. The increase in annual average temperature has been variable, such that the coolest parts of the state in the Limestone Coast (LC) region,have seen the lowest increases (top figure). The highest rate of increase in temperature is observed in the South Australian Arid Lands (SAAL) region, where mean annual temperatures in some areas have increased by up to 1.5°C over the past 50 years in what was already the warmest part of South Australia.	The trend text provides observations on the temperature trend map within the top figure of the report card and the graph in the bottom figure. The statement regarding the mean annual temperature, averaged across South Australia now being approximately 1.1 degrees Celsius (°C) warmer than in the 1970s is derived from the difference between the South Australian state average annual temperature anomaly (from 1961–1990 baseline) in the past 10 years (2013–2022) and the average annual temperature anomaly for the 10-year period of 1970–1979, using the temperature anomaly data underlying the bottom figure in the report card. The temperature trend map in the top figure and the data for the graph in the bottom figure are drawn from the statewide temperature trend data for 1970–2022 from the Australian climate variability and change trend tracker website (Bureau of Meteorology 2023b): (http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries) The statements on the variations in rates of the warming between different parts of South Australia are based on observation of the temperature trend map in the top figure of the report card.
Condition quote	The condition is rated as fair. Overall, changes in temperature across South Australia since the 1970s have been manageable.	The condition rating was applied according to the criteria for a 'fair' condition: 'The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought).' This rating was selected as the current condition of annual temperatures, having shown a rising trend over recent decades, particularly in the warmest regions of South Australia, does not consistently meet environmental, economic and social expectations, in all areas and particularly at times of temperature extremes, such as during heat waves.
Condition text	In the 30 years from 1993–2022, South Australia has not experienced any years with a mean temperature below the mean annual temperature of the 20th century (bottom figure). The hot and arid north-east of South Australia now experiences a higher frequency of very hot daytime and nighttime temperatures during summer. In Adelaide, the average frequency of days reaching 40°C in the 10 years from 2013–2022 has been 5.1 days per year.	The comment on all of the past 30 years (1993–2022) having an annual mean temperature below the mean annual temperature of the 20th century is based on an observation of the South Australian annual temperature anomaly graph shown in the bottom figure of the report card, which shows the annual mean temperature anomalies for South Australia compared with the record of temperatures from 1910–2000. The comment on the frequency of days reaching over 40°C in Adelaide over the past ten years is based on a count of the frequency of 40+°C days in the period 2013–2022 (5.10 days/year) in the Bureau's ACORN-SAT daily maximum temperature dataset for Adelaide (station numbers 23090 and 23000), compared with

Report card element	Content	Information sources / analysis
	This is nearly 3 times the frequency of 40°C days in the preceding 40 years.	the frequency of occurrence of these days during the previous 40-year period 1973–2012 (1.725 days/year).
Quote	Average annual temperatures have increased across South Australia, particularly in the the arid north-east.	This comment is based simply on an observation of the South Australian regional temperature trends map shown in the top figure of the report card.
Top figure		The temperature trend contour map, showing zones of decadal temperature trends covering the whole of South Australia, was provided by the Bureau of Meteorology Business Solutions Group. A similar map, using the same underlying dataset, is available from the Bureau's temperature trend maps website (Bureau of Meteorology 2023): http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=trend-maps The temperature trends in the map are calculated from a homogeneous temperature dataset (known as the Australian Climate Observations Reference Network - Surface Air Temperature, or ACORN-SAT, dataset) developed for monitoring climate variability and change in Australia (Bureau of Meteorology 2023a).
Bottom figure		The graph of the statewide annual mean temperature anomaly is constructed from data drawn from the data download option at the Bureau's Australian variability and change trend tracker website (Bureau of Meteorology 2023b): http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=trend-maps The graph shows the difference (anomaly) between statewide mean annual temperature for each year from 1910 to 2022, compared to the mean annual statewide temperature during the period 1910 to 2000.
Rationale	Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline. One example of the impact of a rise in average temperatures is an increase in the occurrence of severe heatwaves. This has important implications for human health, food production and biodiversity.	This is a general comment on the rationale for providing a report on the trend and condition of temperature in South Australia.

Report card element	Content	Information sources / analysis
Drivers	According to the Australian Academy of Science, "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."	This statement from the Australian Academy of Science was selected to describe this pressure as it encapsulates a statement of the primary cause of warming, the effects on the Earth's physical environment in the past and future. The statement is drawn from Australian Academy of Science (2015) www.science.org.au/climatechange
What is being done?	The Government of South Australia supports a wide range of initiatives to reduce greenhouse gas emissions and help the state to adapt to the changing climate. These include supporting renewable energy generation and storage, carbon sequestration, land use planning reforms, climate related hazard risk reduction, coastal protection, greening to cool urban environments, circular economy initiatives and regional adaptation projects. The government provides downscaled climate projections information and tools for South Australia.	Information on the Government of South Australia's climate change response initiatives are drawn from DEW's Climate Change web page: SA Government action on climate change.

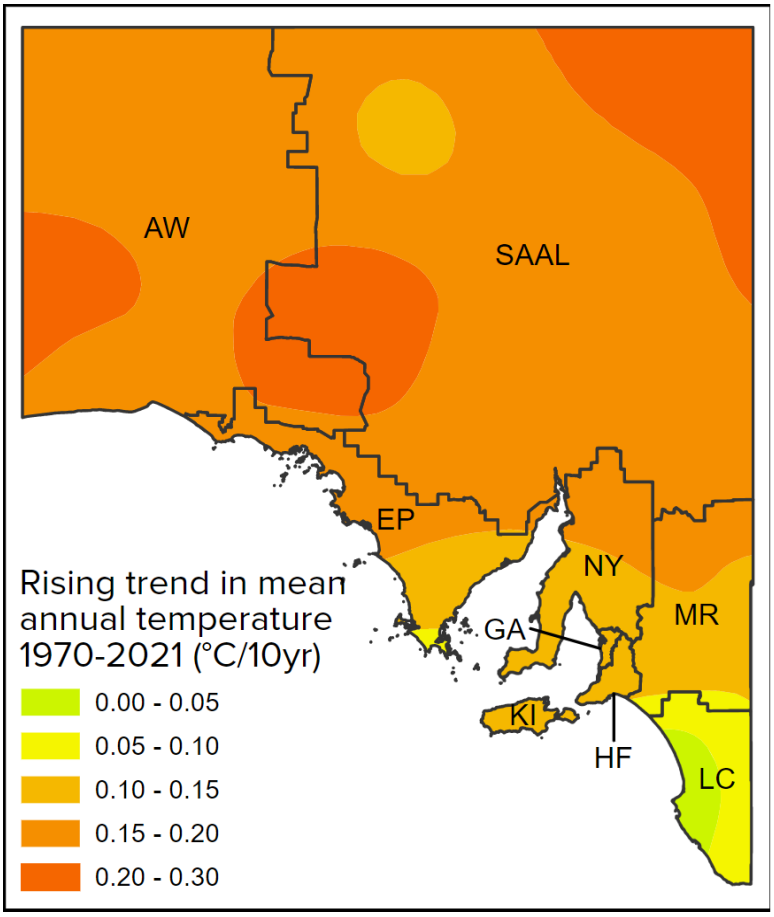


Figure 2.1. Rising trend in mean annual temperature (°C/10yr) for South Australia, 1970–2021

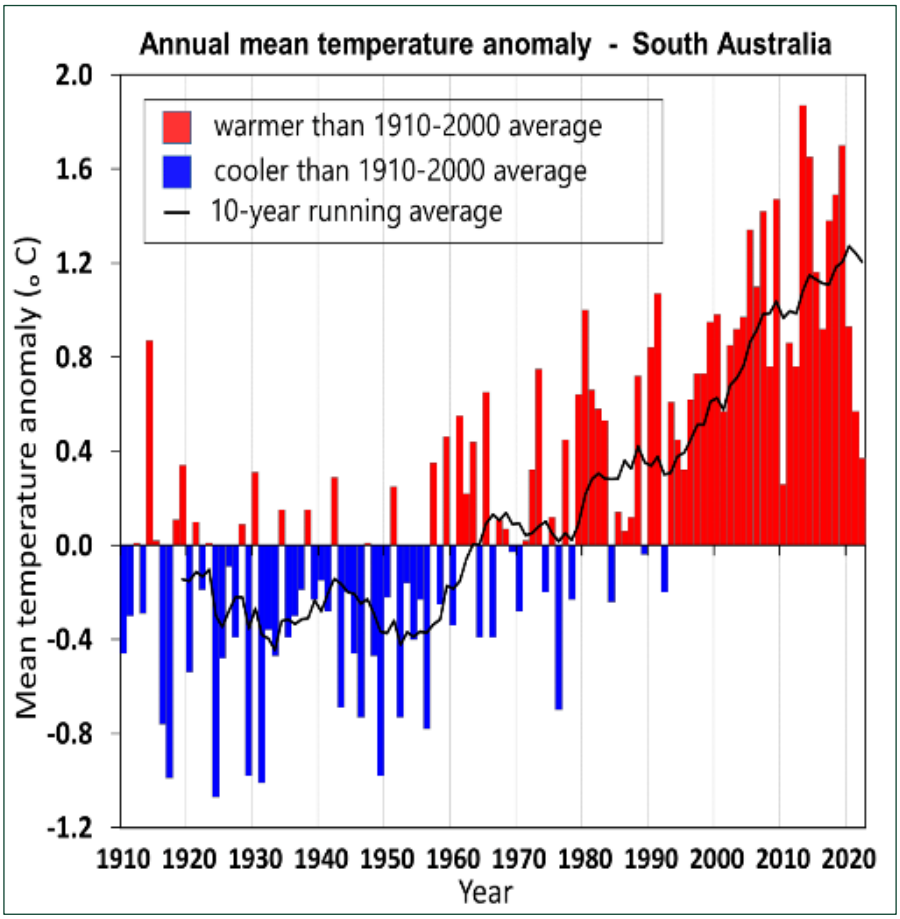


Figure 2.2. Annual mean temperature anomaly (°C) for South Australia, 1910–2022

2.3 Methods to assign trend, condition and reliablity

2.3.1 Trend

Table 2.2. Definition of trend classes used

Trend	Description
Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence
Stable	Over a scale relevant to tracking change in the indicator it is neither improving nor declining in status
Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence
Unknown	Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above trend classes

2.3.2 Condition

Table 2.3. Definition of condition classes used

Condition	Description
Very good	The natural resource is in a state that meets all environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for all processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Good	The natural resource is in a state that meets most environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for only some processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Fair	The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Poor	The natural resource is in a state that does not meet most environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from most processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Unknown	Data are not available to determine the state of this natural resource, based on this indicator
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above condition classes

2.3.3 Reliability

Information is scored for reliability based on the minimum of subjective scores (1 [worst] to 5 [best]) given for information currency, applicability, level of spatial representation and accuracy. Definitions guiding the application of these scores are provided in Table 2.4 for currency, Table 2.5 for applicability, Table 2.6 for spatial representation and Table 2.7 for accuracy.

Table 2.4. Guides for applying information currency

Currency score	Criteria
1	Most recent information >10 years old
2	Most recent information up to 10 years old
3	Most recent information up to 7 years old
4	Most recent information up to 5 years old
5	Most recent information up to 3 years old

Table 2.5. Guides for applying information applicability

Applicability score	Criteria
1	Data are based on expert opinion of the measure
2	All data based on indirect indicators of the measure
3	Most data based on indirect indicators of the measure
4	Most data based on direct indicators of the measure
5	All data based on direct indicators of the measure

Table 2.6. Guides for applying spatial representation of information (sampling design)

Spatial score	Criteria
1	From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown
2	From an area that represents less than 25% the spatial distribution of the asset within the region/state
3	From an area that represents less than half the spatial distribution of the asset within the region/state
4	From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified
5	From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design

Table 2.7. Guides for applying accuracy information

Reliability	Criteria
1	Better than could be expected by chance
2	> 60% better than could be expected by chance
3	> 70 % better than could be expected by chance
4	> 80 % better than could be expected by chance
5	> 90 % better than could be expected by chance

2.4 Data transparency

Data transparency for this report card is represented in Appendix A.

3 Results

3.1 Trend

The trend rating for temperature was determined to be 'getting worse'. The statewide rise in average annual temperatures over the recent decades is assessed to be a trend that is 'getting worse' due to the increased risk of extreme heat conditions, threats to water security and potential impacts to agriculture and ecosystems that may result from a warmer climate.

3.2 Condition

The condition rating assigned is 'fair' because, while temperatures have risen throughout South Australia, the changes in annual temperatures in most of the state have been manageable. For example, in a study by CSIRO and the South Australian Research and Development Institute (SARDI) (Nidumolu et al. 2023), farmers in South Australia's low rainfall grain cropping regions and arid interior grazing regions reported that they are continually adapting to season–to–season variations and to the changing climate. Most farmers felt that their current business model was working and that they had not been forced to make drastic changes in response to climate change.

The higher temperatures now experienced in South Australia have caused some readjustment of industries and communities, but in most cases the changes experienced to date have been overcome by adjusting working and management practices.

3.3 Reliability

The overall reliability score for this report card is 3 out of 5 based on Table 3.1. A reliability rating of 'good' has been assigned.

Table 3.1. Information reliability scores for temperature

Indicator	Applicability	Currency	Spatial	Accuracy	Reliability
Temperature data	5	5	3	4	3

3.3.1 Notes on reliability

The information has a currency score of 5 as measured temperature data up to 2022 have been used.

The information has an applicability rating score of 5 because the data are based on measurements which are direct indicators of temperature and these measurements are locationally-specific, being from rain measurement stations distributed across South Australia.

A spatial representation score of 3 has been assigned because the data are from temperature monitoring stations that are distributed throughout the area of the state, however, each one is representative of temperature over a limited area within the vicinity of the monitoring station. Hence, the whole extent of the state is represented by the monitoring network, however the measurements do not fully represent the spatial variation of temperature within the state.

The observed changes in average annual temperature are based on direct measurements of daily temperatures at calibrated monitoring stations distributed across South Australia. However, the coverage of these monitoring

stations is variable across the state, with the more remote areas having a sparse distribution of stations. As a result, the accuracy of the data, for the purpose of the report card, has been ascribed a score of 4.

4 Discussion

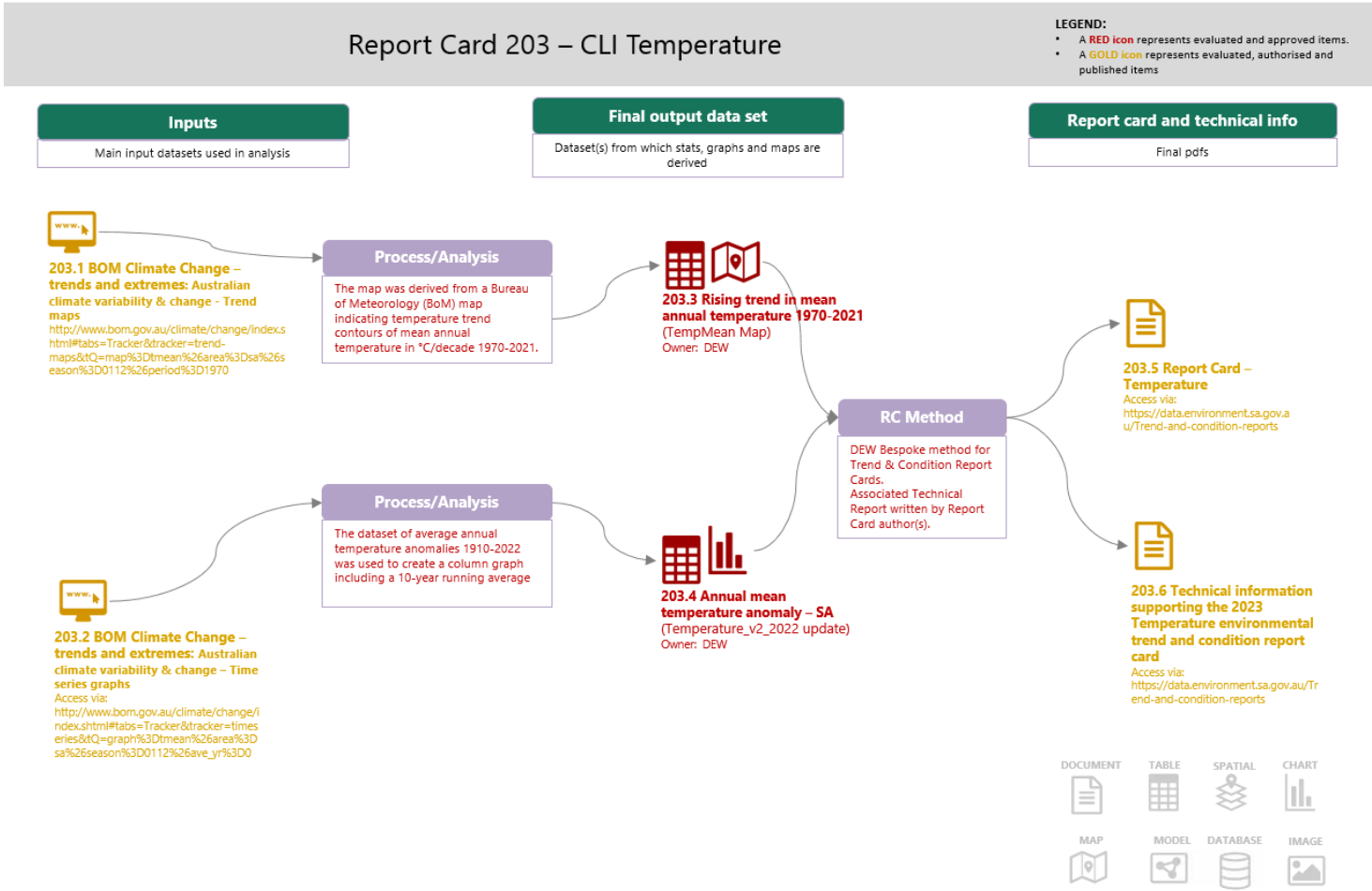
4.1 Trend

The trend rating for temperature was determined to be 'Getting worse' as the average annual temperature is rising over the whole of South Australia. The rate of temperature rise is greatest in the northern regions of the state, which already experience a hot climate.

4.2 Condition

The condition rating assigned is 'Fair' because, while annual average temperature has risen over the whole of South Australia over recent decades, the changes in average temperatures experienced to date have been manageable.

5 Appendix A: Managing environmental knowledge chart for Temperature



6 References

Australian Academy of Science (2015). "The science of climate change: Questions and answers", Australian Academy of Science, Canberra www.science.org.au/climatechange.

Bureau of Meteorology (2020). Long-term temperature record Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) synthesis paper: www.bom.gov.au/climate/change/acorn-sat/documents/About_ACORN-SAT.pdf.

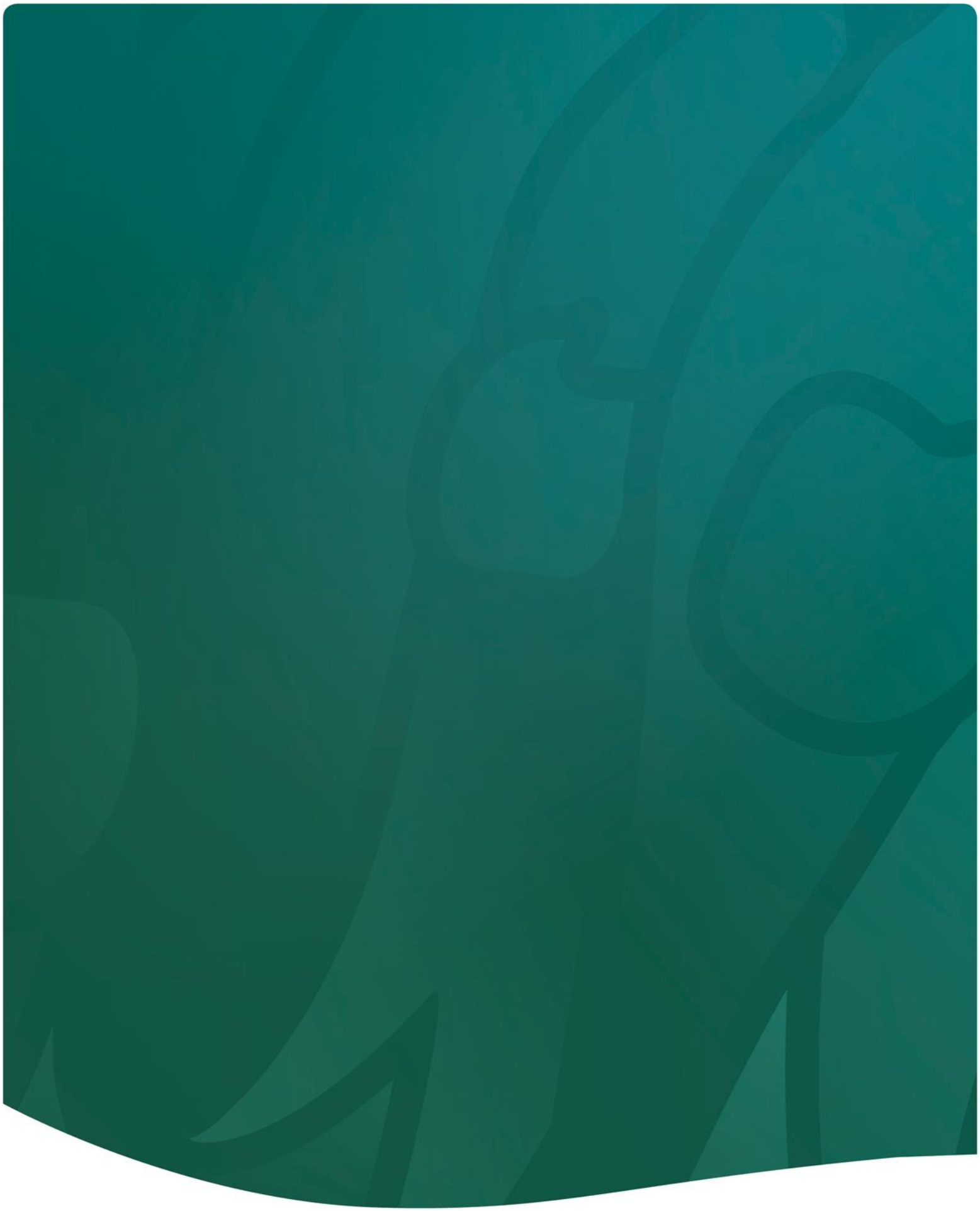
Bureau of Meteorology (2022). State of the Climate 2022 website: www.bom.gov.au/state-of-the-climate/.

Bureau of Meteorology (2023a). Long-term temperature record: Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) website: www.bom.gov.au/climate/change/acorn-sat/.

Bureau of Meteorology (2023b). Climate change – trends and extremes: Australian climate variability & change - Trend maps website: www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=trend-maps.

DEWNR (2017). Trend and Condition Report Cards for South Australia's Environment and Natural Resources. Report. Department of Environment, Water and Natural Resources, Government of South Australia. Available at: https://data.environment.sa.gov.au/NRM-Report-Cards/Documents/Trend_Condition_Report_Cards_2017.pdf.

Nidumolu U, Hayman P, Fletcher A, Ota N, Cooper B, Thomas D, Chen C, Round V & Ratcliff C (2023). *Farming on the edge: assessing the impact of historical and future climate change and adaptation options in the Australian Mediterranean cropping margins.* Paper to the national Climate Change Adaptation Conference, Adelaide, 2023.



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