Australia's climate change: a new empirical model - MASTER INDEX

Plan of paper

Submission to the House Standing Committee on the Environment and Energy in respect of the Climate Change (National Framework for Adaptation and Mitigation) Bill 2020 and Climate Change (National Framework for Adaptation and Mitigation) (Consequential and Transitional Provisions) Bill 2020

Dr Bill Laing
Climate scientist & former Geological Consultant to the international mining industry

4 December 2020

Support I support the Climate Change Bill. As a former 50-year international geological consultant to the mining industry on all continents, and now as a climate scientist who has developed and is publishing a new empirical synthesis of Australia's climate from 1856 to 2018, I have identified that Australia is heating at a mean rate of 2.4 DPC (degrees per century). This is double the world heating rate. It is a huge wake-up call to me and my fellow Australians.

Personal statement I am making this submission because, having in the submitted study identified the first rigorous heating rate for Australia, at double the world rate, I am alarmed more than I have ever been as a long-term climate activist. I have children and grandchildren, I can see the world they are inheriting, and is scares me. I want the Climate Bill to proceed, and I want our politicians to act at last on our climate emergency.

Conscience vote: I ask that the decision by Parliamentarians be a conscience vote, to allow MPs to represent the views and voices of Australians in their electorate. In 2019 300,000 ordinary Australians went on strike, in the middle of a working Friday, to express their plea for action on climate change and to express their anger at politicians and the Federal Government for their failure to act on climate change. I flew from Townsville to Sydney for the day, to march with likeminded people and with my sister-in-law, niece, and great-niece. This issue is the greatest test Australians have ever faced (and I have had killed and wounded relatives in World War I and II). Climate change is the world's worst nightmare, and its saving grace is that we can act to mitigate it for future generations.

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Key points:

- I am a Climate Scientist who has completed a two year study producing a new synthesis of Australia's climate since our weather records started in 1856.
- Using the publicly available weather data from the Bureau of Meteorology, a subset which is internationally accredited as rigorously high quality (the BOM ACORN-SAT database). The minimum temperatures are those seen nightly on TV.
- This is the first whole-of-continent study of Australia's empirical climate. It contains no forward computer modellling or model-based predictions. It is solely evidence-based. It does contain a major set of predictions: a projection of each Australian location into the near future - the 1-5 decades in which climate change will really be dealt with - or not.
- The study reveals, in a number of new understandings, the following:
  - Australia is heating at a mean rate of 2.4 degrees per century (DPC) - this is double to world rate
  - Australia has been heating since a well-defined startdate at circa 1956 (the tightly-constrained mean of 95 heating startdates) - a baking period of 65 years.
  - The highest rate is at Longreach Queensland with 5.3 DPC, and 5 other stations are heating at more than 4 DPC.
  - 75% of Queensland is heating at more than 3 DPC, or three times the cited world rate.
- Australia's heating rate is faster than many other nations. Figure 21 shows Los Angeles at an identical rate to the Australian mean of 2.4 DPC. Many locations in eastern Australia possess much faster heating rates than LA and other wildfire-prone parts of California. Much of Eastern Australia has baked at a higher rate than California.

This Submission addresses the following aspects of the Bill:

1	√√	**Objectives and long-term emissions reduction commitment**
2	√√	**Why legislating Net Zero by 2050 and regular 5 year budgets is important**
3		**Guiding principles to be applied**
4	√	**Risk and adaptation assessments for all sectors**
5	√	**Technology readiness assessment**
6		**Independent climate change Commission and skills needed on the Commission**

Australia's climate change: a new empirical model

Australia's climate regime 1856-2018 - a coherent continent-scale system sequestered from the other continents by circumcontinental ocean currents, with Stage 1 cooling reversing at 1956 ± 9 into Stage 2 heating at double the cited world rate. The system significantly enhances global heating models.

Dr Bill Laing

4 December 2020

Dedicated to James Jardine Butler; my geography teacher, mentor and friend

Australia's climate change: a new empirical model

Summary

1 This two year study delivers the first comprehensive empirical model of Australia's climate from start of records 1856 to 2018.

2 This is believed to be the first temporo-spatial study of climate change across a continent. Australia is the only continent which is (**Figures 1-2** and **Appendix**):
- *wholly within one hemisphere* (southern)
- *quarantined from the industrial revolution for 150 years*, which provides a picture of anthropogenic heating sharper than the northern hemisphere
- *quarantined from the other continental landmasses,* by three oceans; one of only two continents *wholly enveloped by ocean*
- *enveloped by major throughgoing ocean currents:* East Australian, Leeuwin, Circum-Antarctic
- a *sub-equant landmass* (3900 x 3700 kilometres), with no major shape anisotropy influencing its main climate drivers
- a *temperate* location (11^{o}S to 44^{o}S), representative of much of the planet's continents
- the most *topographically subdued* continent (maximum elevation 2230 metres)
- uniquely a *single-jurisdiction nation*, with a *weather database spanning the planet's anthropogenic heating phase*, and *equal in quality to the world's best*.

1 The current Australian climate regime is interpreted to be largely confined to its continent, and constrained by a suite of drivers which are largely unaffected (directly) by other landmasses.

2 We use the BOM internationally accredited ACORN-SAT database: 109 high-quality stations representative of the continent.

3 Major climate change is seen in the minimum temperature (Tmin) data: rapid cooling in Stage 1 followed by rapid heating in Stage 2: **Figures 3-6**. Australian stations share (INSERT % OF STATIONS) a *characteristic temperature* profile: two stages, each stage closely approximated by a straight line supported by linear and moving average regressions, and whose validity is confirmed by internally and externally consistent temporo-spatial patterns.

4 The transition from stage 1 to stage 2 is generally sudden, seen as a slope reversal and a distinctive V shaped graph: **Figure 3**.

5 The slope reversal, marking the start of stage 2 heating, is remarkably consistent over the continent; at 1956±9: **Figure 7**. Stage 2 startdate for the East Continent is 1957±8, West Continent is 1954±12.

6 The cooling and heating are rapid: maximum rates are (degrees per century DPC) stage 1: -3 DPC and stage 2: +5.3 DPC: **Figures 8-11**. The mean rates are stage 1: -0.8 DPC and stage 2: +2.4 DPC.

7 These rates are substantially higher than the IPCC- and BOM-cited world rate of ca 1 DPC: **Figures 12-14.** Australia's mean Tmin rate is more than double the world Tmean rate, which after allowing for the difference between Tmin and Tmean, maintains an Australian heating rate distinctly faster than the world rate.

Australia's climate change: a new empirical model

Summary

8 Australia's cooling-heating climate system flags a global message: **Figure 15**. The world's conventional measure of climate heating, being "the *net* temperature increase since records began", denies the reality of a climate system which is heating in a stepped manner: much of Australia has only *net* heated 1 or 2 degrees but in its current stage 2 is heating at up to 5.3 DPC. Global climate systems which contain a neutral (no heating) stage like Australia's (Figure INSERT) are significantly misrepresented by a net heating figure, and those which contain a cooling phase are seriously misrepresented. The real measure of climate evolution is the heating rates of its sequential differentiated stages, not the *historic net* rate. The staged heating rates represent real heating events; the net rate does not represent any heating event. Heating graphs which are meaningfully interpreted in *stages* (linear or non-linear) deliver "big picture" information - particularly dates of climate transformation - which is not captured in *net* heating "rates" and allied fictional "events" (**Figures 13-14**).

9 There is clear evidence of acceleration in heating; Melbourne and Sydney in the past 26 years show rates of 6.5 and 4.2 DPC: **Figure 16**. Other locations, including remote sites removed from any urban heat island effects, show similar acceleration of heating in the last several decades.

10 The consistency and detail of the results, down to well-defined subregions of climate change at only 500 kilometre scale, clearly illustrate the impacts of *near-field* (continent-scale) climate drivers rather than *far-field* (global-scale) drivers such as sunspot activity or atmospheric GHG content. The near-field drivers manifest in this study are most obviously (1) circumcontinental ocean currents, and (2) distance from the ocean: **Figures 8, 17-21**. We may also speculate that continental topography, albeit mostly low-frequency, has played an important role.

11 There appears to be a dynamic - causal - relationship between stage 1 cooling and stage 2 heating. The majority of regions of anomalous stage 1 cooling are also regions of anomalous stage 2 heating: **Figures 8-9** and **21-22.** This relationship is observed in the two largest (in area and/or magnitude) paired stage 1-stage 2 anomalies: the Queensland Low-High and the Bass Low-High. This "lightning strikes twice in the one place" is an unexpected situation which begs explanation; one which may shed light on the near-field processes of climate change.

12 The increase in Australia's current Tmin heating rate to 2.4 DPC requires accommodation in national and international climate databases.

13 Australia's Tmin heating rate of 2.4 DPC contrasts with the southern hemispheric Tmean heating rate of 0.9 DPC: **Figure ....**. Allowing for Tmin/Tmean adjustment, the heating rates for the other contributing continents remain manifestly below the mean southern hemispheric rate. Given the Antarctic Tmean of (1.8 DPC - CHECK), the heating rates for South America and southern Africa must be (notionally) ca 1 DPC or less.

Summary

14 The information embodied in the results is ripe for further analysis, by meteorologists, climatologists and geographers. Fertile subjects include the mechanisms of heat exchange between ocean (currents) and landmass, and the resulting changes in pattern of airmasses from pre-stage 2 startdate into stage 2 heating. Why such a sharp temporal boundary between stages 1 and 2? Why such a sharp spatial boundary between the two different continental halves? What do these superficially unrelated sharp boundaries tell us about the atmospheric-hydrospheric-lithospheric mechanisms and interactions which control climate (change)?

15 The climate change experienced by Australia has been directly experienced, in digital form, by all adult Australians. Most adult Australians watch the weather report on the nightly TV news, and have seen the reported overnight minimum temperatures. If they had graphed the weather presenter's nightly Tmin, over their screen-watching lifetime, they would be well aware of the climate heating at their location. Australians do not need climatologists to appraise them of Australia's climate change.

16 The significant modification of, and increase in, Australia's current heating rate is a clarion call to our community. Our political leaders have been tardy in responding to the climate emergency, based on the accepted world (IPCC) and Australian (BOM) heating rate of "around one degree per century". Given the new, real, Australian rate at double the accepted rate, what will the Australian Government's response be now? The "old" rate underpins a whole national edifice of bureaucracy and of corporate affairs: planning and management of much of our social infrastructure and culture has been based on a seriously underestimated climate heating event. The new rate, and its related weather and climate manifestations in all their detail around our continent, need to be substituted for the "old" rate, and expeditiously.

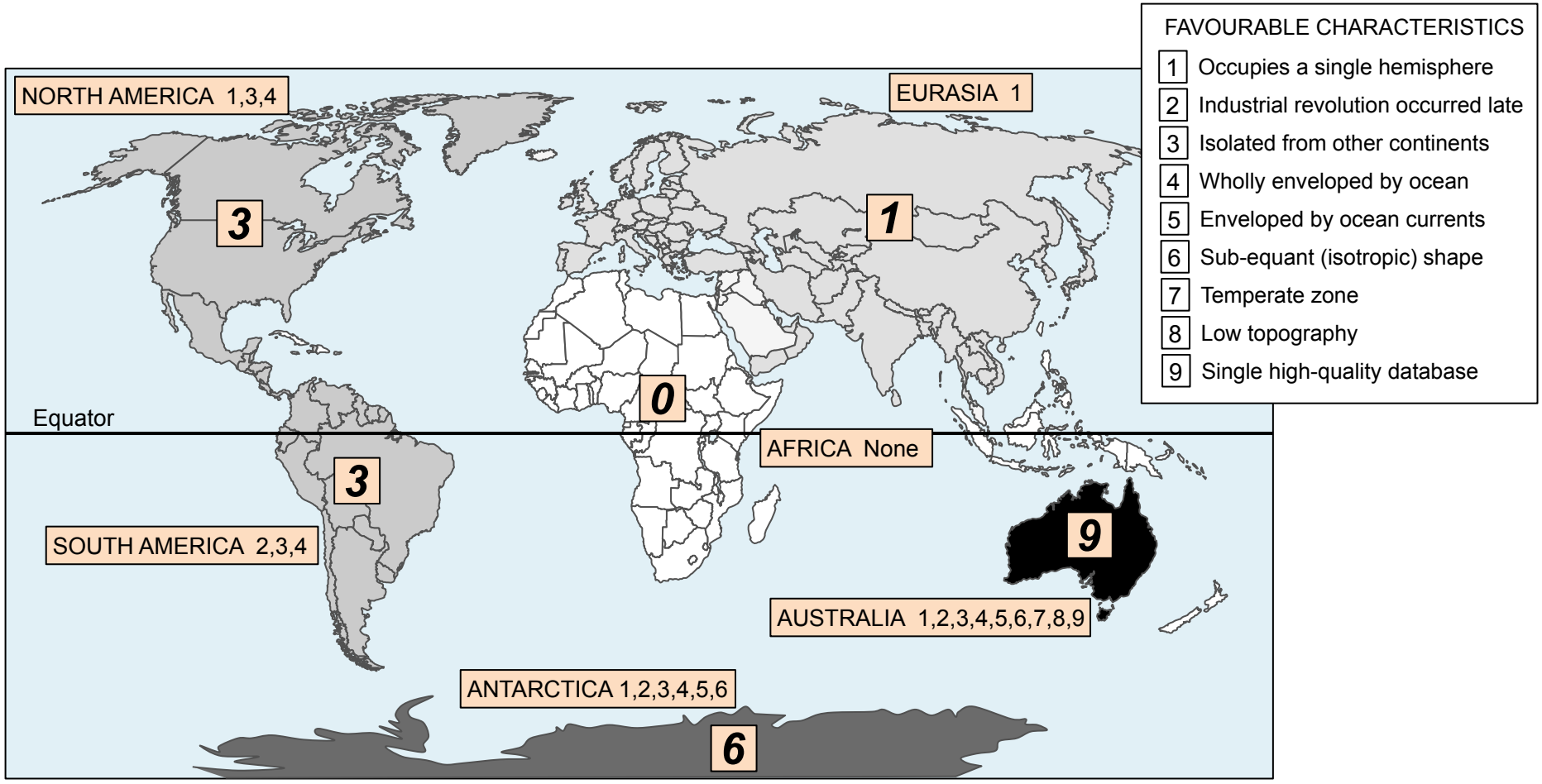
17 Australia's climate change? 2.4 DPC mean heating rate (minimum temperature), which commenced at a uniform continent-wide startdate 1956±10.

Australia is a unique climate change laboratory delivering unique answers

For each continent on the map below:

The italicised large number measures the favourable characteristics which facilitate climate modelling of that continent

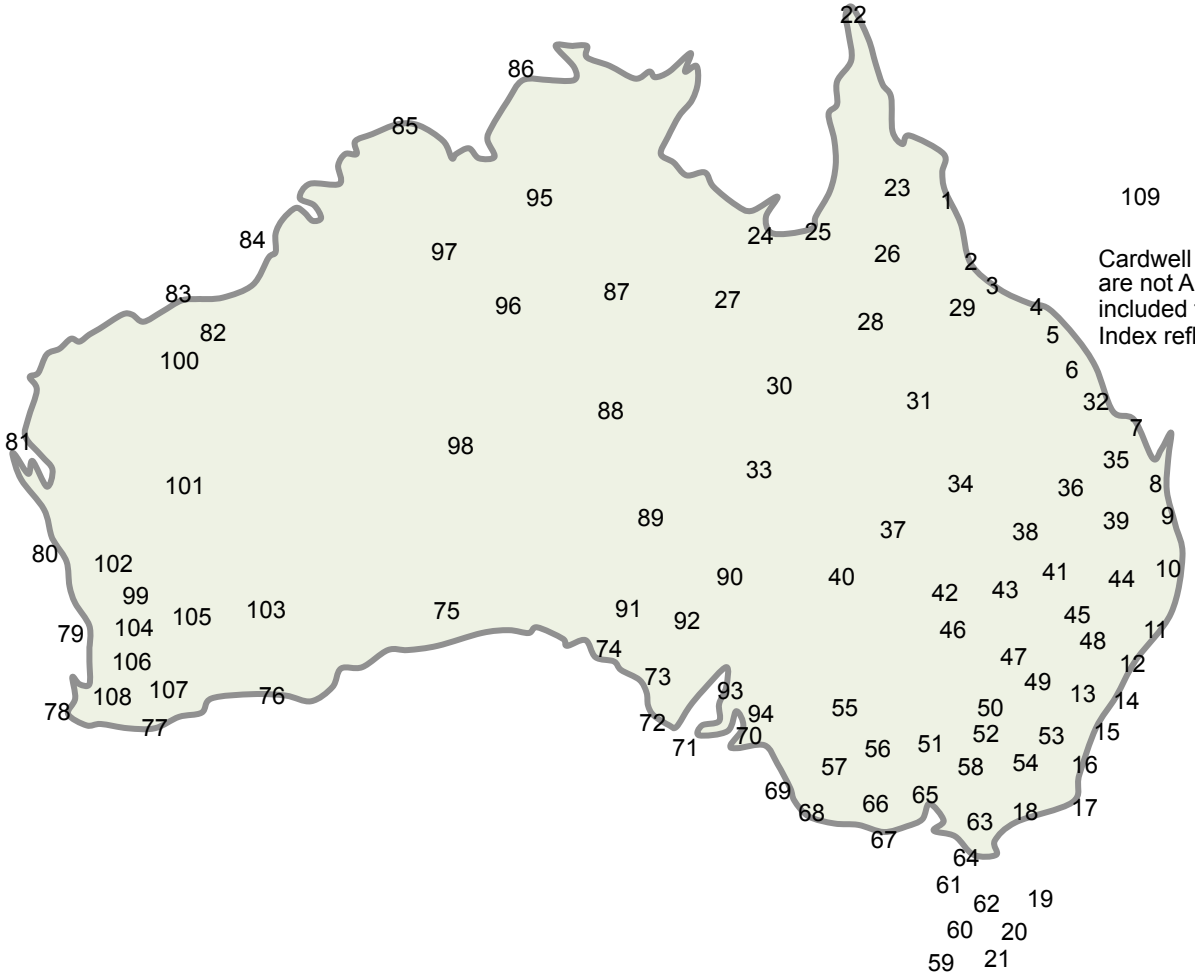
Its greyscale shading is proportional (in darkness) to the number of favourable characteristics



https://slidelizard.com/en/blog/powerpoint-world-map

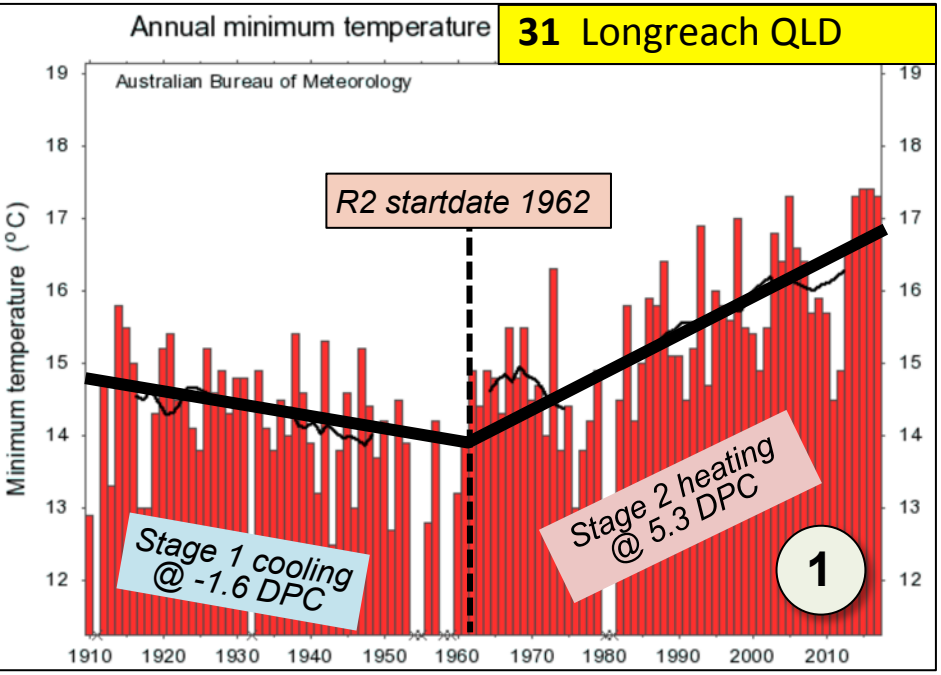
Figure 1

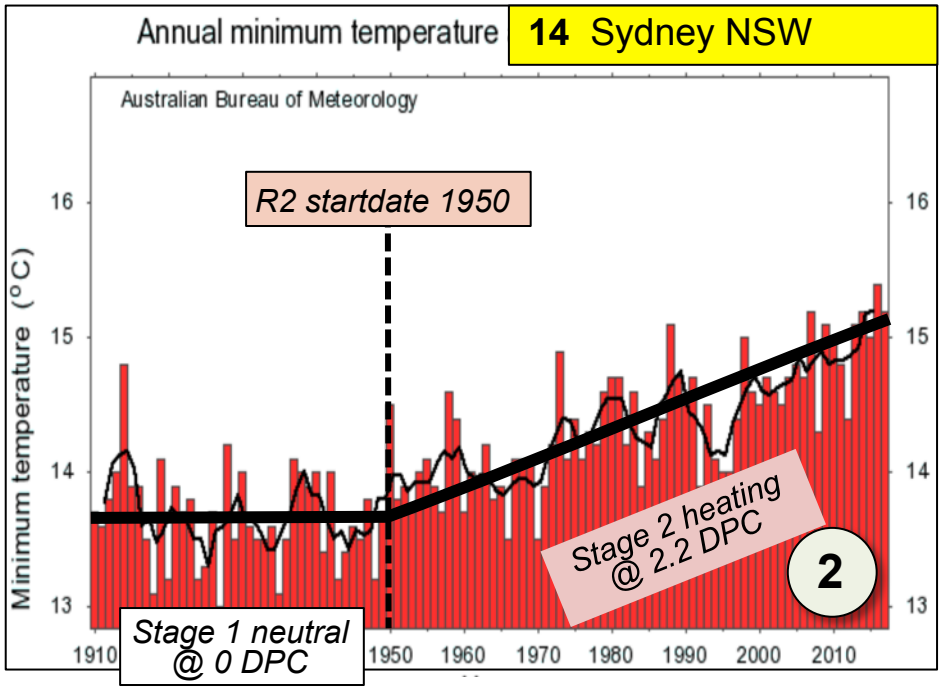
Australian distribution: ACORN-SAT weather stations

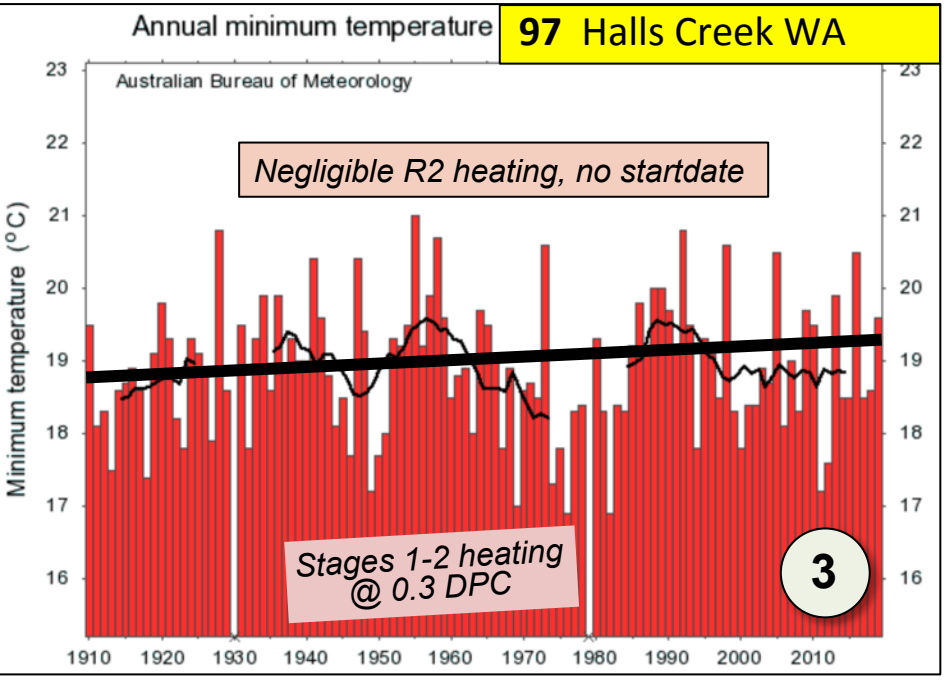


Cardwell 2, Bowen 4 and St Lawrence 6 are not ACORN-SAT stations but are included for important detail. Their Quality Index reflects their lower credibility.

Figure 2





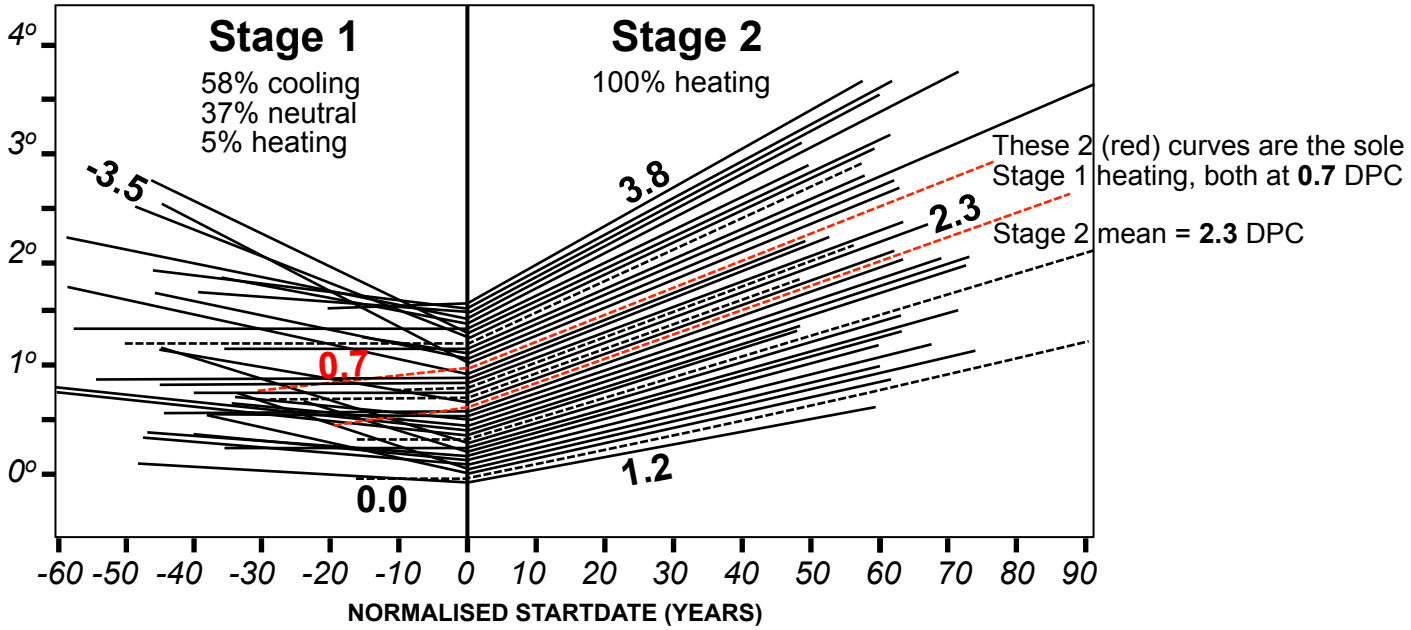


Typical heating graphs representing the 3 major types of climate temperature change in Australia:

Type 1	*Stage 1* ***Cooling*** *then Stage 2* ***Heating***
Type 2	*Stage 1* ***Neutral*** *then Stage 2* ***Heating***
Type 3	*Stages 1 and 2 (almost)* ***Neutral*** *and* ***indistinguishable***

The linear regression is manual (visual), constrained by a calculated moving average ranging between 2 and 10 years.

Figure 3



SUMMARY*

STAGE 1 Predominantly cooling

Maximum heating rate	**0.7**	In 2 stations
Maximum cooling rate	**-3.5**	Over 38 stations
Minimum cooling rate	**0.0**	Over 38 stations
Mean cooling rate	ca **-1**	Over 40 stations

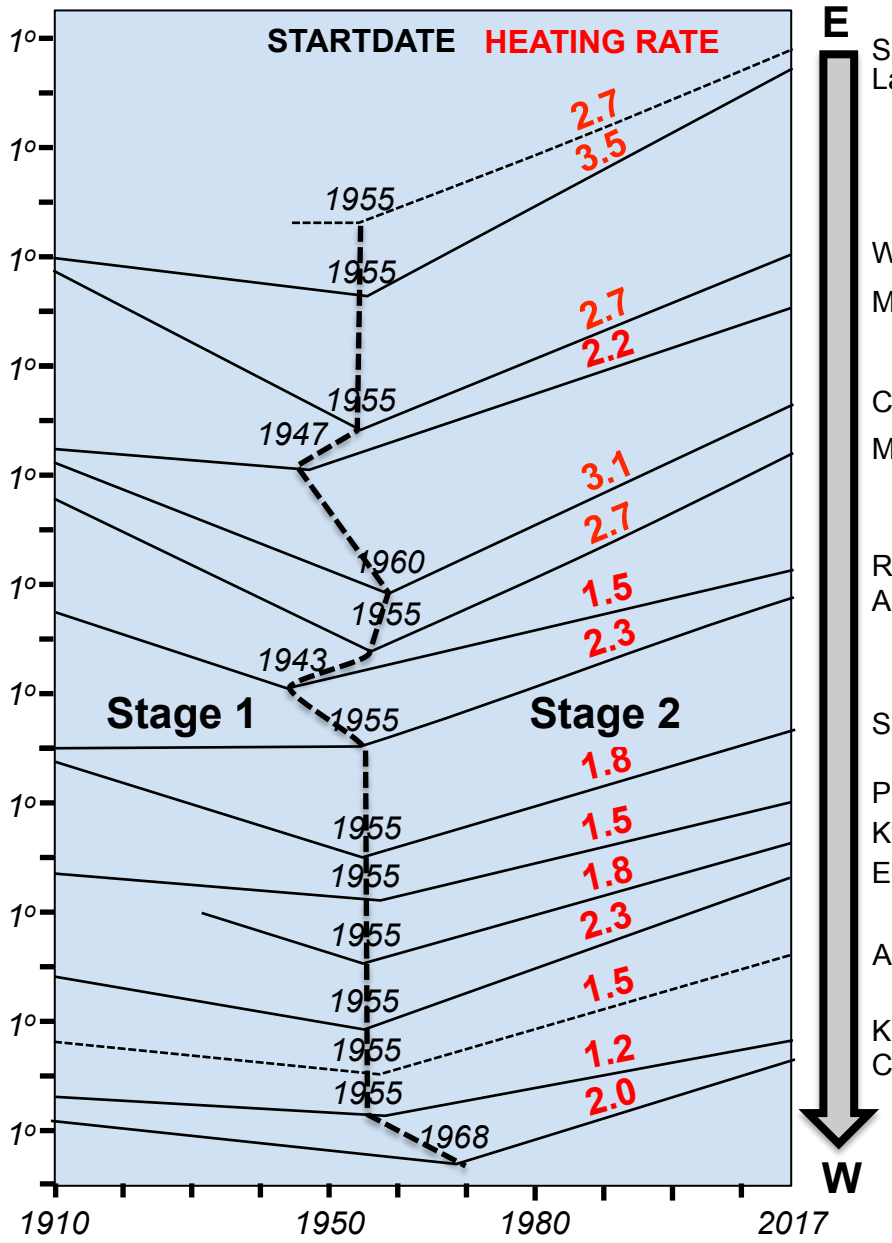
STAGE 2 Completely heating

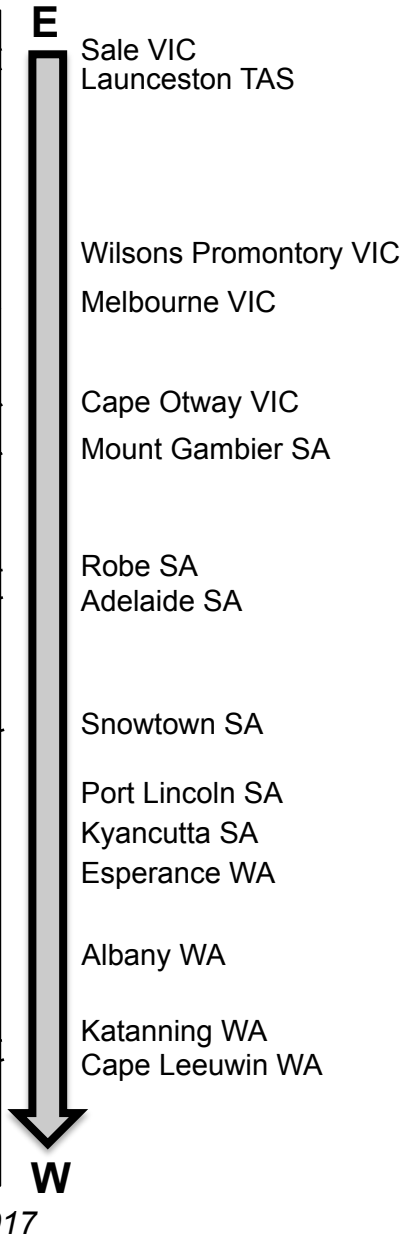
Maximum heating rate	**3.8**	Over 57 stations
Minimum heating rate	**1.2**	Over 57 stations
Mean heating rate	**2.3**	Over 57 stations

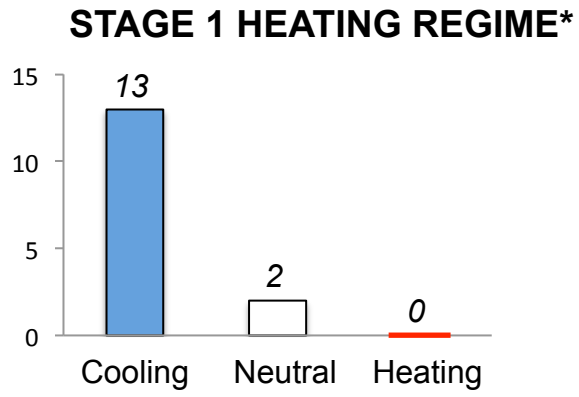
* In degrees per century (DPC)

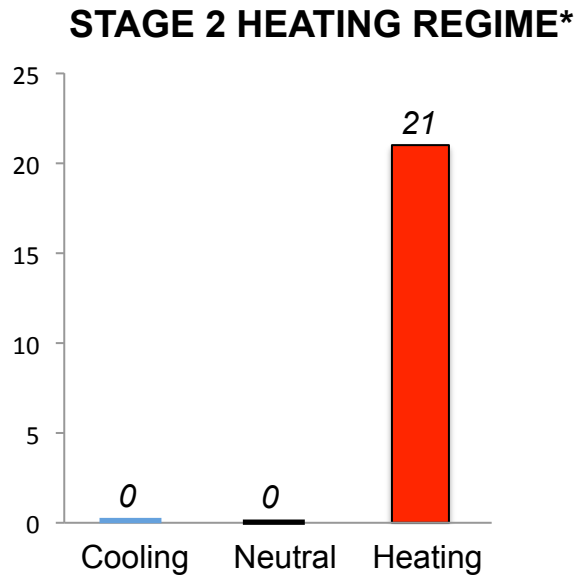
The heating graphs of coastal Australia, normalised to startdate "0", and arranged to display their array of Stage 2 heating rates. Stage 1 curves range from 2 heating (red), through 15 neutral, to 23 cooling. Numbers indicate heating (+) or cooling (-) rates in DPC. Solid curves have reliability 3/3, dashed curves have reliability 2/3.

Figure 4









* Stage 2 has more stations than Stage 1 because some younger stations do not cover Stage 1

Transect of heating graphs (minimum temperature) along Australia's South coast domain, using only high-reliability stations (score 3/3) plus Sale and Albany (2/3). Transect is E to W (arrow, top to bottom). The strong differentiation of each station's opposing-slope stages 1 and 2 permits the two-stage "V-shaped" manual linear regression shown.

Figure 5

Australia's climate stages 1 and 2: Summary

Stage 1: from start of records to heating startdate at ca 1956, was mostly cooling or neutral
Stage 2: from startdate to the present, is uniformly heating except in the WA interior (neutral)

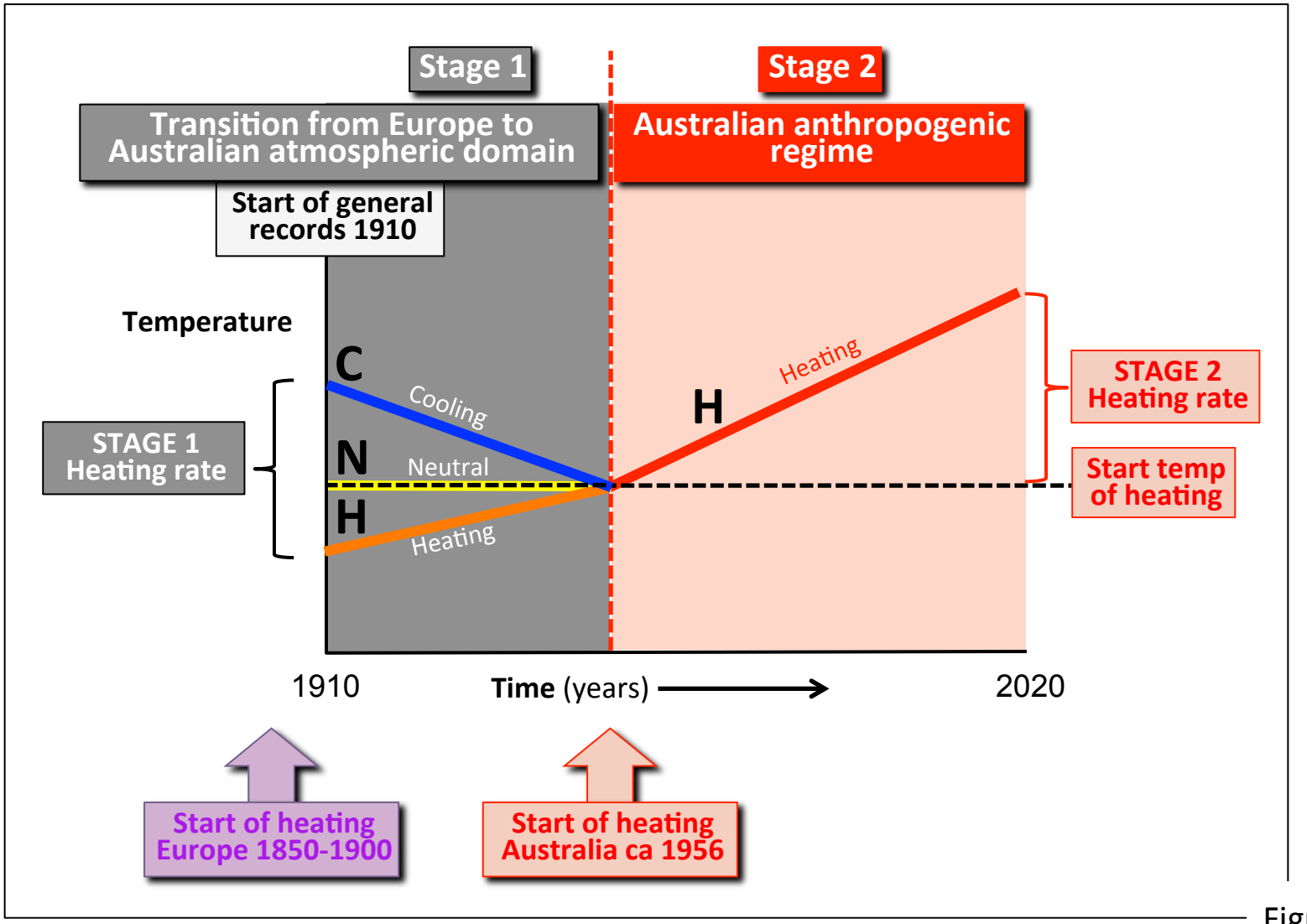


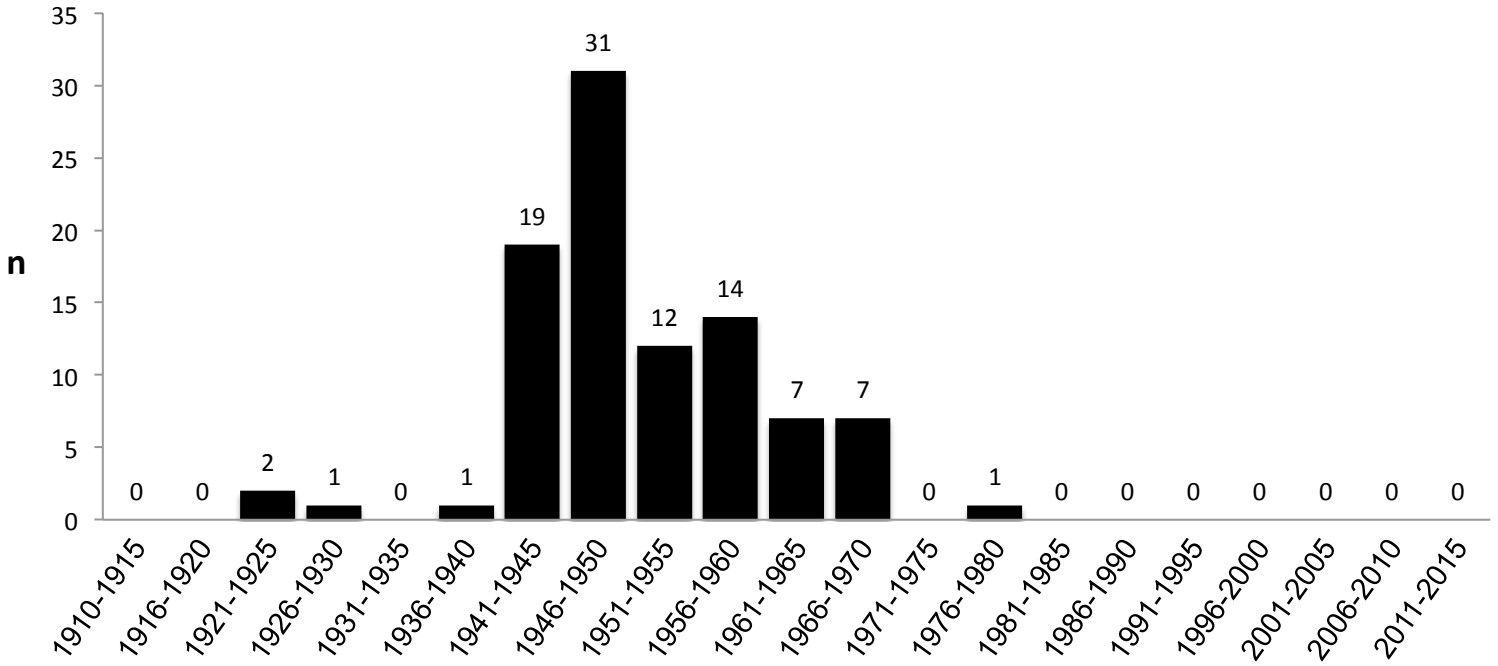
Figure 6

Australia's climate heating started at a similar time almost everywhere

Startdate for Stage 2 heating R2

1946-1950 has 31 entries = 33% of all stations
90 stations started heating in the 30 year period between 1941 and 1970: this is 95% of the continent.

Whole of Australia	**Mean = 1956**	**Standard Deviation = 9.2**
East Australia	**Mean = 1957**	**Standard Deviation = 8.4**
West Australia	**Mean = 1954**	**Standard Deviation = 11.6**



The date range is that of the BOM ACORN-SAT database; accredited Australian weather stations operated from 1910.

Frequency plot of Stage 2 startdates, from all-quality stations (Quality Index QI varies from 1/3 to 3/3).

Figure 7

Stage 1: Cooling/Heating Rate R1

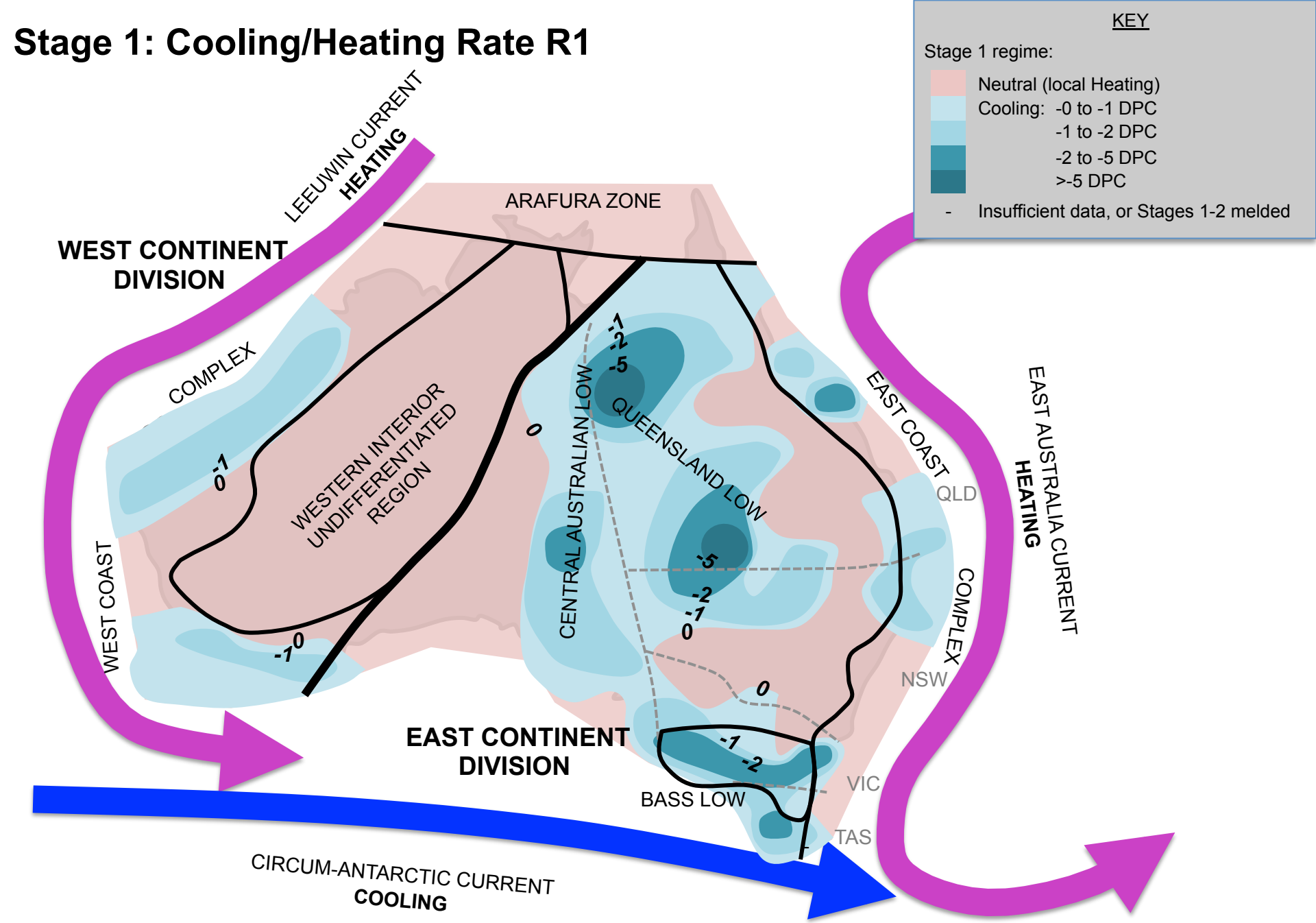


Figure 8

Stage 2: Heating rate R2

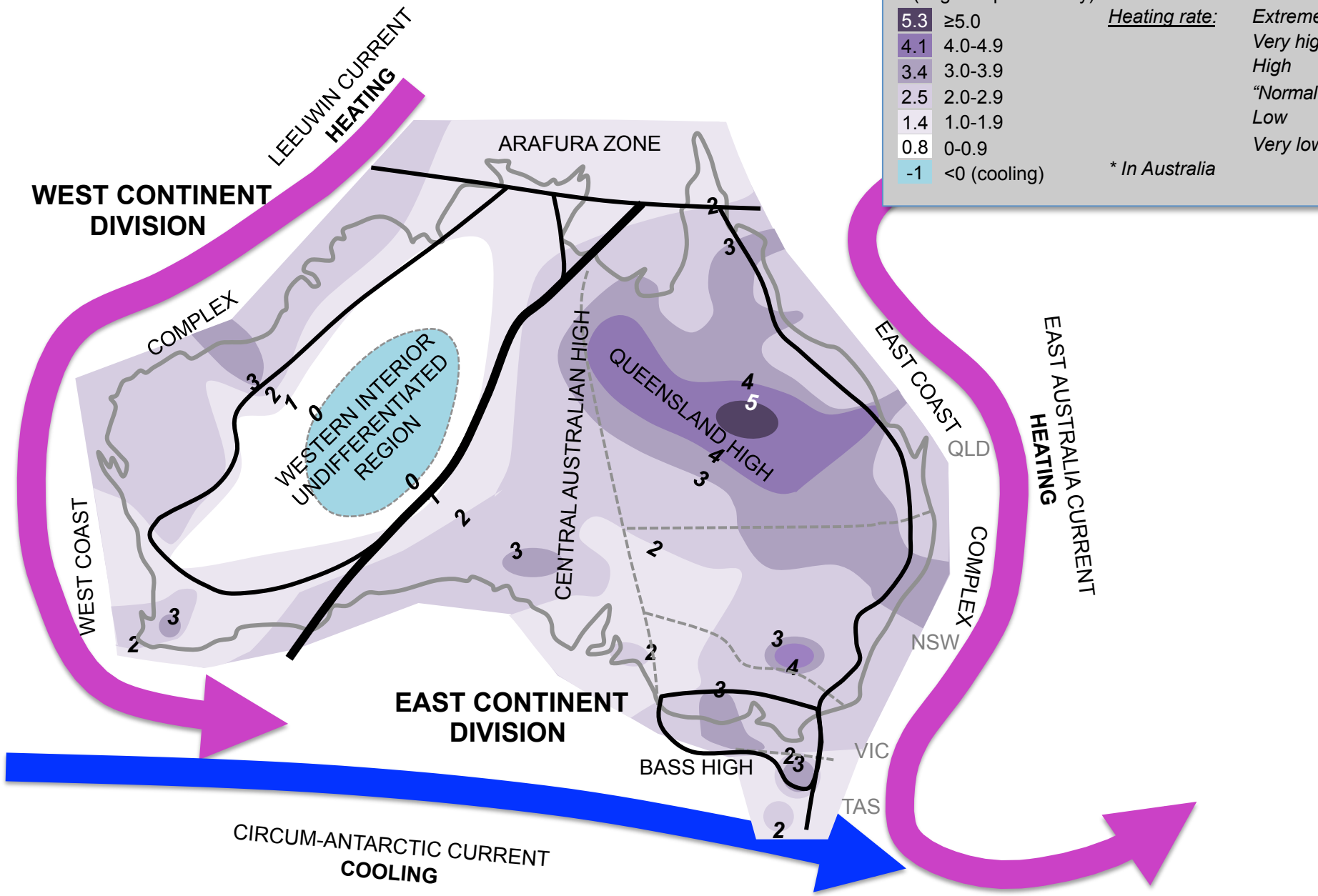


Figure 9

Stage 2: ΔHeat

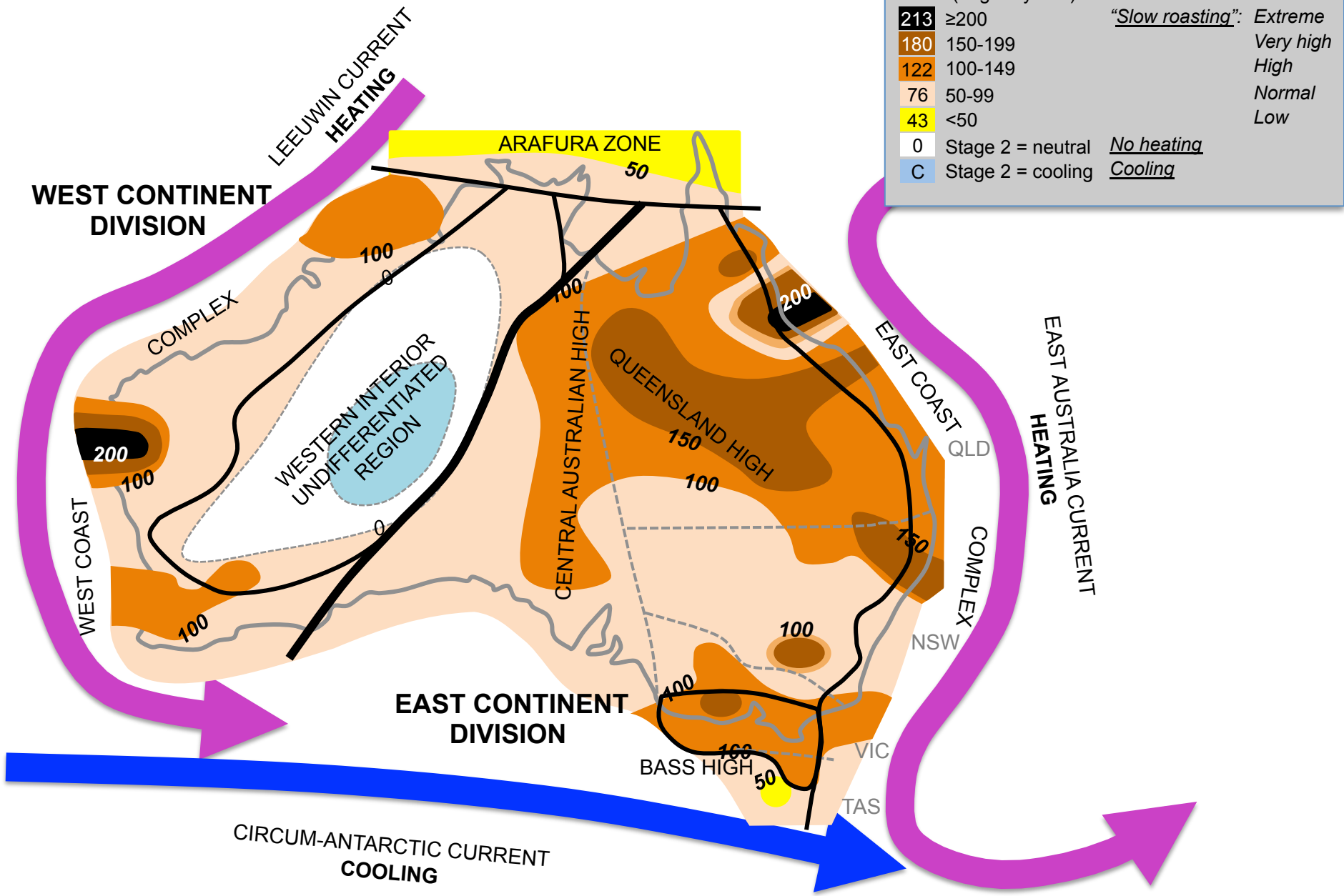
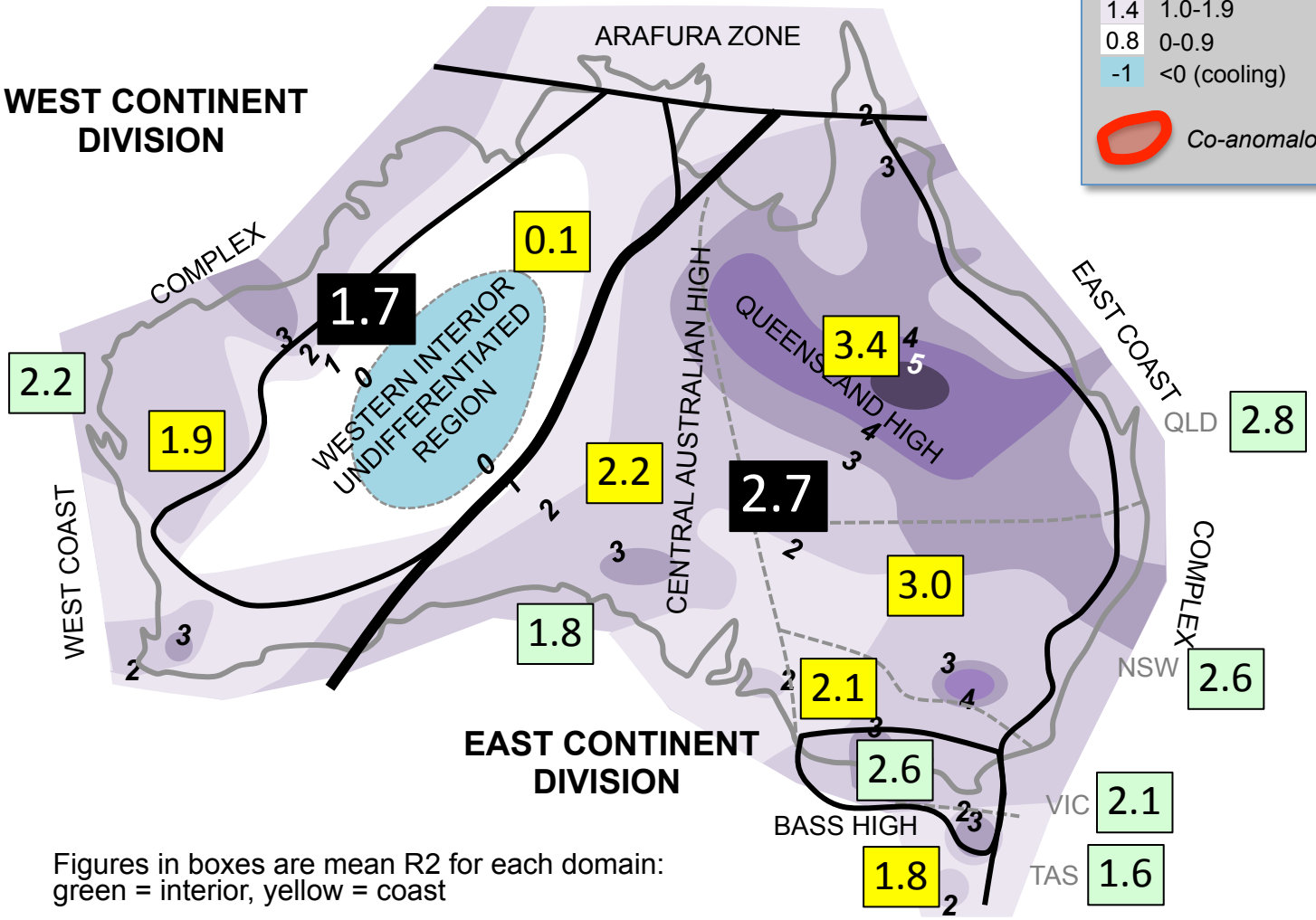


Figure 10

Stage 2: Heating rate R2 - Domain means



Figures in boxes are mean R2 for each domain:
green = interior, yellow = coast

Whole of Australia: **2.4**

Figure 11

BOM analysis of Australia's climate "warming"

CLIMATE CHANGE IN AUSTRALIA
PROJECTIONS FOR AUSTRALIA'S NRM REGIONS

Extract from
Climate Change in Australia *(Technical Report; Australian Bureau of Meteorology, CSIRO)*

4.2 Observed trends and attribution in the Australian region

4.2.1 Temperature: average surface temperature

Australian temperatures have warmed by 0.9 °C since 1910, with more warming in night time minimum temperature than daytime maximum temperature based on the homogenised daily Australian Climate Observation Reference Network - Surface Air Temperature (ACORN-SAT) data (Trewin, 2013, Fawcett *et al*. 2012). Figure 4.2.1 (below) shows mean temperature (the average of maximum and minimum temperature) changes across Australia from 1950 to 2013. Warming has been apparent in all seasons and all States and Territories. 2013 was Australia's warmest year since records began in 1910 (BOM, 2014b).

Regional climate change attribution studies have shown significant consistency between observed increases in Australian temperatures and those from climate models forced with increasing greenhouse gases (Hegerl *et al*. 2007, Karoly and Braganza, 2005). By extension, many aspects of warming over Australia are also attributable to the enhanced greenhouse effect.

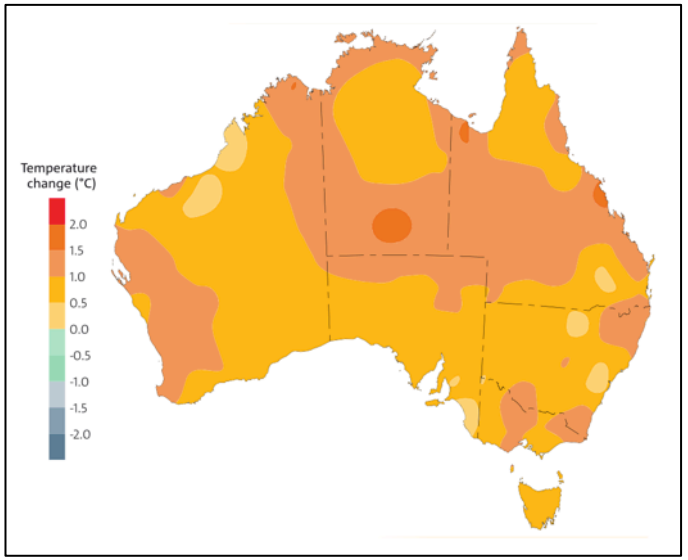
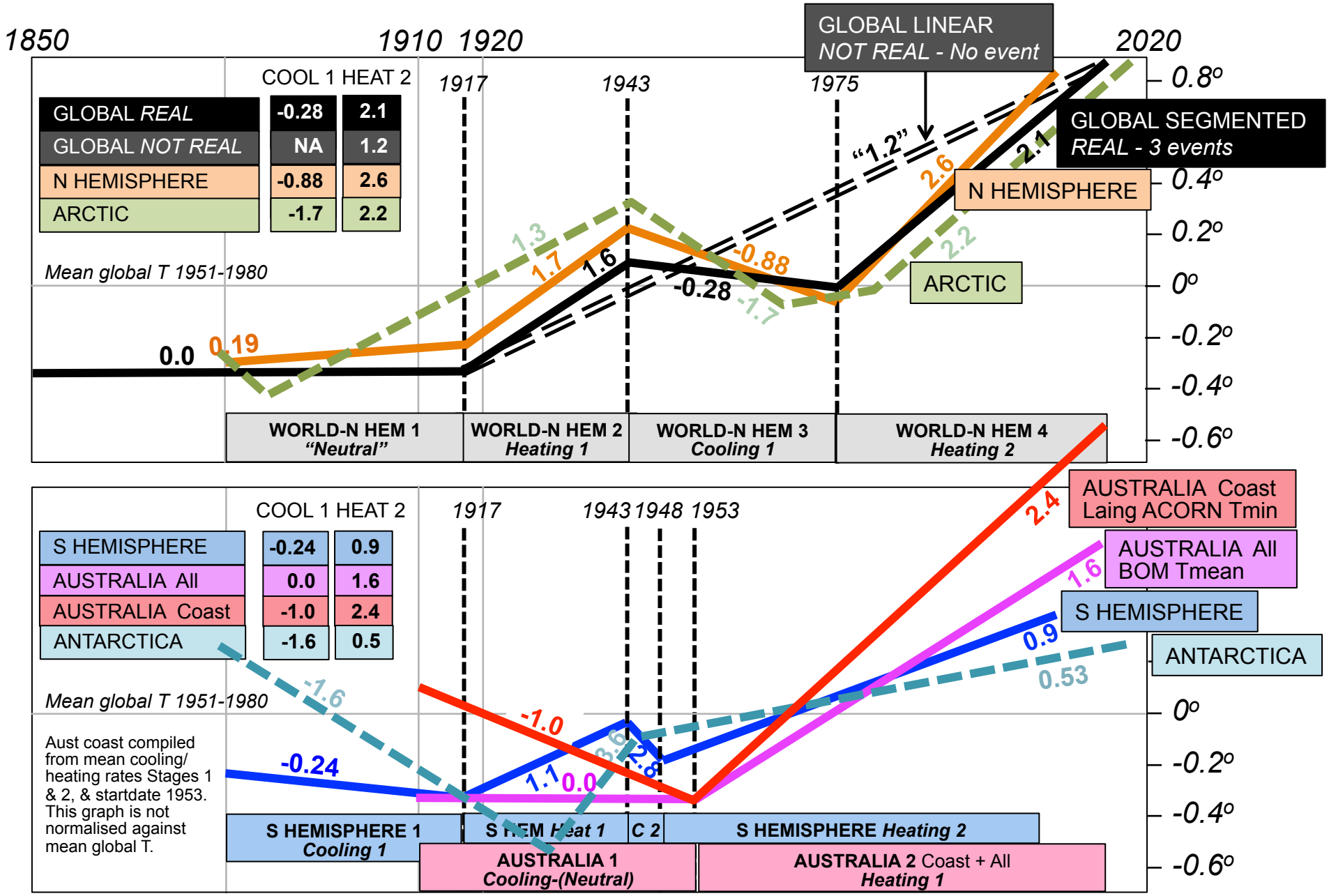


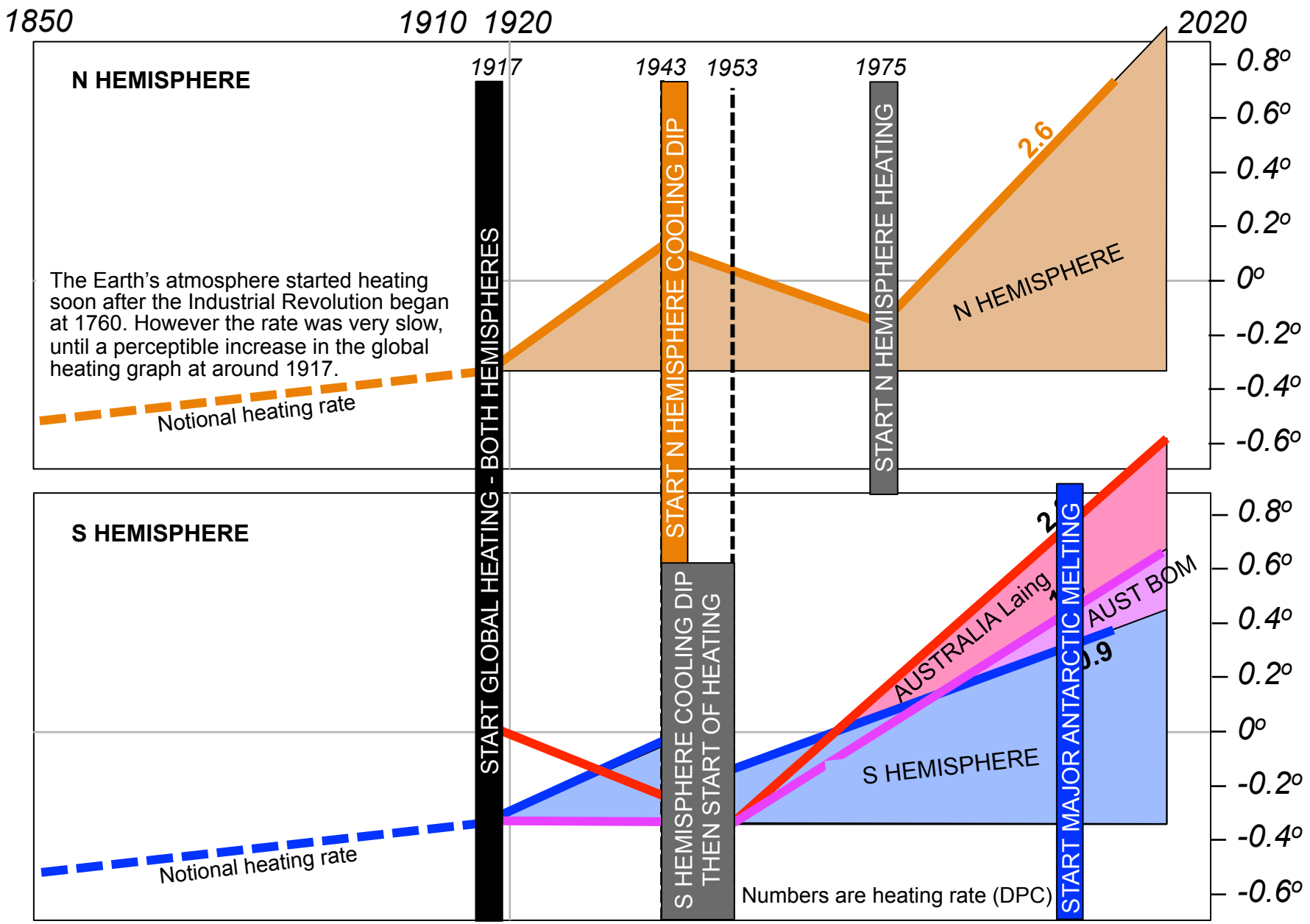
Figure 4.2.1: Linear trend in Australian mean temperature from the Australian Climate Observations Reference Network (ACORN-SAT) calculated for the entire period 1910 to 2013 (Source: BOM, 2014a).

Figure 12



Heating graphs: Global & N Hemisphere (top), S Hemisphere & Australian (bottom). Each manually regressed by the writer using Australia's strongly-constrained heating graph as a part-template. Sources: Global, N Hemisphere & S Hemisphere (Tmean) - Berkeley land + Hadley ocean; Australia (Tmean) - BOM; Australia (Tmin) - Laing BOM; Antarctic (Tmean) - Science Advances 4 Dec 2019. All graphs Tmean except Australia coast (Tmin).

Figure 13



Summary of climate milestones identified in stepped analysis of heating graphs; for the globe, each hemisphere, and Australia: 1850-2020. Graph sources cited in previous Figure.

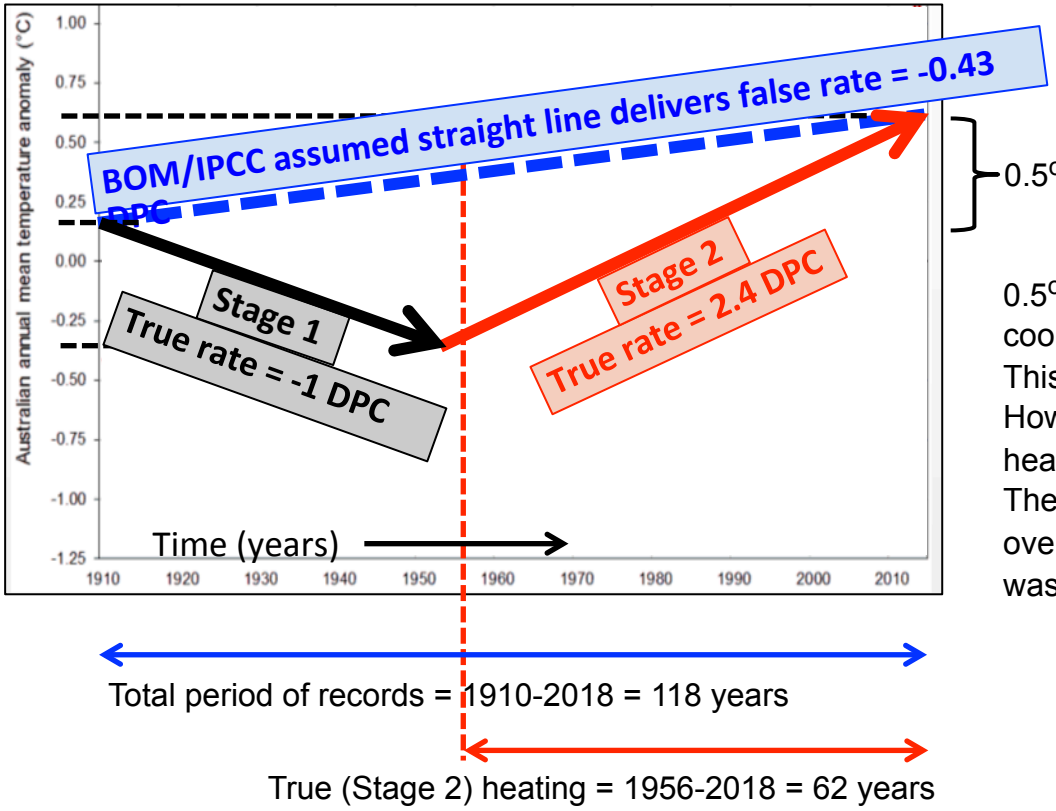
Figure 14

Australia's and world heating is inherently and seriously underestimated

Over most of Australia, climate "heating" started via cooling Stage 1 until 1956±9, then heating Stage 2 to the present. Calculations of heating rate from the simple net heating (the temperature difference between "beginning of 19th century" and now+) include two stages, cooling then heating, *which do not get represented in the published number, and which completely fail to recognise the specific heating rates of the cooling stage and the heating stage*. Such published heating "rates", made by BOM^, KNMI+, and IPCC publications, significantly underestimate the real heating rate.

Australia is heating at a true heating rate of 2.4 DPC, half an order of magnitude higher than BOM, KNMI, and IPCC calculations.

Stage 1 Cooling = 1910-1956 = -1 DPC Stage 2 Heating = 1956-present = 2.4 DPC.



* DPC = degrees C per century

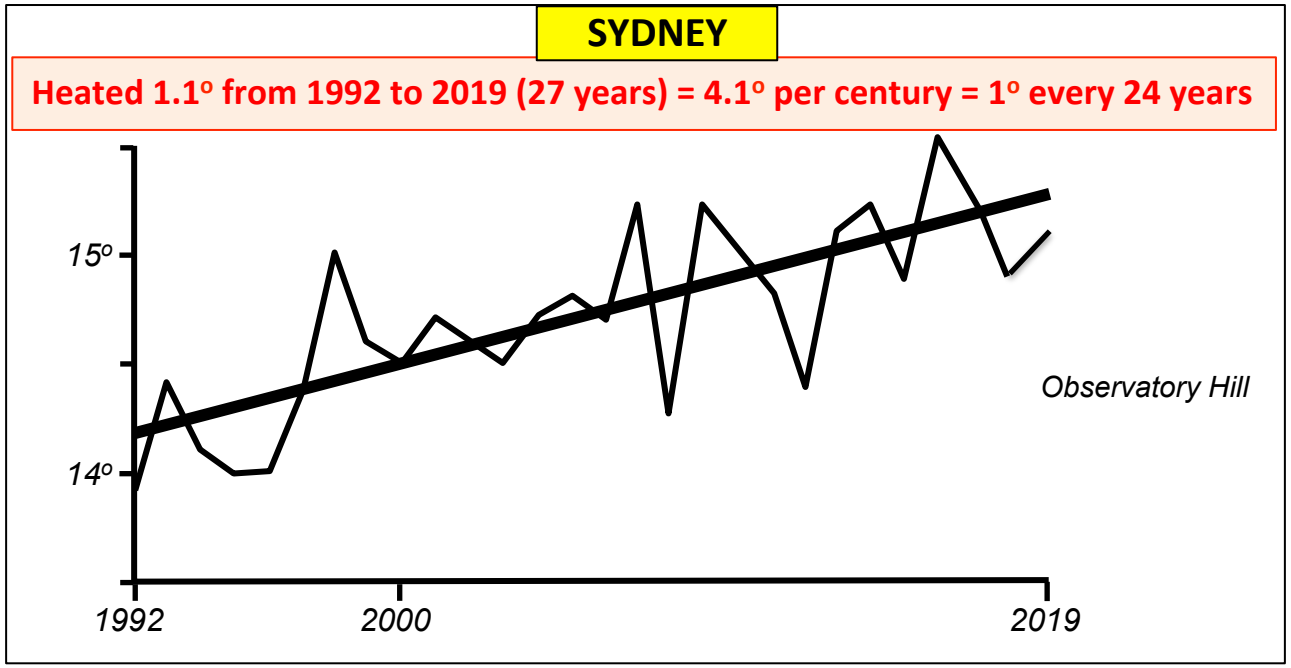
0.5° heating net. Total temperature change = 1.5°

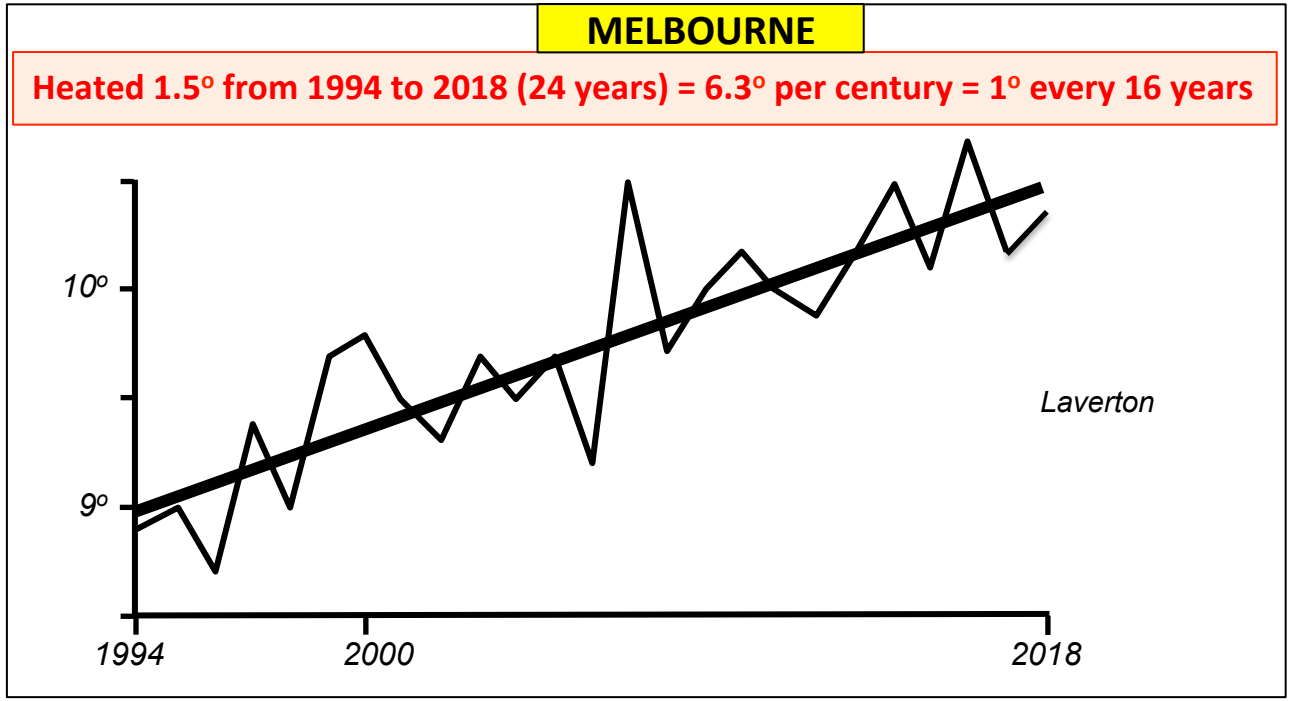
0.5° heating has been achieved over 118 years by cooling 0.5° to 1956 then heating 1° to the present. This delivers an apparent heating rate of **0.43** DPC. However this "rate" has no meaning - ihere was no heating event at this "rate" between 1910 and 2017. The 1.0° heating occurred in a much shorter period, over 62 years between 1956 and 2018, and its rate was **2.4** DPC.

^ *Including BOM 2019 Climate Report*
+ *KNMI Climate Explorer (2019), published in Financial Times 20 July 2020*

Figure 15

Accelerating climate heating in Sydney, Melbourne and other locations





From BOM ACORN-SAT dataset.

Some Australian locations have sufficiently dense data to show accelerated heating in the past 25 years (this precludes many stations, because proof of accelerated change requires denser data than linear change).

These graphs show minimum daily temperatures for Sydney and Melbourne over the past quarter century, with a calculated linear regression line.

Their heating rates are respectively 4.1 and 6.3 degrees per century (DPC).

These are respectively 205% and 290% greater than each city's heating rate since heating began (respectively 2.0 and 2.2 DPC, each starting ca 1945).

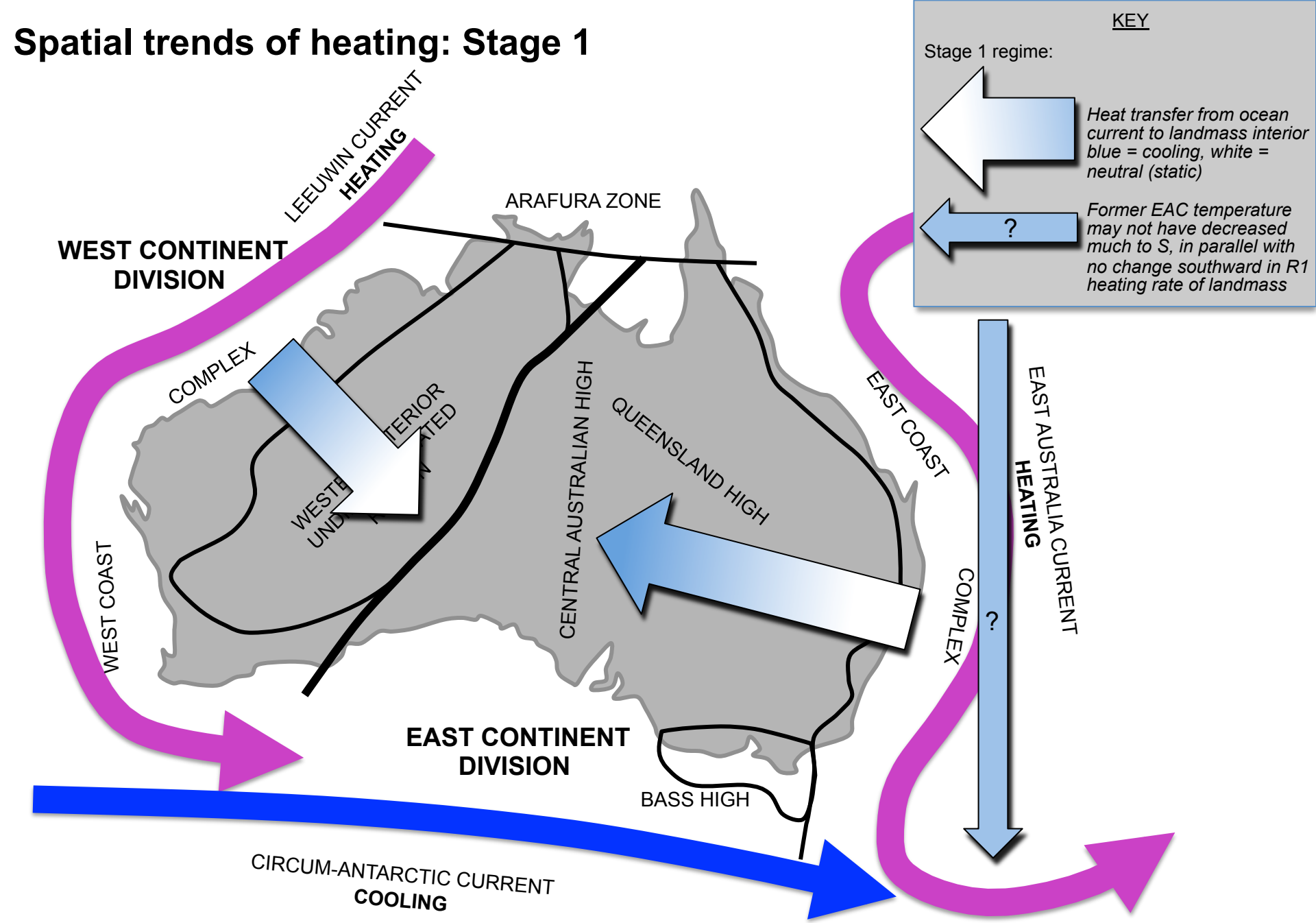
Their accelerations in the past quarter century, 205% and 290%, show a mean 250% acceleration.

Other locations, including remote non-urban sites, show similar acceleration of heating in the past several decades.

http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=site-networks

Figure 16

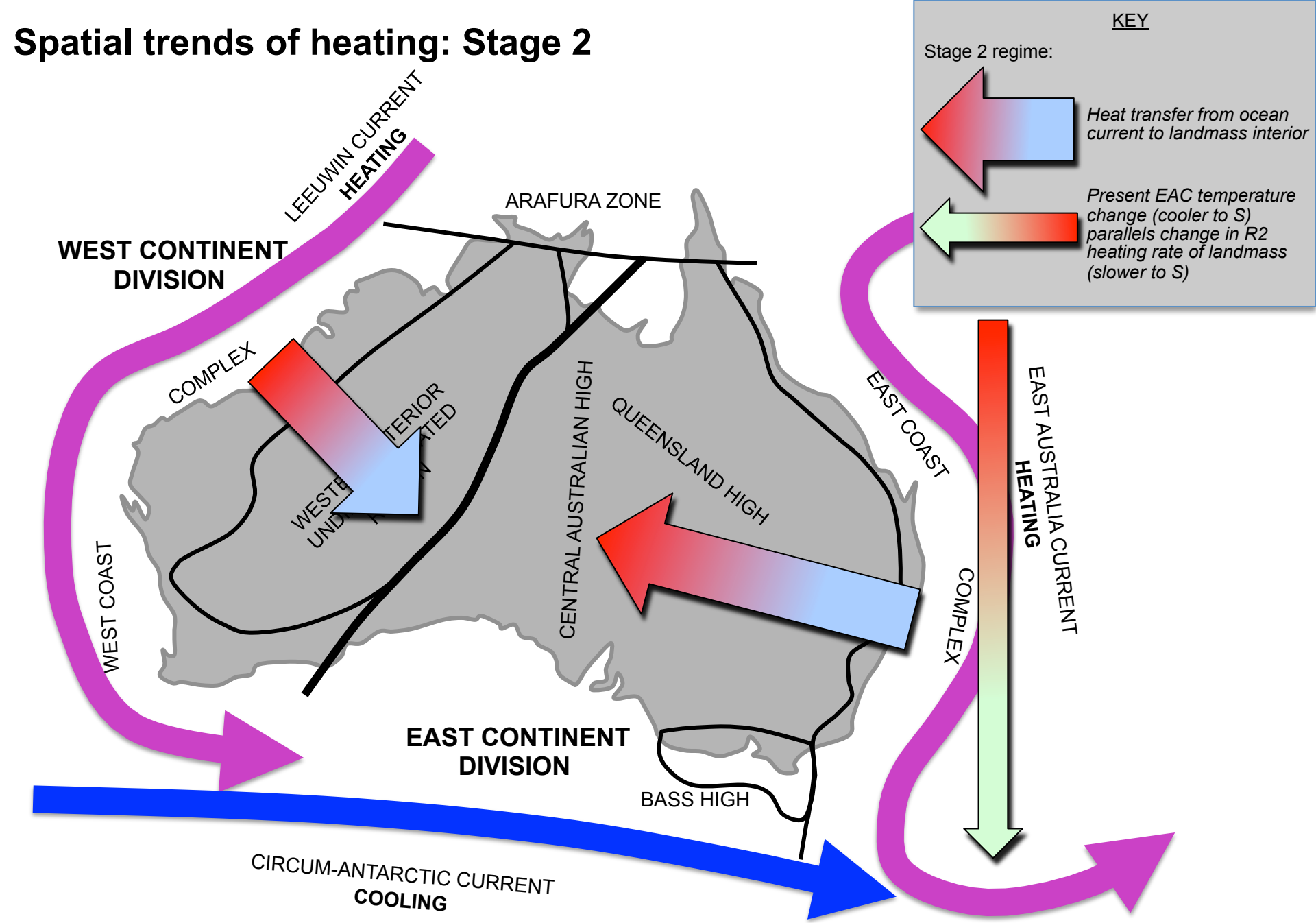
Spatial trends of heating: Stage 1



The E and W halves of the Australian continent show opposite heating patterns in Stage 1, from coast to interior:
E half = R1 cooling rate increases; W half = R2 cooling rate reduces to zero

Figure 17

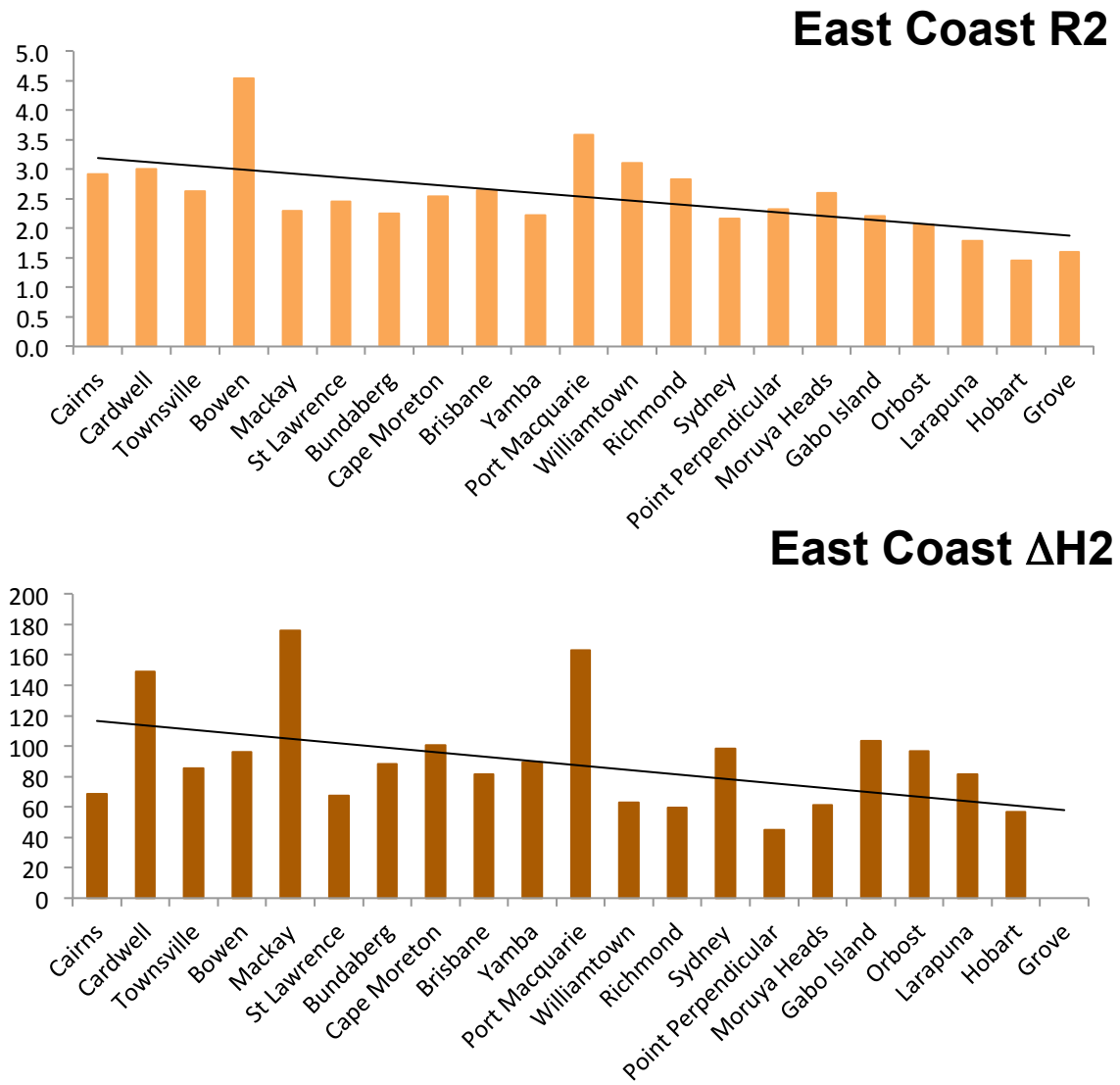
Spatial trends of heating: Stage 2



The E and W halves of the Australian continent show opposite heating patterns in Stage 2, from coast to interior:
E half = R2 heating rate increases; W half = R2 heating rate reduces to zero

Figure 18

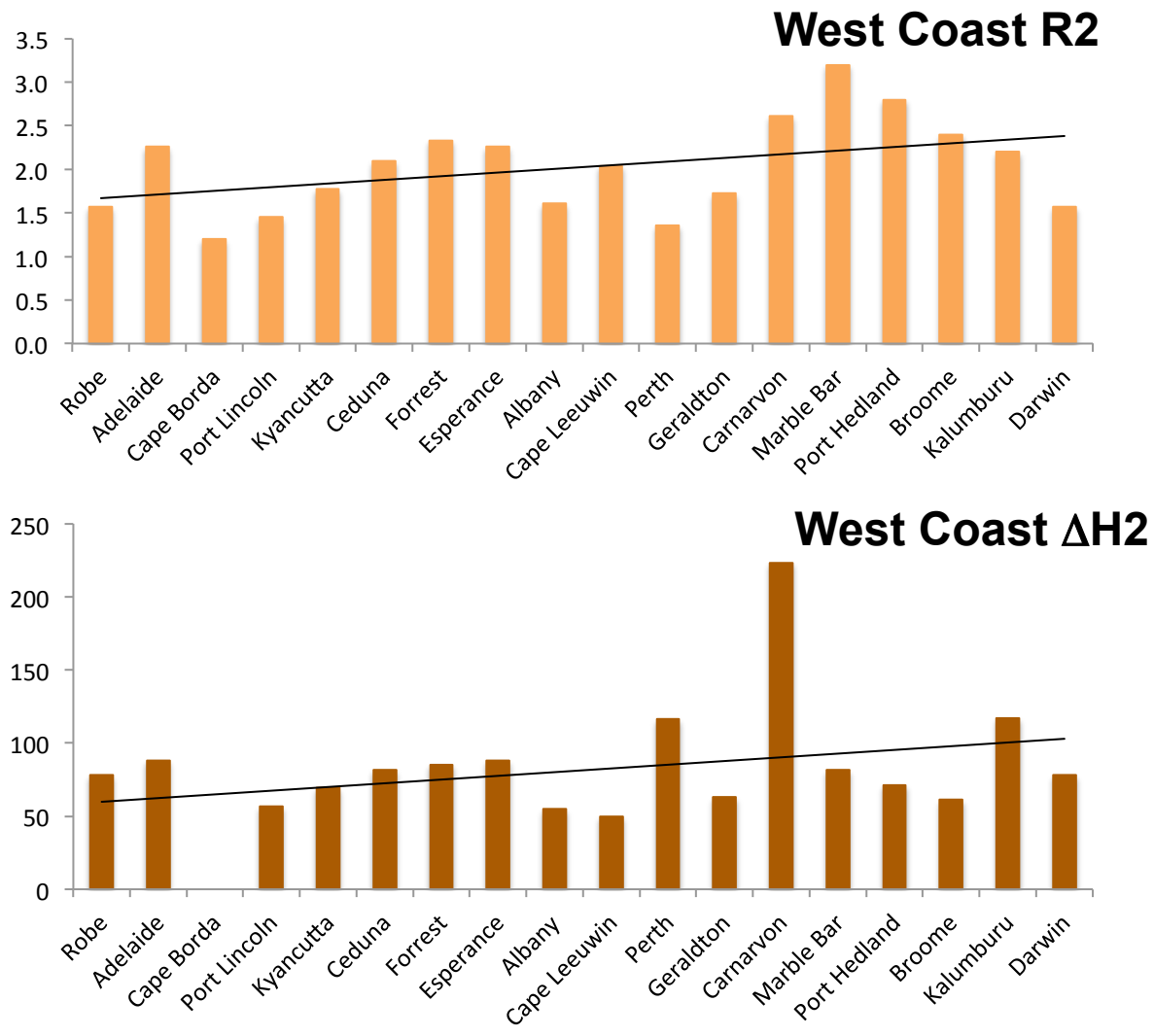
Stage 2 heating rates show a clear decrease down the East Coast



Profile of Stage 2 impact on Australia's East Coast, graphed from North (left) to South (right). Linear regression shown. (Top) R2 heating rate (DPC) (Bottom) ΔHeat for Stage 2 (degree years)

Figure 19

Stage 2 heating rates show a clear decrease down the West Coast



Profile of Stage 2 impact on Australia's West Coast, graphed from South (left) to North (right). Linear regression shown. (Top) R2 heating rate (DPC) (Bottom) ΔHeat for Stage 2 (degree years)

Figure 20

Stage 1 and Stage 2 are not synchronous, but they co-vary; strong R1 often means strong R2

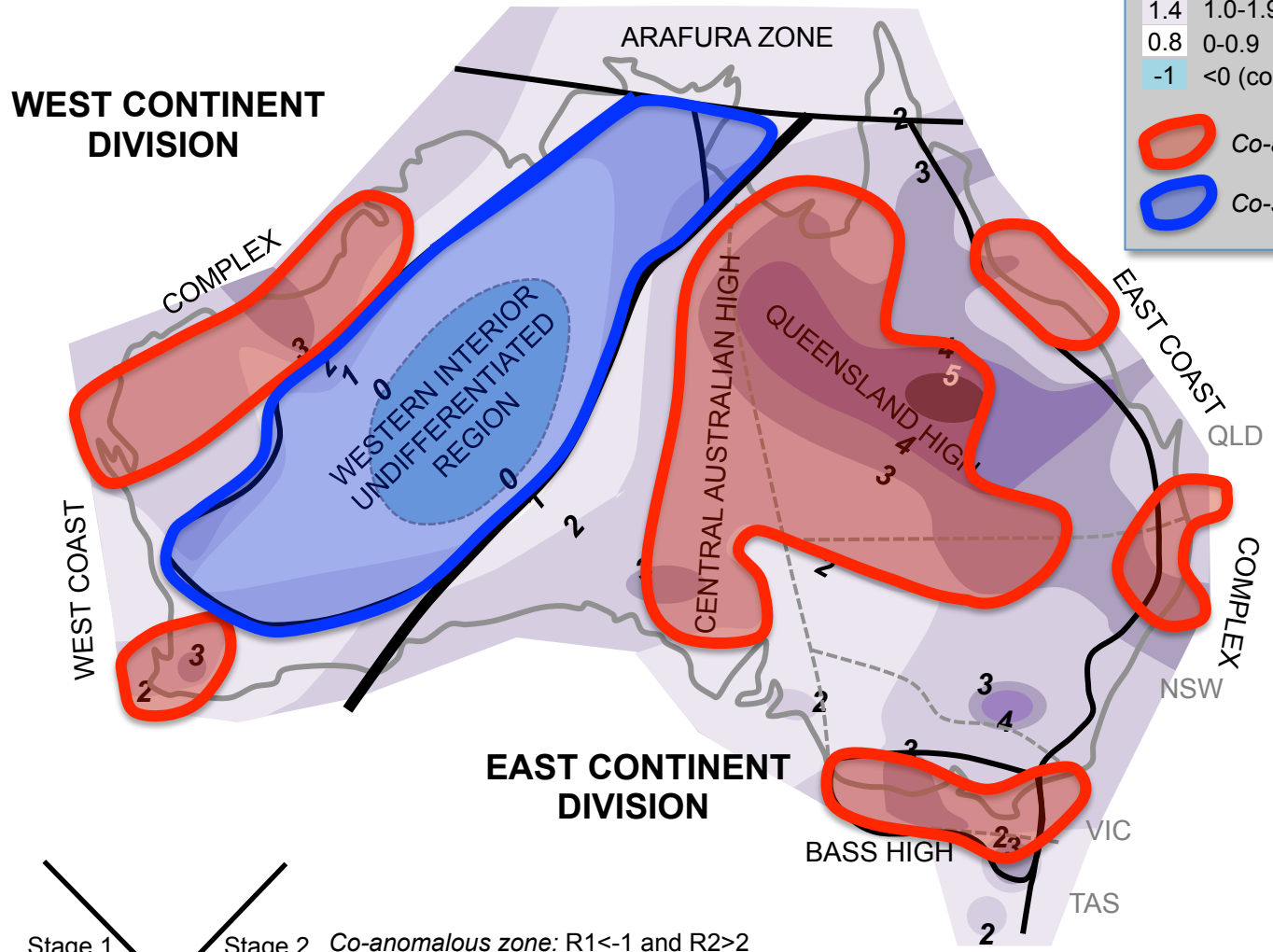


Figure 21

Stage 1 & Stage 2 co-vary; strong R1 often means strong R2

The absolute values of R1 and R2 show a positive relationship (after transforming R1 to -R1), as seen below.

Slope of regression line = *R1/R2 = 0.33* = correlation coefficient C

That is, for every degree per century (DPC) which R1 decreases, R2 increases by 3 DPC. This relationship applies in principle to all stations. In reality, there is a broad range of (mostly) positive correlation between -R1 and R2. The range limits are (high end of C) Thargomindah C = 7.2/3.0 = 2.4, and (low end of C) Longreach = 1.6/5.3 = 0.3. The positive correlation is relatively weak, with ca 50% of stations showing no correlation or a weak negative correlation.

The positive relationship means that, at stations showing the relationship (which from the graph is ca 50%); *the stronger the R1 cooling, the stronger is the subsequent R2 heating*. The reason(s) for this positive relationship are not known. They would be clarified via plotting the distribution of complying stations across the continent.

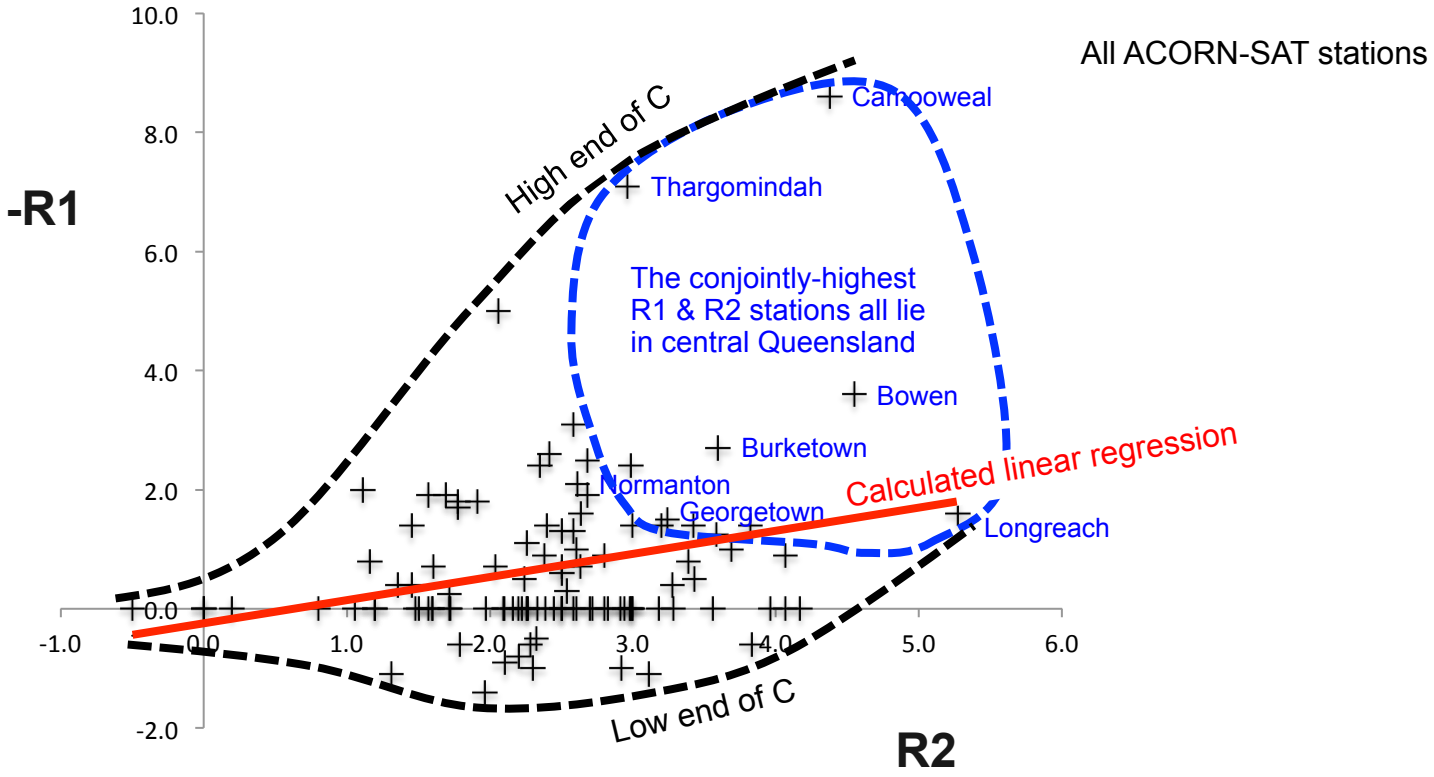
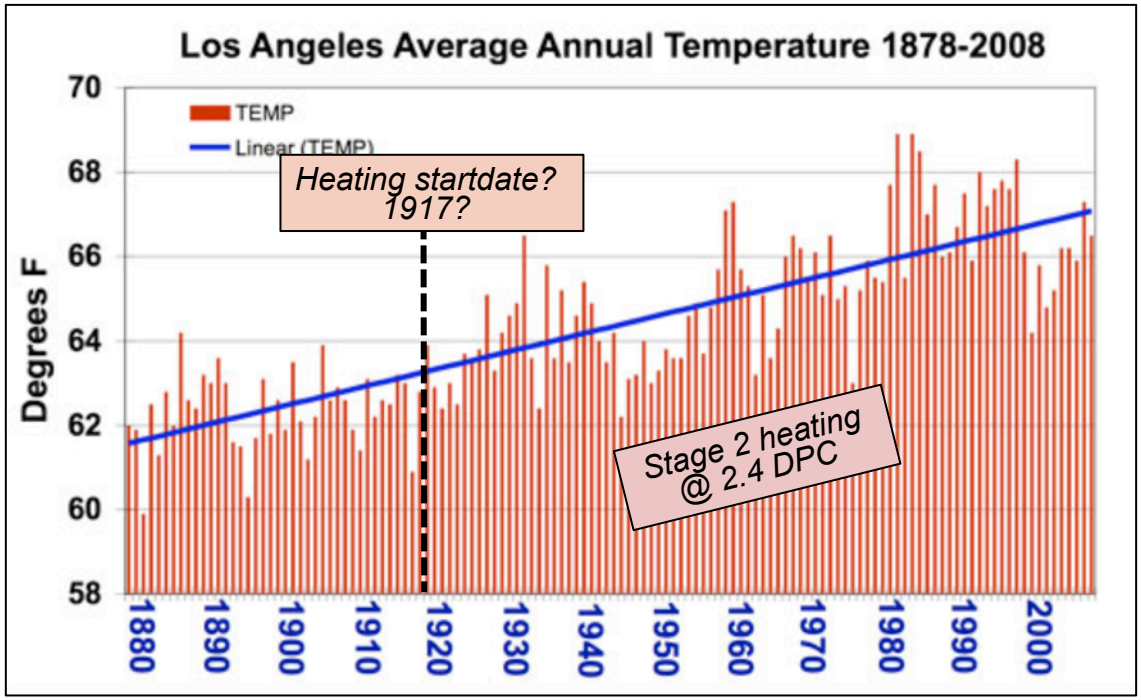


Figure 22

California is heating slower than eastern Australia: its wildfires are ours



https://climate.nasa.gov/news/23/southern-californians-get-a-cool-summer-but-a-warm-future/

LOS ANGELES

Stage 2 temperature rise = 4.0^{o}F = 2.2^{o}C
*Heating period = 2008-1917 = 91 years**

Heating rate = 2.4 DPC

** The heating rate is independent of a startdate, at 2.4 DPC, as the slope of the graph is constant even prior to any assumed heating startdate (I have selected 1917).*

Figure 23