2015 Annual Conference

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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Technical Committee 4.2:

How Australasian HVAC design conditions are affected by El Niño Southern Oscillation

ASHRAE Design Day Weather Data

Monday, June 29, 2015: 5PM Atlanta
(7 AM June 30 Townsville Queensland Australia)

Atlanta, Georgia

Australian design temperature

- That temperature equalled or exceeded 10 days per year inclusive of one standard deviation.

- The 10th highest observation at 3 PM in a hot year*.

"Suggested ASHRAE design temperature" could be set to be the 35th highest hourly temperature observed during a hot-year, such that 0.4% of the 8760 hours equal of exceed this level.*

Acknowledgments

- Following Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) *Future of HVAC Conference* presentation Melbourne 2013, with support by the Australian Commonwealth Department of Resources, Energy and Tourism

- Co-authored by J. Ben Liley, National Institute of Water & Atmospheric Research, NIWA Lauder, New Zealand

- Thanks to Ian Swain, Canberra, editorial support - working in the Australian Federal Government

- AIRAH DA9 revision team members Lawrence Lum, Jason Jacuzzi, and James Fricker

Inter-annual variability

- Load characteristics vary year-to-year.
- Humid monsoonal summers require outdoor air handler to dehumidify.
- Hot dry summers can be served with evaporative cooling.
- El Niño Southern Oscillation - instability

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EL NIÑO IN AUSTRALIA

SPOTTING AN EL NIÑO

TEMPERATURES
in the tropical Pacific Ocean warm, both at the surface and below

SURFACE PRESSURE
changes across the Pacific; higher in the west, lower in the east

TRADE WINDS
weaken, and sometimes reverse

CLOUD
increases near the Date Line

TYPICAL IMPACTS ON OUR CLIMATE

RAINFALL DECREASES IN EASTERN AUSTRALIA

TEMPERATURE INCREASES IN SOUTHERN AUSTRALIA (DAYTIME TEMPERATURES)

OTHER IMPACTS

- INCREASED BUSHFIRE RISK
- FEWER TROPICAL CYCLONES
- LATER START TO NORTHERN WET SEASON
- MORE HEATWAVES
- LONGER FROST RISK SEASON
- REDUCED CHANCE OF WIDESPREAD FLOODS
- LESS CHANCE OF INDIAN OCEAN HEATWAVES
- STRONGER SEABREEZES

WHEN DO THEY OCCUR?

USUALLY EL NIÑO DEVELOPS IN **AUTUMN TO WINTER** AND STARTS TO DECAY IN SUMMER

EL NIÑO EVENTS CAN LAST FOR AS LITTLE AS 6 MONTHS *OR AS LONG AS* **2 YEARS**

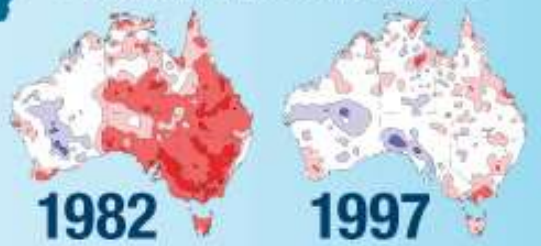
ON AVERAGE THEY OCCUR EVERY **3 TO 5 YEARS**

THE LAST EL NIÑO *WAS IN* **2009–10**

GLOBALLY, **7 OUT OF 10** OF THE HOTTEST YEARS ON RECORD WERE IN AN EL NIÑO YEAR OR THE YEAR FOLLOWING

EVERY EL NIÑO IS DIFFERENT

EL NIÑO WINTER AND SPRING RAINFALL



1982 **1997**

RED = *DRIER THAN NORMAL* BLUE = *WETTER THAN NORMAL*

THERE HAVE BEEN **26** EL NIÑO EVENTS SINCE 1900 **17** HAVE BROUGHT WIDESPREAD DROUGHT

7 OF AUSTRALIA'S 10 DRIEST YEARS ON RECORD WERE DURING EL NIÑO

10 days per year "inclusive of one standard deviation"

- Australian data was not logged hourly pre-1990.
- Observations were taken at 9 AM, noon, & 3 PM.
- AIRAH design standard 10 days exceedance per year "inclusive of one standard deviation".
- Year-to-year standard deviation of exceedances works out to be typically 3 or 4 days per year.
- Therefor AIRAH design was exceeded 6 or 7 days in an average year – before climate change!

* Propose now: 35th highest hour during a hot year.

or add the year-to-year standard deviation of the 35th highest hourly temperature to the long term 0.4% hourly temperature recorded by automatic weather stations published in ASHRAE Fundamentals 2013.

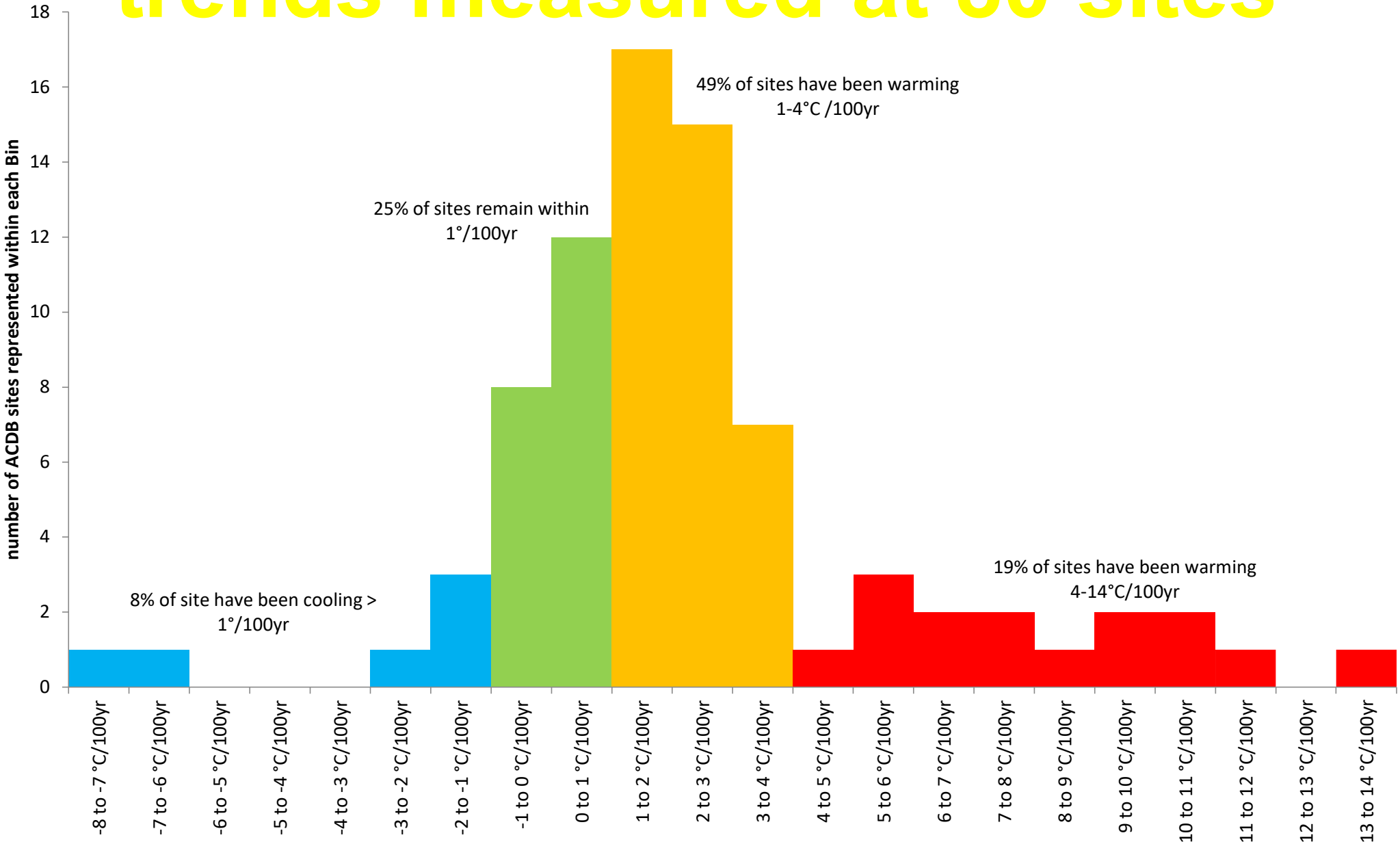
AIRAH Design temperatures based on period -1988 compared to ASHRAE 2013

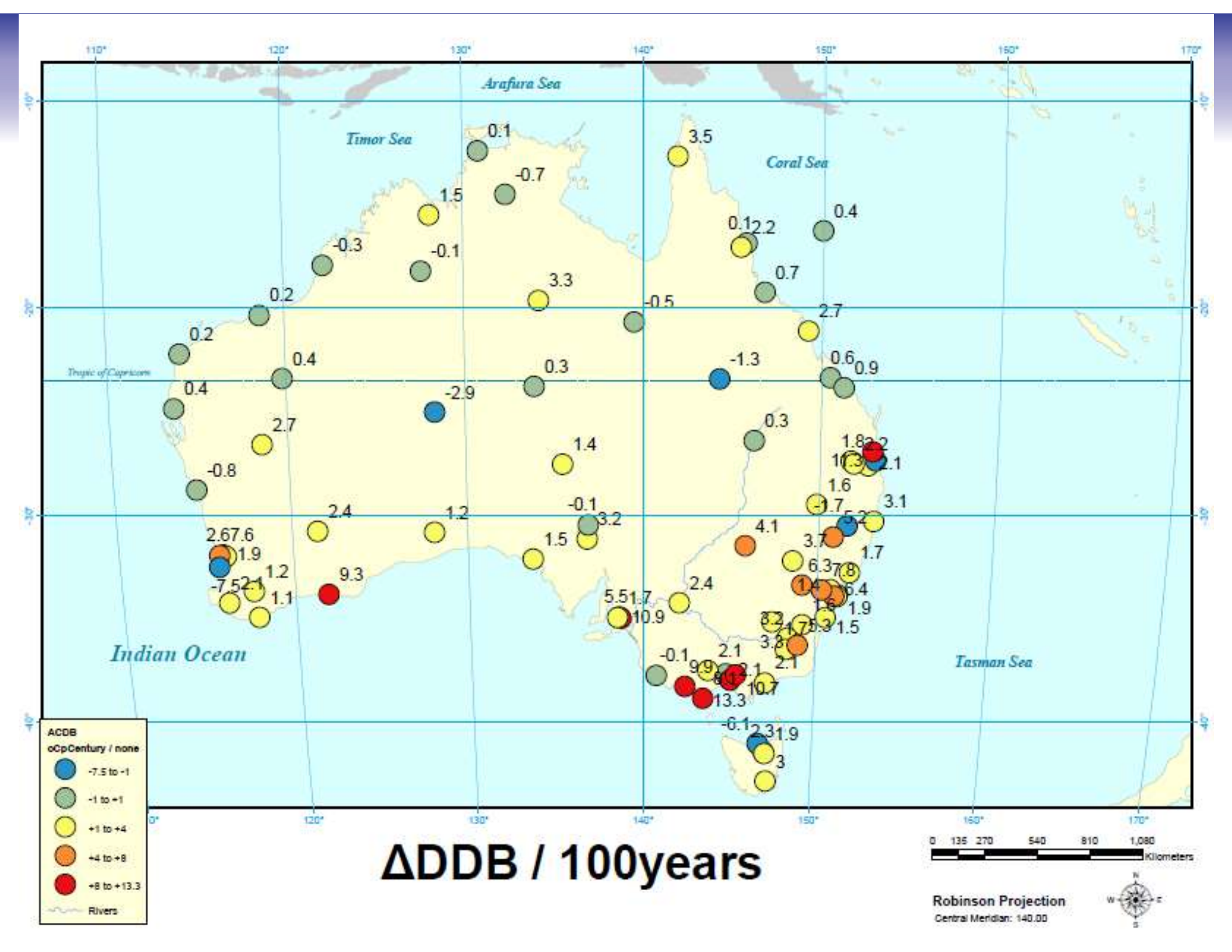
	Weather Station		Design DB/MCWB AIRAH vs ASHRAE		Design MCDB/WB AIRAH vs ASHRAE		ASHRAE 20 to 25 years ref
Location	BoM	WMO	DA9 opt 1	ASHRAE 0.4	DA9 opt 2	ASHRAE 0.4	-2010
Sydney RO	66062	947680	31.1/19.8	31.1/20.0	29.5/22.7	27.1/23.0	1991-
Adelaide KT	23090	946750	37.0/20.1	37.5/19.1	35.1/21.4	31.1/21.6	1991-
Melbourne RO	86071	948680	34.3/19.4	34.8/18.8	32.3/20.5	28.6/21.1	1991-
Brisbane Aero	40842	945780	30.8/22.8	31.0/22.5	29.7/24.9	28.4/25.2	1986-
Perth Aero	9021	946100	37.4/19.4	37.2/19.2	33.6/21.9	30.8/22.1	1986-
Darwin Aero	14015	941200	34.4/23.6	34.1/23.5	32.1/27.7	30.9/27.6	1986-
Hobart RO	94029	949700	27.0/17.1	28.1/17.0	25.8/18.0	24.6/18.7	1990-
Canberra Aero	70014	949260	34.1/17.8	33.6/17.8	30.2/19.2	27.4/20.1	1986-

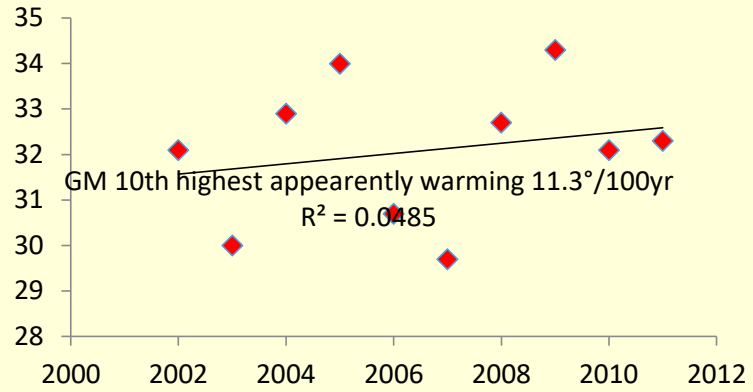
AIRAH Design temperatures 1970's-1988 vs 1967-2011

Location Summary	Option 1 Dry summer (design DB/coinc WB)		Option 2 Wet summer (coinc DB/design WB)		Change of option 1 design db	Change of option 2 design wb
	1970's-1988	1967-2011	1970's-1988	1967-2011		
SY 17 Sydney RO	31.1/19.8	31.9 / 19.1	29.5/22.7	26.0 / 22.6	+0.8°C db	-0.1°C wb
AD 16 Adelaide	37.0/20.1	38.0 / 18.6	35.1/21.4	29.3 / 20.9	+1.0°C db	-0.5°C wb
ME 21 Melbourne RO	34.3/19.4	35.5 / 18.2	32.3/20.5	27.5 / 20.3	+1.2°C db	+0.2°C wb
BR 10 Brisbane	30.8/22.8	31.6 / 21.6	29.7/24.9	27.9 / 24.9	+0.8°C db	=0.0°C wb
PE 13 Perth	37.4/19.4	38.2 / 19.0	33.6/21.9	29.3 / 21.5	+0.8°C db	-0.4°C wb
DA 1 Darwin	34.4/23.6	34.7 / 22.4	32.1/27.7	30.5 / 27.4	+0.3°C db	-0.3°C wb
HO 26 Hobart	27.0/17.1	28.3 / 16.3	25.8/18.0	24.1 / 18.3	+1.3°C db	+0.3°C wb
CA 24 Canberra	34.1/17.8	34.6 / 17.1	30.2/19.2	26.0 / 19.5	+0.5°C db	+0.3°C wb

Histogram of design change trends measured at 80 sites




Arafura Sea
Timor Sea
Coral Sea
Tropic of Capricorn
Indian Ocean
Tasman Sea
ACDB
oCpCentury / none
-7.5 to -1
-1 to +1
+1 to +4
+4 to +8
+8 to +13.3
Rivers
ΔDDB / 100years
0 135 270 540 810 1,080
Kilometers
Robinson Projection
Central Meridian: 140.00



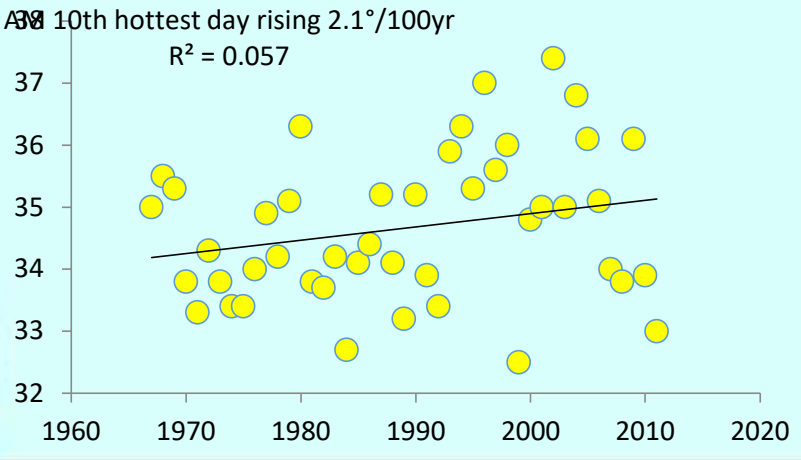
Glasshouse Mountains GM 11.3°/100yr

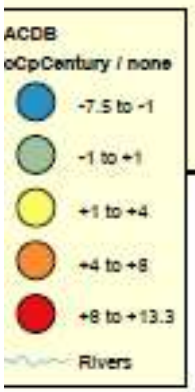
Oakey OA 1.8°/100yr

Brisbane BR -1.6°/100yr

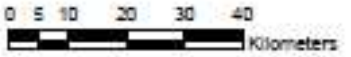
Toowoomba TW 2.2°/100yr

Amberley AM 2.1°/100yr

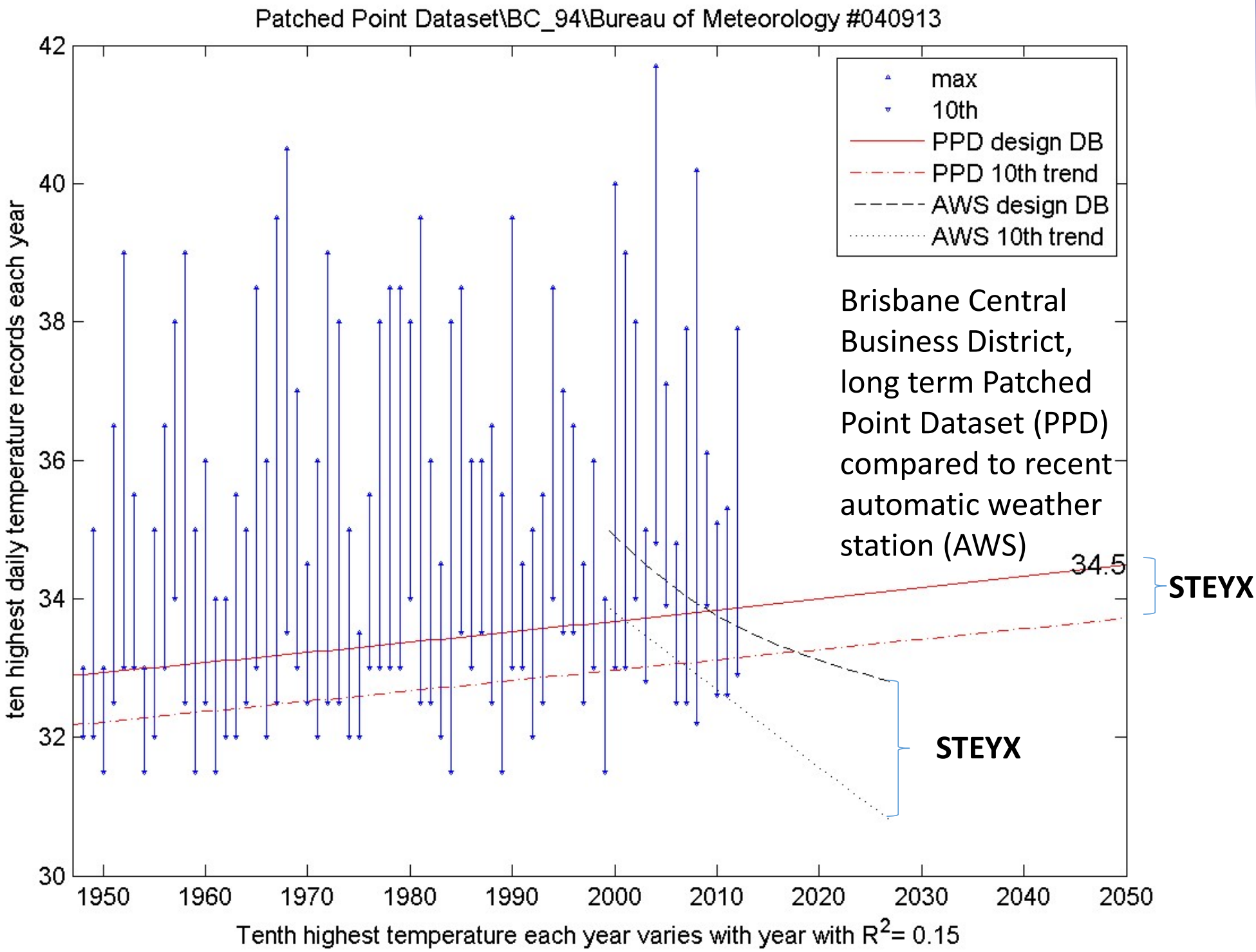




ΔDDB / 100years

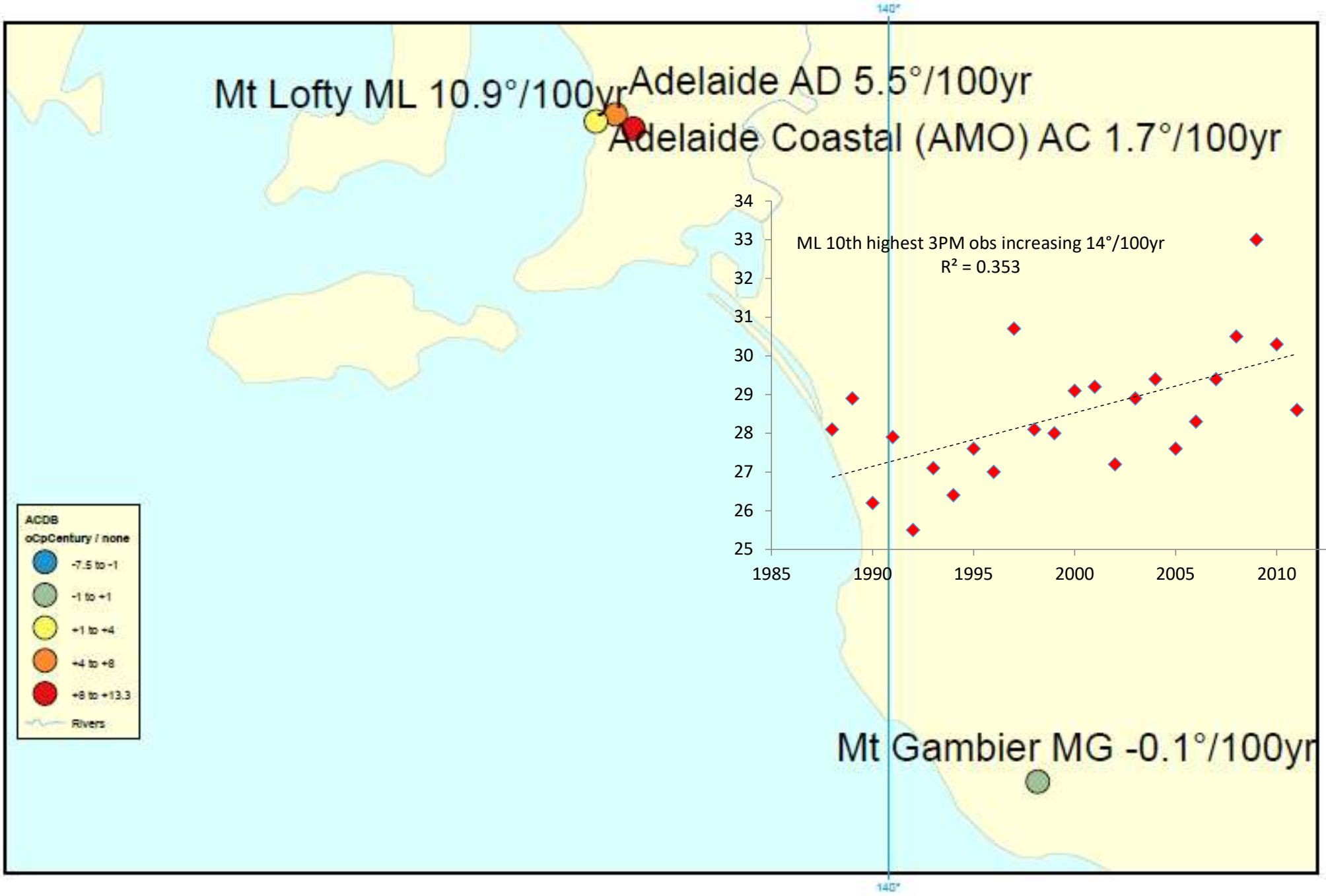


Robinson Projection
Central Meridian: 140.00


Patched Point Dataset\BC_94\Bureau of Meteorology #040913
max
10th
PPD design DB
PPD 10th trend
AWS design DB
AWS 10th trend
Brisbane Central Business District, long term Patched Point Dataset (PPD) compared to recent automatic weather station (AWS)
34.5
STEYX
STEYX
ten highest daily temperature records each year
Tenth highest temperature each year varies with year with R2= 0.15
42
40
38
36
34
32
30
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050

STEYX, standard error of Y

- If there is no climate change with respect to time (plotted on the X-axis) then scatter of events plotted on the Y-axis is measured with the standard deviation.
- STEYX, standard error of estimate measures the dispersion of prediction errors when you are trying to forecast Y values from X timeline by regression.



ΔDDB / 100years

0 12.5 25 50 75 100
Kilometers

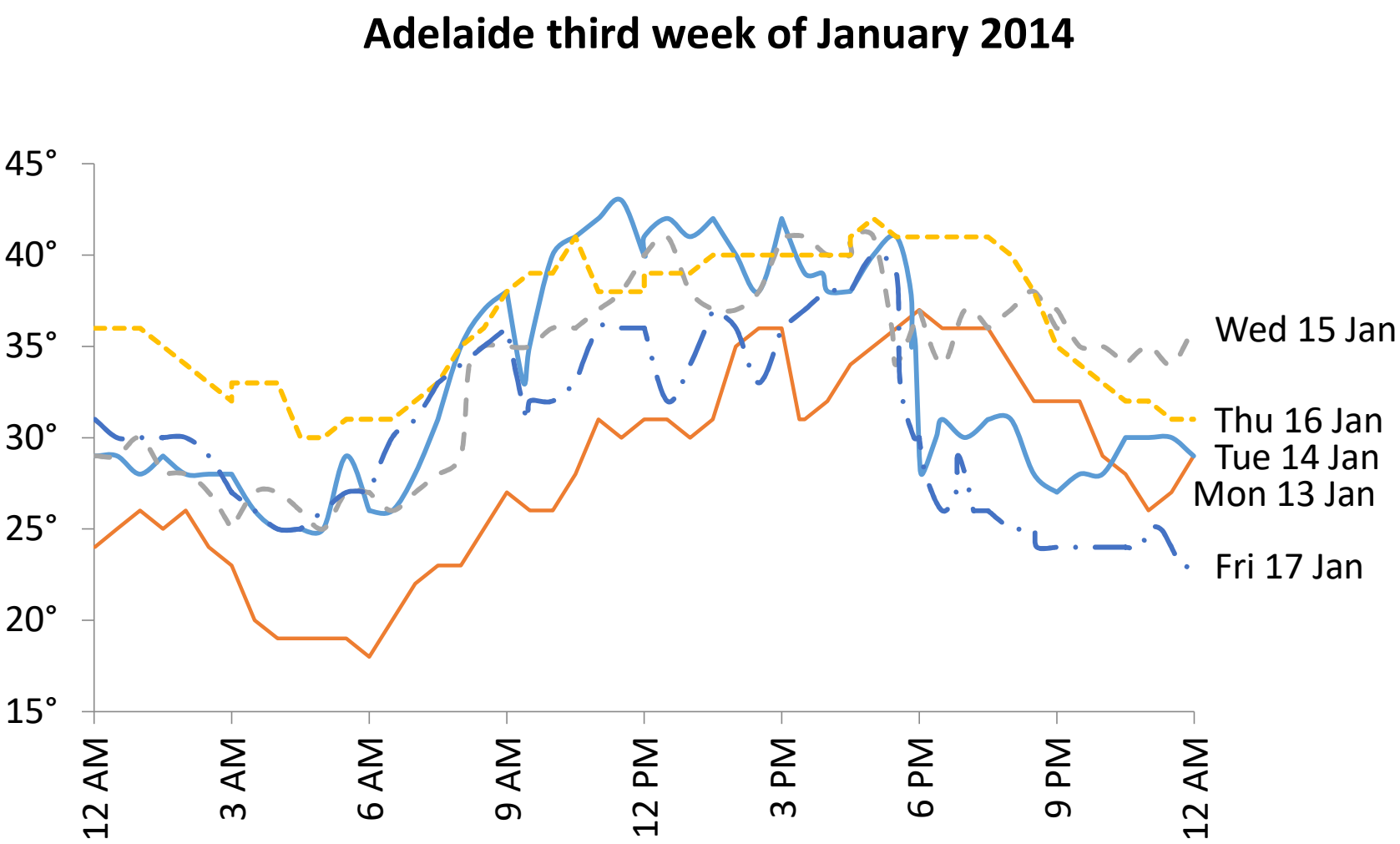
Robinson Projection
Central Meridian: 140.00

Adelaide, Australia: January 2014 when 5 consecutive days exceeded 42 °C

SA police captured this photo of the fire ground at Watraba January 16 2014

Weather History for YPAD

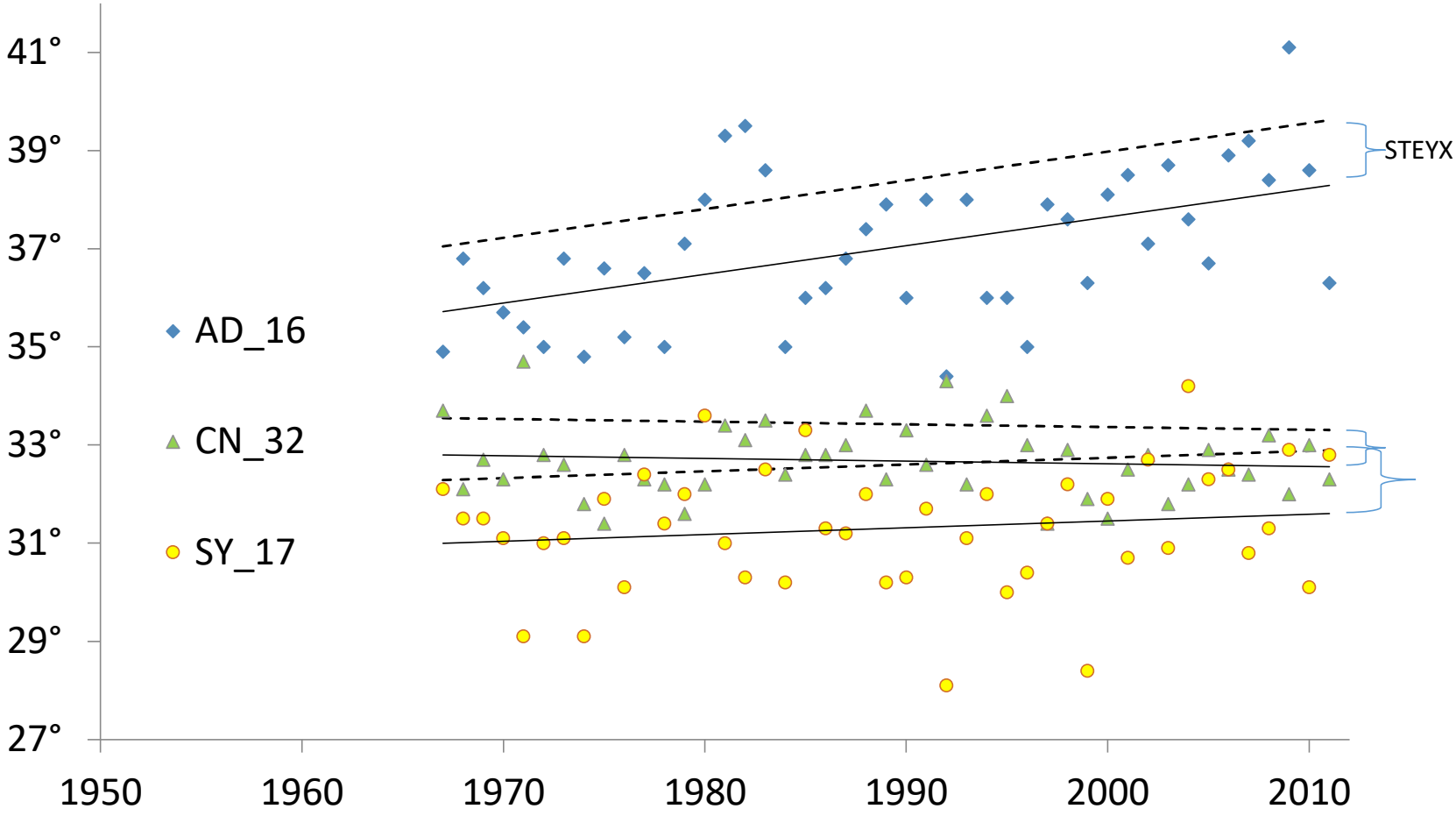
Nearest airport to Adelaide Regional Office



Proposal for ASHRAE: design = linear regression + standard error of the estimate

Annual 0.4% dry bulb temperature

- - - - - - - = linear regression + STEYX



Conclusions

- ASHRAE's 0.4% of hourly design temperatures are not as stringent as AIRAH's use of the ten-highest 3PM observation during extreme years.
- This is because the variability of weather year-to-year is not accounted for by the ASHRAE methodology.
- With the recognition of climate change, add standard error to linear regression.

Bibliography

AIRAH Ecolibrium Forum. Peterson & Liley 2015. Recent development of current-climate data for load estimation and design optimisation – Part 2 Validating the updated ACDB-2011, and distillation of “ASHRAE-style” design temperatures

Australian Institute of Refrigeration, Air Conditioning and Heating peer-reviewed article in-press, June 2015.

Following part 1, published 15th May 2015

http://www.airah.org.au/imis15_prod/AIRAH/EcoLibrium/2015/Ecolibrium_May_2015.aspx

Questions?

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