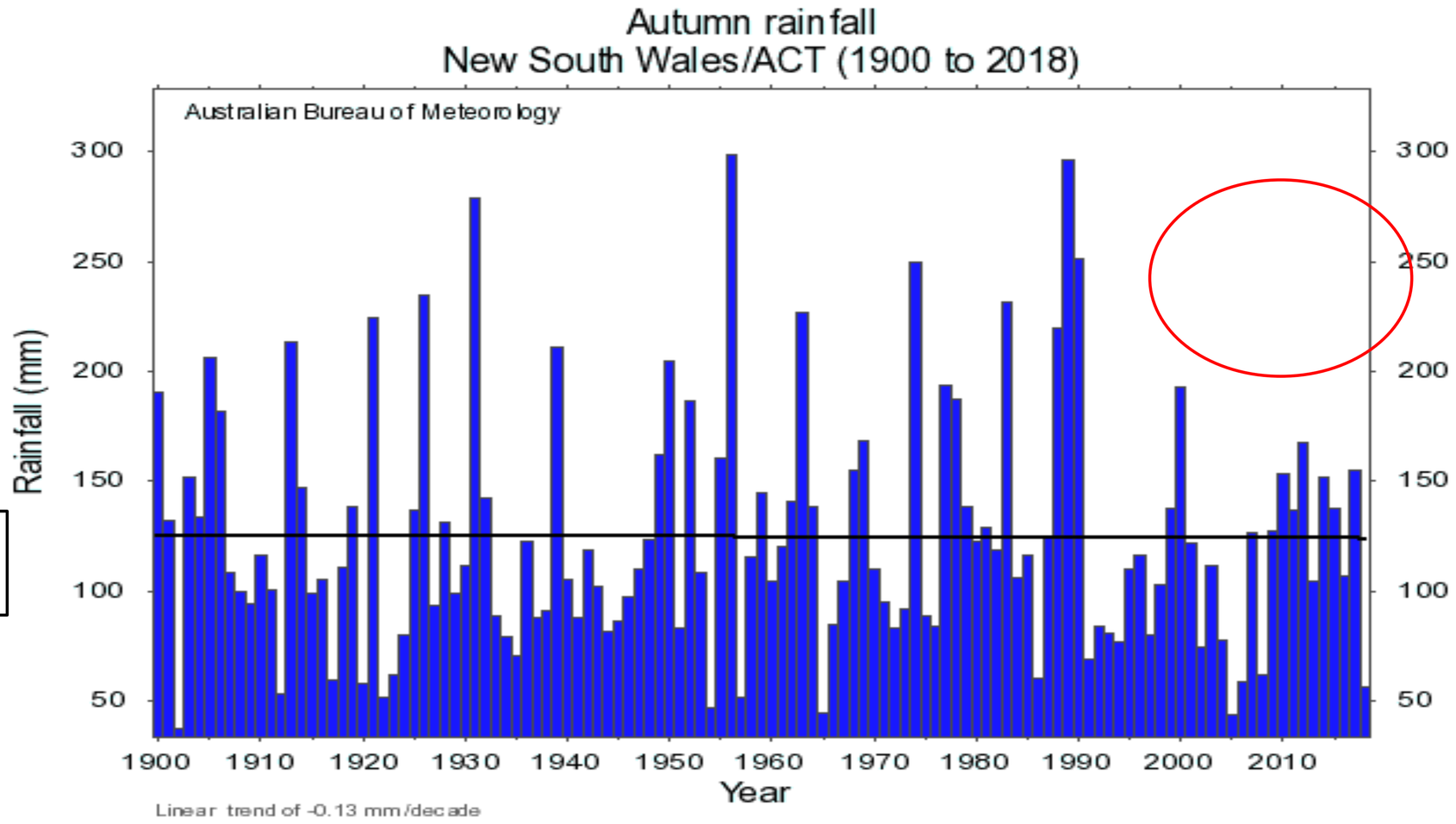
climate extremes

ARC centre of excellence

Drought

Stationary or Non-stationary?
NSW/ACT Autumn Rainfall



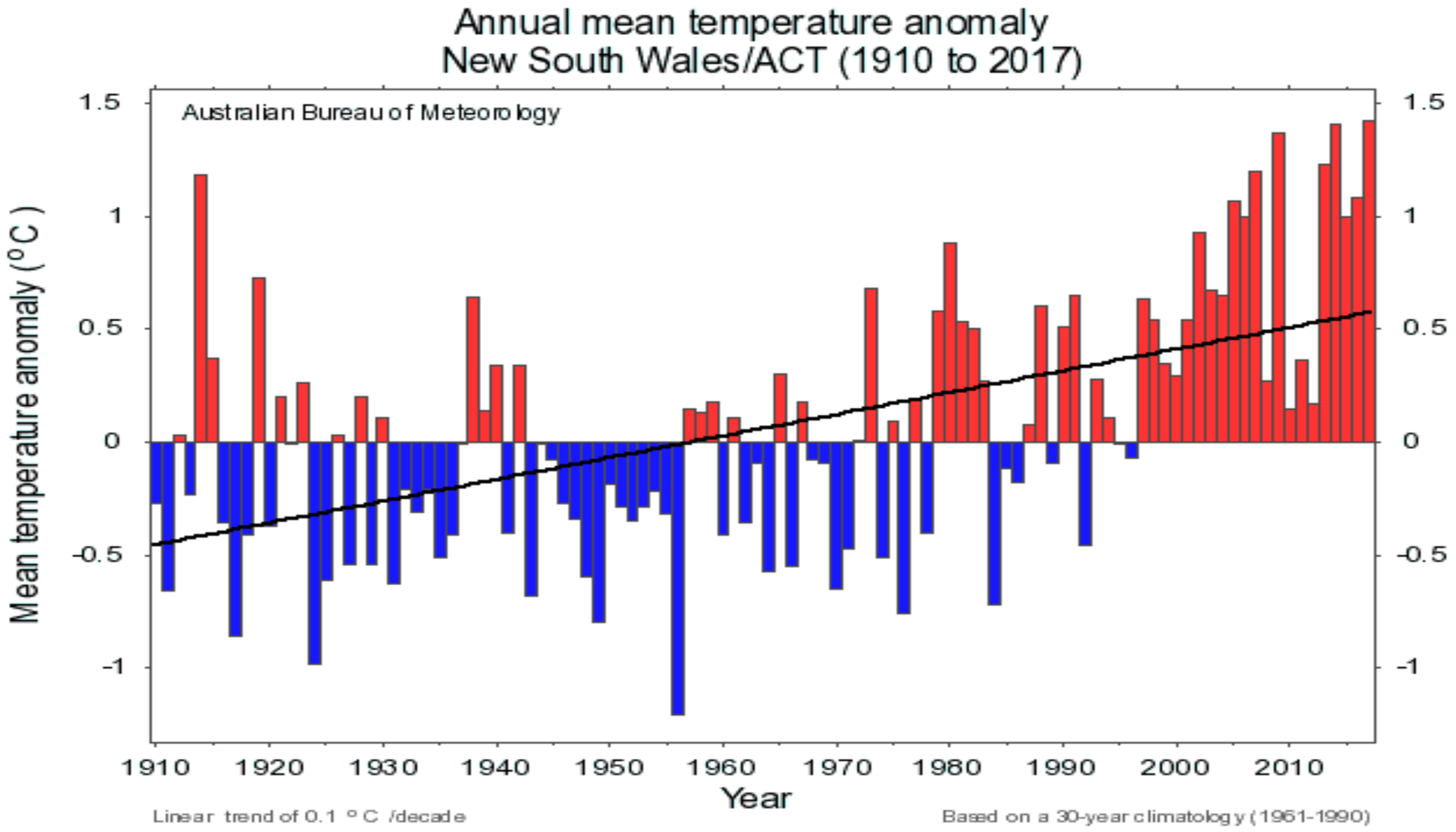
Mean 124 mm
SD 55 mm

Lack of higher Autumn Rainfalls since 1990s

Trend: Autumn P lower by ~ 2 mm (- 1%) over 12 decades

Stationary or Non-stationary?
NSW/ACT Annual Temperature

Anomaly Stats		
Mean	0	degC
SD	0.56	degC

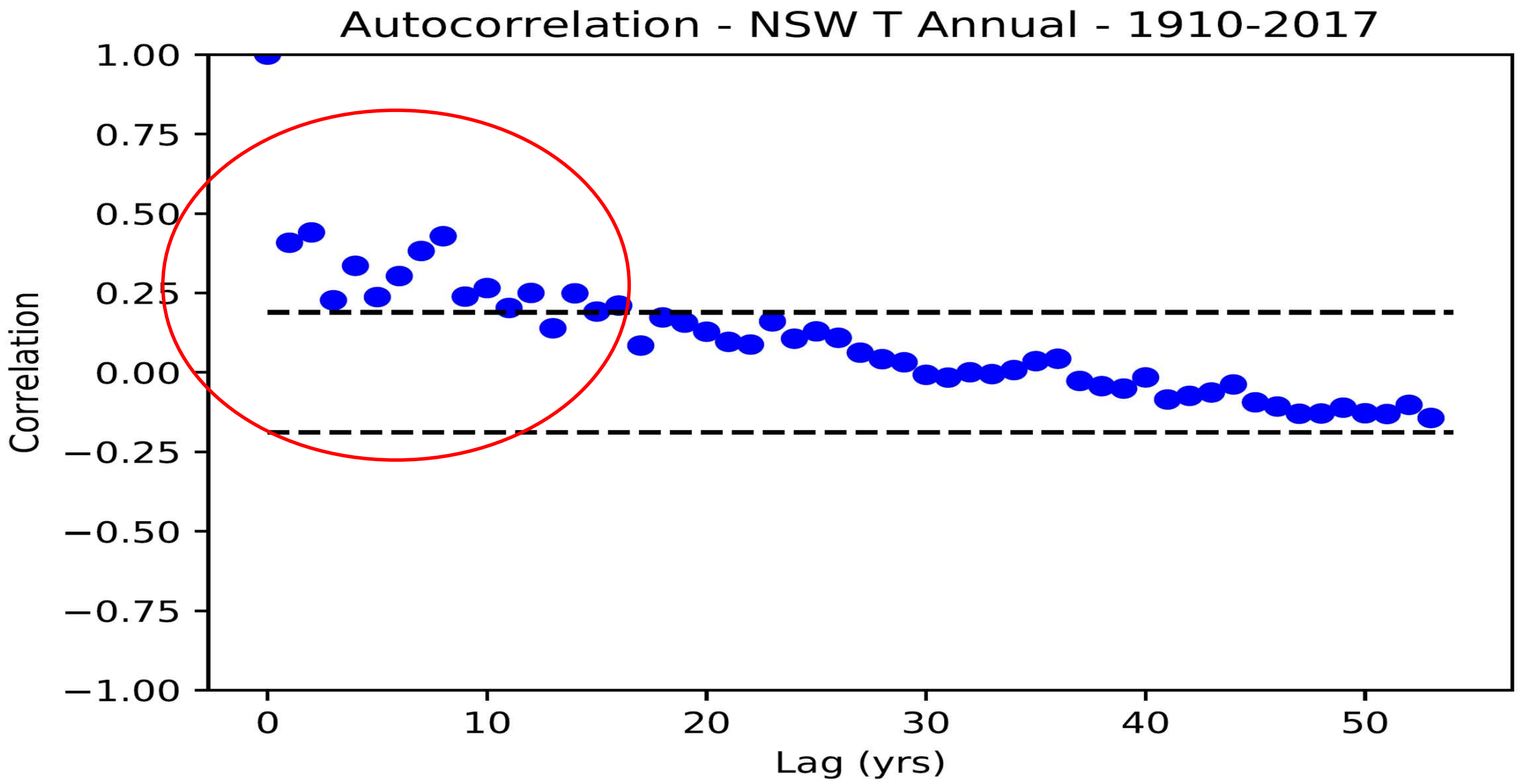


Trend: Annual T higher by ~ 1 degC over 11 decades

Stationary or Non-stationary?
NSW/ACT Annual Temperature

Text book signature of a non-stationary time series

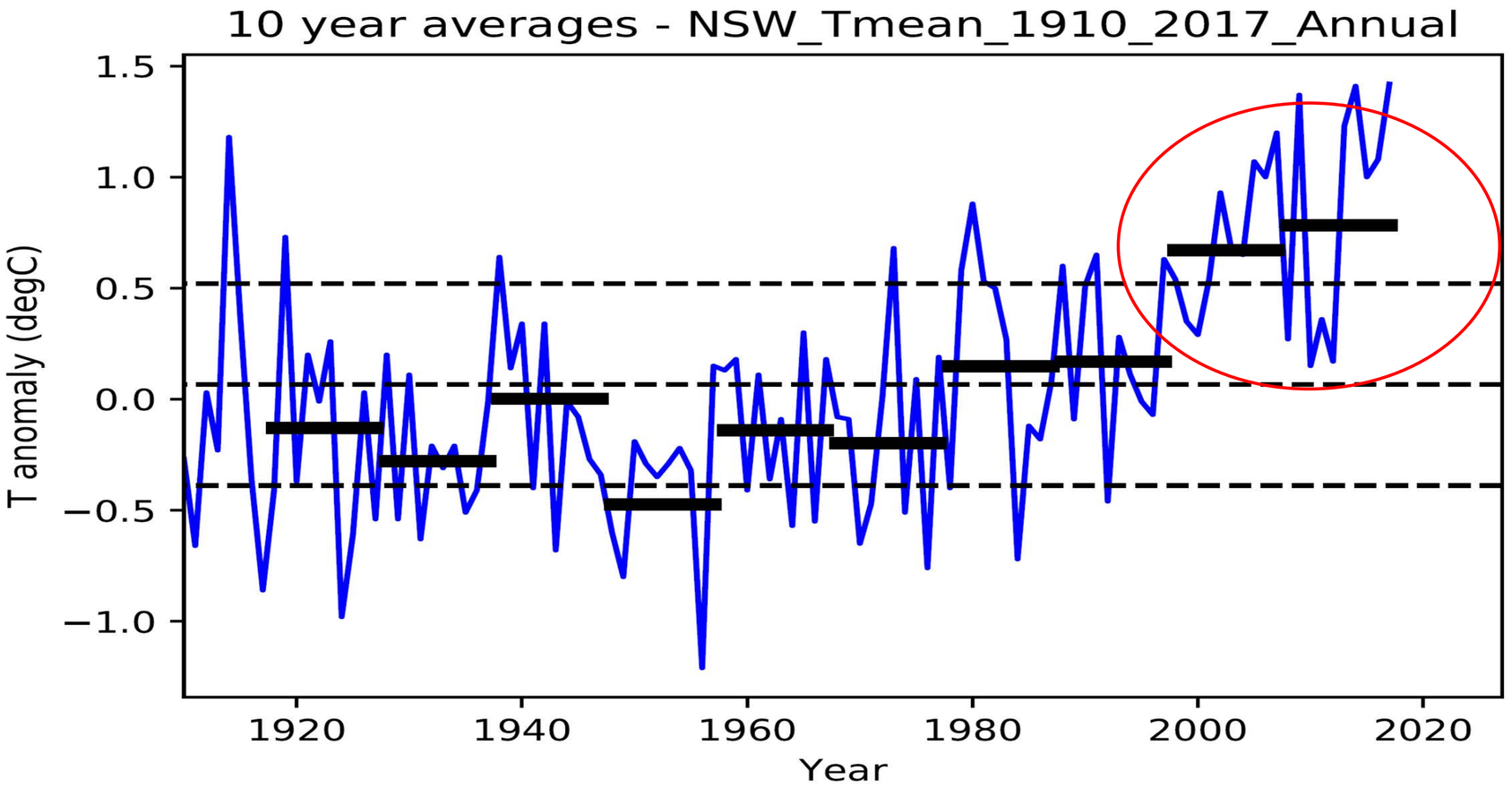
Magnitude of trend is much larger than “noise”



Conclusion: Non-Stationary (95% Confidence)

For method, see Sun, Roderick, Farquhar (2018) PNAS

Stationary or Non-stationary?
NSW/ACT Annual Temperature

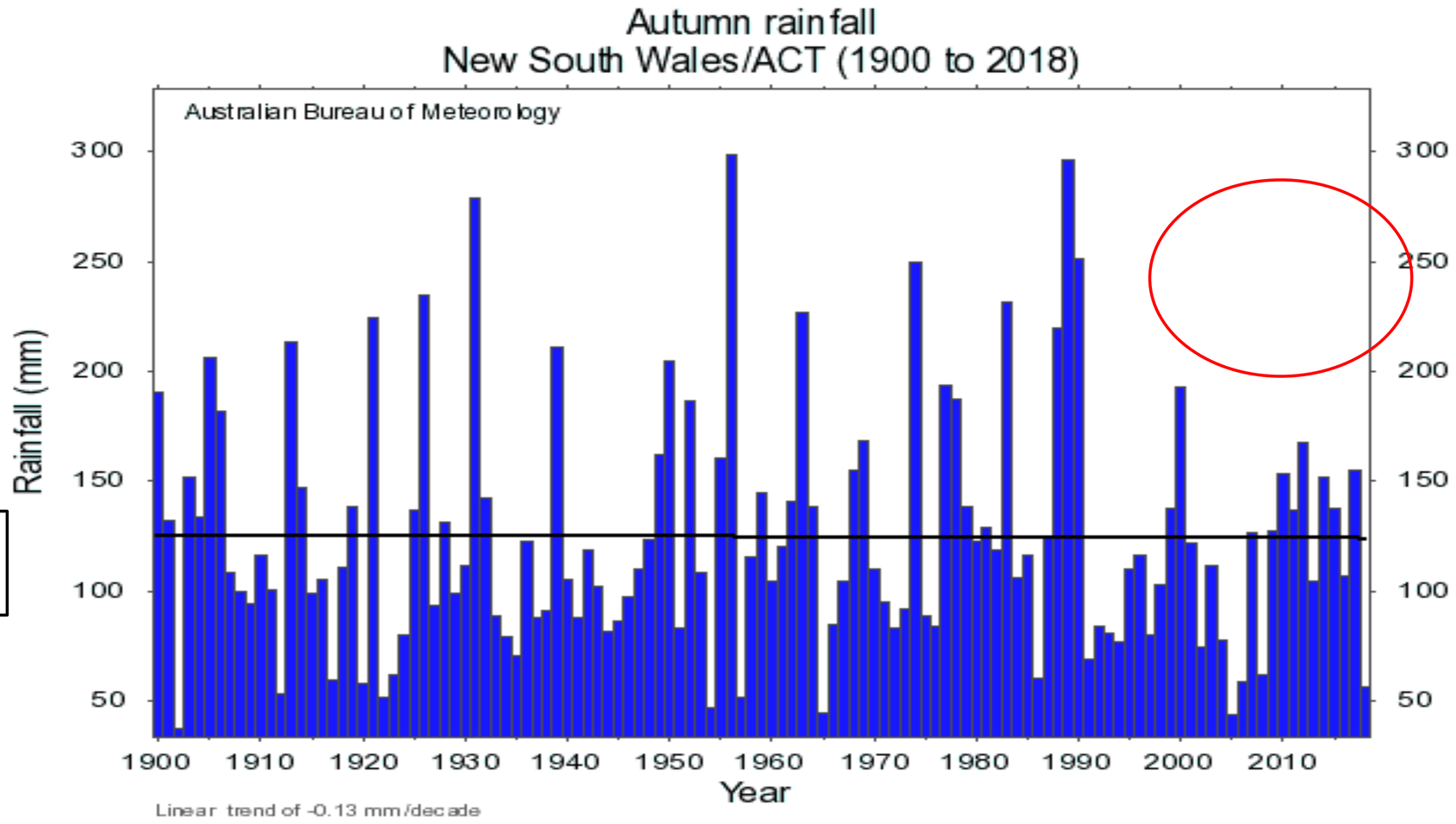


Outside the bounds of a stationary process.

Conclusion: **Non-Stationary** (95% Confidence)

For method, see Sun, Roderick, Farquhar (2018) PNAS

Stationary or Non-stationary?
NSW/ACT Autumn Rainfall



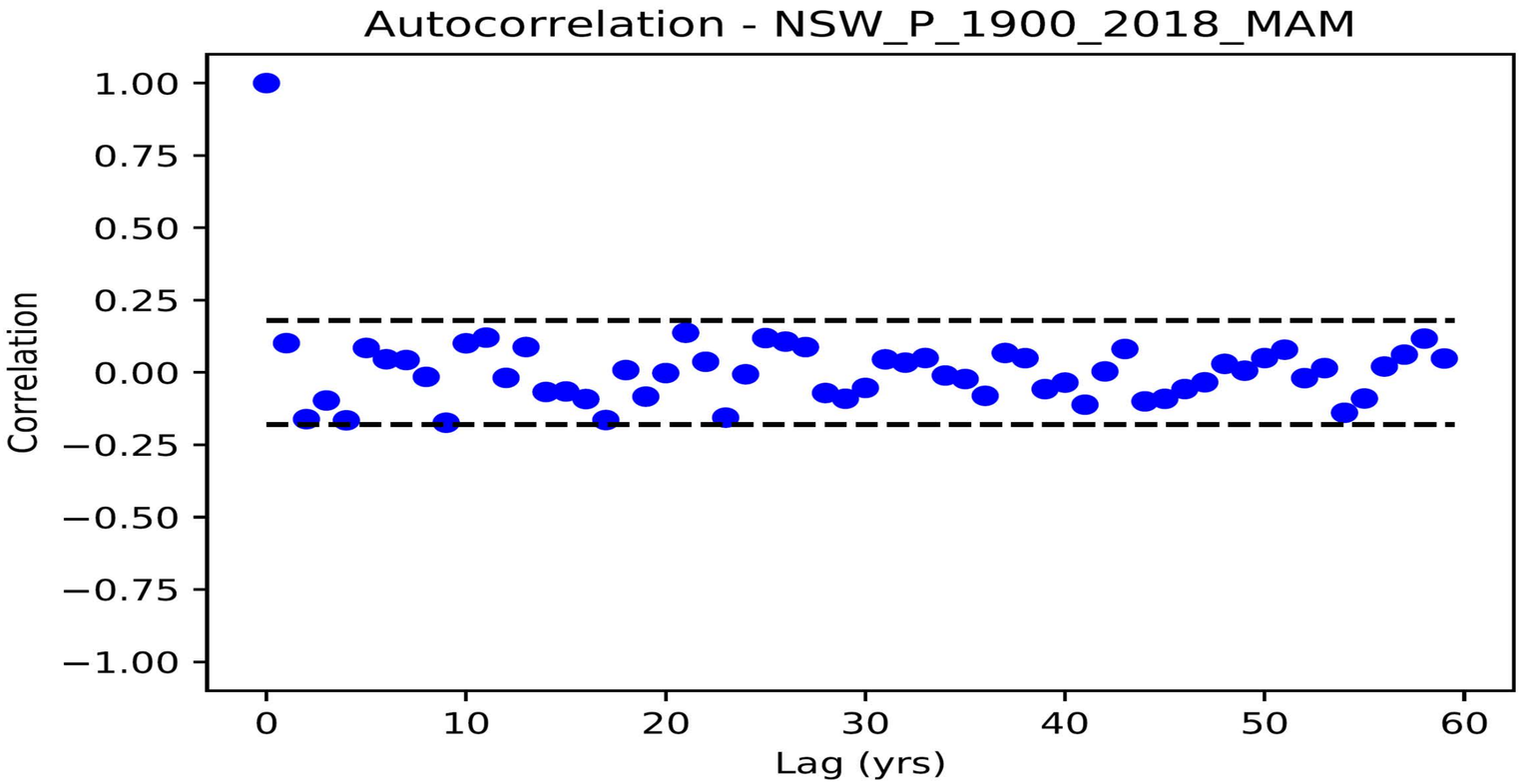
Mean 124 mm
SD 55 mm

Lack of higher Autumn Rainfalls since 1990s

Trend: Autumn P lower by ~ 2 mm (- 1%) over 12 decades

Stationary or Non-stationary?
NSW/ACT Autumn Rainfall

Text book signature of a stationary time series



95% CI

Conclusion: Stationary (95% Confidence)

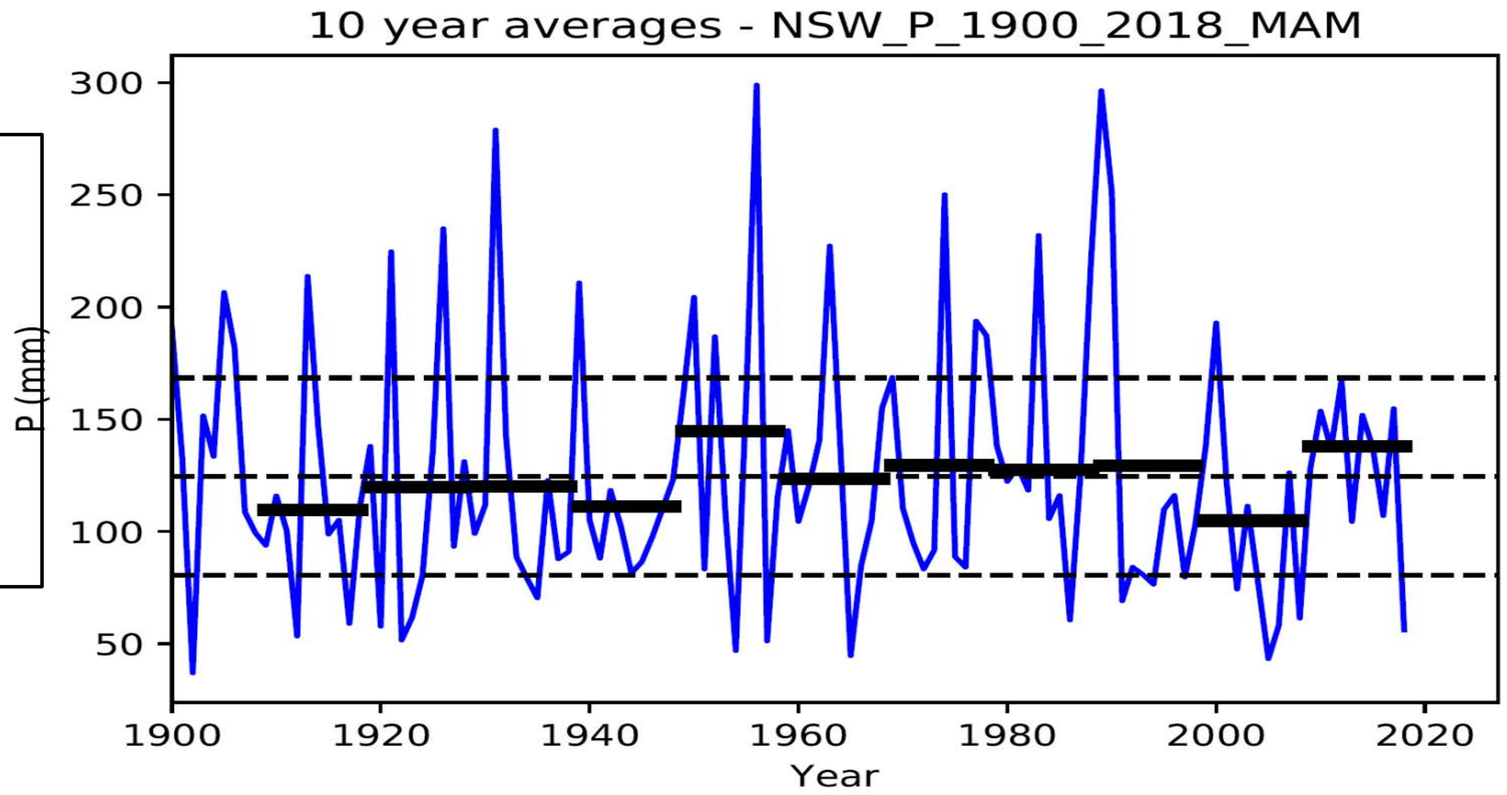
For method, see Sun, Roderick, Farquhar (2018) PNAS

Stationary or Non-stationary?
NSW/ACT Autumn Rainfall

Mean 124 mm
SD 55 mm

Any 10 year period,
SE Mean = $55/10^{0.5}$
SE Mean ~ 17 mm.

95% CI
= 1.96 SD
= 33 mm



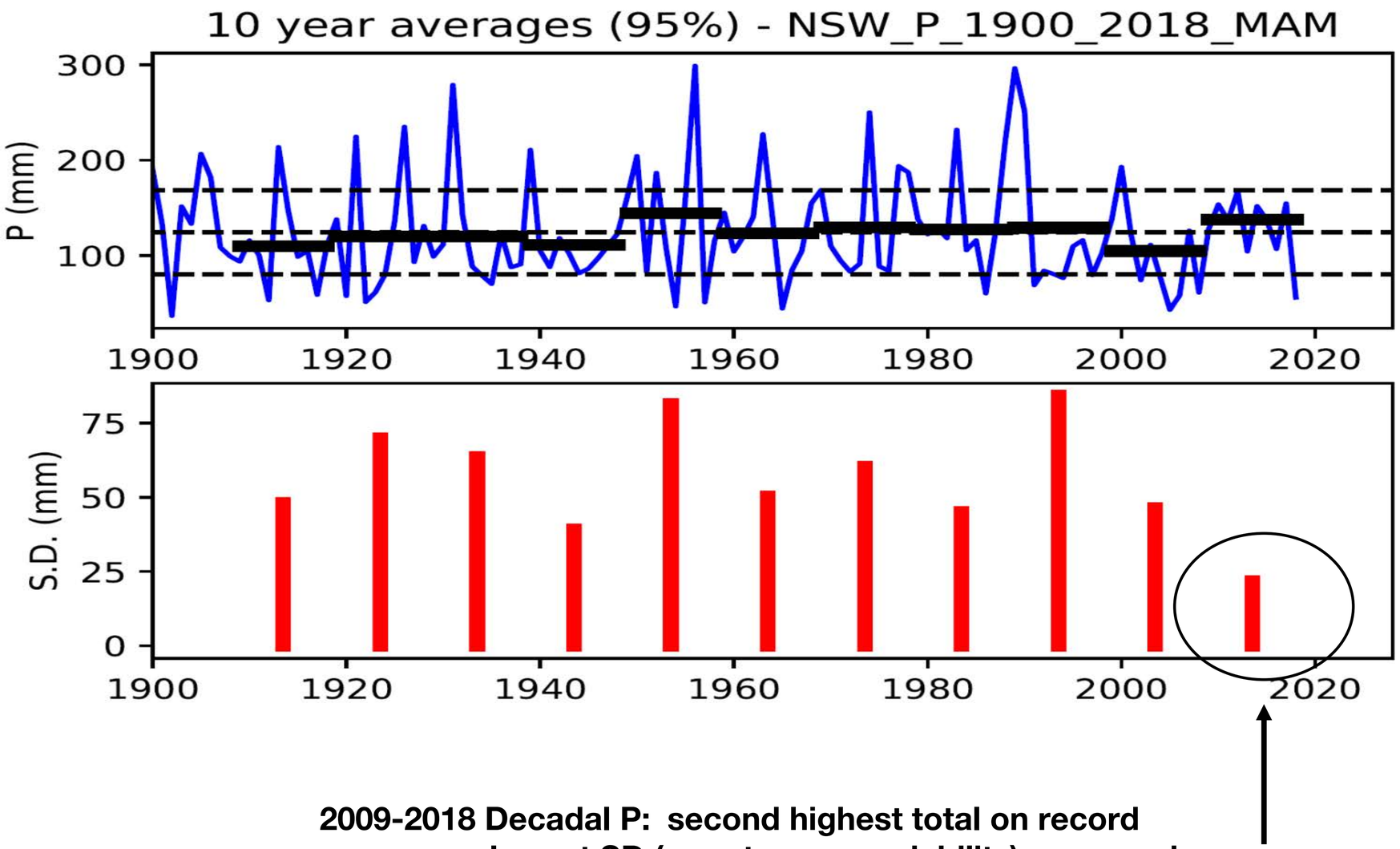
Autumn Rainfall in last decade (2009-2018) is slightly above the long term average.

The year-to-year variability has declined in the most recent two decades.

Conclusion: Stationary (95% Confidence)

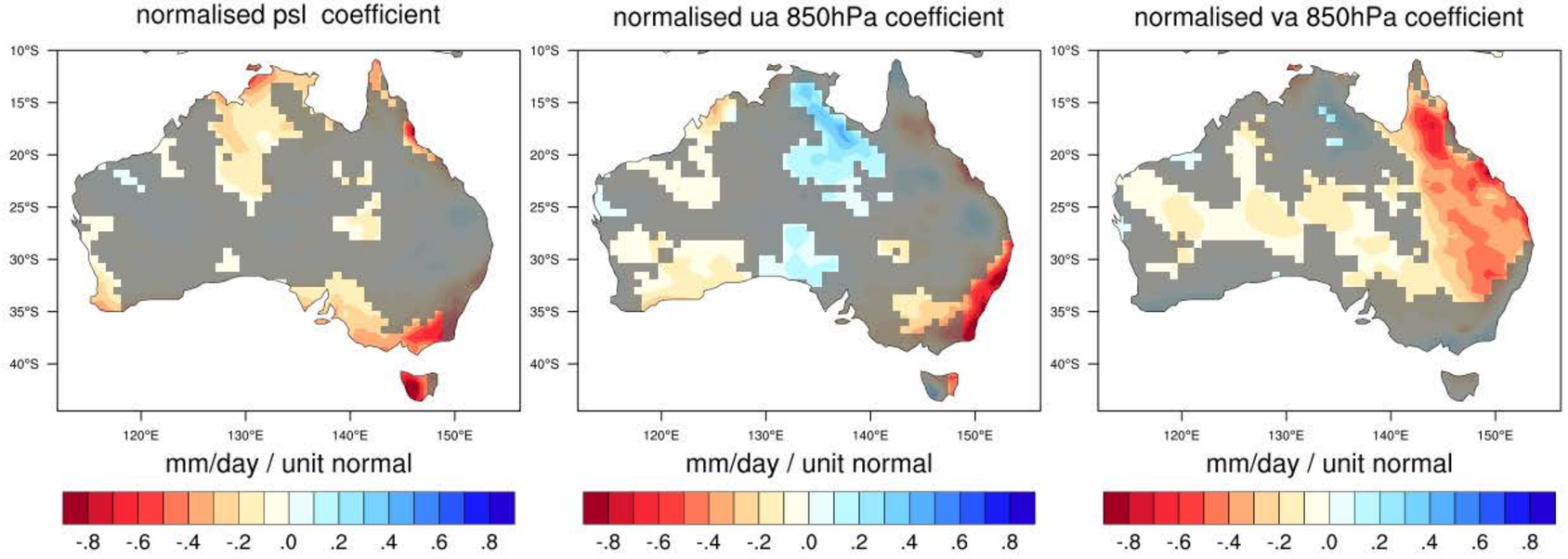
For method, see Sun, Roderick, Farquhar (2018) PNAS

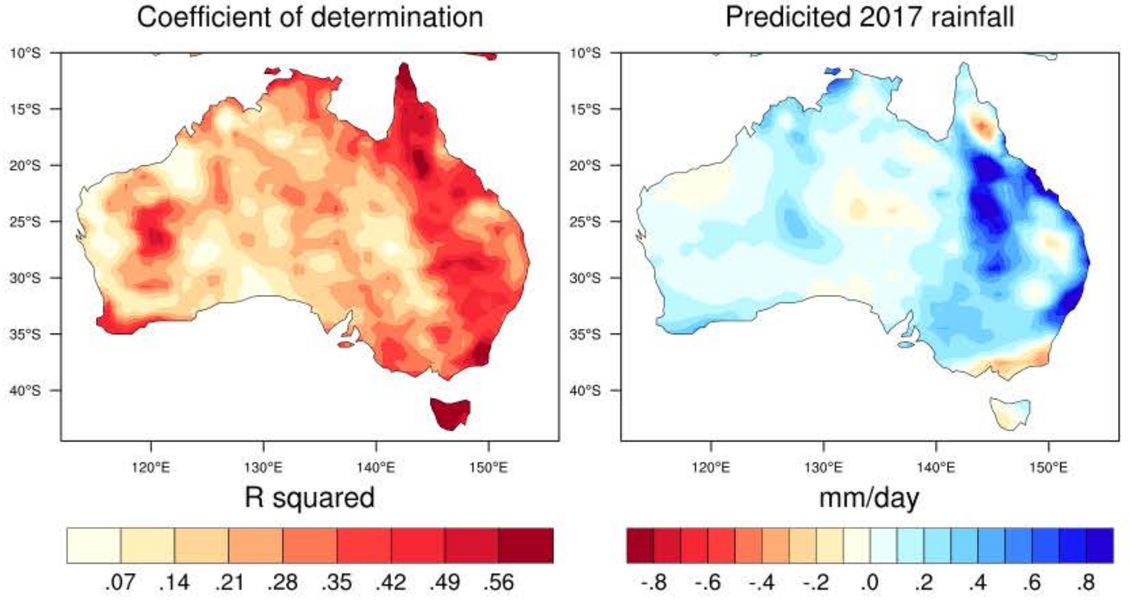
NSW/ACT Autumn Rainfall

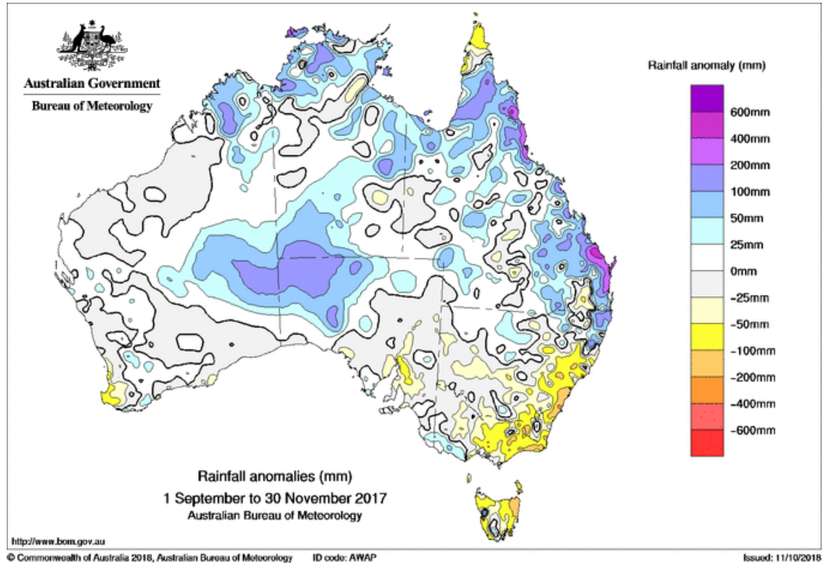


2009-2018 Decadal P: second highest total on record
lowest SD (year-to-year variability) on record

Multiple regression using Obs, SON
pr vs. normalised (psl, 850hPa ua, 850hPa va)

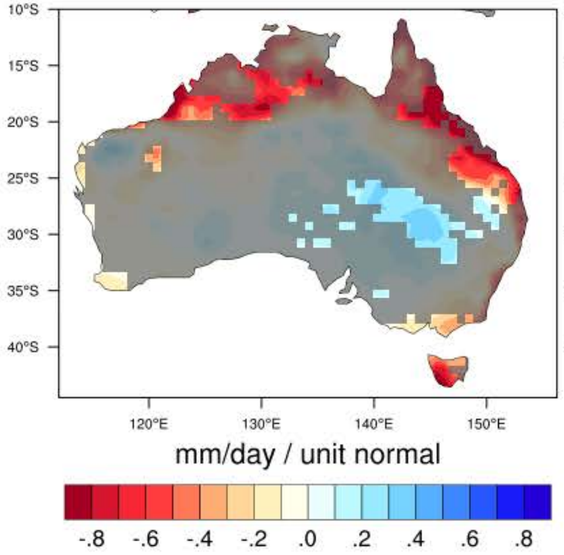




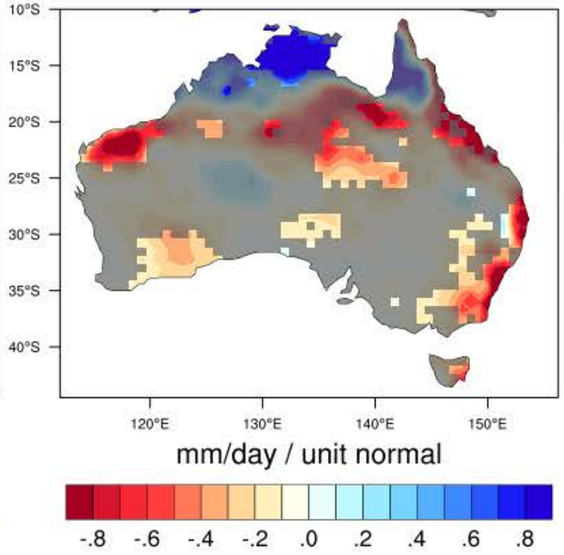


Multiple regression using Obs, DJF, 1980-2008
pr vs. normalised (psl, 850hPa ua, 850hPa va)

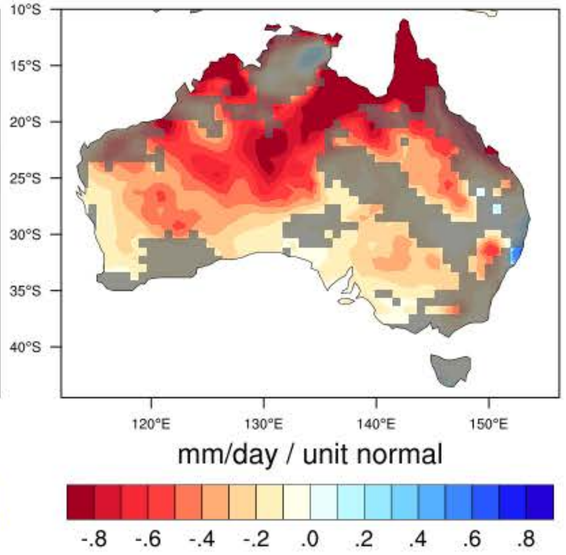
normalised psl coefficient



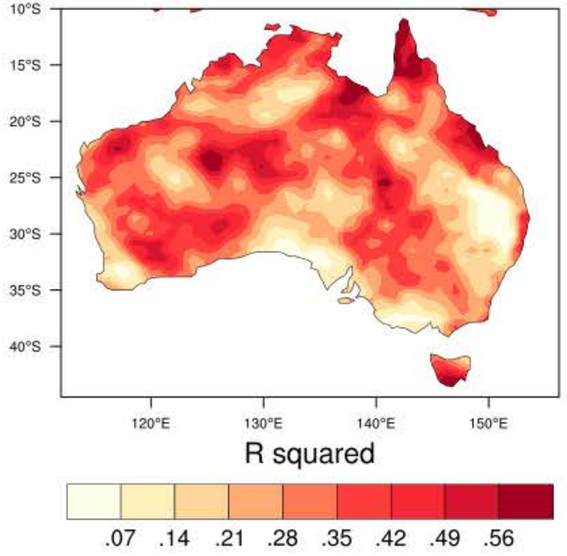
normalised ua 850hPa coefficient



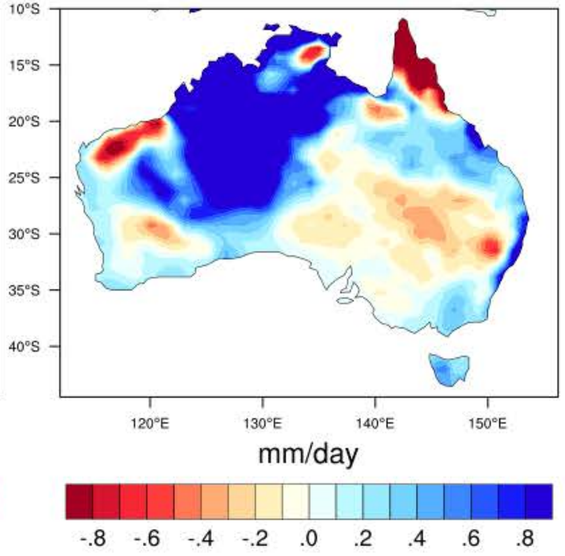
normalised va 850hPa coefficient

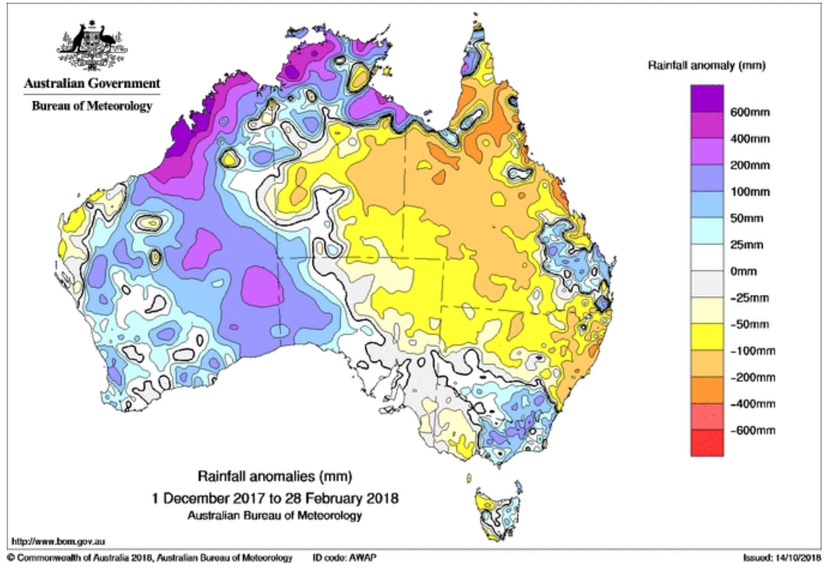


Coefficient of determination

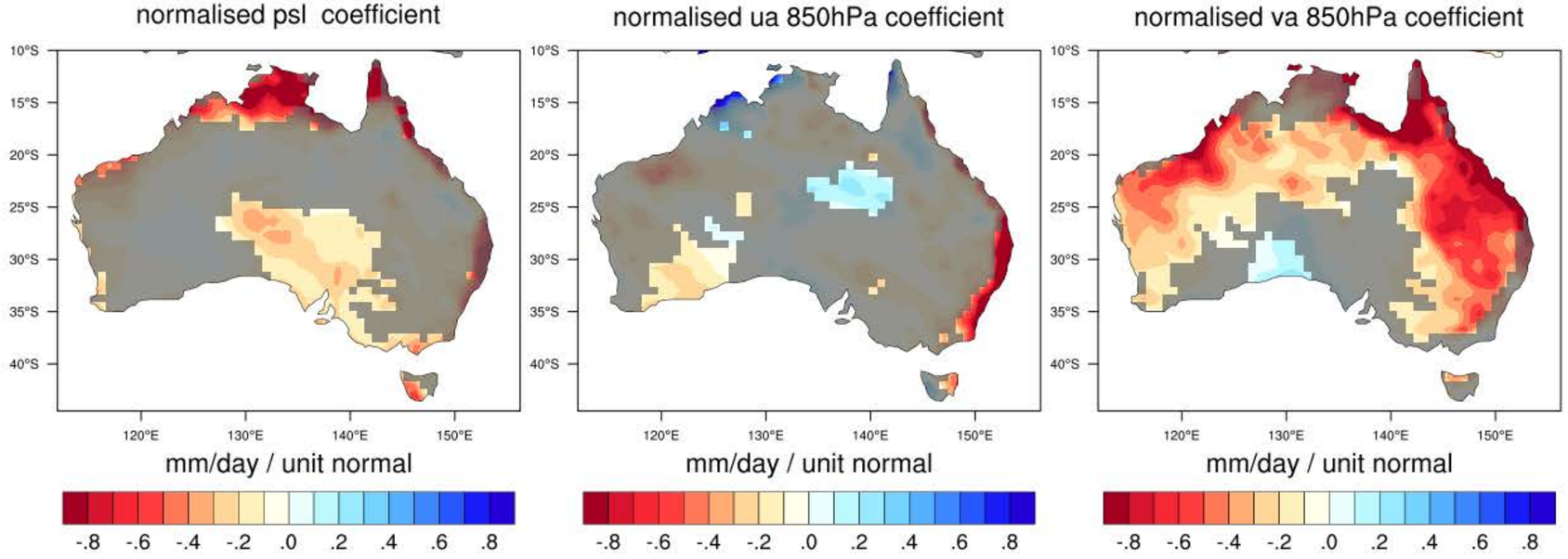


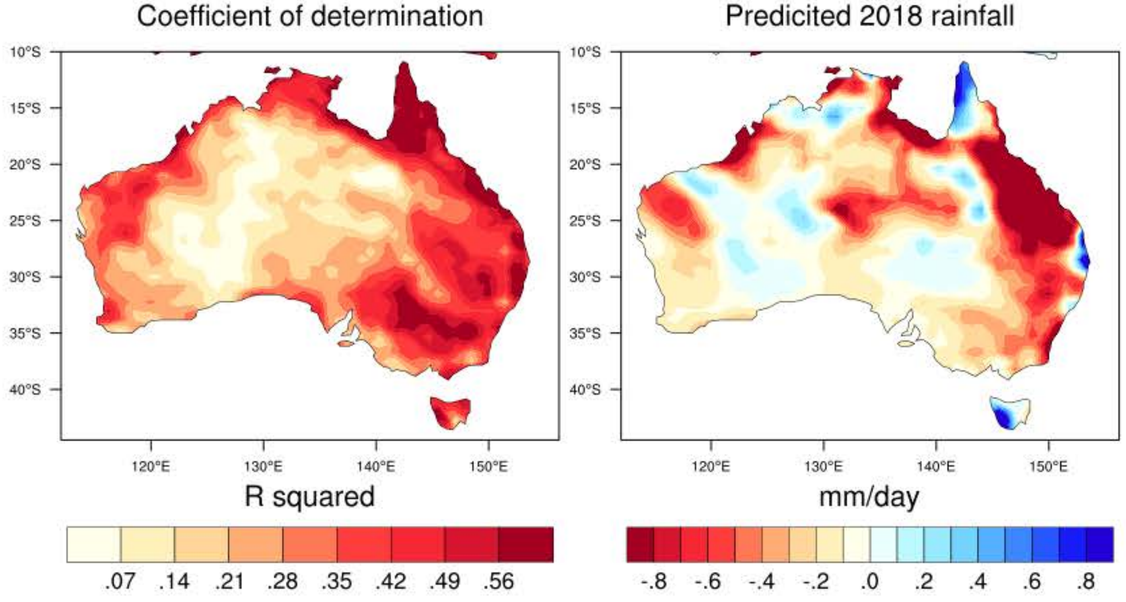
Predicited 2018 rainfall

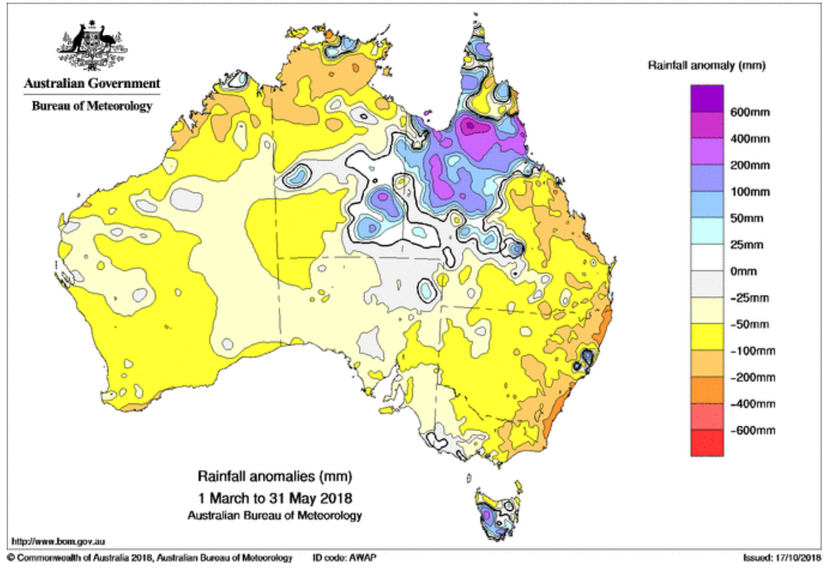




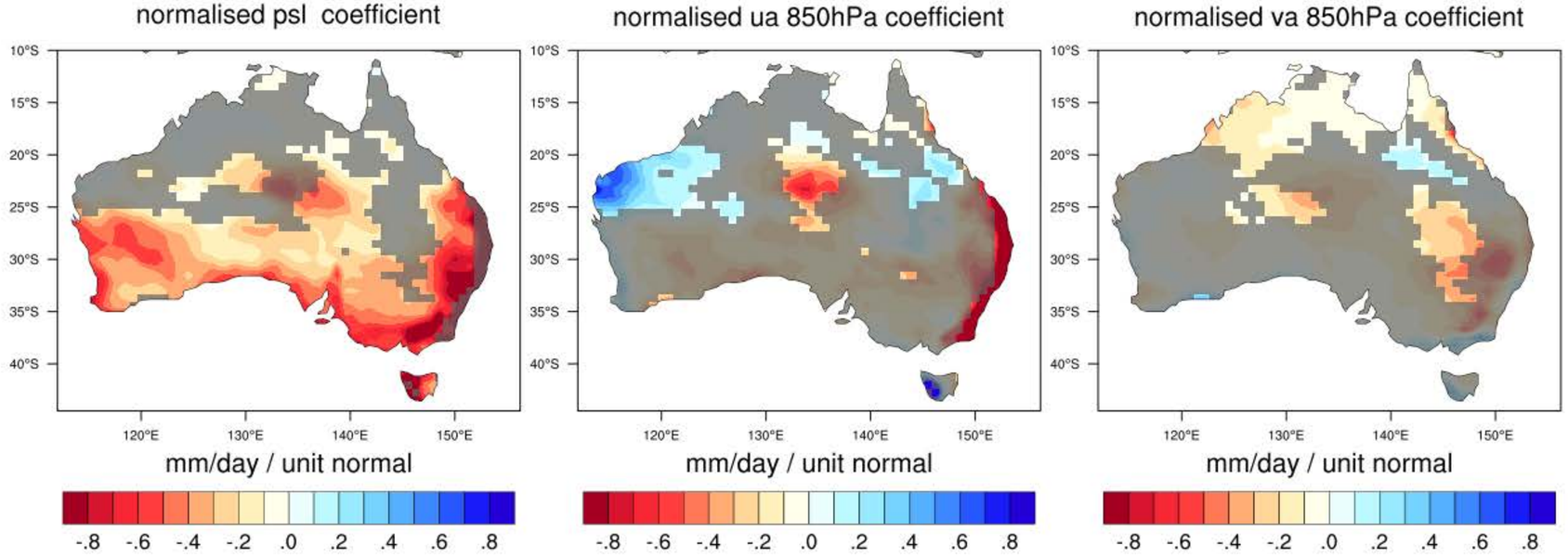
Multiple regression using Obs, MAM
pr vs. normalised (psl, 850hPa ua, 850hPa va)

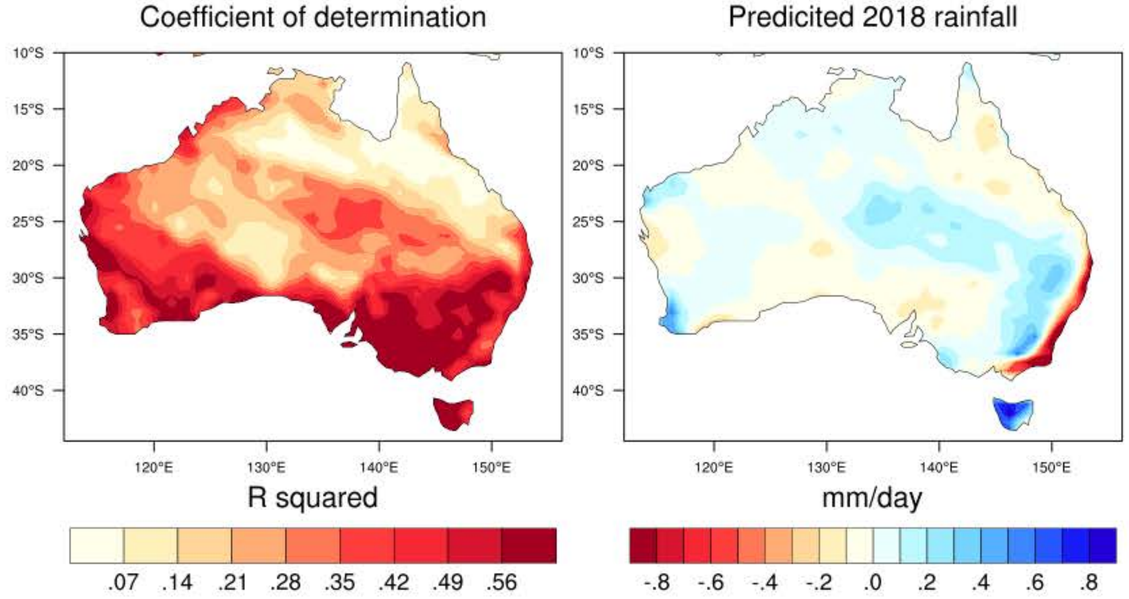


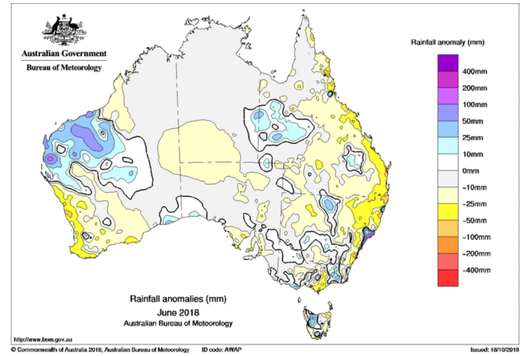


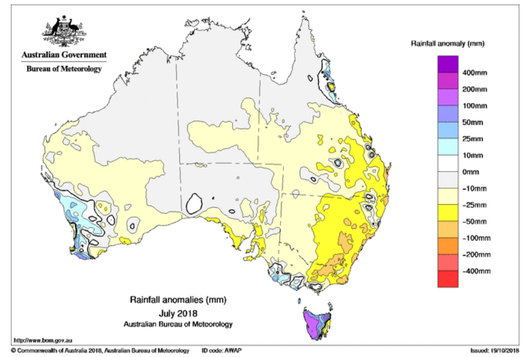


Multiple regression using Obs, JJ
pr vs. normalised (psl, 850hPa ua, 850hPa va)



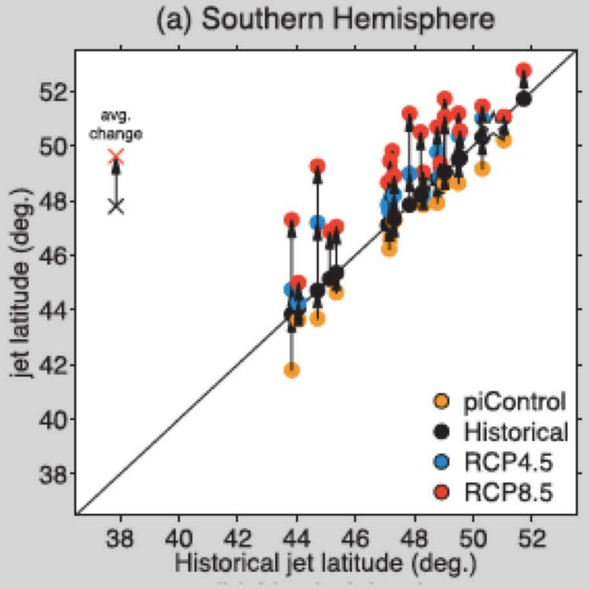


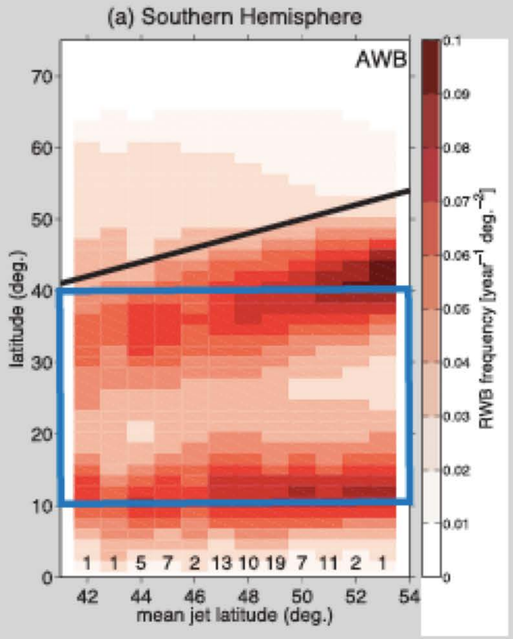




Climate Change Dynamics

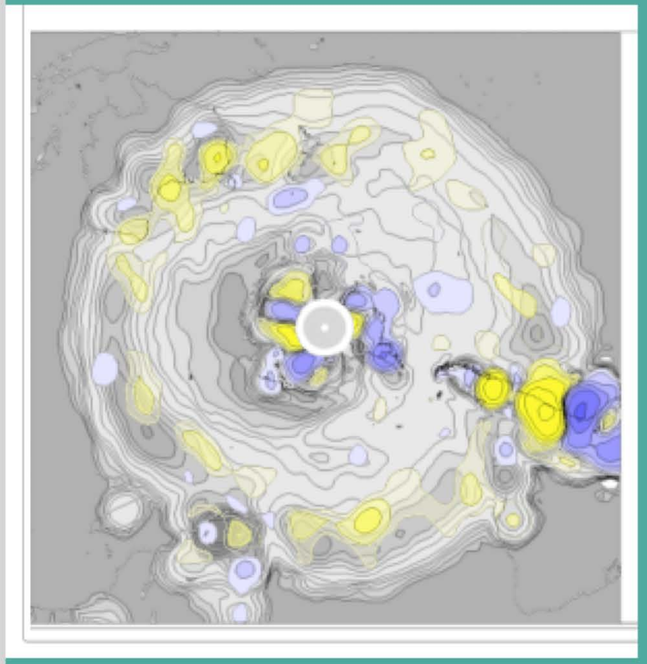
Barnes & Polvani JC (2013):

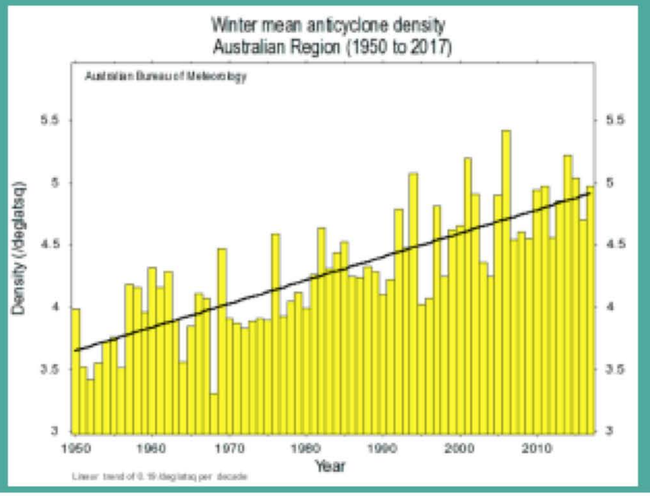


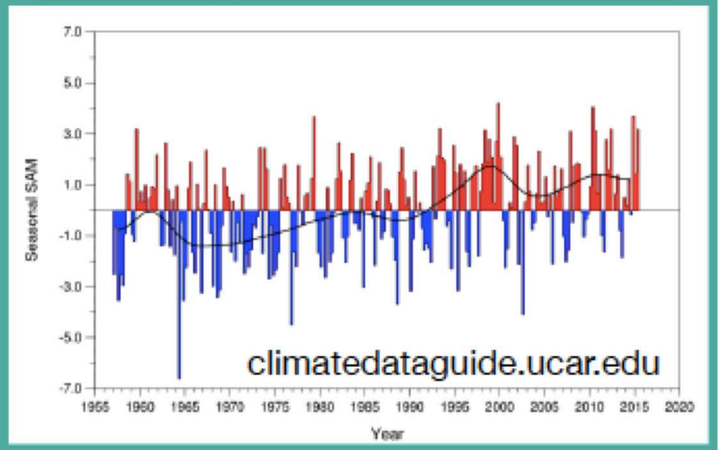


1) CMIP5 RCP8.5: Poleward shift of jet
2) With poleward jet position comes change in
    1) Frequency of anticyclones
    2) Position of anticyclones
3) Anticyclone over Tasman Sea important for NSW heat waves [Gibson et al JC (2017)]

bom.gov.au:

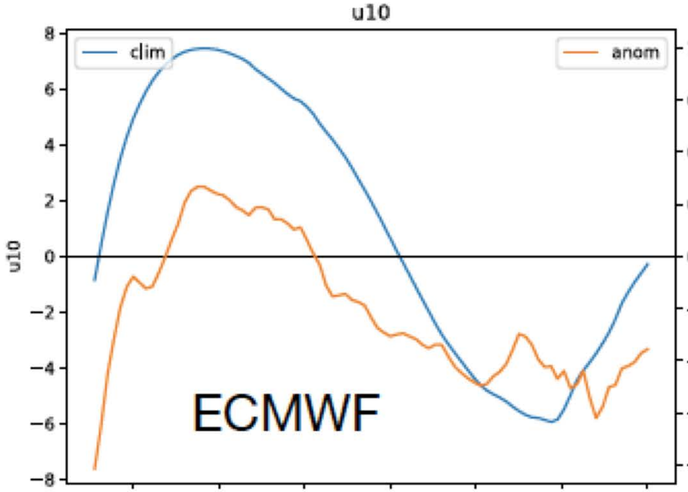


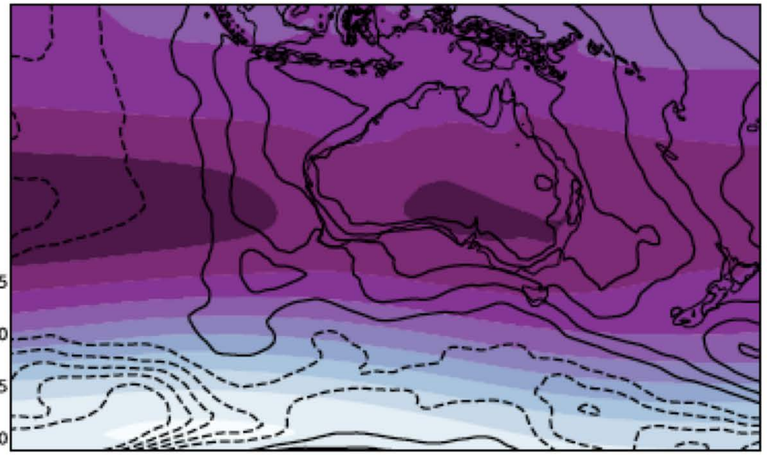


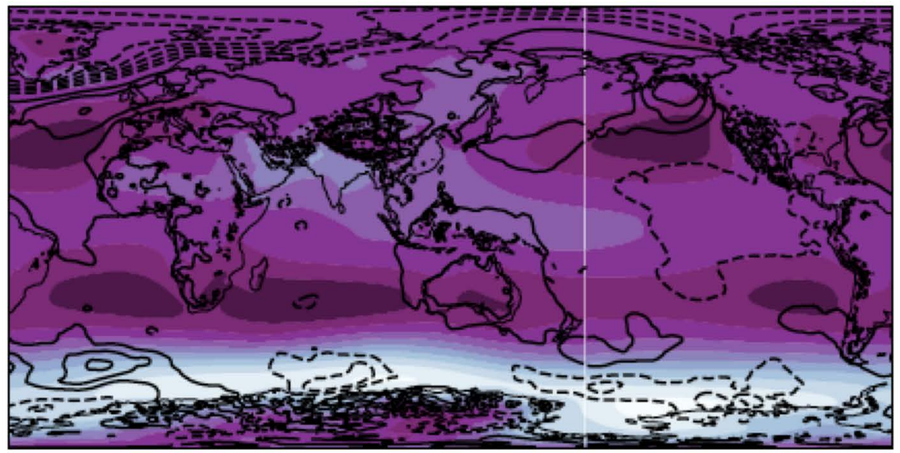


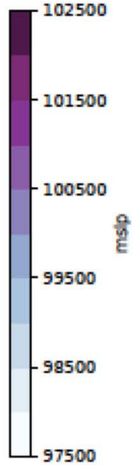
1) SAM positive trend
2) Anticyclones:
    1) Increase in anticyclone frequency
    2) poleward shift of anticyclone position
3) Increase in frequency where it matters for NSW heat waves

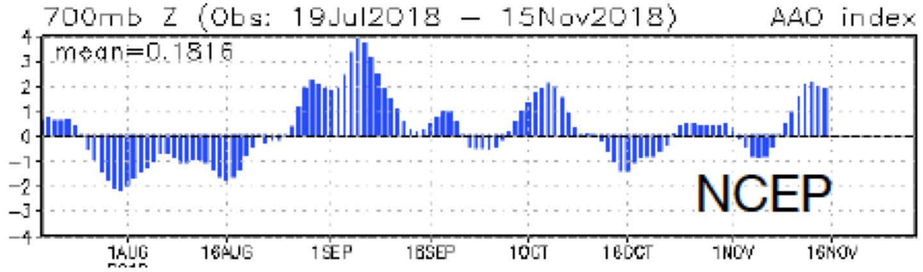
Winter 2018?



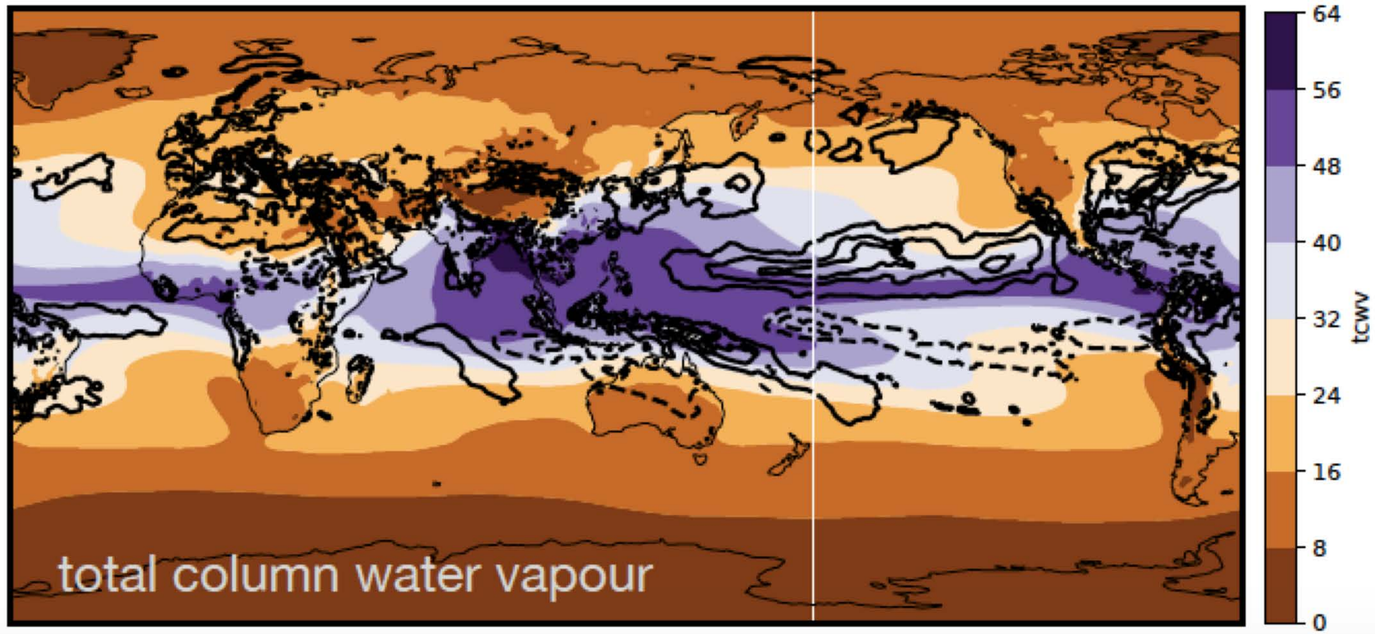








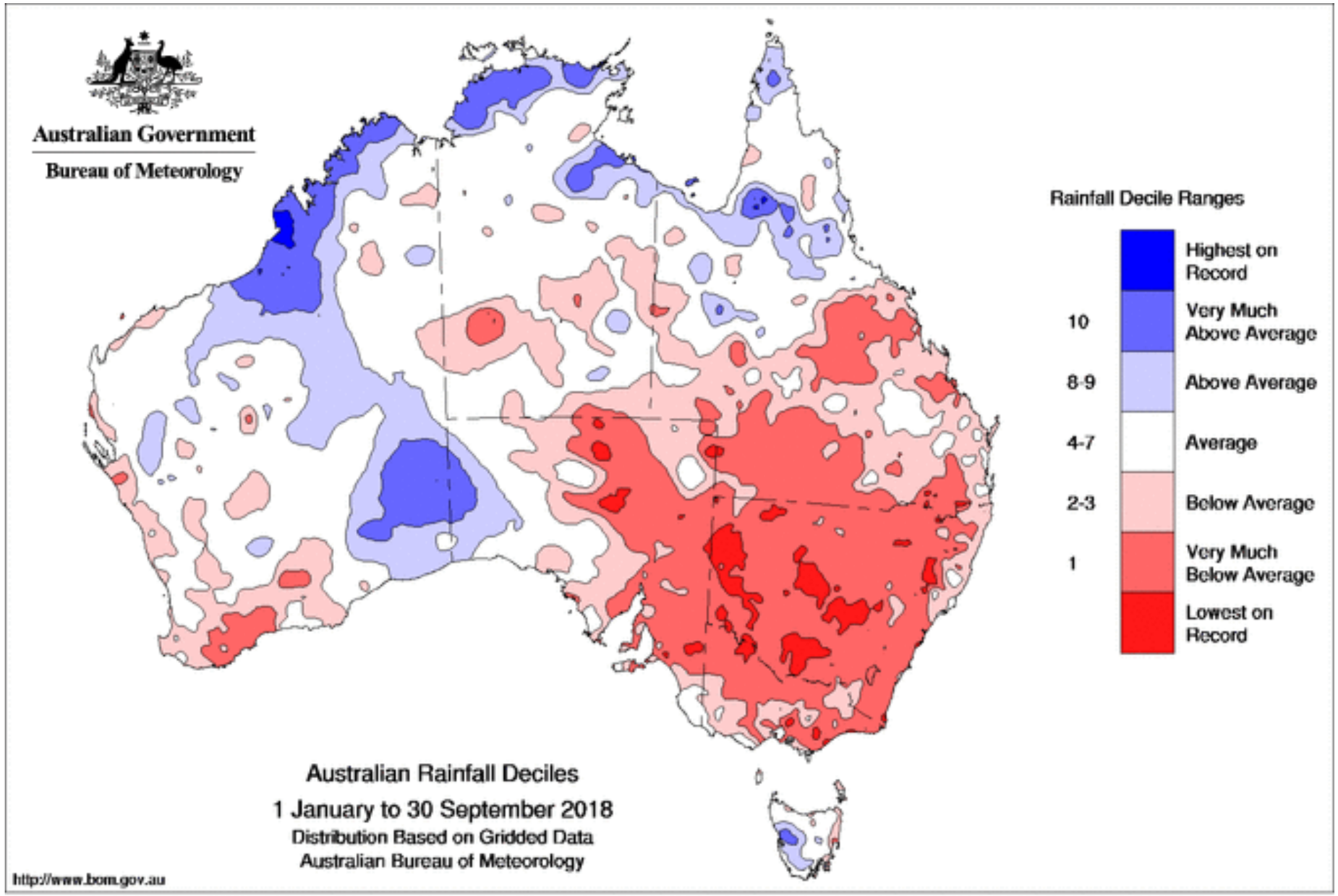
Tropical stationary wave? Excited by what? (neutral ENSO!)



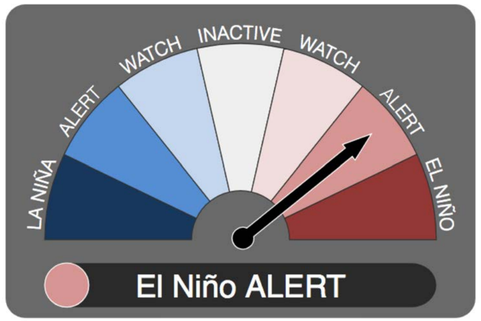
1) CMIP5 RCP8.5: Poleward shift of jet
2) With poleward jet position comes change in
    1) Frequency of anticyclones
    2) Position of anticyclones
3) Anticyclone west of NZ important for NSW heat waves [Gibson et al JC (2017)

THE UNIVERSITY OF MELBOURNE

Current drought



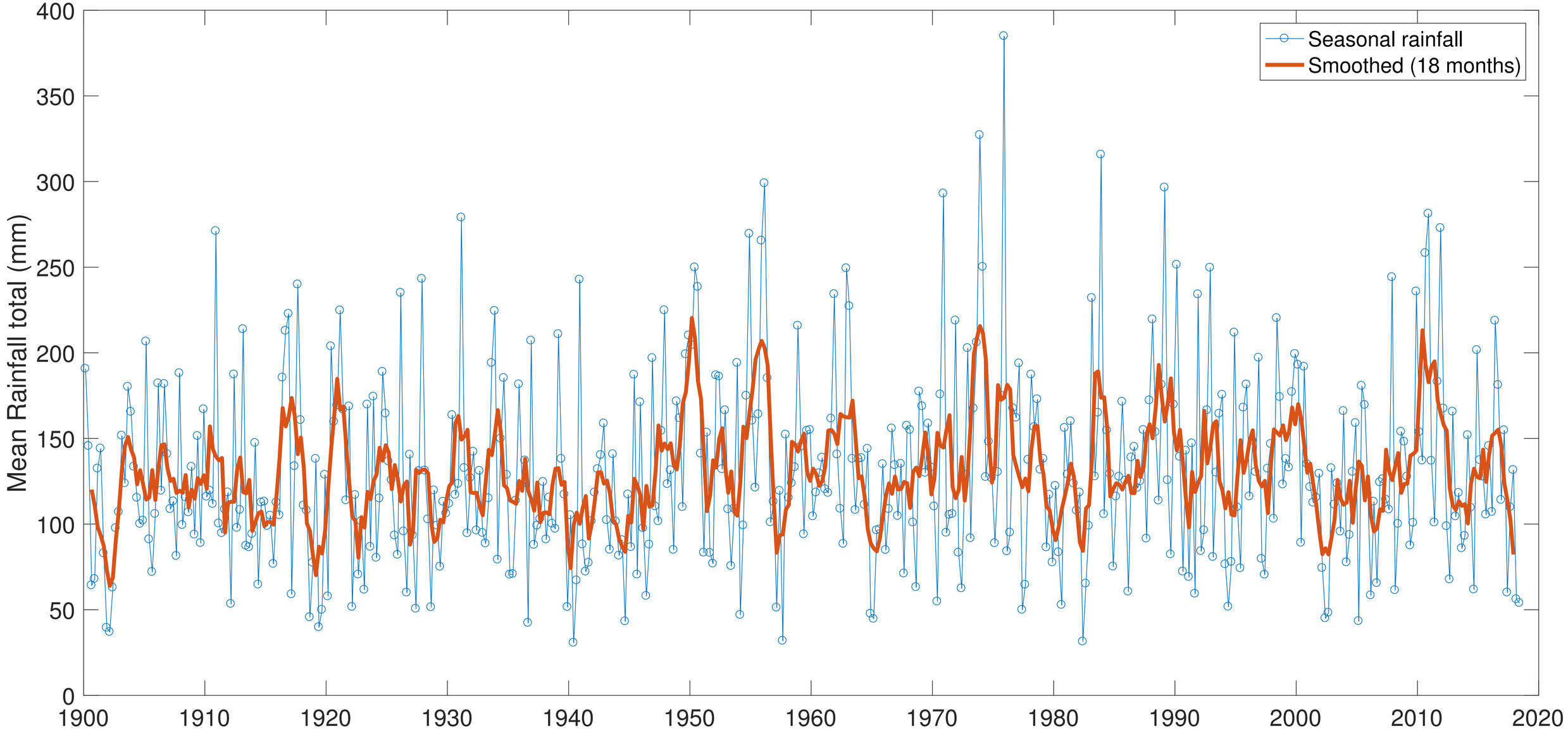
El Niño Alert: 70% chance of an El Niño this year



Bureau of Meteorology

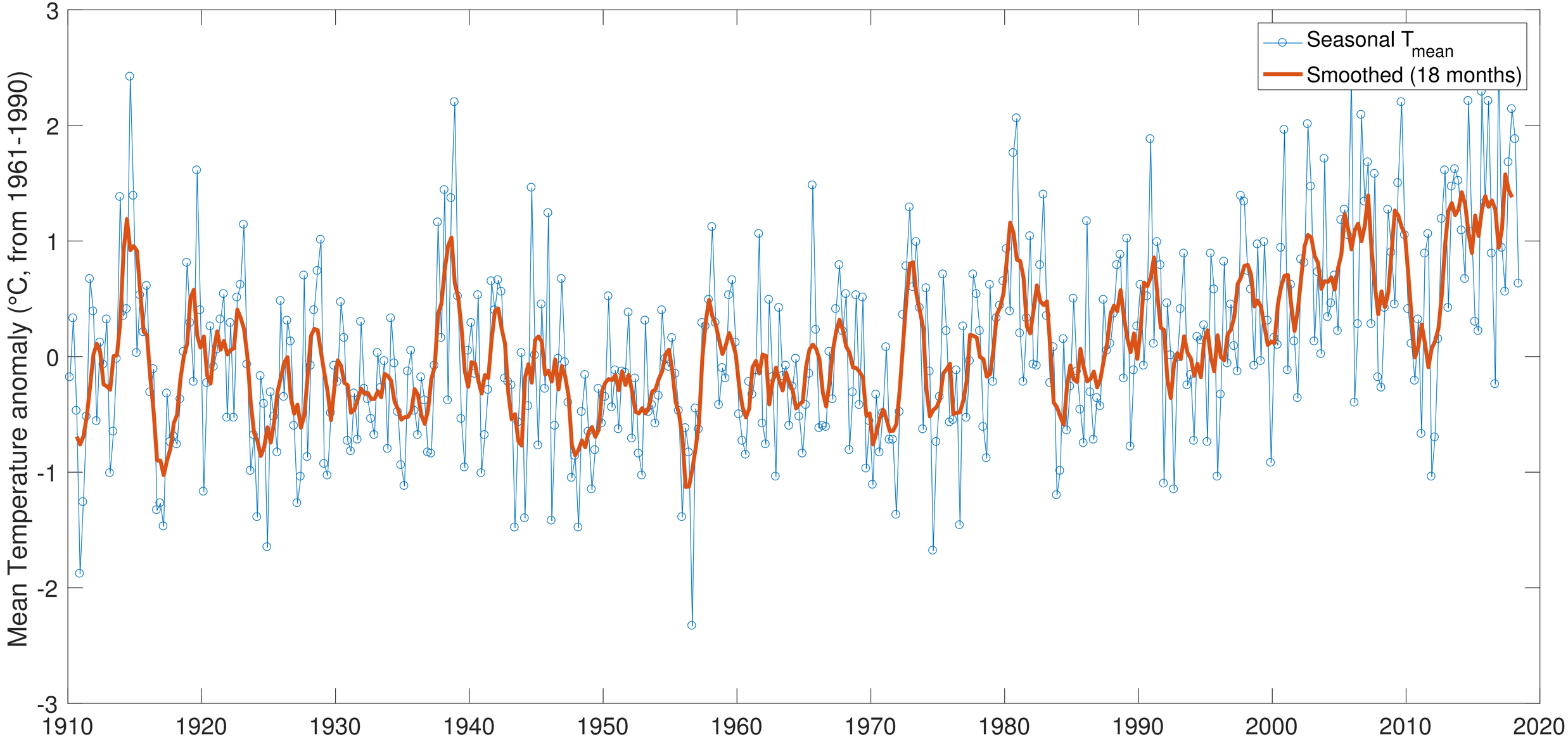
THE UNIVERSITY OF MELBOURNE

NSW seasonal rainfall total (mm)



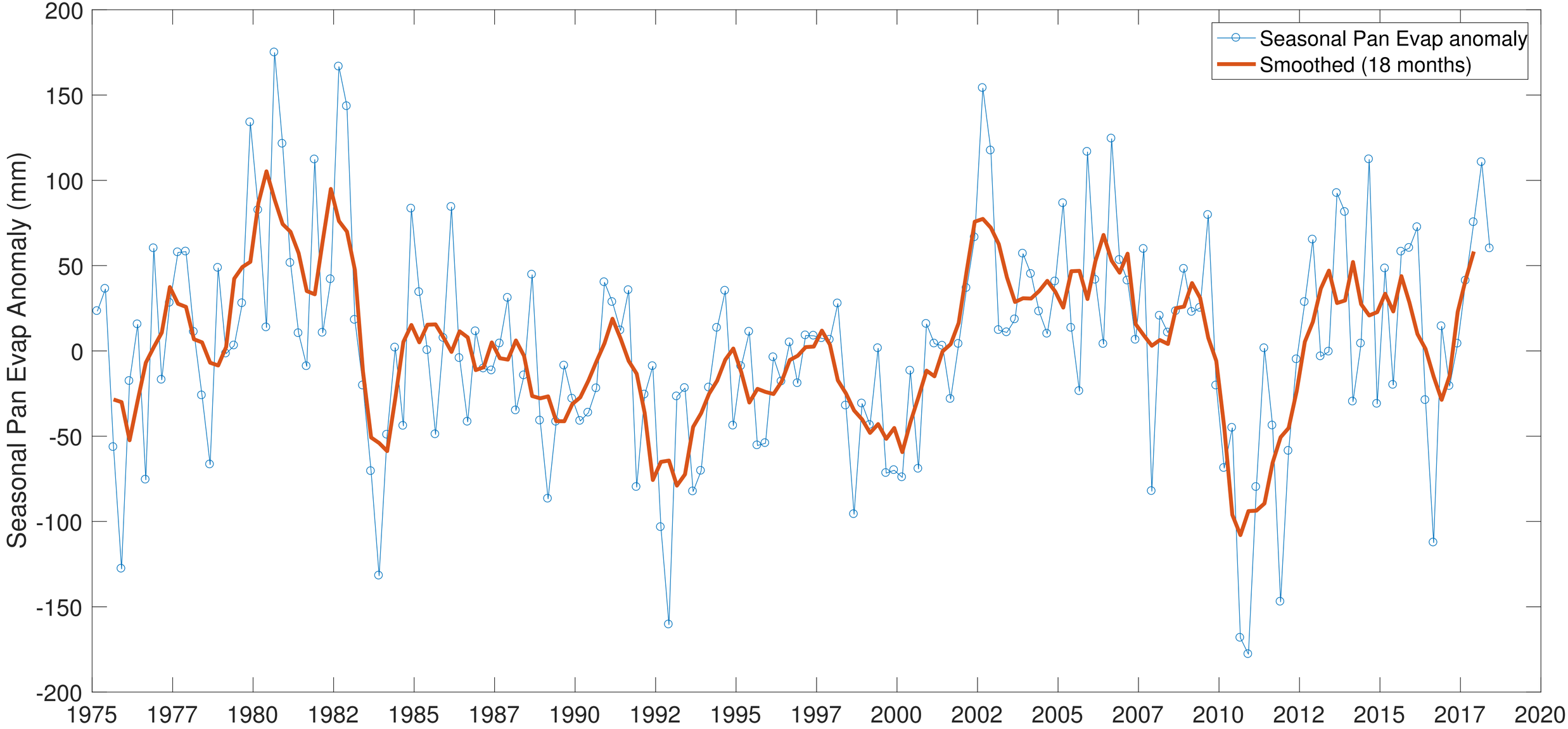
THE UNIVERSITY OF MELBOURNE

NSW seasonal temperature anomaly

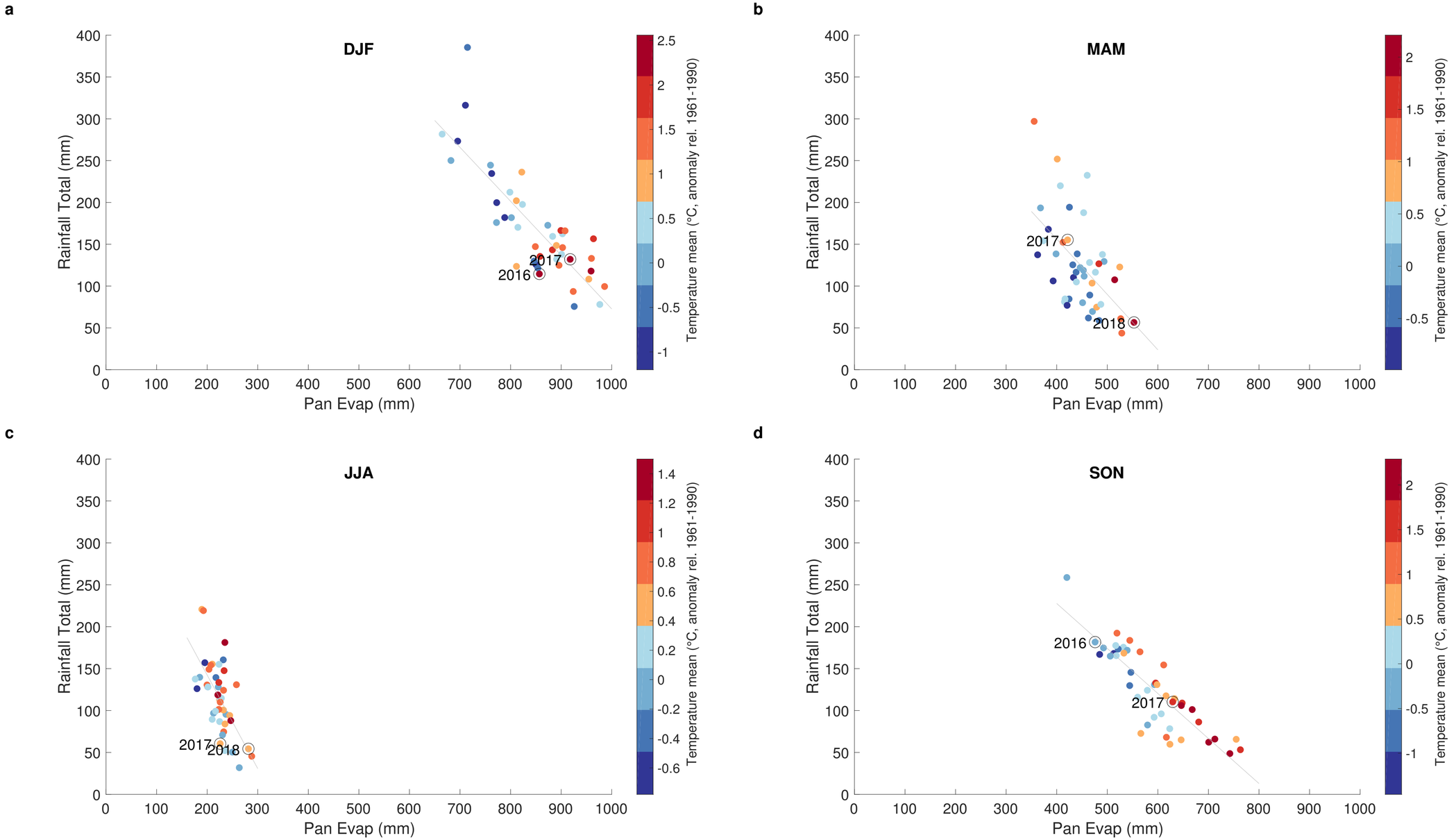


THE UNIVERSITY OF MELBOURNE

NSW seasonal rainfall total (mm)



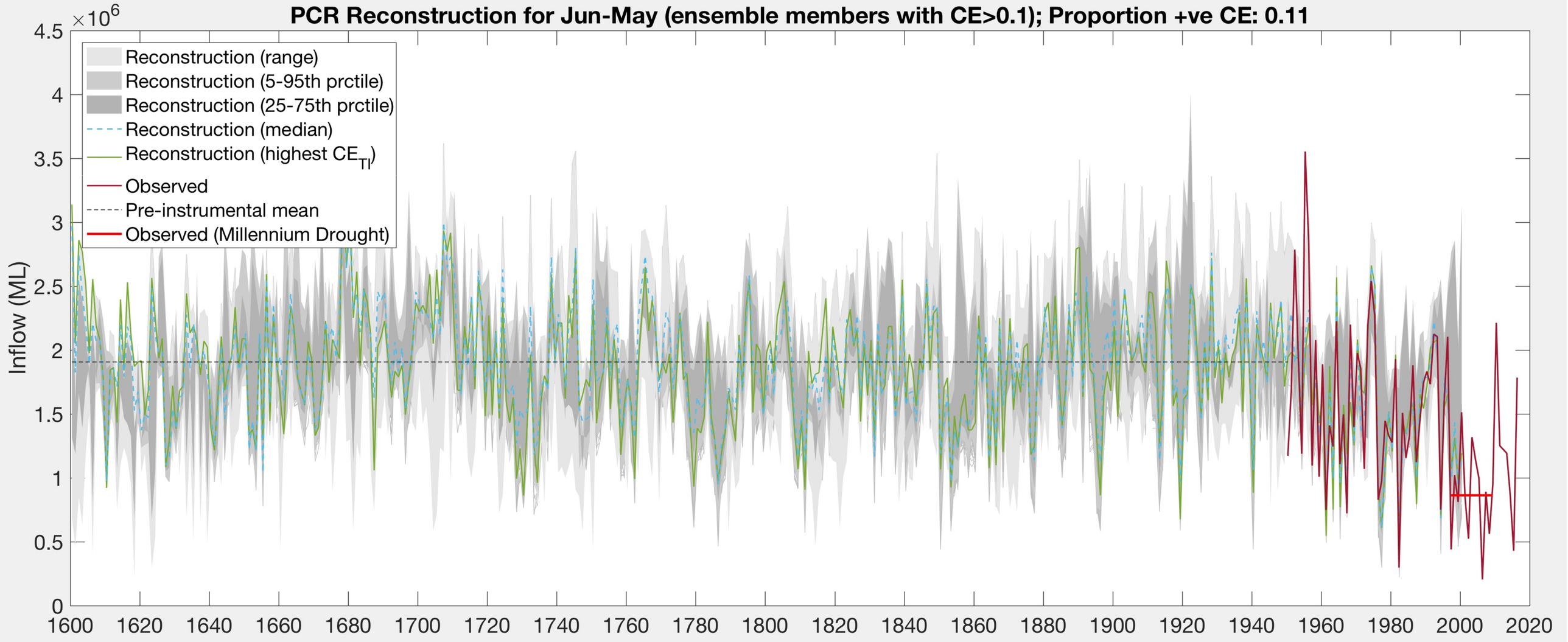
NSW seasonal rainfall-temperature-evaporation relationships



@benhenley

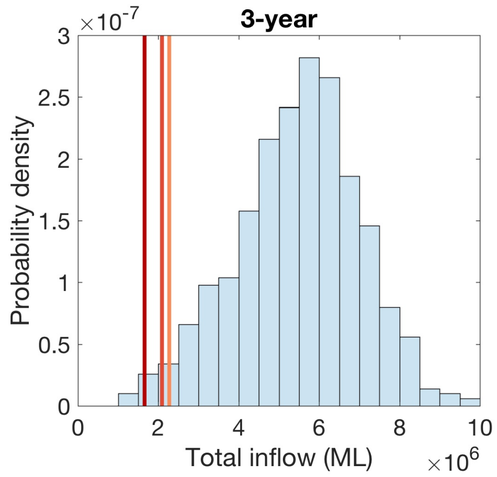
THE UNIVERSITY OF MELBOURNE

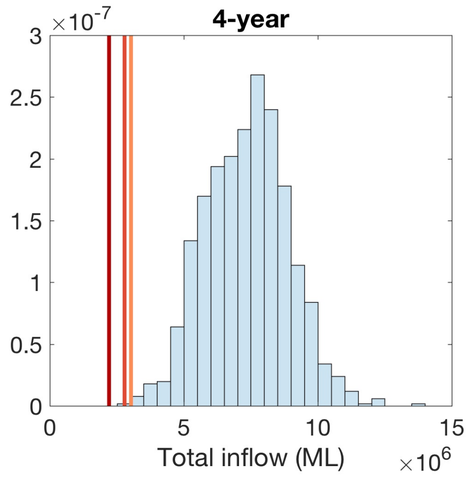
That's not a drought, *this* is a drought!

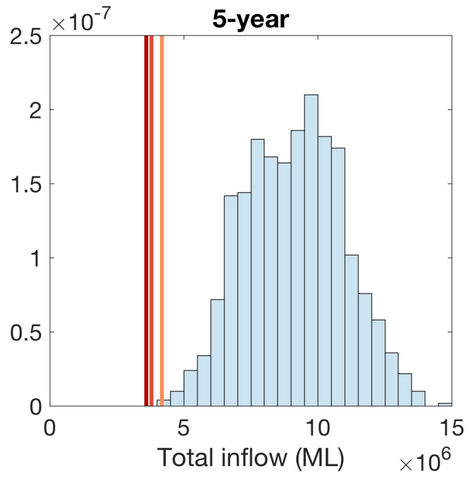


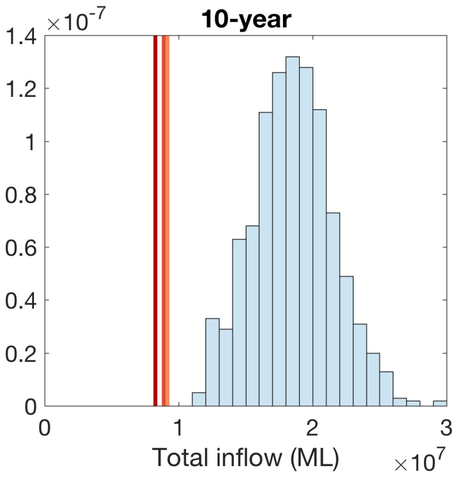
@benhenley

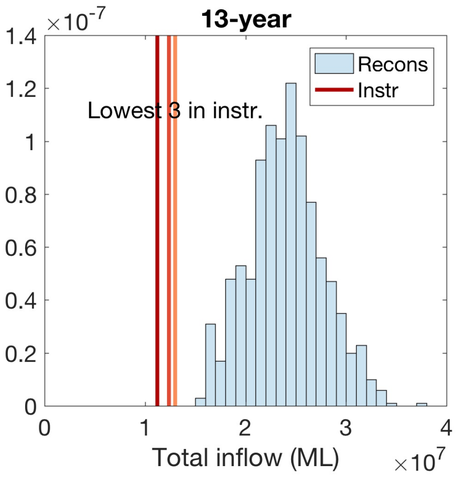
That's not a drought, *this* is a drought!

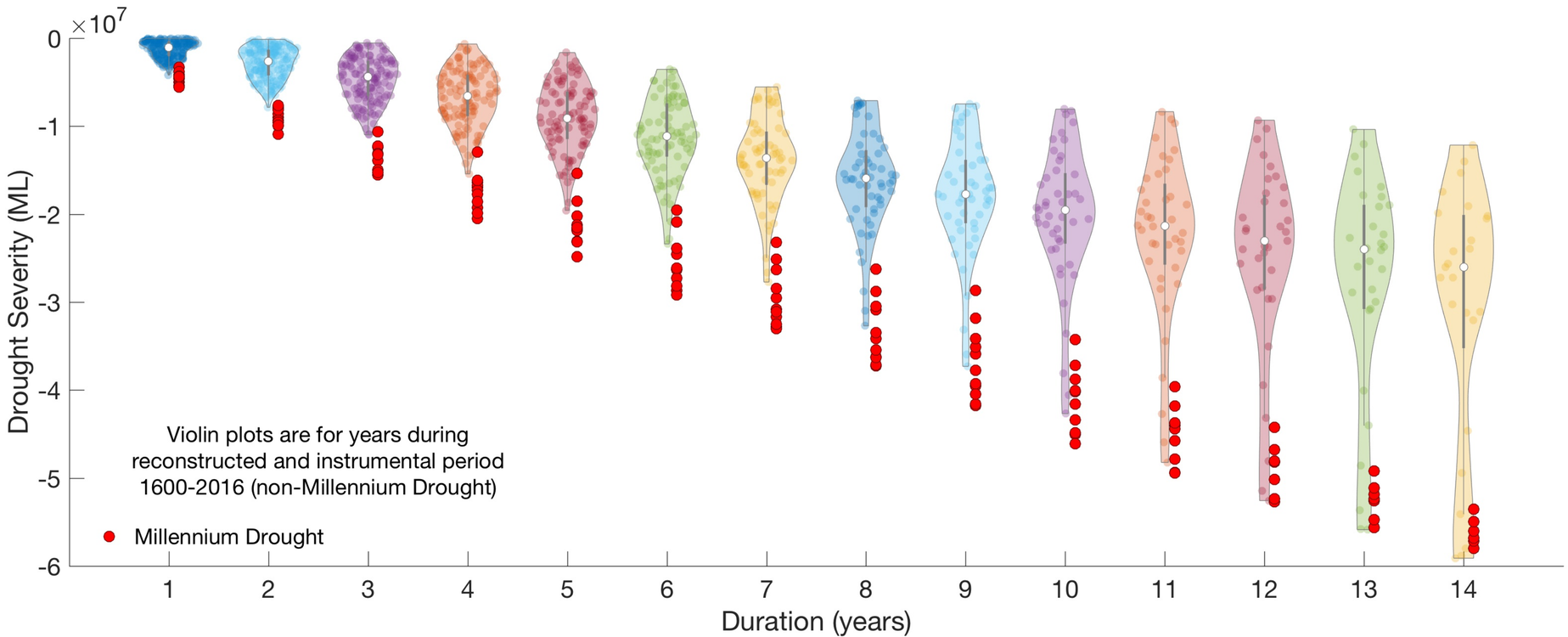






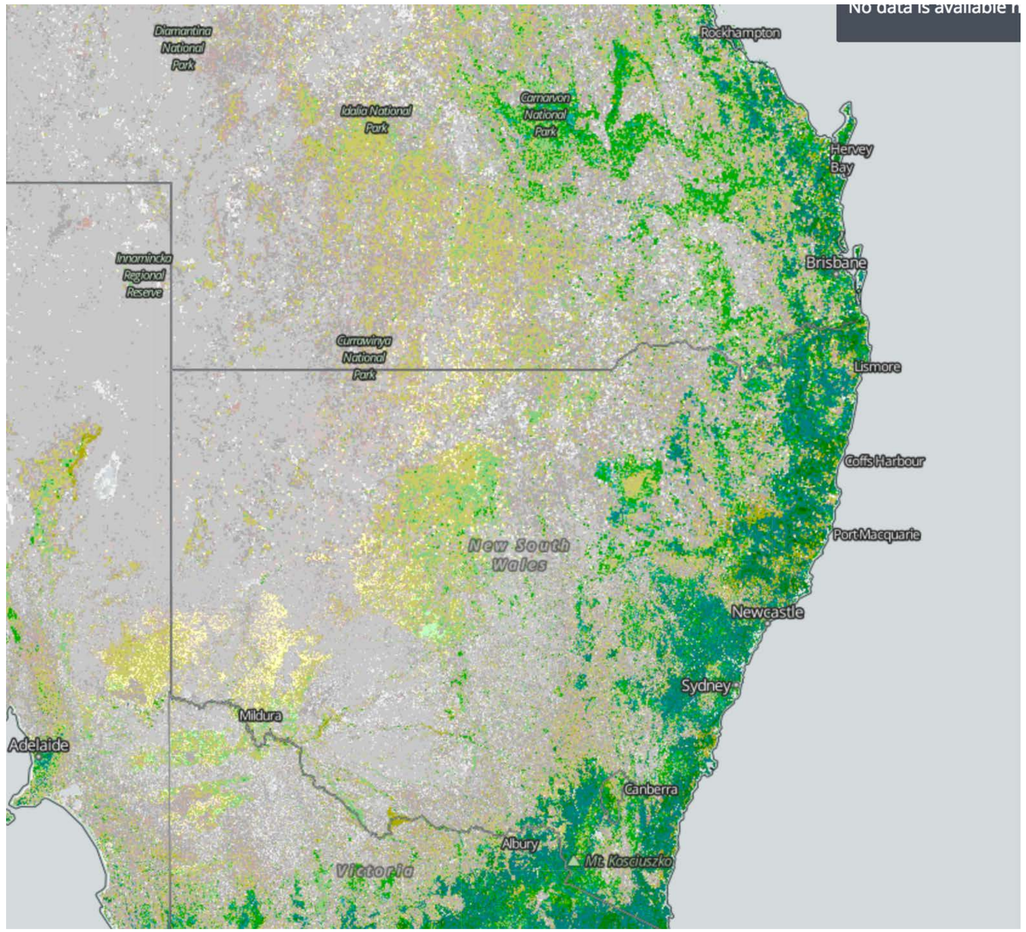




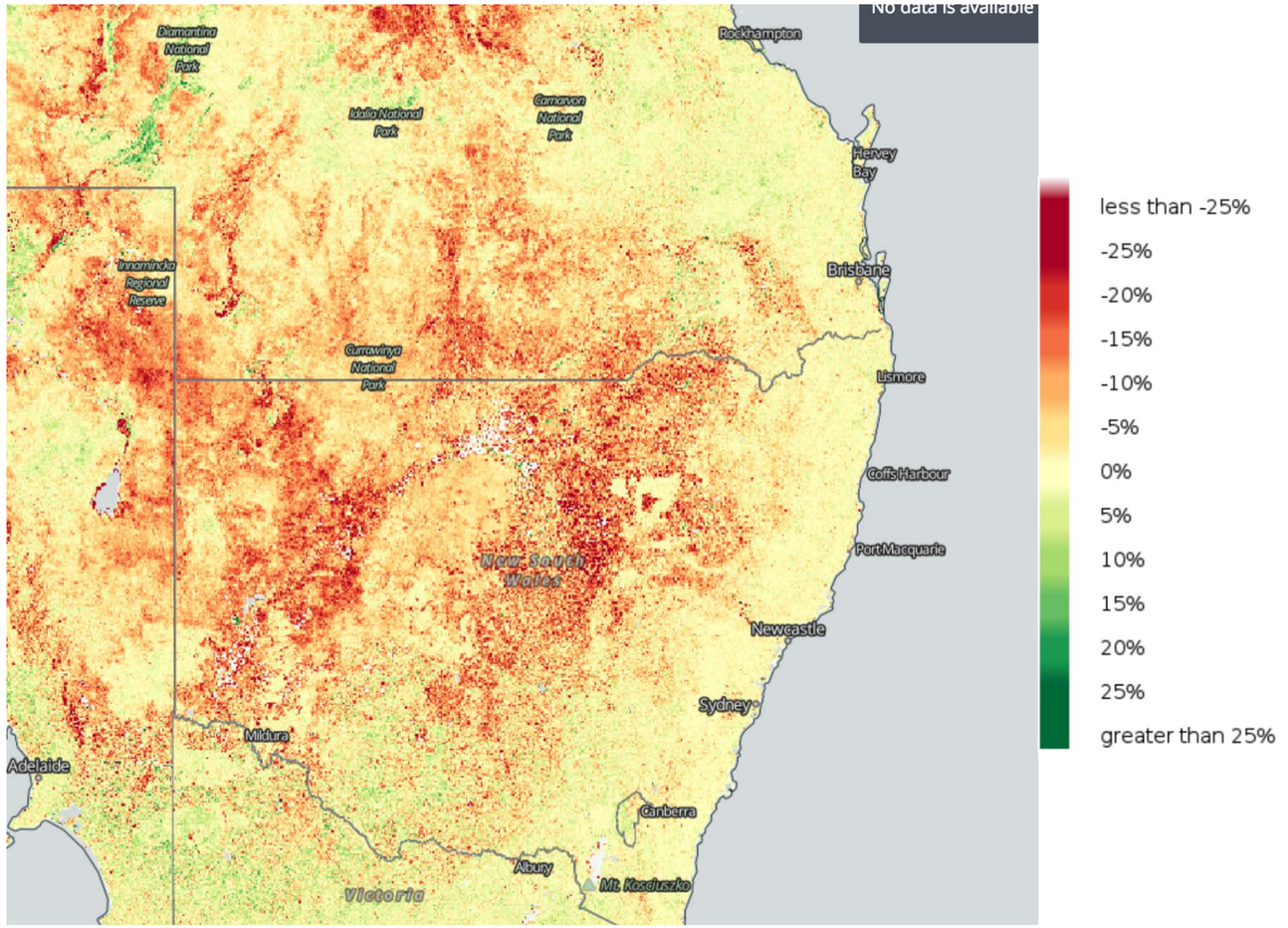


@benhenley

Impact of drought, so far …

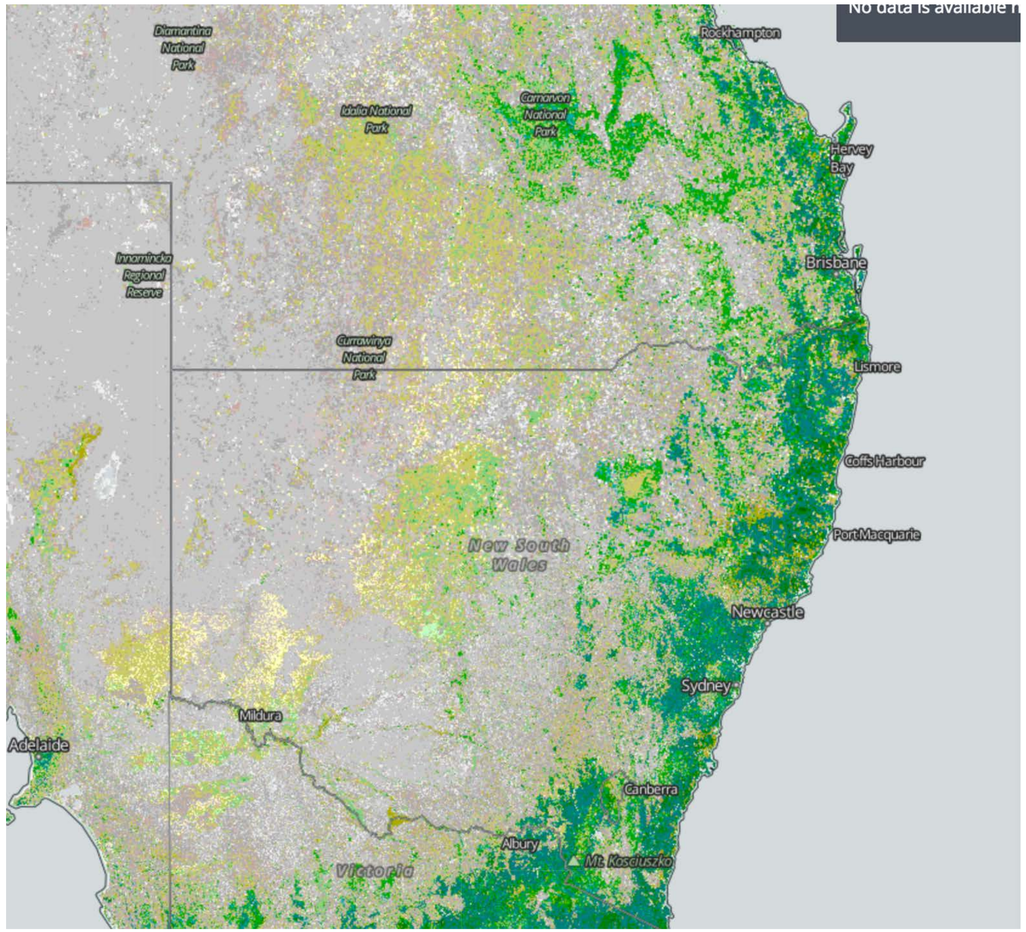


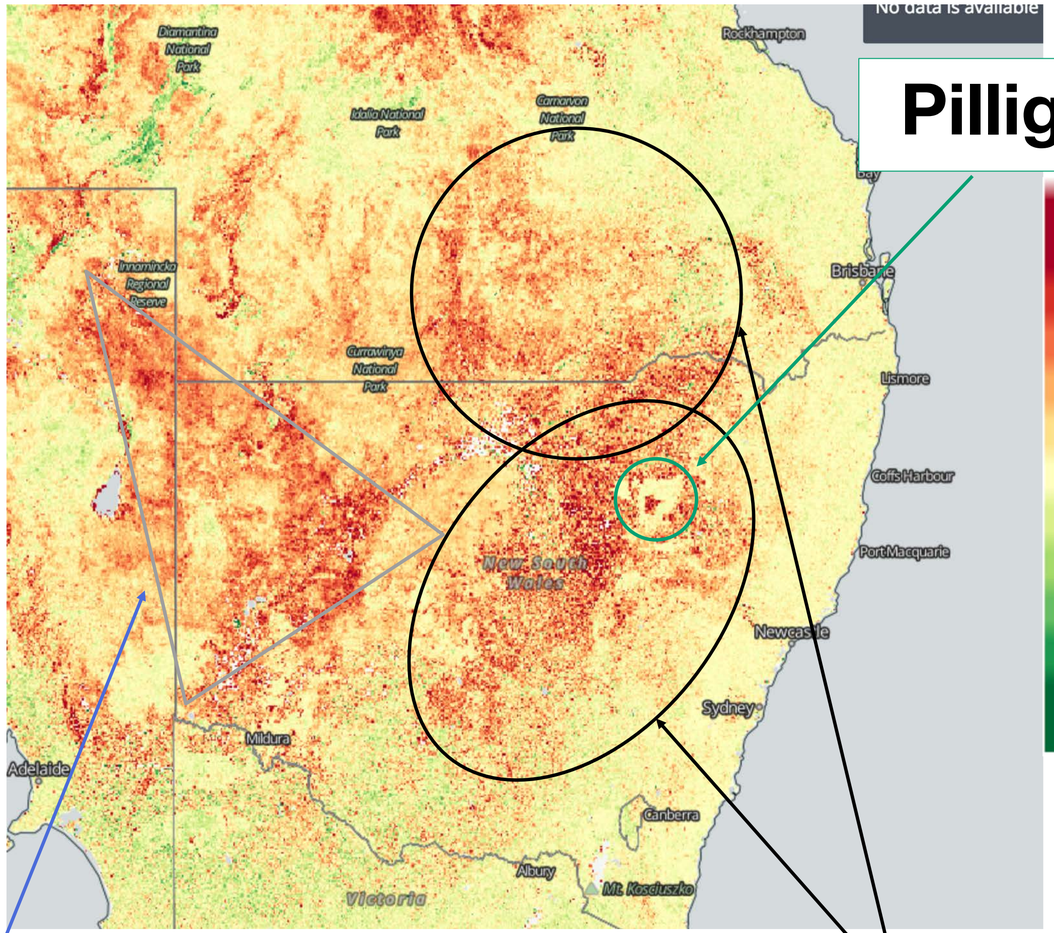
Grassland
Grassland with isolated shrubs
Grassland with isolated trees
Low open woodland
Medium open woodland
Tall open woodland
Low woodland
Medium woodland
Tall woodland
Low open forest
Medium open forest
Tall open forest
Very tall open forest
Extremely tall open forest
Tall closed forest
Very tall closed forest



“Vegetation cover”

Impact of drought, so far …





Pilliga forest

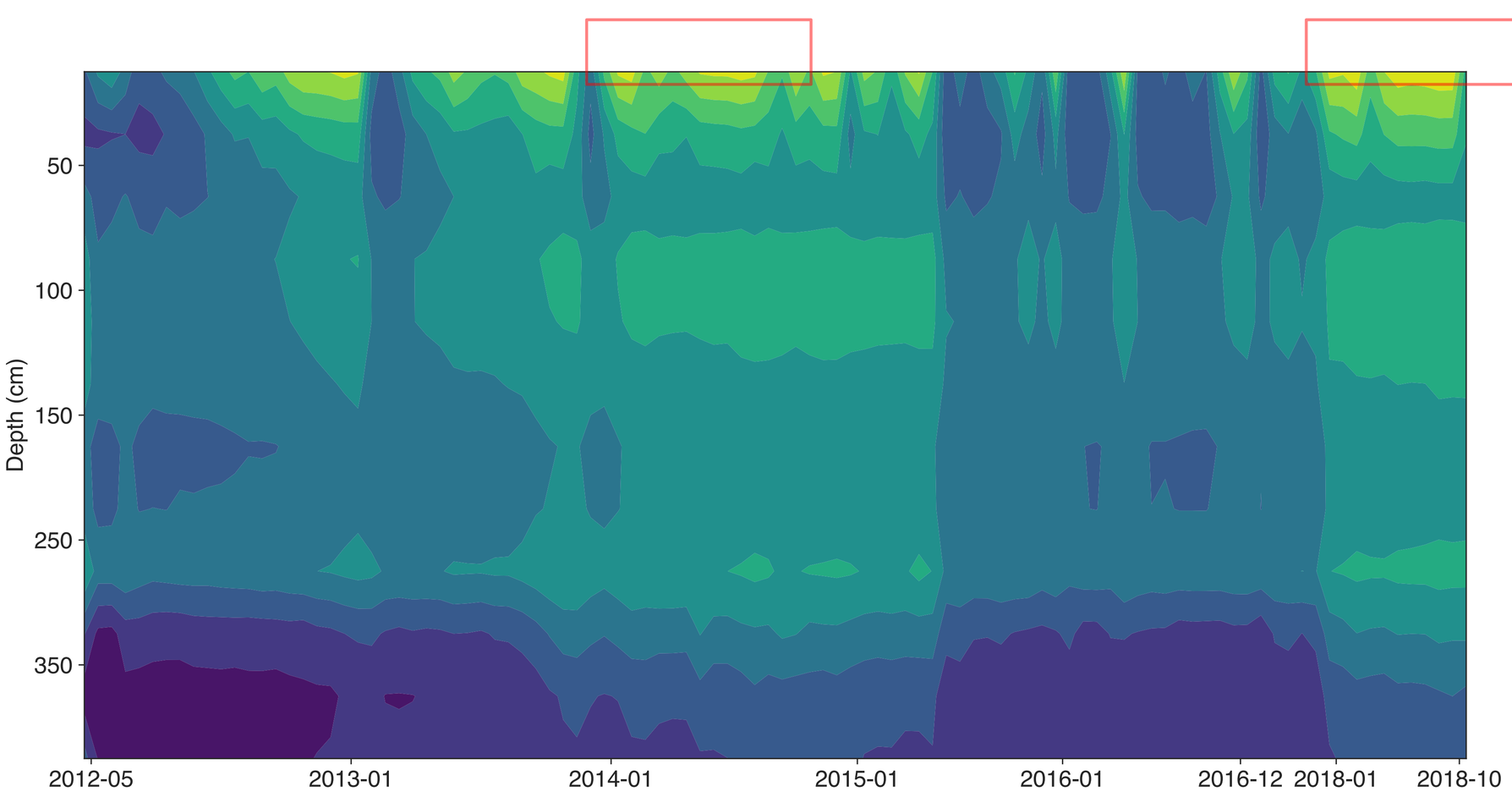
Grassland
Grassland with isolated shrubs
Grassland with isolated trees
Low open woodland
Medium open woodland
Tall open woodland
Low woodland
Medium woodland

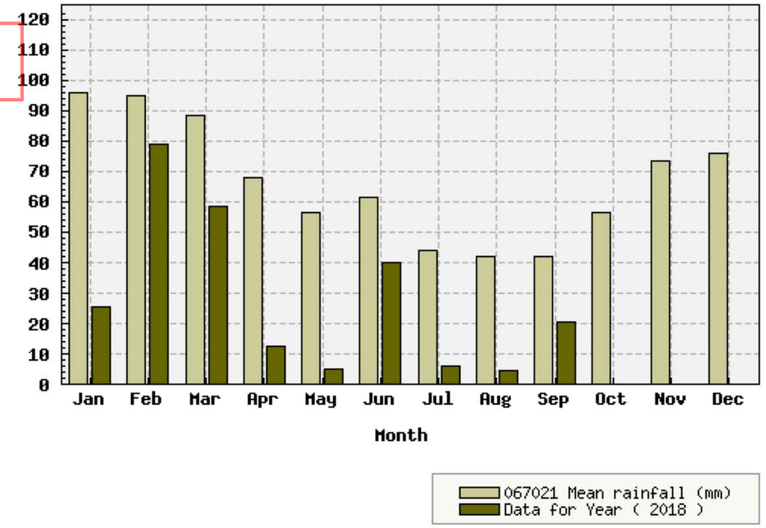
Tall woodla
Low open f
Medium op
Tall open forest
Very tall open forest
Extremely tall open forest
Tall closed forest
Very tall closed forest

Arid grazing

Wheat / Sheep / Cattle

Soil neutron probe data from EucFACE





Attribution of the Southeast Australian Drought

Can we determine whether climate change contributed to the current drought?

Comprehensive approach: numerous variables, time periods, model assessments

Lewis, King, Henley, Perkins-Kirkpatrick, Gallant, Ho
Pepler

NSW region

Paleo study to follow later (Henley)

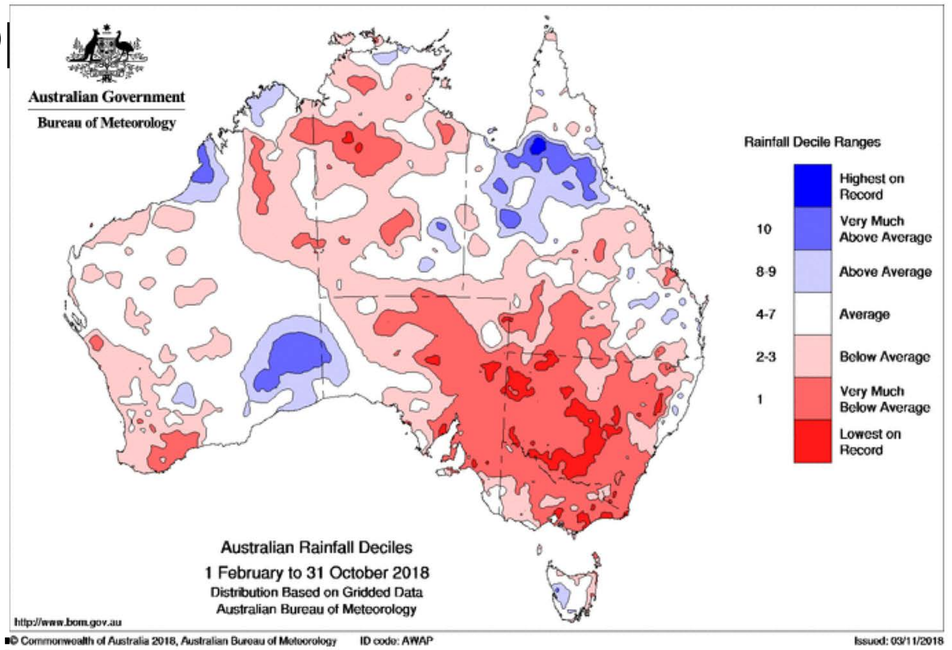
Model assessments:

CMIP5, CESM

POAMA/other BoM methods

C20C/HAPPI

→how to evaluate across ensembles, variables and time periods?



@benhenley

Approach – per model ensemble:

Timescale (ending end of September 2018)	Hot conditions (Tmin, Tmean, Tmax?)	Hot and dry conditions (which is conditional?)	Dry conditions (average/total rainfall?)	Evaporative fraction ($Q_E/(Q_E+Q_H)$)
3 months				
6 months				
9 months				
12 months				
18 months				
24 months				