2018 – climate conditions Eastern Australia

Dr Pandora Hope

Principal Research Scientist, Bureau of Meteorology

CLEX workshop, November 2018

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Who am I?

- Lead Scientist – Bureau of Meteorology – DELWP Victorian Water and Climate Initiative
  - Large-scale drivers, weather and rainfall of Victoria, and how they are changing
  - Baselines – what is the best choice, can we do better?

- National Environmental Science Program (NESP) Earth System and Climate Change Hub
  - Lead Investigator: 'Understanding climate variability and change' El Niño, La Niña, Indian Ocean and Southern Ocean drivers of Australia's rainfall, and Event Attribution science – how can we disentangle the drivers of extreme events such as major flood events

- Bureau of Meteorology Hydro Projections – Climate lead.
  Questions of climate model selection, preserving the change signal etc.

- CLEX Associate Investigator – Everything + detection and attribution (event attribution)
- IPCC lead author (currently – hence why I look so tired!)

Input from a lot of people at the Bureau

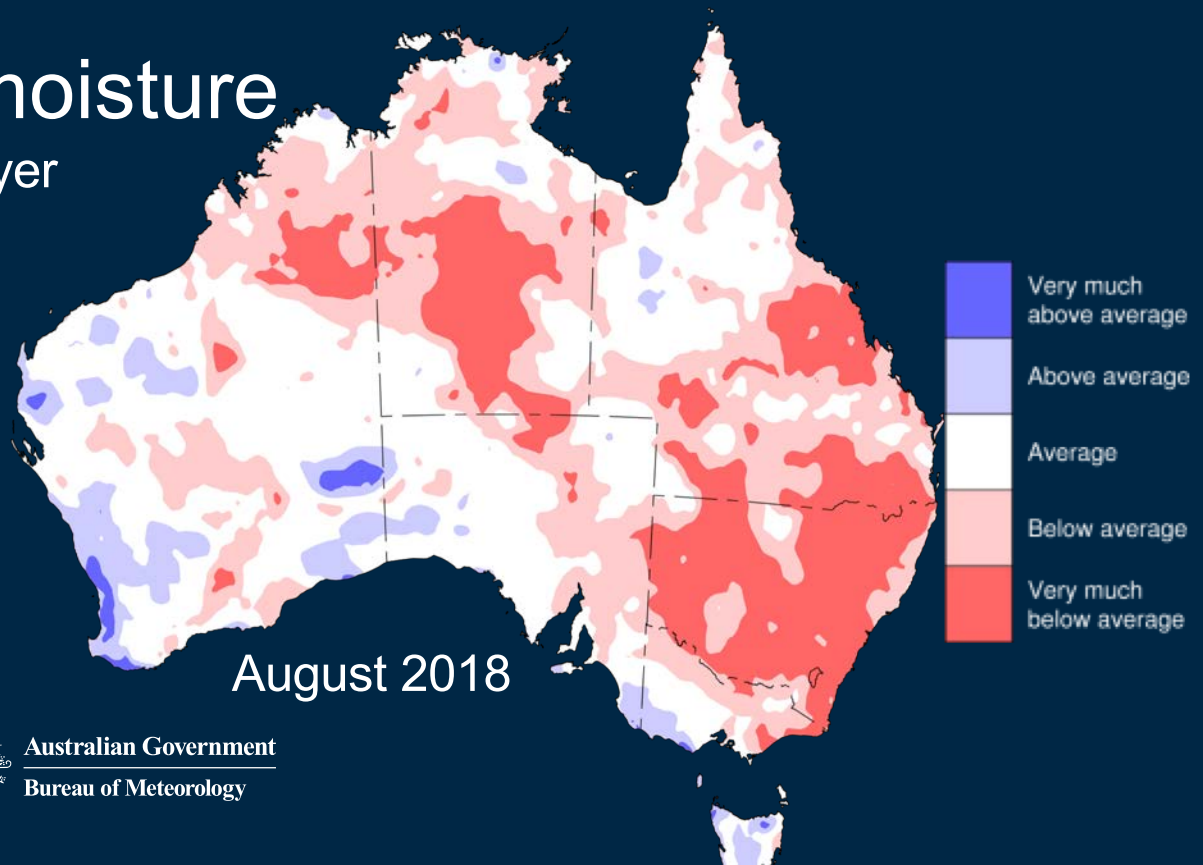
- Andrew Watkins
- Harry Hendon
- Acacia Pepler
- David Martin
- Felicity Gamble
- Catherine Ganter
- Blair Trewin
- Others in the Climate monitoring and prediction teams
- Hanh Nguyen and Matt Wheeler (and David Martin)
- Elisabeth Vogel and the BoM hydro projections team

What is drought?

- Meteorological drought – low rainfall
- Agricultural drought – Low P-E (timescales relevant to e.g. pasture, crops, trees)
- Hydrological drought – longer-term P-E deficit – that influences streamflow

Soil moisture

Lower-layer



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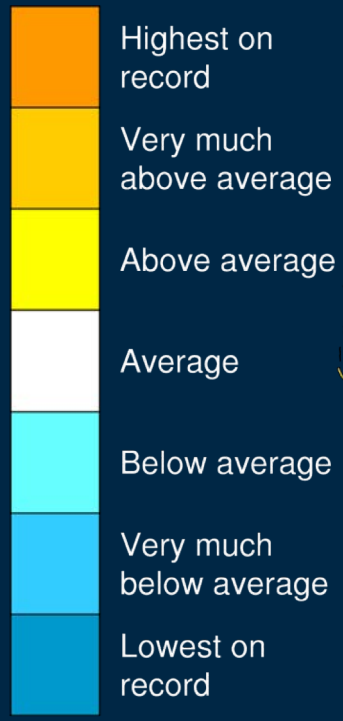
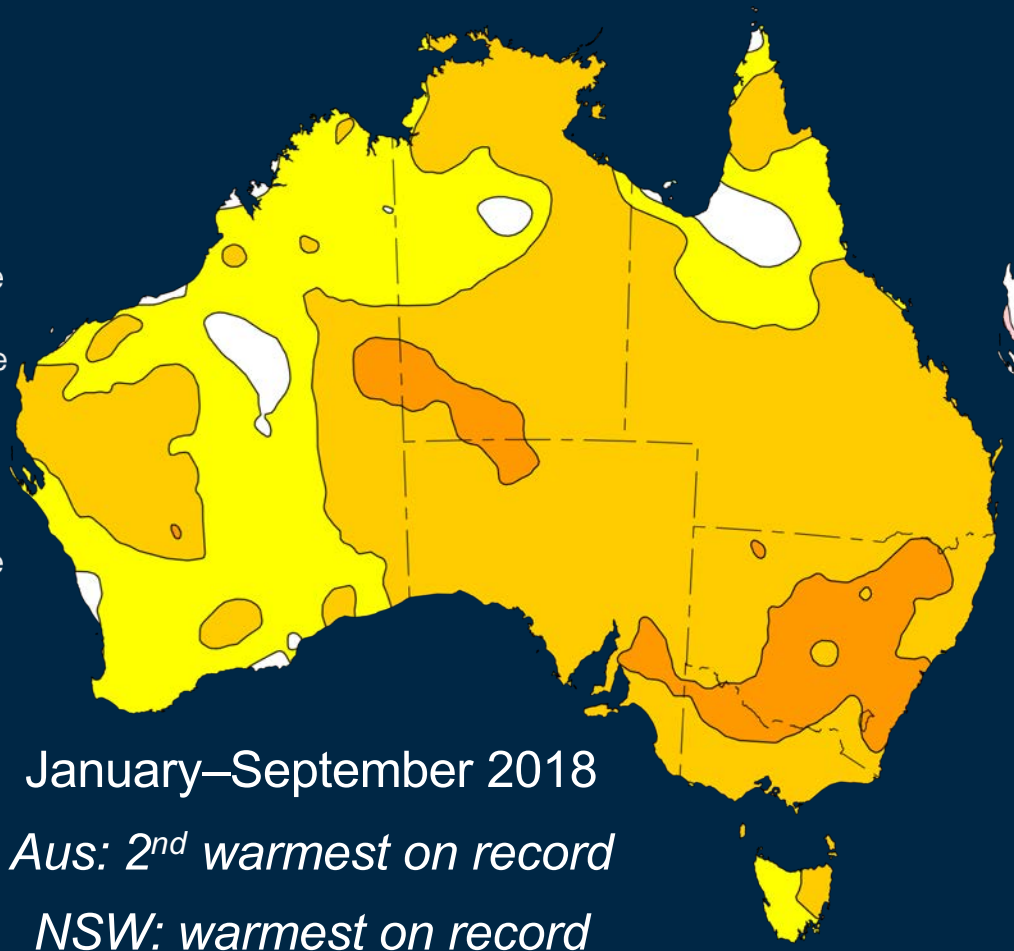
Outline

- Components of the drought – high potential evaporation
- Progression of NSW climate – rainfall, 'flash drought'
- Drivers of the drought – Weather systems, SST, Indices, climate change?

Recent conditions

Rainfall and Maximum temperature deciles

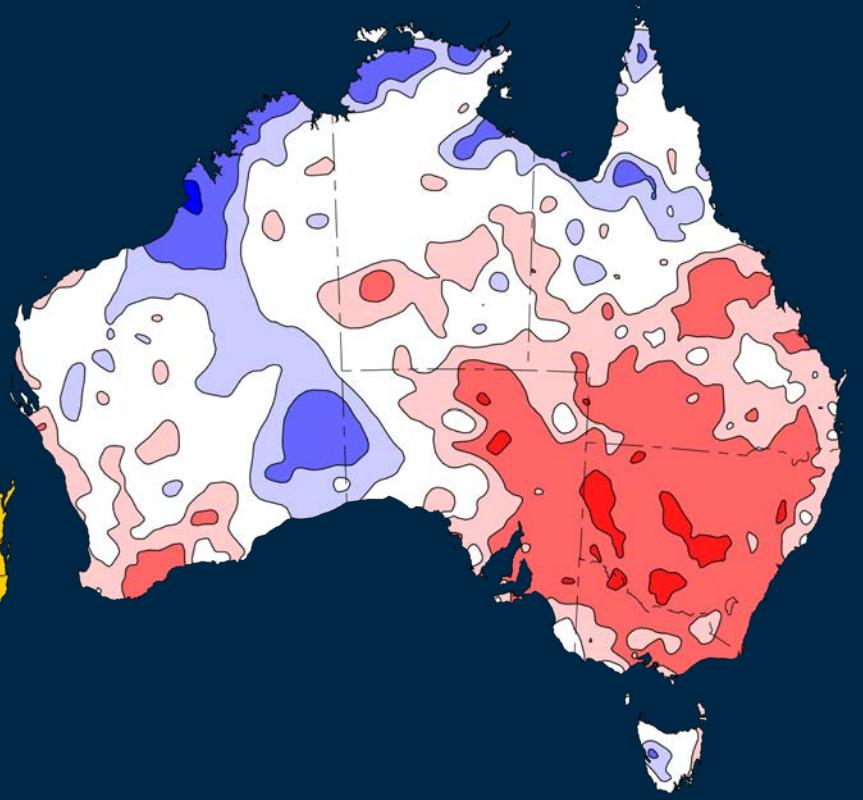


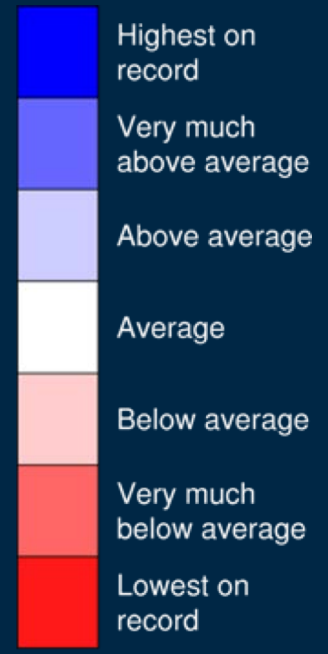


January–September 2018

Aus: 2nd warmest on record

NSW: warmest on record





January–September 2018

NSW: 3rd lowest rainfall

MDB: 2nd lowest rainfall

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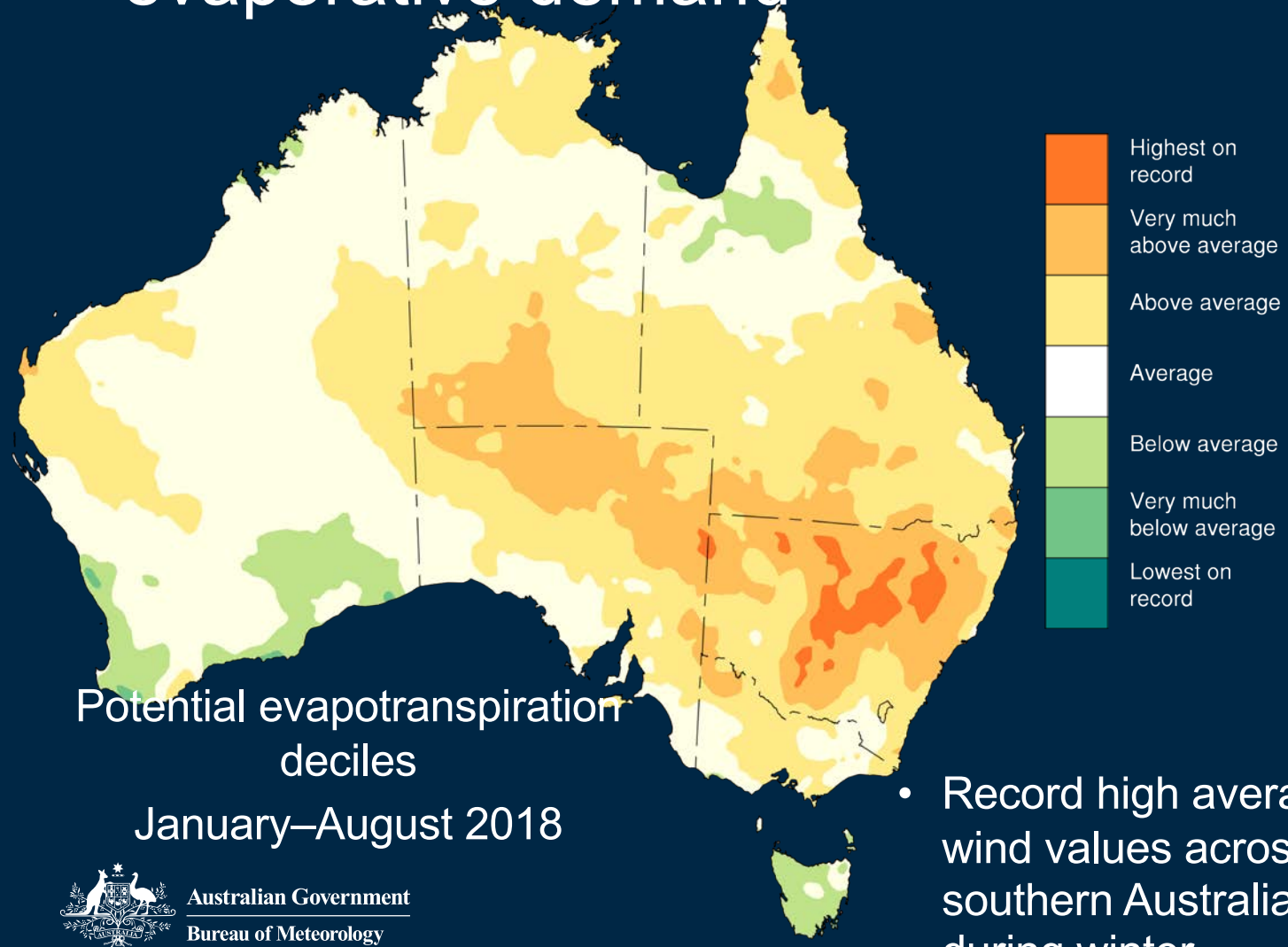
Recent potential evaporation and pan evaporation - 'evaporative demand'



Potential evapotranspiration deciles

January–August 2018

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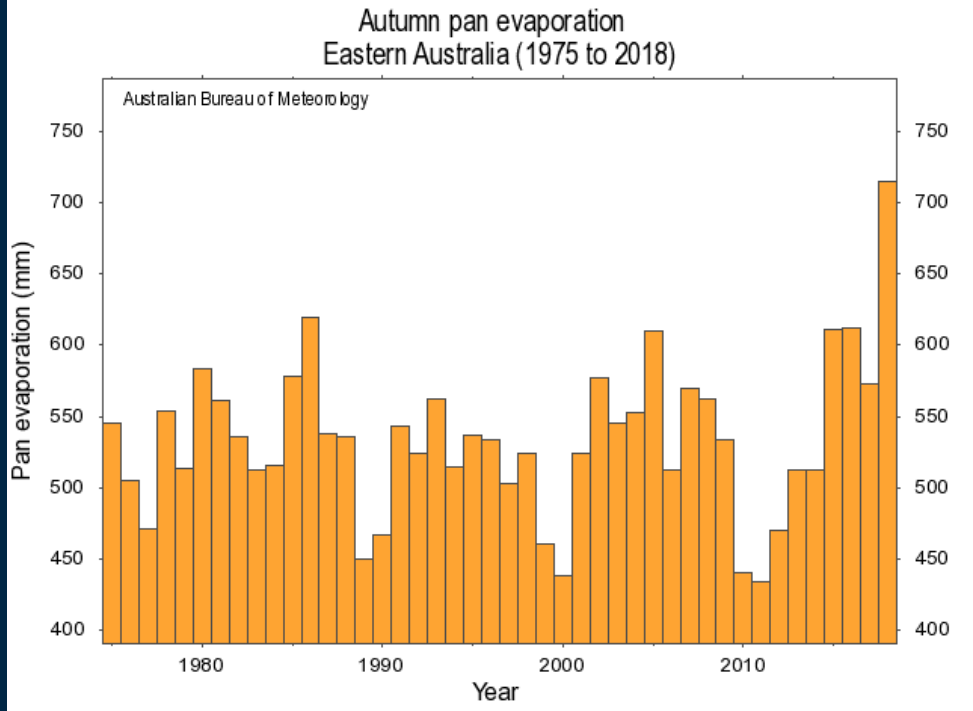
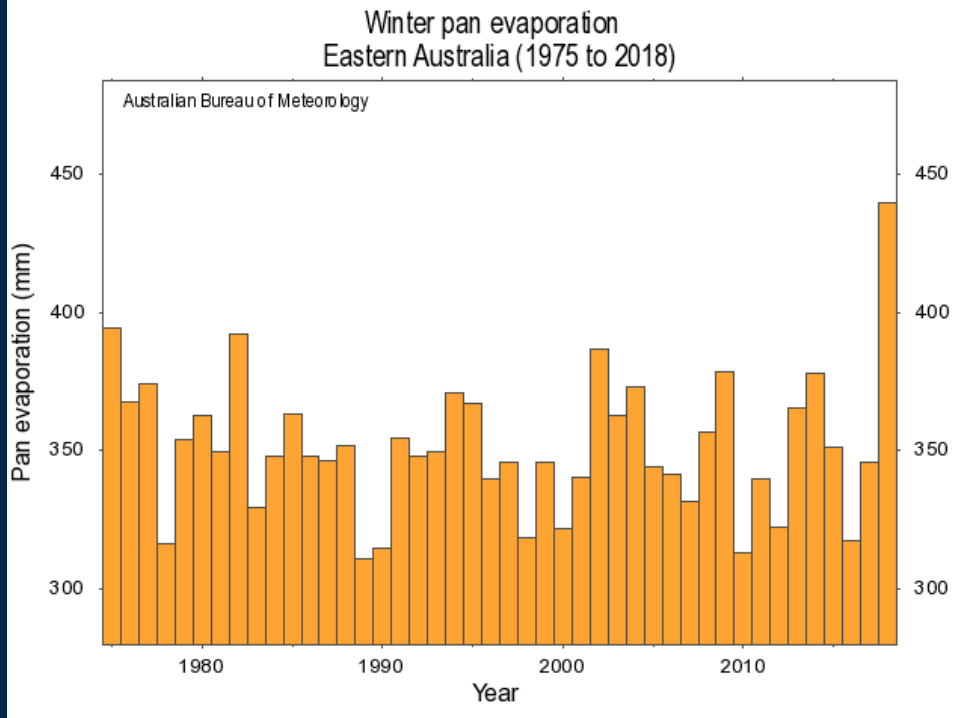
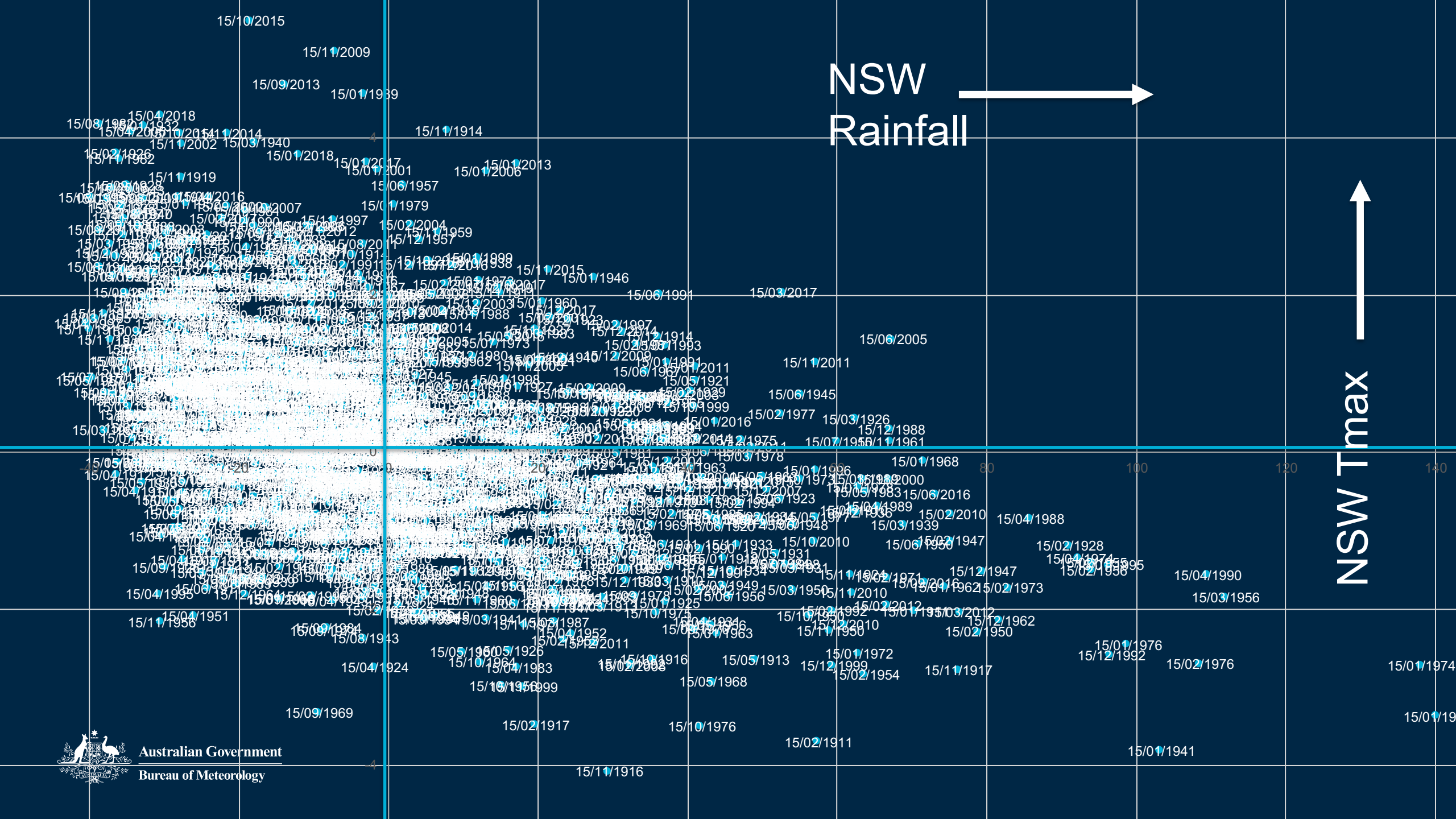
- Record high average wind values across southern Australia during winter







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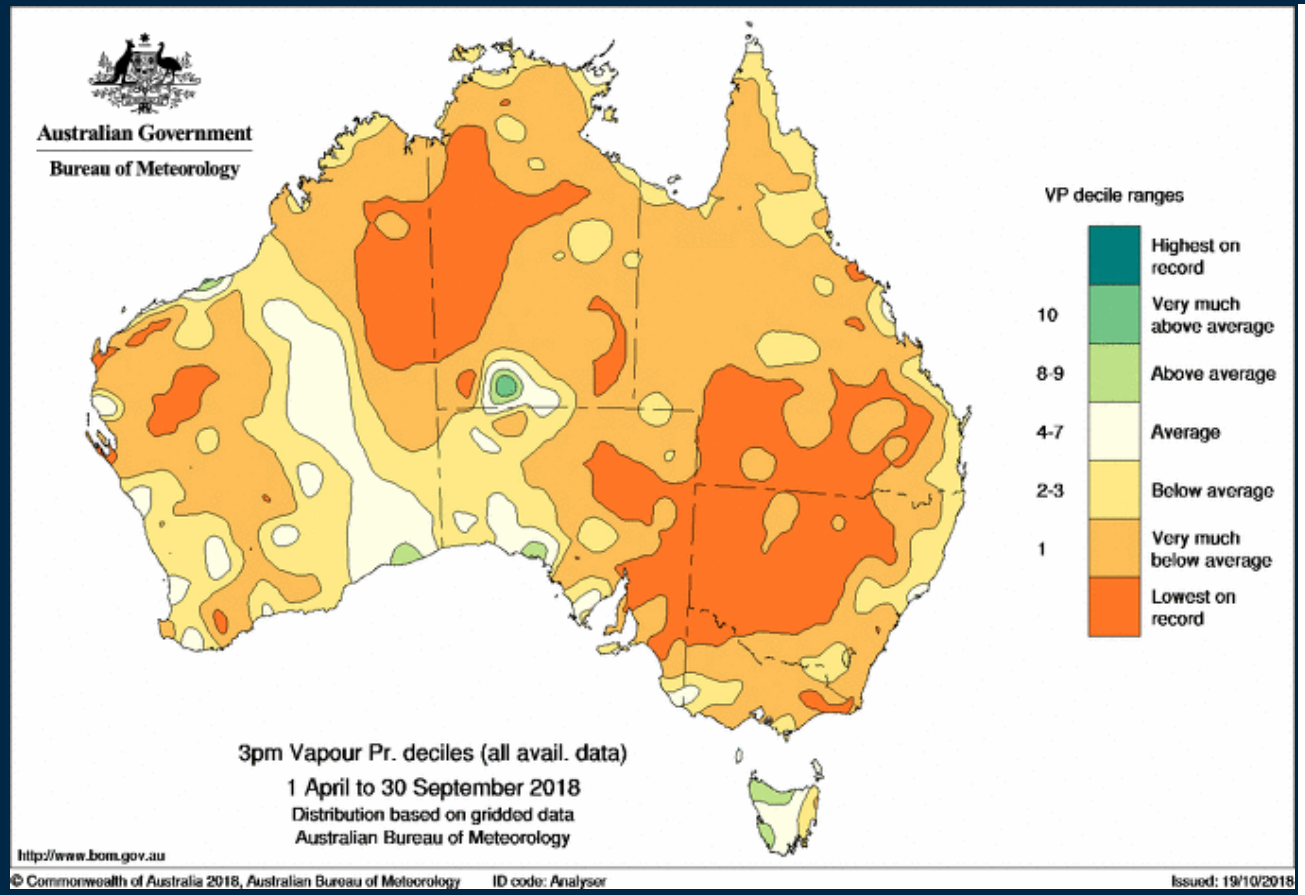
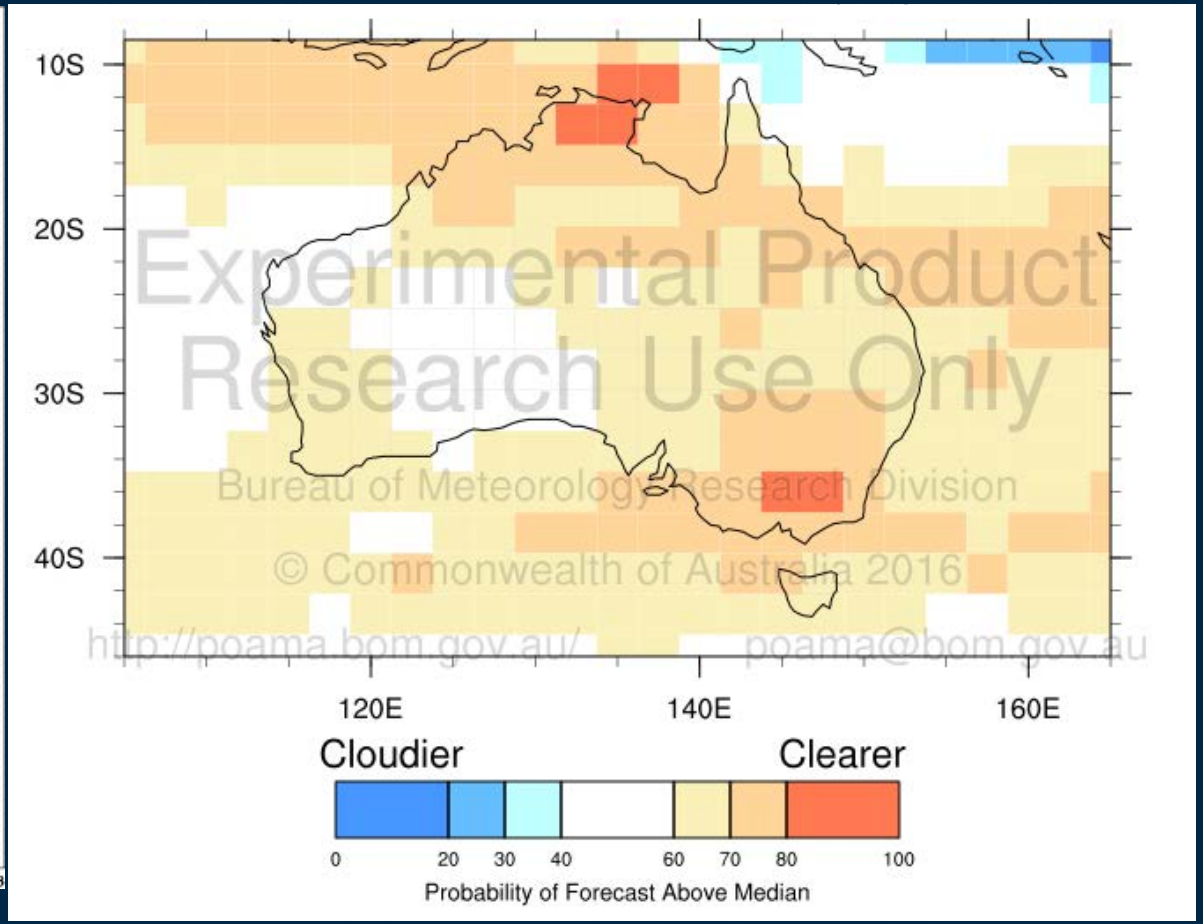
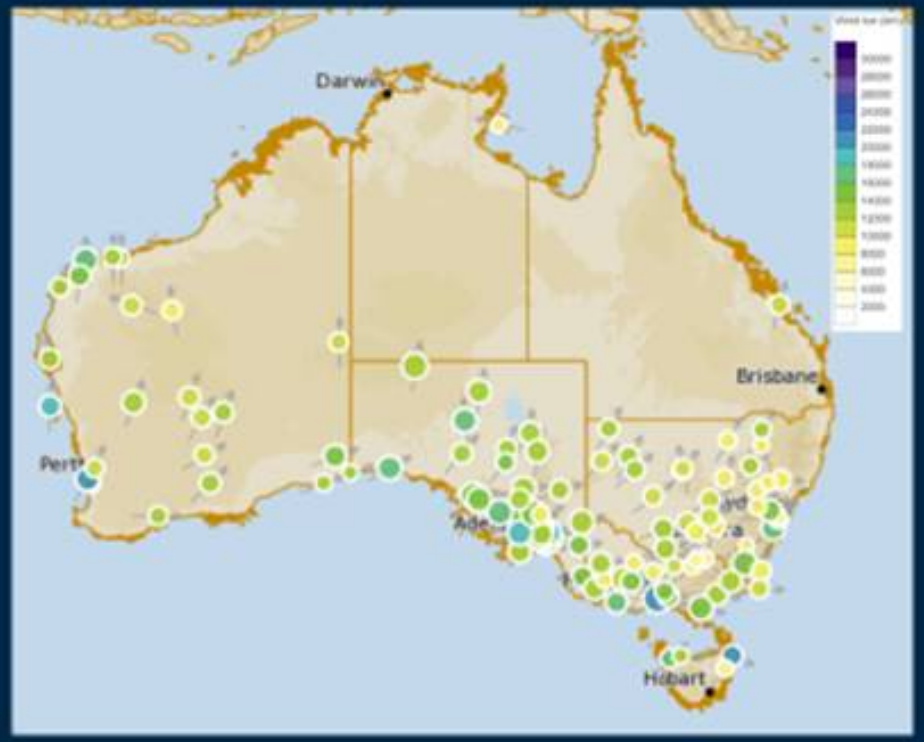
3pm vapour pressure Deciles



Chance of above average Spring Clearer Skies



Recent wind records

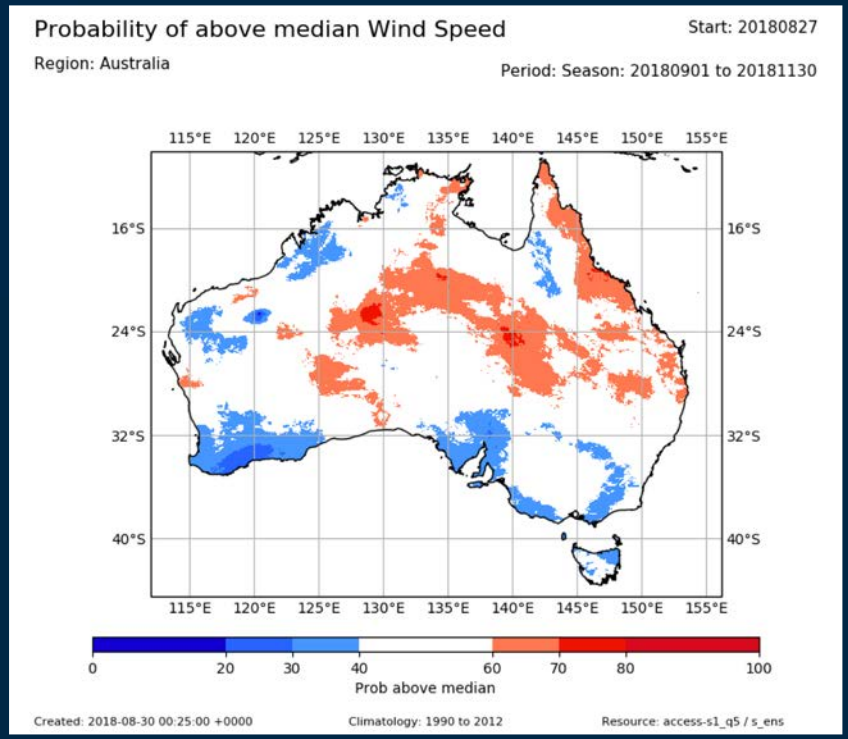


Wind-run records: August 2018.

- Record mean wind-run for many locations during July and August

Photo: news.com.au
Adelaide, 30 August 2018

Chance of above average Spring Wind Speed



How important is wind to evaporation (actual or potential), and soil moisture?

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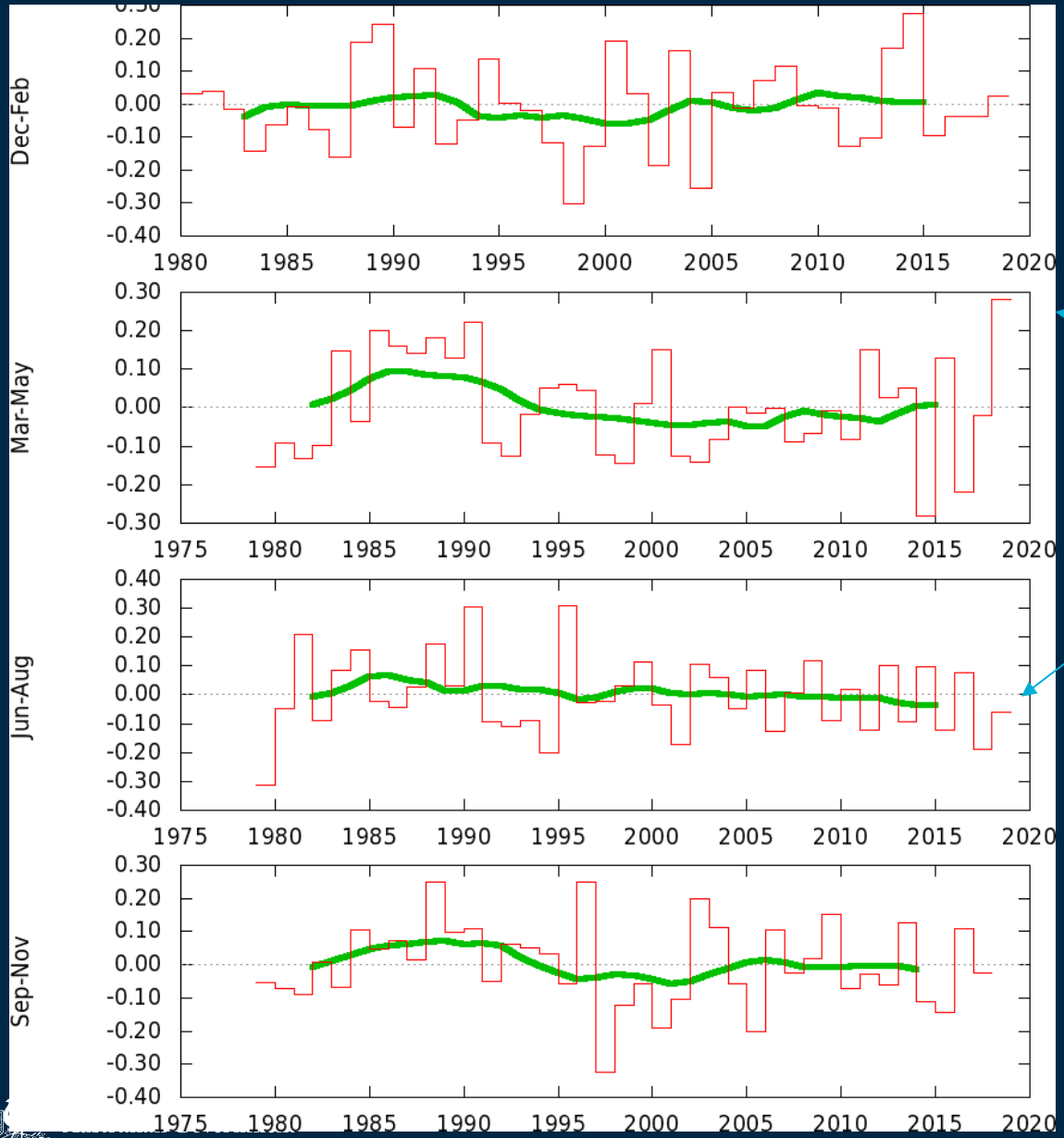
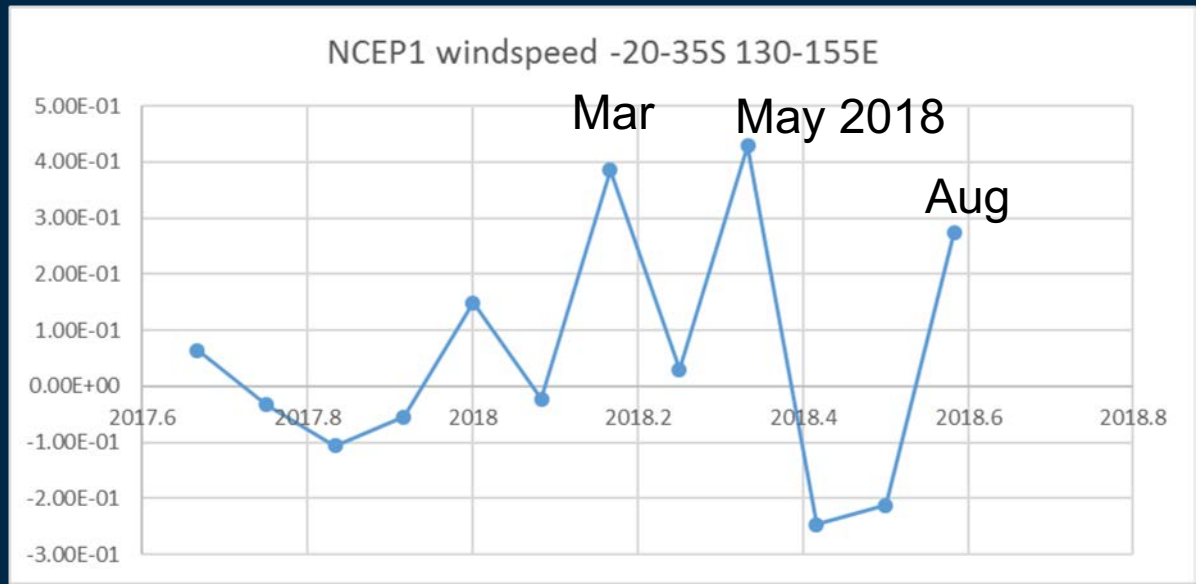
Central-east Australia windspeed anomalies from ERA-I 20-35S, 130-155E



Windspeed in Mar-May 2018 strongest on record

Jun-Aug 2018



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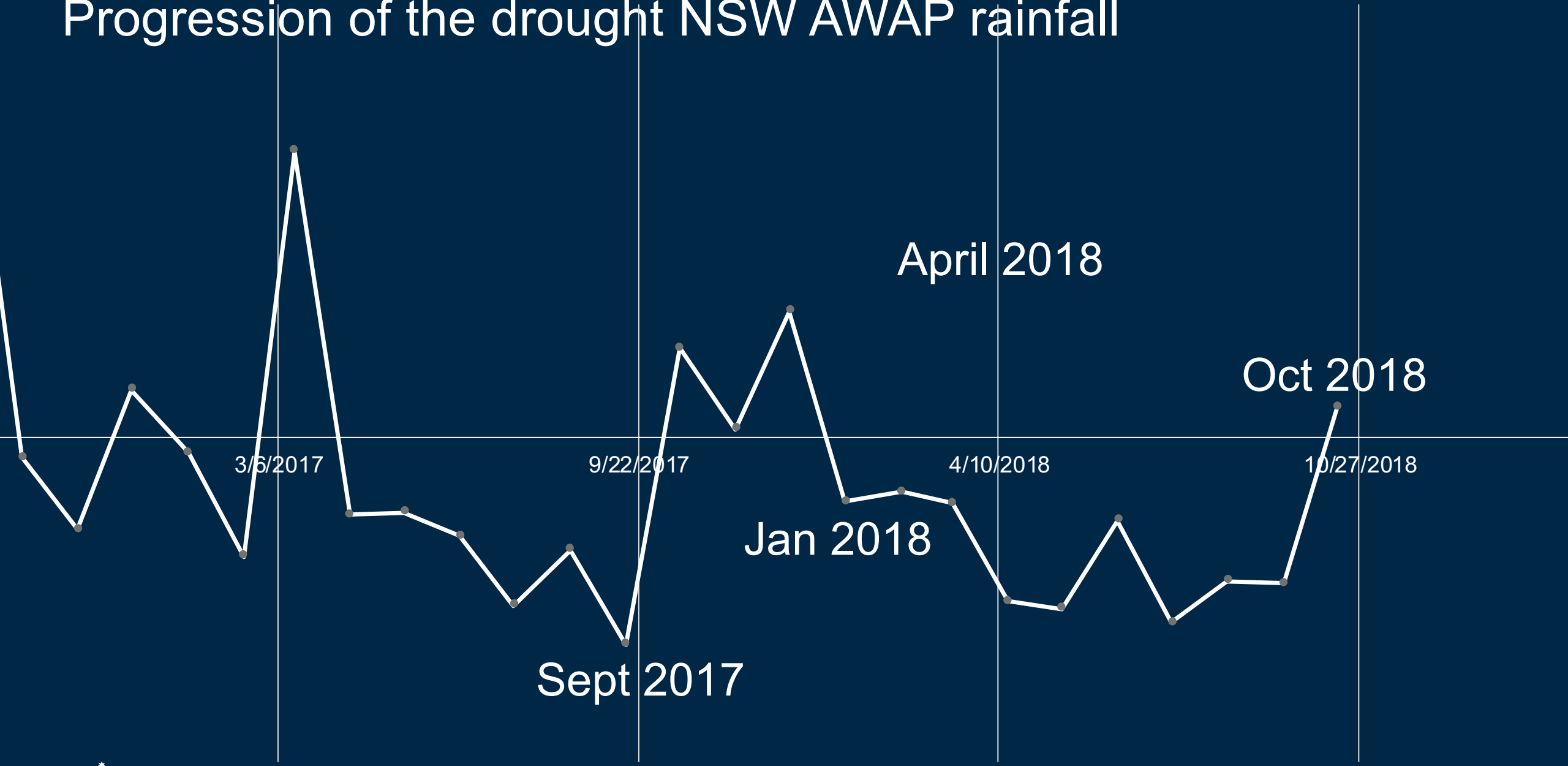
Maintain observations of evaporation… And wind…

- P-E is very important
- Monitoring of evaporation
- New SA network of soil moisture measuring sites – Western Vic as well – including comms

Progression of the drought NSW AWAP rainfall



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'Flash Drought' Episodes in 2017/18, mid-eastern Australia?

- What is Flash Drought?

- Rapid intensification of the current drought (when averaged over NSW) occurred mostly in July 2017 and February 2018, and not in winter 2018. That is, the aspects that may allow us to call this a 'flash drought' occurred mostly over a year ago.
- Evaporative Stress index

- From Hanh Nguyen and Matt Wheeler
  – BoM, working on a project with Meat and Livestock Australia

Progression: 'Rapid Drying Episodes

Maps of 1-month drying of AWRA-L average soil moisture from above average to below average levels.

David Martin,
Operational Climate,
BoM

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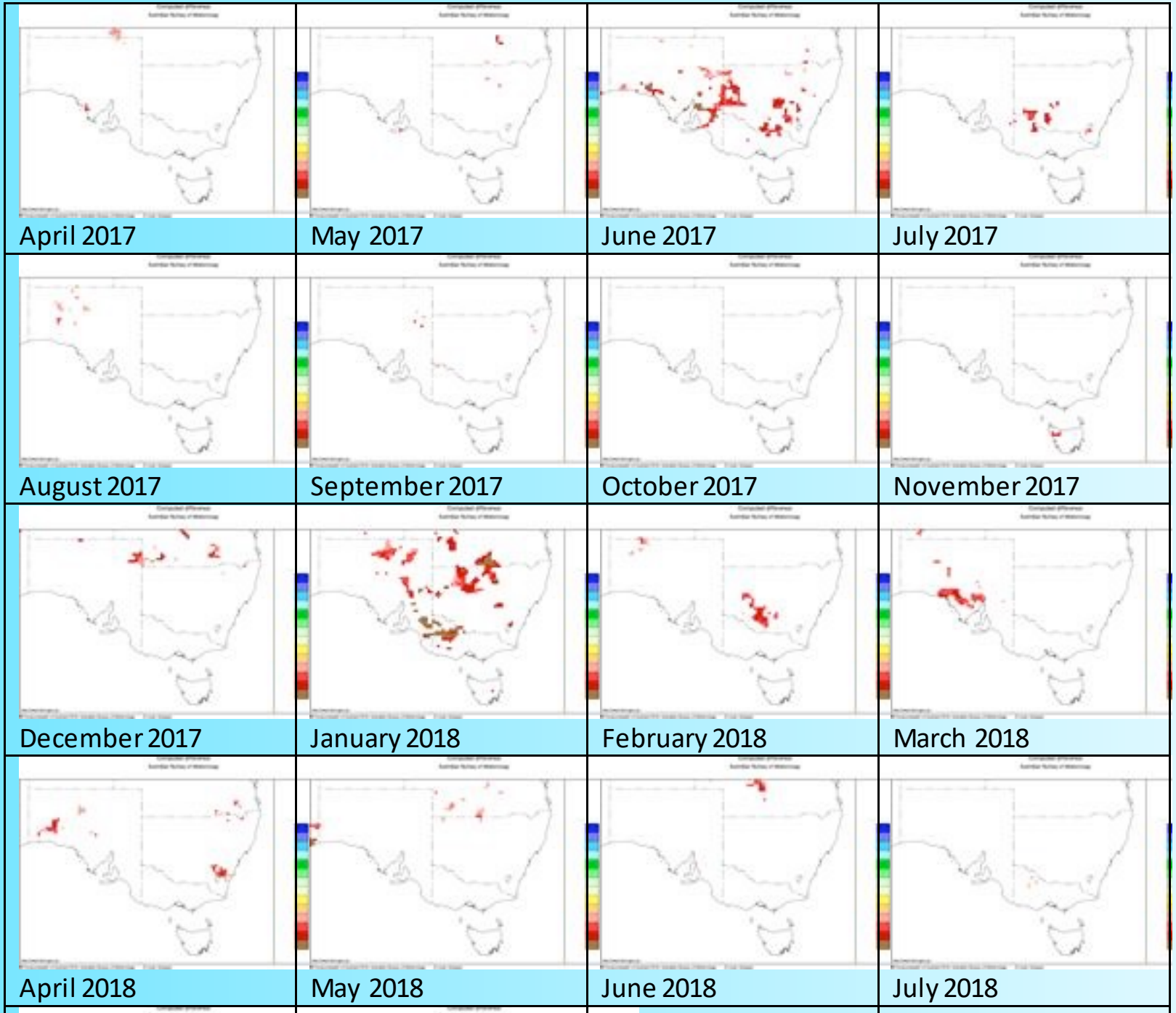
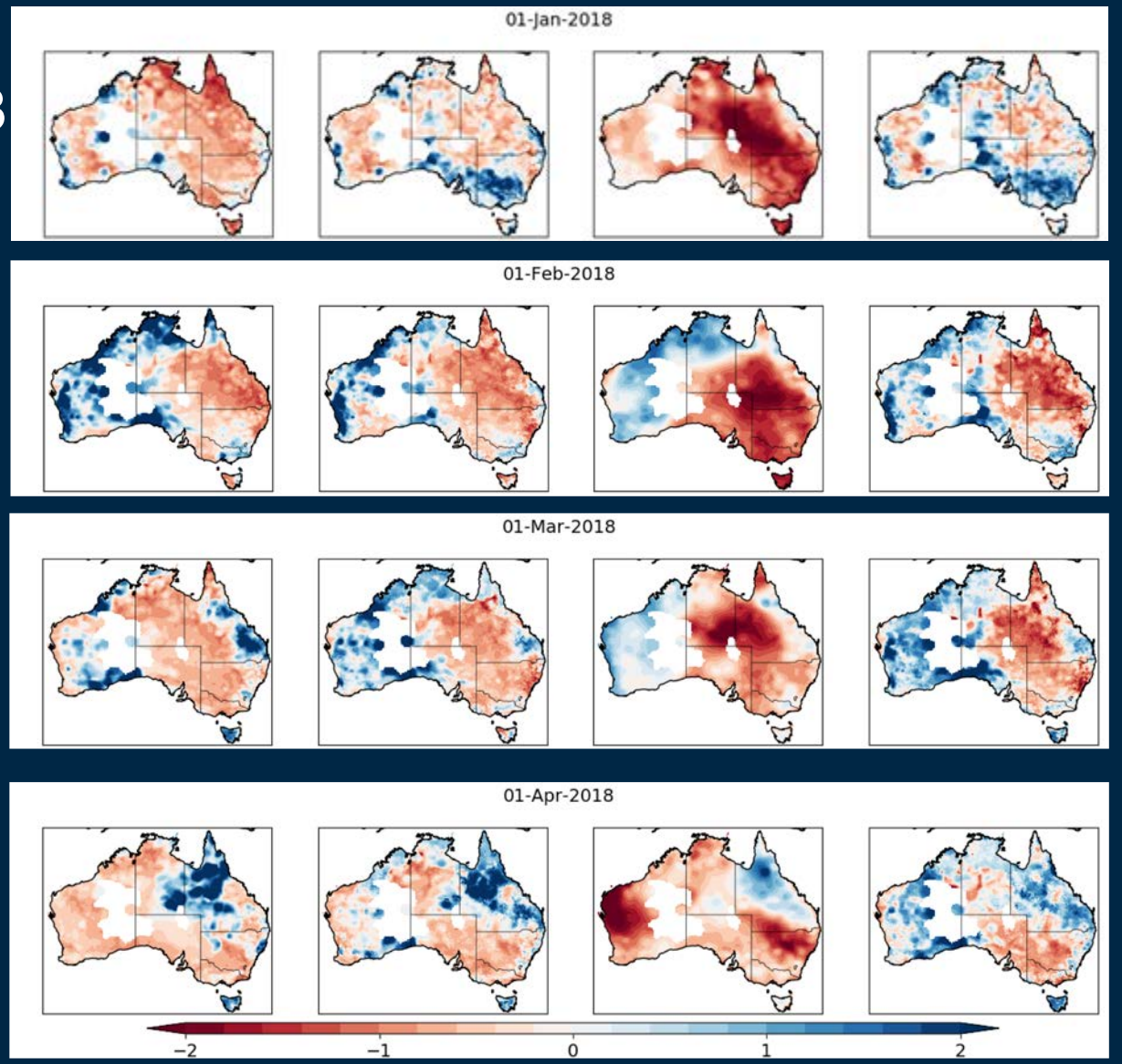
April 2017 to September 2018:

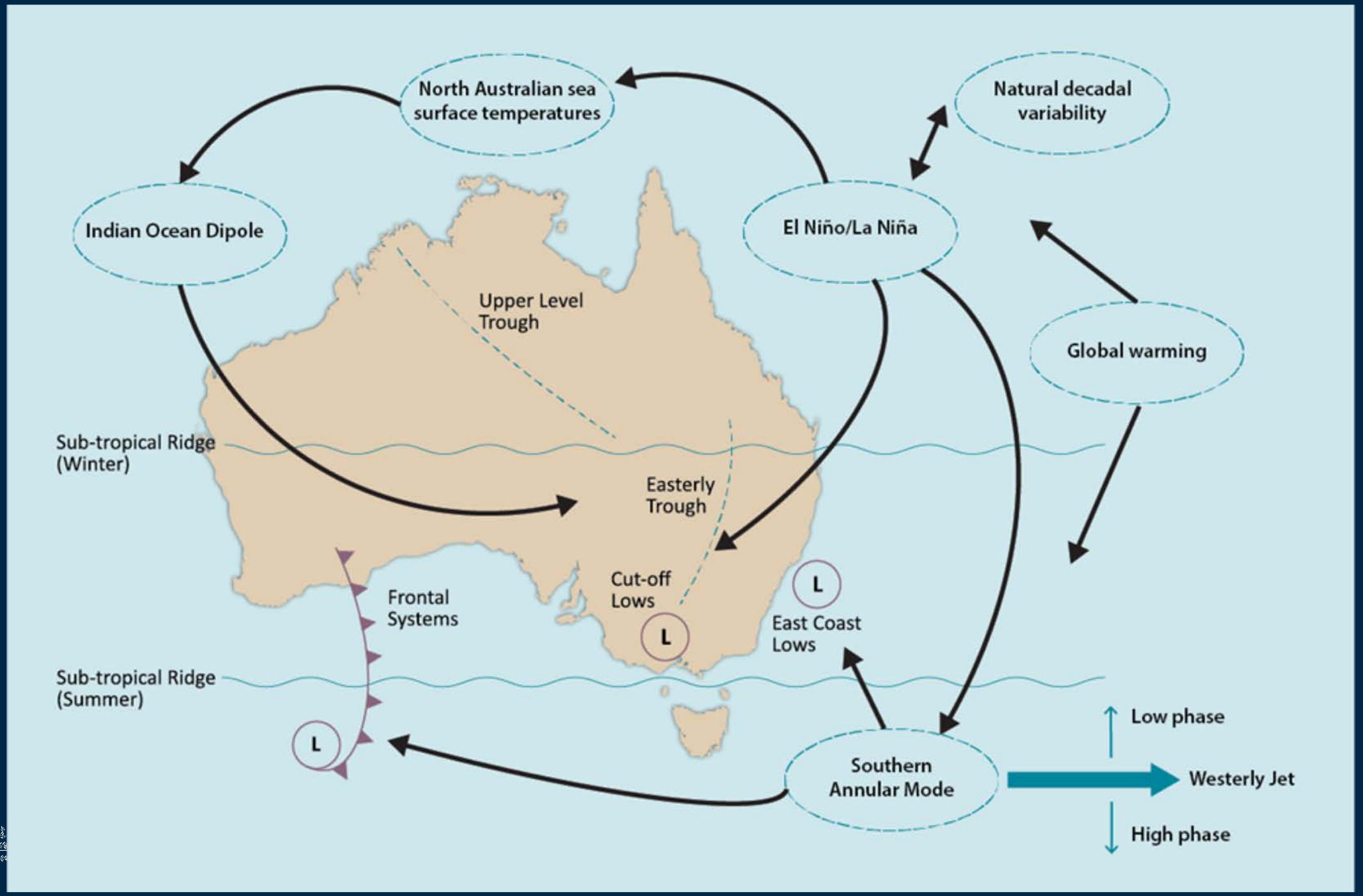


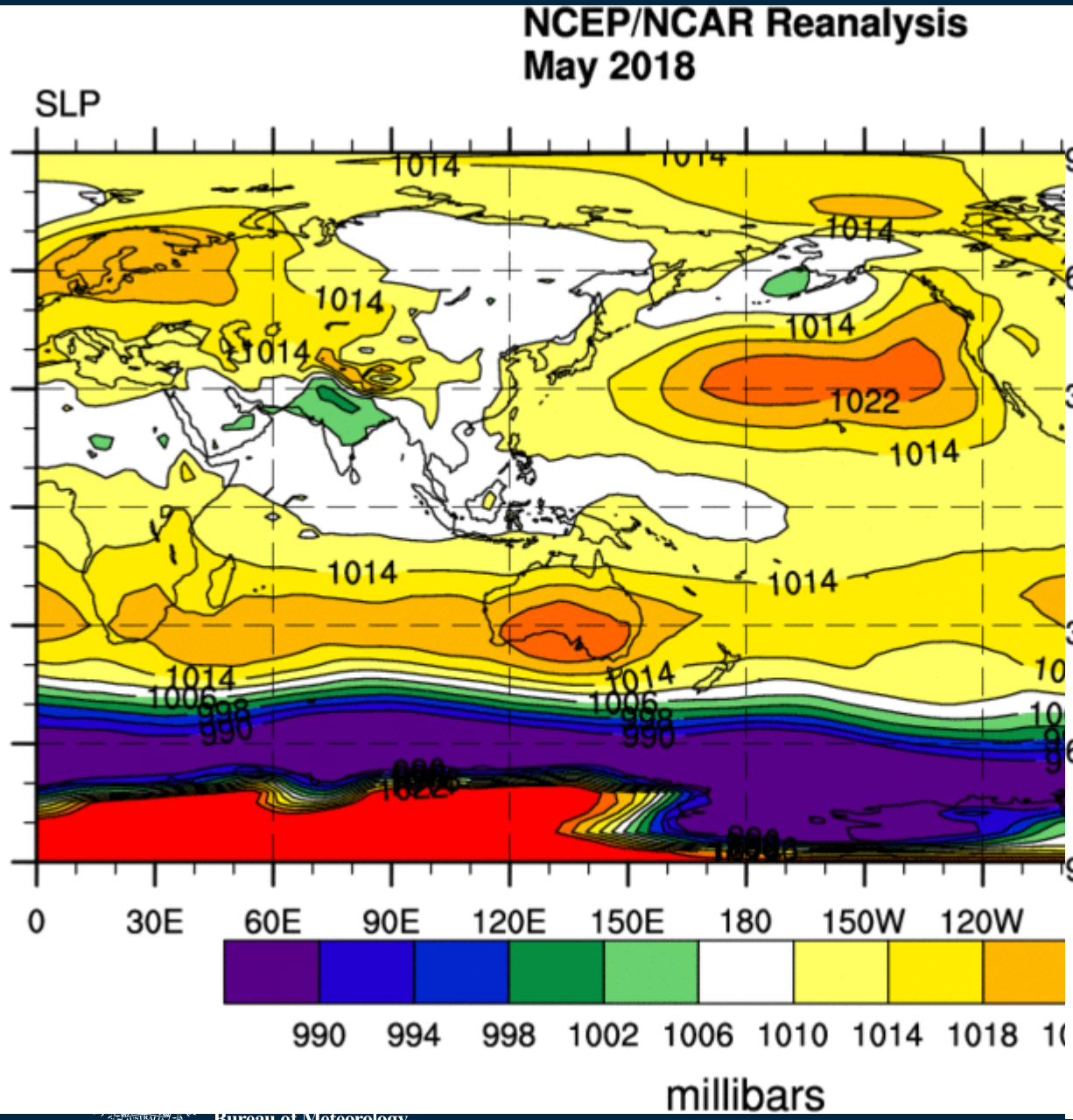
Evaporative Stress Index

- Nguyen et al. 2018

- The sign of surface temperature is reversed.
- Evap/potential evap




North Australian sea surface temperatures
Natural decadal variability
Indian Ocean Dipole
El Niño/La Niña
Upper Level Trough
Global warming
Sub-tropical Ridge (Winter)
Easterly Trough
Cut-off Lows
L
Frontal Systems
East Coast Lows
L
L
Sub-tropical Ridge (Summer)
Low phase
Southern Annular Mode
Westerly Jet
High phase


NCEP/NCAR Reanalysis
May 2018
SLP
1014
1022
1006
998
990
90N
60N
30N
0
30S
60S
90S
0
30E
60E
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180
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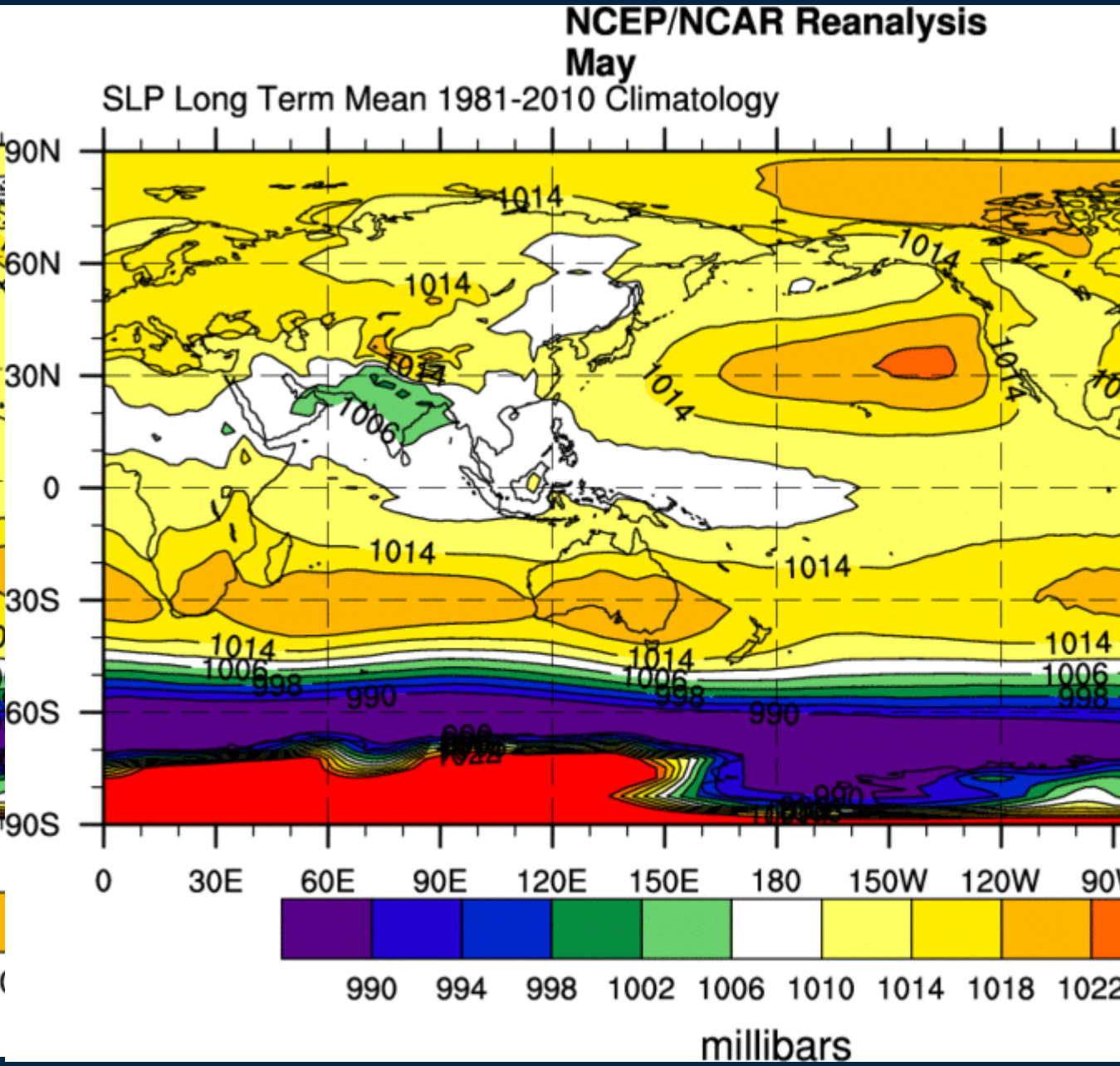
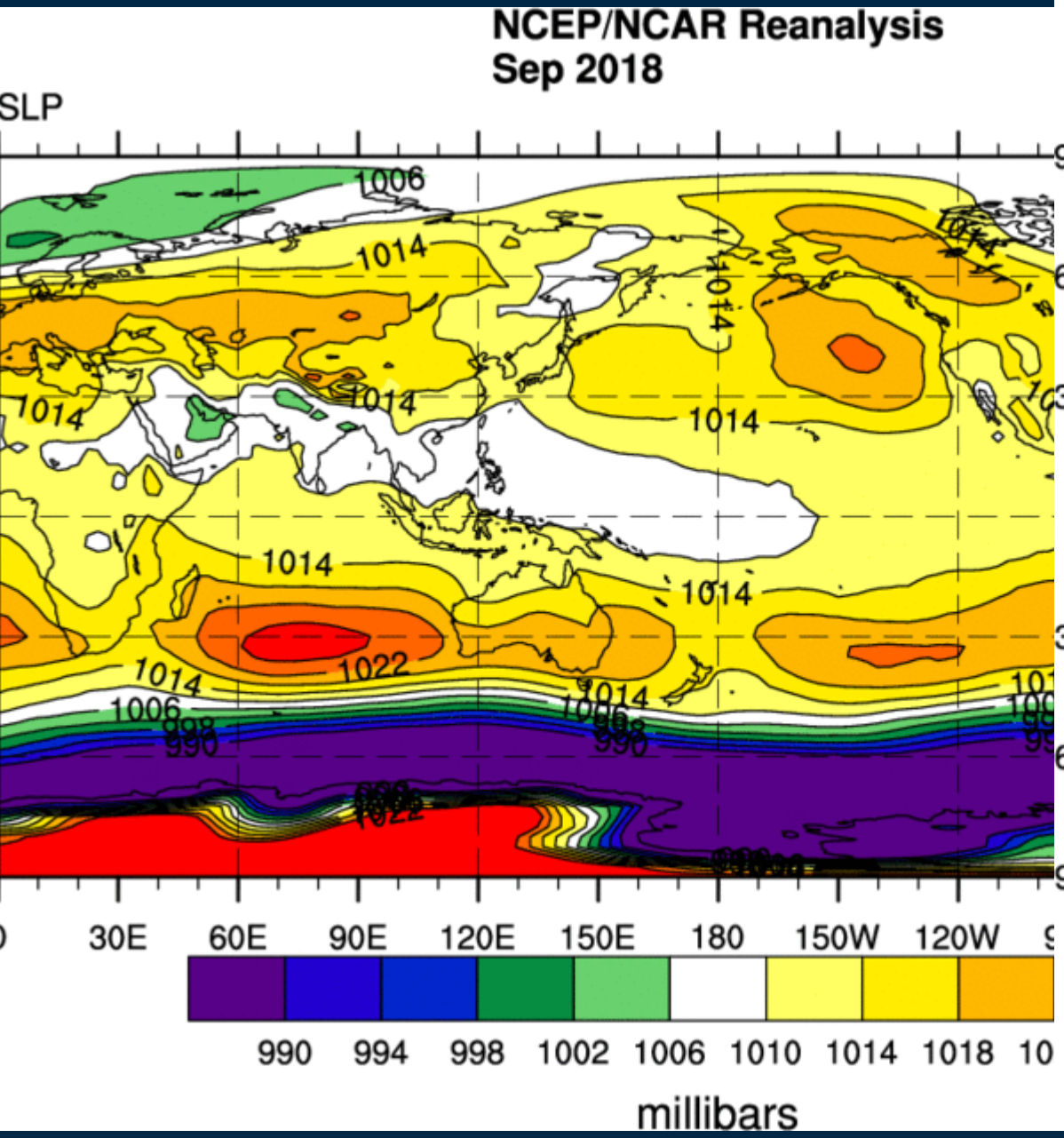
990
994
998
1002
1006
1010
1014
1018
millibars


NCEP/NCAR Reanalysis
May
SLP Long Term Mean 1981-2010 Climatology
1014
1006
998
990
0
30E
60E
90E
120E
150E
180
150W
120W
990
994
998
1002
1006
1010
1014
1018
1022
millibars


NCEP/NCAR Reanalysis
Sep 2018
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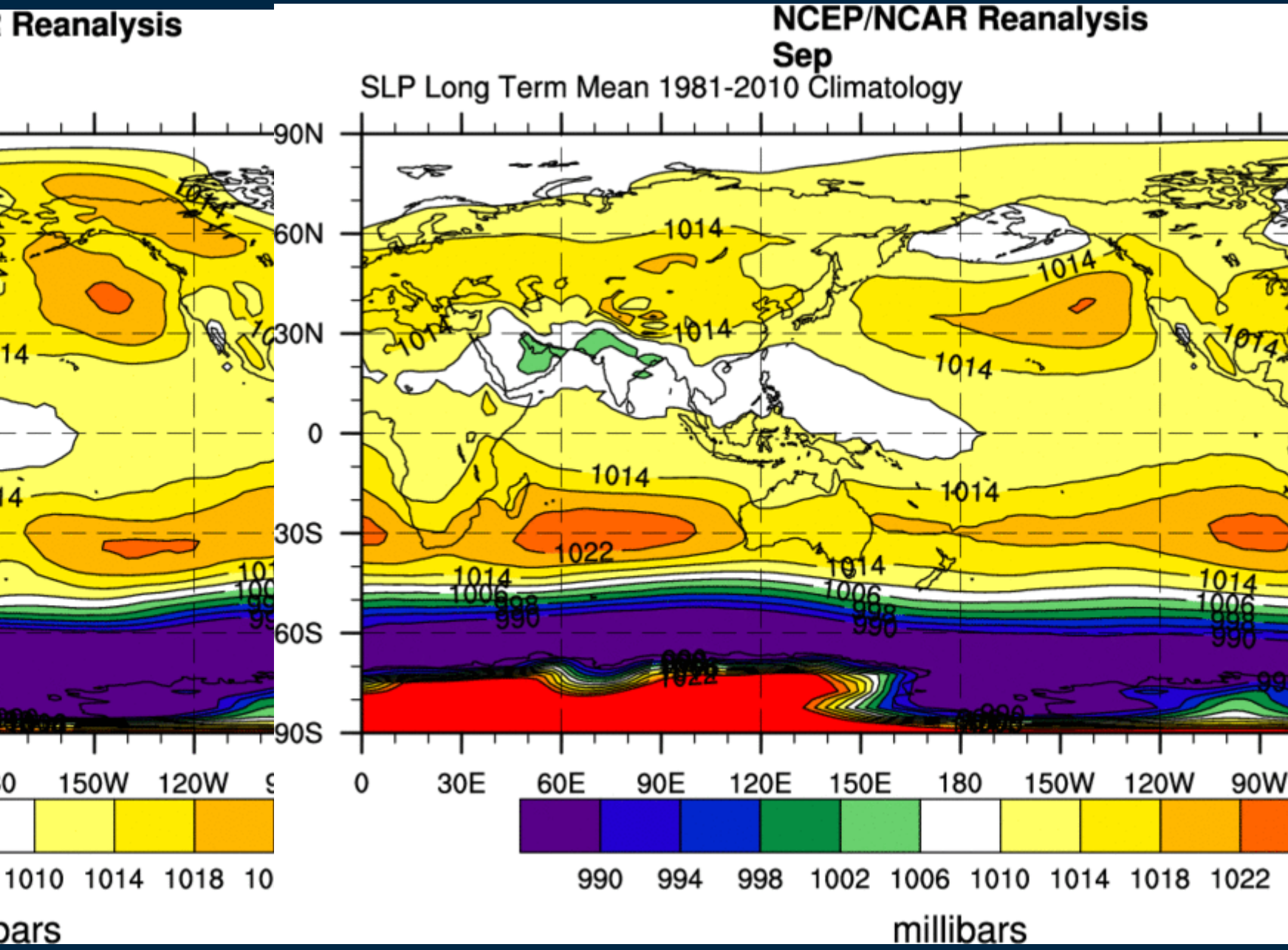
millibars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90N
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30E
60E
90E
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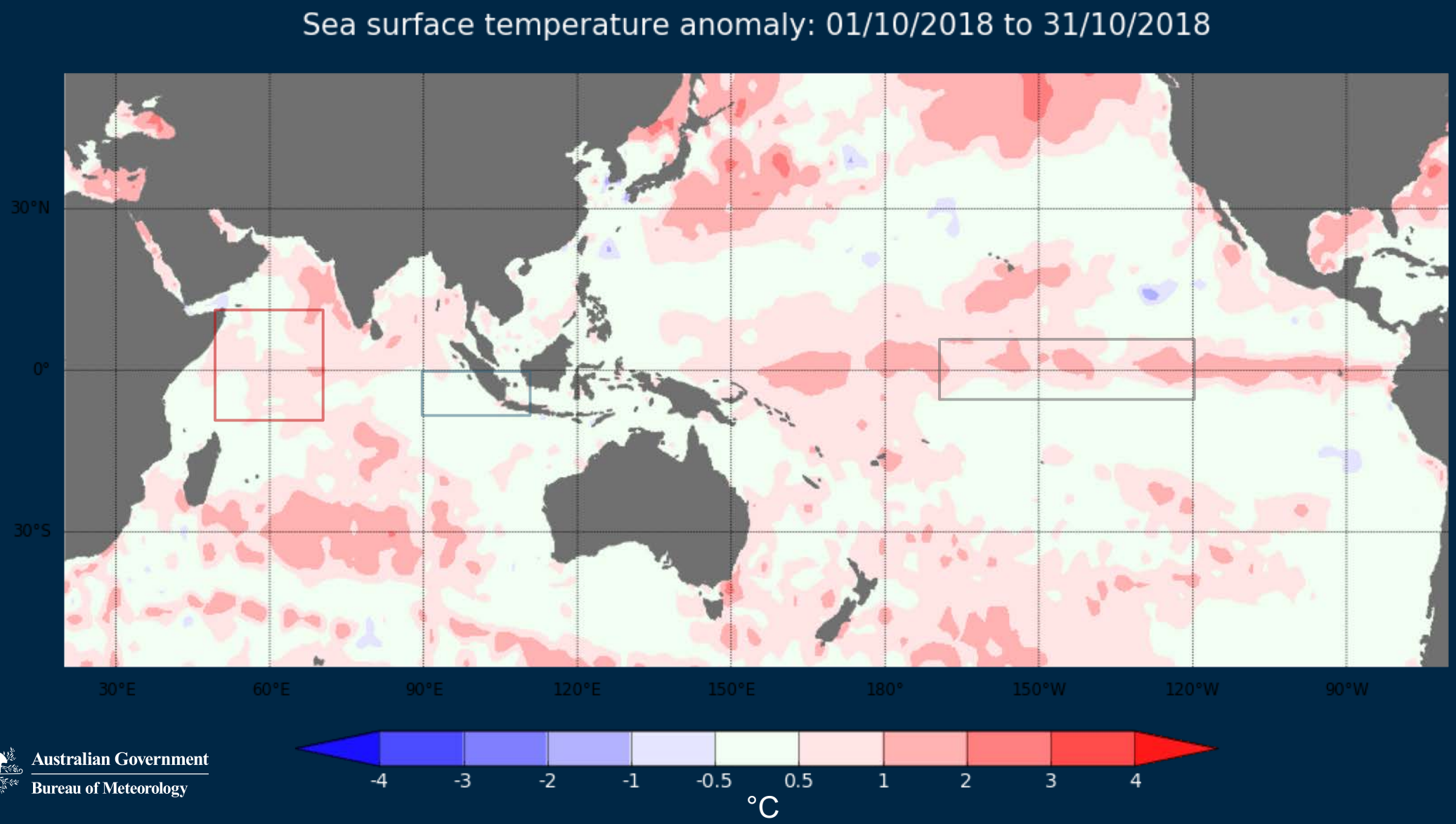
90W
990 994 998 1002 1006 1010 1014 1018 1022
millibars

Sea surface temperature

Latest monthly anomalies



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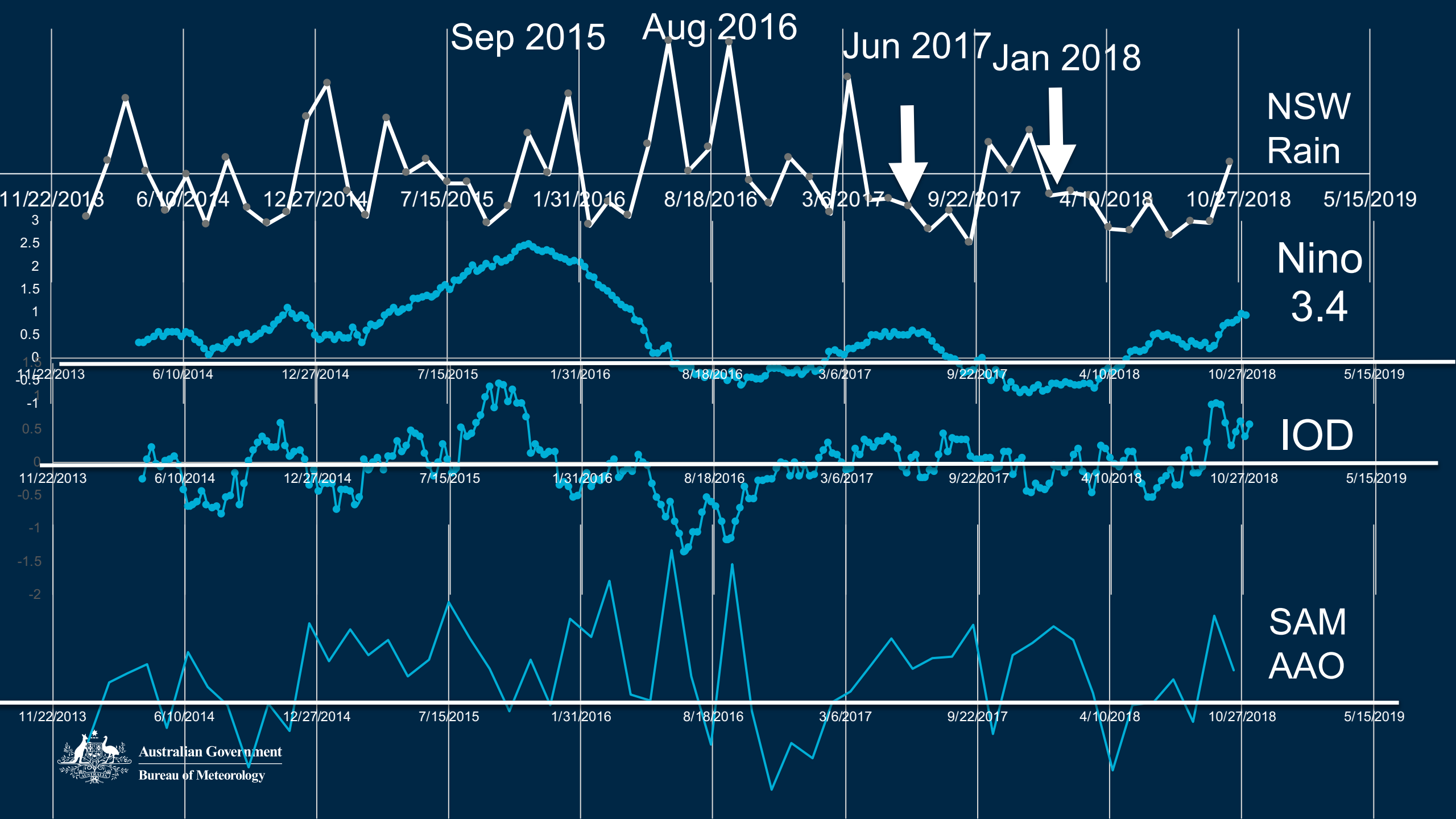

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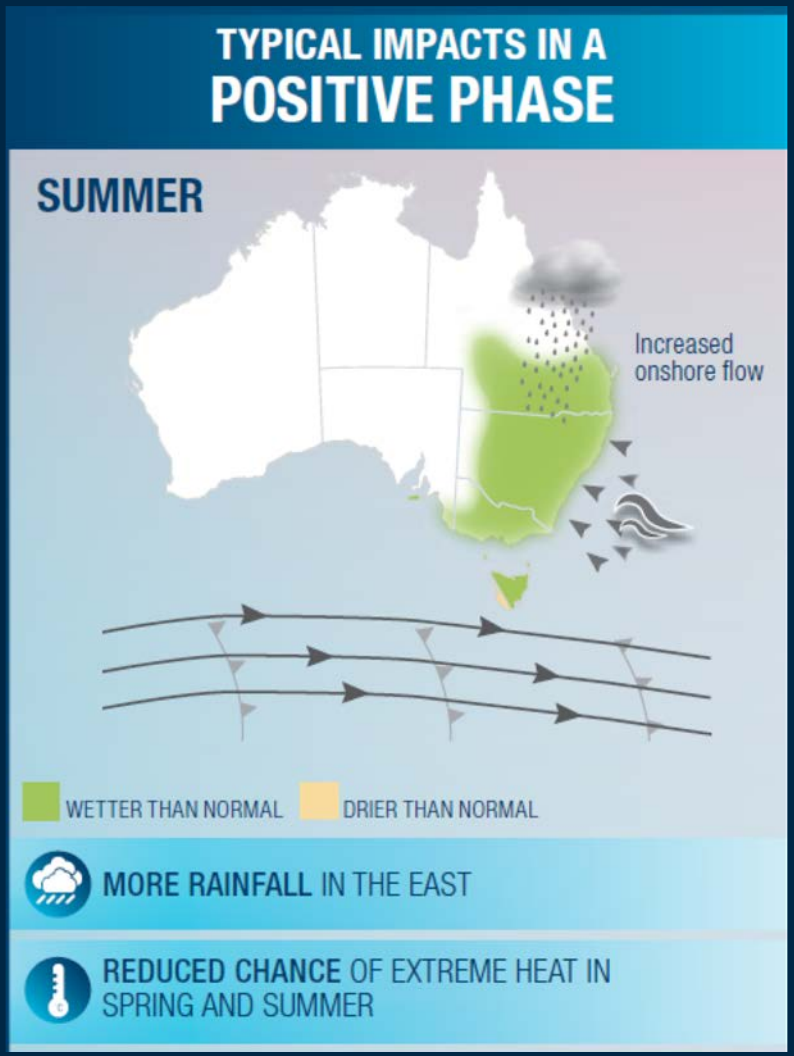
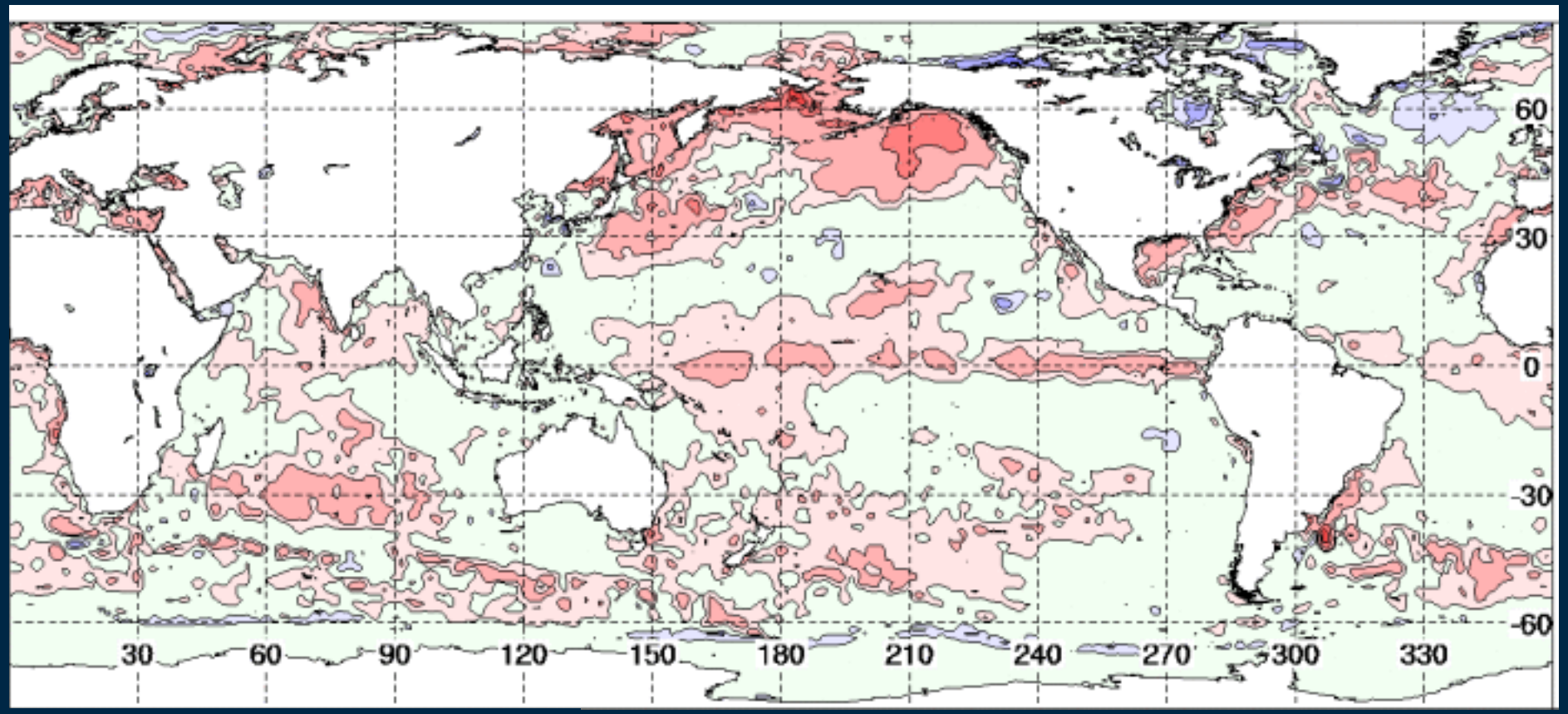
Southern Annular Mode

- The Bureau's climate model suggests the Southern Annular Mode is likely to enter a positive phase in December 2018
- This is reflected in the Bureau's rainfall outlook for December
- It is likely to dissipate by the end of the year



Evolution of global SST anomalies

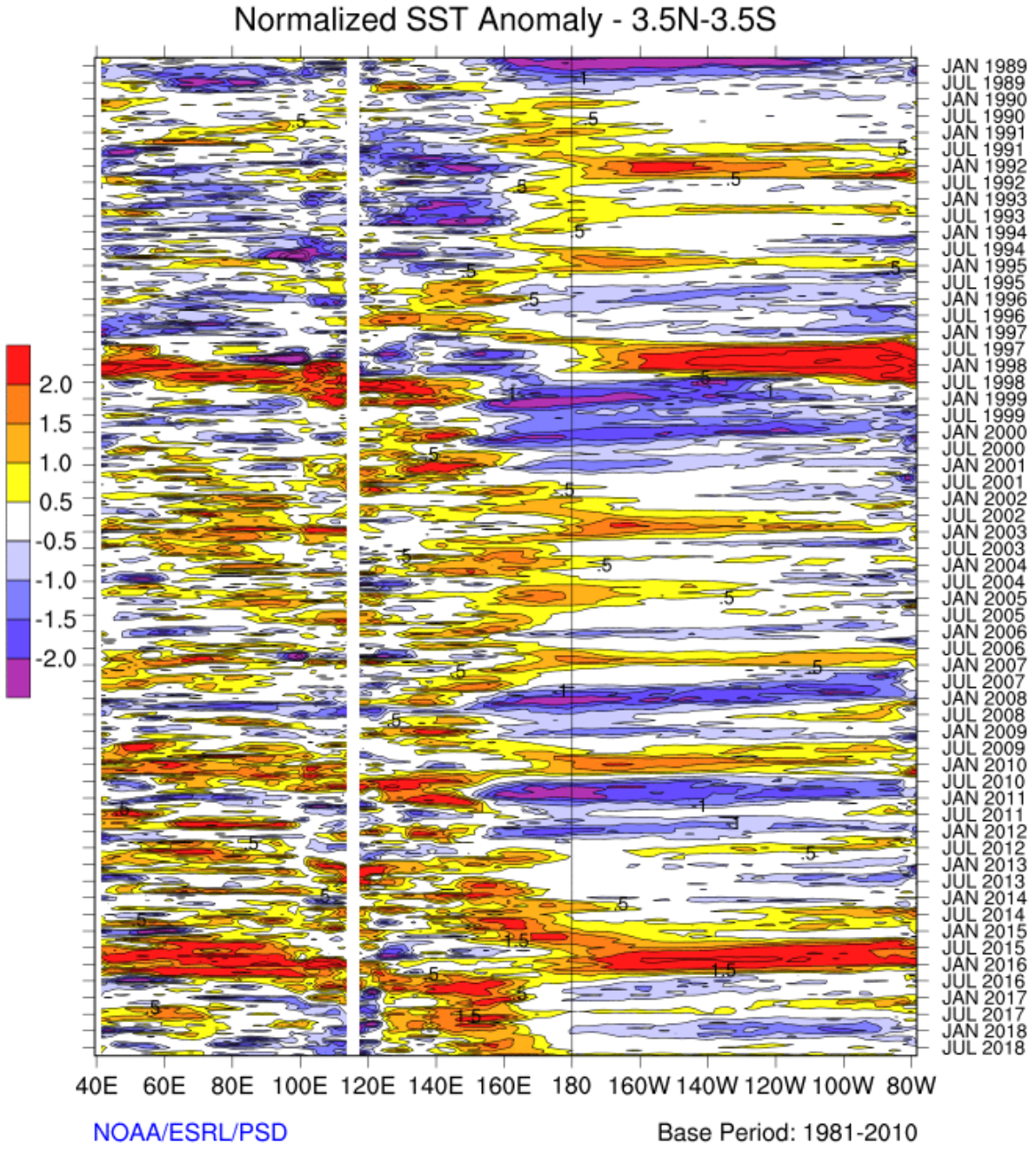


October 2018

- Persistence of warmth in the southern Indian & southern Pacific oceans
- Migration of Tasman Sea heatwave to the east

Normalised SST 3.5S to 3.5N

https://www.esrl.noaa.gov/psd/map/clim/sst.shtml



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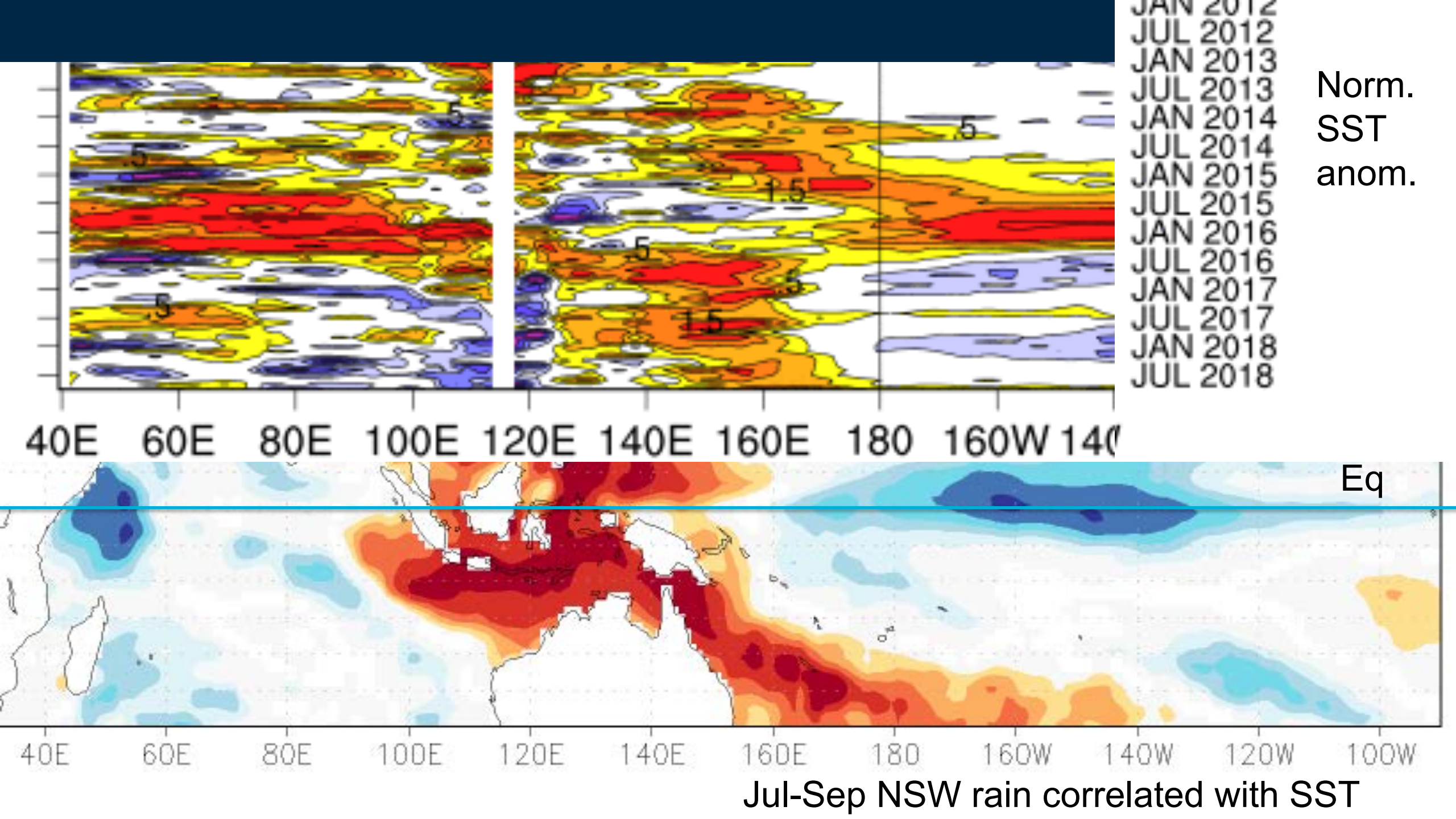
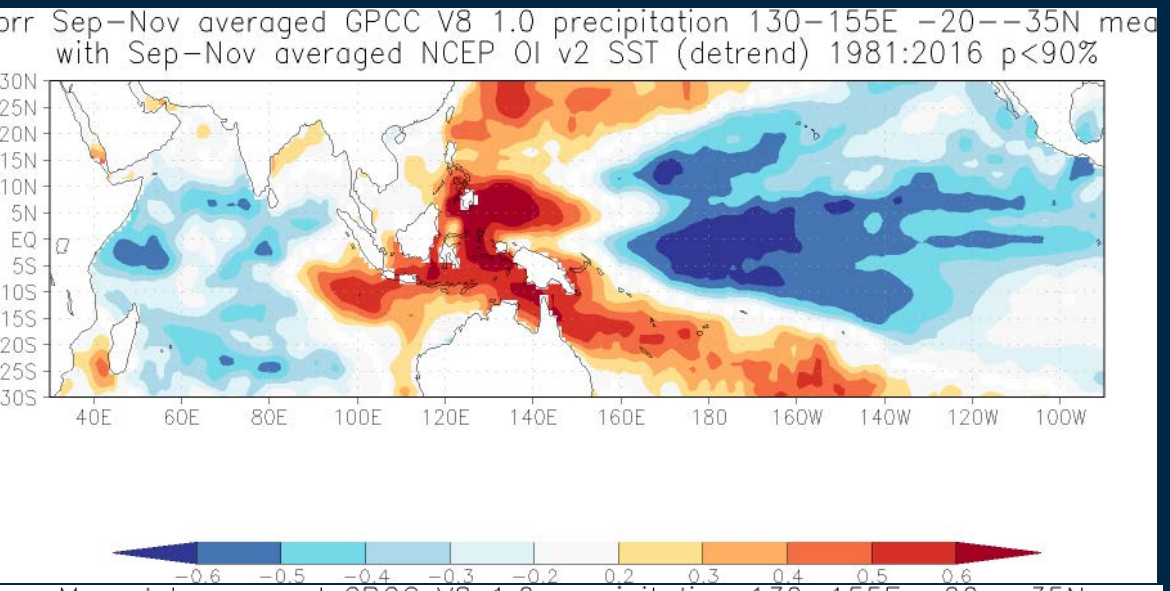
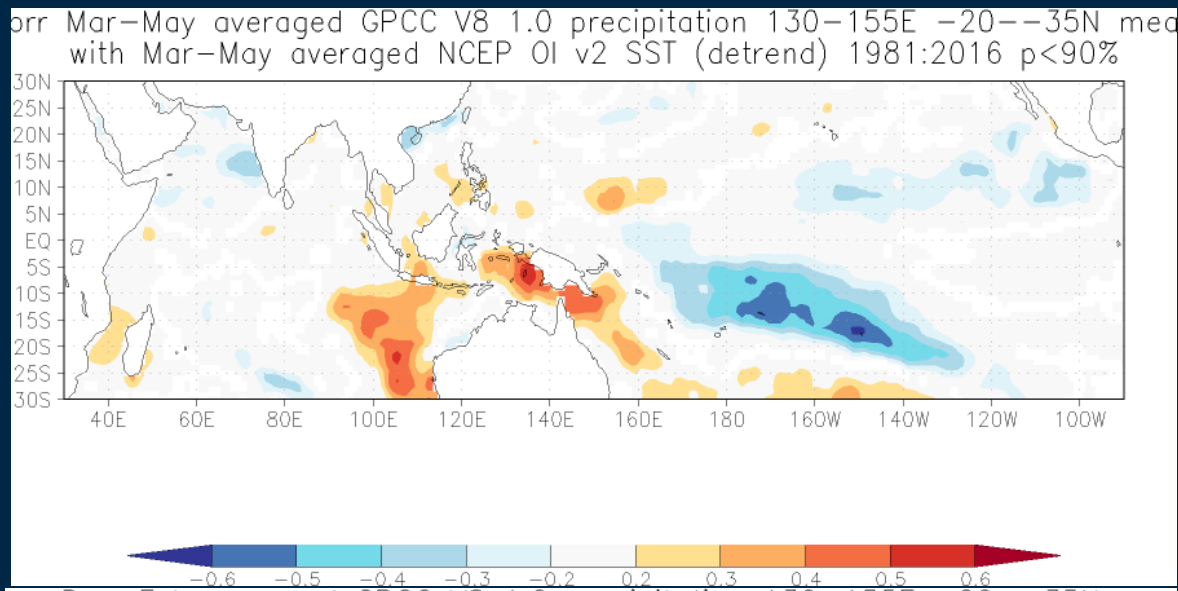
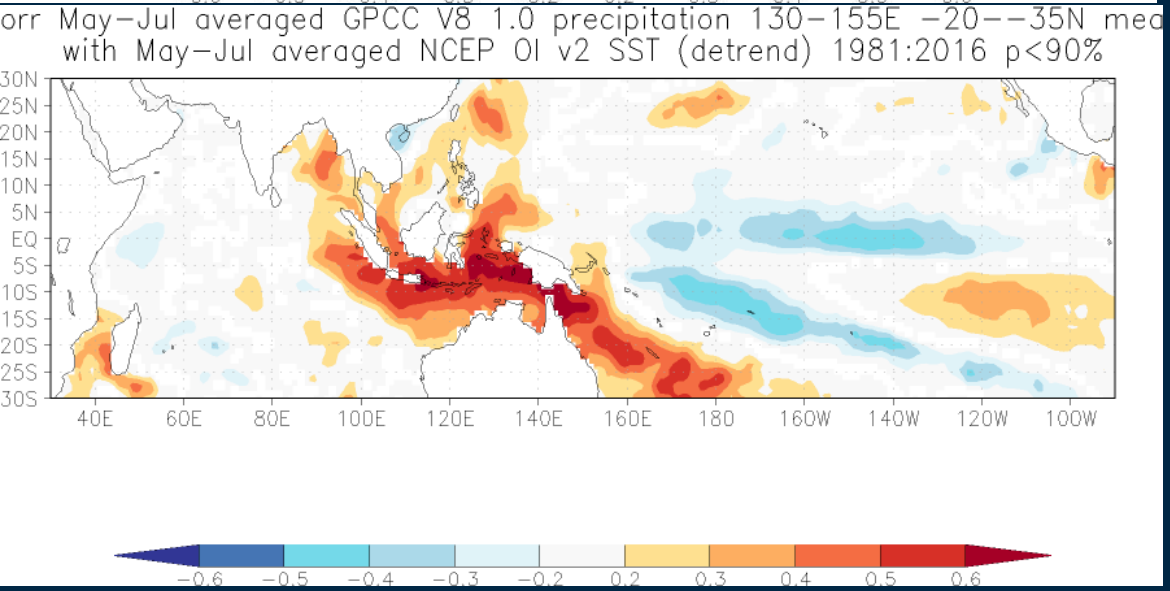

JAN 2012
JUL 2012
JAN 2013
JUL 2013
JAN 2014
JUL 2014
JAN 2015
JUL 2015
JAN 2016
JUL 2016
JAN 2017
JUL 2017
JAN 2018
JUL 2018
Norm. SST anom.
40E 60E 80E 100E 120E 140E 160E 180 160W 140
Eq
40E 60E 80E 100E 120E 140E 160E 180 160W 140W 120W 100W
Jul-Sep NSW rain correlated with SST

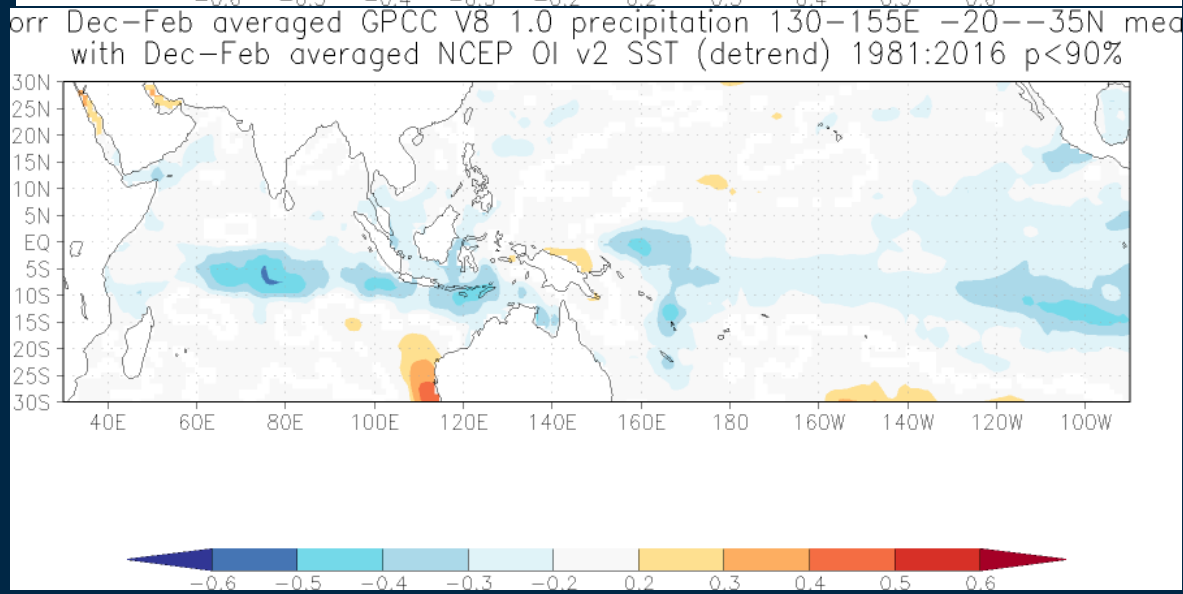
Correlations central-east rainfall with SST (all detrended)





MAM





DJF

High-lat drivers

- Of course that southwards shift of our weather systems in autumn/winter has become a typical pattern which has persisted in the east (at least) of the country since the start of the millennium drought in 1996
- For southern Australia, only two autumn/winter periods have had above average rainfall since 1996

Summary

- maybe a more classic +IOD forcing of the dry of late, but prior to that it appears to be more related to a weakening of the mid-latitude westerlies, which may be associated with these mid-latitude 'blobs' of warmer than average water. Or has the weakened mid-lat westerlies caused the warmer blobs….

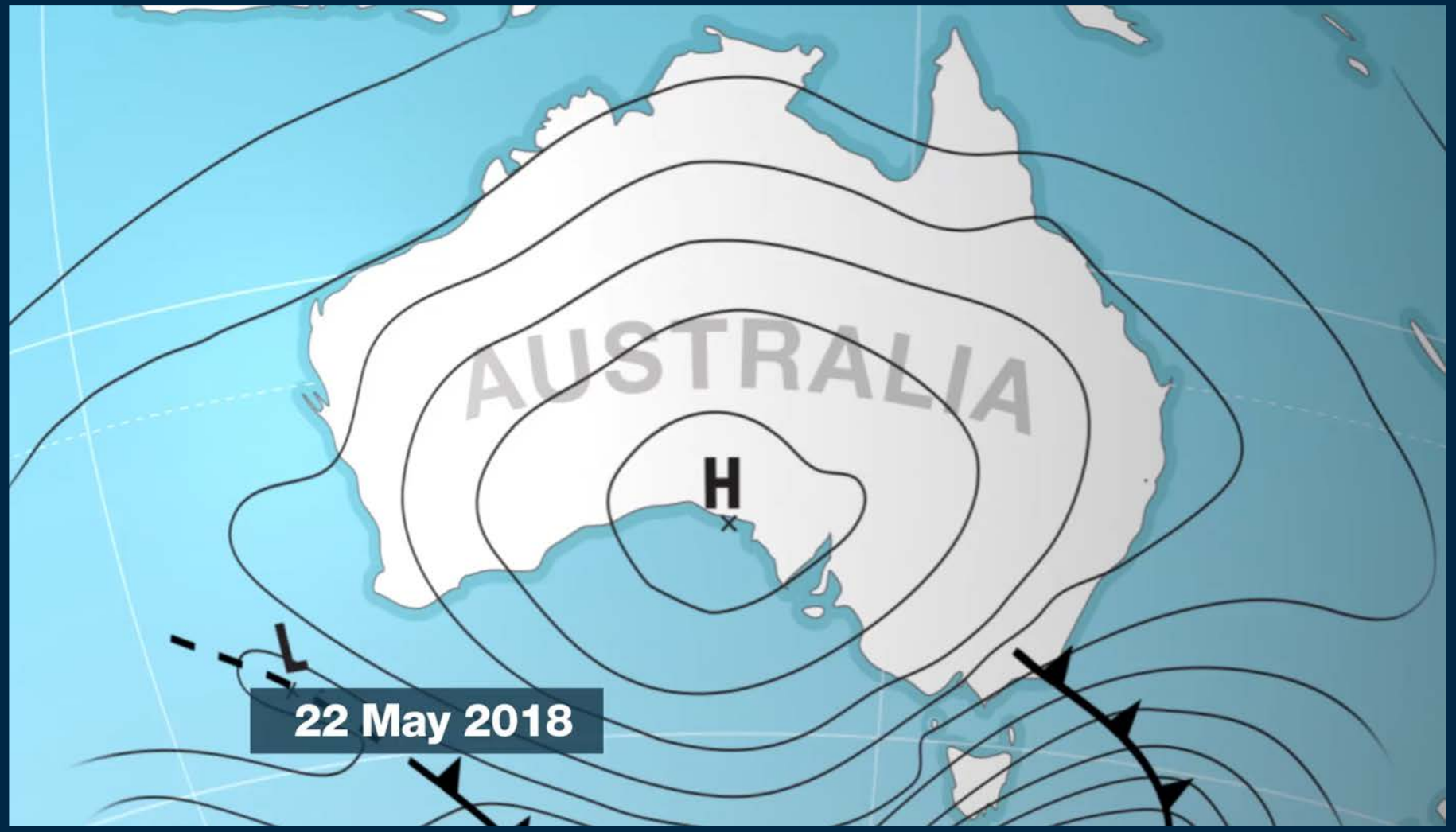
- just being a lack of a clear wet signal from the oceans, so the result of no wet signal is now drier than average conditions for many areas of Australia. David Martin and colleagues

- Westerlies just not bringing rain-bearing systems
- Cut-offs/East coast lows?

- Timing?

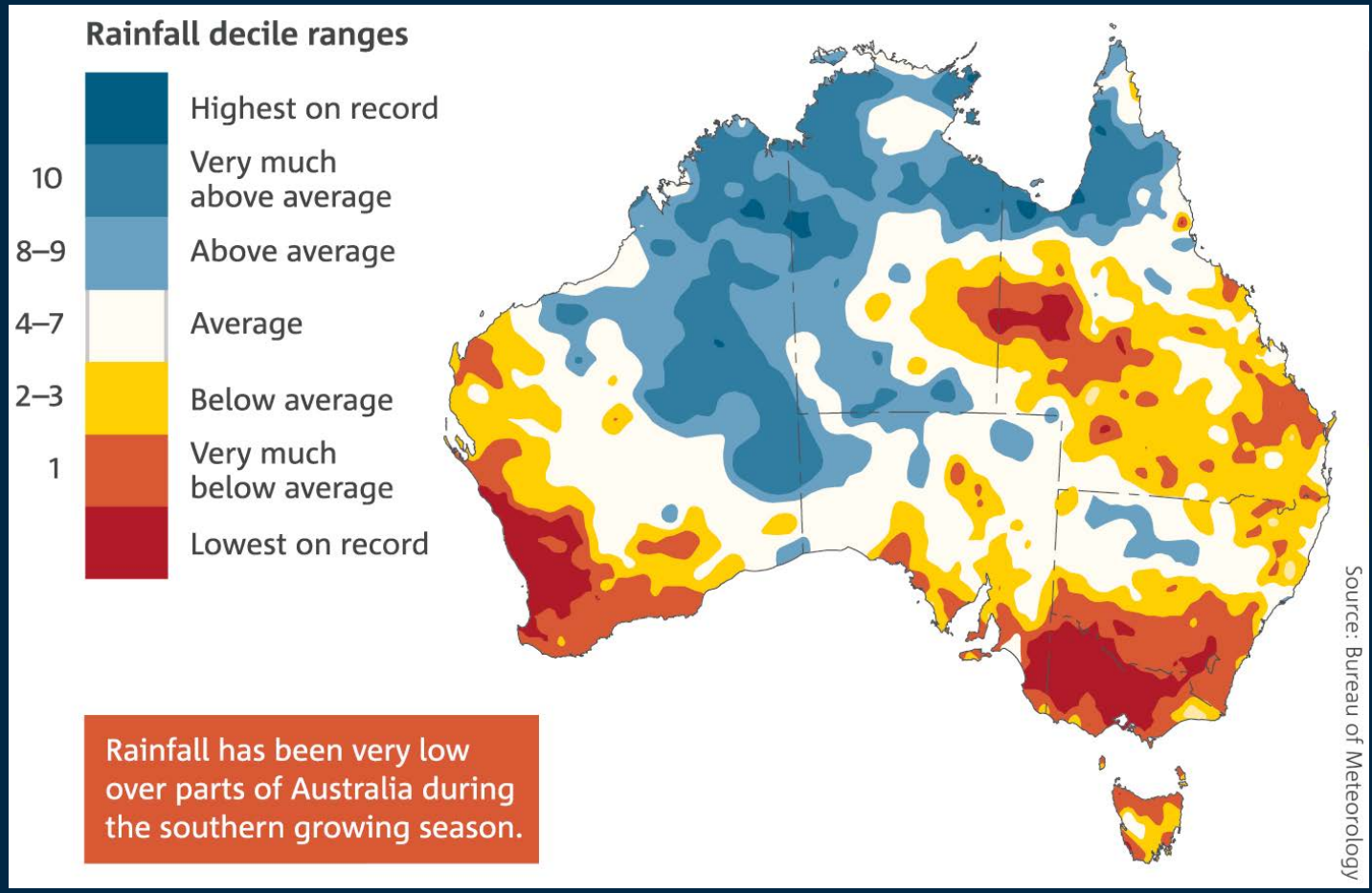
Why has rainfall been below average?

- Cooler water to Australia's northwest
- Warmer water in Tasman Sea
- Higher pressure over Australia
- Rain bearing fronts pushed south
- Stronger winter westerlies pushing dry (interior) air into NSW

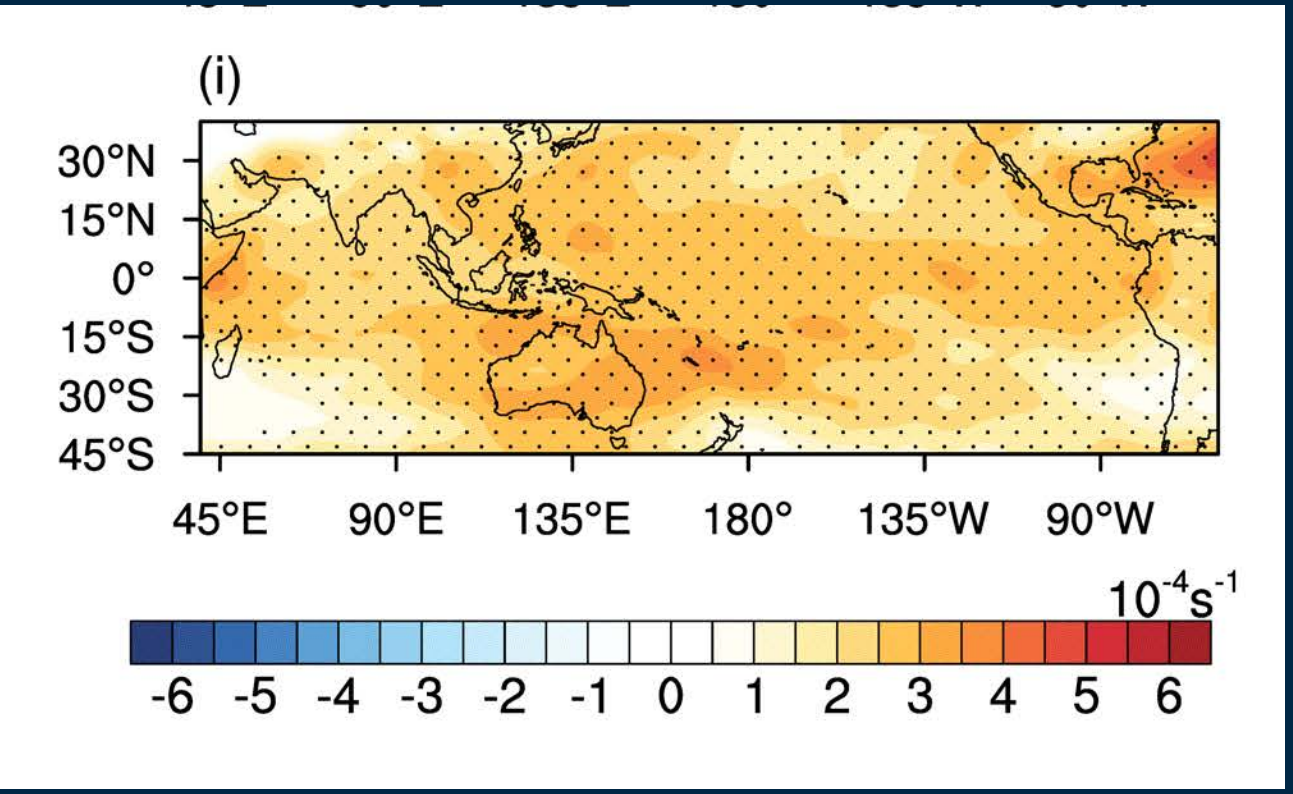


Influence from climate change

- Southern Australia Rainfall Decline – April – October, Recent decades



Greenhouse gases as a driver



Hope et al. 2018

Vertical Stability
Buoyancy frequency (N^2)

Climatology of
'current' minus 'low-CO2'

High altitude rainfall did not see as strong reductions as elsewhere (Adelaide hills, Snow mountains).

Blair Trewin

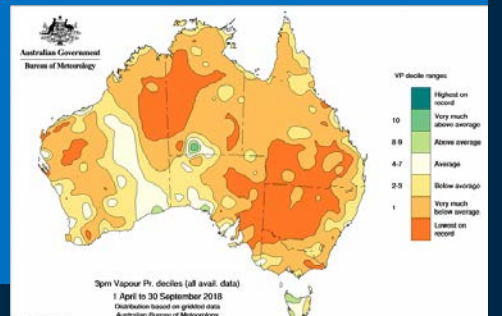


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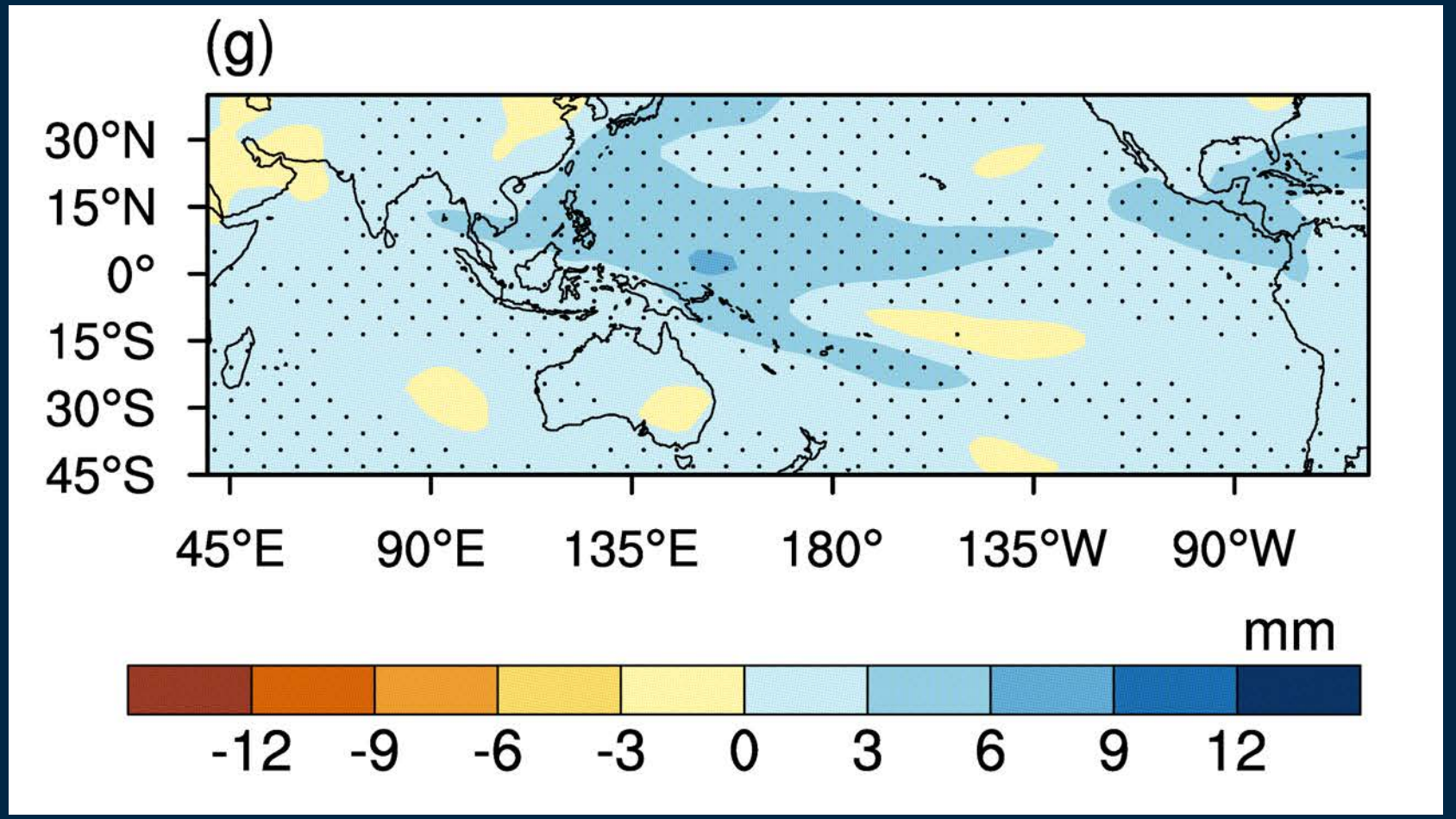
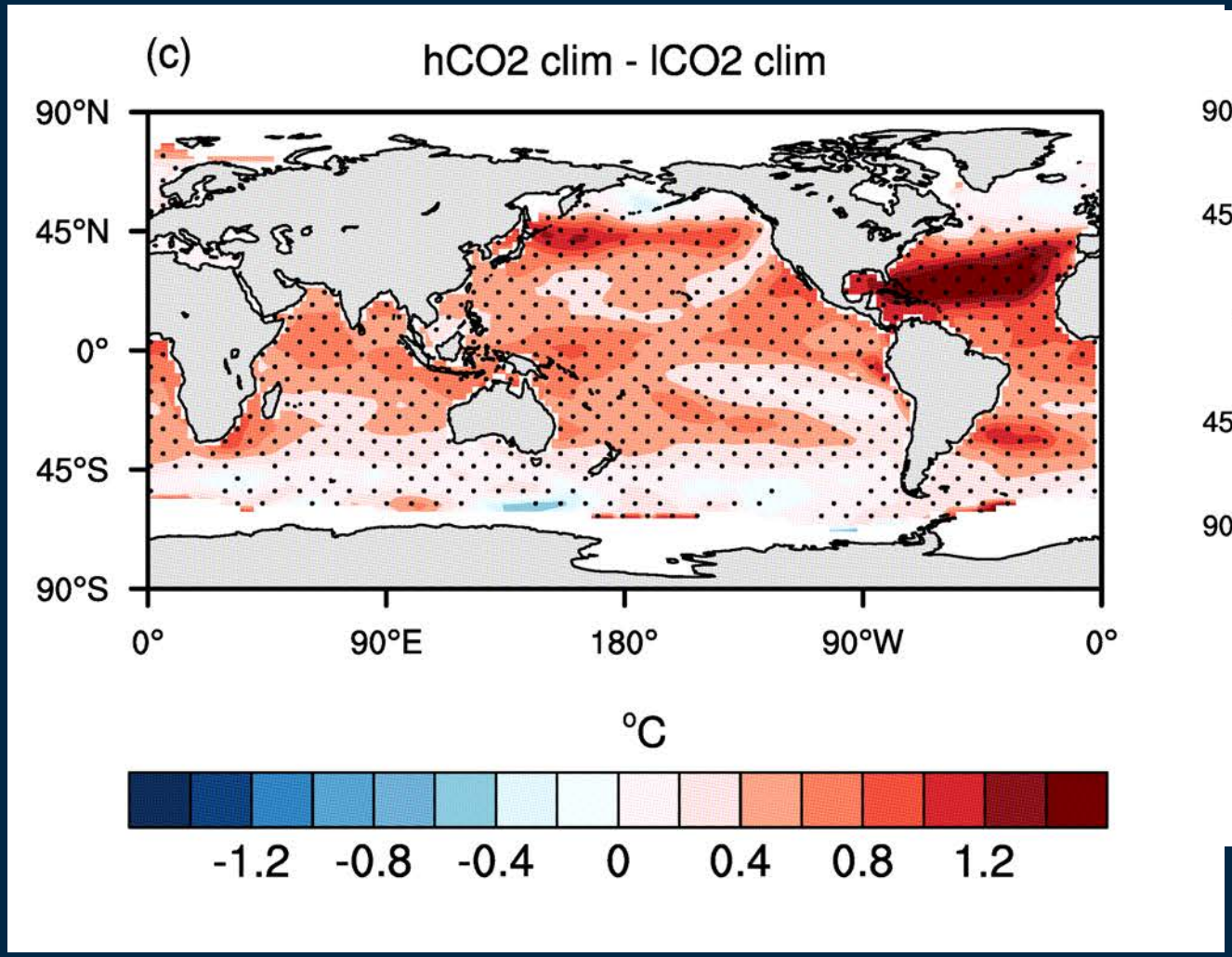
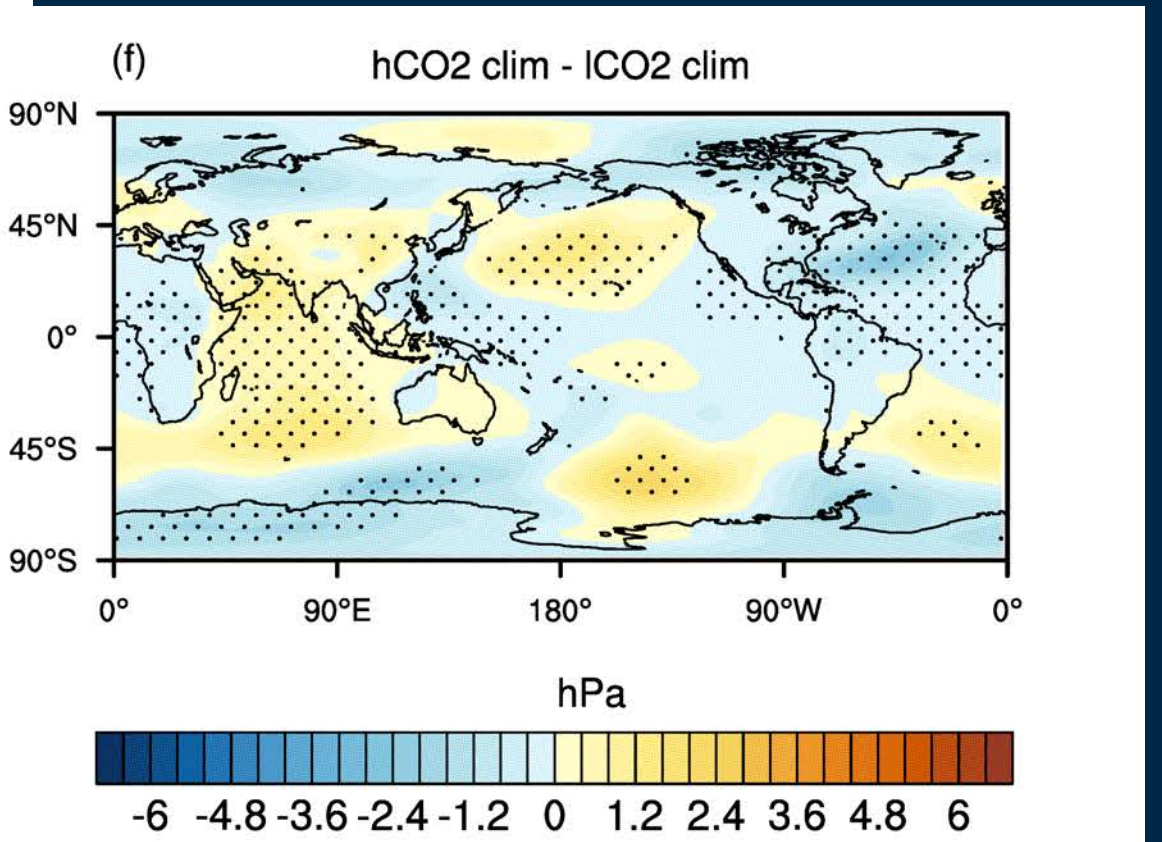
Fig S2b Precipitable Water



SST, MSLP


(c)
hCO2 clim - lCO2 clim
90°N
45°N
0°
45°S
90°S
0°
90°E
180°
90°W
0°
°C
-1.2
-0.8
-0.4
0
0.4
0.8
1.2

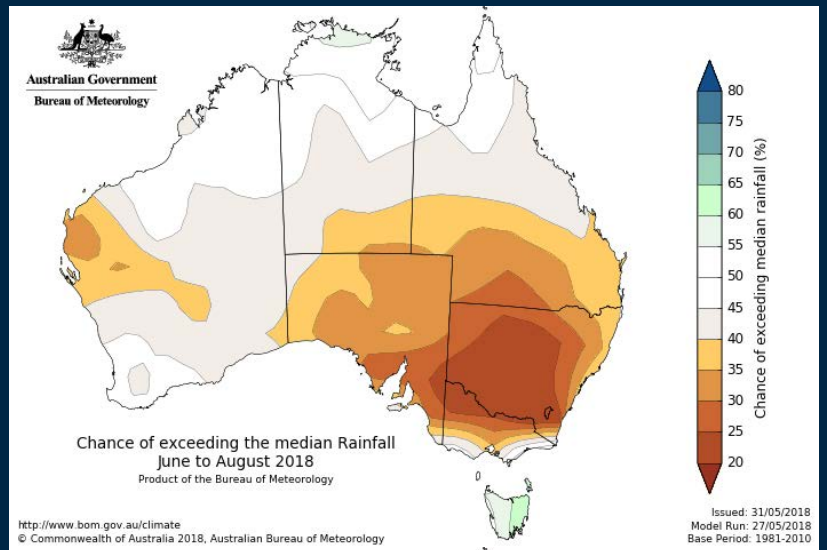

(f)
hCO2 clim - lCO2 clim
90°N
45°N
0°
45°S
90°S
0°
90°E
180°
90°W
0°
hPa
-6
-4.8
-3.6
-2.4
-1.2
0
1.2
2.4
3.6
4.8
6

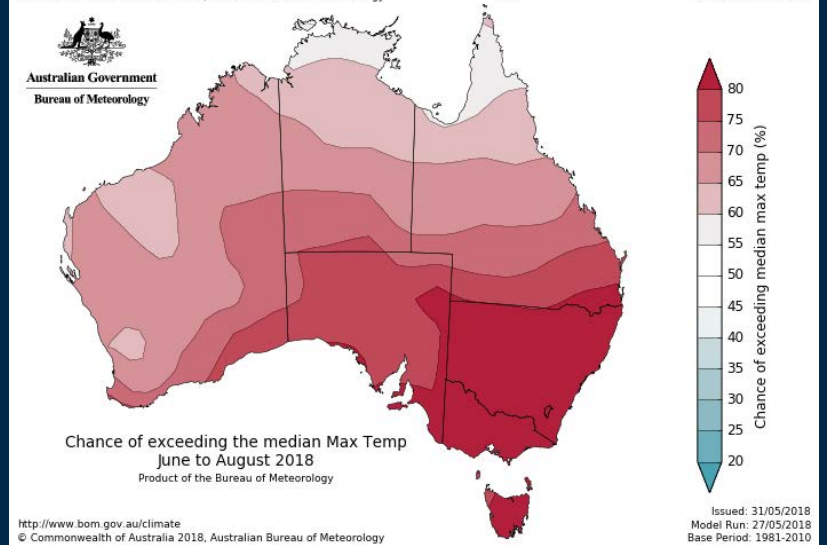
Rapid Attribution for winter 2018

- Dry, hot winter was forecast by POAMA from May
- Looking back, this was a good forecast!

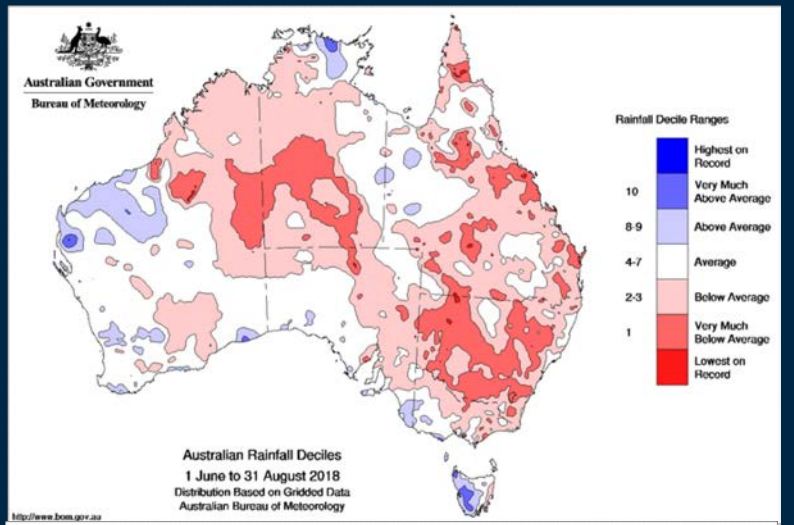
Acacia Pepler
Pandora Hope
Guomin Wang
EunPa Lim
Harry Hendon
Julie Arblaster
Abhik Santra

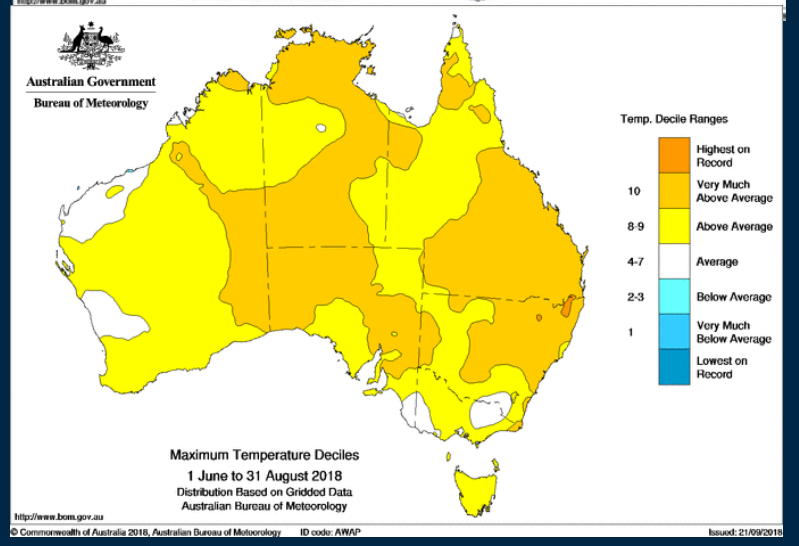
Forecasts





Observed anomalies





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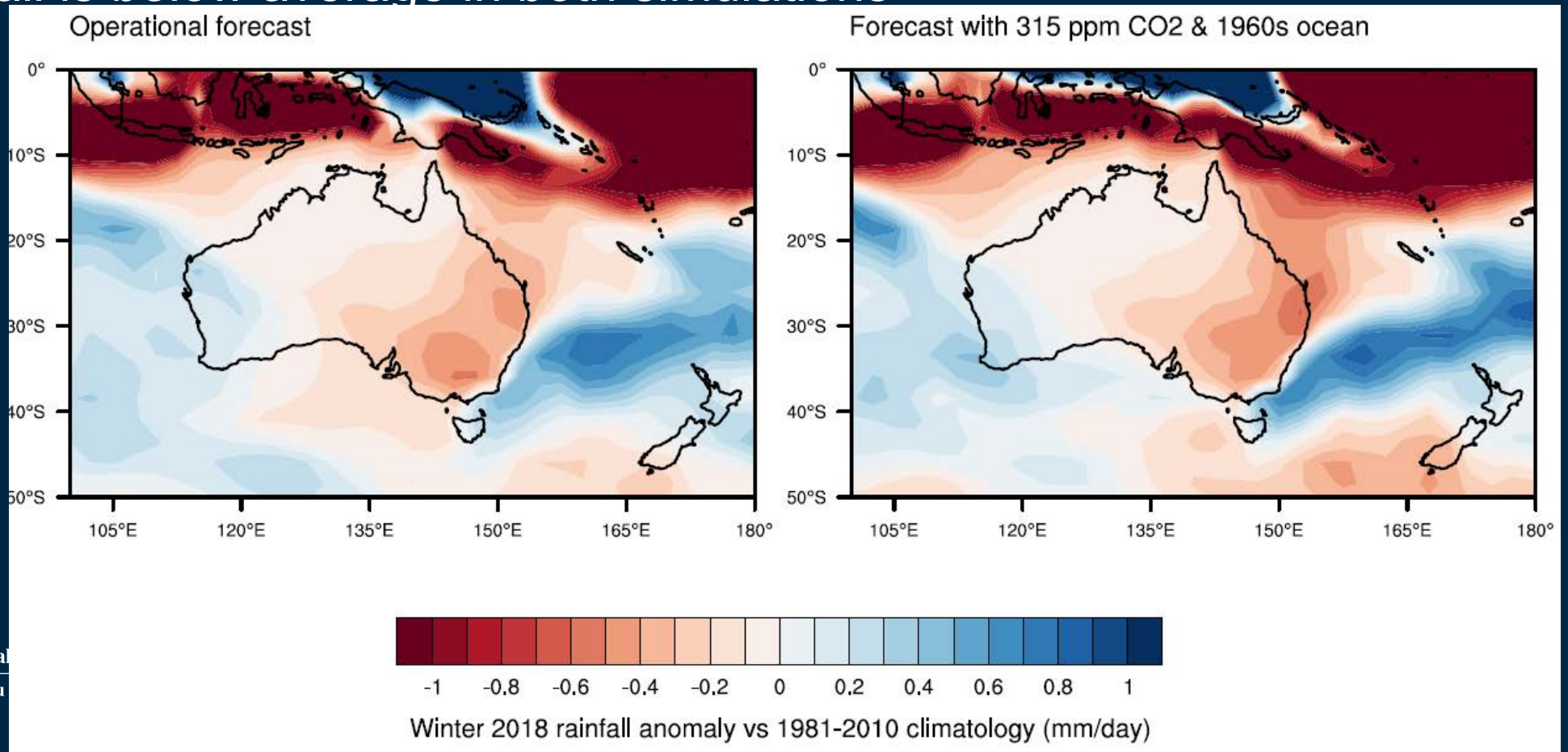
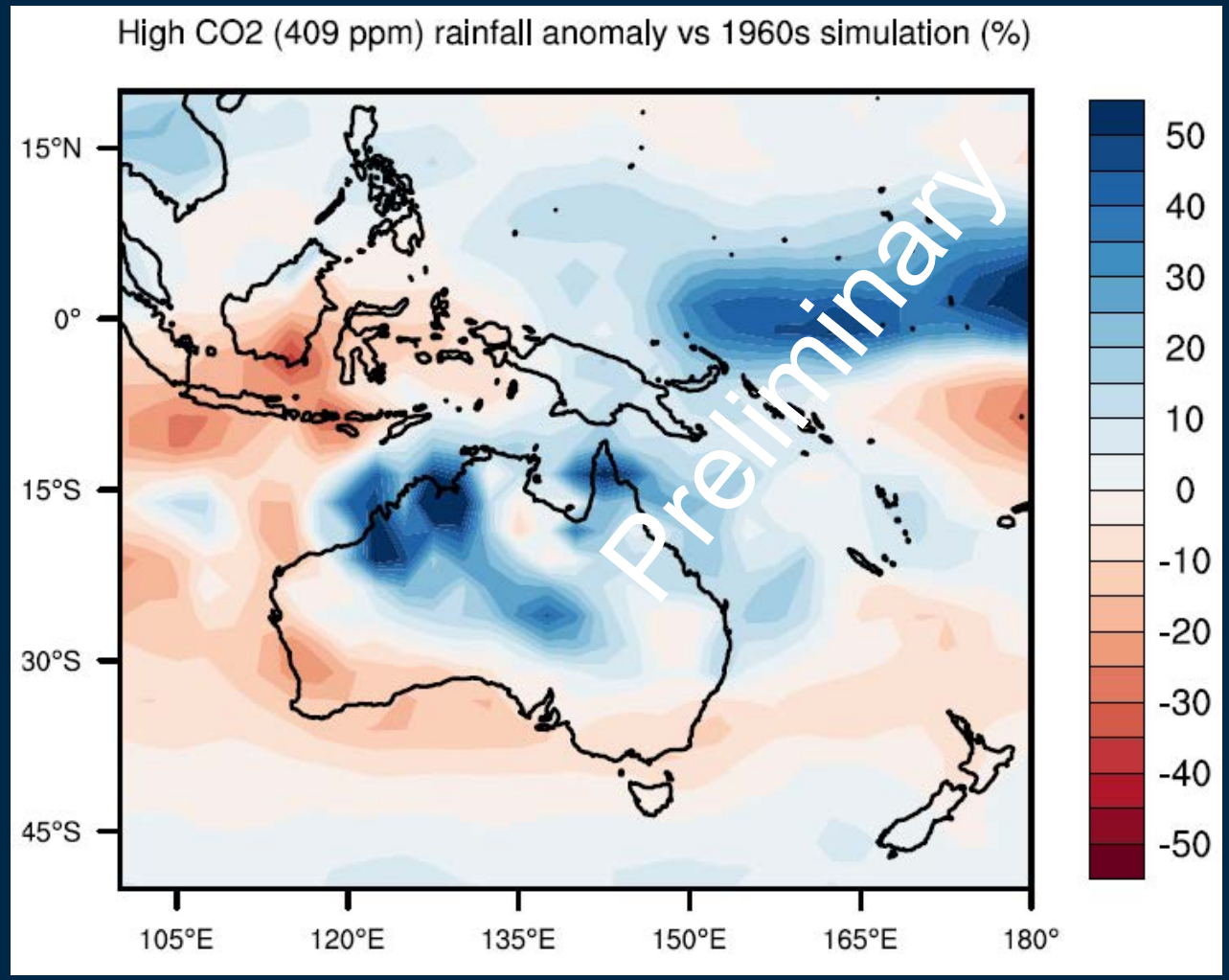
Rapid Attribution for winter 2018

- Seasonal forecasts run for 20180527 and 20180531 initialisations in both the high and low CO_2 worlds
- Both are compared to the *operational POAMA climatology*
- Rainfall is below average in both simulations



Rapid Attribution for winter 2018

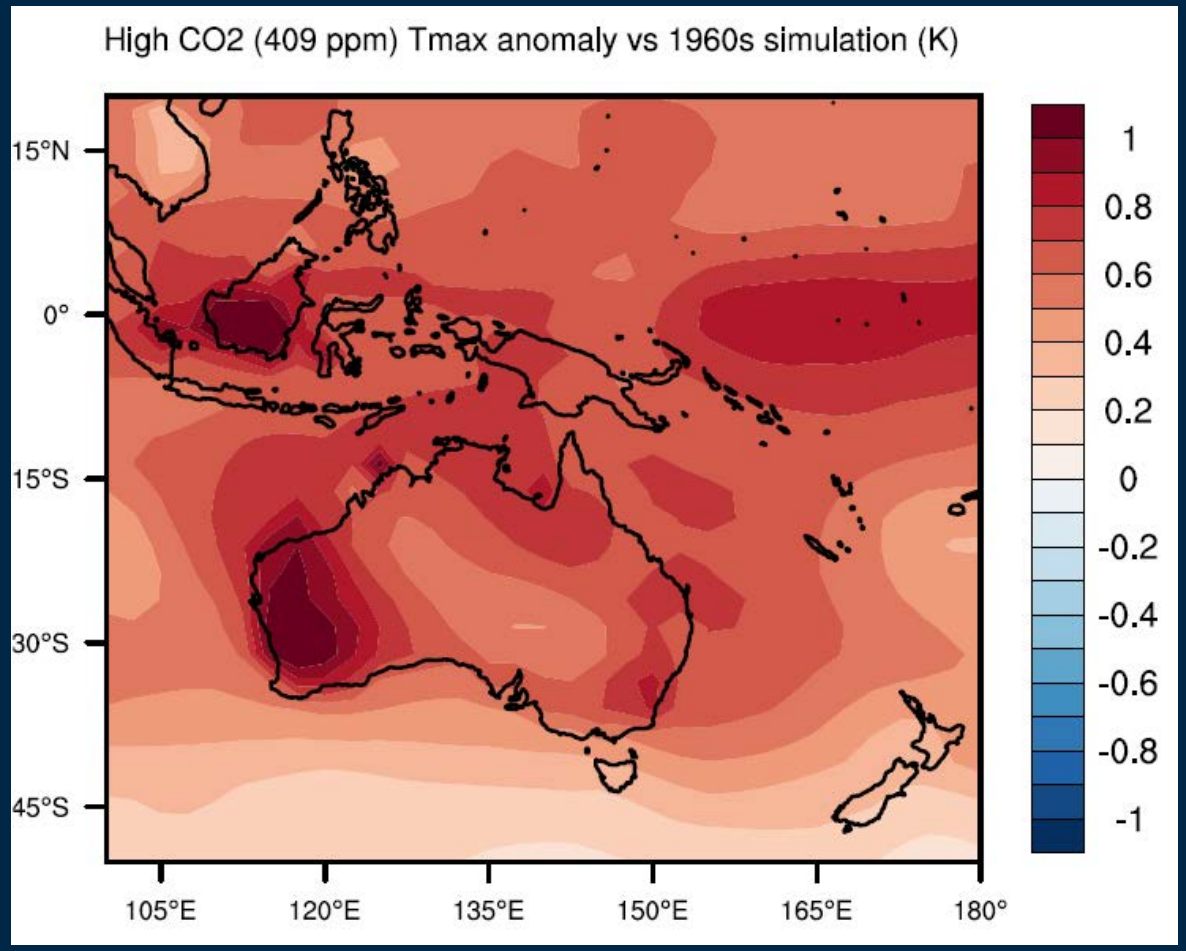
- The current climate forecast is only drier than the 'low CO_2' forecast over southern Australia, NOT NSW
- However, this is not the same story for other seasons.
- Preliminary Results. See Pandora Hope, Acacia Pepler



Rapid Attribution for winter 2018

- Temperatures were above average in eastern Australia for both scenarios, but warmer in the current climate compared to a 'low CO_2' world

Tmax
Current –
lowCO2



Thank you

Questions

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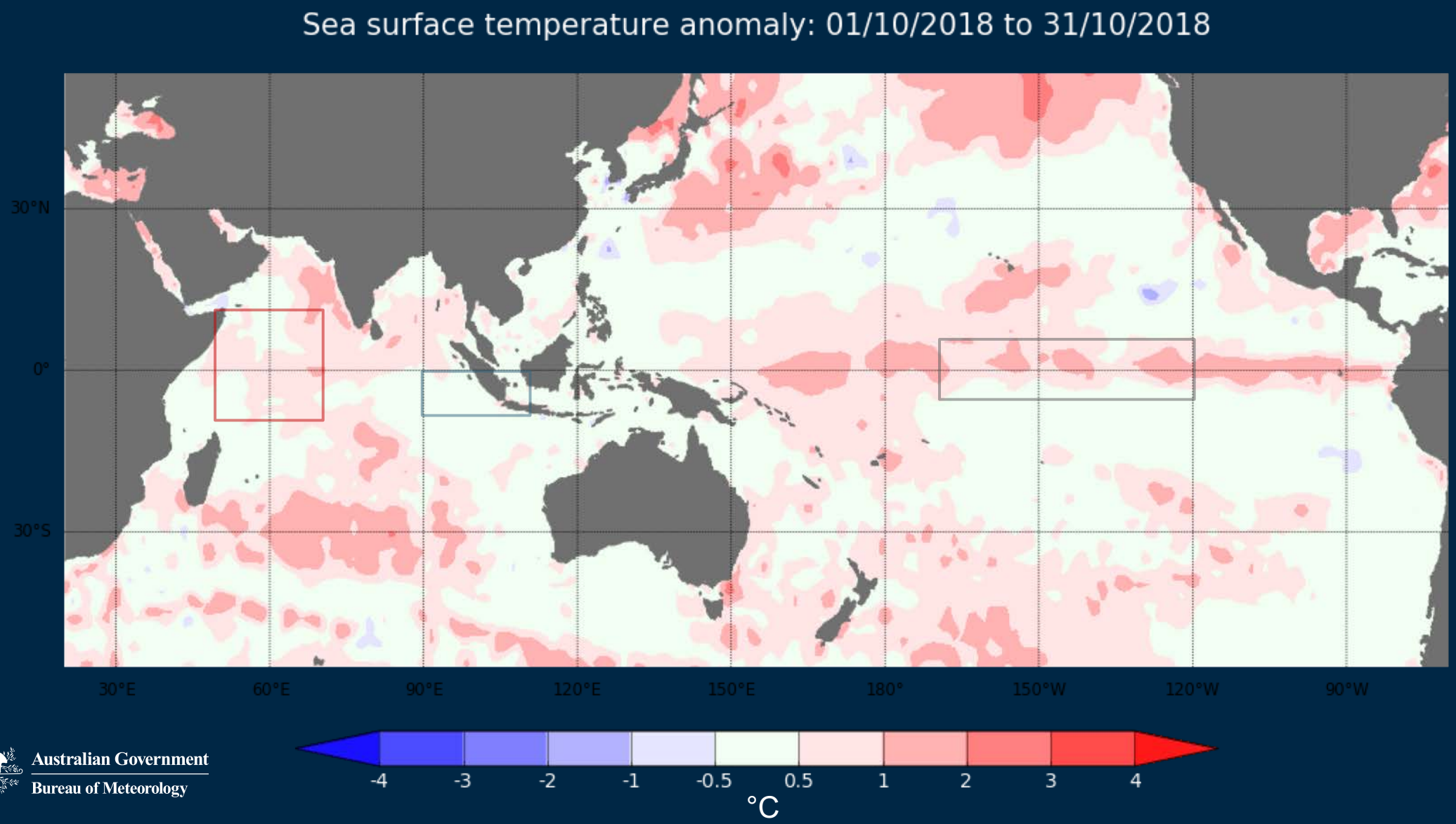
Bureau of Meteorology

Sea surface temperature

Latest monthly anomalies



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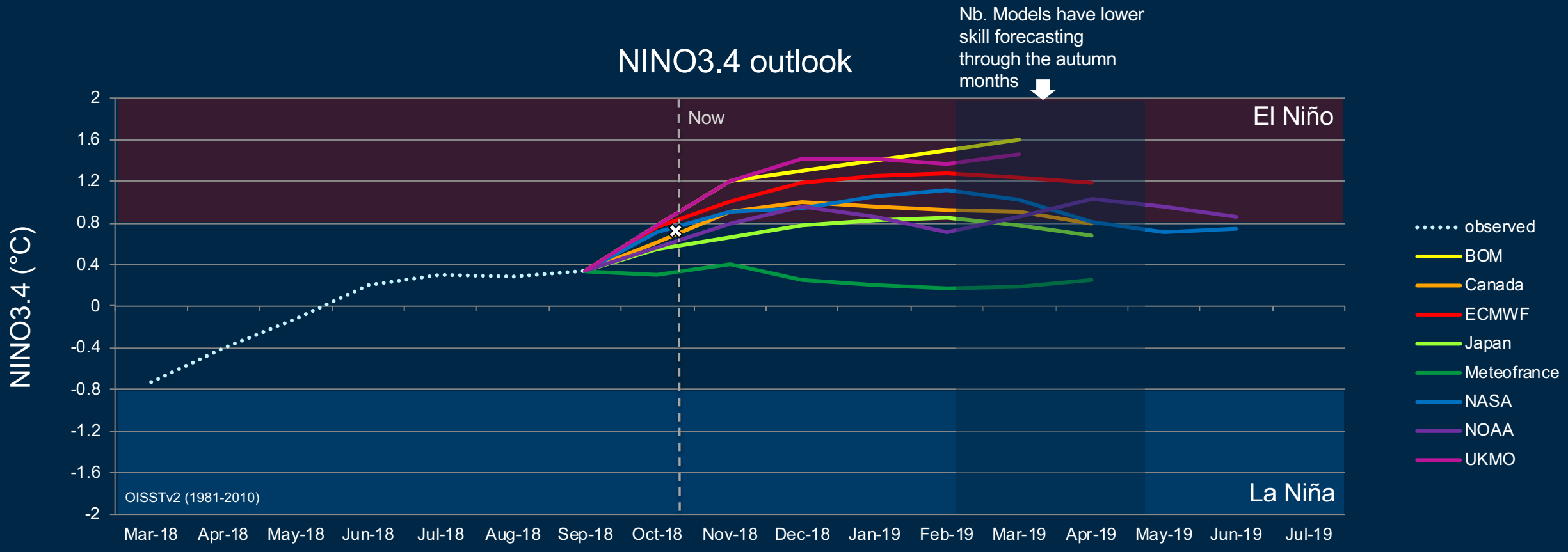
El Niño–Southern Oscillation outlook: October 2018



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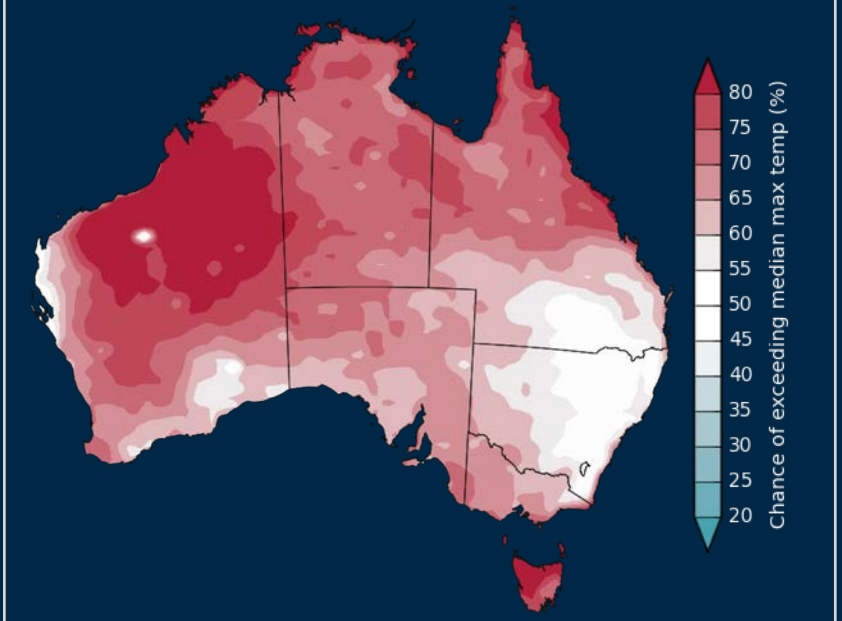
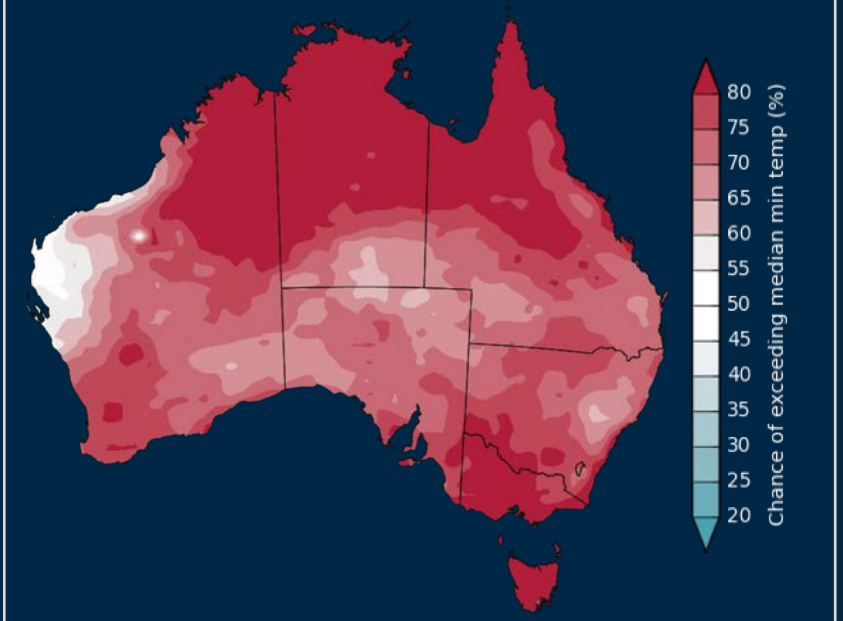
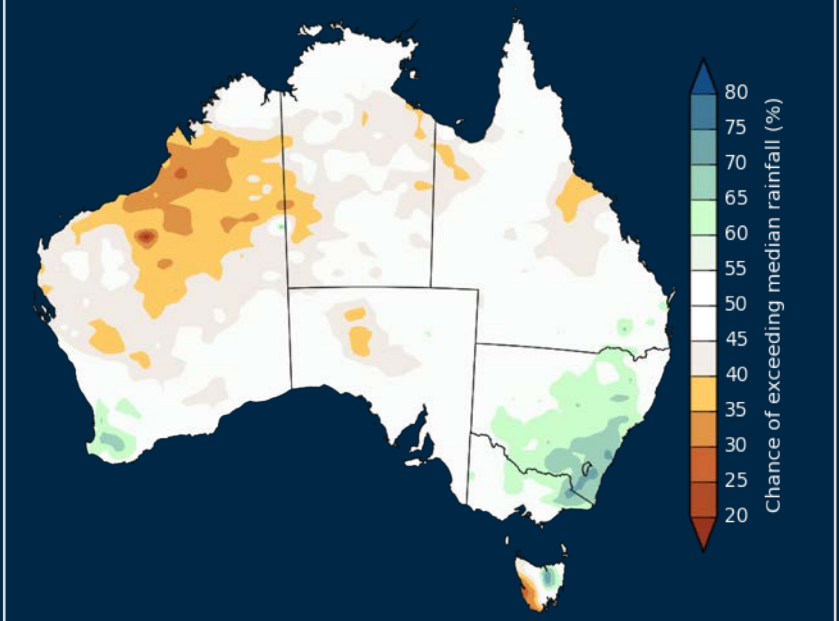
December 2018 outlook

Maximum temperature	Minimum temperature	Rainfall
		

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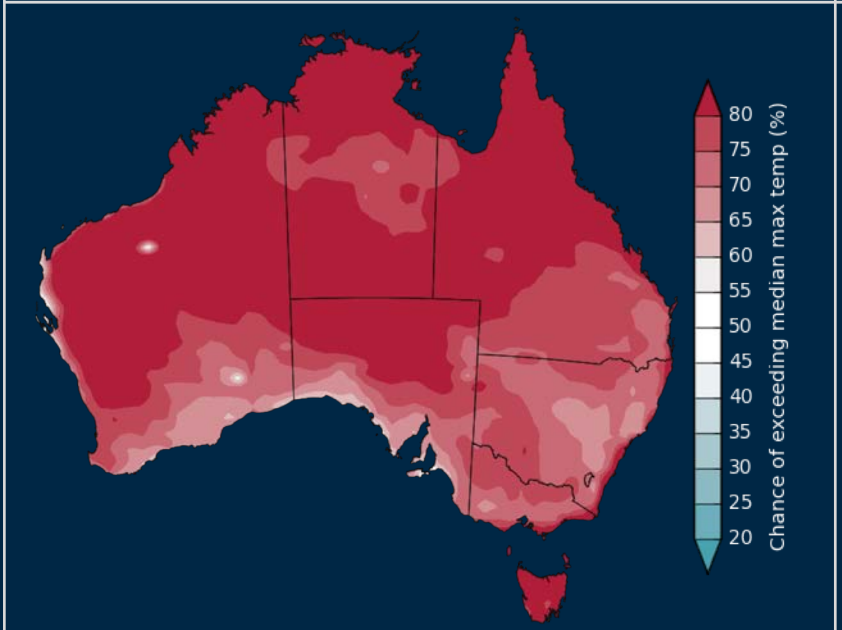
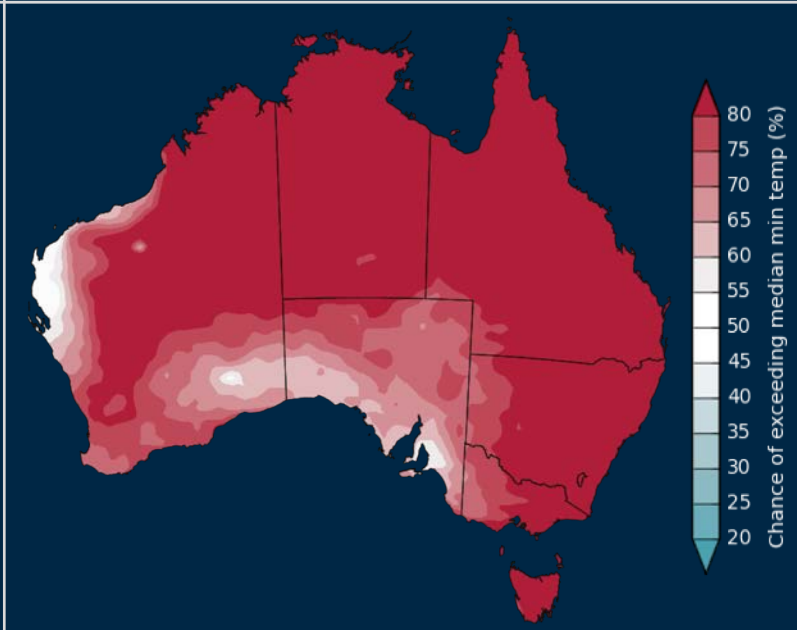
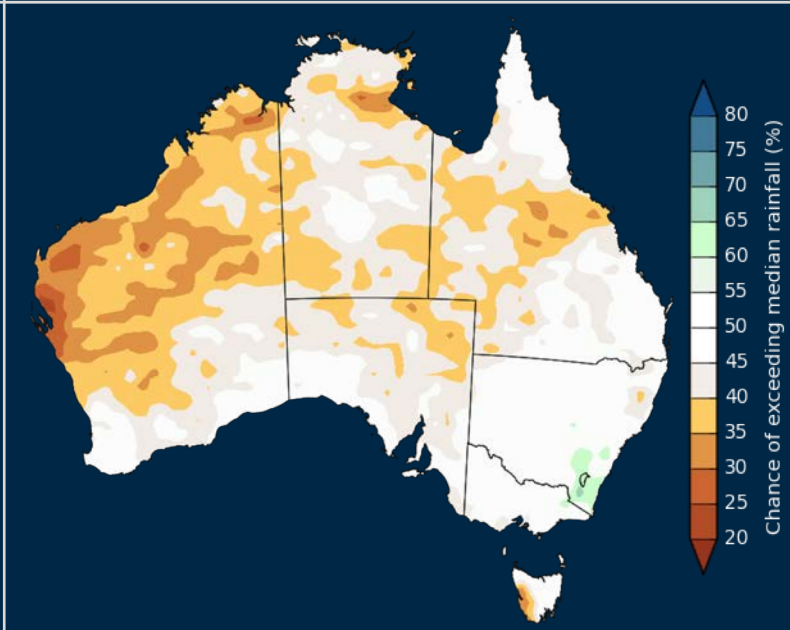
December 2018 – February 2019 outlook

Maximum temperature	Minimum temperature	Rainfall
		

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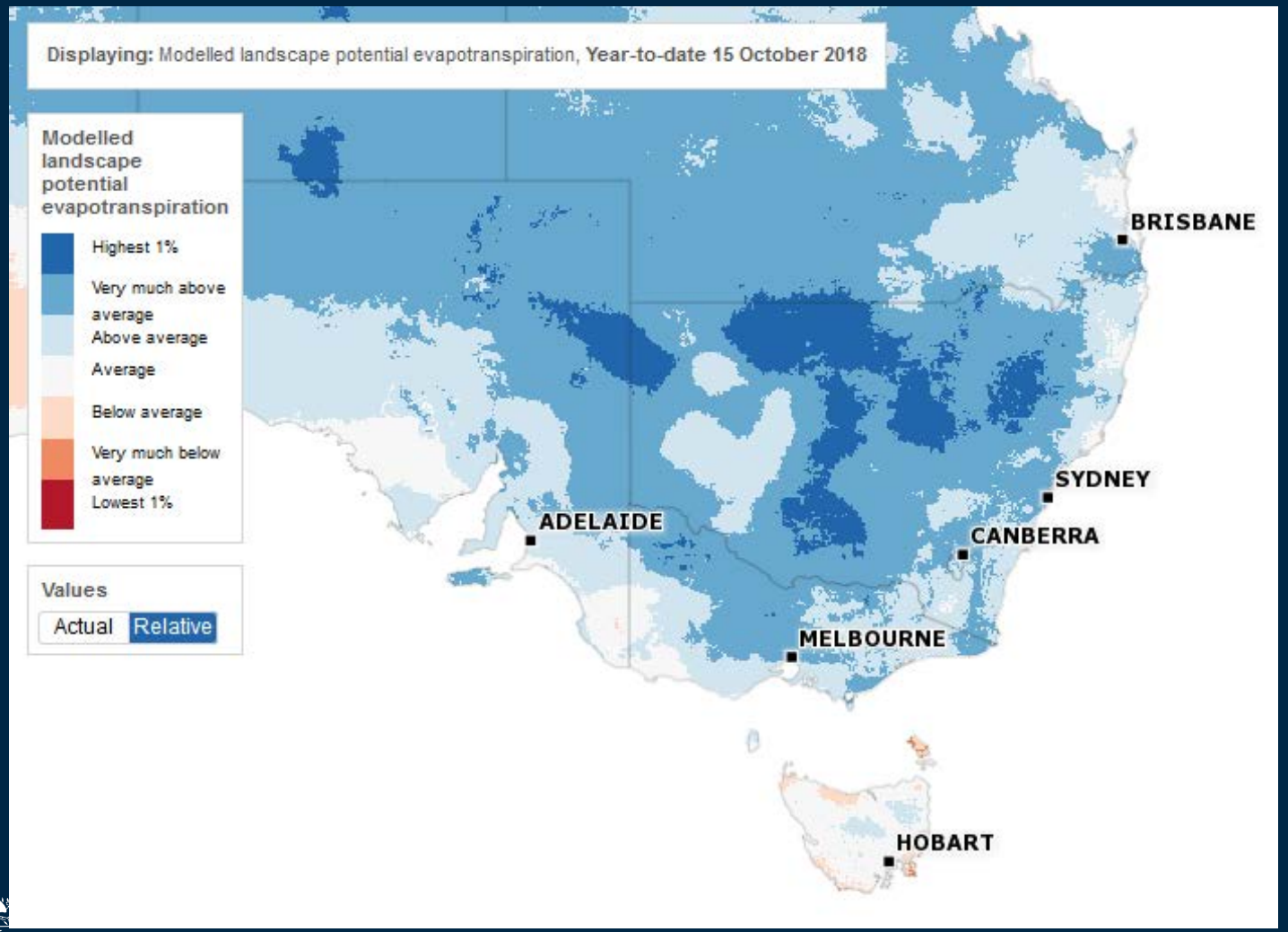
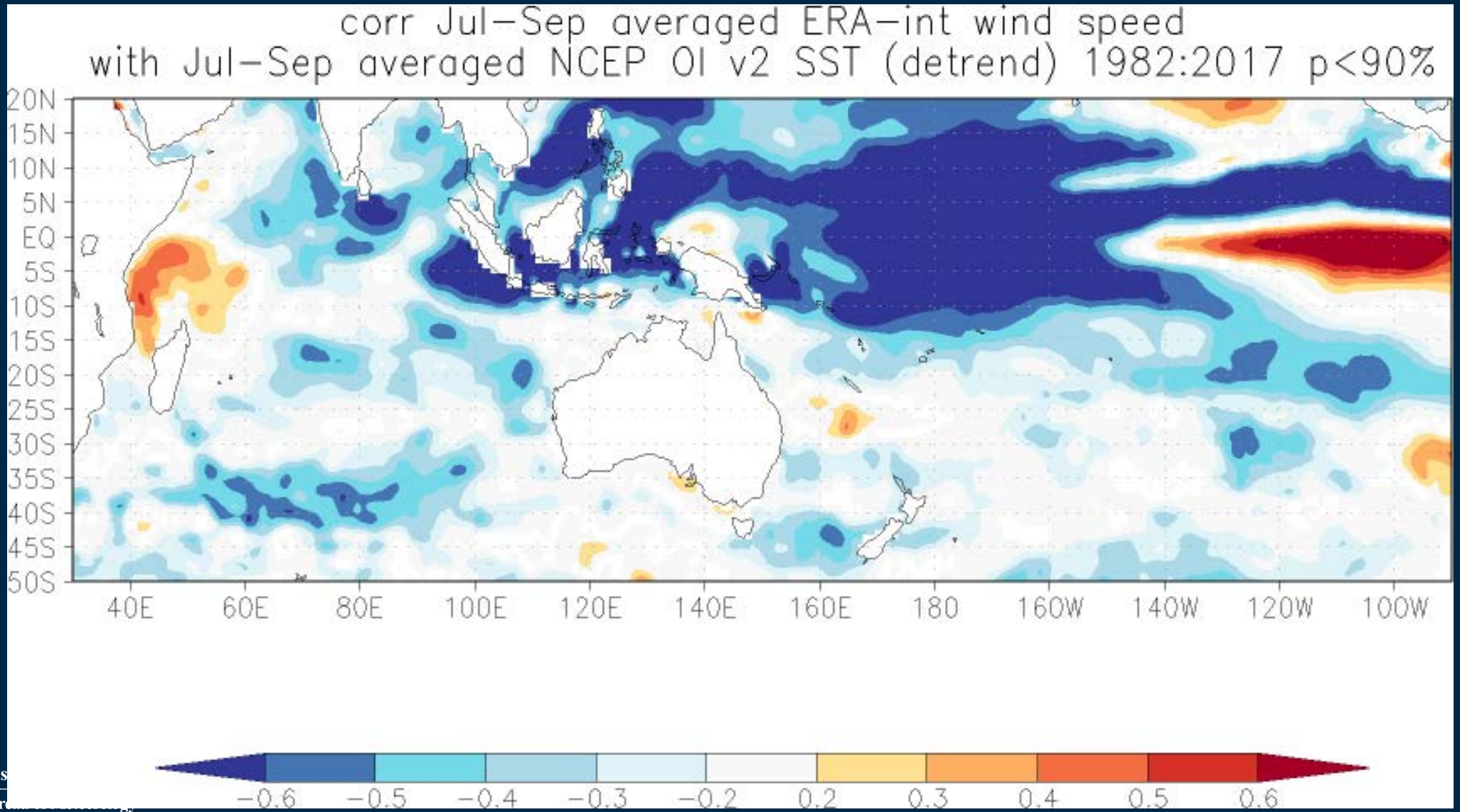
AWRA-L modelled potential evapotranspiration deciles for 2018 year-to-date



Note – AWRA-L is being upgraded, results from the new version will be available ~now.

It includes observed wind estimate, amongst other changes.
Vogel is leading a study on the changes due to wind.

Central-eastAustra windspeed correlated with SST for Jul-Sep



Projected wind