Changes and Projections in the Annual Cycle of the Southern Hemisphere Circulation, Storm Tracks and southern Australian Rainfall

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Australian Government
Bureau of Meteorology

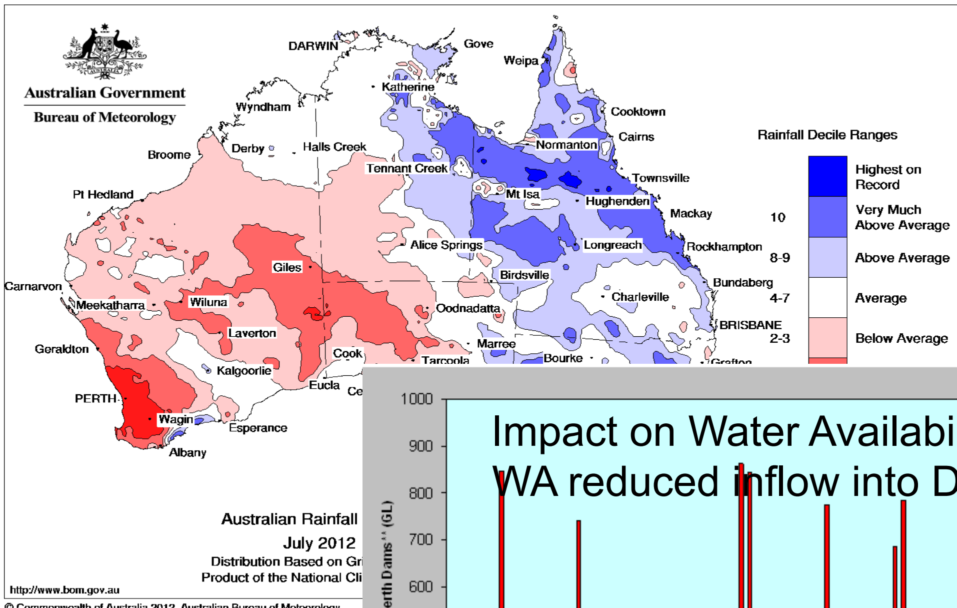
The Centre for Australian Weather and Climate Research
A partnership between the Bureau of Meteorology and CSIRO

CSIRO

Historical and Recent Changes in SWWA Rainfall

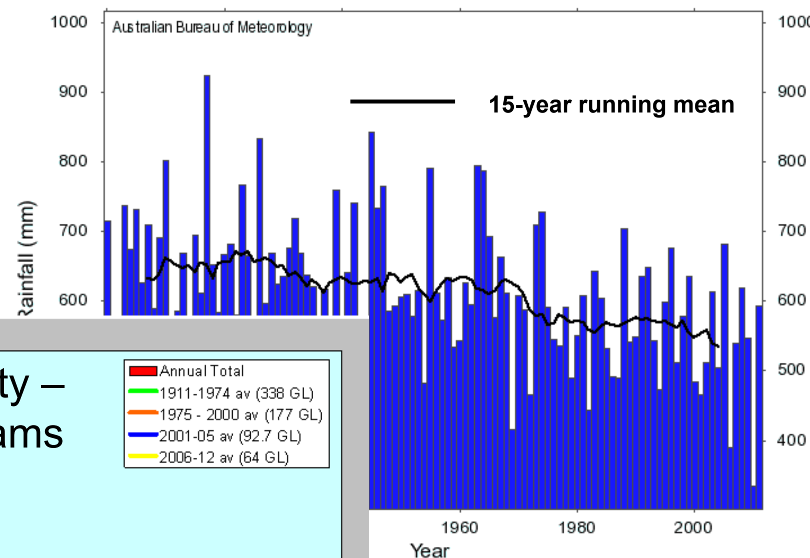
Rainfall Deciles July 2012 :

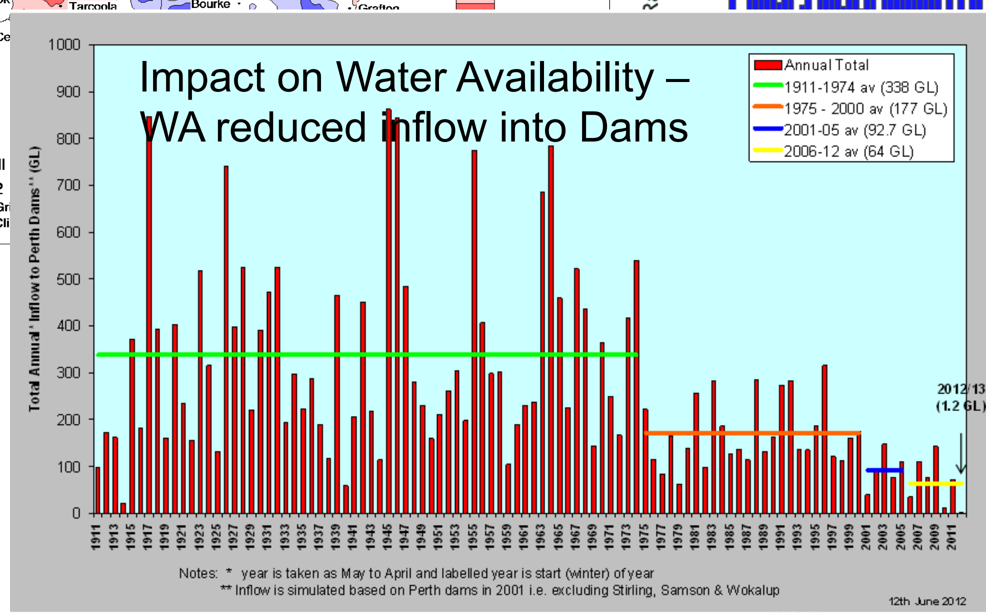
SWWA lowest on record



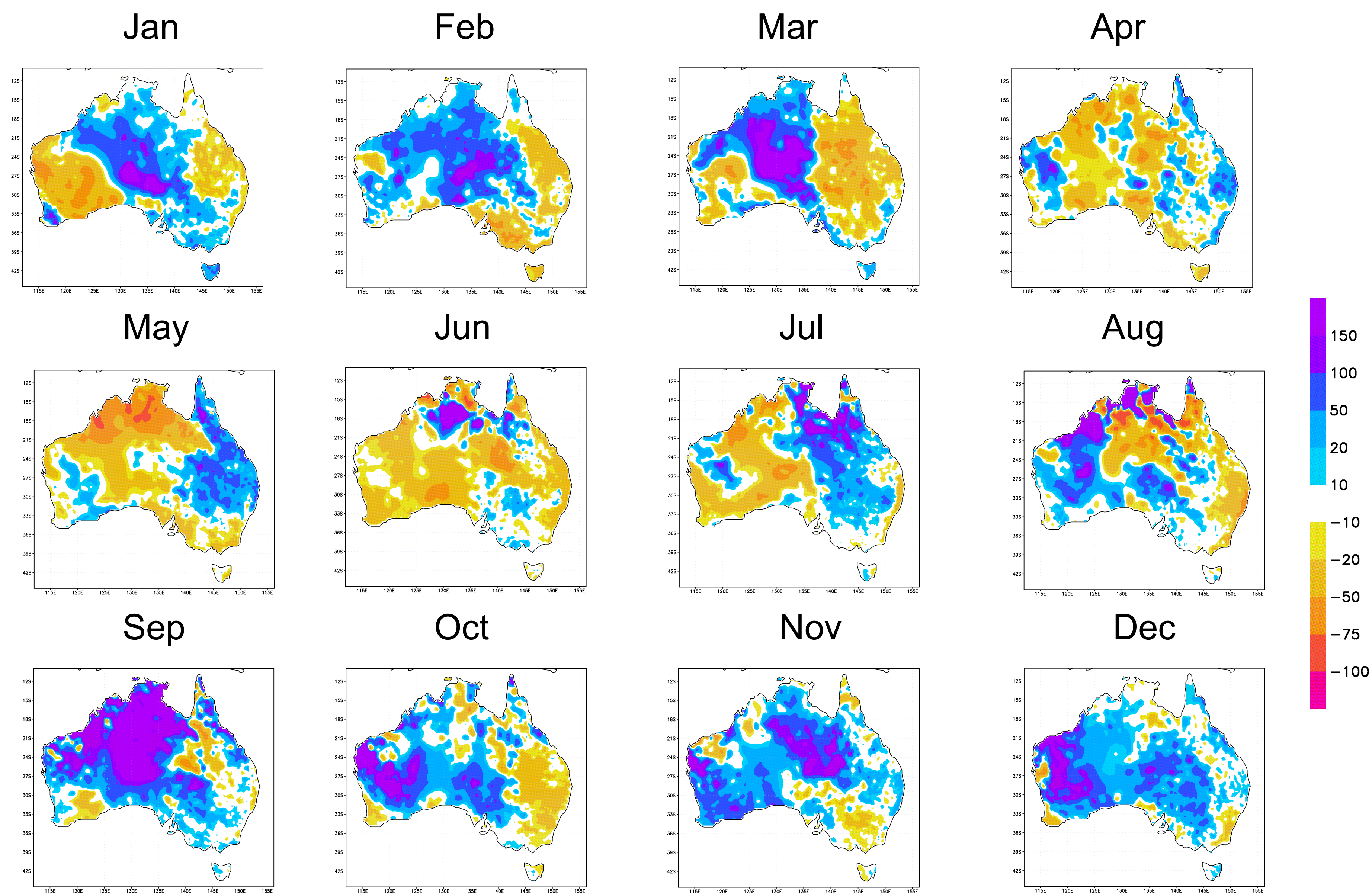
SWWA Rainfall :

May – October (1900-2012)

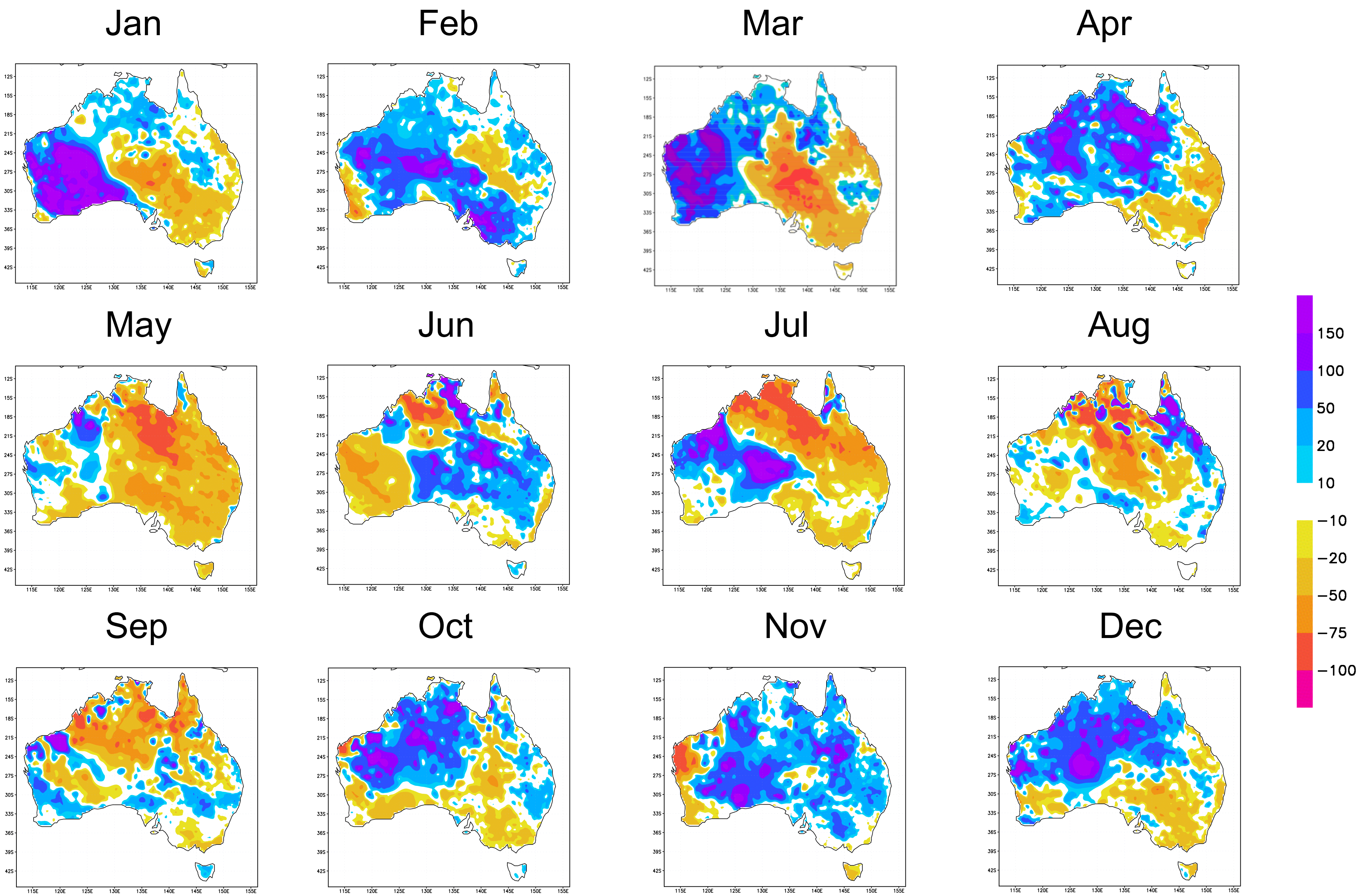




% Changes Rainfall (1975-94) – (1949-68)



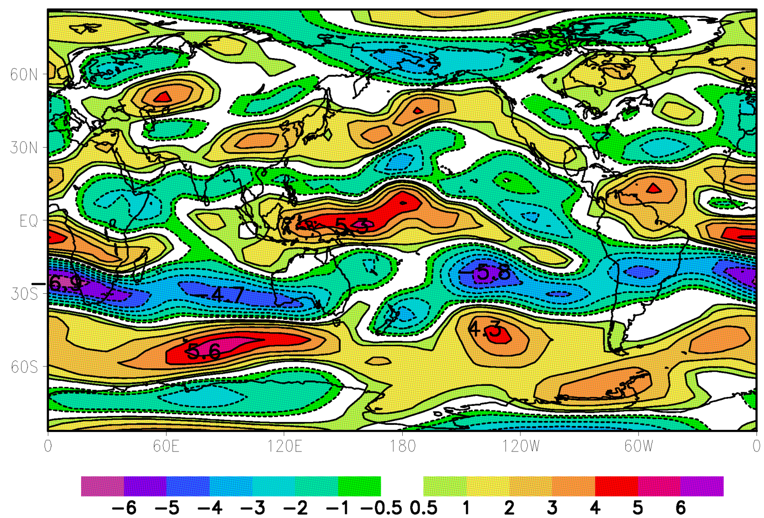
% Change Rainfall (1997-06) – (1975-94)



Changes in Mean Climate of Global Circulation

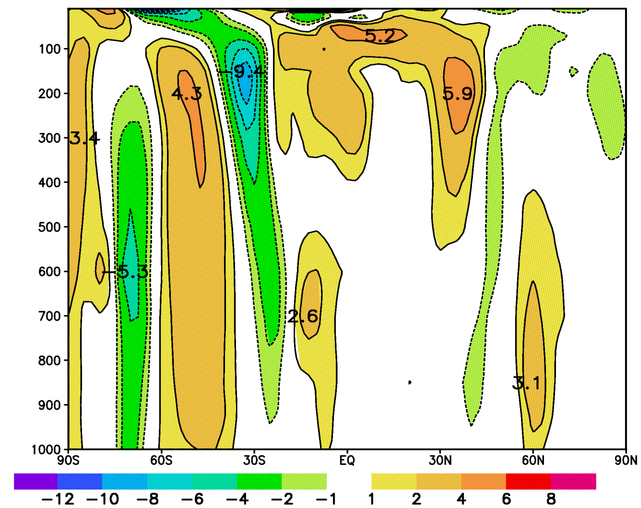
NCEP July Zonal Wind (300hPa) ms^{-1}

(1975–94)–(1949–68)



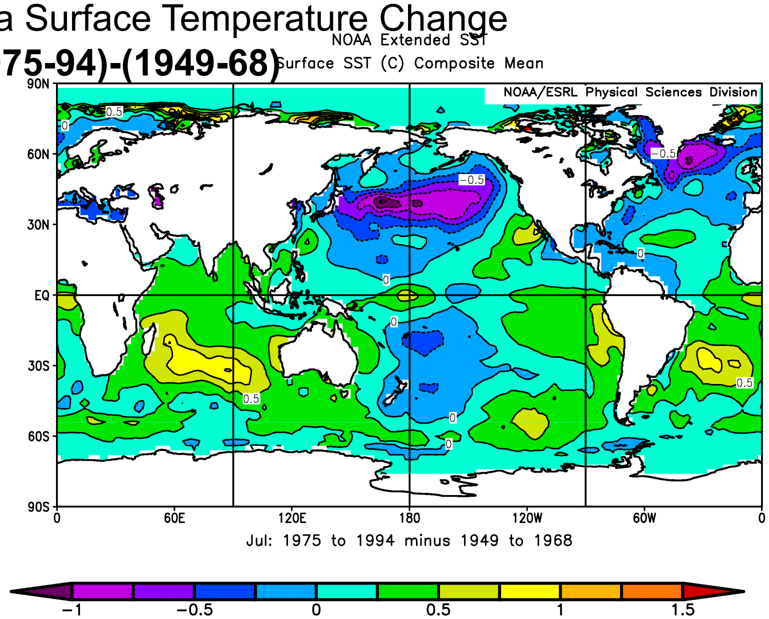
NCEP July Zonal Wind (100E-130E) ms^{-1}

(1975–94)–(1949–68)



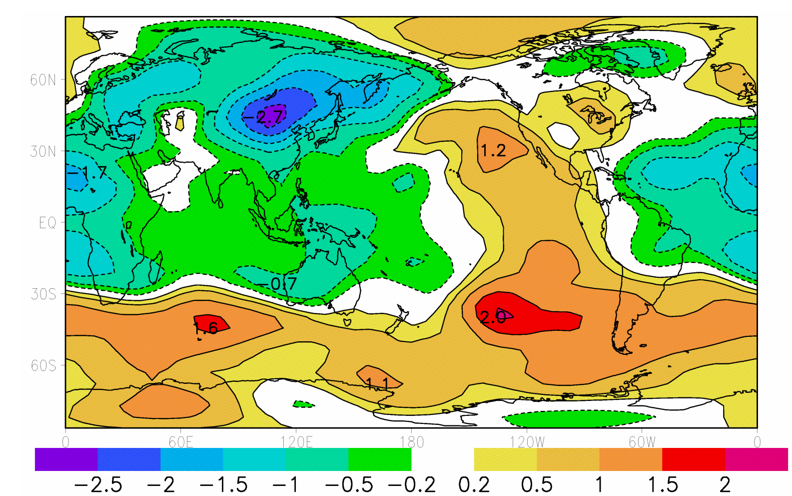
Sea Surface Temperature Change

(1975-94)-(1949-68)



NCEP July Vertical Mean Pot. Temp. °K

(1975–94)–(1949–68)



Annual Cycle in Atmospheric Baroclinic Instability

Phillips Criterion

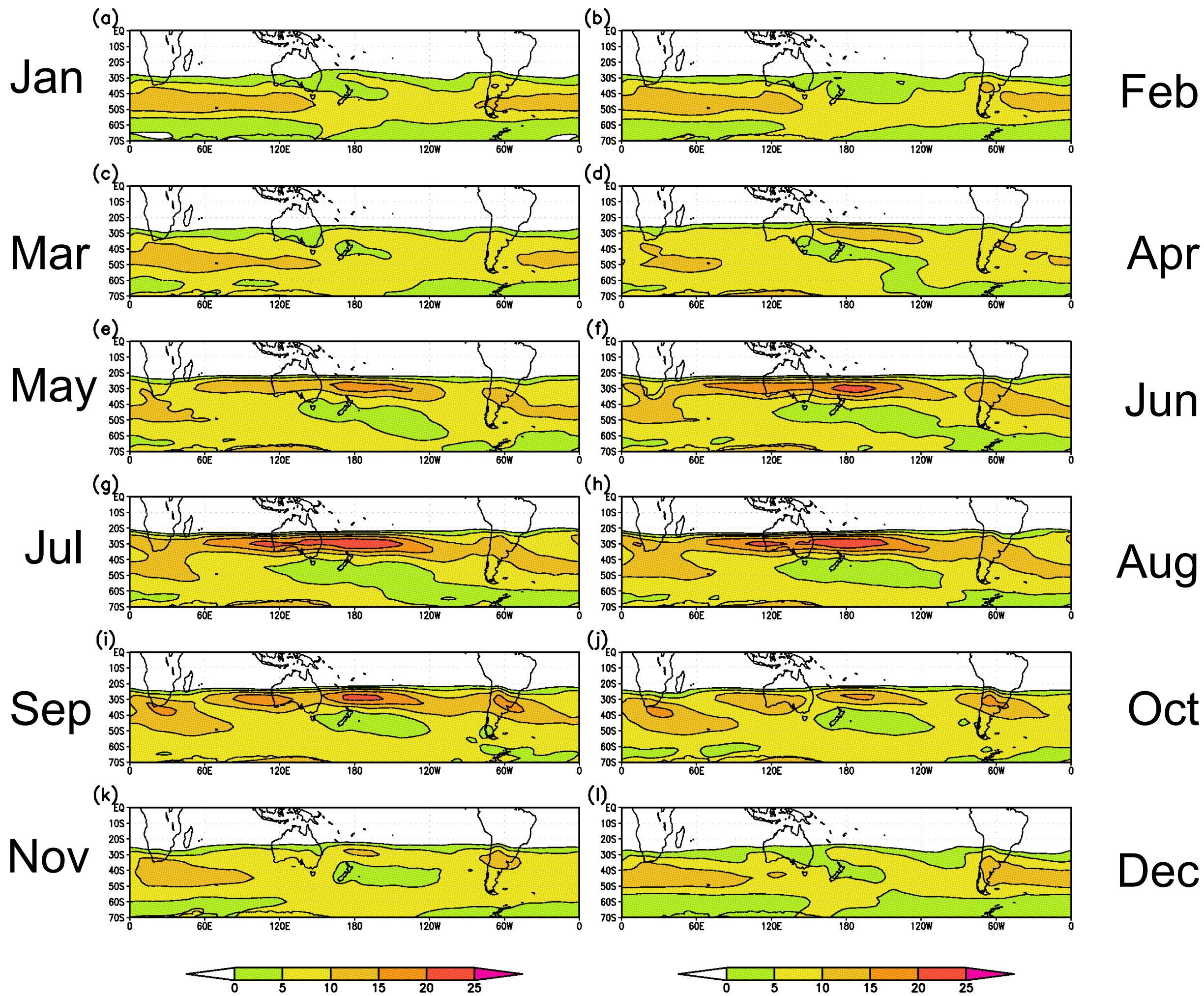
$$\overline{u}^{(1)} - \overline{u}^{(3)} - \frac{b_{\kappa} c_p \overline{\sigma}}{a\Omega} \frac{(1-\mu^2)^{1/2}}{\mu^2} \geq 0,$$

$\overline{u}^{(1)}$ **300hPa zonal wind**

$\overline{u}^{(3)}$ **700hPa zonal wind**

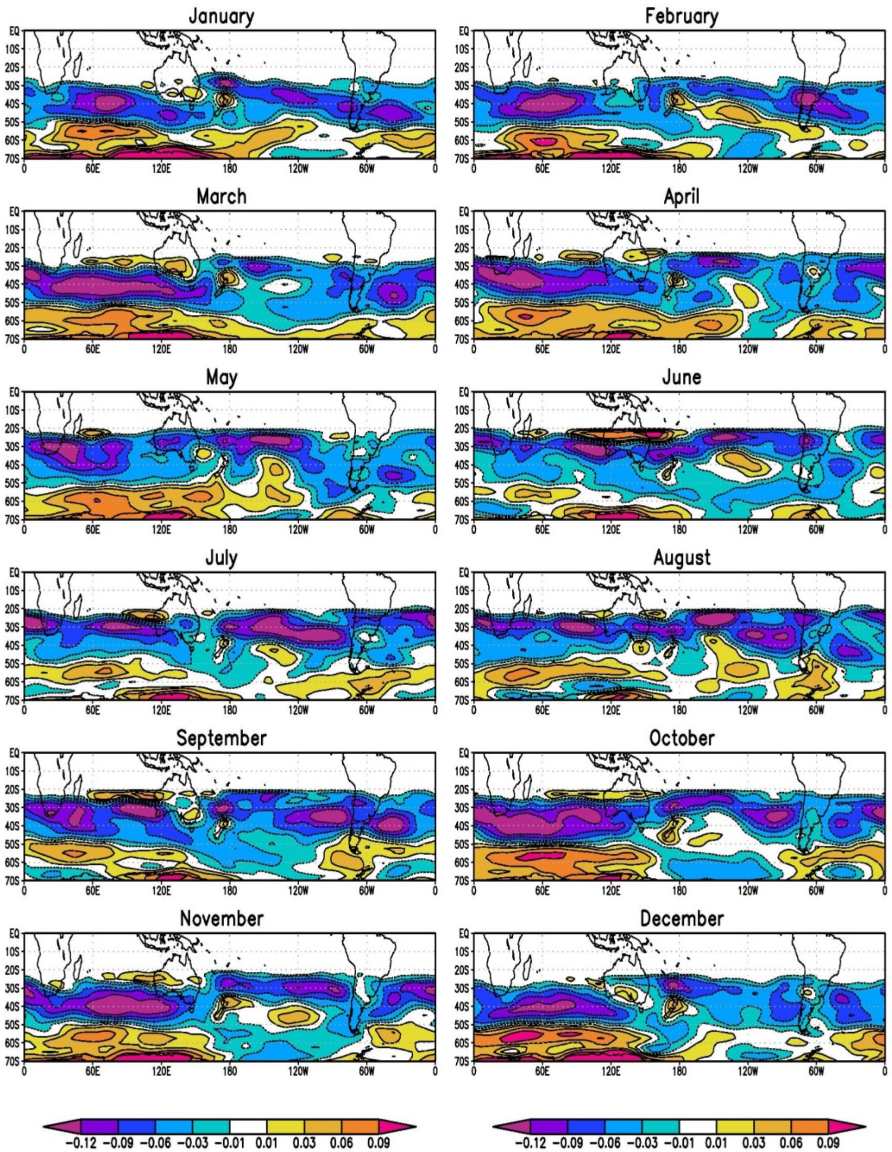
$\overline{\sigma}$ **300hPa - 700hPa shear potential temperature**

Phillips Criterion (m/s)

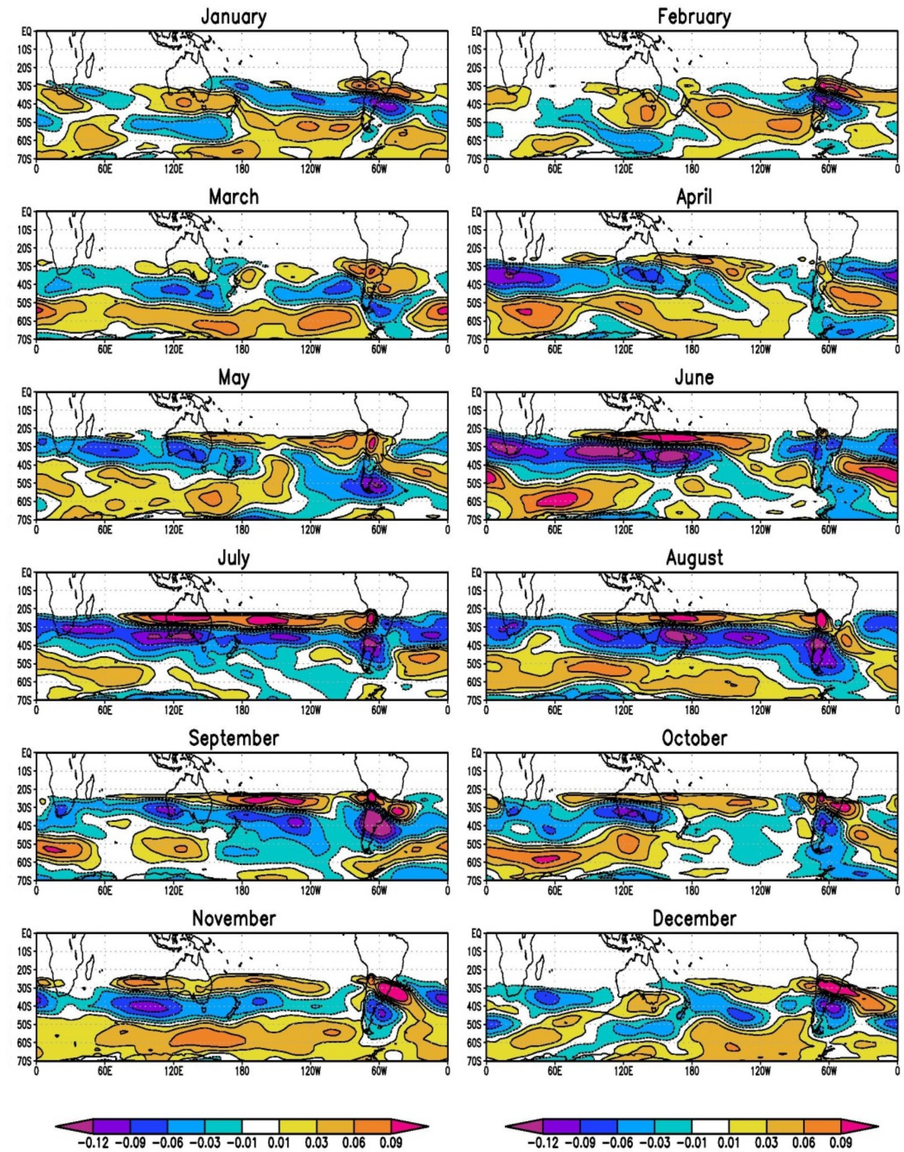


Trends in Atmospheric Baroclinic Instability (m/s/year)

NCEP Trend 1950-99



20CR Trend 1950-99



Changes in Storm Track Modes : July

Methodology

3D Primitive Equation Instability Model:

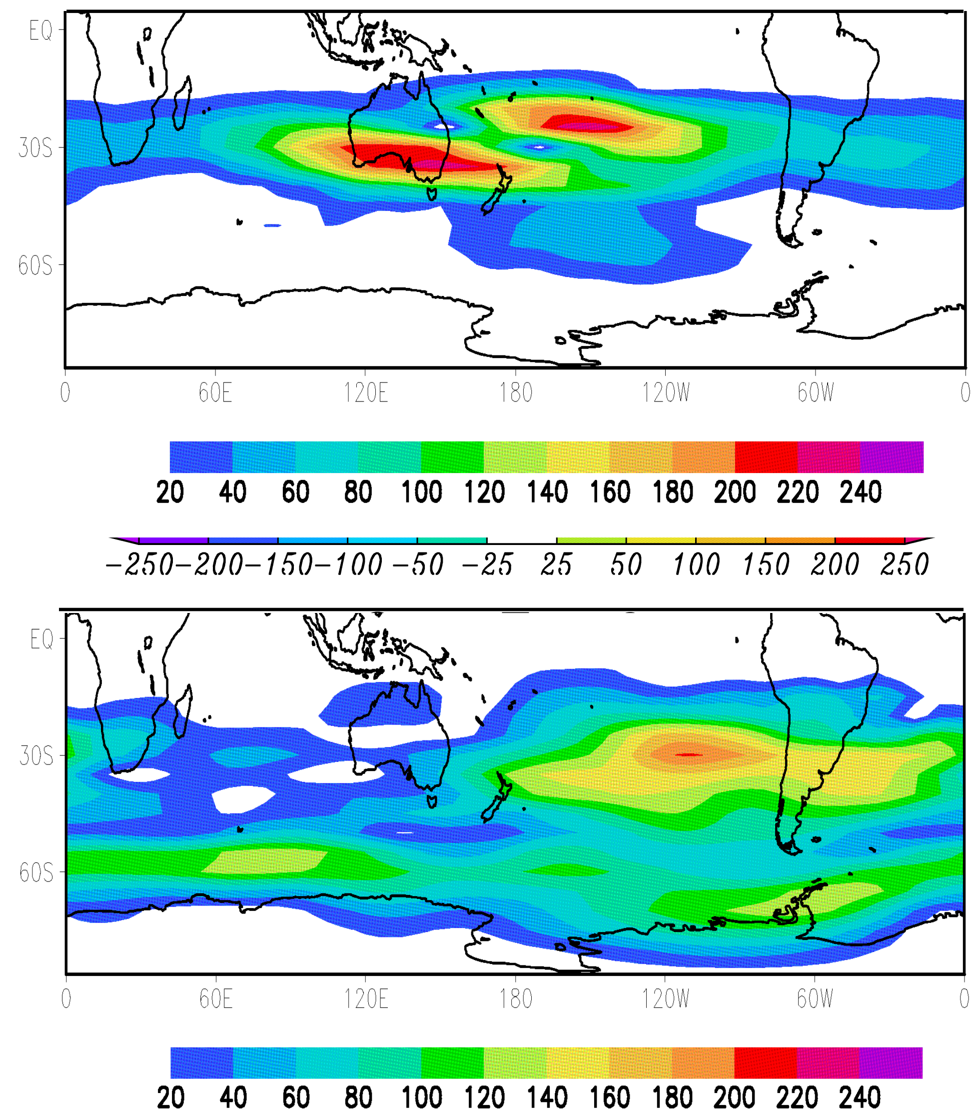
Solve a large eigenvalue problem for disturbances growing on the Climate Basic States for periods (1949-68), (1975-94) and (1997-2006).

*Frederiksen and Frederiksen, 2007: "Interdecadal changes in Southern Hemisphere winter storm track modes" Tellus, **59** A, 599-617.*

1949-68: Type 1 weather system predominates and has large impact on Southern Australian rainfall

1975-94: Growth Rate of Type 1 has continually decreased (~33%) and Type 2 is equally likely to occur

1997-2006: Type 1 is even less likely to occur (Growth Rate reduced by ~37%)



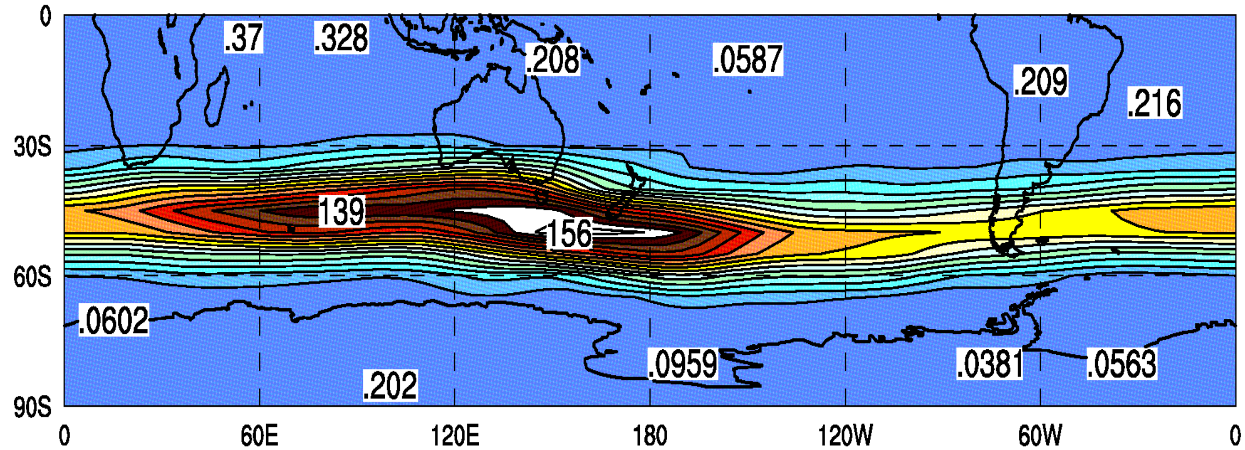
Amplitude

Changes in Storm Track Modes : January

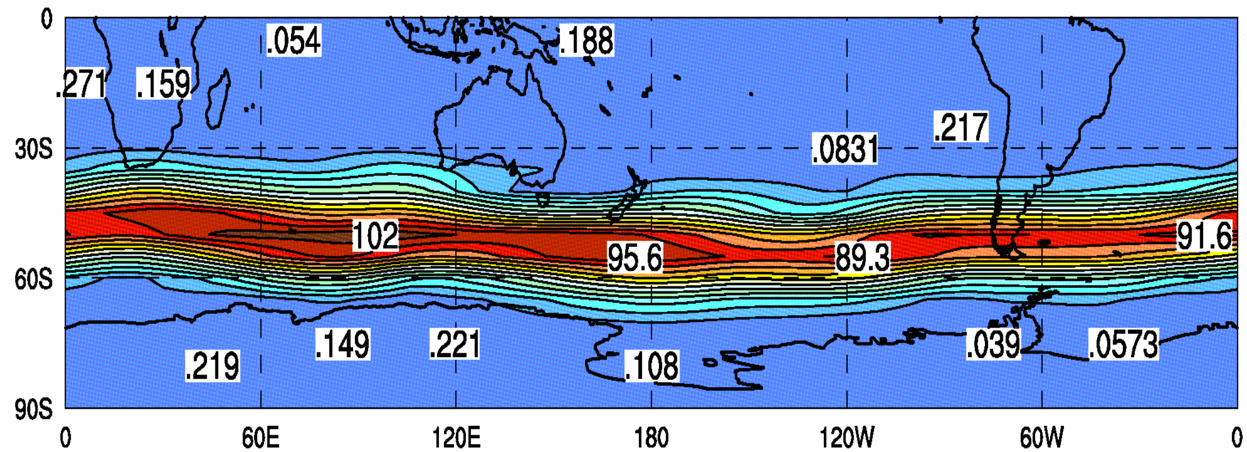
Amplitude

700hPa Streamfunction

(1949 to 1968)



(1997 to 2006)



In Summer (January) there is a poleward shift in the location of the dominant mid-latitude storms. Unlike for winter, the reduction in growth rate (likelihood) of these storm is only modest compared to (1949-1968) – 9% for (1975-1994) and 4% for (1997-2006)

Dominant Mid-latitude Storms – Autumn (April)

700hPa Streamfunction (1949 to 1968)

1949-68: Storm Type 1 and Type 2 have very similar growth rates and are equally likely to occur

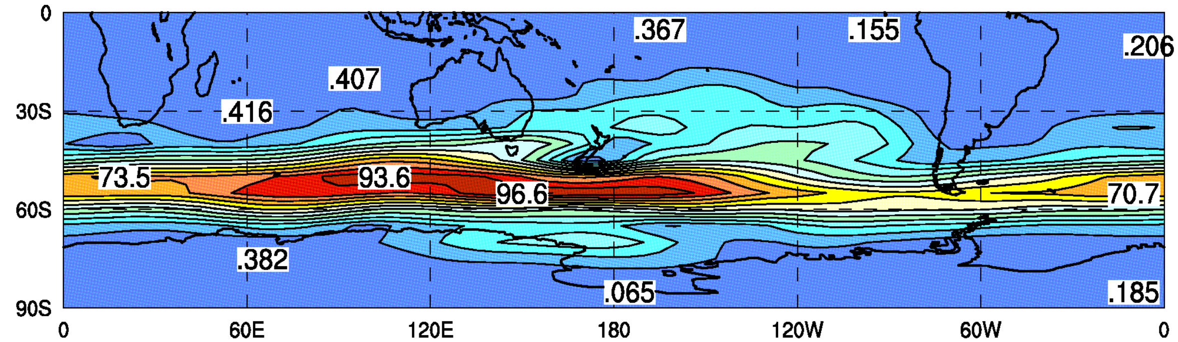
Type 2 has more impact on southern Australia than Type 1

(1975 to 1994)

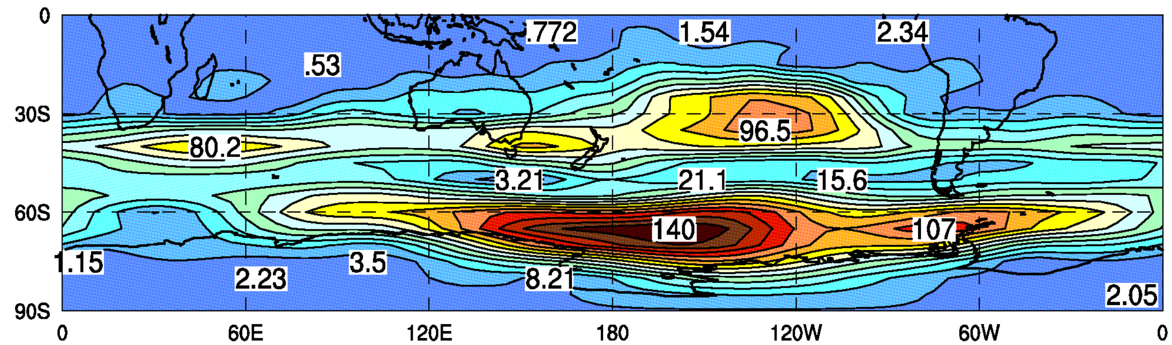
1975-94: Type 1 predominates – increase of 11% in growth rate.

Growth rate for Type 2 reduced by 21%

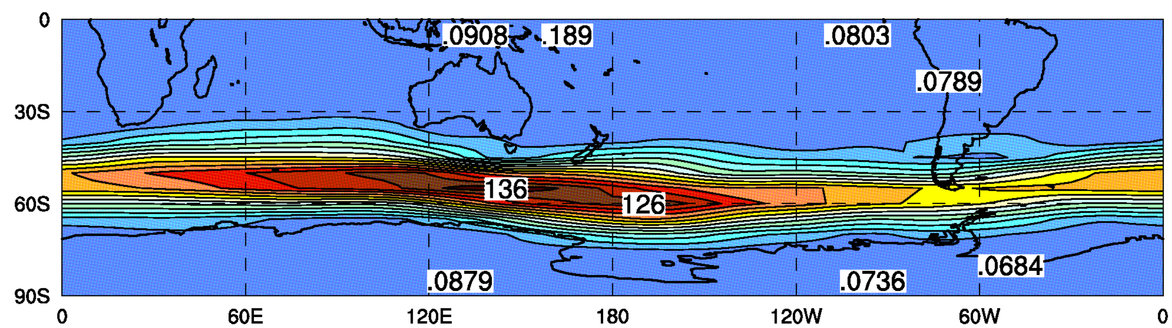
Storm Type 1



Storm Type 2



Storm Type 1



Dominant Mid-latitude Storms – Autumn (April)

700hPa Streamfunction (1949 to 1968)

1949-68: Storm Type 1 and Type 2 have very similar growth rates and are equally likely to occur

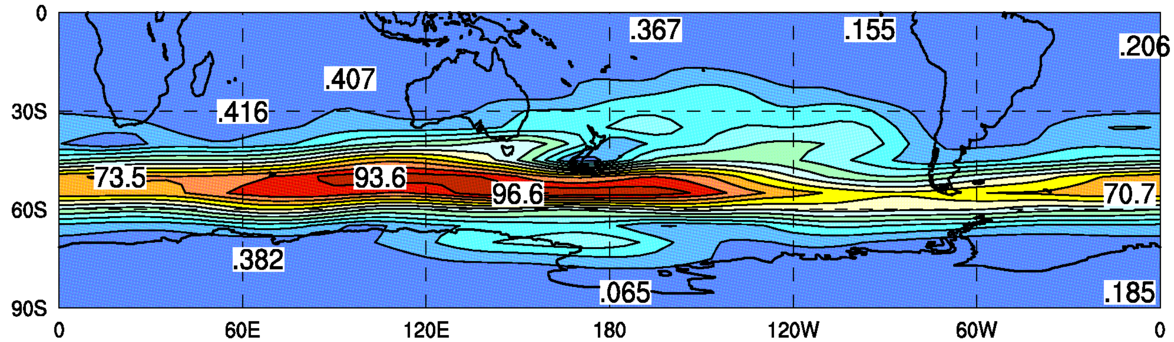
Type 2 has more impact on southern Australia than Type 1

(1997 to 2006)

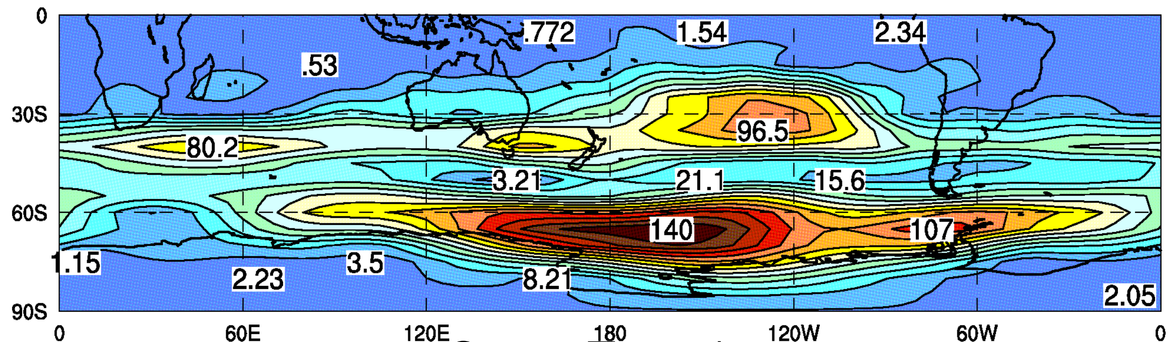
1997-06: Type 1 predominates – increase of 11% in growth rate.

Growth rate for Type 2 reduce by 14%

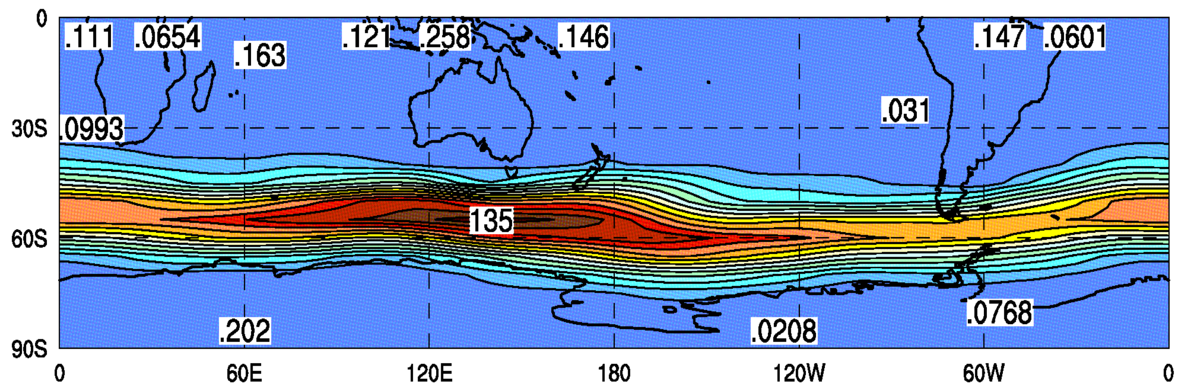
Storm Type 1



Storm Type 2



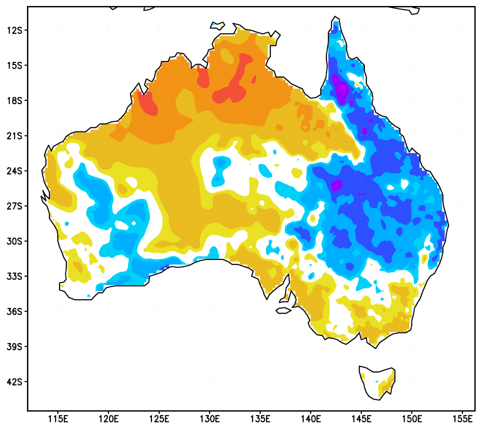
Storm Type 1



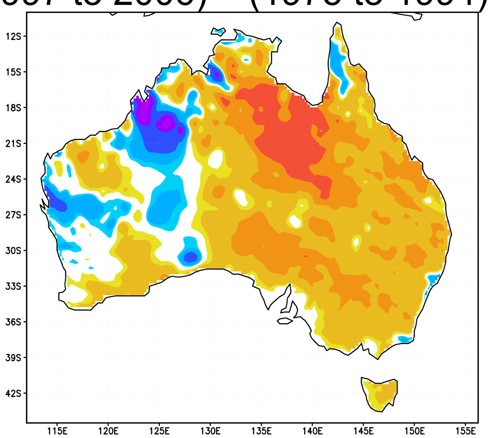
Streamfunction Amplitudes of Storms for May

% Change May Rainfall

(1975 to 1994) – (1949 to 1968)



(1997 to 2006) – (1975 to 1994)



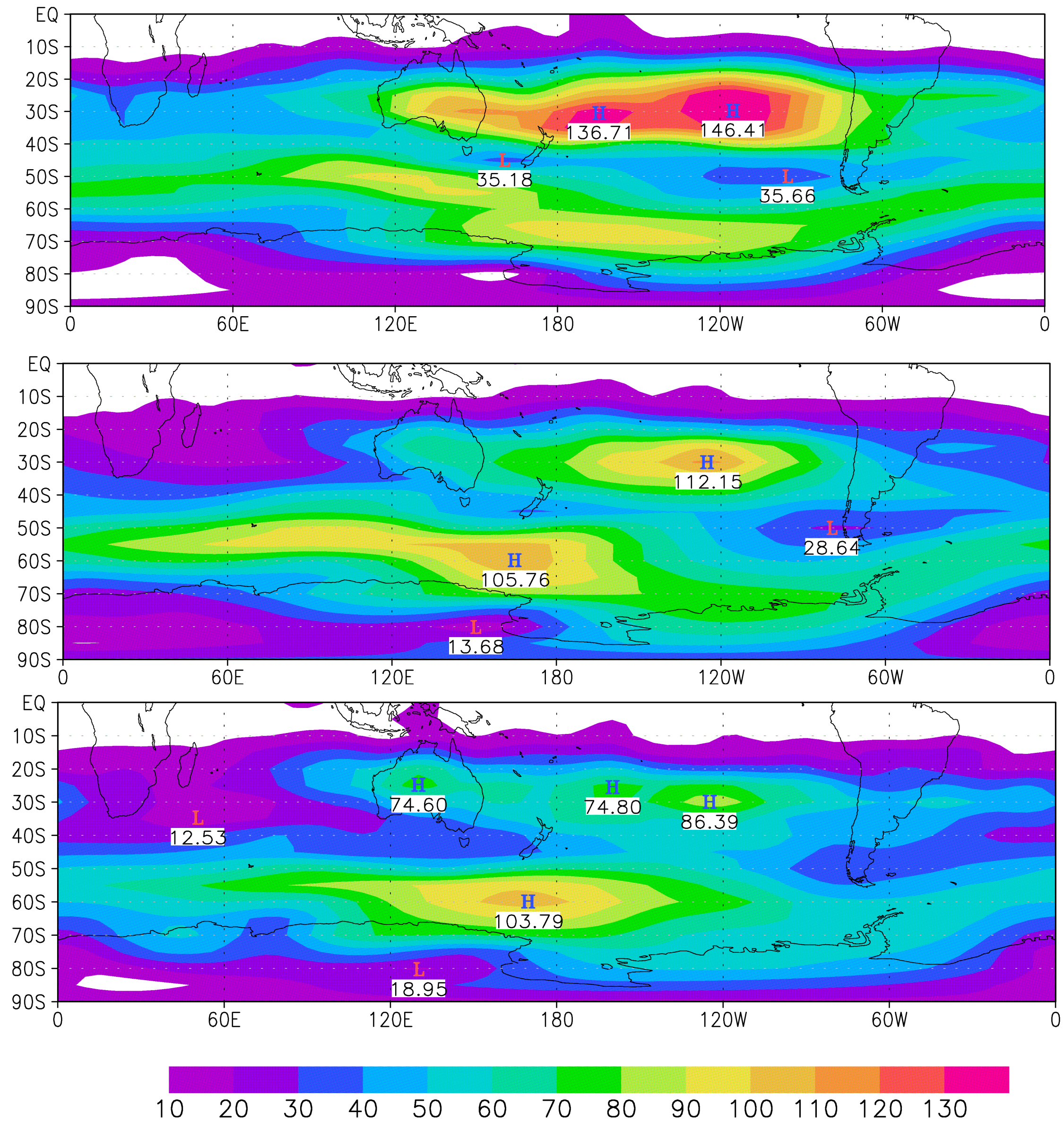
Storms weaken and move from sub-tropical jet to polar jet

300hPa RMS Streamfunction (av. 20 modes)

1949-68

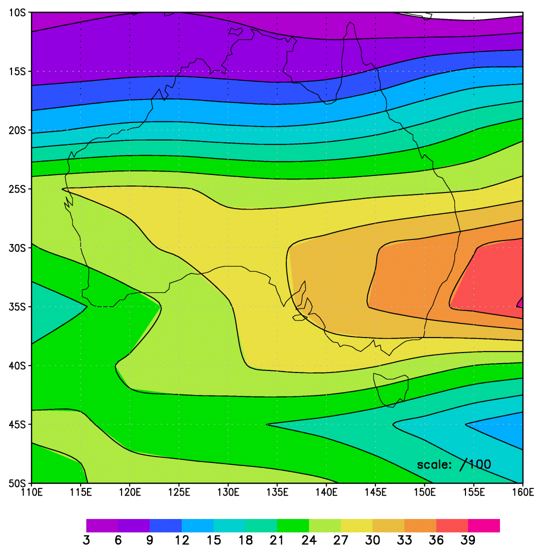
1975-94

1997-2006

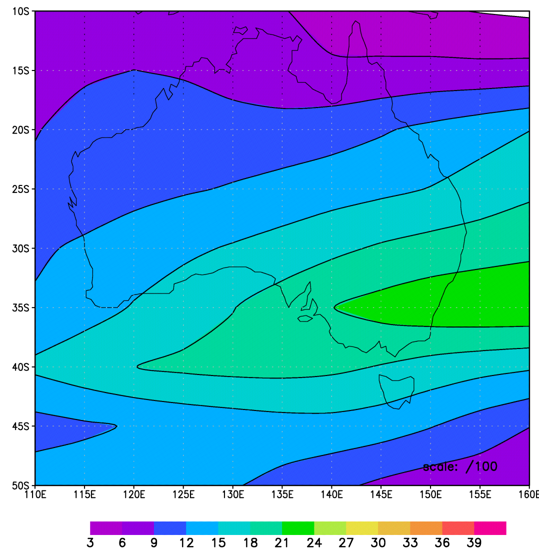


700 hPa Divergence Amplitude

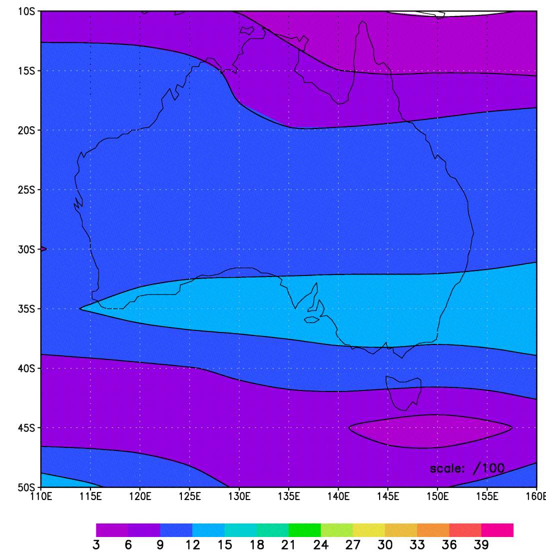
1949-68



1975-94



1997-2006



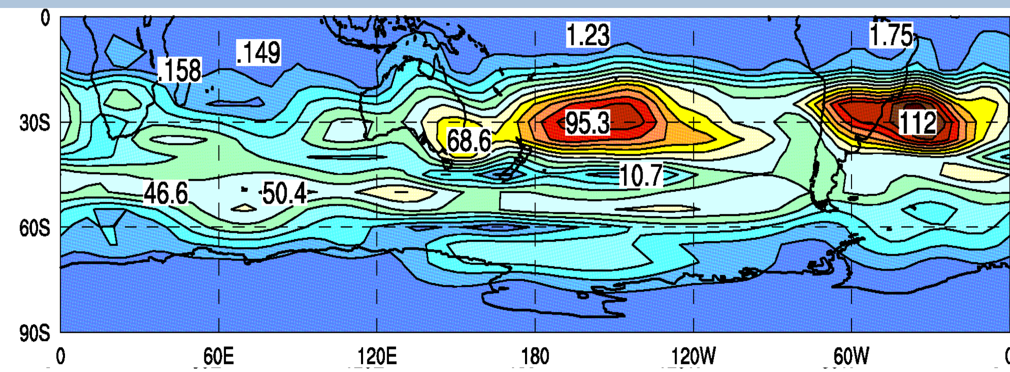
Divergence is proportional to Rainfall

Dominant Mid-latitude Storms – Spring (October)

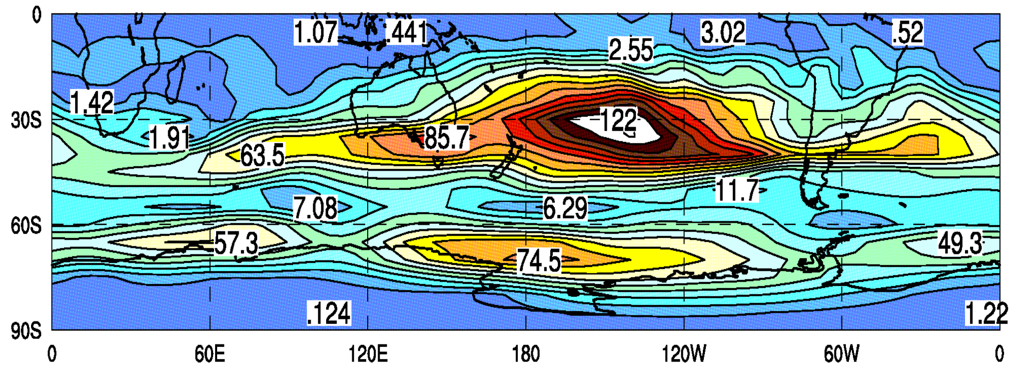
700hPa Streamfunction

In Spring (October) the structure of the dominant mid-latitude storms are quite different between the three periods. By 1997-2006, the storms track to the south of Australia. There is only a modest reduction in growth rate (likelihood) of these storm compared to (1949-1968) – about 5% for (1975-1994)

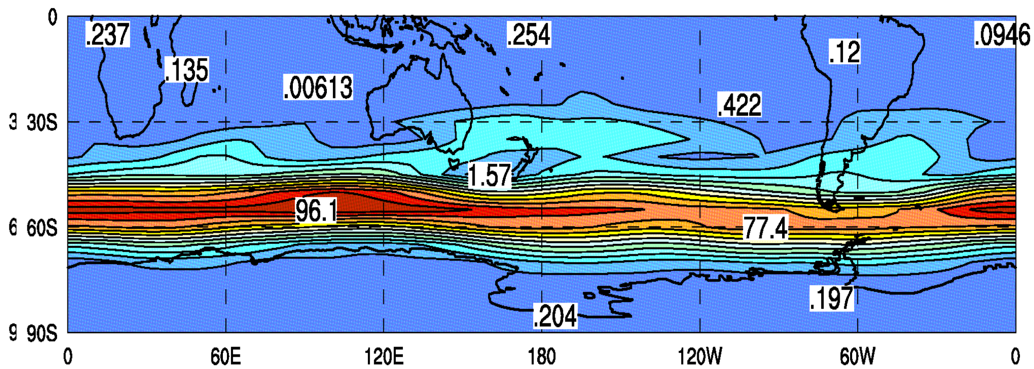
(1949 to 1968)



(1975 to 1994)

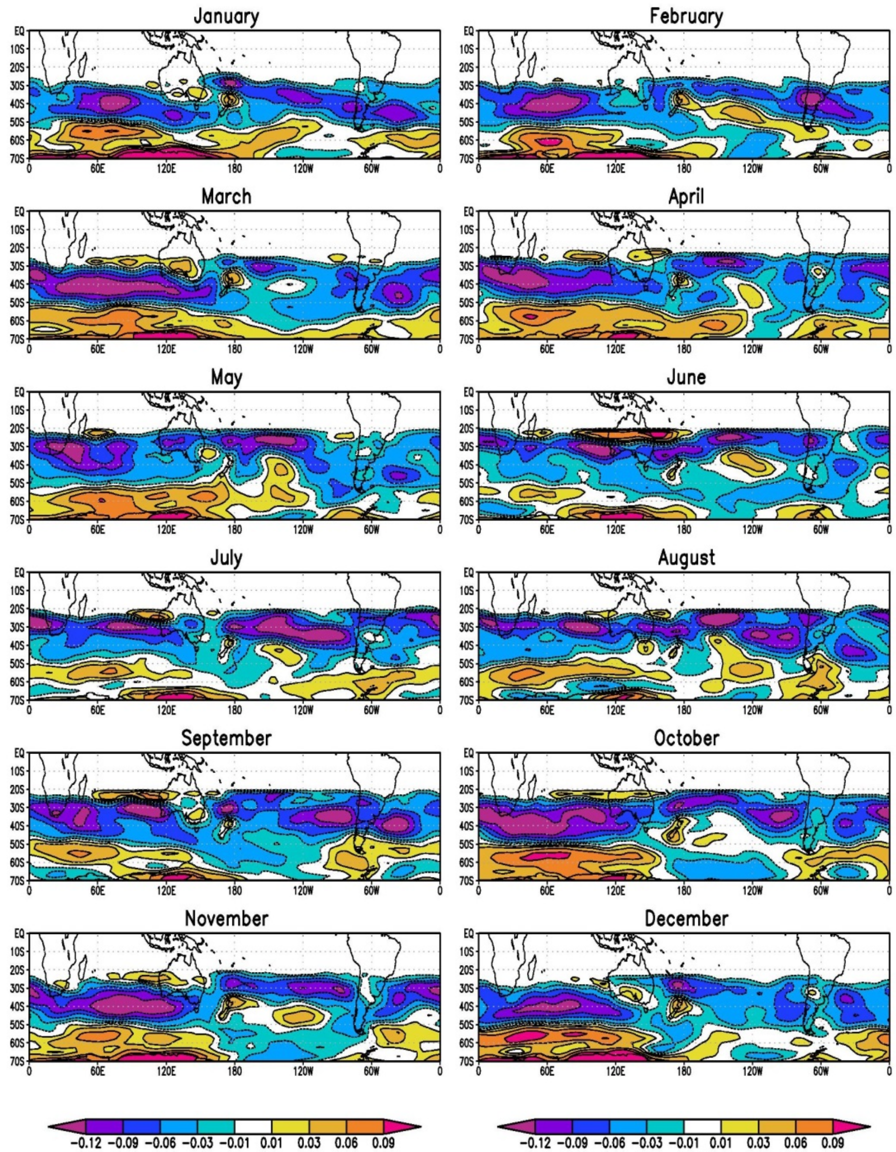


(1997 to 2006)

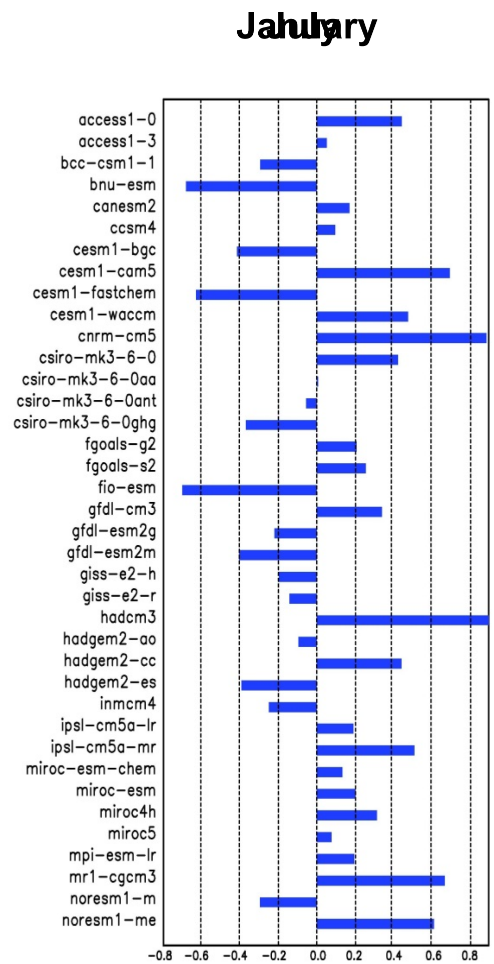


CMIP5 Trends in Baroclinic Instability (m/s/year)

Trend 1950-99

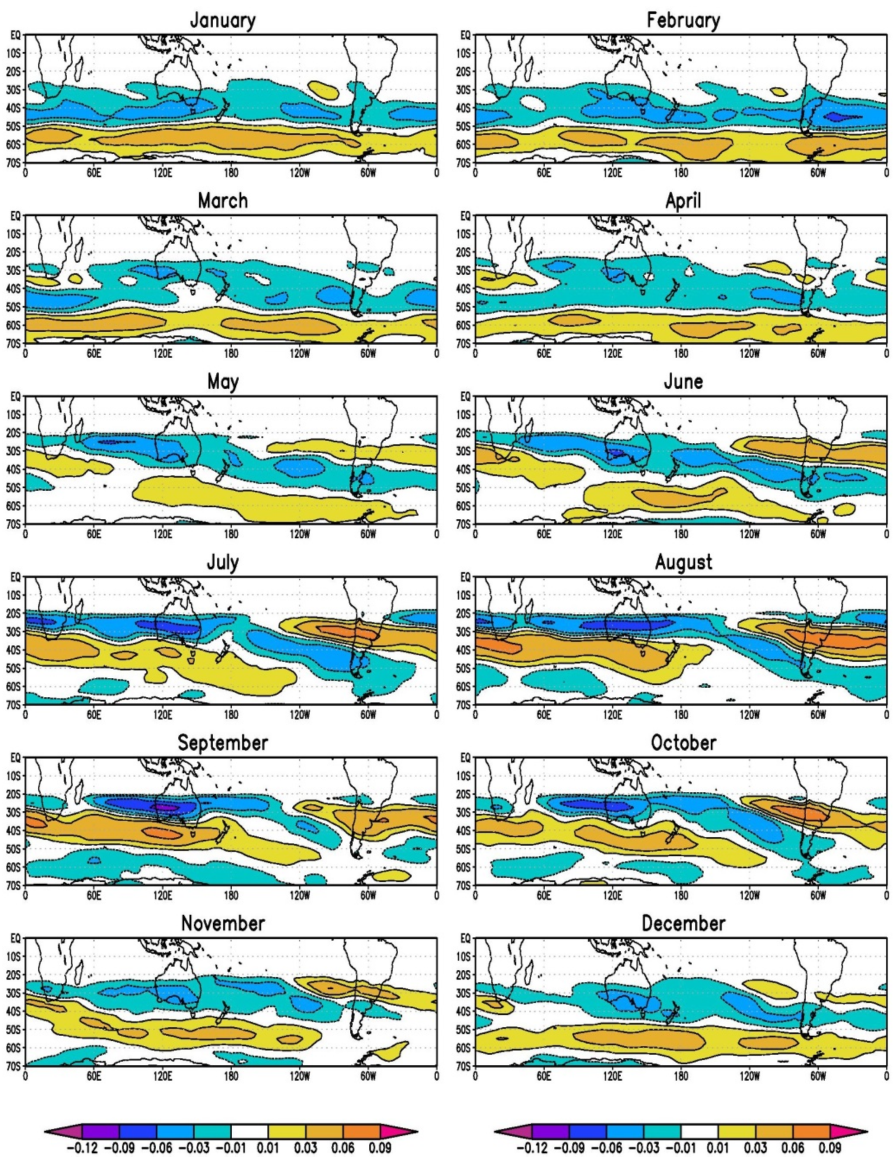


Anomaly Pattern Correlation : CMIP5 Models (60E-150E, 50S-20S)

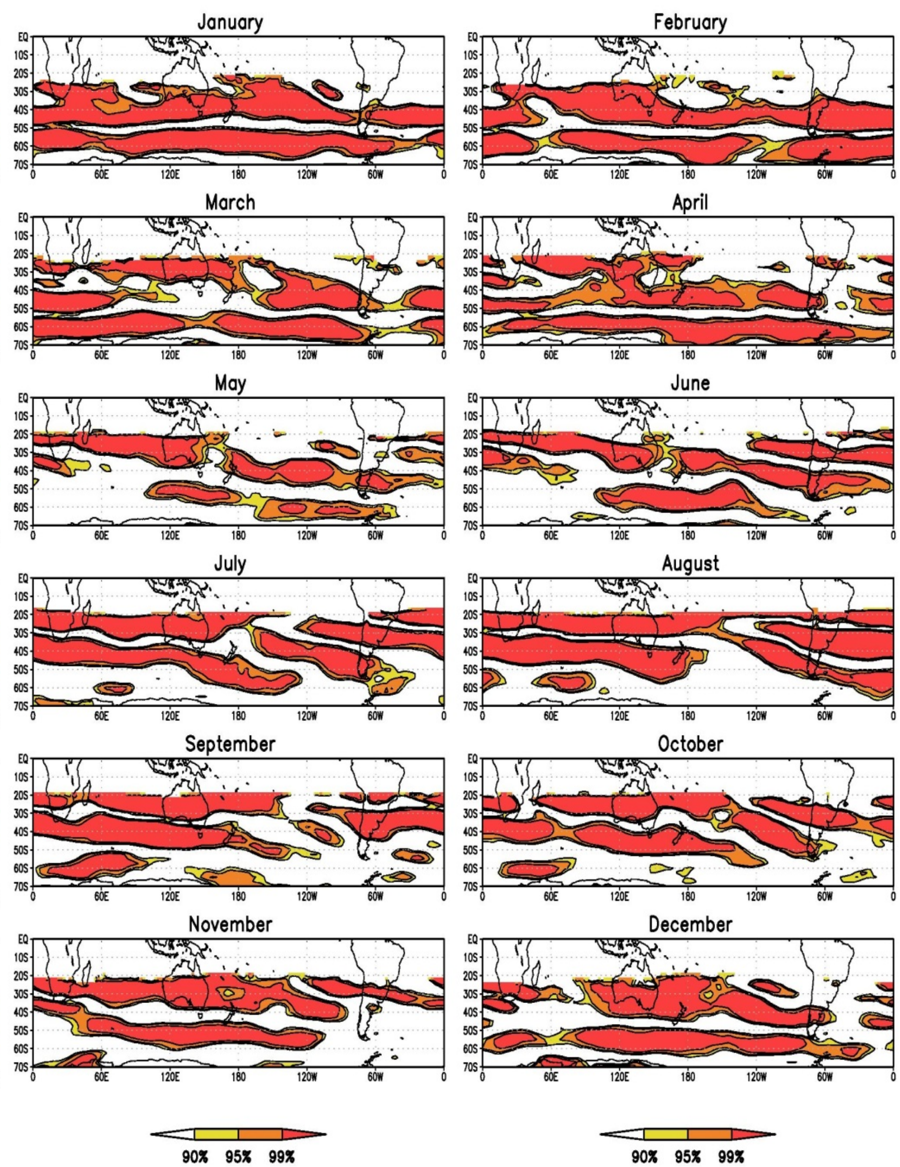


Projection RCP85 : Phillips Criterion

Trend 2050-99



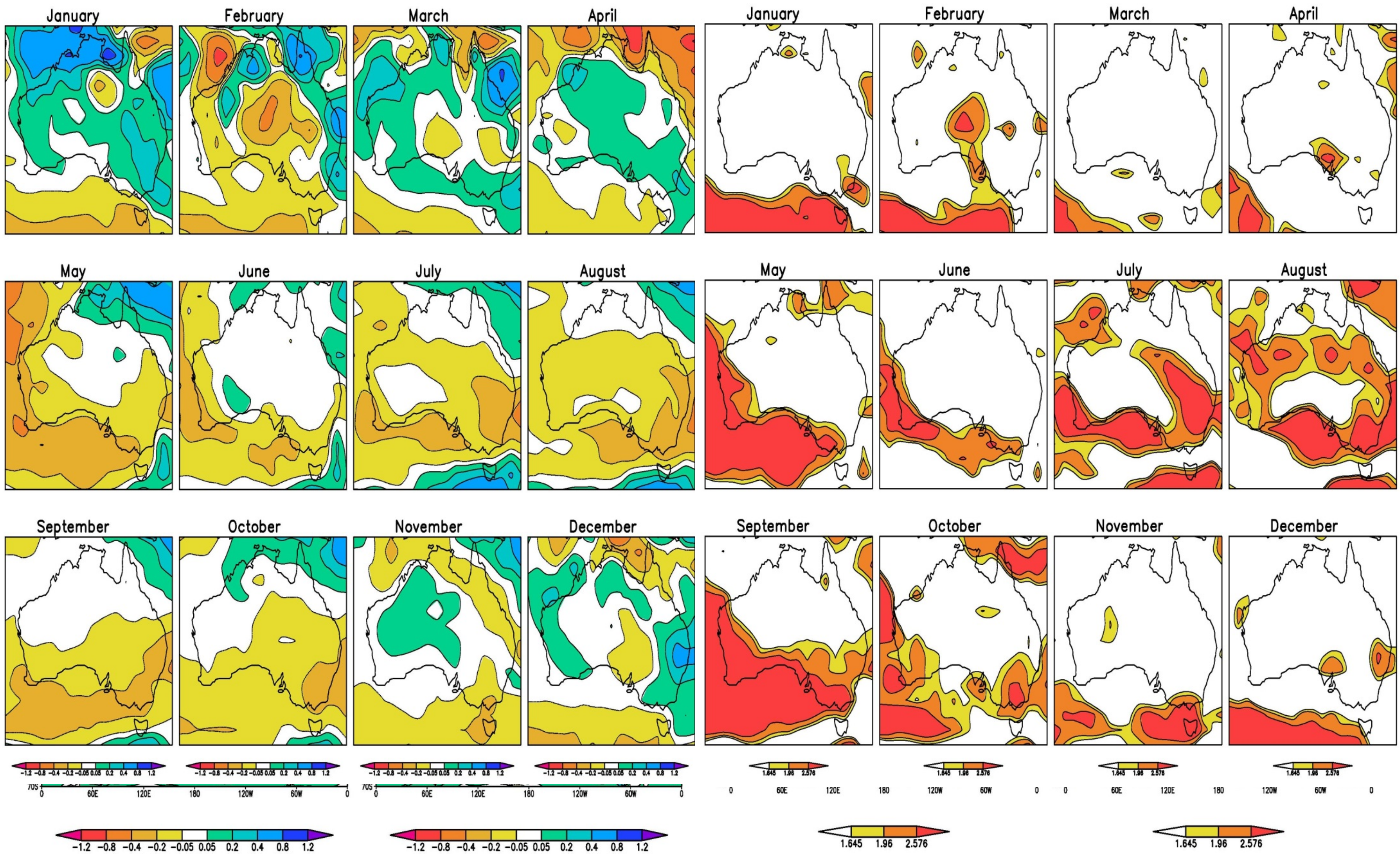
Statistical Significance



Projection RCP85 : Precipitation

Trend 2050-99 **(mm/month/year)**

Statistical Significance



Thank you

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