

# Urban Water Security Research Alliance



## **Dynamical Downscaling of Rainfall over South East Queensland**

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**Climate and Water Project**

**18 August 2009**



# Dynamical downscaling of rainfall over South East Queensland

## Reasons for downscaling

- provides forcing from detailed orography of the region of interest
- Provides extra diagnostic variables not available in observations

## Background of rainfall climatology over SEQ

## Two downscaling simulations

### 1) NCEP Reanalysis :

provides “ideal” initial and boundary conditions and provides bench-mark of the model performances

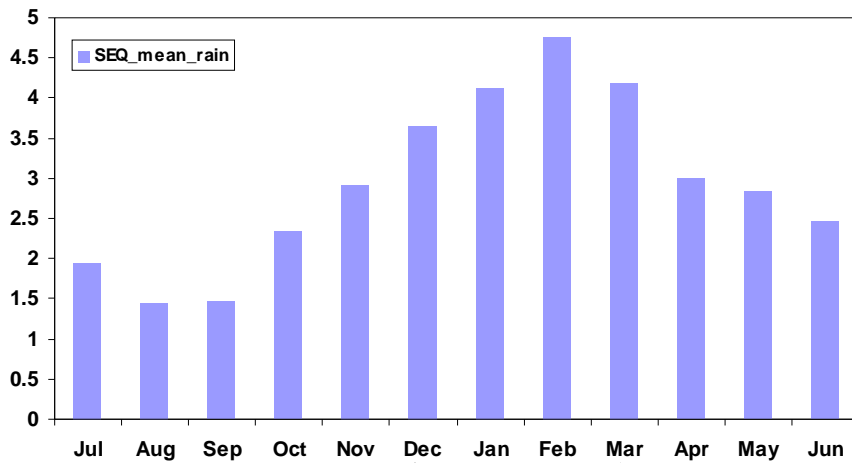
### 2) CSIRO Mk 3.5 GCM :

imperfect initial and boundary conditions - permits study of future climate

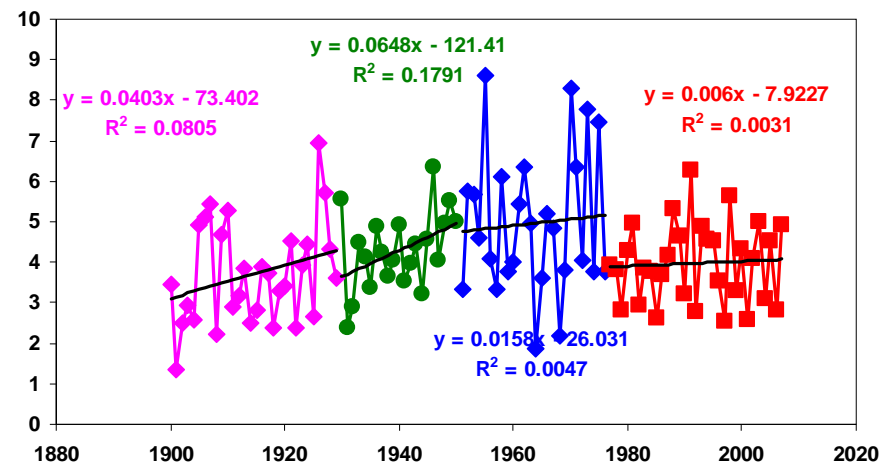
## Conclusions

# Area-average of observed rainfall (mm/day) over SEQ

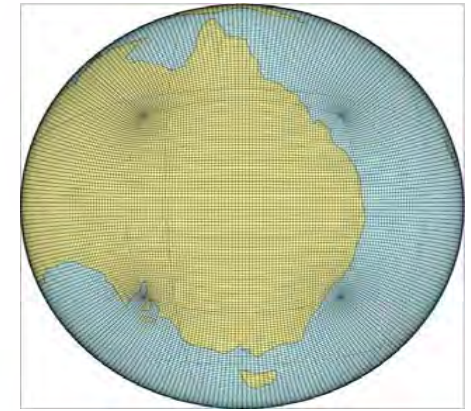
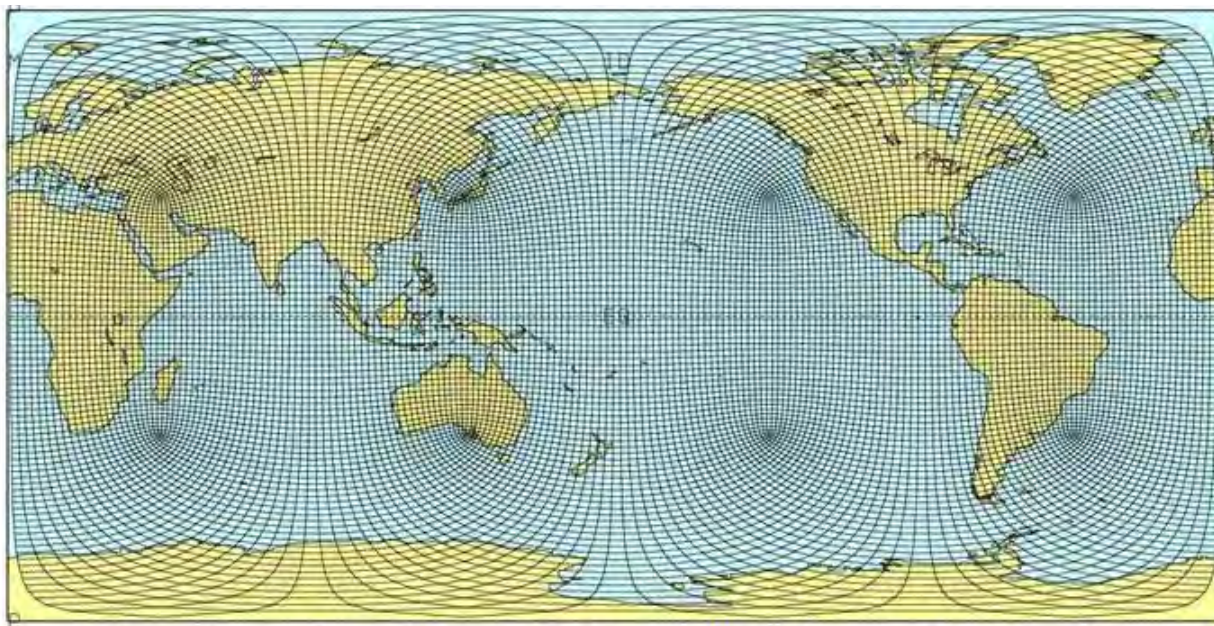
## Monthly mean



## December to March



150 -155 E, 25 - 30 S  
(1900-2007)



20 km

Example of quasi-uniform C48 grid with resolution about 210 km

## CCAM dynamics

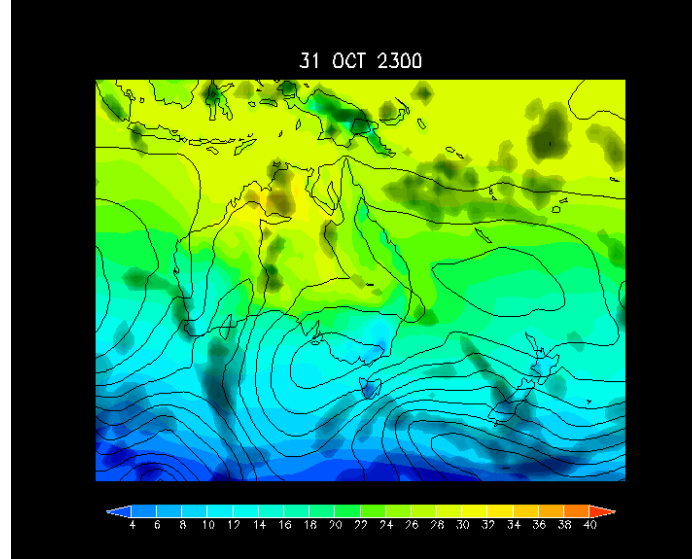
- atmospheric GCM with variable resolution
- 18 atmospheric layers
- semi-Lagrangian, semi-implicit – allows long time steps
- TVD vertical advection
- reversible staggering
  - - good behaviour of atmospheric waves
- conservation of mass and moisture

## CCAM physics

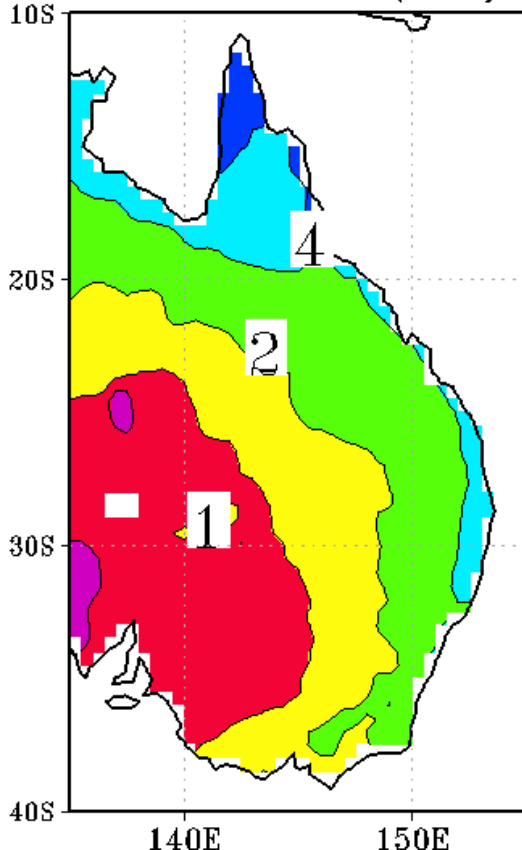
- cumulus convection
  - CSIRO mass-flux scheme, including downdrafts
  - up to 3 simultaneous plumes permitted
- includes liquid and ice cloud-water
  - used to derive cloud distributions
- stability-dependent boundary layer with non-local vertical mixing
- vegetation/canopy scheme
  - 6 layers for soil temperatures
  - 6 layers for soil moisture
- GFDL parameterization for long and short wave radiation

- Global nudging of winds above 500 hPa from the large-scale fields and e-folding time of 24 h

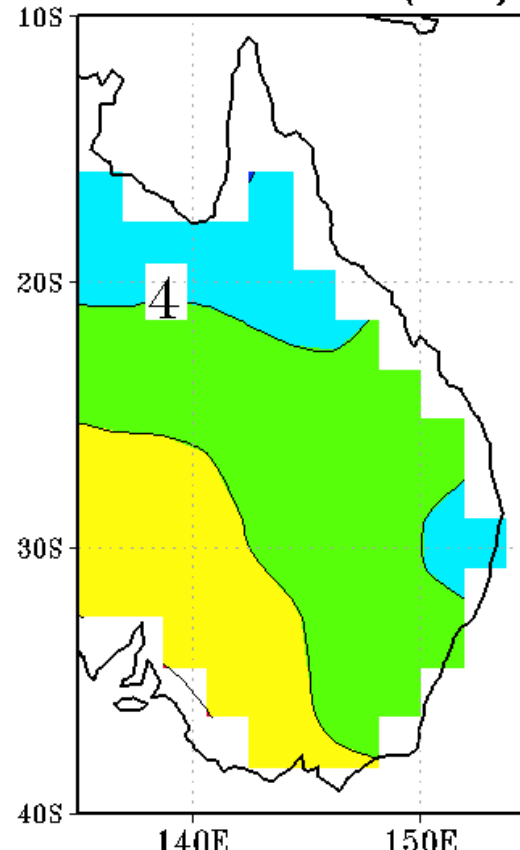
# THE POWER OF DOWNSCALING



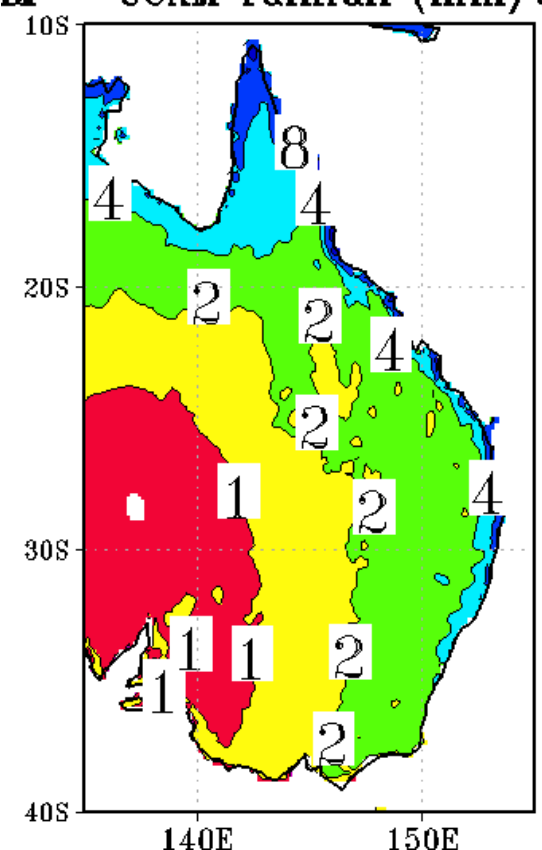
**DF - OBS rainfall (mm/day)**



**DF - GCM rainfall (mm/day)**



**DF - CCAM rainfall (mm/day)**



## Seasonal-mean (1950 to 2005) observed and CCAM rainfall

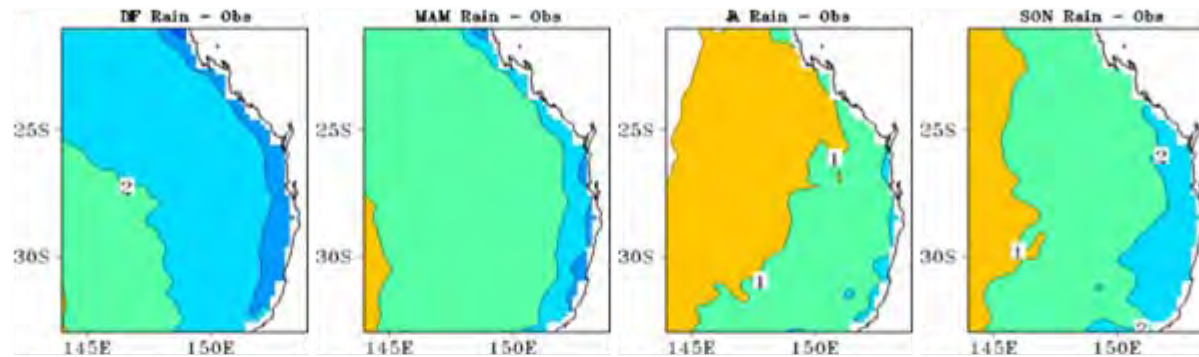
**DJF**

**MAM**

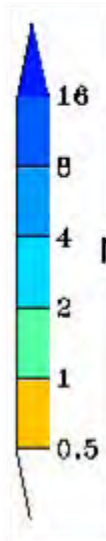
**JJA**

**SON**

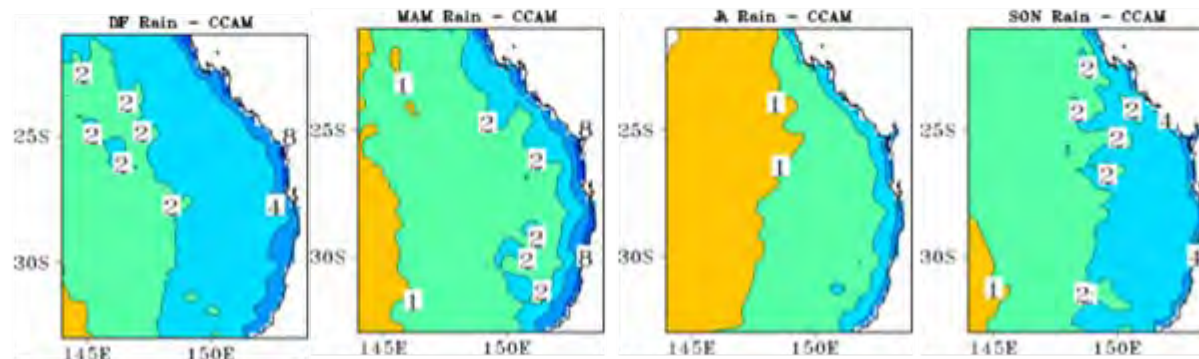
Observed



mm/d

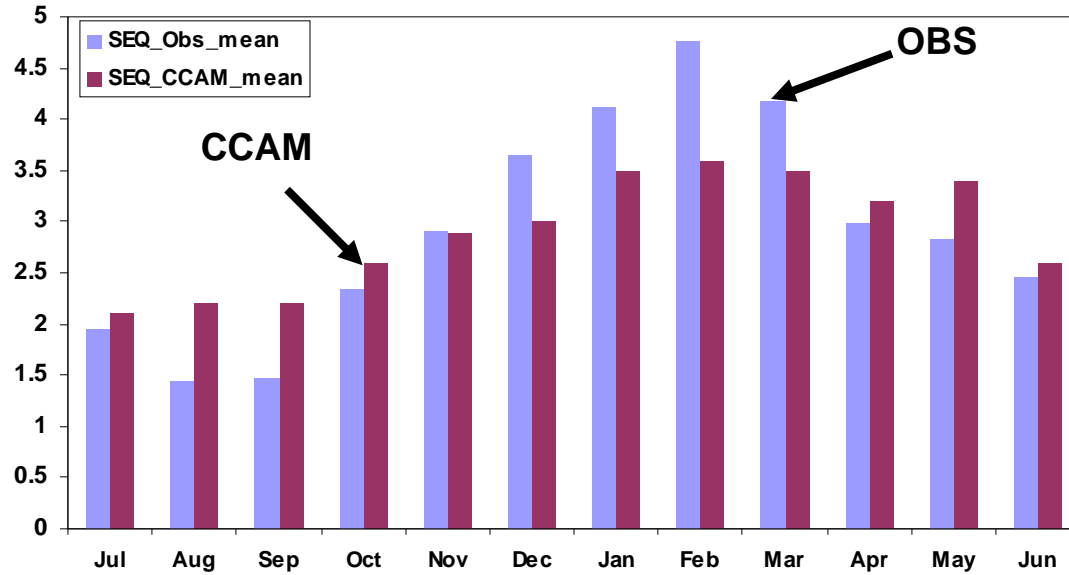


CCAM

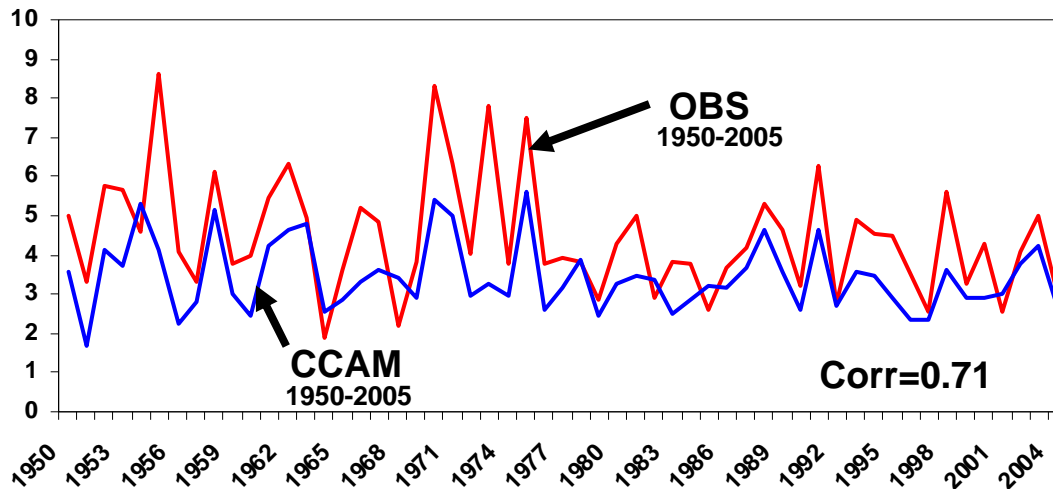


# Observed and CCAM rainfall (mm/day)

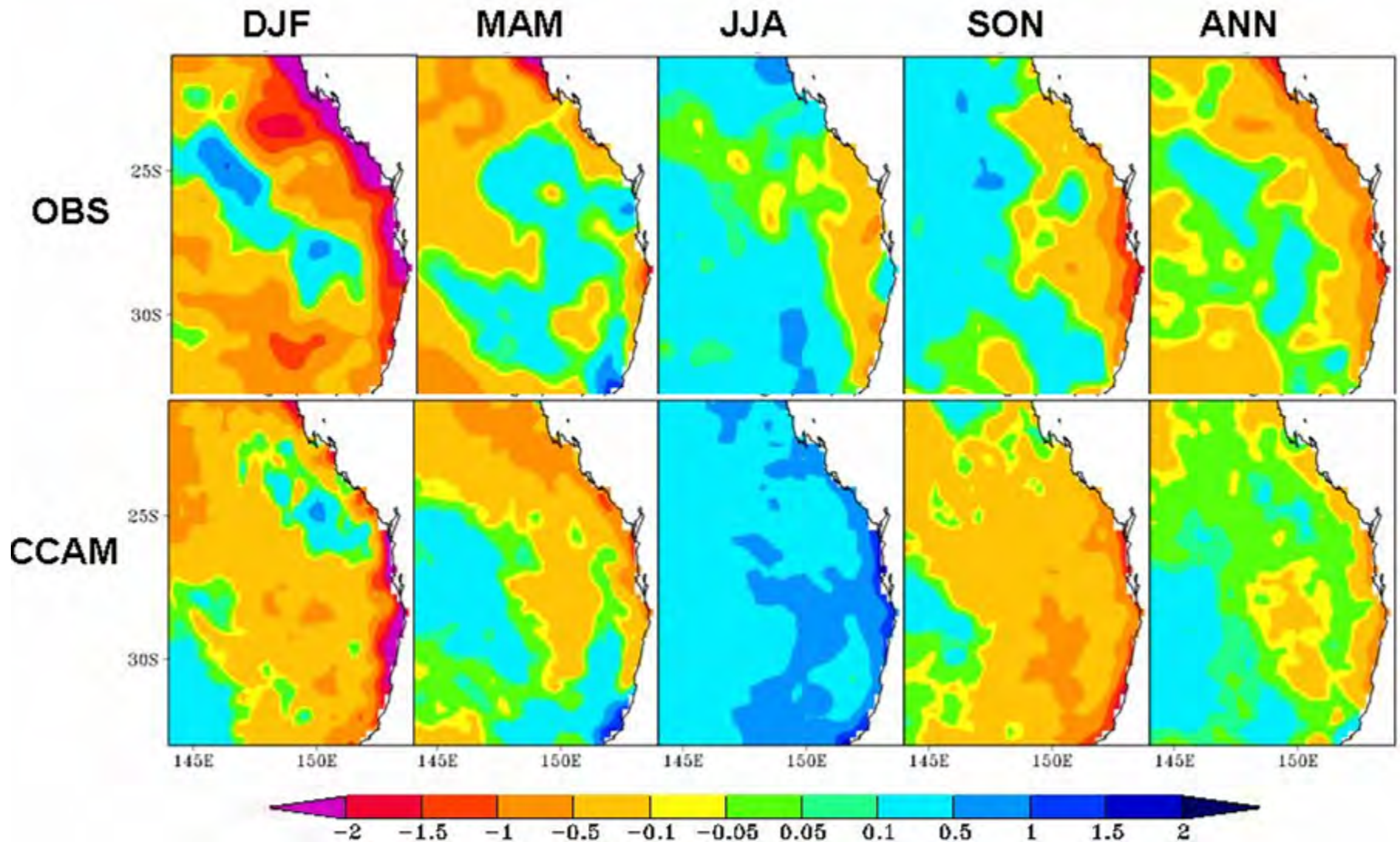
Monthly mean



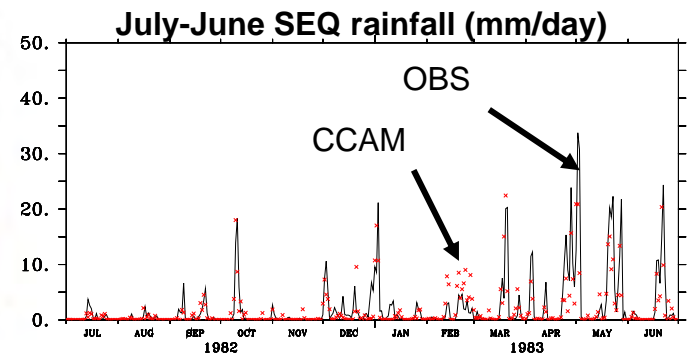
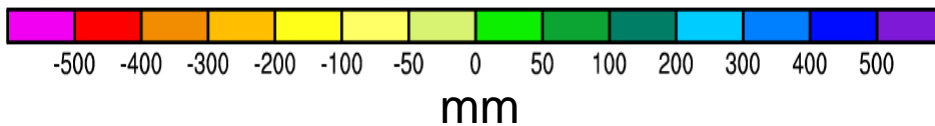
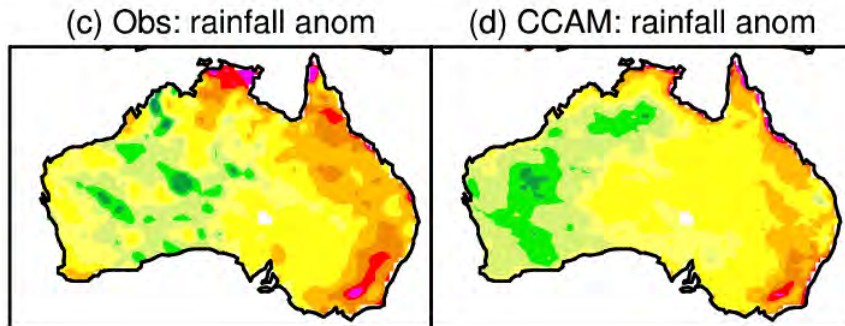
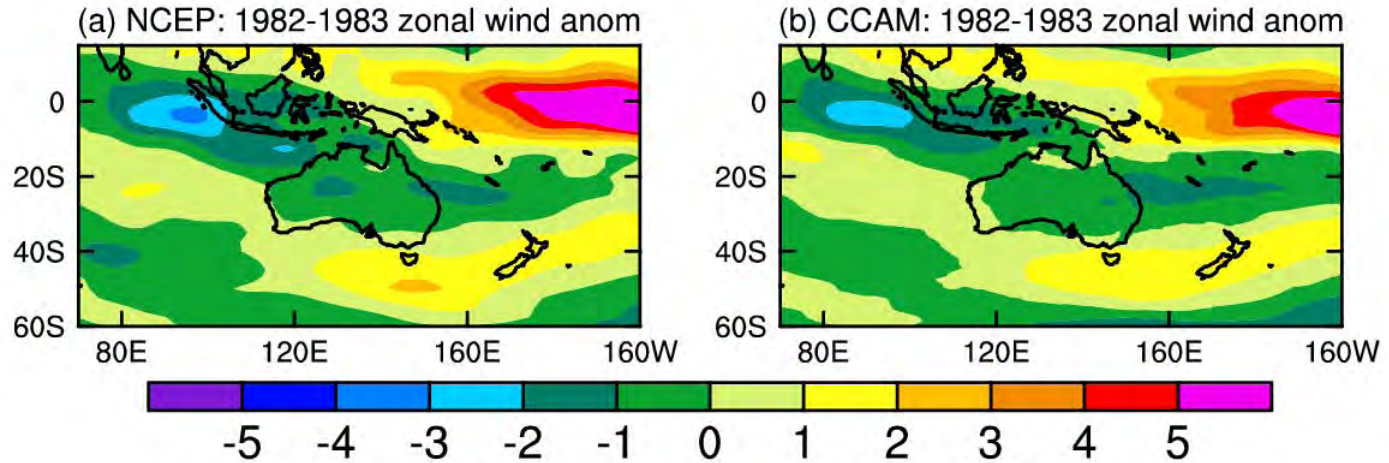
December - March



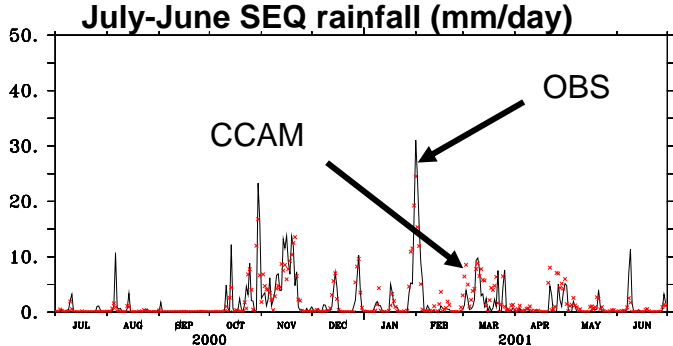
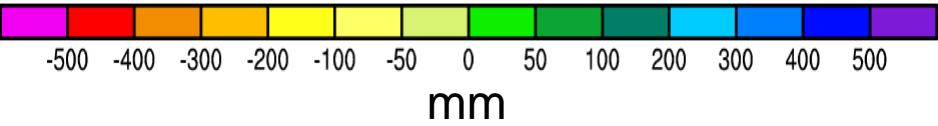
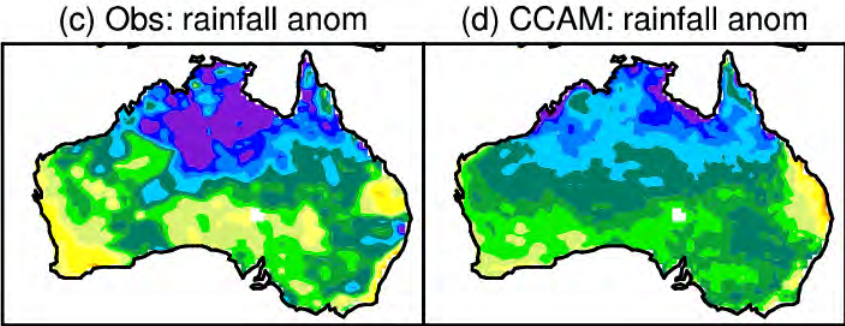
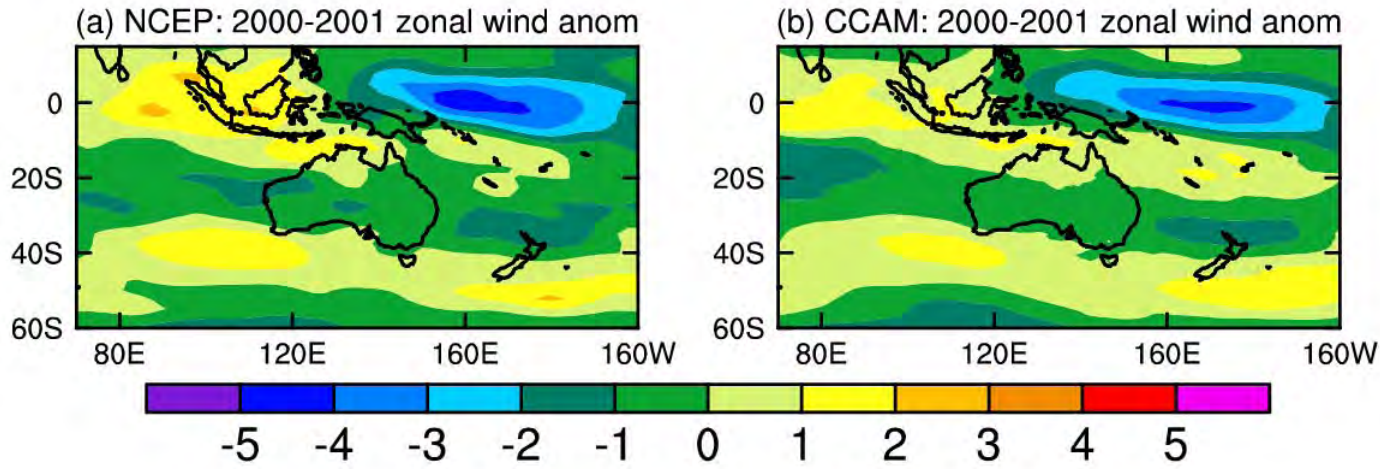
# Rainfall trends (1970-2005, change in mm/day)



# Case study one: 1982-1983 strong El Nino event



# Case study two: 2000-2001 La Nina event

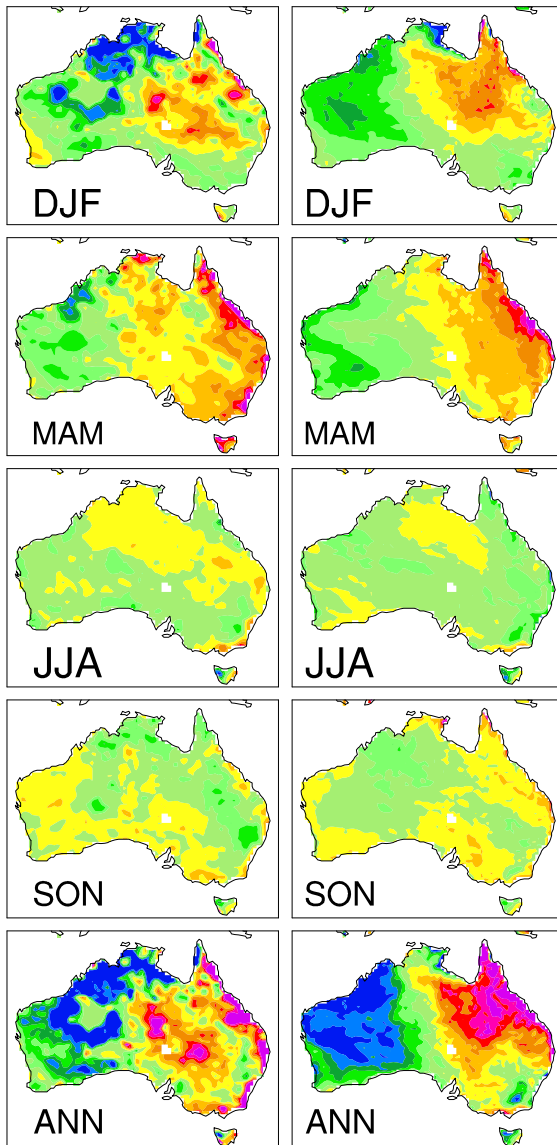


# Trend (mm/decade)

1970-2005

Obs

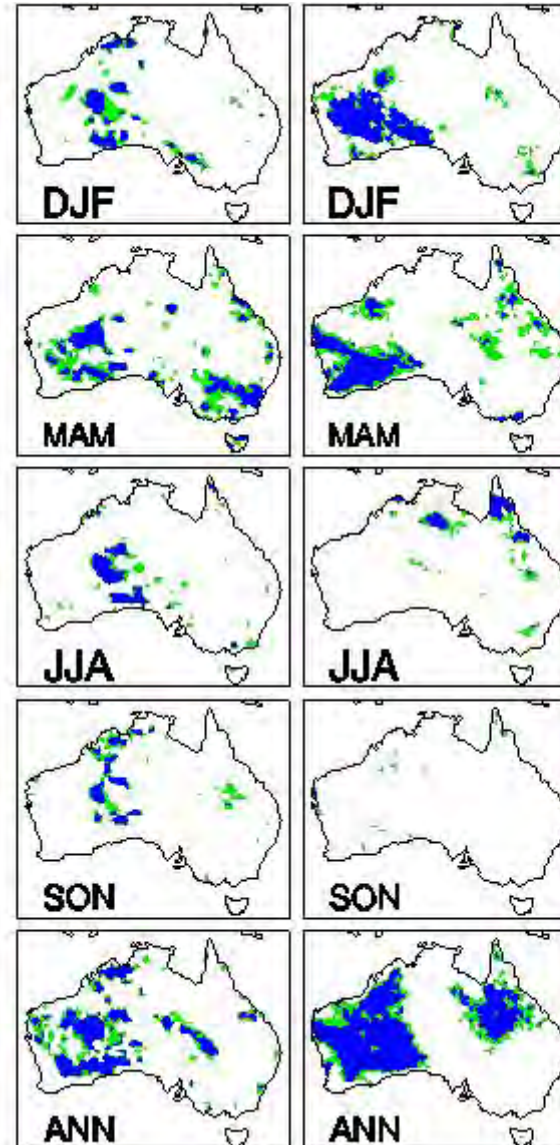
CCAM



# Significance

Obs

CCAM



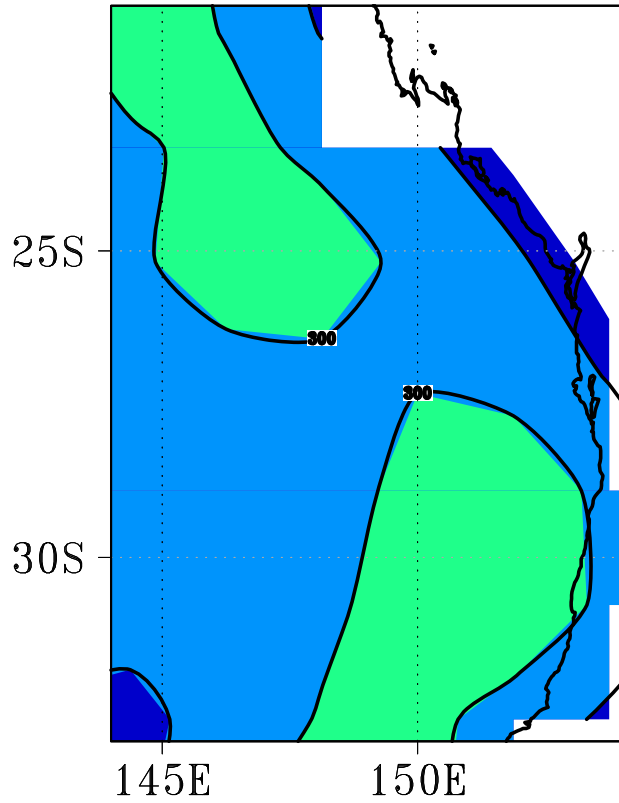
# CCAM simulation using SSTs from CSIRO Mk 3.5 GCM SRES A2

Two steps

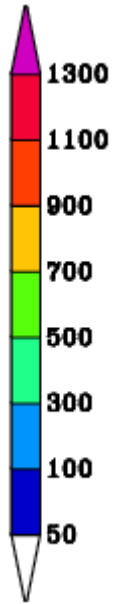
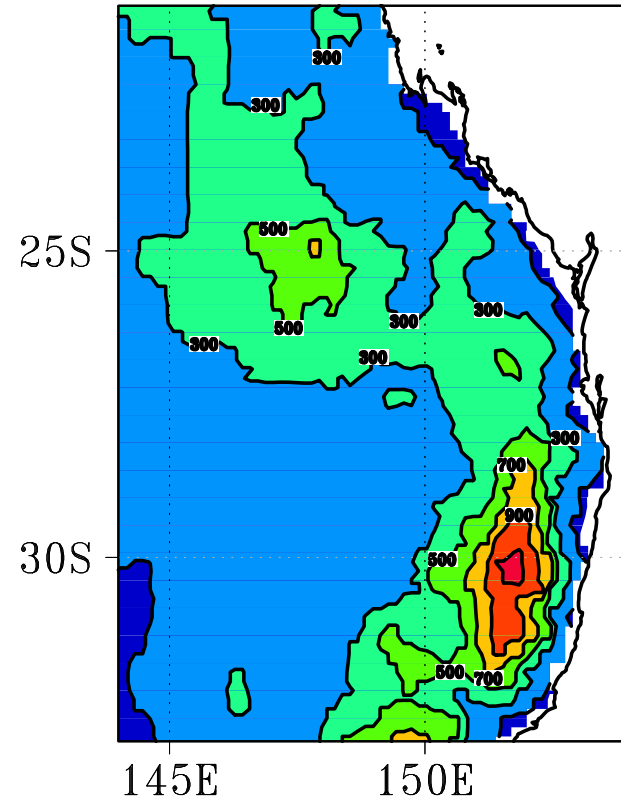
1. CCAM global simulation at 200 km forced by the CSIRO Mk3.5 SST.
2. CCAM downscales to 20 km from the results of step 1

# Orography height (m)

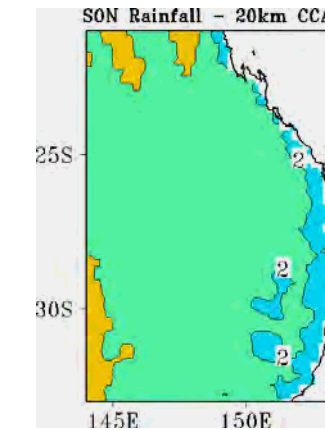
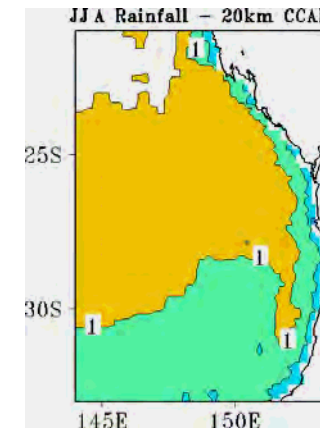
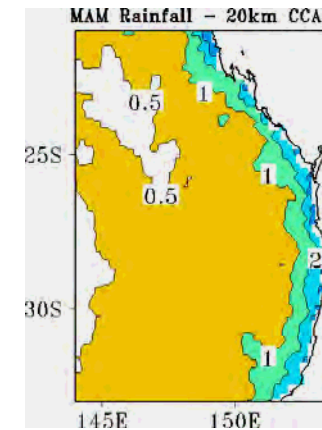
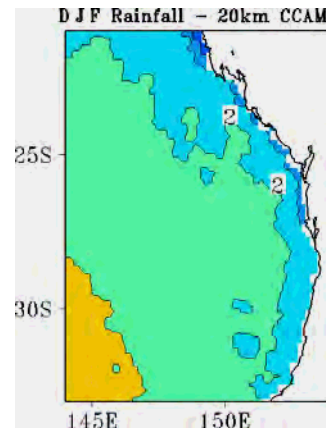
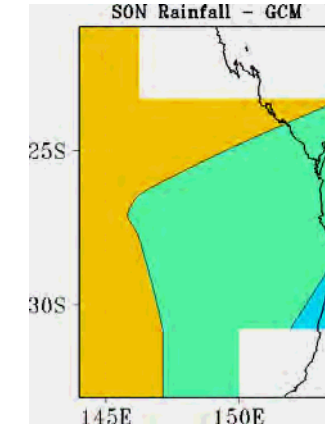
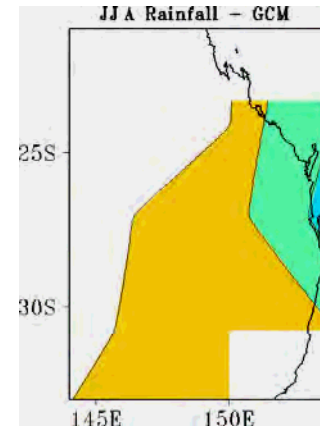
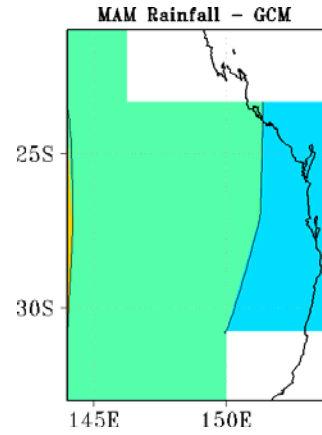
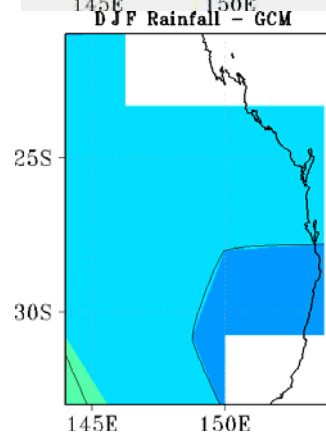
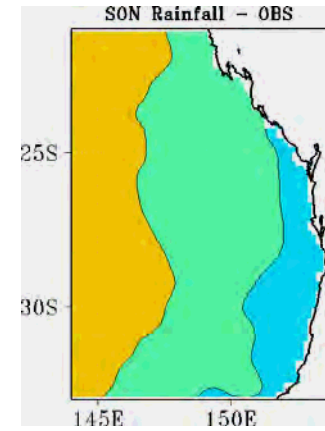
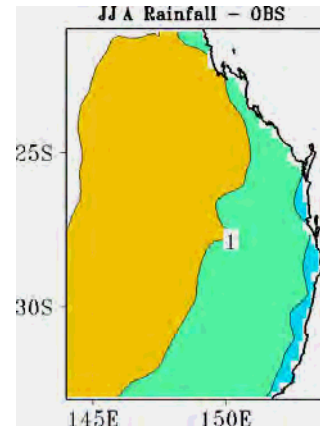
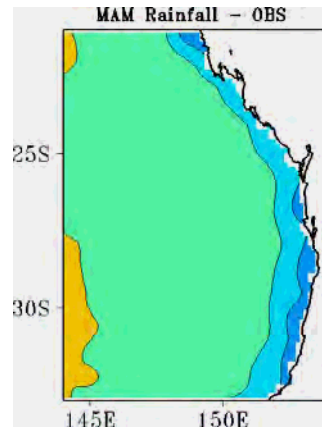
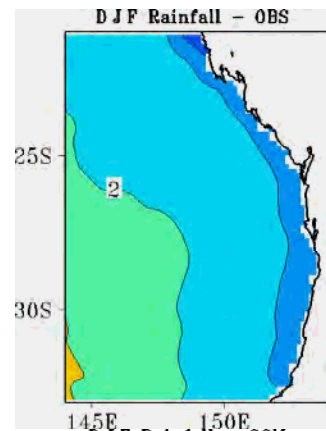
GCM 250 km



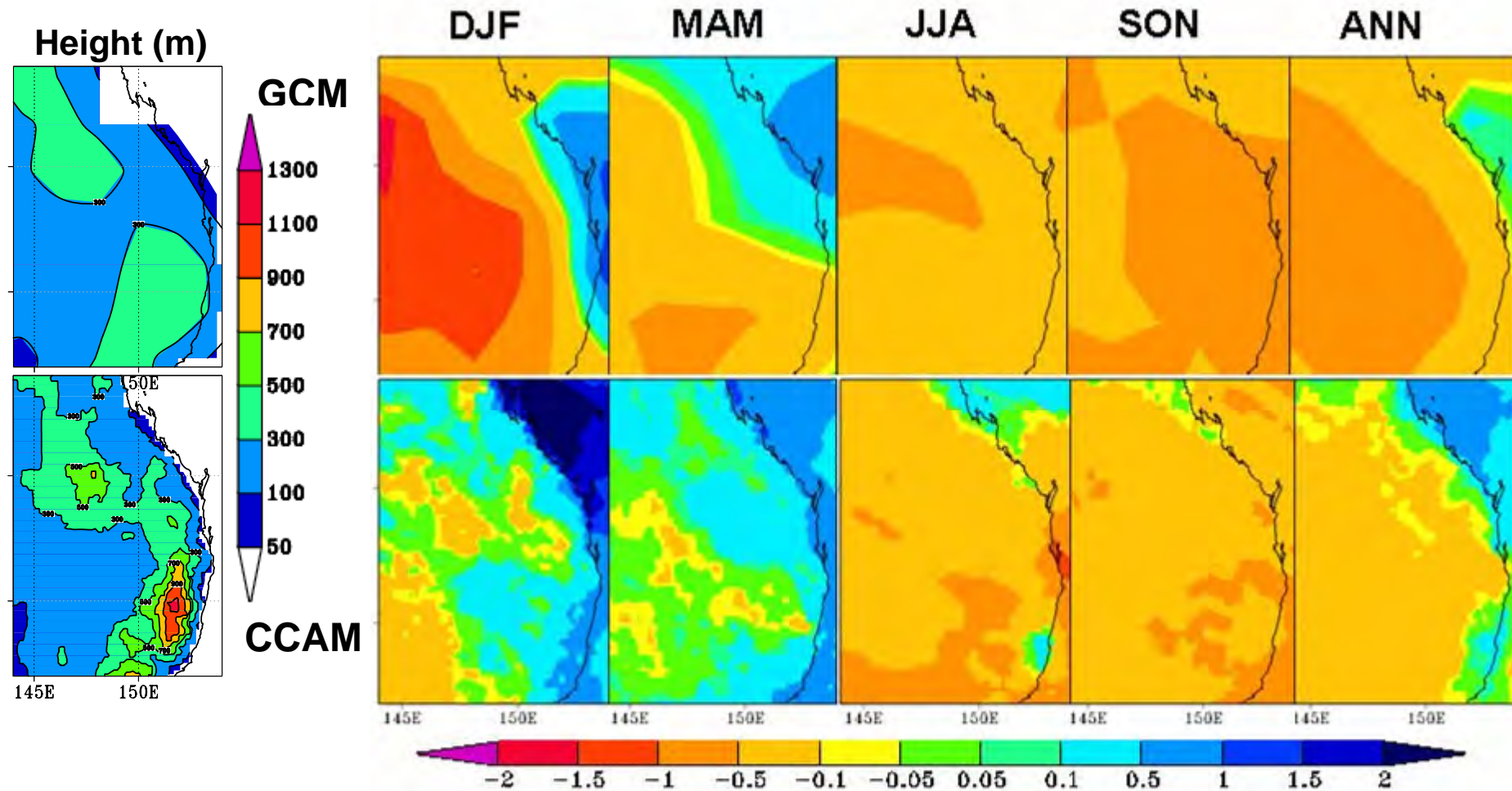
CCAM 20 km



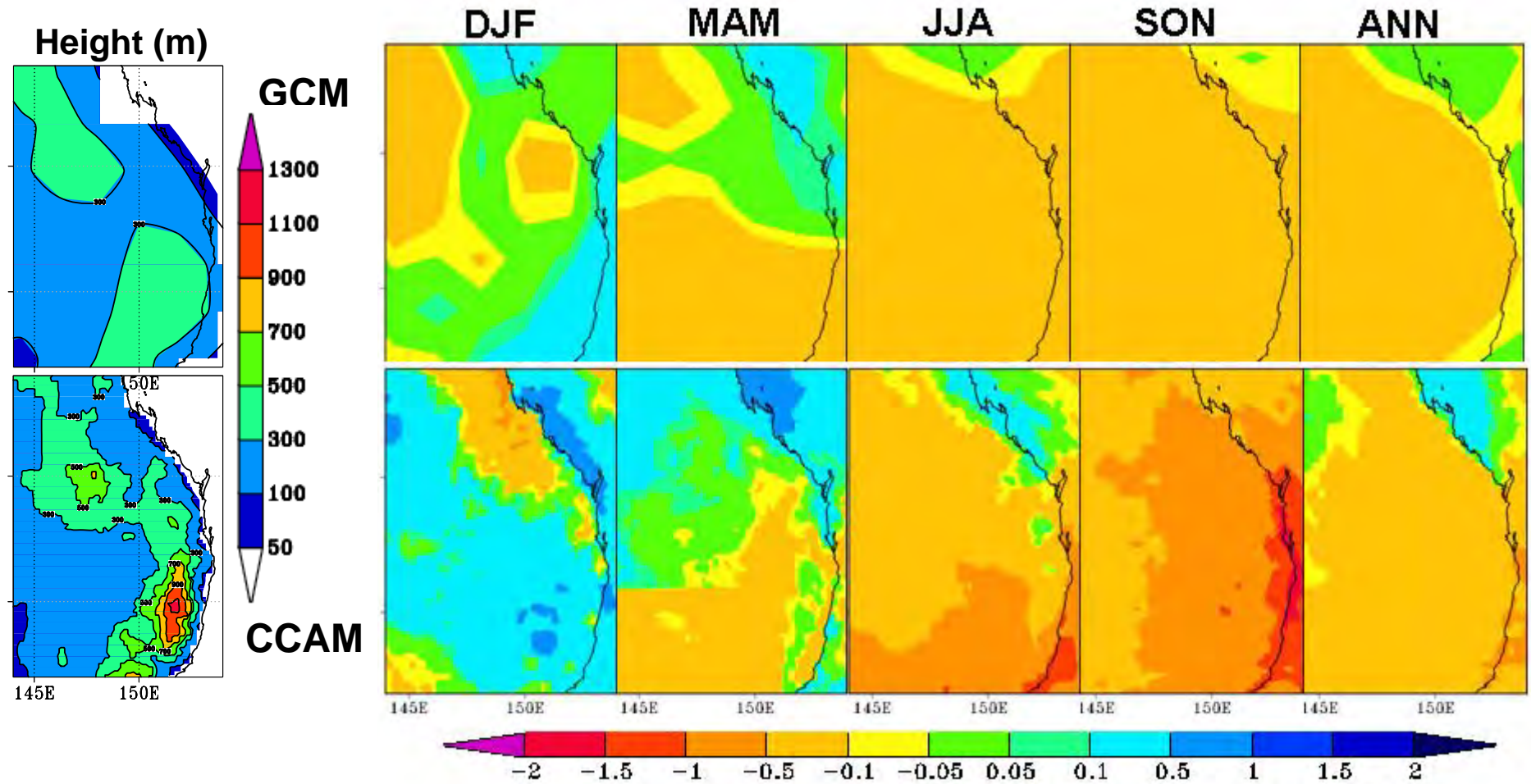
# Average seasonal rainfall – Obs, Mk 3.5, CCAM



# Near-future rainfall trend (change in mm/day) for 1961-2030



# Future rainfall trend (change in mm/day) for 1961-2100



# Conclusions

## Downscaling NCEP reanalyses (1975-2005)

- CCAM captures reasonably well the declining rainfall in all seasons (except for JJA)
- CCAM captures well the inter-annual variability in the two ENSO cases
- CCAM simulates insufficient rainfall along the east coast for DJF and ANN

# Conclusions (cont)

## Downscaling from Mk 3.5

- CCAM produces a big improvement of the rainfall pattern compared to the coarse resolution GCM.
- CCAM and Mk 3.5 predict rainfall decreases by 2030 over the whole region in JJA and SON.
- CCAM predicts increased rainfall by 2030 along the east coast in DJF and MAM.
- There is minor disagreement between CCAM and Mk 3.5 in predicting the future rainfall change in DJF and MAM
  - Somewhat different behaviour of convective rainfall, which may be due to resolution, orography, etc.
- Multi-ensemble members of experiments are needed to take into account of uncertainties from emissions, model biases and multi-decadal variability.

Thank you

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