climate extremes
ARC centre of excellence

# Exploring changes in extreme rainfall over Australia

**Margot Bador**[1], Sugata Narsey[2], Ghyslaine Boschat[2], Stefan Contractor[1] and Lisa Alexander[1]

[1] Climate Change Research Centre, UNSW Sydney
[2] Monash University

UNSW SYDNEY MONASH University

CLEX annual workshop, 21.11.2018

1. Context - Rainfall extremes and their changes by the end of the 21$^{st}$ century
2. Focus on Australia : observations and model projections
3. Future plans - Constraining the projections over Australia
4. Conclusion and future work

# Rainfall extremes response to warming

## Physical considerations

- atmospheric specific humidity is expected to increase with temperature by $\approx 7\% K^{-1}$ (Clausius-Clapeyron)

  Allen and Ingram (2002) ; Trenberth et al. (2003) ; Held and Soden (2006)

- changes in extreme rainfall are primarily controlled by the change in total atmospheric moisture availability

  Allen and Ingram (2002) ; Allan and Soden 2008

An intensification of rainfall extremes is expected in response to warming

Allan and Soden (2008) ; Trenberth (2011)

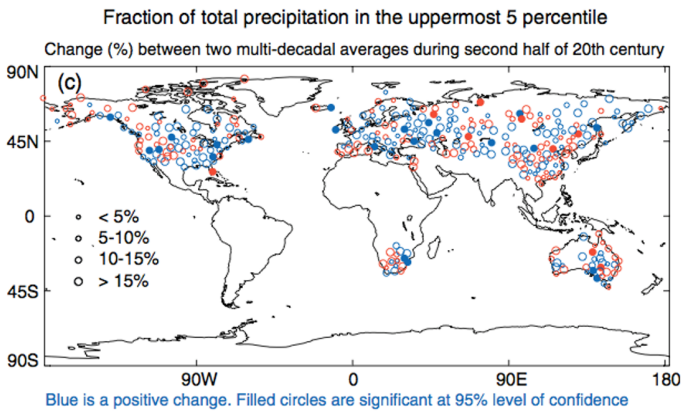
## IPCC results - AR5

From model and observational evidence :
"there is high confidence that the intensity of extreme precipitation events will increase with warming, at a rate well exceeding that of the mean precipitation"

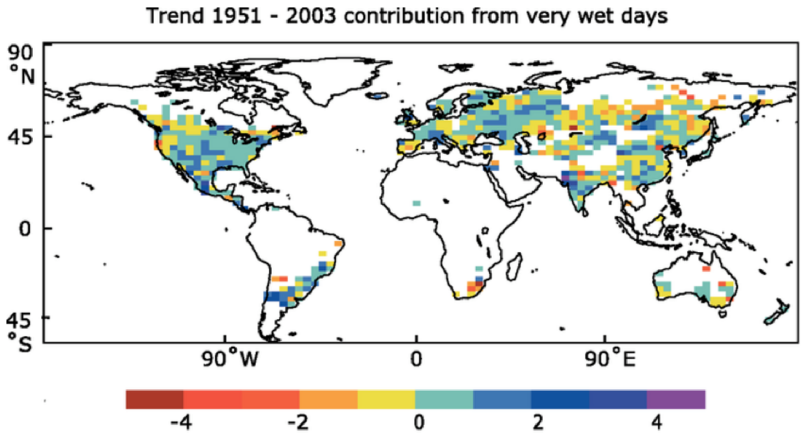
Collins et al. 2013

# Observational evidence

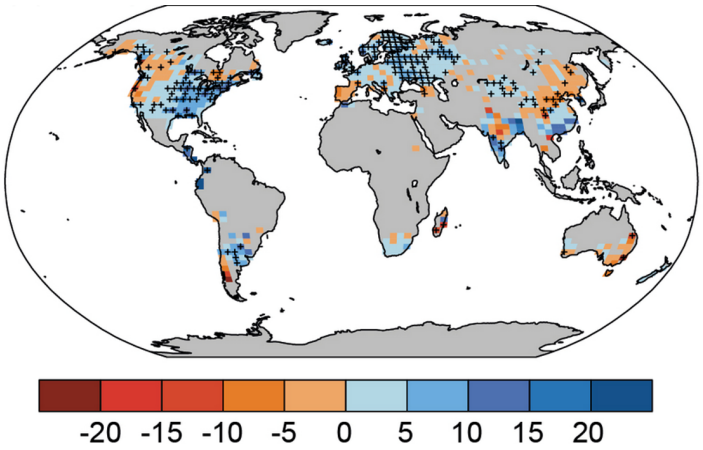
## TAR




## AR4




## AR5




Contribution from heavy ($> 95^{th}$ percentile) precipitation to total precipitation

No improvement in coverage between IPCC Assessments for long-term global extreme precipitation trends

# Observed trends in extreme rainfall

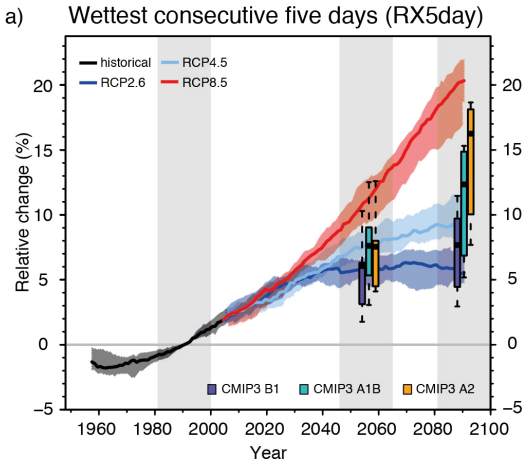
Trends (1950-2013) in the wettest day in a year or season

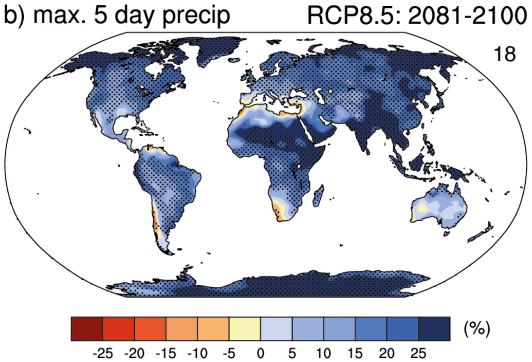
REGEN dataset,
Stefan Contractor

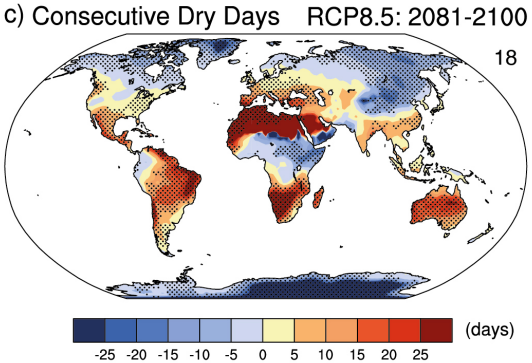
Over land, more increase than decrease in extreme precipitation is observed in the instrumental record

Groisman et al. 2005 ; Alexander et al. 2006 ; Westra et al. 2013 ; Donat et al. 2013

# Model evidence - Future change in extreme rainfall



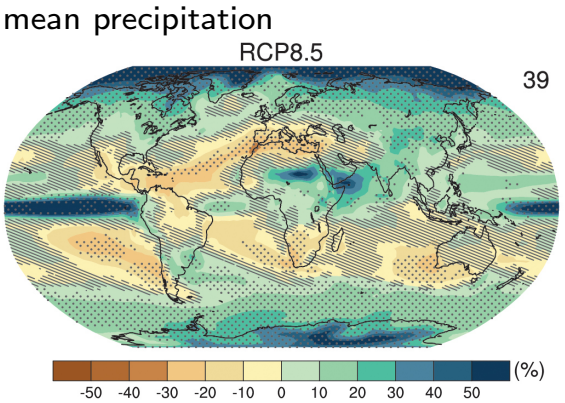



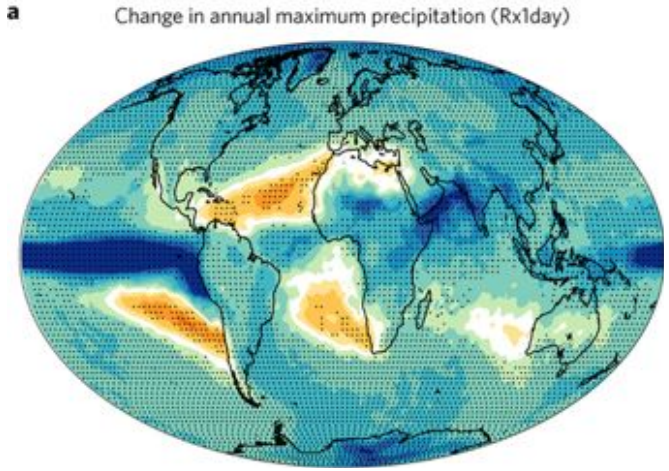

## Late 21st century changes

- from 5% (RCP2.6) to 20% (RCP8.5) more precipitation during very wet 5-day periods
- few regions where this index decreases in the RCP8.5 scenario coincide with areas of robust decreases in the mean precipitation
- longer dry periods in semi-arid regions of subtropics and midlatitudes

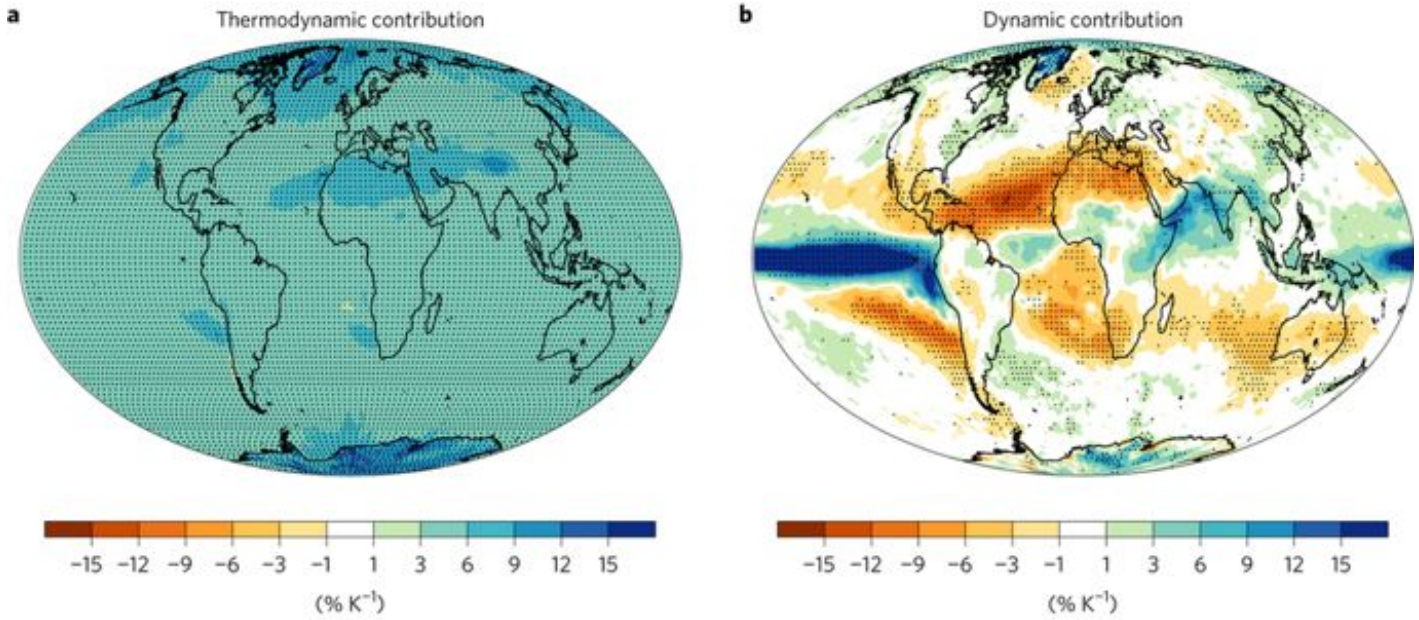
Collins et al. (2013), AR5



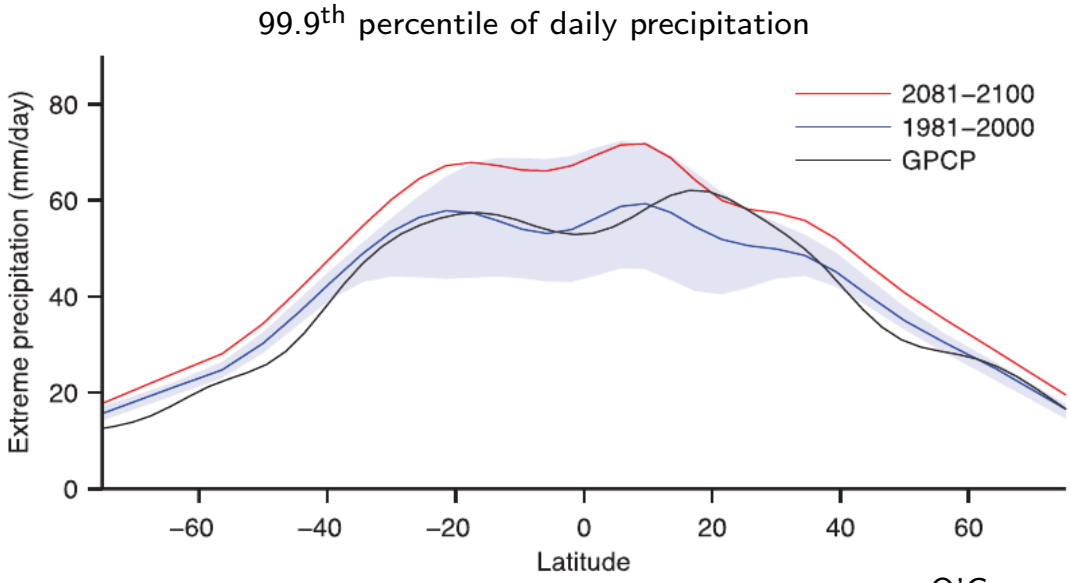
# Thermodynamical vs. Dynamical changes




Pfahl et al. (2017)



# Model limitations




O'Gorman and Schneider 2009

## global climate models

- parameterize the convective processes
  $\rightarrow$ climate models are not reliable in the tropics

Kharin et al. 2013 ; O'Gorman 2015

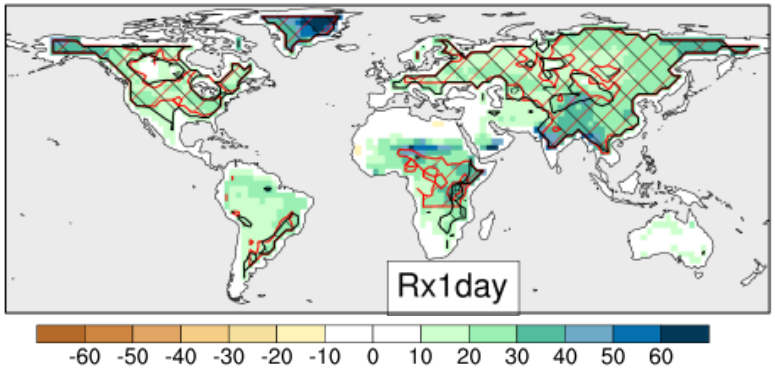
- generally precipitate too often and too lightly
  $\rightarrow$ it affects the frequency, not necessarily the intensity of rainfall extremes

Stephens et al. 2010 ; Dai 2006

1. Context - Rainfall extremes and their changes by the end of the 21st century
2. **Focus on Australia : observations and model projections**
3. Future plans - Constraining the projections over Australia
4. Conclusion and future work

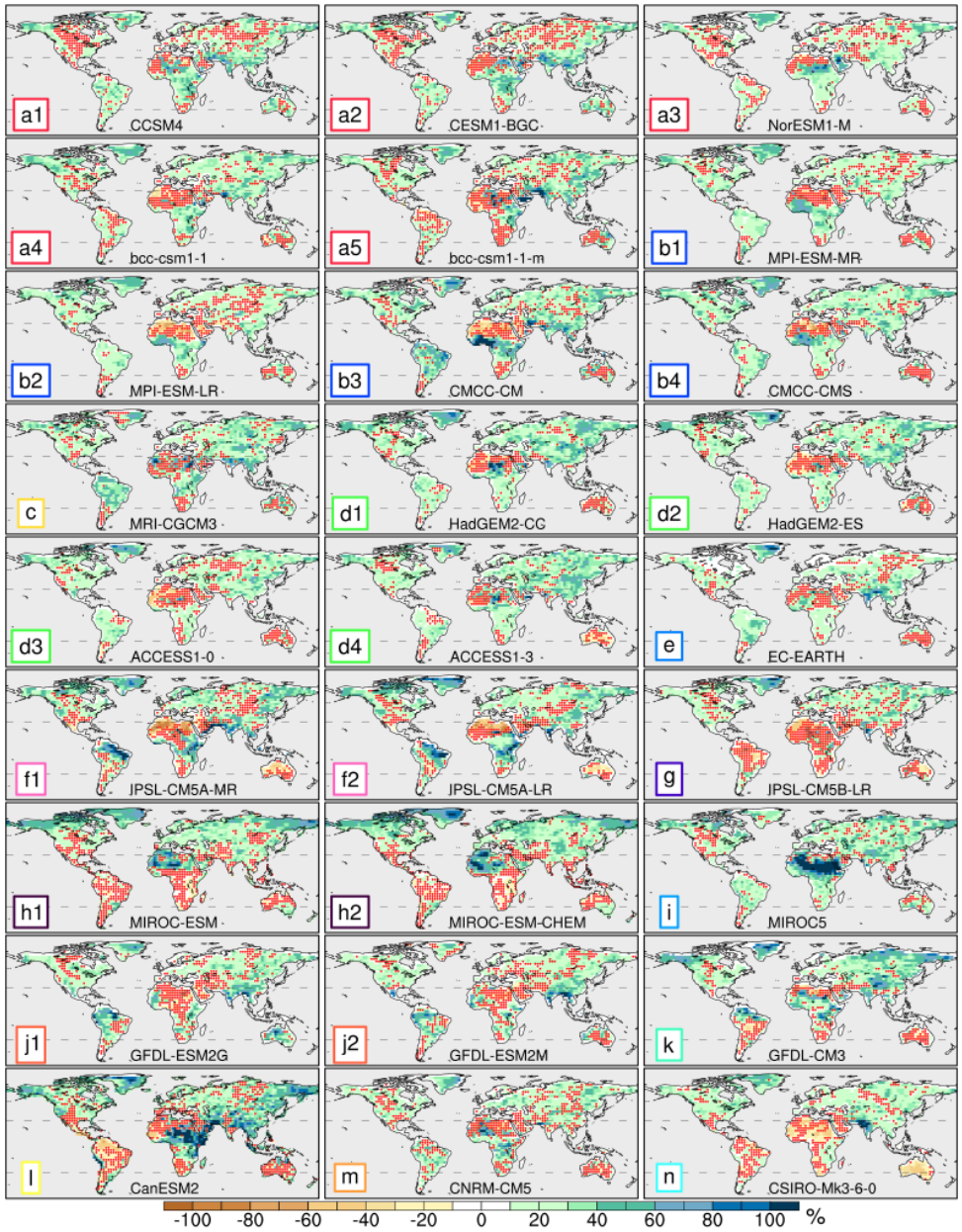
# Behind the multi-model mean

Late 21st century relative change (%) in the wettest day of the year, RCP8.5 scenario




## Sources of uncertainties

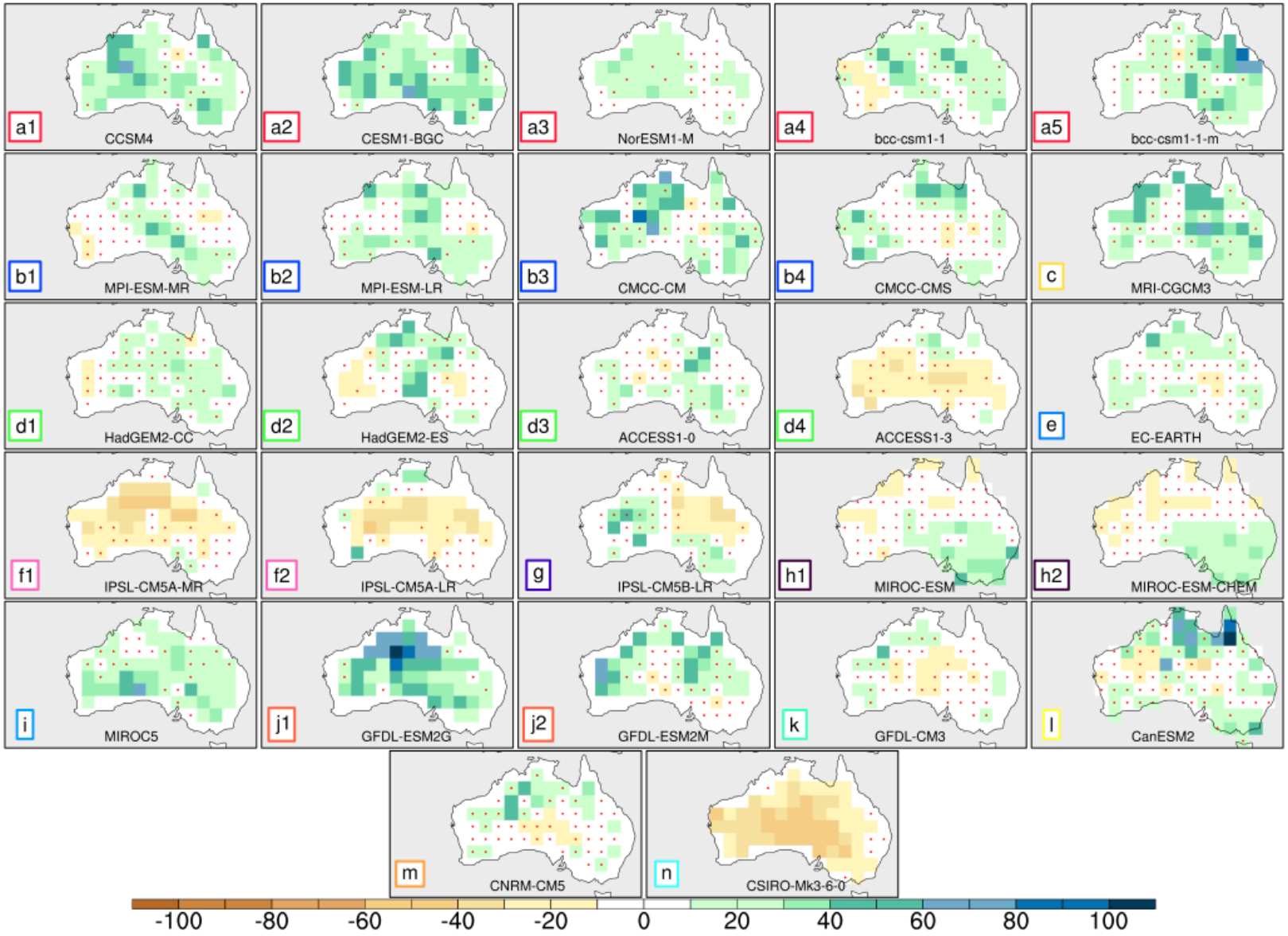
- inter-model differences (structural uncertainty)
- internal variability uncertainties (aleatoric uncertainties)




Bador et al. 2018

# Behind the multi-model mean

Late 21st century relative change (%) in the wettest day of the year, RCP8.5 scenario



# Seasonal projections

## Annual projections

- increase in the most intense rainfall events with few regions of significant and robust change across the models
- decrease in mean rainfall over most regions consistent with increase in dry days

Hope (2006) ; Alexander and Arblaster (2017)

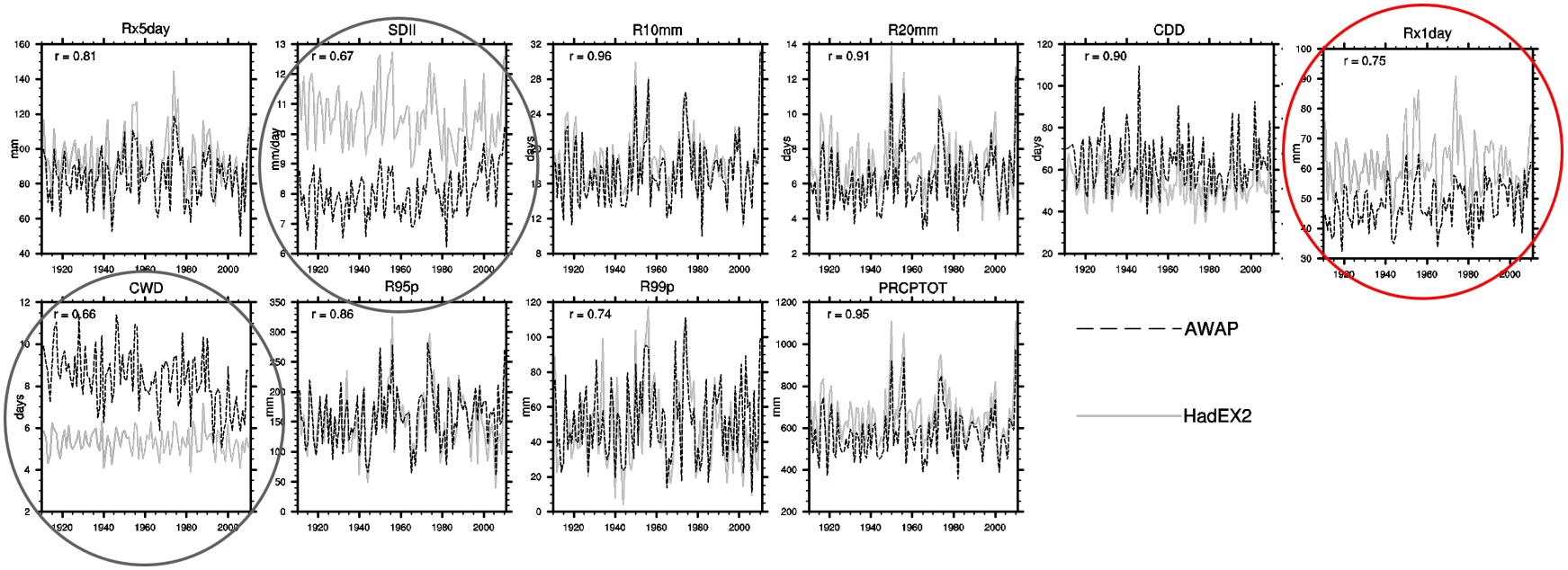
# Spatial aggregation

# Model evaluation - which observations ?

Guidance document in preparation !

Products compare relatively well over Australia !

# Model evaluation - which index ?




Alexander and Arblaster (2017)

## How do observations compare for different indices ?

- generally well but big differences in some indices
- relatively well for Rx1day

1. Context - Rainfall extremes and their changes by the end of the 21st century

2. Focus on Australia : observations and model projections

3. **Future plans - Constraining the projections over Australia**

4. Conclusion and future work

# Annual cycle of precipitation

# Size of the system leading to extreme rainfall

# Synoptic conditions leading to extreme rainfall

# Influence of modes of variability

## Objectives

1. Diagnose modes of variability in observations
2. Analyse the seasonal modulation of the teleconnections and compare to literature (e.g. King et al. 2014)
3. Compare the simulated and observed teleconnection patterns
4. Constrain projections by mode of variability influence

1. Context - Rainfall extremes and their changes by the end of the 21st century
2. Focus on Australia : observations and model projections
3. Future plans - Constraining the projections over Australia
4. **Conclusion and future work**

## Conclusions

### Changes in extreme rainfall over Australia

Compared to other regions of the globe :

- some of the largest uncertainties because of large inter-model differences and large uncertainties due to internal variability (dynamical changes)
- observations compare relatively well

## Future works

### Constraining future projections of extreme rainfall

- early stage for all the different approaches, everyone interested in is welcome to join !
- model evaluation across the centre

# Thank you, questions ?

m.bador@unsw.edu.au