

Droughts generated by atmospheric variability

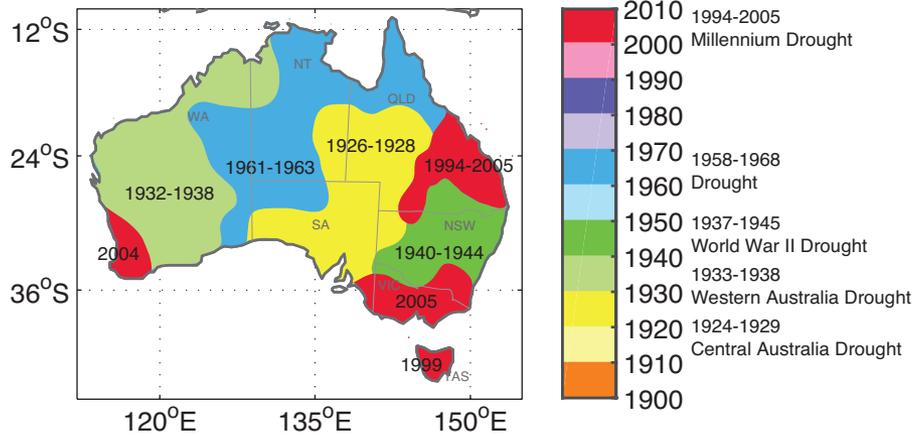
by Andréa S. Taschetto
Sen Gupta, Ummenhofer and England



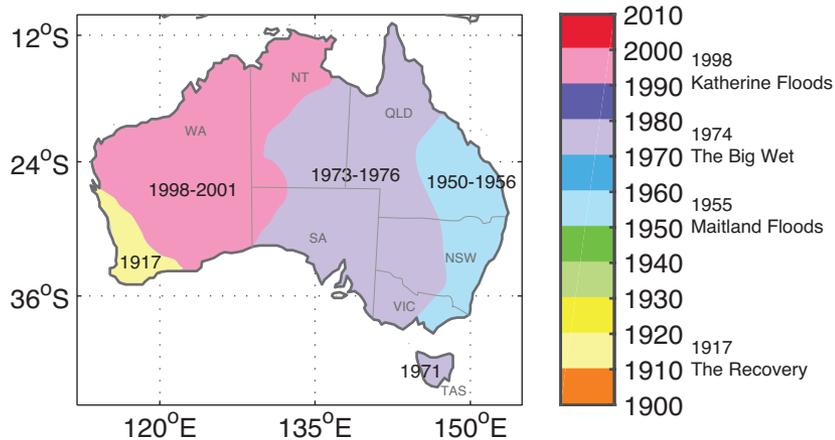
a.taschetto@unsw.edu.au

Oceans & Global Precipitation

The Driest Eras

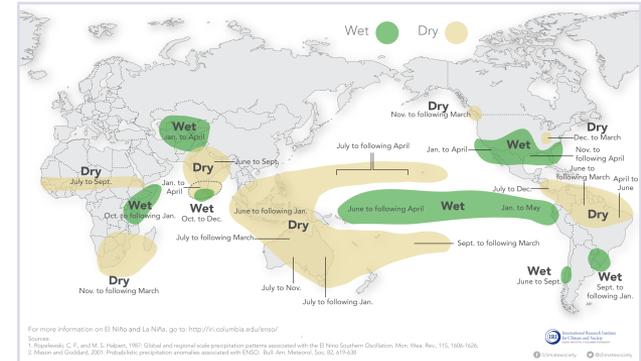


The Wettest Eras

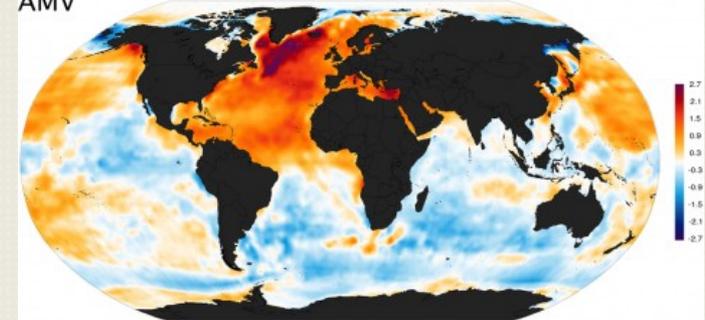


El Niño and Rainfall

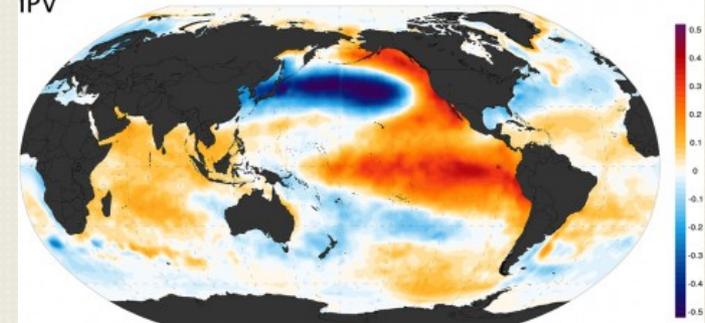
El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.



AMV



IPV

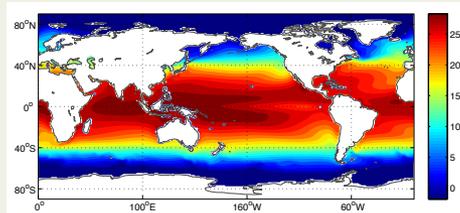


Research Questions

- Can extensive periods of droughts occur in absence of ocean variability?
- Do we see droughts and floods in a world without ENSO?
- What is the contribution of the ocean variability for rainfall mean, variability and extremes (e.g. droughts)?

Methodology: NCAR CESM Experiments

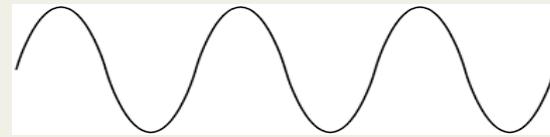
SST Climatology



CPLD

Fully Coupled Experiment

- CAM4 atmosphere
- control run
- 1.9 lat x 2.5 lon
- 900yrs
- Contains all sorts of variability



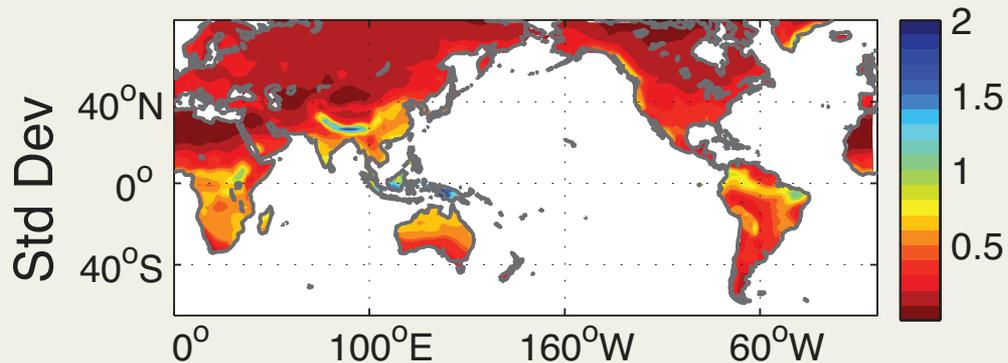
AGCM

Atmosphere Experiment

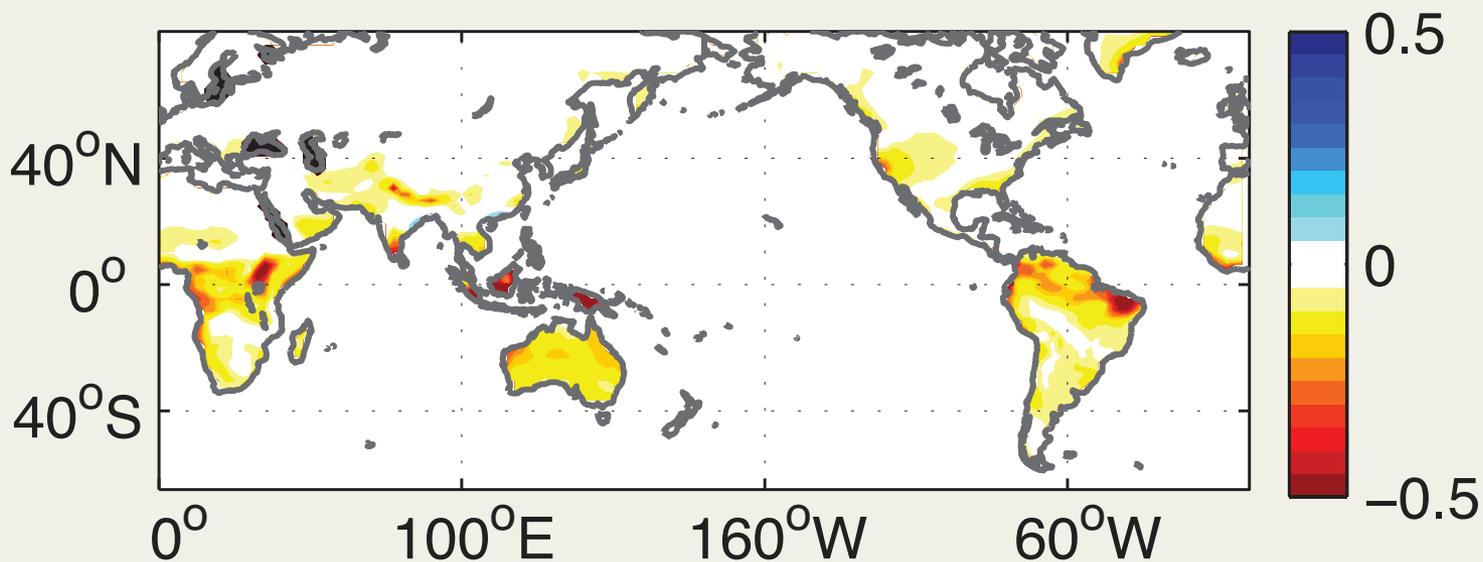
- CAM4 atmosphere
- 1.9 lat x 2.5 lon resolution
- 1000yrs simulation
- No ocean feedback
- Forced by modelled SST climatology
- No SST interannual forcing

Difference in Rainfall Variability

CPLD

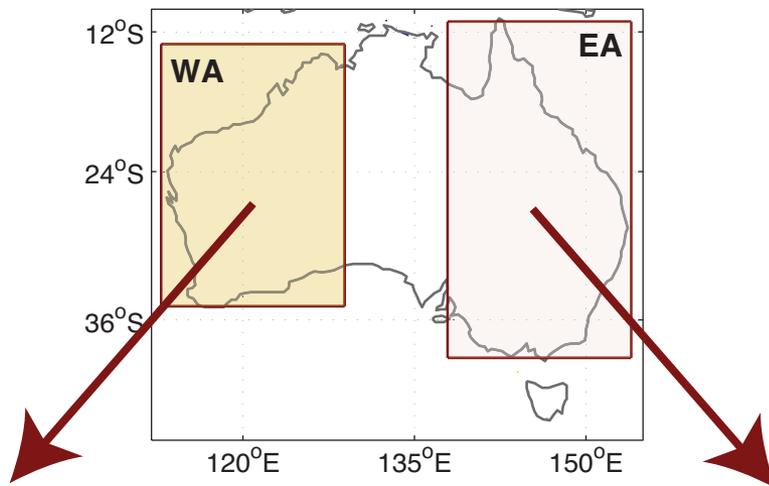


AGCM – CPLD

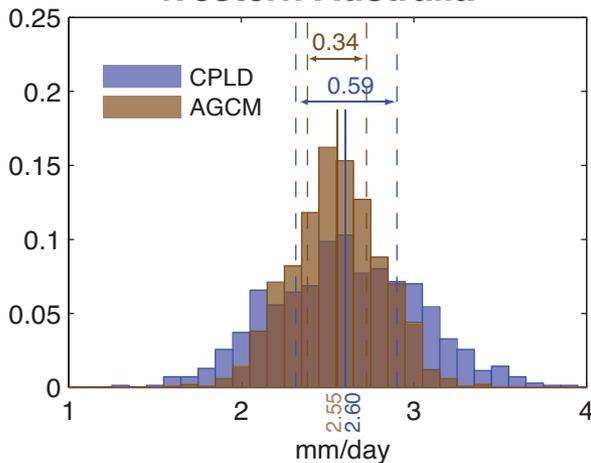


SST variability leads to ~40% more variations in Australian rainfall

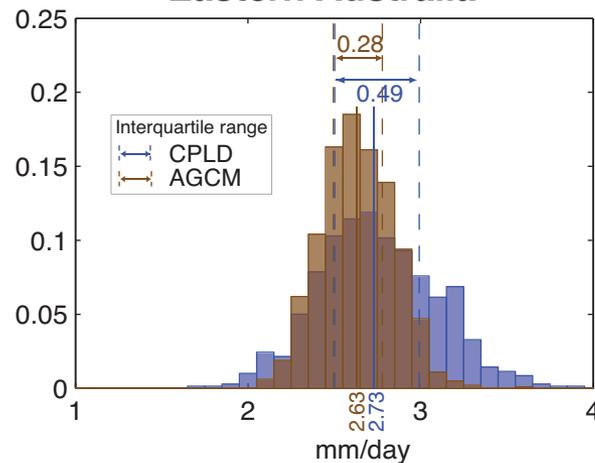
Rainfall Distribution



Western Australia



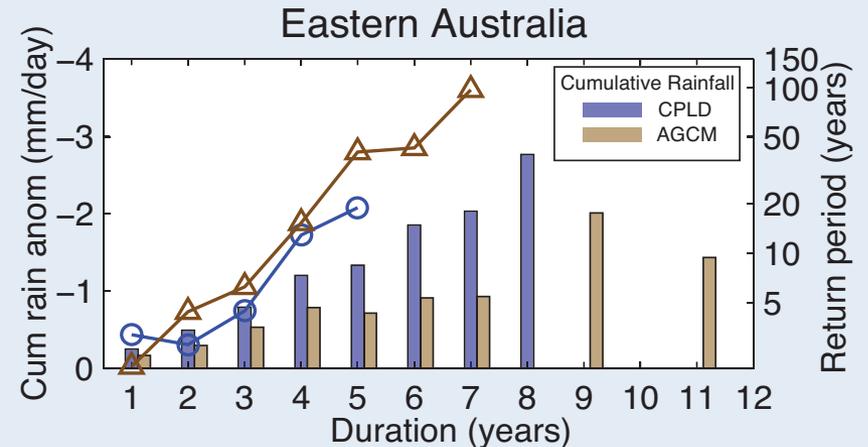
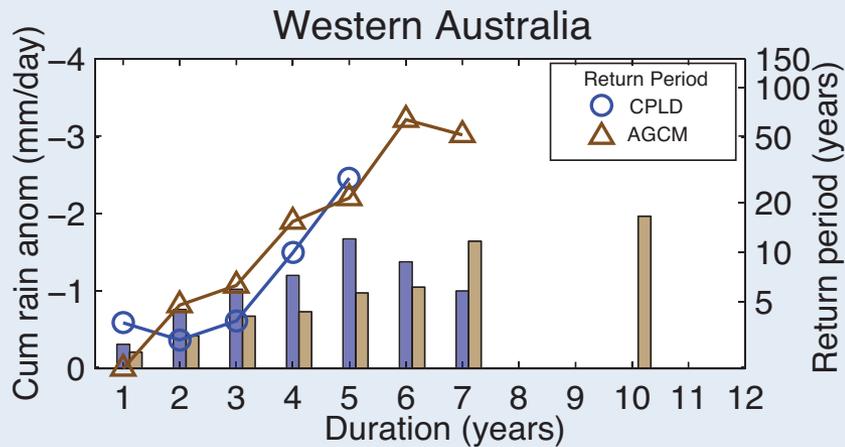
Eastern Australia



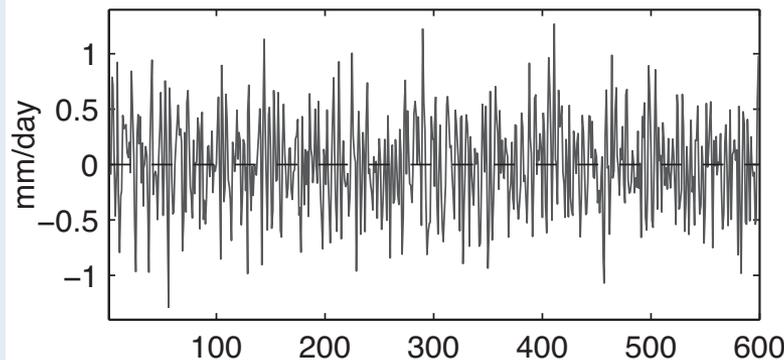
Severity of Dry Spells

- Ocean variability makes droughts more severe

Dry Spells

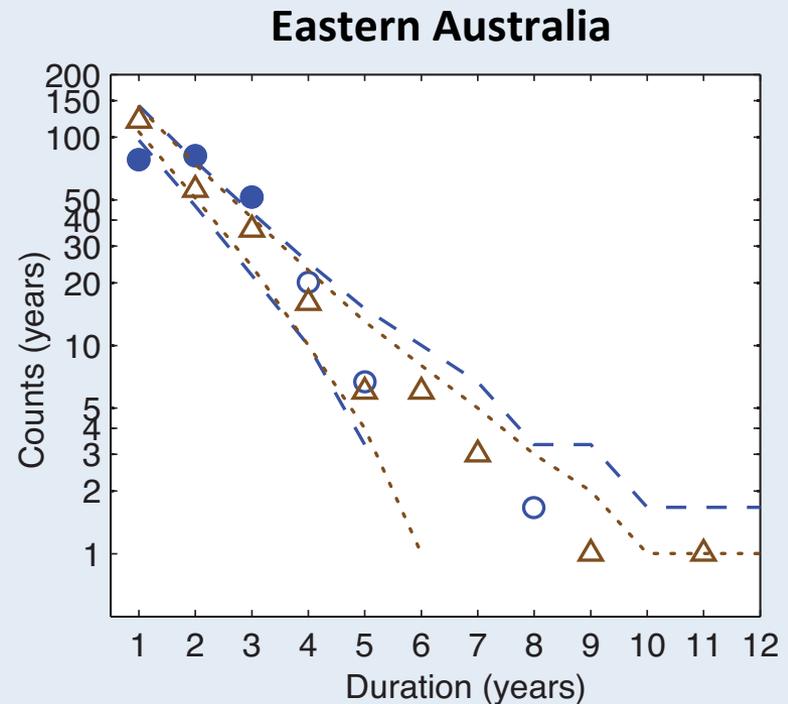
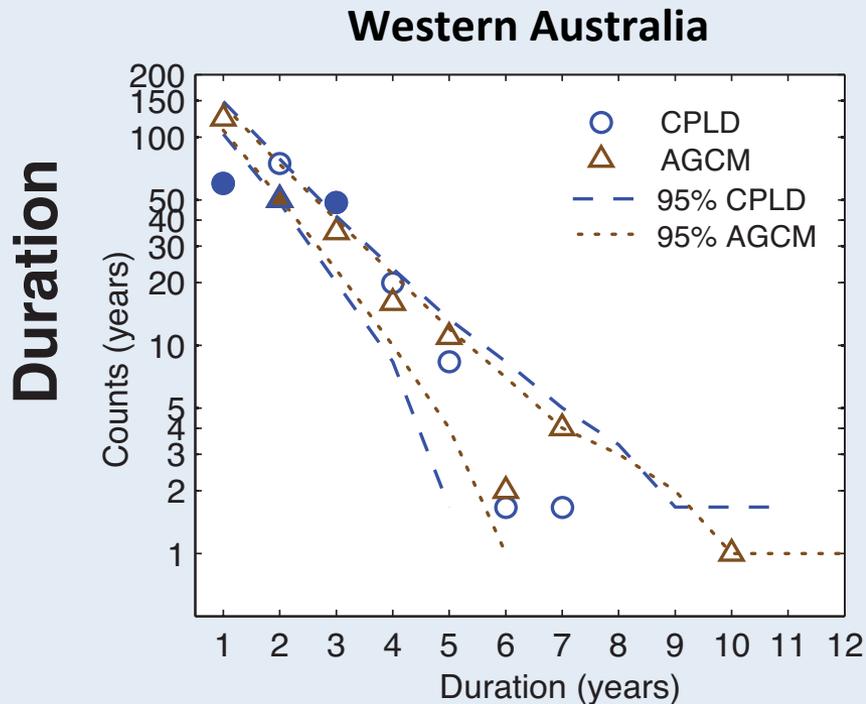


CPLD - WA



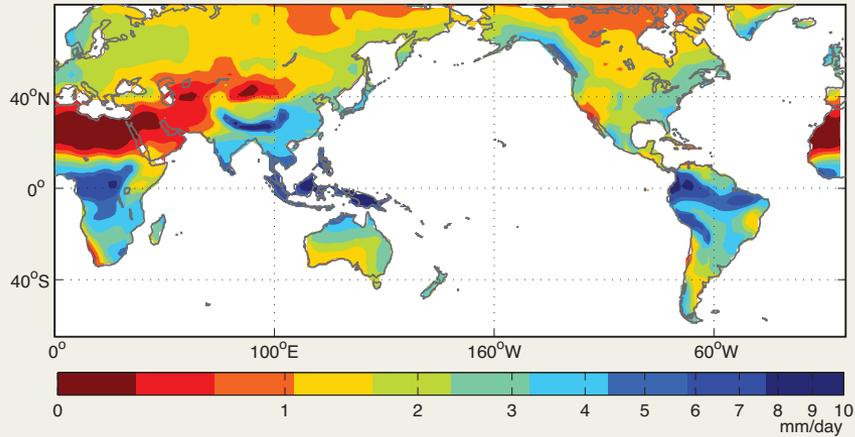
Duration of Dry Spells

- **Long-term** droughts occur in **both** runs
- **AGCM** produces more **single year** event than CPLD
- CPLD produces more **2 to 3 year** drought duration than AGCM
- For droughts lasting **>3yr**: **no evidence** that ocean significantly affects long time-scale events

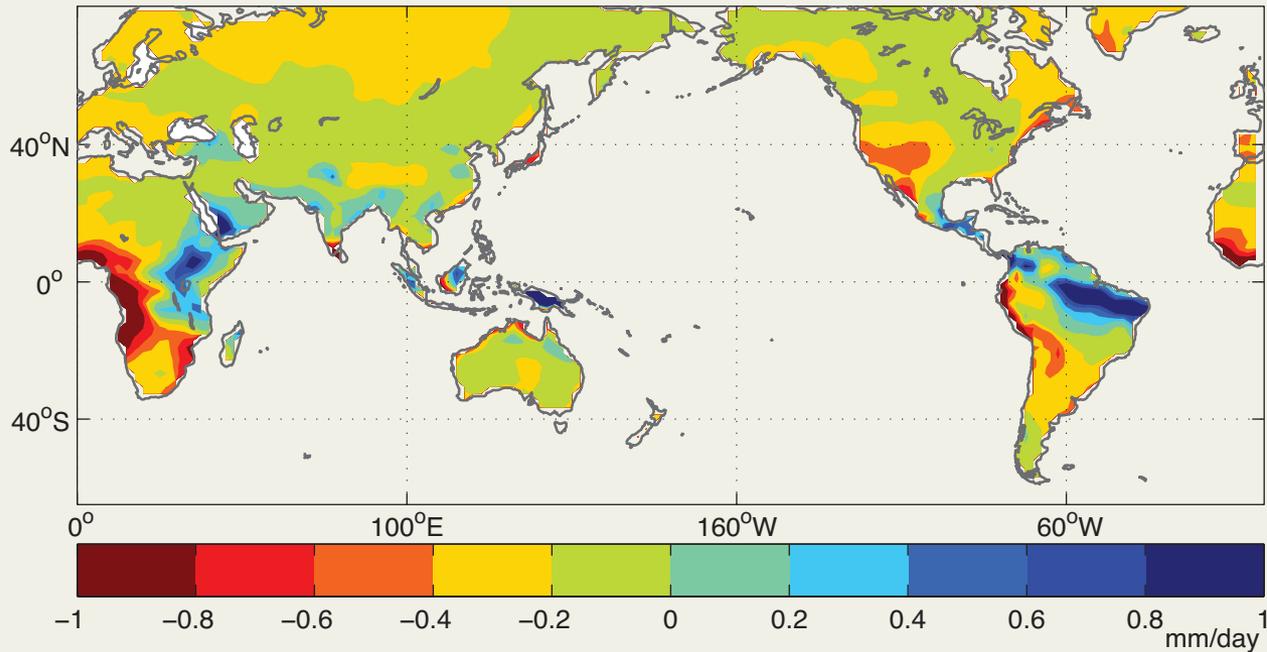


Annual Mean Rainfall Difference

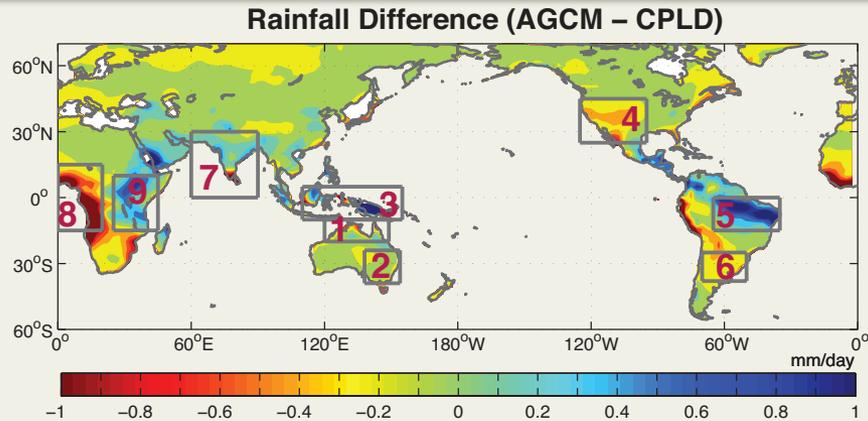
CPLD



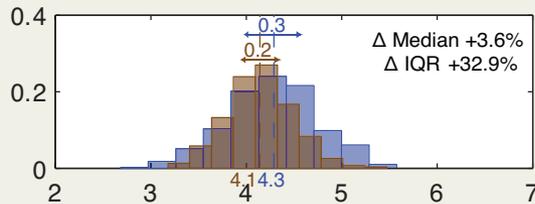
AGCM – CPLD



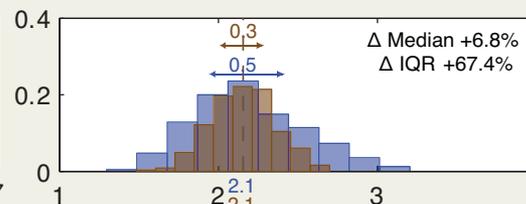
Rainfall Difference (AGCM – CPLD)



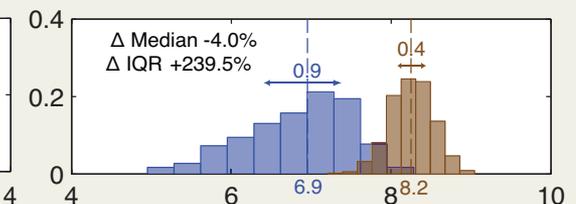
1 Northern Australia



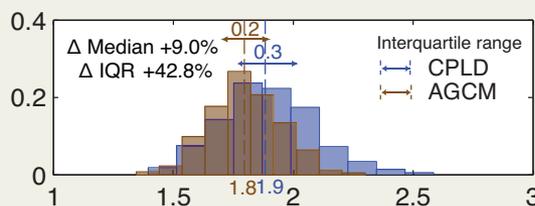
2 Southeast Australia



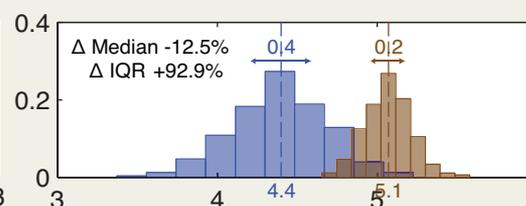
3 Maritime Continent



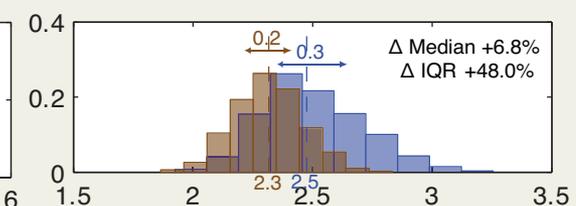
4 North America



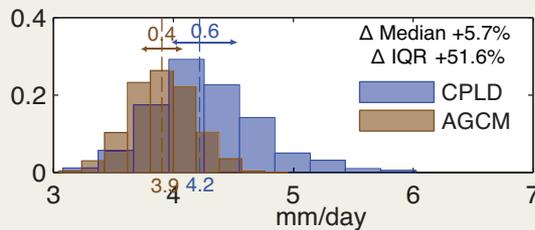
5 South America



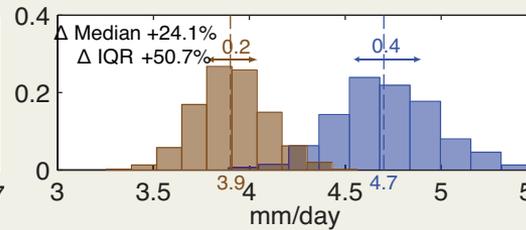
6 Southeast South America



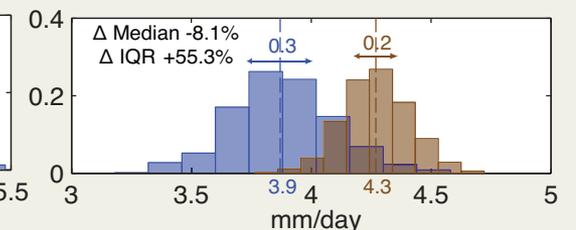
7 South Asia



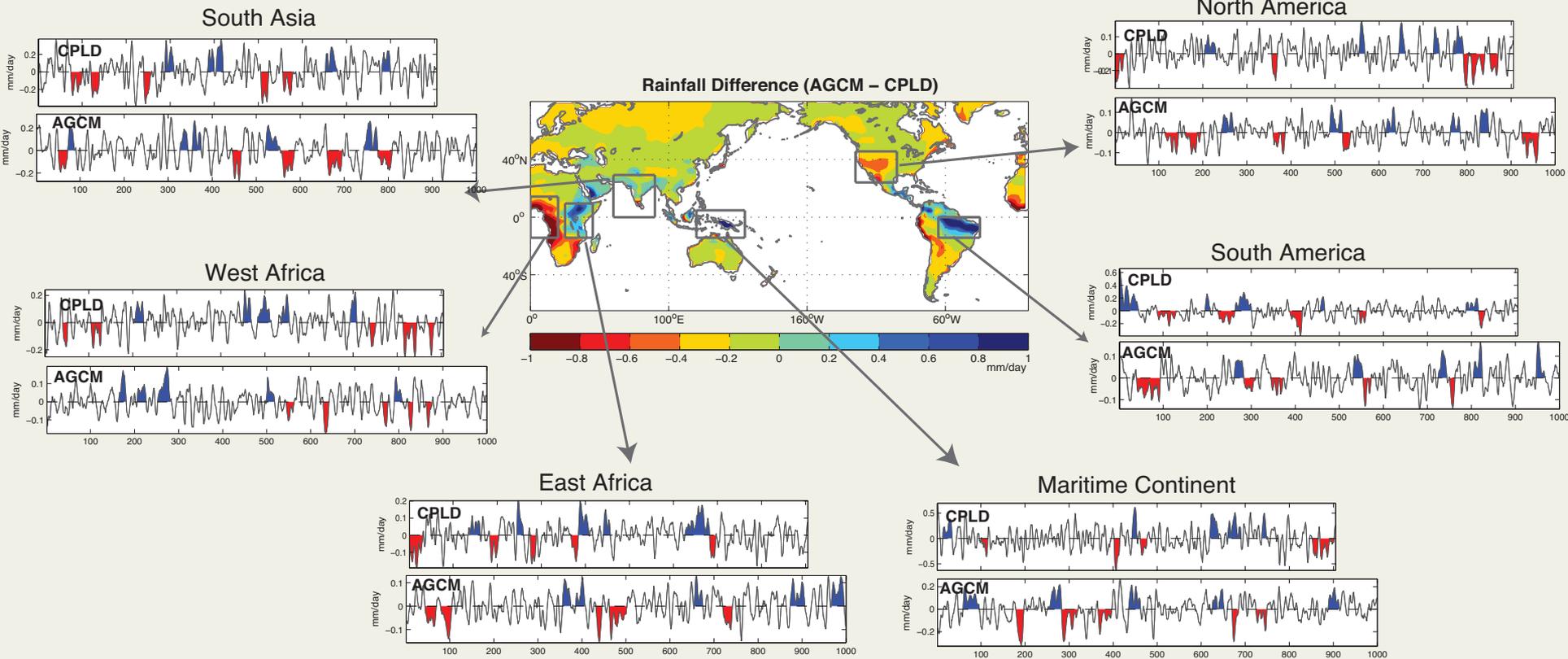
8 West Africa



9 East Africa

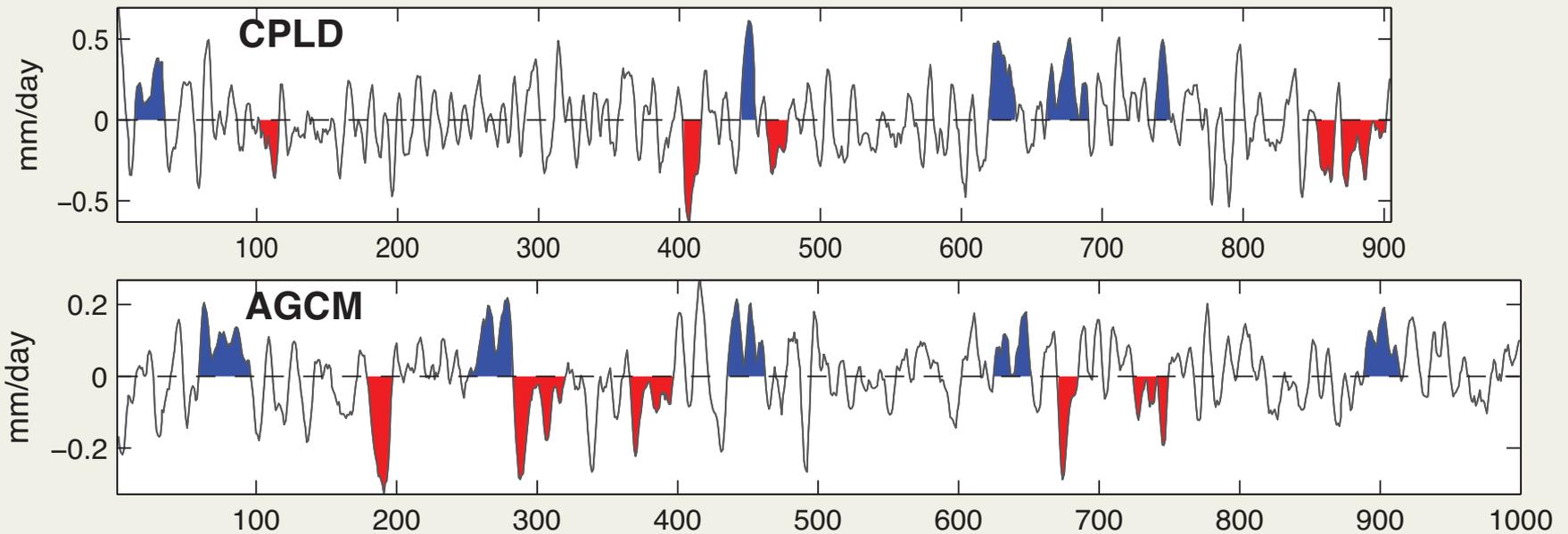


Rainfall Timeseries (AGCM – CPLD)



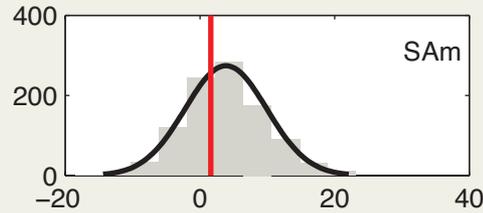
Megadrought Duration longer in AGCM?

Maritime Continent

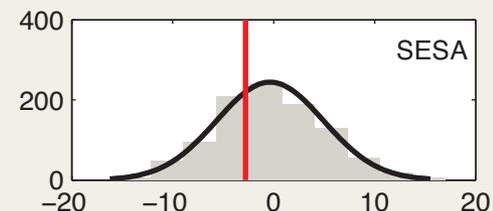
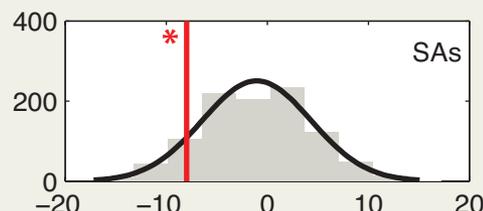
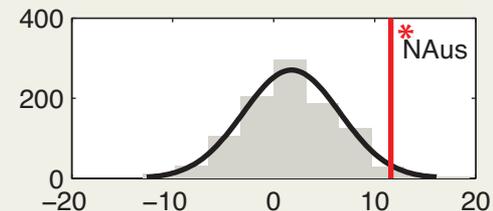
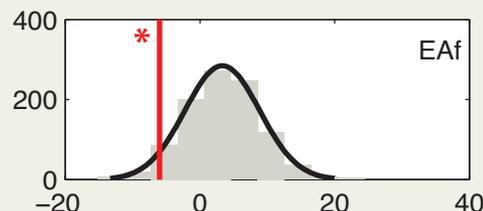
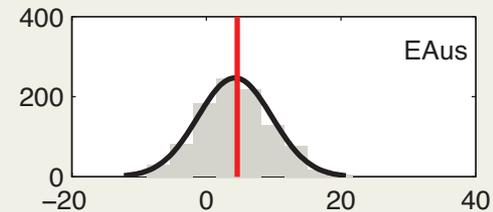
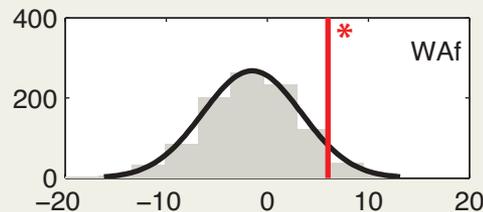
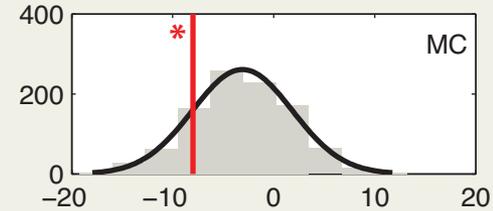
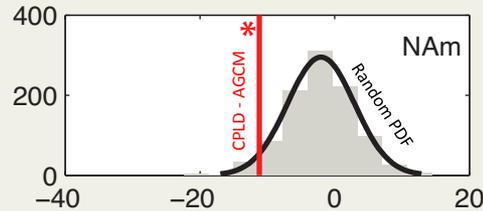


Megadrought Duration longer in AGCM

Region	Maximum Drought Duration (Decadal)	
	CPLD	AGCM
South America	30	53
North America	35	39
Western Africa	32	13
Eastern Africa	30	41
South Asia	17	35
Maritime Continent	24	38
Eastern Australia	32	31
Northern Australia	43	16
SE South America	25	32



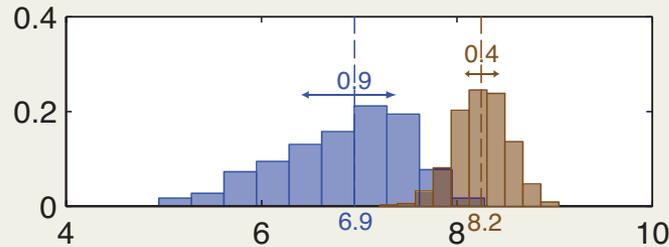
**Dry Spells
Duration Difference
(CPLD – AGCM)**



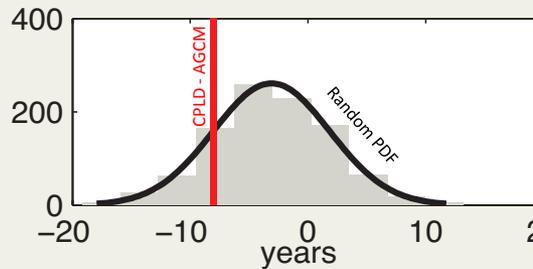
Drought Duration longer in AGCM

- Rainfall variability
- Shifts in mean rainfall
- Duration of dry spells

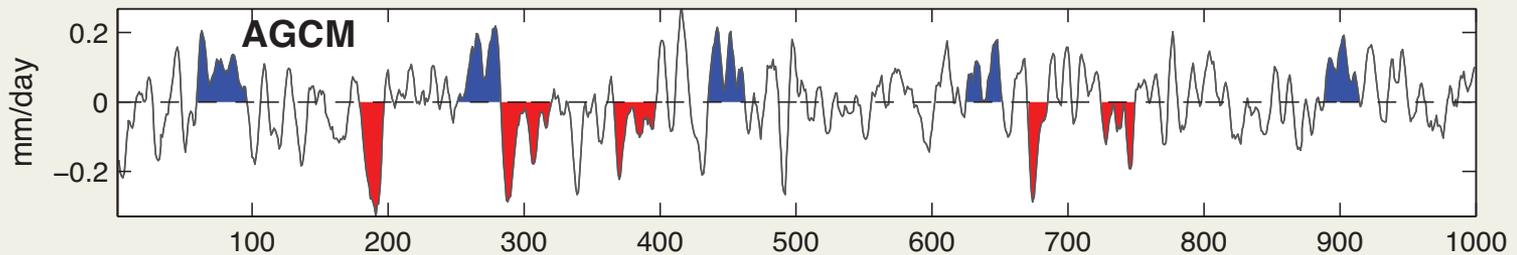
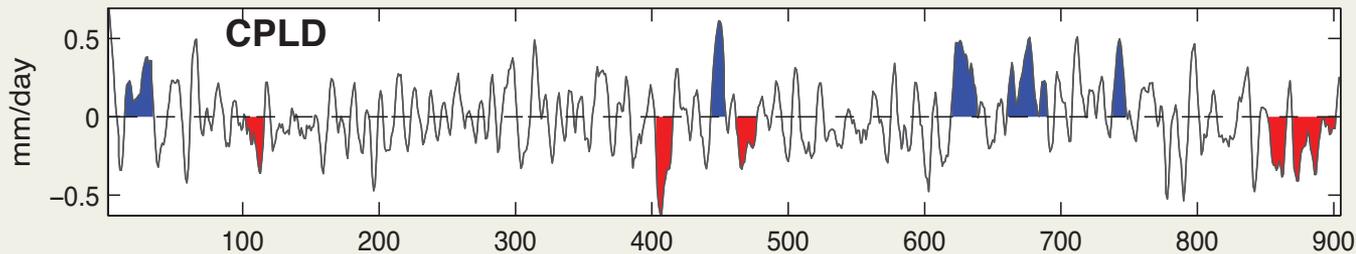
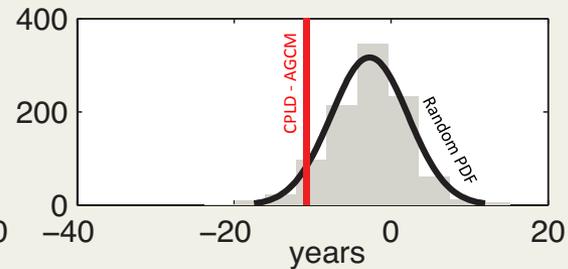
Maritime Continent



Dry Spell Duration



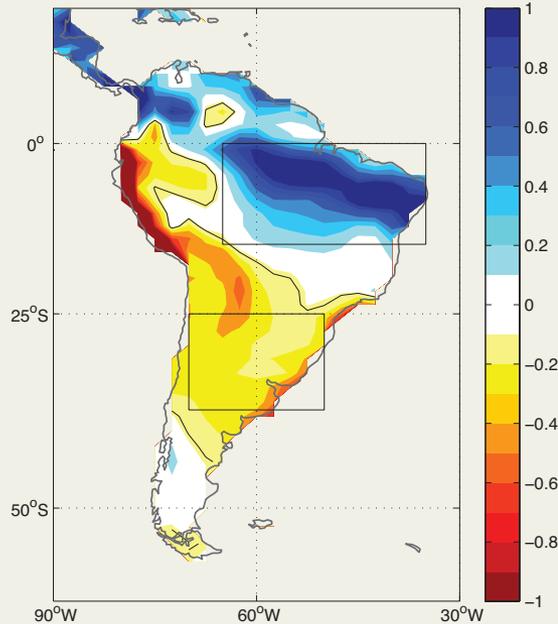
Wet Spell Duration



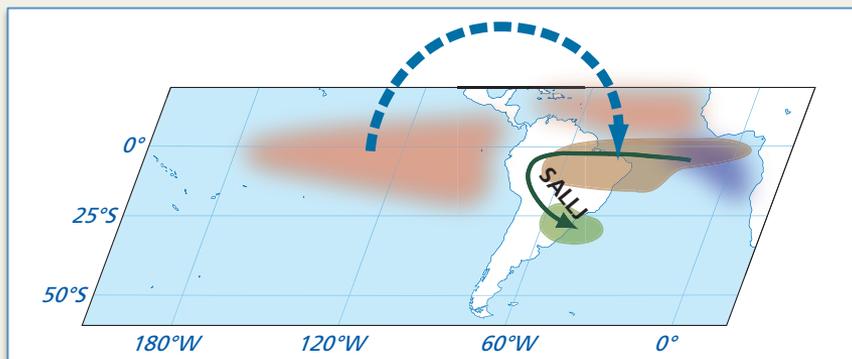
Example: South America

AGCM - CPLD

Mean

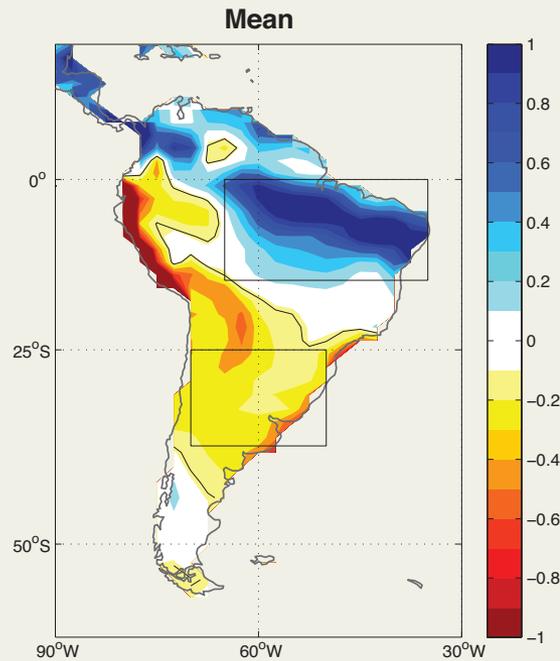


- Wetter climate in the northeast
- Drier climate in the southeast
- Similar to ENSO pattern:
- Less rain in the NE due to Walker circulation
- More rain in the SE due to enhanced LLJ

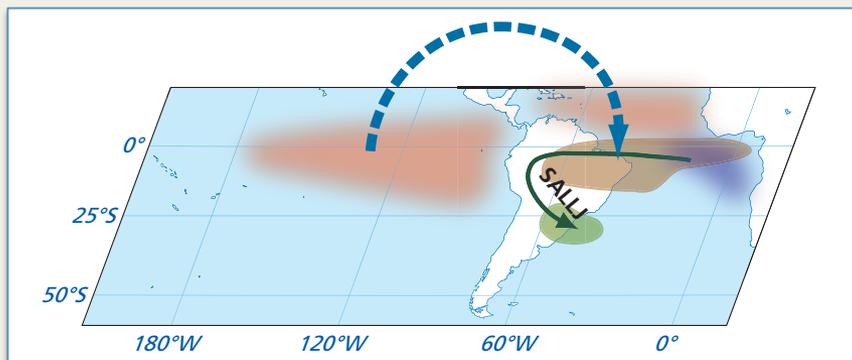
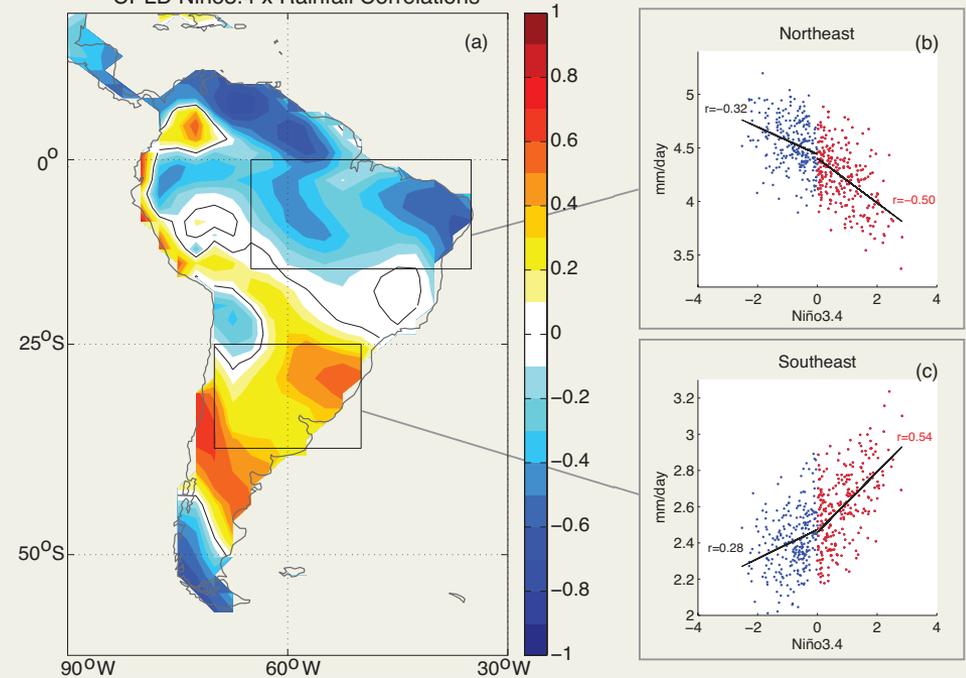


Example: South America

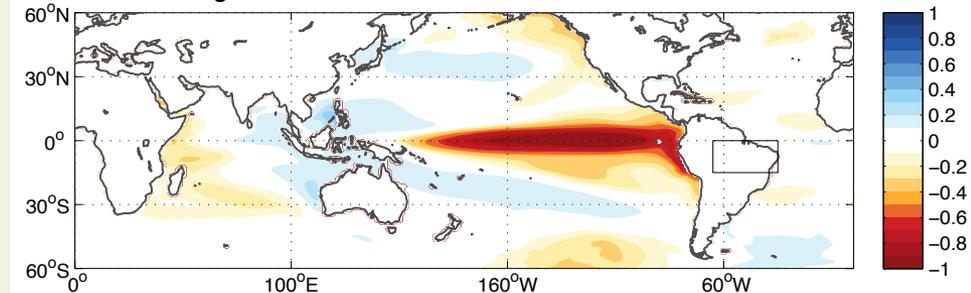
AGCM - CPLD



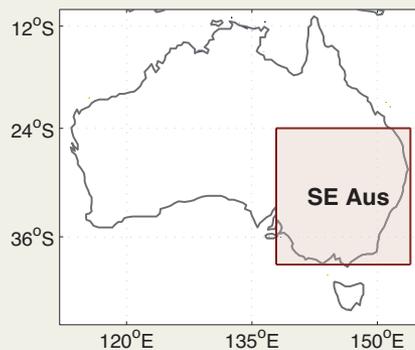
CPLD Niño3.4 x Rainfall Correlations



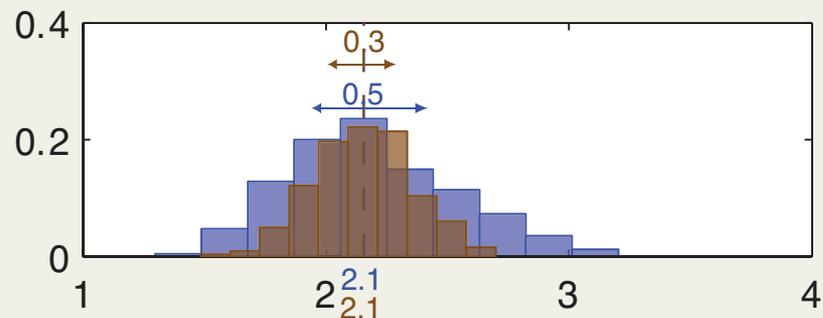
OCN Regression Annual Rain x Annual Mean SST - SAM



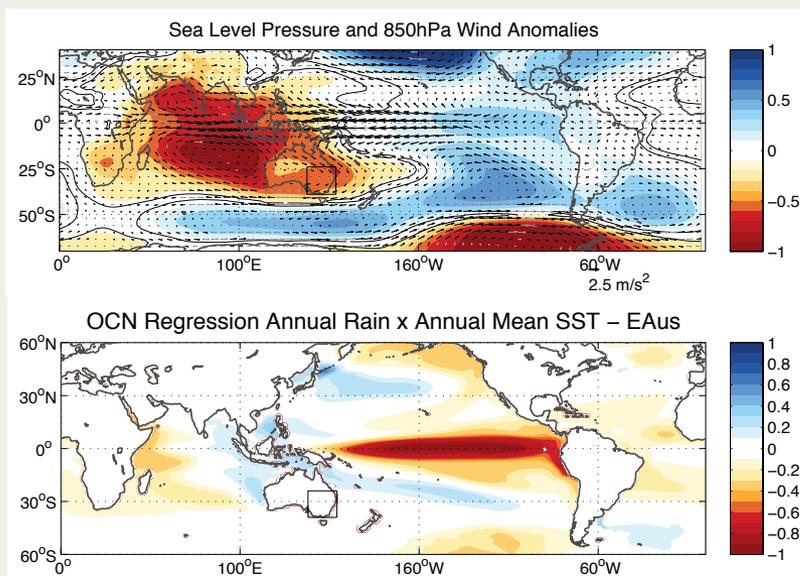
Coming back to Southeast Australia



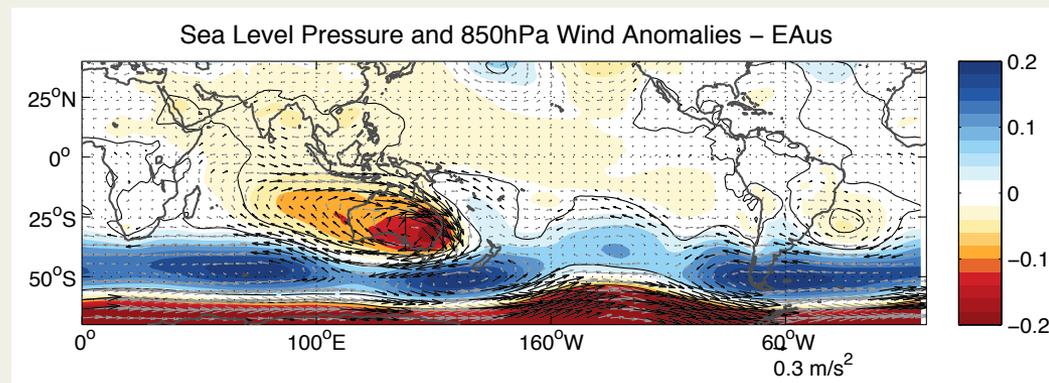
Southeast Australia



CPLD



AGCM



Summary

- i. Ocean variability plays an important role for rainfall variability and extremes.
- ii. **Ocean variability makes droughts** and wet spells **more severe** compared to the those generated by internal atmospheric variability.
 - i. Rainfall variability is damped by ~30% in Australia the absence of ocean variability.
- iii. Ocean variability also determines **mean rainfall** over certain areas in the tropics.
 - i. Rainfall increases by ~14% in the northeast and decreases by ~6% in southeastern South America
- iv. Ocean variability tends to produce droughts with 3yr duration, while **atmospheric driven droughts** can last **longer**.
- v. ENSO acts as a terminating mechanism for droughts and wet events.
- vi. Without ocean variability, drought periods can extend much longer, as there is no natural oscillation with marked periodicity that brings the climate system back to neutral state.