# The ICTP-CORDEX simulations. Overview of the CREMA ensemble results

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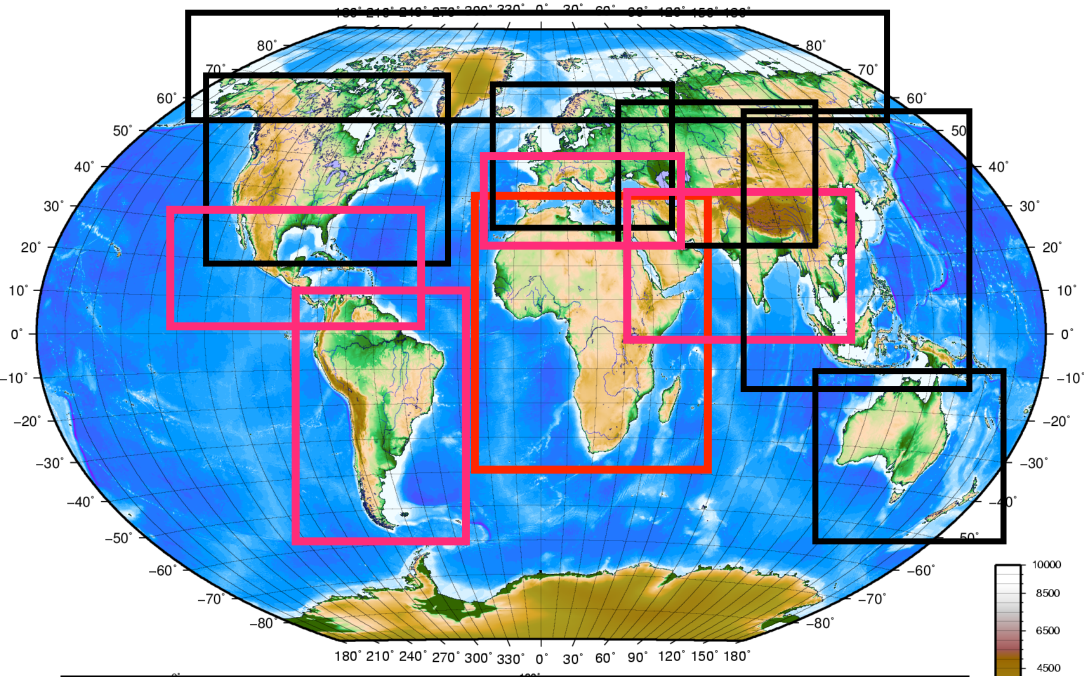
# CREMA domains




| | Africa | C America | India | Med | S. America |
|---|---|---|---|---|---|
| HAD-CLM-GE | 2 | | | 1 | |
| HAD-CLM-E | | 2 | | | 2 |
| HAD-BATS-G | | 2 | | | |
| HAD-BATS-GE | | | | 1 | 2 |
| MPI-CLM-E | | 1 | 1 | | 1 |
| MPI-BATS-G | 1 | 1 | | | |
| MPI-BATS-GE | | | | 1 | |
| MPI-CLM-GE | | | | 1 | |
| GFDL-CLM-E | | | 2 | | 1 |
| GFDL-CLM-EG | | | 2 | | |

- 33 scenario simulations were completed, each extending from 1970 to 2100
- 1976-2005 being used as reference for the assessment of the model present day climate

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# ICTP Regional Climate Model
# CREMA Parameterization tested

- **Dynamics**:
  - Hydrostatic (Giorgi et al. 1993a,b)
  - Adaptable to any region
  - Non-hydrostatic in progress
- **Radiation:**
  - **CCM3 (Kiehl 1996)**
- **Large-Scale Clouds & Precipitaion:**
  - SUBEX (Pal et al 2000)
- **Cumulus convection:**
  - **Grell (1993)**
  - Anthes-Kuo (1977)
  - **MIT (Emanuel 1991)**
  - **Mixed convection**
  - Tiedtke (in progress)
- **Planetary boundary layer:**
  - **Modified Holtslag, Holtslag (1990)**
  - UW-PBL (O' Brien et al. 2011)
- **Land Surface:**
  - **BATS (Dickinson et al 1993)**
  - SUB-BATS (Giorgi et al 2003)
  - **CLM (Oleson et al. 2008)**
- **Ocean Fluxes**
  - **BATS (Dickinson et al 1993)**
  - **Zeng (Zeng et al. 1998)**
  - Diurnal SST
- **Configuration**
  - Adaptable to any region
  - Tropical belt configuration
- **Extensive code remake**

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ics

# CREMA Experiment set-up

- CORDEX domain specifications
- Simulation period
  - 1970-2100
  - Reference: 1976-2005
- Greenhouse gas scenarios
  - RCP8.5, RCP4.5
- Driving GCMs
  - HadGEM2-ES
  - MPI-ESMMR
  - GFDL-ESM
- Observations
  - CRU, GPCP, TRMM

# Special Issue of Climate Change

- Coppola et al.
  - Present and future climatologies in the Phase I CREMA experiment
- Giorgi et al.
  - Changes in extremes and hydroclimatic regimes in the CREMA ensemble projections
- Diro et al,
  - Tropical cyclones in a regional climate change projection with RegCM4 over the CORDEX Central America domain
- Mariotti et al.
  - Seasonal and intraseasonal changes of African monsoon climates in 21st century CORDEX projections
- Llopart et al.
  - Climate change impact on precipitation for the Amazon and La Plata basins
- Guttler et al.
  - Sensitivity of the regional climate model RegCM4.2 to planetary boundary layer parameterisation
- Da Rocha et al;
  - Interannual variability associated with ENSO: present and future climate projections of RegCM4 for South America-CORDEX domain

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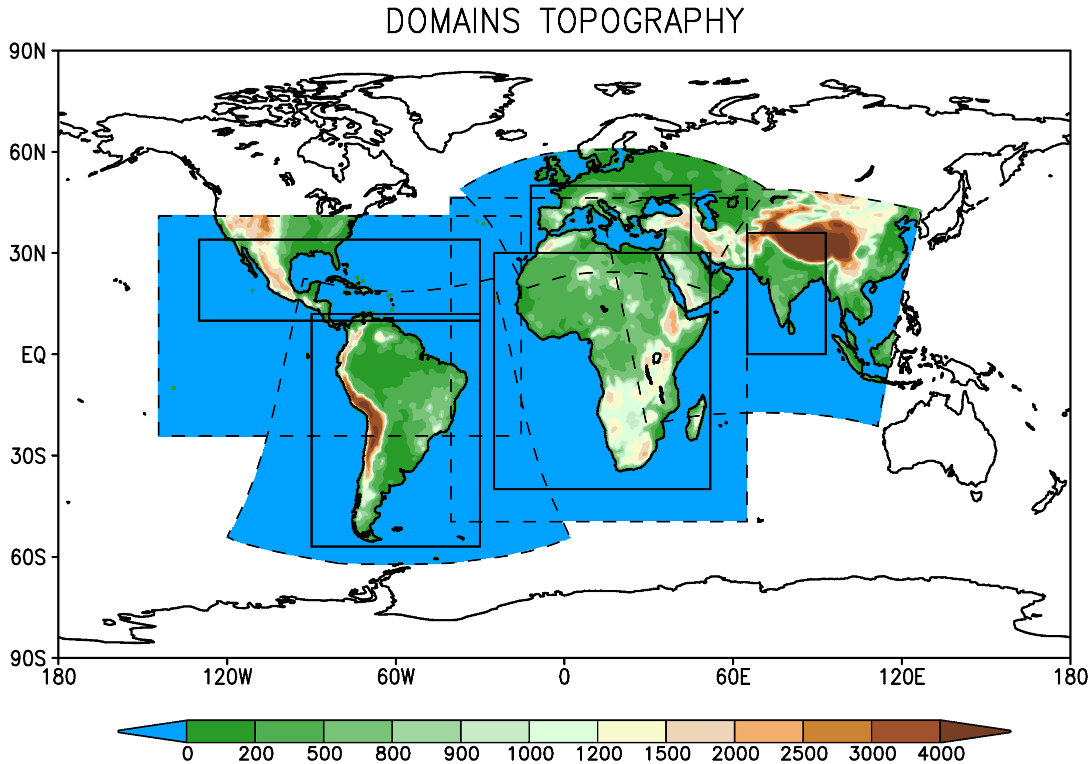
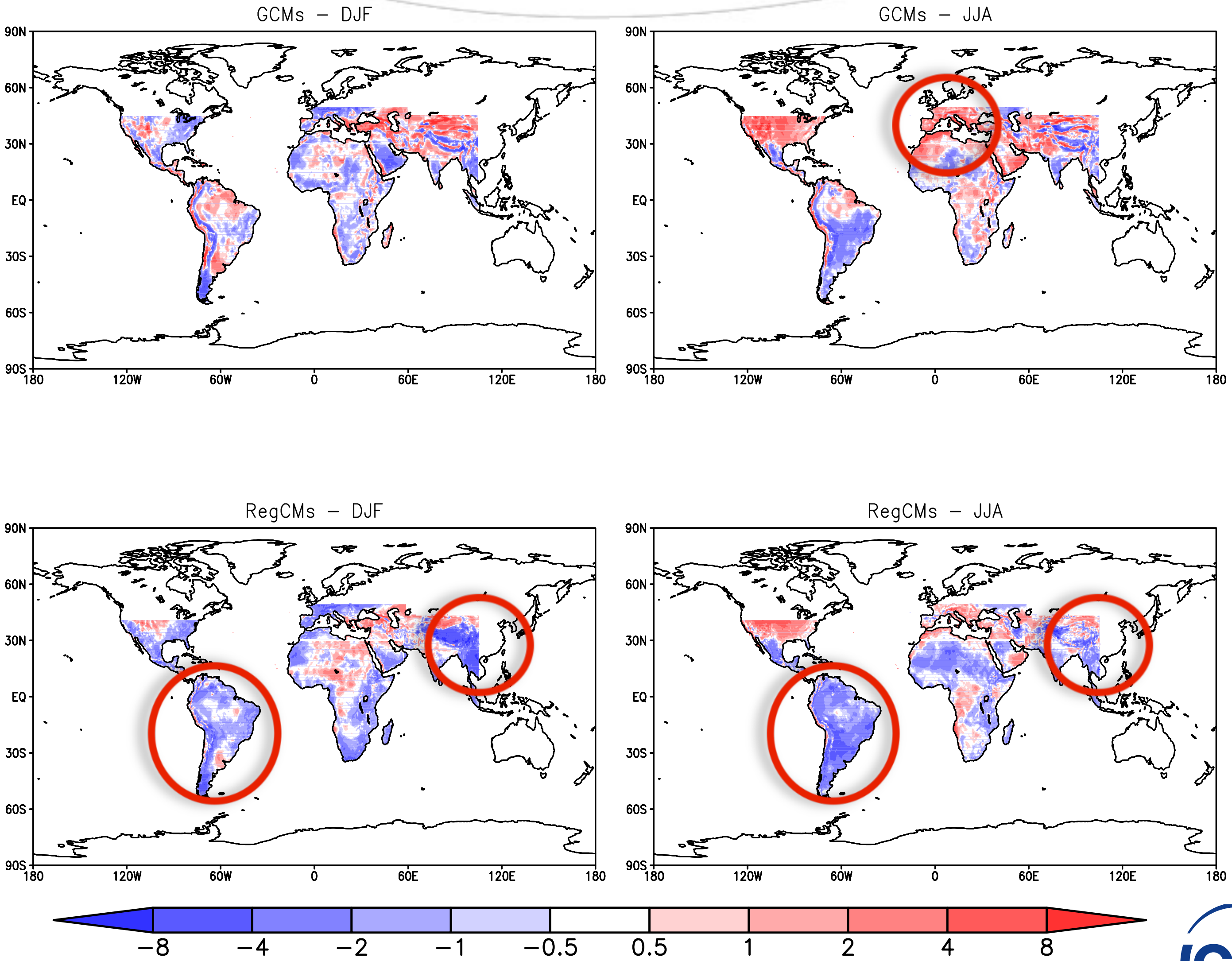
# Mean Climate

## Coppola et al. (2013)



# Temperature Bias

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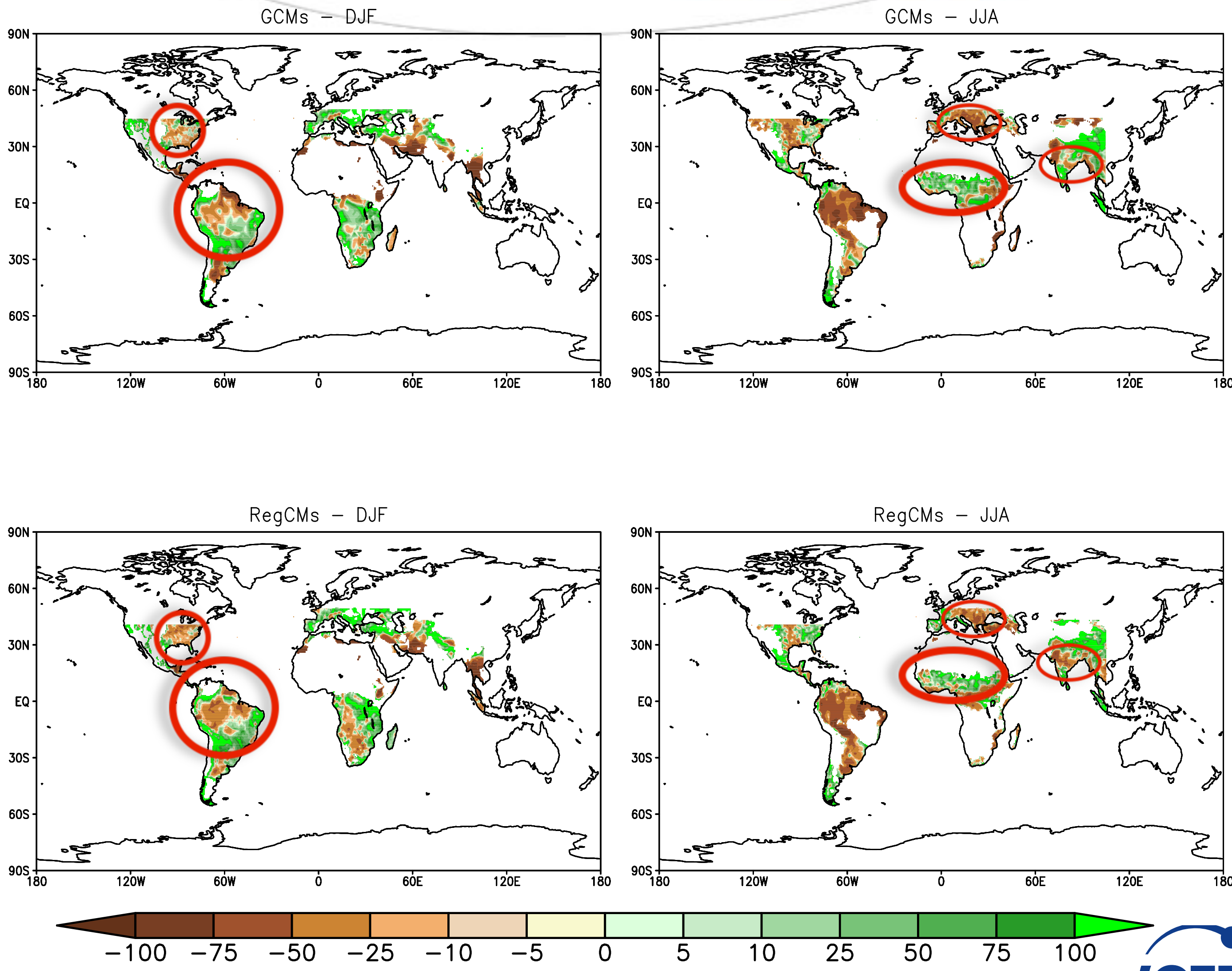
# Precipitation Bias

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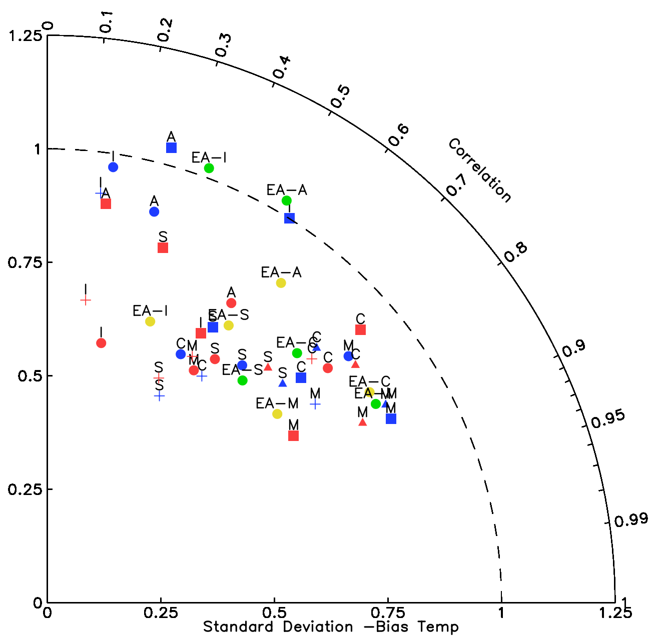
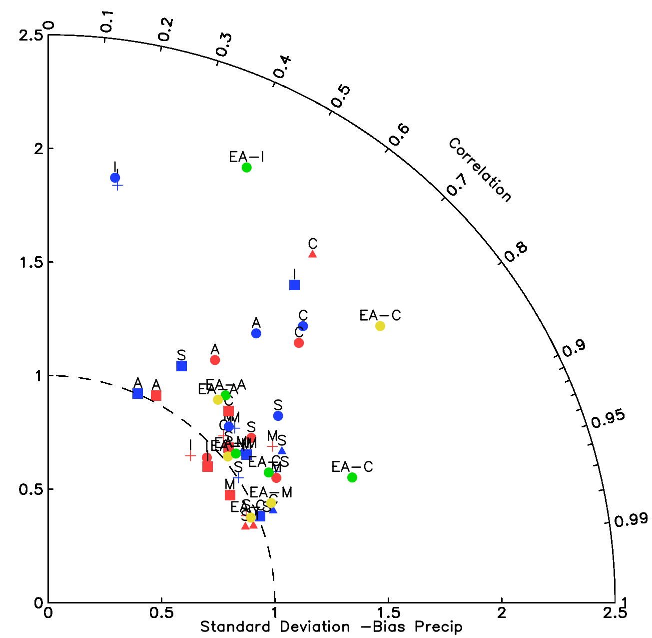
# Variant of the Taylor diagram

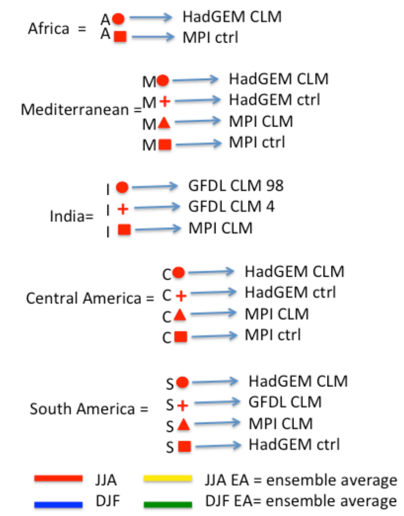
- pairs of driving GCM / nested RegCM bias patterns for each simulation are compared
- value of 1 on the diagram would mean that the bias patterns are exactly the same in the two simulations.
- The surface **temperature** biases in the regional models appear to be mostly tied to the internal model physics, and likely the land use definitions.
- A greater large scale boundary forcing appears to be exerted on the **precipitation** bias patterns




Temperature




Precipitation

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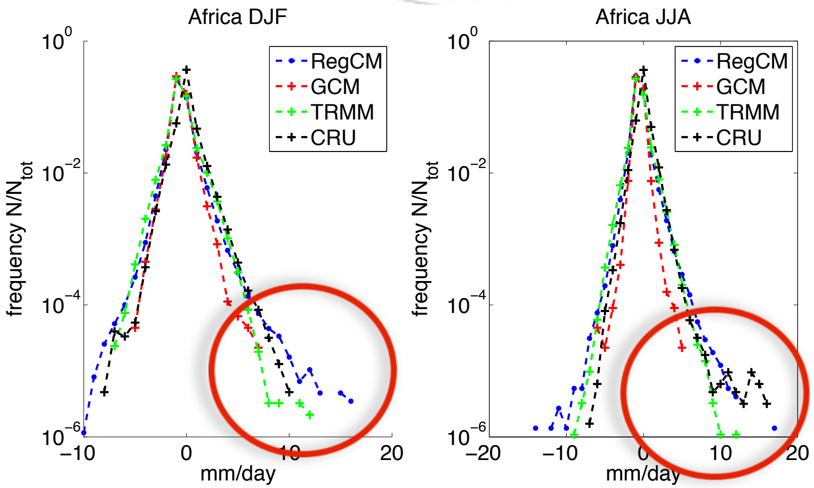
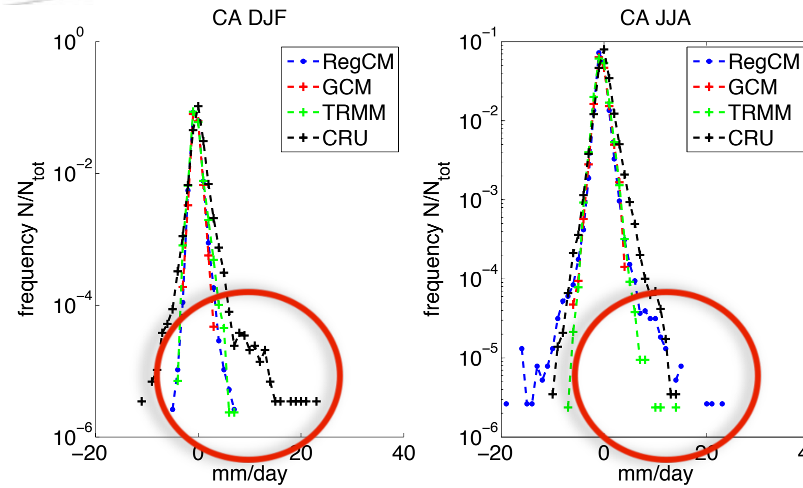
# Precipitation seasonal anomaly

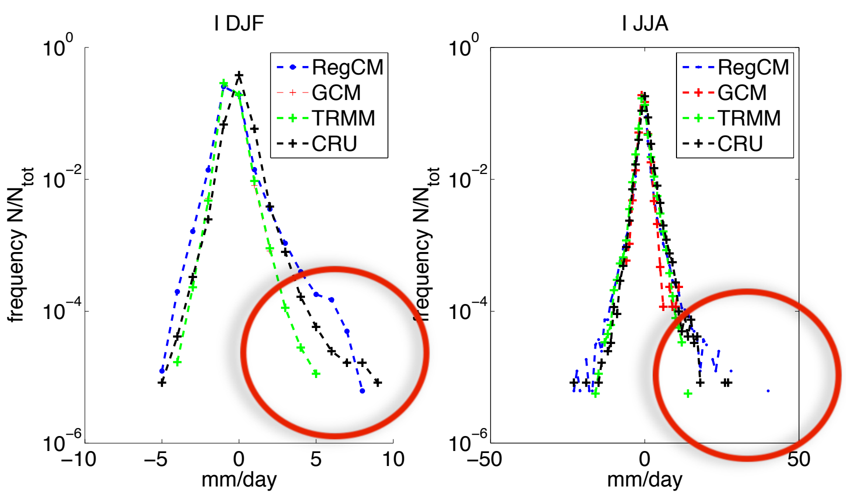
## AFRICA



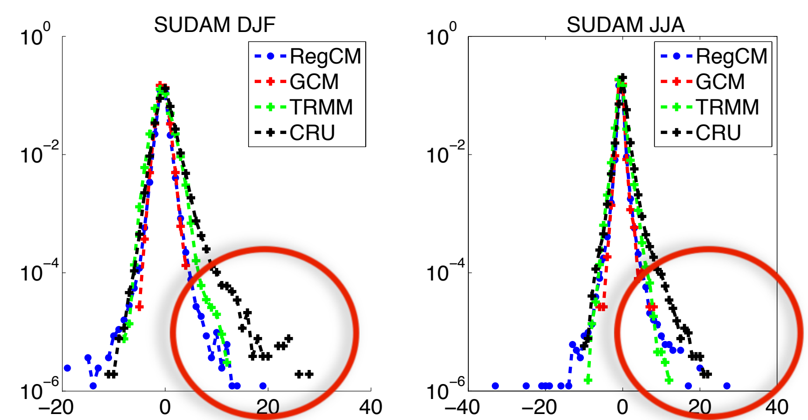

## C AMERICA




## INDIA




## S AMERICA

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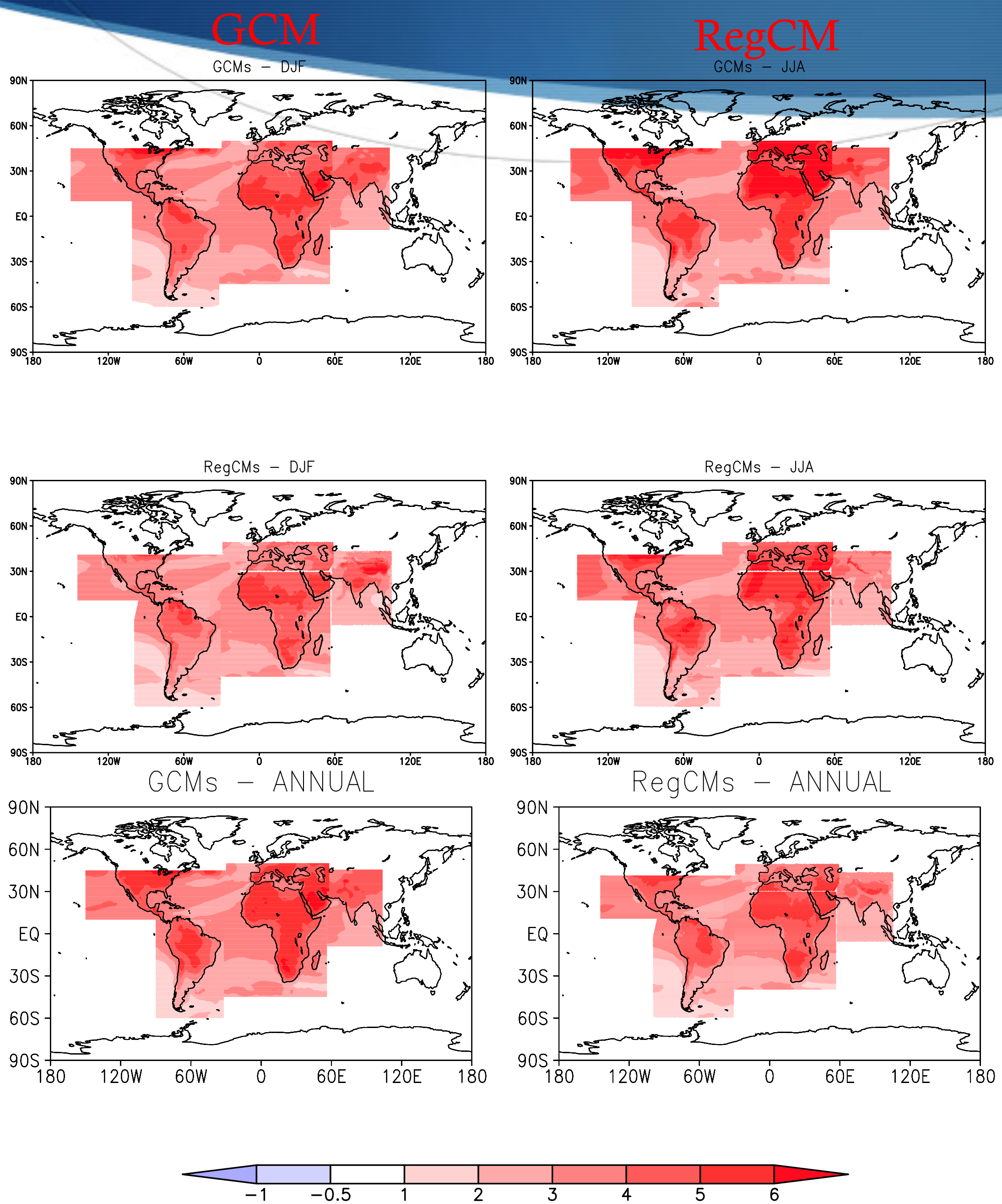
# Temperature change RCP8.5 (2070/2100-1976/2005)




- values exceeding 5 degrees in the inner continental interiors
- RegCM ensemble shows lower amounts of warming by several tenths of a degree
- CLM scheme generally exhibits less sensitivity to increased GHG forcing than BATS

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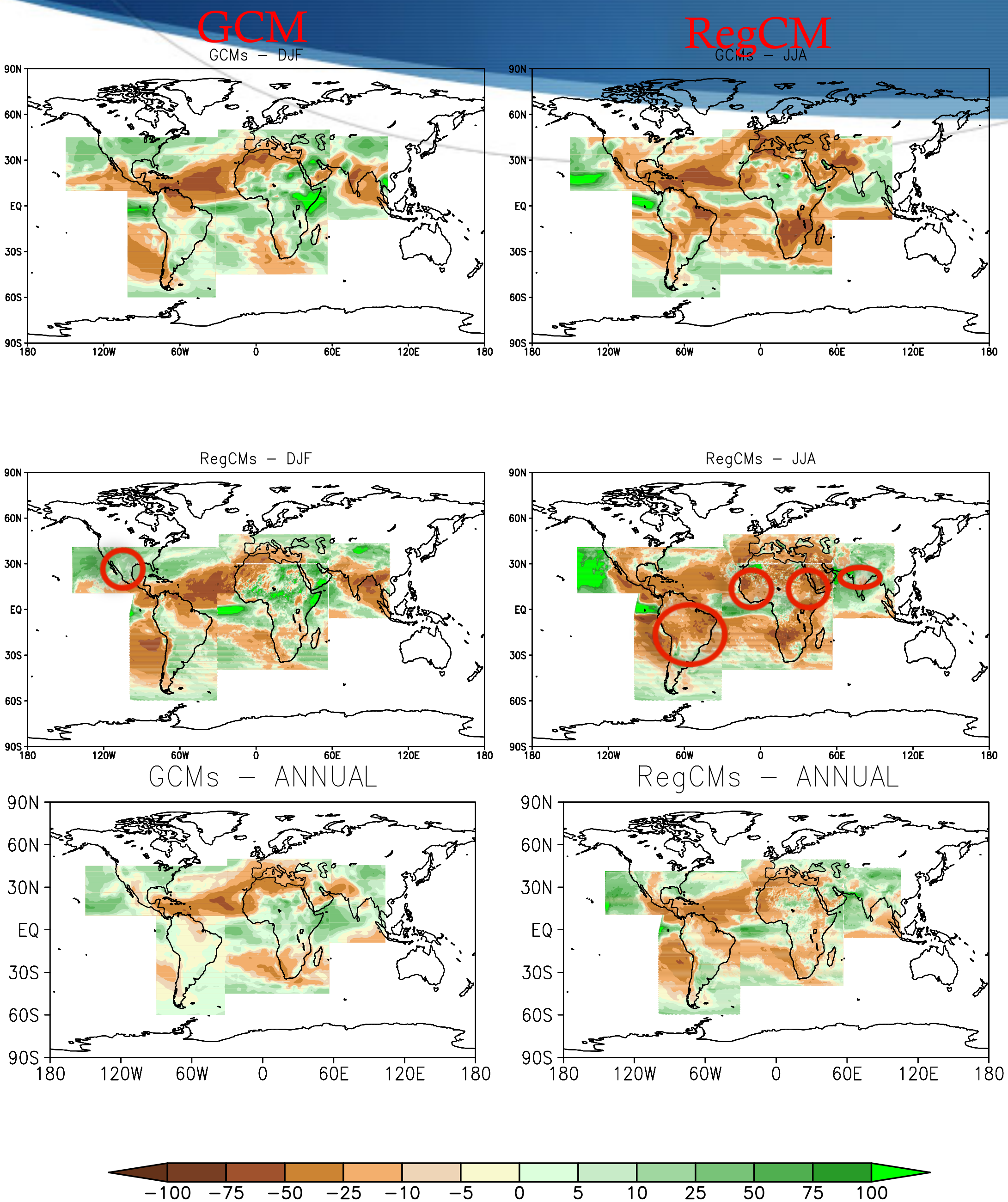
# Precipitation change RCP8.5 (2070/2100-1976/2005)




- The forcing of the driving GCMs on the large scale patterns of change simulated by the RCMs is evident from the similarities in the large scale structure of the changes
- important regional differences between GCM and RegCM (different descriptions by the models of land-atmosphere interactions, response to SST changes and local topographical forcings) details in talk by Llopart et al.; Fuentes-Franco et al; Dash et al.)
- CLM/E configuration shows a weaker signal compared to the BATS/G

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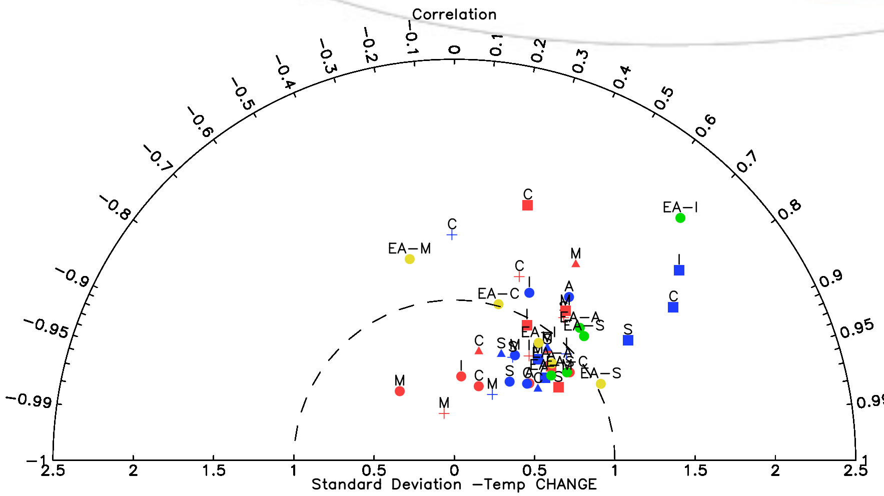
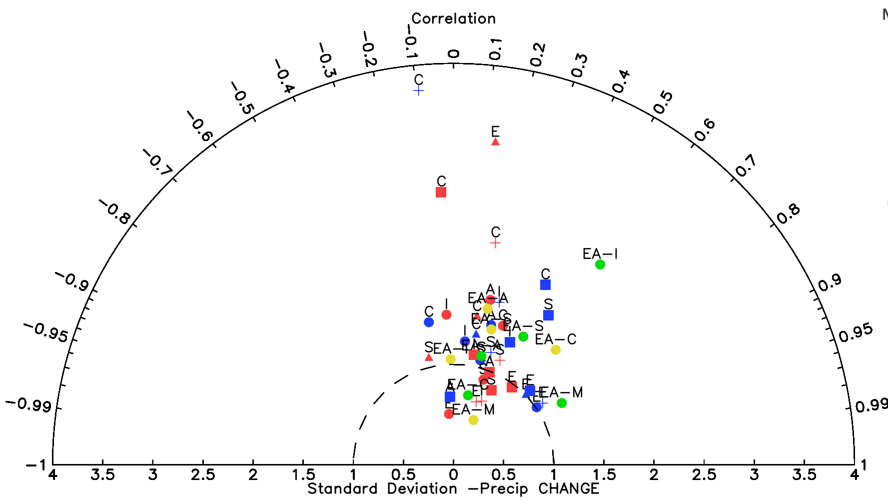
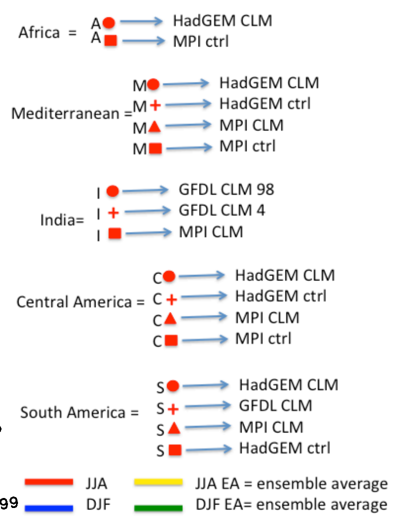
# Taylor diagram applied to the change instead of the bias




Temperature




Precipitation




T :

- better agreement between the GCM and RegCM change patterns : correlations 0.3 and 0.8 ; standard deviations 0.50-1.50
- GCM forcing substantially affects the temperature change spatial pattern of the RegCM, both in terms of spatial pattern and spatial variability

P:

- correlations are generally low less than 0.6
- spatial standard deviation mostly higher
- show importance of fine scale forcings and processes

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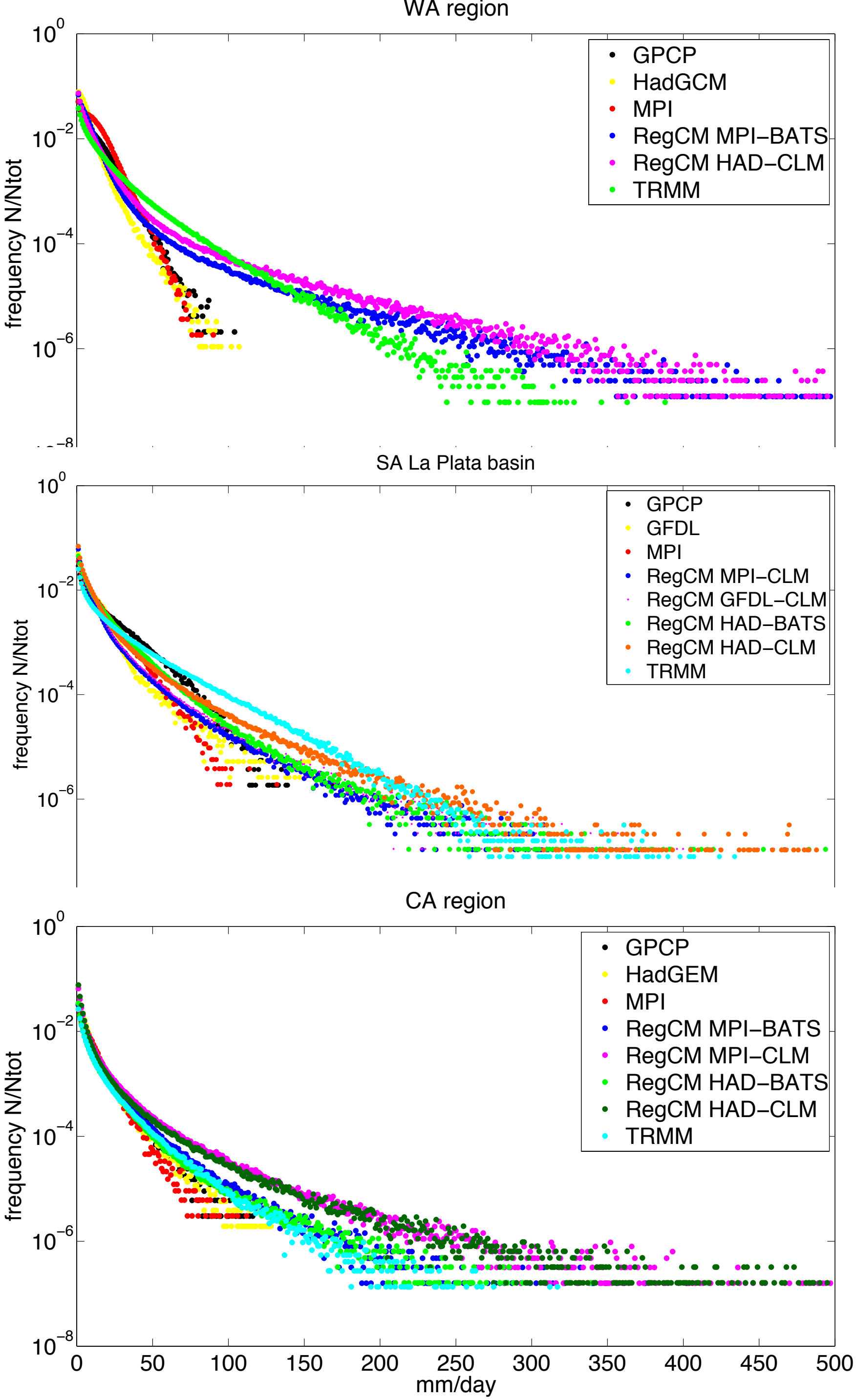
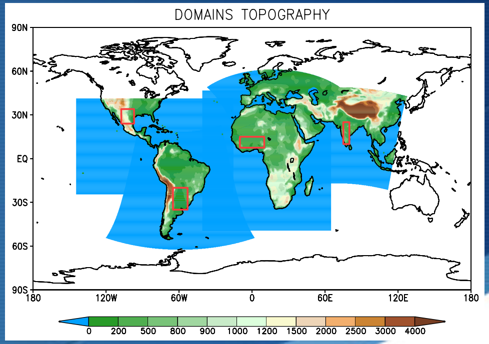
# Extremes

Giorgiet al. (2013)




# Empirical PDFs of daily precipitation events in models and observations (GPCP, TRMM)

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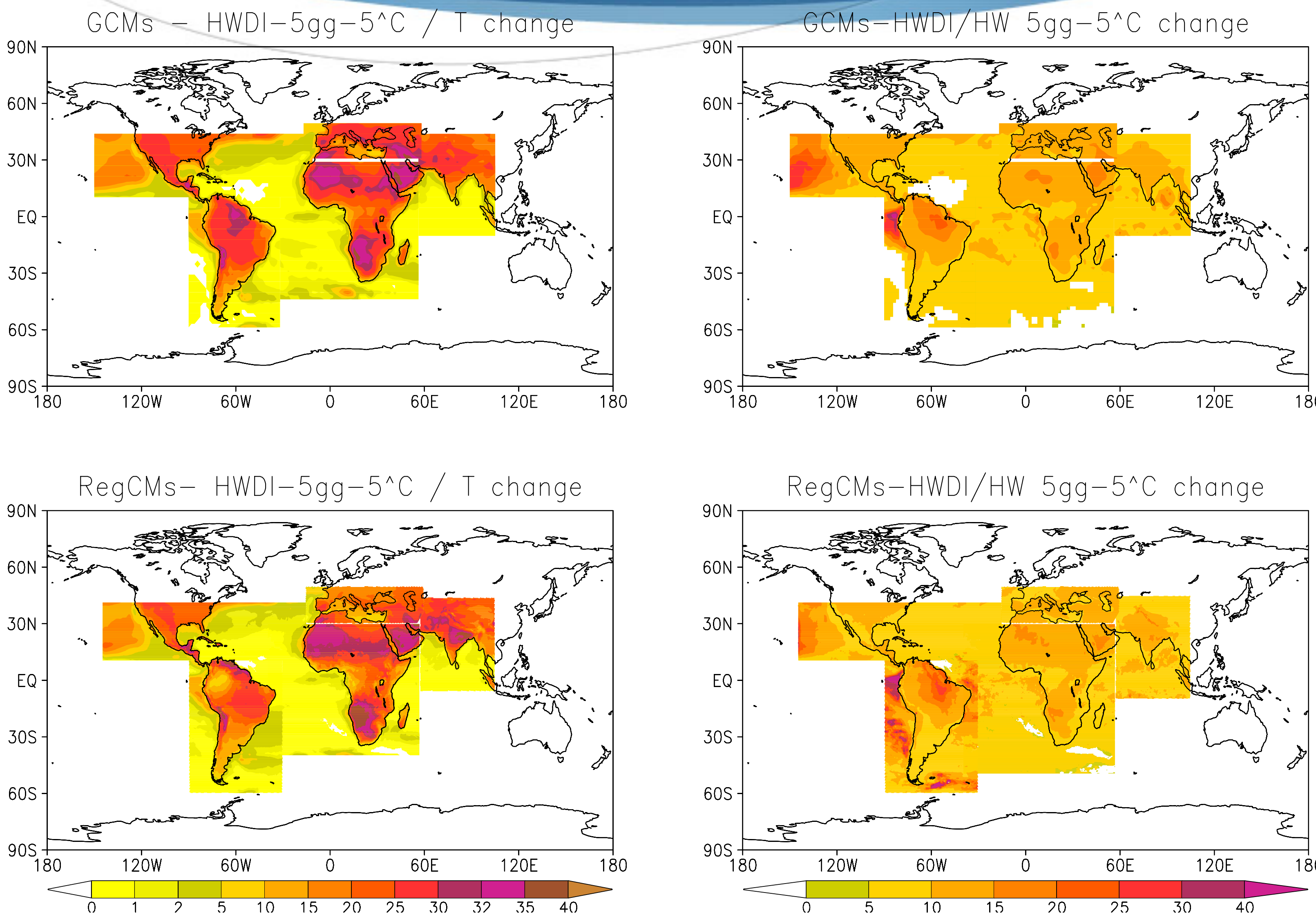
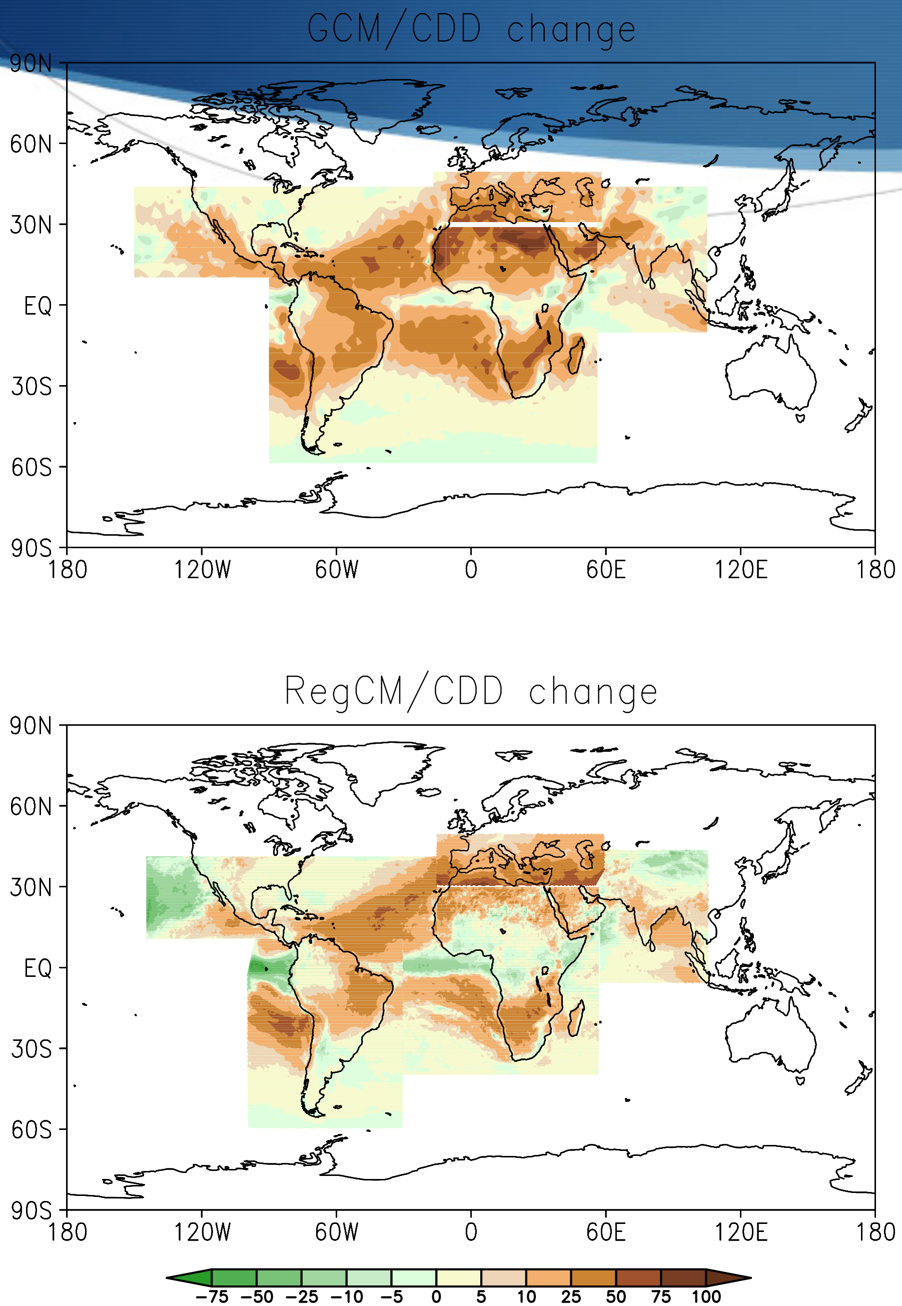
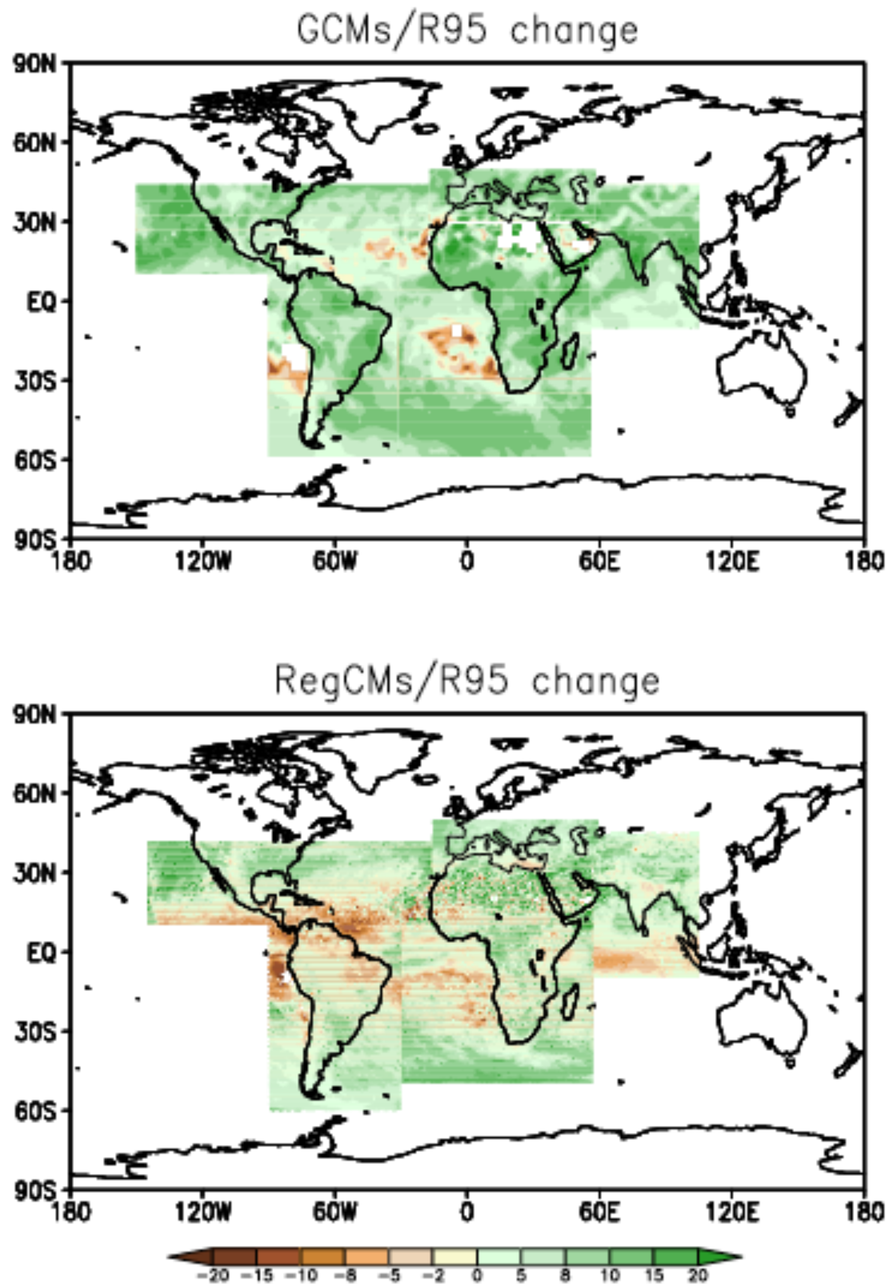
Ensemble mean change (2071-2100 minus 1976-2005) in heat wave characteristics for the thresholds Nd=5 days and Nt = 5°C over the five CREMA domains. Left column: change in number of HWD (compared to present day means) per year per degree of (local) warming. Right column: change in mean heat wave length in days.

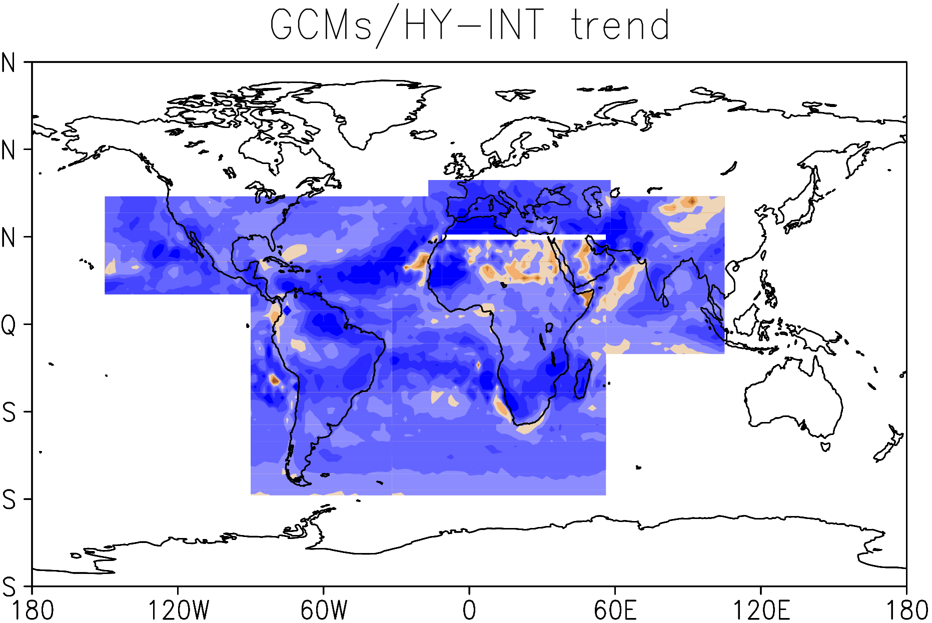




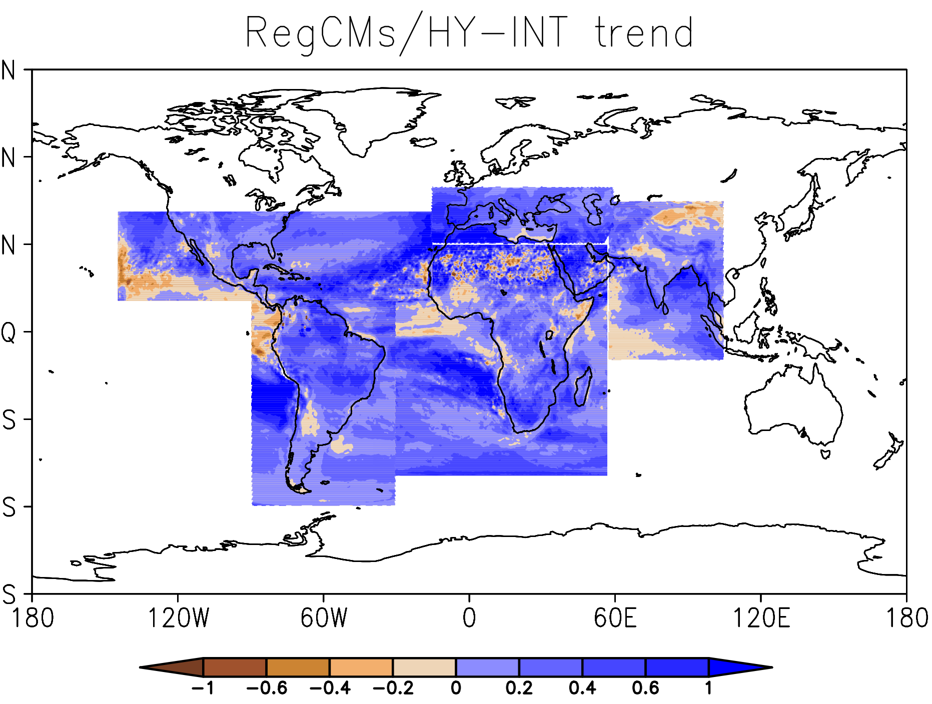

Ensemble mean change (2071-2100 minus 1976-2005) in **CDD** over the five CREMA domains. The CDD is calculated for each year and then averaged over the 30-year period. Upper panel shows the GCM runs, lower panel shows the RegCM4 runs. Units are No. Days.




Ensemble mean change (2071-2100 minus 1976-2005) in **R95** over the five CREMA domains. The R95 is calculated for each year and then averaged over the 30-year periods. Upper panel shows the GCM runs, lower panel shows the RegCM4 runs. Units are %.




# 21st Century trends in the hydroclimatic regime index HY-INT ( I x DSL )




## Global warming leads to more Intense, less frequent events

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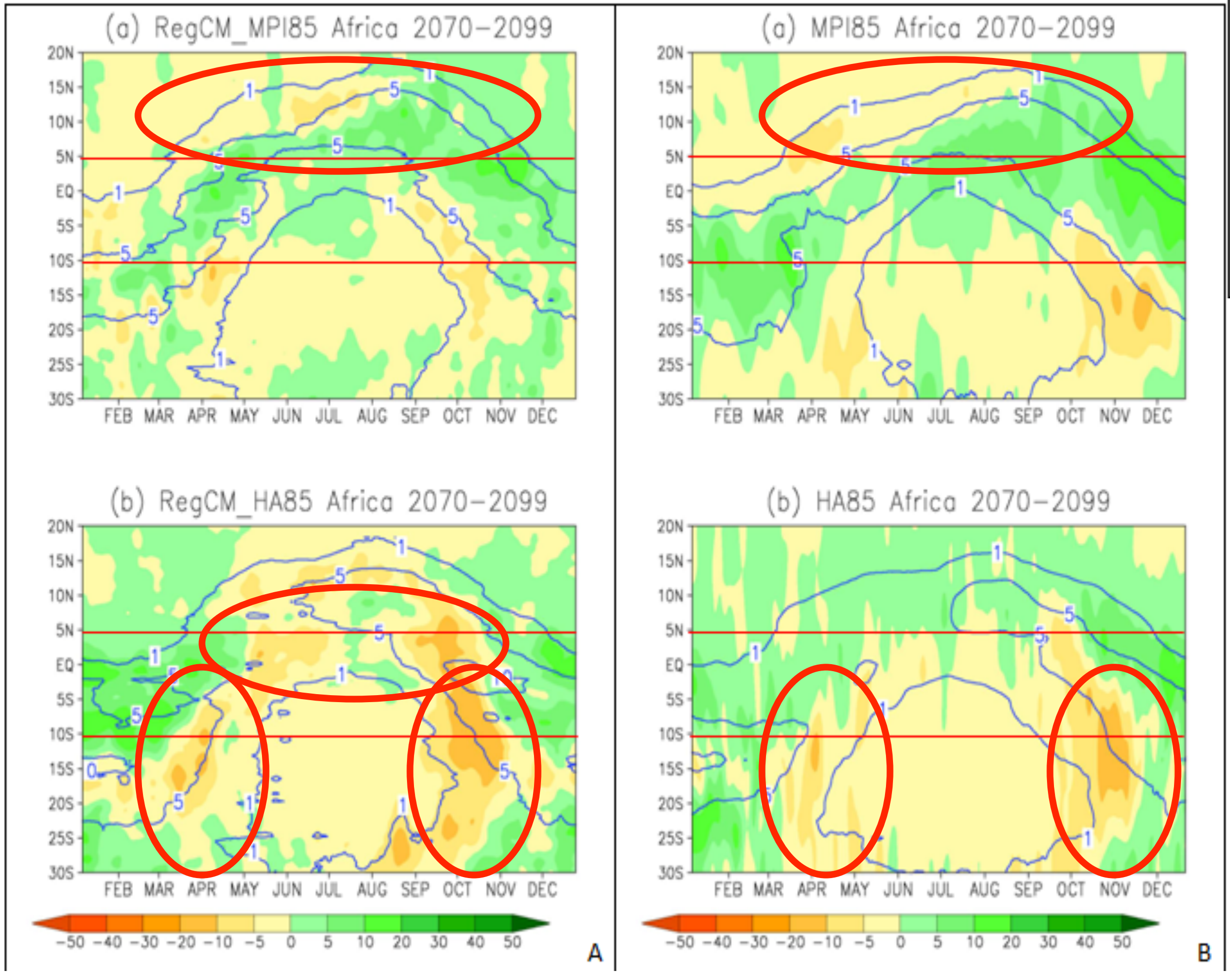
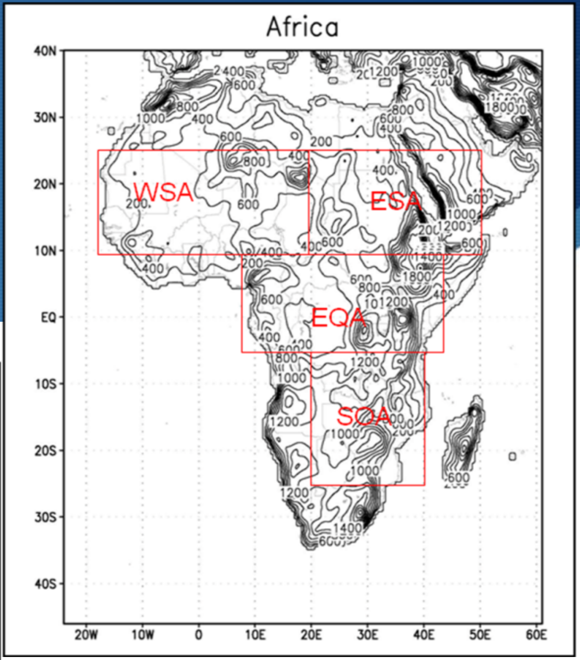
# Hovmoller diagram of change in daily precipitation over Africa

GCM RegCM




Mariotti et al (2013)

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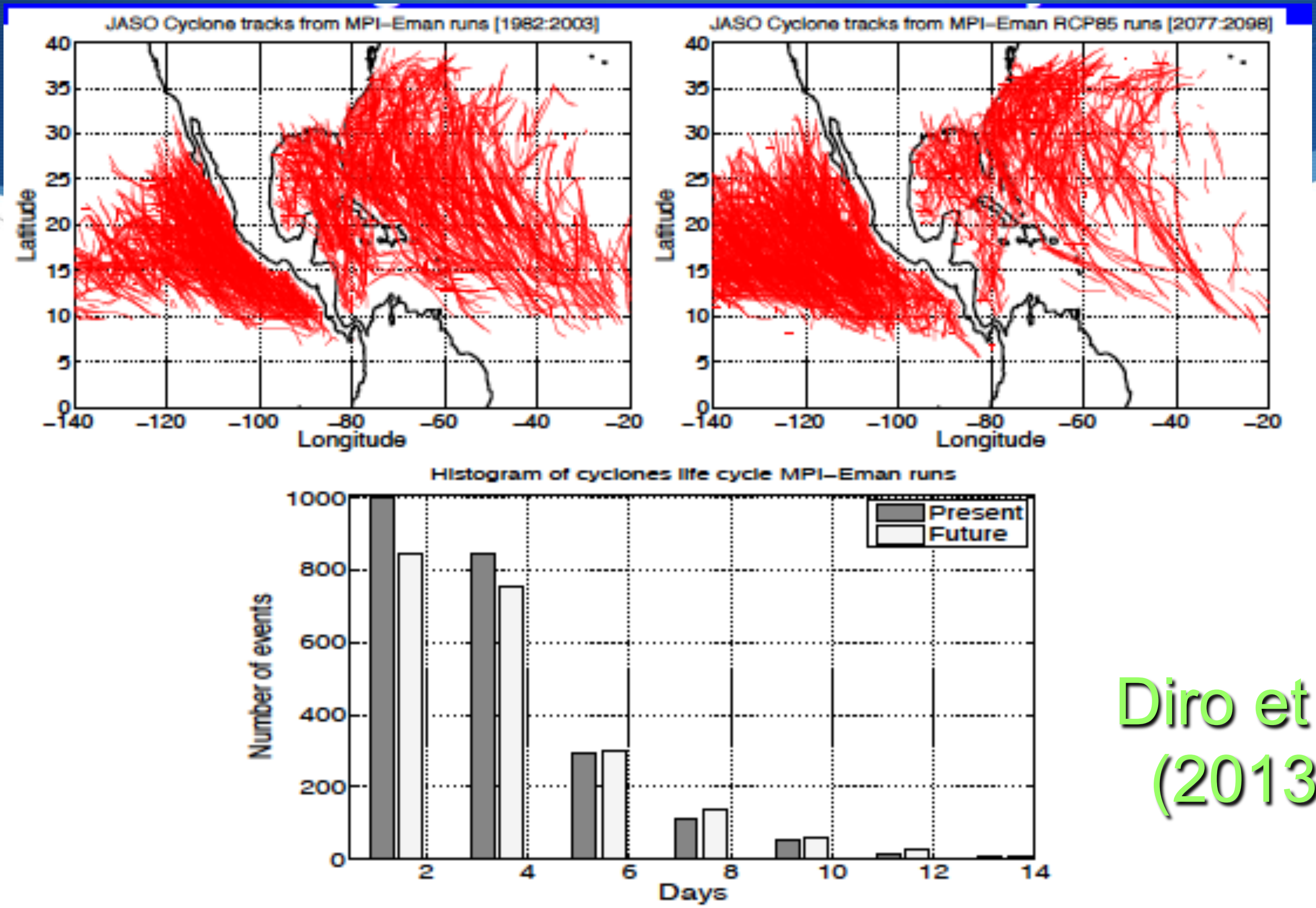
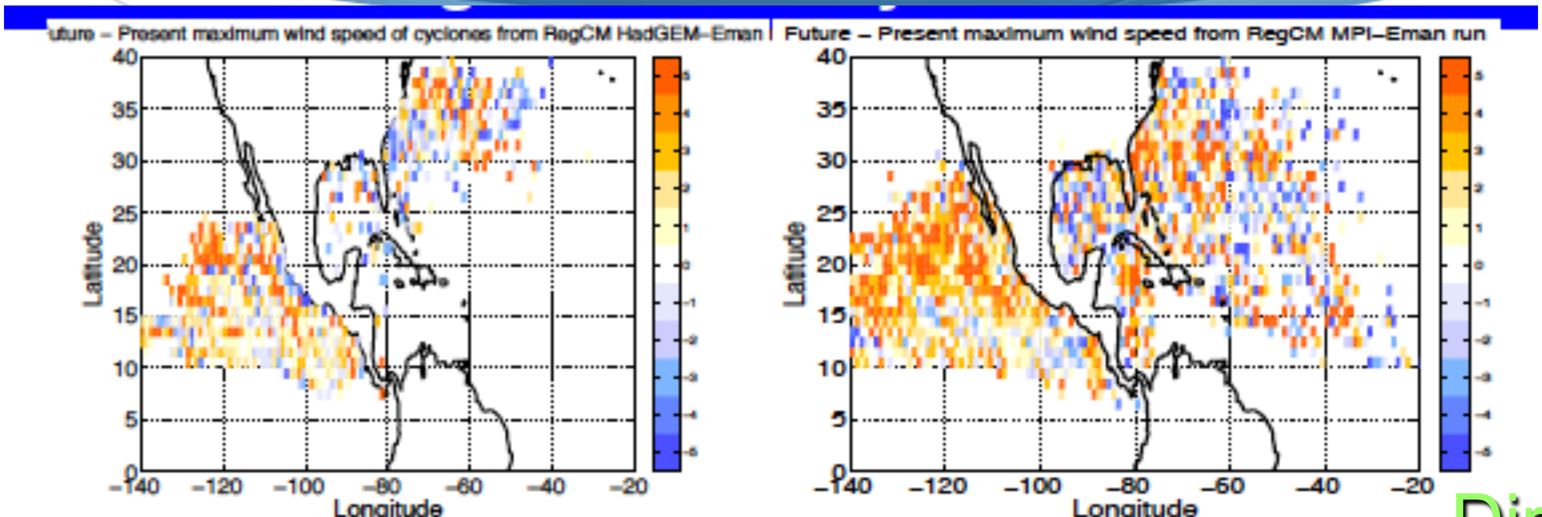
# Change in tropical cyclones




Diro et al (2013)

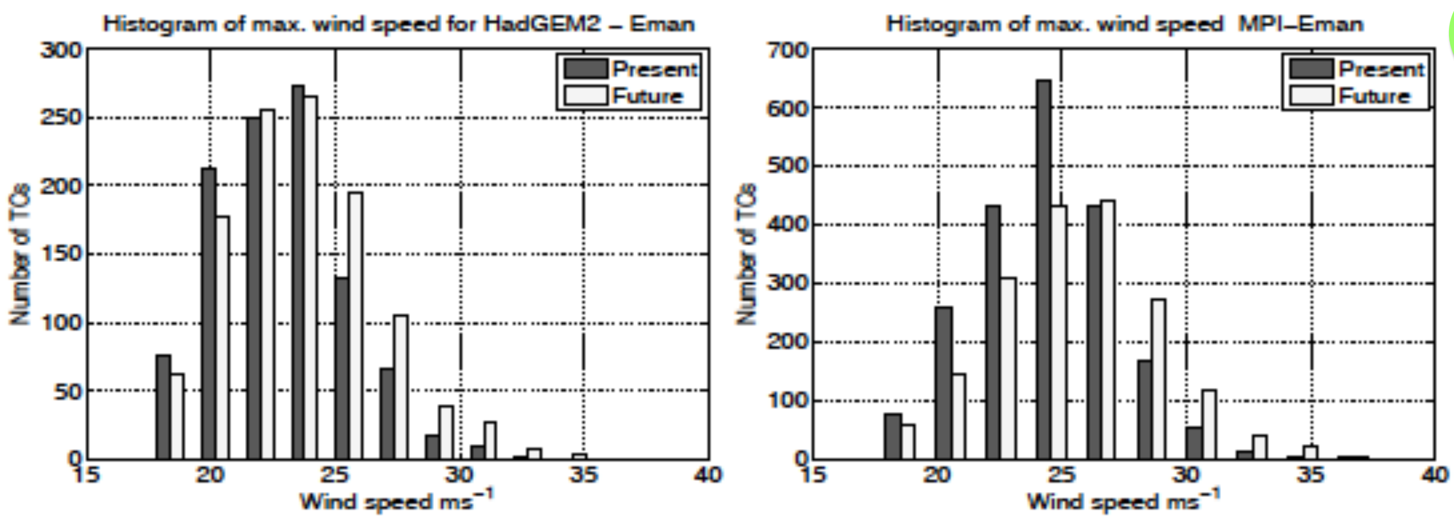
The frequency of short lived TCs decreases, the number of TCs that lasts longer than a week, however, shows a slight increase

# Change in intensity of cyclones




East Pacific- the highest change in the wind intensity

Diro et al (2013)




A decrease in the weak TCs but an increase in the frequency of the strongest TCs

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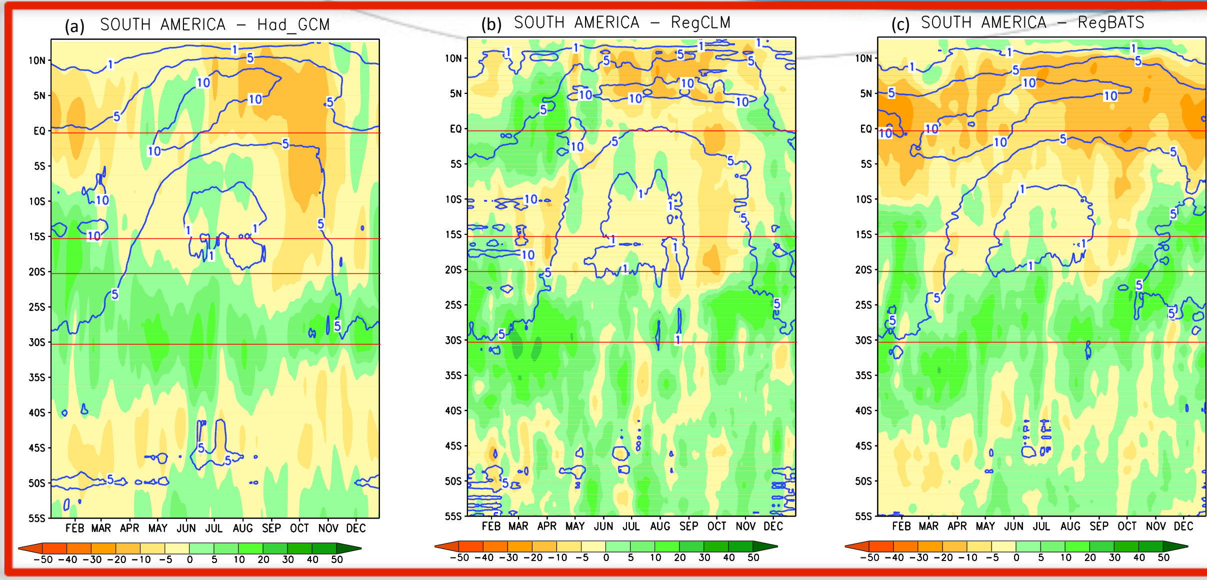
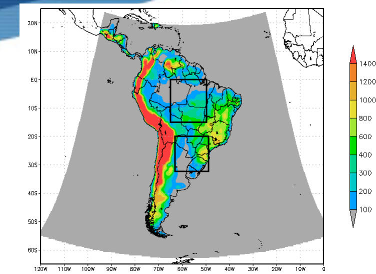
# Effects of land surface feedbacks on precipitation change over South America

HadGEM

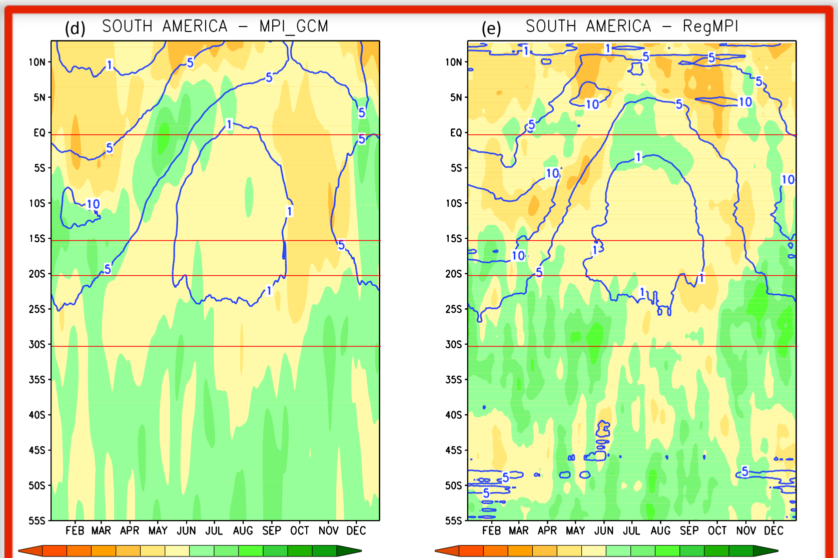


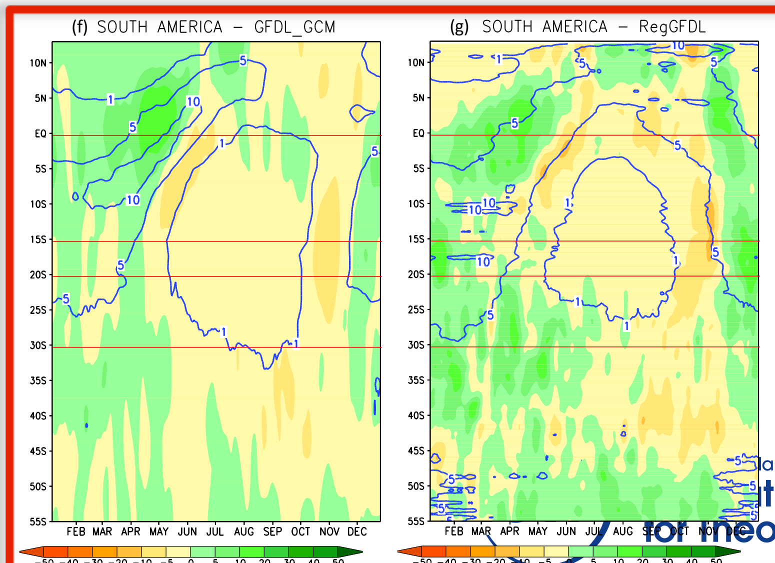
Hovmoller diagram of change in daily precipitation

Llopart et al (2013)

MPI

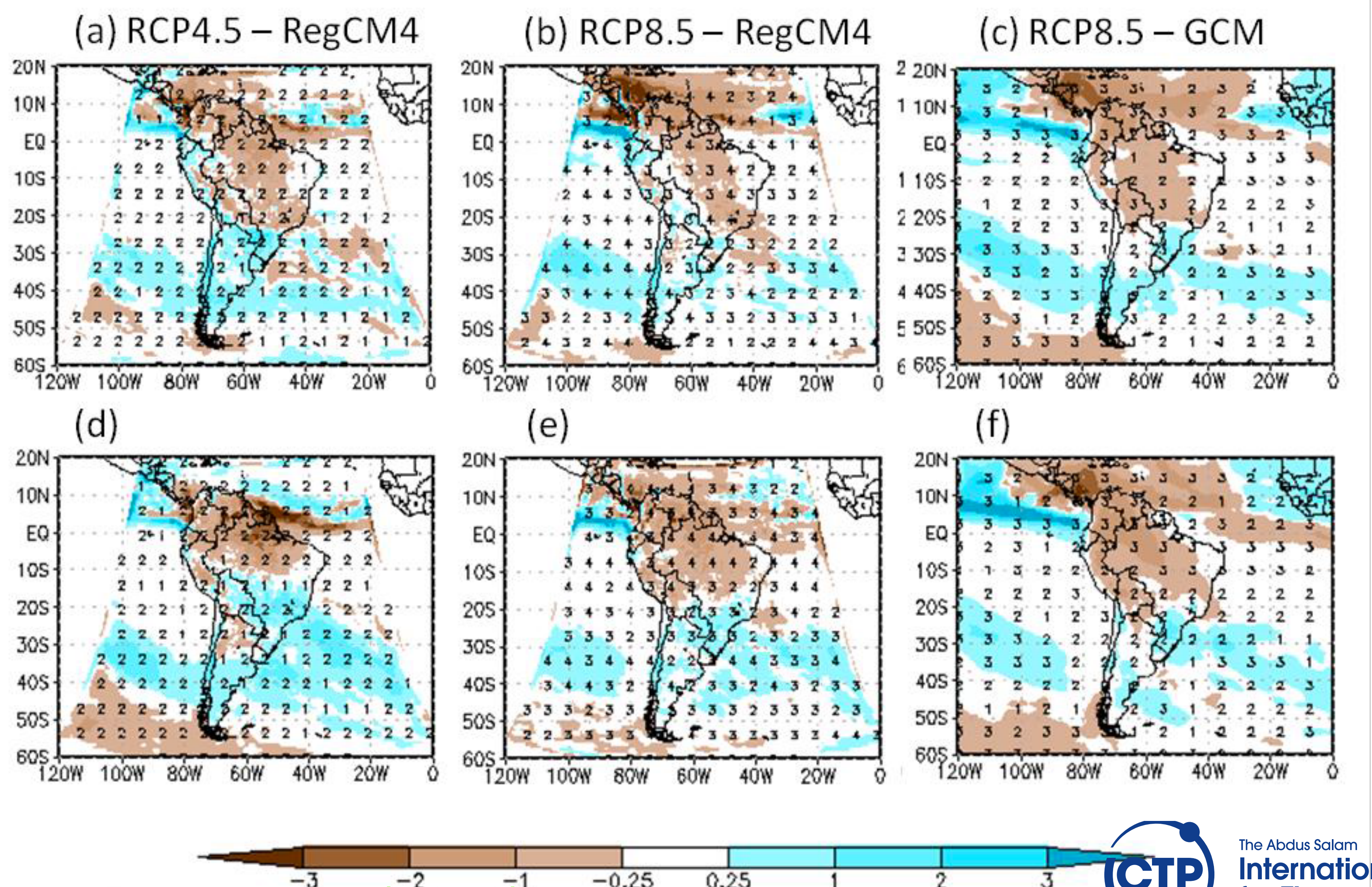



GFDL



# Interannual variability associated with ENSO: present and future climate projections of RegCM4 for South America-CORDEX domain

SON composites of EN-LN differences of precipitaton




near

far

da Rocha et al (2013)

# Conclusions

- A new ensemble of 34 21st century climate projections over five CORDEX domains is available: The Phase I CORDEX RegCM hyper-Matrix (CREMA) experiment.
  - Africa, Med-CORDEX, South America, Central America, South Asia
- The ensemble includes different GHG RCPs, driving GCMs and RegCM4 physics configurations
- The projections showed substantial sensitivity to all these three factors (sources of uncertainty).
- A special issue of Climatic Change is in press, and it provides a first basic analysis of this ensemble
- The output from these simulations (about 200 TB) will be made available into the CORDEX data nodes for further analysis and for use in impact assessment studies.
- If you are interested in these simulations please ask us

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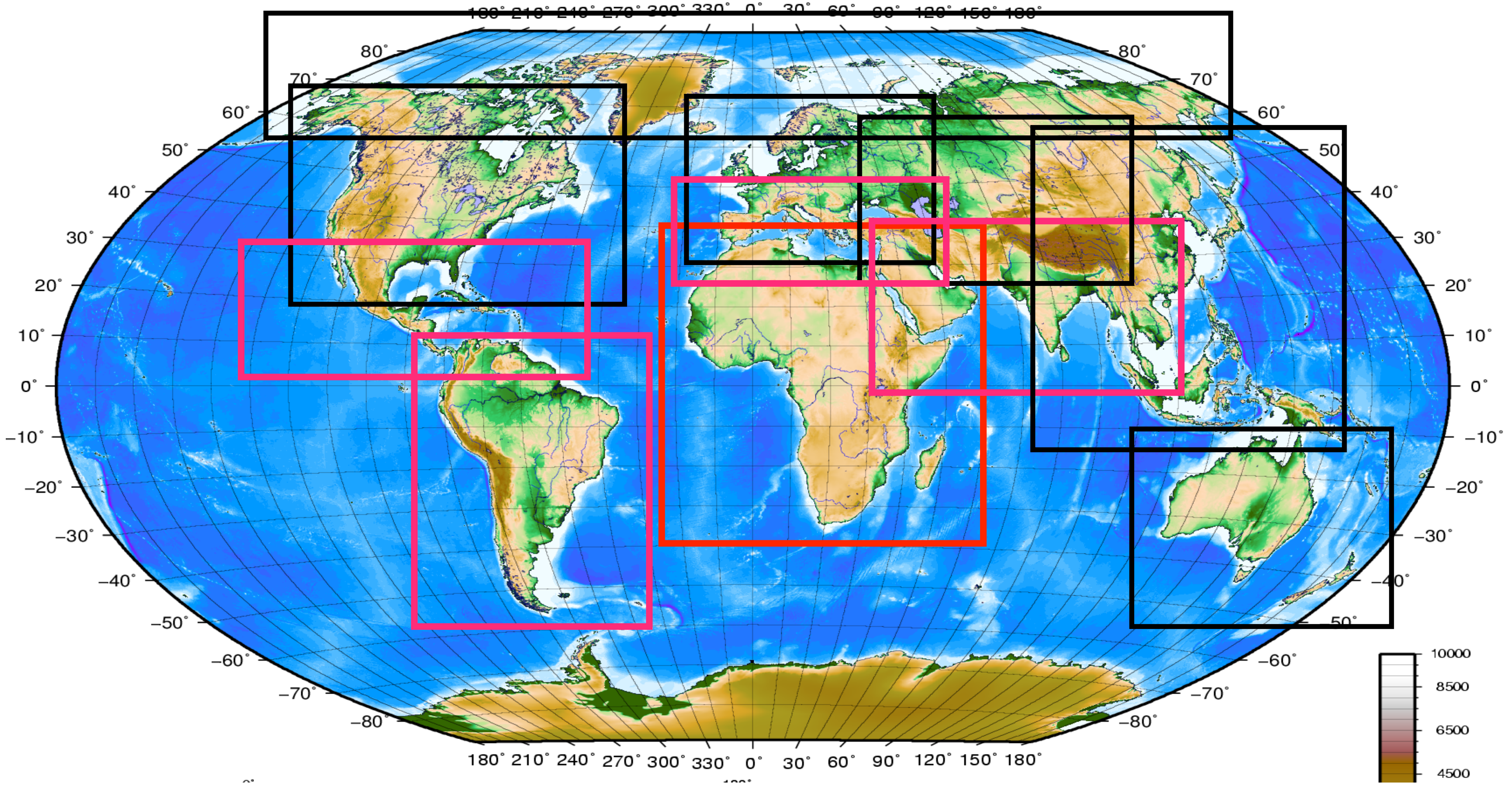
# Thank you


180° 210° 240° 270° 300° 330° 0° 30° 60° 90° 120° 150° 180°
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−20°
−30°
−40°
−50°
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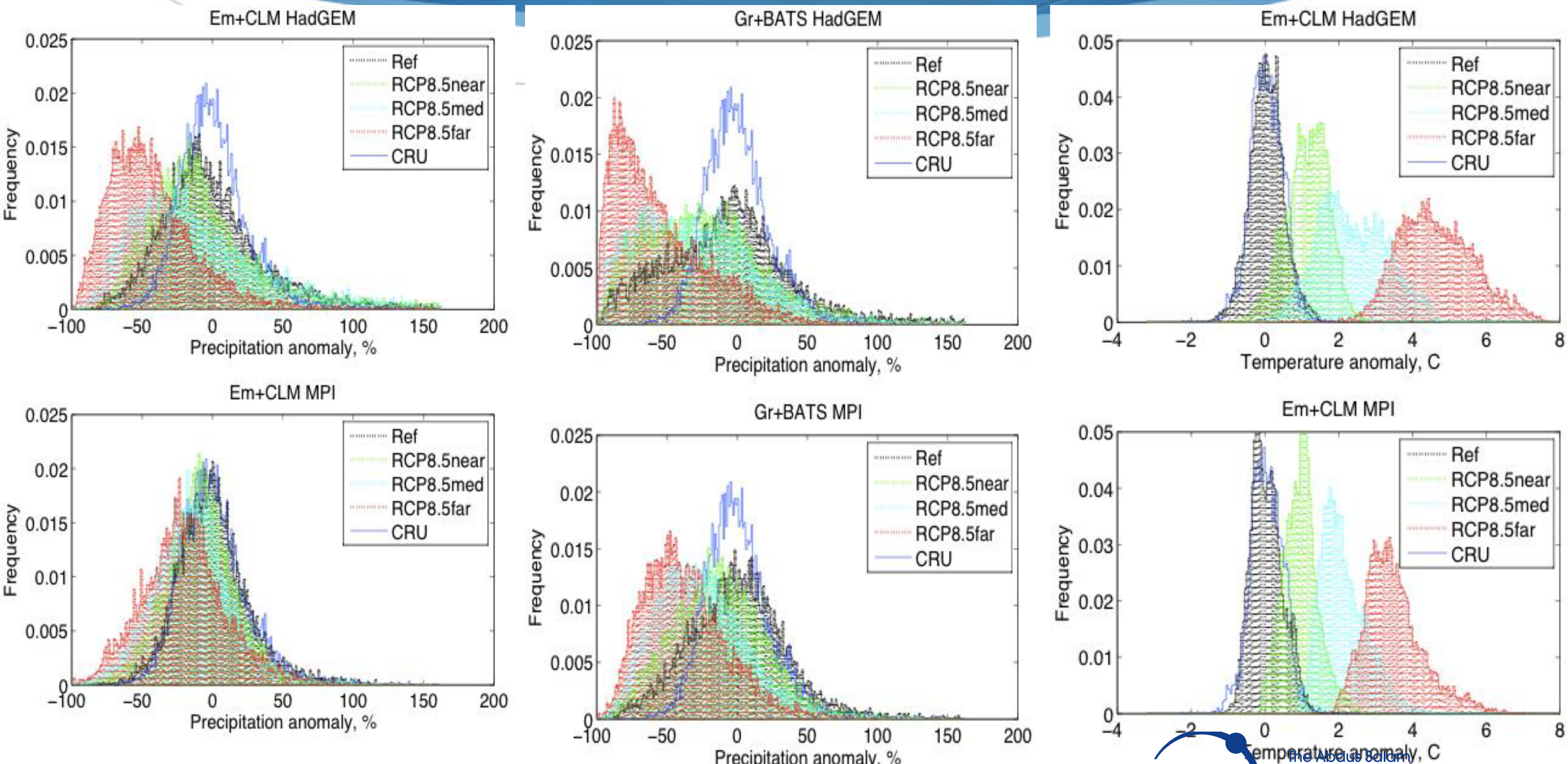
6500
4500

# Empirical PDFs of present day and future seasonal precipitation and temperature anomalies over Central America (Fuentes-Franco et al)

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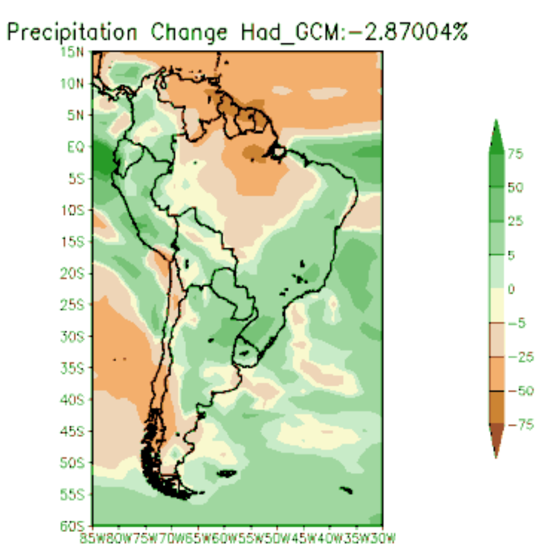
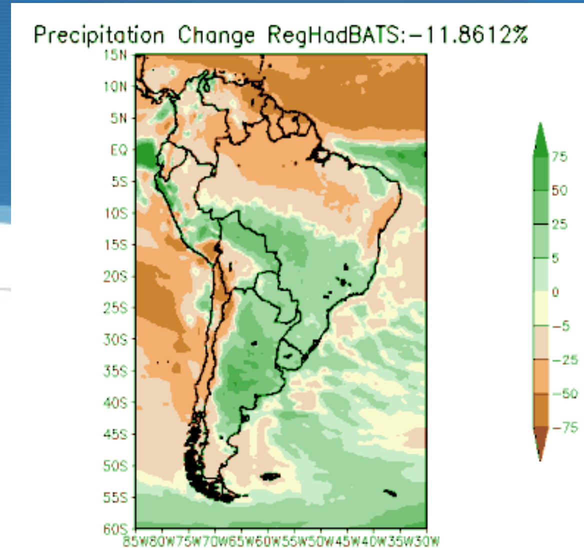
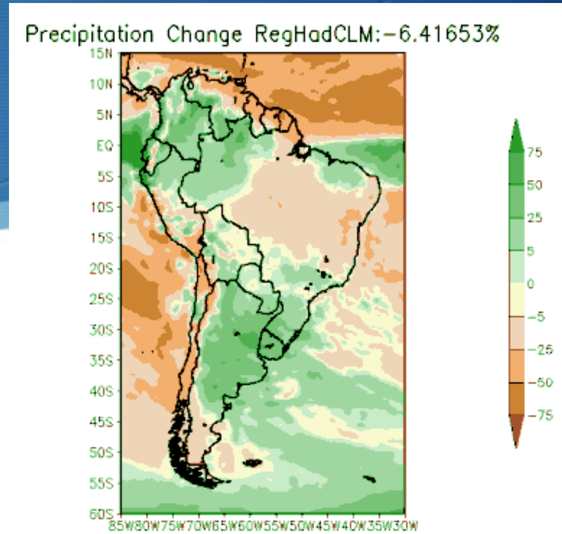
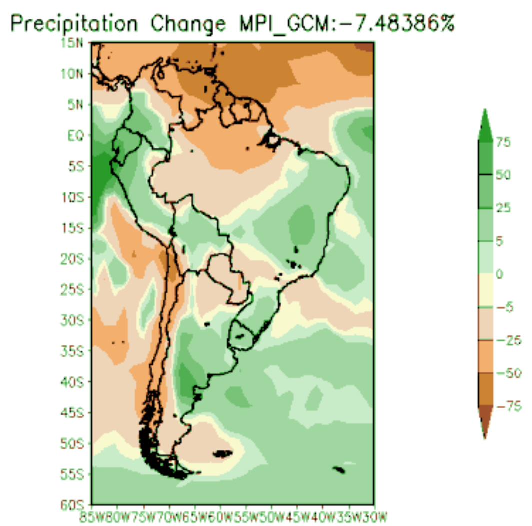
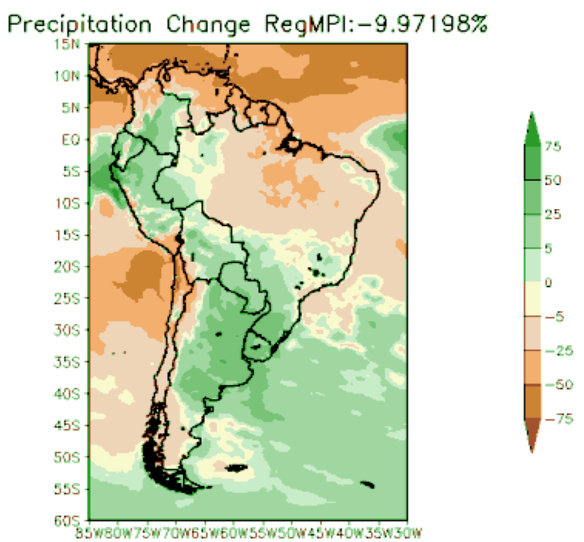
# Effects of land surface feedbacks on precipitation change over South America




Llopart et al (2013)

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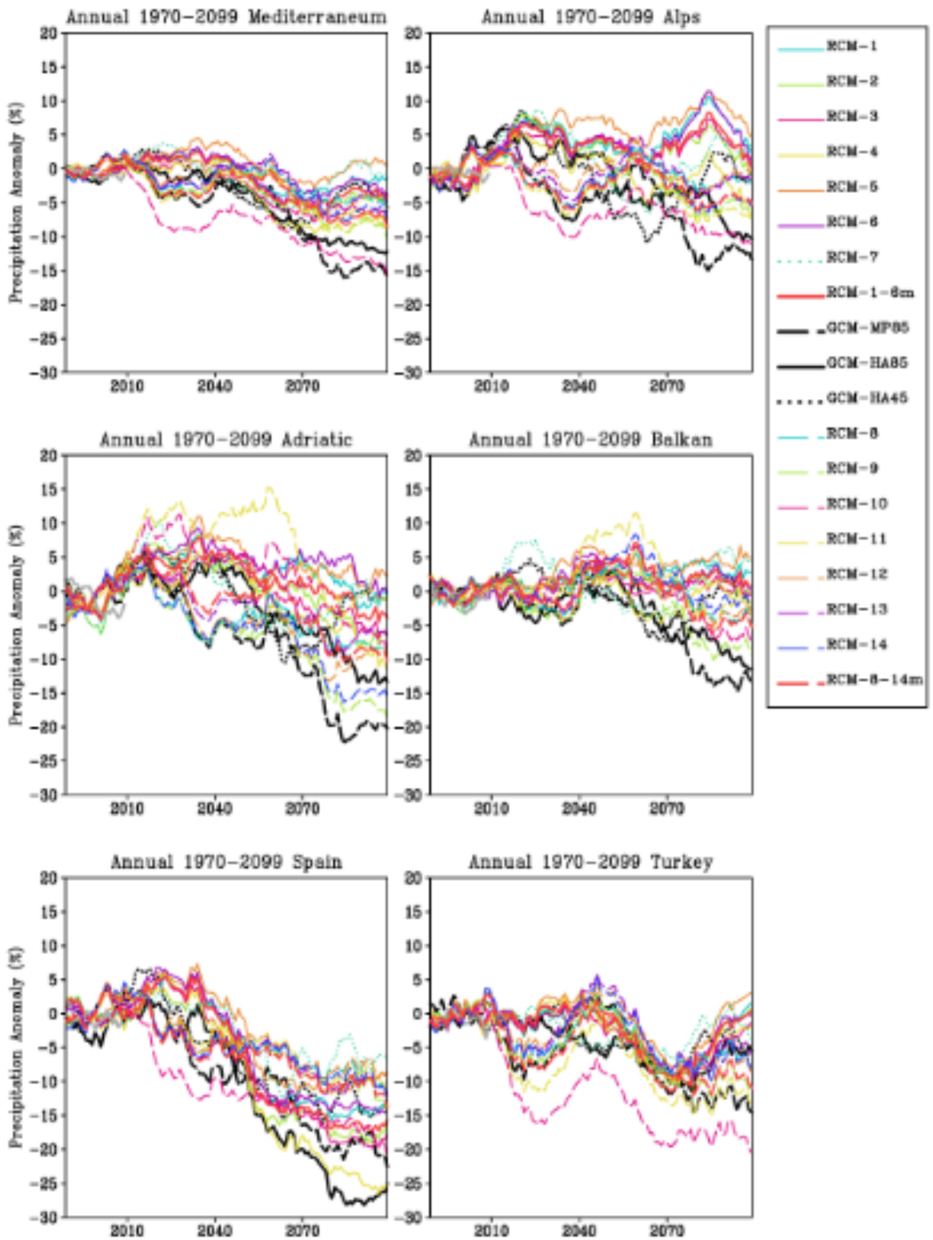


Ensembles of 21st century projections over the MED-CORDEX domain with different model physics schemes

Torma et al.

# Summary

- Temperature and precipitation biases show a high degree of spatial variability
- Magnitude of the biases is similar in the GCM and RegCM ensembles
- GCMs appear to provide a greater forcing for precipitation than temperature in terms of the spatial distribution of the biases
- For the changes, a greater degree of agreement is found across the GCM and RegCM ensembles, at least in terms of large scale spatial patterns
- The RegCM ensemble is characterized by a lower climate sensitivity (expecially CLM runs)
- Greater differences are found at sub-regional scales, evidently tied to the simulation of more local feedbacks and forcings
- Little influence of the model biases on the simulated change is found

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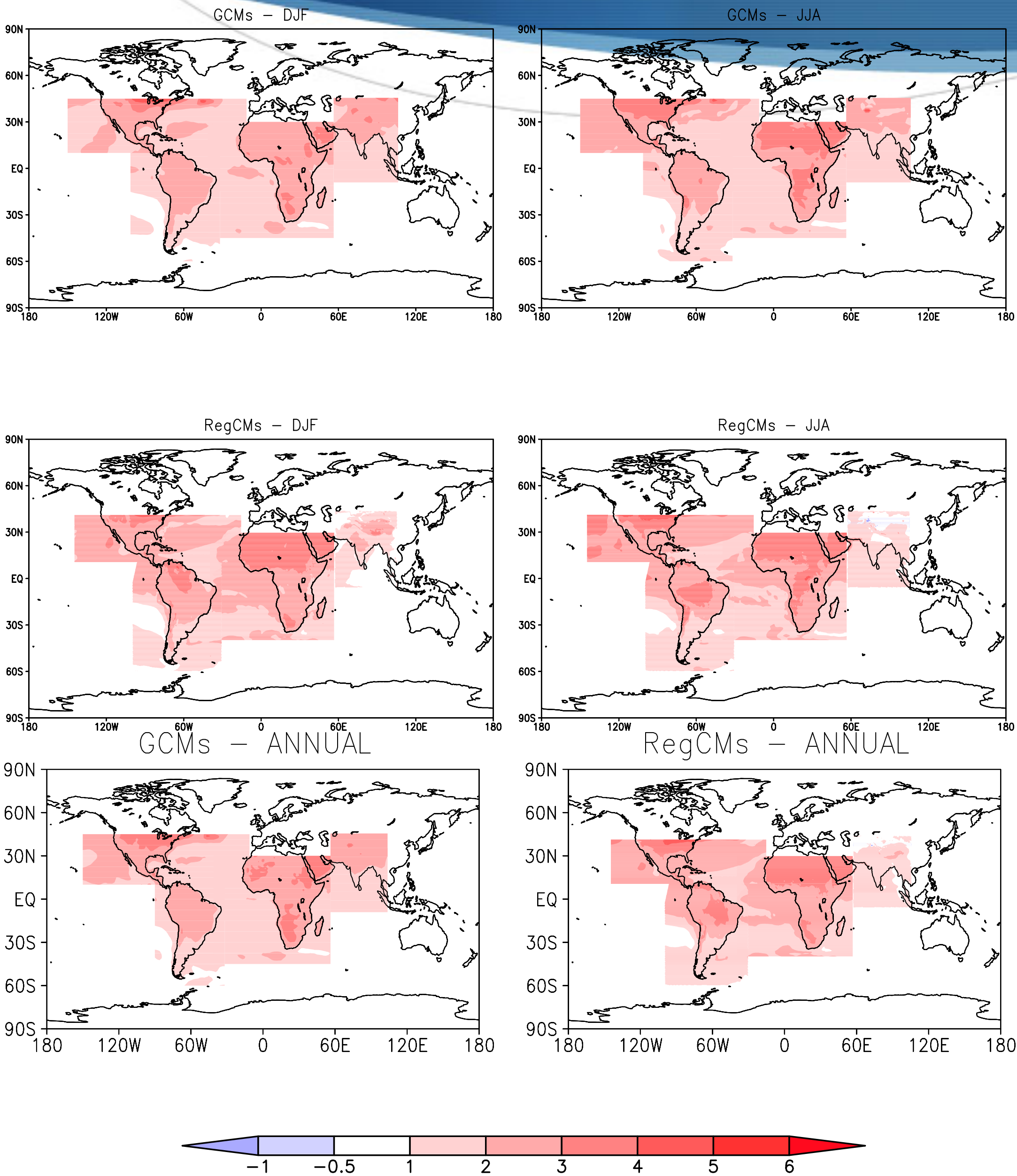
# Temperature change RCP4.5 (2070/2100-1976/2005)




The warming signal shown by the GCM ensemble is between 2 and 3 degrees and the corresponding warming in the RegCM ensemble is few tenths of degree lower

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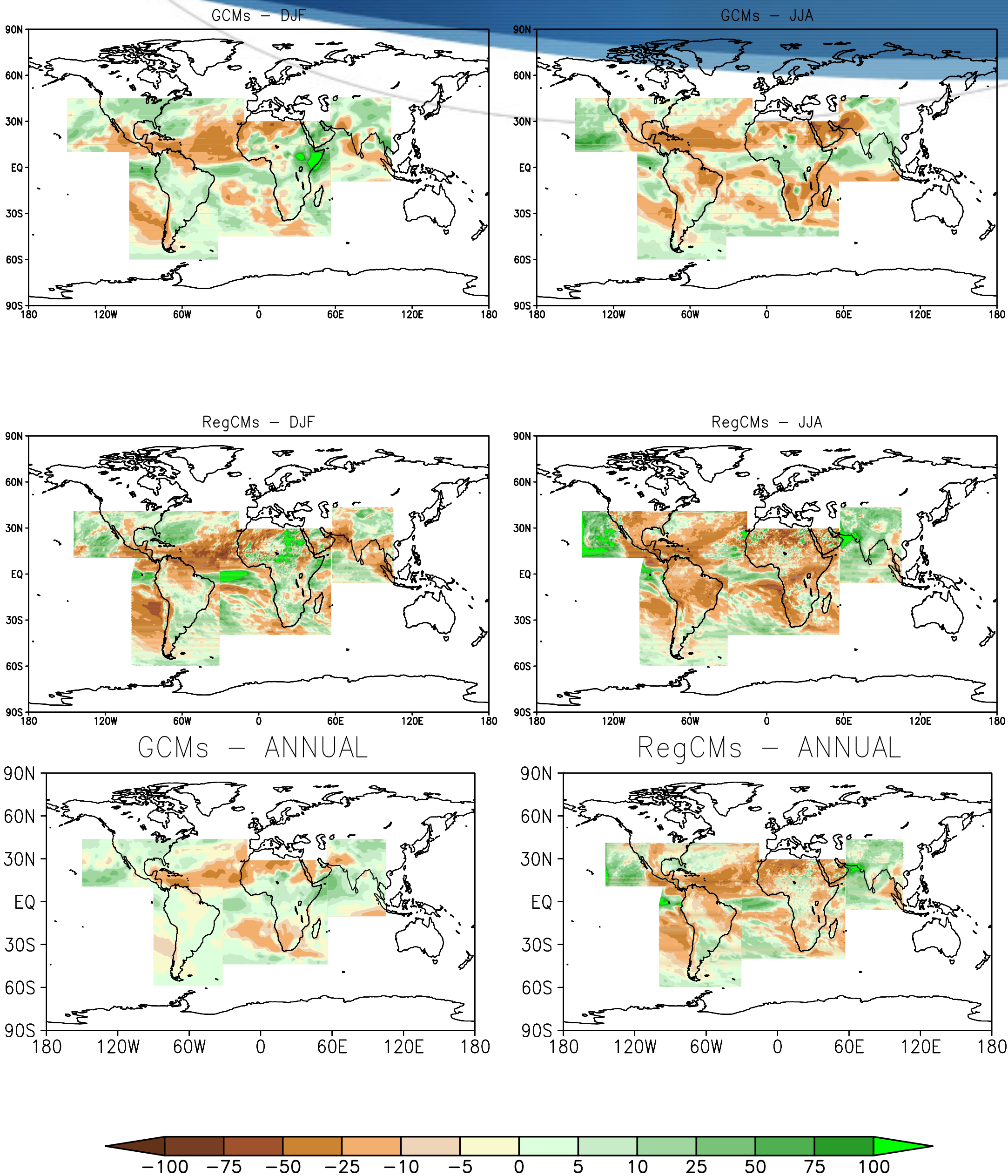
# Temperature change RCP4.5 (2070/2100-1976/2005)




- RCP4.5 precipitation changes show some noticeable differences compared to the RCP8.5
- ensemble is much smaller these are difficult to interpret

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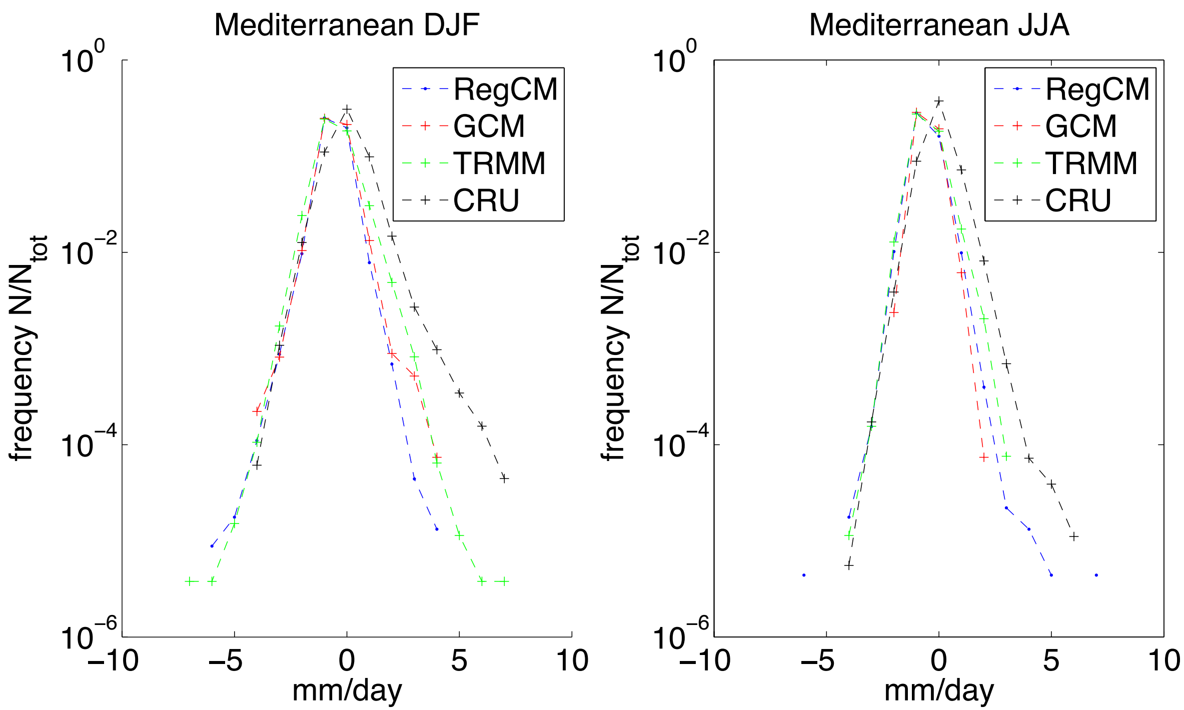
Spatial correlation between ensemble average bias and change for the GCM and RegCM ensembles over each domain

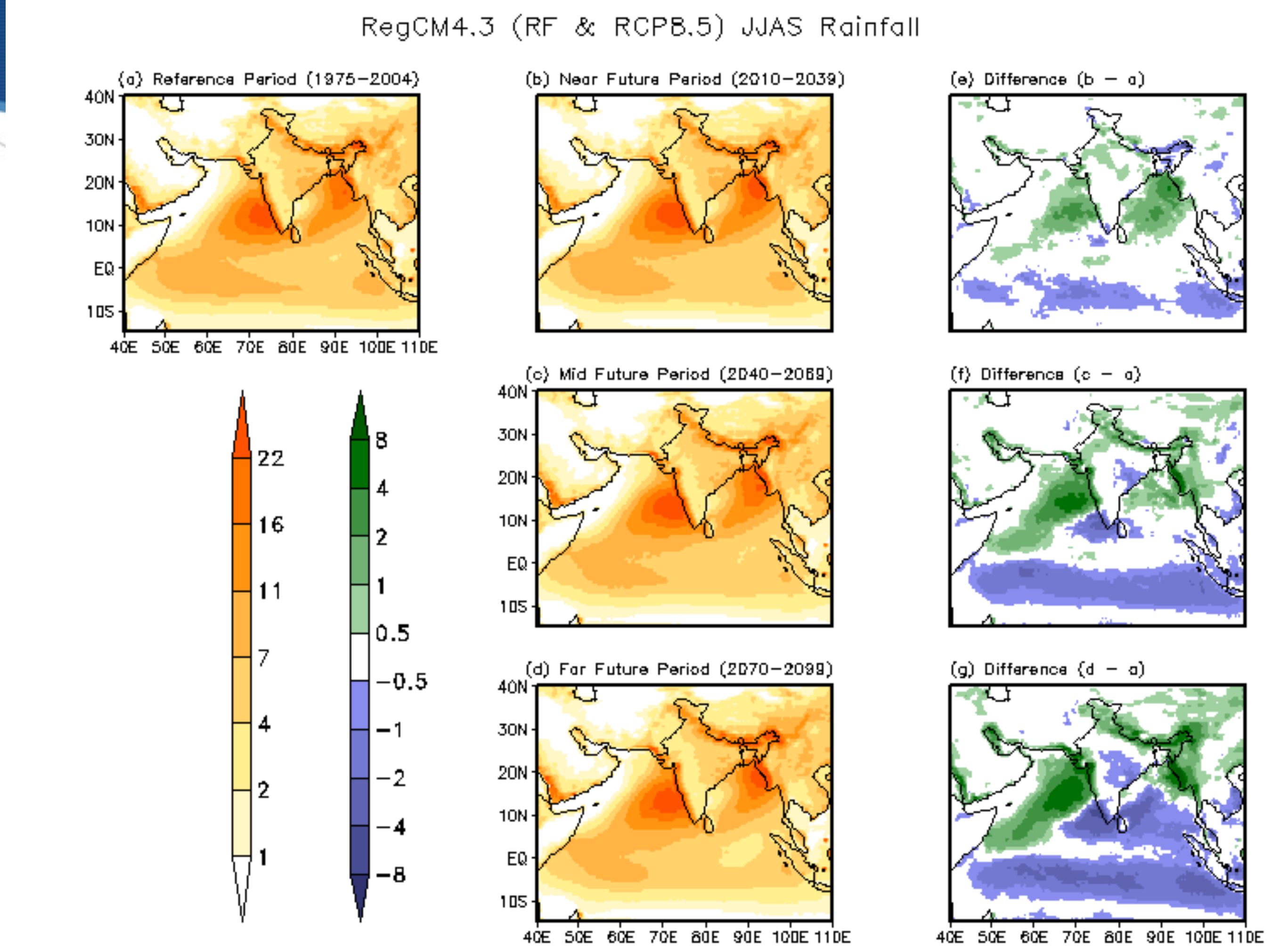
| | corr. bias-change Temperature | | corr. bias-change Precipitation | |
|---|---|---|---|---|
| | DJF GCM-RegCM | JJA GCM-RegCM | DJF GCM-RegCM | JJA GCM-RegCM |
| Africa | 0.32 -0.003 | 0.05 -0.23 | -0.29 0.16 | -0.12 -0.22 |
| C America | -0.30 0.35 | -0.12 -0.36 | 0.07 0.18 | 0.32 0.18 |
| India | 0.35 -0.04 | 0.70 -0.04 | -0.01 -0.43 | 0.28 -0.23 |
| Med | 0.29 0.16 | 0.39 -0.34 | -0.31 -0.37 | 0.26 0.79 |
| S. America | 0.34 0.09 | 0.13 0.01 | 0.67 0.74 | 0.55 0.07 |

**The biases have little effect on the change**



Mediterranean DJF
Mediterranean JJA
RegCM
GCM
TRMM
CRU
frequency N/N$_{tot}$
$10^{0}$
$10^{-2}$
$10^{-4}$
$10^{-6}$
−10
−5
0
5
10
mm/day

# Weakening of monsoon precipitation over India (Dash et al)

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