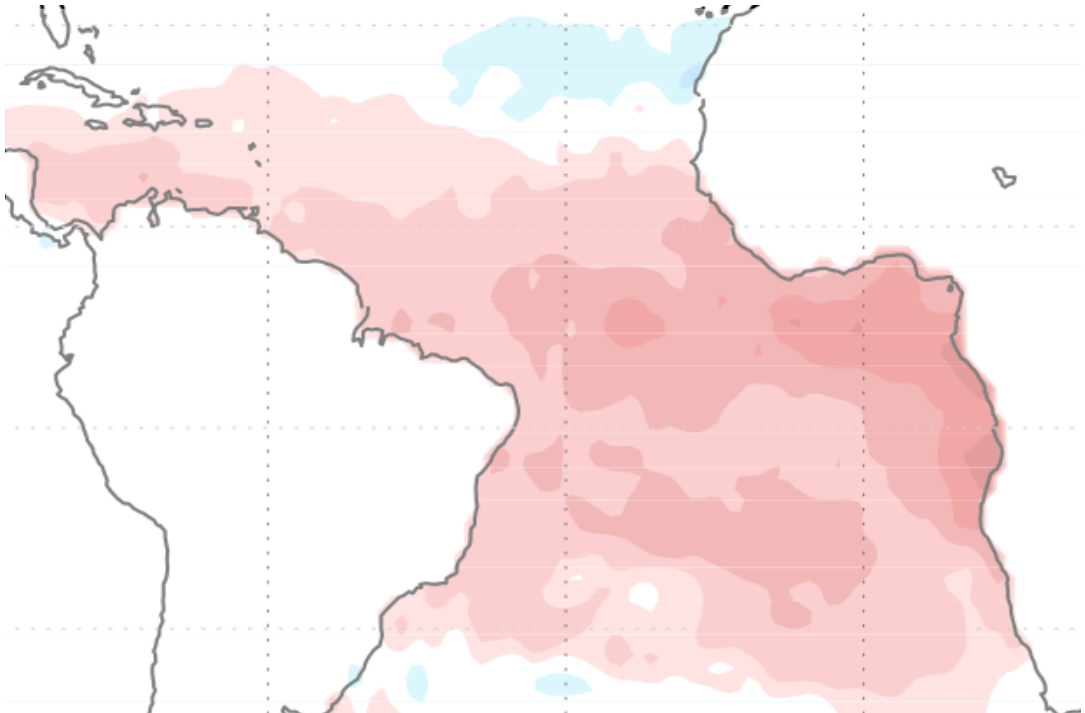
TROPA UCM

Impacts of the Atlantic Equatorial mode in a warmer climate

Elsa Mohino, Teresa Losada

Universidad Complutense de Madrid



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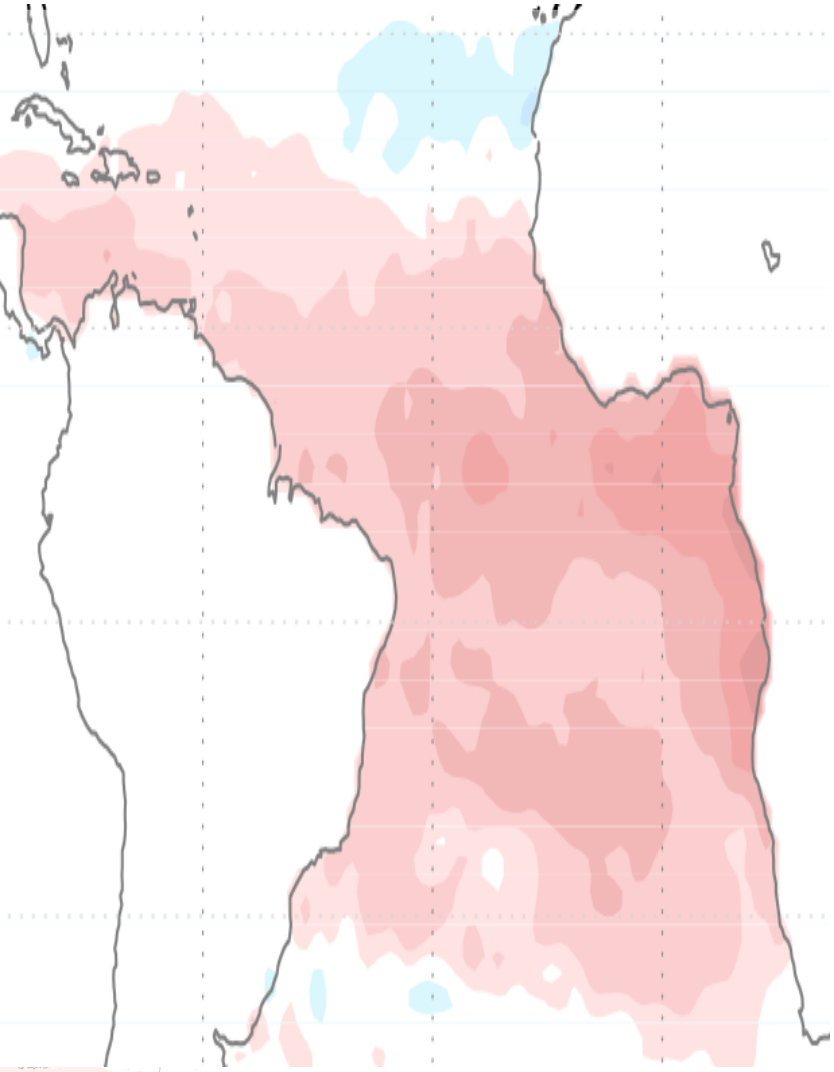
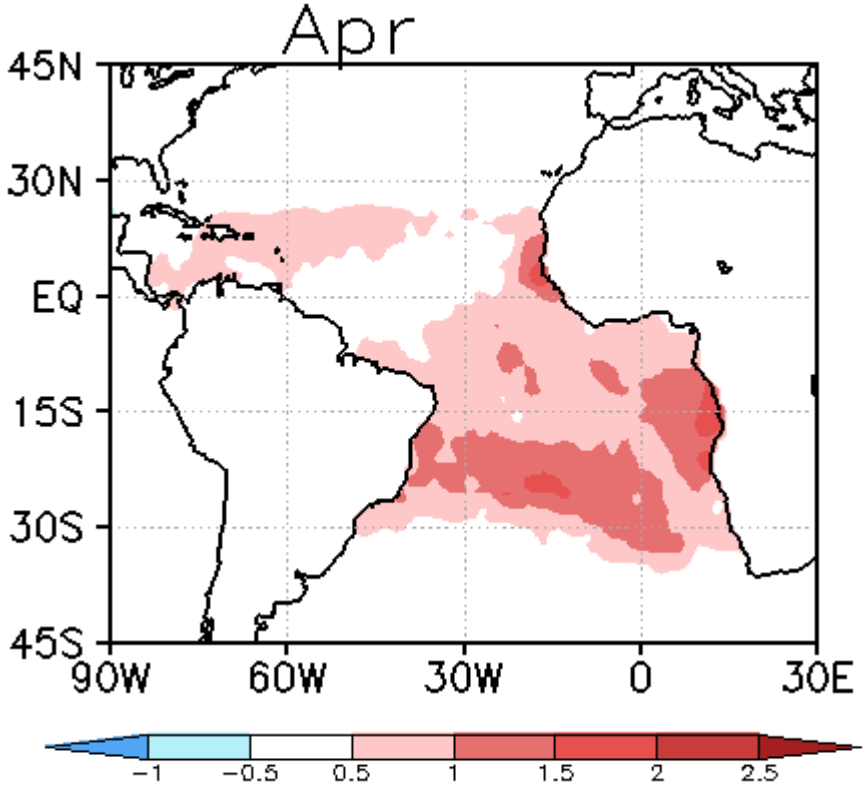
Outline



- Introduction
- Methods
- Results
  - Summer rainfall
  - Summer surf. temp.
  - Origin of the changes
- Summary & Conclusions

Introduction

Interannual variability in the Tropical Atlantic is dominated by the Equatorial Atlantic Mode



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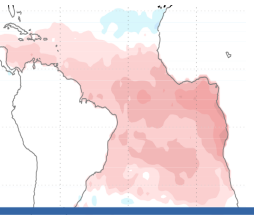

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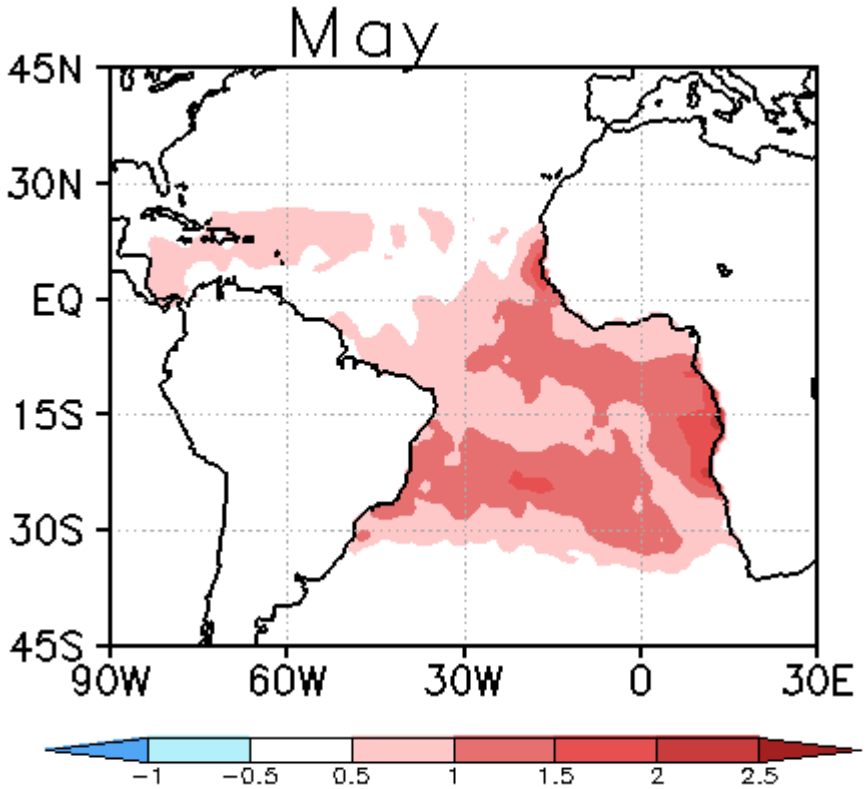

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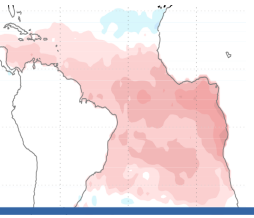

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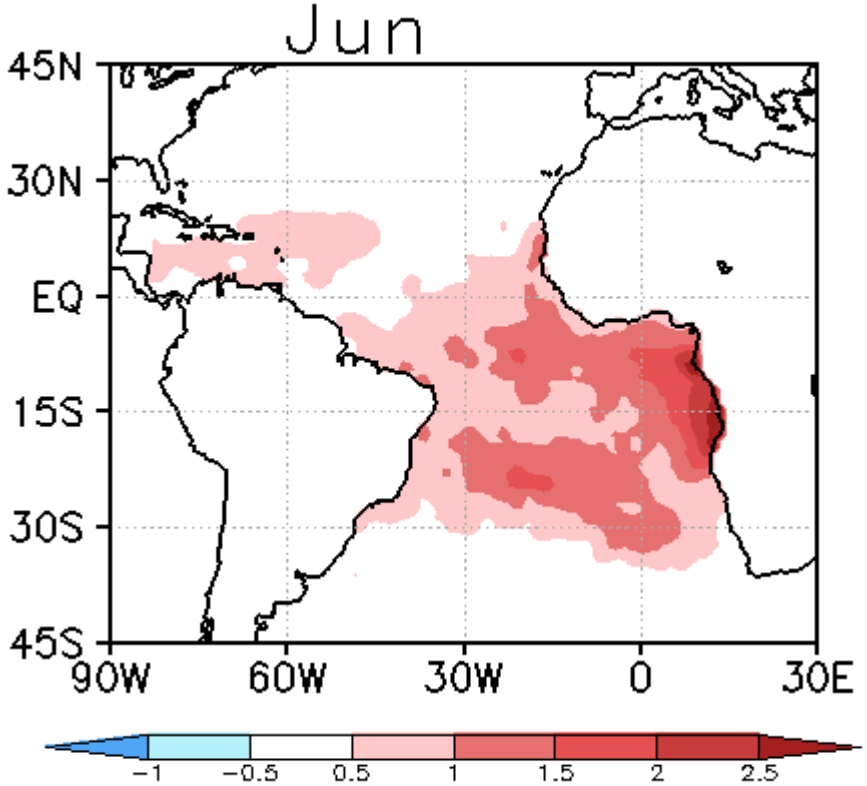

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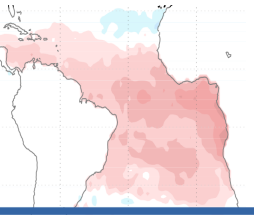

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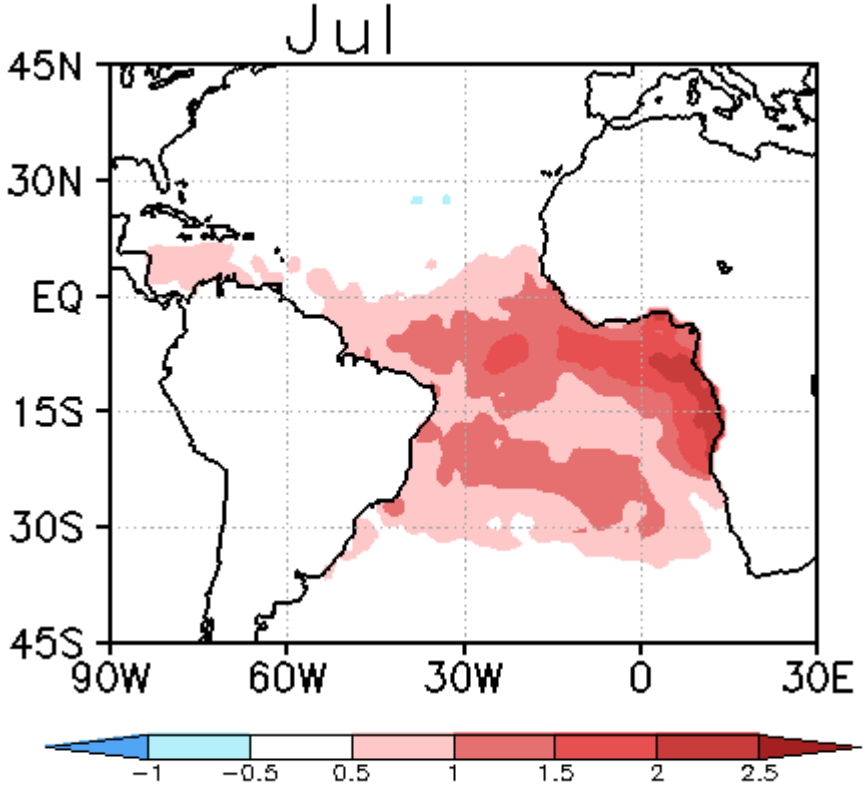

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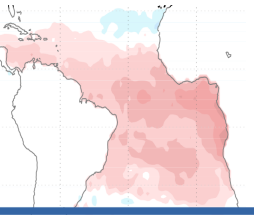

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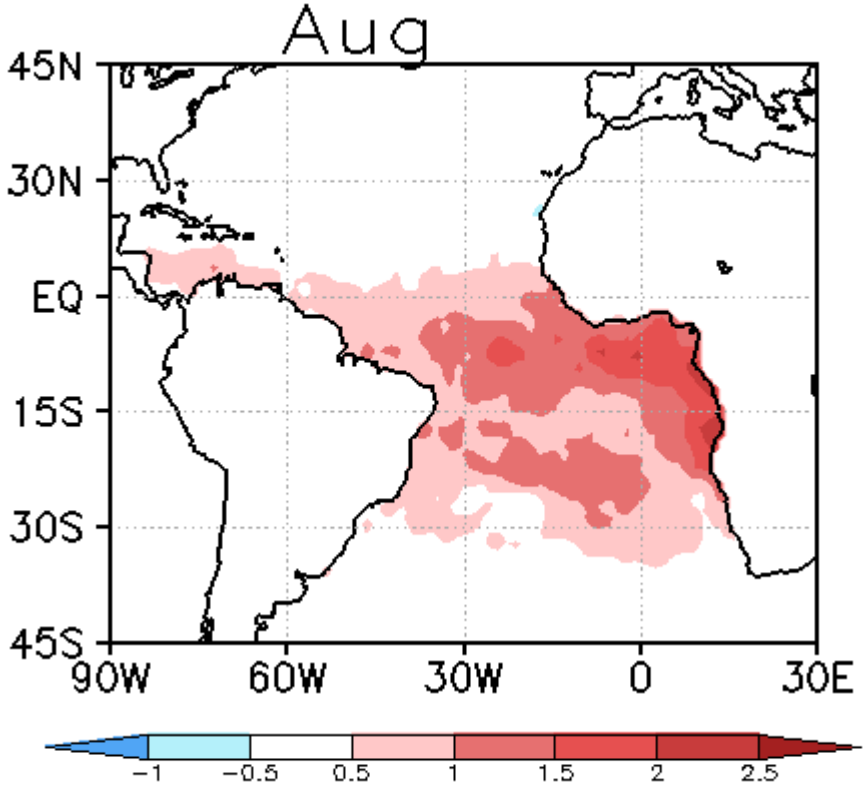

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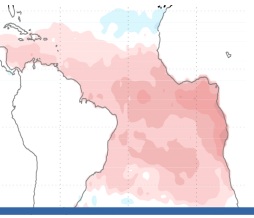

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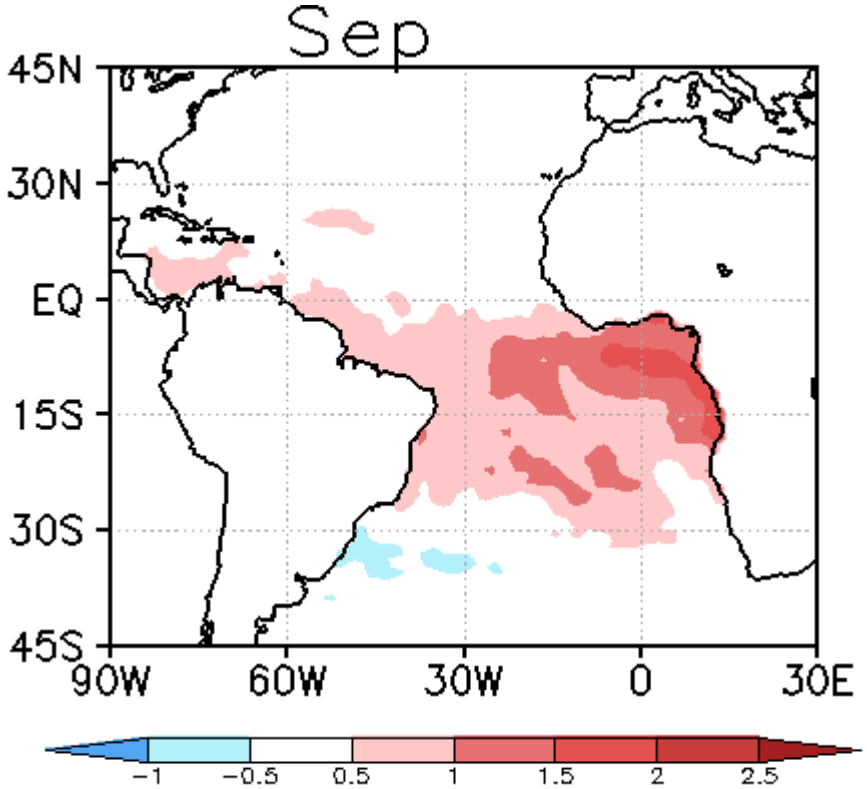

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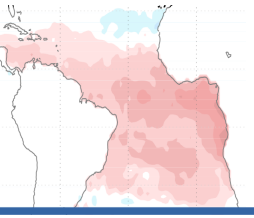
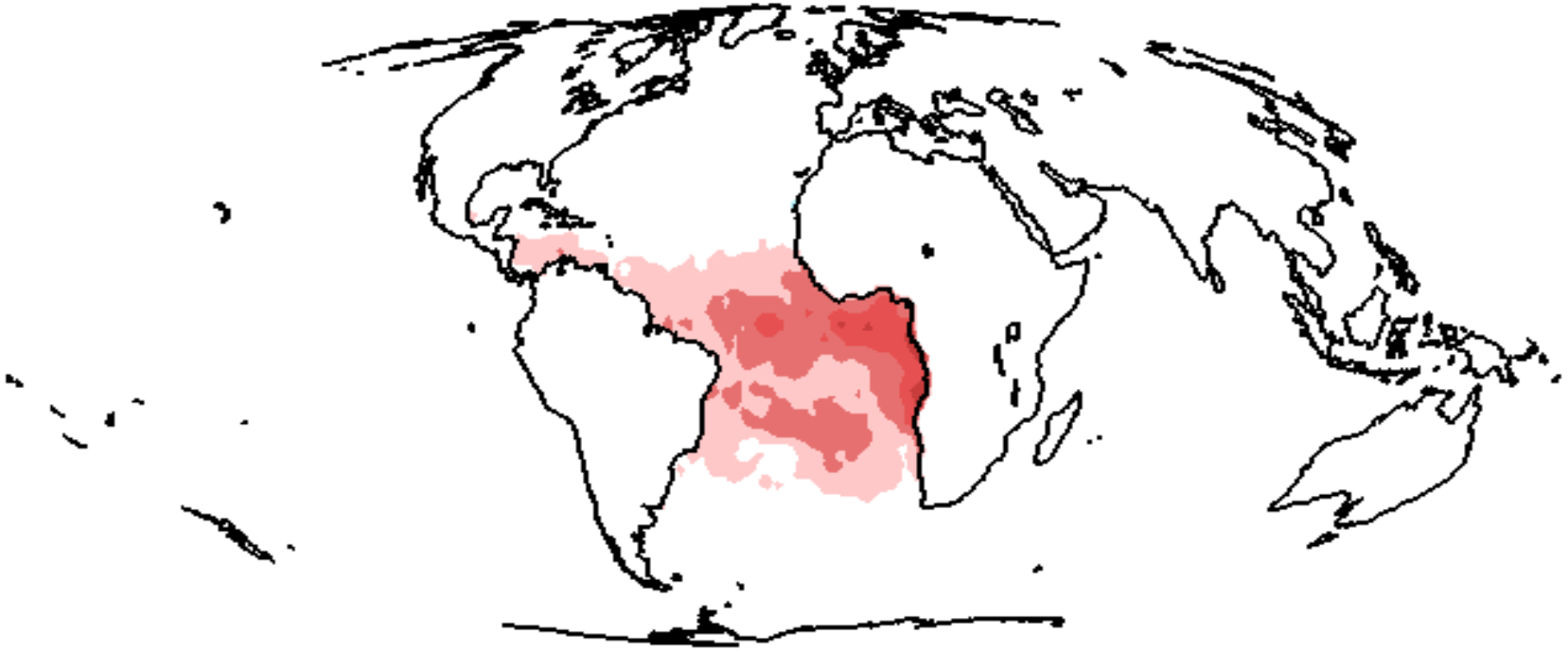
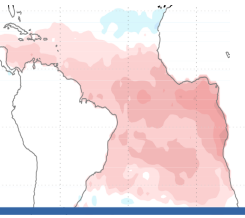


Introduction

The Equatorial Atlantic Mode affects adjacent and remote regions





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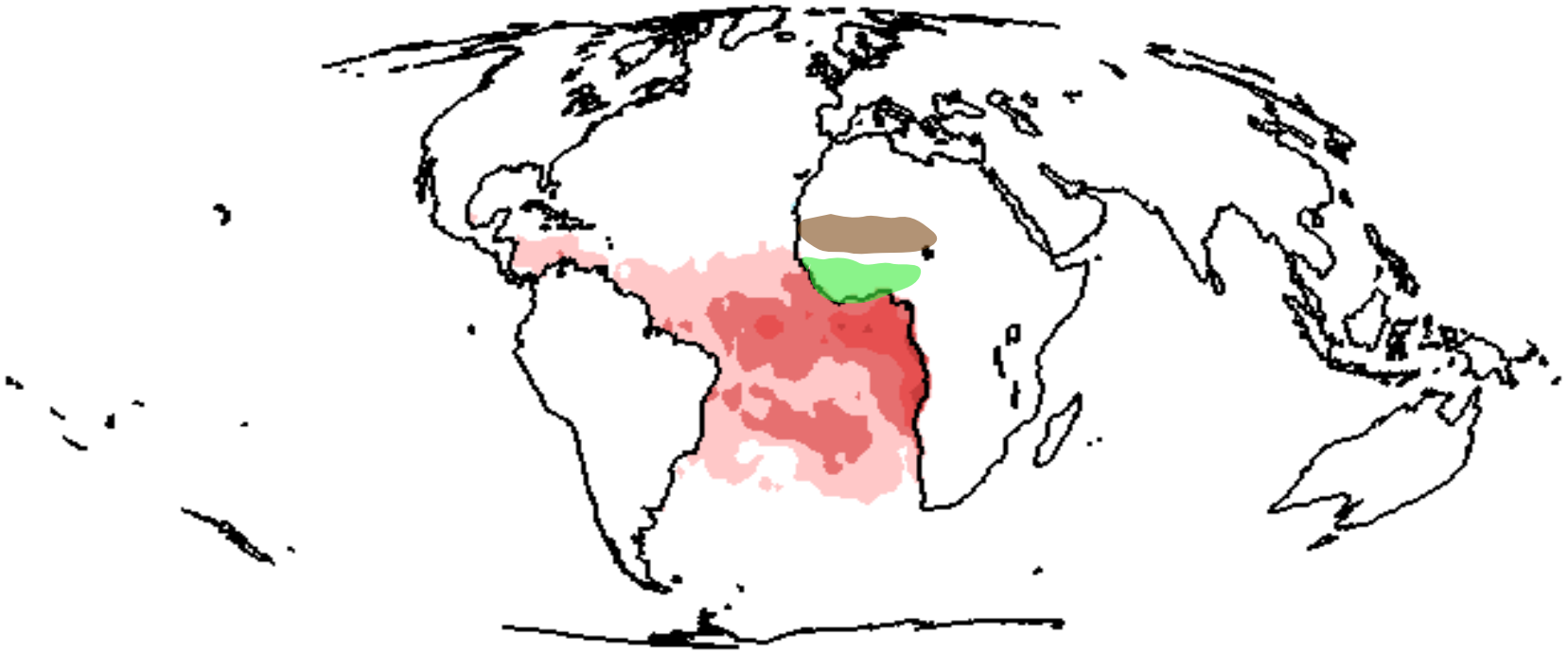
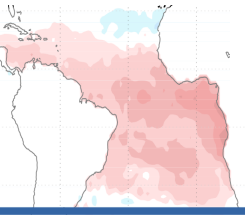


- West Africa (e.g. Janicot et al. 1998; Giannini et al. 2005; Losada et al. 2010a)



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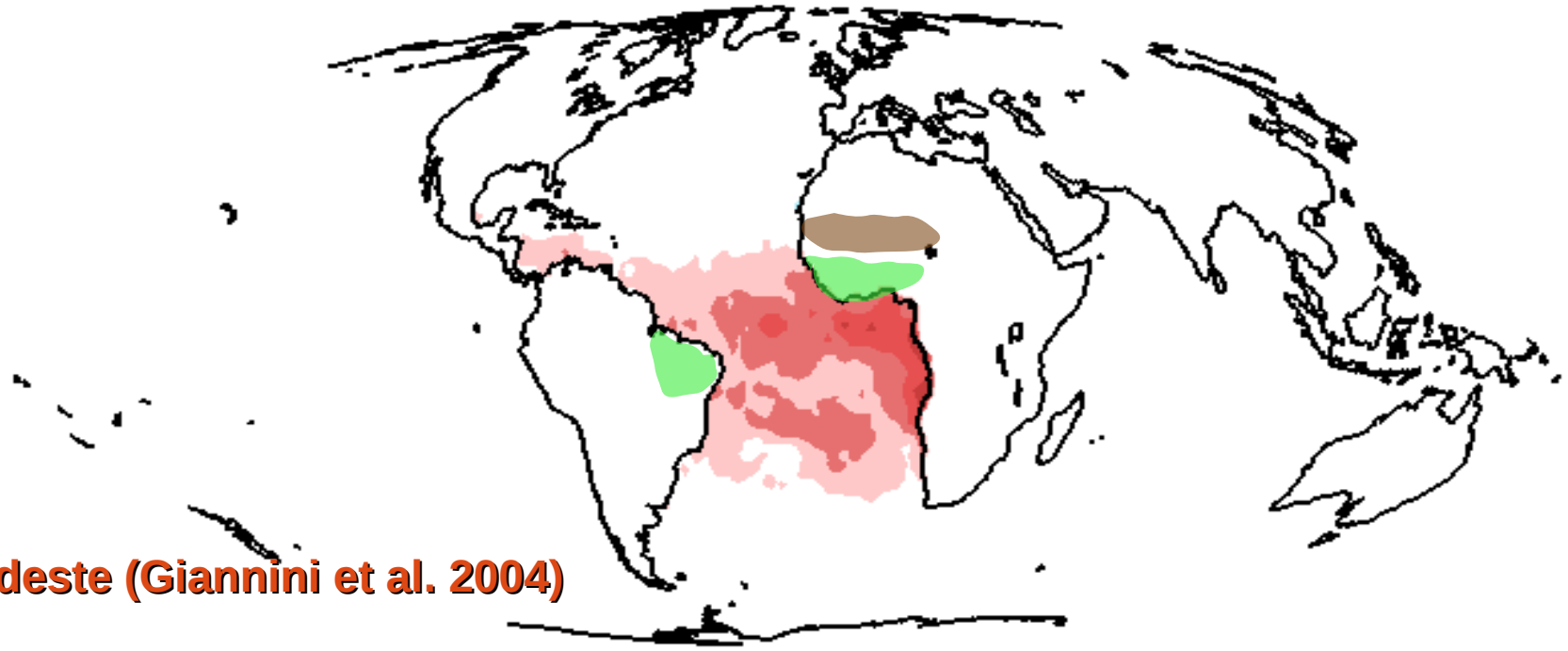

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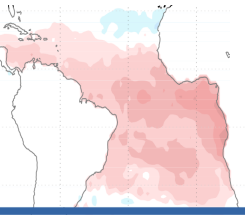

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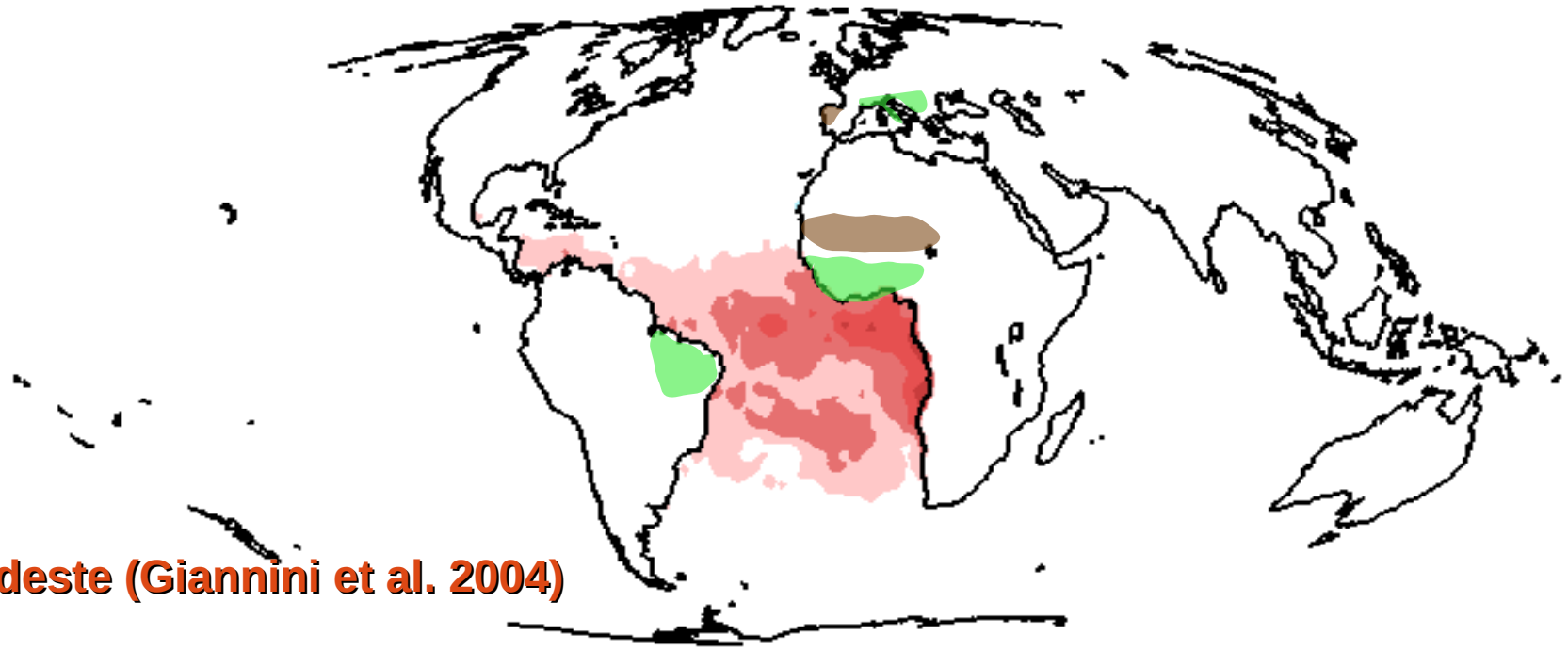

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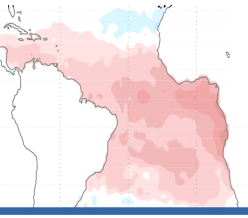

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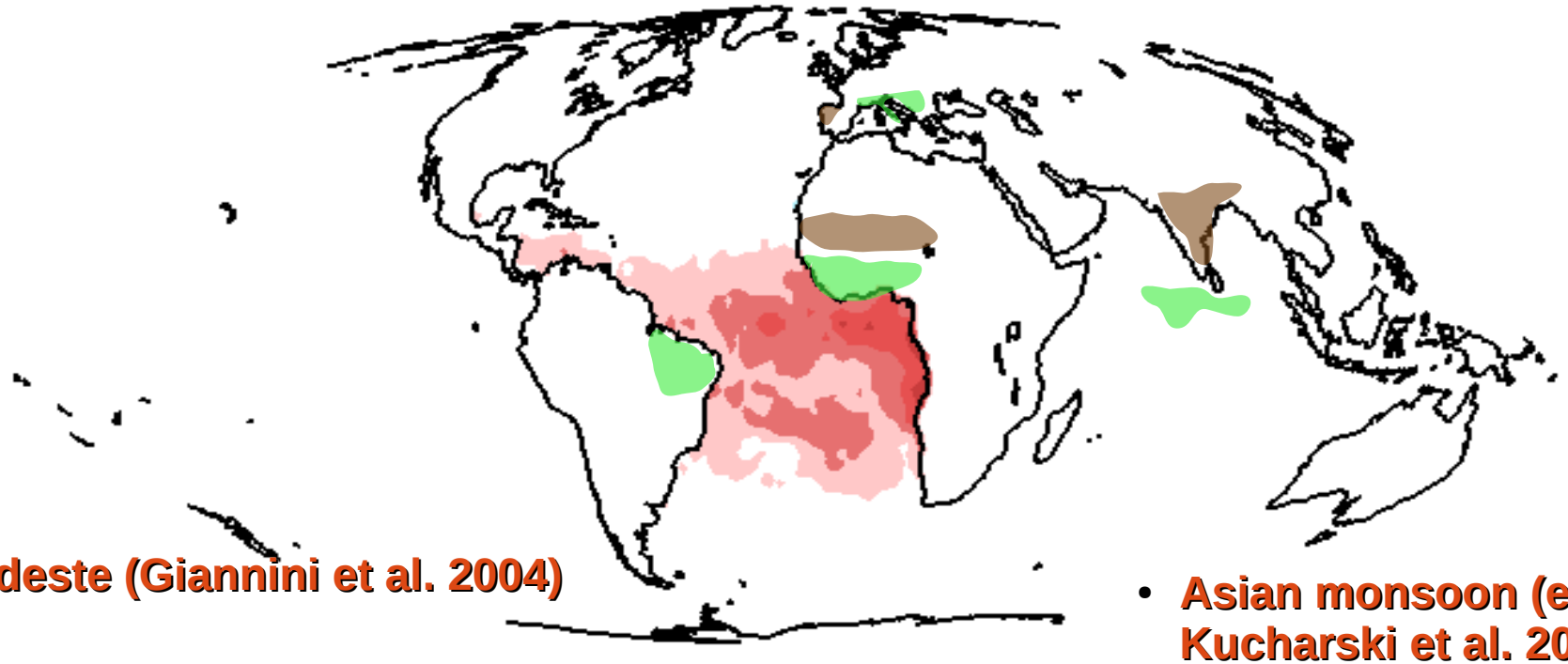

- Nordeste (Giannini et al. 2004)
- Asian monsoon (e.g. Kucharski et al. 2008; Losada et al. 2010b)
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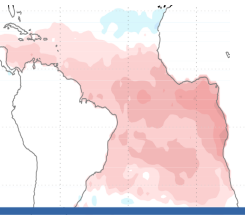

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The Equatorial Atlantic Mode affects adjacent and remote regions

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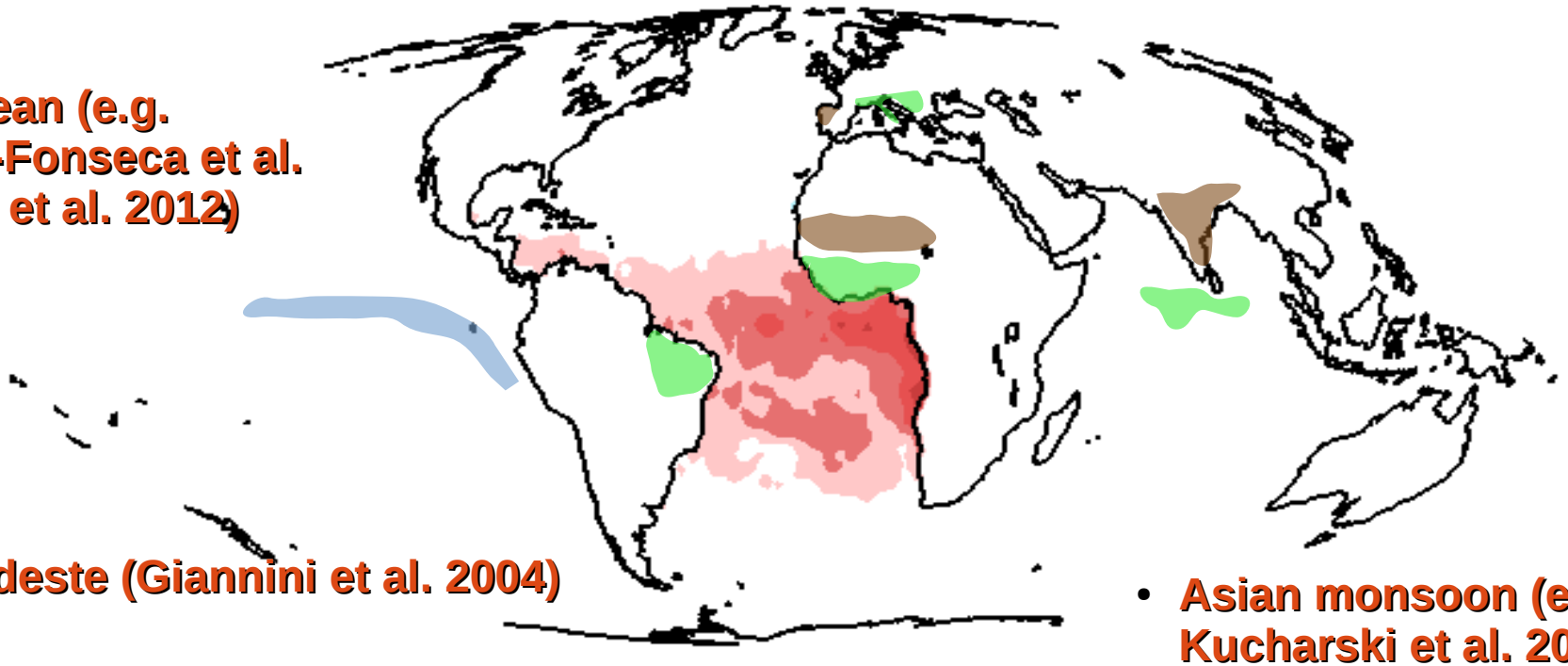
- Pacific Ocean (e.g. Rodriguez-Fonseca et al. 2009; Ding et al. 2012)



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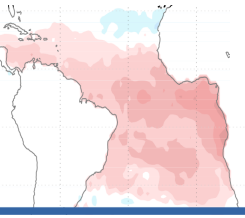
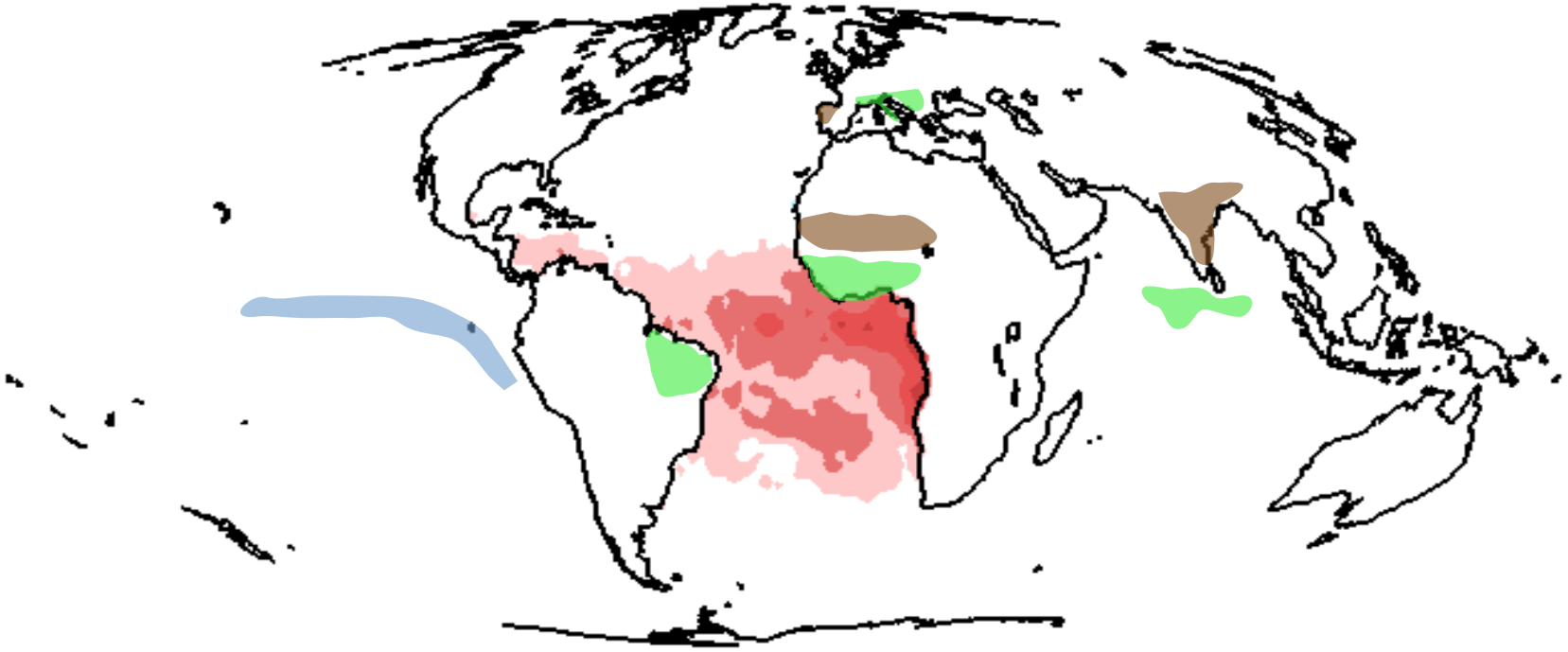
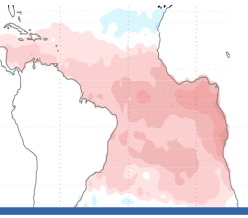


Introduction

Can these impacts change in a warmer climate?





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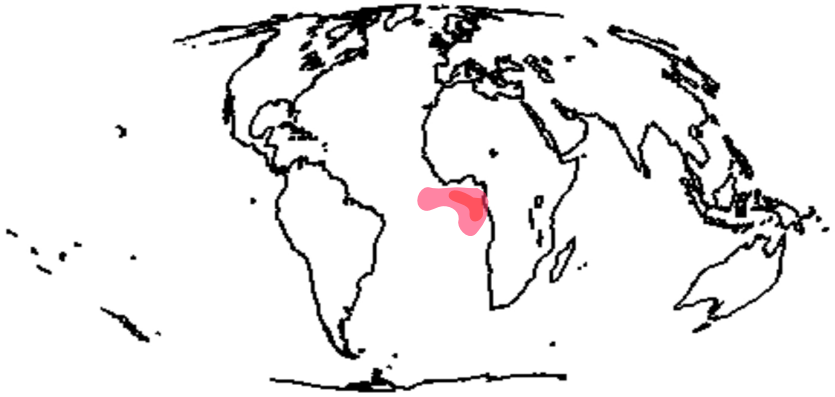

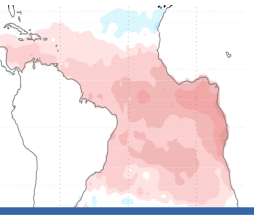

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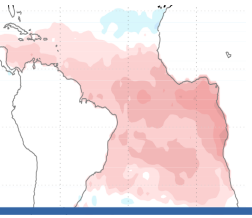

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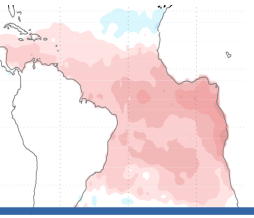
2. Changes in the climatology



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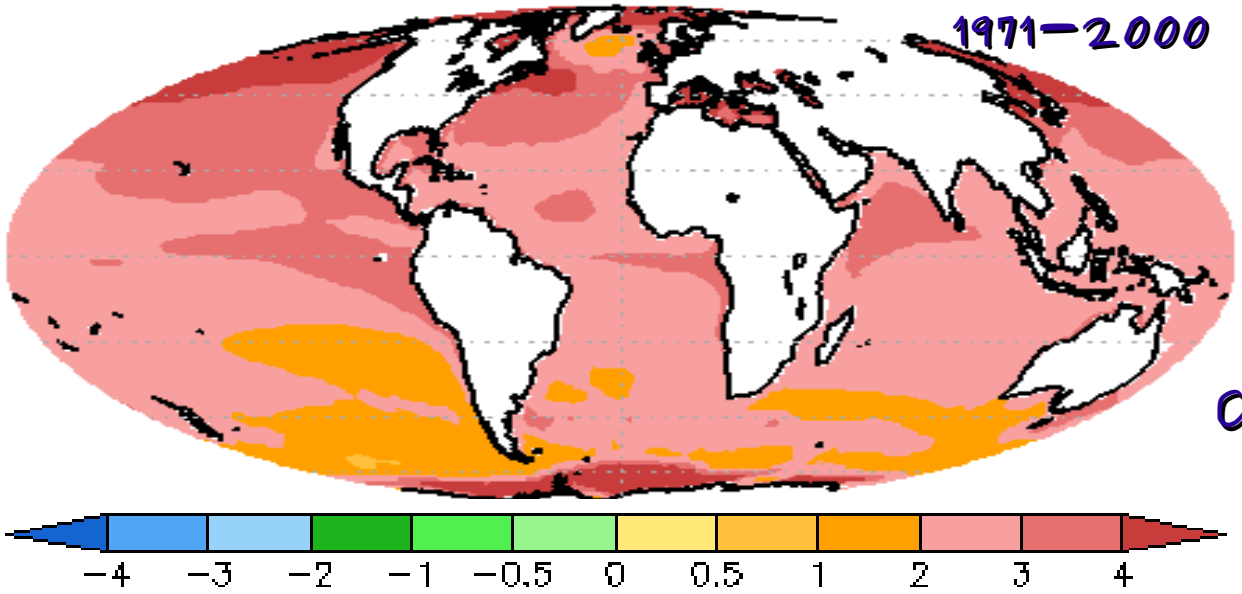
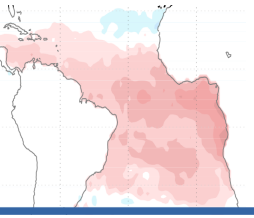
2. Changes in the climatology

Projected SST change from 1971–2000 to 2071–2100



CMIP5 RCP8.5



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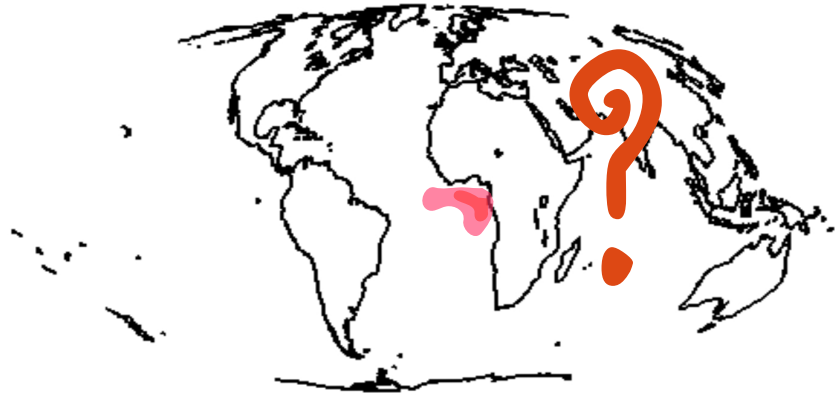

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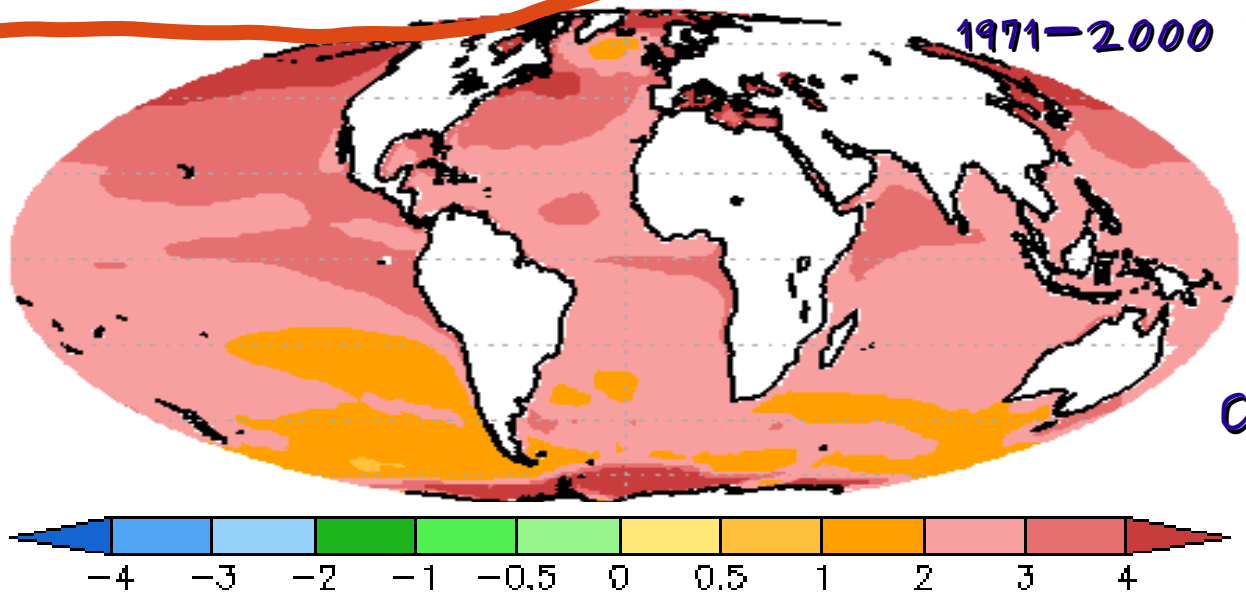

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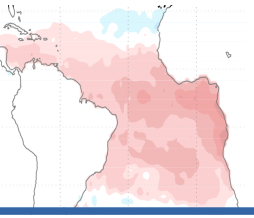
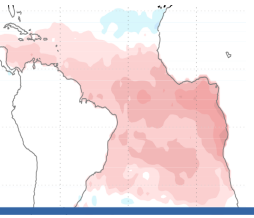


Methods

AGCM sensitivity experiments with SPEEDY.



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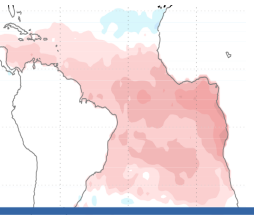

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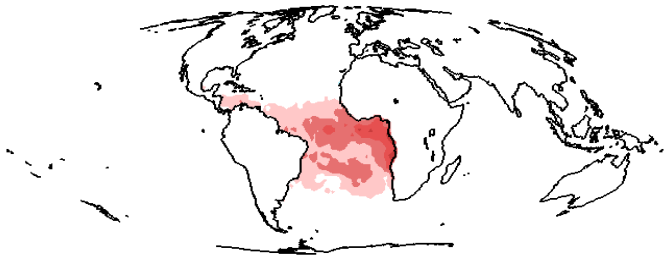

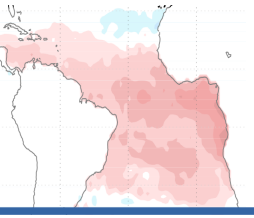

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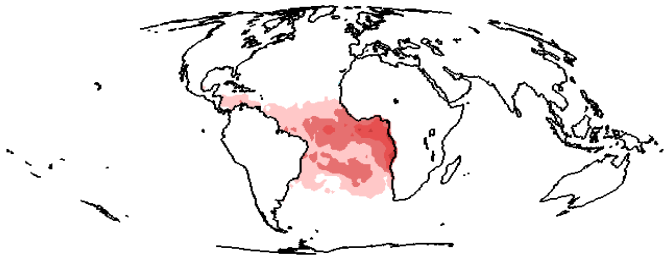

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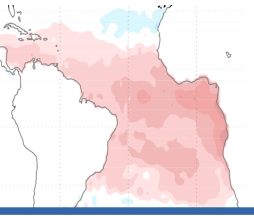
-selection of years for composite analysis 1973, 1984, 1987, 1998 vs 1976, 1982, 1992



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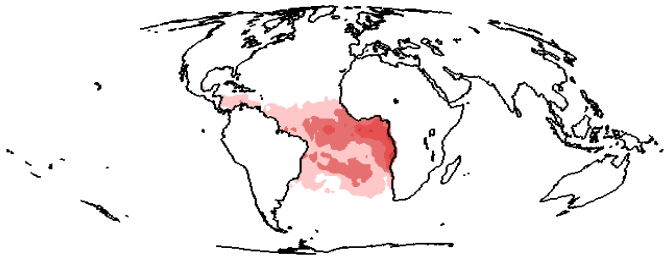

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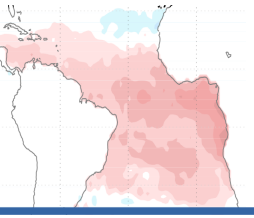

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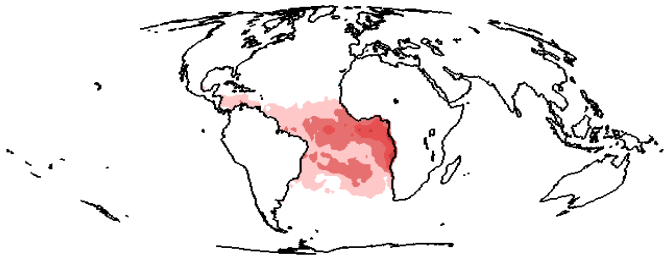

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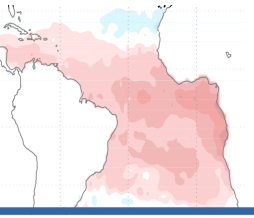
-Future: 2071-2100 (CMIP5 RCP8.5)



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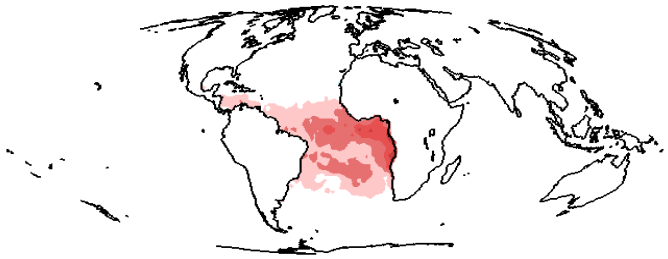

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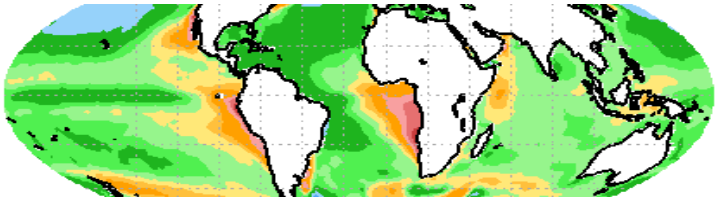
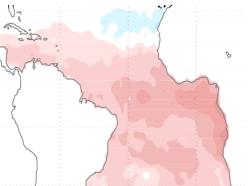
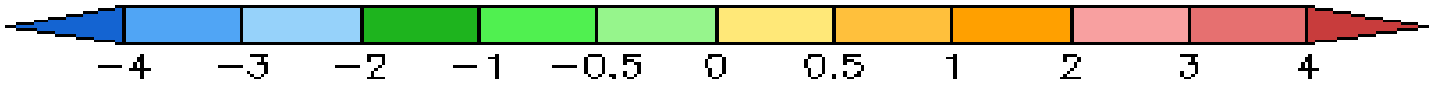


Mean GCM biases in SST





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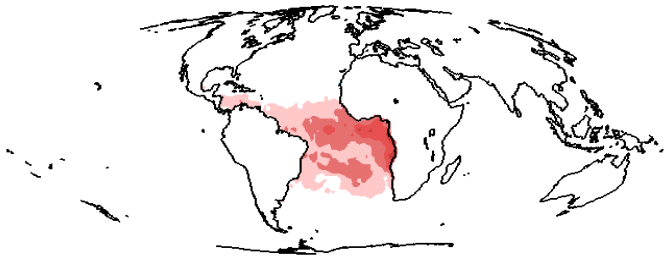


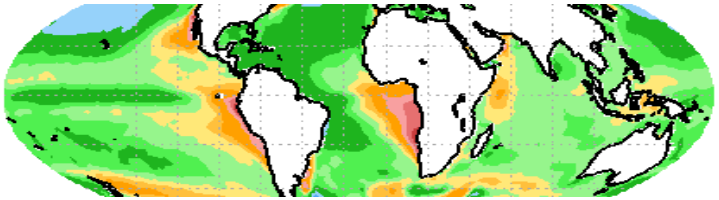
-EOF analysis (1971-2000)

-selection of years for composite analysis 1973, 1984, 1987, 1998 vs 1976, 1982, 1992

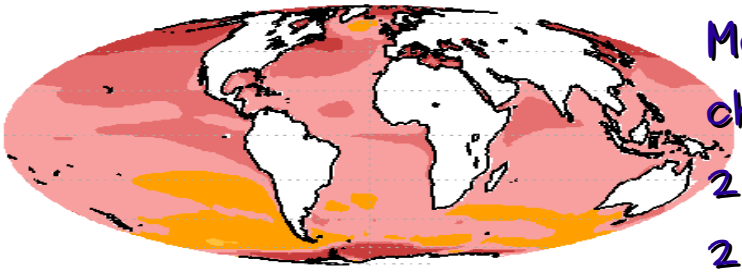
2. Definition of the climatology

-Present: 1971-2000 (HadISSTI)

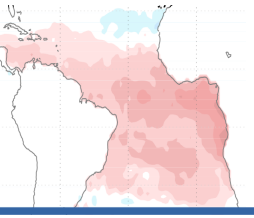
-Future: 2071-2100 (CMIP5 RCP8.5)

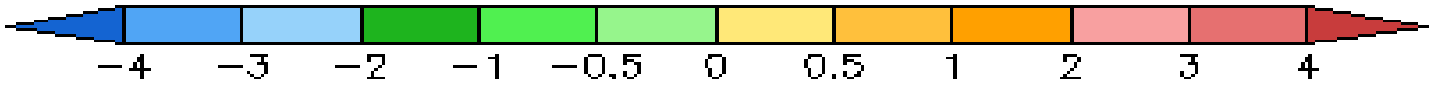


Mean GCM biases in SST



Mean projected change in SSTs 2071-2100 vs 1971-2000





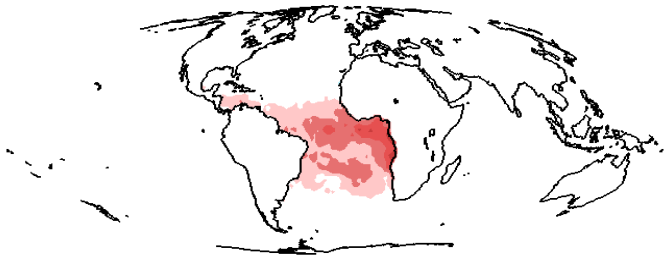
Impacts of the Atlantic Equatorial Mode in a warmer climate

Methods

AGCM sensitivity experiments with SPEEDY.

SST boundary conditions:

1. Definition of the mode



-EOF analysis (1971-2000)

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-Present: 1971-2000 (HadISSTI)

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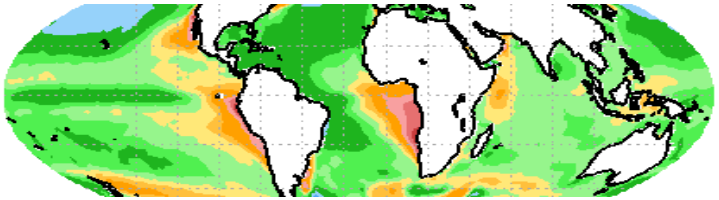
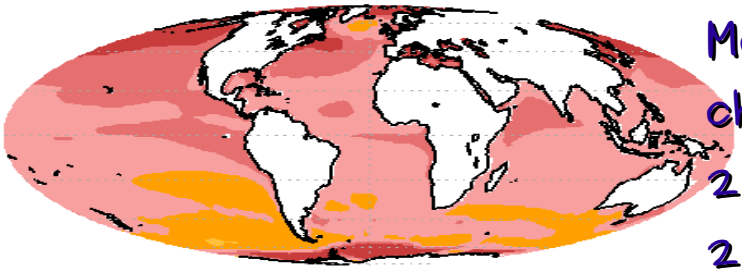
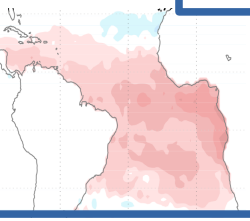


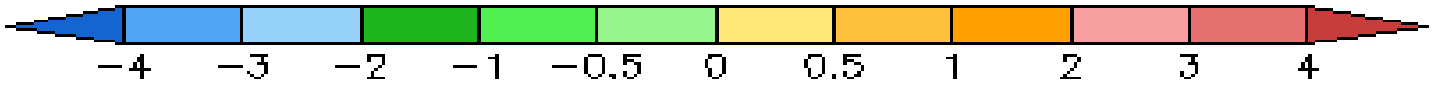
Mean GCM biases in SST



Mean projected change in SSTs 2071-2100 vs 1971-2000

Future clim= pres. clim (obs) + proj. SST change (CMIP5)





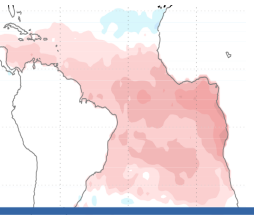
Impacts of the Atlantic Equatorial Mode in a warmer climate

Methods

AGCM sensitivity experiments with SPEEDY.

Two sets of experiments:

1. Present climate (1971–2000)
2. Future climate (2071–2100)



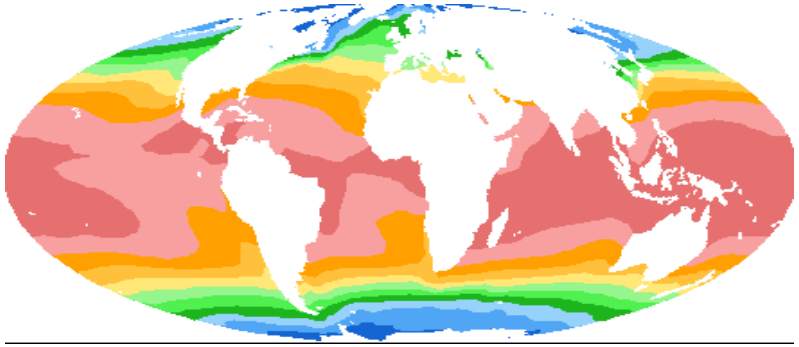
Methods

AGCM sensitivity experiments with SPEEDY.

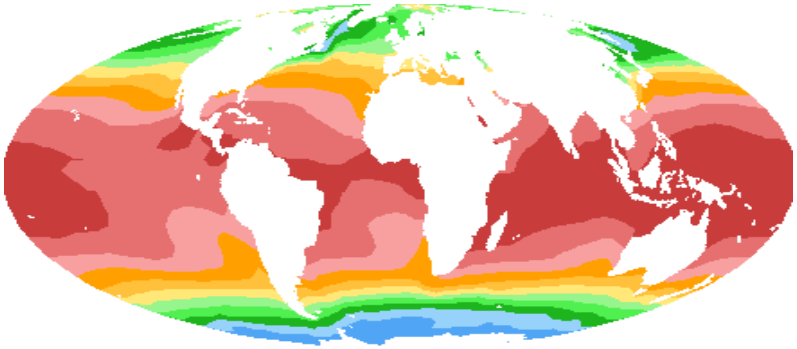
Two sets of experiments:

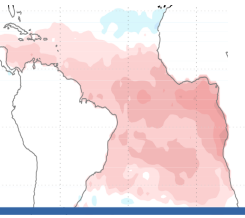
1. Present climate (1971–2000)

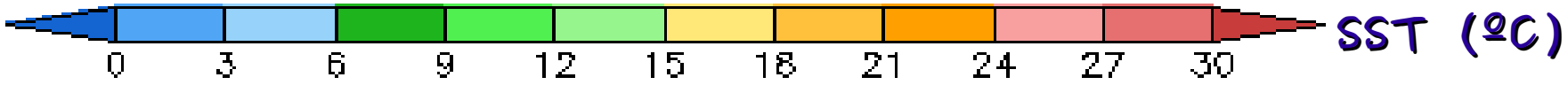
SST



2. Future climate (2071–2100)







Methods

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Two sets of experiments:

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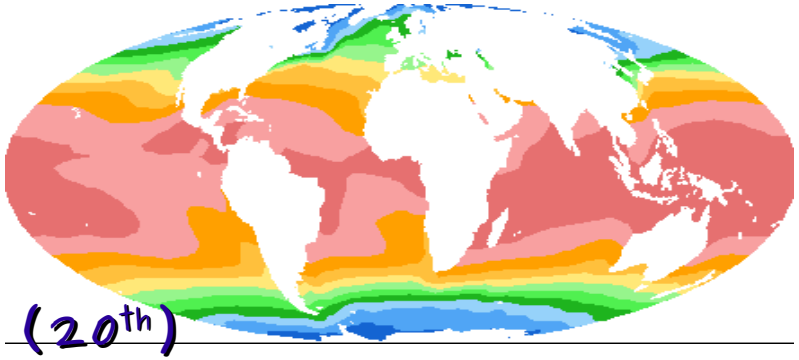
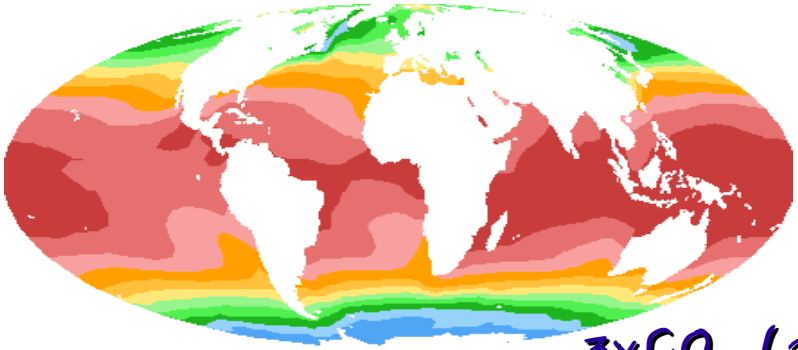
2. Future climate (2071–2100)

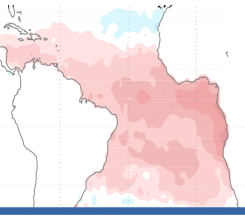
SST

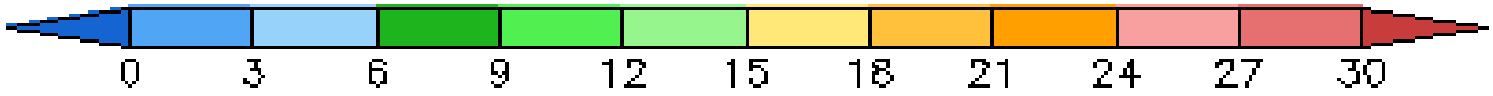


CO_2 (20th)



$3xCO_2$ (20th)





Methods

AGCM sensitivity experiments with SPEEDY.

Two sets of experiments:

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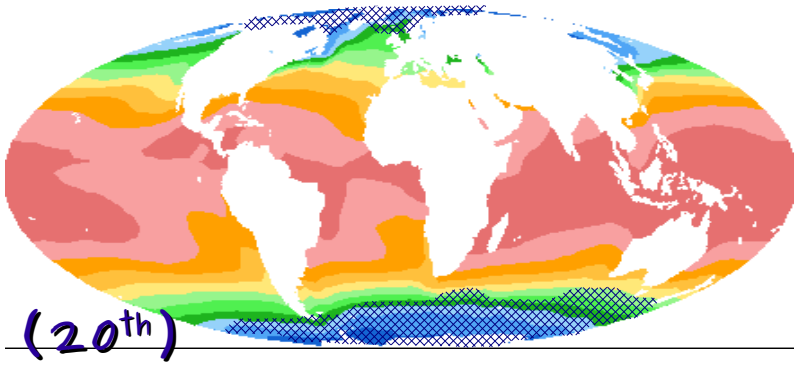
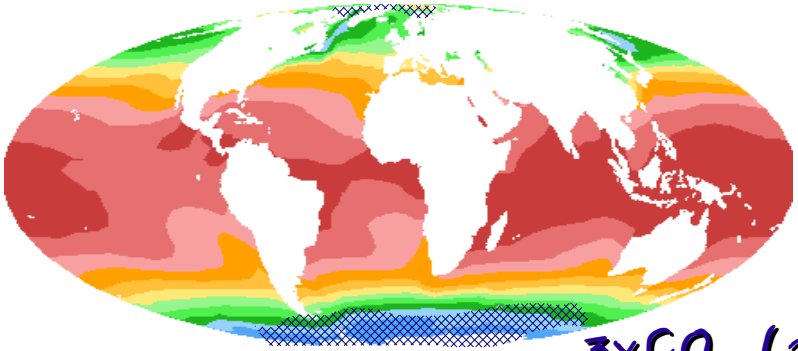


SST

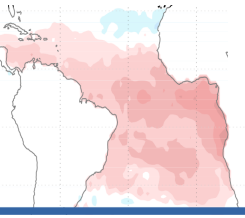
SIC

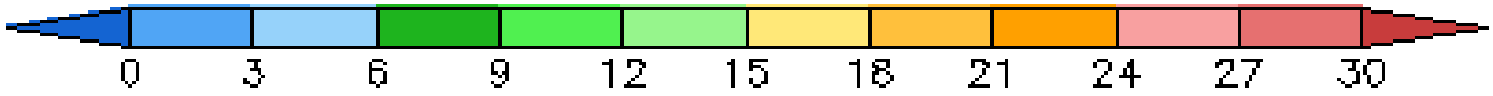
CO_2 (20^{th})

2. Future climate (2071–2100)



$3xCO_2$ (20^{th})





Methods

AGCM sensitivity experiments with SPEEDY.

Two sets of experiments:

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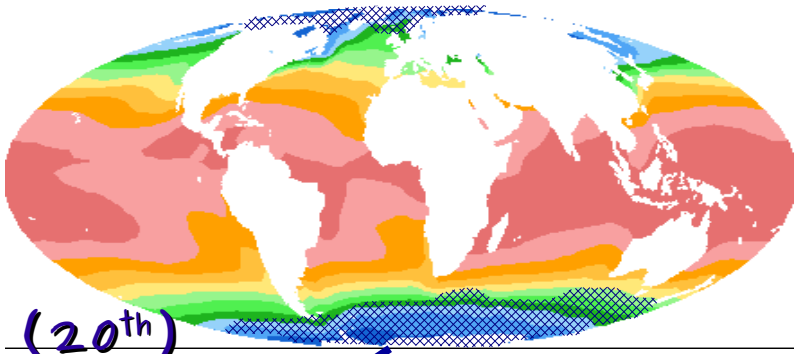
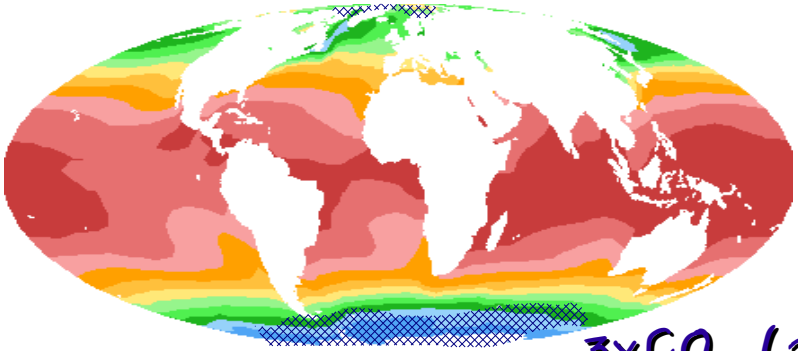


CO_2 (20th)

SST

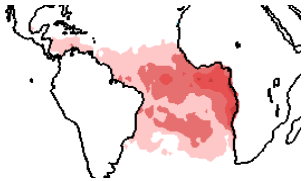
SIC

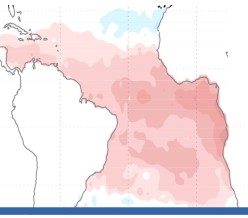
2. Future climate (2071–2100)

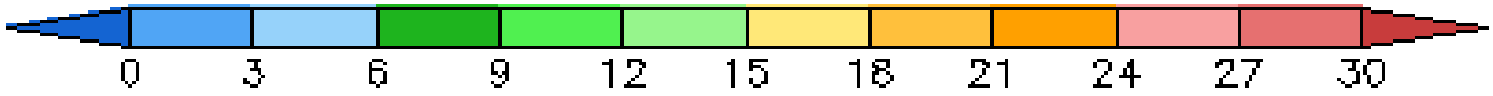


$3xCO_2$ (20th)

A. Present_pos







Impacts of the Atlantic Equatorial Mode in a warmer climate

Methods

AGCM sensitivity experiments with SPEEDY.

Two sets of experiments:

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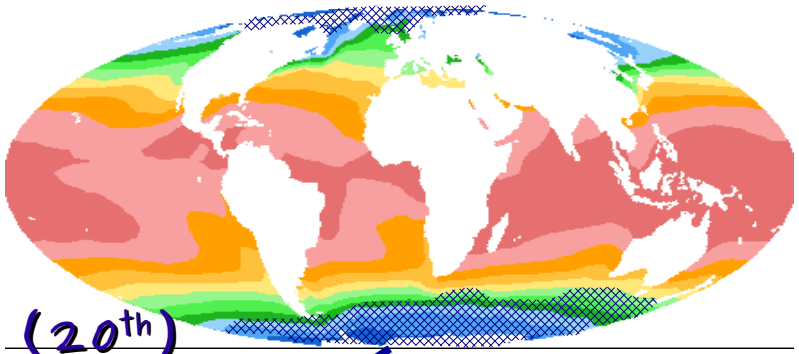
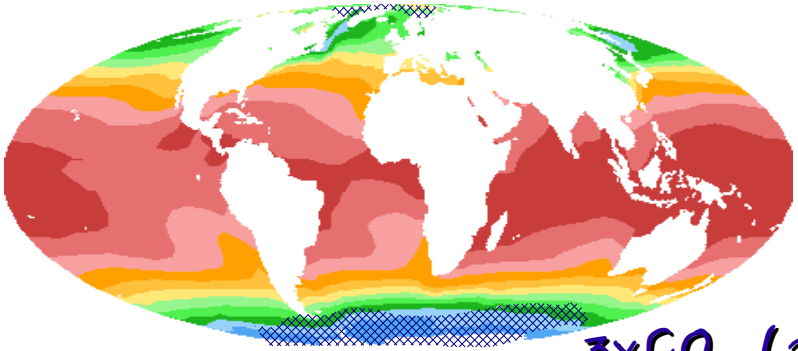


SST

SIC

CO_2 (20^{th})

2. Future climate (2071–2100)



$3xCO_2$ (20^{th})

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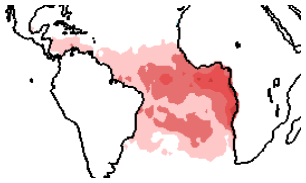
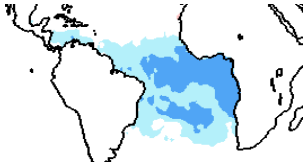
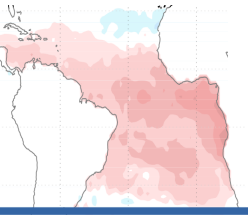
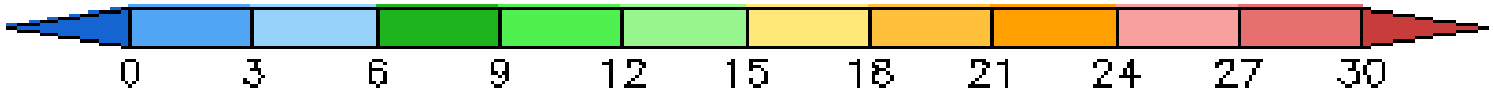


B. Present_neg







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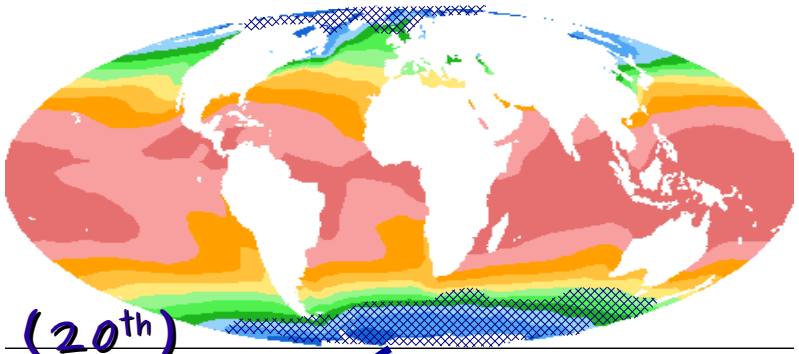
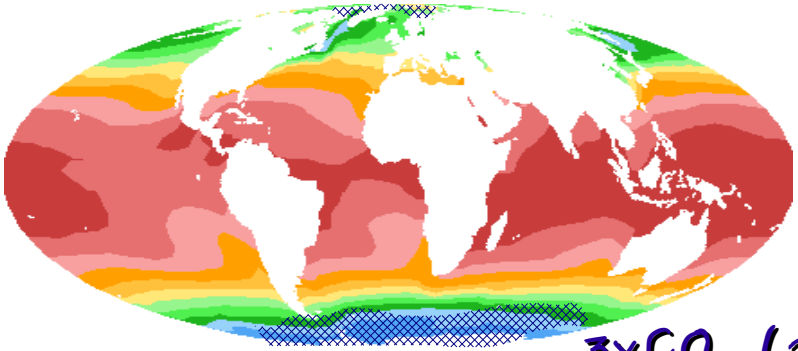


SST

SIC

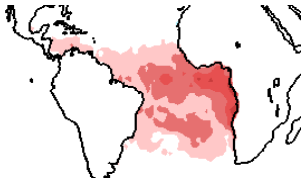
CO_2 (20^{th})

2. Future climate (2071–2100)

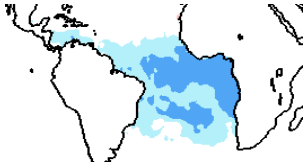


$3xCO_2$ (20^{th})

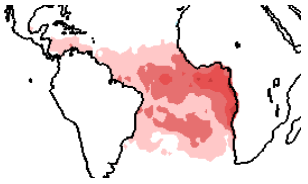
A. Present_pos



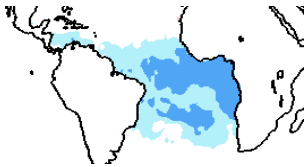
B. Present_neg

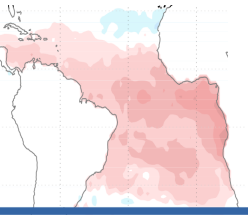


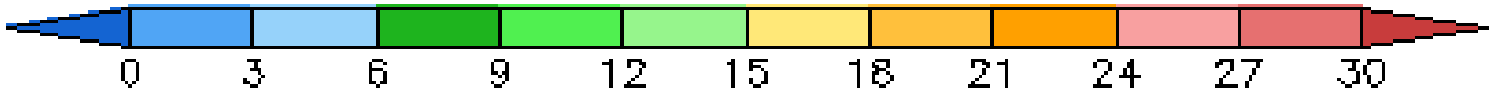
C. Future_pos



D. Future_neg







Methods

AGCM sensitivity experiments with SPEEDY.

Two sets of experiments:

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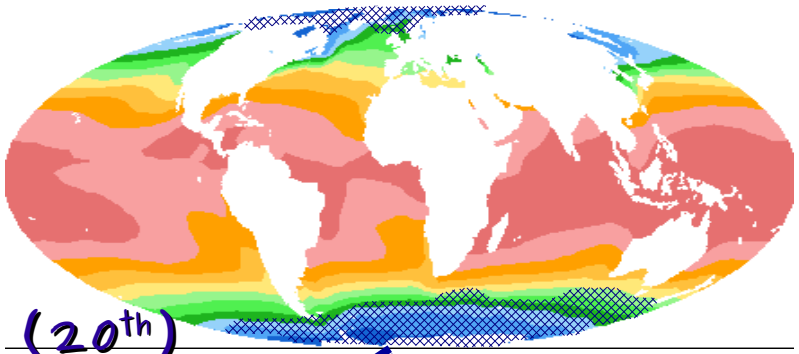
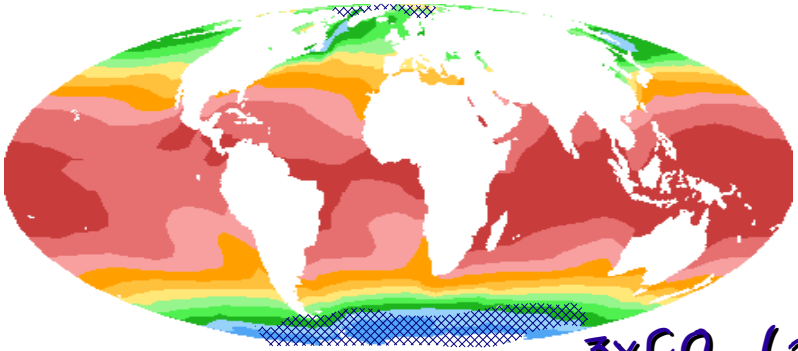


SST

SIC

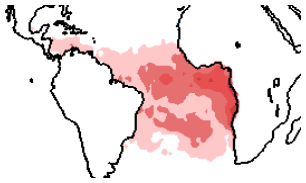
CO_2 (20^{th})

2. Future climate (2071–2100)

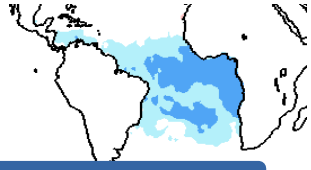


$3xCO_2$ (20^{th})

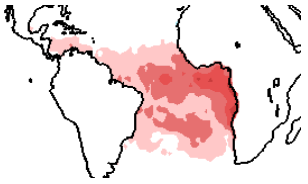
A. Present_pos



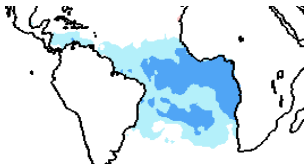
B. Present_neg



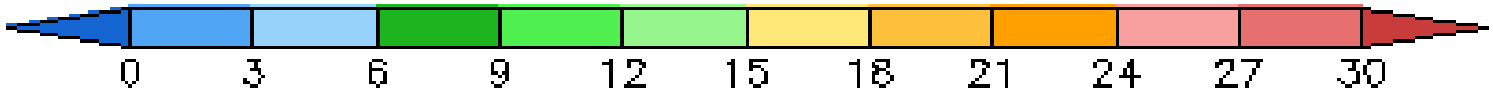
C. Future_pos

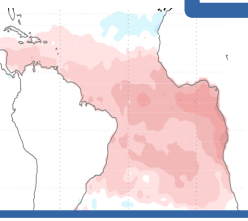


D. Future_neg



Present impact = A–B





Impacts of the Atlantic Equatorial Mode in a warmer climate

Methods

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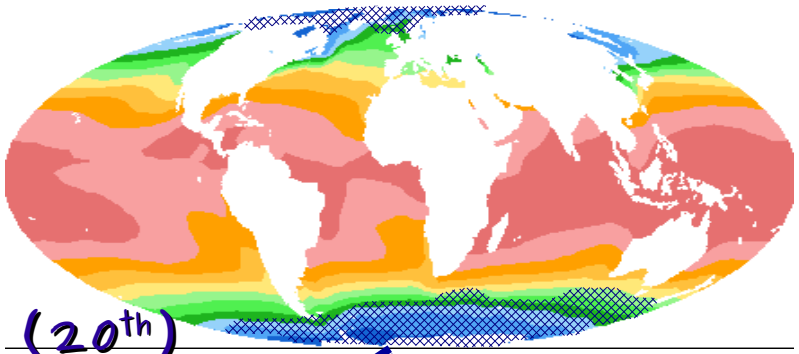
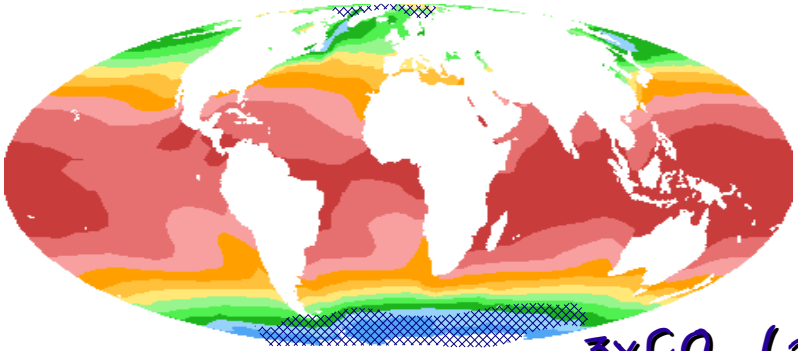


SST

SIC

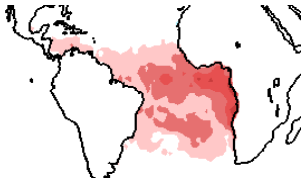
CO_2 (20^{th})

2. Future climate (2071–2100)

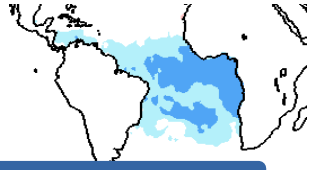


$3xCO_2$ (20^{th})

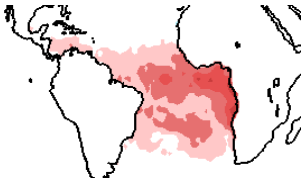
A. Present_pos



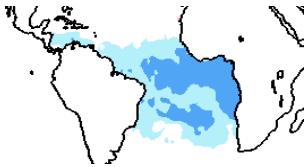
B. Present_neg



C. Future_pos

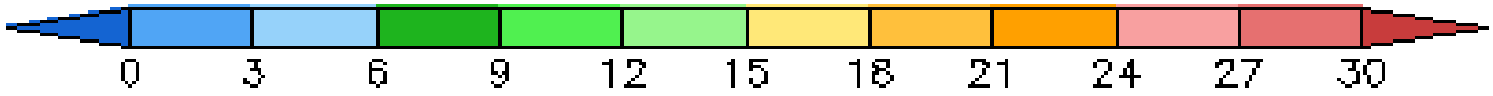


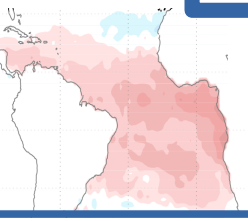
D. Future_neg



Present impact = A–B

Future impact =C–D



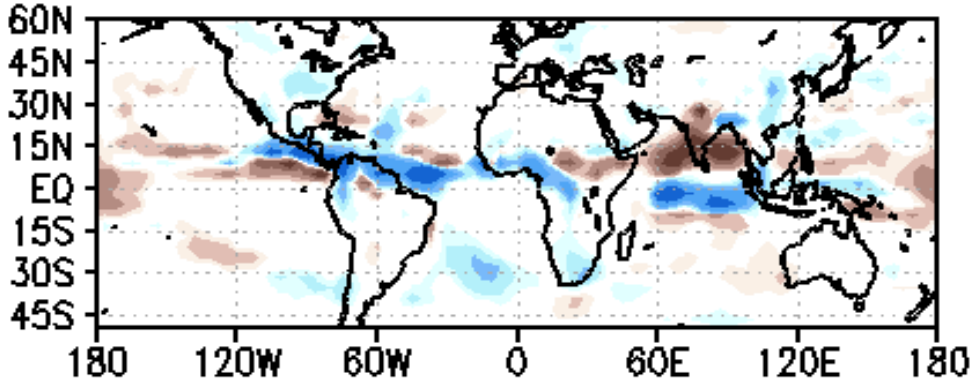


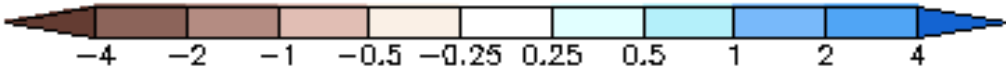
Impacts of the Atlantic Equatorial Mode in a warmer climate

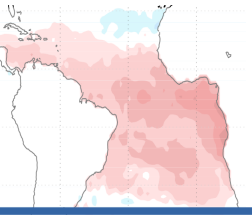
Results: JAS rainfall

Present impact = A−B

Consistent with previous works

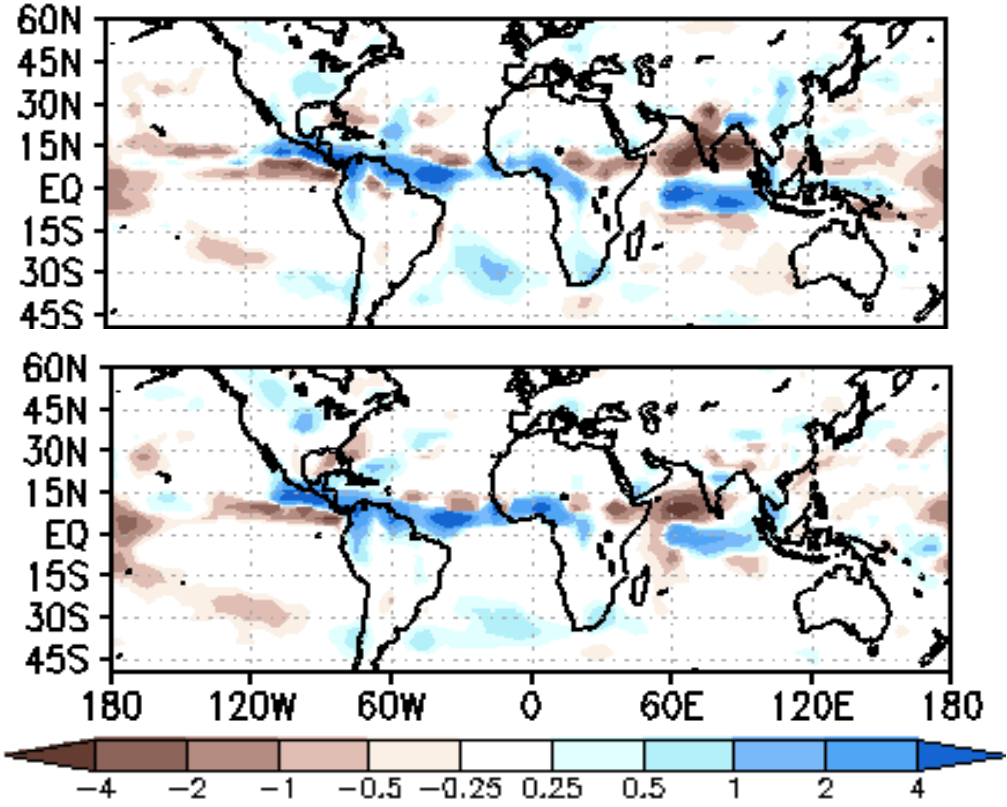


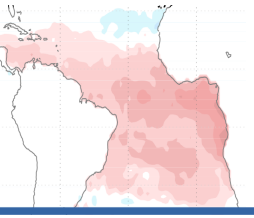




Results: JAS rainfall

Future impact =C−D

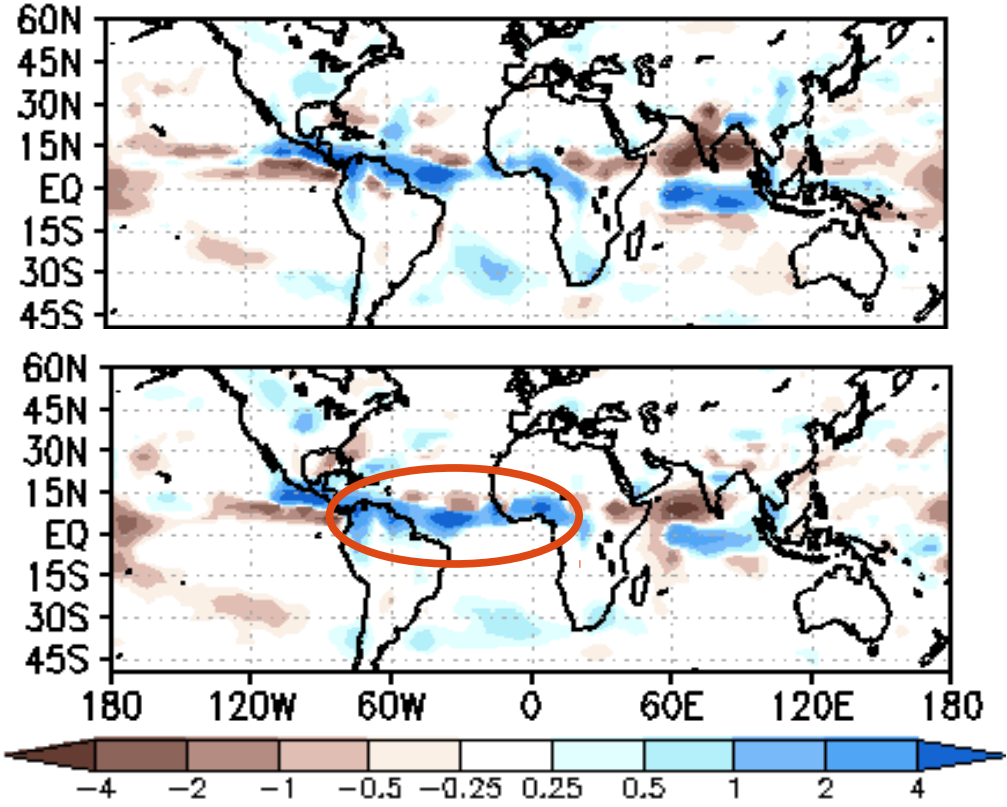


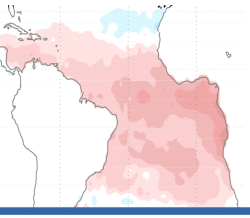


Results: JAS rainfall

Future impact =C−D

- + impact over TA (Amazonia, WA)

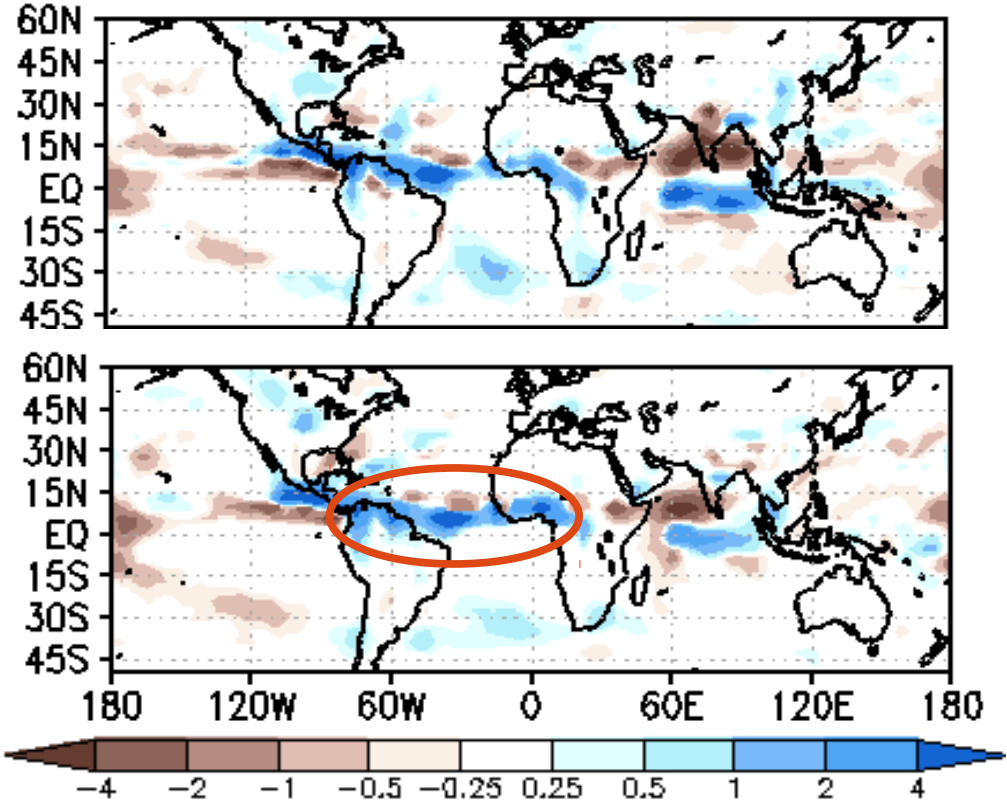


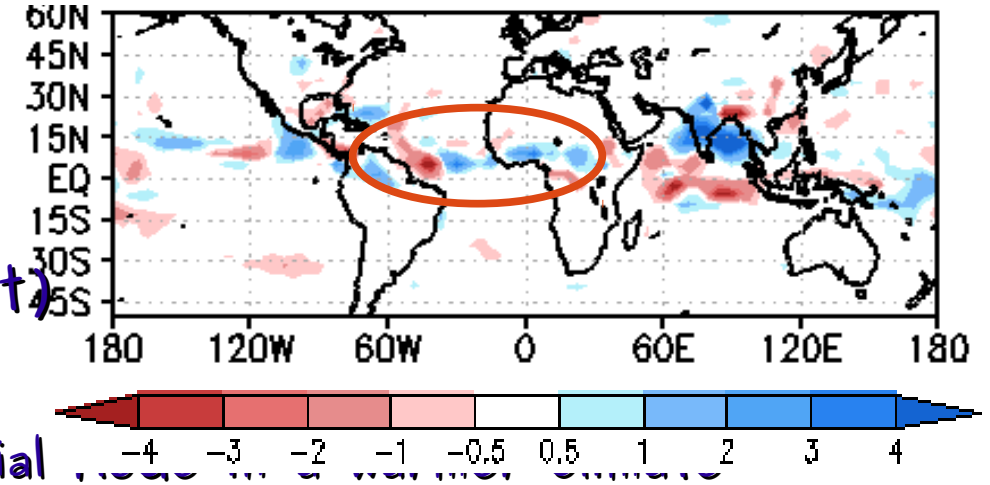


Results: JAS rainfall

Future impact =C−D

- + impact over TA (Amazonia, WA)





(Future impact) - (Present impact)

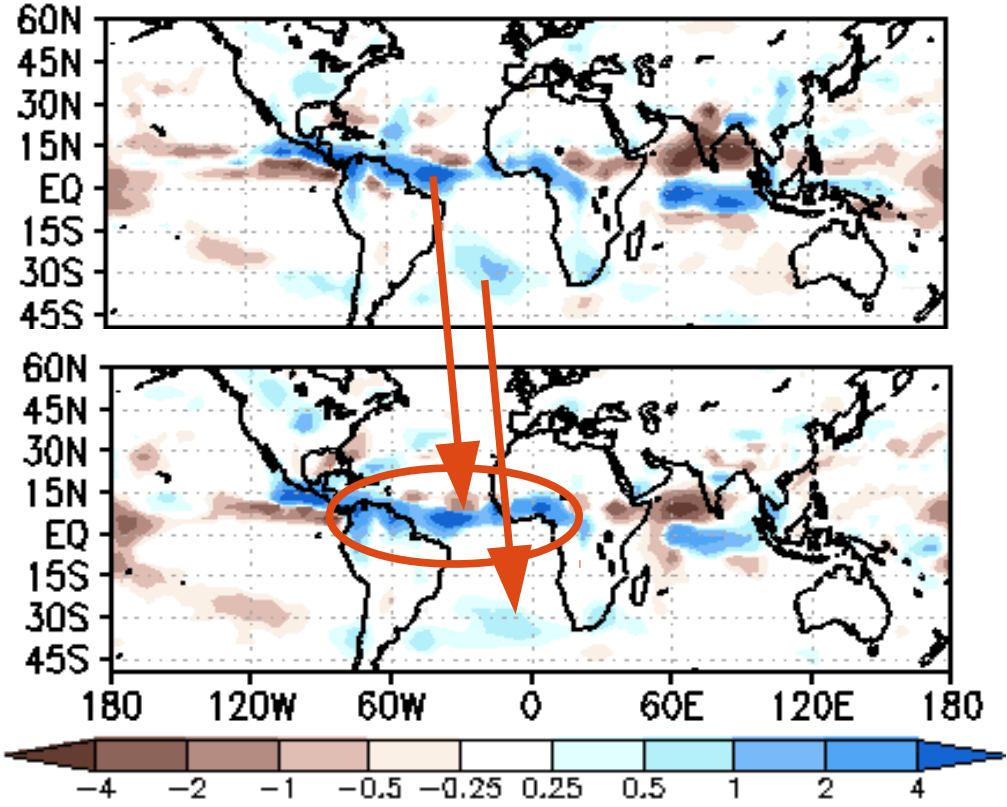
=(C−D)−(A−B)

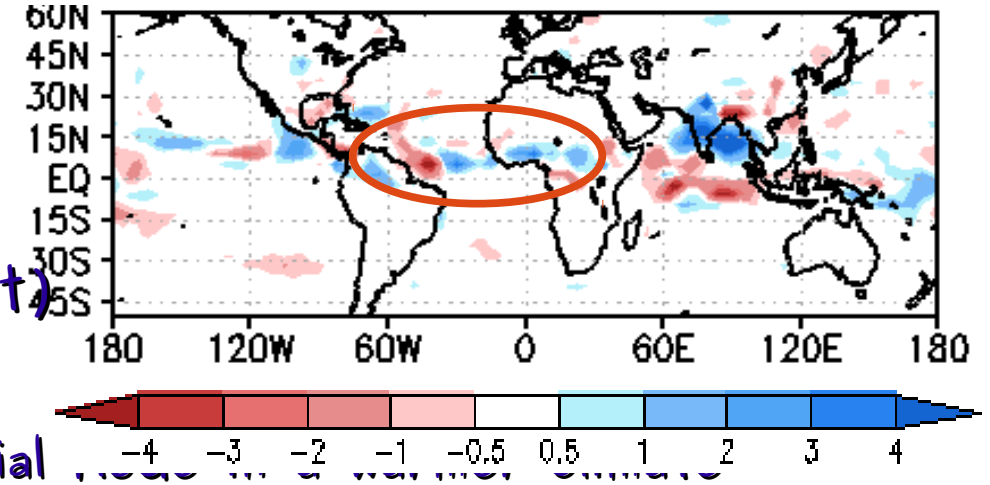
Impacts of the Atlantic Equatorial

Results: JAS rainfall

Future impact =C−D

- + impact over TA (Amazonia, WA)
- Max. TA anom shift to E





(Future impact) − (Present impact)

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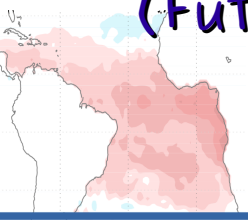


Impacts of the Atlantic Equatorial

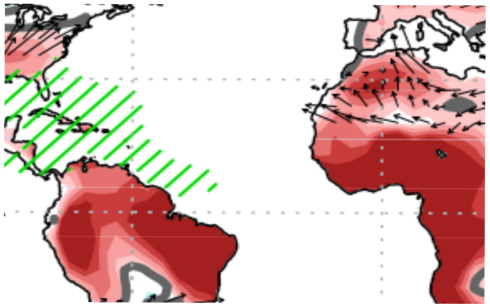
Results: JAS rainfall

Future impact =C−D

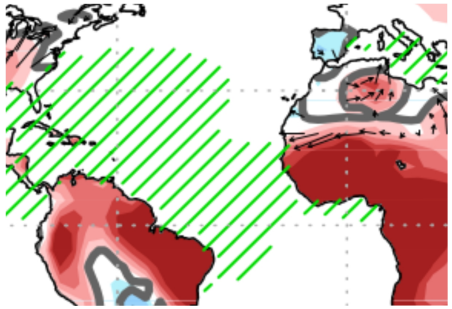
- + impact over TA (Amazonia, WA)
- Max. TA anom shift to E

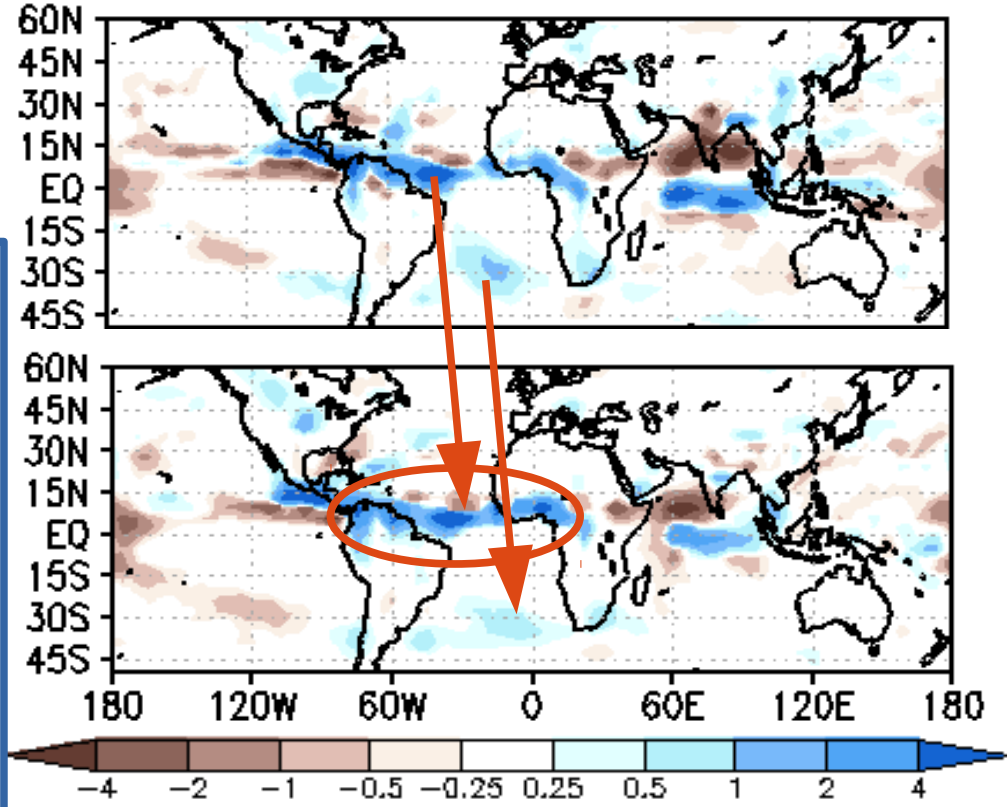
→ Related to the increase in region where 28ºC threshold for convection is reached in the future

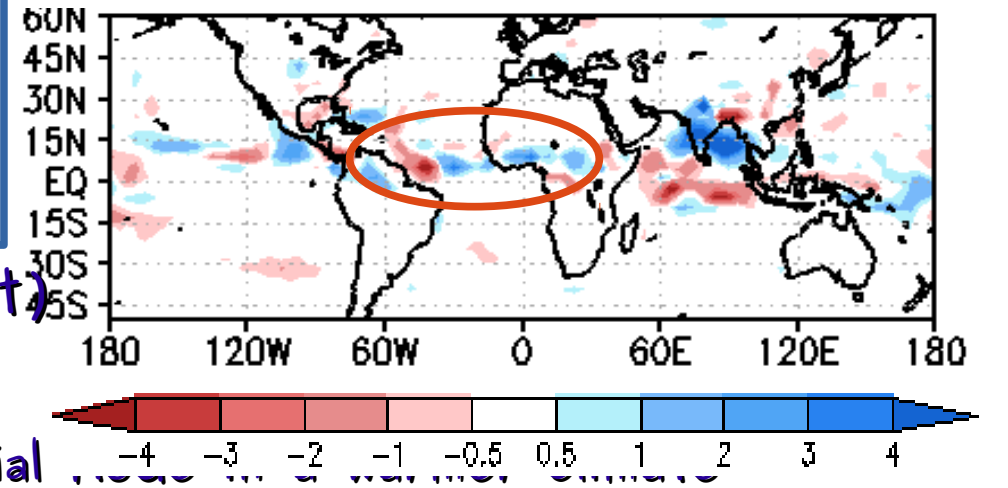
1971−2000



2071−2100

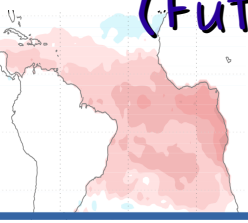






(Future impact) − (Present impact)

=(C−D)−(A−B)



Impacts of the Atlantic Equatorial

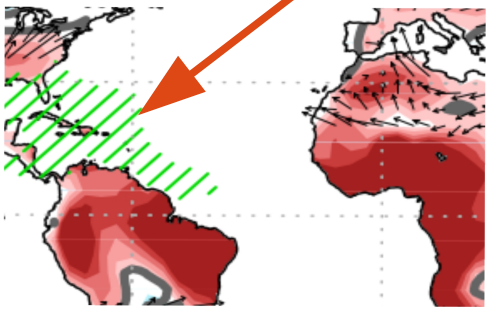
Results: JAS rainfall

Future impact =C−D

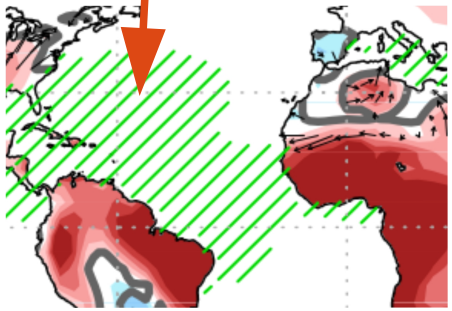
- + impact over TA (Amazonia, WA)
- Max. TA anom shift to E

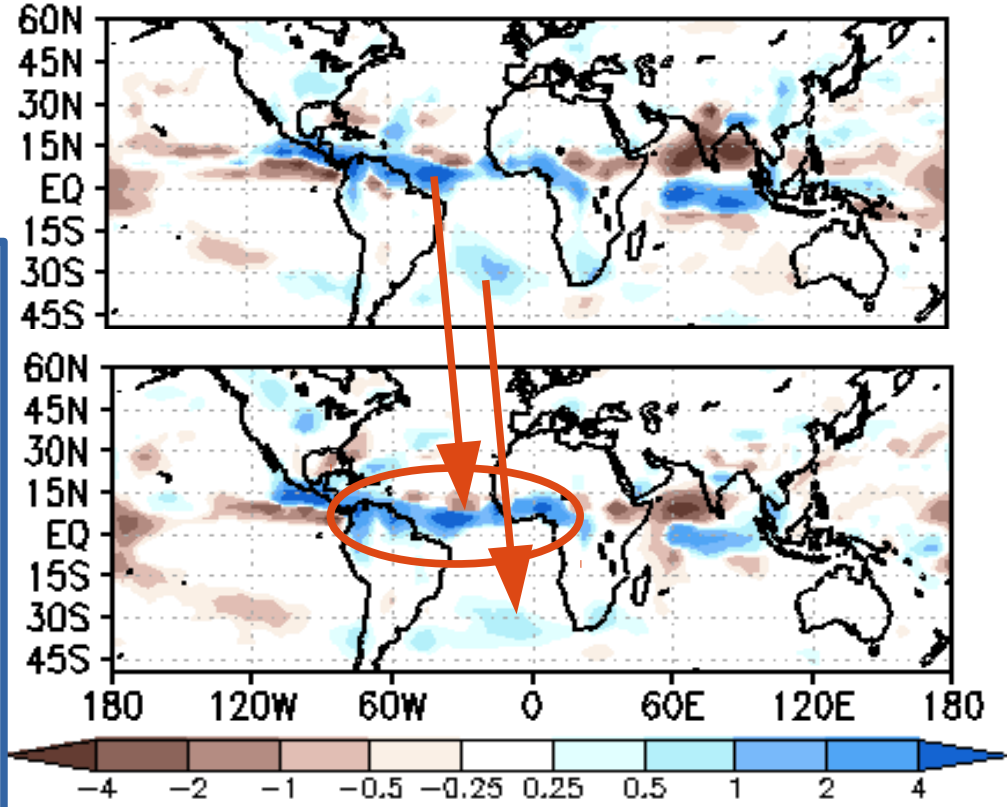
→ Related to the increase in region where 28ºC threshold for convection is reached in the future

1971−2000



2071−2100





(Future impact) − (Present impact)

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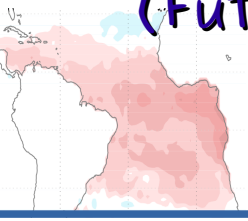
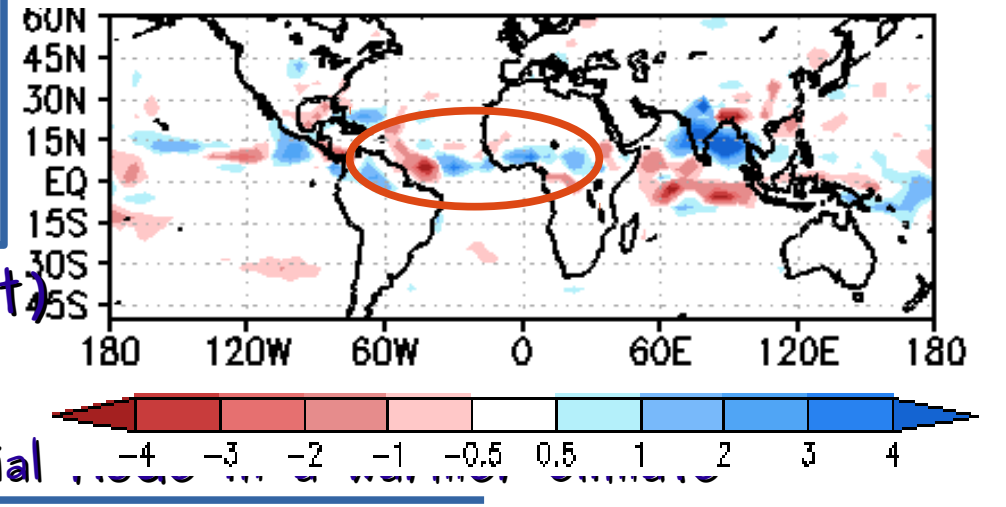


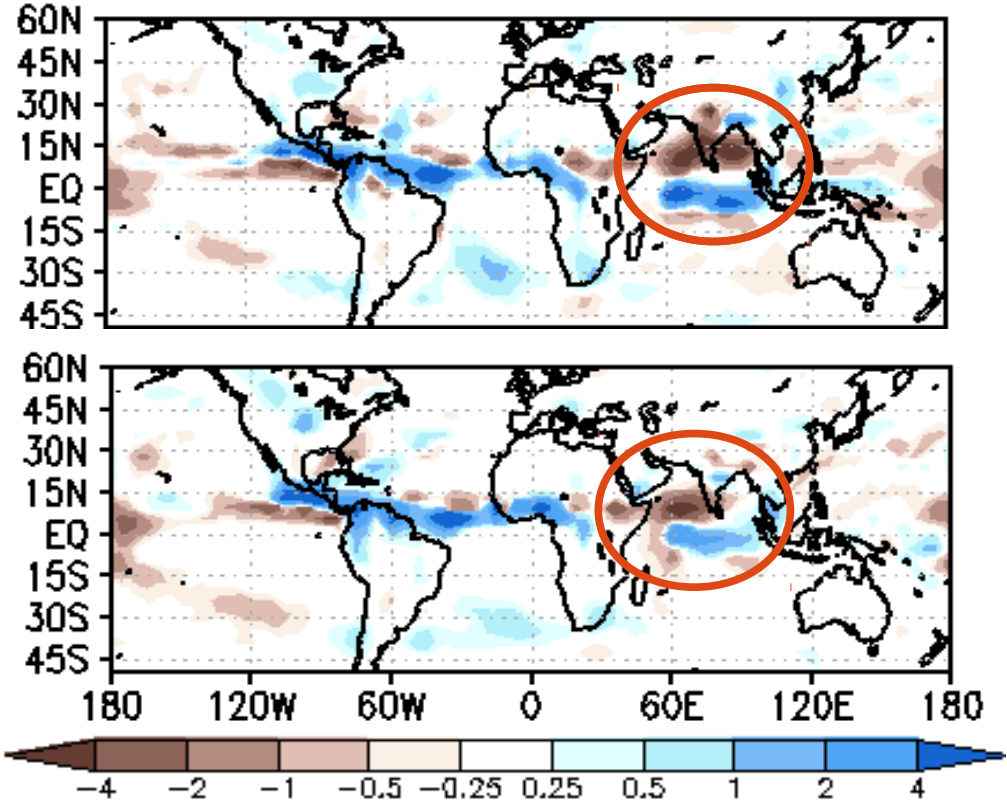


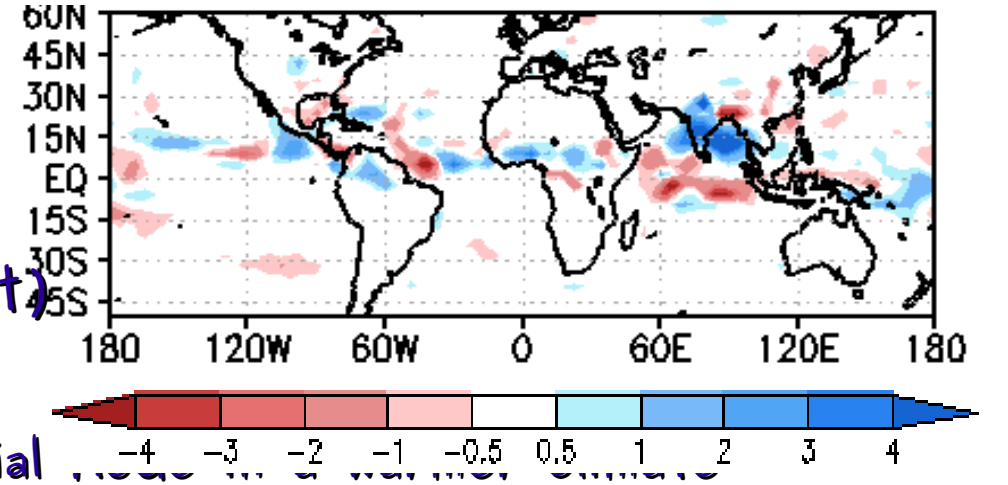
Impacts of the Atlantic Equatorial

Results: JAS rainfall

Future impact =C−D

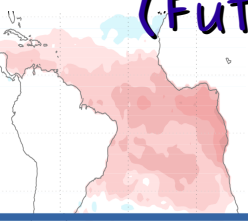
- + impact over TA (Amazonia, WA)
- Max. TA anom shift to E
- Indian anom shift to W





(Future impact) − (Present impact)

=(C−D)−(A−B)



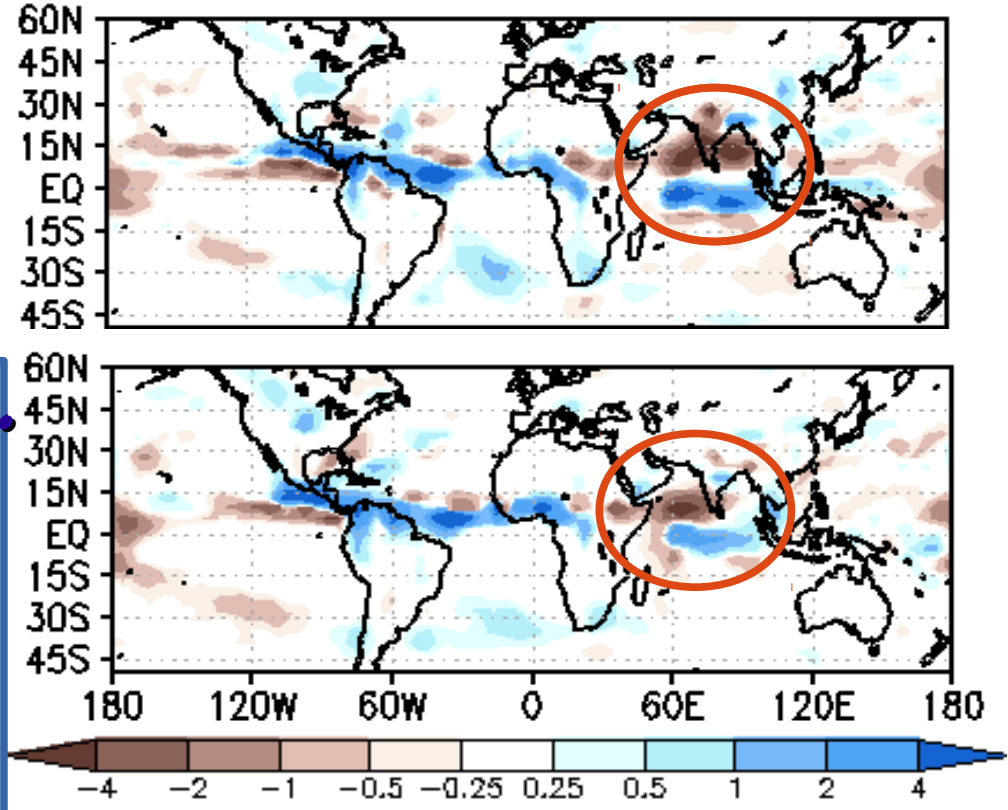
Impacts of the Atlantic Equatorial

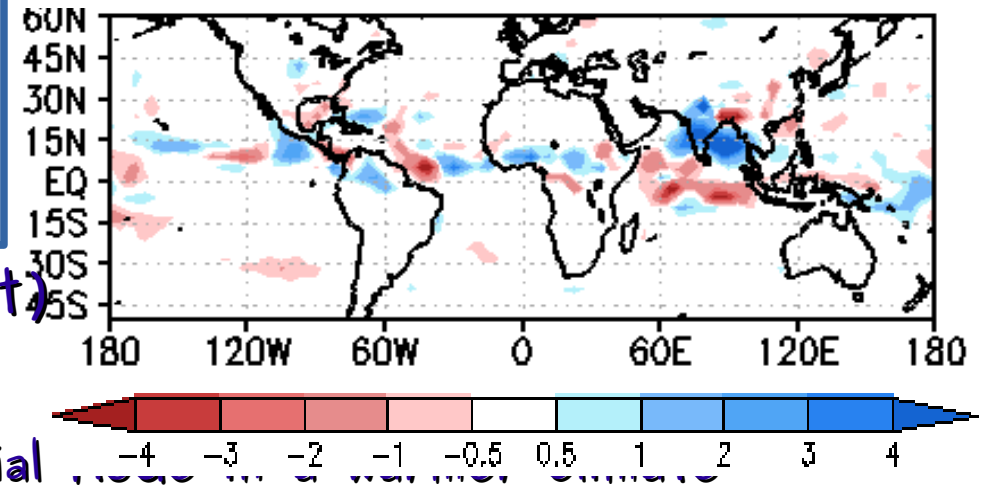
Results: JAS rainfall

Future impact =C−D

- + impact over TA (Amazonia, WA)
- Max. TA anom shift to E
- Indian anom shift to W

→ Related to changes in local clim. SST gradients that shift to W climatological convection





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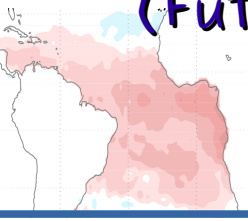

Impacts of the Atlantic Equatorial

Results: JAS rainfall

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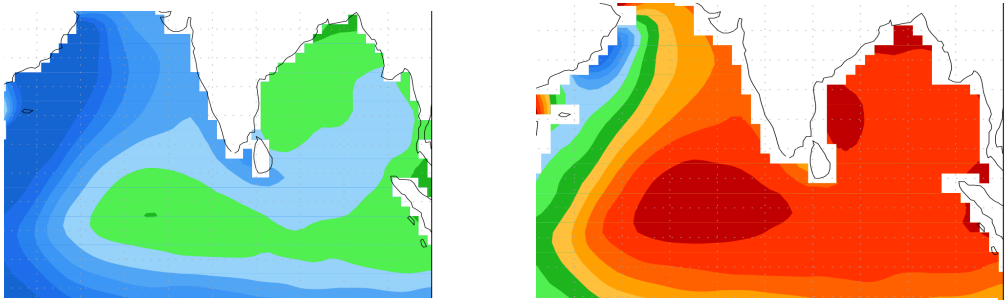
→ Related to changes in local clim. SST gradients that shift to W climatological convection

1971−2000 2071−2100



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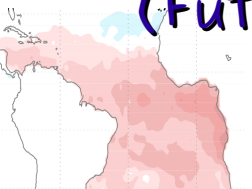
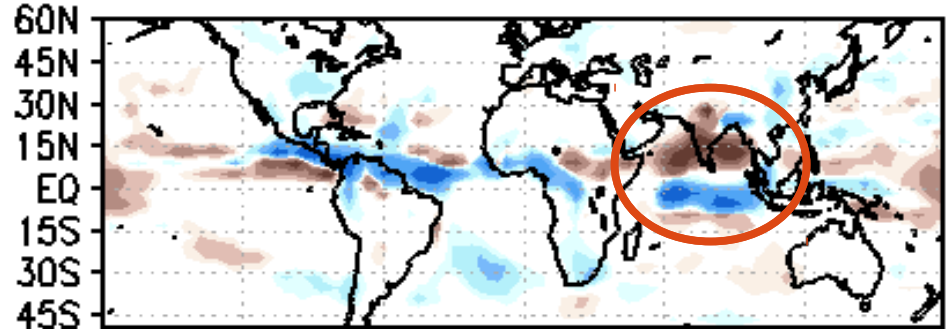
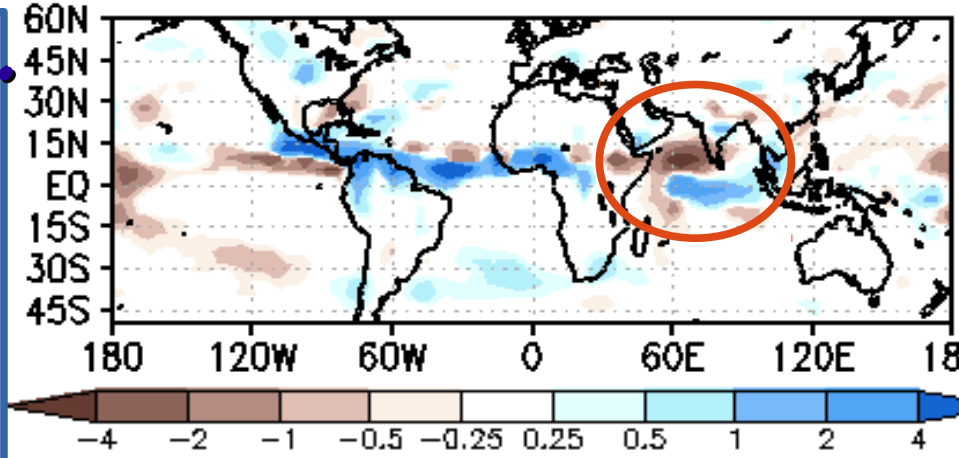
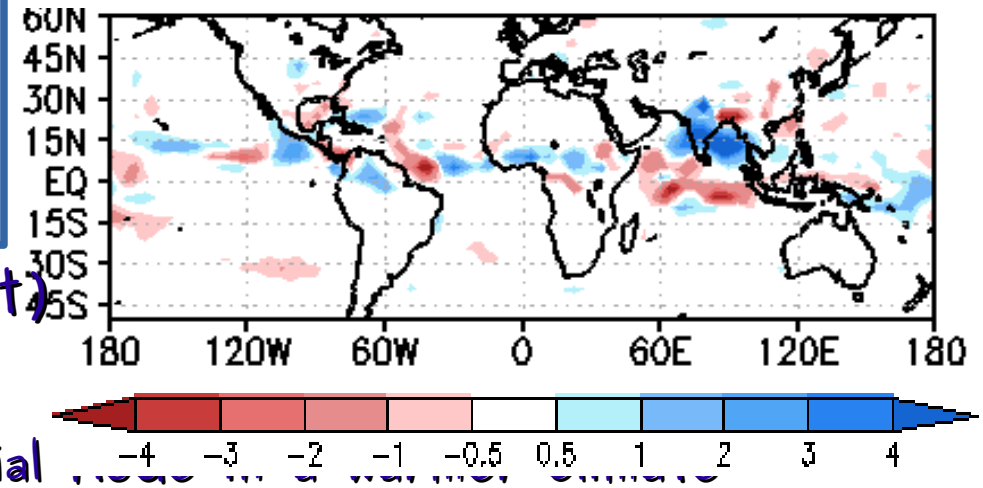
=(C−D)−(A−B)









Impacts of the Atlantic Equatorial

Results: JAS rainfall

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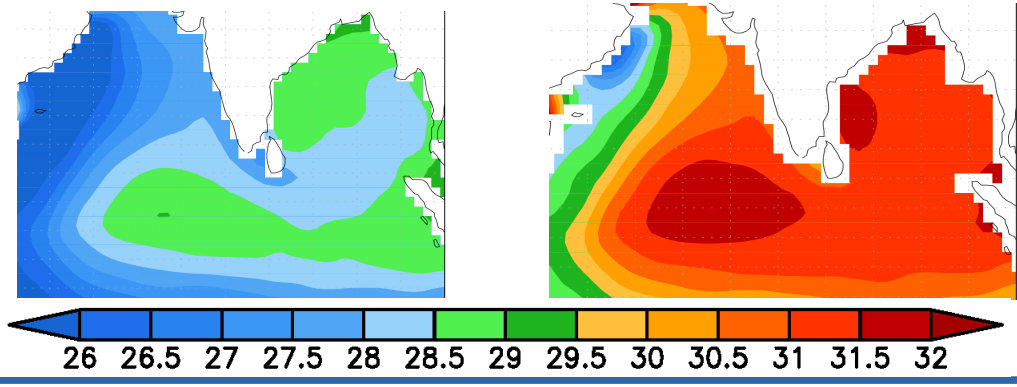
→ Related to changes in local clim. SST gradients that shift to W climatological convection

1971−2000 2071−2100



(Future impact) − (Present impact)

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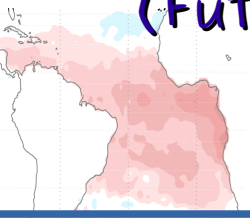
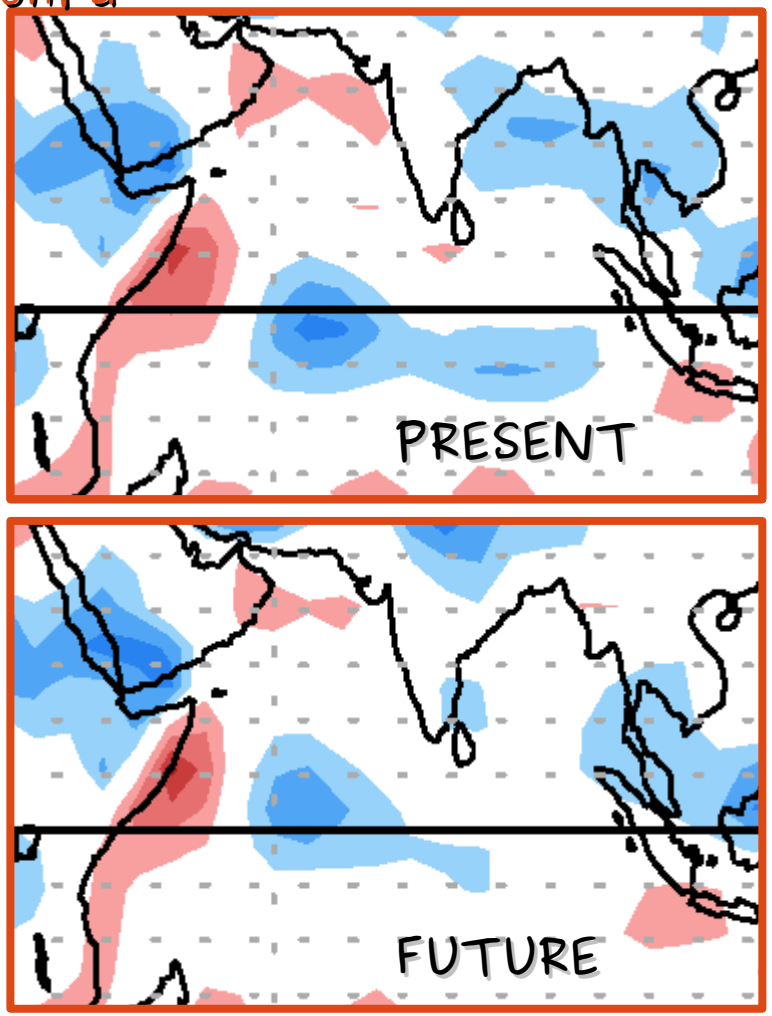
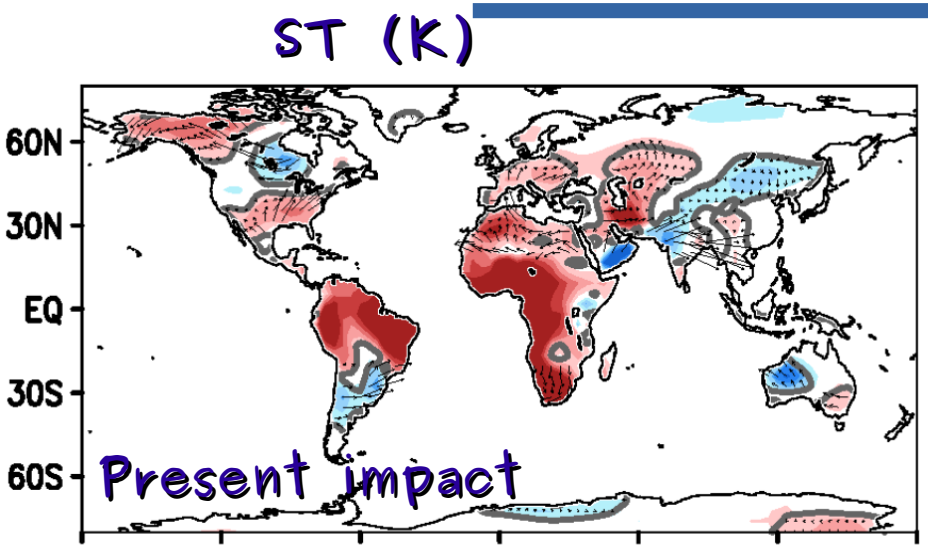


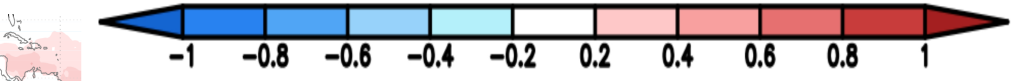
Climatological divergence at 925hPa

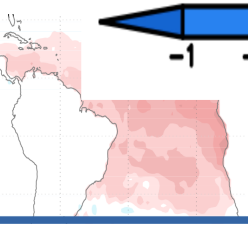


Results: JAS surface temperature



- Impacts on surf. T due to the anomalous advection of climatological temperatures





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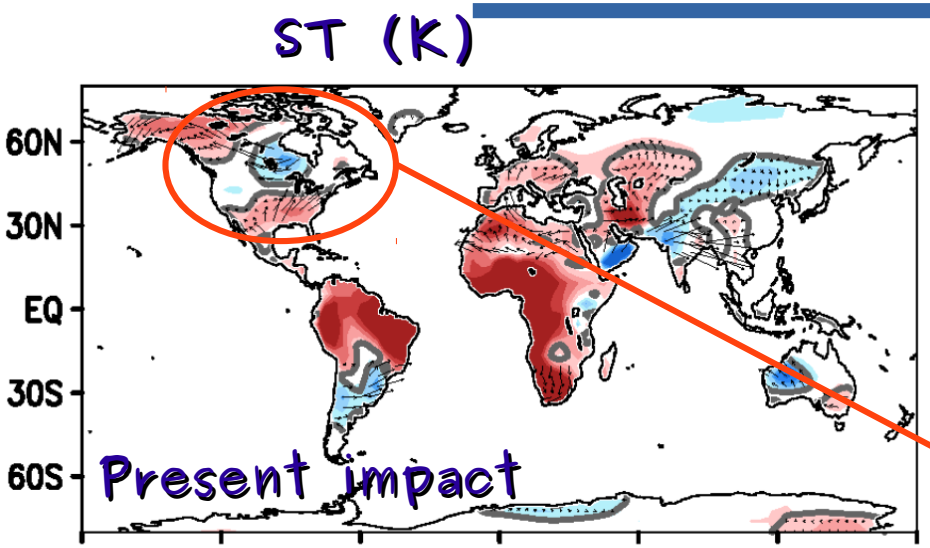

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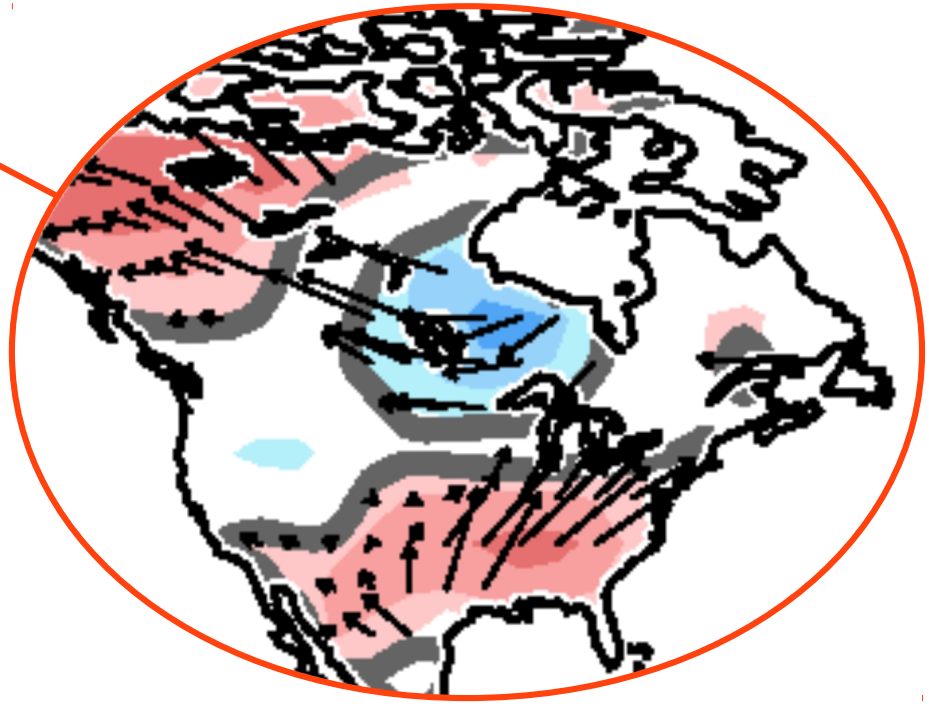
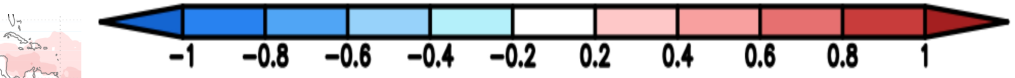
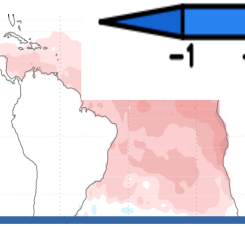
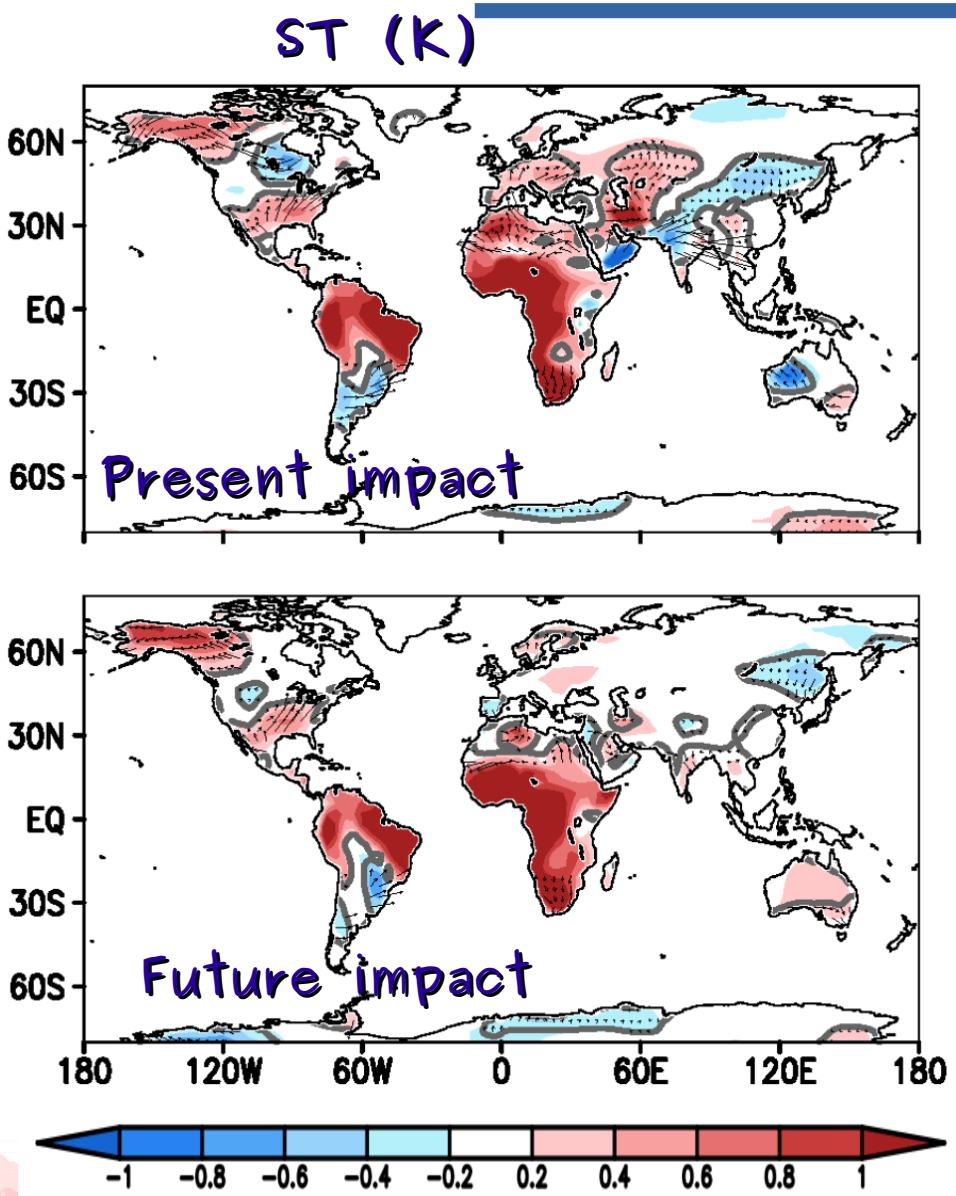






Results: JAS surface temperature



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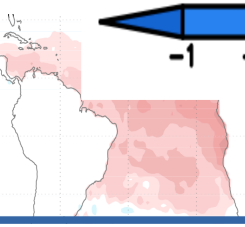
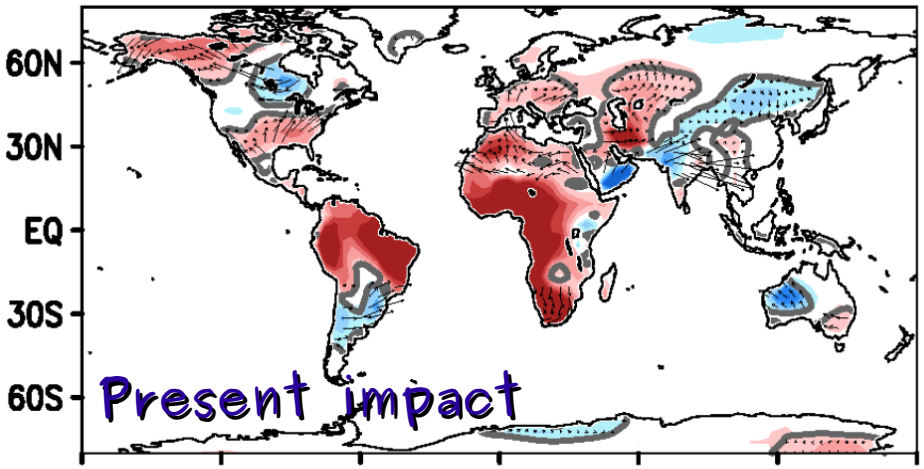
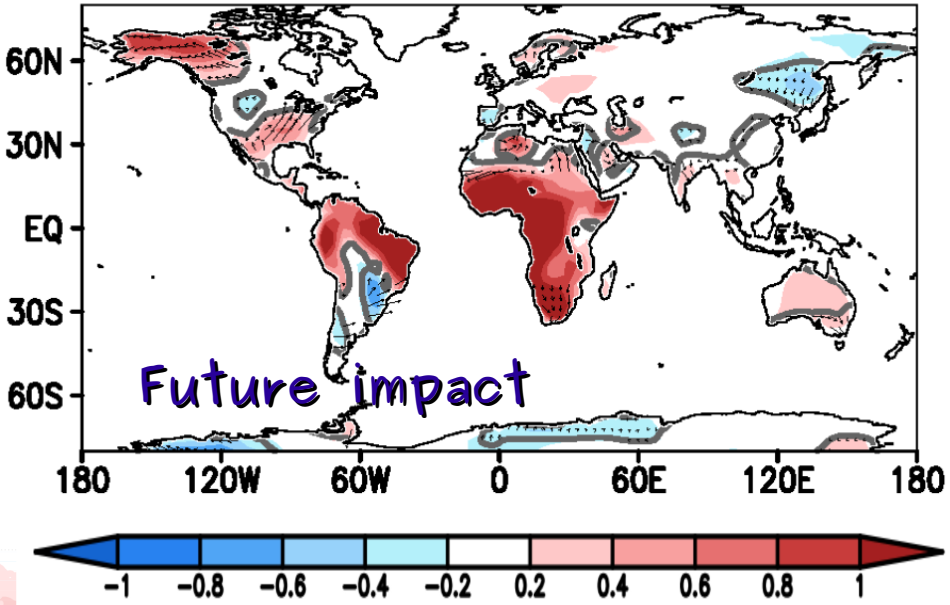


Impacts of the Atlantic Equatorial Mode in a warmer climate

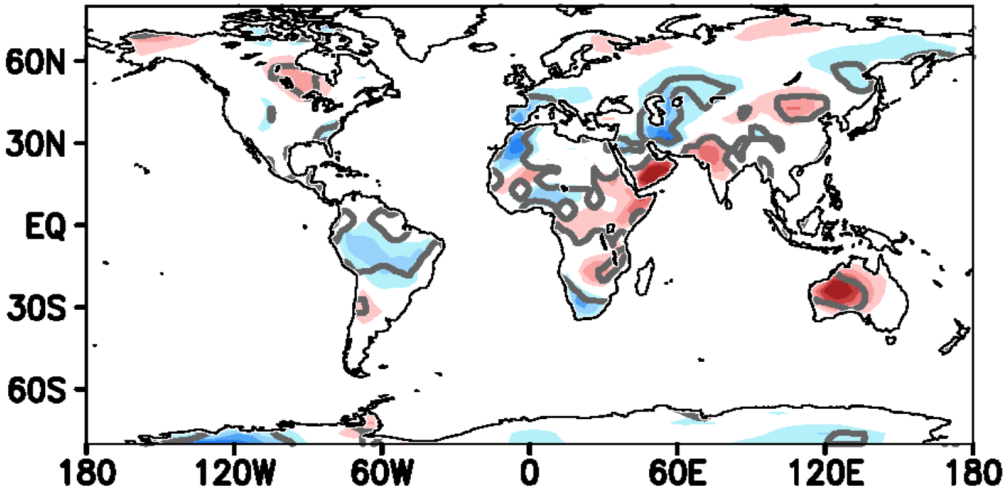
Results: JAS surface temperature

ST (K)

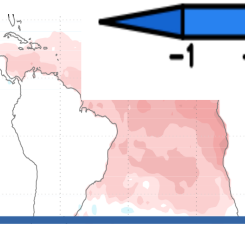




- Impacts on surf. T due to the anomalous advection of climatological temperatures
- Future impact: changes in anomalous winds drive changes in surf. T impacts

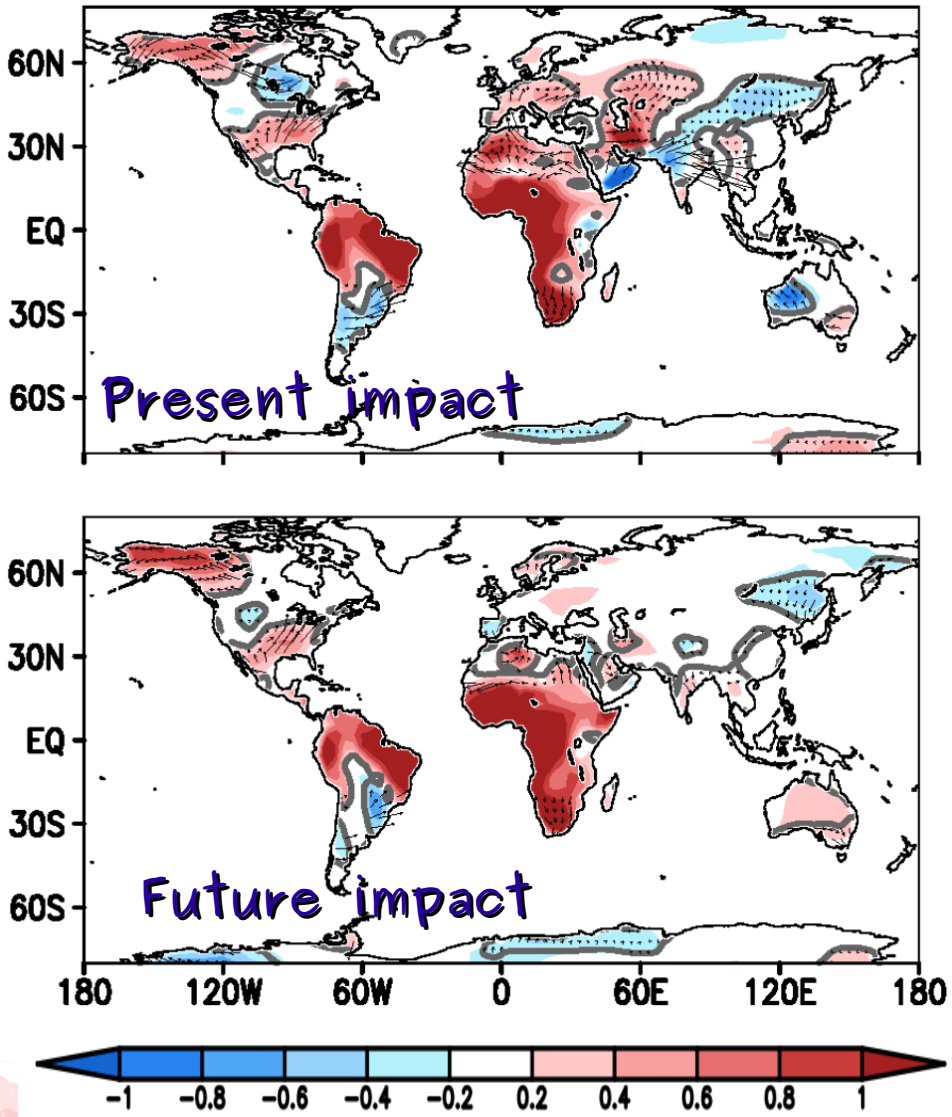


(Future impact) - (Present impact)

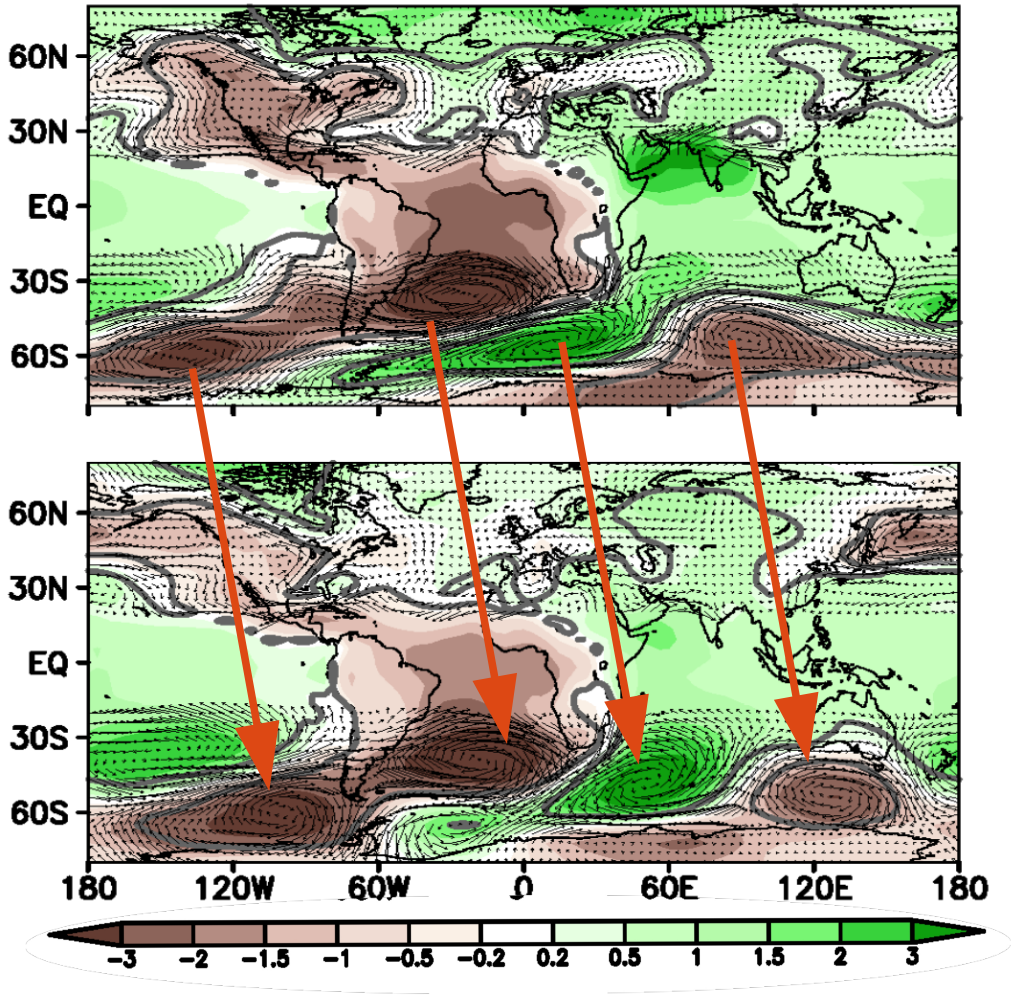


Results: JAS surface temperature

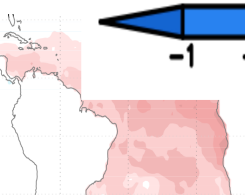
ST (K)



Mslp (hPa) & surf. winds (m/s)



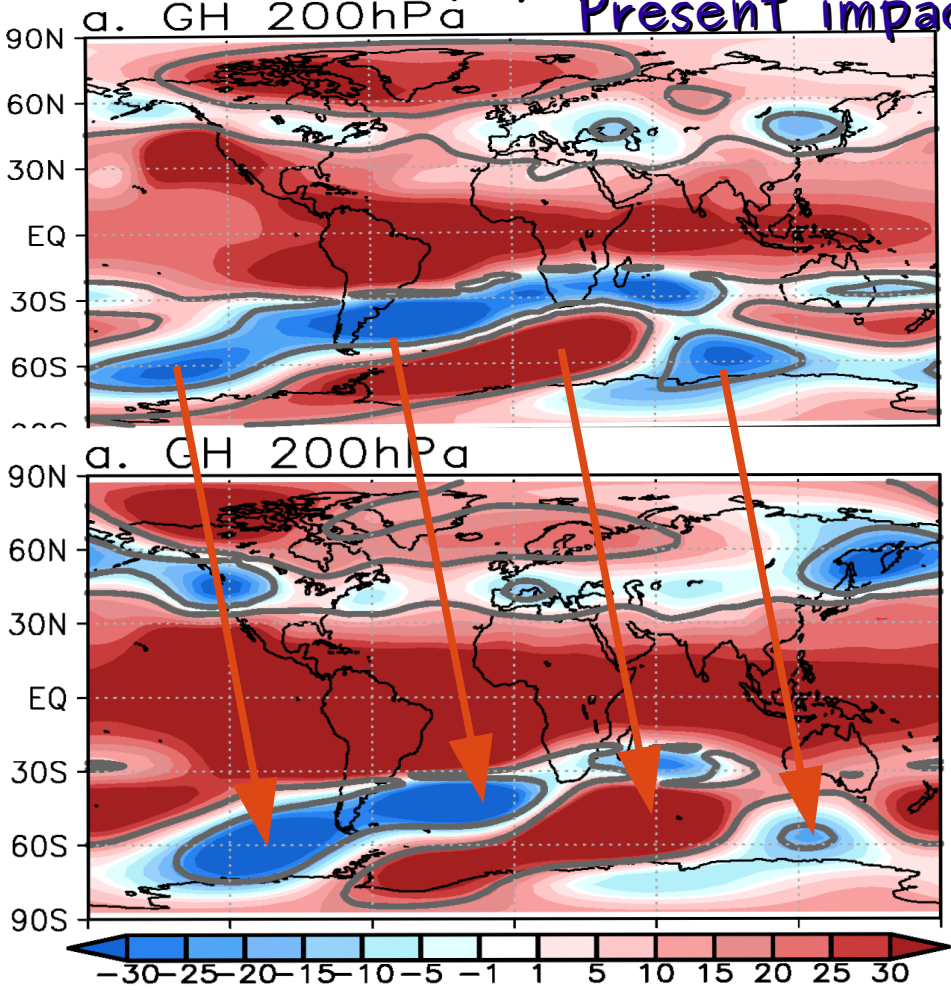
→ due to shift to E of Rossby waves in the future



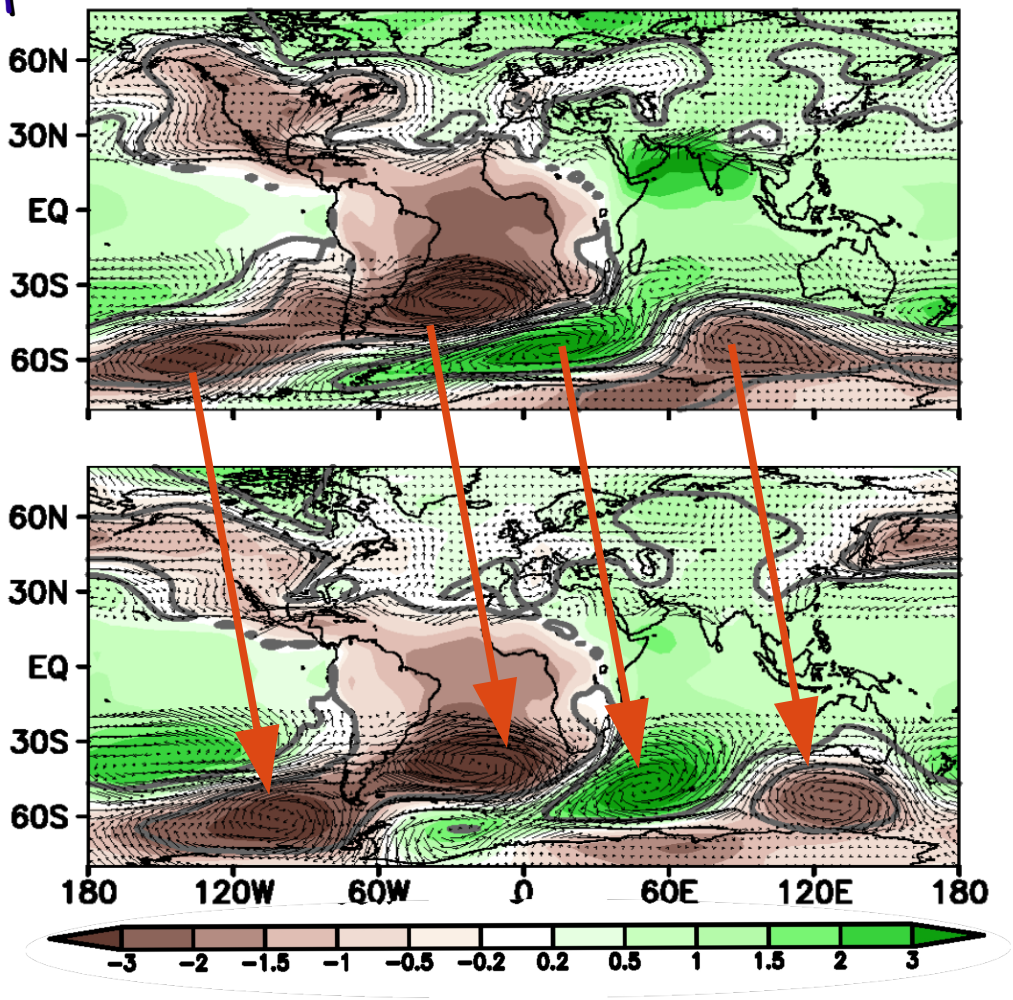
Results: JAS surface temperature

GH at 200 hPa(m)

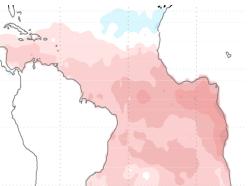
Present impact



Mslp (hPa) & surf. winds (m/s)

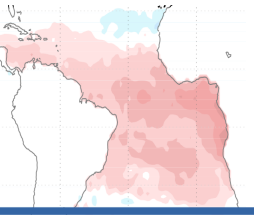


→ due to shift to E of Rossby waves in the future



Results: origin of the changes

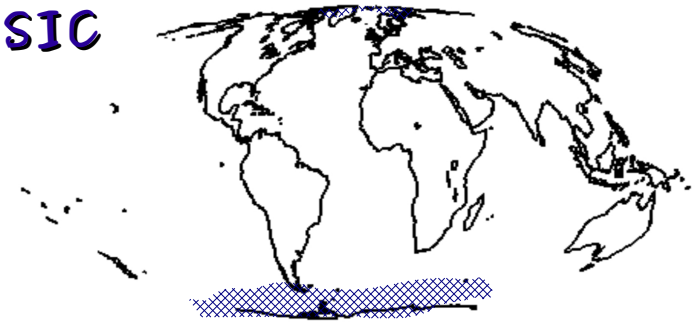
Differences in Future vs Present climate

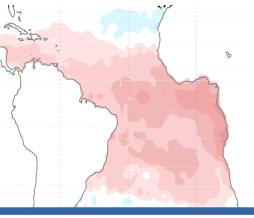


Results: origin of the changes

Differences in Future vs Present climate

1. SIC

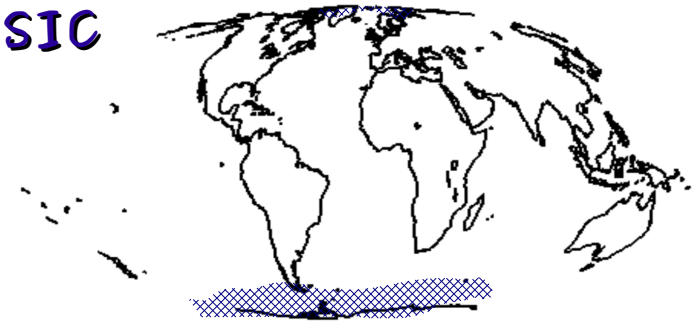




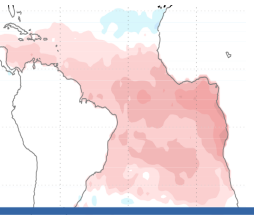
Results: origin of the changes

Differences in Future vs Present climate

1. SIC



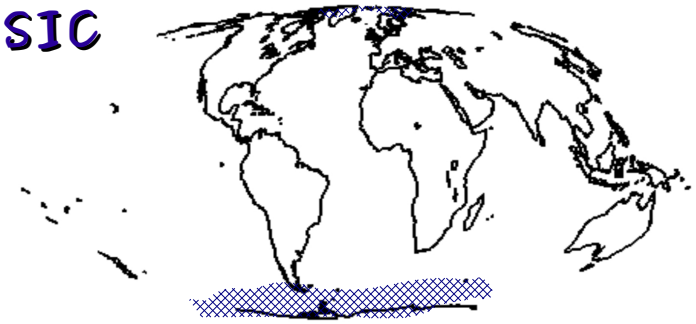
2. $3xCO_2$ (20^{th})



Results: origin of the changes

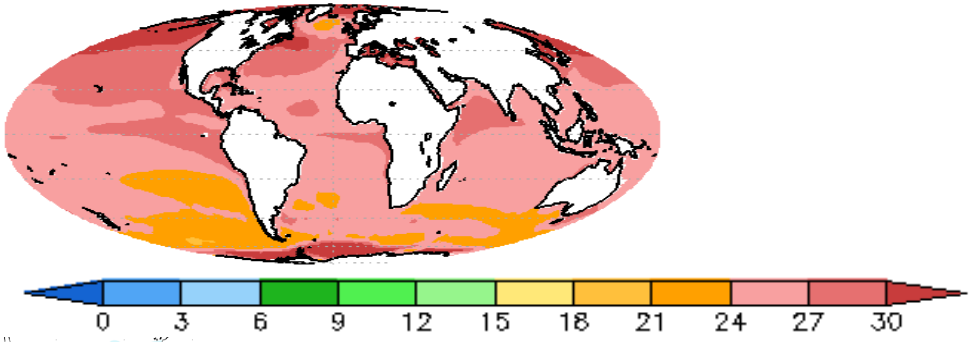
Differences in Future vs Present climate

1. SIC

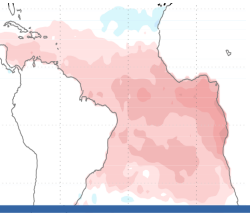


2. $3xCO_2$ (20^{th})

3. SST increase



SST (ºC)

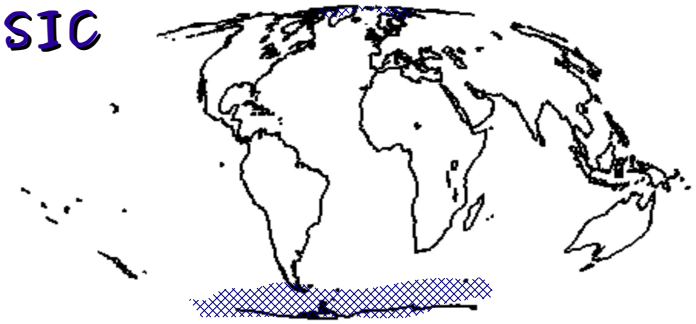


Impacts of the Atlantic Equatorial Mode in a warmer climate

Results: origin of the changes

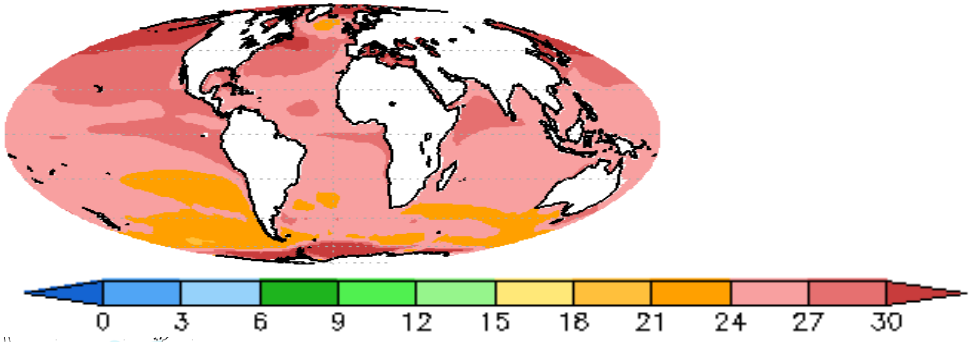
Differences in Future vs Present climate

1. SIC



2. $3xCO_2$ (20^{th})

3. SST increase



SST (ºC)

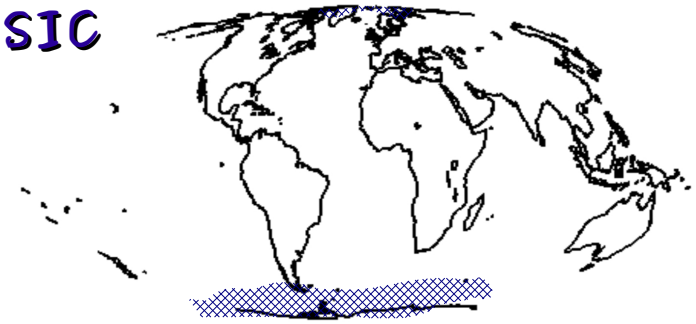
Additional AGCM sensitivity experiments with SPEEDY.

1. Only change SIC

Results: origin of the changes

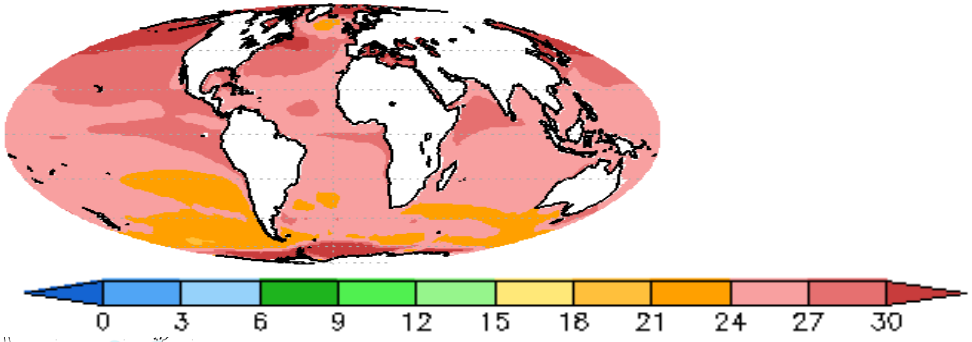
Differences in Future vs Present climate

1. SIC



2. $3xCO_2$ (20^{th})

3. SST increase



SST (ºC)

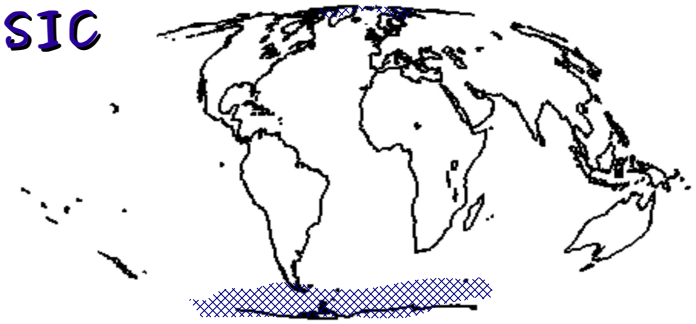
Additional AGCM sensitivity experiments with SPEEDY.

1. Only change SIC
2. Only change CO2

Results: origin of the changes

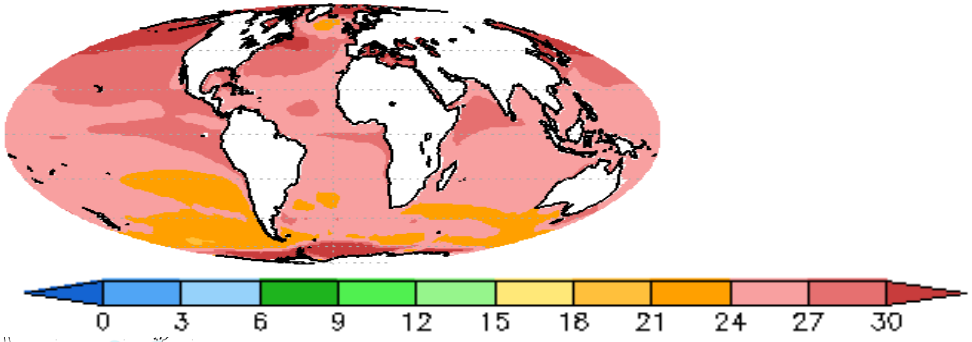
Differences in Future vs Present climate

1. SIC



2. $3xCO_2$ (20^{th})

3. SST increase



SST (ºC)

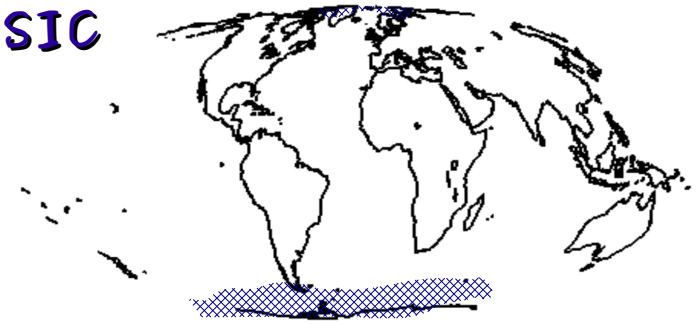
Additional AGCM sensitivity experiments with SPEEDY.

1. Only change SIC
2. Only change CO2
3. Only change SST

Results: origin of the changes

Differences in Future vs Present climate

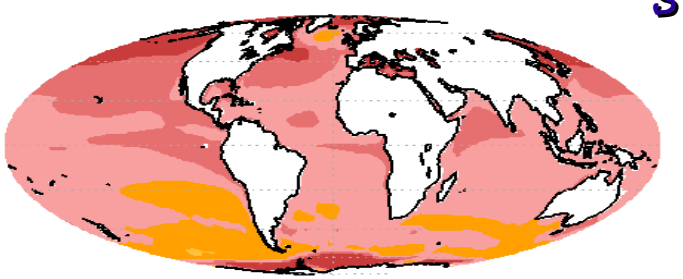
1. SIC



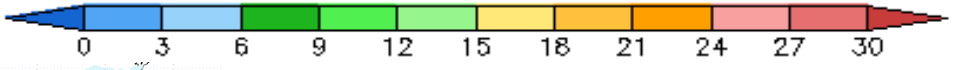
2. $3xCO_2$ (20^{th})

3. SST increase

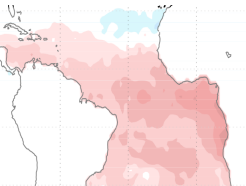
3.1 Changes in the SST gradients



3.2 Average increase of approx. 3ºC



SST (ºC)



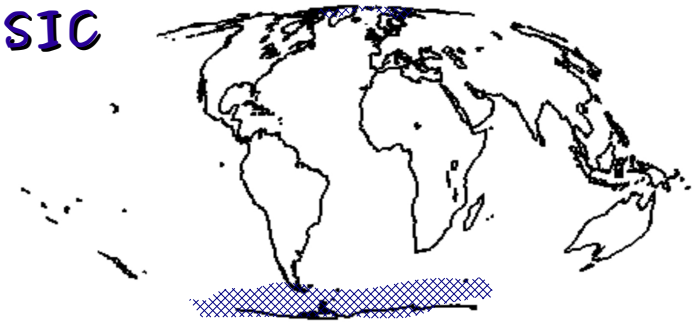
Additional AGCM sensitivity experiments with SPEEDY.

1. Only change SIC
2. Only change CO2
3. Only change SST

Results: origin of the changes

Differences in Future vs Present climate

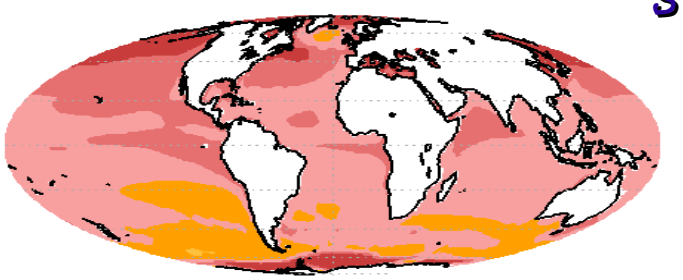
1. SIC



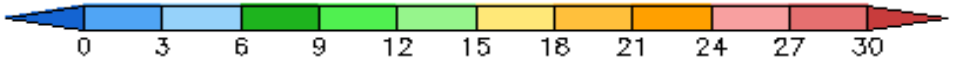
2. $3xCO_2$ (20^{th})

3. SST increase

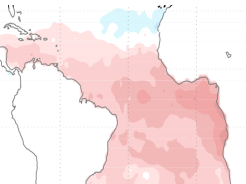
3.1 Changes in the SST gradients



3.2 Average increase of approx. 3ºC



SST (ºC)



Additional AGCM sensitivity experiments with SPEEDY.

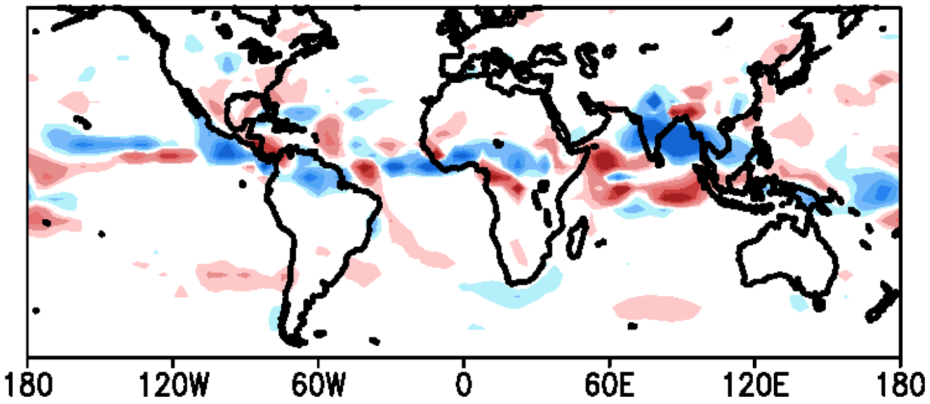
1. Only change SIC
2. Only change CO2
3. Only change SST
4. Only change SST gradients to 21^{st} Cent.
5. Only change SST to 20^{th} Cent. SST+3ºC

Results: origin of the changes

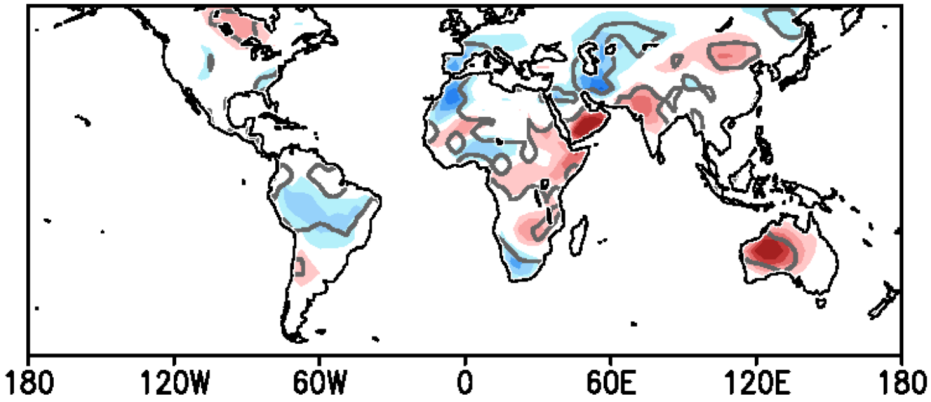
1. Only change SIC

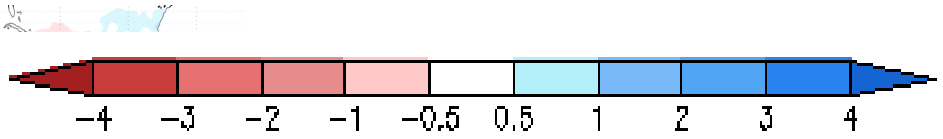
(Future impact) - (Present impact) = (C-D)-(A-B)

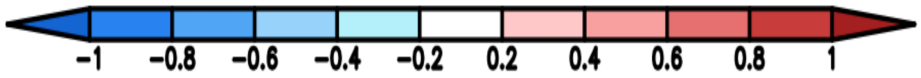
Rainfall (mm/day)



ST (K)





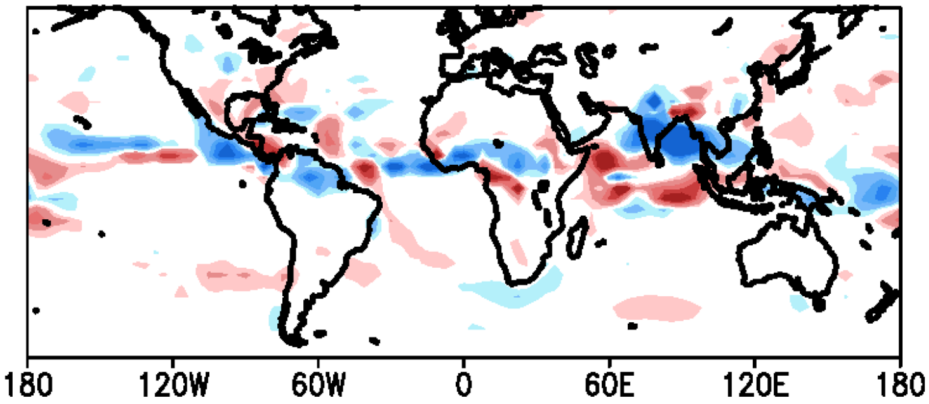


Results: origin of the changes

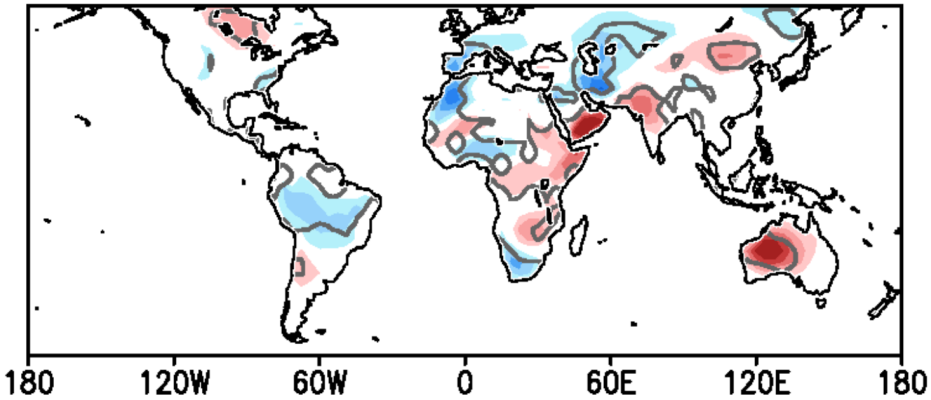
1. Only change SIC

(Future impact) - (Present impact) = (C-D)-(A-B)

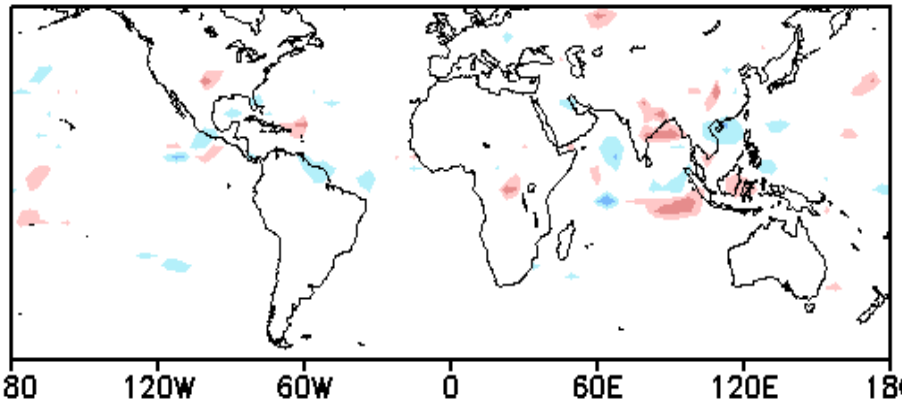
Rainfall (mm/day)

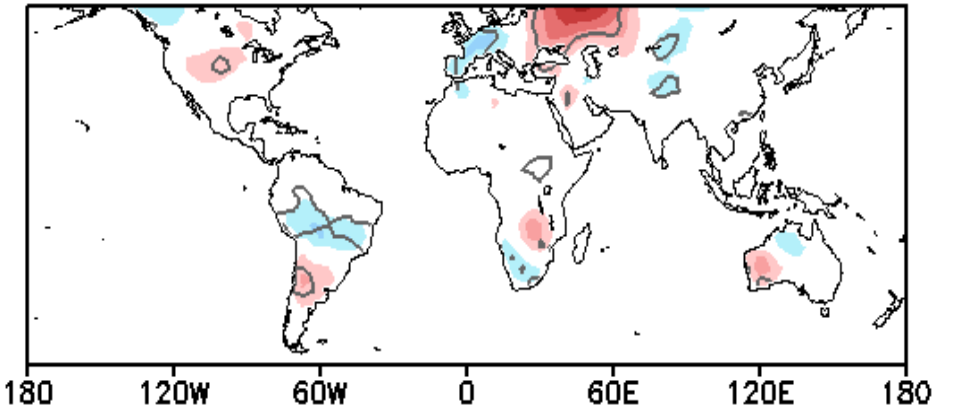


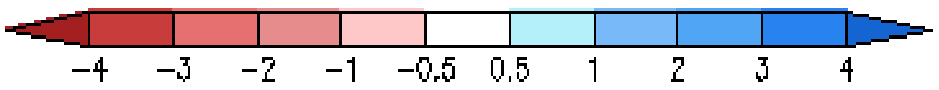
ST (K)

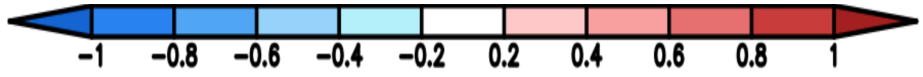


Only changing SIC climatology (not CO2 nor SST)







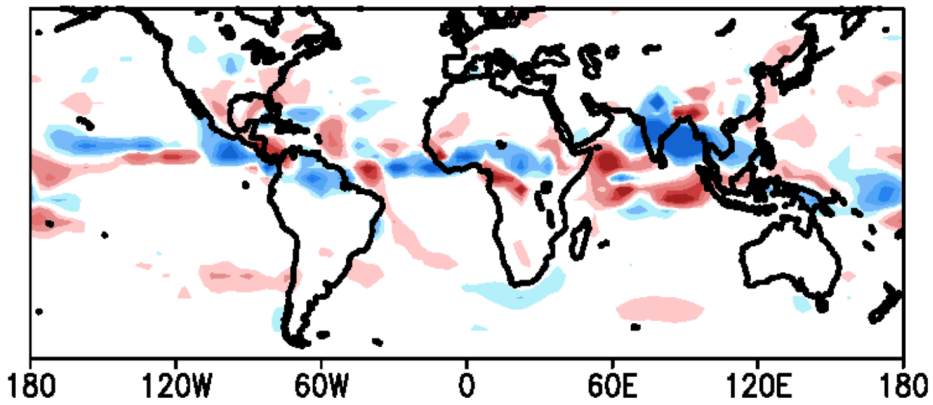


Results: origin of the changes

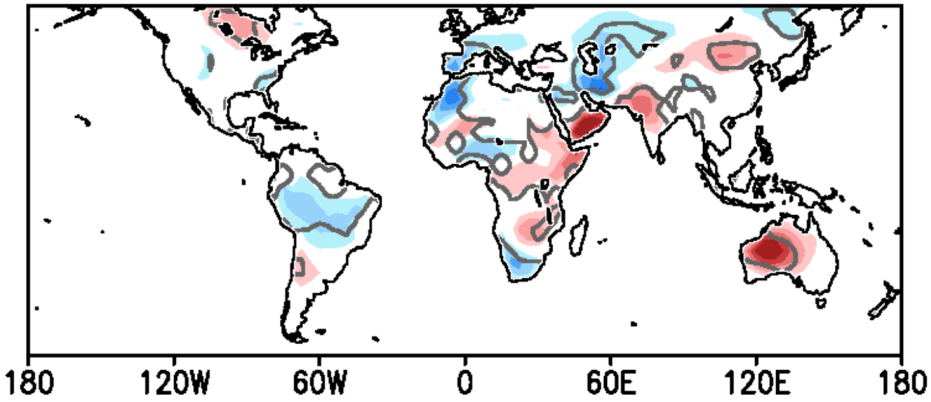
2. Only change CO2

(Future impact) - (Present impact) = (C-D)-(A-B)

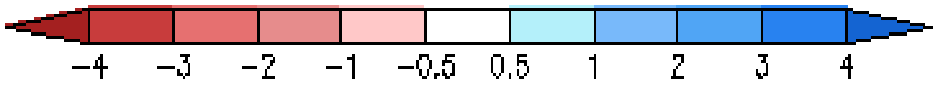
Rainfall (mm/day)

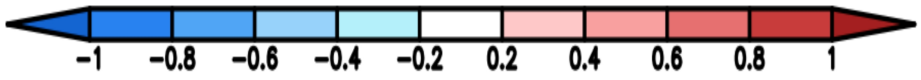


ST (K)



Only changing CO2 climatology (not SIC nor SST)



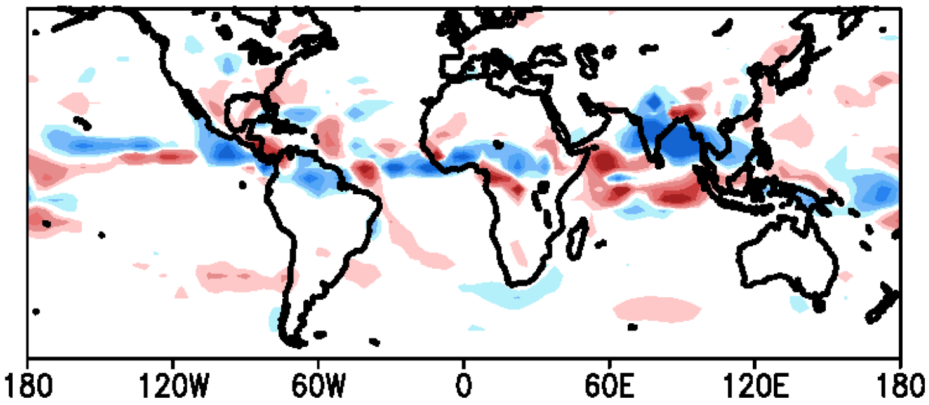


Results: origin of the changes

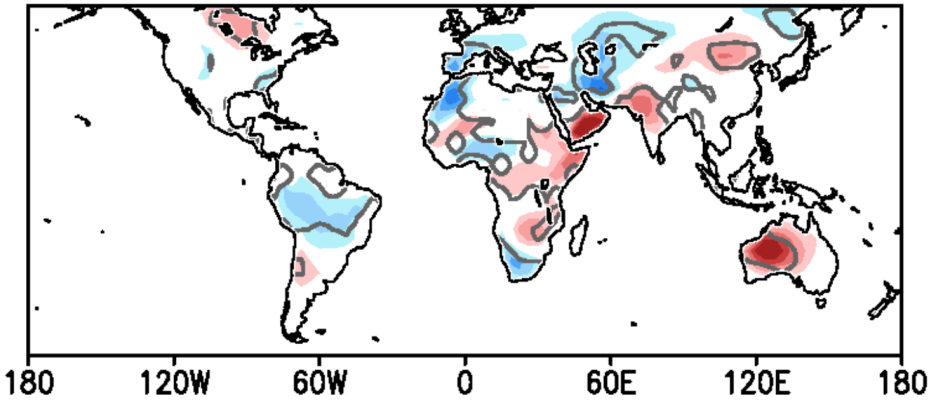
2. Only change CO2

(Future impact) - (Present impact) = (C-D)-(A-B)

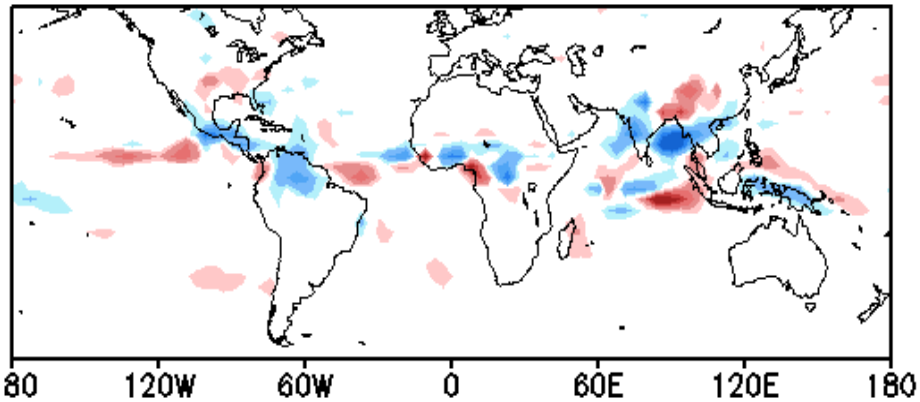
Rainfall (mm/day)

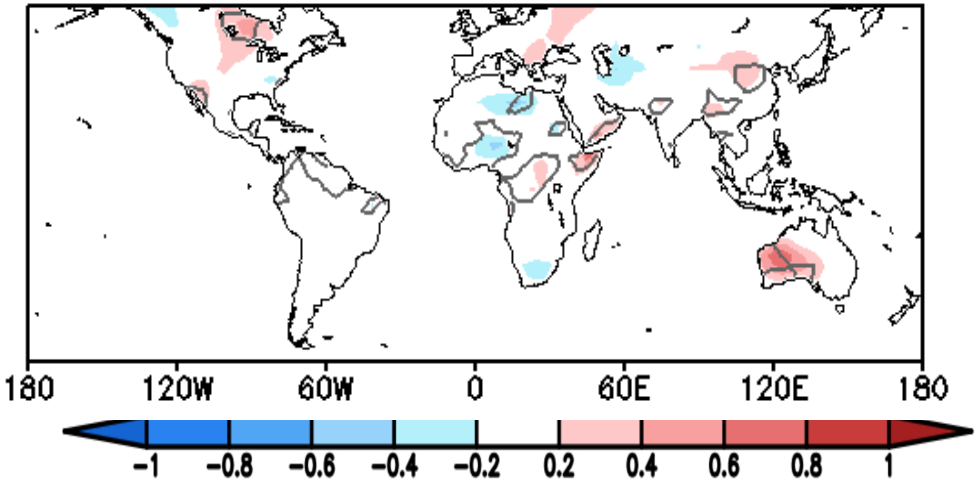


ST (K)



Only changing CO2 climatology (not SIC nor SST)



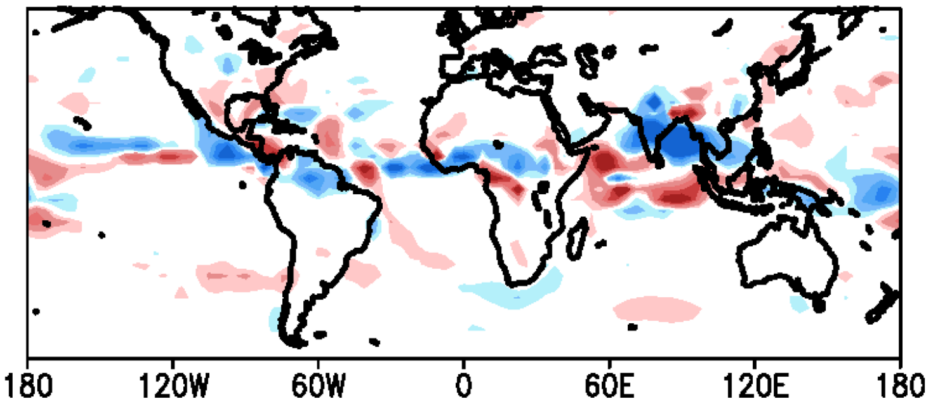


Results: origin of the changes

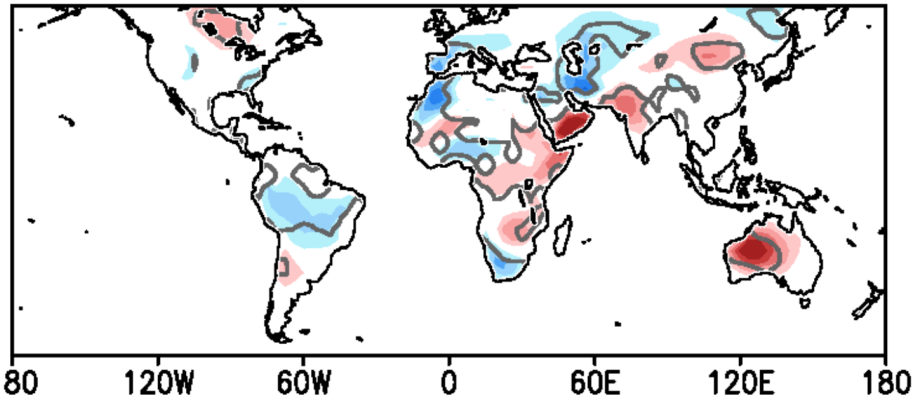
3. Only change SSTs

(Future impact) - (Present impact) = (C-D)-(A-B)

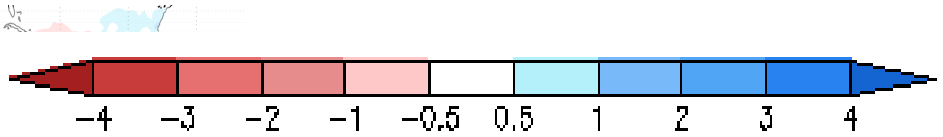
Rainfall (mm/day)

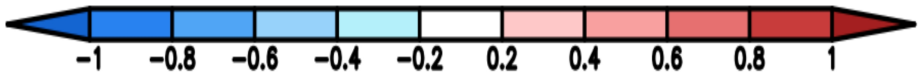


ST (K)



Only changing SST climatology (not CO2 nor SIC)



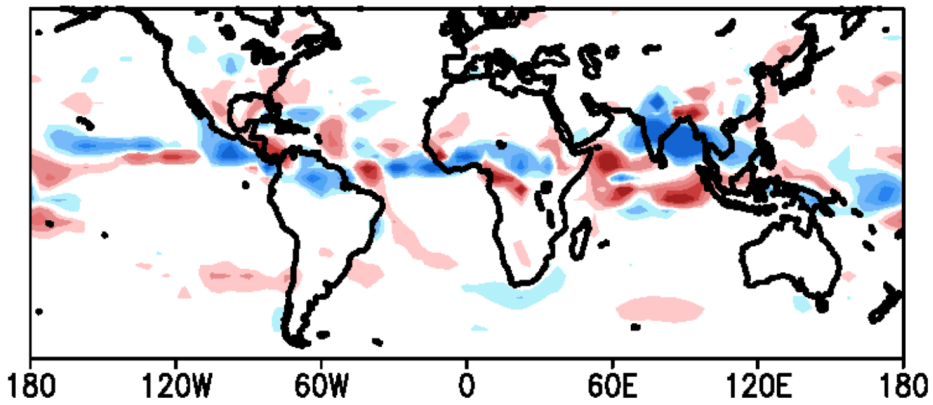


Results: origin of the changes

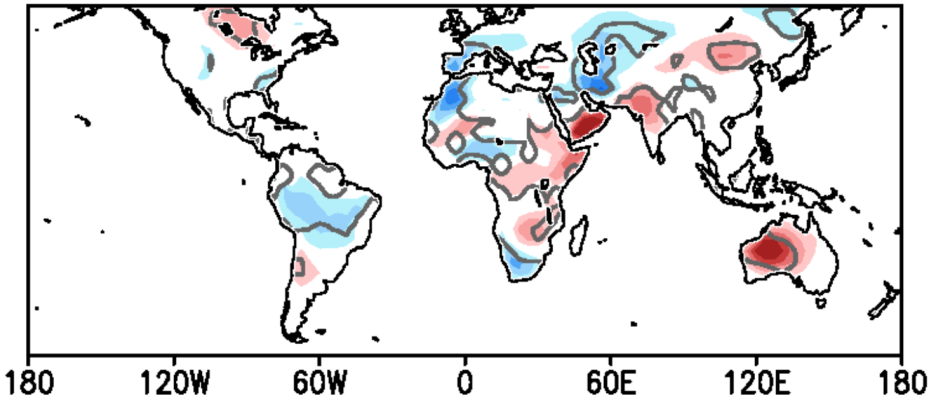
3. Only change SSTs

(Future impact) - (Present impact) = (C-D)-(A-B)

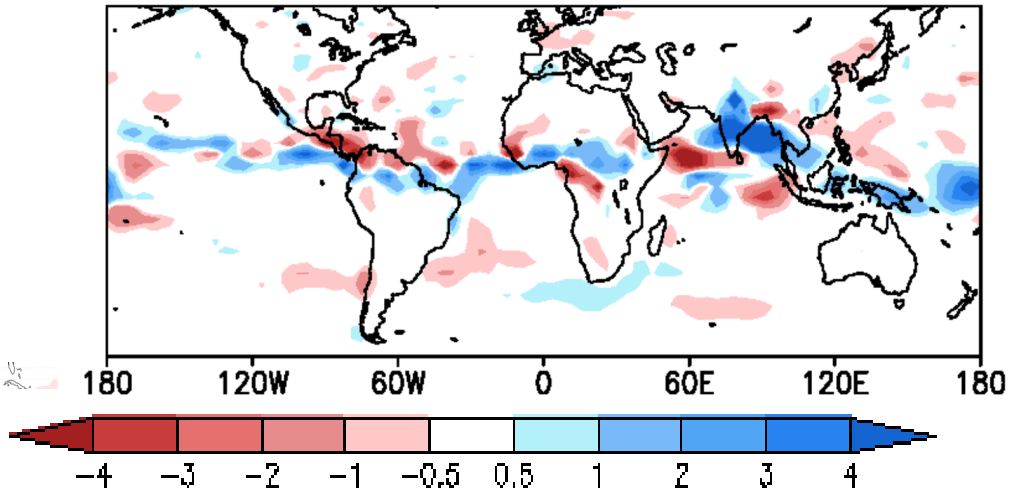
Rainfall (mm/day)

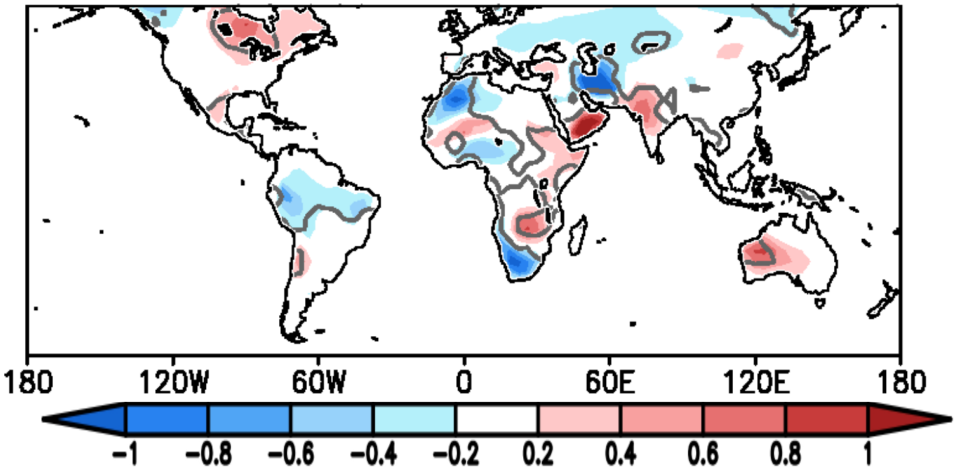


ST (K)



Only changing SST climatology (not CO2 nor SIC)



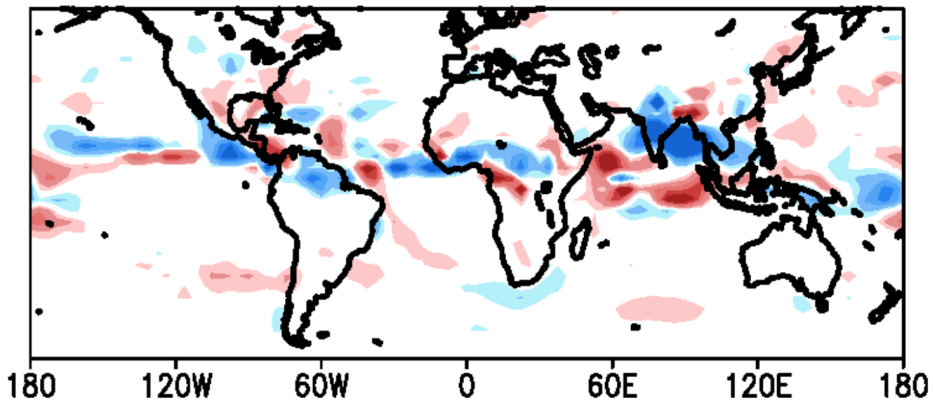


Results: origin of the changes

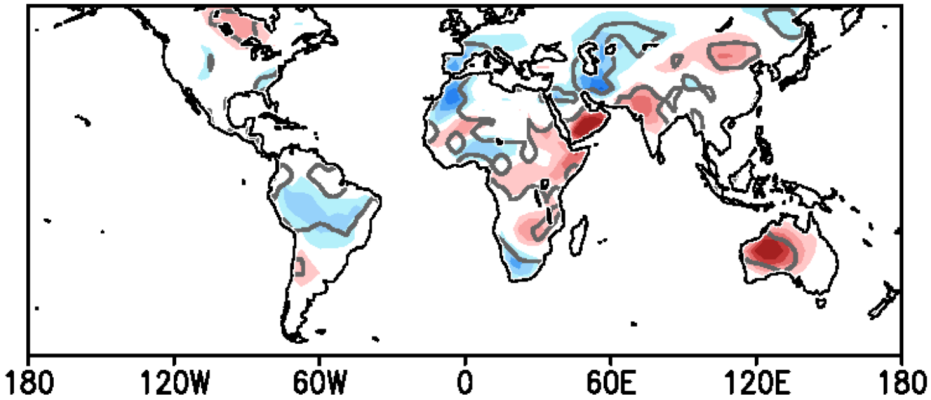
4. Only change SST gradients to 21st Cent.

(Future impact) – (Present impact) = (C–D)–(A–B)

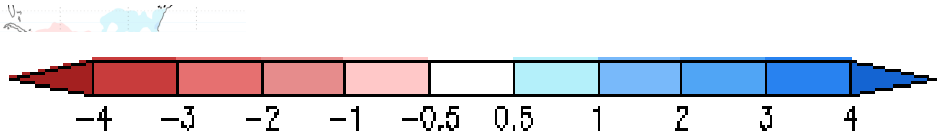
Rainfall (mm/day)

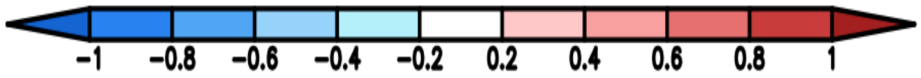


ST (K)



Only changing SST gradients



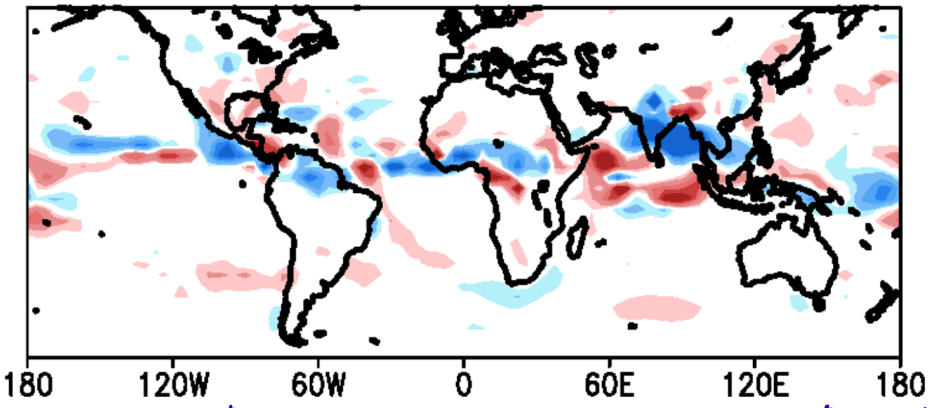


Results: origin of the changes

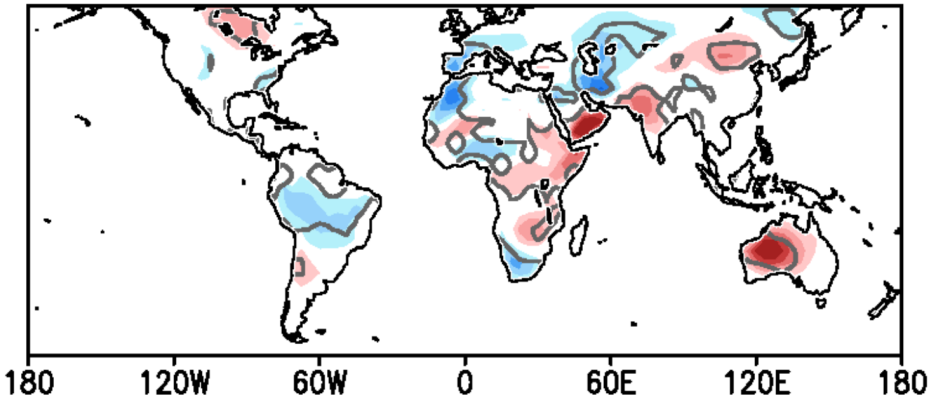
4. Only change SST gradients to 21st Cent.

(Future impact) - (Present impact) = (C-D)-(A-B)

Rainfall (mm/day)



ST (K)



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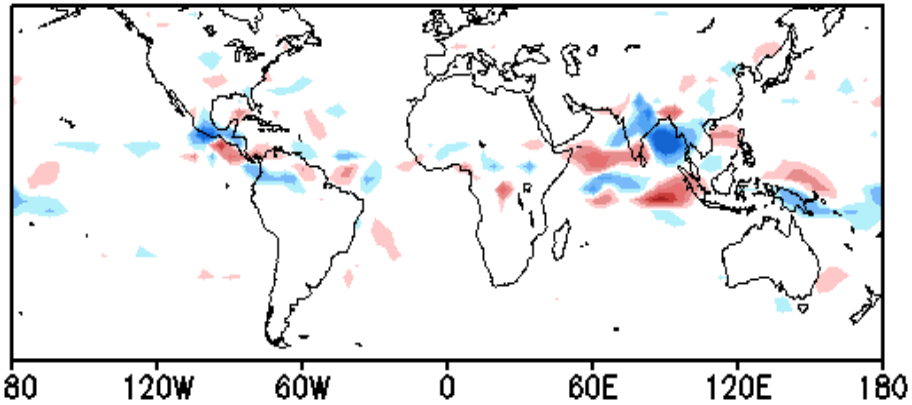
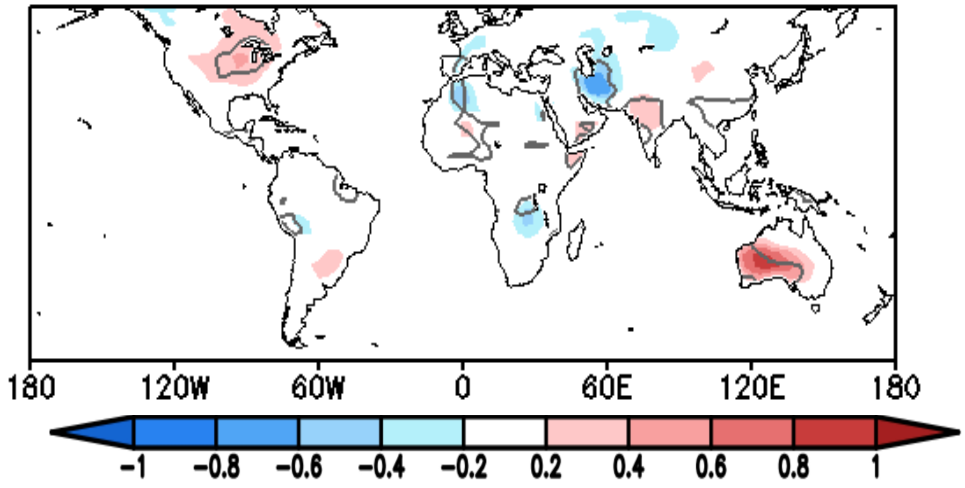


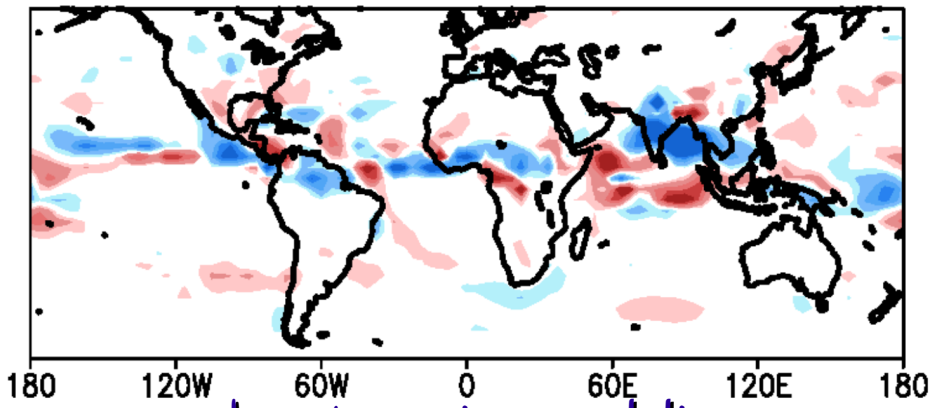


Results: origin of the changes

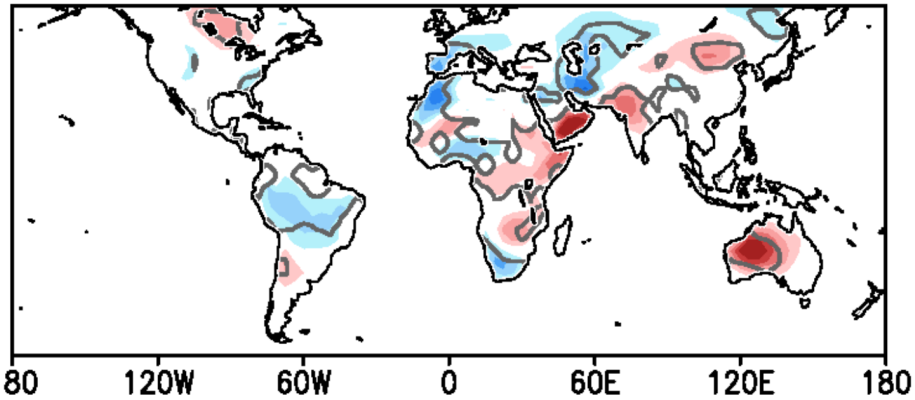
5. Only change SST to 20th Cent. SST+3ºC

(Future impact) - (Present impact) = (C-D)-(A-B)

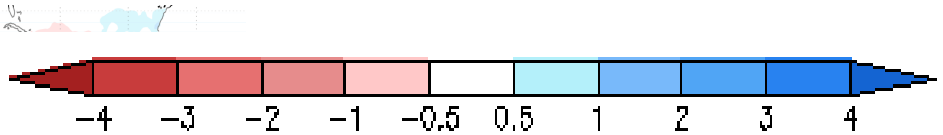
Rainfall (mm/day)

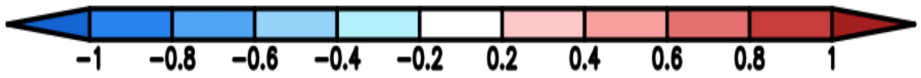


ST (K)



Only changing adding approx. 3ºC to present climatology





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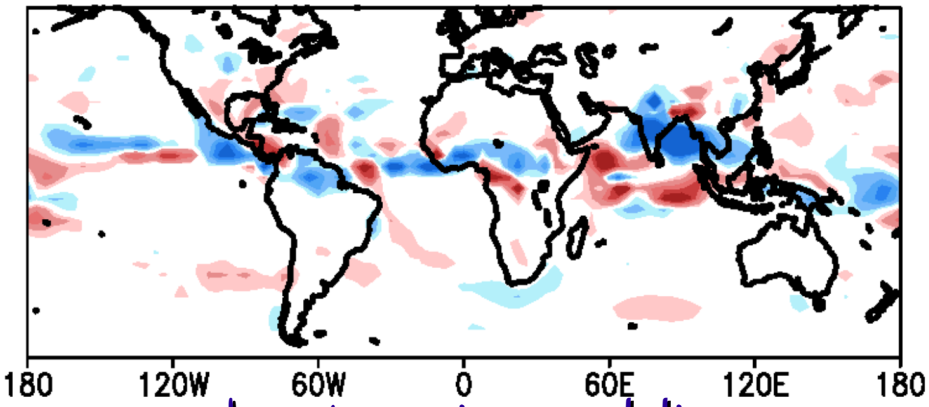

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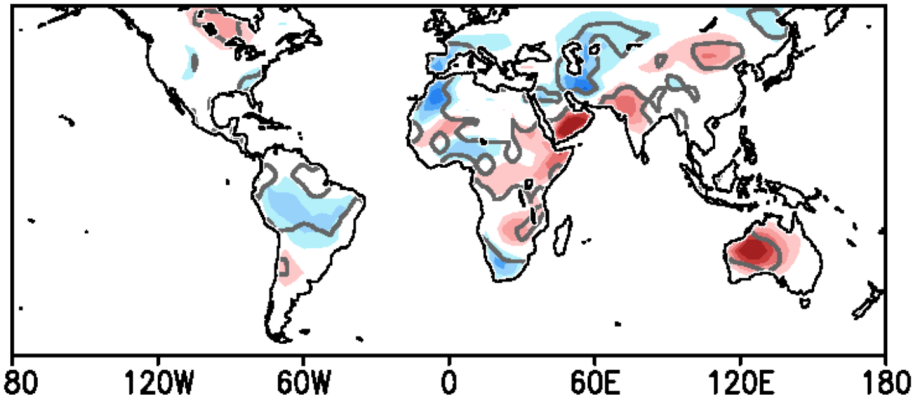

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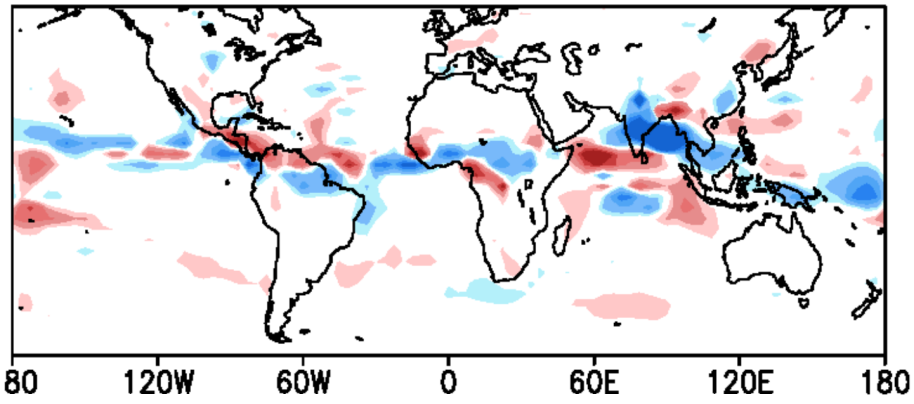
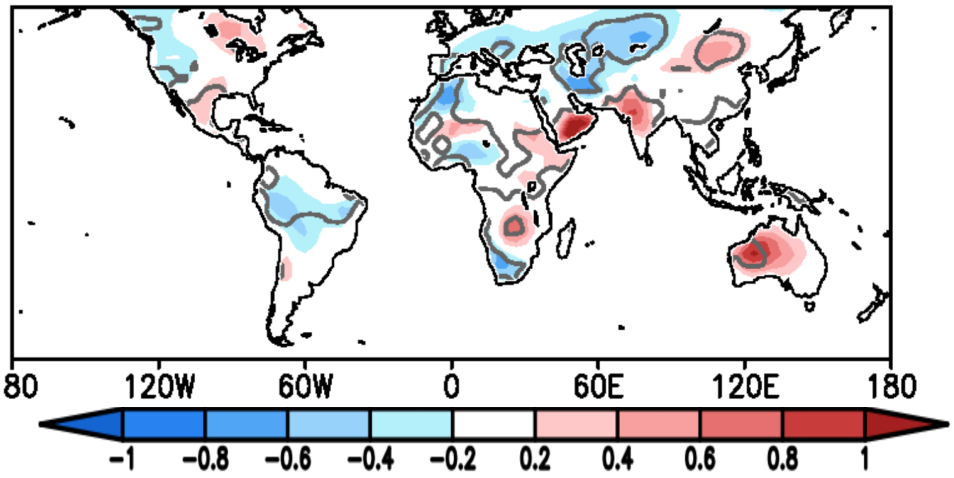
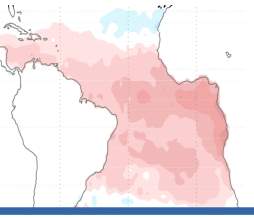




Summary & conclusions

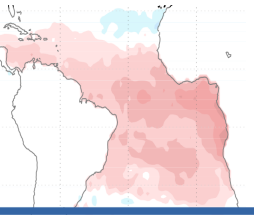
Given a change in SST climatology, the impacts of the Atlantic Equatorial mode will change. For a warmer (RCP8.5) climate:



Summary & conclusions

Given a change in SST climatology, the impacts of the Atlantic Equatorial mode will change. For a warmer (RCP8.5) climate:

- Warmer climatological SSTs over TA → convection can reached in a wider area → drives main anomalous divergence to the East



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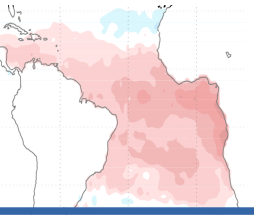
- The gradient of climatological SSTs changes in the Indian basin → changes the impact of the Eq. Mode over Asian monsoon



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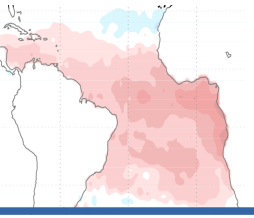

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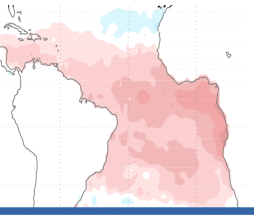

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- The gradient of climatological SSTs changes in the Indian basin → changes the impact of the Eq. Mode over Asian monsoon

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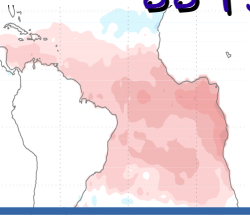
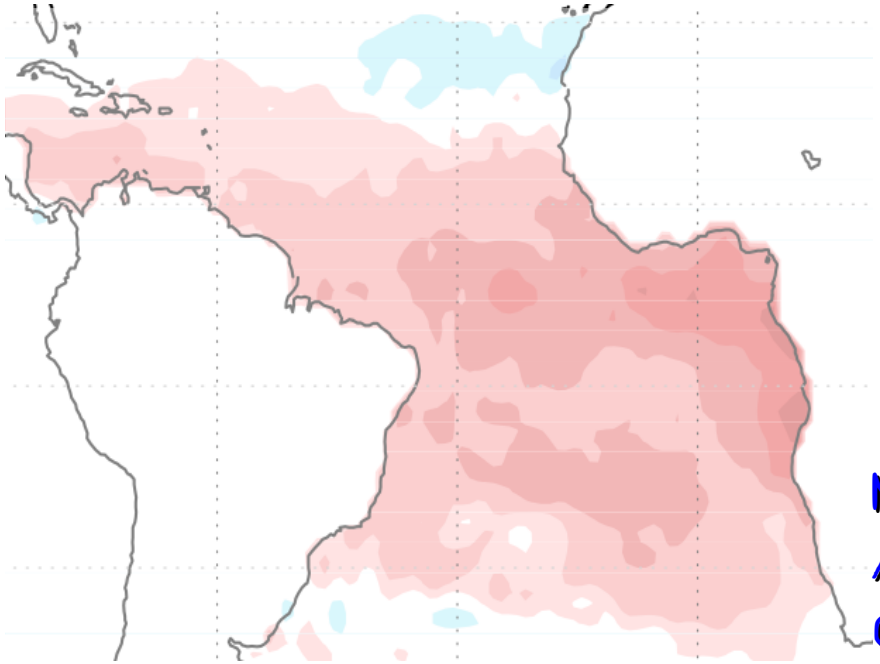
- The main effect comes from the uniform increase of climatological SSTs



Thank you for your attention!



Mohino E, Losada L (2015) Impacts of the Atlantic Equatorial Mode in a warmer climate. Clim Dyn. DOI: 10.1007/s00328-015-2471-4