

Relationships Among Inter-model Spread and Biases in Tropical Atlantic Sea Surface Temperatures

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¹University Complutense of Madrid (Spain)

²IGEO (Spain)

³University of Reading (UK)

⁴University of California, Los Angeles (EEUU)

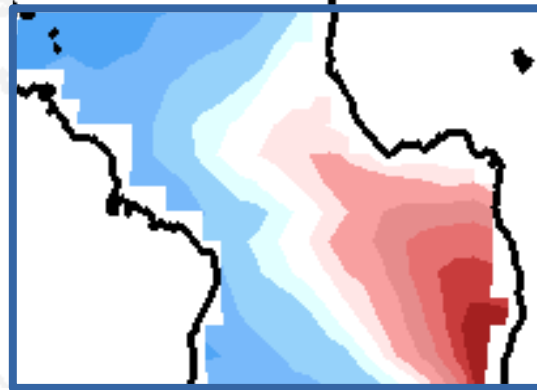
Mohino E, B Rodríguez-Fonseca, T Losada, I Polo, CR Mechoso (2018) Relationships among inter-model spread and biases in Tropical Atlantic SST. To be submitted.



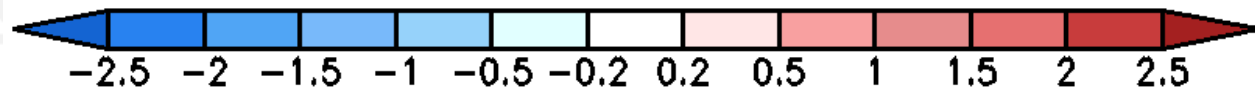
Biases in Tropical Atlantic SST

Local

Remote



SST mean bias with 24 CMIP5 models



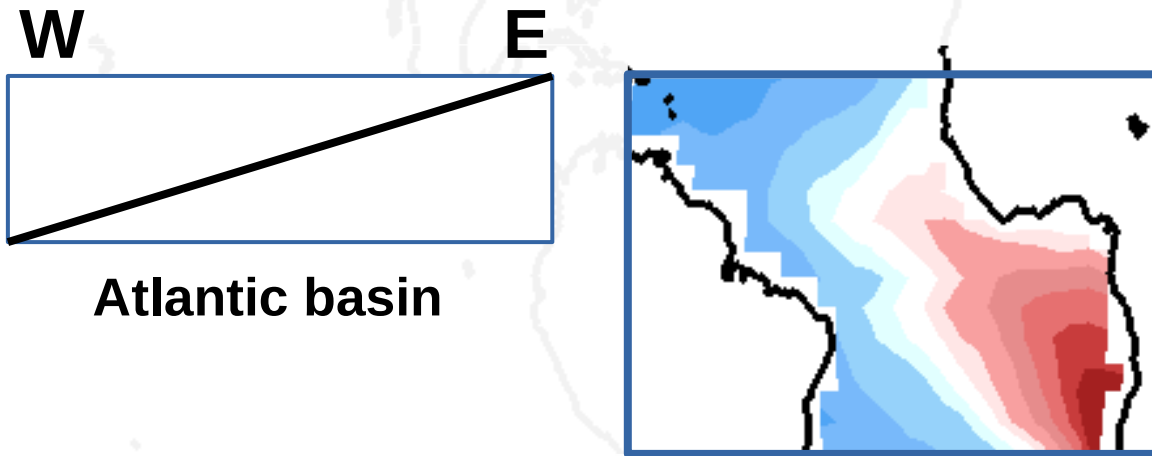
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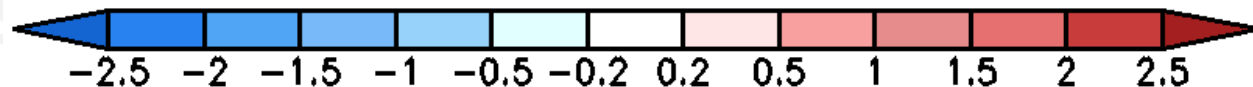
Remote

- Weaker-than-observed easterlies leading to too shallow thermocline in the west and too deep in the east and inhibition of cold tongue

(Xu et al. 2014; Richter et al. 2012; 2015)



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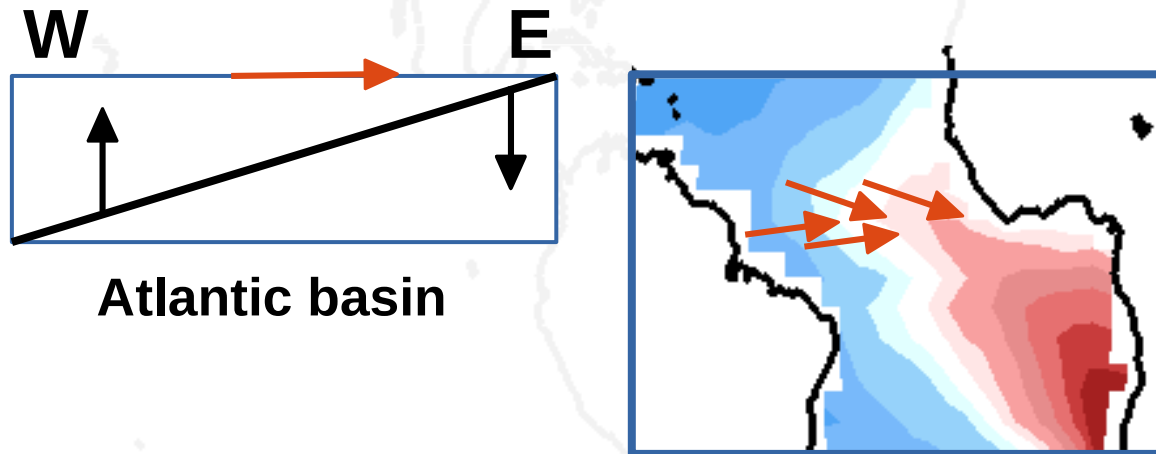
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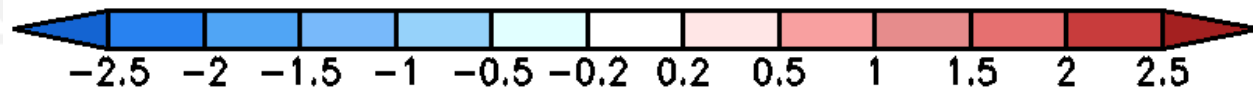
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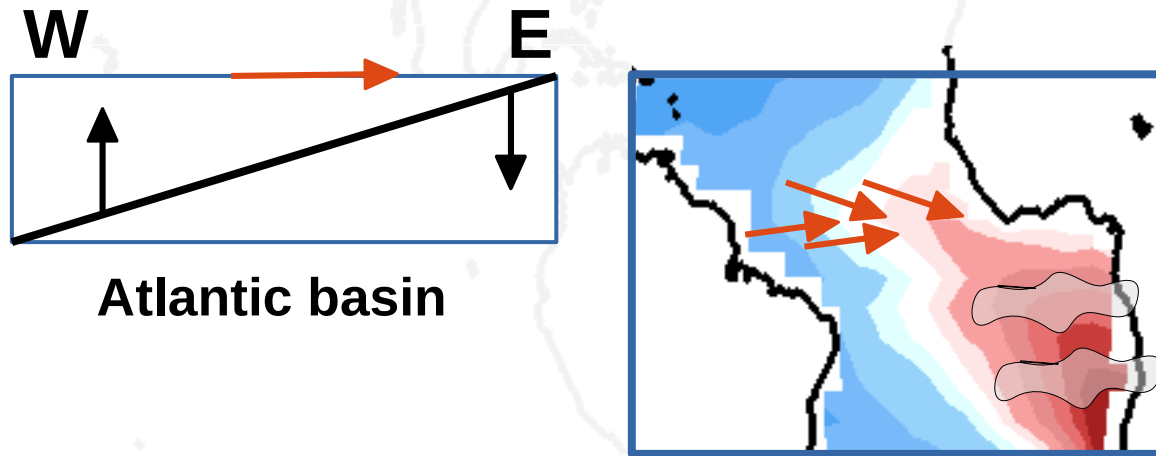
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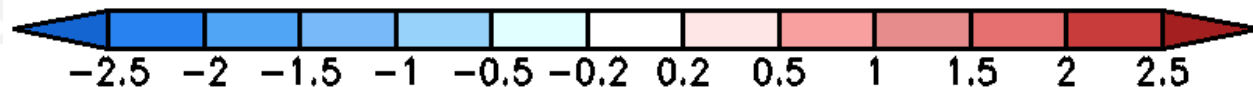
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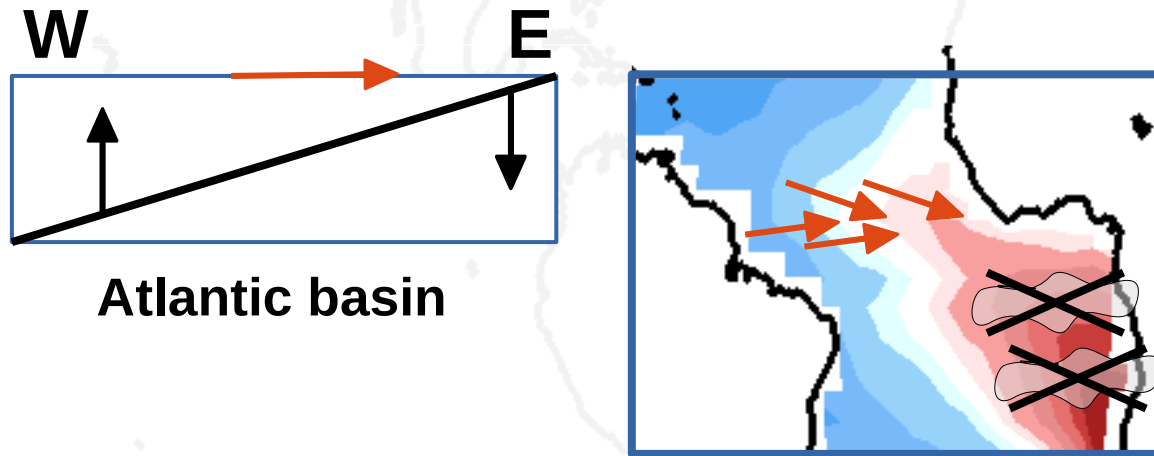
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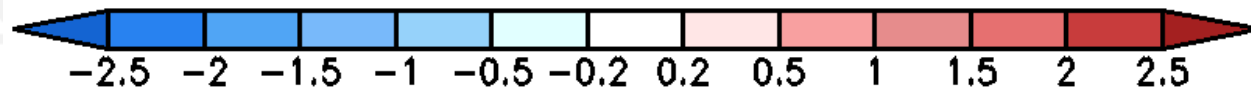
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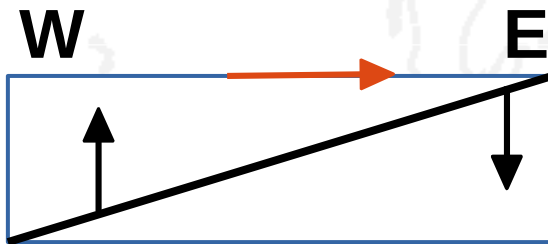


Biases in Tropical Atlantic SST

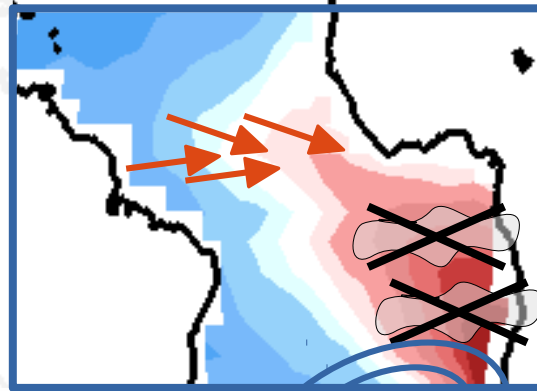
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Atlantic basin



Remote

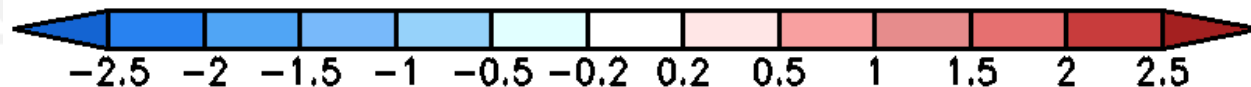
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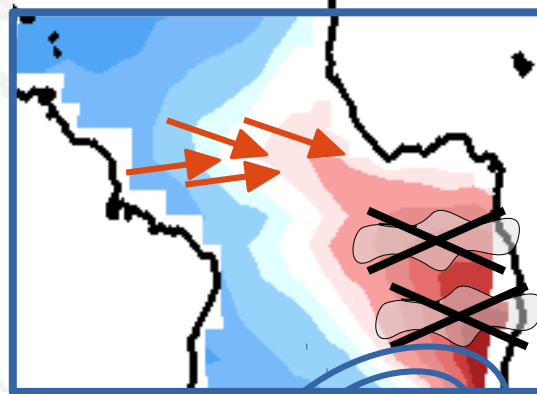
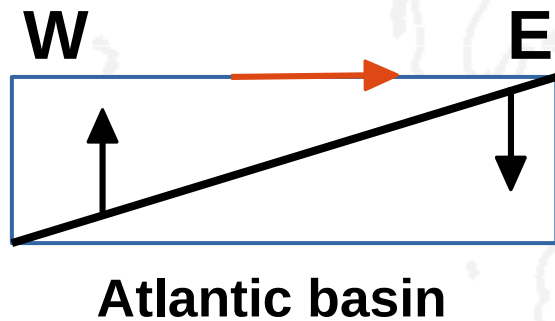
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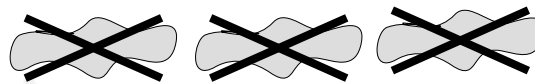
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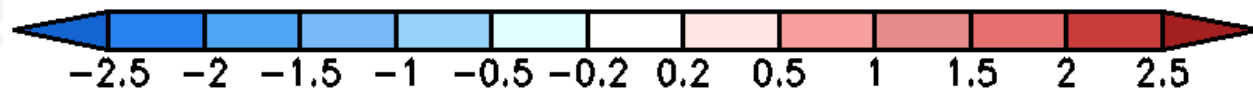
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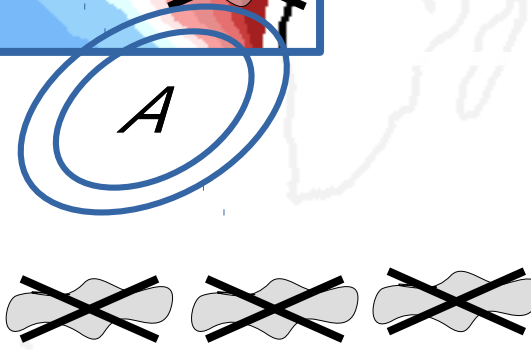
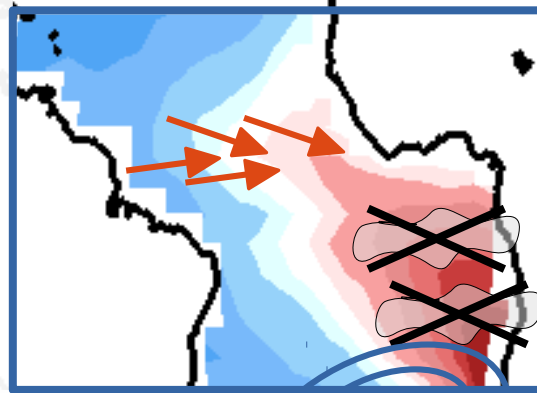
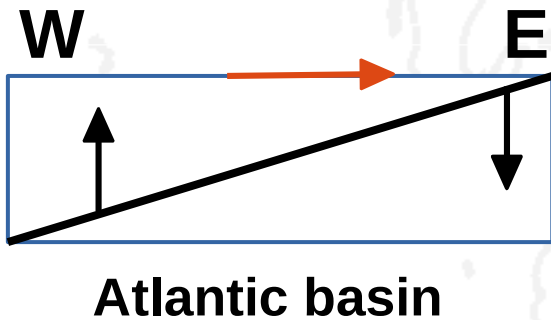
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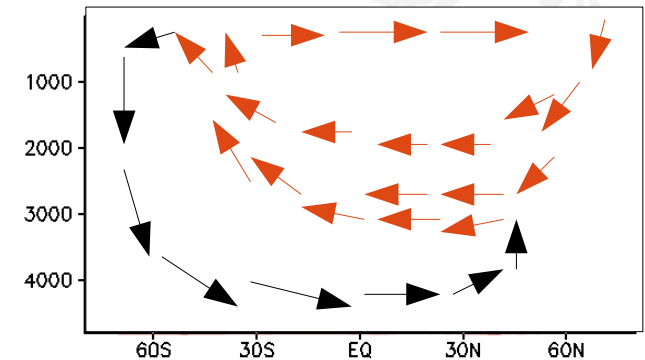
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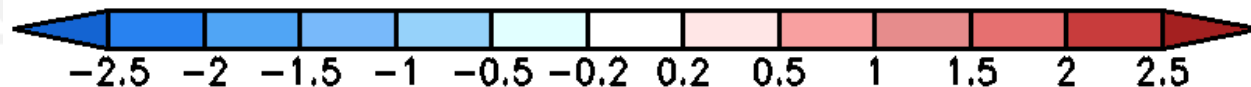


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- Too weak simulated AMOC
(Wang et al. 2014)



SST mean bias with 24 CMIP5 models



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A world map with a light gray background. A rectangular box highlights a region in the Indian Ocean, specifically the area around the Indian subcontinent and the Southeast Asian archipelago. The highlighted area is filled with a light blue and light red color gradient. The text is overlaid on the map.

What are the main differences in the simulation of TA SSTs among models?

A faint world map is visible in the background. A rectangular box highlights a region in the Indian Ocean, specifically the area between the equator and the Tropic of Capricorn, and between the Indian subcontinent and East Africa. This region is shaded with a light blue-to-red gradient, indicating a specific area of interest for the conference.

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What mechanisms can explain these differences?



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What mechanisms can explain these differences?

What can we learn from this ?

Aim

Aim & Methods

- Evaluate mechanisms for inter-model spread in the representation of Tropical Atlantic SST
- Relate mean bias pattern with inter-model spread

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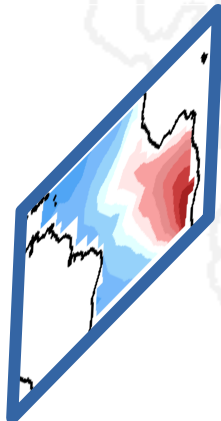


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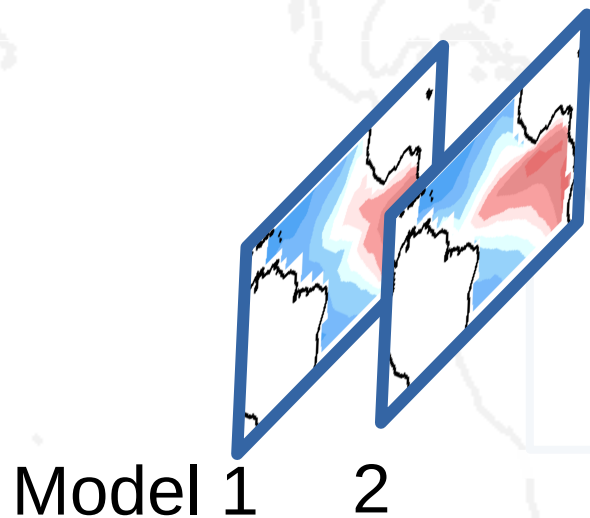
Model 1

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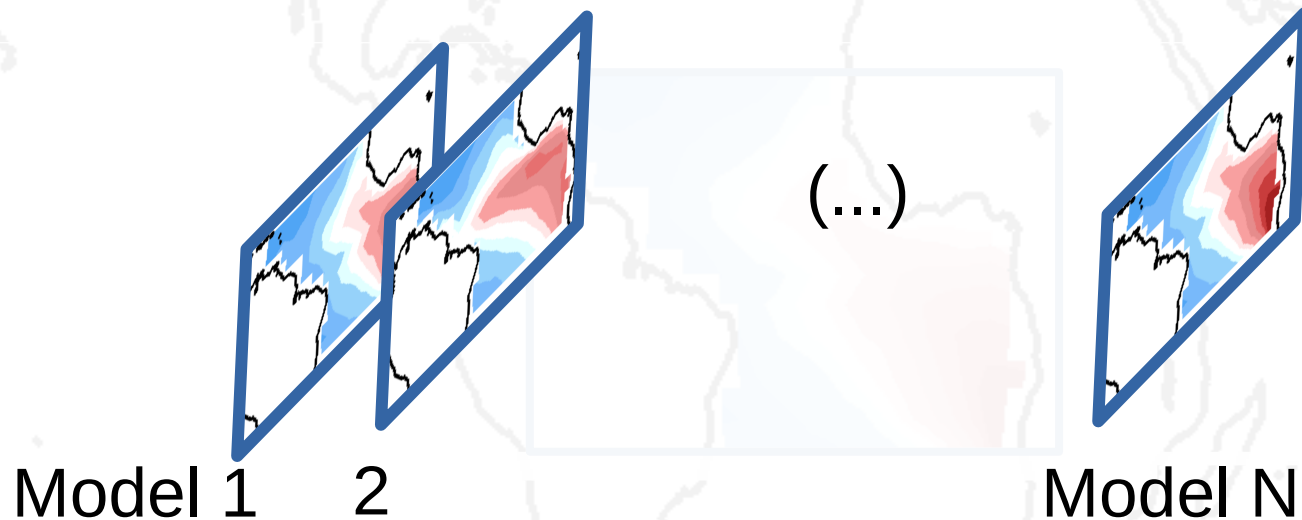


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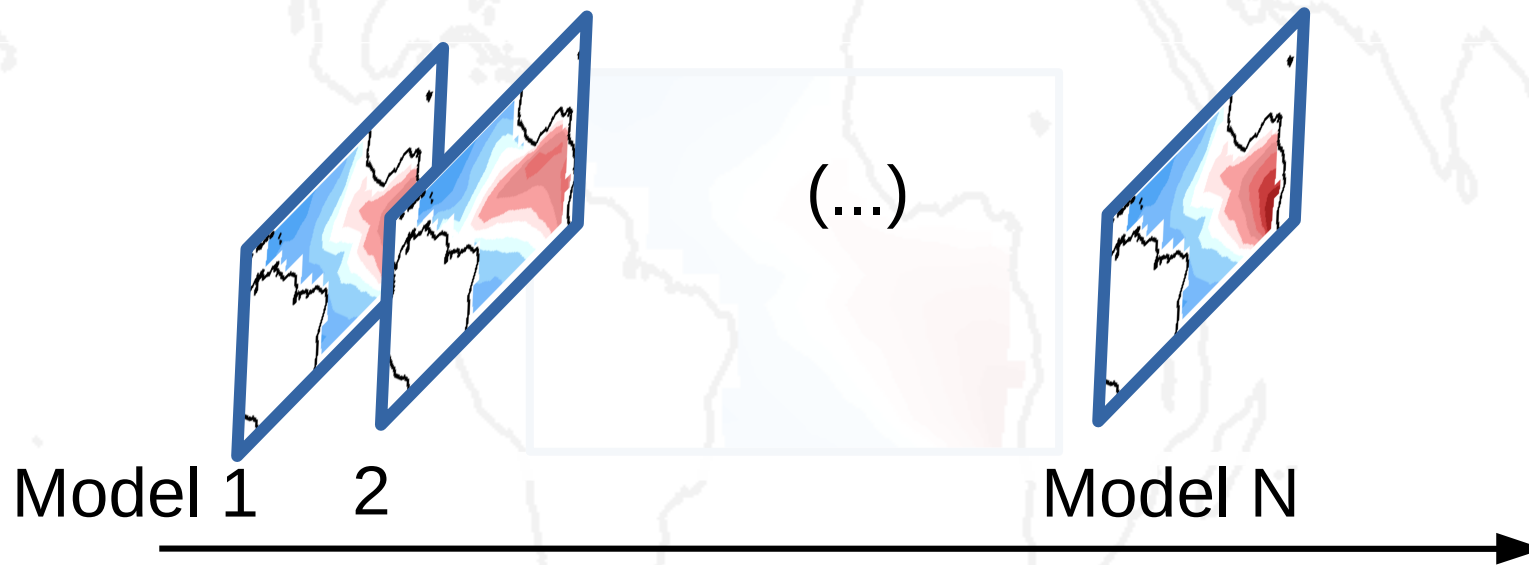


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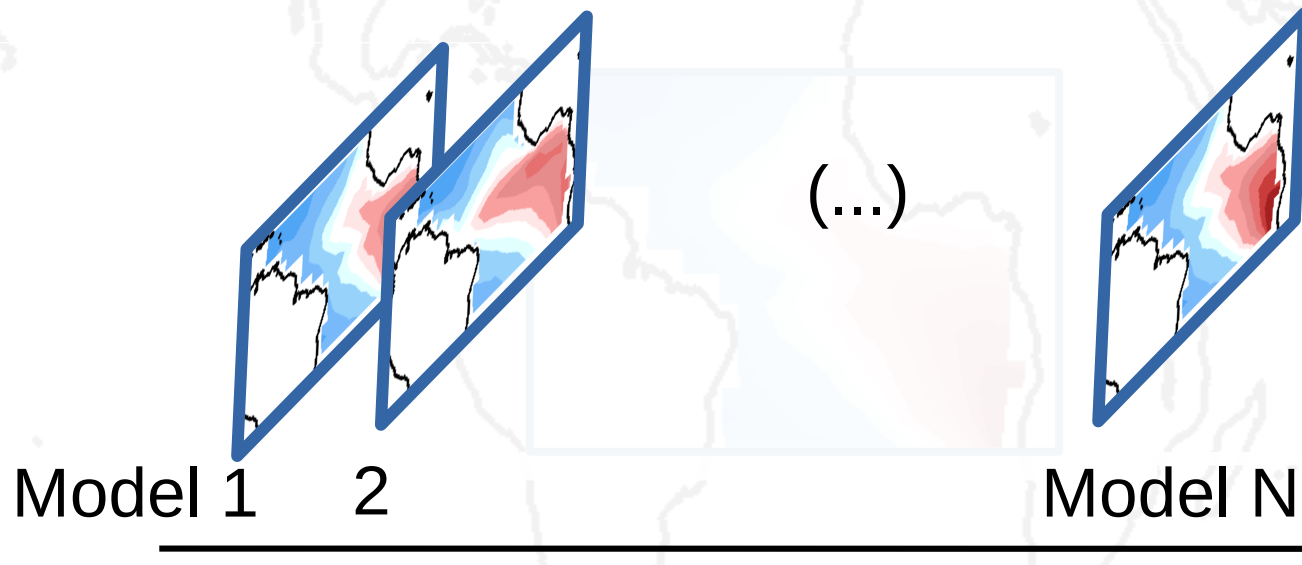


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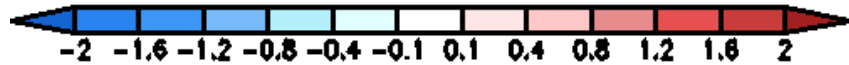
Methods



- Main modes of inter-model spread in simulated climatological SSTs in TA (20°N-20°S) using EOF
- piControl simulation using 24 CMIP5 models (100-1000 yr)

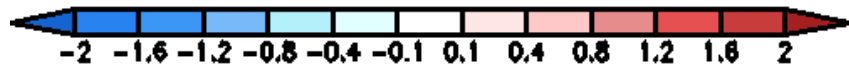
RESULTS: EOF#1

SST (K)



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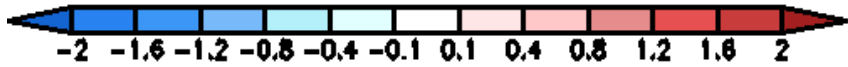
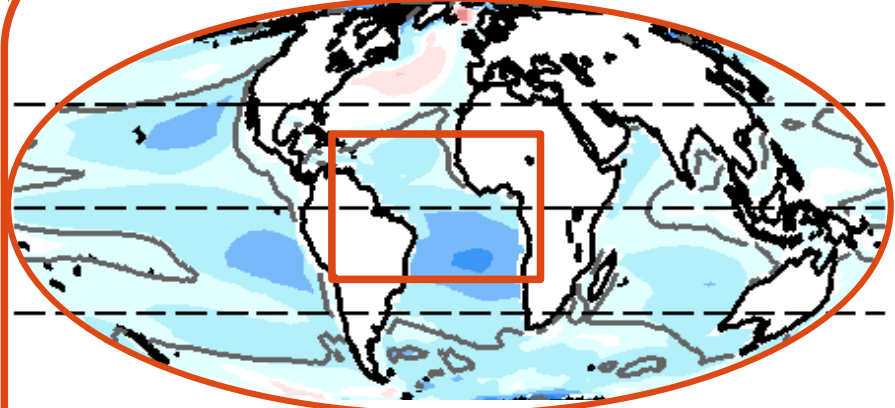
SST (K)



- Same signed anomalies

RESULTS: EOF#1

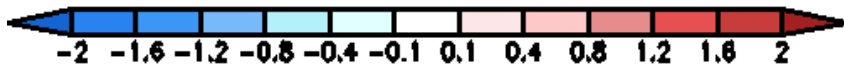
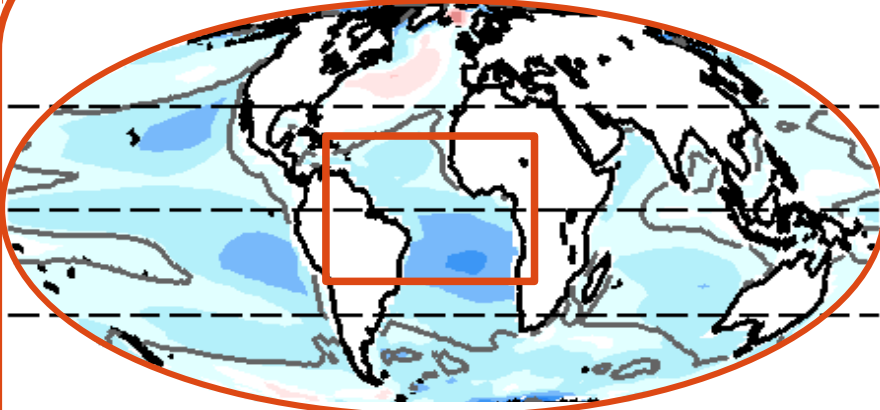
SST (K)



- Same signed anomalies
- Cover whole tropics

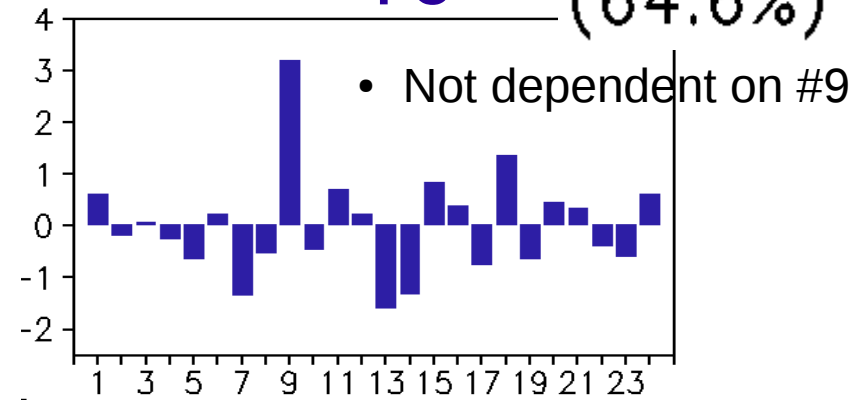
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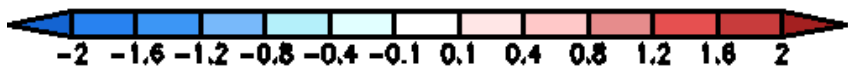
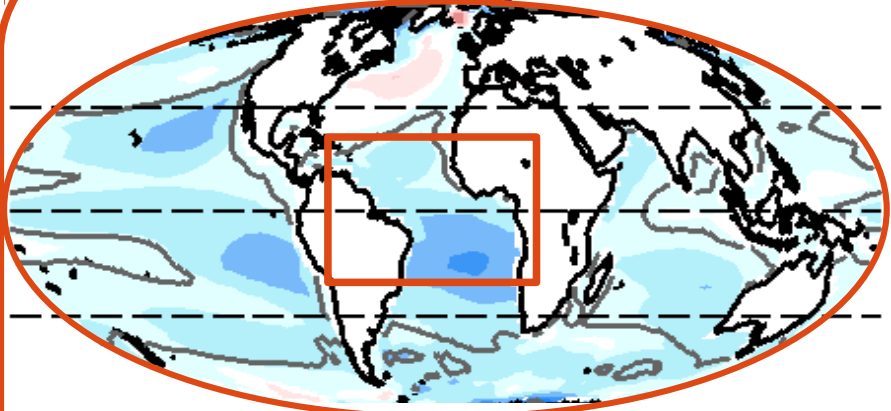
PC (64.6%)



- Highly insensitive to area chosen

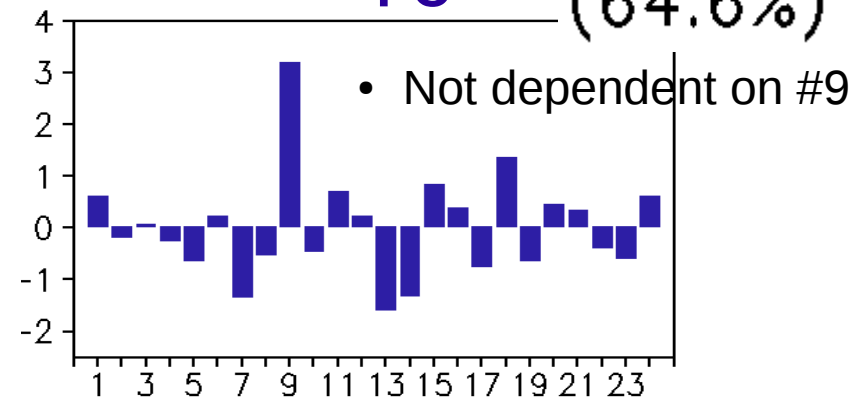
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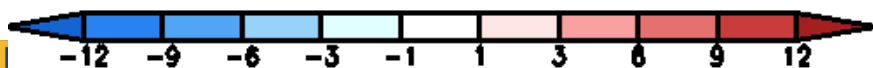
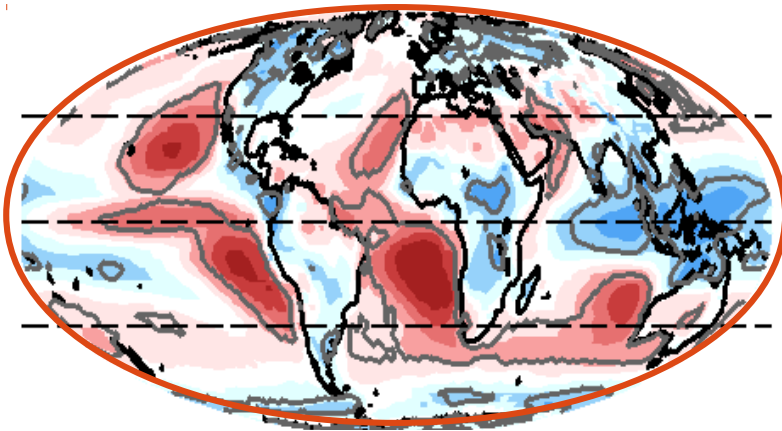
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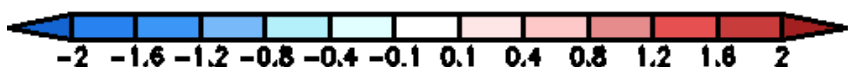
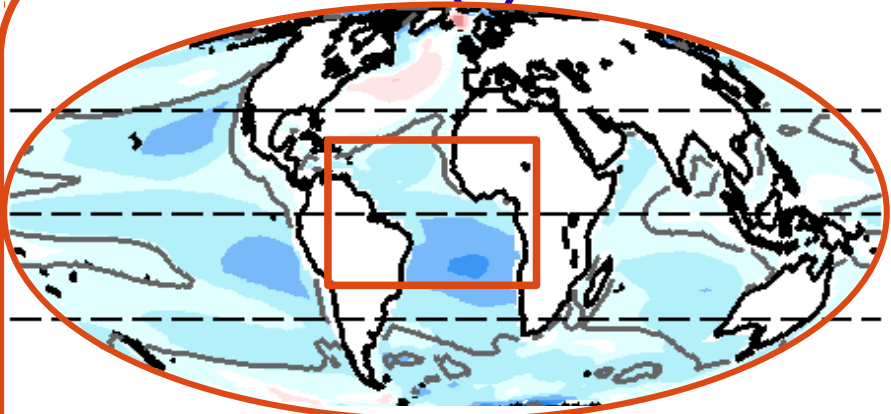
net radiative flux at TOA (W/m^2)



- Related to radiative cooling at TOA

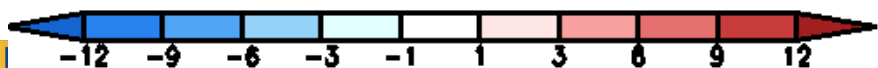
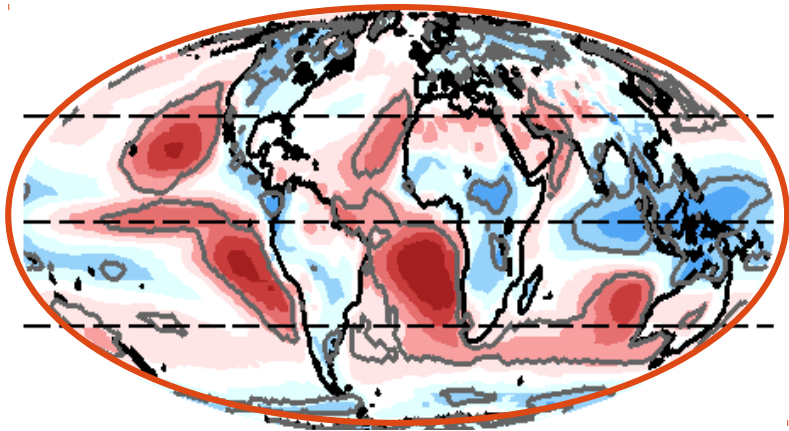
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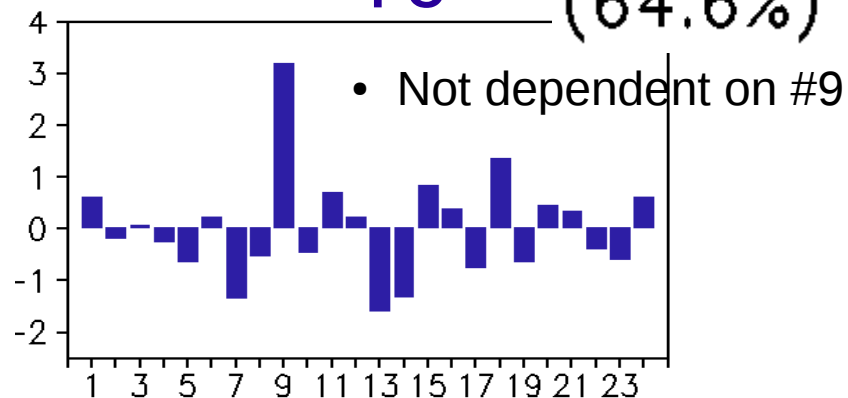
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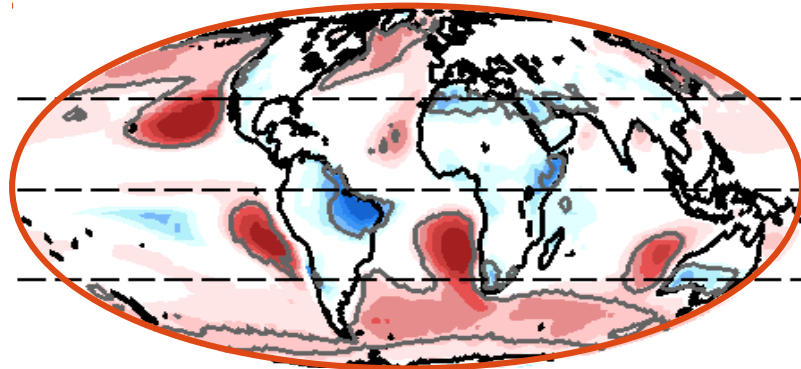
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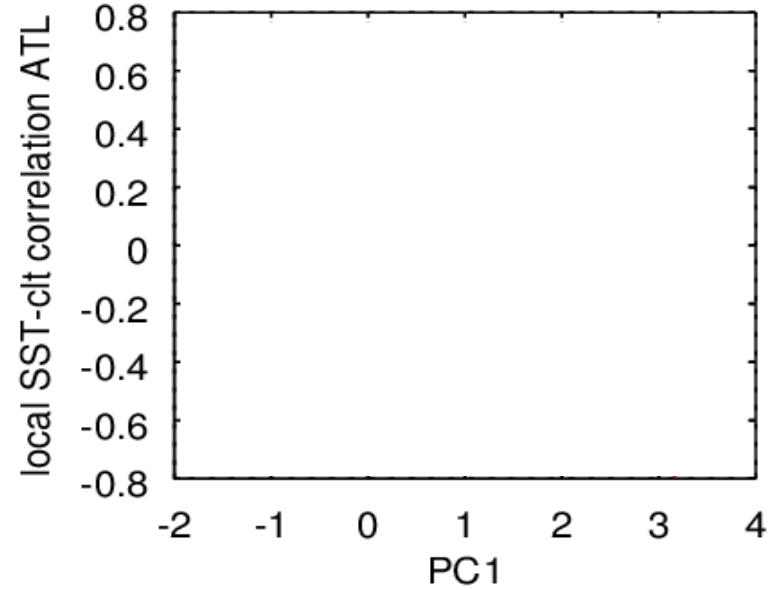
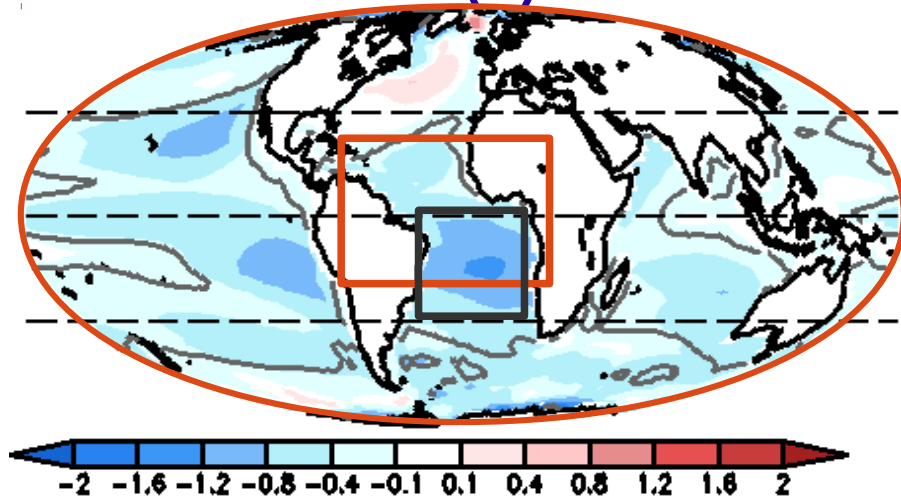
cloud cover (%)



- Increased Sc_u in upwelling in eastern tropical oceans (increased albedo and reflexion of short wave radiation)

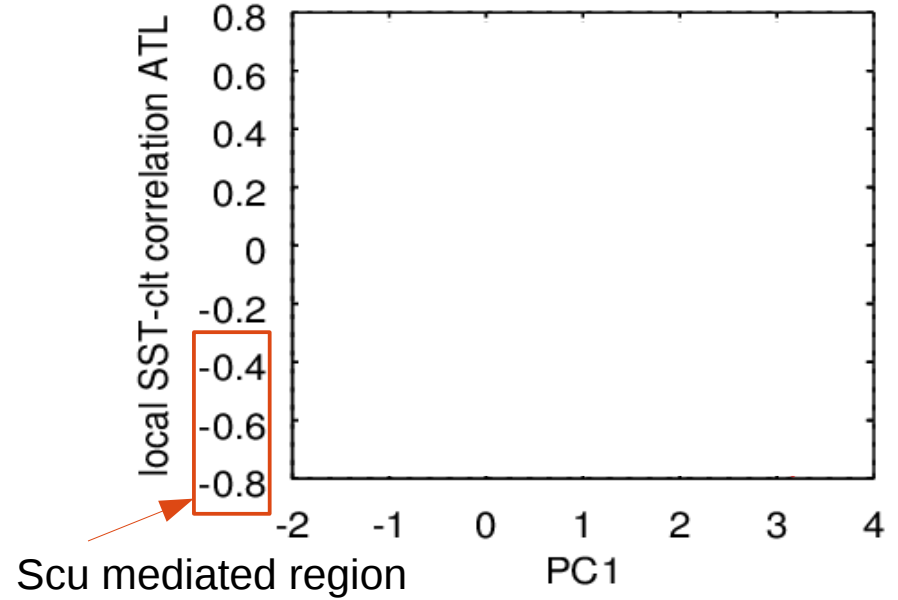
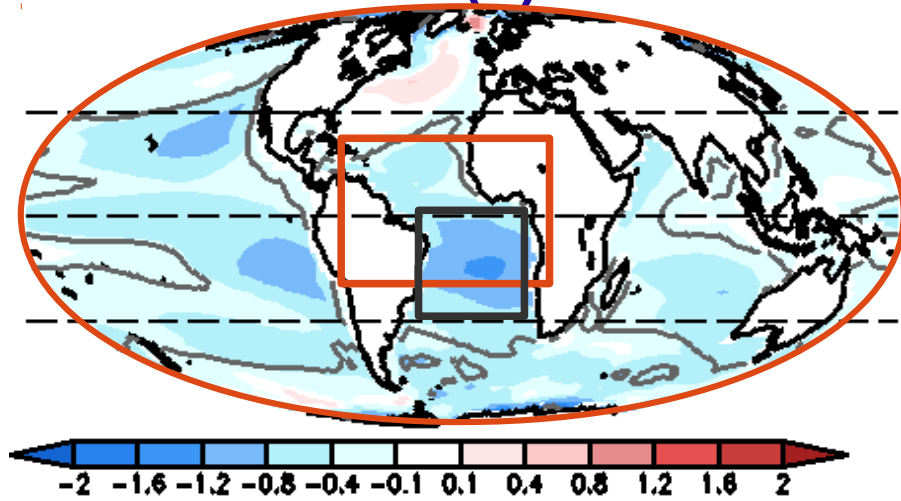
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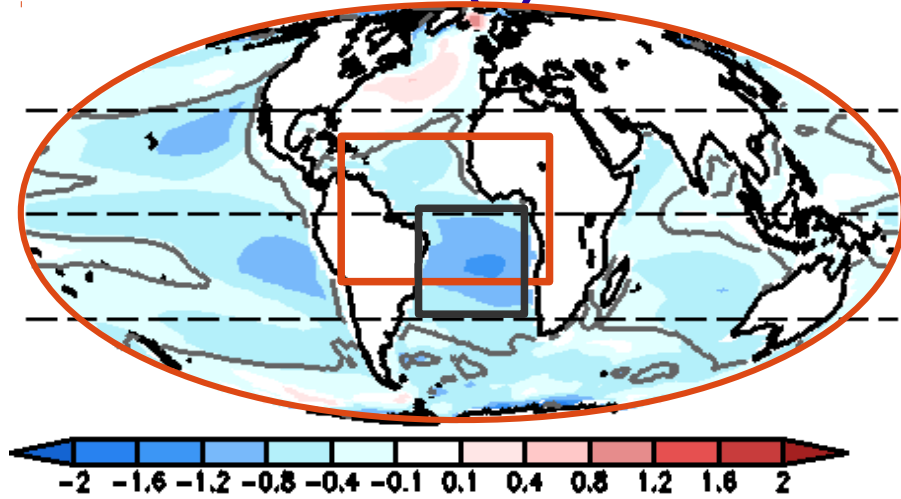
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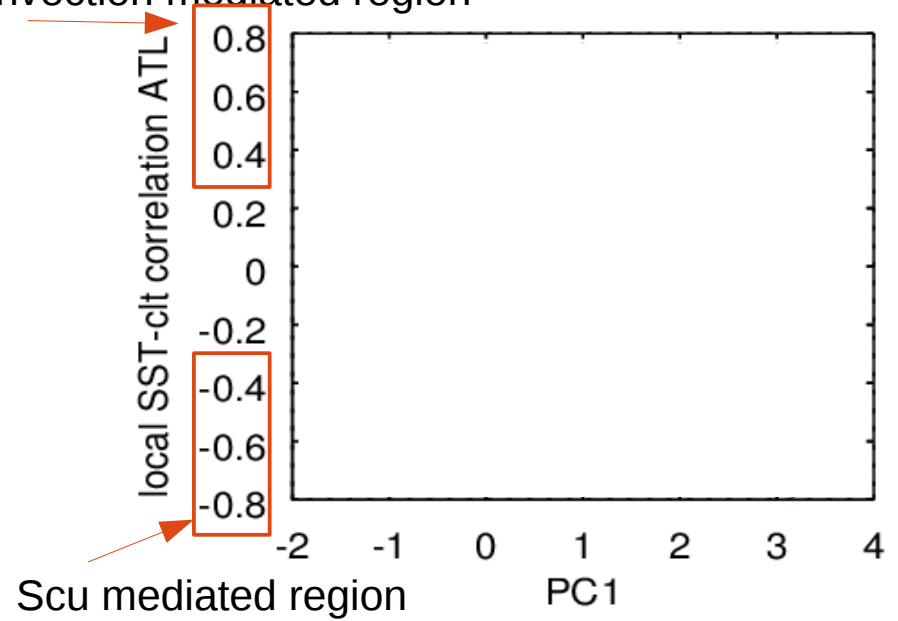


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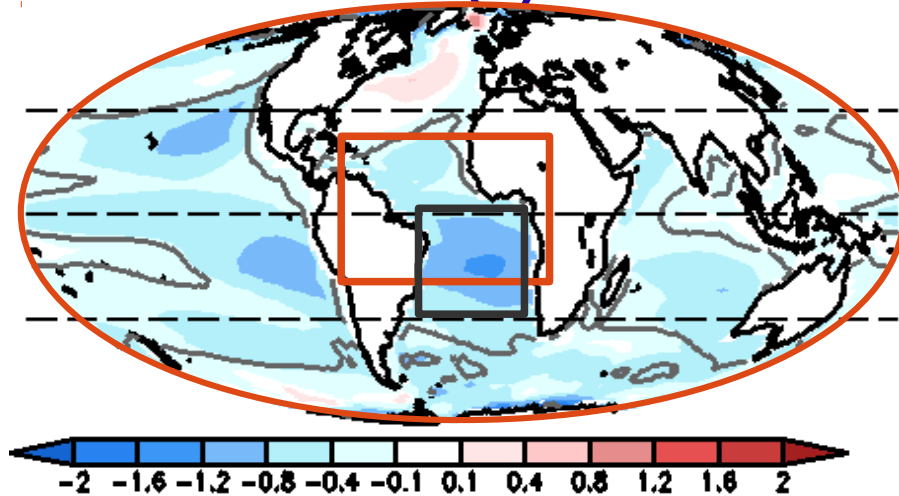


Convection mediated region

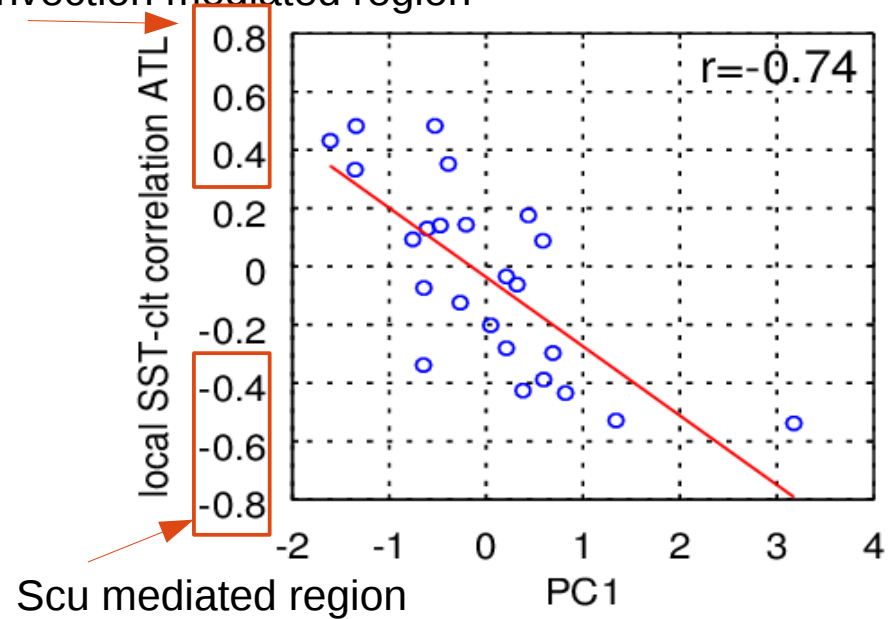


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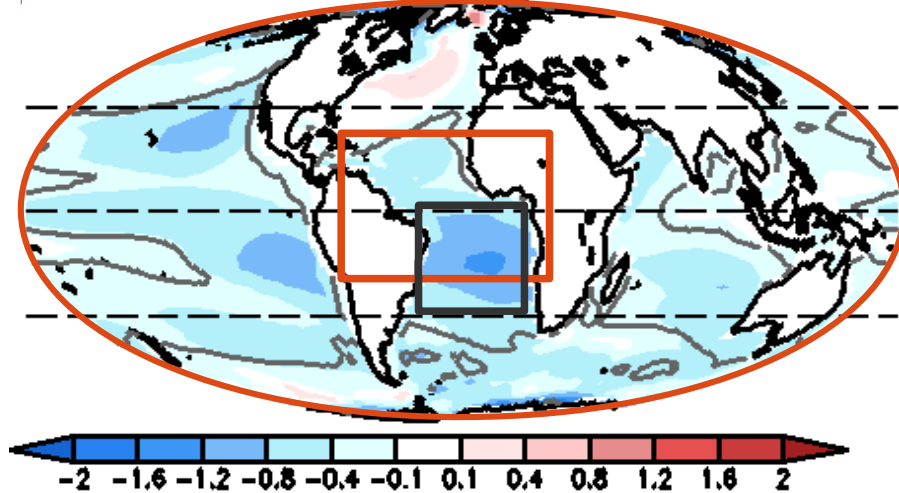
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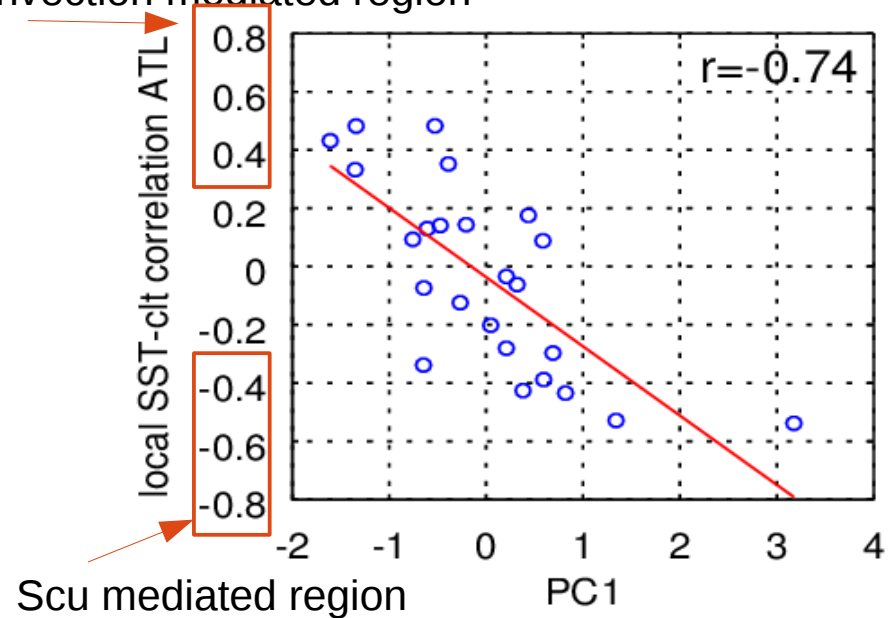
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SST (K)



Convection mediated region



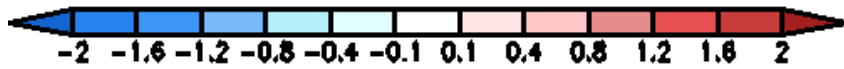
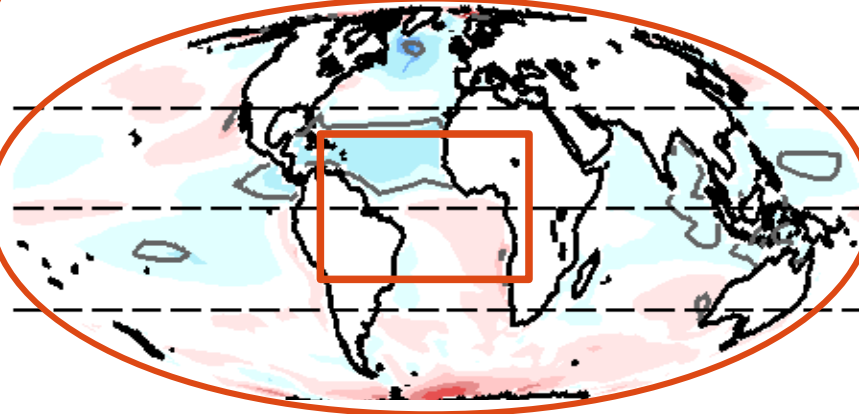
- Related to positive local feedback between clouds and SSTs in SE TA

Main mode of intermodel variability in TA (and global tropical) SSTs is related to amount of Scu in eastern tropical oceans.

Models with **more (less) Scu cover** in eastern tropical oceans tend to show **cooler (warmer) SSTs** locally and globally and a **stratocumulus (convection) mediated** eastern TA

RESULTS: EOF#2

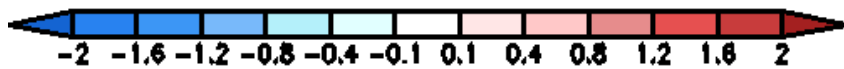
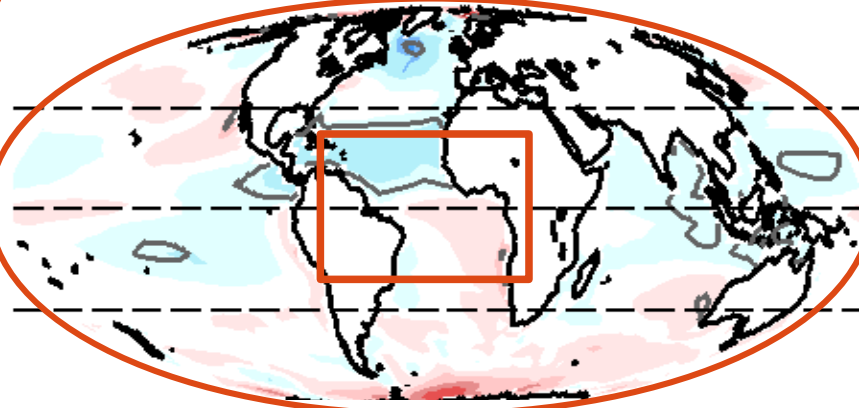
SST (K)



- North-South dipole in the Atlantic
- Reminiscent of AMV pattern

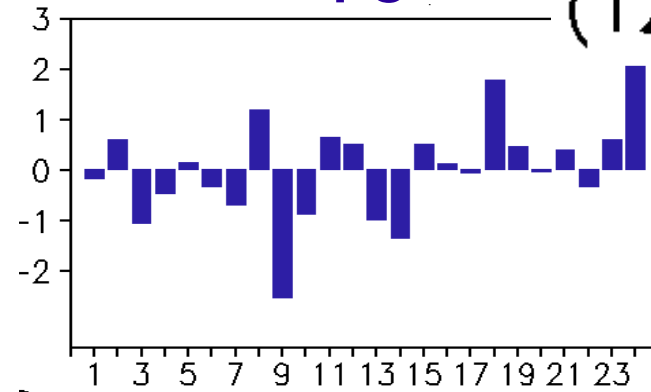
RESULTS: EOF#2

SST (K)



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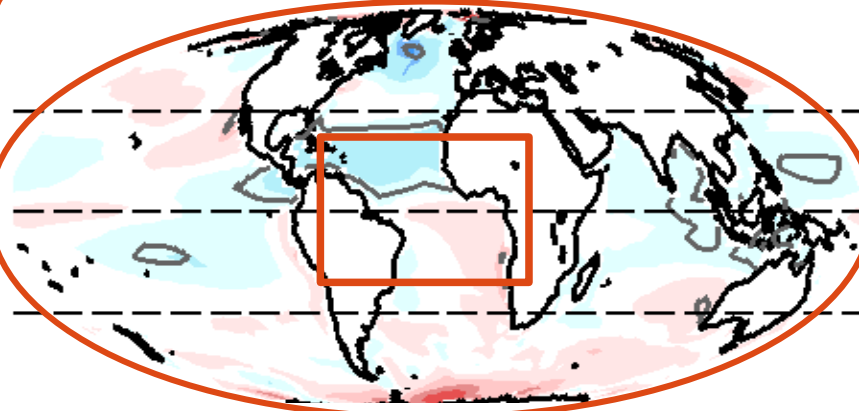
PC (12.6%)



- Restricted to the Atlantic basin

RESULTS: EOF#2

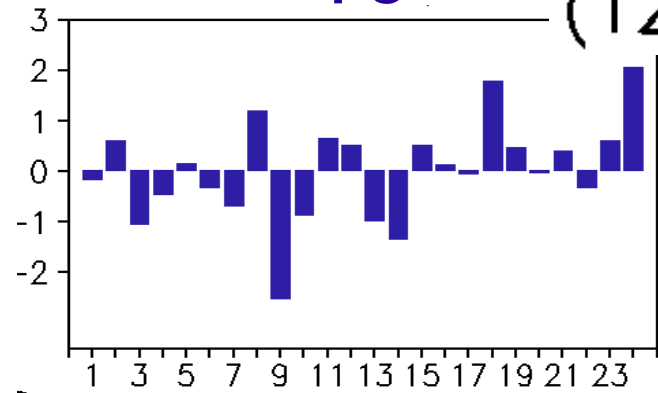
SST (K)



-2 -1.6 -1.2 -0.8 -0.4 -0.1 0.1 0.4 0.8 1.2 1.6 2

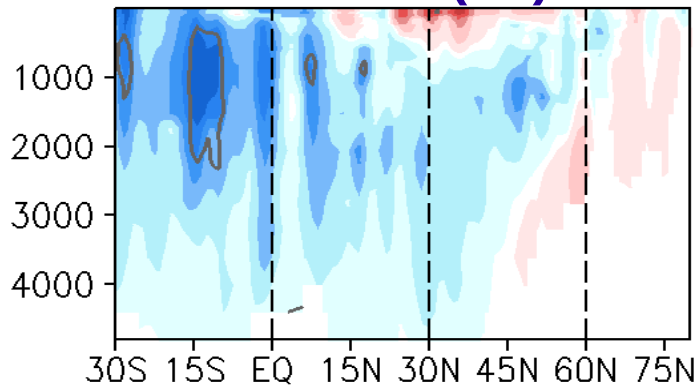
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AMOC (Sv)



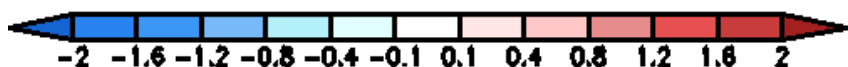
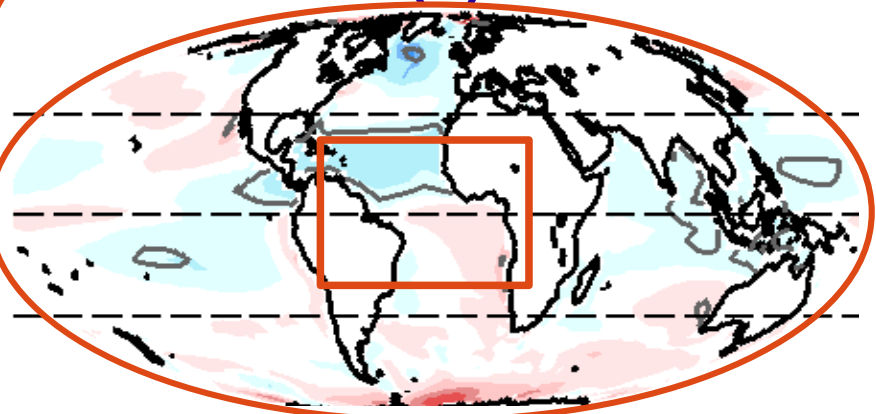
-2.5 -2 -1.5 -1 -0.5 -0.1 0.1 0.5 1 1.5 2 2.5

- Related to reduced AMOC



RESULTS: EOF#2

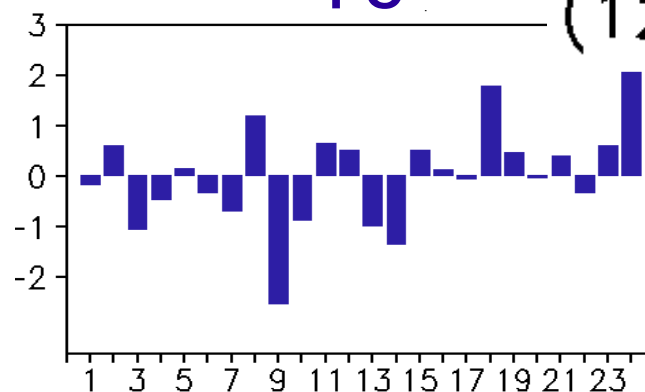
SST (K)



- North-South dipole in the Atlantic
- Reminiscent of AMV pattern

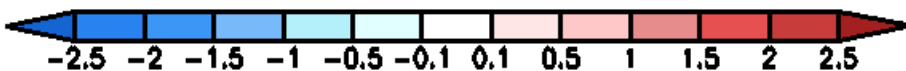
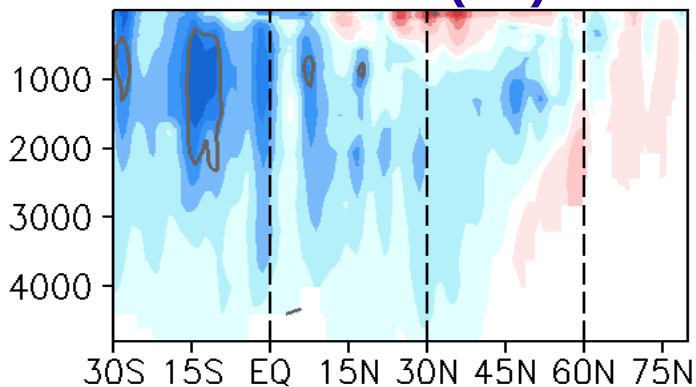
PC

(12.6%)



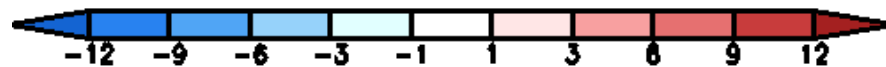
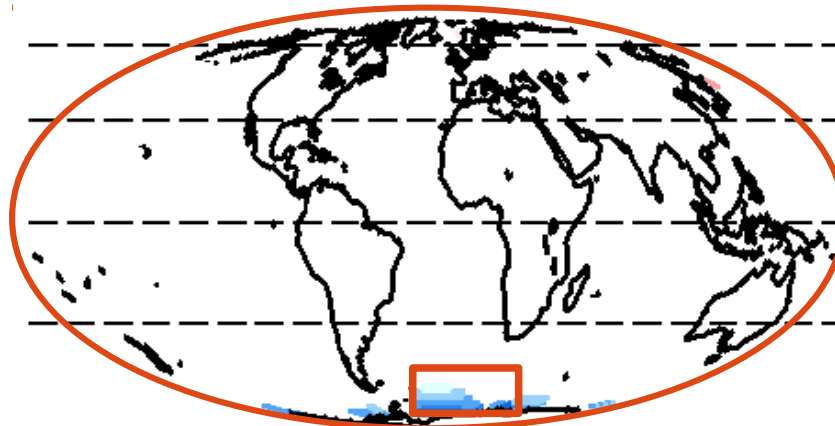
- Restricted to the Atlantic basin

AMOC (Sv)



- Related to reduced AMOC

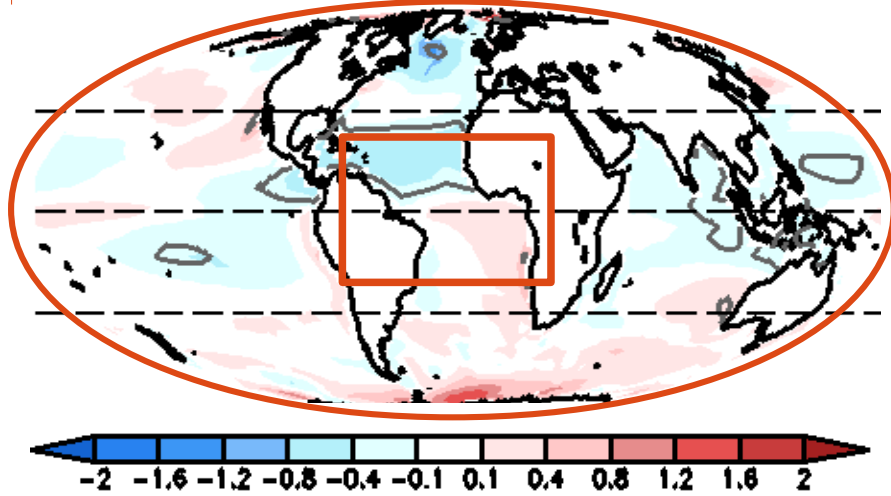
SIC - djf (%)



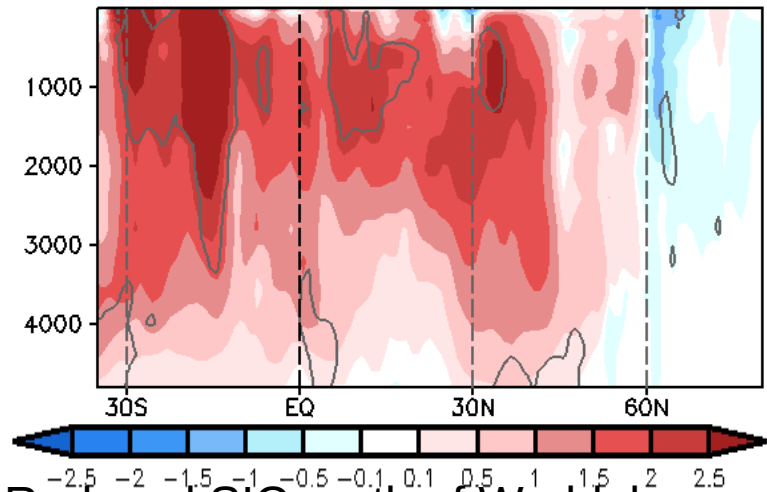
- Related to reduced sea ice cover north of Weddell sea, especially in Dec to Feb

RESULTS: EOF#2

SST (K)



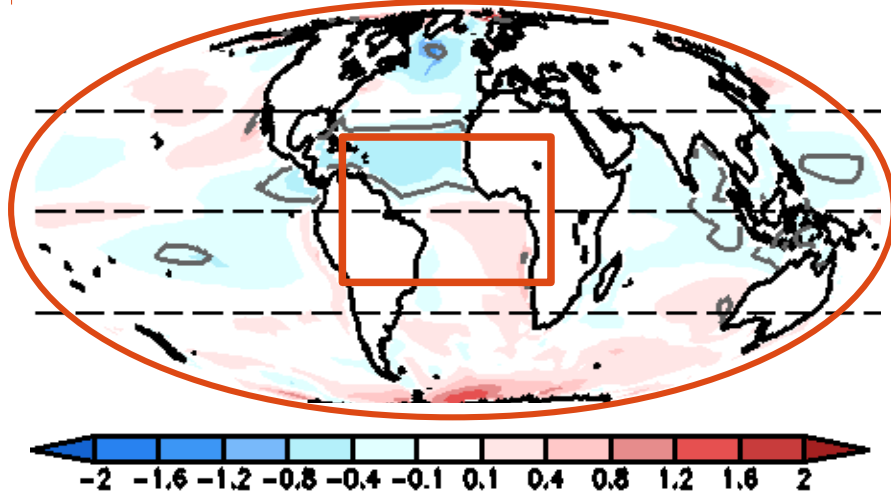
AMOC (Sv) projected onto SIC-djf index



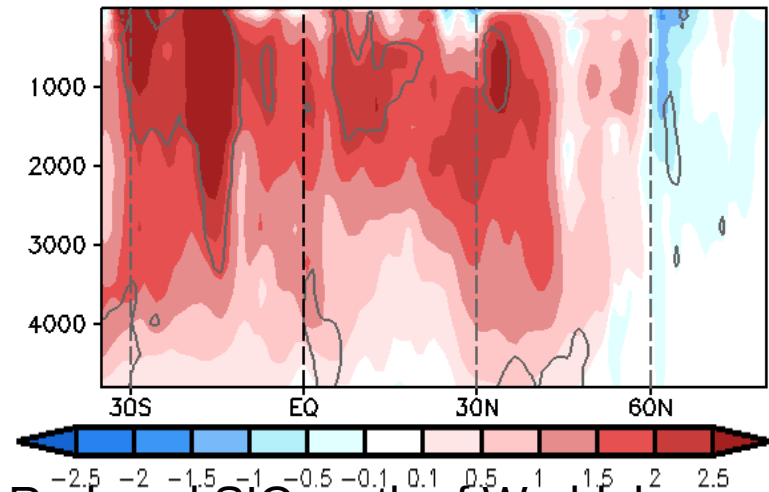
- Reduced SIC north of Weddell sea relates to reduced AMOC

RESULTS: EOF#2

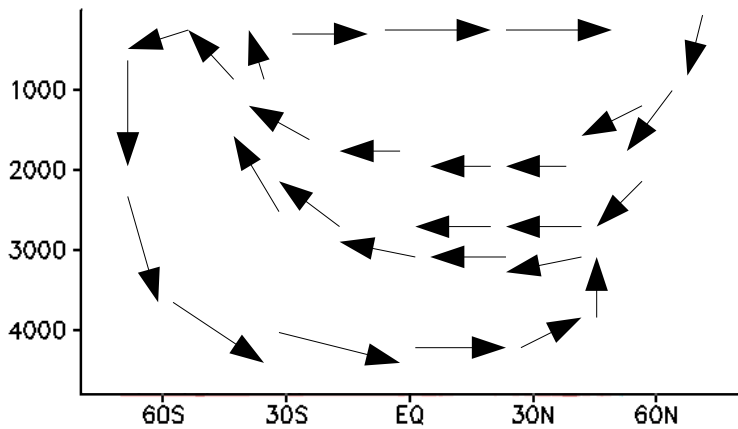
SST (K)



AMOC (Sv) projected onto SIC-djf index

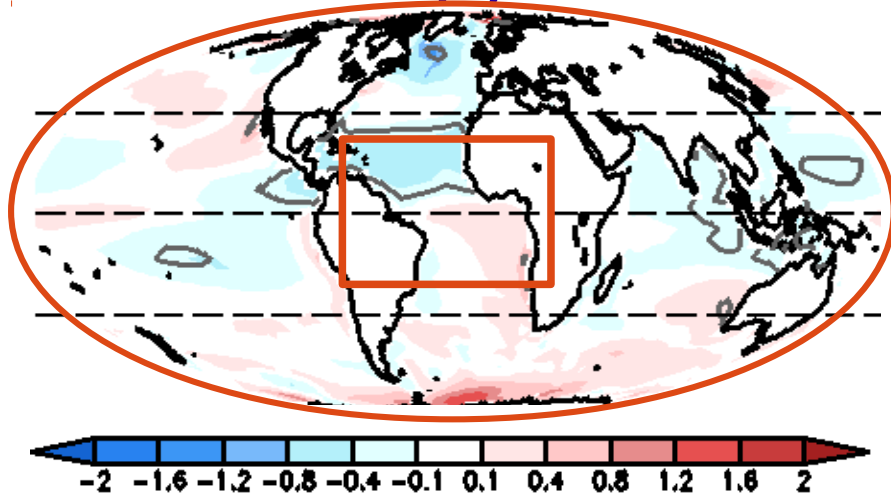


- Reduced SIC north of Weddel sea relates to reduced AMOC

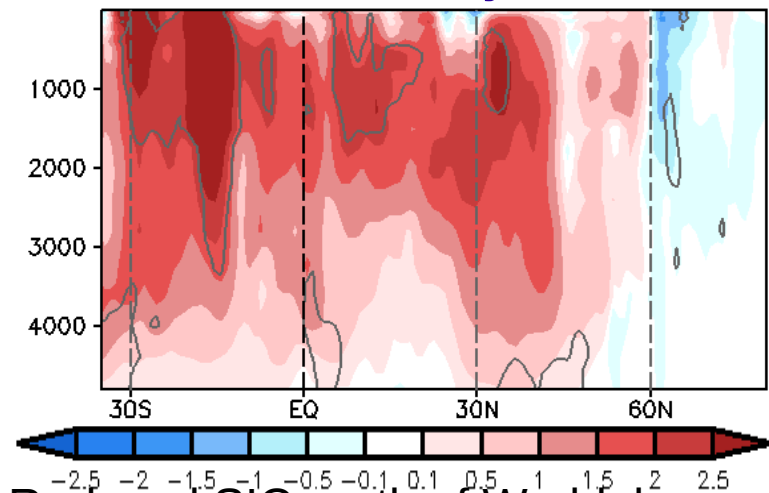


RESULTS: EOF#2

SST (K)

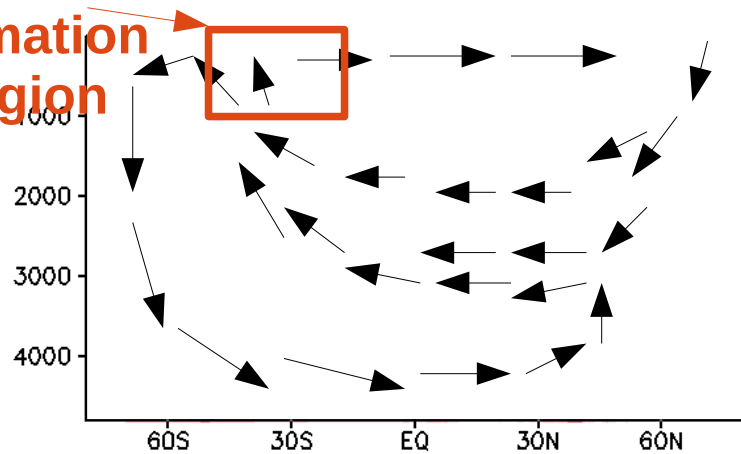


AMOC (Sv) projected onto SIC-djf index



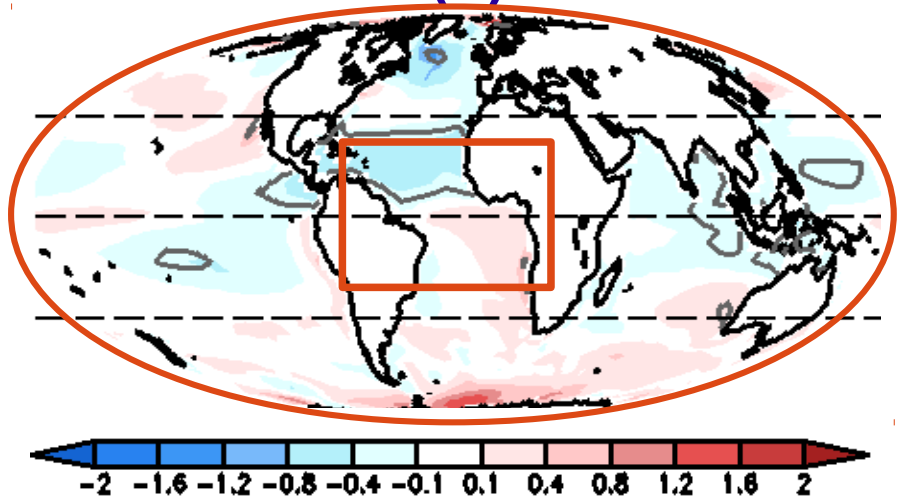
- Reduced SIC north of Weddel sea relates to reduced AMOC

AAIW formation region

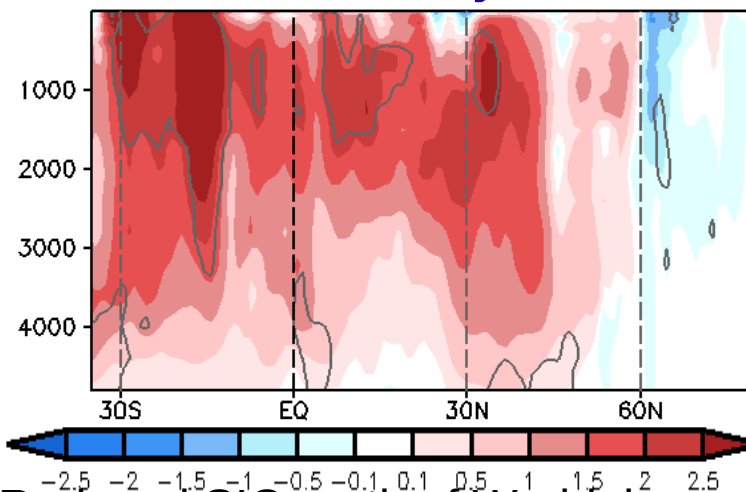


RESULTS: EOF#2

SST (K)



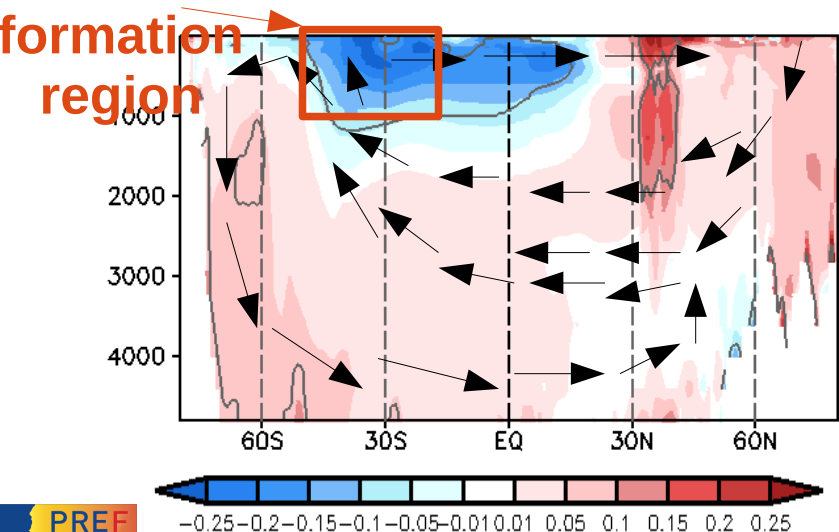
AMOC (Sv) projected onto SIC-djf index



- Reduced SIC north of Weddel sea relates to reduced AMOC

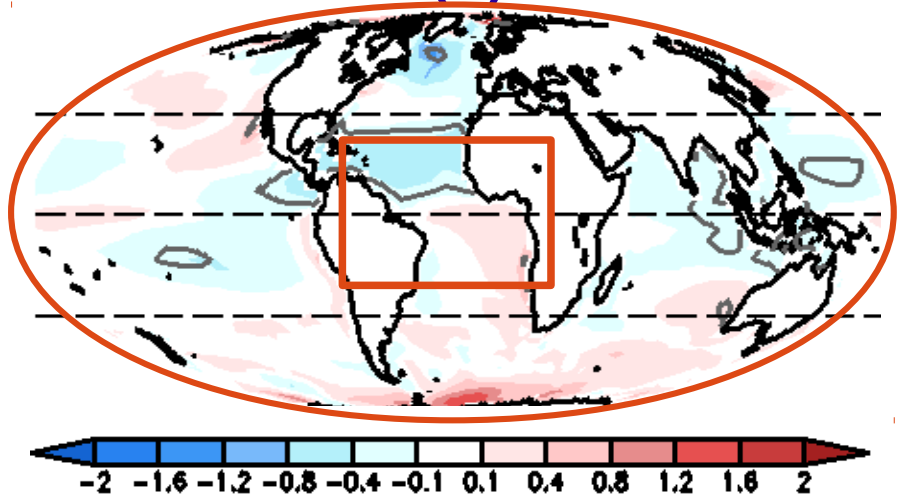
Zonal mean Atlantic salinity (psu) projected onto SIC-djf index

AAIW onto SIC-djf index

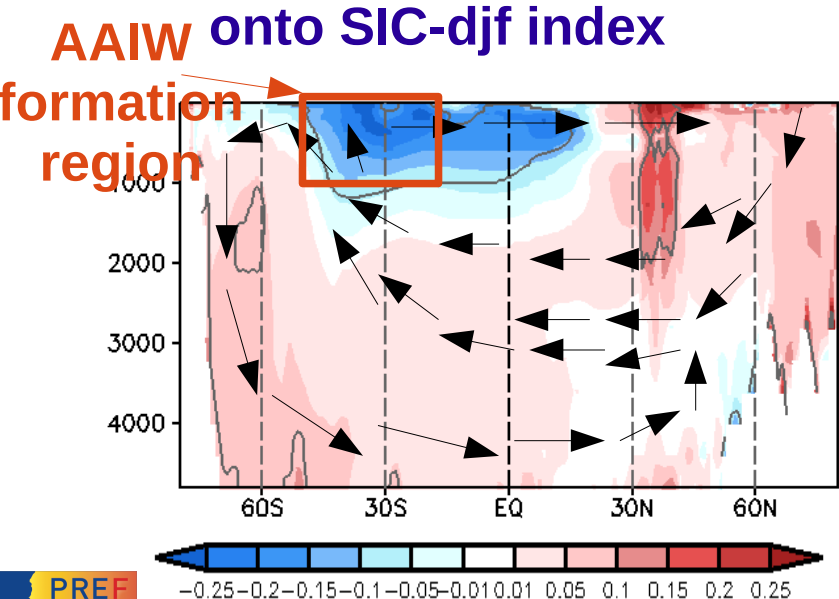


RESULTS: EOF#2

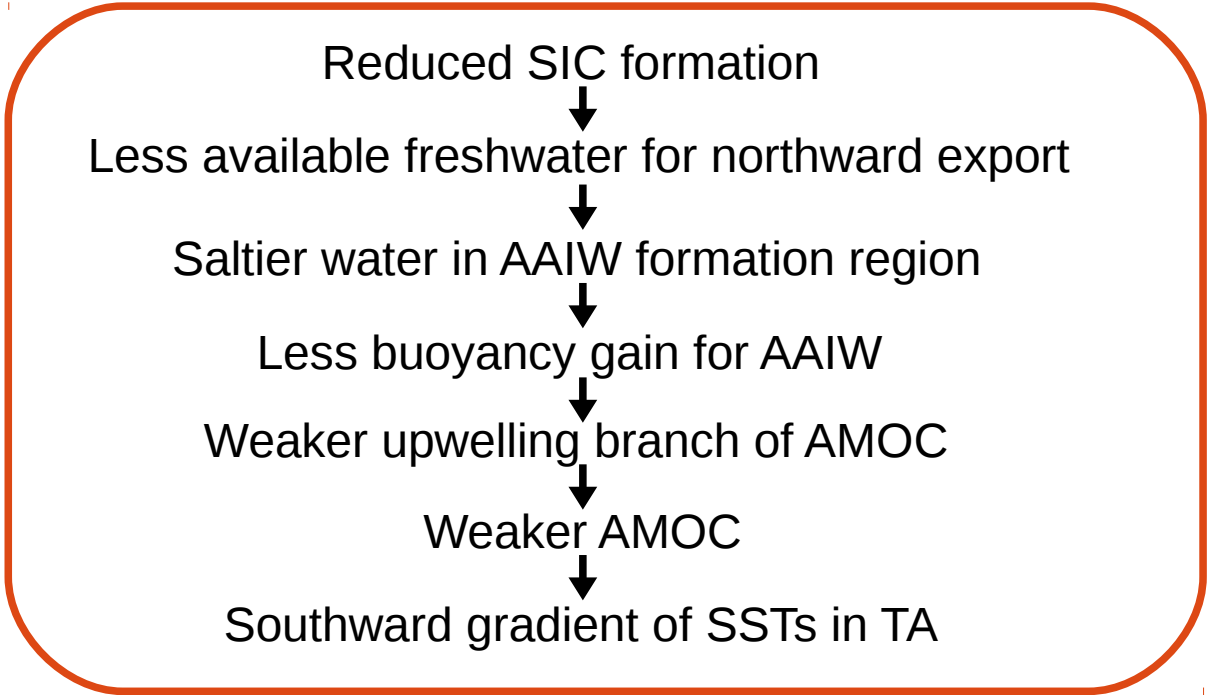
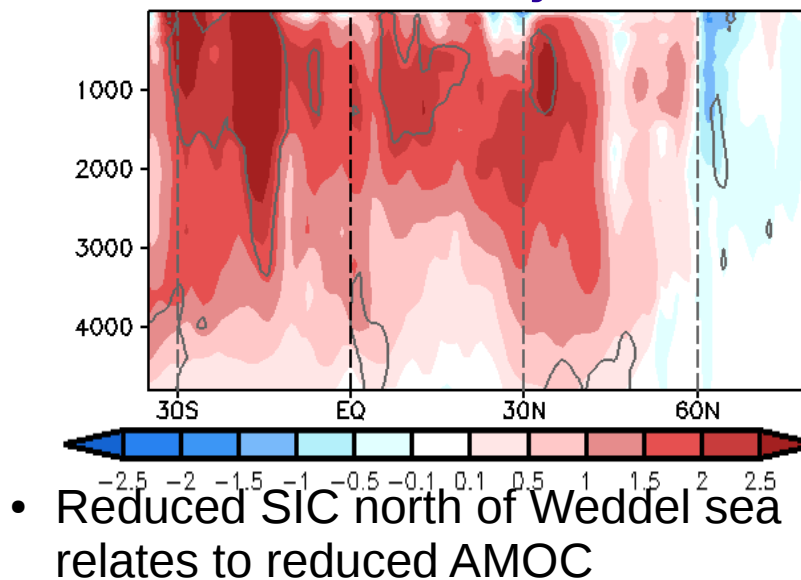
SST (K)



Zonal mean Atlantic salinity (psu) projected onto SIC-djf index

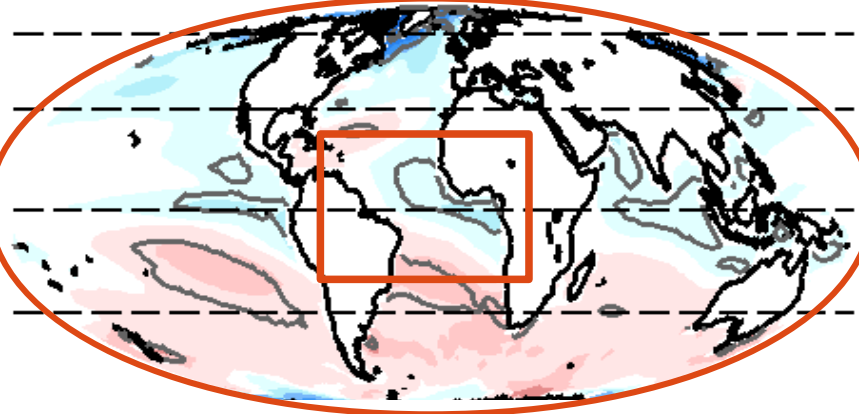


AMOC (Sv) projected onto SIC-djf index



RESULTS: EOF#3

SST (K)

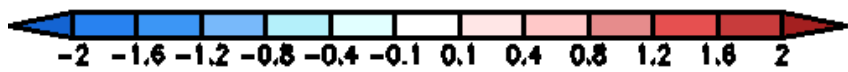
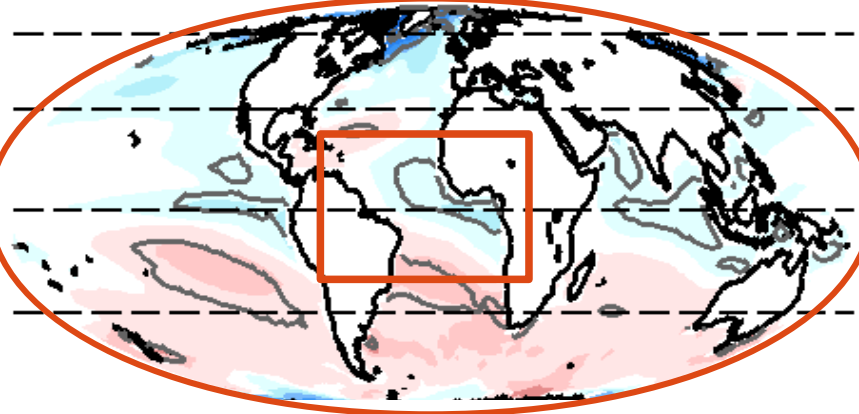


-2 -1.6 -1.2 -0.8 -0.4 -0.1 0.1 0.4 0.8 1.2 1.6 2

- World-wide inter-hemispheric pattern

RESULTS: EOF#3

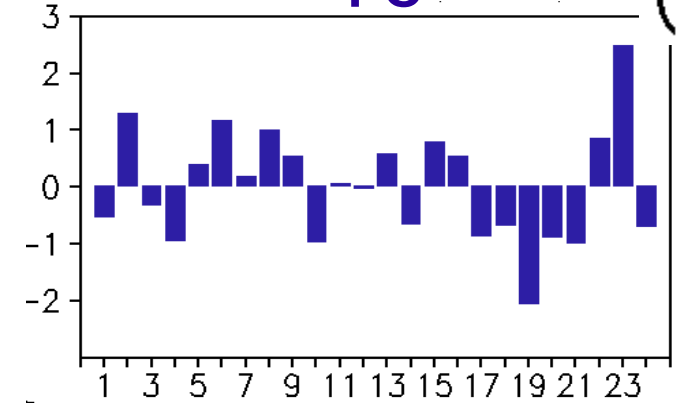
SST (K)



- World-wide inter-hemispheric pattern

PC

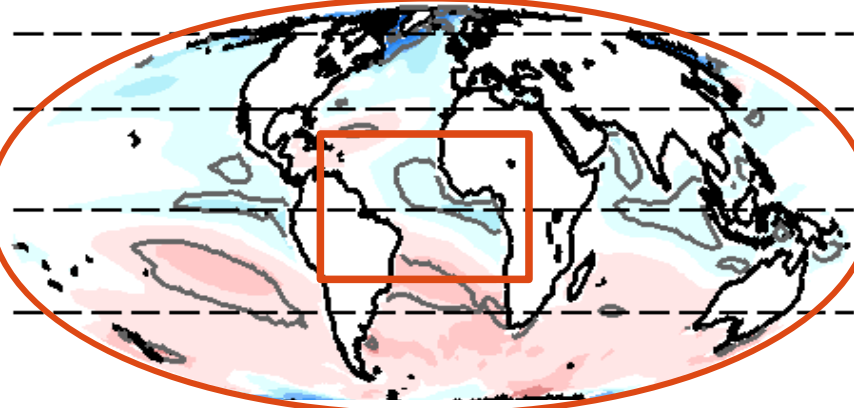
(8.4%)



- More dominant in the Pacific (EOF#2, 15%)

RESULTS: EOF#3

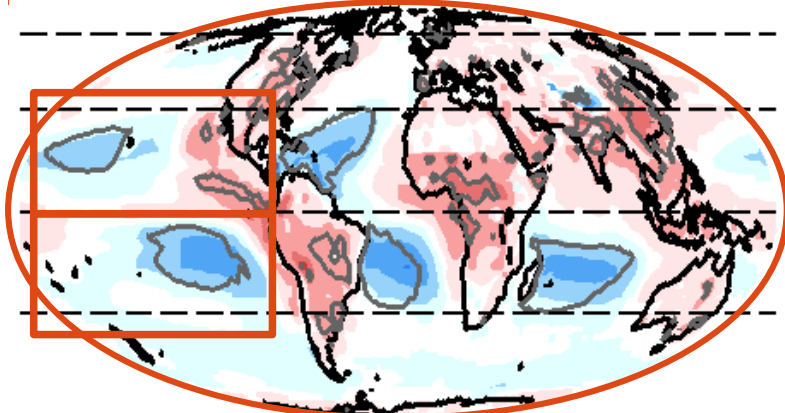
SST (K)



-2 -1.6 -1.2 -0.8 -0.4 -0.1 0.1 0.4 0.8 1.2 1.6 2

- World-wide inter-hemispheric pattern

net radiative flux at TOA (W/m^2)

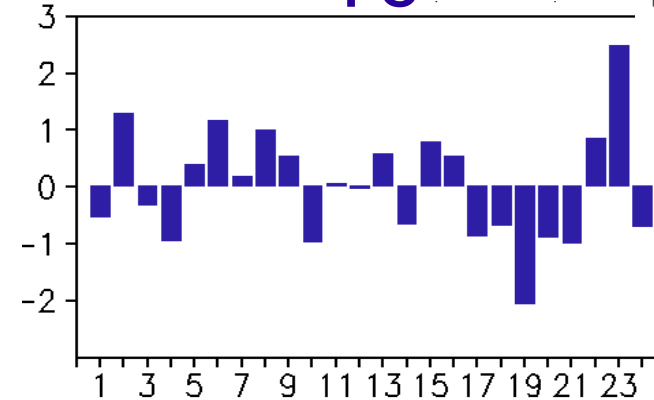


-12 -9 -6 -3 -1 1 3 6 9 12

- Atmospheric origin
- Less loss of net radiation co-located over enhanced SST anomalies

PC

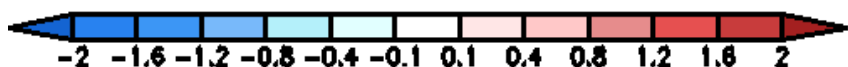
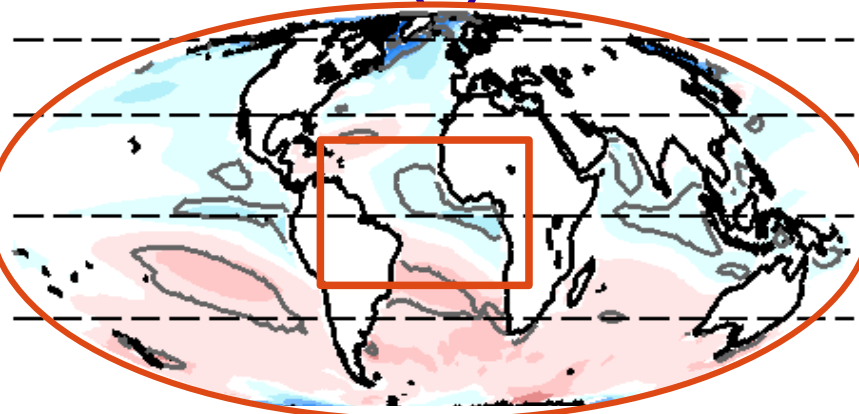
(8.4%)



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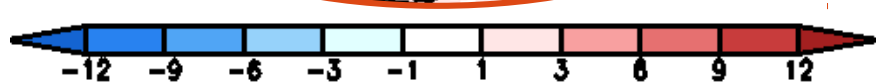
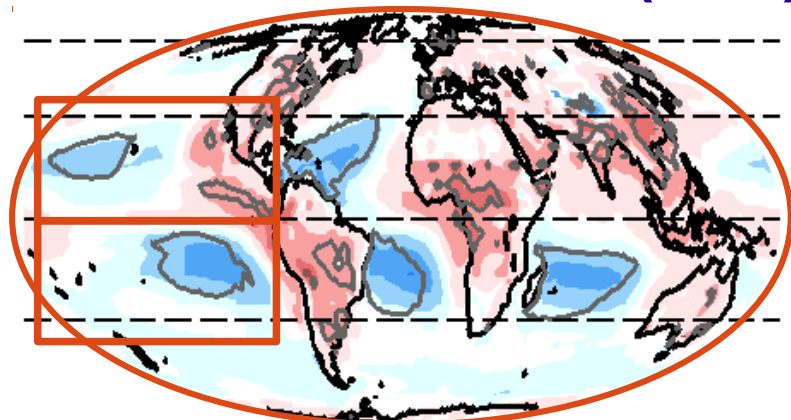
RESULTS: EOF#3

SST (K)



- World-wide inter-hemispheric pattern

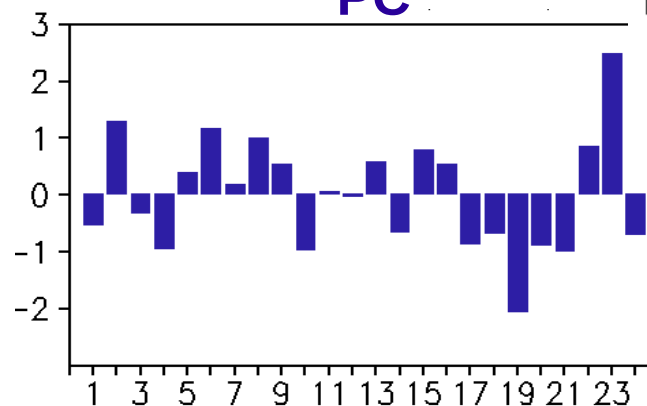
net radiative flux at TOA (W/m^2)



- Atmospheric origin
- Less loss of net radiation co-located over enhanced SST anomalies

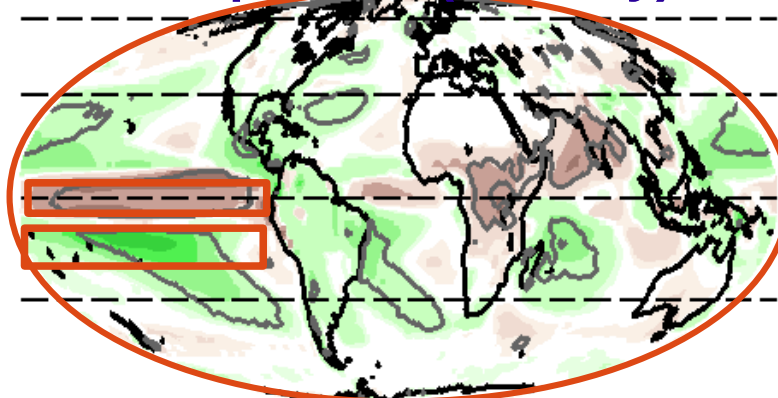
PC

(8.4%)



- More dominant in the Pacific (EOF#2, 15%)

Precipitation (mm/day)

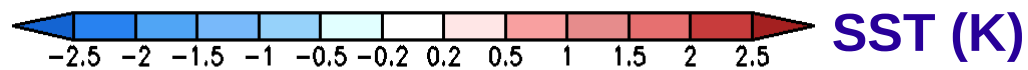
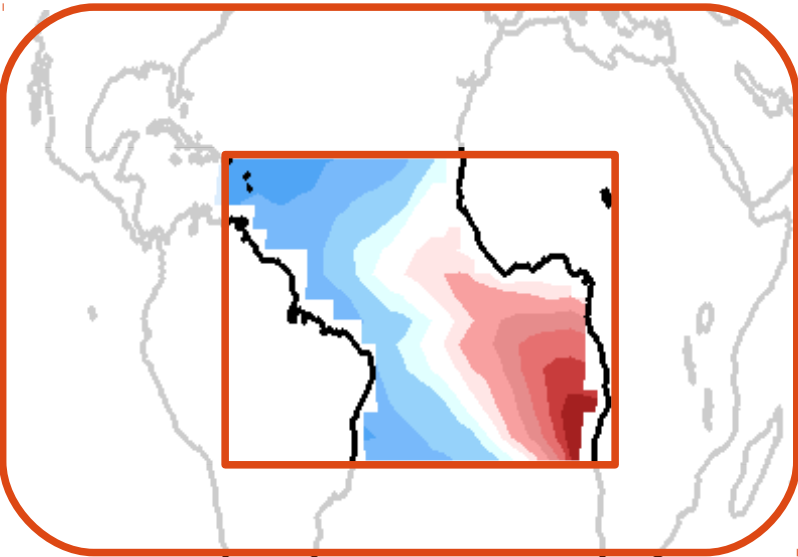


- Consistent with SST anomalies
- Related to Double ITCZ (DI) problem especially in the Pacific basin

BIAS IN TA SST and EOFs

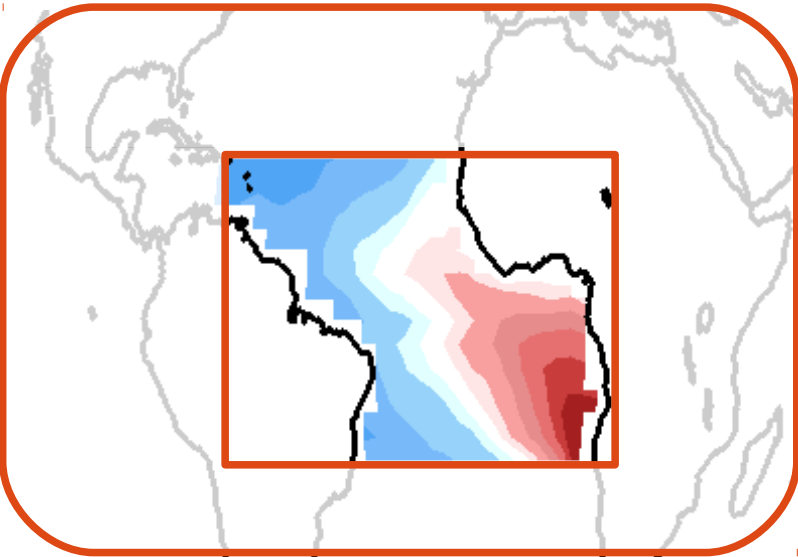
Mean SST bias (24 models)

Reconstructed bias with EOFs

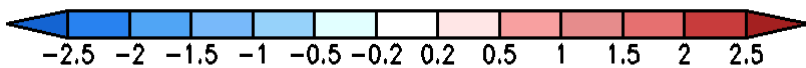
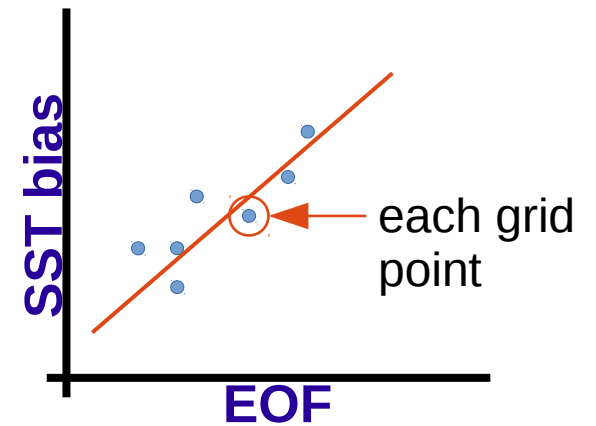


BIAS IN TA SST and EOFs

Mean SST bias (24 models)



Reconstructed bias with EOFs



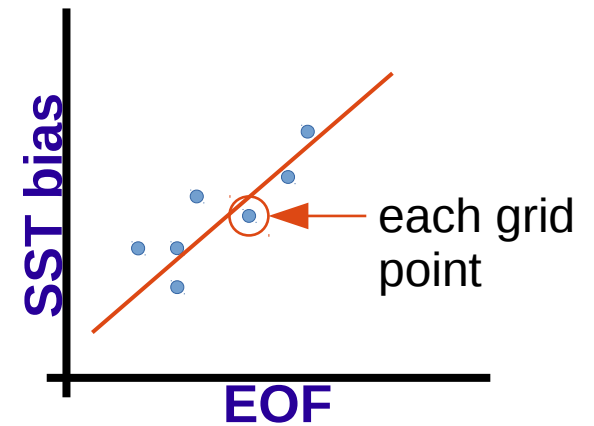
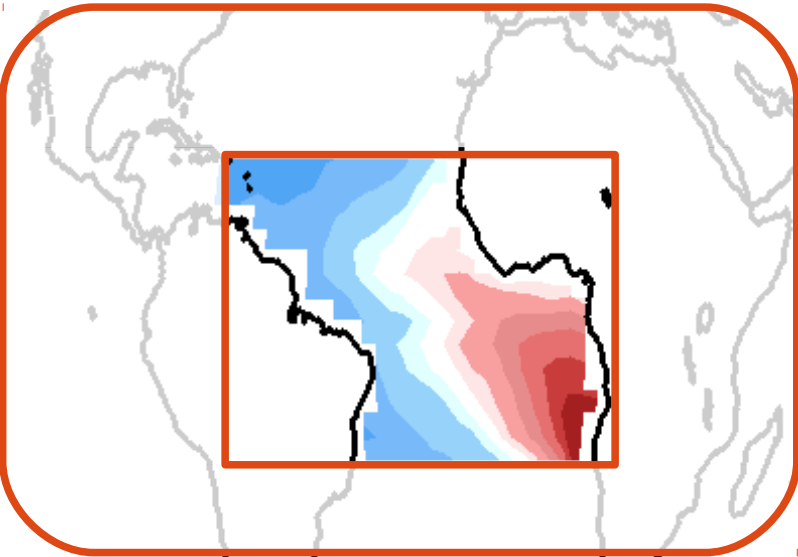
SST (K)



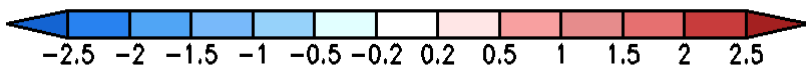
BIAS IN TA SST and EOFs

Mean SST bias (24 models)

Reconstructed bias with EOFs



EOF	Coefficient	% Expl VAR
1	-0,05±0,13	1,5
2	2,63±0,29	54
3	-1,67±0,36	16



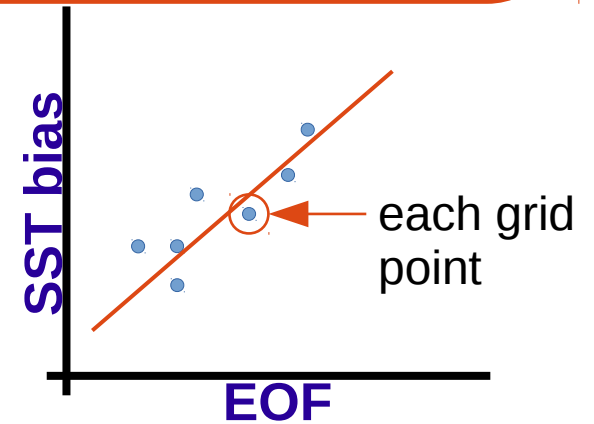
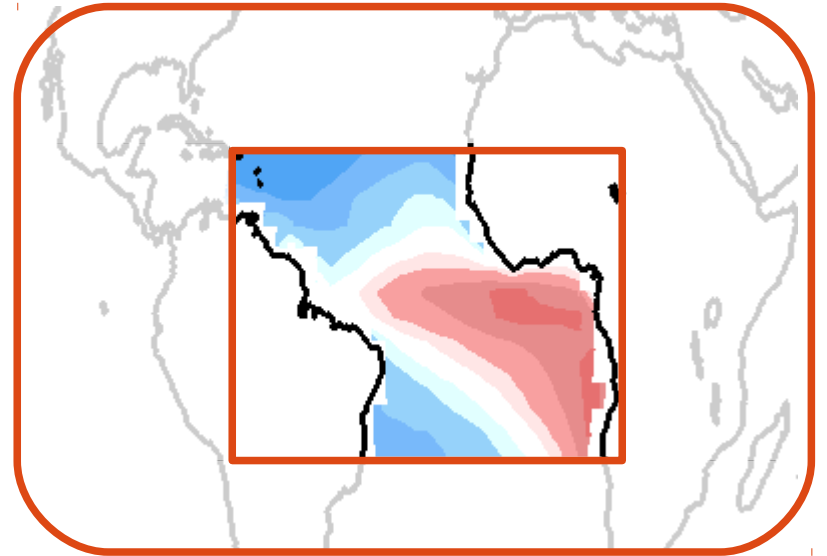
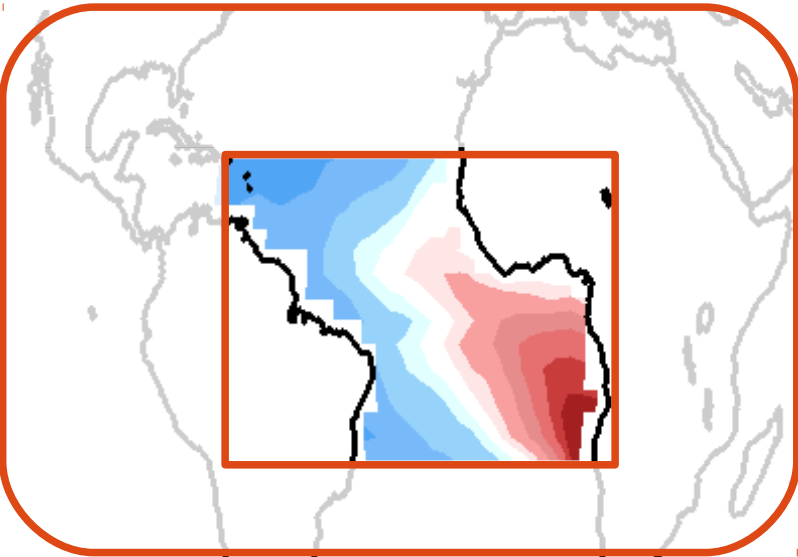
SST (K)



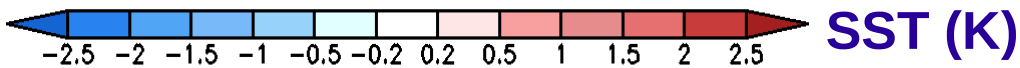
BIAS IN TA SST and EOFs

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Reconstructed bias with EOFs

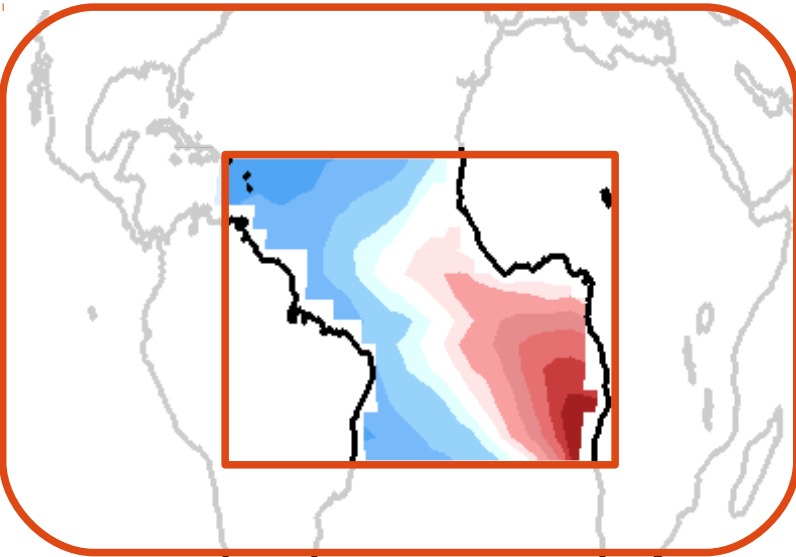


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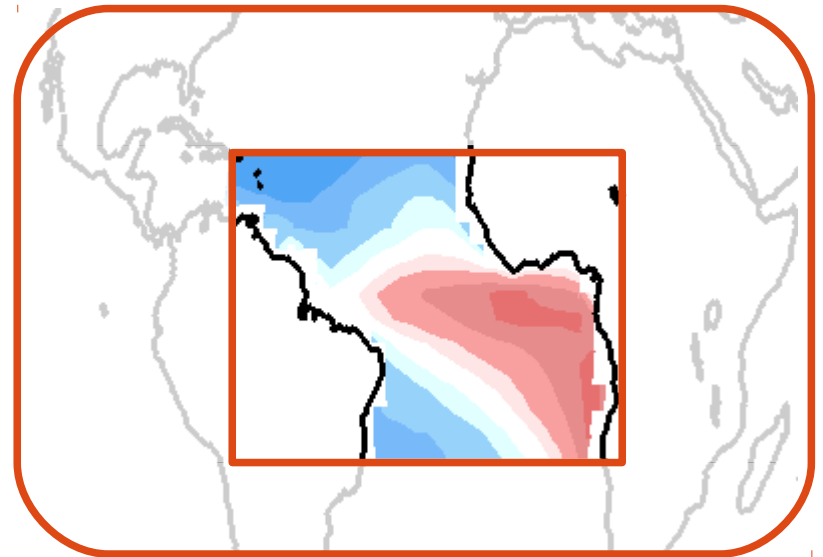


BIAS IN TA SST and EOFs

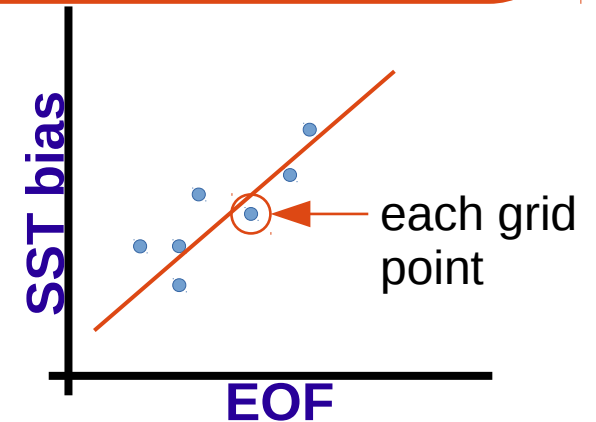
Mean SST bias (24 models)



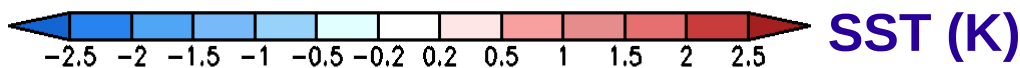
Reconstructed bias with EOFs



- Main contributor to TA bias structure is EOF#2, followed by EOF #3
- Surprisingly, EOF#1 does not project onto TA SST bias
- This suggests mean factor controlling TA SST bias pattern is strength of AMOC

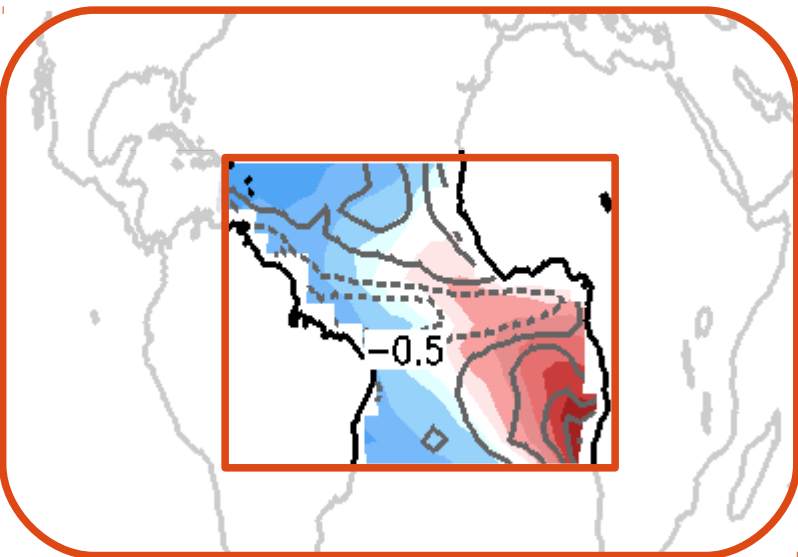


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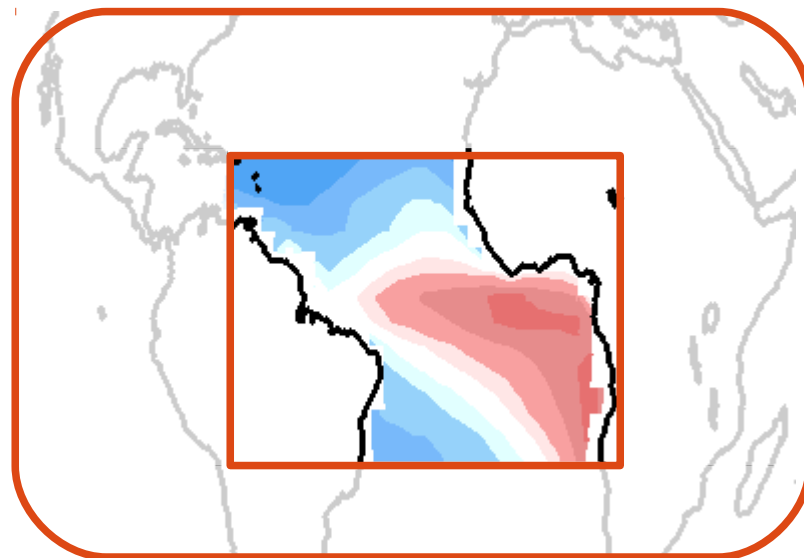


BIAS IN TA SST and EOFs

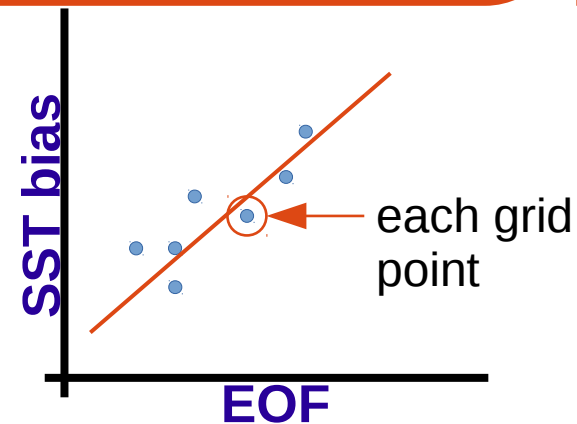
Mean SST bias (24 models)



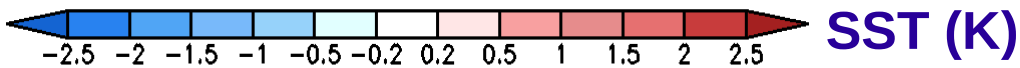
Reconstructed bias with EOFs



- Main contributor to TA bias structure is EOF#2, followed by EOF #3
- Surprisingly, EOF#1 does not project onto TA SST bias
- This suggests mean factor controlling TA SST bias pattern is strength of AMOC
- Mismatches between original and reconstructed bias are shown in equatorial Atlantic and southeastern TA, where local effects could dominate



EOF	Coefficient	% Expl VAR
1	-0,05±0,13	1,5
2	2,63±0,29	54
3	-1,67±0,36	16



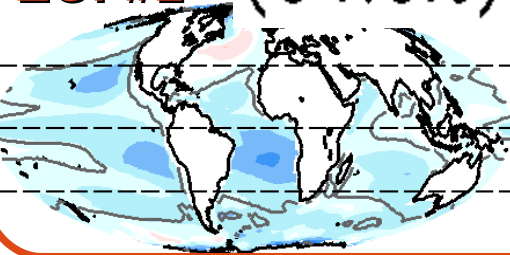
CONCLUSIONS

EOF#1 (64.6%)

Related to simulation of Scv in eastern tropical oceans

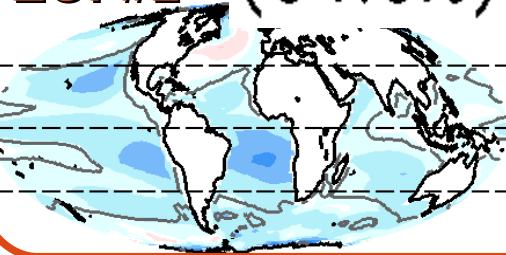
More (less) Scv cloud deck cover there leads to:

- **cooler** (warmer) SST (through albedo and shortwave radiation loss to space).
- **stratocumulus** (convection) mediated eastern TA



CONCLUSIONS

EOF#1 (64.6%)

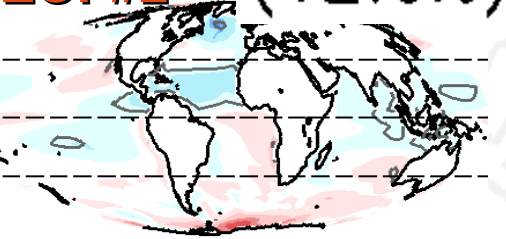


Related to simulation of Scu in eastern tropical oceans

More (less) **Scu** cloud deck cover there leads to:

- **cooler** (warmer) SST (through albedo and shortwave radiation loss to space).
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EOF#2 (12.6%)

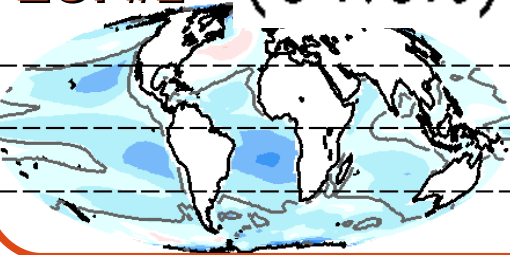


Related to simulation of AMOC and Antarctic sea ice production

- **Weaker** (stronger) **AMOC** tend to show **southward** (northward) **SSTs** gradient in TA.
- **Reduced** (enhanced) **sea ice** north of Weddell sea weakens (strengthens) **upwelling branch of AMOC** through freshwater fluxes.

CONCLUSIONS

EOF#1 (64.6%)

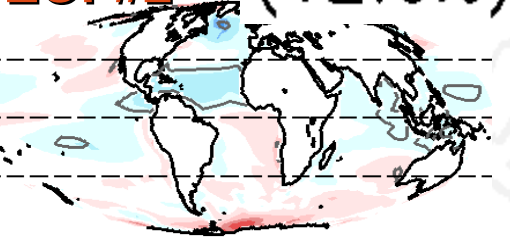


Related to simulation of **Scu** in eastern tropical oceans

More (less) **Scu** cloud deck cover there leads to:

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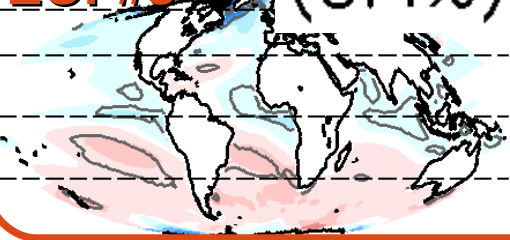
EOF#2 (12.6%)



Related to simulation of **AMOC** and **Antarctic sea ice** production

- **Weaker** (stronger) **AMOC** tend to show **southward** (northward) **SSTs** gradient in TA.
- **Reduced** (enhanced) **sea ice** north of Weddell sea weakens (strengthens) **upwelling branch of AMOC** through freshwater fluxes.

EOF#3 (8.4%)



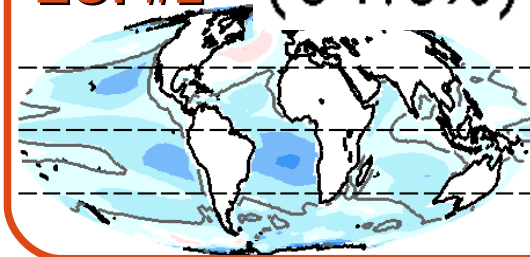
Related to **asymmetries in net radiation flux at TOA, in Pacific**

Less (more) net radiation loss at TOA in South Pacific

- **Warmer** (cooler) **SSTs** over Southern Hemisphere
- **Increased** (decreased) double ITCZ problem in the Pacific

CONCLUSIONS

EOF#1 (64.6%)

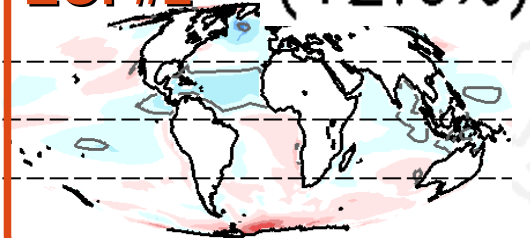


Related to simulation of Scu in eastern tropical oceans

More (less) **Scu** cloud deck cover there leads to:

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- **stratocumulus** (convection) mediated eastern TA

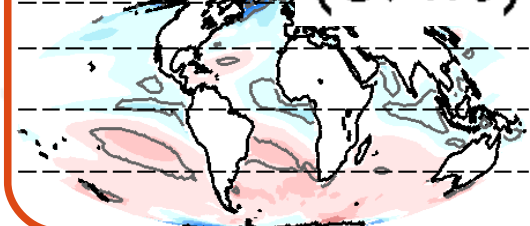
EOF#2 (12.6%)



Related to simulation of AMOC and Antarctic sea ice production

- **Weaker** (stronger) **AMOC** tend to show **southward** (northward) **SSTs** gradient in TA.
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EOF#3 (8.4%)

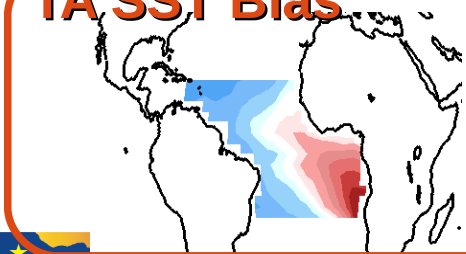


Related to asymmetries in net radiation flux at TOA, in Pacific

Less (more) net radiation loss at TOA in South Pacific

- **Warmer** (cooler) **SSTs** over Southern Hemisphere
- **Increased** (decreased) double ITCZ problem in the Pacific

TA SST Bias



Dominated by EOF#2:

Weak (strong) AMOC **aggravates** (alleviates) TA biases pattern

- Need to **improve Antarctic sea ice** to enhance freshwater export to southern Atlantic and enhance upwelling branch of AMOC