ICTP Workshop on
Teleconnections in Present and Future Climate,
2016 Trieste, Italy

# Atlantic influence on Pacific from interannual to centennial time scales

**Presenting Author: Fred Kucharski, Abdus Salam ICTP, Trieste, Italy**

**Thanks to collaborators: Franco Molteni, In-Sik Kang, Riccardo Farneti, Martin P. King, Aforja Parvi, Belen Rodriguez-Fonseca, Marta Martin-Rey, Irene Polo, Elsa Mohino, Teresa Losada, Carlos R. Mechoso**

The Abdus Salam
International Centre
for Theoretical Physics

**Results published in:**

**Kucharski, F. et al.,** *Atmosphere* **2016**, *7*(2), 29; doi:10.3390/atmos7020029

**and**

**Rodriguez-Fonseca, et al., Geophys. Res. Lett. 2009, 36, L20705.**

**Polo, I. et al., Clim. Dyn. 2014, 44, 115–131.**

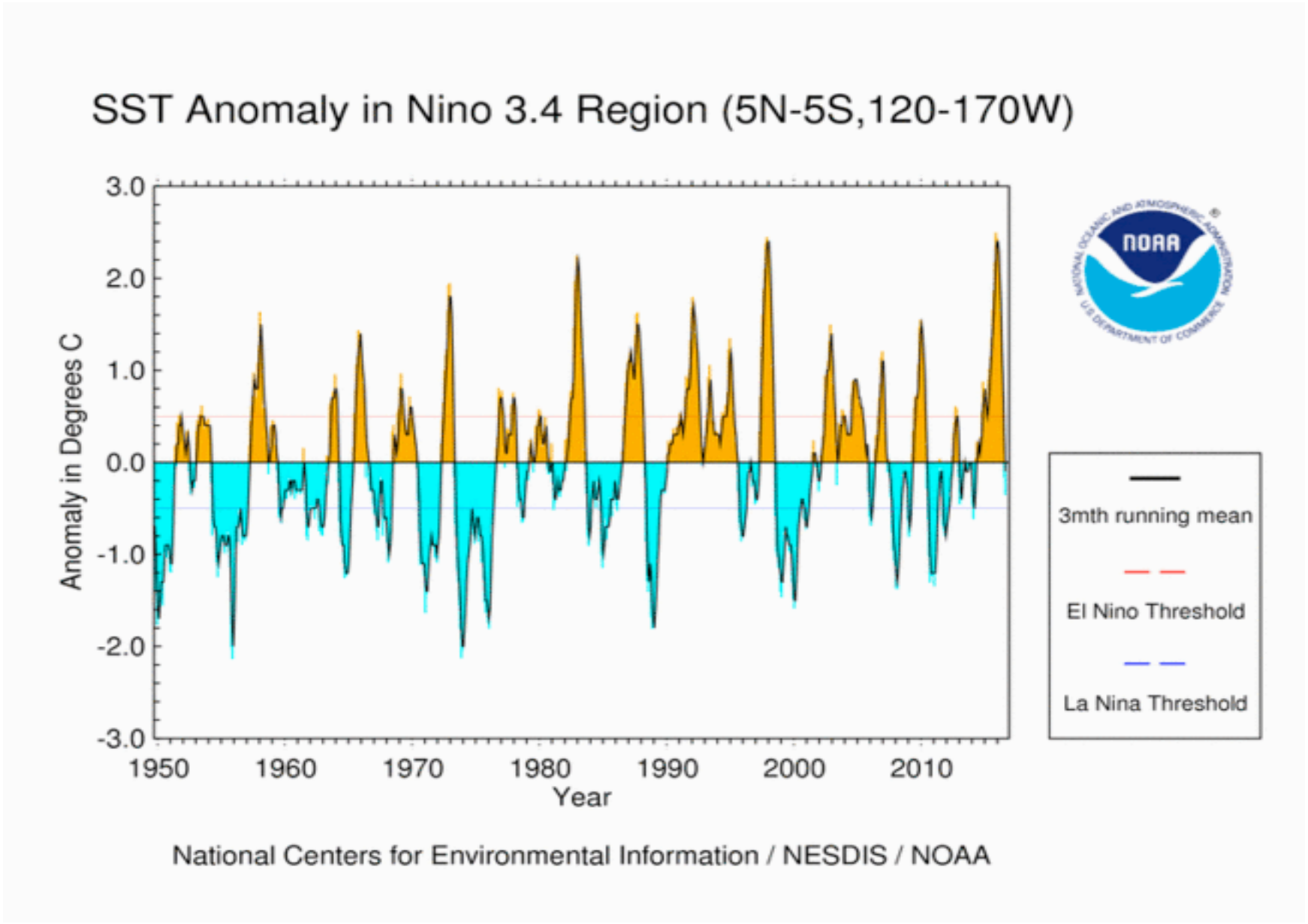
**Martin-Rey M. et al., Sci. Mar. 2012, 76, doi:10.3989/scimar.03610.19A.**

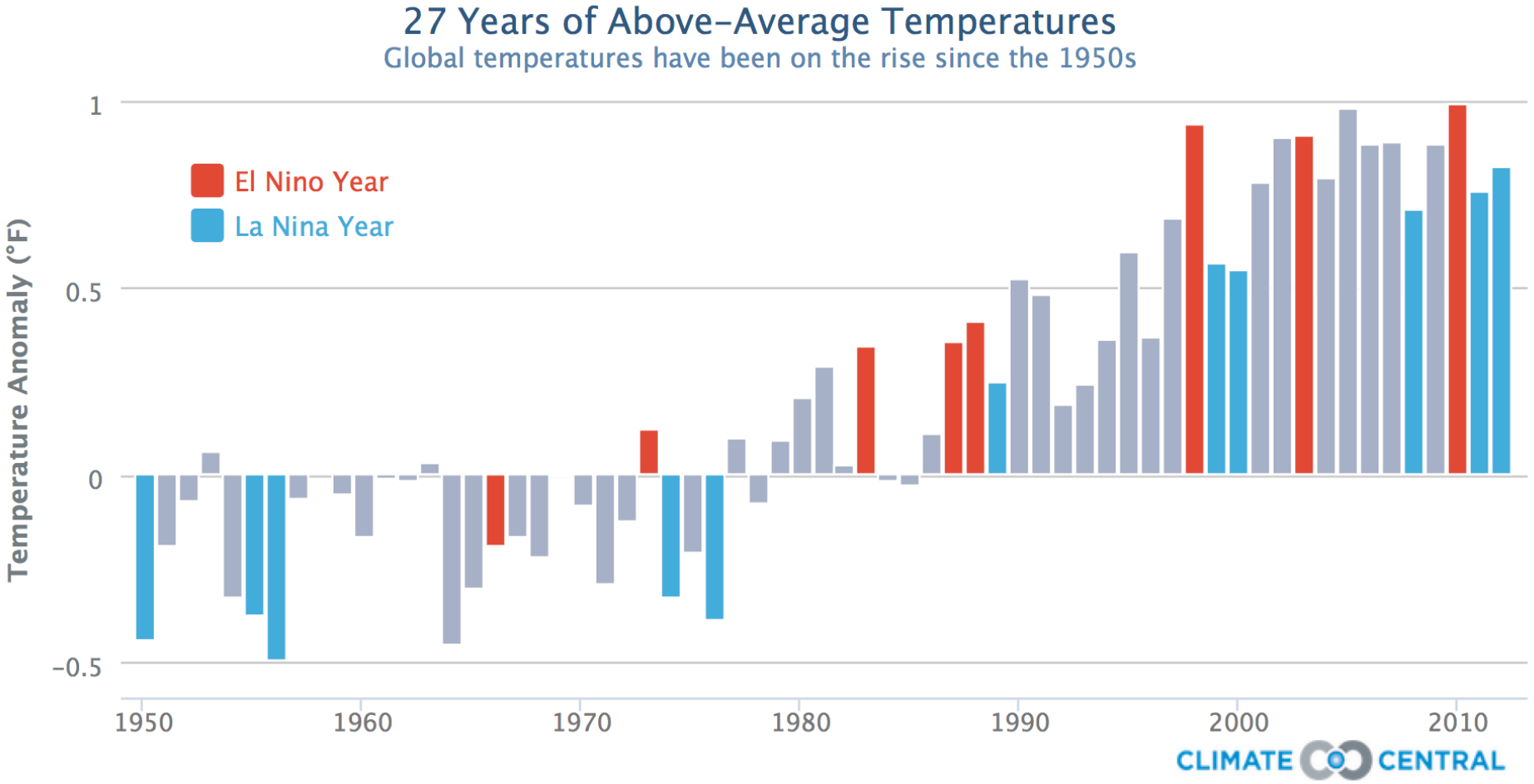
**Martin-Rey, M. et al., Clim. Dyn. 2014, 43, doi:10.1007/s00382-014-2305-3.**

**Kucharski, F. et al. Clim. Dyn. 2014, 44, doi:10.1007/s00382-014-2228-z.**

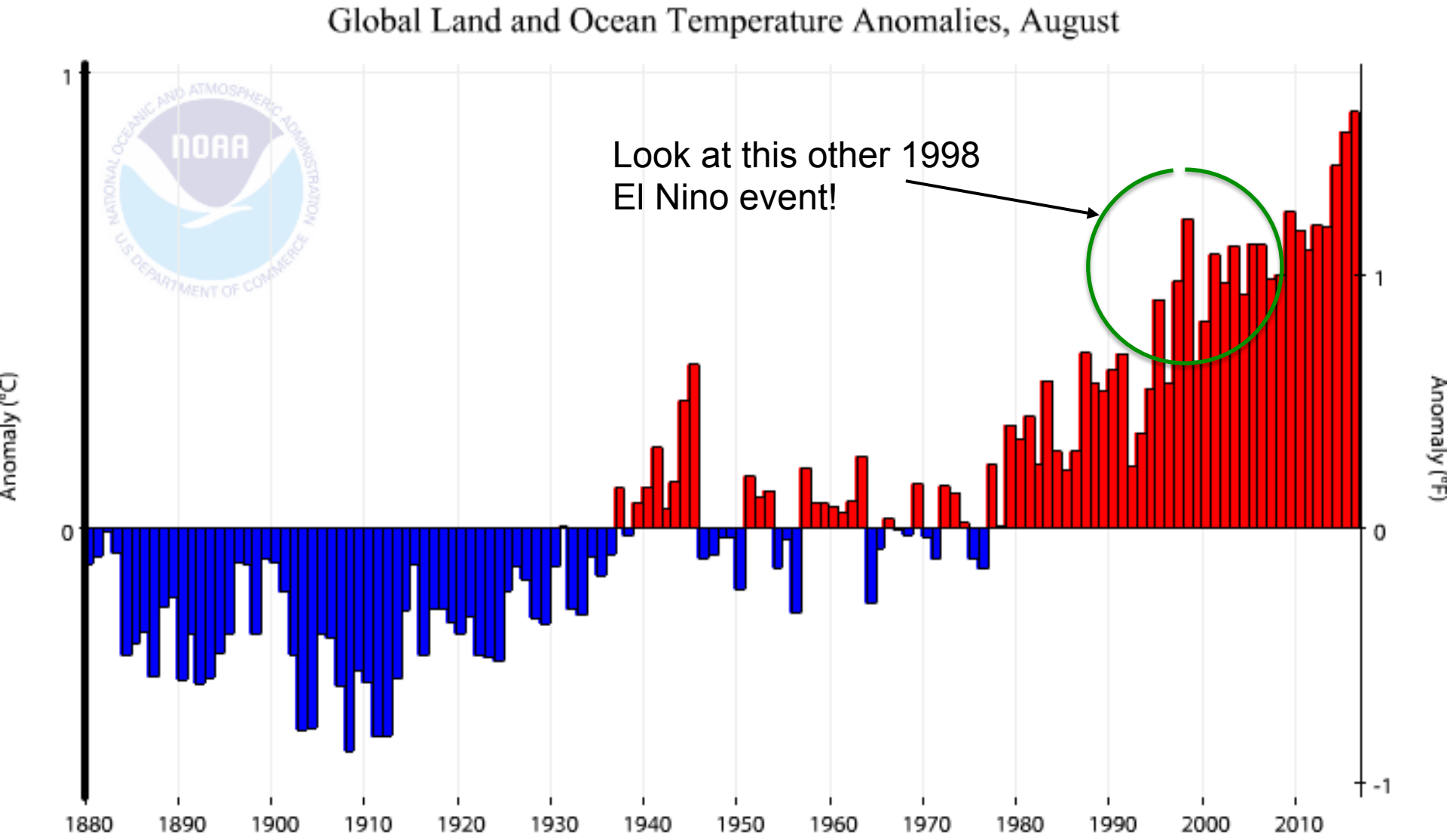
**Kucharski, F. et al., Clim. Dyn. 2015, doi:10.1007/s00382-015-2705-z.**

It turns out that the 2015/2016 El Nino event was the strongest in the recent history

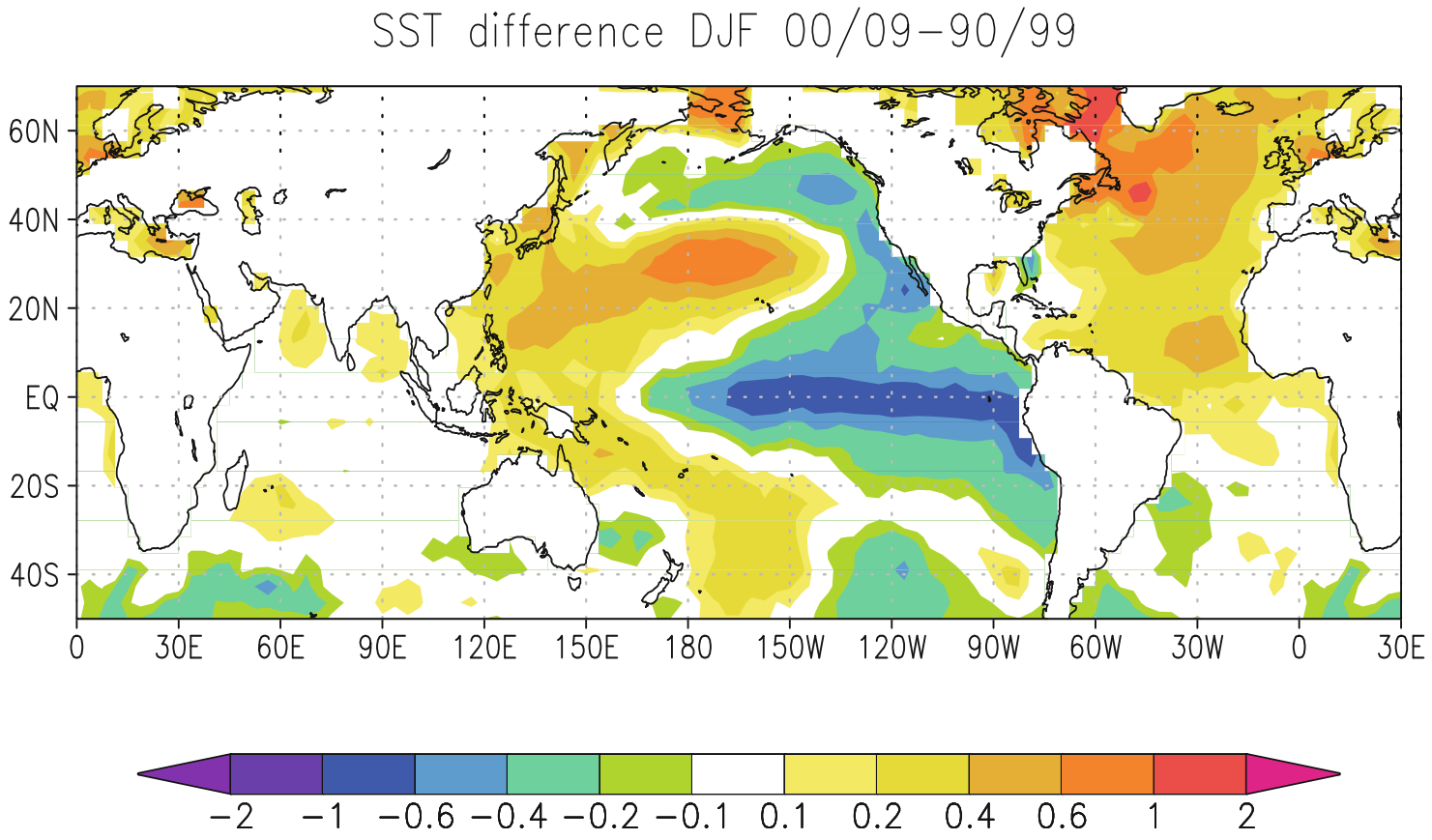



27 Years of Above-Average Temperatures
Global temperatures have been on the rise since the 1950s
El Nino Year
La Nina Year
Temperature Anomaly (°F)
1
0.5
0
-0.5
1950
1960
1970
1980
1990
2000
2010
CLIMATE CENTRAL

First impact: Global mean temperatures have started to rise more strongly again after a period of stagnation (hiatus)



This was due to a decade of La Nina-type mean state conditions in the tropical Pacific (Figure from Farneti et al, 2013)

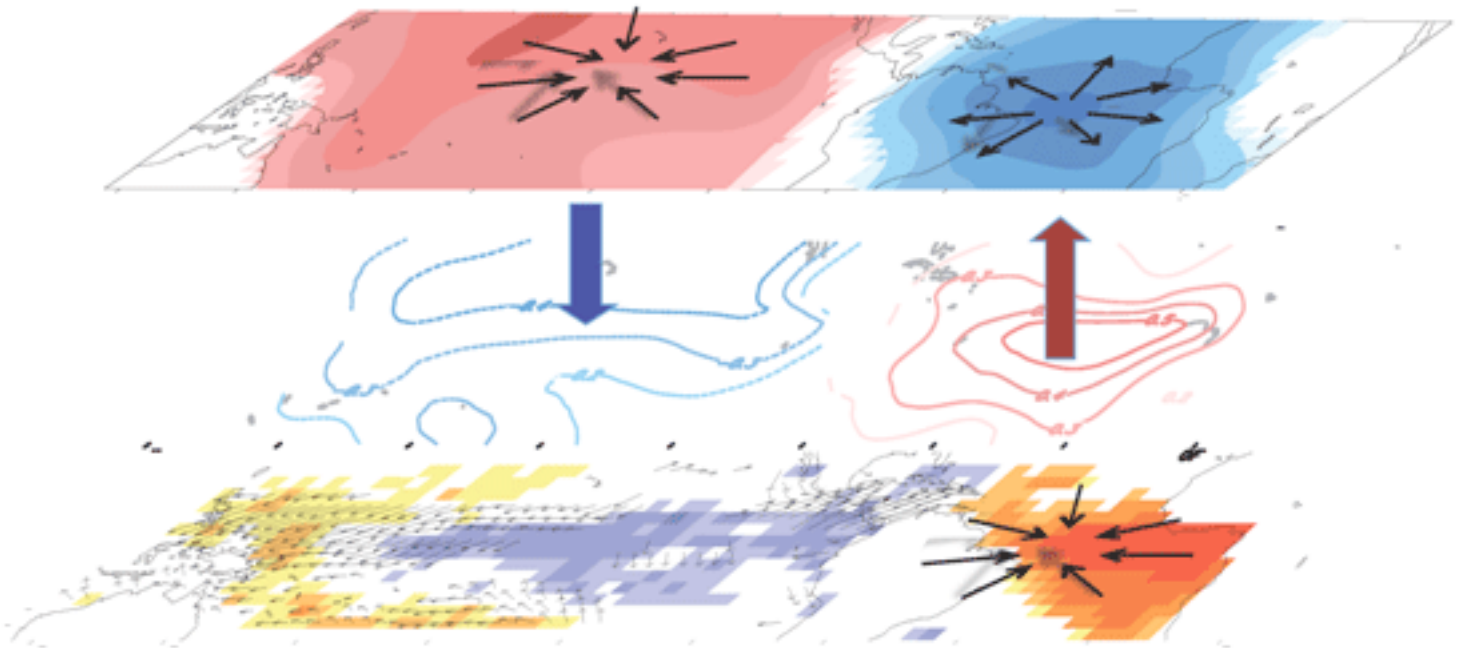


**Recent literature on Atlantic impact on Pacific:**

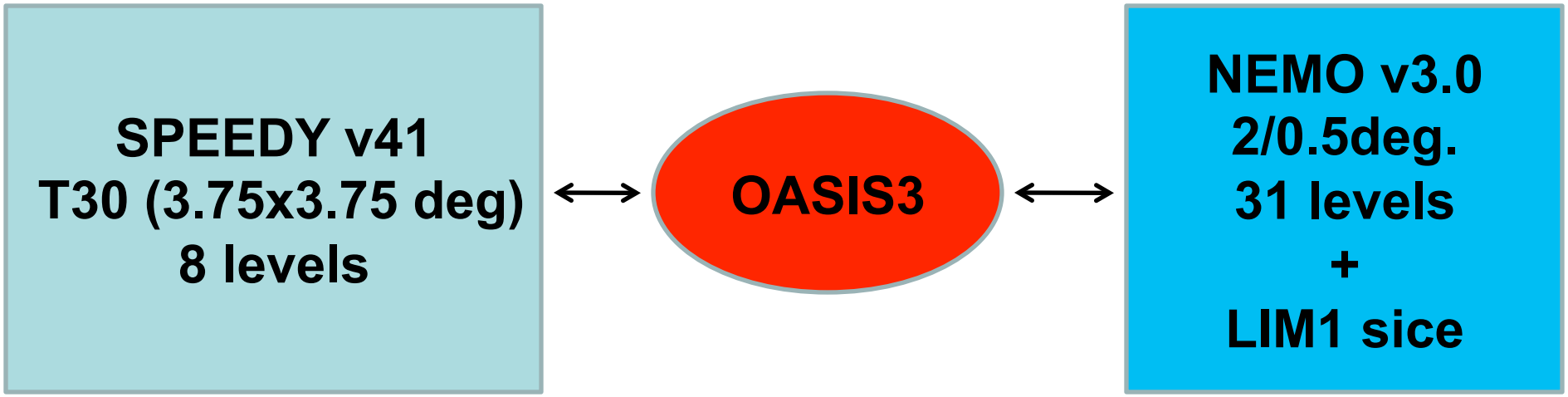
**a) Interannual, for example:**
**Rodriguez-Fonseca et al. (2009), Jansen et al. (2009), Martin-Rey et al. (2012, 2014, 2015), Ding et al. (2012), Frauen et al. (2012), Keenlyside et al. (2013), Ham et al. (2013a, 2013b), Polo et al. (2014), Kucharski et al. (2014), Sasaki et al. (2014), Terray et al. (2016), .....**

**b) Decadal-to-multidecadal, for example:**
**Timmermann et al. (2007), Zhang and Delworth (2007), Lu et al. (2008) Kucharski et al. (2011, 2015, 2016), Chikamoto et al. (2012, 2015, 2016), McGregor et al. (2014), Kang et al. (2014), Li et al., (2015), and likely many more....**

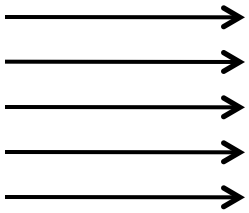
**How can the ‘small’ Atlantic Ocean impact variability in the ‘big’ Pacific Ocean? Probably the Atlantic Ocean can provide some initial persistent forcing that is amplified in the Pacific through positive feedback (e.g. Bjerknes feedback and others).**



## Coupled SPEEDY-NEMO-LIM model



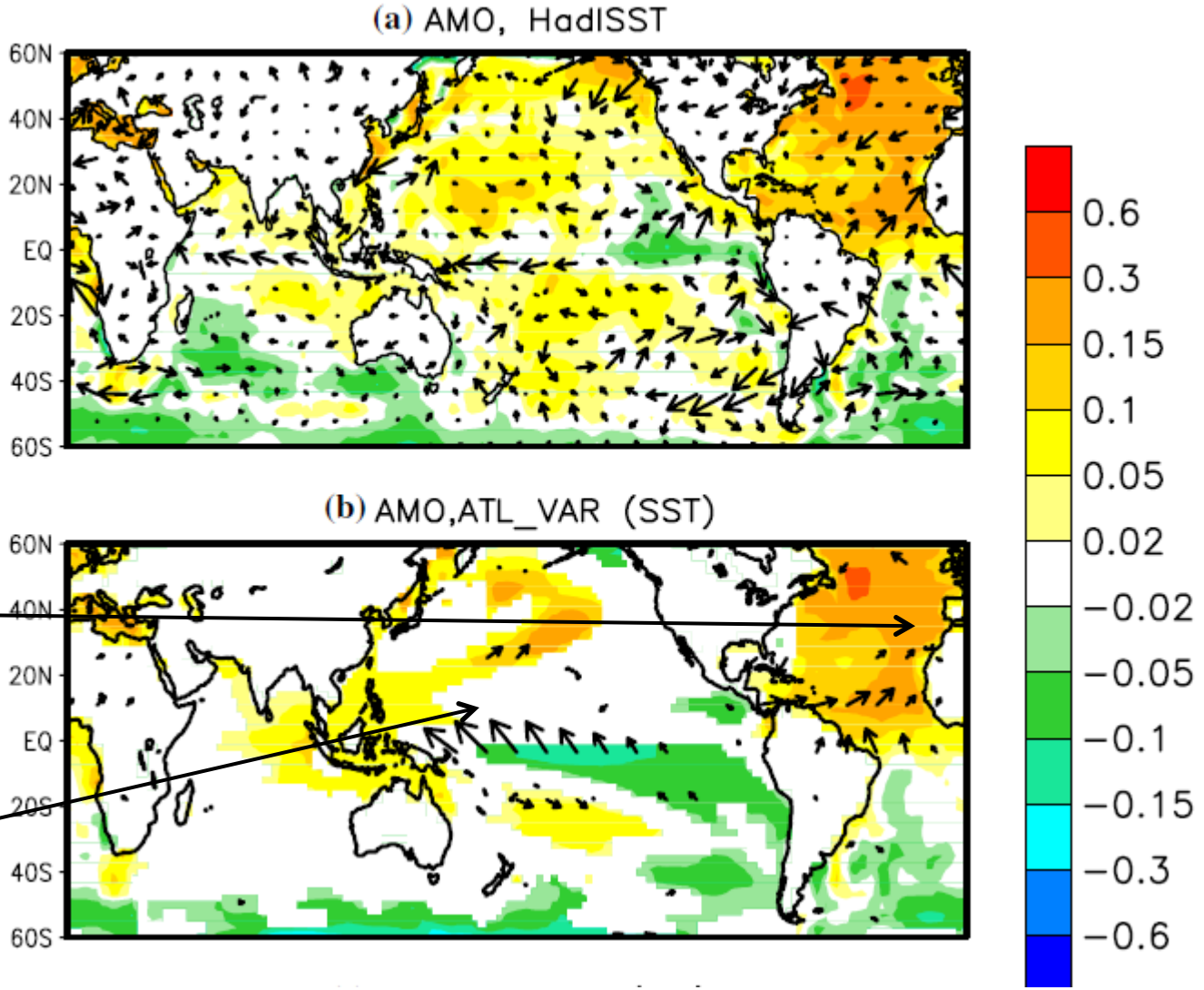

Ens. generation



**Pertur. Init. Cond.**

A short history!

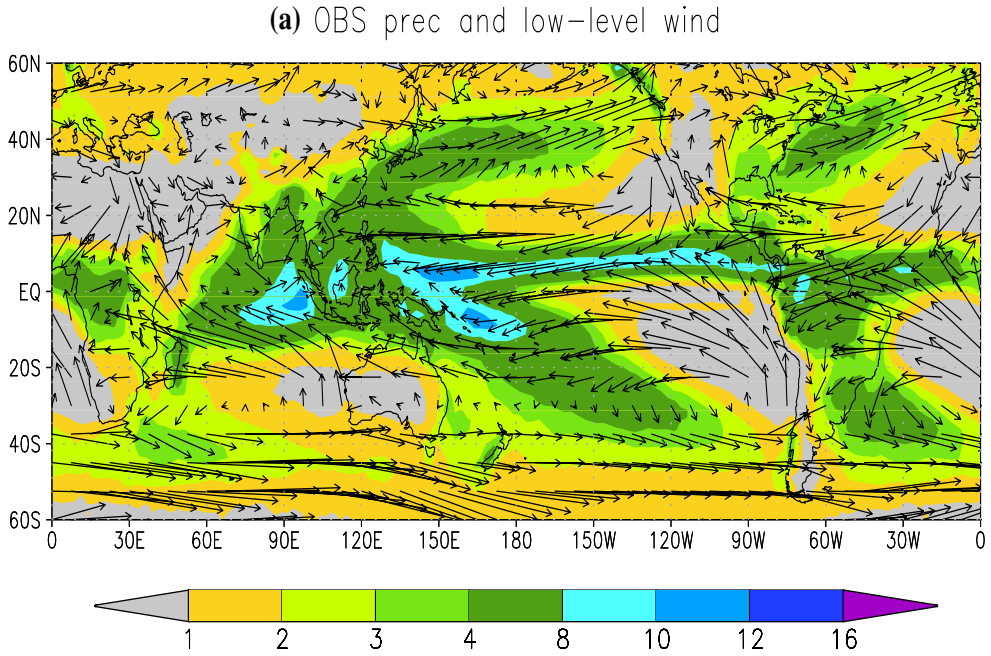
# Atlantic Pacemaker experiments

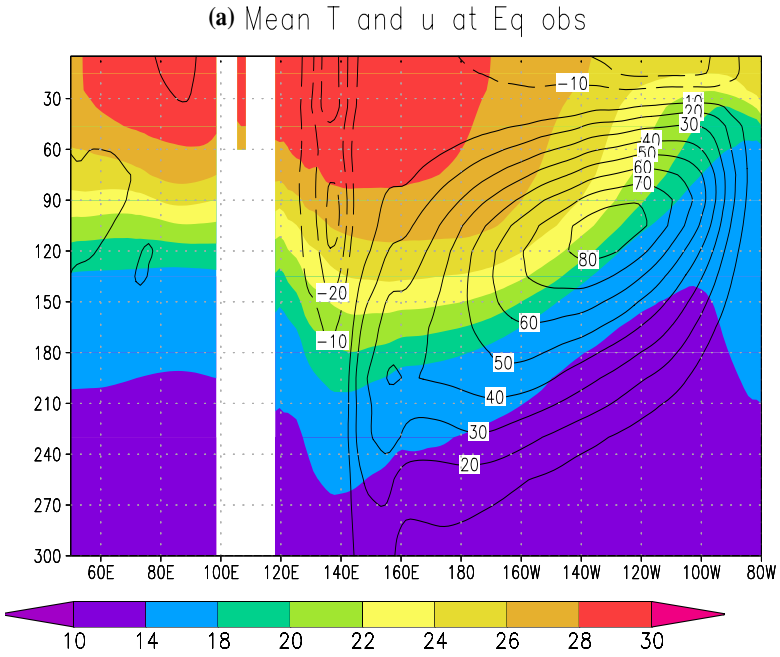


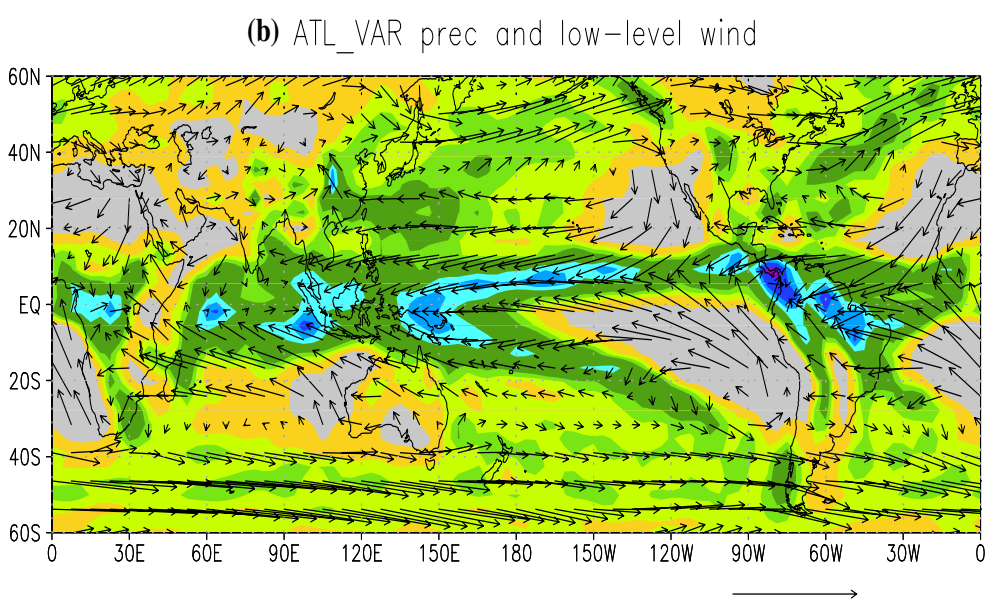

Prescribed Observed SSTs in Atlantic

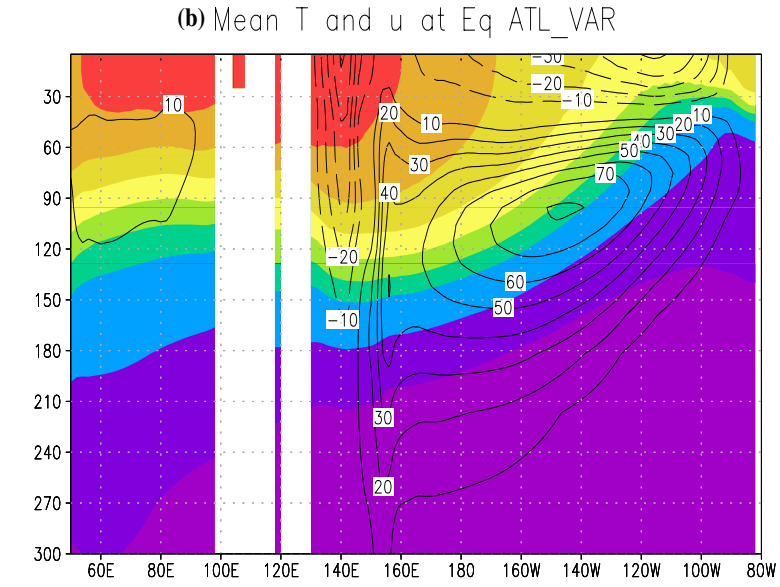
Fully coupled in Indo-Pacific (but flux-corrected)

# Some basic validation: Rainfall and Eq. Pacific Ocean

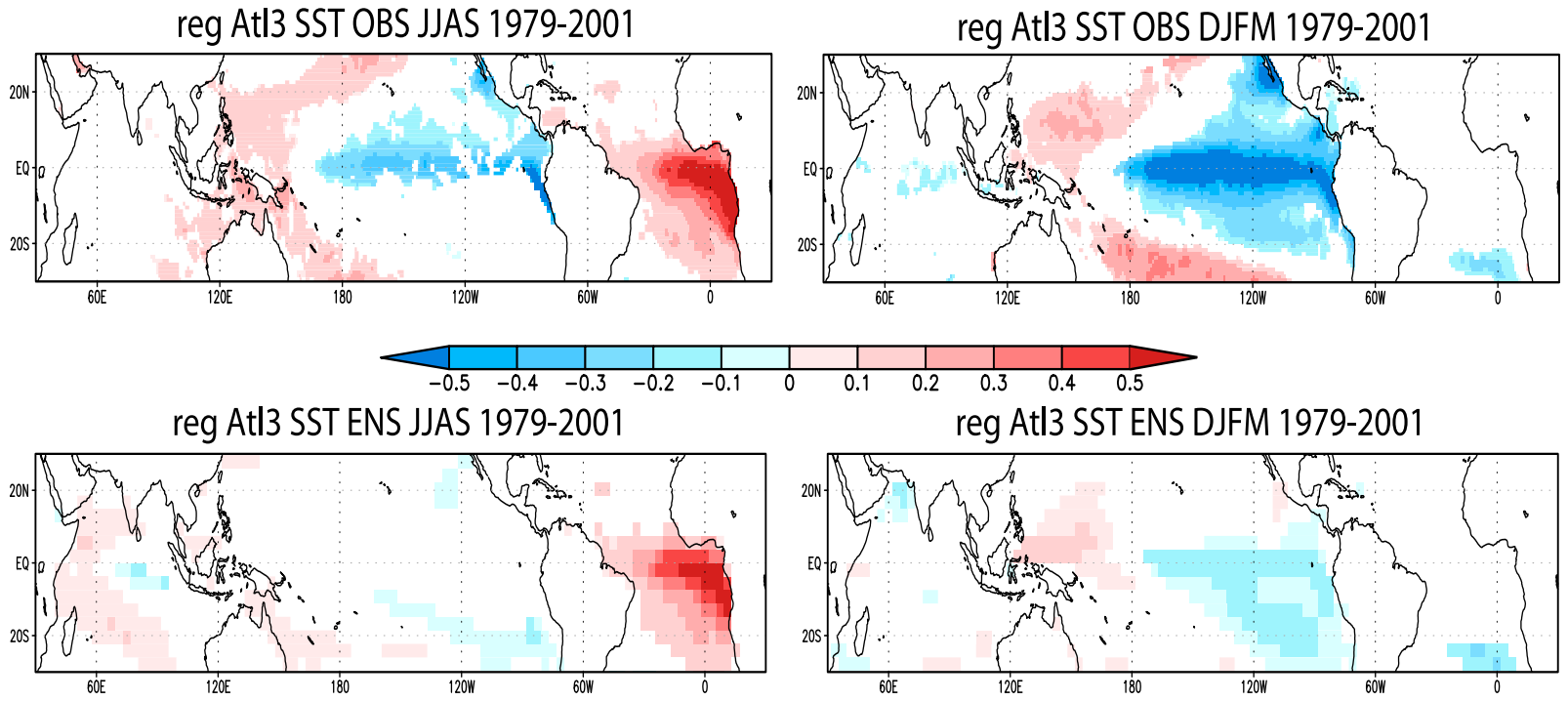


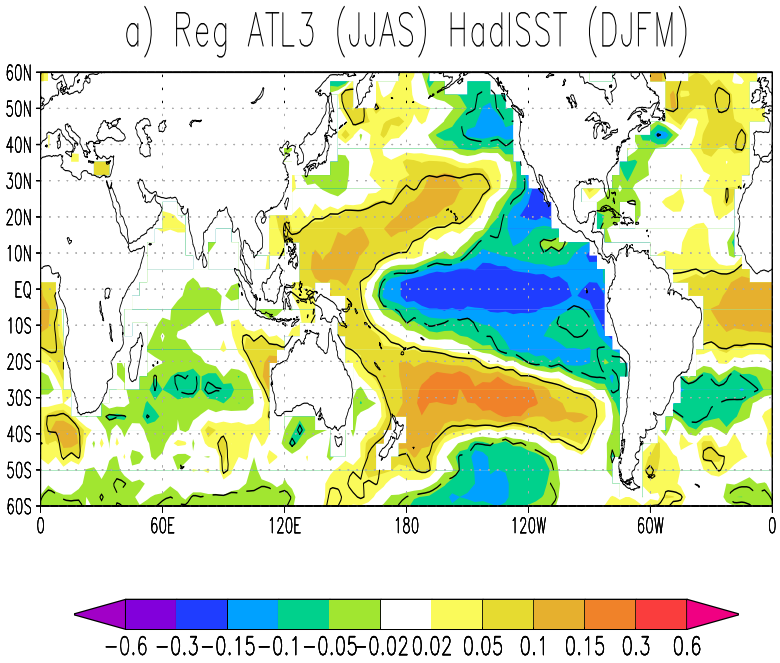



a) Atlantic zonal mode impact on ENSO

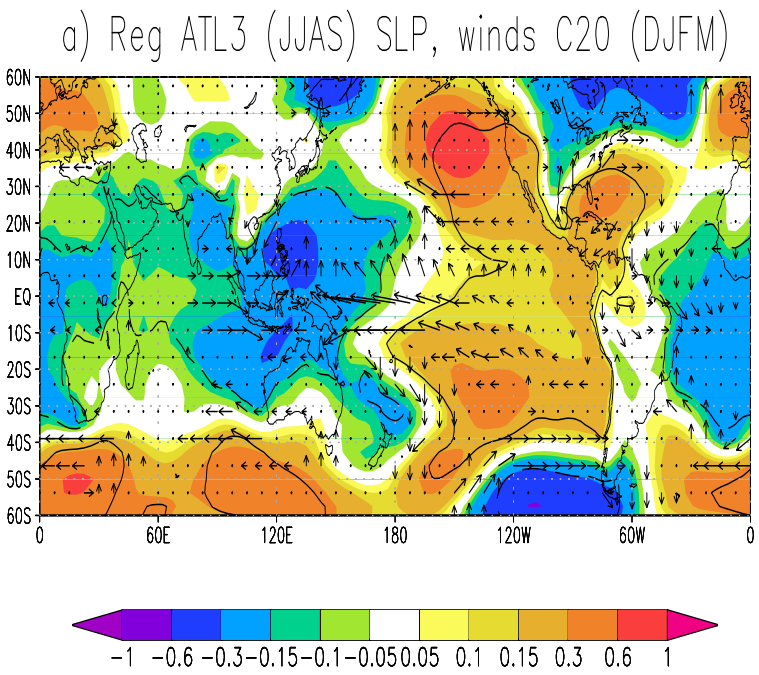


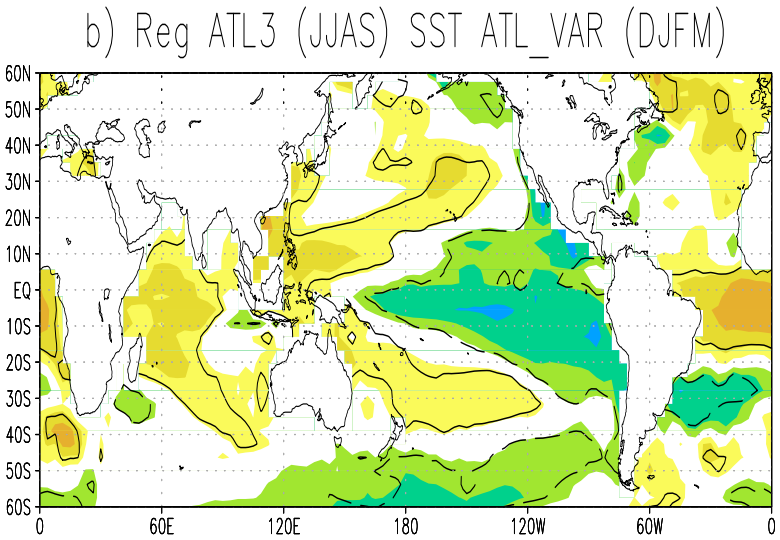

From Rodriguez-Fonseca et al. (2009) for period 1979 to 2001
Experiments done with speedy coupled to an RGO.

# Analysis period: 1901 to 2010, JJAS ATL3 regression onto following DJFM fields

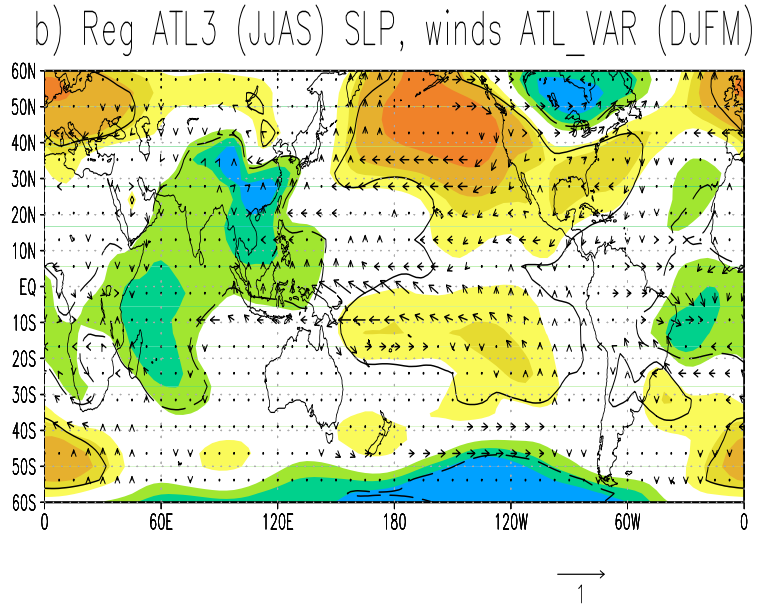



**OBS**



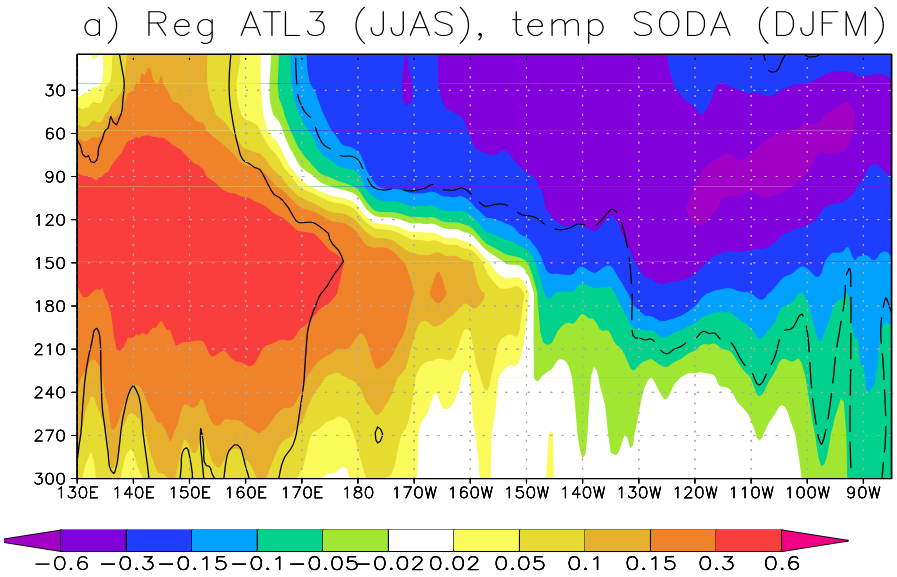

**Model**



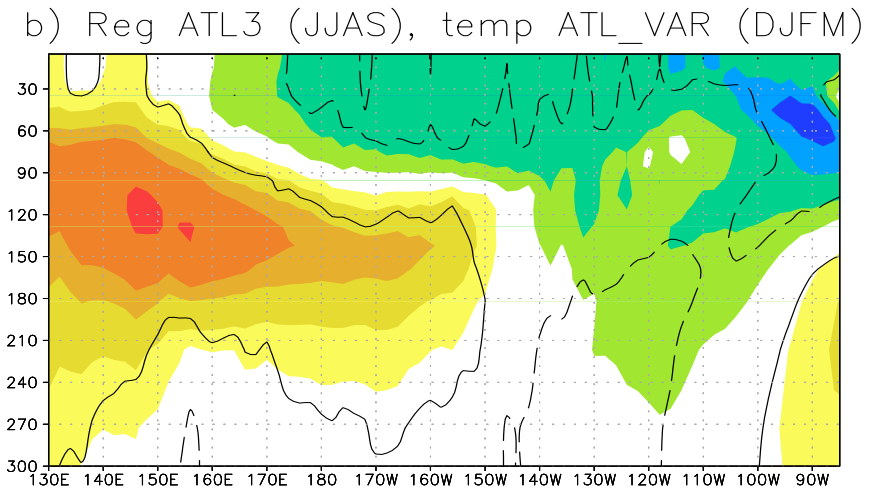
**Analysis period: 1901 to 2010, JJAS ATL3 regression onto following DJFM fields**

Equatorial Pacific section

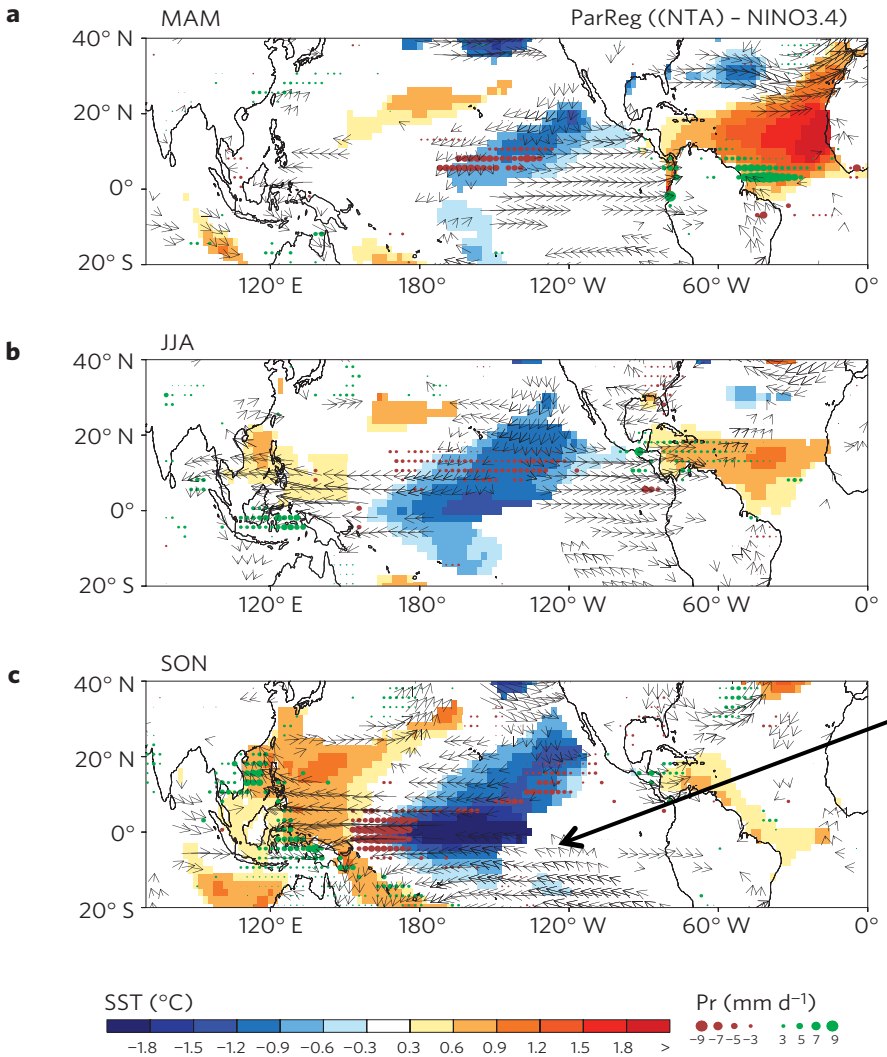
**OBS**




**Model**



## b) North tropical Atlantic impact on ENSO

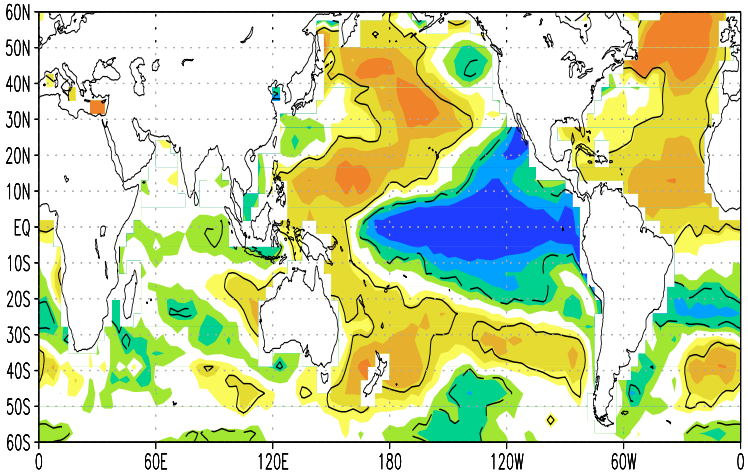


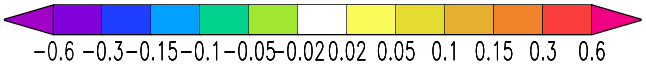

In this paper they argued that ENSO's forced by the North Tropical Atlantic are typically central Pacific ENSOs (perhaps helped by lack of stat. sig. response in eastern parts

From Ham et al. (2013) for period 1980 to 2010

# Analysis period: 1901 to 2010, FMA NTA regression onto following DJFM fields

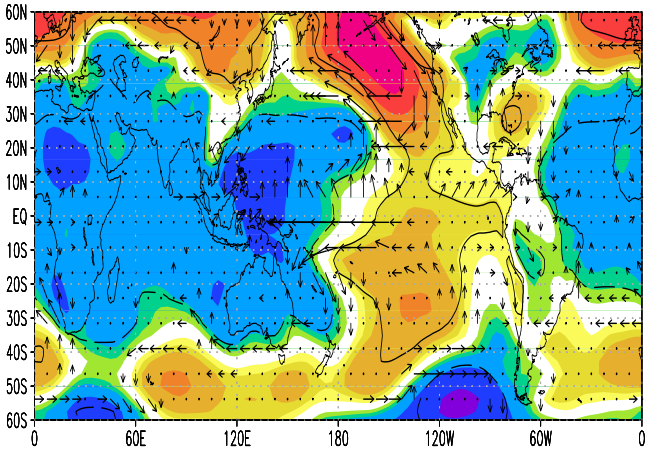
a) Reg NTA (FMA) HadISST (DJFM)

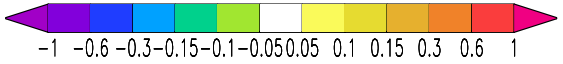


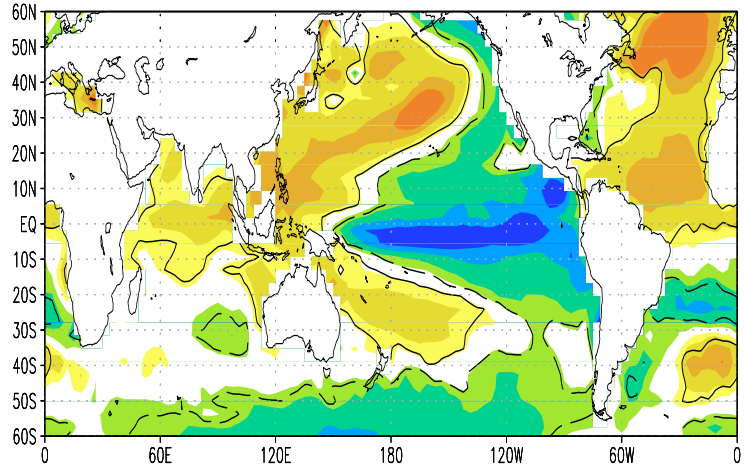

**OBS**

a) Reg NTA (FMA) SLP, winds C20 (DJFM)



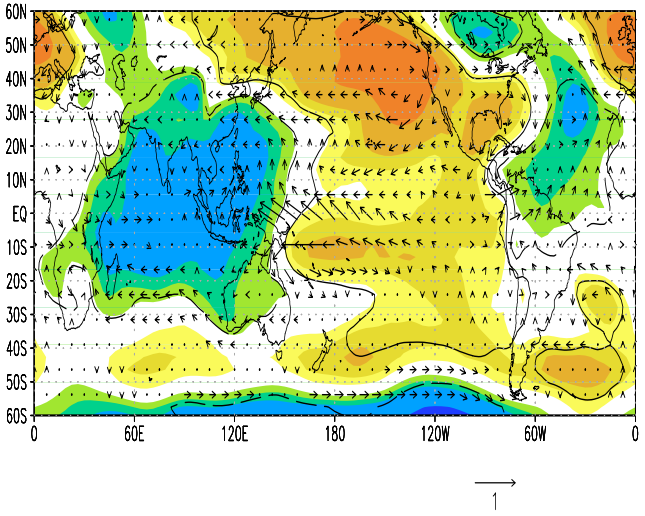




b) Reg NTA (FMA) SST ATL_VAR (DJFM)




**Model**

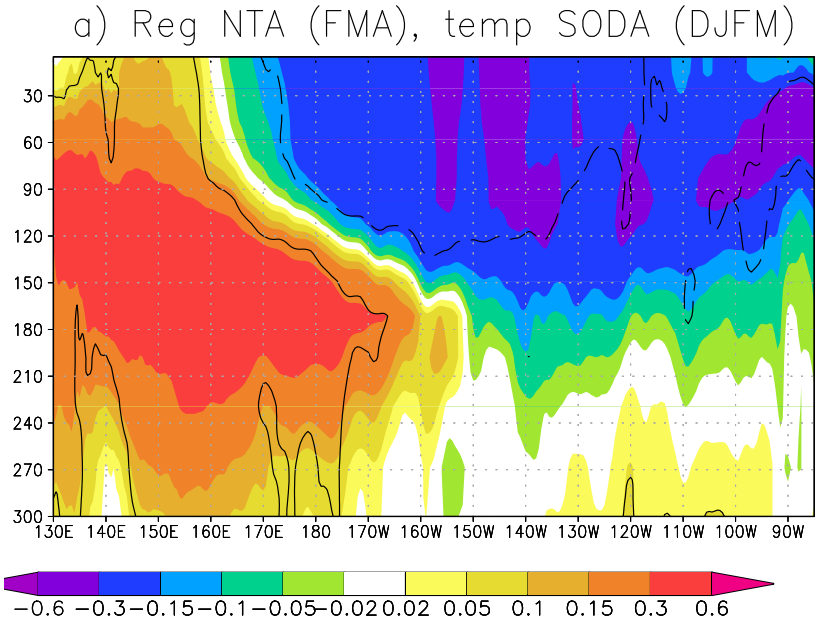
b) Reg NTA (FMA) SLP, winds ATL_VAR (DJFM)



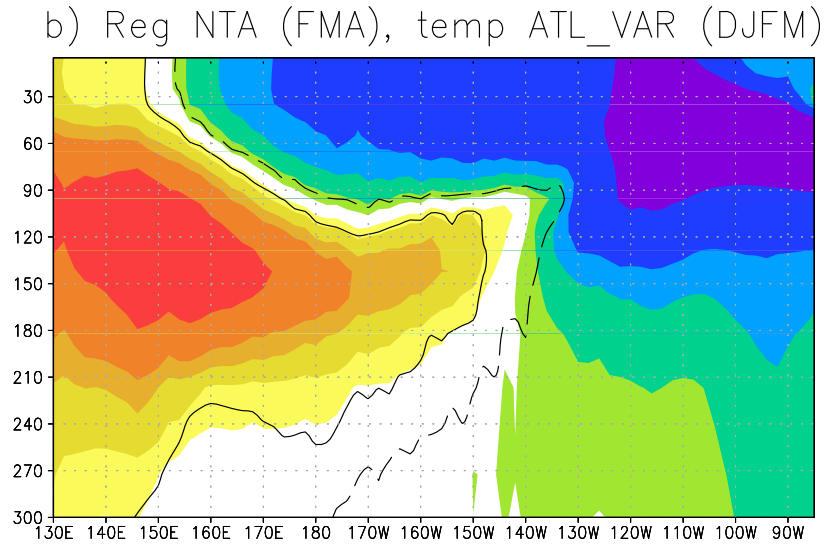
**Analysis period: 1901 to 2010, FMA NTA regression onto following DJFM fields**

Equatorial Pacific section

**OBS**

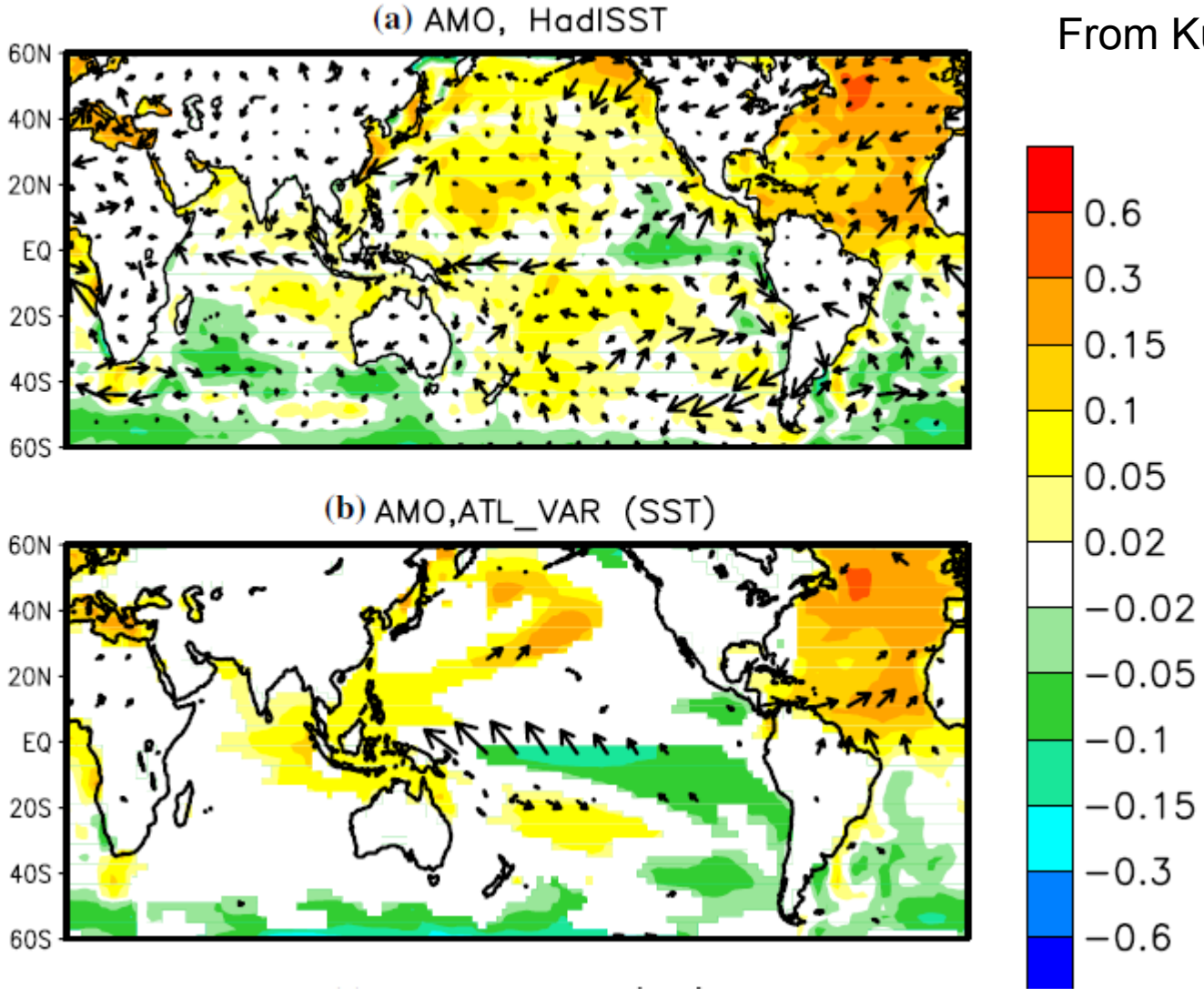



**Model**



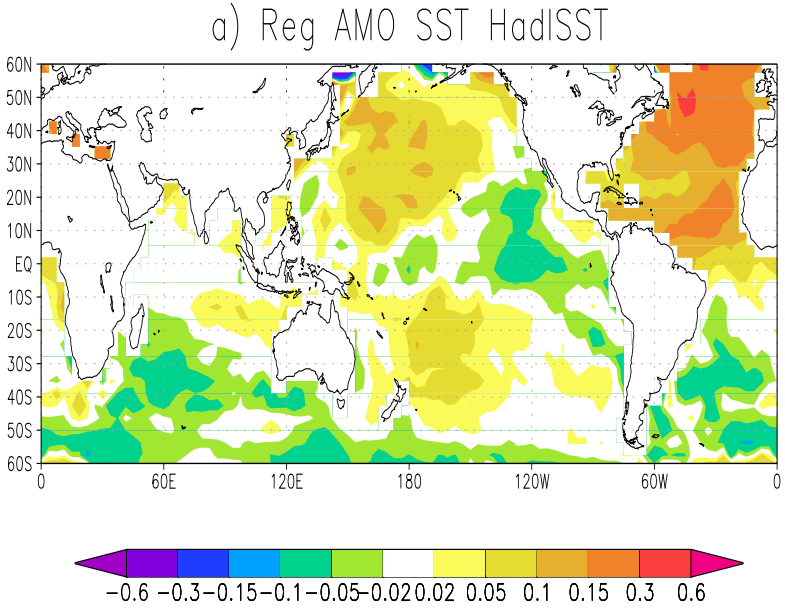

Seems rather canonical to me!

c) Atlantic Multidecadal Variability impact on Indo-Pacific

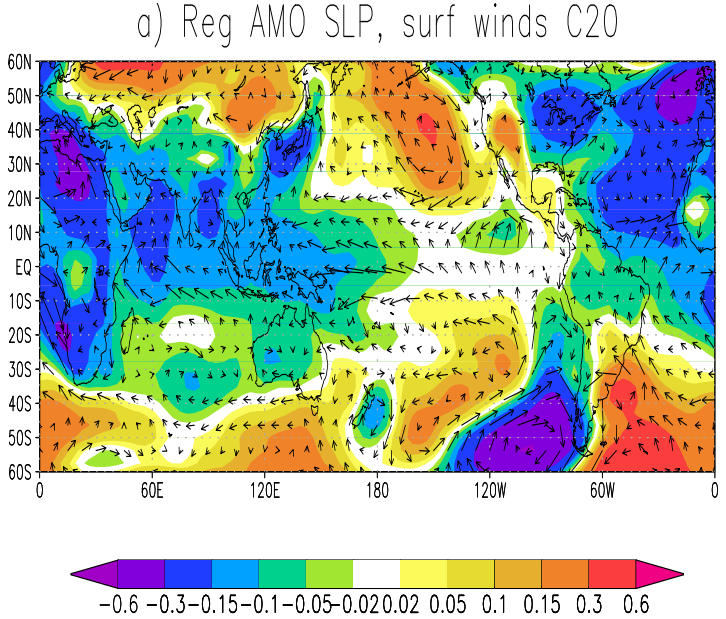


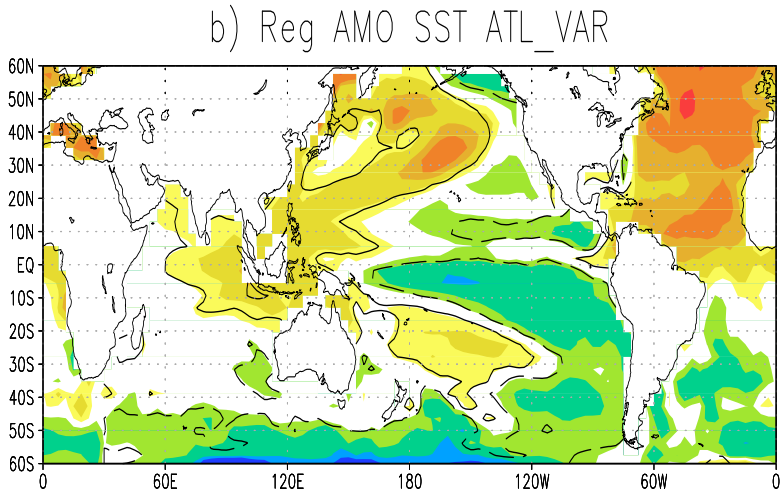

From Kucharski et al. (2015)

# Analysis period: 1901 to 2010, annual mean AMO index regressions

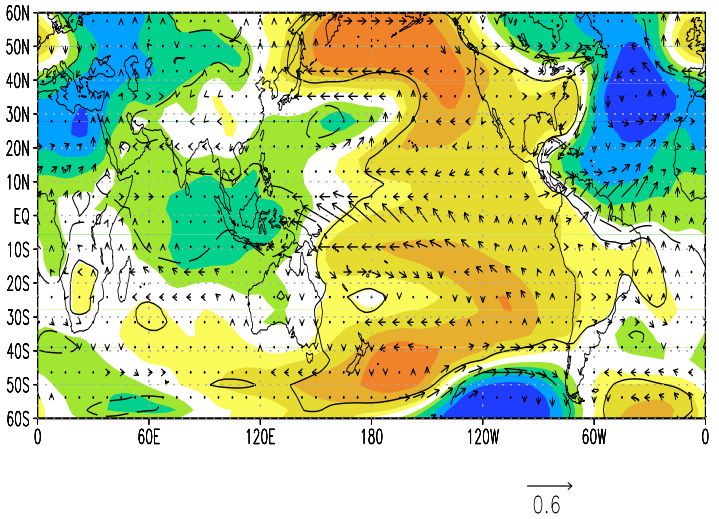



**OBS**



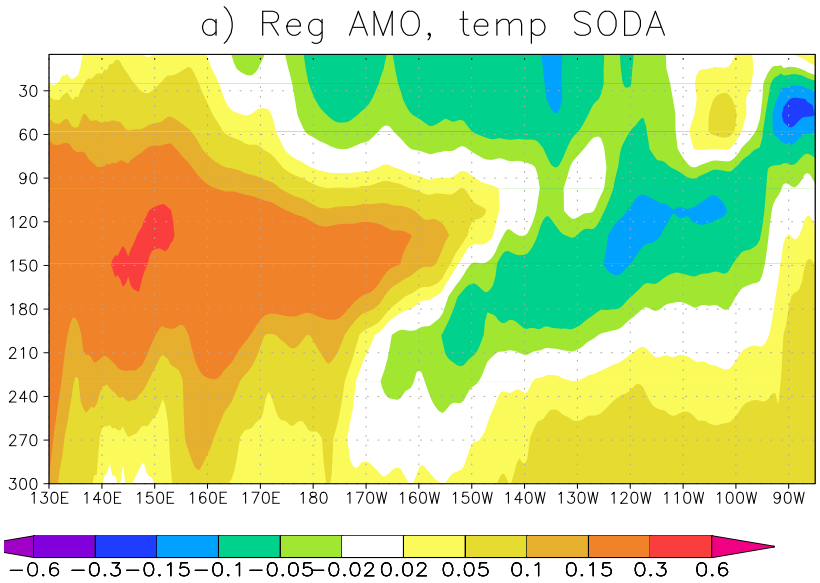

**Model**



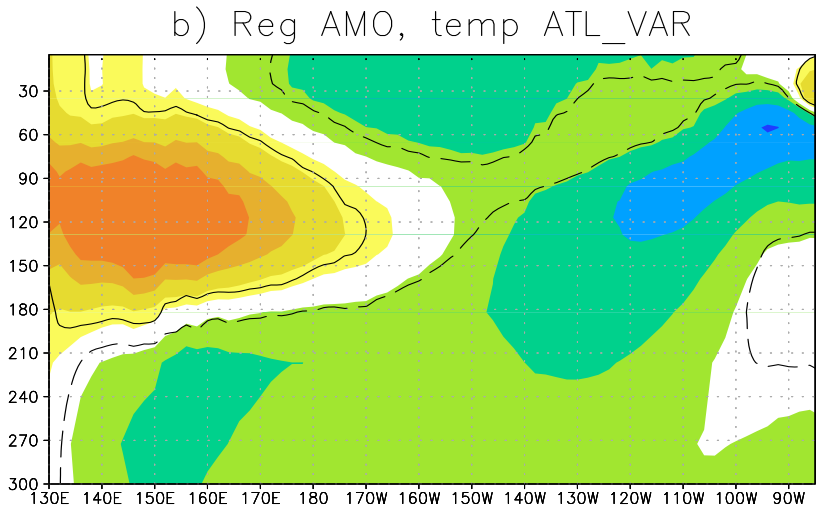
# Analysis period: 1901 to 2010, annual mean AMO index regressions

## Equatorial Pacific section

**OBS**



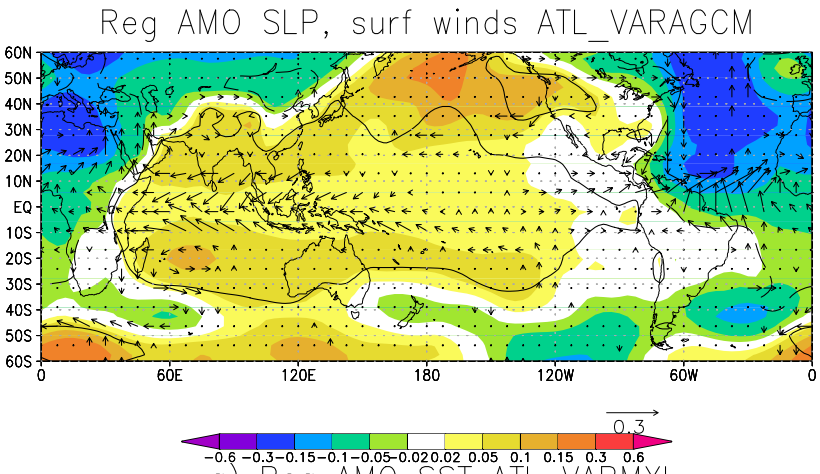

**Model**



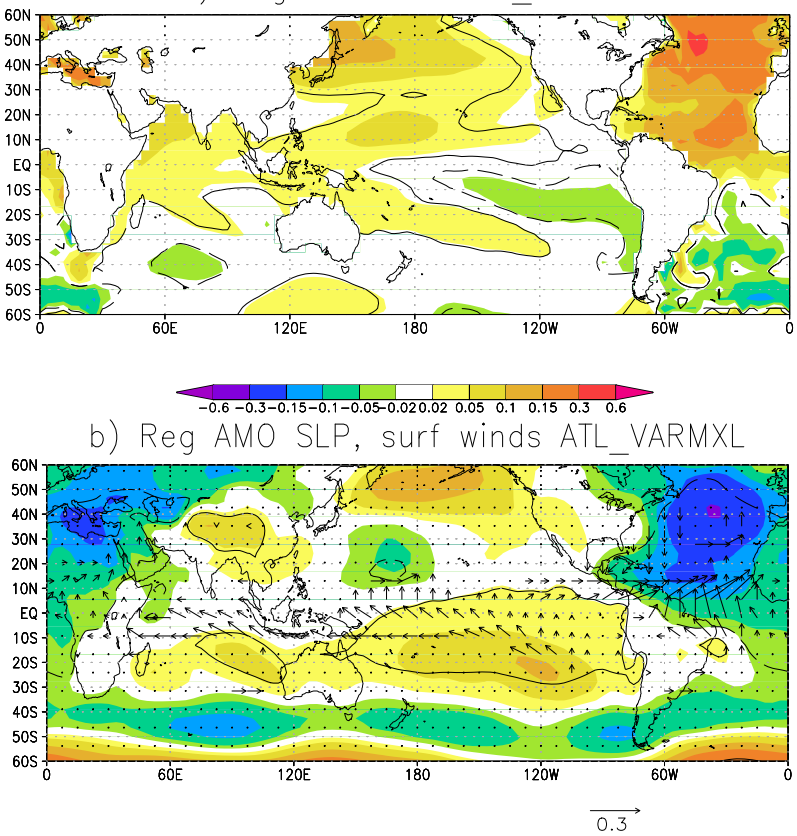

Subsurface signal indicates importance of ocean dynamics

# Analysis period: 1901 to 2010, annual mean AMO index regressions

AGCM

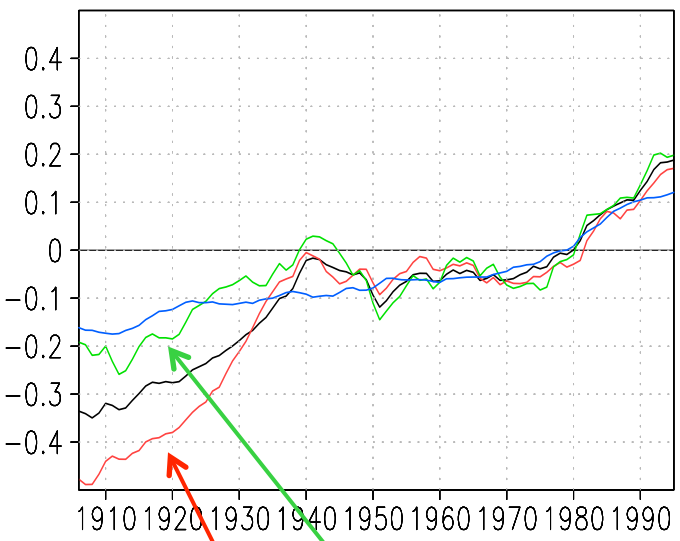



Slab-Ocean




Li et al. (2015) in a Nat. Geo. paper pointed to the importance of mixed-layer adjustment proc in WP. Indeed, it seems that mixed-layer adjustments are very important as preconditioning, also verified for interannual time scales!
And perhapsdominate the WP response!

# d) Atlantic long term trend influences on Indo-Pacific



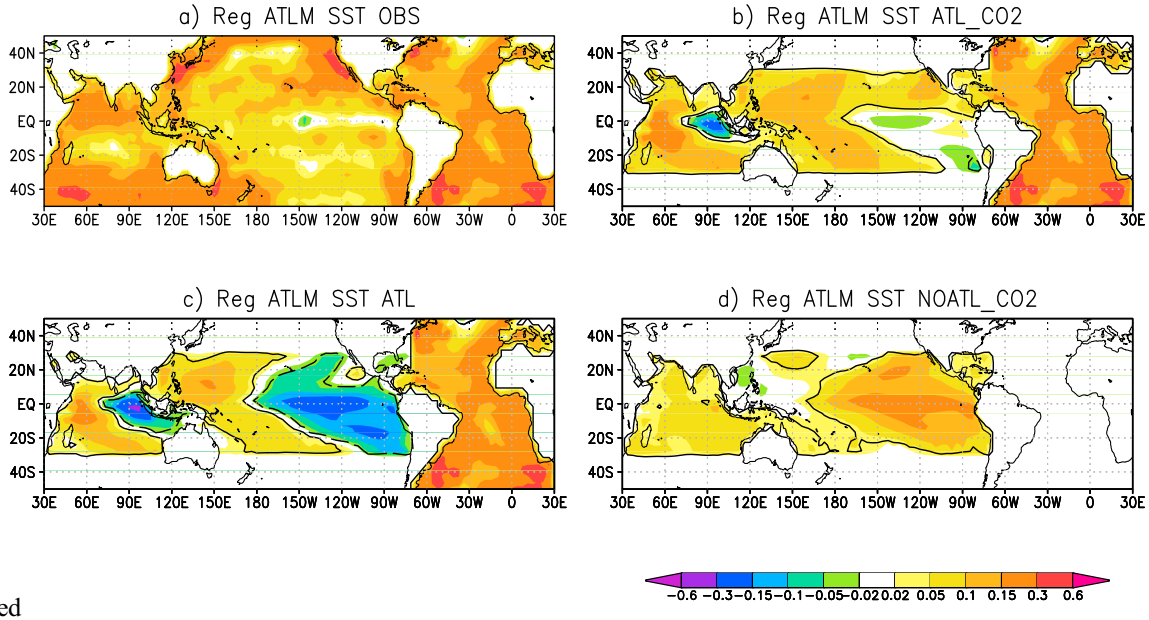




**Figure 1.** Time series of annual mean and 11-year filtered SST anomalies (with respect to the period 1961 to 1990); Global mean SST (black), Atlantic mean SST (red), tropical Pacific mean HadISST (green) and Pacific mean ATL_CO2 (blue). Unit are K.

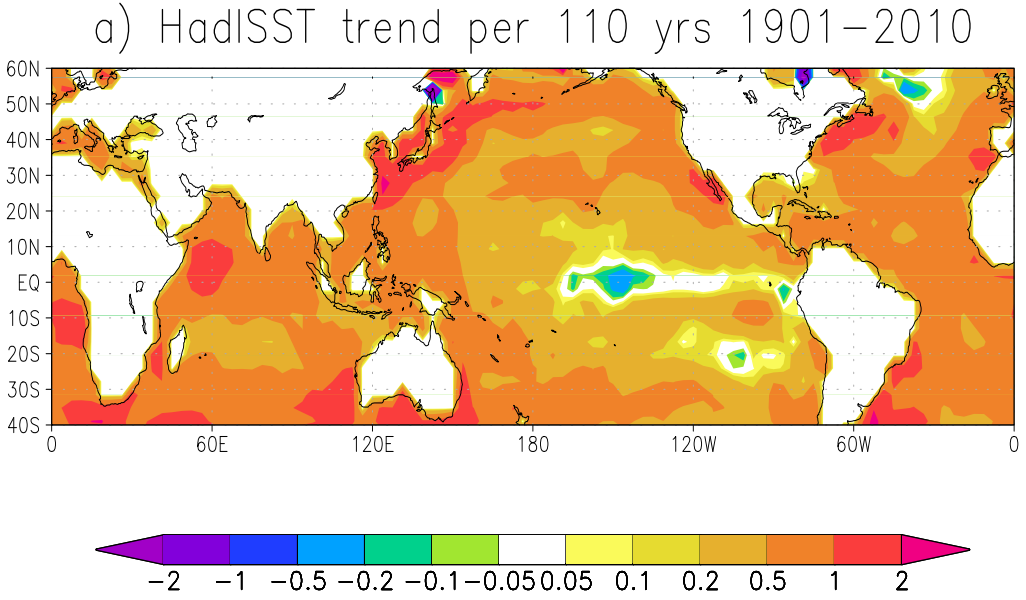
Tropical Pacific

Tropical Atlantic

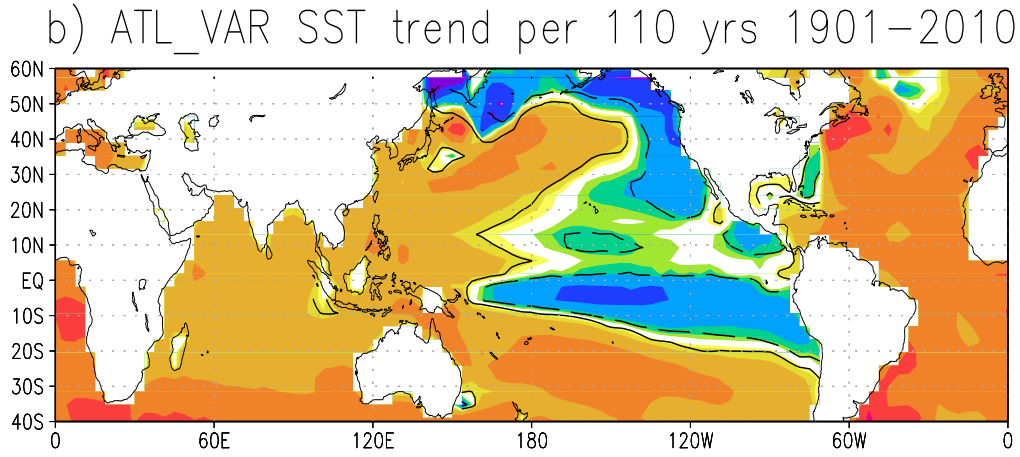
From Kucharski et al. (2011); also here speedy coupled to RGO

# Linear trend for period 1901 to 2010

**OBS**



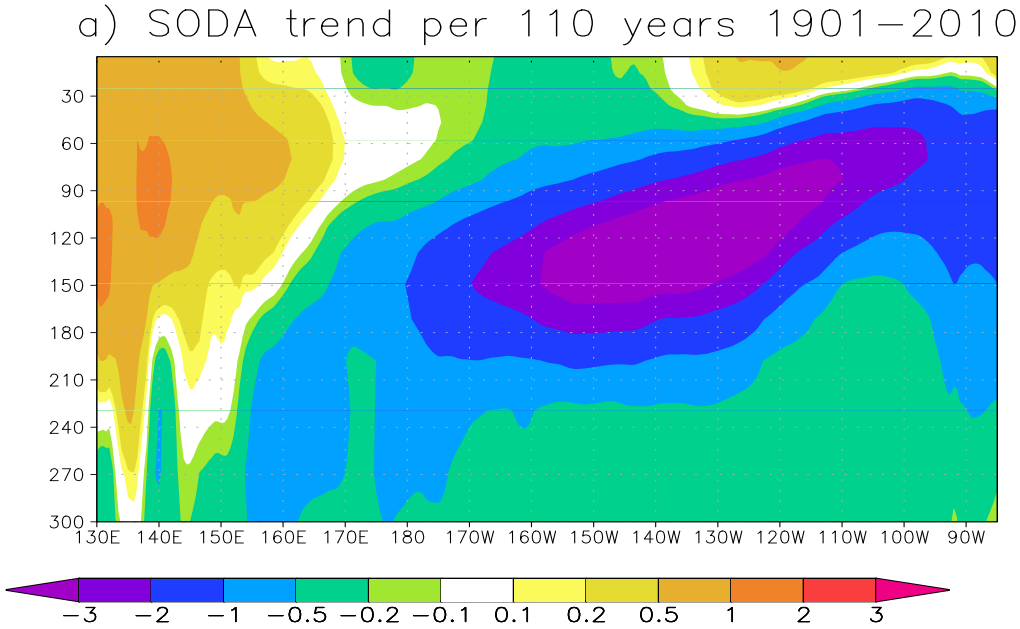

**Model (no CO2 forcing)**



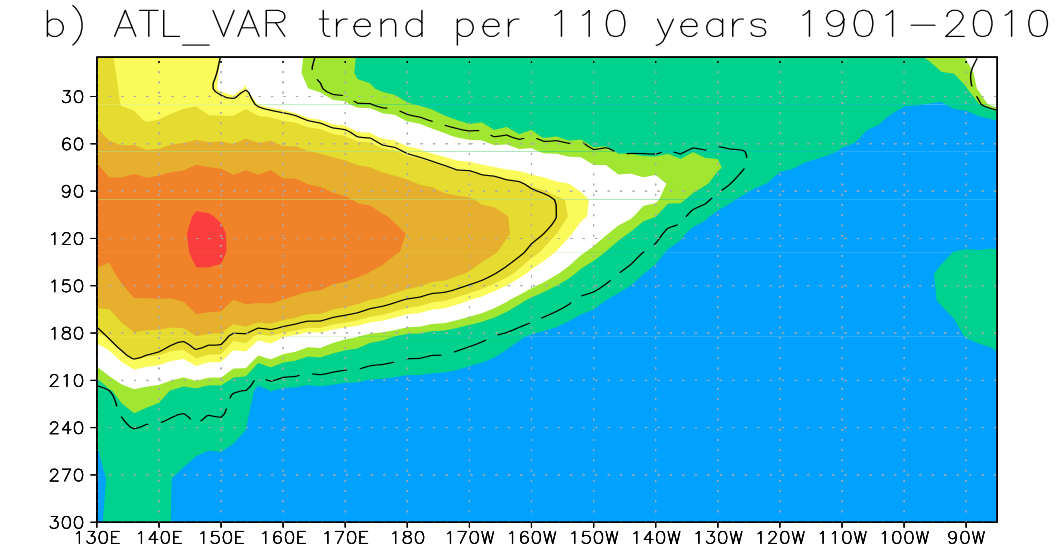
# Linear trend for period 1901 to 2010

## Equatorial Pacific section

**OBS**

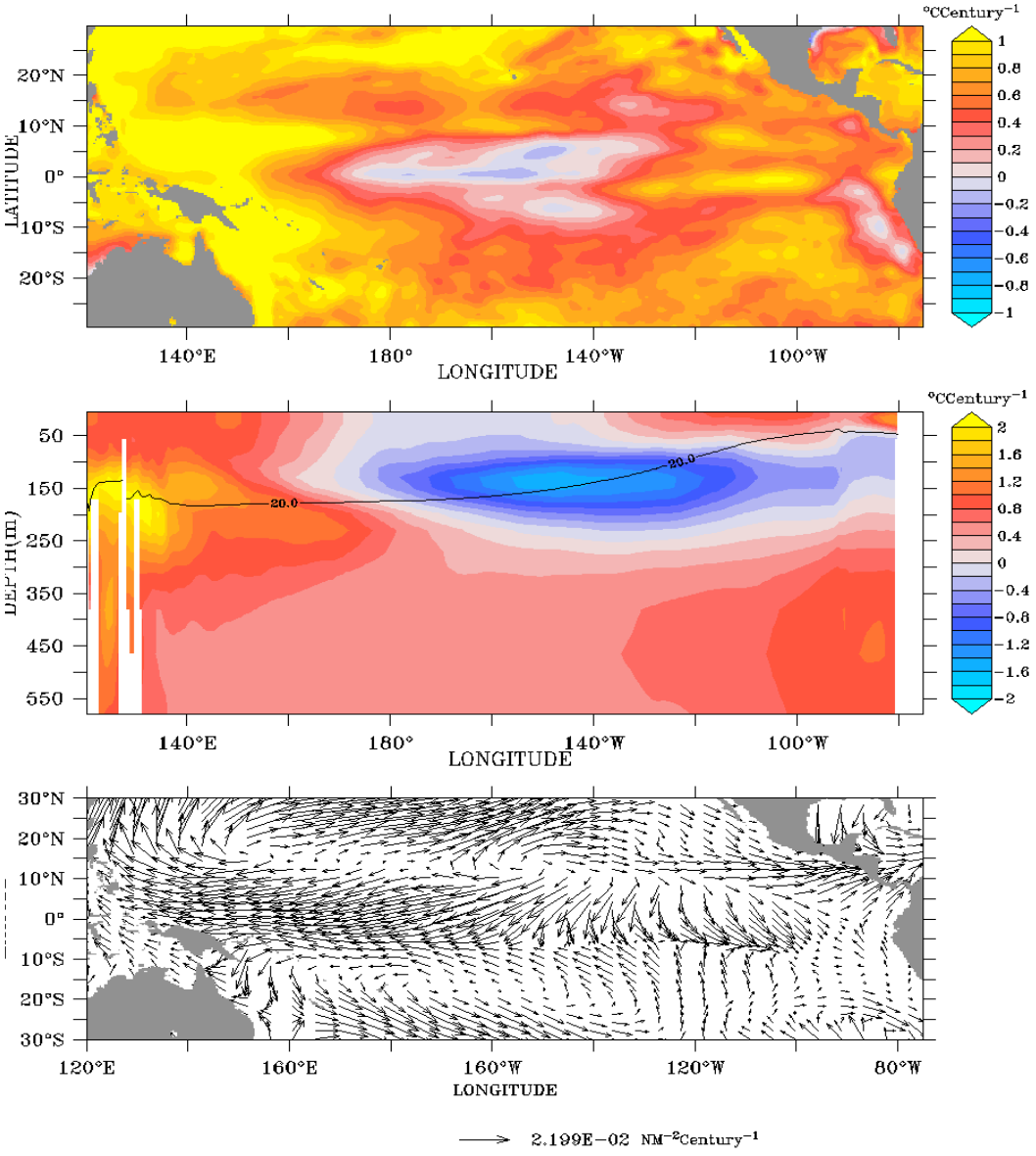



**Model (no CO2 forcing)**



# Linear trend for period 1900 to 2008

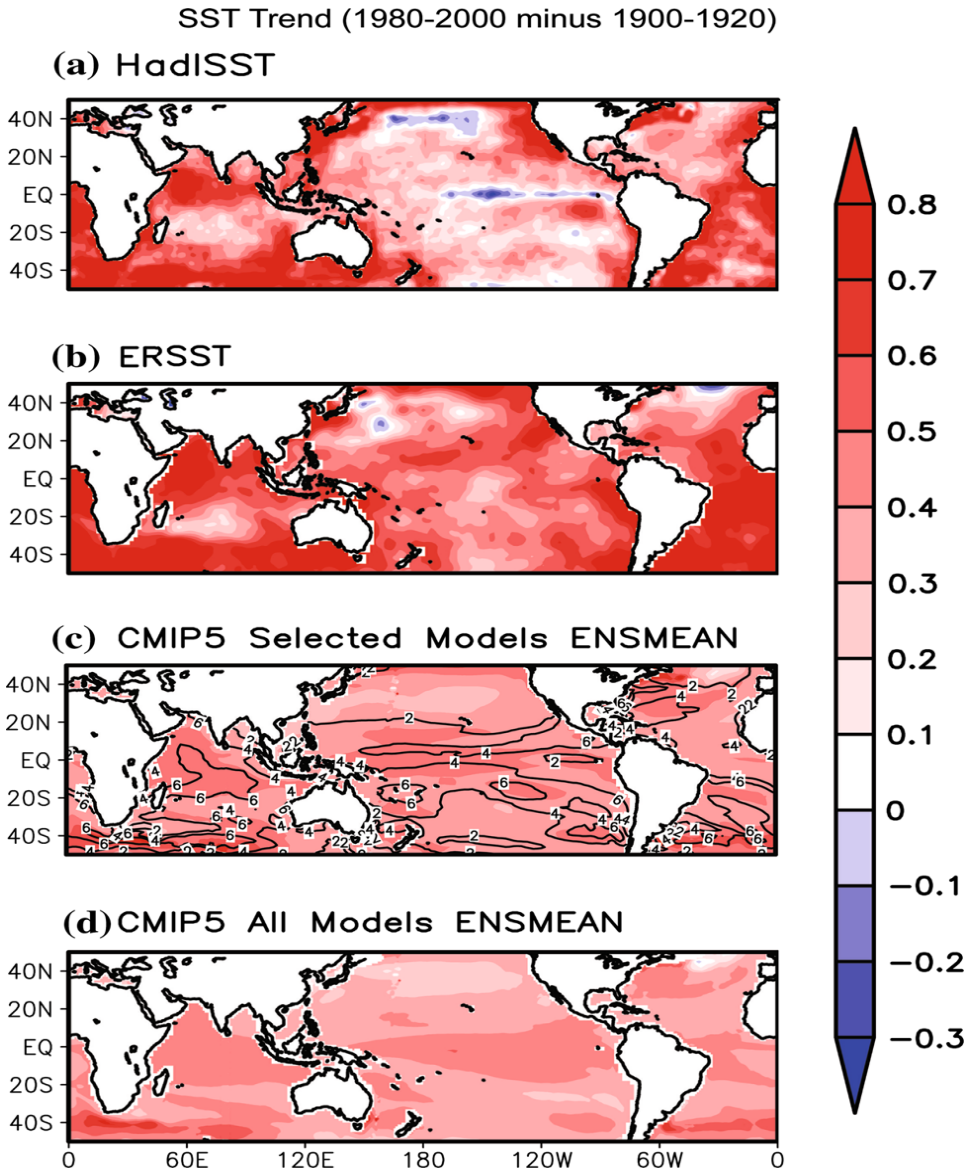
Quite consistent with a
a SODA data ensemble
analysed in Yang et al., 2015




**igure 2. Linear trends in SODAsi.1 from 1900 to 2008 of (a) sea surface temperature, (b) mperature as a function of depth on the equator and (c) vectors of zonal and meridional ind stress.**

# Differences 1980 to 2000 minus 1900 to1920

Different datasets show different things...




HadISST

ERSST

CMIP5

Fig. from Kucharski et al. 2014

**Fig. 7** SST change (1980–2000 minus 1900–1920). **a** HadISST, **b** ERSST, **c** CMIP5 selected Models ensemble mean, **d** CMIP5 all models ensemble mean. Signal-to-noise ratio in **c** is in contours

Summary:

•There is a robust impact from the Atlantc to the Indo-Pacific regions from interannual to centennial time scales.

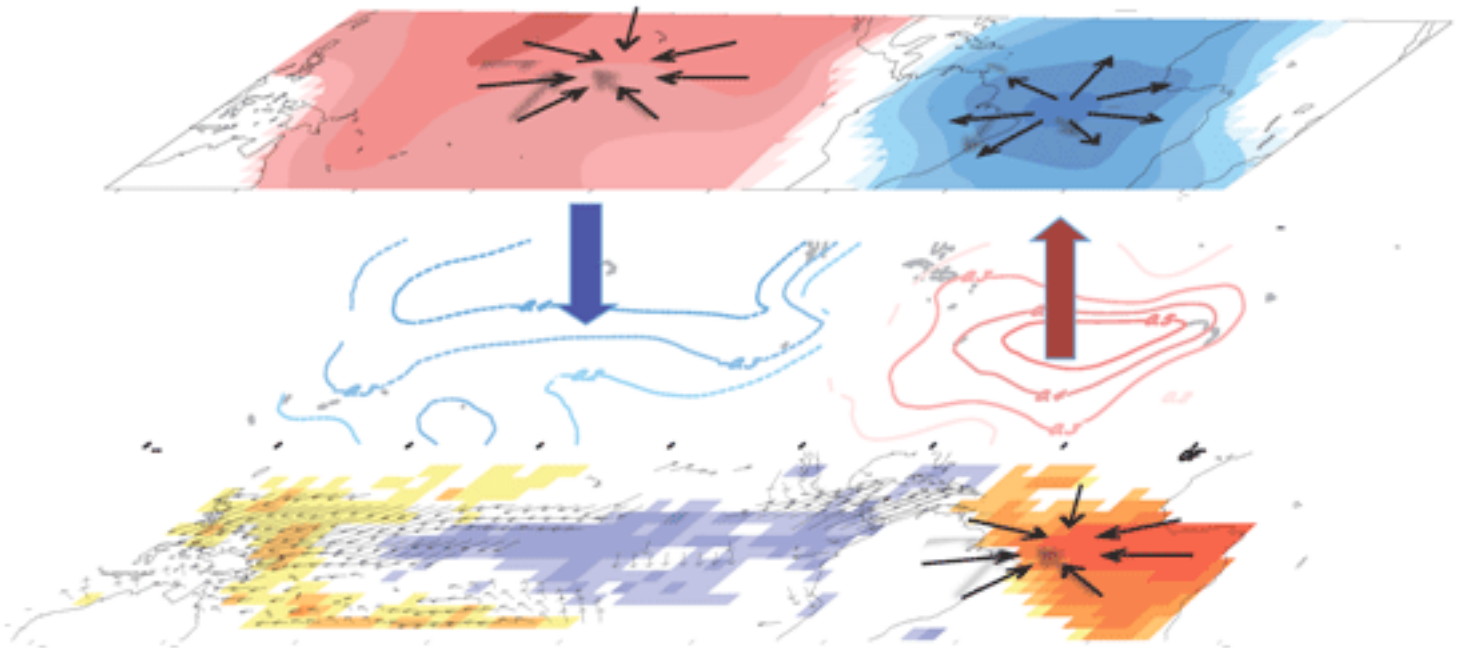
•There is strong evidence that a modification of the Walker Circulation plays an important role in all so far identified teleconnections.

•Ocean mixed-layer sdjustment processes may provide an important pre-conditioning before ocean dynamical feedback mechanisms can set-in (e.g. Bjerknes feedback). This seems particularly true for the Western Pacific region.

• The Atlantic warming seems to have even modified the spatial structure of the global warming trend, and may 'switch-on' a tropical Eastern Pacific thermostat. Reasons for the stronger Atlantic warming still to be completely clarified.

• Also relative roles of local GHG warming in the tropical Pacific versus Atlantic-induced cooling needs to be clarified in details.

**How can the ‘small’ Atlantic Ocean impact variability in the ‘big’ Pacific Ocean? Probably the Atlantic Ocean can provide some initial persistent forcing that is amplified in the Pacific through positive feedback (e.g. Bjerknes feedback and others).**



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# Introducing

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