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Understanding the influence of ENSO on North Pacific variability

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Conference on Teleconnections in the Atmosphere and Oceans
17-20 November 2008, ICTP, Trieste, Italy

Understanding the influence of ENSO on the North Pacific variability

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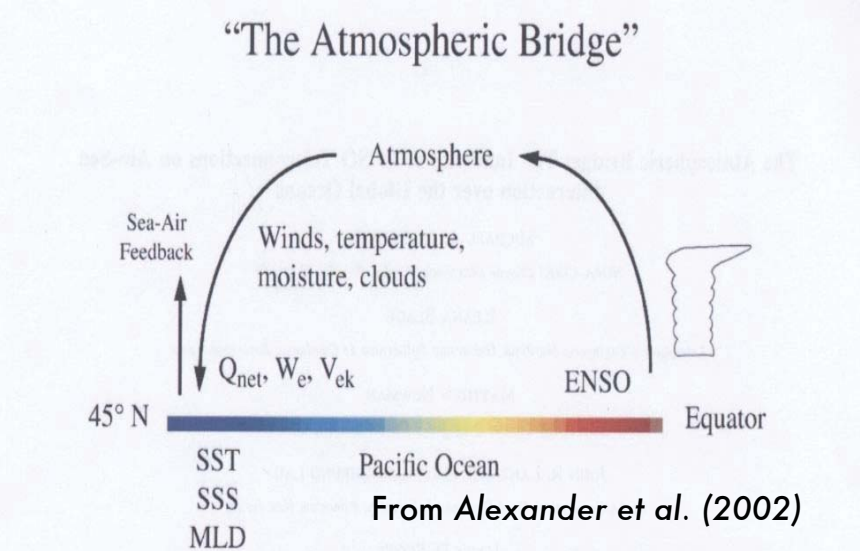
MOTIVATION OF THE STUDY:

uncertainty in the origin of the variability in the North Pacific sector

ENSO is the major player for the teleconnections all over the world

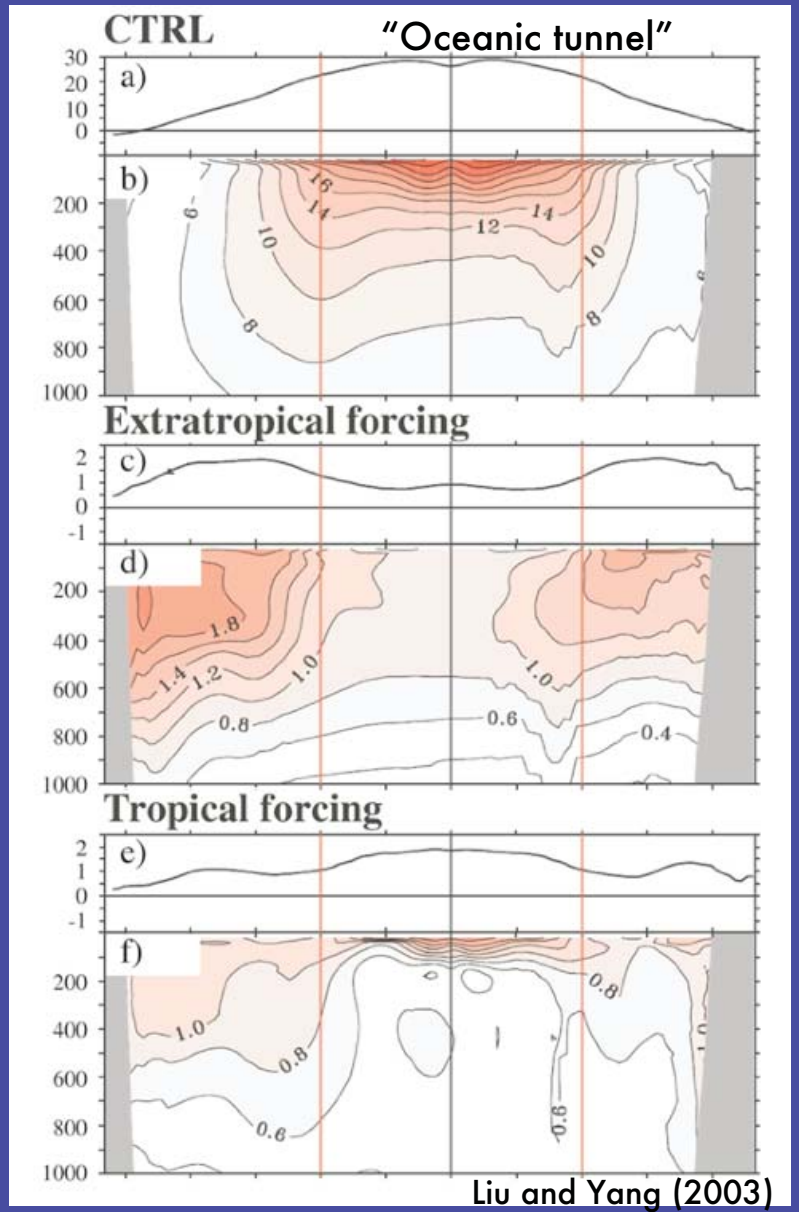
improvements in the simulation of ENSO when SINTEX has an higher resolution atmospheric component: which is the impact on the tropics-extra tropics connection?

BACKGROUND



From *Alexander et al. (2002)*

"The bridge occurs through changes in the Hadley and Walker cells, Rossby waves and interactions between the quasi-stationary flow and storm tracks" (*Trenberth et al., 1998*)

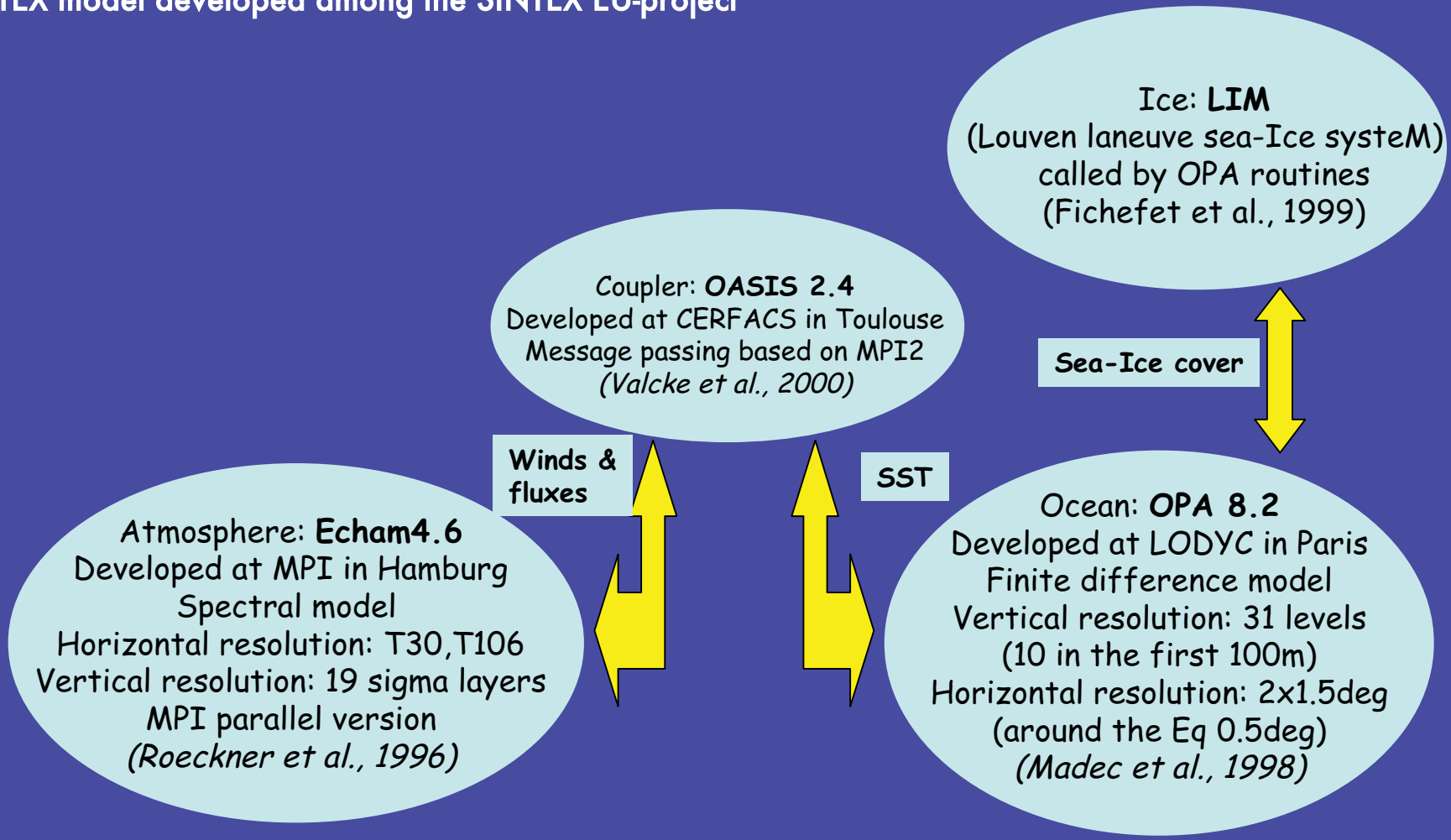


Liu and Yang (2003)

The remote response of extra-tropical SST to tropical forcing is comparable with the remote response of tropical SST to extra-tropical forcings

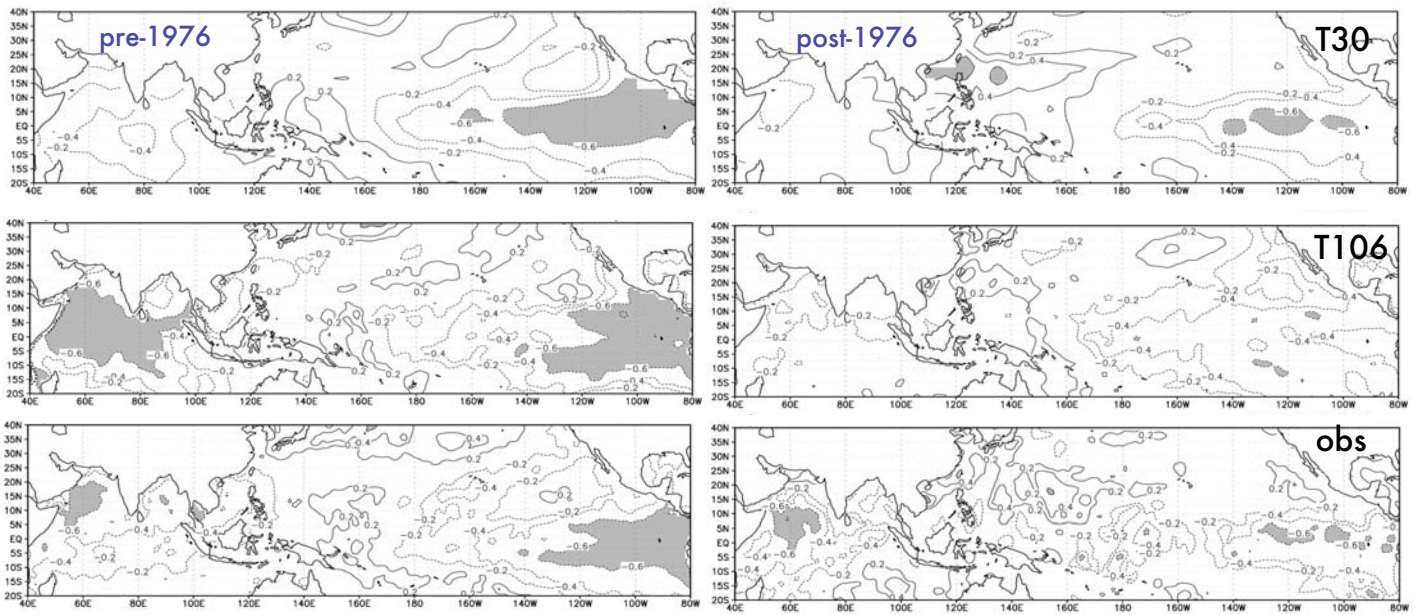
The SINTEXG CGCM

it is an atmosphere-ocean-sea-ice coupled model developed at INGV following the background of the SINTEX model developed among the SINTEX EU-project



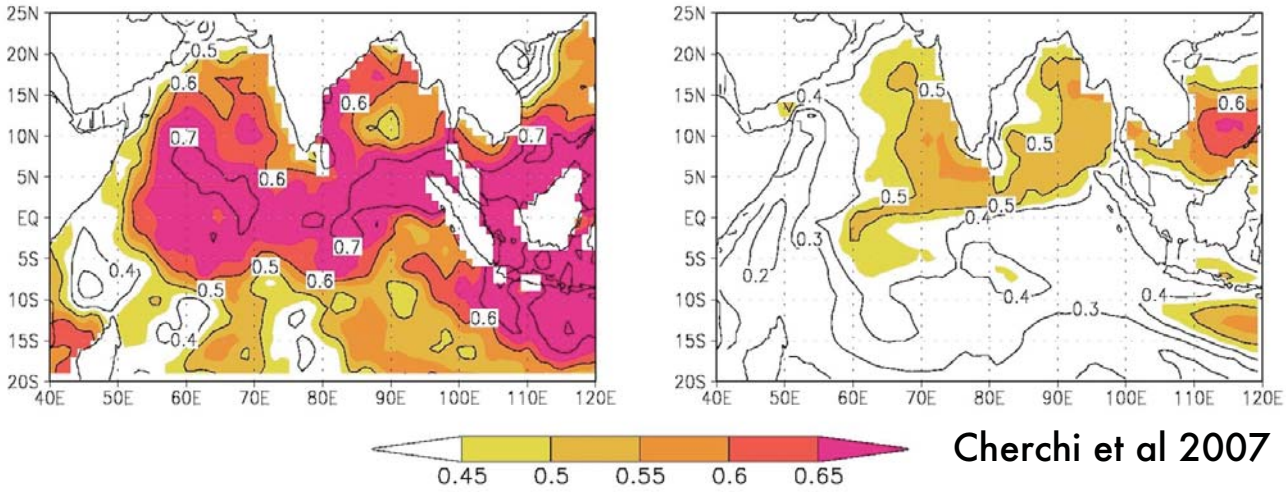
For a description of the mean climate simulated by the model see the web page:
https://www.cmcc.it/web/public/ANS/models/ingv-sxg & Gualdi et al., 2008 (J. Climate)

ENSO-monsoon connection: 1976 climate shift (JJA SST vs Indian monsoon index)



Cherchi and Navarra, 2007

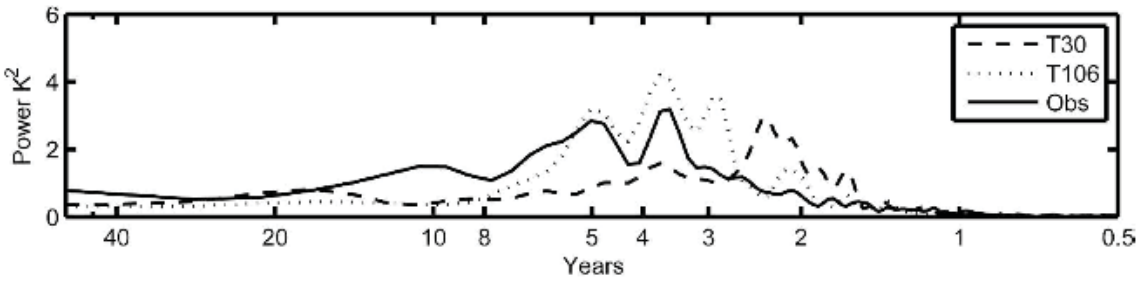
% of variance of TrIndOc SST linked to TrPacOc SST



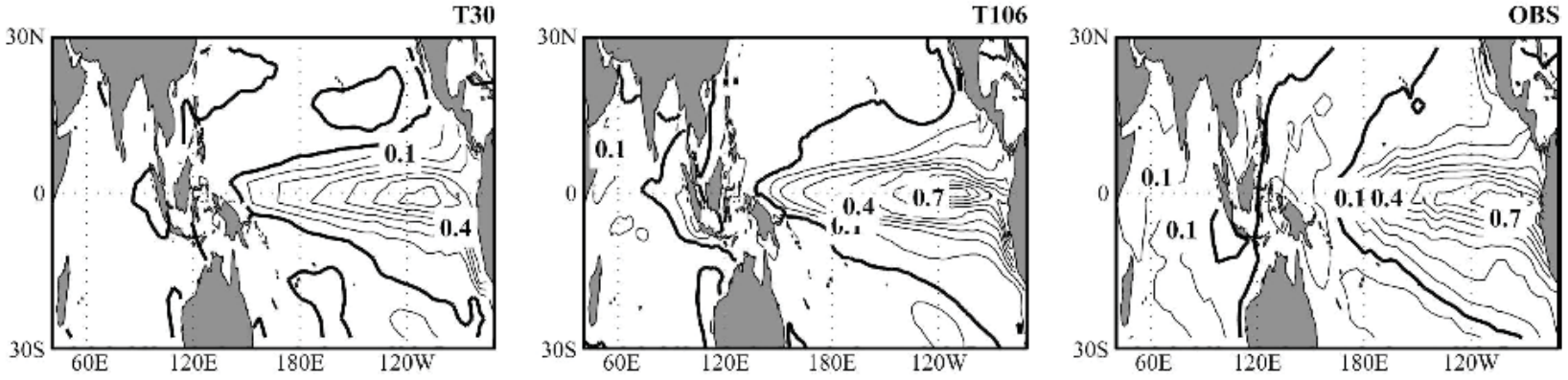
Cherchi et al 2007

The coupled model underestimate the influence of the TPO on the TIO

Power spectra of NINO3 index



SST vs NINO3 (linear regression)



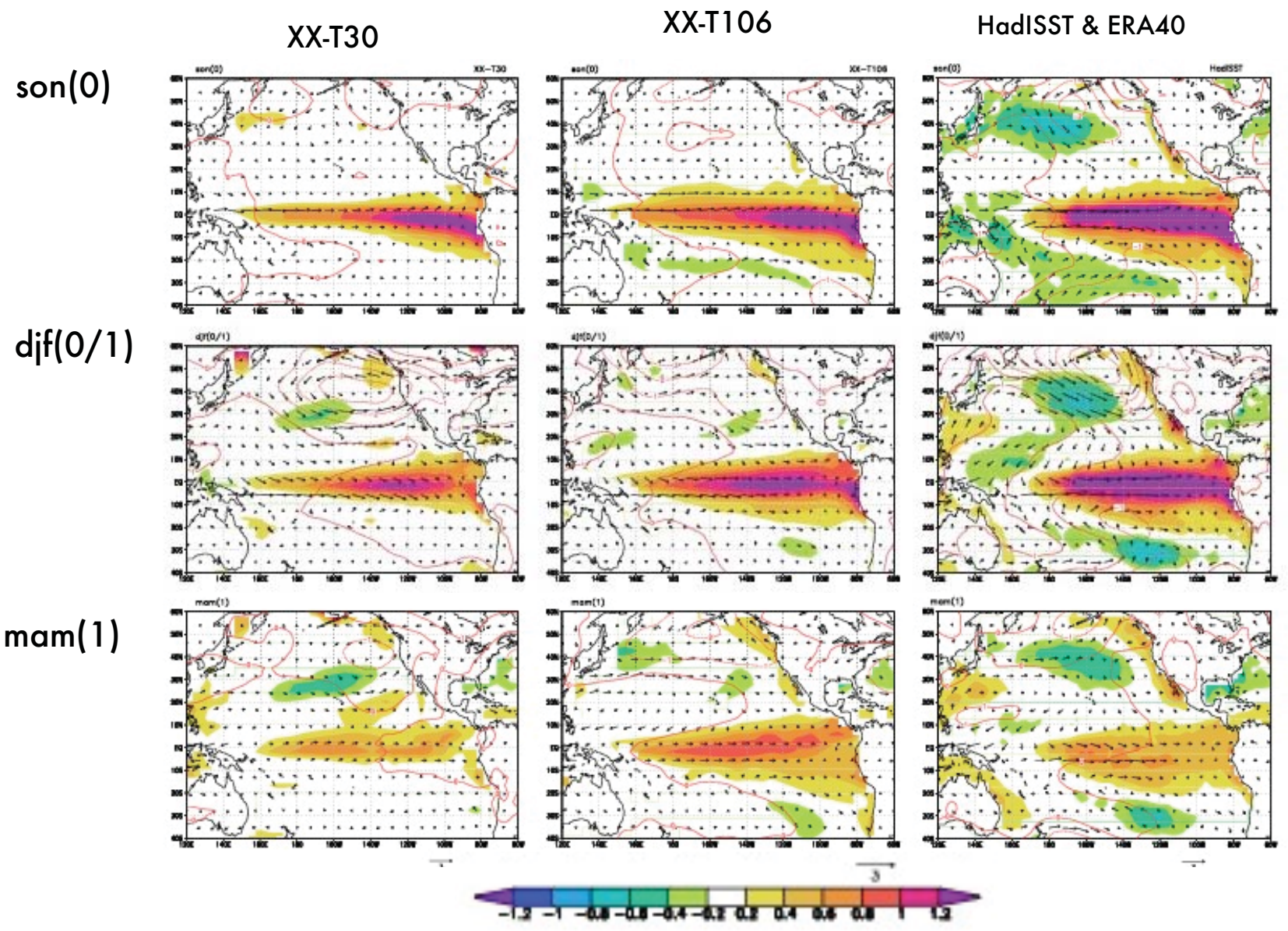
Navarra et al 2008

Our analysis is aimed at give a contribution to the issue of the north Pacific-Tropical Pacific connection focusing on:

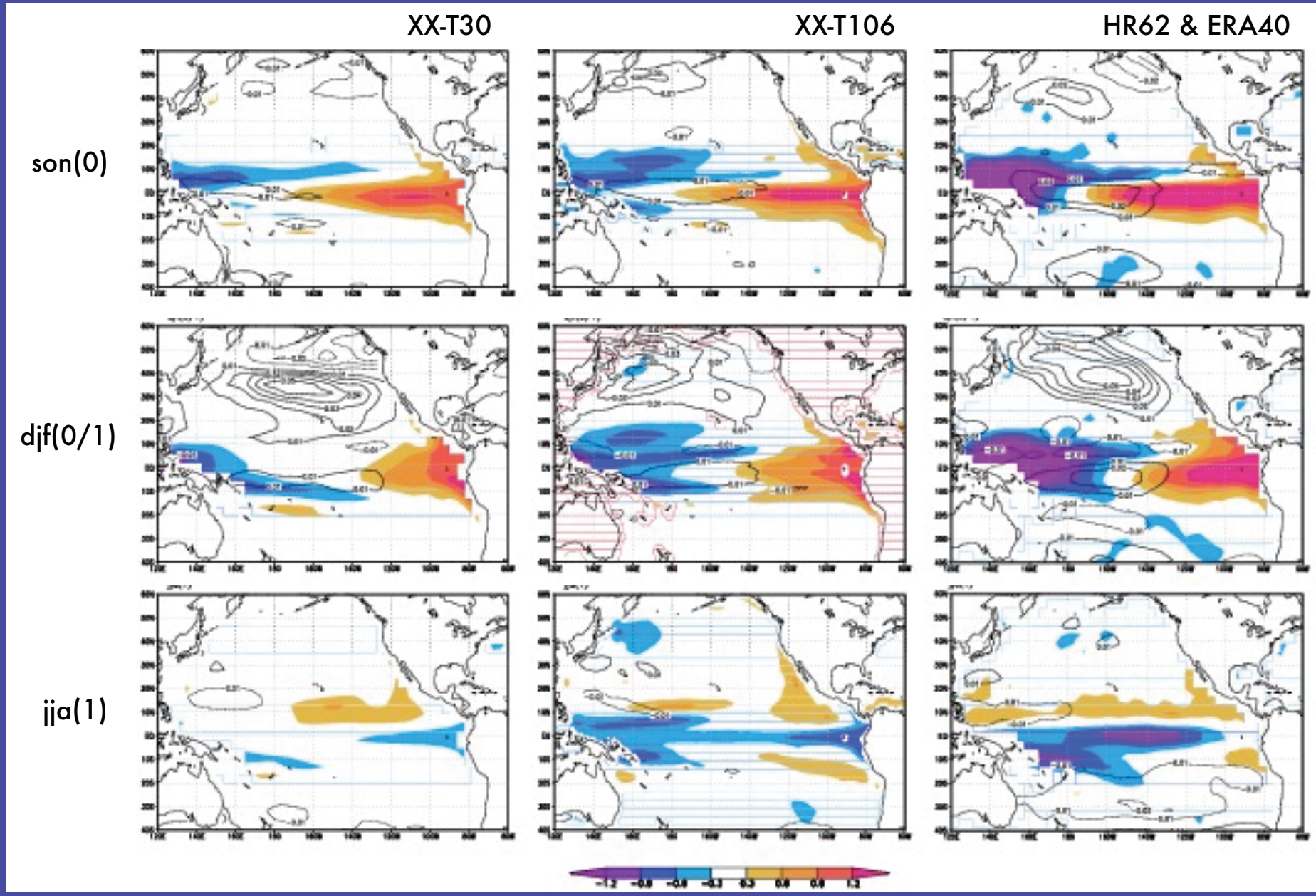
importance of “coupling issue”
distinction between low and high frequency

EXPERIMENTS USED
XX-T106 (SINTEXG T106 20th forcing)
XX-T30 (SINTEXG T30 20th forcing)
(starting from the condition of 1870, increasing the concentration of CO2, CH4, N2O, CFC11 and CFC12 following a table containing measured values of that concentration year by year until 2000, including atmospheric ozone and aerosols)

Interannual timescales: “warm ENSO” composite (SST, SLP & 850mb WIND)



Interannual timescales: "warm ENSO" composite (heat content 300 m and USTR)



HR62 is an ocean analysis (Masina et al 2004)

Coupled Manifold technique (Navarra and Tribbia, 2005)

A new statistical method to detect the portion of co-variability between 2 climatic fields

Mathematical formulation:
the problem is $Z = A\,S$
where Z and S are data matrices expressing fields at fixed times.

The solution is found applying the *"Procrustes minimization approach"* and it is $A = ZS'(SS')^{-1}$

with $(SS')^{-1} = \sum_{i=1}^{K} u_i \lambda_i^{-1} u_i'$

Note that:
the method is applied to the EOFs of Z and S to minimize the computation;
A is the matrix which contains the relation and consists of correlation coeff.;
a statistical significance test is applied to the solution found.

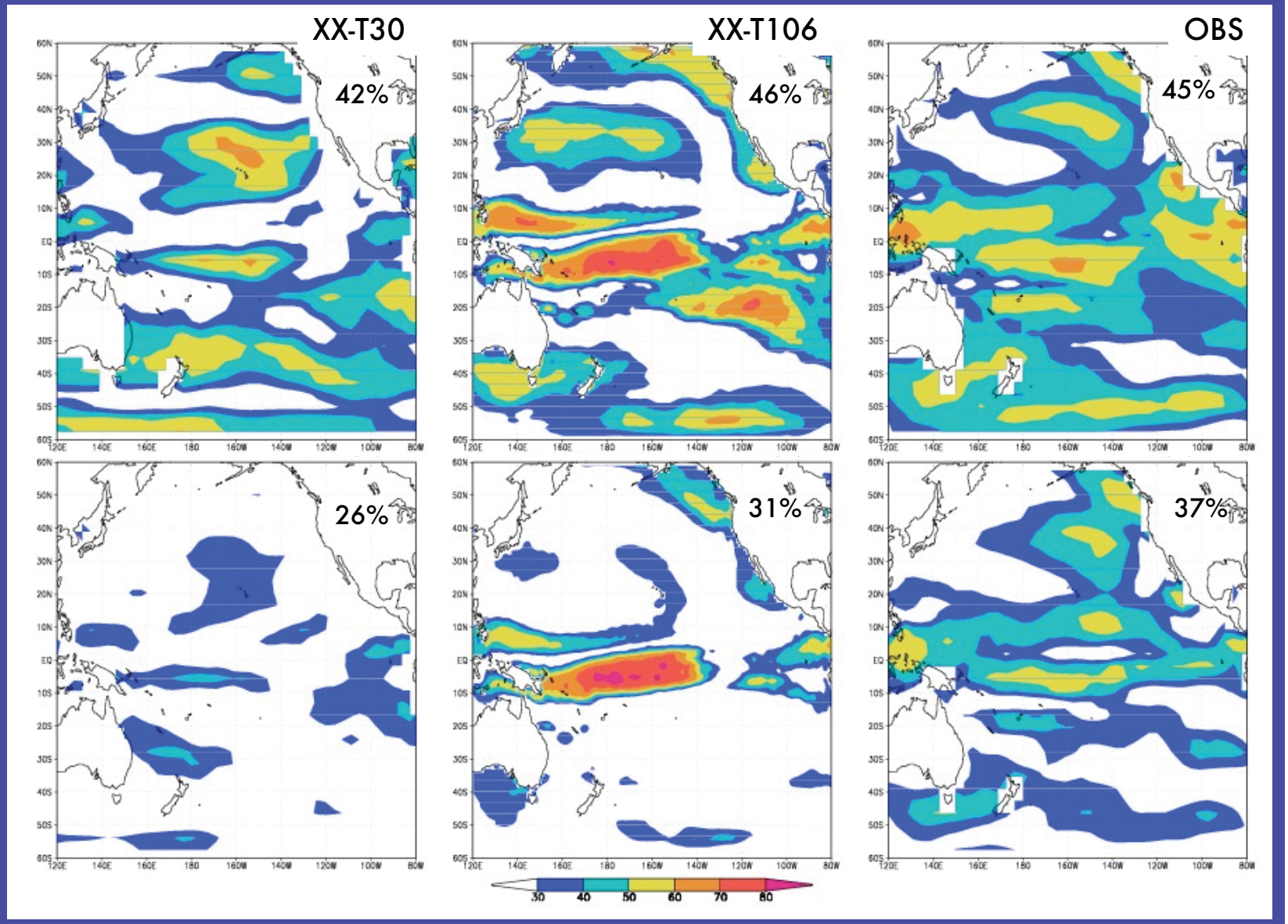
The coupled manifold may be used to:

i) compute the % of variance of an atmospheric field linked to another atmospheric field, and the reverse
ii) separate Z in Zfor (subspace where variation of one field are connected to variations of the other field) and Zfree (a subspace where variations are indipendent)
iii) identify one-way ("forced manifold") and two-way ("coupled manifold") relations between the fields considered

Coupled manifold: % variance of USTR linked with SST

Pacific USTR vs Pacific SST

Pacific USTR vs Tropical Pacific SST

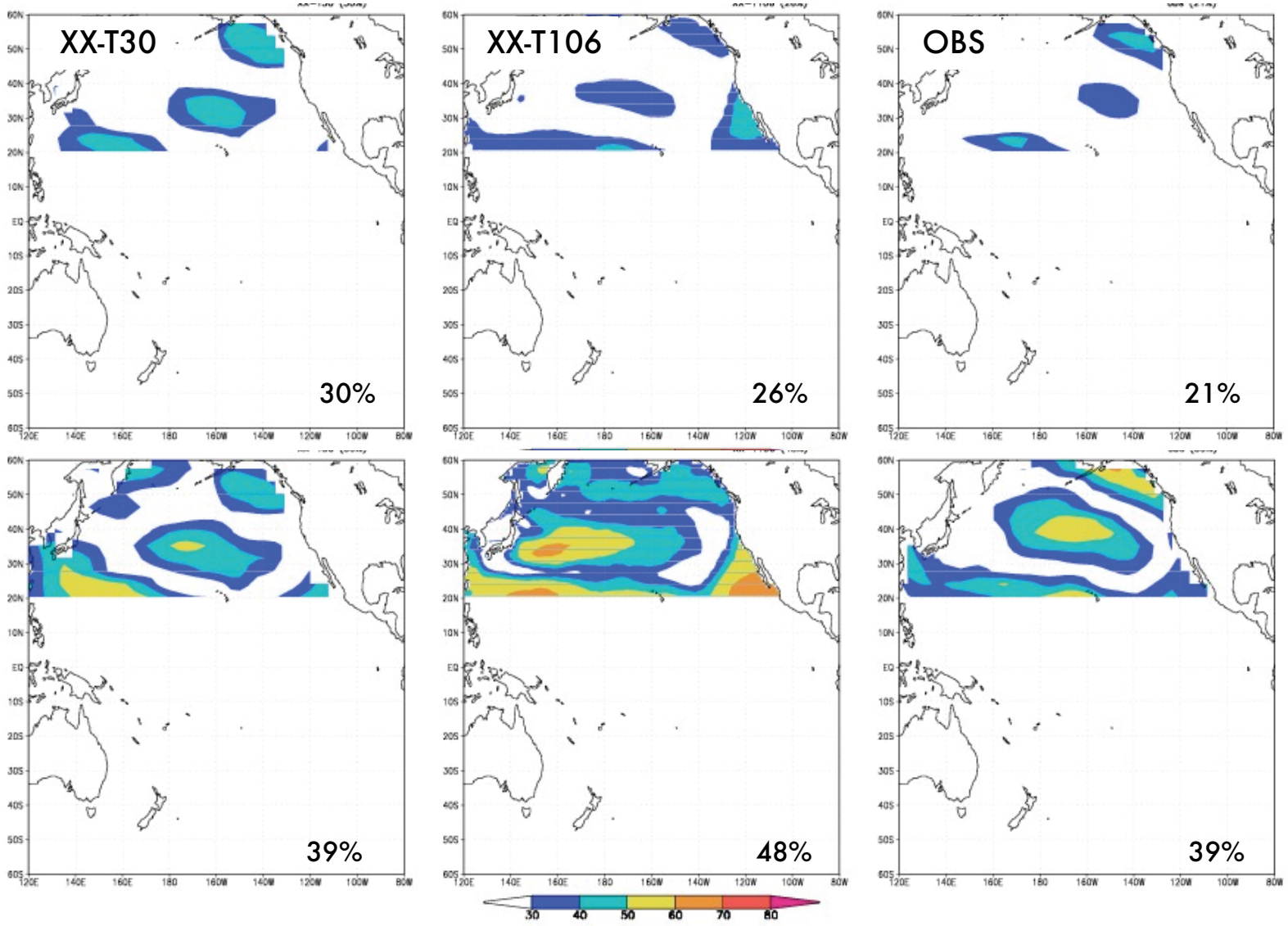


N.B. plotted values passed a significance test at 95%

Coupled manifold: % variance of USTR linked with SST (2)

North Pacific USTR vs Tropical Pacific SST

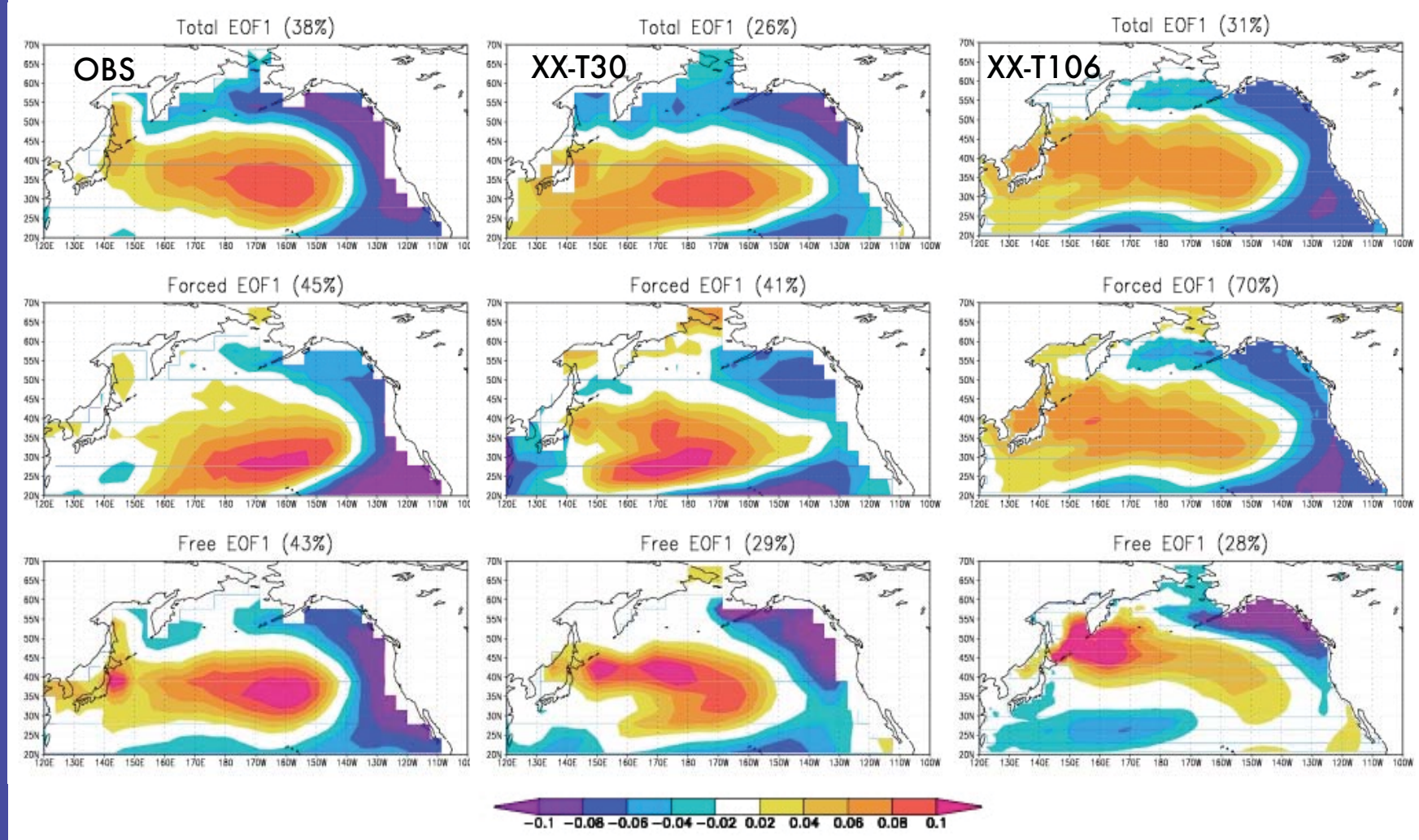
North Pacific USTR vs North Pacific SST



in the Pacific 1/3 of variance of USTR is linked with tropical Pacific SST
in the North Pacific the link between USTR and SST is stronger than the link between USTR and tropical Pacific SST

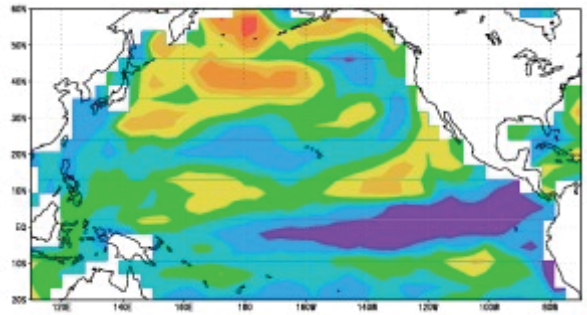
North Pacific SST is linked with Tropical Pacific SST
(XX-T30: 20% XX-T106: 33% OBS: 37%)

North Pacific SST variability (EOF1)

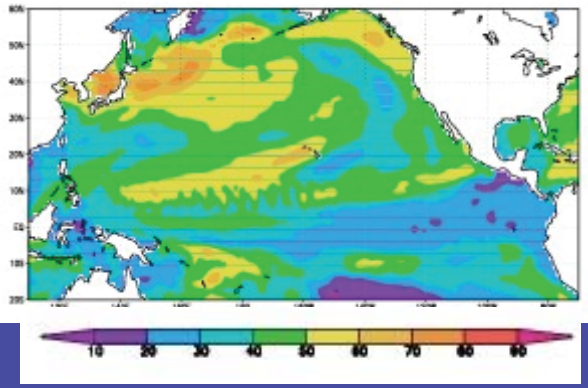


Fraction (low/total) of SST variance

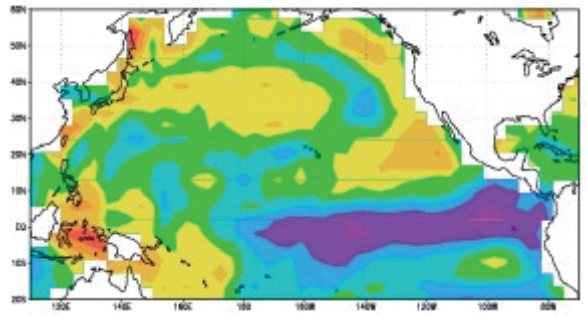
XX-T30

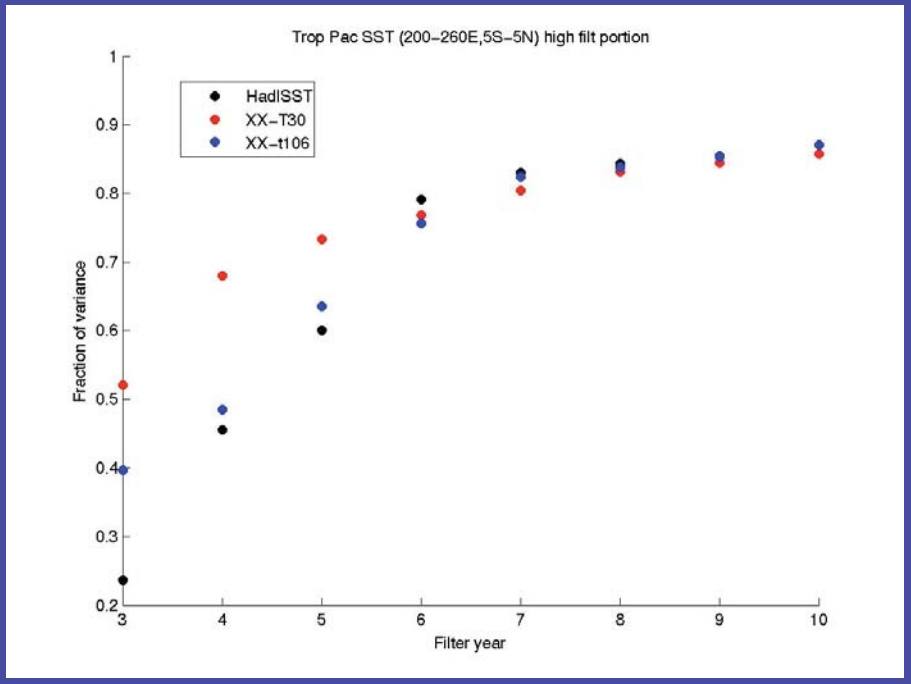


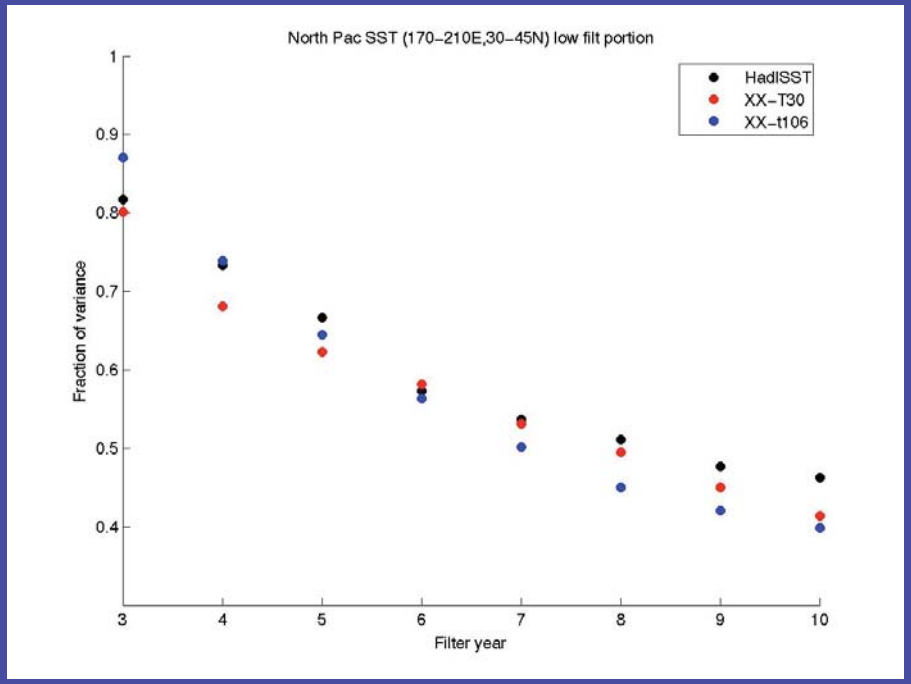
XX-T106



HadISST

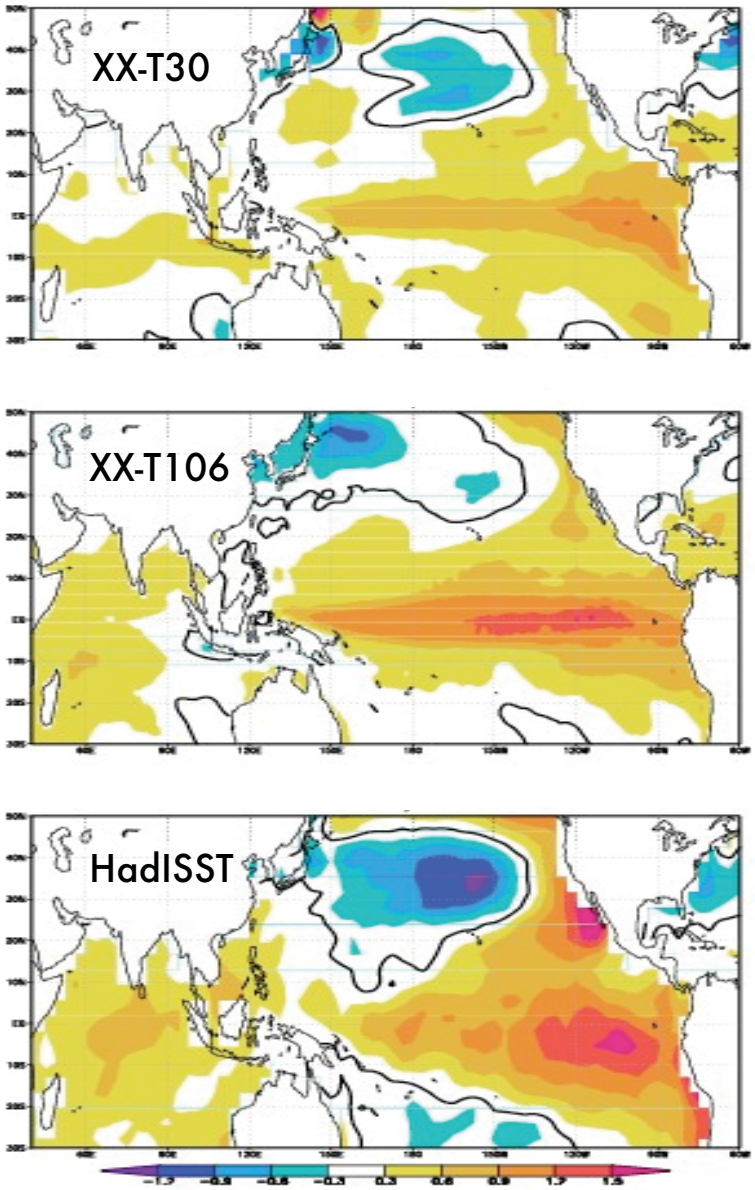




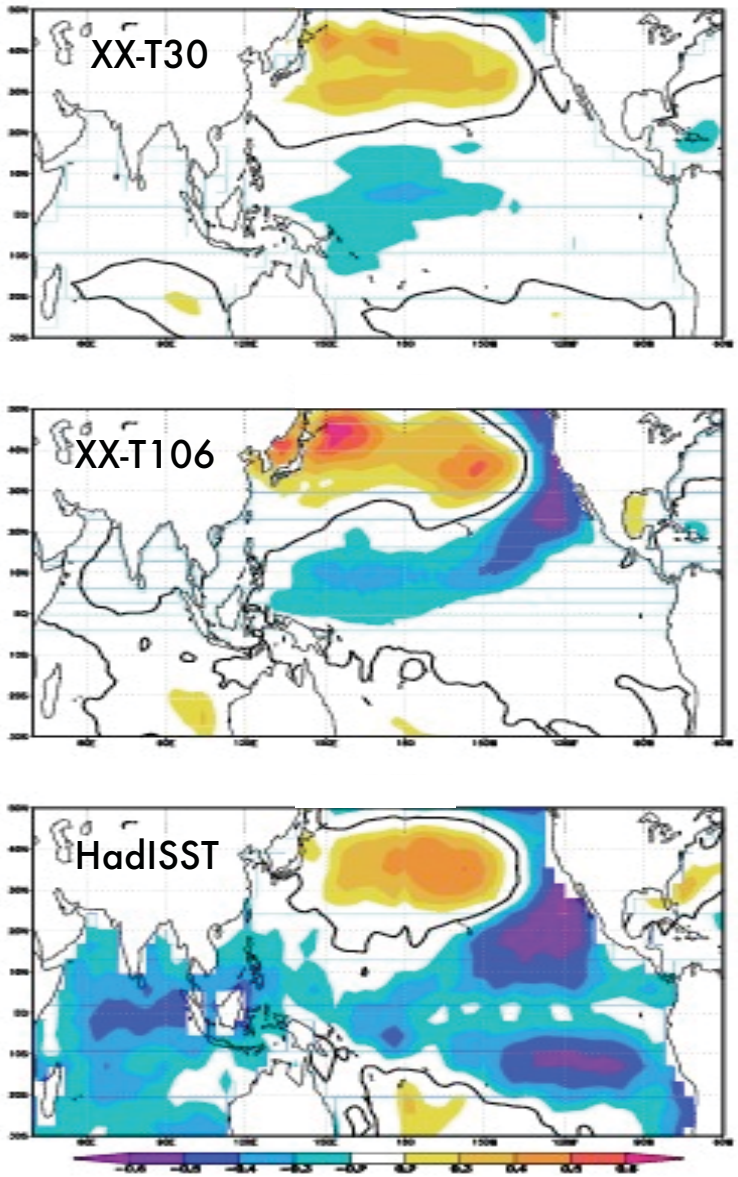


Low frequency (7 yrs) TPac - NPac SST connection

NINO3 vs SST (regression)



NPacPC1 vs SST (correlation)



CONCLUSIONS

A better representation of ENSO is not enough to obtain the correct connection between tropical and extra-tropical Pacific

the coupled model simulates a stronger than observed connection in the tropics (at least at T106) but a weaker than observed relationship in the north Pacific (in terms of USTR and SST - coupled manifold)

the distinction between forced and free (from the tropical Pacific) variability in the north Pacific is hard, but at a first approximation the first mode of variability in the north Pacific is more similar to the "free" mode than to the "forced" mode

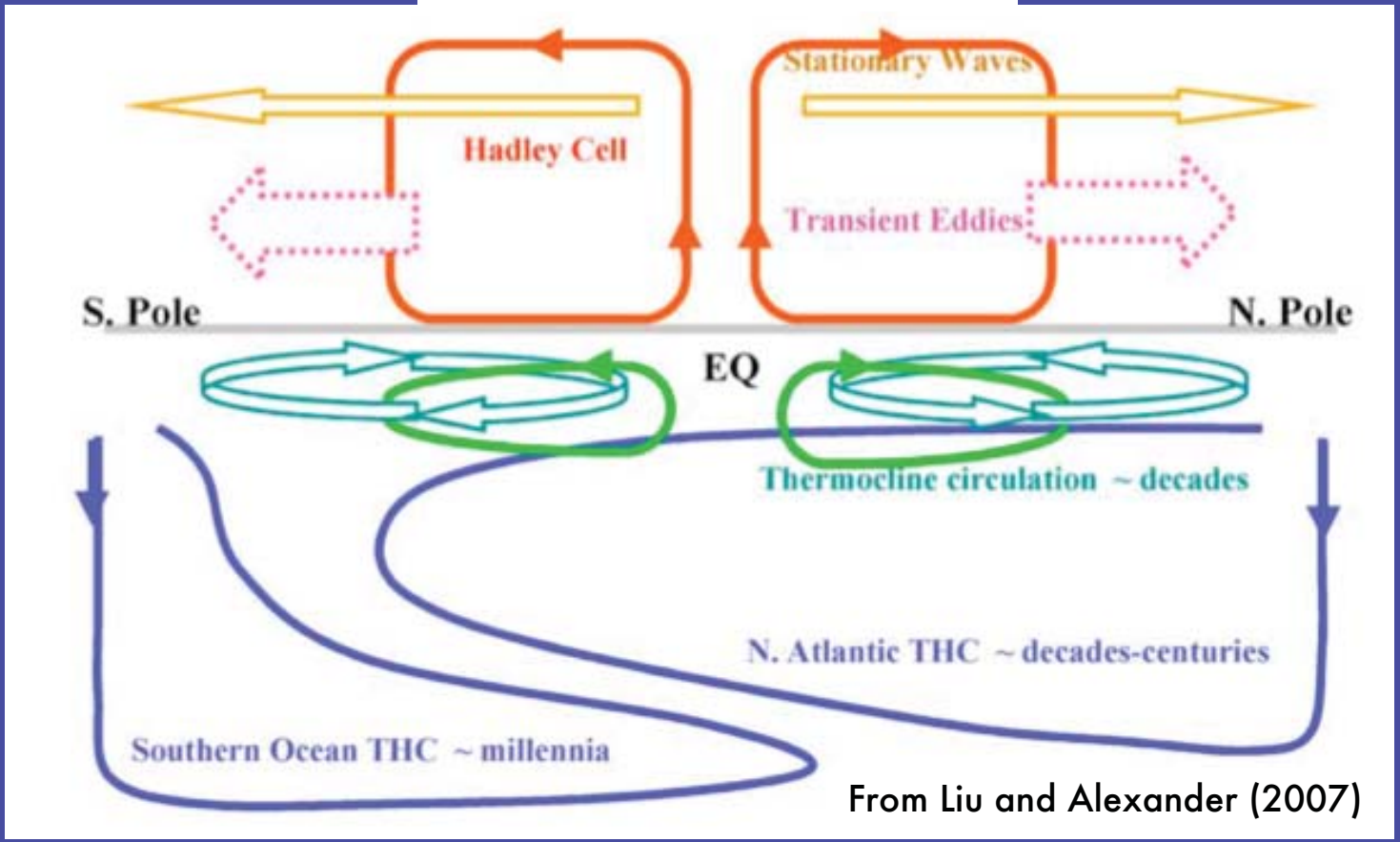
The variance of the SST in the north Pacific sector has the low portion larger than 50% compared to the total variance

The low frequency connection between north and tropical Pacific (regression/correlation analyses) simulated by the model is weaker than observed

THANK YOU !

BACKGROUND

Global climate teleconnections

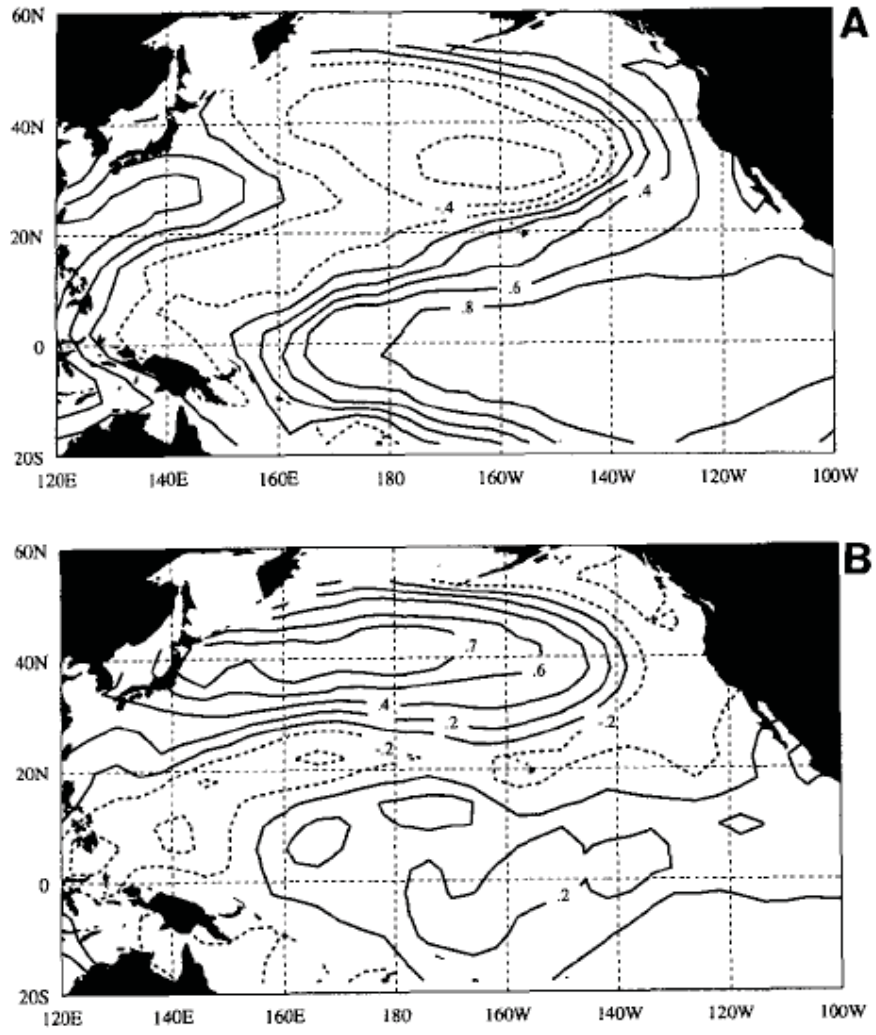


From Liu and Alexander (2007)

Atmospheric and oceanic processes involve different timescales

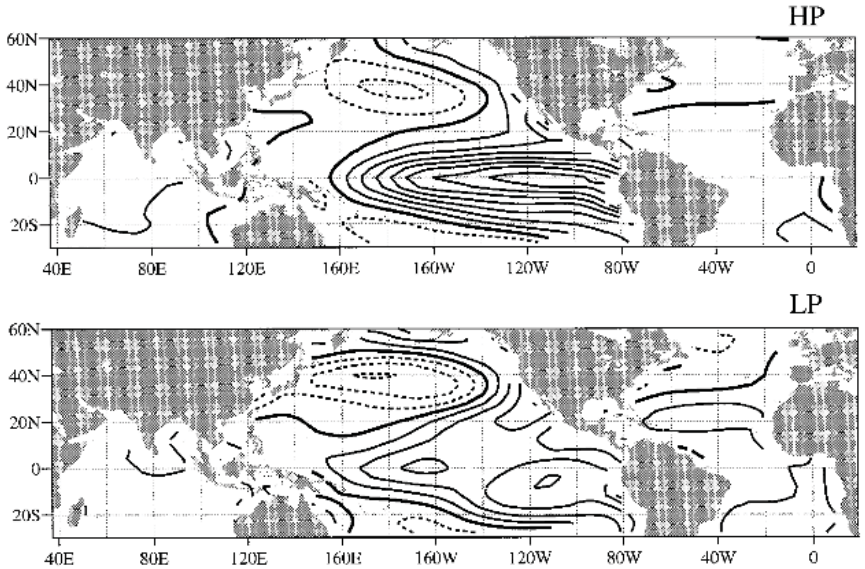
BACKGROUND (2)

EOF1, EOF2 for NDJFM SSTA



Deser and Blackmon (1995)

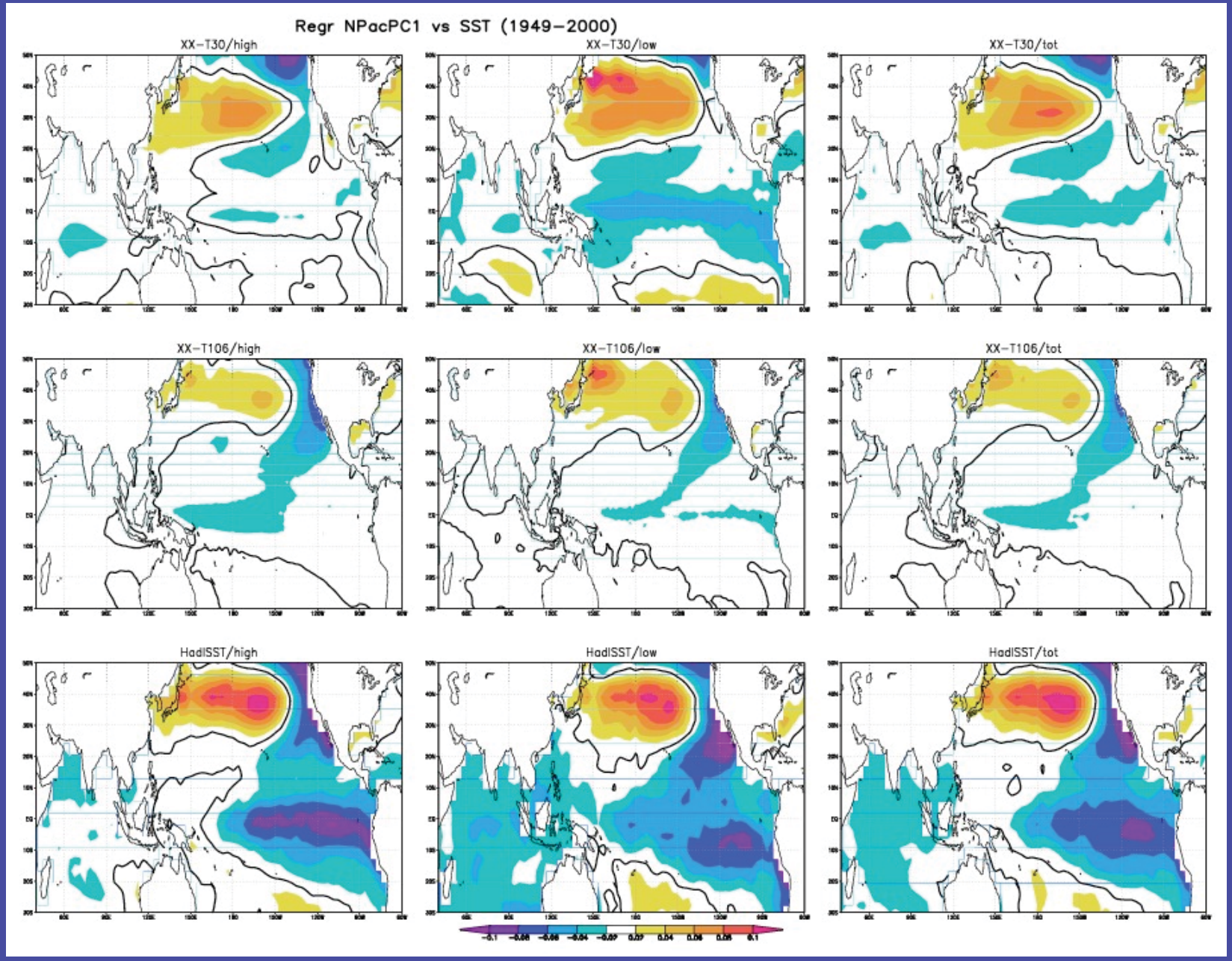
Low/high frequency regressed with SST



Zhang et al., 1997

OUTLINE

Motivation and Background
Model, experiments & analysis
Results
Conclusions


Regr NPacPC1 vs SST (1949–2000)
XX–T30/high
XX–T30/low
XX–T30/tot
XX–T106/high
XX–T106/low
XX–T106/tot
HadISST/high
HadISST/low
HadISST/tot