Removing Tropical-extratropical coupled dynamics from North Pacific Climate Variability

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Introduction

1. **To what extent have ENSO-related variations contributed to the North Pacific variability?**
2. **Can climate models capture these variance?**

How to decouple the tropics and extra-tropics?

Previous studies: remove the linear regression on the time series of some ENSO index, such as the Nino 3.4 SST index and the leading PC of the dominant EOF pattern of the tropical SST. (e.g., Cane et al. 1997; Angell 2000; Chiang and Vimont 2004; Thompson et al. 2008, 2009; Vyushin and Kushner 2009)
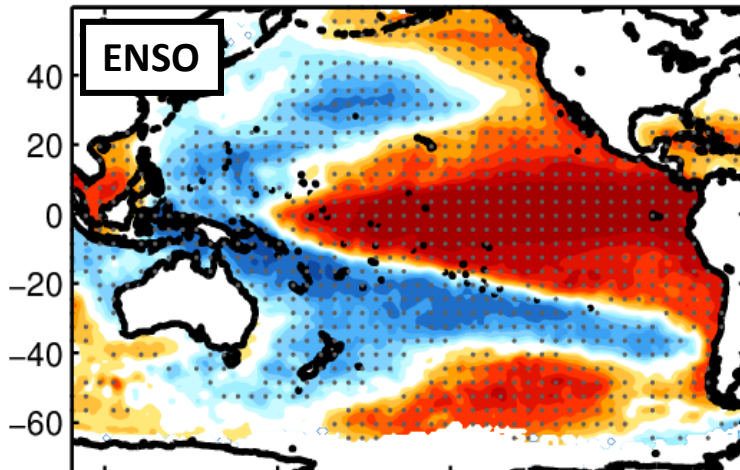
ENSO

ENSO is better viewed not as an index but as an evolving dynamical process.

Better way is to remove the effects of the tropical from the tendency.

Linear Inverse Model (LIM)

Method (LIM) and data

Assume a linear stochastic system:

$$\frac{d\mathbf{x}}{dt} = \mathbf{L}\mathbf{x} + \boldsymbol{\xi}$$

Here the evolution of the system X is controlled by the linear dynamical evolution operator **L** and the noise forcing ξ

State vector:

$$X = \begin{Bmatrix} SST_{tropics} \\ SSH_{tropics} \\ SST_{North\ Pacific} \\ SSH_{North\ Pacific} \end{Bmatrix} \rightarrow X = \begin{Bmatrix} x_{TP} \\ x_{NP} \end{Bmatrix}$$

Coupled system:

$$\frac{d}{dt}\begin{Bmatrix} x_{TP} \\ x_{NP} \end{Bmatrix} = \begin{Bmatrix} L_{TT} & L_{NT} \\ L_{TN} & L_{NN} \end{Bmatrix}\begin{Bmatrix} x_{TP} \\ x_{NP} \end{Bmatrix} + \begin{Bmatrix} \xi_T \\ \xi_N \end{Bmatrix}$$

Coupling effects are determined by L_{NT} and L_{TN}. So to decouple the system, just zero out the appropriate submatrices within **L**..

Decoupled system:

$$\frac{d}{dt}\begin{Bmatrix} x_{TP} \\ x_{NP} \end{Bmatrix} = \begin{Bmatrix} L_{TT} & 0 \\ 0 & L_{NN} \end{Bmatrix}\begin{Bmatrix} x_{TP} \\ x_{NP} \end{Bmatrix} + \begin{Bmatrix} \xi_T \\ \xi_N \end{Bmatrix}$$
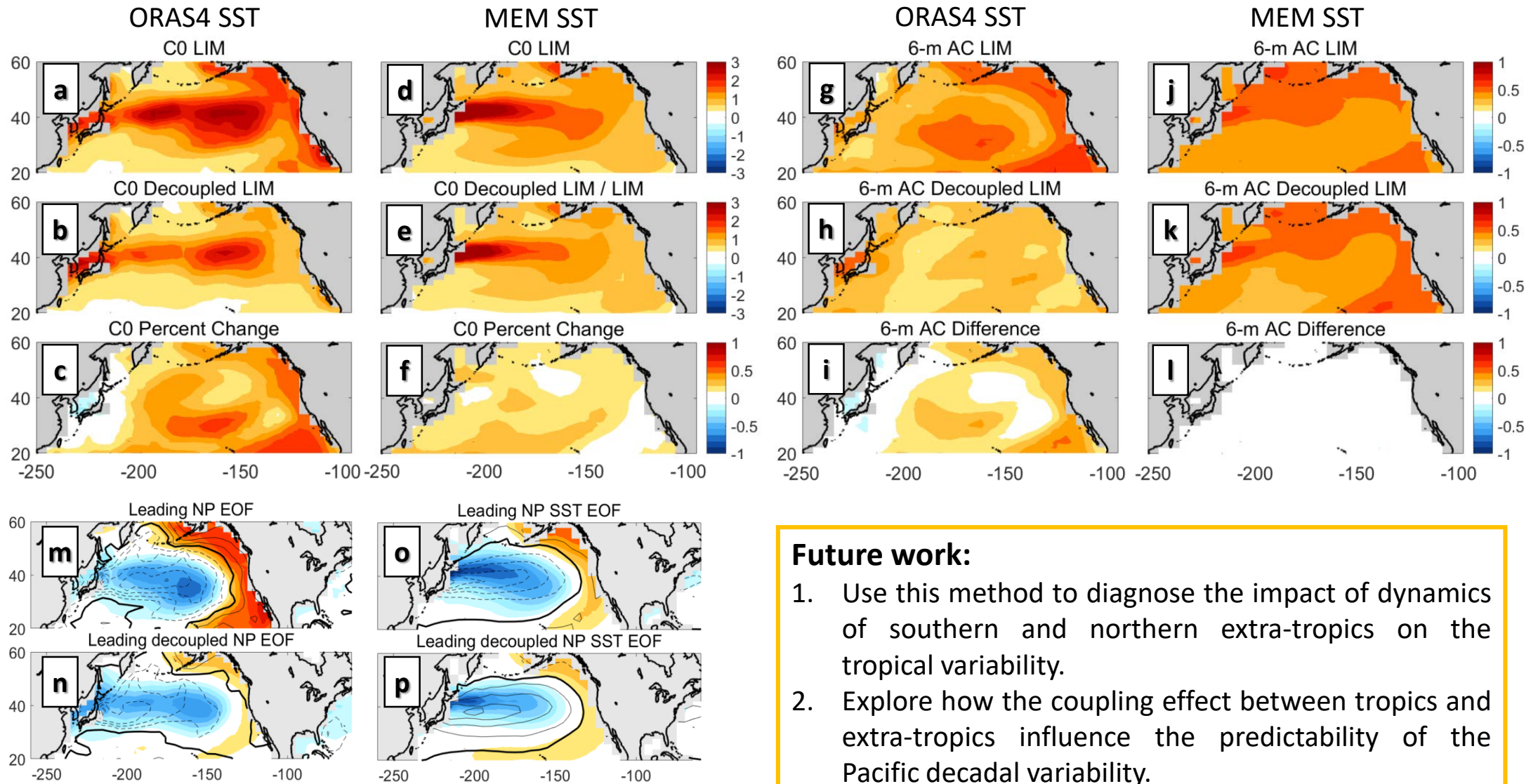
Observation Data:
SSH: **ORAS4** from 1958 to 2015
SST: **ORAS4** from 1958 to 2015
Model data:
Historical run (r1i1p1f1) of CMIP6.

Results

Future work:
1. Use this method to diagnose the impact of dynamics of southern and northern extra-tropics on the tropical variability.
2. Explore how the coupling effect between tropics and extra-tropics influence the predictability of the Pacific decadal variability.
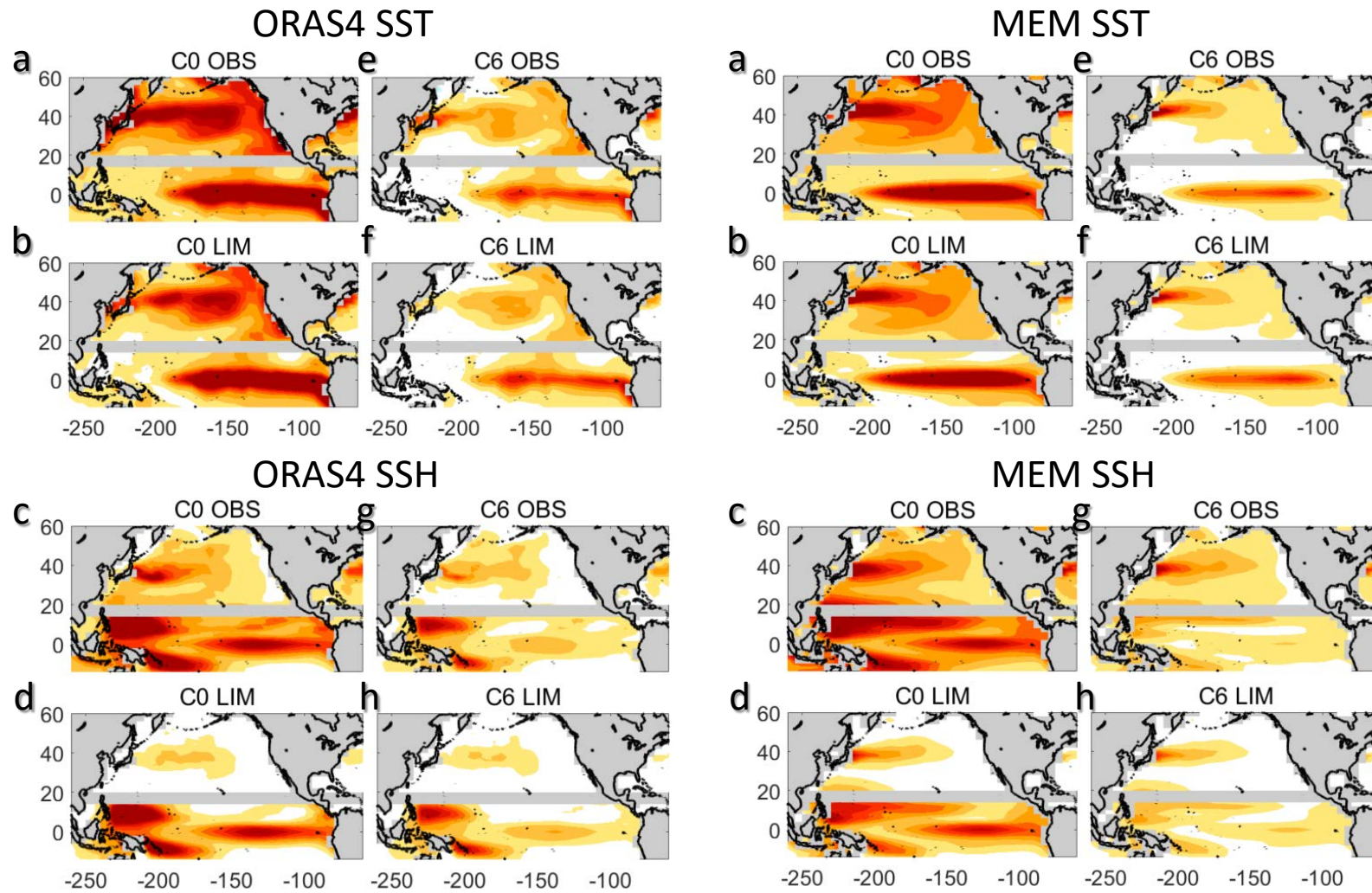
Figure S1. SST and SSH covariance and lag-covariance patterns of observation and MEM of the full field and the coupled LIM.