

The atmospheric response to SST forcing within the North Pacific western boundary current

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Climate Change/Variability Working Group Meeting

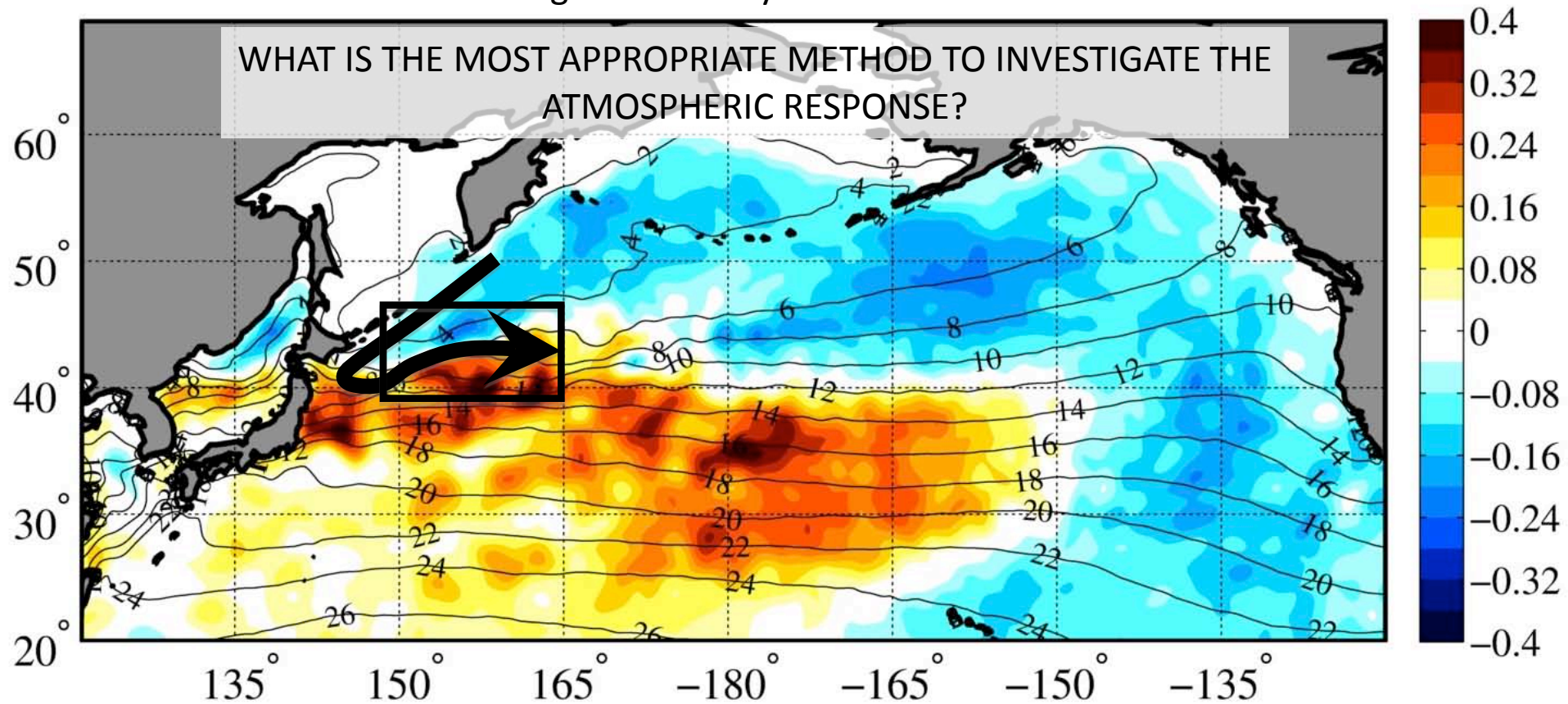
3.4.2013

Outline

- Overview of Oyashio Extension (OE) variability
 - Justification of prescribed SST experiments
- Modeling OE variability with CAM5
 - Local response
 - Remote response
- Conclusions

The Oyashio Current

SST Regressed on Oyashio Extension Index

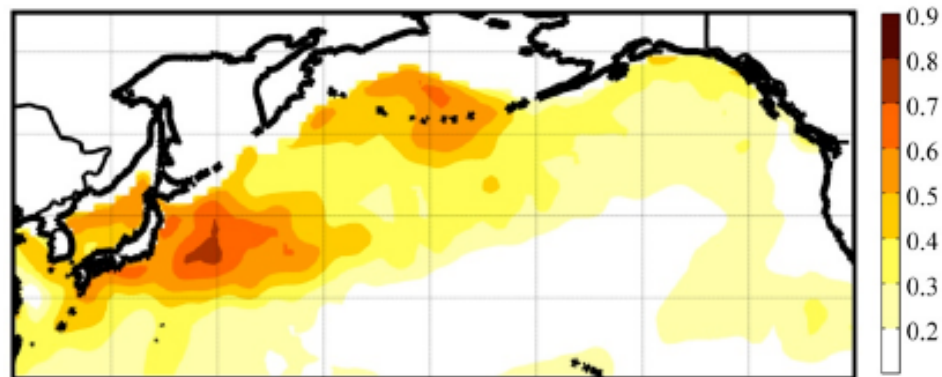


Prescribing SST anomalies

- Extratropical SSTs are largely *forced* by the atmosphere
- However, western boundary currents contain internal oceanic dynamics capable of generating SST anomalies
- Extend Barsugli and Battisti (1998) coupled model, but *empirically*:

$$\frac{d}{dt} \begin{bmatrix} T_A \\ T_S \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} T_A \\ T_S \end{bmatrix} + \begin{bmatrix} \xi_A \\ \xi_S \end{bmatrix} \quad \begin{array}{l} b : T_S \rightarrow T_A \\ c : T_A \rightarrow T_S \end{array}$$

Fraction of uncoupled SST variance



Smirnov, D., M. Newman and M. Alexander, 2013: Investigating the role of ocean-atmosphere coupling in the North Pacific Ocean. *J. Climate*, submitted.

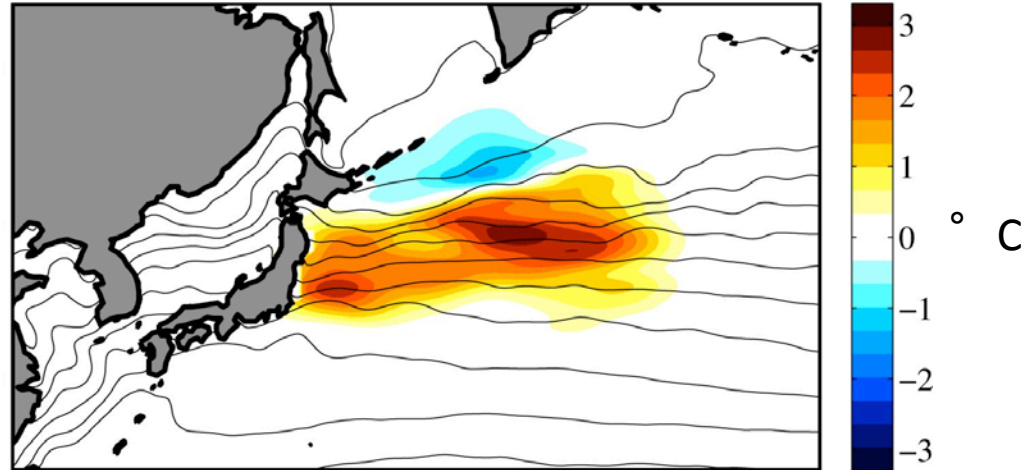
Oyashio front strength

Northward Front
Shift

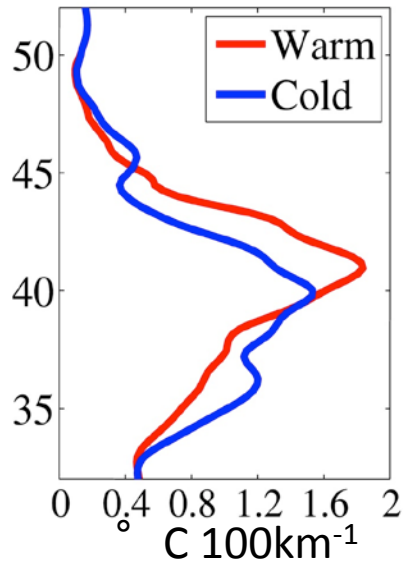


WARM

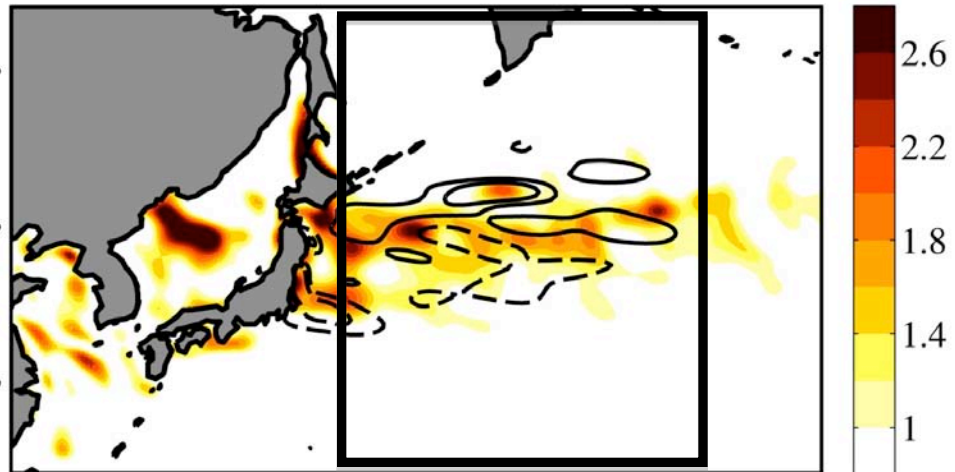
Mean NDJFM SST and anomaly



Zonal mean ∇ SST



∇ SST and anomaly



Experimental design

0.25° CAM5

- Finite volume dynamical core
- Hybrid P/ σ vertical coordinate with 30 levels
 - 8 levels within boundary layer (1000-800 mb)
- Prescribed sea-ice and SST (0.25° NOAA-OI), fully coupled land

Experiments

- Initialize 25 warm and cold ensembles with SST anomaly on Nov 1 (**warm** → northward/stronger Oyashio SST front)
- Initial land condition does not vary
- Simulations run through Dec 31

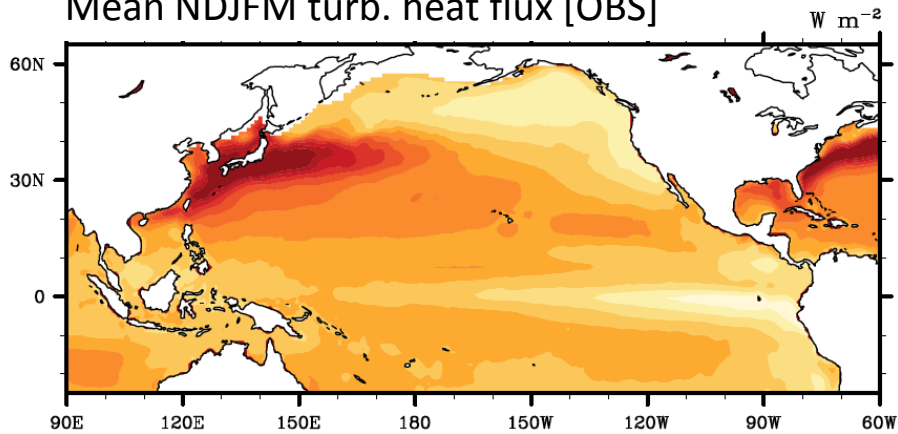
0.25° CAM5 Control climate*

*Simulation was run by M. Wehner (LBNL)

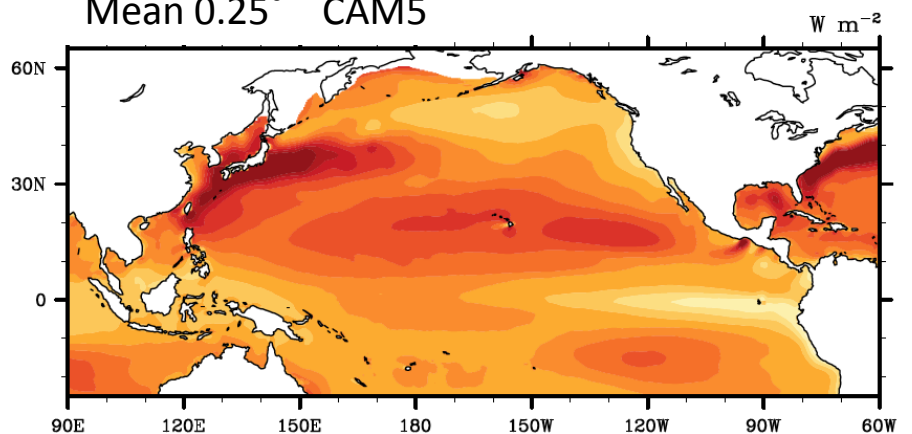
CAM5 Control: Heat flux

→ 0.25° CAM5 control forced by *observed* SST from 1980-2006.

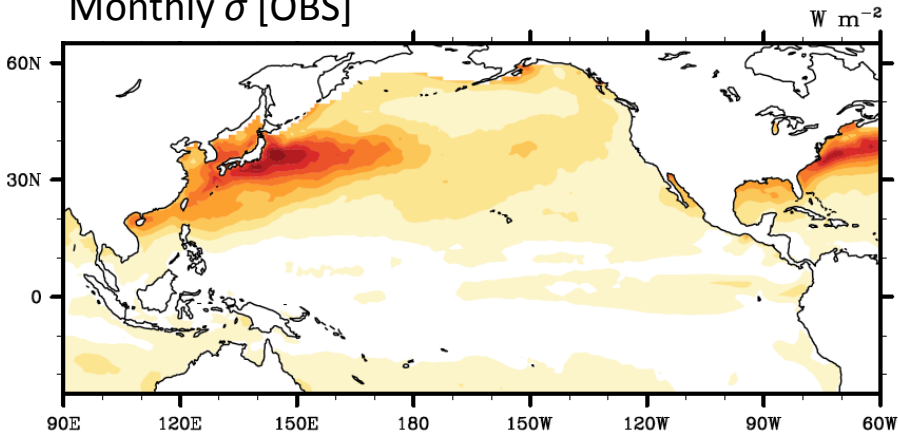
Mean NDJFM turb. heat flux [OBS]



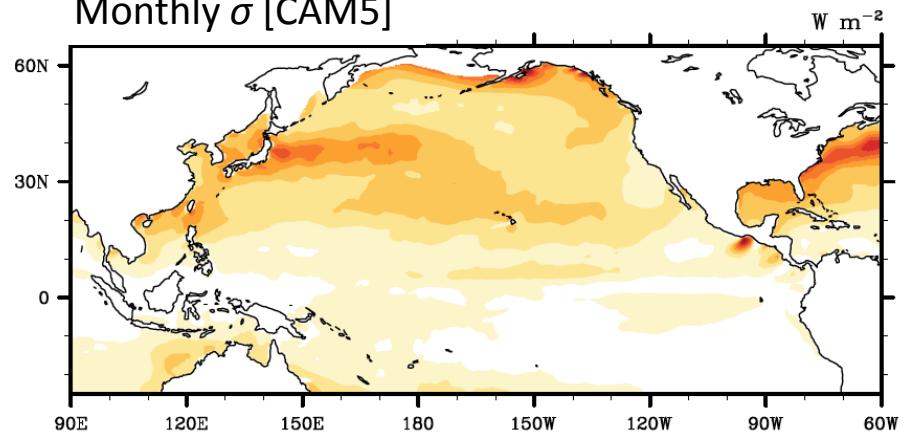
Mean 0.25° CAM5



Monthly σ [OBS]

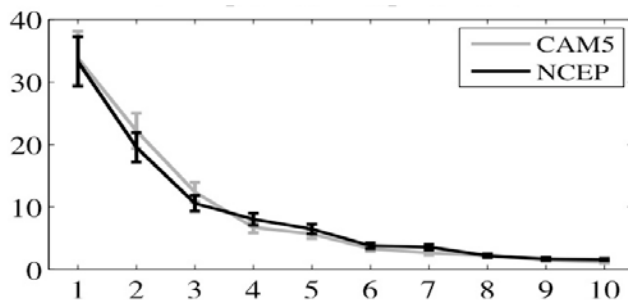


Monthly σ [CAM5]

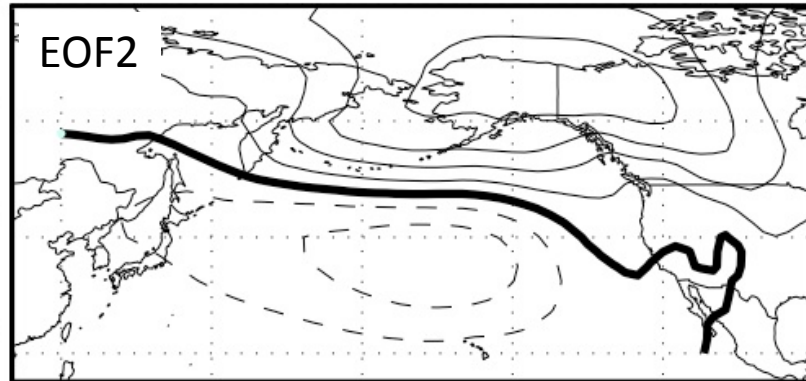
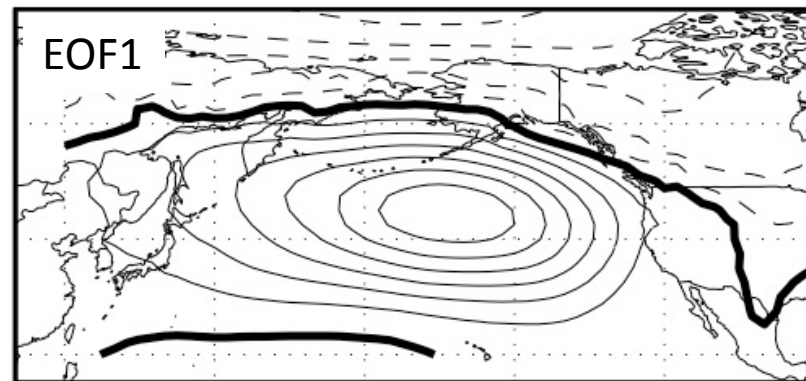
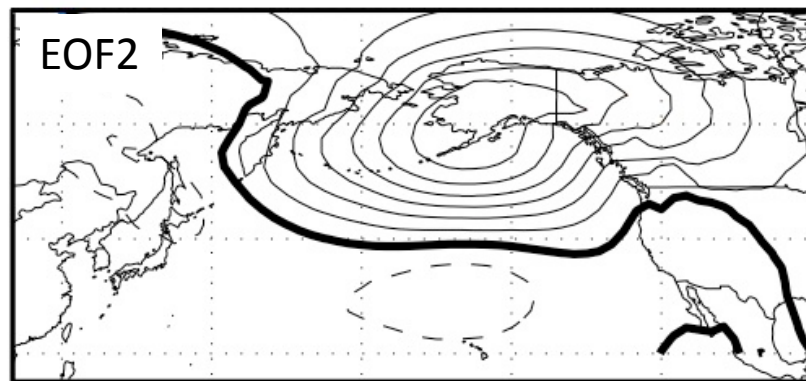
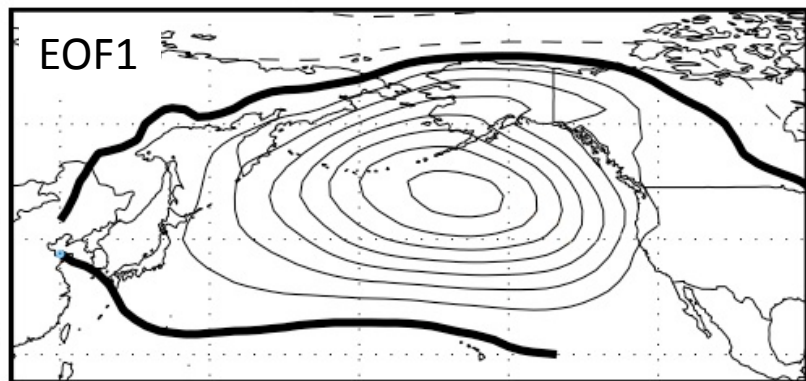


CAM5 Control: SLP Variability

Pacific Decadal Oscillation



North Pacific Oscillation



NCEP

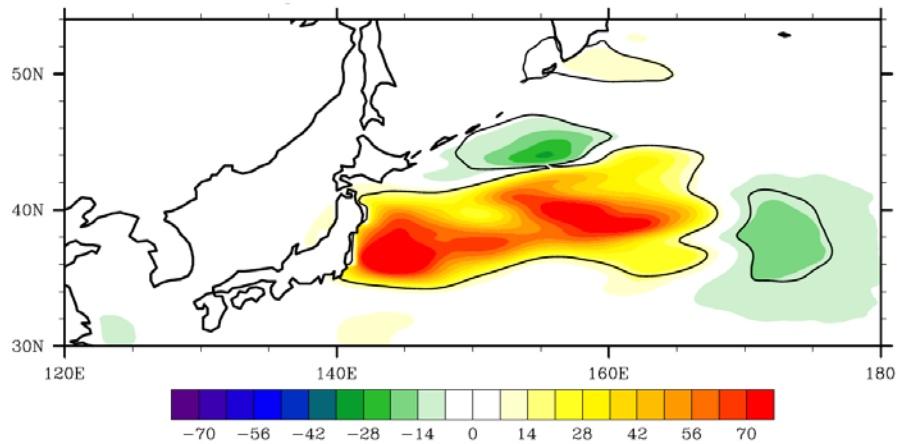
CAM5

Oyashio Front experiment: LOCAL RESPONSE

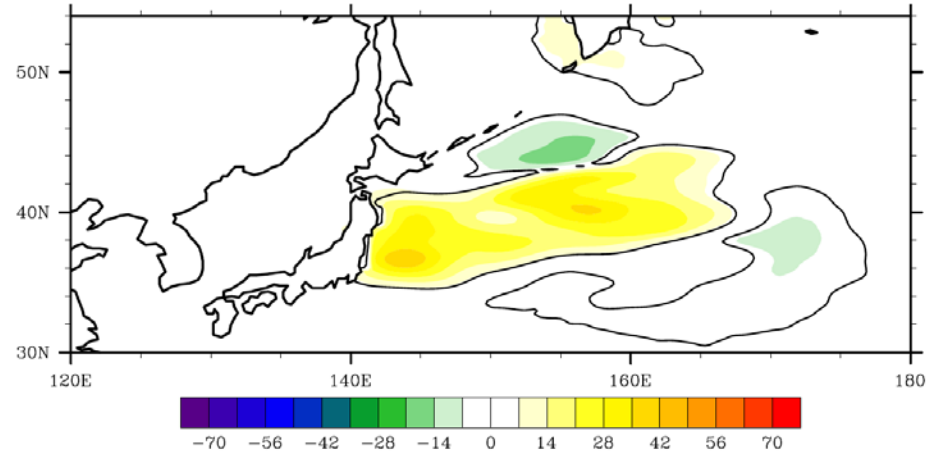
Local response: energy budget

$$\Delta NHF = \Delta SW + \Delta SH + \Delta LH + \Delta LW$$

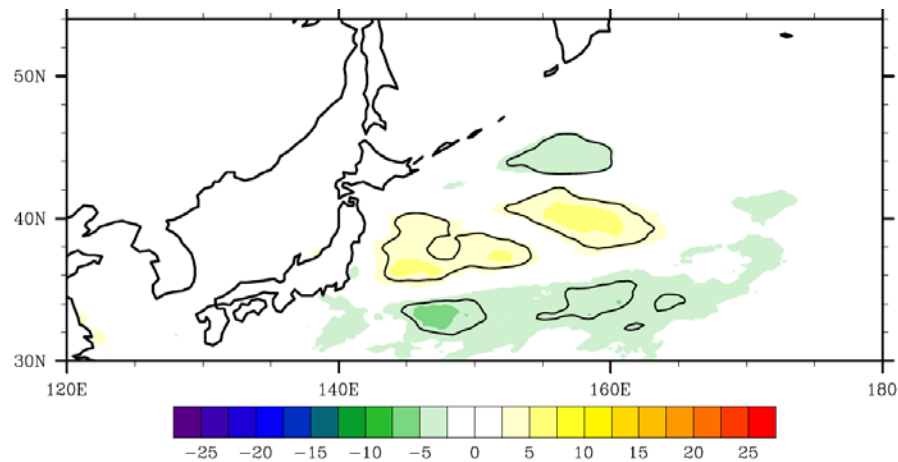
ΔLH Flux



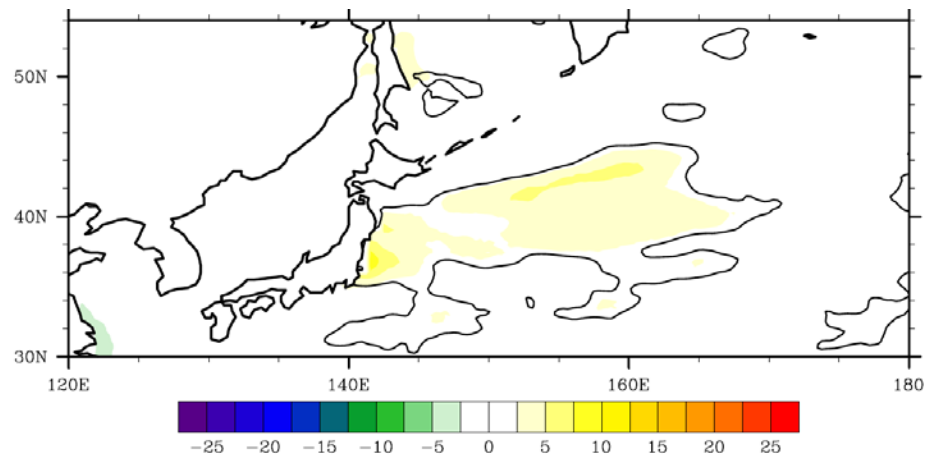
ΔSH Flux



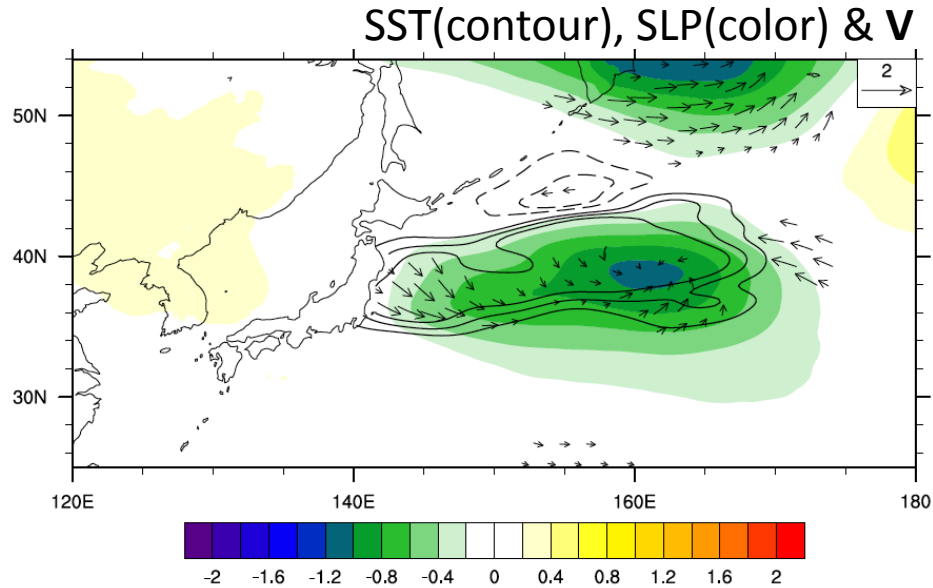
ΔSW Flux



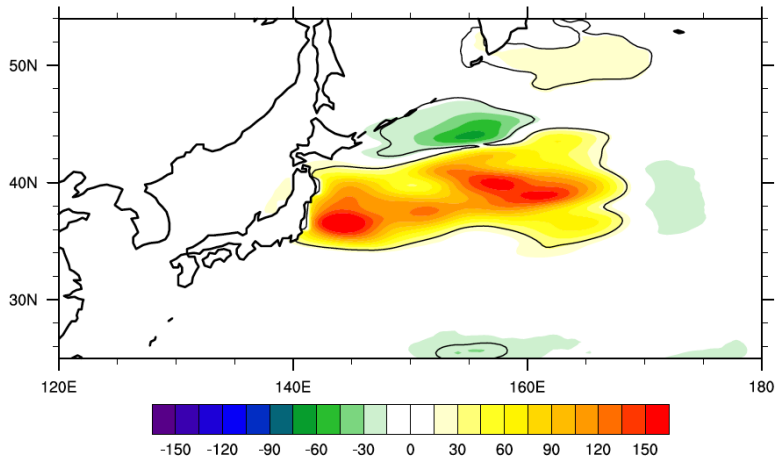
ΔLW Flux



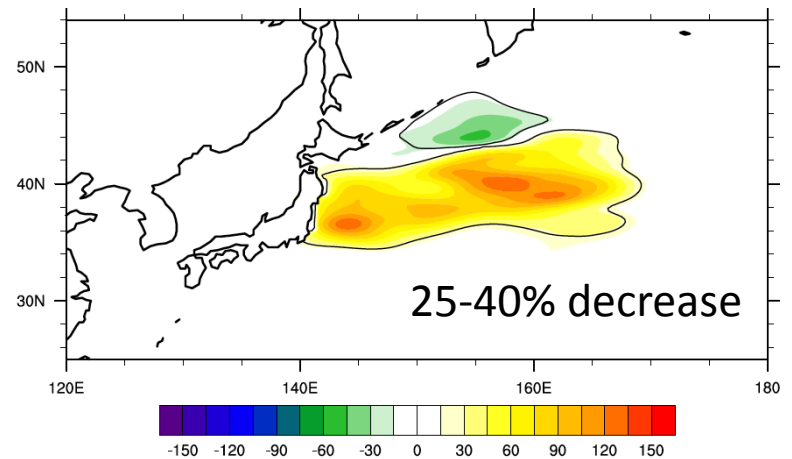
Local response: wind feedback



SH + LH Flux

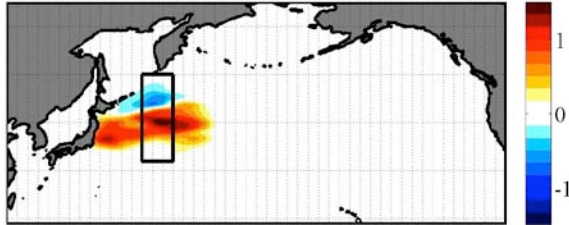


SH + LH Flux w/climo V

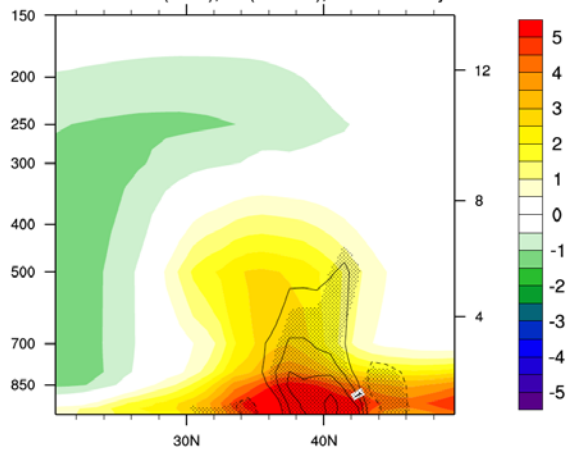
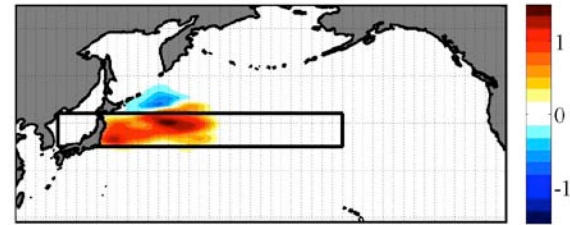


Local response: vertical depth

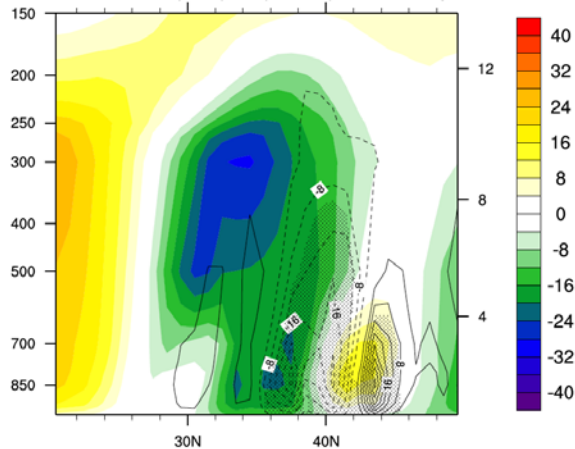
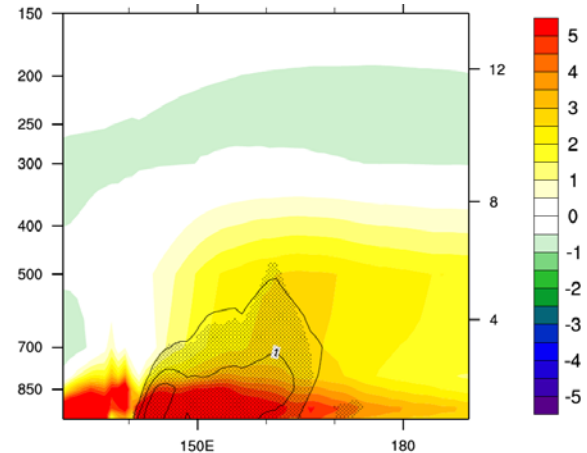
Zonally averaged area



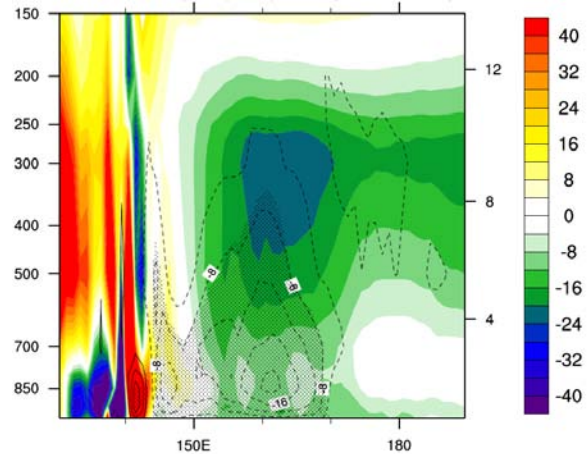
Meridionally averaged area



Total diabatic heating
[K day⁻¹]

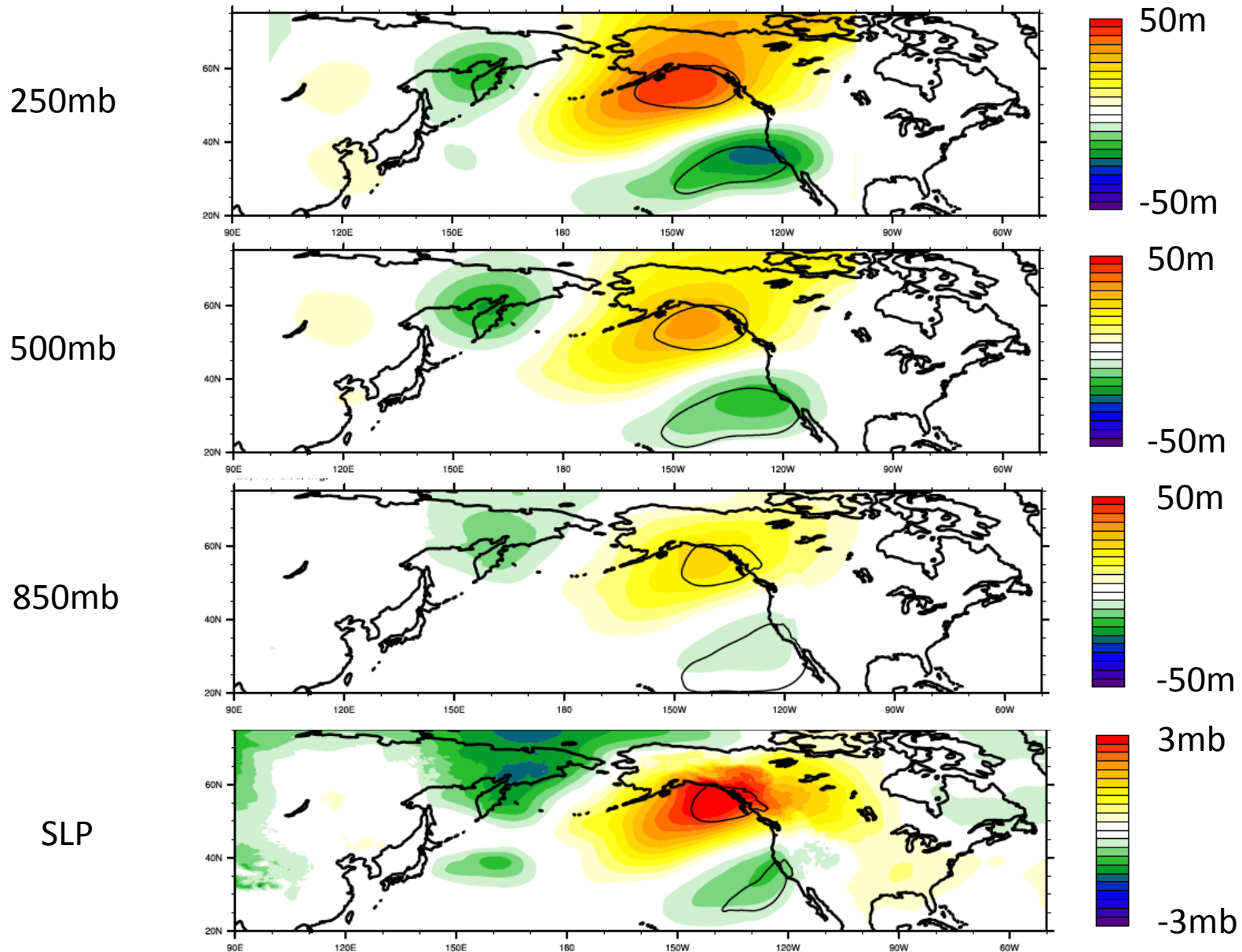


Omega
[mb day⁻¹]



REMOTE RESPONSE

Remote response: mean circulation

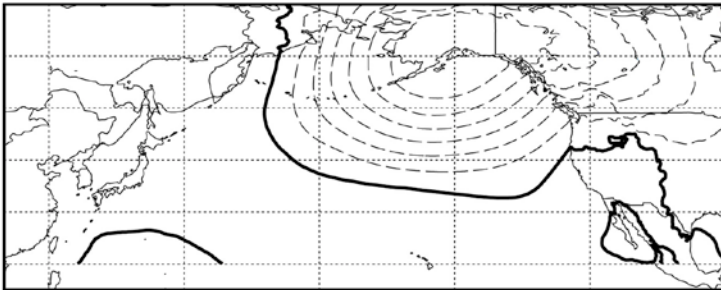


Remote response: SLP variability

WARM

EOF1

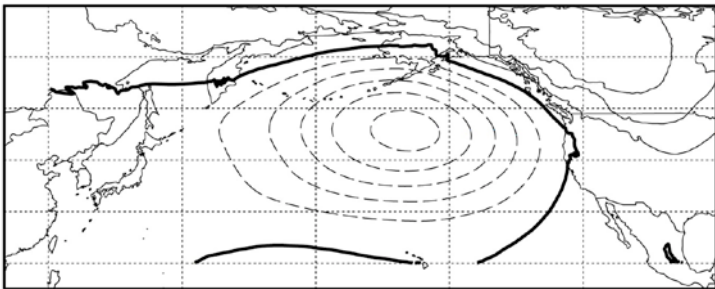
21%



Pat. correlations
* = significantly
different
0.87*

EOF2

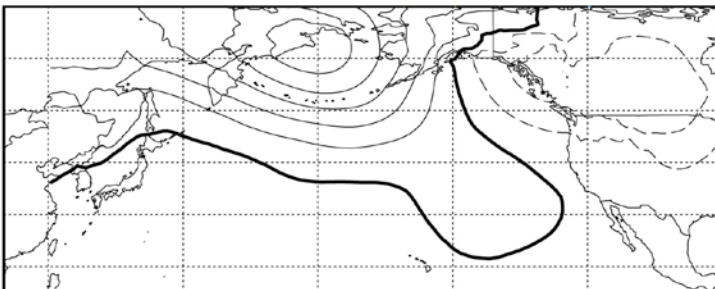
15%



0.87*

EOF3

11%

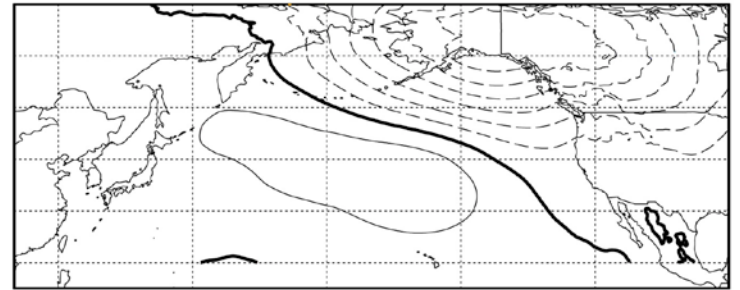


0.93

COLD

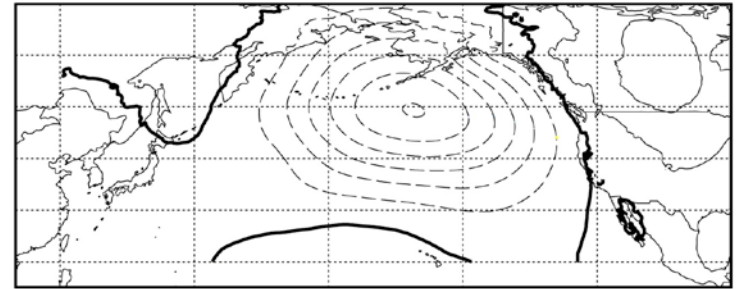
EOF1

20%



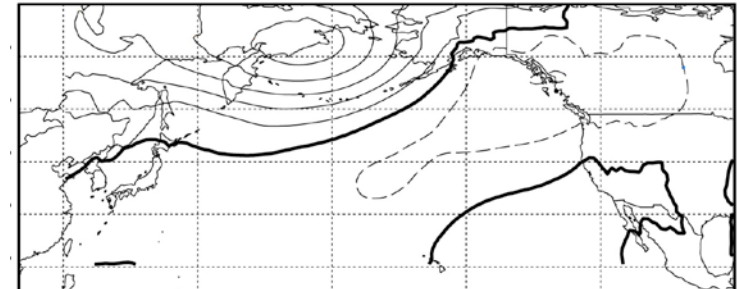
EOF2

14%



EOF3

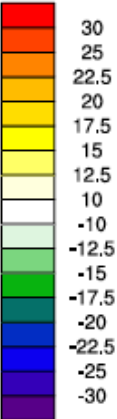
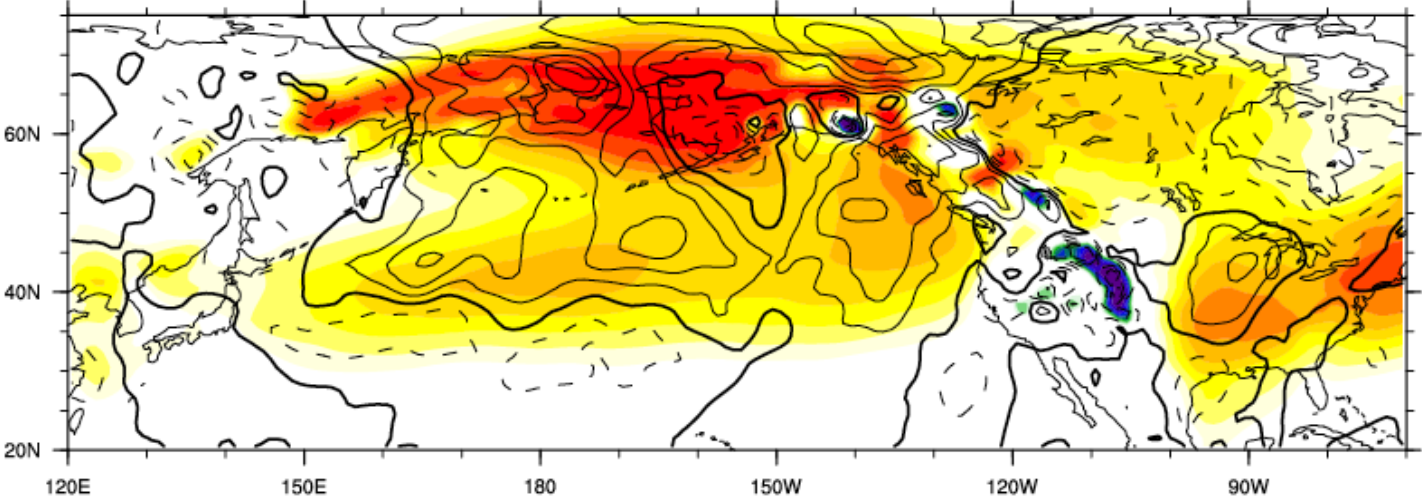
10%



Remote response: transient HF

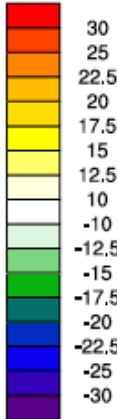
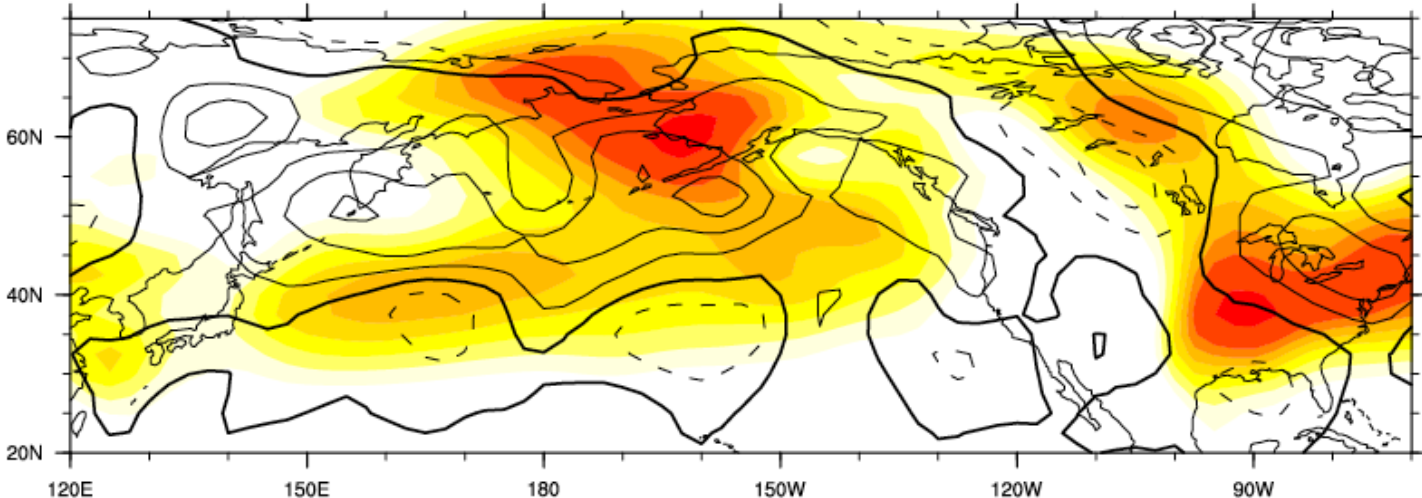
850mb v'T': mean (color), warm-cold (contour)

CAM5



850mb v'T': mean (color), OE regression (contour)

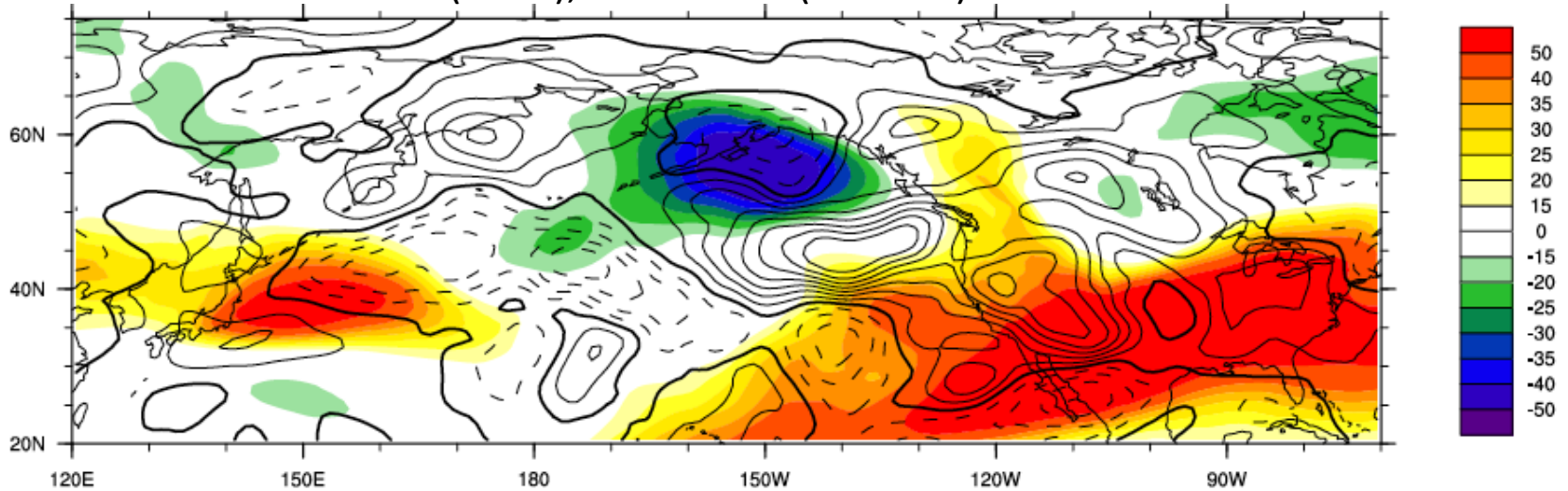
NCEP



Remote response: momentum flux

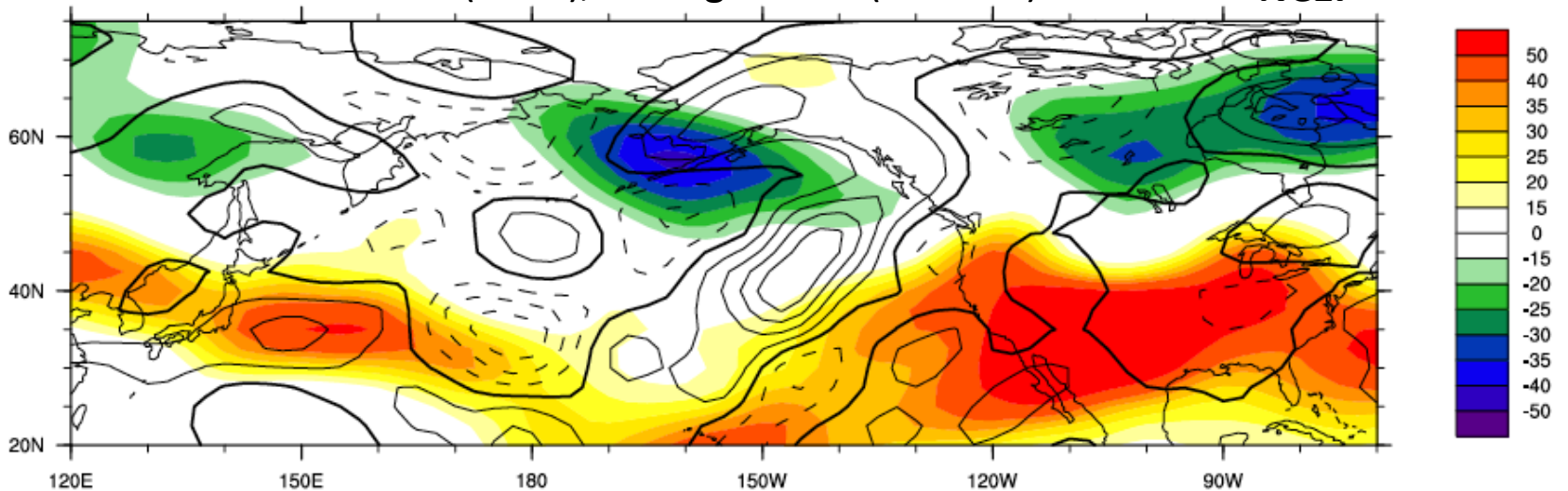
300mb $u'v'$: mean (color), warm-cold (contour)

CAM5



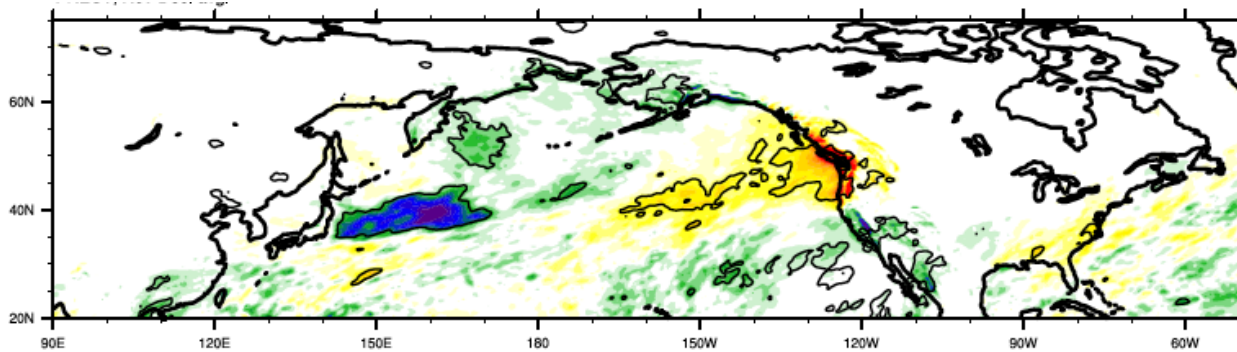
300mb $u'v'$: mean (color), OE regression (contour)

NCEP

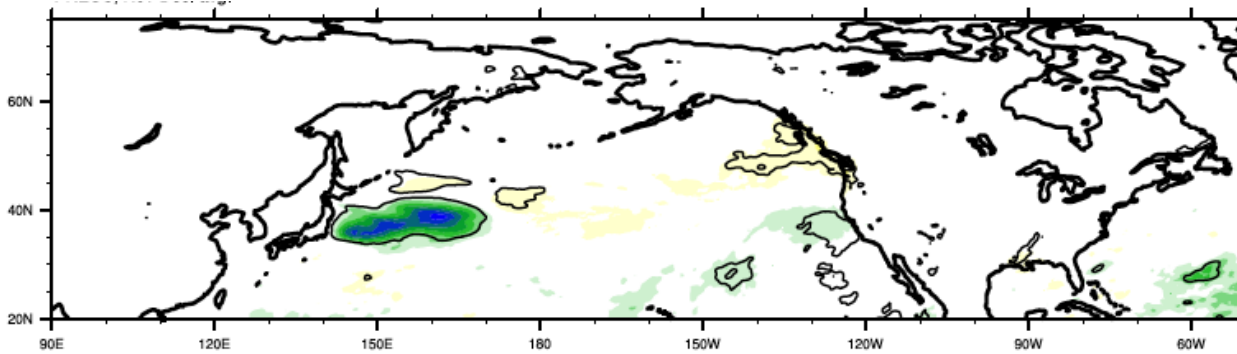


Remote response: sensible impact

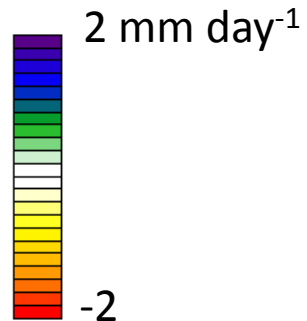
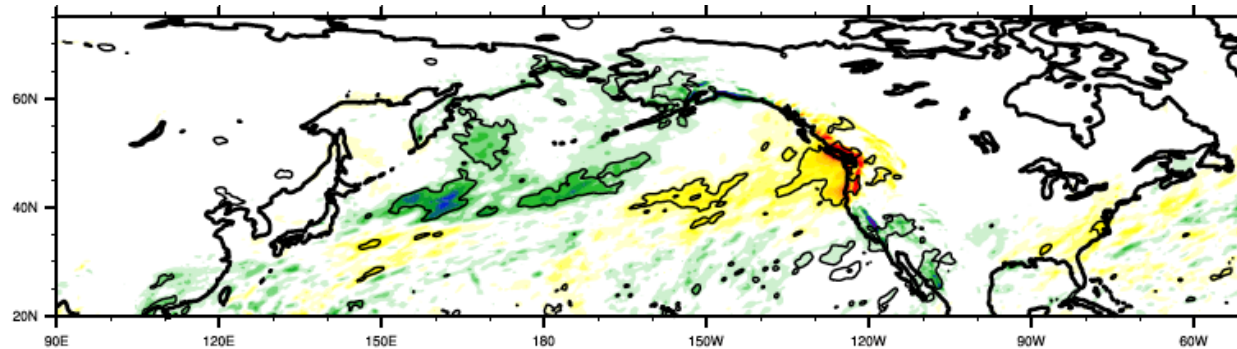
TOTAL
PRECIP



CONVECTIVE



STRATIFORM

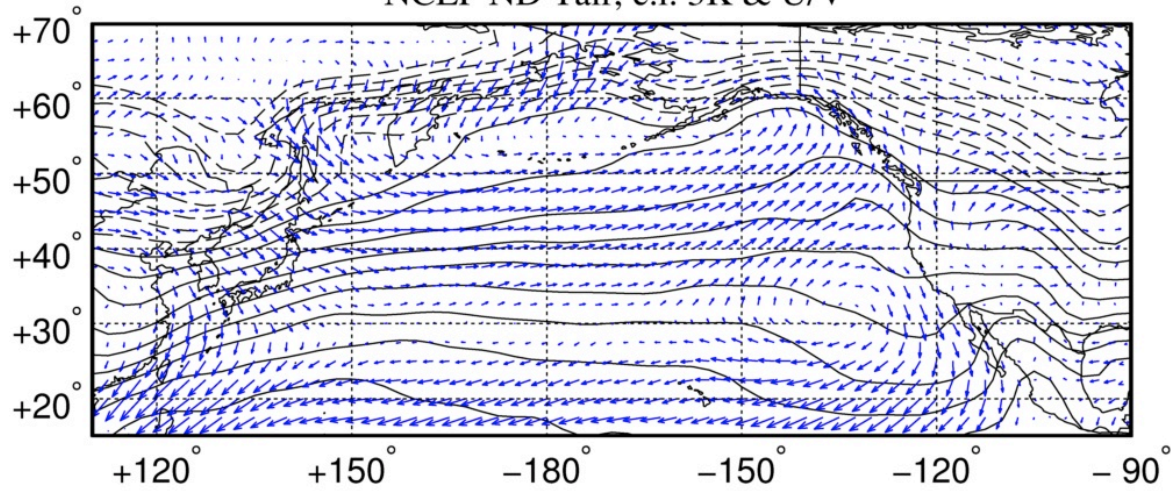


Conclusions

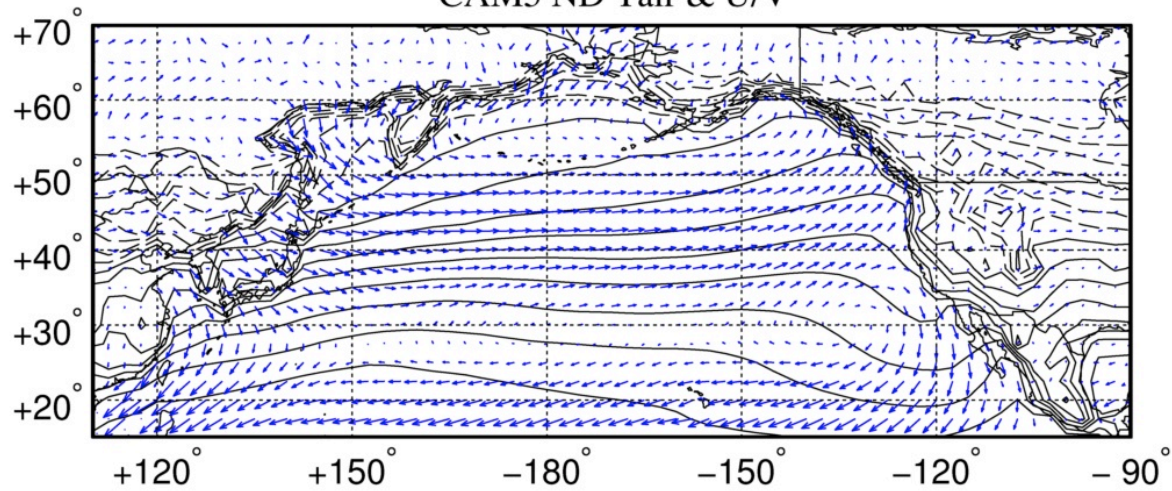
- The impact of the Oyashio SST front on the atmosphere can be modeled by prescribing SST anomalies
- The *local* response is characterized by a large change in turbulent fluxes, altering the atmospheric circulation to ~400mb
- The *local* dynamical response amplifies heat flux anomalies by 25-40%
- The *remote* response alters the mean strength of the Aleutian low and the structure of the dominant modes of SLP variability
- Sensible impacts include large changes in precipitation along the west coast of North America

Miscellaneous

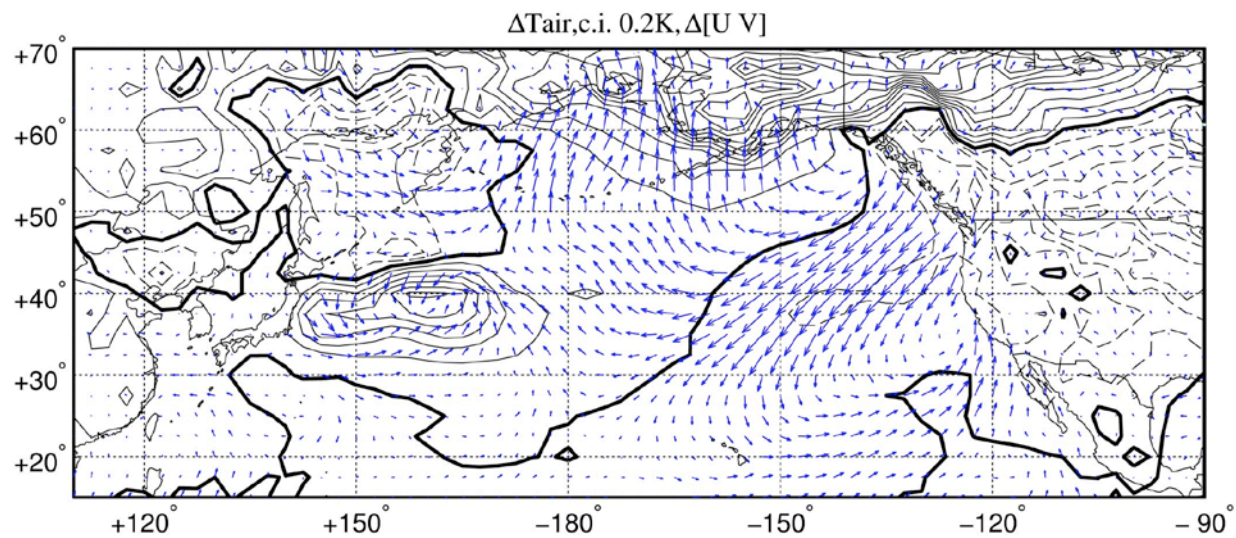
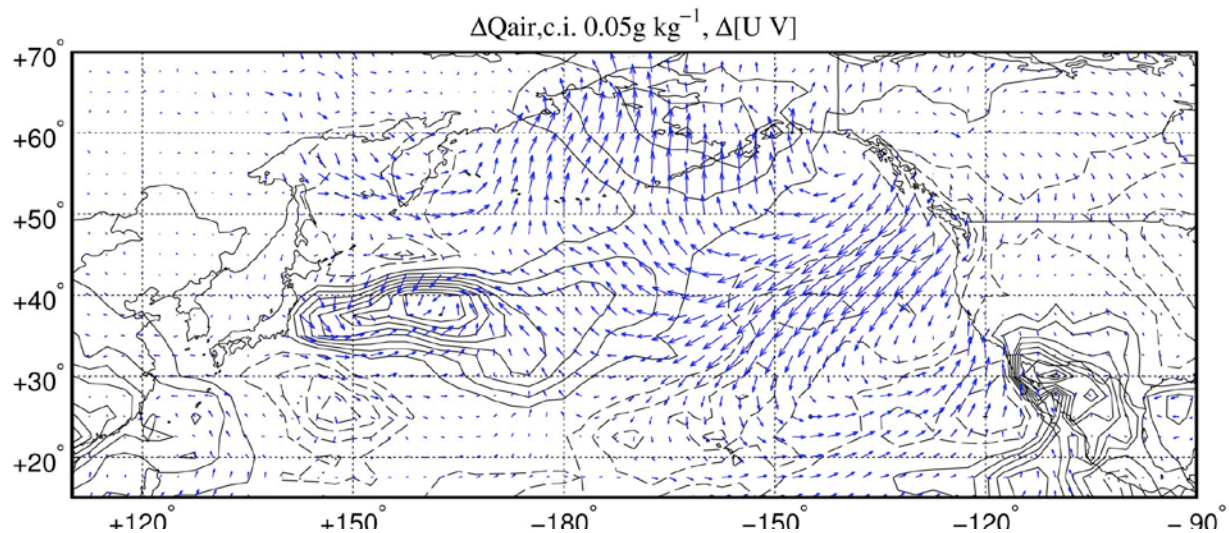
NCEP ND Tair, c.i. 3K & U/V



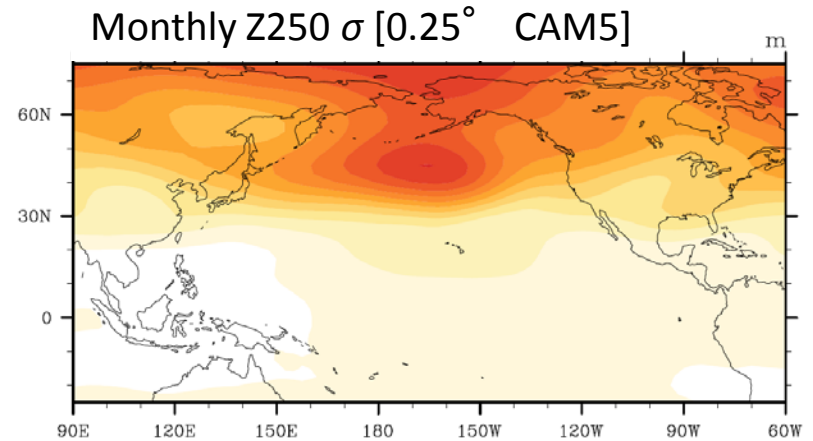
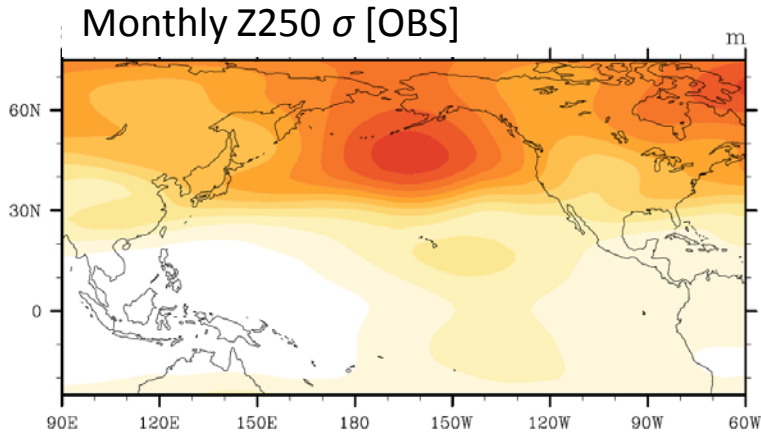
CAM5 ND Tair & U/V



Miscellaneous

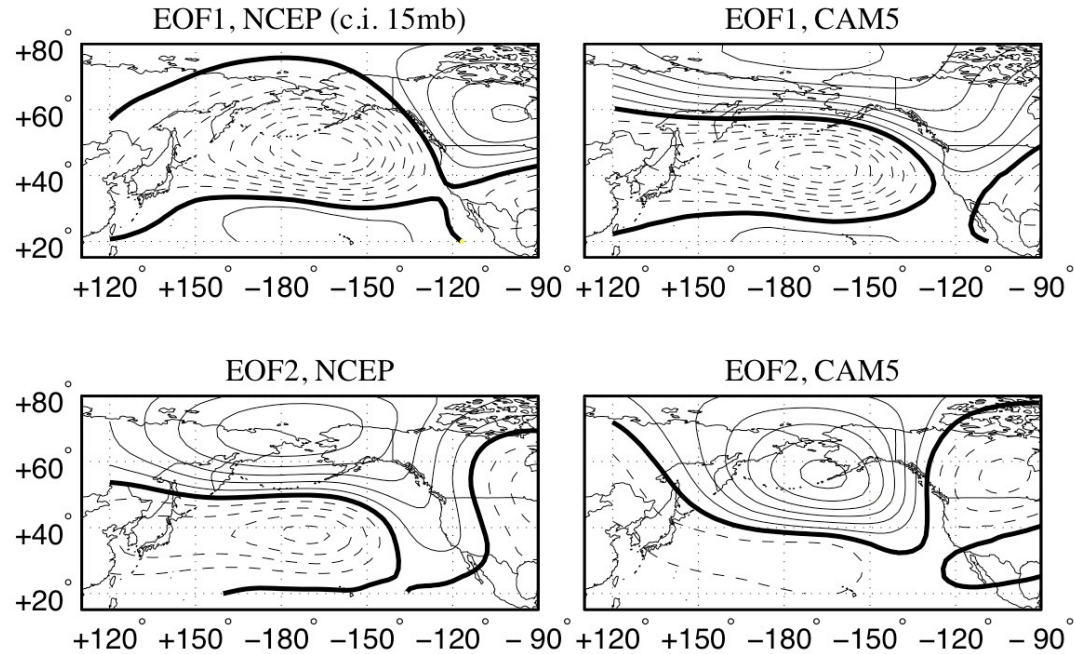


CAM5 Control: 250Z Variability



CAM5 Control: 250Z Variability

EOFs of NDJFM 250Z anomalies



% Explained in top 10 EOFs

