PICES-2011 Annual Meeting

MONITOR/POC/FUTURE Topic Session

"How well do our models really work and what data do we need to check and improve them?"

Decadal variability of the Kuroshio/Oyashio Extension fronts, their atmospheric influences, and implications to prediction

Bunmei Taguchi

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in collaboration with

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1. ESC/JAMSTEC, 2. Univ. of Tokyo, 3.RIGC/JAMSTEC, 4. UH

19 October, 2011 Official Conference Hall, Khabarovsk, Russia

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Outline:

1. Decadal variability of Kuroshio/Oyashio extension (KOE) fronts.

   One-way prediction of the KE front speed: wind-forced Rossby wave propagations.

2. Large-scale atmospheric response to KOE frontal variability.

   2-way prediction of the KE frontal variability considering atmospheric feedback.

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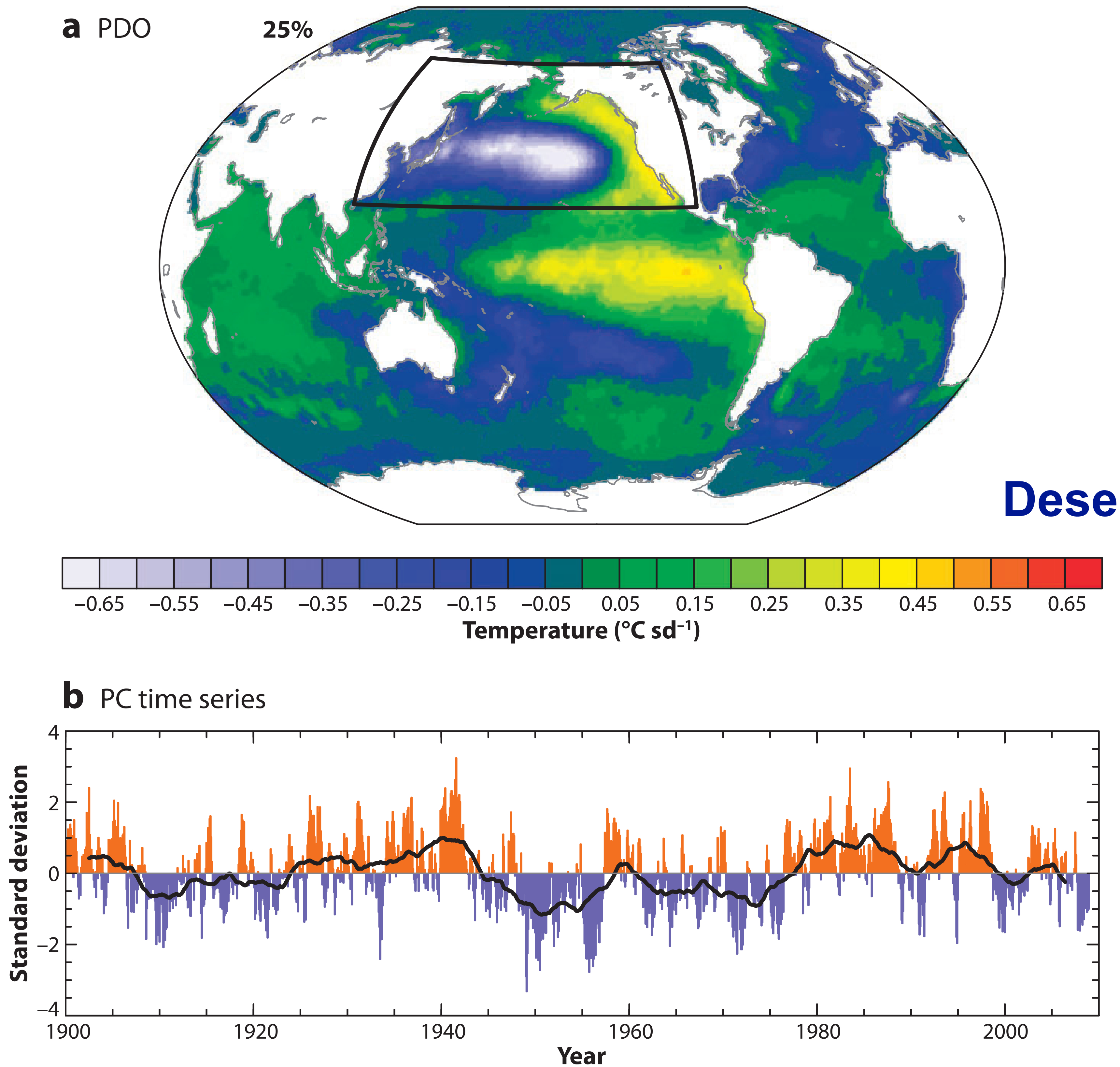
Pacific Decadal Variability

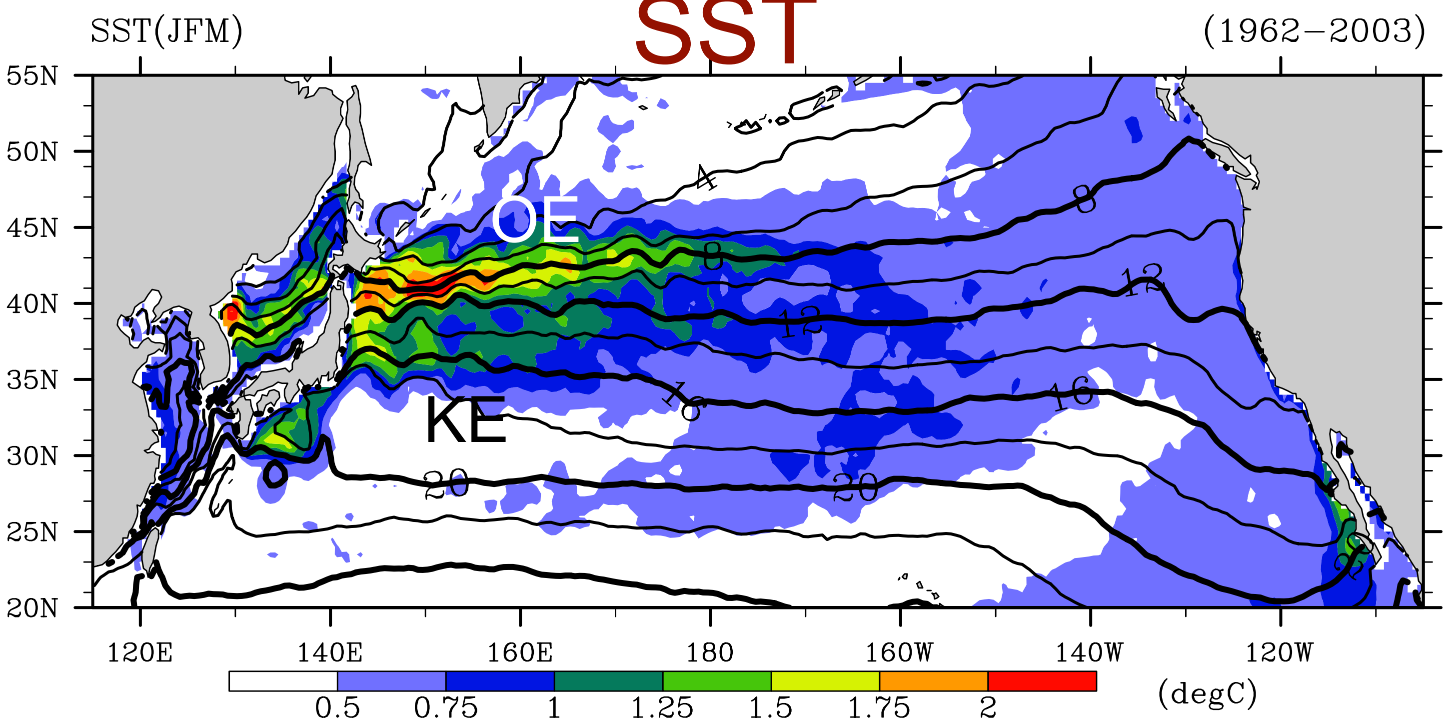


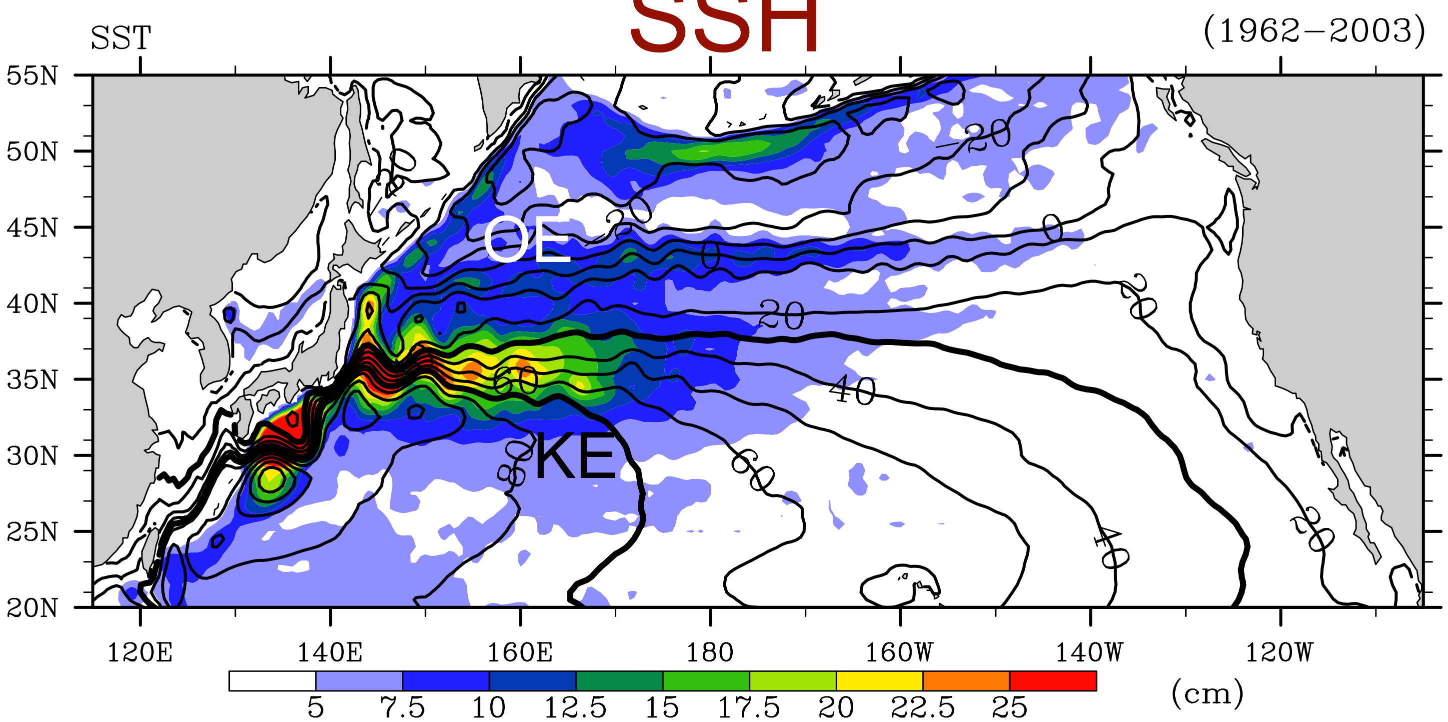
Deser et al. (2011)

Useful index. However ...

Large interannual-to-decadal variability is confined within narrow latitudinal bands of KOE fronts

standard deviation (> 1 year; color) and mean (contour)





54-year eddy-resolving (0.1º) OFES hindcast

Sasaki et al. (2008)

Large interannual-to-decadal variability is confined within narrow latitudinal bands of KOE fronts

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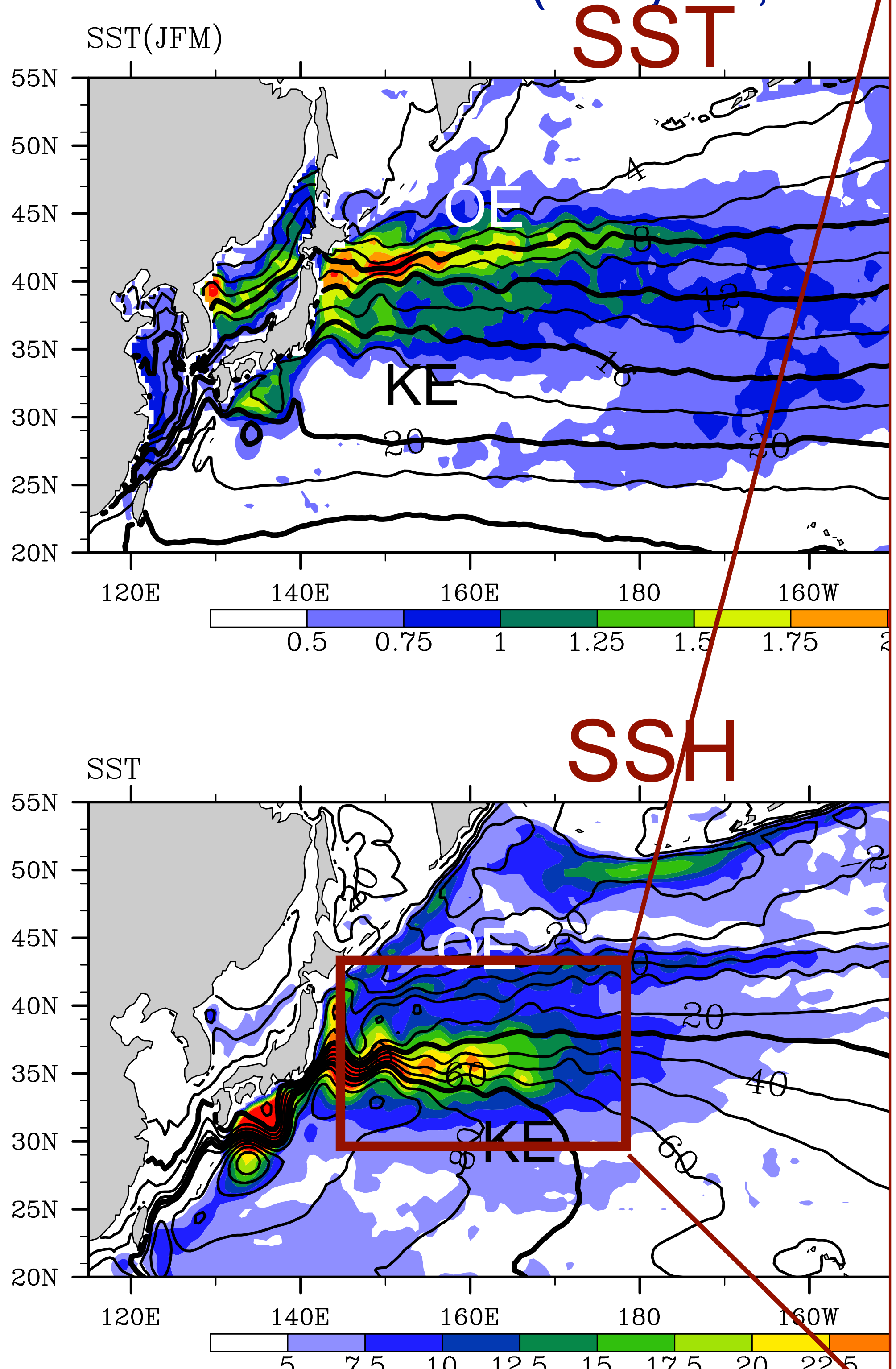
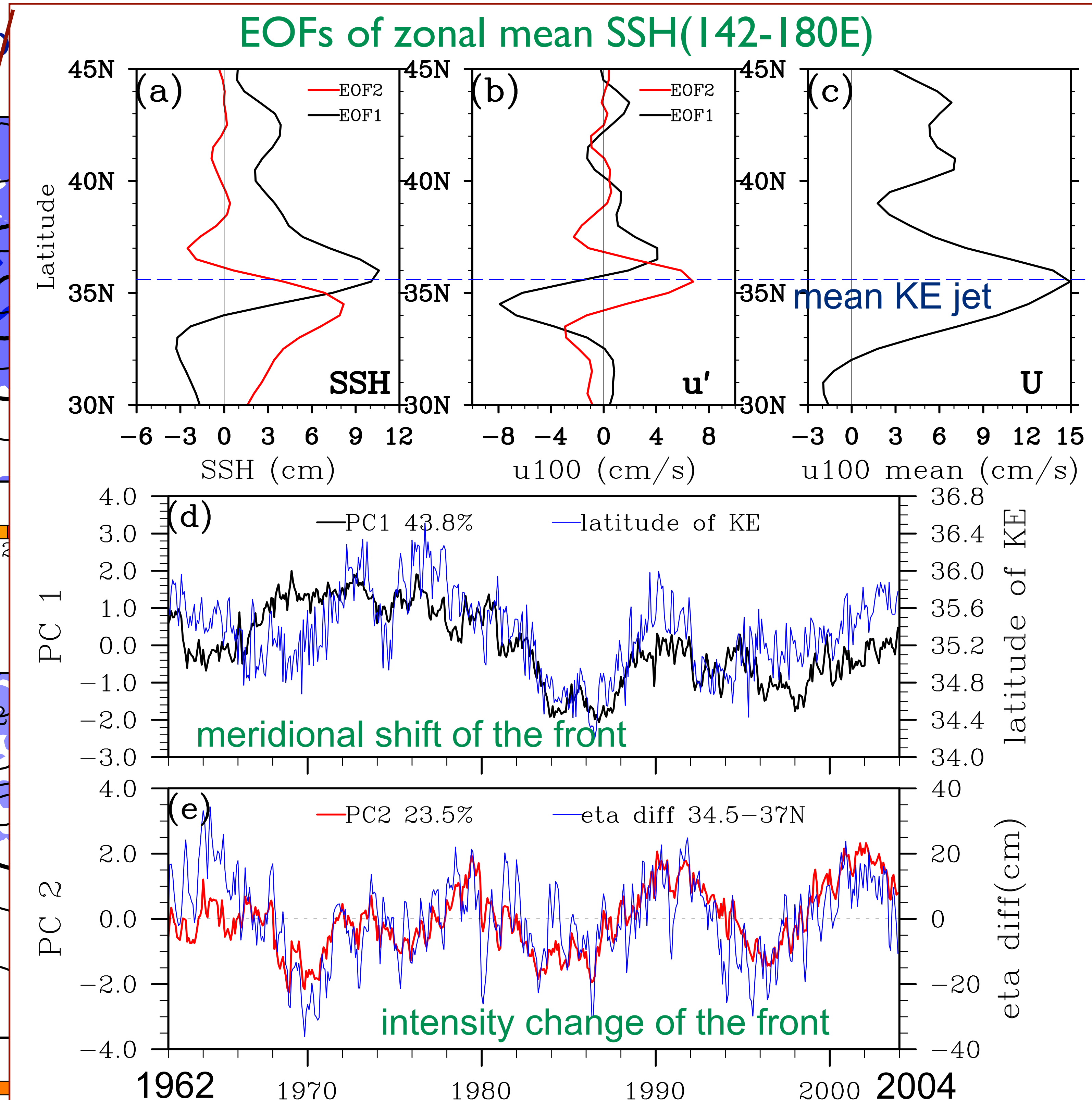


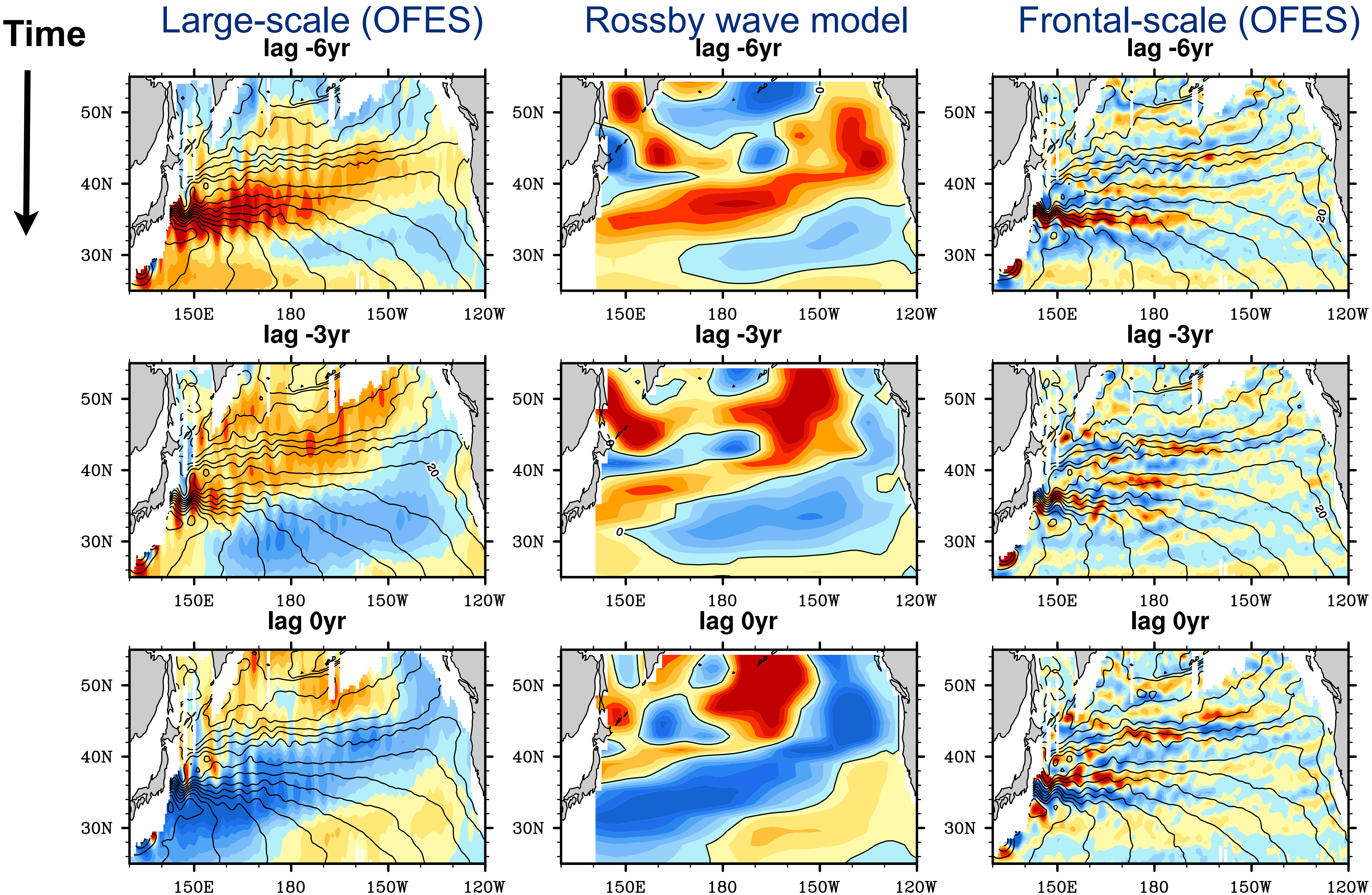


54-year eddy-resolving (0.1°) OFES hindcast
Sasaki et al. (2008)

Taguchi et al. (2007,JC)

Large- vs. frontal-scale variability (SSH; 2nd mode)

KE speed is an important predictor for infant sardine mortality (Nishikawa and Yasuda)



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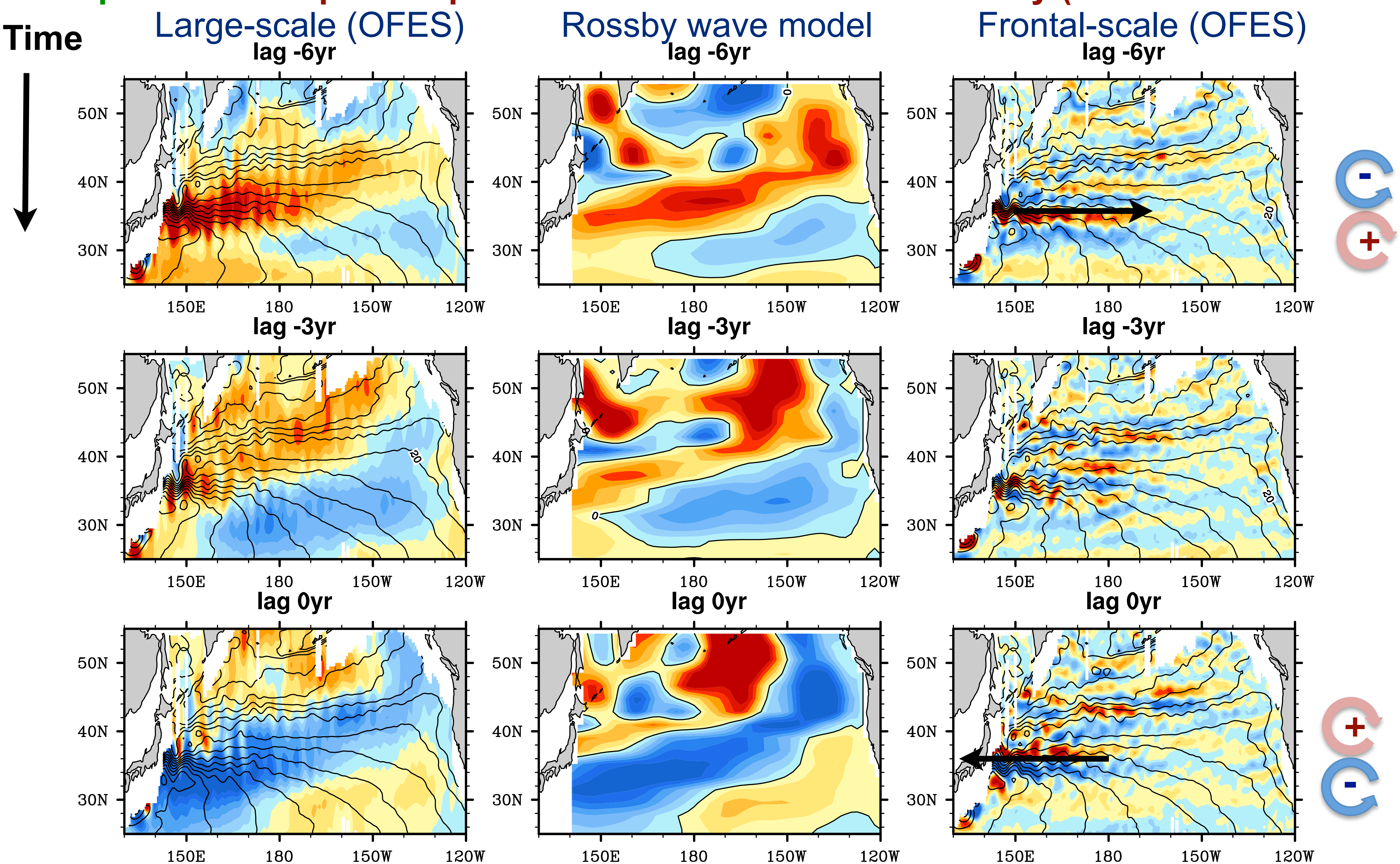


- Frontal-scale recirculation variations give rise to KE speed change.
- Large-scale RWs are transformed into latitudinally narrow jet structures.
- KE speed variations can be traced back to NPGO. (Ceballos et al. 2009)

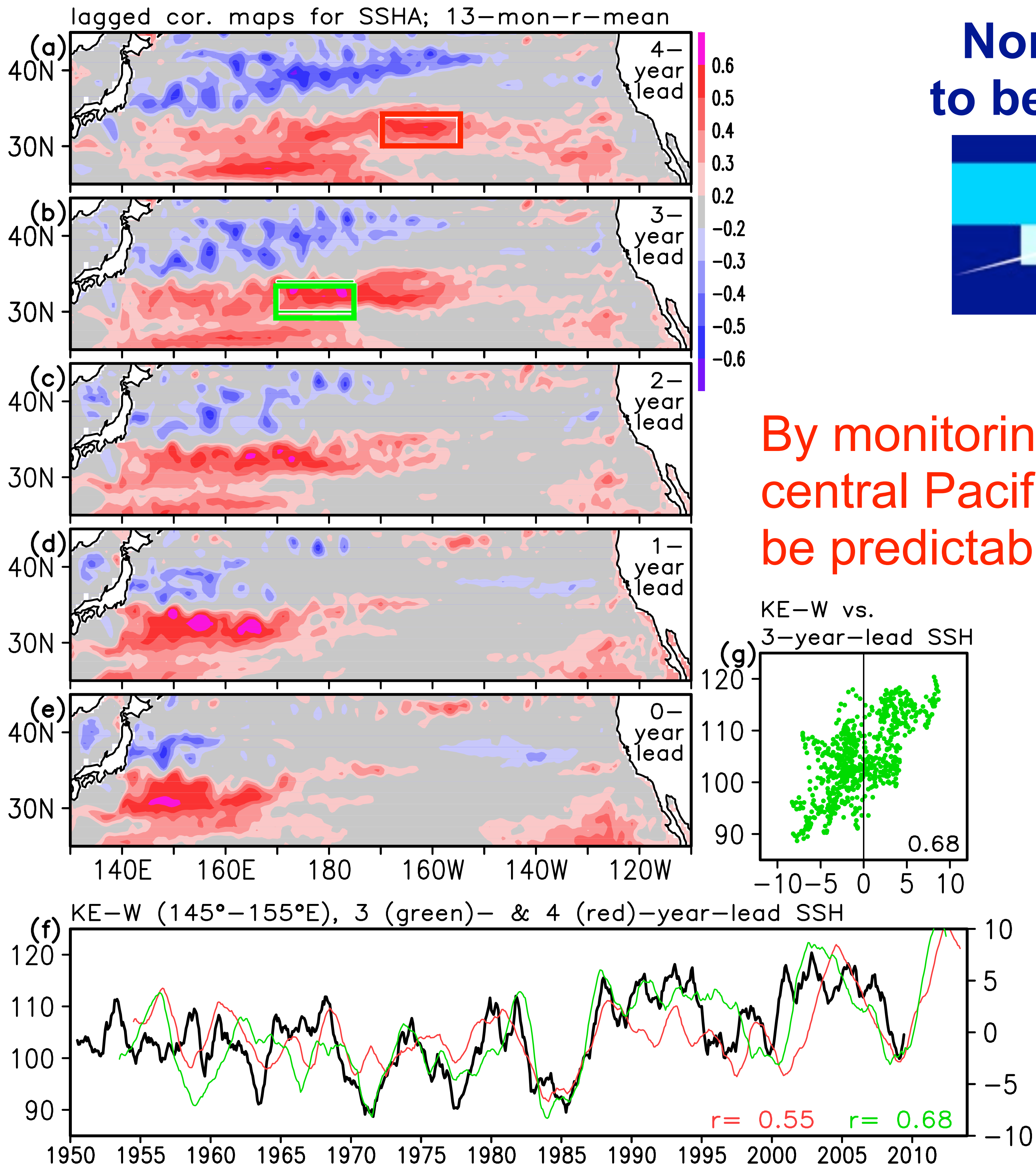
Potential predictability of the KE jet speed variability

Lagged correlation between anomalous KE jet speed and SSHa (60-year OFES hindcast)

Nonaka et al. to be submitted

4-year lead

3-year lead



By monitoring SSHa in the central Pacific, KE seed can be predictable 3 years ahead.

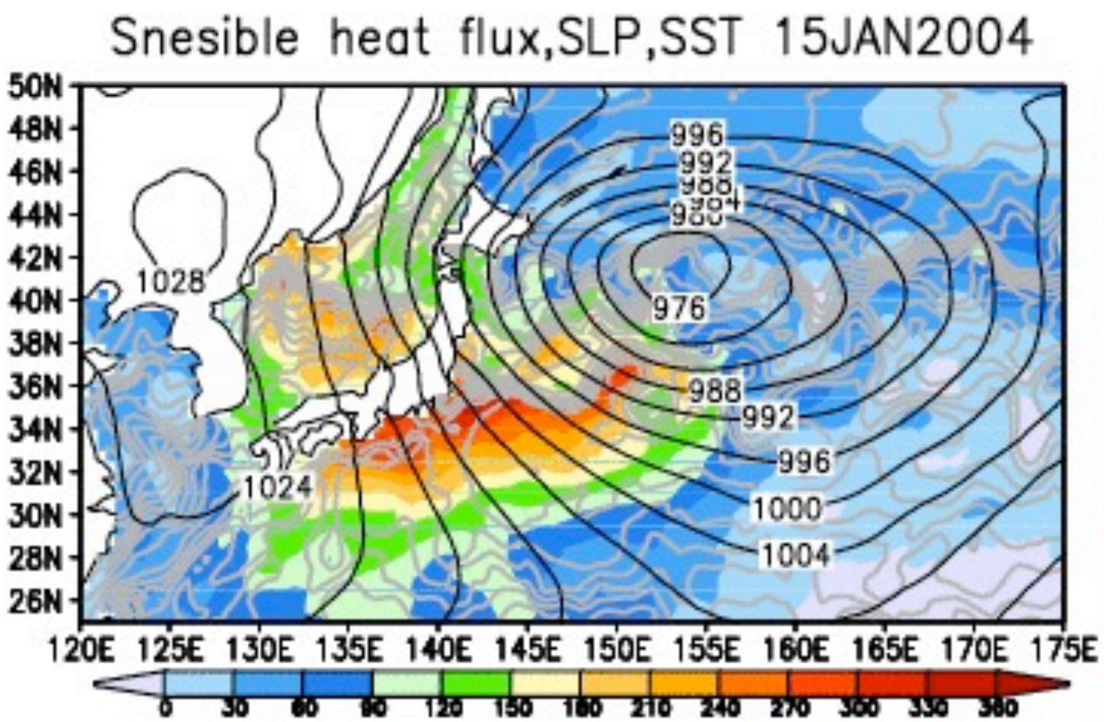
KE jet speed
Central Pac. SSHa 3-yr ahead

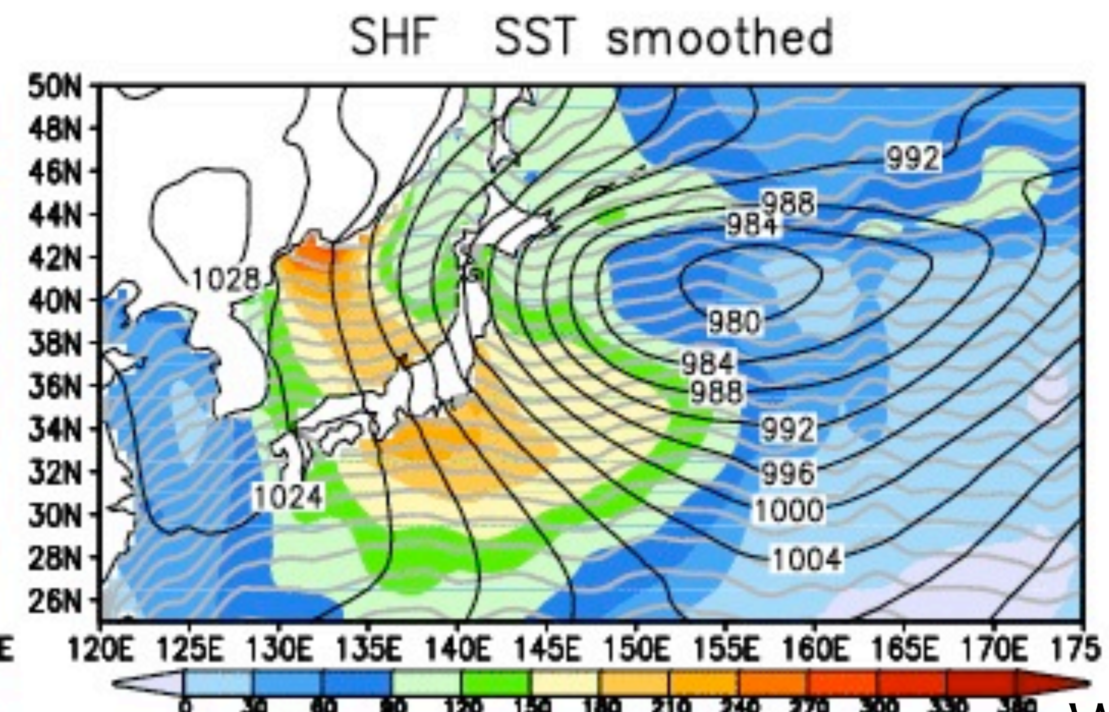
Influence of the KOE fronts on the atmosphere

Regional atmospheric model study **Taguchi et al. (2009,JC)**

Control Exp. w/ sharp SST gradients | **SST smoothed Exp.**

Sensible heat flux & SLP (snap)



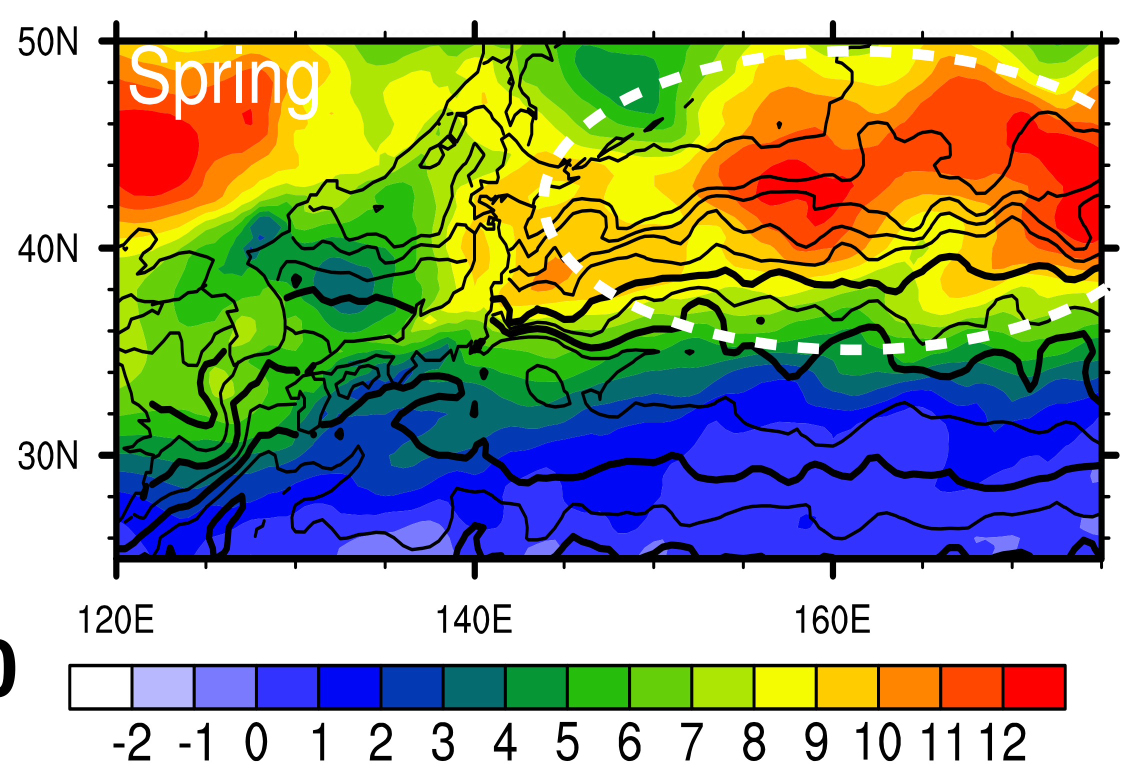


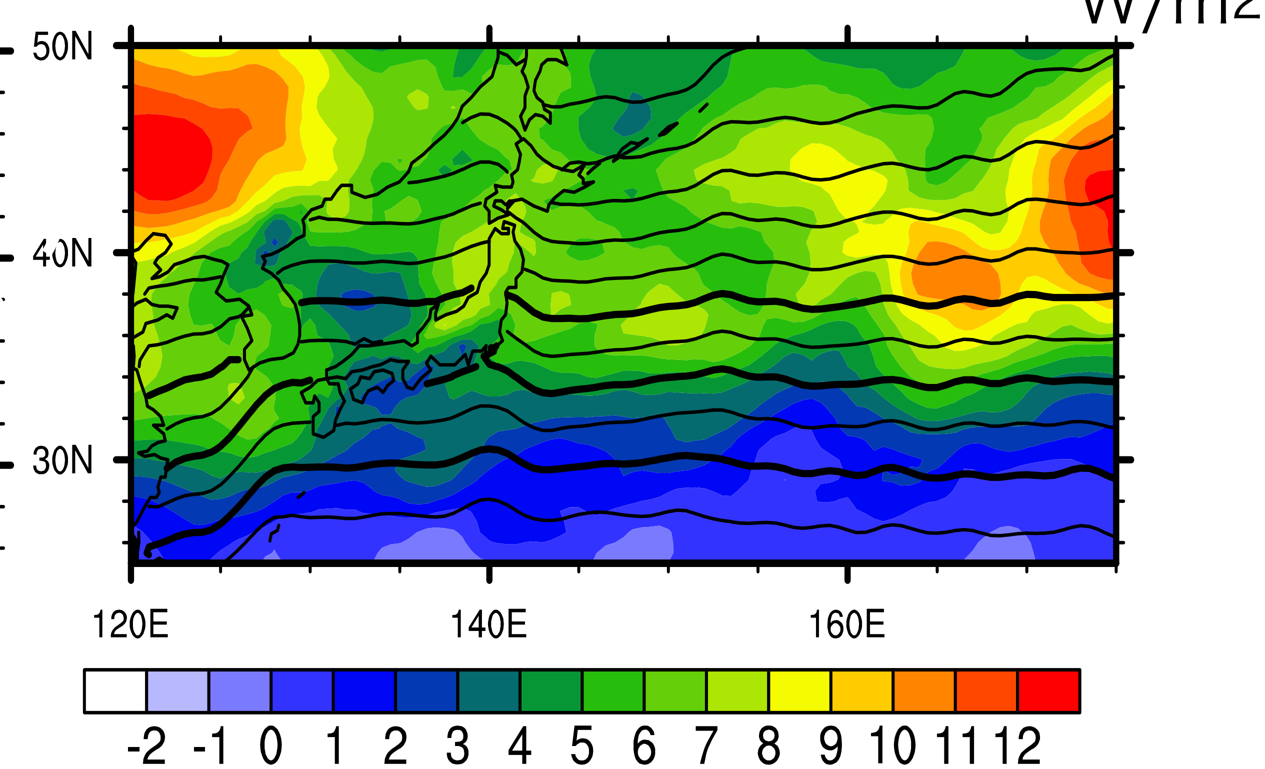
Storm track activity

$$\overline{v'T'}$$

850hPa

Spring mean (3/16-4/30/2004)





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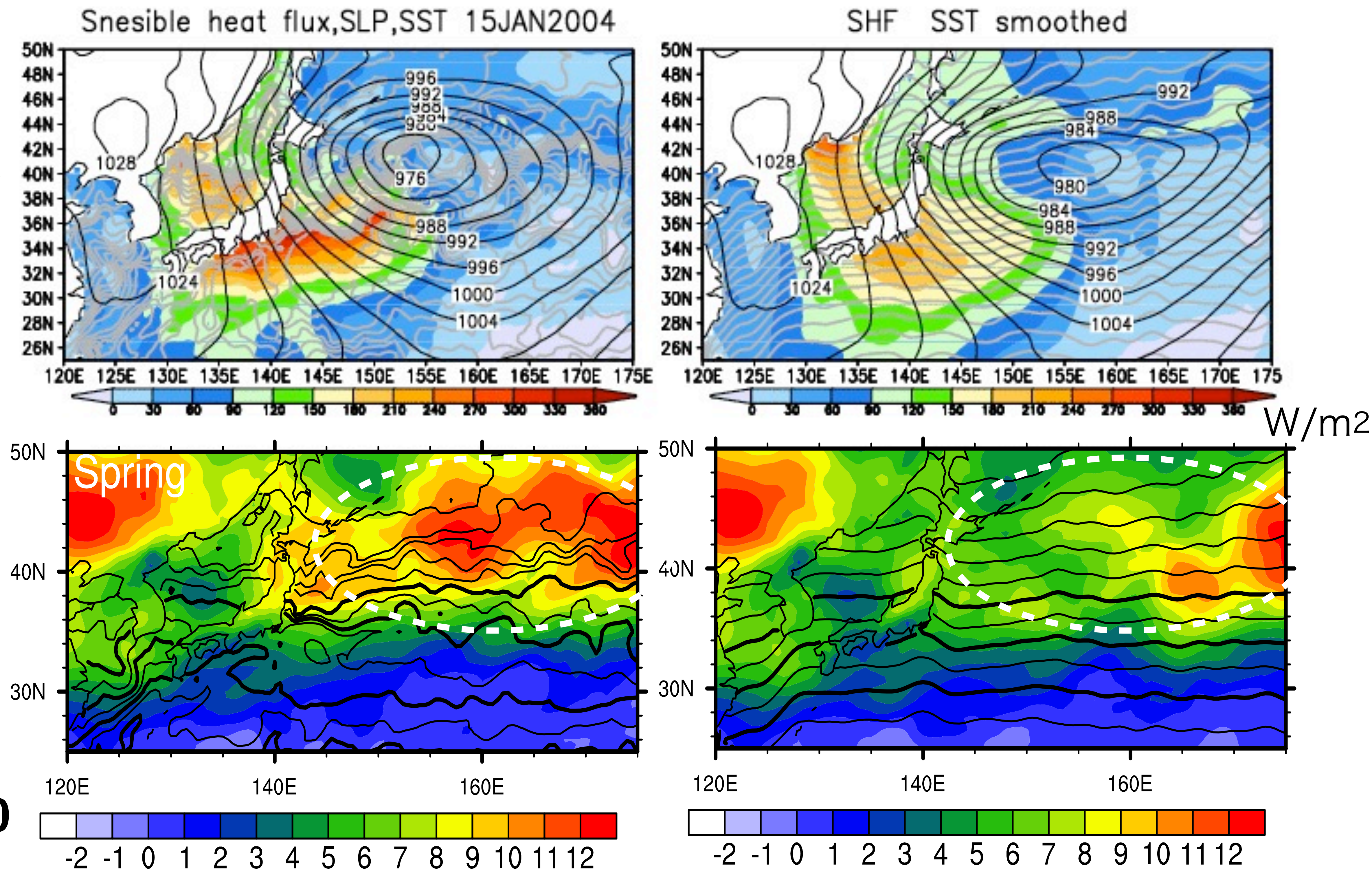
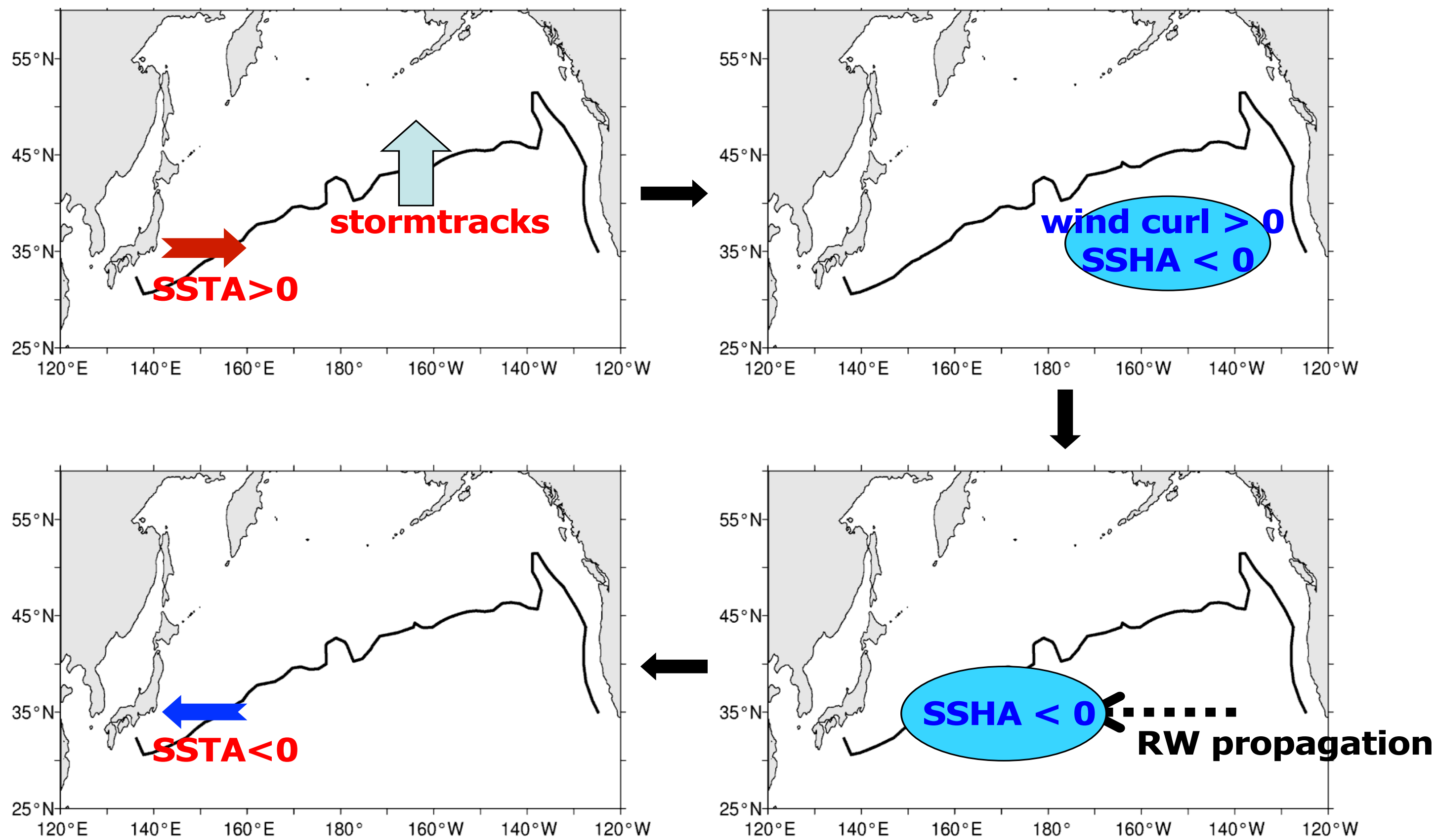


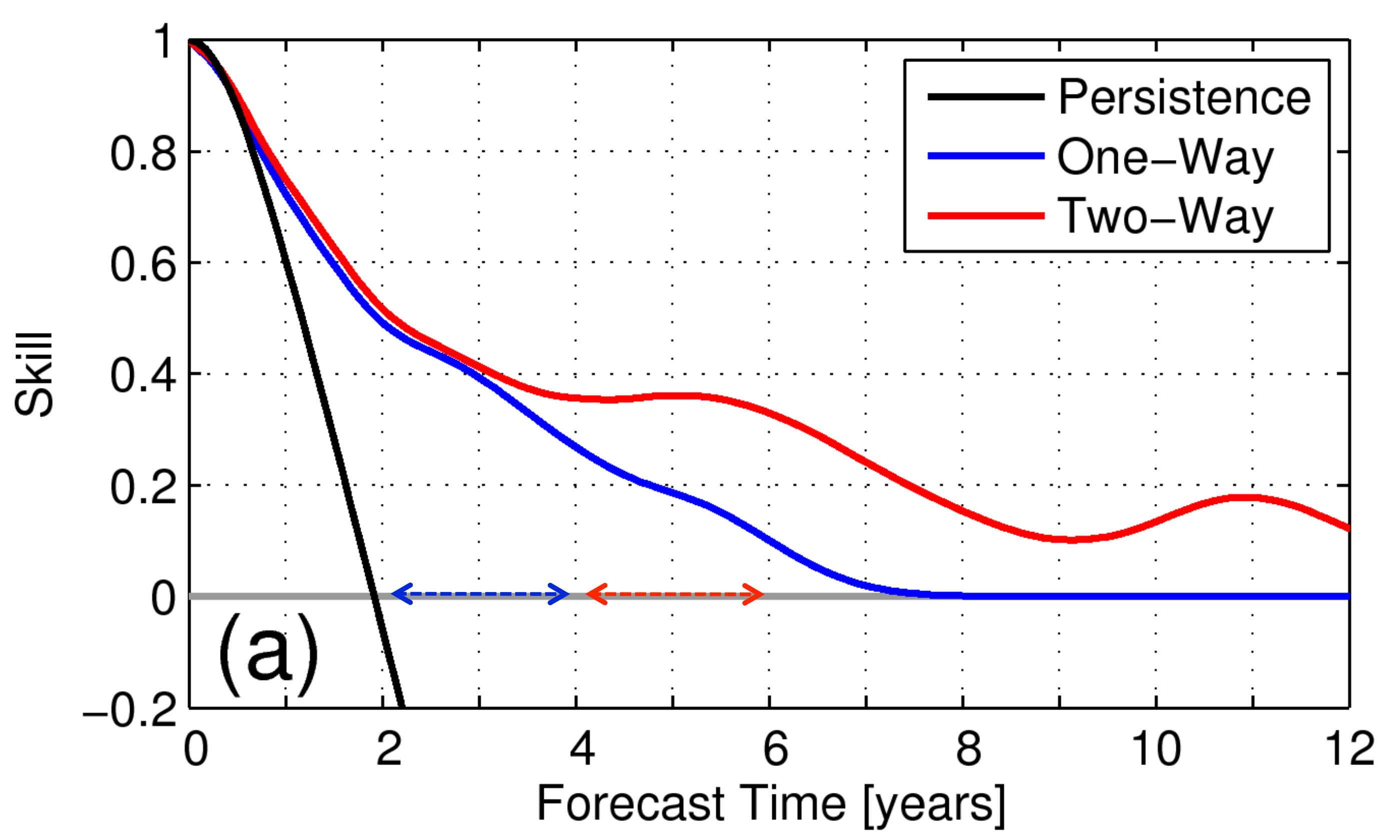
Smoothed SST front substantially underestimates atmospheric storm track activity.

2-way prediction of the KE dynamical state

Schematic for a delayed negative feedback decadal oscillation



Mean square skill of the predicted KE index



Qiu et al. to be submitted

1. Prediction with Rossby wave dyn.

$$h_1(x,t) = h_{obs}\,[x+c_R(t-t_0),\ t_0]$$

where

$h_{obs}(x, t_0)$ **: initial SSHAs**

c_R **: Rossby wave speed**

2. Prediction with Rossby wave dyn. + KE feedback to wind forcing

$$h_2(x,t) = h_1(x,t) + \int_{t_0}^{t} b[x+c_R(t'-t_0)]\,K(t')\,dt'$$

where

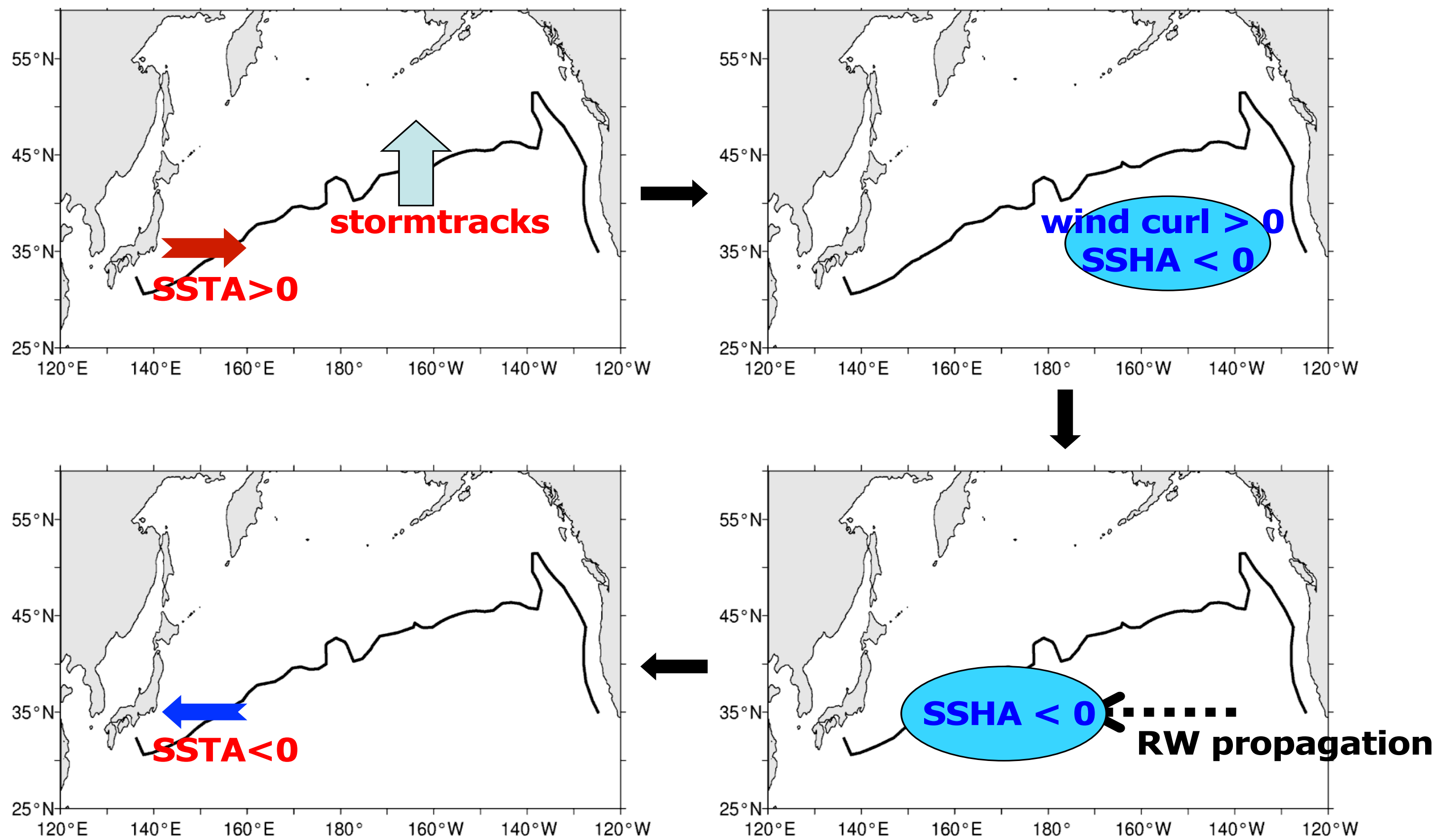
$b(x)$ **: feedback coeff.**

$K(t)$ **: forecast KE index**

Considering the wind forcing due to the KE feedback provides additional predictive skill.

2-way prediction of the KE dynamical state

Schematic for a delayed negative feedback decadal oscillation



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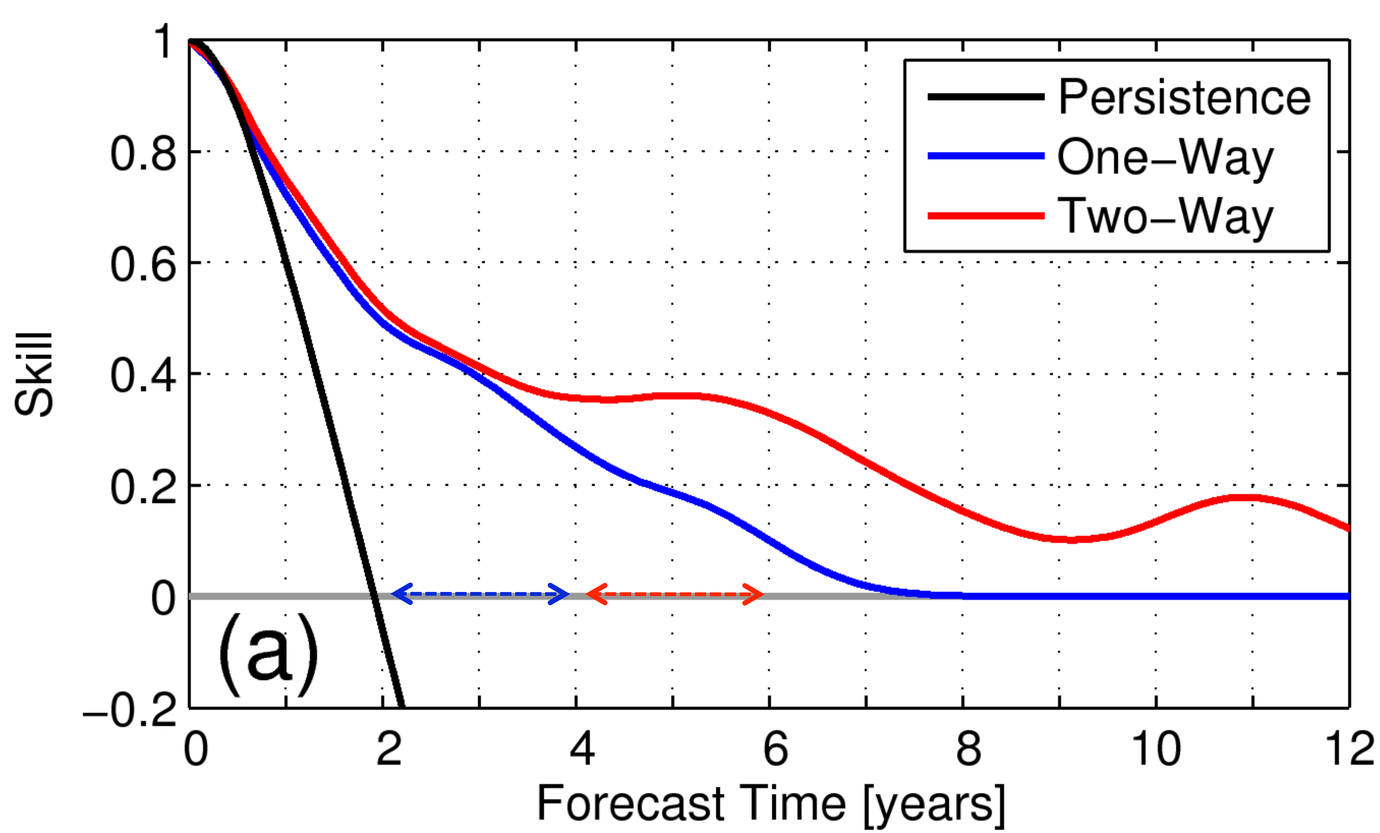

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$b(x)$ **: feedback coeff.**

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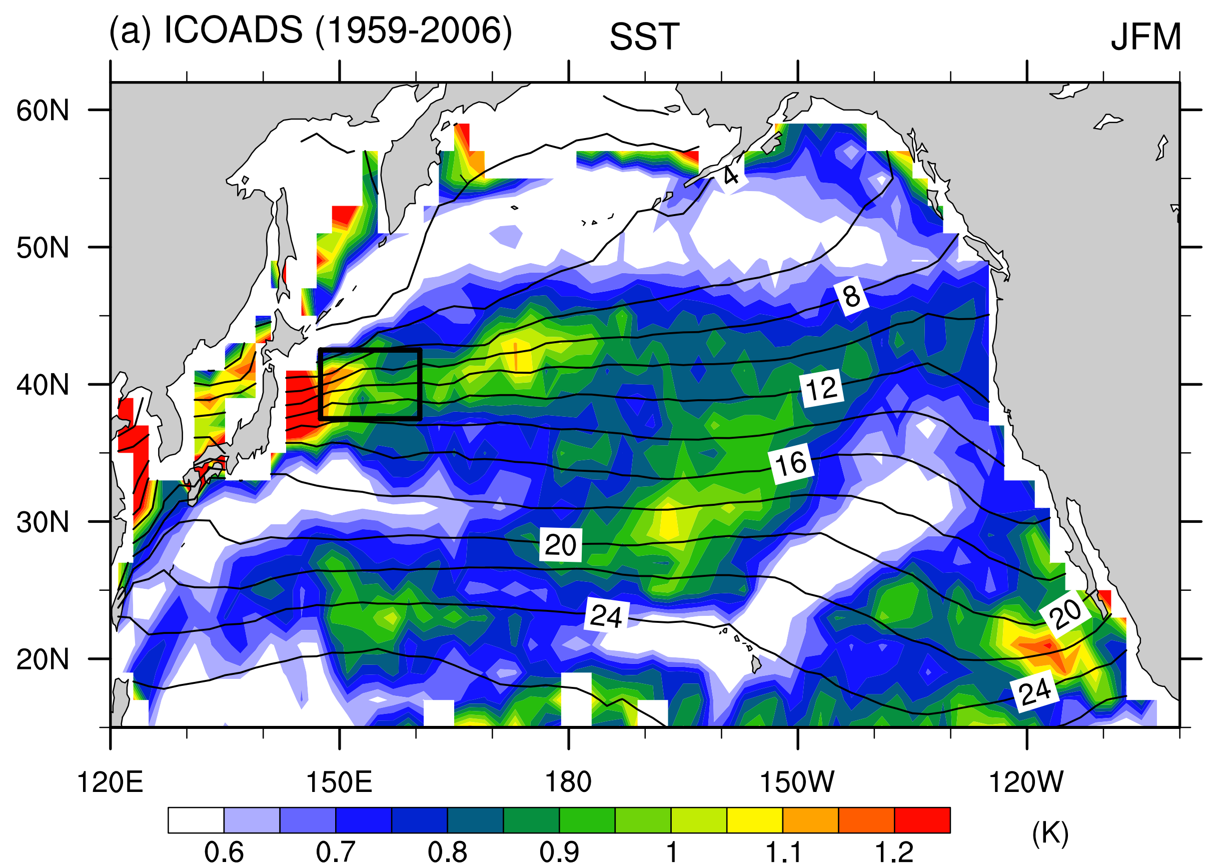
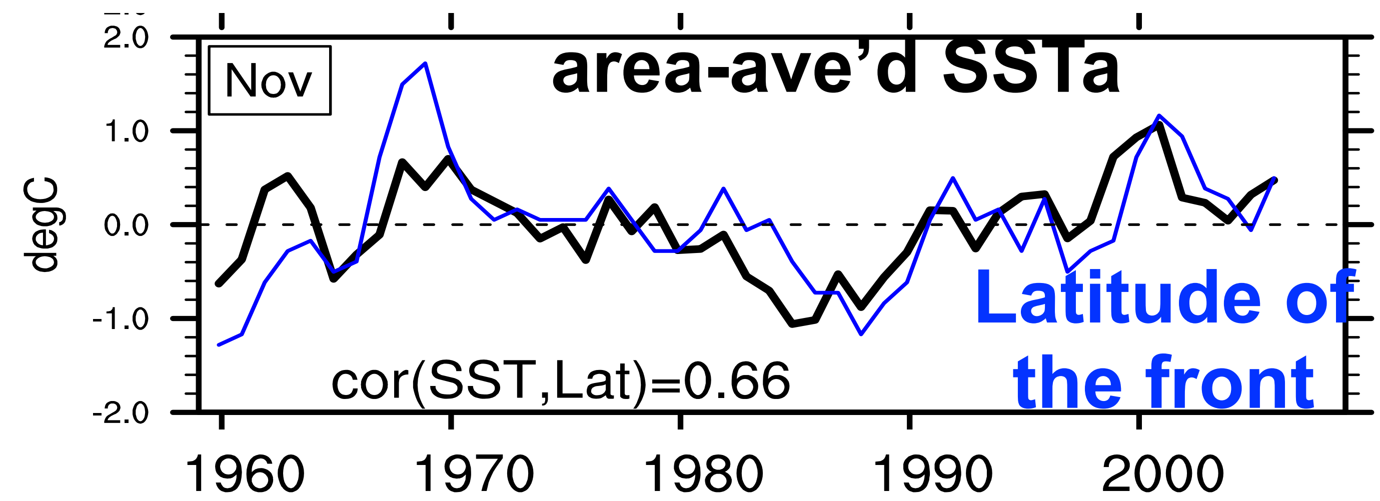
$b(x)$ determined statistically from NCEP reanalysis (1977-2010)

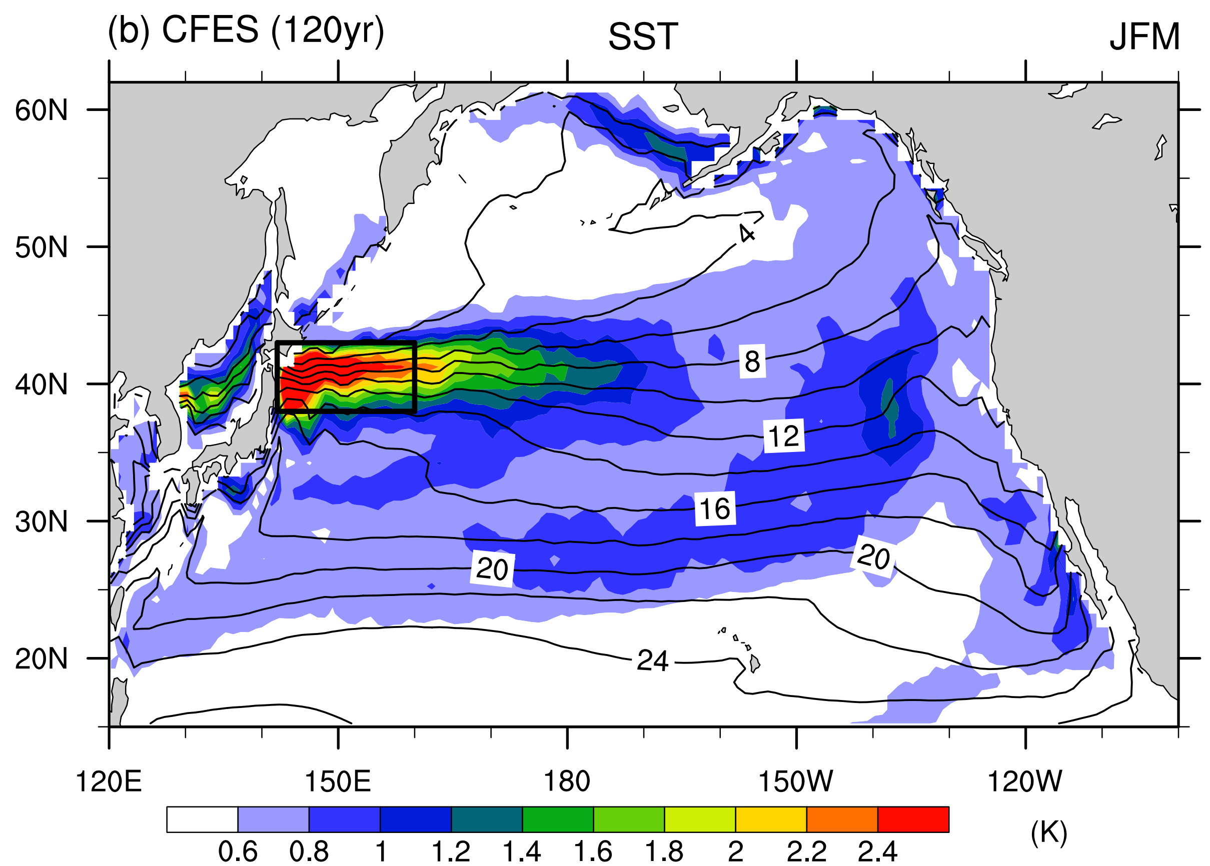
Considering the wind forcing due to the KE feedback provides additional predictive skill.

SST anomalies induced by frontal shift in subarctic frontal zone (SAFZ): Historical Obs & CGCM

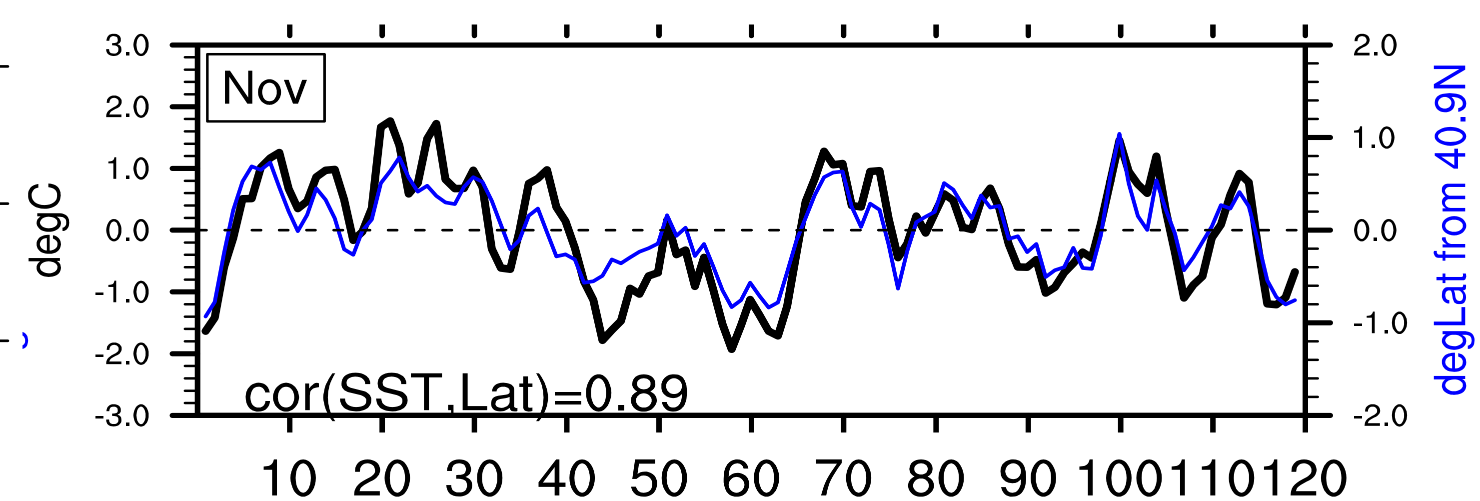


• ICOADS SST (2ºx2º, 1959-2006)
Courtesy of H. Tokinaga (IPRC)





• CFES (CGCM for Earth Simulator)
Ocn-Res 0.5º, 120-year integratioin



Atmospheric response (Jan) to SSTa (Nov) in SAFZ

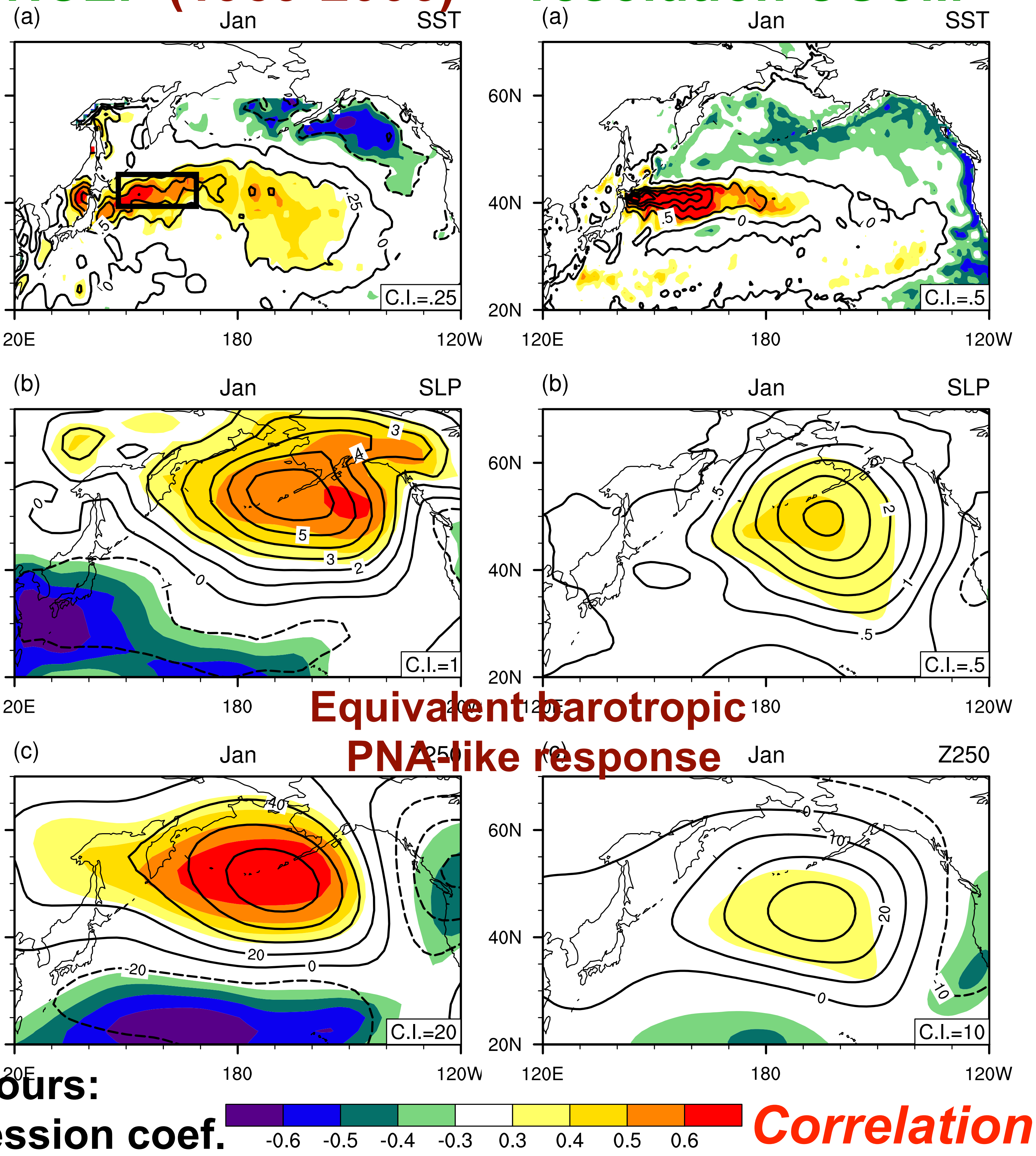
Taguchi et al. (2011) JC in press

ICOAD SST & NCEP (1959-2006) | **120-year medium resolution CGCM**

SST

SLP

Z250

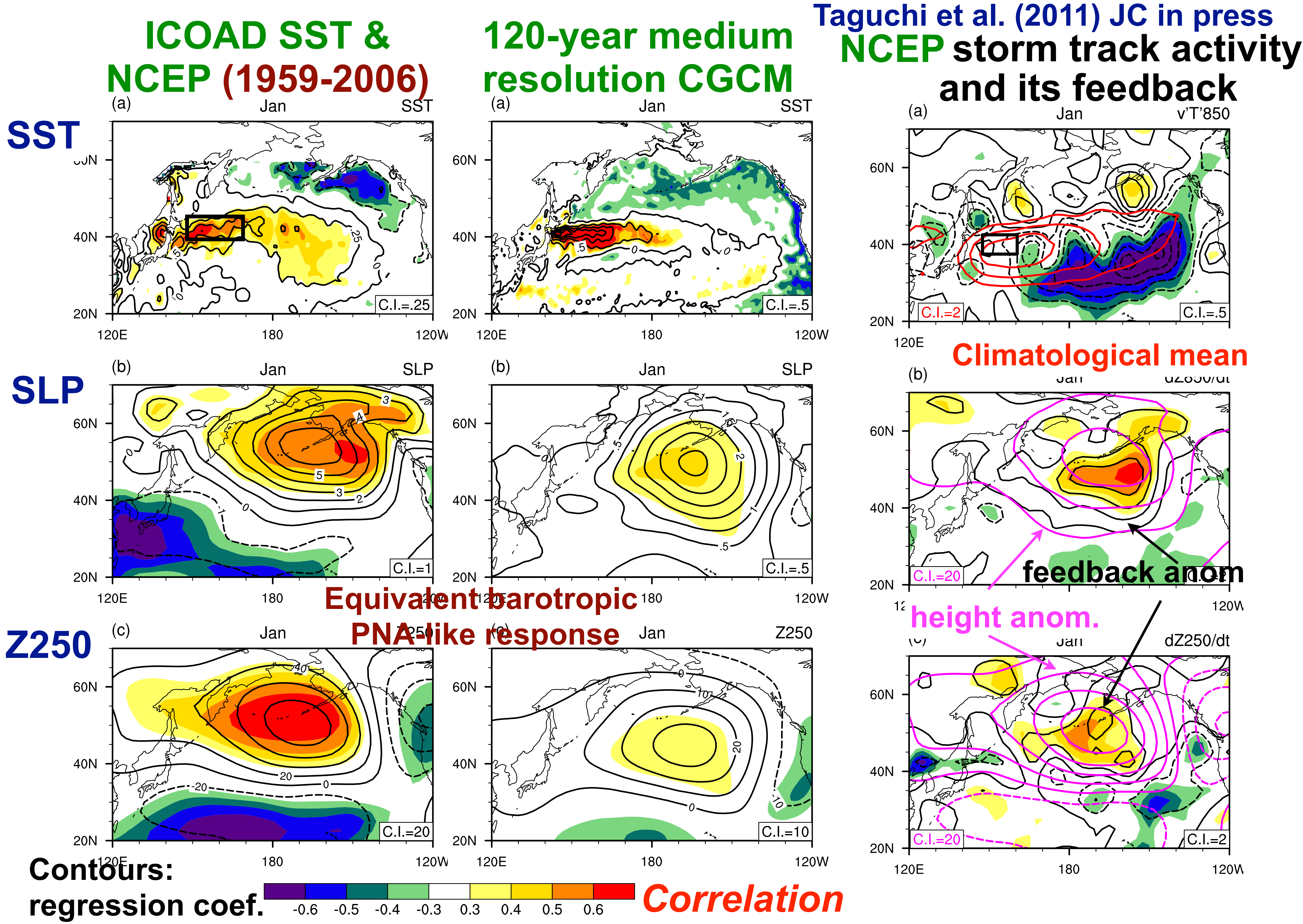


Equivalent barotropic PNA-like response

Contours: regression coef.

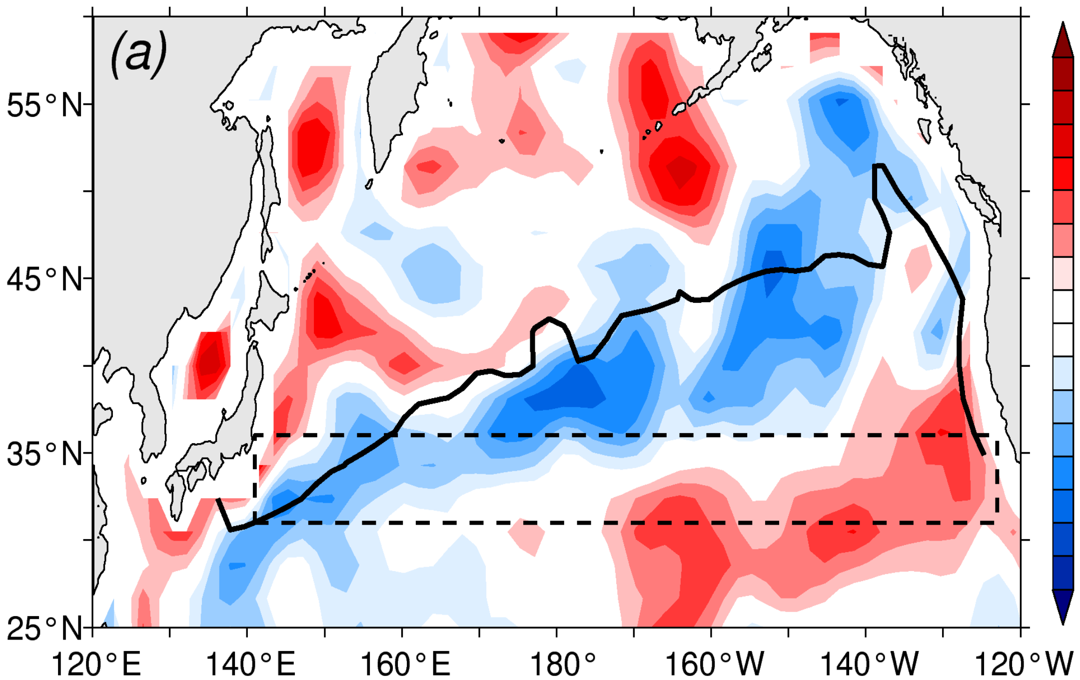
Correlation

Atmospheric response (Jan) to SSTa (Nov) in SAFZ



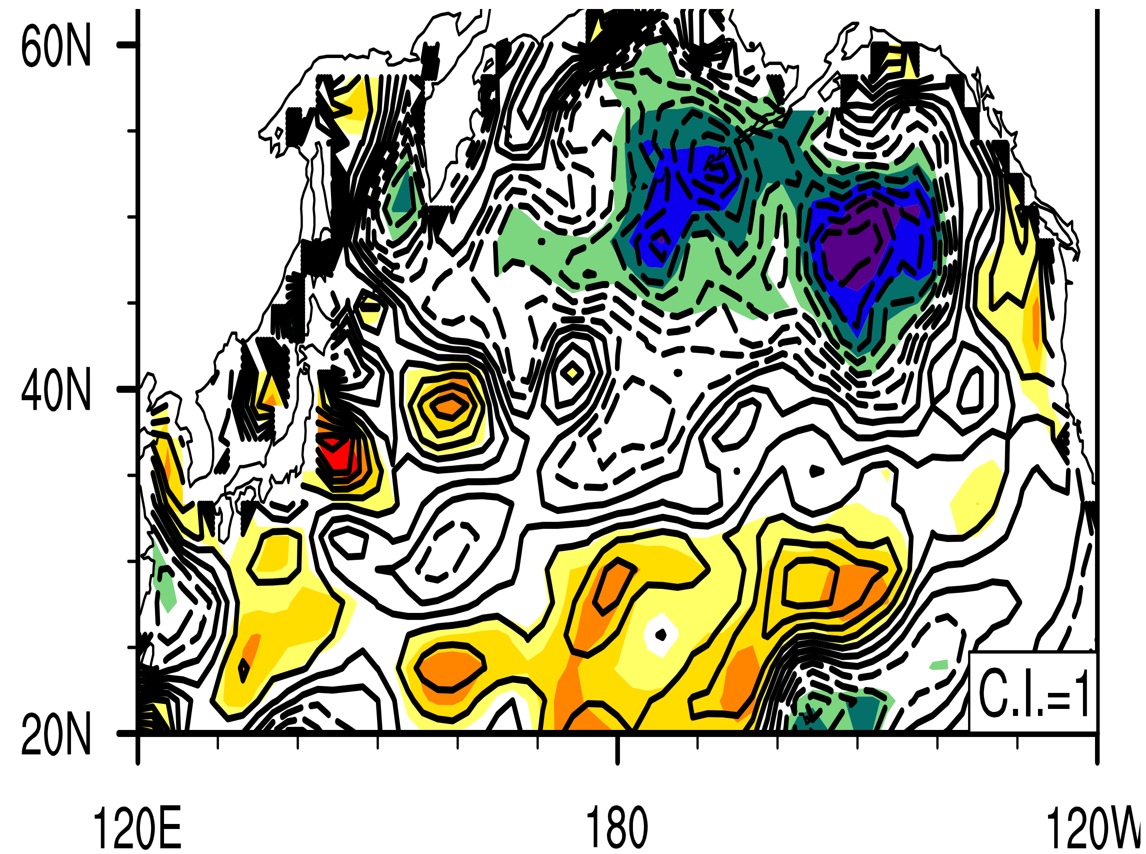
Wind stress curl response patterns

NCEP (1977-2010)



Wind stress curl response to KE-index used in Bo Qiu's 2-way prediction

NCEP (1959-2006)



Wind stress curl response to SAFZ SSTa

Atmospheric response to KOE frontal variability and its feedback onto the ocean still need investigations.

Summary

- Wind-forced Rossby wave propagations can be exploited to predict with a lead time about 3 years KE jet speed variability, an important forcing factor for natural mortality of infant sardine.
- 2-way prediction considering wind forcing due to feedback from the KE could provide additional multi-year predictive skill.
- It has been and still is a long-standing problem whether such 2-way interaction exists between extra-tropical ocean and atmosphere, with large-scale atmospheric response to the ocean being one of the biggest uncertainties.