PICES 2012 Annual Meeting

S3 POC Topic Session:
Challenges in understanding Northern Hemisphere ocean climate variability and change

Dynamics of North Pacific oceanic heat content variability on decadal time-scale

Bunmei Taguchi
Earth Simulator Center, JAMSTEC
Niklas Schneider
International Pacific Research Center, Univ. Hawaii

Hiroshima, Japan
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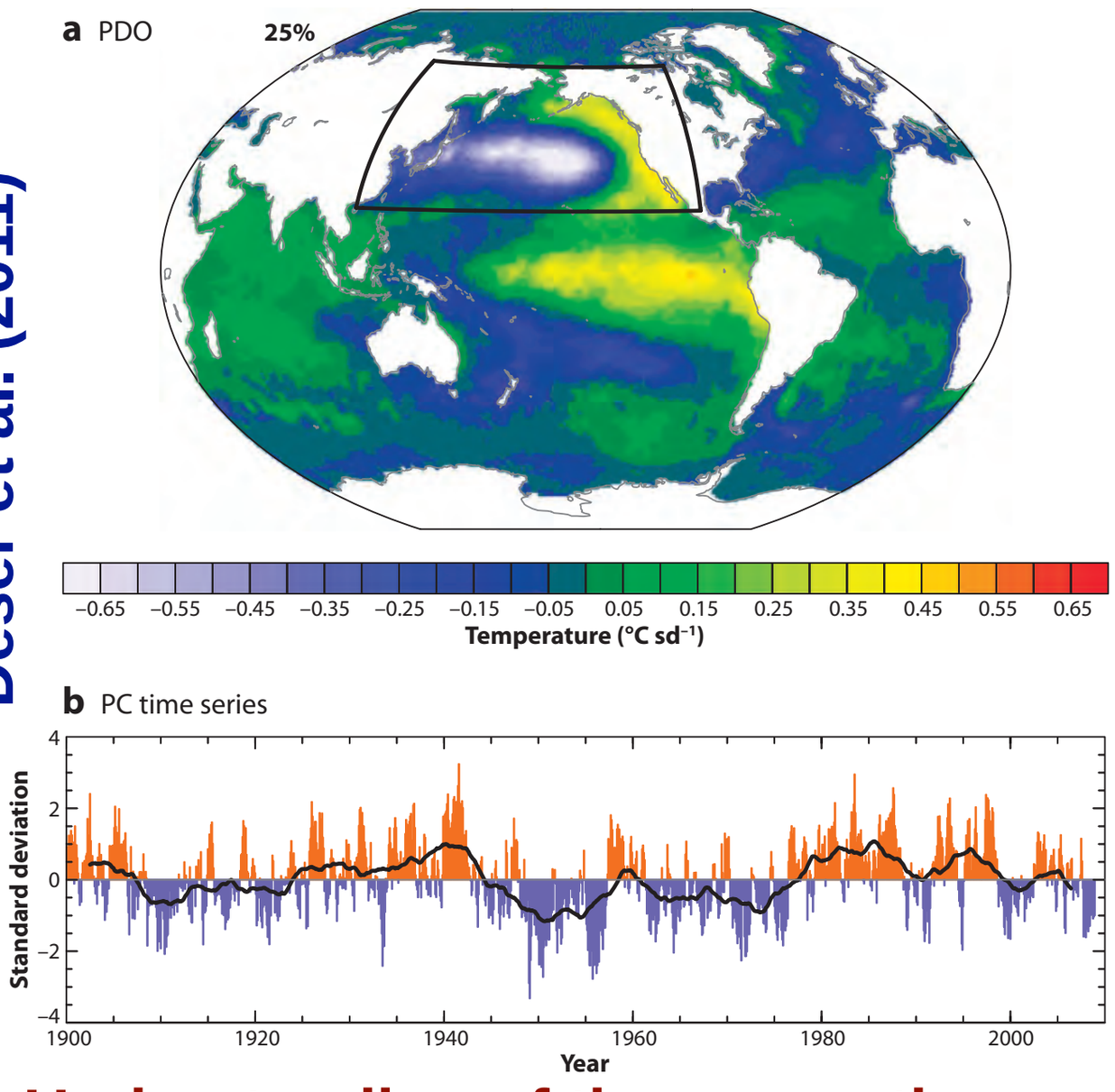
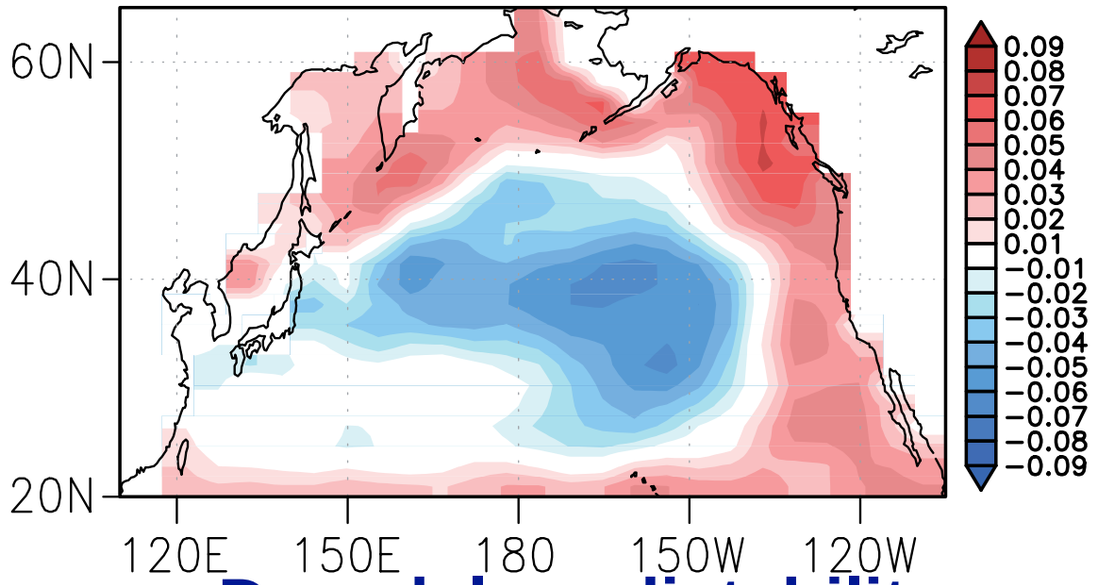
Pacific Decadal Variability and upper ocean heat content (OHC)

PDO (SST EOF1): Mantua et al. (1997)

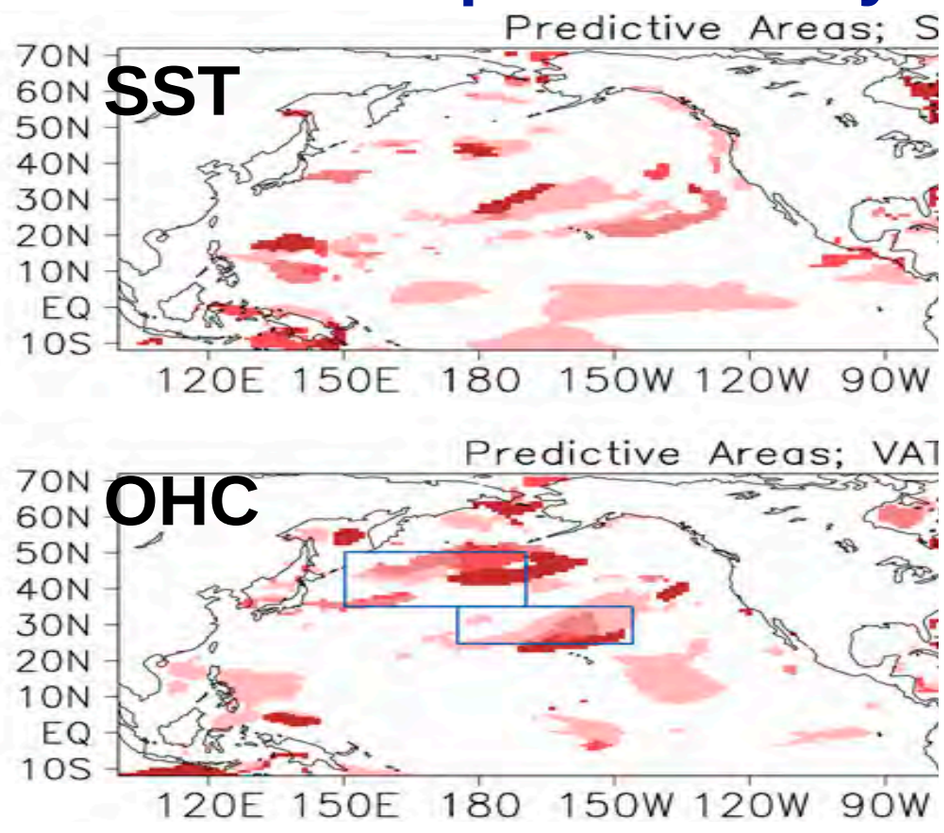


Deser et al. (2011)

Upper ocean heat content EOF1



Decadal predictability



Mochizuki et al. (2010, 2012)

Understanding of the generation and propagation mechanisms of OHC are important for PDV.

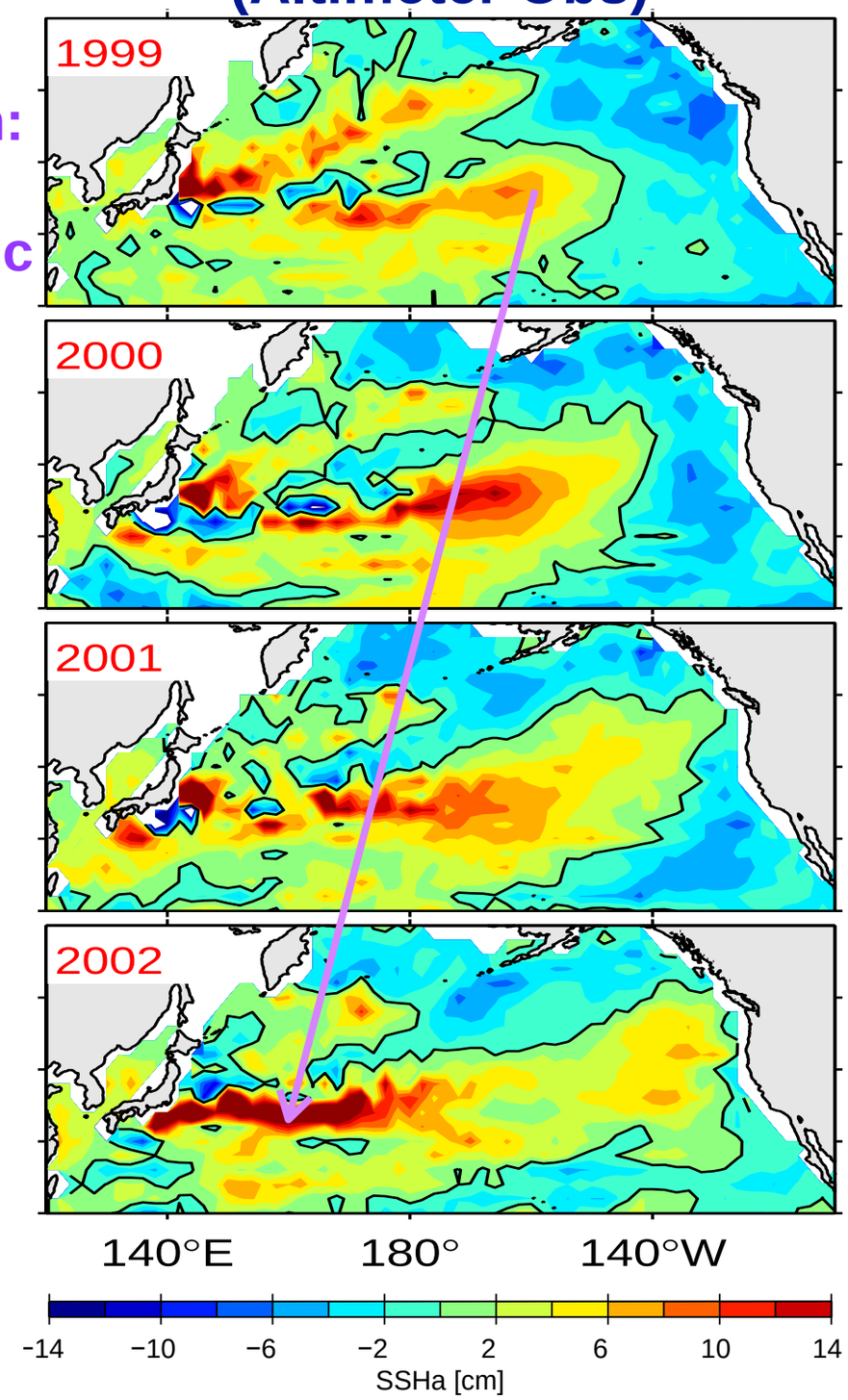
OHC has better predictive skill than SST.

Contrasting propagation features of decadal-scale signals

Sea Surface Hight Anomaly (Altimeter Obs)

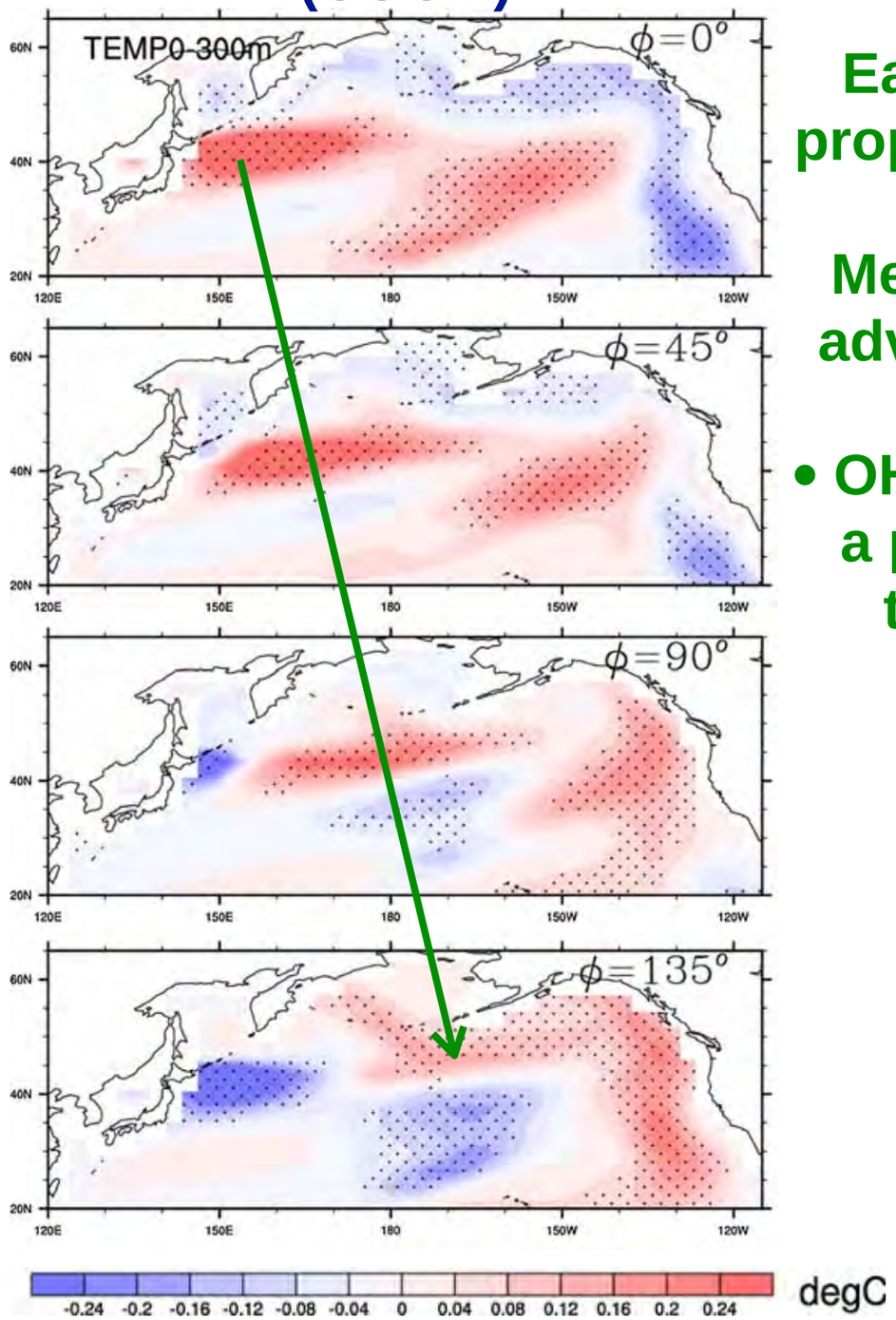
Westward propagation:

1st baroclinic Rossby waves



Qiu and Chen (2010)

Ocean Heat Content Anomaly (CGCM)



Teng and Branstator (2010)

Eastward propagation:

Mean flow advection?

- **OHC is not a passive tracer.**

Possible mechanisms for the propagation feature

associated w/ density change

Westward propagating signals:

First baroclinic mode RWs

(e.g., Pedlosky 1996; Liu 1999)

Independent of the mean flow.

Eastward propagating signals:

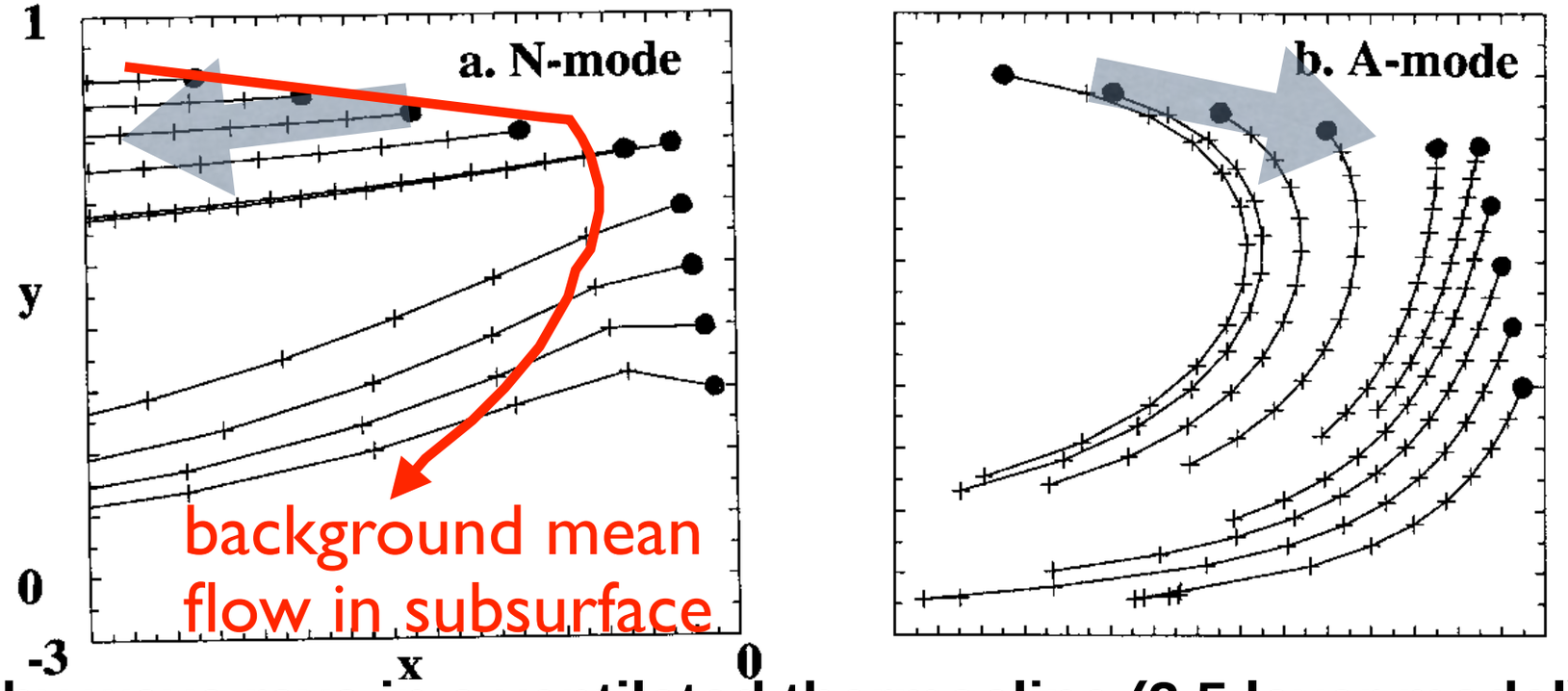
1. Higher baroclinic mode RWs

(Liu 1999, Nonaka & Xie 2000)

Following the mean flow.

no density change

2. Density-compensated T & S
(Spiciness: e.g., Schneider 1999)



Rossby wave rays in a ventilated thermocline (2.5 layer model) Liu (1999)

Are the eastward propagating OHC signals Rossby waves or spiciness?

Possible mechanisms for the propagation feature

associated w/ density change

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Objective

- To examine dynamics underlying propagation features of decadal-scale OHC signals, analyzing a long-term CGCM simulation.
- To distinguish OHC signals in terms of higher baroclinic modes RWs and spiciness anomalies, and examine their origins.
- To establish the link between the westward- and eastward propagating oceanic signals.

CGCM integration: interannual standard deviations

CFES: Coupled atmosphere-ocean GCM for Earth Simulator

Komori et al. (2008)

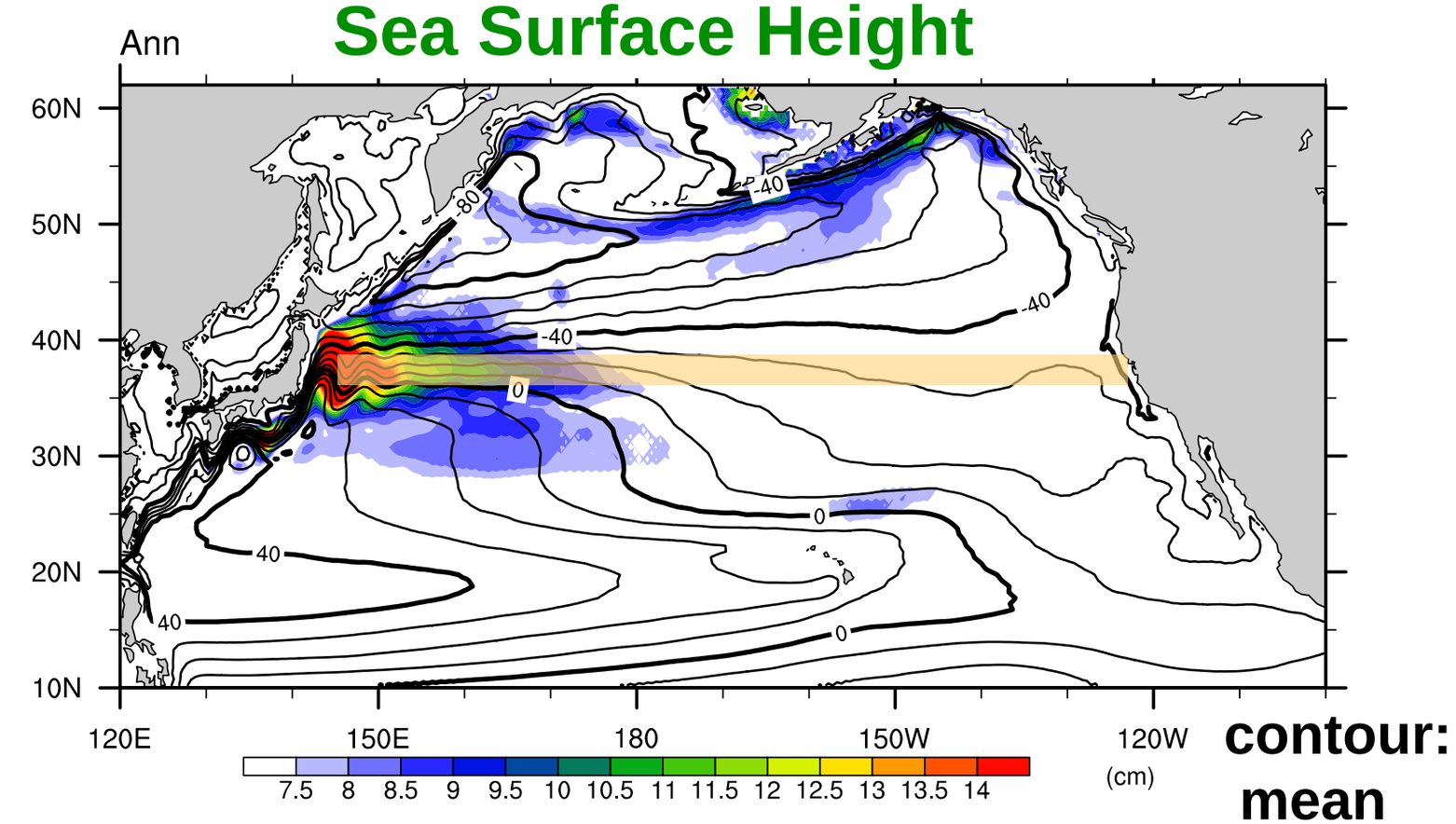
Medium resolution CFES

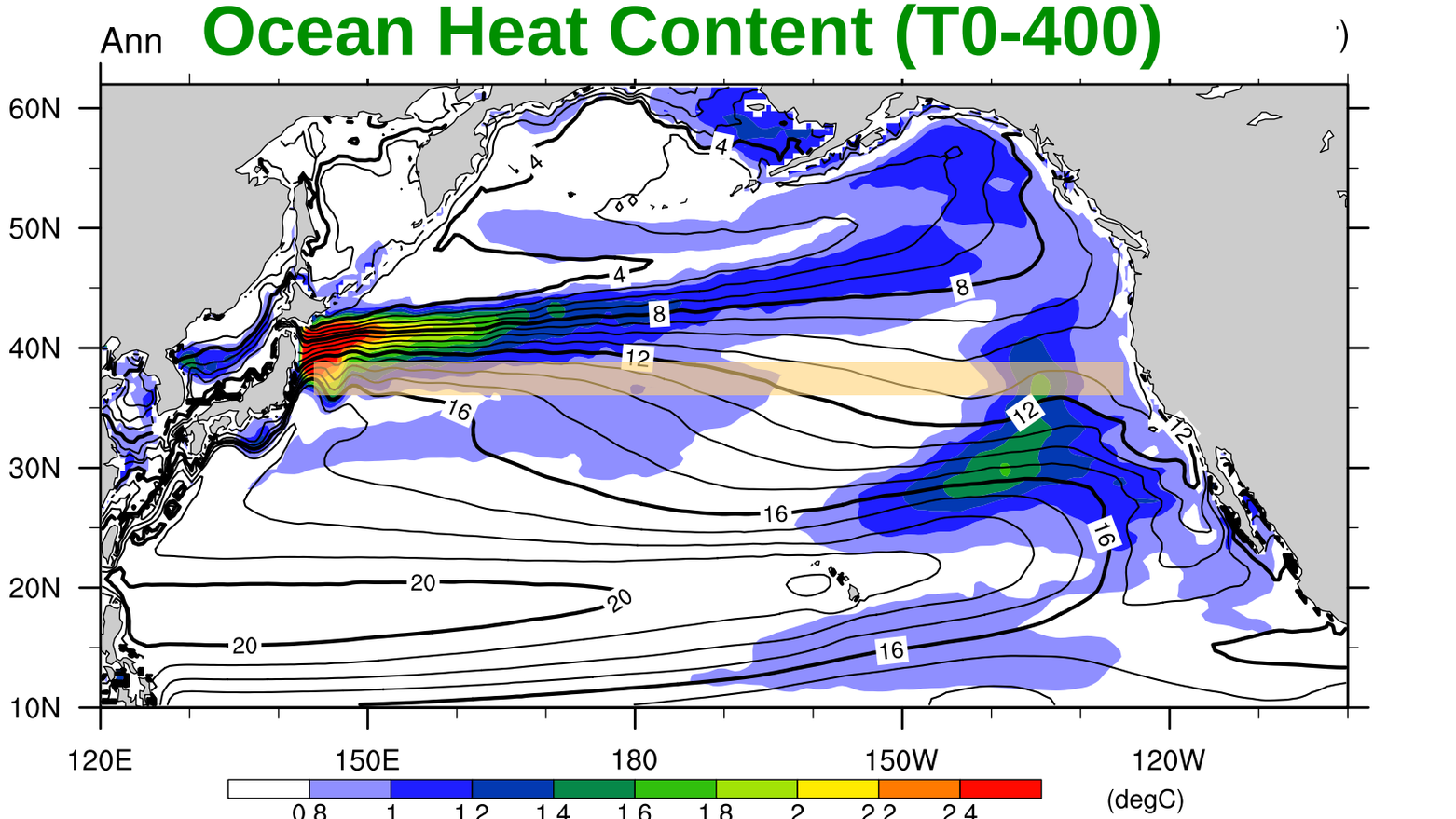
A: T119 (~100 km) L48:

O: 0.5º L54:

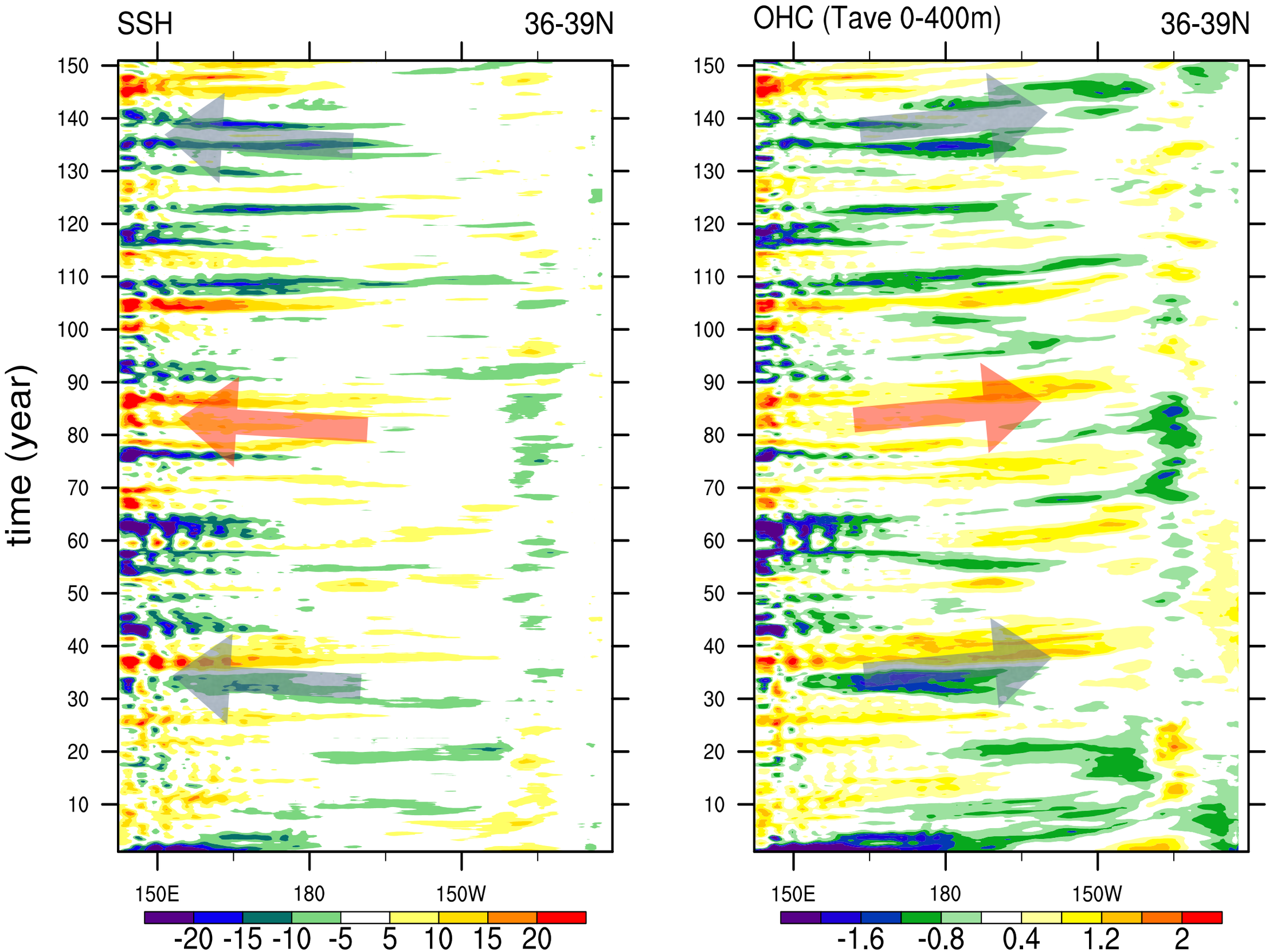
Integration : 150 years

Taguchi et al. (2012)



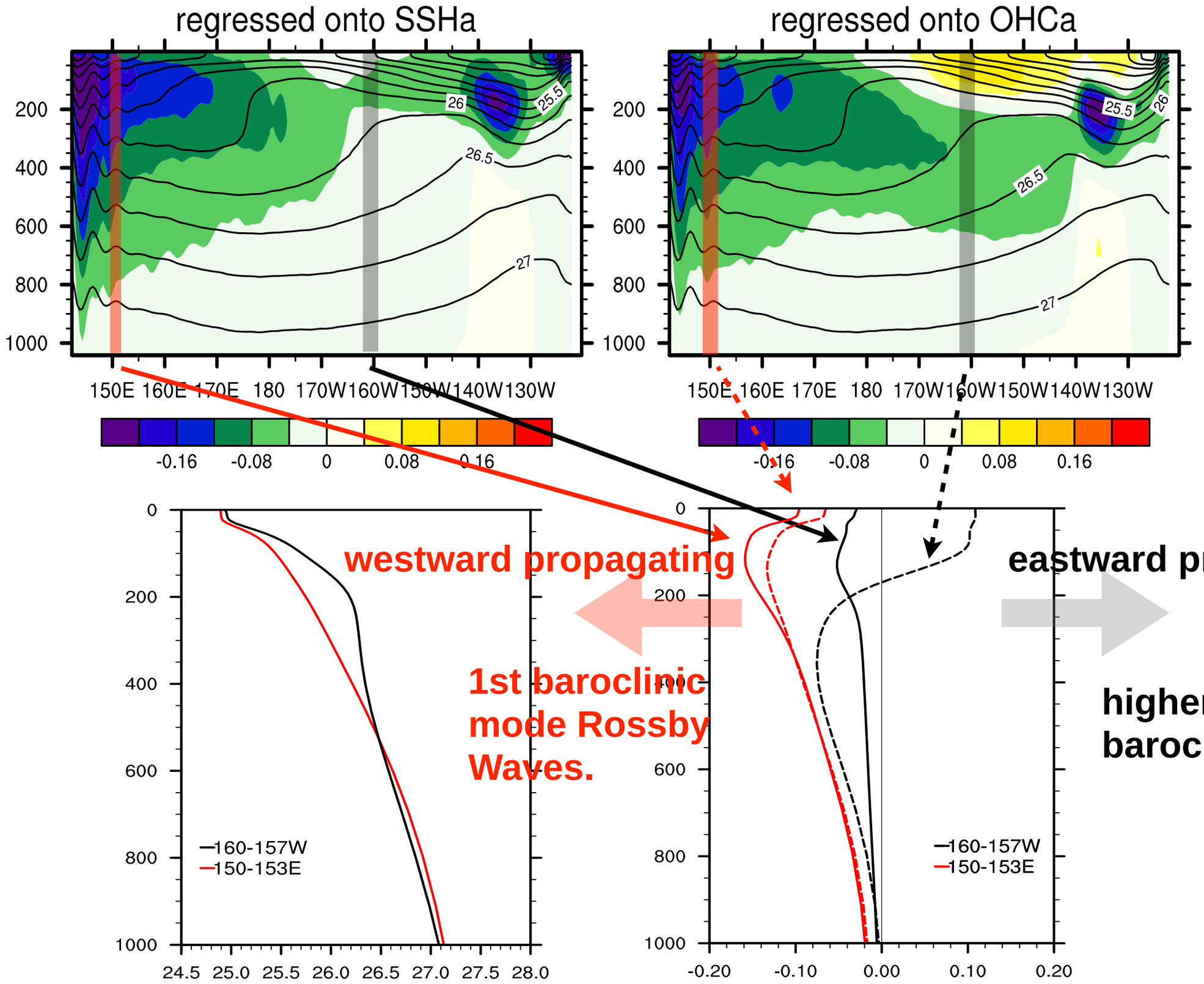


Simulated propagating signals of SSH & OHC



monthly climatological mean removed, 3-year running mean

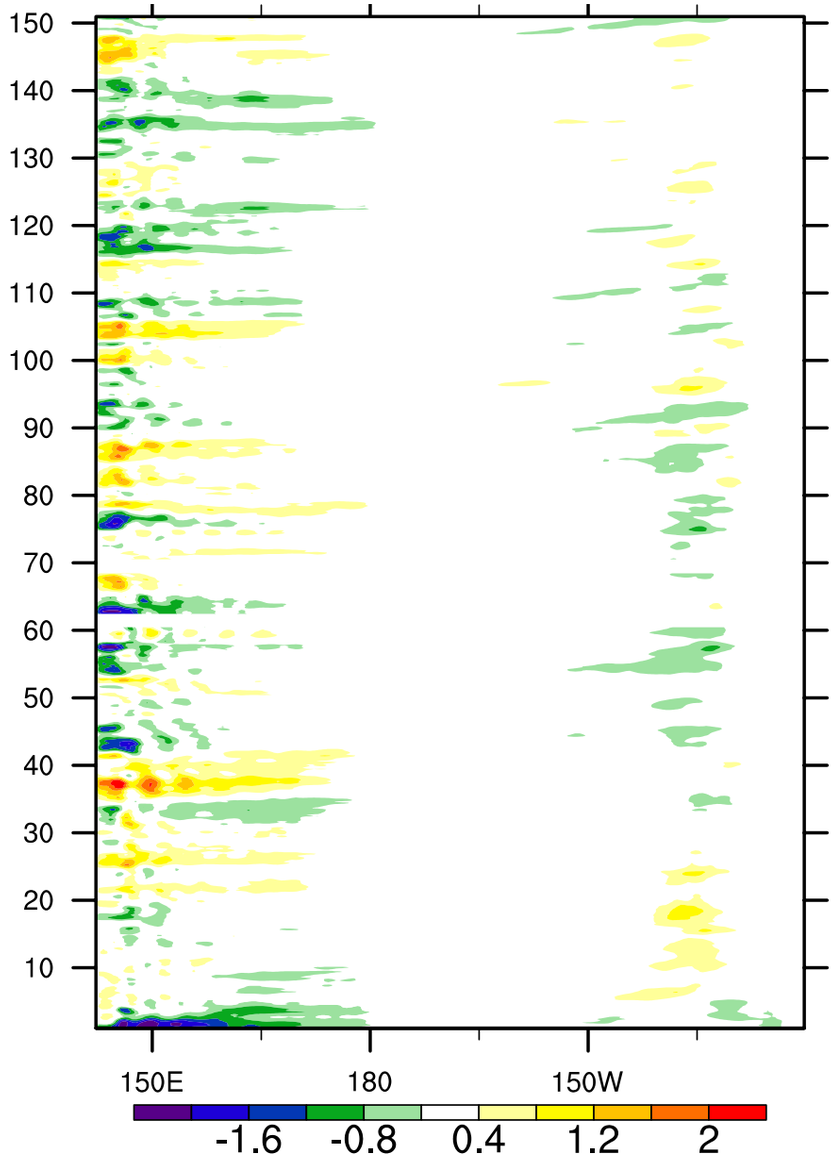
Vertical structures of density anomalies associated with SSH and OHC anomaly signals



Splitting OHCa into density and spiciness compnents

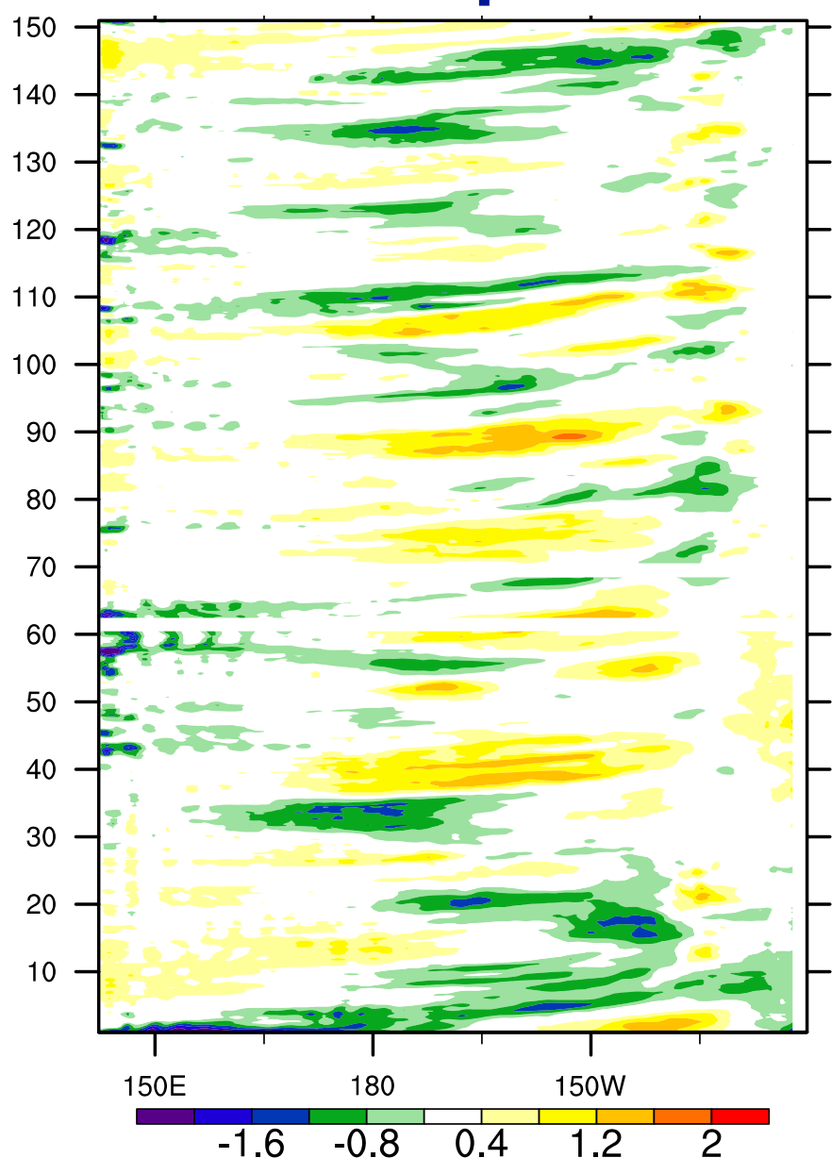
$$\mathbf{T'} = \mathbf{T'_{dyn}}\left(= \frac{\mathbf{d\overline{T}}}{\mathbf{d\overline{\rho}}}\rho'\right) + \mathbf{T'_{spi}} \qquad \frac{d\overline{T}}{d\overline{\rho}} = \frac{\nabla\overline{T}\cdot\nabla\overline{\rho}}{|\nabla\overline{\rho}|^2}$$

OHCa associated w/
T' due to density signals



1st & higher baroclinic Rossby waves

T' due to spiciness



advection of T' (compensated w/ S')

Spiciness generation in the KOE region

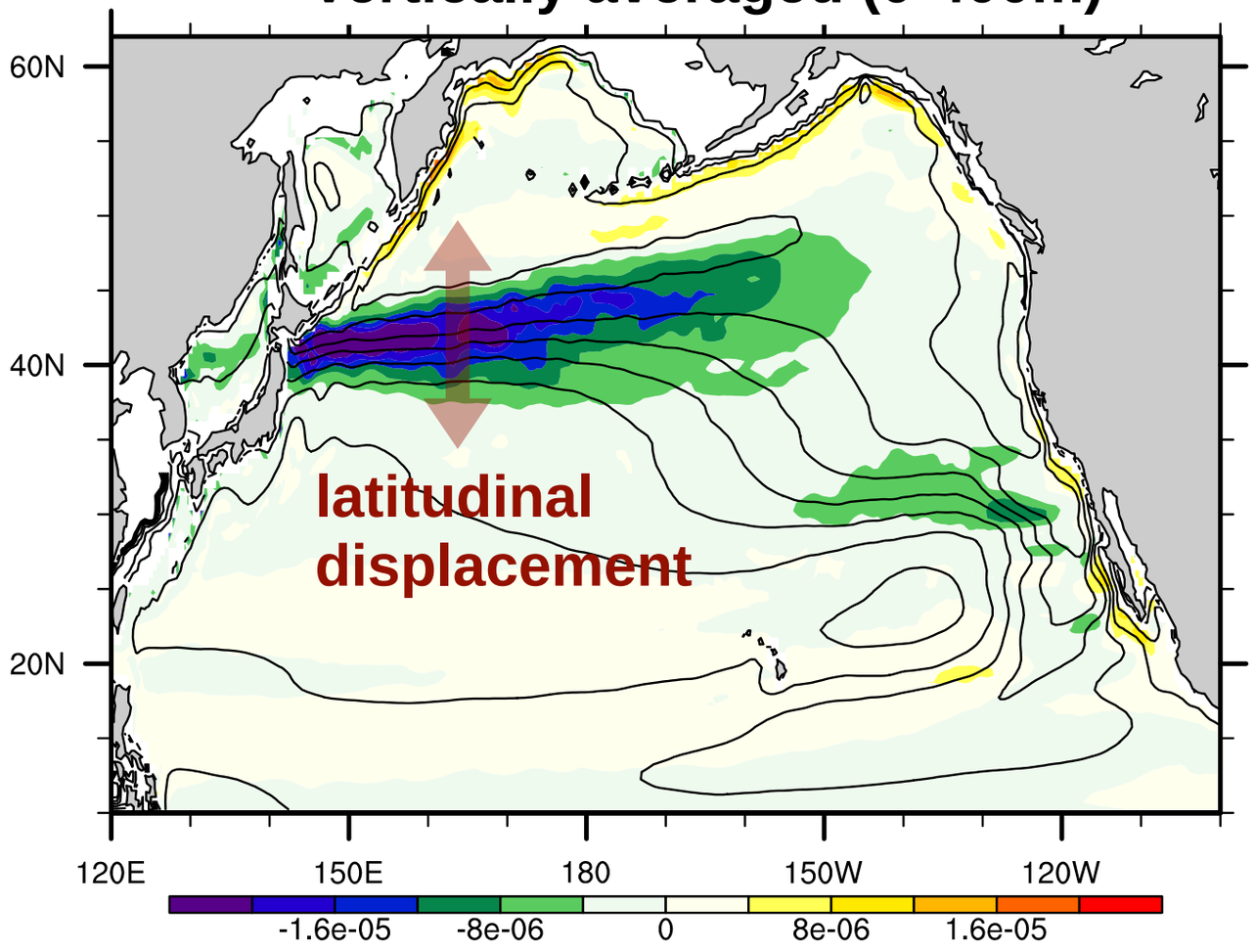
$$\nabla T = (\nabla T)_\rho + \boxed{(\nabla T)_\chi}$$

cross-isopycnals **along-ispycnals**

mean spiciness gradient

$$\overline{((\nabla T)_\chi)_y}$$

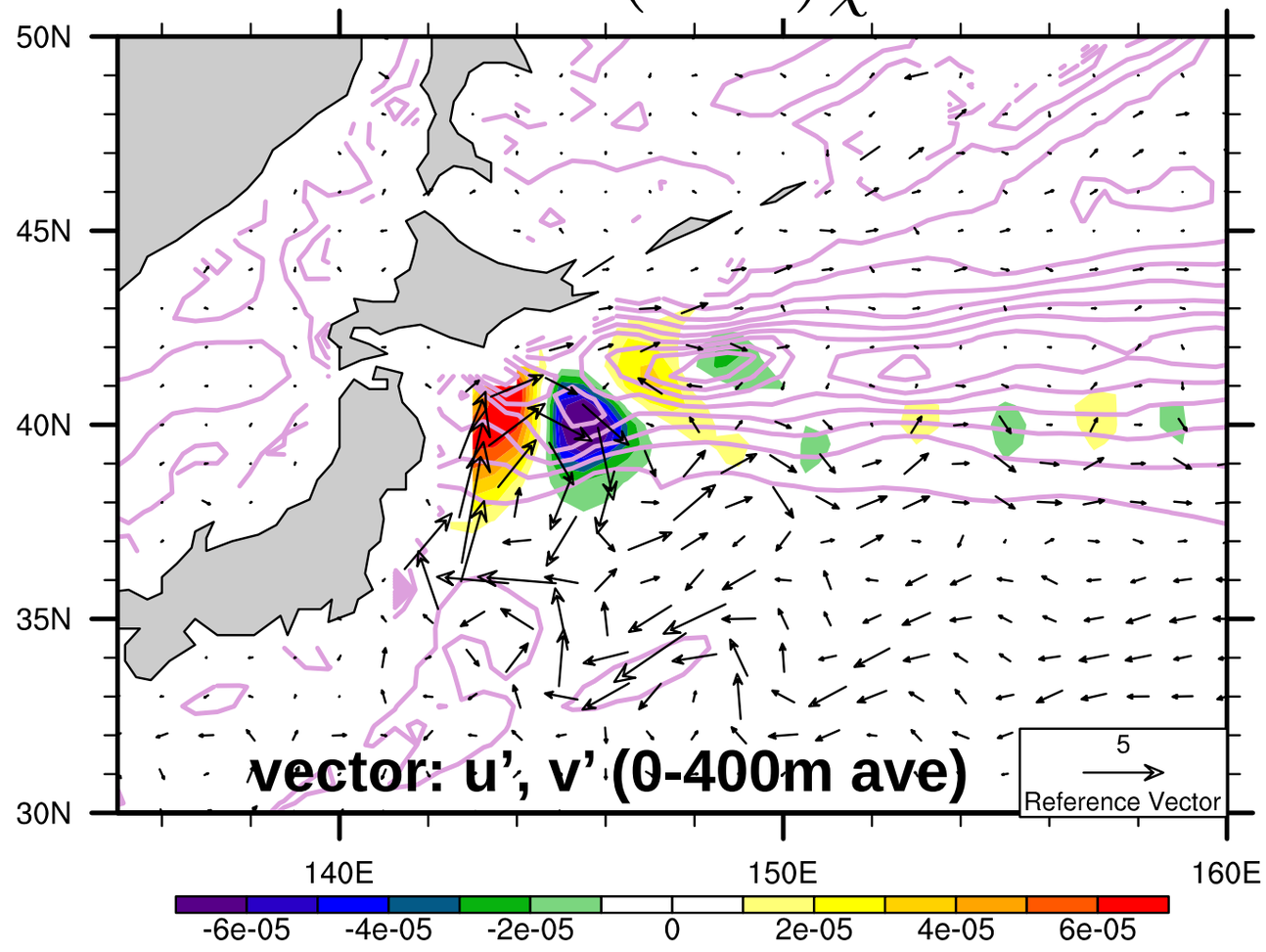
Vertically averaged (0-400m)



Contour: Salinity (0-400m ave)

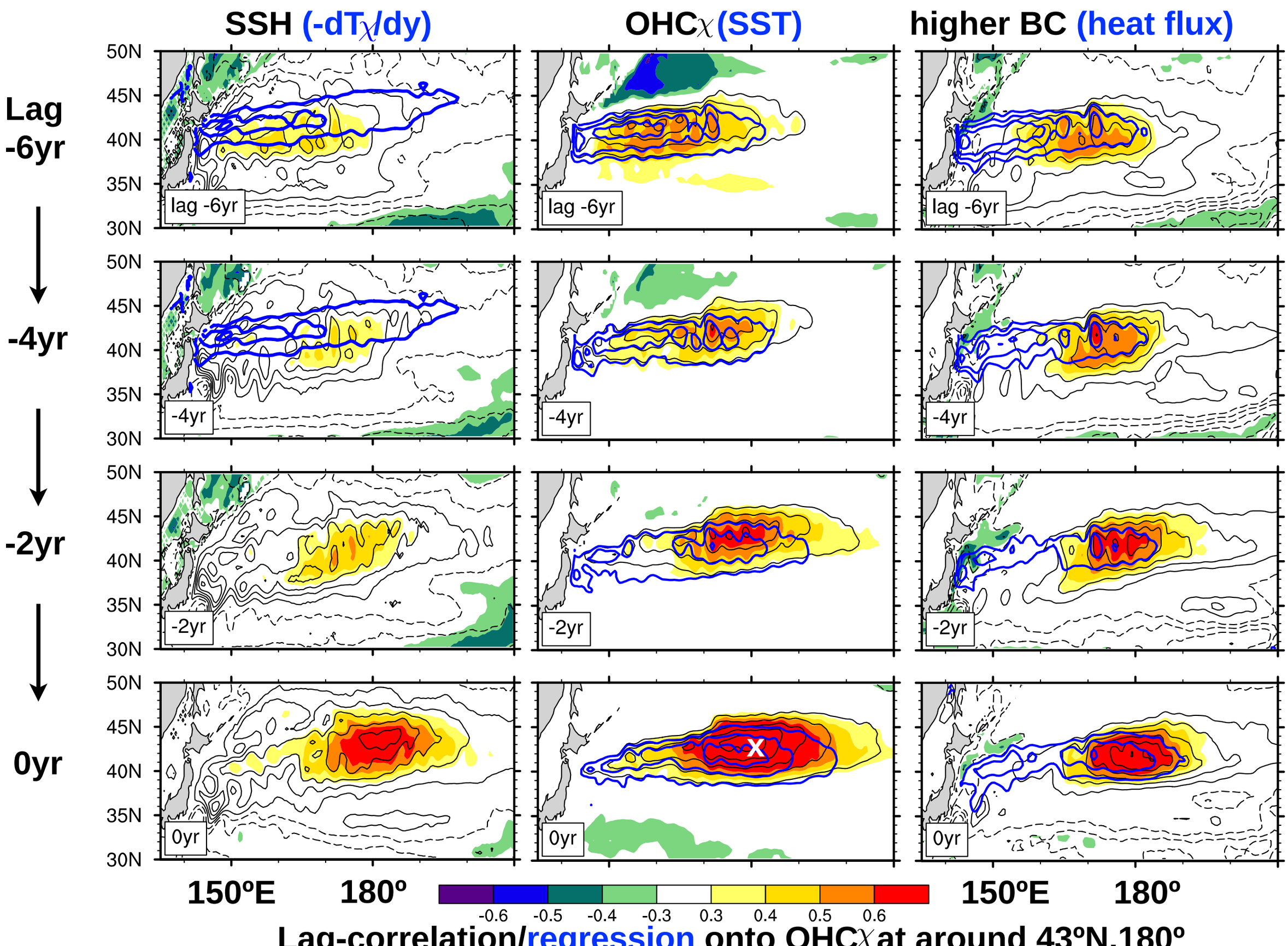
northward frontal shift advects water across mean spiciness gradient

$$-\mathbf{u}' \cdot \overline{(\nabla \mathbf{T})_\chi}$$



contour: $\overline{((\nabla T)_\chi)_y}$

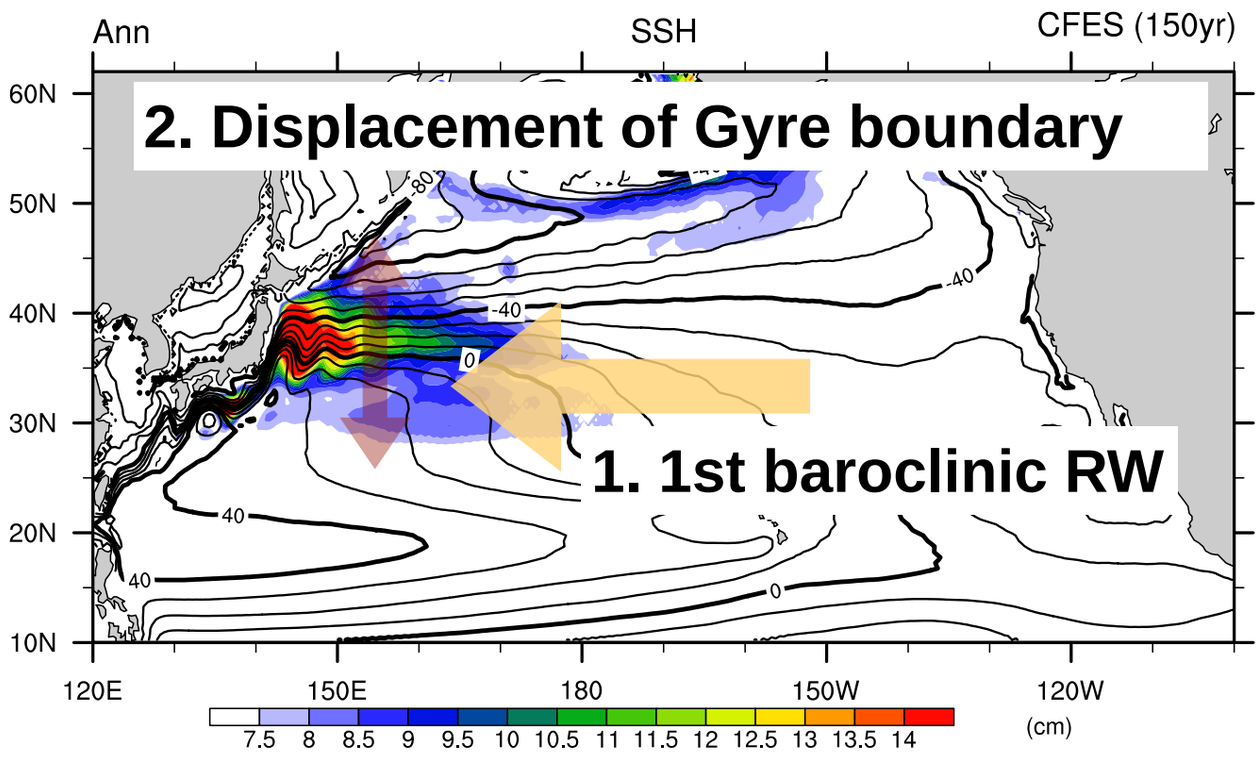
Generation of spiciness & higher baroclinic modes



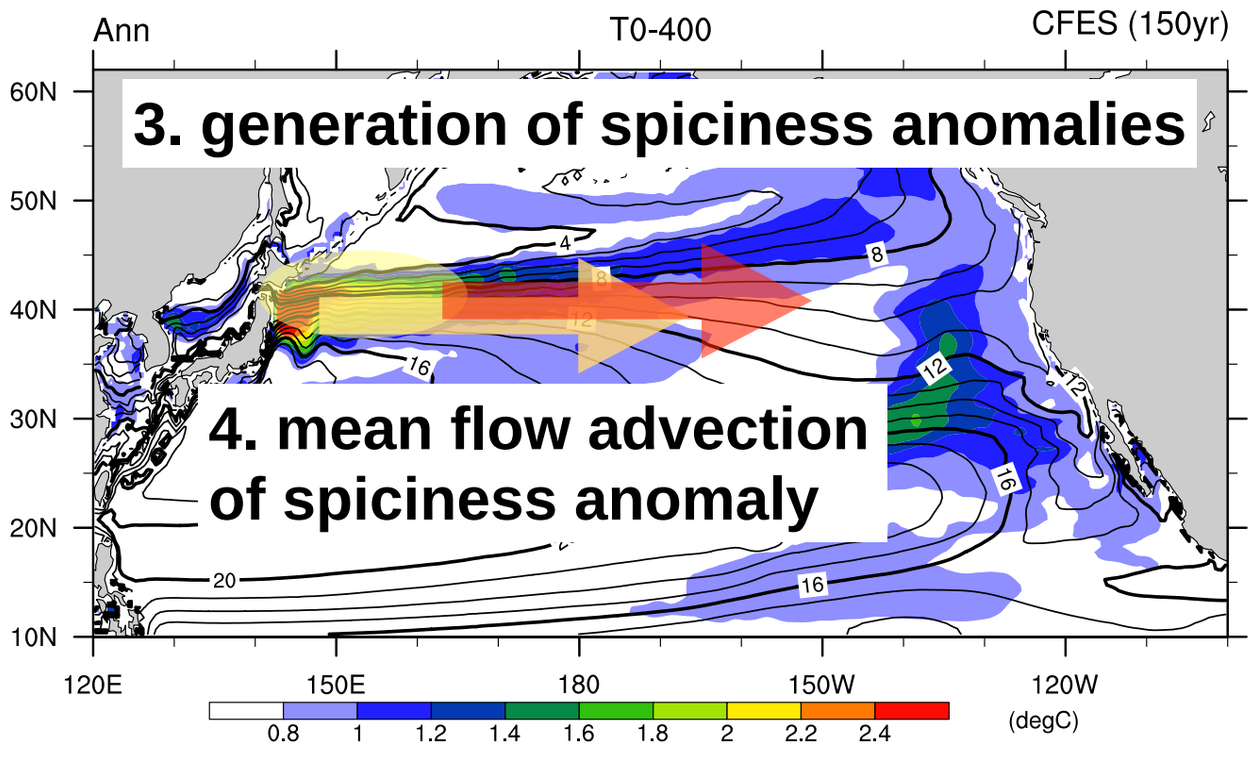
Summary

•We have investigated processes and the origin of the eastward-propagating Ocean Heat Content (OHC) signals simulated in a 150-year CFES simulation.

westward-propagating SSHa



eastward-propagating OHCa



5. T' associated w/ spiciness damped by air-sea heat exchange → ρ' → higher modes RWs

- The wind-forced westward propagating SSH signals are transformed into the eastward-propagating Ocean Heat Content signals through the latitudinal shift of the subarctic front and the associated anomalous spiciness generation.

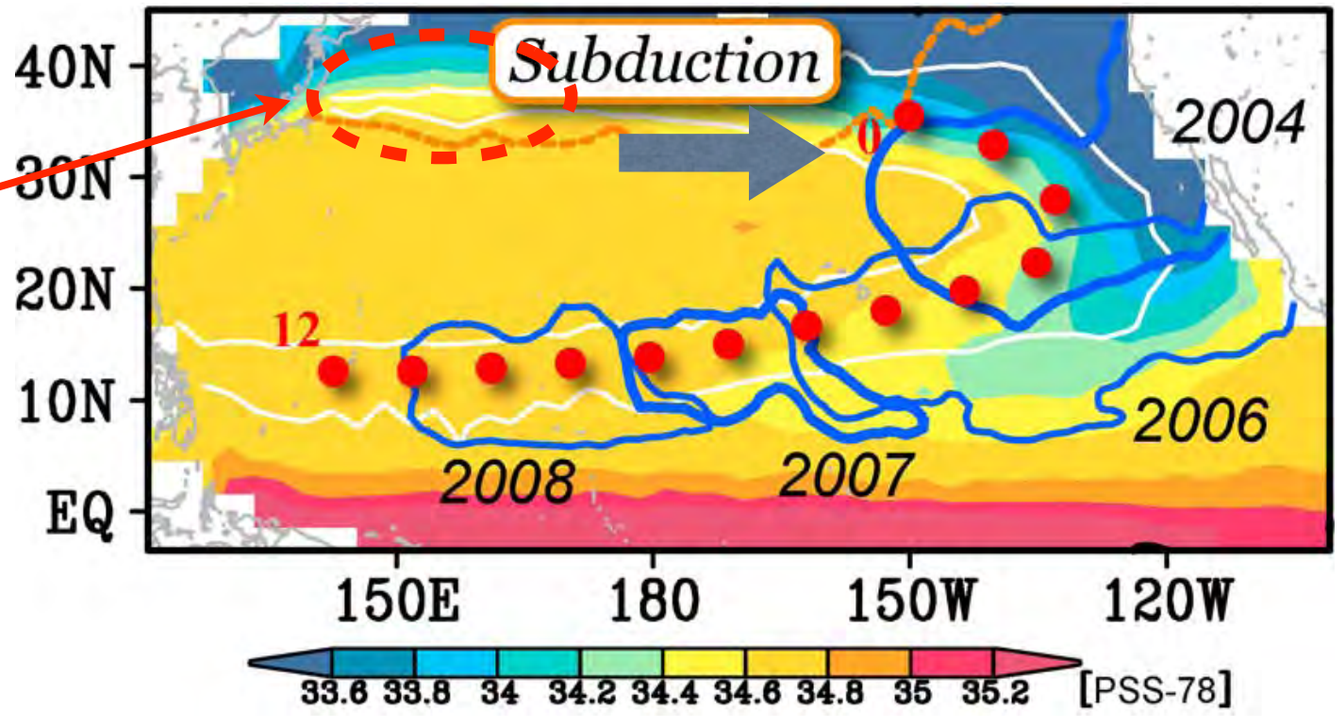
Implications and future studies

- Possible pathway of decadal subsurface signals from west to east

  Observed spiciness propagation in the subtropical thermocline

YN Sasaki et al. (2010)

anomalous spiciness generation discussed in the present study



- Revisit the link btw/ OHC and Mode Water variability.

- Analyze Argo data, ocean reanalysis, high-res. OGCM and other CGCMs.