Interannual to decadal variability of the Gulf Stream and Kuroshio Extension jets

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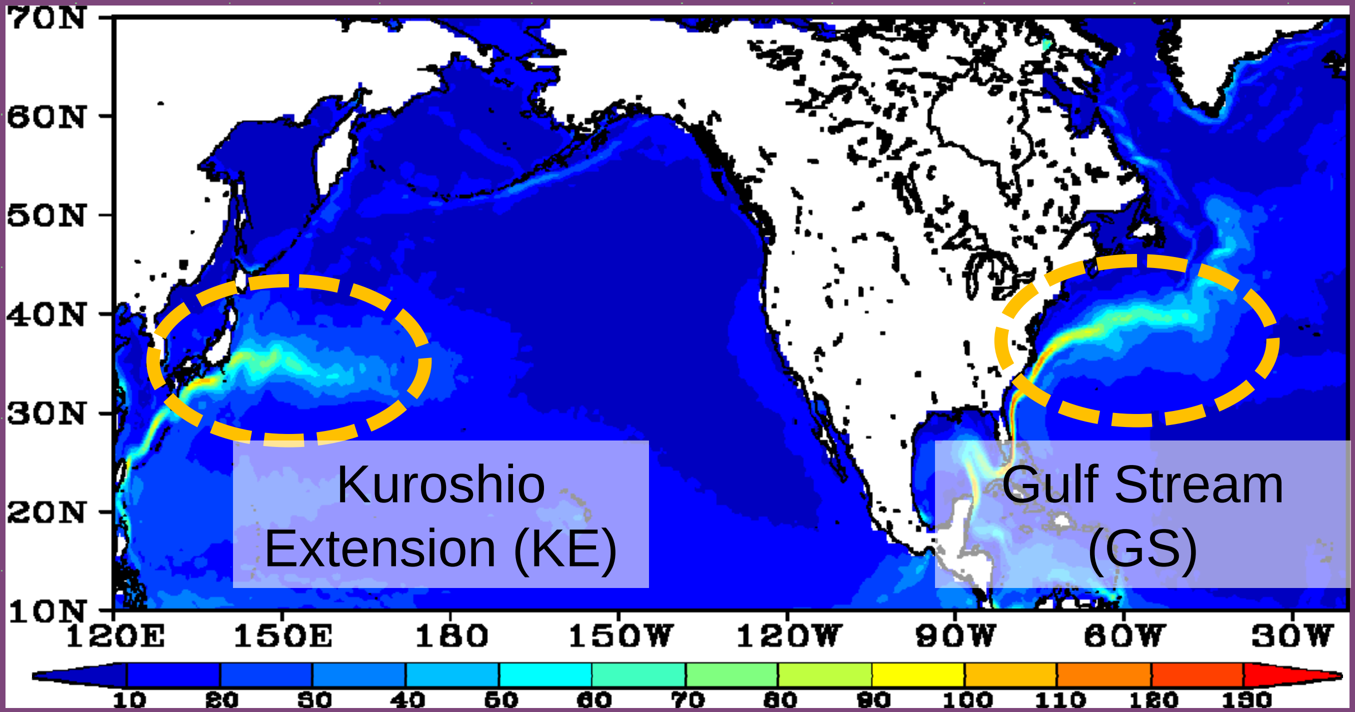
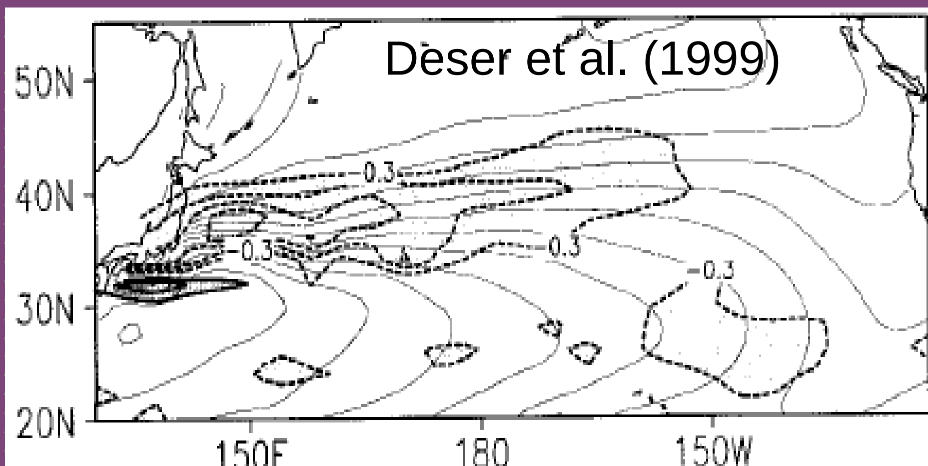
Outline

Surface current velocity

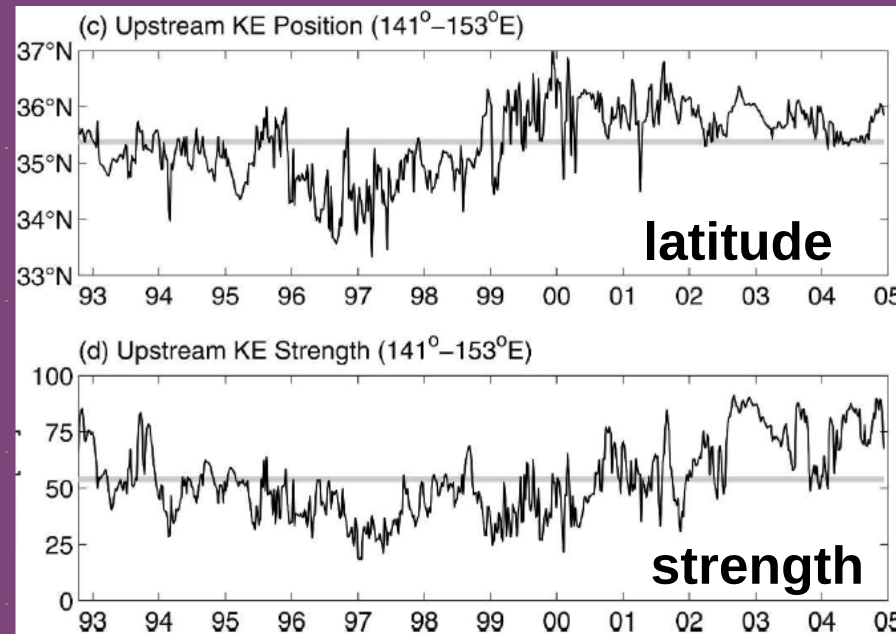


- A new mechanism for decadal shifts of the KE and GS jets
- A new mechanism of acceleration of the KE jet on decadal timescales

Decadal variability in KE



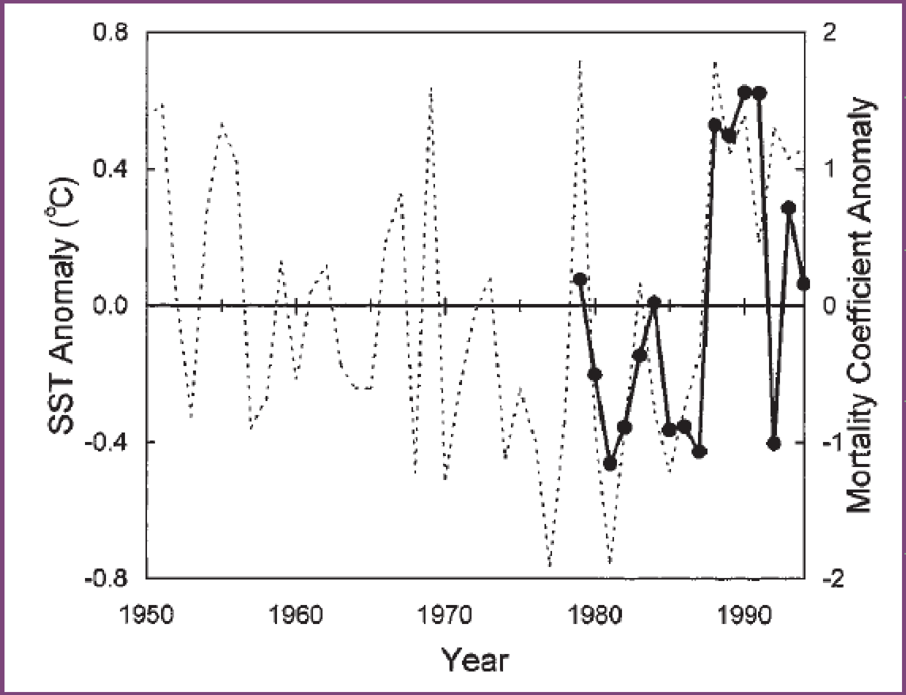
Temperature changes at 400-m depth
(1982–1990 minus 1970–1980)



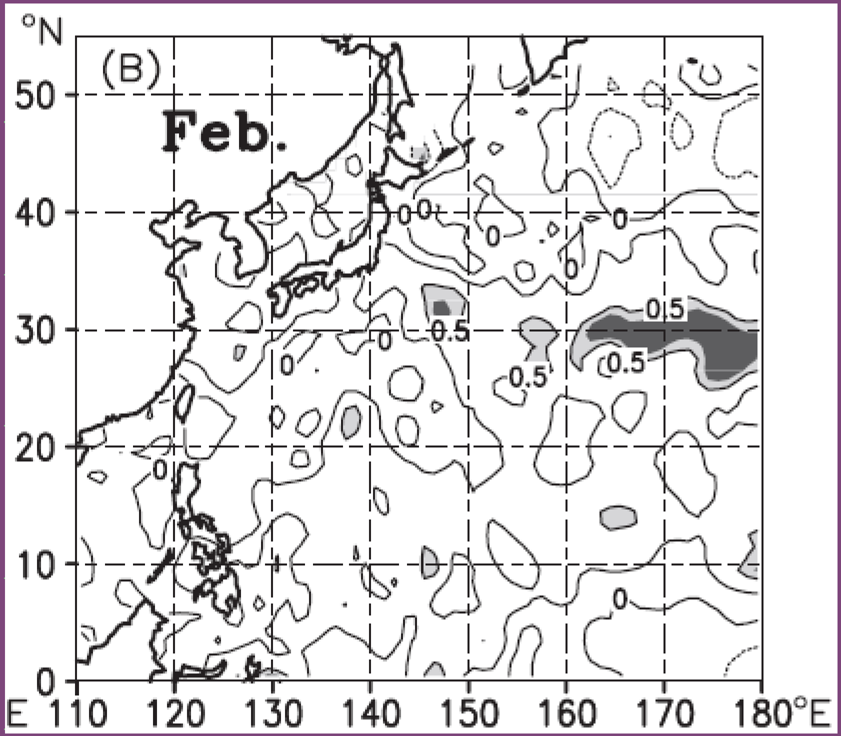
Qiu and Chen (2005)

- The KE jet exhibits prominent decadal variability

Decadal variability in KE



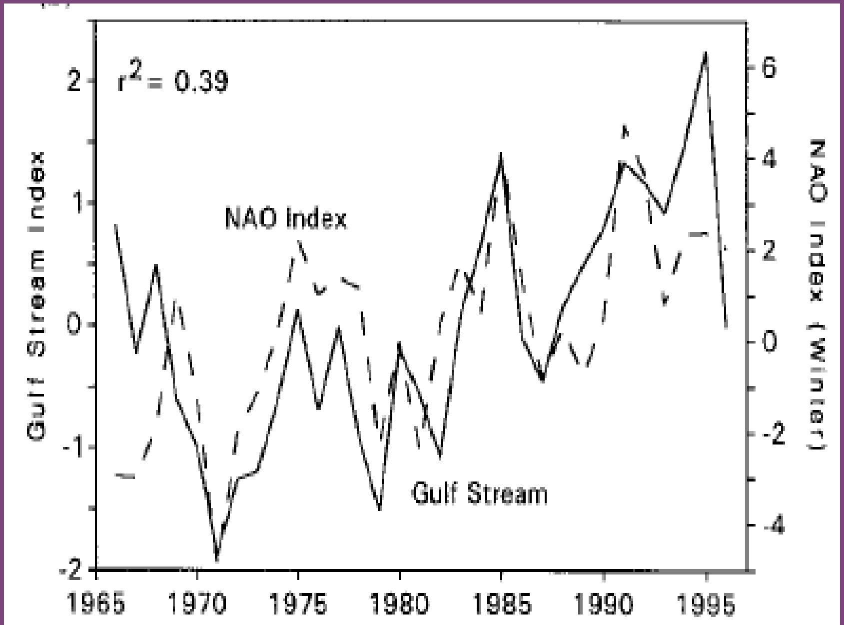
Corr of SST and larva mortality



Noto and Yasuda (1999)

- Decadal variability in KE is associated with Japanese sardine changes
- Nishikawa et al. (2011) showed an importance of strength changes of the KE jet

Decadal variability in GS



Taylor and Stephens (1998)

- The latitude of the GS jet also shows large decadal variability
- The shift of the GS jet is forced by the North Atlantic Oscillation (NAO)

Decadal variability in GS

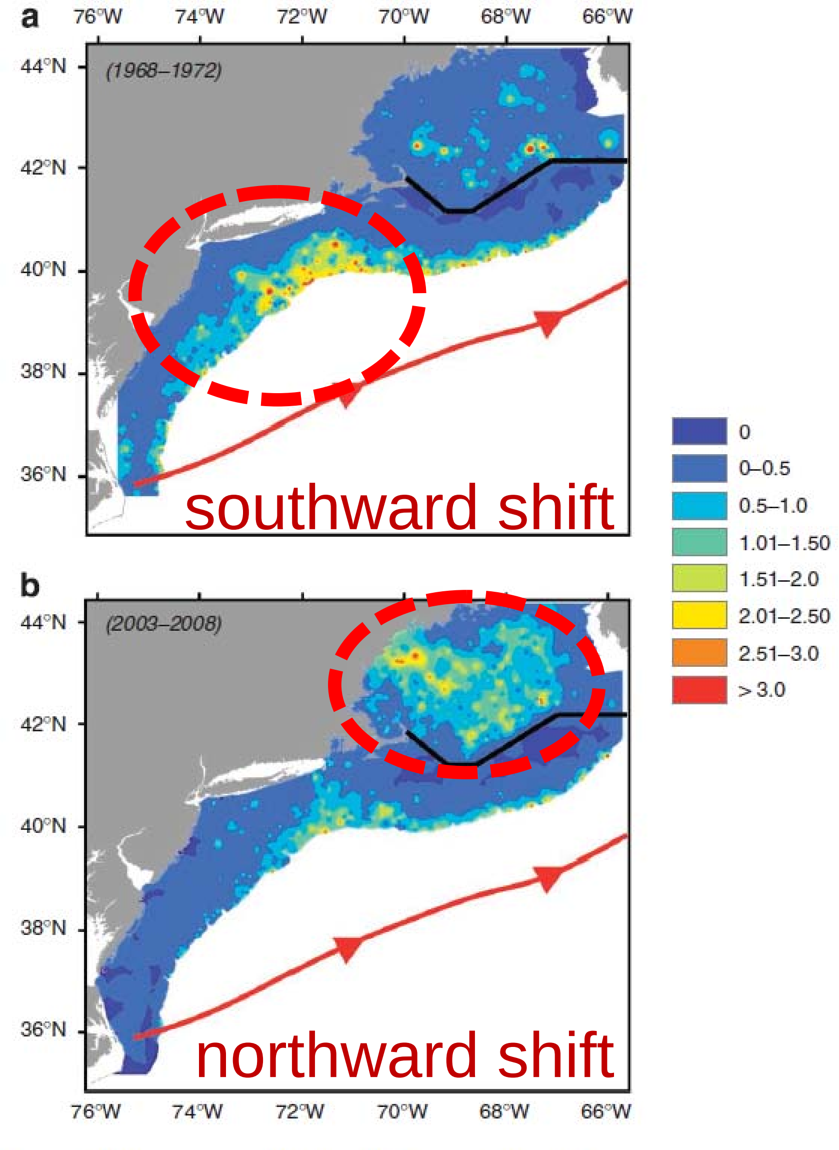
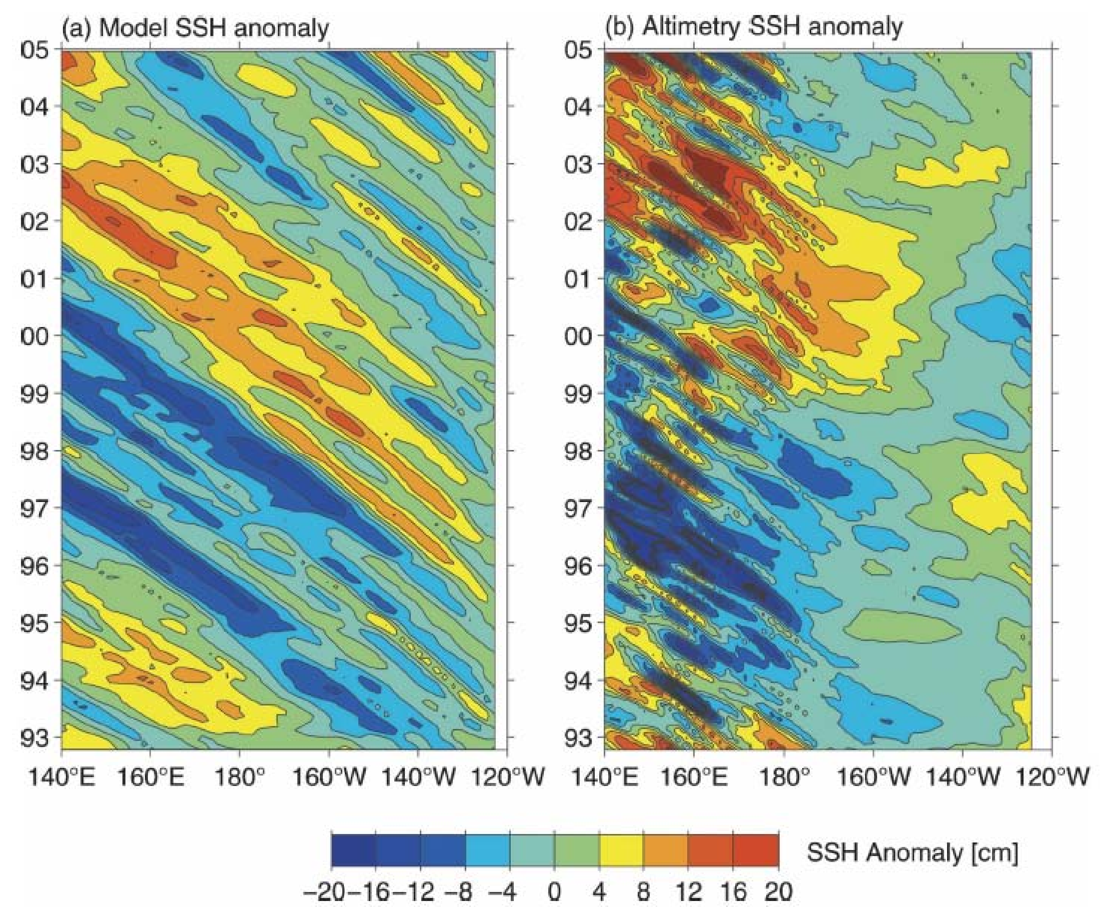


Figure 1 | Changing spatial distribution of silver hake.

- Decadal variability of the GS latitude is associated with spatial distribution changes of silver hake

Nye et al. (2011)

What is the mechanism?

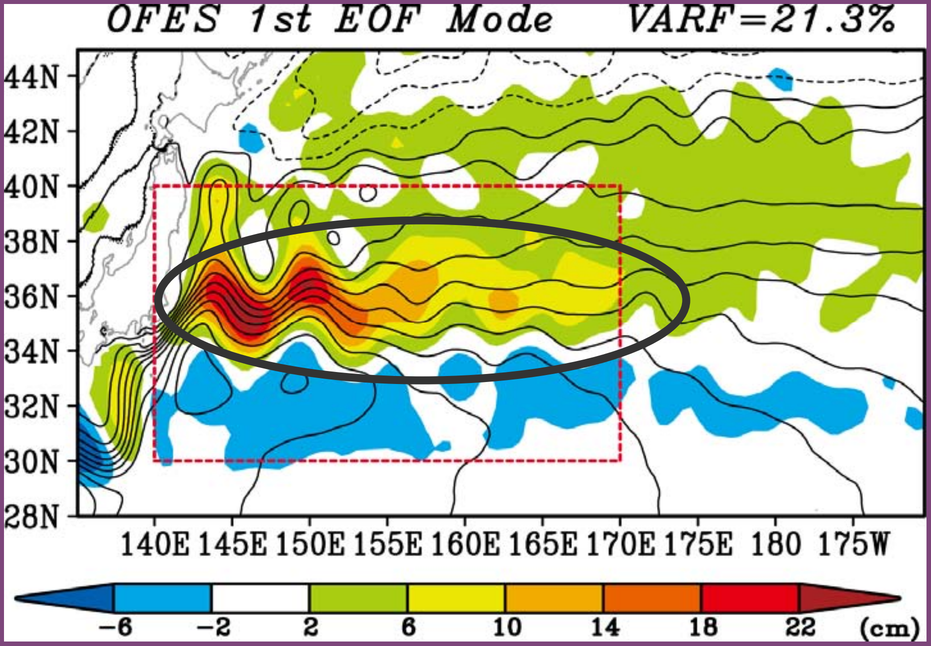


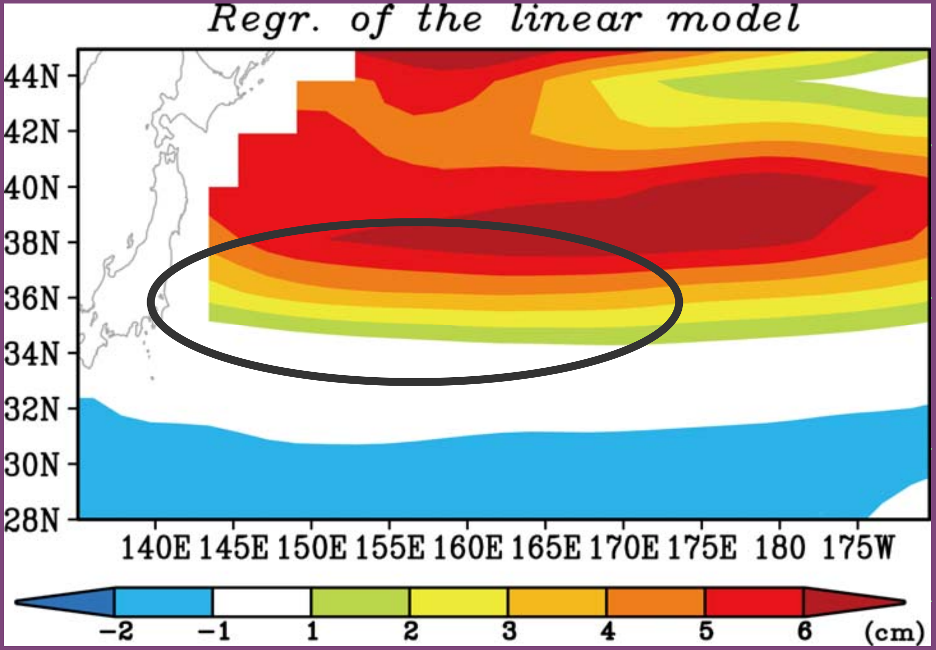
sea level anomaly averaged 32–34°N

Qiu (2003)

- Decadal variability in the KE is largely attributed by westward propagating signals
- A popular mechanism is a linear long Rossby wave

Problem



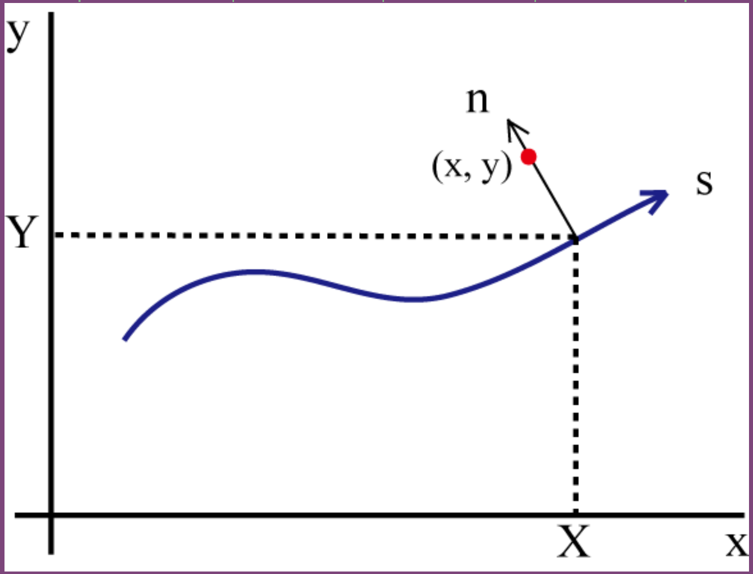


Sasaki and Schneider (2011)

- A linear long Rossby wave does not show large sea level anomalies around the KE jet

⇒ Another dynamic framework is necessary

Thin-jet theory (Cushman-Roisin et al. 1993)



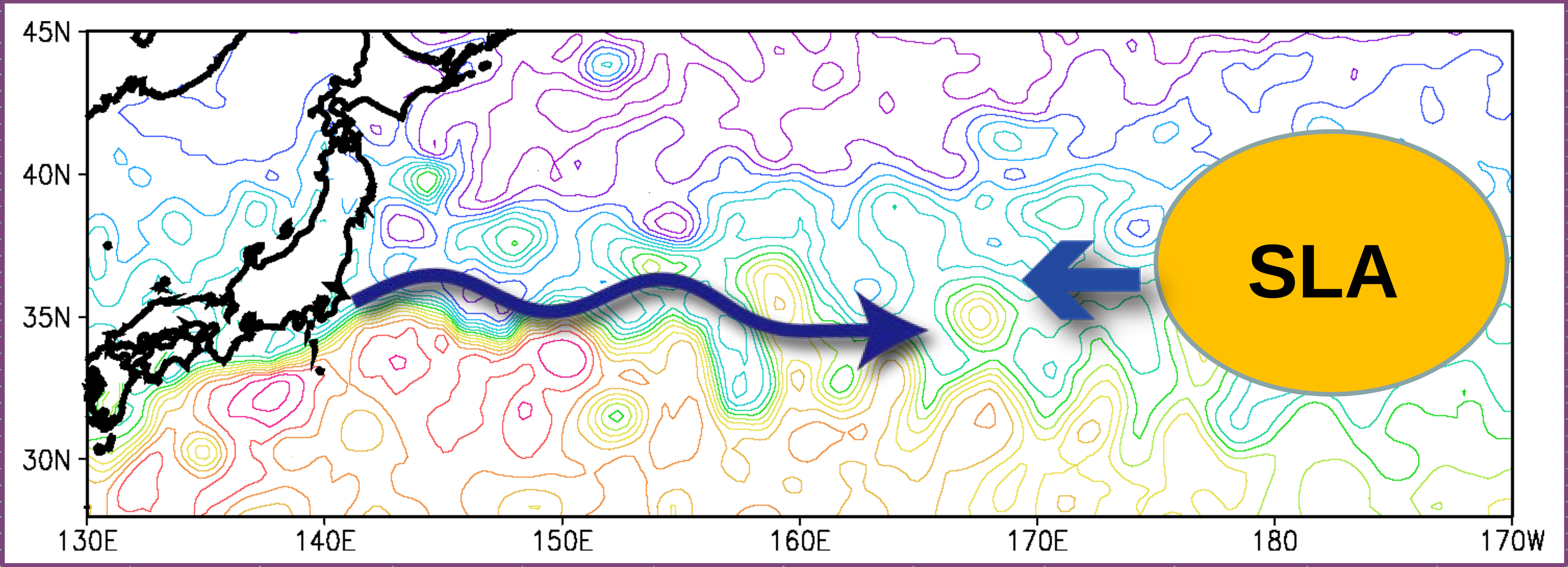
s: the distance along the jet

n: the distance from the arbitrary point (x, y) to the nearest jet

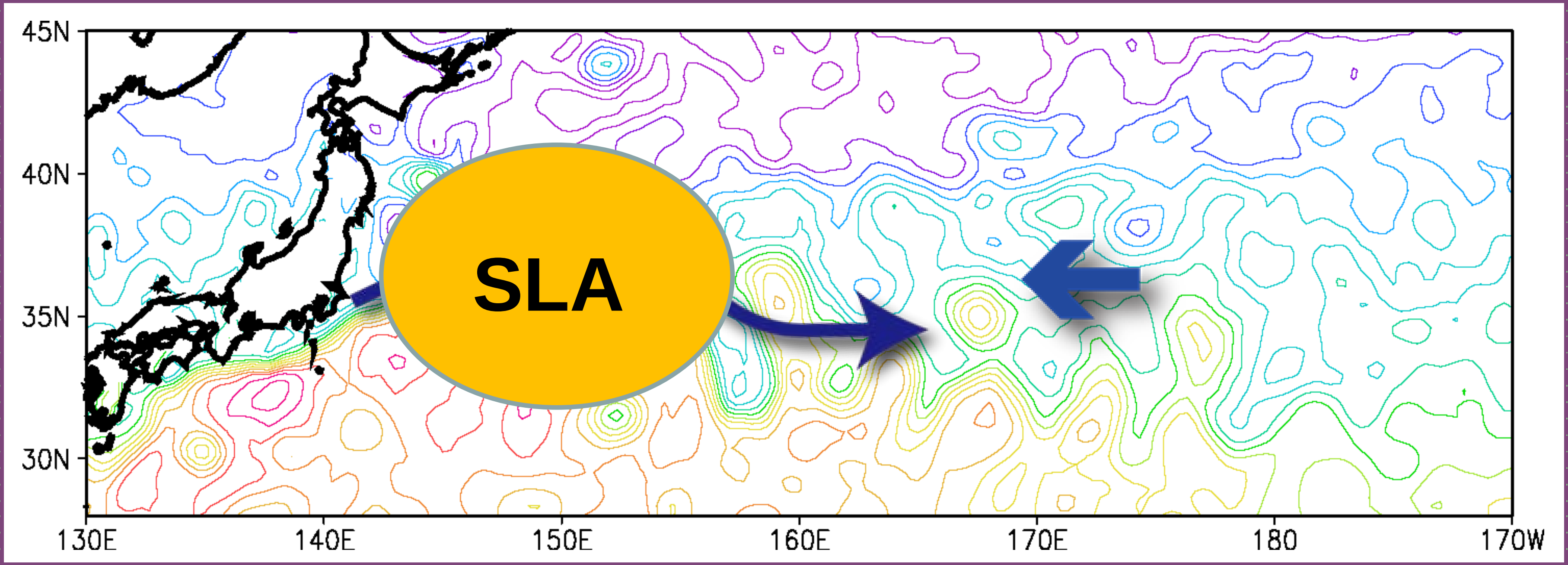
X, Y: the point on the jet

- Sasaki and Schneider (2011, JPO) modified this theory for the meridional shift of the KE jet on decadal timescales
- Meridional shifts of the jet propagate westward along the jet axis
- We refer to as jet-trapped Rossby wave

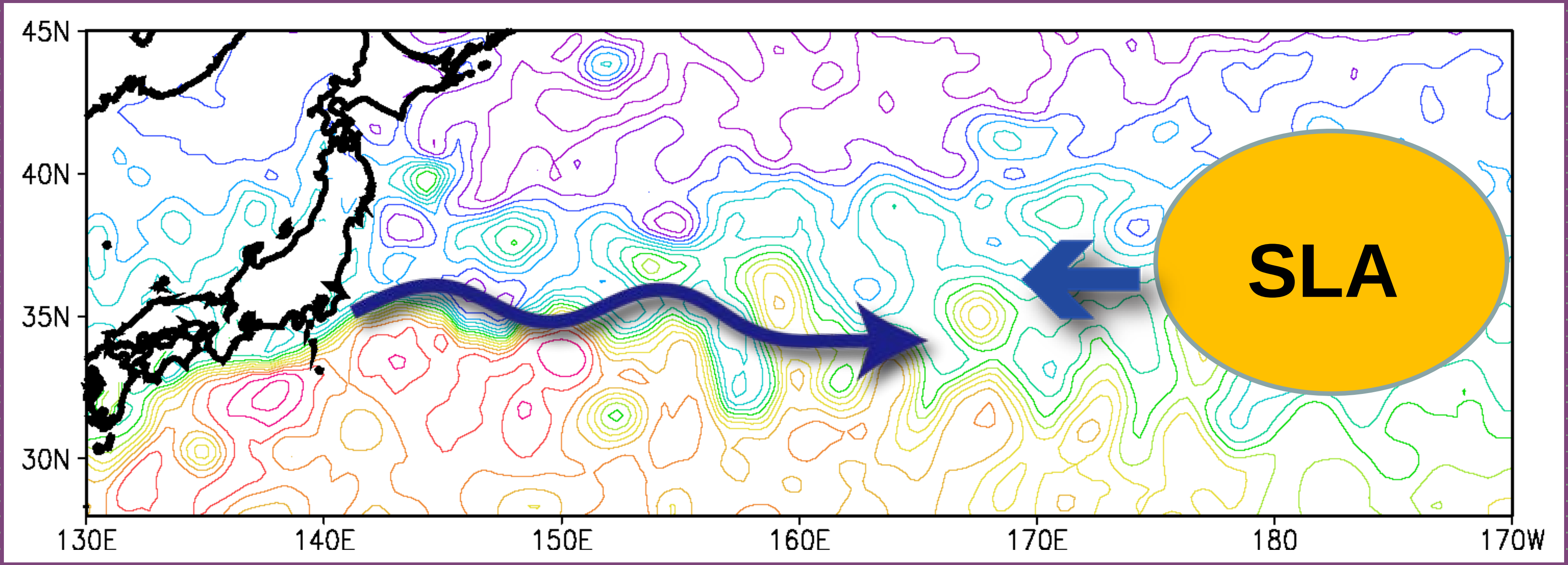
Linear long Rossby wave



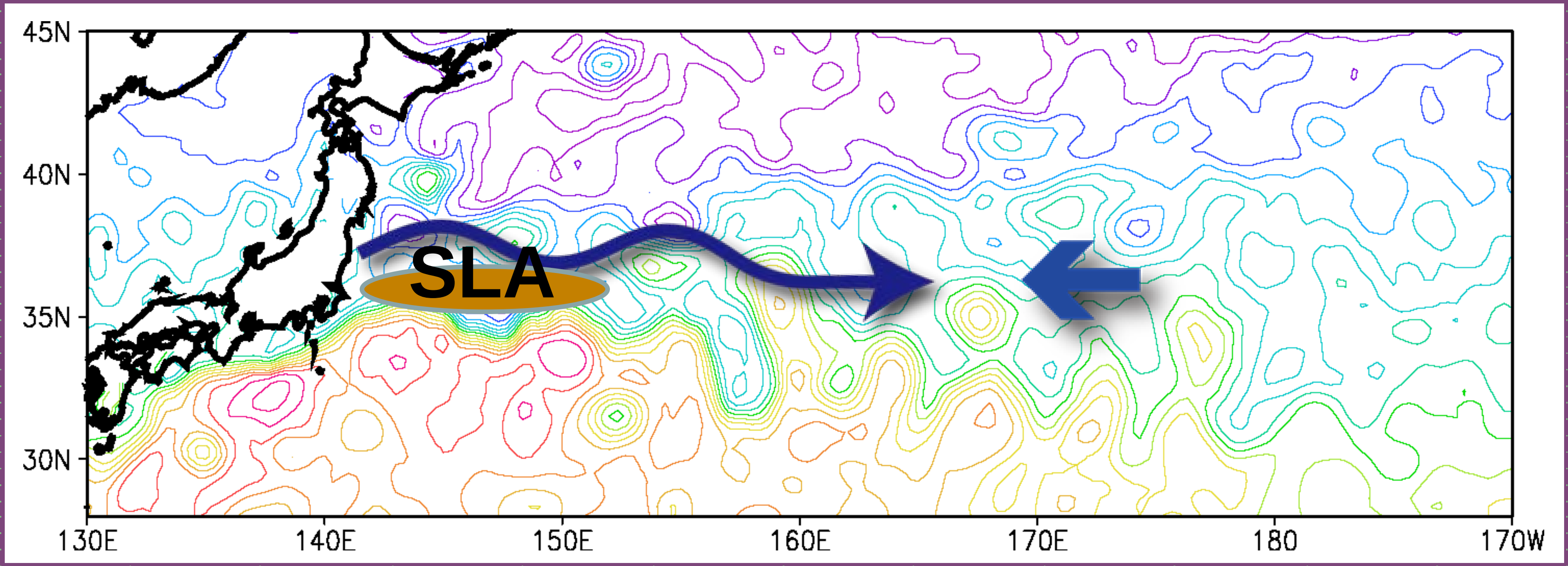
Linear long Rossby wave



Jet-trapped Rossby wave



Jet-trapped Rossby wave



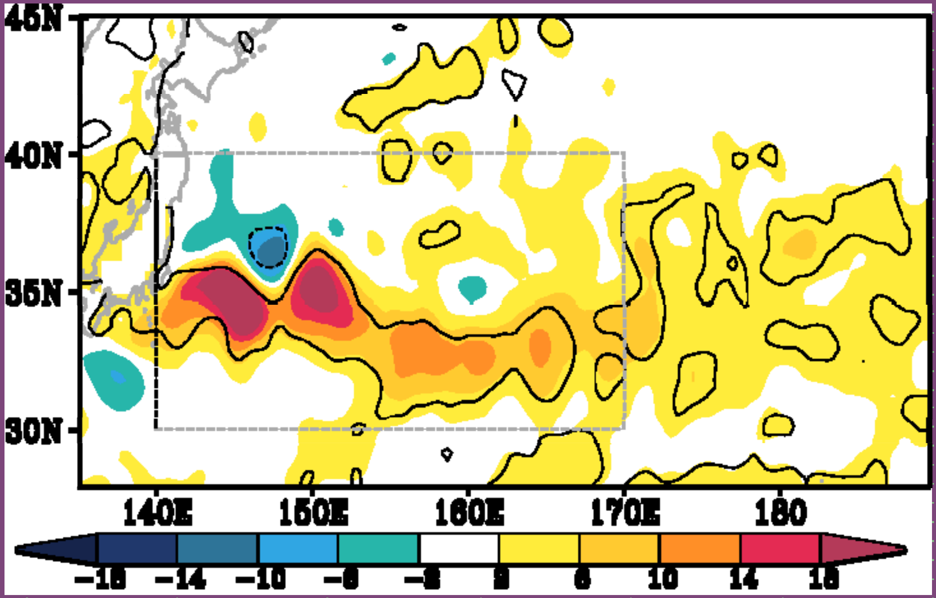
⇒ The jet acts as a waveguide of propagation

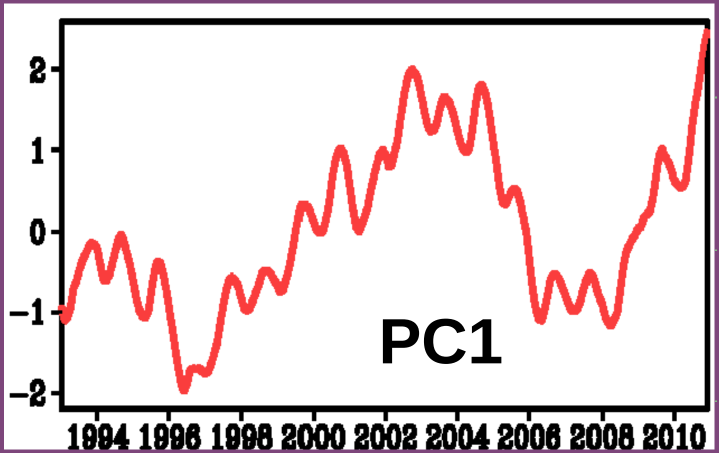
Purposes

- To clarify the extent to which the jet-trapped Rossby wave explains decadal shifts of the KE and GS jets
- To propose a new mechanism of acceleration of the KE jet

North Pacific Region

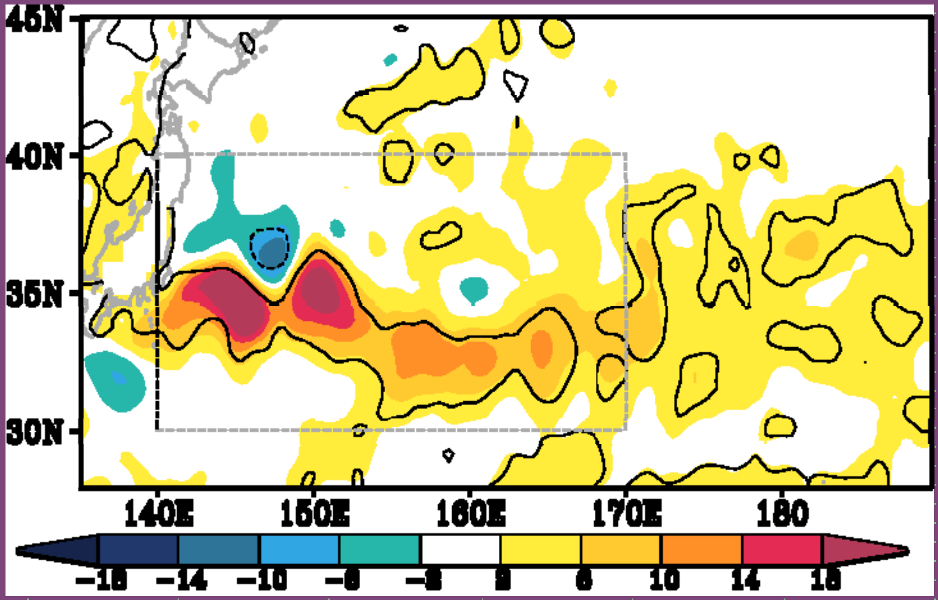
Dominant sea level variability

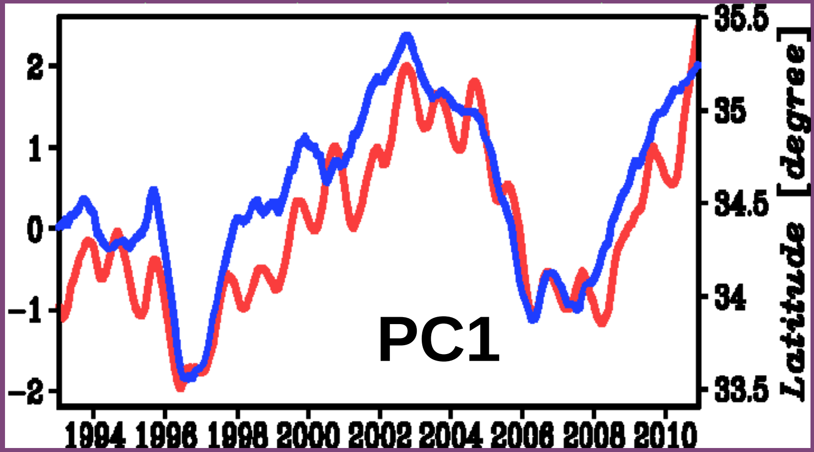




- The 1st EOF mode of sea level shows large positive anomalies along the KE jet axis

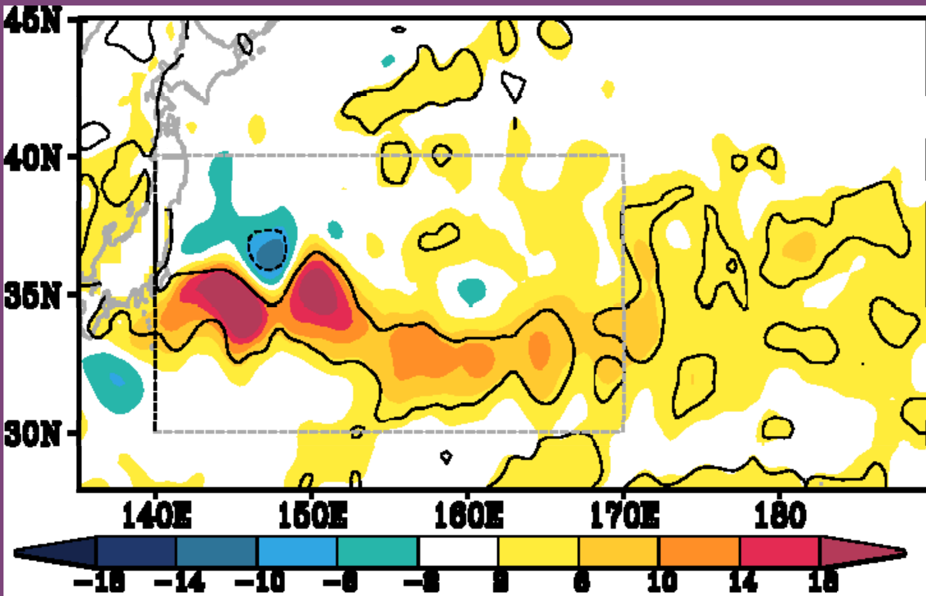
Dominant sea level variability

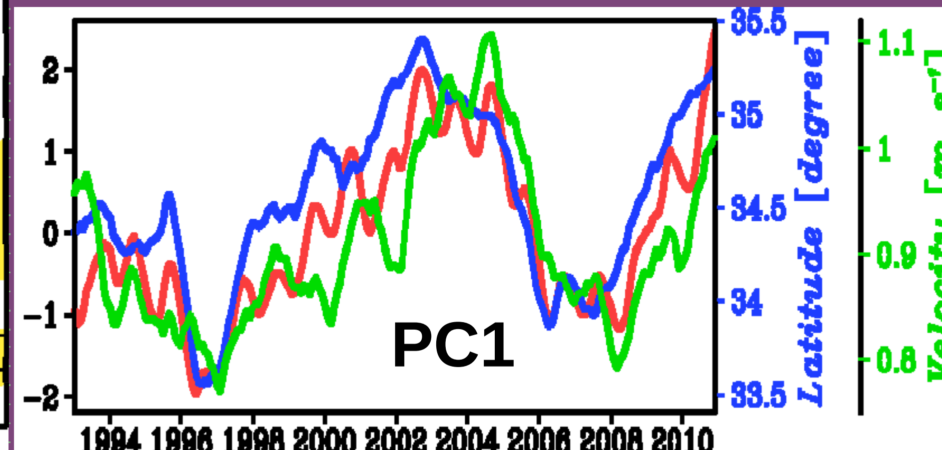




- The 1st EOF mode of sea level shows large positive anomalies along the KE jet axis
- The corresponding principal component is well correlated with variations of the jet latitude

Dominant sea level variability

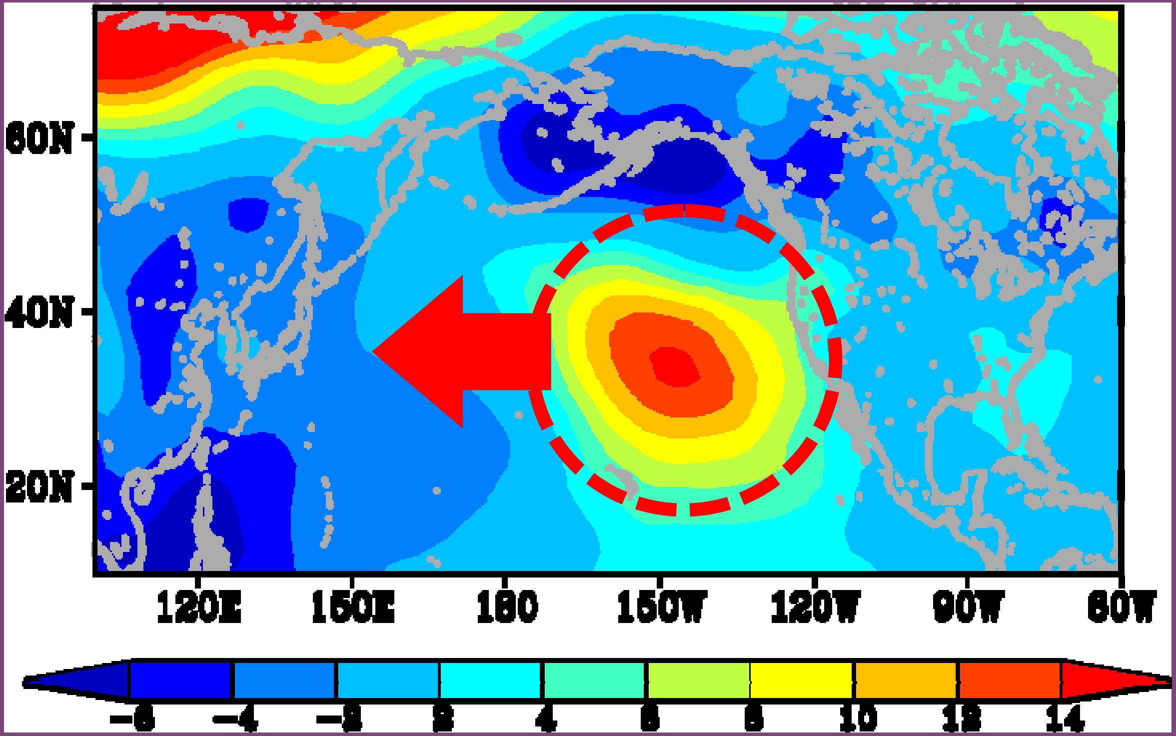




- The northward (southward) displacement of the jet leads the strengthening (weakening) of the jet by 9 months

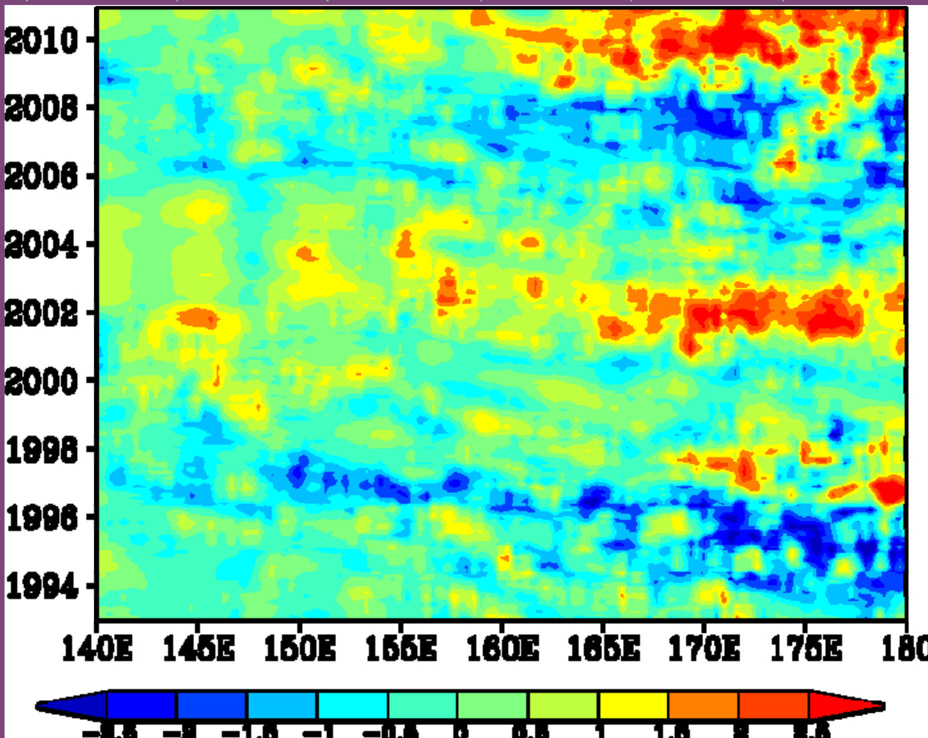
Atmospheric fluctuations

Z1000 anomalies (3-yr leading)



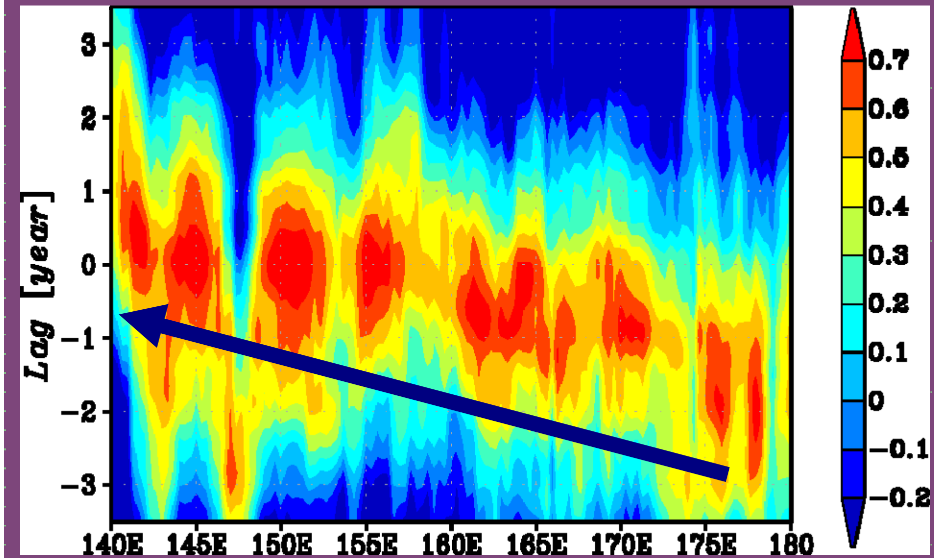
- Atmospheric fluctuations over the eastern North Pacific likely force the decadal variability in KE
- Does the KE jet really act as a waveguide?

Meridional shift of the jet



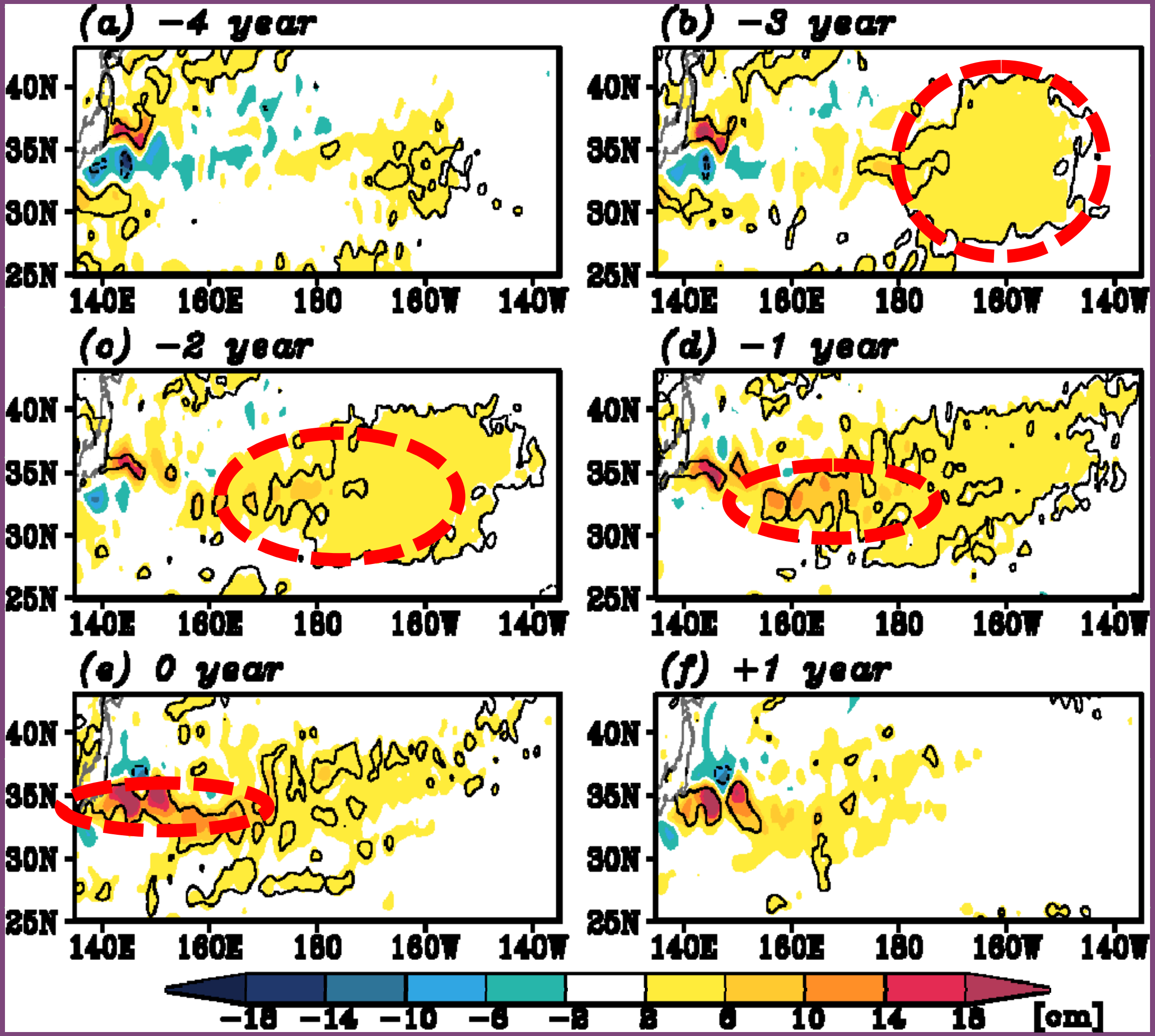
[degree]

Lag-corr of PC1 onto the latitude



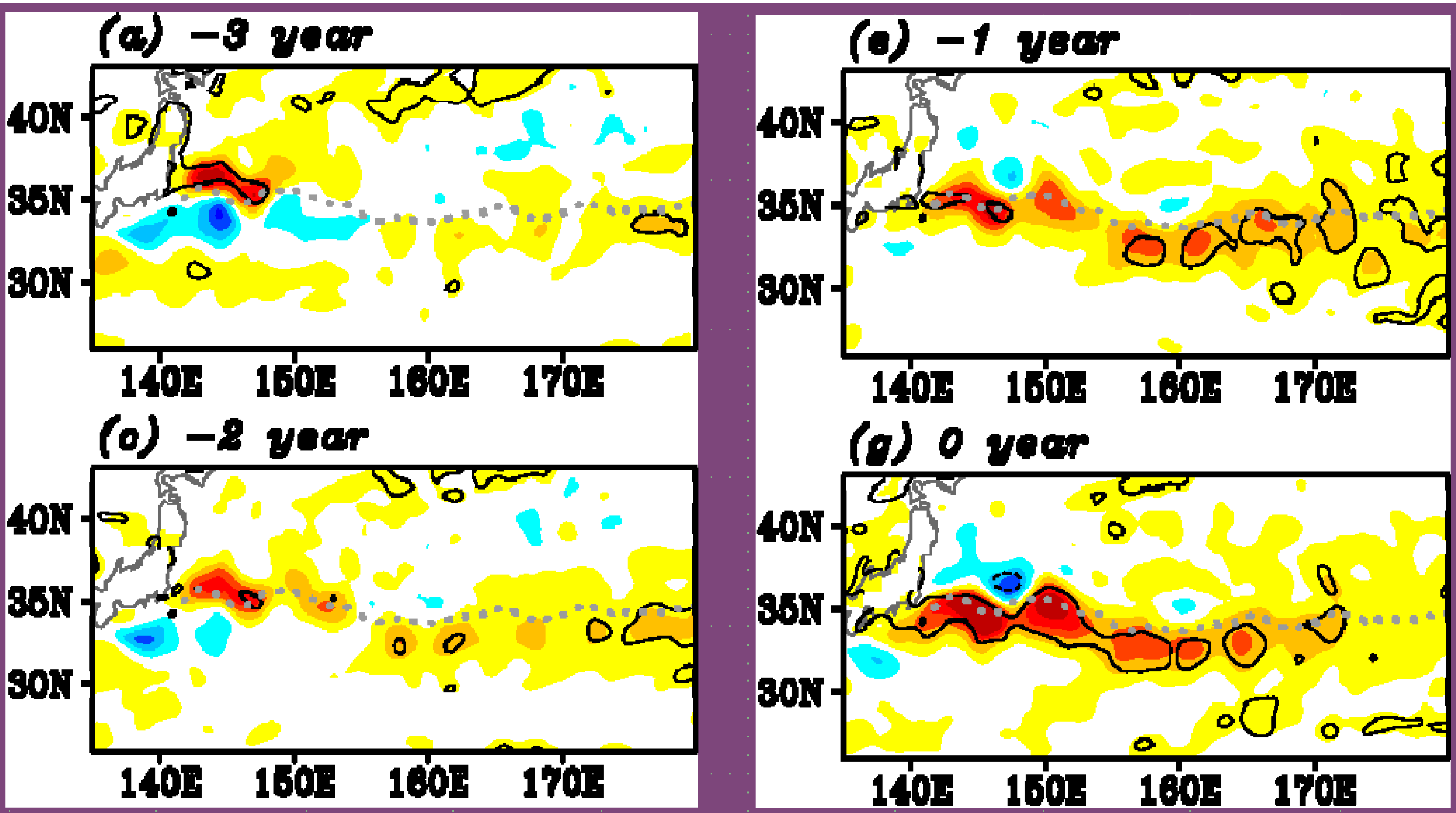
- Meridional shifts of the KE jet propagate westward, consistent with the jet-trapped Rossby wave

Propagating signal



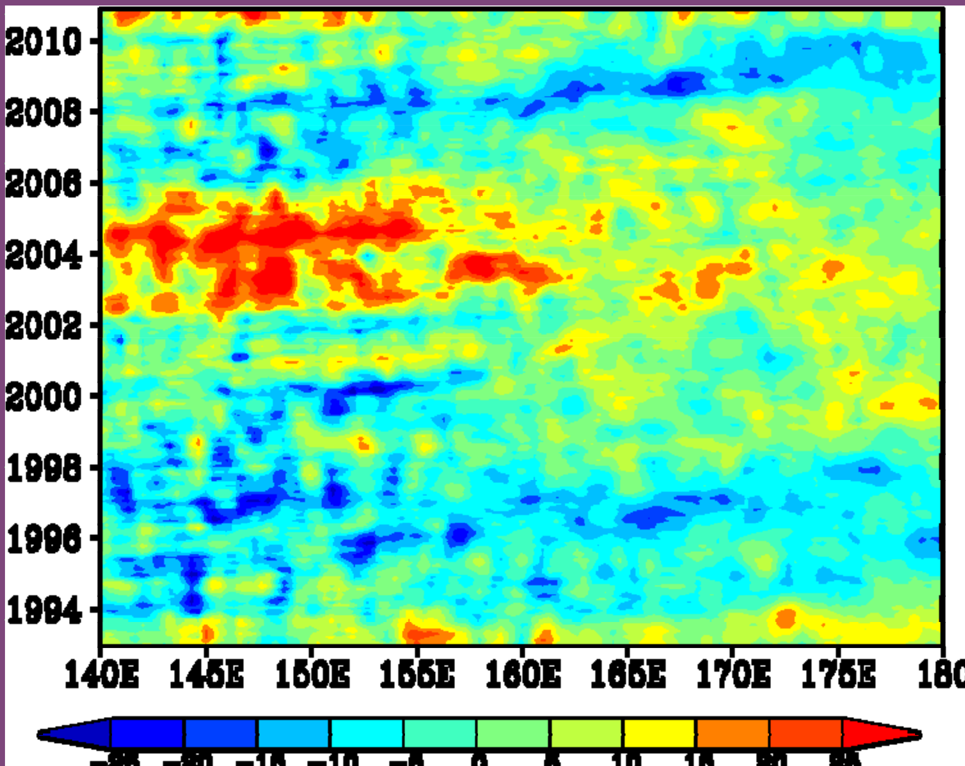
- Broad SLAs emerge 3–4 years before the jet shift, and propagate westward
- Their meridional scale gradually narrows, and their amplitude gradually increases

Propagating signal



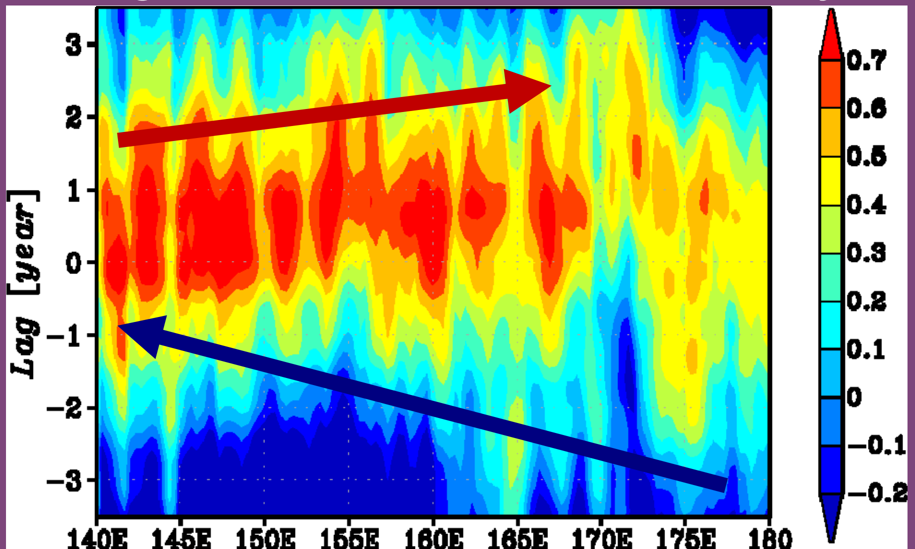
- The KE jet acts as a waveguide of the propagation signals, consistent with the jet-trapped Rossby wave

Acceleration of the jet



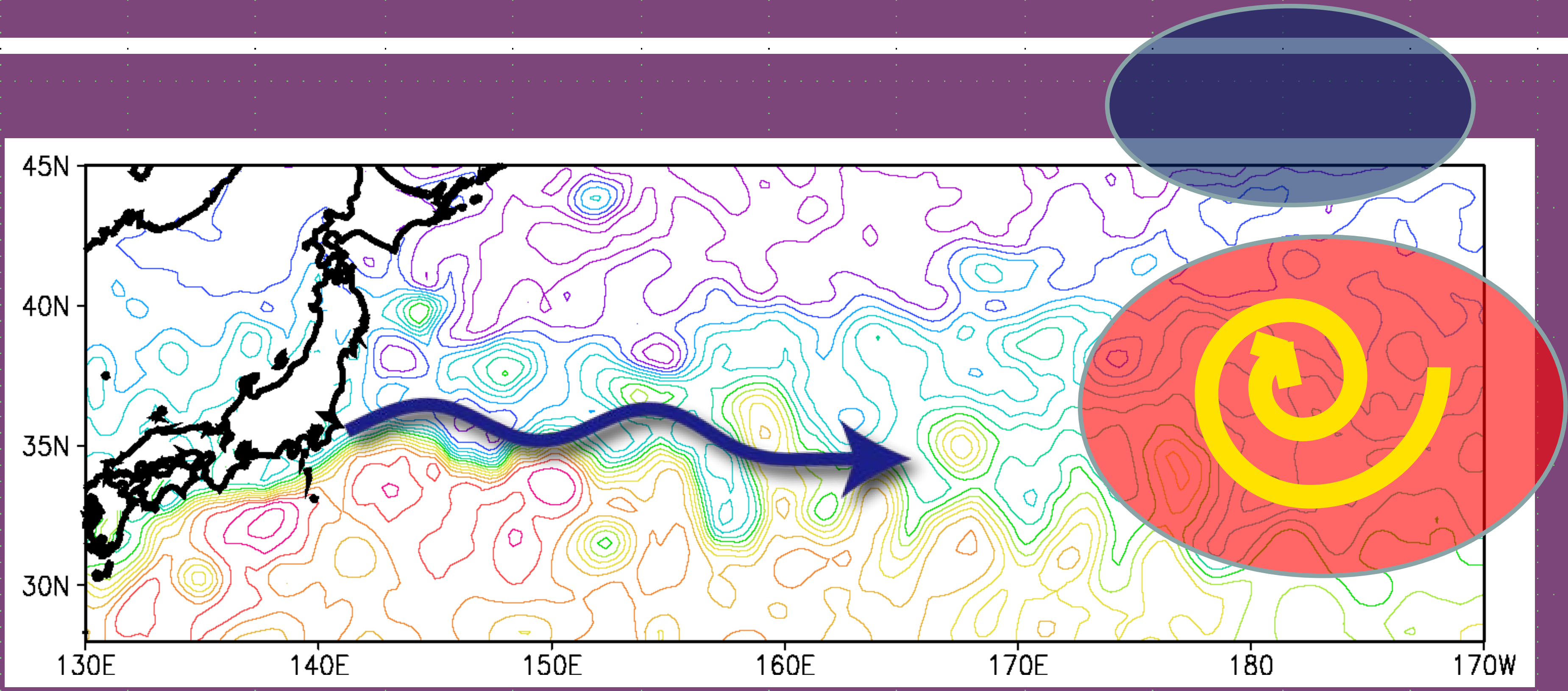
[cm/s]

Lag-corr of PC1 onto the velocity

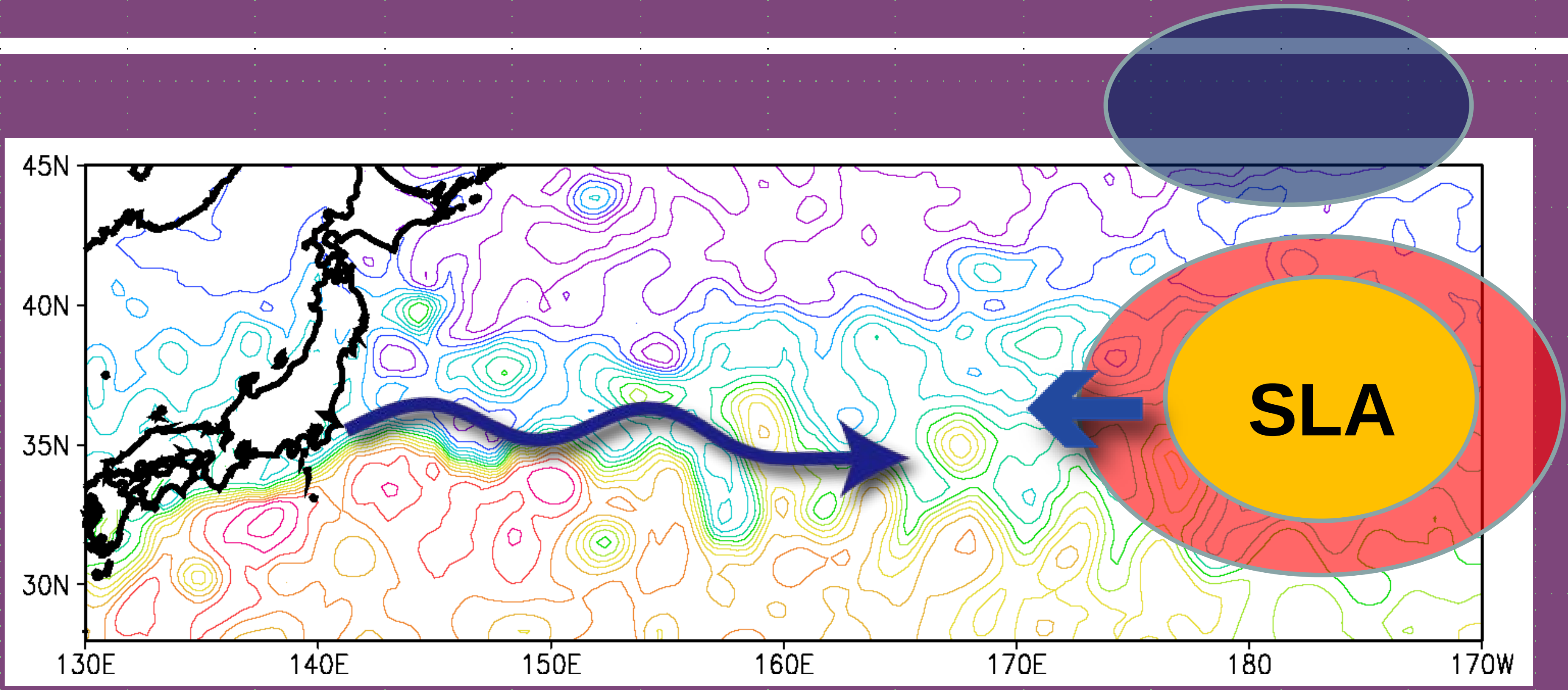


- The velocity changes of the KE jet propagate eastward in response to its shift, suggesting an importance of boundary processes

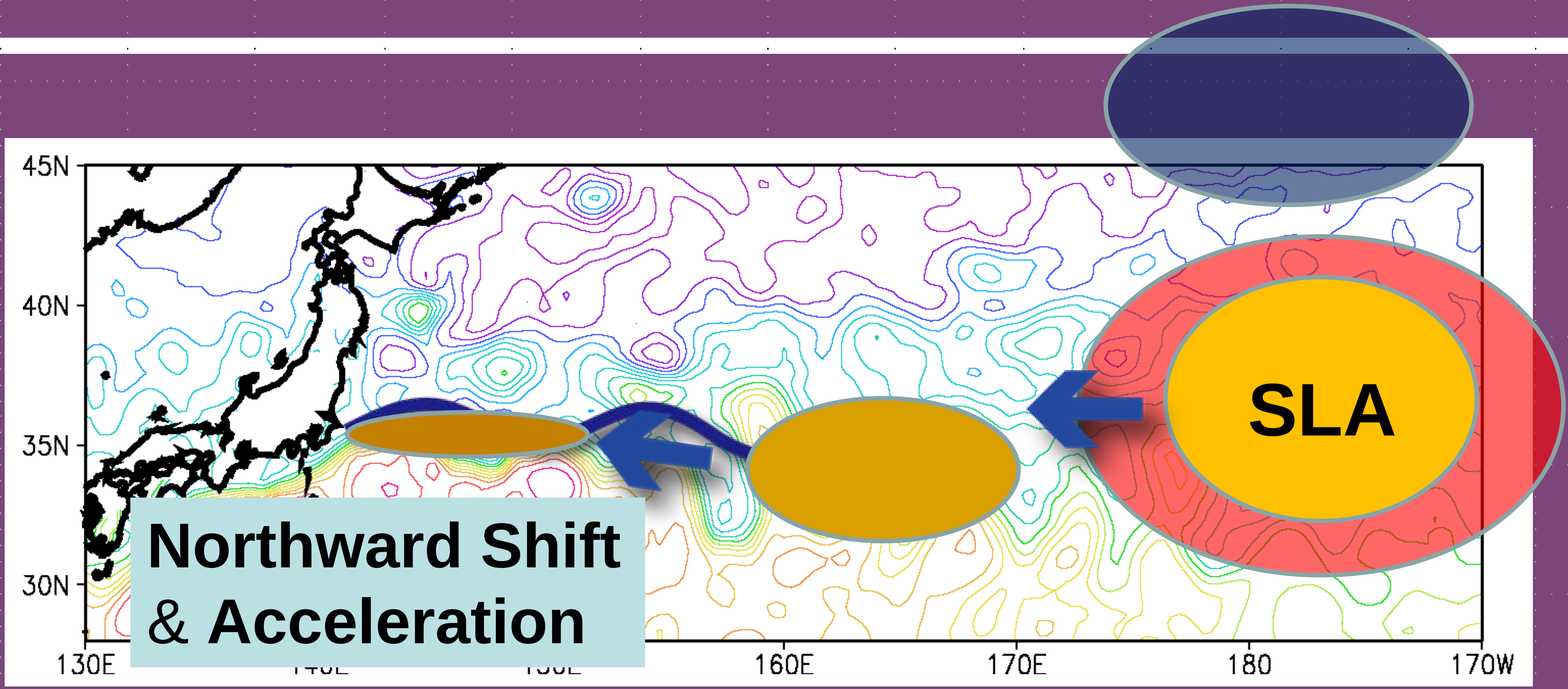
Schematic



Schematic

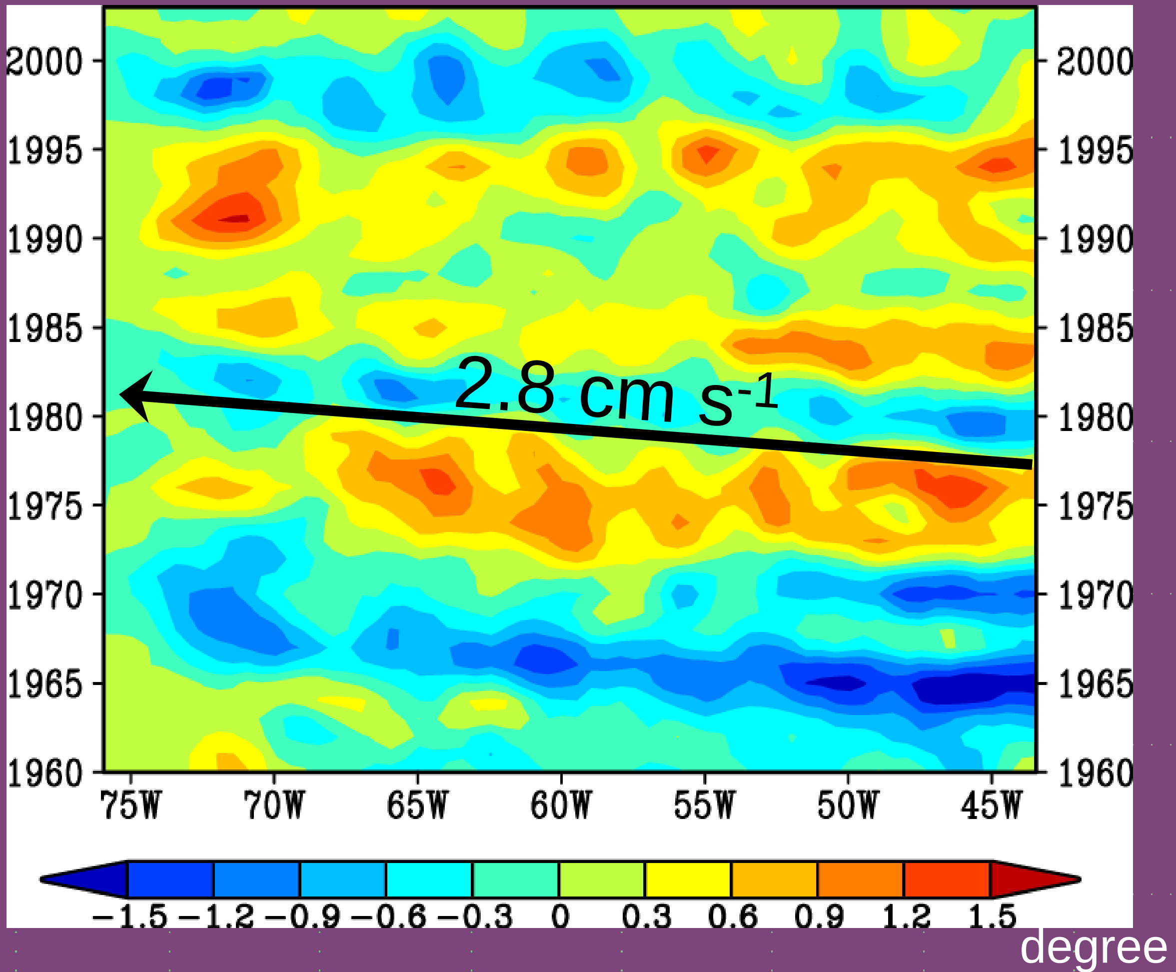


Schematic


45N
40N
35N
30N
130E
160E
170E
180
170W
SLA
Northward Shift
& Acceleration

North Atlantic Region

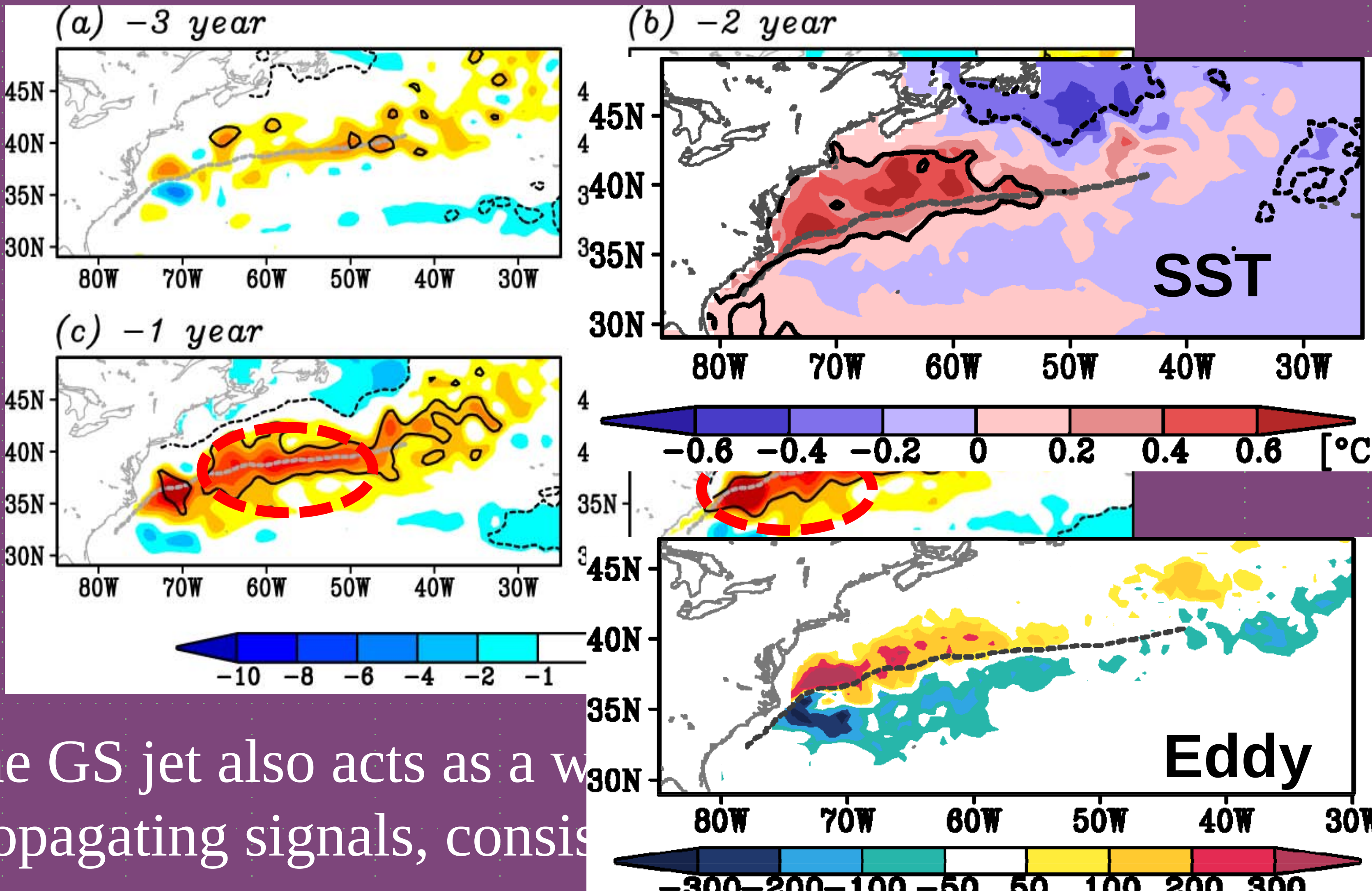
Meridional shift of the jet



- The shift of the jet propagates westward

Propagating signal

Sea Level Anomalies



- The GS jet also acts as a w
propagating signals, consis

Summary

- The jet-trapped Rossby wave causes the decadal shifts of the KE and GS jets
- The information of shifts of the downstream jet gives a long-time prediction of upstream conditions

References

•Sasaki, Y. N., S. Minobe and N. Schneider, 2012: Decadal response of the Kuroshio Extension jet to Rossby waves: Observation and thin-jet theory. *Journal of Physical Oceanography, in press*.

•Sasaki, Y. N., and N. Schneider, 2011: Interannual to decadal Gulf Stream variability in an eddy-resolving ocean model. *Ocean Modelling*, 209−219.

•Sasaki, Y. N., and N. Schneider, 2011: Decadal shifts of the Kuroshio Extension jet: Application of thin-jet theory. *Journal of Physical Oceanography*, 979−993.