Decadal response of the Kuroshio Extension jet to Rossby waves

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Conclusions

- ✓ Sea level anomalies (SLAs) occurring in the eastern North Pacific propagate westward along the jet axis
  - These propagation pathway and speed are consistent with the thin-jet theory (Sasaki and Schneider 2011, JPO)
- ✓ The meridional scale of the SLAs gradually decreases, and their amplitude gradually increases during the propagation
- ✓ After the propagating signals of positive (negative) SLAs reach at the western boundary, the KE jet strengthens (weakens)

1. Introduction

The Kuroshio Extension (KE) jet undergoes significant shifts on decadal timescales, and has attracted much attention due to its impact on climate and marine ecosystem. Nevertheless, the mechanisms for the westward propagation and the associated shift are not fully understood. One puzzling aspect is that wind forcing and the corresponding response of sea level in the eastern North Pacific have a broad spatial scale (~1000 km), but the response in the KE region to the forcing has a much narrower meridional scale (~100 km).

Our purpose is to clarify the extent to which the thin-jet theory by Sasaki and Schneider (2011) can explain the westward propagation using satellite altimeter data. In addition, we also document that a shift of the KE jet latitude leads changes of its intensity by a few months and investigate possible underlying mechanisms.

2. Dominant KE Variability

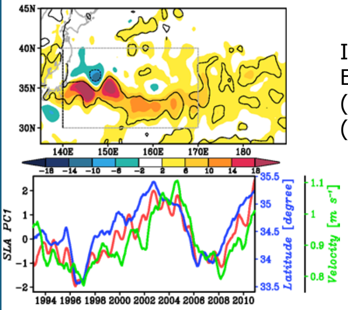

Fig. 1 First EOF mode of sea level of satellite observation. (top) Regressions of SLAs. (bottom) PC1, and the latitude and velocity of the KE jet

In the positive (negative) phase of the 1st EOF mode, the KE jet is shifted northward (southward) and strengthens (weakens) (Figs. 1–2)

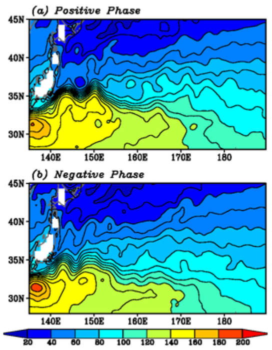

Fig. 2 Sea surface height defined as the climatology (a) plus and (b) minus the regression coefficients of SLAs onto PC1.

The highest lag correlations are

- ☐ PC1 vs the jet latitude: zero lag (r=0.91)
- ☐ PC1 vs the jet strength: PC1 leads by 9 months (r=0.89)

⇒ Shifts of the jet are a key process in decadal variability in the KE region

3. Propagation Signals

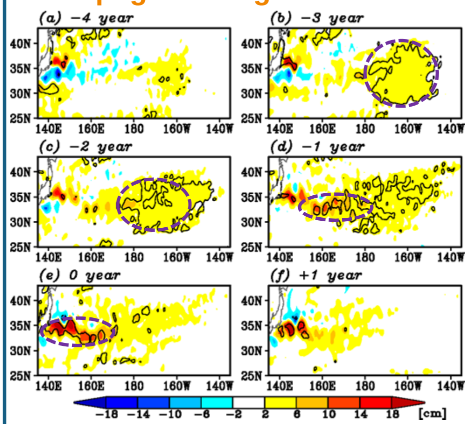

Fig. 3 Lag regressions of SLAs of the satellite observation onto PC1. The black solid and dashed contours indicate the regions where the correlations are greater and lower than 0.6 and −0.6, respectively.

Broad SLAs occurring in the eastern North Pacific 3 year before the KE jet shift propagate westward (Fig. 3)

During the propagation, the meridional scale narrows, and the amplitude increases

The jet acts as a waveguide of propagation signals (Fig. 4; left column)

Consistent with the thin-jet theory, meridional shifts of the KE jet propagate westward, consistent with the thin-jet theory (Figs. 5–6)

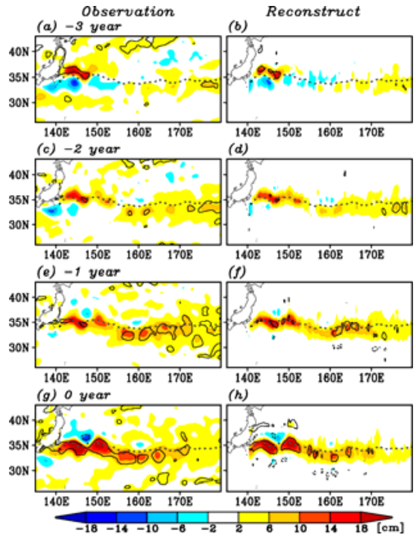

Fig 4 Lag regressions of SLAs (left) of satellite observation and (right) by the reconstruction onto PC1 The gray dotted line denotes the climatological position of the KE jet.

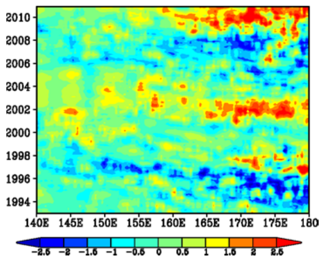

Fig. 5 Latitude anomalies of the KE jet

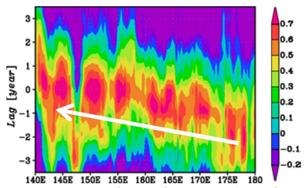

Fig. 6 Lag correlations between PC1 and the latitude of the KE jet

Sasaki and Schneider (2011) represented SLAs caused by the shift of the jet in the thin-jet framework as (Fig. 7):

$$\eta(x, y, t) = \overline{\eta}_L\left[x, y_0(x) + dy(x, t)\right]$$

dy is given by observational values. The meridional position, amplitude and meridional scale of the reconstructed SLAs well correspond to those of the observations (Fig. 4; right column)

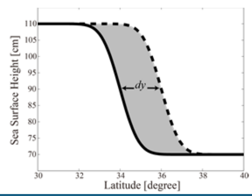

Fig. 7 A schematic diagram of the reconstruction. The solid line denotes a climatological sea surface height of the jet. Its northward displacement dy, shown by the dashed line, induces SLAs indicated by gray shading

4. Acceleration of the KE jet

Interestingly, the acceleration of the KE jet propagates eastward (Figs. 8–9)

This eastward propagation implies that PV advection from the western boundary plays an important role in the changes of the KE jet strength

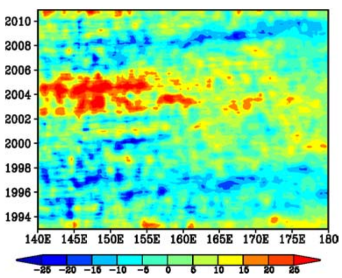

Fig. 8 Velocity anomalies of the KE jet

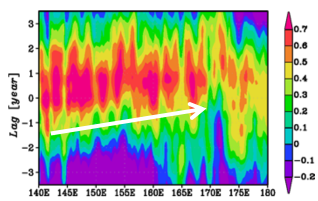

Fig. 9 Lag correlations between PC1 and the strength of the KE jet

The strength changes of the KE jet are associated with the changes of the northern and southern recirculation gyres in response to the incoming signals from east (Fig. 10)

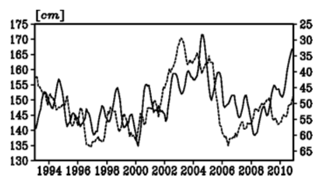

Fig. 10 The sea surface height averaged south of the KE jet averaged over 140°–153°E (solid line; left axis) and north of the KE jet averaged over 145°–153°E (dashed line; right axis). The direction of the right axis is reversed

References

- Sasaki, Y. N., and N. Schneider, 2011: Decadal shifts of the Kuroshio Extension jet: Application of thin-jet theory. J. Phys. Oceanogr., 41, 979–993.
- Sasaki, Y. N., S. Minobe and N. Schneider, 2012: Decadal response of the Kuroshio Extension jet to Rossby waves: Observation and thin-jet theory. J. Phys. Oceanogr., in press.