Meridional Shift of the Oyashio Extension Front in the Past 35 Years

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The subtropical sea surface temperature fronts (SSTF) in the Ocean, anchored by the strong western boundary currents, are the key regions in the climate system with huge heat and mass transport, high eddy activities, strong atmospheric storms, as well as major CO2 sink. They are also the most challenge areas in the climate model simulations and projections. Ongoing efforts are seeking to understand their variability, especially associated with climate change, such as the Hadley Cell (HC) expansion.
With the HC expansion, would the Oyashio Extension (OE) front in the North Pacific Ocean move poleward?

Data and Methods

- OI-SST and ERA-interim wind data from 1982 to 2016.
- Two methods to identify the position of the OE front: a fixed meridional SST gradient threshold (>1.2 degree per latitude) and the maximum meridional SST gradient.
- For the wind stress curl calculation, we firstly average the annual mean wind stress curl in each latitude. Secondly, we calculate the zero-curl position to analyze its meridional shift.

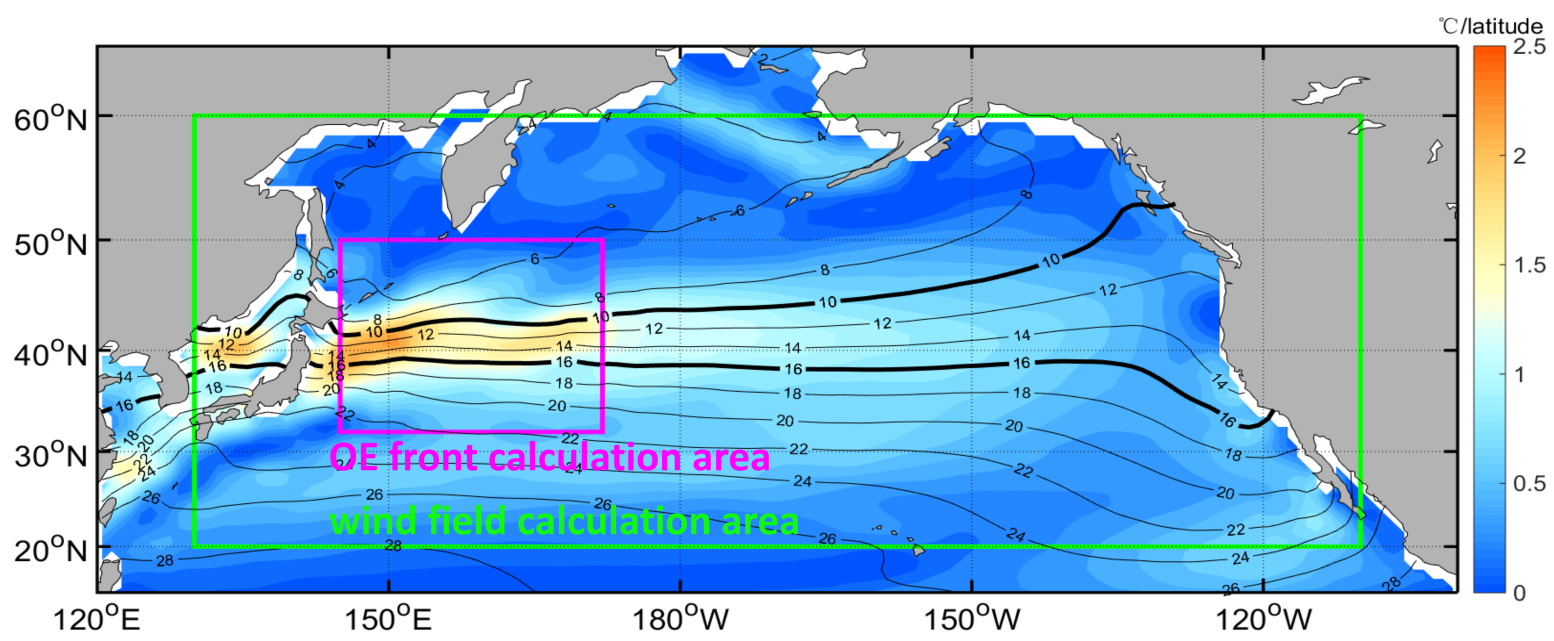


Figure 1: Calculation area (magenta box for OE front [32N~50N 145E~172E]; green box for wind [20N~60N 130E~110W]). Climatological SST (thin black) and its meridional gradient (color shading).

Results

- The annual mean zonal averaged meridional shift of the OE front is around 0.125 degree per decade which is consistent with the Hadley Cell expansion.

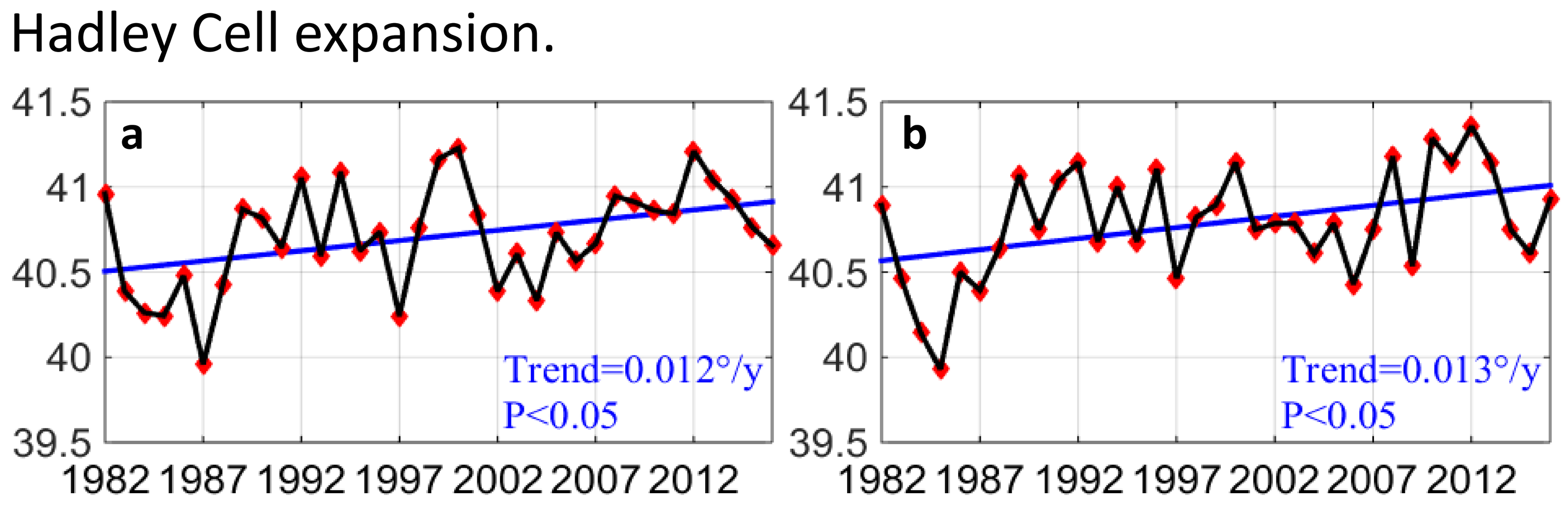
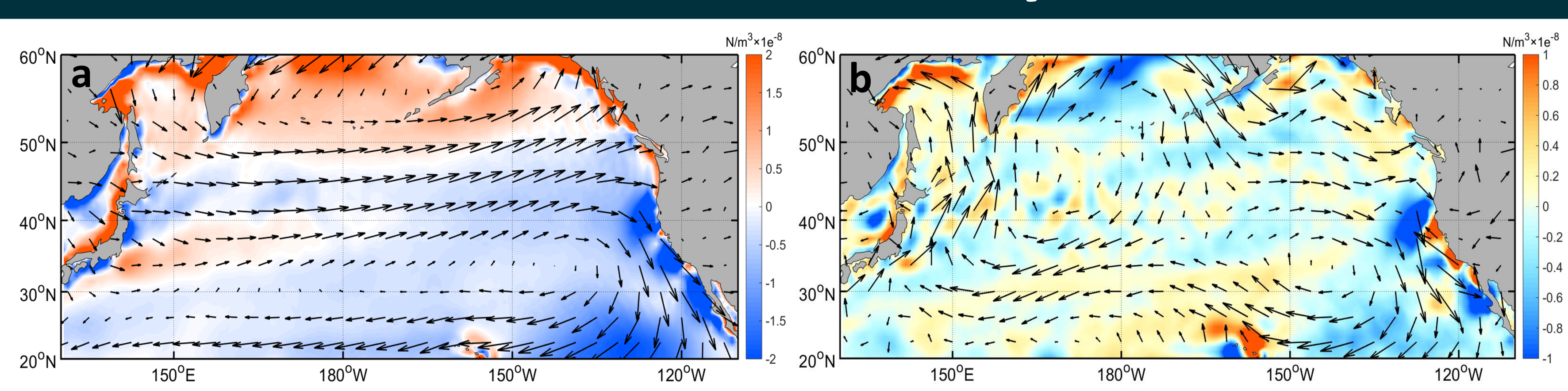


Figure 2: Annual mean **z**onal averaged OE front position from 1982 to 2016 (**a** for threshold method and **b** for maximum method).

The OE front position can be considered to represent the western boundary jets, whose variability is determined by the dynamics and thermodynamics. So, we will firstly check the wind dynamics and calculate the wind stress zero-curl line shift and then check the influence of the surface Ekman heat transport on the SSTF shift.

Mechanism of Wind Dynamics



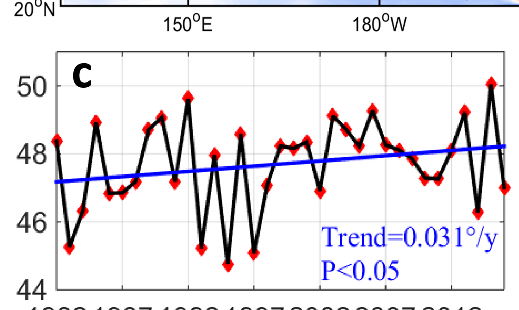


Figure 3: **a** Annual mean wind stress curl (color shading) and the wind field (vectors).

b The anomaly of **a** in the past 35 years.

c Annual mean wind stress zero-curl position from 1982 to 2016.

- Trade wind becomes stronger and broader and the whole wind field moves northward in the past 35 years. This pushes the wind stress zero-curl line and then the zonal averaged position of the OE front also moving northward.

Mechanism of Thermodynamics

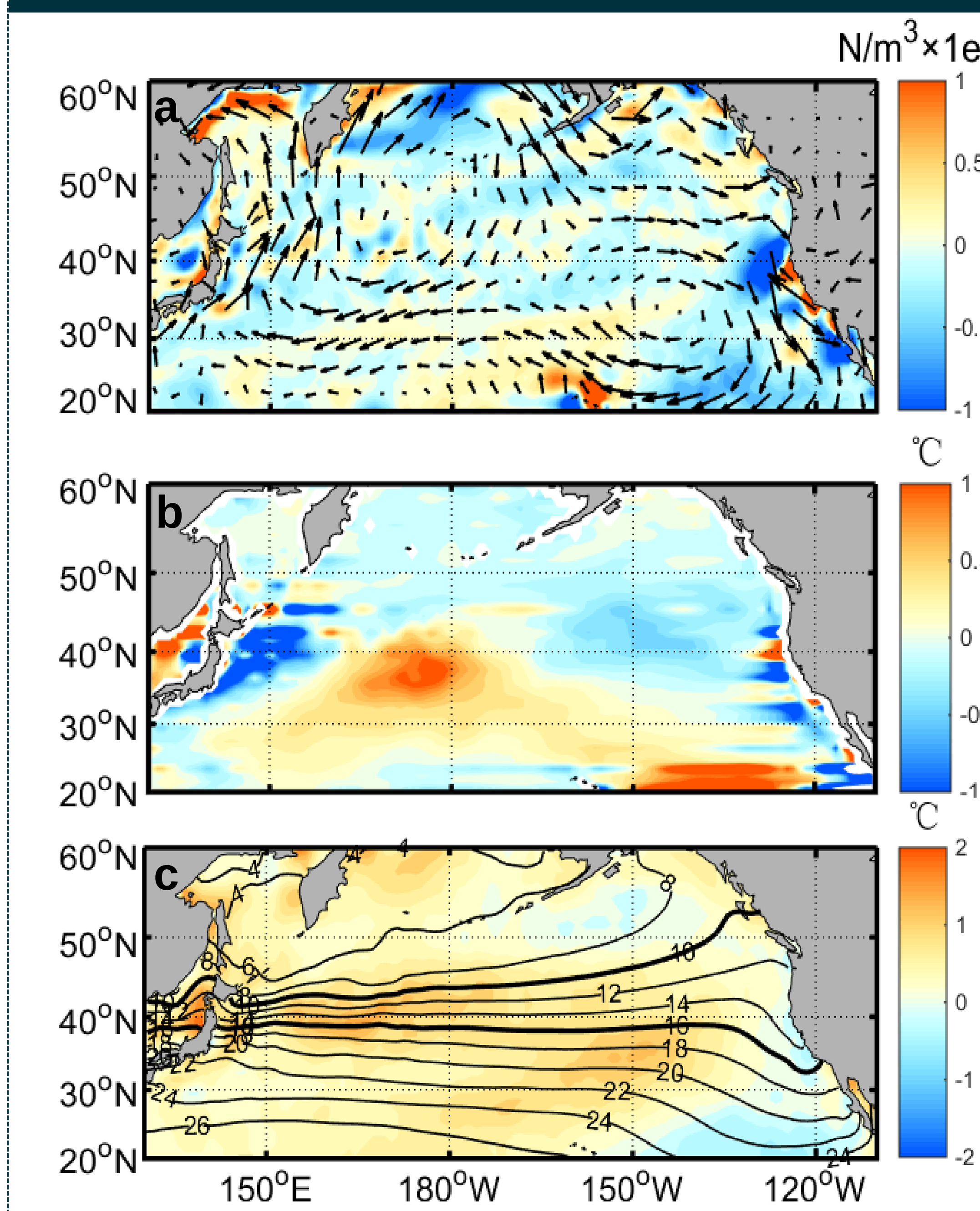


Figure 4:

a Annual mean anomaly of wind stress curl (color shading) and wind speed (vectors)

b Annual mean SST anomaly caused by Ekman Heat Transport (color shading)

c Annual mean SST (contours) and SST anomaly (color shading)

- In the central North Pacific, the enhanced trade wind would bring more northward Ekman transport (the anomalous warm Ekman advection) which will warm the SST in the southern front and push the OE front northward.

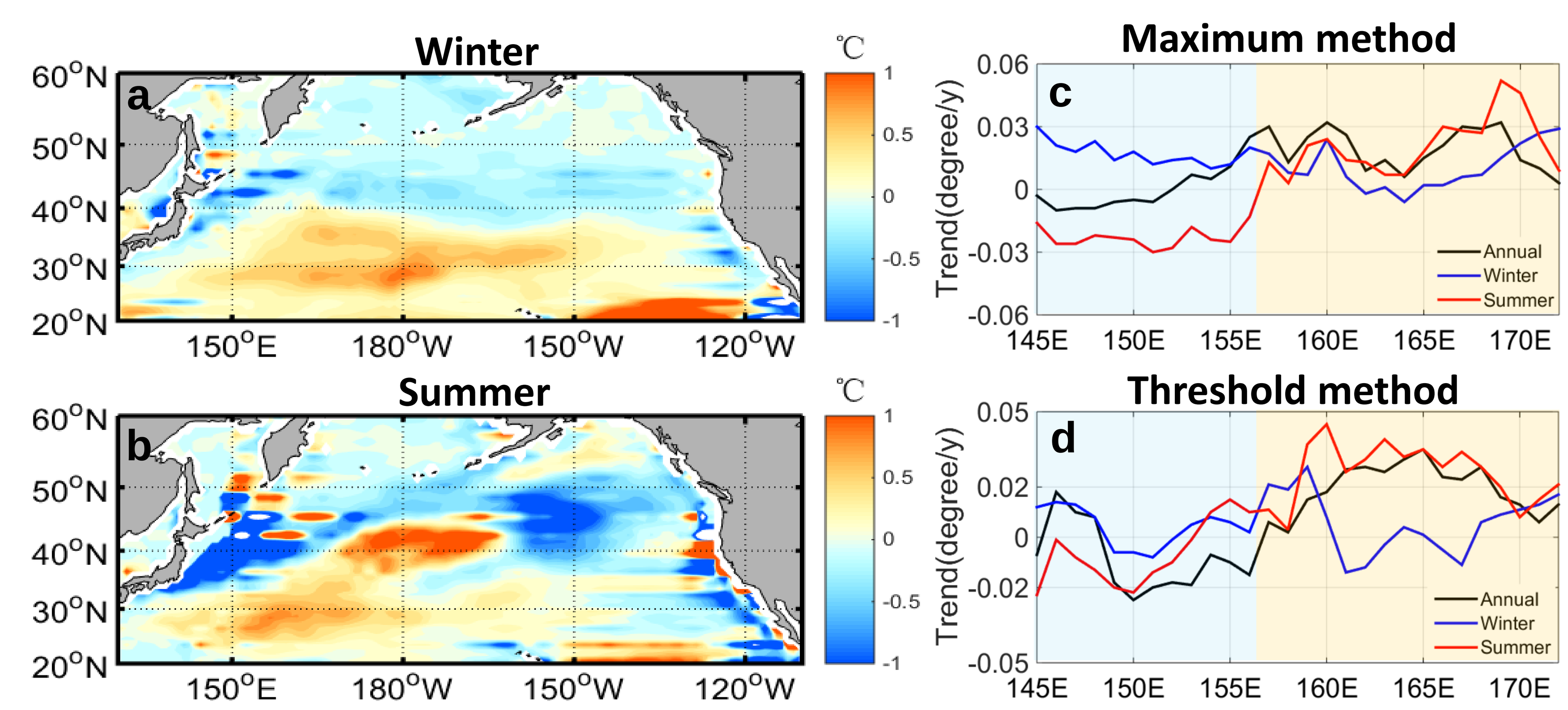


Figure 5: left column SST anomaly caused by Ekman Heat Transport in winter and summer. **right column** OE front shift trend in each longitude.

- Both in annual and summer time, the SST anomaly caused by Ekman heat transport has a west-east dipole pattern and it is the same as the OE front shift trend in each longitude, northward shift in the east of 155E and southward shift in the west of 155E.
- While in the winter time, the Ekman heat transport has less influence on the SST anomaly comparing with the summer time.

Summary

- ➢ The Oyashio Extension (OE) front moves poleward under the Hadley Cell expansion in the past 35 years.
- ➢ Annual mean meridional shift of the OE front is basically determined by the wind stress zero curl line.
- ➢ Meridional shift of the OE front in each longitude in annual and summer have a west-east dipole pattern, which is consistent with Ekman heat transport.