Interdecadal decreasing trend of the Oyashio on the continental slope off the southeastern coast of Hokkaido, Japan.

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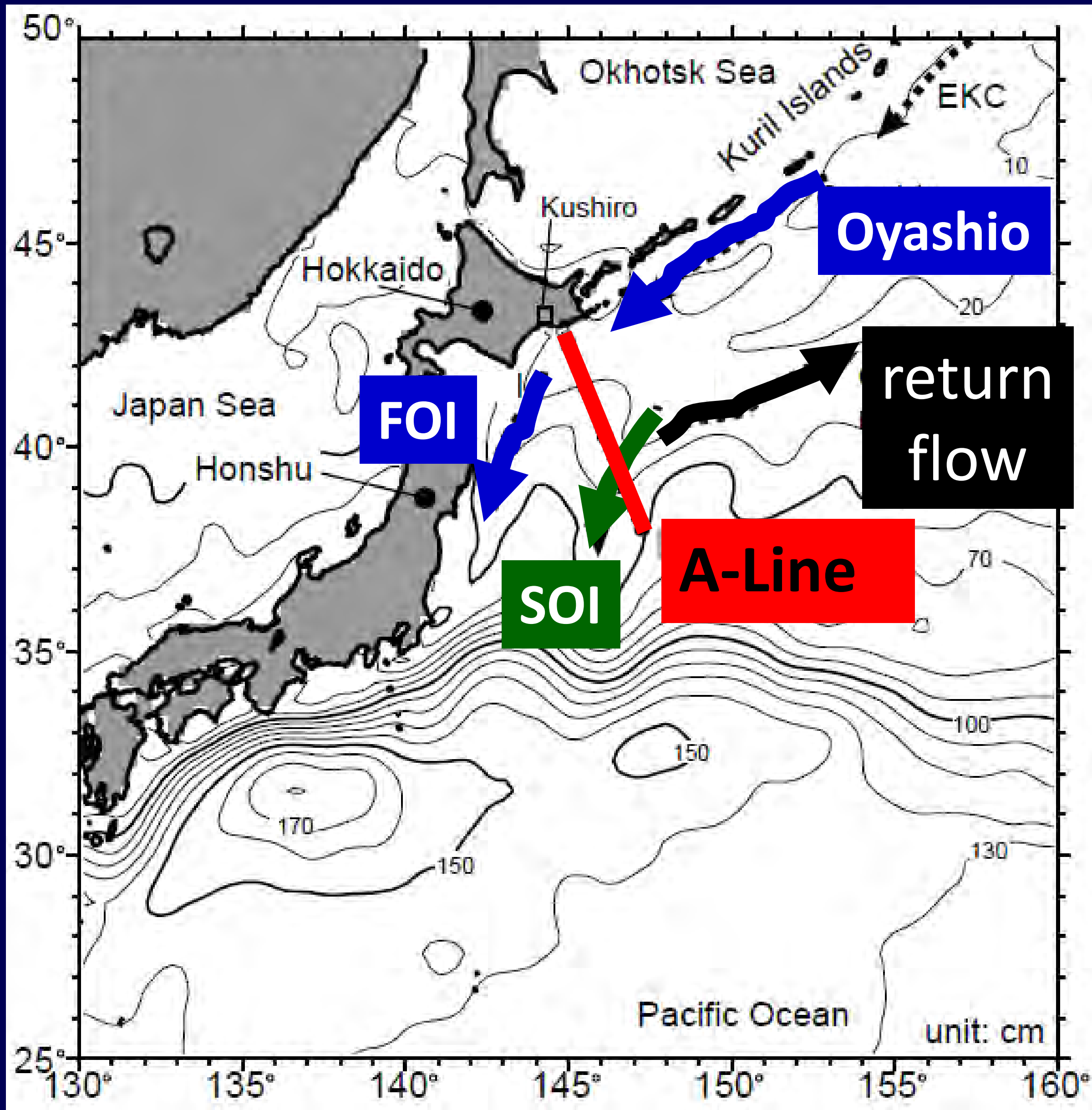
INTRODUCTION A-Line & Oyashio system

Oyashio system

(1) FOI
First Oyashio Intrusion

(2) SOI
Second Oyashio Intrusion

(3) Oyashio
Return flow



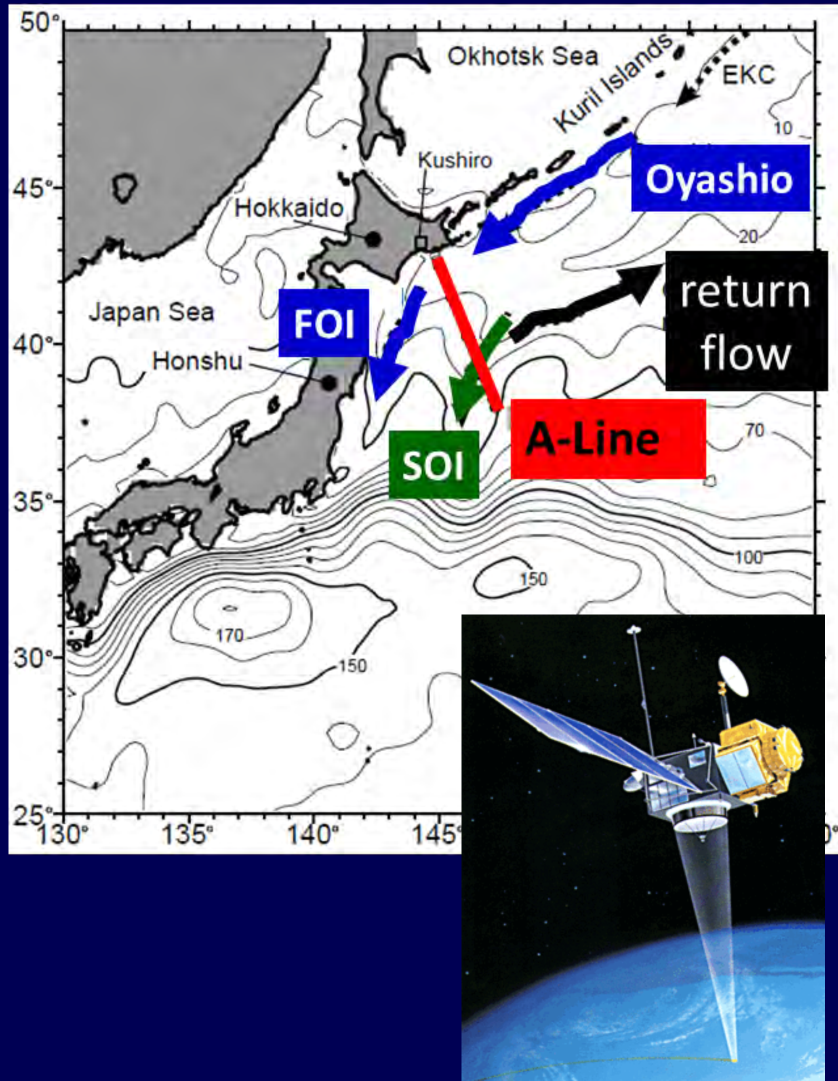
INTRODUCTION A-Line & Altimeter observations

A-Line monitoring

- since 1988
- about 5 times/year
- T, S, currents, Chla, Nutrients, Norpac, FCM, …etc

Altimeter (T/P, Jason-1,2)

- since 1992
- about 10 days/cycle
- High-quality SLA data



INTRODUCTION Purpose of this study

Using altimetry and A-Line monitoring data,

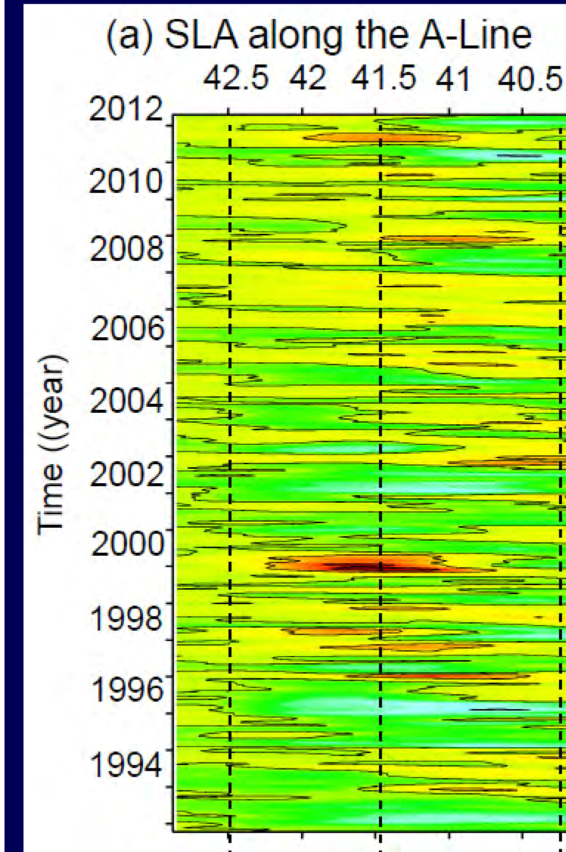
the purpose of this study is
to detect an interdecadal variation of the Oyashio
mainly by using linear trend analysis from 1993 to 2011,

and

to discuss possible causes of the interdecadal trend
by examining wind stress over the North Pacific.

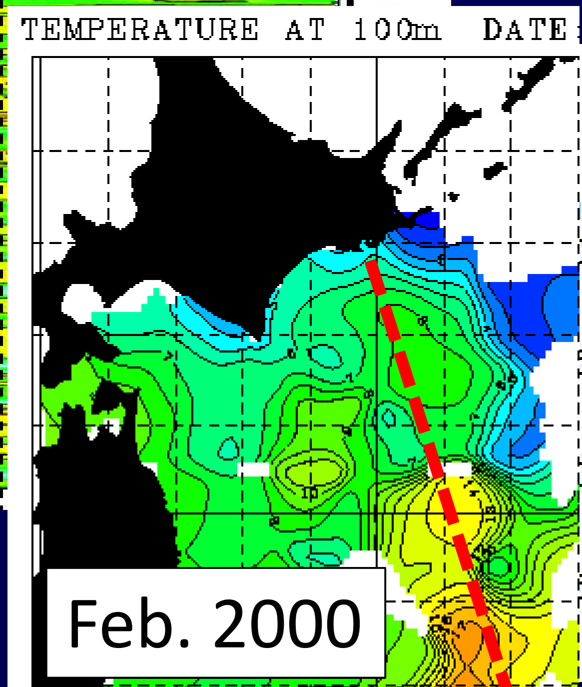
Properties of sea-level variations on the A-Line
（AVISO gridded SLA is interpolated onto the A-Line position）

SLA (Sea Level Anomaly) on the A-Line



Coast

Trench



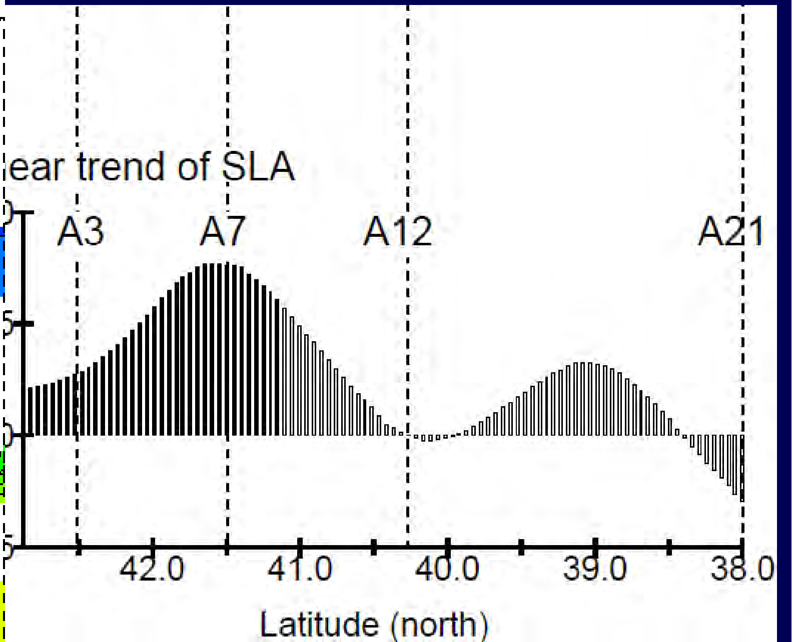
Linear trend estimated from annual mean SLAs

Black bar: significant (95% C.L.)

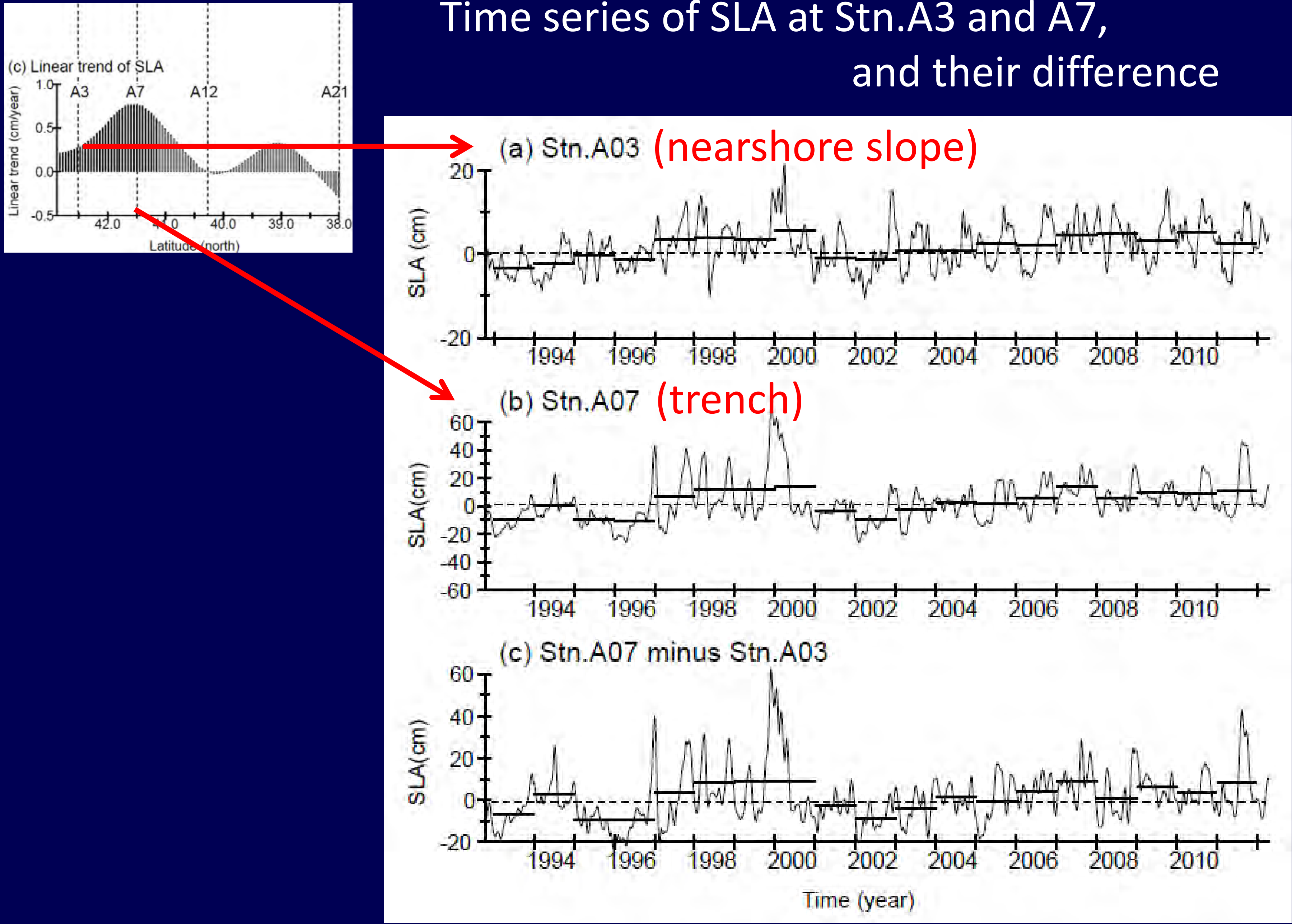
Trench

Coast

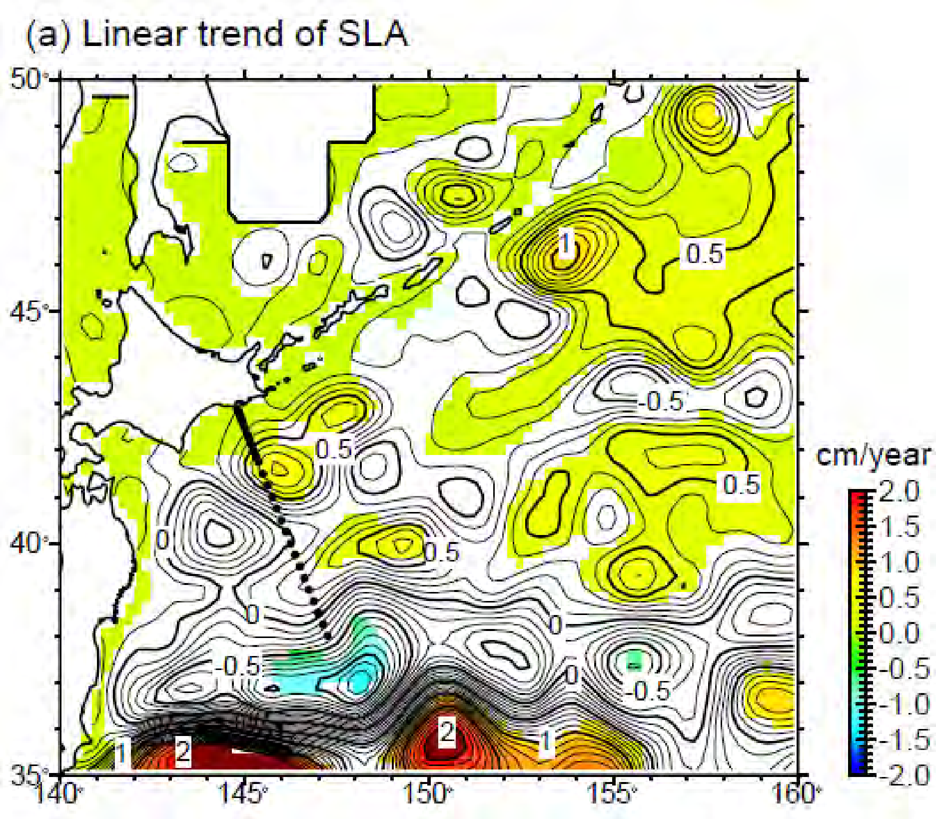
Offshore



Time series of SLA at Stn.A3 and A7, and their difference

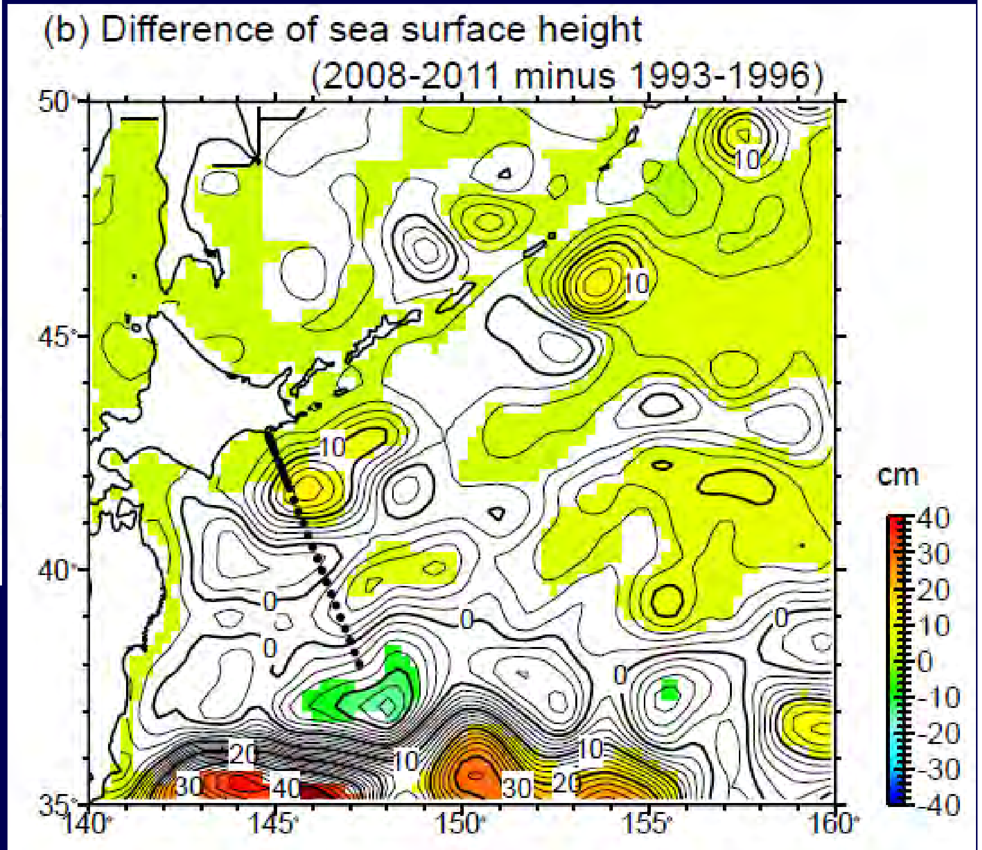


Linear trend based on annual mean SLA (Background color: significant values (95%C.L.))



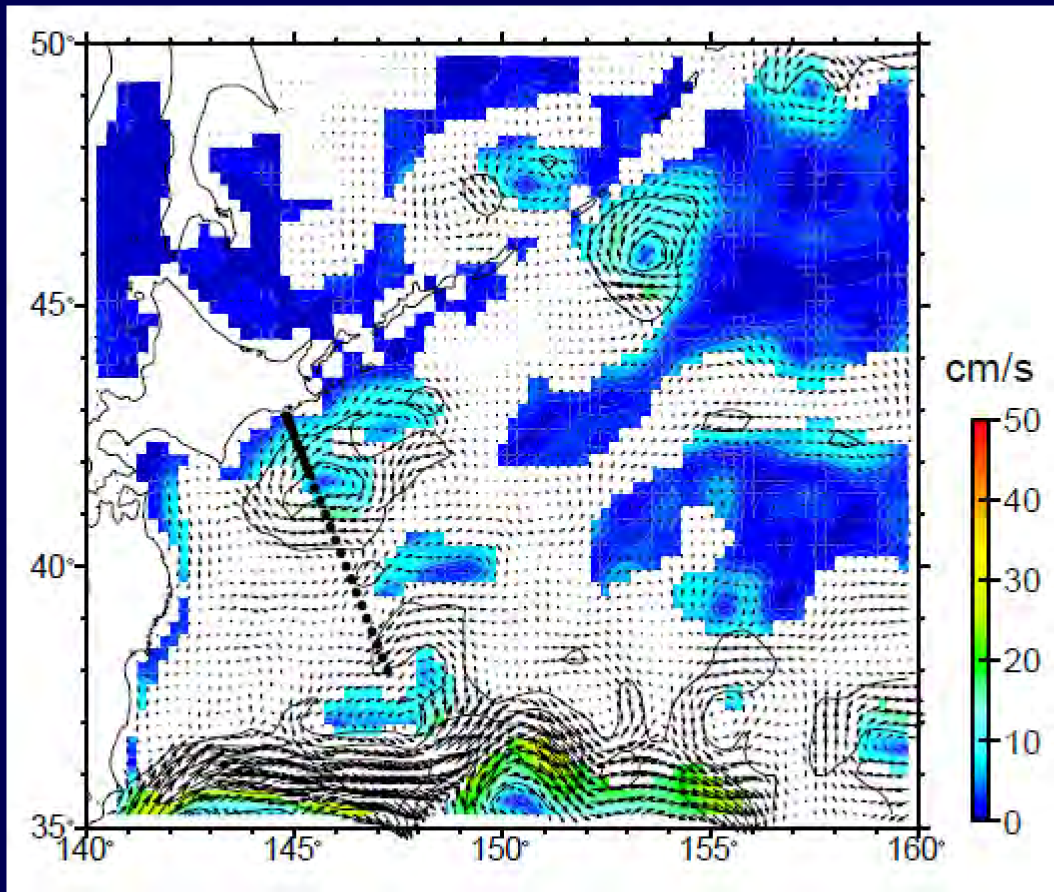
4-year mean difference of SLA (2008-2011) minus (1993-1996)

(Background color: same as left Fig.)



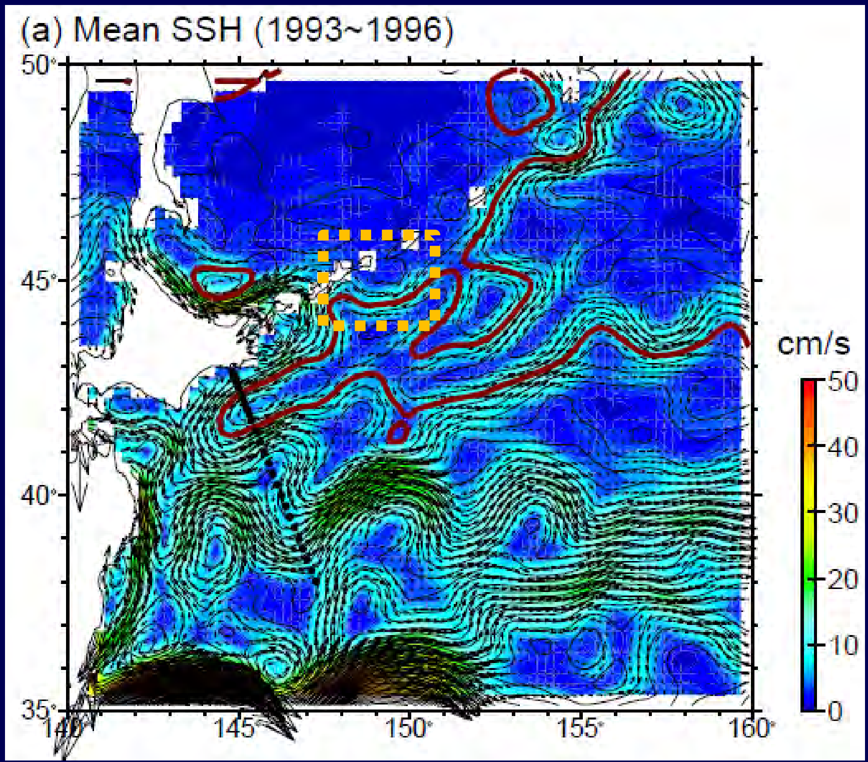
4-year mean difference of geostrophic velocity anomaly (2008-2011) minus (1993-1996)

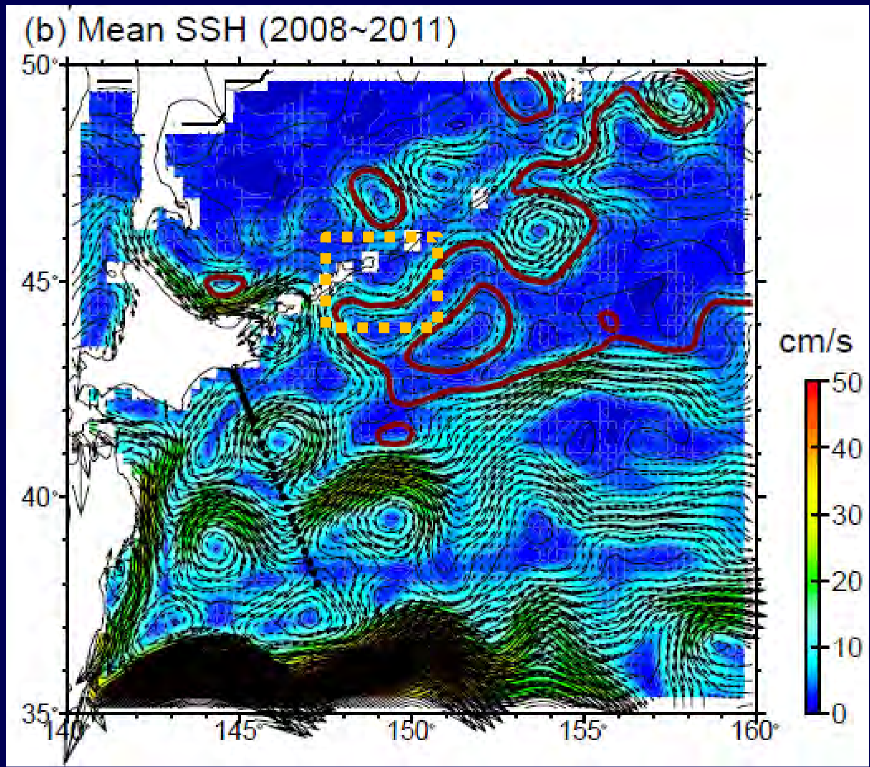
（Background color：
significant values of SLA trend (95%C.L.))



4-year mean (1993-1996)
absolute geostrophic velocity
at the sea surface

4-year mean (2008-2011)
absolute geostrophic velocity
at the sea surface



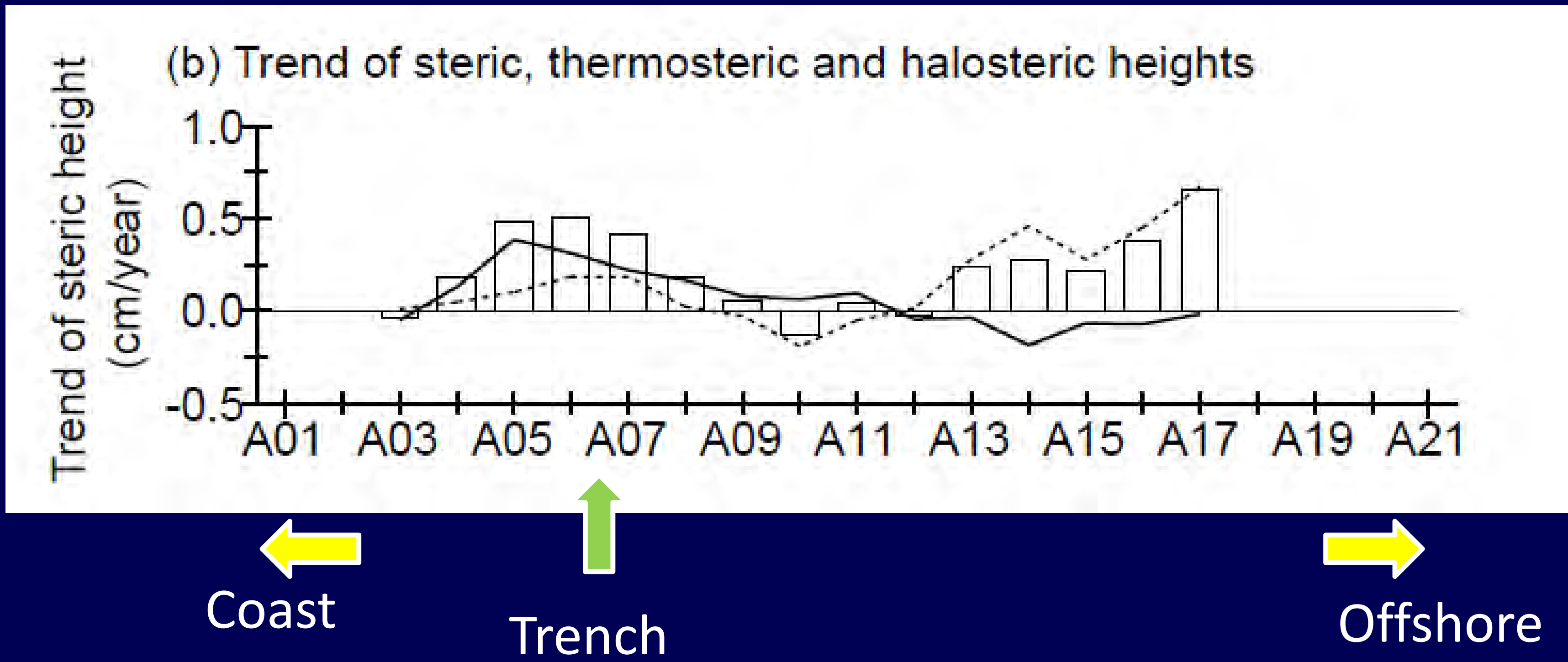


Estimation from AVISO MADT (Map of Absolute Dynamic Topography)

Thick red line corresponds to the Oyashio main stream position
: an Isoline of 4-year mean absolute dynamic topography
which is averaged along the Oyashio stream within the orange box

Linear trends on the A-Line of steric height (bar chart)
thermosteric height (dashed line)
halosteric height (solid line)

bottom or 3000-db reference level

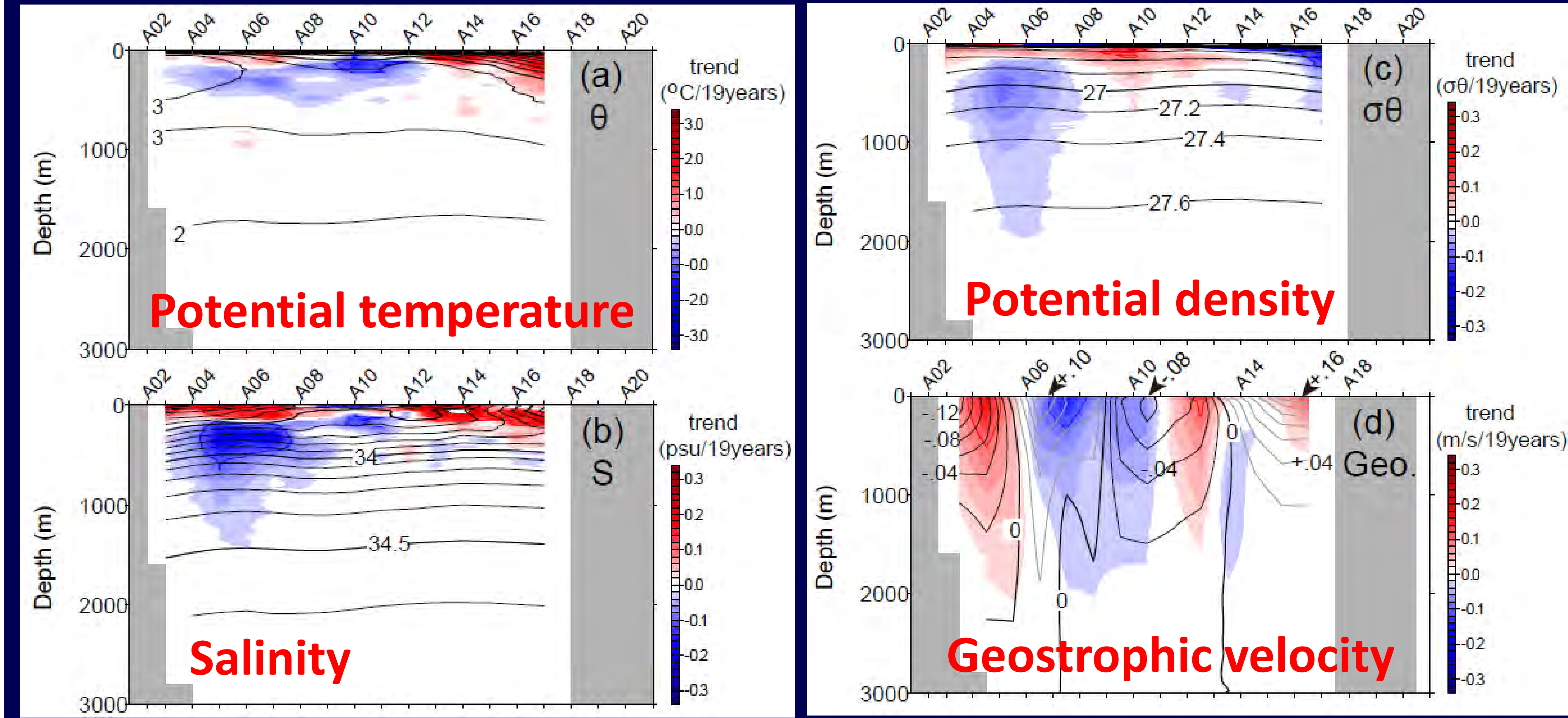


North of the trench,
50-80 % of steric-height trend ~ halosteric-height trend

ISO-DEPTH ANALYSIS

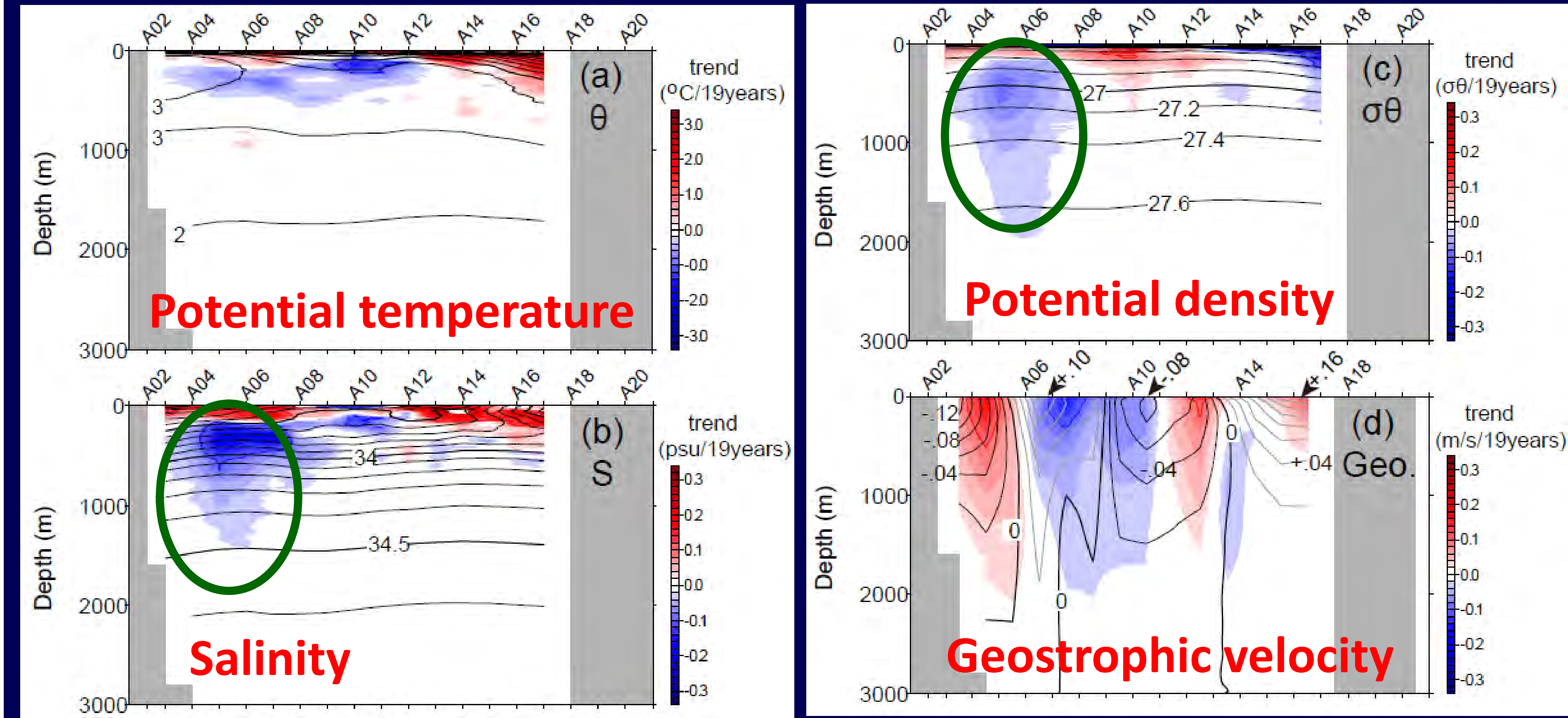
19-year [1993-2011] mean values (black contour)

Linear trends (background color: blue ~ red)



Decreasing trends of salinity and density near the trench

Decreasing trend of the Oyashio north of the trench (-8.9 Sv/19years)



QUESTION:

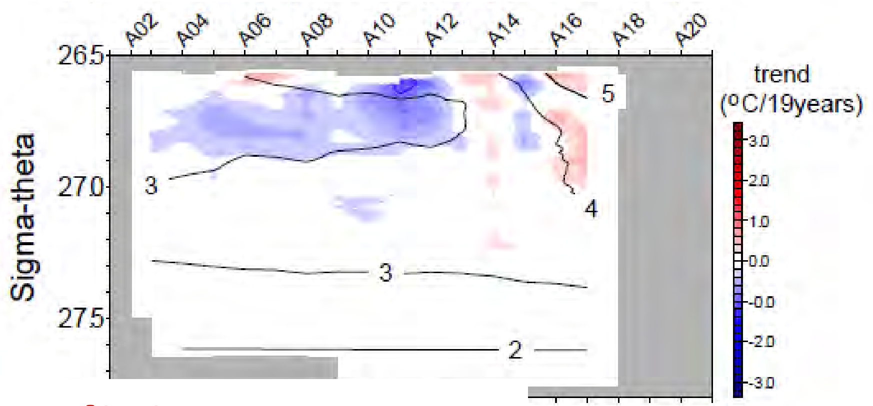
What does determine decreasing trends of salinity and density?

ISOPYCNAL ANALYSIS

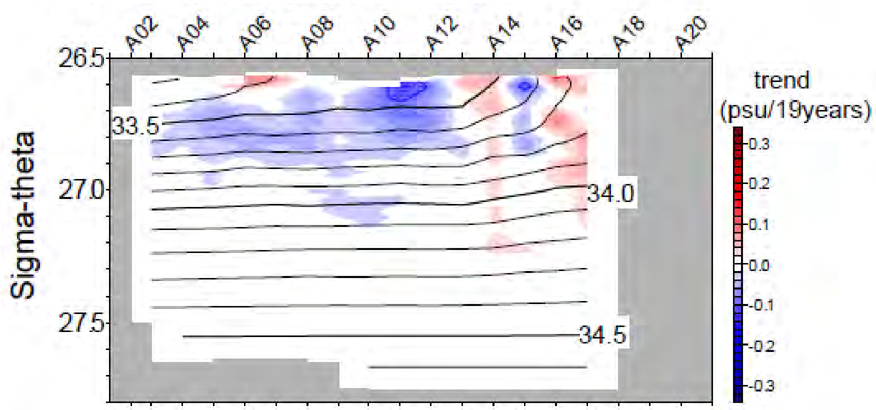
19-year [1993-2011] mean values (black contour)

Linear trends (background color: blue ~ red)

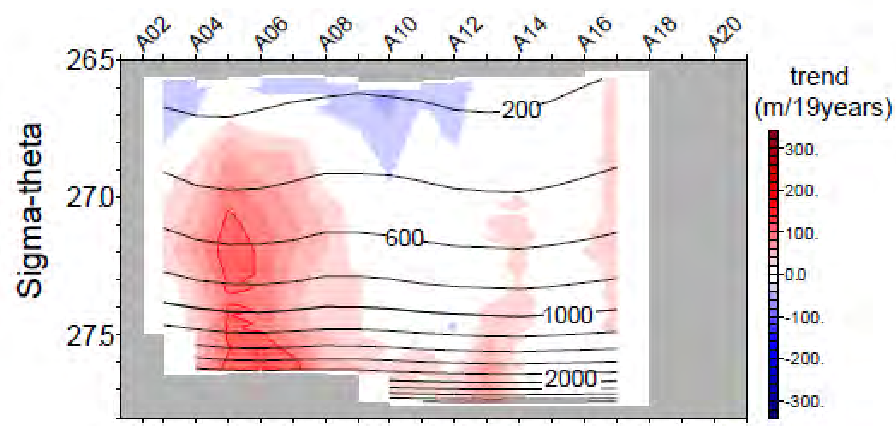
Potential temperature



Salinity

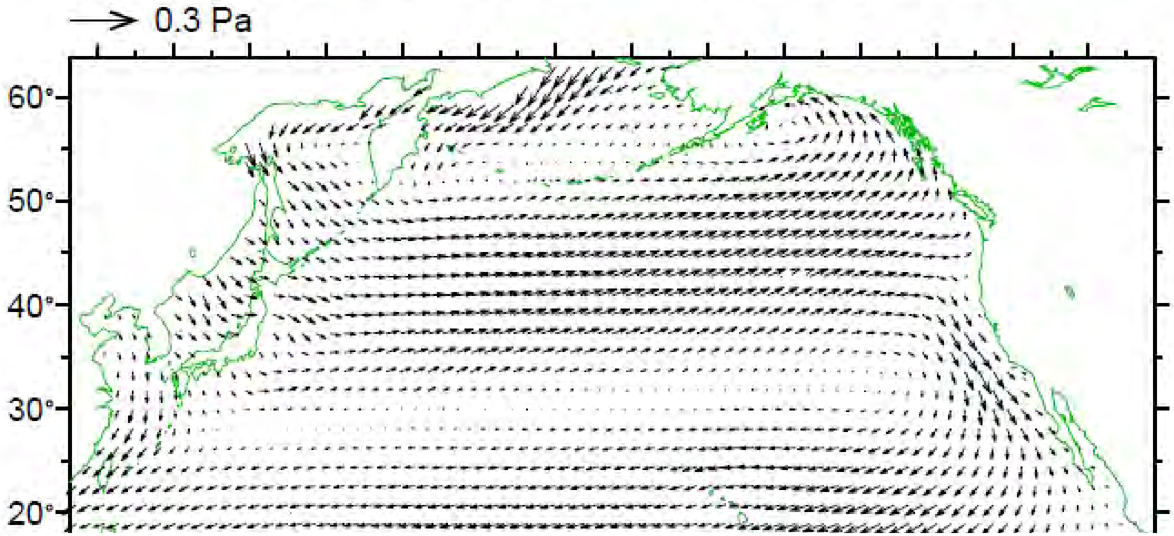


Depth of isopycnal surface

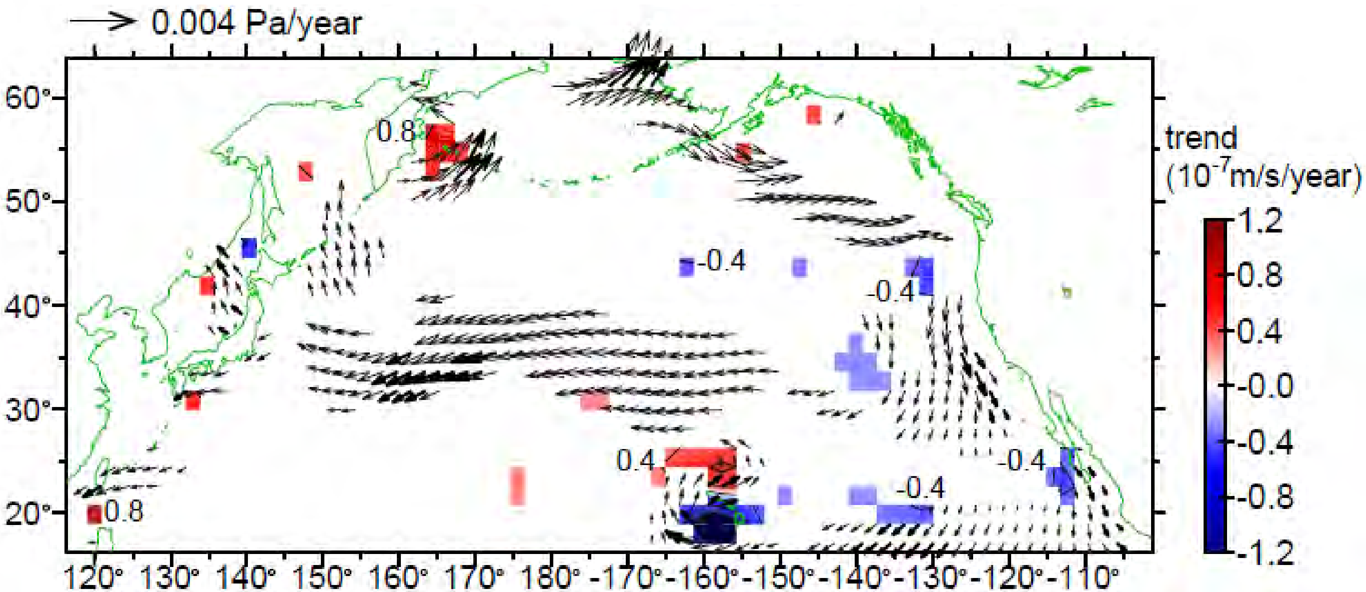


Increasing trends of isopycnal depth north of the trench

Wind stress averaged in 1993-2011 (vector)



Trend of wind stress (vector) and
Trend of divergence of Ekman transport (background color)

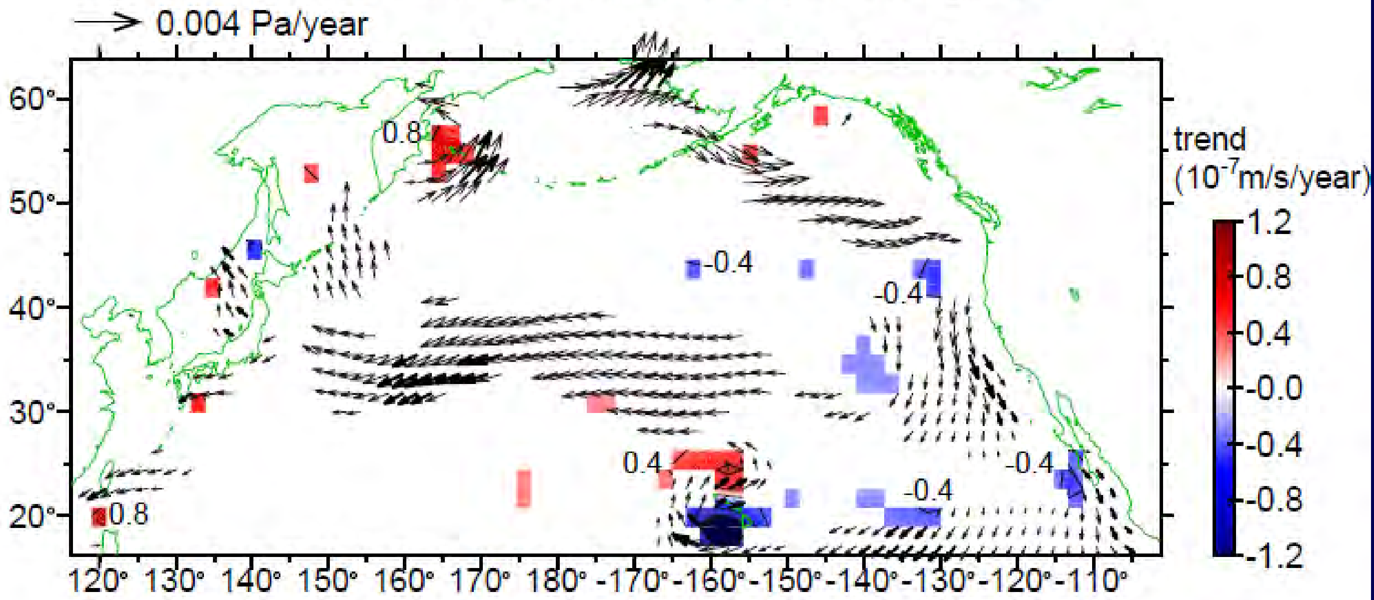


Analysis of wind stress data (NCEP/NCAR) in 1993-2011

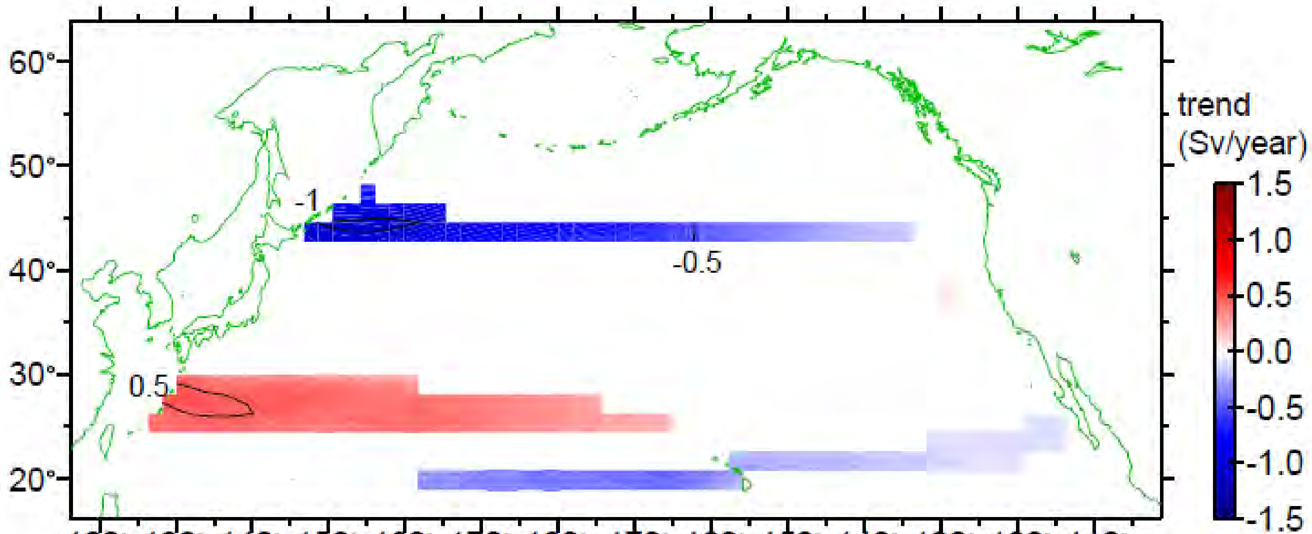
Trends are estimated from the annual mean time series (N=19)

Displayed trends are significant under the 95% C.L.

Trends of wind stress and divergence of Ekman transport



Trend of Sverdrup transport integrated from the eastern coast



Analysis of wind stress data (NCEP/NCAR) in 1993-2011

Trends are estimated from the annual mean time series (N=19)

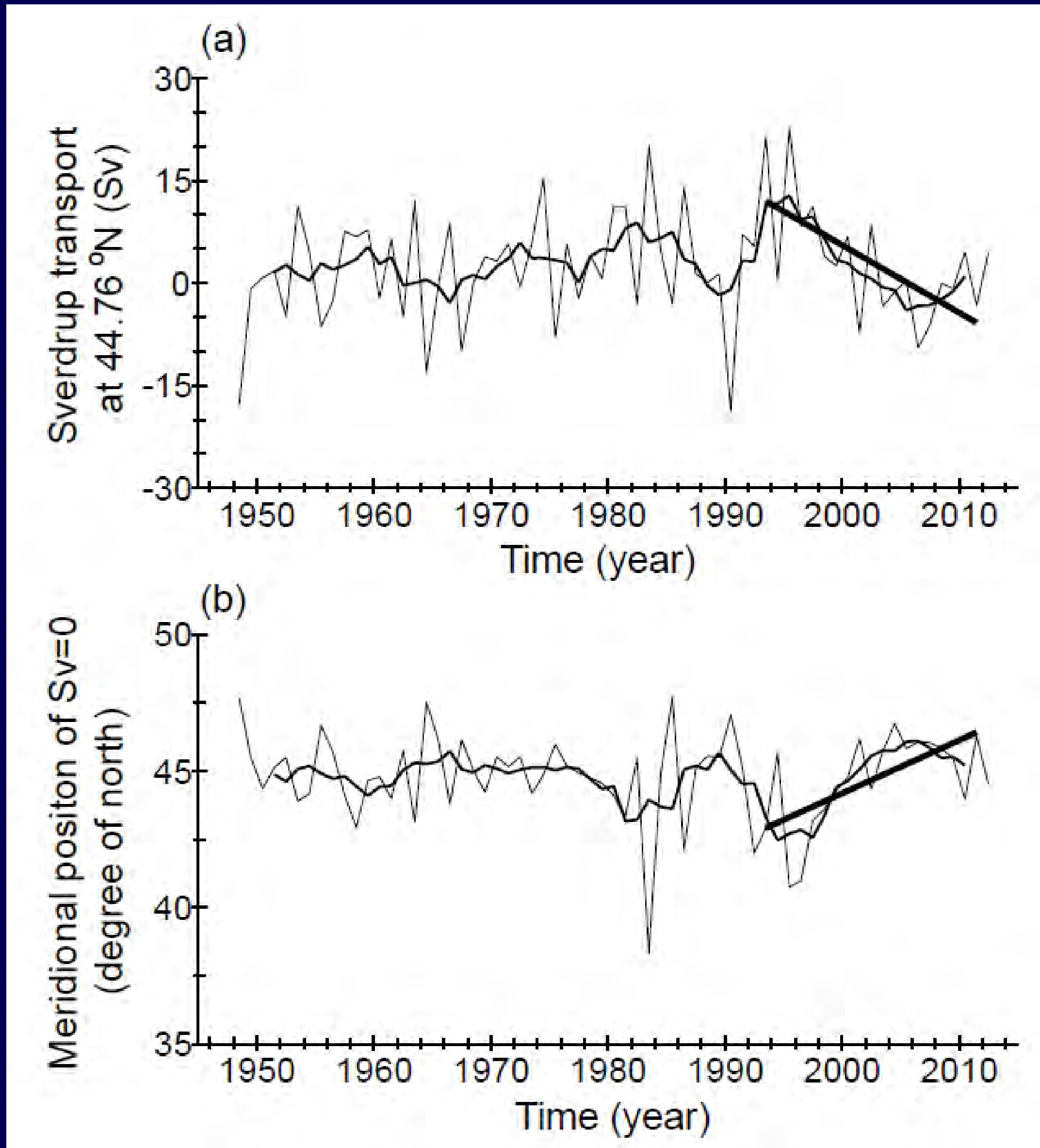
Displayed trends are significant under the 95% C.L.

-1 Sv /year = -19 Sv/19 years ~ about twice as large as BC Oyashio.

Analysis of wind stress based on NCEP/NCAR reanalysis from 1948 to 2011

Sverdrup transport
at the western coast
of 44.8° N
(annual mean time series)

Meridional position
of Sv=0 contour
(annual mean time series)

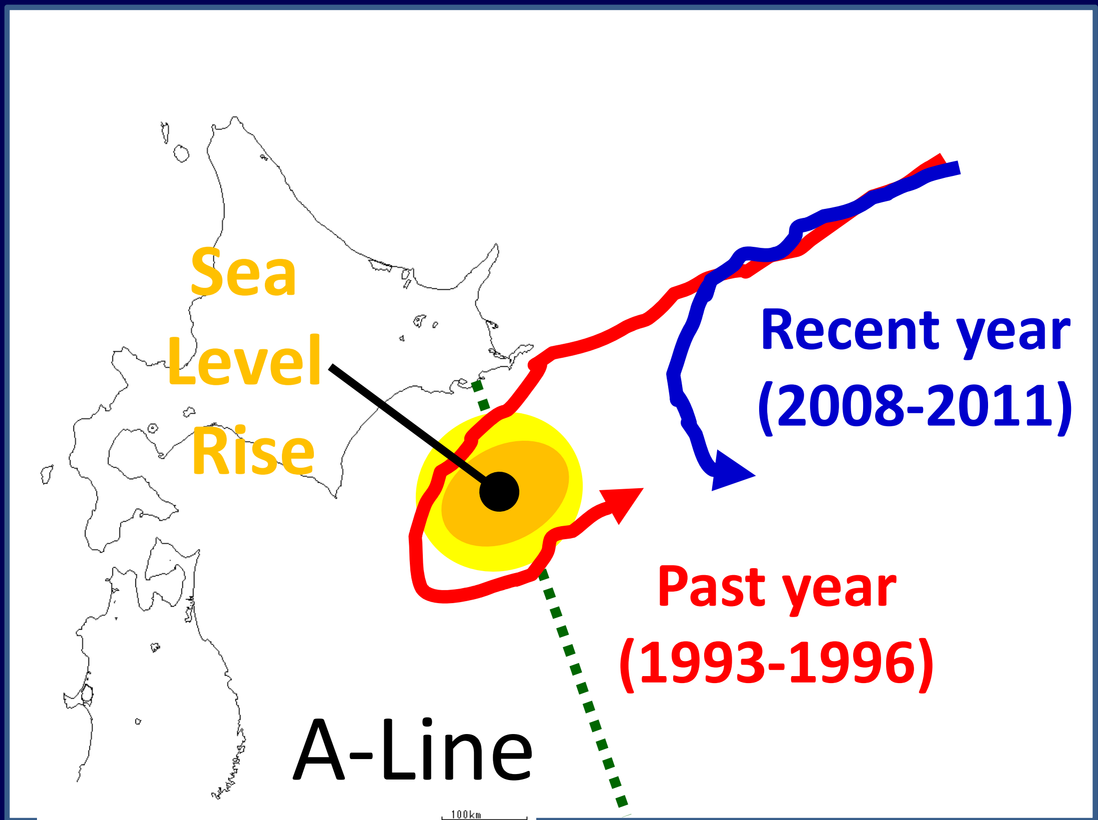


Conclusions

(1) From the altimetry data,
we detected sea level rise north of the Kuril-Kamchatka trench with the maximum near the trench (0.8cm/year)

➔Decreasing anomaly of the Oyashio and the offshore return flow

➔The Oyashio main stream seems to be changed from the nearshore path to the offshore path



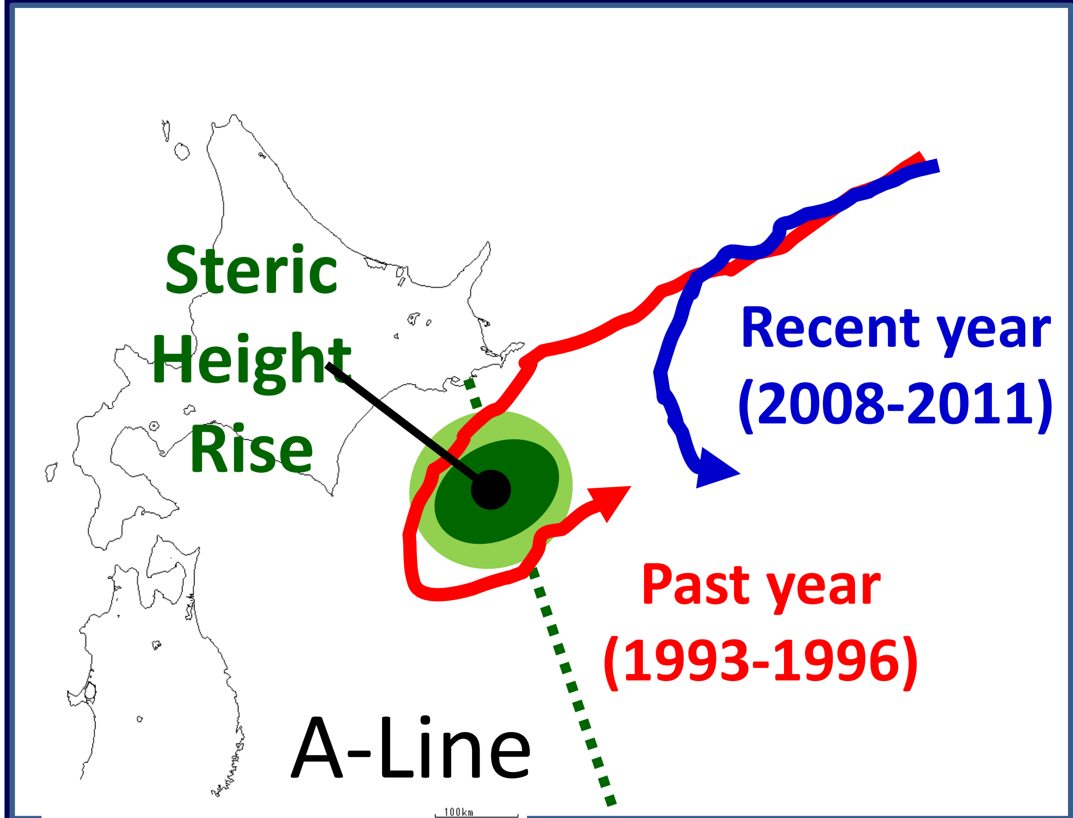
Conclusions

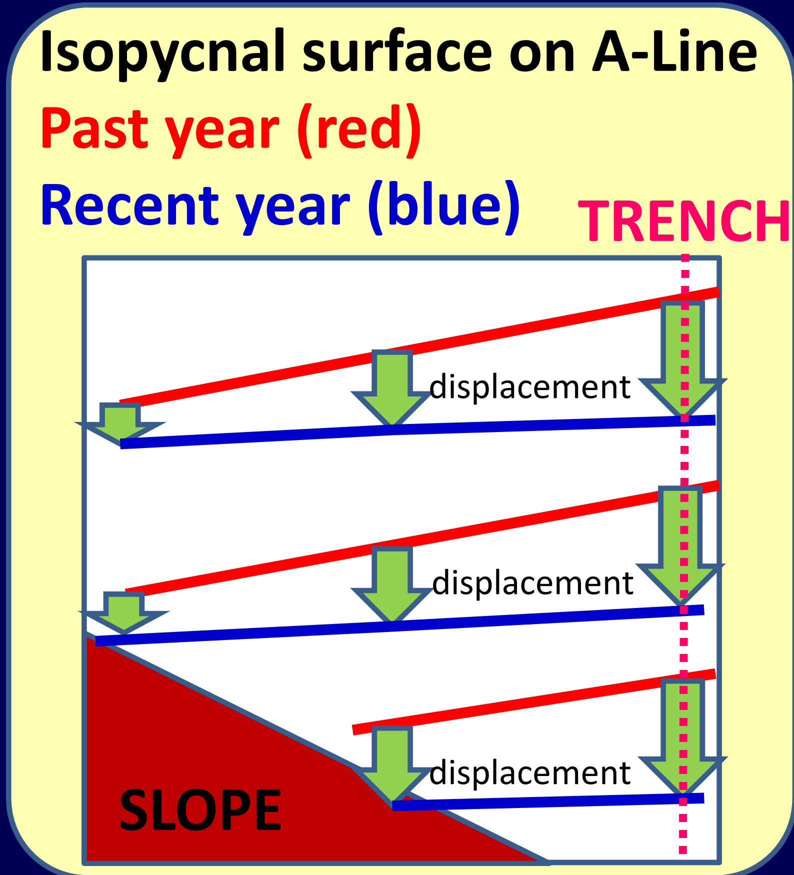
(2) From the A-Line data,

we detected increasing trend of steric height and decreasing trend of salinity/density in the subsurface north of the trench

→Downward displacement of isopycnal surfaces

→Decreasing of the BC Oyashio transport (-8.9 Sv/19years)





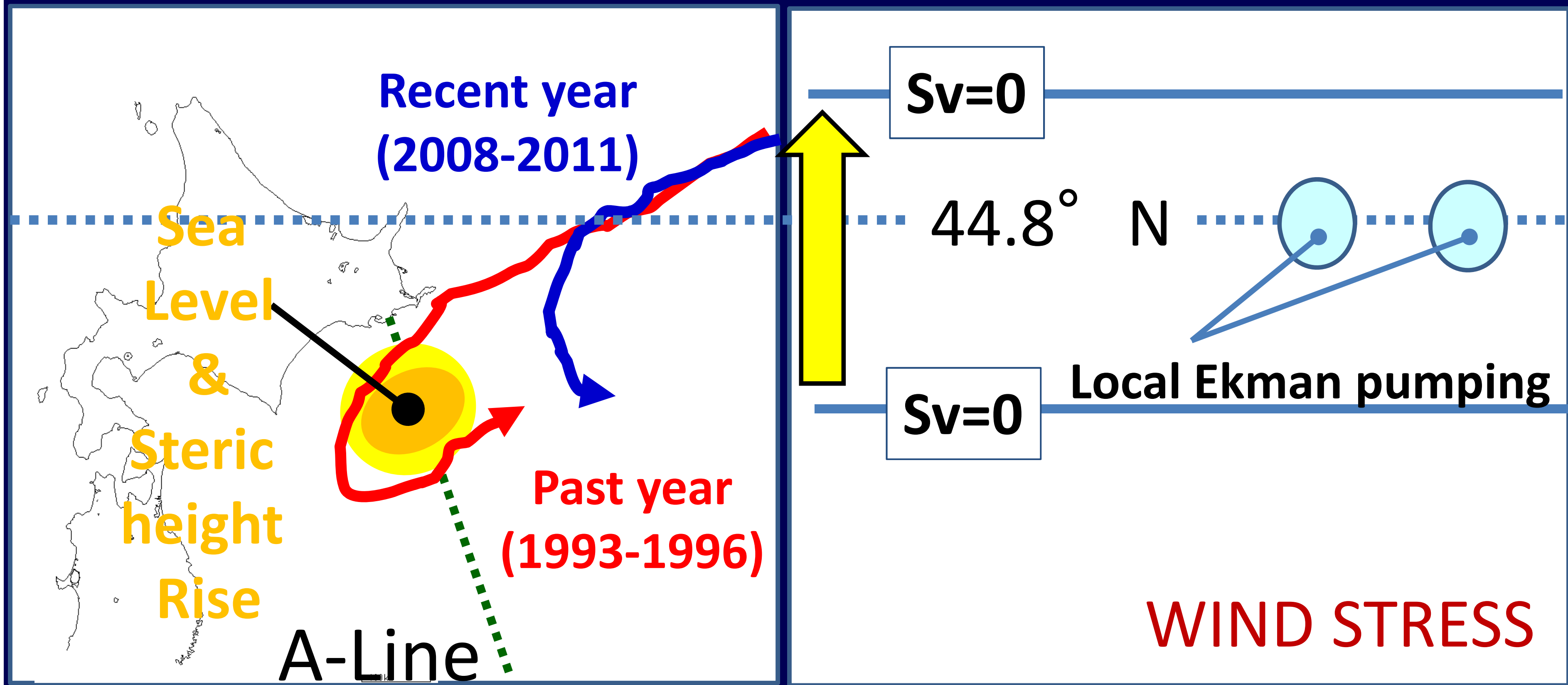
Conclusions

(3) From the wind stress data

we detected locally intensified trends of Ekman pumping for the eastern part of the North Pacific at 44.8° N

➔Decreasing trend of the Sv transport at the western coast

➔Northward shift of the wind-driven gyre boundary (Sv=0 line)




Thank for your attention!
Seascape from the A-line (3 Oct. 2013)