CUrrent dynamics Research Laboratory

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Heat Content Variations in the Southwestern East/Japan Sea

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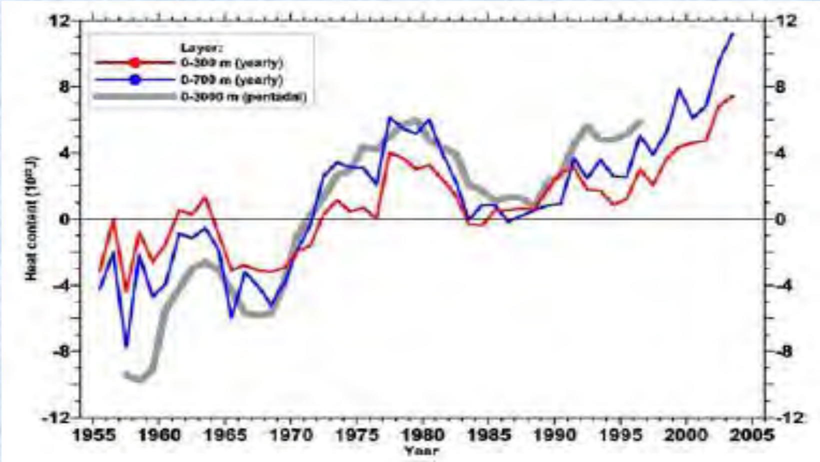
1. Introduction

★ WHY HEAT CONTENT??

The ocean heat content may be the dominant component of the variability of the Earth's heat balance.

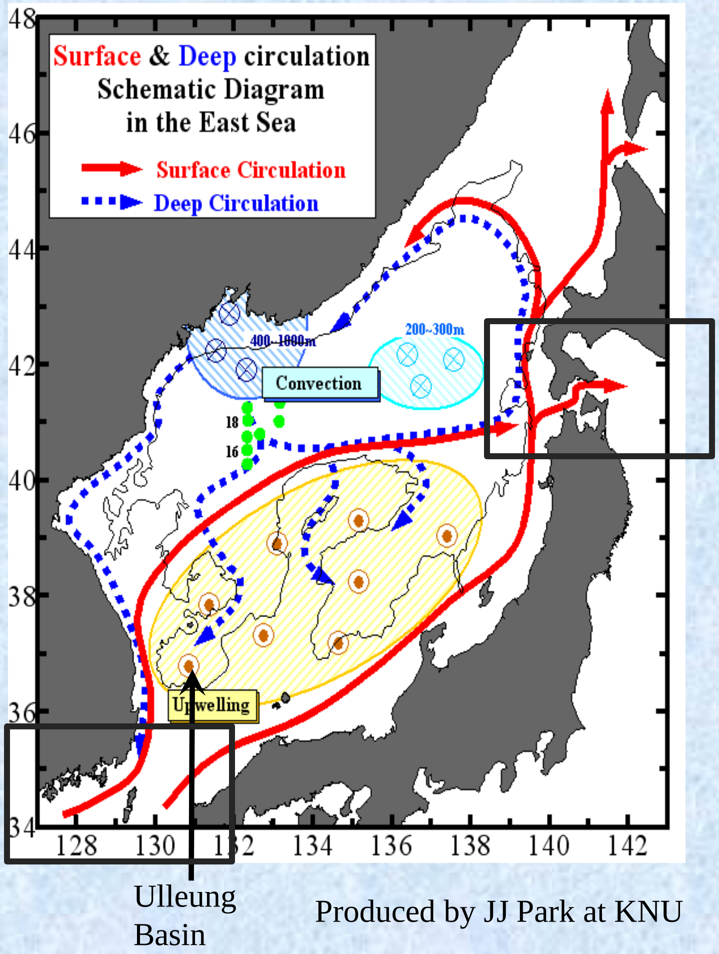


Levitus et al. (2005)

*** The heat content of the world ocean increased between mid 1950s and mid-2000s.**

★ THE EAST/JAPAN SEA(EJS)

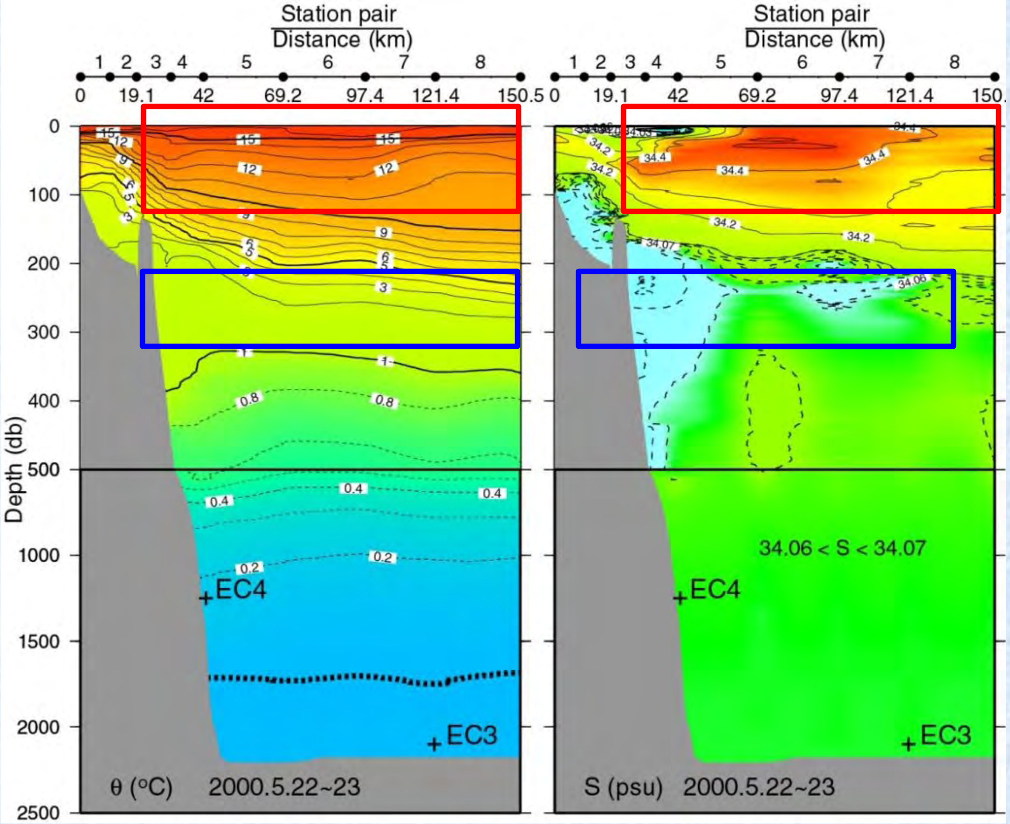
- Deep marginal sea in the northwestern Pacific (ave./max. depth ~ 1700/3500 m)
- 3 deep basins (JB, UB, YB)
- Upper layer inflow-outflow system of the Tsushima Current, warm & thin (<200m) upper circulation south of the SPF over a thick cold water layer (over 90% in its volume, θ<1.0°C)
- Thermohaline circulation: deep water formation and southward discharge
- Rapid ventilation timescale ~ 100 years
- Other features: subduction, mesoscale eddies, high productivity (273.0 gC/m2/yr, Kwak et al., 2013)



Produced by JJ Park at KNU

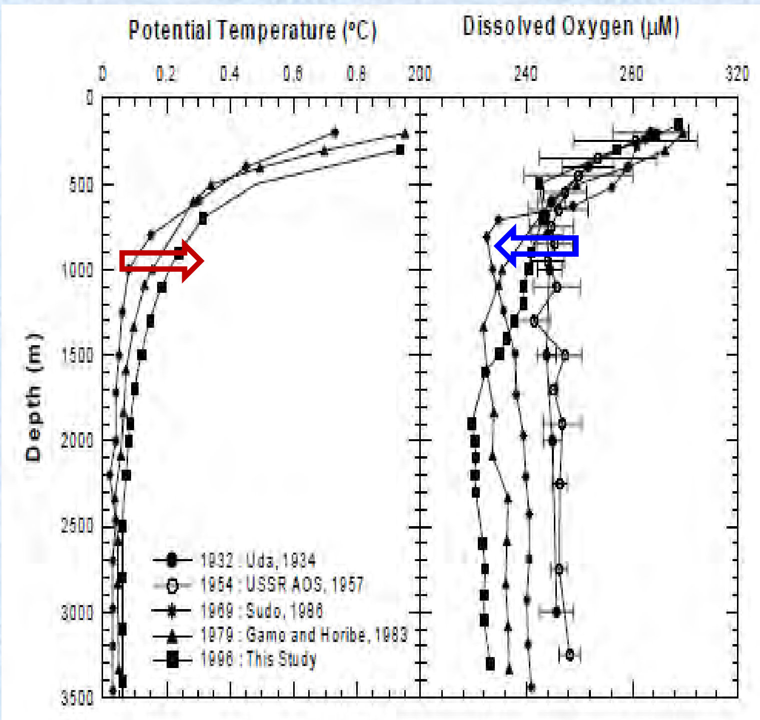
★ WATER MASSES IN THE UB

- Tsushima Warm Water: high T, high S, low DO (major surface inflow)
- In summer it is capped by thin fresh layer.
- East Sea Intermediate Water: low θ (1~5°)), salinity min. layer, DO max. layer brought into the UB from the JB. Carried by the coastal boundary current or subductiuon along subpolar front
- Proper Water (θ < 1.0°C)



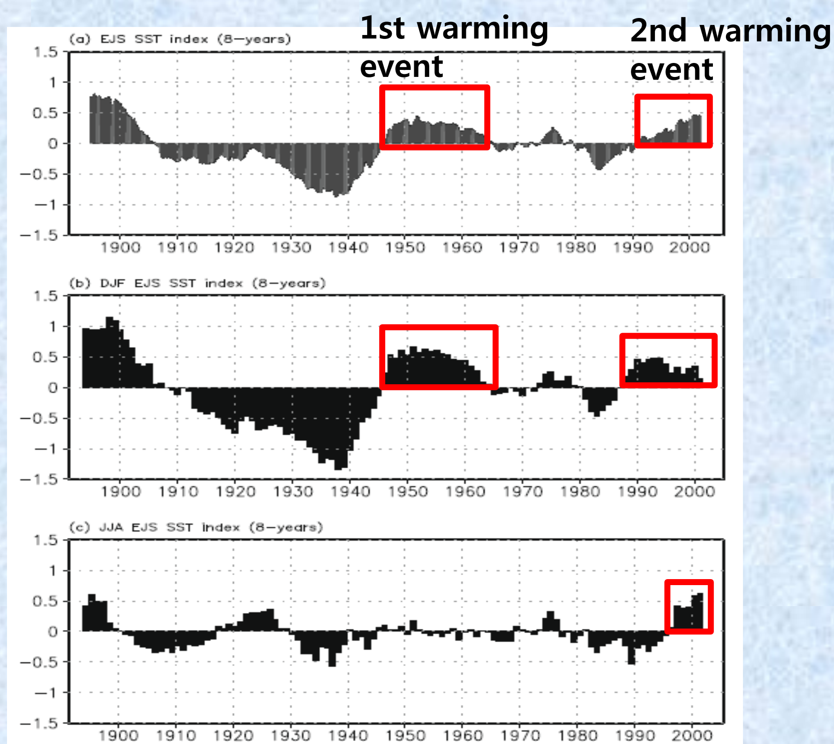
★ TEMPERATURE VARIATION IN THE EJS

Kim et al. (2001)



* **Warming trend in the below 500m during the last more than 40 years.**

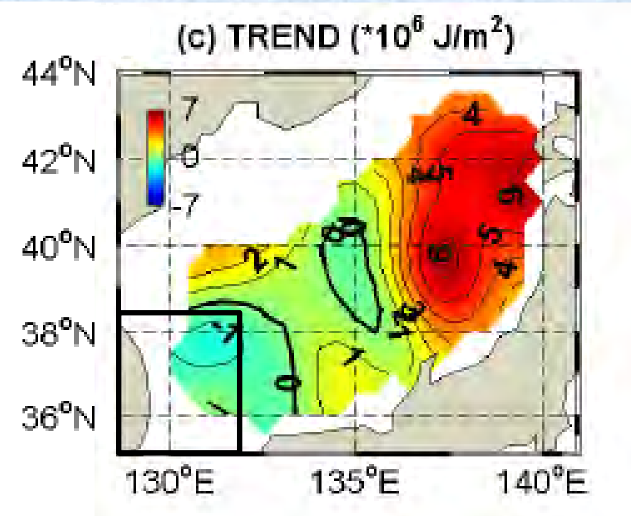
Yeh et al. (2010)



* **Warming trend of SST in the EJS is unclear(decadal variation).**

Na et al. (2011)

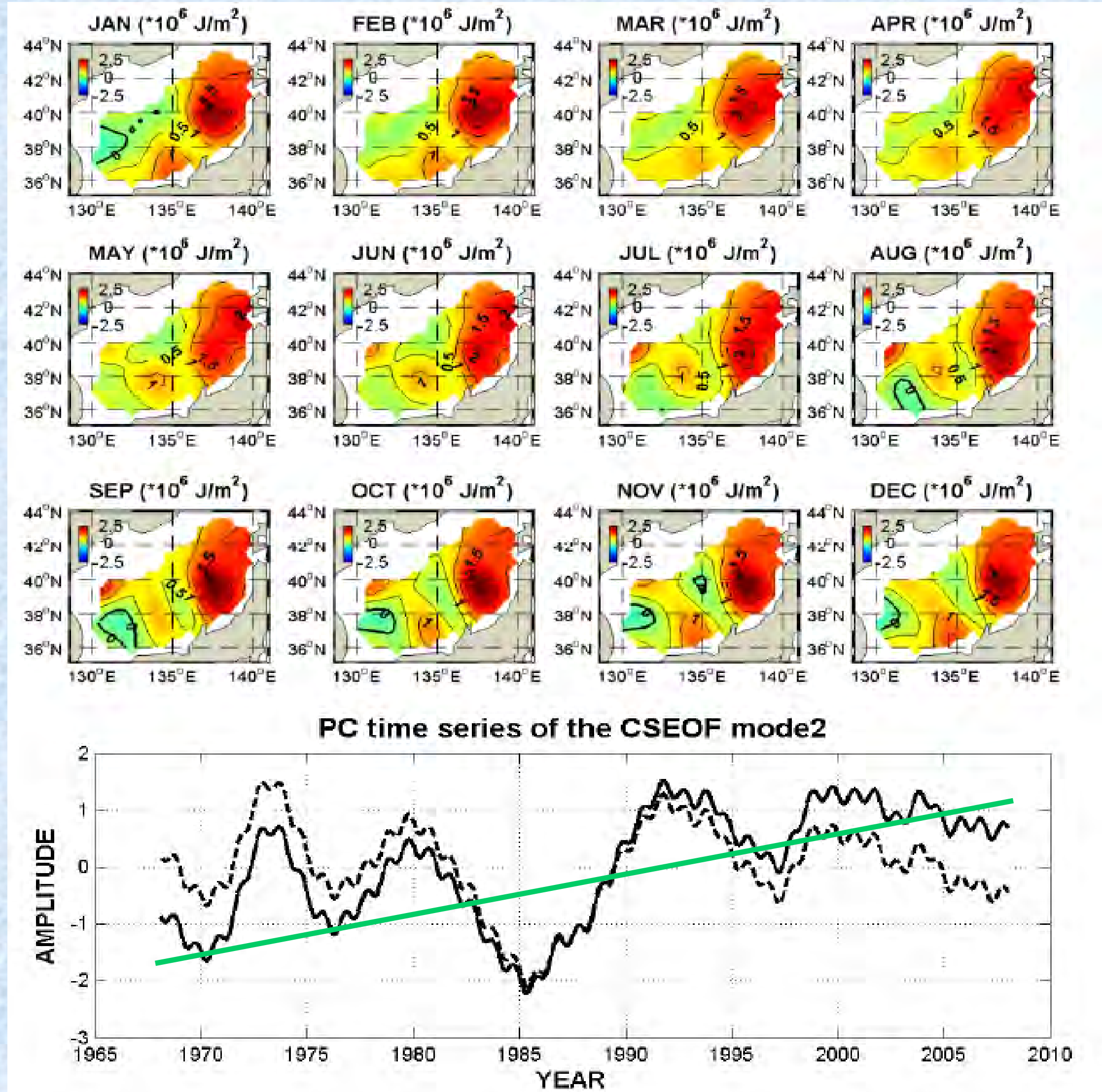
Variability of the upper-ocean heat content in the EJS.



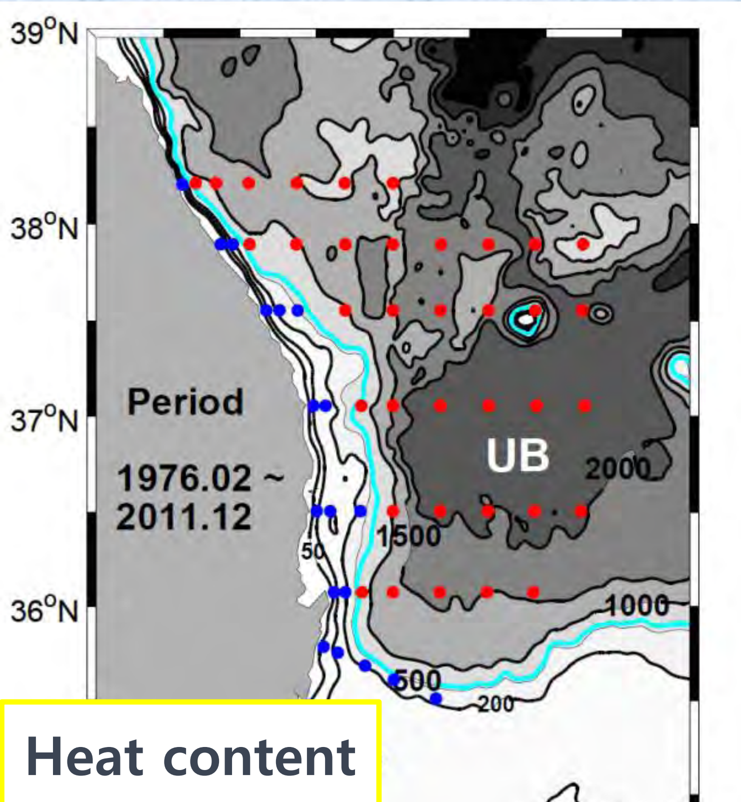
Lozier et al. (2008)

Basin-averaged changes can mask important spatial differences.

* Non-seasonal decadal variation

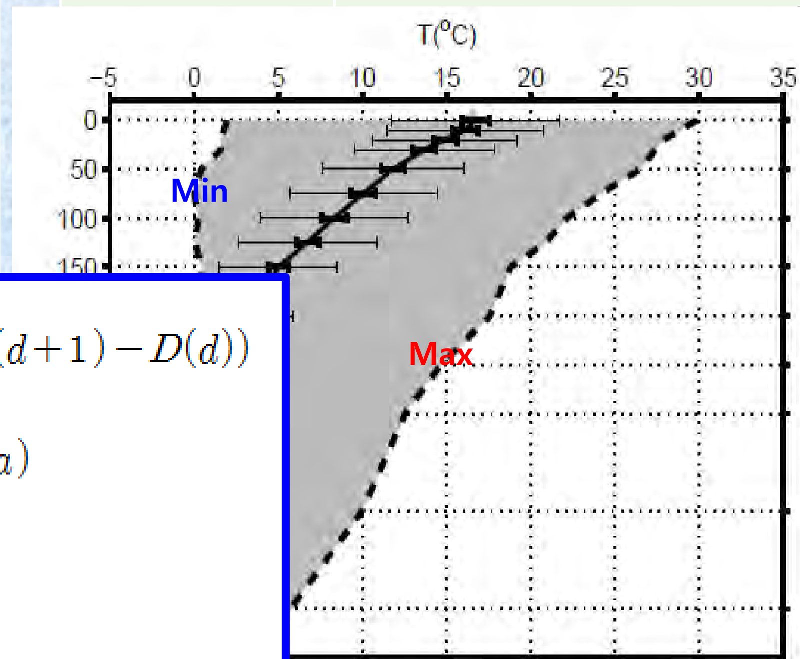


2. Data and Method



★ **Temperature data from KODC/NFRDI**

Data properties	
# of stations	36(deeper than 500m(red)) 22(shallower than 500m(blue))
Time interval	Bimonthly(2,4,6,8,10,12)
Depth	Standard depth(m)
	… below 0℃. …natology.



◀ Spatially and temporally averaged temperature profile.

Heat content

$$Q(x,y,z,t) = \sum_d \rho C\left(\frac{T(d)+T(d+1)}{2}\right)(D(d+1)-D(d))$$

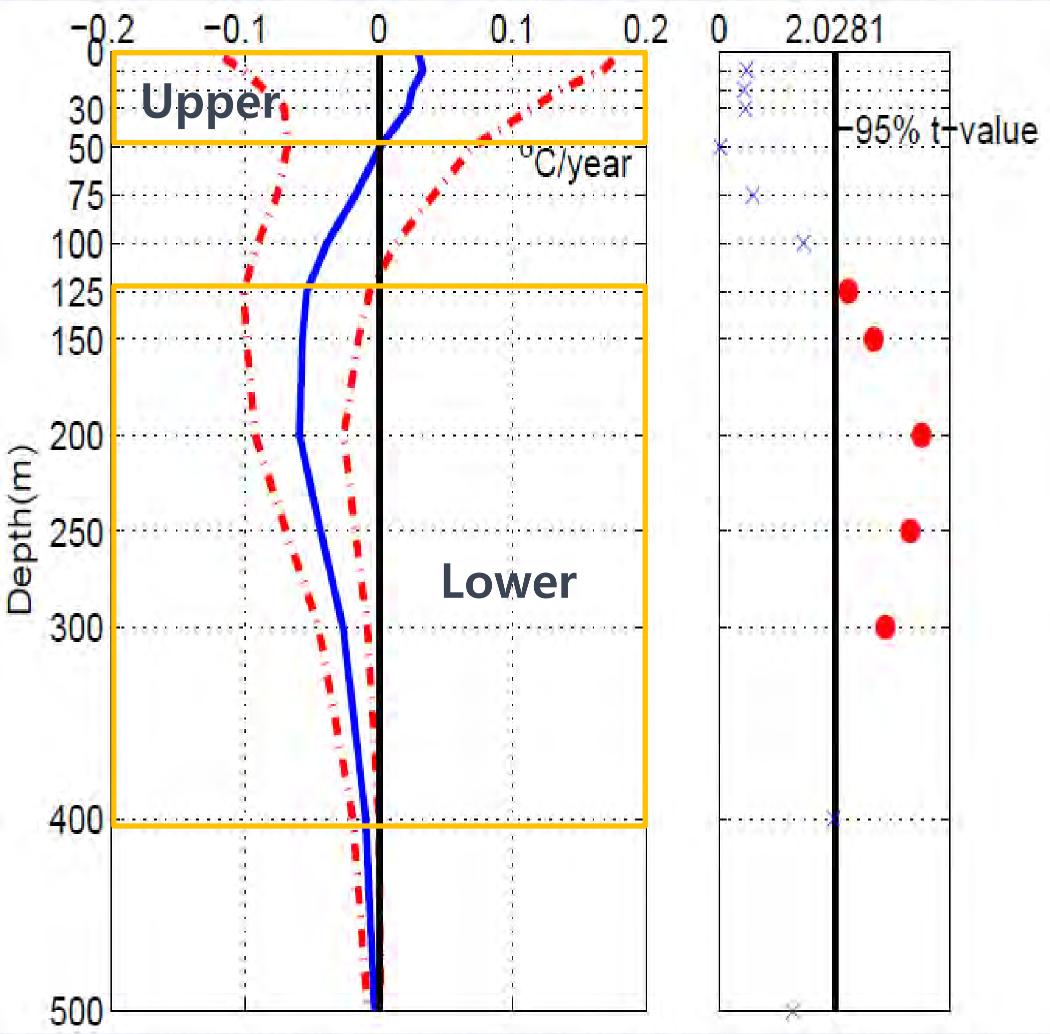
HCA $= Q(x,y,z,t) - Q(x,y,z,clima)$

$C = 4\times10^3 J/(℃\,kg)$

$\rho = 1025 kg/m^3$

3. Results

1) Basin-averaged temperature trend profile

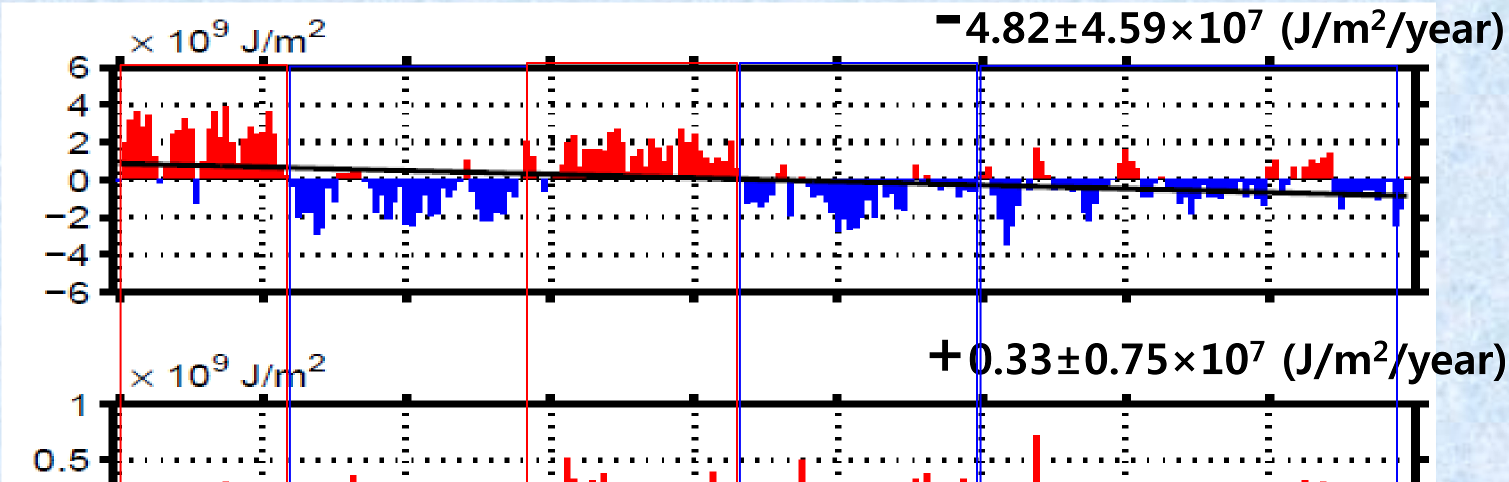


◀ Basin-averaged temperature trend profile and the results of T-test(95%).

*** Surface~50m temperature has an warming trend but it is not significant.**

*** 125~300m temperature has a significant cooling trend.**

2) Basin-averaged HCA time series



Total 0~ 500m

Upper 0~ 50m

Low 100 400

r)

To find out causes of UHCA and LHCA variations,

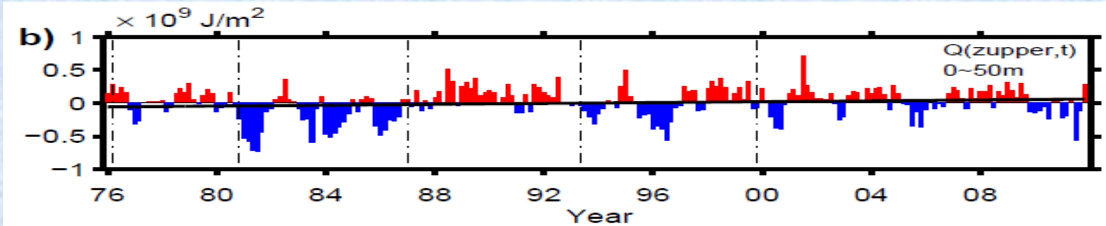
1) Horizontal distributions of $\mathbf{T_a}$ in each period.

2) Vertical profiles of $\mathbf{T_a}$ in each period.

※ T_a = mean T over the each period
– mean T over the entire period

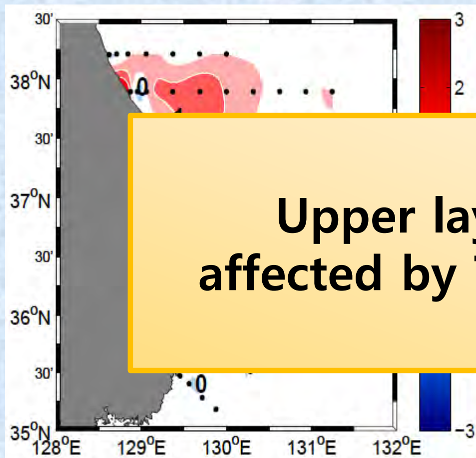
3) Horizontal distributions of T_a

Results

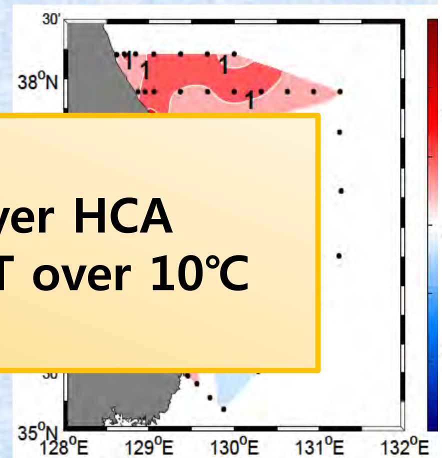


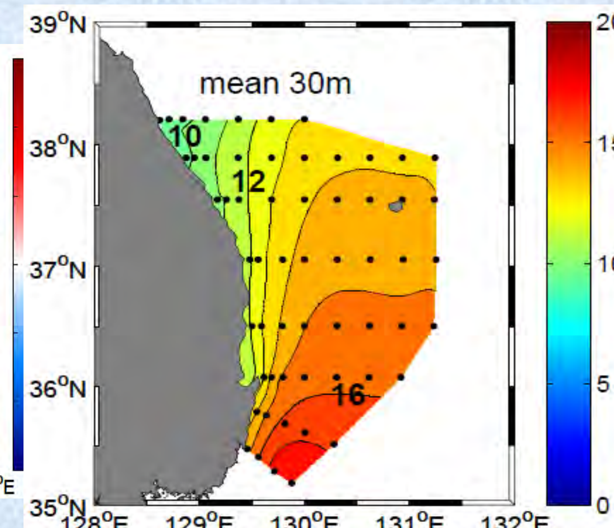
*** 30m**

W1 T_a



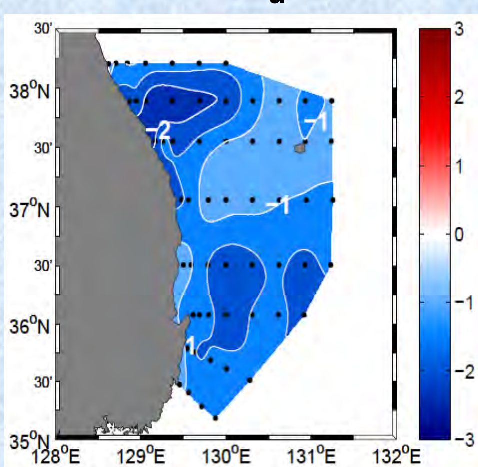
W2 T_a



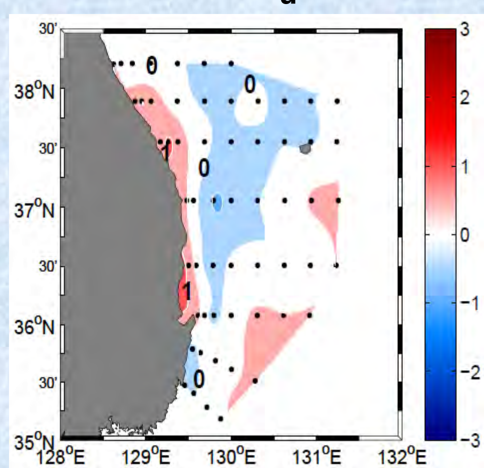


Upper layer HCA affected by T over 10℃

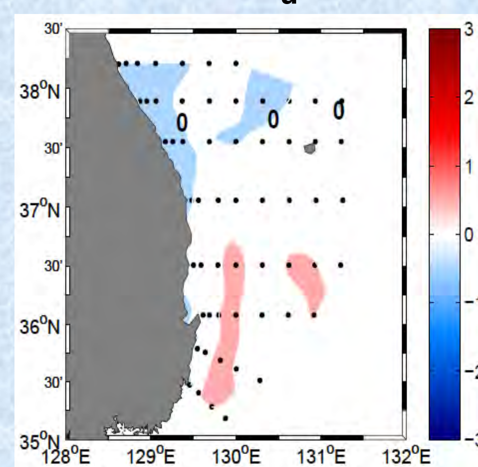
C1 T_a



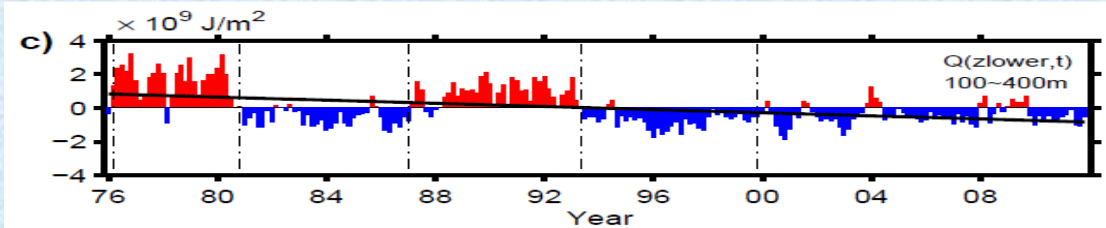
C2 T_a



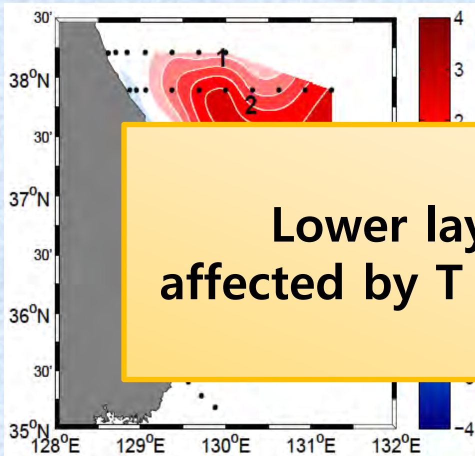
C3 T_a



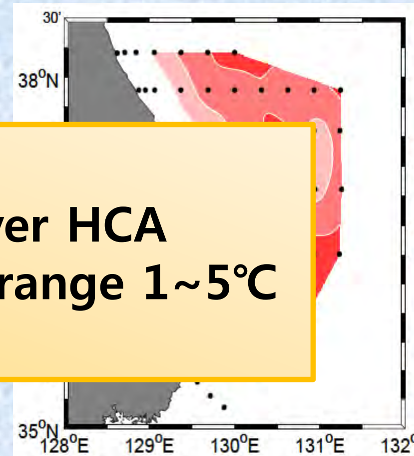
* 200m



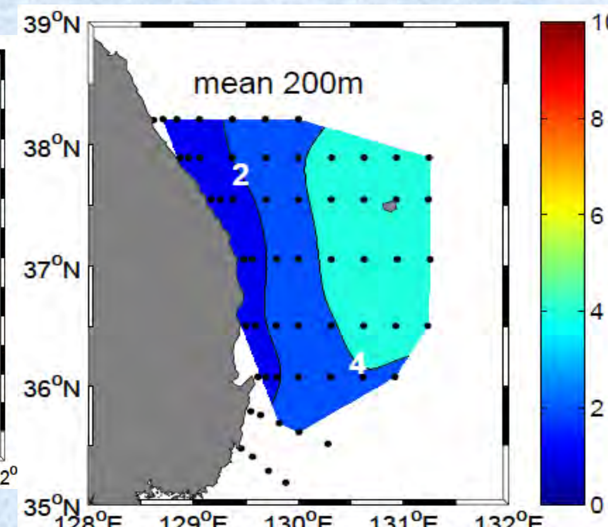
W1 T_a



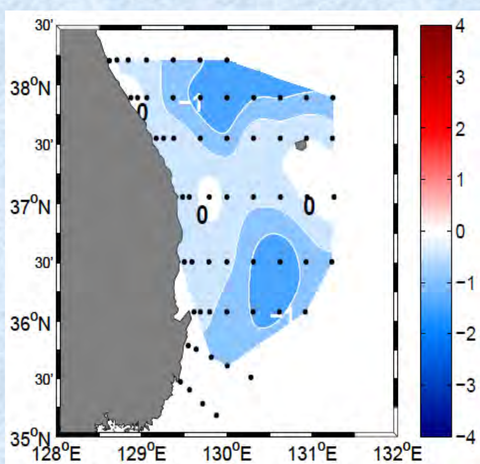
W2 T_a



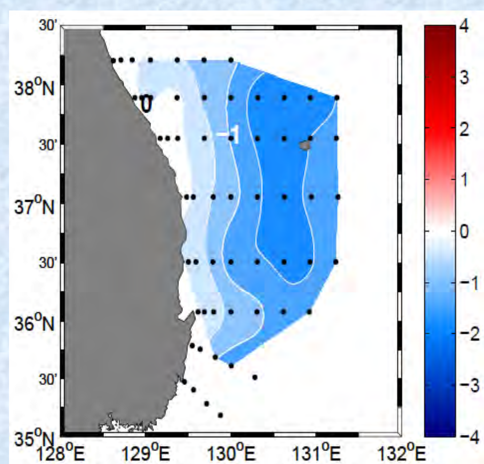
Lower layer HCA affected by T range 1~5℃



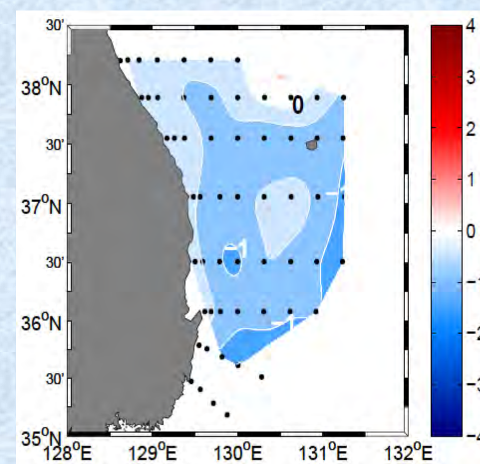
C1 T_a



C2 T_a

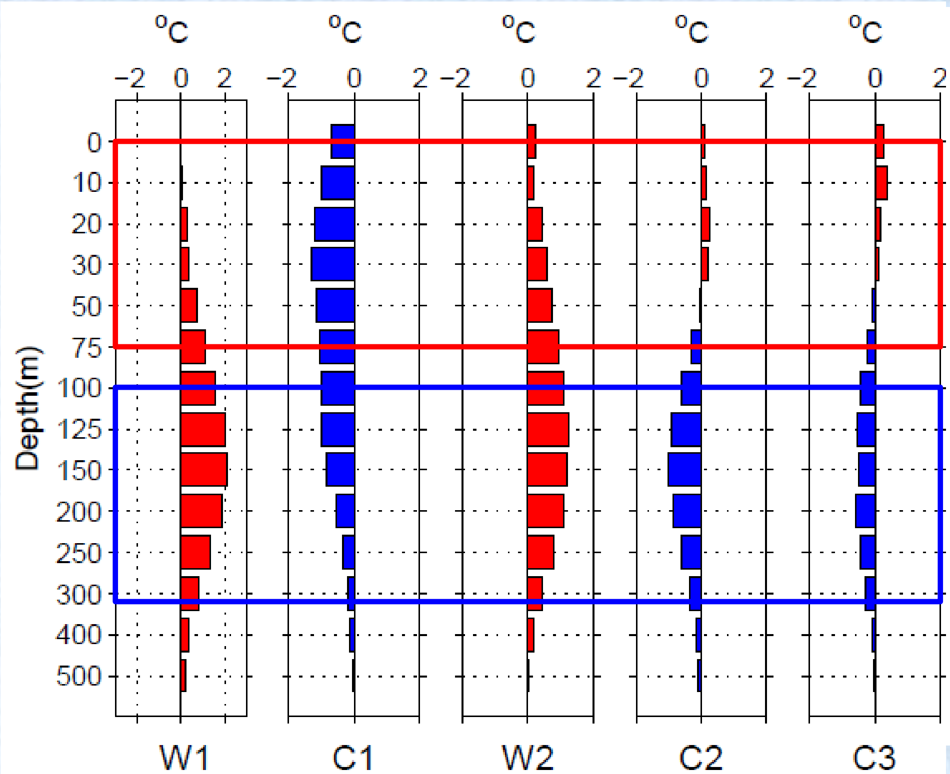


C3 T_a

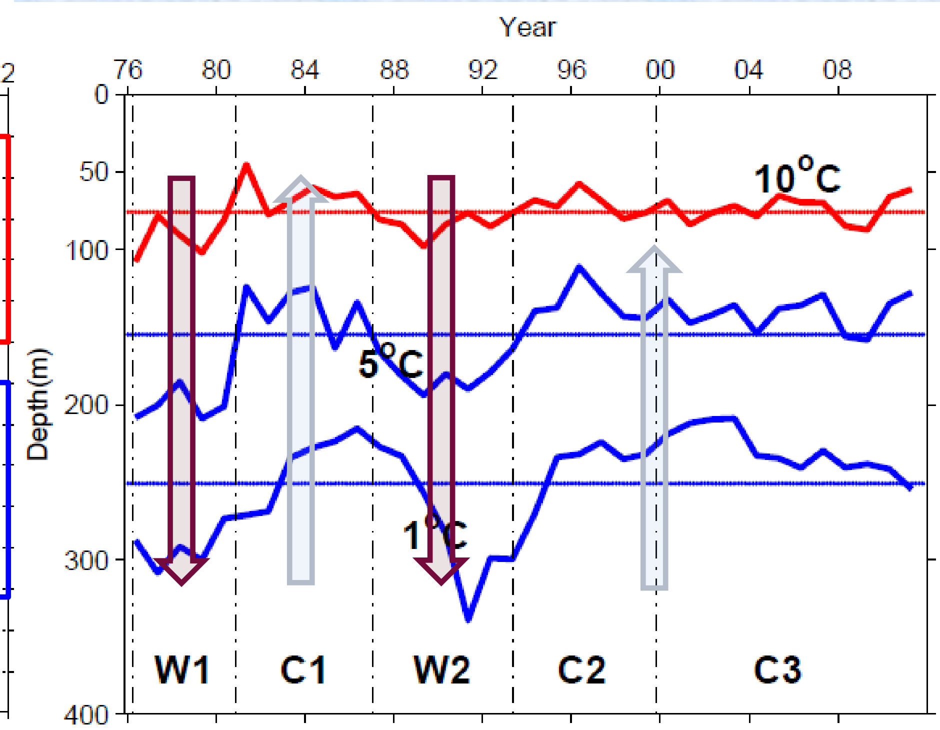


4) Profiles of T_a and depth of isotherms

Results



▲ Profiles of basin-averaged T_a in each period.



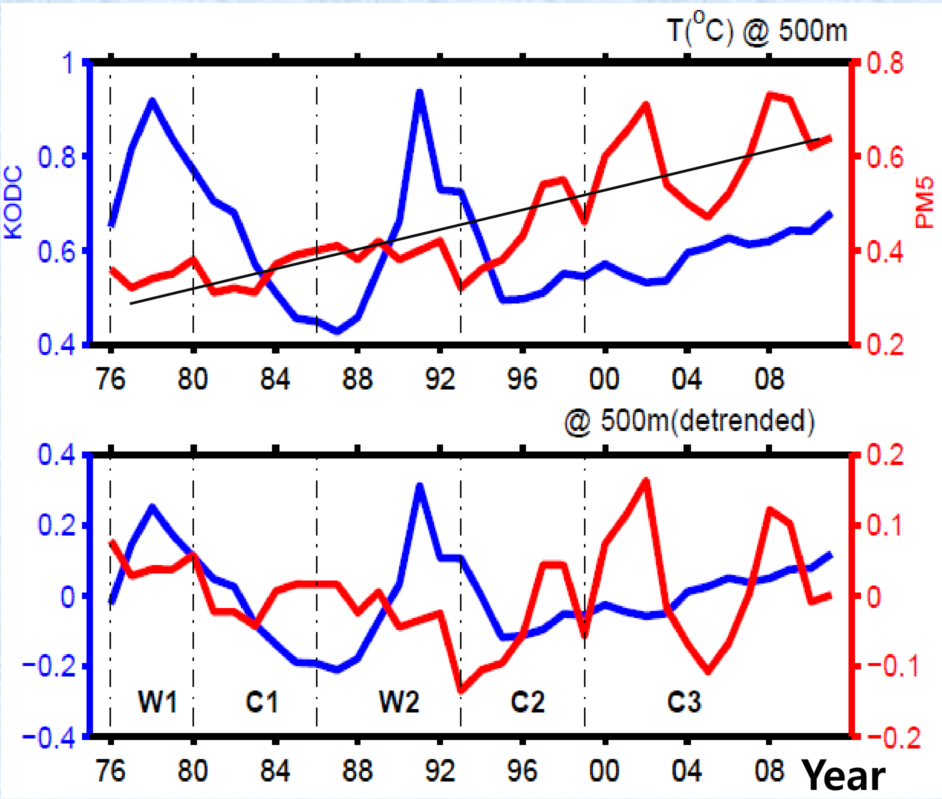
▲ Annual mean time series of basin-averaged isotherms 10°C, 5°C and 1°C.

Water mass	W1	C1	W2	C2	C3
TWW	Strong	Weak	Strong	Strong	Strong
ESIW	Weak	Strong	Weak	Strong	Strong

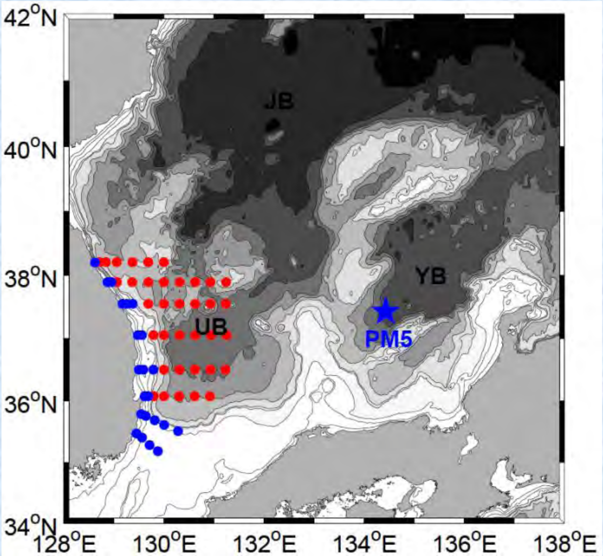
5) Comparison with other studies

(1) Basin to basin comparison

Minami et al. (1999) and Cui et al. (2010)



▲ Compare the PM5's temperature(r) at 500m with the basin-averaged KODC temperature data(b) at 500m.



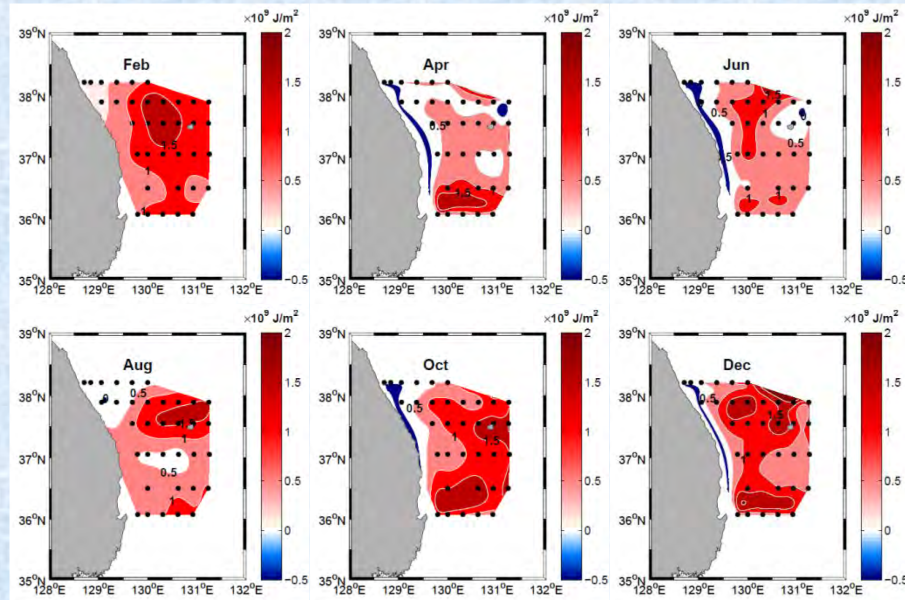
* Temperature at PM5 shows a warming trend.

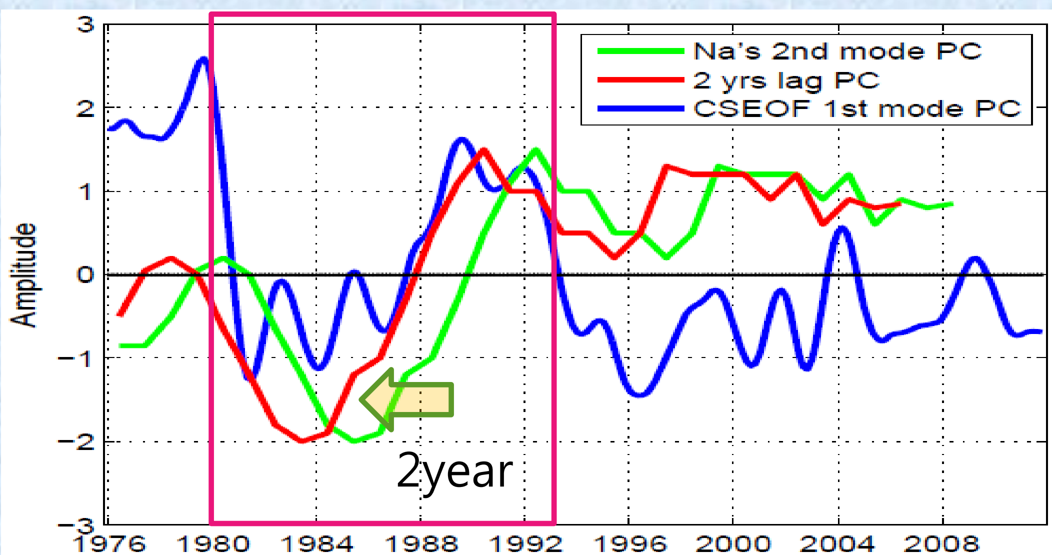
* Before C2, large fluctuations show in KODC temperature time series but after C2, large fluctuations show in PM5 temperature time series.

(2) Comparison with the heat content in the EJS

Na et al. (2011), In the EJS

1st CSEOF mode of 0~300m HCA(26%), In the UB





From Aug to Jan

Sign of the UB's spatial patterns in two cases are opposite.
Opposite decadal variation shows in box period with 2-year lags (the UB leads) but after this, eastern part of the EJS and the UB shows similar variation.

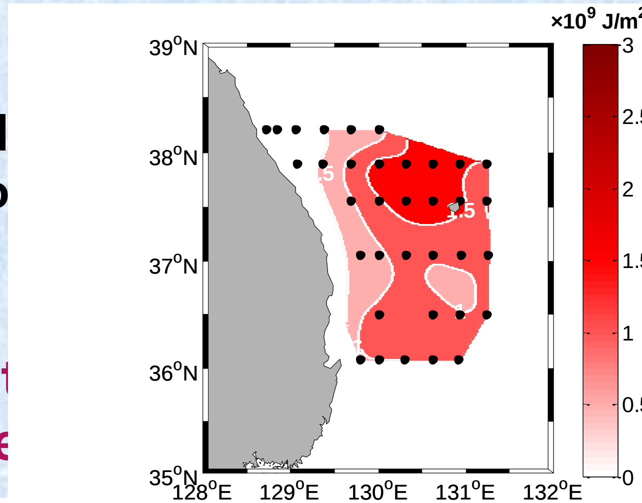
(3) Comparison with the neighboring marginal sea

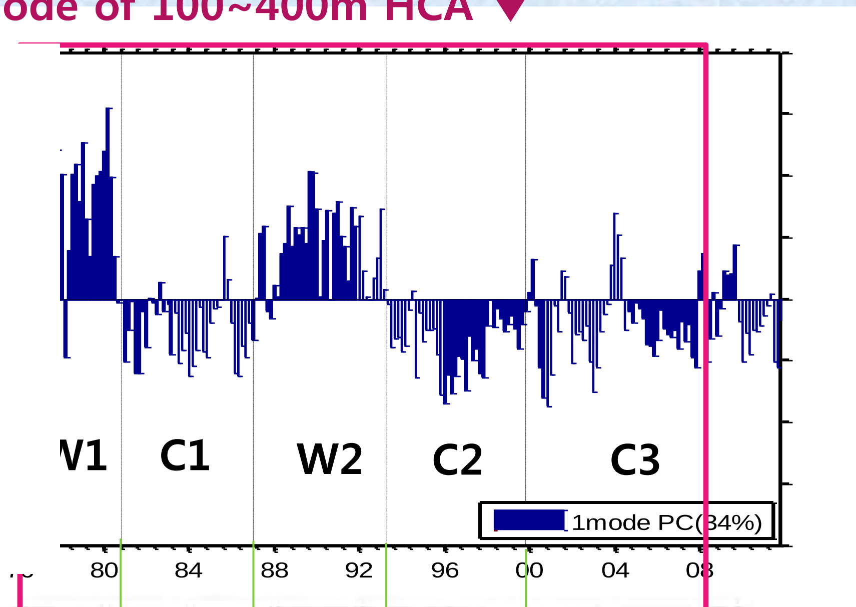
The 1st EOF mode of 100~400m HCA ▼

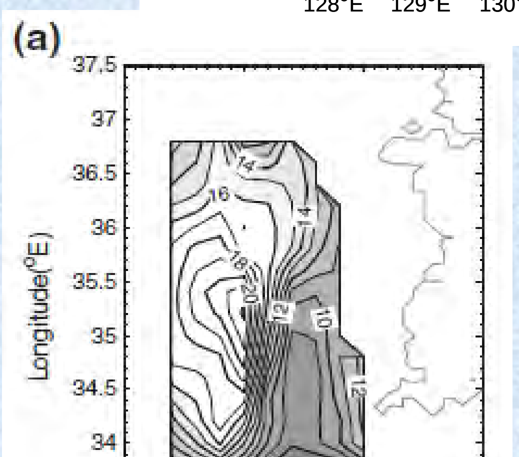
Park et al.

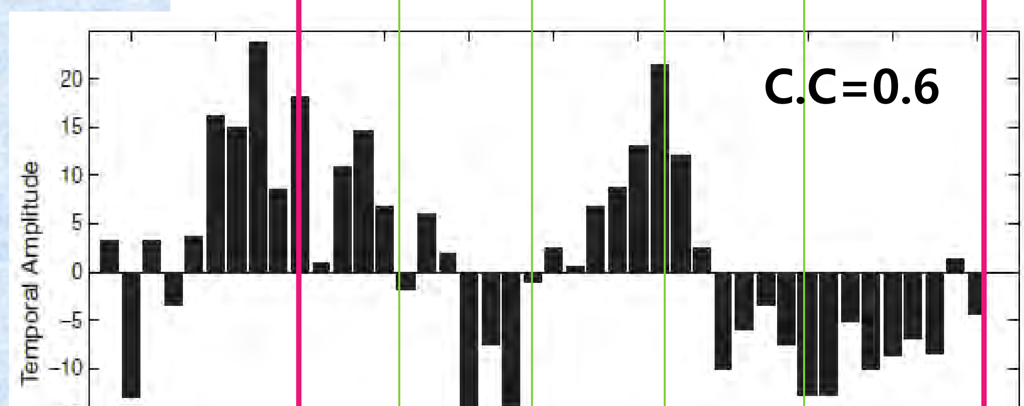
Interannual
of the Yello

* EOF 1st
(50m te









* We will infer possible mechanisms for changing properties of water masses in the UB.

4. Conclusion

* Contrary to increasing heat content in the EJS, the HCA in the upper 500m of the southwestern EJS has been decreasing.

* Influence of two water masses is important factor for

In the future,

> We check whether UHCA is affected by heat flux or not.
> Compare atmospheric variables like climate indices, wind stress curl, SLP, SAT and etc with the UHCA and LHCA variations.
> Using reanalysis data, calculating 3 dimensional heat budget.
>…


THANK
YOU