Impact of climate variability on the **neon flying squid** *(Ommastrephes bartramii)* winter-spring cohort stock

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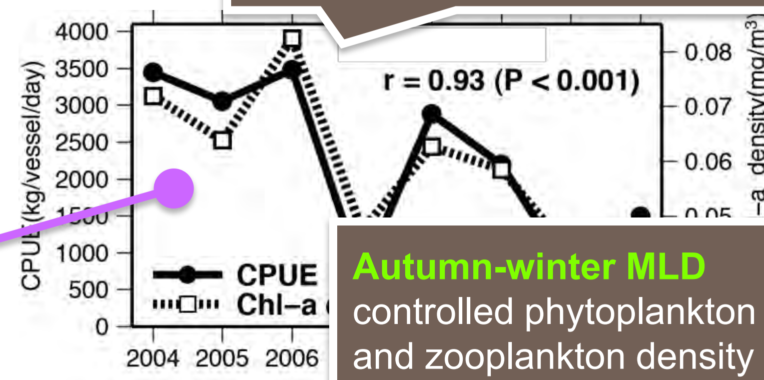
Introduction

Life history of winter-spring cohort of the neon flying squid

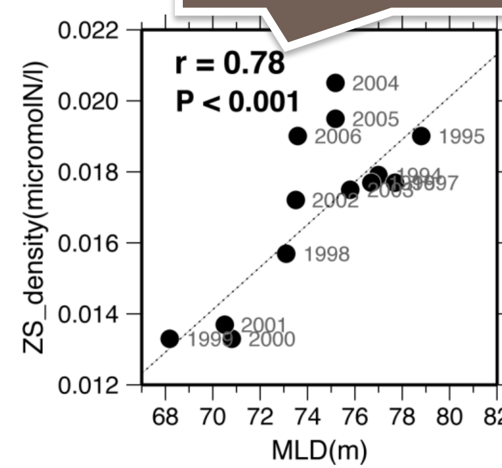
Paralarvae stay in spawning grounds until May and feed on zooplankton.

Significant positive correlation between the CPUE and **Chl-a density in the spawning grounds** (Nishikawa *et al*., submitted)



CPUE: calculated by Jap
Chl-a: satellite data

Autumn-winter MLD controlled phytoplankton and zooplankton density through nutrient supply from deep layer



MLD and plankton: output of ecosystem model

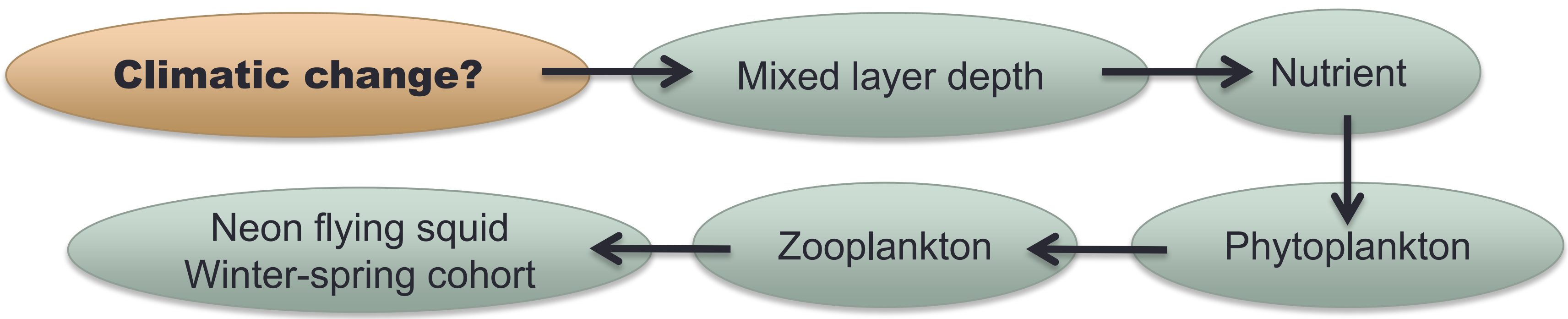
OUR HYPOTHEISIS

Autumn-winter MLD interannual variation affects on the neon flying squid stock through zooplankton availability in the early life stage.

Purpose of this study

Clarify the underlying climate impact on autumn-winter MLD interannual variation

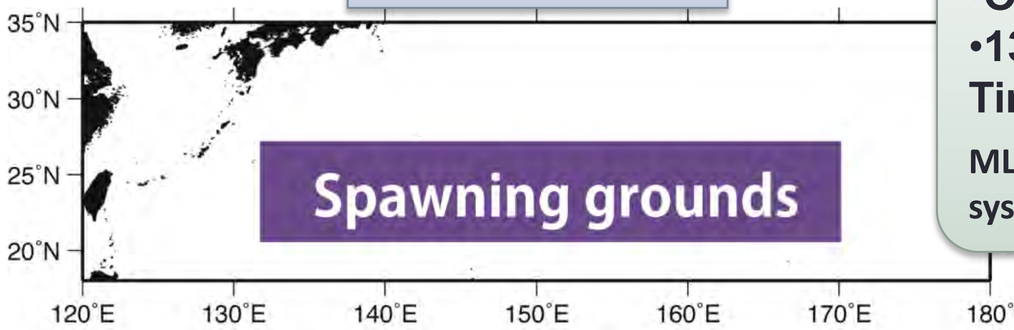
Bottom-up process



Clarification of bottom-up process will be helpful to predict the squid stock.
Because zooplankton variation is a direct cause for stock variation but it is difficult to obtain.

Methods

Target area



Averaged MLD in the spawning grounds
- October–February
- 135–170ºE and 20–27ºN

Time span: 1994–2006

MLD data is derived from 4D-VAR data assimilation system (Masuda et al, 2006).

Autumn-winter MLD in this area depends on entrainment

Bulk mixed layer model

Entrainment Velocity

$$\frac{1}{2}\alpha g h_m \Delta T \cdot \boxed{\mathrm{We}} = m_0 u_*^3$$

Wind friction

$$+\frac{\alpha g}{\rho_0 c}\int_{-h_m}^{0} q(z)\,dz$$

Shortwave radiation

$$-m_c \frac{\alpha g h_m}{4\rho_0 c}\left(\left|Q_{\mathrm{net}}\right| - Q_{\mathrm{net}}\right) - \frac{\alpha g h_m}{2\rho_0 c}\left(Q_{\mathrm{net}} + q_{\mathrm{d}}\right)$$

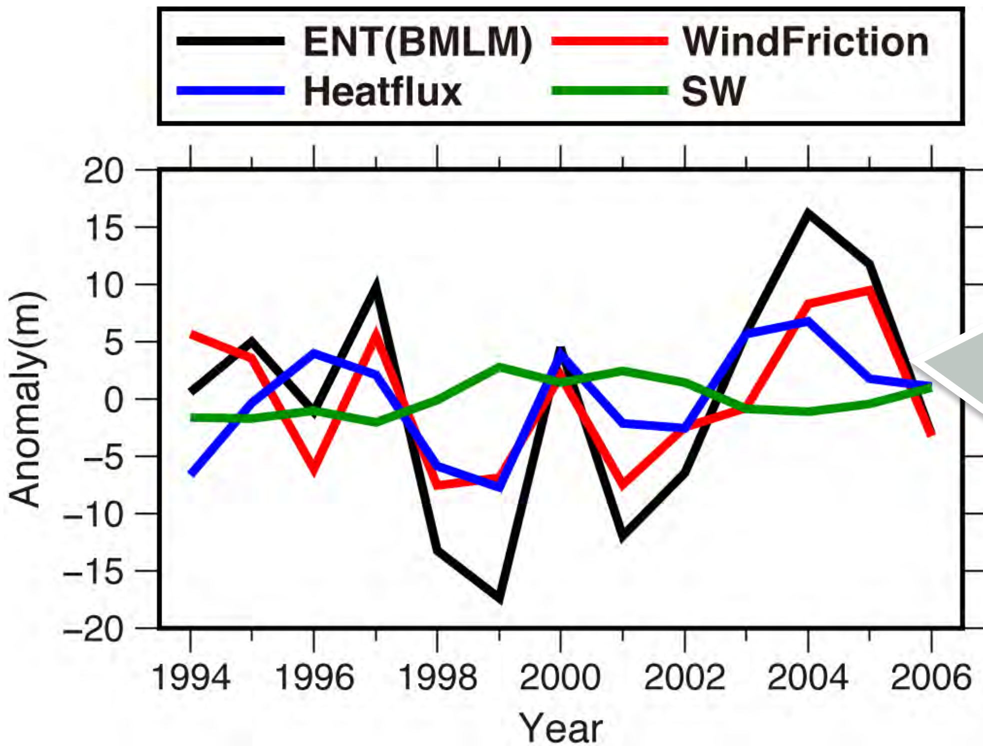
Heat flux

We use Bulk mixed layer model (Qiu and Kelly, 1993) to separate contributions of Wind friction, Shortwave radiation and Heat flux to the entrainment.

Results

Cause of Entrainment

Anomaly of entrainment and each components (1994–2006)

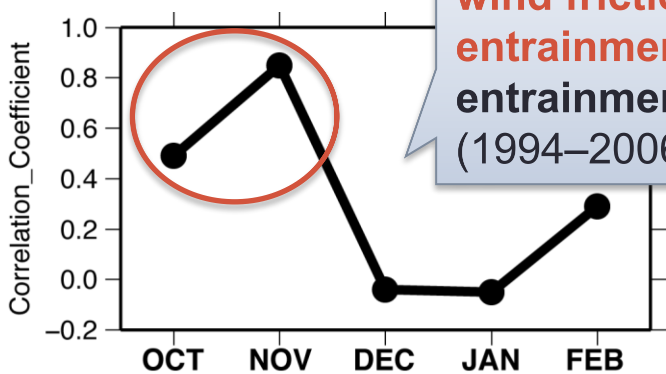


Autumn-winter Entrainment interannual variation depends on Wind friction and Heat flux

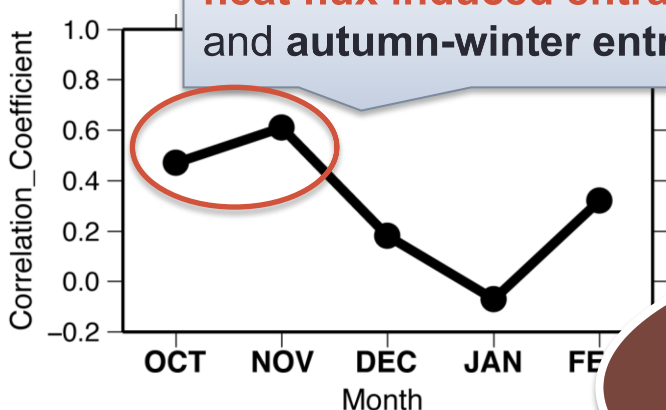
Wind friction: 28.8±6.1m、r = 0.89
Heat flux: 56.0±4.7m、r = 0.77

When wind friction/heat flux deepens Mixed layer?

Correlation coefficient between **wind friction induced entrainment** and **autumn-winter entrainment** in **each month** (1994–2006)



heat flux induced entrainment and **autumn-winter entrainment**

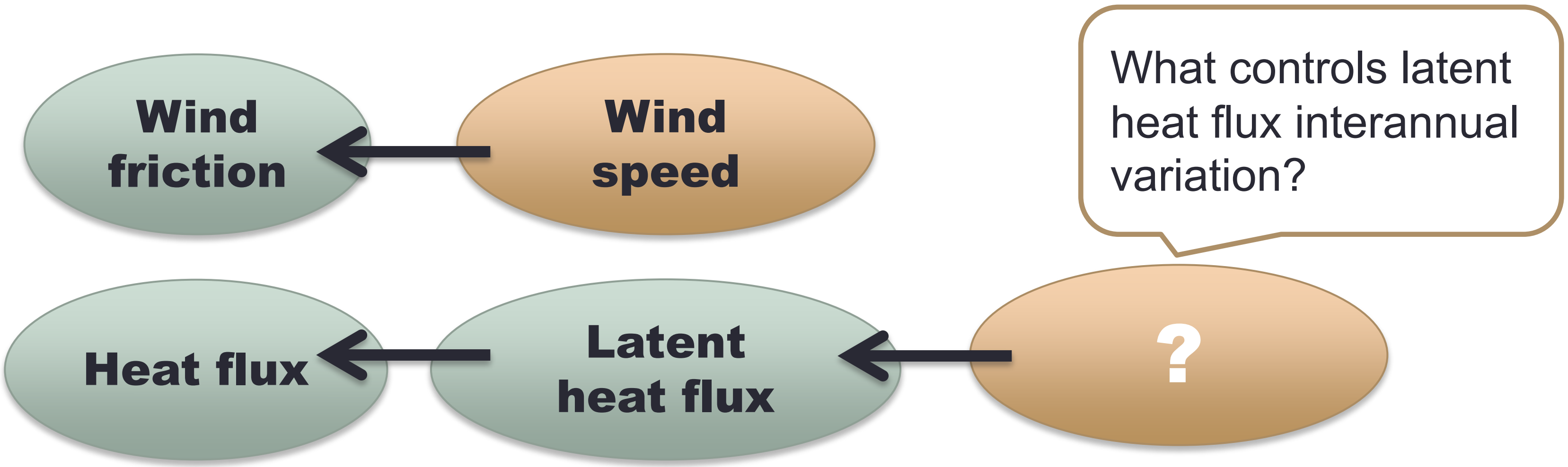


Time series of **Oct-Nov wind friction and heat flux induced entrainment** and **autumn-winter entrainment** (anomaly)

High correlation coefficients are shown in **October and November**

October and November wind friction and heat flux explain almost autumn-winter MLD interannual variation

What controls heat flux?



Bulk formula of latent heat flux

Wind speed at 10 m

$$Q_{LA} = -\underline{\rho_a L C_E} U_{10} \left(q_s - q_a \right)$$

Denisty of air, Latent heat of evapolation and Transfer coefficient are **nearly constant**.

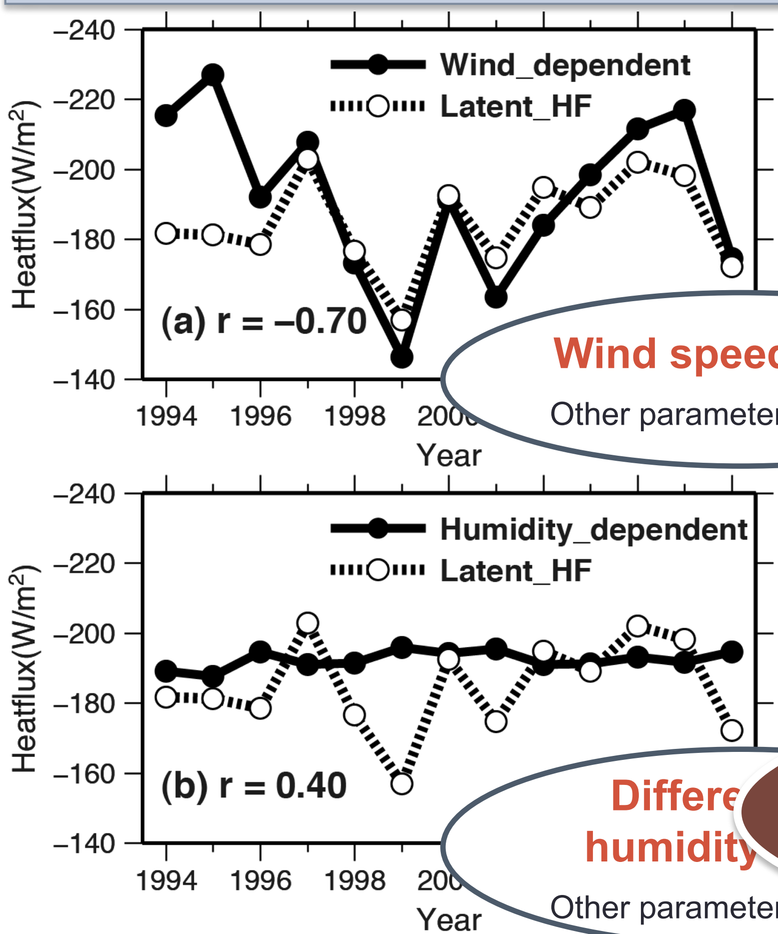
Difference between spcific humidity at the sea surface and spcific humidity of air at 10m

Possible control factor:

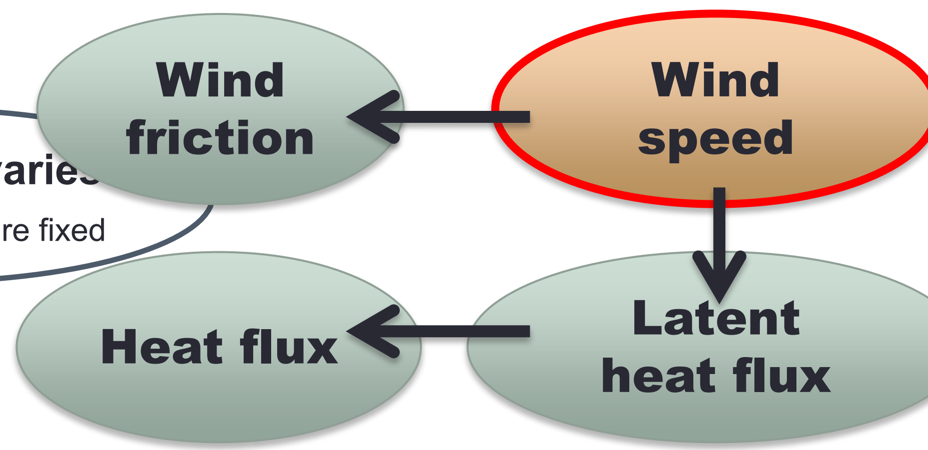
Wind speed or **Humidity**

What controls heat flux?

Estimation of Latent heat flux according to bulk formula



Obviously, latent heat flux interannual variation is controlled by **wind speed**.



October–November wind speed determines autumn-winter MLD

Summary

Wind speed, MLD and CPUE

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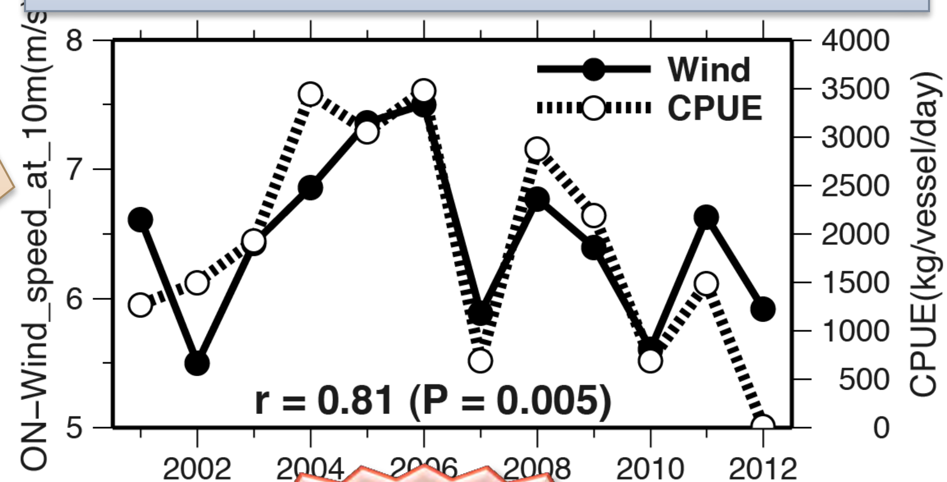
Time-series of the neon flying squid CPUE corresponds to autumn wind speed in the spawning grounds two years ago.

Hypothesis

Strong autumn wind in the spawning grounds induced deep mixed layer that causes high plankton density and links to good catch of the neon flying squid.

CPUE and Oct-Nov wind speed (Two years ago)



CPUE o... m a dataset
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Stock prediction may be possible

e.g.

Autumn of 2004 | Winter of 2005 | Spring of 2005 | Winter of 2006

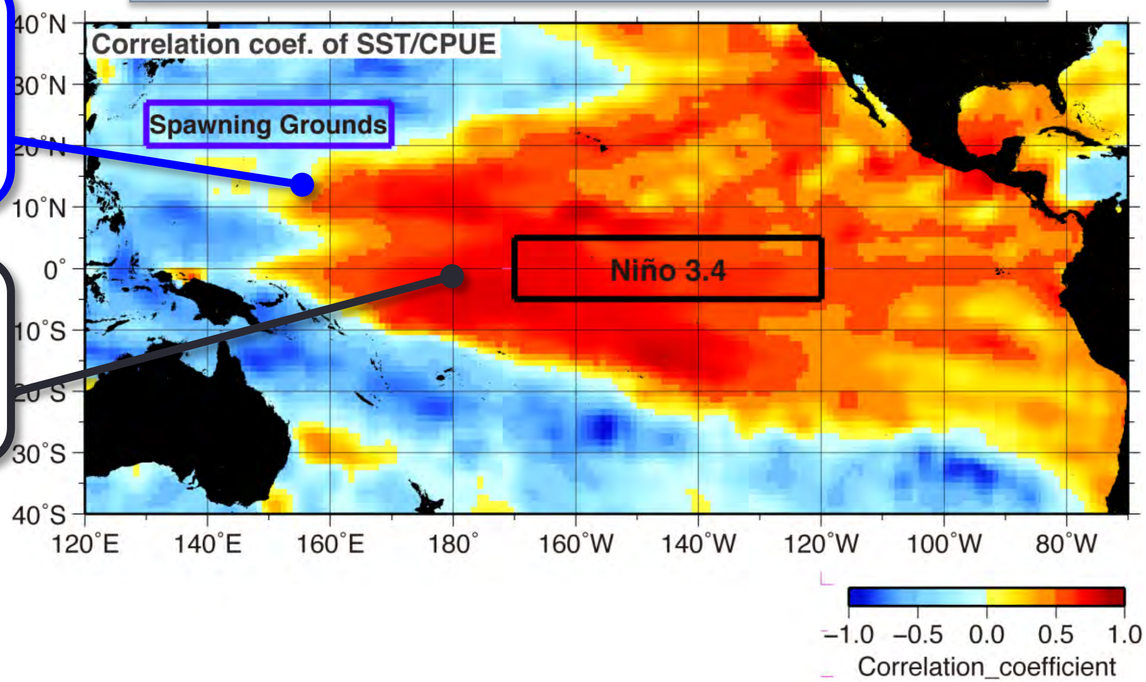
Windy → **Deep mixed layer** → **High plankton density**
↓
Good feeding condition → **Good catch**

Why wind speed varies interannually?

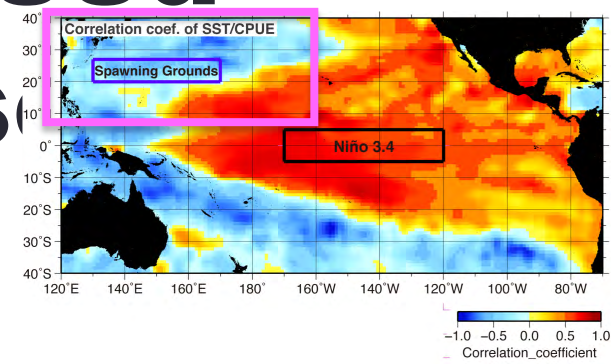
We focused that **high SST was shown in El Niño year in the south of spawning grounds**.

Neon flying squid CPUE tends to be high after two years of El Niño (Chen et al., 2007).

Correlation coef. CPUE/SST two years ago



Why wind speed often increas



Possible scenario

High SST in the south of spawning grounds

↓

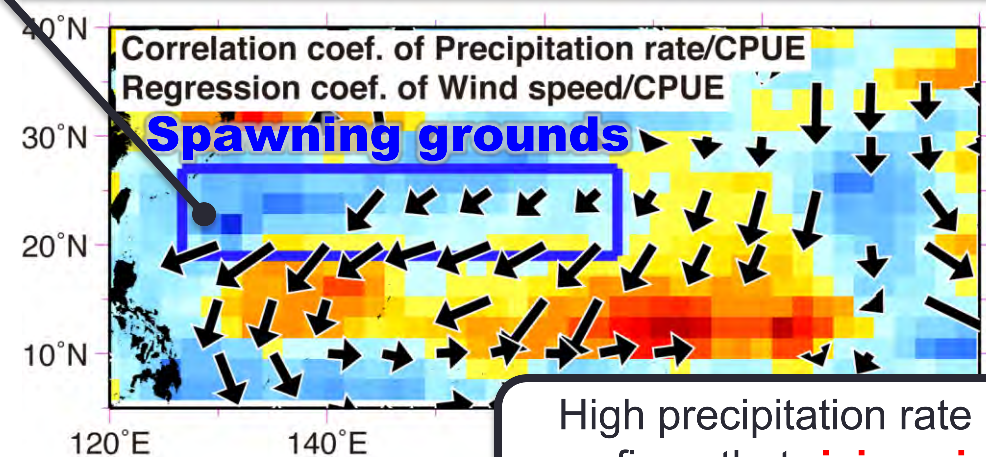
Rising air on the south of spawning grounds

↓

Convergence zone on the south of spawning grounds intensify wind on the spawning grounds

Wind blows on the spawning grounds due to convergence zone

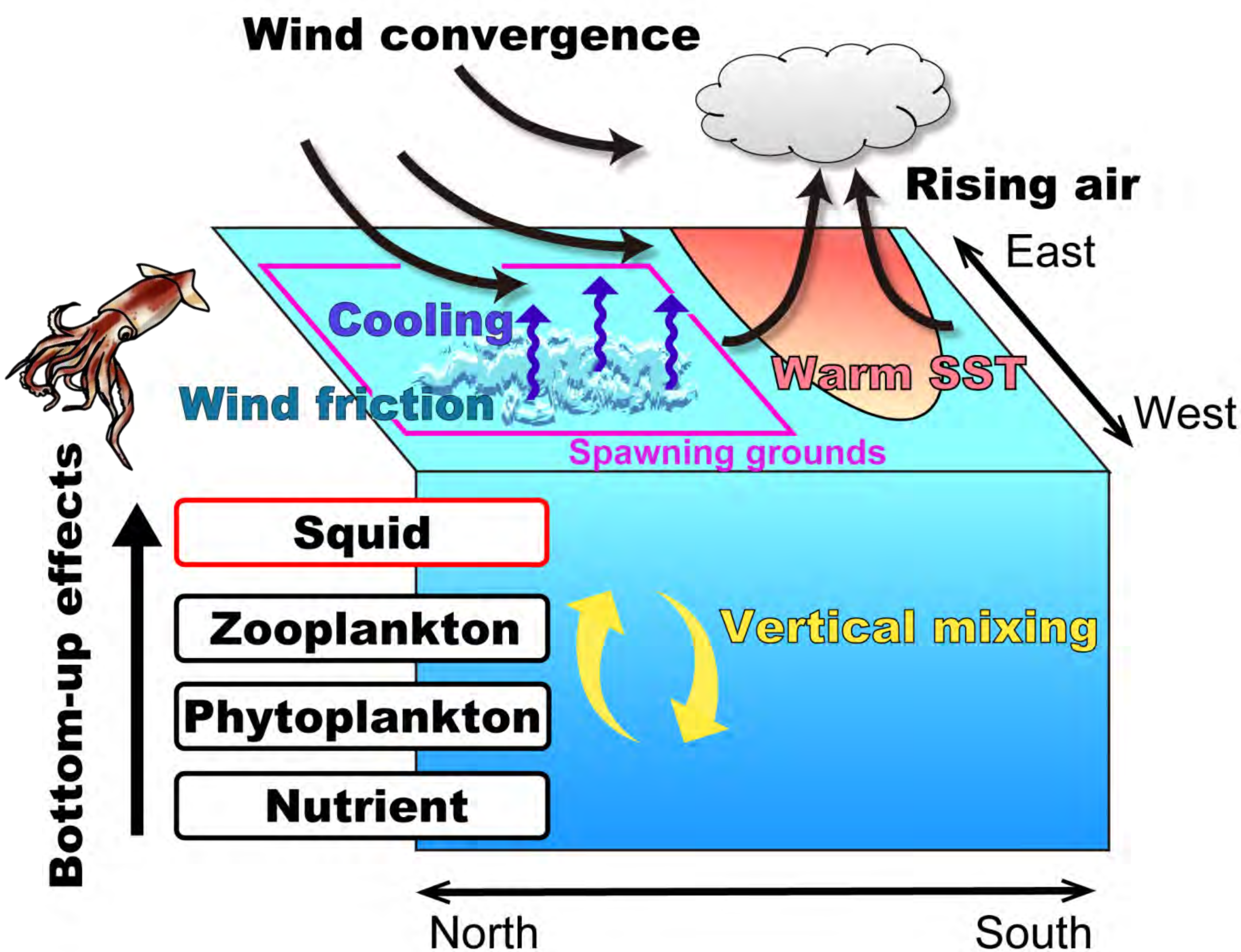
Expanded figure around the spawning grounds



High precipitation rate confirms that **rising air** formed clouds

Colored back ground: Correlation coef. between Precipitation rate/CPUE
Arrows: Regression coef. between Wind speed/CPUE (Vectors are intensified in high CPUE year)

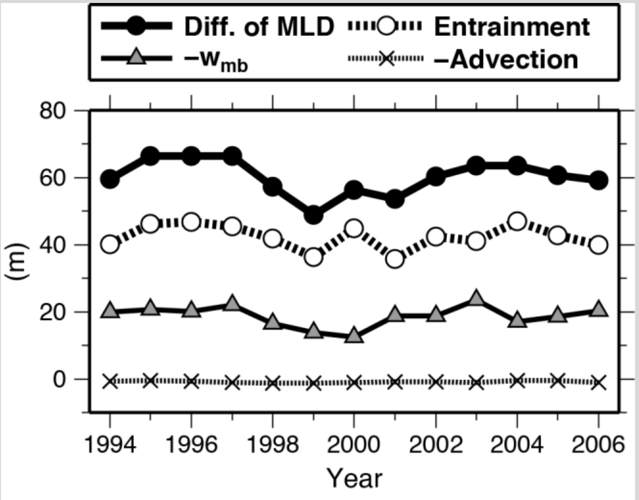
Schematic diagram of climate-squid relation



Cause of ML deepening

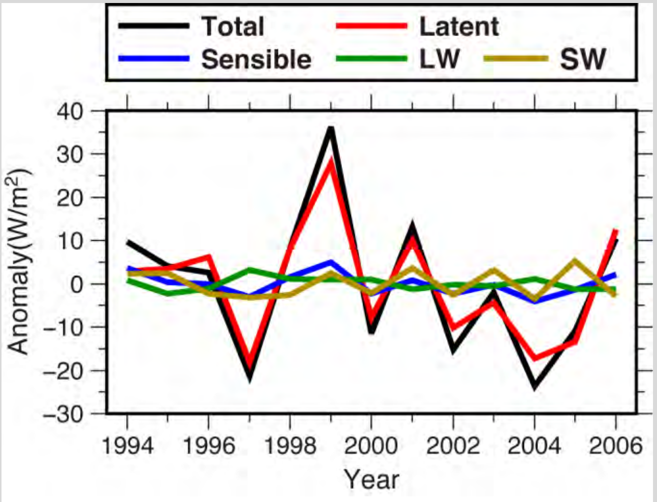
$$\frac{\partial h_m}{\partial t} = E - w_{mb} - u_{mb} \times \nabla h_m$$

E: instant entrainment rate
W and u is vertical and horizontal velocities of the mixes layer.



dMLD: 60.1±5.3m
ENT: 42.3±3.7m、r = 0.80
wMLD: 18.7±3.0m、r = 0.69
Adv: 0.85±0.27m、r = -0.51

Content of Heat flux



Monthly wind