Role of the Yellow Sea Cold Water Mass in Modulating Winter Sea Surface Temperature

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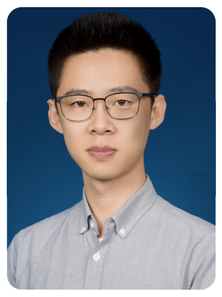


BACKGROUND

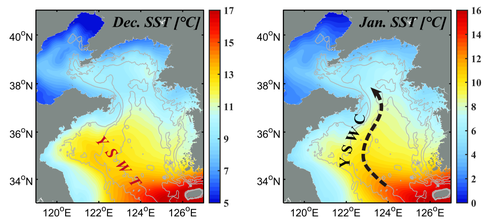
Traditional View Points

1

Summer → Yellow Sea Cold Water Mass (YSCWM)

Winter → Yellow Sea Warm Water Tongue (YSWT)

} **NO overlap**



2

Yellow Sea Warm **Current** (YSWC)

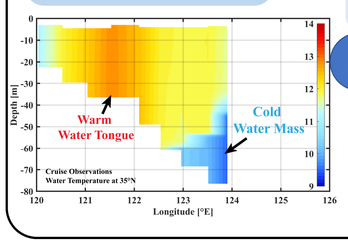
FORMS

Yellow Sea Warm **Water Tongue**

Recent Discovery

1

Cold Water Mass and Warm Water Tongue Coexist in early winter



2

The main axis of the Warm Current and the Warm Water Tongue are NOT in same position

Research Questions

- Is the Warm Water Tongue really formed by the Warm Current?
- Does the Cold Water Mass played a Role in forming the Warm Water Tongue?

DATA & MODEL

- Cruise field observations
- Satellite SST observations——MURSST
- ROMS simulations——2.5km, 2 layer nesting

WARM WATER TONGUE & COLD WATER MASS

$$T_N(x,t) = \frac{T(x,t) - \frac{\sum_{x=1}^{n} T(x,t)}{n}}{max\left(\left|T(x,t) - \frac{\sum_{x=1}^{n} T(x,t)}{n}\right|_{x=1,2,\ldots,n}\right)}$$

Normalized water temperature (T_N)
To depict the main axis of the YSWT and the location of the YSCWM

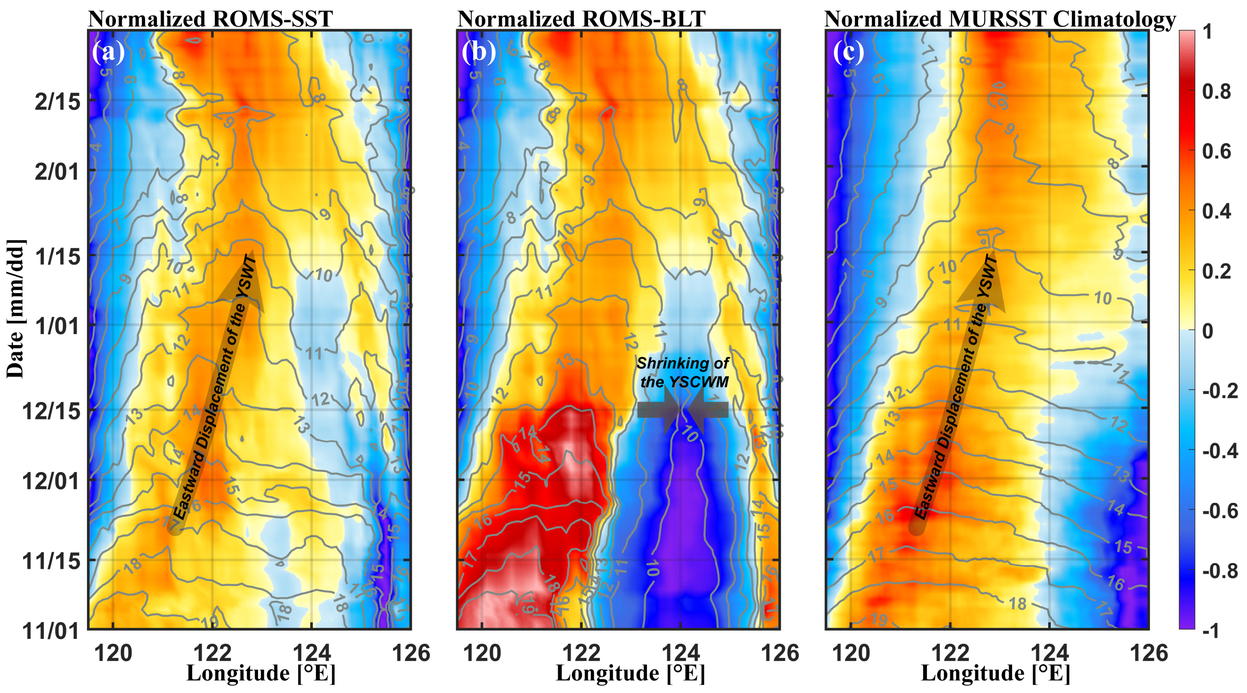


Fig. 1 (a) Longitude-vs.-time Hovmöller diagram of ROMS-simulated SST (contours) and normalized SST (color) along 35°N. (b) Same as (a) but for bottom layer temperature. (c) Same as (a) but for climatological MURSST.

- The main axis of the Warm Water Tongue shows an **eastward displacement** during its formation
- The main axis of the Warm Water Tongue **coincides** with the western boundary of the bottom Cold Water Mass
- The formation and displacement of the Warm Water Tongue and the dissipation of the Cold Water Mass are concurrent processes

MIXED LAYER HEAT BUDGET

$$\underbrace{\frac{\partial T_M}{\partial t}}_{RATE} = \underbrace{-\frac{1}{h}\int_{-h}^{0} u\frac{\partial T}{\partial x}dz - \frac{1}{h}\int_{-h}^{0} v\frac{\partial T}{\partial y}dz - \frac{1}{h}\int_{-h}^{0} w\frac{\partial T}{\partial z}dz}_{ADV} + \underbrace{\frac{Q_{net} - Q_{sw}(h)}{\rho_0 C_p h}}_{FLUX} \underbrace{-\frac{1}{h}\left(A_{kt}\frac{\partial T}{\partial z}\right)_{z=-h}}_{DIFF} + Res$$

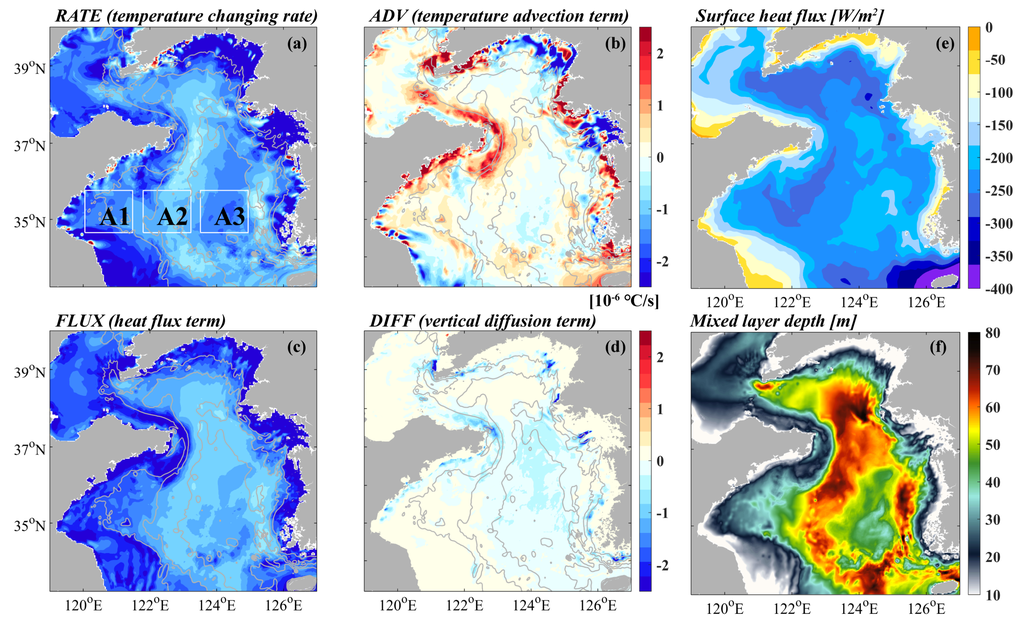


Fig. 2 (a) Monthly mean mixed layer temperature changing rate (RATE) in December. (b-d) Same as (a) but for the advection term (ADV), the surface air-sea heat flux term (FLUX), and the vertical diffusion term (DIFF). (e) Monthly mean surface heat flux during December. (f) Monthly mean mixed layer depth during December.

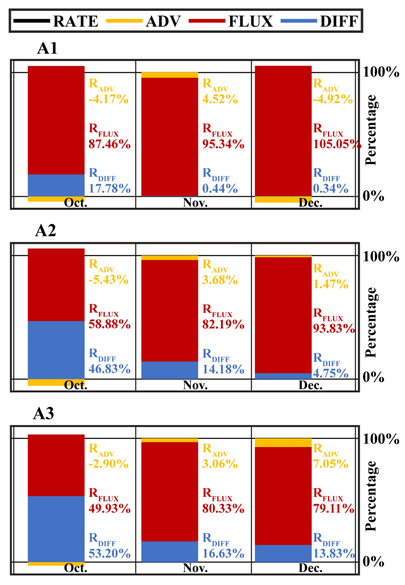


Fig. 3 Relative contributions of the ADV term (yellow bar), FLUX term (red bar), and DIFF term (blue bar) to the RATE term for the respective months from October to December. Negative percentiles in (d-f) represent the warming effect.

- The formation of the Warm Water Tongue (A2) is mainly the result of the intensified surface cooling in both the coastal waters (A1) and the deep waters (A3)

Role of the YSCWM in cooling the central Yellow Sea

- the surface cooling is induced by the **upward mixing of cold water** associated with the dissipation of the YSCWM (the DIFF term)
- the presence of the YSCWM results in **a shallower local mixed layer**, facilitating enhanced cooling processes (the FLUX term)

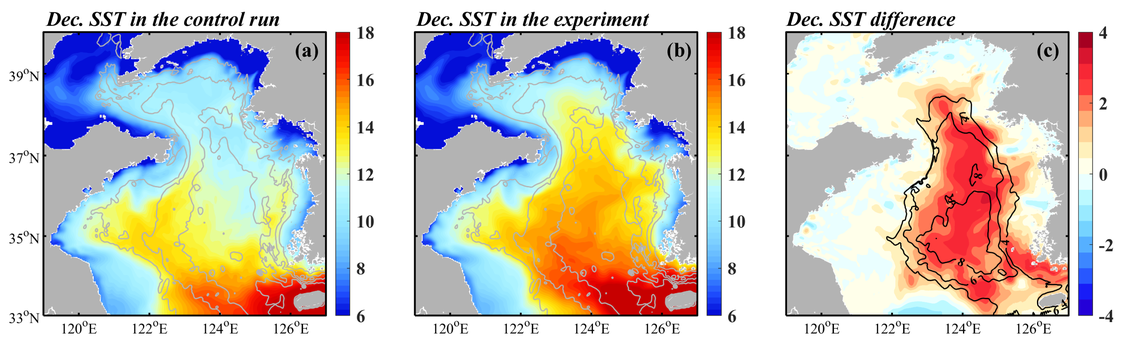


Fig. 4 (a) SST in the control run in December. (b) Same as (a) but in the experimental run where the bottom Cold Water Mass was removed. (c) SST difference between the control run and the experimental run.

- In the absence of the bottom Cold Water Mass, the Warm Water Tongue would be broader and the SST in the center water would be higher

CONCLUSIONS

- The effects of the Yellow Sea Cold Water Mass are manifested in upward mixing of bottom cold water and shallowing of the mixed layer
- The Yellow Sea Warm Water Tongue forms under stronger cooling in the nearshore waters and the region of the Cold Water Mass. The northward current player limited role in forming the Warm Water Tongue in early winter

Reference

Liu, X., Yu, F., Chen, Z., Si, G., Nan, F., Wang, J., Ren, Q., Hu, Y., 2024. The Critical Role of Thermal Stratification Associated With the Yellow Sea Cold Water Mass in Modulating Winter Sea Surface Temperature. J. Geophys. Res. Ocean. 129, 1–18.

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