SYMPOSIUM OP'24 — ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

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Regional ocean circulation prediction

Interannual variation of the Yellow Sea Cold Water Mass in the long-term high resolution regional ocean reanalysis

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Introduction

- The **Yellow Sea Cold Water Mass (YSCWM)** , defined as **waters with temperature lower than 10 °C** in the Yellow Sea (YS) (Guan, 1963), is a hydrographic feature shaped by the interplay of complex bottom topography and the seasonal variability of circulation in YS.
- The YSCWM plays important roles, such as **potentially weakening typhoon intensification and affecting biogeochemical production and cycling in the YS** (Guan et al., 2021; Liu et al., 2022; Chen et al., 2004; Fu et al., 2016; Hur et al., 1999; Lie et al., 2001).
- Various studies have linked variations of YSCWM to large-scale climate variability modes including the El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Arctic Oscillation(AO) (Song et al., 2009; Park et al., 2011; Wei et al., 2013; Guo et al., 2021).

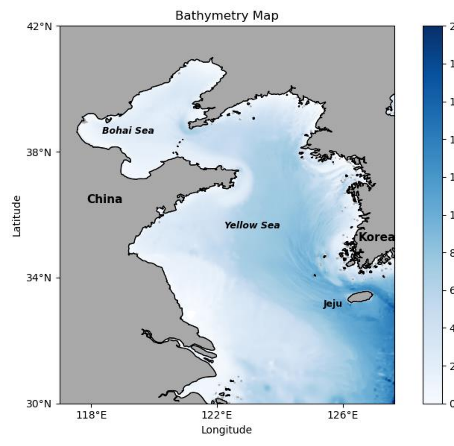


Fig 1. Bathymetry and schematic illustrations of regional circulation in the YS

Data and Method

- **K-ORA22 (KOOS-OPEM Reanalysis 2022)** *Chang et al., 2024*

- Ocean model : KOOS-OPEM (Ocean Predictability Experiment for Marine environment)
- Based model : GFDL-MOM5
- Domain : 5-63˚N, 99-170 ˚E (Northwestern Pacific)
- Resolution : 1/24 ˚x 1/24 ˚ (Arakawa B-grid) & 51 layers (Z* coordinate)
- Method : Ensemble Optimal Interpolation (Kim et al., 2015)
- Altimetry assimilation system : Cooper and Haines (1996, CH96)
- The number of ensemble members : 50

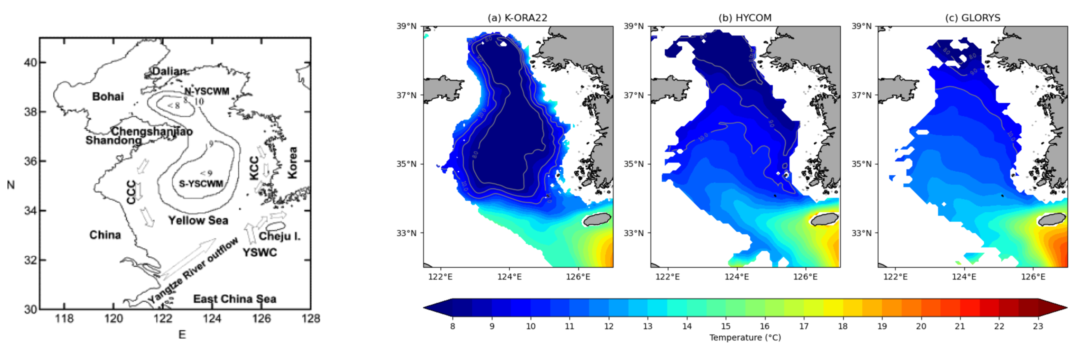


Fig 2. Sea water temperature at 50m averaged in boreal a summer (JJA) season from 2011 to 2019 and contour lines of isotherms for K-ORA22 (a), HYCOM (b), and GLORYS (c) in the YS

- **Climate indices**
  - The PDO(Pacific Decadal Oscillation) index
  - The AO(Arctic Oscillation) index
  - The ENSO(El Niño/Southern Oscillation) index
  - Siberian High index(SHI)
  - Western Pacific pattern(WP)

Season	YSCWM volume & SHI
MAM	0.50
JJA	0.44
SON	0.38

Table 2. Linear correlation coefficients between SHI and YSCWM by season

Winter Climate Index / Variables	YSCWM Volume (JJA)	ENSO	PDO	SHI	WP	AO
Wind speed (DJF)	0.35	-0.25	-0.15	**0.69**	**-0.57**	0.07
2m Temp (DJF)	**-0.54**	0.29	0.01	**-0.57**	**0.51**	**0.44**
YSCWM volume (JJA)	-	0.02	0.02	**0.44**	-0.24	-0.28

Table 1. Linear correlation coefficients between winter climate indices and winter surface wind speed, 2m air temperature, summer YSCWM

- **Meridional Heat Advection**

$$Heat_v = \int_{x_1}^{x_2}\int_{z_1}^{z_2} v\frac{\partial T}{\partial y}dzdx$$

- The meridional heat advection is calculated by integrating the product of the meridional velocity component (v) and the meridional temperature gradient ($\partial T/\partial y$) across the southern boundary of the YSCWM region.
- (x_1, x_2): 122.3°E to 126.5°E
- (z_1, z_2): 40 m to 100 m

- **Surface Heat Transport**

$$Heat_w = \int_{x_1}^{x_2}\int_{y_1}^{y_2} w\frac{\partial T}{\partial z}dydx$$

- (x_1, x_2): 121.65°E to 125.82°E
- (y_1, y_2): 34°N to 39°N

Result

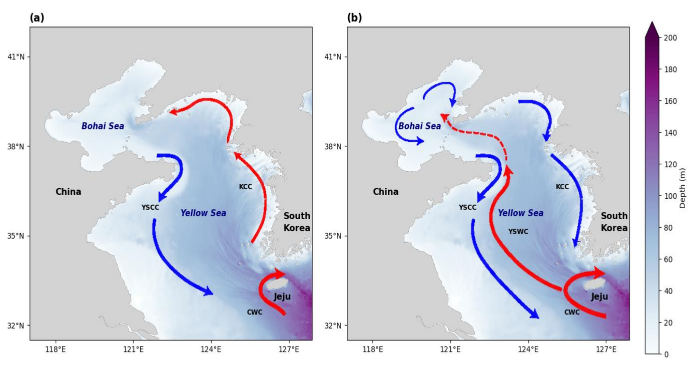


Fig 3. Bathymetry and schematic illustrations of regional circulation during (a) summer and (b) winter in the YS

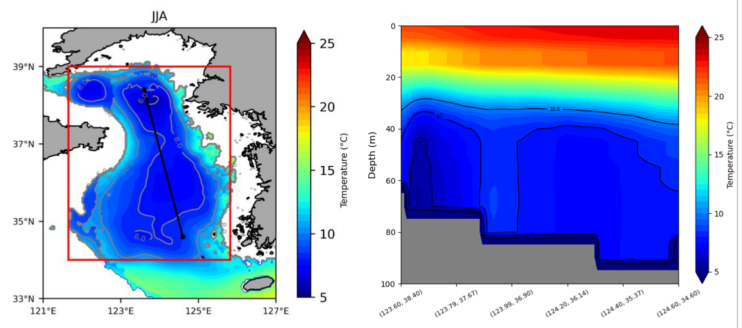
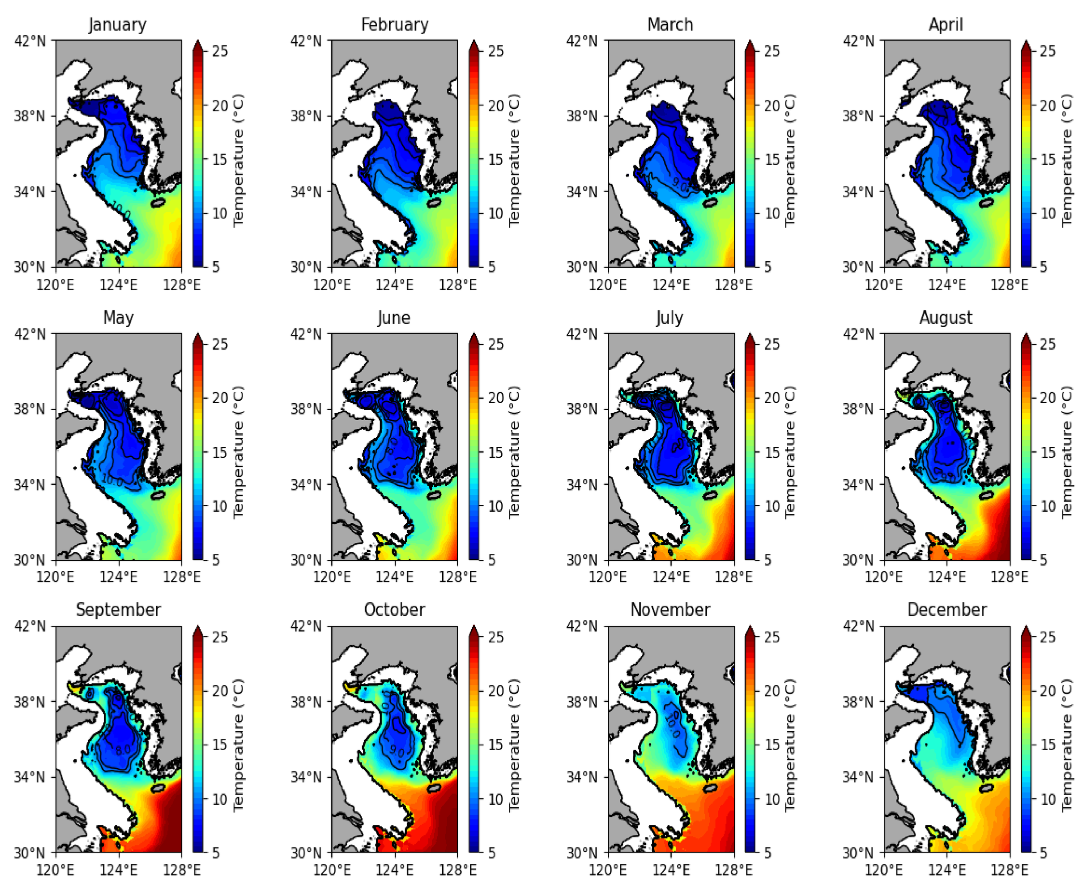


Fig 4 Schematic structure of the YSCWM (JJA) (the left panel shows the YSCWM distributions at 50m depth and the right panel shows the corresponding the section structures of the YSCWM).



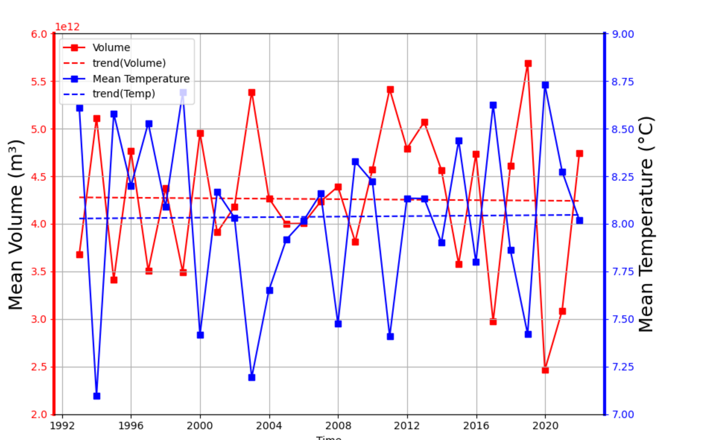


Fig 6 Volume and mean temperature of YSCWM with linear trends

Fig 5 Climatological monthly averaged temperature at the depth of 50 m in the YS.

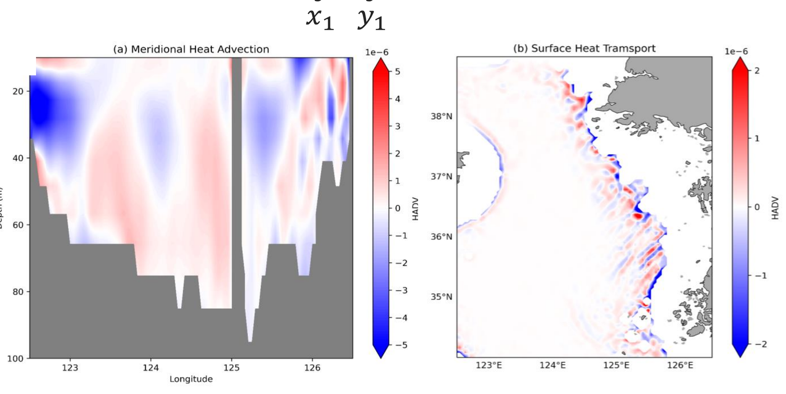


Fig 7 Climatology of heat advection at 34°N (a) and climatology of surface heat transport (b) (JJA).

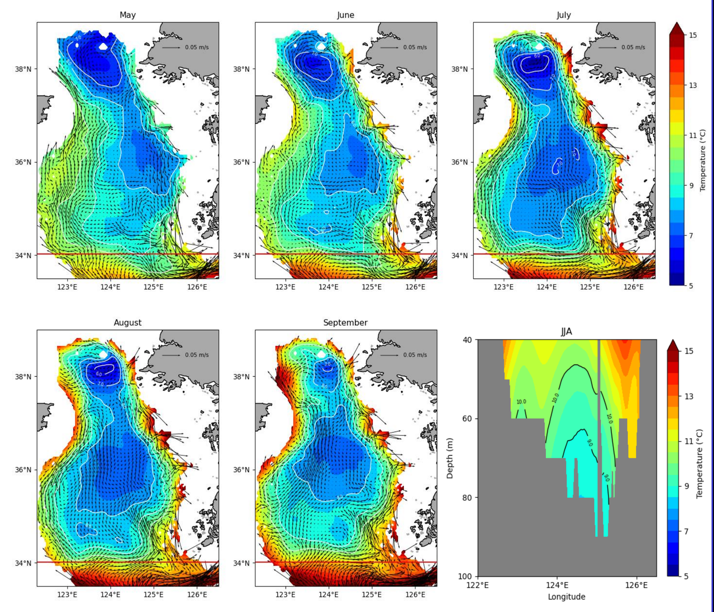


Fig 8. Climatology of temperature (°C) and currents(m/s) and contour line of isotherms at the depth of 50 m from May to September. and Climatology of temperature at 34°N (JJA).

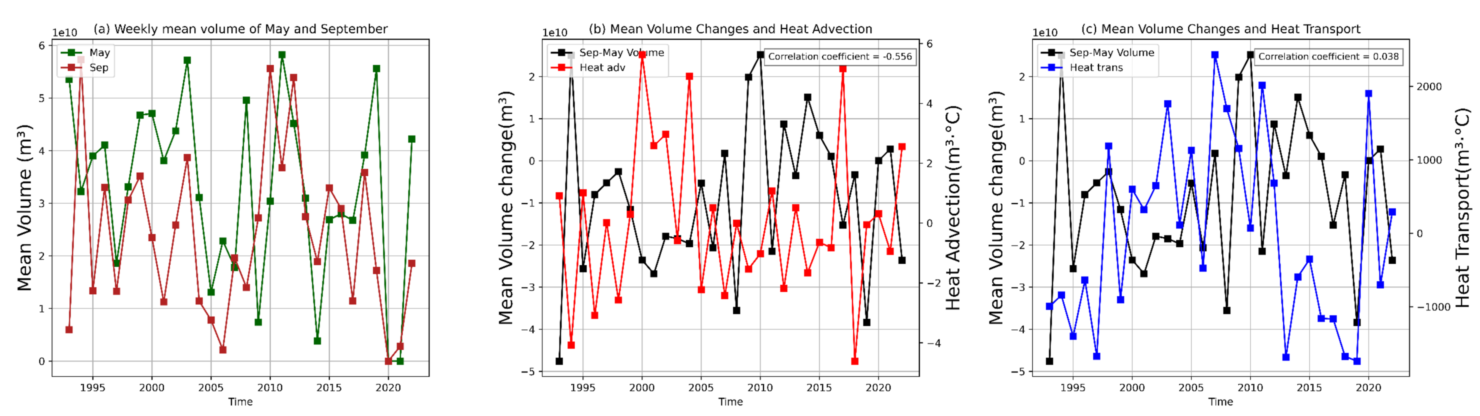
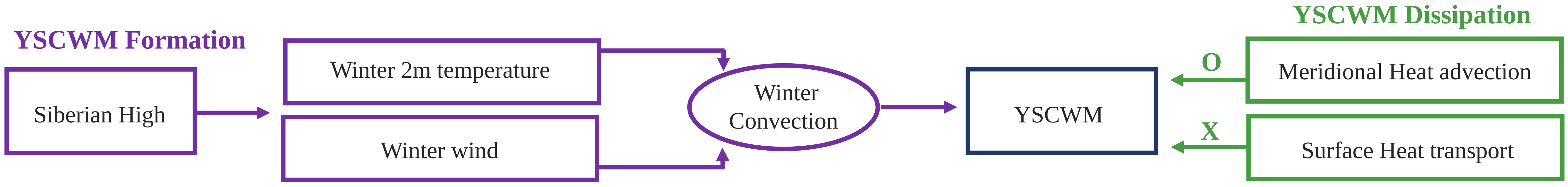


Fig 9 Time series of (a) YSCWM volume in the last week of May (green) and first week of September (brown), (b) May–September volume change (black) and JJA meridional heat advection (red), and (c) JJA surface heat transport (blue).

Conclusions



- This study utilized **the high-resolution K-ORA22E dataset**, which offers a more accurate representation of the YSCWM compared to other reanalysis datasets.
- **The seasonal variation of the YSCWM** is clearly observed at the climatology temperature at the depth of 50m. The water column, which is formed in winter and concentrated in the north due to the seasonal northwesterly winds and the northward-flowing Yellow Sea Warm Current (YSWC), migrates southward the YSWC dissipates in spring and dominates the Yellow Sea during the summer.
- **Stronger winter winds and colder air temperatures promote YSCWM formation**, with the **Siberian High emerging as the dominant atmospheric driver**, strongly correlating with changes in its volume and temperature.
- **Meridional heat advection is the key factor in the seasonal reduction of YSCWM**, with a strong negative correlation to its volume change, highlighting the importance of oceanic heat transport. In contrast, surface heat transport has a negligible affect on this seasonal variation.
- Future research should refine **the understanding of how atmospheric conditions and oceanic heat transport affect the YSCWM** and explore potential feedbacks with broader climate systems. Continued monitoring and modeling are essential for effective climate change strategies in the YS region.