# Synoptic variability of wintertime wind-driven circulation in the Bohai, Yellow and East China Seas

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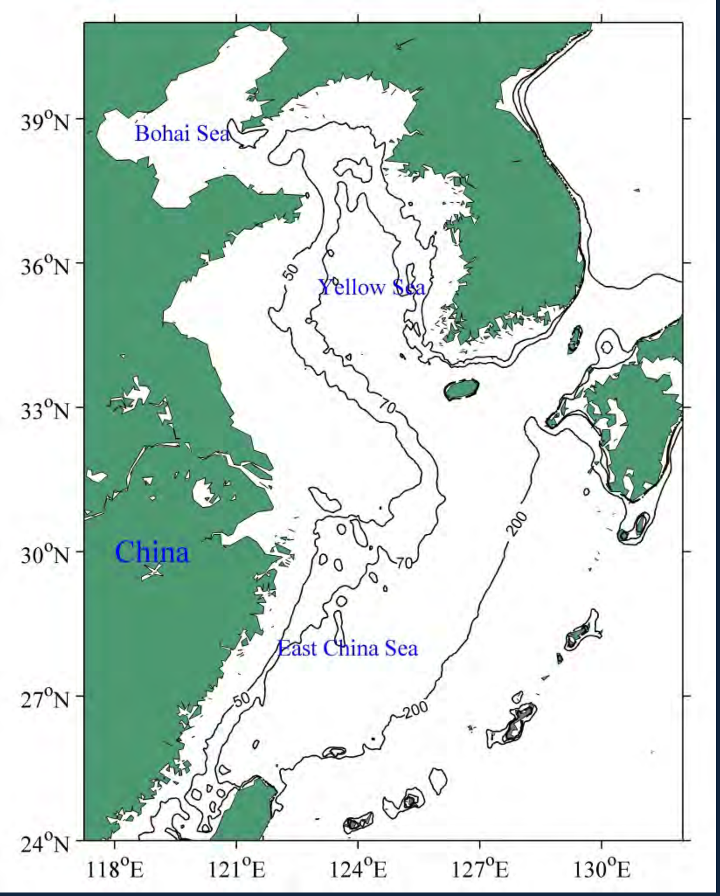
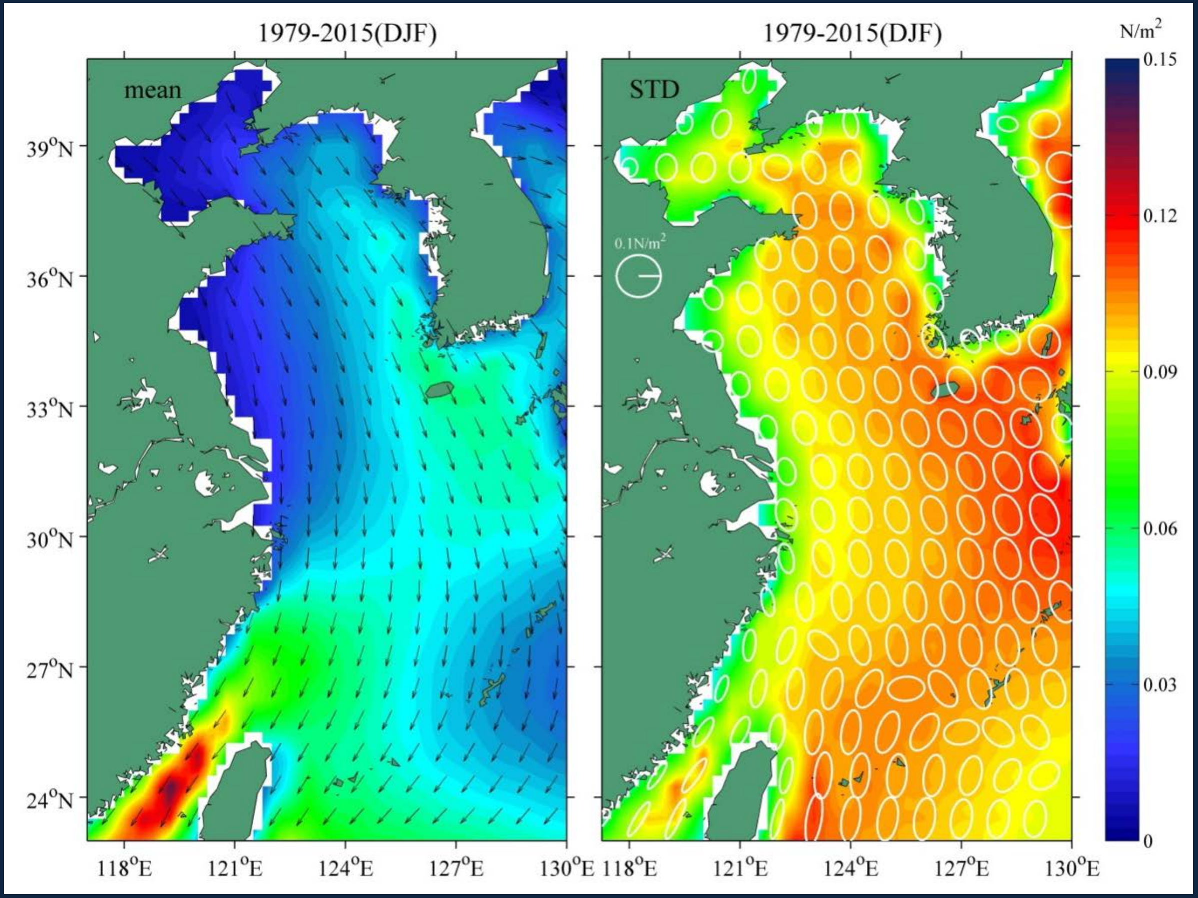
# Outline

1. Background
2. Data and methods
3. Results
4. Summary

# 1. Background

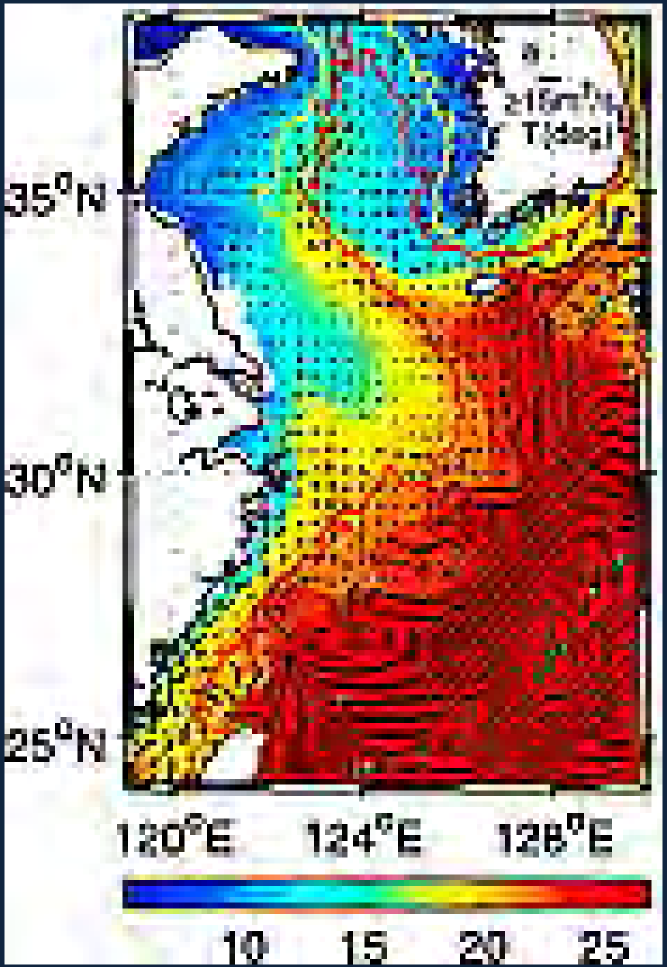



Bathymetry of the BYECS

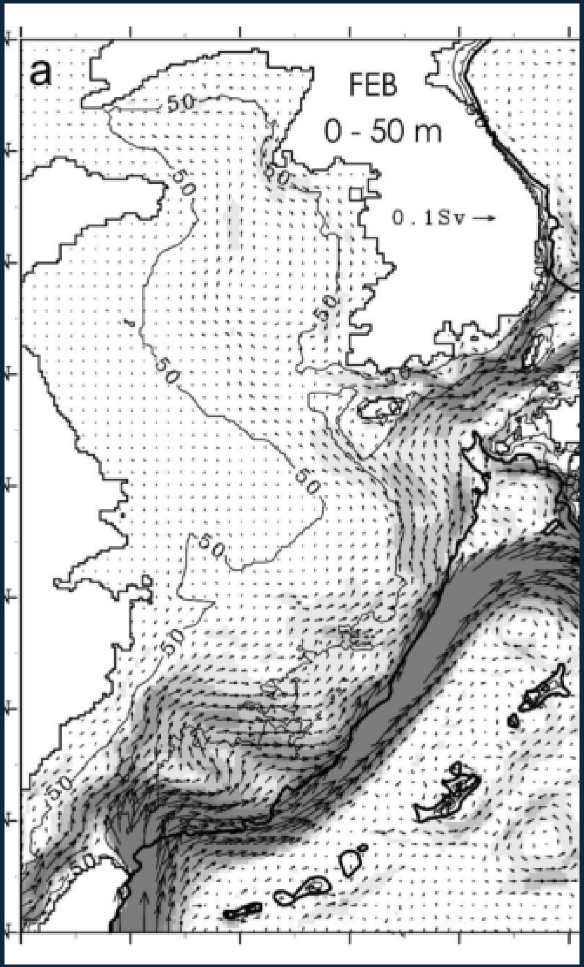



Multi-years wintertime (DJF) mean and STD of wind stress from 3 h ECMWF wind data

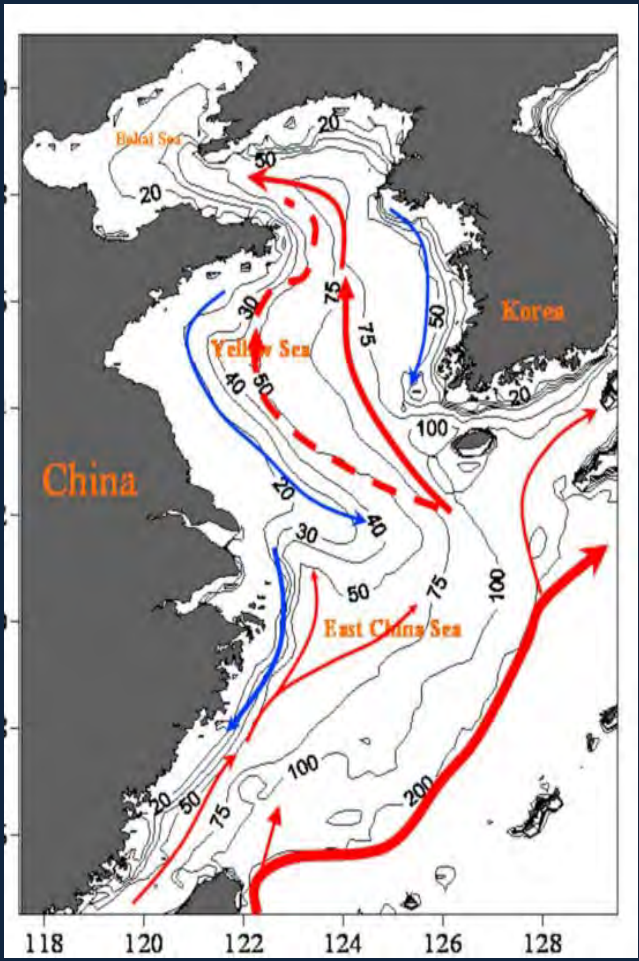
# Seasonal Circulation in winter




Huang et al., 2005, GRL

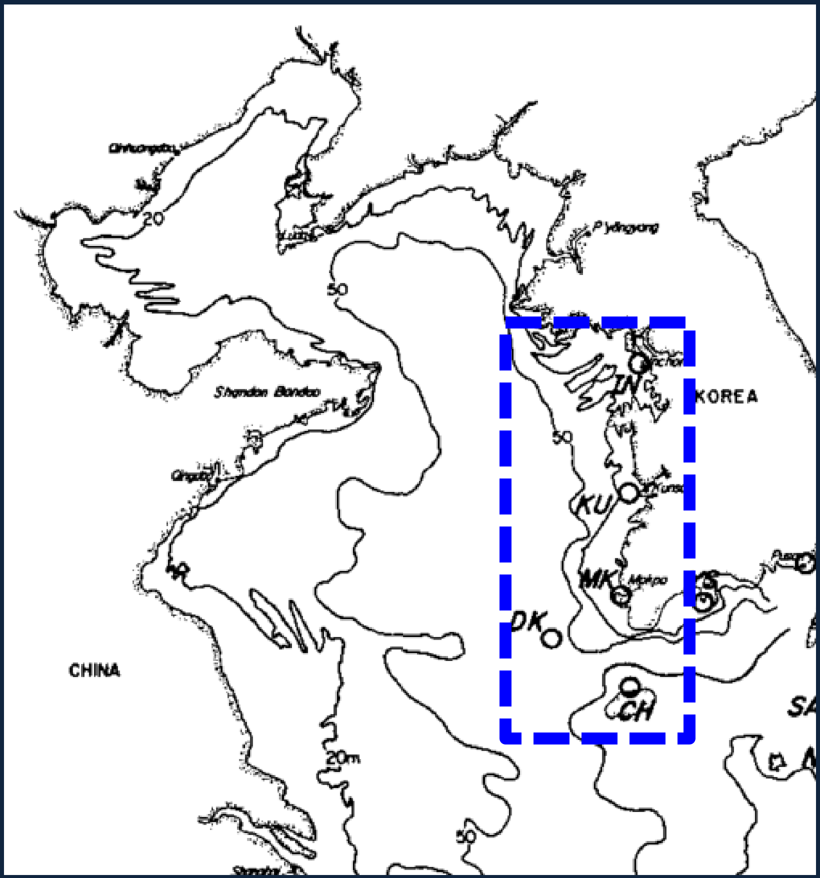



Guo et al., 2006, JPO

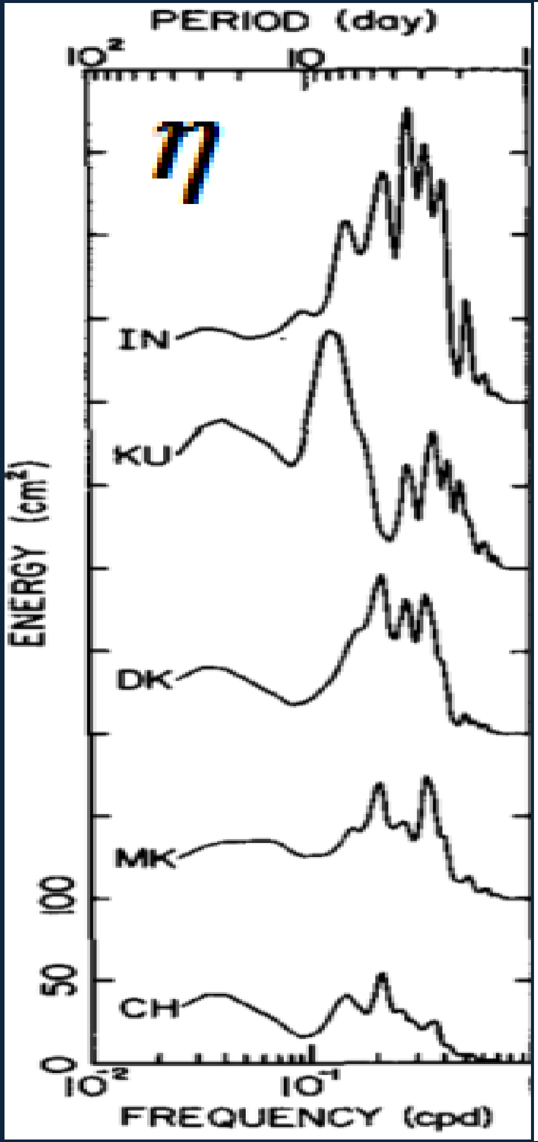


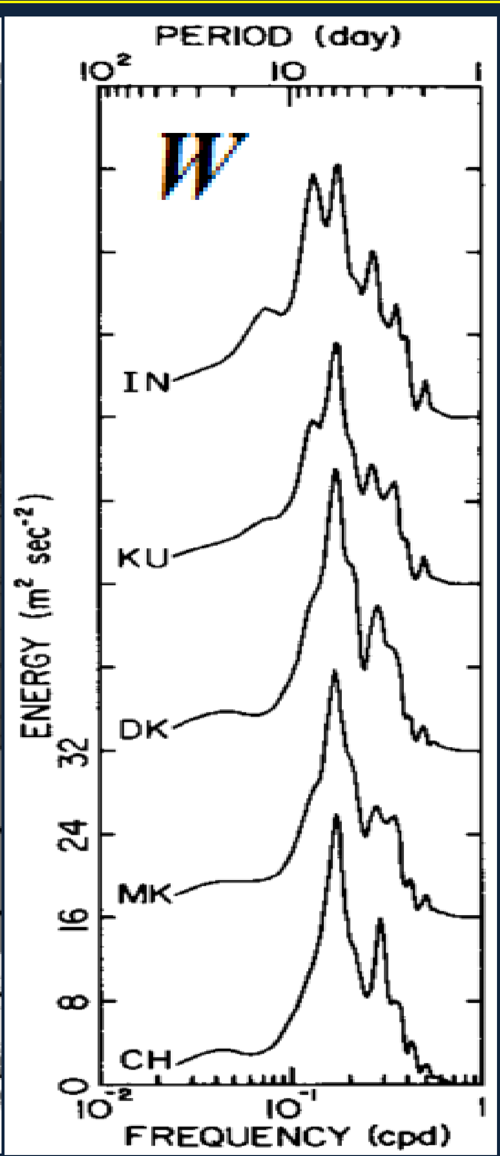

Lin et al., 2011, JGR

# Synoptic variation of SSH and Wind

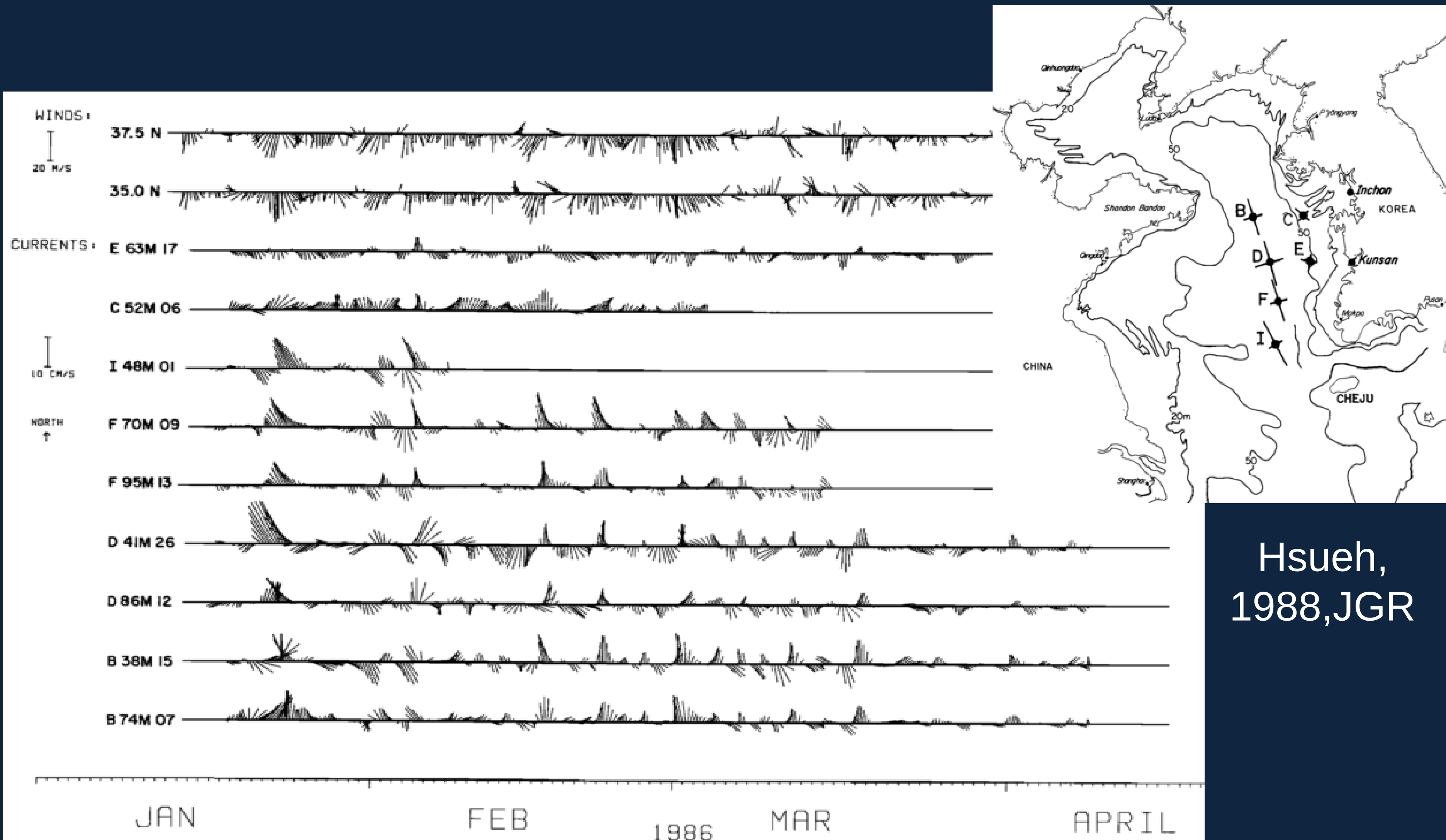



Hsueh and Romea, 1983, JPO



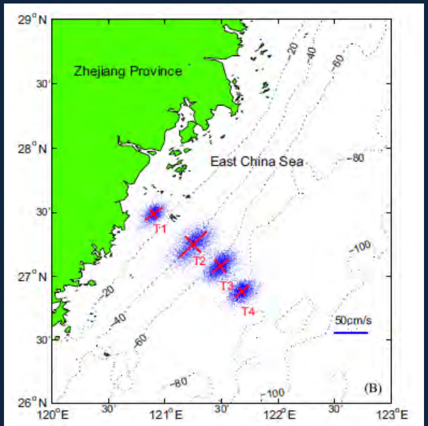



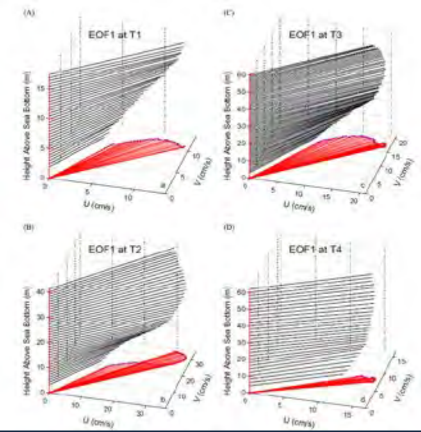
# Synoptic variation of Current and Wind

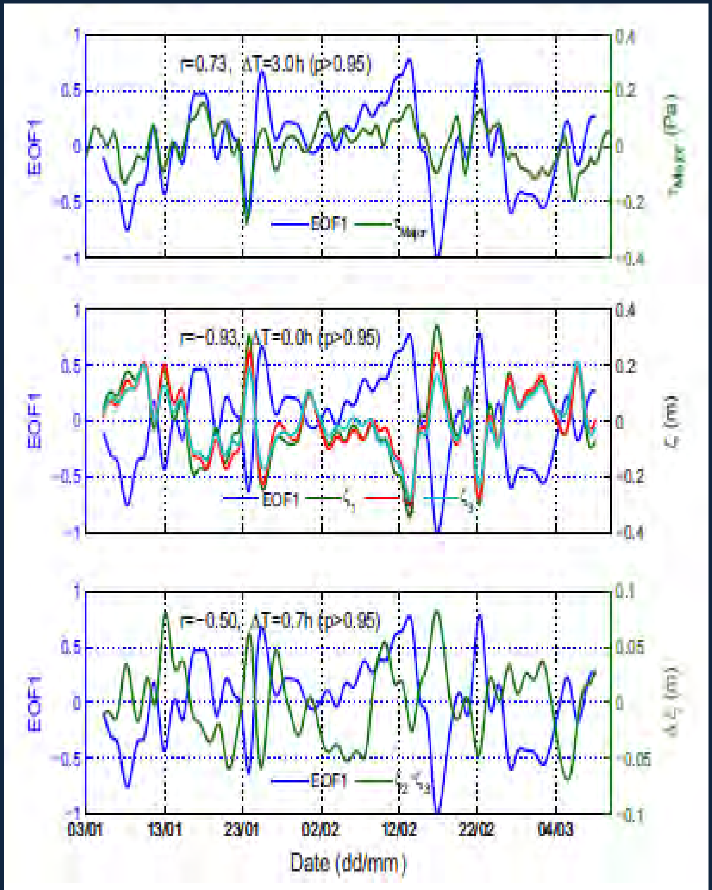


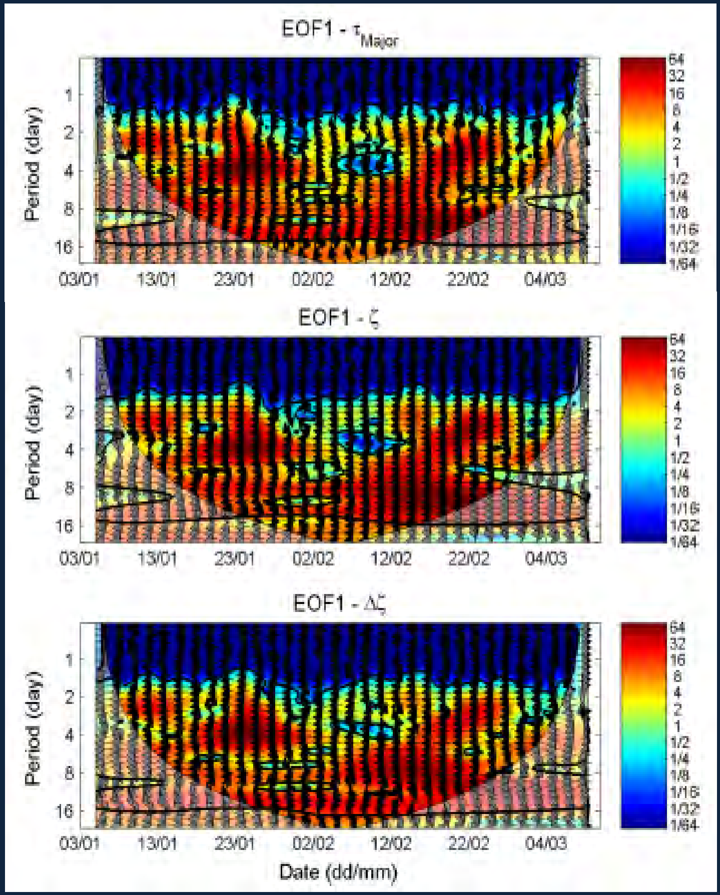

Hsueh, 1988,JGR

# Synoptic variation of SSH, Current and Wind



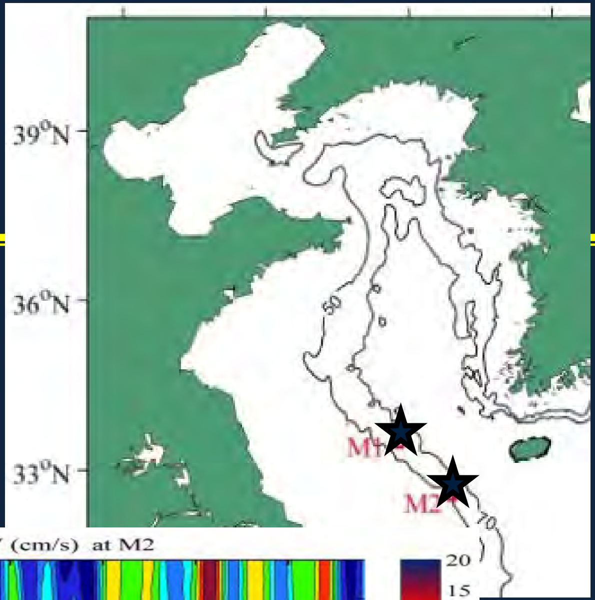



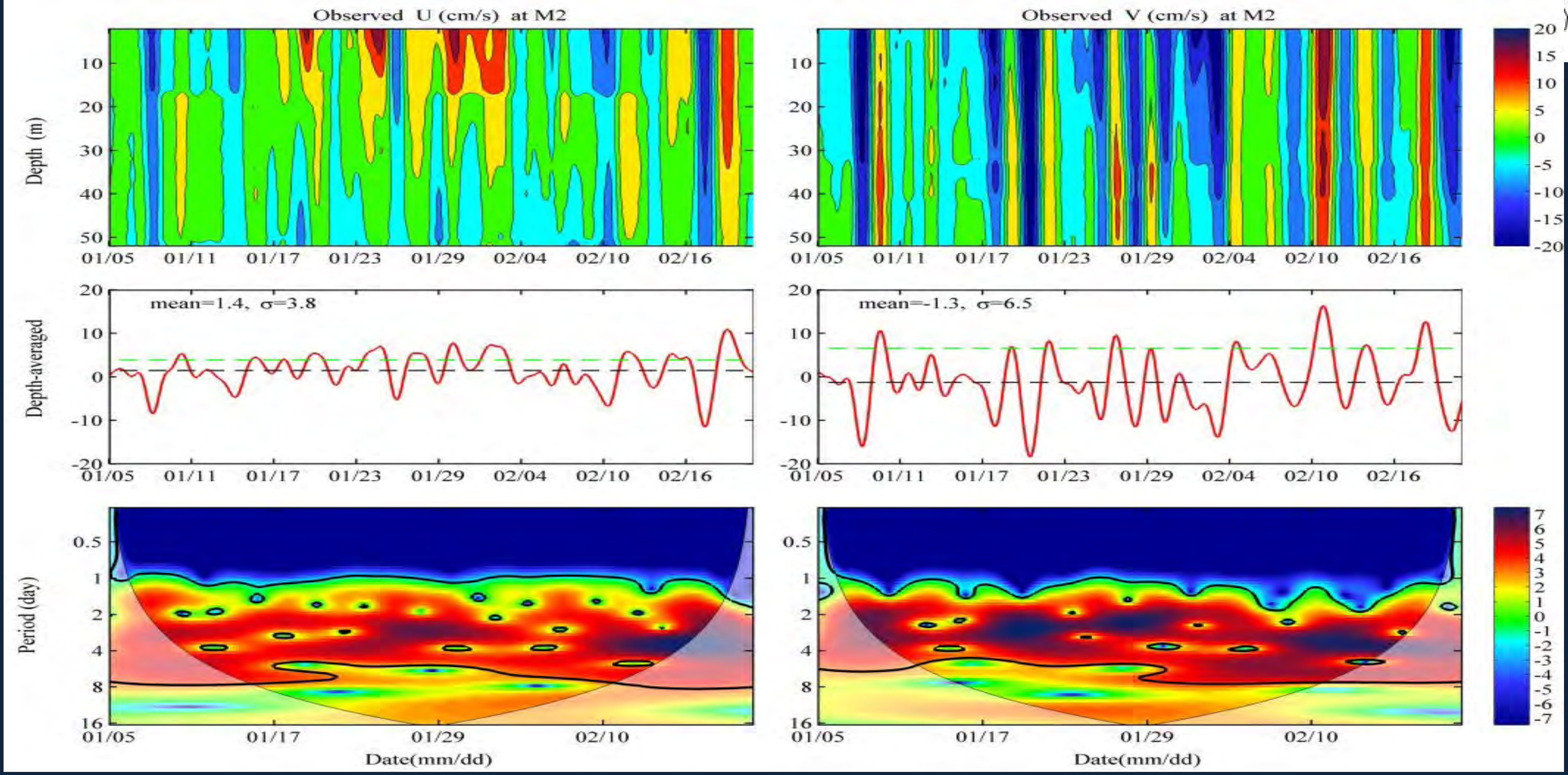




Huang, D., et al, 2016, *DSR II*

# Observed synoptic currents in 2014



# Objective

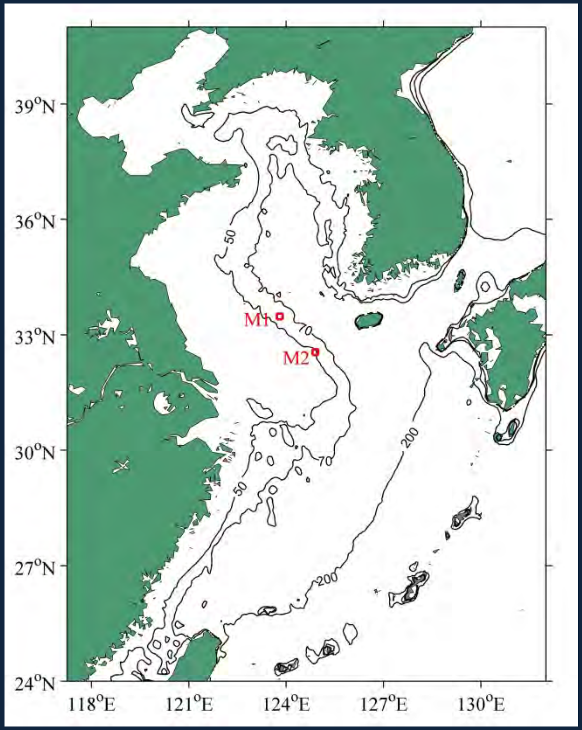
Because of the limitation of spatial resolution and coverage of the observed data, the basin wide spatial and temporal characteristics and the associated dynamical processes of the BYECS in response to synoptic wind are not fully recognized.

First, from the point of view of kinematics, what are the overall characteristics of the SSHA and current in the BYECS in response to strong synoptic wind in winter?

Second, from the point of view of dynamics, how do the SSHA and current in the BYECS response to the wind, namely what is the relationship between wind, SSH and current?

# 2. Data and methods

- **MITgcm**
  - Resolution: 1/20 ×1/20 Deg & 36 levels
  - Topography: Choi (2001)

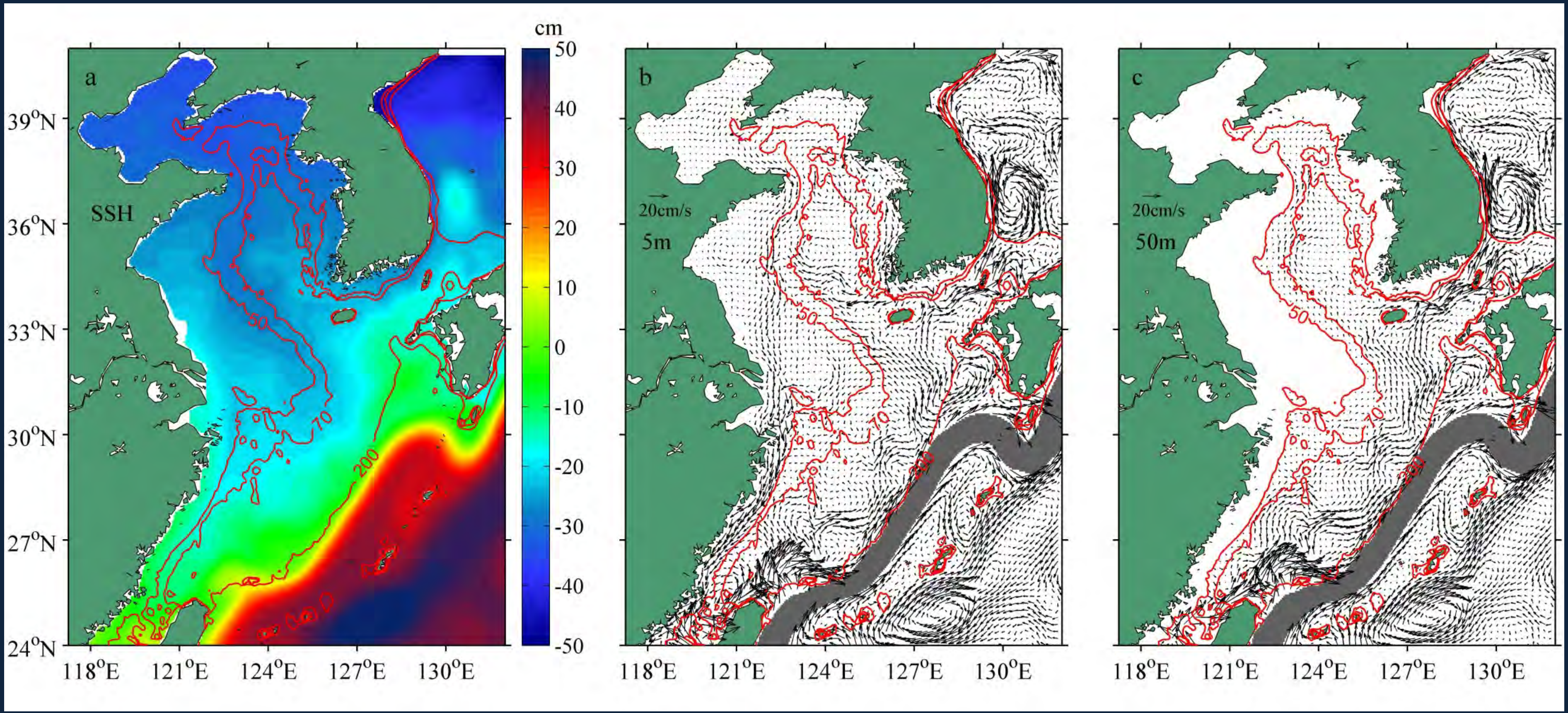



- **Open Boundary Condition**
  - Daily temperature, salinity and velocity obtained from HYCOM results

- **Surface Boundary Condition**
  - Net heat flux and net fresh water flux from ECMWF (3 h)
  - Surface wind speed from ECMWF (3 h)
  - Data assimilation (daily SST from REMSS and SSS from HYCOM)

- **Simulated from Dec. 1, 2013 to Mar. 1, 2014, 3 h outputs**

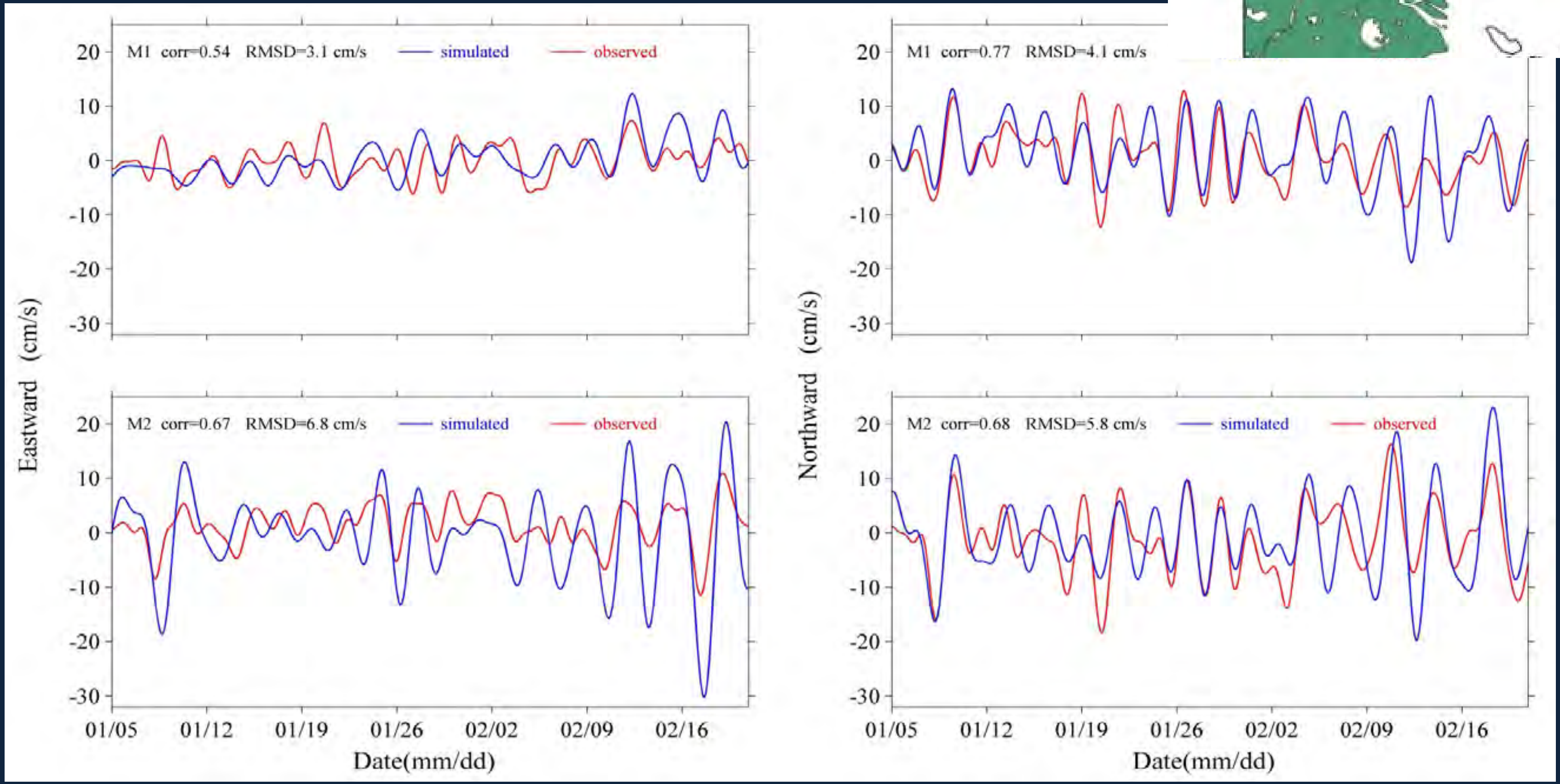
# Model Validation




Simulated wintertime mean of SSH and current

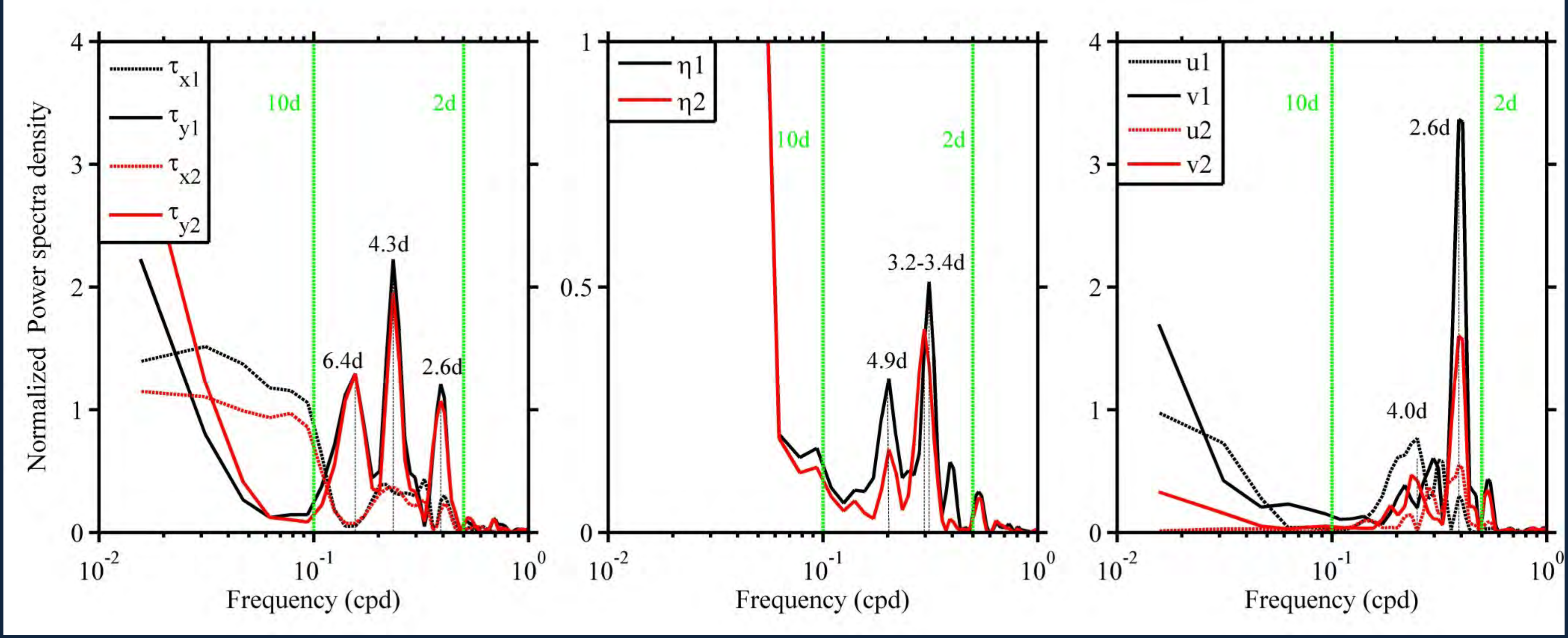
# Model Validation

Comparison between observed and simulated depth-averaged current at M1 and M2

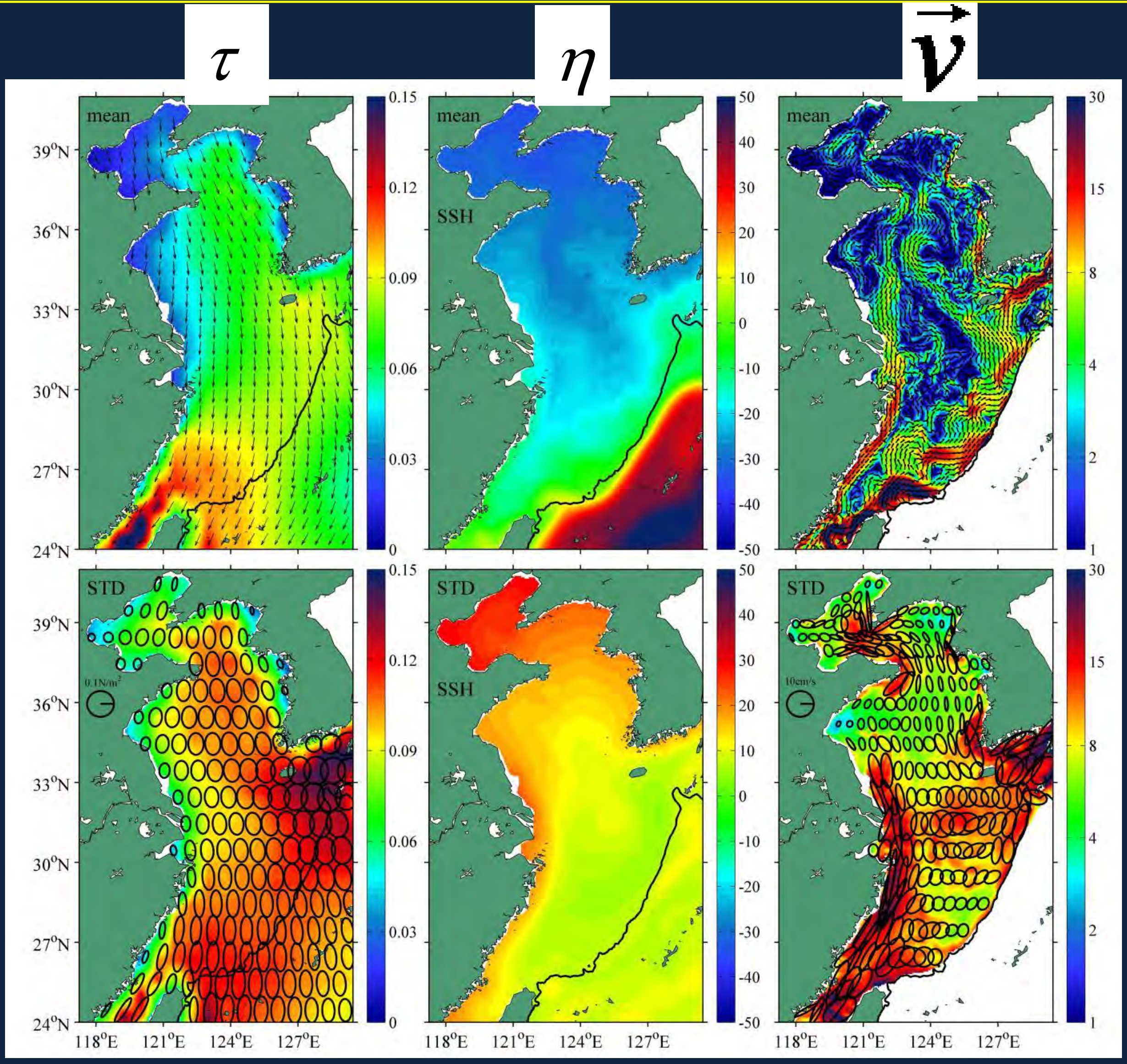



# 3. Results – Band passed


Power spectra of wind stress, SSHA and depth-averaged current at M1 and M2



# Mean and STD of wind stress and simulated SSHA and depth-averaged current




mean

STD

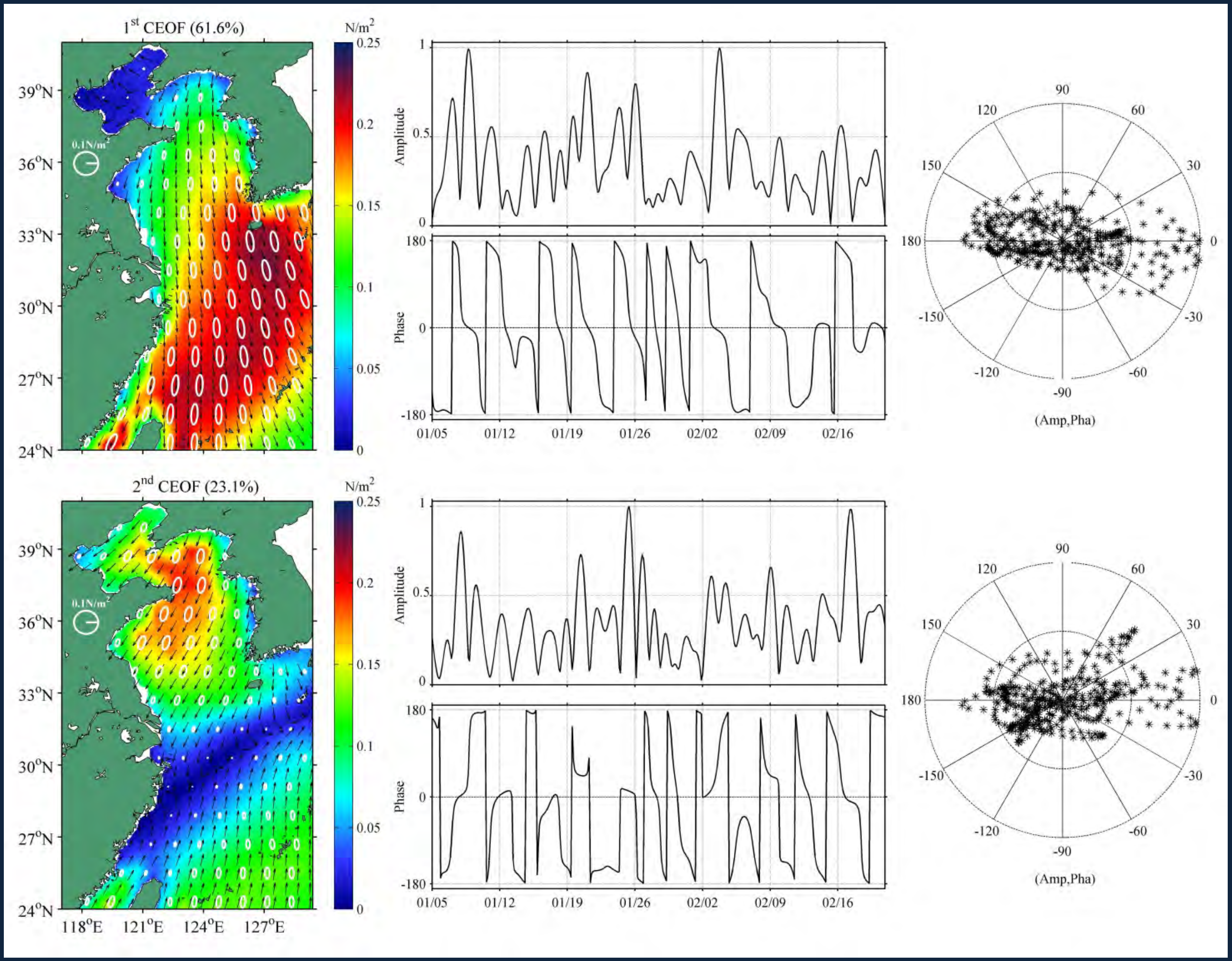
# Complex EOF

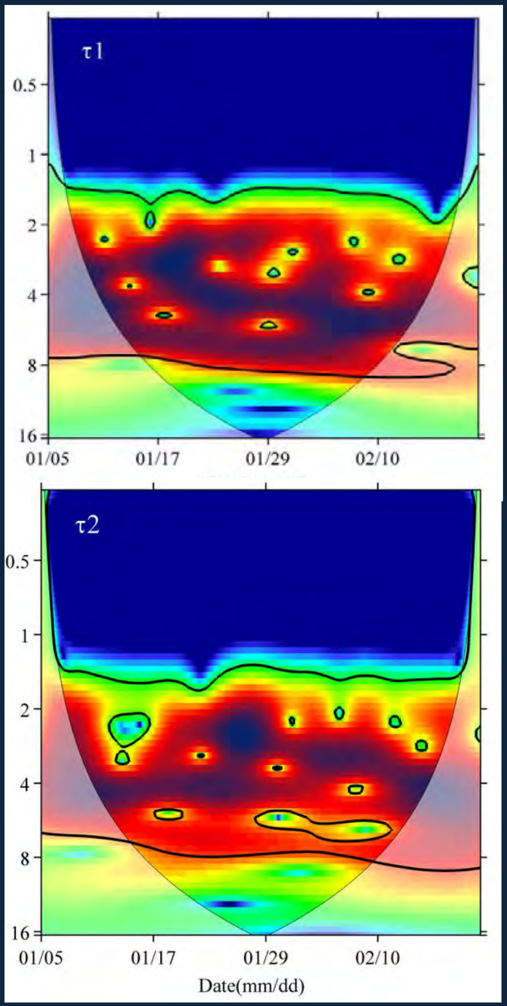
$$\zeta(x,t) = \sum_n A_n(t) \cdot B_n^*(x)$$

$A_n(t)$ : complex principal components

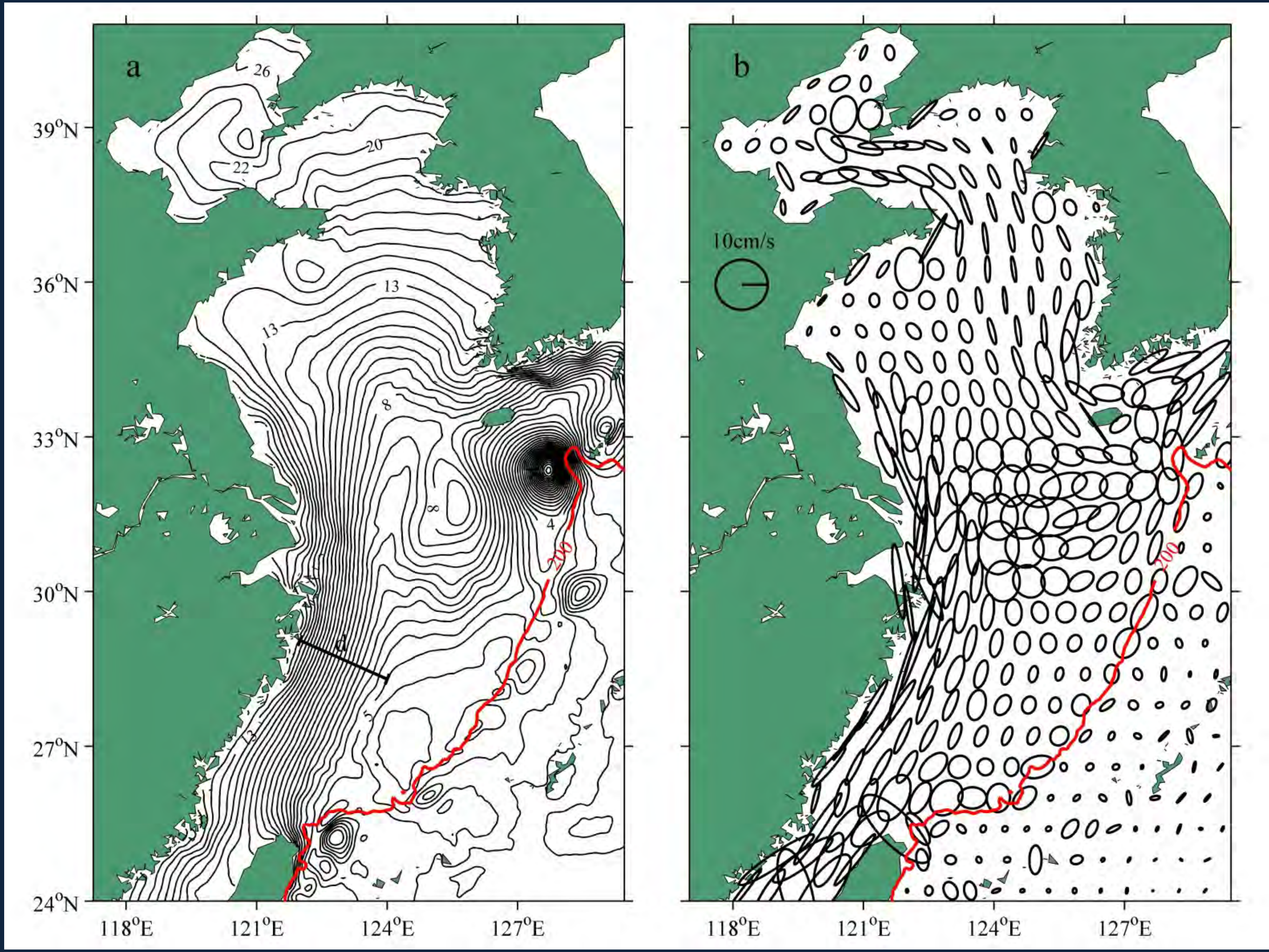
$B_n(x)$ : complex spatial patterns

# Two leading CEOFs (61.6%, 23.1%) of wind stress

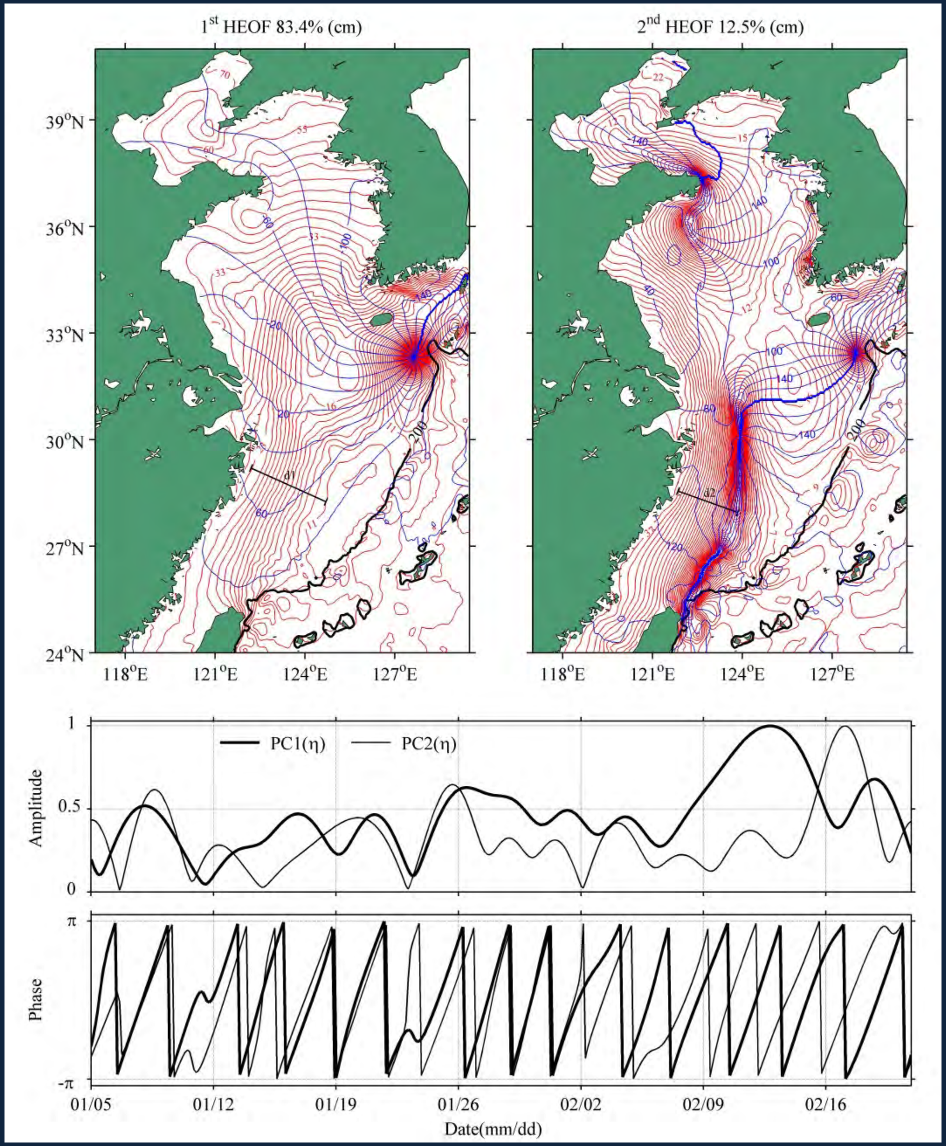


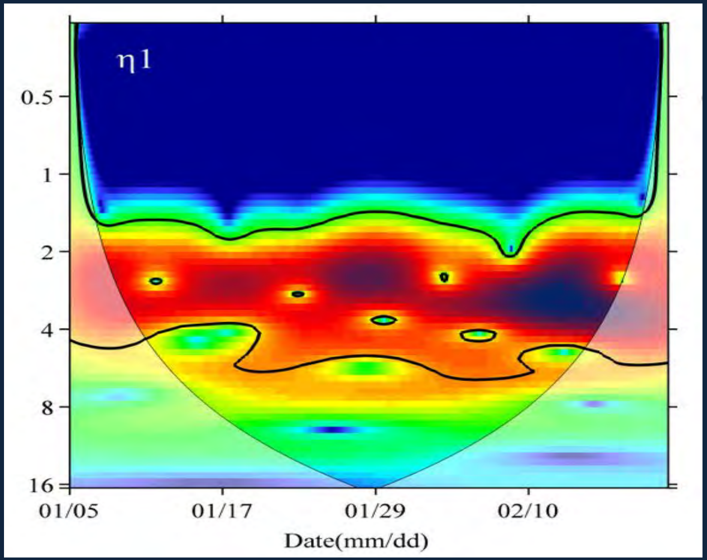



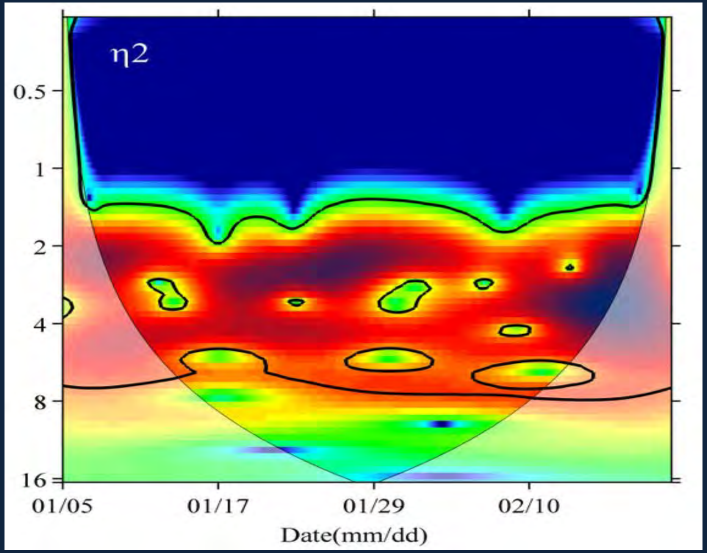
# STD of SSHA (left, cm) and current (right, cm/s)



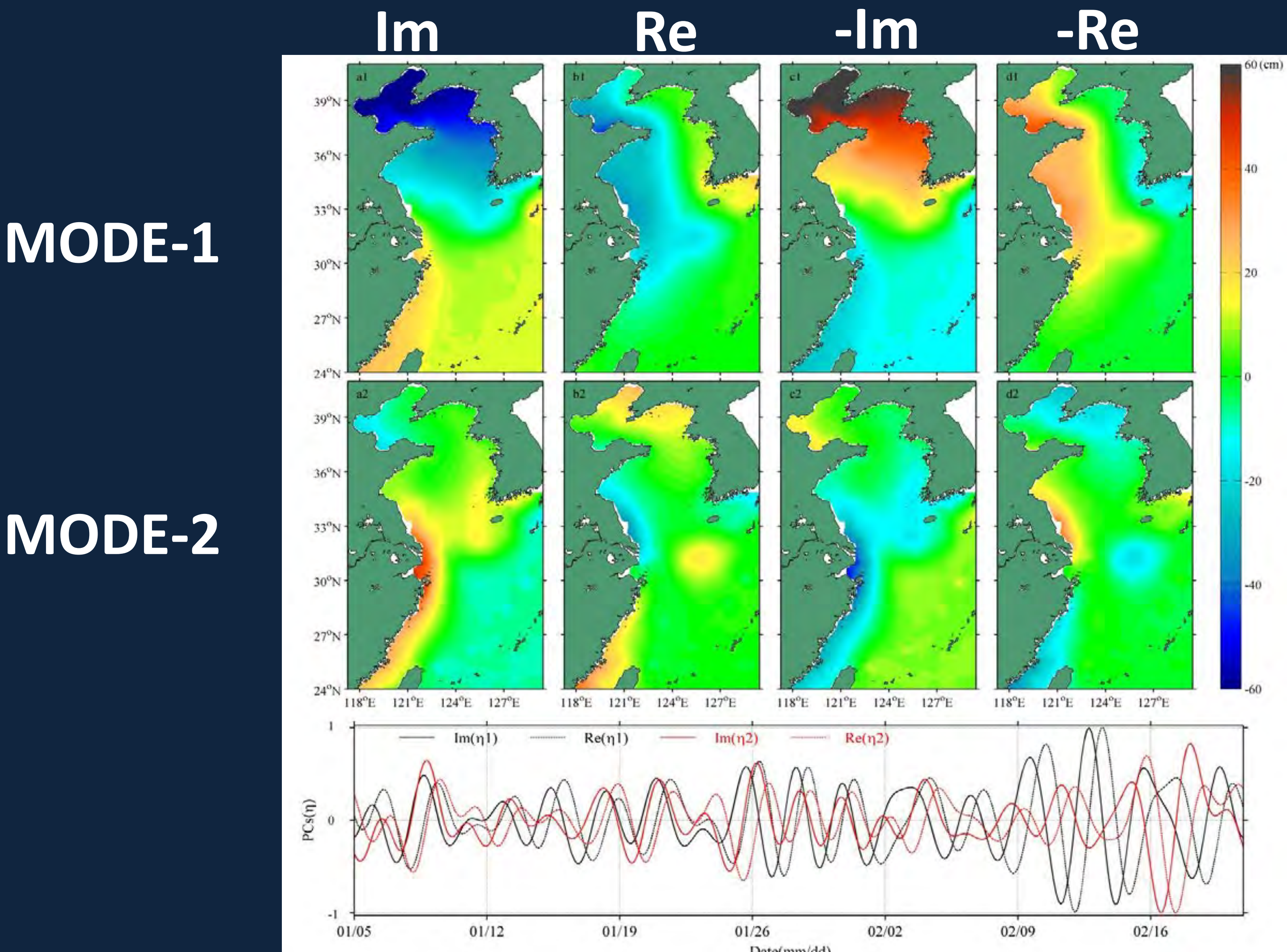
# Two leading HEOFs (83.4%, 12.5%) of SSHA



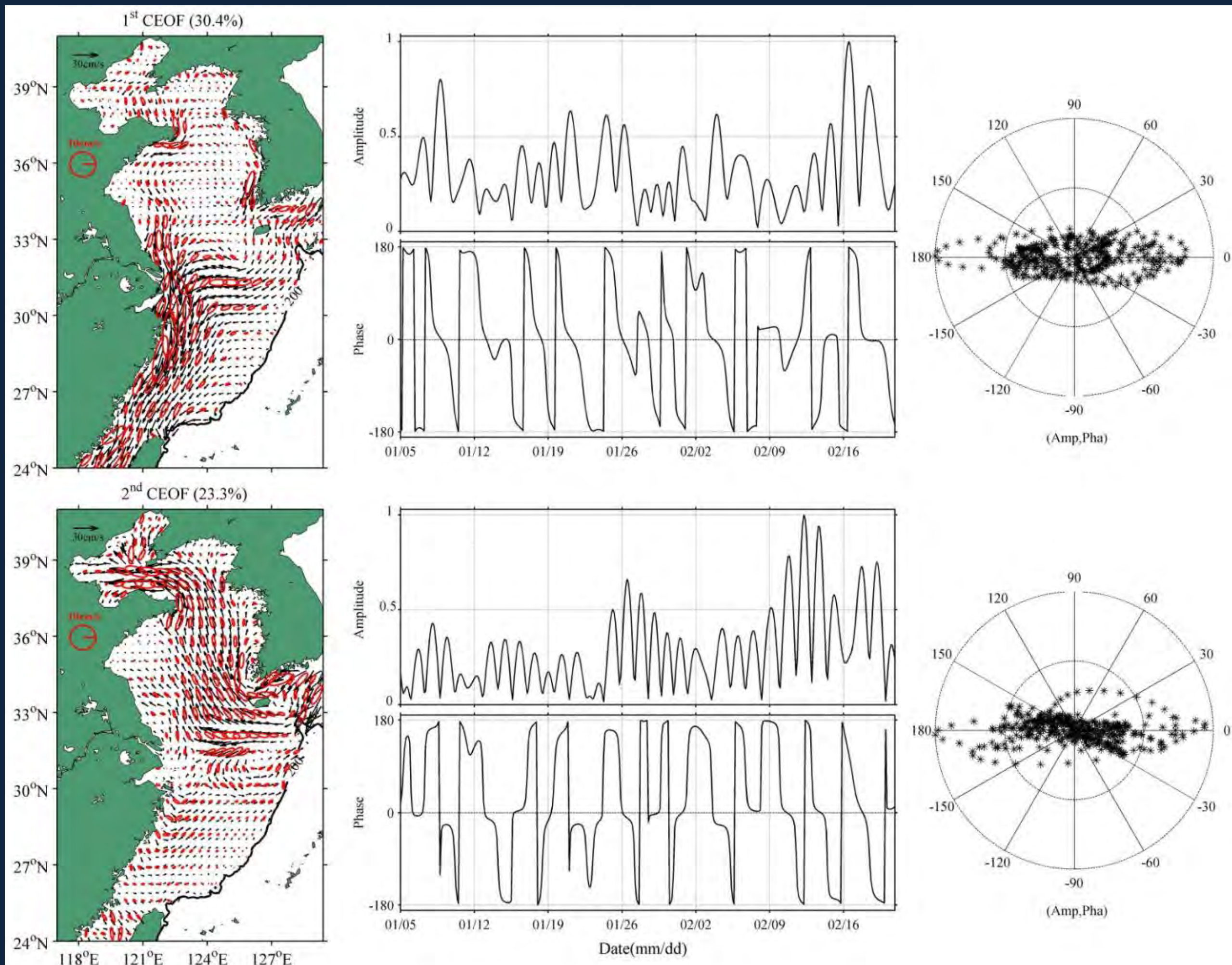



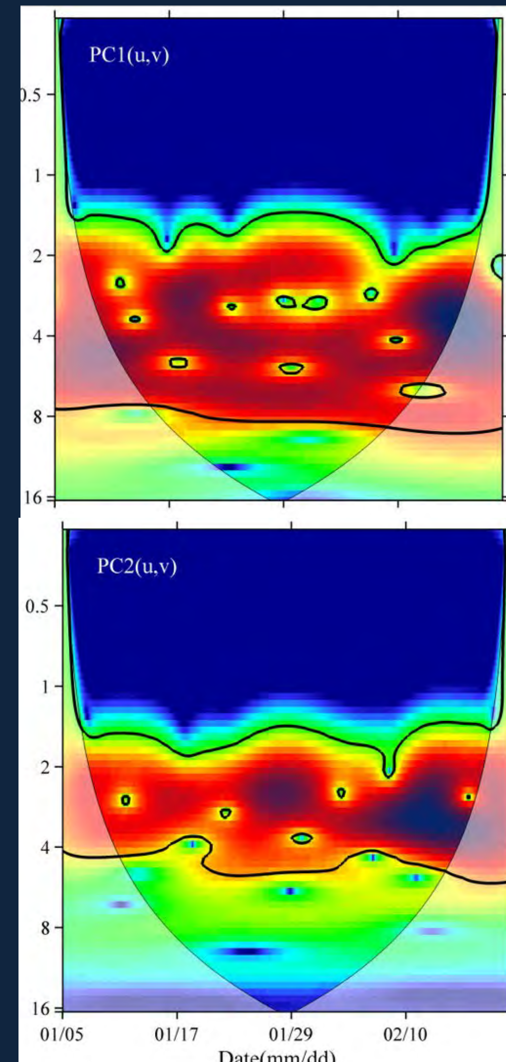



# Interpretation of two leading HEOFs of SSHA



# Two leading CEOFs (30.4%, 23.3%) of current



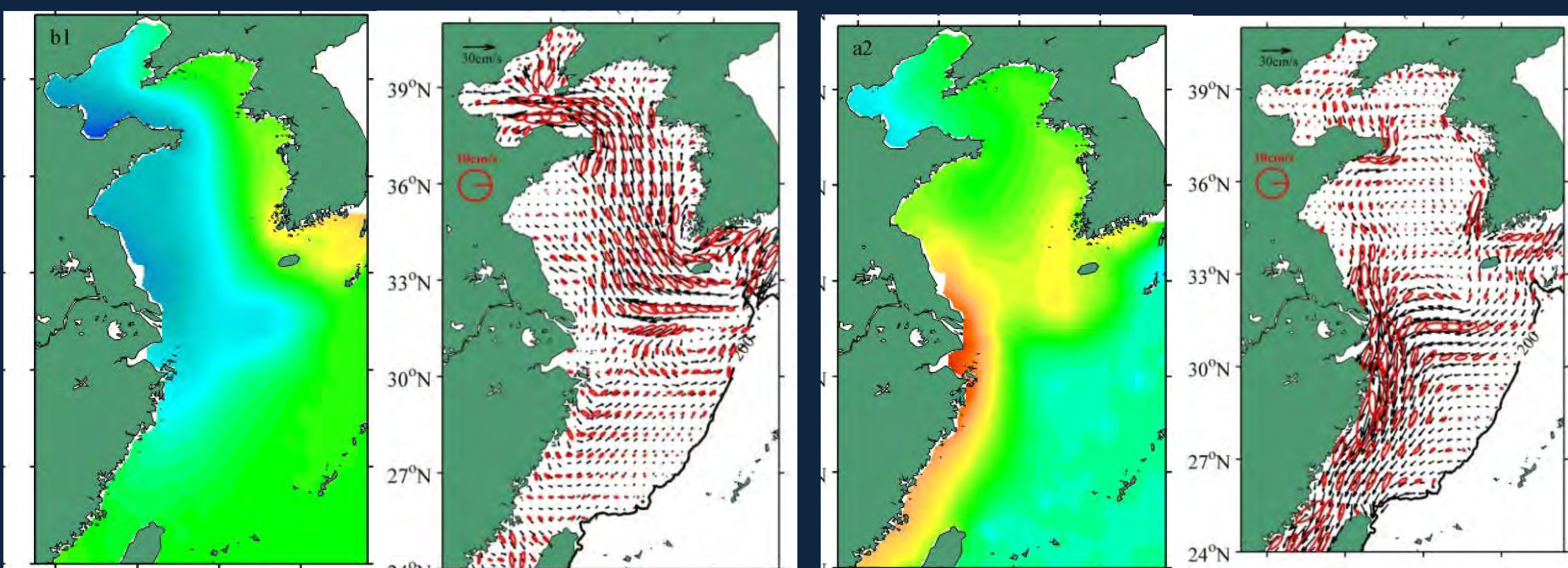




Reversing current

# Correlation between wind SSHA and current

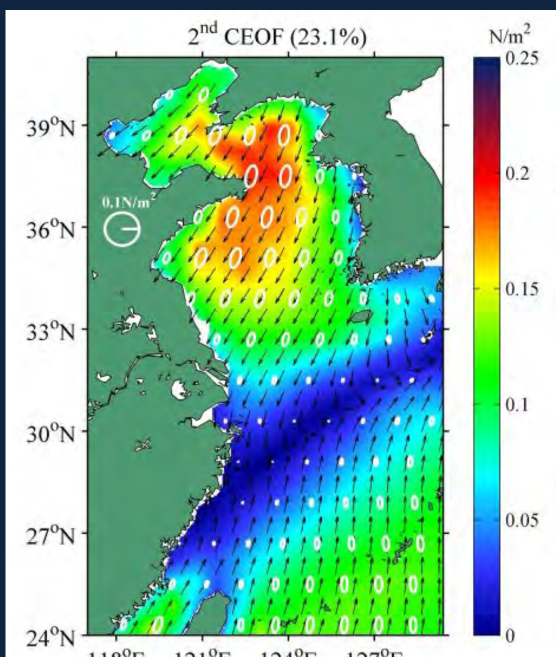
| | $(u, v)_1$ | $(u, v)_2$ |
|---|---|---|
| $\eta_1$ | 0.26 | **0.95** |
| $\eta_2$ | **0.82** | 0.46 |

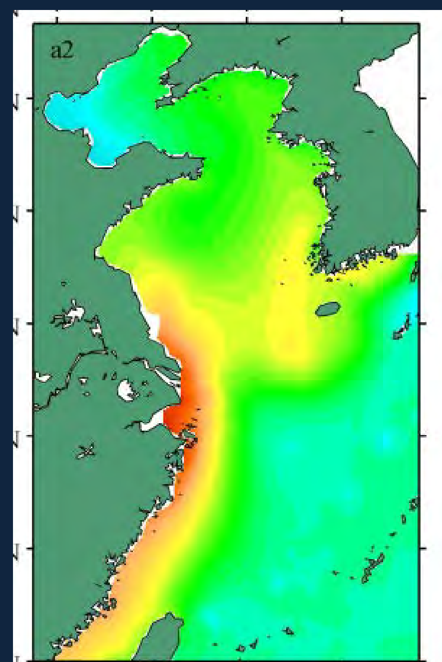
**Predominant geostrophic balance between HEOF1 and CEOF2 and between HEOF2 and CEOF1**

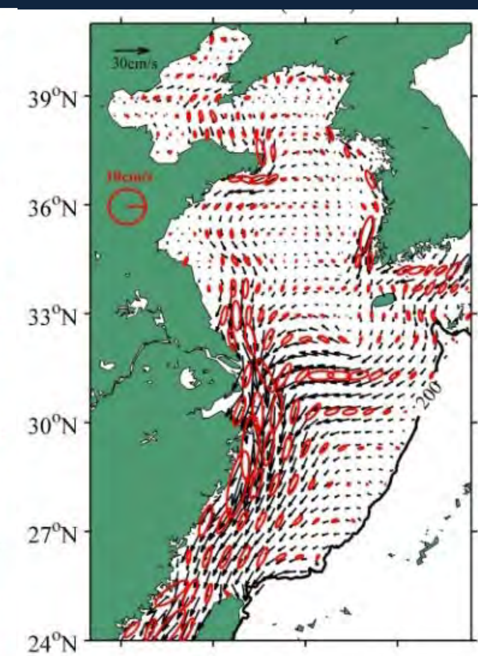


# Correlation between wind stress and SSHA, current

| | $\eta_1$ | $\eta_2$ | $(u, v)_1$ | $(u, v)_2$ |
|---|---|---|---|---|
| $\tau_1$ | 0.27, 7h | **0.53, 5h** | **0.84, 0h** | -0.20, 6h |
| $\tau_2$ | 0.35, 3h | **0.70, 0h** | **-0.69, 6h** | -0.36, 3h |



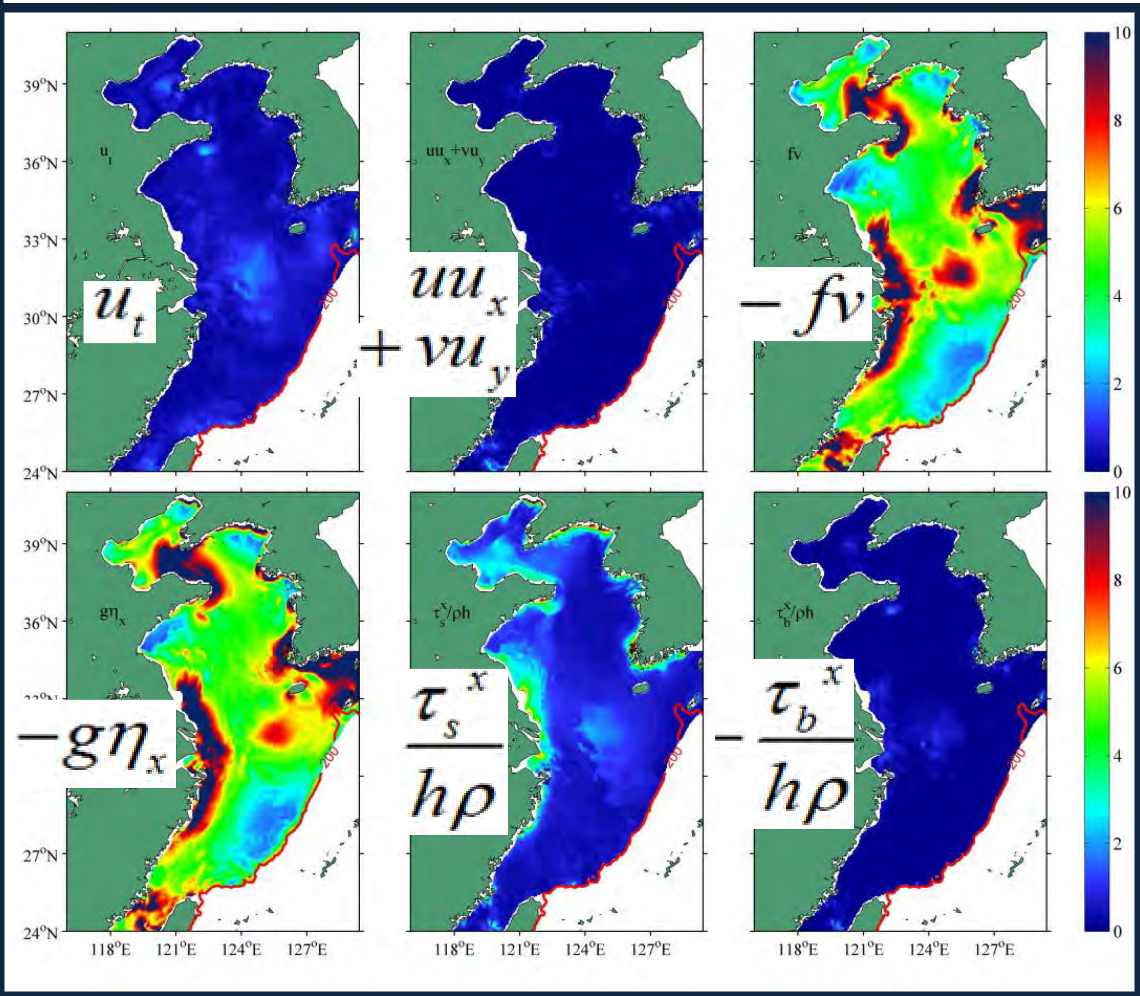




HEOF2 and CEOF1 are strongly correlated with stress

# Dynamic balance: in minor axis direction

$$u_t + uu_x + vu_y - fv = -g\eta_x + \frac{\tau_s^{\ x}}{h\rho} - \frac{\tau_b^{\ x}}{h\rho}$$

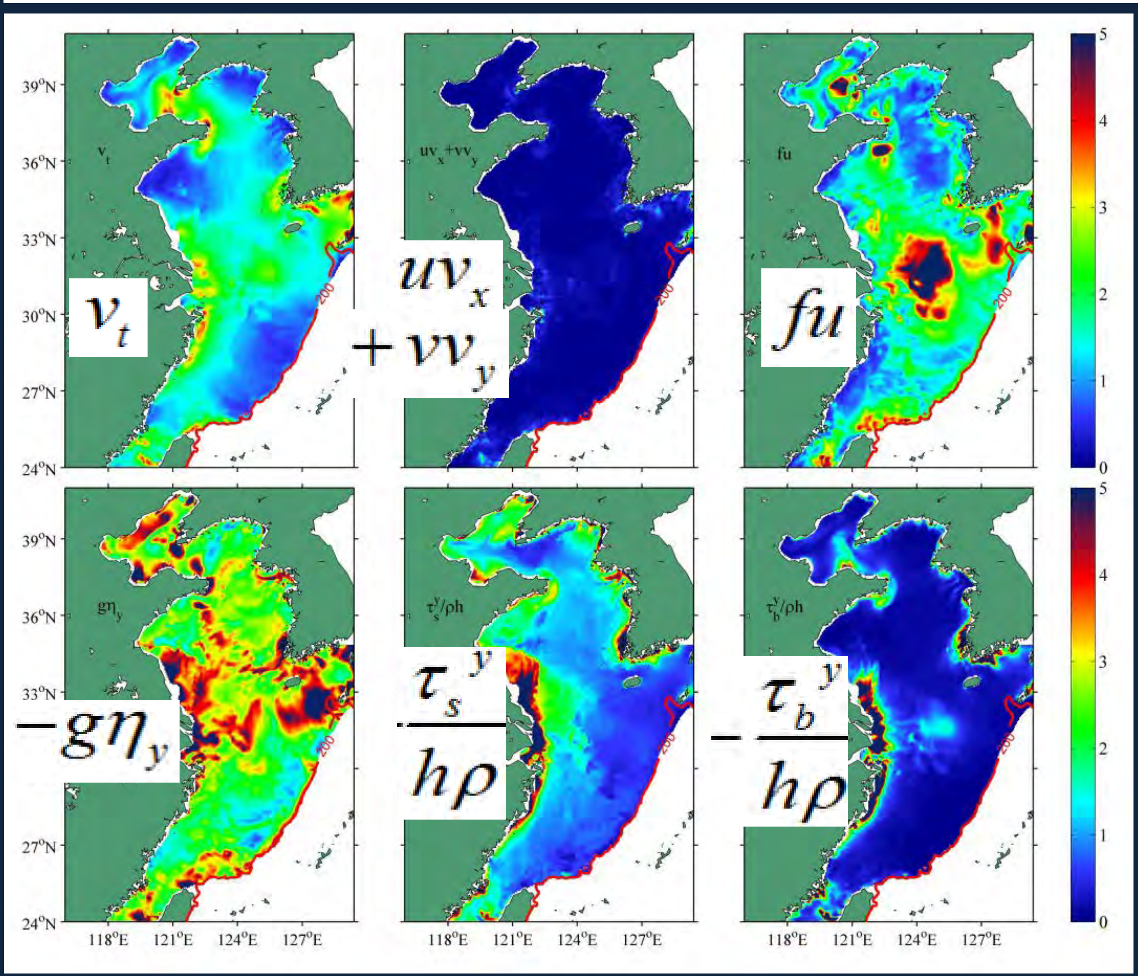



unit: $10^{-6} ms^{-2}$

**Geostrophic Balance**

# Dynamic balance: in major axis direction

$$v_t + uv_x + vv_y + fu = -g\eta_y + \frac{\tau_s^{\ y}}{h\rho} - \frac{\tau_b^{\ y}}{h\rho}$$



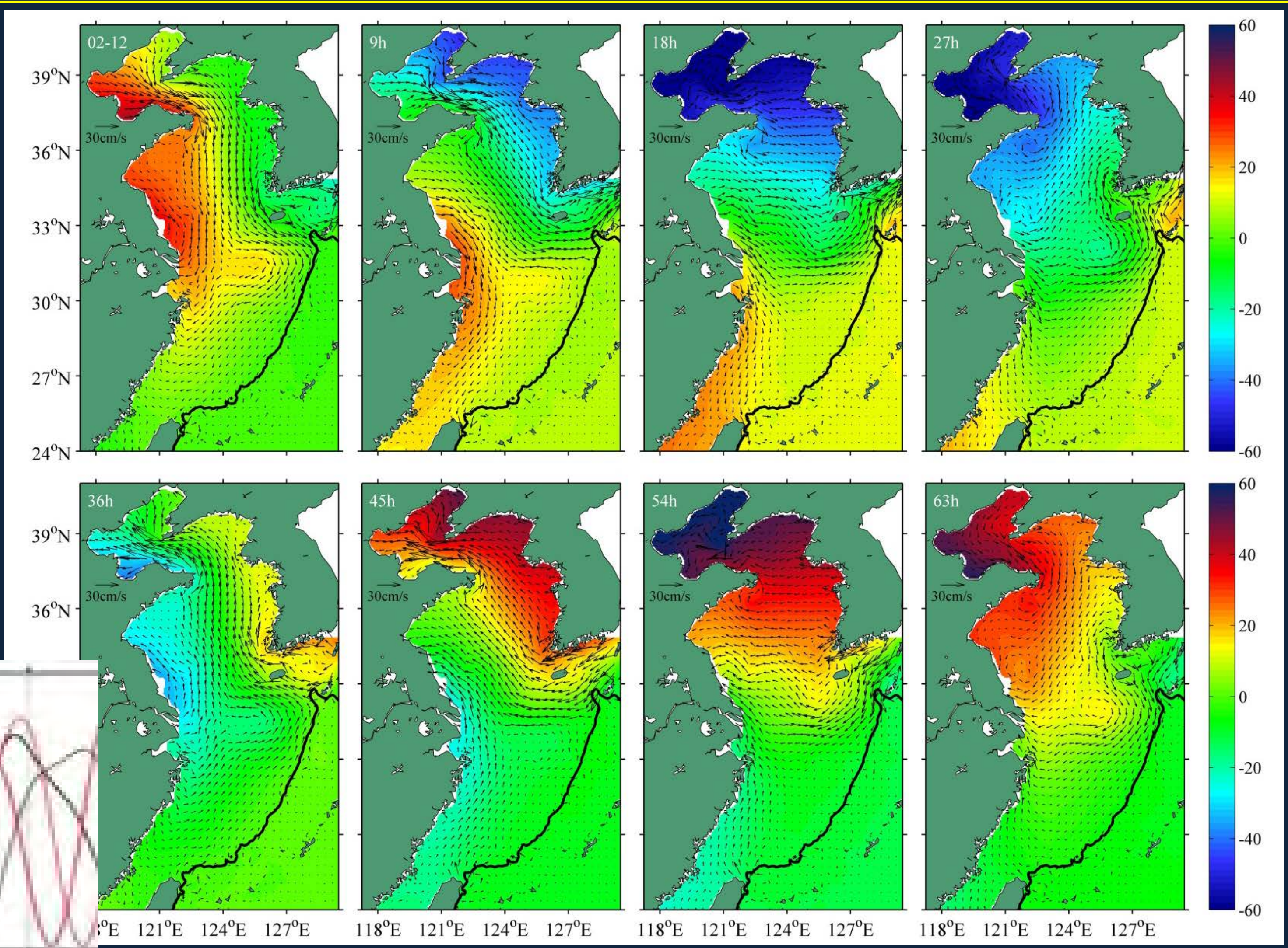

unit: $10^{-6}ms^{-2}$

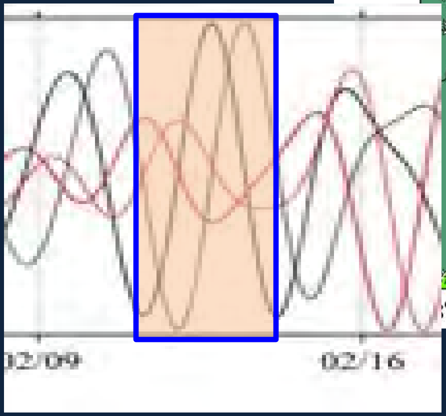
- Tendency
- Coriolis Force
- Pressure Gradient
- Wind Stress

- Non-linear
- Bottom Friction

# Reconstructed SSHA and associated geostrophic currents from HEOF-1

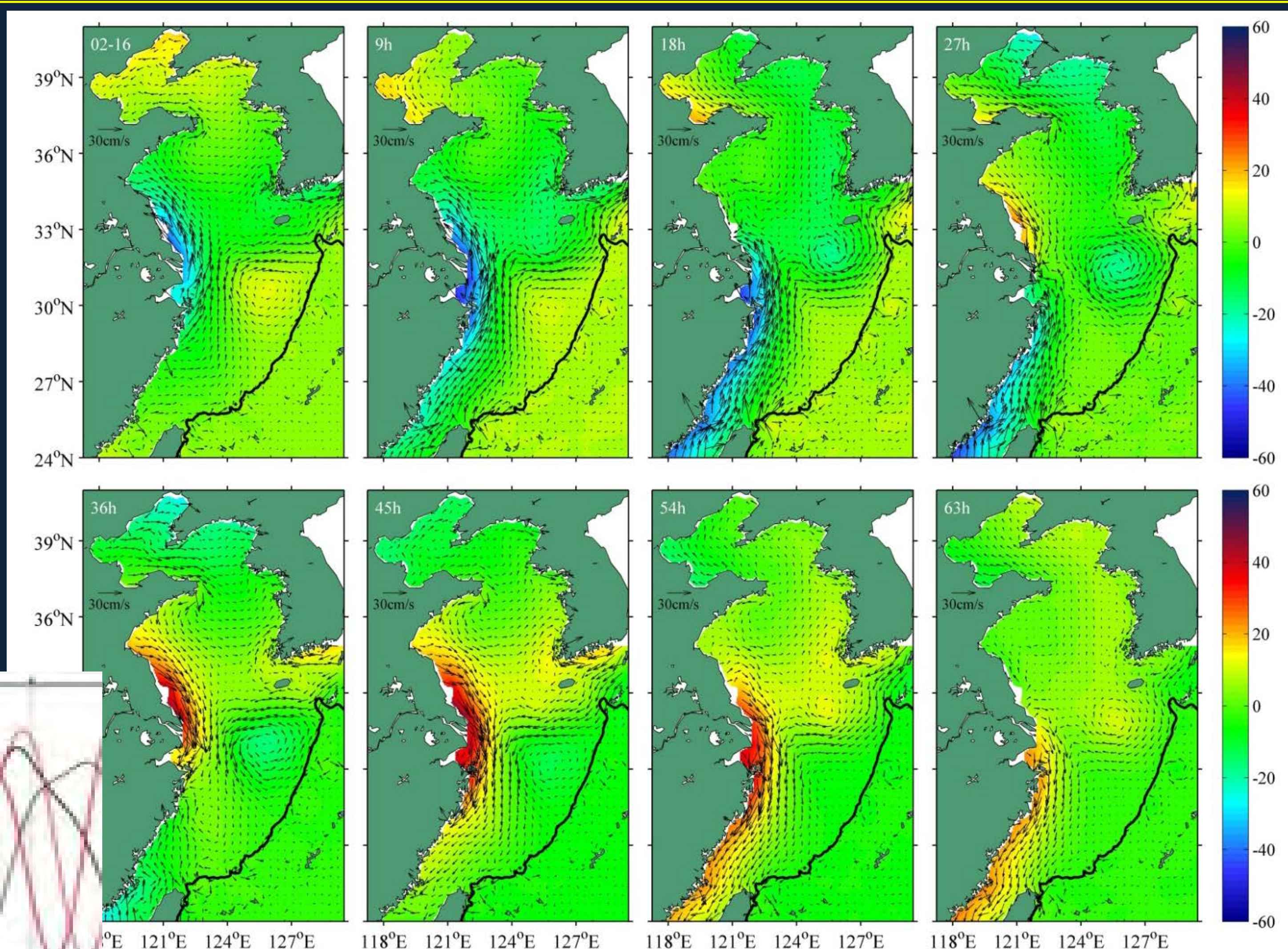
$$\Delta t = 9h \approx \frac{1}{8}T$$

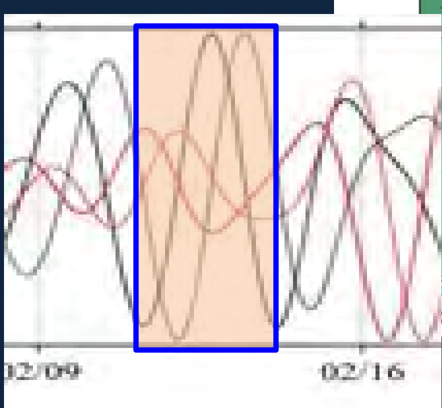


# Reconstructed SSHA and associated geostrophic currents from HEOF-2

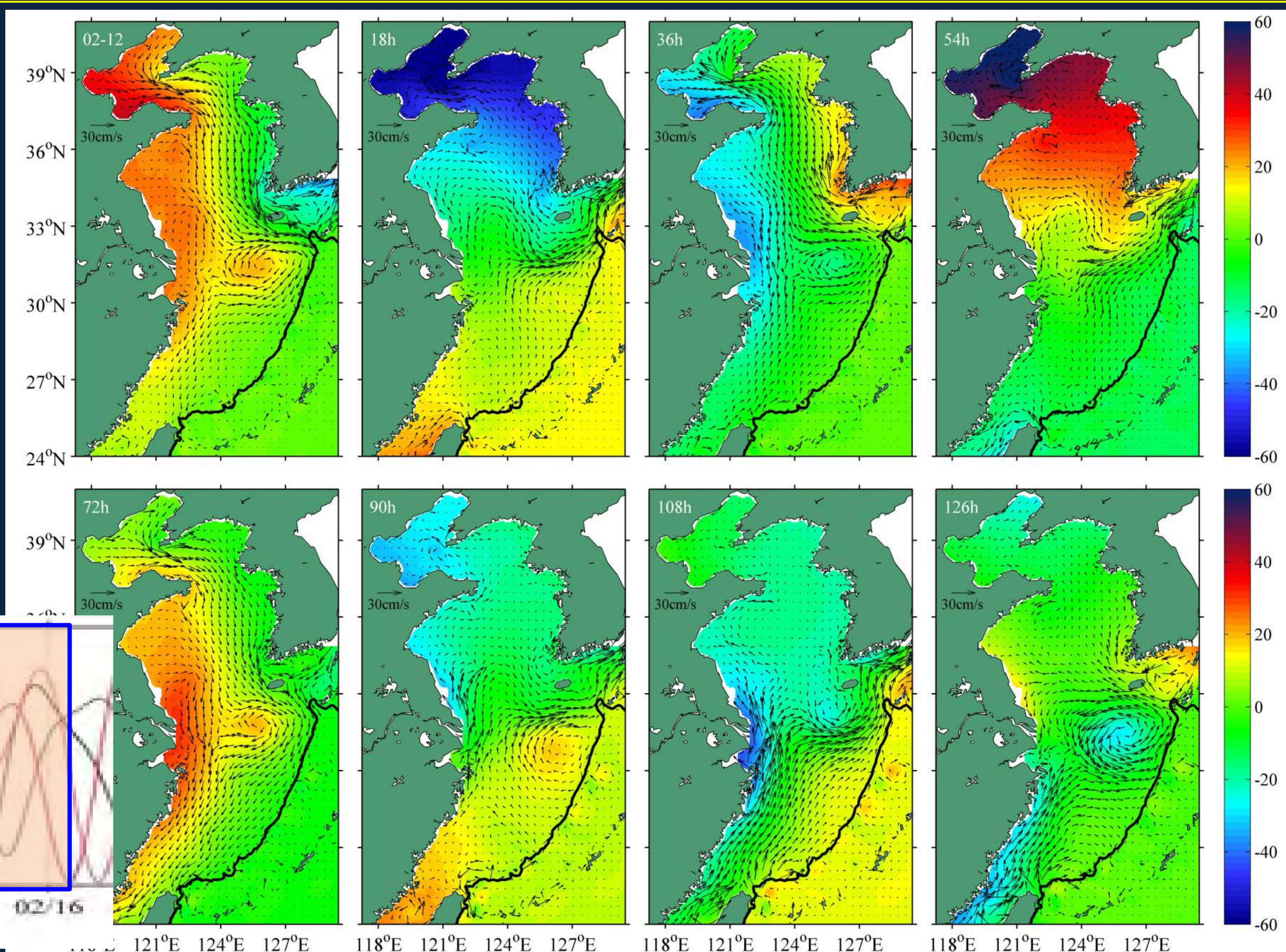
$$\Delta t = 9h \approx \frac{1}{8}T$$

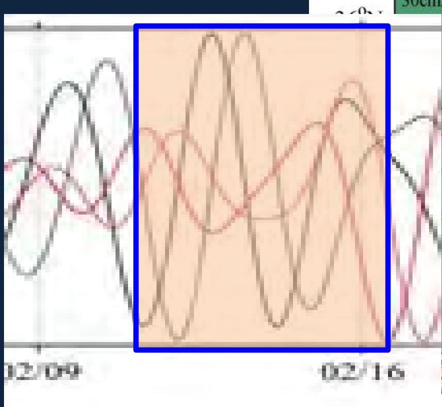


# Simulated SSHA and current anomaly

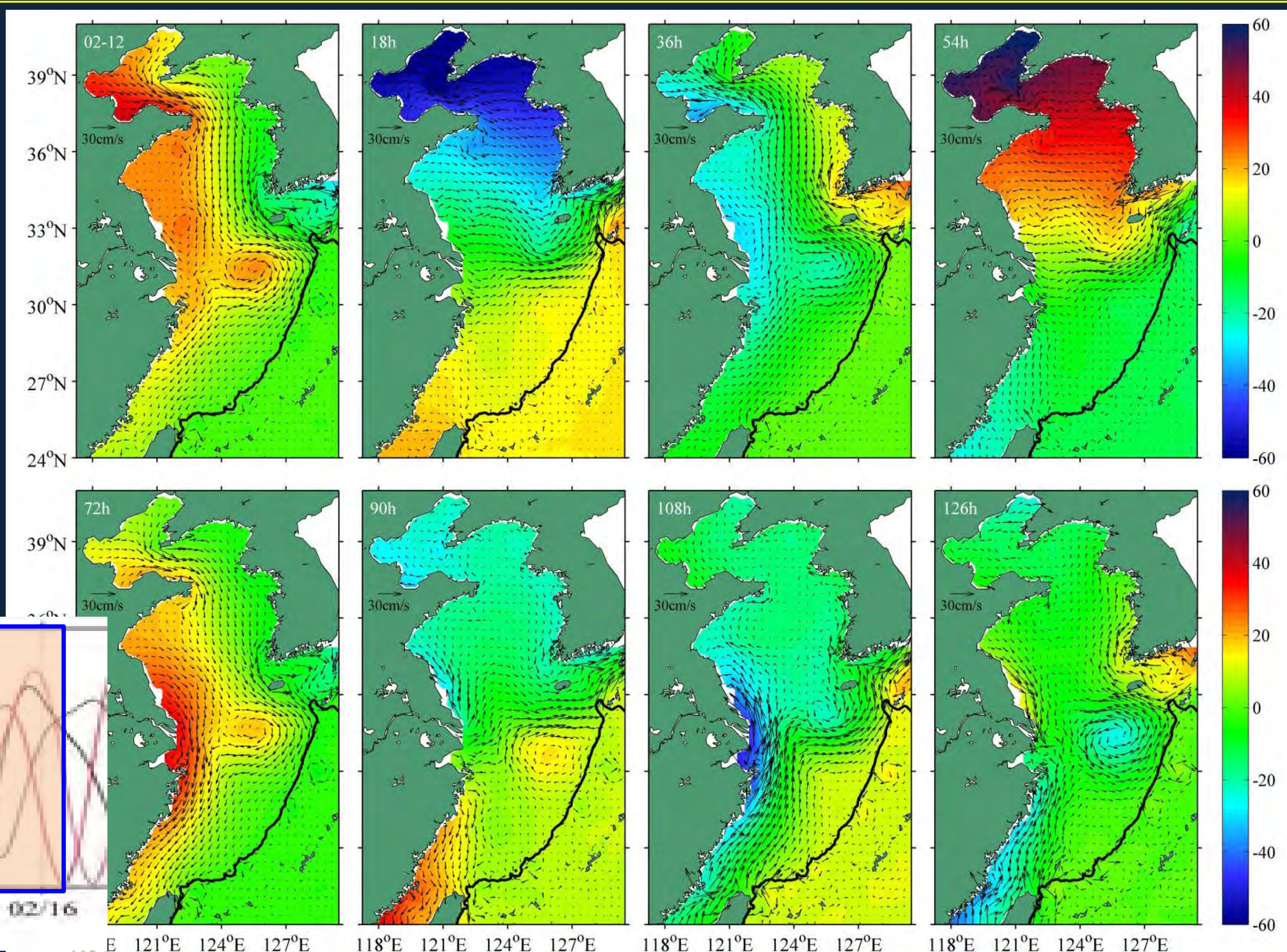
$$\Delta t = 18h \approx \frac{1}{4}T$$

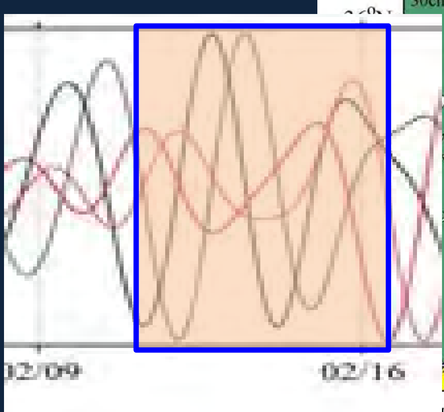


# Reconstructed SSHA and associated geostrophic currents from two HEOFs

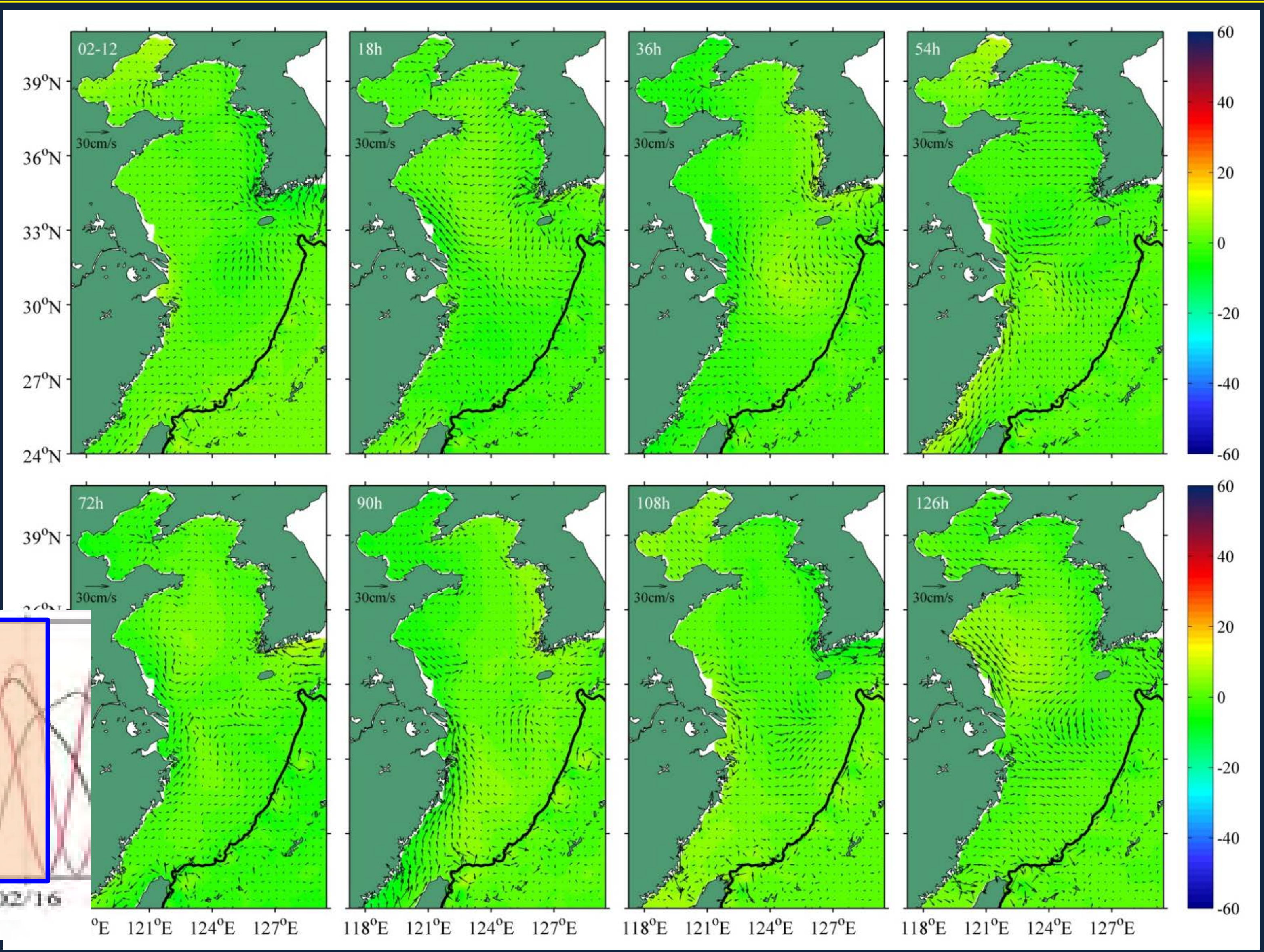
$$\Delta t = 18h \approx \frac{1}{4}T$$

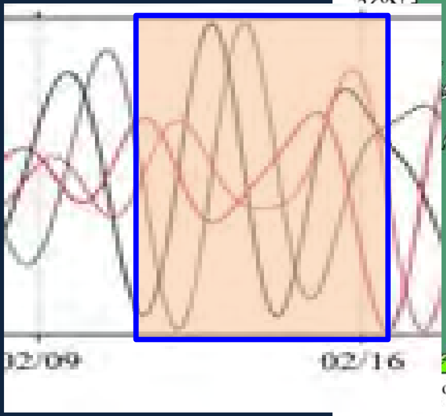


# Residual SSHA and currents after two HEOFs and associated geostrophic currents

$$\Delta t = 18h \approx \frac{1}{4}T$$



# 4. Summary

The response of SSHA and current to wind shows much stronger synoptic variability than their means.

The synoptic variation of SSHA is reflected by two leading coastal trapped waves with one and three nodes, respectively.

The current is closely associated with SSH via geostrophic balance and is accelerated by wind stress and pressure gradient.

# Thank You for Your Attention!