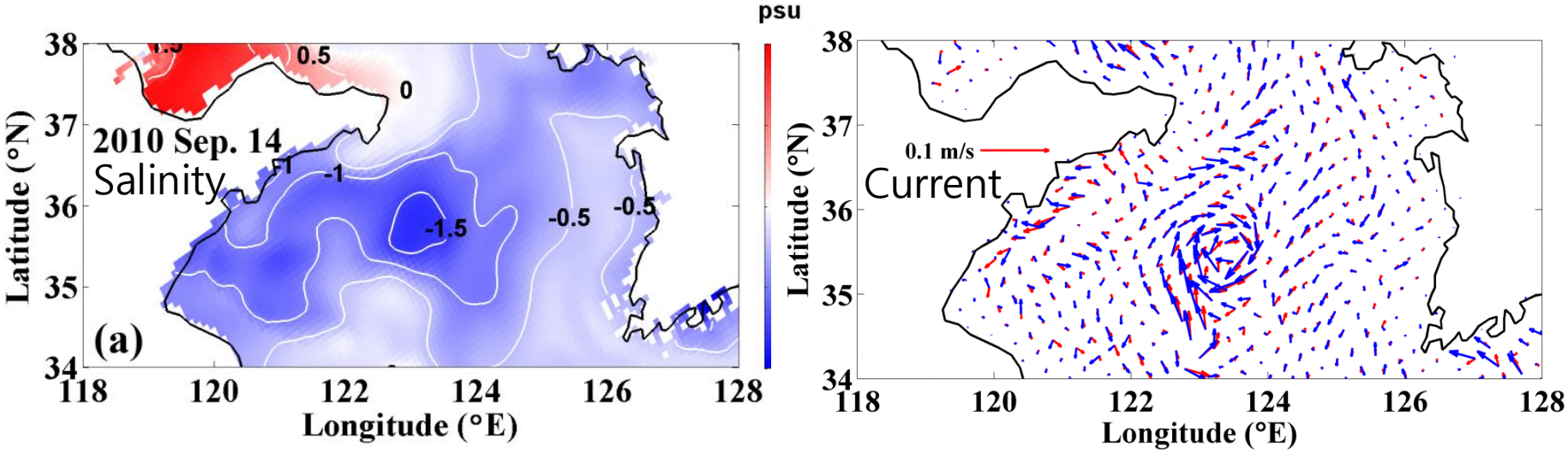
Response of mid-latitude coastal ocean to the heavy rainfall: model simulations in the Yellow Sea



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01. Introduction

1.1. Background

There are **high precipitation during the summer** and high evaporation during the winter over the surface of Yellow Sea, Bohai Sea and East China Sea. Short term effect of precipitation and evaporation on the ocean surface has not get much attention as surface forcing in the mid-latitude coastal ocean.

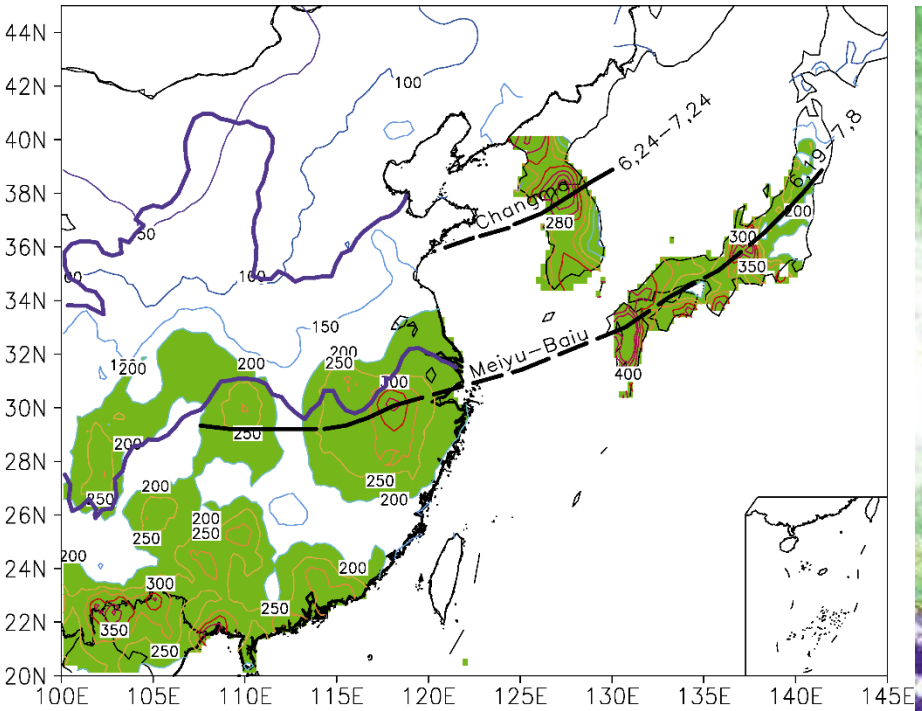
1.2. Objectives

◈ To estimate the effect of precipitation and evaporation on changes in salinity, temperature, and surface current distribution in a coastal ocean.

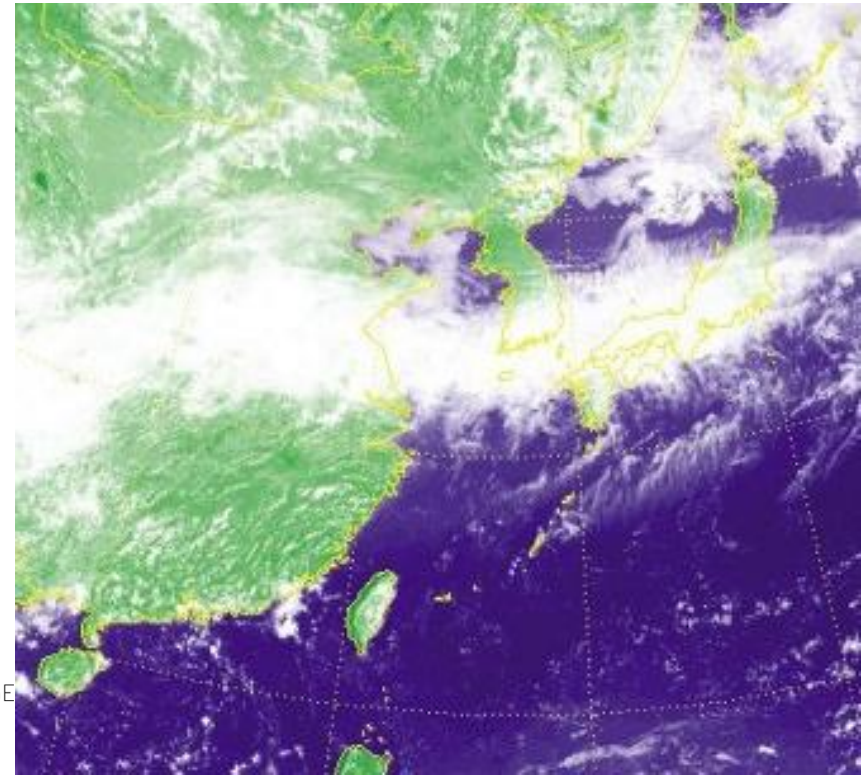
◈ To understand accumulation and mixing processes of rain water during the high precipitation events.

01. Introduction

Cloud band indicates heavy rain by Asian Summer Monsoon (Changma, Meiyu, or Baiu) front

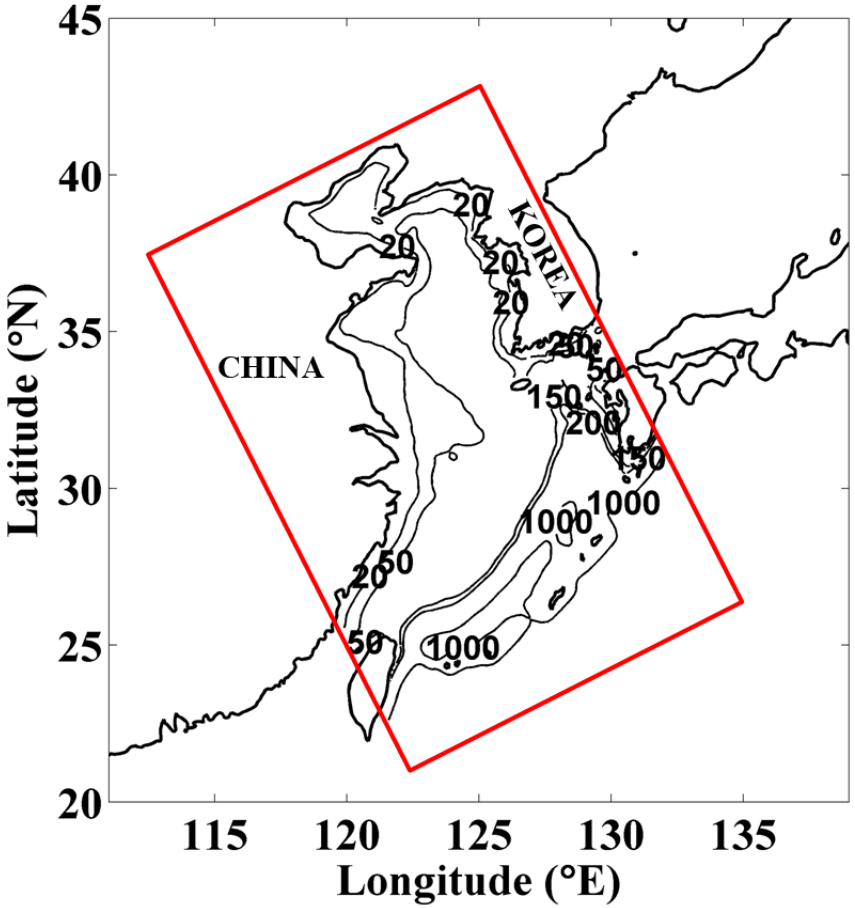


LÜ et al. *Atmospheric and Oceanic Science Letters*, 2013.



Precipitation: 300-500 mm/week

02. Method



1. Model

- ROMS with horizontal grid spacing 1/12° and 30 vertical sigma levels
- Bohai, Yellow and East China Seas
- Bathymetry from ETOPO5 and KorBathy30s [Seo, 2008] .

2. Boundary and Initial Condition

- U, V and Z from Northwest Pacific regional model [Seo et al., 2011]
- Initial Temp and Salinity from WOA

3. Forcing

- Hourly air temperature, surface pressure, relative humidity, short wave radiation, precipitation, and winds from KIOST WRF.
- 12 tidal constituents from TPX06.

4. River Discharge: 14 rivers

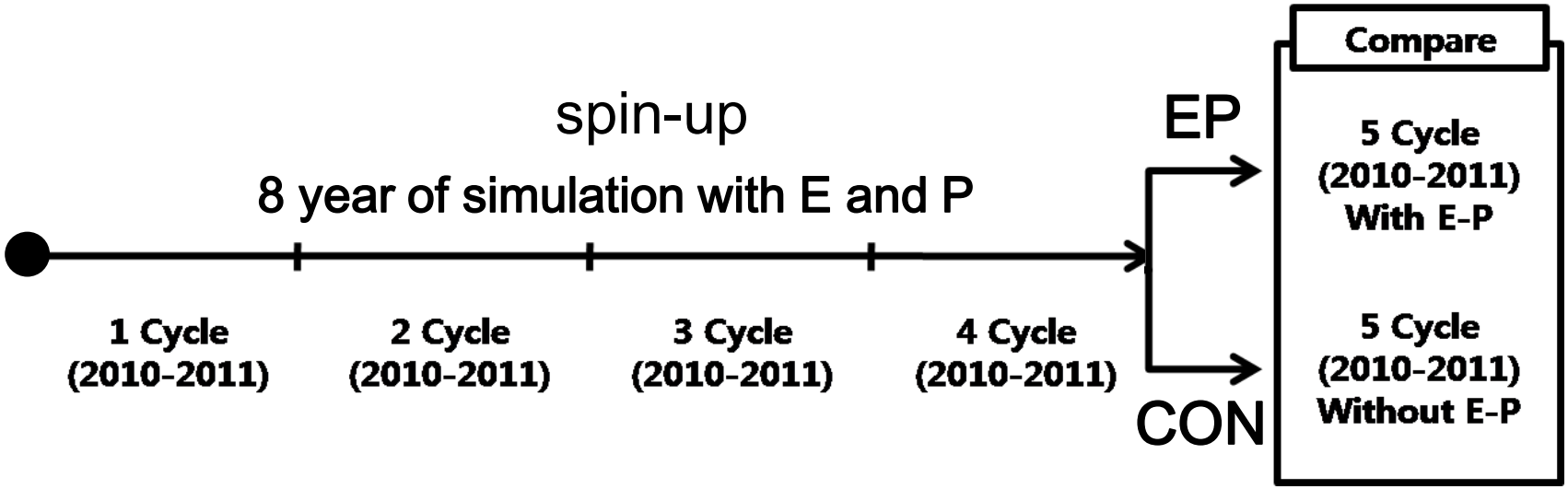
02. Method

experiment design and spin-up

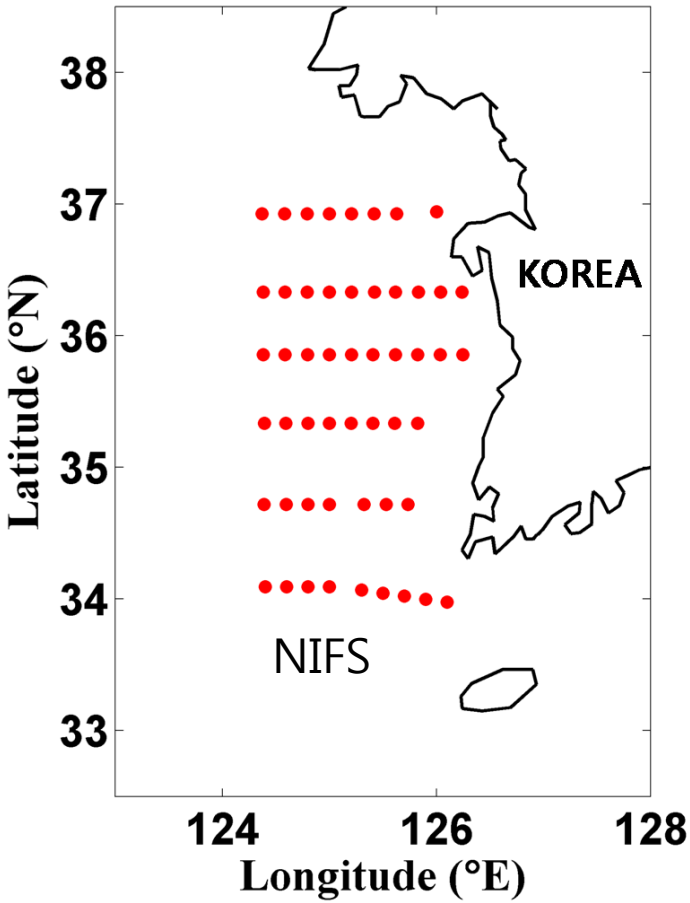
Experiment	Evaporation	Precipitation
EP	Included	Included
CON	Not Included	Not Included

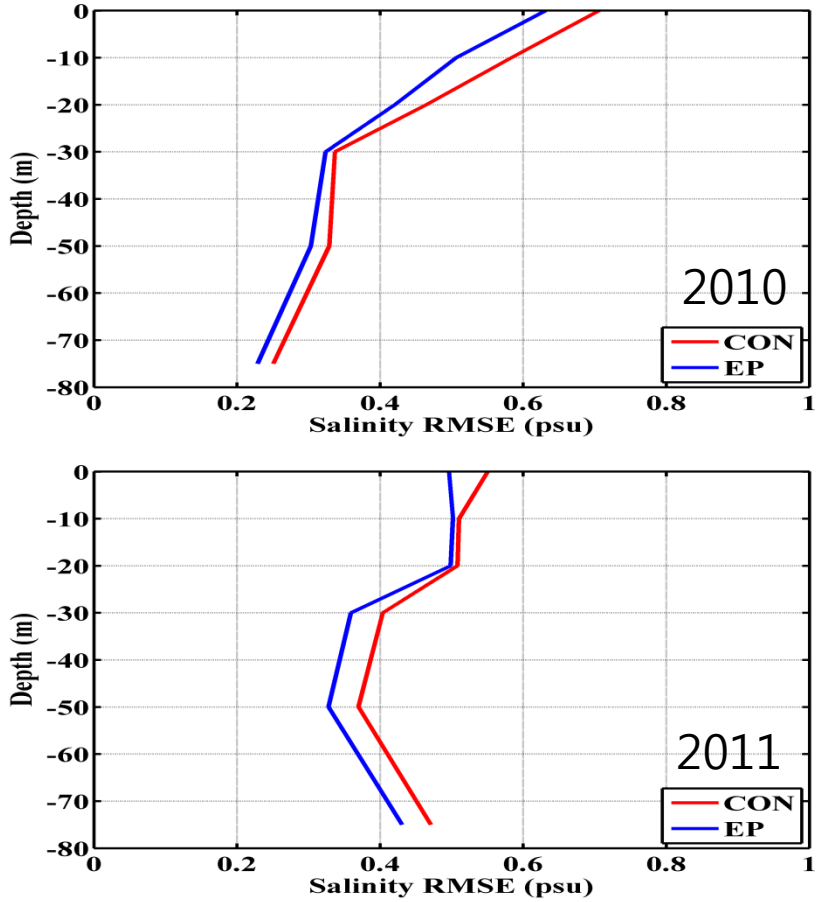
With E + P

Without E + P



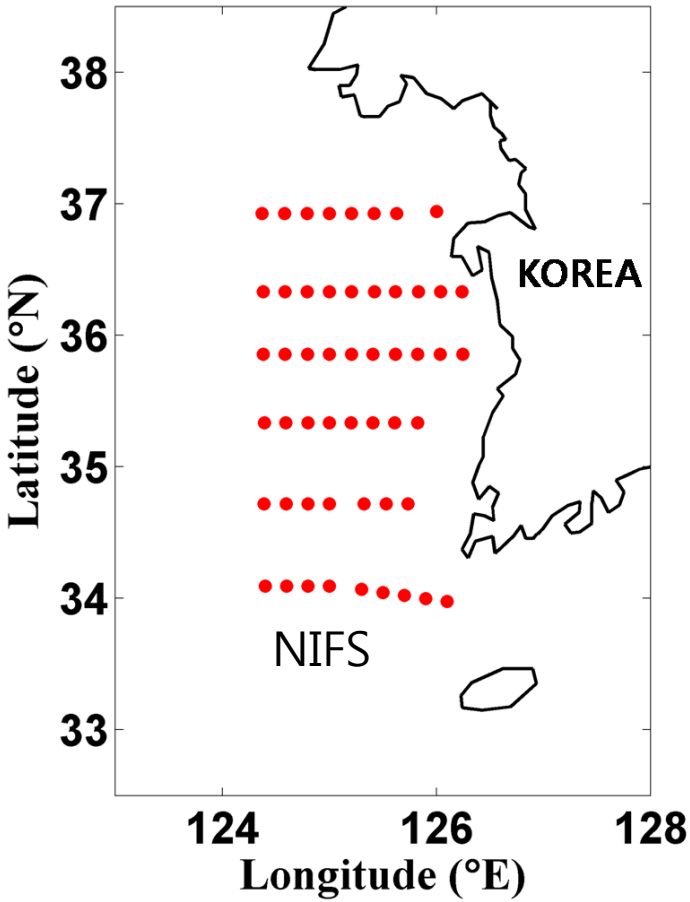
3.1. Validation of simulated salinity with observed salinity profiles in 2010 and 2011

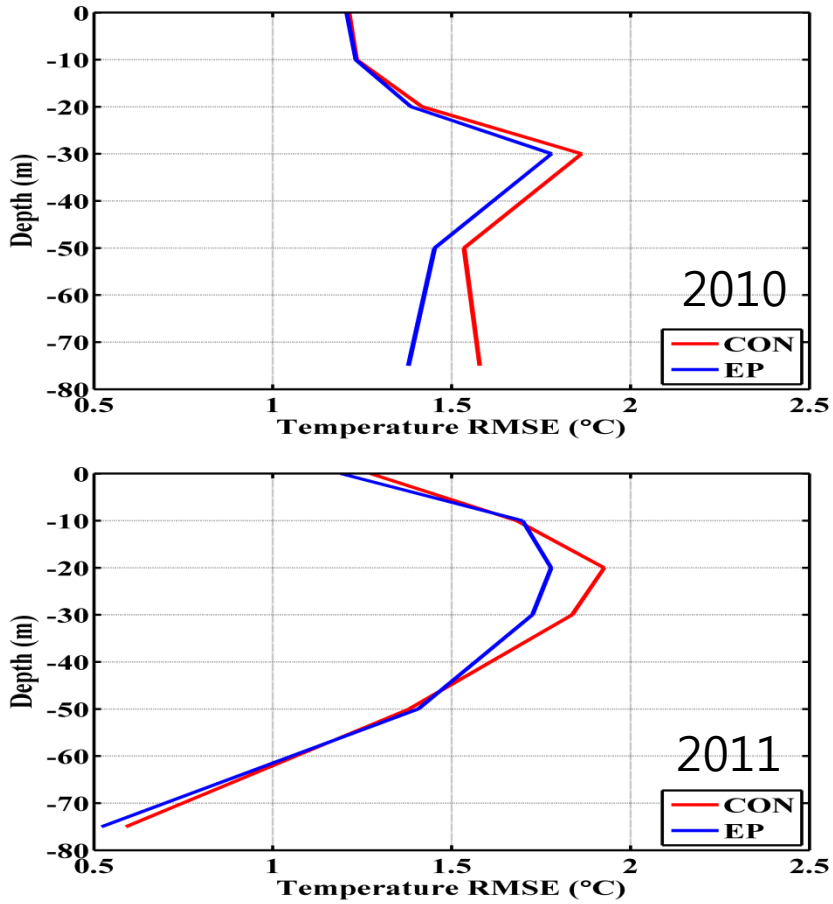




◈ RMSE in vertical salinity profiles from EP and CON simulations were calculated. It was 0.2–0.7 psu. RMSE of salinity from EP simulation was smaller that from CON simulation.

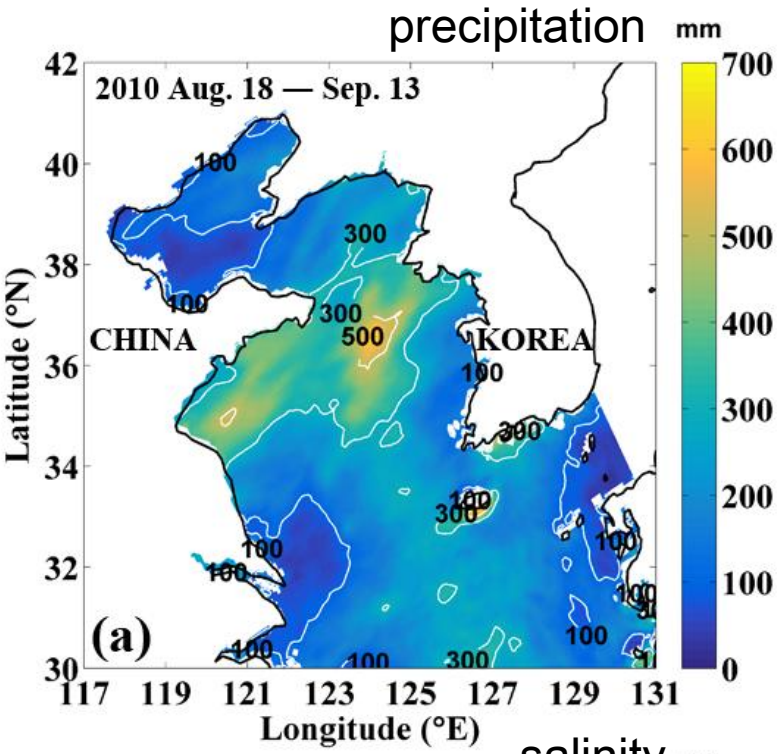
3.1. Validation of simulated temperature with observed temperature profiles in 2010 and 2011

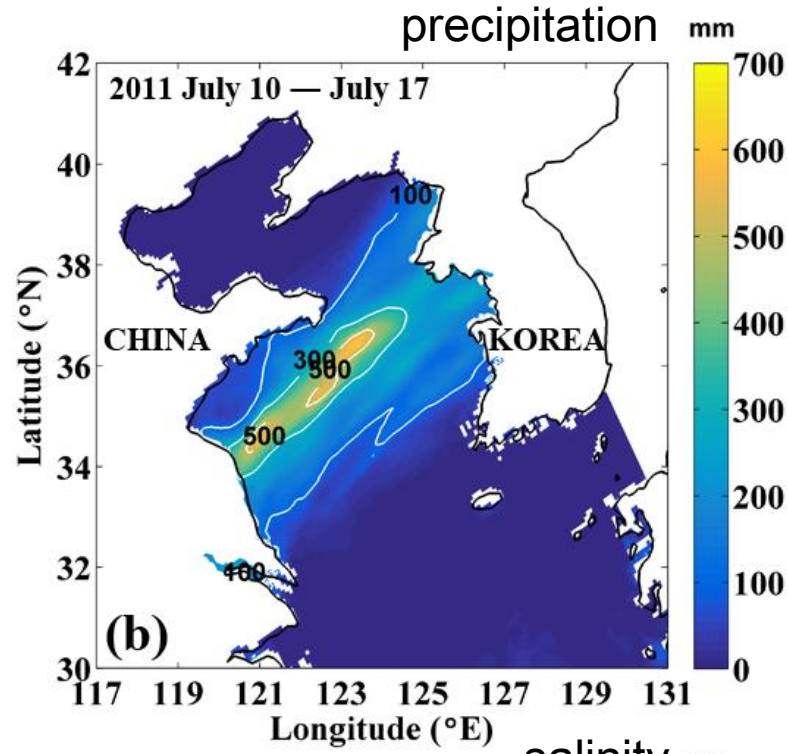


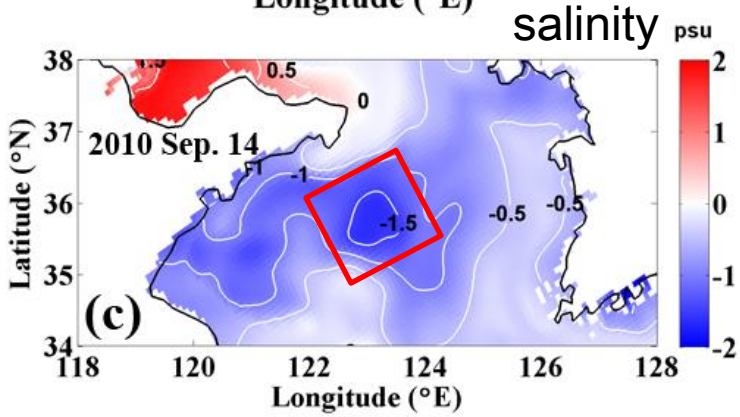


◈ RMSE in vertical temperature profiles from EP and CON simulations were calculated. It was 0.5–1.9°C. RMSE of temperature from EP simulation was smaller that from CON simulation.

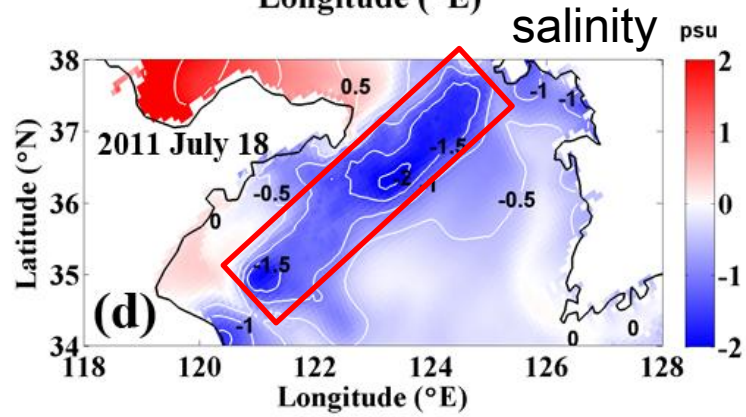
03. Results 3.2. Rain band affects salinity and temperature



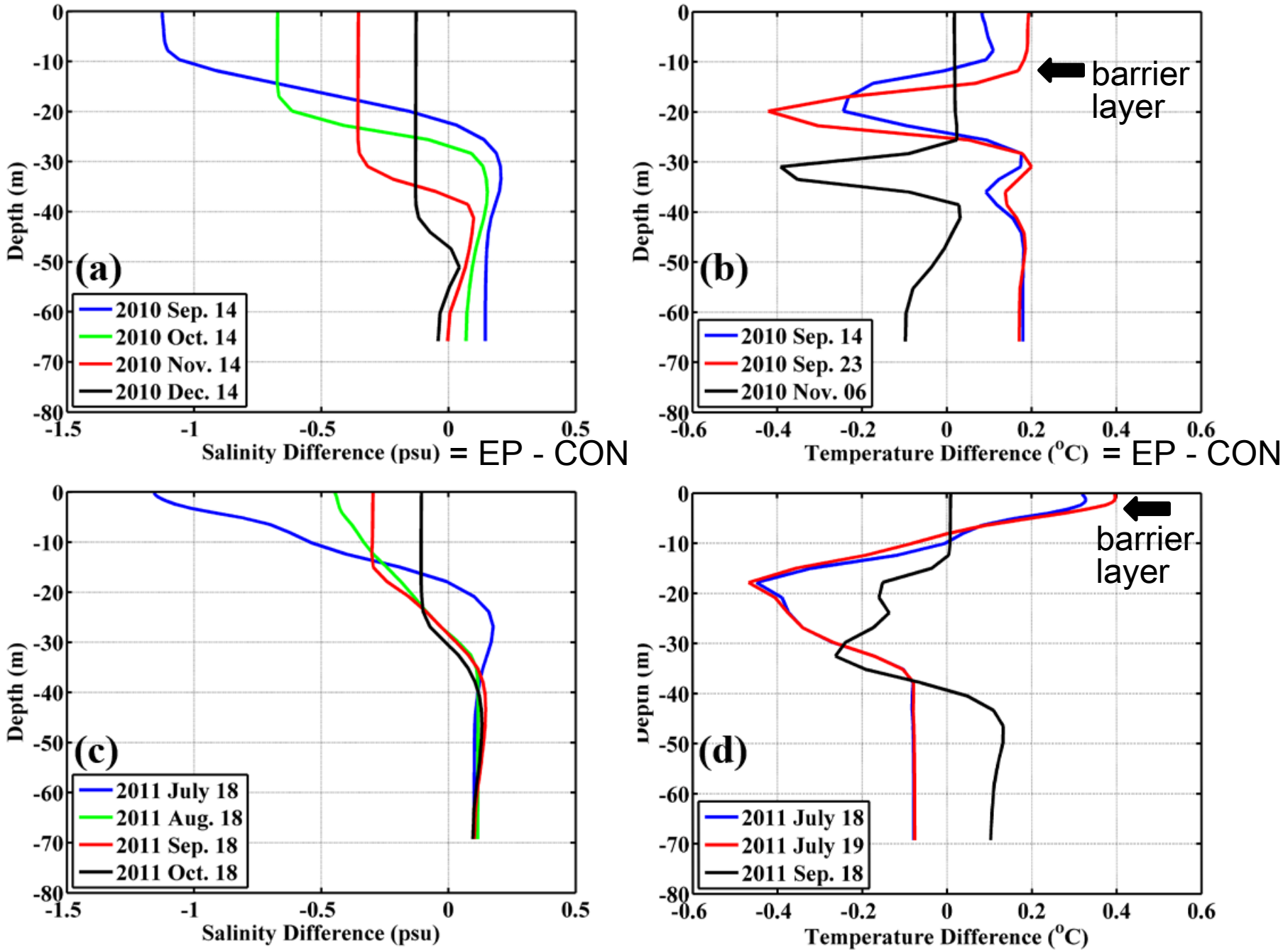




salinity anomaly = EP - CON

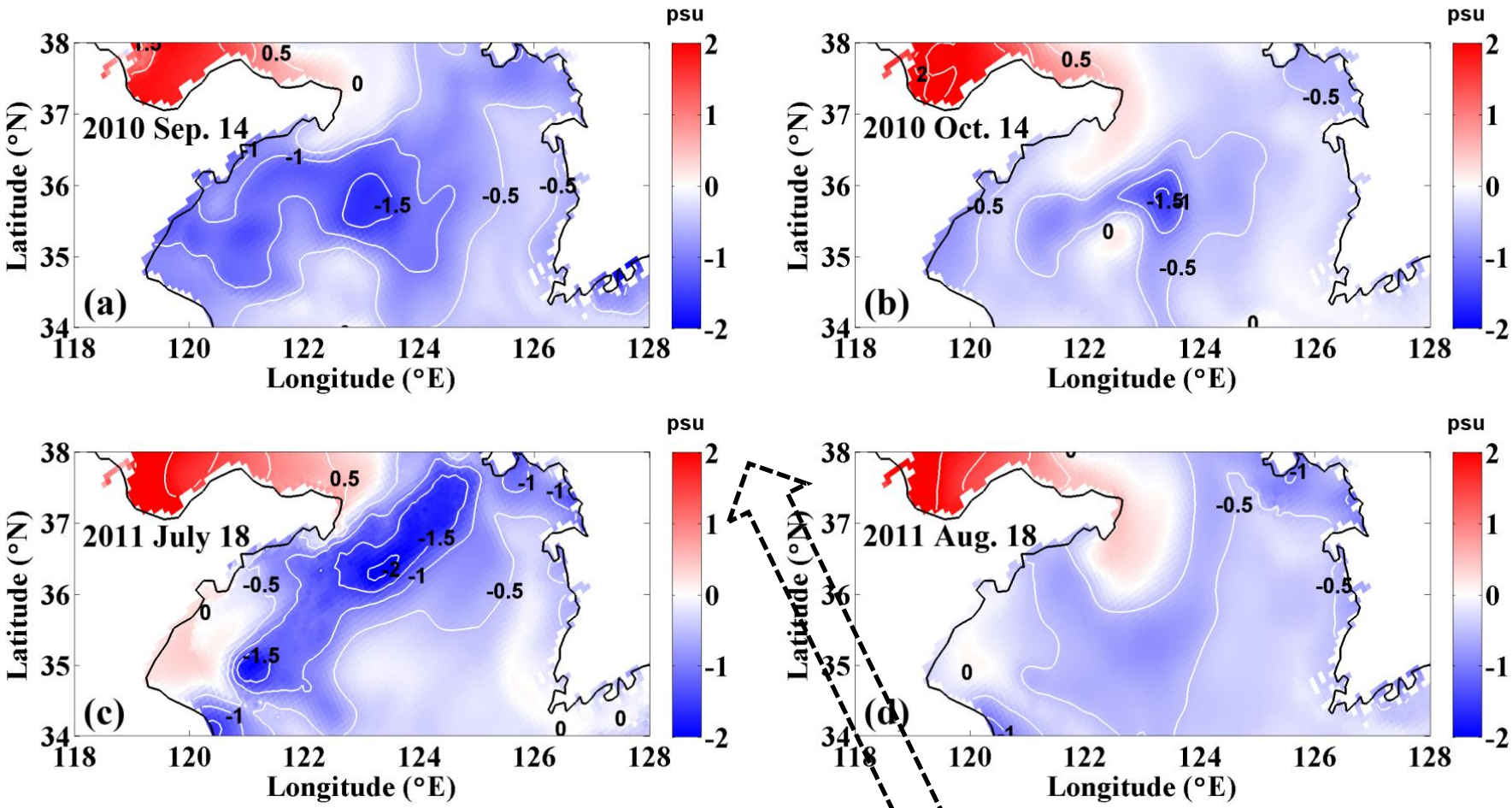


salinity anomaly = EP - CON


(a)
2010 Sep. 14
2010 Oct. 14
2010 Nov. 14
2010 Dec. 14
Depth (m)
Salinity Difference (psu) = EP - CON
(b)
barrier layer
2010 Sep. 14
2010 Sep. 23
2010 Nov. 06
Depth (m)
Temperature Difference (°C) = EP - CON
(c)
2011 July 18
2011 Aug. 18
2011 Sep. 18
2011 Oct. 18
Depth (m)
Salinity Difference (psu)
(d)
barrier layer
2011 July 18
2011 July 19
2011 Sep. 18
Temperature Difference (°C)

03. Results

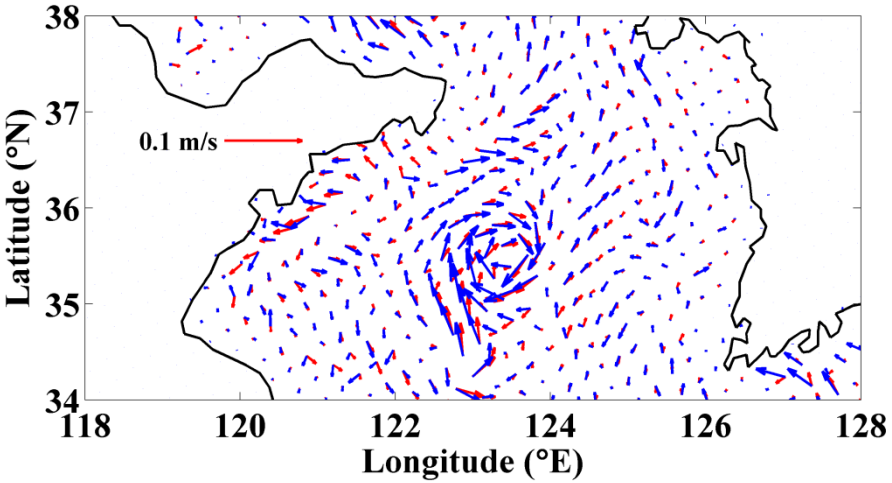
3.3. Decay of low salinity cores



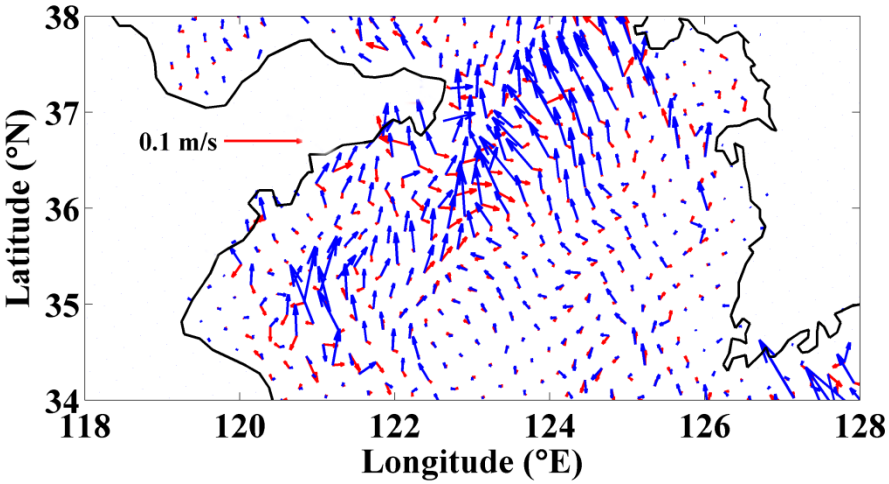
Typhoon Muifa
on 2011 Aug. 06-08

3.4. Heavy rainfall changes surface currents

Surface current anomaly
2010 Sep. 14



Surface current anomaly
2011 July 18



	Surface current anomaly (cm/s)	Geostrophic current anomaly (cm/s)	Others (wind driven current, cm/s)	Wind stress (N/m^2)
2010 Sep. 14	2.56	1.73	0.84	0.0039
2011 July 18	4.05	1.24	2.80	0.0336

When thickness of low salinity core is thick and wind speed was low as in 2010, the surface current anomalies make a clockwise circulation mainly due to horizontal density difference [Geostrophic Current].

When thickness of low salinity core is thin and wind speed was relatively strong as in 2011, the surface current anomalies are induced mainly by the surface wind stress [Ekman Current].

Implication: For accurate short term (3-7 days) and medium range (7-100 days) ocean forecast, precipitation may need to be considered in a coastal ocean model.

04. Discussion and Summary

◈ The simulations were performed with (EP) and without (CON) precipitation and evaporation processes.

◈ The heavy precipitation (300 mm) event for 8−26 days in July and September created **low salinity cores** in the surface of Yellow Sea.

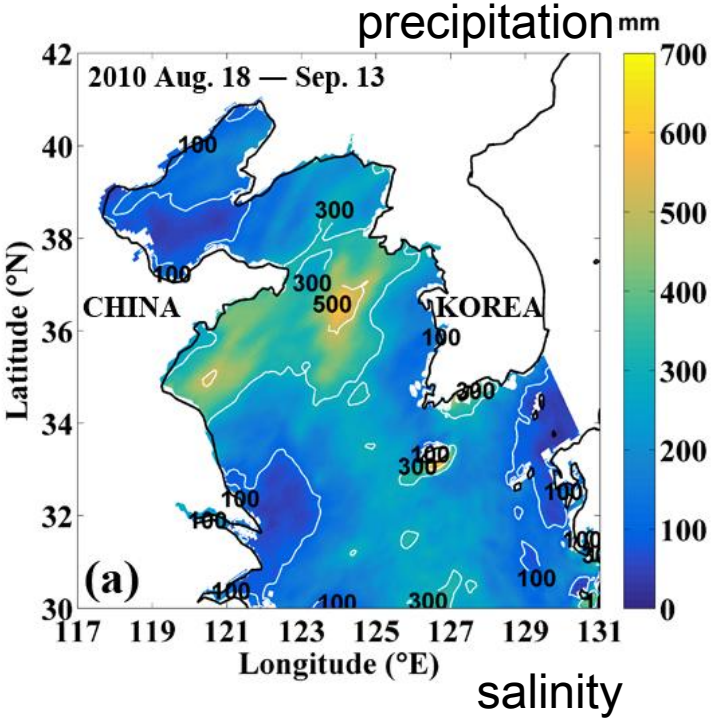
◈ During the rainy days, freshwater accumulated in the surface layer and surface salinity was reduced about 1.0 psu in the surface 10-m layer. After the rainy days, barrier layer formed at the bottom of low salinity core and diminished heat transfer from the surface layer to thermocline layer, which made the surface 10-m layer warmer about 0.1-0.4°C and thermocline layer cooler about 0.5°C.

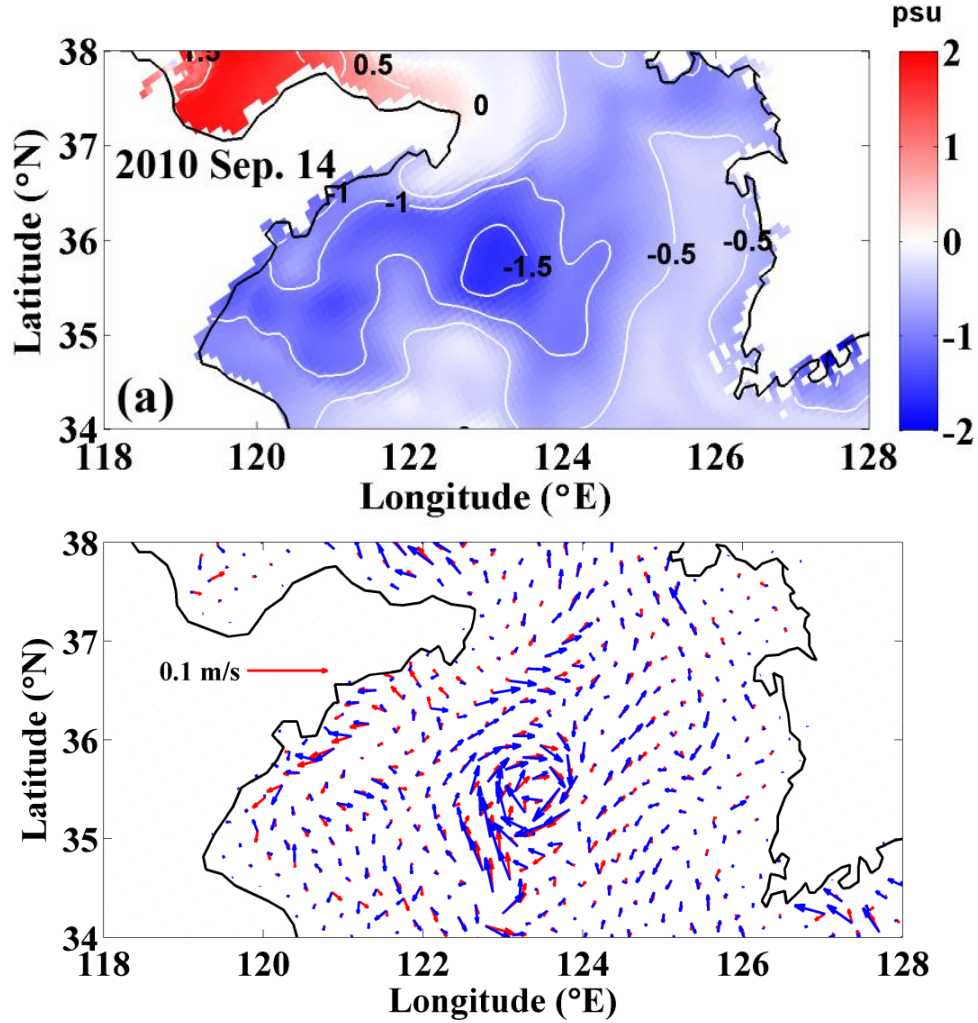
04. Discussion and Summary

◈ When wind speed was small, the low salinity cores were decayed by vertical mixing with time scale of 100 days and surface baroclinic circulation was induced in the surface layer.

If there are high wind events such as Typhoon in 2011, horizontal dispersion as well as vertical mixing affect the decay of the low salinity cores with short time scale of several days.

◈ Surface currents were induced over the surface low salinity cores by density difference and by the wind.





Thank you for you attention!