The Analysis of sea temperature and sea surface wind variation in response to typhoon Lekima (1909)

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2023.5.3

CONTENTS

Why do we choose this subject?

- For sea surface temperature and vertical sea temperature
  - Typhoon generates in sea areas with high SST, which is conducive to increasing water vapor and latent heat flux on sea surface(Zhang，et al，2020)；
  - The study of typhoon induced SST reduction is an important aspect of typhoon dynamics and forecast(Zhu，et al，1997);
  - The typhoon will also have a certain impact on the internal structure of the ocean, among which the most significant variations are the depth, temperature and salinity of the mixing layer(Zhang，2019).

Why do we choose this subject?

- For sea surface wind

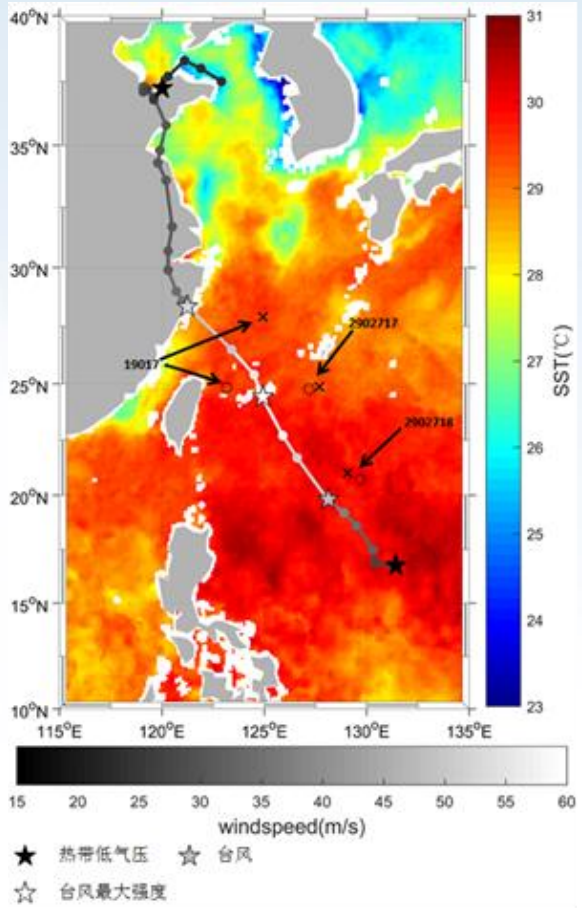
  - The sea surface wind field is the **main power source** of the upper ocean movement (Lu Kewei et al., 2012), and one of the important factors determining the energy exchange between the atmosphere and the ocean;
  - The sea surface wind field during tropical cyclone is very important for **storm surge modeling**, **disaster risk assessment** and **Marine environment change** before and after tropical cyclone(Tian et al., 2023);
  - Sometimes the wind speed of CCMP is more reliable, while the wind speed of NCEP is higher during Southwest monsoon. It is opposite during the Northeast monsoon (Kuang Fangfang et al., 2015);
  - Sometimes the ERA-Interim, CCMP, and CFSR data showed lower wind speed and rightward wind direction. The wind direction and wind speed of CCMP data are better than the other two kinds data(Han Yukang et al., 2019).

Typical Super Typhoon Lekima(1909)

Northward Typhoon "Lekima" (1909)

- A tropical depression formed on the ocean surface 950km east of Luzon Island at 6:00 a.m. on August 4;
- At 09:00 p.m. on August 6, it strengthened into typhoon level;
- At 03:00 p.m. on August 7, it reached super typhoon level (the maximum wind speed was 52m/s);
- At 12:00 a.m. on August 8, the maximum wind speed reached 62m/s;
- At 19:00 on August 9, the typhoon landed Wenling, Zhejiang Province;
- At 12:00 on 10 August, it weakened to tropical storm level;
- At 00:00 a.m. on August 13, it weakened to tropical depression level (maximum wind speed was 16m/s)

In 2019, Super Typhoon Lekima made landfall with high intensity, long land hold and wide impact, causing serious disaster losses to China's coastal area.



The circles and × indicate the areas where the **Argo buoy and drift** bouy were located before Typhoon Lekma formed and when it became a tropical depression on August 13, respectively

CONTENTS

Data Source

Marine meteorological drifting buoy

- The marine meteorological drifting buoy is a marine meteorological mobile observation device **developed independently by CMA** , which can provide stable and reliable observation data for a long time (Cao, et al., 2019)
- Measurement element: **air pressure, air temperature, wind direction, wind speed, SST, salinity**
- Temporal resolution: **10 min**
- One drifting buoy: nearby the Likima's path

Argo Float

- "Array for Real-time Geostrophic Oceanography"
- Temporal resolution: daily
- Two Argo Floats: nearby the Likima's path

Data Source

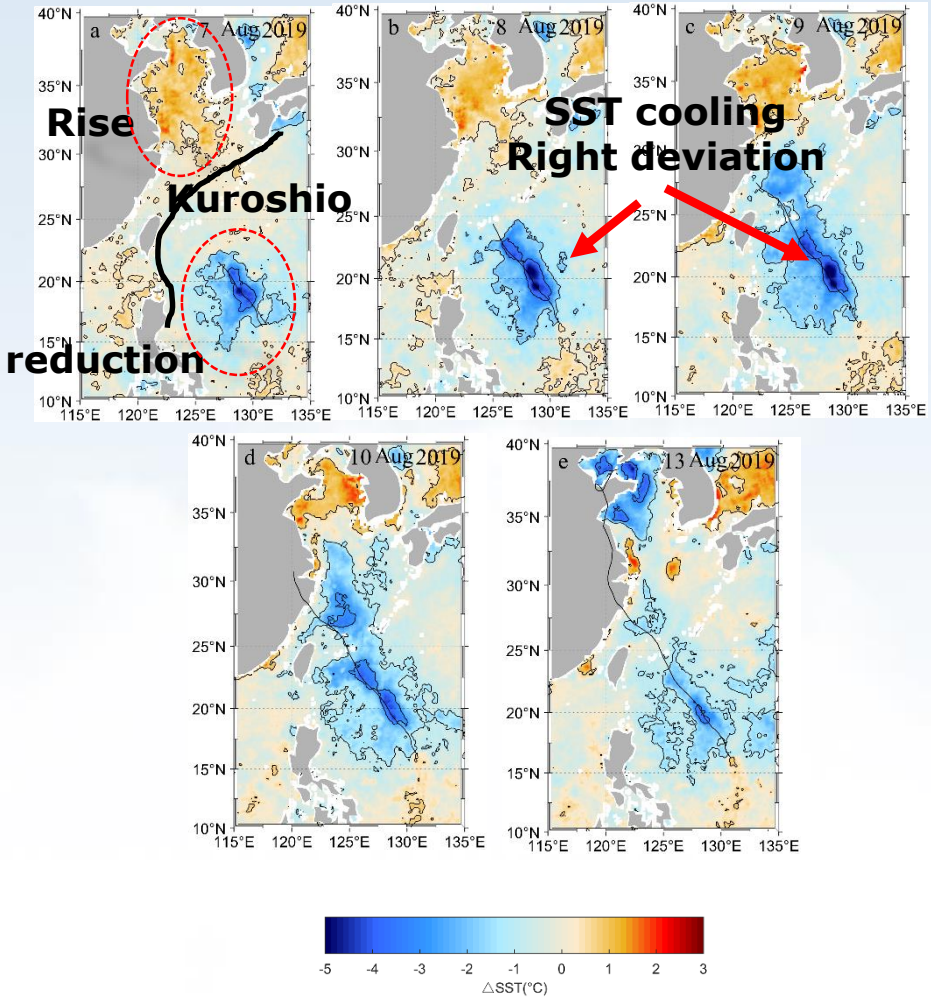
- **Typhoon track data**
  - The typhoon track data comes from the Best Track Dataset of the Tropical Cyclone Data Center of the China Meteorological Administration
  - The time frequency is once every three hours
- **Satellite data(optimally interpolated SST,OISST)**
  - this product combines the through-cloud capabilities of the microwave data with the high spatial resolution and near-coastal capability of the infrared SST data
  - Horizontal resolution: 0.25°×0.25°
  - Temporal resolution: daily
- **HYCOM Global Analysis Dateset**
  - HYbrid Coordinate Ocean Model
  - Horizontal resolution: 0.08°×0.08°
  - Temporal resolution: hourly

The Response of SST Variation

Satellite data（OISST）

- The maximum cooling of SST can reach more than 5℃, and the core cooling area is skewed to the rightside of the typhoon path
- The core cooling area of SST caused by Lekima lagged behind the center of Lekima by about 1~2 days
- The core cooling area of SST can indicate the typhoon path

Date	Vertical distance between cooling center and Lekima path (km)	Offset direction
0807	-	-
0808	30	Right deviation
0809	40	Right deviation
0810	10	Right deviation
0813	-	-

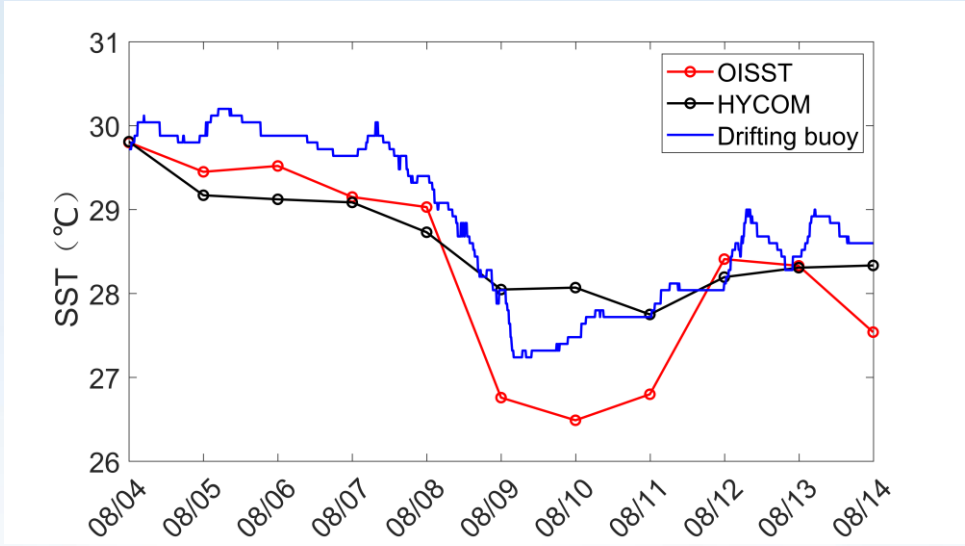


OISST data relative to sea surface temperature distribution on August 4

Data Comparison

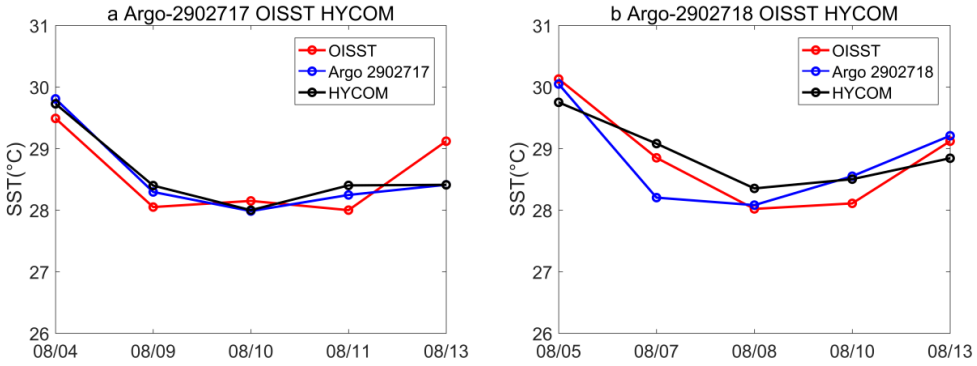
Data source:

1. OISST
2. HYCOM
3. Marine meteorological drifting buoy
4. Argo buoy



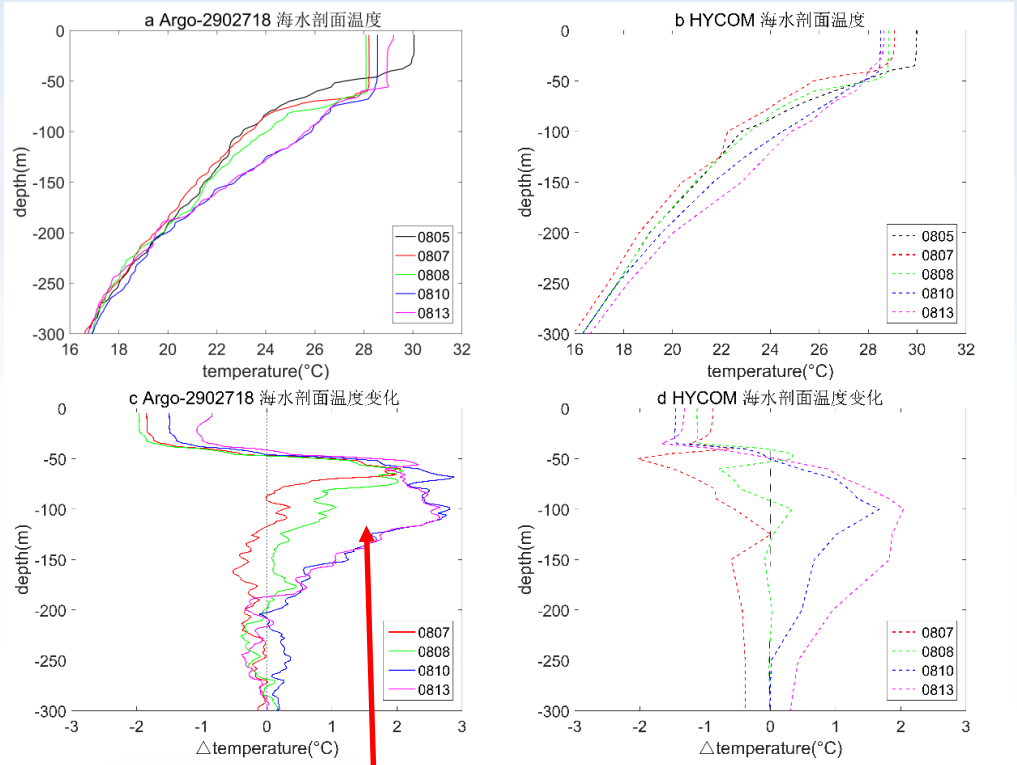
OISST and HYCOM daily mean SST variation and high frequency SST variation in 10mins

- **The variation trend of SST data provided by OISST and HYCOM is consistent with the measured data of Argo buoy and marine meteorological drifting buoy.**
- **The data of drifting buoy can accurately capture the temperature variation, due to the direct observation and the higher sampling frequency.**



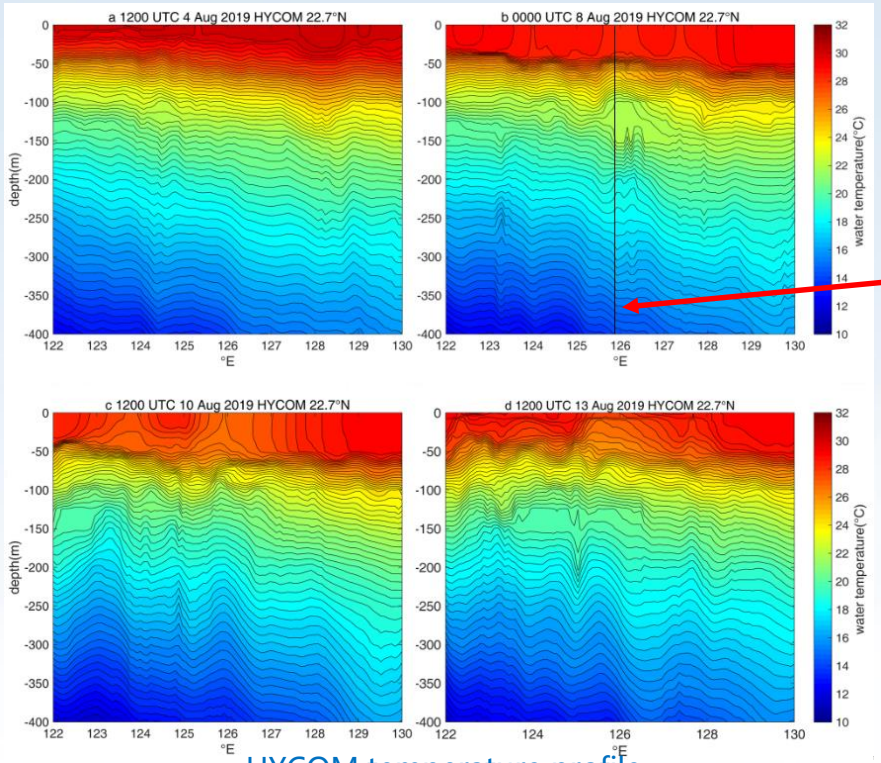
Argo, OISST, HYCOM SST variation

Vertical Profile Variation



Argo float 2902717 and HYCOM sea temperature profile changes (a and c are daily sea temperature profiles; b and d are the variation of SST profile relative to August 4)

On August 10, the temperature range reached the maximum, with a maximum increase of 2.5℃, and the seawater thermocline deepened further.



HYCOM temperature profile

The location of the "Lekima" center at 0:00 a.m. on August 8

The passage of "Lekima" **brought strong wind stress**, which destroyed the original layered structure of seawater, resulting in mixing of internal ocean water, vertical mixing of near-surface and subsurface water, heating of subsurface water, increasing the depth of the mixing layer, and increasing the temperature of seawater below the mixing layer.

CONTENTS

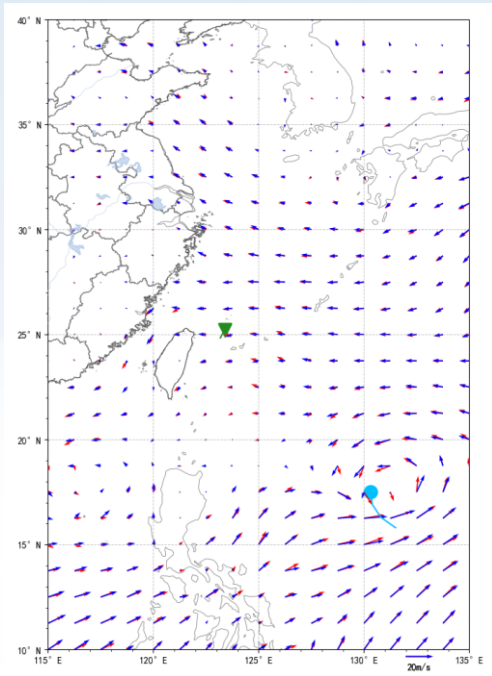
Data used in this part

- **Drifting buoy Observational data:**
  - Temporal resolution: 10 minutes
  - Used variables: wind speed, wind direction
- **The China Meteorological Administration(CMA) tropical cyclone database**
  - The best track of Lekima(1909)
  - Temporal resolution: 3 hours
  - Used variables: 2-minute mean maximum wind speed near the center of tropical cyclone

Data used in this part

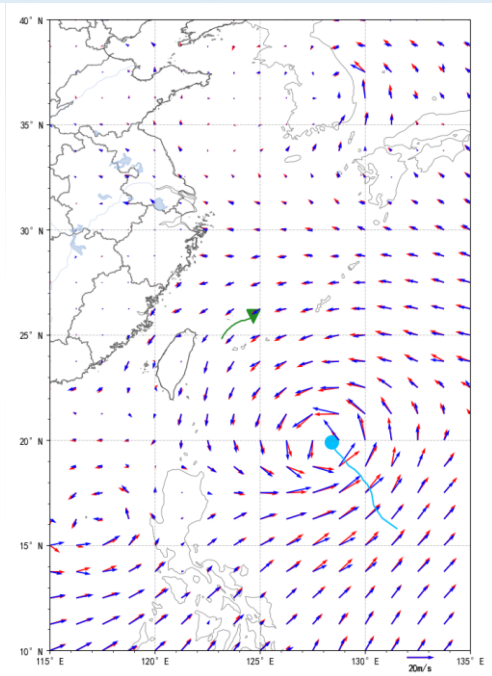
- **Cross-Calibrated Multi-Platform gridded surface vector winds(CCMP)**
  - Horizontal resolution: 0.25°×0.25°
  - Temporal resolution: 6 hours
  - Used variables: 10m wind speed, 10m zonal wind(U), 10m meridional wind(V)
- **ERA5 hourly data on single levels**
  - Horizontal resolution: 0.25°×0.25°
  - Temporal resolution: hourly
  - Used variables: 10m u-component of wind, 10m v-component of wind

Location between Lekima & drifting buoy



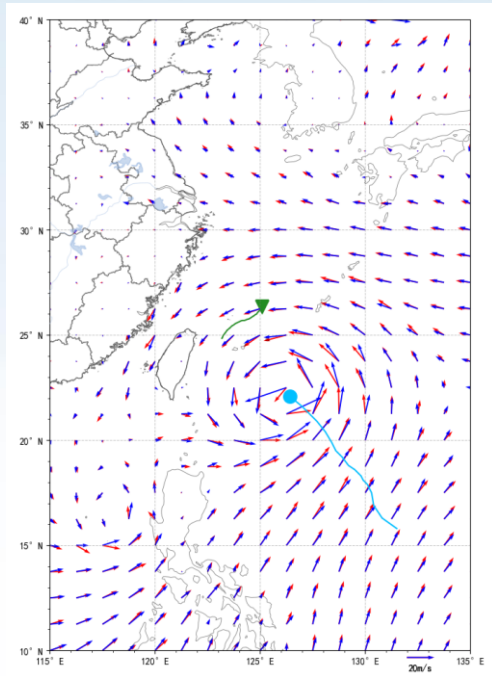
12:00, 4th

Tropical storm



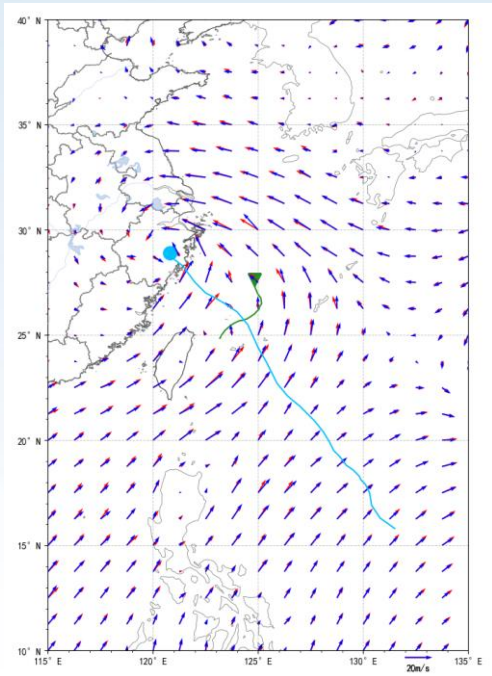
18:00, 6th

Typhoon



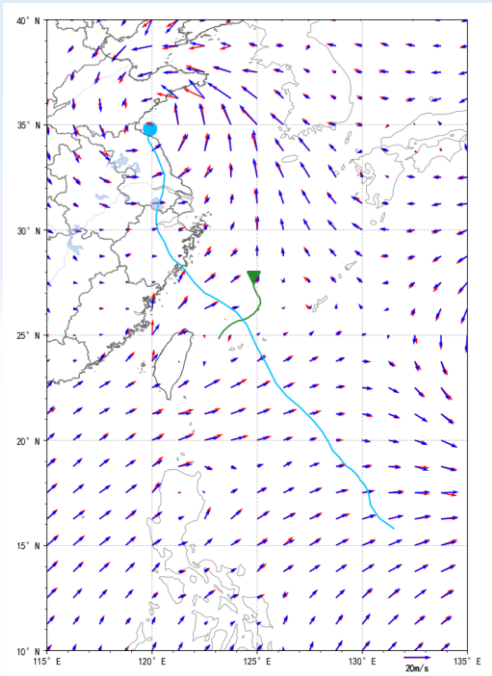
18:00, 7th

Super Typhoon



00:00, 10th

Typhoon

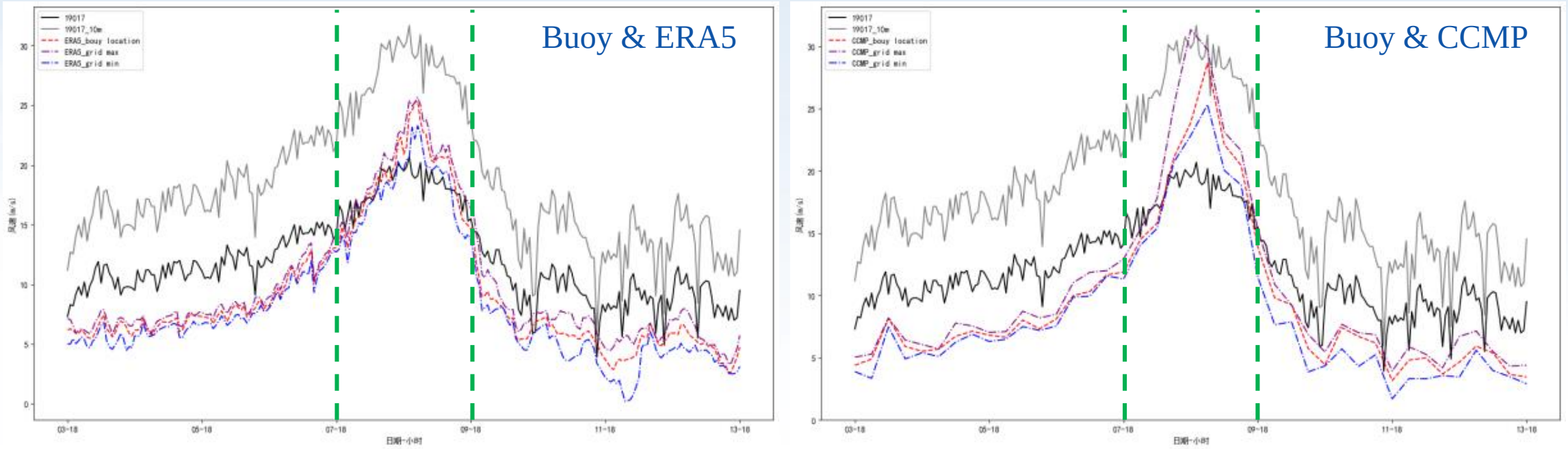


06:00, 11th

Tropical storm

Comparative analysis of wind speed

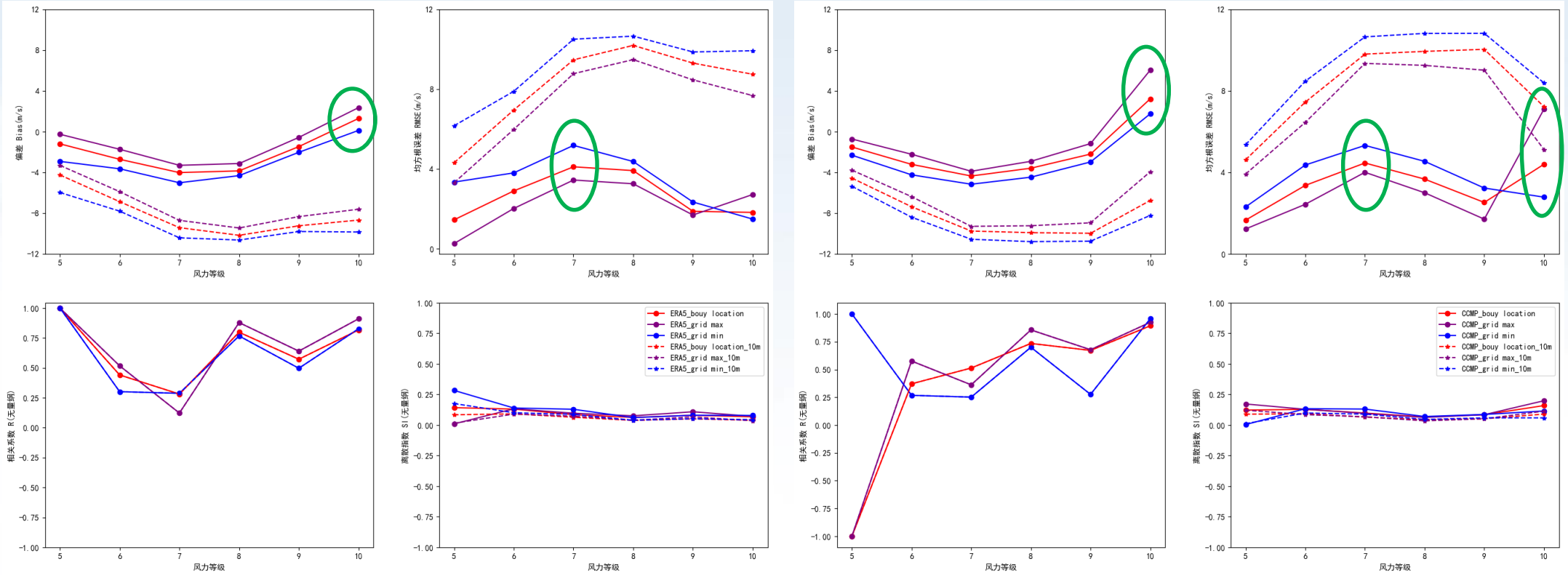
■ Comparative analysis of wind speed time series:



Time series of wind speed and direction on the track of drifting buoy

Comparative analysis of wind speed

Comparative analysis of wind speed in different wind grade:

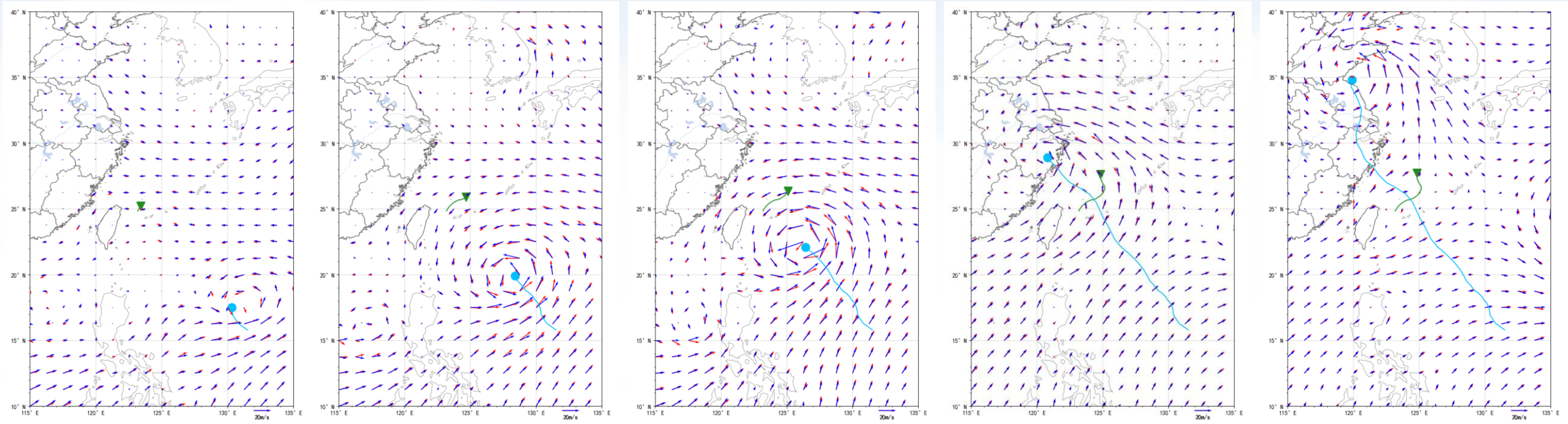


(a) (b)

Wind speed deviation between drifting buoy and (a)ERA5 (b)CCMP in different wind grade

Comparative analysis of sea surface wind field

- During "Lekima", the wind direction and wind speed of ERA5 and CCMP in the area near the center of tropical cyclone had a large deviation, while the area far away from the center of typhoon was less affected by typhoon, and the wind field of the two data had a high coincidence.



12:00, 4th
Tropical storm

18:00, 6th
Typhoon

18:00, 7th
Super Typhoon

00:00, 10th
Typhoon

06:00, 11th
Tropical storm

CONTENTS

4 Summary

- The data of the marine meteorological drfting buoy has a good correlation with the data of national observation stations, which can provide stable and reliable observation data of sea temperature, sea salt, air temperature, air pressure, wind speed and so on for a long time，compared with satellite data.
- In this study, several datesets were used to analyze the spatio-temporal variation of the sea temperature and windspeed when Lekima passed through. However, the in situ measurement data near the typhoon center is still scarce. In the future, drifting buoy and mooring buoy can be designed to be deployed in advance in typhoon-prone area. Meanwhile, sea surface observation sensors can be dropped by airborne to obtain more marine variation characteristics, thereby confirming the reliability of satellite data, analysis/reanalysis data, and improving typhoon observation capabilities.

Thanks for your attention

中国气象局气象探测中心
Meteorological Observation Center