ESCAP/WMO TYPHOON COMMITTEE 17th Integrated Workshop

"Tropical Cyclone Planning, Forecasting and Response Services for Early Warning and Early Action"

# Extratropical impact on the subseasonal-to-seasonal tropical cyclone frequency over the Northwestern Pacific

Rui Jin

Co-authors: Hui Yu, Zhiwei Wu, Ming Ying, Peng Zhang

2022.11.29, Shanghai

# Background

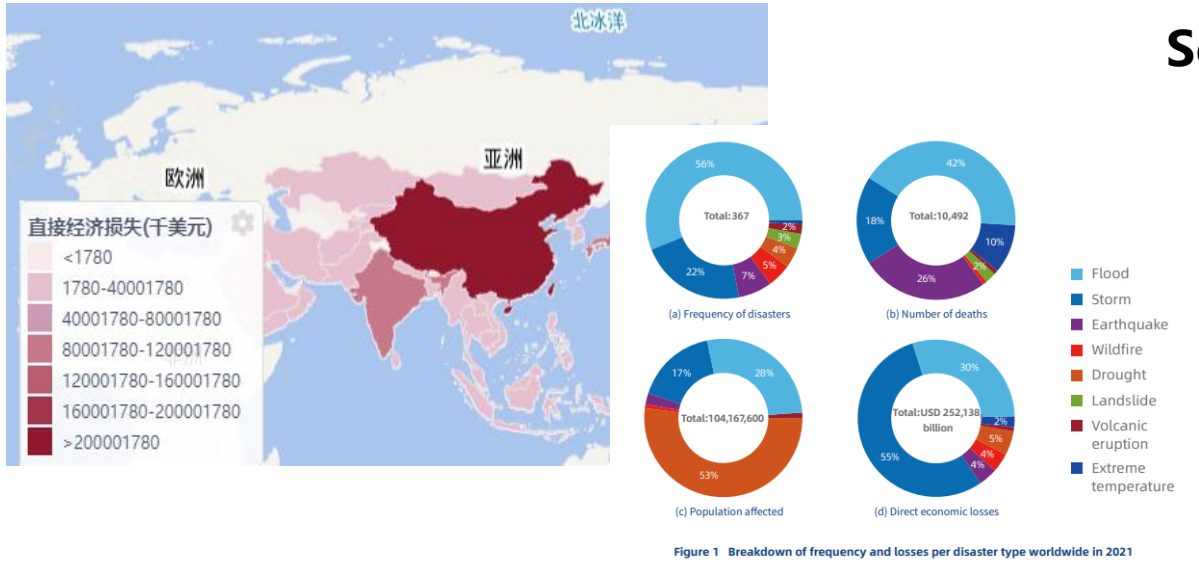


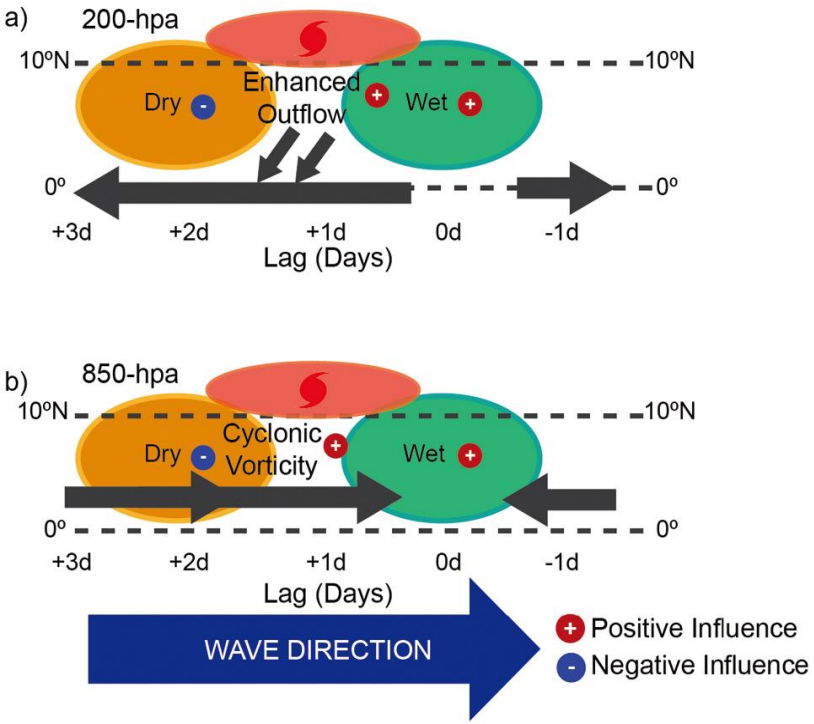

Figure 1 Breakdown of frequency and losses per disaster type worldwide in 2021

- The western North Pacific tropical cyclone accounts for almost **one-third of named TCs per year in the world**.
- **Billions of people** in Pacific islands and coastal regions are frequently subject to TC-induced damage (Zhang et al. 2009).

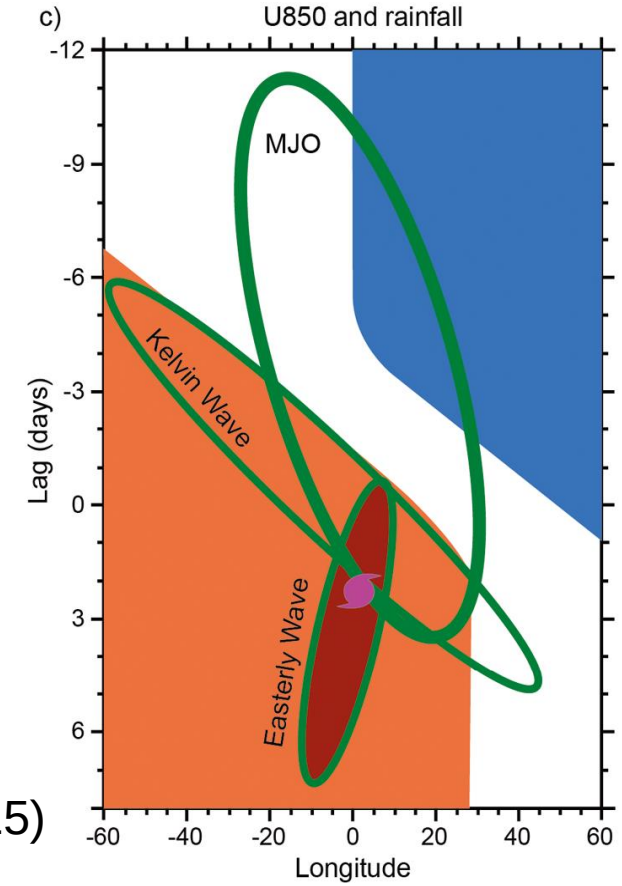
**Severe wind, torrential rain, storm surge, and landslide**

**☐ Improve the subseasonal and seasonal prediction skill brings profound socioeconomic benefits**

# Background




Schreck et al. (2015)




Schematic of impacts of Kelvin waves on tropical cyclogenesis (a, b) and time–longitude interactions between the Kelvin wave, MJO, and the parent easterly wave (c).

- **Easterly wave**
(Shapiro 1977; Molinari et al. 2007; Gall and Frank 2010)

- **Equatorial Rossby wave**
(Takayabu and Nitta 1993; Fu et al. 2007; Chen et al. 2018; Wu et al. 2014 )

- **Convectively-coupled Kelvin wave**
(Ventrice et al. 2012; Schreck 2015; Fang and Zhang 2016)

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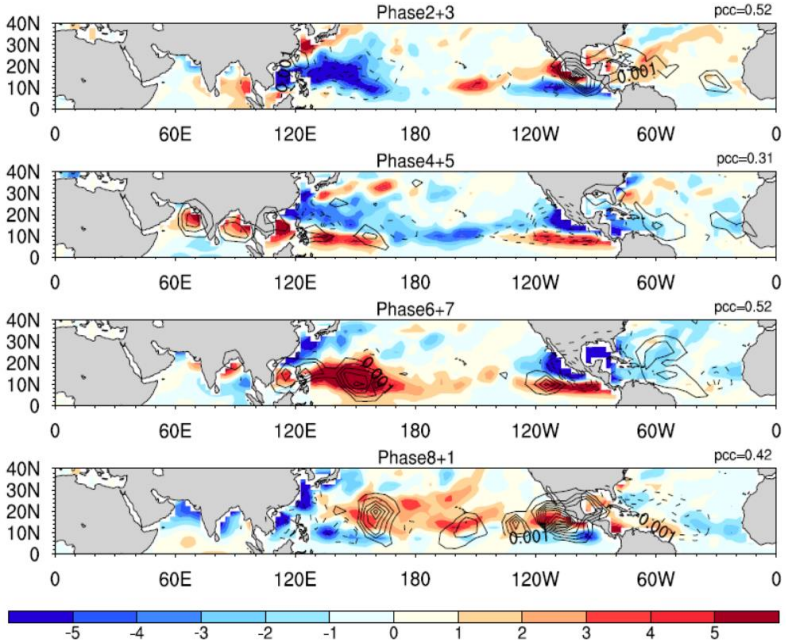
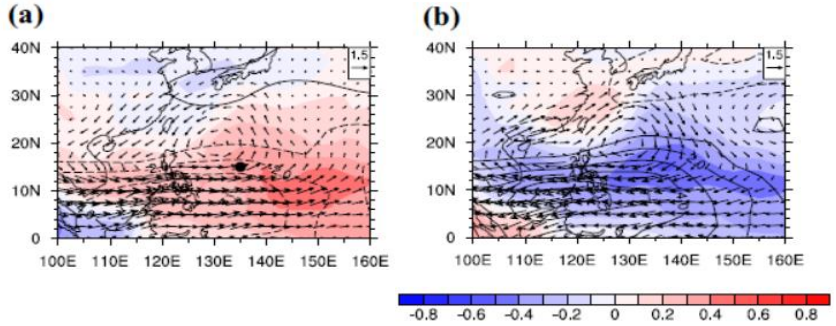
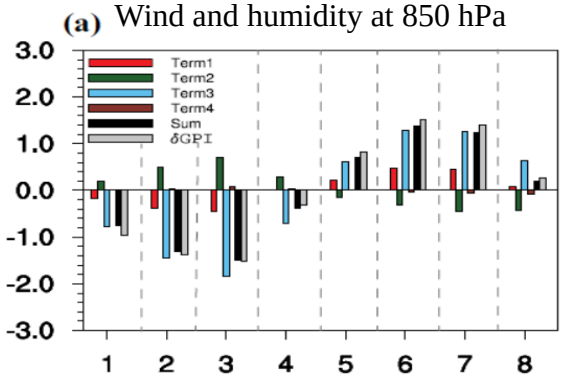
# Background

Zhao and Li 2018

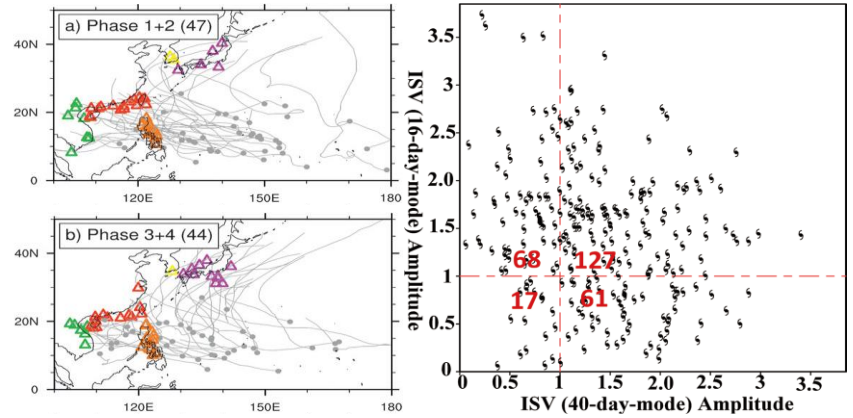



GPI：阴影；生成频数：等值线

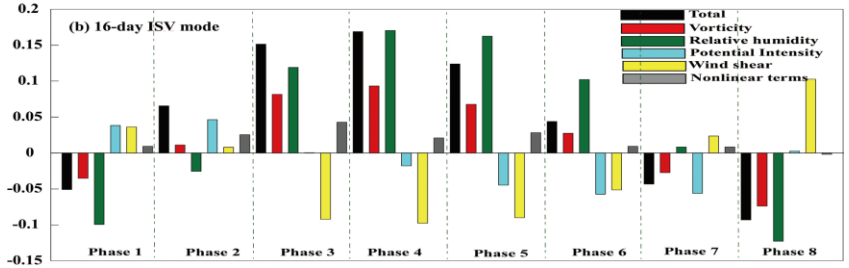


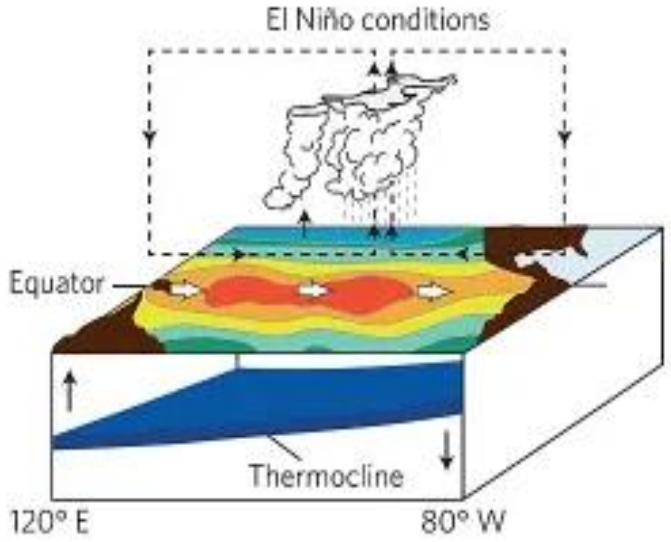

Recognized as two vital ISO modes, **MJO and QBWO** exhibit different origins, spatial scales, and propagation characteristics and **result in distinctive TC modulation** in the western North Pacific Ocean.

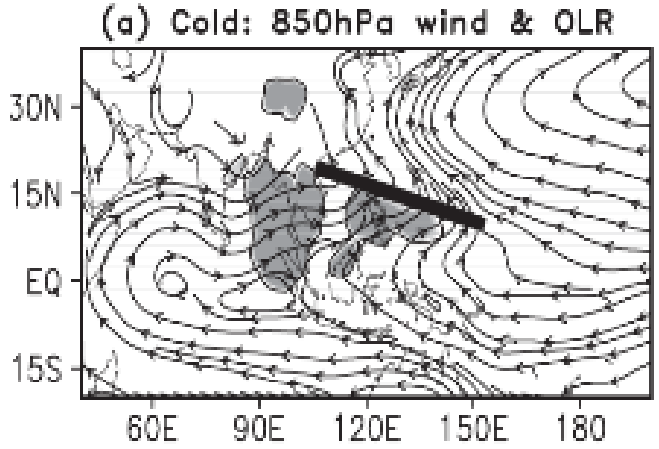


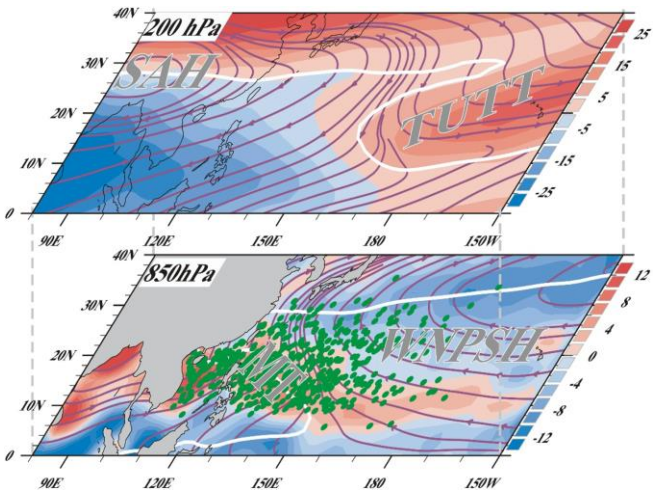

Zhao et al., 2015

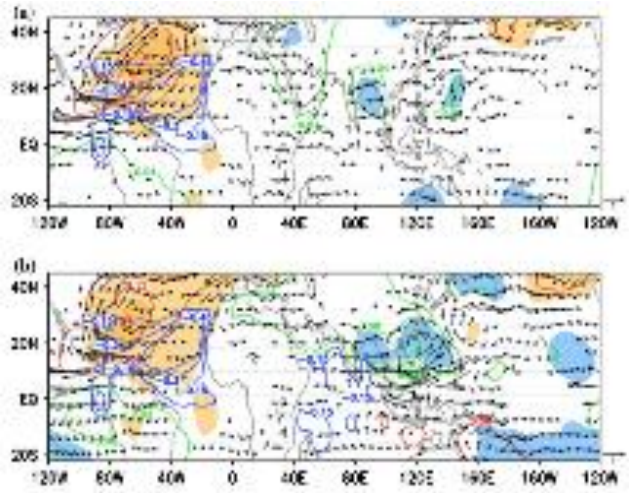


# Background



- **ENSO**
(Chan 1985, 2000; Lander 1993, 1994; Wang and Chan 2002; Camargo and Sobel 2005)

- **Indian ocean and North Atlantic**
(Zhan et al. 2011a, b; Du et al. 2011; Yu et al.)

- **The Pacific Meridional mode**
(Zhang et al. 2016a; Zhan et al. 2017; Wu et al. 2018; Wang et al. 2018b)

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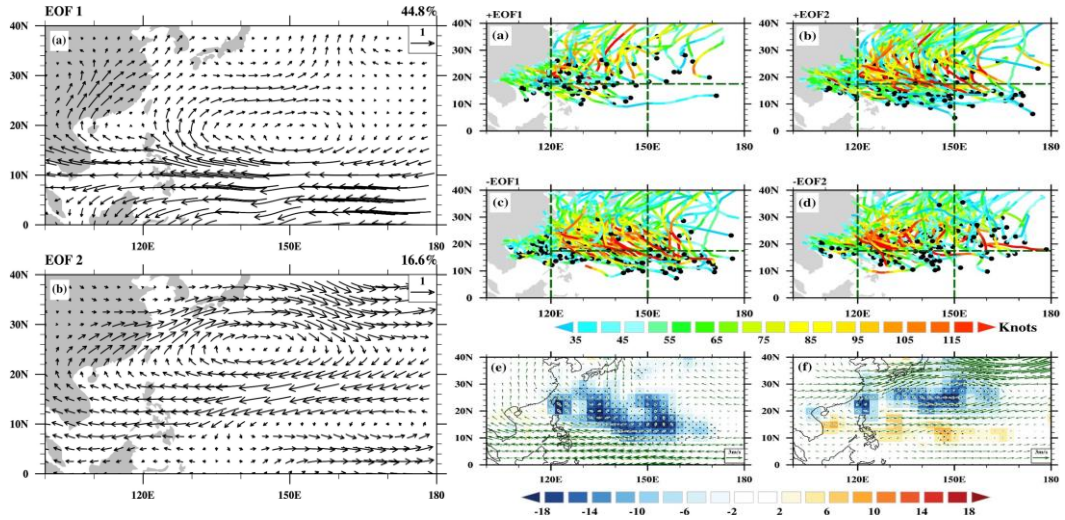
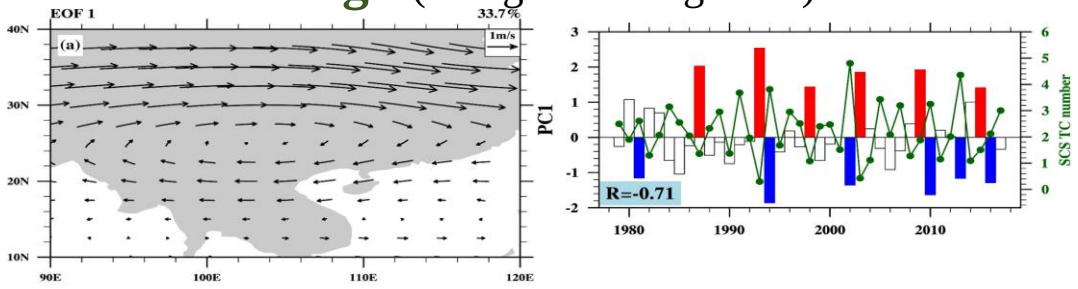
# Background

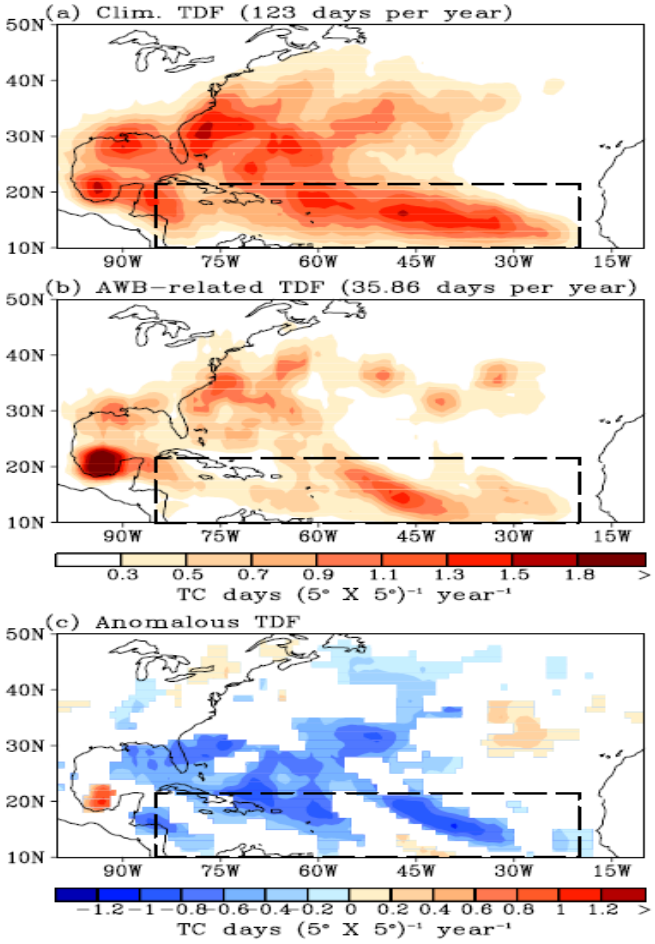
**western Pacific subtropical high** (Wang et al. 2013; Wang and Wang 2019)

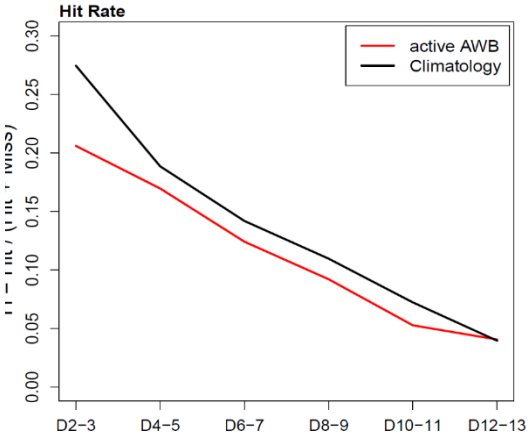



**South Asia high** (Wang and Wang 2021)



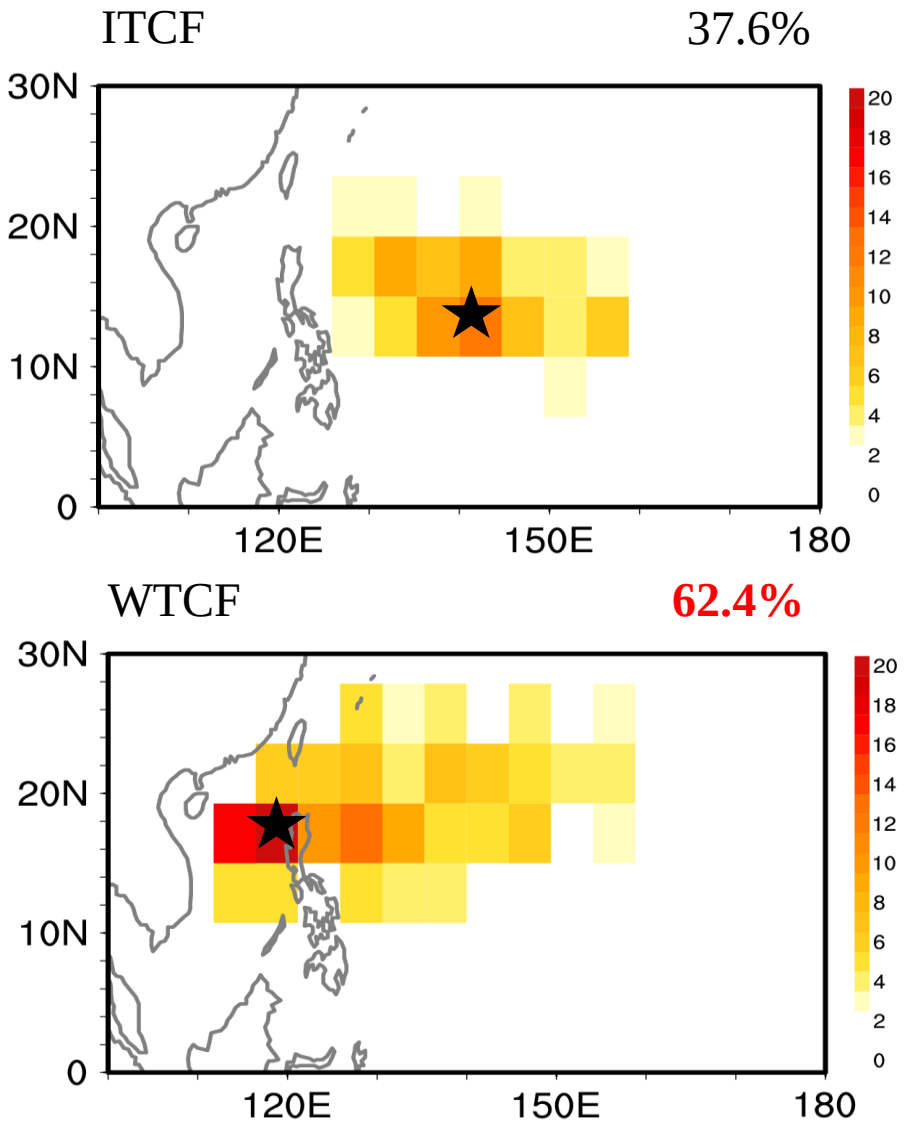

**Extratropical Rossby wave breaking** (Li et al. 2018)

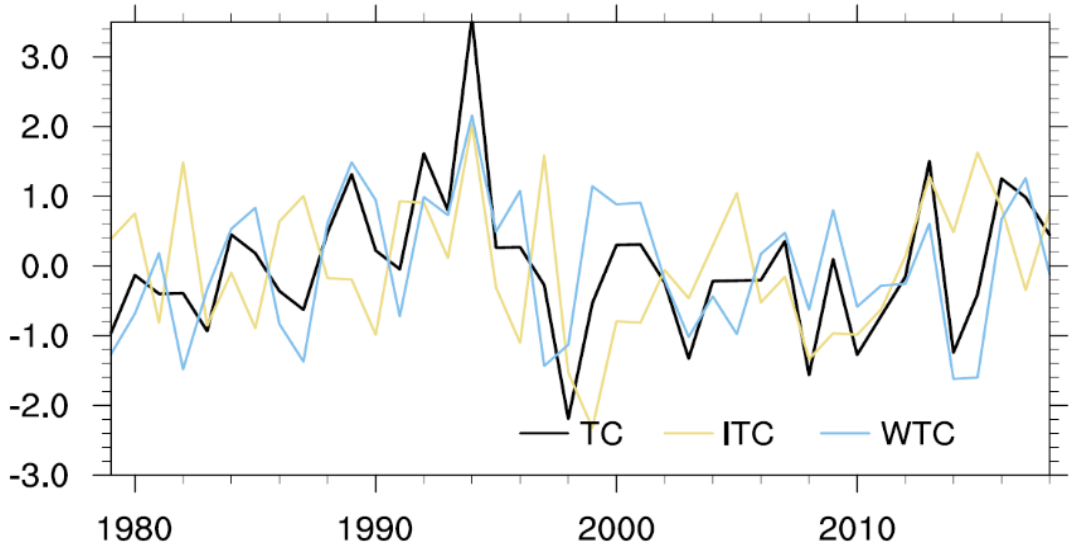



**The detailed impact of extratropical systems on subseasonal and seasonal TC activities is unclear , whether it can improve the prediction skill also needs further study.**

# Seasonal TC frequency with different intensity

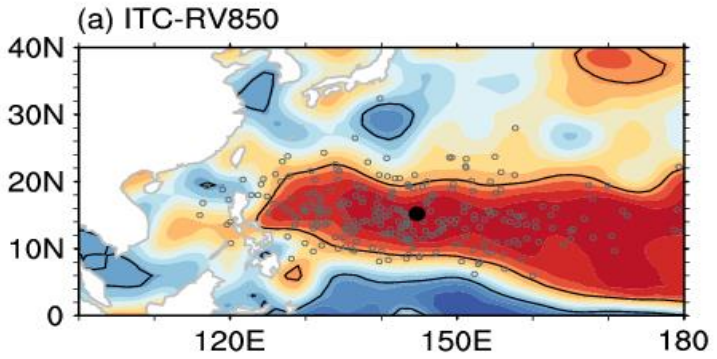


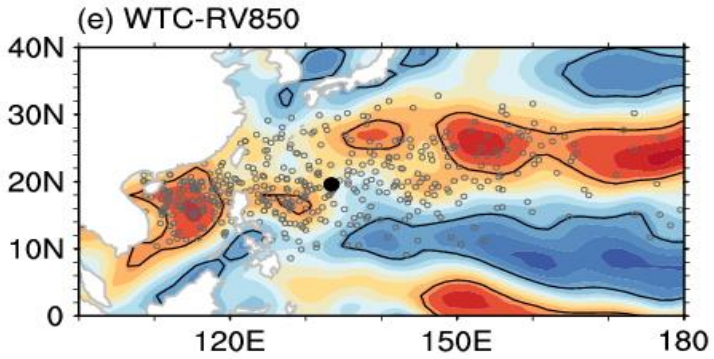

- **WTC:** TC events with their lifetime Vmax greater than 17 m/s and less than 42 m/s, including **TS, STS, and TY**
- **ITC:** TC events with their lifetime Vmax greater than 42 m/s, including **STY and SuperTY**

# Seasonal TC frequency with different intensity

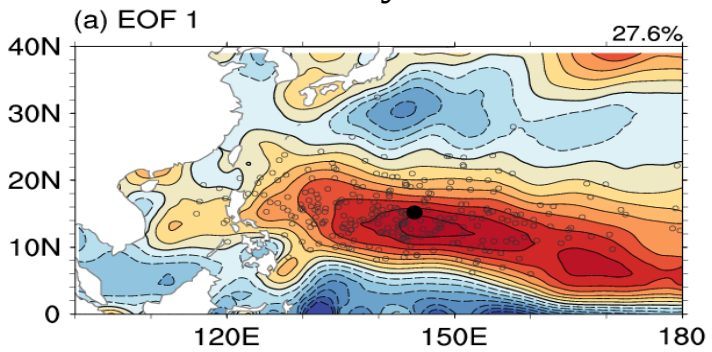
Intense TC

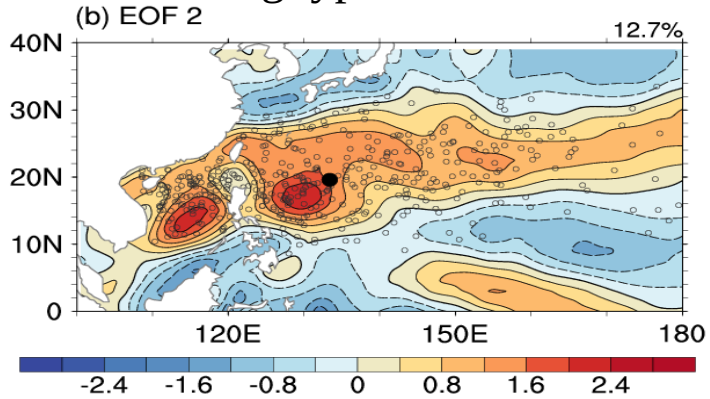



Weak TC




EOF analysis for RV850 in the WNP during typhoon season

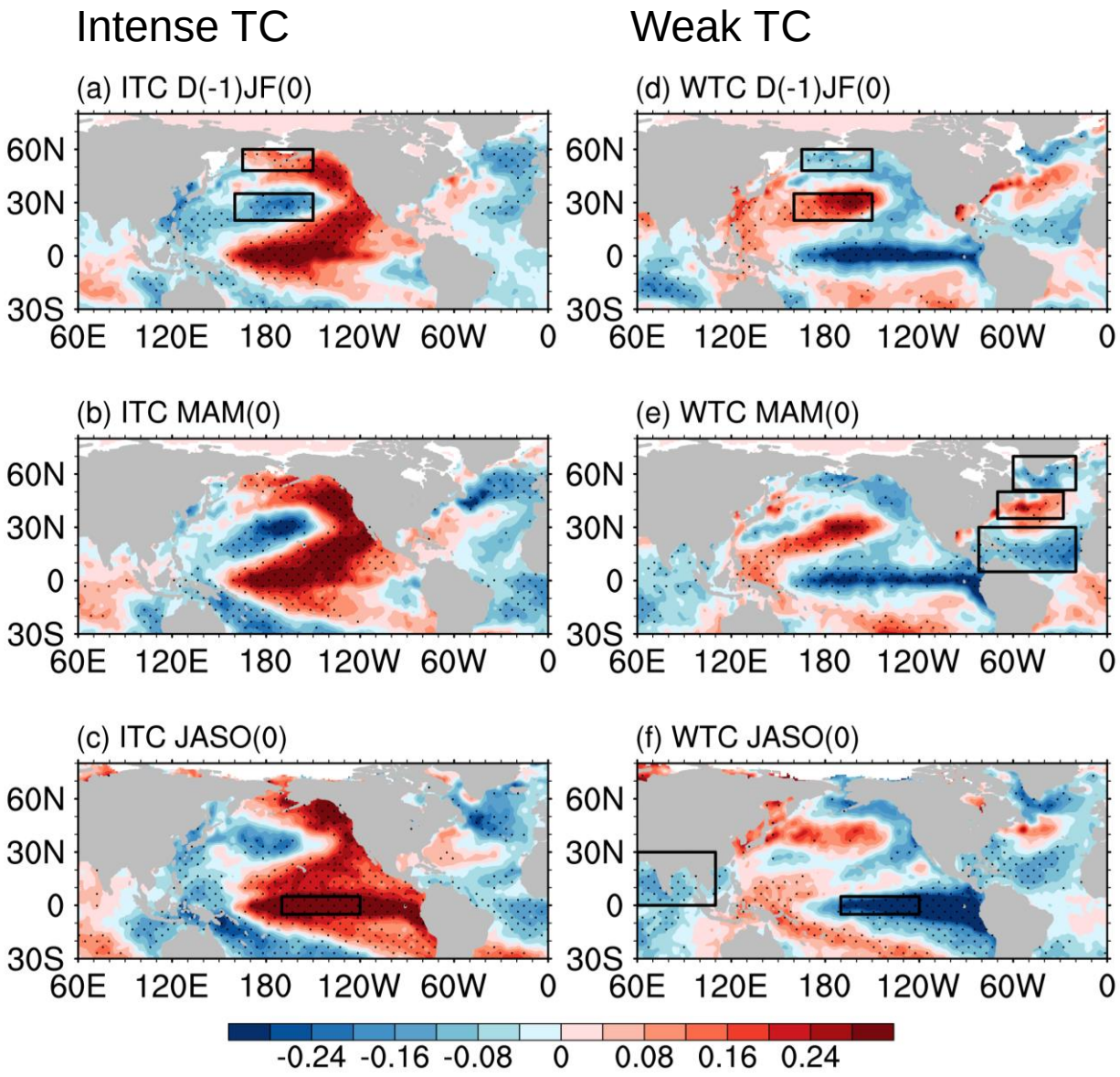



The temporal correlation coefficient (TCC) between the two leading principal components and both TC frequencies are **0.65 and 0.55**, respectively

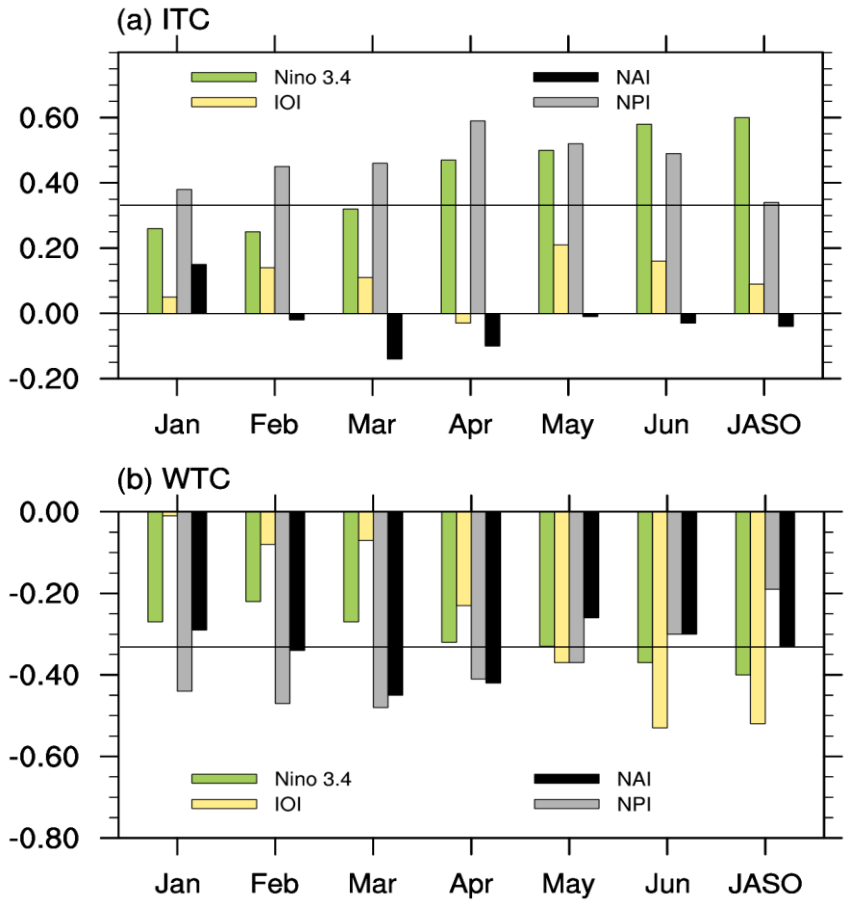
**☐ Since the intense and weak TCs show great differences, their origins can also vary**

# Seasonal TC frequency with different intensity




**Intense TC frequency： Pacific impact**

**Weak TC frequency： Inter-basin interaction**




Intense TC

Niño 3.4

NPI

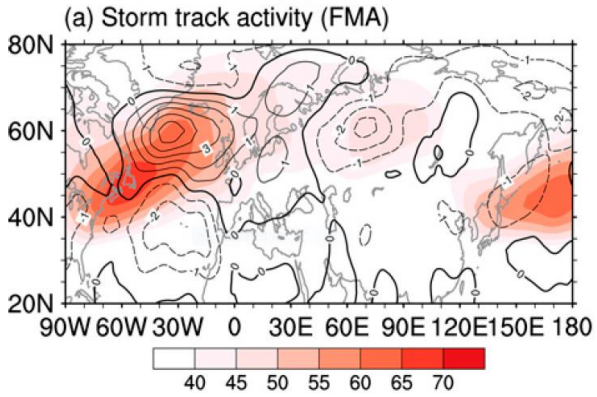
Weak TC

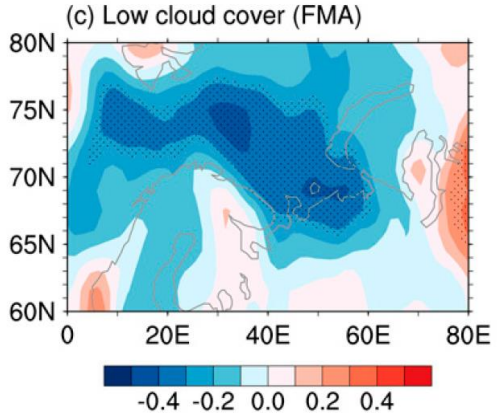
IOI

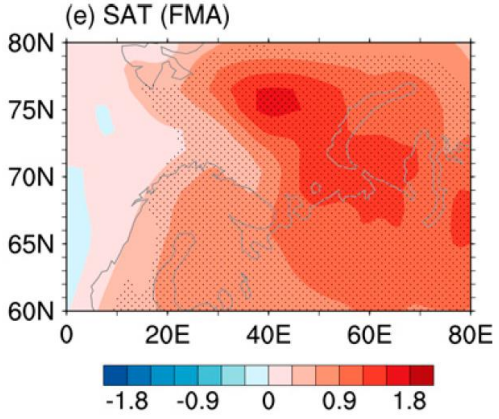
NPI

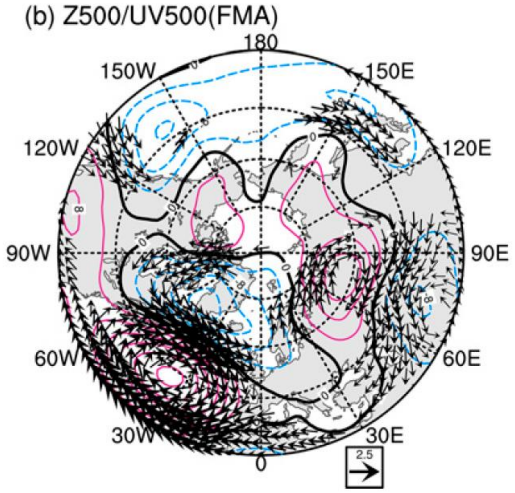
**NAI**

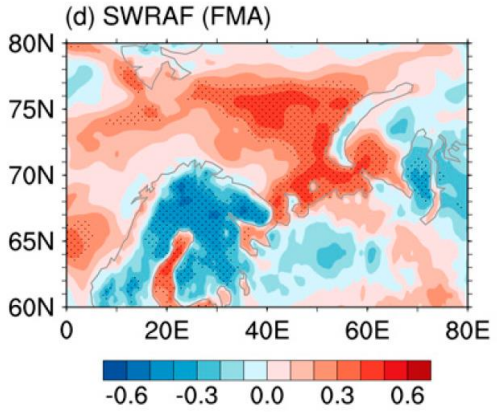
# Seasonal TC frequency with different intensity

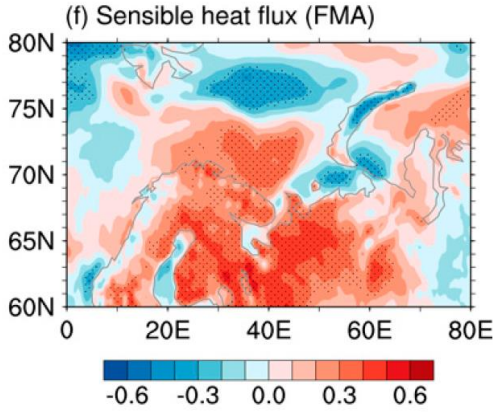


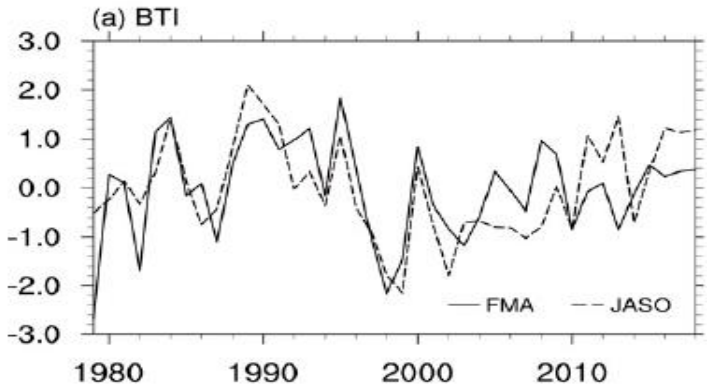



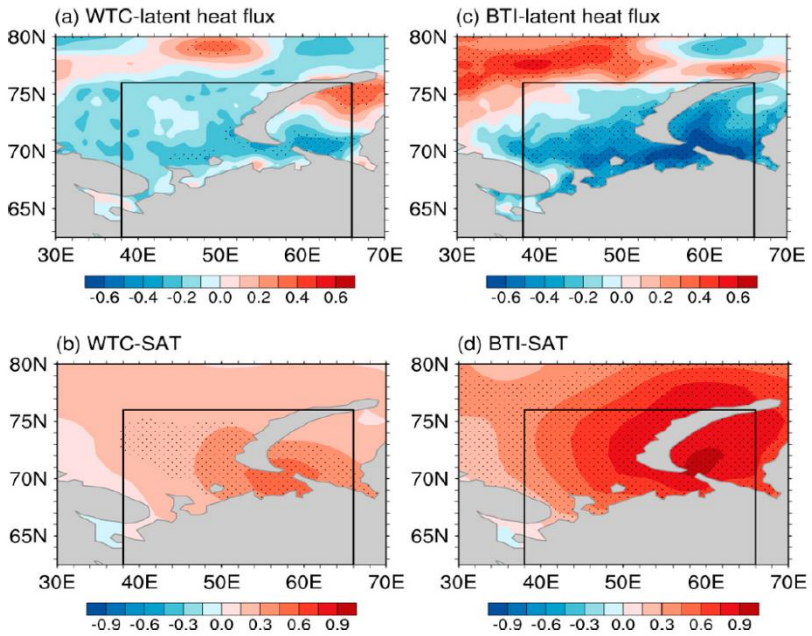




**The tripole SSTA (+)**

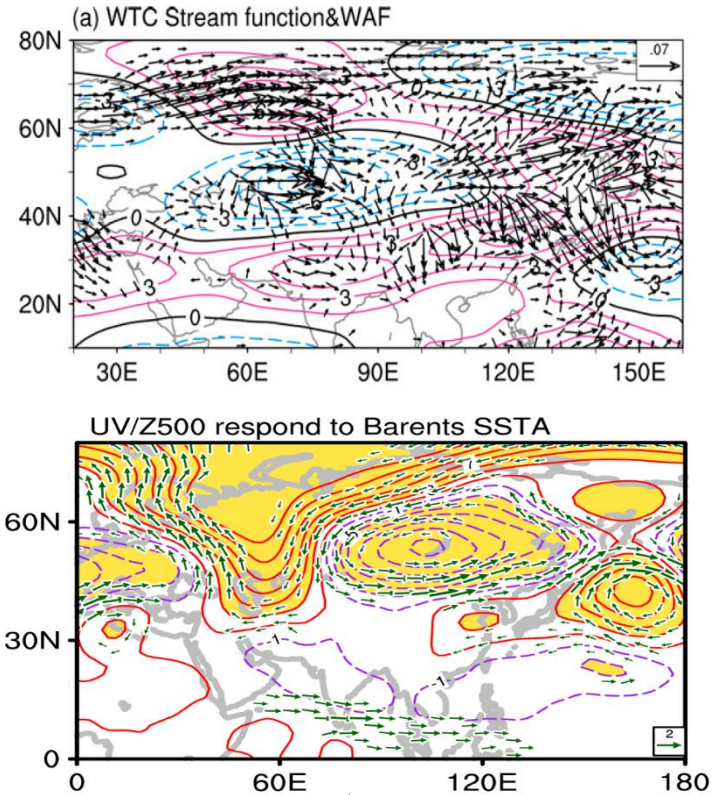
→**AC** in the Barents Sea
→decreases the **low cloud cover** and increases the **solar radiation**
→heat the atmosphere
→more **downward sensible heat flux**
→melt the sea ice and warm **the ocean**



# Seasonal TC frequency with different intensity



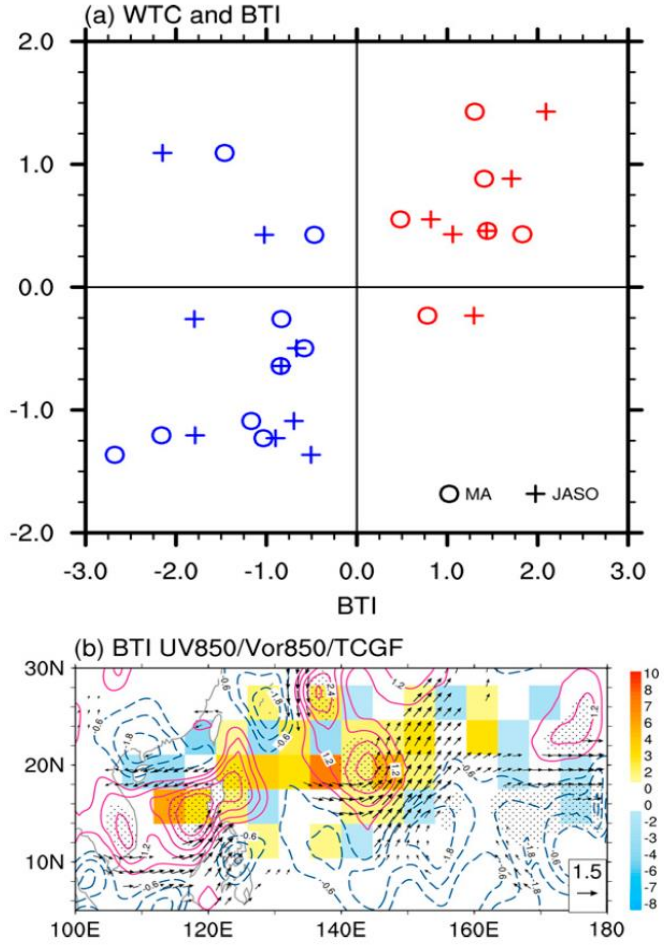

**Observation**




**Model result**

Warm the ocean
→more upward latent heat flux
→stimulate southeastward wave train
→AC in Northeast China
→ Cyclonic vorticity to its south favors the weak TC formation.

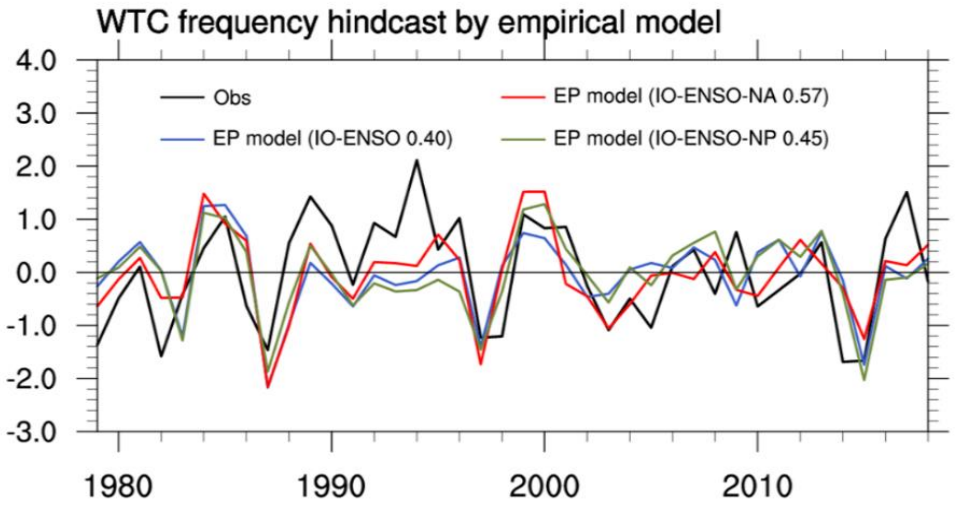
Scatterplot of BTI and the WTC frequency




**More TCs form when the Barents sea is warmer than normal, with prominent local cyclonic vorticity.**

# Seasonal TC frequency with different intensity

## Physical-based empirical prediction schemes




**Multiple regression:**

ENSO+TIO：**0.59**

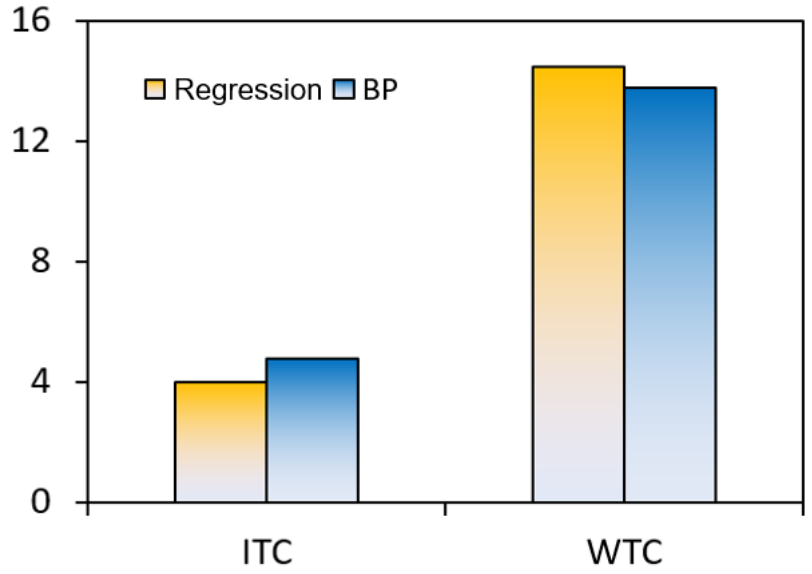
ENSO+TIO+NA：**0.71**

**Cross-validated estimates (1979–2018):**

ENSO+TIO：**0.40**

ENSO+TIO+NA：**0.57**

## Prediction for the past typhoon season in 2022

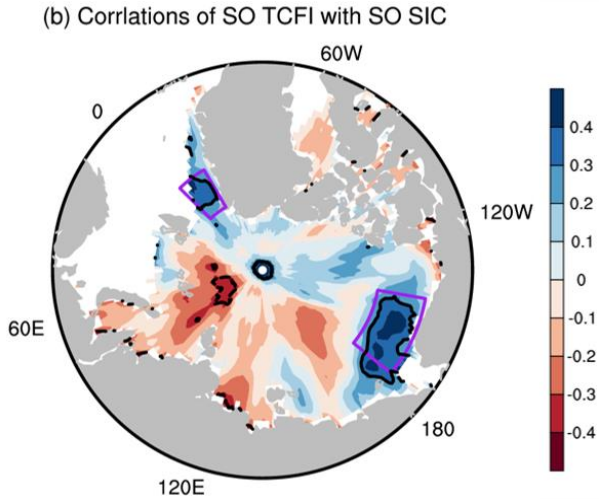


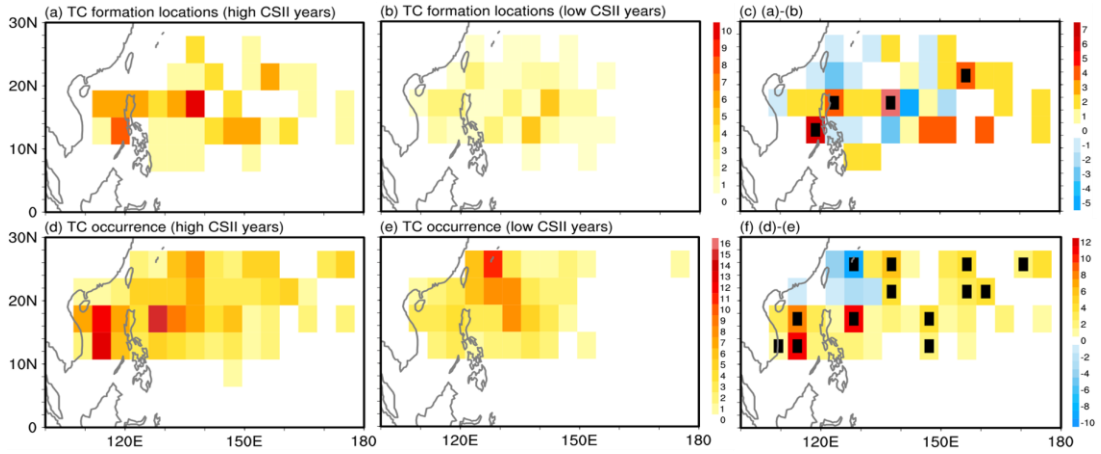

- In observation, we had 7 ITC and **13 WTC**
- We predicted 4-5 ITC and **13-14 WTC**

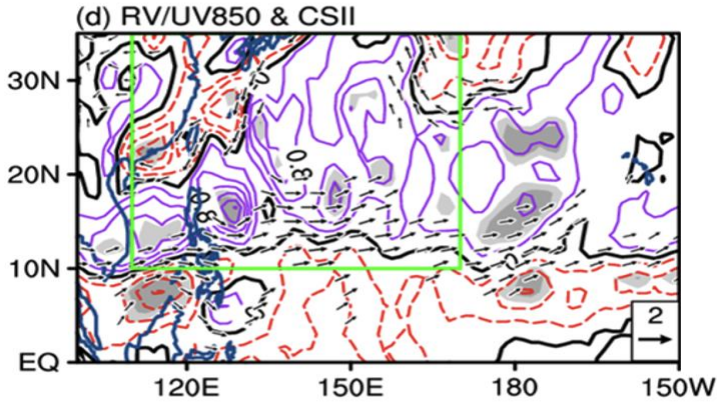
# Seasonal TC frequency in early autumn

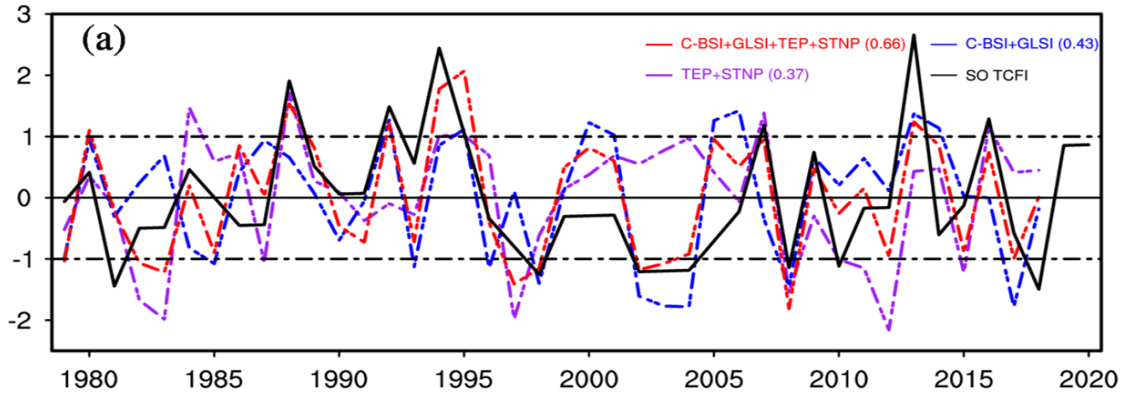
**The positive impact of the Chukchi-Beaufort and Greenland sea ice**

Zhang et al. 2022 ERL



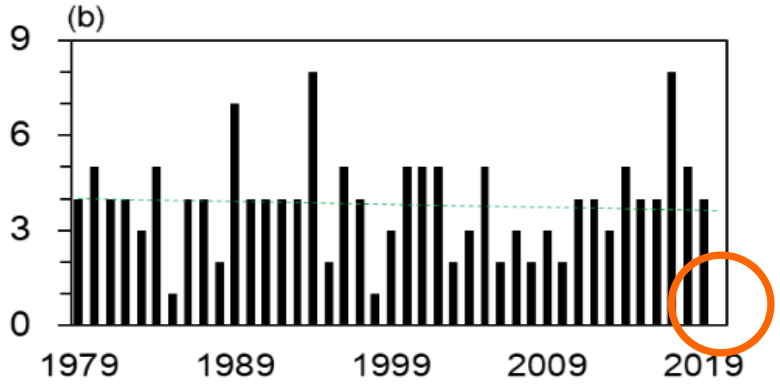



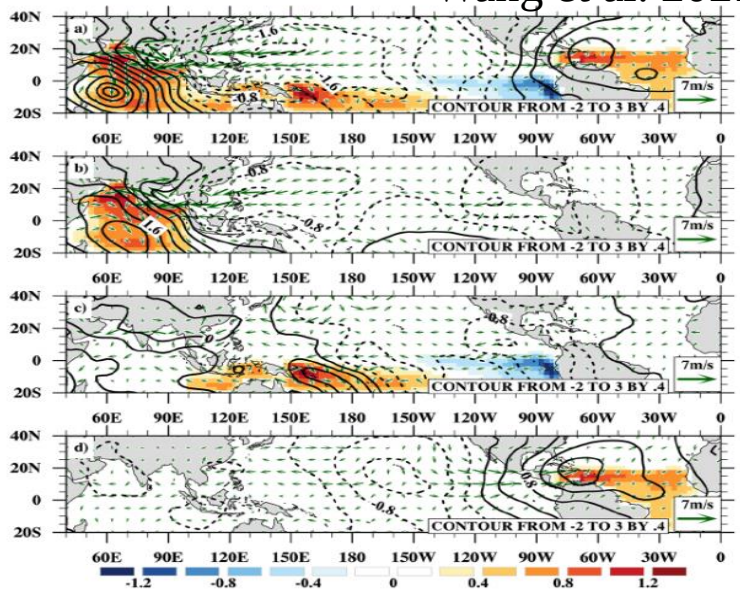



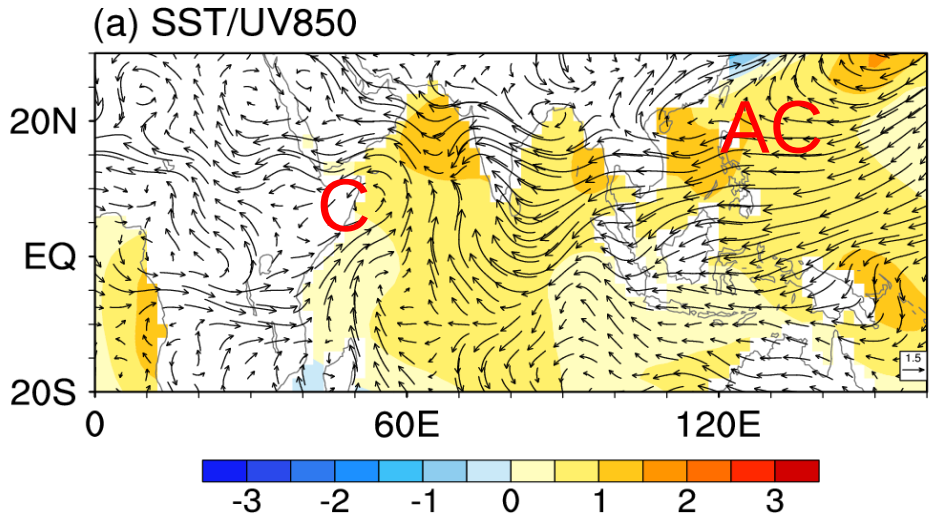

- **TC seasonal prediction skill can be improved by considering both the tropical SSTAs and the Arctic sea ice**

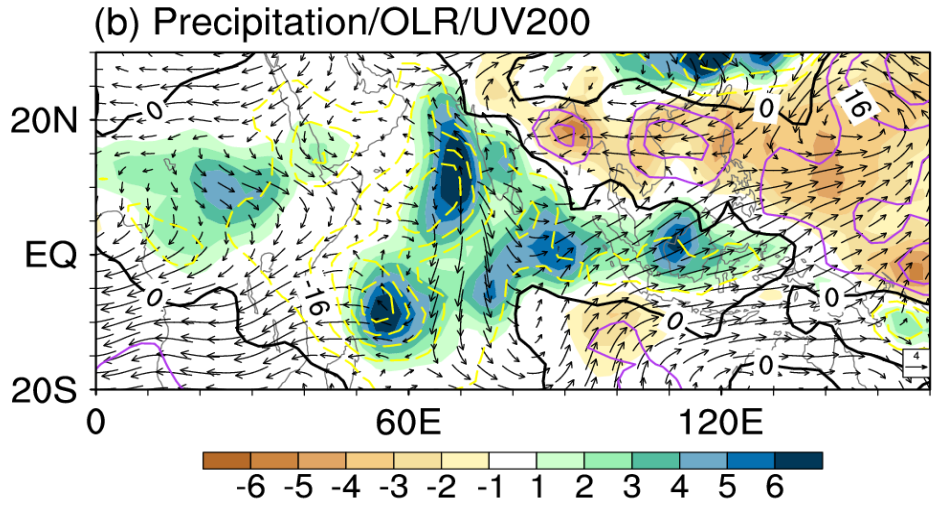
# Subseasonal TC frequency (The extreme TC silence in July 2020)




Wang et al. 2021



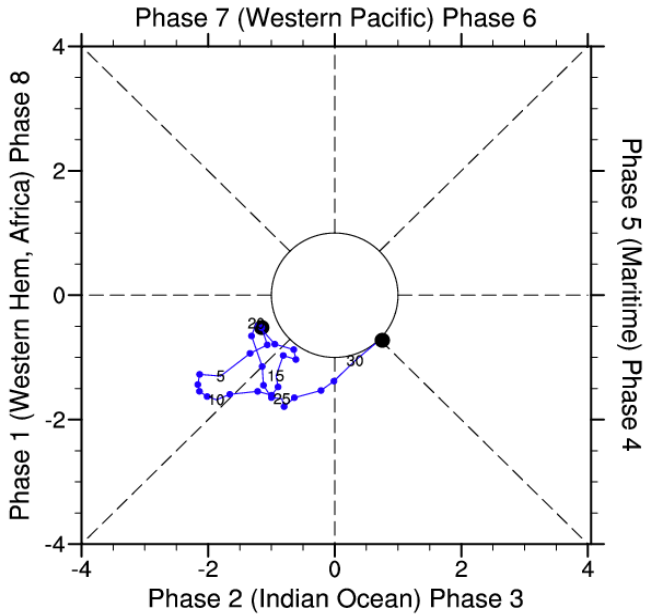



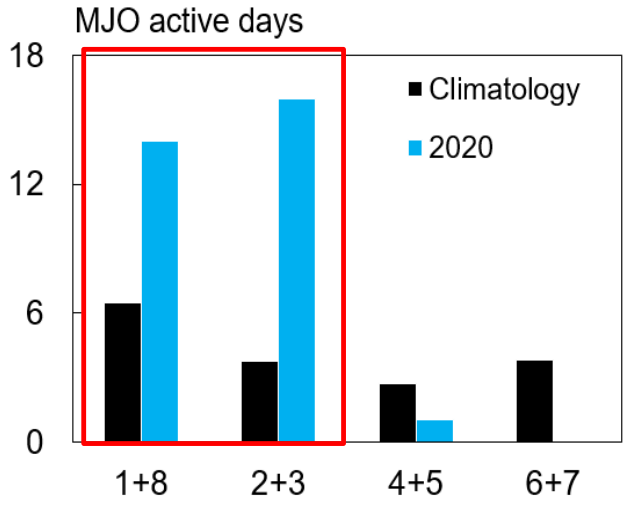



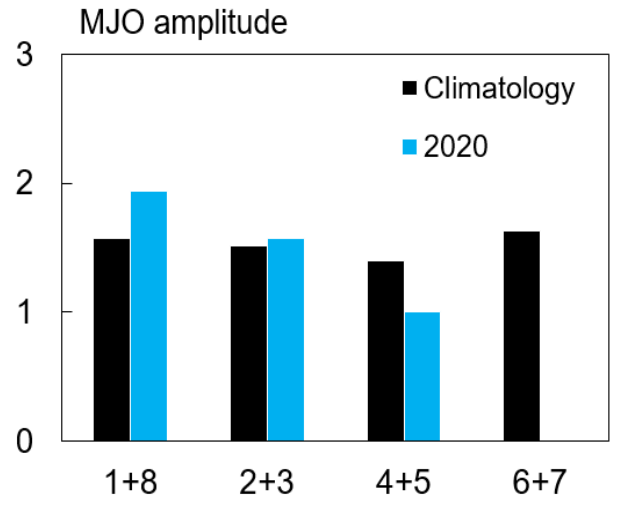

- **Extremely warm Indian Ocean**

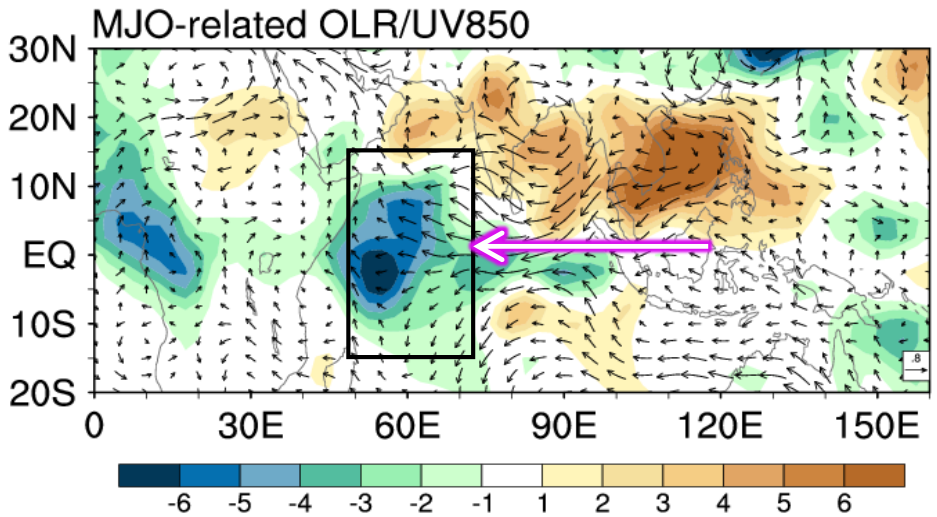
# Subseasonal TC frequency (The extreme TC silence in July 2020)

| Phase | 1+8 | 2+3 | 4+5 | 6+7 | Total |
|---|---|---|---|---|---|
| MJO days | 268 | 153 | 111 | 157 | 1271 |
| TC number | 24 | 12 | 17 | 32 | 160 |
| DGR (%) | 9.0 | 7.8 | 15.3 | 20.4 | 12.6 |



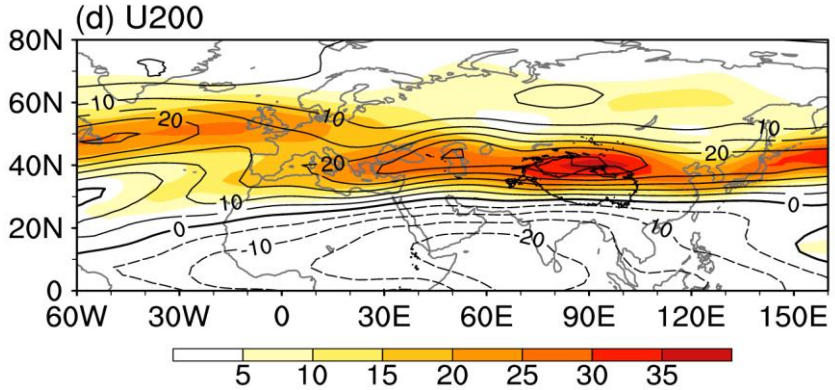




- **Sustained MJO activity in phases 1+8 and 2+3 further suppress TC formation**

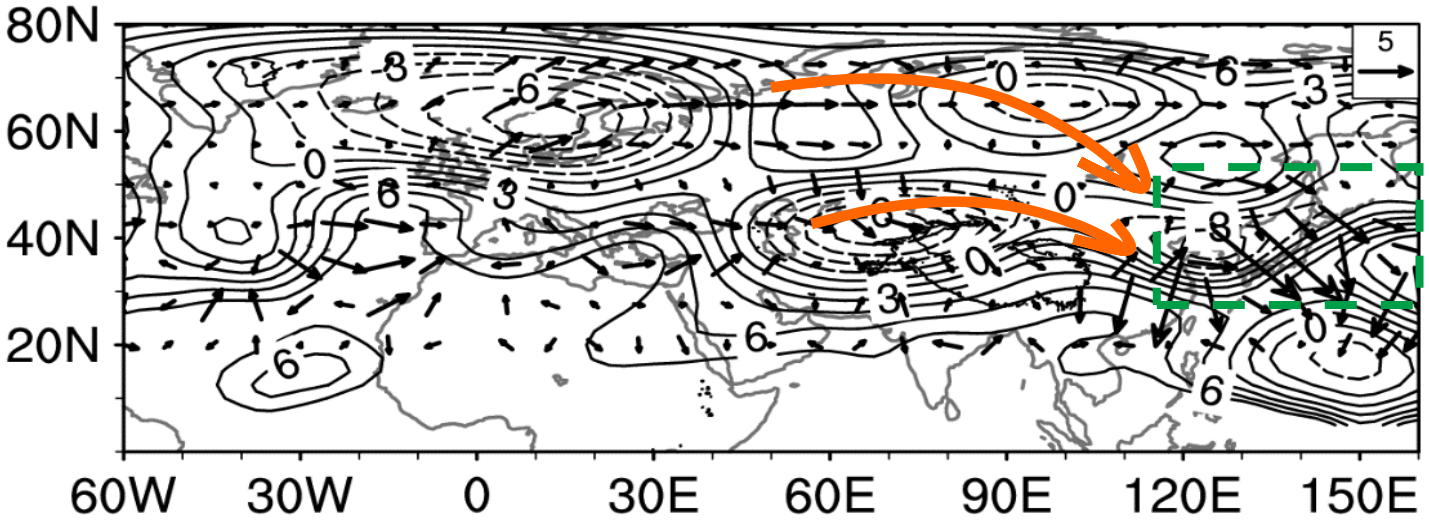
# Subseasonal TC frequency (The extreme TC silence in July 2020)

200hPa zonal wind




Counter: Climatological mean
Shading: Value for July 2020

200hPa stream function and wave flux




***Strengthened*** subtropical and subpolar ***jet streams*** in July 2020;

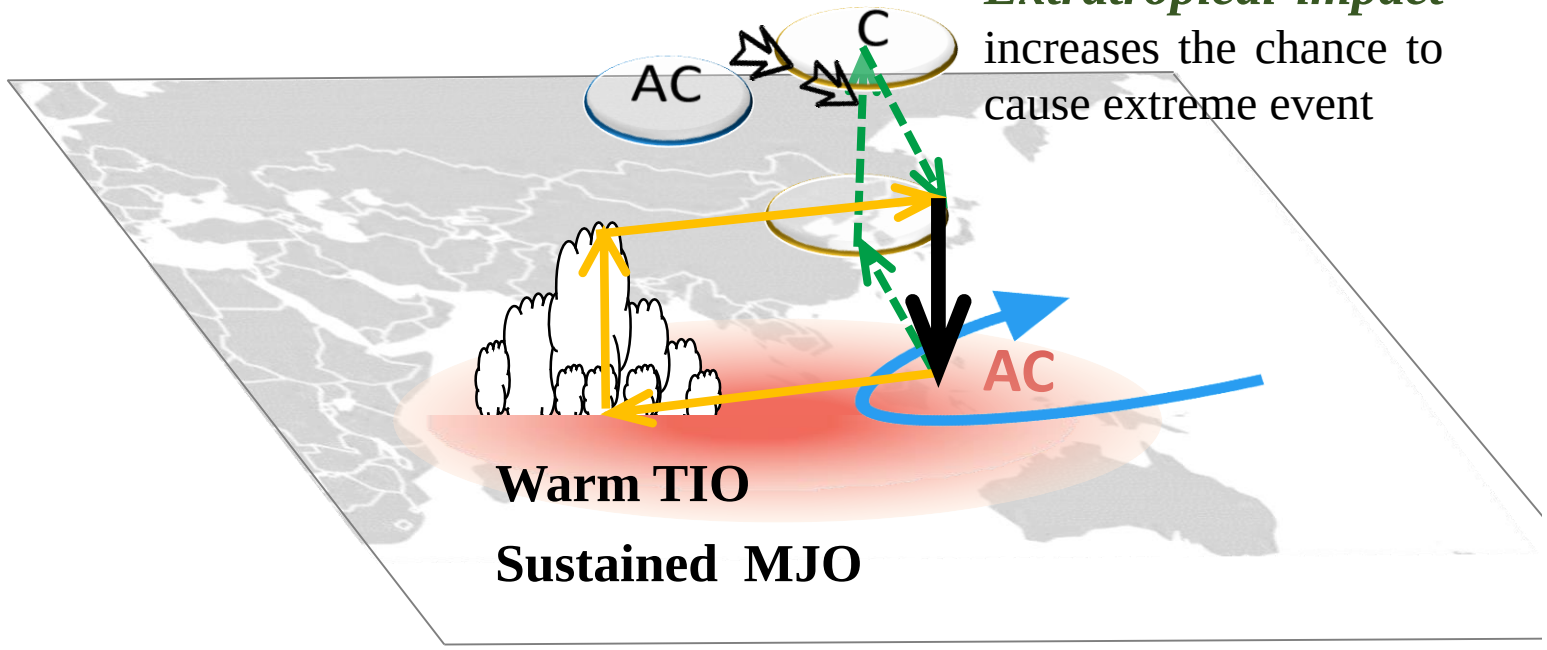
Along the jet stream, prominent ***quasi-barotropic structures*** and wave flux throughout the Eurasian continent;

Flux gather around Northeast China, which favors the equatorward subtropical jet stream and the WPSH.

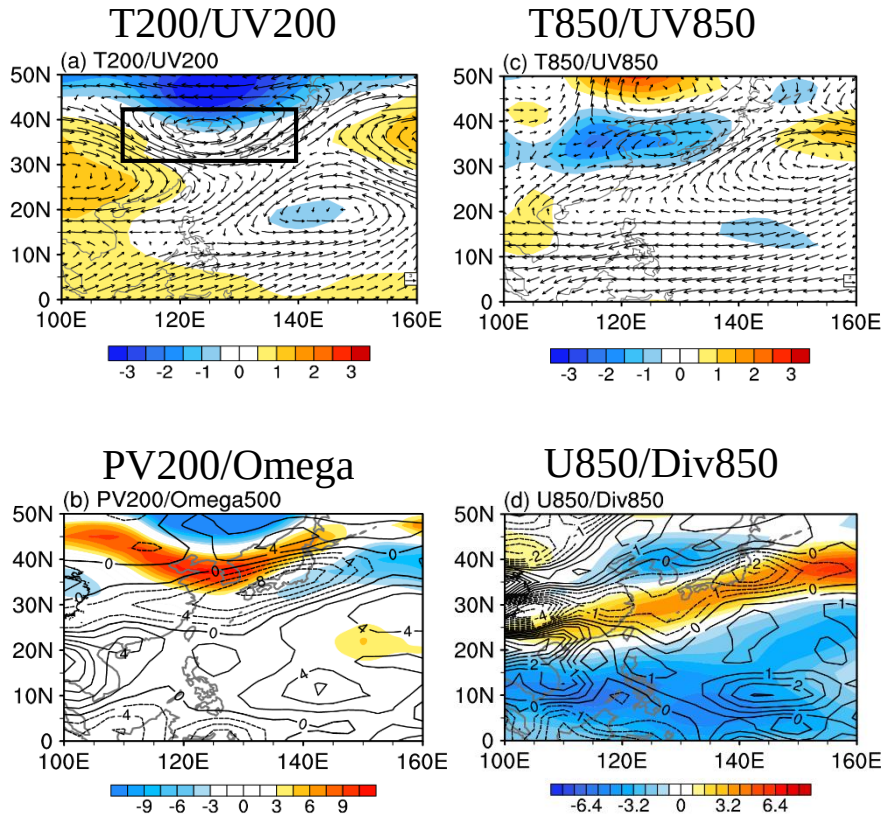
- **Here, we highlight the potential impact of extratropical circulation**

# Subseasonal TC frequency (The extreme TC silence in July 2020)

## ☐ Tropical-extratropical interaction




***Extratropical impact*** increases the chance to cause extreme event




**Cyclonic circulation** in Northeast China → local meridional circulation → **descending motion** in the tropics

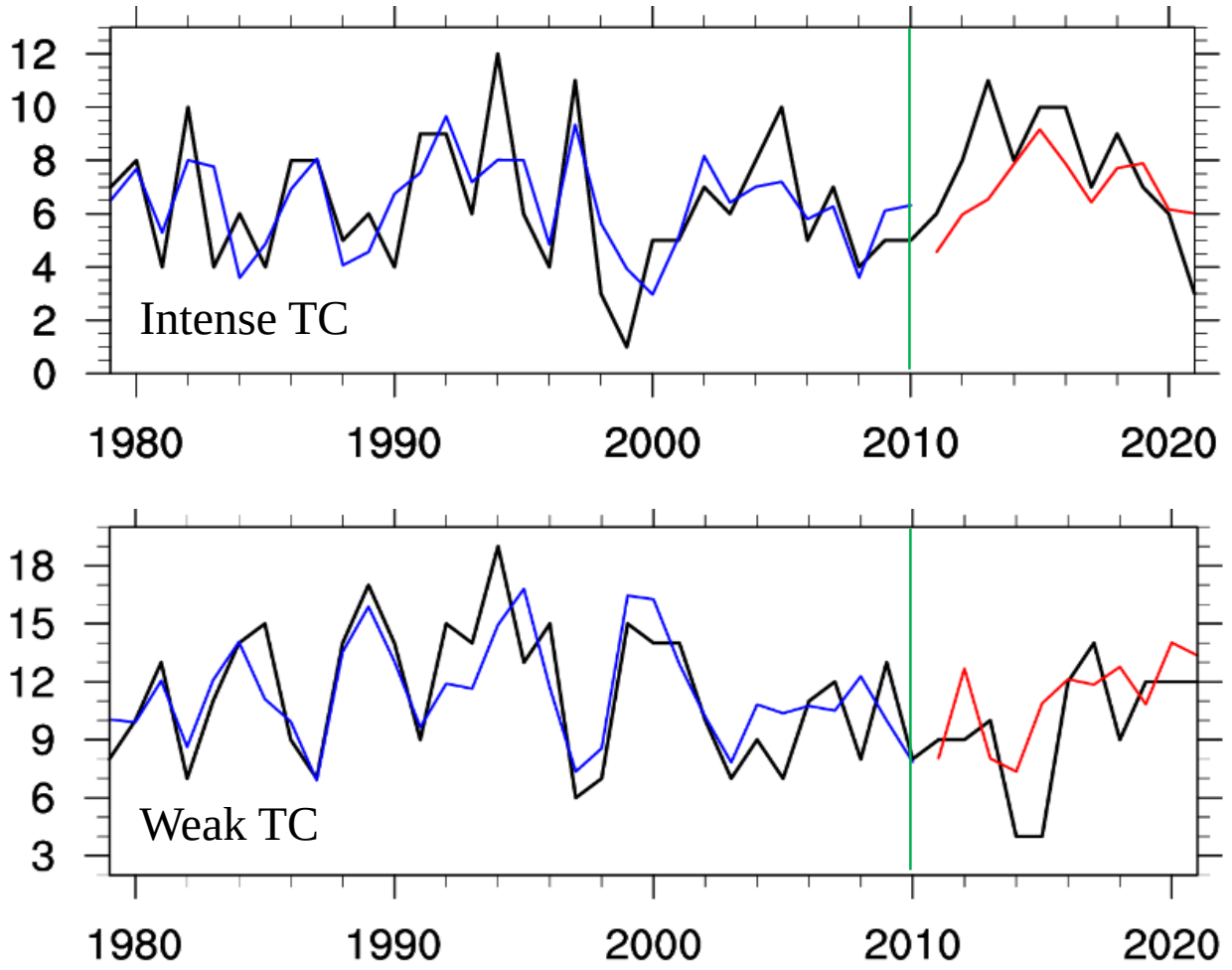
**Cold air temperature** → increased gradient across the WNP → **Anti-cyclonic vorticity** in the tropical WNP


**Jin R**, H Yu*, Z Wu, P Zhang. 2022. Impact of the North Atlantic Sea Surface Temperature Tripole on the Northwestern Pacific Weak Tropical Cyclone Frequency. Journal of Climate, 3057–3074, https://doi.org/10.1175/JCLI-D-21-0056.1.

**Jin R**, H Yu*, M Ying, Z Wu. 2022. An Extreme Tropical Cyclone Silence in the Western North Pacific in July 2020. Atmosphere Ocean, 60(1), 23–34, https://doi.org/10.1080/07055900.2022.2060179.

Zhang, P., Wu, Z.*, Zhu, Z., and **Jin, R**. 2022. Promoting seasonal prediction capability of the early autumn tropical cyclone formation frequency over the western North Pacific: effect of Arctic sea ice. Environmental Research Letters. 17, 124012.

## Seasonal prediction models




- The independent forecast skill for the latest 10 years reach about 0.7