Equatorial Rossby Wave in western North Pacific during Warm Season

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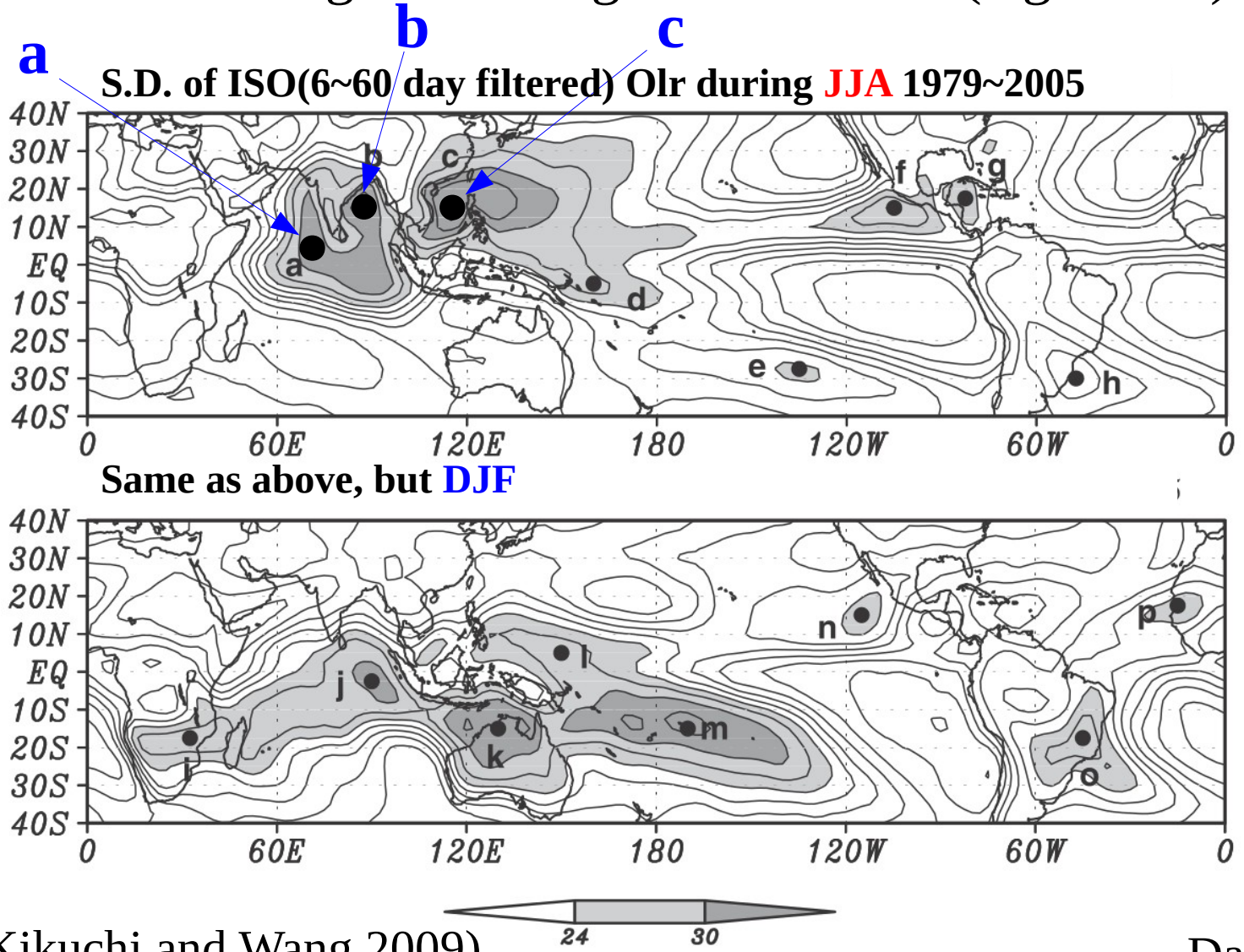
Outline

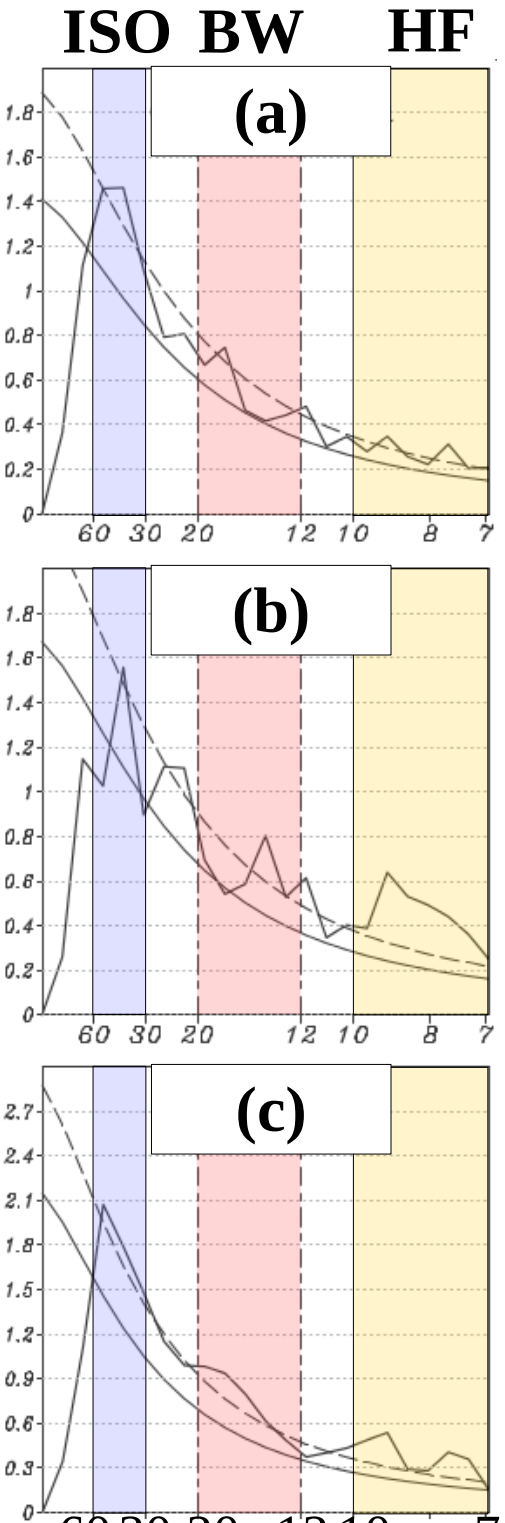
- **Motivation**, **Objective**, and **Data**
- **Part I**: Equatorial Rossby wave: Linear Theory and Observed Properties
- **Part II**: Different types of ER wave
- **Summary**

Motivation

- Significance of quasi bi-weekly oscillation in monsoon regions during warm seasons(e.g. WNP).



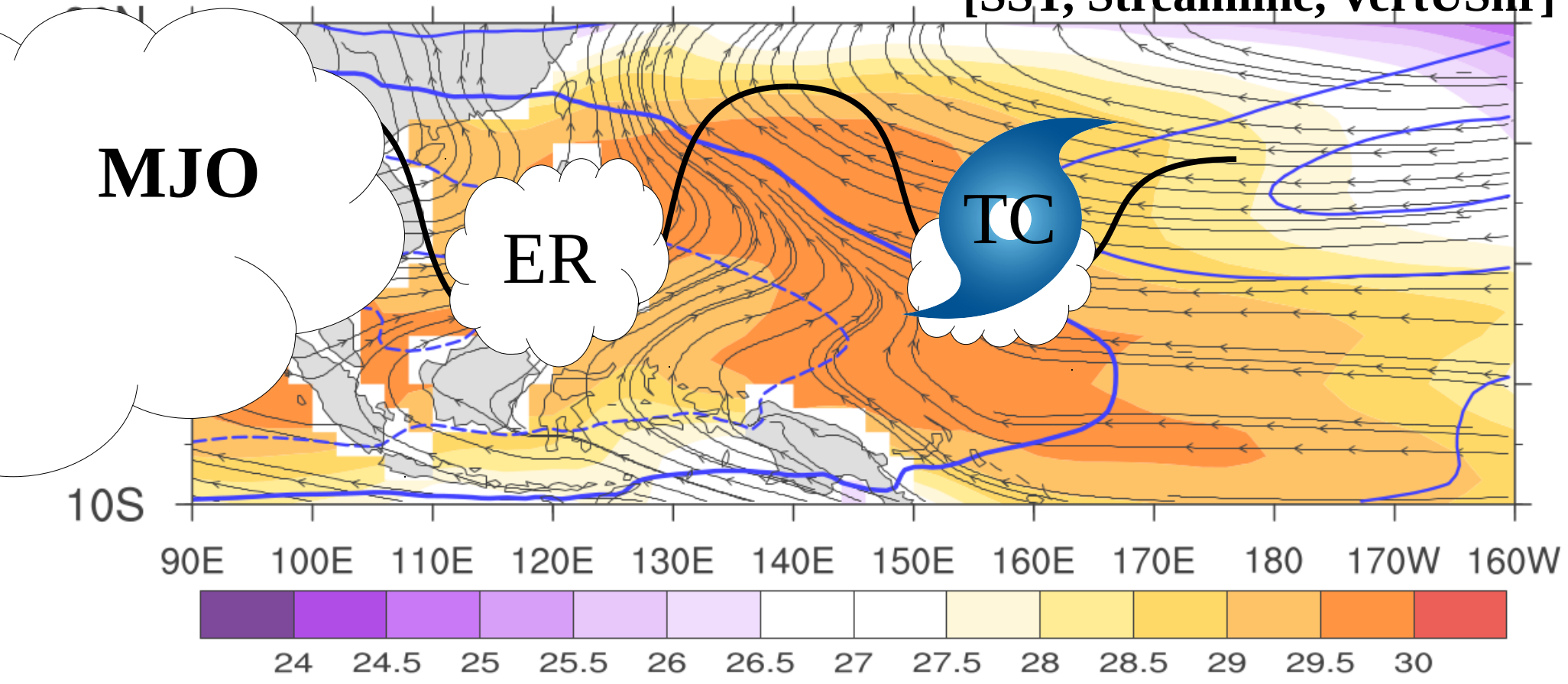
(Kikuchi and Wang 2009)



Motivation

- Large-scale condition is favorable for TC genesis (TCG)
- Tropical wave(e.g. ER wave) grows via barotropical energy conversion and cumulus heating.
- MJO activity => modulate low-frequency field

[SST, Streamline, VertUShr]



Motivation

- It's complicated with each other => **multi-scale interaction** in WNP

Objective

1) Will ER have different behavior sitting on various background flow?
2) Will different types of ER influence the TC genesis?

Data

Variables	Data sets	Period	Resolution
OLR	NOAA	2000 ~ 2010	• $2.5^{\circ} \times 2.5^{\circ}$ • Daily data
u, v, Vorticity, divergency	ECMWF Interim	2000 ~ 2010	• $0.75^{\circ} \times 0.75^{\circ}$ • 6 hourly*

*6 hourly data are averaged to **daily data**

Part I

Equatorial Rossby wave:

Linear Theory and

Observed Properties

Single-layered Free Shallow Water Model

(Matsuno 1966)

- Barotropic
- **No basic state**
- No moisture: adiabatic
- No forcing: free

Properties of Linear & Free Equatorial Rossby Wave

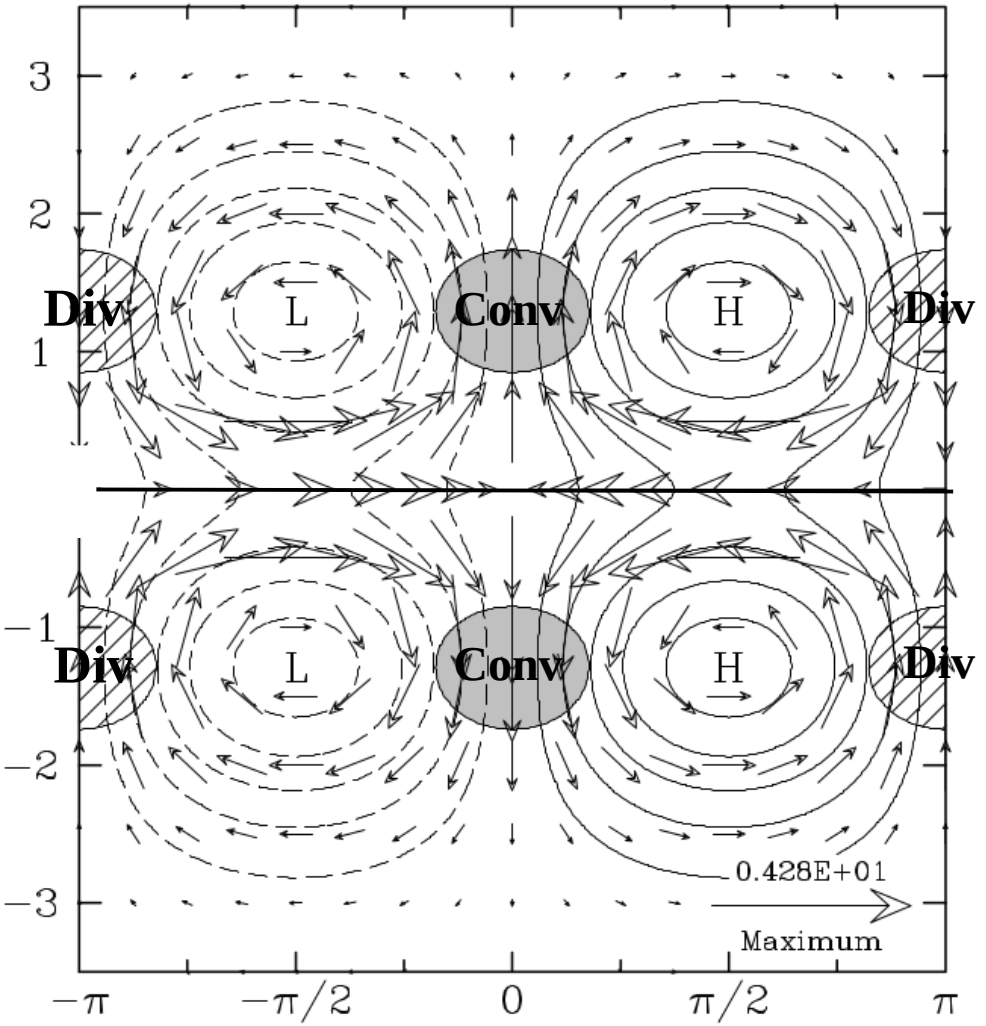
1) **Symmetric alone equator**

2) **Amplitude decays with latitude**

3) Maximum zonal wind along equator

4) Westward propagating

n = 1 k*=1 Equatorial Rossby Wave



Contour: geopotential

Vector: wind

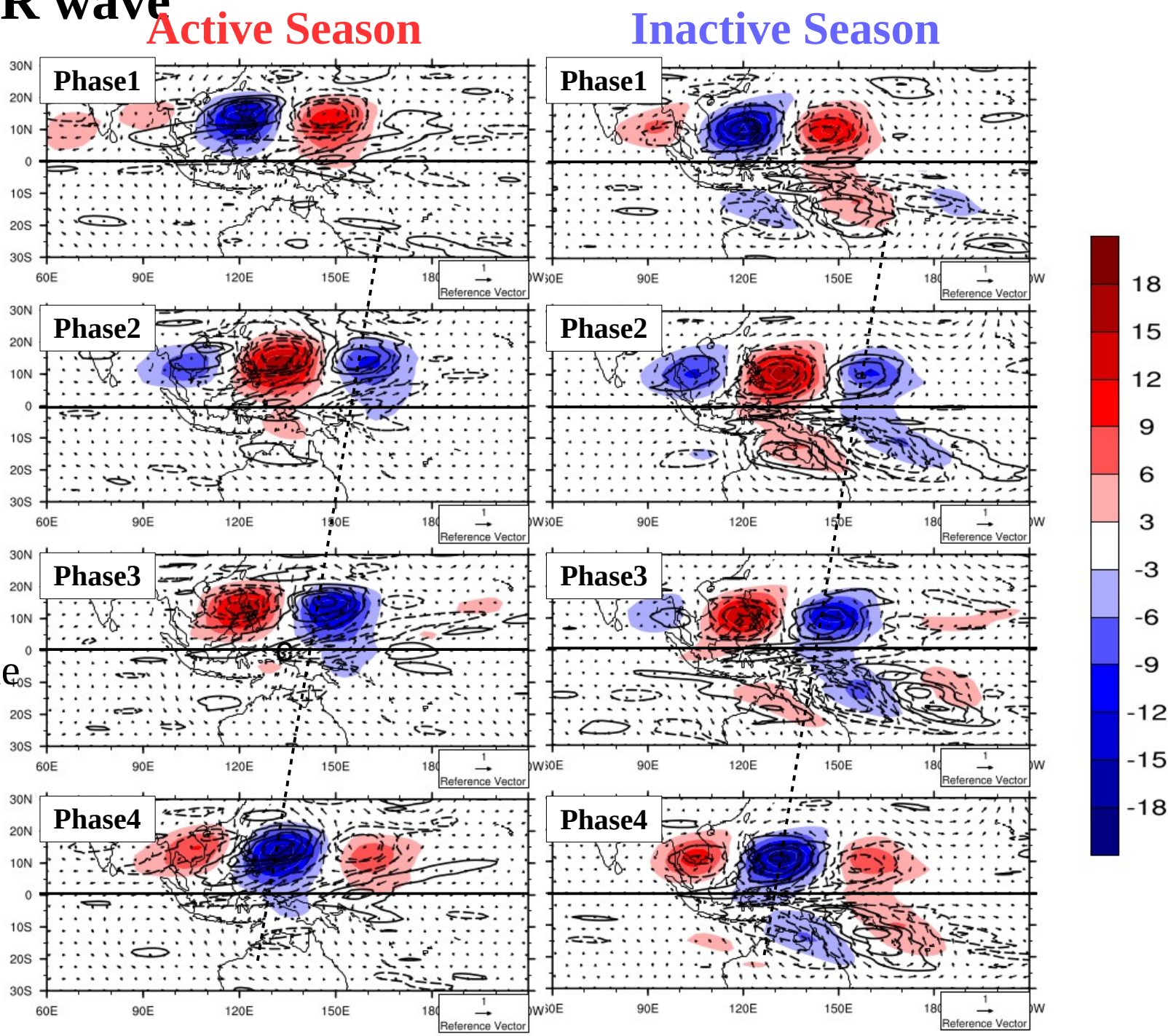
Conv **Div**

Phase Composite Of Observed ER wave

[ErOlr, ErVort, ErWind]

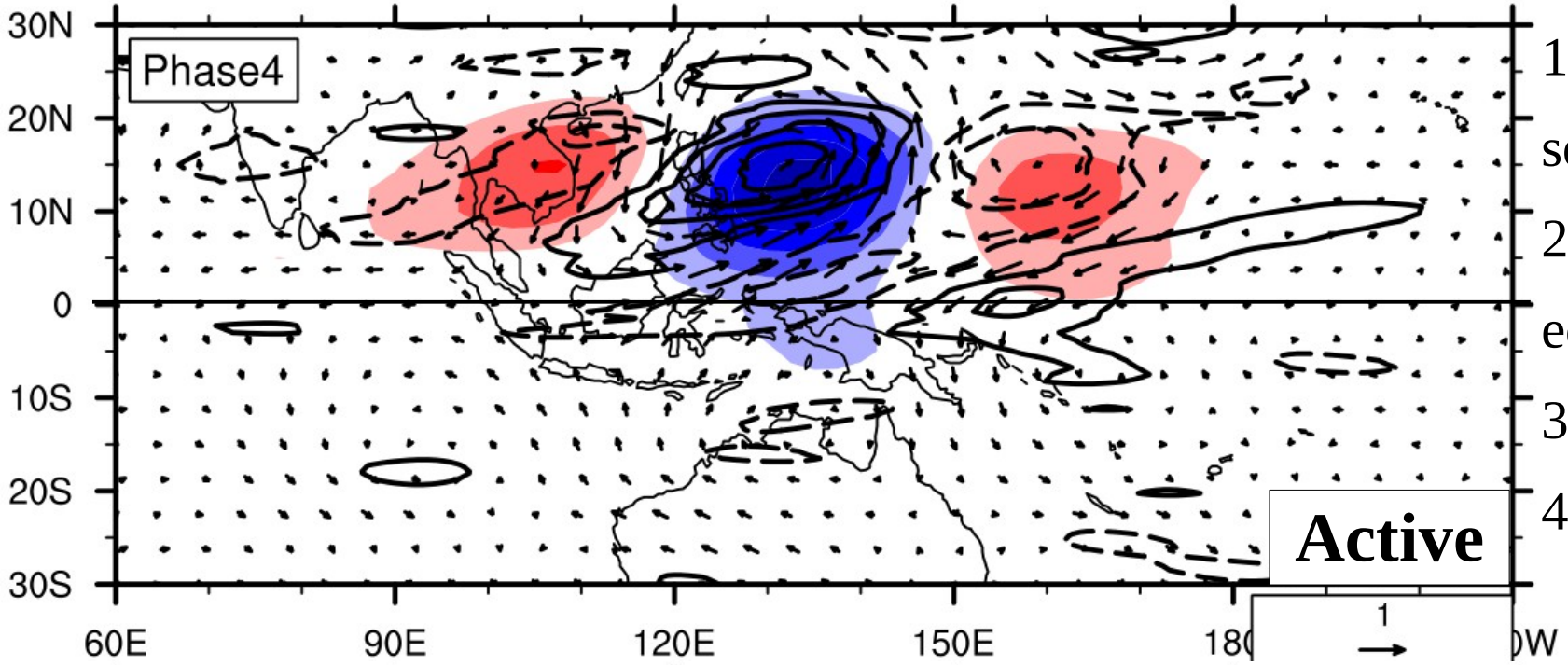
Background flow

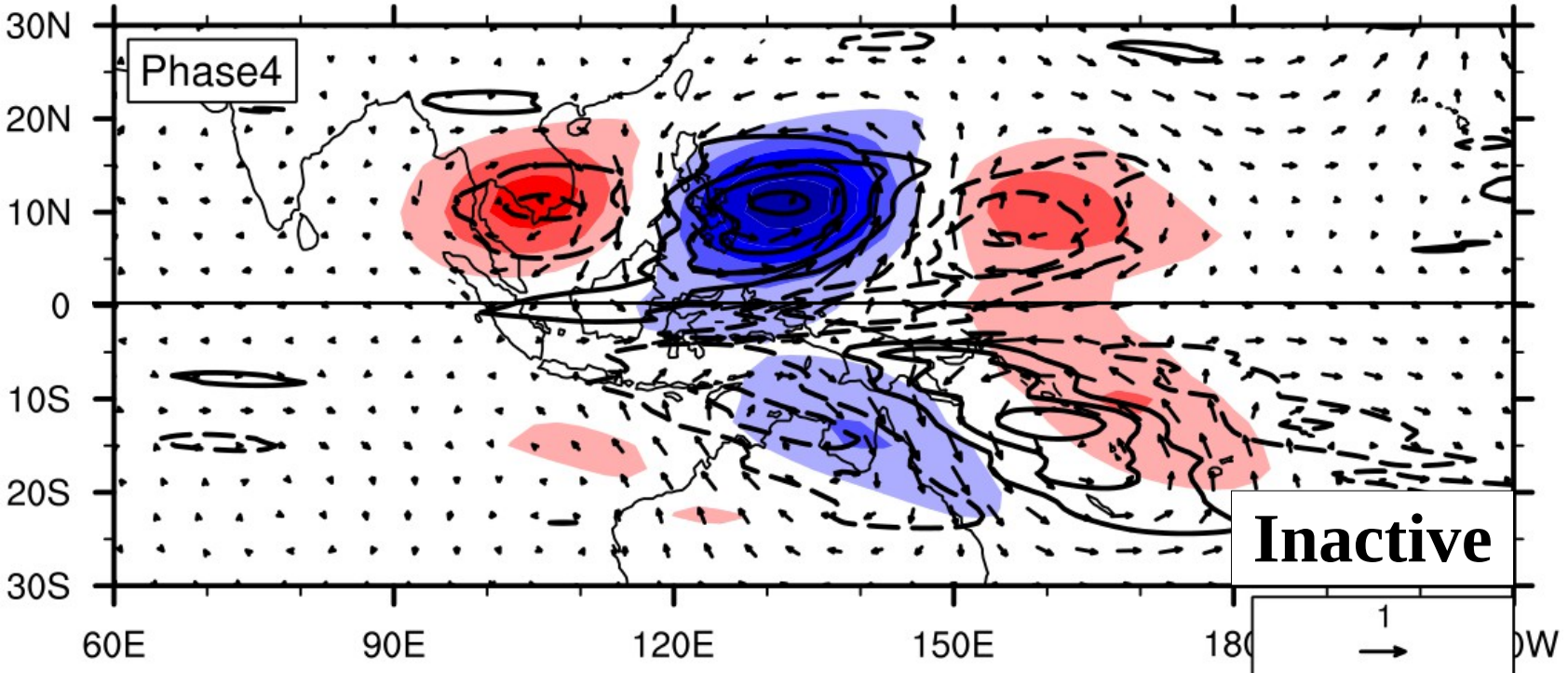
- Seasonality
- Propagation
- Wavelength
- Phase speed
- Phase relationship
- Tilting of phase line
- Asymmetric



A closer look

[ErOlr, ErVort, ErWind]





1) Original linear solution

2) Asymmetric to equator

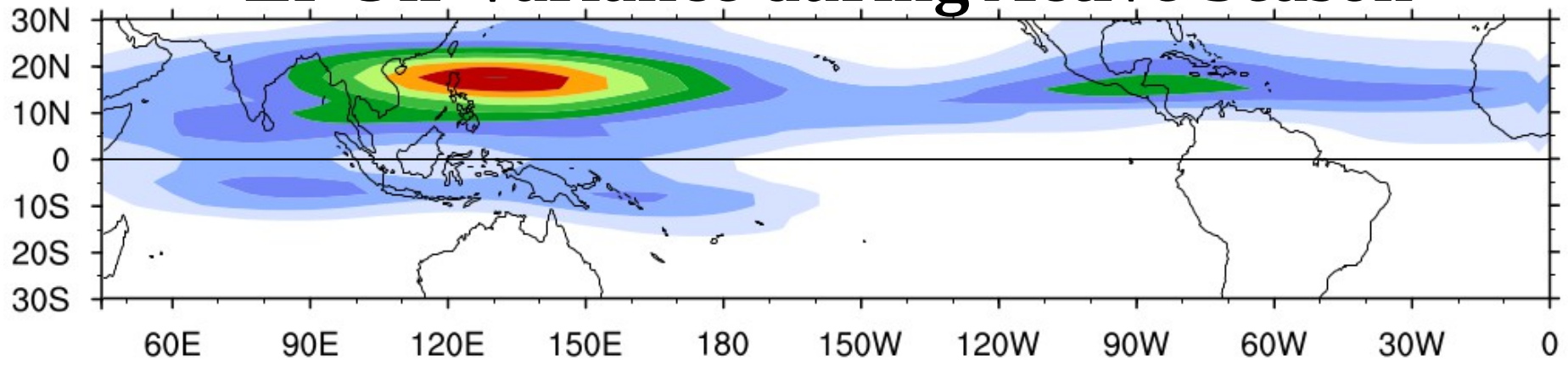
3) Tilting

4) Phase relation

Part II

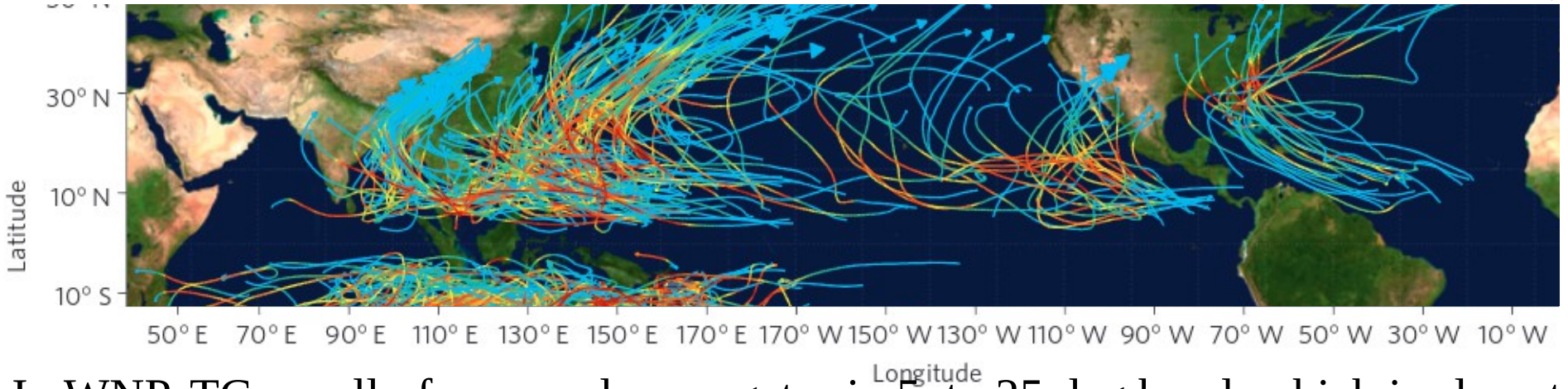
Different Types of ER Wave and their Influence on TC Genesis

Er Olr Variance during Active Season



Tropical Cyclone Track

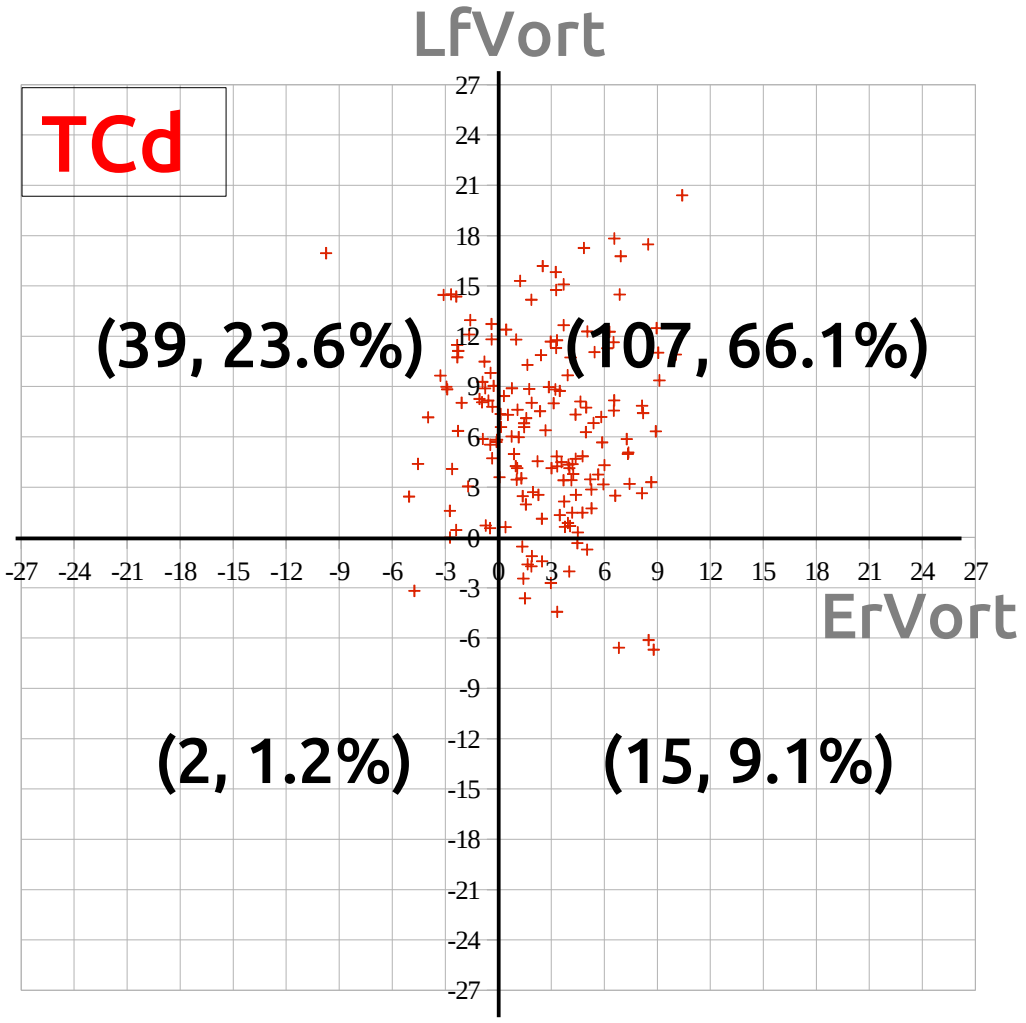
(Mendelsohn 2012)

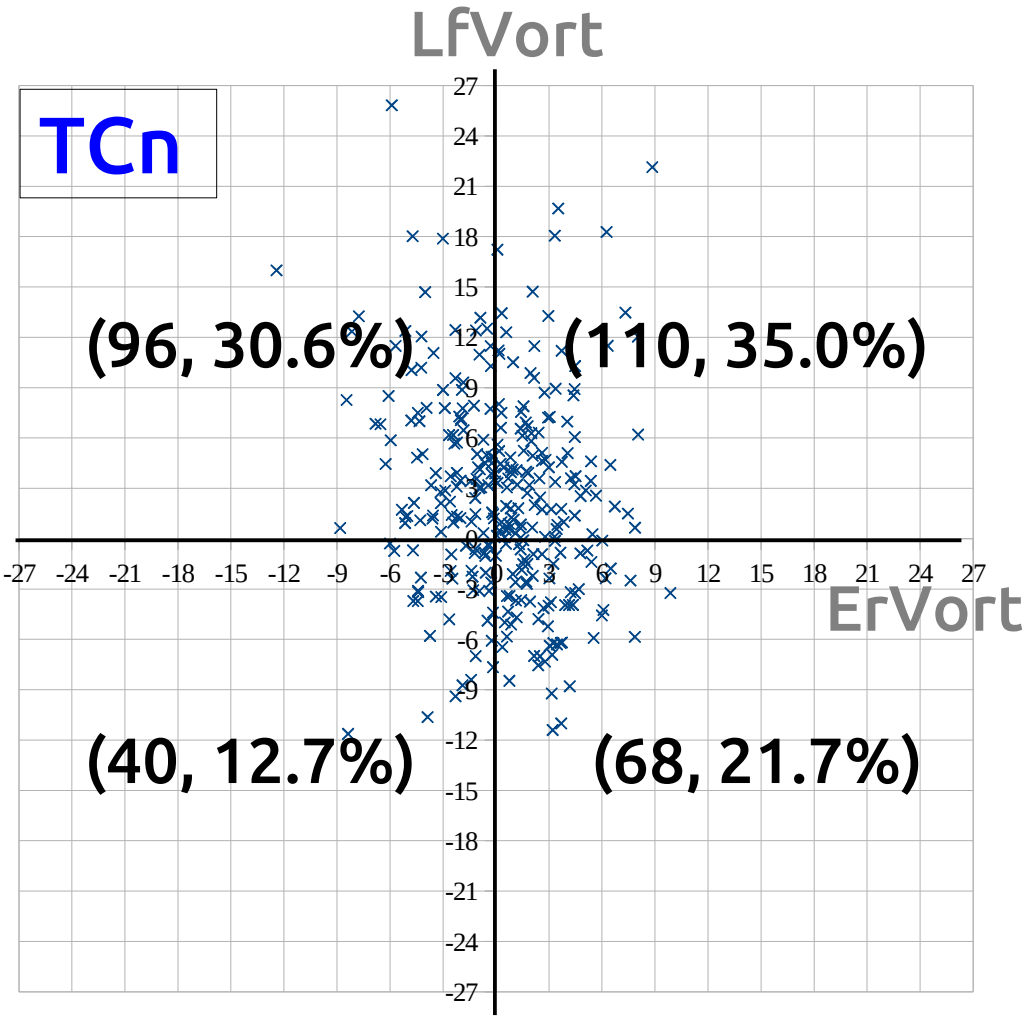


- In WNP, TC usually forms and propagates in 5° to 25 deg band, which is almost coincident with the ER's active region. They may interact with each other.
- ER provides positive low level vorticity, moisture convergence, convective heating, and high RH% enviroment.
- TC and ER are closely related.

Quadrants for Low-frequency Field and Er Wave (May to Sep, 2000 to 2009)

(Ching-Hsuan Wu)





(163, 34.2%)

(314, 65.8%)

(TC Numbers: Perctentage)

	TCd	TCn	Total
All TCs	(163) 34.2%	(314) 65.8%	(477)
TCG with ER+	(122) 40.7%	(178) 59.3%	(300) 62.9%
TCG with ER-	(41) 23.2%	(136) 76.8%	(177) 37.1%

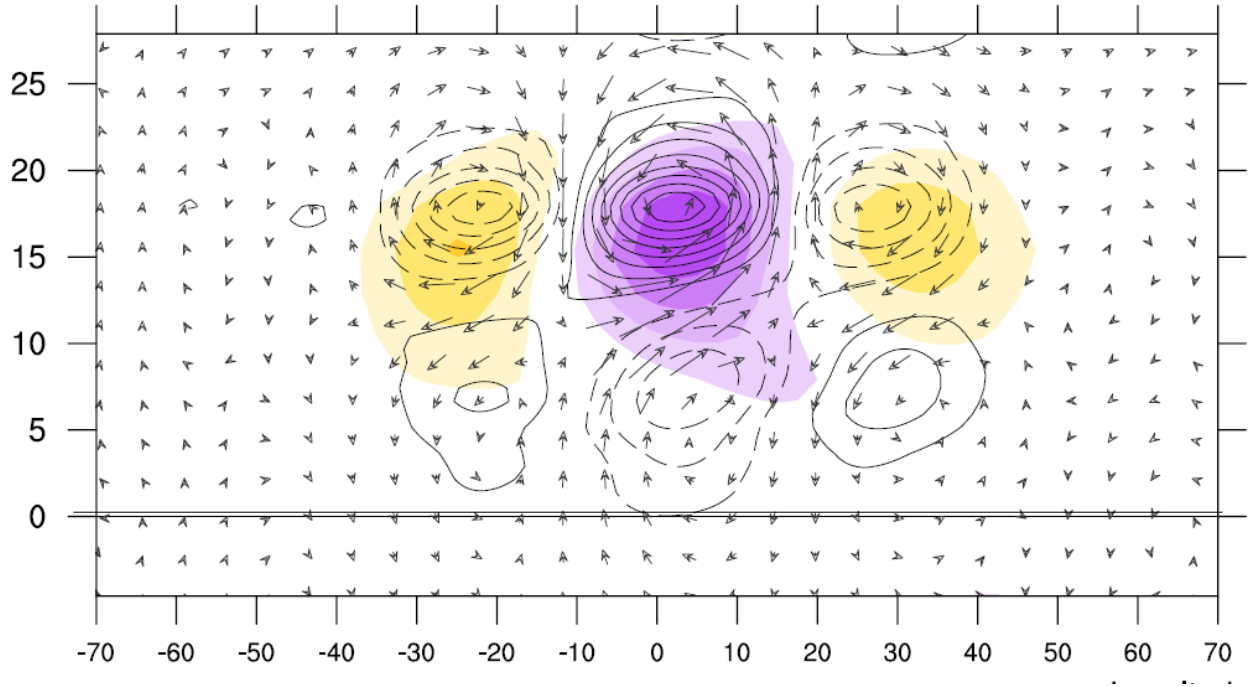
Type1 ER Composite

850mb_ErOlr(shaded)Vort(Contour)Wind

(134 cases)

MeanErLat=17.9 deg N

- Asymmetric
- Tilting of phase line
- Wavelength
- Phase relationship

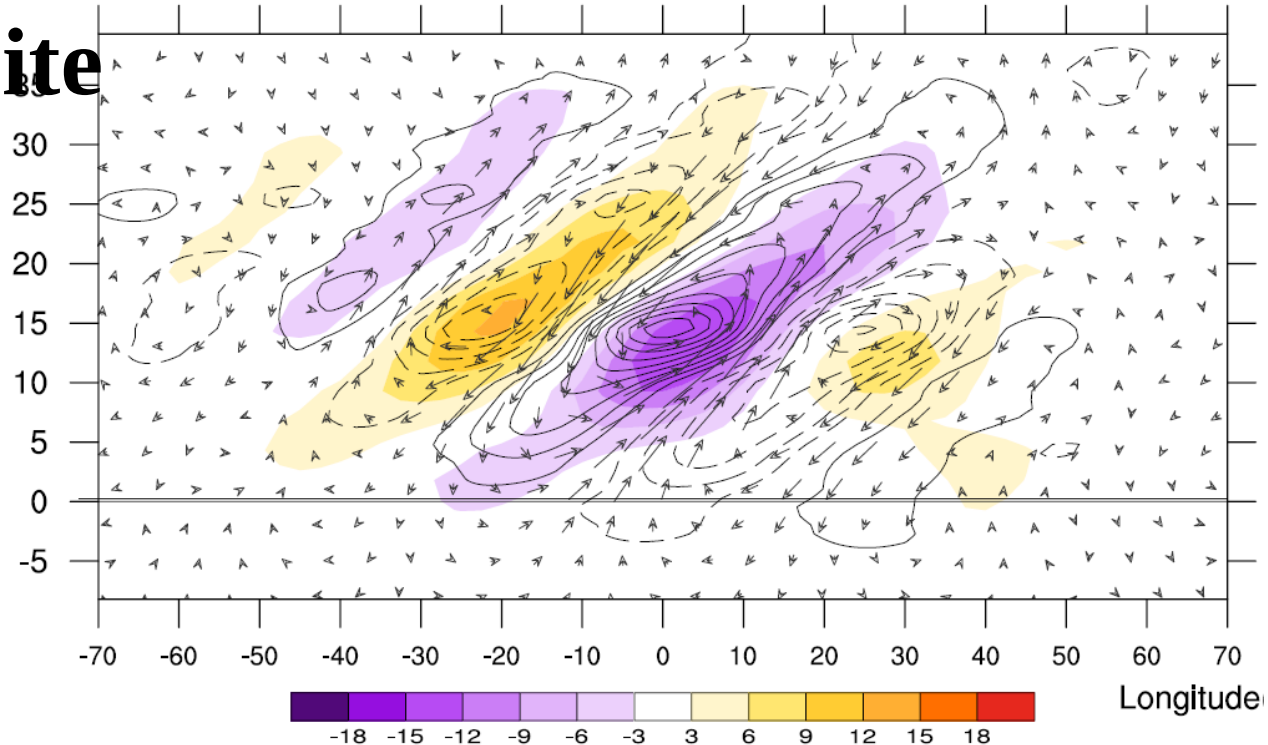


Type2 ER Composite

(67 cases)

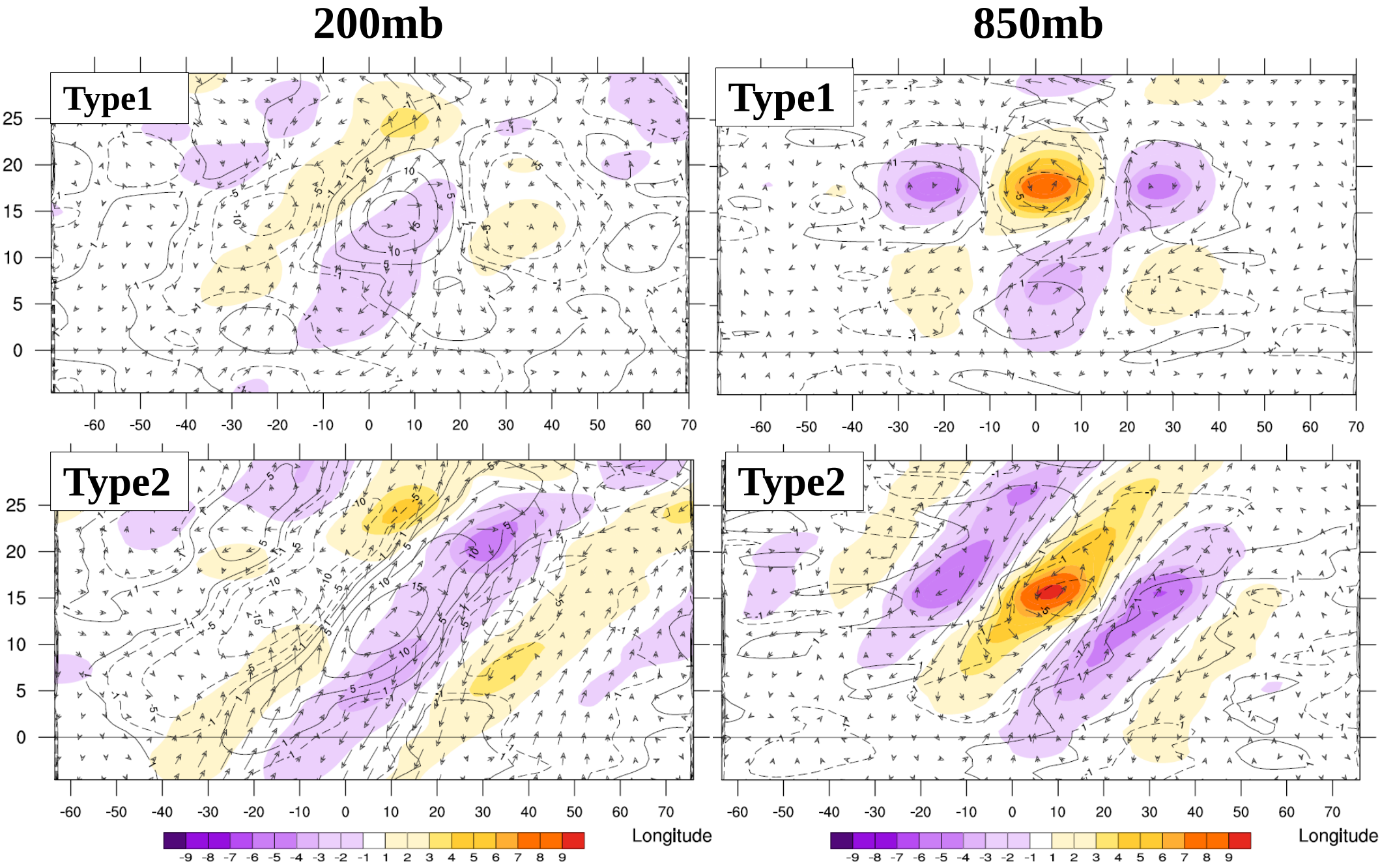
MeanErLat=14.8 deg N

- Unstable ER



ErVor(shaded)Div(contour)Wind

Vertical Structure of the Two Type



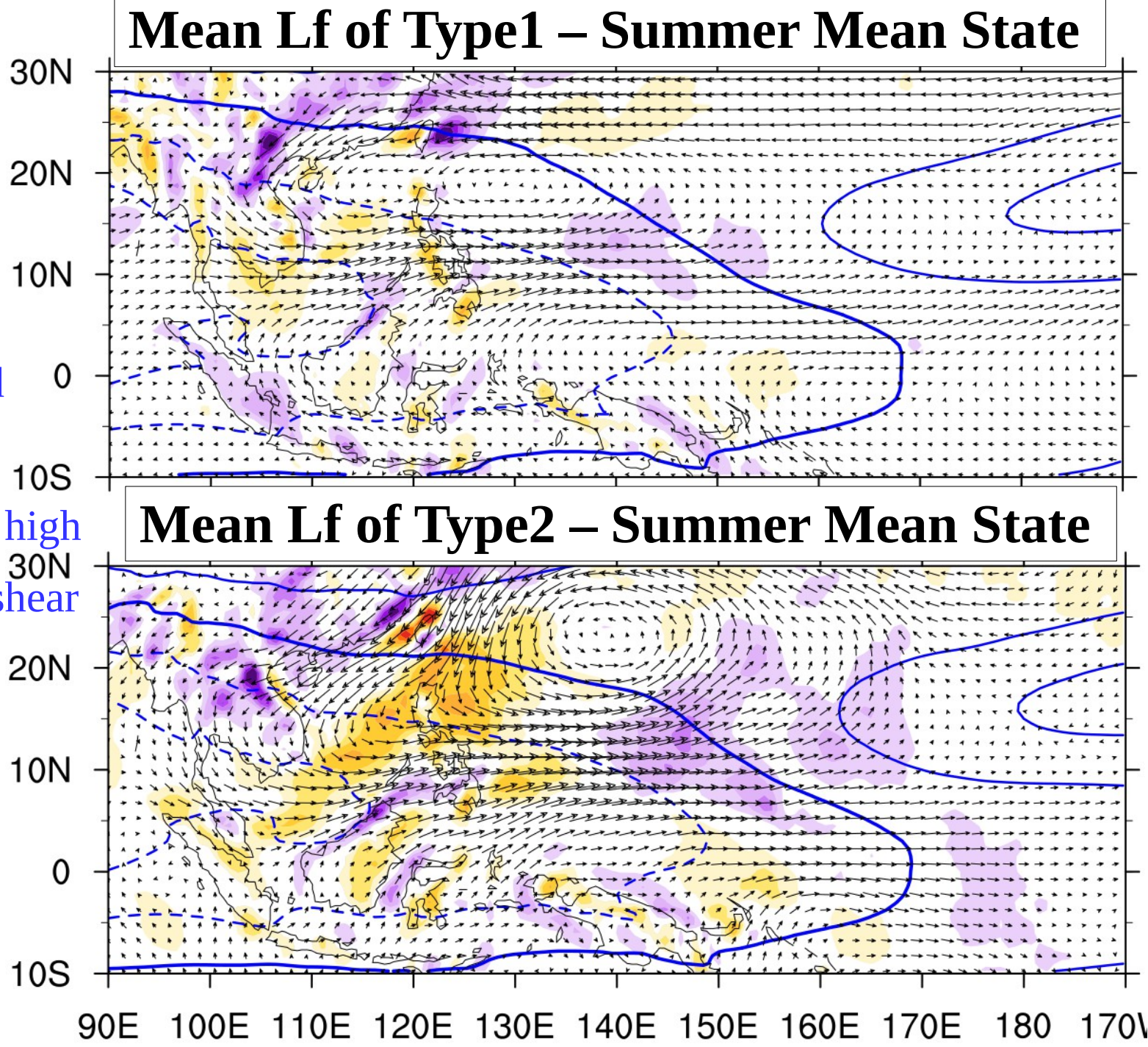
	TCd	TCn	Total
All TCs	(163) 34.2%	(314) 65.8%	(477)
TCG with type1	(53) 39.6%	(81) 60.4%	(134)
TCG with type2	(29) 43.3%	(38) 56.7%	(67)

Different Background Flow between the two Type

1) Stronger zonal wind convergence

2) Weaker Subtropical high

3) Easterly vertical U shear



Shaded: Lf U Conv
Contour: Lf Vert U Shear
Vector: Lf Wind

- **Type 2 is more unstable than type 1**

Possibilities:

1) **Stronger zonal wind convergence** => more barotropic energy conversion

2) **Weaker Subtropical high** => Enhanced convection => coupled with wave => Diabatic heating

3) **Easterly vertical U shear + diabatic heating** => unstable wave(Xie and Wang 1996)

Summary II

- The large-scale condition in WNP warm season is favorable for TCG and growth of ER wave. TCG will be modulated by ER.
- Equatorial Rossby wave have positive contribution to TC genesis
- Stronger zonal wind convergence, weaker subtropical high, and easterly vertical U shear may lead to unstable ER wave type.

THANK YOU VERY MUCH!

- 在全部的 TC 以及 ER+ 比較 TCG 大小，呈現 ER 的重要性。
- 主觀從伴隨 TC 的 ER 中挑出明顯的兩個 type
- Type1, 2 對 TCG 的影響。
- 比較兩個 type 的差異：水平結構、垂直結構
- 比較兩種 type 的低頻場
- 推論可能造就 type1, 2 的原因