Large scale environment influences on tropical cyclone genesis clustering in the Western North Pacific

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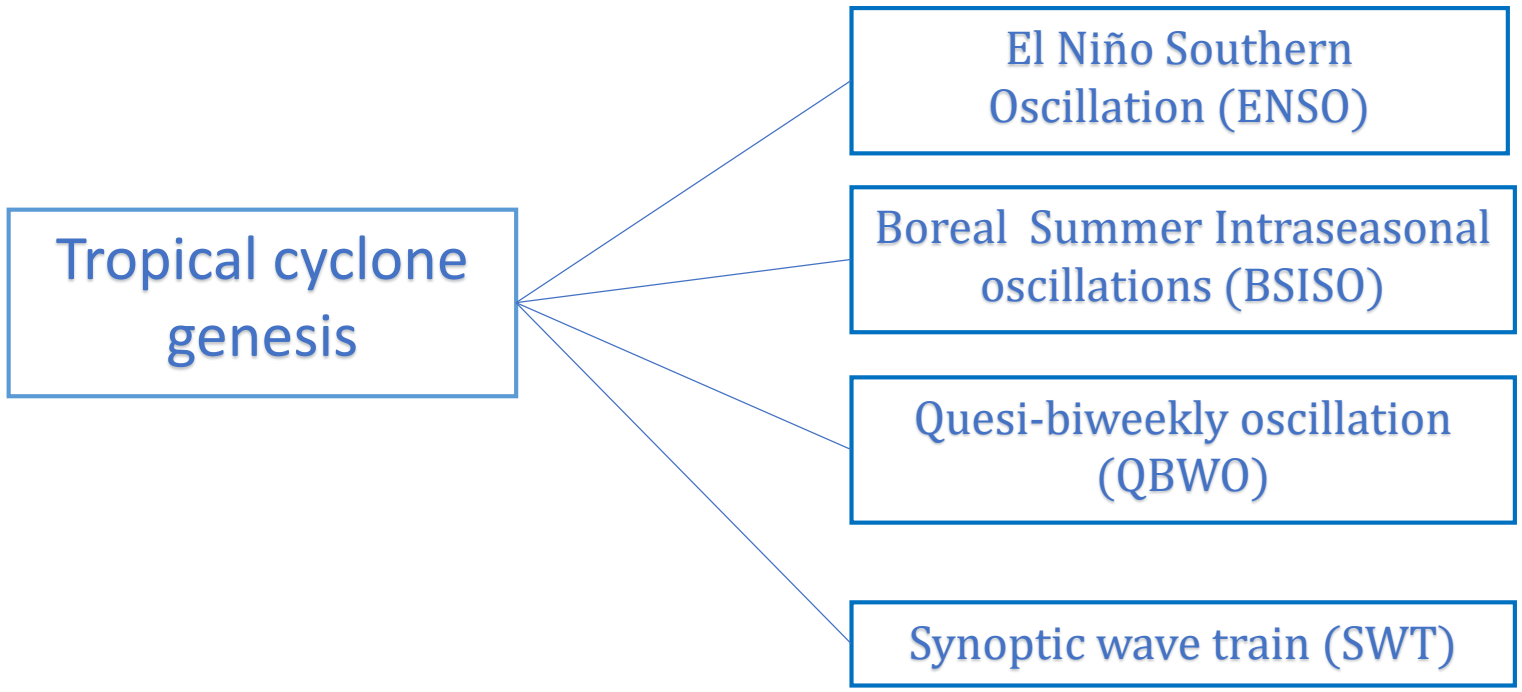
Large scale environment influence on tropical cyclone genesis



Lander, 1994a
Wang and Chan, 2002
Kim et al., 2011

Liebmann et al. 1994;
Maloney and Hartmann 2000
Kim et al., 2008
R. C. Y. Li and Zhou,2013
Zhao et al., 2015
You et al., 2019

Lau and Lau 1990
Shapiro and Ooyama,1990
Li and Fu, 2006
Frank and Roundy, 2006

- Most tropical cyclone genesis (TCG) in Western North Pacific (WNP) occurs in July-October when the westerly monsoon developed to meet easterly trade winds.
- WNP exhibits strong signals of interannual variability (IAV) by El Niño–Southern Oscillation (ENSO) and , intraseasonal oscillation (ISO) and quasi-biweekly oscillation (QBWO) that are known to influence the location and probability of TCG (e.g. Chen et al. 2018).

Large scale environment influence on tropical cyclone genesis

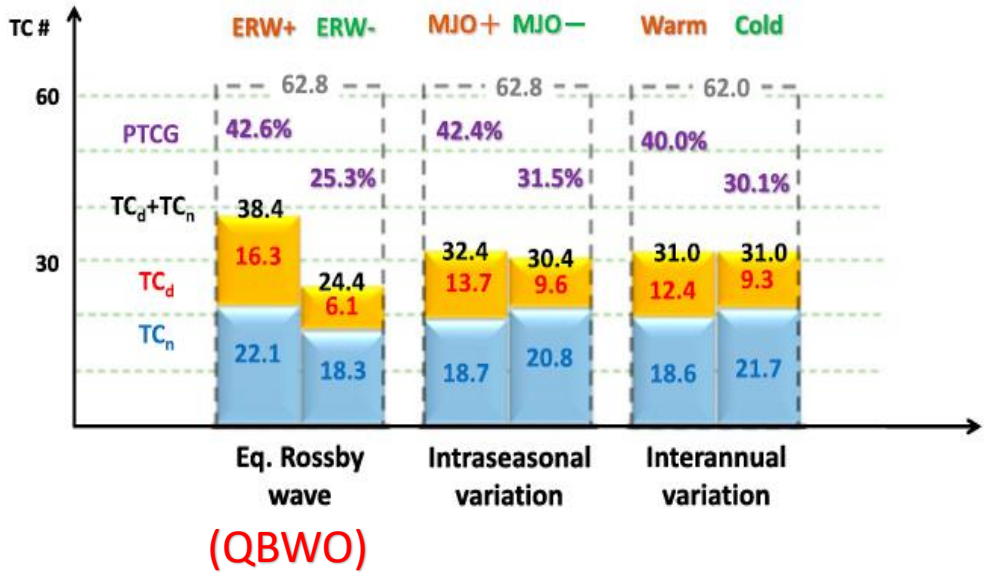
		El Niño		La Niña		Normal	
		aMJO	iMJO	aMJO	iMJO	aMJO	iMJO
ENSO–MJO–ERW combination	Positive vorticity ERW	23.1/17.9 ***0.56***	15.1/20.1 **0.44**	17.2/18.2 **0.49**	11.9/24.5 *0.33*	21.2/21.2 **0.50**	13.8/24.1 0.36
	Negative vorticity ERW	9.6/19.2 **0.33**	4.9/17.0 *0.23*	5.0/17.6 *0.22*	4.7/23.1 ***0.17***	7.5/17.6 0.30	6.3/16.1 *0.28*
ENSO–MJO combination		16.3/18.9 0.47	10.0/18.5 0.35	11.1/17.4 0.38	8.3/24.2 0.26	14.1/19.4 0.43	10.0/20.0 0.33

- Among ENSO, MJO, and QBWO, QBWO have the most effective influence on TCG efficiency.
- ENSO, MJO, and QBWO may combination promote TCG efficiency.

TC_n: Number of Tropical disturbance/100days

TC_d: Number of named tropical cyclones/100days

$$P_{TCG} = \frac{TC_d}{TC_d + TC_n}$$



Chen et. al 2018

TCG clustering (or multiple TCGs): TCGs tend to cluster in a short period, and at other time there is very little cyclone activity. (Gray 1979)

Large-scale forcing point of view	Active ISO or BWO event in WNP may cause the successive formation of TCs from east to west(e.g. Gao and Li.2011; You et. al.2019)
Synoptic self-triggering of MTC	TC energy dispersion or wave energy accumulation in a confluence zone(e.g., Li et al.2003, Li and Fu, 2006, Li et al., 2006)

Scientific Questions of this study

Could the ENSO, and ISO in Western North Pacific (WNP) affect TCG clustering events?

Define TCG clustering event

1. Define TCG by intensity 25kts in WNP (110°E-180°, 5-25°N) and calculate TCG per 10 days.
2. Find maximum TCG per 10 days during these time, and 5 TCG/10 days is most extremely events.
3. Find correlation between ENSO/BSISO/QBWO an d TCG clustering events simply.

→4-5 TCG/10 days events are selected for the current TCG clustering (TCGc) analysis.

*Also analysis 0TCG/10days events (TCGn) to compare with TCG clustering events.

TCG per 10 days	Events
5	4
4	31
3	50
2	82
1	98
0	58
Sum	323
Total TCG	556

1991-2021 JASO TCG events

ENSO and ISO index to analysis TCG clustering

- ENSO

- Refer Oceanic Nino index (ONI) from Climate Prediction Center (CPC)
- Detect December-February ONI maximum or minimum to determine ENSO phase developing or decaying of the year.

- SVD-BSISO index

- BSISO index perform from SVD method is referred from Chen et. al. 2021.
- Search significant BSISO from 1991-2021 July to October by detect that BSISO transited from phase 1-2 to 7-8 continuously, and during BSISO transition, amplitude higher than 1 over half of time .

→ Detect TCG clustering events is associate with significant BSISO.

- QBWO index

- QBWO pattern of low-level positive and negative vorticity changes referred from Chen and Sui 2010.
- Perform a 10–20-day band-pass filter to the 850-hPa relative vorticity, and conducted EOF to construct QBWO index.
- → Detect TCG clustering events is associate with significant QBWO.

TCG clustering and Non-TCG associate with ENSO

1. TCG clustering events annual frequency in different ENSO phase is not significant difference.
2. Non-TCG events have higher annual frequency in La Niña years.

*ENSO may attribute low frequency field of WNP, also effect TCG location (Wang, and Chan 2002).

→Low frequency field by ENSO also effect TCG clustering?

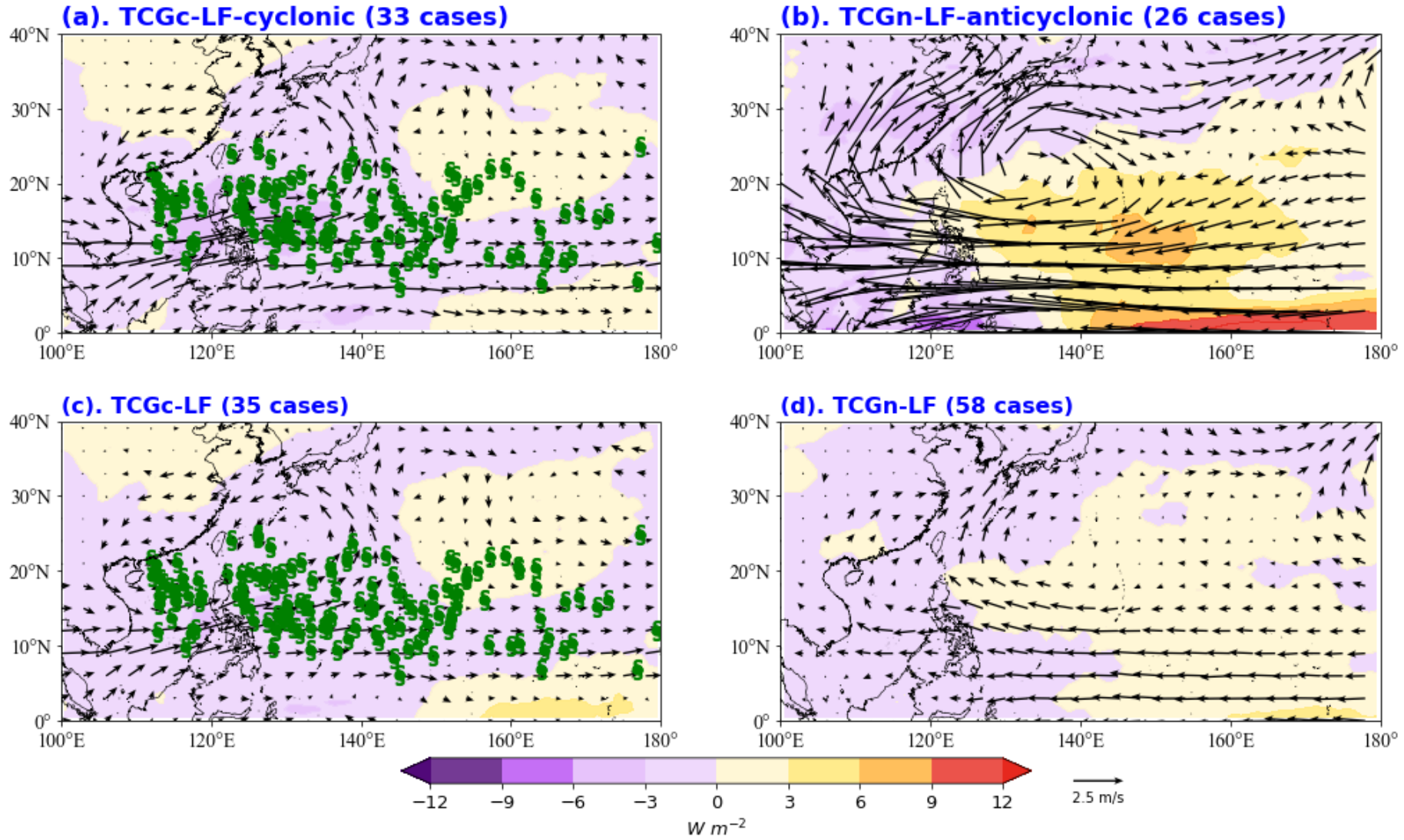
	El Niño (12 years)	Neutral (6 years)	La Niña (13 years)
TCGc	1.17	1	1.15
TCGn	1.58	1.33	**2.39+**

Annual frequency of TCG clustering events and, Non-TCG events in different phases of interannual oscillations developing (1991-2021 JASO), "+"is 90% significant level

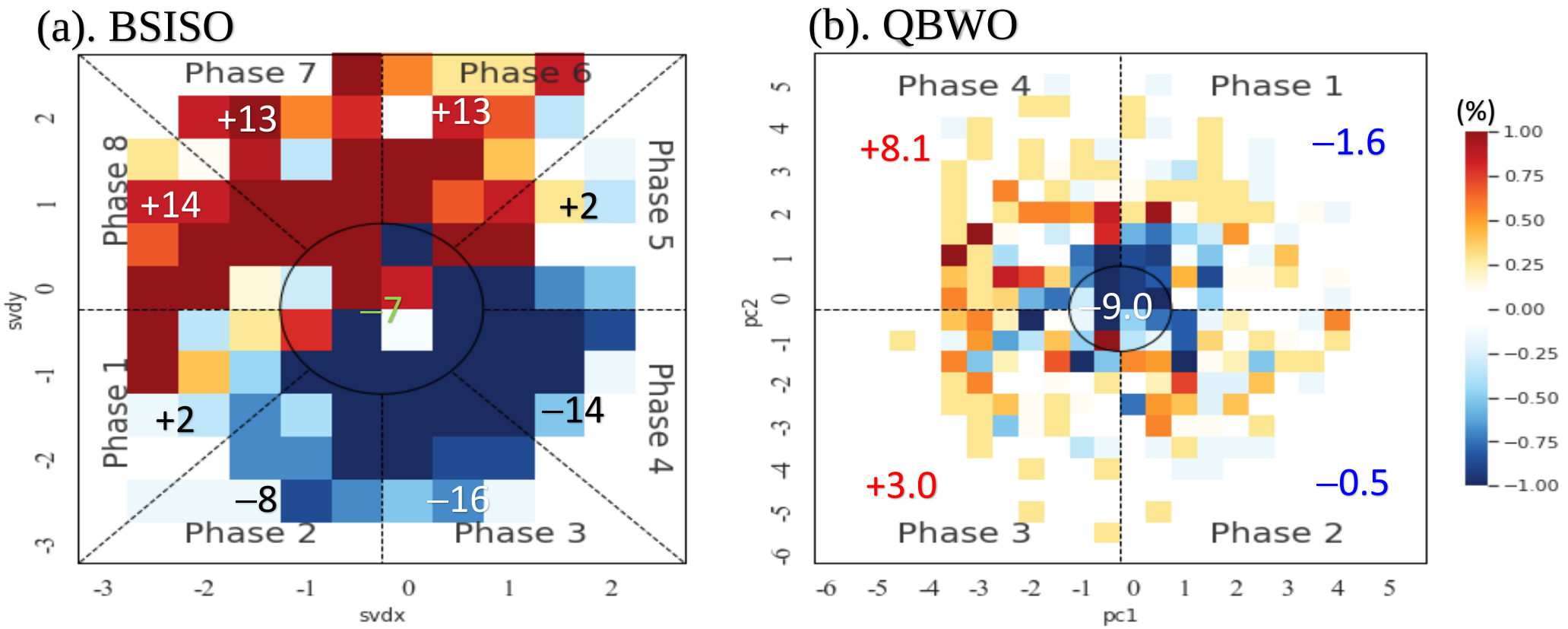
	El Niño (12 years)	Neutral (7 years)	La Niña (12 years)
TCGc	1.17	1.14	1.08
TCGn	2.0	1.71	1.83

Annual frequency of TCG clustering events and, Non-TCG events in different phases of interannual oscillations decaying (1991-2021 JASO)

TCG clustering and Non-TCG events LF (150 days filter) background



TCG clustering V.S. Non TCG - BSISO and QBWO



More TCG-clustering days occur in ISO phase 6, 7, and 8, while more no-TCG days in phase 2, 3, and 4. For QBWO, the figures show significant differences in magnitude, i.e. stronger QBWO associated with TCG events than with TCGn events, and weak differences in phase, i.e. slightly higher TCG occurrence in phase 3-4 when anomalous cyclonic vorticity resides over the main development region of tropical cyclones.

ISO associate with TCGc and TCGn events

1991-2021 JASO	ISO	TCGc	TCGn
ISO with 1TCGc	8	**8**	0
ISO with 1TCGn	7	0	**7**
ISO with 2TCGn	2	0	**4 (2x2)**
ISO with 1TCGc+1TCGn	3	3 (1X3)	3 (1x3)
ISO with 1TCGc+3TCGn	1	1	3 (3x1)
Total	21	12	17

- 1991~2021 JASO total with 45 significant ISO.
- Total ISO associate with TCGc or TCGn events is 21.

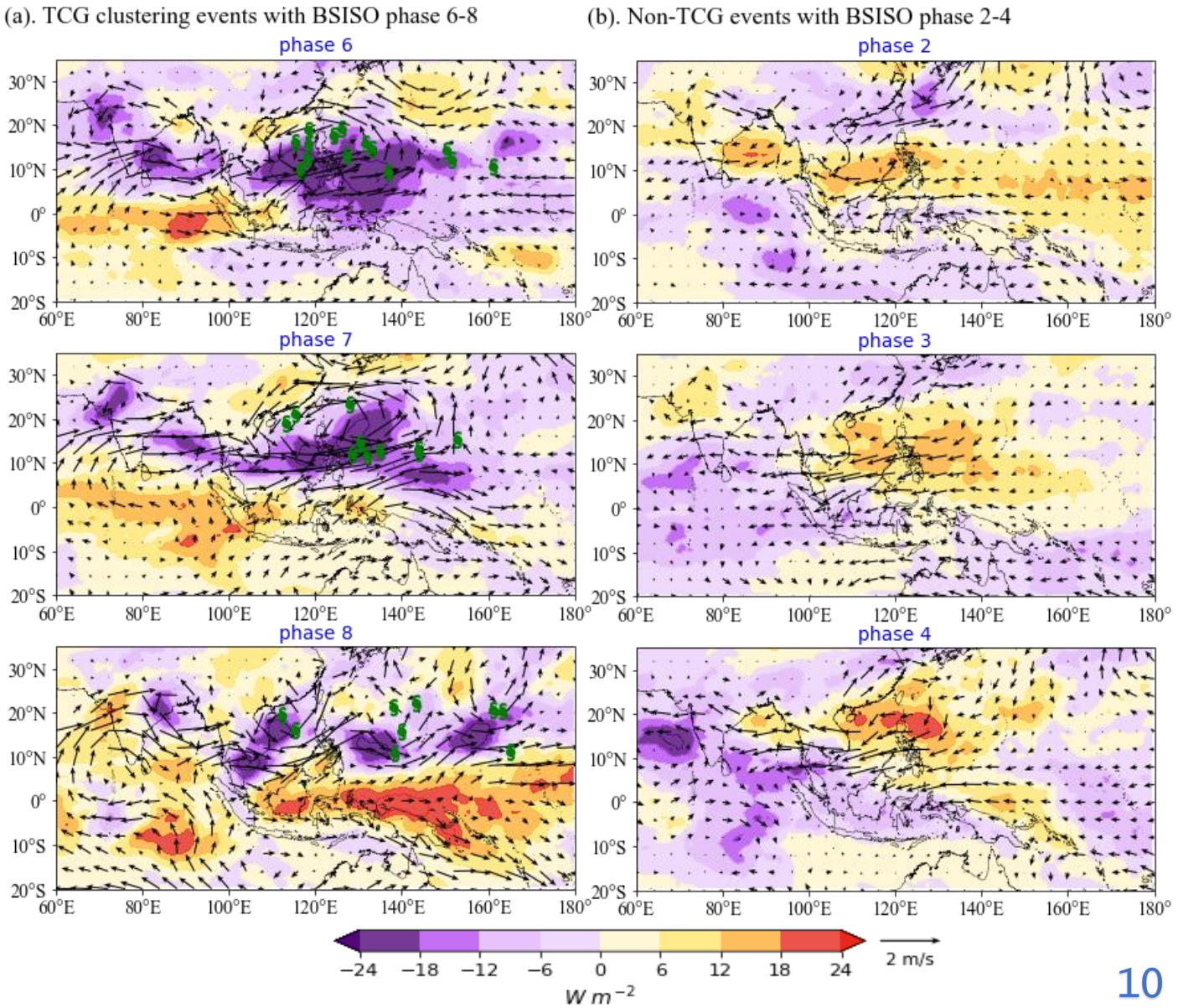
→TCGc associate with ISO is 12

→TCGn associate with ISO is 13

Total ISO not associate with TCGc or TCGn events is 24.

TCG clustering and Non-TCG associate with ISO

- TCGc in BSISO phase 6-7-8 with cyclonic flow and strong convection embedded with tropical cyclone.
- TCGn events with BSISO phase 2-3-4, and it's suppress in WNP. It's also have anti-cyclonic flow so it's not favor for TCG.



TCG clustering and Non-TCG associate with ISO

- 25 TCG clustering events are associated with LF cyclonic flow and additional favorable condition: significant ISO in phase 6-7-8 (convection active in WNP) or active QBWO.
- 26 non-TCG events with LF anti-cyclonic flow, and 14 non-TCG events with LF cyclonic flow correspond to significant ISO in phase 2-3-4 (convection suppress in WNP) or QBWO not active.

→About 70% of TCG clustering events (25/35), and non-TCG events (40/58) can be attributed to the influence of large scale environment.

→ISO and QBWO combinate with low frequency background offer favor or unfavored condition for TCG clustering.

TCGc (35 events)

LF	ISO	QBWO
Cyclonic (33)	Significant (10)	Active (9) Inactive (1)
	Insignificant (23)	Active (15) Inactive (8)
Anticyclonic (2)	Significant (2)	Inactive (2)

TCGn (58 events)

LF	ISO	QBWO
Anticyclonic (26)	Significant propagating (9)	Active (3) Inactive (6)
	Insignificant (17)	Active (5) Inactive (12)
Cyclonic (32)	Significant (8)	Active (5) Inactive (3)
	Insignificant (24)	Active (13) Inactive (11)

Conclusion

- 年際變化伴隨的環流距平對於TCGc及TCGn發生頻率沒有顯著影響，45次顯著季內震盪中，僅21次伴隨TCGc或TCGn事件，顯示單純低頻背景場及季內震盪無法有效影響群發。
- 低頻背景場、季內震盪及準雙週震盪則能解釋約70%的TCGc及TCGn事件，顯示了多重時間尺度震盪疊加作用對於TCGc事件發生與否之重要性。

→低頻氣旋距平在WNP夏季背景場增強熱帶東風垂直風切，進一步有利於BSISO對流及赤道羅士比波北傳(QBWO活躍）。

→ WNP低層正渦度增加及對流活躍，有利於TCGc事件的發生。

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