Contributions of different time scale variations to tropical cyclogenesis over the western North Pacific

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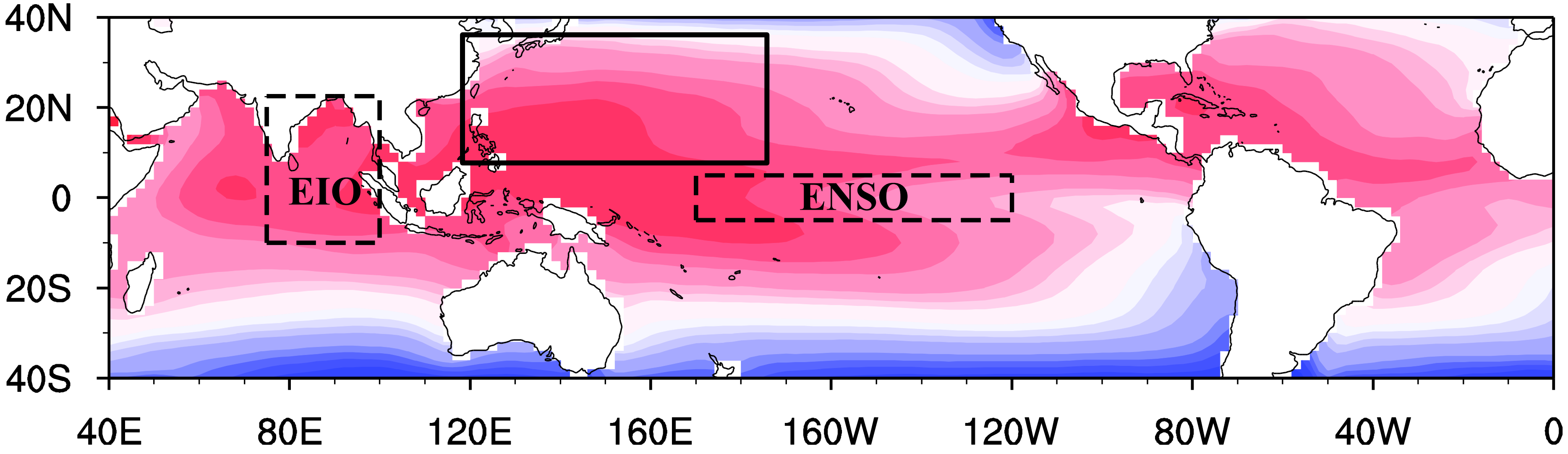
Introduction-interannual

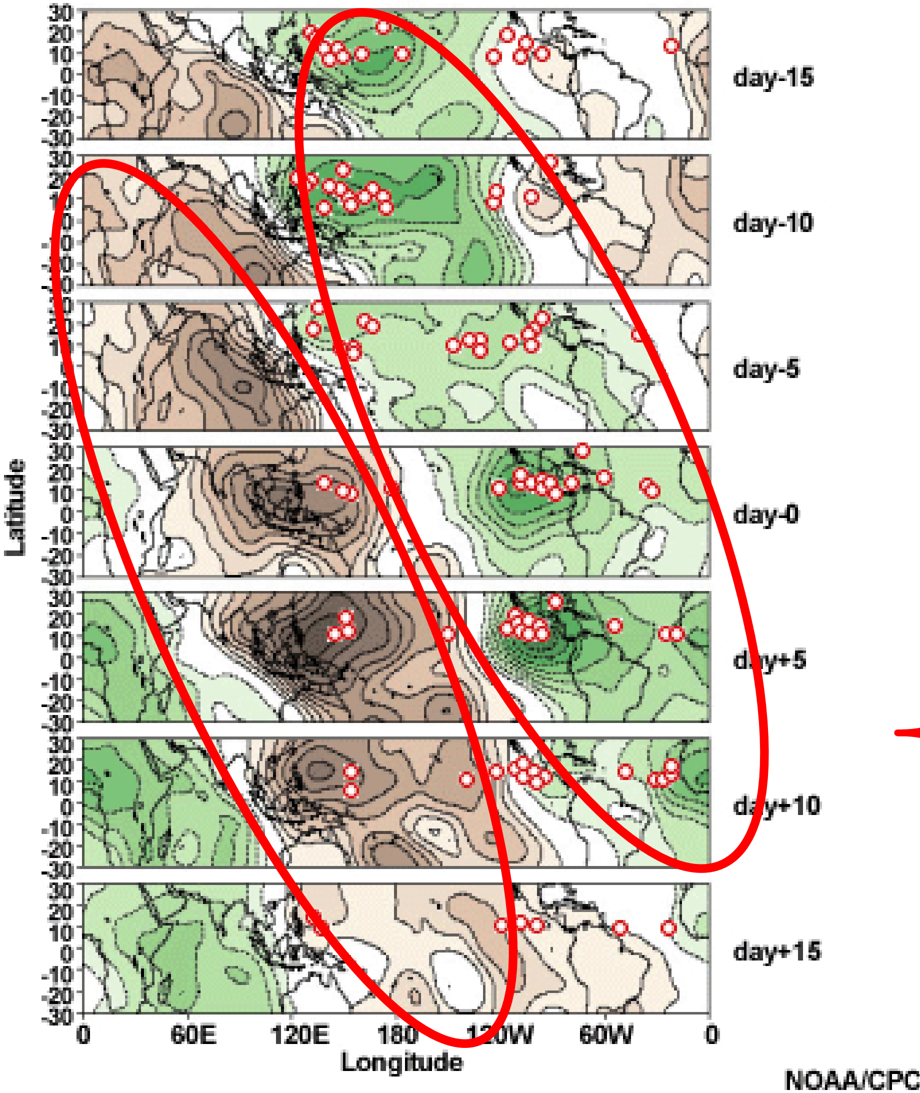


- The **ENSO** is found to be closely associated with **TC genesis variability over the WNP**.

  The frequency of TC genesis is above normal **in the southeastern part**, but below normal **in the northwestern part** of the WNP during the **El Niño summers** *（e.g., Chan, 1985, 2005; Lander, 1994; Chen et al., 1998; Wang and Chan, 2002; Camargo et al., 2007; Chen and Huang, 2008; Li, 2012; Wu et al., 2012）*

- **SST in the tropical Indian Ocean** has been found to exert a significant influence on **TC genesis** over the **WNP** *(Saji and Yamagata, 2003; Yoo et al., 2006; Yang et al., 2007, 2010; Xie et al., 2009; Luo et al., 2012)*

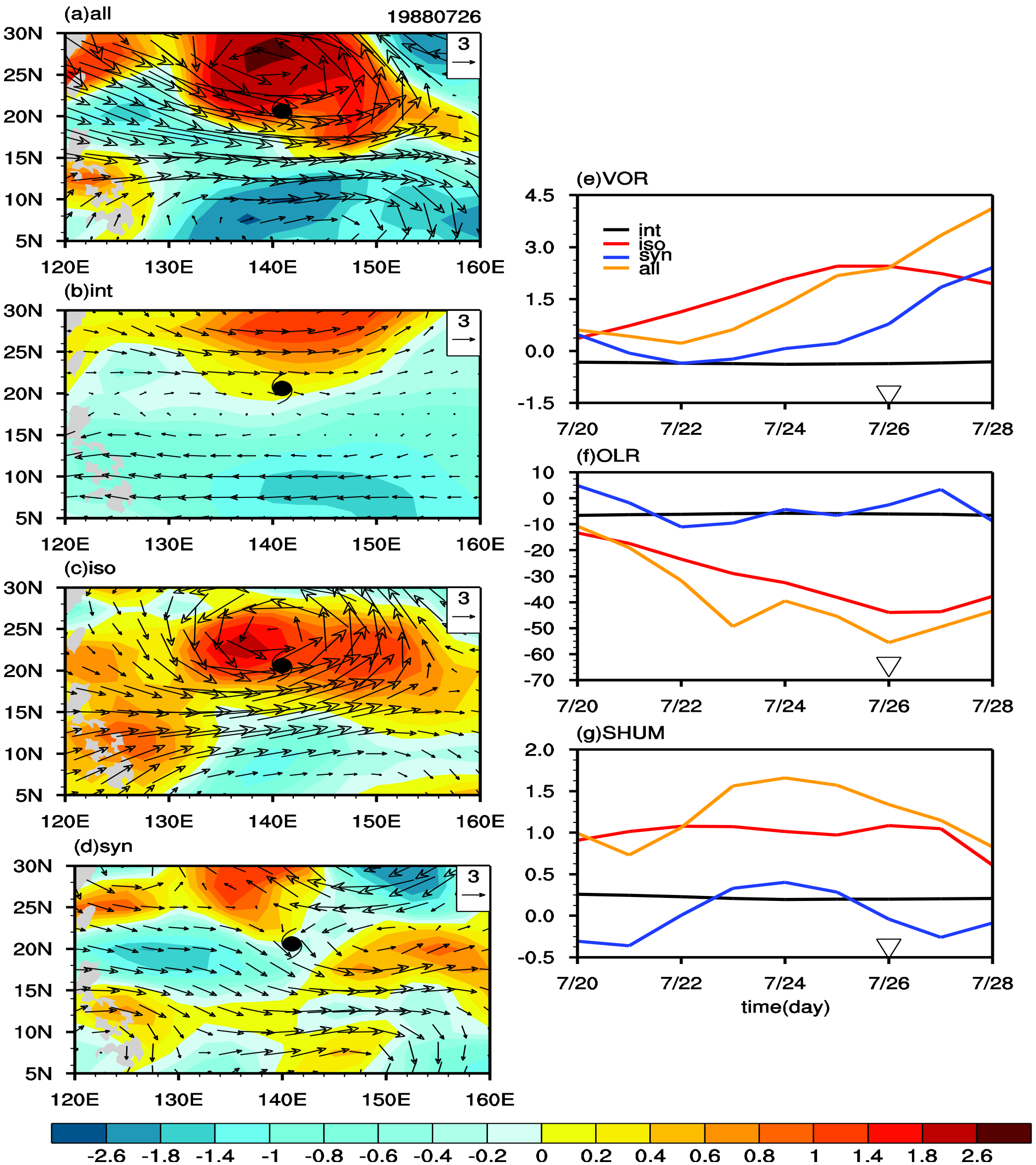
Introduction-ISO



◆The **Madden-Julian oscillation** plays an important role for the **TC formation** in global different areas. *(Nakazawa, 1986; Liebmann et al., 1994; Maloney and Hartmann, 2000a; Hall et al., 2001; Bessafi and Wheeler, 2006; Kim et al., 2008; Chen and Huang, 2009; Huang et al., 2012)*

- **Barotropic eddy kinetic energy conversion** *(Maloney and Hartmann, 2001; Hsu et al., 2011; Cao et al., 2012)*
- **The change of background humidity** *(Camargo et al., 2009)*

Case study--Scientific questions



The case is on July 26, 1988 that is a La Niña year.

In this case, the TC genesis is mainly attributed to intraseasonal and synoptic components when the seasonal mean state is unfavorable.

it is necessary to examine the state at a locality to find out **the relative contributions of different time scales to the TC genesis.**

Data and methodology

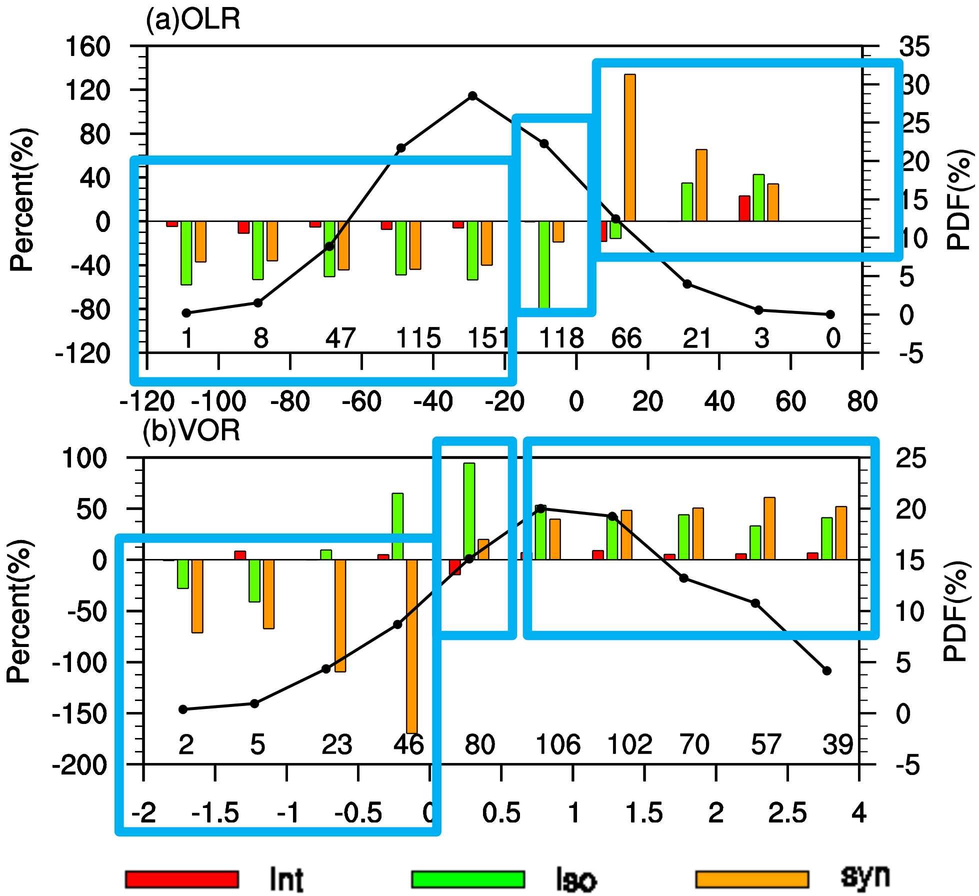
- 2.5° × 2.5° NCEP/NCAR reanalysis data *(Kalnay et al. 1996)*
- 2.5° × 2.5° NOAA OLR data *(Liebmann and Smith 1996)*
- 1° × 1° NOAA OI SST (Reynolds et al. 2007)
- International Best Track Archive for Climate Stewardship (IBTrACS) Version 3 *(Knapp et al., 2010)* JTWC

- TC genesis index is defined as the first record of TC best-track data over the WNP (0–25N and 120E–180E) during the JASO from 1979 to 2013 .
- We separate the whole original daily anomalous fields into interannual (>90 days), intraseasonal (10–90-day), and synoptic (3–8-day) components.
- The anomalous fields include SST, specific humidity, OLR, vertical shear of zonal wind, lower-level relative vorticity, and barotropic energy conversion.

Contributions of different time scale variations to the TC genesis

OLR

VOR



below -20 W m^{-2}: intraseasonal and synoptic variations **comparable**

between -20 and 0 W m^{-2}: intraseasonal variation **dominant**.

More than 0: synoptic variation **negative.**

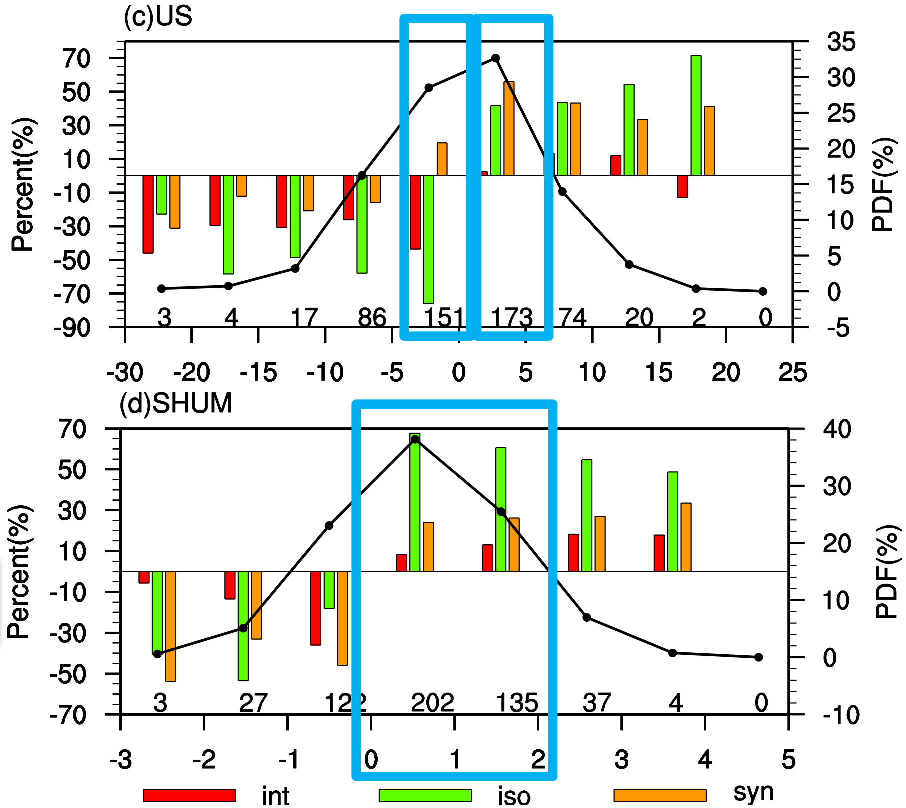
Similar to OLR

Percent (%) distribution of anomalies of (a) OLR and (b) 850-hPa relative vorticity, on interannual (red bar), intraseasonal (green bar), and synoptic (orange bar) time scales **associated with the 530 TCs** over the WNP during JASO of 1979–2013. The solid line (scale at right) indicates the PDF distribution of TC genesis number. The digit number above the x-axis indicates the corresponding number of TCs at the respective range.

Contributions of different time scale variations to the TC genesis

US

SHUM



Over the WNP, **climatological** vertical wind shear **is weak easterly wind** on average, less than -5 m/s.

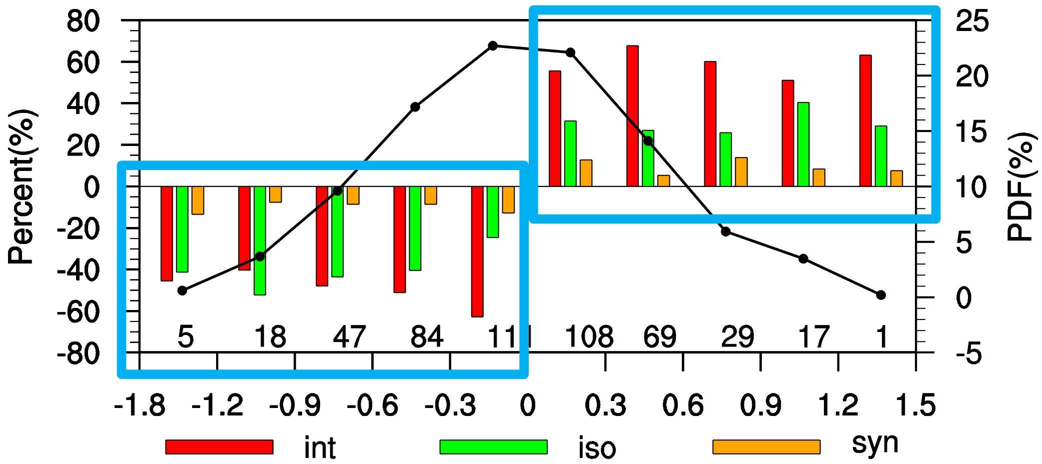
The contribution by the intraseasonal variation is **almost two times** more than that by the synoptic variation.

64%

Percent (%) distribution of anomalies of (c) **vertical shear of zonal wind** between 200 hPa and 850 hPa, and (d) 700-hPa **specific humidity** on interannual (red bar), intraseasonal (green bar), and synoptic (orange bar) time scales **associated with the 530 TCs** over the WNP during JASO of 1979–2013. The solid line (scale at right) indicates the PDF distribution of TC genesis number. The digit number above the x-axis indicates the corresponding number of TCs at the respective range.

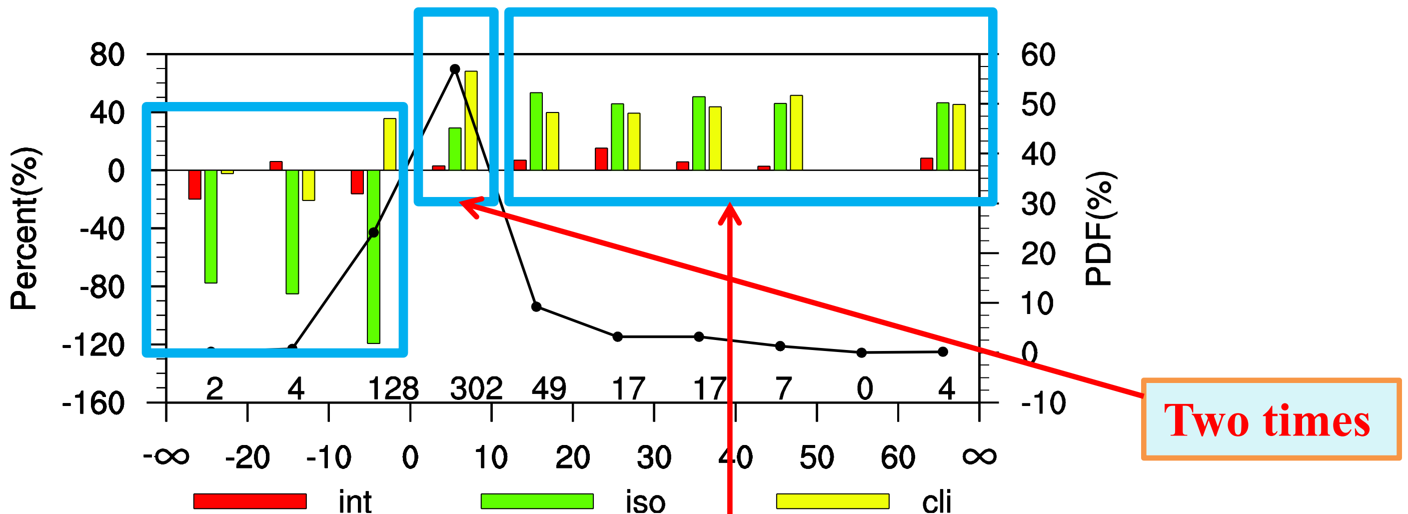
Contributions of different time scale variations to the TC genesis

SST



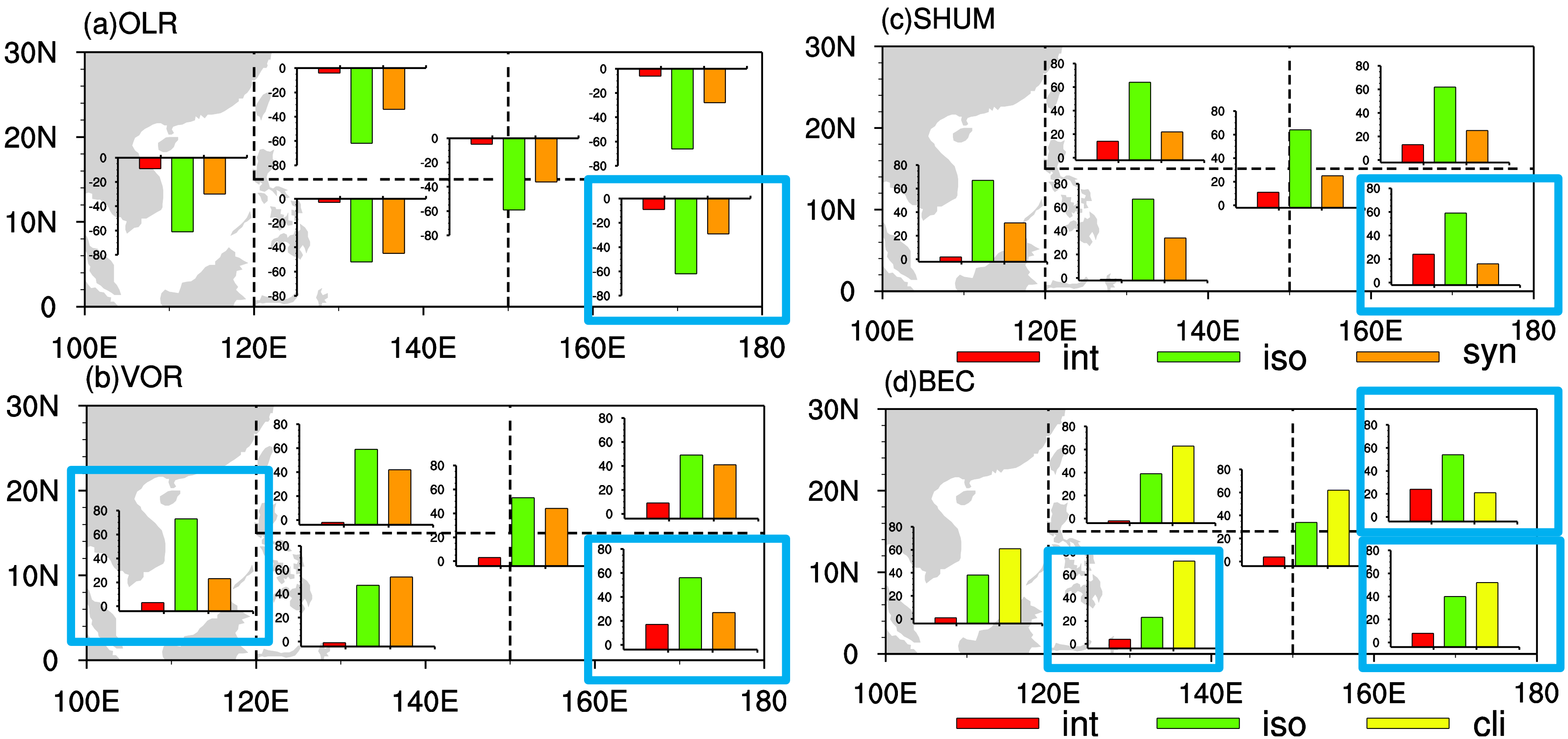
1) The **interannual and intraseasonal** components have a larger contribution than the synoptic component . 2)There are half of the TCs that form when total SST anomalies are negative.

barotropic energy conversion



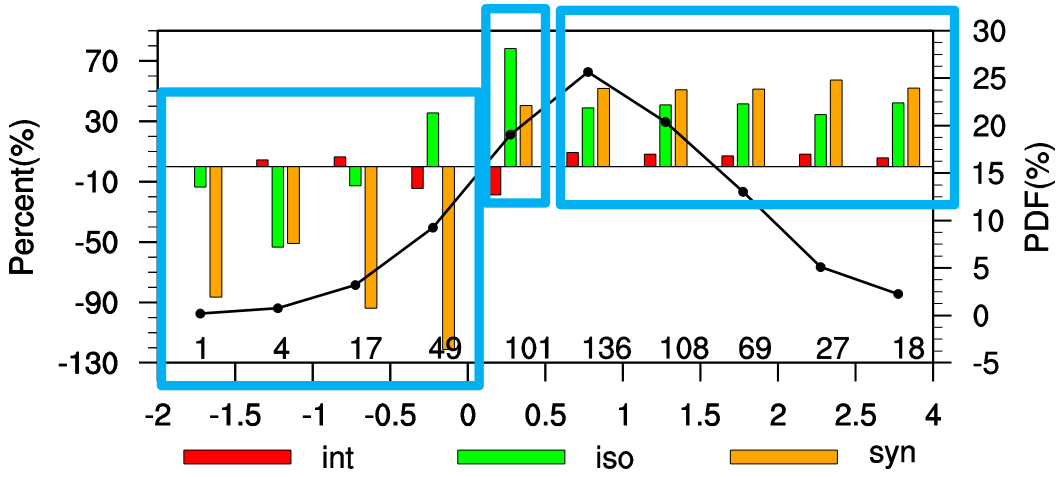
When barotropic energy conversion is larger than 10, synoptic-scale disturbances mainly obtain energy from **climatological mean and intraseasonal variation** of circulation.

The comparison of relative contributions among the sub-regions

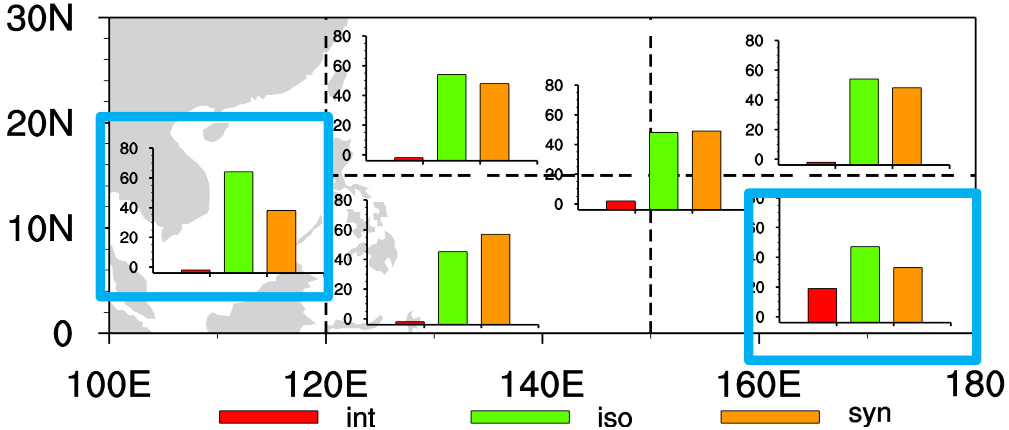


- The contribution of relative **vorticity** to TC genesis is much larger from the intraseasonal variation than that from the synoptic variation **over the SCS**.
- There is a major difference in lower-level **barotropic energy conversion** between the **northeast and southwest quadrants** of the WNP.
- Relative contributions of four environmental factors in relation to **interannual variations** are **obviously enhanced over the southeast quadrant**.

The influence of TC signal to relative vorticity



- Hsu et al. (2007) indicated that the TCs contribute significantly to the intraseasonal and interannual variance of lower-level vorticity over the WNP along the TC tracks.
- Bi et al. (2015) showed that the TC impact depends upon the variable and the spatial resolution.



- **The TC signal does not change the major results** of the contributions of variations on interannual, intraseasonal, and synoptic time scales to TC genesis over the WNP **obtained based on total winds.**

Summary

1) Distinct from previous studies that are concerned with large-scale spatial patterns during a certain period, **the present study focuses on local and instantaneous conditions of the TC genesis.**

2) Contribution of **convection and lower-level vorticity** to TC genesis is mainly due to **intraseasonal and synoptic variations**. The contribution of **mid-level specific humidity** is almost **two times** from intraseasonal variations than from synoptic variations. The contribution of **SST** to TC genesis is mainly due **to interannual and intraseasonal variations**.

3) The barotropic energy for synoptic-scale disturbances during the TC genesis comes mainly from **climatological mean flows over the southwest quadrant** and from **intraseasonal wind variations over the northeast quadrant** of the WNP, respectively. The contribution of interannual variations to TC genesis is **enhanced over the southeast quadrant** of the WNP.

Thanks!