Changma Research Center

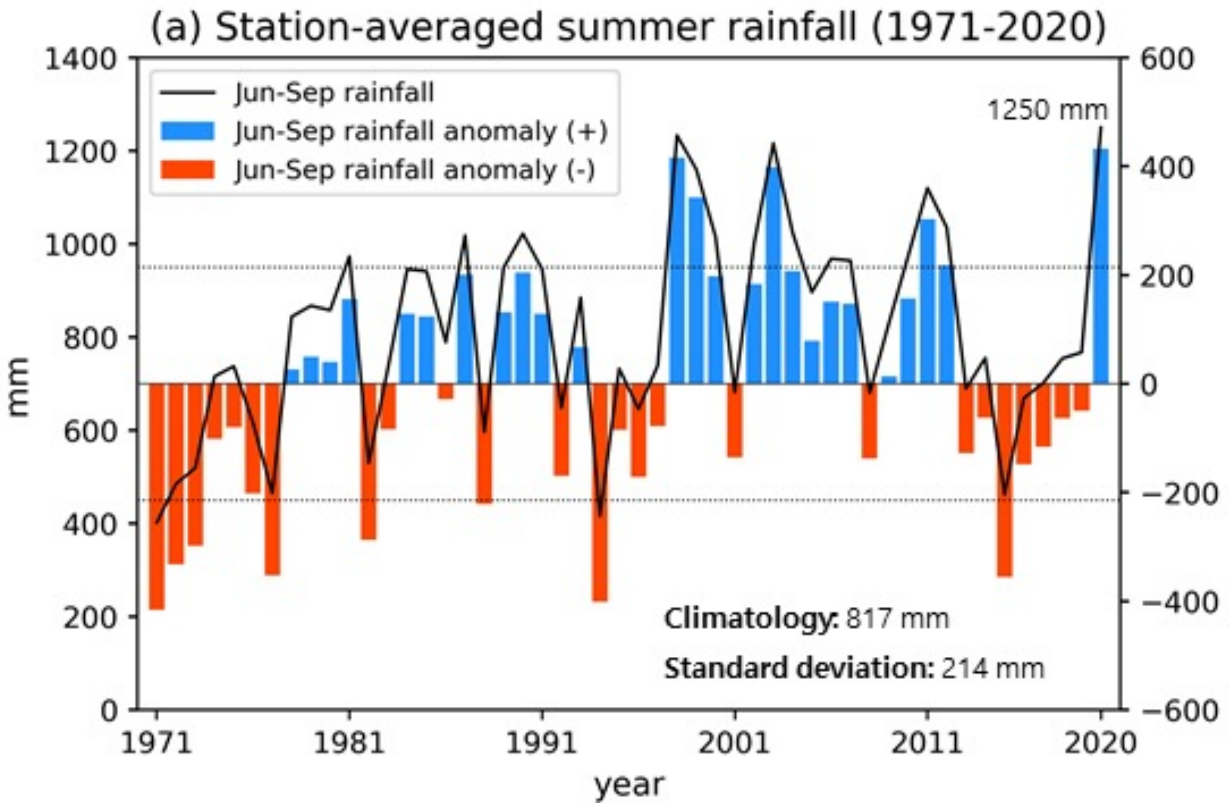
기상청 Korea Meteorological Administration

기록적인 2020년 여름 집중호우의 종관 특성과 대규모 대기 순환의 역할

손석우
서울대학교 지구환경과학부

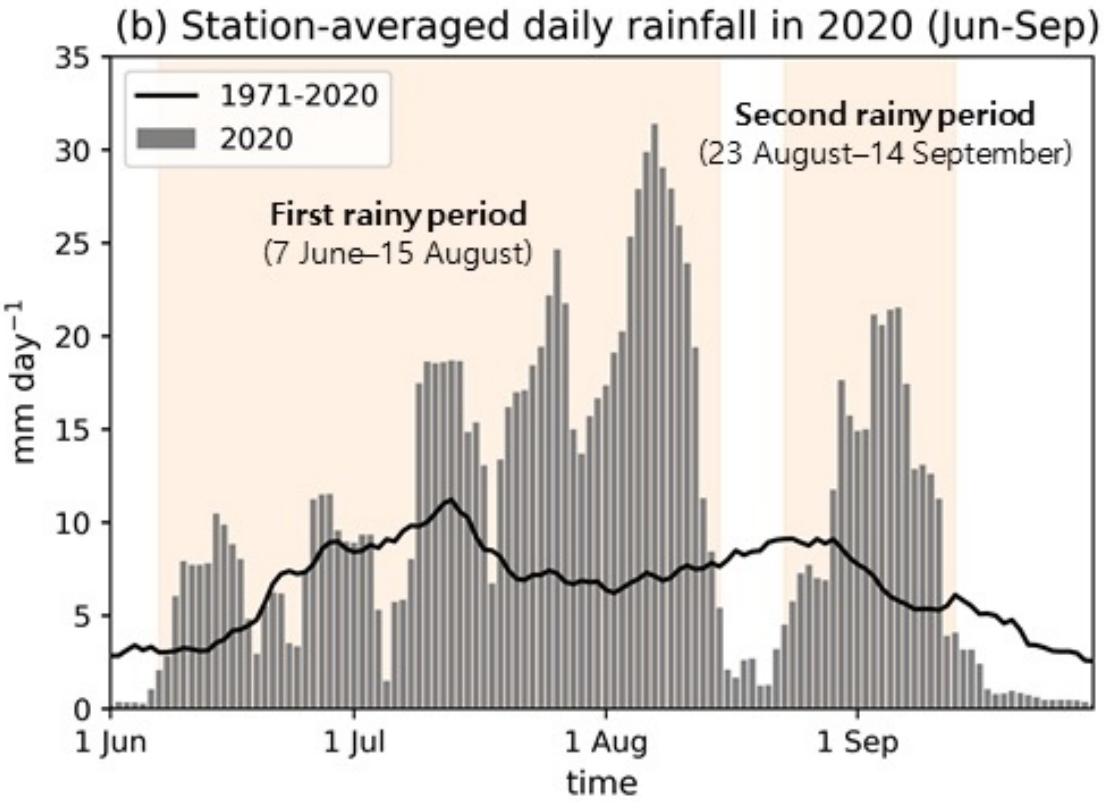
- Park, C., S.-W. Son, and co-authors, 2021: Record-breaking summer rainfall in South Korea in 2020: Synoptic characteristics and large-scale circulation, *Monthly Weather Review (in minor revision)*
- Ham, Y.-G. and co-authors, 2021: The origin of systematic forecast errors of extreme 2020 Ea st Asian Summer Monsoon rainfall in GloSea5, *Geophysical Research Letters (in review)*

Record-breaking summer rainfall in 2020



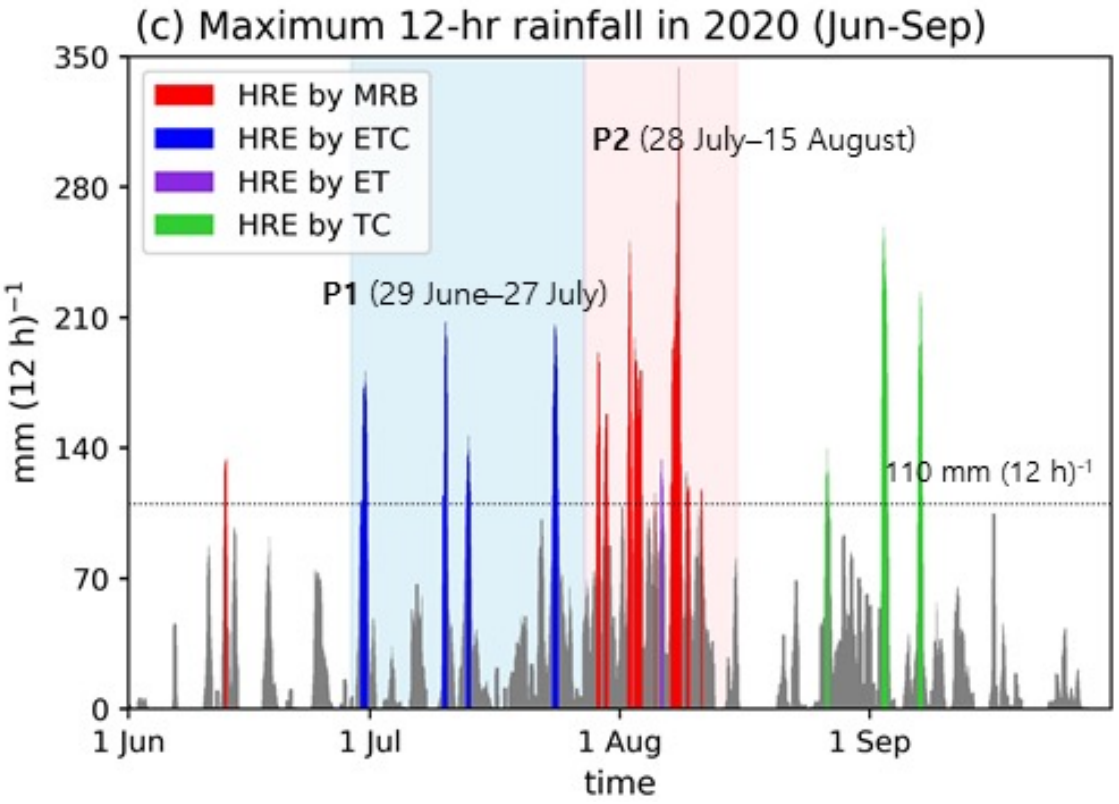
- Record-breaking June–September accumulated rainfall amount in 2020 (53% greater than climatology)

Record-breaking summer rainfall in 2020



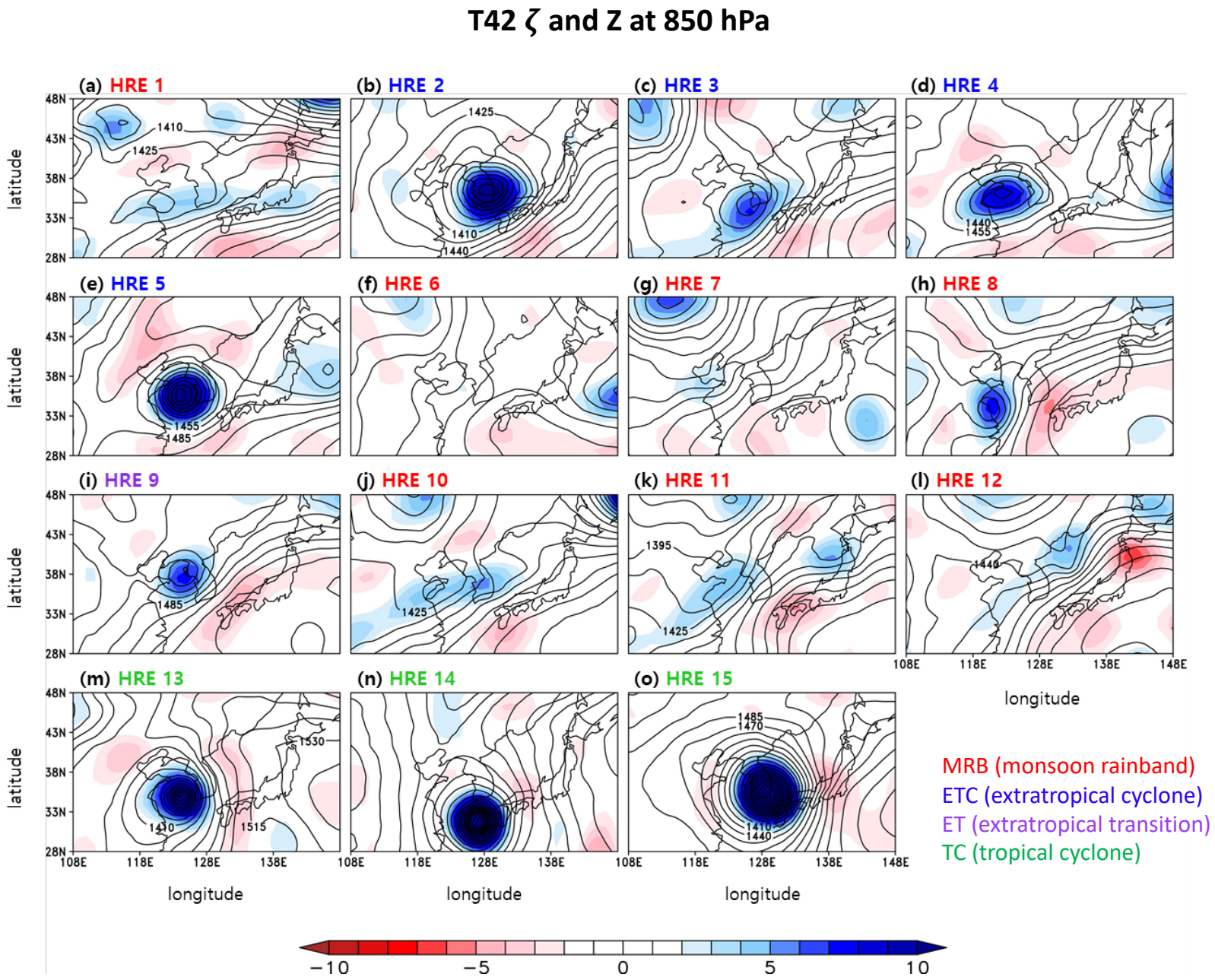
- Long-lasting first rainy period in 2020 (from mid-June to mid-August)

Record-breaking summer rainfall in 2020



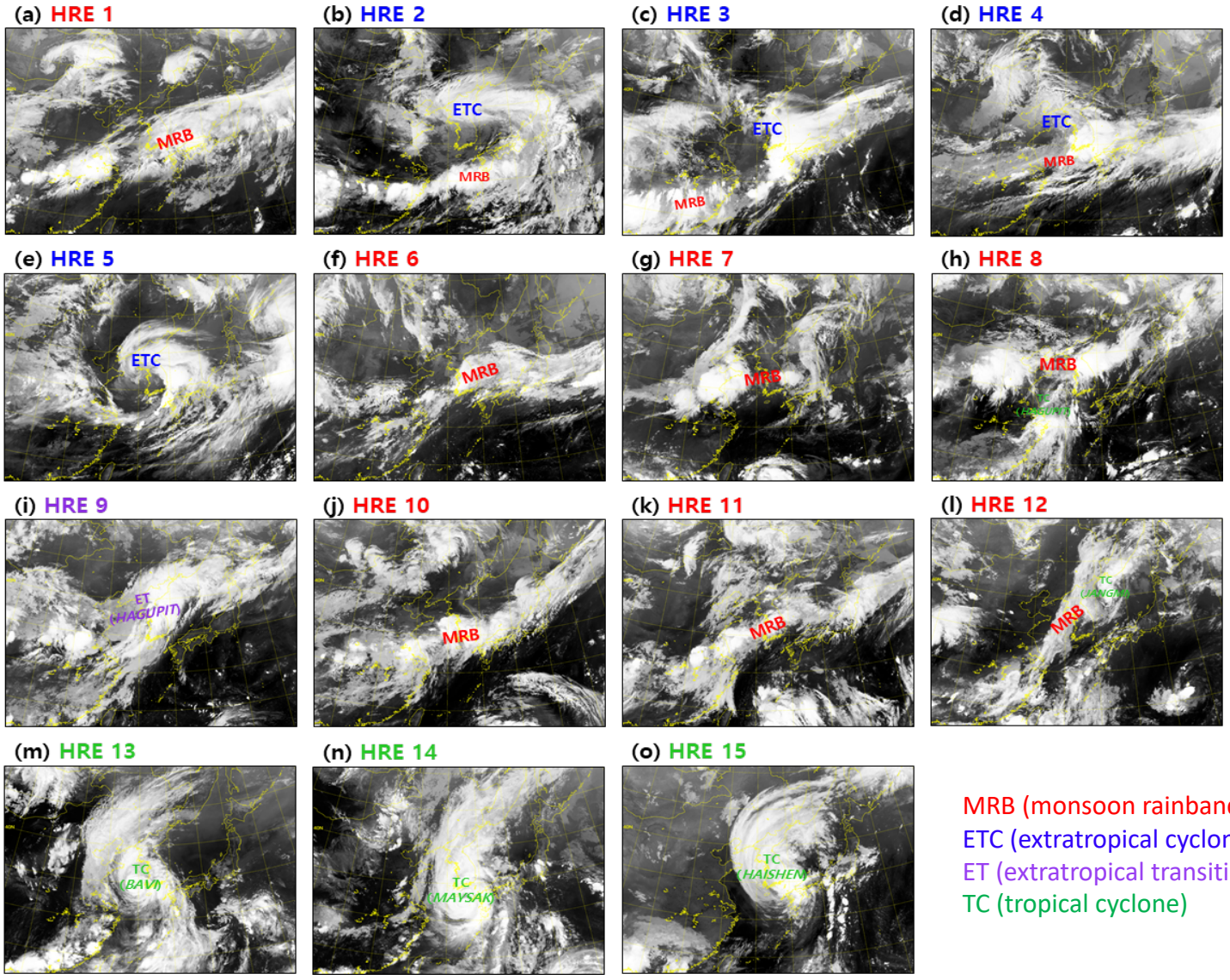
- Extratropical cyclone (ETC) type in P1 (29 June–27 July)
- Monsoon rainband (MRB) type in P2 (28 July–15 August)
- Tropical cyclone (TC) type in late summer

HREs in summer 2020



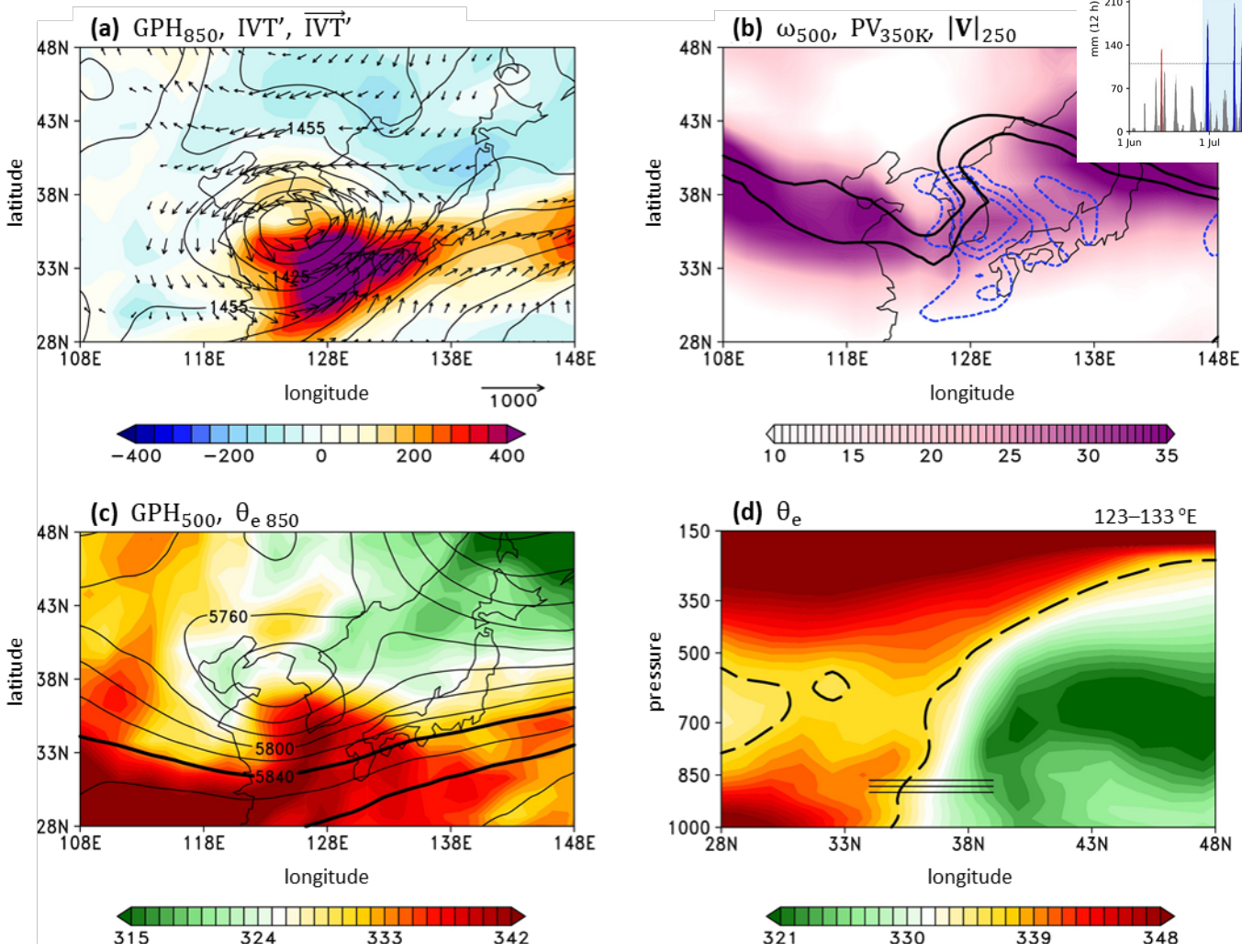
HREs in summer 2020

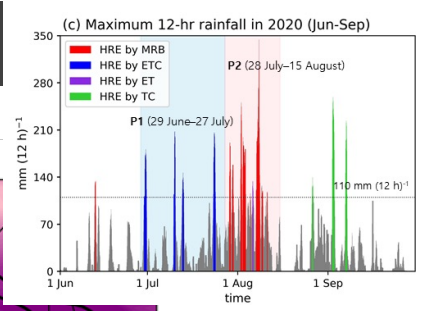
Satellite image (10.5 μm)



MRB (monsoon rainband)
ETC (extratropical cyclone)
ET (extratropical transition)
TC (tropical cyclone)

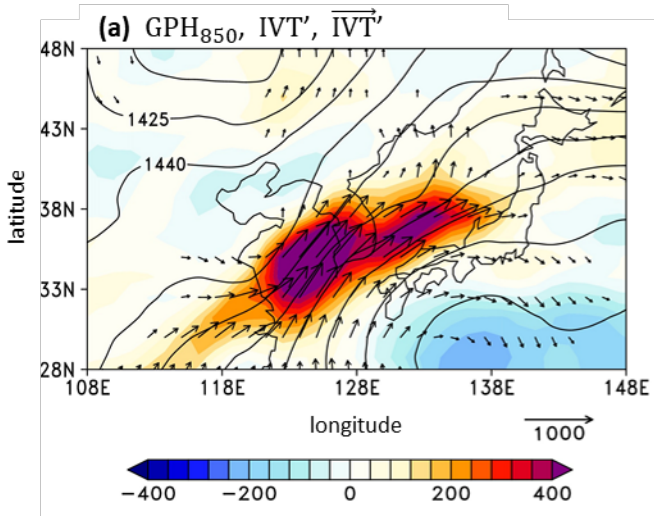
Synoptic structure of HREs in P1 (29 June-27 July)

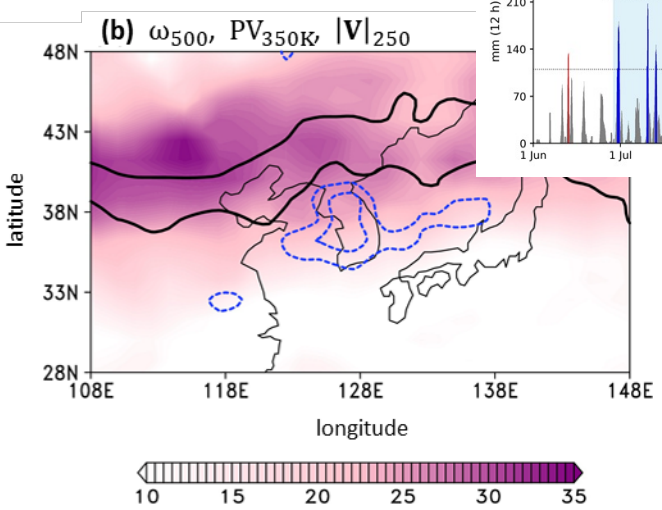


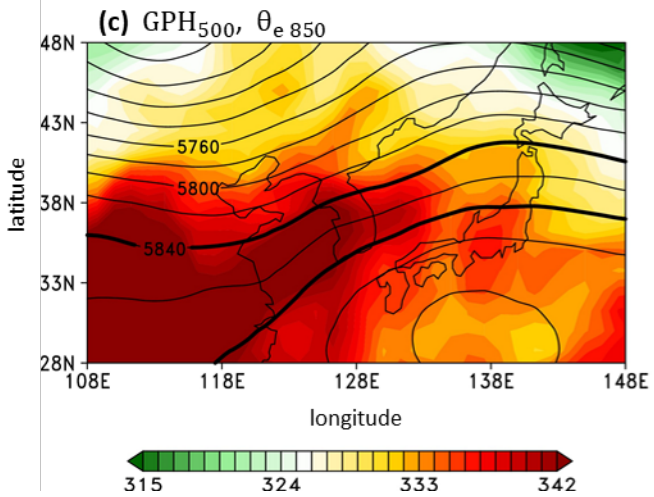


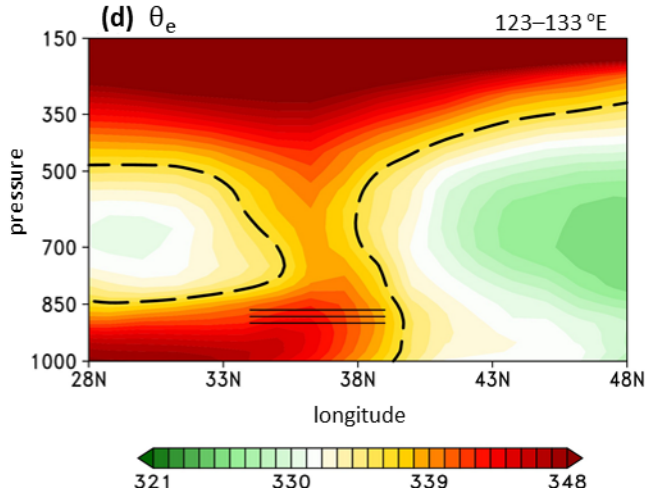
- Baroclinically-developing cyclone
- 5840- and 5880-gpm lines to the south of Korea
- Moist-adiabatically near-neutral condition

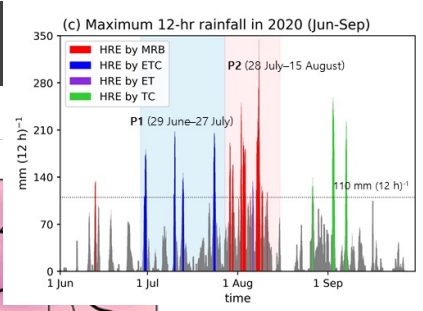
Synoptic structure of HREs in P2 (28 July-15 August)





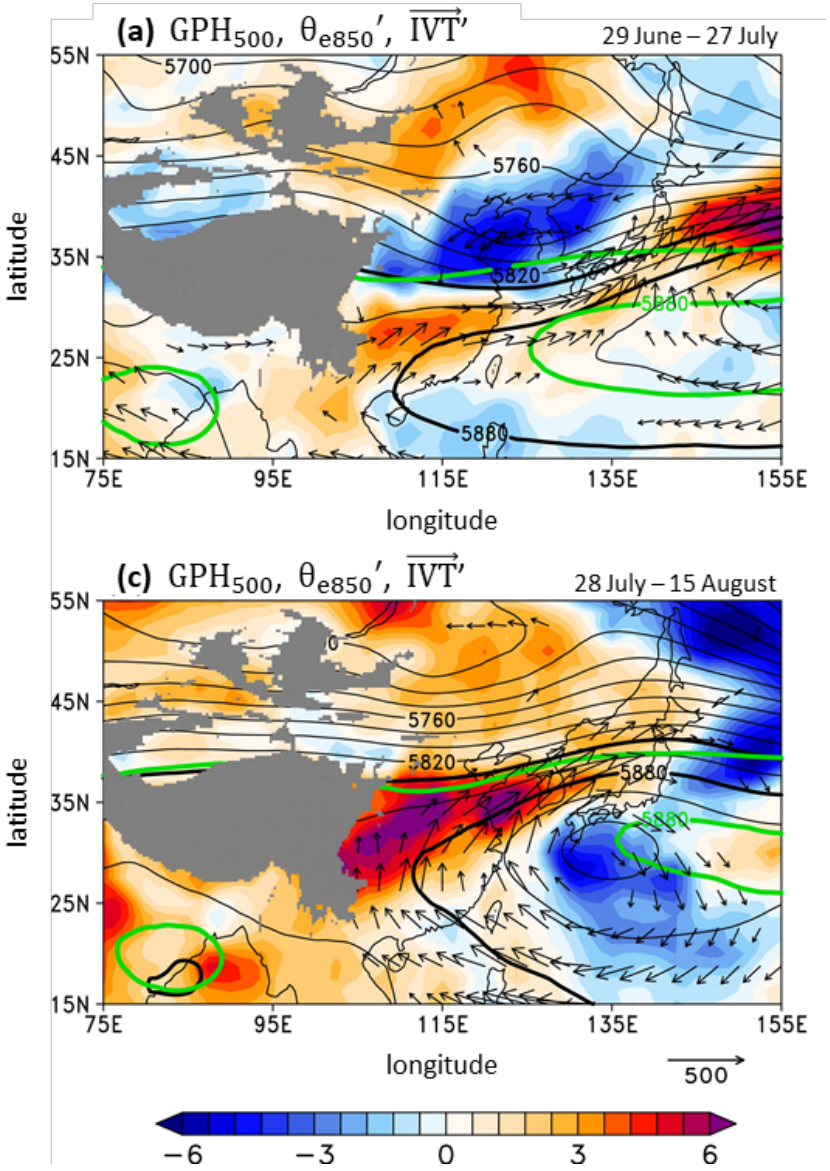






- No synoptic-scale disturbance
- 5840- and 5880-gpm lines right over the Korean Peninsula
- Moist-adiabatically unstable condition

Regional circulations: P1 vs. P2



P1:

- Westward-extended WNPH
- Delayed northward march of the WNPH
- Quasi-stationary trough over South Korea
- Increased monsoon southwesterly to the south of Korean Peninsula
- HREs by developing ETCs

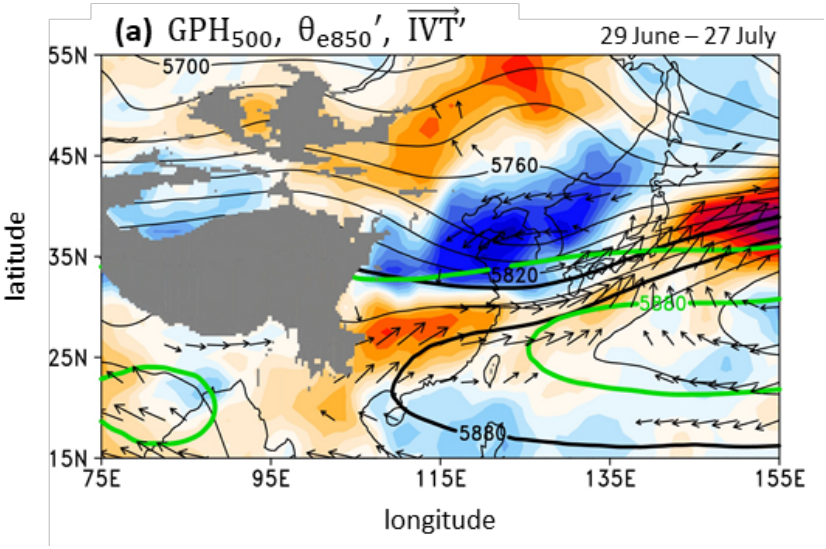
P2:

- Northward expansion of the WNPH
- Intense moisture transport toward the Korean Peninsula along the northern boundary of the WNPH
- HREs along the Changma front

Shading: 850-hPa θ_e anomaly
Vectors: tropospheric moisture flux anomaly

Thick black lines: 5840- and 5880-gpm in 2020
Thick green lines: 5840- and 5880-gpm of climatology

Frequent ETCs in P1?



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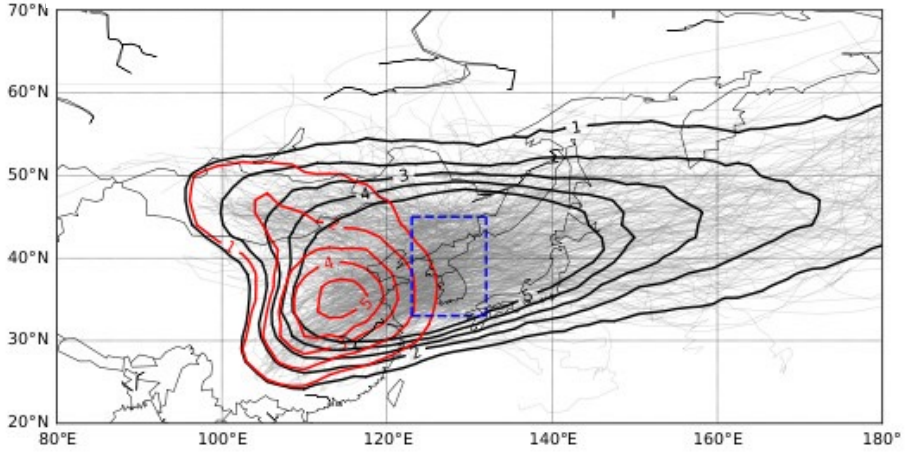
Climatological Summer ETC Frequency (#/mon)

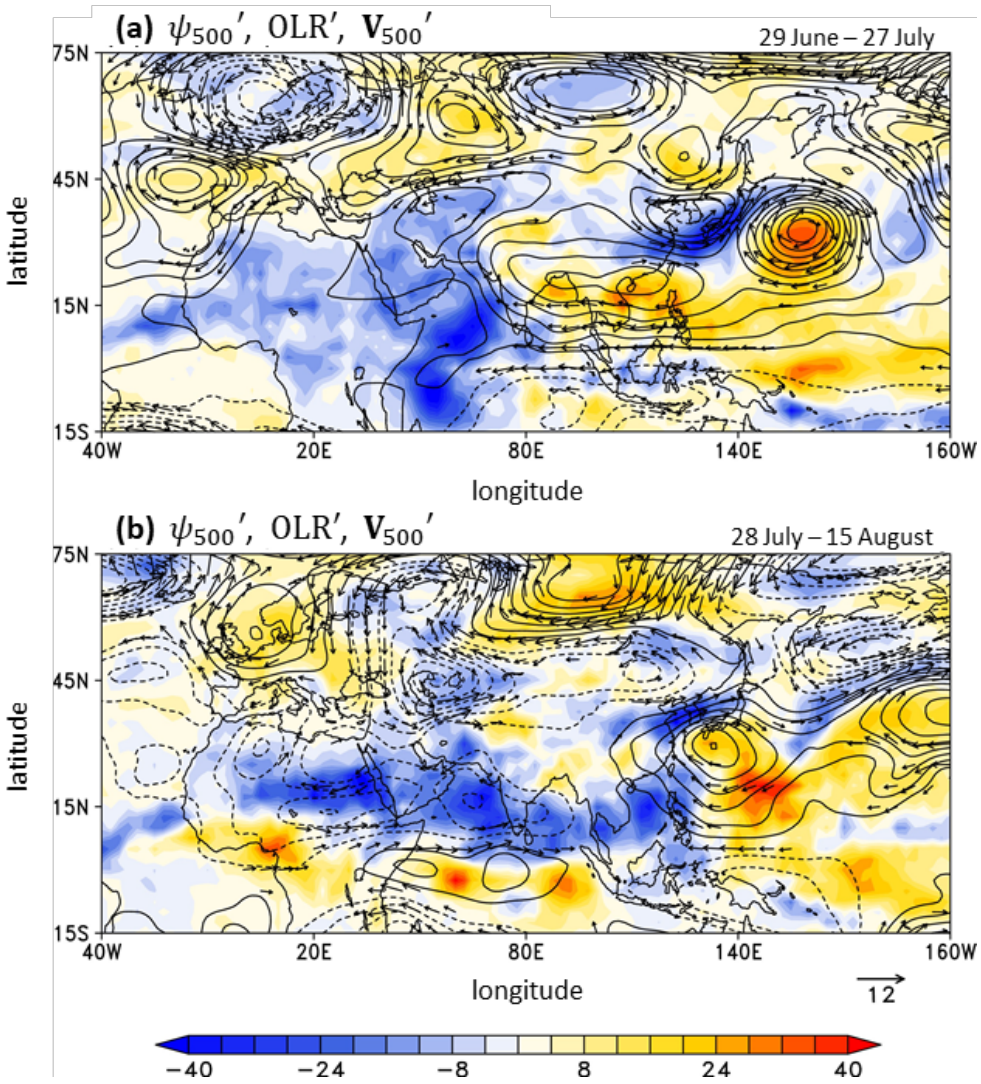


- A large amount of moisture transport from the southwest and wet soil allow the development of thermal low. It becomes ETCs as the upper-level trough developes.

Shading: 850-hPa θ_e anomaly
Vectors: tropospheric moisture flux anomaly

Thick black lines: 5840- and 5880-gpm in 2020
Thick green lines: 5840- and 5880-gpm of climatology

Large-scale circulations: P1 vs. P2



Shading: OLR anomaly
Contours: 500-hPa GPH
Vectors: 500-hPa wind anomaly

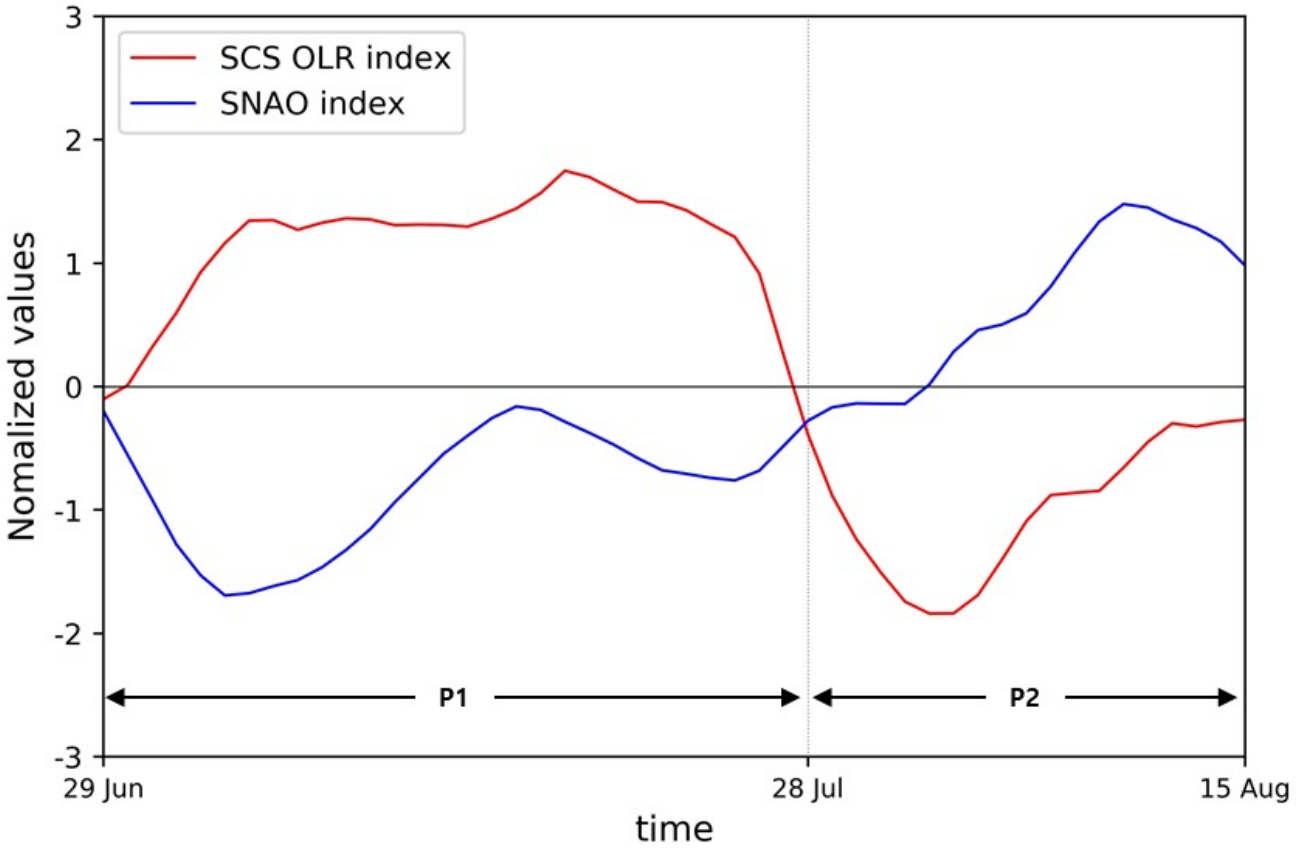
P1:

- Suppressed convection over the South China Sea (SCS) & PJ-like meridional pattern
- Silk-road-like pattern from -SNAO
- Cyclonic lobe over the Korean Peninsula

P2:

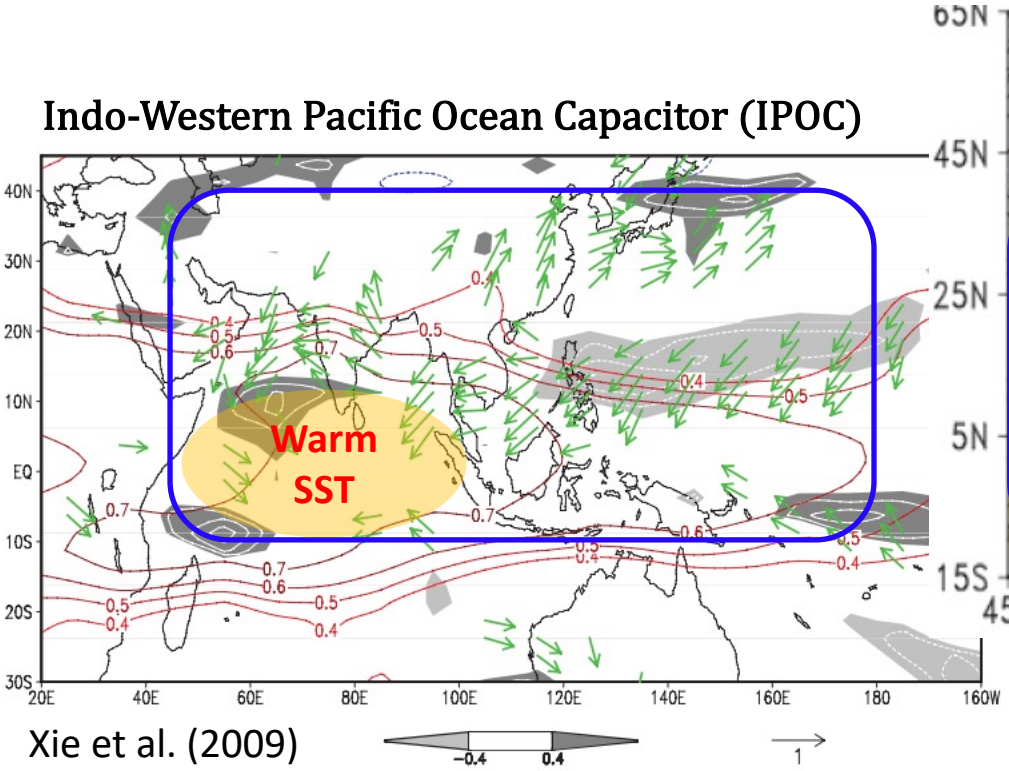
- Enhanced convection over the SCS
- Silk-road-like pattern from +SNAO
- Anticyclonic anomaly centered at the south of Japan & strong moisture transport across the Korean Peninsula.

Teleconnection indices: P1 vs. P2



- An abrupt monsoon circulation change from P1 to P2 is likely due to the combined effect of *SCS convection* and *SNAO*. Their changes are most likely due to internal variability.

Westward extension of WNPH & Suppressed SCS convection in P1?



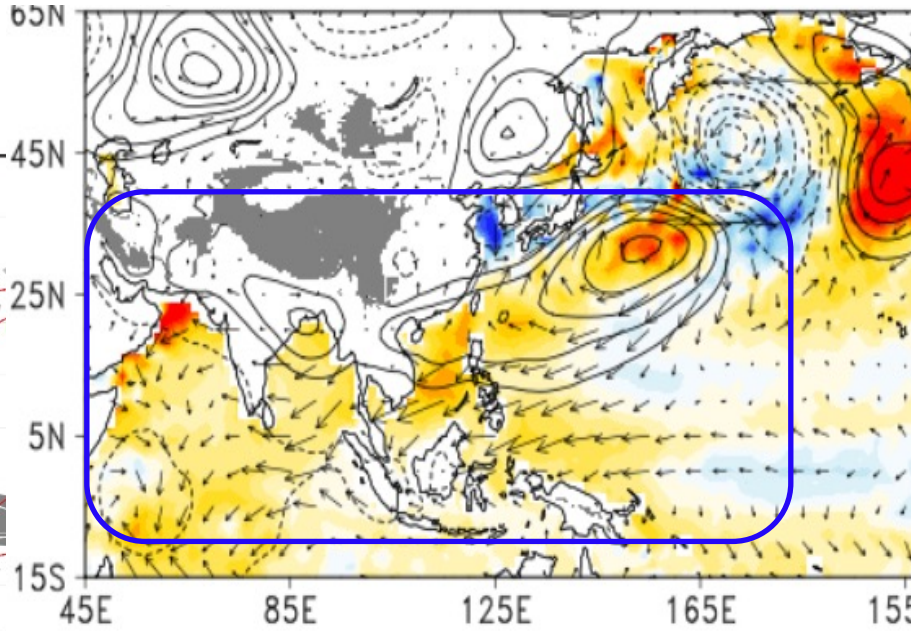
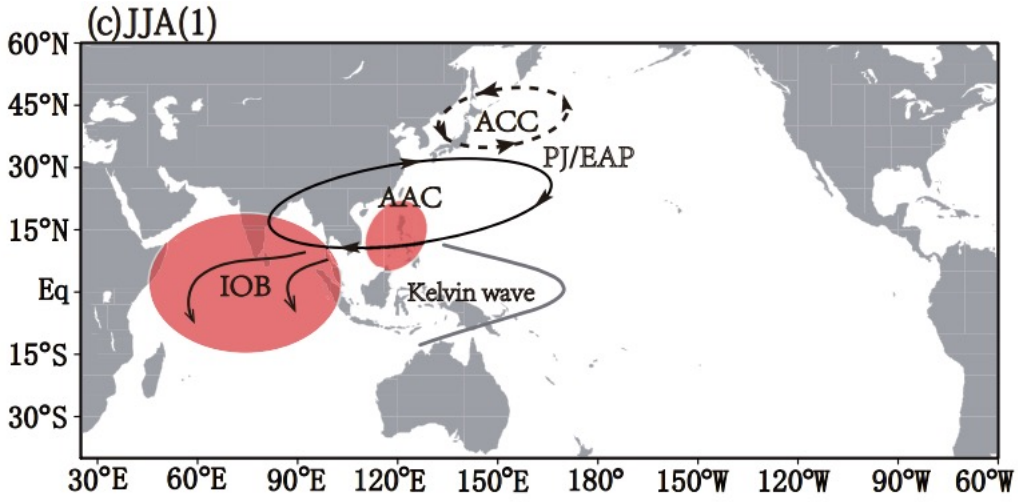


FIG. 6. JJA(1) correlation with the NDJ(0) Niño-3.4 SST index: tropospheric (850–250 hPa) temperature (contours), precipitation (white contours at intervals of 0.1; dark shade > 0.4; light < −0.4), and surface wind velocity (vectors).

- IPOC effect in 2020 summer: 2019/2020 El Nino → 2020 June-July warm SST over Indian Ocean → Gill-type circulation response and anticyclonic circulation anomaly over SCS → Westward extension of NPH and suppressed convection over SCS

Delayed northward expansion of WNPH in P1?

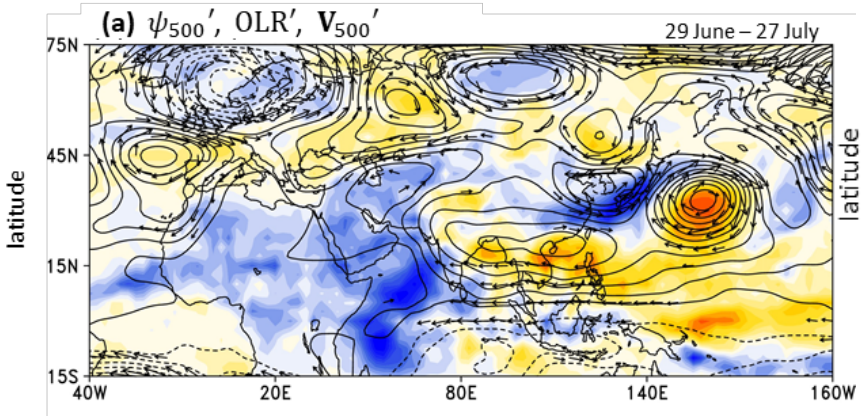


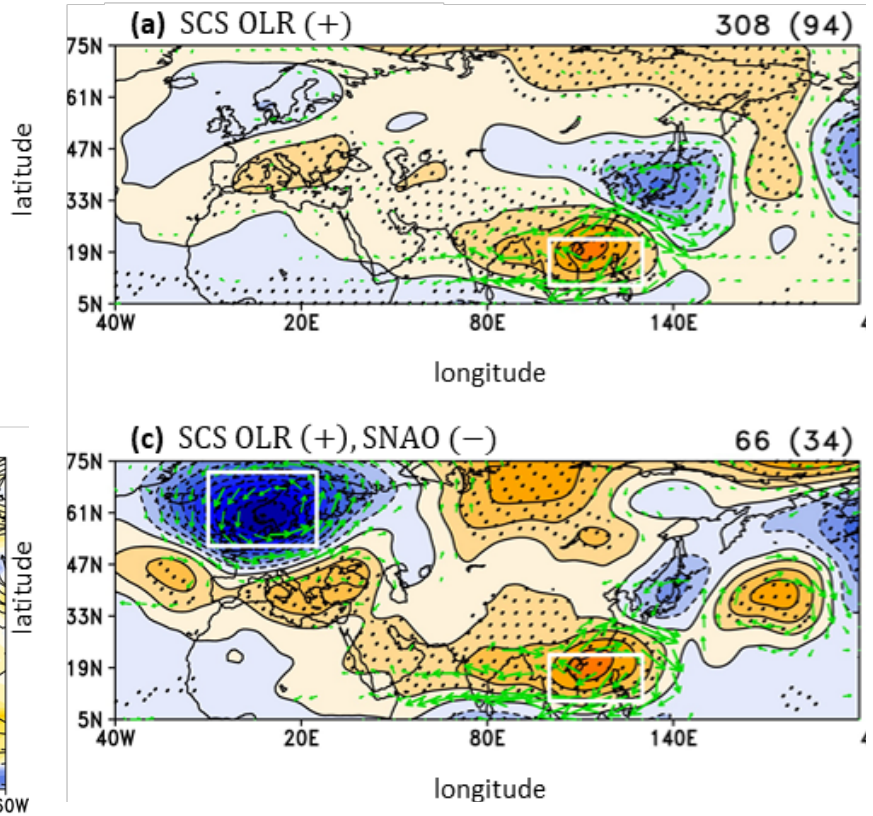
Summer SSTA (shading)
& low-level circulation (contour)
after El Nino winter (Xie et al. 2016)

- Suppressed convection over SCS → PJ-like pattern (slightly different from typical pattern in 2020 due to high-latitude teleconnections)

SCS convection vs. SNAO in P1?

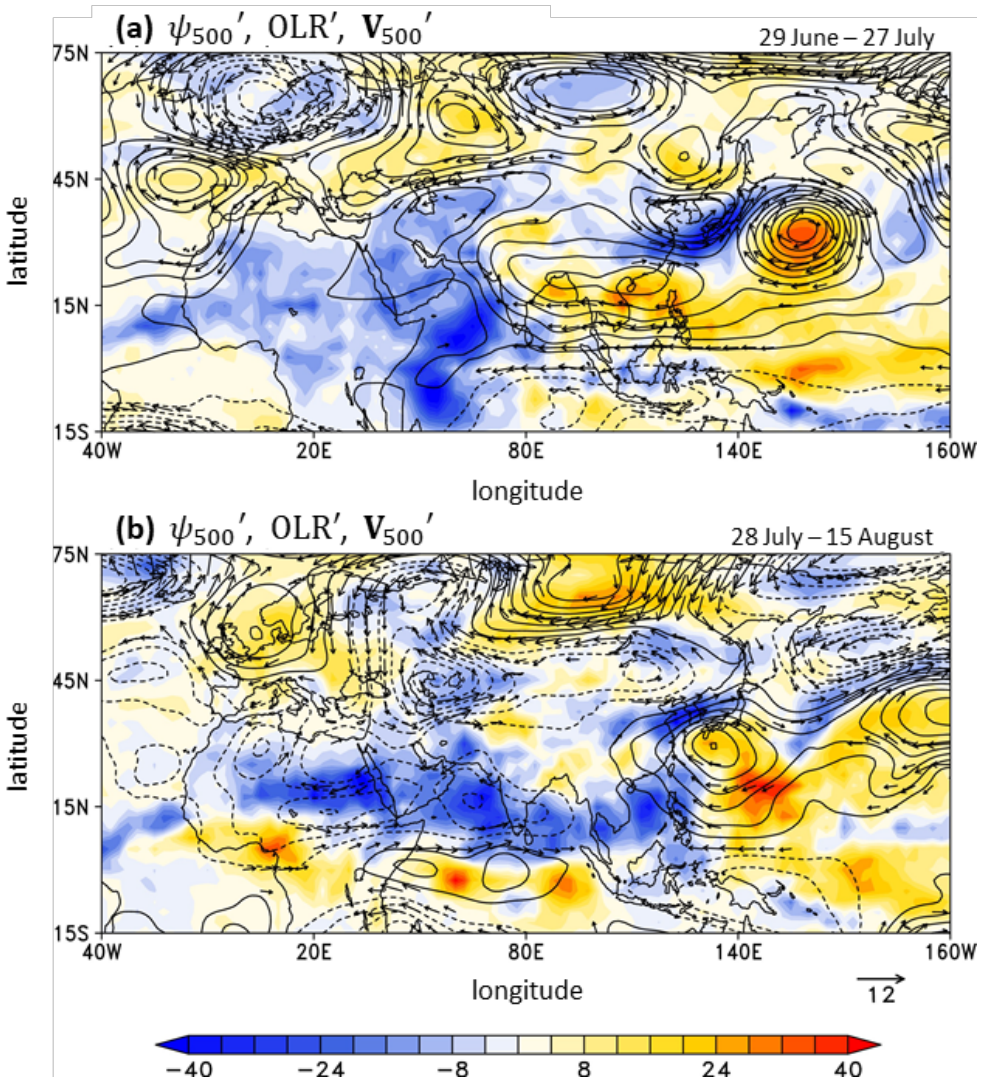
Long-term composite (P1: 29 June–17 July)





- The anomalous monsoon circulation in P1 is likely determined by teleconnections of *suppressed SCS convection* and *–SNAO*, although the latter is relatively minor.

Large-scale circulations: P1 vs. P2



Shading: OLR anomaly
Contours: 500-hPa GPH
Vectors: 500-hPa wind anomaly

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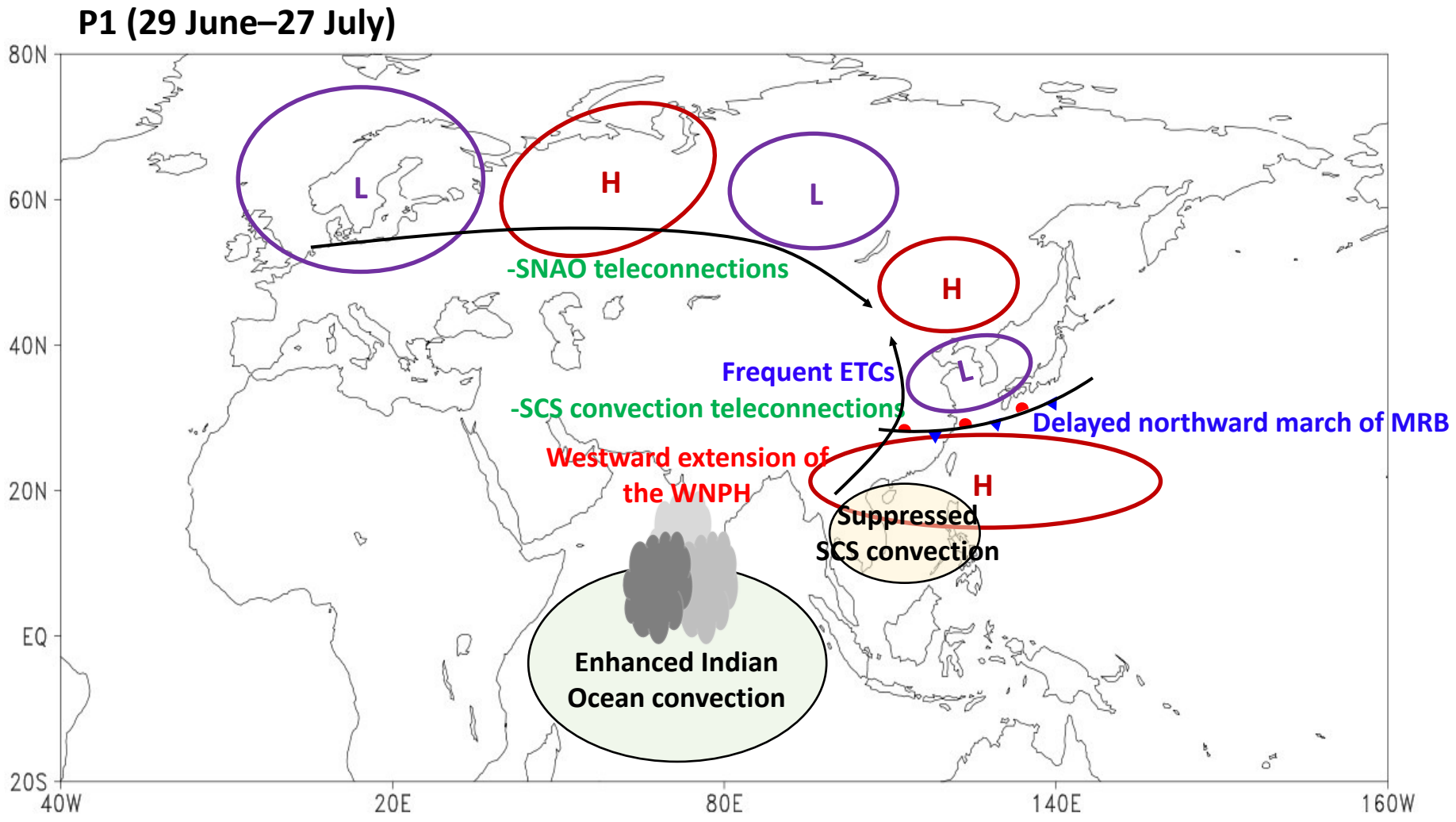
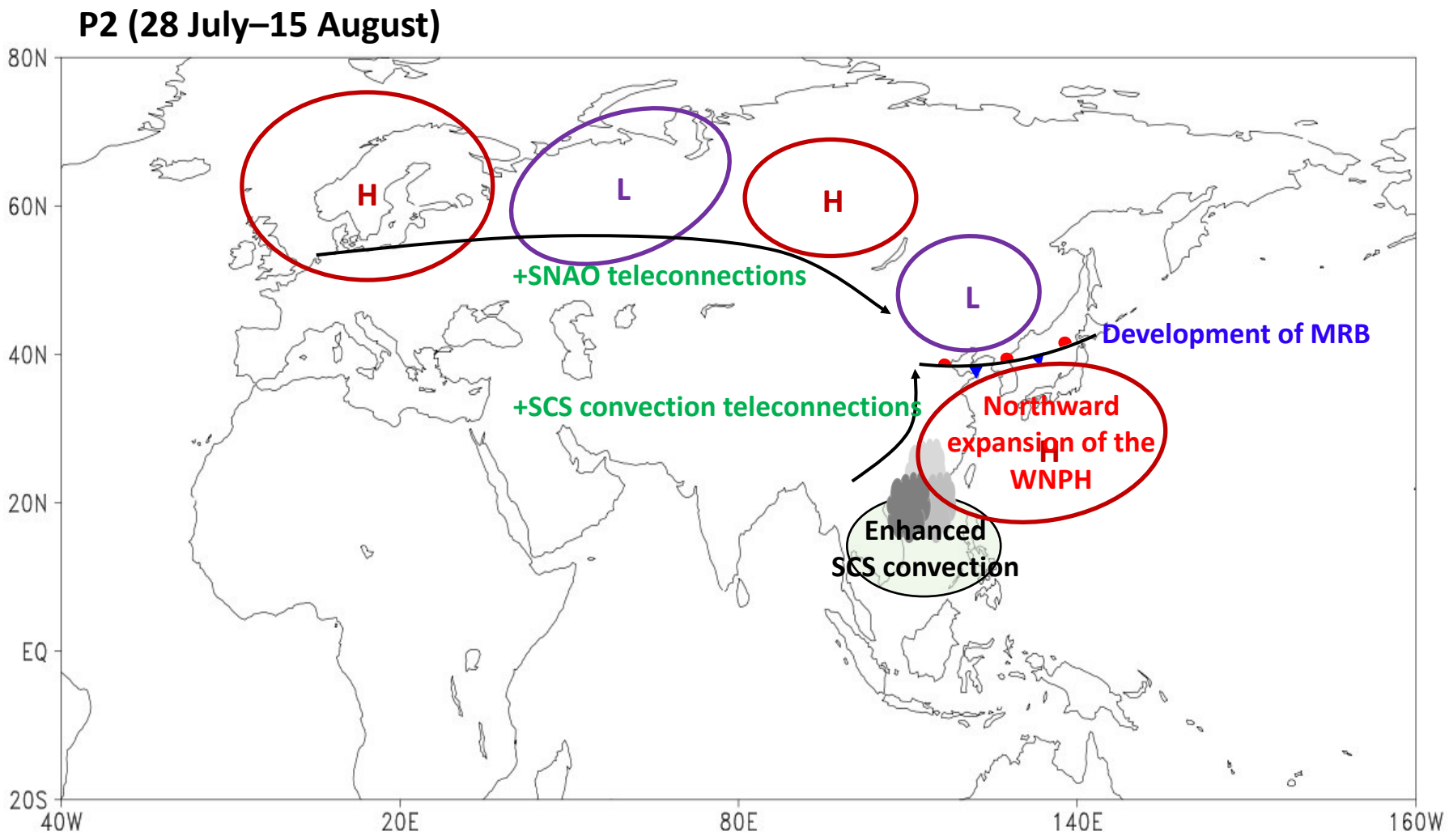
  → Northward expansion of WNPH

Summary

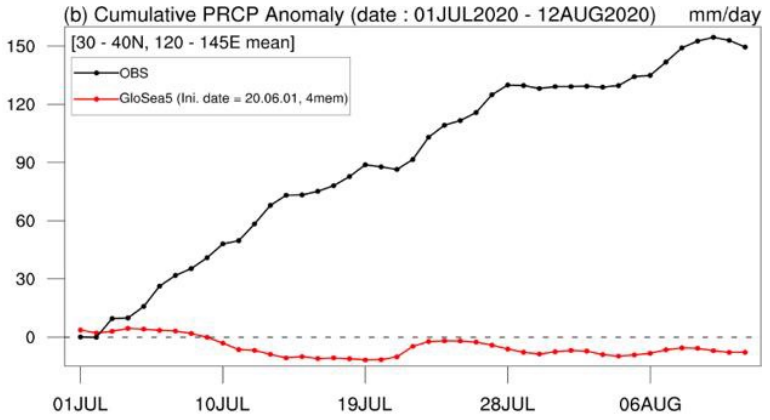

P1 (29 June–27 July)
80N
60N
40N
20N
EQ
20S
40W
20E
80E
140E
160W
L
H
L
-SNAO teleconnections
H
Frequent ETCs
L
-SCS convection teleconnections
Delayed northward march of MRB
Westward extension of
the WNPH
H
Suppressed
SCS convection
Enhanced Indian
Ocean convection

Summary

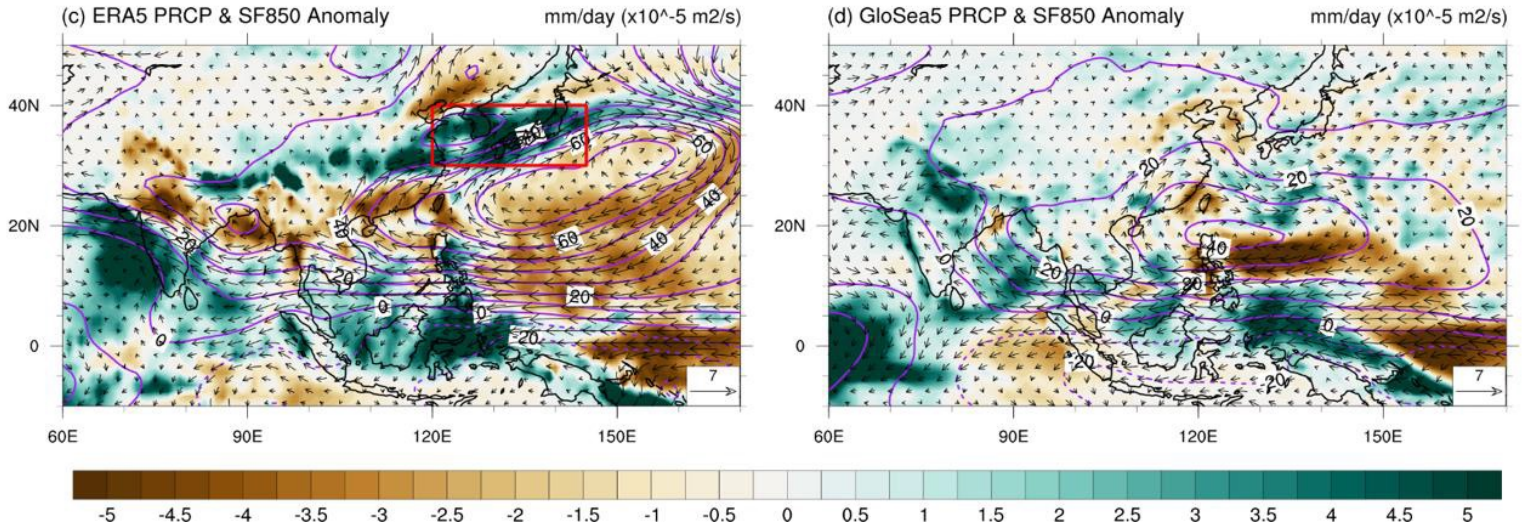

P2 (28 July–15 August)
80N
60N
40N
20N
EQ
20S
40W
20E
80E
140E
160W
H
L
H
L
+SNAO teleconnections
Development of MRB
+SCS convection teleconnections
Northward expansion of the WNPH
H
Enhanced SCS convection

Failure of seasonal prediction

P1+P2 (1 July–12 August)



Shading: precipitation anomaly
Contours: 850-hPa stream function anomaly



- GloSea5 failed to predict record-breaking wet summer.

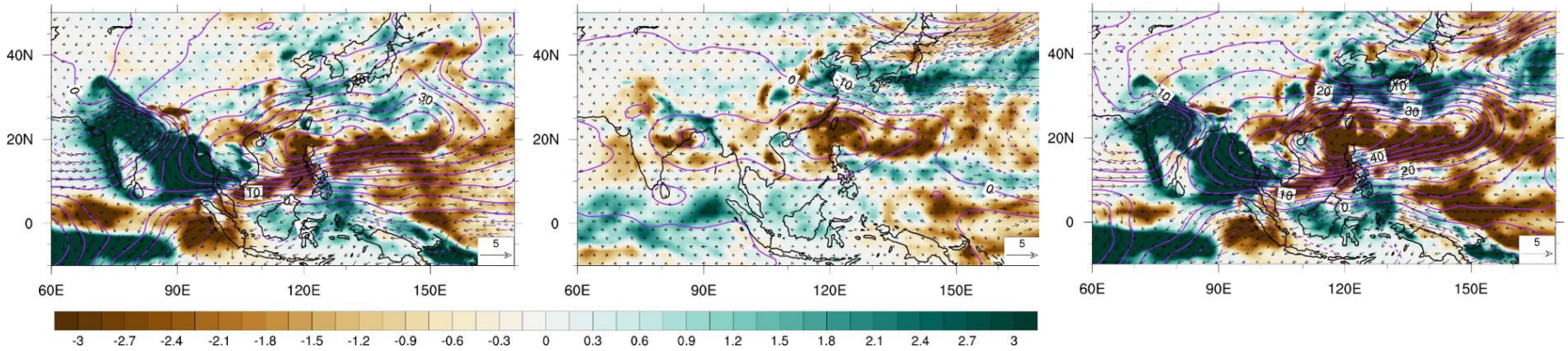
Source of errors: SST

SST partial nudging experiments

A: Indian Ocean SST
(40E-100E & 20S-20N)

B: Eq. Pacific SST
(180W-75W & 20S-20N)

A+B



- Summer precipitation can be partly reproduced by better constraining tropical SST.
- Similar experiment can be conducted to identify the role of North Atlantic SST and Arctic SST/SIC.

References

- Park, C., S.-W. Son, H. Kim, Y.-G. Ham, J. Kim, D.-H. Cha, E.-C. Chang, G. Lee, J.-S. Kug, W.-S. Lee, Y.-Y. Lee, H. C. Lee, and B. Lim, 2021: Record-breaking summer rainfall in South Korea in 2020: Synoptic characteristics and large-scale circulation, *Monthly Weather Review (in minor revision)*

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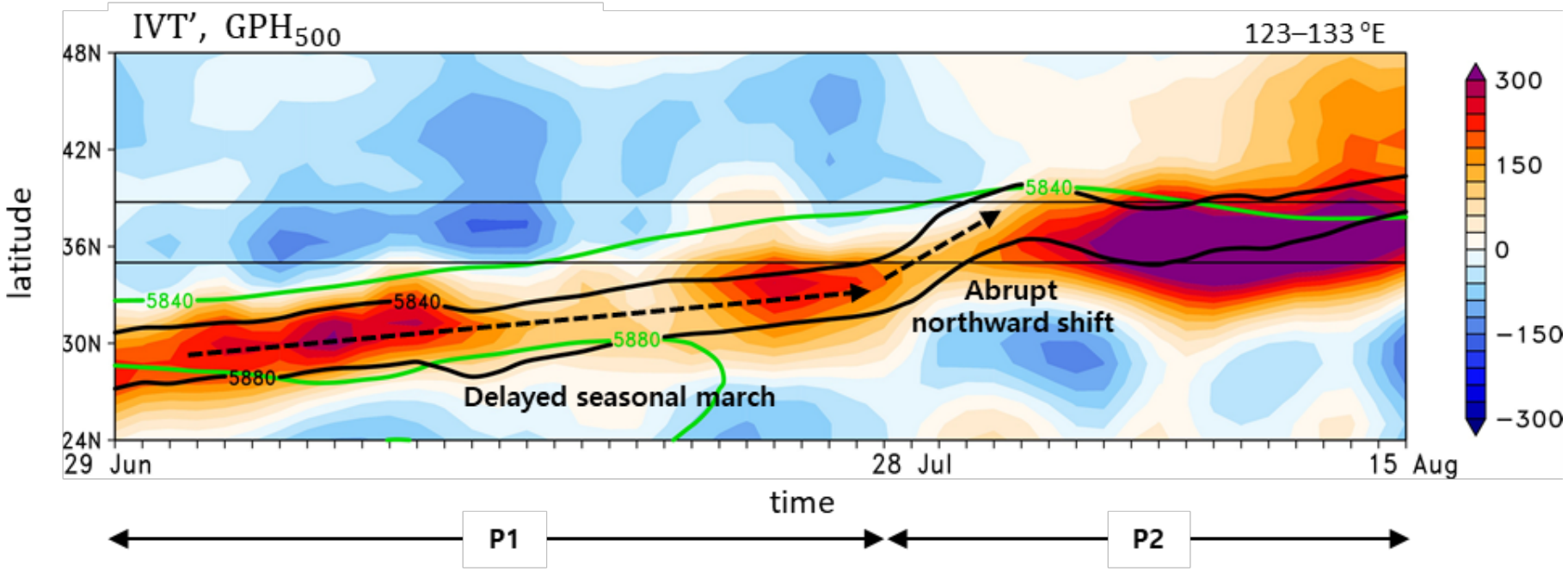
Temporal evolution of Z500



Shading: tropospheric moisture transport anomaly

Black lines: 5840- and 5880-gpm in 2020

Green lines: 5840- and 5880-gpm of climatology

- Delayed northward march of the western North Pacific subtropical high (WNPH) in P1
- Abrupt northward expansion of the WNPH in late July and the resulting strong moisture transport throughout P2

SCS convection vs. SNAO in P2?

Long-term composite (P2: 28 July–15 August)