

ENSO Teleconnections and Impacts on North America during La Niña summers

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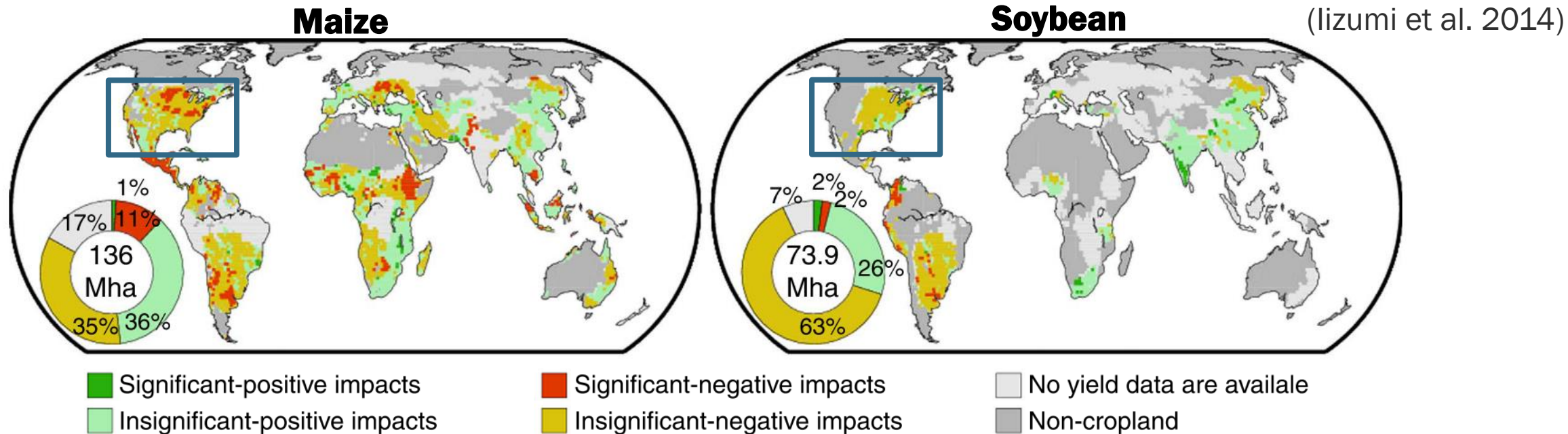
October 18, 2018

**IV International Conference on ENSO
Guayaquil, Ecuador**

ENSO affects crop yields over North America during summer flowering season

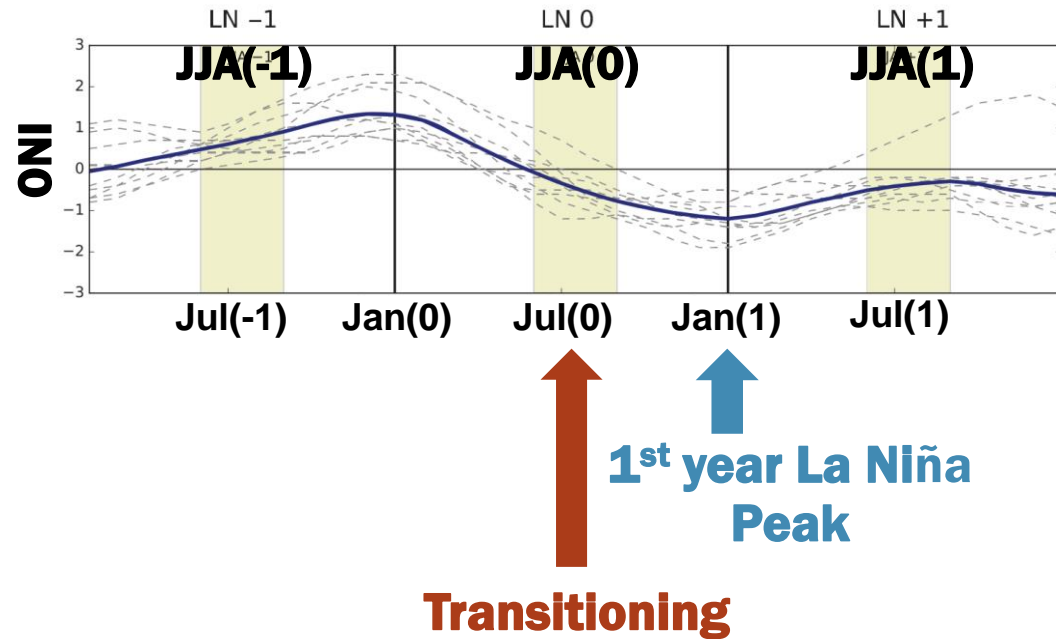
- Summer (Jun-Aug): Flowering season for maize & soybean over NA
- Maize and soybean yields are positively correlated with flowering season Nino3.4 SST anomalies in the US. (Anderson et al. 2017)

Impacts of La Niña on crop yields

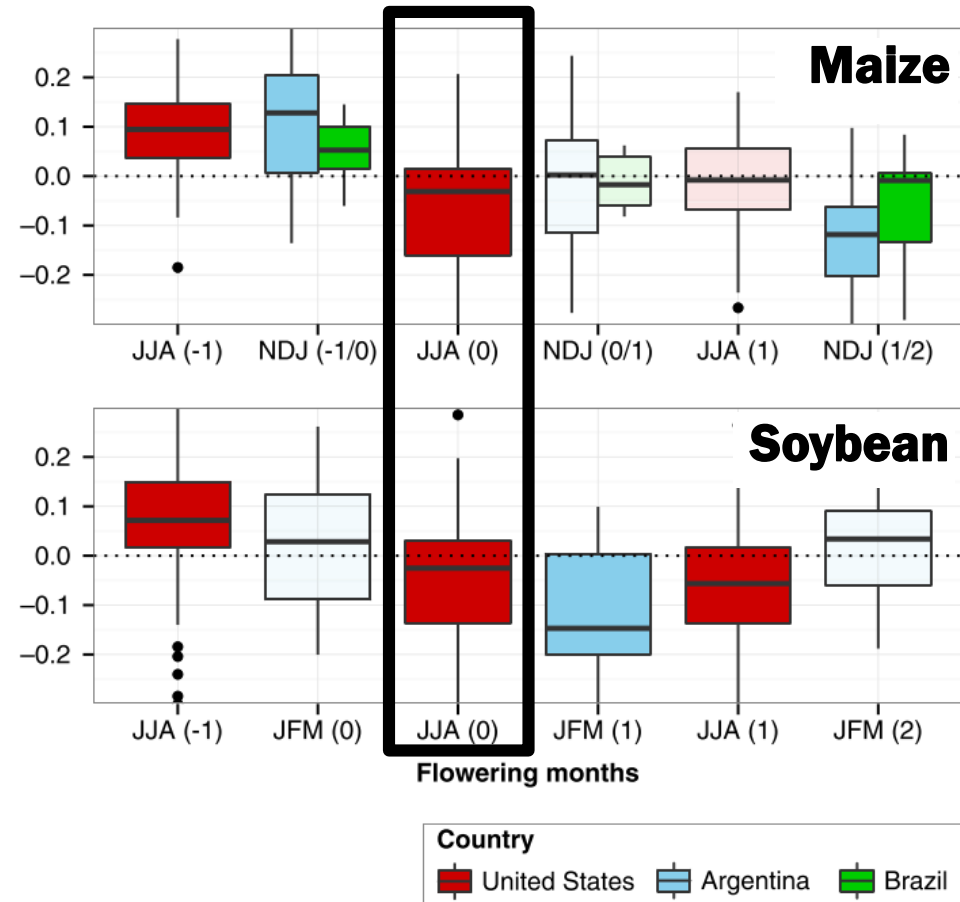


ENSO affects crop yields over the Midwest during summer flowering season

La Niña life cycle

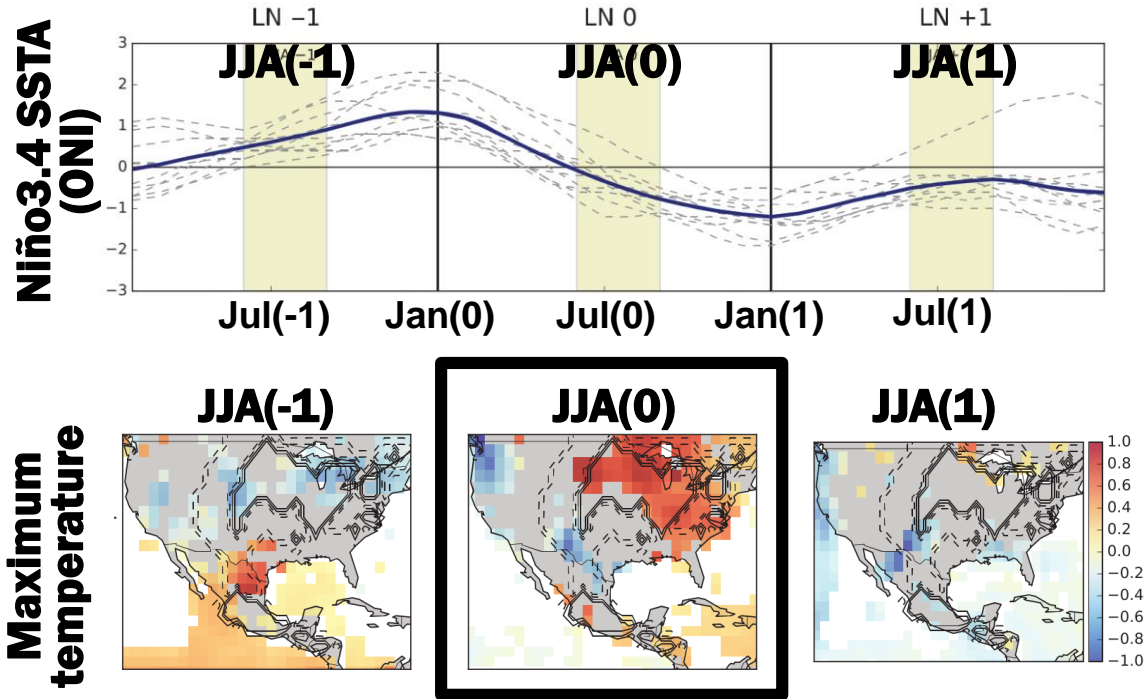


Life cycle of yield anomalies



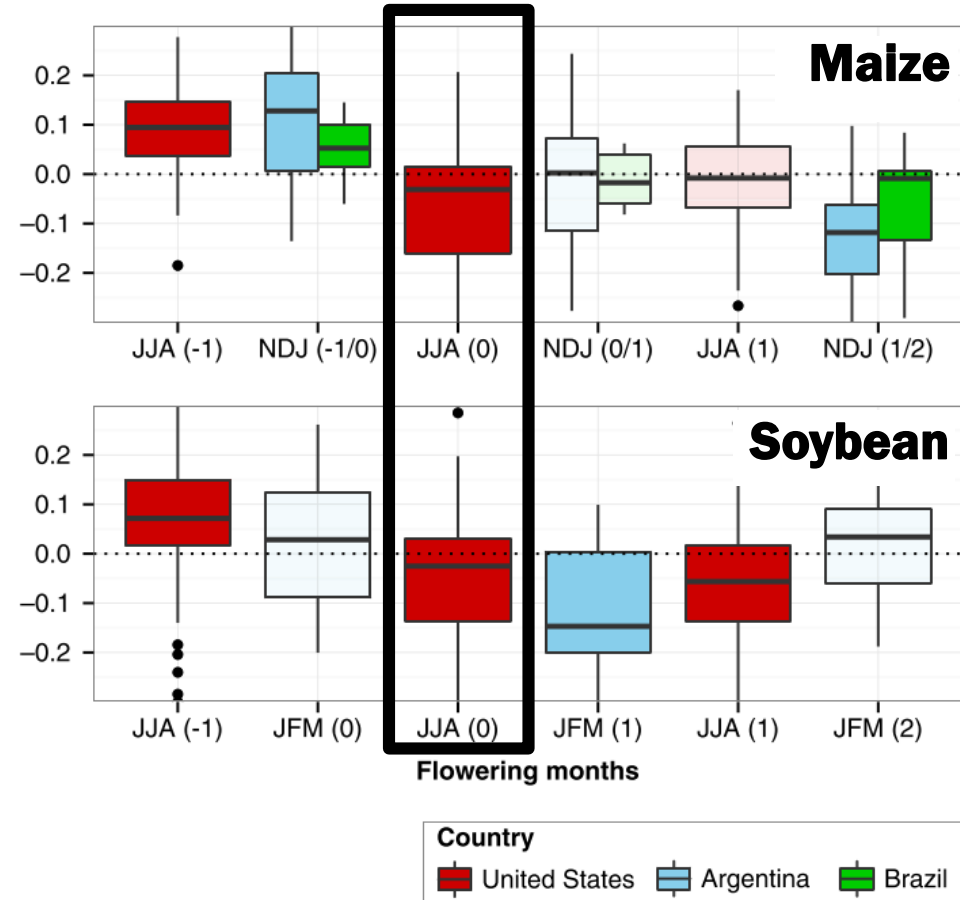
ENSO affects crop yields over the Midwest during summer flowering season

La Niña life cycle



Physical mechanism that causes this warming?

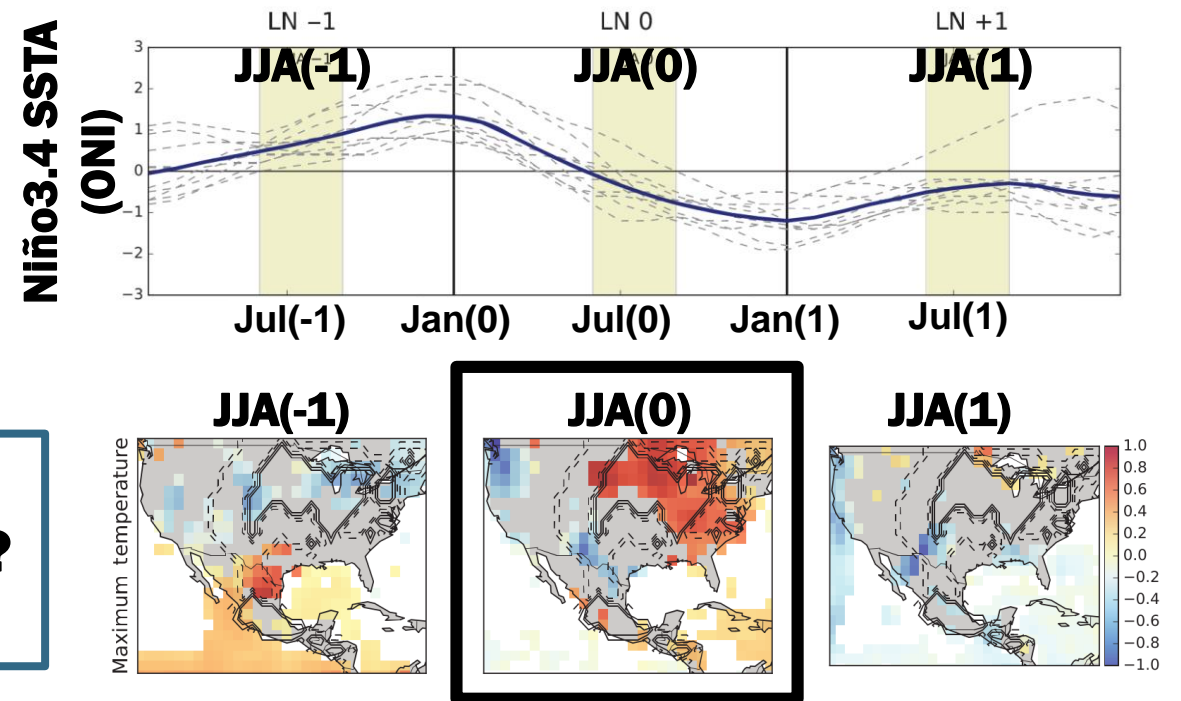
Life cycle of yield anomalies



Objective

1. The physical process behind the warm anomalies over the Midwest during ENSO transition summer.

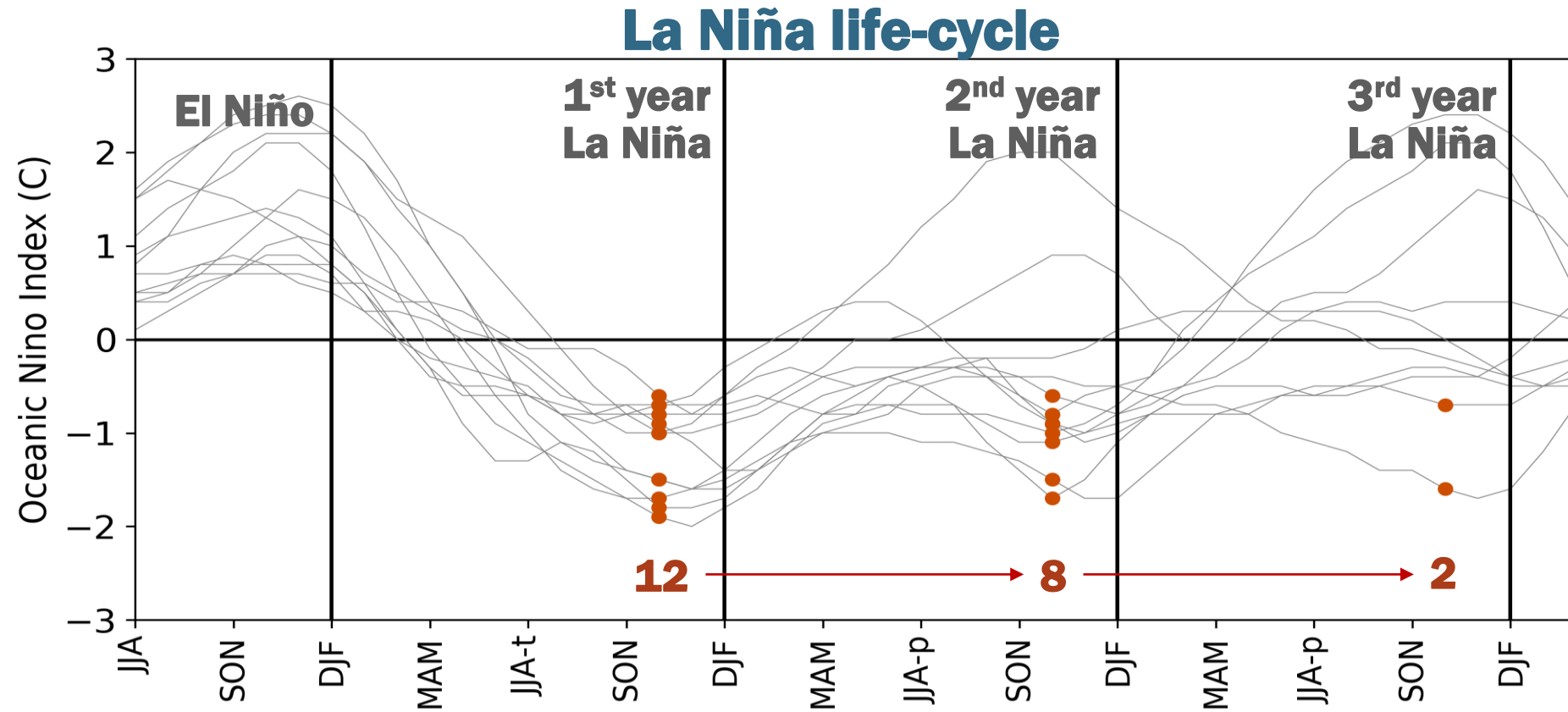
La Niña life cycle



Session5: 10:50 ~ 11:10

How relevant is ENSO to global crop production?
(Weston Anderson)

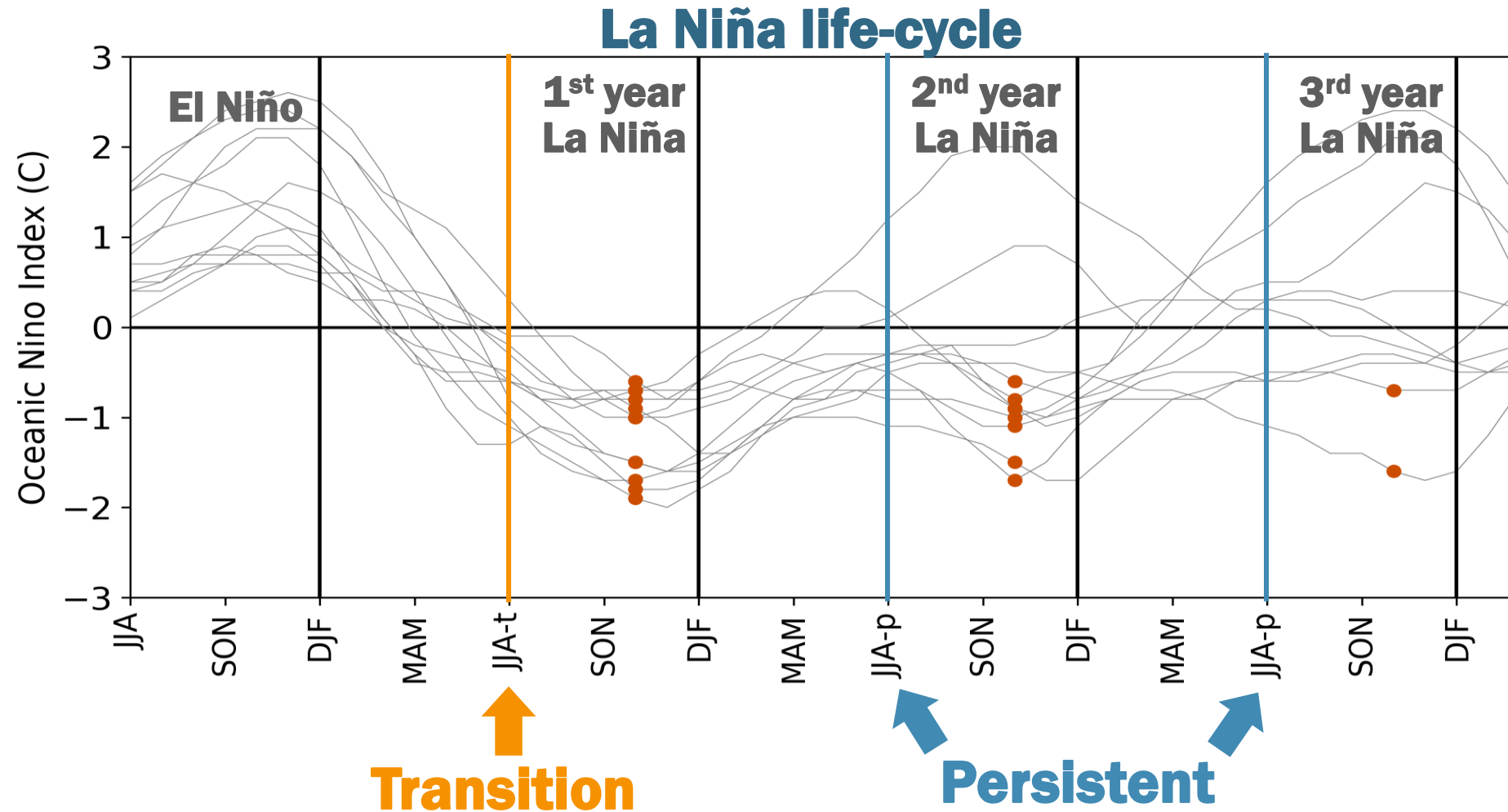
La Niña: either transition from El Niño or persistent from La Niña



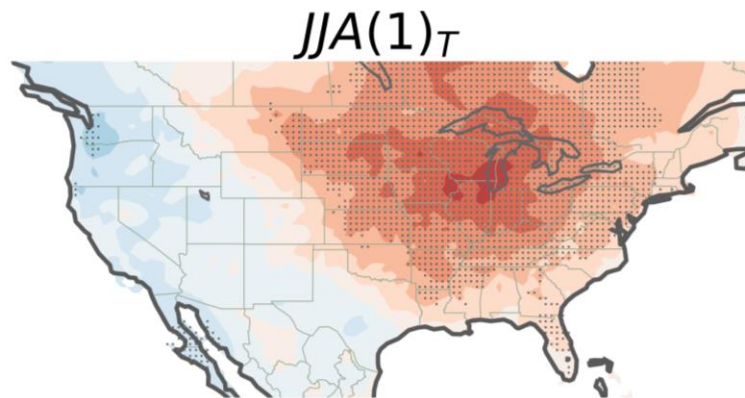
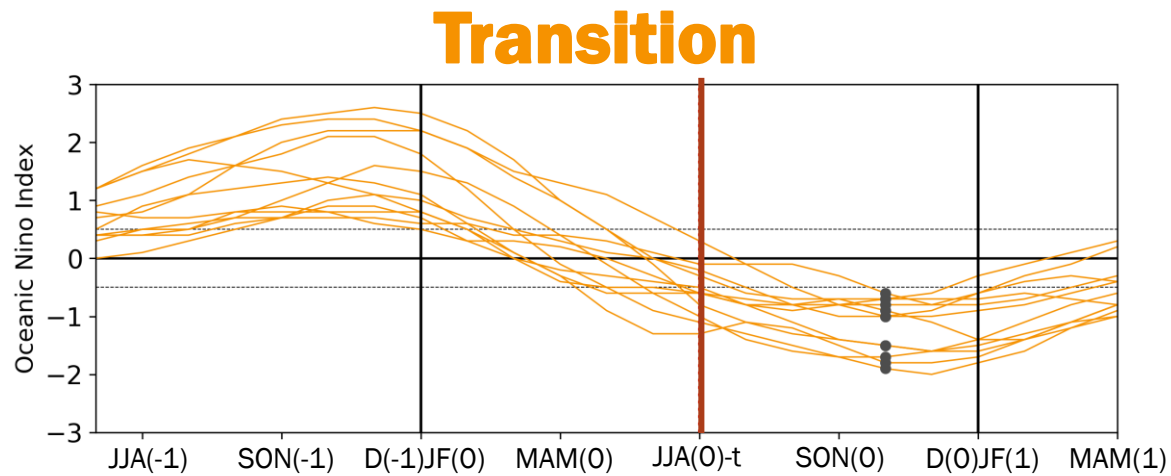
Criteria: ERSSTv5 3-month averaged Niño3.4 SSTA < -0.5°C in October-December (OND)

● La Niñas during 1950-2016

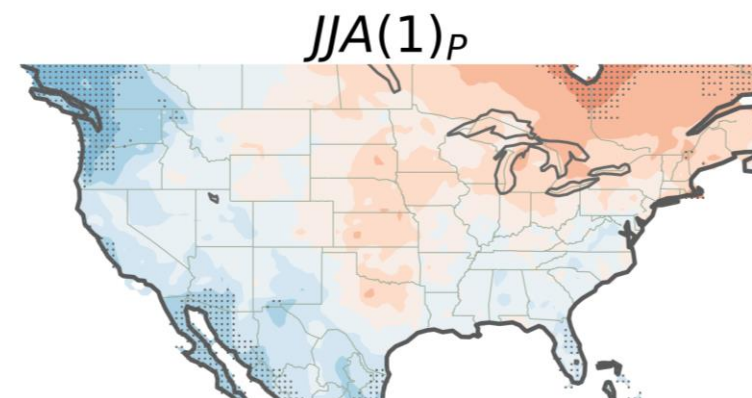
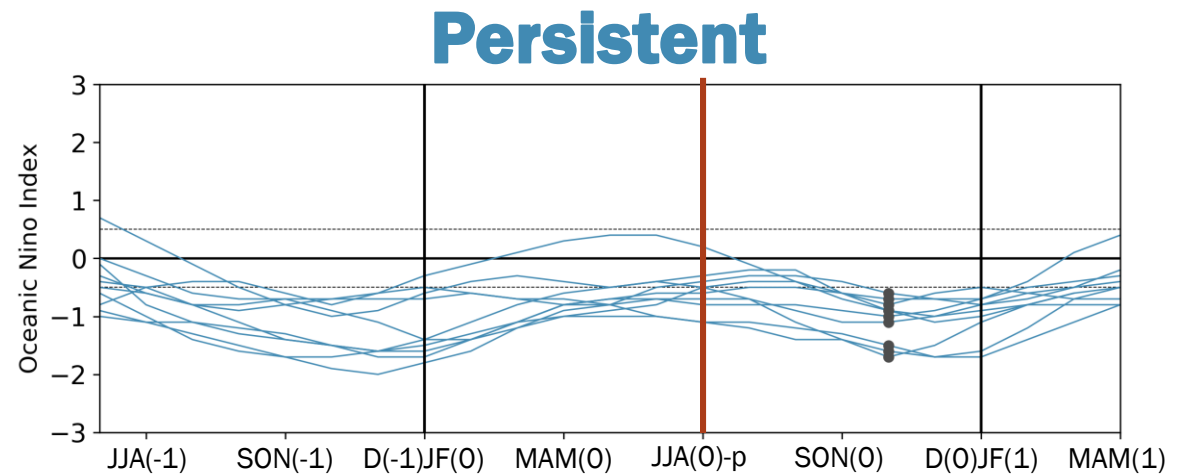
La Niña: either transition from El Niño or persistent from La Niña



The warm anomalies: only happen during the summer when El Niño transitions to La Niña



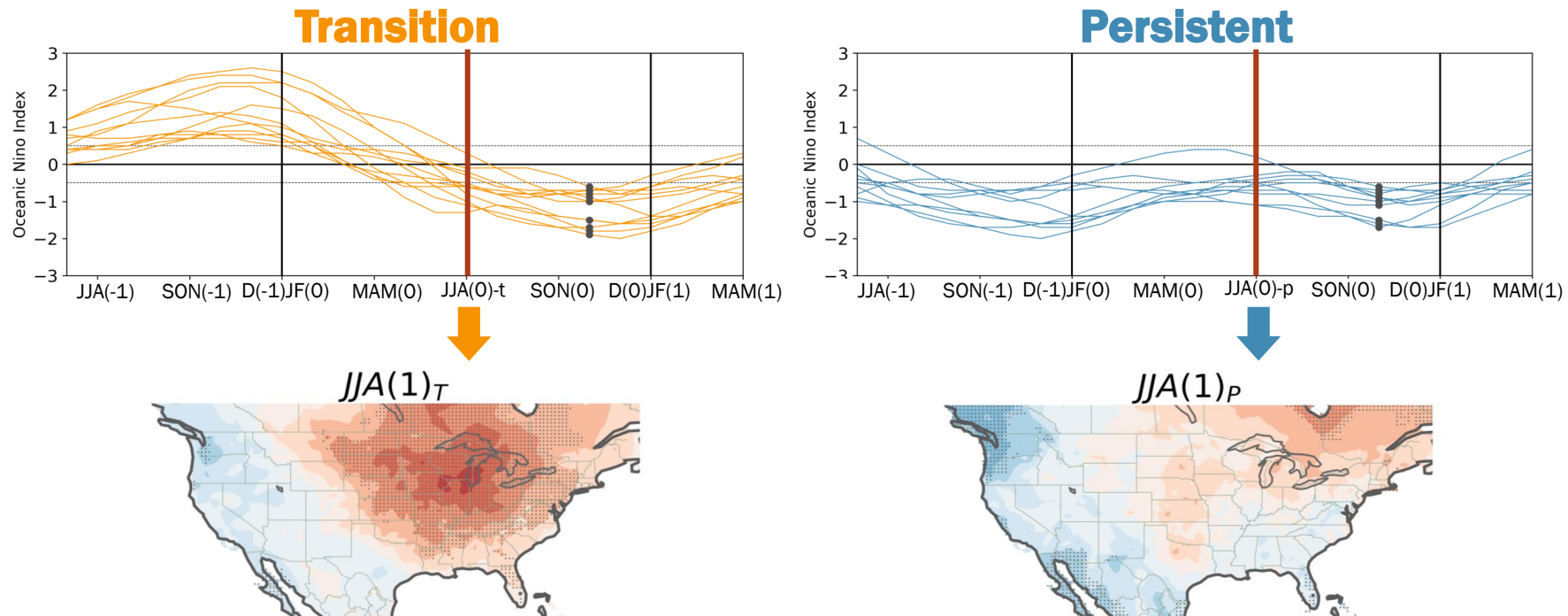
CRU detrended Ts



CRU detrended Ts

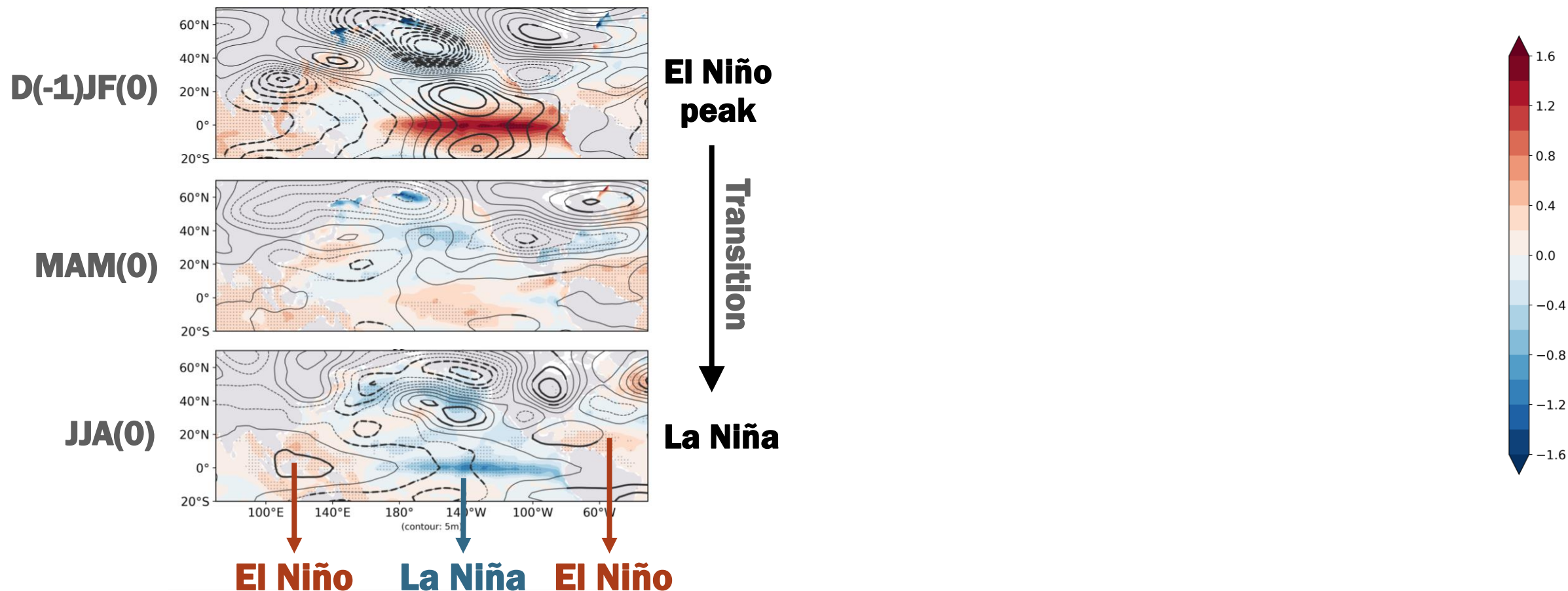
Objective

- 1. The physical process behind the warm anomalies over the Midwest during ENSO transition summer.**
- 2. The differences between the transition and persistent summers.**

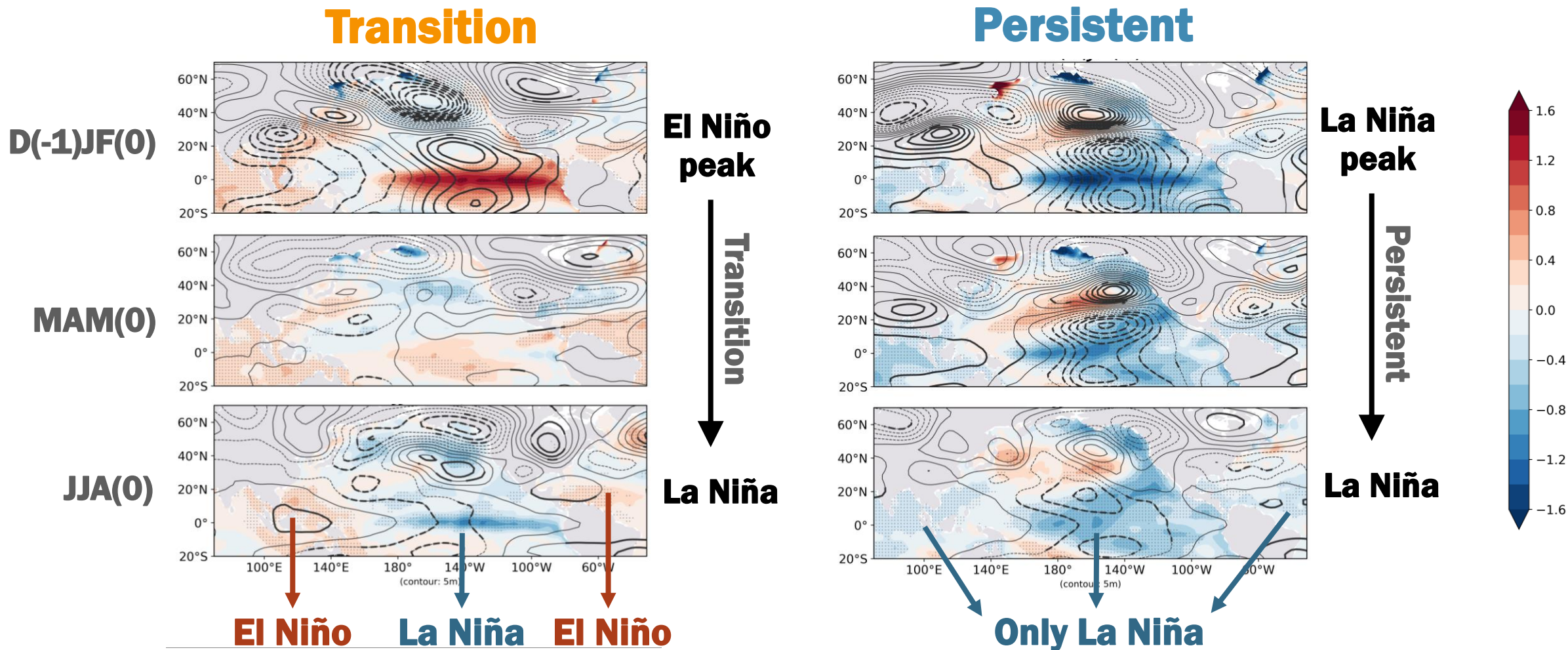


Transition summer: shares the characteristics of both the decaying El Niño and the developing La Niña

Transition



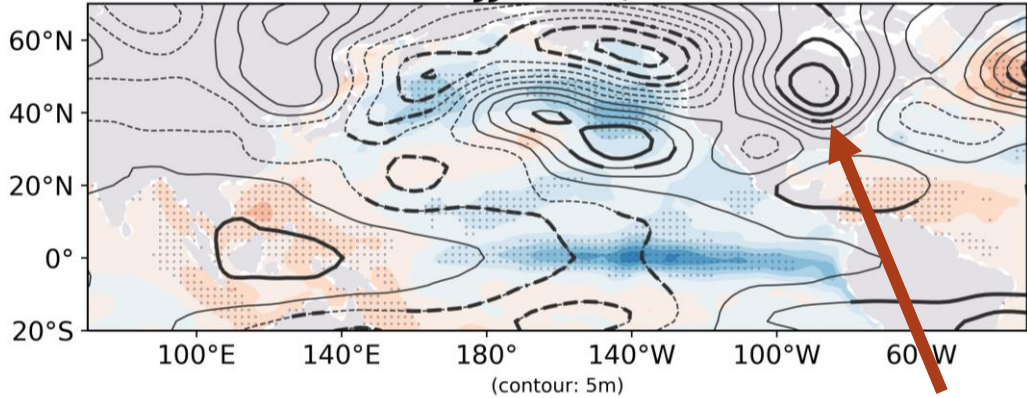
Transition summer: shares the characteristics of both the decaying El Niño and the developing La Niña



Transition summer: An anomalous ridge over eastern North America

Transition

JJA(0)_T



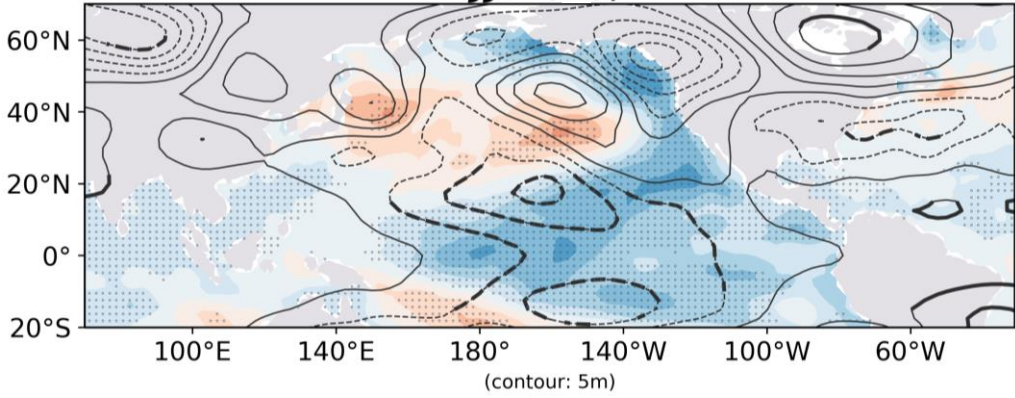
Ridge



Teleconnections propagate toward extratropical North America.

Persistent

JJA(0)_P

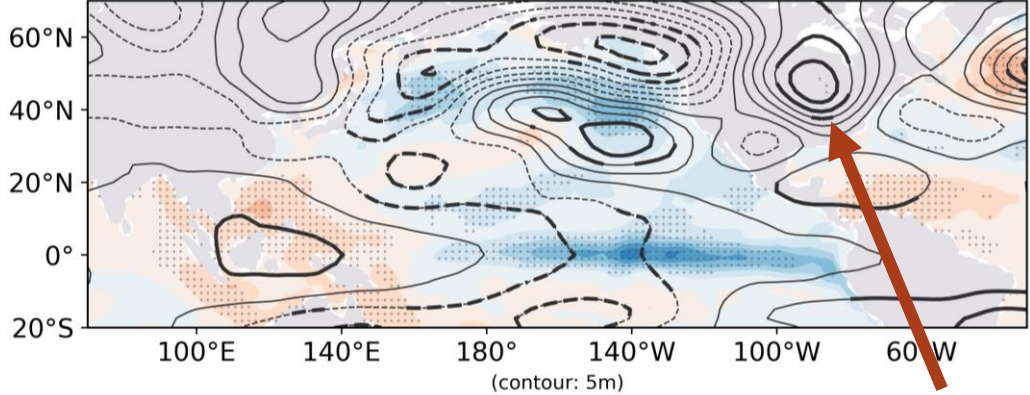


Anomalous circulations are more confined in the tropics.

Transition summer: An anomalous ridge over eastern North America

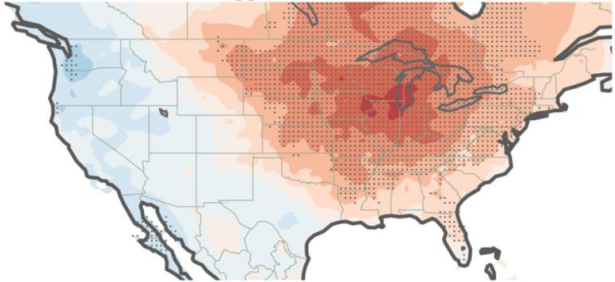
Transition

$JJA(0)_T$



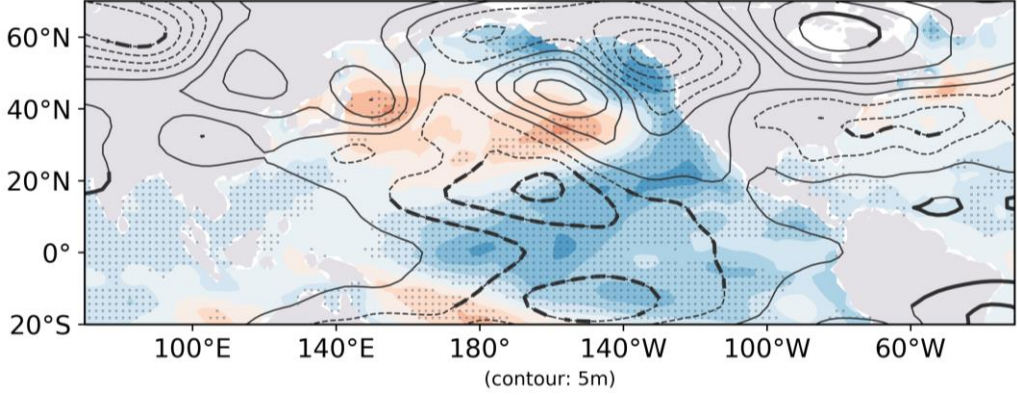
Ridge

$JJA(0)_T$



Persistent

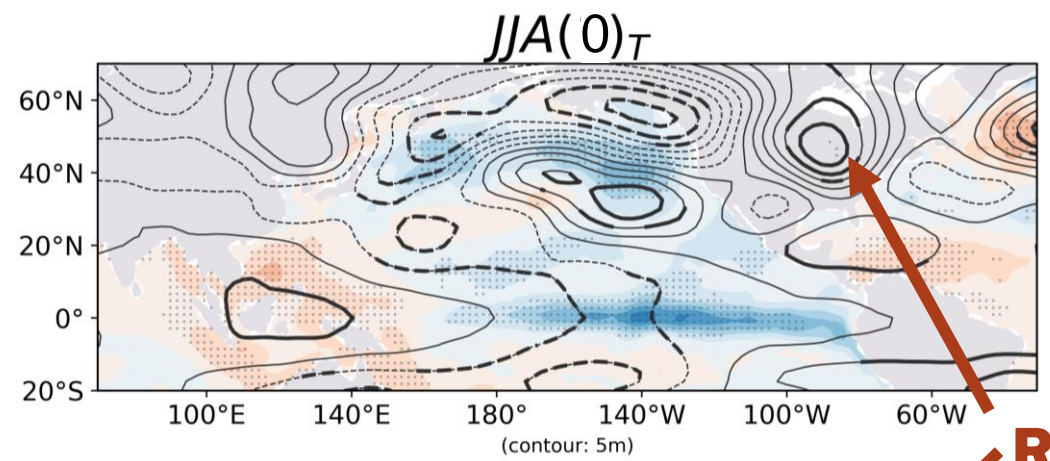
$JJA(0)_P$



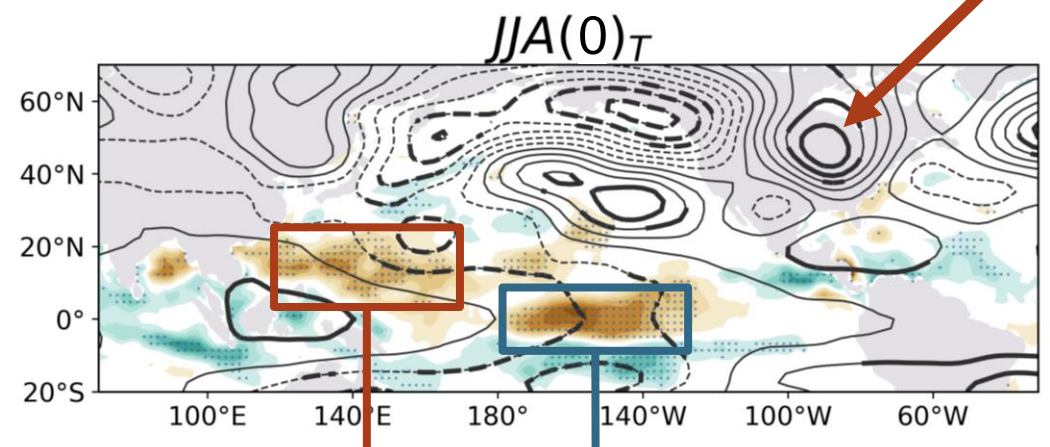
Anomalous circulations are more confined in the tropics.

Transition summer: Rossby waves from both central and western tropical Pacific

Transition



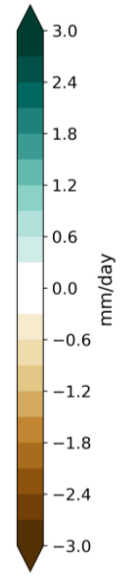
Ridge



El Niño

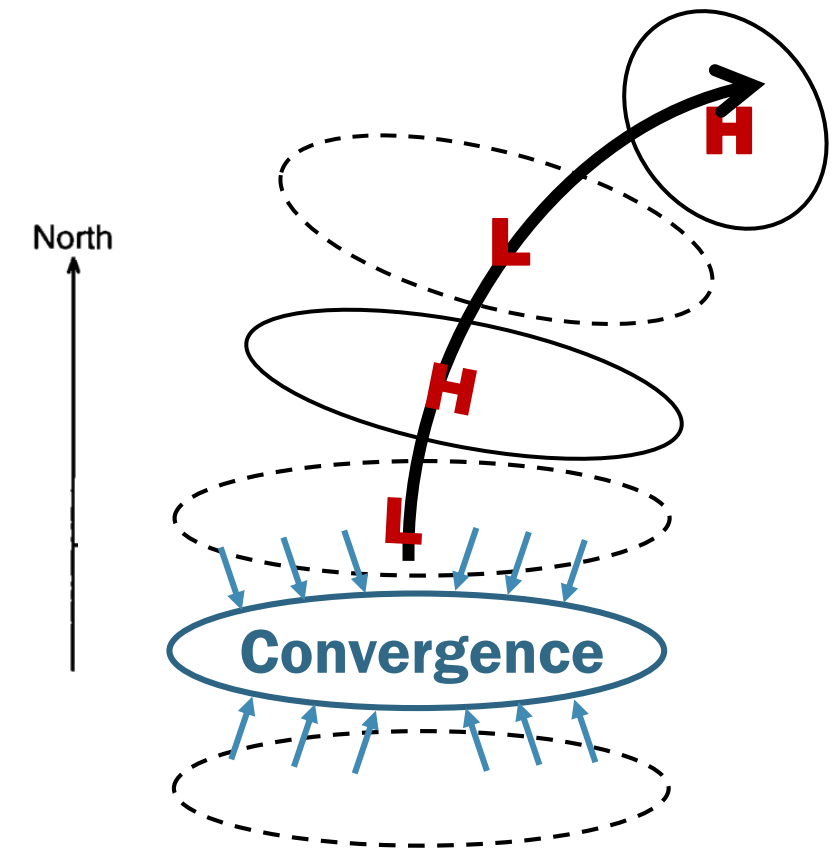
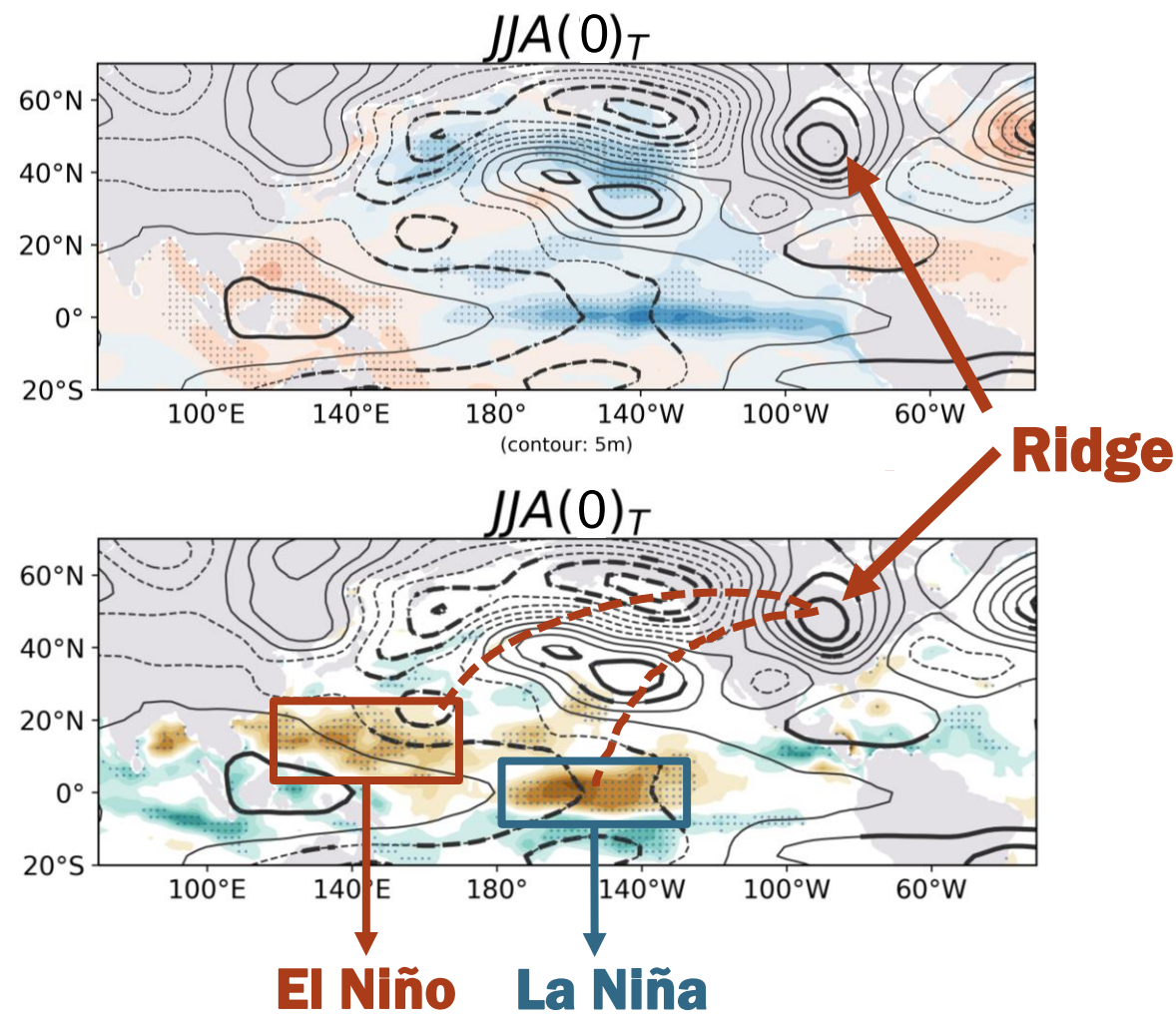
La Niña

**western Pacific:
Caused by the delayed Indian Ocean
warming due to the previous El Niño.**
(Xie et al. 2009)



Transition summer: Rossby waves from both central and western tropical Pacific

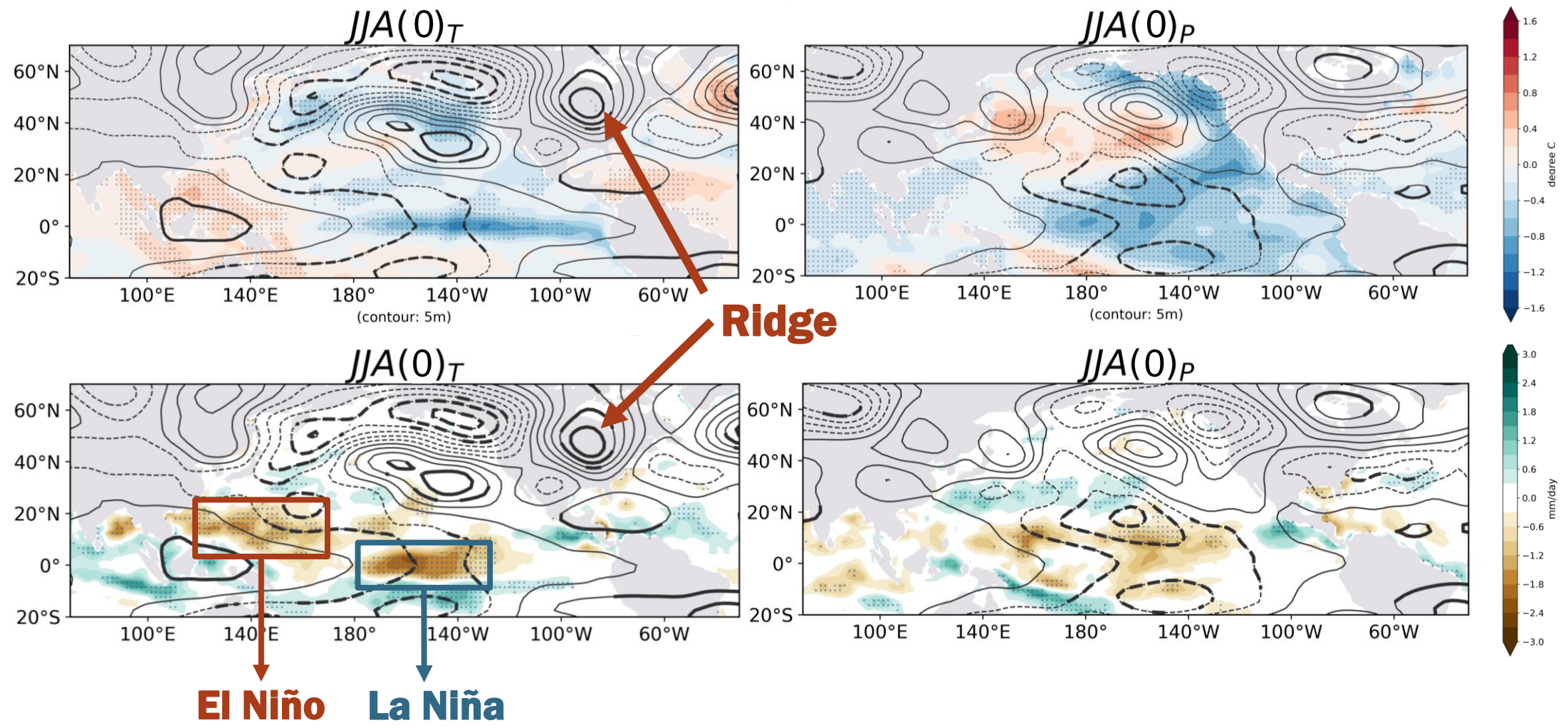
Transition



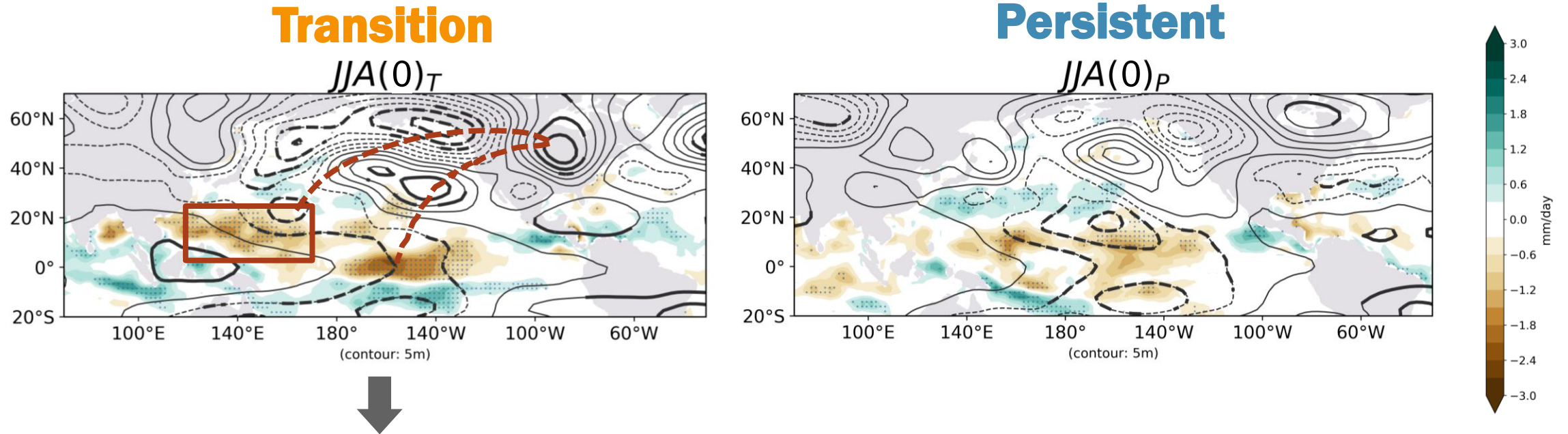
Transition summer: Rossby waves from both central and western tropical Pacific

Transition

Persistent



Transition summer: Rossby waves from both central and western tropical Pacific

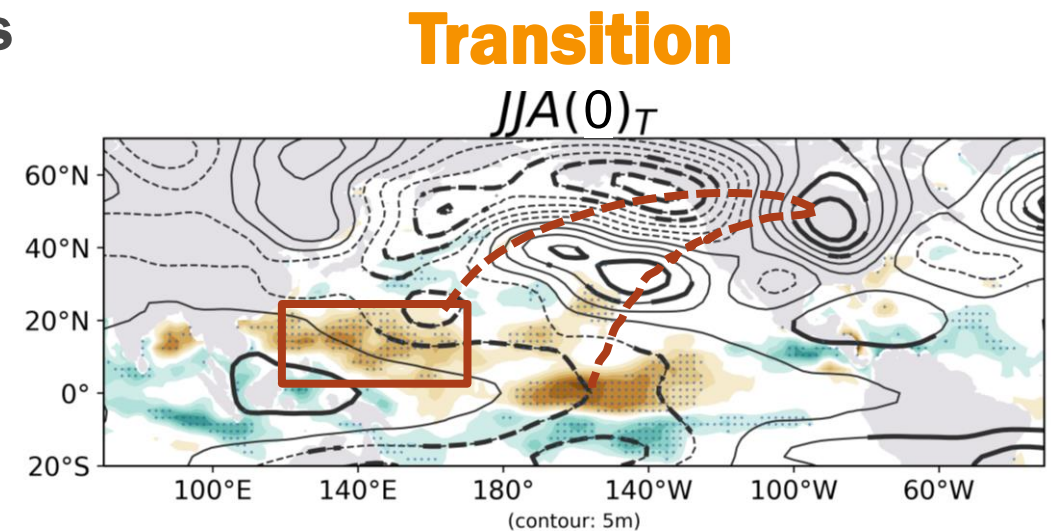


The suppressed deep convection over the western Pacific due to the previous El Niño also trigger a stationary wave propagate toward NA.

Use Stationary Wave Model to examine to the role of tropical forcing during the developing La Niña summer

Stationary wave model (Ting and Hoerling 1993; Ting and Yu 1998)

- Linear, primitive equation, steady-state baroclinic model
- Deviations from a prescribed zonally asymmetric basic state
- Interior Rayleigh drag: 15-day
- Forcing: diabatic heating, transient eddies

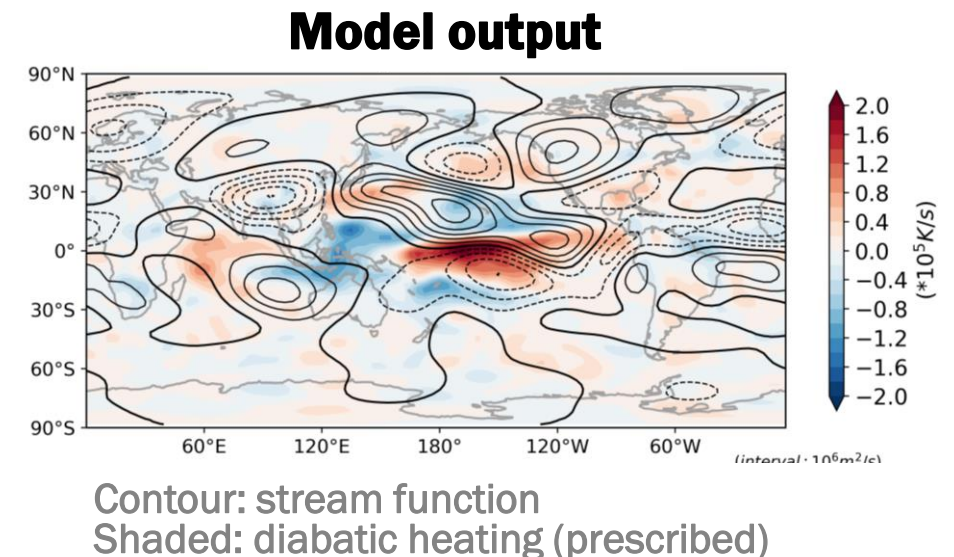
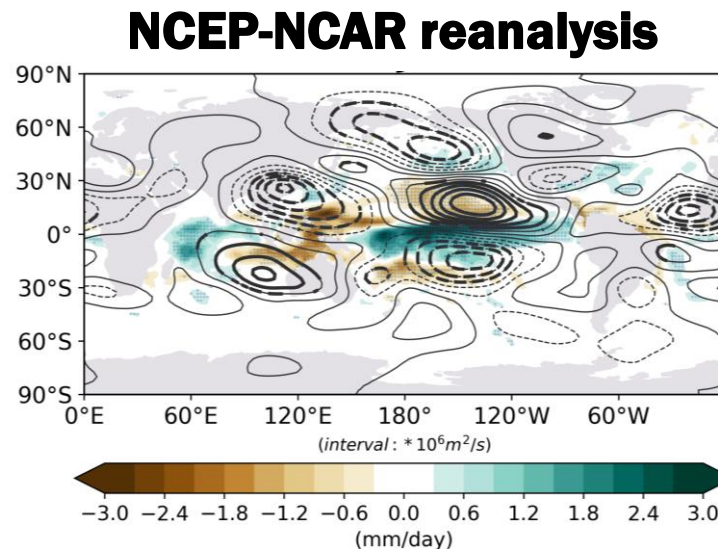


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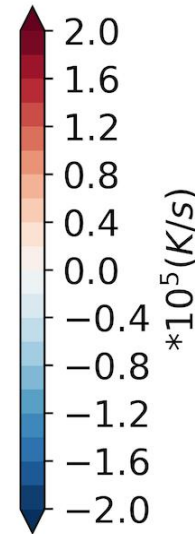
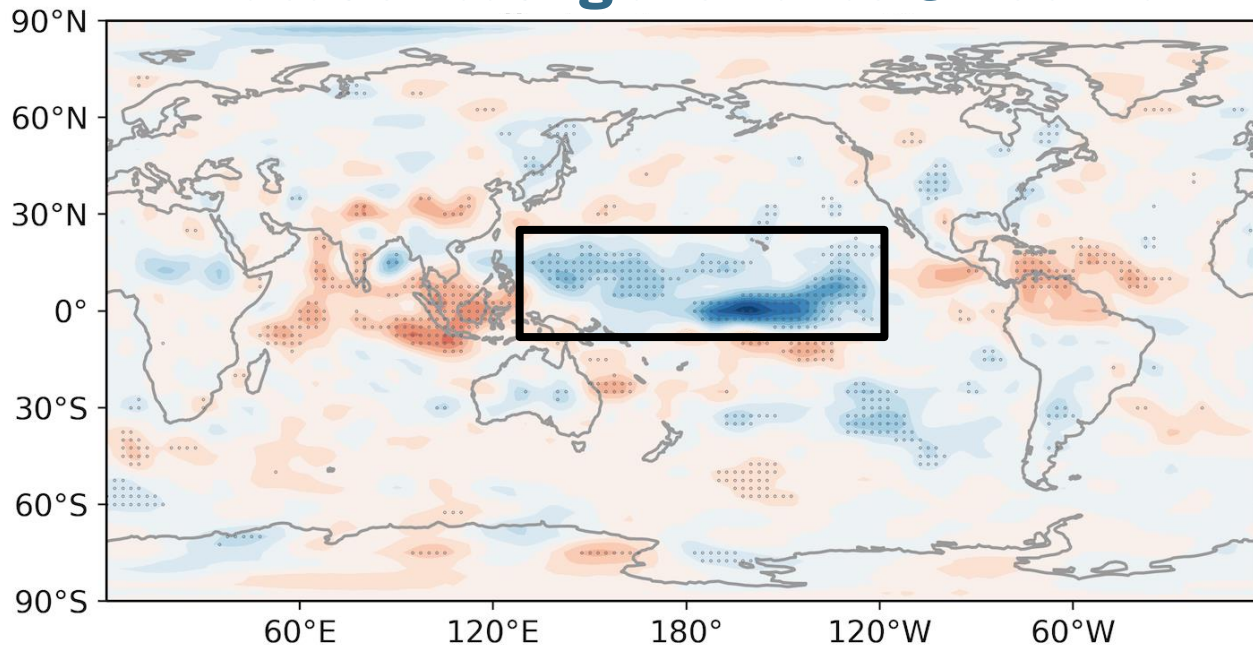
- Linear, primitive equation, steady-state baroclinic model
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El Niño winter :

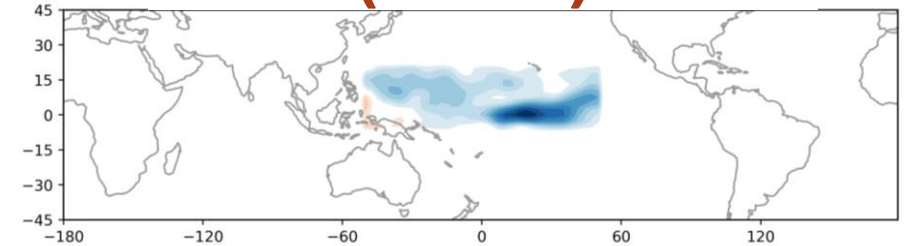


Decompose the diabatic heating/cooling anomalies over the western and central tropical Pacific

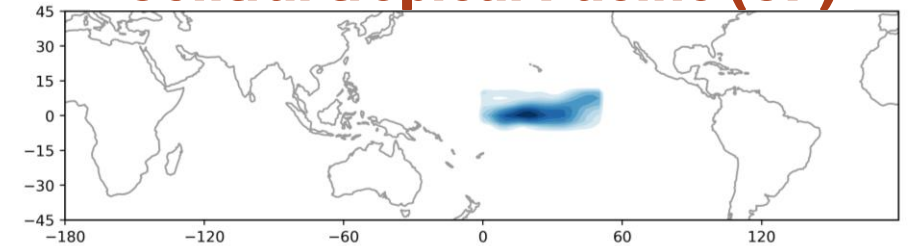
Transition JJA(0)
Diabatic heating anomalies @ 400hPa



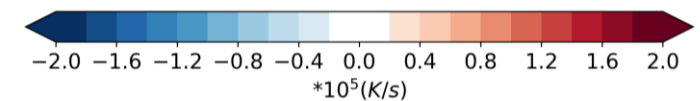
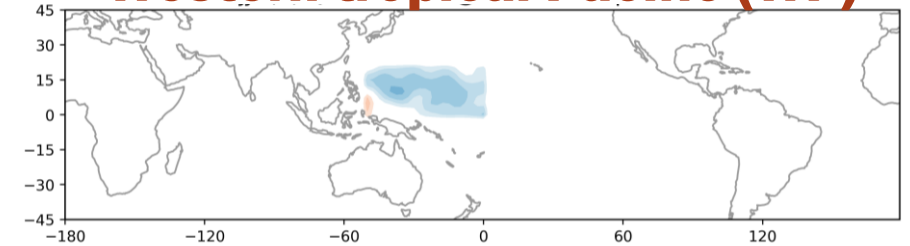
Western & Central tropical Pacific (WP+CP)



Central tropical Pacific (CP)



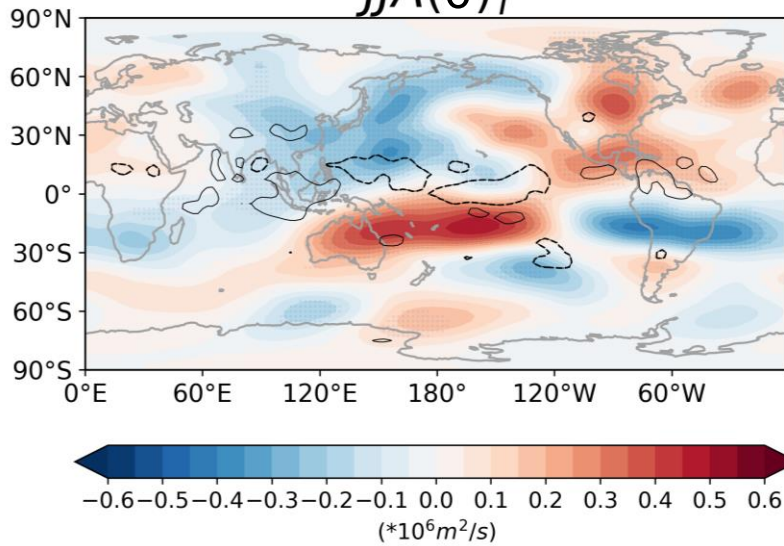
Western tropical Pacific (WP)



The contributions from anomalous diabatic cooling over the WP & CP dominate the teleconnection patterns.

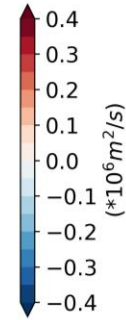
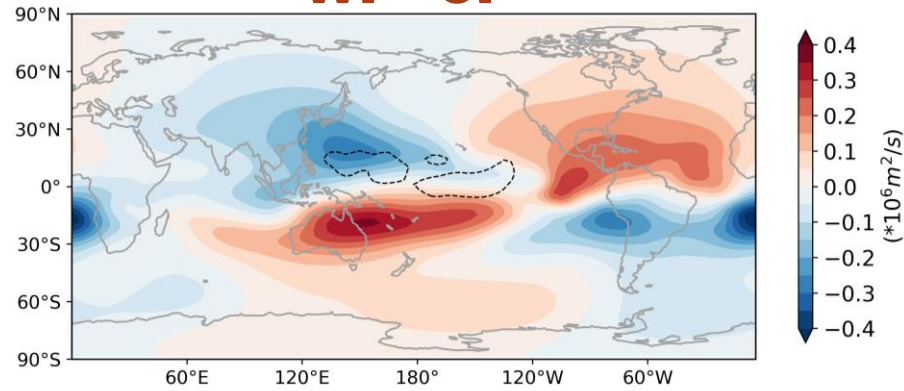
Observation

JJA(0)_T



Model

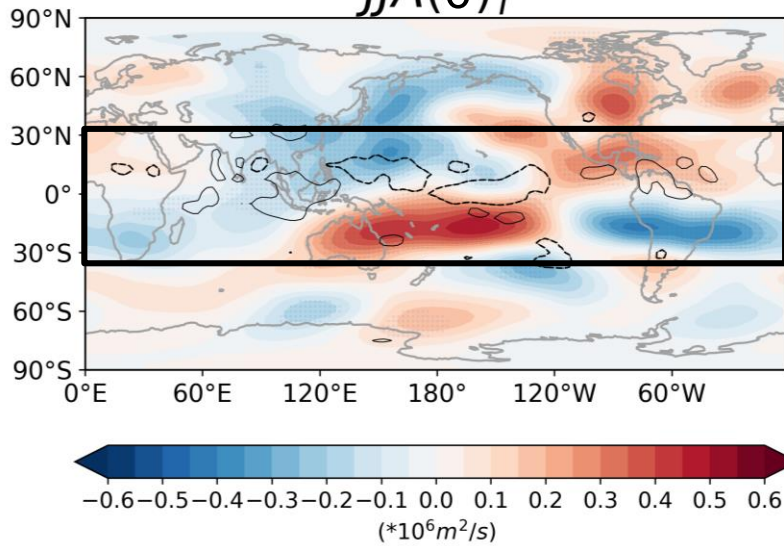
WP+CP



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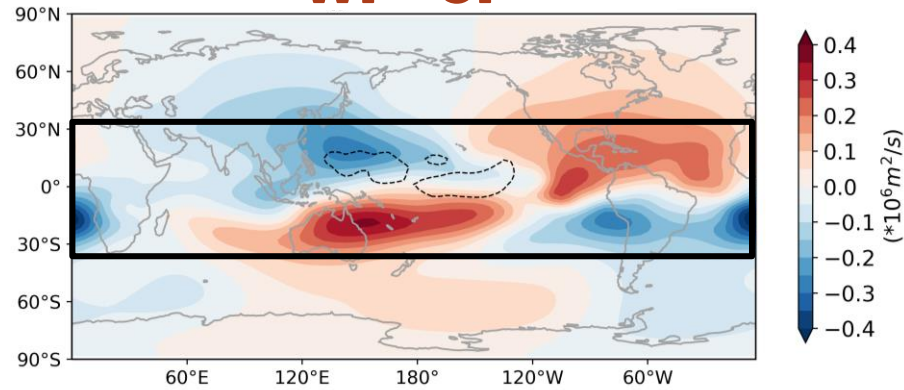
Observation

JJA(0)_T



Model

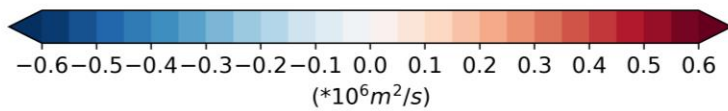
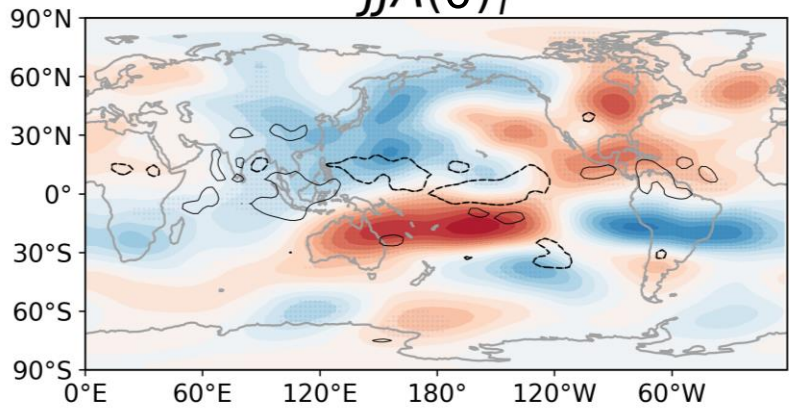
WP+CP



The anomalous diabatic cooling over the WP does modulate the teleconnection patterns during the transition summer

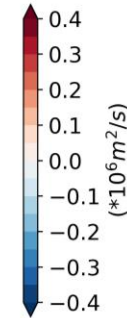
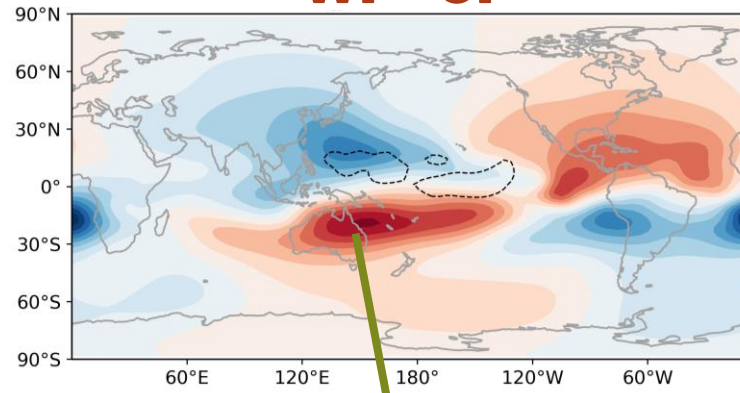
Observation

JJA(0)_T

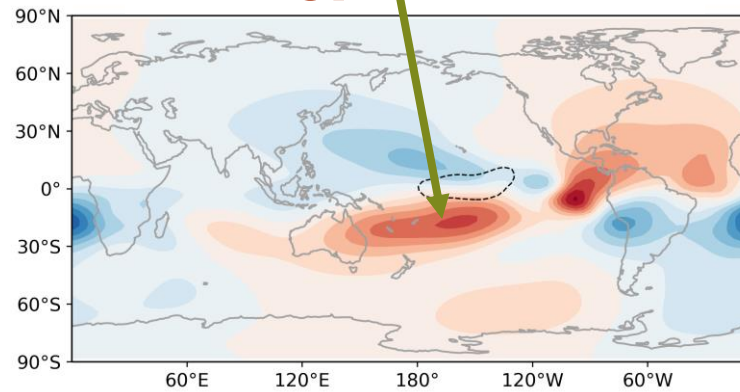


Model

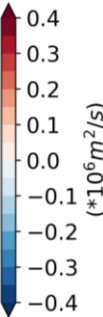
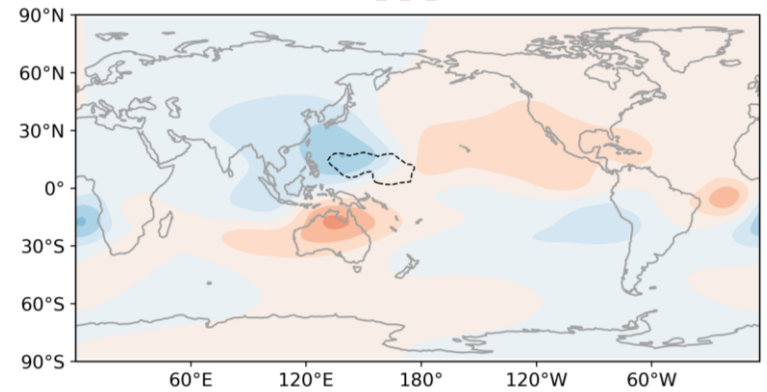
WP+CP



CP

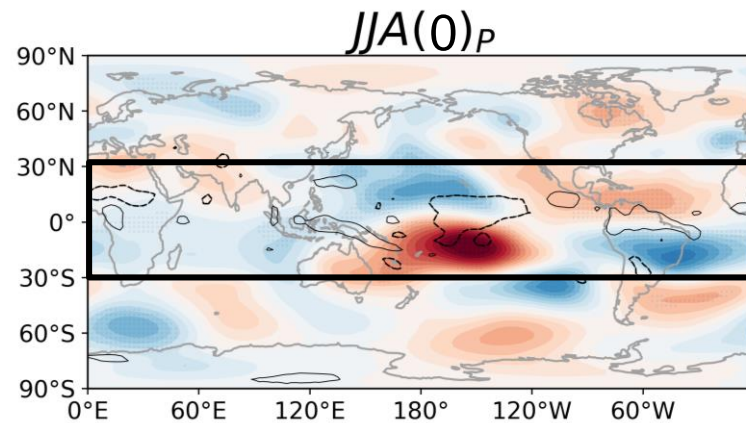
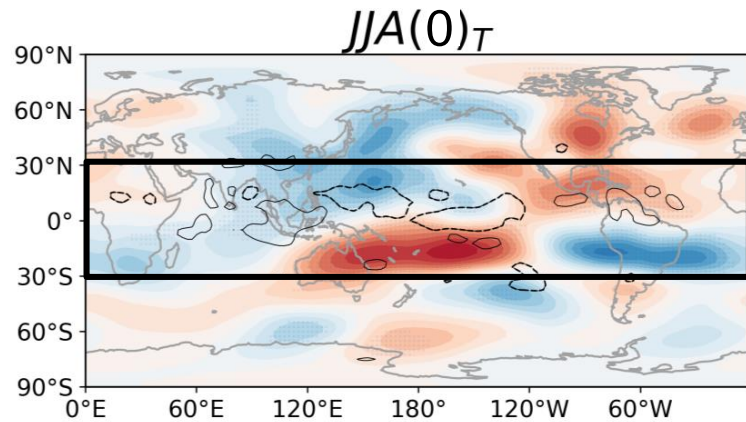


WP

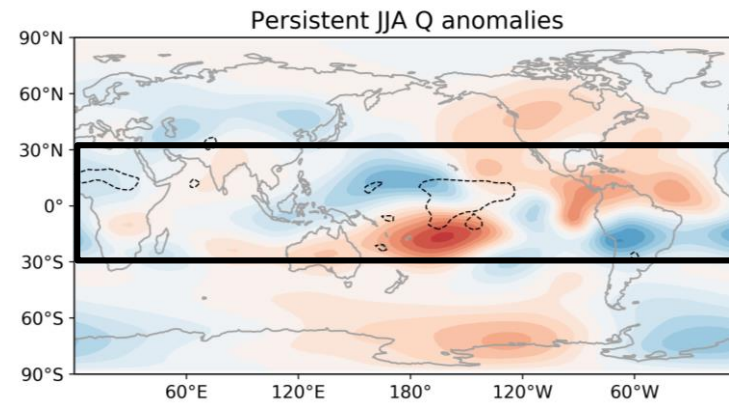
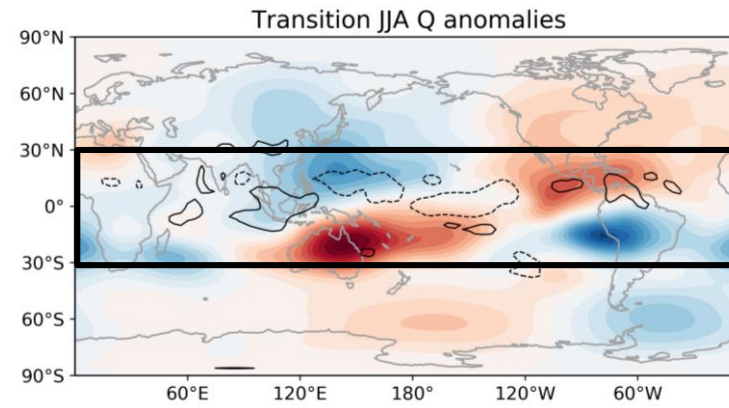


The anomalous diabatic cooling over the WP does play a role in distinguishing the transition and persistent summers

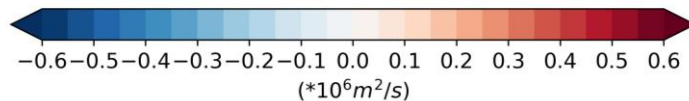
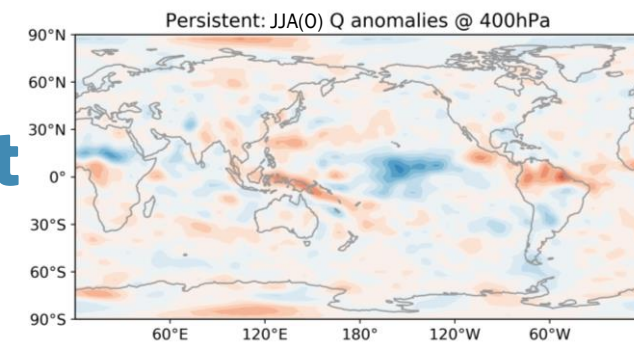
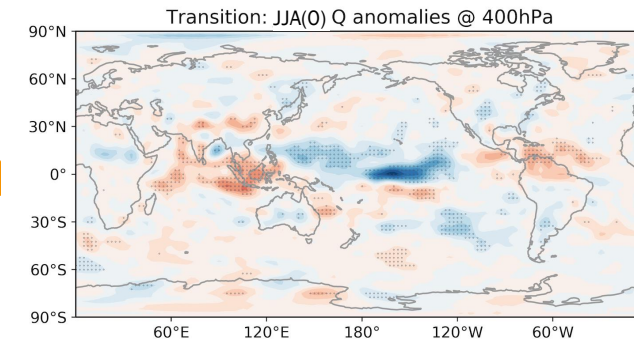
Observation



Model



Diabatic heating



Transition

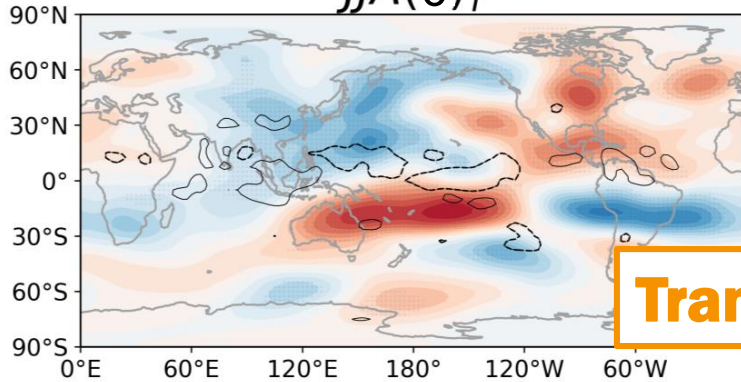
Persistent

Shaded: 200hPa streamline function anomalies

The anomalous diabatic cooling over the WP does play a role in distinguishing the transition and persistent summers

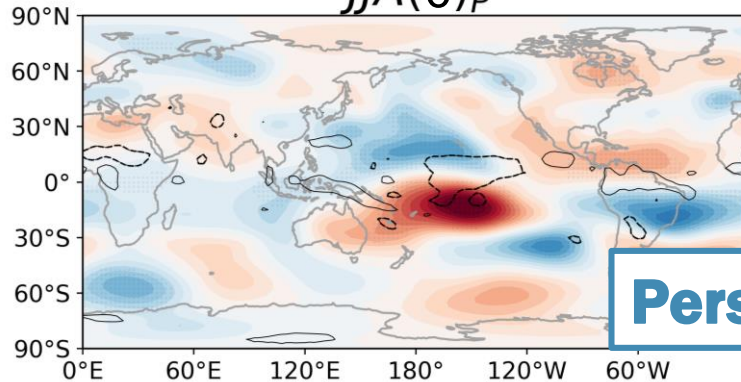
Observation

JJA(0)_T



Transition

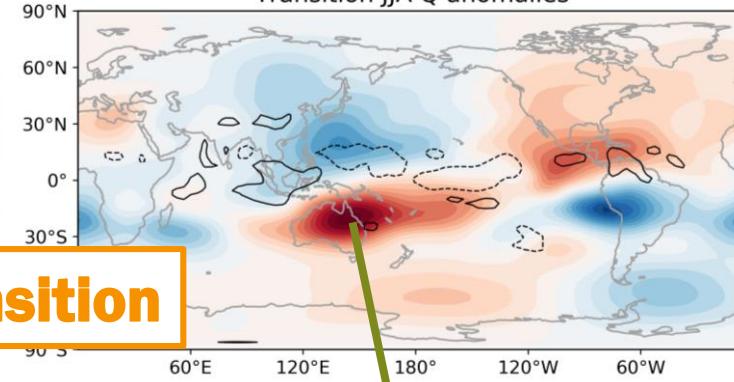
JJA(0)_P



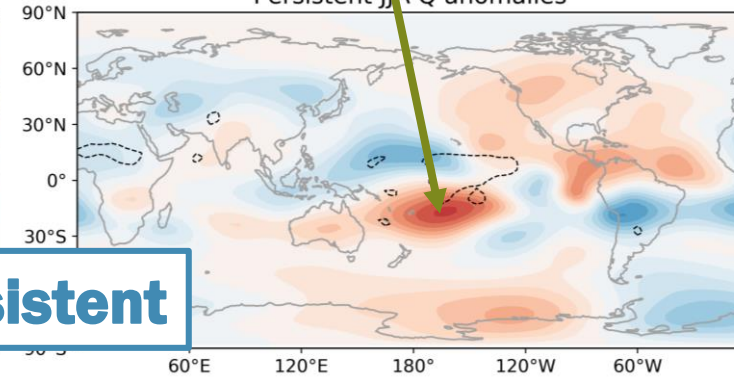
Persistent

Model

Transition JJA Q anomalies

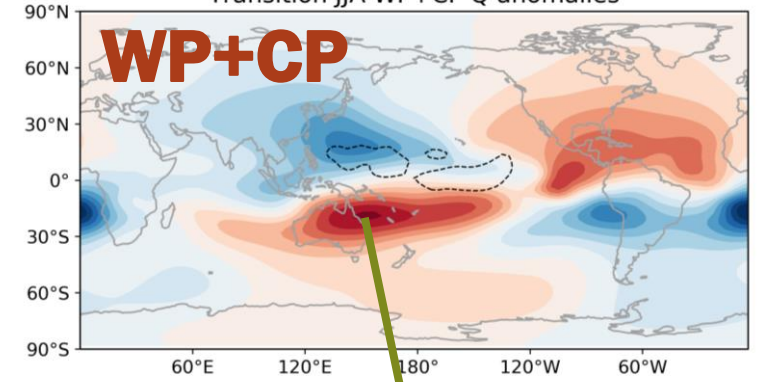


Persistent JJA Q anomalies



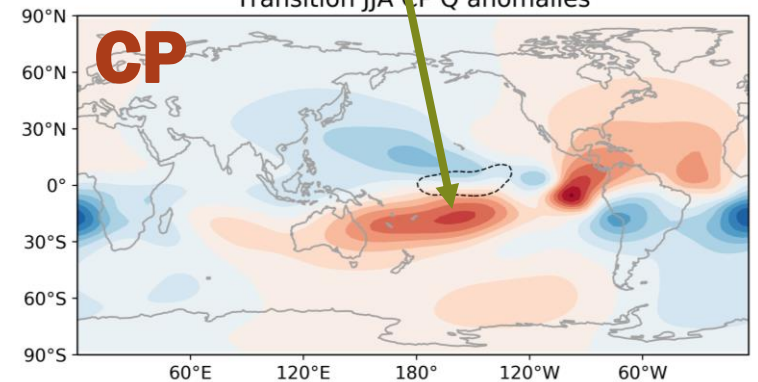
Transition Summer Q

Transition JJA WP+CP Q anomalies

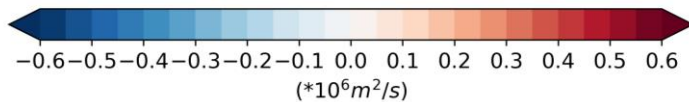


WP+CP

Transition JJA CP Q anomalies



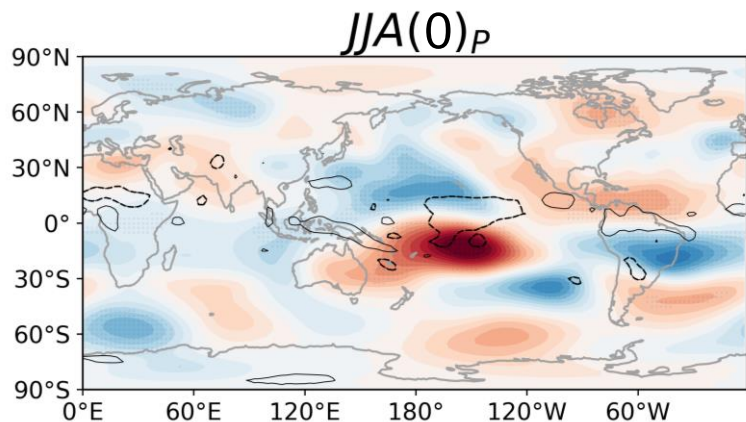
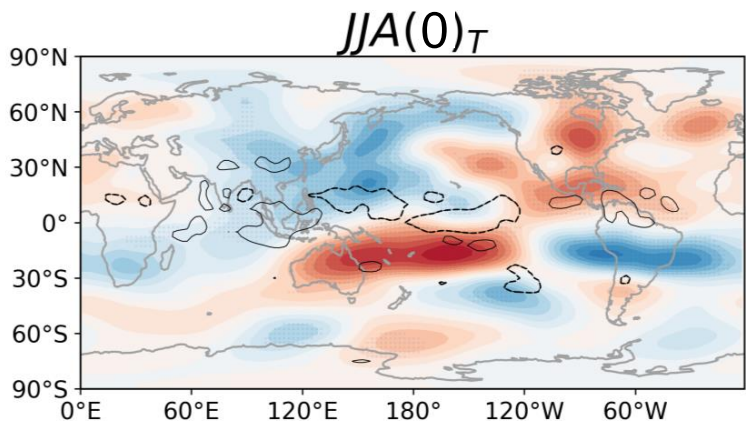
CP



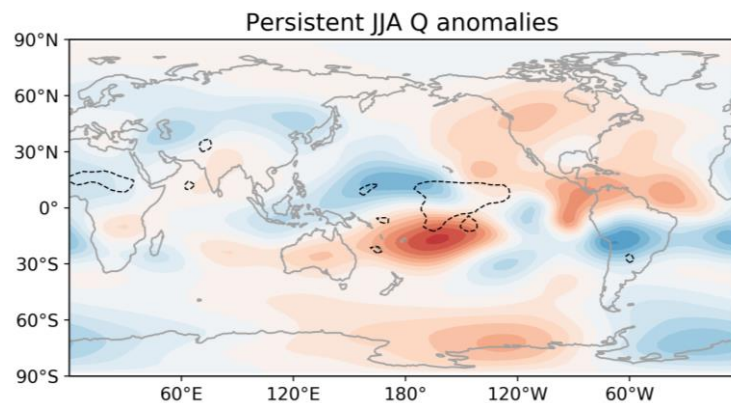
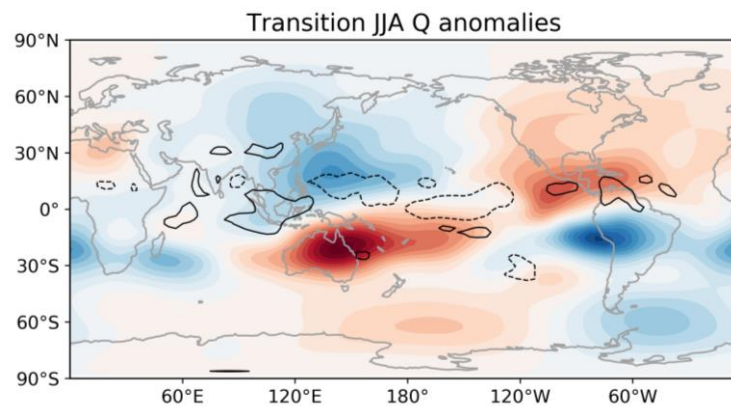
Shaded: 200hPa streamline function anomalies

Over North America, the anomalous circulations are alike if only diabatic heating prescribed

Observation

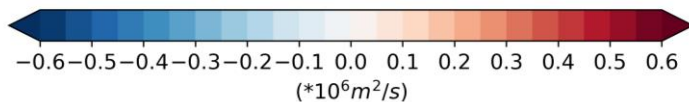


Forcing: Q



Transition

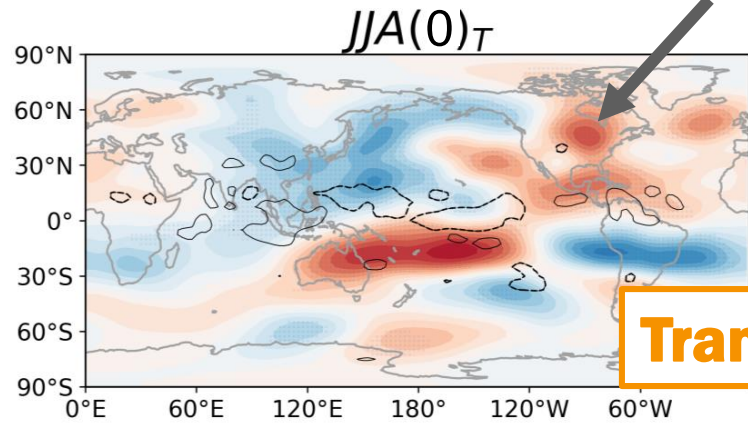
Persistent



Shaded: 200hPa streamline function anomalies

Transient eddies shape the teleconnections pattern over extratropical North America

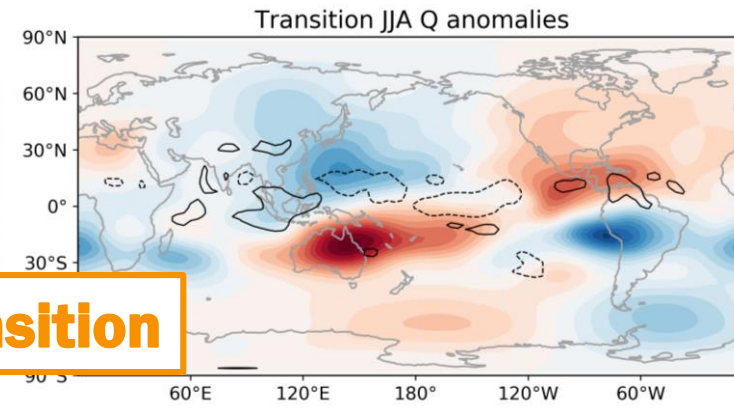
Observation



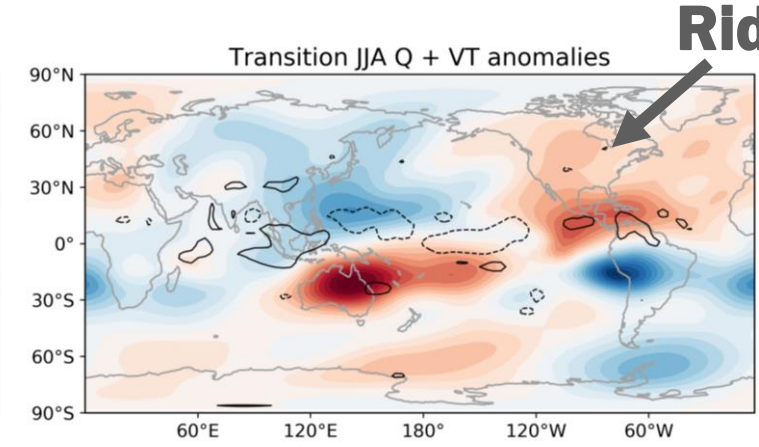
Ridge

Transition

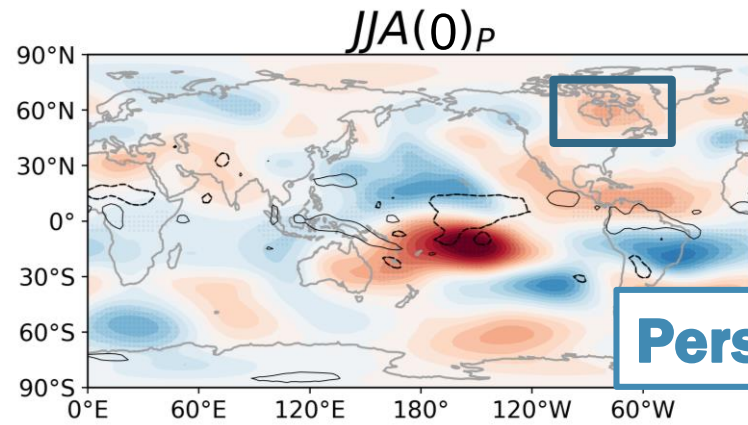
Forcing: Q



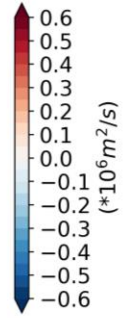
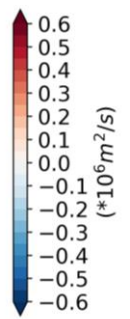
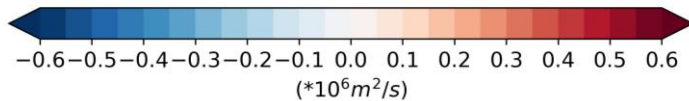
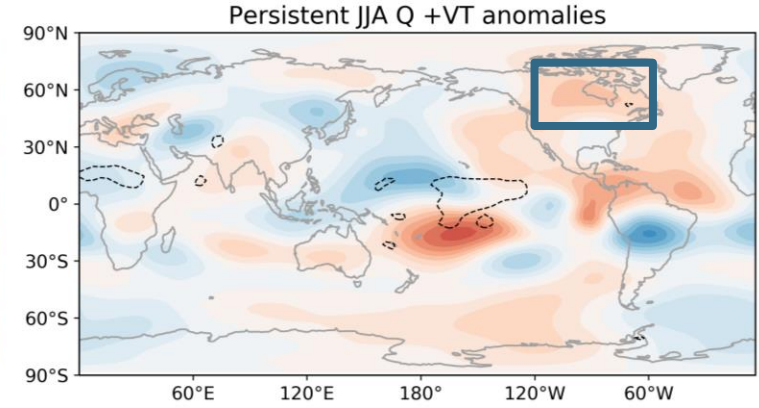
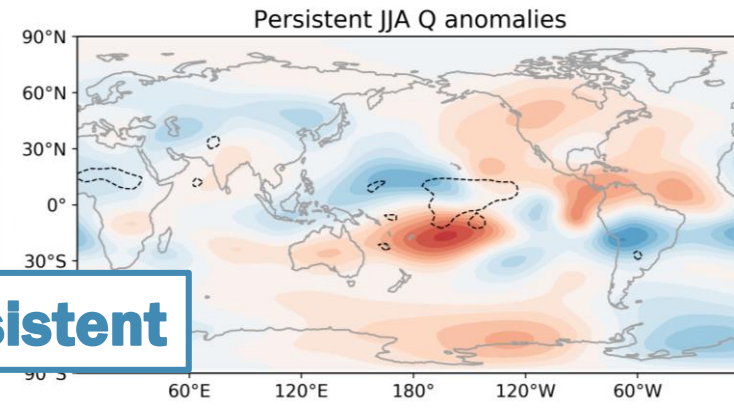
Forcing: Q + Transient eddies



Ridge



Persistent



Shaded: 200hPa streamline function anomalies

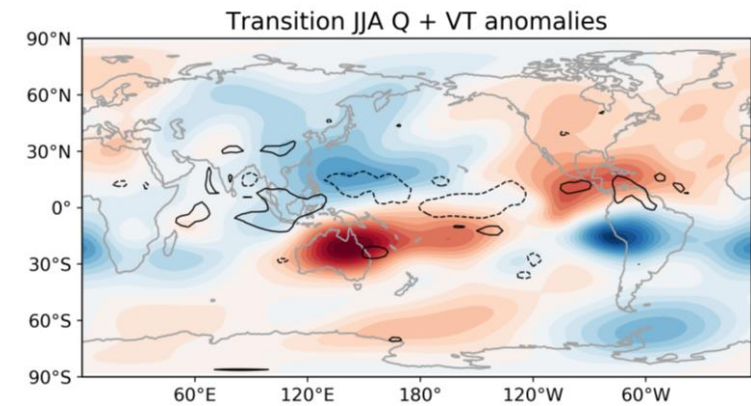
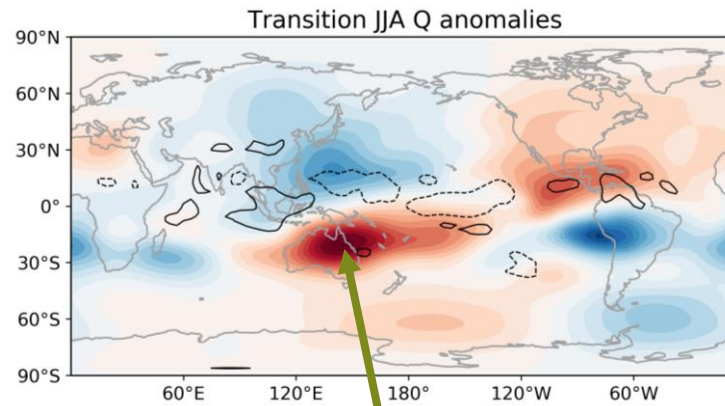
WP diabatic cooling: shift the teleconnections pattern

Transient eddies: shape the teleconnections over the extratropics

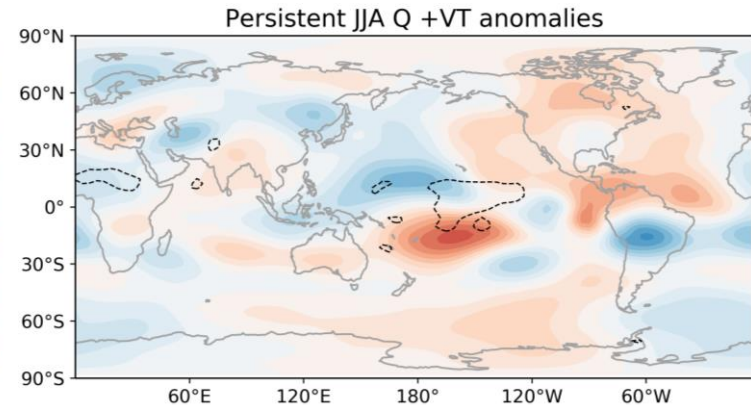
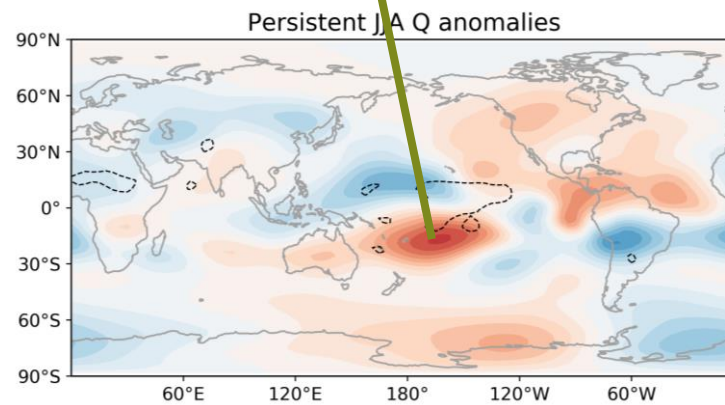
Forcing: Q

Forcing: Q + Transient eddies

Transition



Persistent



Shaded: 200hPa streamline function anomalies

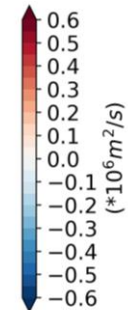
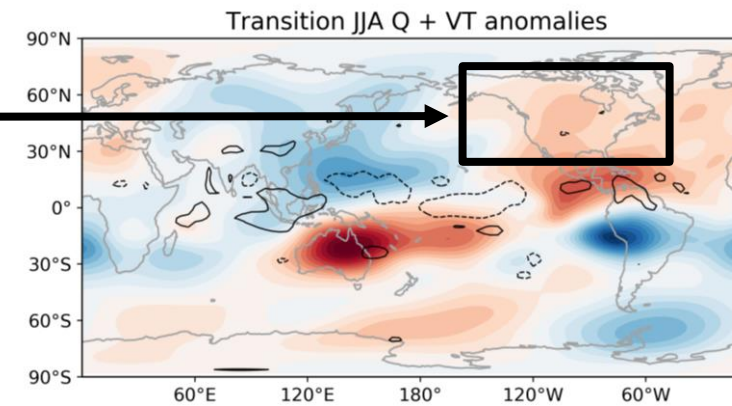
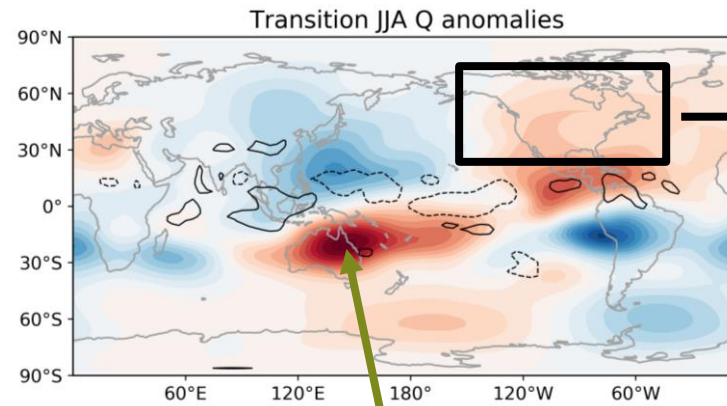
WP diabatic cooling: shift the teleconnections pattern

Transient eddies: shape the teleconnections over the extratropics

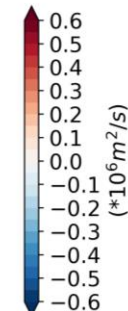
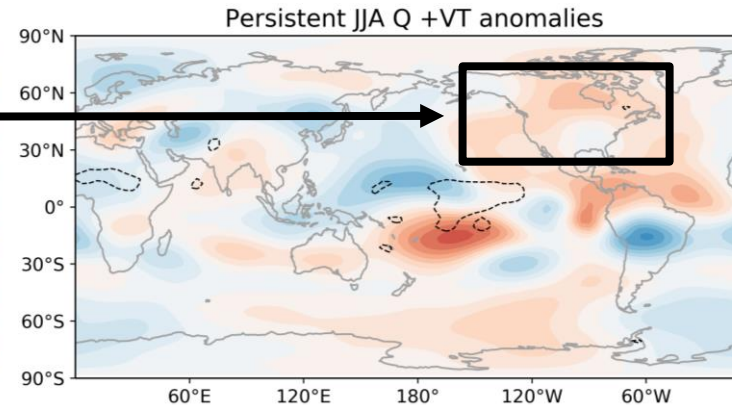
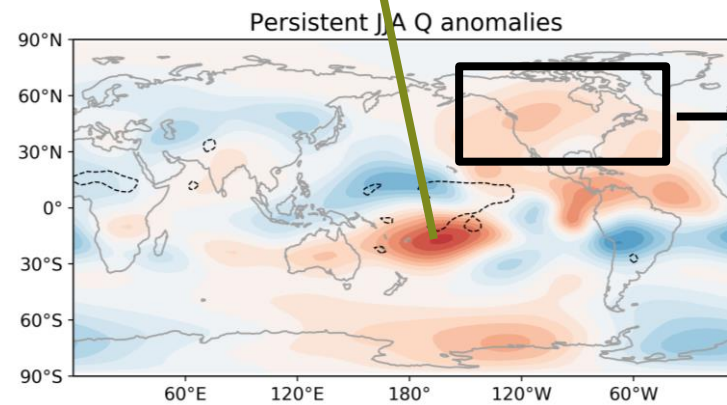
Forcing: Q

Forcing: Q + Transient eddies

Transition



Persistent



Shaded: 200hPa streamline function anomalies

WP diabatic cooling: shift the teleconnections pattern

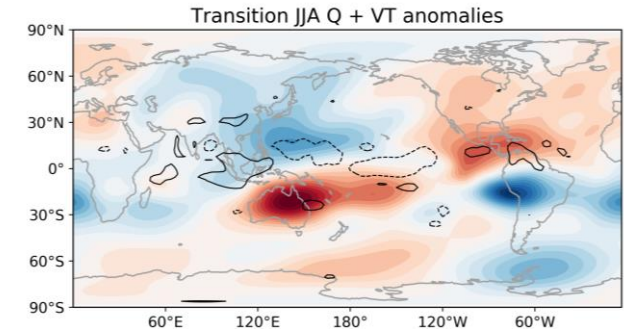
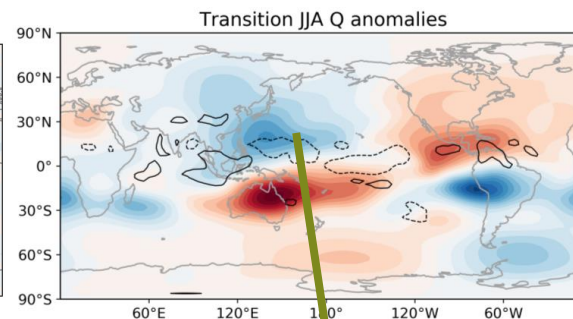
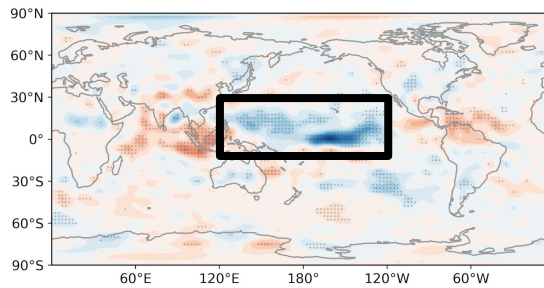
Transient eddies: shape the teleconnections over the extratropics

Diabatic heating

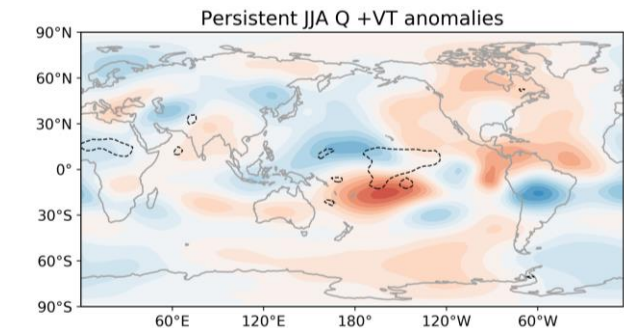
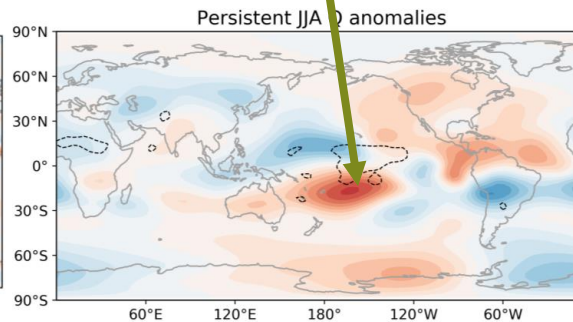
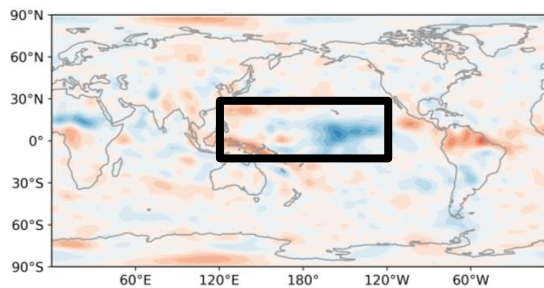
Forcing: Q

Forcing: Q + Transient eddies

Transition



Persistent



Different tropical forcing



Different anomalous circulation



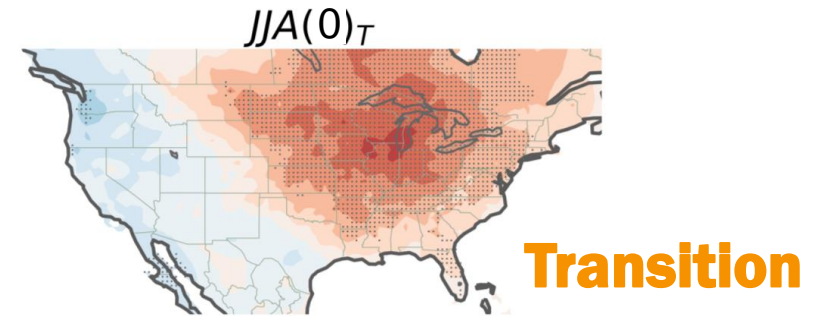
Different transient eddies response



Different feedback to teleconnections

La Niña summer teleconnections in North America

- Robust warm anomalies over the Midwest during transition summer (El Niño -> La Niña)



- During transition summer, two suppressed deep convections:
 - central tropical Pacific (developing La Niña)
 - western tropical Pacific (decaying El Niño)

➡ **Rossby waves from both forcings**

- According to SWM experiments,
 - Diabatic cooling over WP: shift the teleconnections
 - Transient eddies: shape the details of teleconnections over the extratropics

