

Using the Onset Dynamics to Understand ENSO Complexity

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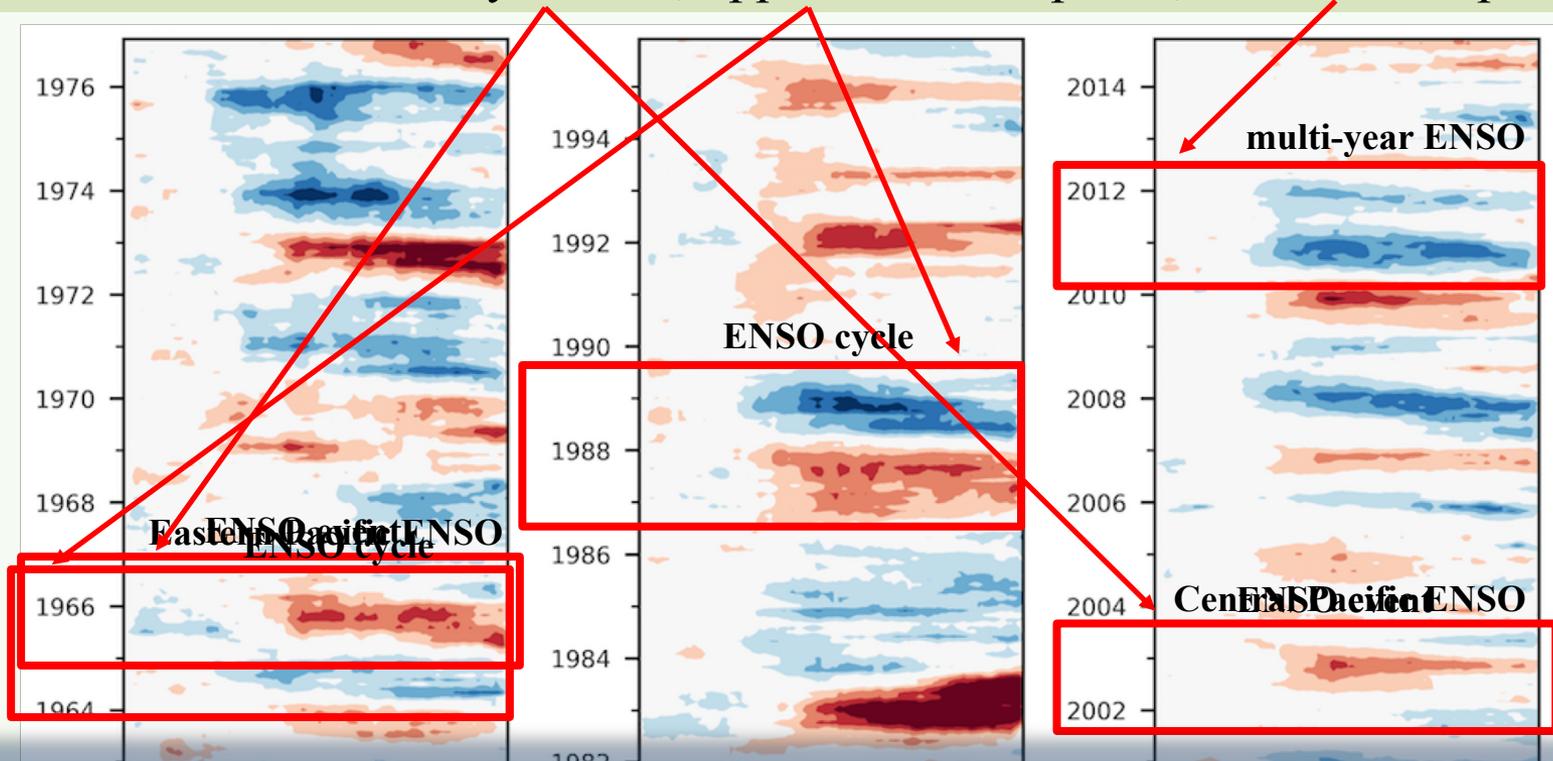
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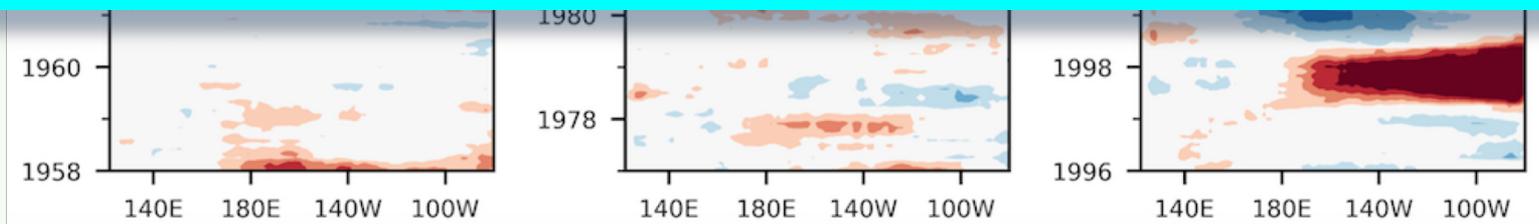
ENSO Complexity

Type: Eastern Pacific (EP) ENSO vs. Central Pacific (CP) ENSO

Transition: followed by neutral, opposite ENSO phase, same ENSO phase



What controls the ENSO complexity?



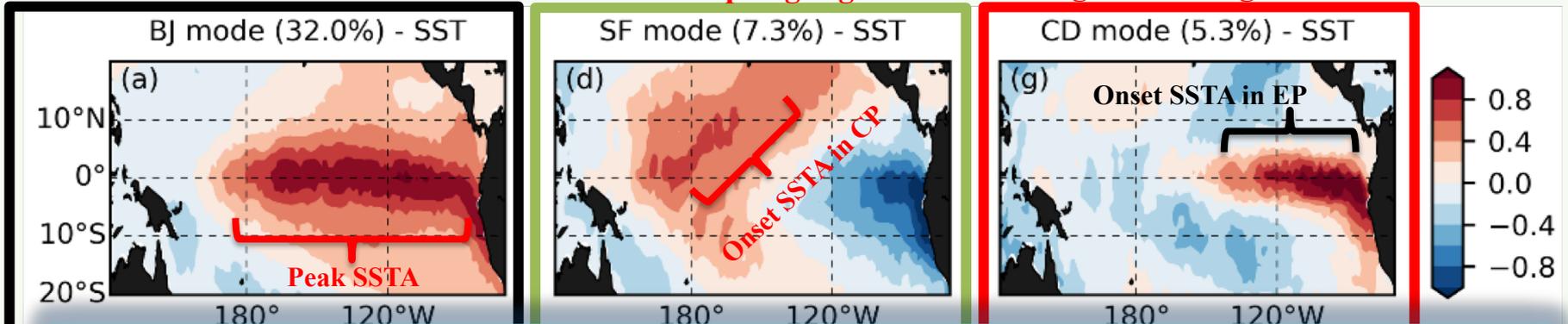
Key Coupling Processes in ENSO Evolution

(MEOF analysis to combined interannual anomalies of SST, SSH, and sfc. Winds)
(1958-2014)

Bjerknes Process

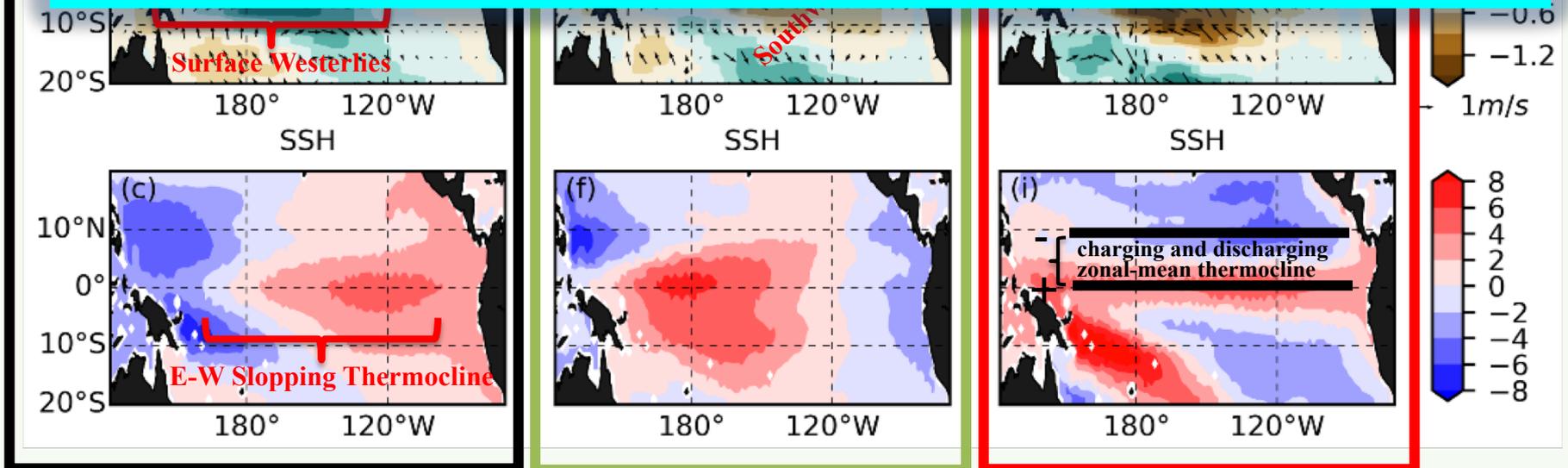
Seasonal Footprinting Process

Charged-Discharged Process



ENSO Complexity =

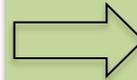
**Two onset mechanisms (CD vs. SF mechanisms)
+ One development mechanism (BJ Mechanism)**



The Complexity in ENSO Transition

ENSO Cycle:

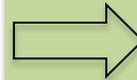
La Nina



El Nino

ENSO Event:

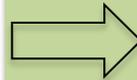
La Nina



neutral

Multi-year ENSO:

La Nina



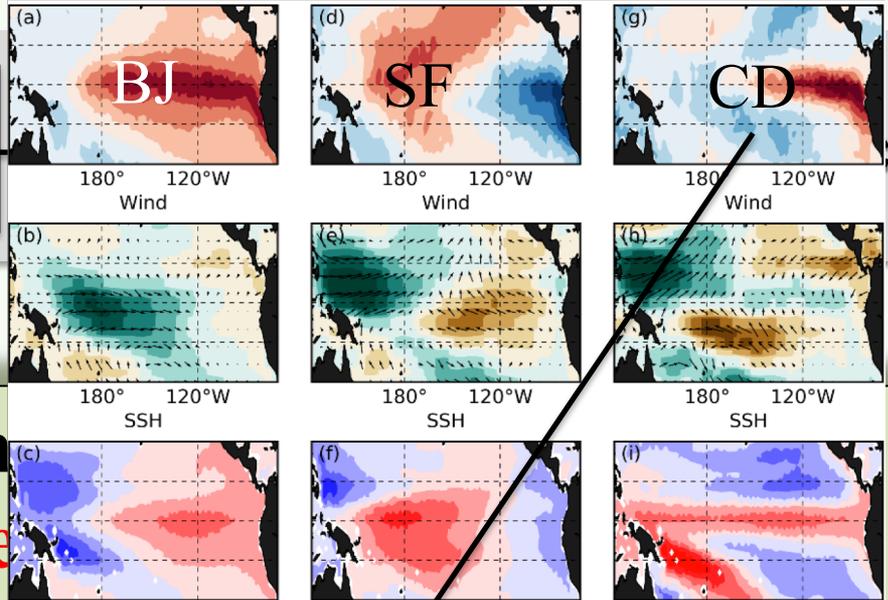
La Nina



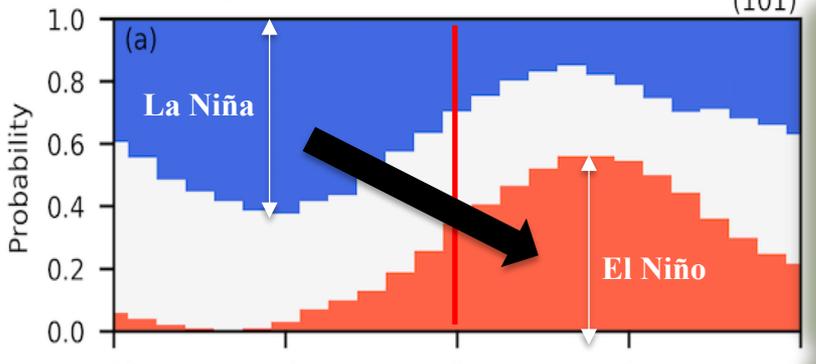
Charged-discharged (CD) mechanism
Seasonal footprinting (SF) mechanism

ENSO Evolution / associated with the CD Mechanism

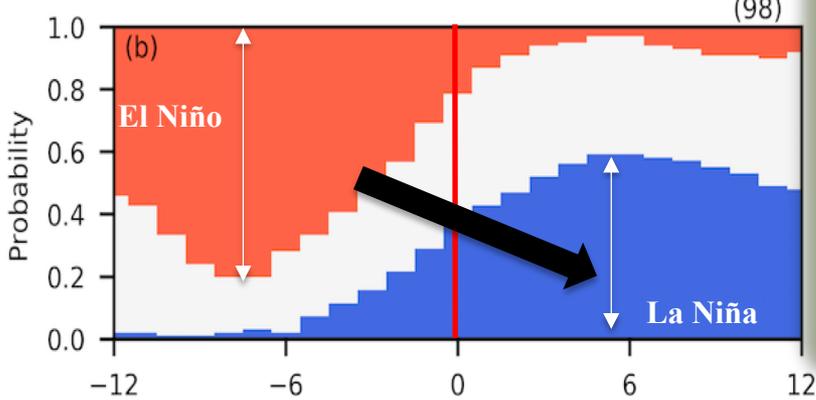
(composites from strong CD events)



Strong **Positive** CD-onset Events (101)



Strong **Negative** CD-onset Events (98)



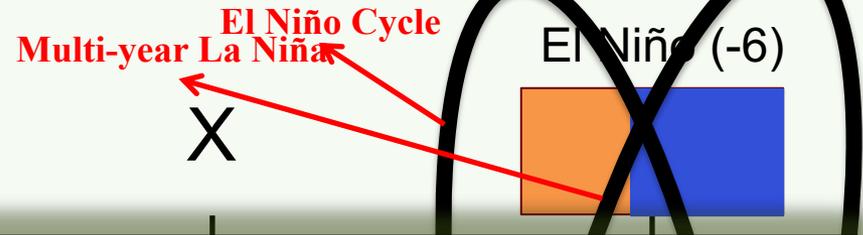
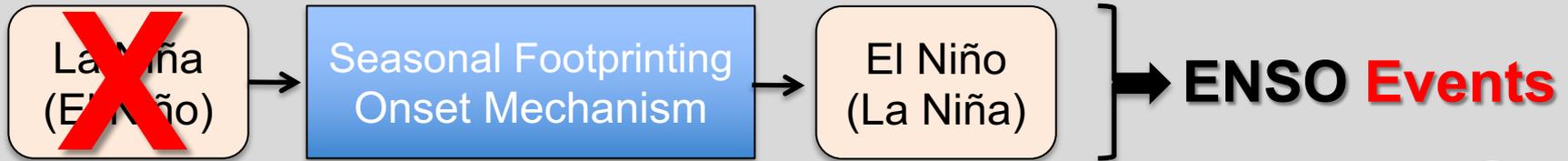
The **mechanism** does not explain the ENSO complexity.

The **charged-discharged PC mechanism** does not contribute much to El Niño-La Niña asymmetry.

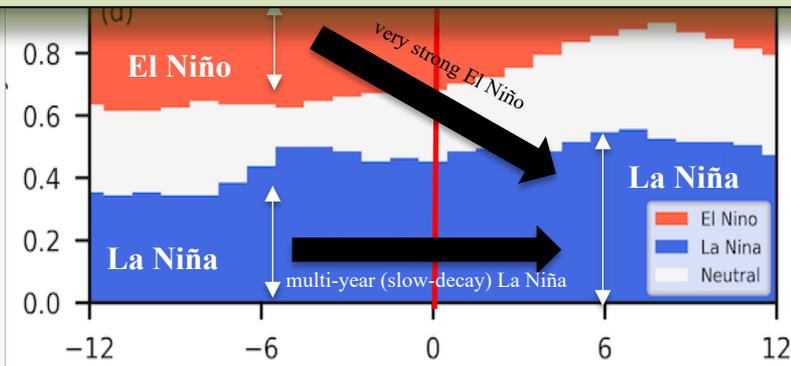
ENSO Evolution / associated with the SF Mechanism

(composites from strong SF events)

(Yu and Kim 2011)

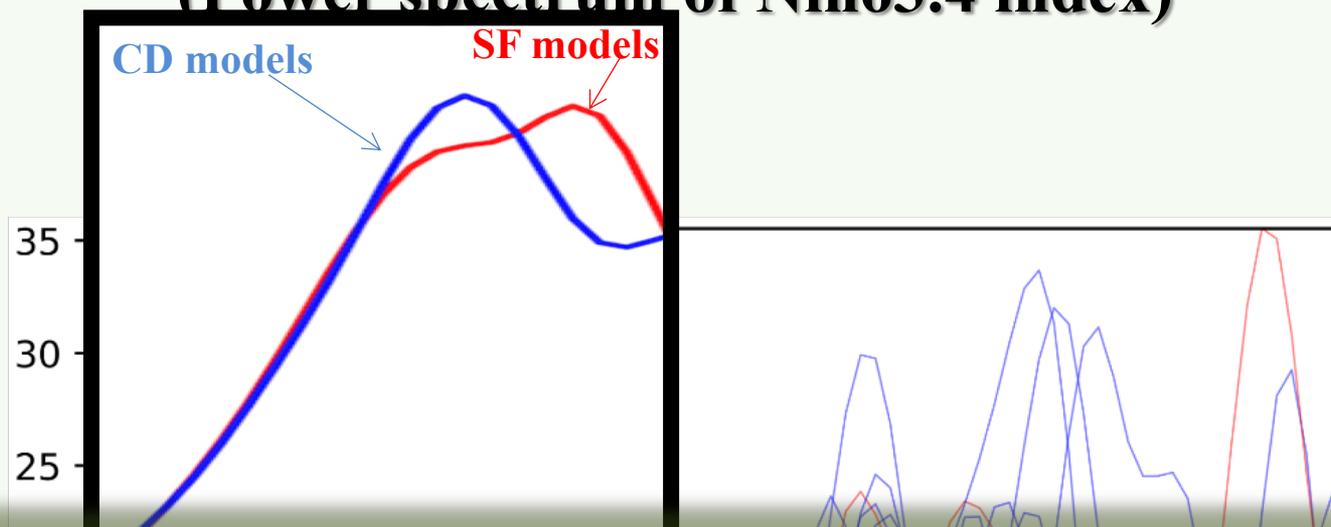


The **seasonal footprinting mechanism** is a key source for complexity in ENSO transition and El Niño-La Niña asymmetry.



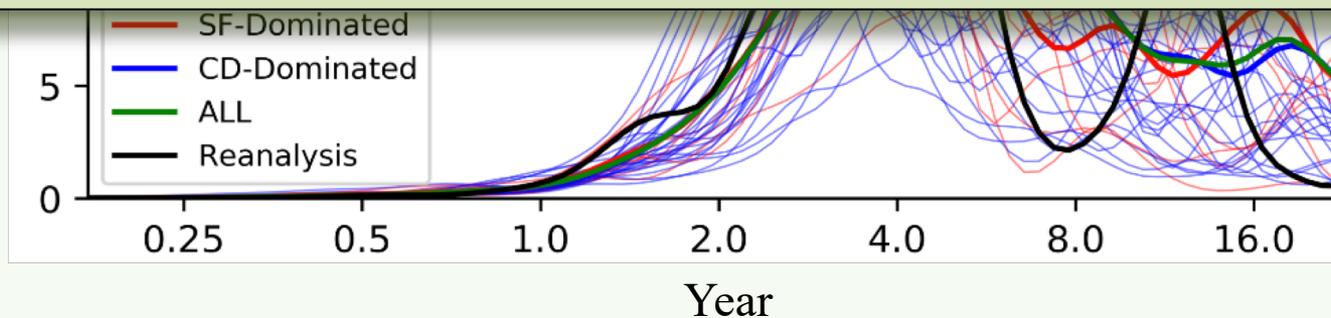
ENSO Periodicity in 34 CMIP5 Models

(Power spectrum of Nino3.4 index)

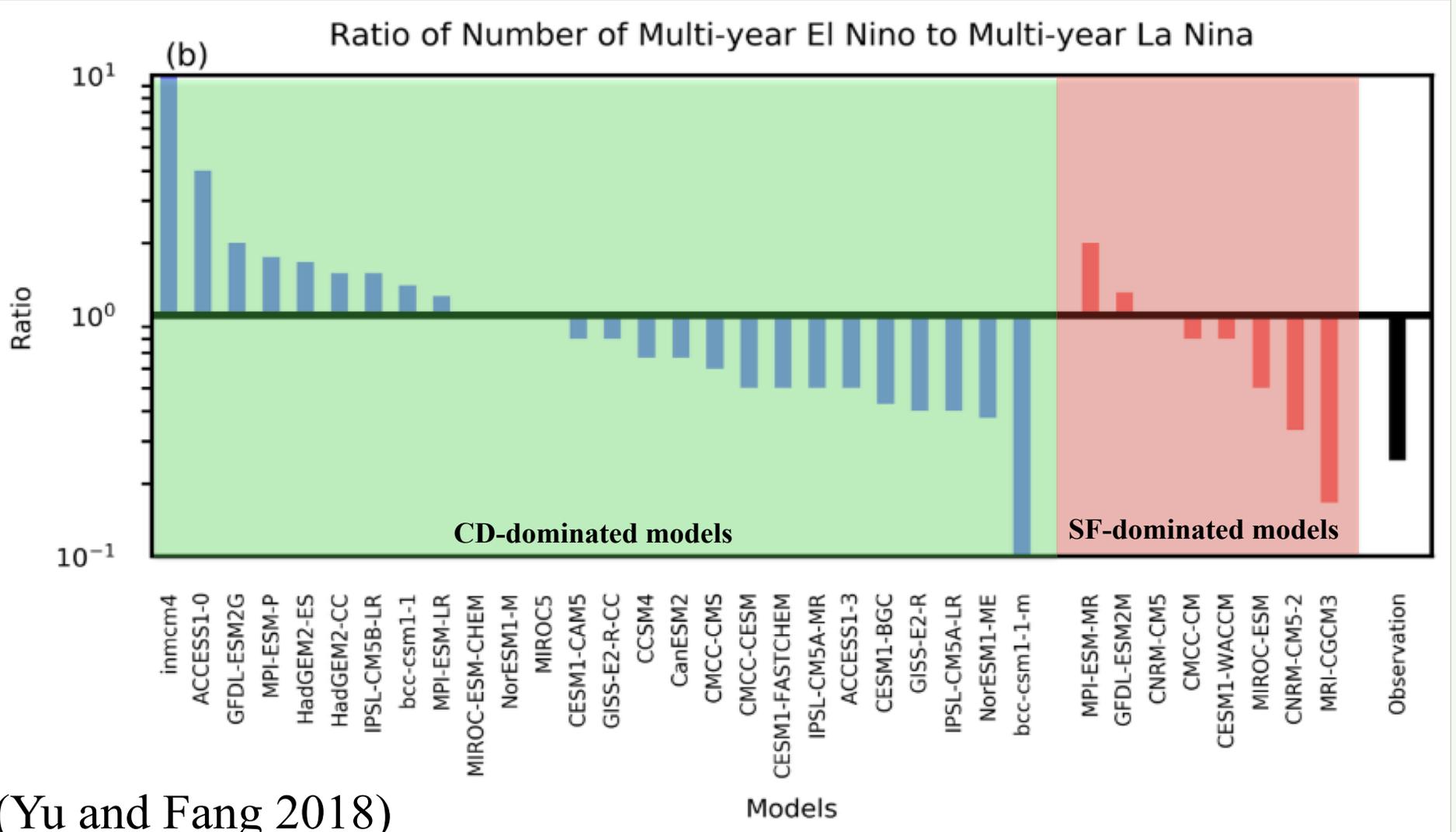


CMIP5 models overestimate CD mechanism but underestimate SF mechanism

→ Model ENSO becomes too regular.



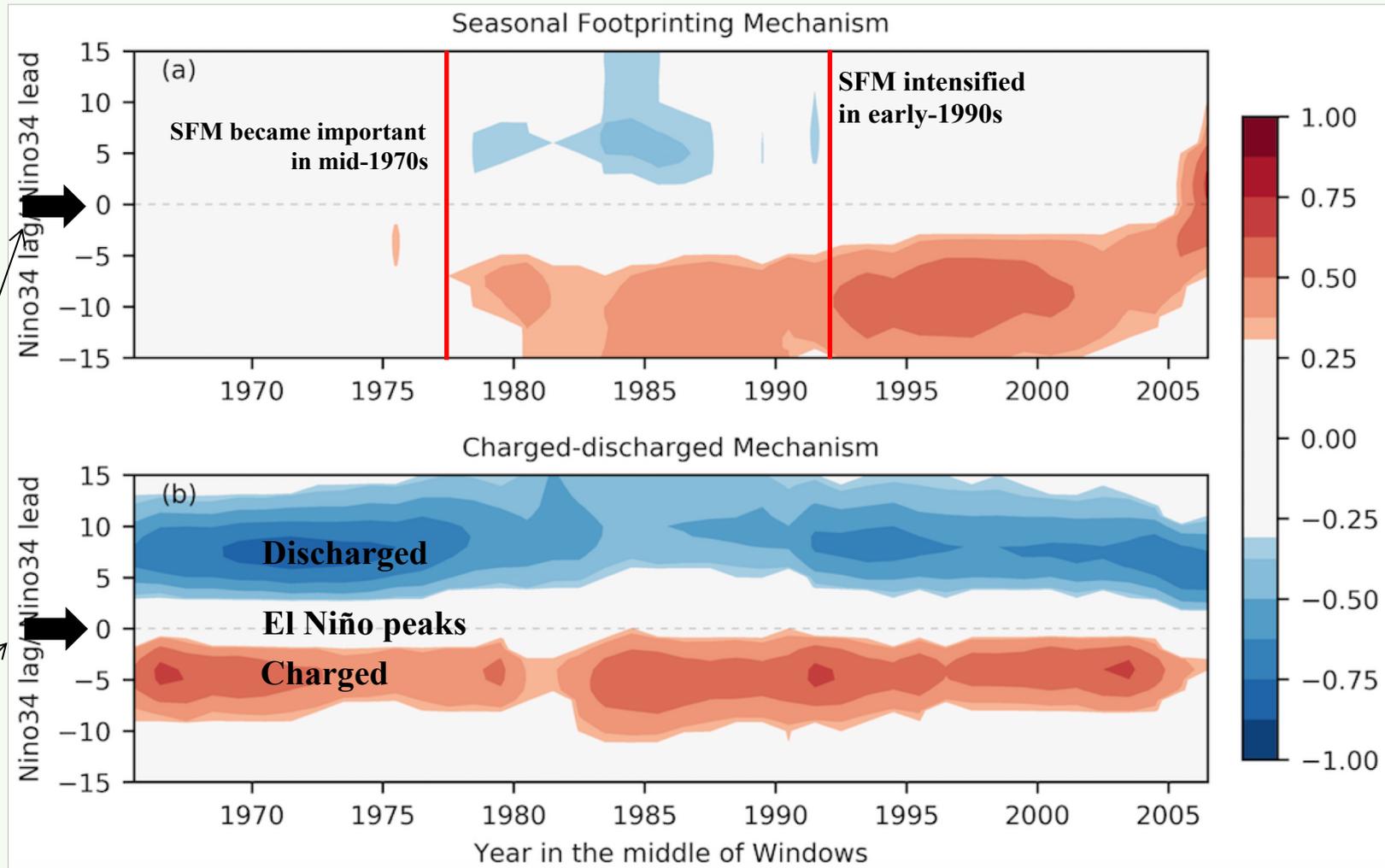
El Niño-La Niña Asymmetry / 34 CMIP5 Models



(Yu and Fang 2018)

Decadal Variability of the Onset Mechanisms

(15-year running correlation with Niño3.4)

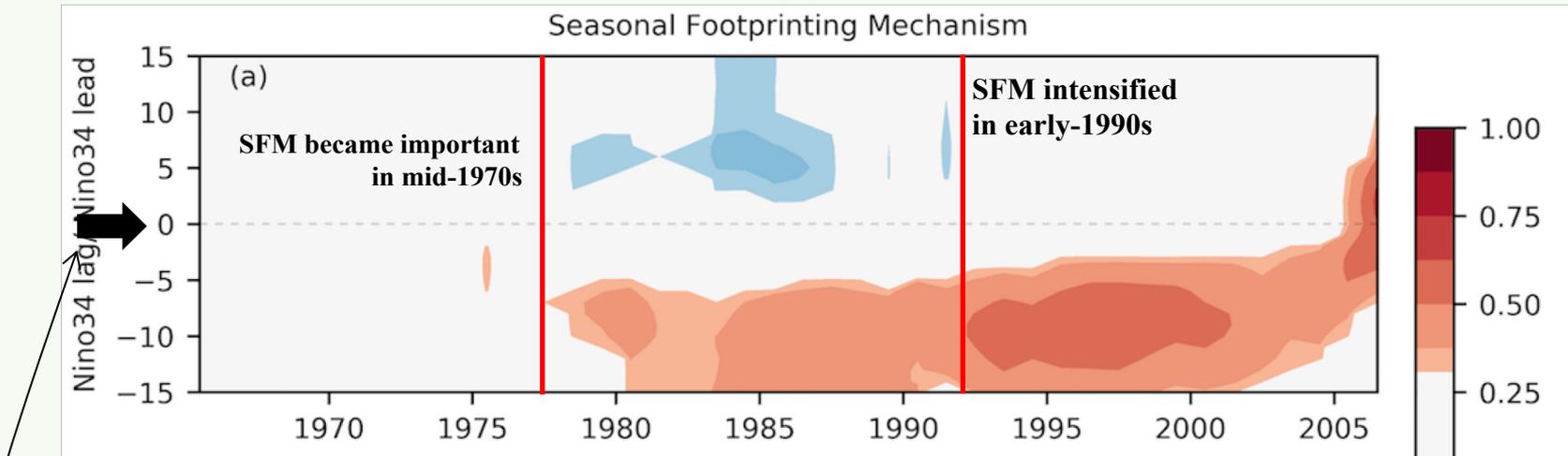


Peak phase of Niño3.4

(Yu and Fang 2018)

Decadal Variability of the Onset Mechanisms

(15-year running correlation with Niño3.4)

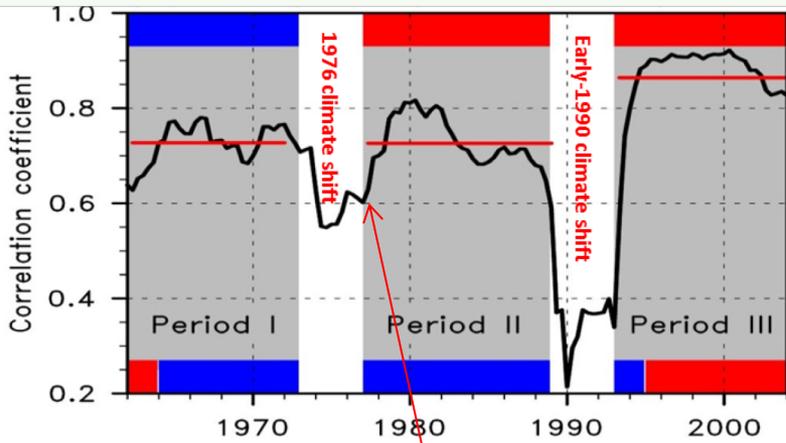


- The SF mechanism has intensified in recent 2-3 decades.
- The ENSO behaviors have become more complex in recent decades.

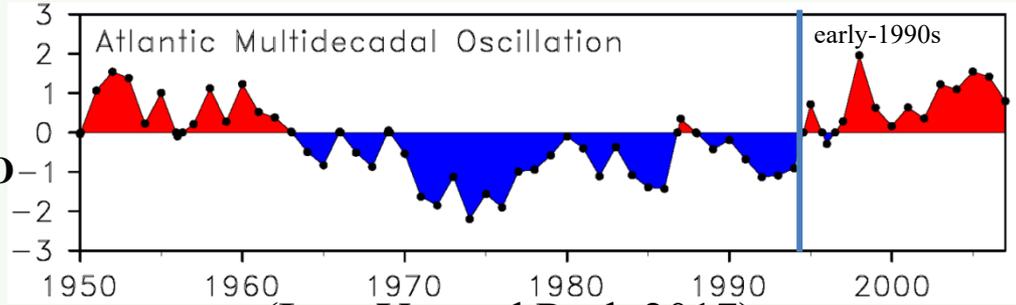
Atlantic-Pacific Interactions → ENSO Complexity

(Yu et al. 2015)

Correlation btw SST and Sfc Wind



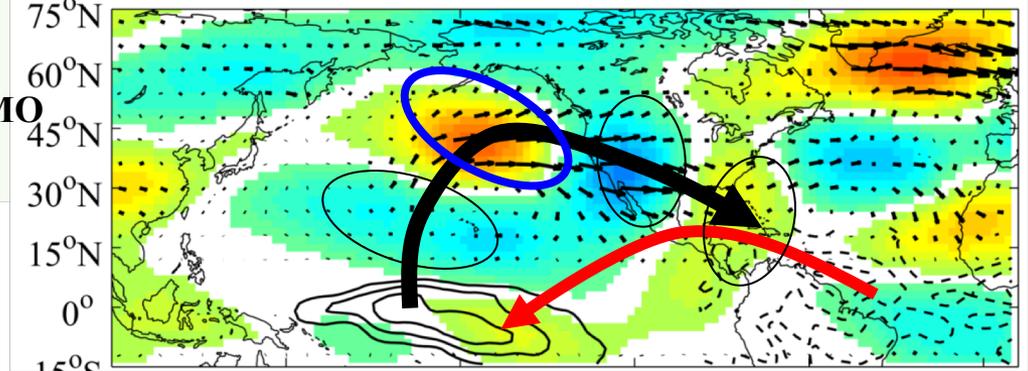
PDO



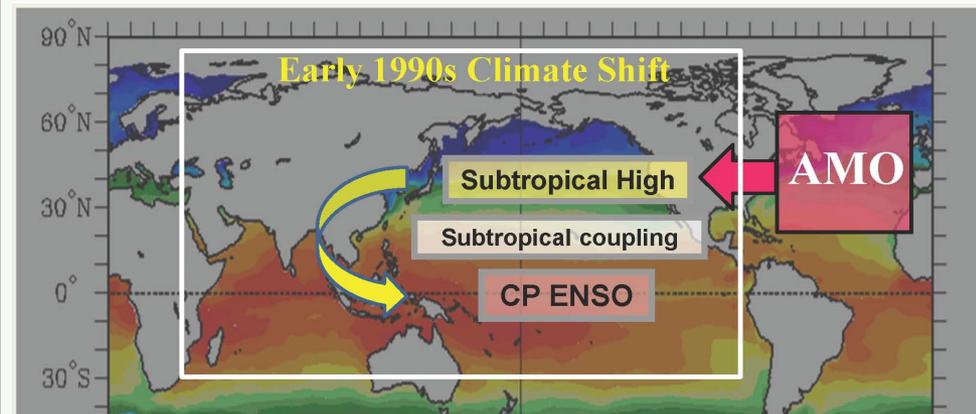
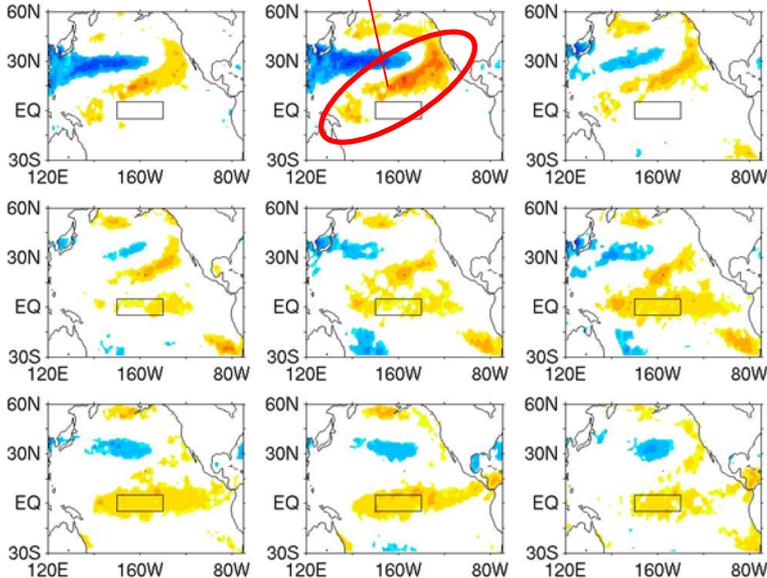
(Lyu, Yu, and Paek 2017)

(Post-1993 mean state) minus (Pre-1993 mean state)

AMO

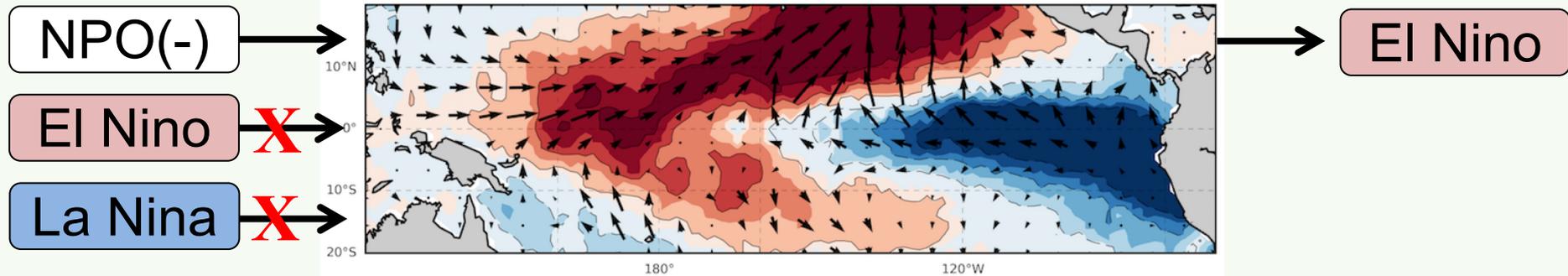


SSTA of CP ENSO

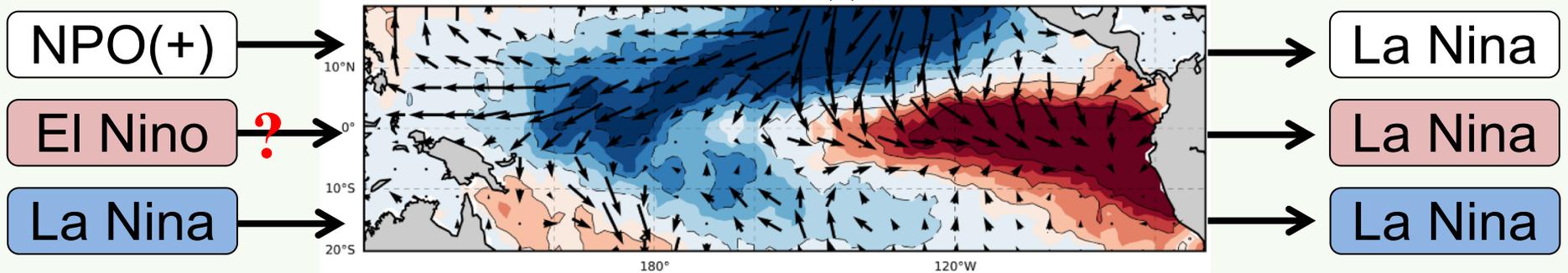


Why are SFM(+) and SFM (-) Asymmetric?

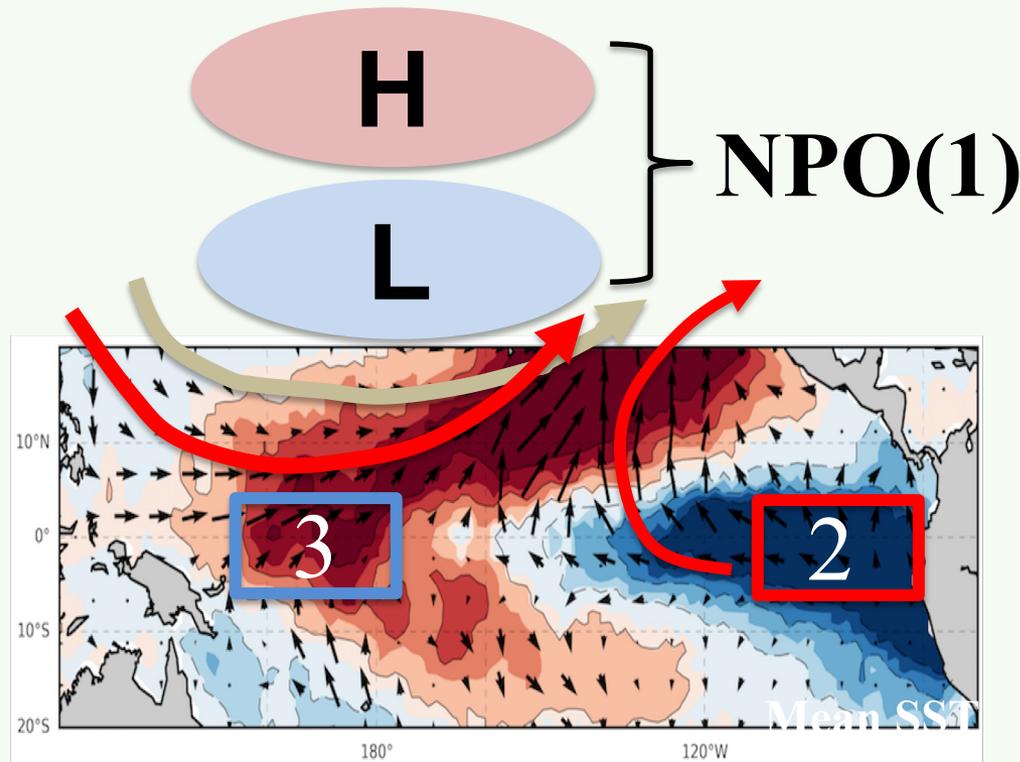
SFM (+)



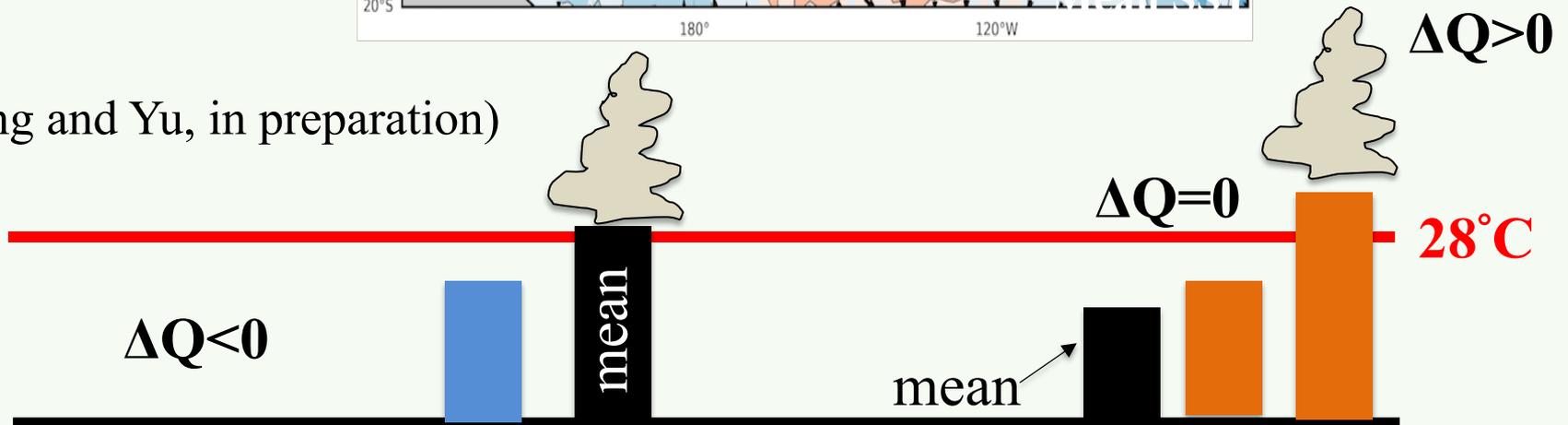
SFM (-)



The Forcing Mechanisms for PMM (SFM)



(Fang and Yu, in preparation)



Summary

- ❑ The seasonal footprinting (SF) mechanism is a key source of ENSO complexity, while the charged-discharged mechanism acts to reduce ENSO complexity.
- ❑ The intensification of the SF mechanism since the early 1990s may have increased the ENSO complexity in recent decades.
- ❑ The asymmetry of the SF mechanism between its positive and negative phases is a key source of El Nino-La Nina asymmetry.
- ❑ The SFM asymmetry is controlled by the mean SST distribution in the tropical Pacific, which can vary in past and future climate.