North Pacific meridional mode has larger impacts on El Niño evolution than the March Madden-Julian Oscillation

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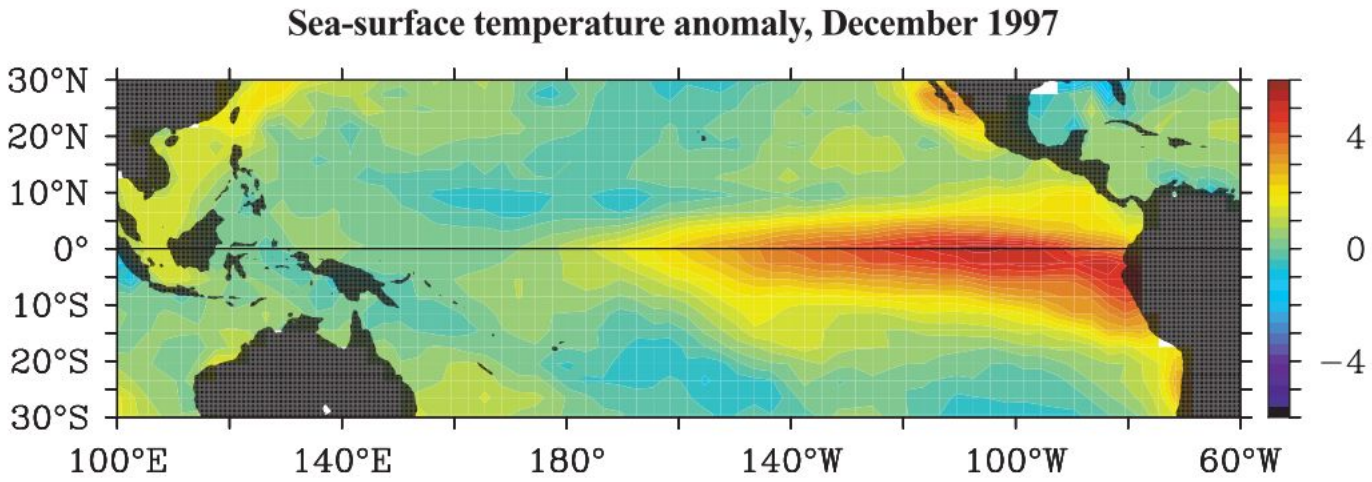
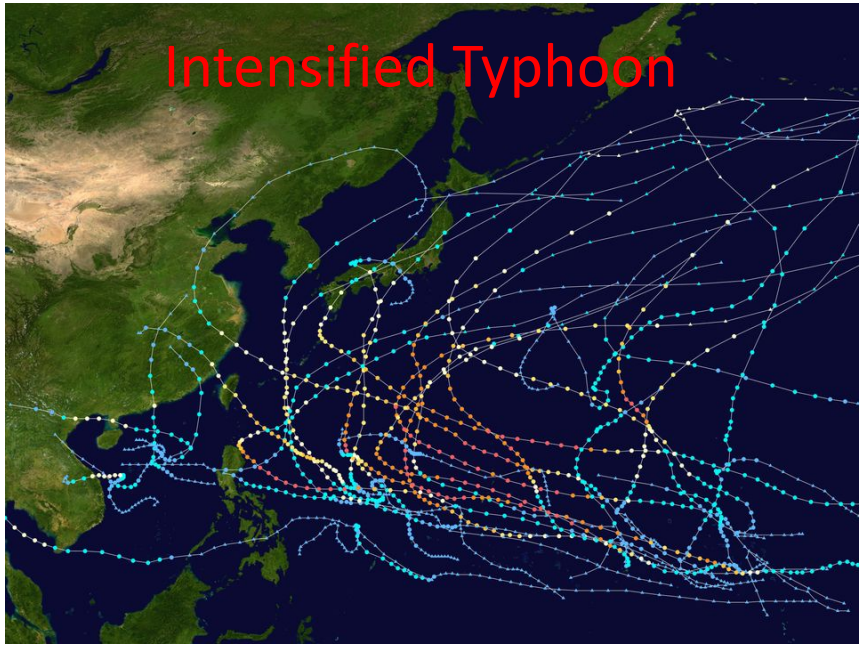
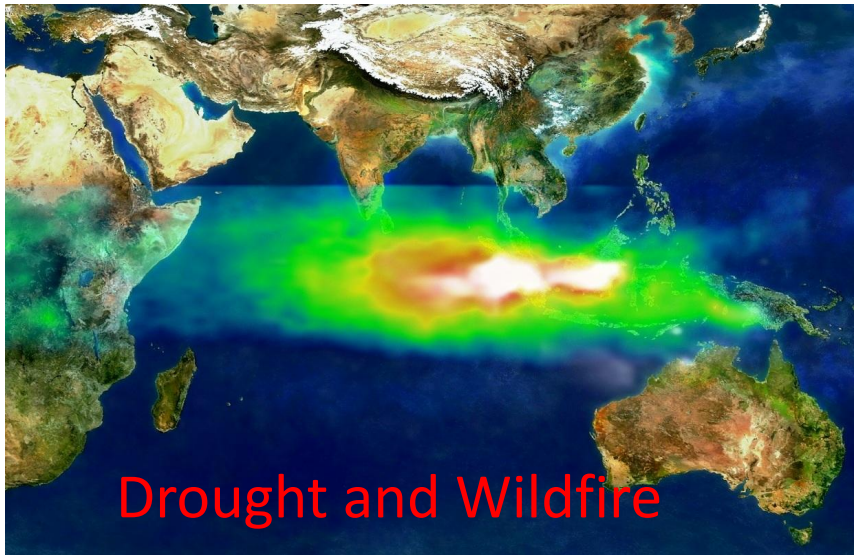
Extreme El Niño and its impacts



McPhaden (1999)

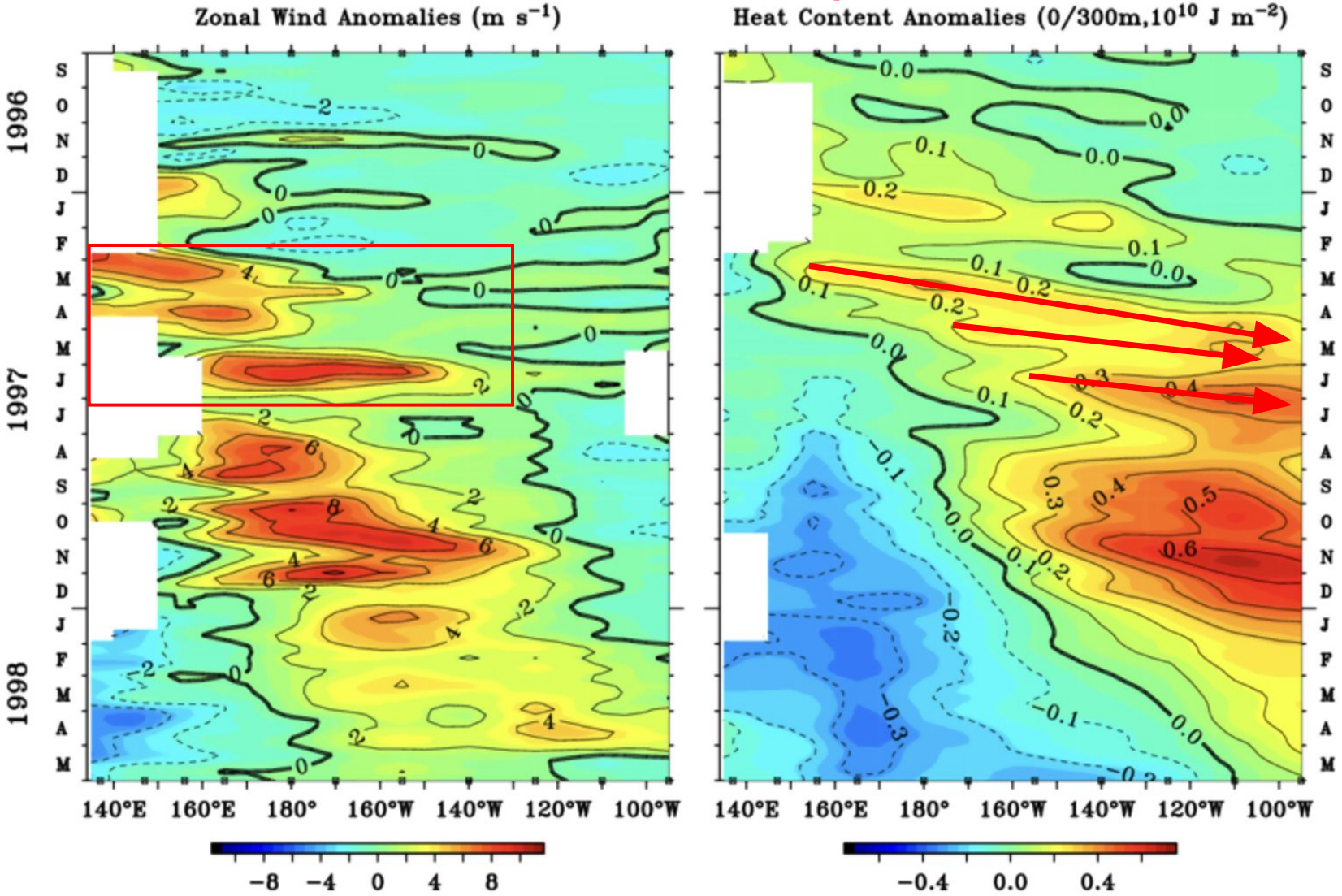




Source: Wikipedia

Early-season westerly wind bursts are suggested critical for extreme El Niño

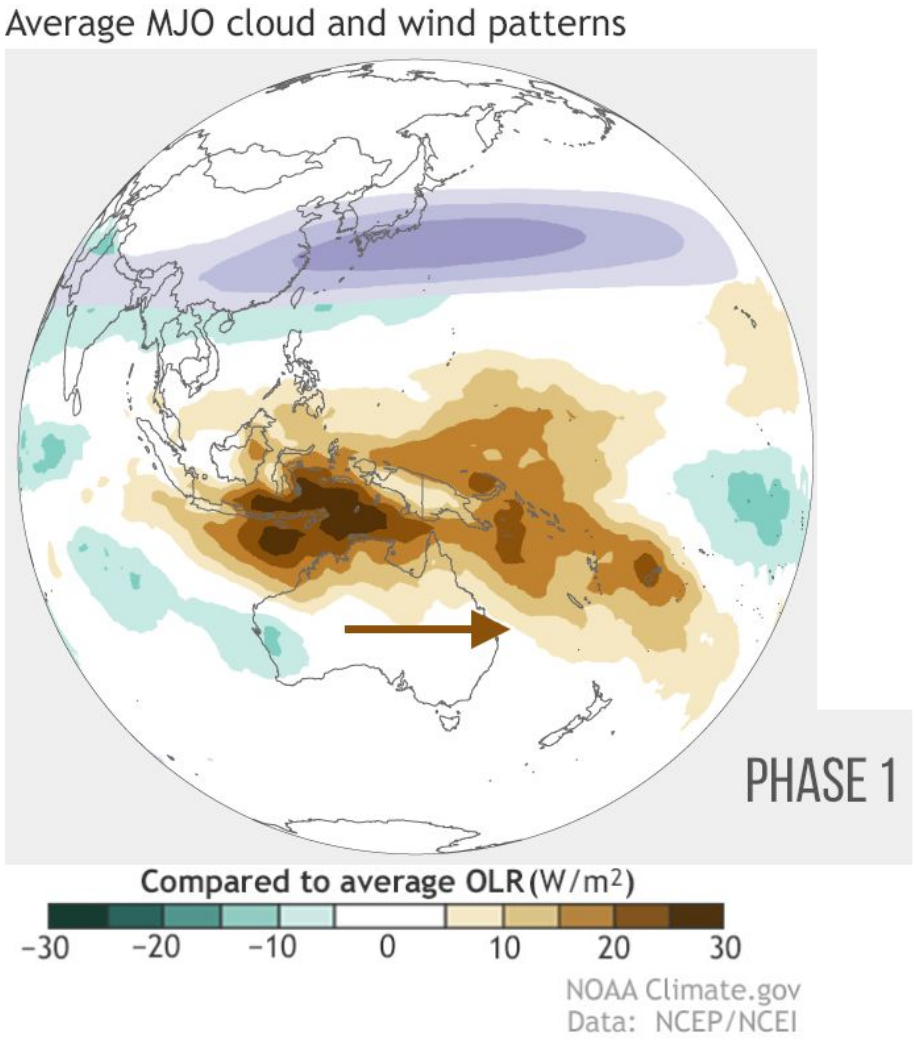
2°N-2°S average



TAO Array

80% of WWBs are associated with the Madden-Julian Oscillation (MJO) during El Niño onset

Liang and Fedorov (2021)



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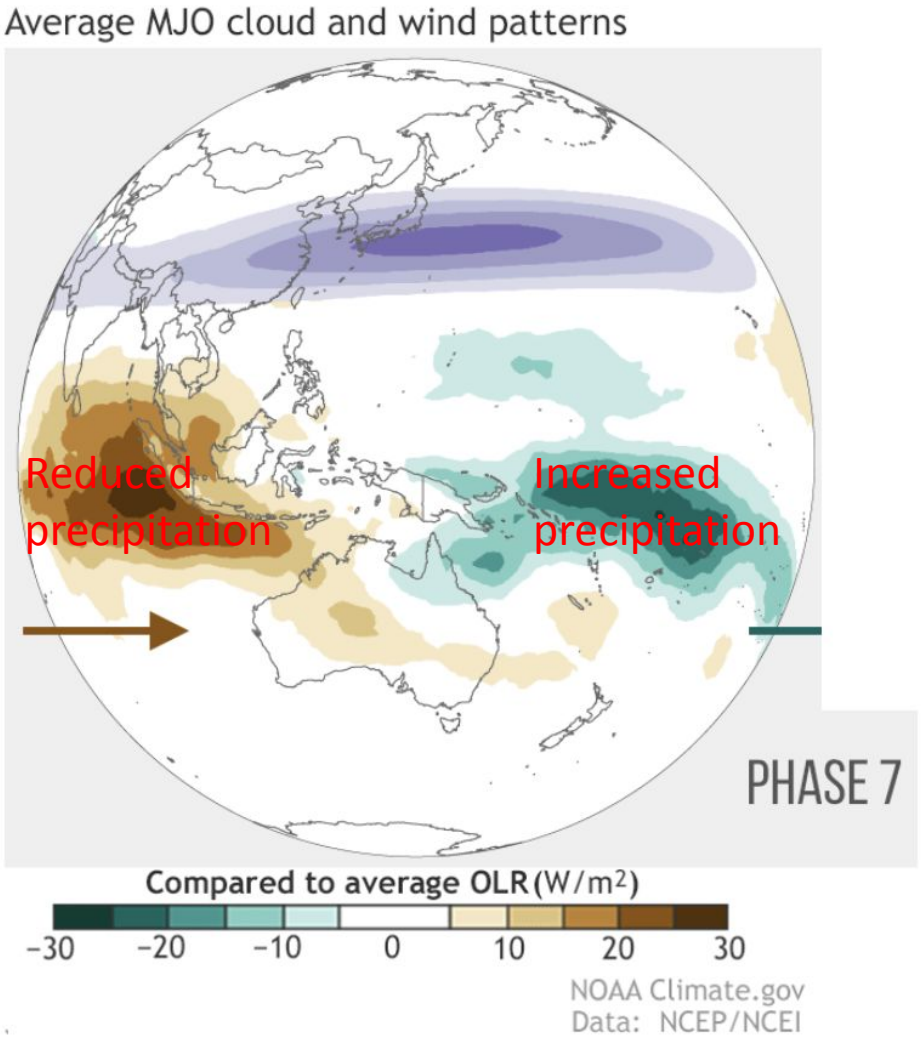
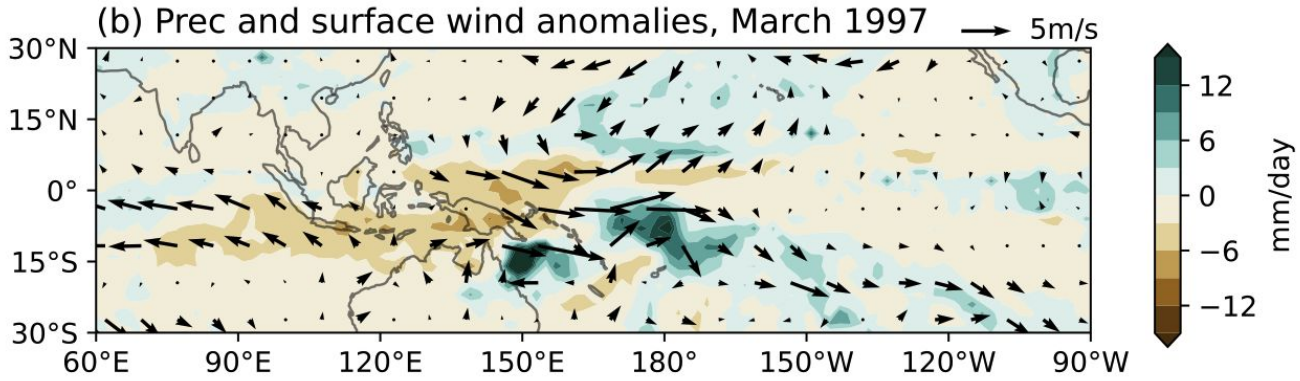
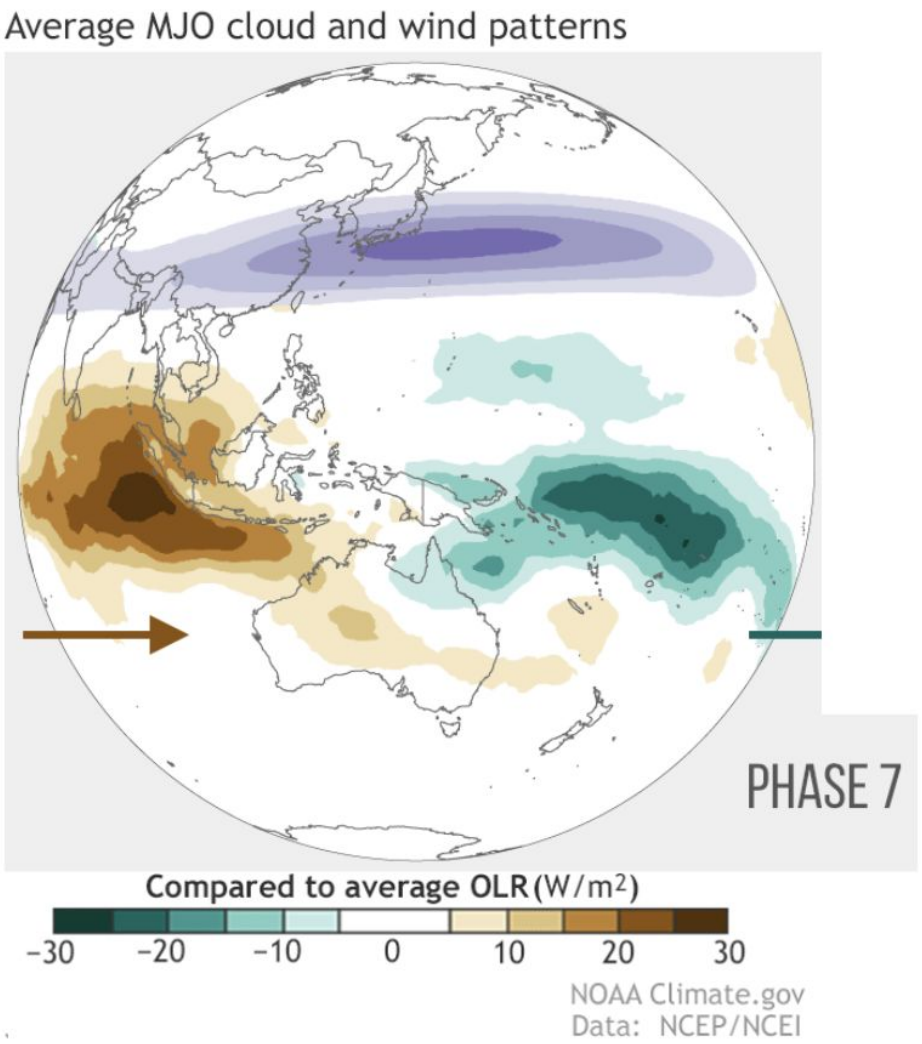
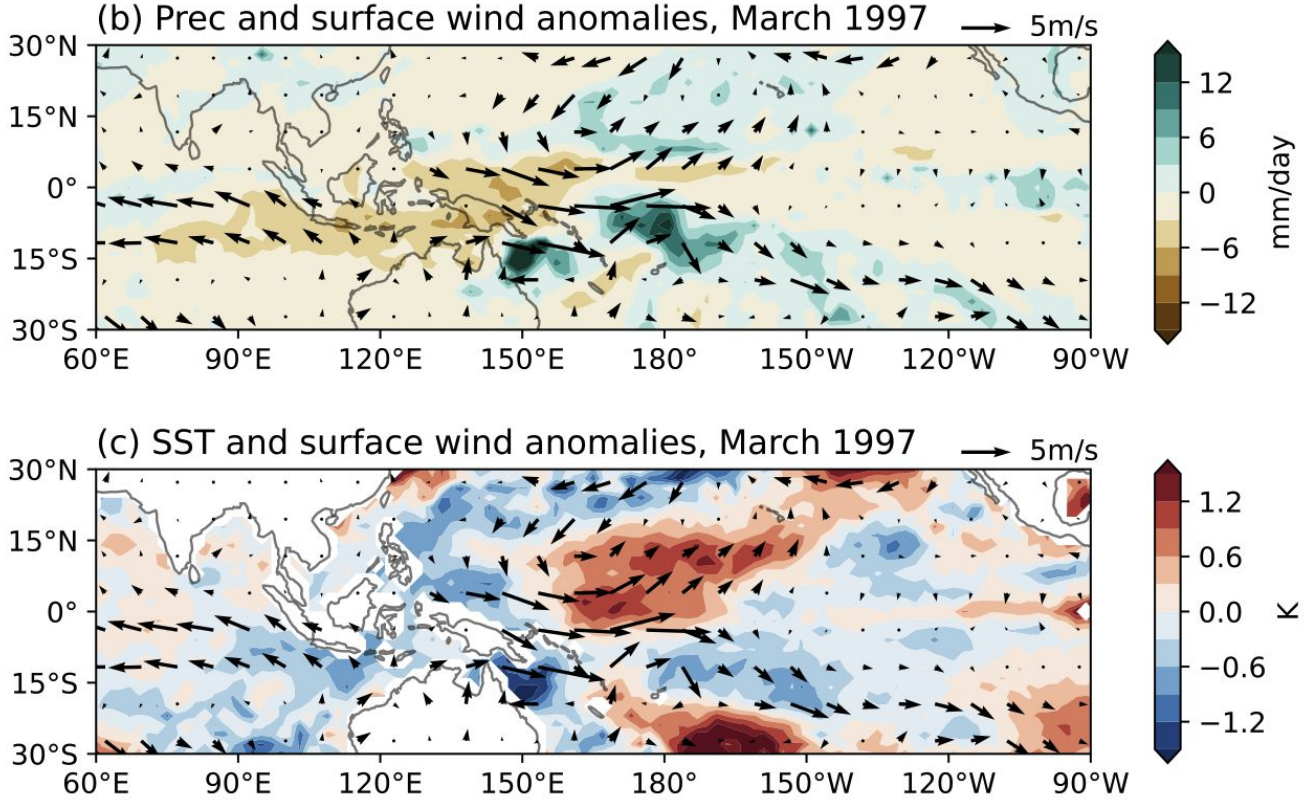




In March 1997, a positive Pacific meridional mode was also present.

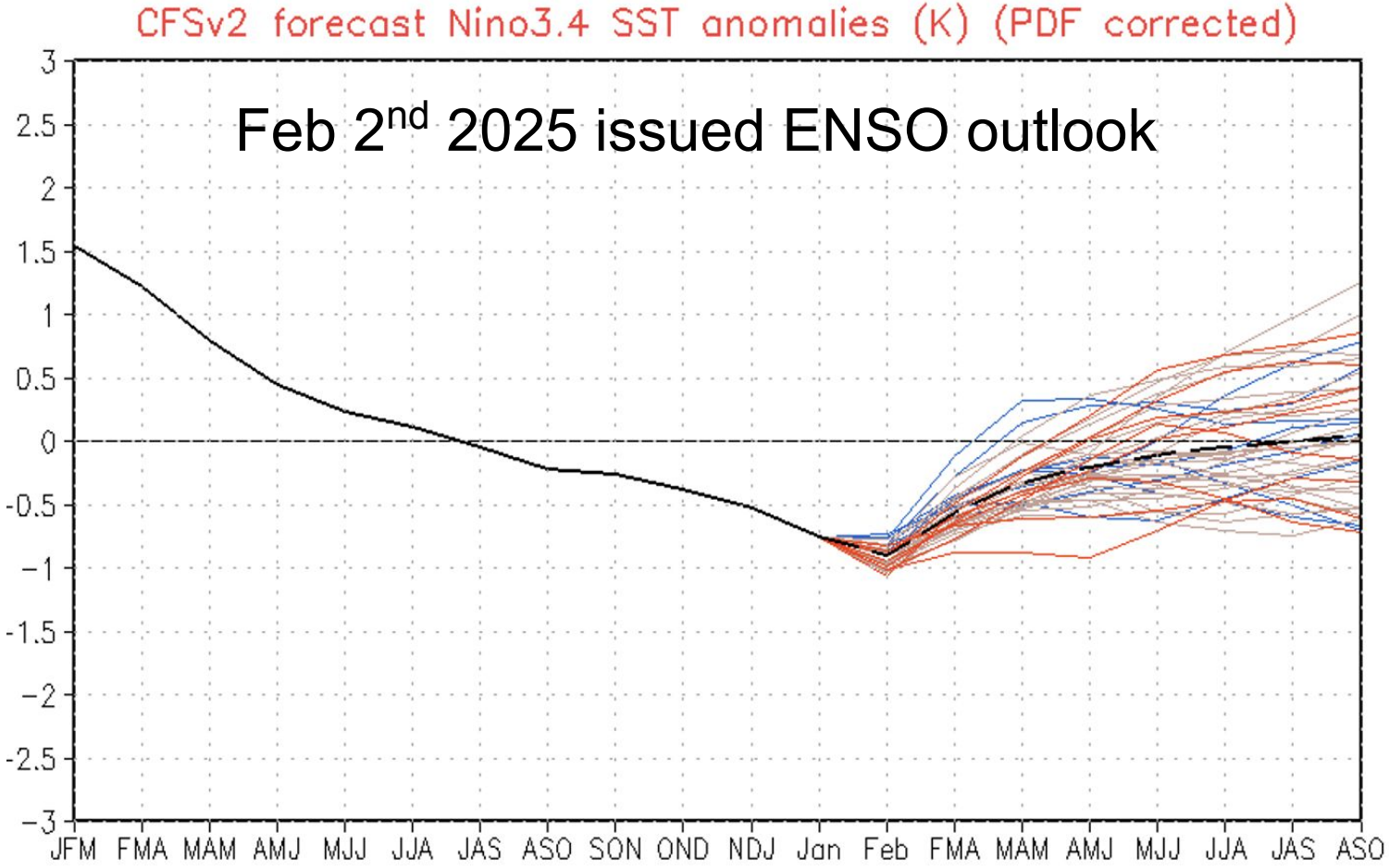




A key question: how does the springtime MJO (e.g., in March) affect ENSO evolution?

- Dataset: CESM2 Seasonal-to-Multiyear Large Ensemble (SMYLE) February 1st initialized hindcasts, from 1970 to 2019, consisting of 20 ensemble members.
- Method:
  - Isolate March MJO from the atmospheric spread of the 20 members in all 50 years.
  - Quantify its impact on ENSO by computing the correlation between the MJO amplitude and the December Niño 3.4 spread.

Isolate the March MJO from the atmospheric ensemble spread

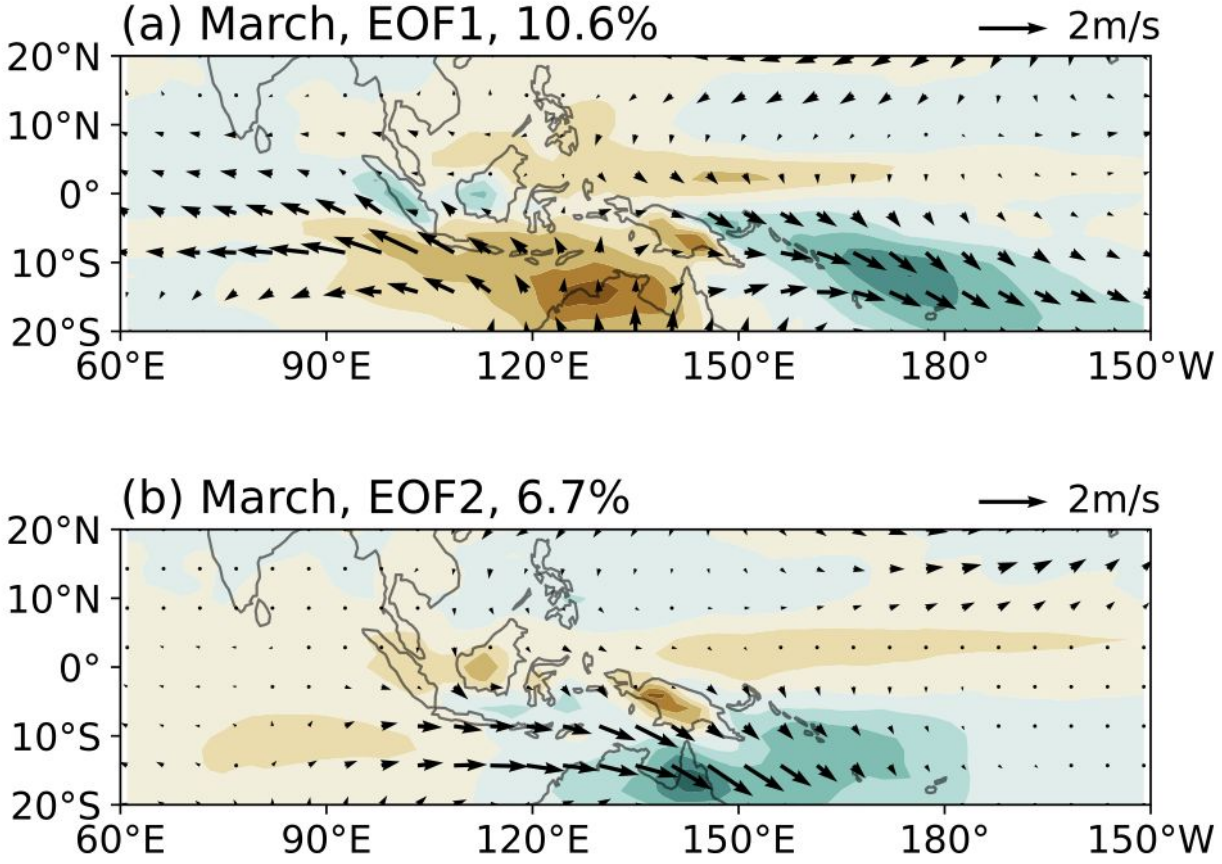


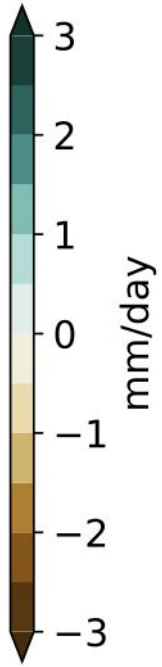
Source: NCEP

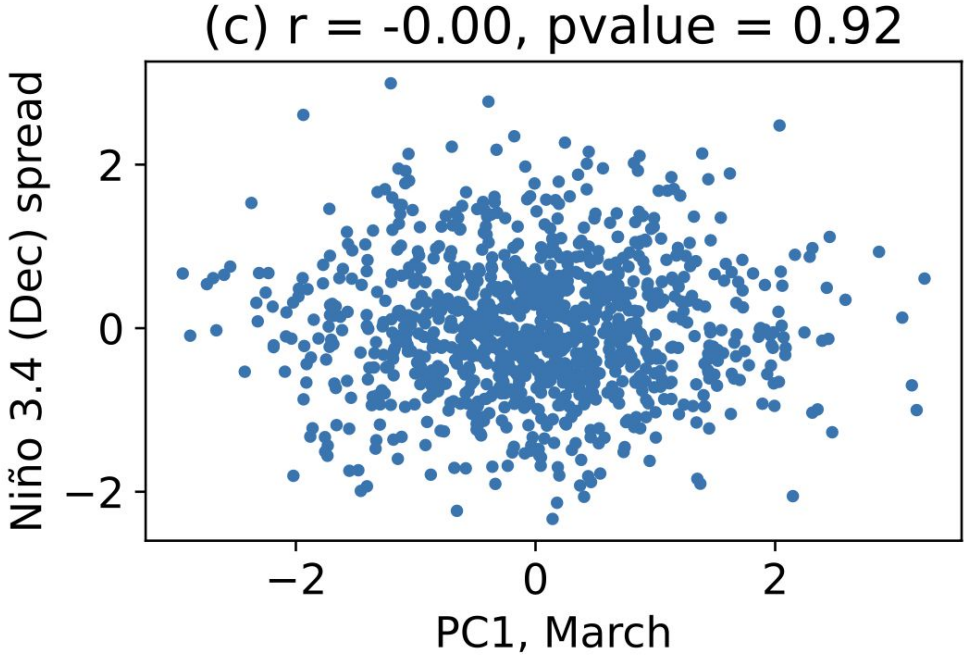
Stochastic atmospheric processes after initiation and associated air-sea interaction cause the ensemble spread of Niño 3.4 SST anomalies

Isolate the March MJO

EOF analysis of the 20-ensemble member spread of precipitation and surface winds between 1970 and 2019.





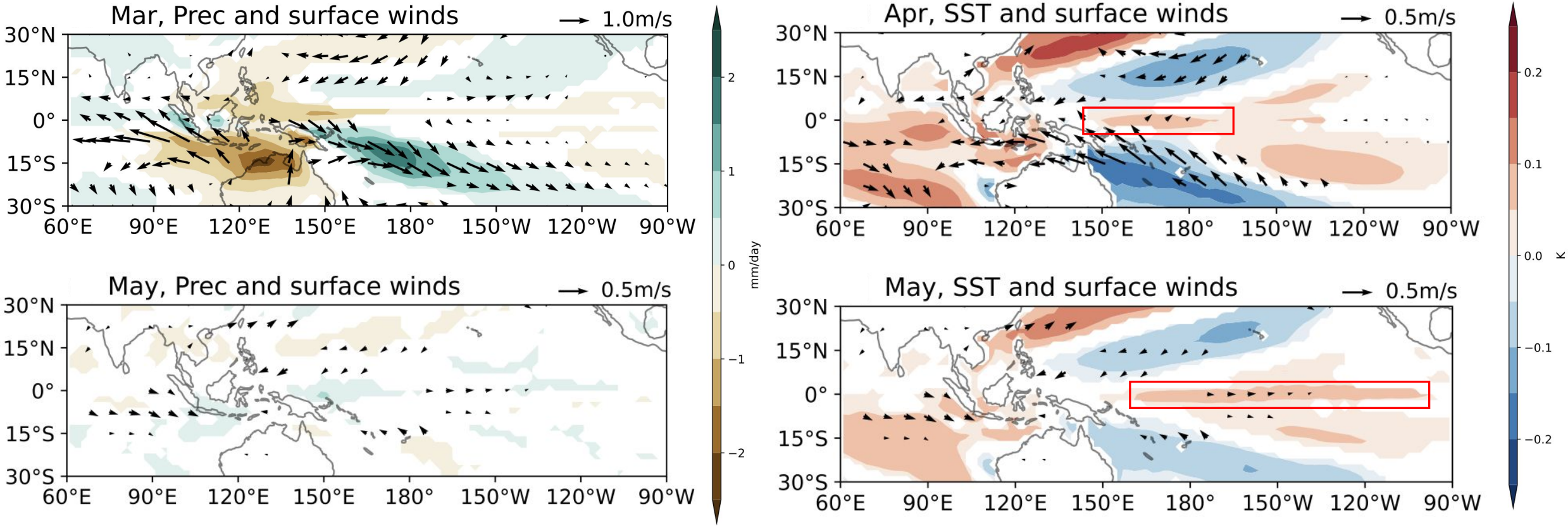


Liang et al. (submitted)

Liang et al. (2024) EOF1 represents the average MJO (in Phase 6-8) amplitude in March.

Quantify March MJO's effects on air-sea interaction

Method: Regress the ensemble spread of SST, precipitation and winds onto PC1



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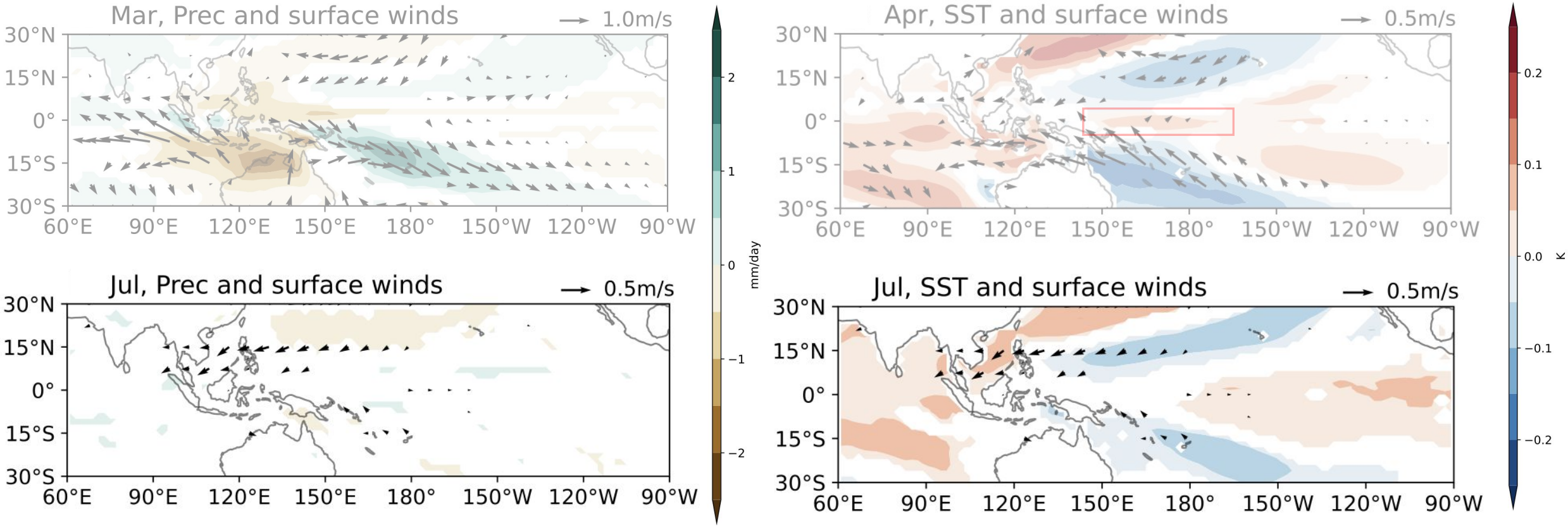
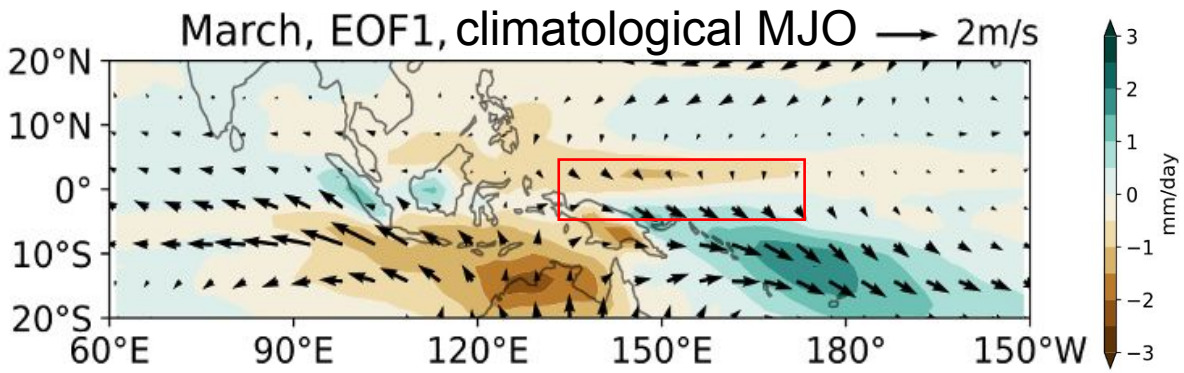
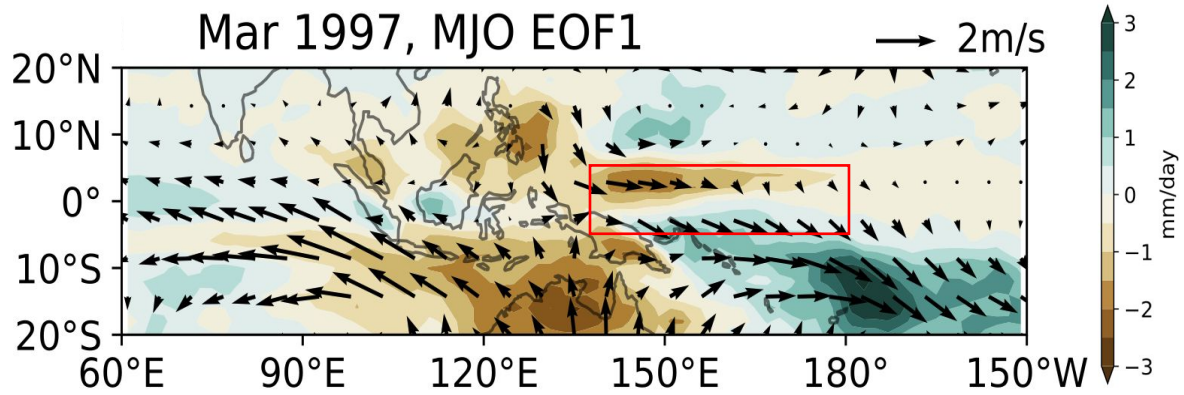


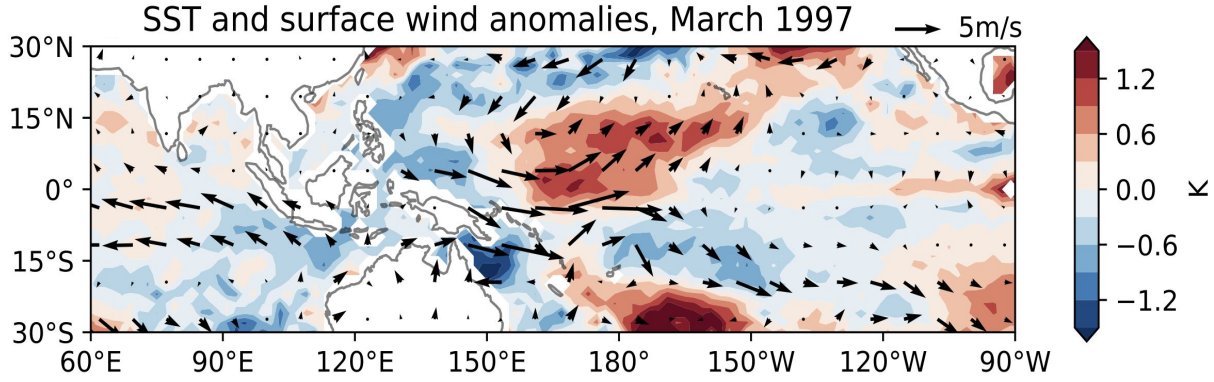
Liang et al. (submitted)

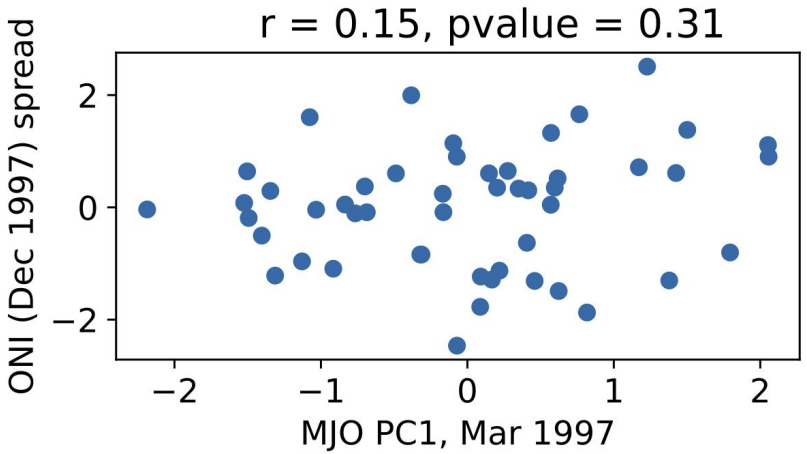
Isolate the MJO in March 1997

Method: EOF analysis of the 50-ensemble member spread of precipitation and surface winds in March 1997.





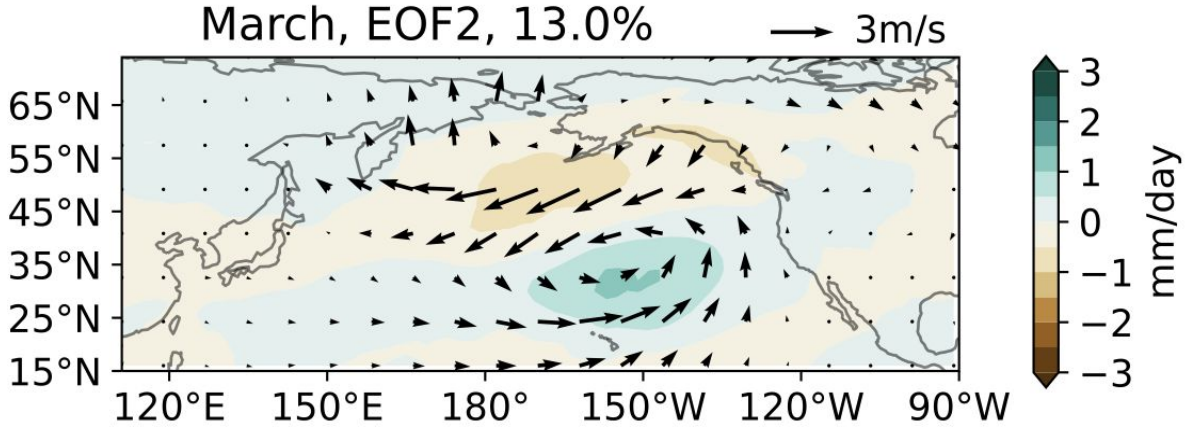


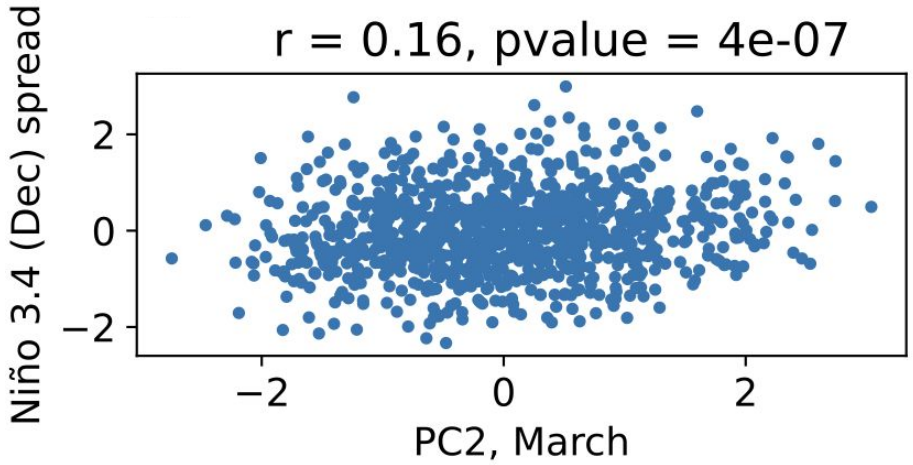


Liang et al. (submitted)

Extratropical circulation favors El Niño growth

Method: EOF analysis of the ensemble member spread of precipitation and surface winds in the extratropics (110°E-90°W, 15°N-75°N).

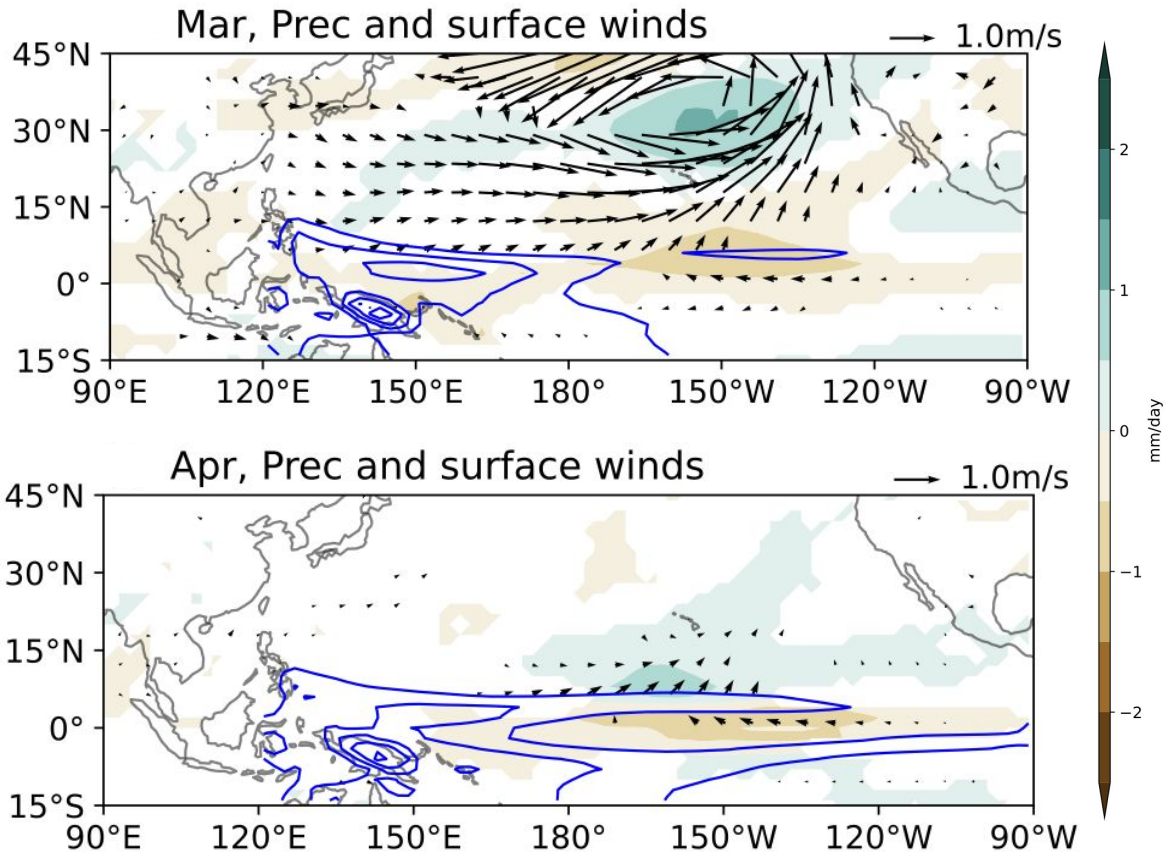


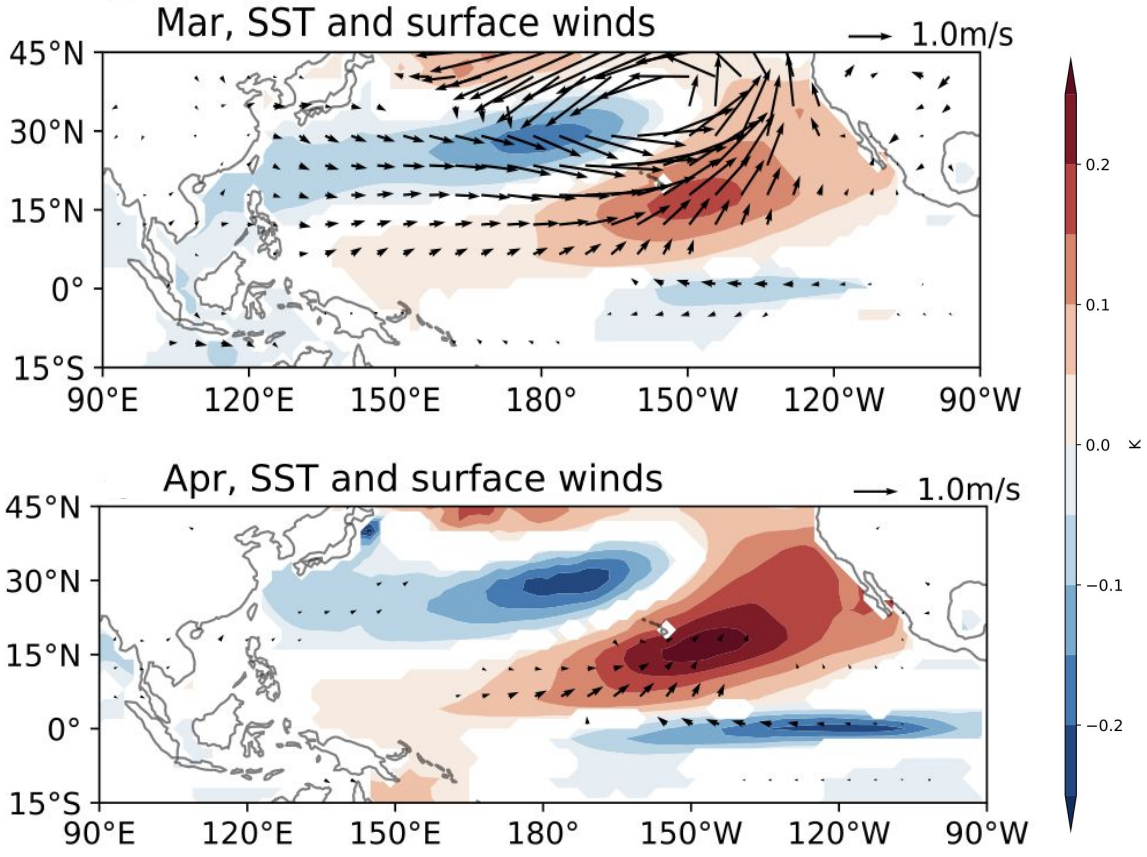


Liang et al. (submitted)

Extratropical circulation favors El Niño growth

Method: Regress the ensemble spread of SST, precipitation and winds onto PC2.





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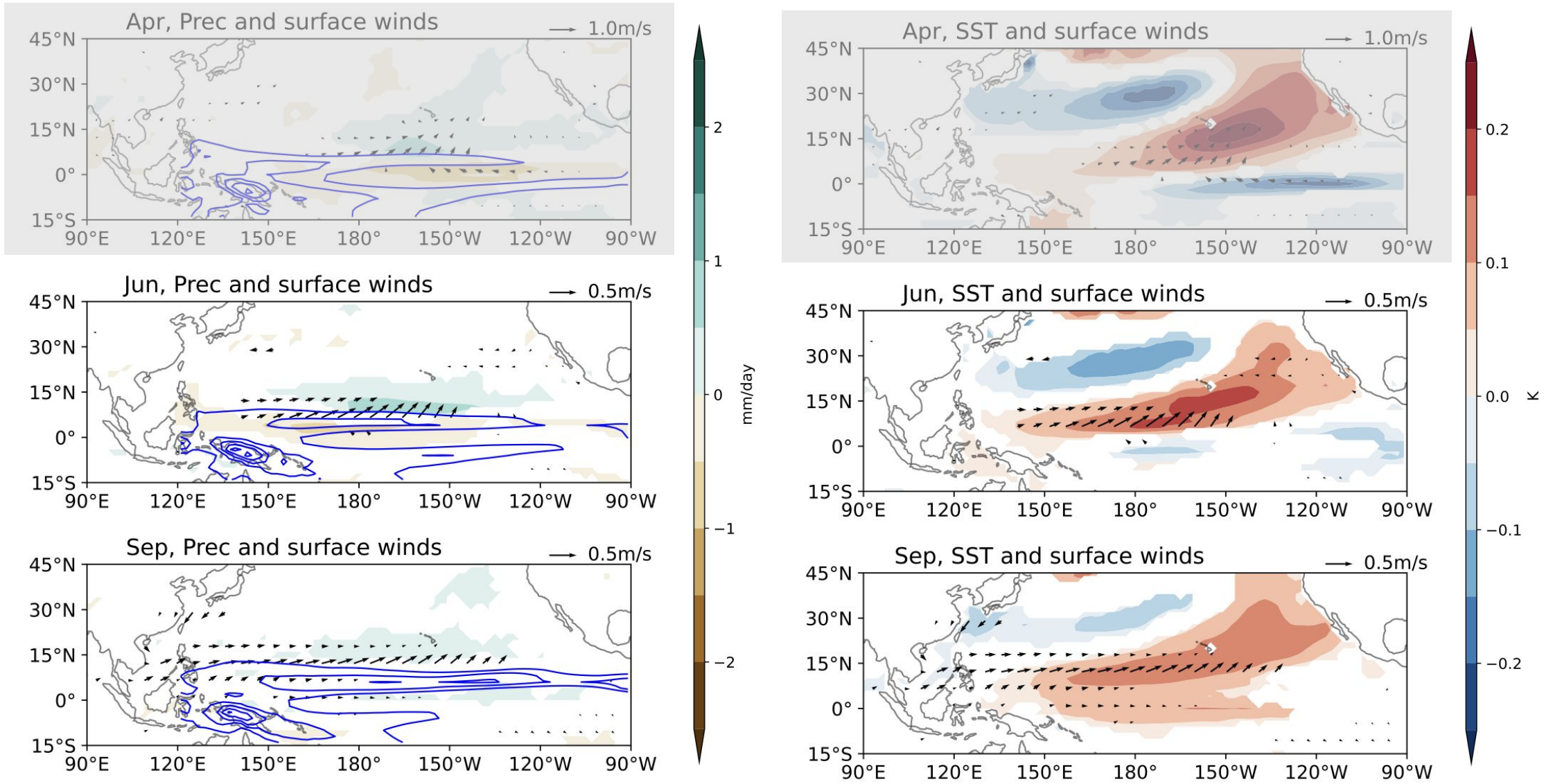

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Summary and Implications

- An ensemble hindcast-based method to quantify the role of stochastic atmospheric processes in ENSO evolution.
- It will take a sequence of MJO events in boreal spring to significantly affect the subsequent ENSO evolution.
- Extratropical circulations can effectively contribute to the ENSO growth by inducing meridional mode-like SST anomalies, which effectively couple with the ITCZ.