# Seasonality of the Great Plains Low-Level Jet and ENSO Relationship

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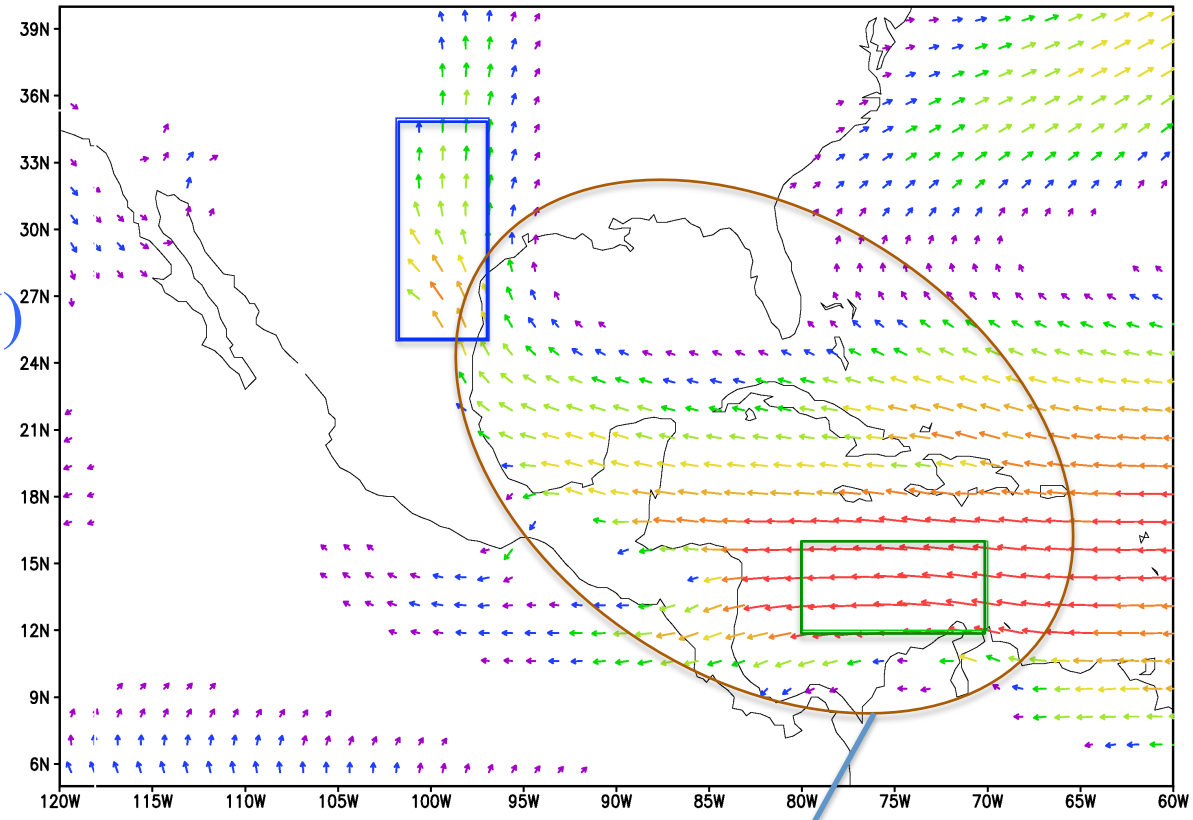
# What is Great Plains Low-Level Jet (GPLLJ) ?

GPLLJ:
Max in V925
(97°W-102°W; 25°N-35°N)

CLLJ:
Max in U925
(80°W-90°W; 12°N-16°N)




Intra Americas Seas

Stronger GPLLJ -> Anomalous V925 winds are southerlies
Stronger CLLJ -> Anomalous U925 winds are easterlies

# Importance of GPLLJ

- GPLLJ serves as an important source of moisture to continental US via CLLJ.
- Profound influence on regional hydroclimate, tornadoes, agriculture, forestry and human health.
- Therefore, a better understanding of the factors that control the variations of the GPLLJ can have profound socio-economic implications over the US.

# Motivation

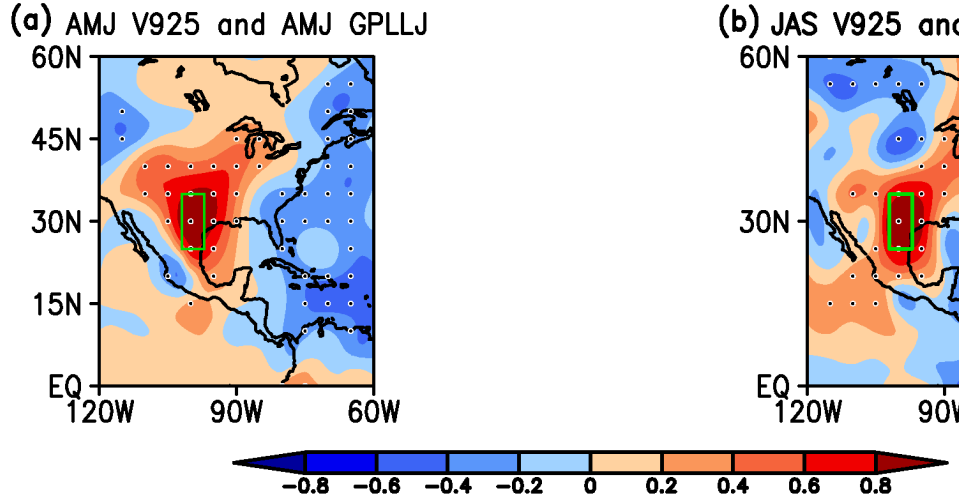
**Seasonal change**

**La Niña leads to stronger GPLLJ in Spring**

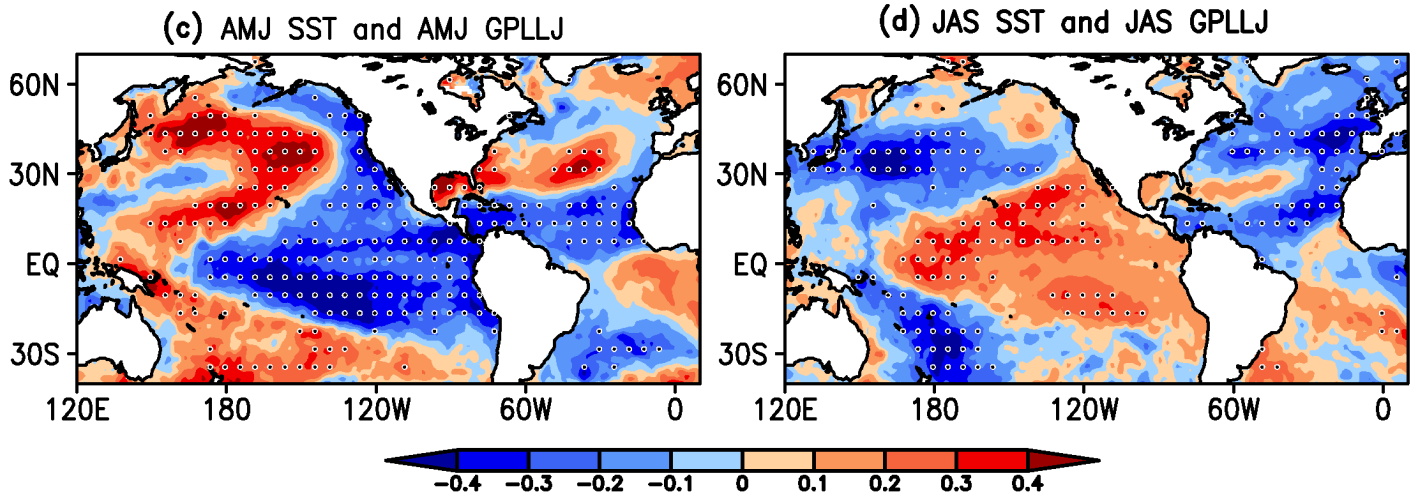
**El Niño leads to stronger GPLLJ in Summer**

**Observations**

**V925 for stronger GPLLJ**



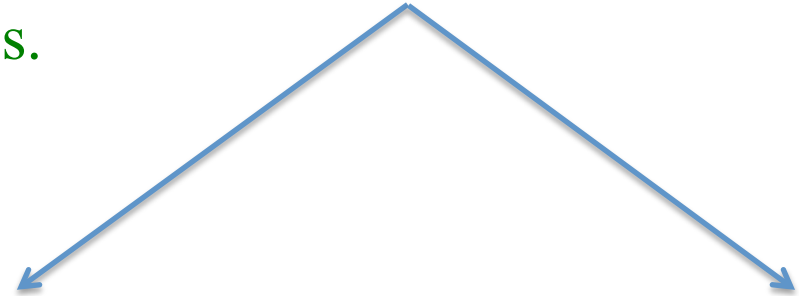

**SST for stronger GPLLJ**



# Motivation

- Seasonality in the ENSO-GPLLJ relation is intriguing.

- Literature review on the ENSO-GPLLJ relation falls into two categories.



Negative Correlation
(La Niña -> stronger GPLLJ)

Munoz and Enfield 2011, Lee et al. 2013

Positive Correlation
(El Niño -> stronger GPLLJ)

Weaver et al. 2008, Schubert et al. 2004, Ting and Wang 1997

# Objectives

1. Whether it is a statistical artifact (from a finite sample) or a true seasonal change in the relationship.

2. If it is not spurious, whether current coupled climate models capture the seasonal changes in the GPLLJ-ENSO relation.

3. What is the mechanism for the GPLLJ and ENSO relationship?

# Approach

- Limited sample size in observed data.

- We test the robustness of the seasonality in ENSO-GPLLJ relationship in long control simulation from FLOR (600 years).

FLOR: High-resolution atmosphere (0.5°) and low-resolution ocean (1°).

- FLOR has better simulation of seasonality, climatological structure and variability of the GPLLJ and its relation to US rainfall.

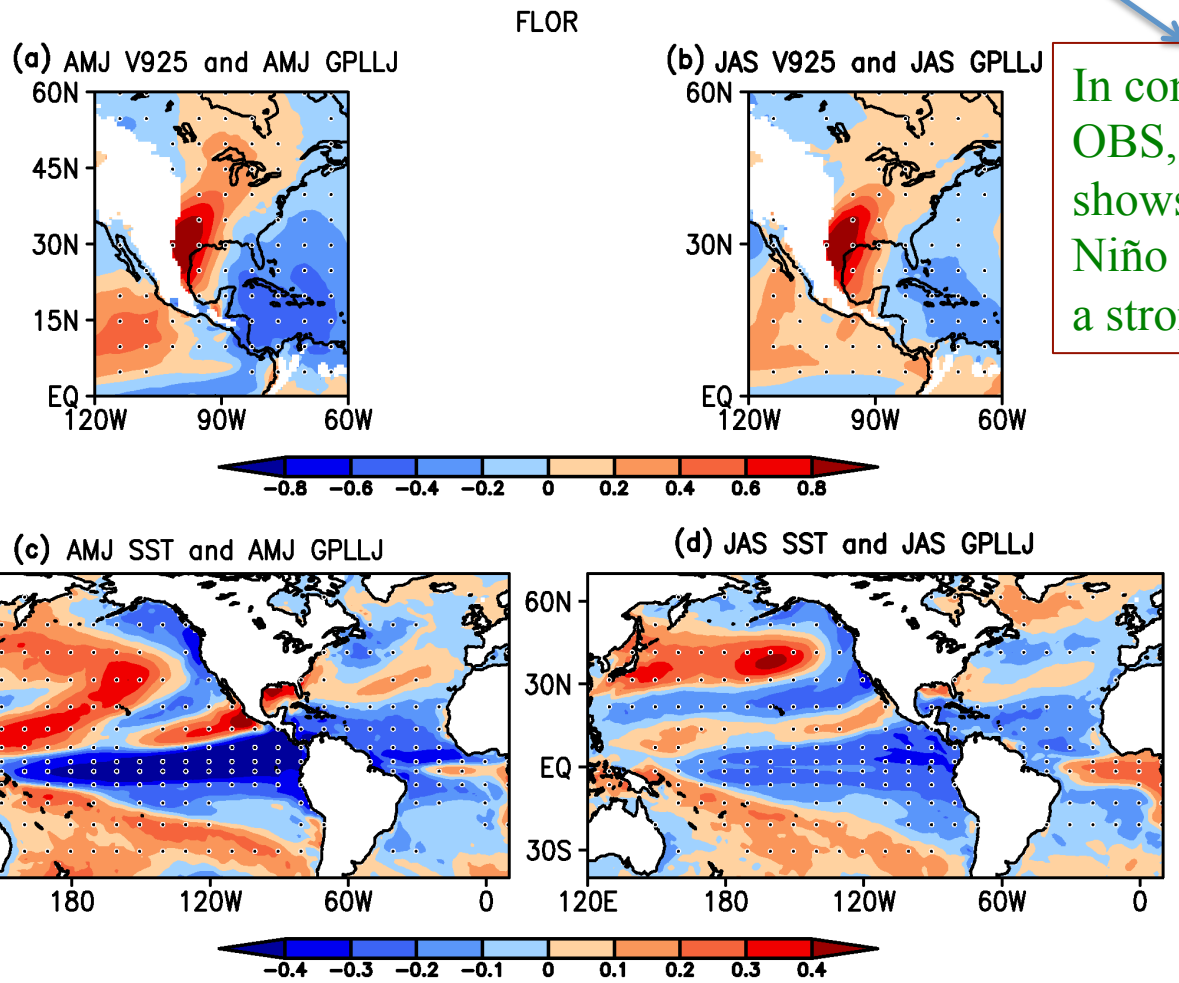
# ENSO-GPLLJ Relation in FLOR

**La Niña leads to a stronger GPLLJ in Spring**

**La Niña leads to a stronger GPLLJ in Summer**

**V925 for stronger GPLLJ**

**SST for stronger GPLLJ**




In contrast to OBS, which shows that El Niño is related to a stronger GPLLJ

# ENSO-GPLLJ Relation in FLOR-FA

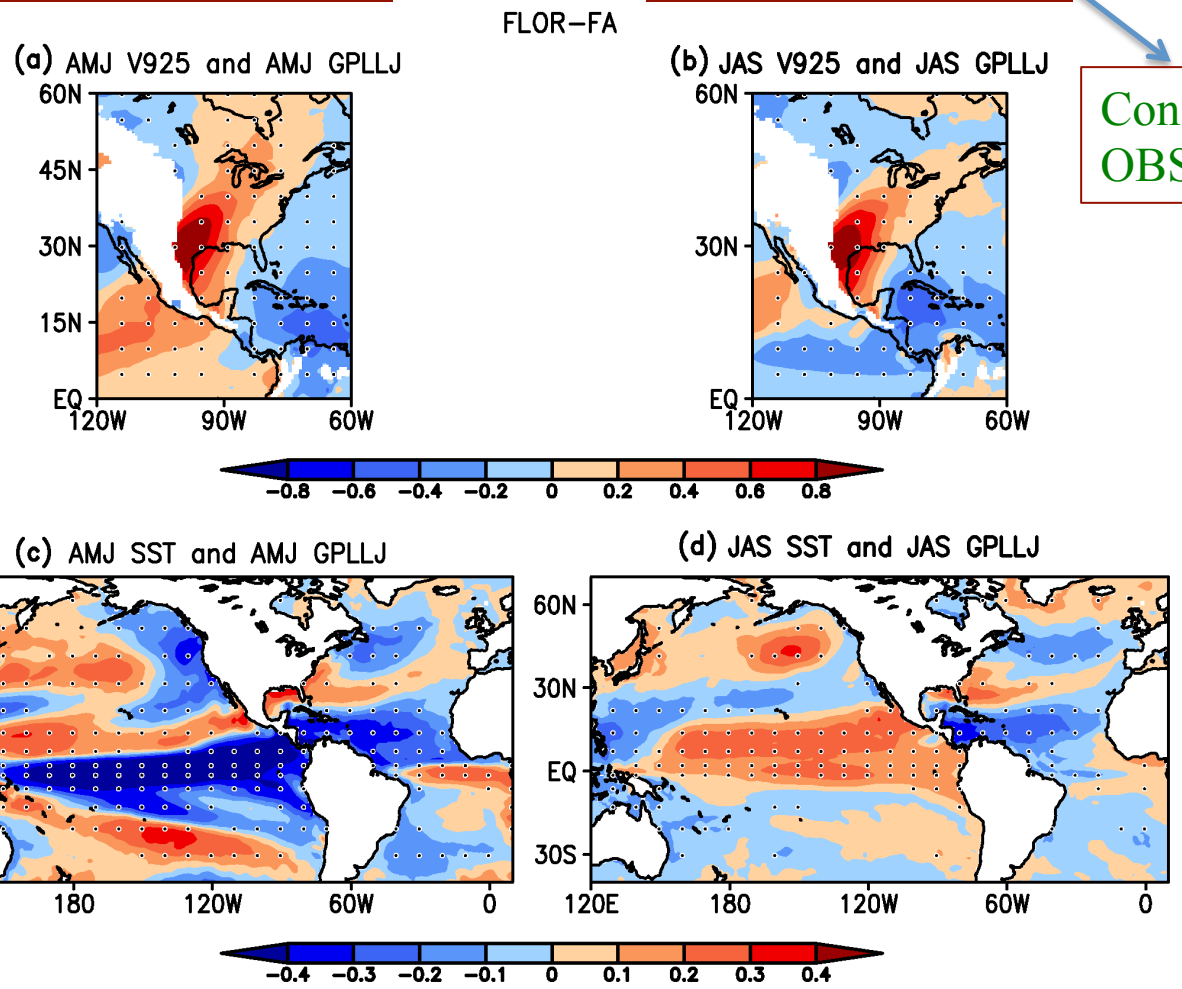
**La Niña leads to stronger GPLLJ in Spring**

**El Niño leads to stronger GPLLJ in Summer**

Consistent with OBS

**V925 for stronger GPLLJ**

**SST for stronger GPLLJ**




FLOR-FA: Flux-adjusted version of FLOR with climatological SST and surface wind stress is closer to observed estimates over 1979-2012.

# Why FLOR fails to simulate seasonal change in the ENSO-GPLLJ relationship?

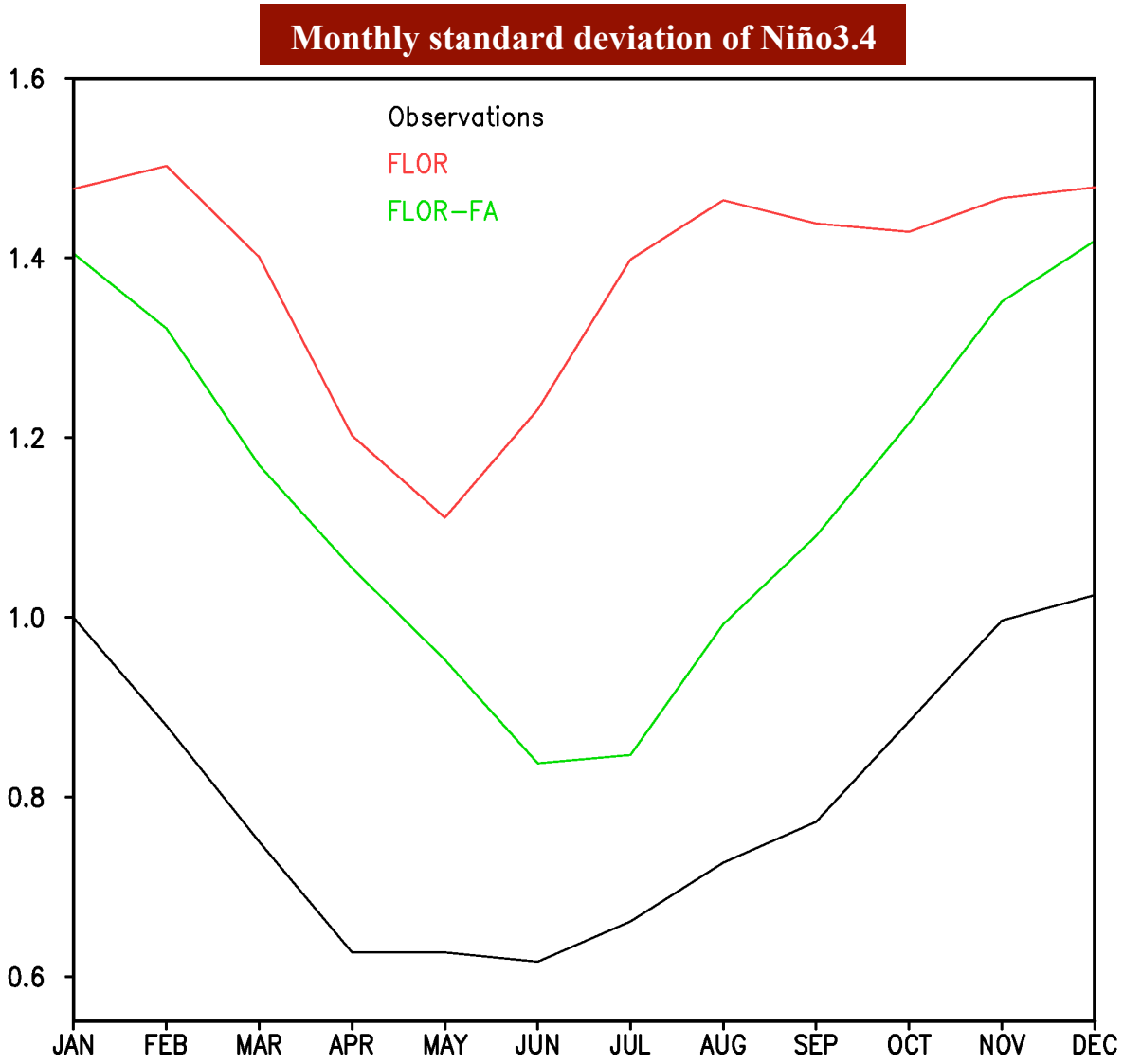
# Reasons for discrepancy between FLOR and FLOR-FA

1. The mean state and variability of the GPLLJ are comparable in FLOR and FLOR-FA.

2. The tropical Atlantic conditions related to the GPLLJ are also very similar in the two models.

3. Analysis of ENSO in FLOR and FLOR-FA reveals that ENSO amplitude and phase locking is different between the two model simulations.

# Variability of ENSO



# Hypothesis

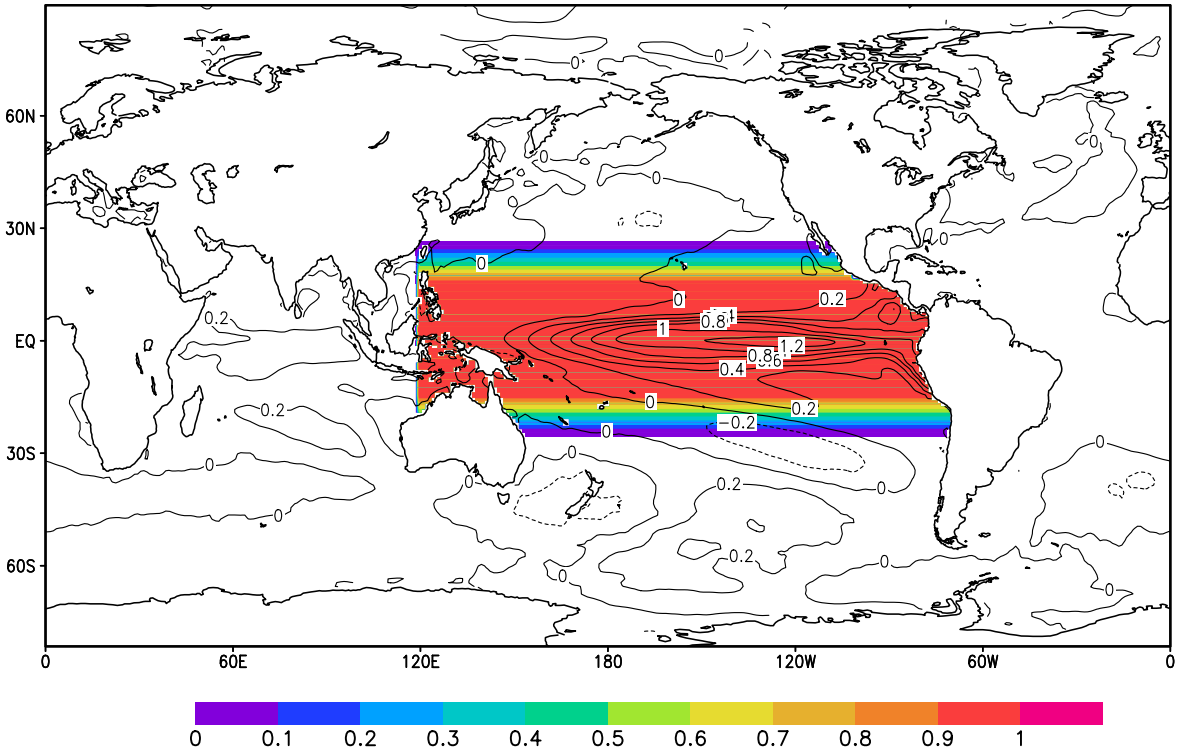
Coupled climate models with better simulation

of phase-locking and strength of ENSO can

simulate seasonal changes in ENSO-GPLLJ Relationship

# Model Experiment (FLOR-FA_enso) to test the hypothesis

- FLOR-FA_enso : Tropical Pacific SSTs are restored to,
  FLOR climatology + FLOR-FA anomalies
- Initial condition from FLOR and run for 100 years.




Restoring timescale = 5 days

# ENSO-GPLLJ Relation in FLOR-FA_enso

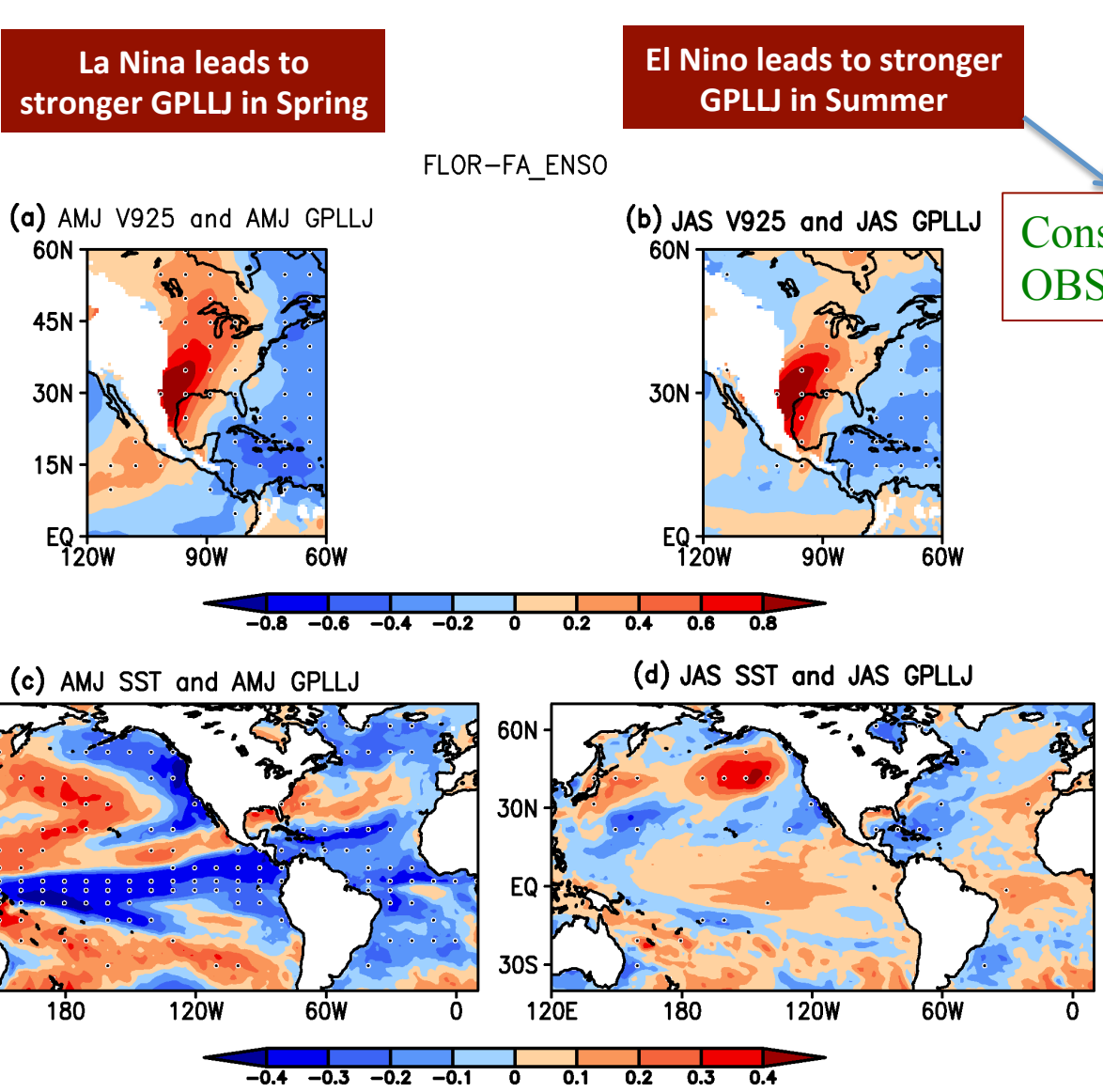
**La Nina leads to stronger GPLLJ in Spring**

**El Nino leads to stronger GPLLJ in Summer**

Consistent with OBS but weak

**V925 for stronger GPLLJ**

**SST for stronger GPLLJ**



What other factors interfere with the

GPLLJ-ENSO relation?

# Role of the North Pacific SSTs

- Hu and Huang (2009) and Ting and Wang (1997)
  - ✓ Warm (cold) phase of PDO is associated with wet (cold) Great Plains.
- Weaver et al. (2012, 2013)
  - ✓ Strengthening of the GPLLJ with warm phase of PDO.
- Schubert et al. (2004)
  - ✓ Based on observational and modeling studies suggest that the low-frequency North Pacific SSTs contribute to the variability of the summer Great Plains rainfall.

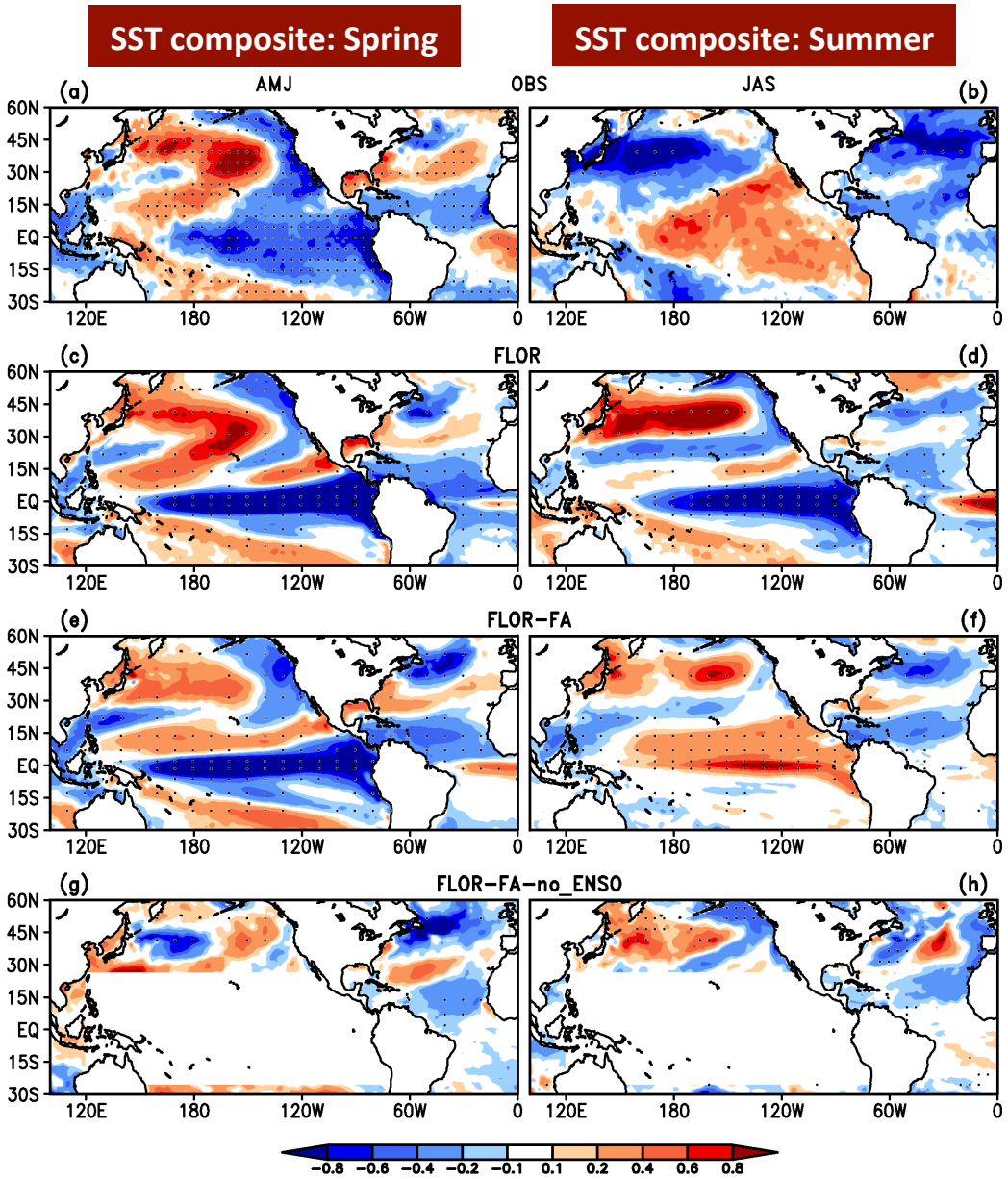
# Role of the North Pacific SSTs

**HADSST**
(15,12)

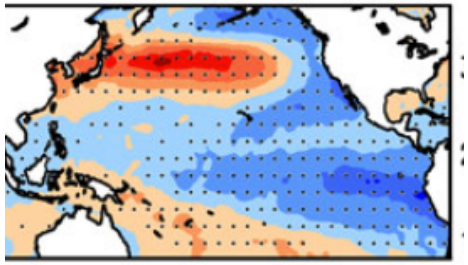
**FLOR**
(100,102)

**FLOR-FA**
(104,98)

**FLOR-FA-no_ENSO**
(12,14)




**Cold PDO**



Negative SSTs extending from the west coast of North America to the Tropical Pacific.

May counteract the positive SSTs weakening the relation of TP with the Great Plains jet.

# Mechanism for Seasonality in ENSO-GPLLJ Relation

# Observed Spring Mechanism

- Munoz and Enfield (2011)

  Strength of the GPLLJ is related to the CLLJ and draws moisture from the tropical Atlantic through the CLLJ.

- Enfield and Mayer (1997), Giannini et al. (2000), Alexander and Scott (2002), Wang (2005)

  ENSO has lagged relationship with the atmospheric conditions over the tropical Atlantic via the Walker and Hadley circulations.

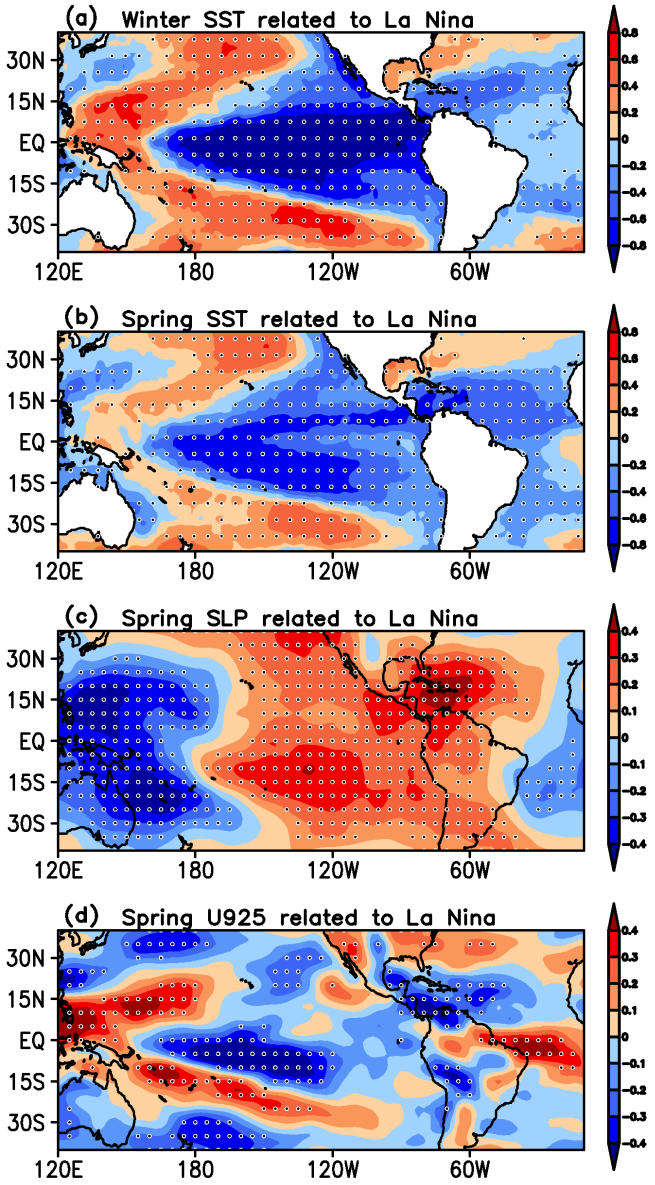
# Observed Spring Mechanism: La Niña -> Stronger GPLLJ

Winter SST

Spring SST

Spring SLP

Spring U925

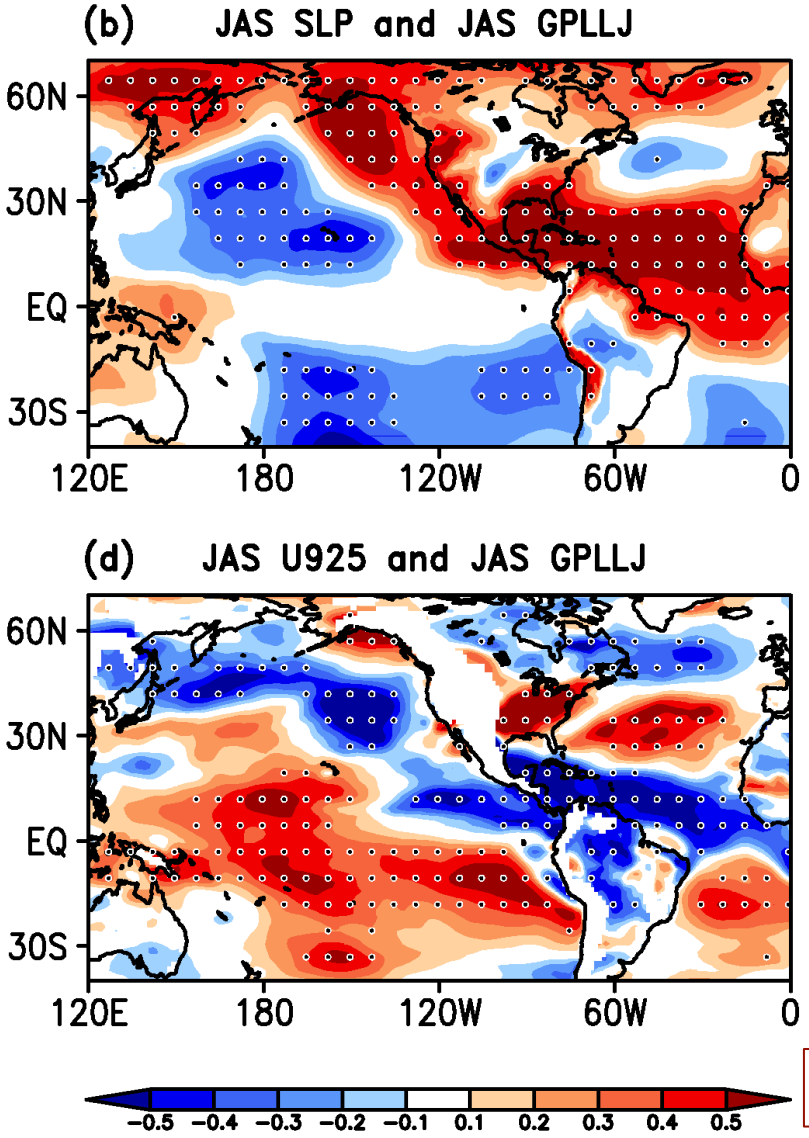



Cor (CLLJ, GPLLJ) = -0.43

# Observed Summer Mechanism
# El Niño -> Stronger GPLLJ

Summer SLP

Summer U925




Cor (CLLJ, GPLLJ) = -0.47

# Evidence for Mechanistic Hypothesis in FLOR-FA

Krishnamurthy, L., Vecchi, G. A., Msadek, R., Wittenberg, A., Delworth, T., Zeng, F., 2015: The Seasonality of the Great Plains Low-Level Jet and ENSO Relationship. *J.Climate*, DOI: http://dx.doi.org/10.1175/JCLI-D-14-00590.1.

# Conclusions

- Observations suggests seasonal changes in the teleconnection between ENSO and the GPLLJ.


- FLOR (600 years) ✗
  FLOR-FA (500 years) ✔

- Through restoring model experiment, it was shown that the differences between FLOR and FLOR-FA arises from the stronger ENSO's and inaccurate phase-locking in FLOR.

- *We emphasize that coupled climate models with better phase-locking and variability of ENSO is important to capture the ENSO's teleconnections.*

- Mechanistic hypothesis that the tropical Pacific SSTs convey their influence on the GPLLJ via the tropical Atlantic was proposed.