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Two flavours of ENSO and its predictability.

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Two Flavors of ENSO and Its Predictability

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What is limiting the ENSO predictability?

✓ **Model Flaws**

→ **mean error, phase shift, different amplitude, and wrong seasonal cycle, etc**

✓ **Flaws in the way the data is used**

→ **data assimilation and initialization, chaos within non-linear dynamics of the coupled system**

✓ **Inherent limits to predictability**

→ **some times are more predictable than others, amplitude of SST anomalies with respect to ENSO phase**

✓ **Gaps in the observing system**

Background and Objective

❑ **Conventional El Niño**

: "as a phenomenon in the equatorial Pacific Ocean characterized by a positive sea surface temperature departure form normal in the NINO 3.4 region greater than or equal in magnitude to 0.5C averaged over three consecutive months" (NOAA)

❑ **Different flavors of El Niño**

• Trans- Niño (Trenberth and Stepaniak, 2001), Dateline El Niño (Lakin and Harrison 2005), El Niño Modoki (Ashok et al. 2007), Non-canonical ENSO (Guan and NIgam, 2008), Warm pool El Niño (Kug et al. 2008), etc.

: Even though there are differences, the distinctive interannual SST variation over the central Pacific which becomes more active in recent year and significantly different global impact form conventional El Niño are common features.

❑ **The transition mechanisms and dynamical structure of two-types of El Nino are significantly different (Kug et al. 2008).**

→In this study, CGCM's ability to predict the distinctive characteristics of two types of El Niño is investigated using two state-of-the-art CGCMs retrospective forecasts.

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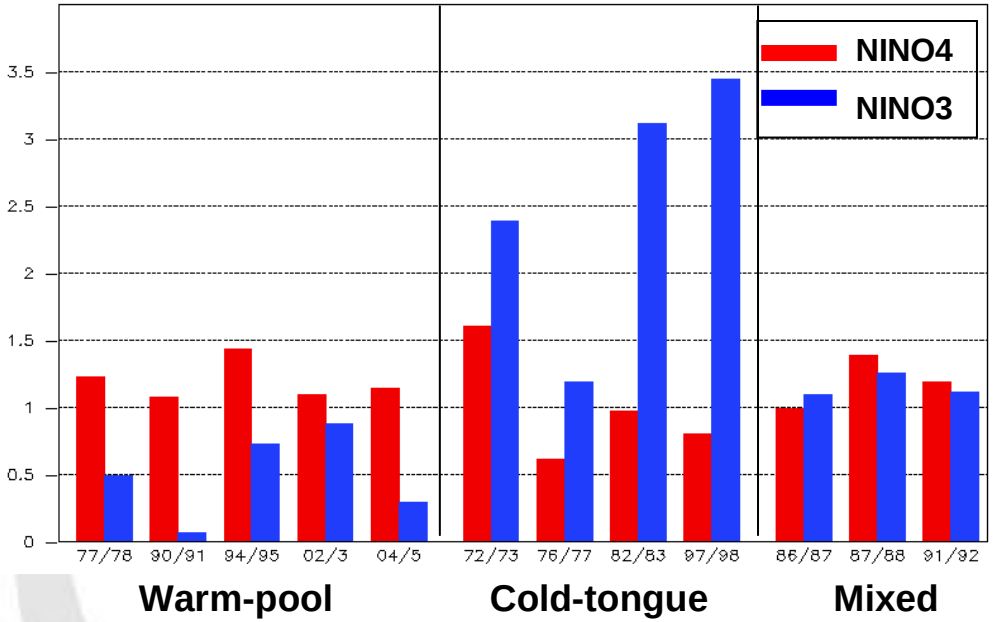
Observed Two Types of El Nino

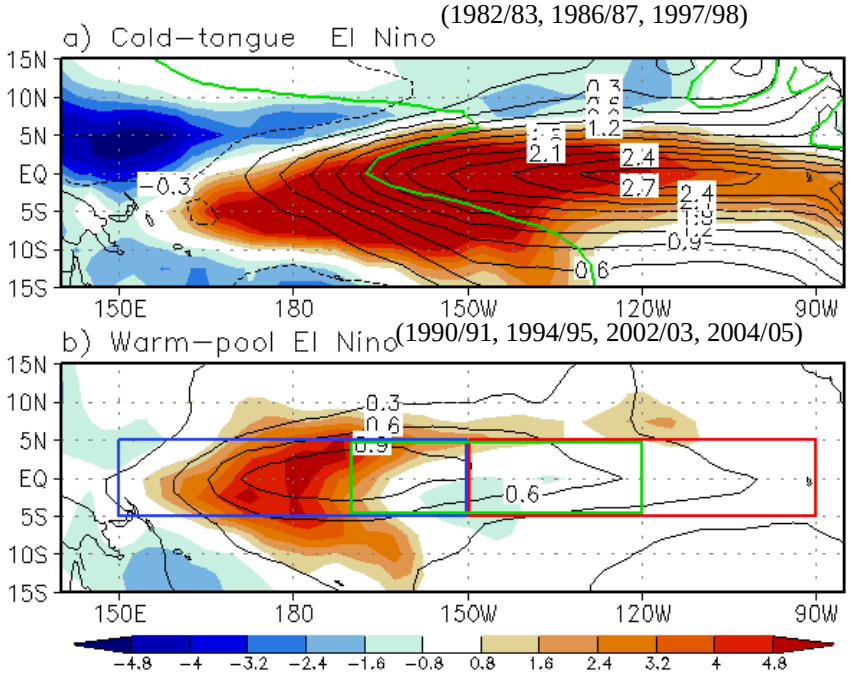
Normalized NINO3 and NINO4 SST



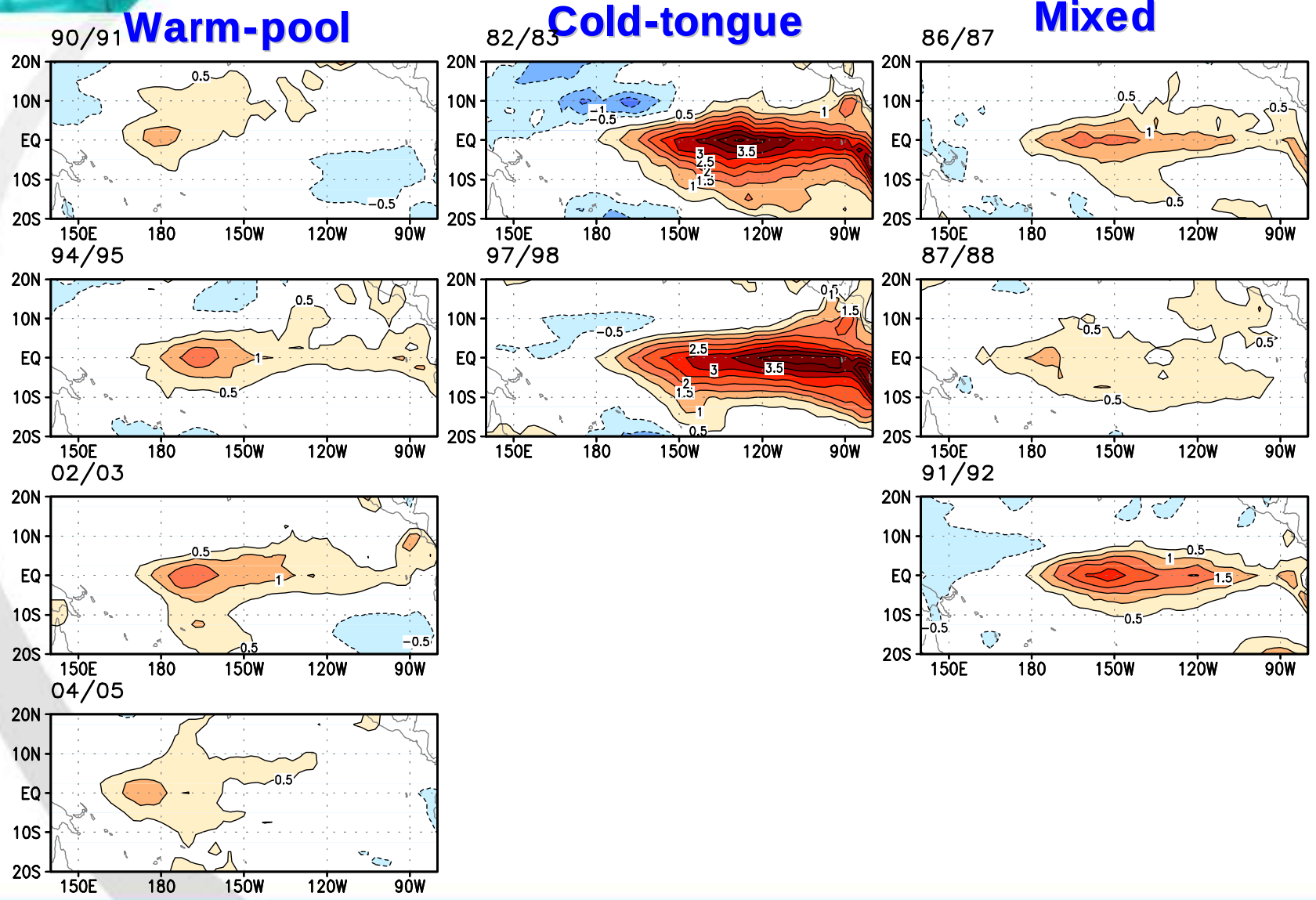
Either NINO3 SST or NINO4 SST is greater than their standard deviation

Kug et al., 2008

Composite of SST (Contour) and Rainfall (Shaded)



Observed DJF SST Anomalies



Model and Dataset

Retrospective Forecast

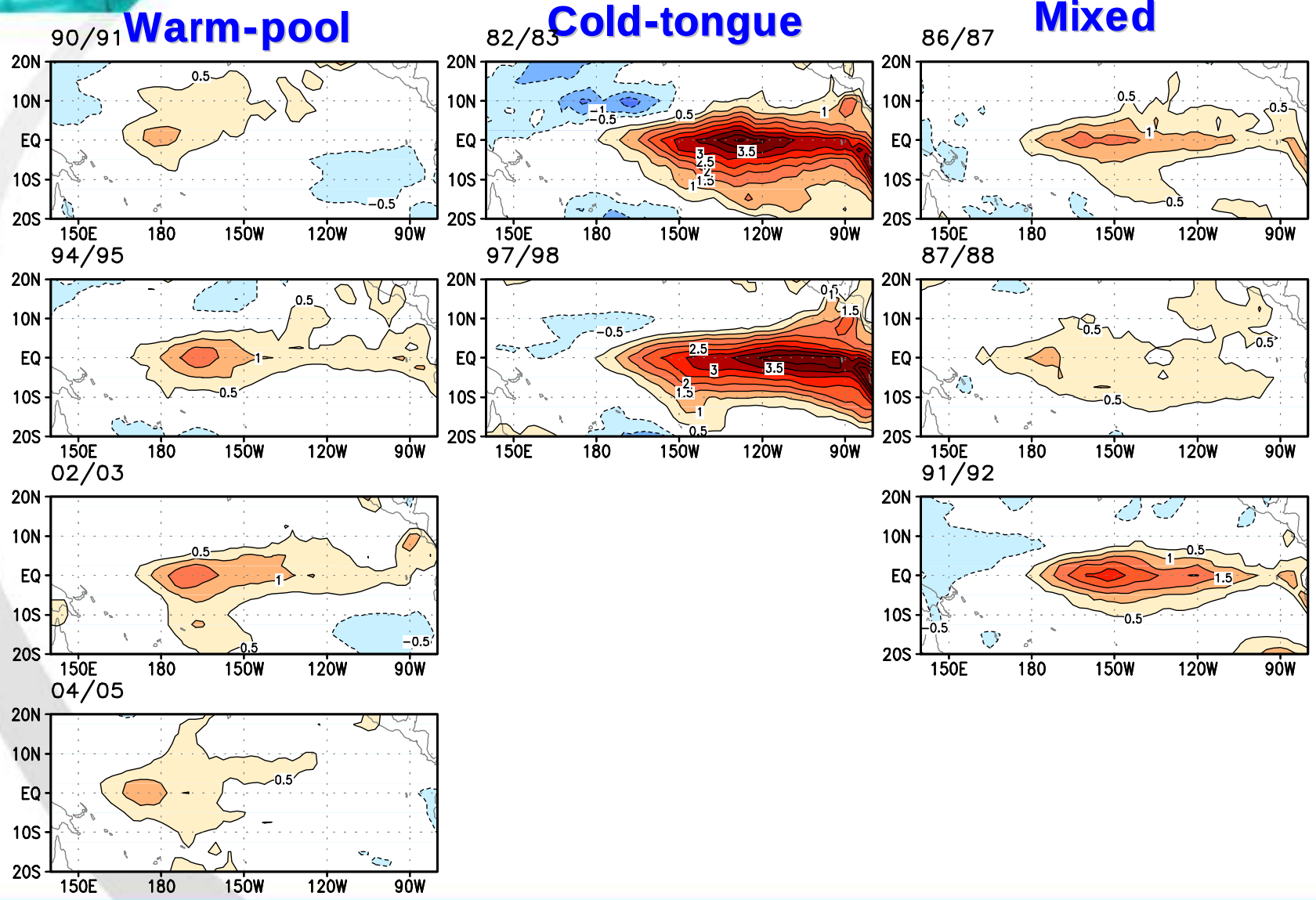
- **Initial condition cases of 12 calendar months are analyzed.**
- **As observational counterparts, OISST, CMAP rainfall, and NCEP/NCAR reanalysis data are used.**

Model	Lead month	Ensemble Member	Period	AGCM	OGCM
FRCGC SINTEX	12	9	1982-2006	ECHAM 4 T106 L19	OPA 8.2 2x2 L31
NCEP CFS	9	15	1981-2006	GFS T62 L64	MOM 3 1/3x5/8 L27

- **In this study, forecast data is reconstructed with respect to lead time (monthly forecast composite).**

Courtesy of *J.-J. Luo, T. Yamagata, and NCEP EMC*

Observed DJF SST Anomalies



Simulated SODJFM SST Anomalies

Forecast lead month 1

CFS

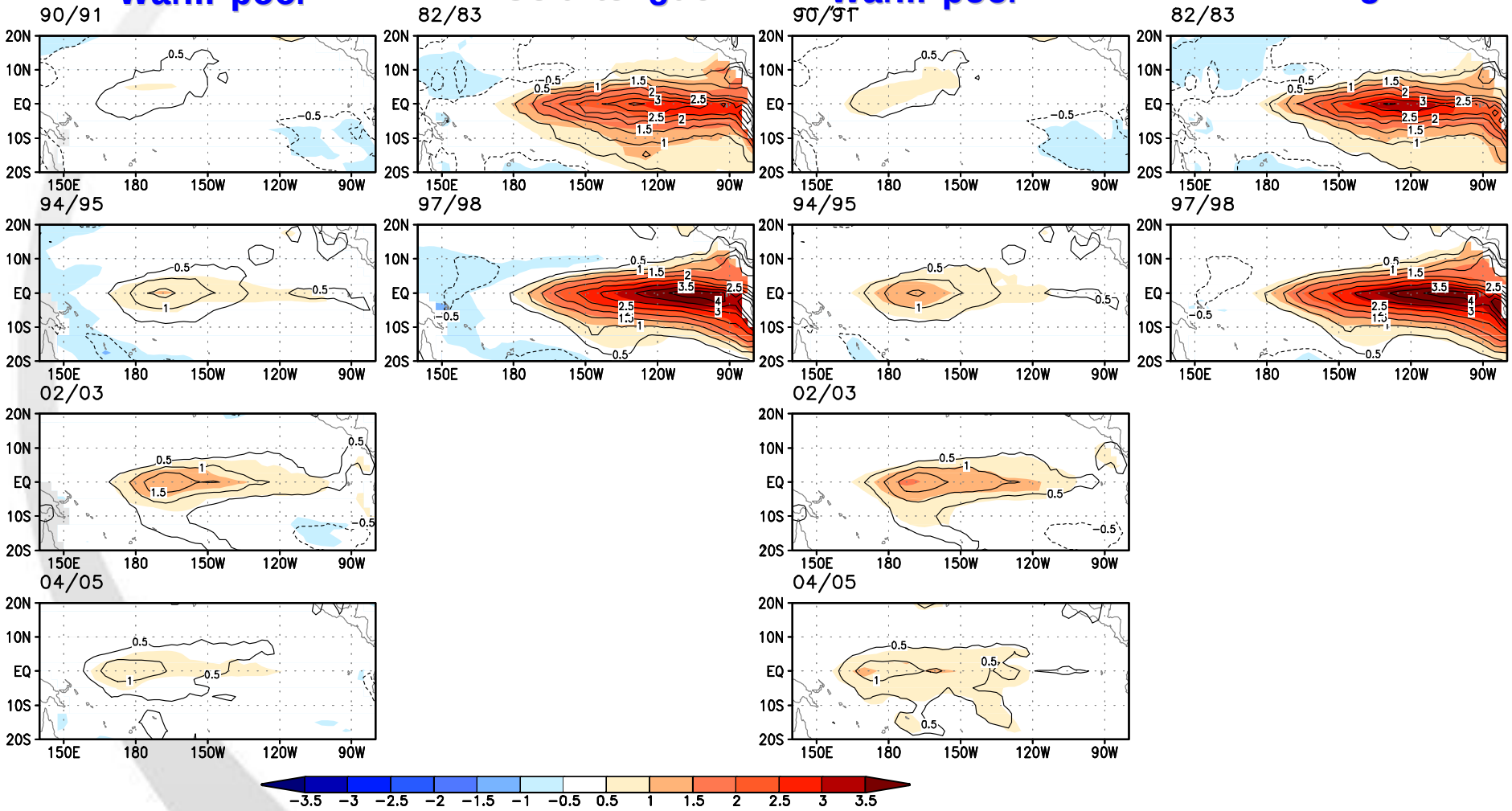
Warm-pool

Cold-tongue

SINTEX

Warm-pool

Cold-tongue



Shading is for model, and contour is for observation

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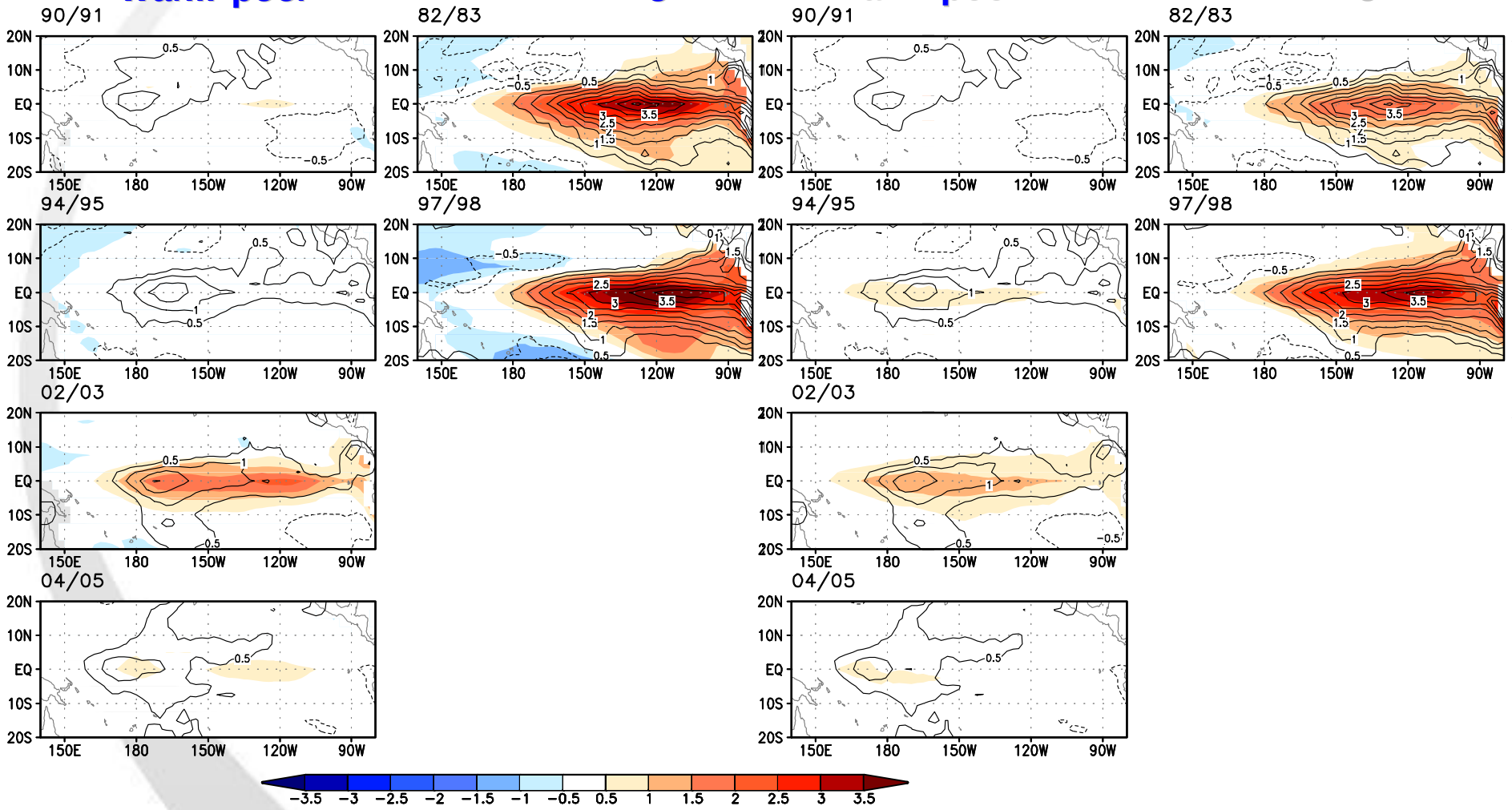
Simulated DJF SST Anomalies

Forecast lead month 6



Note: loss of predictability in the Warm Pool El Nino cases

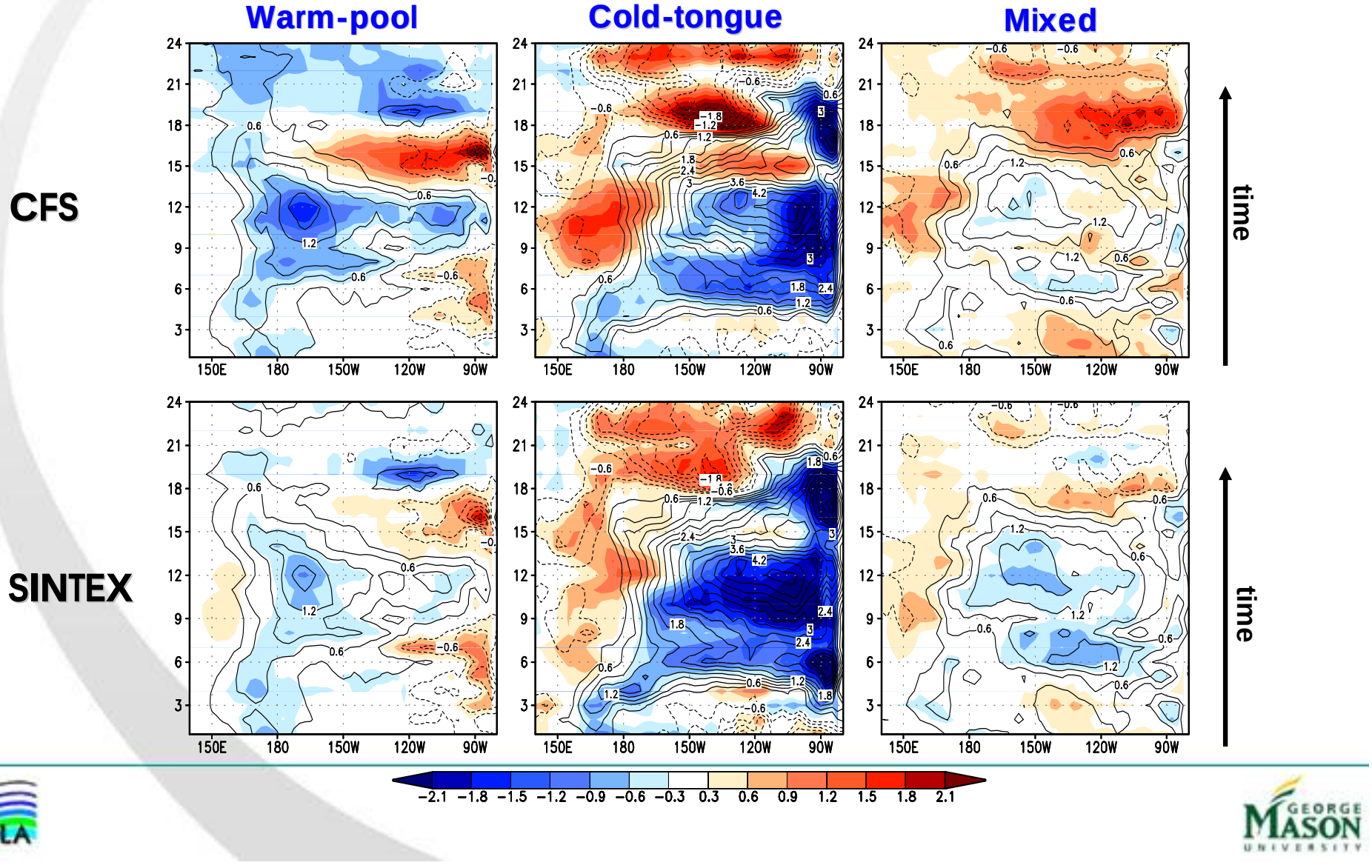
Shading is for model, and contour is for observation

Composite of SST Anomalies along the Equator

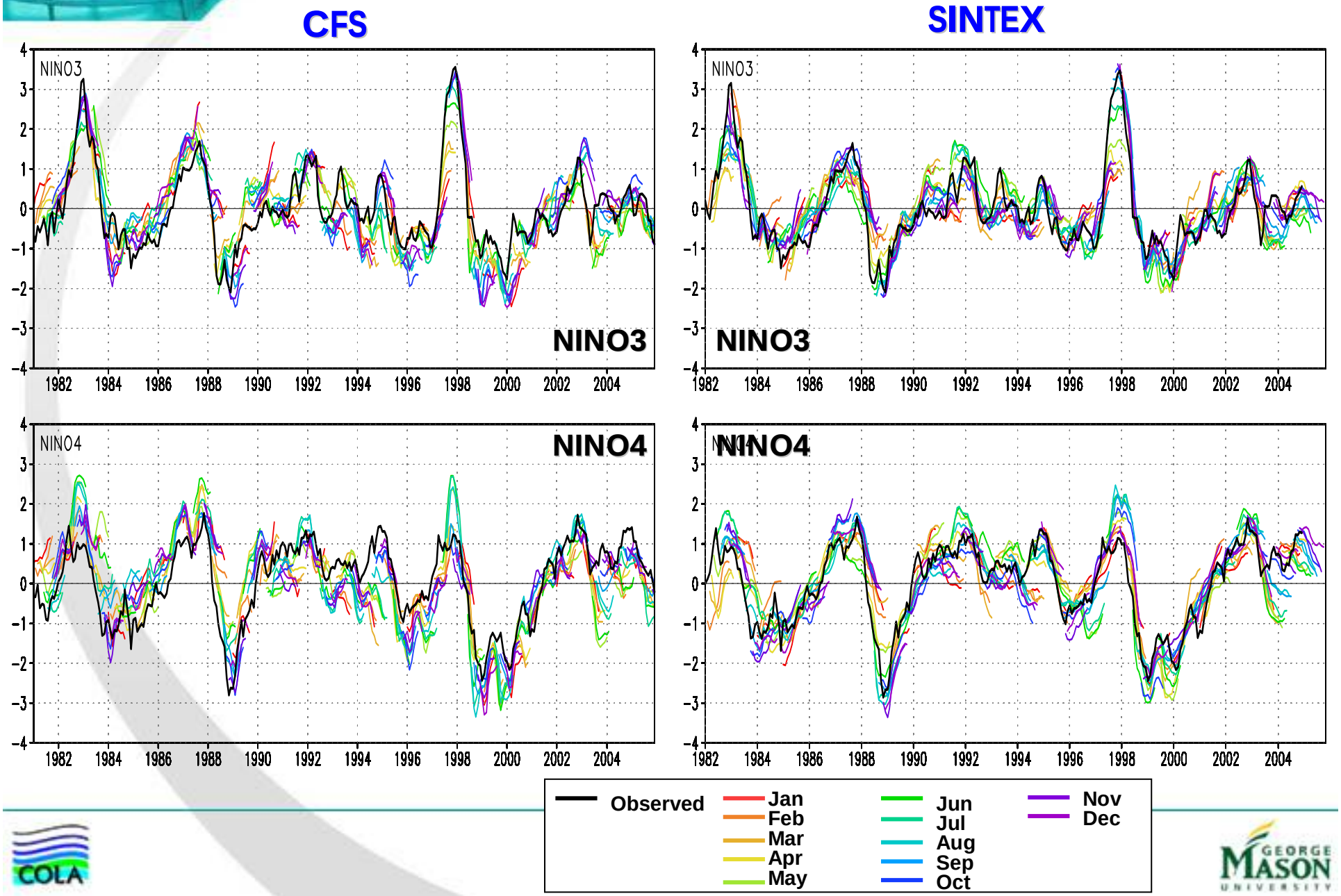
Forecast lead month 7

Note: Positive anomaly and negative bias in the Warm Pool and Cold Tongue

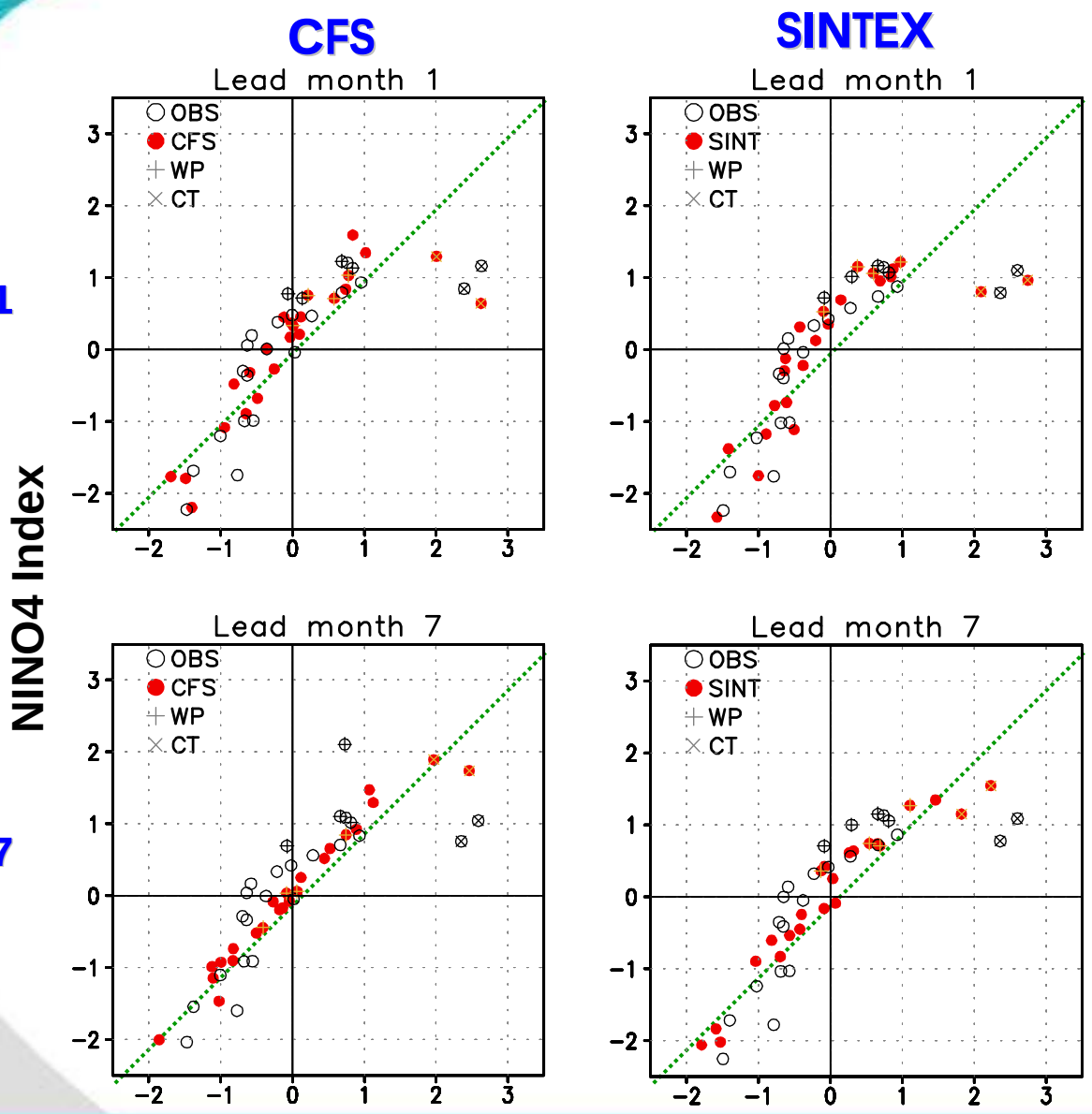
Shading is for model bias, Contour is for observed composite



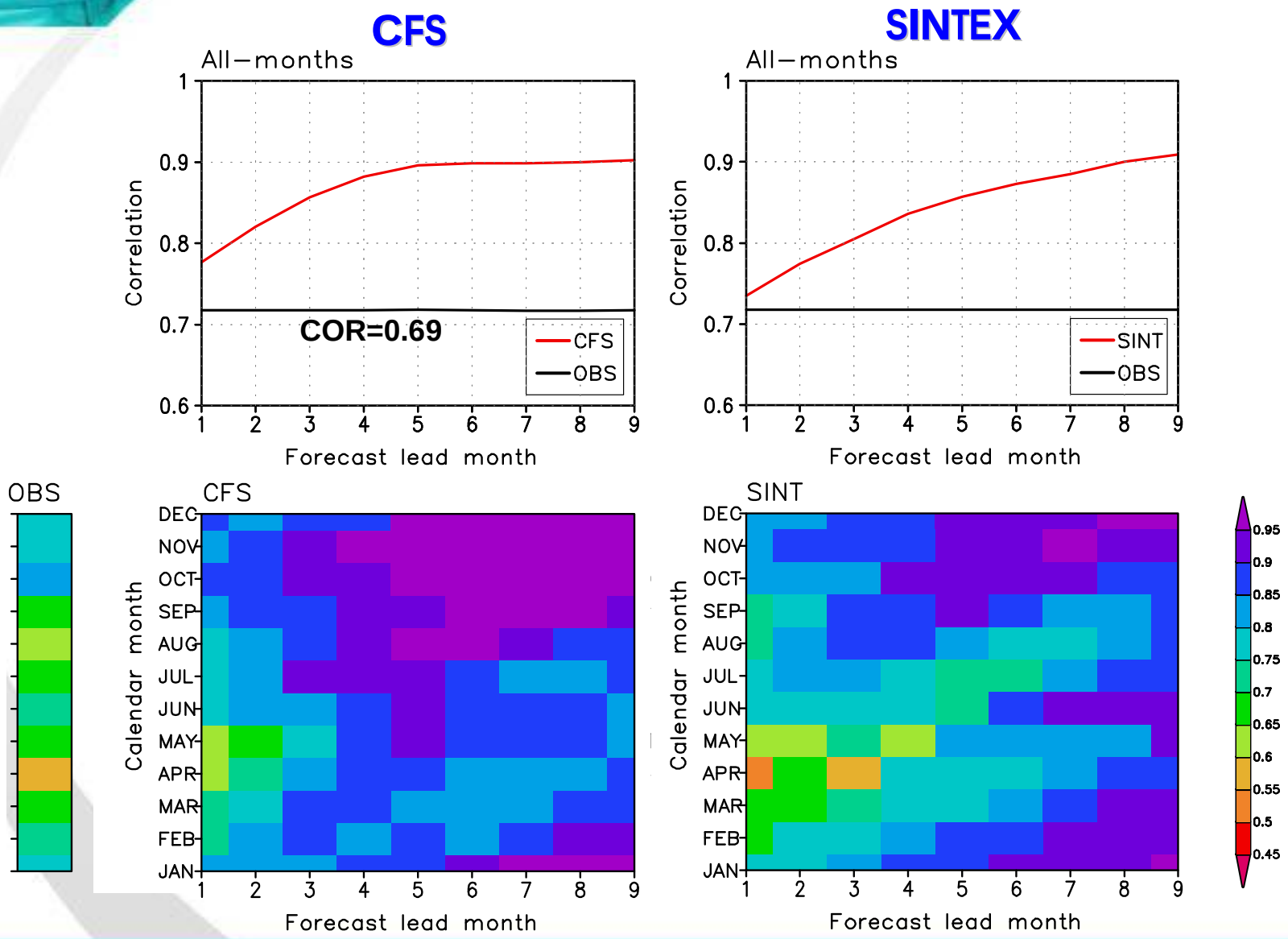
Interannual Variability of NINO3 and NINO4



Scatter Diagram of Normalized DJF NINO3 vs. NINO4

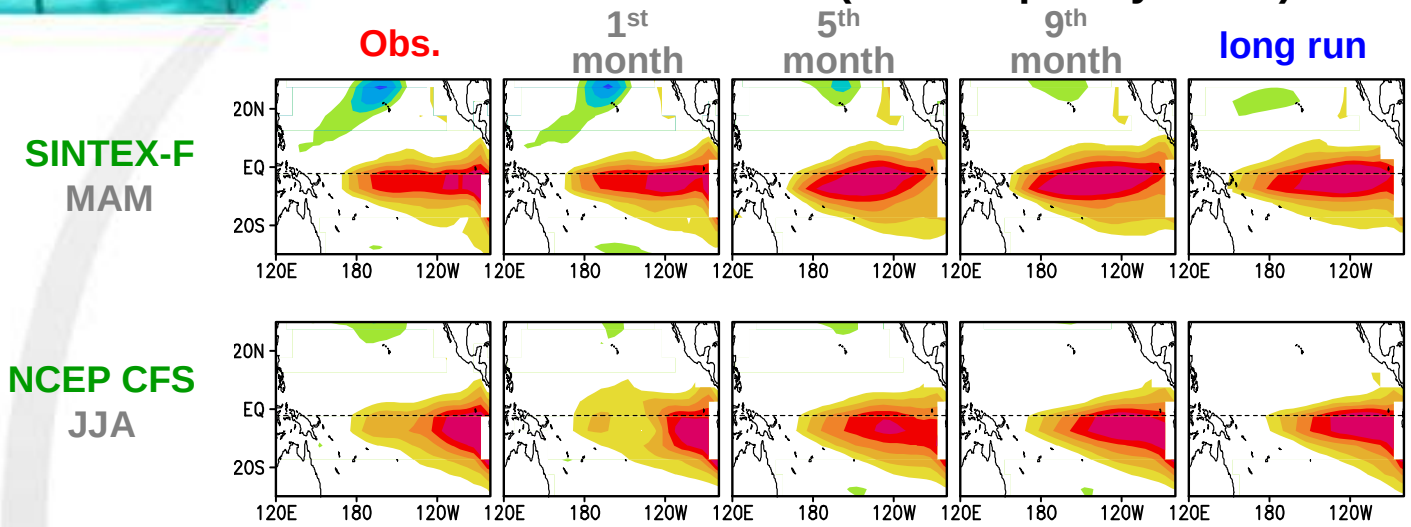


Relationship between NINO3 and NINO4



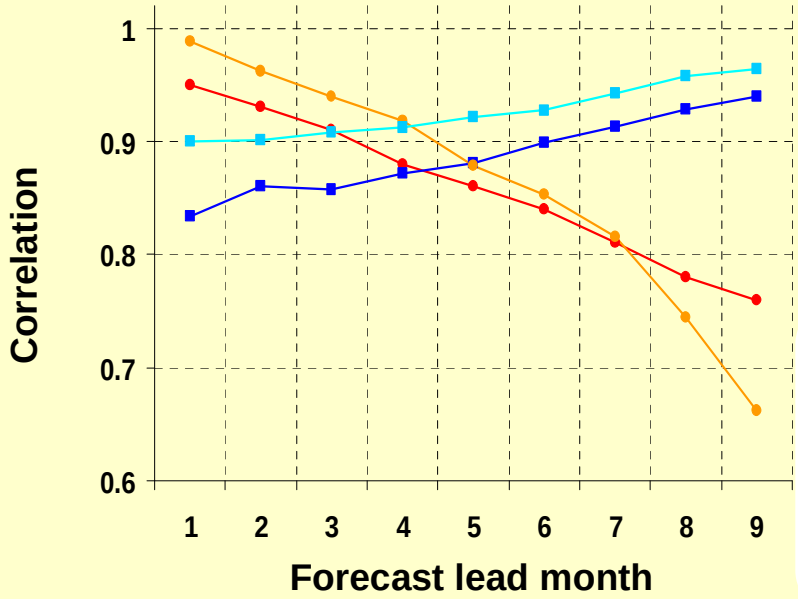
Impact of Couplde Model Error on Predictability

1st mode SEOF of SST (Low frequency mode)



Jin and Kinter, 2008 Climate Dynamics

Correlation coefficients with respect to lead month



SINTEX-F
NCEP CFS
Temporal correlation of PC timeseries with observation

SINTEX-F
NCEP CFS
Pattern correlation of eigenvector with free long run

✓ **With increase of the lead month, the forecast ENSO mode progressively approaches to the model intrinsic mode in free coupled run and departs from the observed.**

Model and Dataset

	Free long run	forecast	
PRCGC SINTEX	• 202-year simulation • Analyzing last 200 years (200-yr climatology)	• 1982-2004 period • 9 members • 12 calendar months ICs • 12 months lead	Luo *et al*. 2005
NCEP CFS	• 52-year simulation • Analyzing last 50 years (50-yr climatology)	• 1981-2003 period • 15 members • 12 calendar months ICs • 9 months lead	Saha *et al*. 2006

Courtesy of *J.-J. Luo, T. Yamagata, and K. Pegion*

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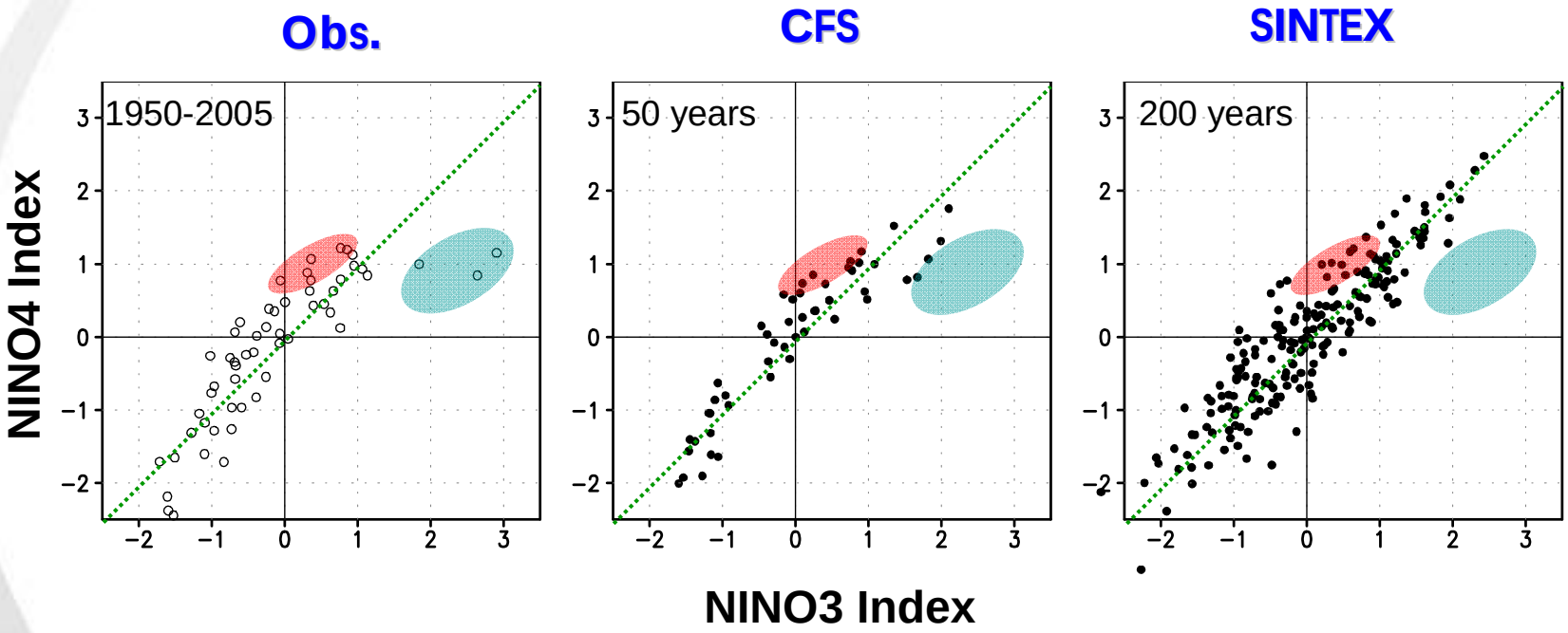
Scatter Diagram of Normalized DJF NINO 3 vs. NINO 4

From free long run of two CGCMs

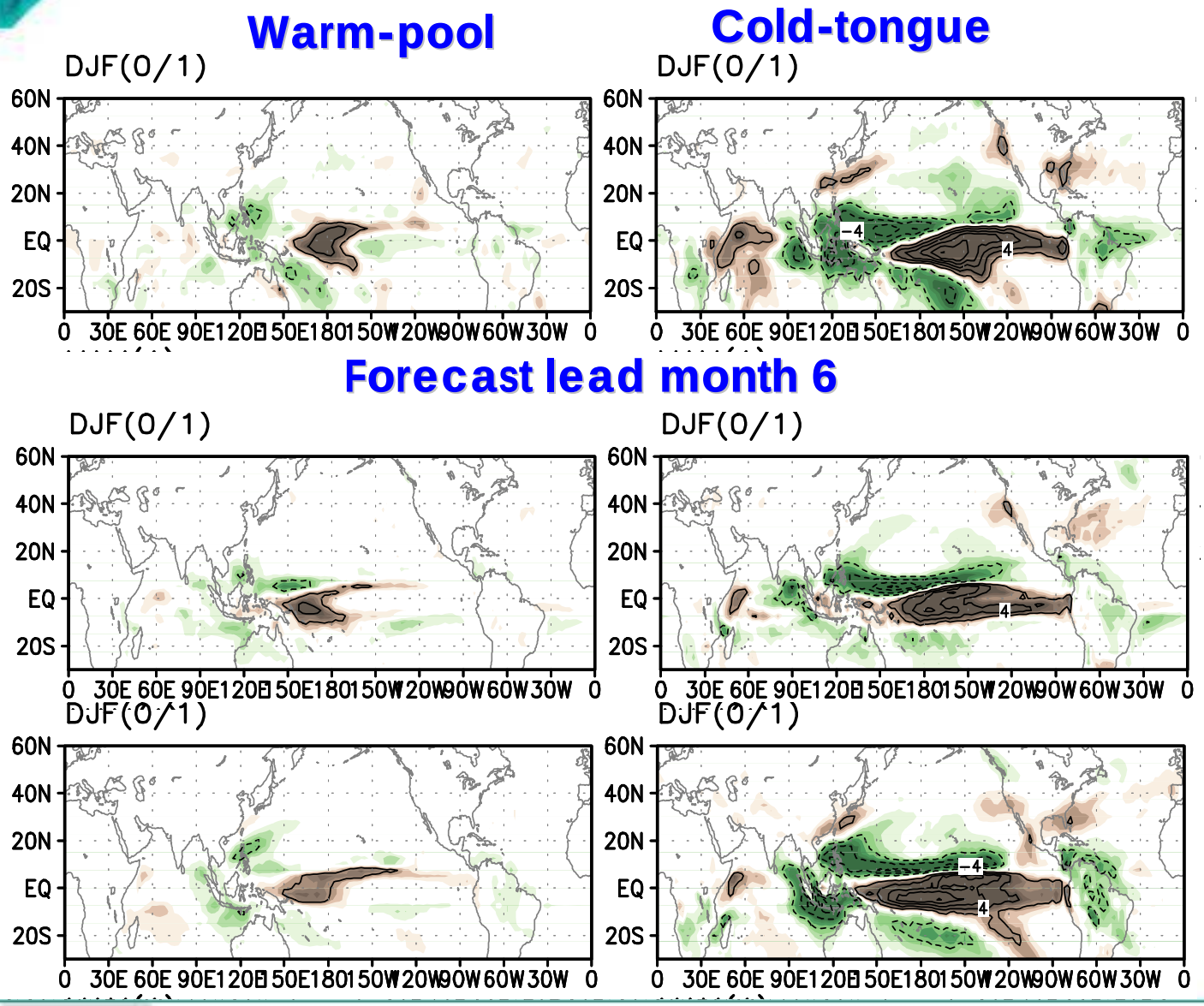


	Obs.	CFS	SINTEX
COR=(NINO3, NINO4)	0.69	0.82	0.86

Shading: Observed; models do not capture observed behavior

→ Model Flaw: One Flavor of El Nino

Observed Composite of Precipitation Anomalies

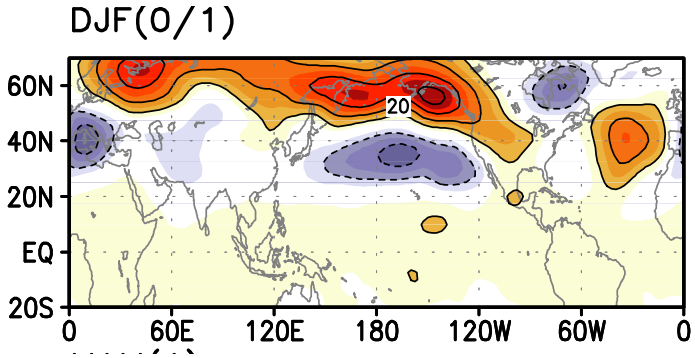


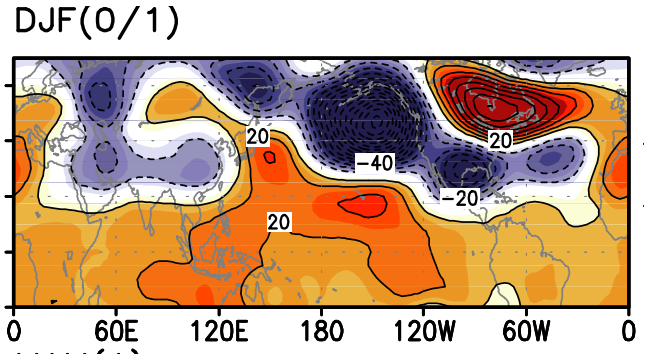
500 hPa GPH Anomalies

Warm-pool

Cold-tongue

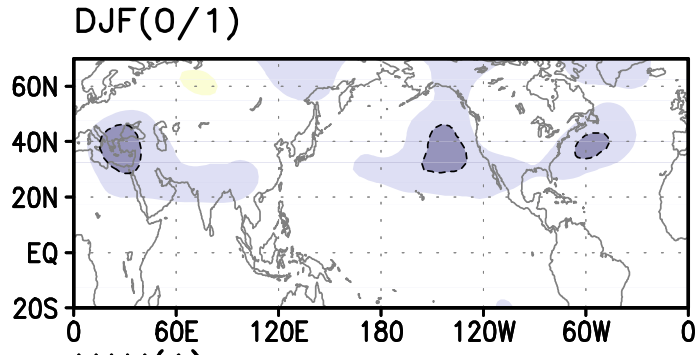
Obs.

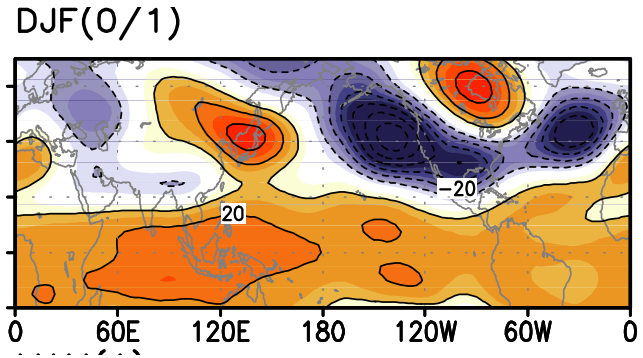




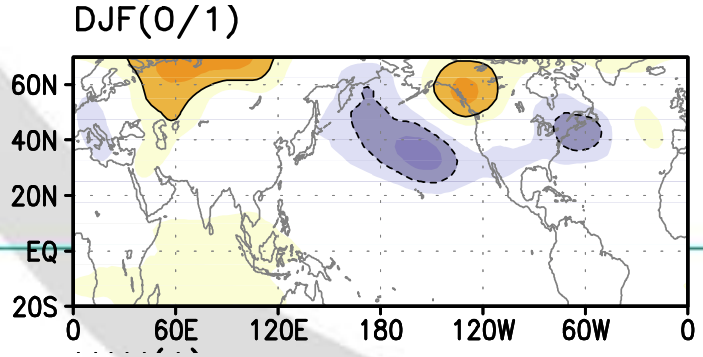
Forecast lead month 6

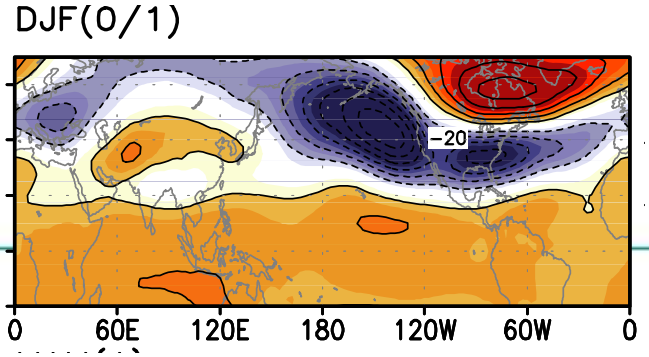
CFS





SINTEX





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Summary

- In two state-of-the-art CGCMs, the forecast skill of El Niño is investigated focusing on two flavors of El Niño: Warm-pool and cold-tongue.

- As the lead month of forecast increases, the models fail to distinguish between two flavors of El Niño.

- Both models have difficulties to reproduce the nonlinear relationship between NINO3 and NINO4 SST anomalies.

- From the free long run, models tend to simulate the mixed mode of El Nino rather than warm-pool or cold-tongue El Niño.

- Tropical precipitation and extratropical circulation anomalies associated with two flavors of El Niño are not captured by models.

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Thank You !

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