Assessment of the MJO Teleconnection Pattern in the Boreal Winter Simulated by Dynamical Seasonal Prediction Systems

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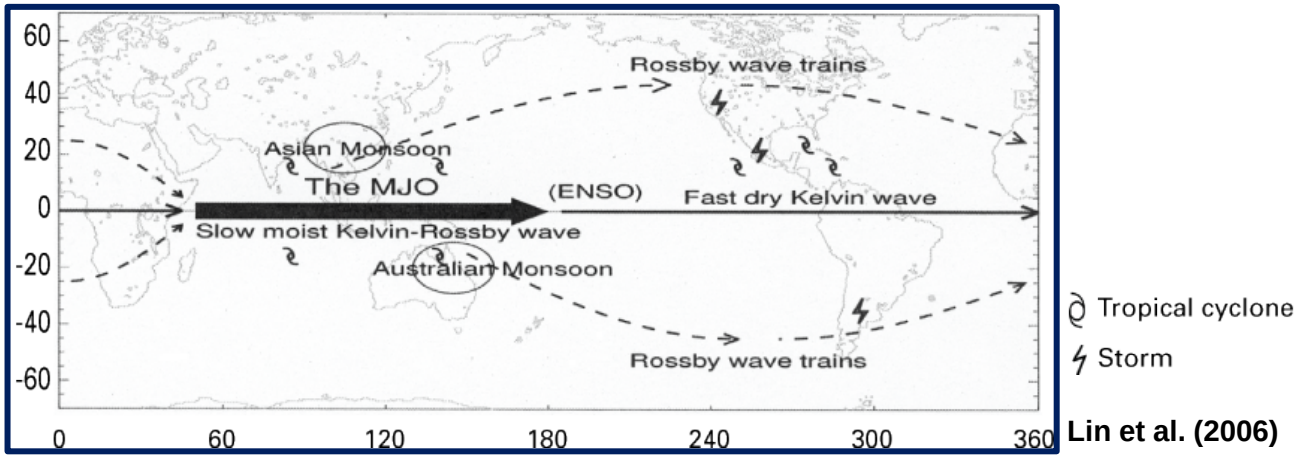
Introduction

- The **Madden-Julian Oscillation (MJO)** is the dominant mode of intraseasonal variability in the tropics atmosphere, with the time scale of 30-70 (or 15-70) days.

- Many precedent researches analyzed using observed data explain that upper-level circulation anomaly related with tropical convection influence directly on weather and climate variances over **tropics** (Maloney and Hartmann, 2000; Ho et al., 2006), and **subtropics and mid-latitudes** (Jeong et al., 2008, Moon et al. 2011) by teleconnection.



Lin et al. (2006)

- Recently, there is a growing interest in prediction of MJO teleconnection, especially related with El Nino/La Nina **using seasonal forecasting system**.

- Thus, this study investigates the predictability of MJO teleconnection patterns associated with El Nino/La Nina simulated by dynamic seasonal forecasting systems.

Description of Seasonal Forecasting Systems

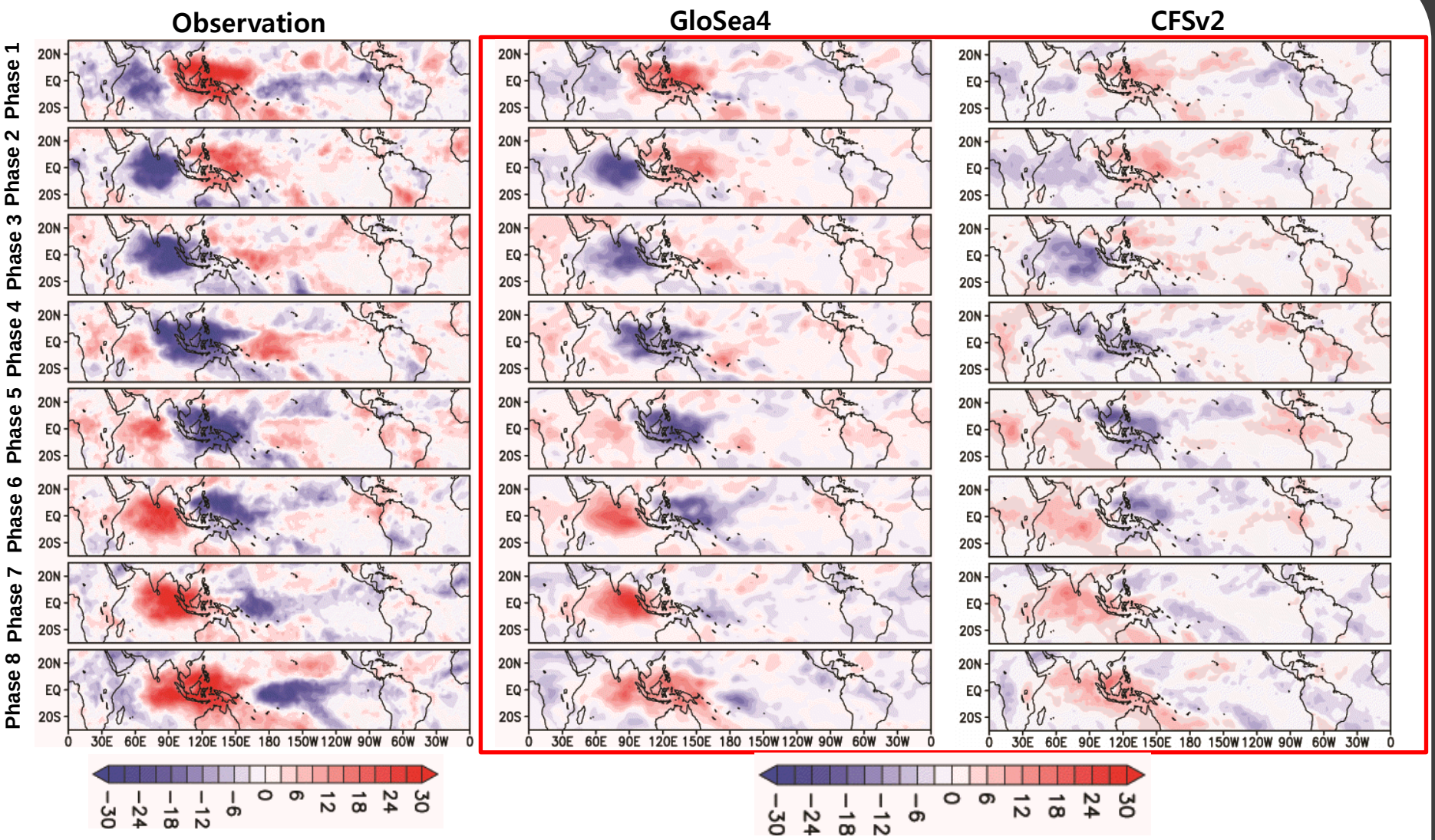
Summary of Dynamical Seasonal Forecasting Systems

		GloSea4	CFSv2
Model	Atmosphere	GA2.0 UM version 7.6	GFS (Global Forecast System)
	Ocean	NEMO 3.0	MOM4
Resolution	Atmosphere	**Horizontal**: N96 (~ 125km) **Vertical**: L85	**Horizontal**: T126 (~ 100km) **Vertical**: L64
	Ocean	**Horizontal**: ORCA tri-polar grid at 1.0° (1/3 of a degree near Equator) **Vertical**: L75	**Horizontal**: 0.5° (0.25° within 10° of the equator) **Vertical**: 40 levels
Initial data	Atm/Land	ERAinterim	CFSR reanalysis
	Ocean	Seasonal ODA reanalysis	NEMO (ECMWF)
Period		1996-2009, Nov.-Mar. (13 winters)	
# of Ensemble Members		**60** (Nov. – Mar.)	**120** (Nov. – Mar.)

- **Validation data**
  - Outgoing long-wave radiation (OLR) from **AVHRR** satellite data
  - Wind field data from **MERRA** reanalysis data

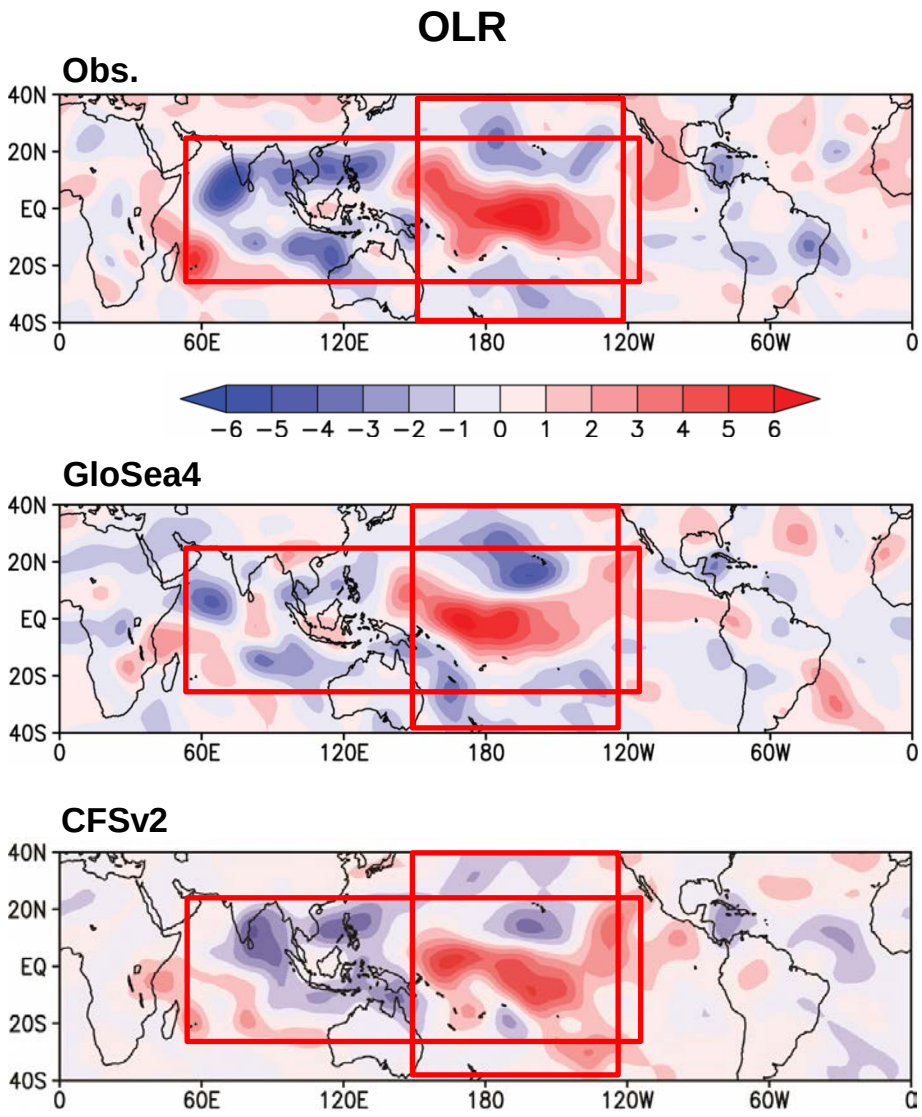
- Intraseasonal variability is defined as filtered data with **30-70 days.**

Eastward Propagation of MJO



- **GloSea4 and CFSv2 represent the tropical convection propagating patterns from the Indian Ocean to the western Pacific reasonably.**

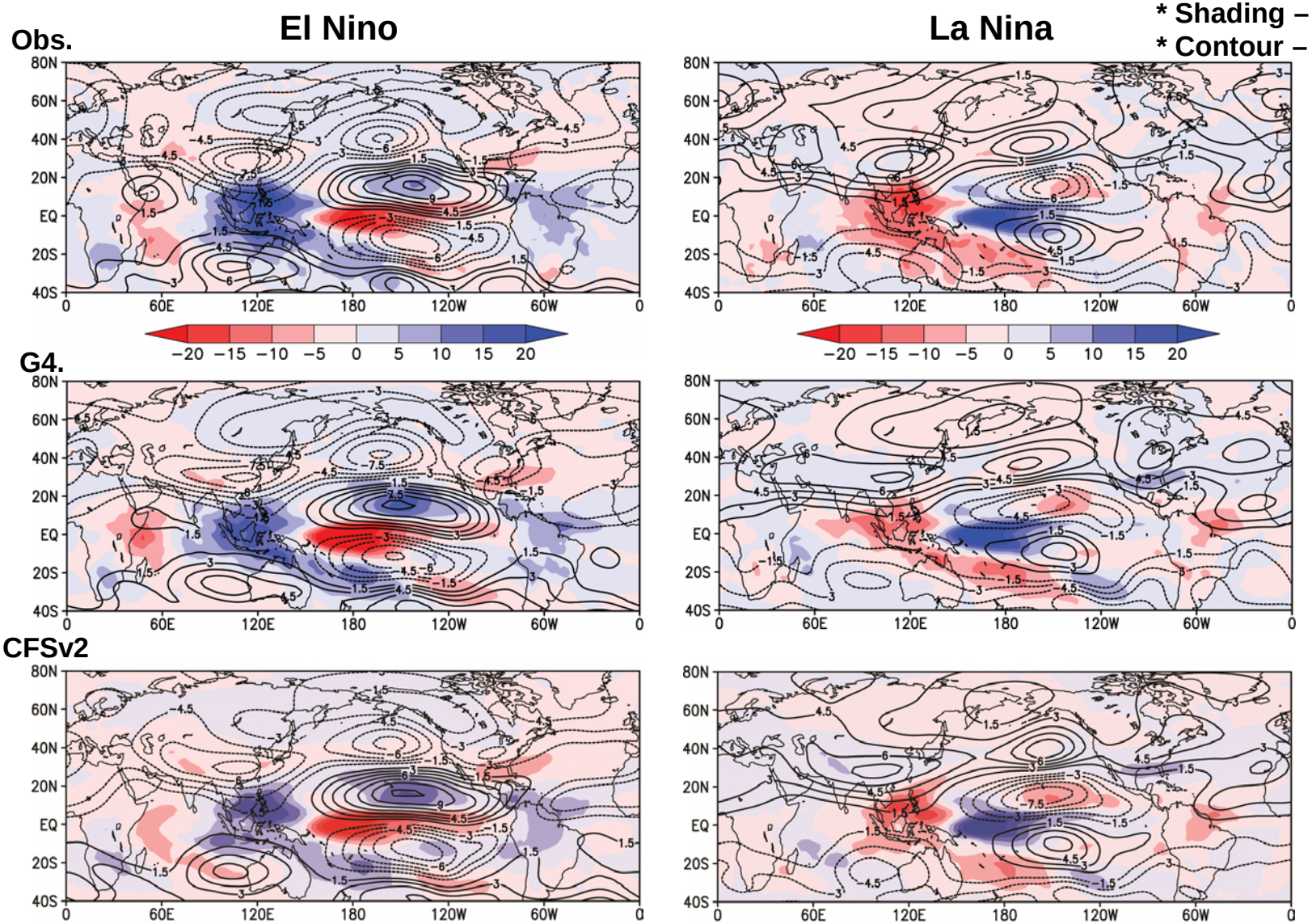
ISV (30~70 days) Changes by ENSO



- Shading – Difference of Intraseasonal variability (ISV) between El Nino – La Nina

- **The ISV of tropical convection in El Nino year is stronger over tropical central Pacific ocean dominantly than La Nina year.**
- **In addition, in La Nina year, the variability appears strongly over the sub-tropic regions in South Asia and the central Pacific ocean.**
- **GloSea4 and CFSv2 depict these features similarly.**
- **Therefore, two seasonal forecasting systems represent difference of ISV between El Nino and La Nina years reasonably.**

ENSO Response in Seasonal Mean

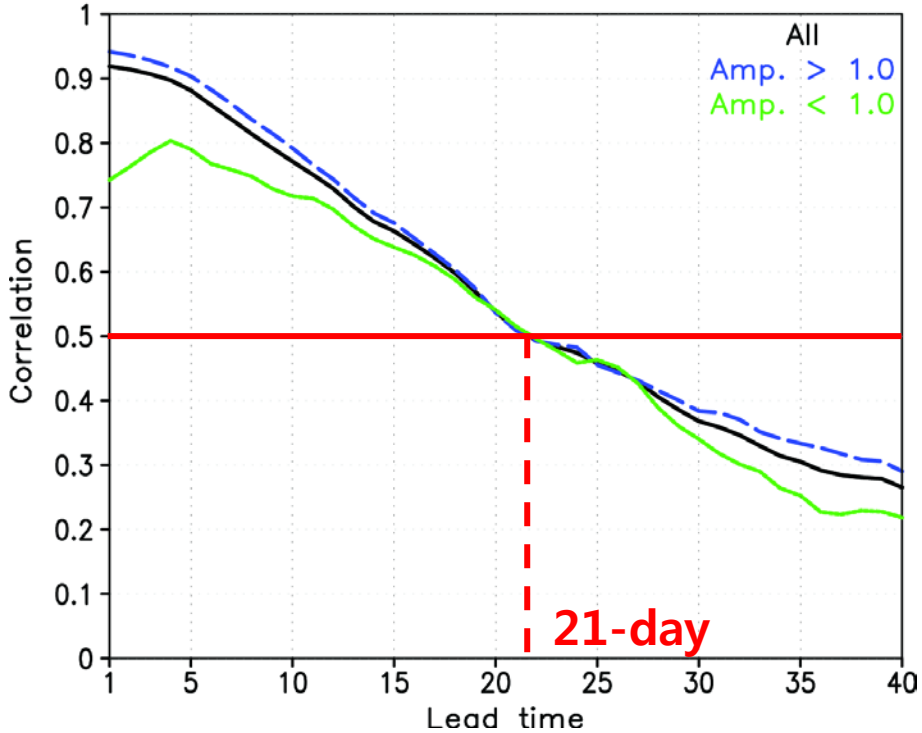


- **Simulated mean fields patterns in wintertime are similar to the observations, but the intensities are weaker than the observed mean fields.**

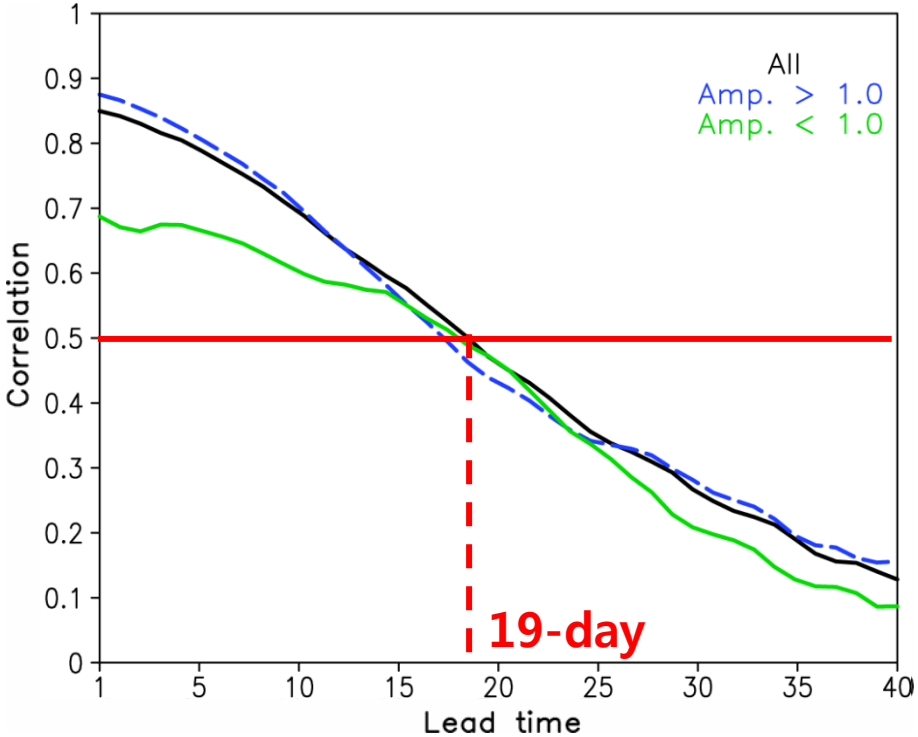
MJO Prediction Skill in the Tropics

- **Correlation coefficient**

(a) GloSea4



(b) CFSv2



- **GloSea4 and CFSv2 produce skillful forecasts until about 21 days and 19 days, respectively.**

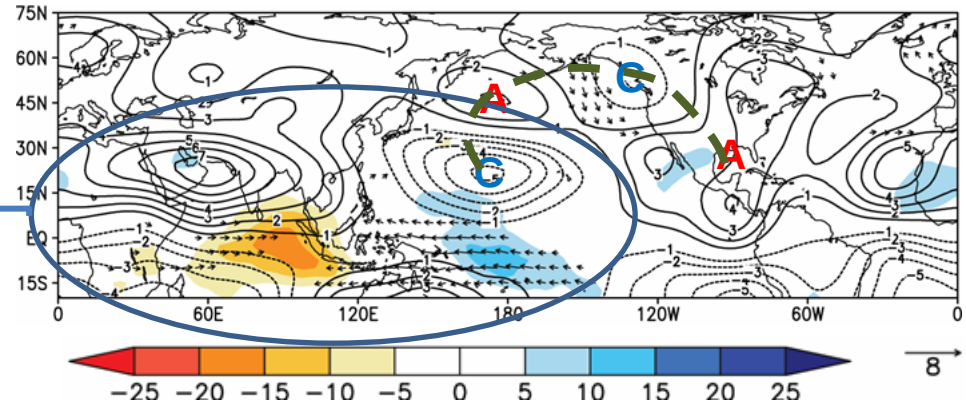
- **The MJO forecast skill of seasonal forecasting systems are sensitive to initial MJO amplitude.**

Observed MJO teleconnection changes by ENSO

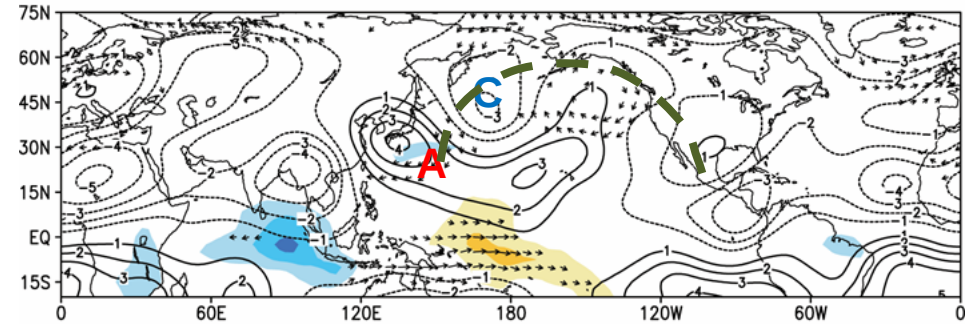
El Nino

* Shading – OLR
* Contour – SF200
* Vector – 850hPa wind

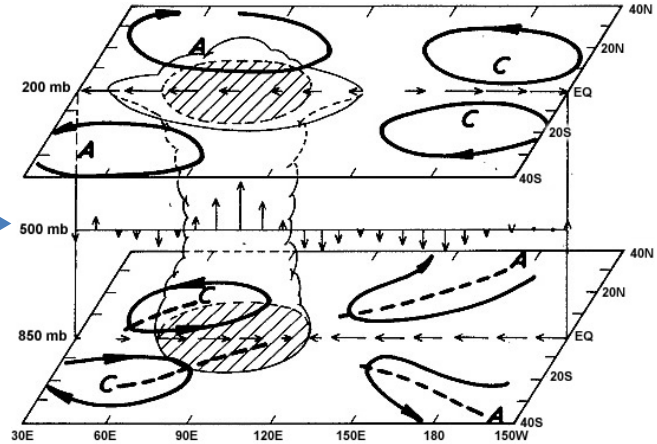
Phase 3



Phase 7



El Nino : 1982, 1986, 1987, 1991, 1994, 1997, 2002, 2004, 2006



Rui and Wang (1990)

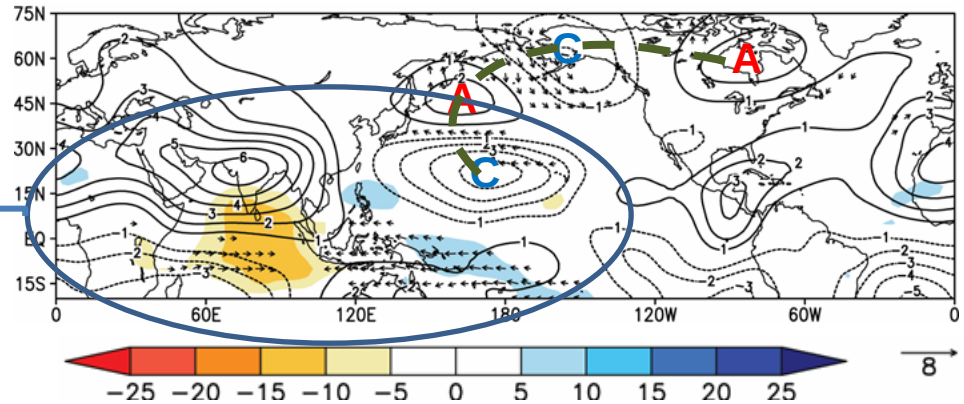
- **30-year observed MJO teleconnection patterns show large-scale wind structure of the MJO in Rui and Wang (1990) clearly.**

Observed MJO teleconnection changes by ENSO

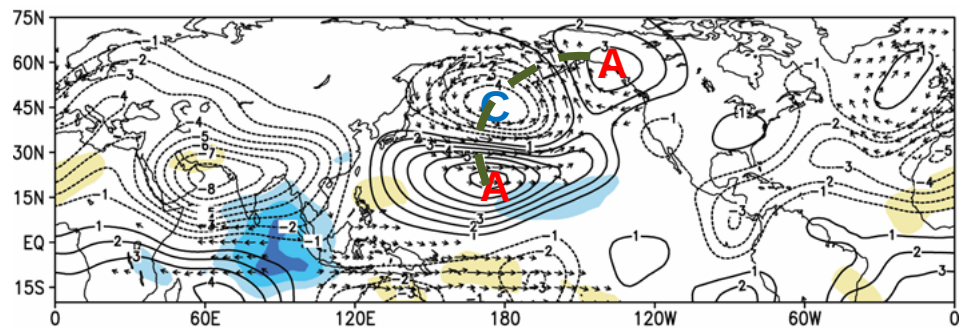
La Nina

* Shading – OLR
* Contour – SF200
* Vector – 850hPa wind

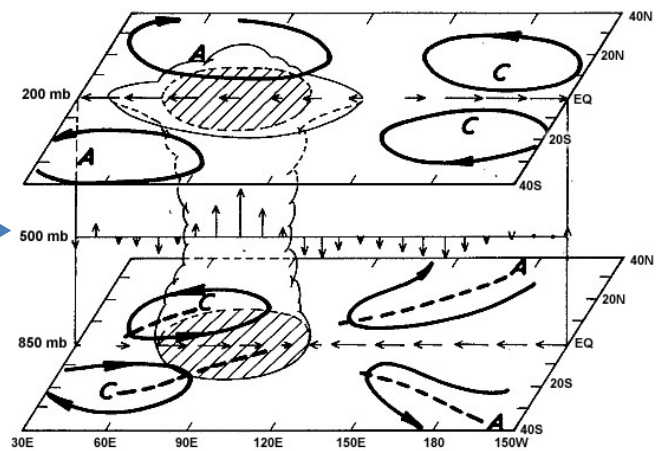
Phase 3



Phase 7



La Nina : 1983, 1984, 1988, 1995, 1998, 1999, 2000, 2005, 2007

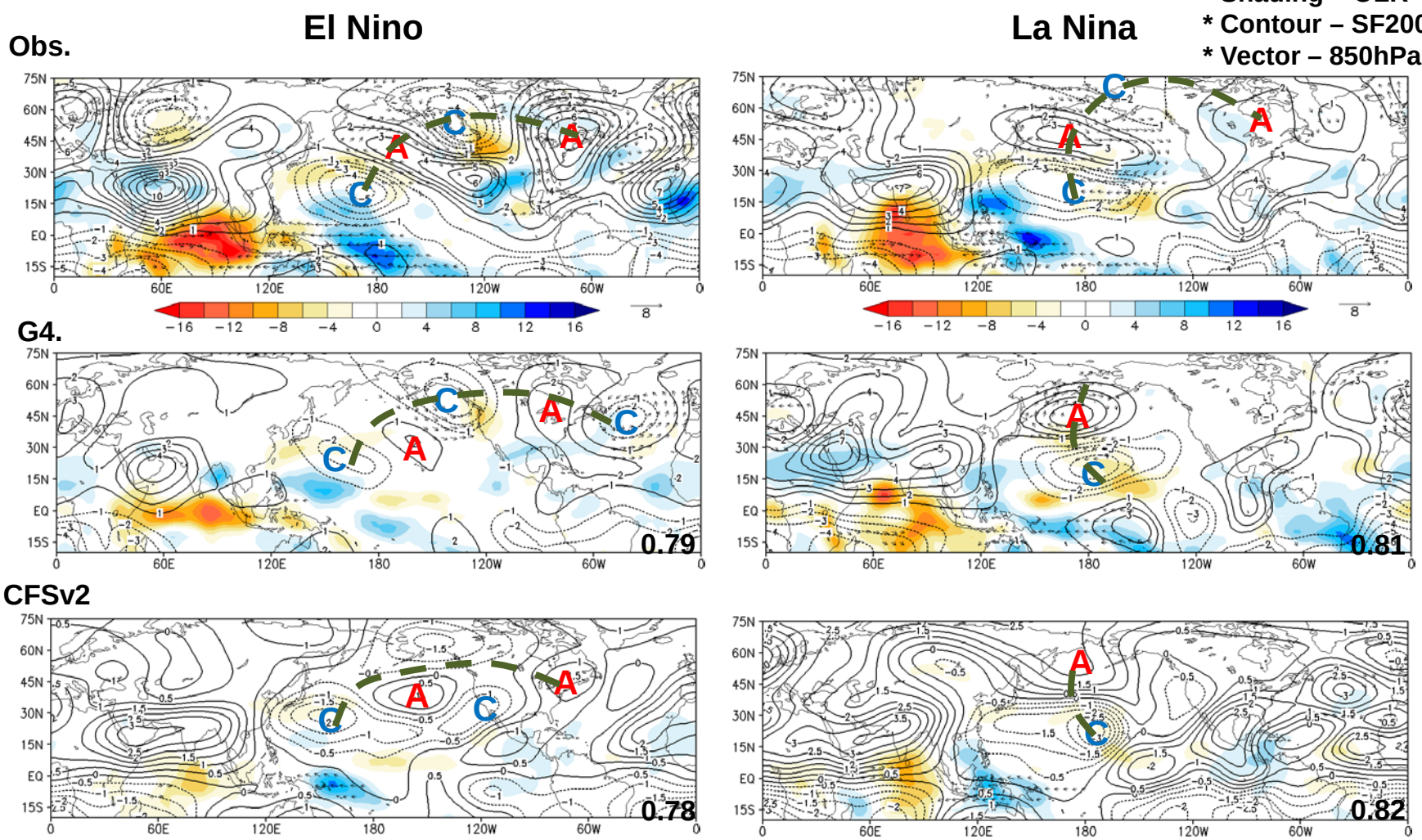


Rui and Wang (1990)

- **30-year observed MJO teleconnection patterns show large-scale wind structure of the MJO in Rui and Wang (1990) clearly.**

Model Comparisons (Phase map, Phase 3)

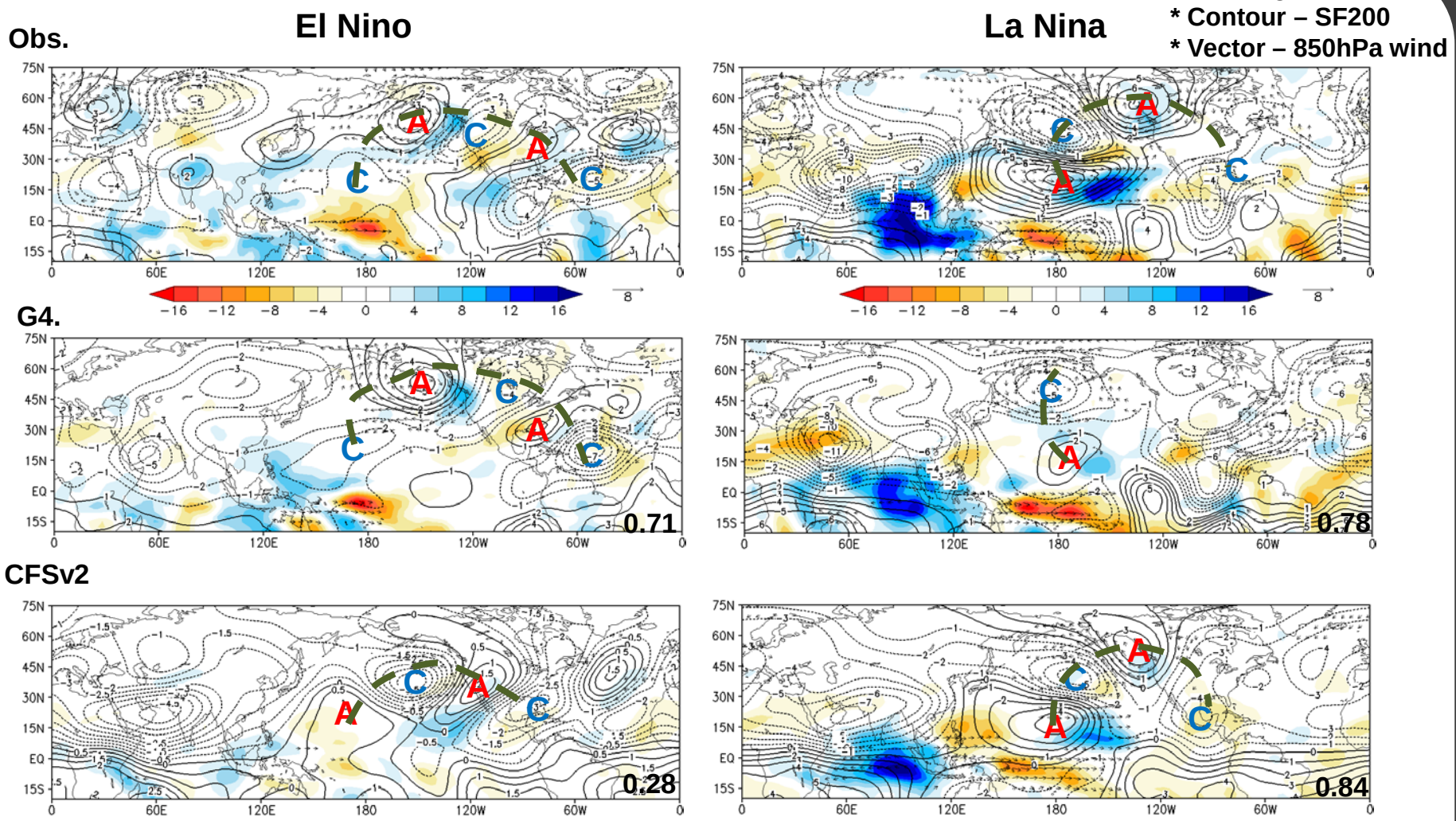
* Shading – OLR
* Contour – SF200
* Vector – 850hPa wind



- **Seasonal forecasting systems produce overall teleconnection patterns although the intensity is weakened considerably.**

Model Comparisons (Phase map, Phase 7)

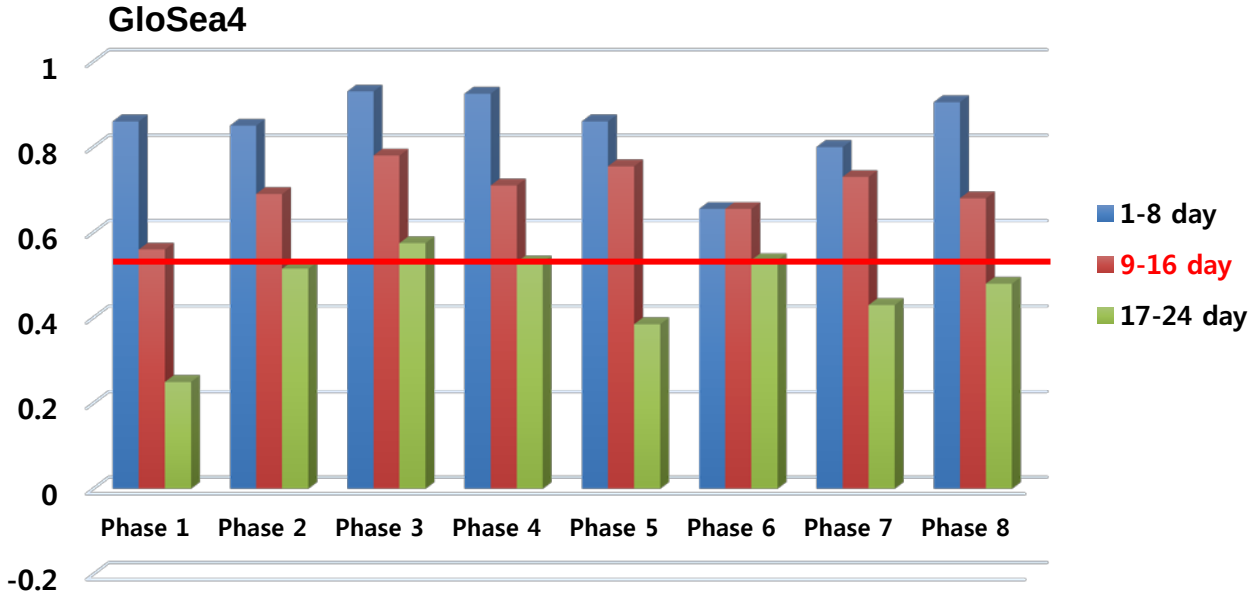
* Shading – OLR
* Contour – SF200
* Vector – 850hPa wind

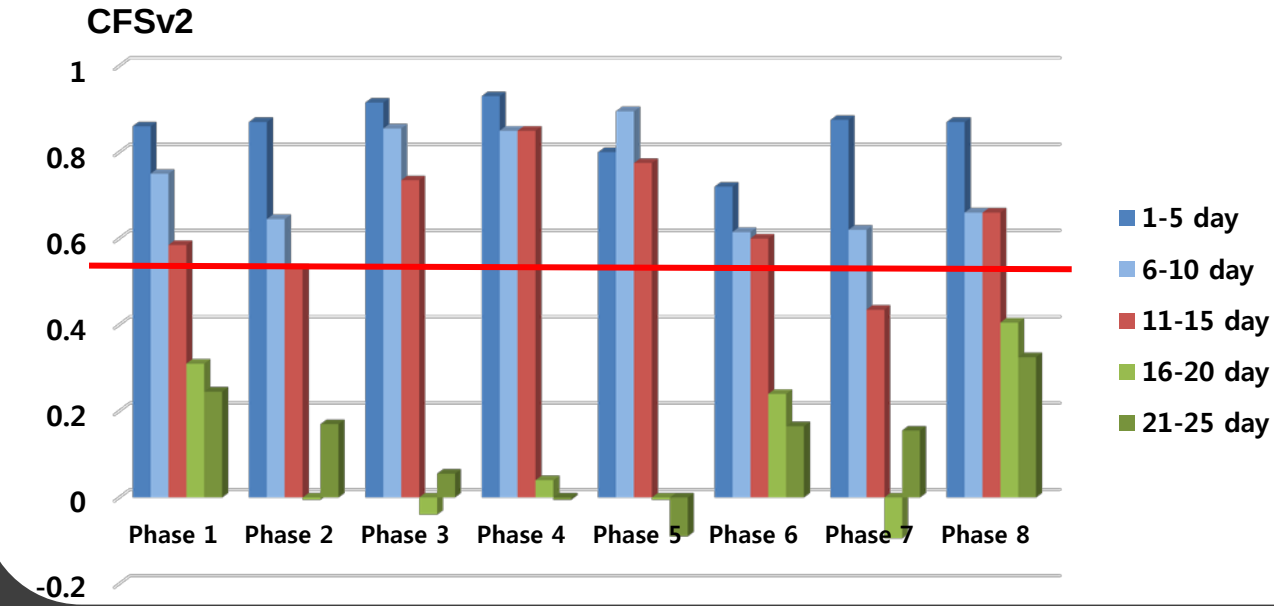


Model Comparisons (Predictability by lead time)

Averaged spatial correlation of El Nino and La Nina

Domain
- Lat. : 15°-80°
- Lon. : 0°-360°

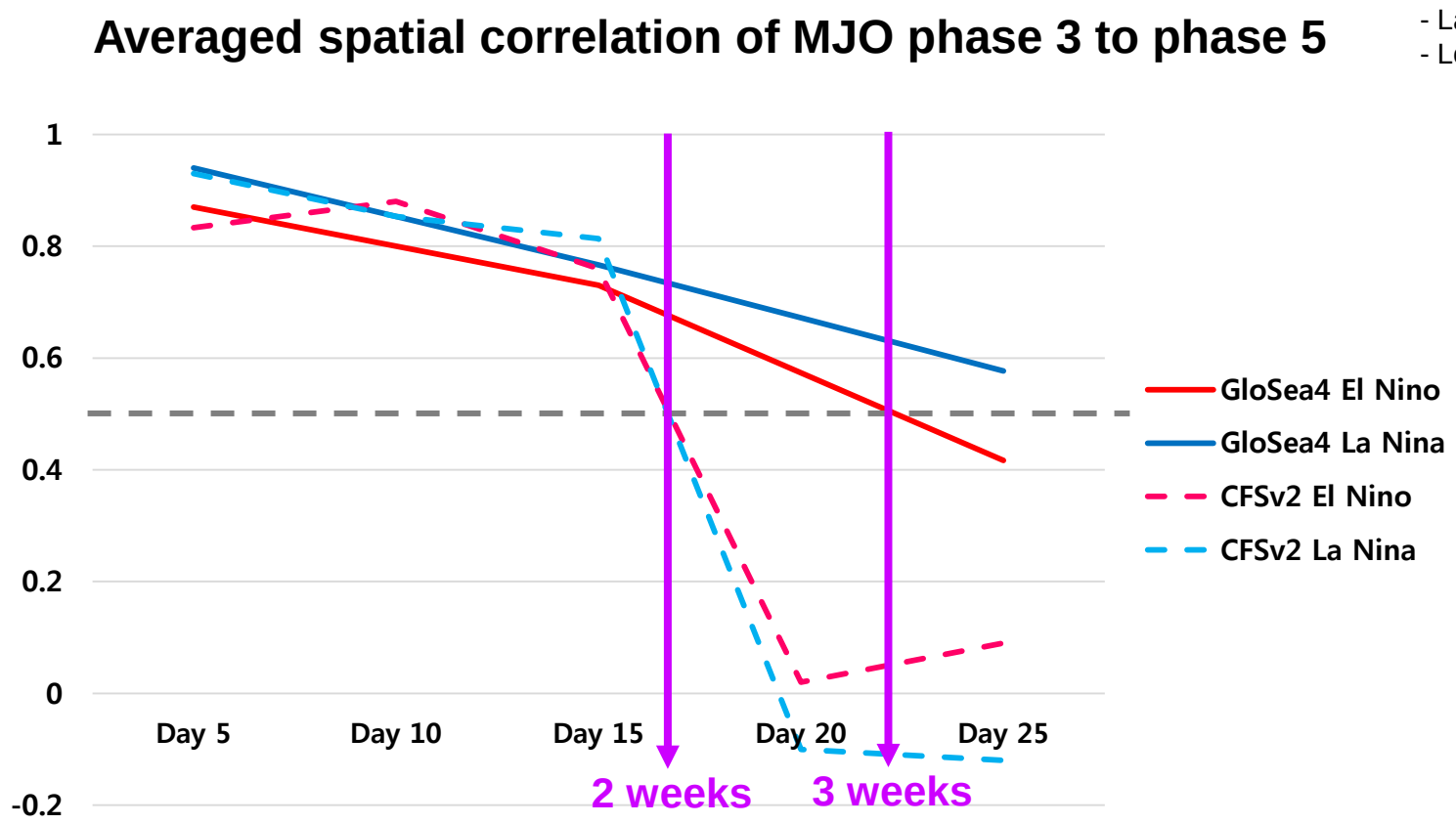




- **Predictability is quite different by MJO phase.**
- **Both systems have MJO teleconnection predictability up to about 2 weeks.**
- **The predictability of MJO teleconnection in seasonal forecasting systems are higher when the tropical convection is located in warm pool region. (Phase 3, 4, and 5)**

Model Comparisons (Predictability by lead time)

Domain
- Lat. : 15°-80°
- Lon. : 0°-360°



- **Within 15 days, GloSea4 and CFSv2 show similar MJO teleconnection predictability, but in La Nina year, the predictability is slightly higher than in El Nino year.**

- **After 15 days (about 2 weeks), the predictability of CFSv2 decreases rapidly.**

Summary & Conclusion

- **The current dynamical seasonal prediction systems (DSPs) demonstrate the MJO prediction skill extended by 2~3 weeks, depending on the performance of the system.**

- **Observational analyses show the MJO teleconnection changes significantly according to the phases of ENSO: the MJO signal excites different routes of Rossby wave trains, presumably by the change in the background state change by ENSO.**

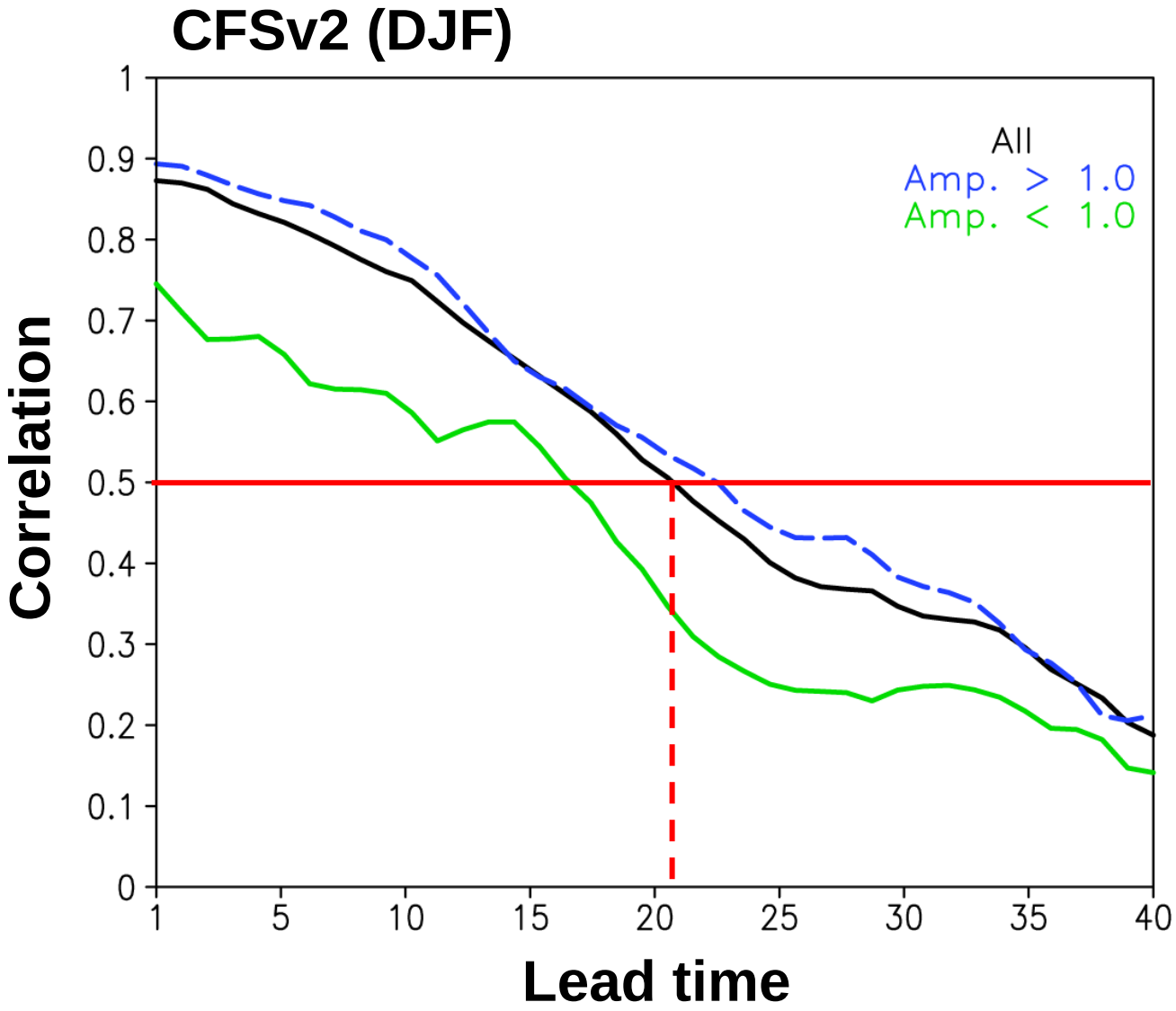
- **The MJO teleconnection also changes according to the phase of MJO: the large-scale circulation anomalies over East Asia and North America show the flipped circulation patterns.**

- **Within 2~3 weeks, these observed features are reproduce realistically by the DSPs – Limitation seems to be caused by the fundamental limit of MJO prediction.**

- **The DSPs demonstrate a higher skill when the MJO convection resides over Indo-Pacific warm pool region. The systems also show a more extended skill for the MJO teleconnection in La Nina, compared with El Nino.**

- **This study highlights that the DSPs exhibit a good potential for the mid-ltatitude circulation anomalies associated with the tropical MJO in the S2S (subseasonal-to-seasonal) time scale.**

Thank You for Your Attention!

MJO Prediction Skill in the Tropics

- **Correlation coefficient**