Air-sea interaction over the Indian Ocean after El Nino in JMA/MRI-CGCM seasonal forecast experiment

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with

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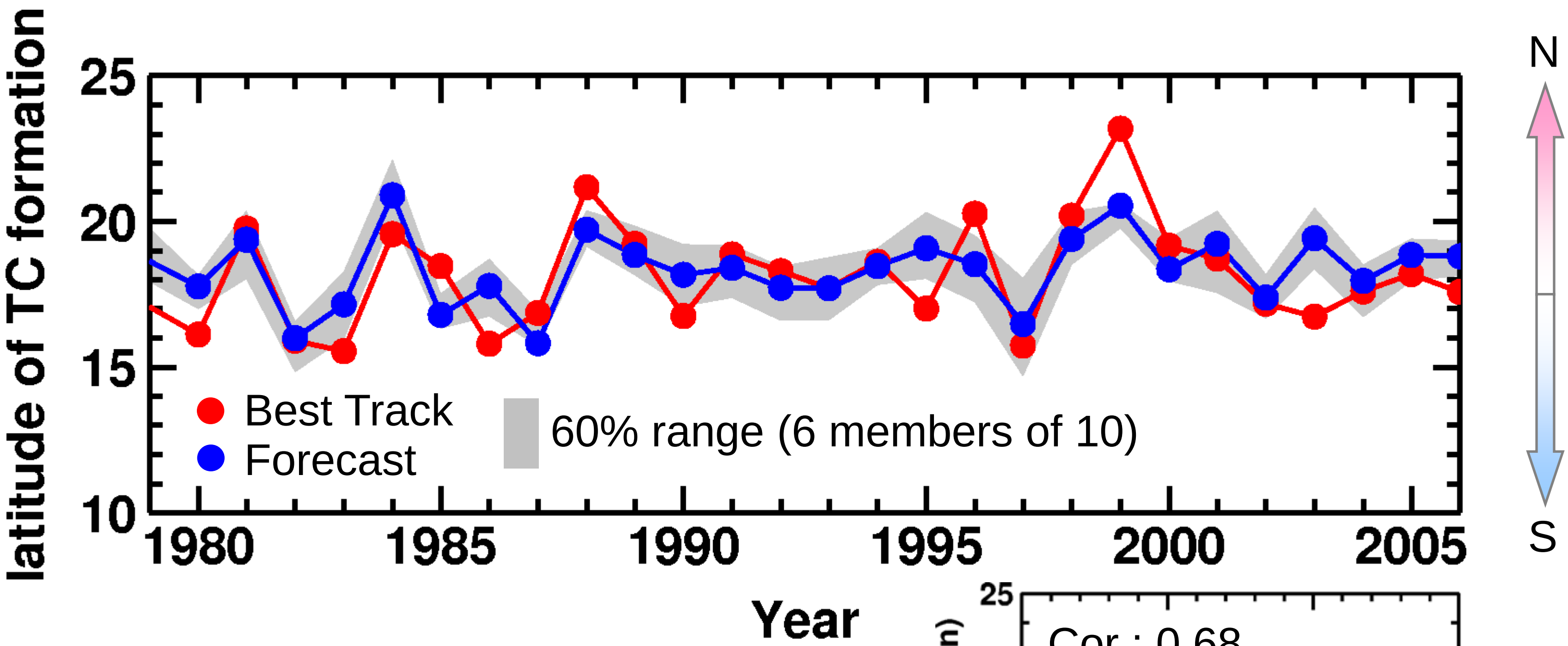
Predictability of the mean location of Typhoon formation in a seasonal prediction experiment with a coupled general circulation model

Takaya, Y., T. Yasuda, T. Ose, and T. Nakaegawa

Journal of Meteorological Society of Japan,
2010, 88, 799-812.

Mean Latitude of TC Formation

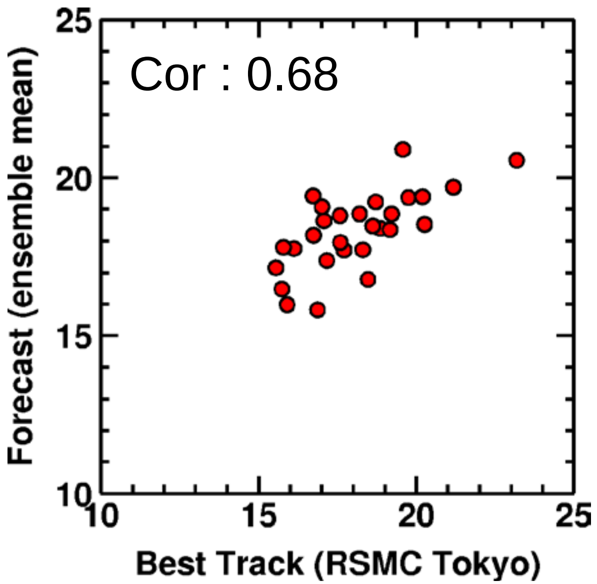


Reference : RMSC Tokyo Best Track

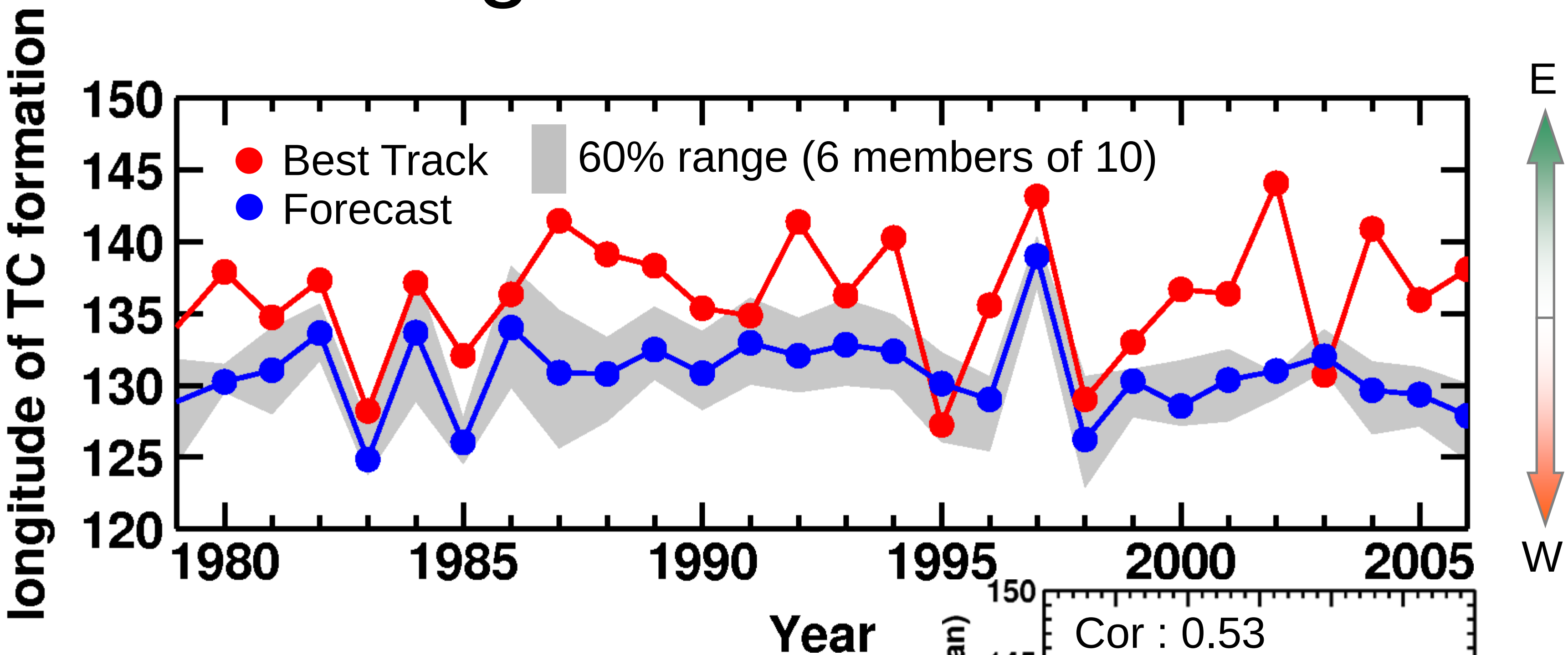
Region : 0-40N, 100E-180

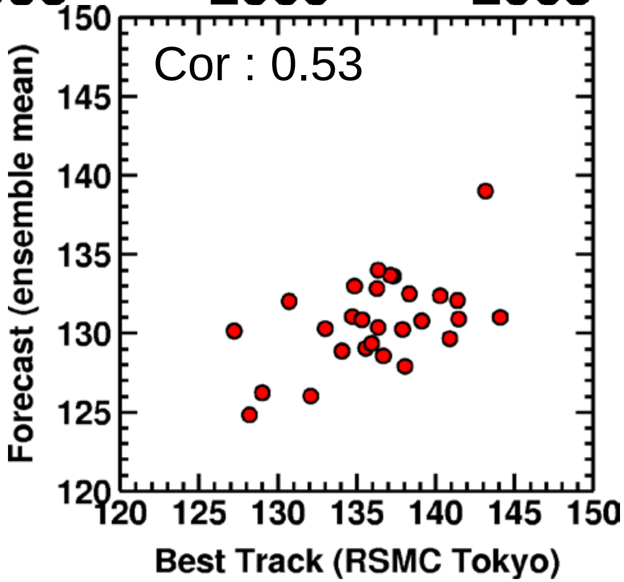
Period : Jun.-Oct.

Correlation : 0.68 (1979-2006)



Mean Longitude of TC Formation





Reference : RMSC Tokyo Best Track

Region : 0-40N, 100E-180

Period : Jun.-Oct.

Correlation : 0.53 (1979-2006)

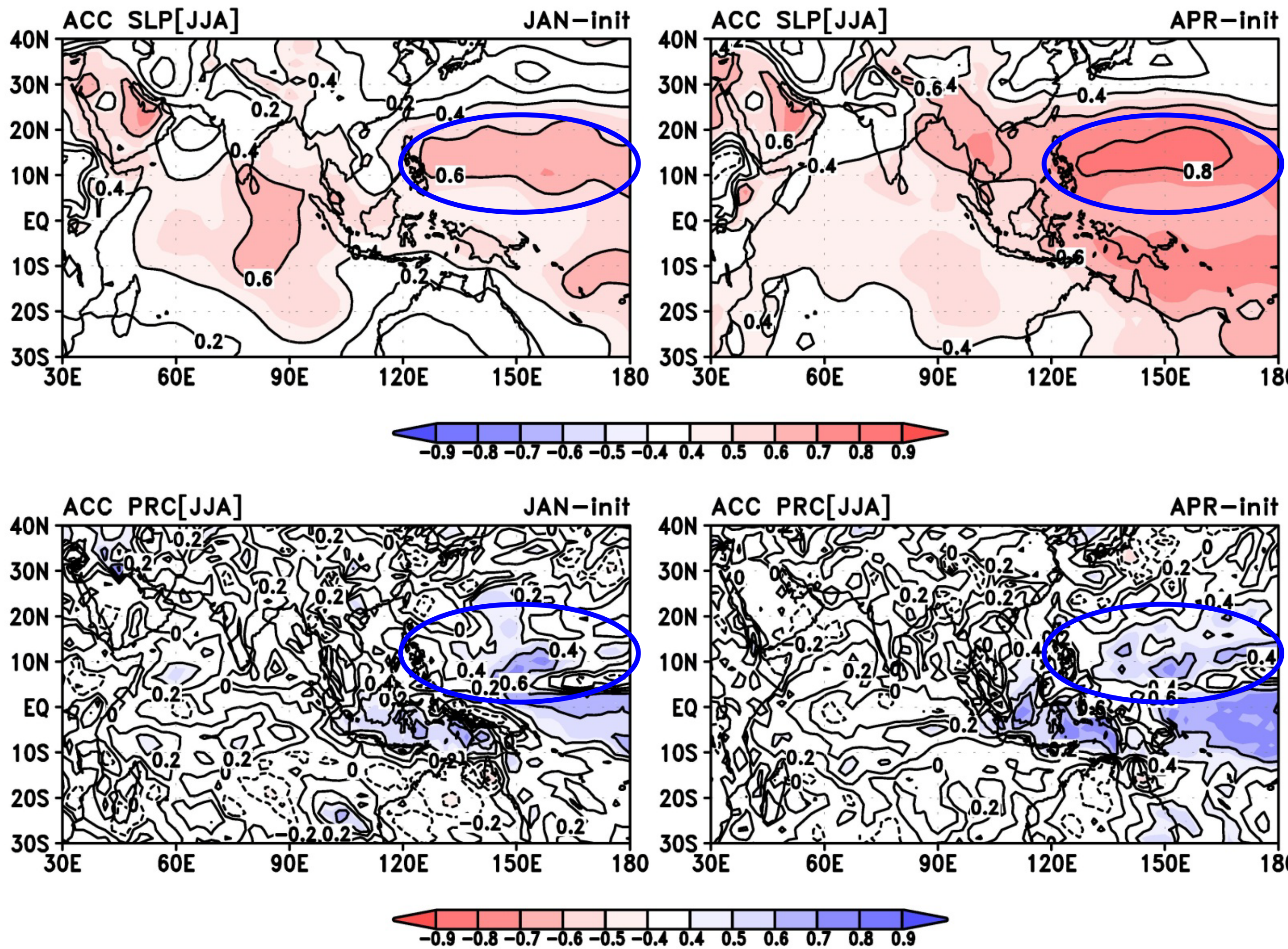
1. Introduction

JJA Forecast skill of
seasonal forecast experiment by JMA/MRI-CGCM

Initial: end of January | **Initial: end of April**

Sea level Pressure

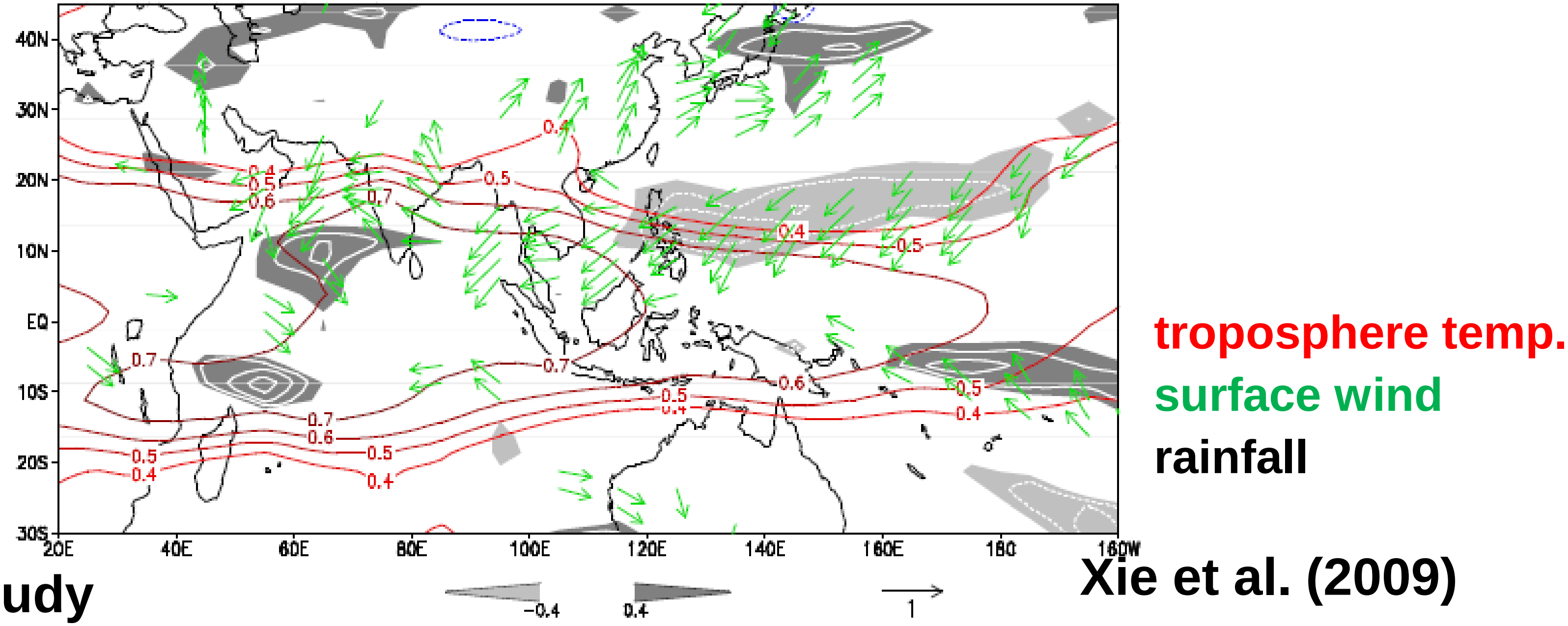
Precipitation



Role of basin-wide Indian Ocean on atmospheric fields in the western North Pacific

- SST warming in the Indian Ocean after El Nino
  (Klein et al. 1999, Xie et al. 2002, Lau and Nath 2003, Ohba and Ueda 2005, Du et al. 2009)
- Zonal SST gradient between Pacific and Indian Ocean
  (Ohba and Ueda 2006)
- Indian Ocean Capacitor effect (Xie et al. 2009, Chowdary et al. 2010)

Lag regression with NINO3.4SST(NDJ)



Xie et al. (2009)

This study

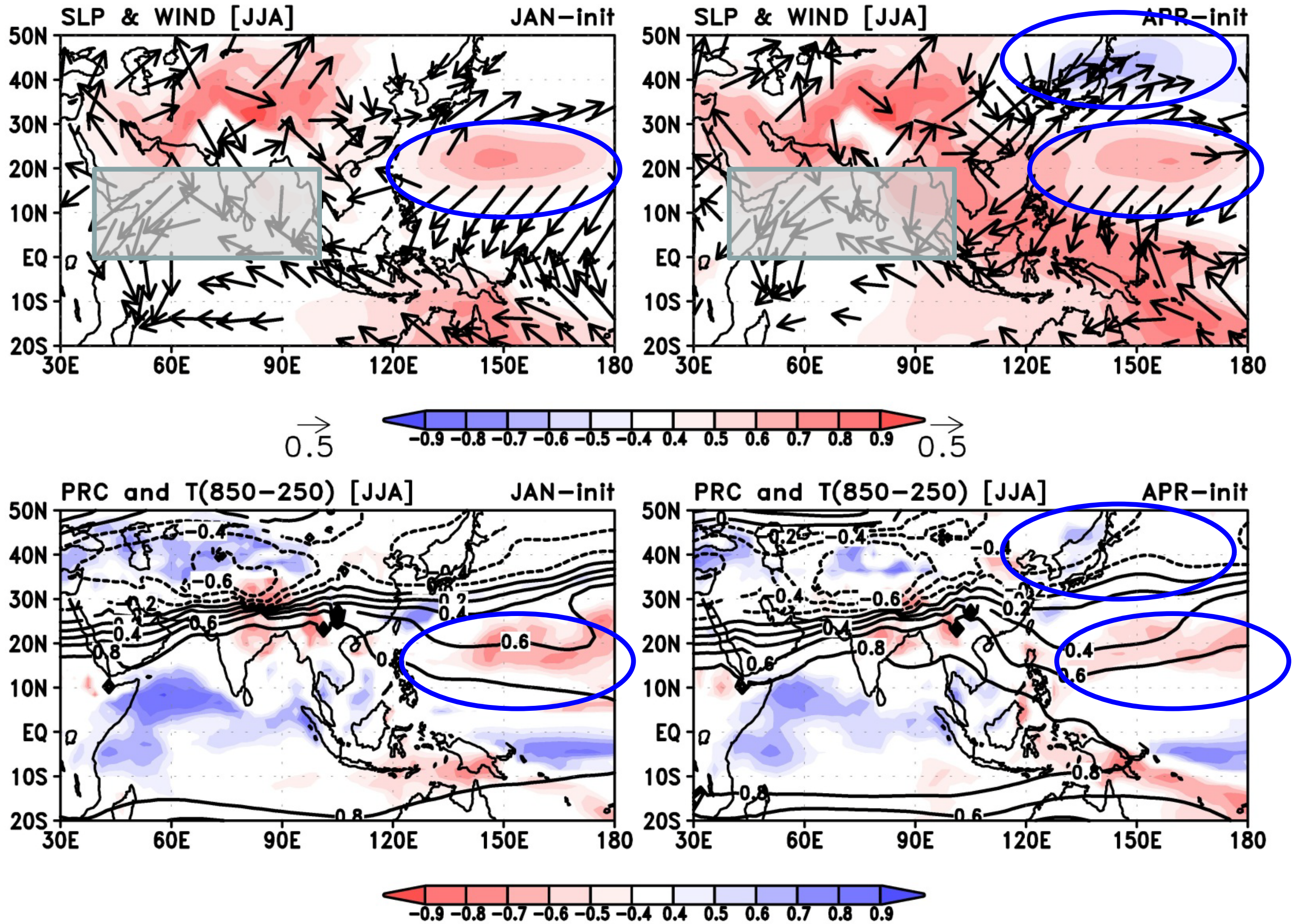
- Processes on SST warming in the Indian Ocean after El Nino
- JMA/MRI-CGCM seasonal forecast experiment

Correlation with JJA NIOSST in seasonal forecast experiment
NIO: North Indian Ocean (40-100E, 0-20N)

Initial: end of January | **Initial: end of April**

SLP (shaded) & Surface Wind

Precipitation (shaded) & Troposphere temperature (contour)



NIOSST influences atmospheric pattern in JJA.

2. Seasonal forecast experiment in JMA/MRI-CGCM

WCRP/WGSIP Climate-system Historical Forecast Project（CHFP）

JMA/MRI-CGCM

- Now used as operational seasonal forecast system at JMA.
- AGCM: JMA unified AGCM. Resolution: TL95L40
- OGCM: Meteorological Research Institute Community Ocean Model (MRI.COM; Ishikawa et al. 2005)
  - OGCM domain: 75S-75N (prescribed sea ice climatology)
  - Resolution: 1deg(lon) x 0.3-1deg(lat), vertical: 50 levels
- Air-sea coupling time interval: 1hour
- Monthly mean momentum and heat flux corrections

Experiment

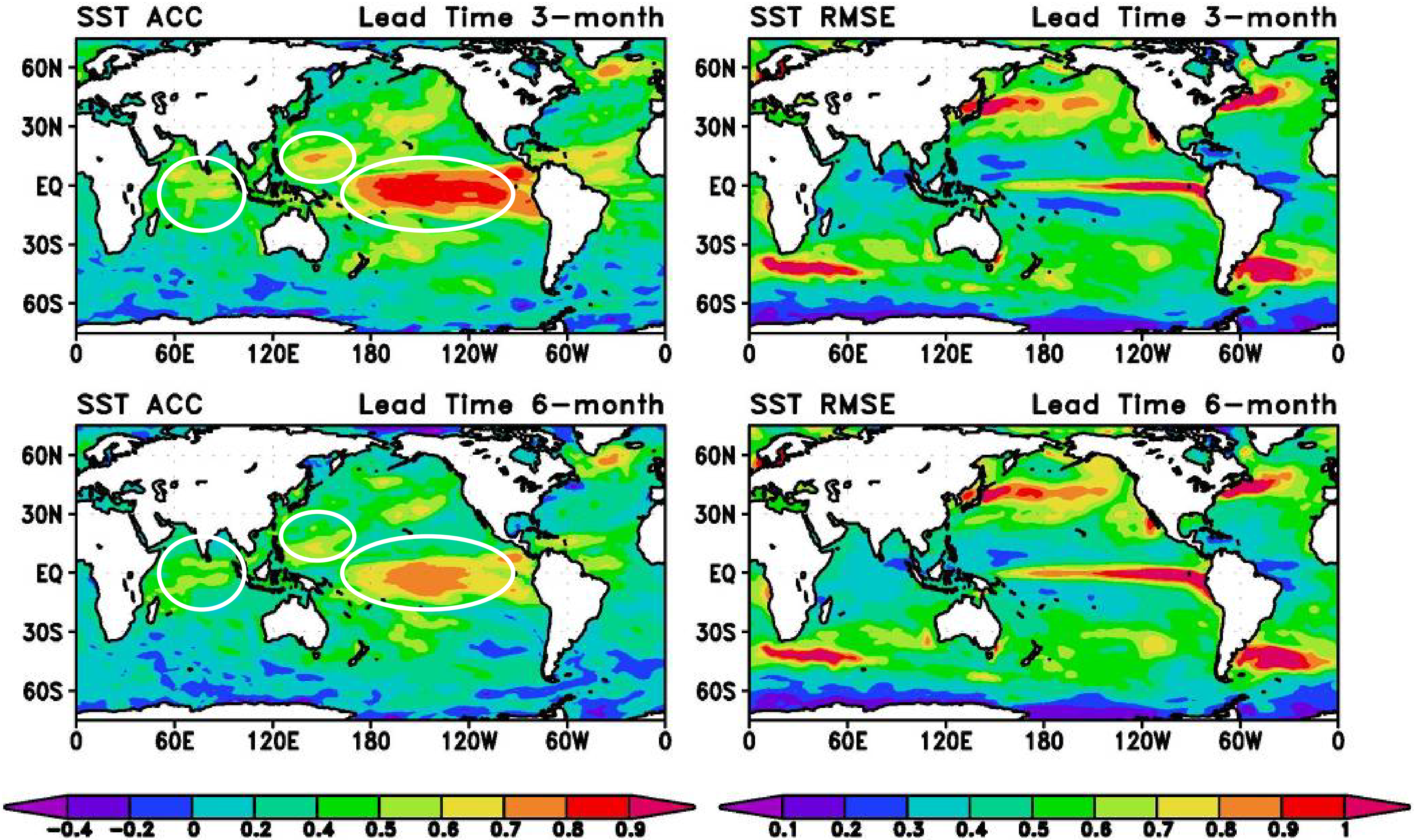
- 7-month forecast (10 member)
- 1979-2006
- 00Z and 12Z in the last 5 days of Jan, Apr., Jul., and Oct.

Initial condition

- atmosphere: JRA25/JCDAS(Onogi et al. 2007)
- ocean: Meteorological Research Institute Ocean Assimilation System (MOVE-G/MRI.COM; Usui et al. 2006)

3. Prediction Skill for SST

Anomaly Correlation RMSE



Prediction skill for SST in the three key regions

Nino3.4

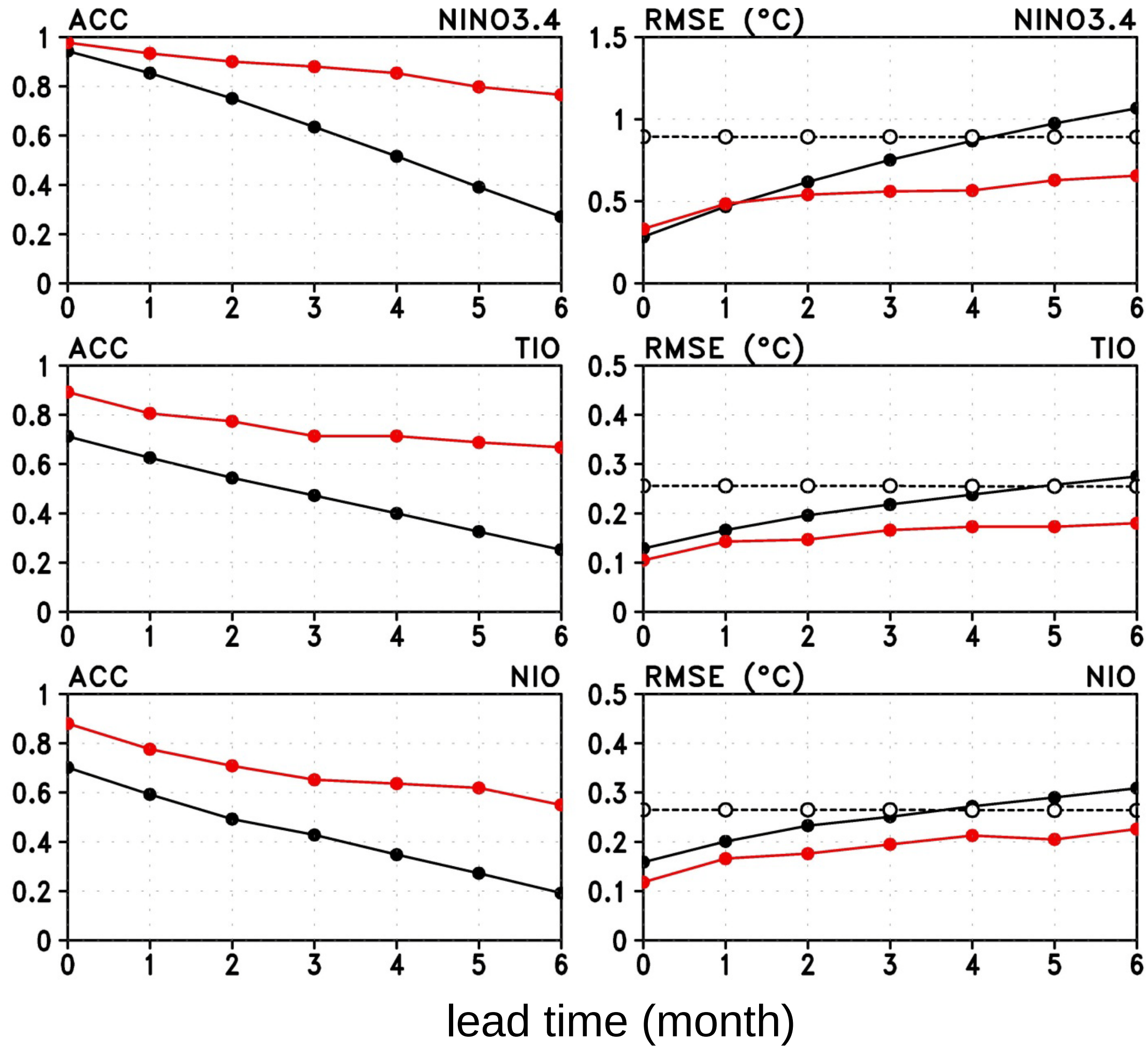
(190-60W, 5S-5N)

Tropical Indian Ocean (TIO)

(40-100E, 20S-20N)

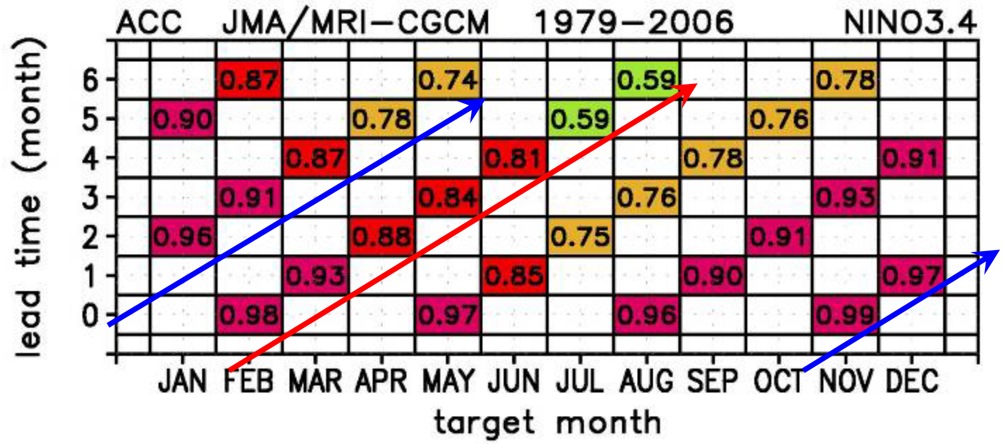
North Indian Ocean (NIO)

(40-100E, 0-20N)

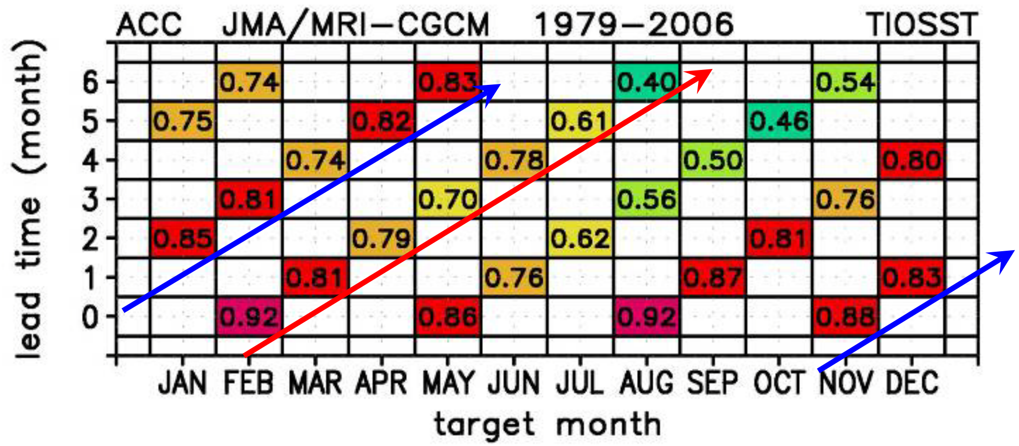


Anomaly Correlation

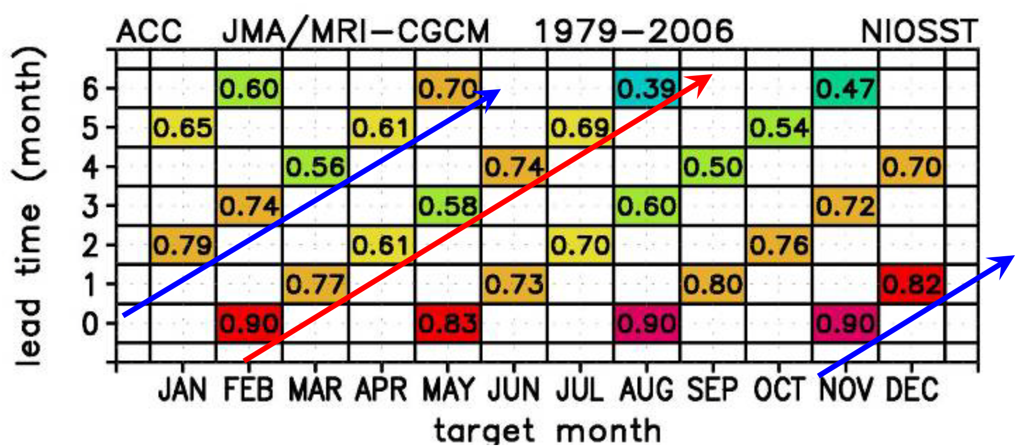
Nino3.4



Tropical Indian Ocean (TIO)



North Indian Ocean (NIO)

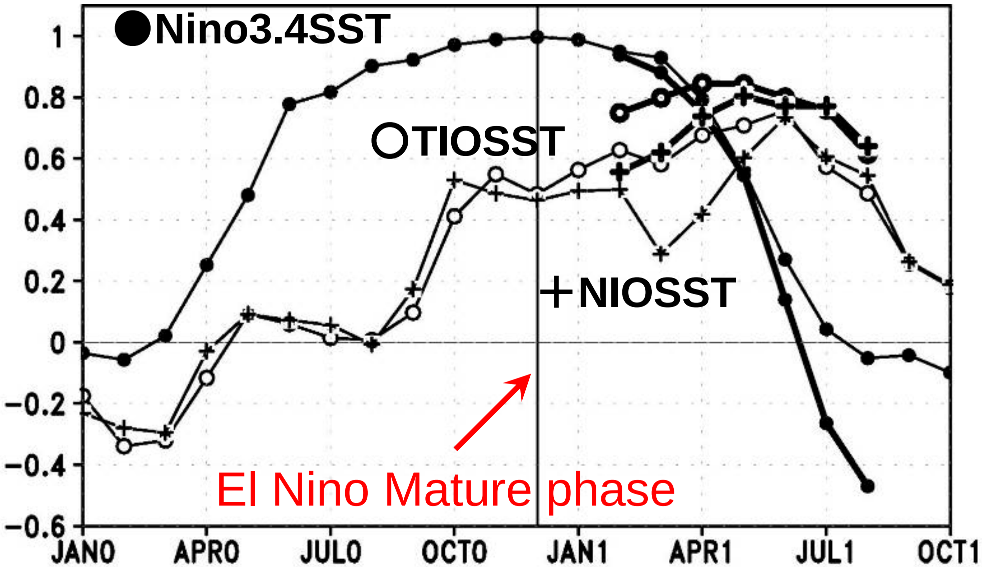


This study:

Focus on the experiments started from end of January

4. SST Relationship between ENSO and Indian Ocean

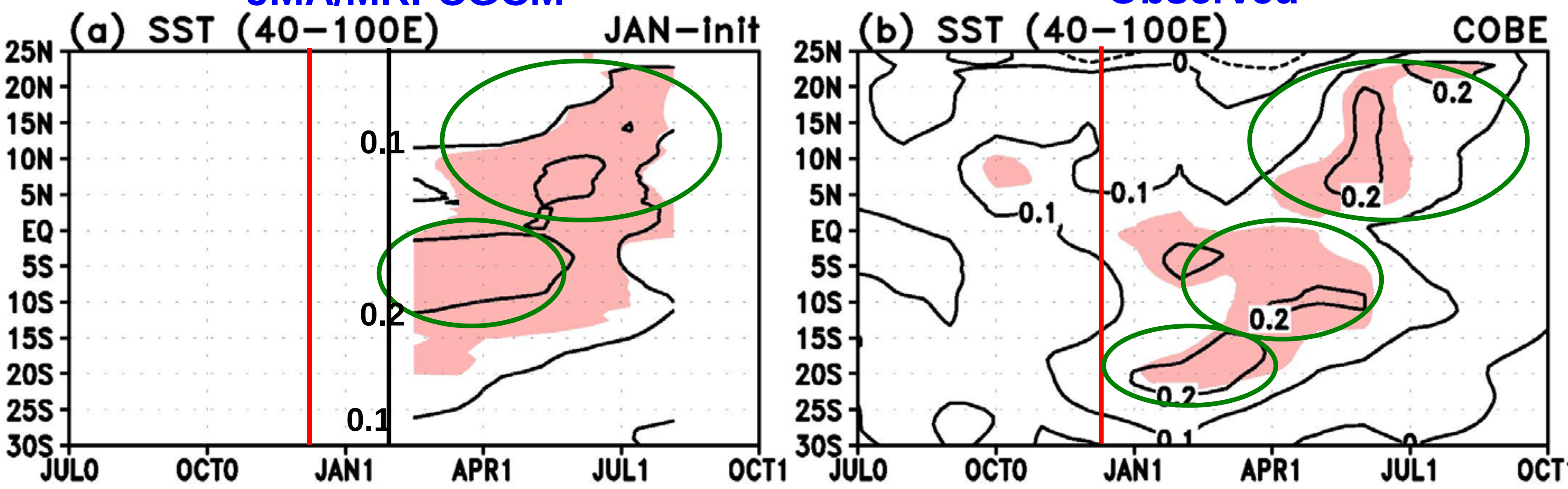
Lag correlation with Nino3.4SST(NDJ)



thin: Observed (COBE-SST)
Bold: JMA/MRI-CGCM

Lag regression of zonal mean SST with NINO3.4SST(NDJ)

JMA/MRI-CGCM **Observed**

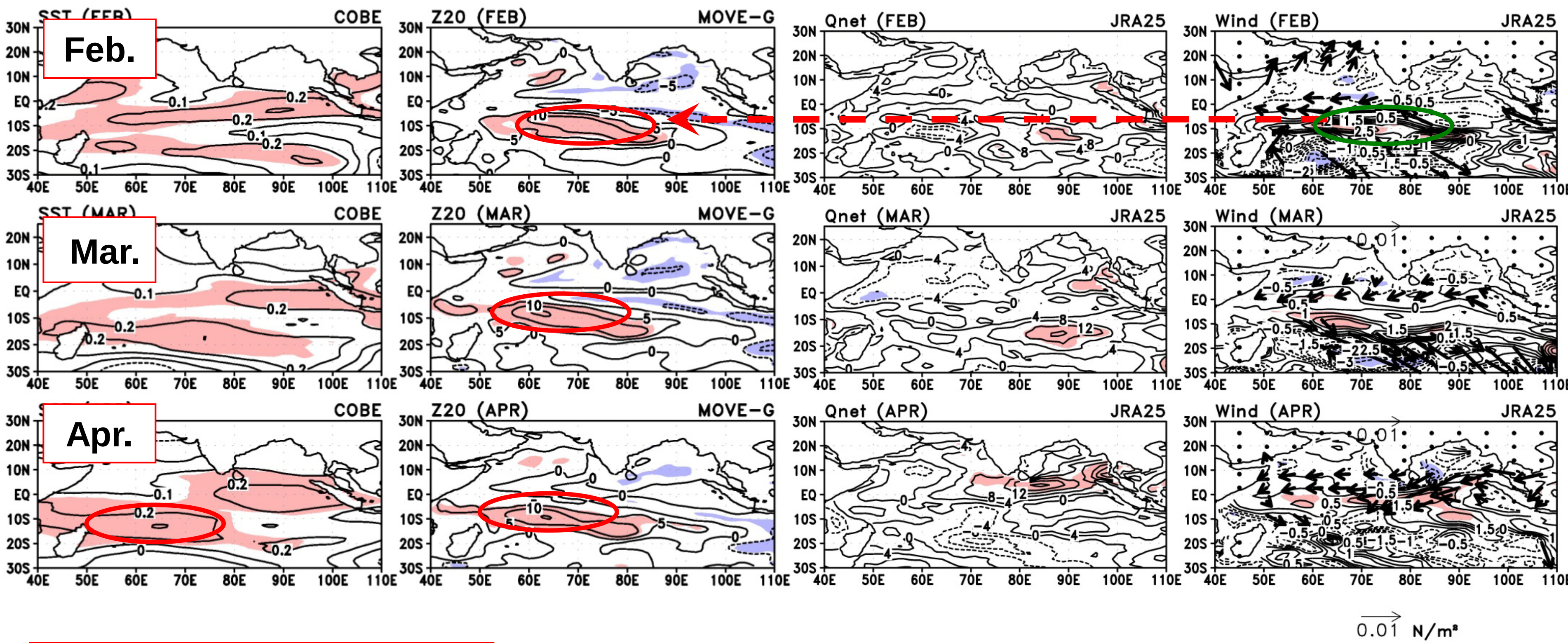


5. Warming in the South Indian Ocean during boreal winter and spring

Lag regression with NINO3.4SST(NDJ)

Observed (COBE-SST, MOVE-G, JRA25)

SST	Z20（20℃depth)	Net Surface Heat Flux	Wind stress & Wind stress curl
CI=0.1℃	CI=5m	CI=4W/m^2	CI=10^{-8}N/m^3



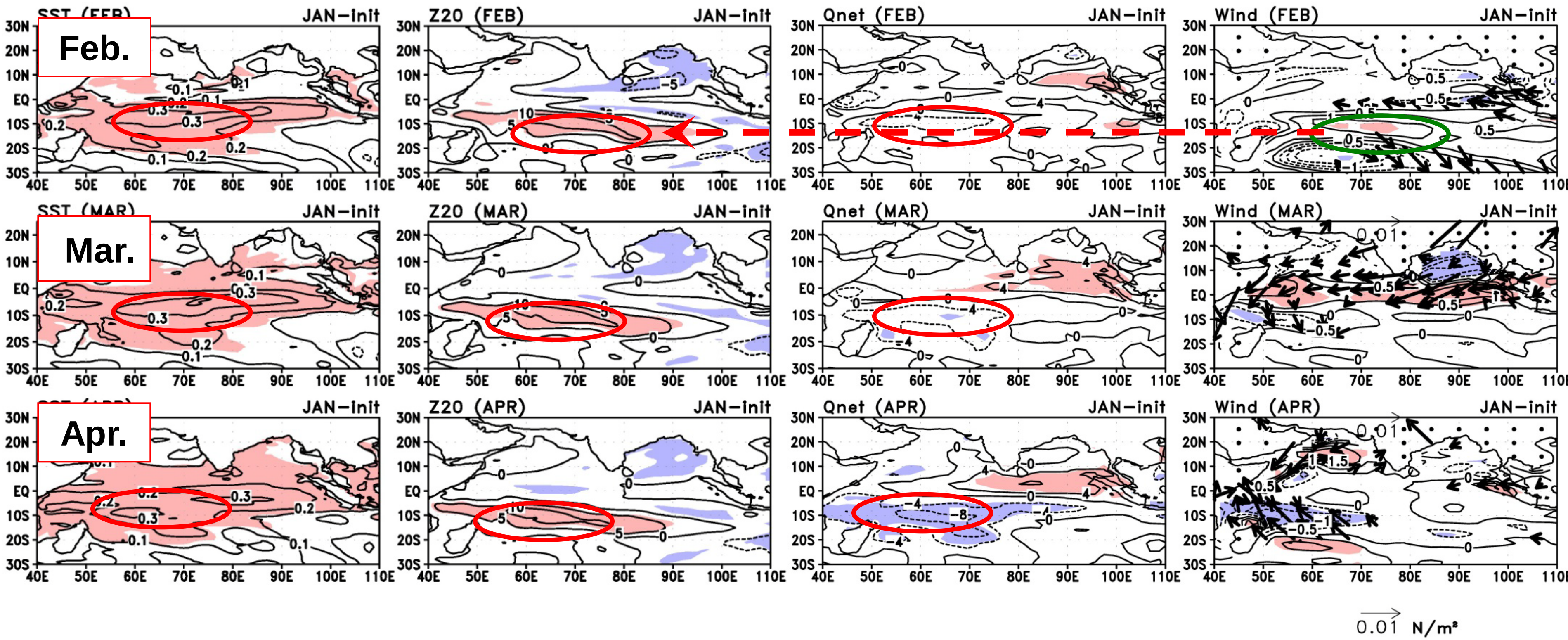
Easterly anomaly along Eq. and Anticyclonic WSC anomaly → **Z20 anomaly and Westward propagation** → **SST warming in the South Indian Oceam**

(Xie et al. 2002, Du et al. 2009)

Lag regression with NINO3.4SST(NDJ)

JMA/MRI-CGCM

SST CI=0.1℃ | **Z20** CI=5m | **Net Surface Heat Flux** CI=4W/m² | **Wind stress & Wind stress curl** CI=10⁻⁸N/m³

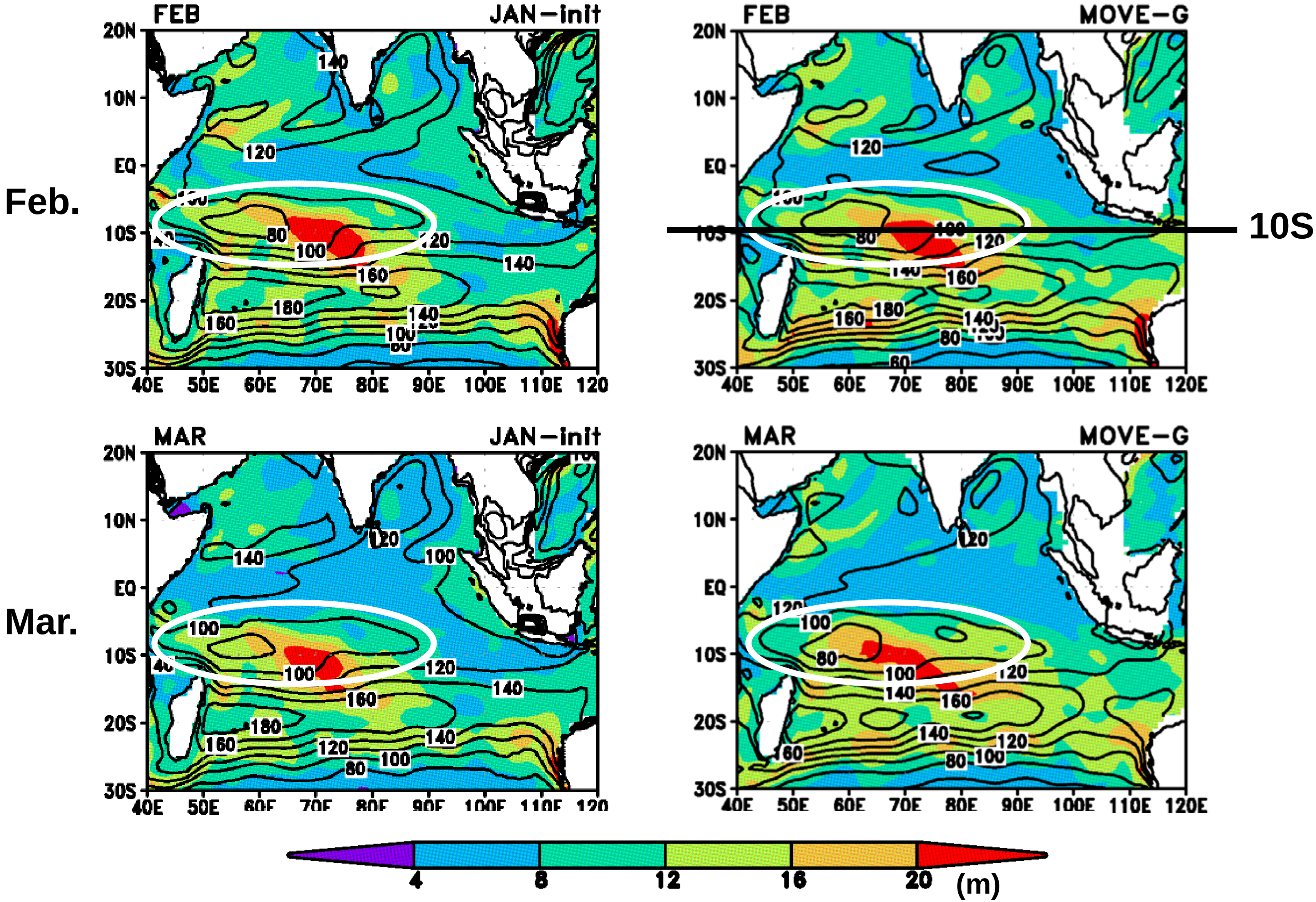


Easterly anomaly along Eq. and Anticyclonic WSC anomaly → **Z20 anomaly and westward propagation** → **SST warming in the South Indian Oceam**

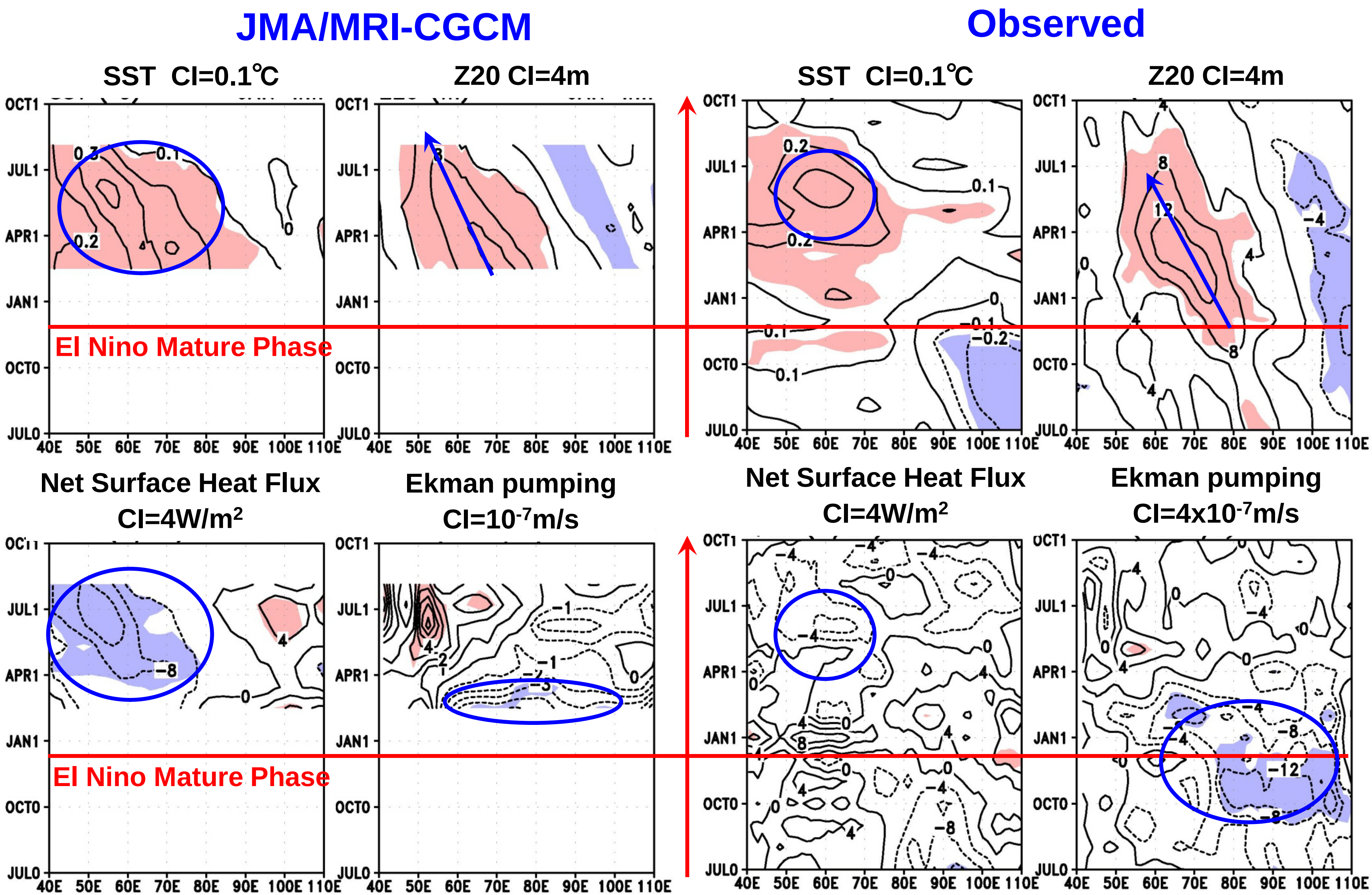
consistent with observation

Z20 (20℃ depth）climatology（contour: CI=20m）
Standard deviation (shaded)

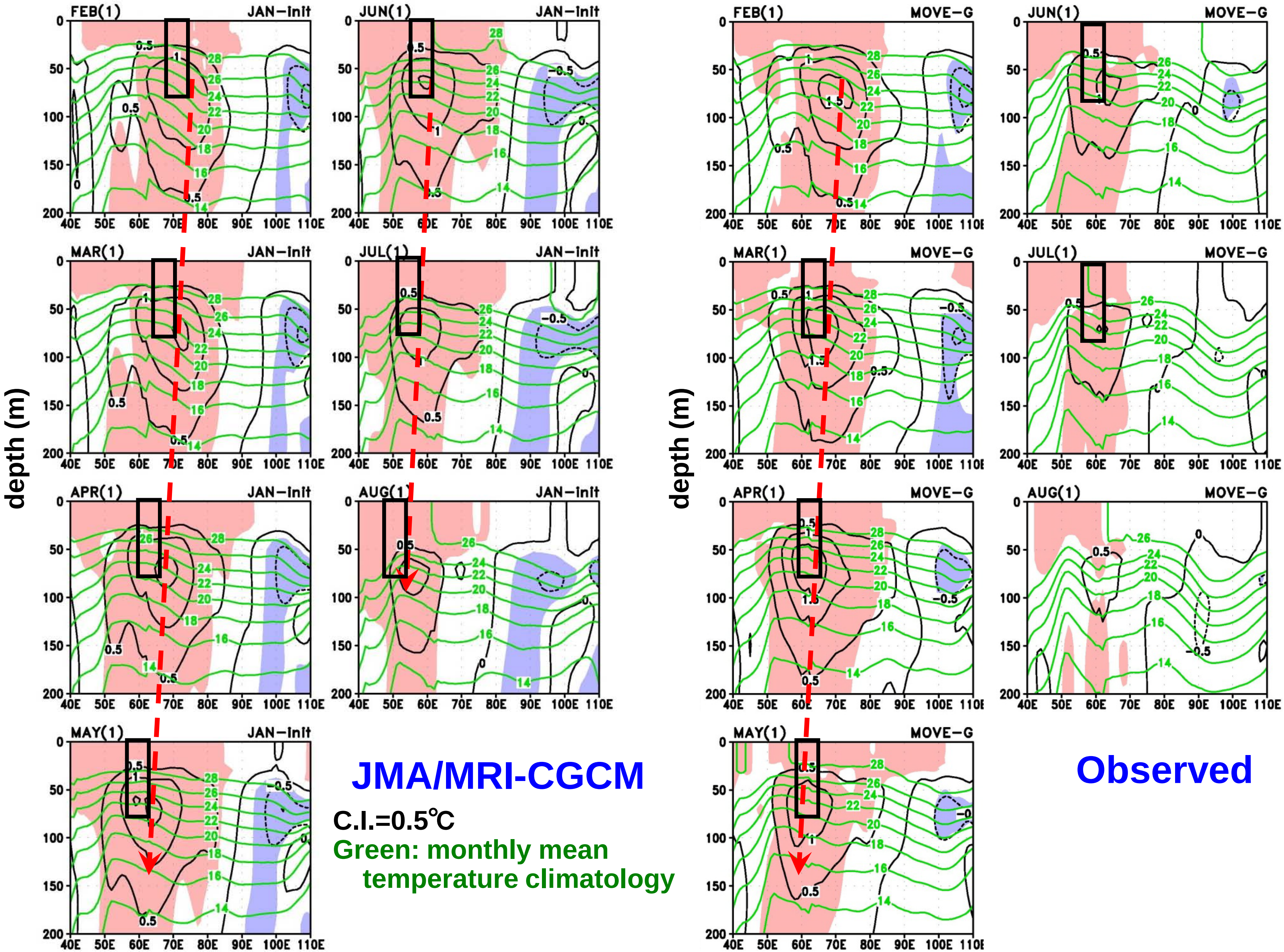
JMA/MRI-CGCM **Observed**



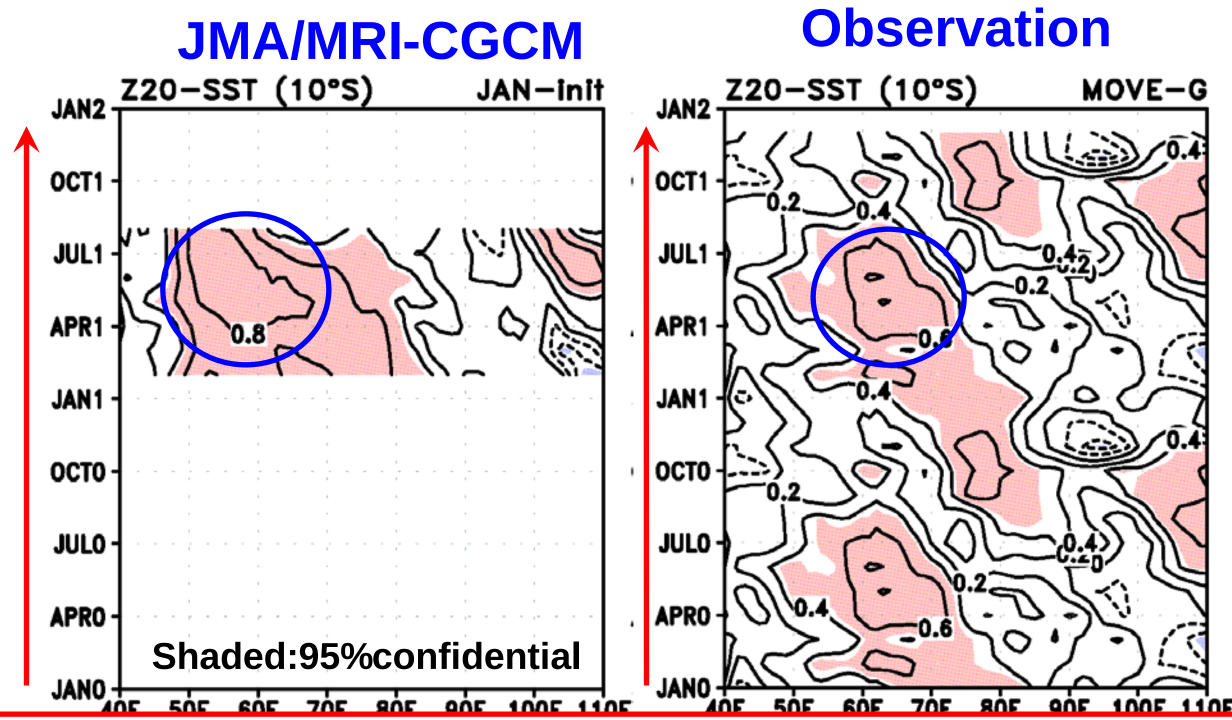
Lag regressions along 10S with NINO3.4SST(NDJ)



Rag regression of temperature zonal section along 10S with NINO3.4SST(NDJ)



Correlation between Z20 and SST along 10S



SST Warming in the South Indian Ocean during boreal winter and spring

Change in the Walker circulation associated with El Nino
Easterly wind anomaly along the equatorial Indian Ocean (IO)

↓

Anticyclonic WSC anomaly in the southeastern IO
Generation and westward propagation of thermocline depth anomaly

↓

Thermocline dome in the western IO
Deepening of thermocline and related weakening of upwelling

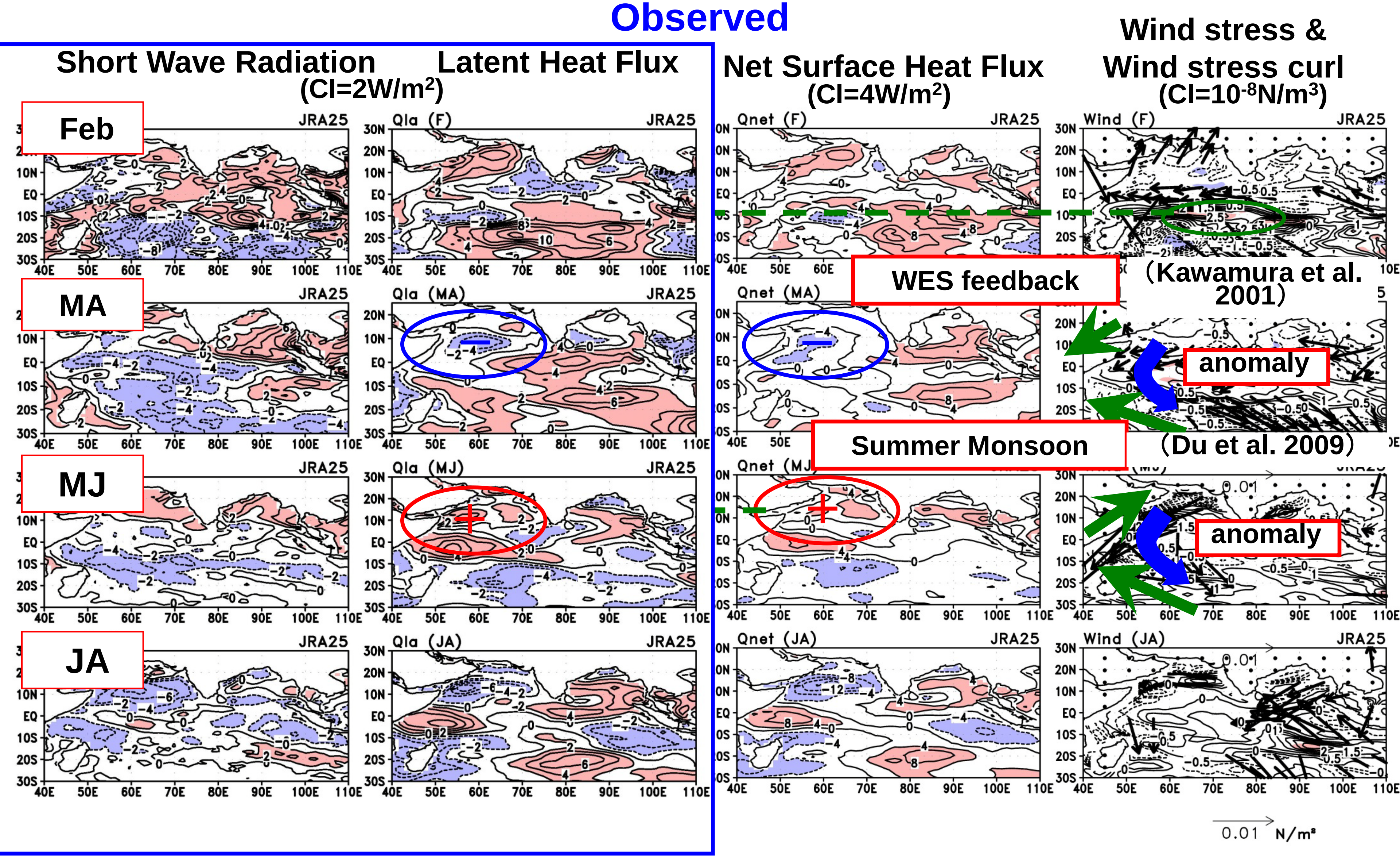
↓

SST warming in the southern IO

6. SST warming in the North Indian Ocean during boreal spring and summer

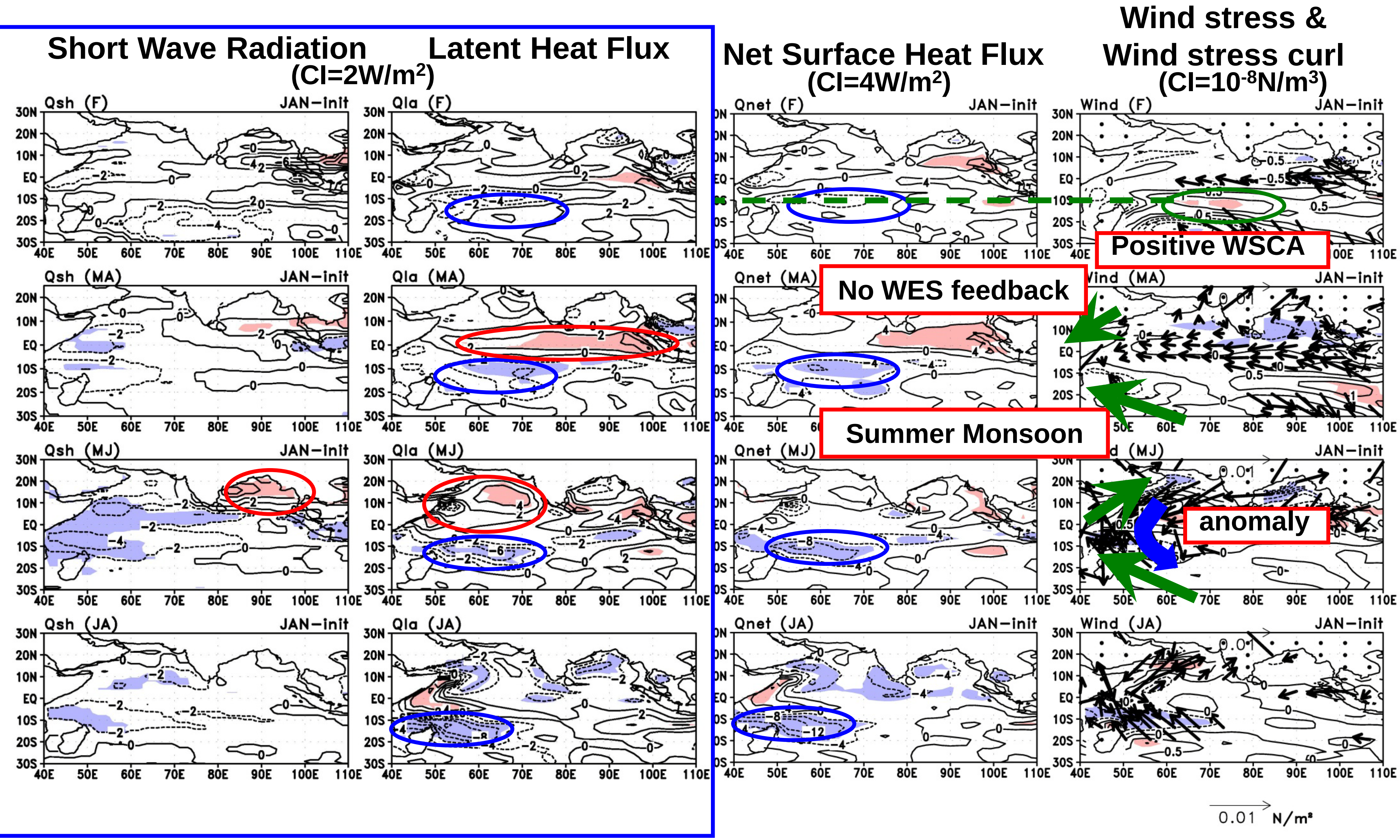
Lag regression with NINO3.4SST(NDJ)

Observed



Lag regression with NINO3.4SST(NDJ)

JMA/MRI-CGCM



8. Summary

- SST warming in the Indian Ocean after El Nino in the seasonal forecast experiment of JMA/MRI-CGCM have been examined.

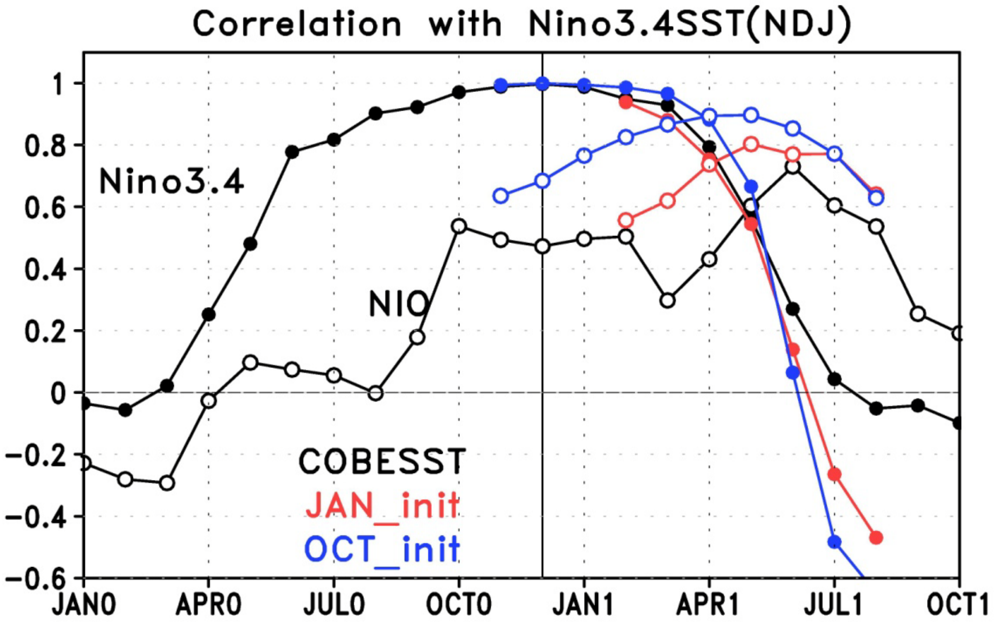
- SST warming in the South Indian Ocean during boreal spring in CGCM is due to deeper thermocline anomaly induced by positive wind stress curl anomaly. However, area (period) of interaction between thermocline and SST is wider (longer) than observation.

- In boreal spring, predicted wind anomaly does not induce WES feedback that prevent SST warming in the western North Indian Ocean in the observation. This is a reason for higher correlation between NIOSST and NINO3.4SST(NDJ) than that in the observation.

- Wind anomaly in boreal summer tend to weaken summer monsoon in the western North Indian Ocean. This reduces latent heat release to the atmosphere, maintaining positive SST anomaly in North Indian Ocean.

- These results are consistent with studies based on the observation. This could be one of causes that we got good forecast skill in the western North Pacific in boreal summer.

Tropical Indian Ocean (TIO)



North Indian Ocean (NIO)