State Key Laboratory of Numerical Modelling for Atmospheric Sciences
and Geophysical Fluid Dynamics(LASG)
Institute of Atmospheric Physics Chinese Academy of Sciences

Projected Changes of East Asian Summer Monsoon in IAP coupled model FGOALS2-s

Qing Bao, Jun Wang, Guoxiong Wu, Yimin Liu

LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences

APCS, Honolulu
Oct 18, 2011

Motivation

- The Asian summer monsoon (including SASM & EASM) is the strongest summer monsoon system in the world
- The agriculture, economy and society across the EASM regions are critically influenced by the intensity, evolution and variation of the EASM
- Updated scenarios in CMIP5 (Taylor et al., 2009)

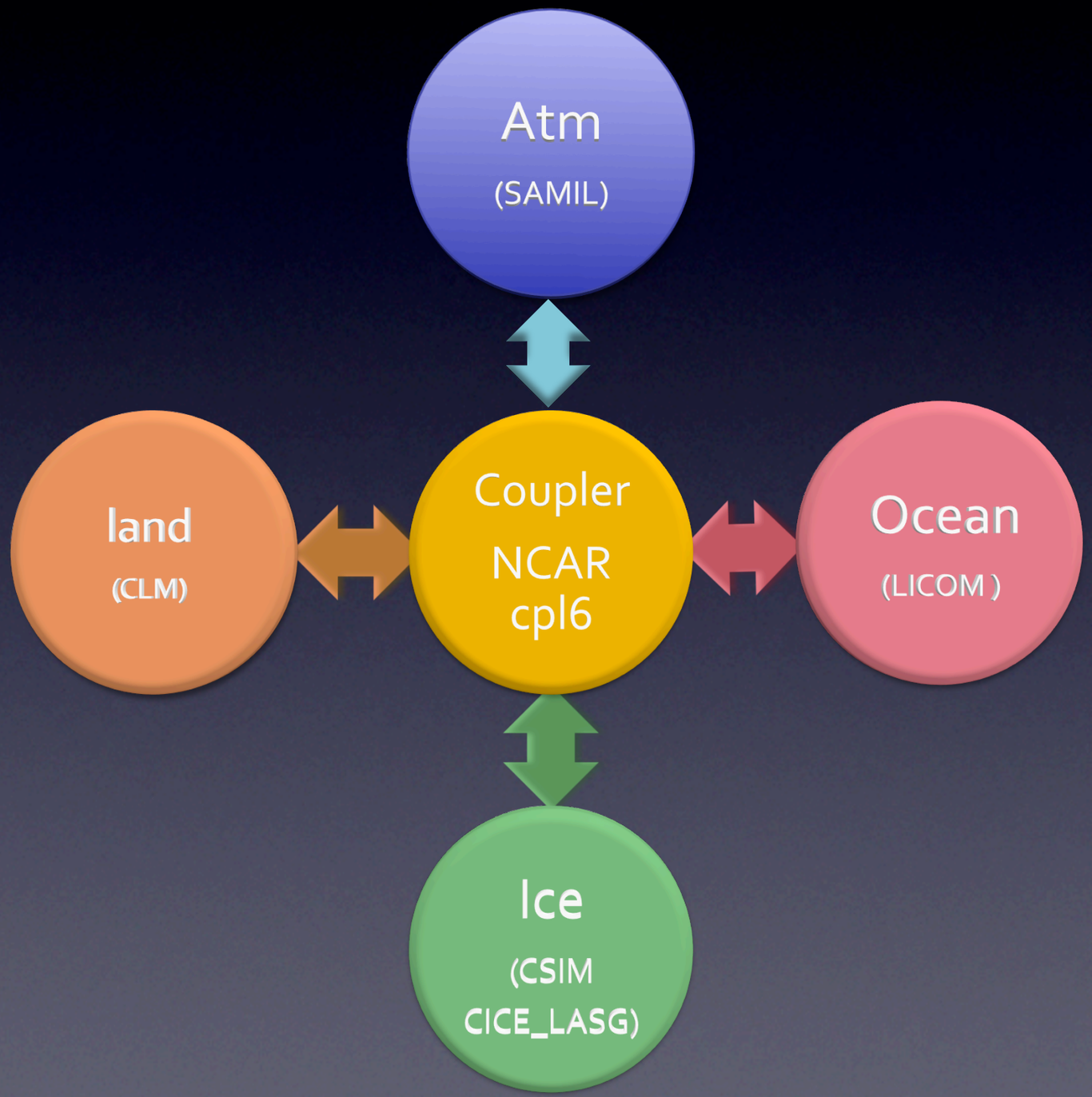
Questions

- **What are the changes of EASM in future scenarios, respectively in its climatology, seasonality, interannual variations and its relationship with ENSO?**

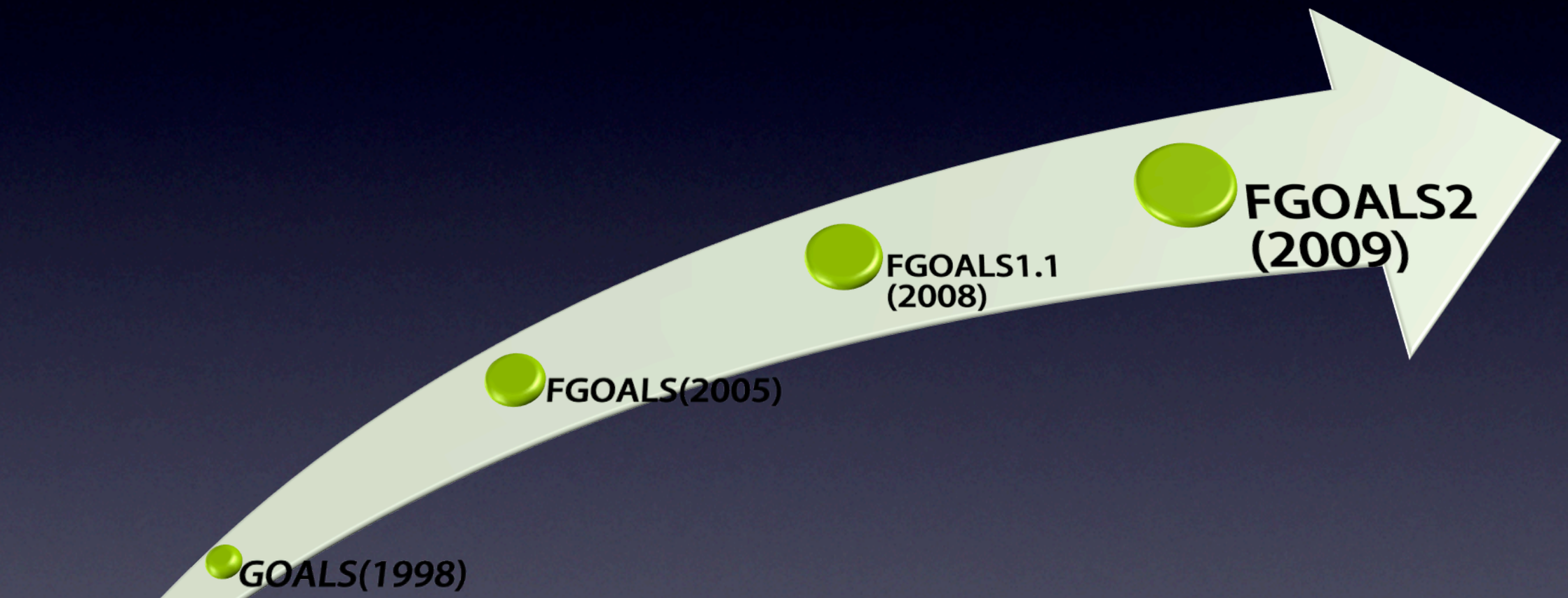
FGOALS

Flexible **G**lobal **O**cean-**A**tmosphere-**L**and **S**ystem

(Zhang et al.,2000; Zhou et al., 2005; Yu et al., 2008; Bao et al., 2010)



The milestones of LASG spectral coupled model



Flexible **G**lobal **O**cean-**A**tmosphere-**L**and **S**ystem

(Zhang et al.,2000; Zhou et al., 2005; Yu et al., 2008; Bao et al., 2010)

AGCM: SAMIL

（**S**pectral **A**tmospheric **M**odel in **I**AP **L**ASG ）

- Resolutions: R42L26 (Spectral transform model with 26 atmospheric layers extending from the surface to 2.19 hPa, and its horizontal resolution is 2.81°x1.66°),
- Physical processes
  - Radiative process: Edwards and Slingo, (1996), (Sun and Rikus, 1999a,b； Li et al., 2009);
  - Convective scheme: Tiedtke, 1989, Nordeng, 1994; Liu, 2009;Wang et al.,2010;
  - Vertical diffusion and PBL: Brinkop and Roeckner,(1995)

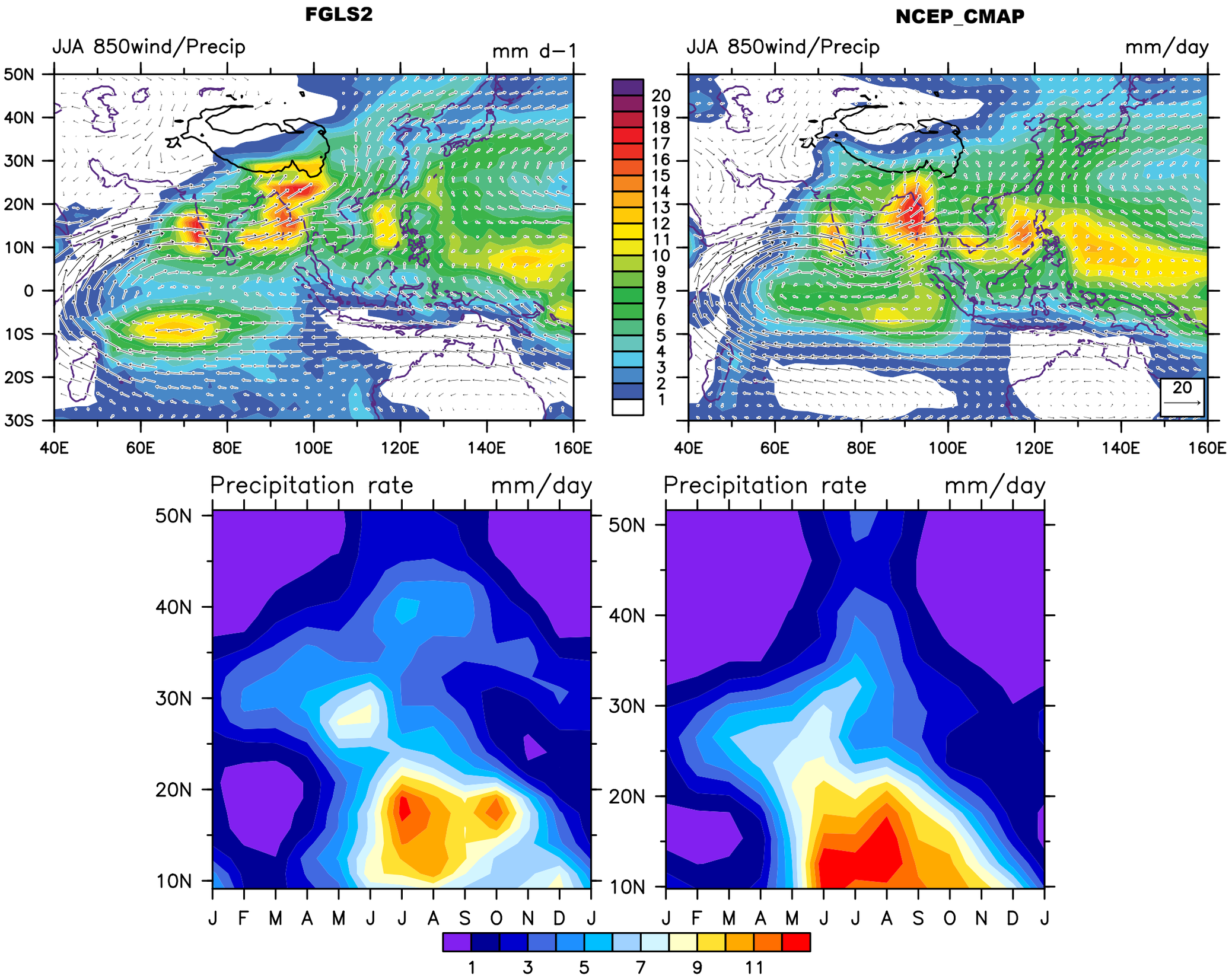
OGCM: LICOM

	AR4（LICOM1.1）	AR5（LICOM2.0）
Horizontal Resolution	1°×1°	1°×(0.5°~1°)
Vertical Resolution	30 levels (25m in upper 300m)	30 levels (10m in upper 150m)
Advection Scheme	2 order central difference	A shape-preserving (Yu, 1994)
Vertical Mixing	Pacanowski and Philander, 1981	Canuto et al., 2001
Mesoscale eddy parameterization	Gent and McWilliams, 1990	Gent and McWilliams, 1990; Large et al., 1997
Horizontal Viscosity	2×10^4 m^2/s	3×10^3 m^2/s
SW Radiation Penetration	Constant (Paulson and Simpson, 1977)	Chlorophyll depended (Ohlmann, 2003)

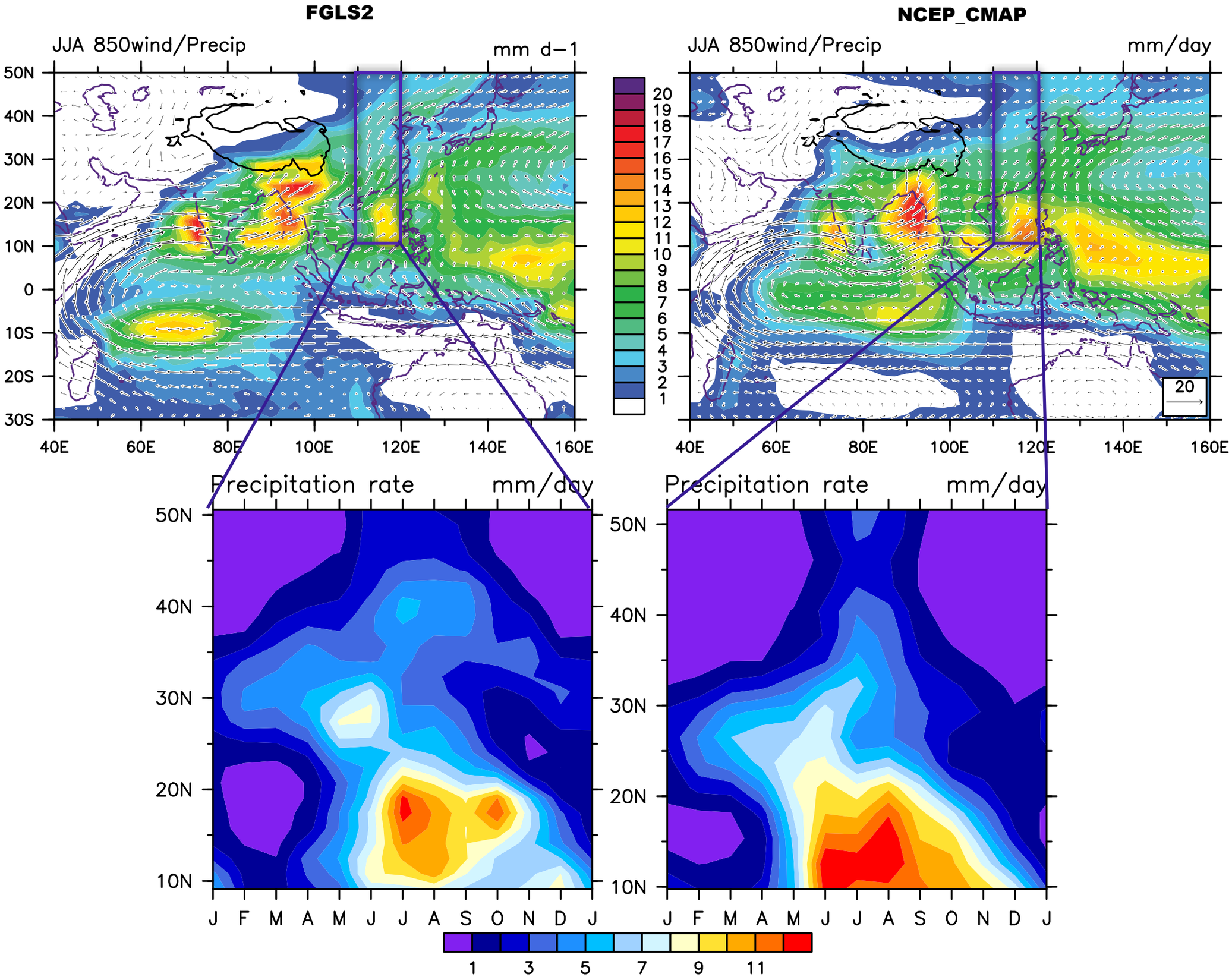
Experimental design

Experiment	Notes	# of years
Historical (1850-2005)	Impose changing conditions (consistent with observations), which may include: • atmospheric composition (including CO2), due to both anthropogenic and volcanic influences • solar forcing • emissions or concentrations of short-lived species and natural and anthropogenic aerosols or their precursors.	156*3
RCP4.5(2006-2100)	Radiative forcing stabilizes at ~4.5W m-2 after 2100.	95*3
RCP8.5(2006-2100)	Radiative forcing reaches ~8.5 W m-2 near ~2100.	95*3

Asian Monsoon



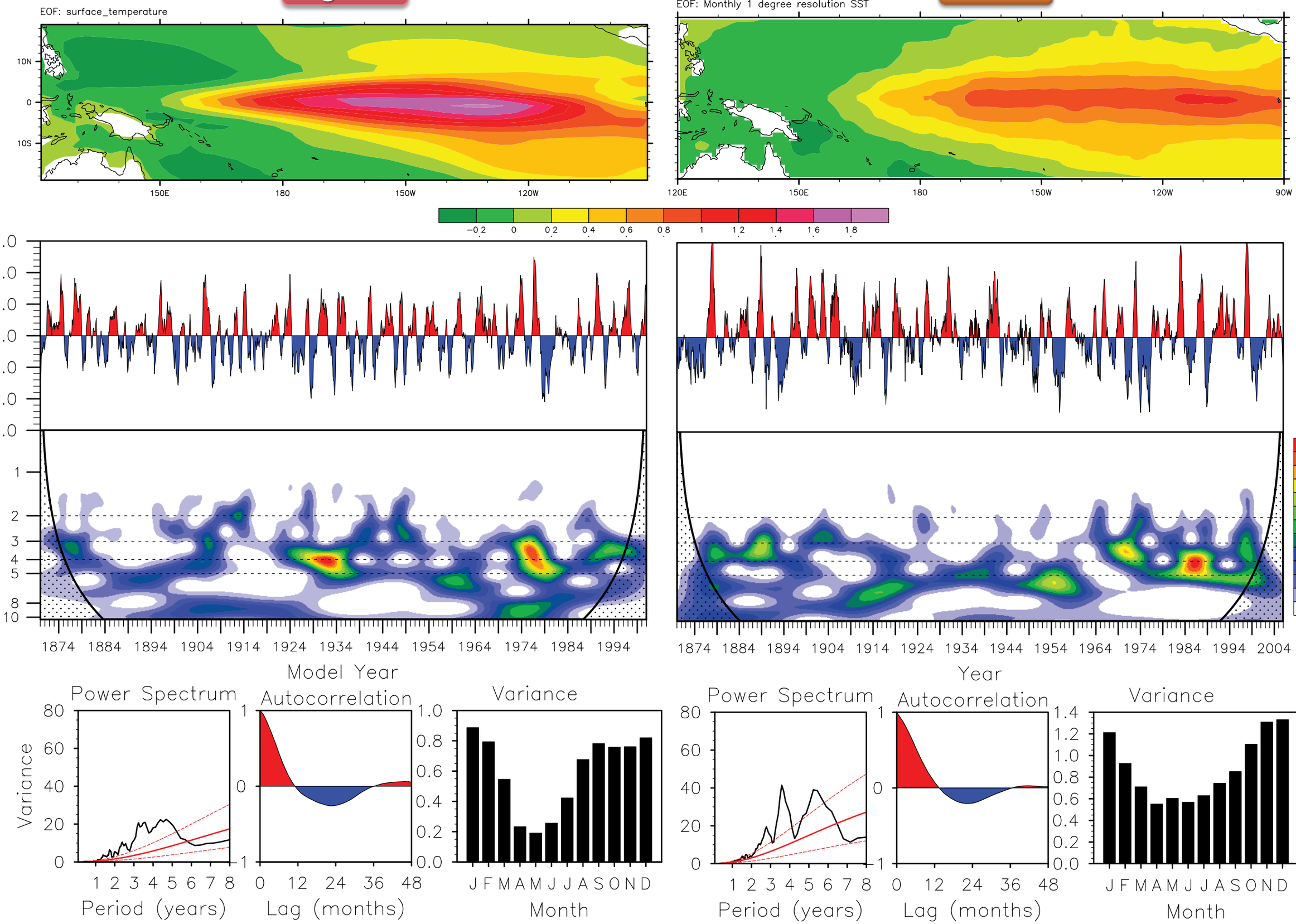
Asian Monsoon



ENSO in FGOALS2-s

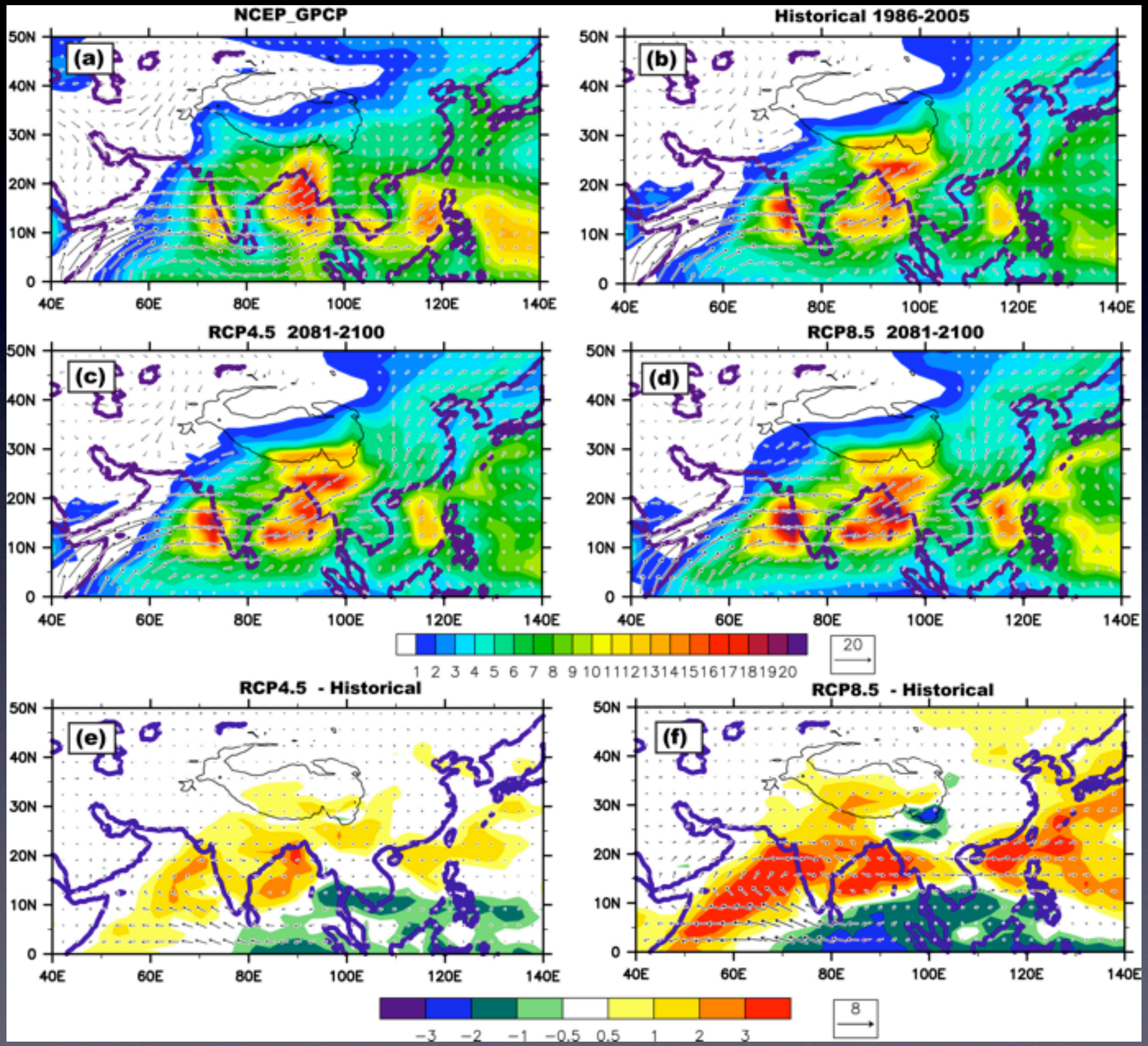
Fgoals

OBS

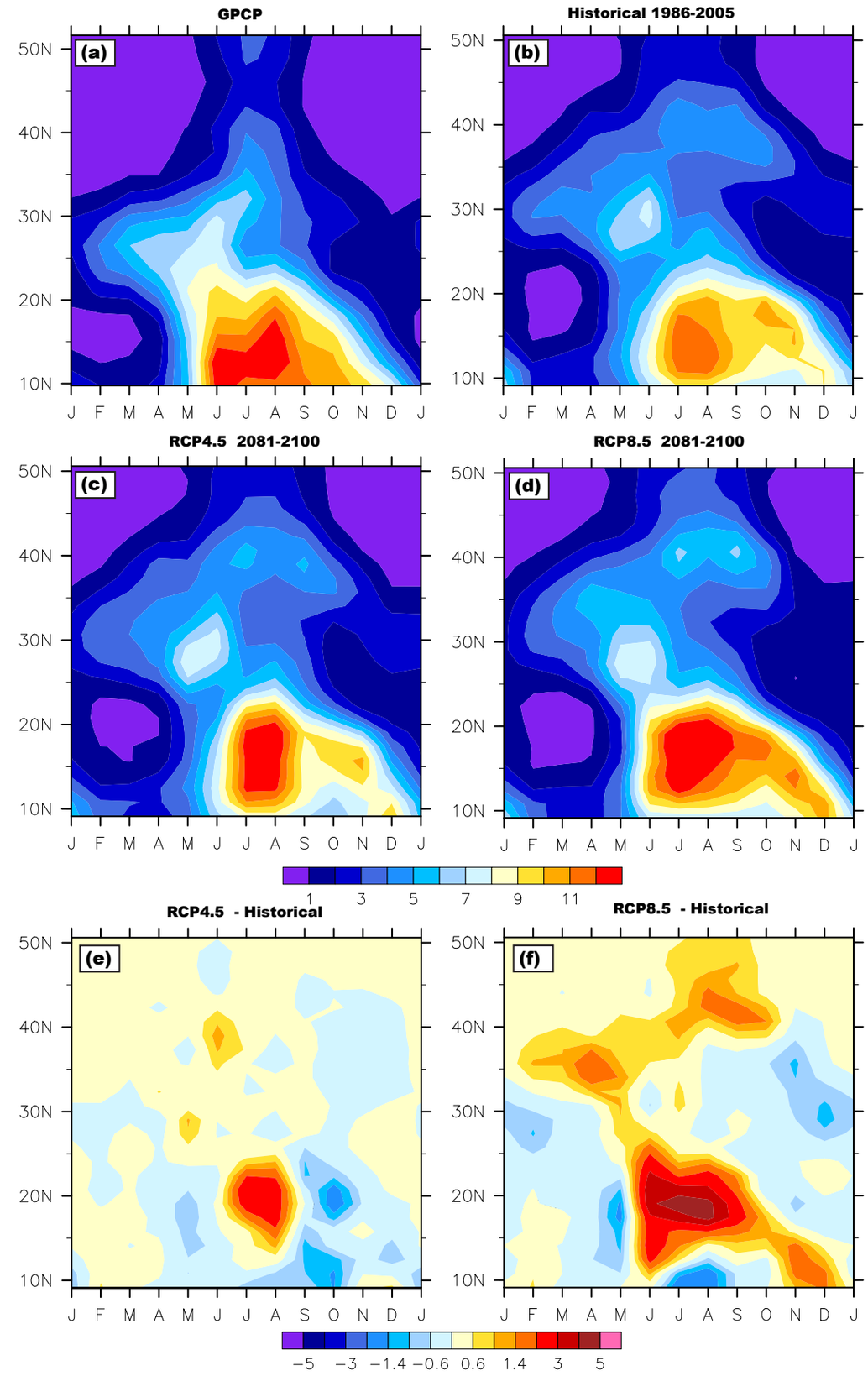


Projected Changes of EASM in IAP FGOALS2-s

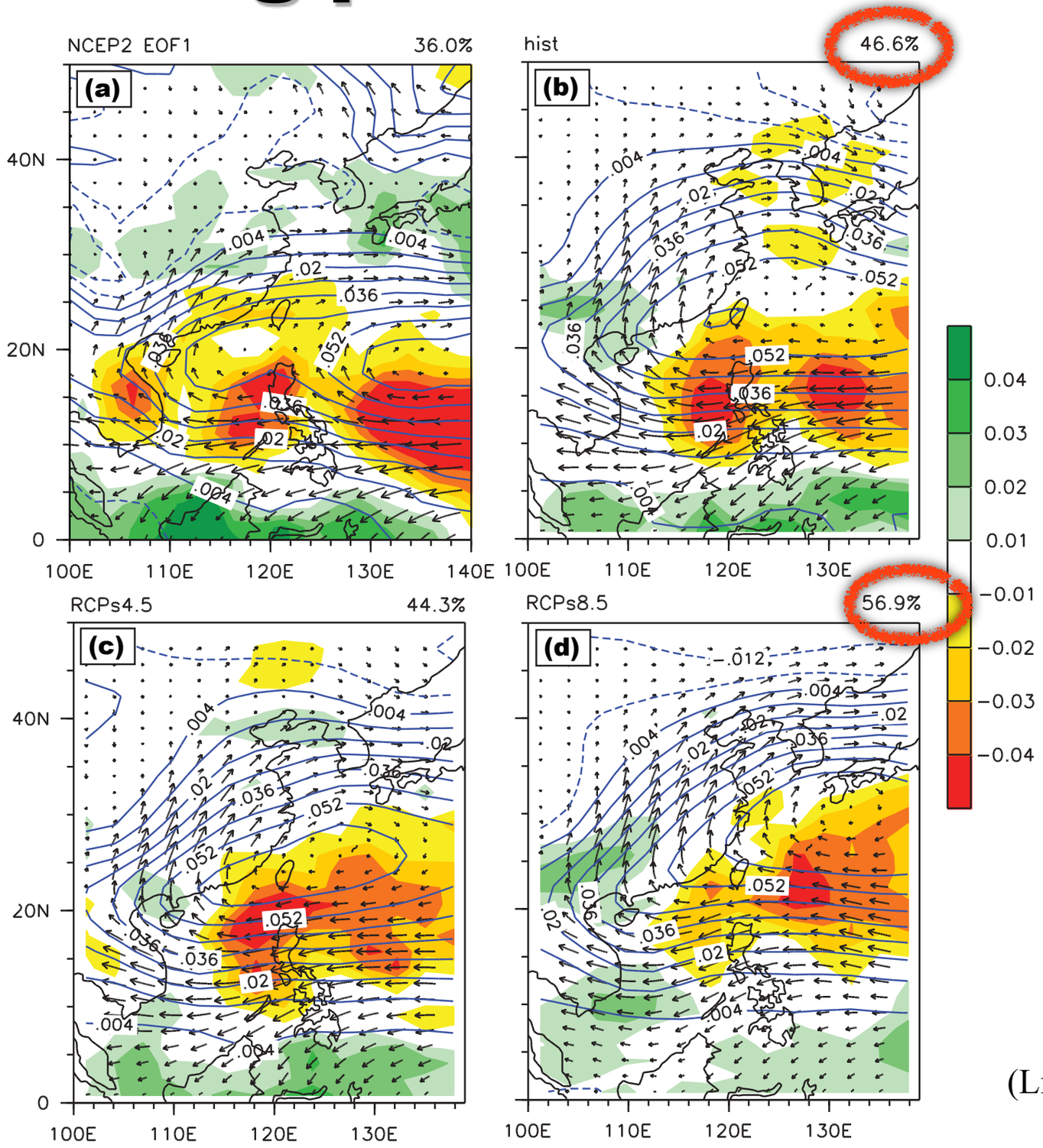
Climatological changes



Climatological annual cycle of zonal mean precipitation (110°E-120°E)



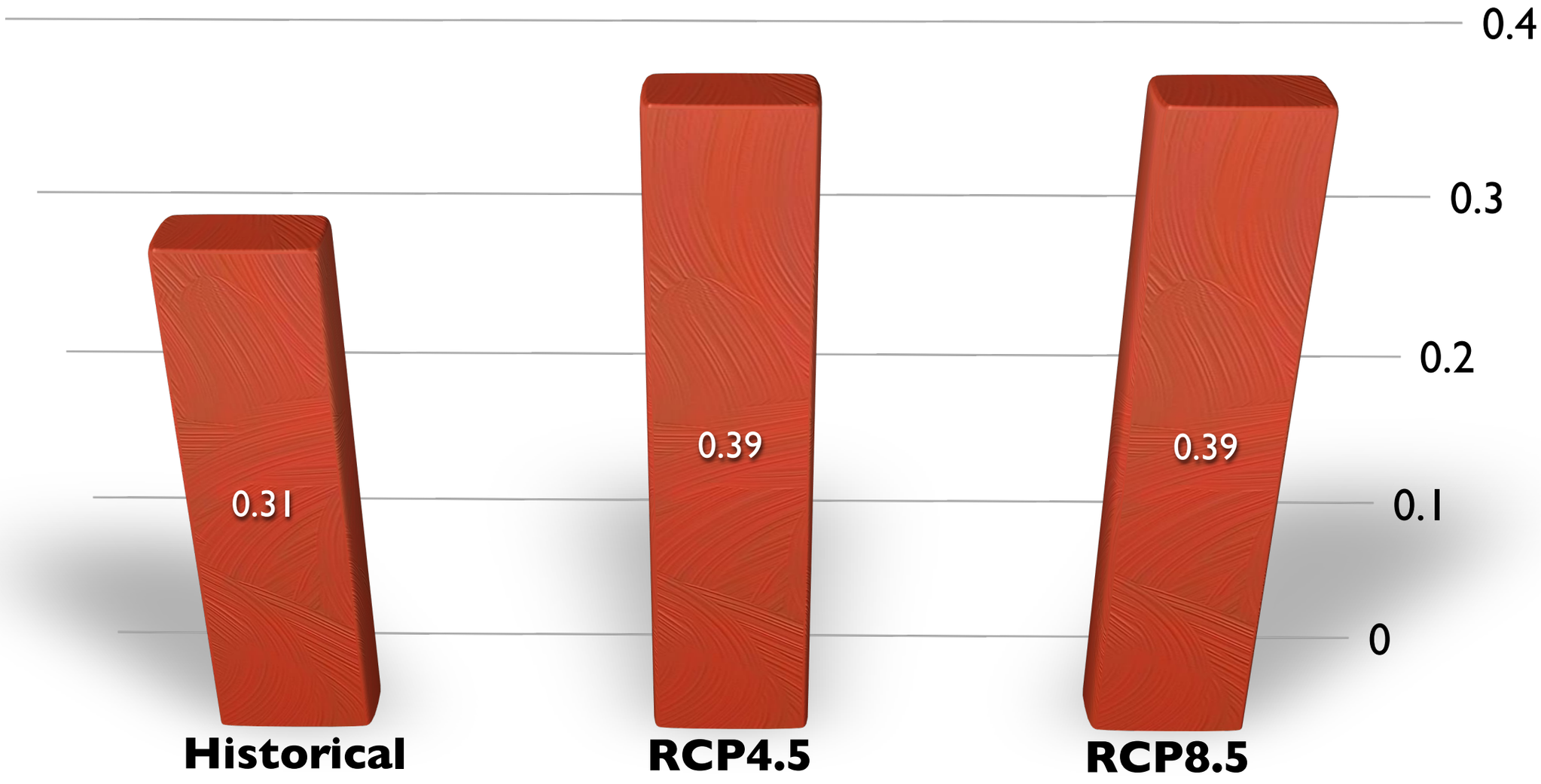
Leading pattern of EASM



(Liu, Wang and Yang, 2008)

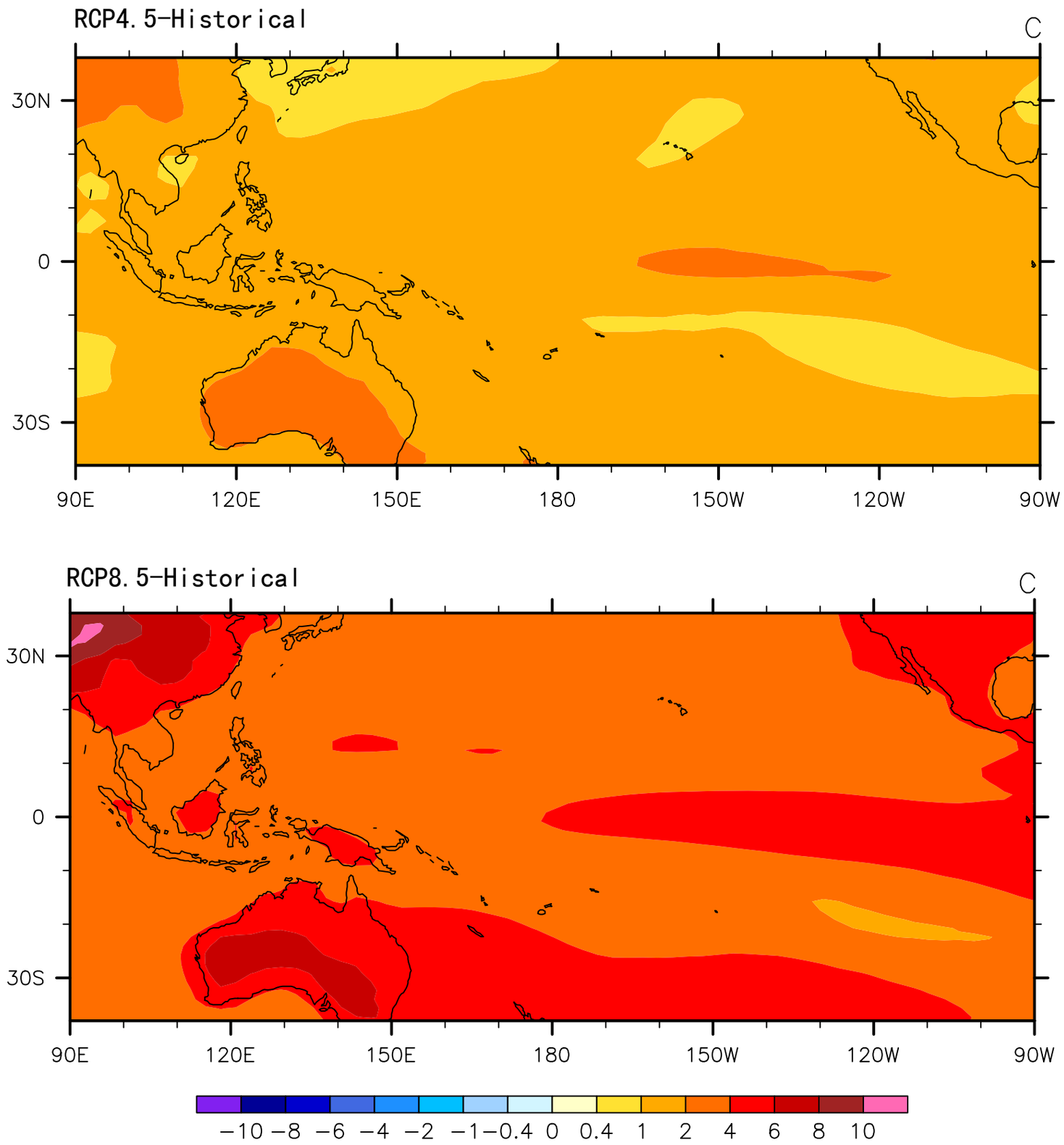
The spatial patterns of the first MV-EOF mode of EASM. All panels are 850 hPa winds (vectors in units of m/s), precipitation (color shading in units of mm/day), and sea-level pressure (contours in units of hPa). (a) Observations, (b) CMIP5-Historical, (c) CMIP5-RCP4.5, (d) CMIP5-RCP8.5.

EASM and ENSO



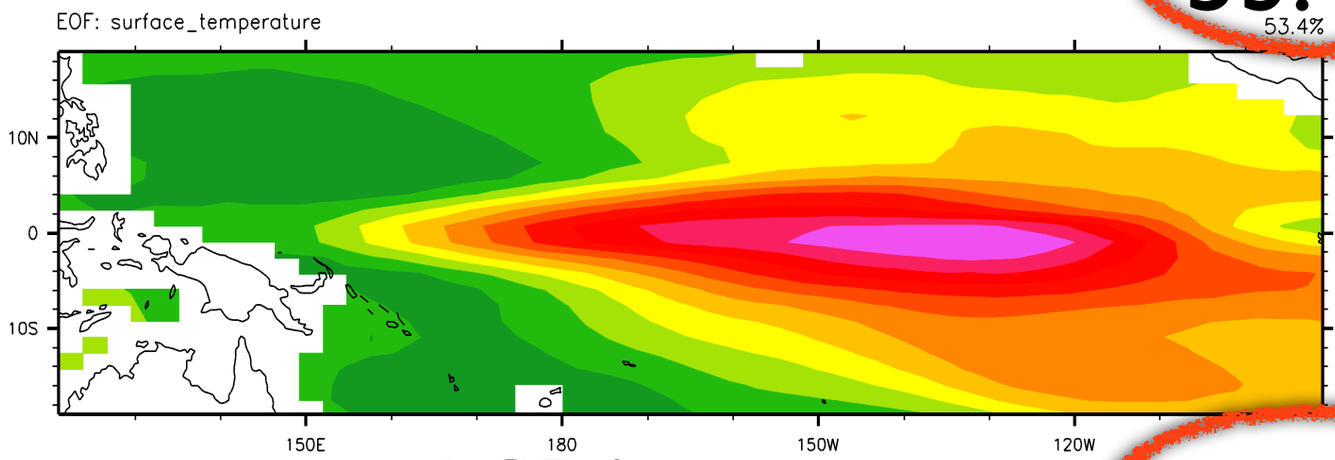
The correlation coefficients between the time series of EASM leading pattern and NINO3.4 index in CMIP5-Historical, CMIP5-RCP4.5, and CMIP5-RCP8.5.

Changes of SST in Winter

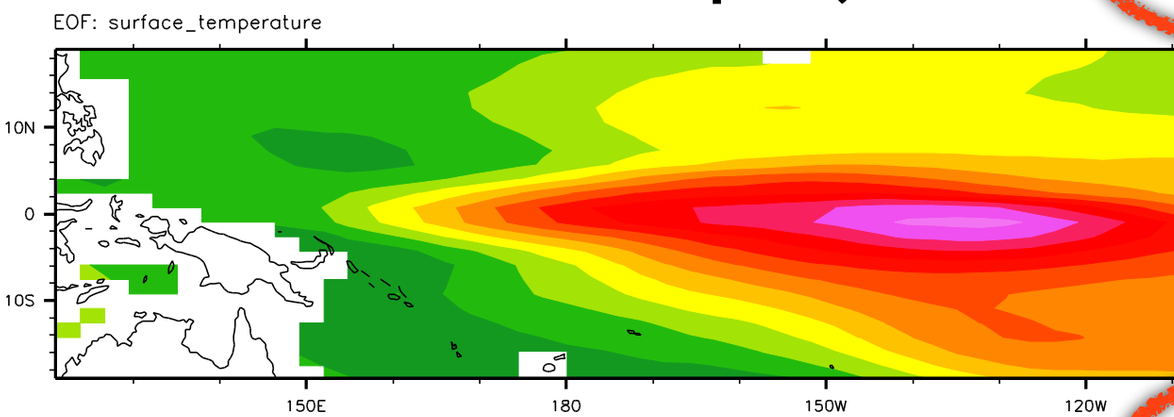


Leading pattern of tropical SST

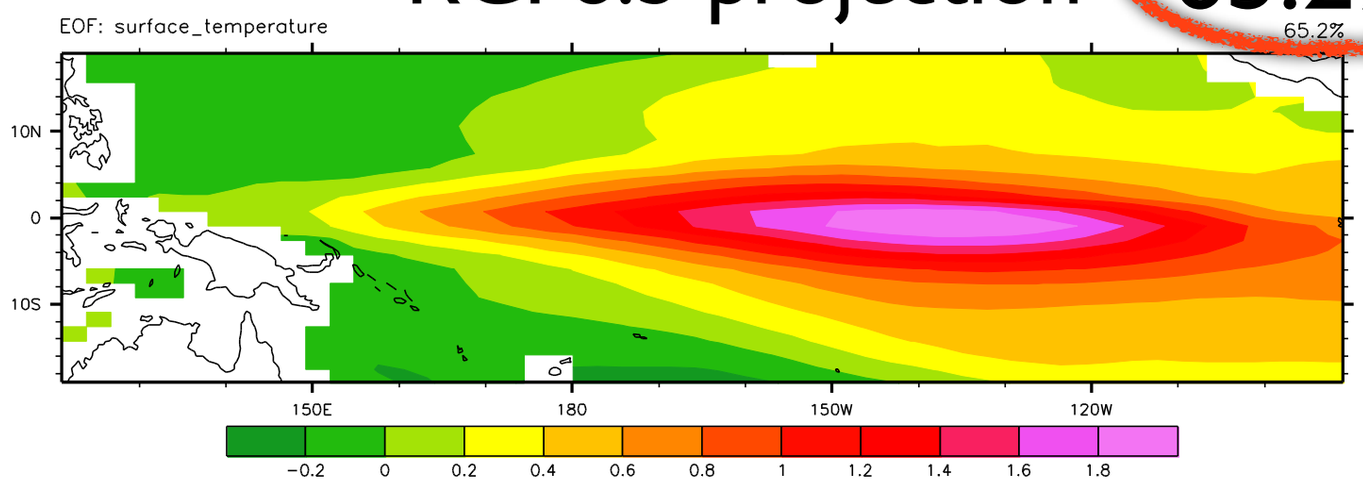
Historical simulations 53.4%



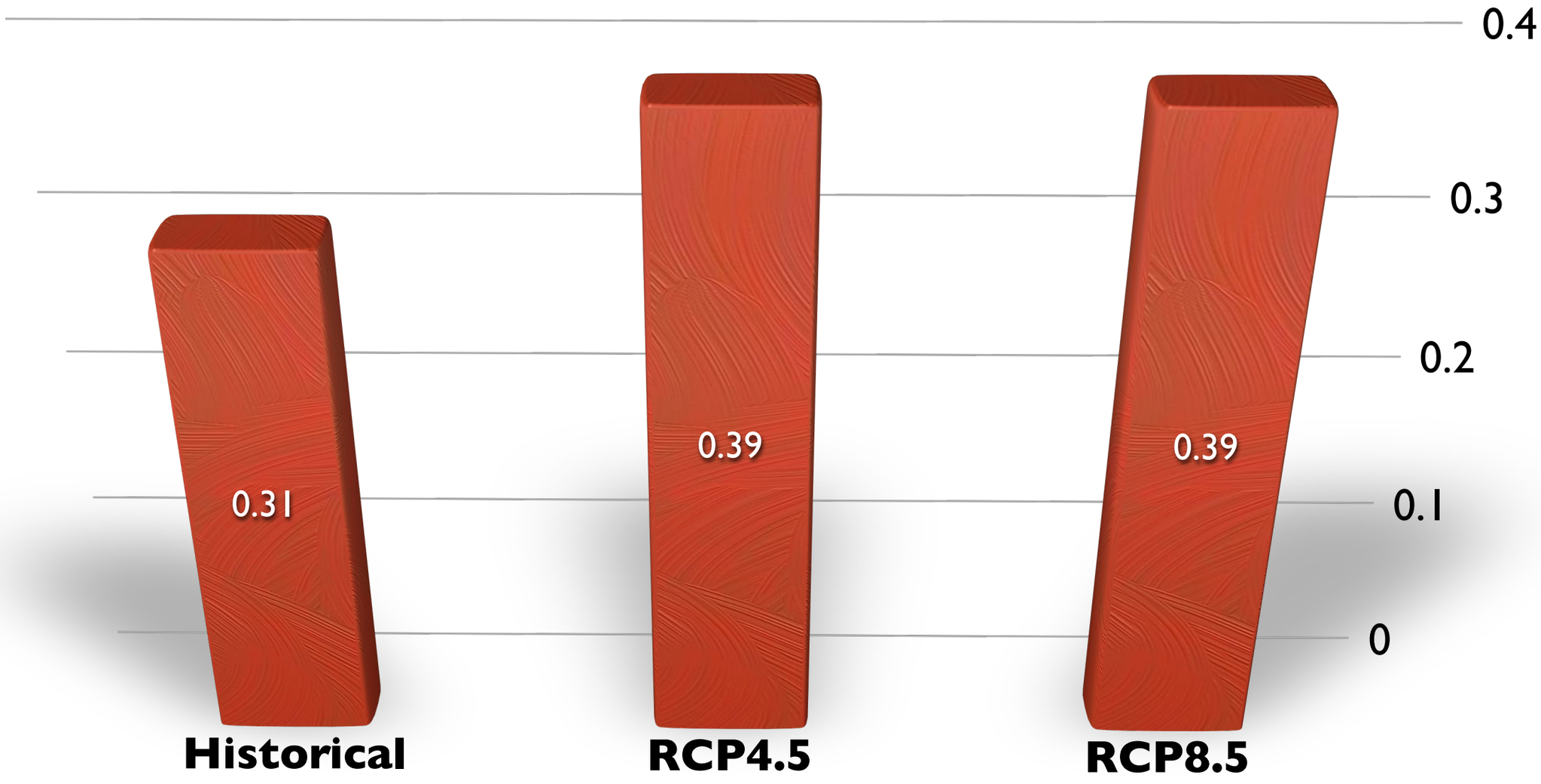
RCP4.5 projection 51.3%



RCP8.5 projection 65.2%



EASM and ENSO



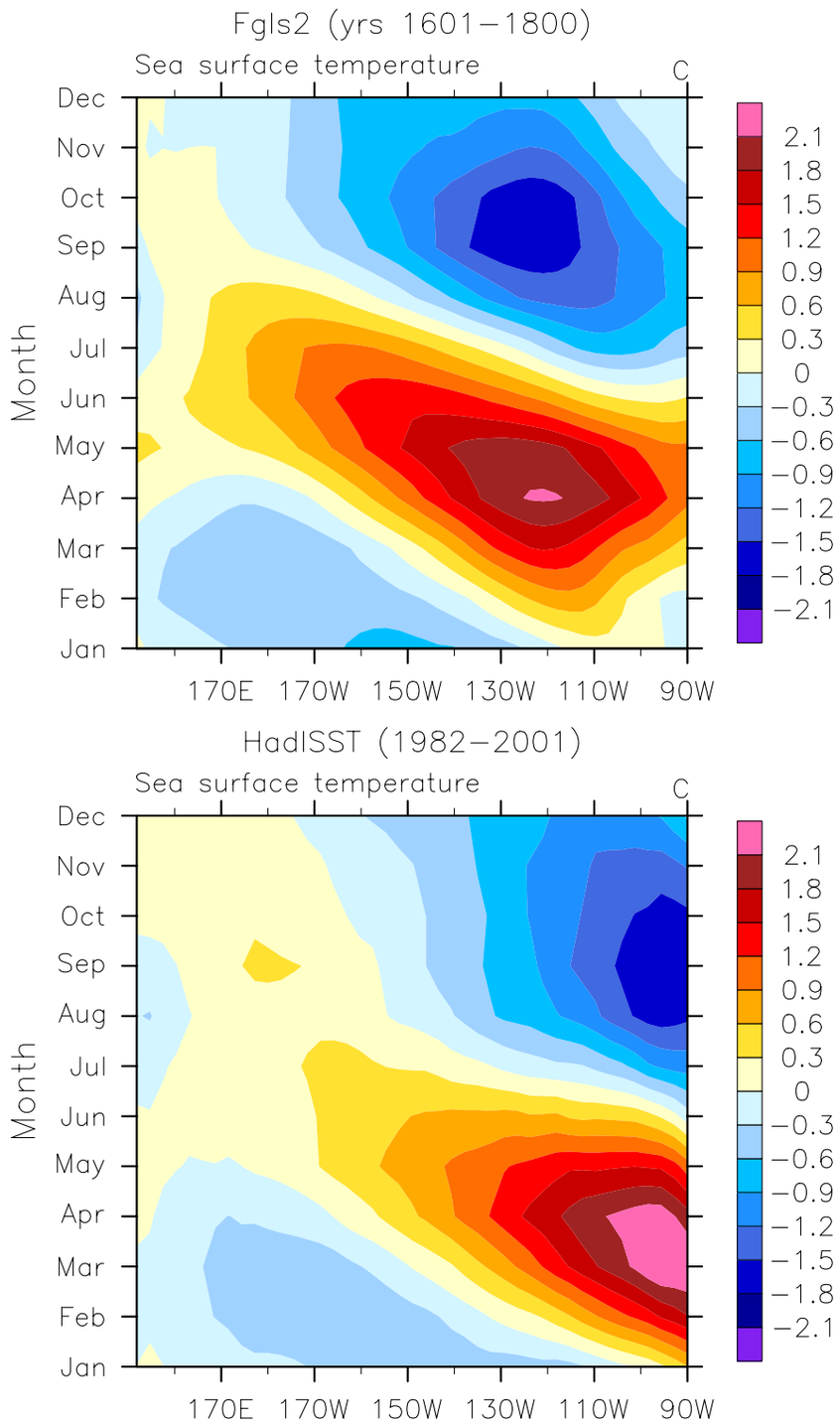
The correlation coefficients between the time series of EASM leading pattern and NINO3.4 index in CMIP5-Historical, CMIP5-RCP4.5, and CMIP5-RCP8.5.

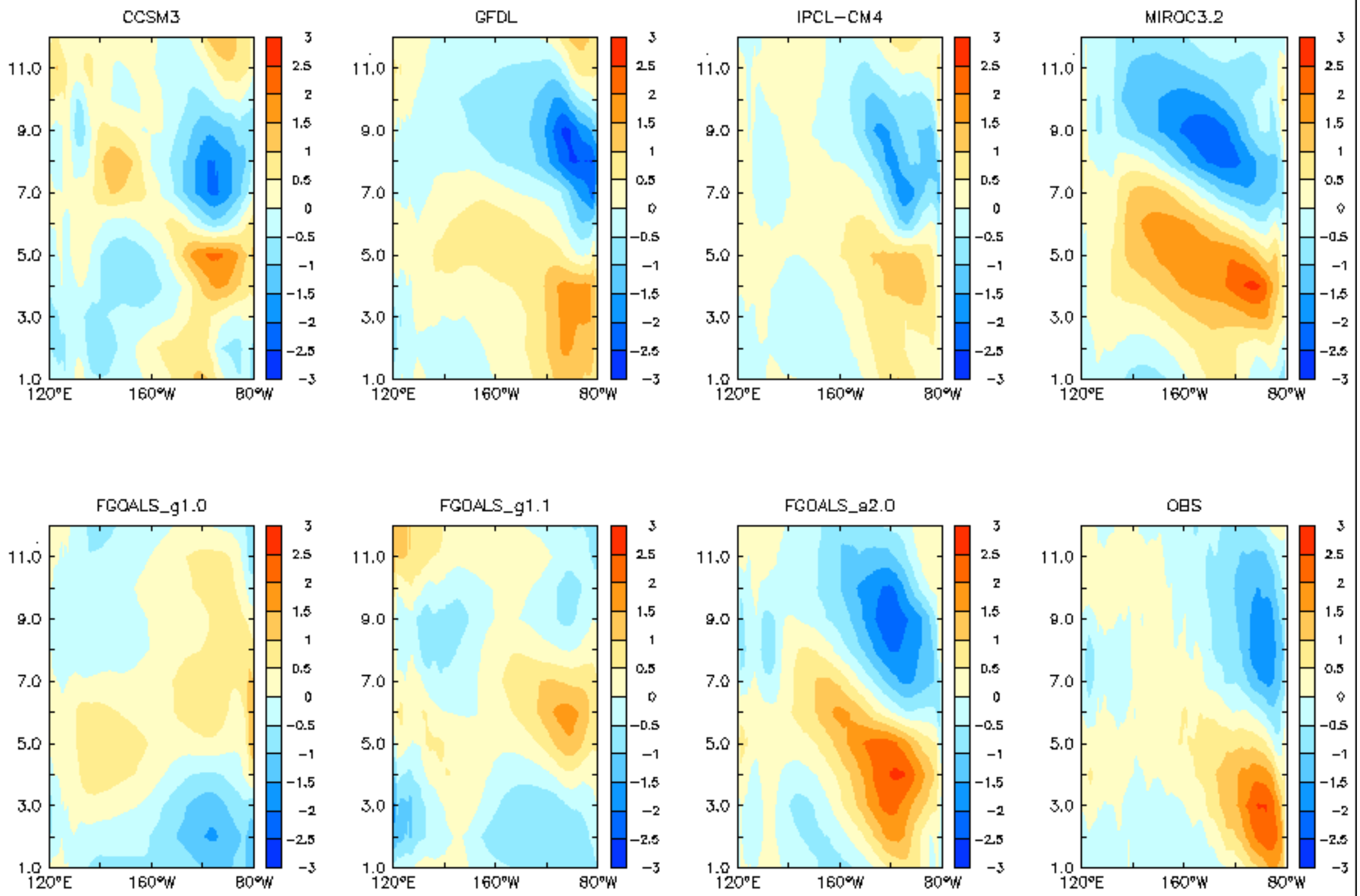
Summary

- EASM become clearly strengthened in term of monsoon precipitation and the monsoon lower-level westerly jet flow;
- The annual cycle of precipitation over EA becomes enhanced, which indicates more abrupt monsoon, while after EA monsoon onset, EASM march more northward;
- The leading pattern of EASM occurs more frequently in high emission scenario, and the reason can be explained by the changes of tropical SST in interannual timescale;
- The relationship between EASM interannual variations and ENSO will strengthen in future projections. It indicates the possible increase on the predictability of EASM interannual variations.

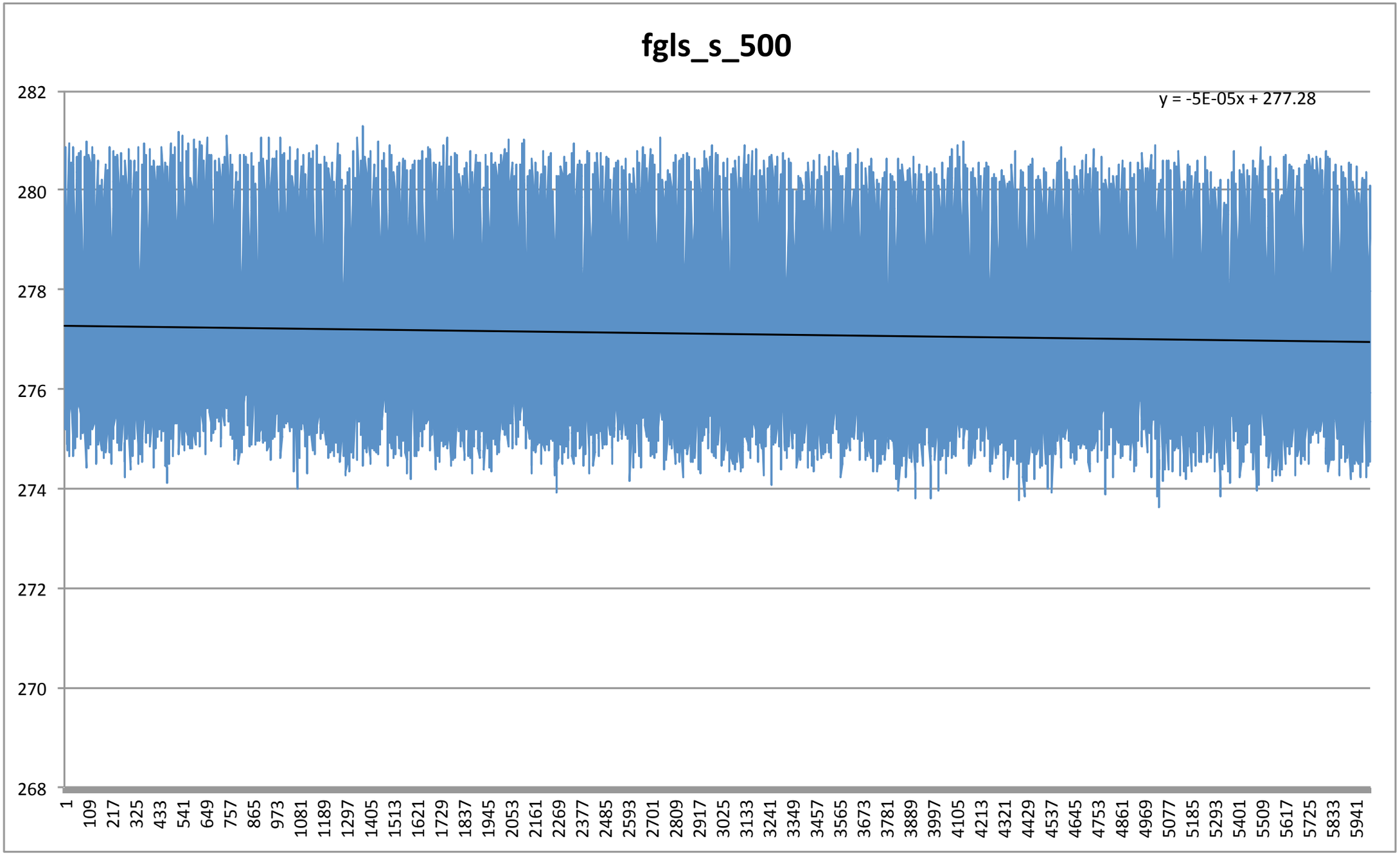
Thank you!

Equatorial Pacific Ocean (5S-5N)




CCSM3
GFDL
IPCL−CM4
MIROC3.2
FGOALS_g1.0
FGOALS_g1.1
FGOALS_a2.0
OBS
11.0
9.0
7.0
5.0
3.0
1.0
120°E
160°W
80°W
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3

Global-average surface temperature



CMIP5气候预估核心试验RCP8.5 & RCP4.5 试对全球气候变化的预估结果