The 2015 Workshop on High-Resolution Climate Simulation, Projection, and Application
Jan. 19-20, 2015, Academia Sinica, Taipei, Taiwan
http://tccip.ncdr.nat.gov.tw/activity/iwcc2015/

The K computer at RIKEN AICS (~10 PFlops)

A 20-year climatology of a NICAM AMIP-type simulation

Masaki Satoh (AORI, The University of Tokyo)

Courtesy of C. Kodama (JAMSTEC) et al.

NICAM outcomes: 10 years history and beyond

Good points of NICAM

Realistic meso-scale circulations, e.g. diurnal cycle

Multiscale structure of cloud systems

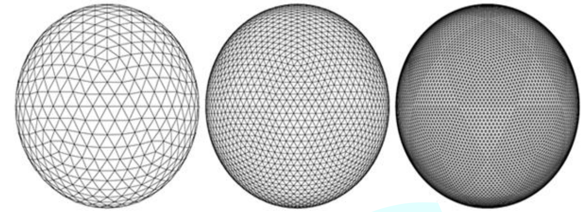
Intra-seasonal oscillation: MJO, BSISO (boreal summer ISO)

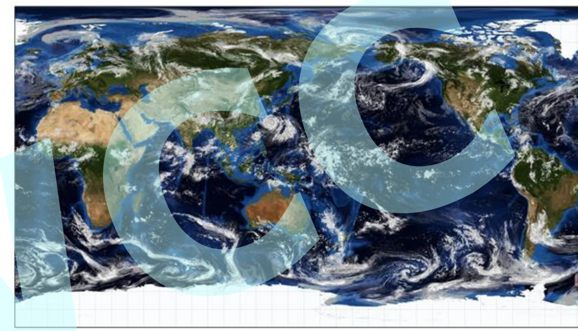
Tropical cyclones

Cloud properties with cloud microphysics

Collaboration with satellite observation

(evaluation, improvements, & assimilation)





K-computer studies

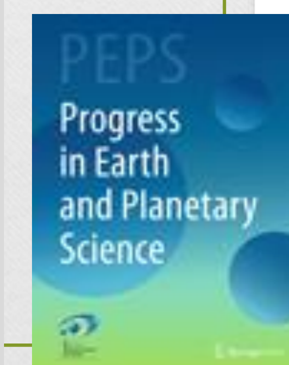
Further high-resolution (dx=870m) (Miyamoto et al. 2014)

Decadal simulations (Kodama et al. 2014)

Ensemble simulations (Miyakawa et al. 2014, Nature Comm; Nakano et al. 2015, GRL)

Overview paper:

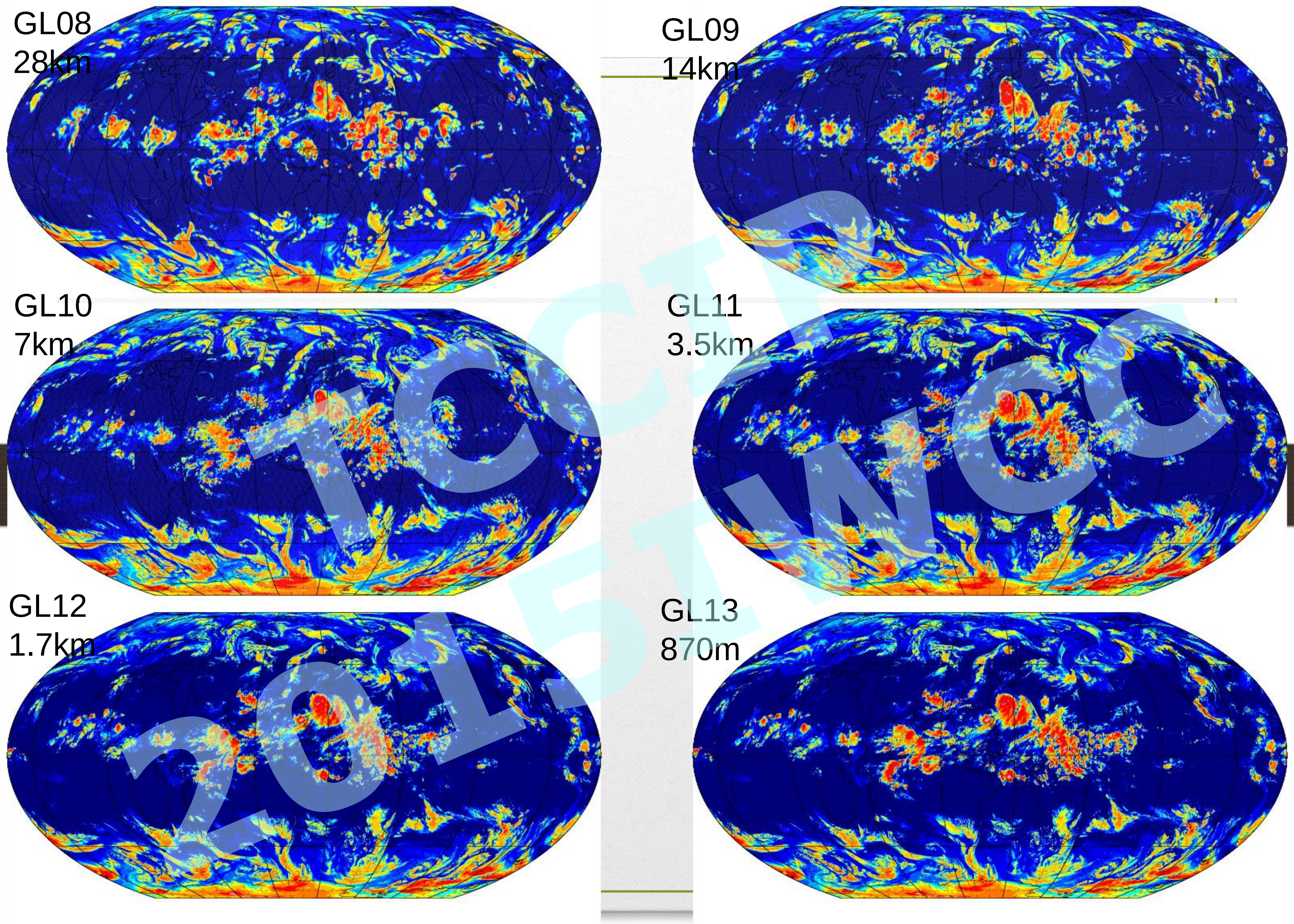
Satoh, M., Tomita, H., Yashiro, H., Miura, H., Kodama, C., Seiki, T., Noda, A. T., Yamada, Y., Goto, D., Sawada, M., Miyoshi, T., Niwa, Y., Hara, M., Ohno, T., Iga, S., Arakawa, T., Inoue, T., Kubokawa, H. (2014) The Nonhydrostatic Icosahedral Atmospheric Model: Description and Development.
Progress in Earth and Planetary Science, **1**, 18.
http://dx.doi.org/10.1186/s4064501400181



NICAM 870m mesh simulation

Miyamoto, Y., Kajikawa, Y., Yoshida, R., Yamaura, T., Yashiro, H., and Tomita, H., 2013: Deep moist atmospheric convection in a sub-kilometer global simulation. Geophys. Res. Lett., 40, 4922-4926. DOI:10.1002/grl.50944.

Miyamoto, Y., R. Yoshida, T. Yamaura, H. Yashiro, H. Tomita and Y. Kajikawa, 2014: Does convection vary in different cloudy disturbances? Atmospheric Science Letters, accepted. DOI:10.1002/asl2.558



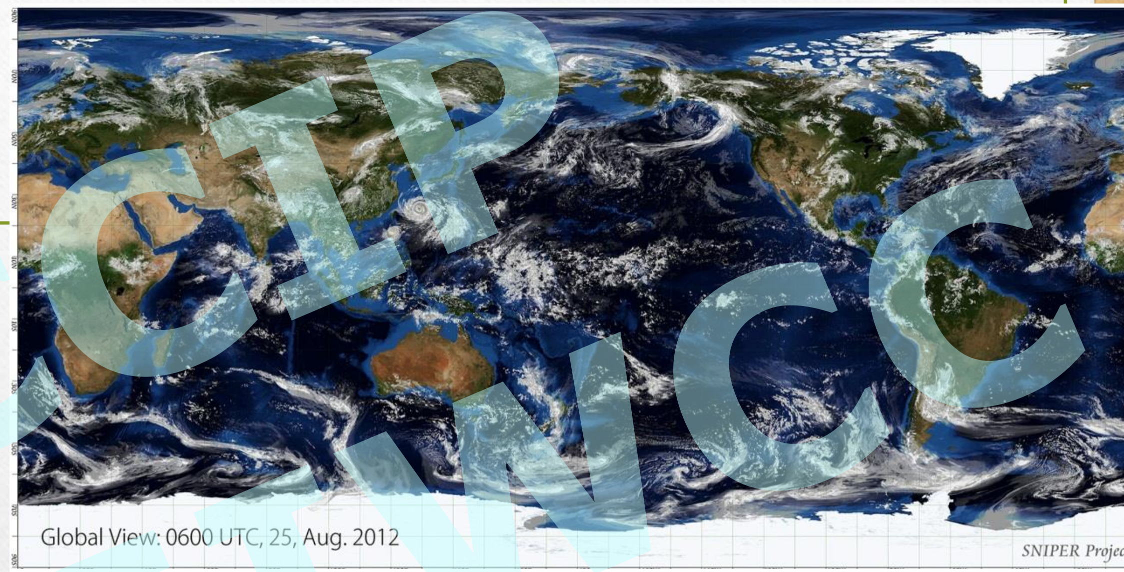
6UTC, 25 Aug. 2012 K-computer by Y. Miyamoto (AICS,RIKEN)

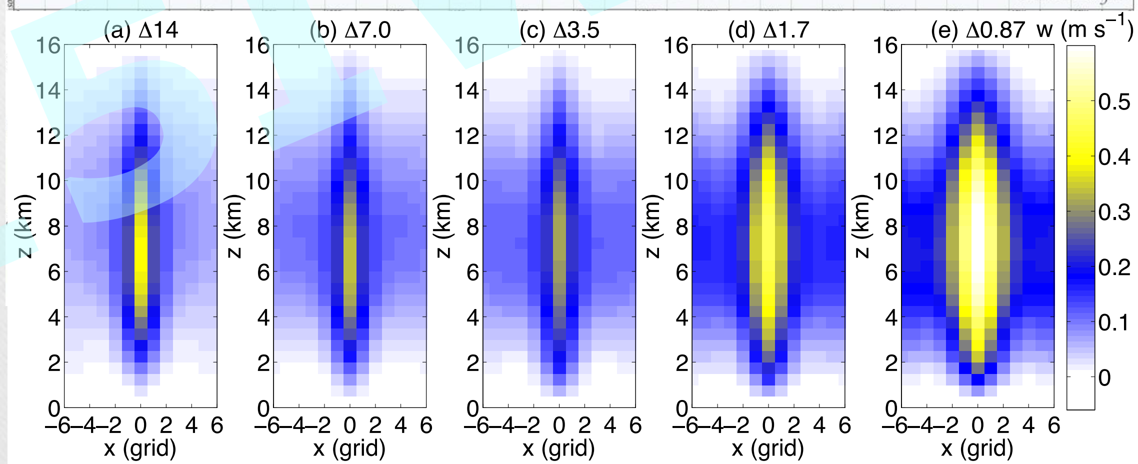
NICAM 870m-mesh simulation

Miyamoto et al. (2013,GRL) using the K computer

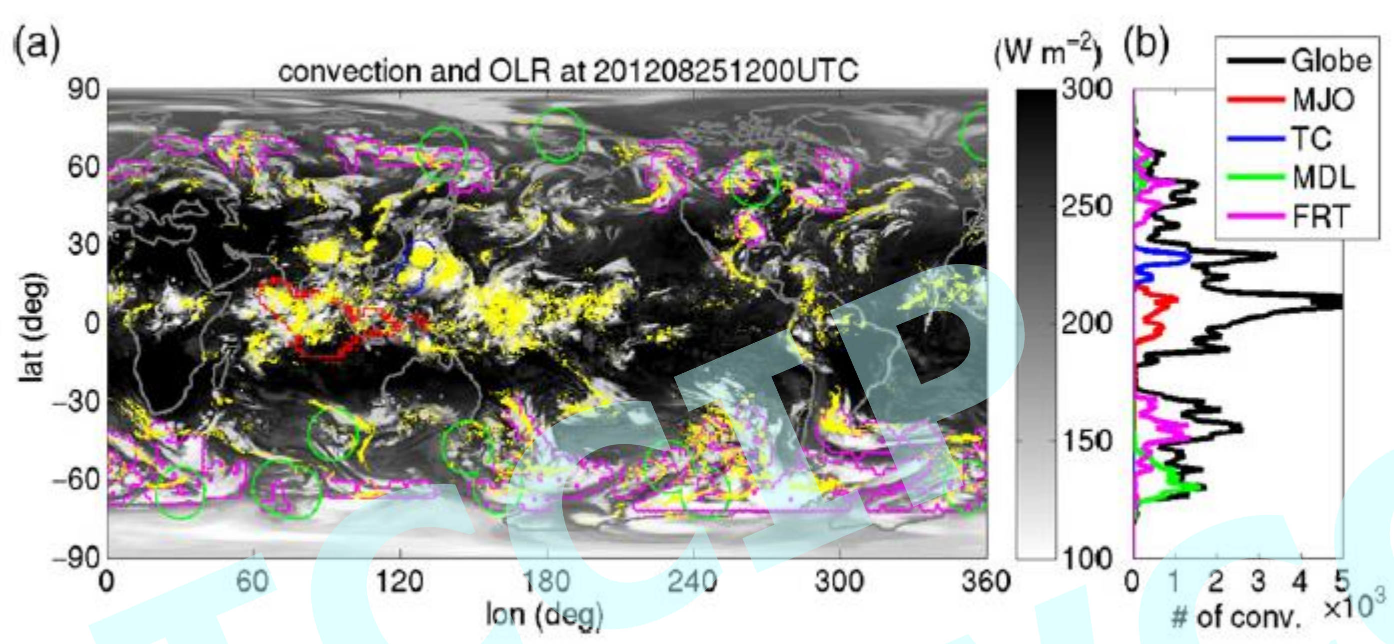
dx=870 m

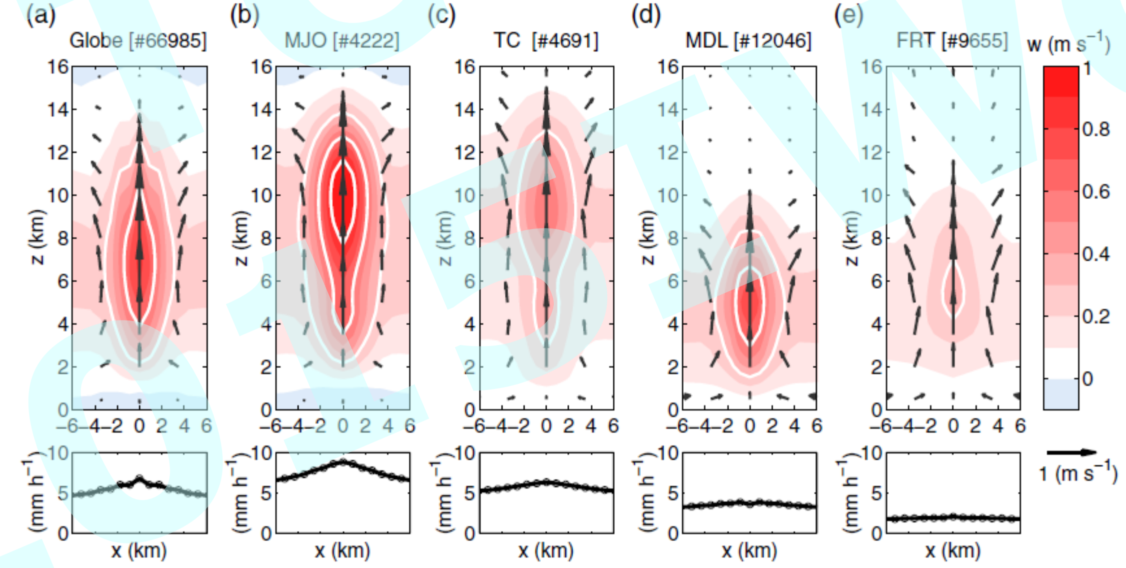
dx=3.5 m





Radius-height cross sections for composites of vertical velocity w

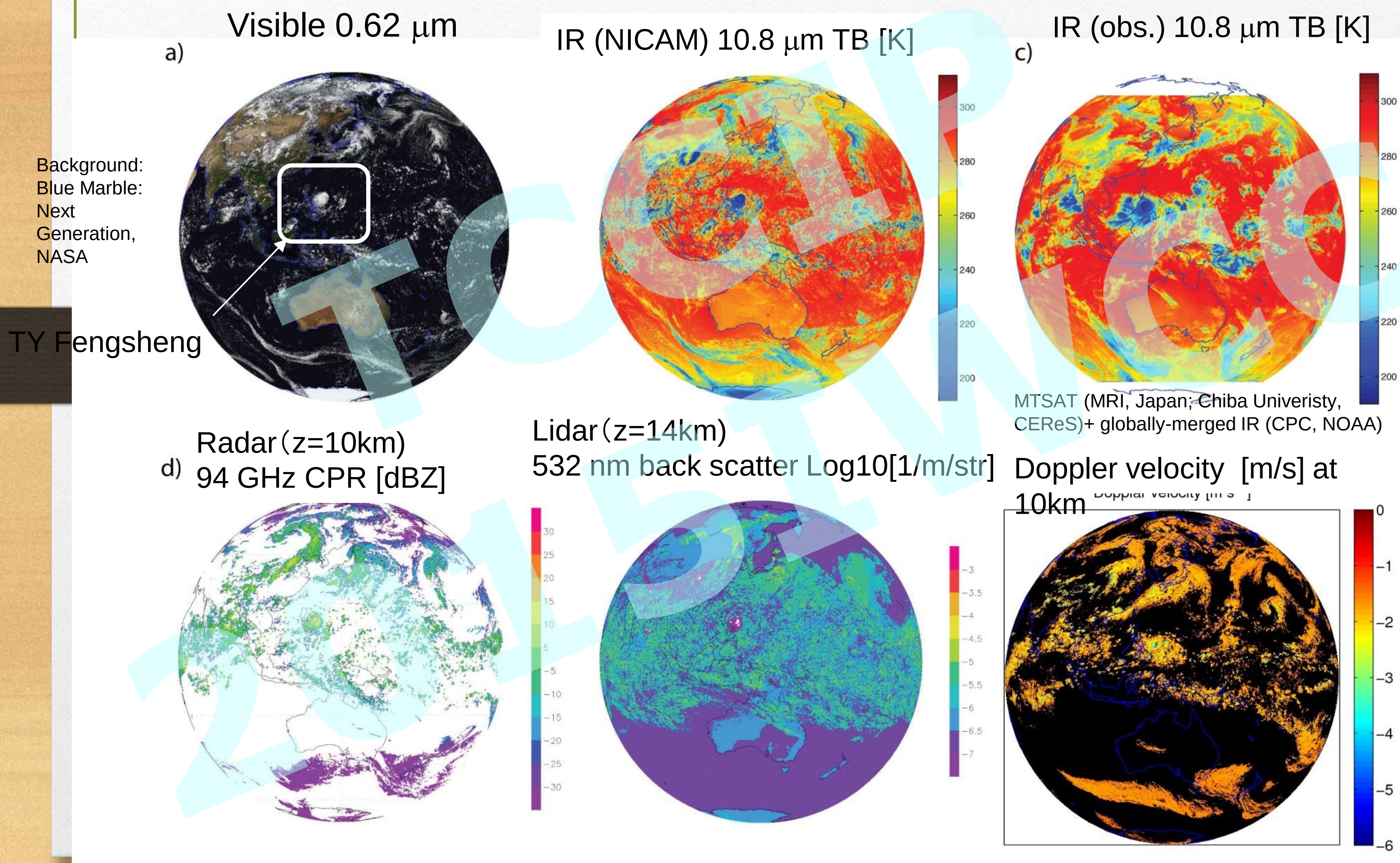




Miyamoto et al. (2015, ASL)

Evaluation of clouds by Joint-Simulator

Hashino et al. (2013) Evaluating Cloud Microphysics from NICAM against CloudSat and CALIPSO, *J. Geophys. Res.*



Okamoto et al., (2007, 2008); Nishizawa et al., (2008)

NICAM AMIP-type simulations: the first-ever climate run for high-reso. NICAM

Kodama, C., Yamada, Y., Noda, A. T., Kikuchi, K., Kajikawa, Y., Nasuno, T., Tomita, T., Yamaura, T., Takahashi, T. G., Hara, M., Kawatani, Y., Satoh, M., Sugi, M. (2014) A 20-year climatology of a NICAM AMIP-type simulation. J. Meteor. Soc. Japan, in revision.

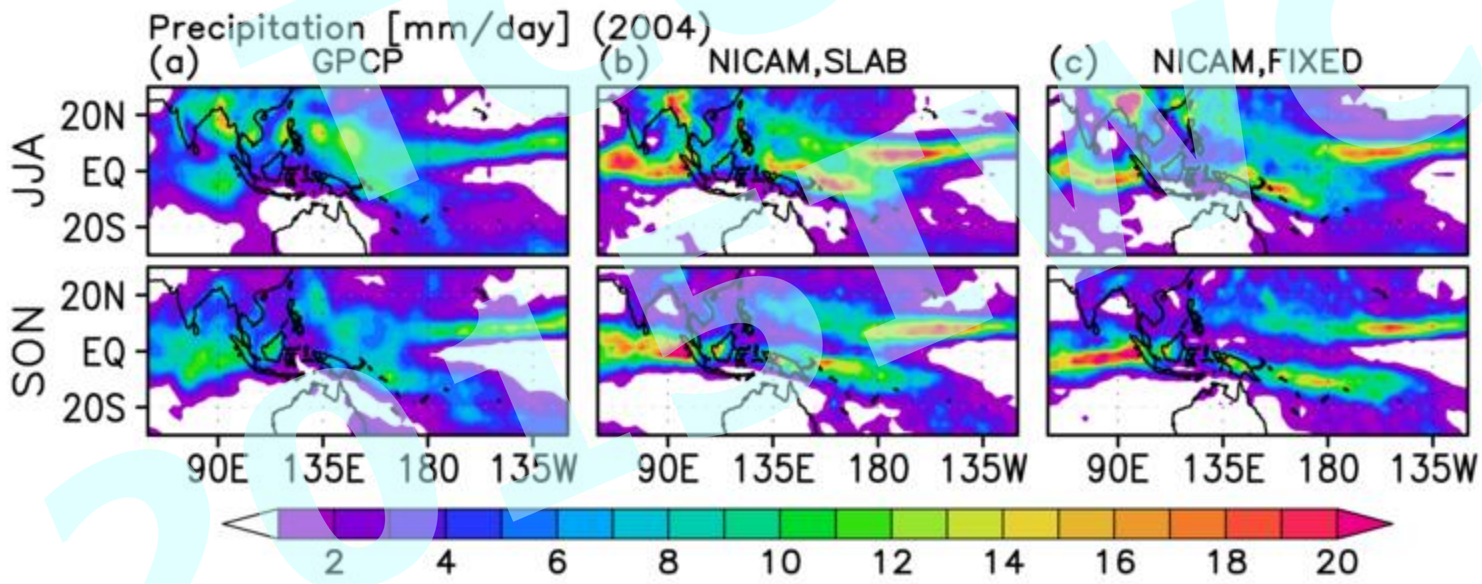
- 14km horizontal mesh and 38 vertical levels up to 40km.
- 1-moment 6-category bulk cloud microphysics (Tomita 2008).
  - No cumulus convection parameterization
  - parameters tuned by several seasonal-scale experiments
- AMIP configurations except for
  - slab ocean model (D=15m & τ=7days) with SST nudging and fixed sea ice
- CNTL run: 1978.06-2009.12
  - monthly mean AMIP2 SST/SSI.
- FUTURE run: 2074.06-2105.12 (A1B scenario)
  - CMIP3 model ensemble dSST = SST(2075-2099) – SST(1979-2003) including trend is added to AMIP2 SST. For sea ice, areal change is considered following Mizuta et al. [2008].

Contents

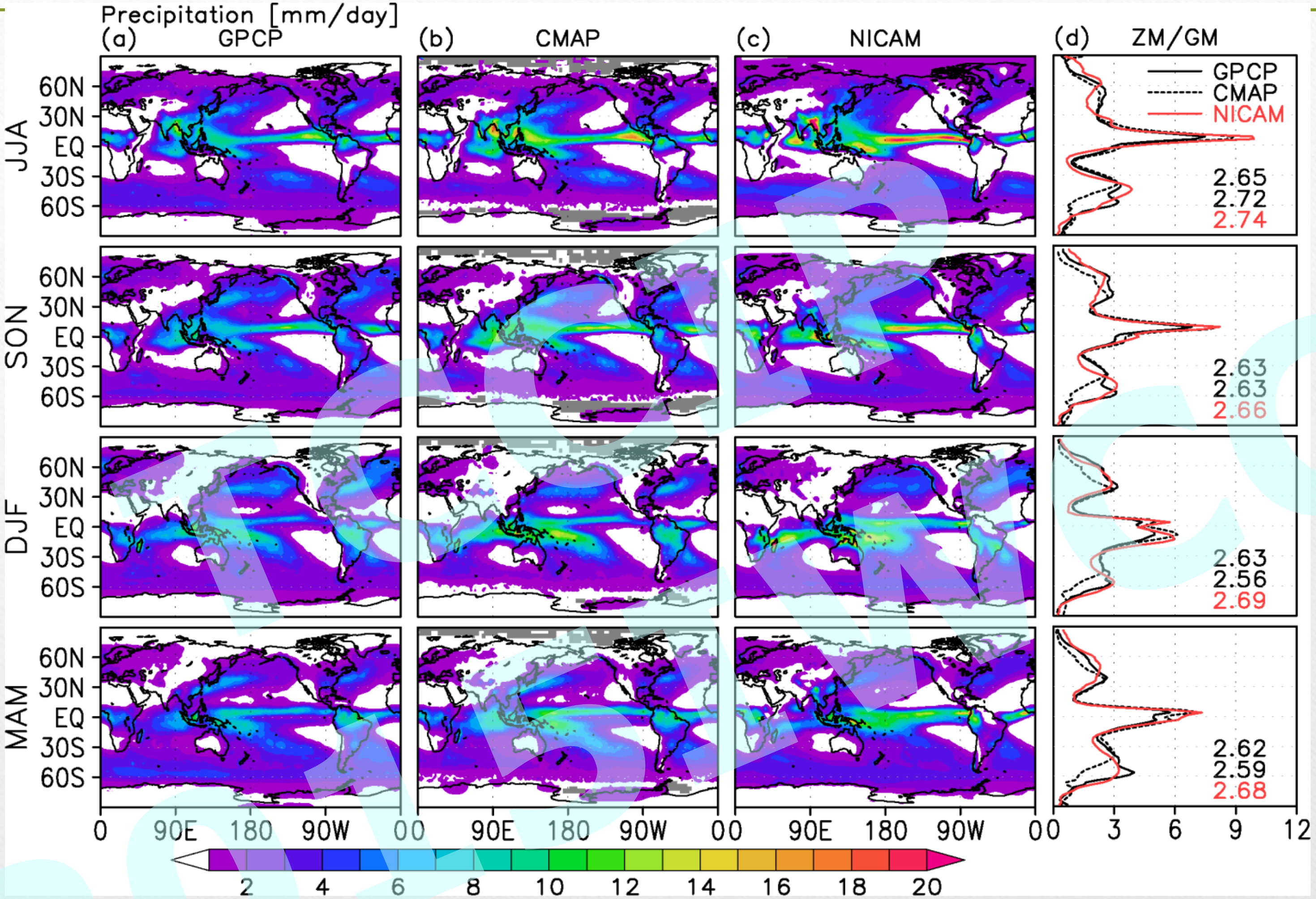
- global precipitation and basic states (C. Kodama)
- tropical cyclone climatology (Y. Yamada & C. Kodama)
- MJO and tropical waves (K. Kikuchi)
- Asian summer monsoon (Y. Kajikawa & T. Nasuno)
- Baiu/Meiyu front (T. Tomita & T. Yamaura)
- diurnal cycle of precipitation (H. Takahashi & M. Hara)
- stratospheric variability (Y. Kawatani)

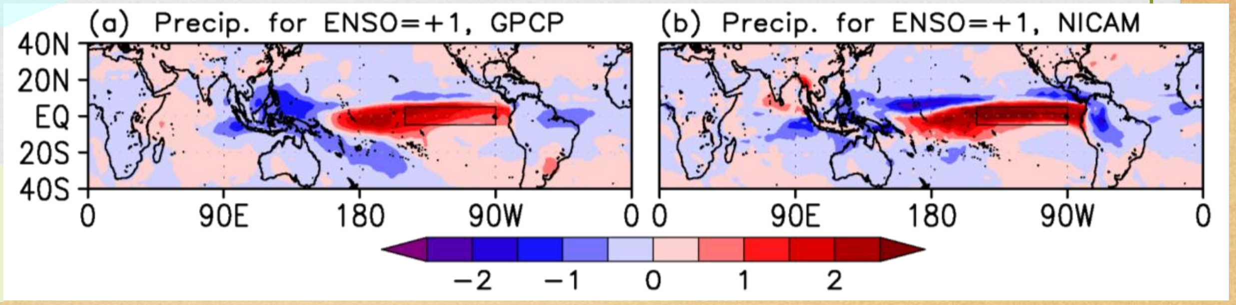
data: CNTL run (1979-1998)

precipitation: SLAB vs. fixed SST



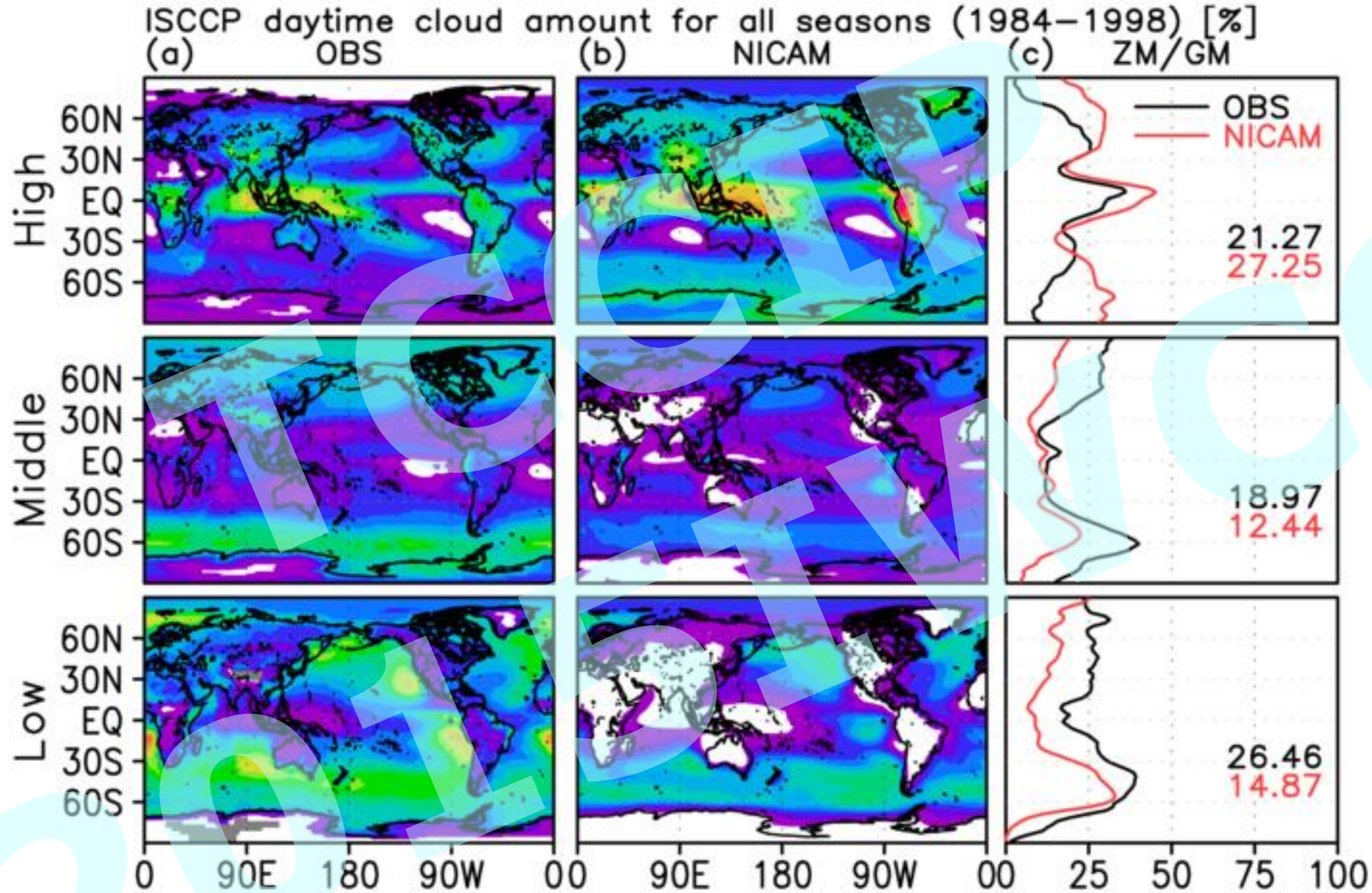
Precipitation rate



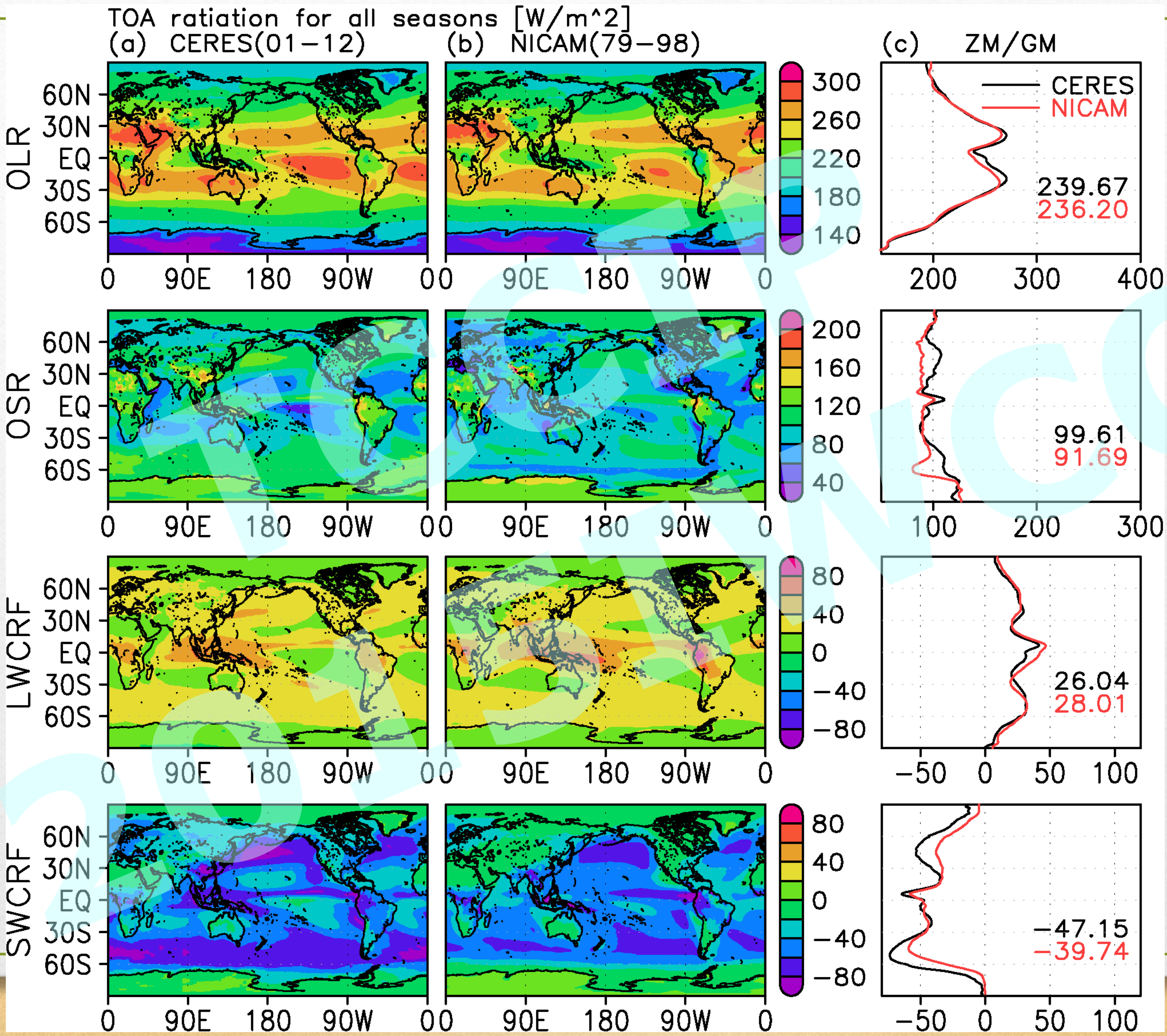


Precip. response to ENSO
(ENSO index = +1 anomaly)

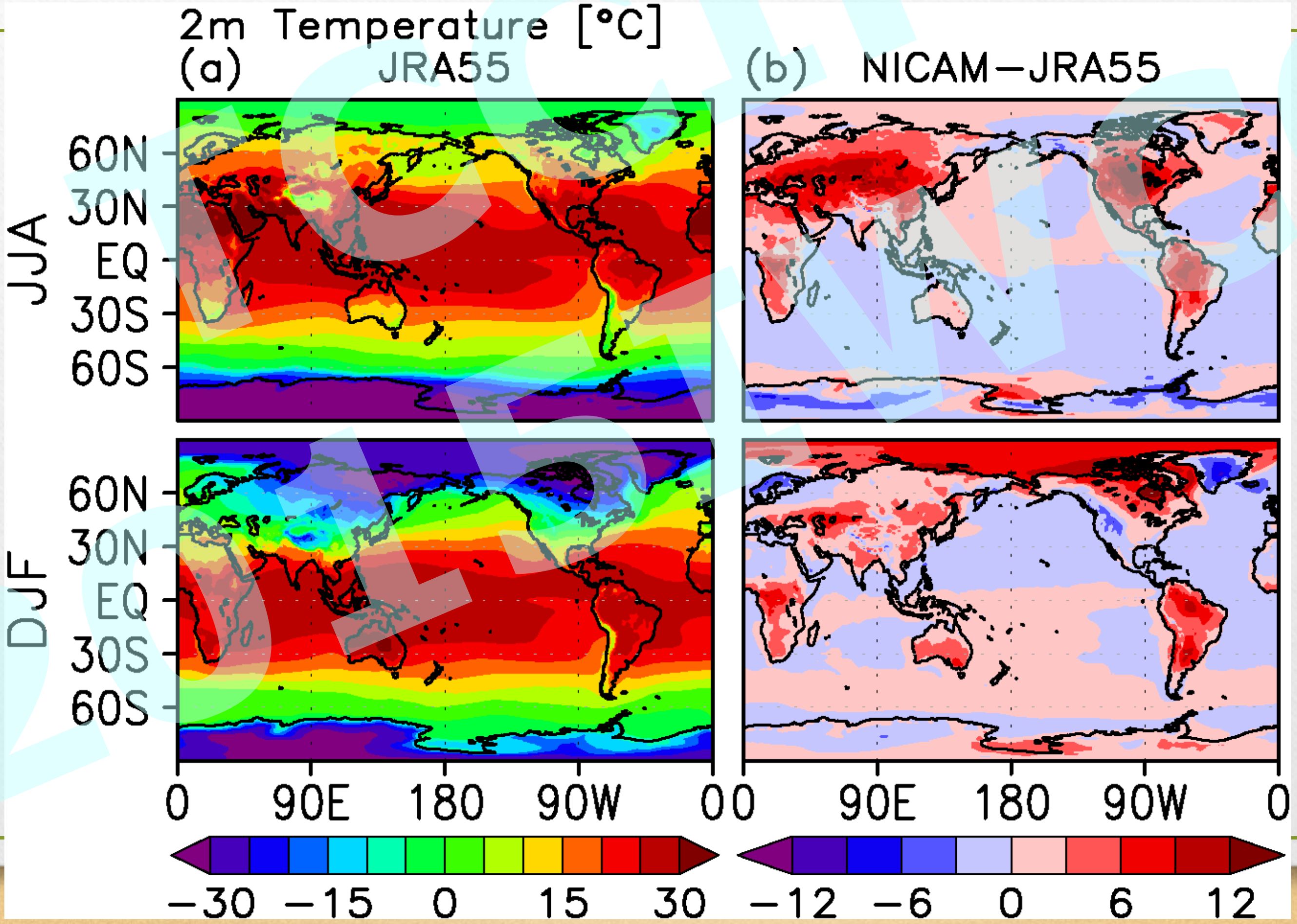
ISCCP cloud amount



TOA radiation

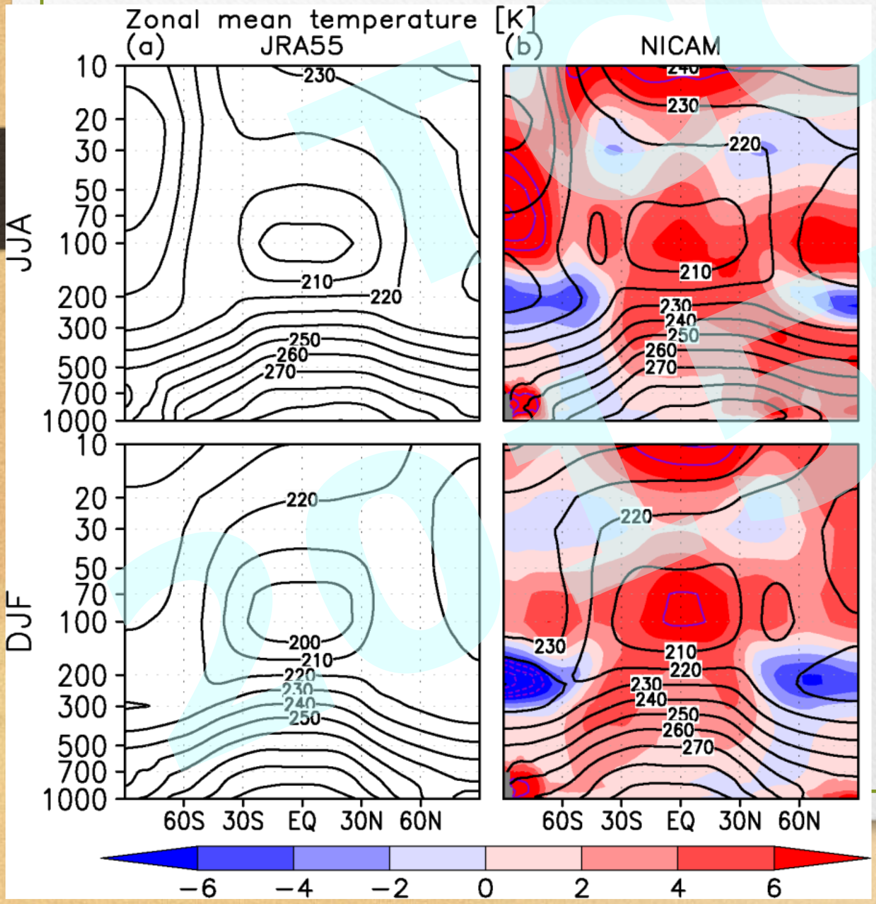


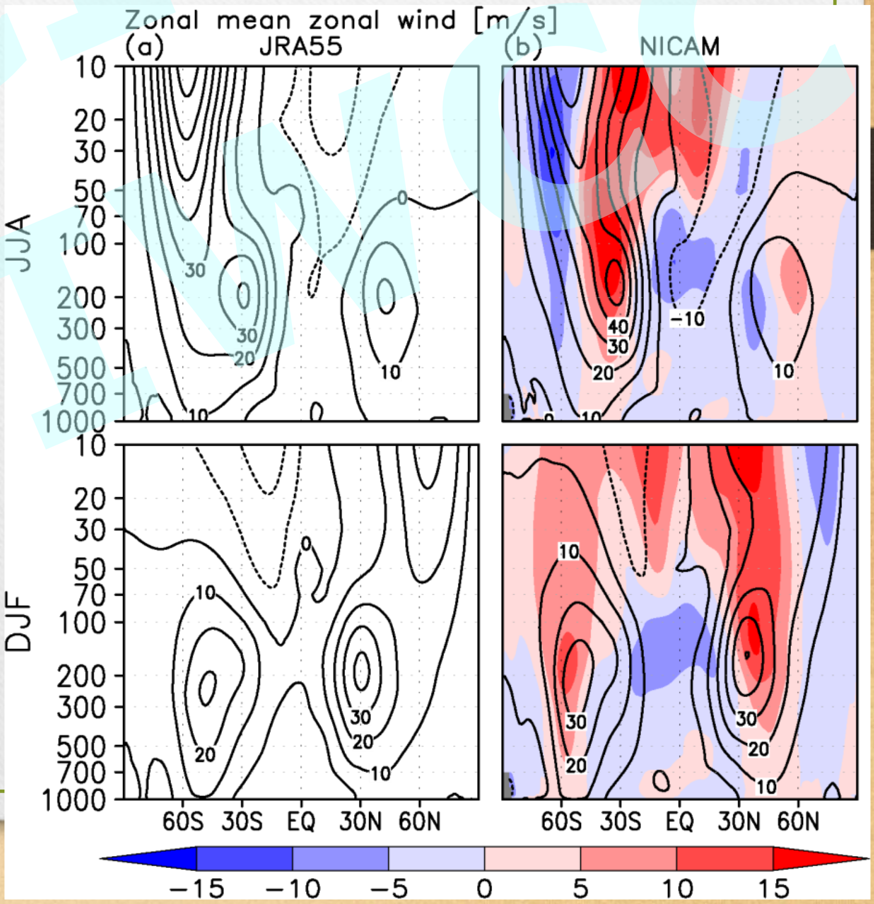
T2m



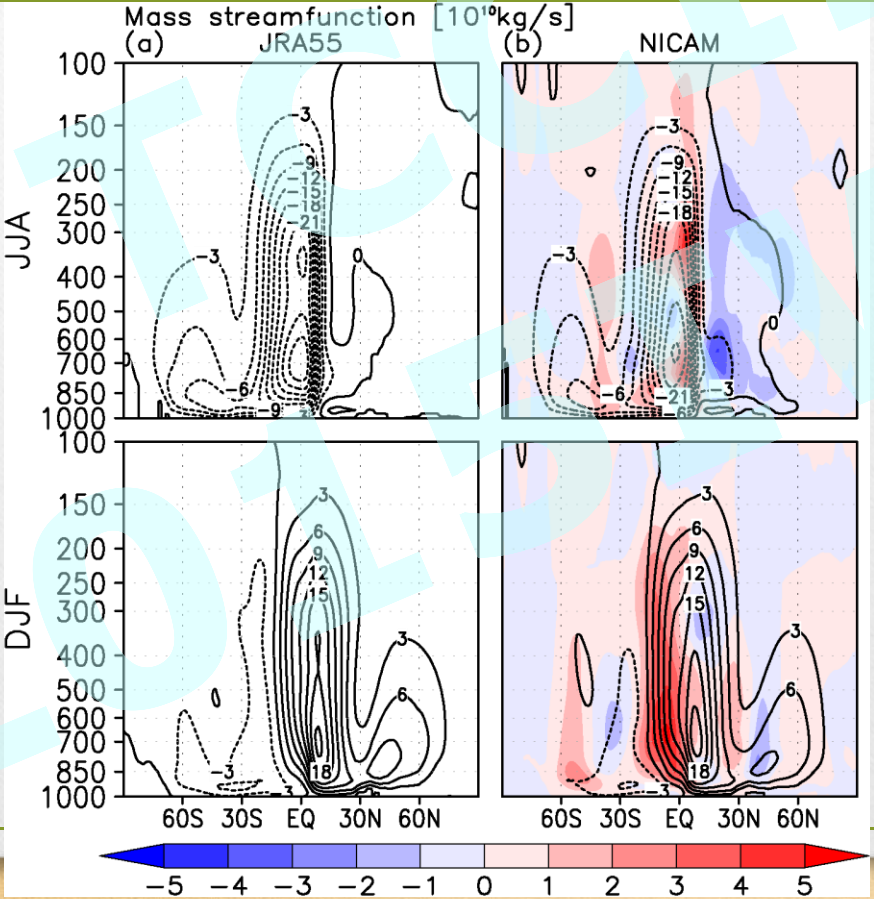
2m Temperature [°C]
(a) JRA55
(b) NICAM−JRA55
JJA
DJF
60N
30N
EQ
30S
60S
0
90E
180
90W
0
−30
−15
0
15
30
−12
−6
0
6
12

Zonal mean T & U





Mean meridional circulation

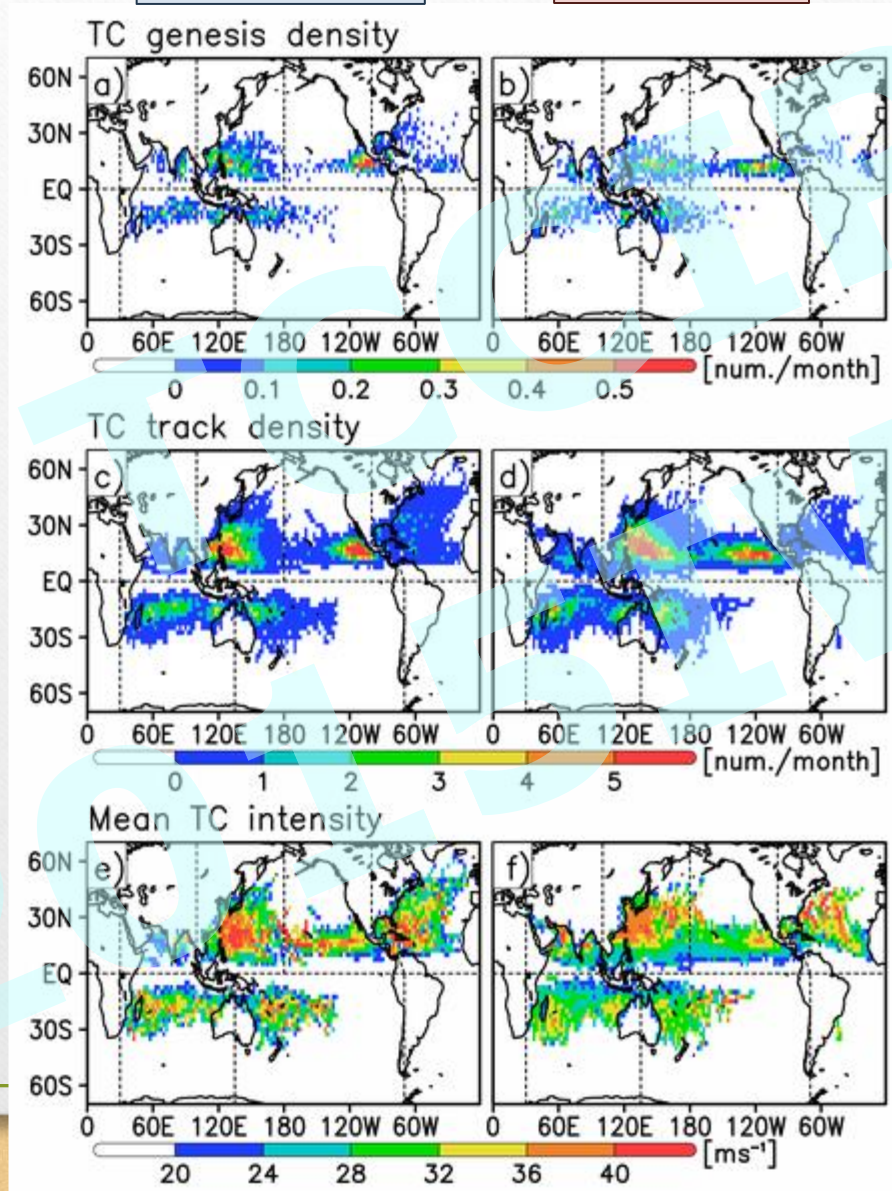


mass-weighted
isentropic zonal mean

positive: clockwise

Tropical cyclone climatology (1/2)

IBTrACS NICAM



Figs. by Y. Yamada

- Seasonality of the TC genesis is very good!

blue: IBTrACS
black: NICAM

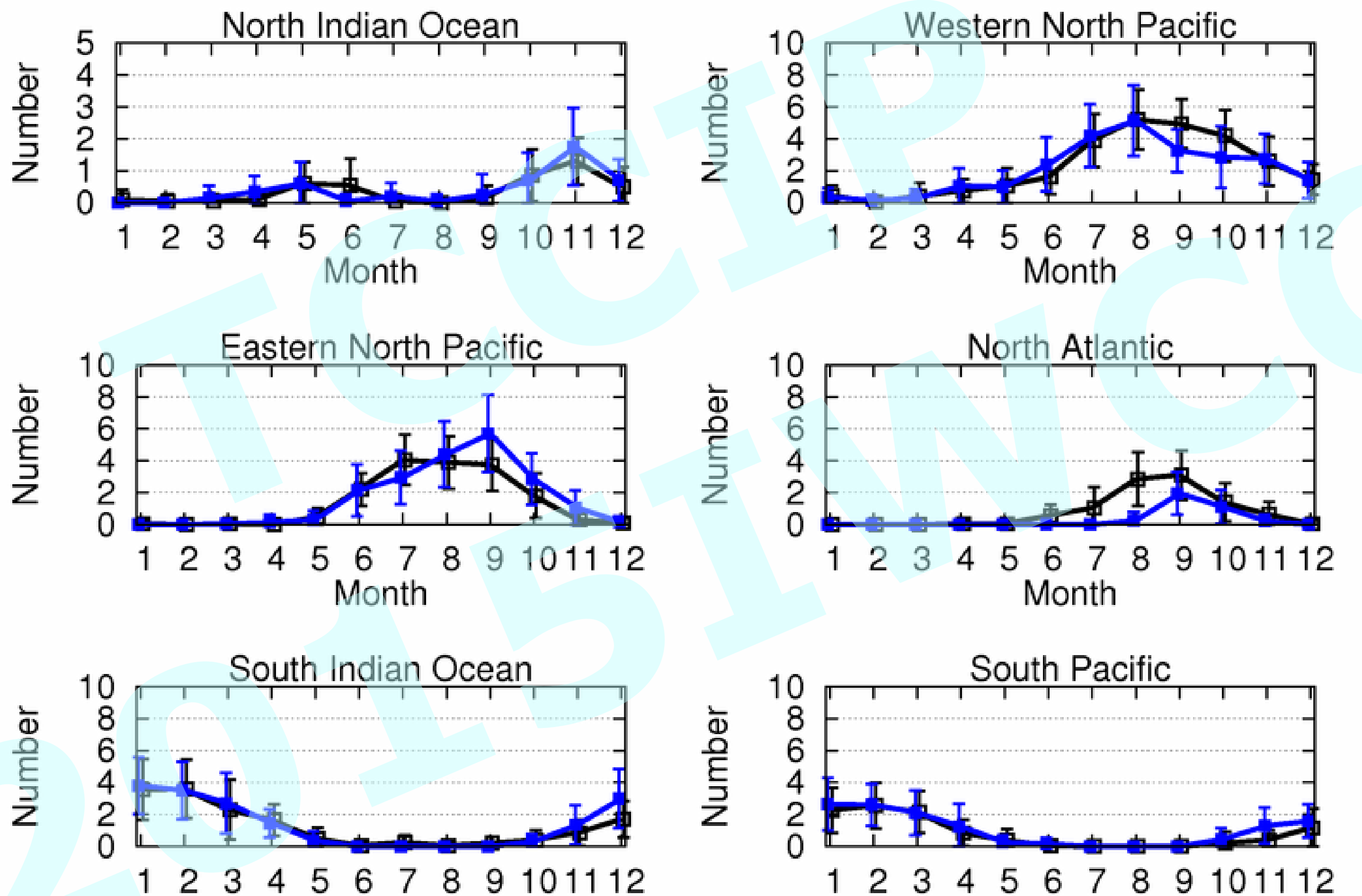


Figure: Number of tropical cyclone per year for each month.

Figs. by Y. Yamada

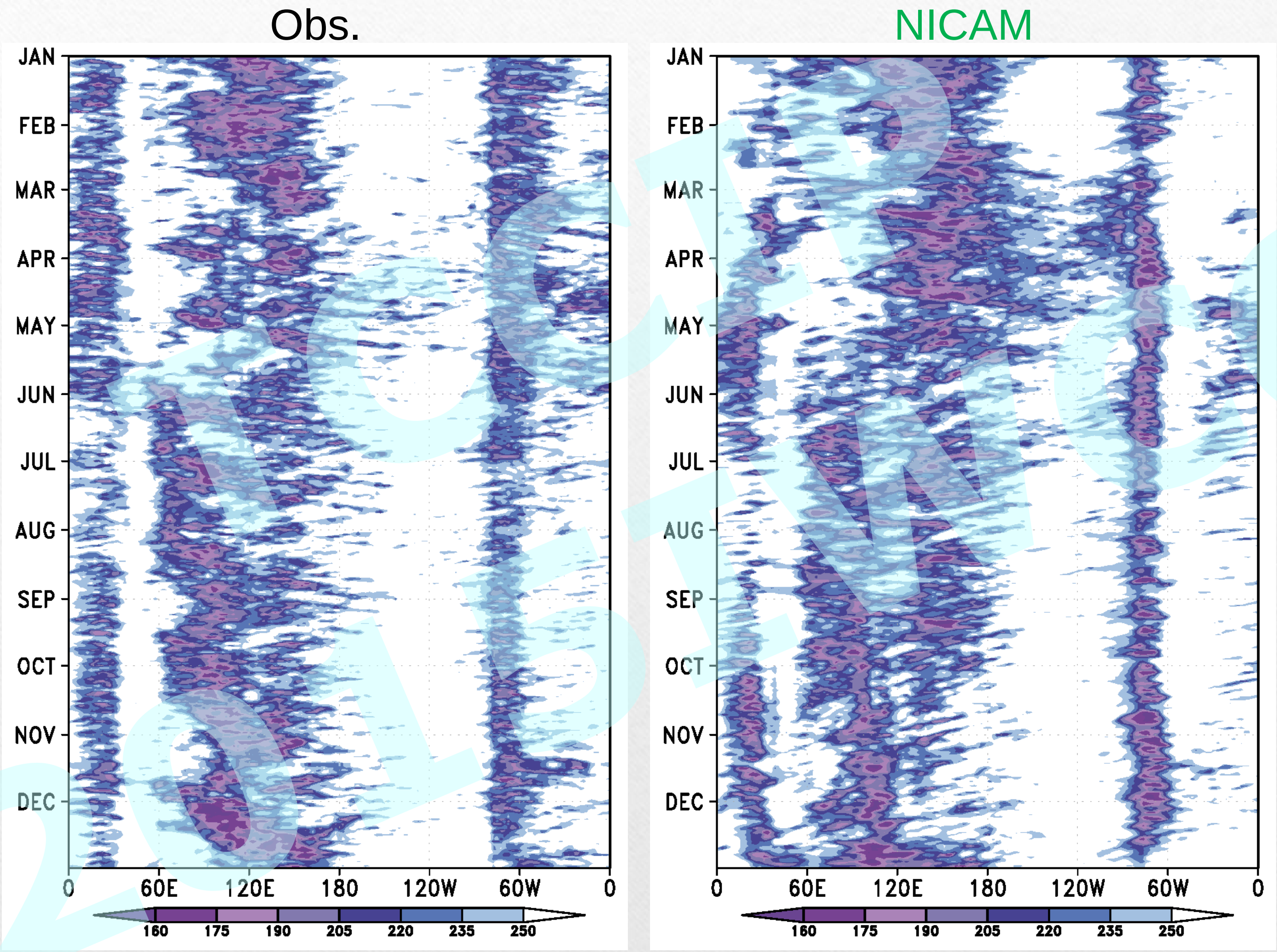
1. tropical intraseasonal oscillation (ISO)

slides by K. Kikuchi @ IPRC

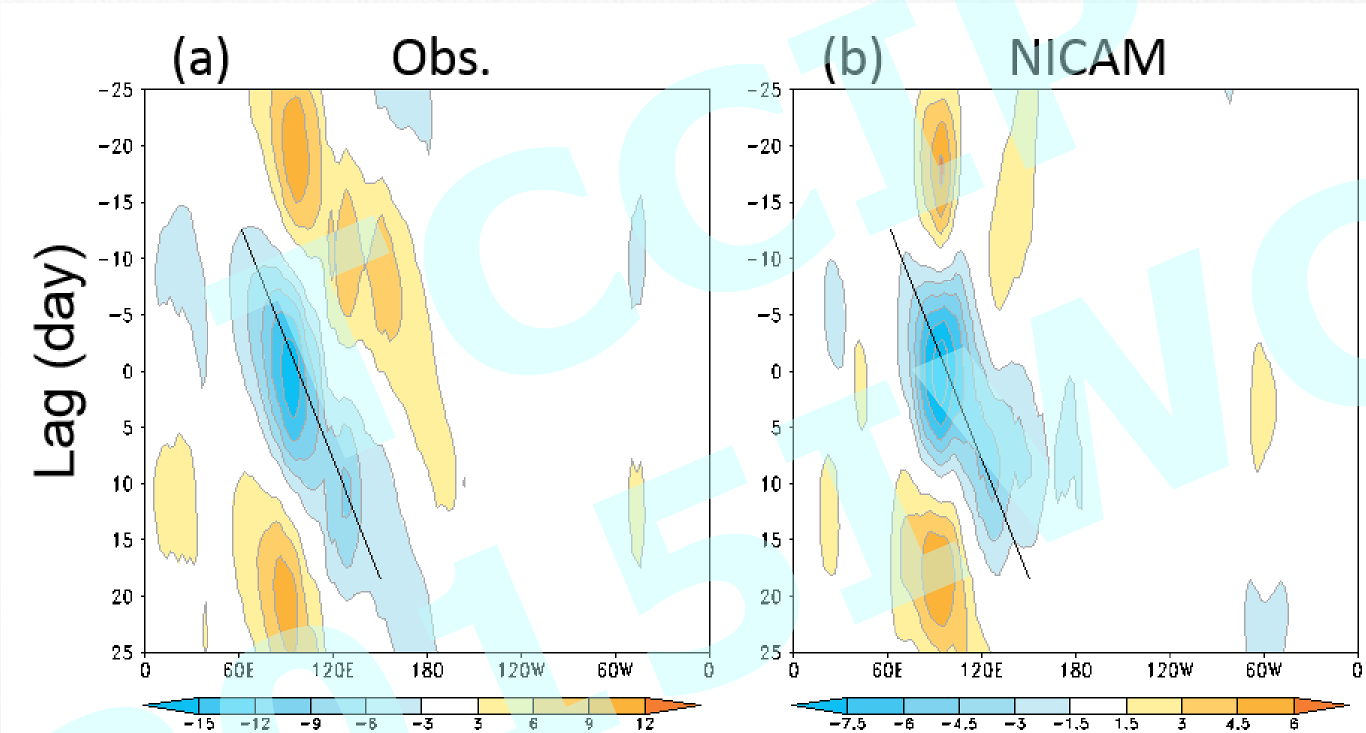
(Kikuchi et al. to be submitted)

NICAM data: 1979-1999

Hovmöller: OLR 7.5S-7.5N 1996



- MJO phase speed: good!
- MJO amplitude is weaker in NICAM

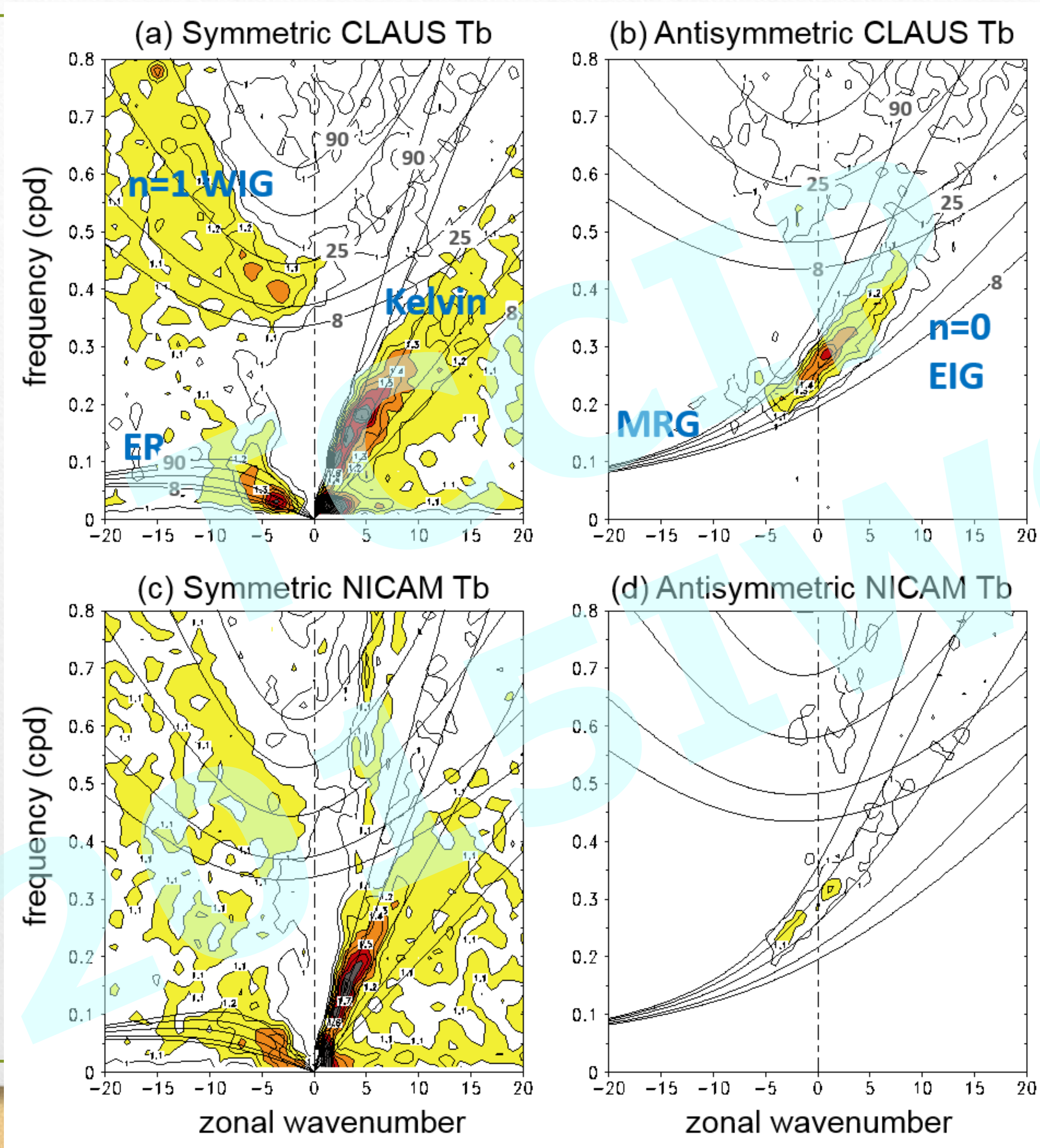


line: 3.6m/s

Figure: Lagged correlation of 25-90 day OLR anomalies averaged over 7.5S and 7.5N against 25-90 day OLR anomalies over the equatorial Indian Ocean (85-95E,5S-5N) during boreal winter (DJF).

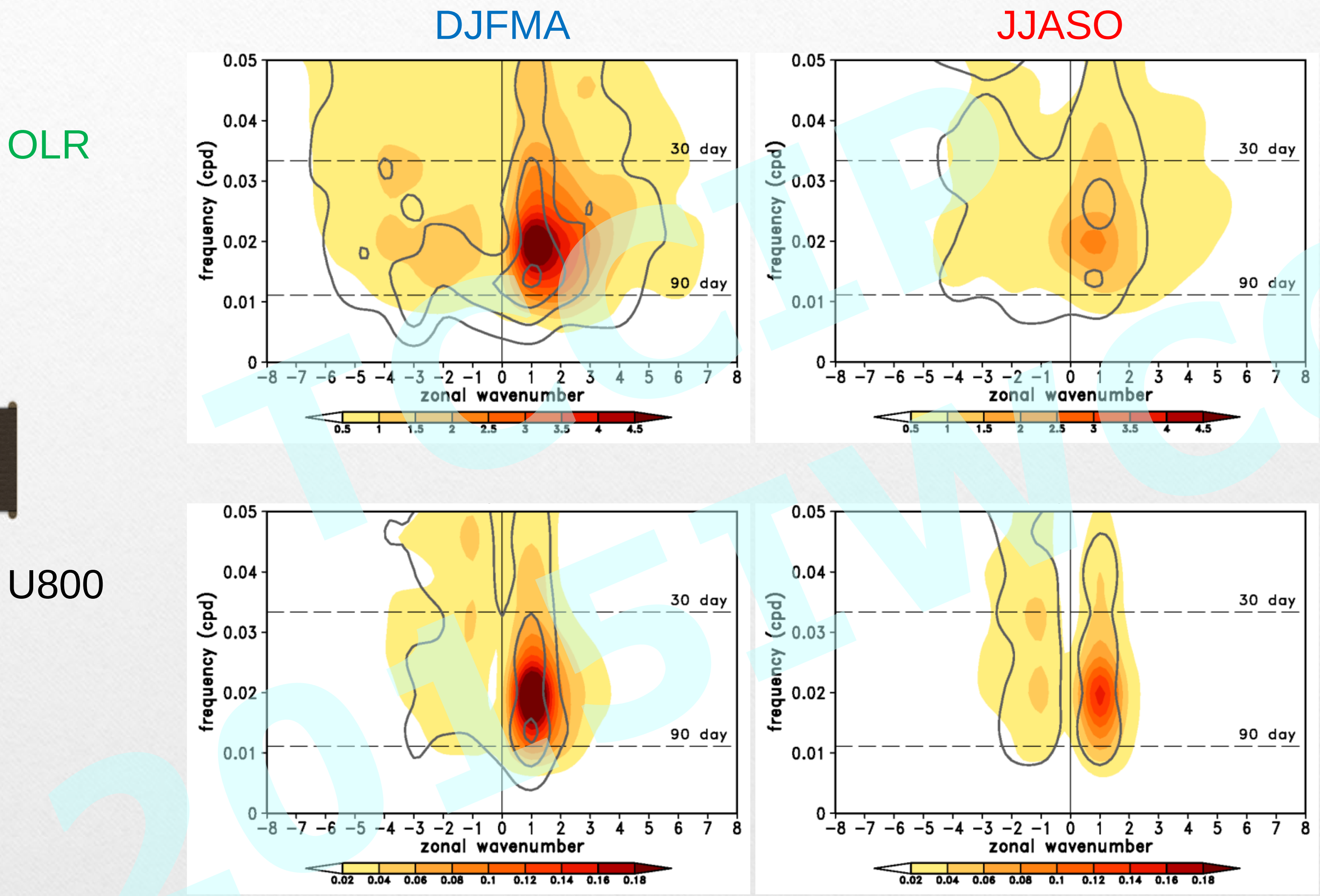
Figs. by K. Kikuchi

MJO and tropical waves (2/2)



Figs. by K. Kikuchi

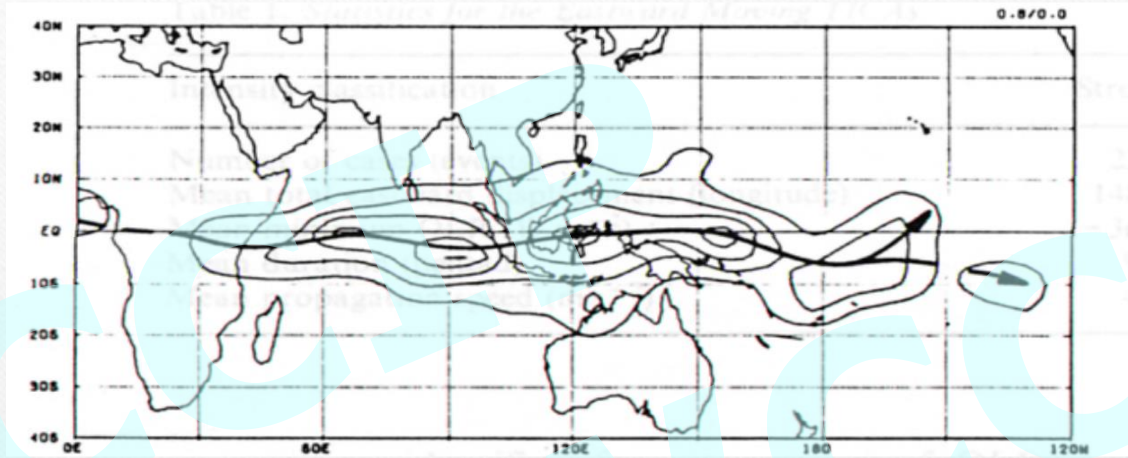
Space-time Power Spectrum



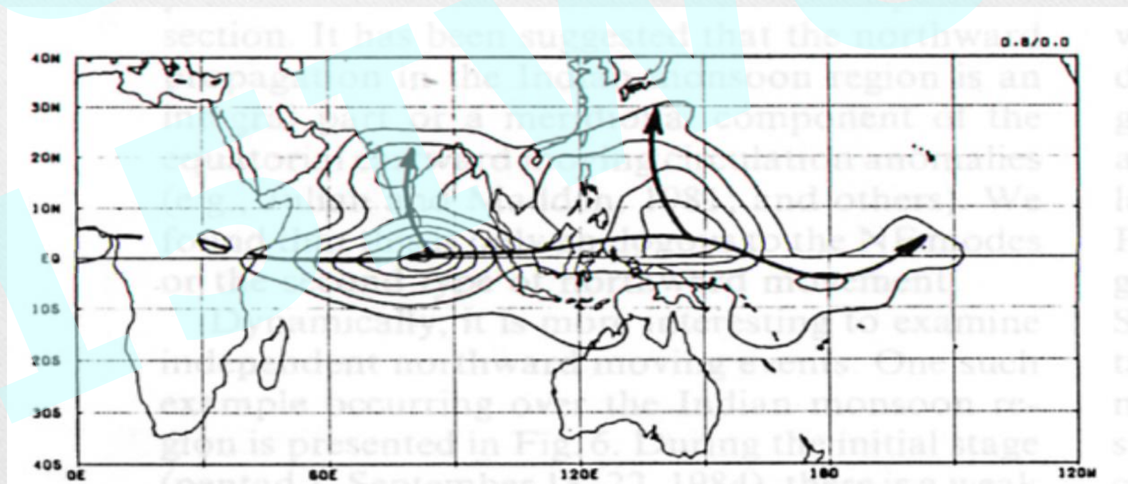
shade: Obs.
contour: NICAM

Seasonal cycle of the ISO

boreal winter

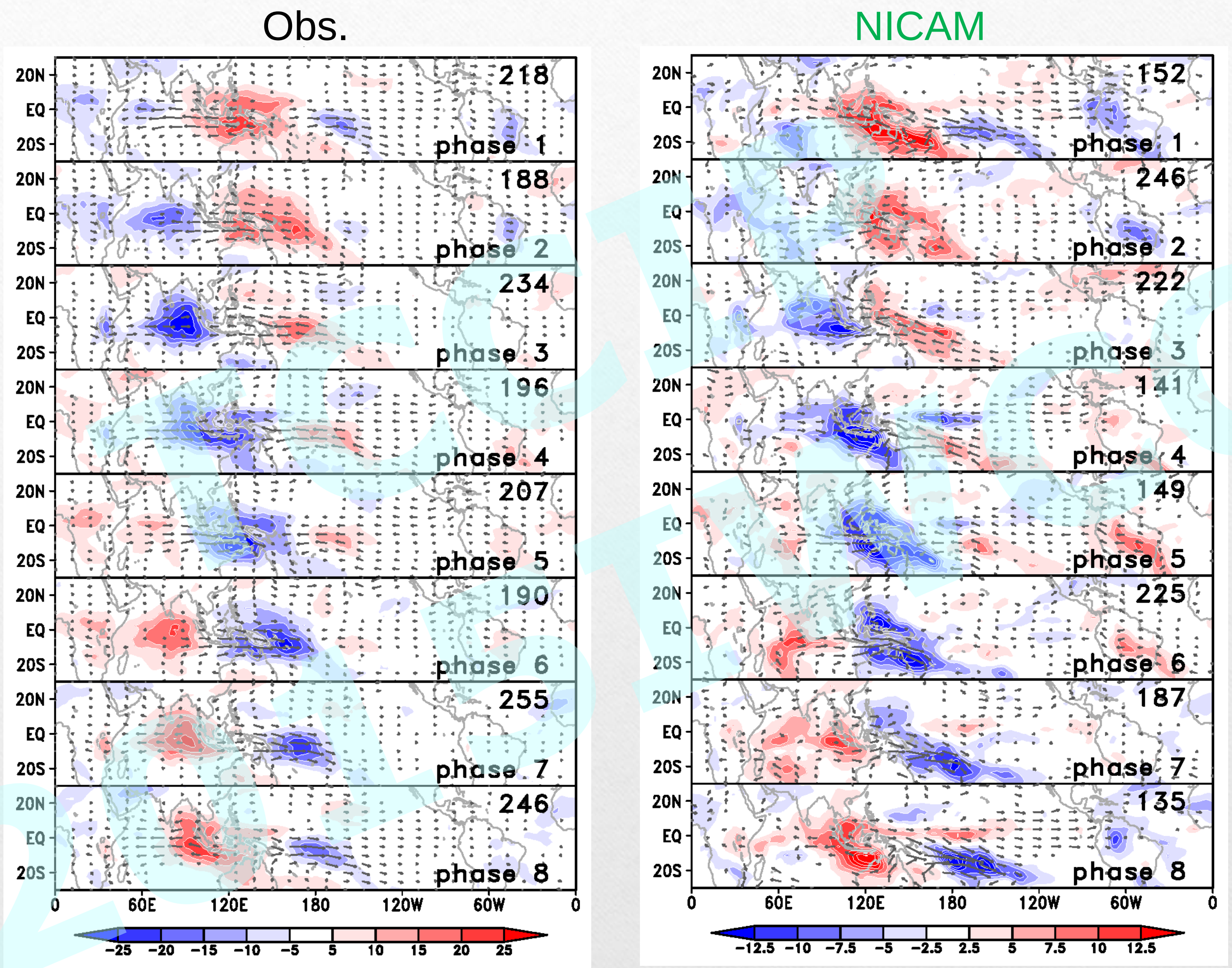


boreal summer

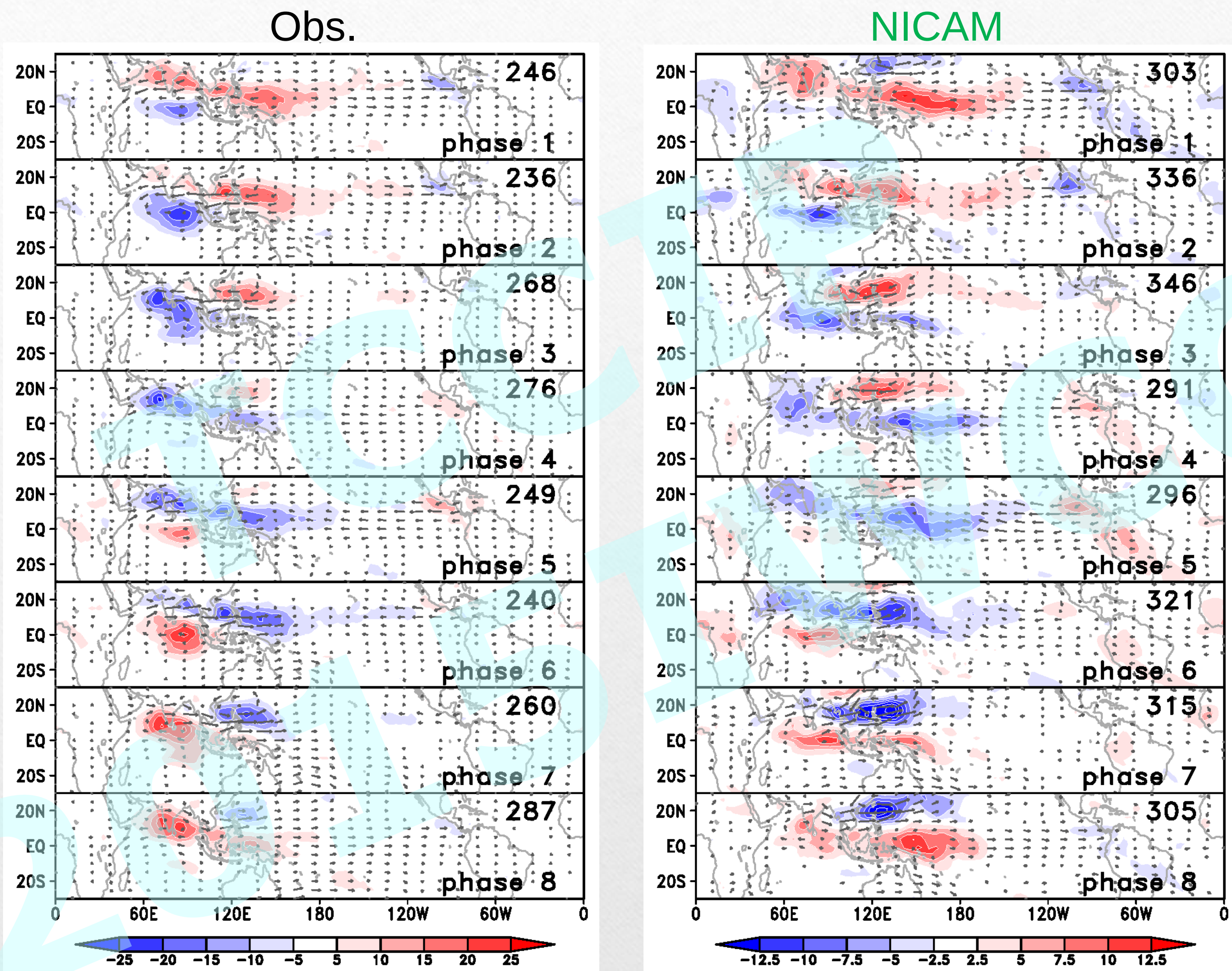


Wang and Rui 1990

MJO Composite



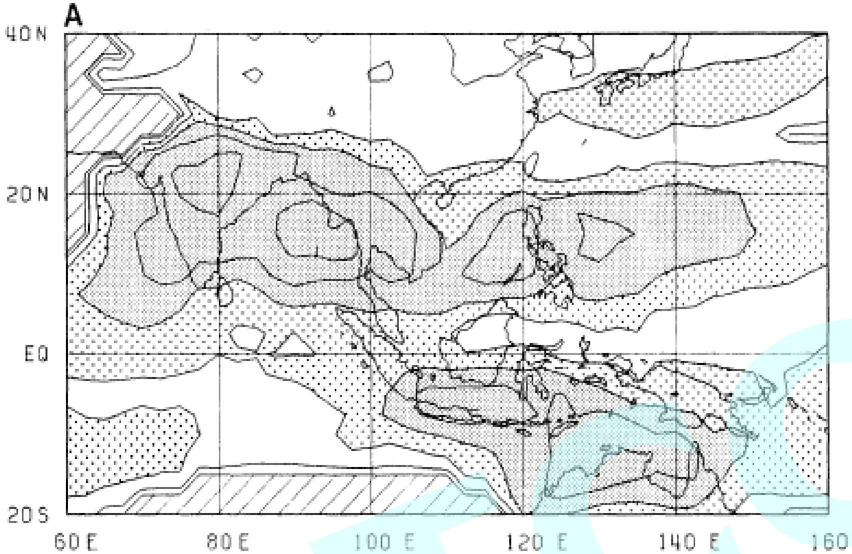
BSISO Composite



3. Asian summer monsoon

slides by T. Nasuno @ JAMSTEC

OLR max-min in annual cycle of 20-yr Climatology



Murakami and Matsumoto (1994)

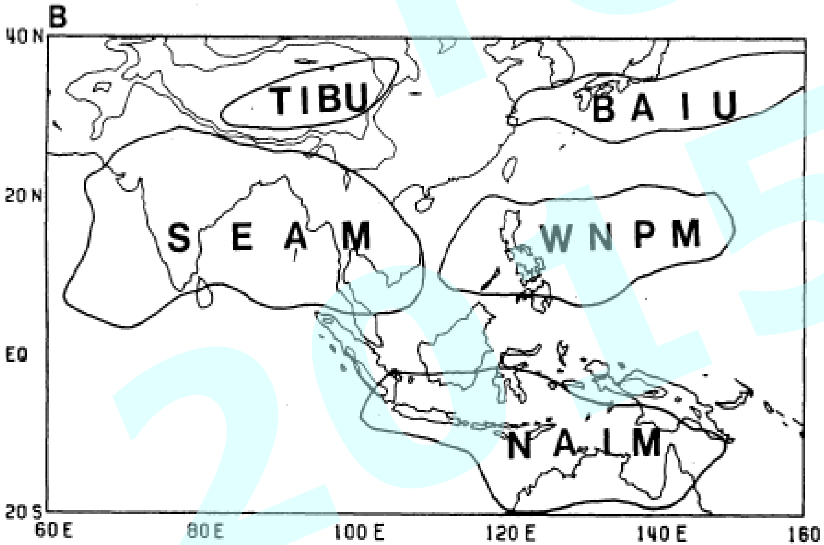
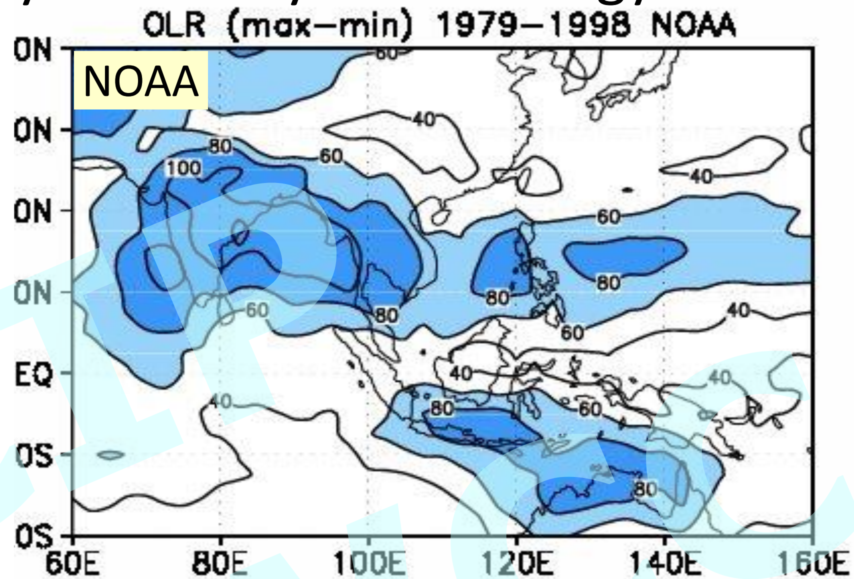
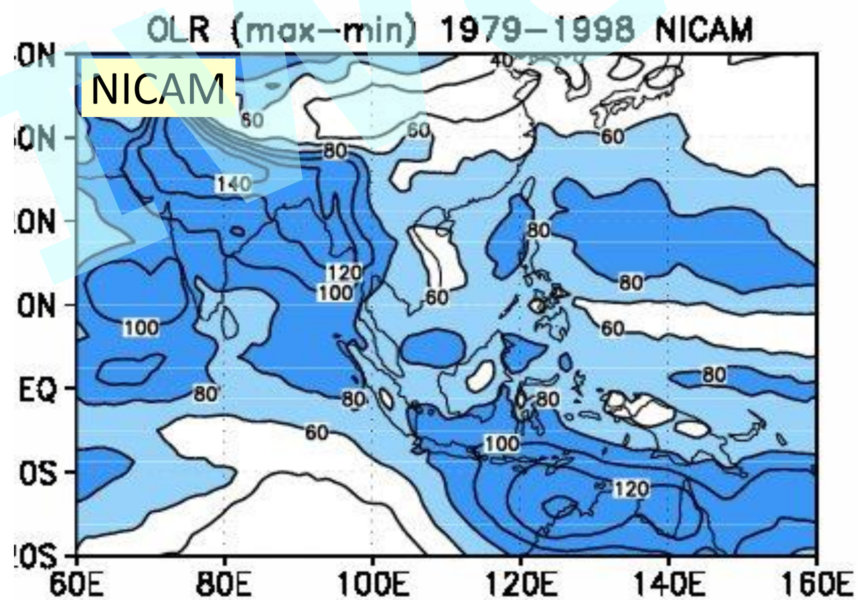


Fig. 1. A: Difference between OLR(max) and OLR(min). Intervals are for 20 Wm^{-2}; hatching denotes OLR(min) greater than 240 Wm^{-2}, while dark (light) shading indicates regions of DD greater than 60 (40) Wm^{-2}. B: The domains of the three monsoon systems SEAM, WNPM and NAlM, as well as two extratropical wet-climate regimes of the TIBU and BAIU. Refer to the text for further information.





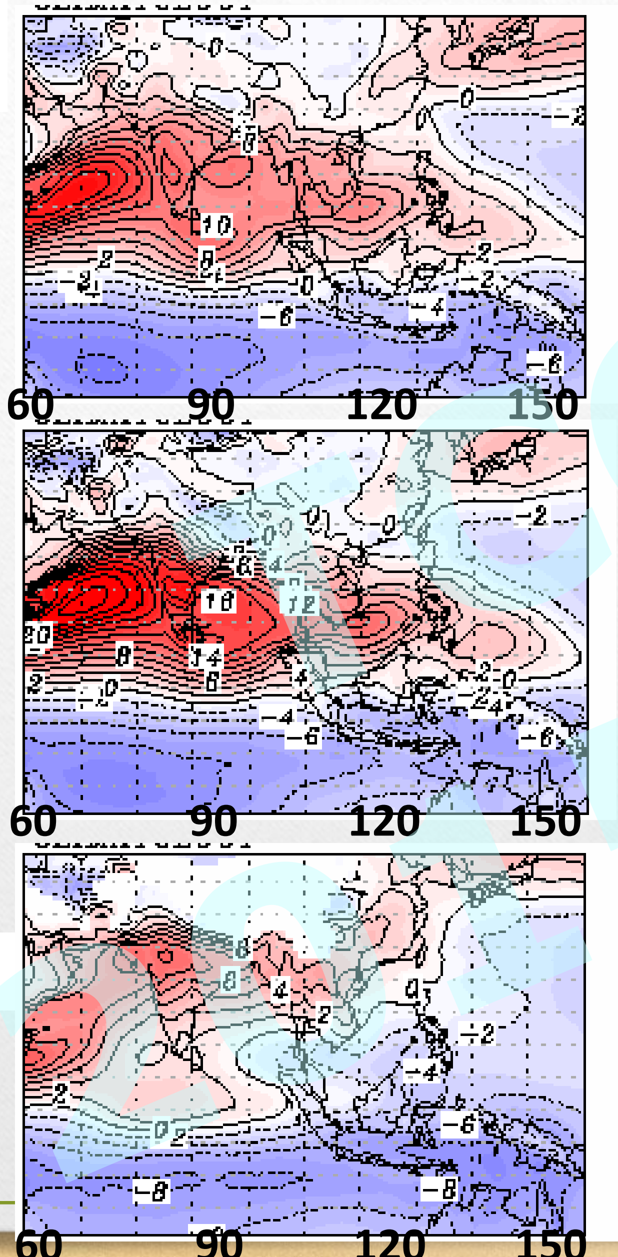
Satoh et al. 2012

8-year mean July

ERA

IFS

NICAM

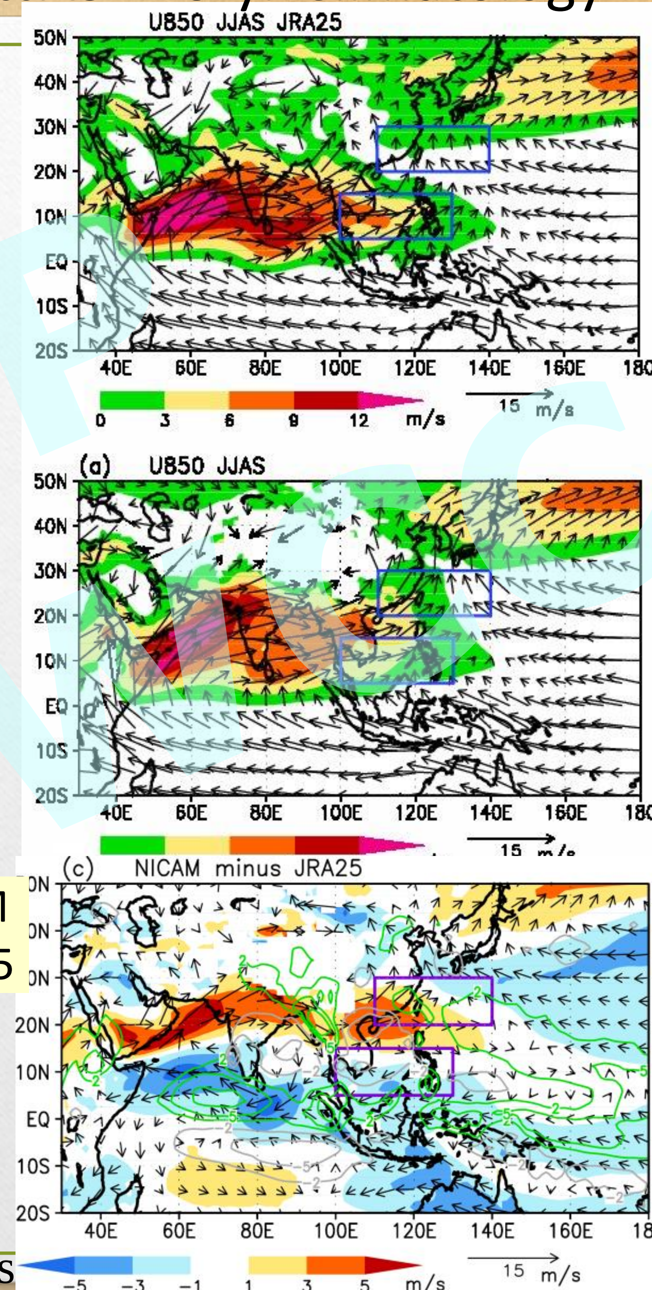


U850 JJAS 20-yr Climatology

JRA25

NICAM

NICAM - JRA25



shade: zonal wind@850hPa
green/gray contours: +/- precipitation bias

precipitation JJAS 20-yr Climatology

Sperber et al. 2014

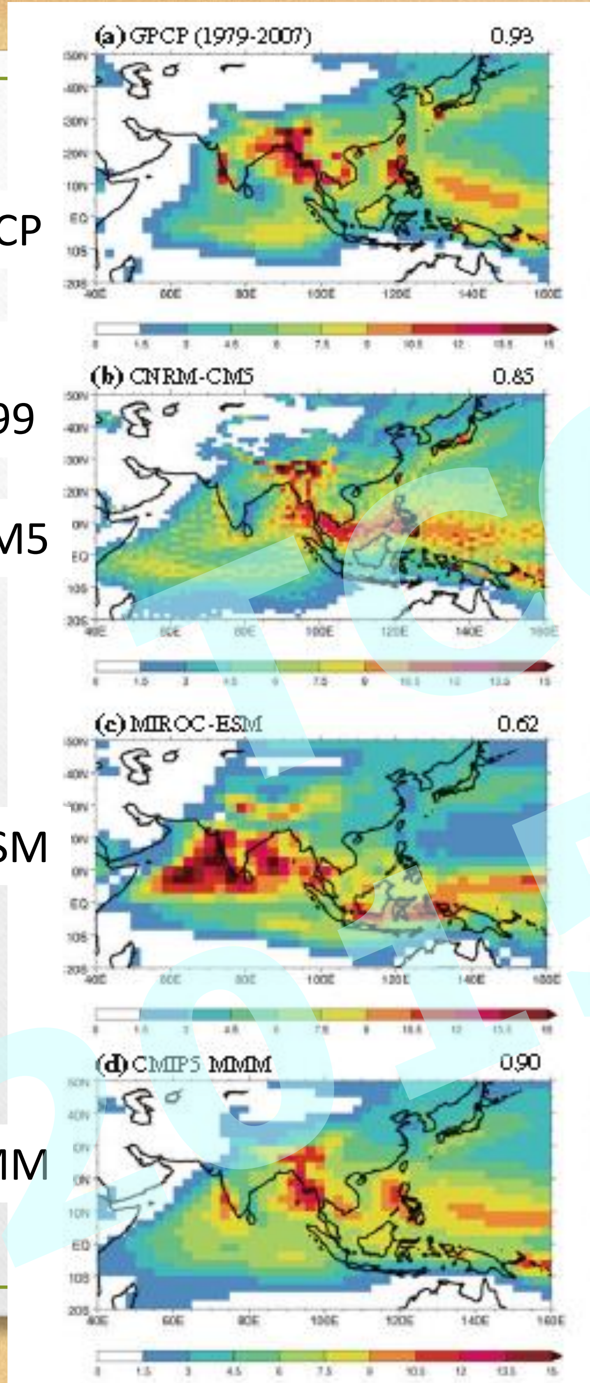
GPCP

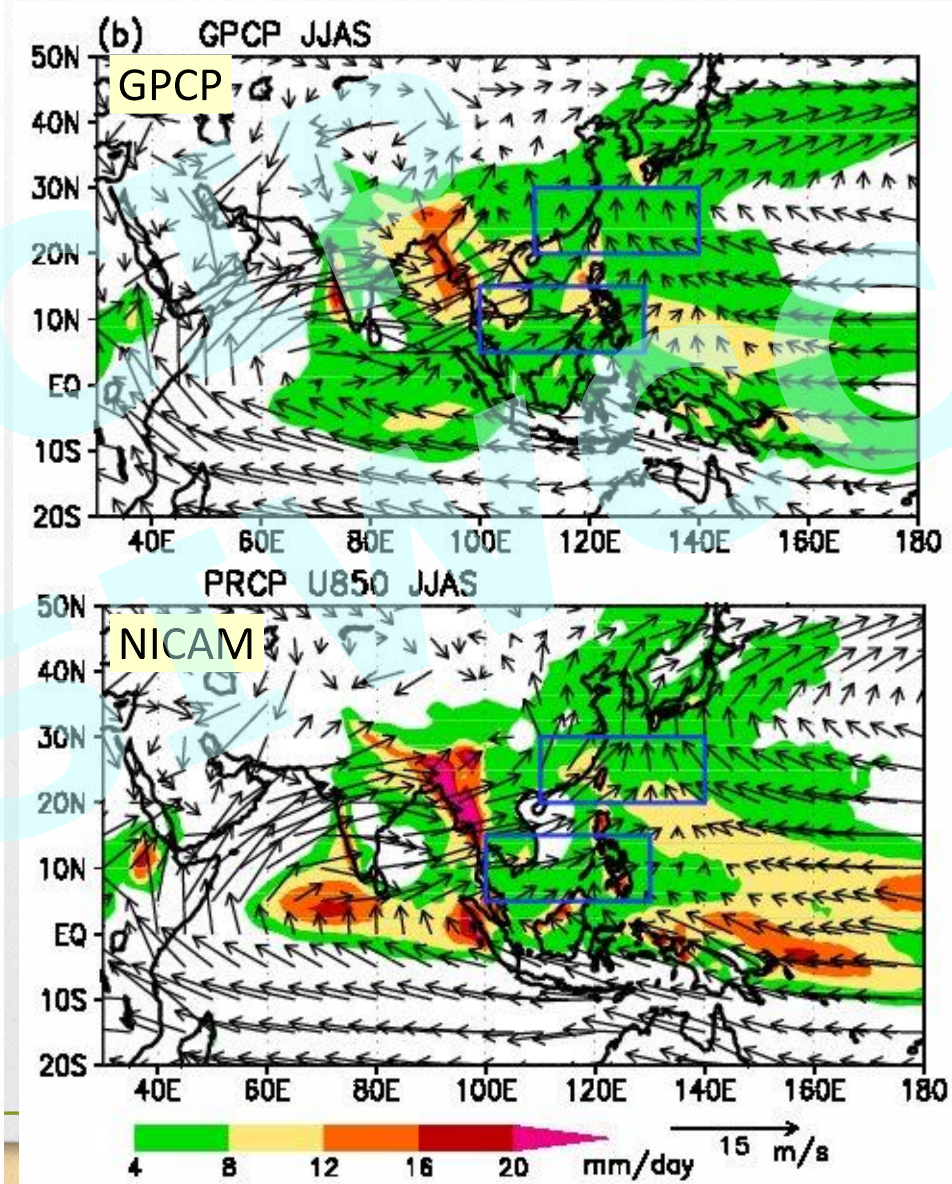
Model: 1961-1999

CNRM-CM5

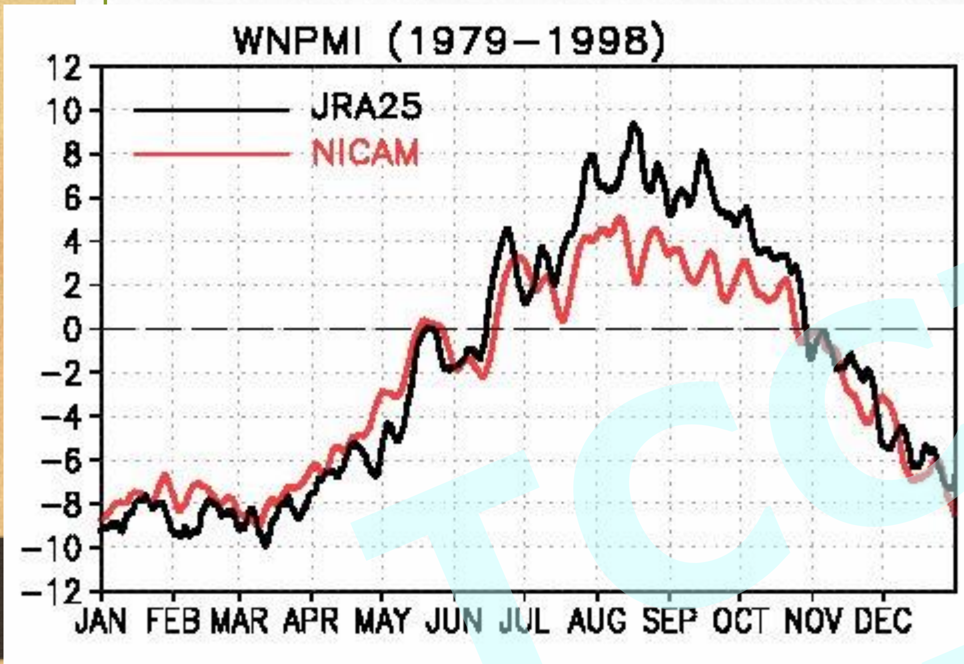
MIROC-ESM

CMIP5-MMM



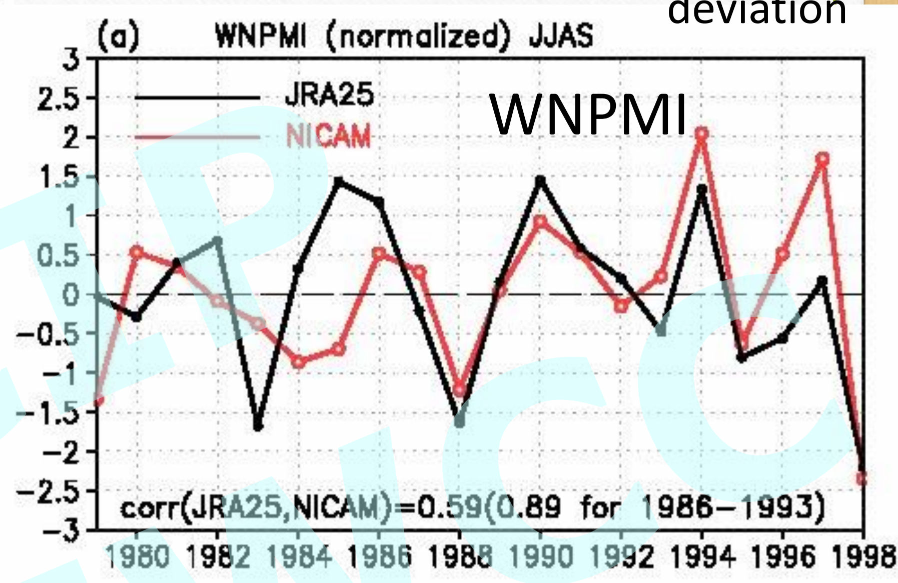


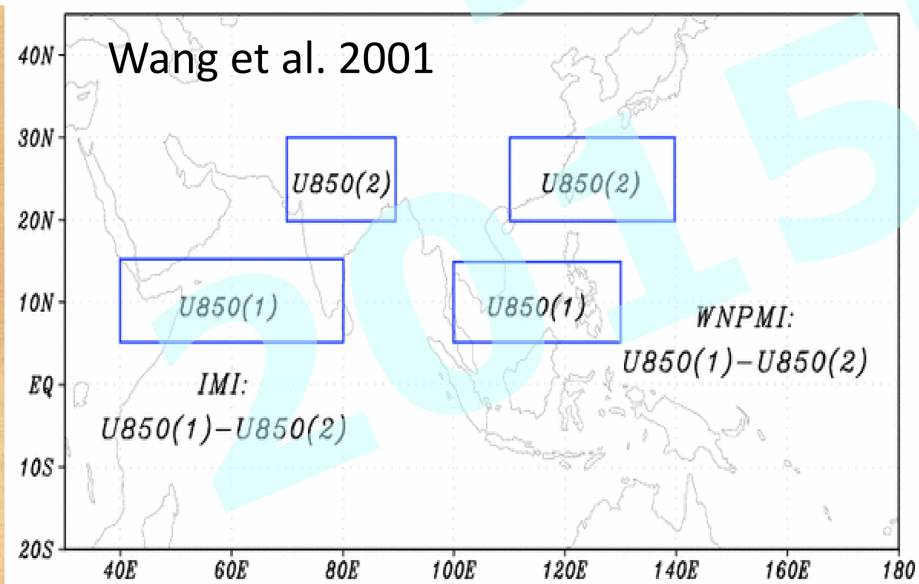
WNPMI JJAS 20-yr Climatology

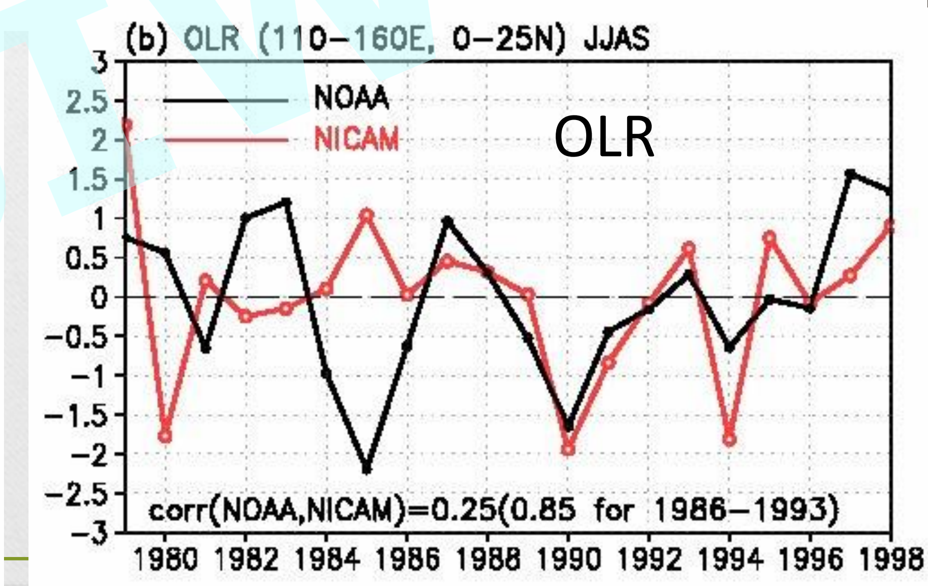


Interannual variation

Normalized by standard deviation







Summary of the model evaluations on tropical disturbances

- tropical intraseasonal oscillation (ISO)
  - Amplitude of the simulated ISO is weaker
  - The behavior of the ISO seems realistic
- tropical synoptic-scale disturbances (TSDs)
  - The distribution and strength of the TSD activity are reproduced well.
  - The axis of the wave train and maximum activity is shifted northward and northwestward, especially during JJA.
- Asian summer monsoon
  - The 20-yr climatology of the seasonal march of Asian monsoon is reproduced (much better than the 8-year JJA simulations).
  - Biases: northward displacement of westerly axis, stronger and earlier than observations.
  - Reproducibility of the interannual variability in monsoonal circulation corresponds to that in convection.

future work: comparisons with CMIP5 models, interannual variation, ...

- Baiu front: structure is reproduced but the seasonal march is too early.

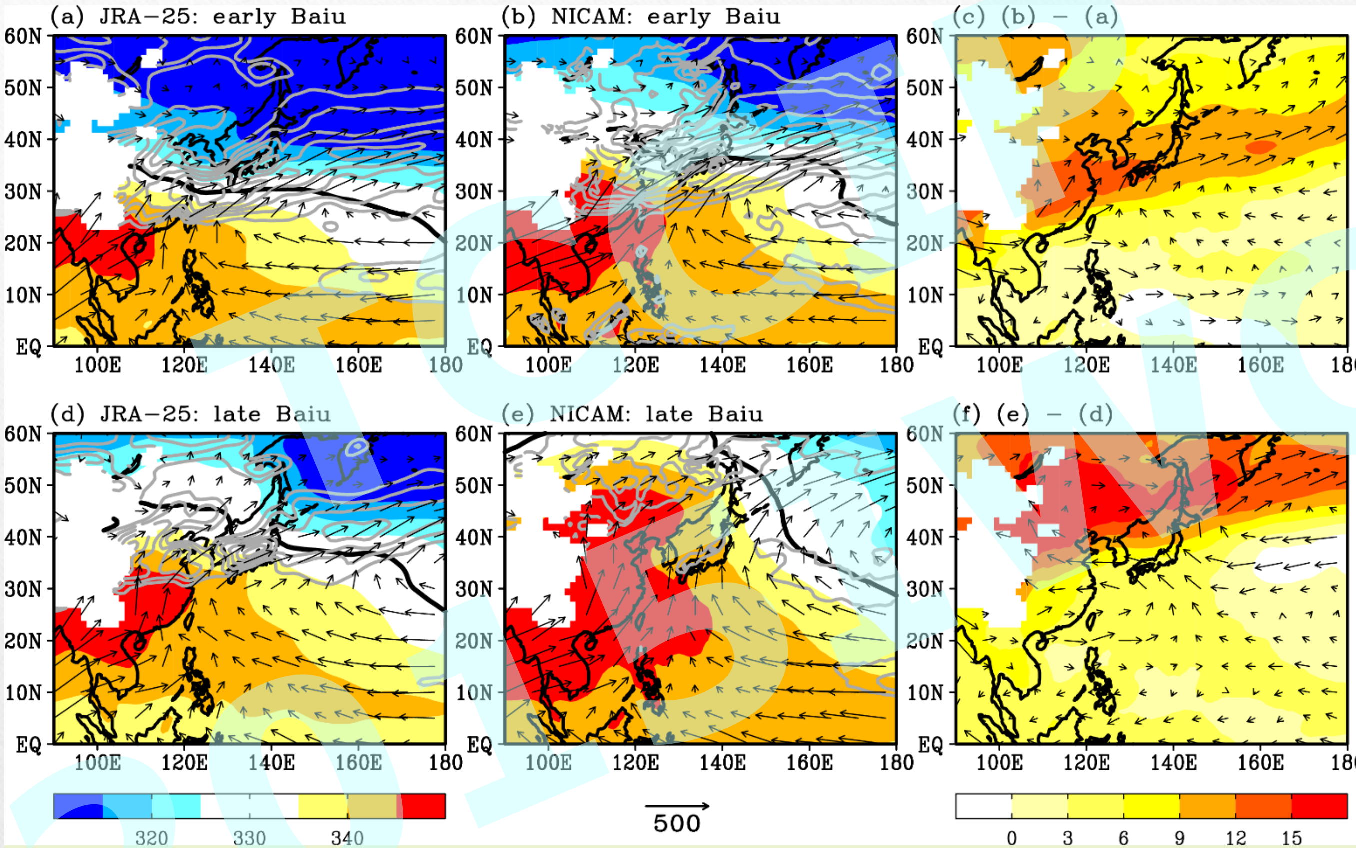
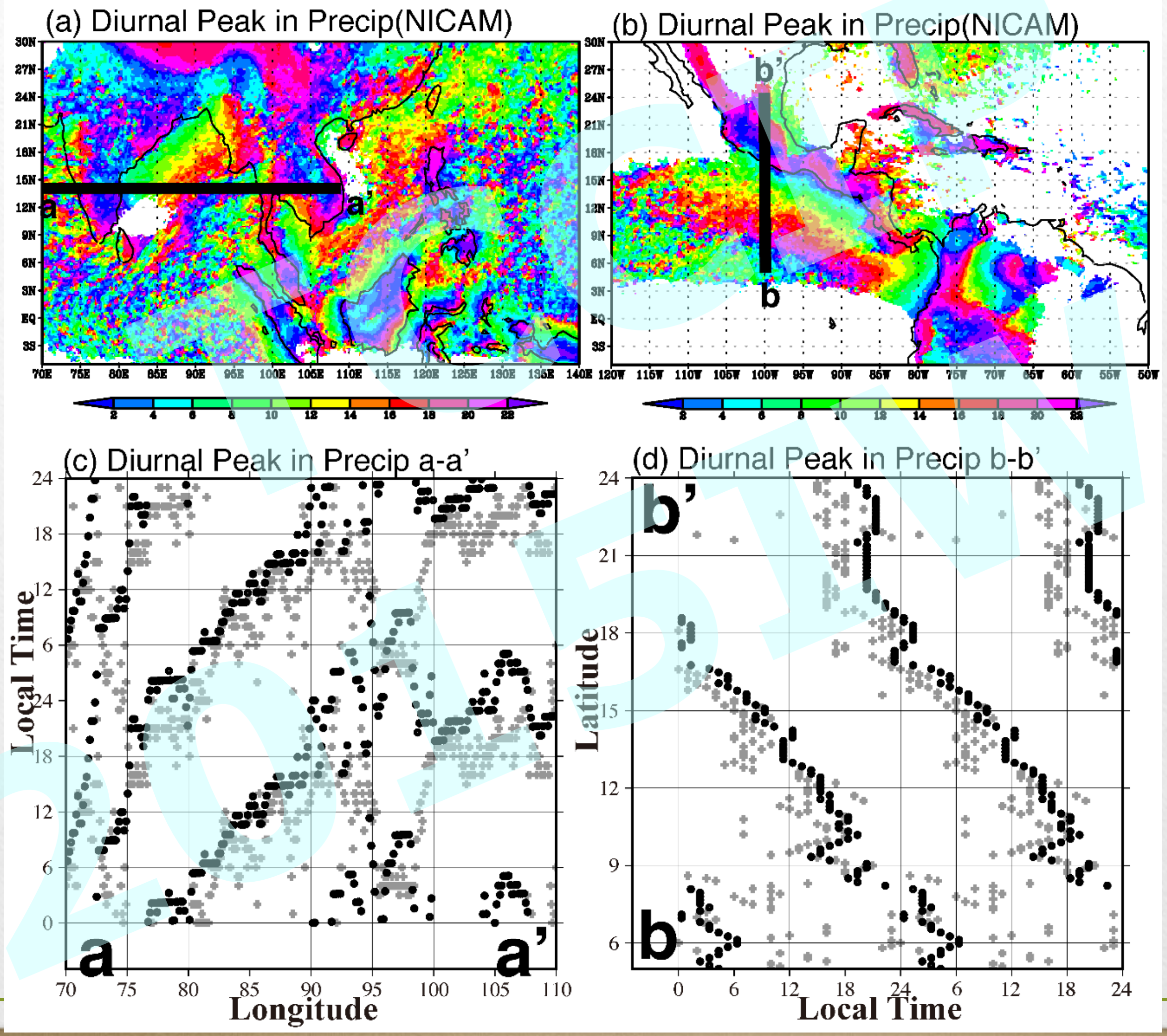


Figure: θe (color shading; solid line for 330K), ∂θe/∂y (gray contours) and vertically-integrated qv flux (vectors).
early Baiu: 3-17/June late Baiu: 13-27/July

Figs. by T. Tomita & T. Yamaura

Diurnal cycle of precipitation

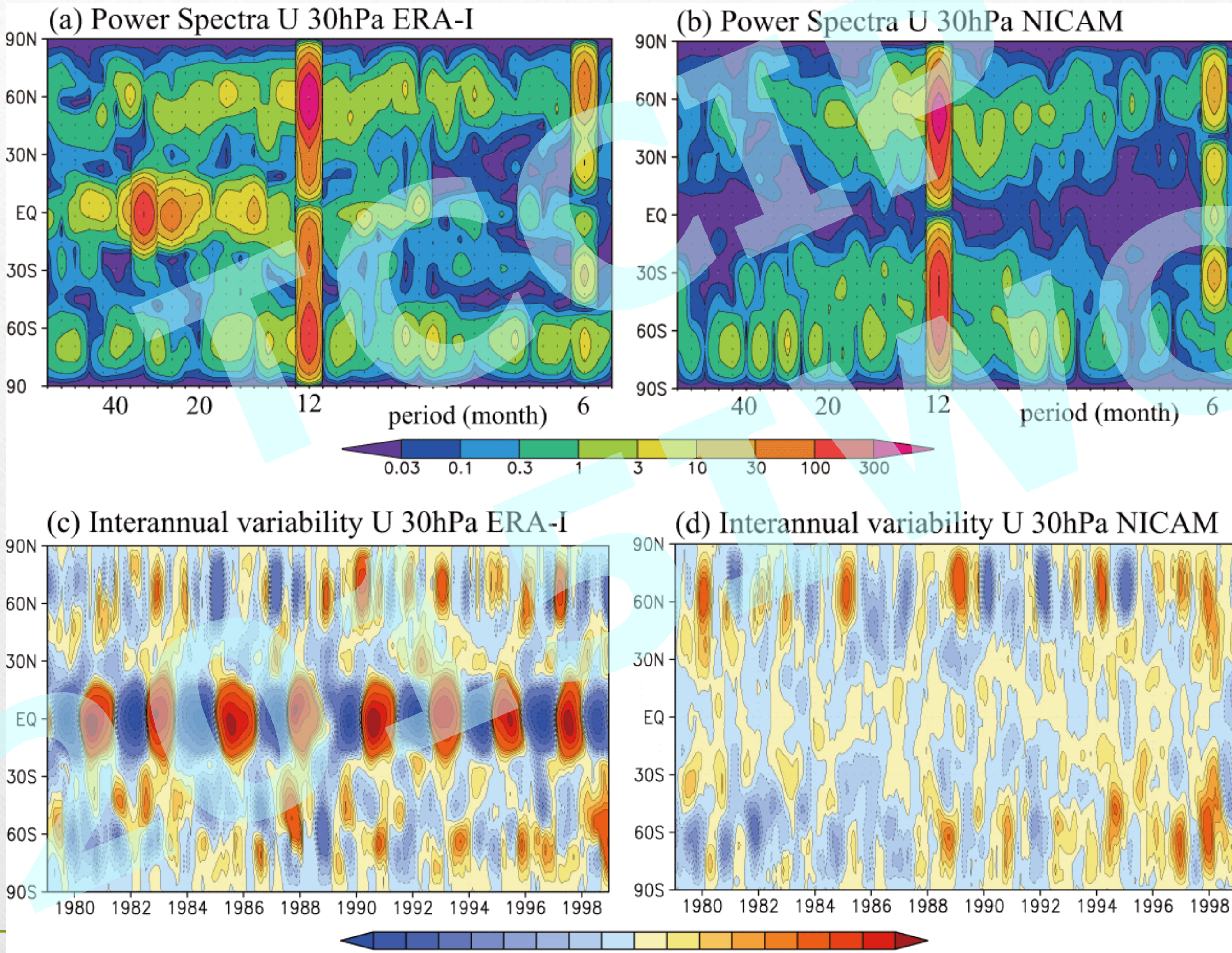
- diurnal cycle of precipitation is well reproduced with the later timing (cf. 7km is better; Sato et al. 2009)



gray: TRMM
black: NICAM

Figs. by H. G. Takahashi & M. Hara

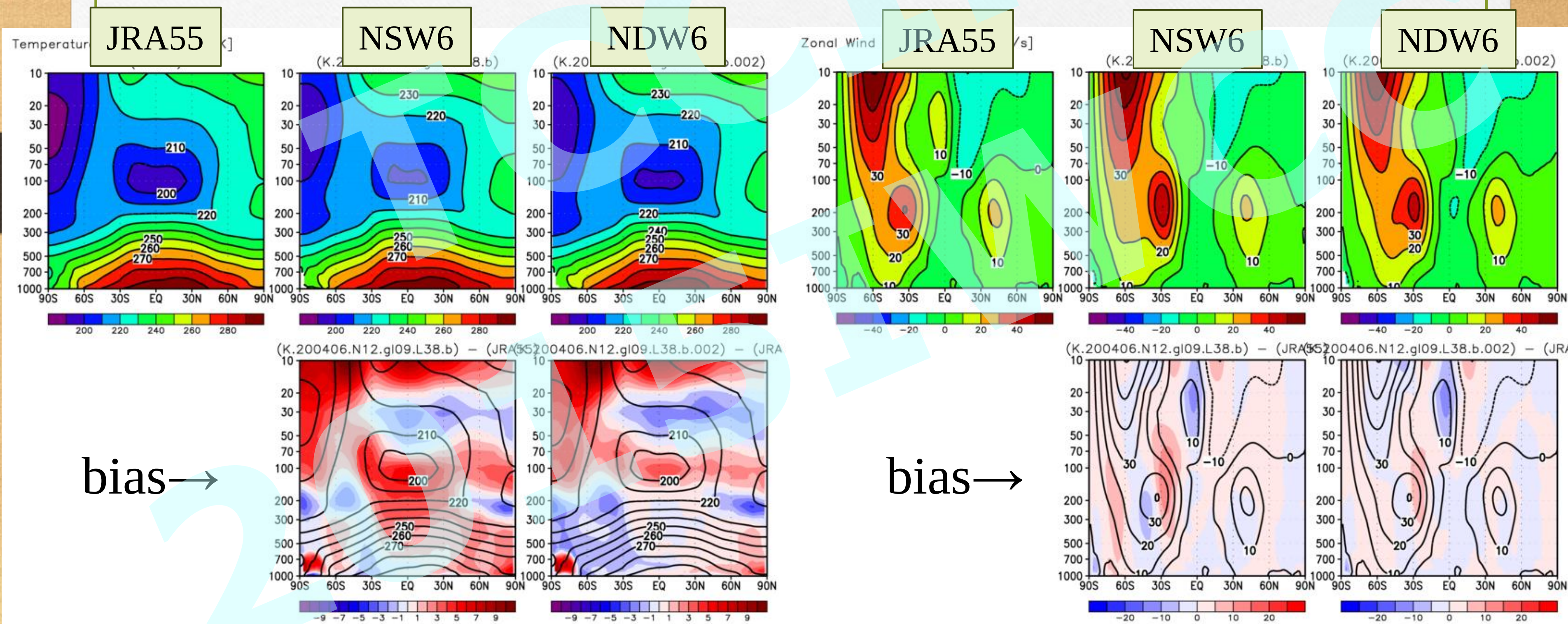
- Annual and semi-annual cycle is well captured in the lower stratosphere.



Figs. by Y. Kawatani

an ongoing sensitivity experiment

Δx=14km, 1-month integration



cf. Seiki et al. JC accepted

Summary of the model overall evaluations

- Climatology of the NICAM AMIP-type simulation
  - well reproduced phenomena (somewhat subjective)
    - precipitation, basic state in general
    - TC intensity & seasonal march
    - MJO and equatorial waves:
    - Asian monsoon onset
    - …
  - biases
    - double ITCZ, too intense ITCZ peak precipitation
    - warmer land surface & tropical upper troposphere
    - too strong jet, jet axis displaced poleward
    - TC genesis @ Atlantic & eastern North Pacific
    - weaker MJO amplitude
    - …

Tropical disturbances in NICAM AMIP-type simulation

C. Kodama (JAMSTEC)

slides by our colleagues

Contents

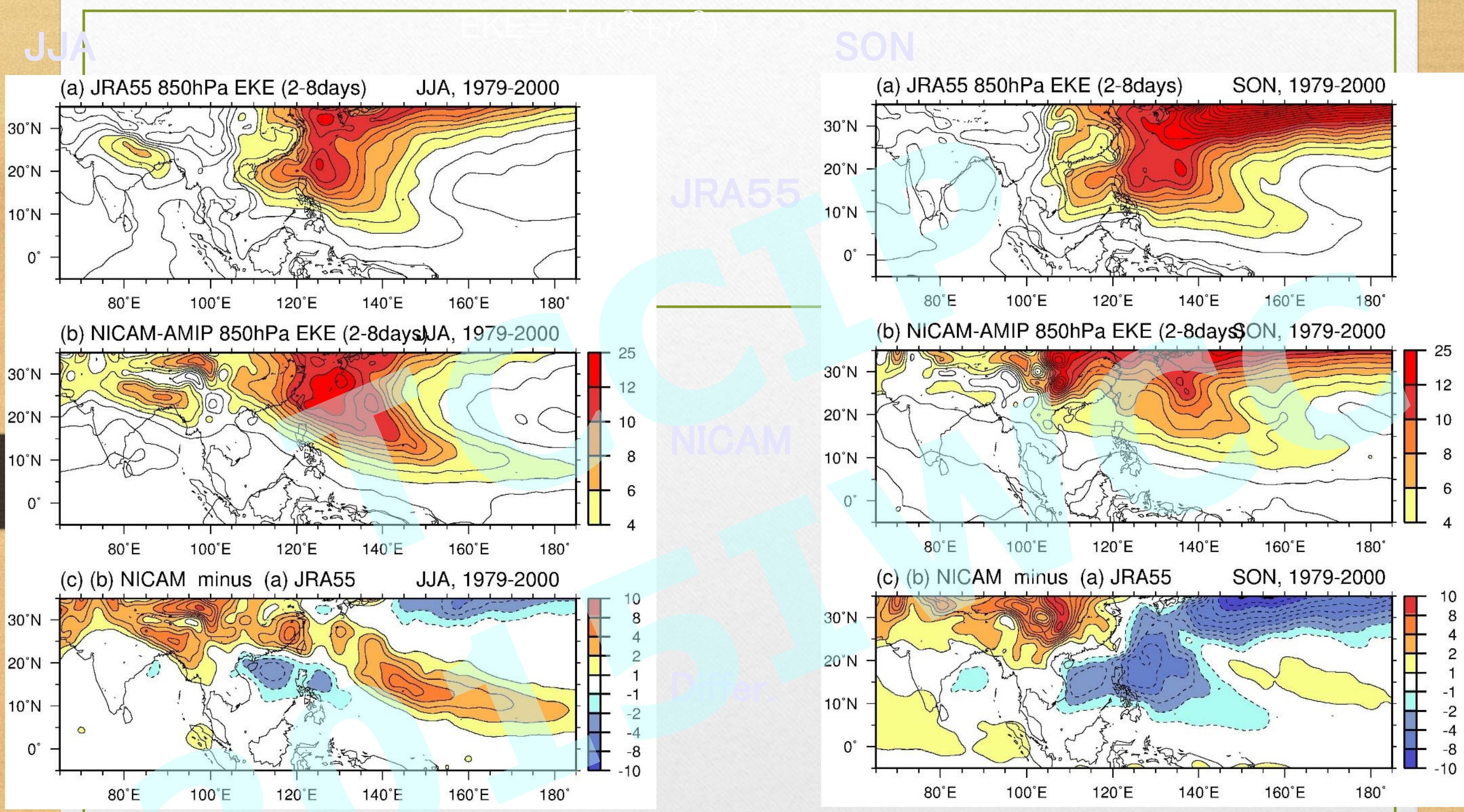
1. tropical intraseasonal oscillation (ISO) (Kikuchi et al. to be submitted)
2. tropical synoptic-scale wave disturbances (TSDs) (Fukutomi et al. submitted to Theor. Appl. Climatol.)
3. Asian summer monsoon (T. Nasuno & Y. Kajikawa)

2. tropical synoptic-scale wave disturbances (TSDs)

slides by Y. Fukutomi @ JAMSTEC

(Fukutomi et al., submitted to Theor. Appl. Climatol.)

Eddy statistics: 850 hPa Eddie Kinetic Energy(EKE) (2-8 days), 1979-2000



EEOF analysis

An extended EOF (EEOF) analysis is performed on the 2–8-day filtered 850-hPa vorticity anomalies (daily).

Domain: Western Pacific (WP) (100–180E, 10S–25N)

Period: JJA (92days), SON (91days) for 22 years (1979—2000)

WP wave modes identified: Leading two modes (EEOF 1 & 2) constitute a pair mode of modes that represent the same wave.

Index for composite analysis: Principal component (PC) time series of the first mode (PC1).

EEOF WP modes: 850 hPa Vort. (2-8 days), JJA & SON 1979-2000

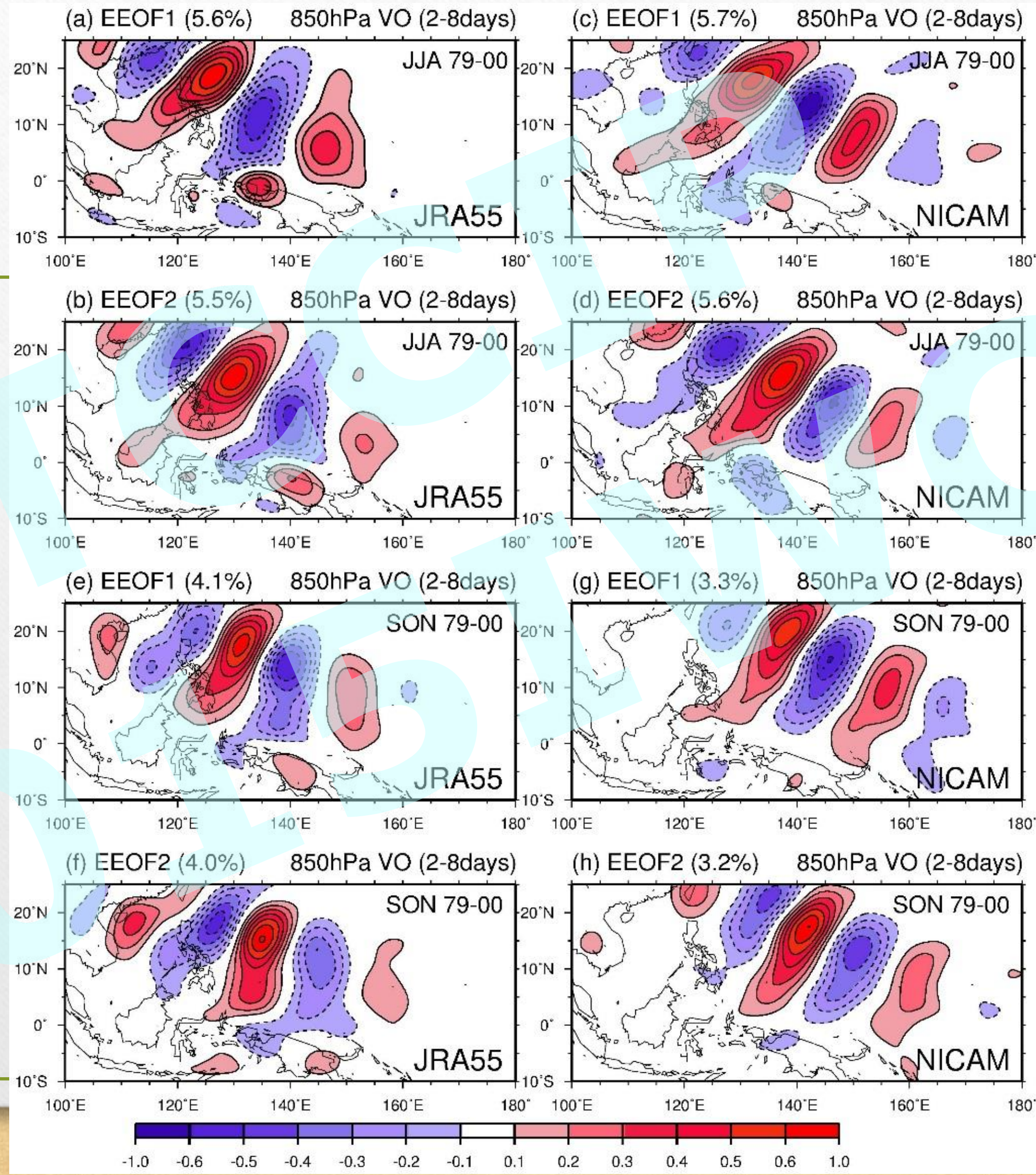
JRA55 NICAM

EEOF1 (JJA)

EEOF2 (JJA)

EEOF1 (SON)

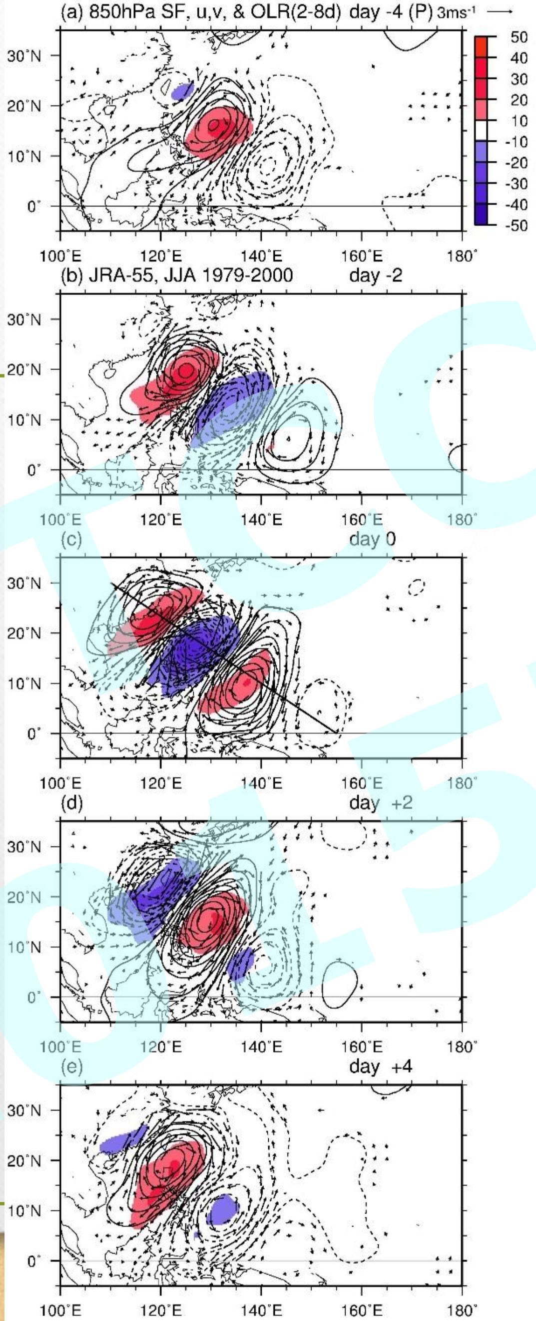
EEOF2 (SON)



Composites for WP mode: 850 hPa U,V, Ψ, OLR (2-8 days), JJA 1979-2000

JRA55

Positive phase



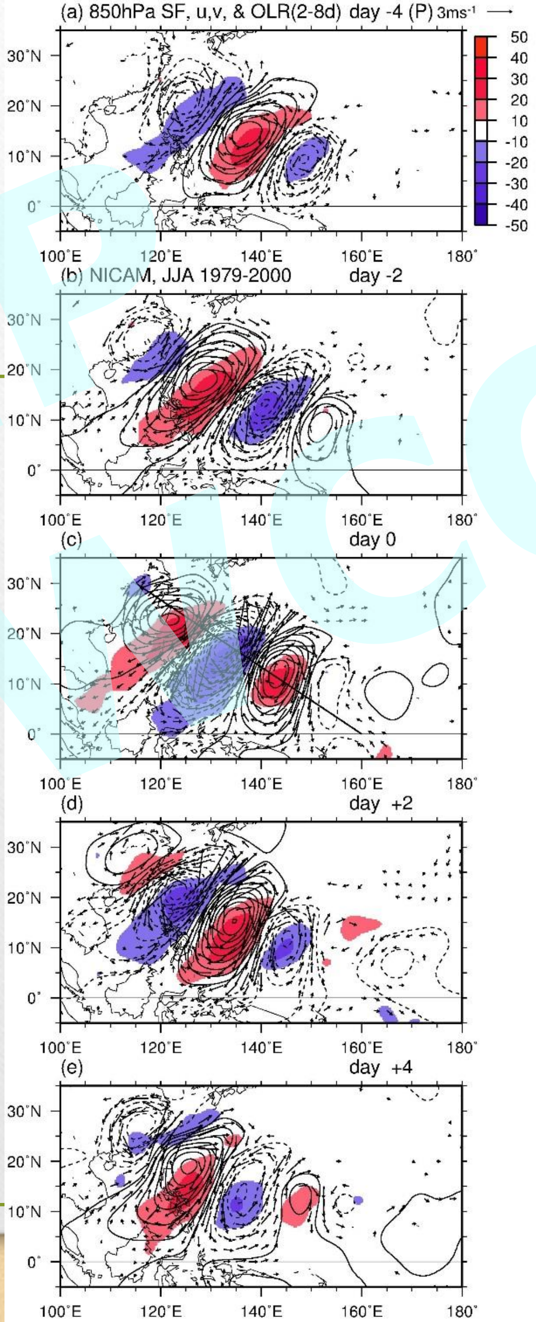
Day −4

Day −2

Day 0

Day +2

Day +4



NICAM

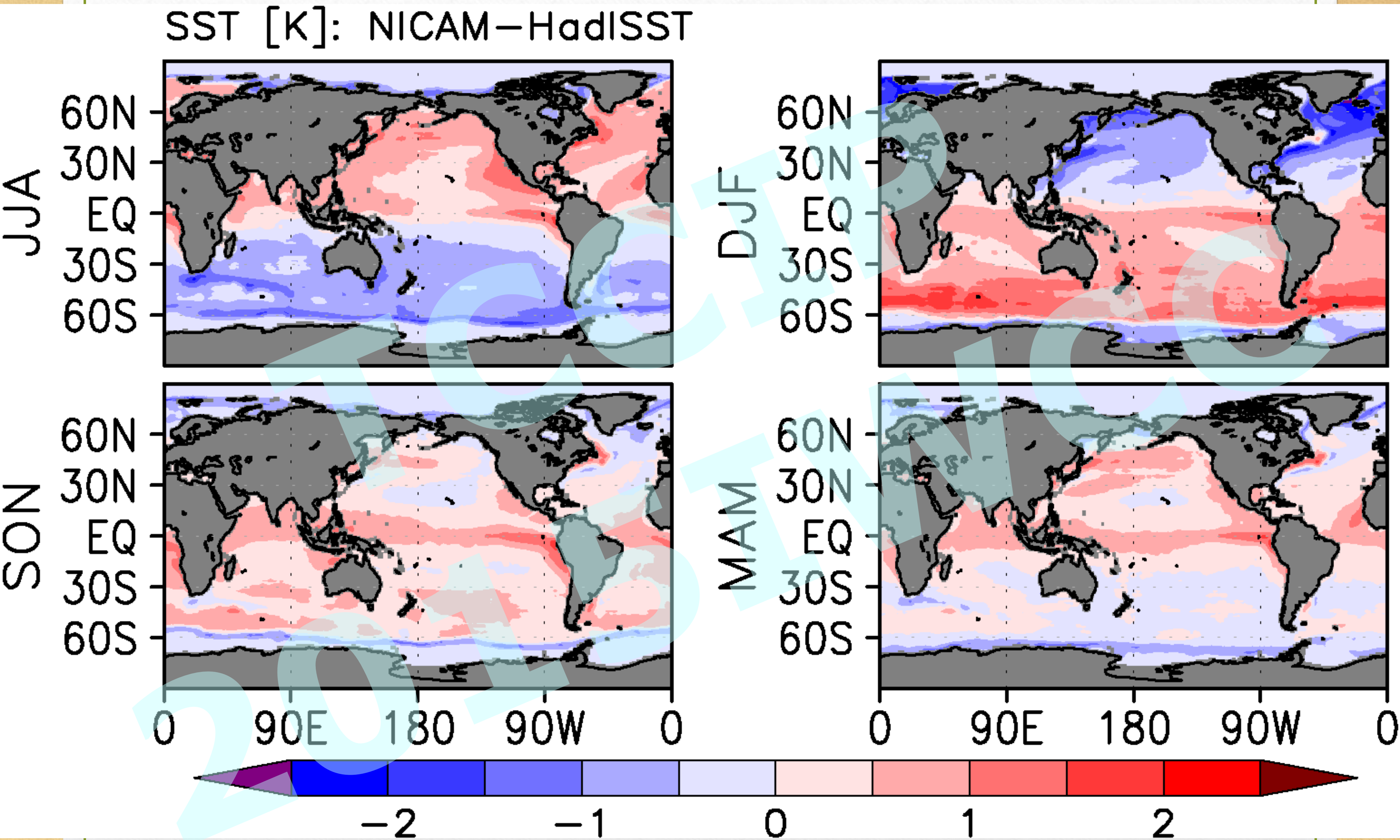
Shadings: OLR

Contours: φ

$3.0 \times 10^{-5} m^2 s^{-1}$

====== backup slides ======

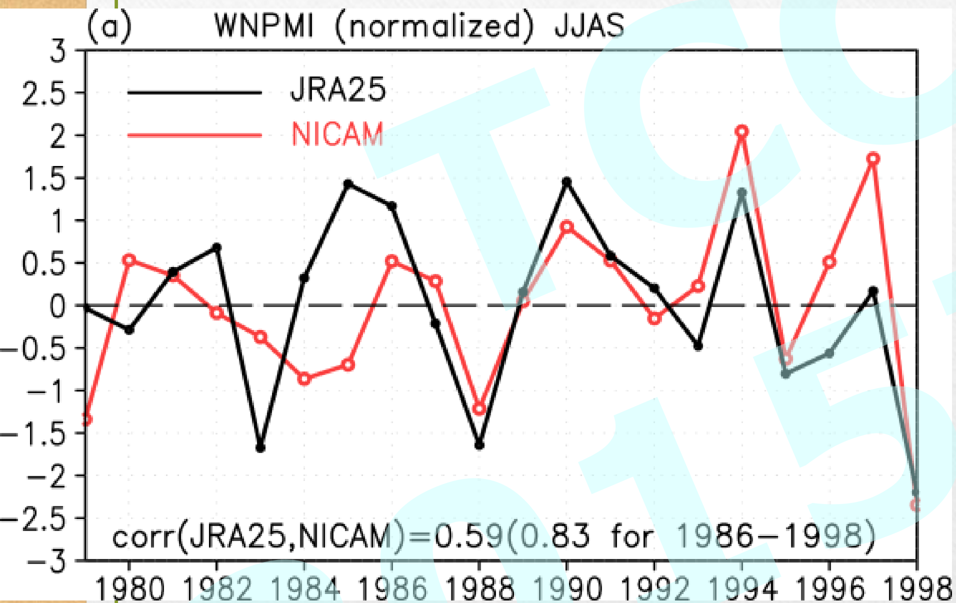
SST

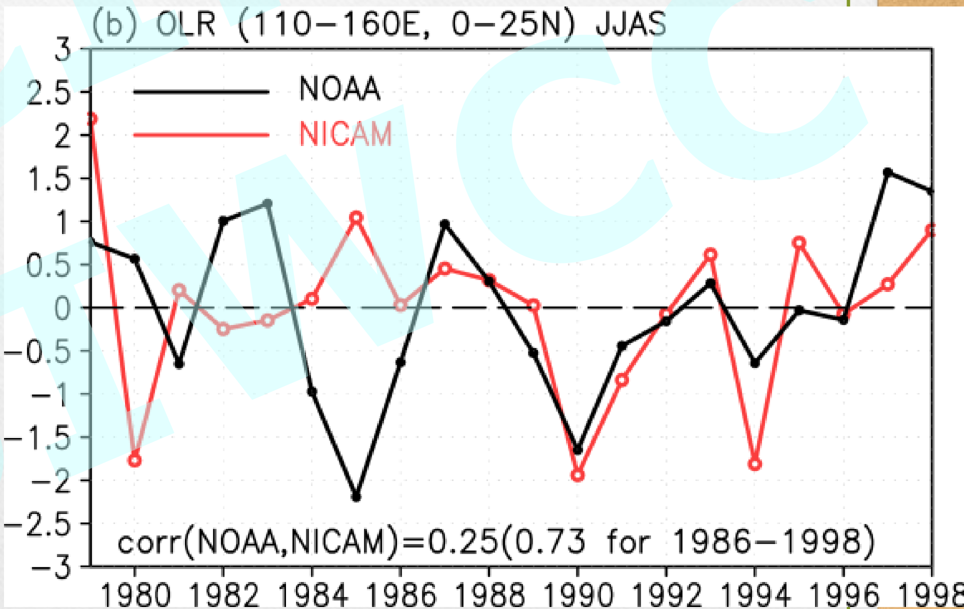


SST [K]: NICAM−HadISST
JJA
DJF
SON
MAM
60N
30N
EQ
30S
60S
0
90E
180
90W
0
−2
−1
0
1
2

Asian summer monsoon (2/2)

- aaa





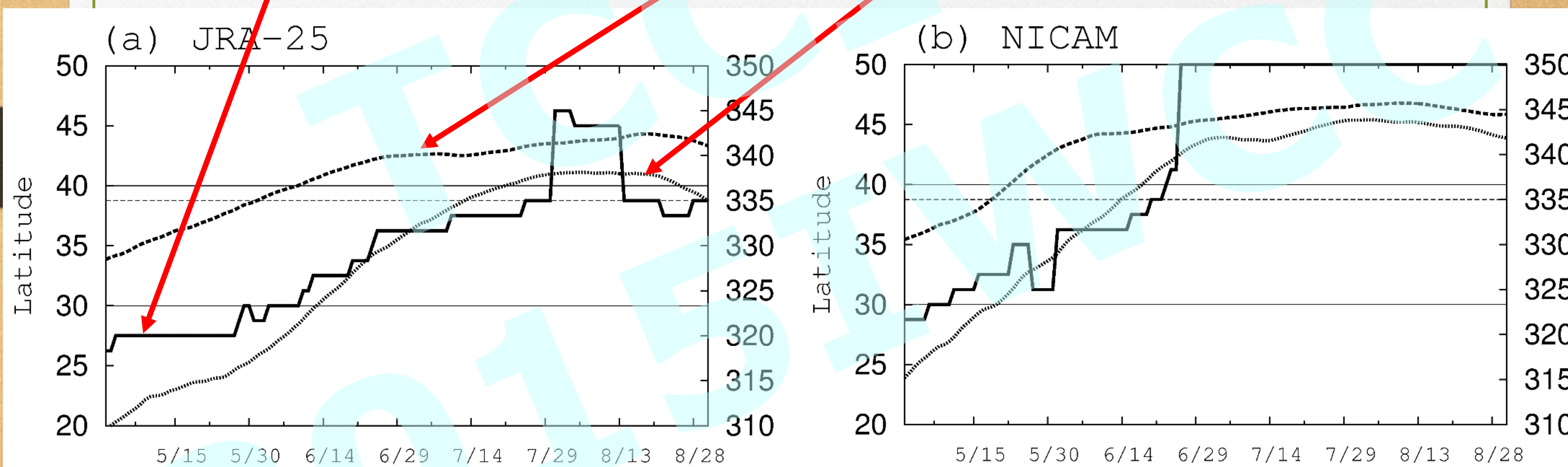
Figs. by Y. Kajikawa & T. Nasuno

Baiu/Meiyu front (2)

θe@125-145E,20-30N

Baiu front lat.
(defined as max(∂θe/∂y))

θe@125-145E,30-40N

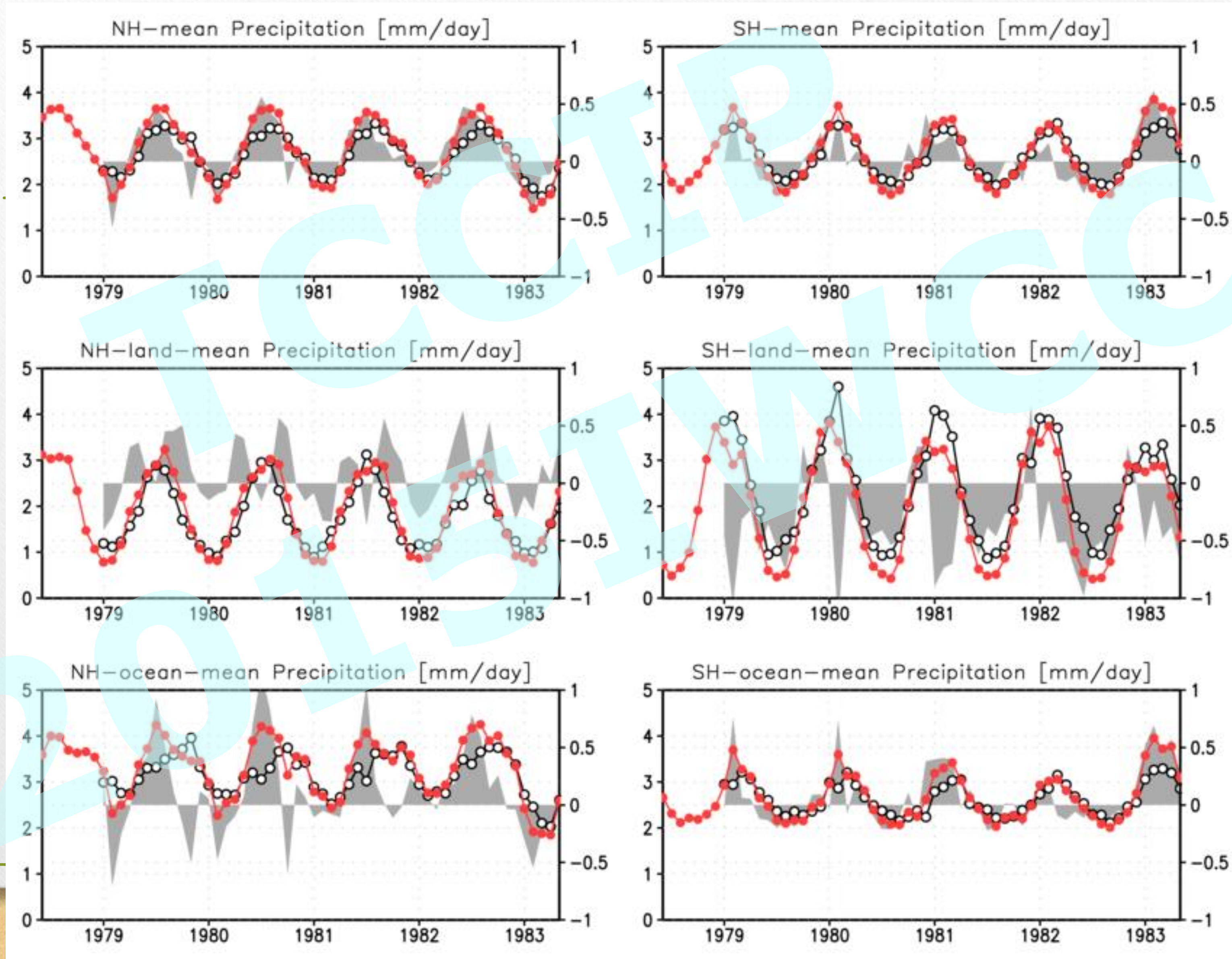


Figs. by T. Tomita & T. Yamaura

左軸 → 黒:GPCP　赤:NICAM
右軸 → シェード:バイアス

NH　　SH

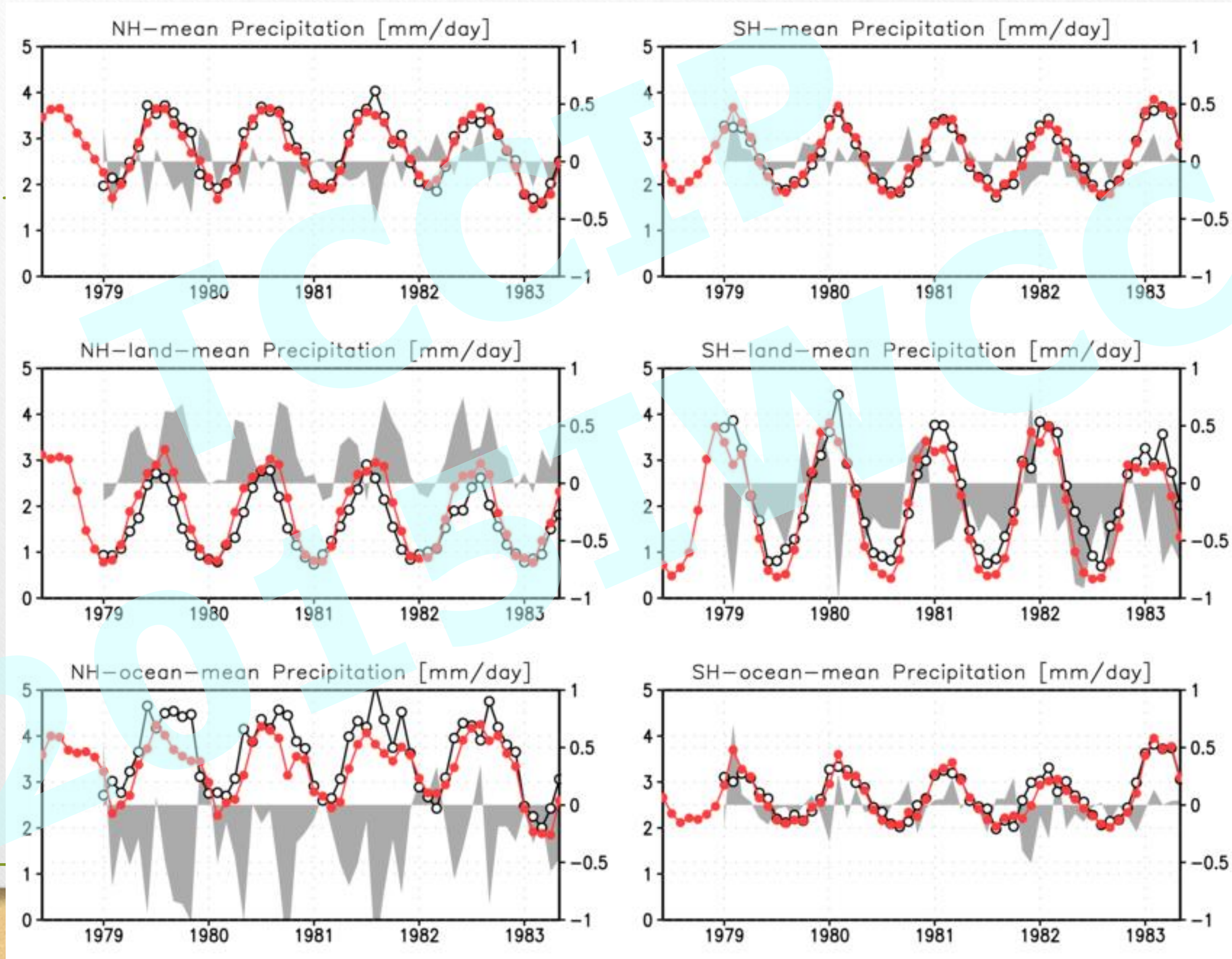
全域
陸上
海上



左軸 → 黒 : CMAP　赤 : NICAM
右軸 → シェード : バイアス

NH　　SH

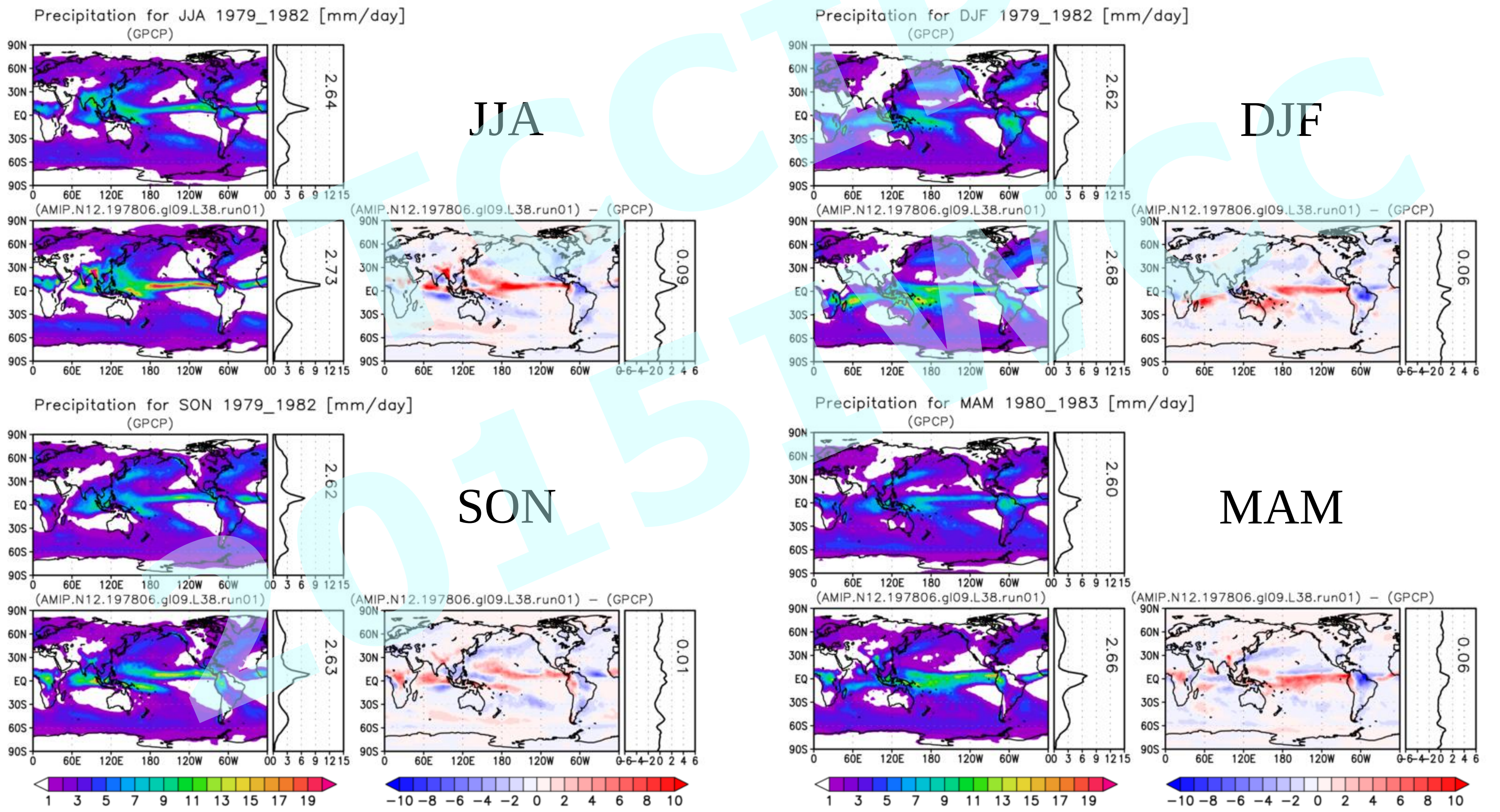
全域
陸上
海上



GPCP（4年）

NICAM（4年）　（下）－（上）

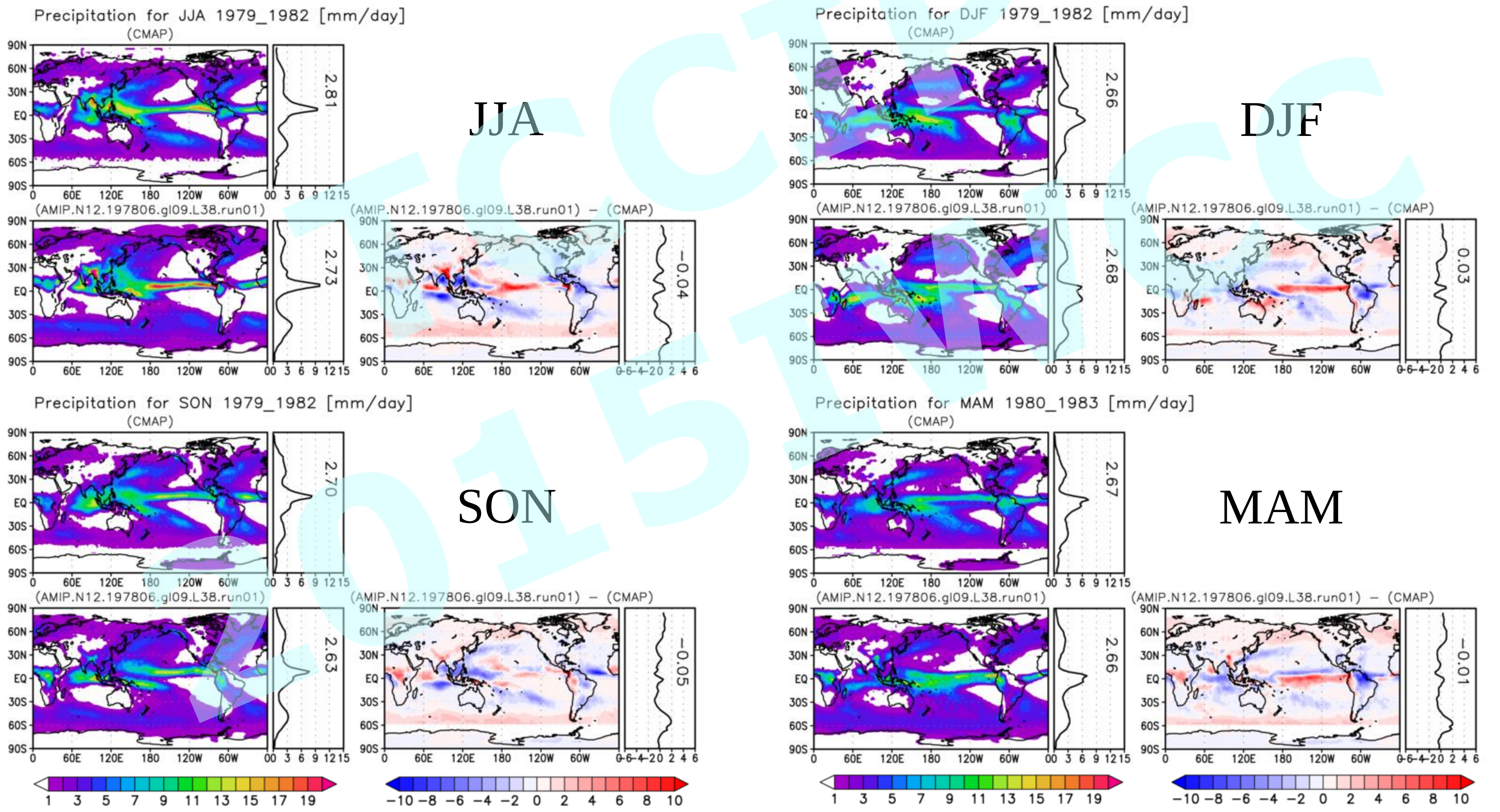
降水（vs. GPCP）



CMAP（4年）

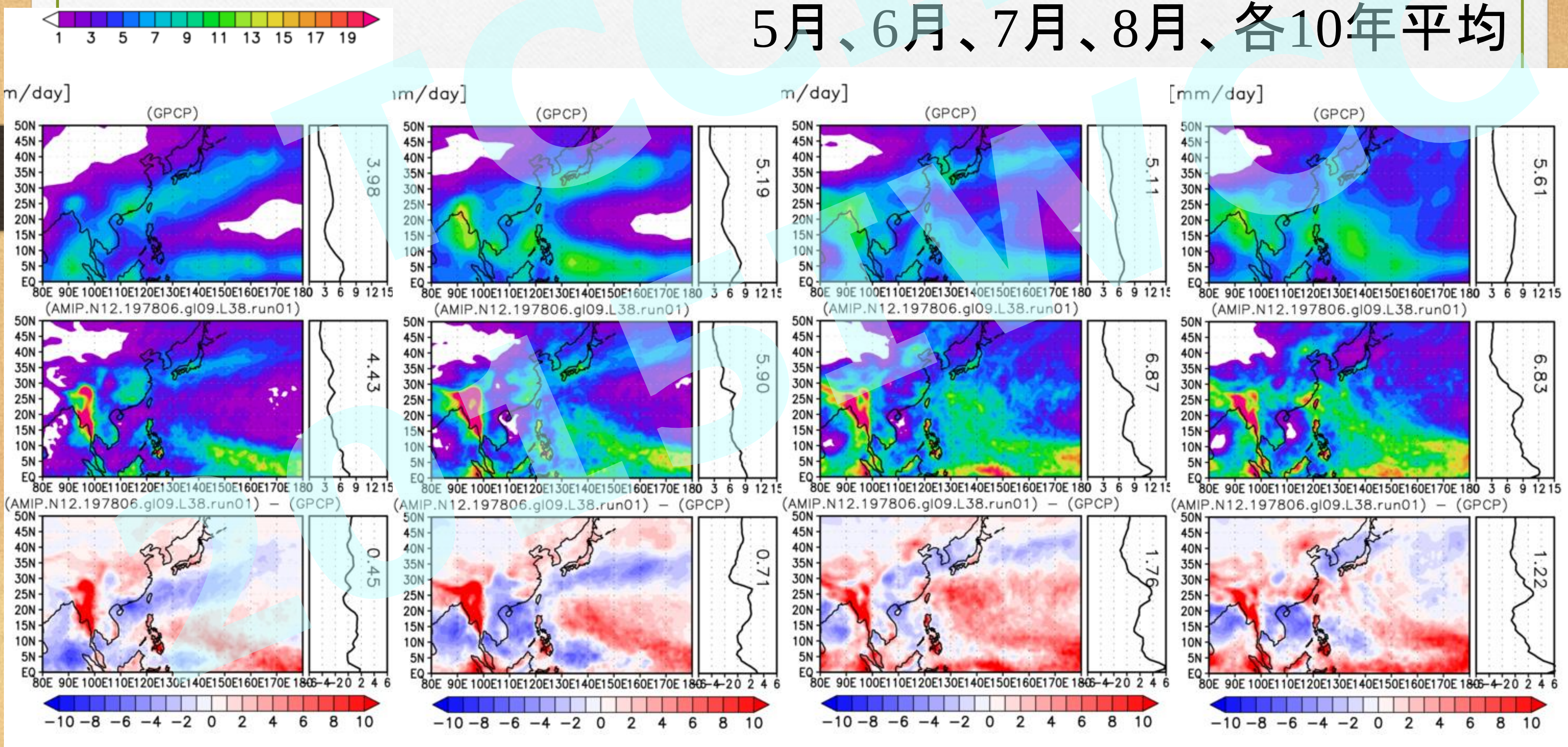
NICAM（4年）　　（下）－（上）

降水（vs. CMAP）



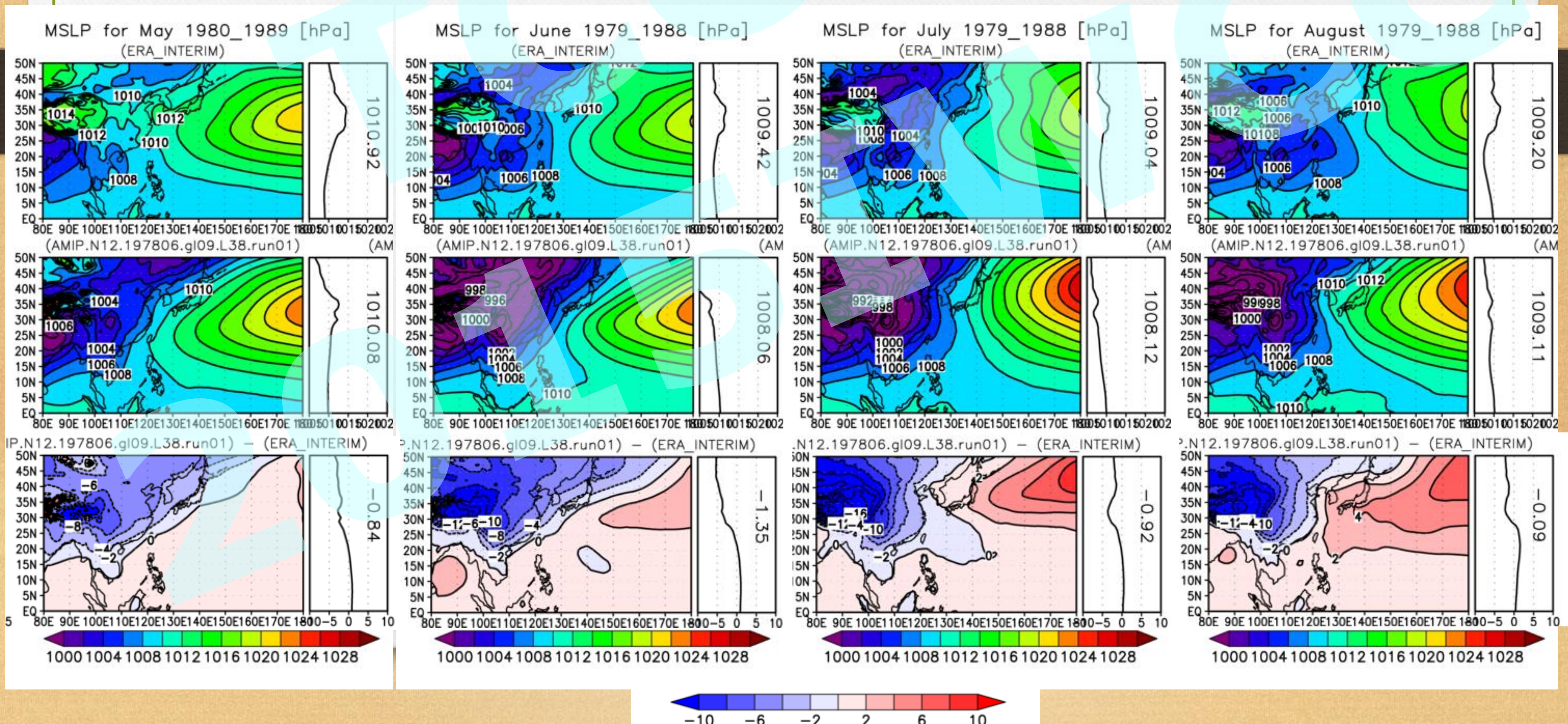
日本付近の降水

5月、6月、7月、8月、各10年平均



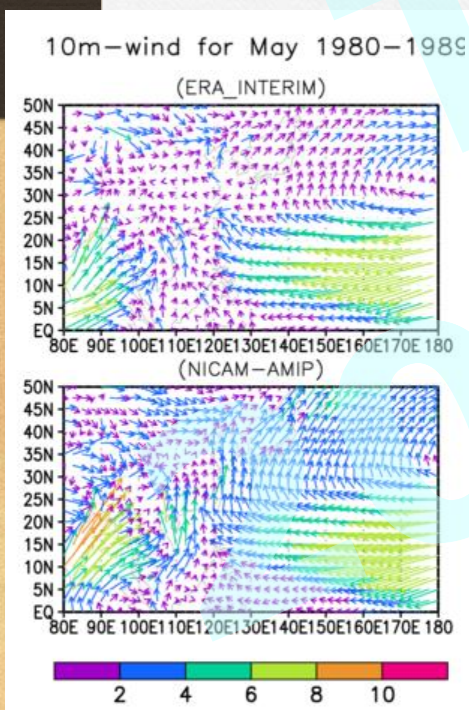
日本付近のMSLP

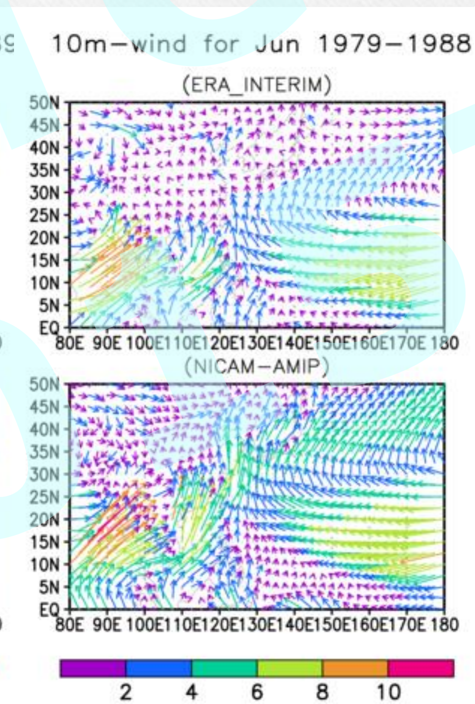
5月、6月、7月、8月、各10年平均

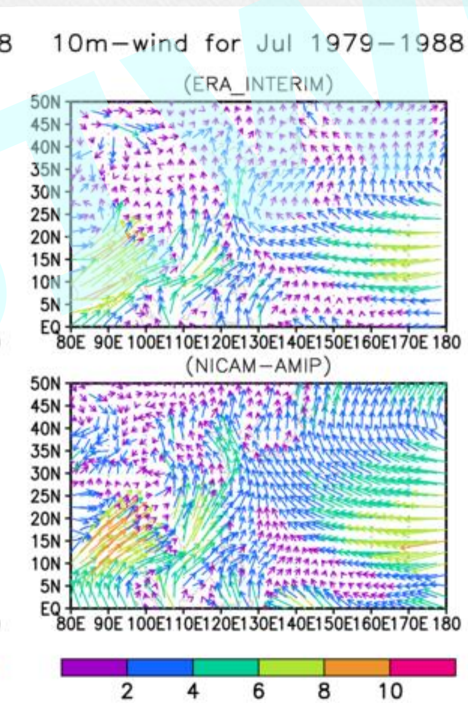


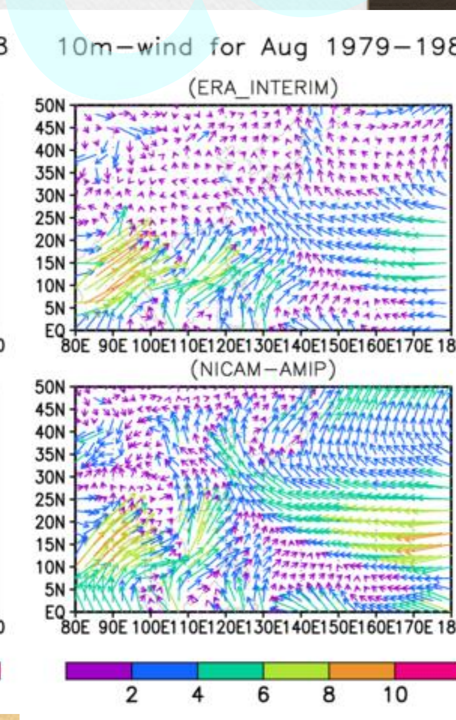
日本付近の地上風

5月、6月、7月、8月、各10年平均







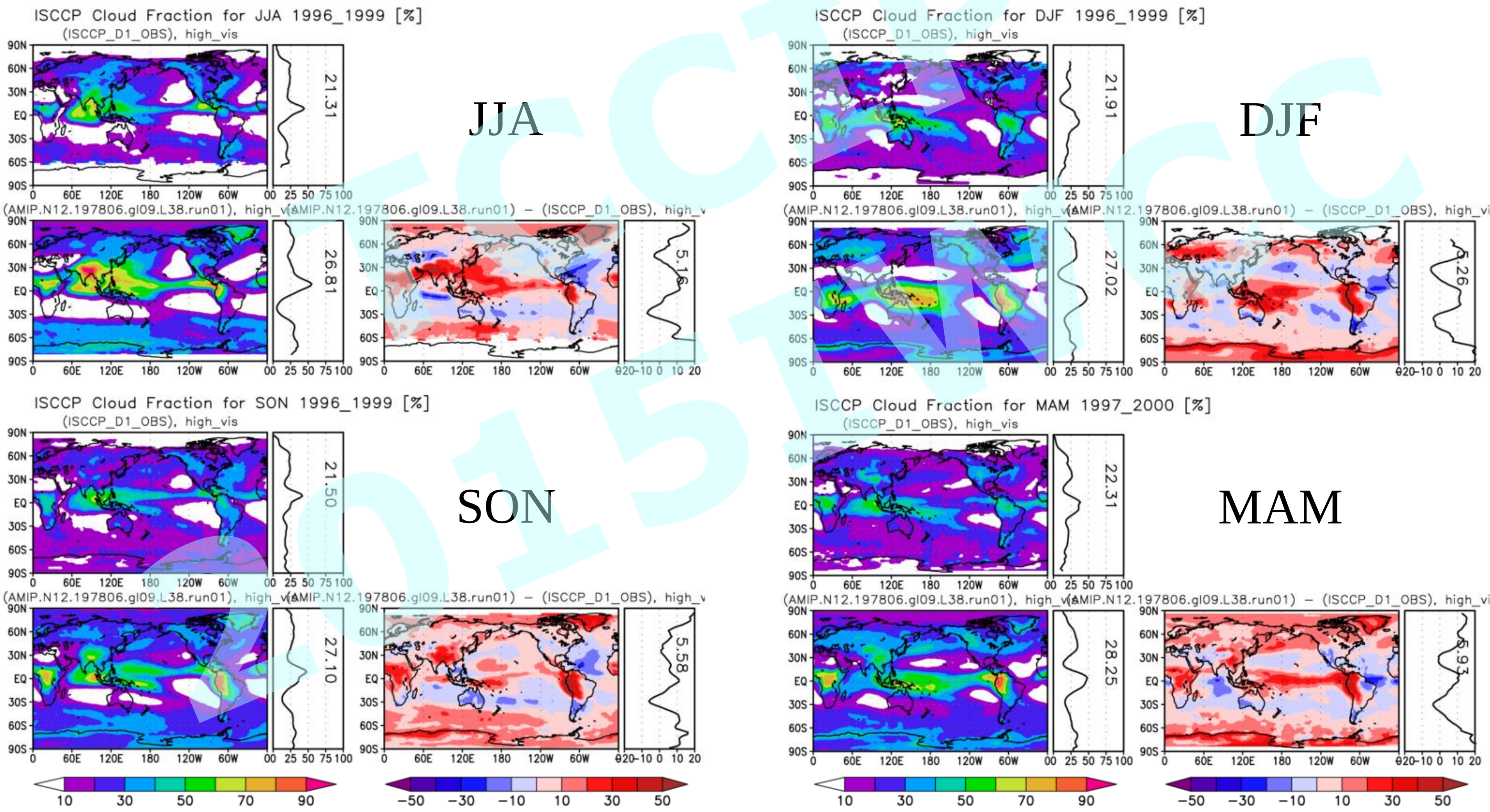


ISCCP（4年）

NICAM（4年）　　（下）ー（上）

※平均期間は17年ずれている

ISCCP上層雲

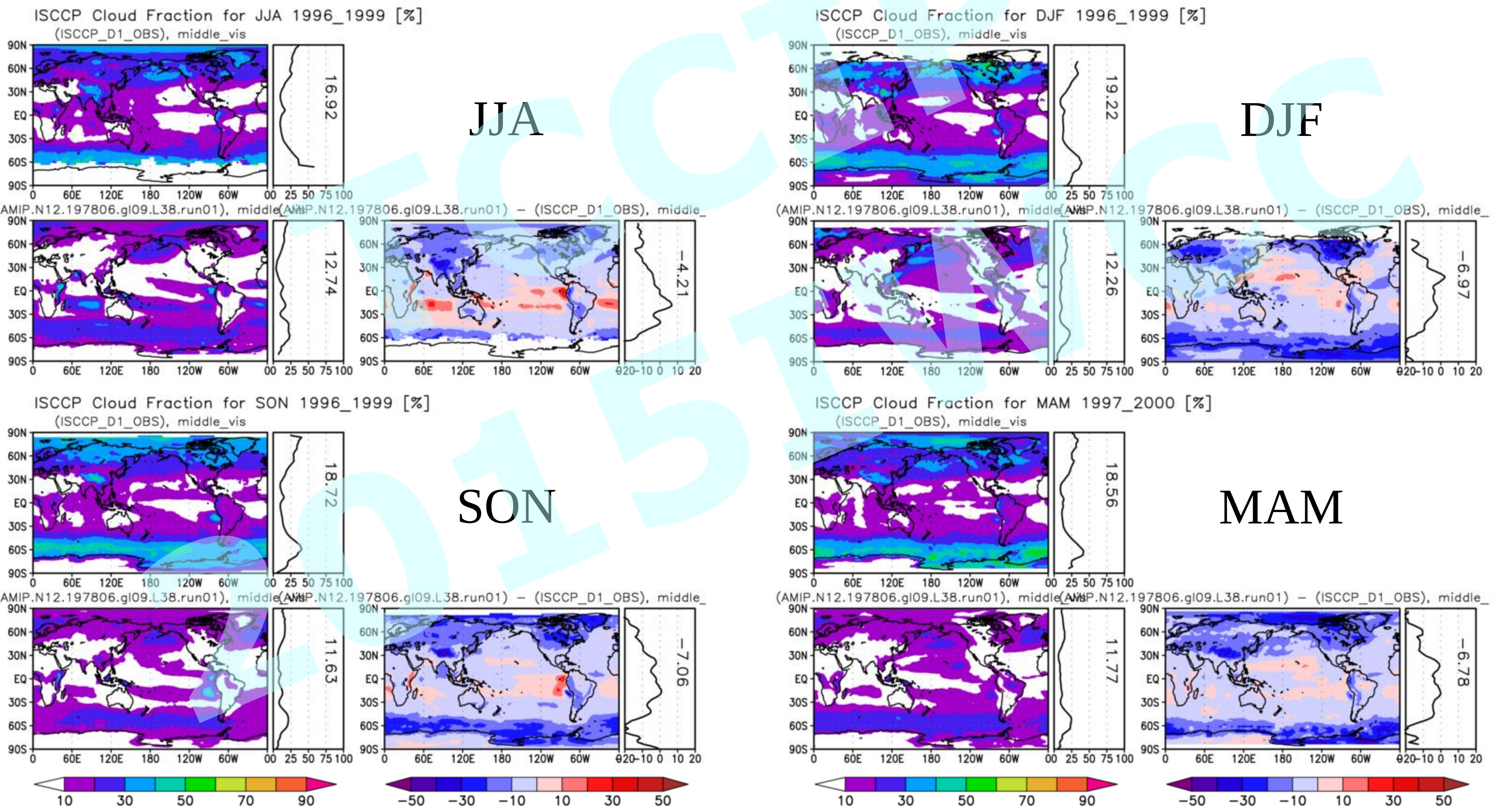


ISCCP（4年）

NICAM（4年）　　（下）ー（上）

※平均期間は17年ずれている

ISCCP中層雲

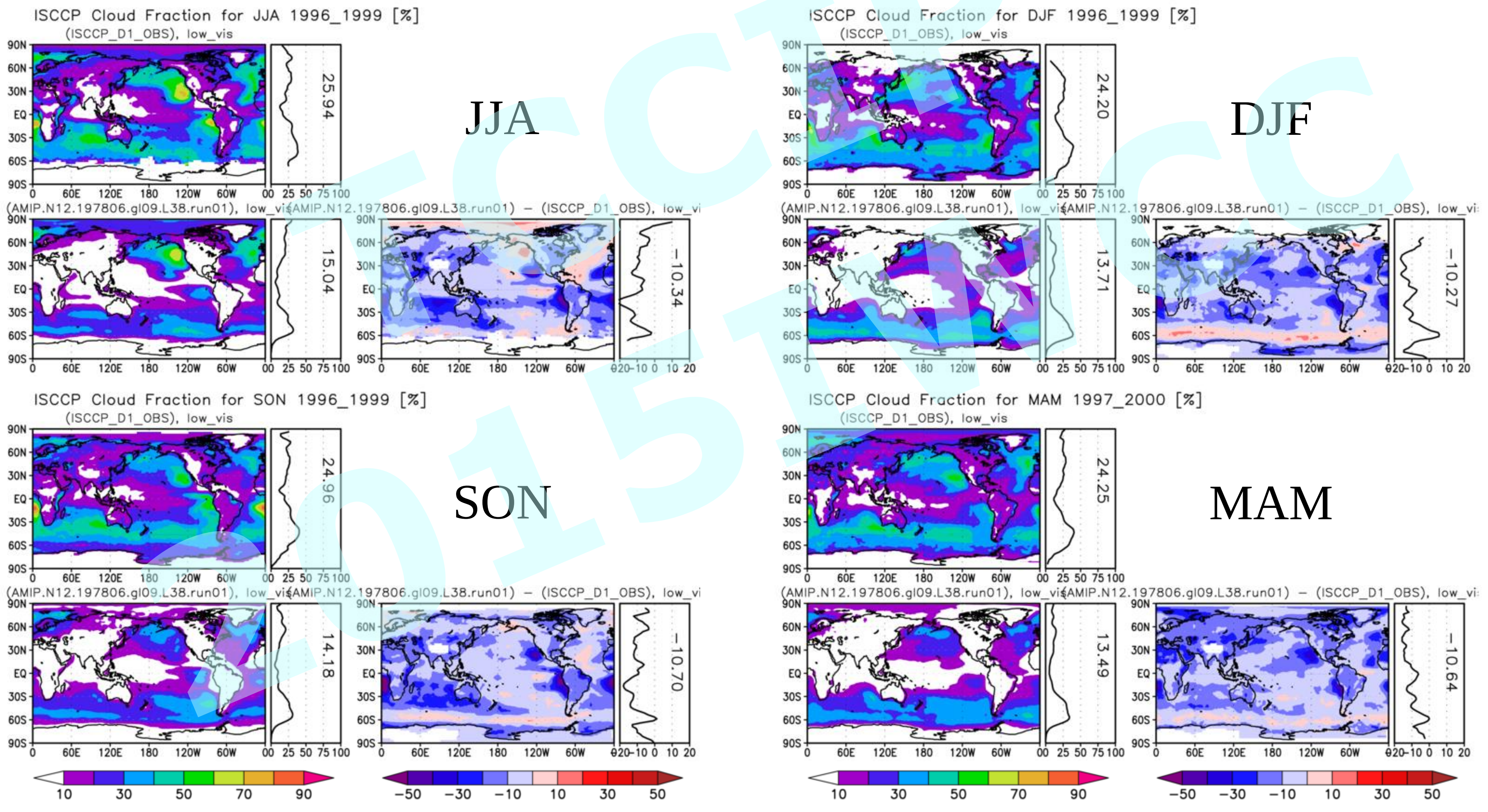


ISCCP（4年）

NICAM（4年）　　　（下）ー（上）

※平均期間は17年ずれている

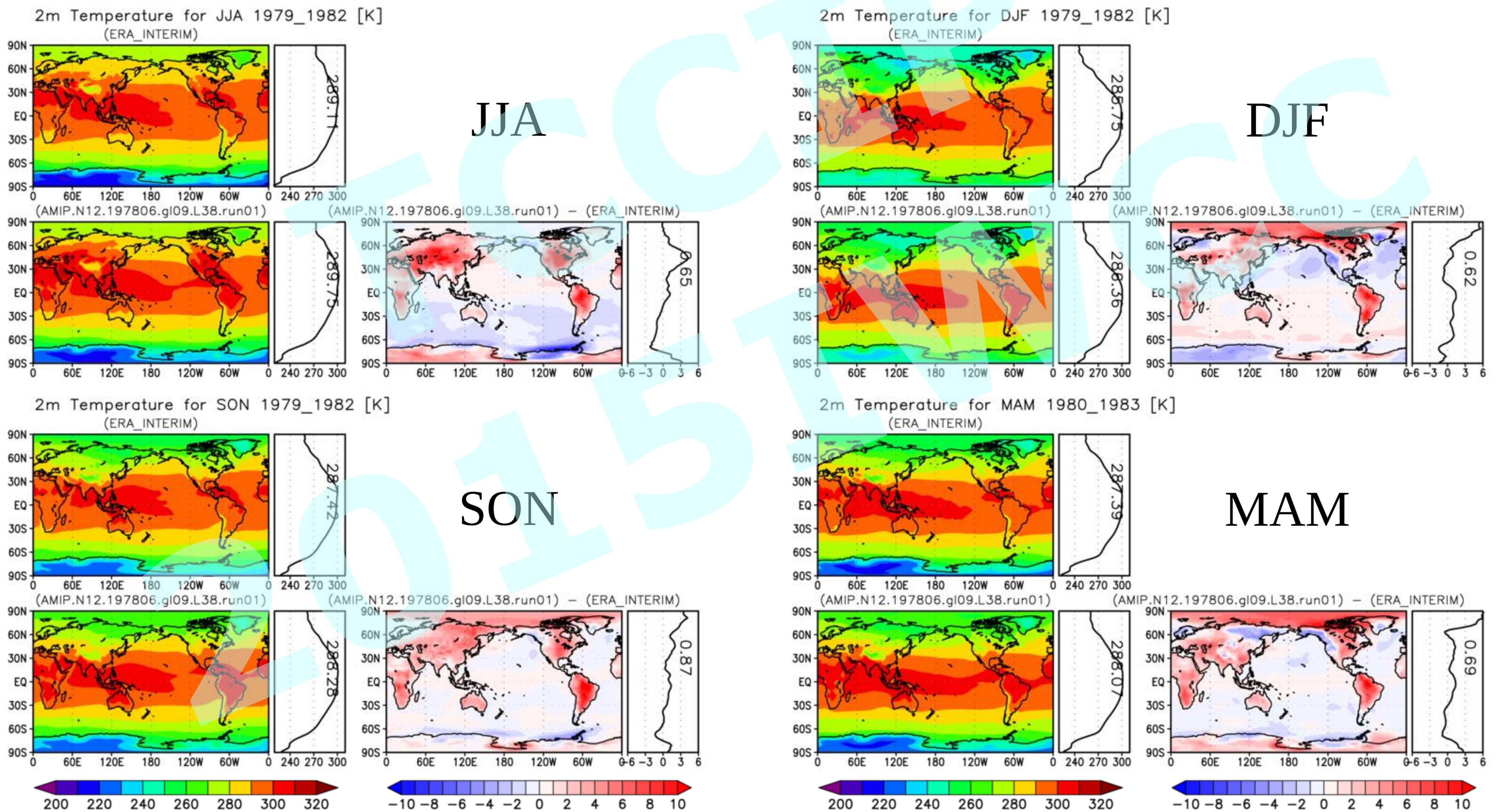
ISCCP下層雲



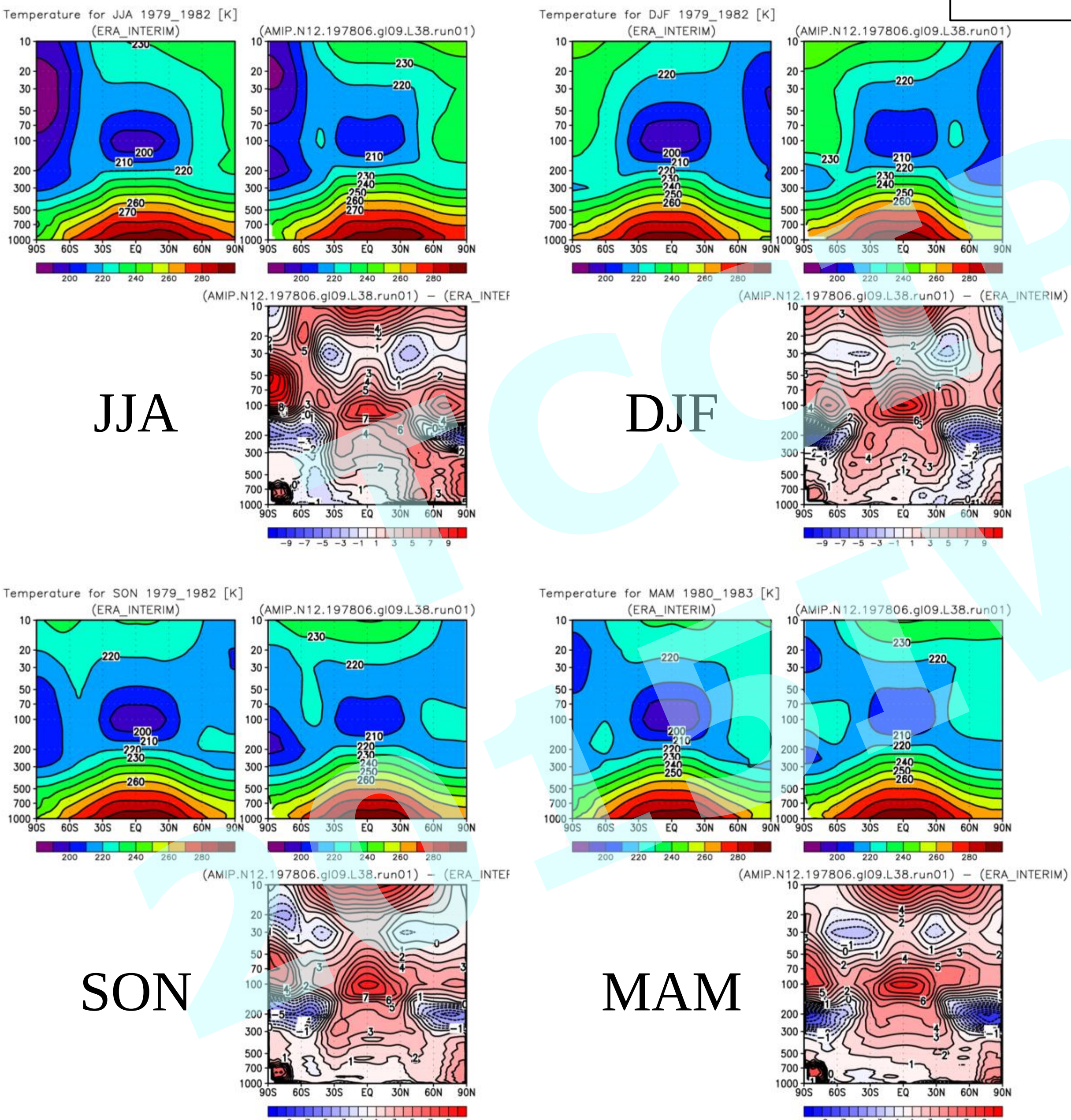
ERA-Interim（4年）

NICAM（4年）　　（下）ー（上）

2m気温



ERA-Interim（4年）　NICAM（4年）
（下）－（上）



ERA-Interim（4年） NICAM（4年）
（下）－（上）