Is Tuning of Auto-conversion important for the Realistic Simulation of Indian Summer Monsoon Intraseasonal Oscillations and MJO in coupled climate model?

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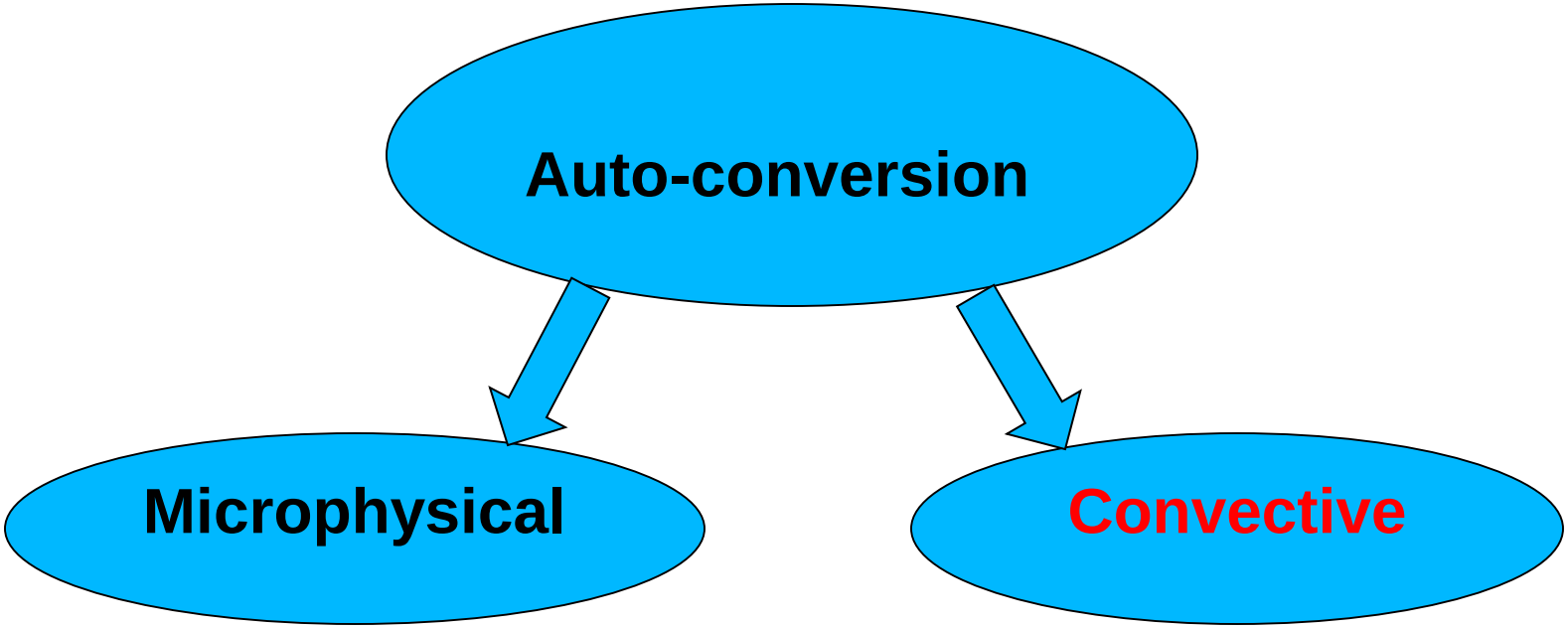


$$P_{raut} = C_0 q_l \left\{1 - exp\left(-\left(\frac{q_l}{b q_{lcrit}}\right)^2\right)\right\}$$

$$q_{lcrit} = \frac{4}{3}\pi r_{crit}^3 N_c \rho_l / \rho_a$$

Where, C_0 is an auto-conversion coefficient, q_l is the cloud liquid water and q_{lcrit} is the critical value of cloud water for auto-conversion. The cloud cover is denoted as b. **[e.g., *Rotstayn* 2000; *Rasch and Kristjansson* 1998;** *Sundqvist et al.,* 1989 **]**

$$rn_c(z) = C_0 q_l(z)$$

Where, C_0 is a constant parameter, *Lord* [1982] proposed a similar auto-conversion function. [*Arakawa and Schubert* 1974; *Grell* 1993; *Pan and Wu* 1995; *Wu* 2012; Lord 1982]:

Design of Experiments in Coupled Global Climate model (CFSv2)

Experiment (Tuning)
CA002MA1.0(E1)
CA002MA1.5 (E2)
CA001MA1.0 (E3)
CA001MA1.5 (E4)
CA001MA2.5 (E5)
CA0005MA1.5 (E6)

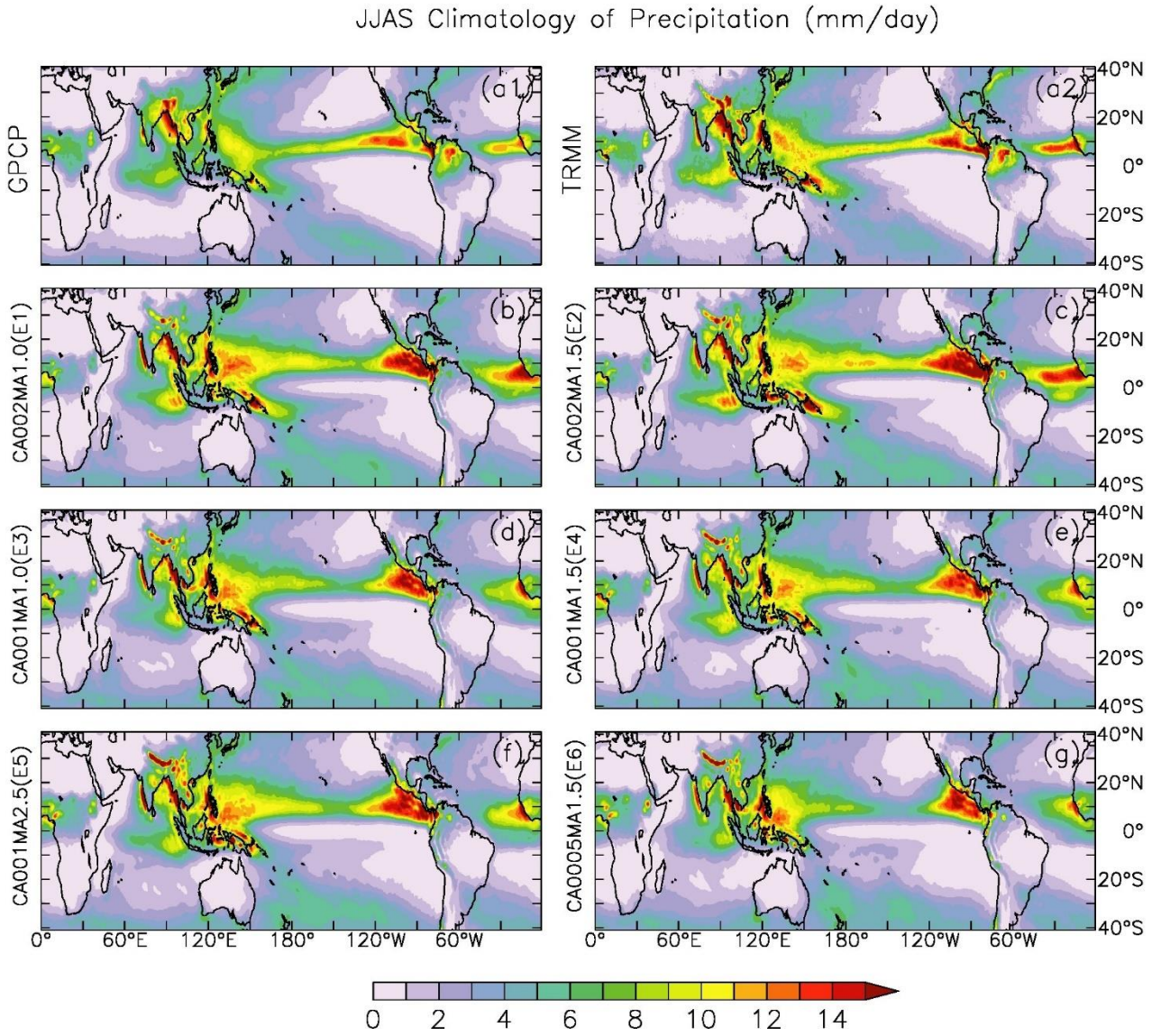
- **"Models need fundamental improvements in their microphysical parameterization (i.e., autoconversion) for the better prediction of the cloud-precipitation-radiation interaction." *(Michibata T & Takemura T, JGR, 2015*)**

- **Incorrect partitioning between convective and non-convective precipitation may lead to biases in the simulated precipitation.(*Chen, D., & Dai, A. JAMES (2019*)**

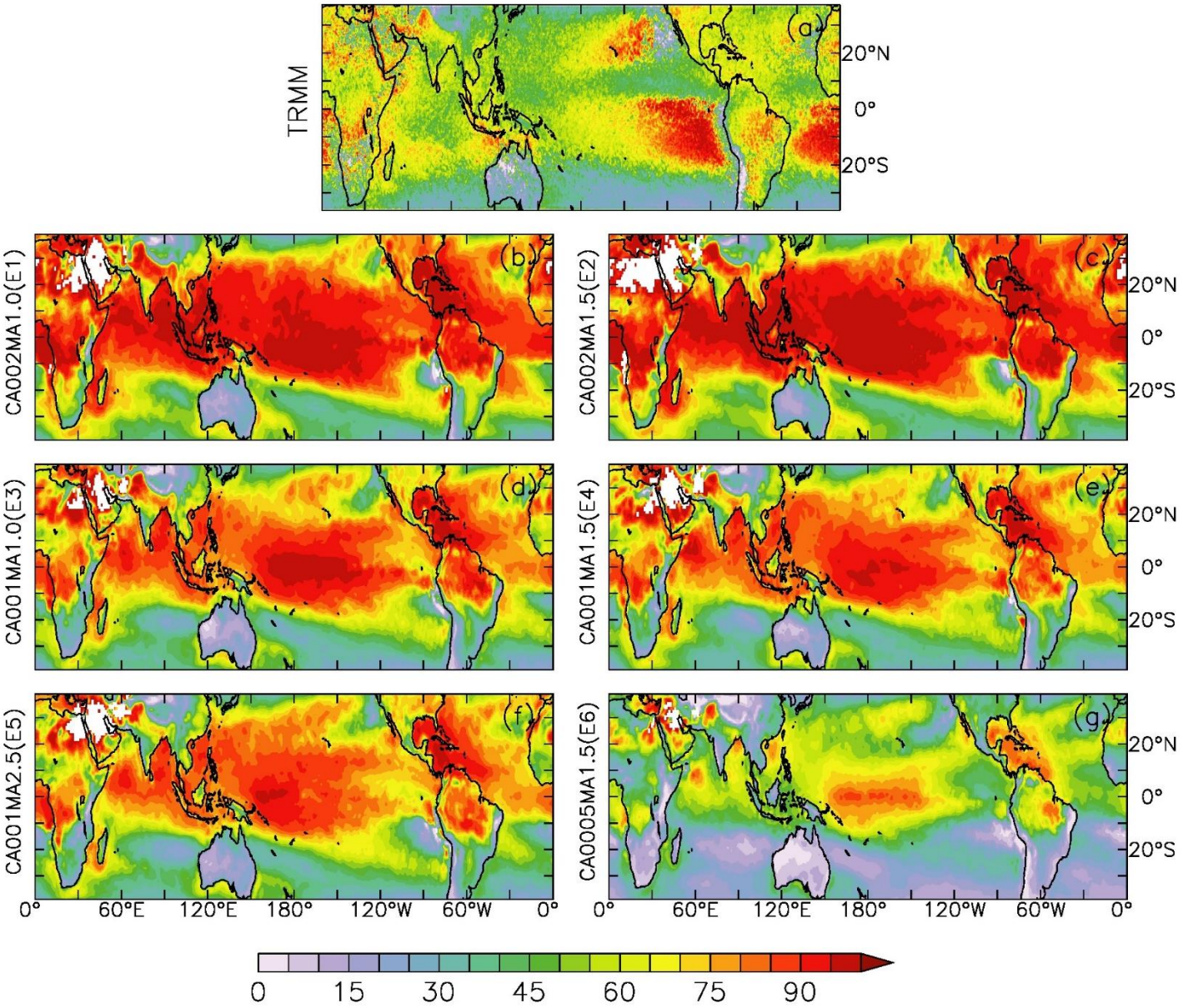
Observational Datasets

Parameter	Time Period	Data Source
OLR	1999-2008	NOAA
Rainfall	1999-2008	GPCP
Wind	1999-2008	NCEP2

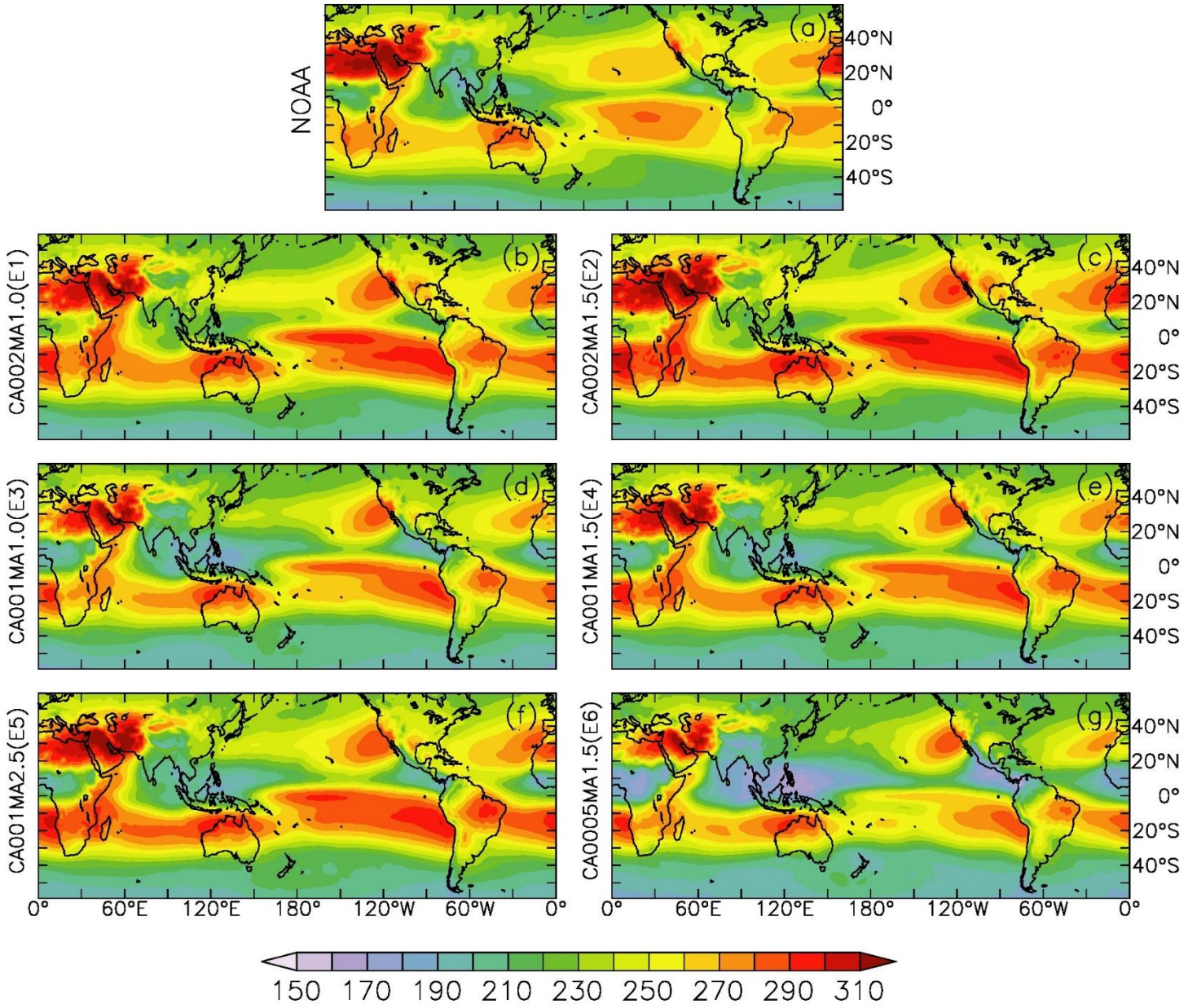
JJAS mean Precipitation (mm/day)



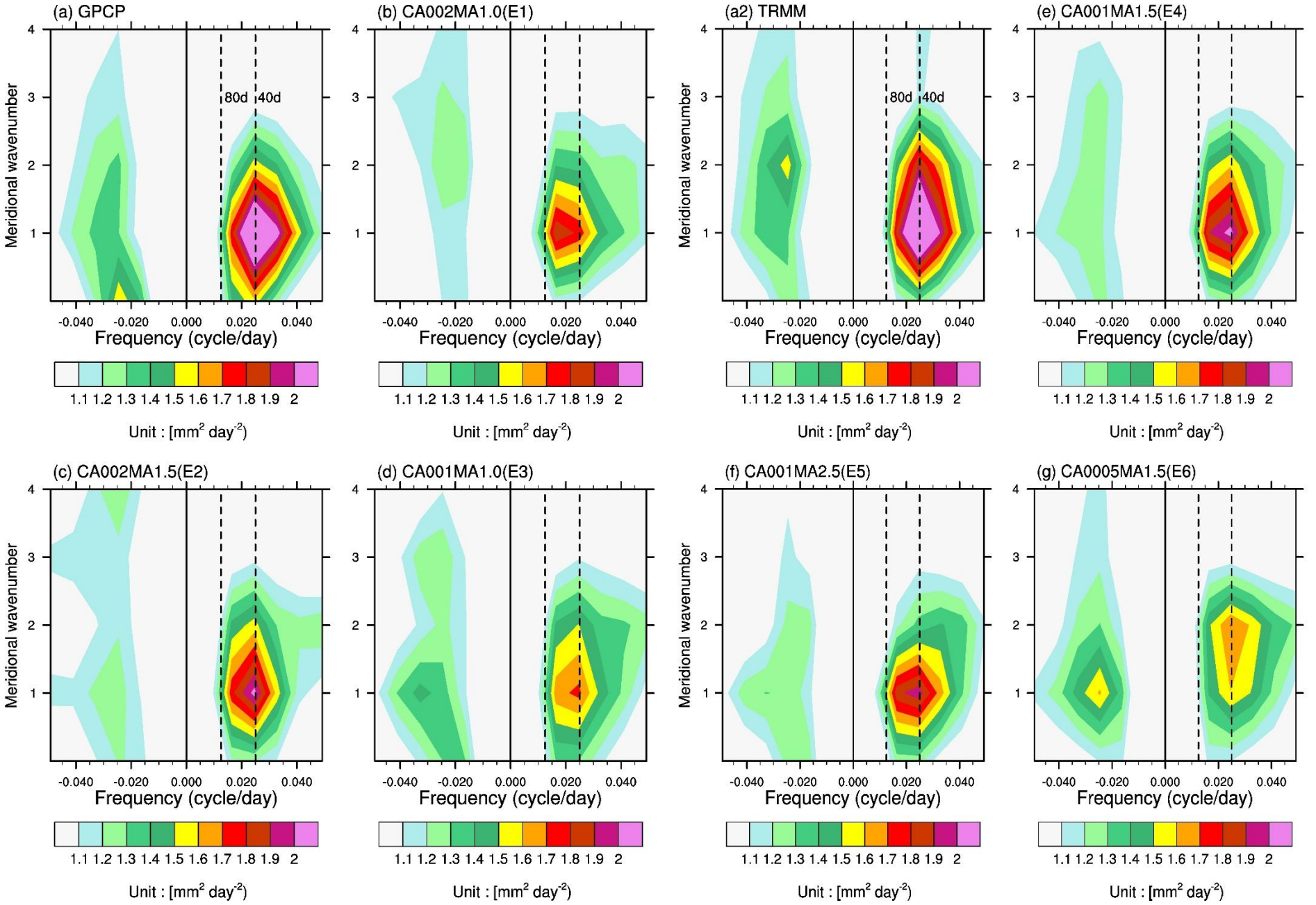
Spatial distribution convective rain as percentage of total rainfall (%)

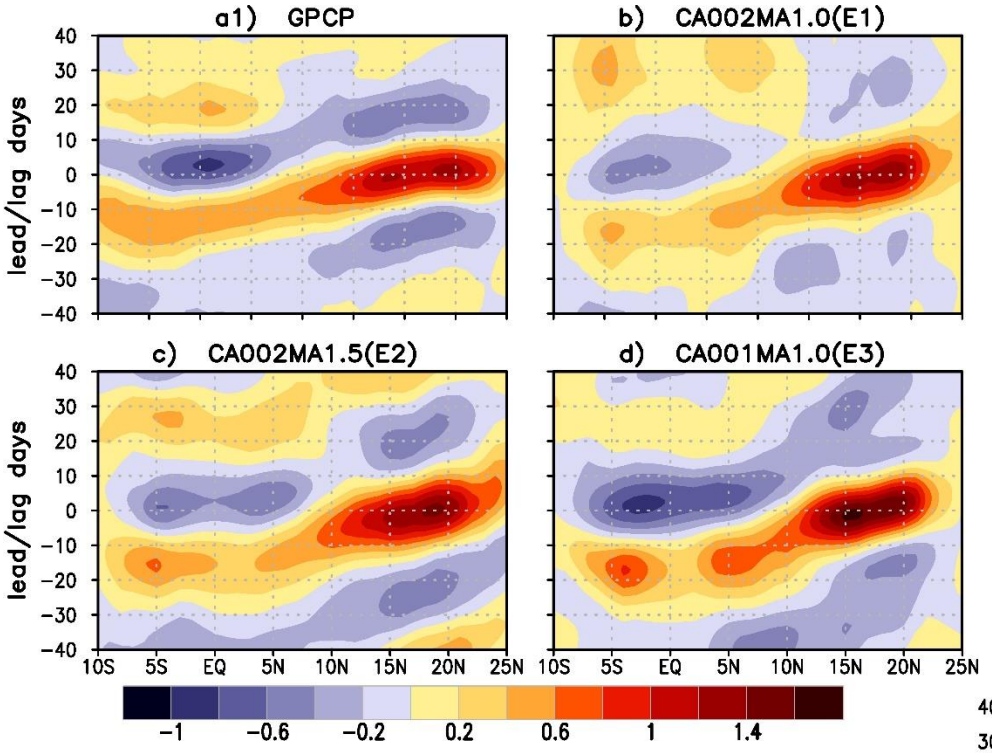


OLR (JJAS Climatology) (W/m2)

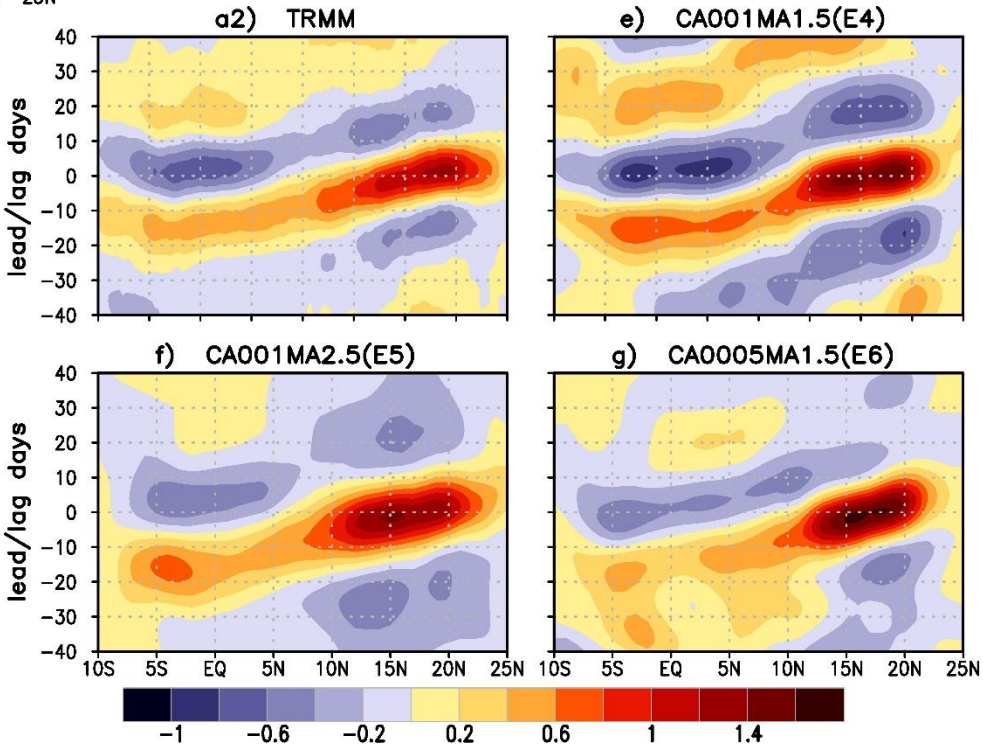


The finite domain space-time spectra (Wheeler & Kiladis, 1999) of 20-100 day filtered rainfall



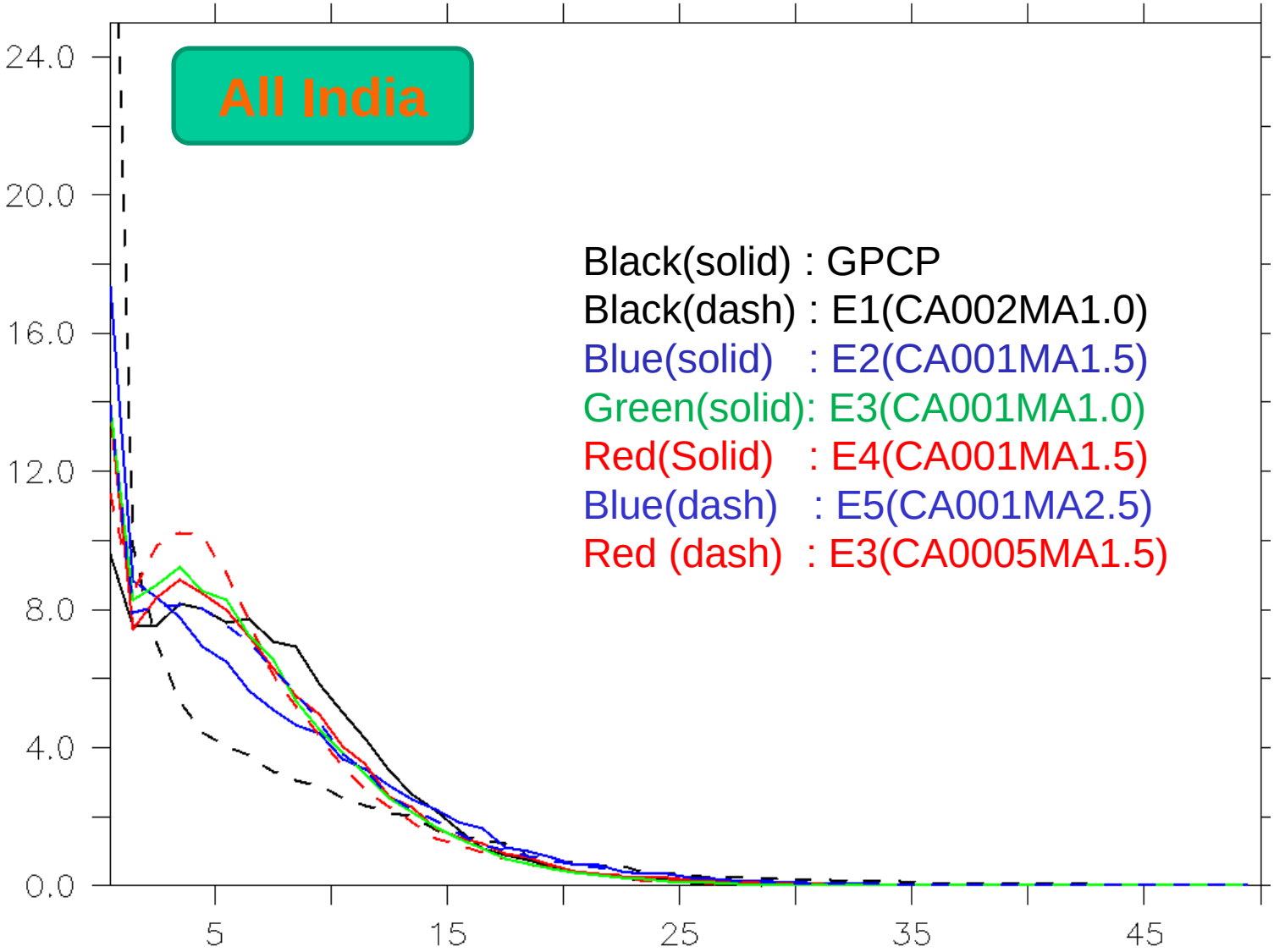


Northward propagation



Lag-Latitude diagram of the Low frequency 30-60 day mode

Probability Distribution Function (PDF in %) of JJAS - rainfall (mm/day)

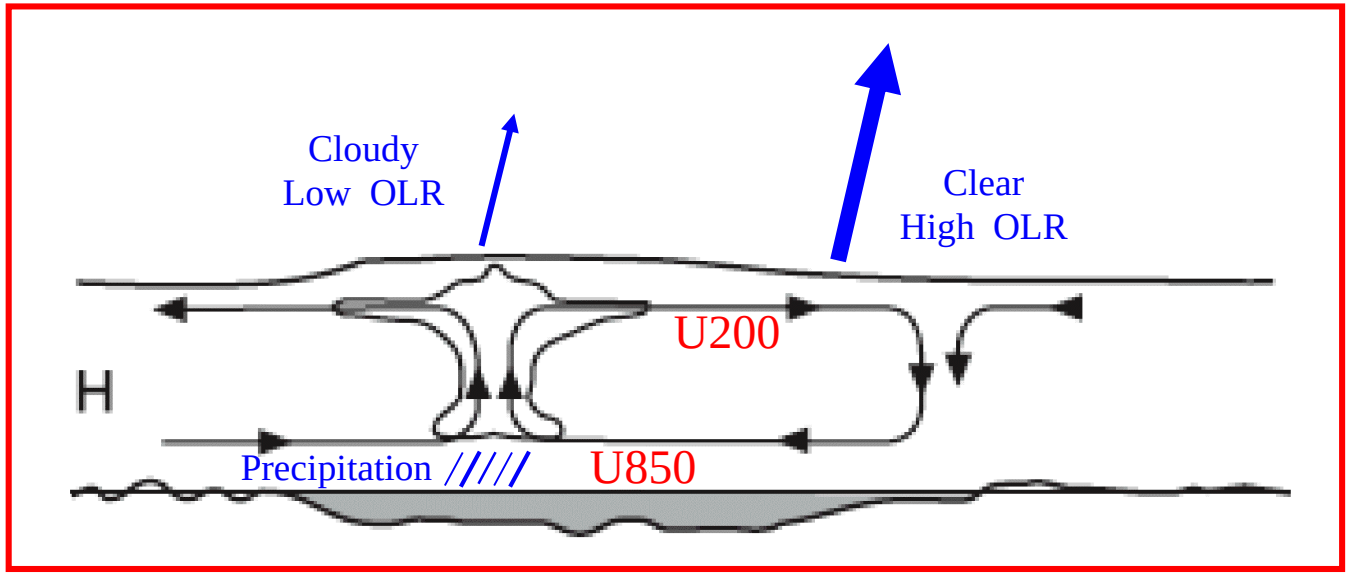


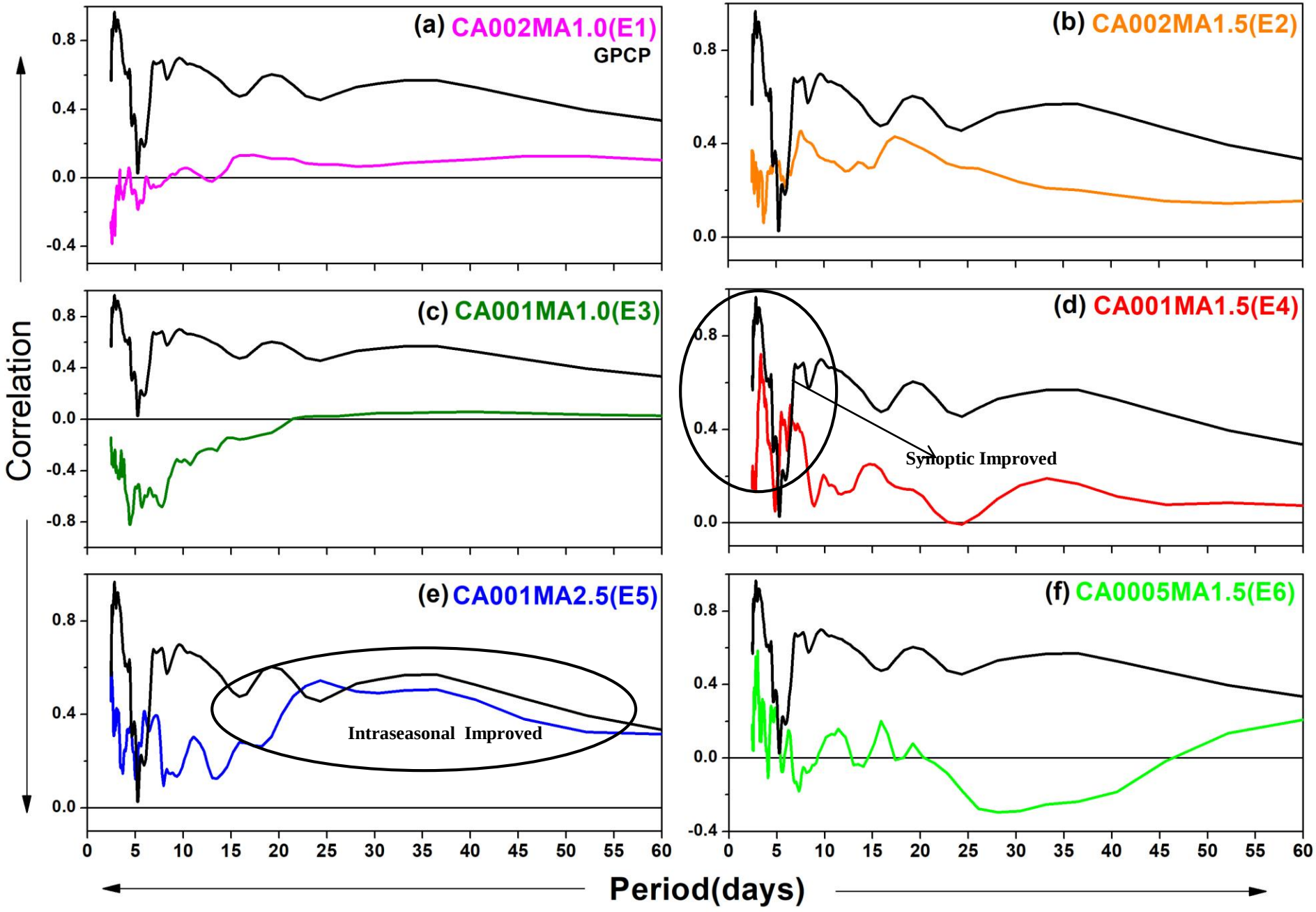
Sensitivity Experiments regarding MJO Simulation

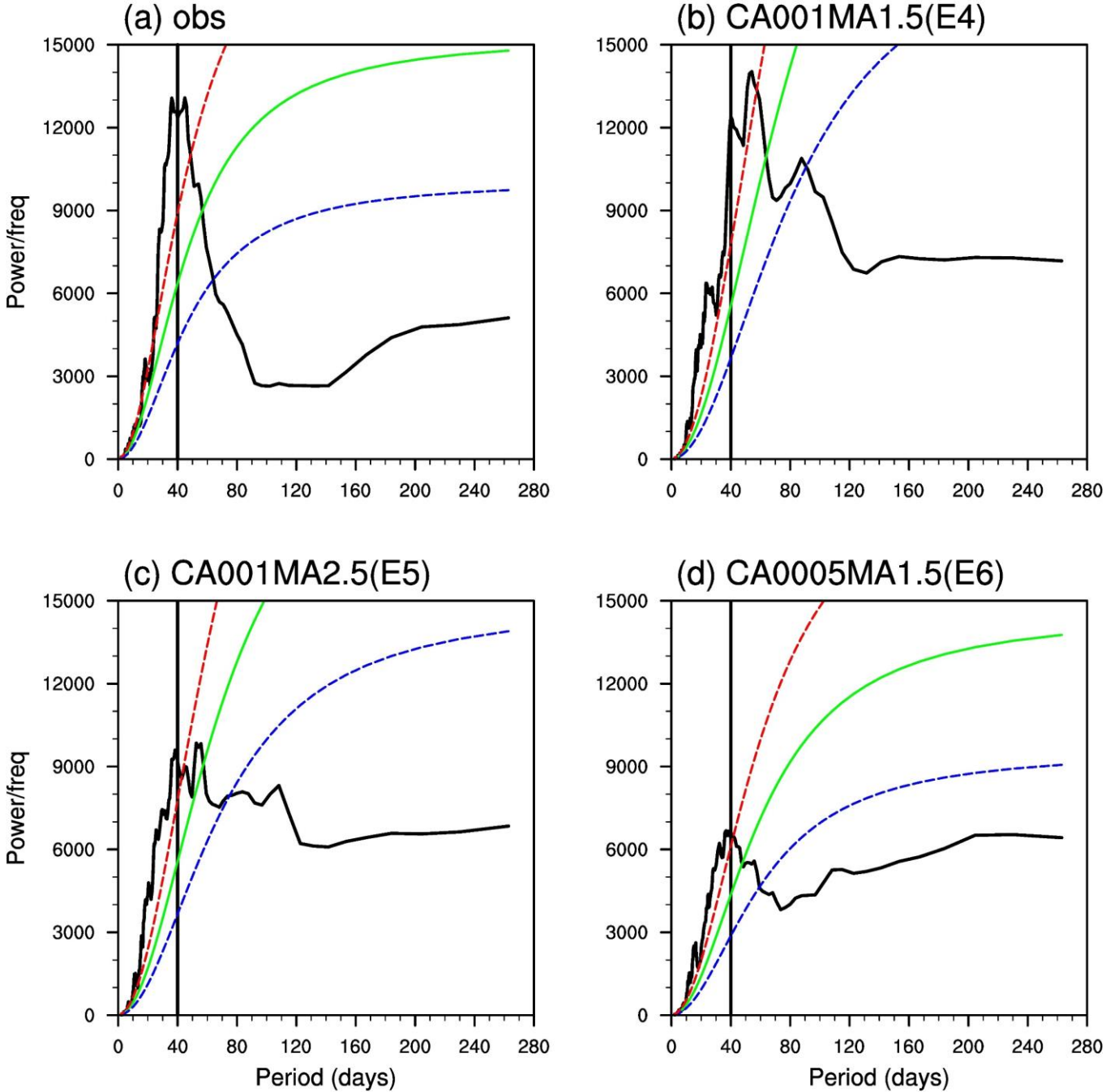
Typical Variables Used for MJO Diagnostics

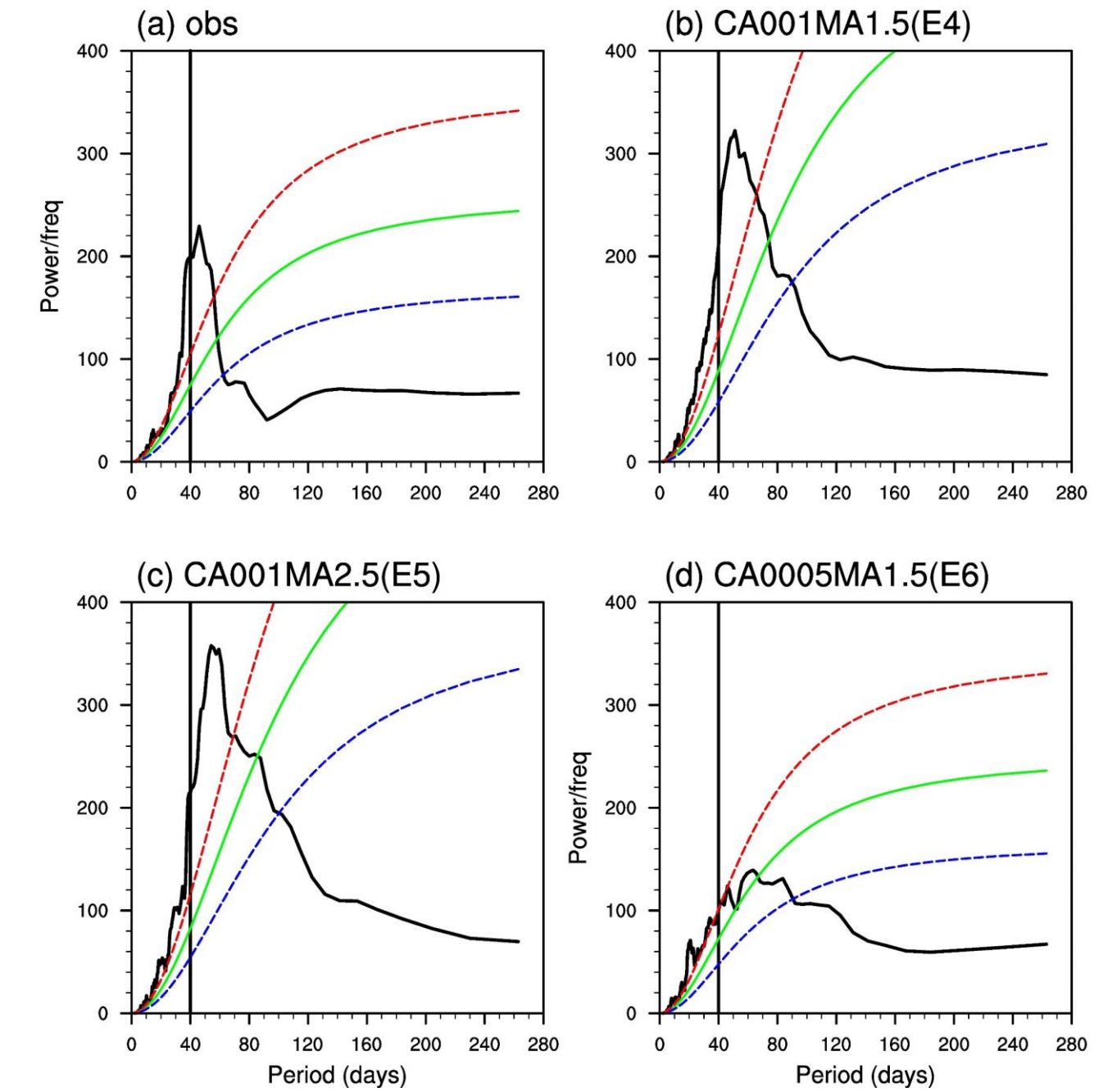
1. Outgoing Longwave radiation (OLR)
2. Precipitation
3. Zonal Wind at lower tropospheric level(850 hPa) → U850
4. Zonal Wind at Upper tropospheric level(200 hPa) → U200

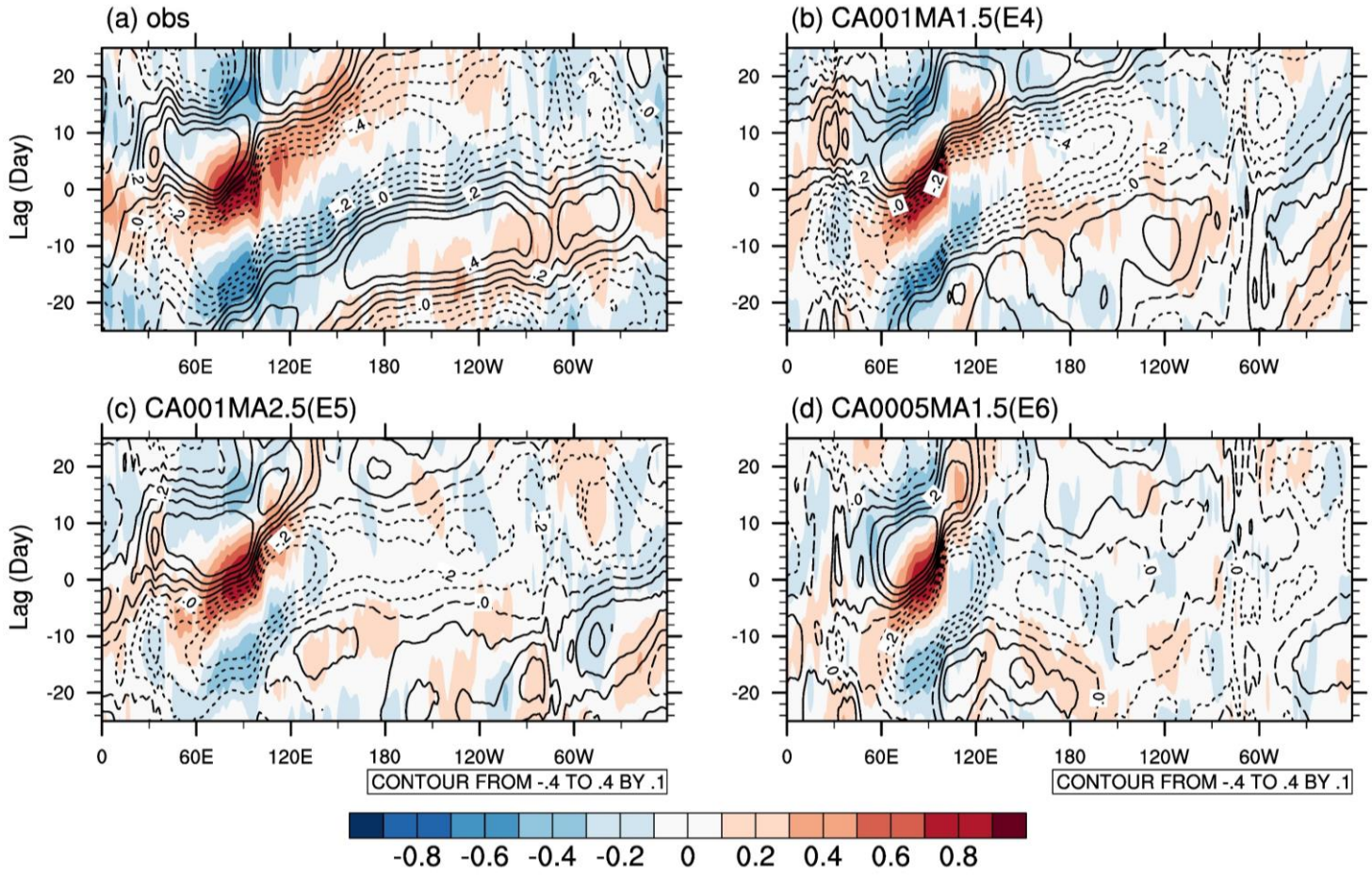
(***Waliser et al.,2009***).



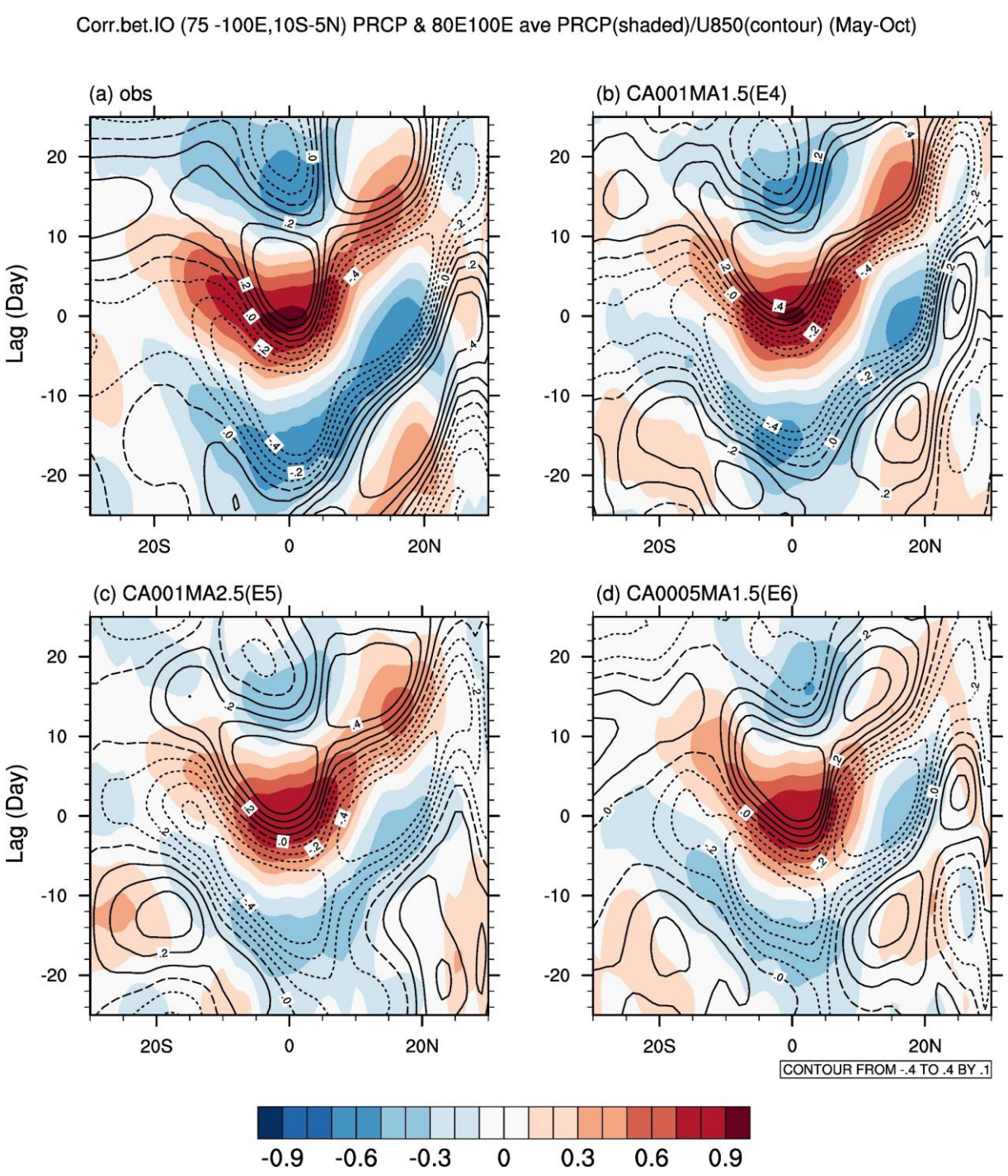

(a) CA002MA1.0(E1)
GPCP
(b) CA002MA1.5(E2)
(c) CA001MA1.0(E3)
(d) CA001MA1.5(E4)
Synoptic Improved
(e) CA001MA2.5(E5)
Intraseasonal Improved
(f) CA0005MA1.5(E6)
Correlation
Period(days)


Power spectra of IO(10S-5N;75-100E) average of OLR (May -Oct)
(a) obs
(b) CA001MA1.5(E4)
(c) CA001MA2.5(E5)
(d) CA0005MA1.5(E6)
Power/freq
Period (days)
0
3000
6000
9000
12000
15000
0
40
80
120
160
200
240
280

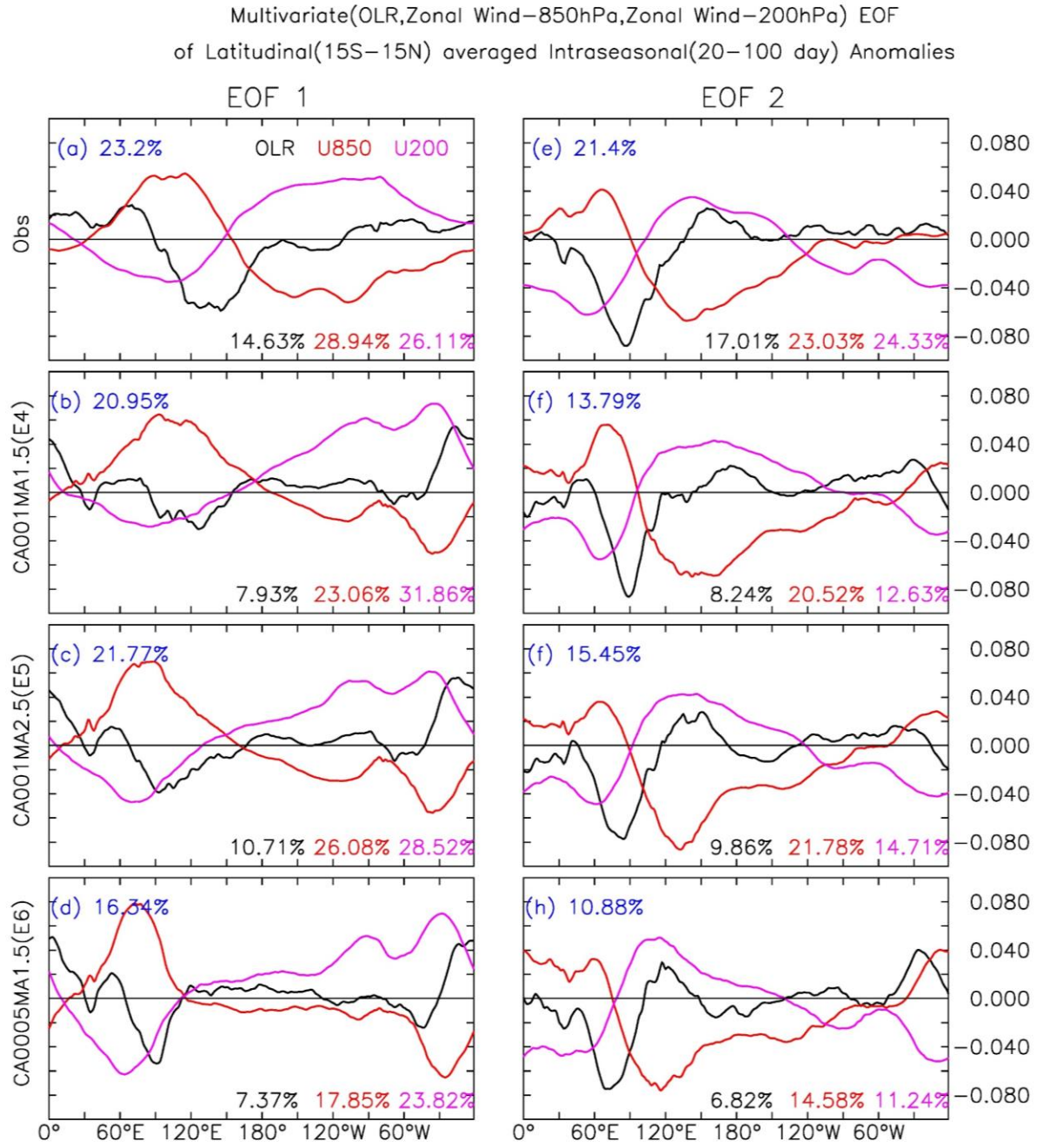

Power spectra of IO(3.75-21.25N;68.75-96.25E) averaged U850 (May -Oct)
(a) obs
(b) CA001MA1.5(E4)
(c) CA001MA2.5(E5)
(d) CA0005MA1.5(E6)
Power/freq
Period (days)
0
40
80
120
160
200
240
280
100
300
400



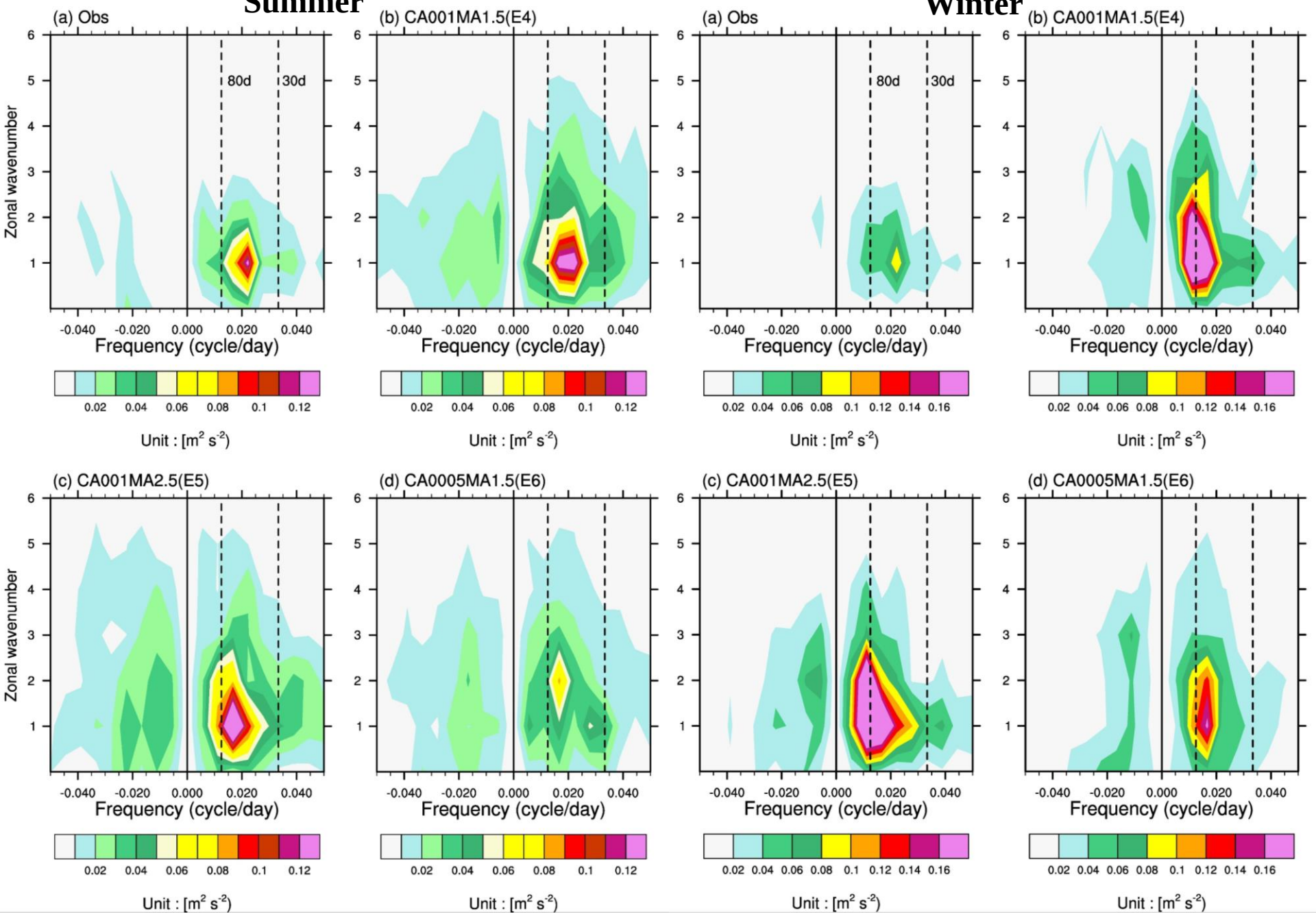
May-October lag-longitude diagram of 10ºN-10ºS averaged precipitation intraseasonal(20-100 day) anomalies(colors) and intraseasonal 850 hPa zonal wind anomalies(contours) correlated against intraseasonal precipitation at the Indian Ocean reference point(Table 2).



May-October lag-latitude diagram of 80ºE-100ºE averaged precipitation intraseasonal(20-100 day) anomalies(colors) and intraseasonal 850 hPa zonal wind anomalies(contours) correlated against intraseasonal precipitation at the Indian Ocean reference point(Table 2).


Multivariate(OLR,Zonal Wind−850hPa,Zonal Wind−200hPa) EOF
of Latitudinal(15S−15N) averaged Intraseasonal(20−100 day) Anomalies
EOF 1
EOF 2
(a) 23.2%
OLR U850 U200
14.63% 28.94% 26.11%
(e) 21.4%
17.01% 23.03% 24.33%
Obs
(b) 20.95%
7.93% 23.06% 31.86%
(f) 13.79%
8.24% 20.52% 12.63%
CA001MA1.5(E4)
(c) 21.77%
10.71% 26.08% 28.52%
(f) 15.45%
9.86% 21.78% 14.71%
CA001MA2.5(E5)
(d) 16.34%
7.37% 17.85% 23.82%
(h) 10.88%
6.82% 14.58% 11.24%
CA0005MA1.5(E6)
0.080
0.040
0.000
−0.040
−0.080
0° 60°E 120°E 180° 120°W 60°W

Space-time Spectra of Zonal wind of 850 hPa

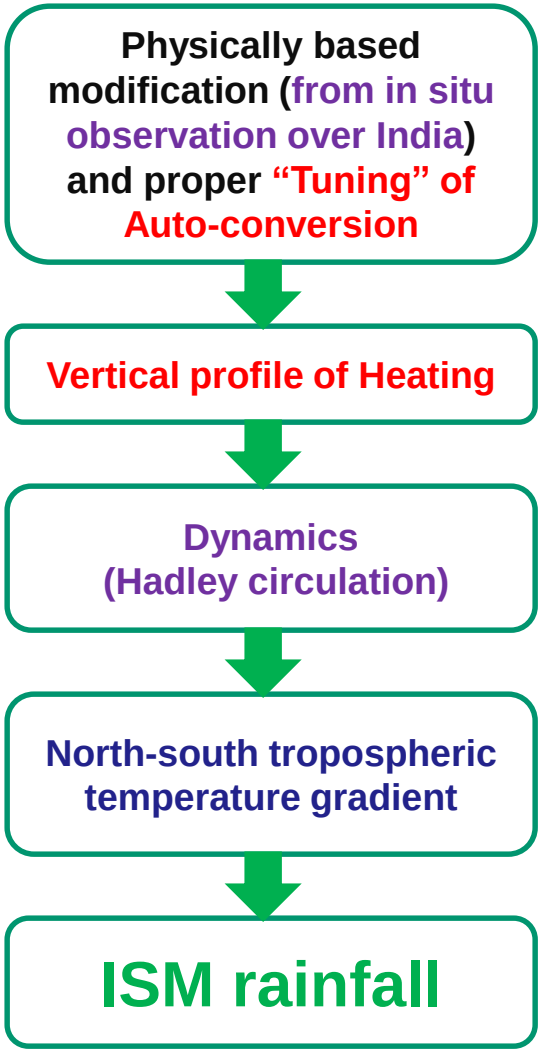


Summary-1

Main points on the "Tuning" auto-conversion in convective microphysics scheme: ISO

In order to make qualitative improvement in simulation of the MISOs and hence the dry bias in seasonal mean simulation:-

- **'triggering' coefficient helps for modification of partitioning of cloud water and ice in the convective scheme.**
- **'triggering' coefficient helps for proper feedback between large-scale condensation and cumulus convection parameterization.**



Summary-2

- E4 and E6 are realistically closer to observation in simulating the correlation of Central India rainfall variance with ISMR seasonal rainfall. In synoptic band.

- E5 is not so good in synoptic band but is in good agreement for intraseasonal oscillation for the above case.

- Power spectra of variables (OLR, u850) for different regions (Indian Ocean shown here) is simulated realistically in E4 for most of the cases. However E5 is also is in good agreement for some cases.

- Eastward propagation is shown in all the sensitivity experiments (E4, E5 and E6) but the phase difference between wind (u850 anomaly) and precipitation is better simulated in E4 and E5.

- Northward propagation is well simulated in E4 and E5.

- Wavenumber-frequency spectra is also well simulated in E4 and E5.

Hence, Tuning the 'autoconversion' can lead to better simulate the MJO.

Thanks