ROLE OF OCEAN IN THE EXTENDED RANGE PREDICTION OF MONSOON'S ACTIVE BREAK CYCLE- IMPROVING HINDCAST SKILL OF THE NCEP- CFS MODELLING SYSTEM

February 2015

Role of Ocean in the Extended Range Prediction of Monsoon's Active Break Cycle – Improving hind cast skill of the NCEP-CFS modeling system

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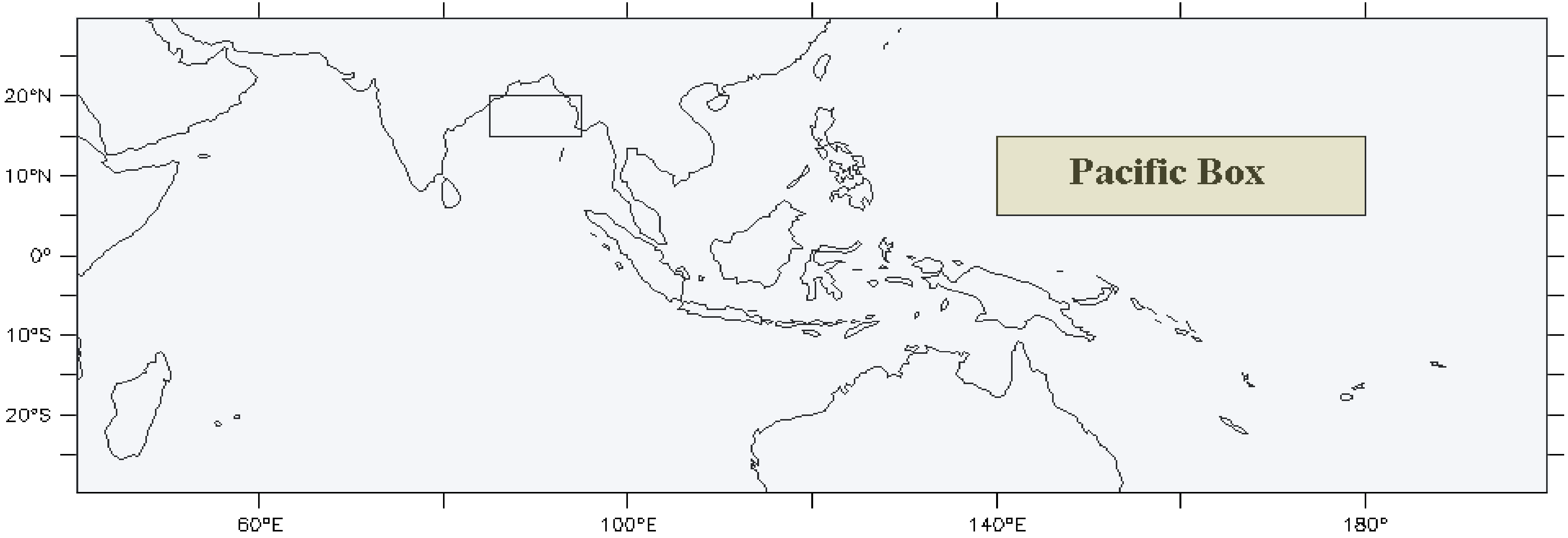
" Our aim is to study the output of the NCEP-CFS coupled model runs done by IITM to see whether the ocean variability in monsoon season is realistically reproduced in the model particularly the Mixed Layer Depth (MLD) and SST variations on the time scale of the Active-Break cycle in normal, La Nina and El-Nino years. We also aim to study the air-sea fluxes of heat in relation to the Active-Break cycle. "

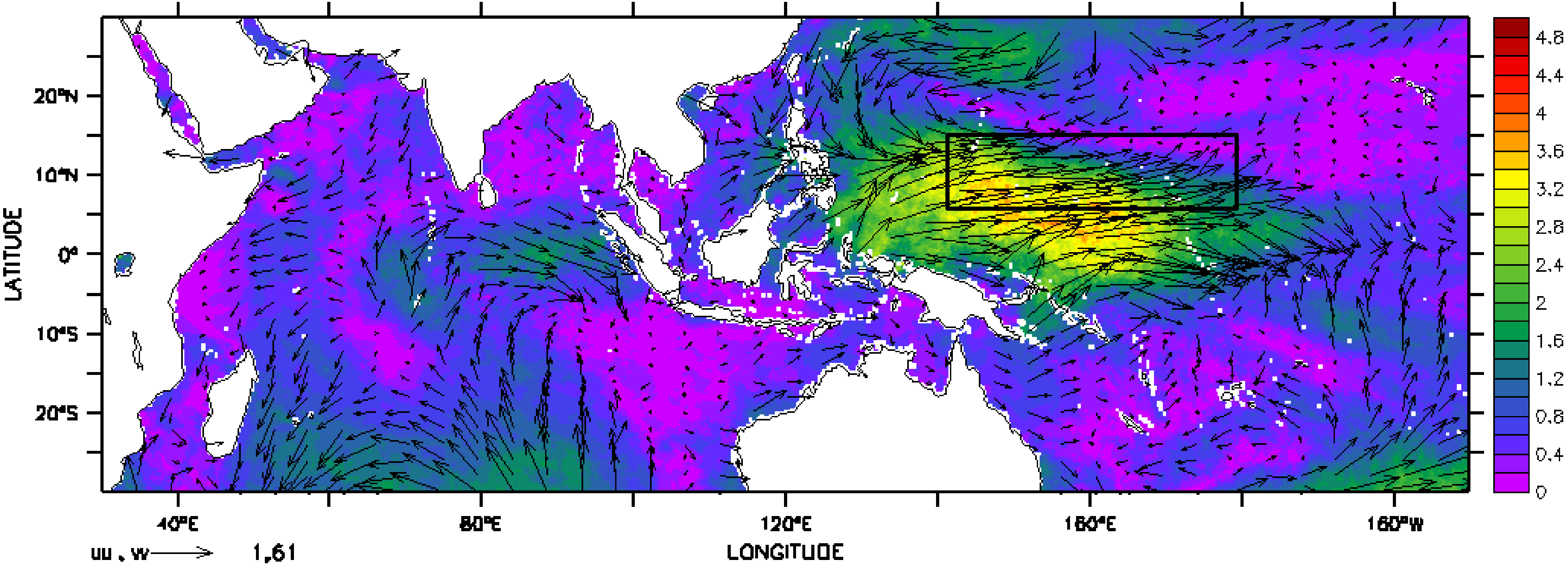
Study Area



QUIKSCAT

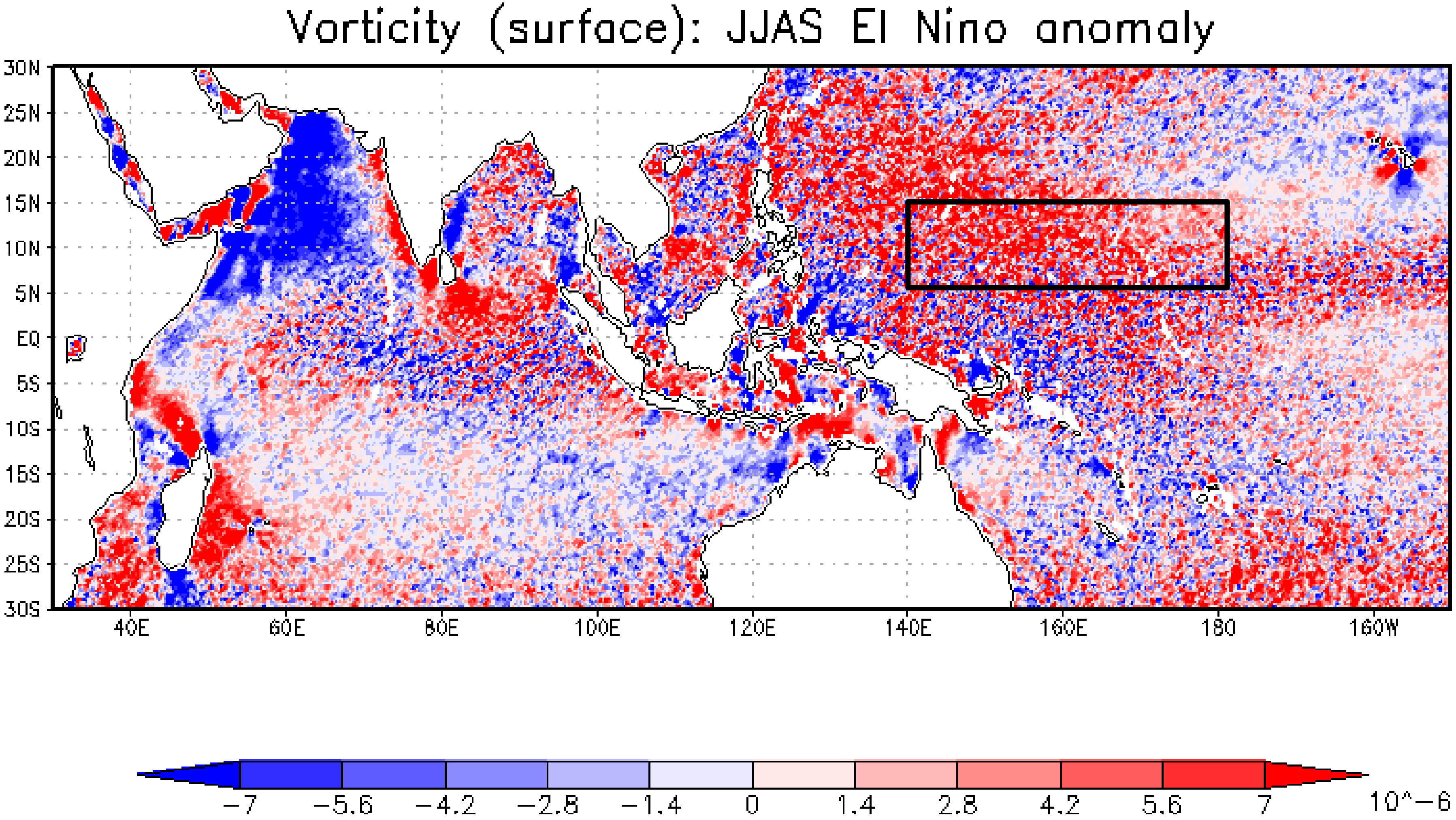
Surface wind

El Nino (2002,04,09) minus Non El Nino (2000,01,03,05,06,07,08)

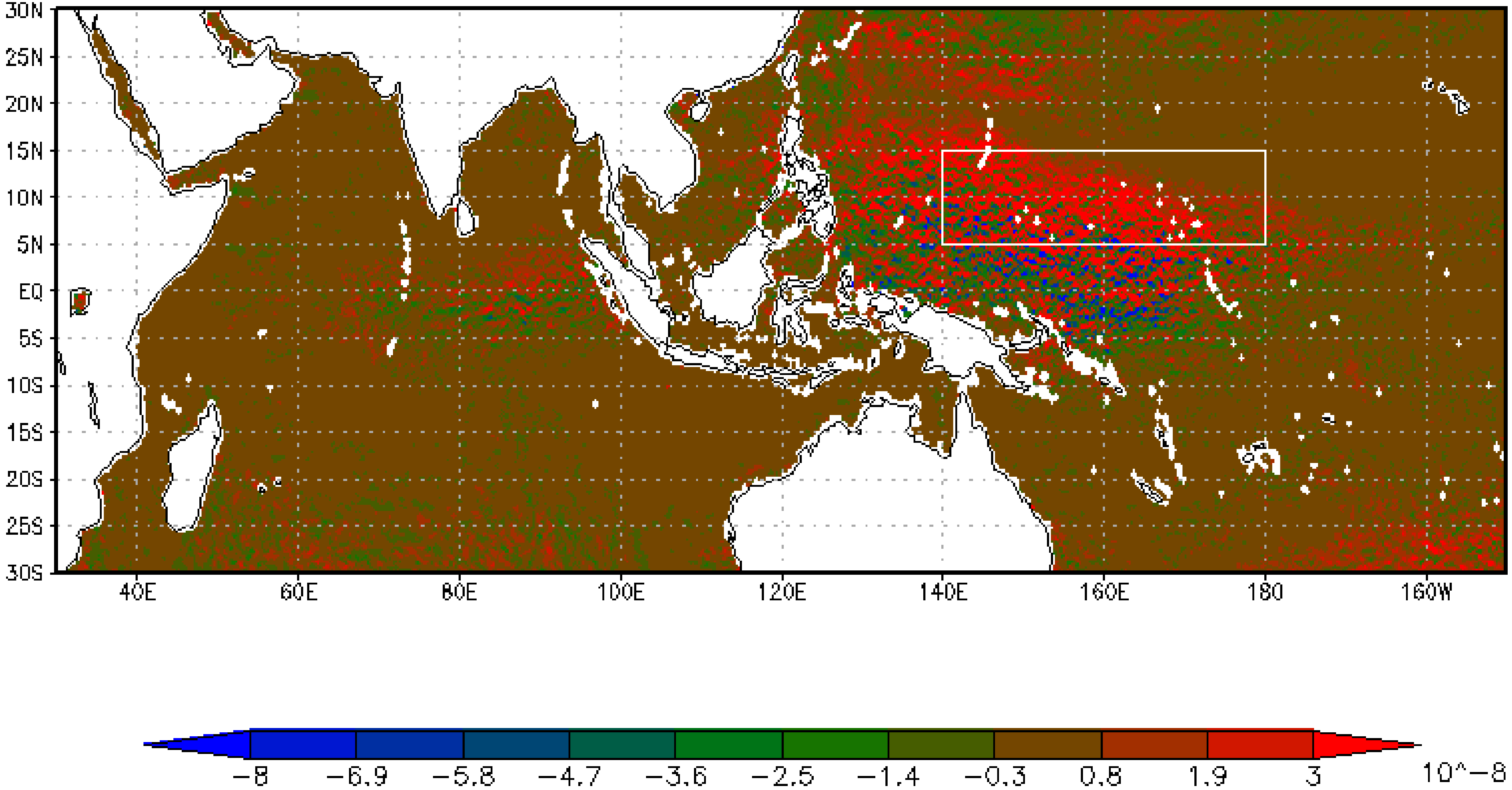


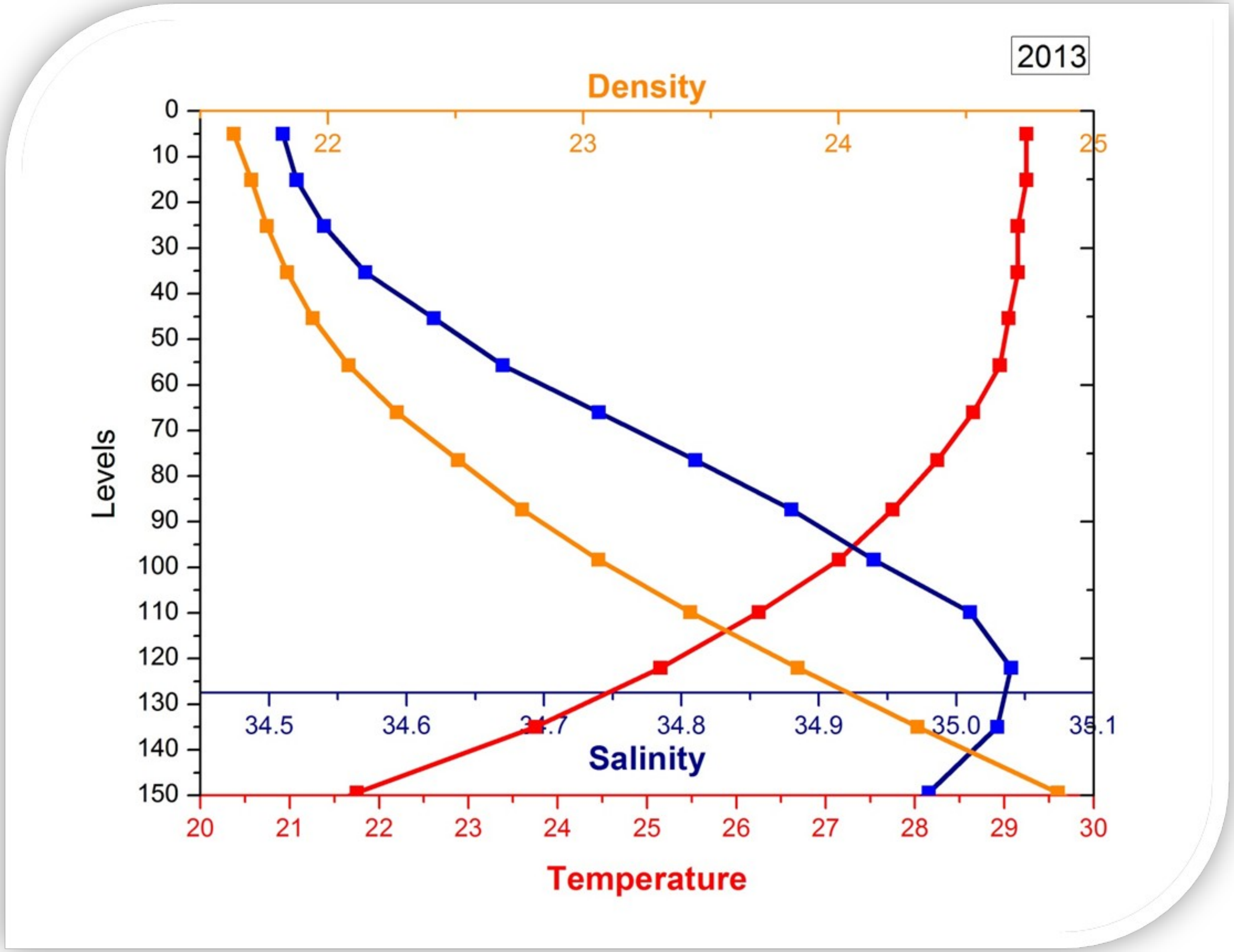
(UU^2+VV^2)^.5

QUIKSCAT
El NINO VORTICITY ANOMALY



Wind Stress Curl : JJAS El Nino anomaly

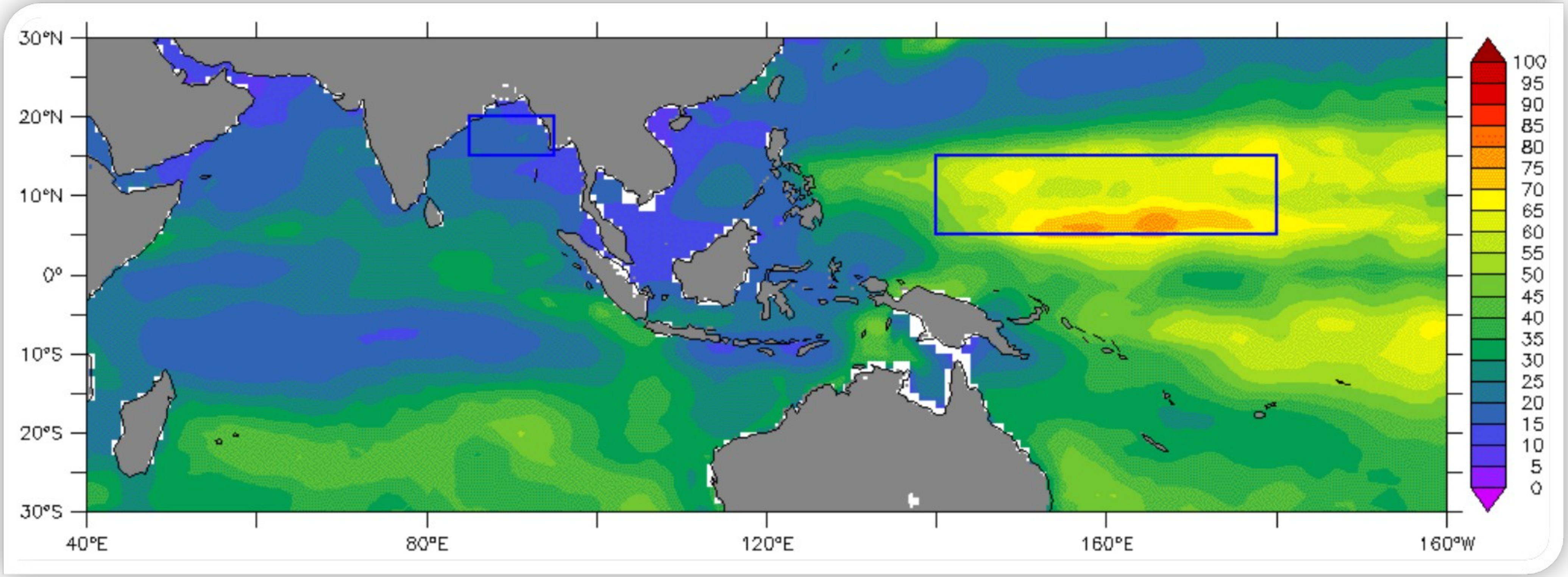




Vertical profiles of temperature, salinity and density in the west Pacific Box (140º to 180º & 5º to 15º) during the monsoon season of 2013 (Hadley center Reanalysis data with inputs from ARGO)

MAM climatology of MLD (Pre monsoon)

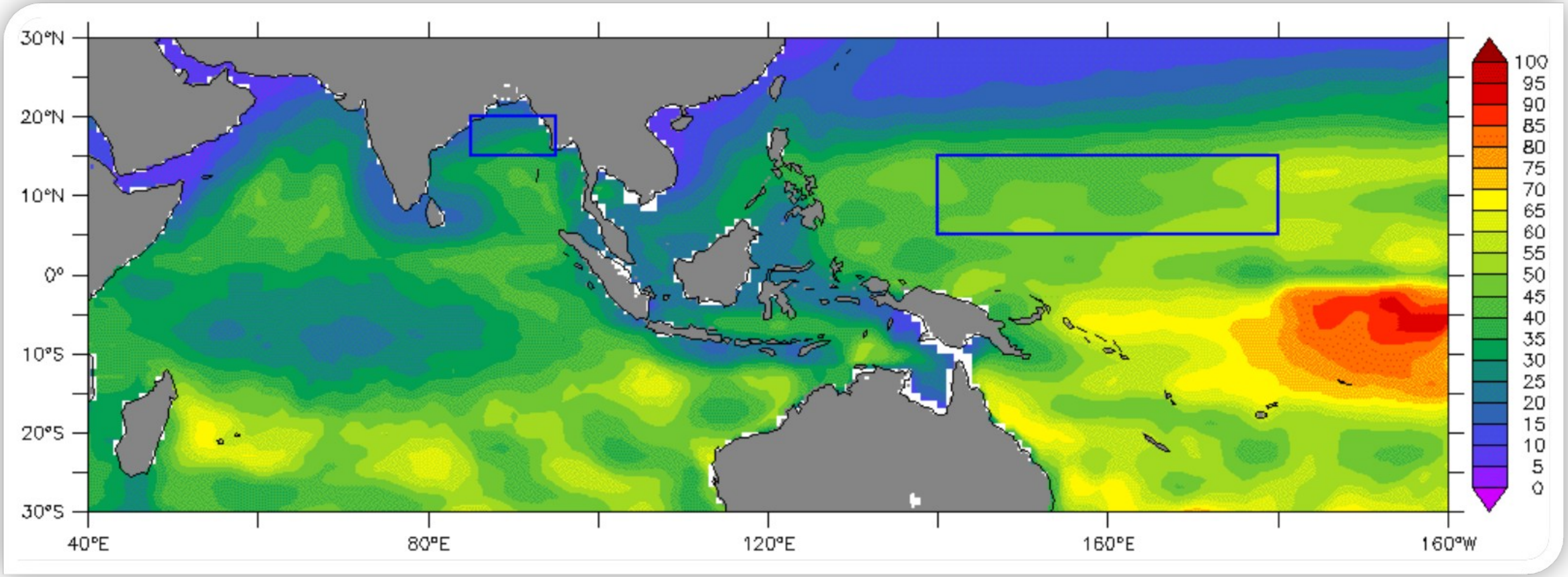
1998 TO 2013



(Hadley Center Reanalysis data with inputs from ARGO)

JJAS climatology of MLD (monsoon)

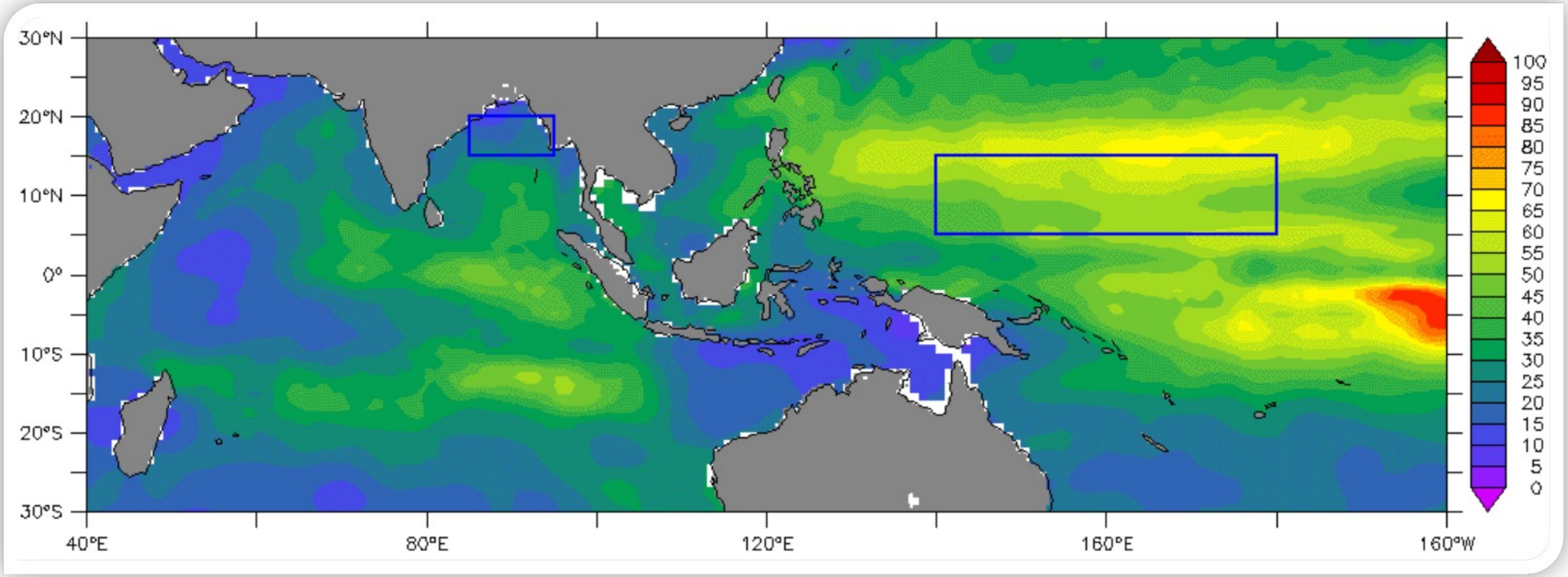
1998 TO 2013



(Hadley Center Reanalysis data with inputs from ARGO)

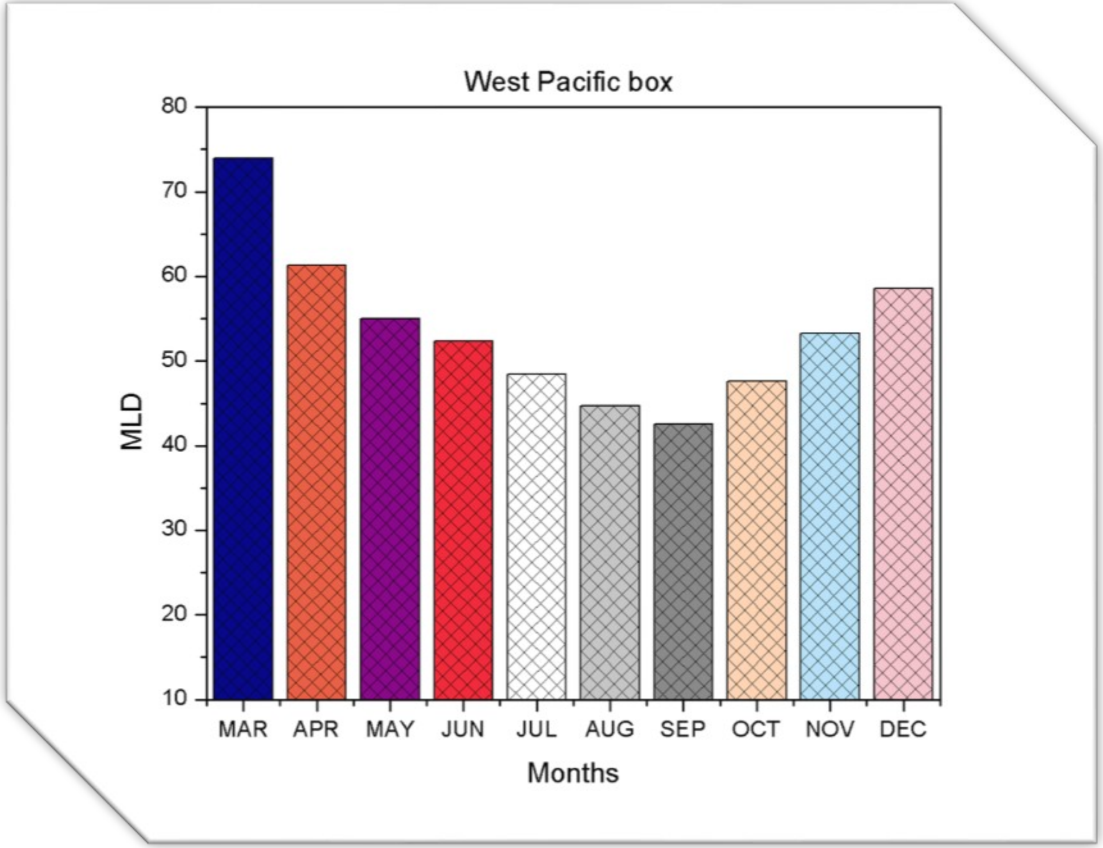
OND climatology (Post monsoon)

1998 TO 2013

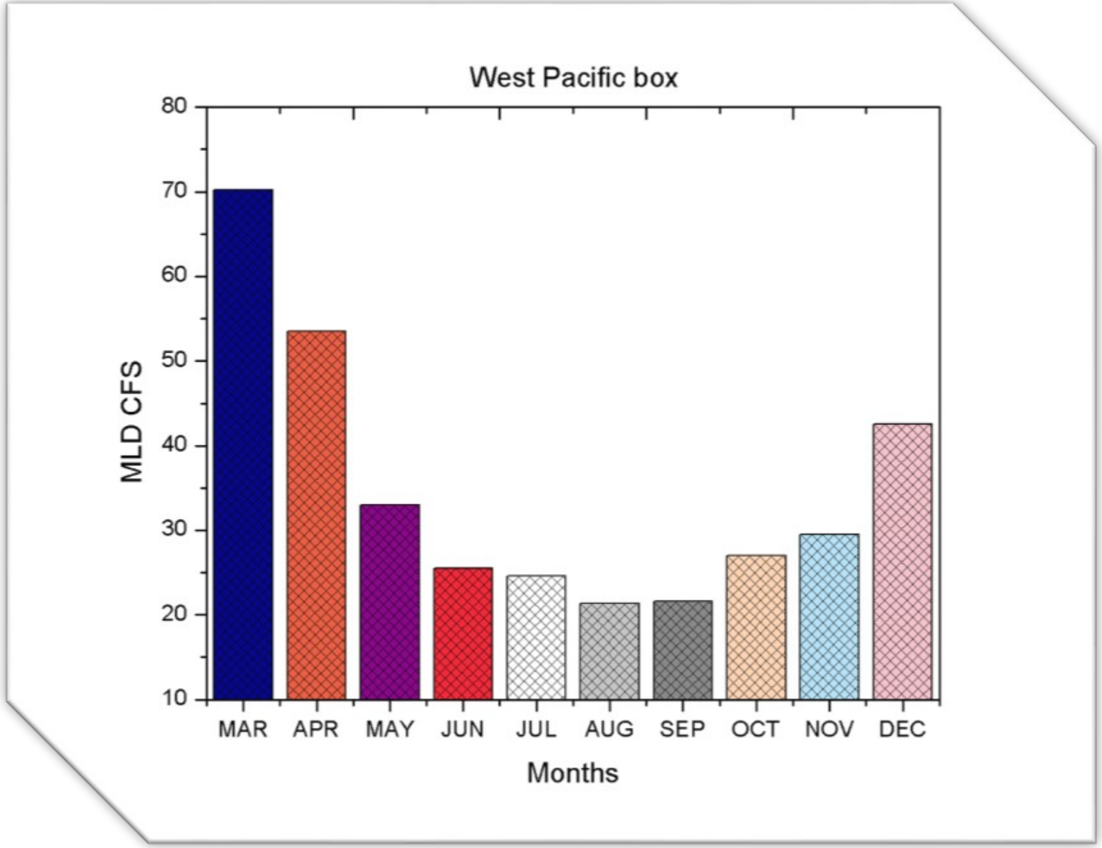


(Hadley Center Reanalysis data with inputs from ARGO)

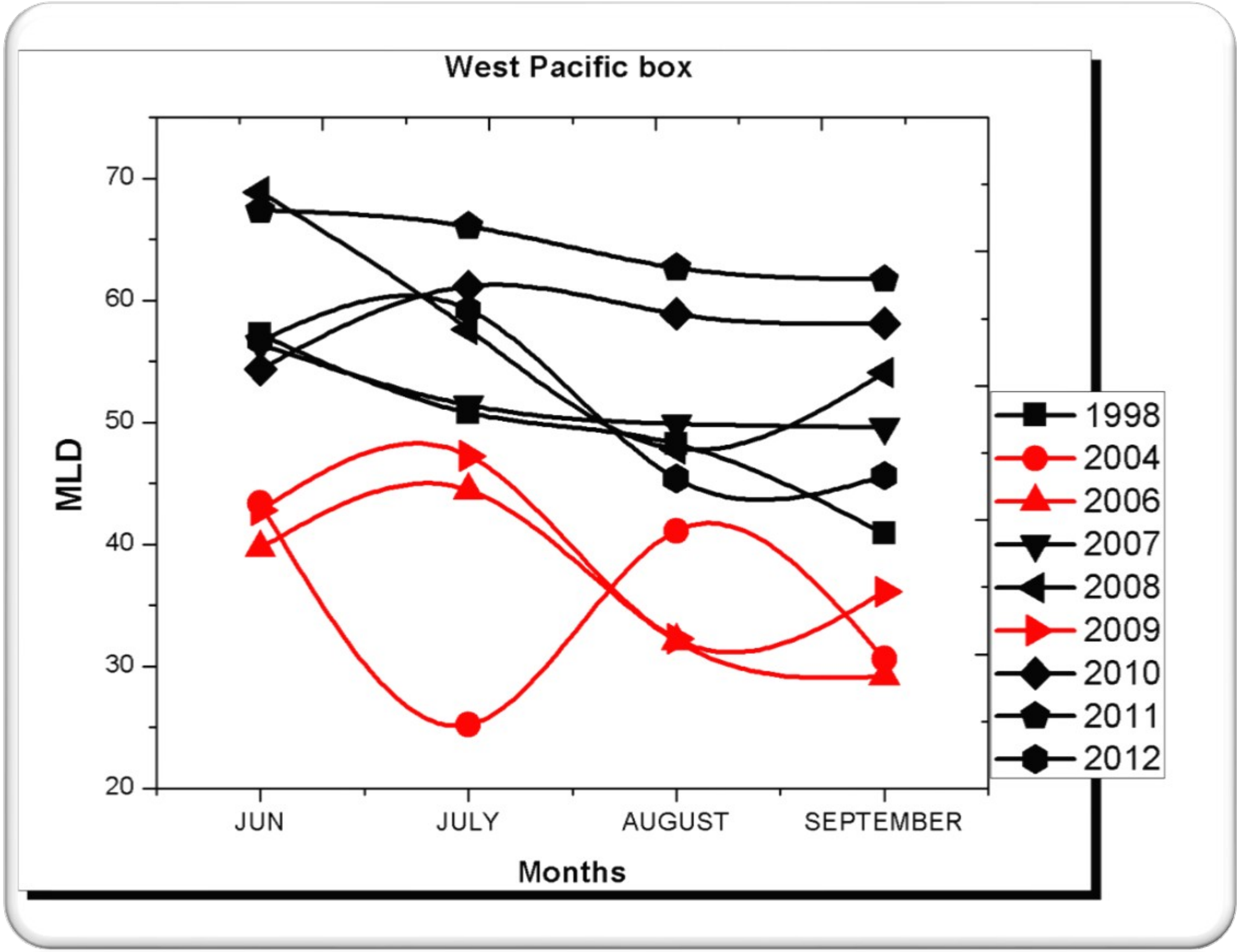
Climatology of MLD (Met Office Hadley Center Data)

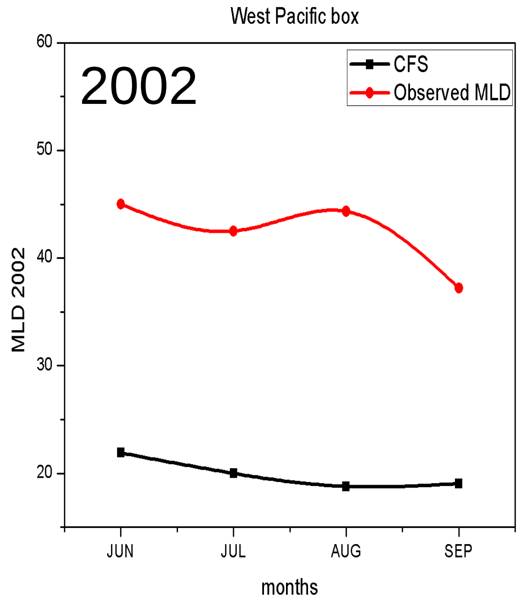


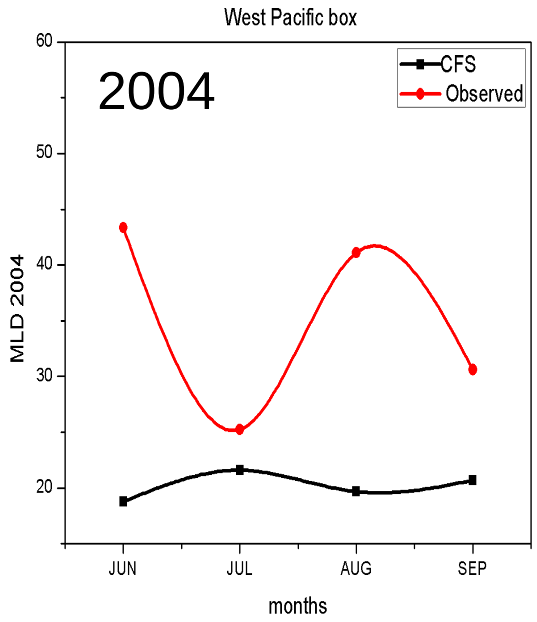
1998, 2002, 2003, 2004, 2007 Composite (CFS)

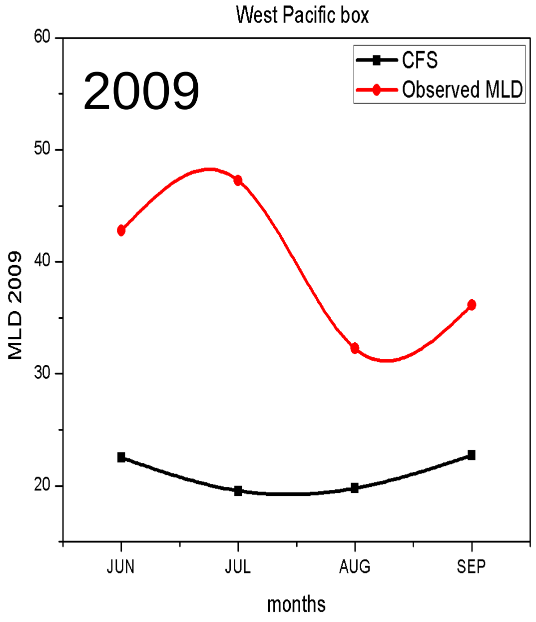


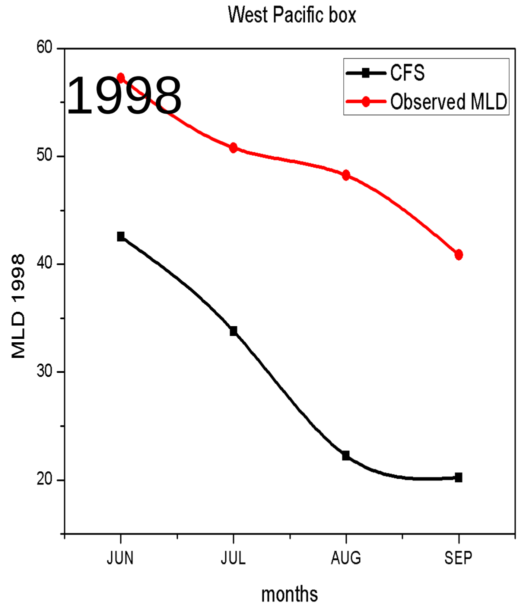
MLD from Hadley Reanalysis of El Nino (red) and Non El Nino (black) years

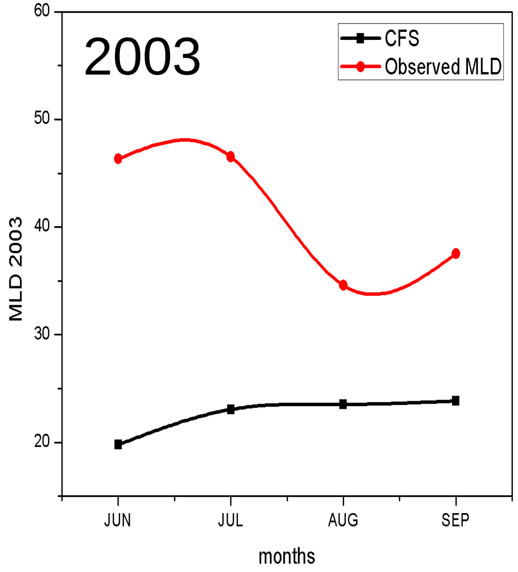


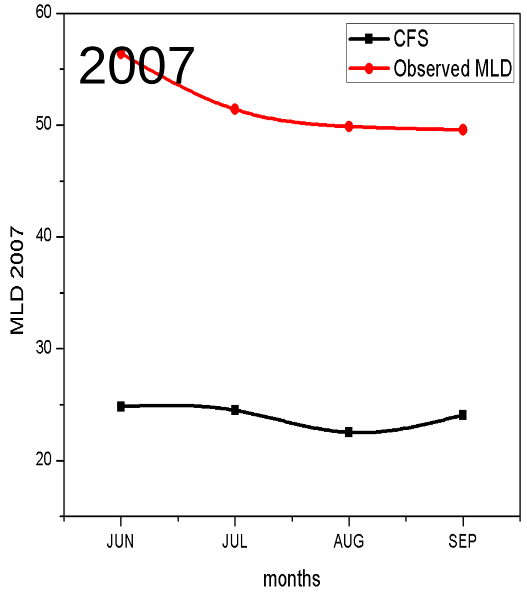

West Pacific box
2002
CFS
Observed MLD
MLD 2002
20
30
40
50
60
JUN
JUL
AUG
SEP
months

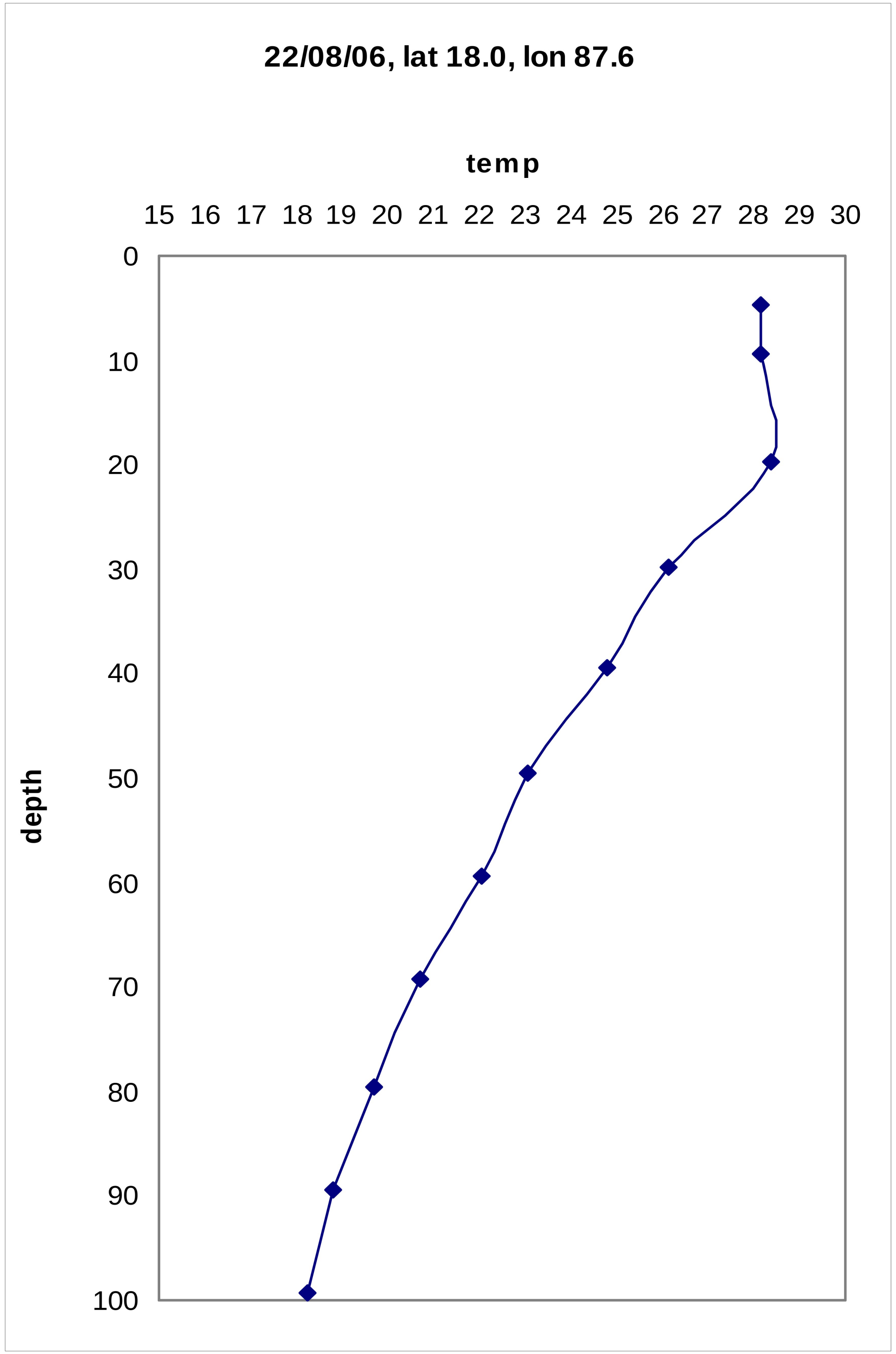

West Pacific box
2004
CFS
Observed
MLD 2004
20
30
40
50
60
JUN
JUL
AUG
SEP
months


West Pacific box
2009
CFS
Observed MLD
MLD 2009
20
30
40
50
60
JUN
JUL
AUG
SEP
months

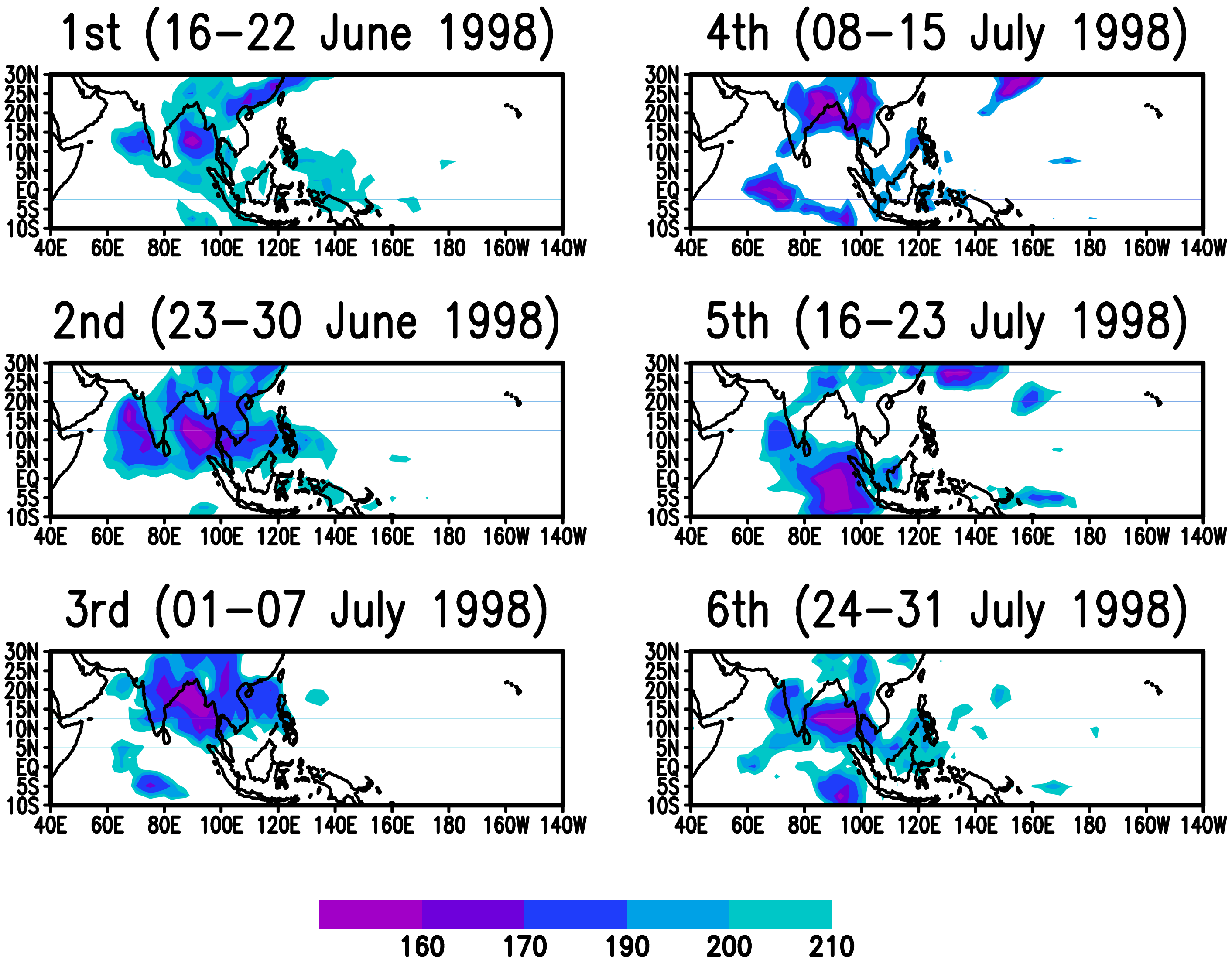

West Pacific box
1998
CFS
Observed MLD
MLD 1998
20
30
40
50
60
JUN
JUL
AUG
SEP
months

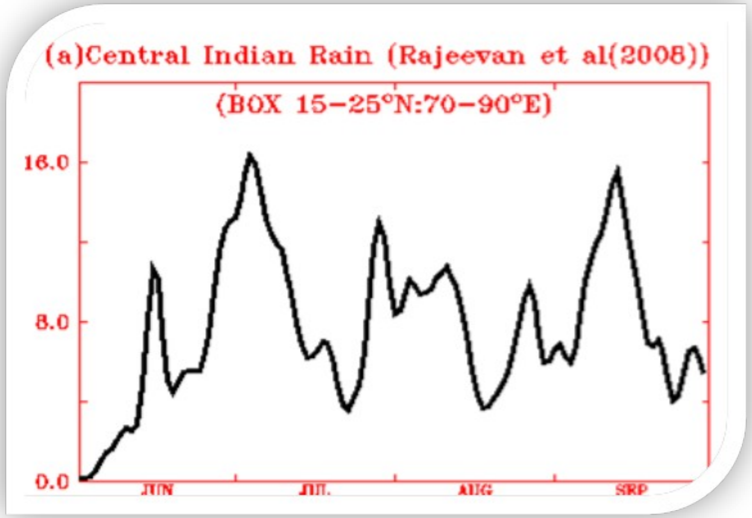

2003
CFS
Observed MLD
MLD 2003
20
30
40
50
60
JUN
JUL
AUG
SEP
months

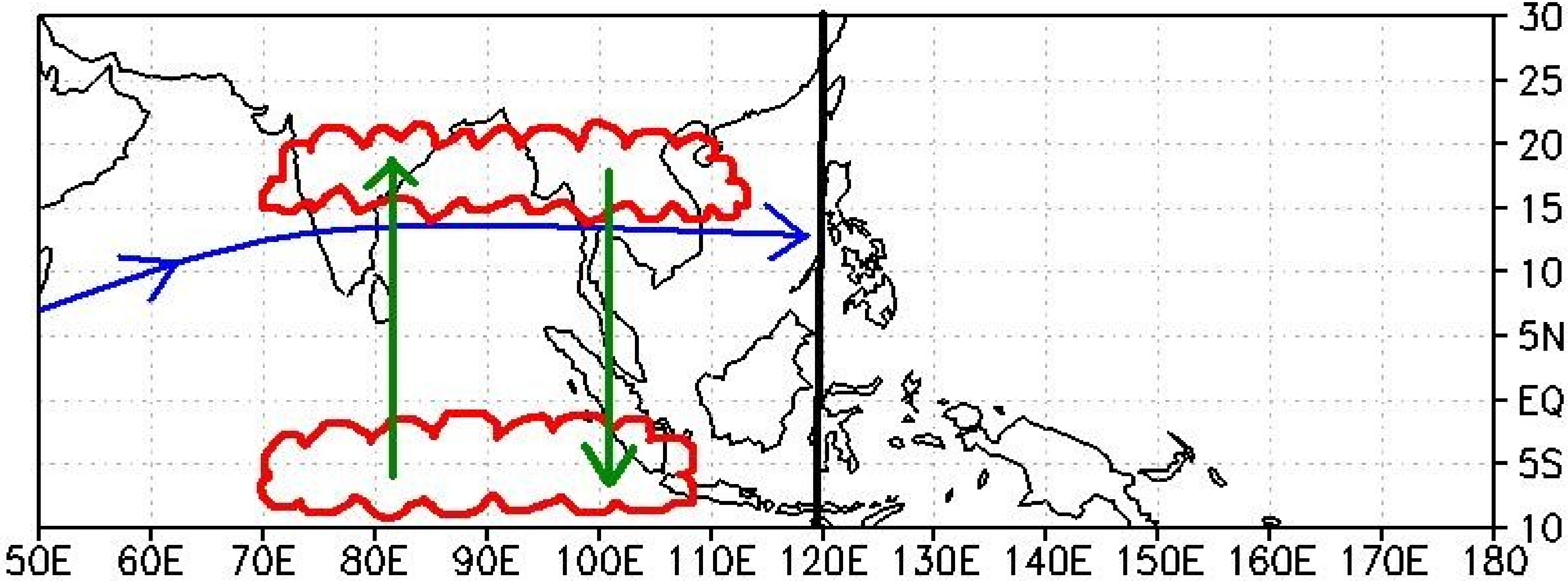

2007
CFS
Observed MLD
MLD 2007
20
30
40
50
60
JUN
JUL
AUG
SEP
months



A typical vertical profile of ocean temperature (ARGO) in North Bay of Bengal during the monsoon season. The mixed layer thickness of 20 metres is typical.


1st (16–22 June 1998)
4th (08–15 July 1998)
2nd (23–30 June 1998)
5th (16–23 July 1998)
3rd (01–07 July 1998)
6th (24–31 July 1998)
30N 25N 20N 15N 10N 5N EQ 5S 10S
40E 60E 80E 100E 120E 140E 160E 180 160W 140W
160 170 190 200 210

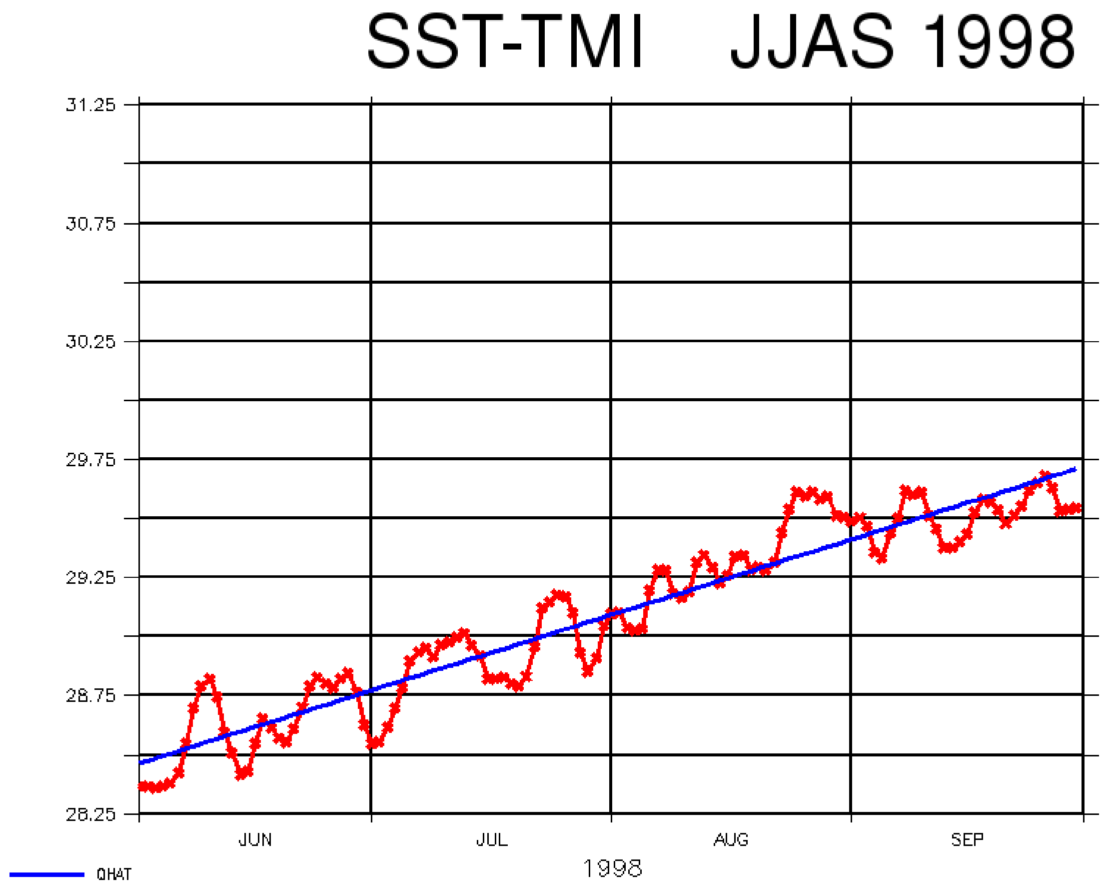

(a)Central Indian Rain (Rajeevan et al(2008))
(BOX 15–25°N:70–90°E)
16.0
8.0
0.0
JUN
JUL
AUG
SEP

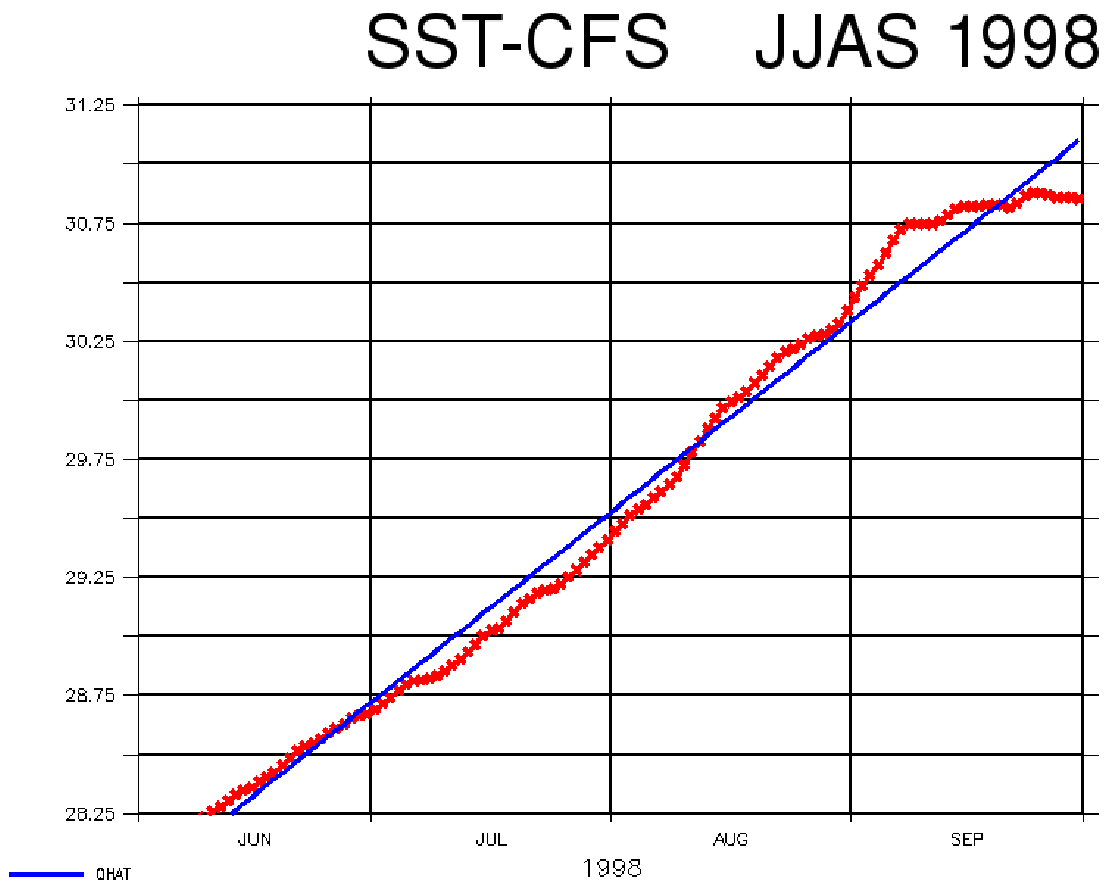


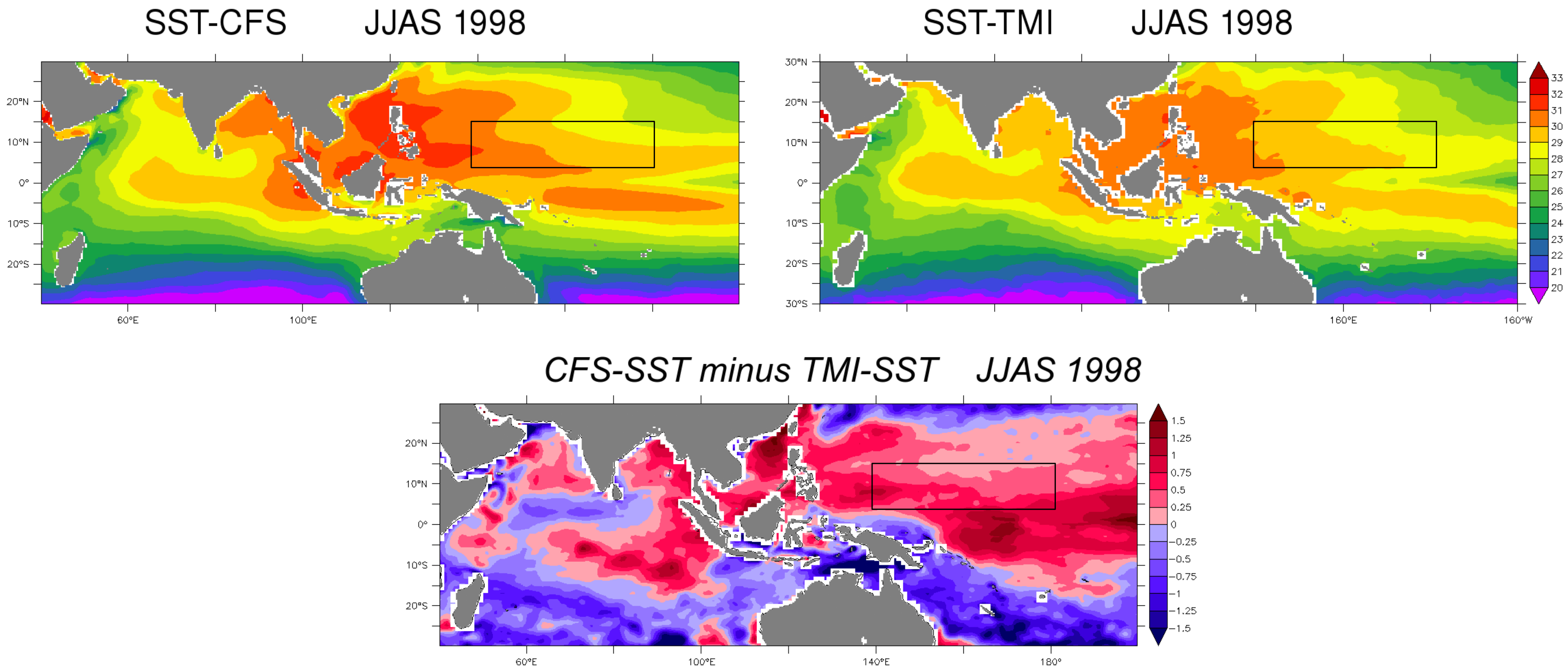
In La Nina, the LLJ is over Asian continent only and the convection is confined to west of 120E fluctuating between equator and 20 N. In the absence of convection Pacific box SST increases steadly. In CFS, since MLD is only 20m the rate of increase of SST (mixed layer temperature) is much larger than climatology

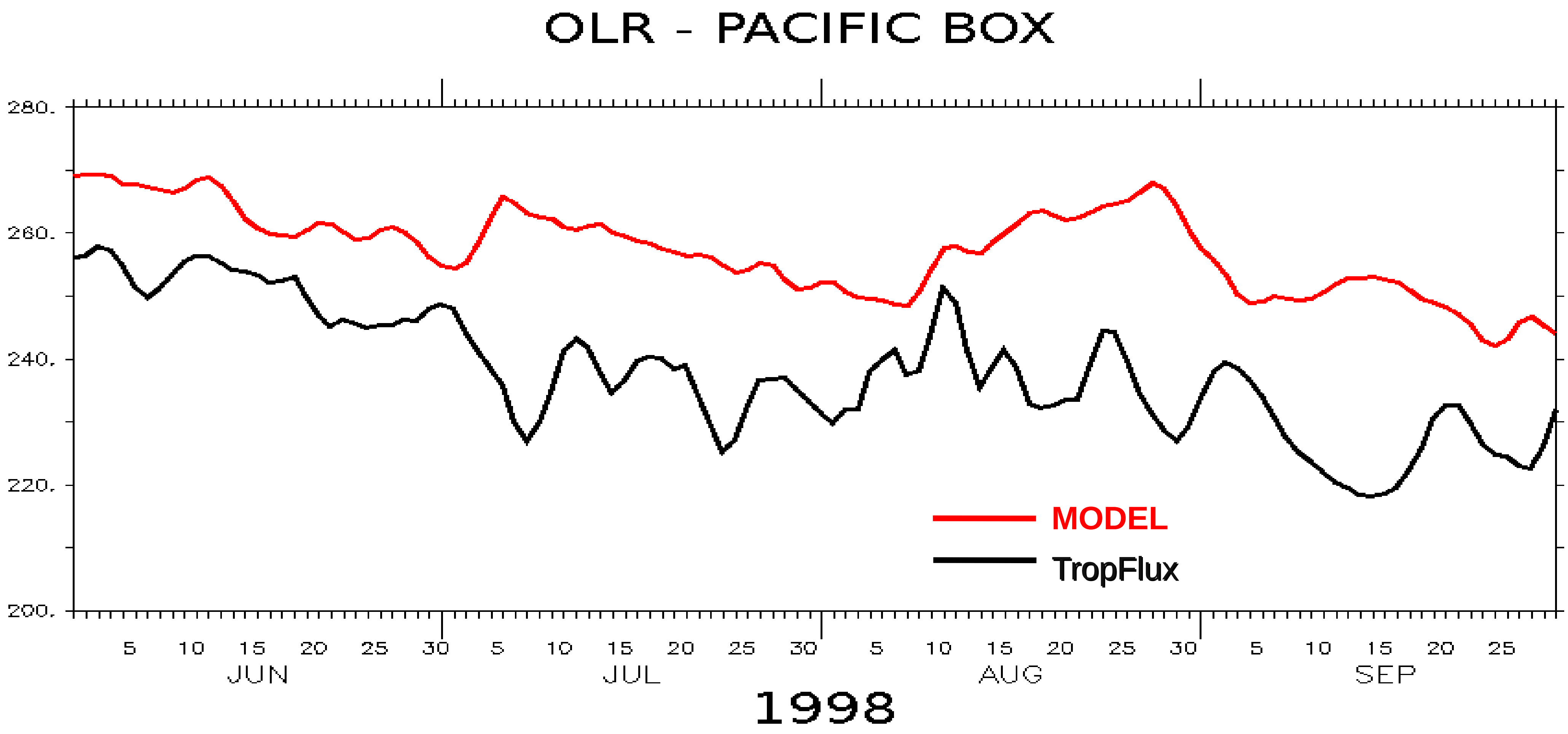
West Pacific Box

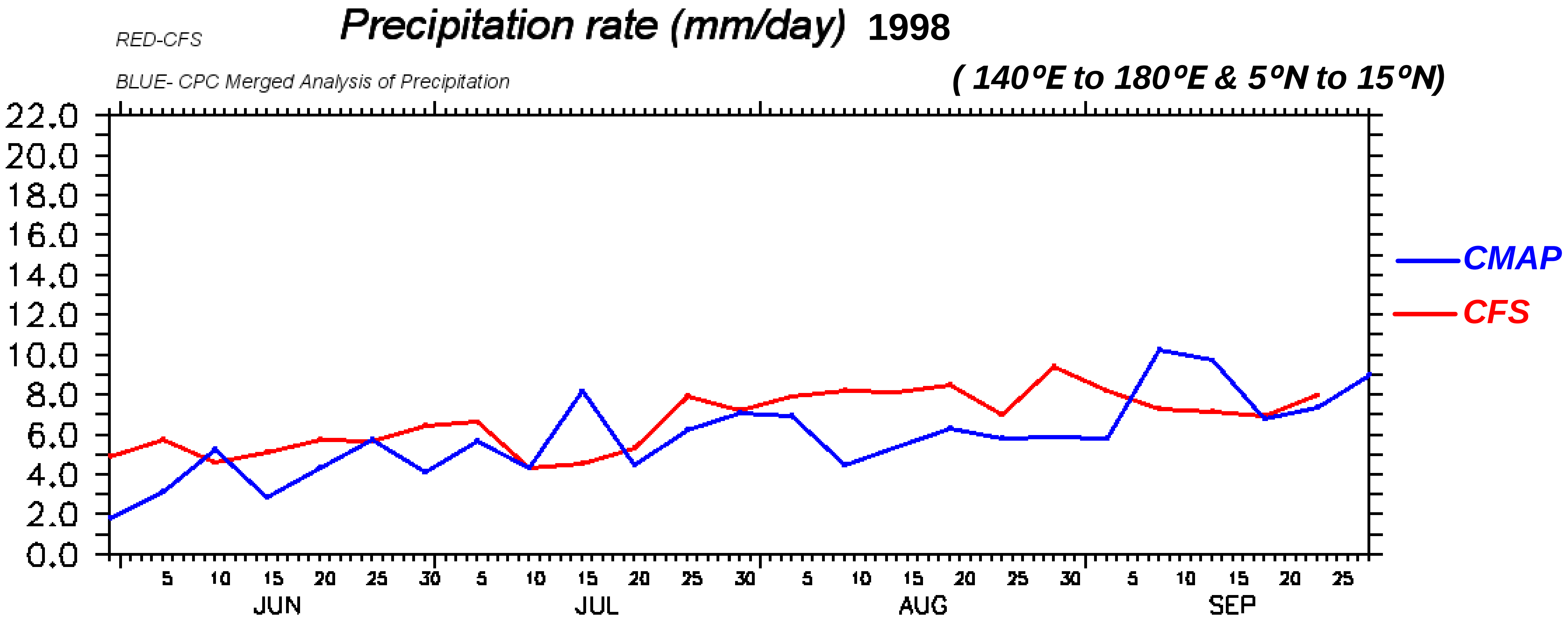
(140ºE to 180ºE & 5º to 15º)



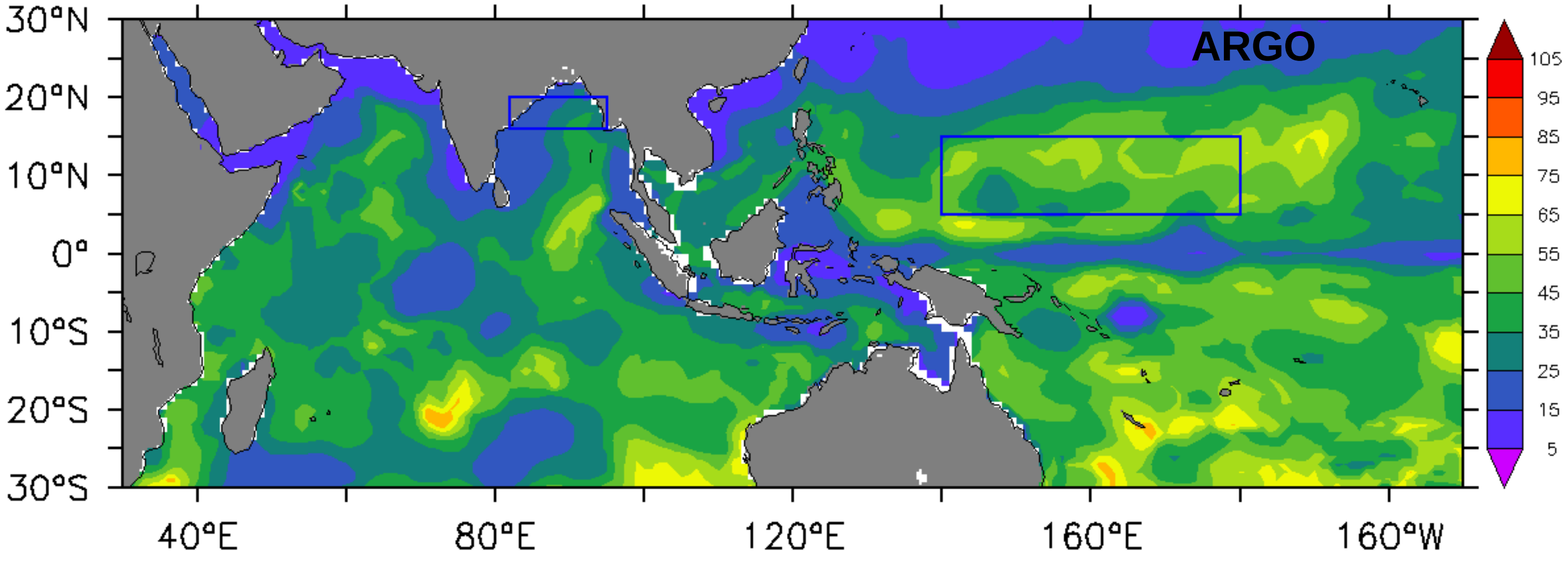


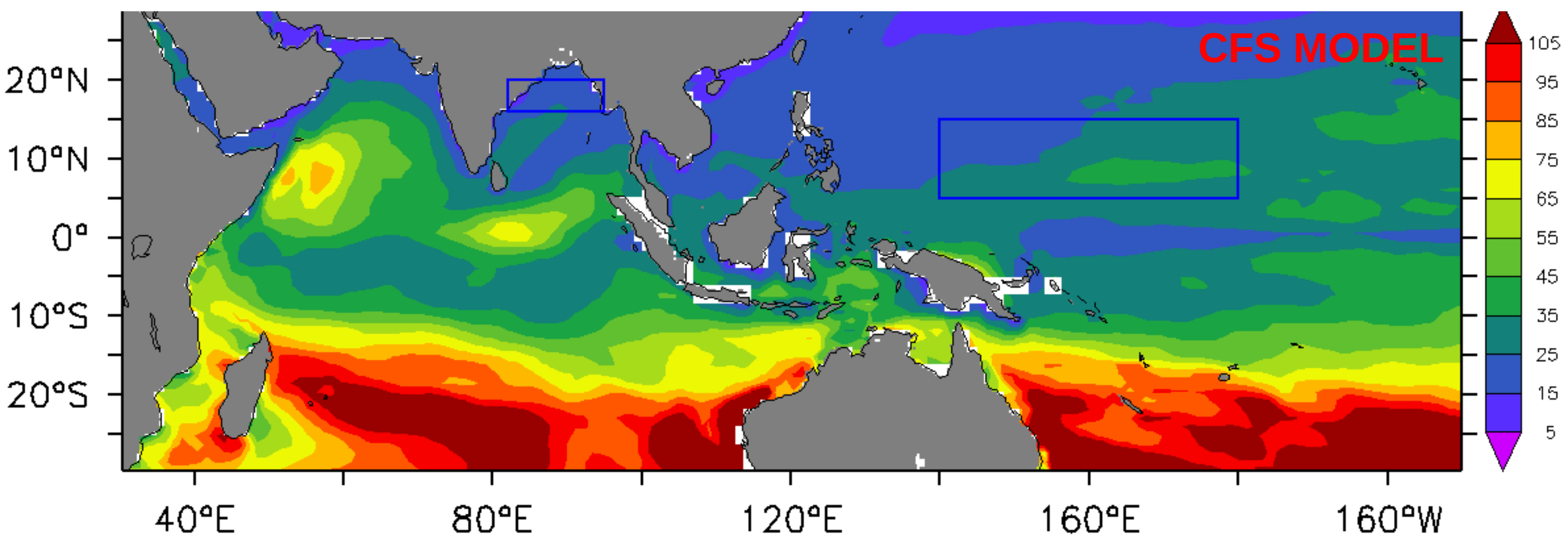

SST-CFS JJAS 1998
SST-TMI JJAS 1998
CFS-SST minus TMI-SST JJAS 1998
30°N
20°N
10°N
0°
10°S
20°S
30°S
60°E
100°E
140°E
160°E
180°
160°W
33
32
31
30
29
28
27
26
25
24
23
22
21
20
1.5
1.25
1
0.75
0.5
0.25
0
−0.25
−0.5
−0.75
−1
−1.25
−1.5

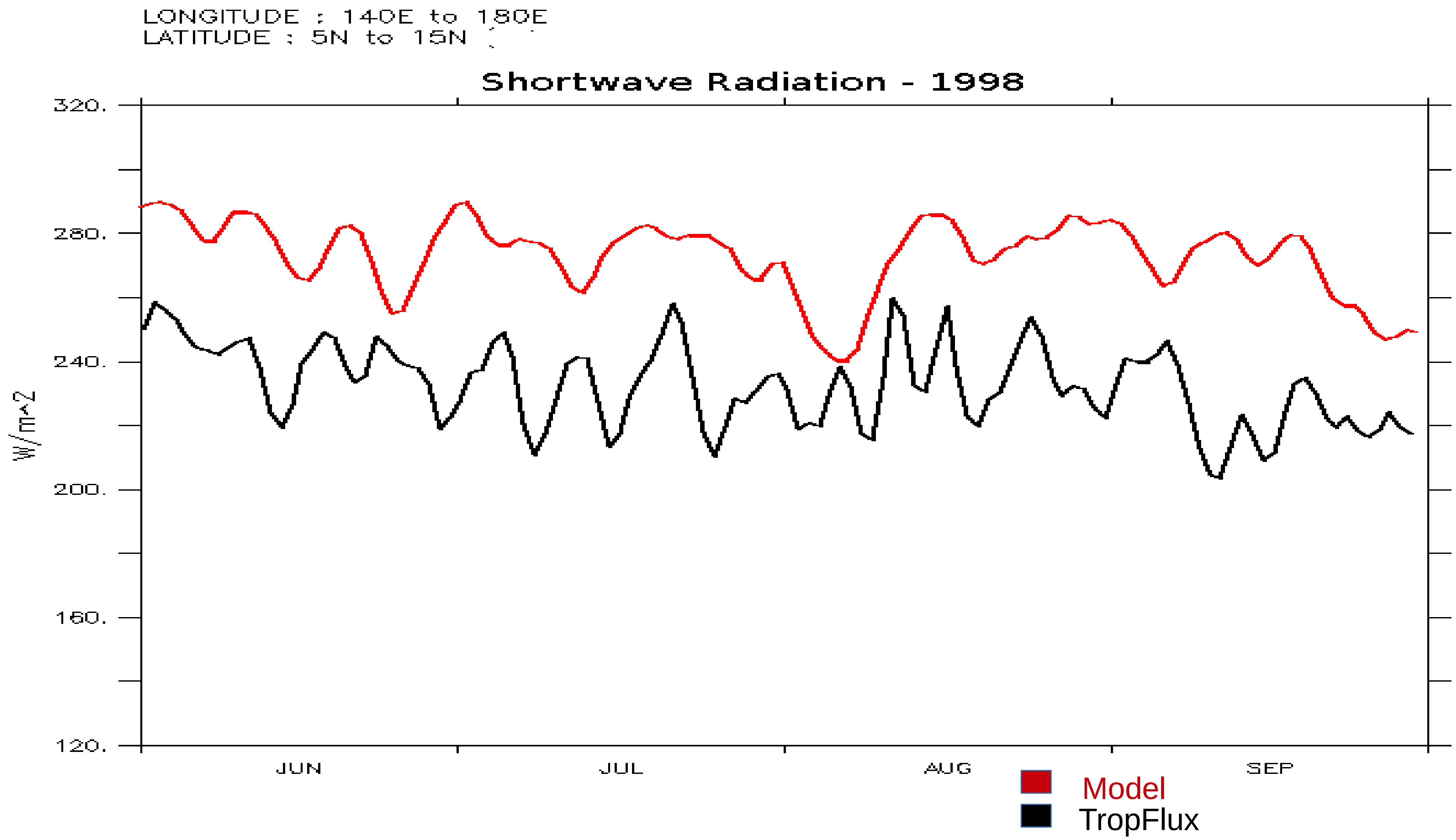

OLR - PACIFIC BOX
280.
260.
240.
220.
200.
MODEL
TropFlux
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25
JUN
JUL
AUG
SEP
1998


Precipitation rate (mm/day) 1998
RED-CFS
BLUE- CPC Merged Analysis of Precipitation
(140ºE to 180ºE & 5ºN to 15ºN)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25
JUN
JUL
AUG
SEP
CMAP
CFS

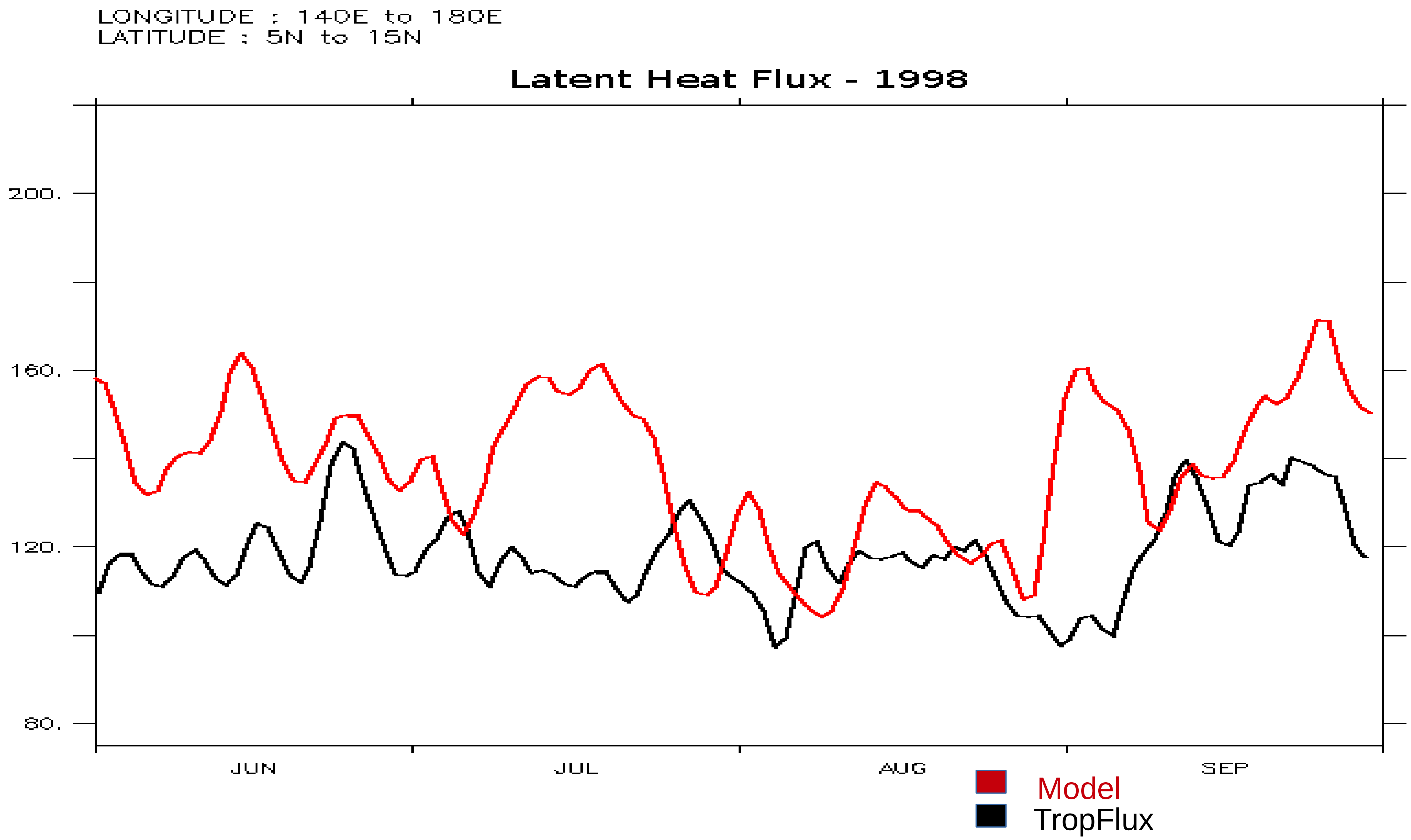
Mixed Layer Depth (01-Jun to 30 Sep 1998)

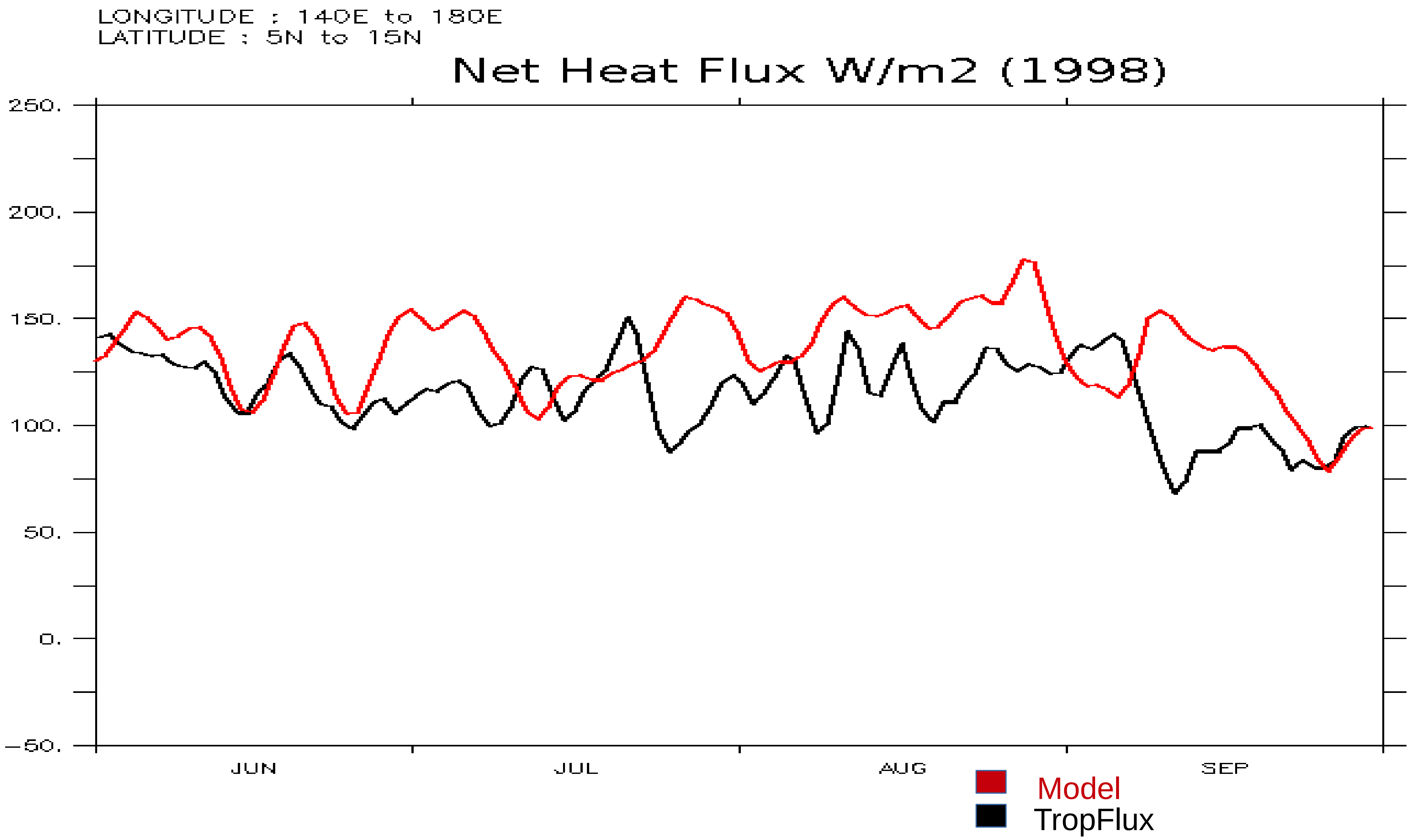






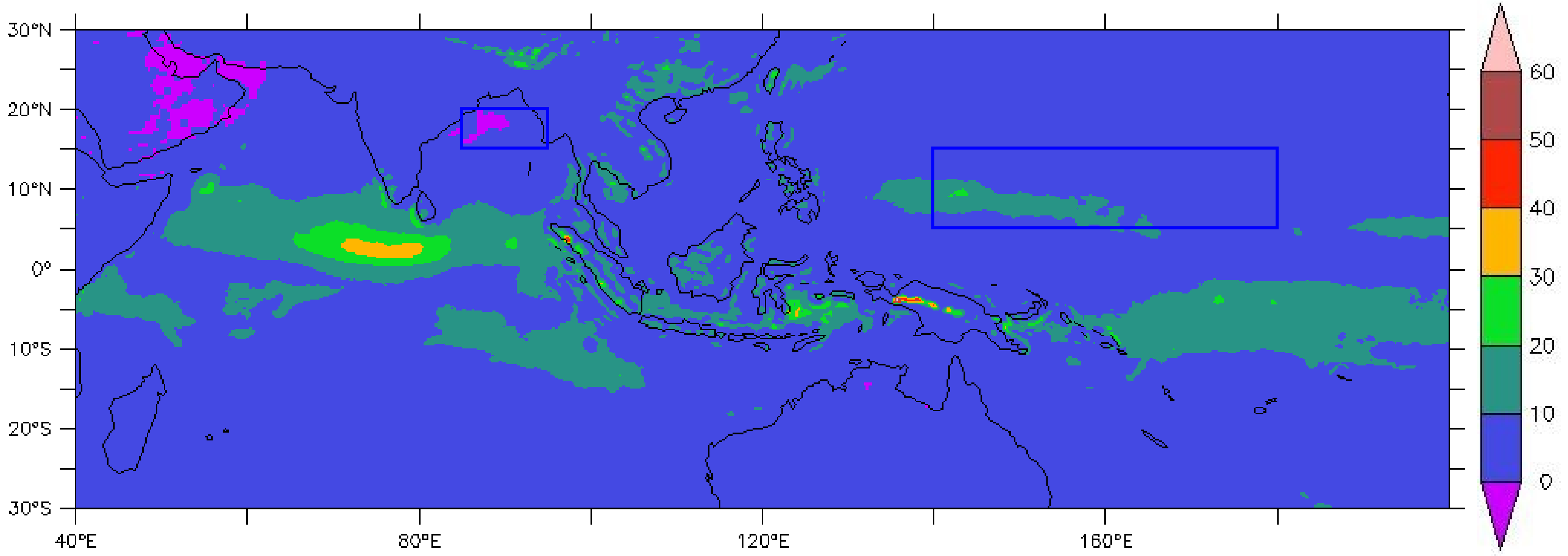
LONGITUDE : 140E to 180E
LATITUDE : 5N to 15N
Shortwave Radiation - 1998
320.
280.
240.
200.
160.
120.
W/m^2
JUN
JUL
AUG
SEP
Model
TropFlux


LONGITUDE : 140E to 180E
LATITUDE : 5N to 15N
Latent Heat Flux - 1998
200.
160.
120.
80.
JUN
JUL
AUG
SEP
Model
TropFlux



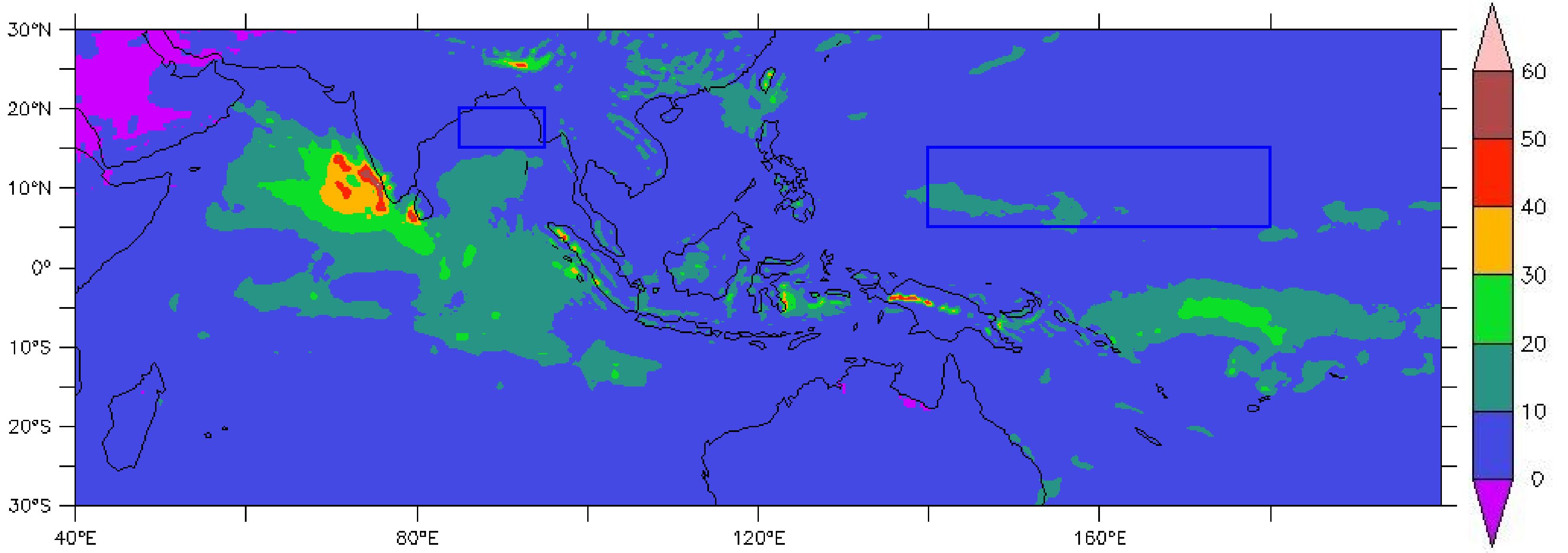
LONGITUDE : 140E to 180E
LATITUDE : 5N to 15N
Net Heat Flux W/m2 (1998)
250.
200.
150.
100.
50.
0.
−50.
JUN
JUL
AUG
SEP
Model
TropFlux

1st-10th average of June 1998



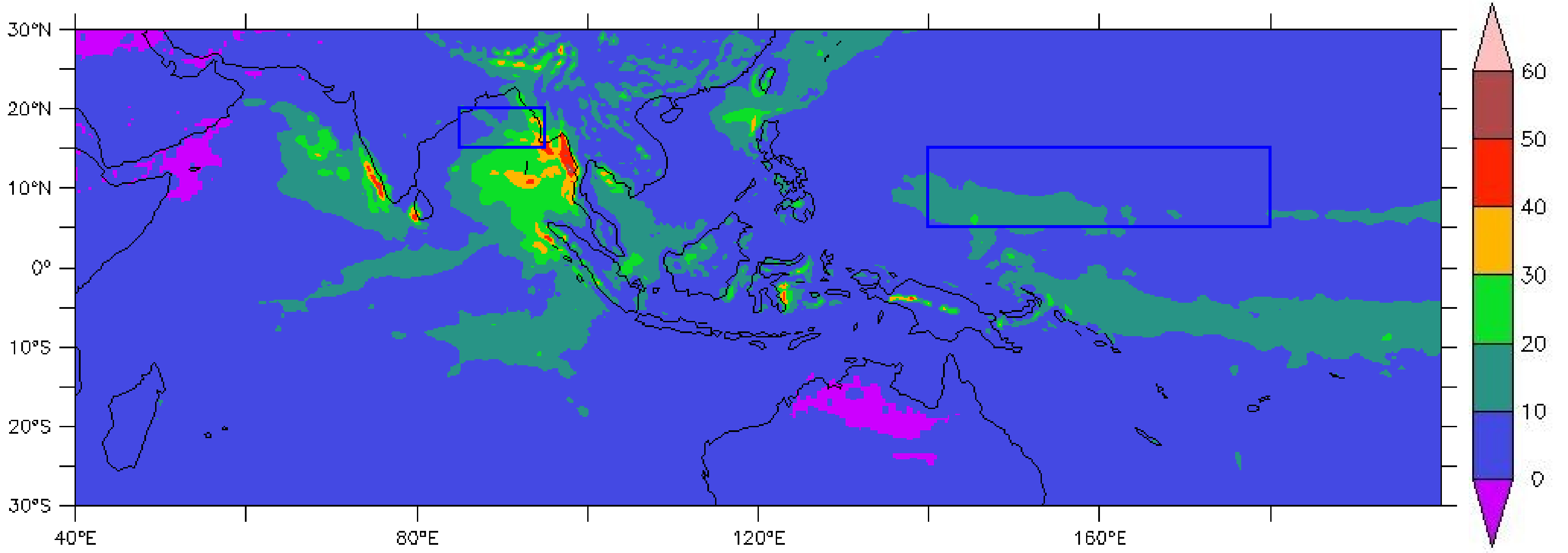
mm/day

11th-20th average of June 1998



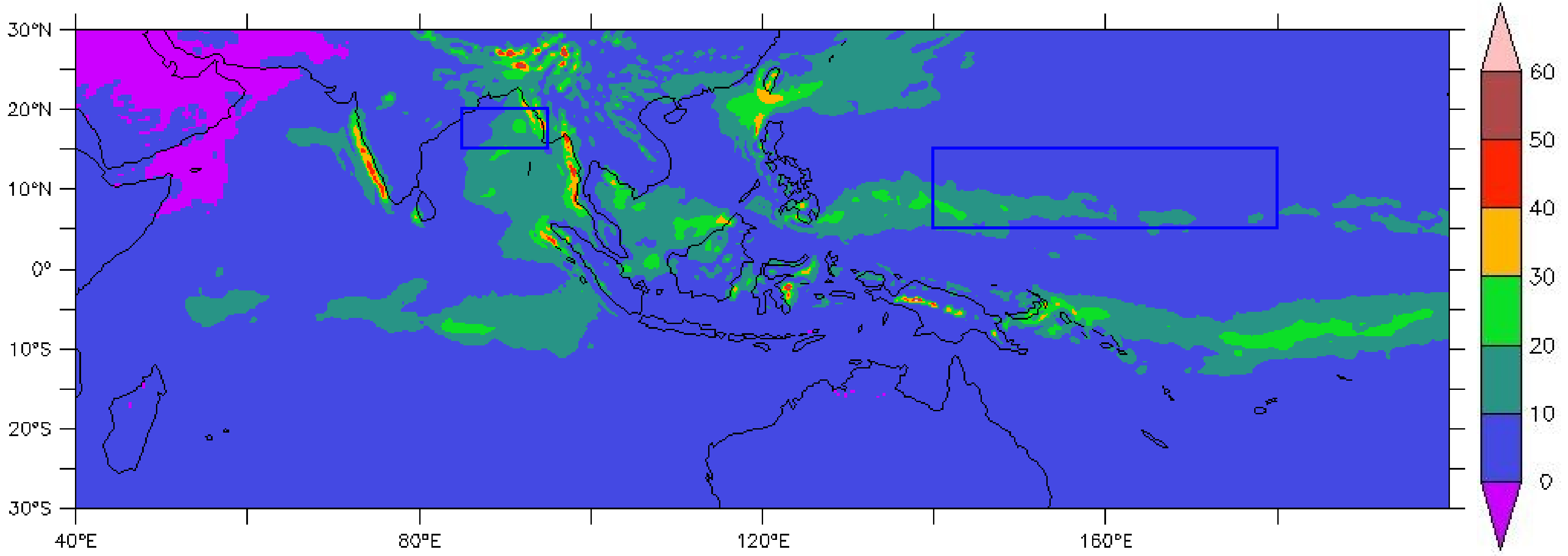
mm/day

21st-30th average of June 1998



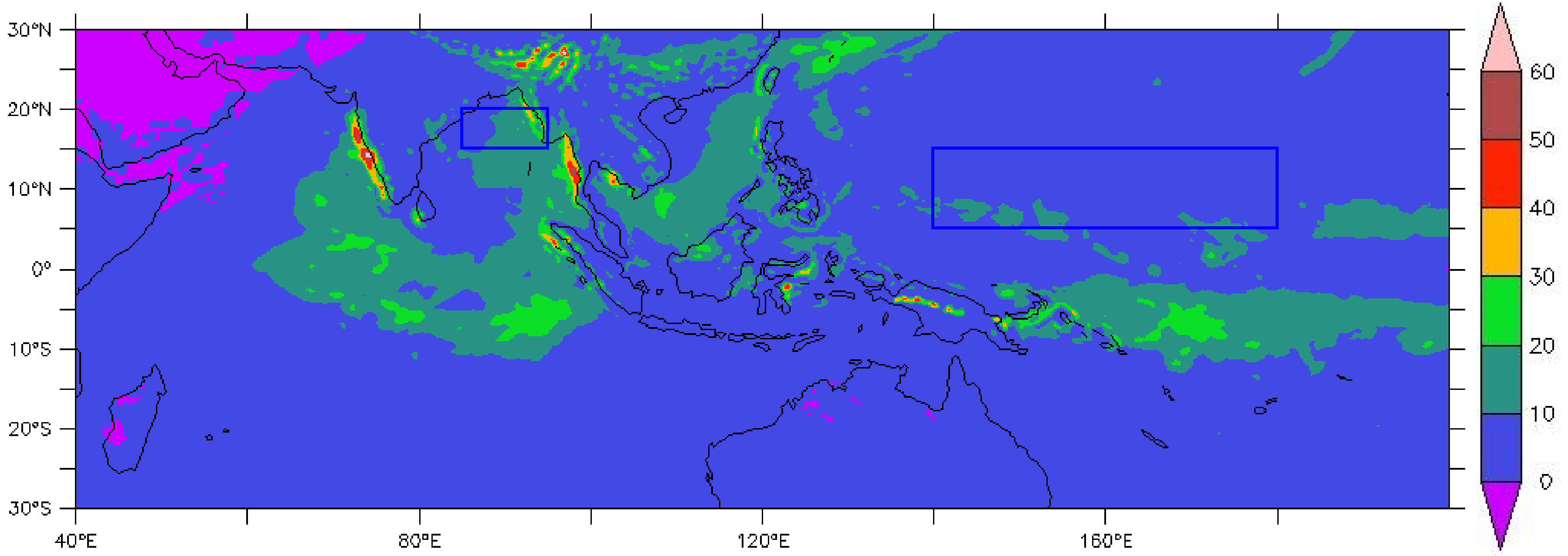
mm/day

1st-10th average of July 1998



mm/day

11^{th}-20^{th} average of July 1998

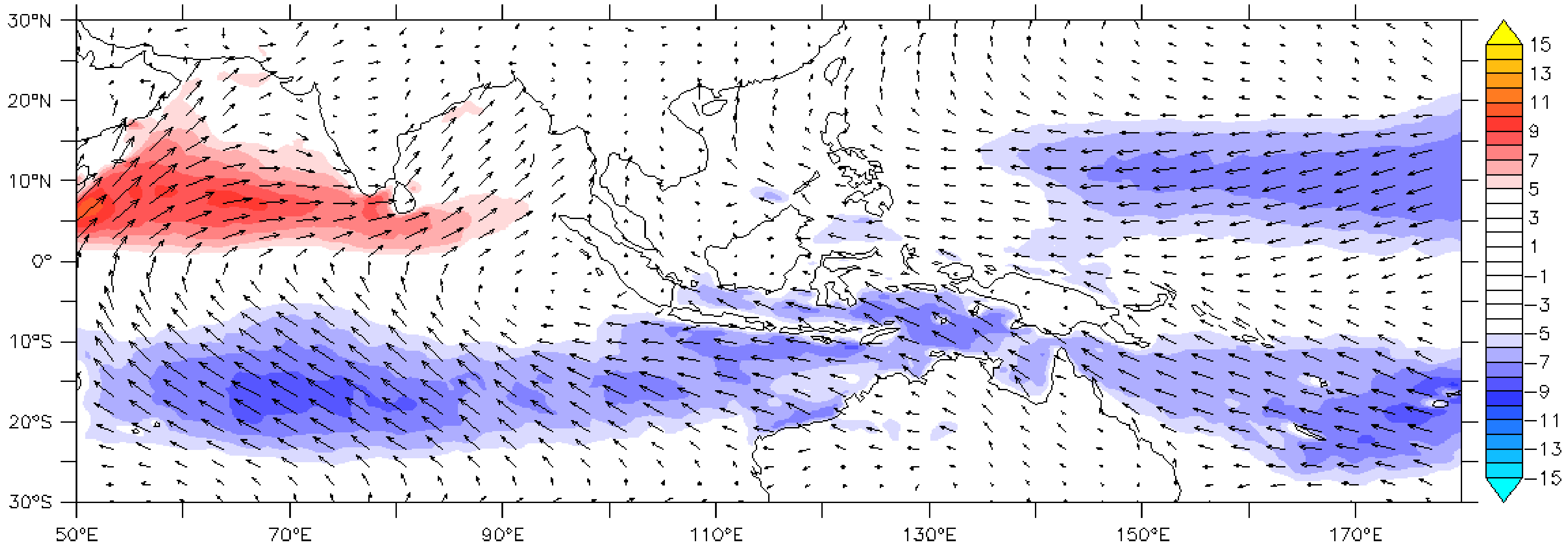


mm/day

1st-10th average of June

CFS

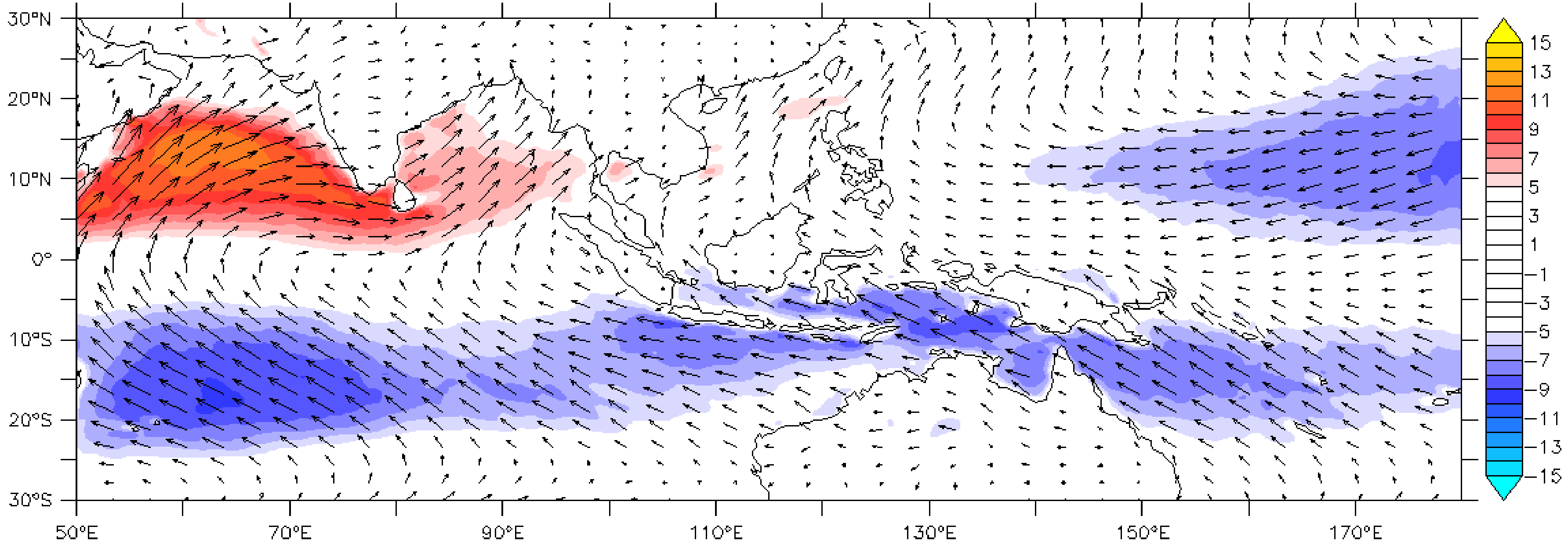
1998



11th-20th average of June

CFS

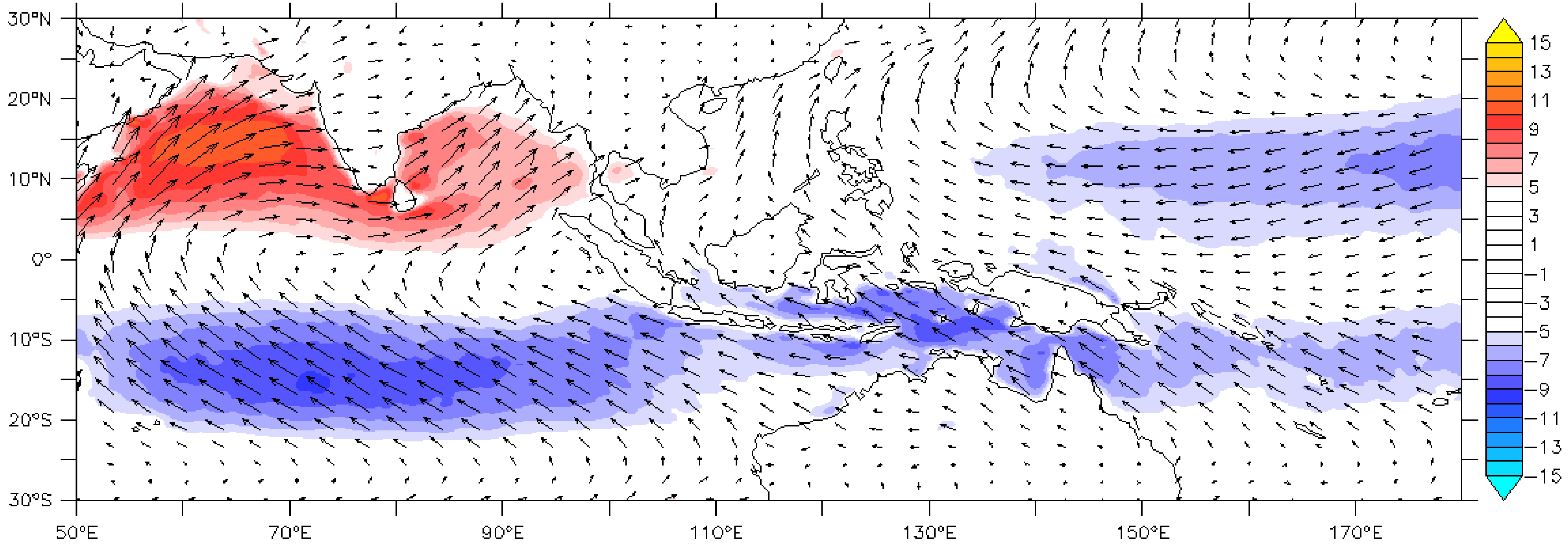
1998



21st-30th average of June

CFS

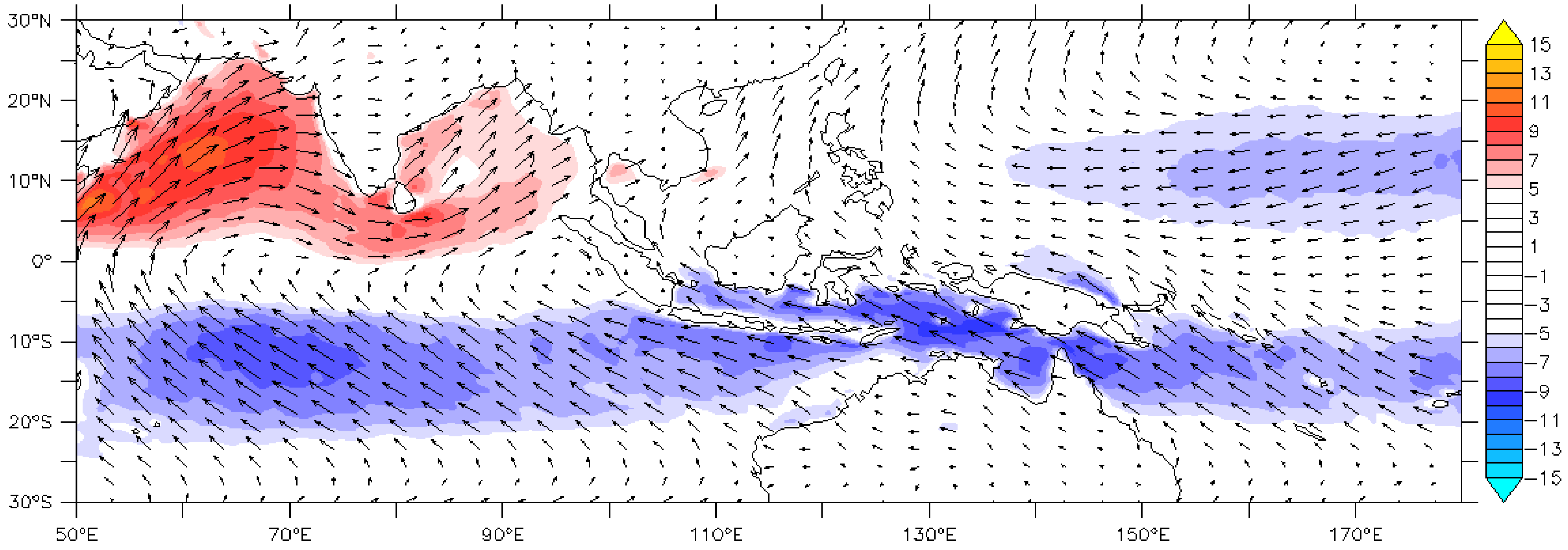
1998



1st-10th average of July

CFS

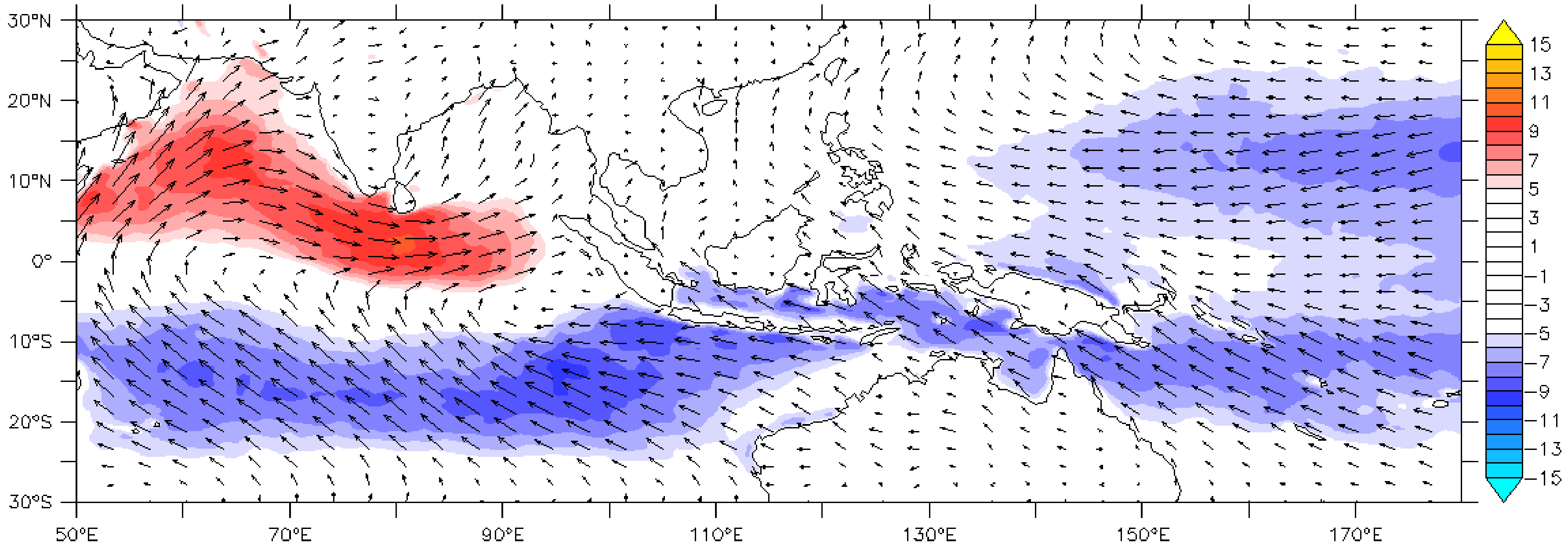
1998

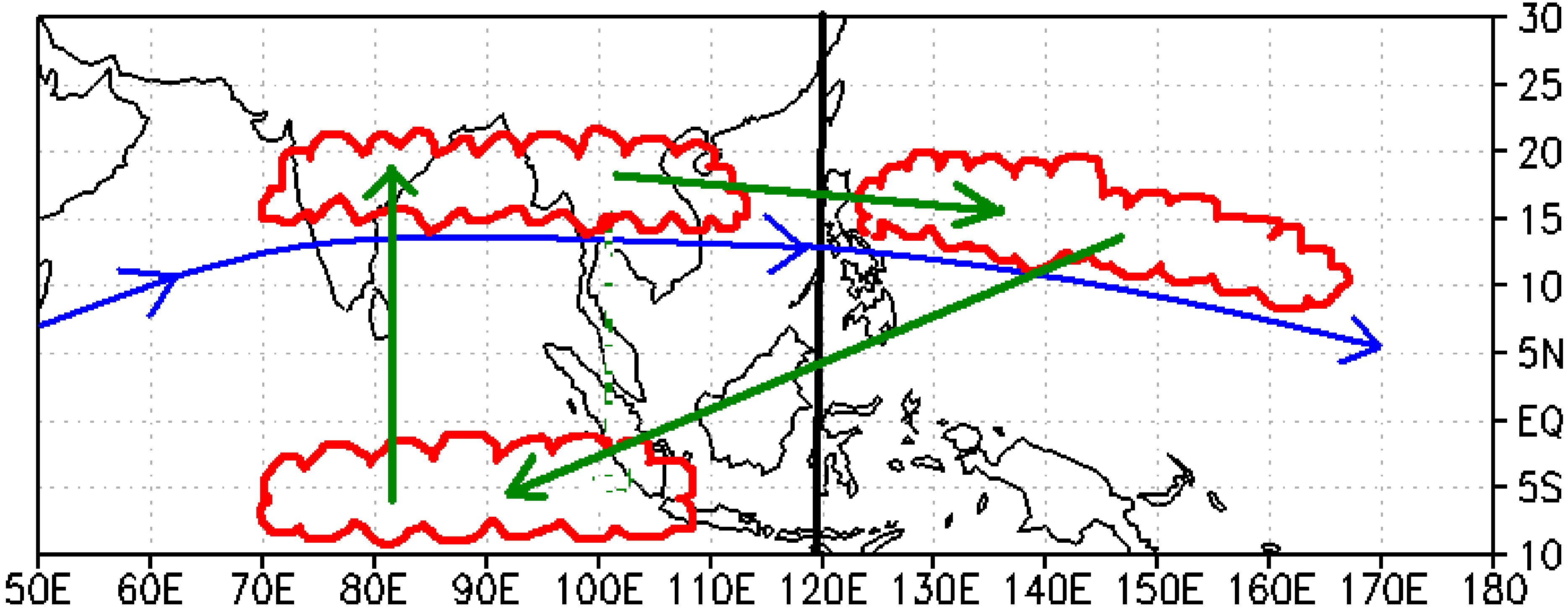


11^{th}-20^{th} average of July

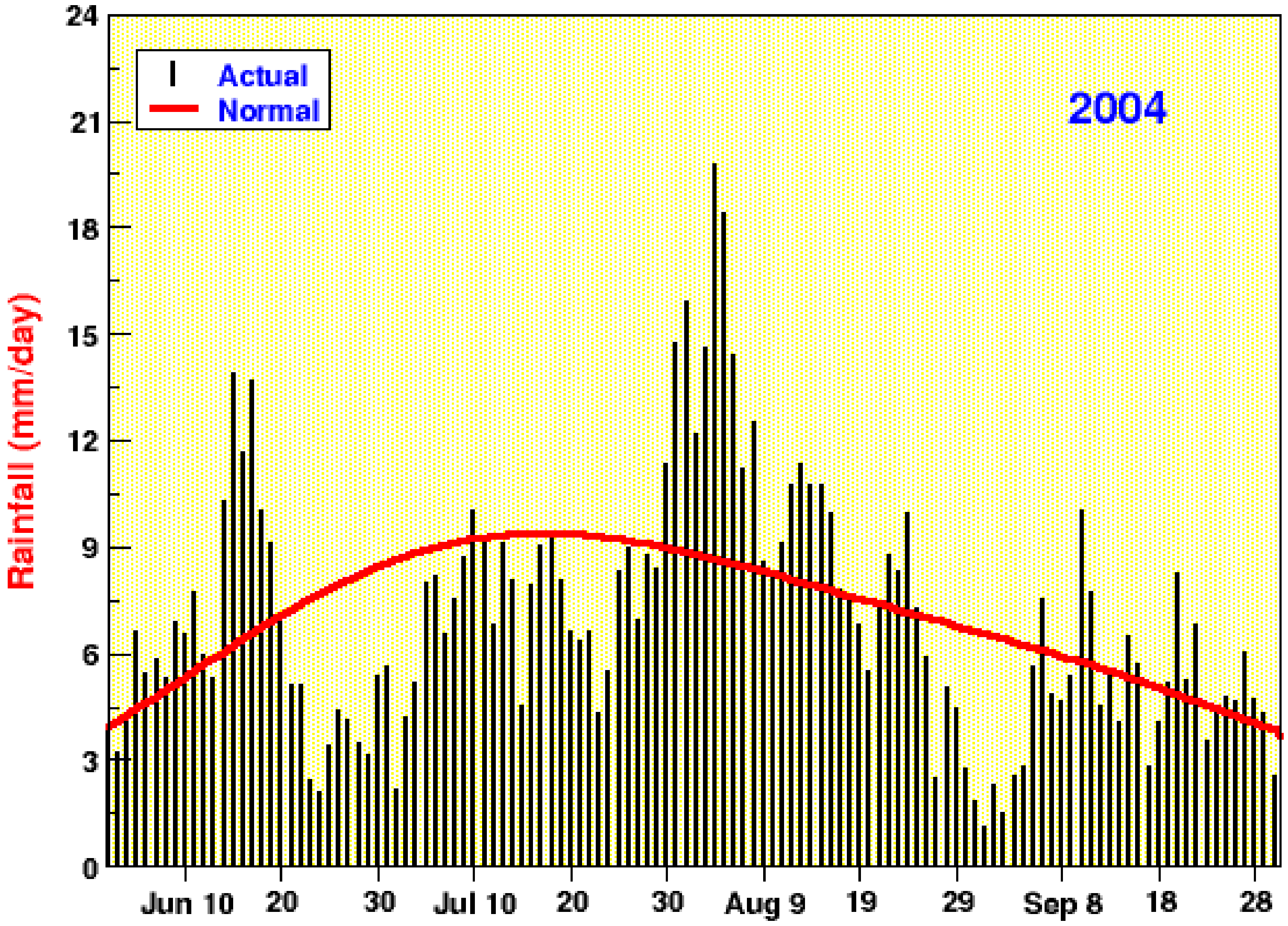
CFS

1998

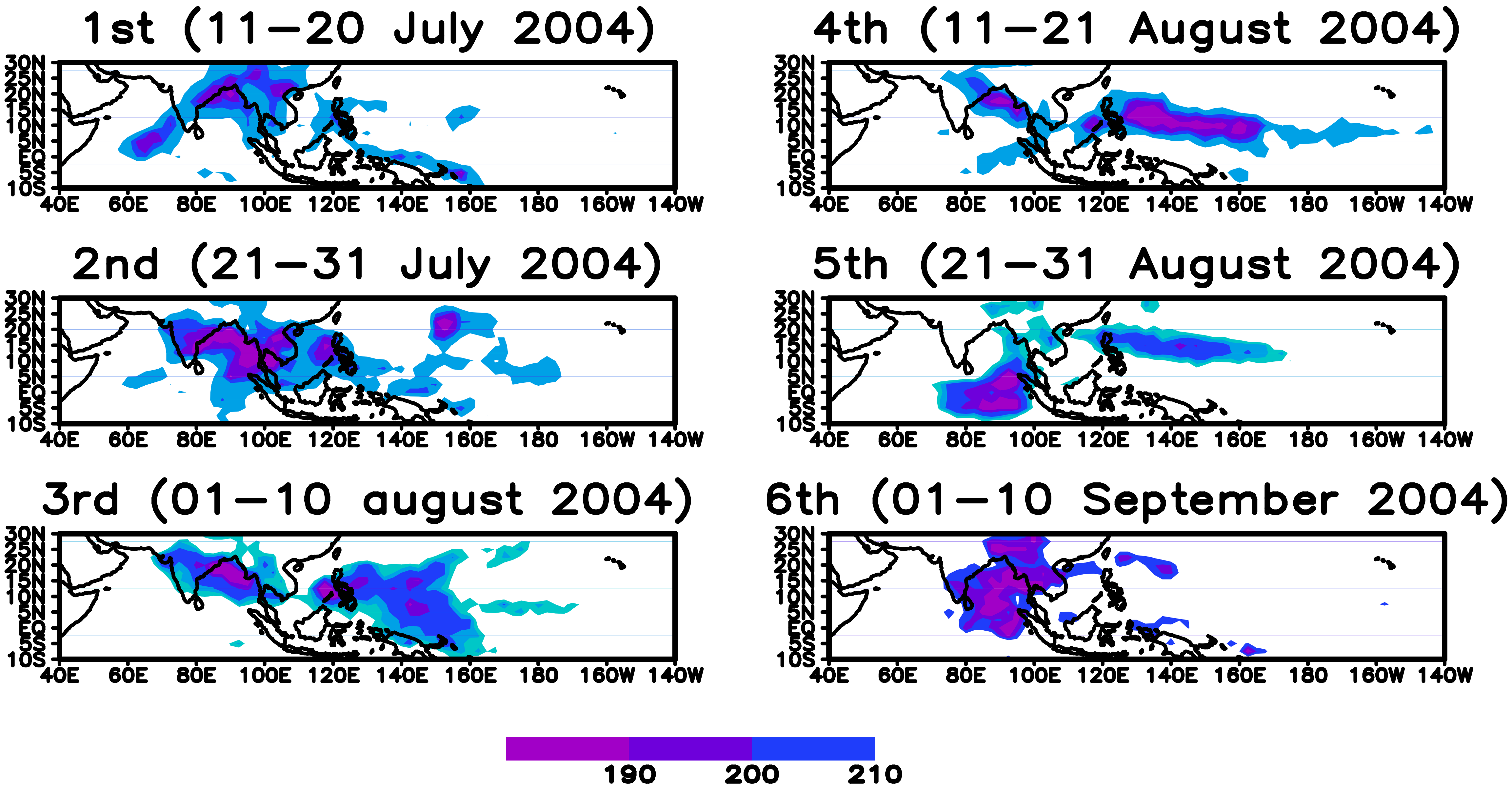


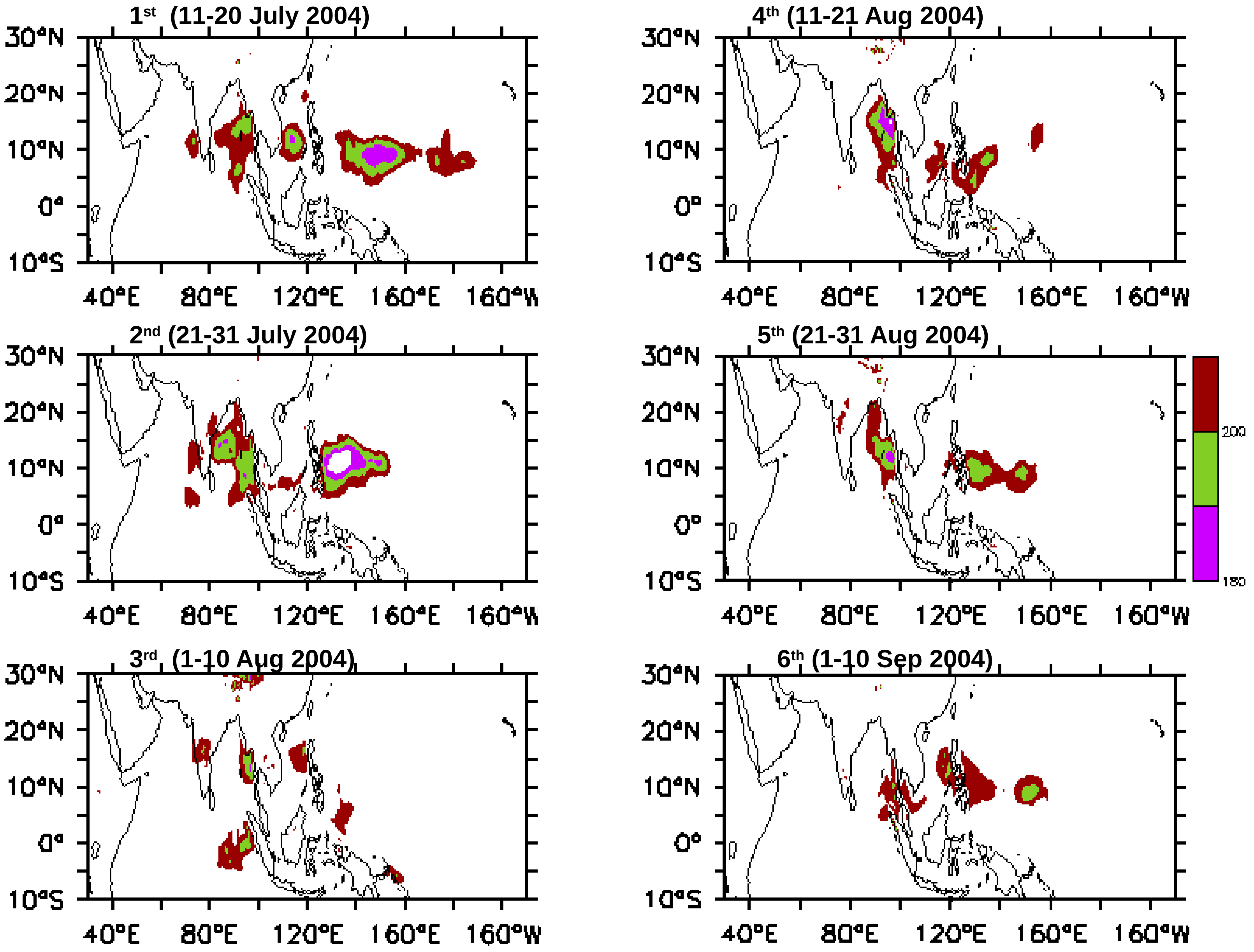


In an El Nino situation, LLJ extends into the Pacific and creates an environment for convection (cyclonic vorticity and moisture). The West Pacific Box having shallow MLD of about 40m in real ocean warms while there is active convection at A. When A cools, convection shifts to B. When area B cools, convection shifts to C. From C convection shifts to A and the AB cycle lasts 2 months.



Daily mean rainfall of India (01-Jun to 30 Sep 2004)

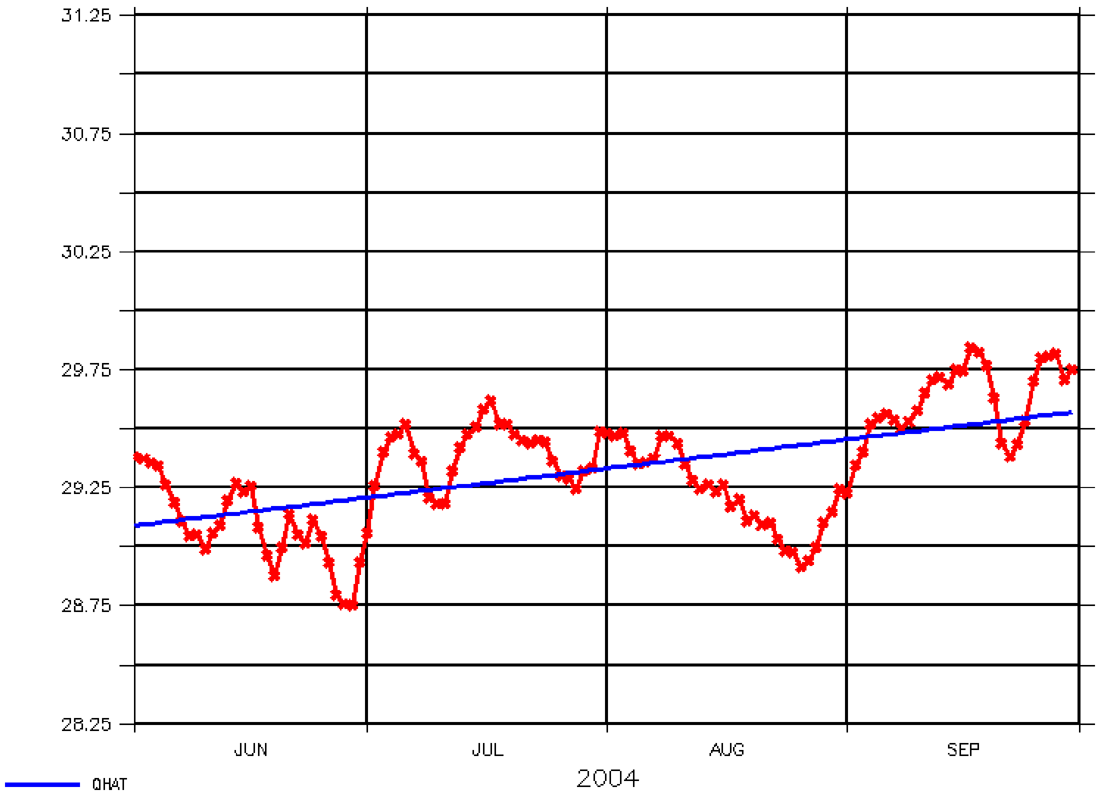

1st (11–20 July 2004)
4th (11–21 August 2004)
2nd (21–31 July 2004)
5th (21–31 August 2004)
3rd (01–10 august 2004)
6th (01–10 September 2004)
30N
25N
20N
15N
10N
5N
EQ
5S
10S
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
190
200
210


1st (11-20 July 2004)
2nd (21-31 July 2004)
3rd (1-10 Aug 2004)
4th (11-21 Aug 2004)
5th (21-31 Aug 2004)
6th (1-10 Sep 2004)
30°N
20°N
10°N
0°
10°S
40°E
80°E
120°E
160°E
160°W
200
180

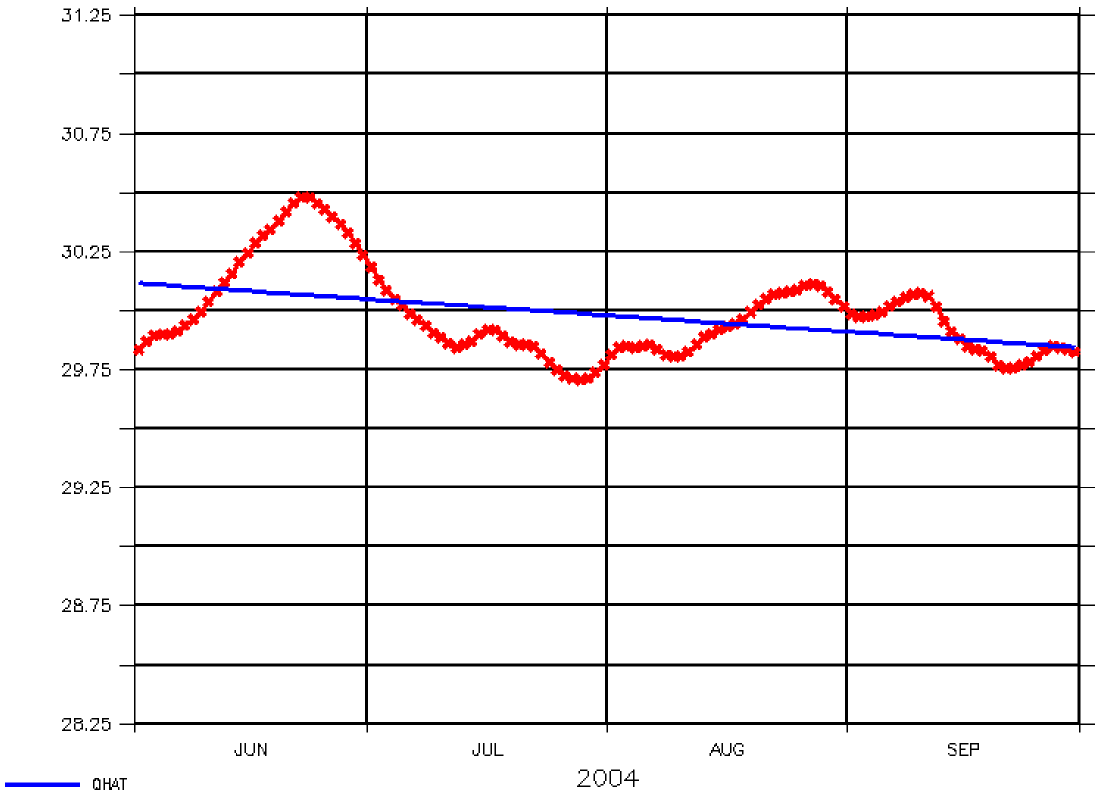
West Pacific Box

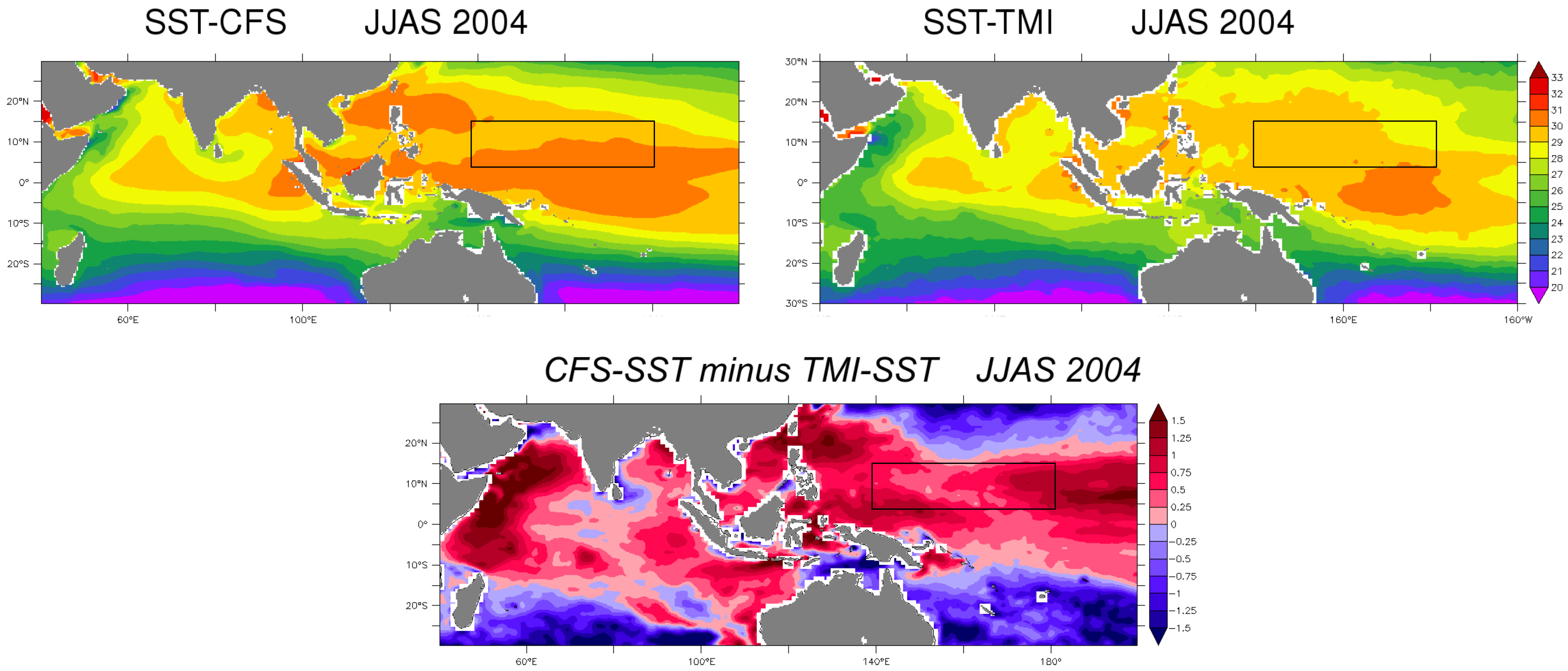
(140º to 180º & 5º to 15º)

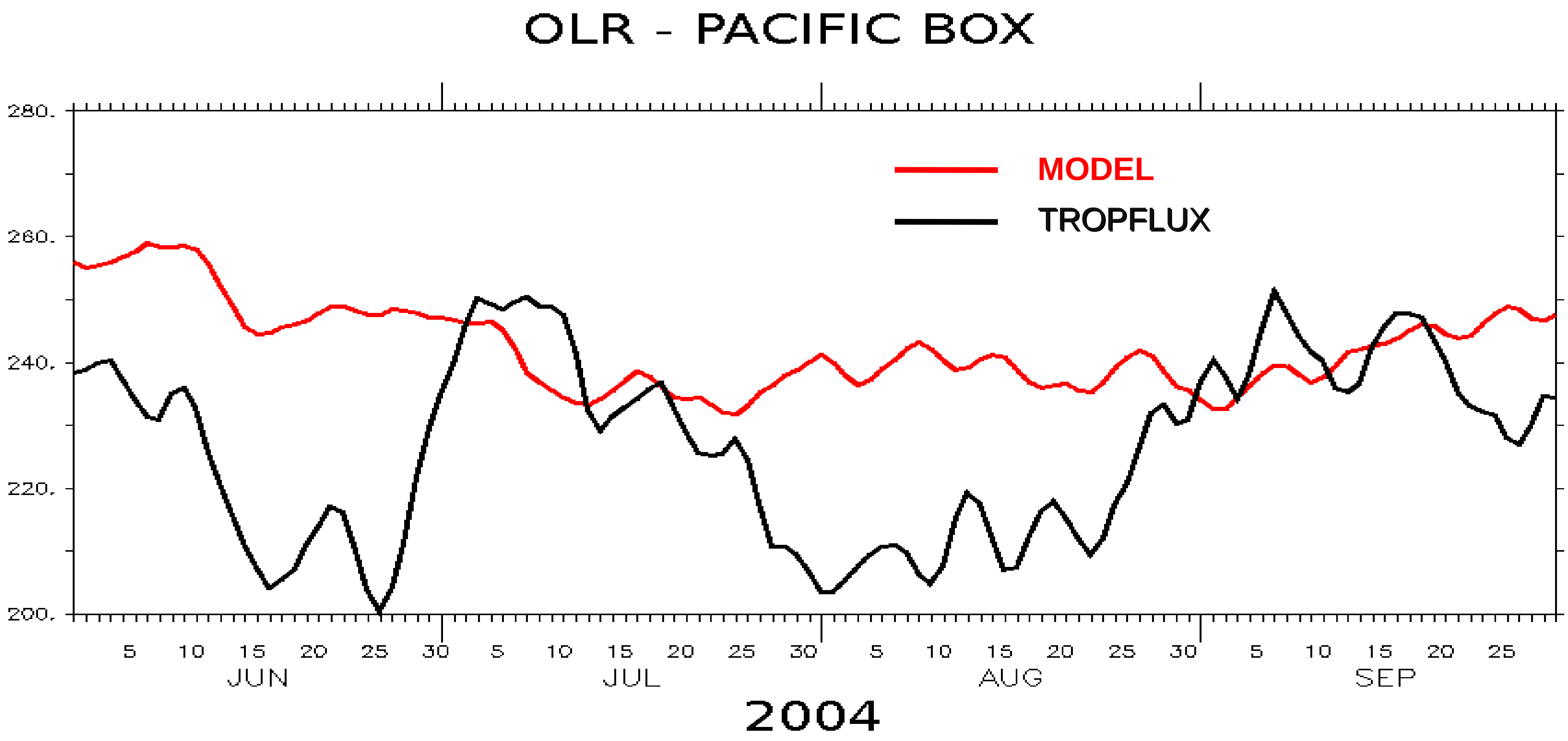
SST-TMI JJAS 2004



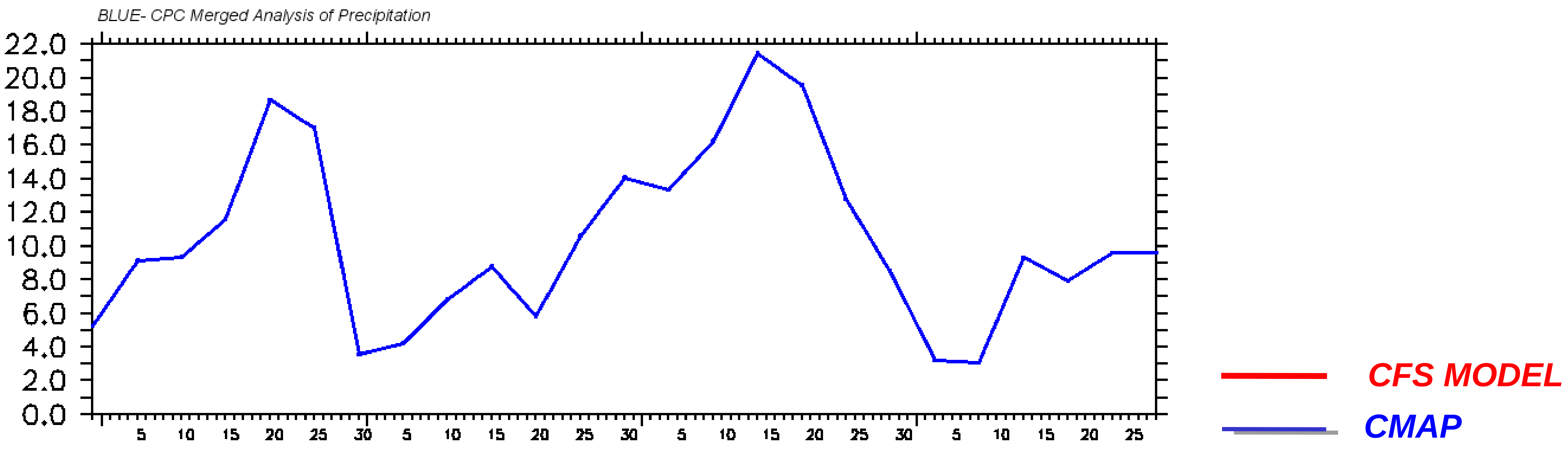
SST-CFS JJAS 2004



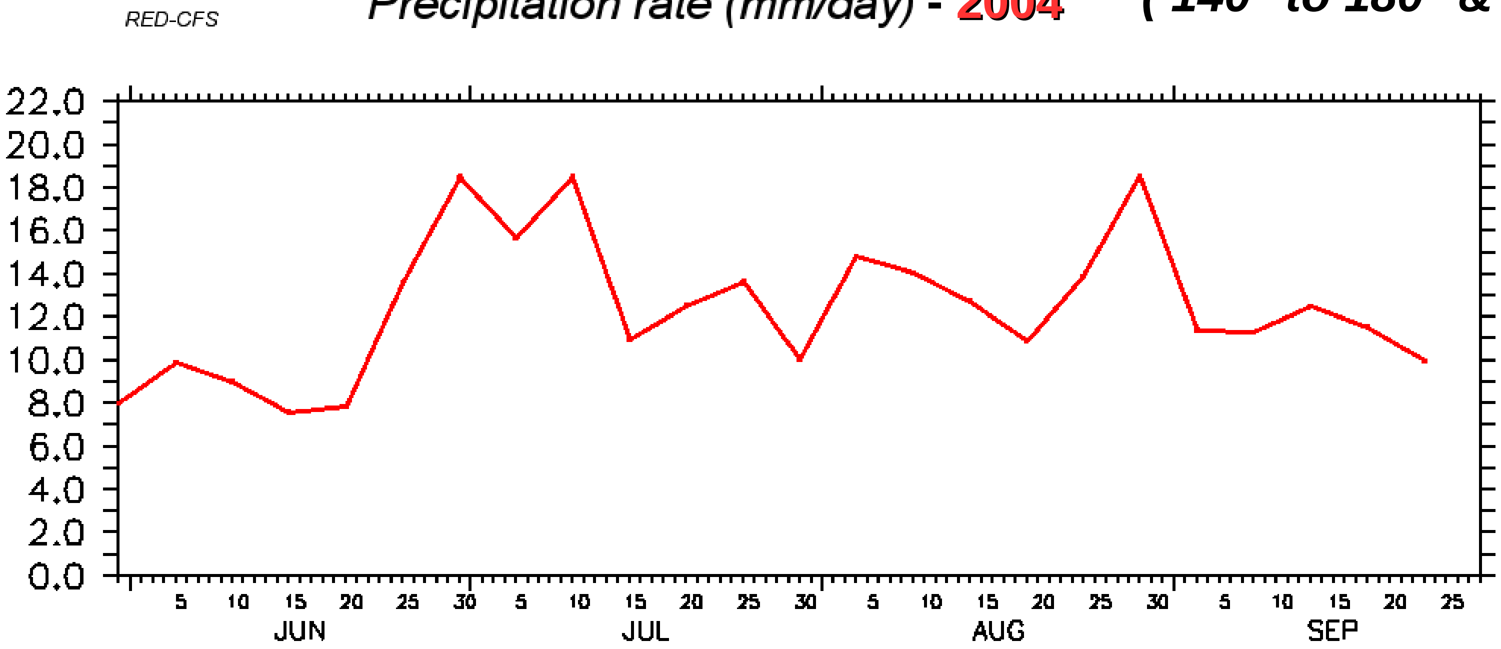

SST-CFS JJAS 2004
SST-TMI JJAS 2004
20°N
10°N
0°
10°S
20°S
60°E
100°E
30°N
20°N
10°N
0°
10°S
20°S
30°S
160°E
160°W
33
32
31
30
29
28
27
26
25
24
23
22
21
20
CFS-SST minus TMI-SST JJAS 2004
20°N
10°N
0°
10°S
20°S
60°E
100°E
140°E
180°
1.5
1.25
1
0.75
0.5
0.25
0
−0.25
−0.5
−0.75
−1
−1.25
−1.5


OLR - PACIFIC BOX
280.
260.
240.
220.
200.
MODEL
TROPFLUX
5
10
15
20
25
30
JUN
JUL
AUG
SEP
2004

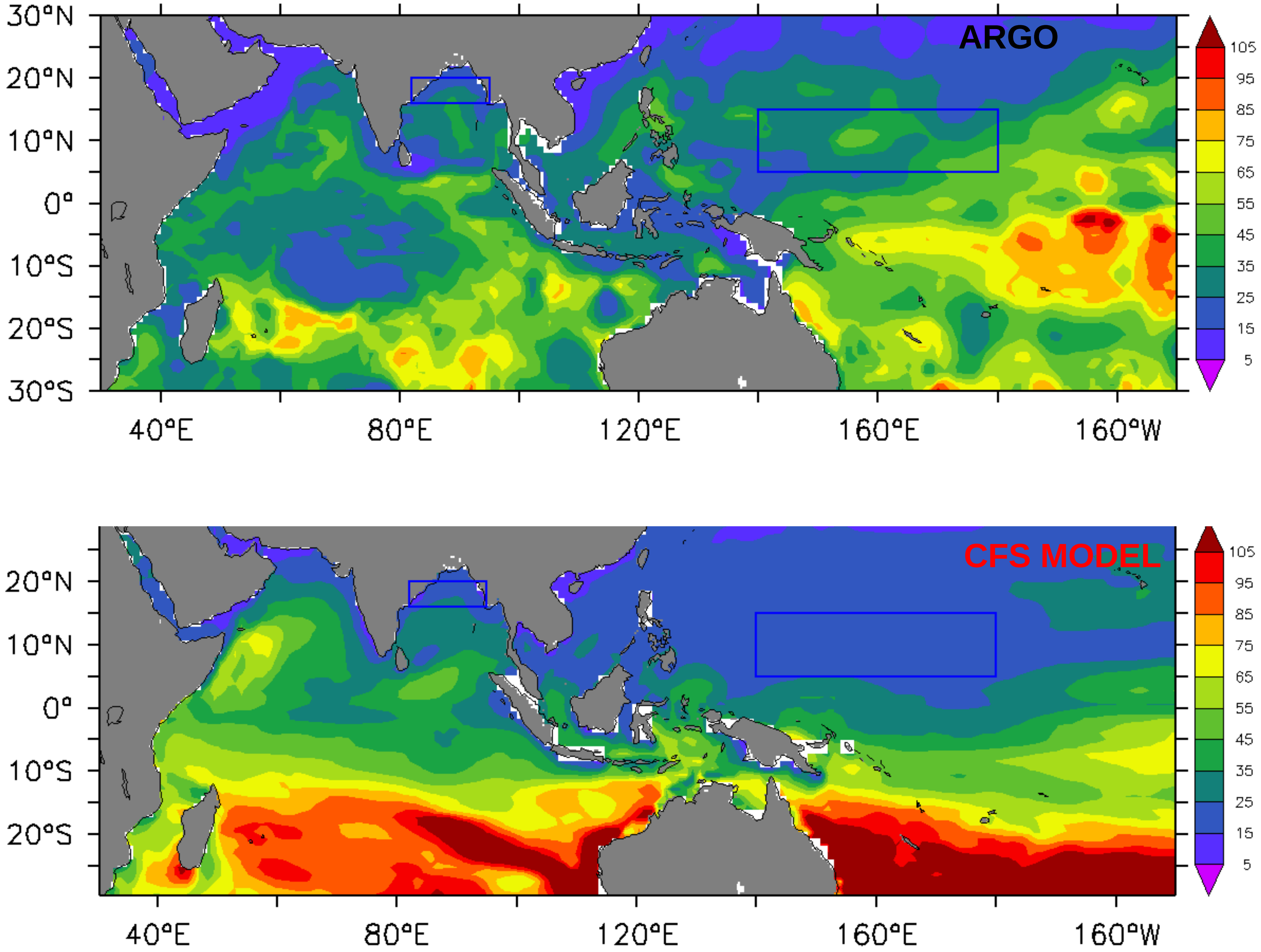
Precipitation rate (mm/day) - 2004 (140° to 180° & 5° to 15°)



Precipitation rate (mm/day) - 2004 (140° to 180° & 5° to 15°)

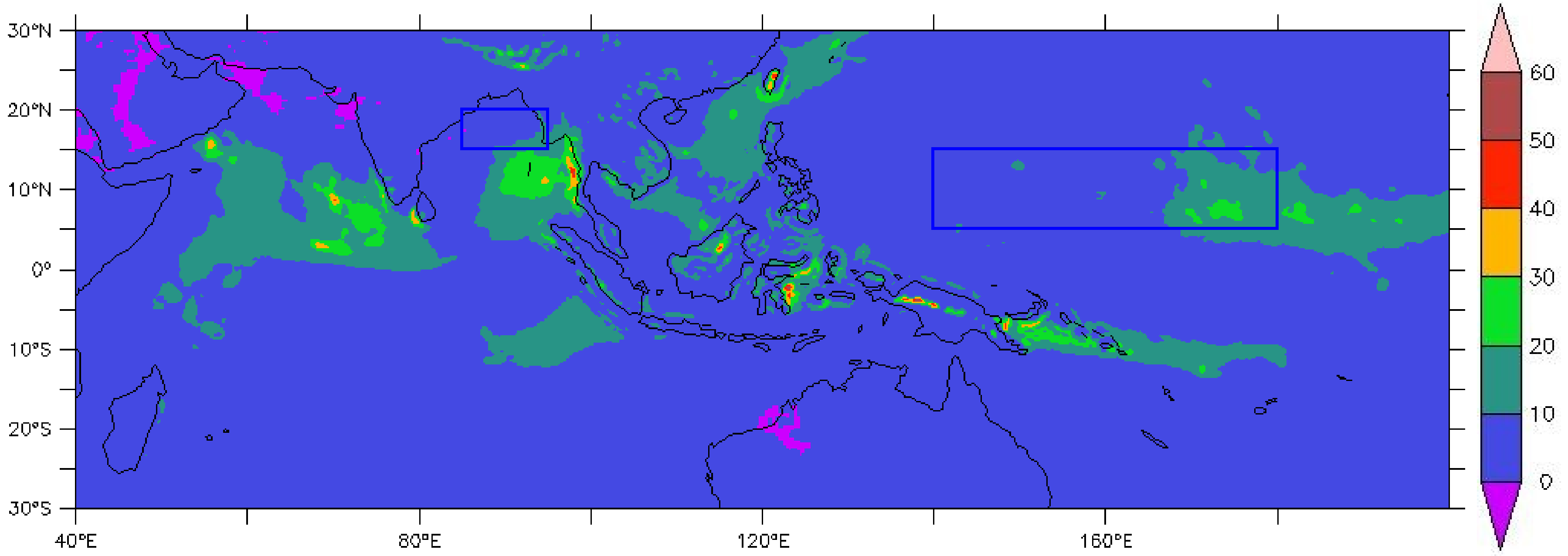


Mixed Layer Depth (01-Jun to 30 Sep 2004)



1st-10th average of June 2004

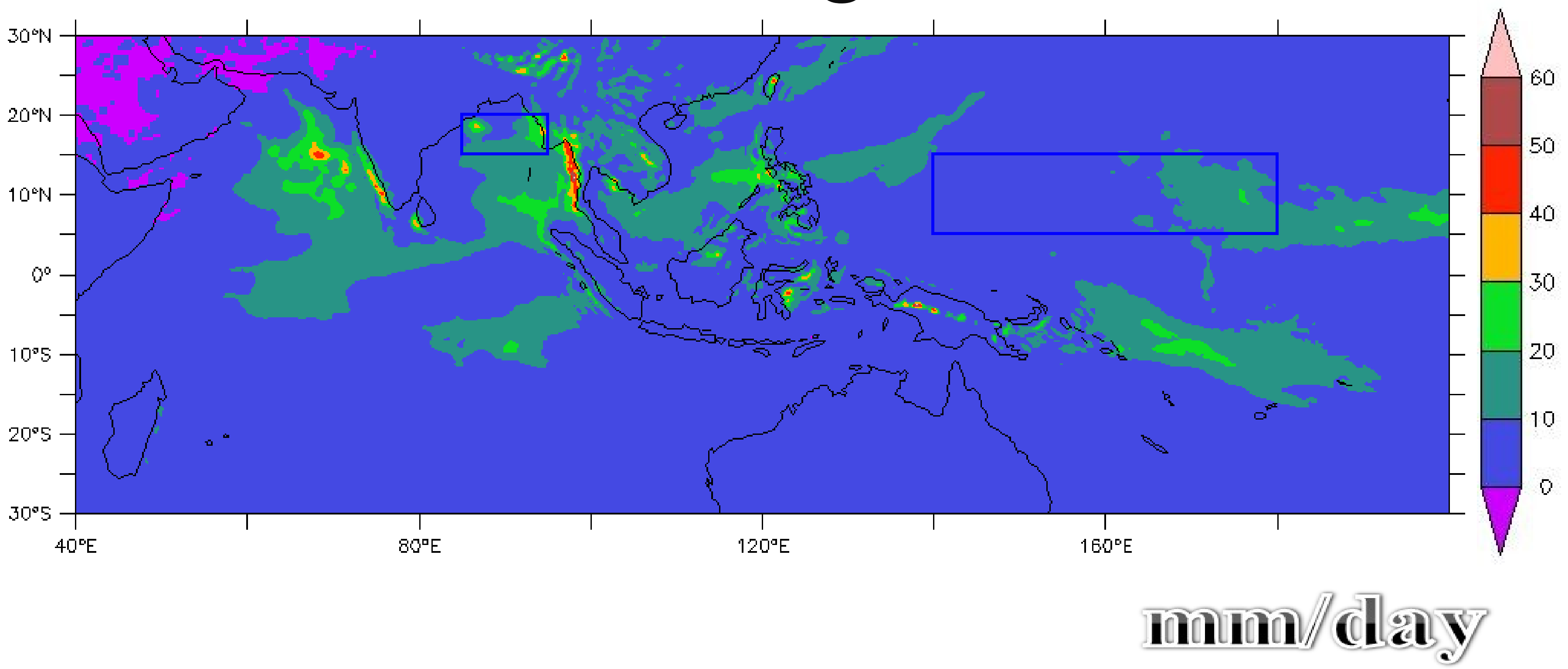
CFS



mm/day

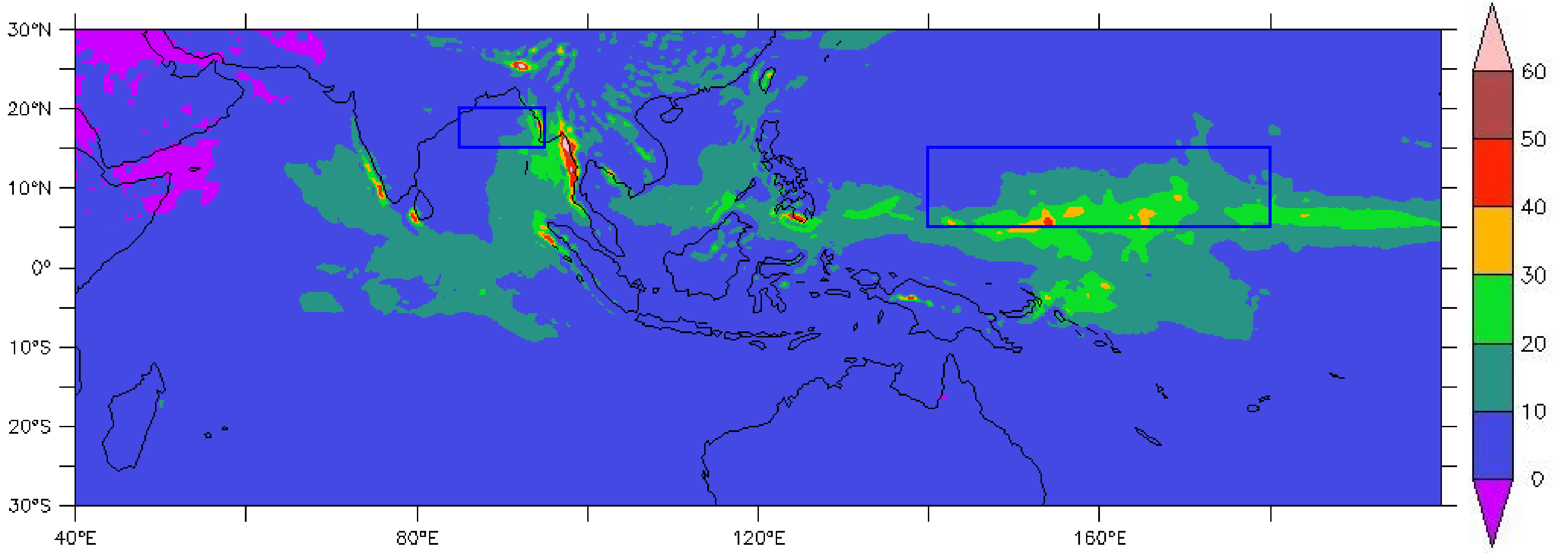
11th-20th average of June 2004

CFS



21st-30th average of June

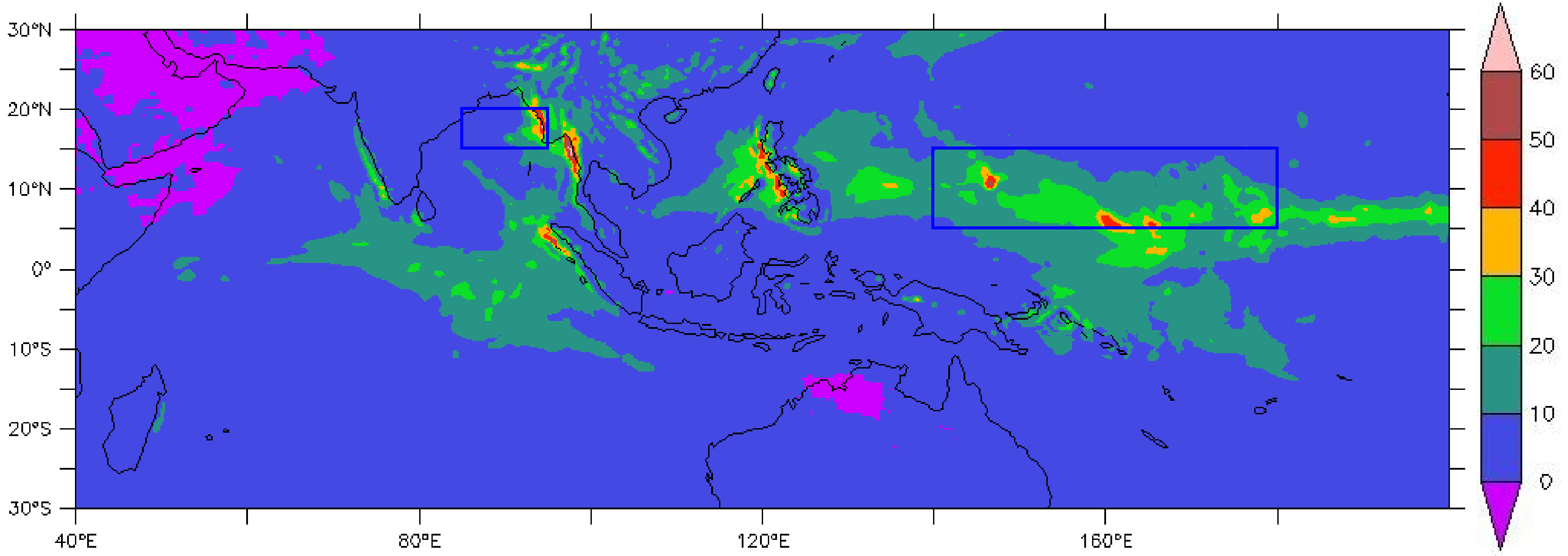
2004 CFS



mm/day

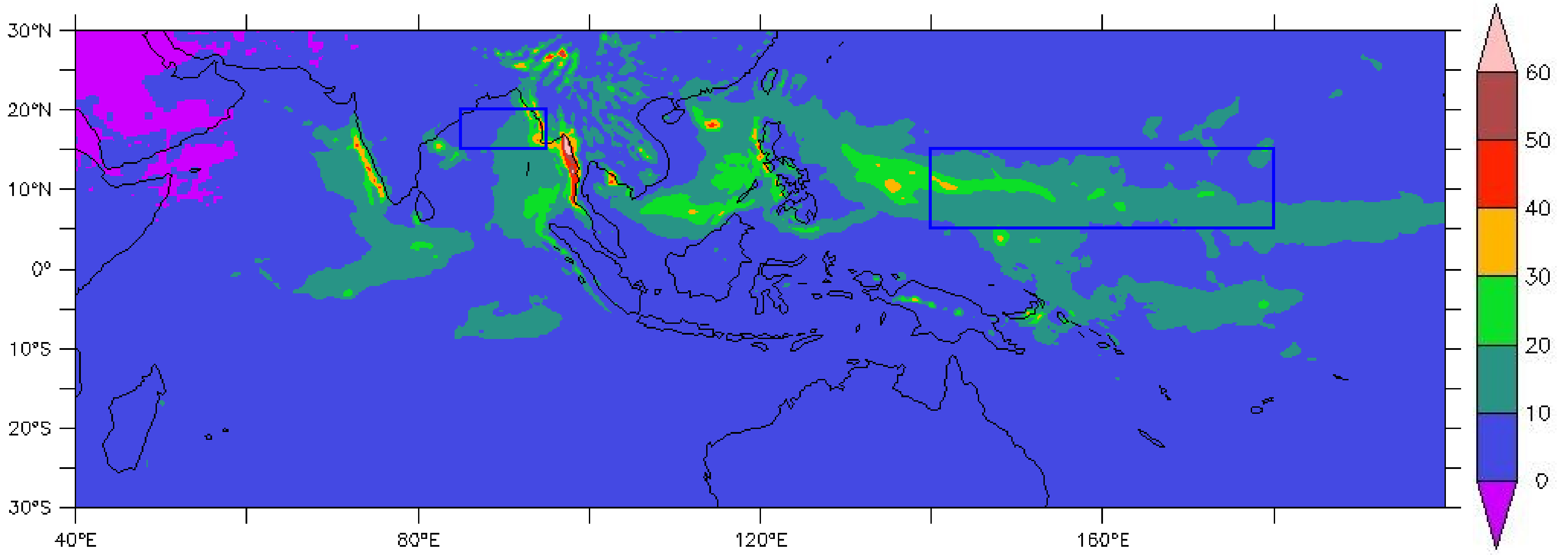
1st-10th average of July

2004 CFS



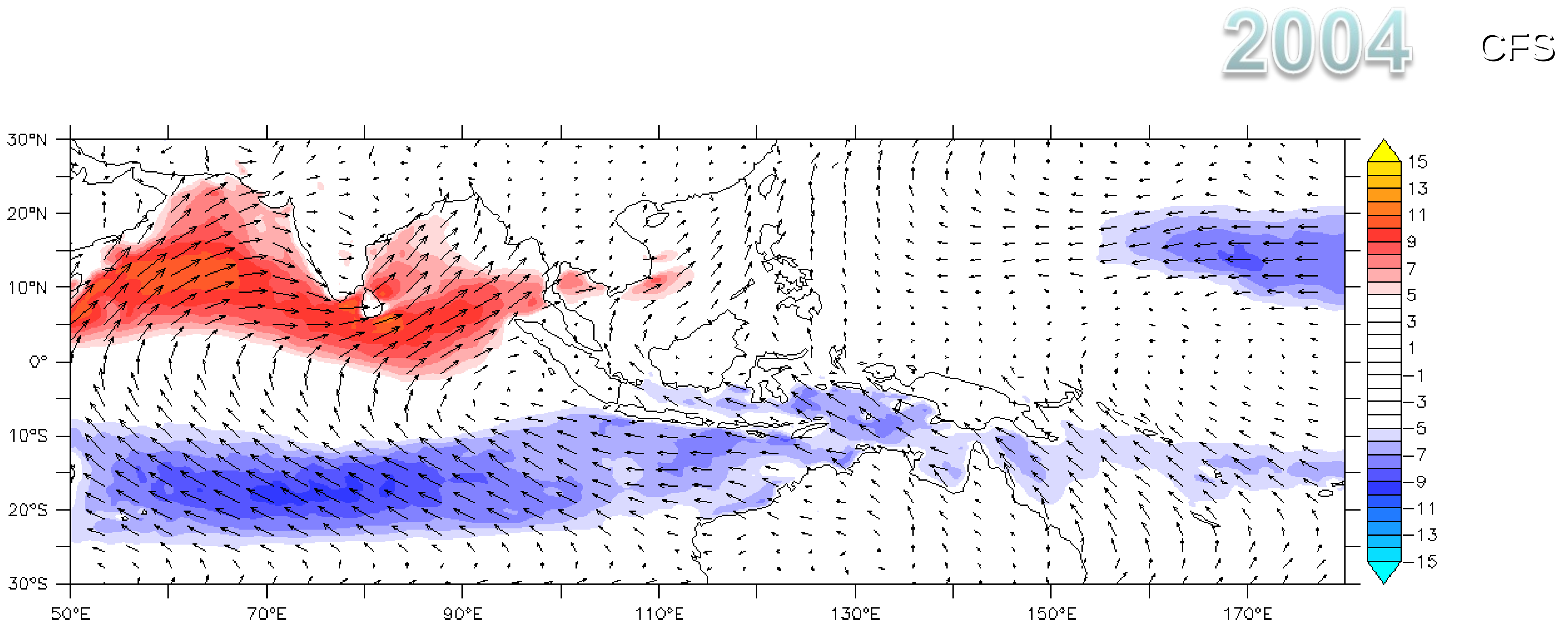
mm/day

11th-20th average of July 2004 CFS



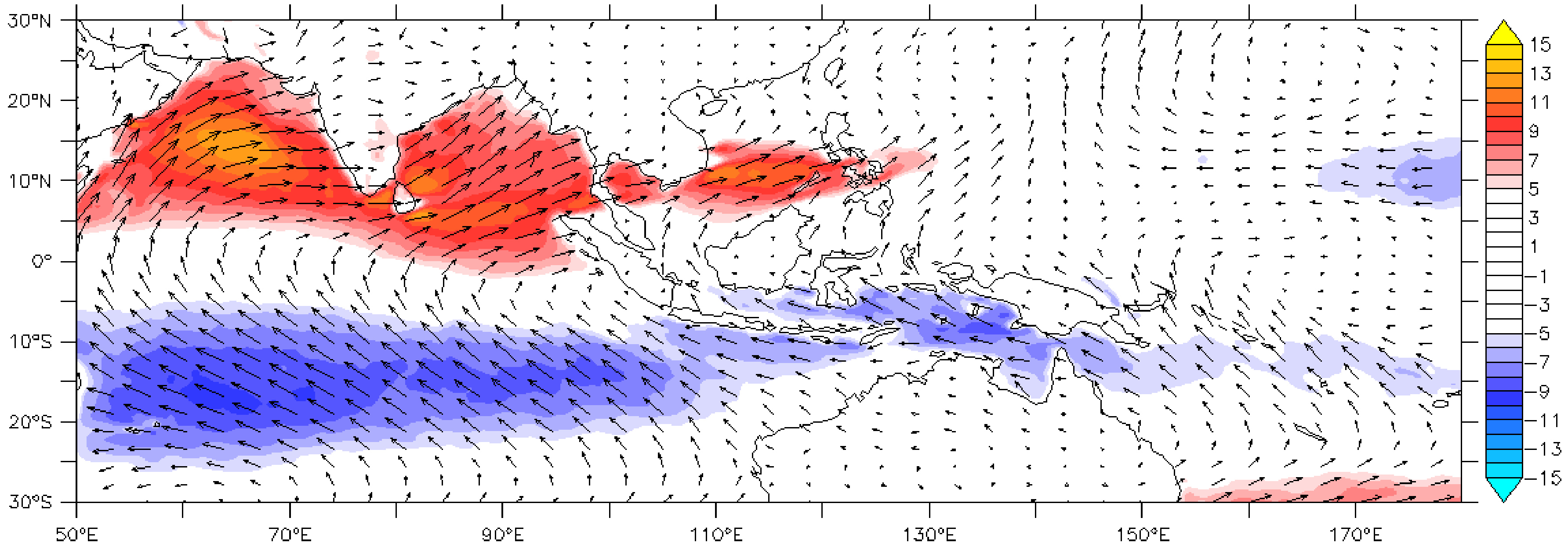
mm/day

1st-10th average of June



11th-20th average of June

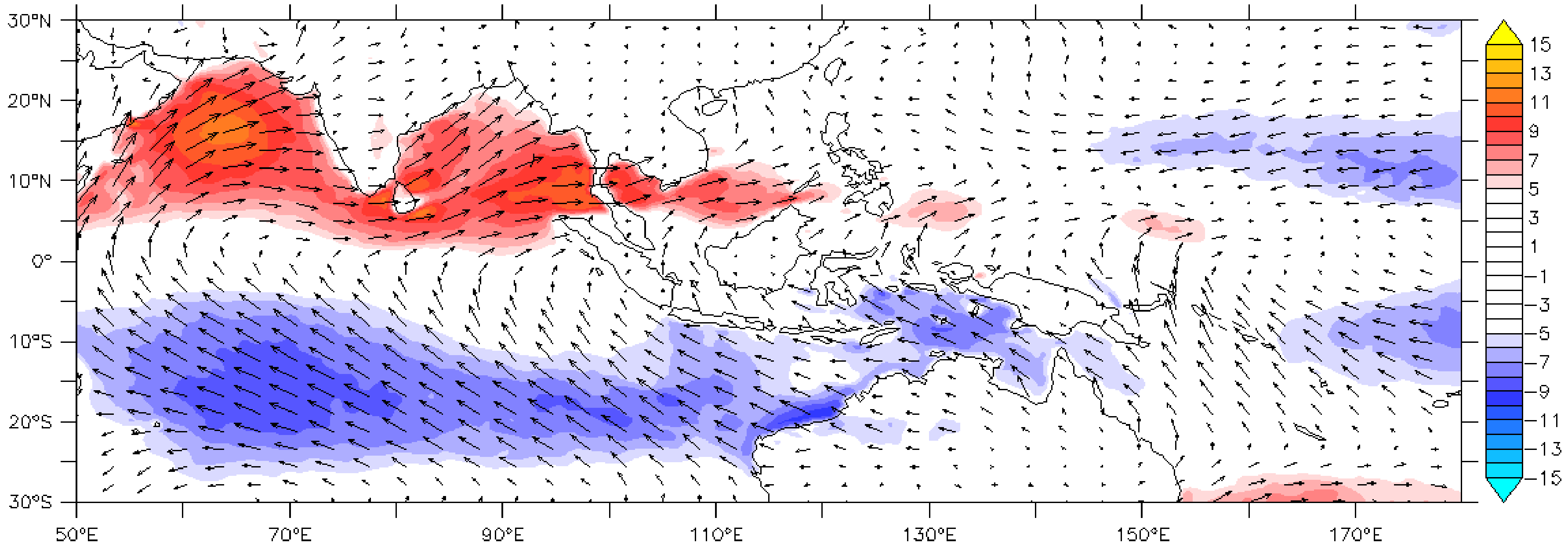
2004 CFS



21st-30th average of June

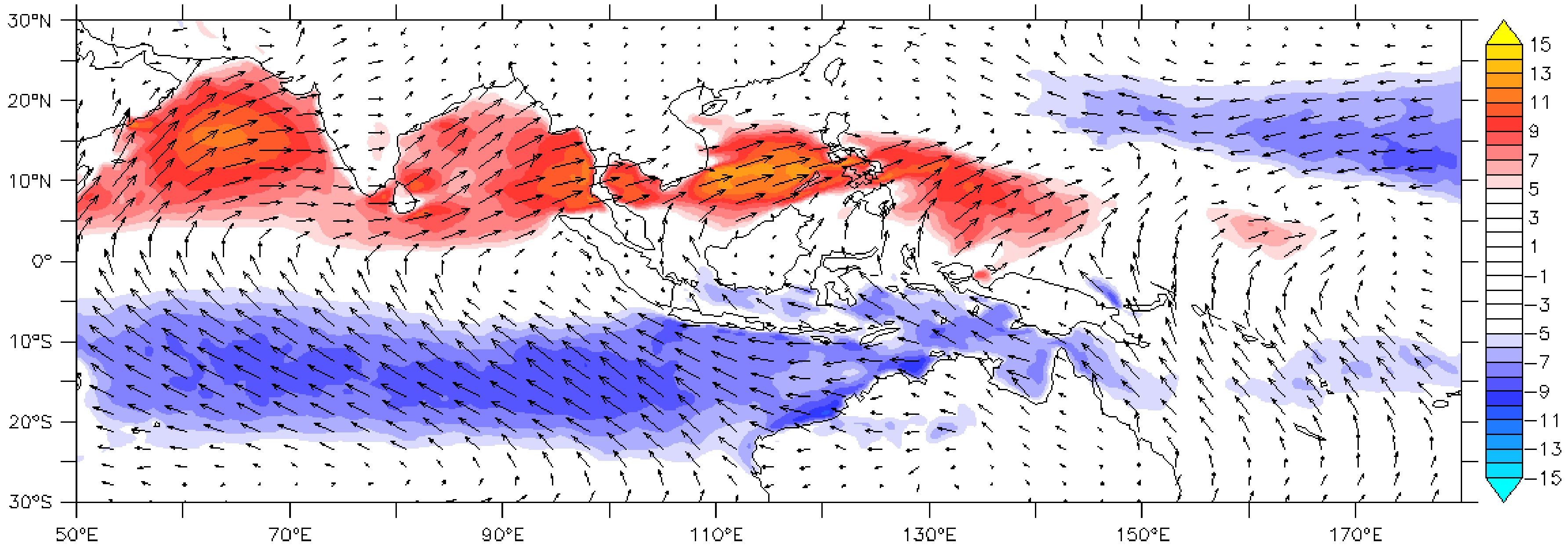
2004

CFS



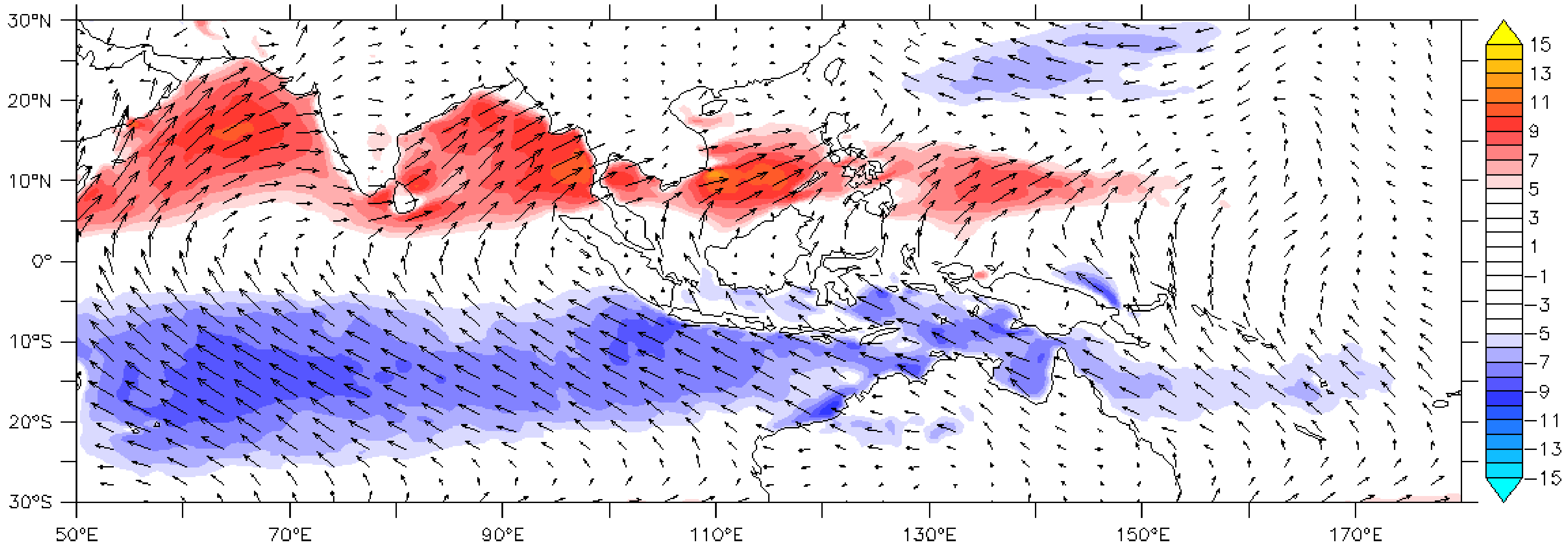
1st-10th average of July

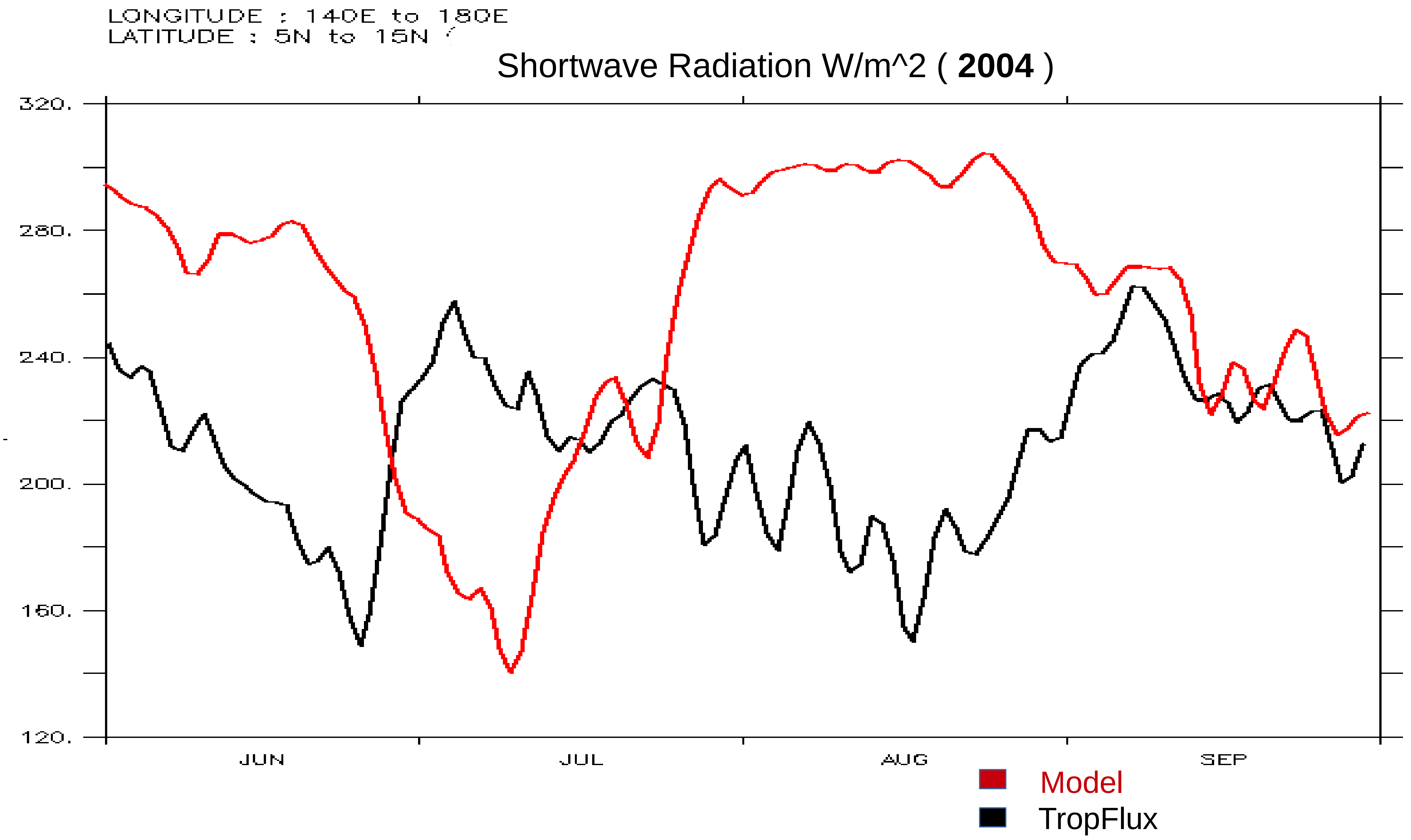
2004 CFS

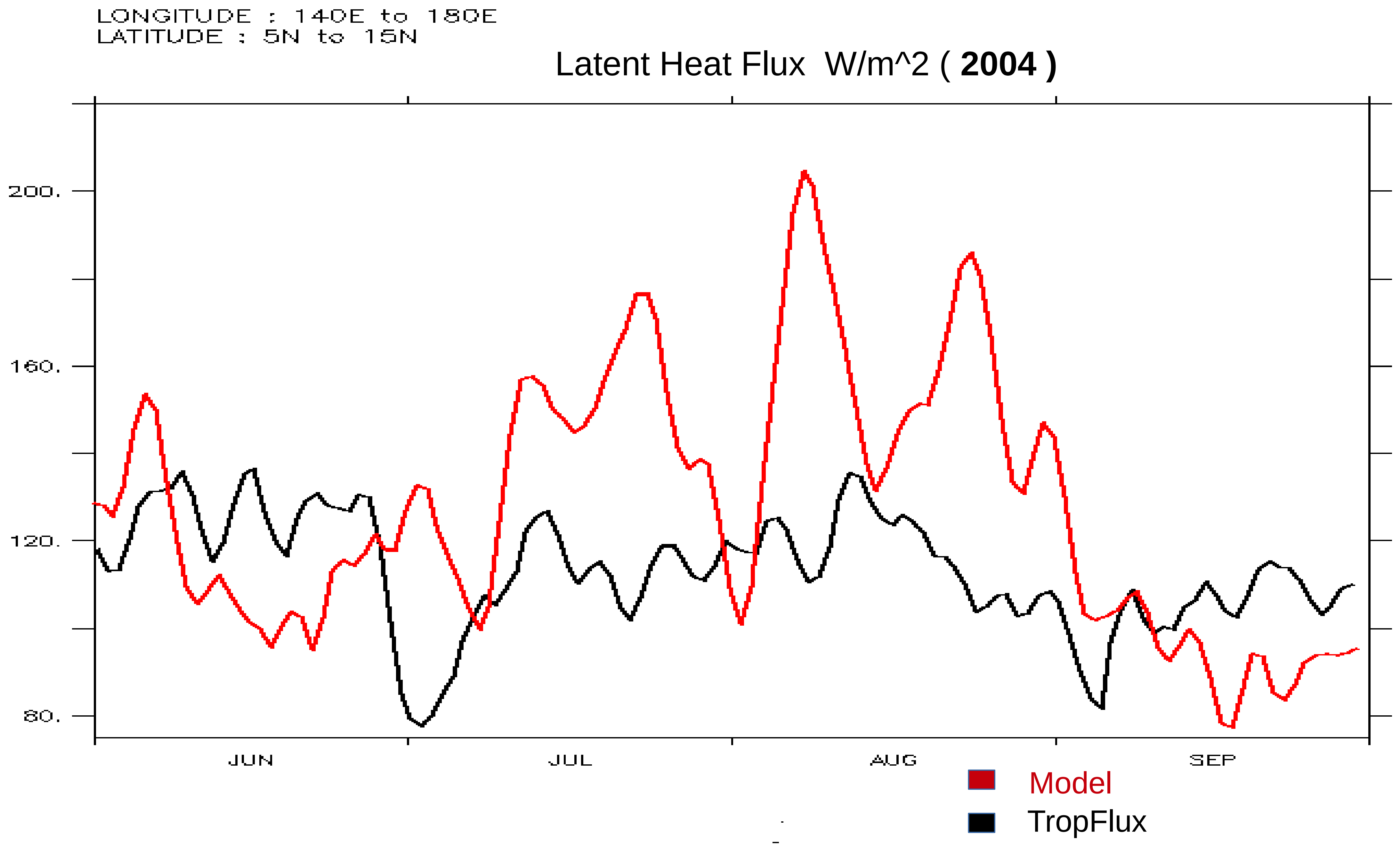


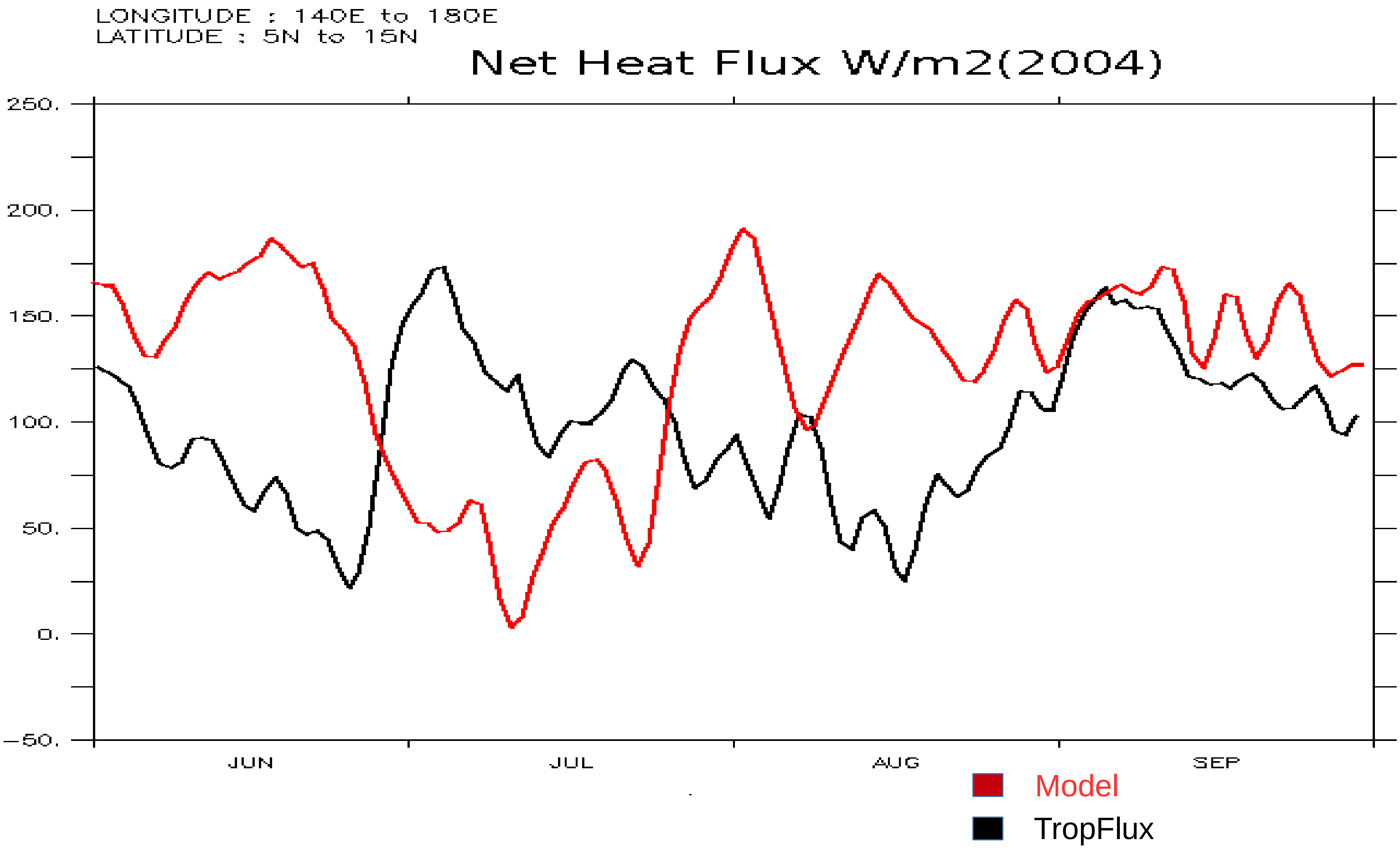
11th-20th average of July

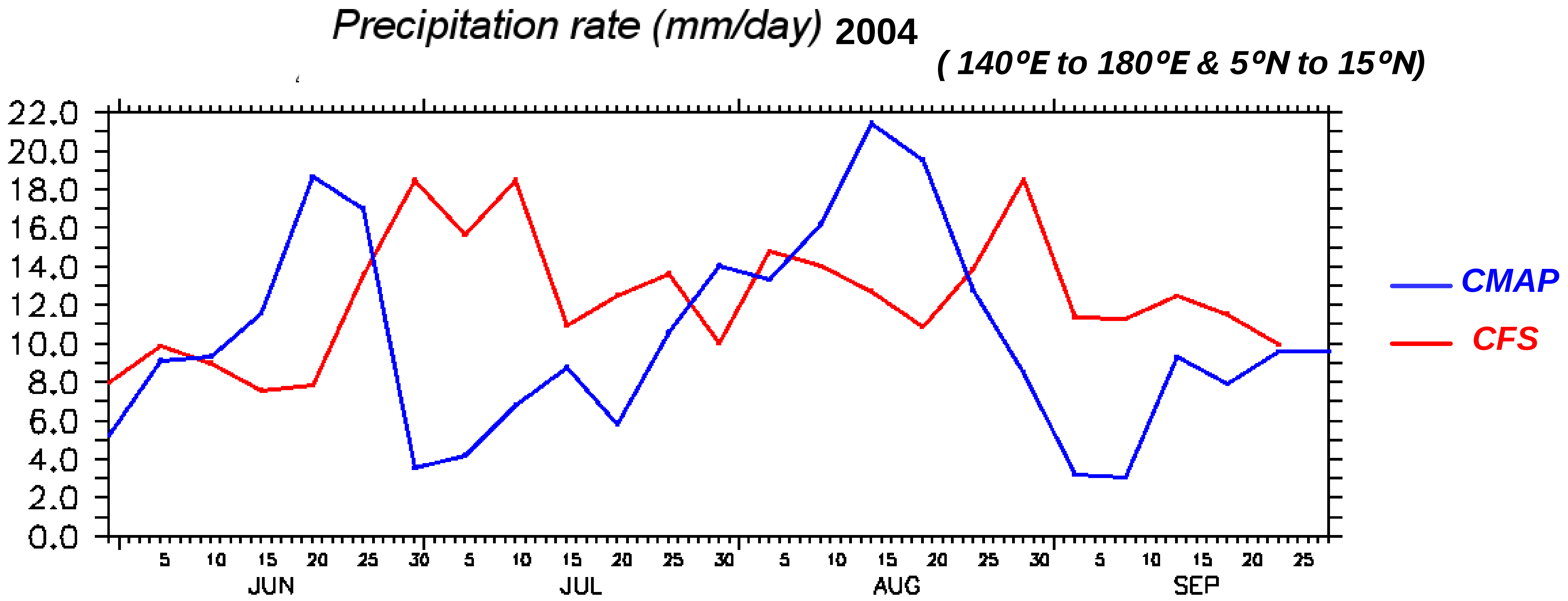
2004 CFS




LONGITUDE : 140E to 180E
LATITUDE : 5N to 15N
Shortwave Radiation W/m^2 (**2004**)
320.
280.
240.
200.
160.
120.
JUN
JUL
AUG
SEP
Model
TropFlux

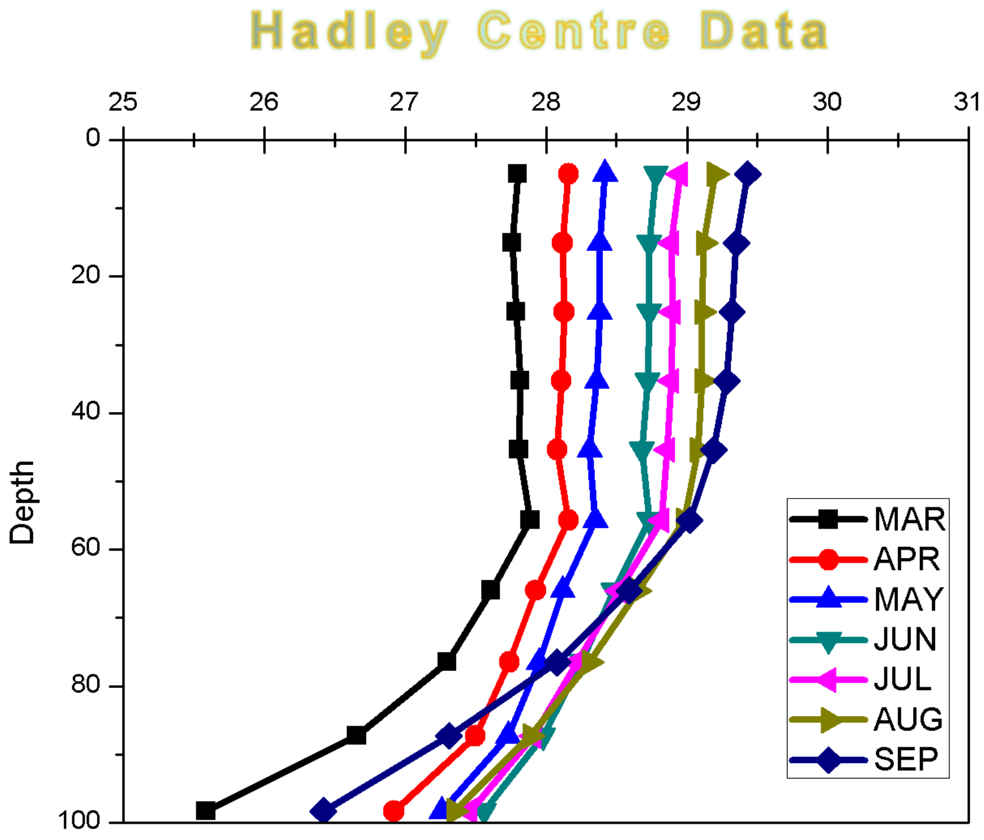

LONGITUDE : 140E to 180E
LATITUDE : 5N to 15N
Latent Heat Flux W/m^2 (2004)
200.
160.
120.
80.
JUN
JUL
AUG
SEP
Model
TropFlux


LONGITUDE : 140E to 180E
LATITUDE : 5N to 15N
Net Heat Flux W/m2(2004)
250.
200.
150.
100.
50.
0.
−50.
JUN
JUL
AUG
SEP
Model
TropFlux

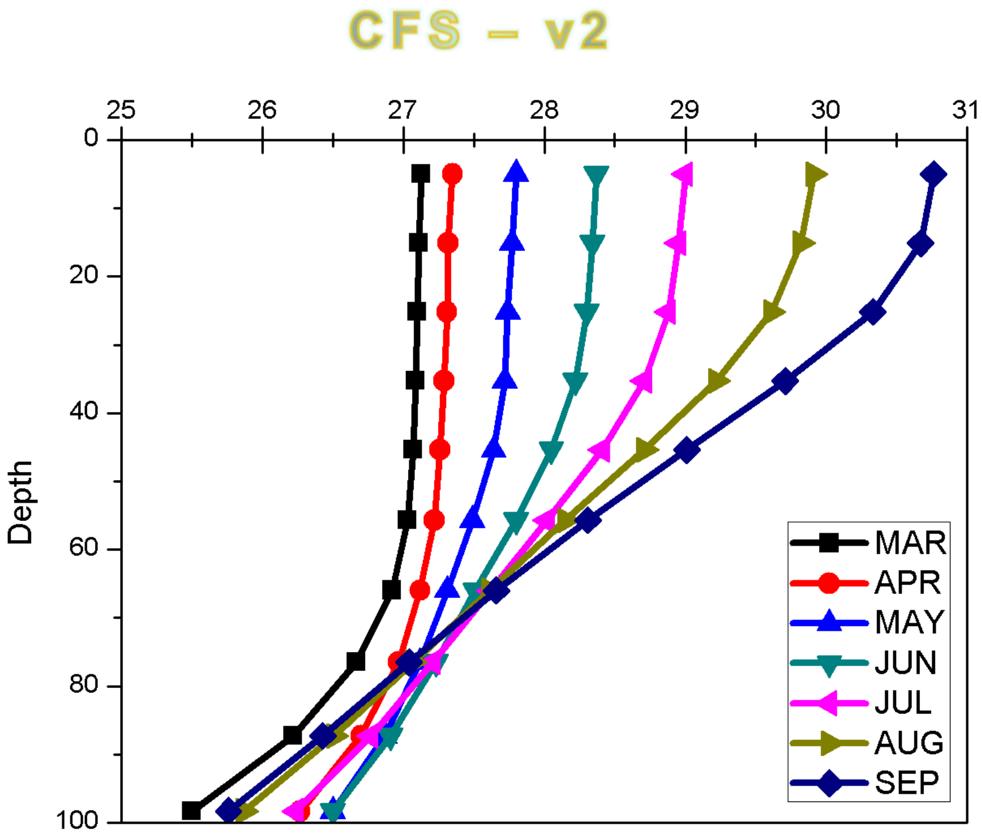


Precipitation rate (mm/day) 2004
(140ºE to 180ºE & 5ºN to 15ºN)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25
JUN
JUL
AUG
SEP
CMAP
CFS

1998

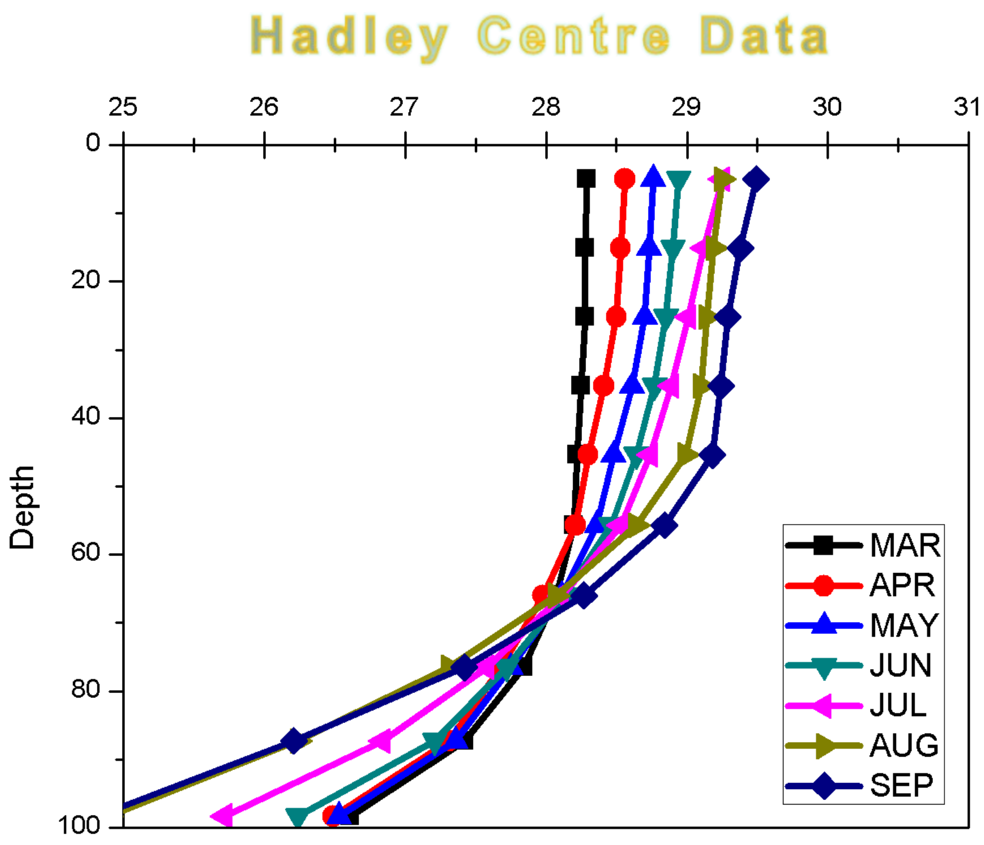


Hadley Centre Data
25
26
27
28
29
30
31
0
20
40
60
80
100
Depth
MAR
APR
MAY
JUN
JUL
AUG
SEP

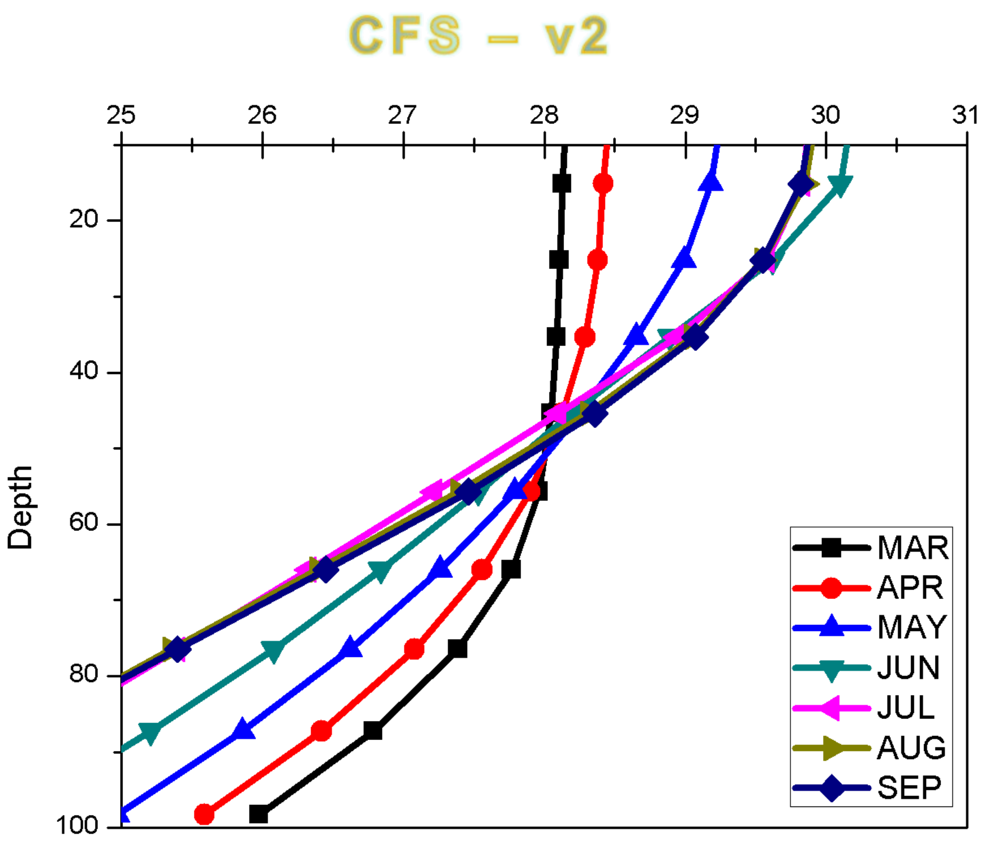


CFS – v2
25
26
27
28
29
30
31
0
20
40
60
80
100
Depth
MAR
APR
MAY
JUN
JUL
AUG
SEP

2004

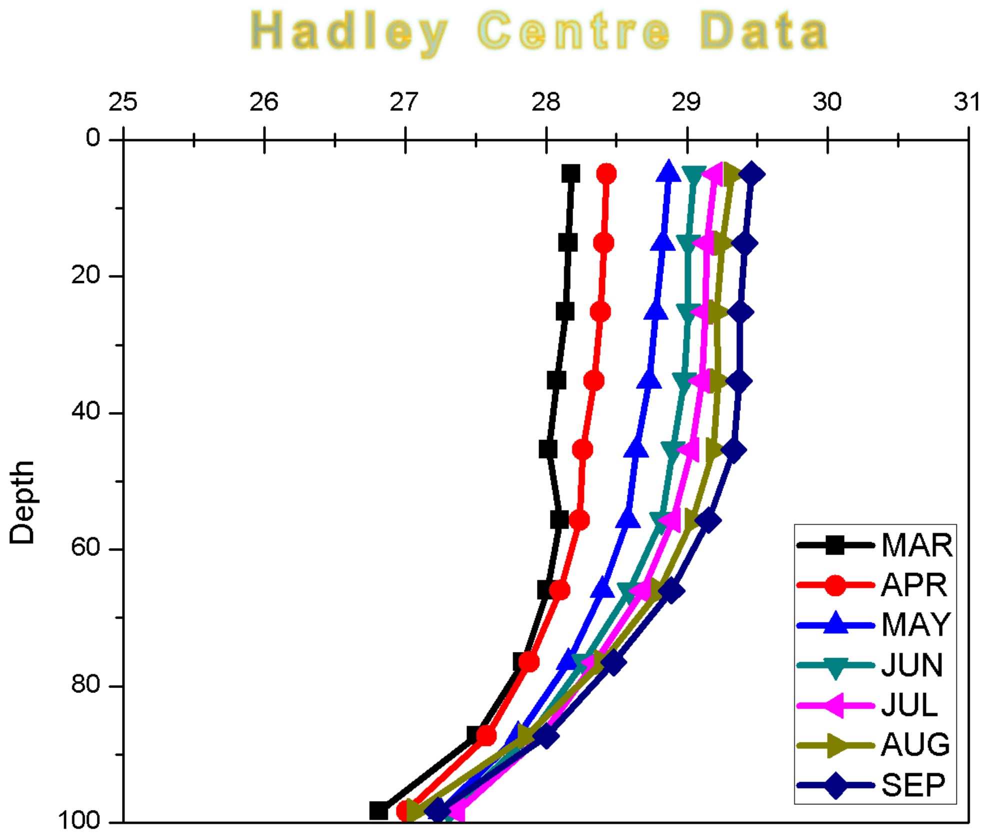


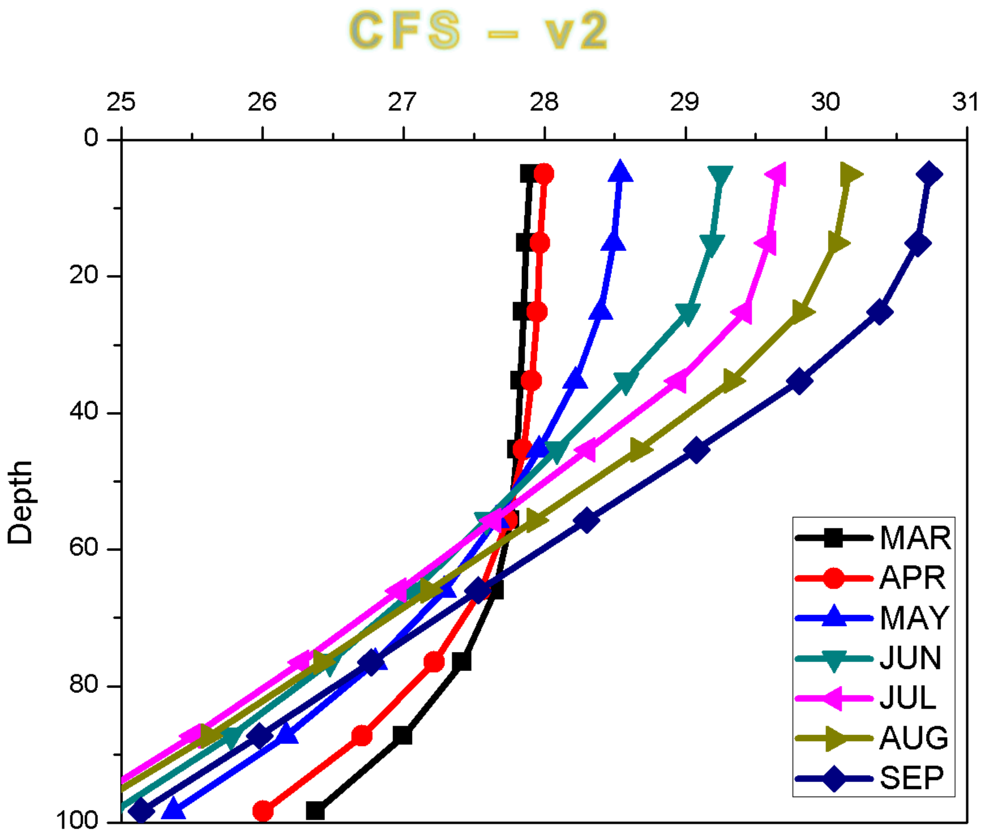
Hadley Centre Data
25
26
27
28
29
30
31
Depth
0
20
40
60
80
100
MAR
APR
MAY
JUN
JUL
AUG
SEP



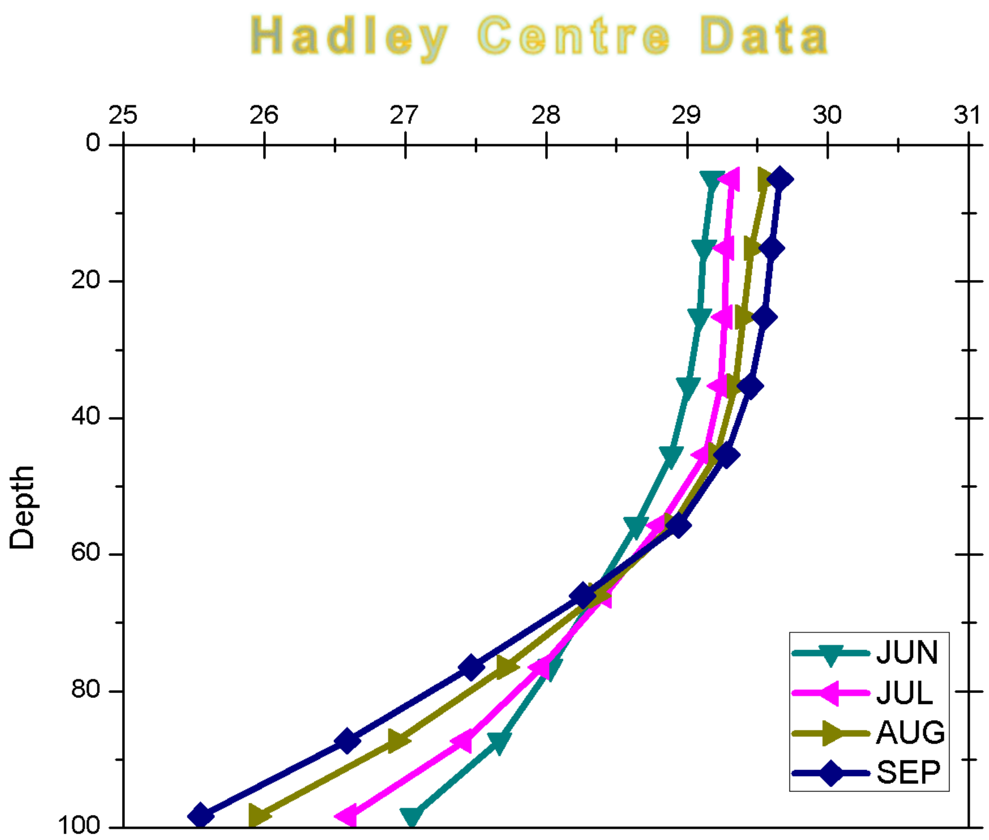
CFS – v2
25
26
27
28
29
30
31
Depth
20
40
60
80
100
MAR
APR
MAY
JUN
JUL
AUG
SEP

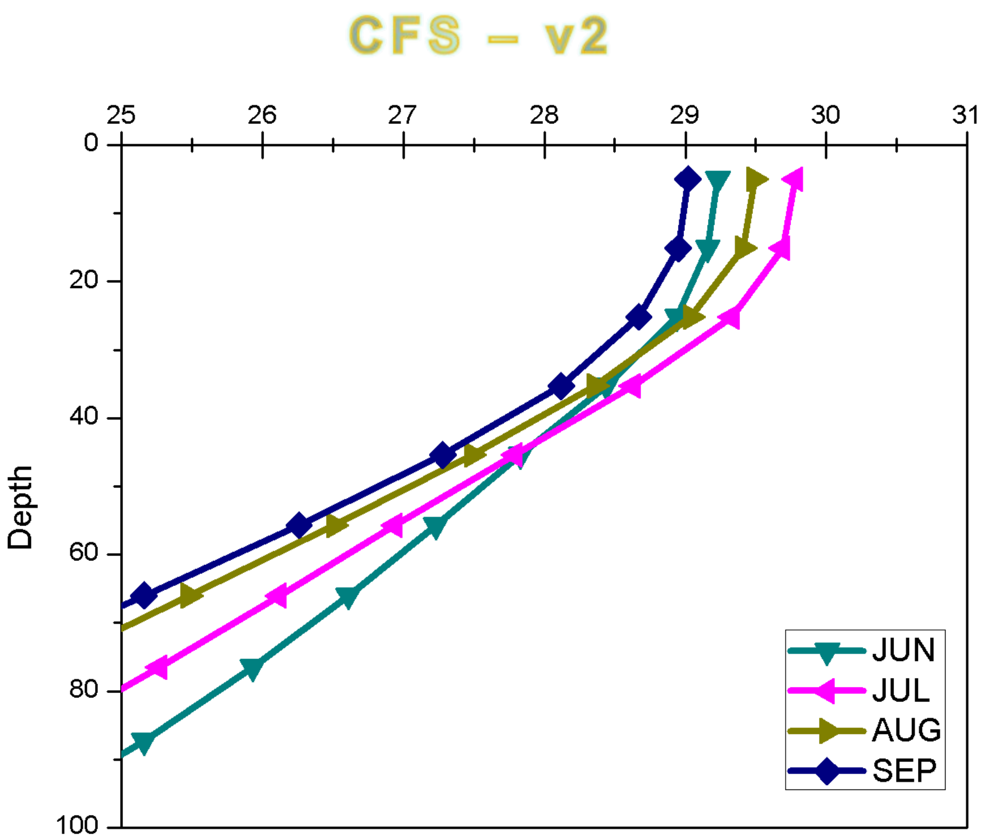
2007


Hadley Centre Data
25
26
27
28
29
30
31
0
20
40
60
80
100
Depth
MAR
APR
MAY
JUN
JUL
AUG
SEP

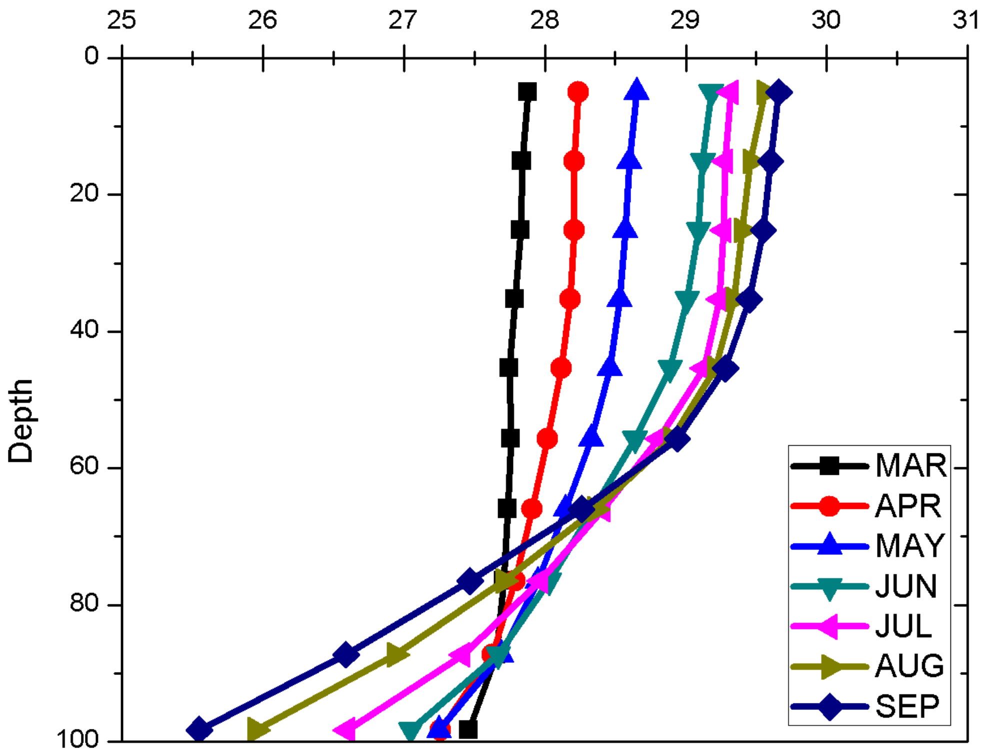

CFS – v2
25
26
27
28
29
30
31
0
20
40
60
80
100
Depth
MAR
APR
MAY
JUN
JUL
AUG
SEP

2009


Hadley Centre Data
25
26
27
28
29
30
31
0
20
40
60
80
100
Depth
JUN
JUL
AUG
SEP


CFS – v2
25
26
27
28
29
30
31
0
20
40
60
80
100
Depth
JUN
JUL
AUG
SEP

2009 observed



MLD Composite of 1998, 2002, 2003, 2004, 2007, 2009

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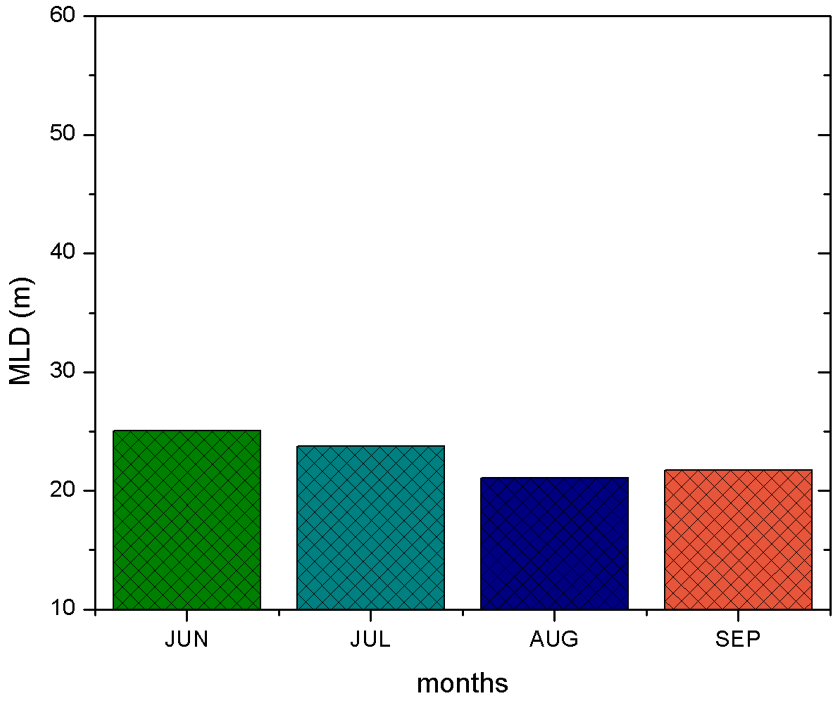
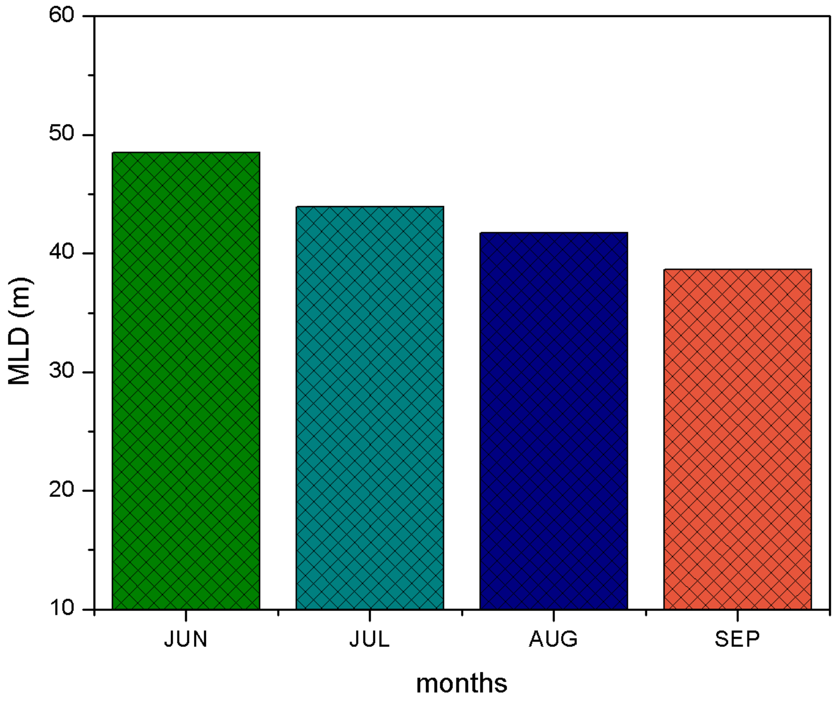


Climatology of MLD (Met Office Hadley Center Data)



1) In the CFS model, the MLD of the Pacific box rapidly decreases during the pre-monsoon season and reaches a value close to 20m during the monsoon season both in El-Nino and La-Nina years. In La-Nina year 1998 with no convection over west Pacific ocean during monsoon season (monsoon convection extends eastwards only up to longitude 120E), SST of Pacific box has increased at a rate more than double the rate of increase in the real ocean due to the model mixed layer depth being 20m. (In a La Nina year the real mixed layer depth is about 50m).

2) In El-Nino year 2004, in the first month of monsoon season (June), SST increased rapidly in the CFS model in the Pacific box with a mixed layer depth of 20m causing a spell of convection and strong westerly winds at 850 hPa there in July whereas in the real atmosphere/ocean the warming of SST was slower and the convection and increased westerly winds in the Pacific occurred in August. In the model, the Pacific box convection has intra-seasonal oscillation of period less than a month, whereas in the real atmosphere/ocean with a mixed layer depth of about 40 m, the period was close to two months.

3) We studied the short wave radiation flux, latent heat flux and net heat flux and their variations in the Pacific box during the monsoon season and found that the net heat flux (sum of short wave flux and latent heat flux, others being small) varied in phase with SST in Pacific box.

We suggest that the CFS model formulation (codes) that generate ocean temperatures in the top 100 meters of the ocean may be modified to produce realistic vertical profile of temperature (mixed layer depth) in the Pacific box during the monsoon season (in normal , El Nino and La Nina years), to enable the model to produce realistic growth rate of SST in the Pacific Box and intra seasonal oscillation.

Thank You

CFS

February Presentation