Slow and Fast Annual Cycles of the Asian Summer Monsoon in the NCEP CFSv2

(Evaluating the CFSv2 simulations for the phase-locked intrasesaonal variation of the Asian summer monsoon)

Chul-Su Shin and Bohua Huang

Center for Ocean-Land-Atmosphere Studies (COLA),
George Mason University

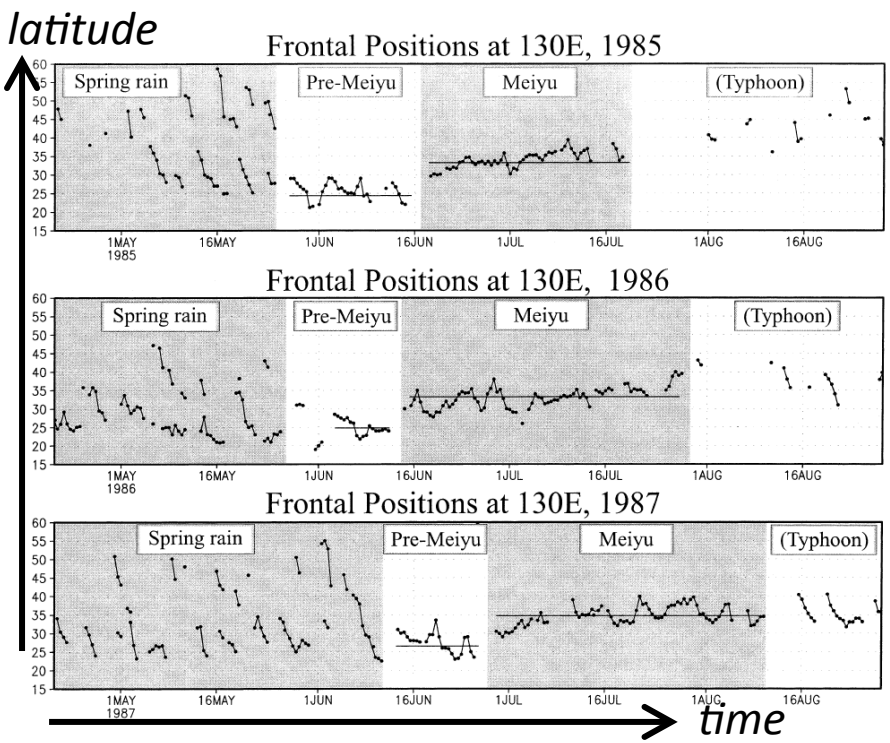
39th Climate Diagnostics and Prediction Workshop *10/22/2014*

Two key characteristics of the Asian monsoon system

1) **A strong annual cycle** with a rainy (dry) season in boreal summer (winter) & two transitions
2) **Abrupt changes on an intraseasonal timescale** during the rainy season (i.e., onset of local rainy season, alternative active-break cycles of local rainy season)

Two key characteristics of the Asian monsoon system

1) **A strong annual cycle** with a rainy (dry) season in boreal summer (winter) & two transitions
2) **Abrupt changes on an intraseasonal timescale** during the rainy season (i.e., onset of local rainy season, alternative active-break cycles of local rainy season)



Linho and Wang (2002, JC)

- ***Slow Annual Cycle (SAC) :***

a slowly evolving seasonal transition

- ***Fast Annual Cycle (FAC) :***

a subseasonal component superposed on the slow annual cycle, which tends to be phased locked in time and space

How well are the SAC and FAC of the Asian monsoon simulated in the CFSv2?

Data

The observational Climatology :
daily NOAA OLR, pentad CMAP precipitation, daily OISSTv2, daily heat fluxes from the OAFlux, *and the* ***NCEP-DOE reanalysis II***.

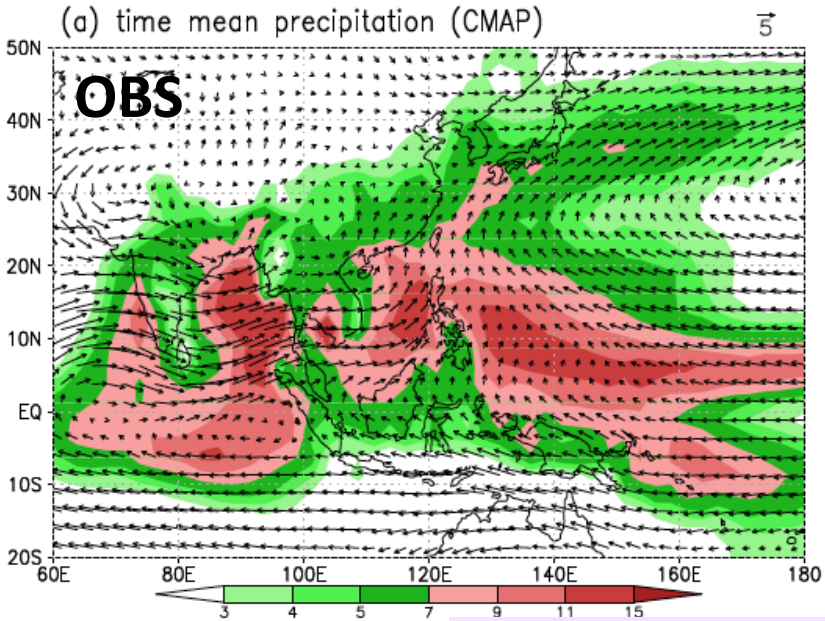
The CFSv2 climatology :
derived **from *the last 25 years of a 30-year simulation starting from the ocean-atmosphere CFSR state*** *on November 2, 1980*

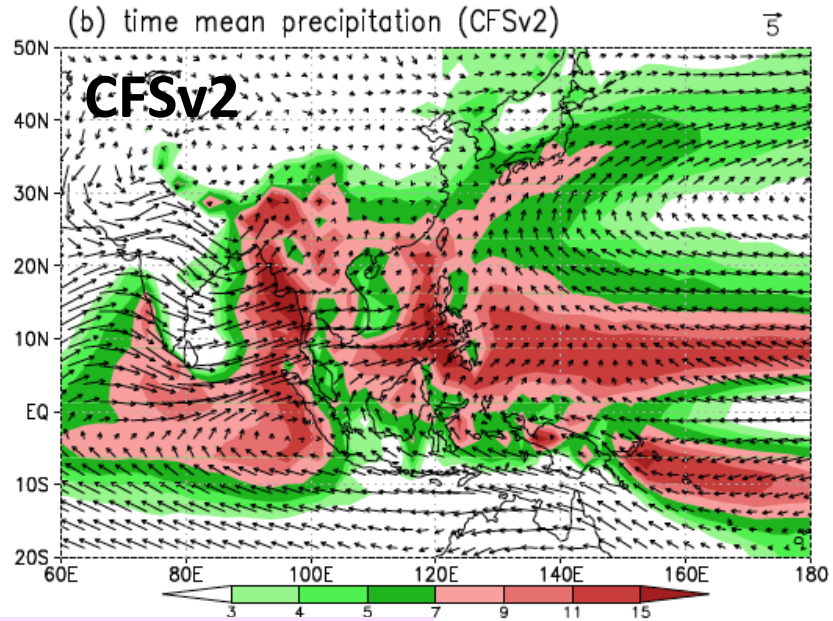
Procedure

Non-overlapping 5-day average to make the pentad data sets;
time average for each calendar pentad & **remove weather noise (~7.5 days)**
⇒ ***the climatological annual cycle (73-pentad dataset)***

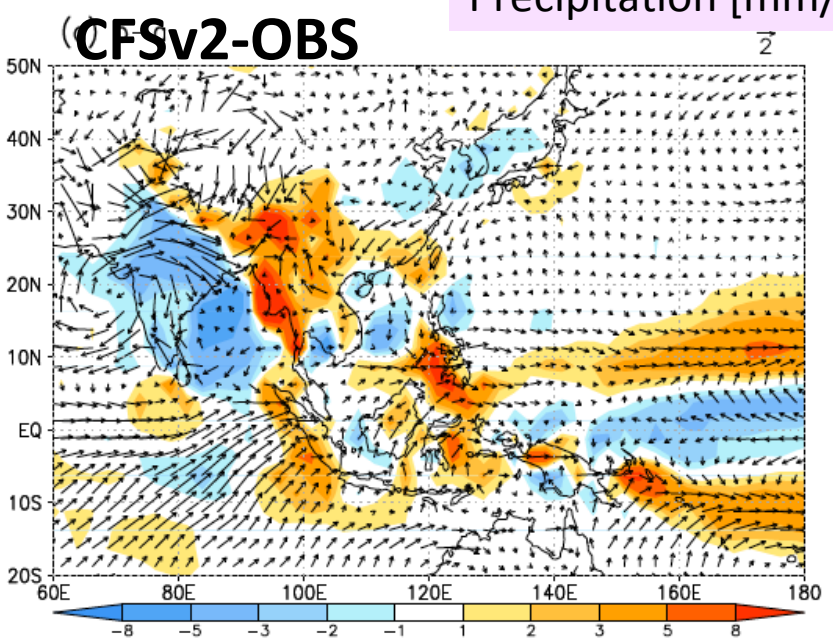
⇒ ***the slow annual cycle (SAC) : the first four harmonics***
⇒ ***the fast annual cycle (FAC) : the resulting time series*** *after subtracting the SAC*

Boreal Summer (MJJAS) Mean States

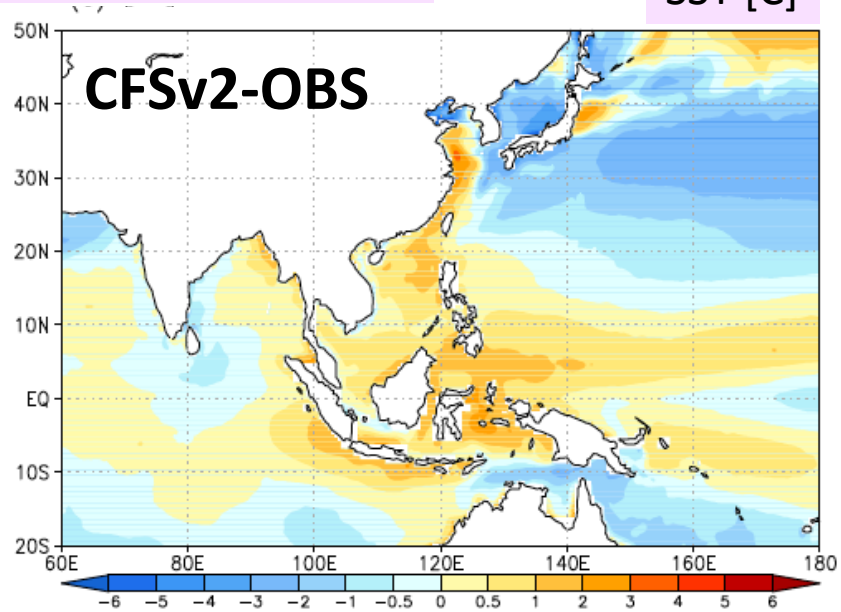




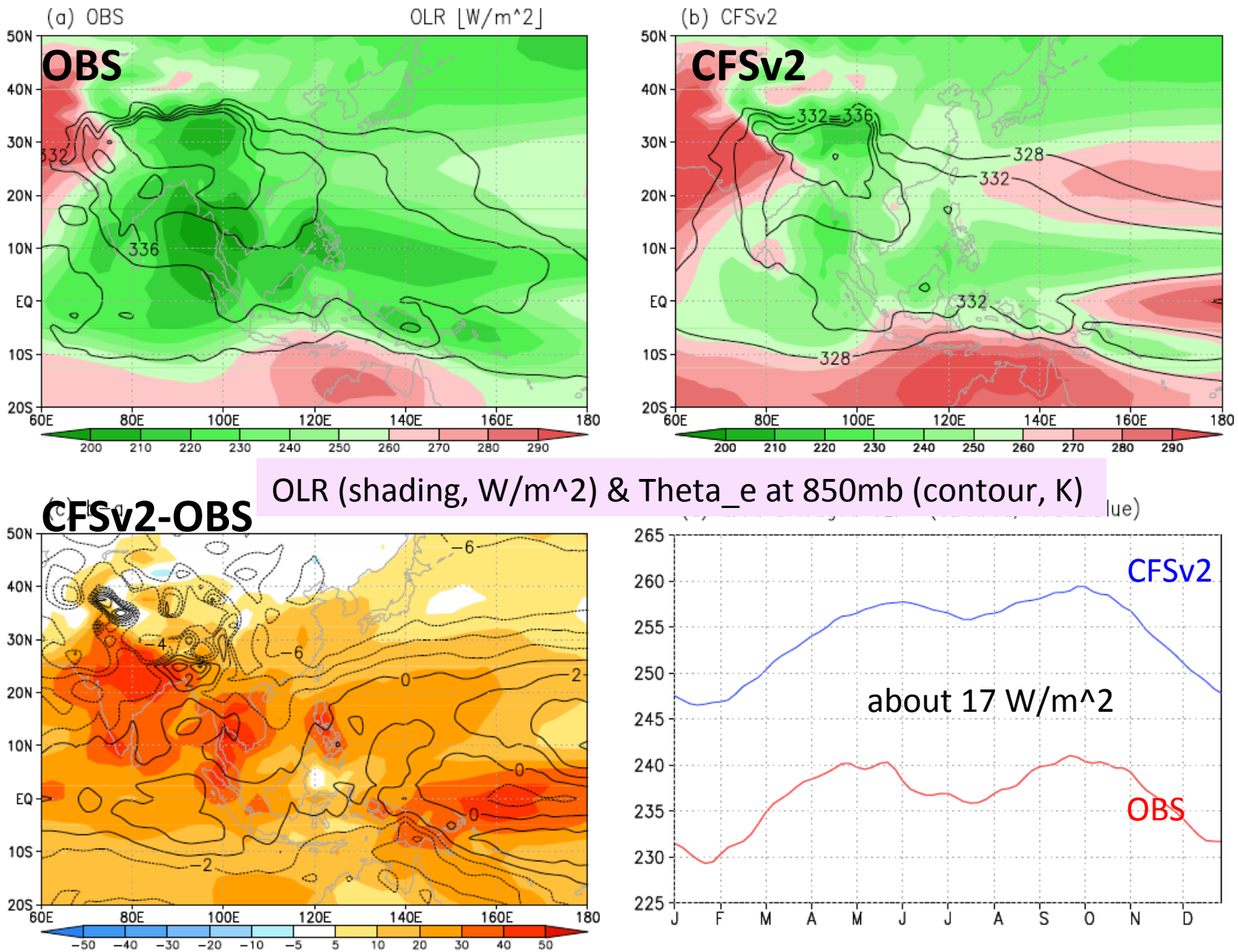
Precipitation [mm/day] & wind at 850mb



SST [C]



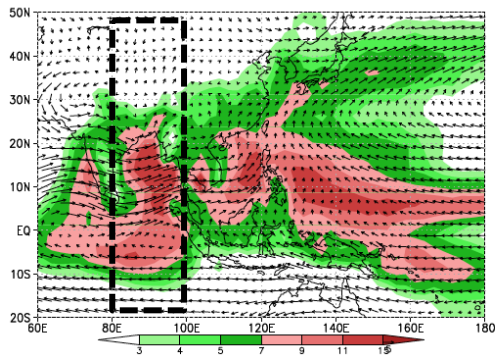
Boreal Summer (MJJAS) Mean States

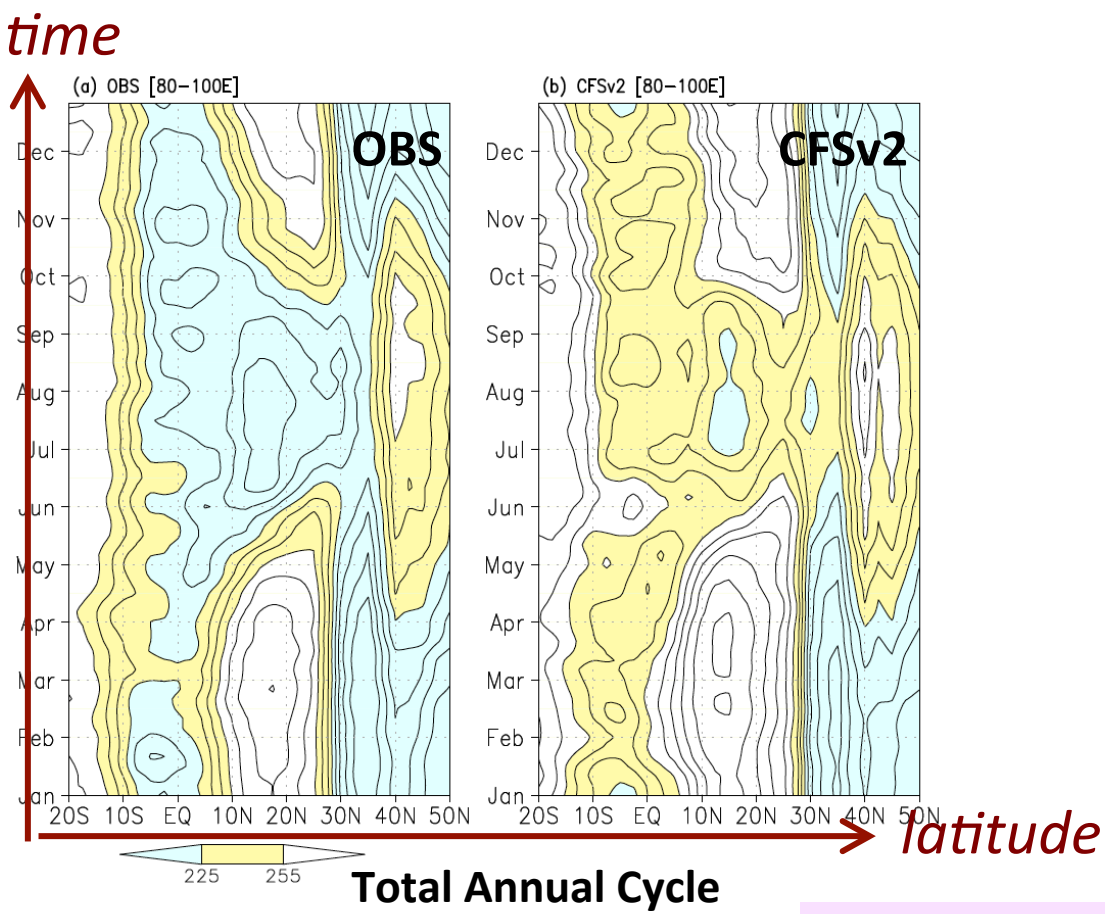


OLR (shading, W/m^2) & Theta_e at 850mb (contour, K)

Slow Annual Cycle

Indian Monsoon Region (80°E-100°E)

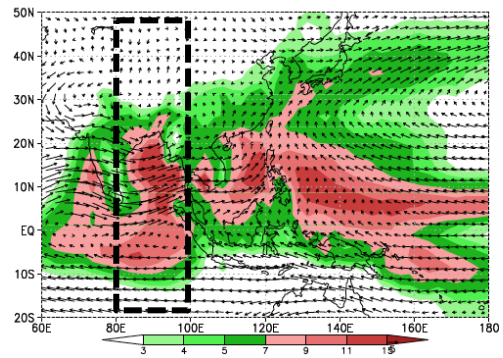


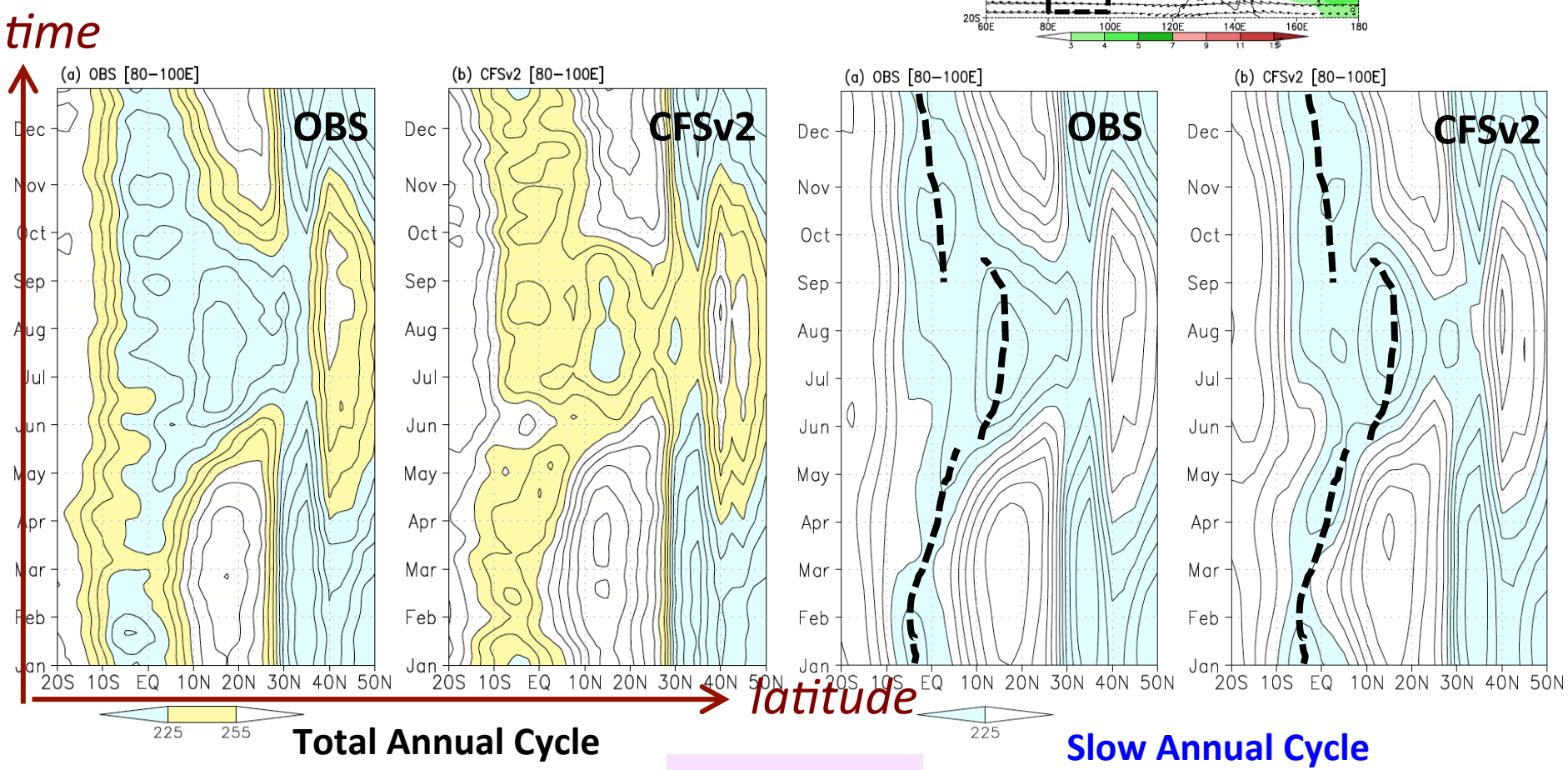


OLR (W/m^2)

Slow Annual Cycle

Indian Monsoon Region (80°E-100°E)





Total Annual Cycle

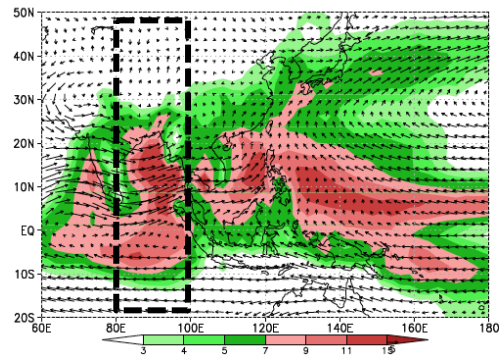
Slow Annual Cycle

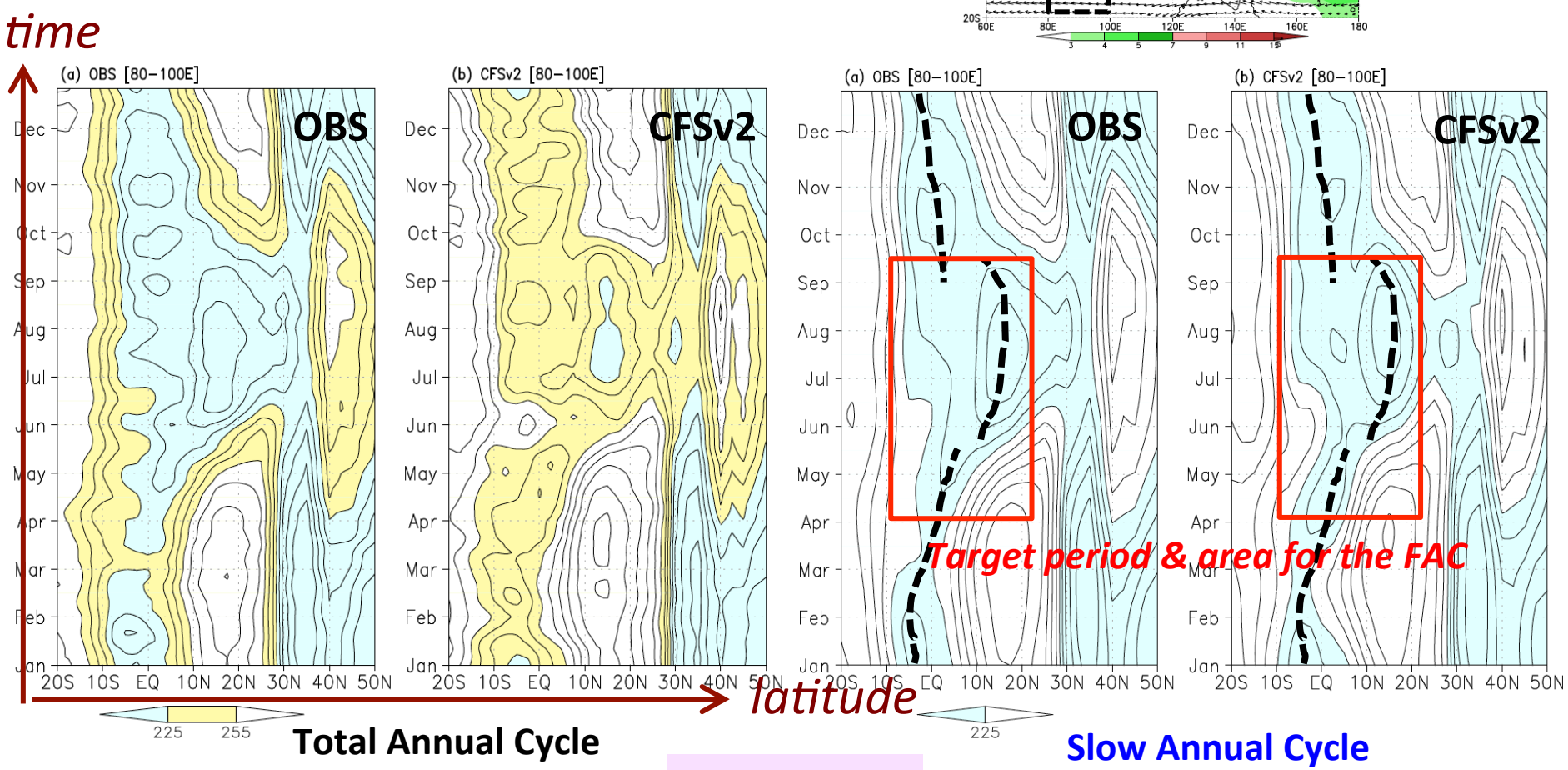
OLR (W/m^2)

**Removed the model bias*

Slow Annual Cycle

Indian Monsoon Region (80°E-100°E)





Total Annual Cycle

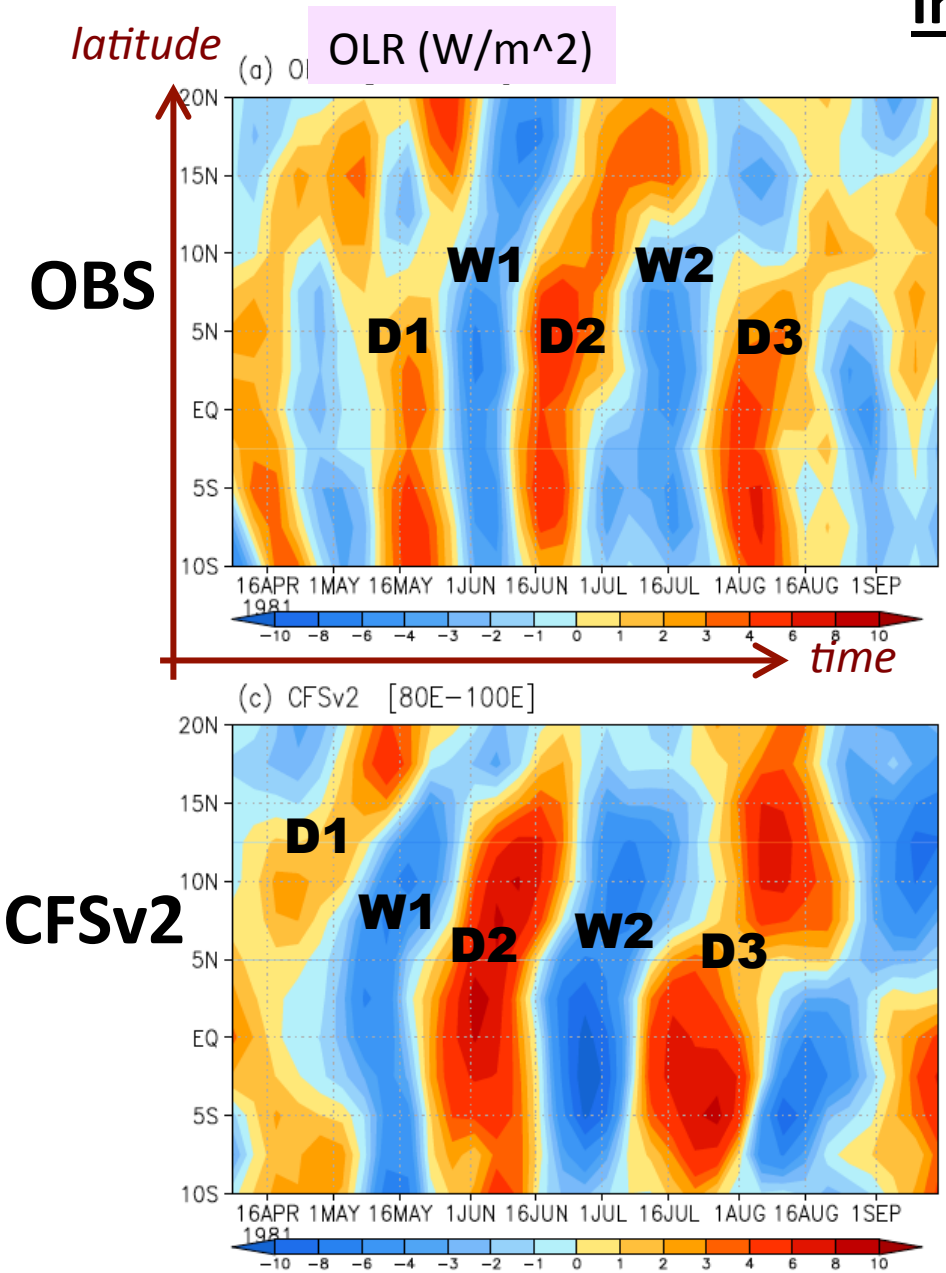
Slow Annual Cycle

OLR (W/m^2)

**Removed the model bias*

Fast Annual Cycle

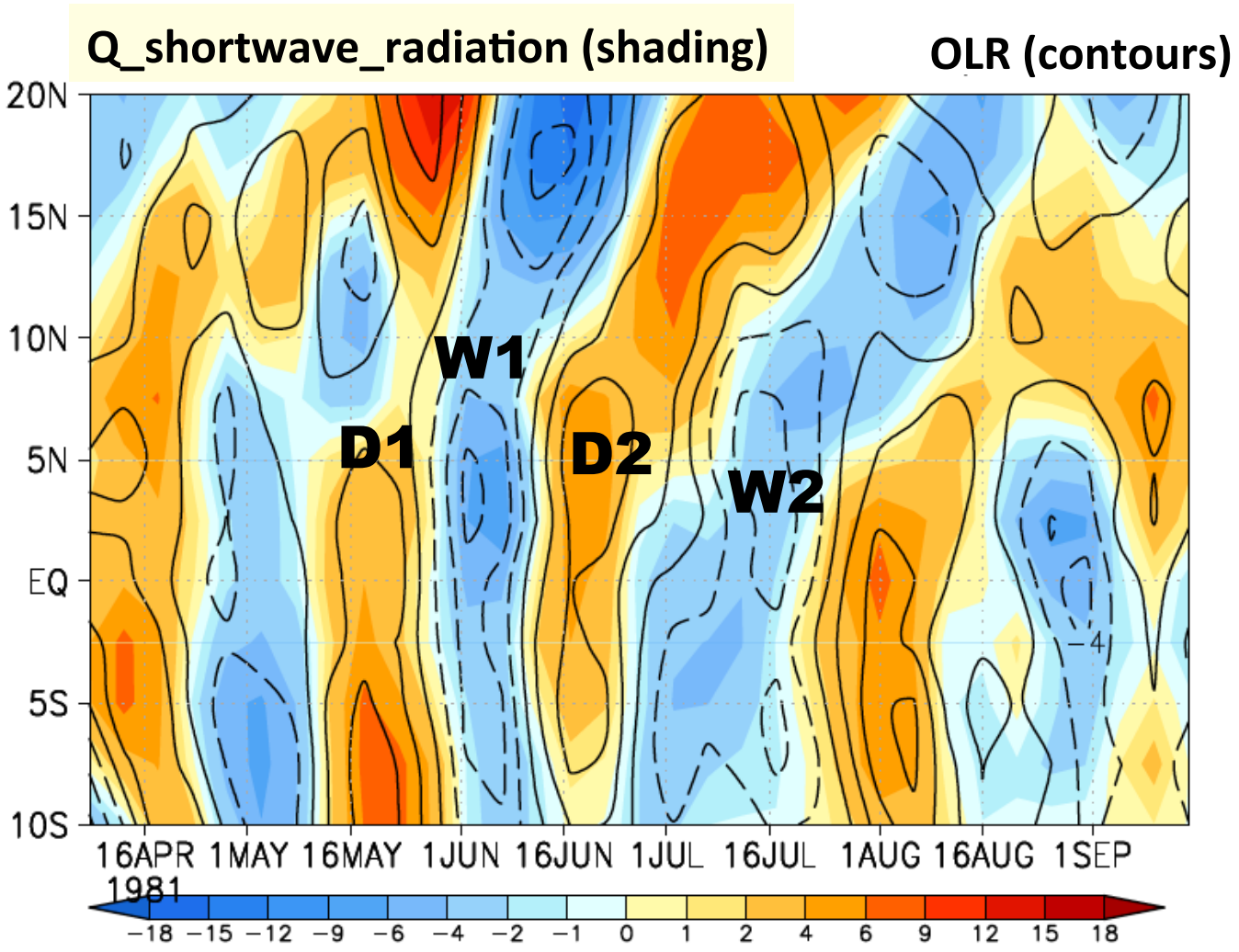
Indian Monsoon Region (80°E-100°E)



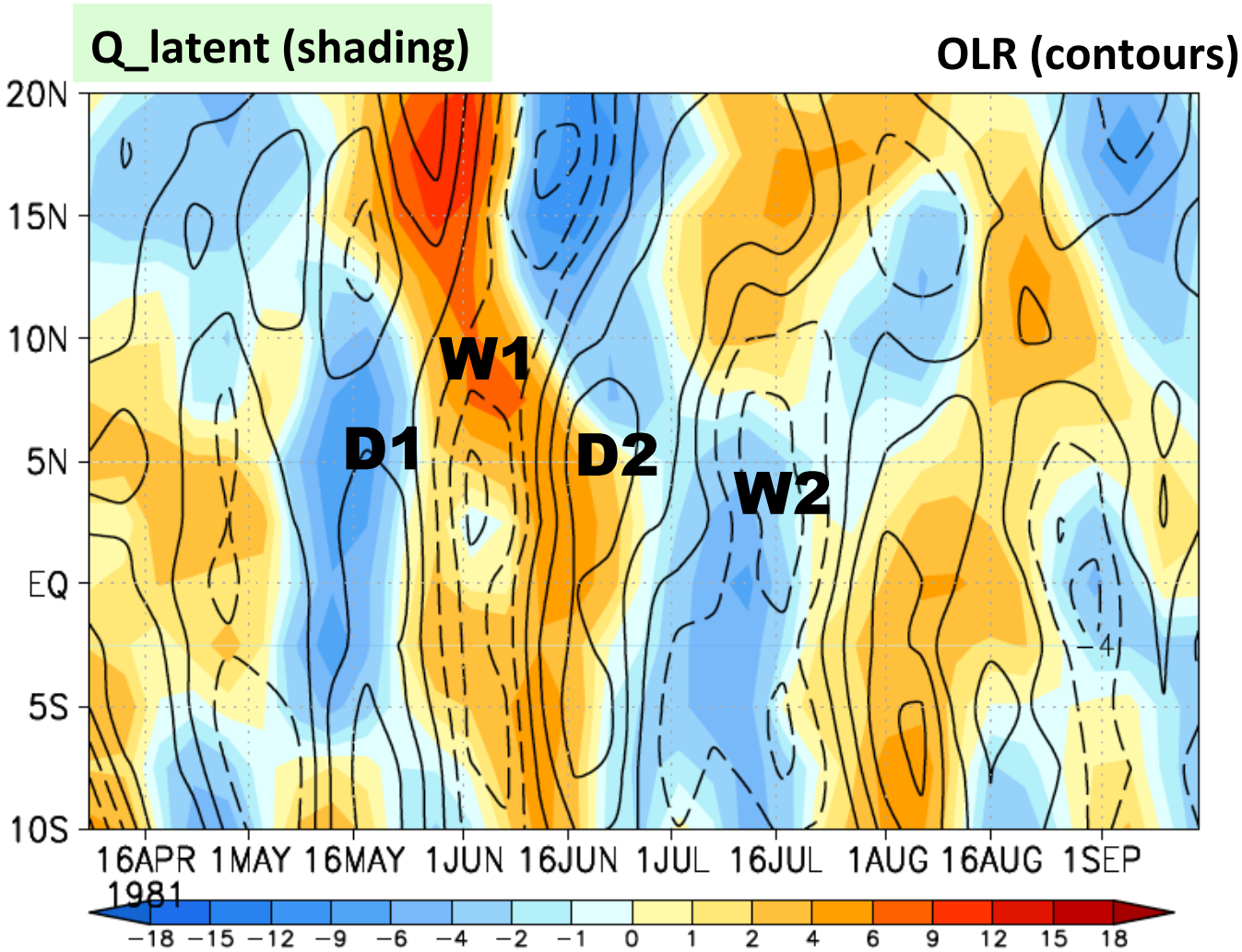
Northward propagating signal of both dry and wet phases are well reproduced by the CSFv2.

Earlier start of monsoon season & Long lasting stronger wet and dry phases in the CFSv2 than the observation

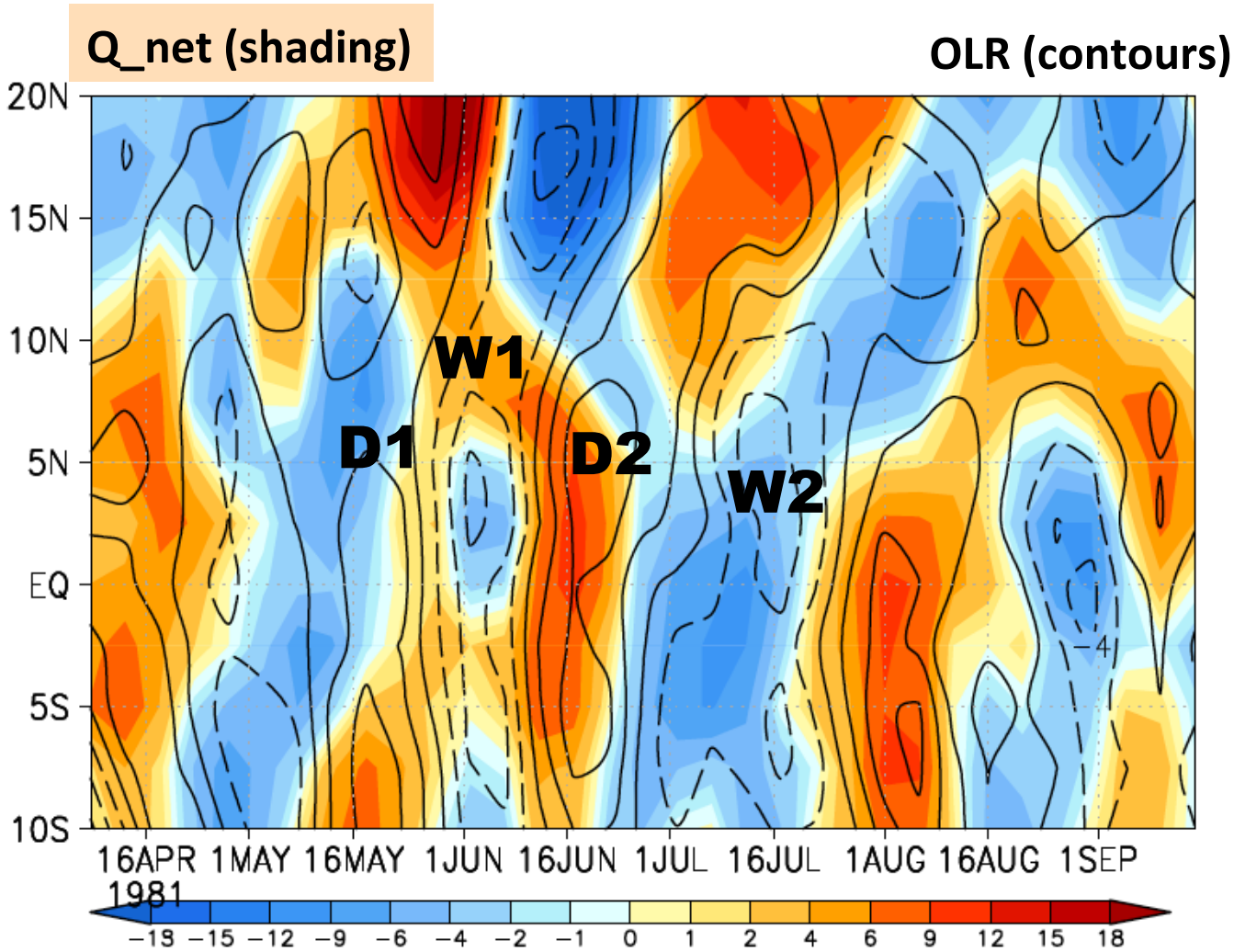
Air-Sea Interaction in the FAC (OBS, 80°E-100°E)



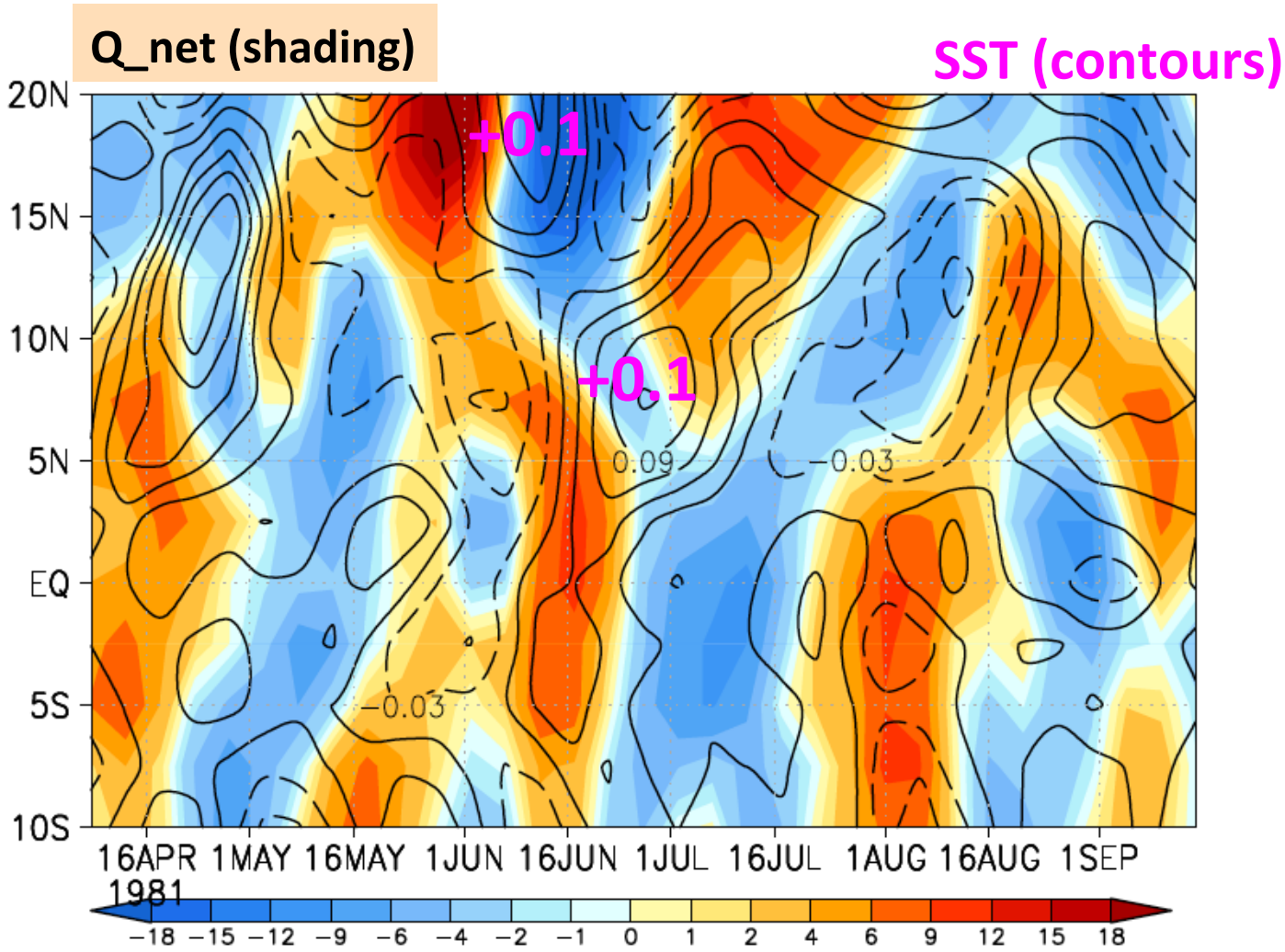
Air-Sea Interaction in the FAC (OBS, 80°E-100°E)



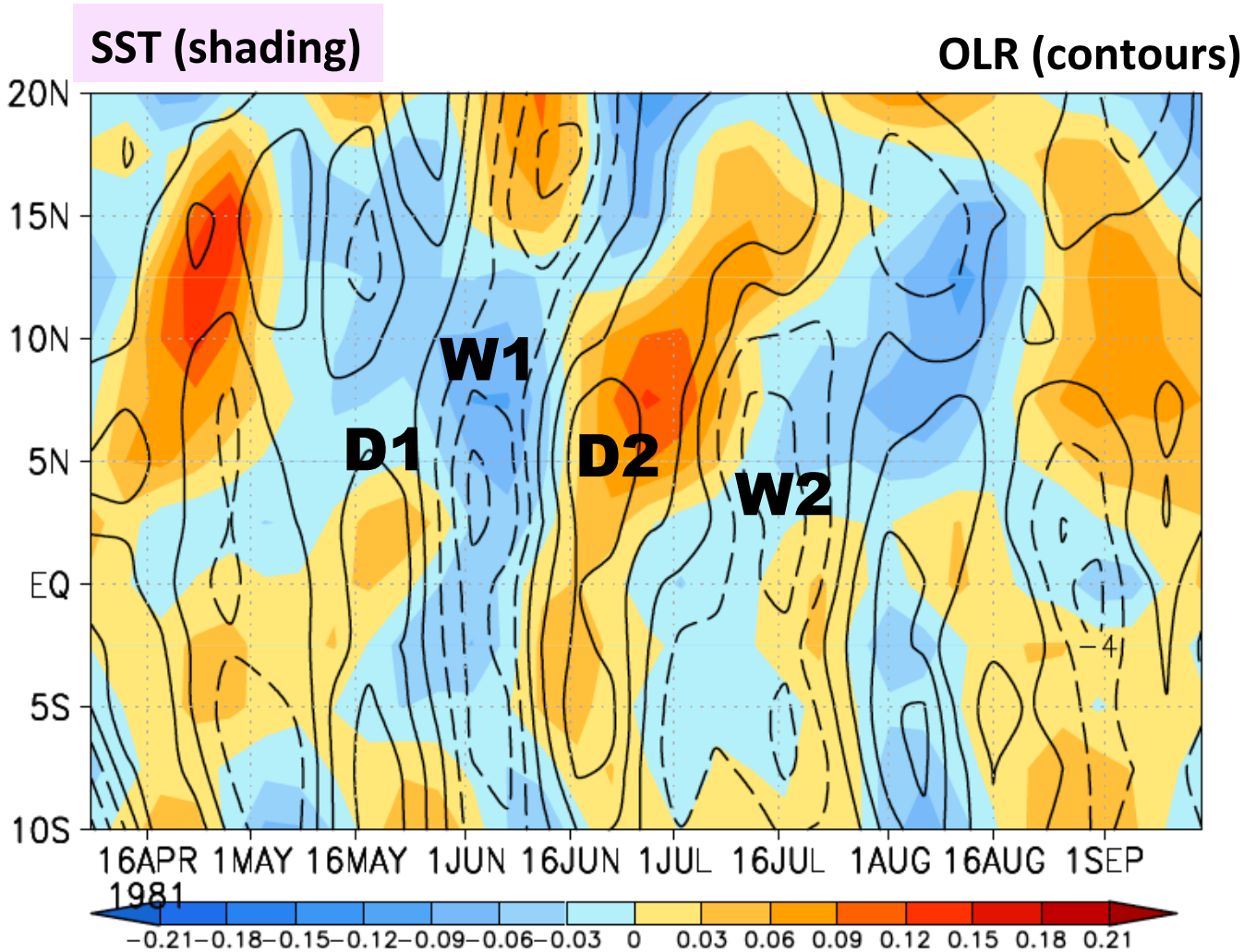
Air-Sea Interaction in the FAC (OBS, 80°E-100°E)

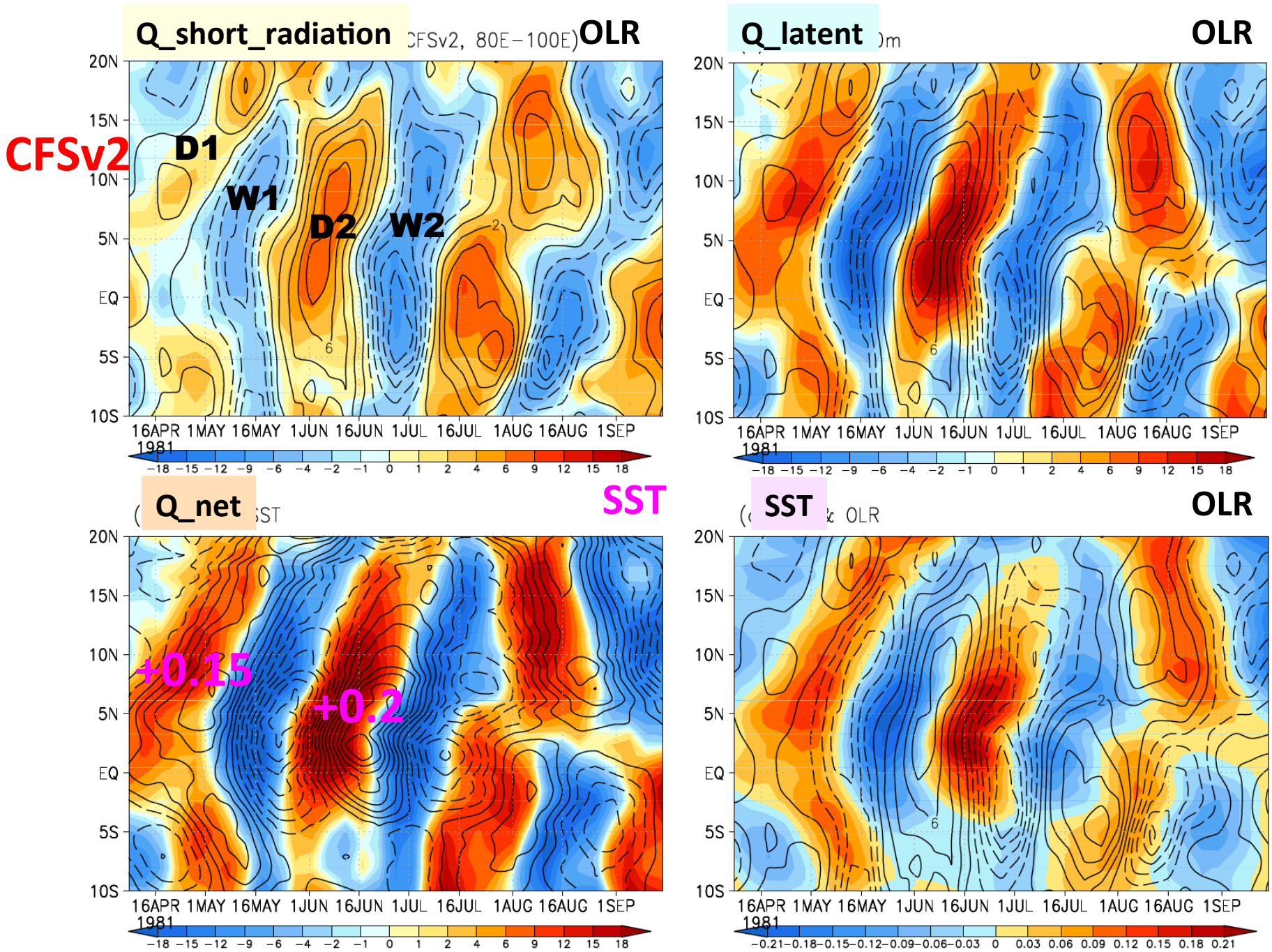


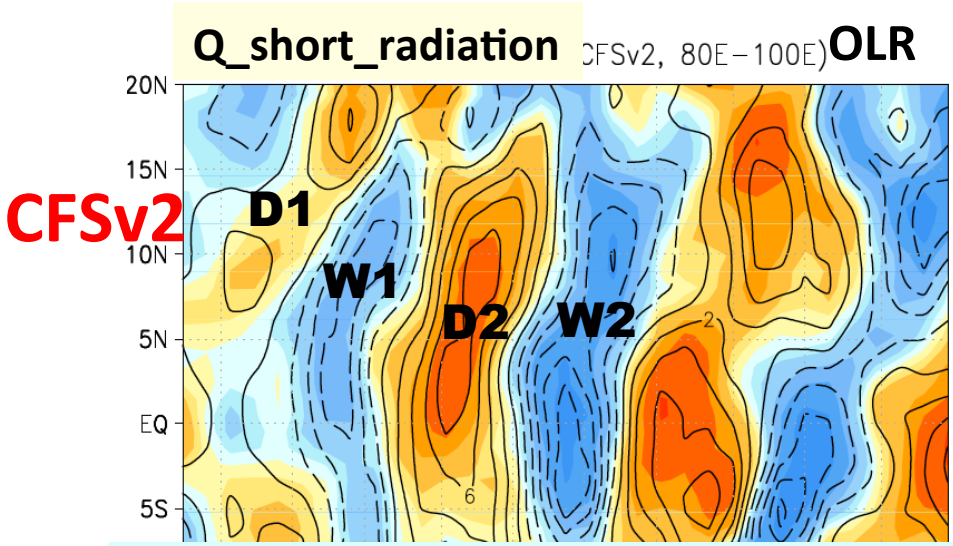
Air-Sea Interaction in the FAC (OBS, 80°E-100°E)

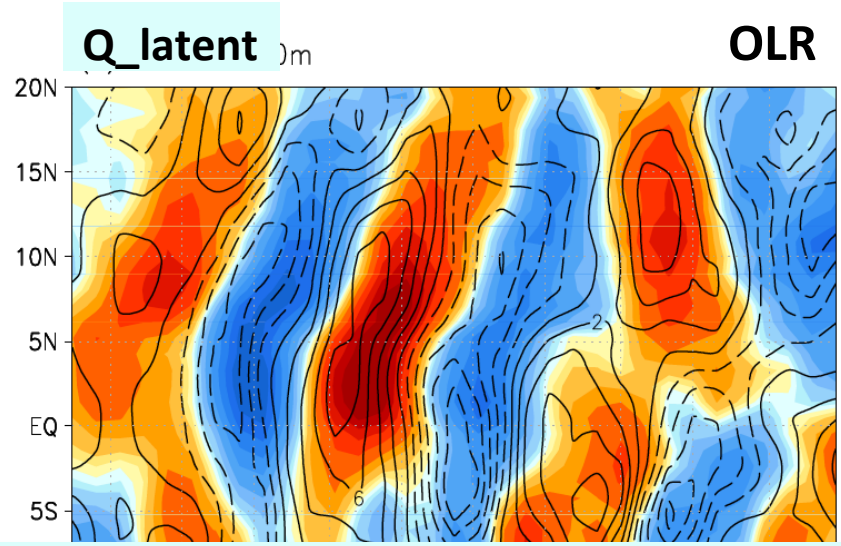


Air-Sea Interaction in the FAC (OBS, 80°E-100°E)

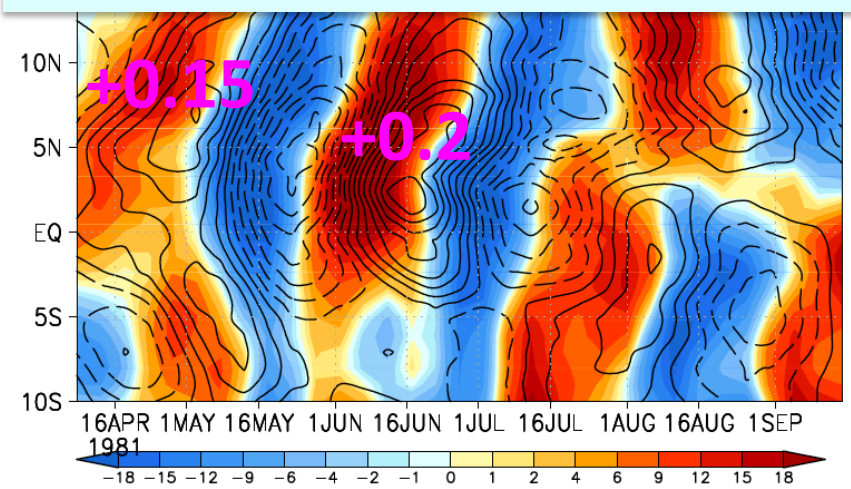


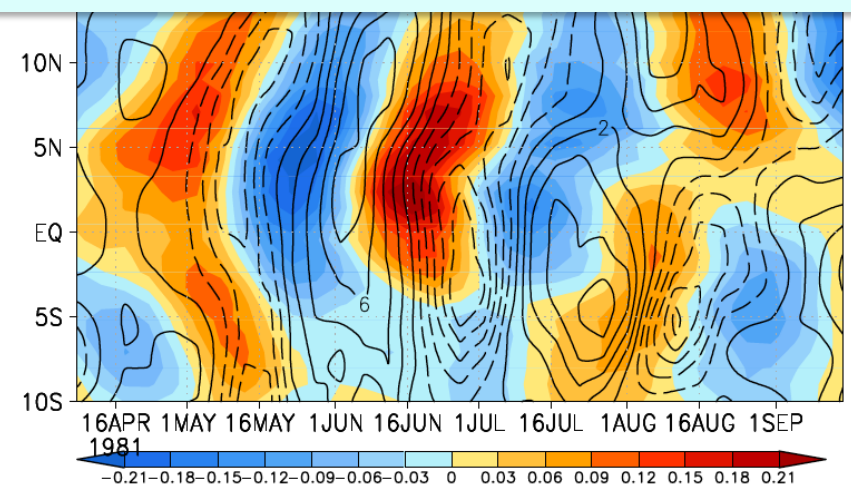

Q_short_radiation
CFSv2, 80E−100E)
OLR
CFSv2
D1
W1
D2
W2
Q_latent
OLR
Q_net
SST
+0.15
+0.2
SST
OLR
20N
15N
10N
5N
EQ
5S
10S
16APR 1MAY 16MAY 1JUN 16JUN 1JUL 16JUL 1AUG 16AUG 1SEP
1981
−18 −15 −12 −9 −6 −4 −2 −1 0 1 2 4 6 9 12 15 18
−0.21 −0.18 −0.15 −0.12 −0.09 −0.06 −0.03 0 0.03 0.06 0.09 0.12 0.15 0.18 0.21





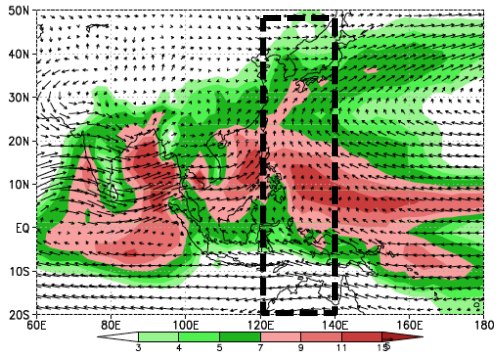
Over the Indian Monsoon region, the CFSv2 tends to show stronger coupling among ocean surface heat fluxes, SST, and convections in the FAC.

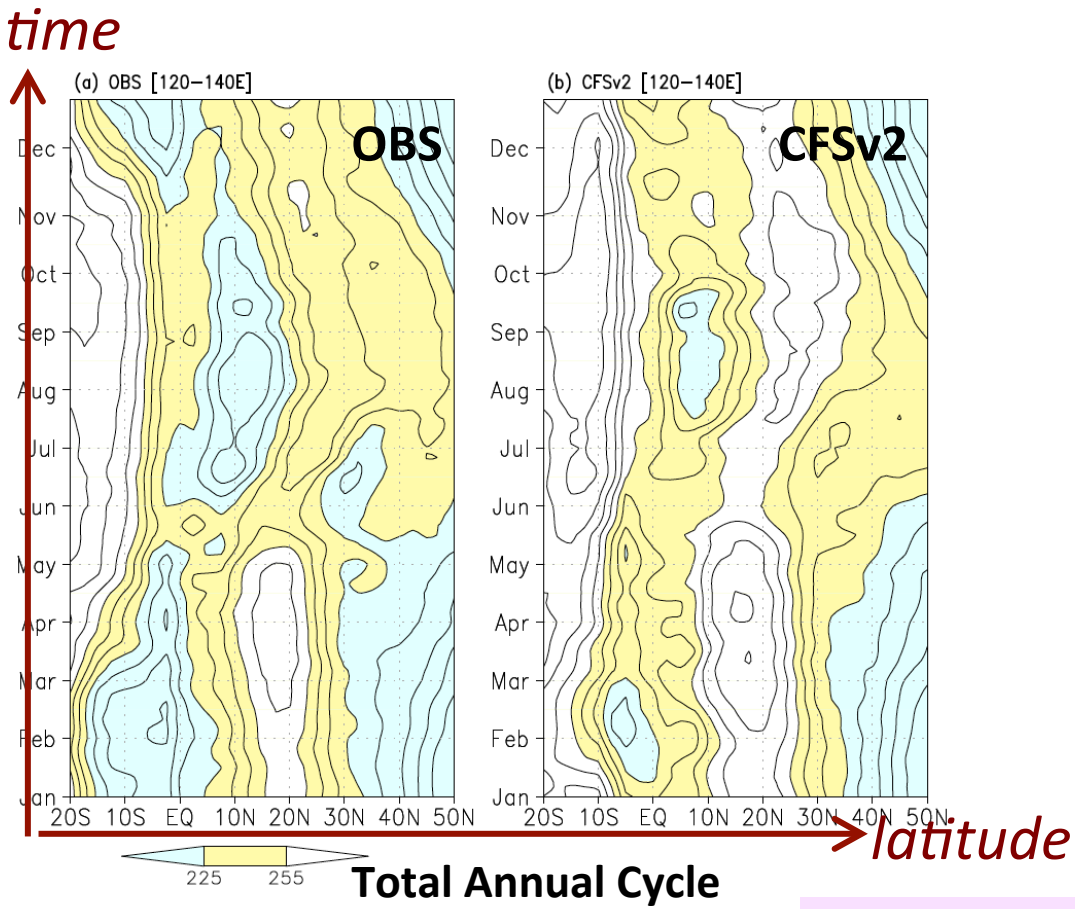




Slow Annual Cycle

East Asian Monsoon Region (120°E-140°E)

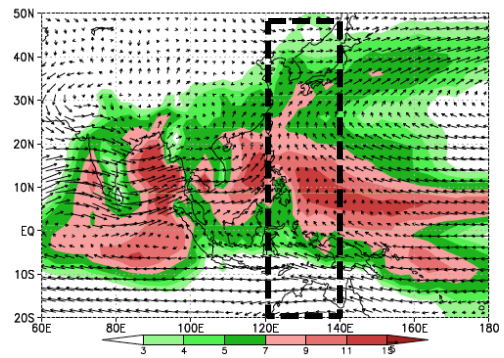


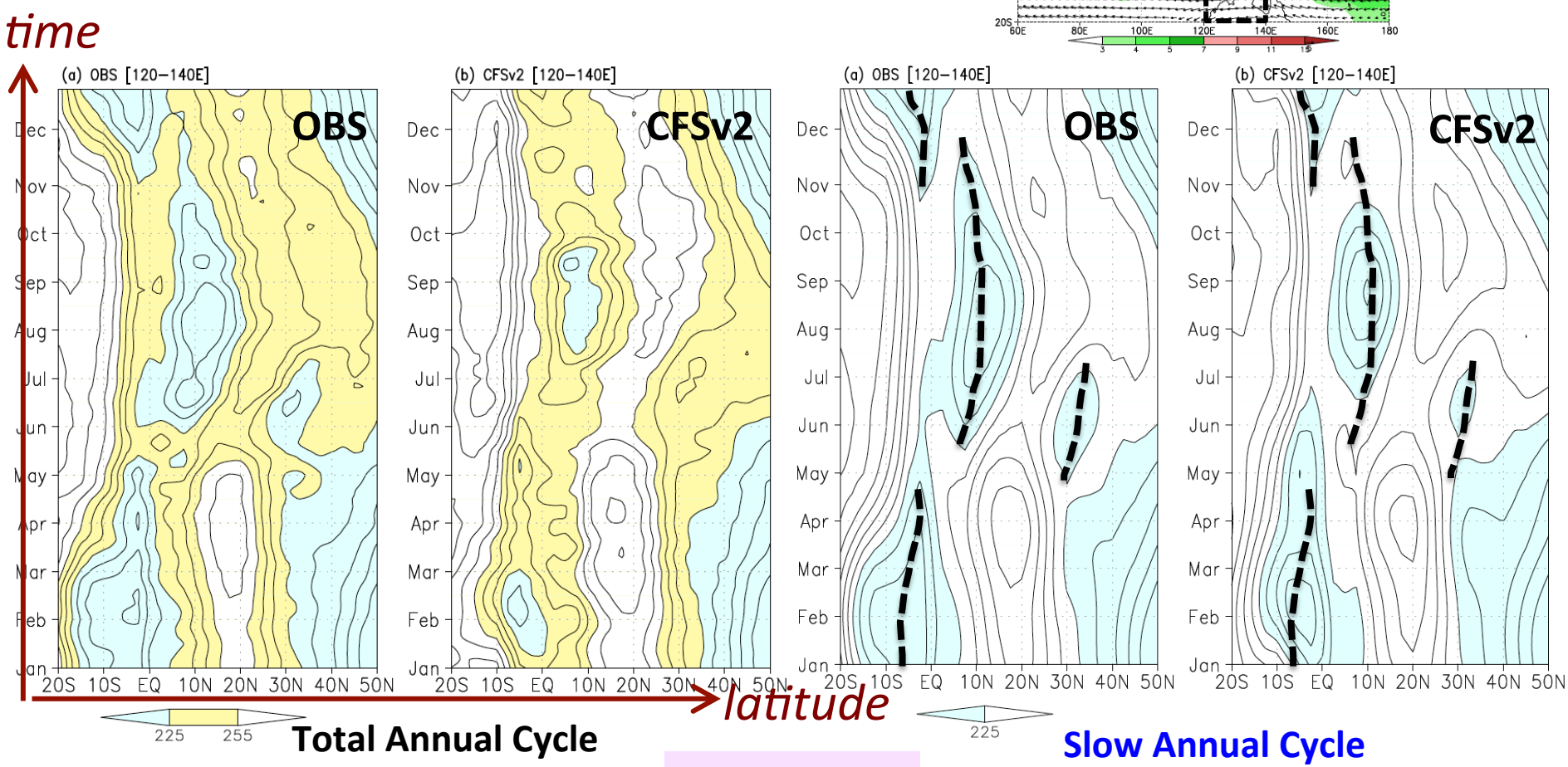


OLR (W/m^2)

Slow Annual Cycle

East Asian Monsoon Region (120°E-140°E)



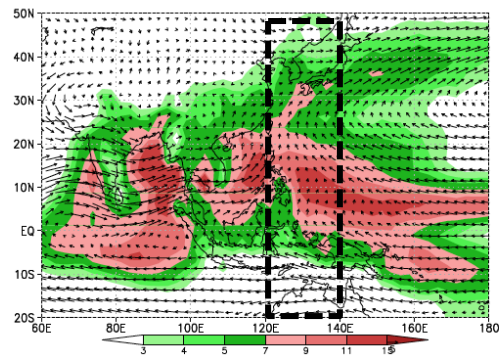


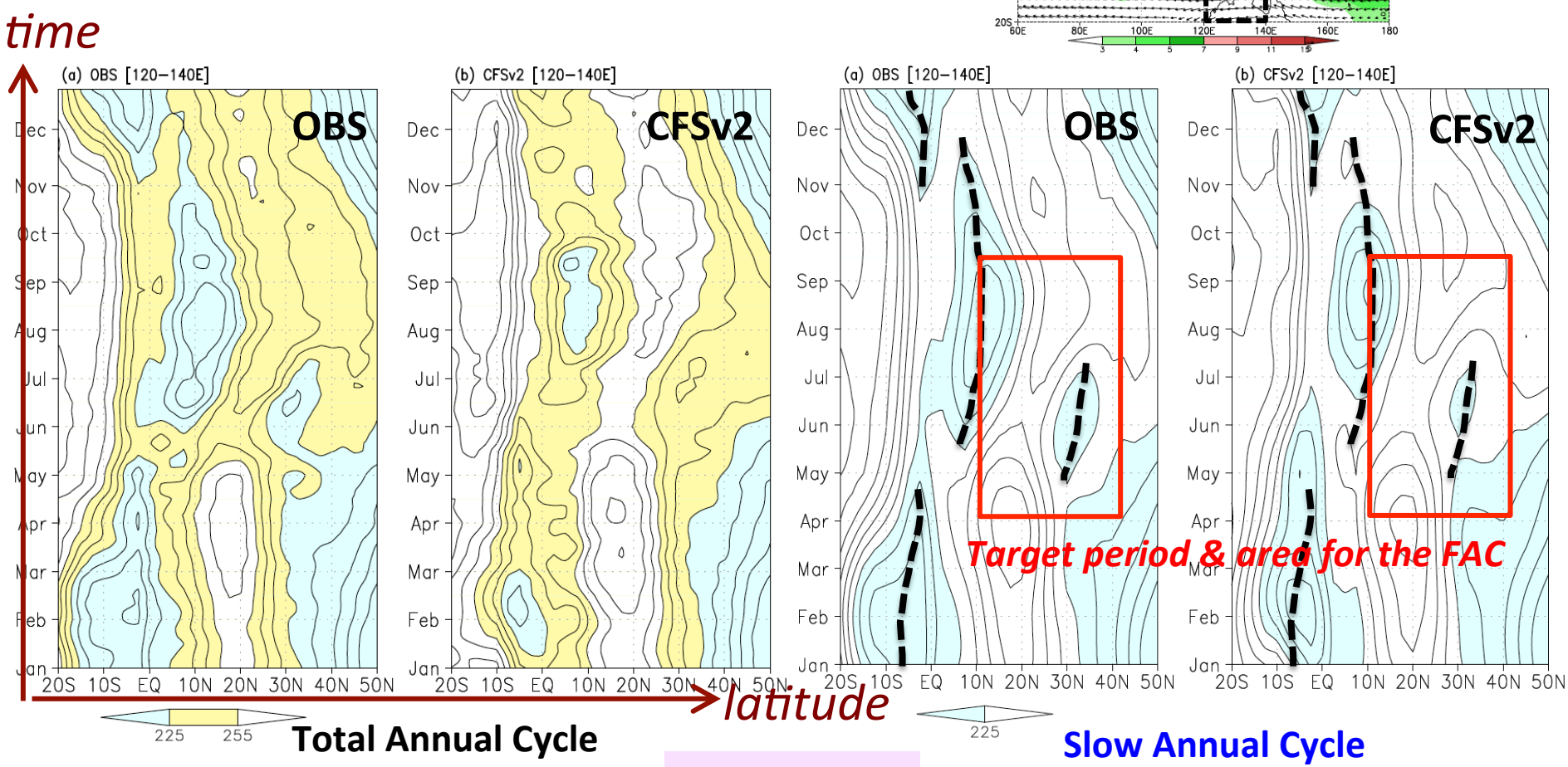
OLR (W/m^2)

**Removed the model bias*

Slow Annual Cycle

East Asian Monsoon Region (120°E-140°E)



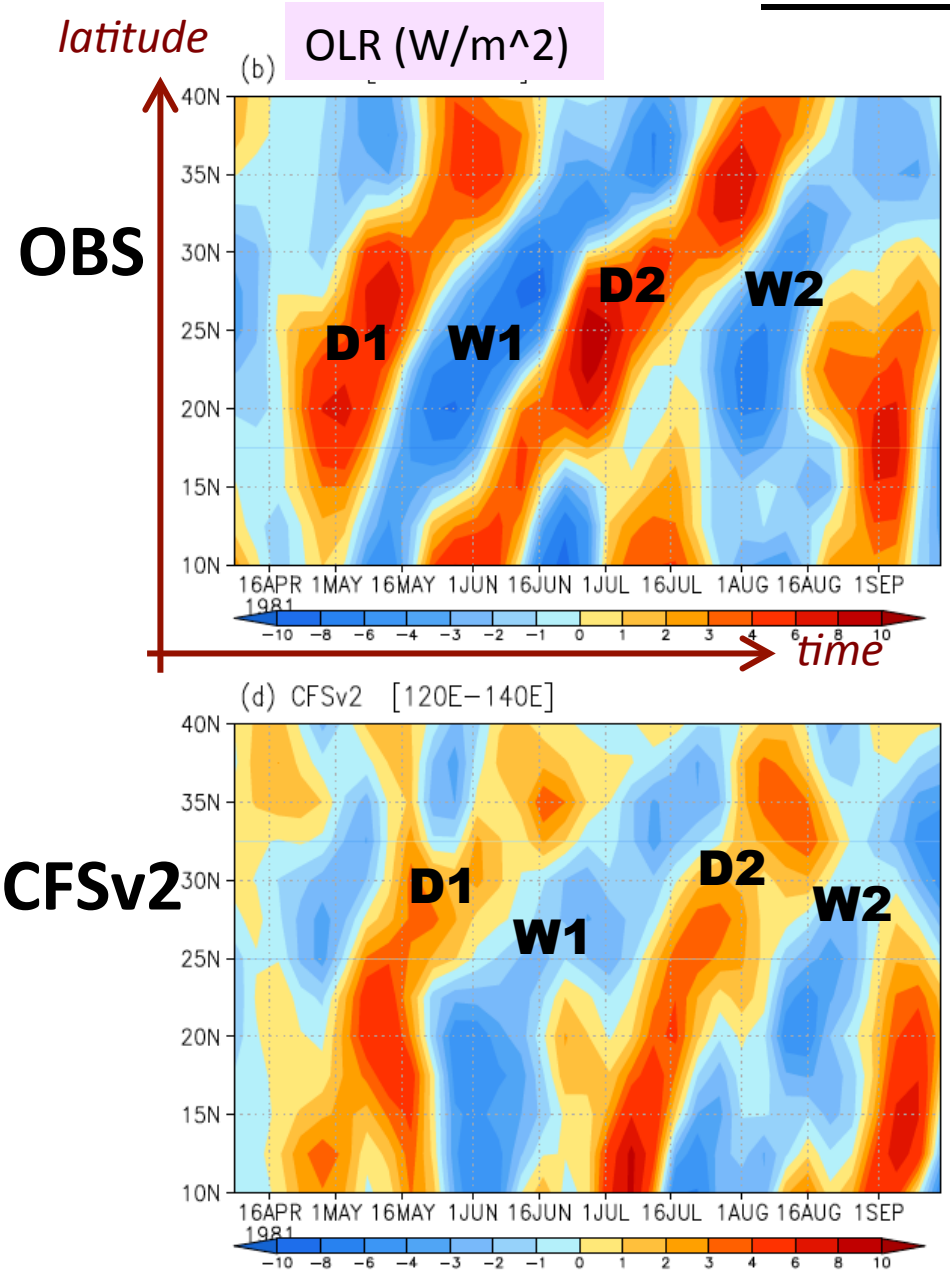


OLR (W/m^2)

*Removed the model bias

Fast Annual Cycle

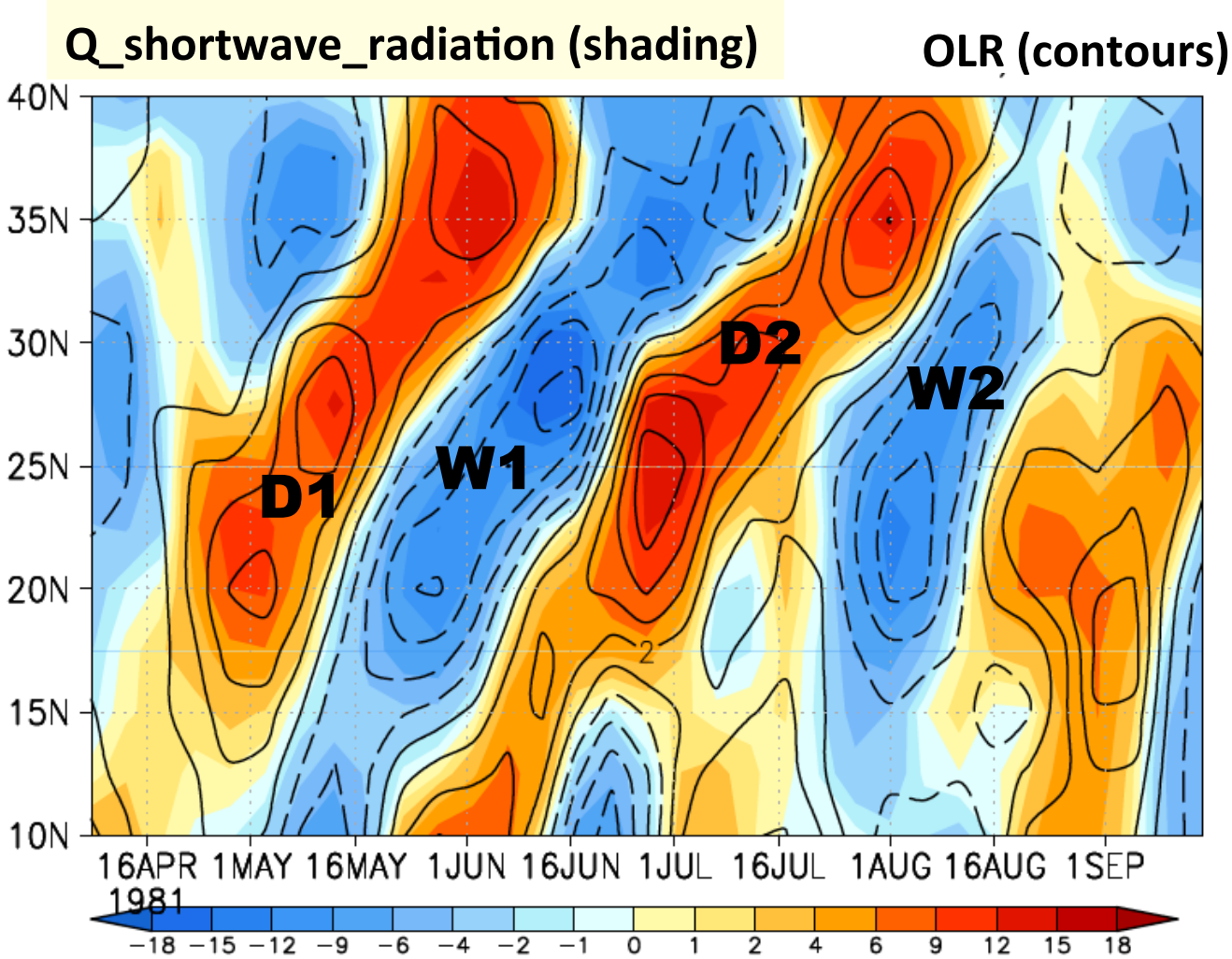
East Asian Monsoon Region (120°E-140°E)



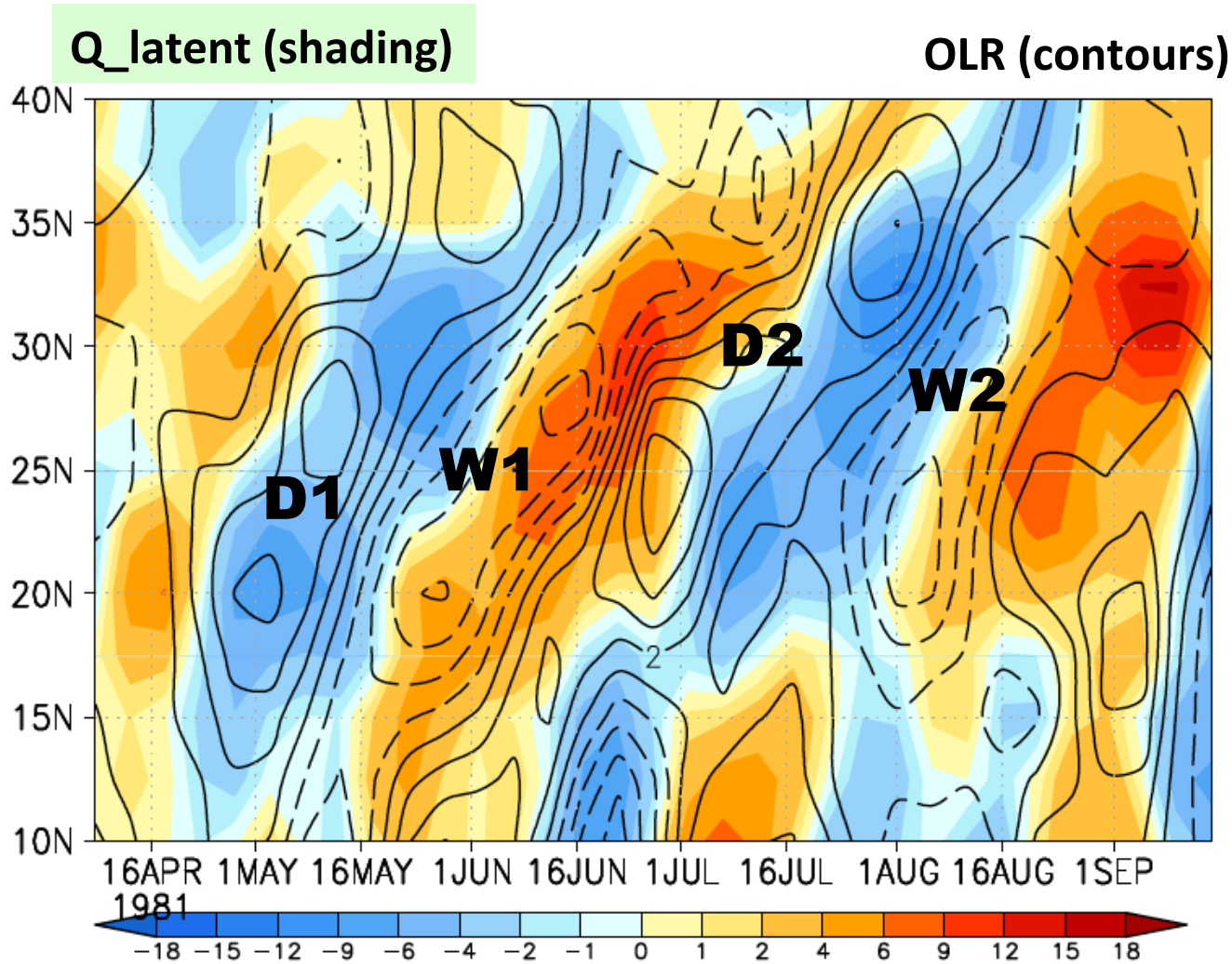
Northward propagating signal of both dry and wet phases are also well simulated by the CSFv2.

Delayed 1st and 2nd wet phases & disorganized wet and dry phases with weaker intensity in the CFSv2 than observation.

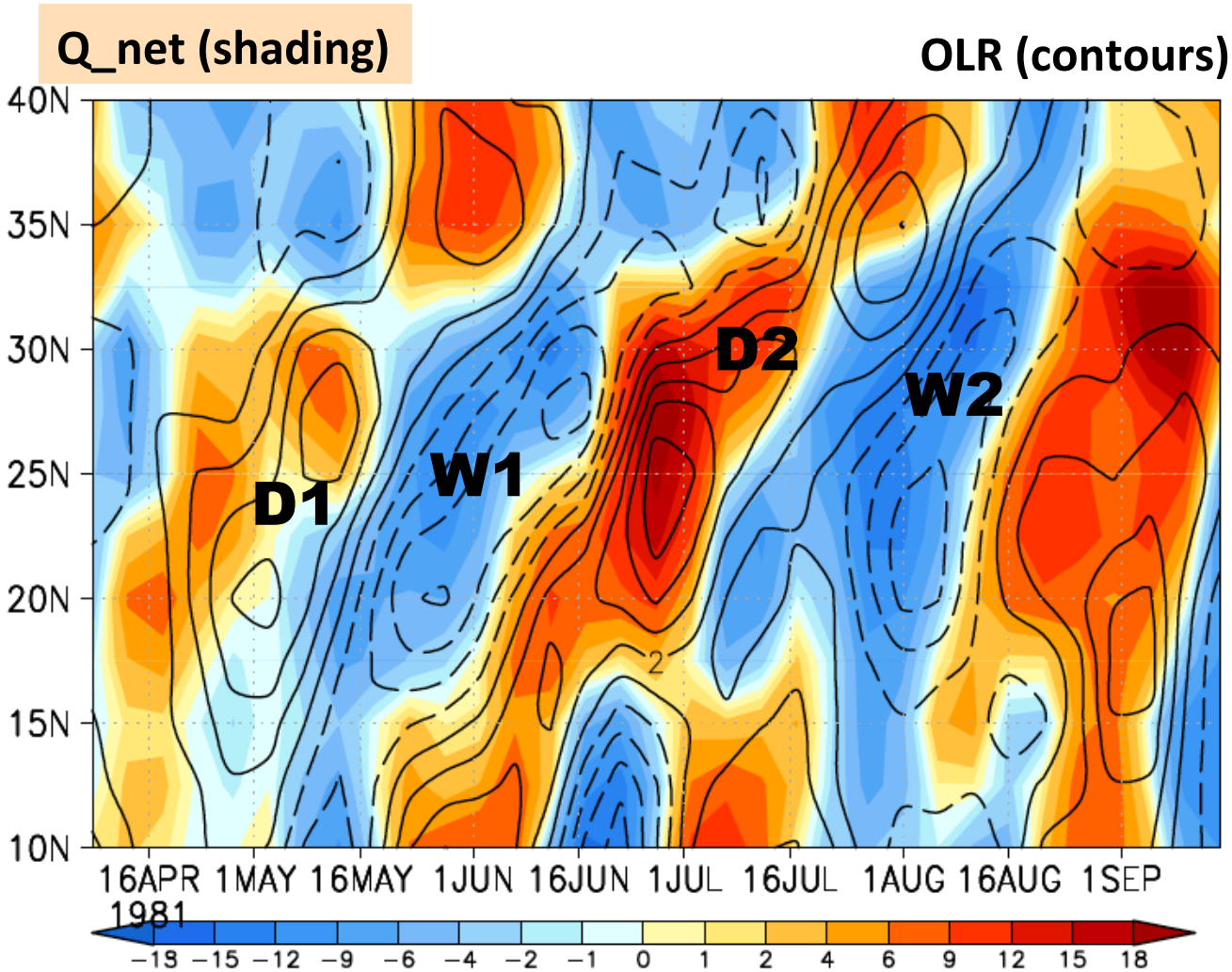
Air-Sea Interaction in the FAC (OBS, 120°E-140°E)



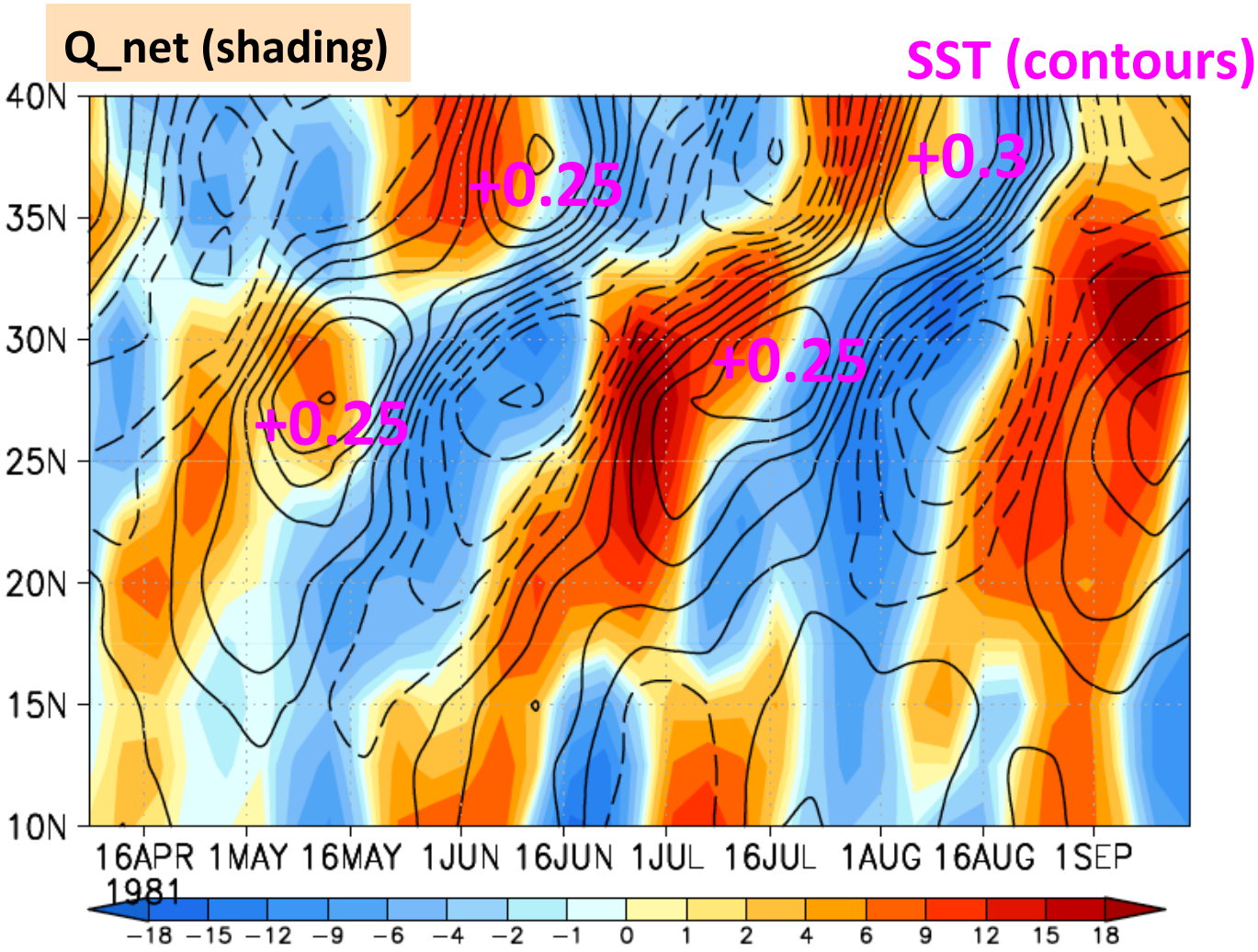
Air-Sea Interaction in the FAC (OBS, 120°E-140°E)



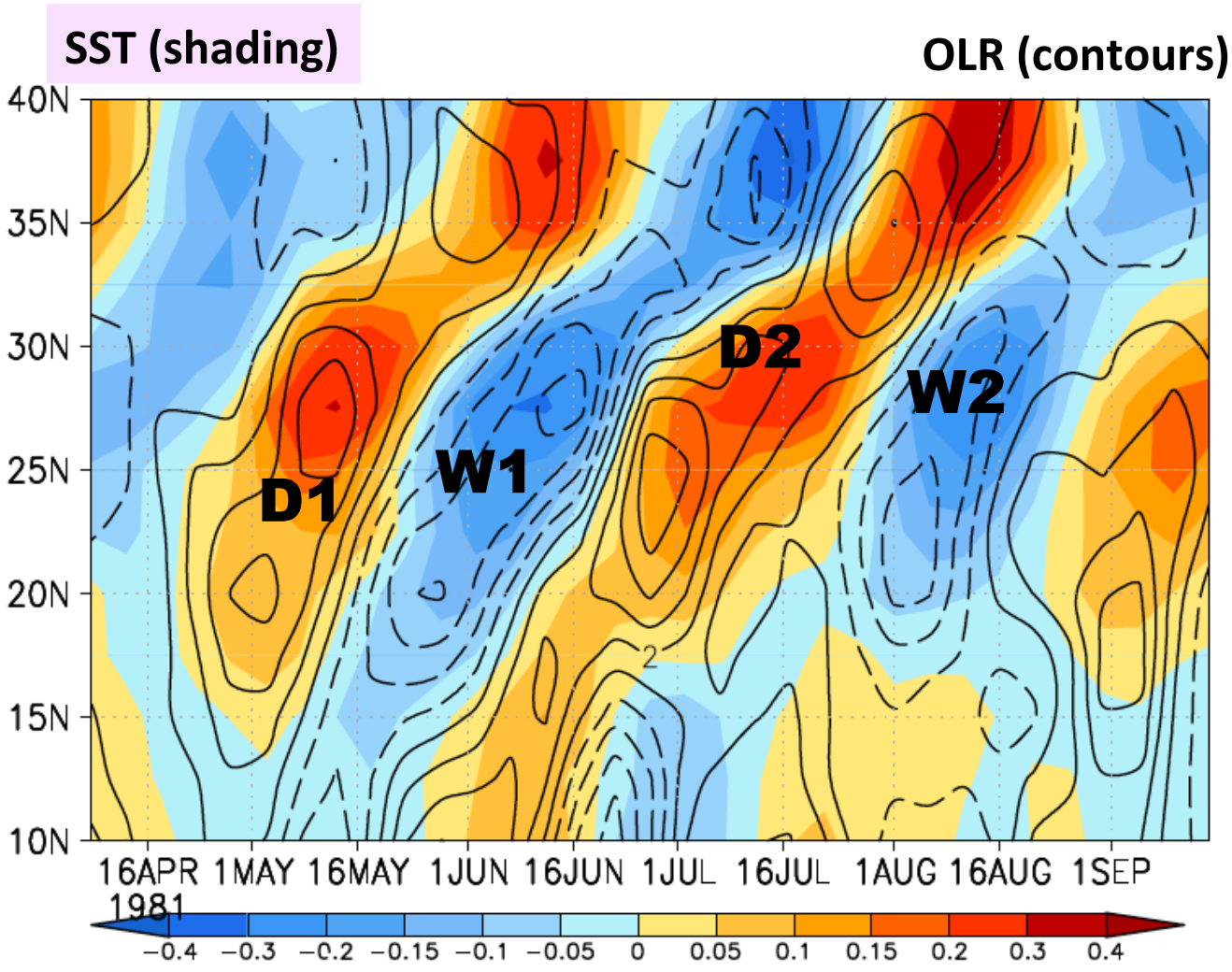
Air-Sea Interaction in the FAC (OBS, 120°E-140°E)

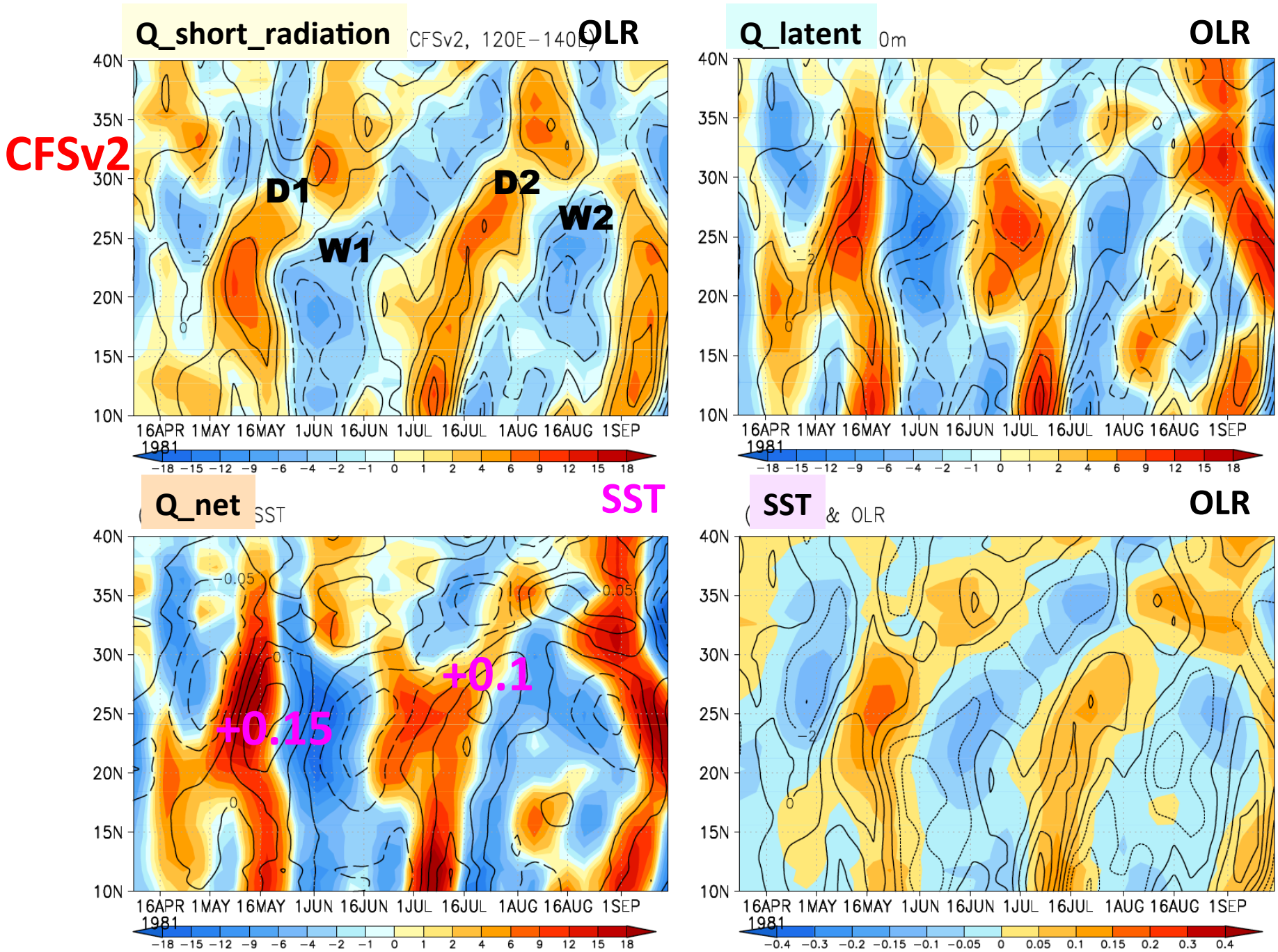


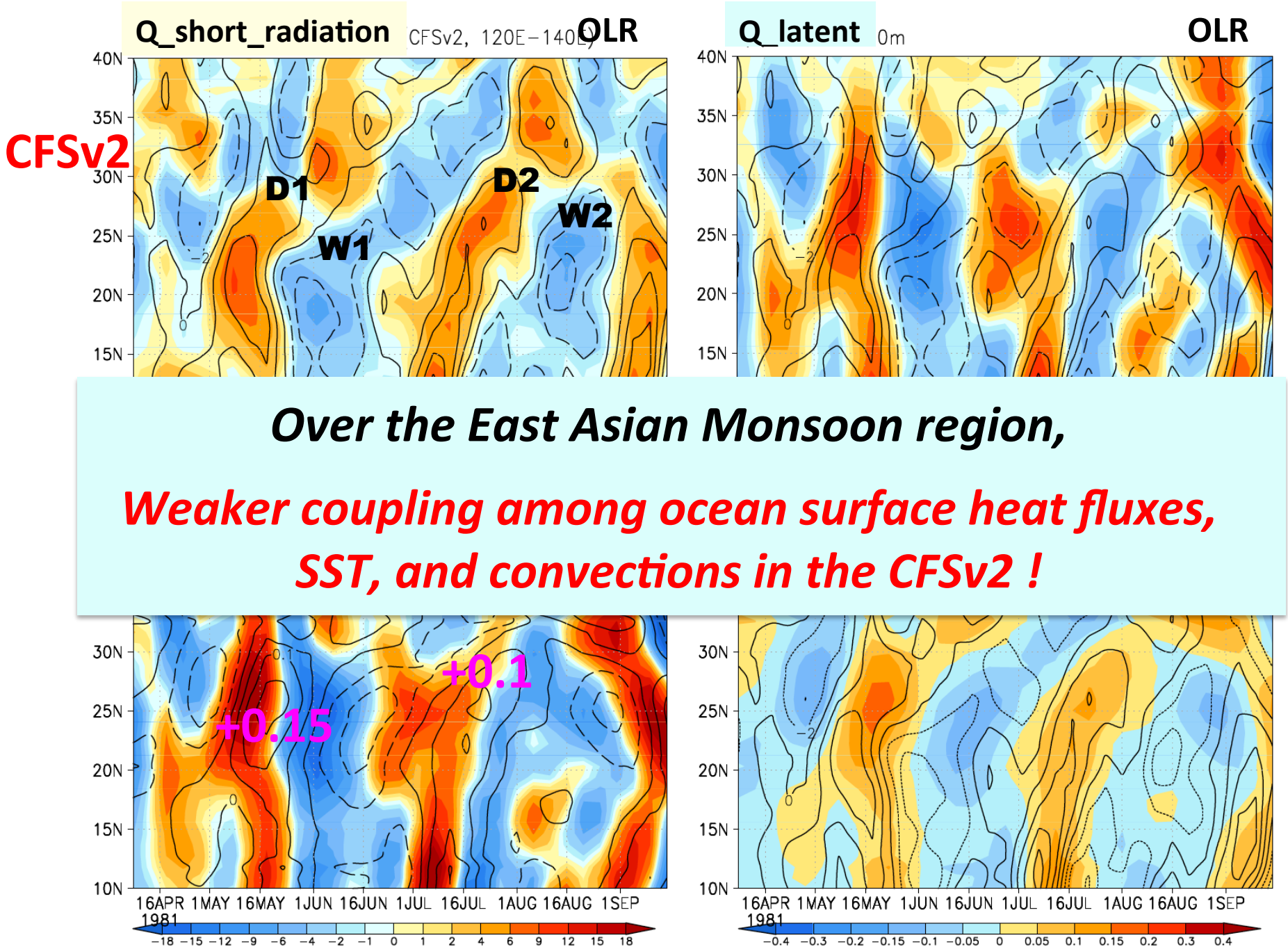
Air-Sea Interaction in the FAC (OBS, 120°E-140°E)



Air-Sea Interaction in the FAC (OBS, 120°E-140°E)




CFSv2
Q_short_radiation
CFSv2, 120E−140E
OLR
D1
D2
W1
W2
Q_latent
0m
OLR
Q_net
SST
SST
& OLR
OLR
+0.1
+0.15
40N
35N
30N
25N
20N
15N
10N
16APR 1MAY 16MAY 1JUN 16JUN 1JUL 16JUL 1AUG 16AUG 1SEP
1981
−18 −15 −12 −9 −6 −4 −2 −1 0 1 2 4 6 9 12 15 18
−0.4 −0.3 −0.2 −0.15 −0.1 −0.05 0 0.05 0.1 0.15 0.2 0.3 0.4

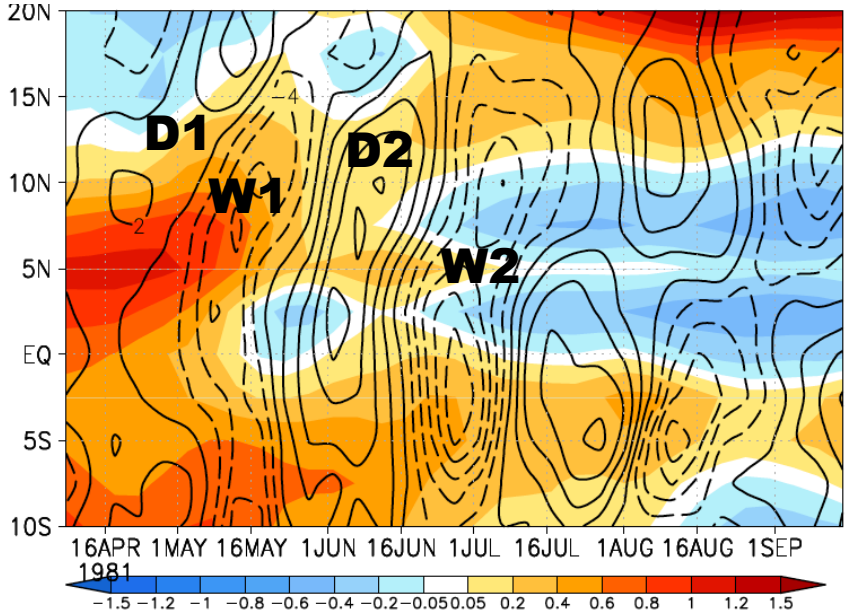


Over the East Asian Monsoon region,

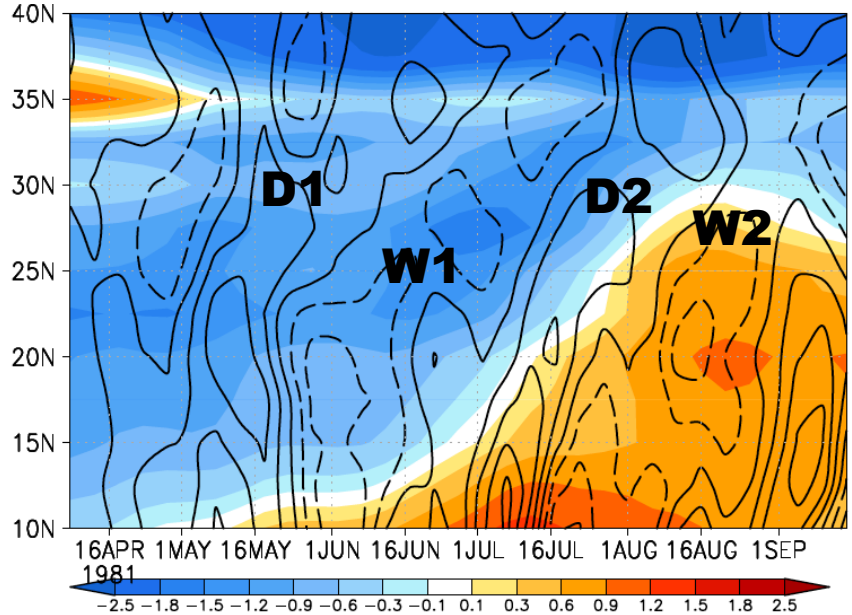
Weaker coupling among ocean surface heat fluxes, SST, and convections in the CFSv2 !

A Reversed Behavior of Air-Sea Interaction in the CFSv2, Why?

SST Bias (CFSv2 – OBS)



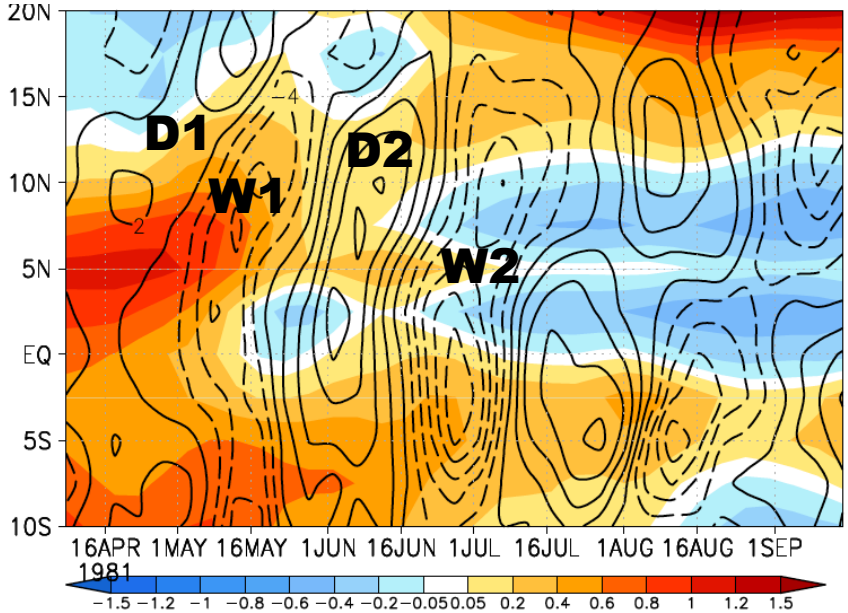
Indian Monsoon Region



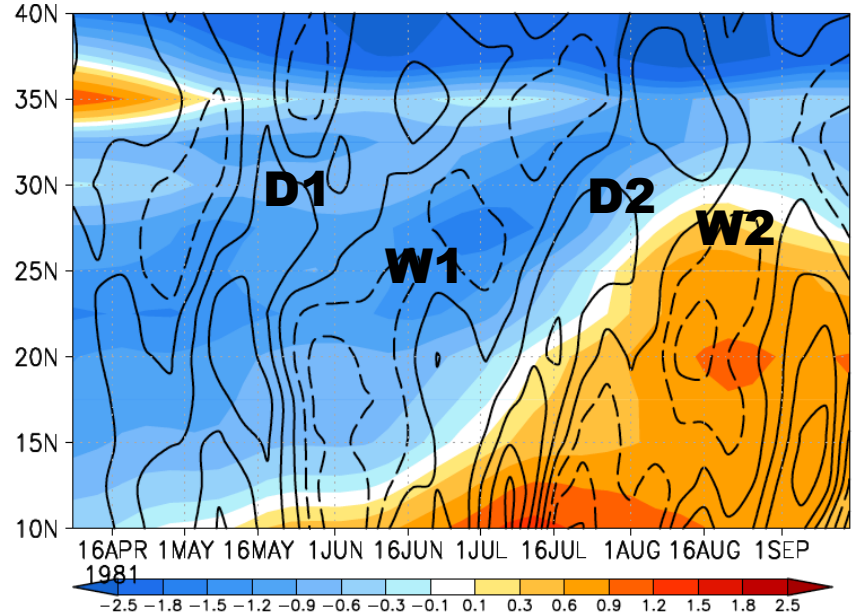
East Asian Monsoon Region

A Reversed Behavior of Air-Sea Interaction in the CFSv2, Why?

SST Bias (CFSv2 – OBS)



Indian Monsoon Region



East Asian Monsoon Region

***Warm SST bias** in spring*

⇒Earlier monsoon onset

⇒more enhanced 1st wet and 2nd dry phases by stronger air-sea coupling

⇒in turn, reducing warm SST bias

⇒cold SST bias after summer monsoon

***Cold SST bias** in spring/early summer*

⇒Delayed monsoon onset

⇒less enhanced and disorganized 1st wet and 2nd dry phases by weaker air-sea coupling

⇒warm SST bias in fall

Evaluation of the simulated SAC and FAC of the Asian Summer Monsoon (ASM) by the CFSv2

Indian Monsoon Region ***East Asian Monsoon Region***

- ***The CFSv2 is capable of reproducing the climatological Slow Annual Cycle (or slow seasonal transition) of the ASM.***
- ***The northward propagation of both wet and dry phases in the Fast Annual Cycle of the ASM is also well simulated by the CFSv2.***

Compared to the observation,

- ✓ ***Warm SST bias prior to the ASM***
- ✓ ***Earlier onset of the ASM***
- ✓ ***Stronger Air-Sea coupling***
- ✓ ***Cold SST bias after the ASM***

Compared to the observation,

- ✓ ***Cold SST bias prior to the ASM***
- ✓ ***Delayed onset of the ASM***
- ✓ ***Weaker Air-Sea coupling***
- ✓ ***Warm SST bias after the ASM***

Our results suggest that reducing climatological SST bias in the model may be a primary factor for better prediction of the Asian summer monsoon.