Coupled Atmosphere-Ocean Modeling of the MJO and Diurnal Cycle in the Maritime Continent

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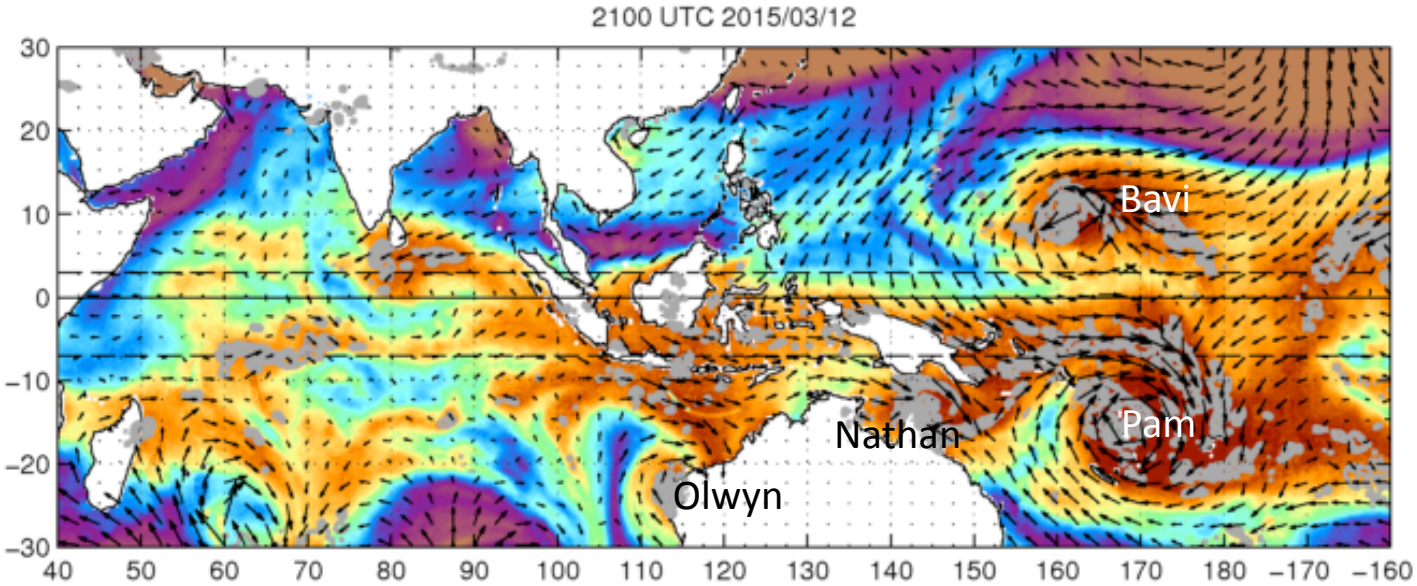
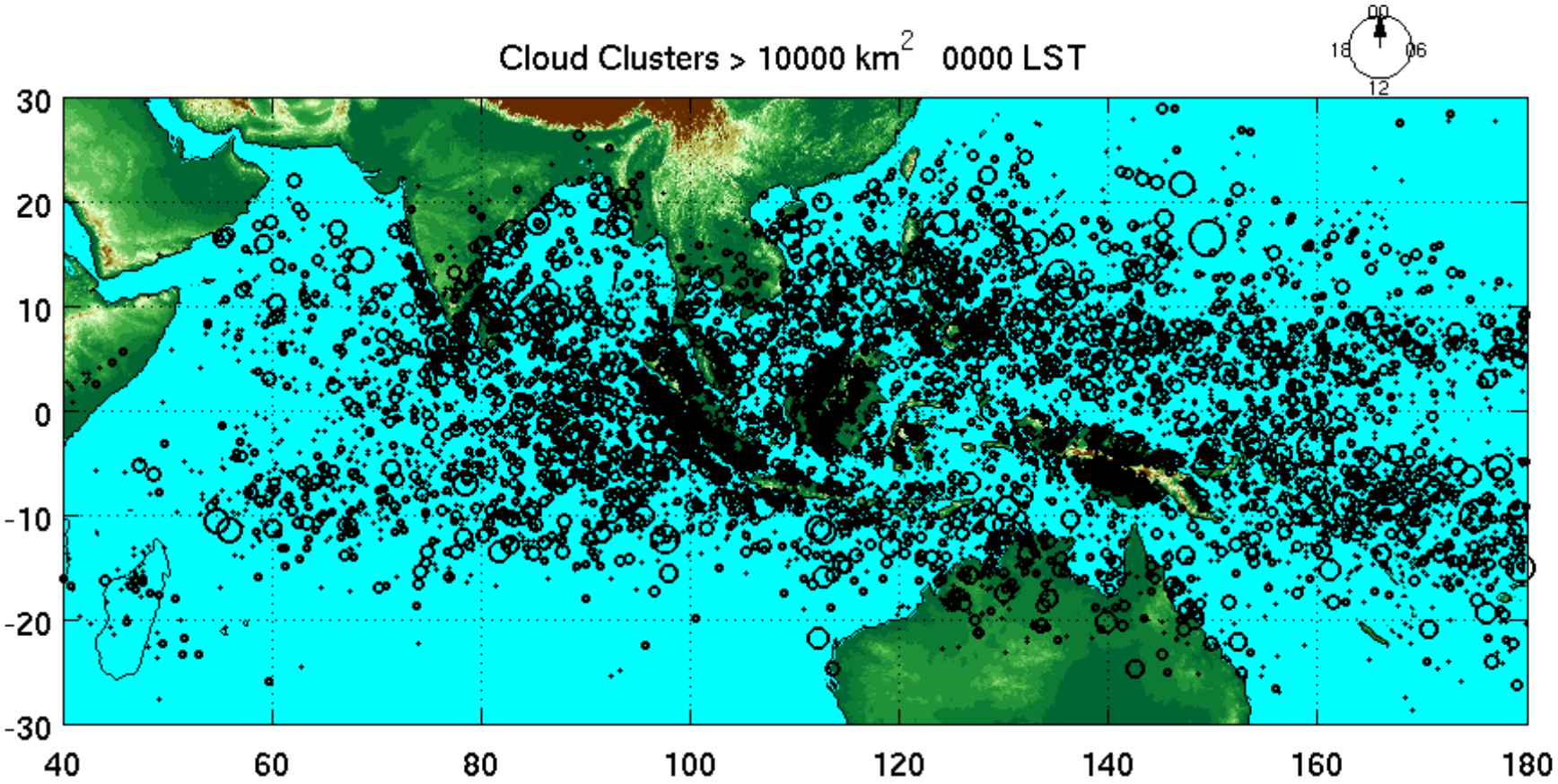


(YMC Workshop, Jakarta, Indonesia, 24-27 November 2015)

MeteoSat7 & MDSat Cloud Clusters (IR < 208 K, hourly, Oct-Dec 2010-2012)



Model and Data

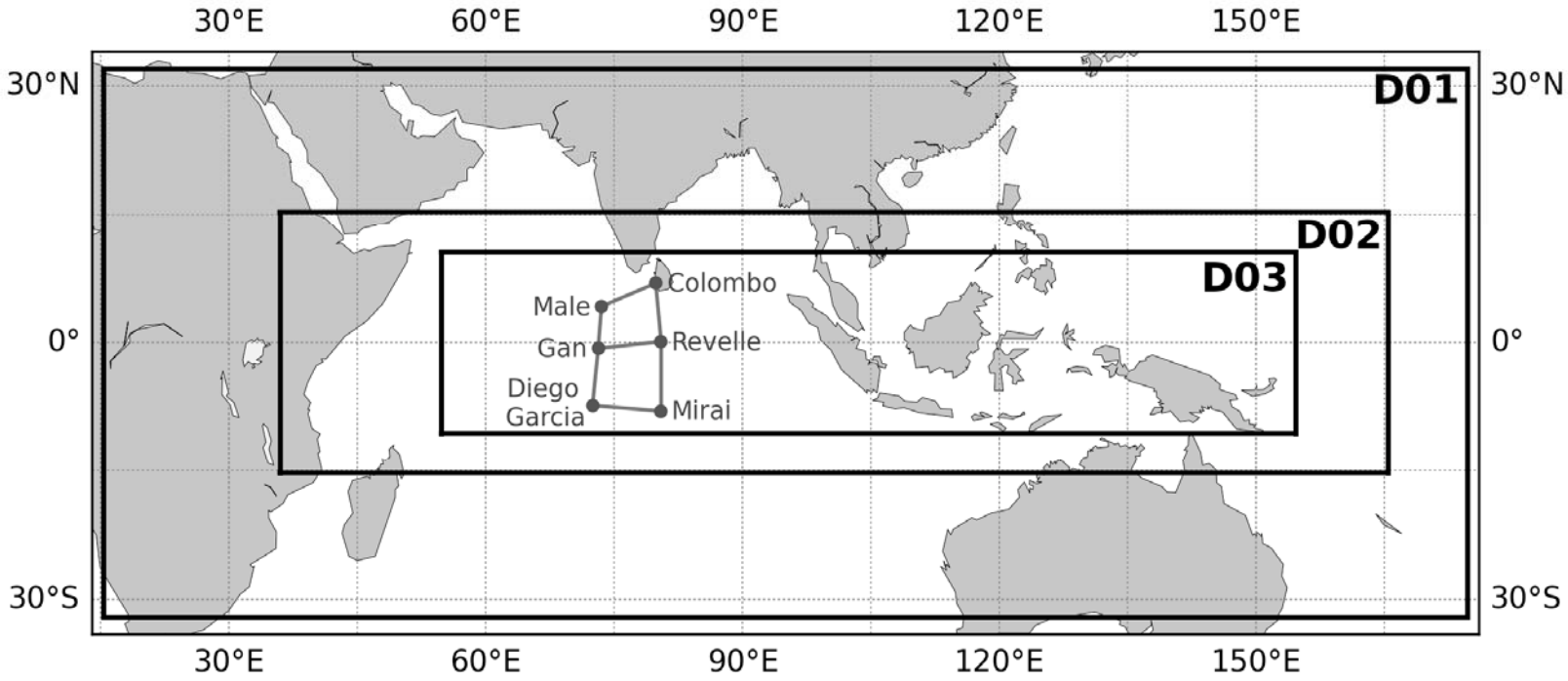
UWIN-CM (Unified Wave Interface-Coupled Model, Chen and Curcic (2015))

WRF (Weather Research and Forecasting, v3.6.1):

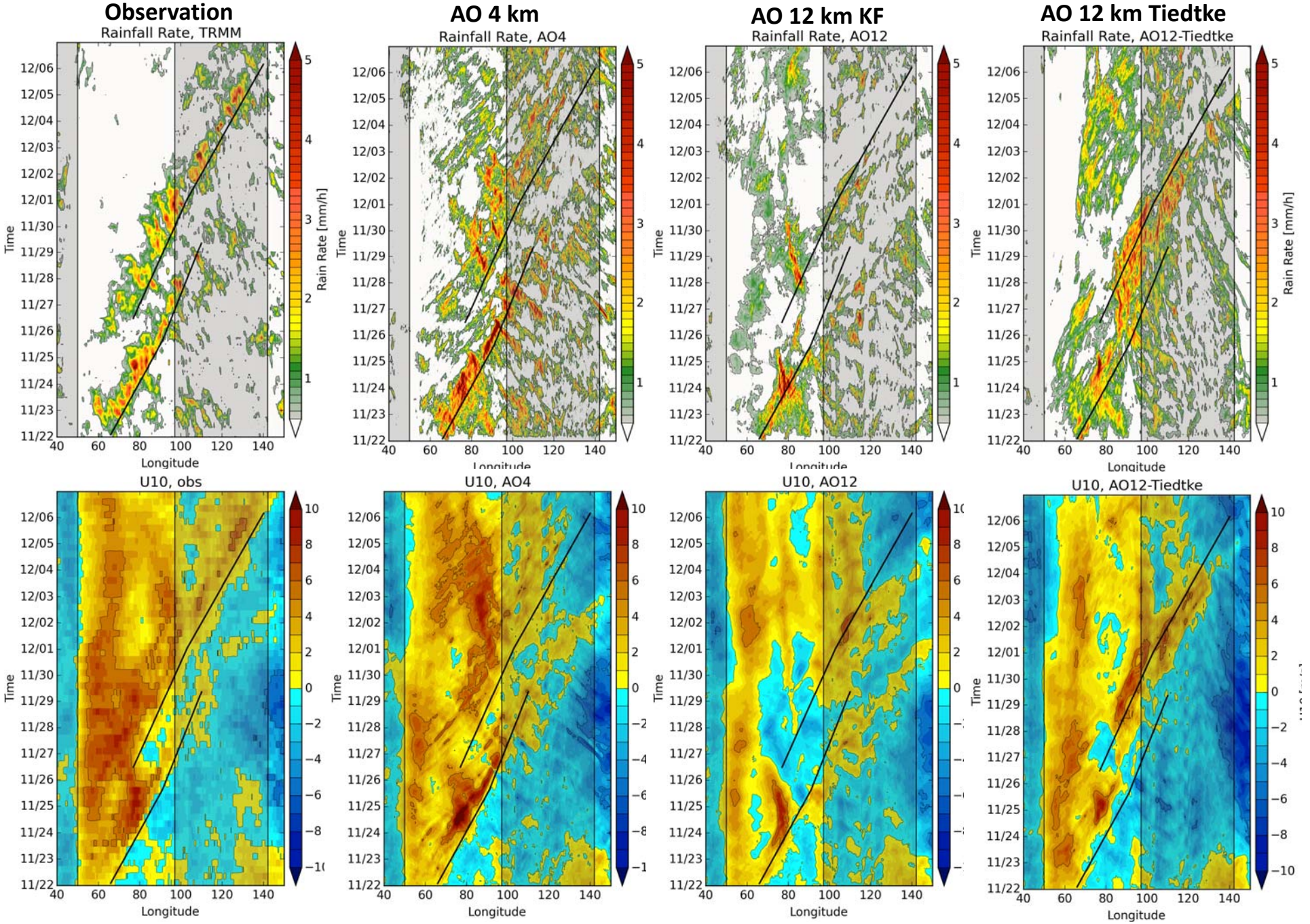
- D01-D02-D03: 36-12-4-km grid spacing, 45 vertical levels
- Initial and lateral boundary conditions from ECMWF analysis fields
- Physics: YSU PBL, WSM5 microphysics, Donelan & Garratt surface layer

HYCOM (HYbrid Coordinate Ocean Model, v2.2.98):

- Uniform 0.08° (~10km) resolution, 32 vertical levels
- Initial and lateral boundary conditions from HYCOM global analysis



Effects of Model Resolution/Physics on MJO Precipitation and Sfc Zonal Wind

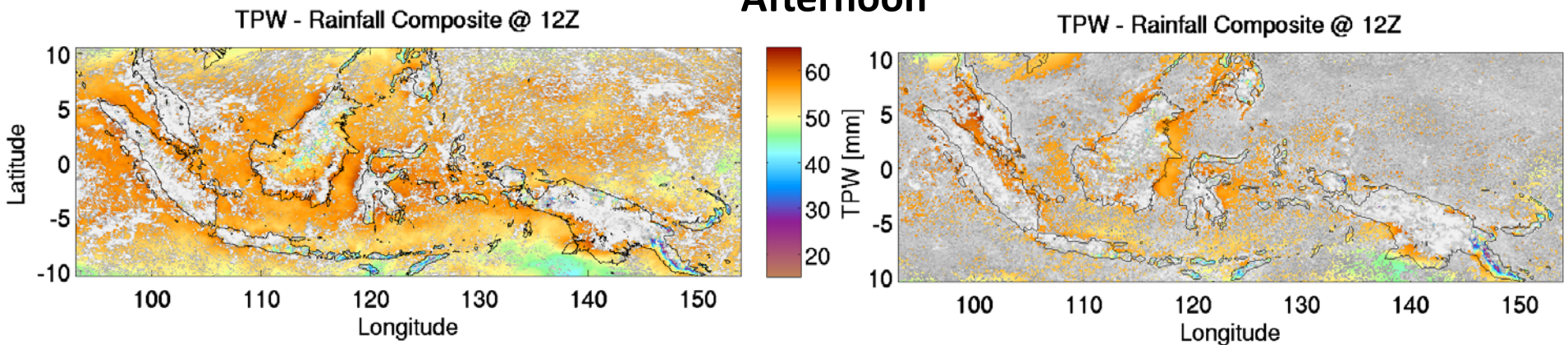


Diurnal Cycle of TPW and Rainfall (Coupled Model)

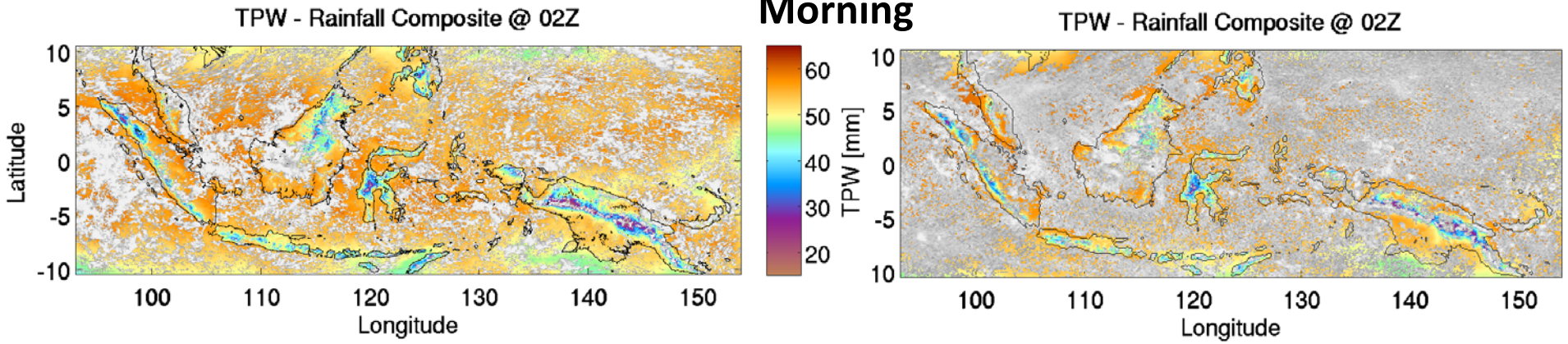
4-km Coupled Model

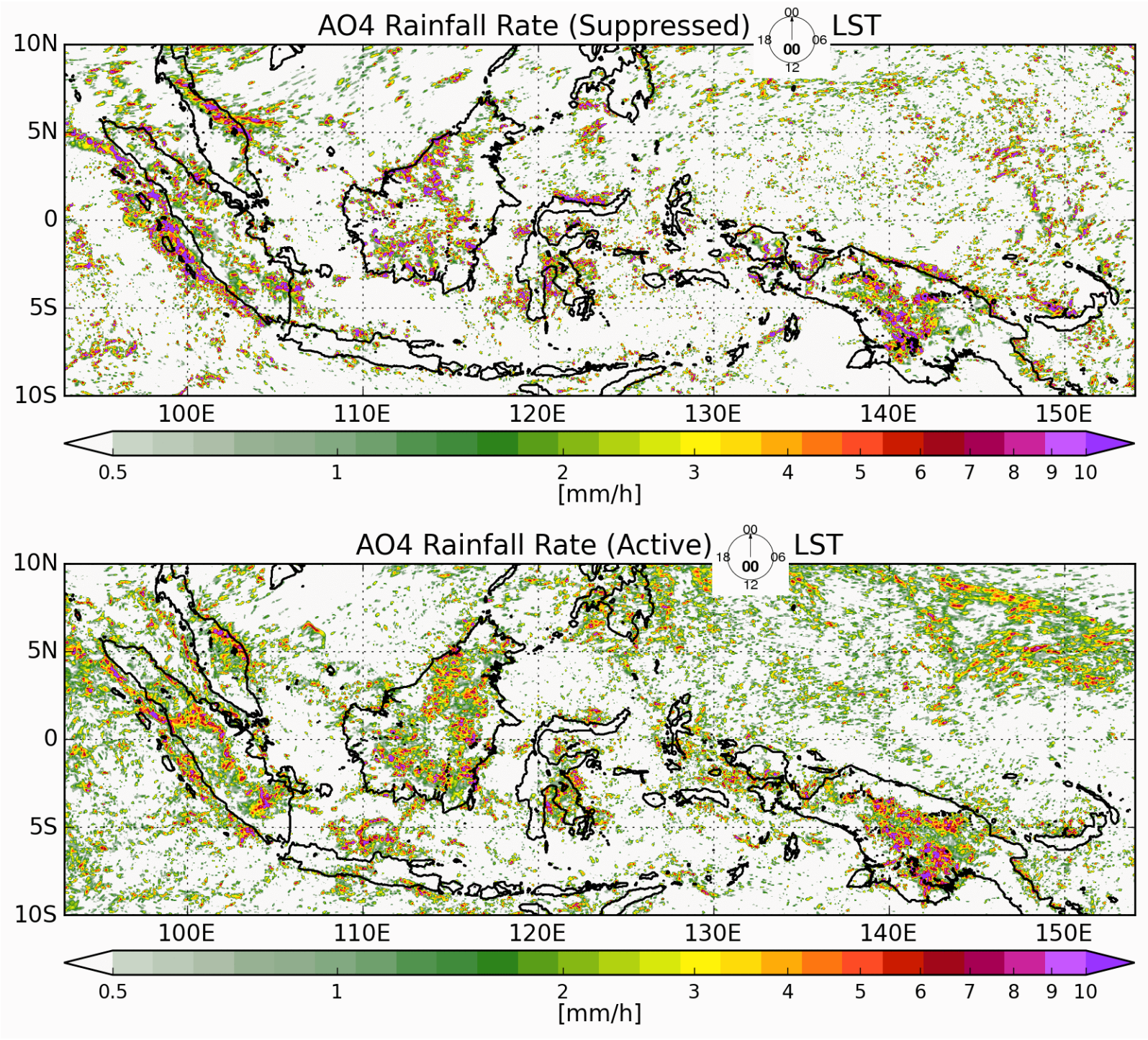
12-km Coupled Model

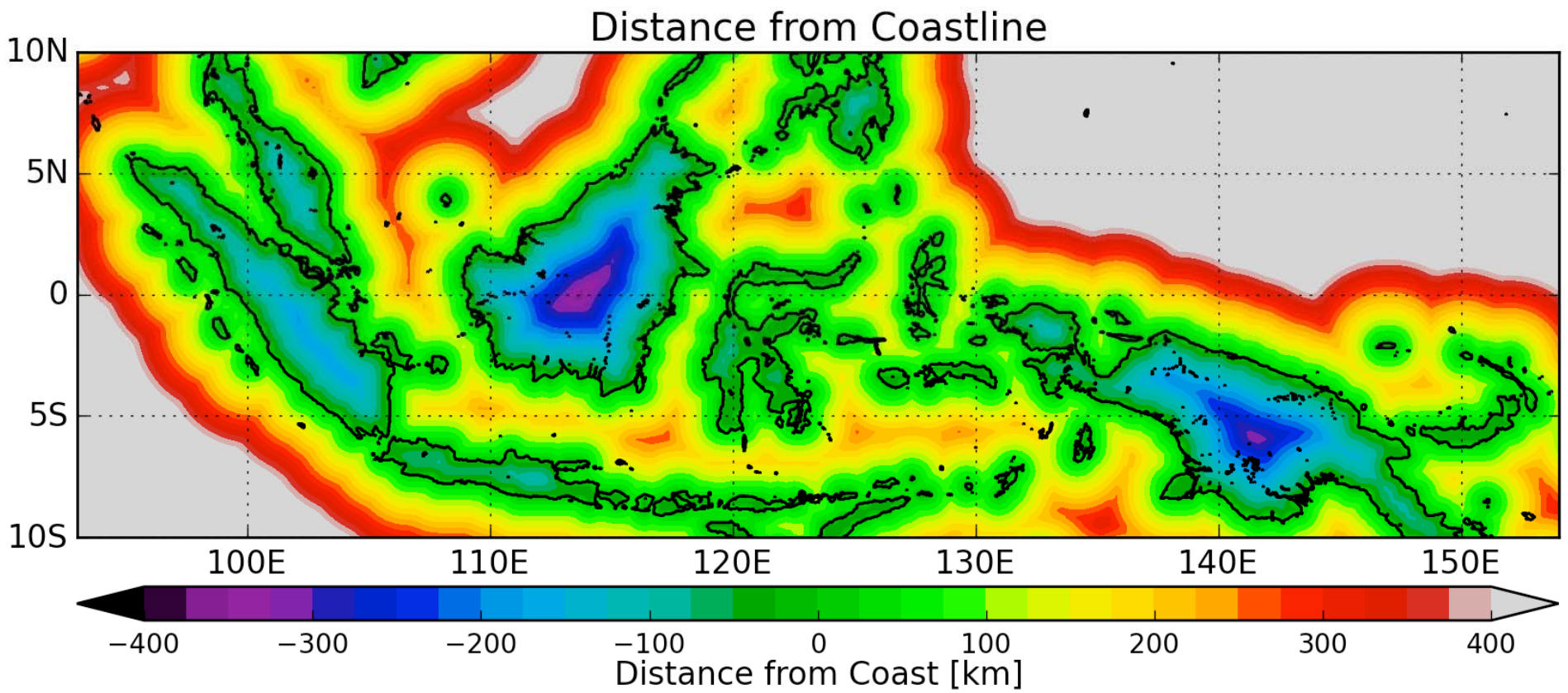
Afternoon



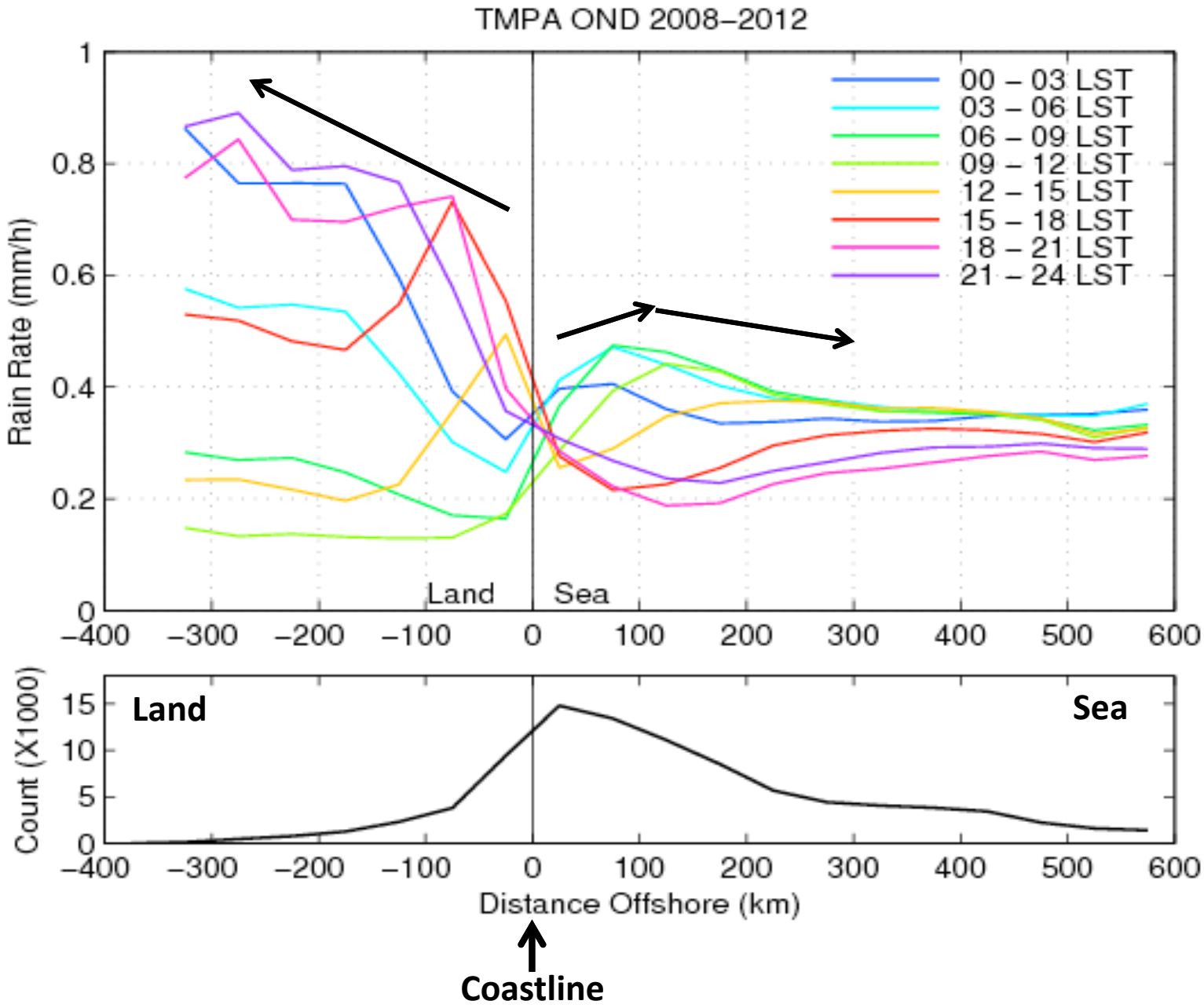
Morning



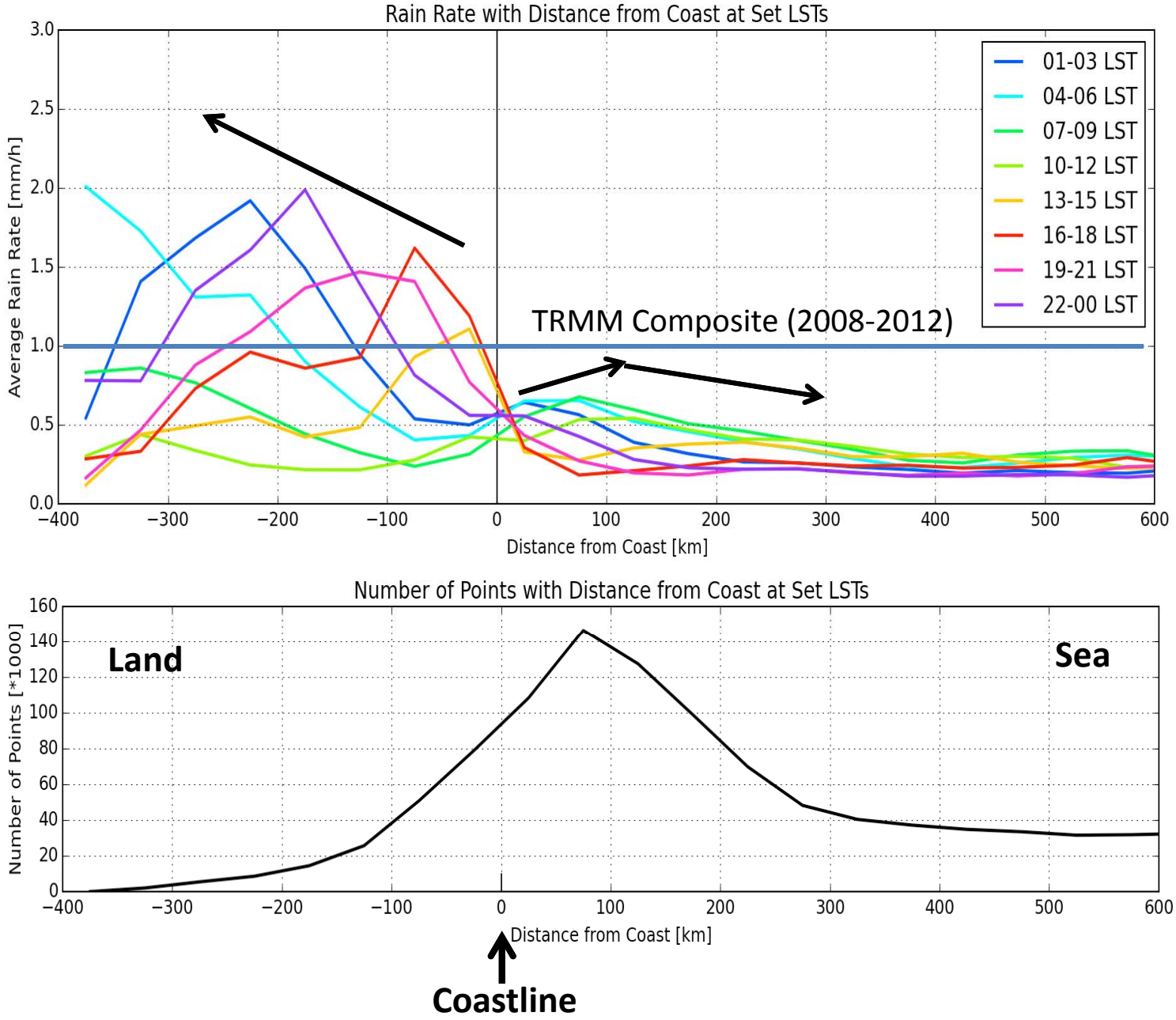

AO4 Rainfall Rate (Suppressed)
LST
00
06
12
18
00
10N
5N
0
5S
10S
100E
110E
120E
130E
140E
150E
0.5
1
2
3
4
5
6
7
8
9
10
[mm/h]
AO4 Rainfall Rate (Active)
LST
00
06
12
18
00
10N
5N
0
5S
10S
100E
110E
120E
130E
140E
150E
0.5
1
2
3
4
5
6
7
8
9
10
[mm/h]

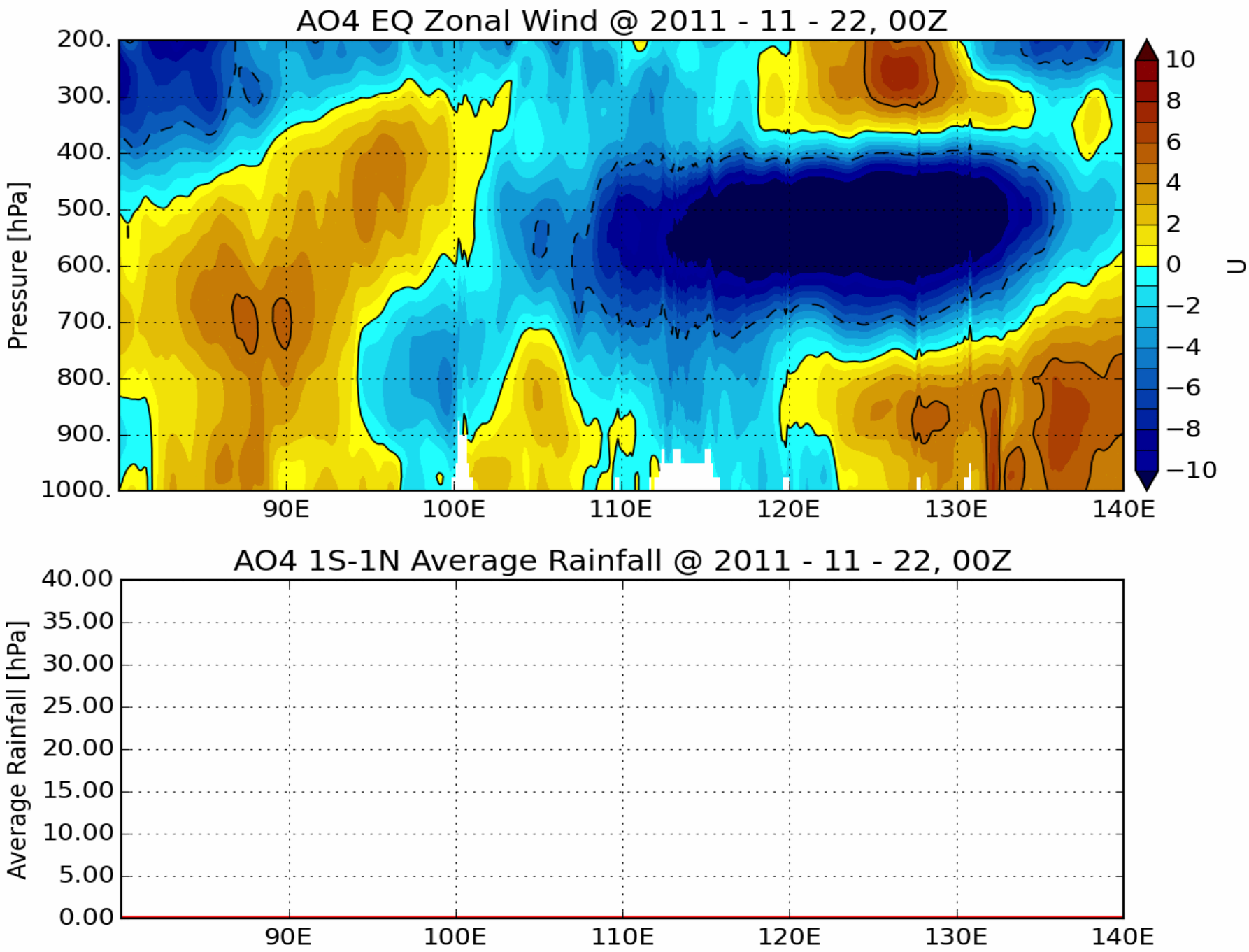

Distance from Coastline
10N
5N
0
5S
10S
100E
110E
120E
130E
140E
150E
−400
−300
−200
−100
0
100
200
300
400
Distance from Coast [km]

TRMM Rain Diurnal Composite



UWIN-CM A04 Rain Diurnal Composite (22 Nov-06 Dec 2011)




AO4 EQ Zonal Wind @ 2011 - 11 - 22, 00Z
Pressure [hPa]
200.
300.
400.
500.
600.
700.
800.
900.
1000.
90E
100E
110E
120E
130E
140E
10
8
6
4
2
0
−2
−4
−6
−8
−10
U
AO4 1S-1N Average Rainfall @ 2011 - 11 - 22, 00Z
Average Rainfall [hPa]
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
90E
100E
110E
120E
130E
140E

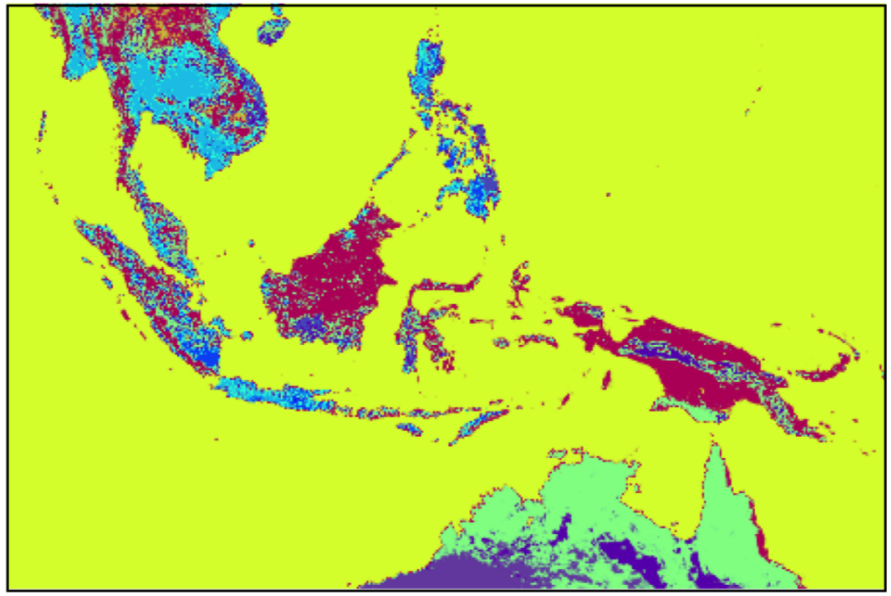
Question: What is the impact of diurnal cycle over MC on the propogation of MJO?

Samson Hagos (PNNL)

WRF model and simulation set-up

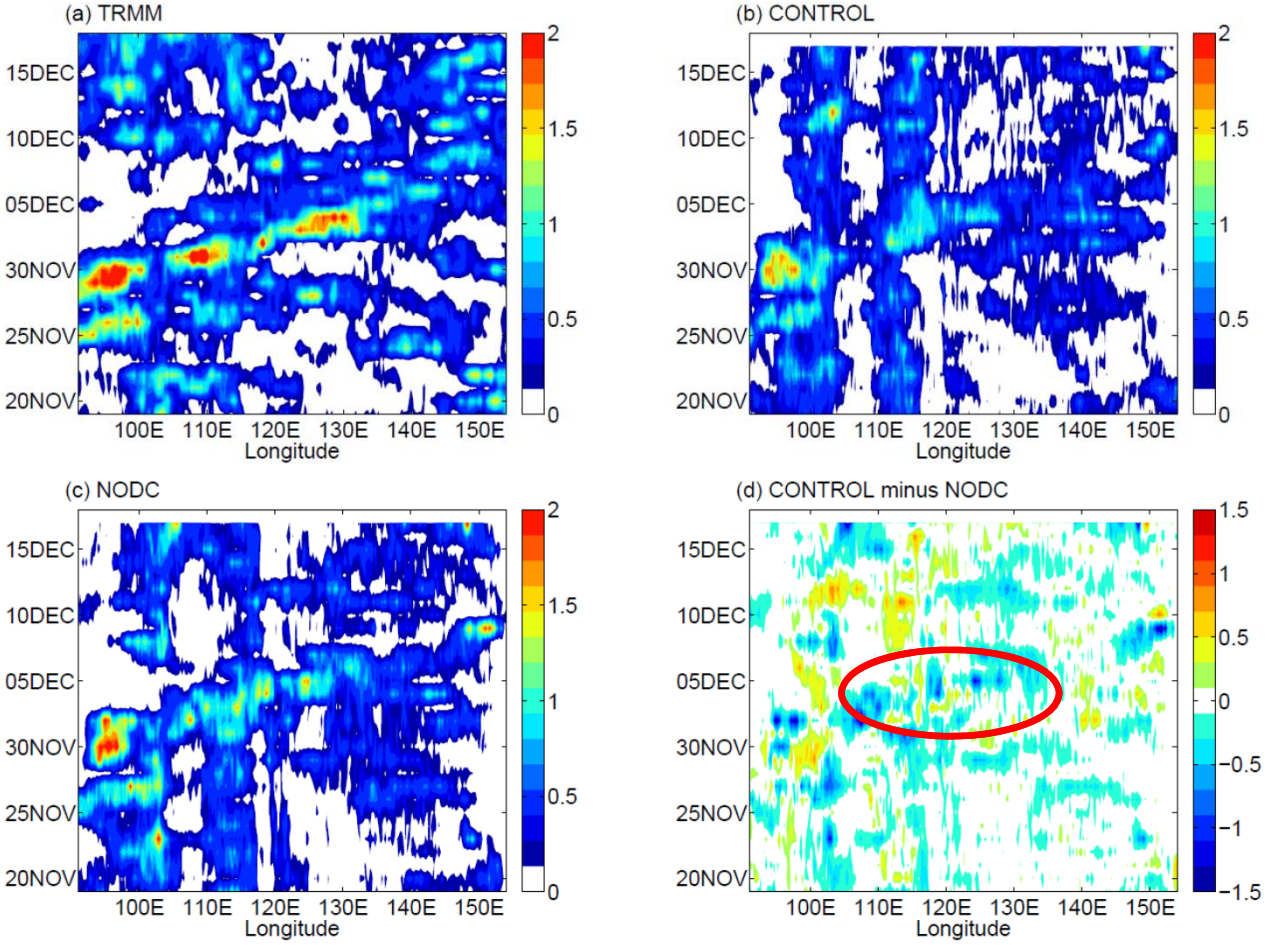
- We focus on the Nov 2011 MJO.
- 4km grid spacing.
- ERA-Interim surface, initial and boundary condition, Initialized only once.
- Boundary conditions and SST updated every 6 hours.
- No cumulus scheme

- **CONTROL:** Realistic diurnal cycle and boundary conditions updated 6 hourly.
- **NODC:** Perpetual morning with clear sky downward SW kept at daily mean value and boundary conditions updated daily



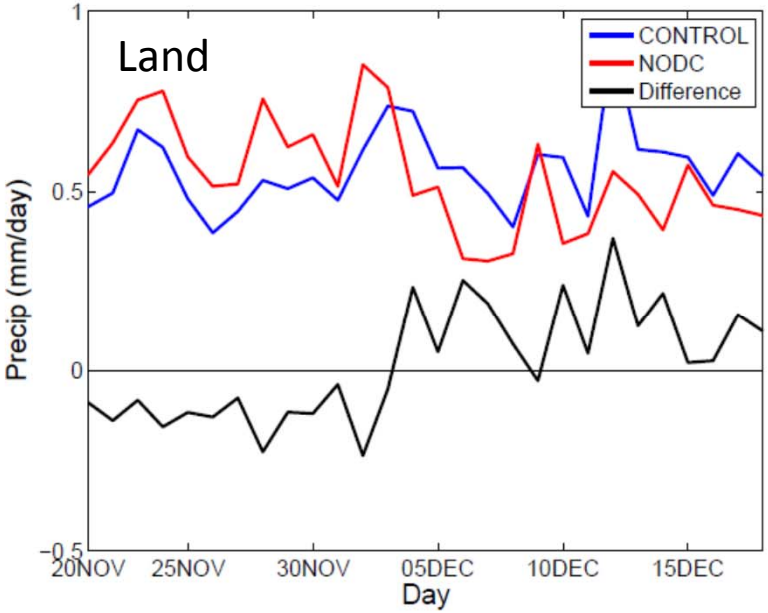
Simulation domain

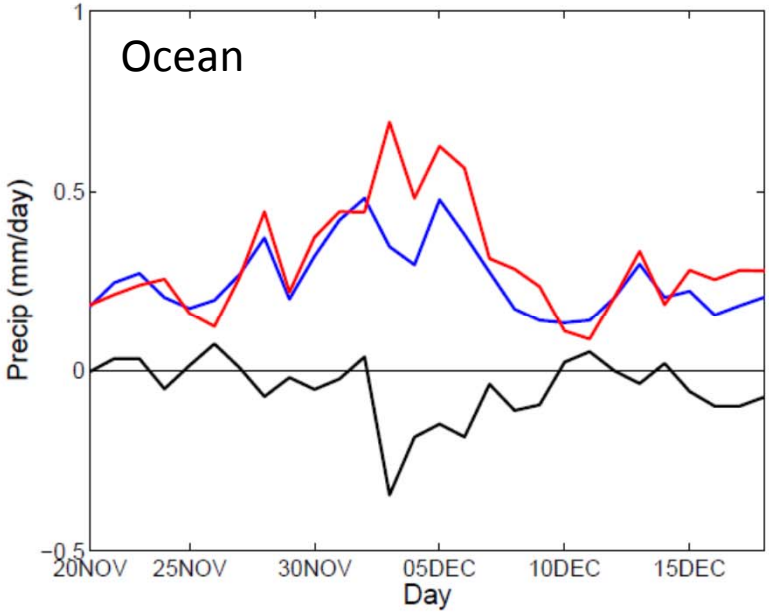
Propagation of Precipitation



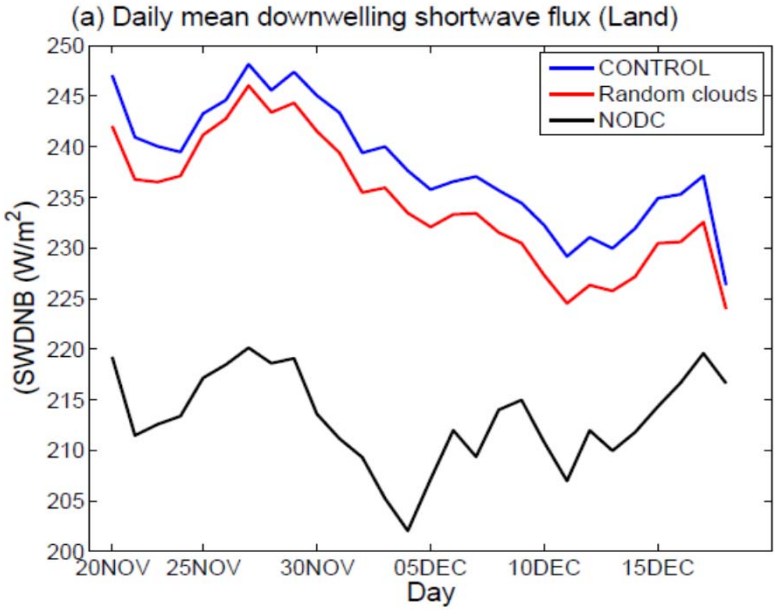
- Diurnal cycle weakens the MJO signal over ocean.

Land vs Ocean

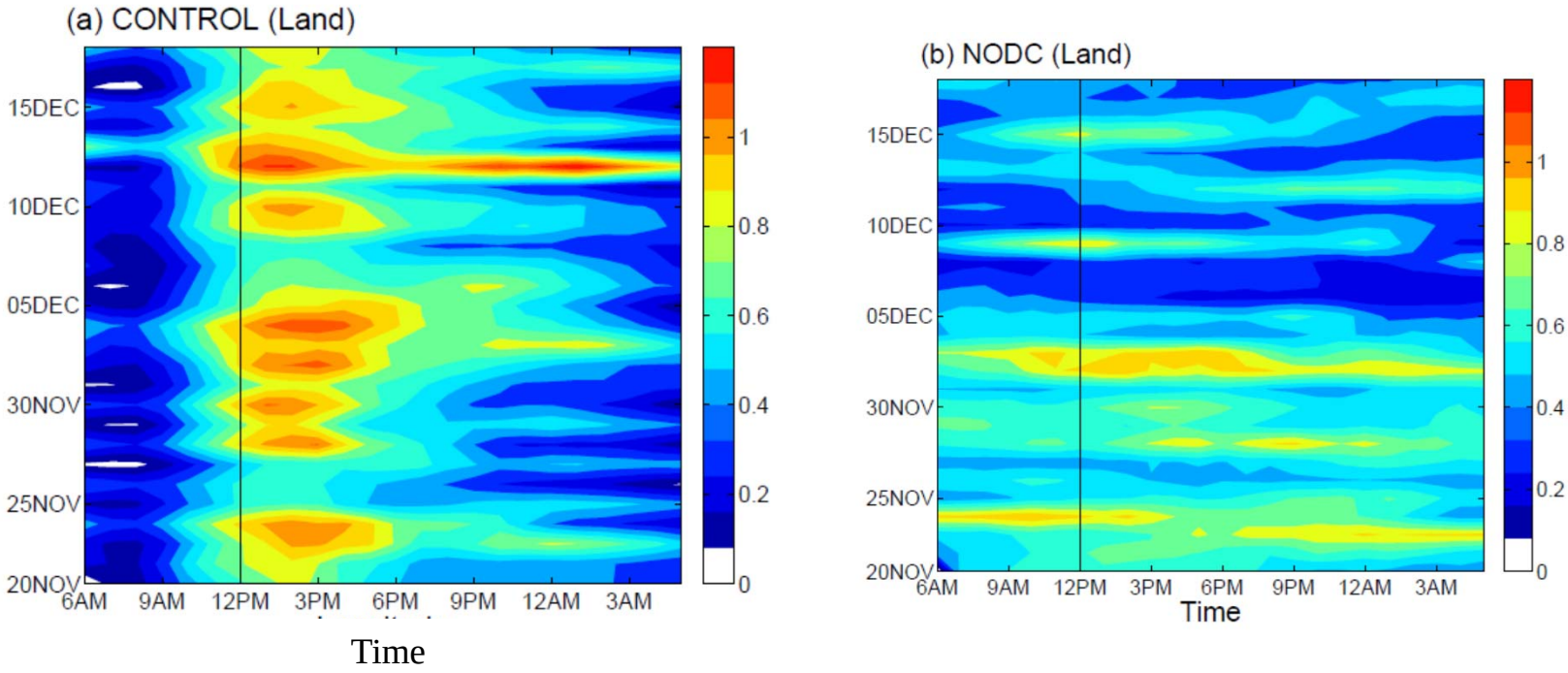




- In the presence of diurnal cycle more of the MJO active phase precipitation stalls over land.

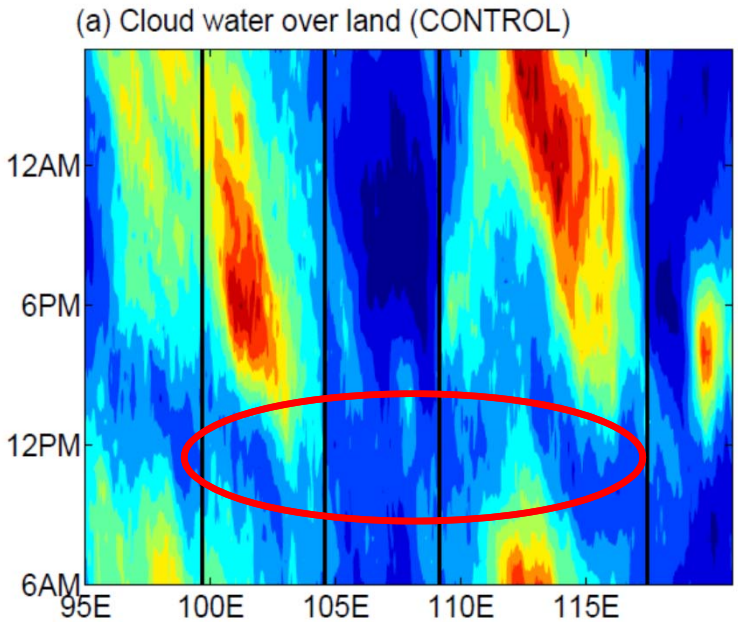


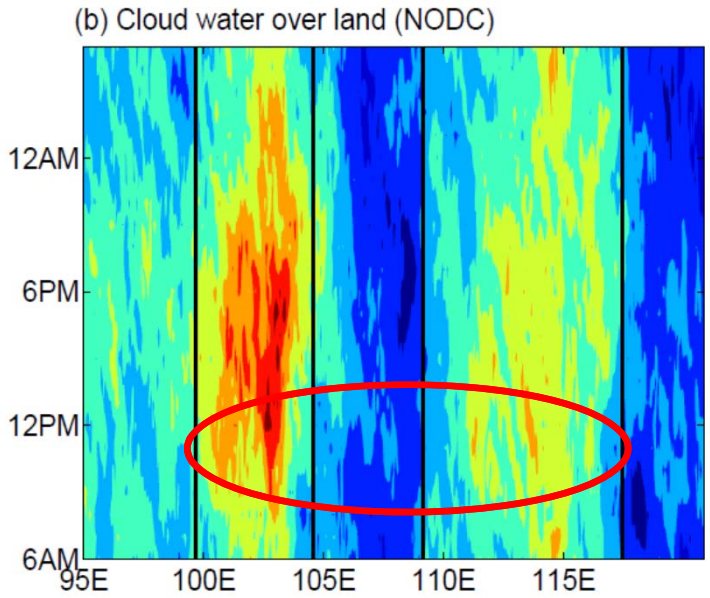
Diurnal cycle of precipitation



- In the control experiment, rain preferentially occurs in the afternoon. In the NODC case it occurs randomly through out the day.
- Precipitation lasts longer during the active phase of the MJO.

Diurnal cycle of cloudiness





- In the presence of diurnal cycle, there clouds are fewer that more shortwave radiation reaches the surface.
- In the no-diurnal cycle case the clouds do not propagate or dissipate as much thus blocking much of the shortwave radiation.

Summary

- The impact of diurnal cycle of clouds varies with MJO phase. During active phase the convection stalls over land likely because of an extra shortwave forcing.
- The extra shortwave forcing is related to the fact that in the control simulation clouds form in the afternoon and allow more shortwaves to reach the surface but in the NODC case clouds are more perpetual and hence block more SW radiation.

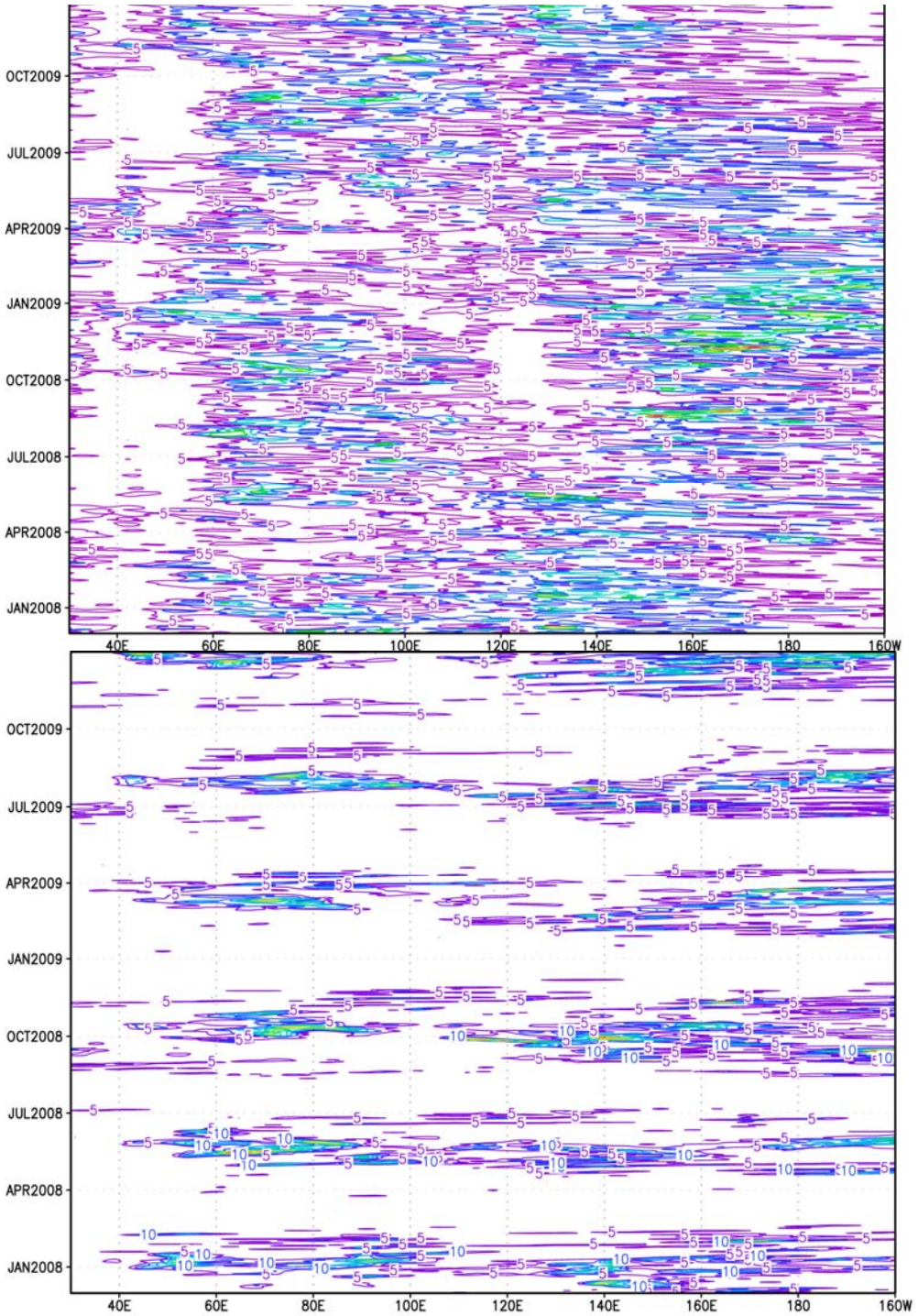
Hongyan Zhu (BOM)

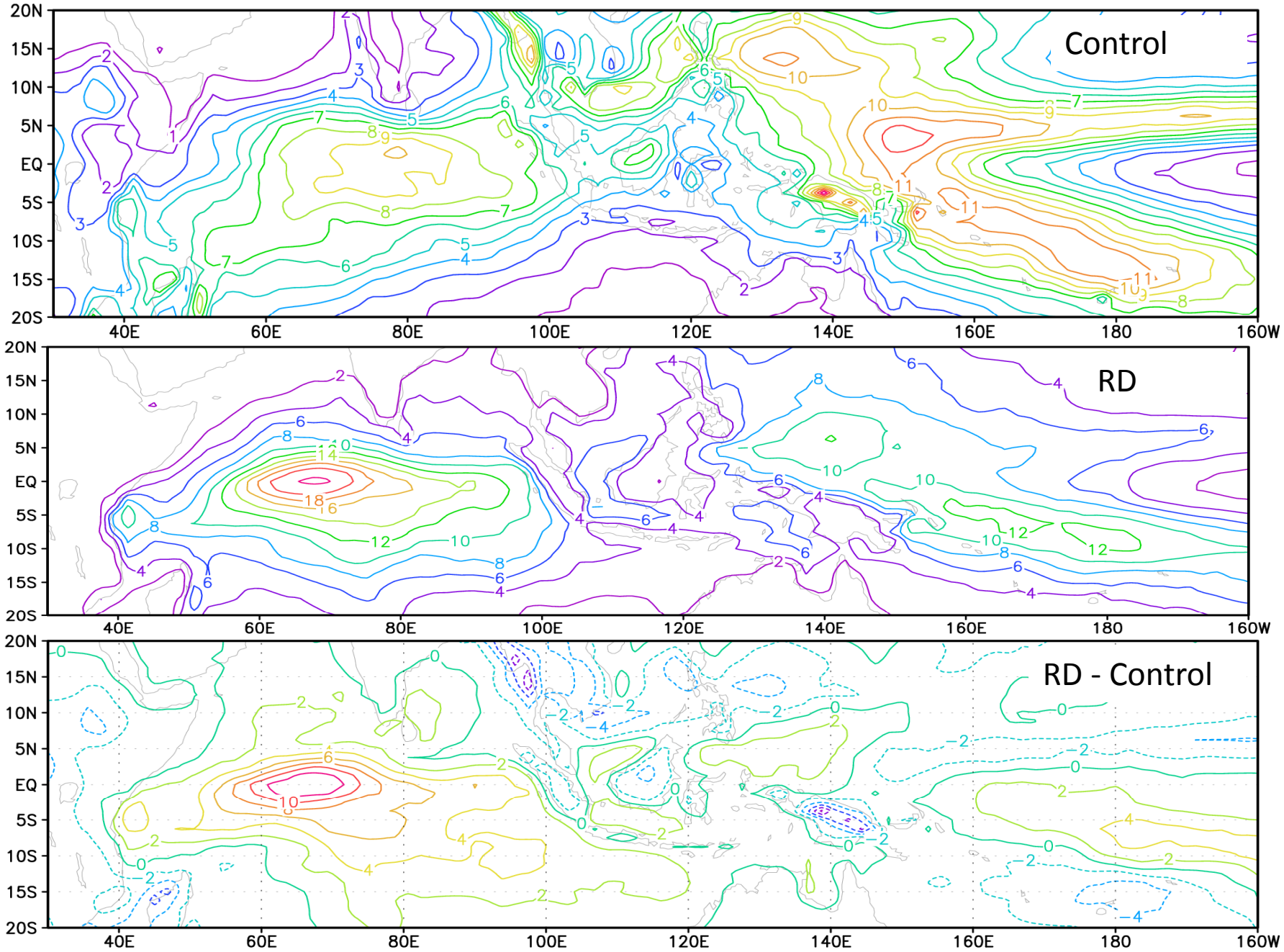
Model: ACCESS
Control: full diurnal cycle in TOA solar radiation
RD: TOA solar zenith angle is fixed at 45 deg
Four year simulations

ratio of land vs ocean rainfall in the MC: 0.85 in control and 0.57 in RD

Slide:

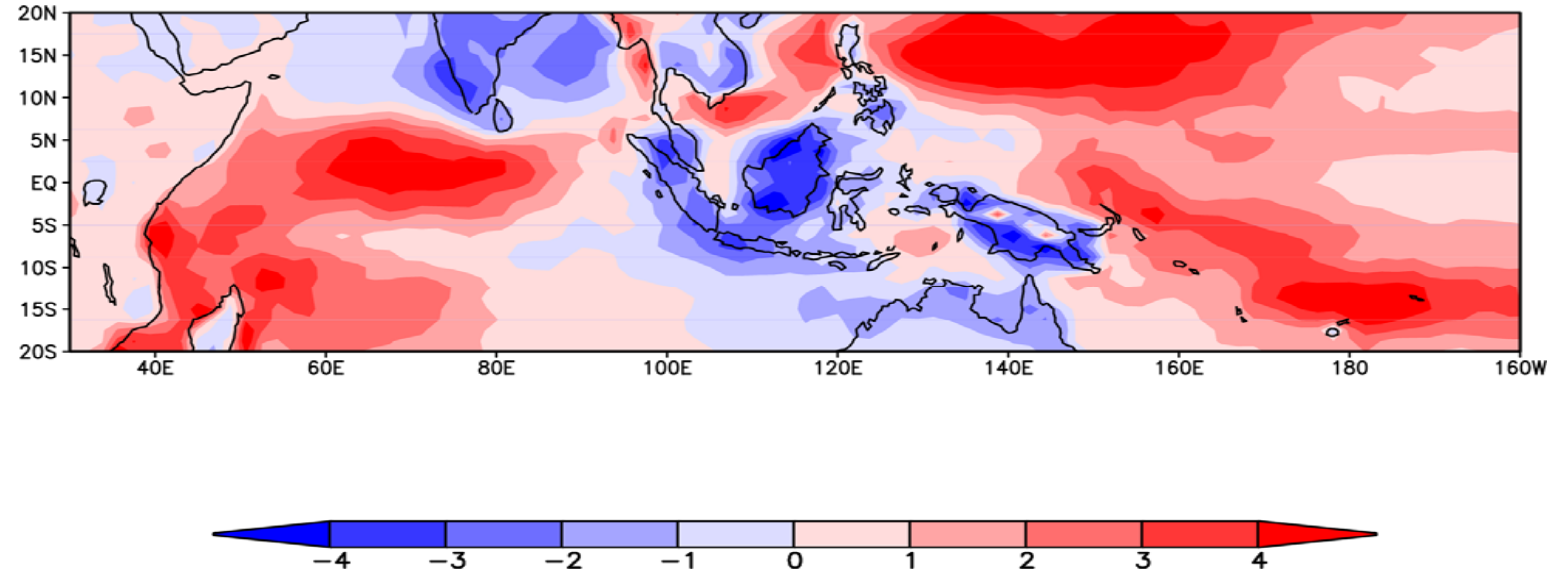
2. time-lon plot (10S – 10N) of rainfall in control
3. time-lon plot (10S – 10N) of rainfall in RD
4. Mean rainfall difference RD – control
5. Mean rain rates in control and RD
6. Deviation of rain rates in control and RD from GPCP

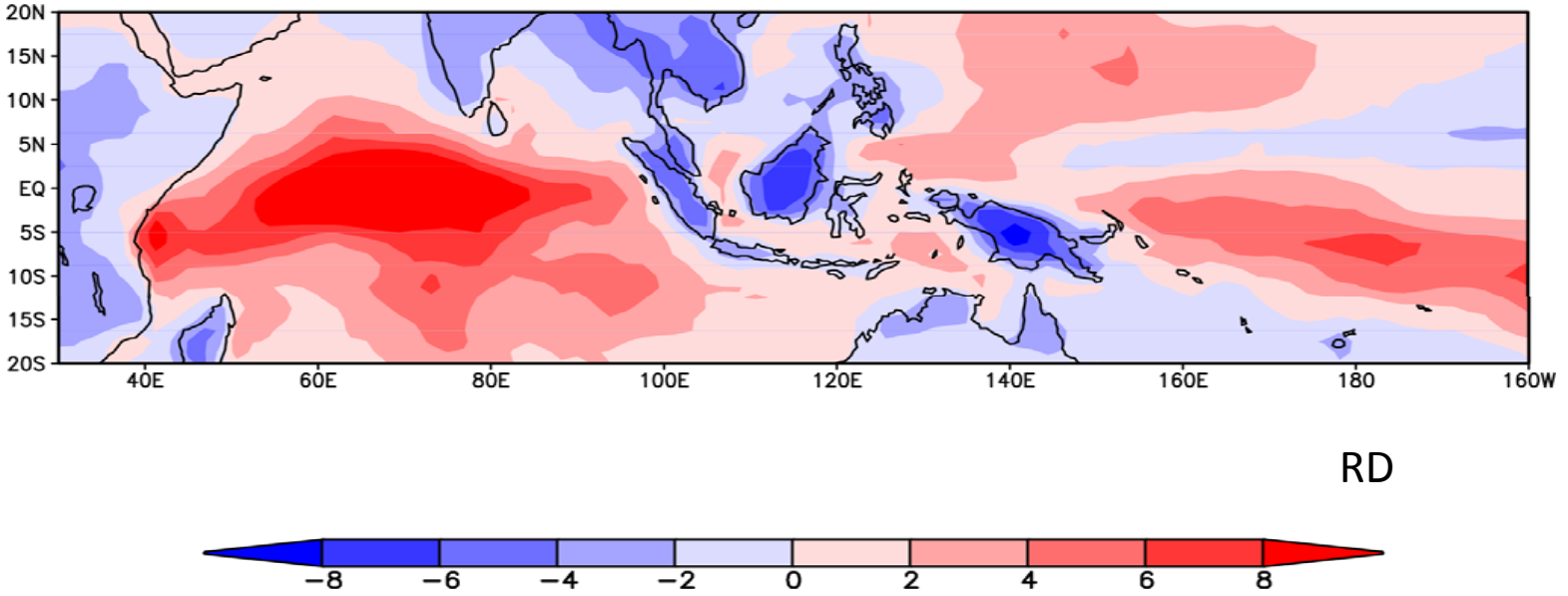

OCT2009
JUL2009
APR2009
JAN2009
OCT2008
JUL2008
APR2008
JAN2008
40E
60E
80E
100E
120E
140E
160E
180
160W


Control
RD
RD - Control
20N
15N
10N
5N
EQ
5S
10S
15S
20S
40E
60E
80E
100E
120E
140E
160E
180
160W

Comparison with GPCP OBS

Control





RD