International Workshop on Climate Downscaling Studies at Tsukuba, October 4, 2017

Climate of the Philippines and the sea surface temperature effect on summer monsoon rainfall in the Philippines

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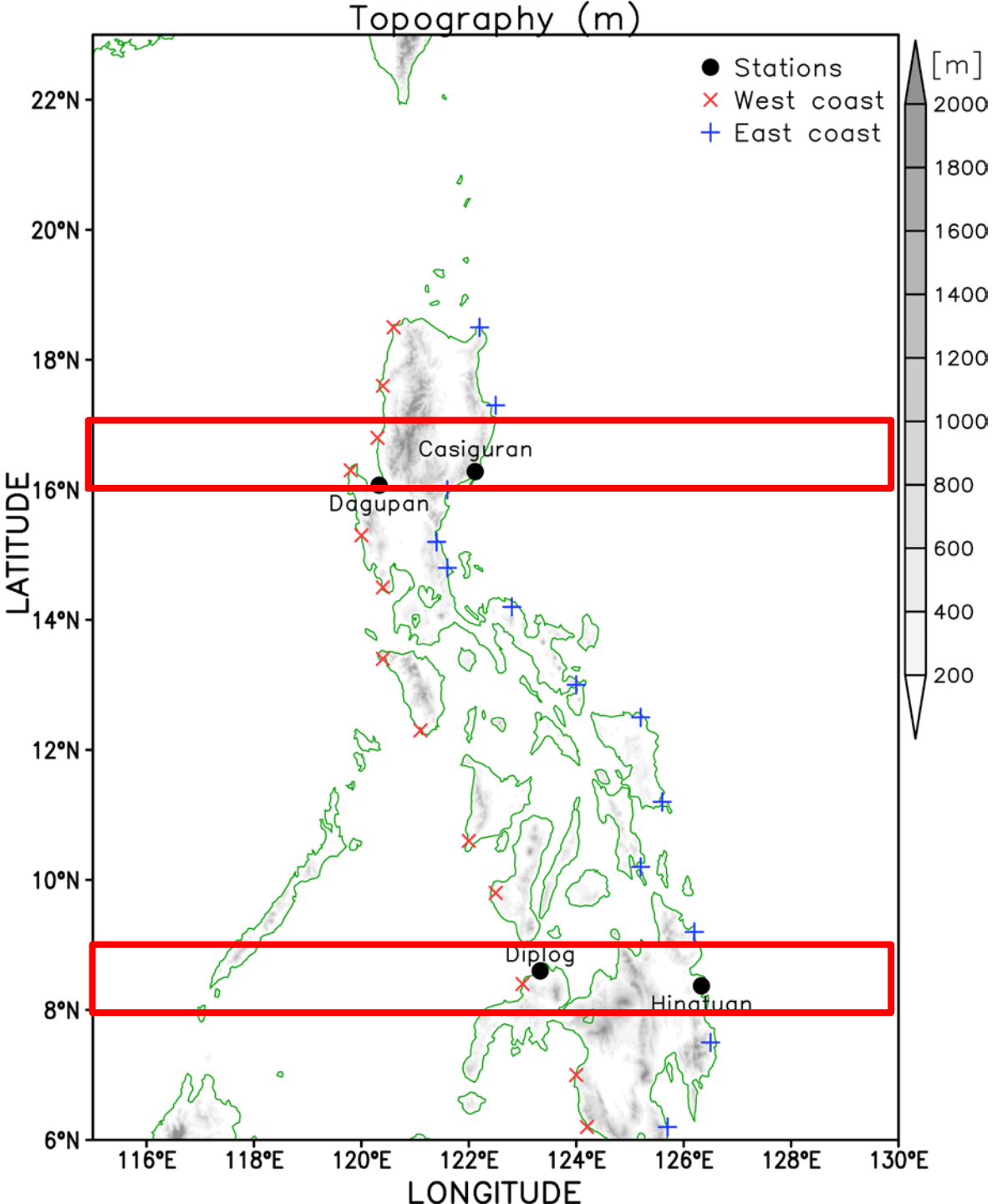
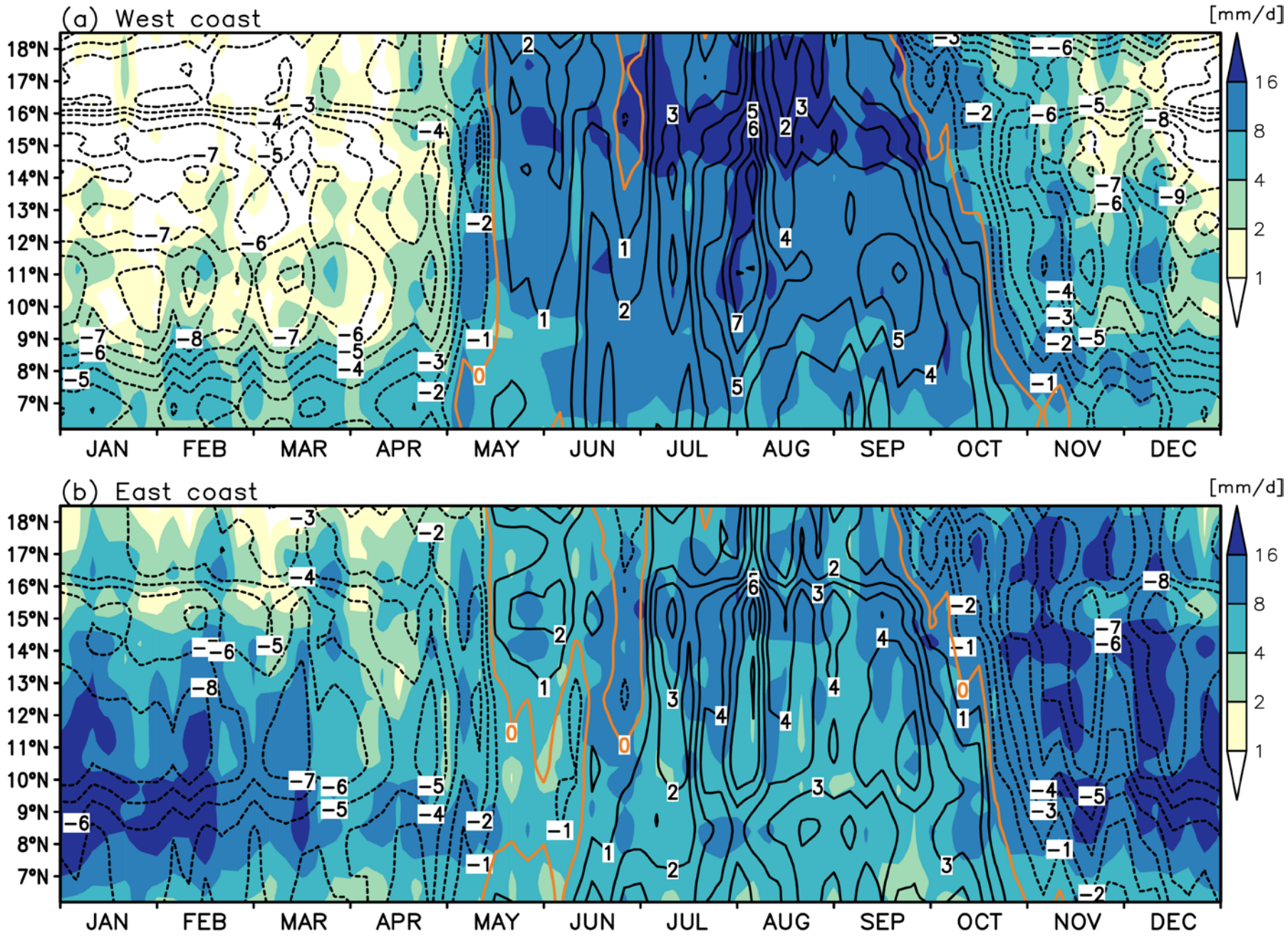
Mt Pinatubo Lahar and Mt. Arayat on the way from Manila to Baguio, March 2012

Outline of this talk

1. Climatic seasonal changes of regional rainfall and wind at 850 hPa in the Philippines by 5-day mean TRMM and ERA_Interim data, respectively.
2. The effect of spatial resolution on simulated rainfall over the western Philippines
3. The potential impact of sea surface temperature on rainfall over the western Philippines

For items 2&3: Using WRF-ARW v3.6.1 Model


Topography (m)
Stations
West coast
East coast
[m]
2000
1800
1600
1400
1200
1000
800
600
400
200
Casiguran
Dagupan
Diplog
Hinatuan
22°N
20°N
18°N
16°N
14°N
12°N
10°N
8°N
6°N
LATITUDE
116°E
118°E
120°E
122°E
124°E
126°E
128°E
130°E
LONGITUDE


Time–latitude sections of rainfall (mm/day) & U850 (m/s)
(a) West coast
[mm/d]
18°N
17°N
16°N
15°N
14°N
13°N
12°N
11°N
10°N
9°N
8°N
7°N
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
16
8
4
2
1
(b) East coast
[mm/d]
18°N
17°N
16°N
15°N
14°N
13°N
12°N
11°N
10°N
9°N
8°N
7°N
JAN
FEB
MAR
APR
MAY
JUN
JUL
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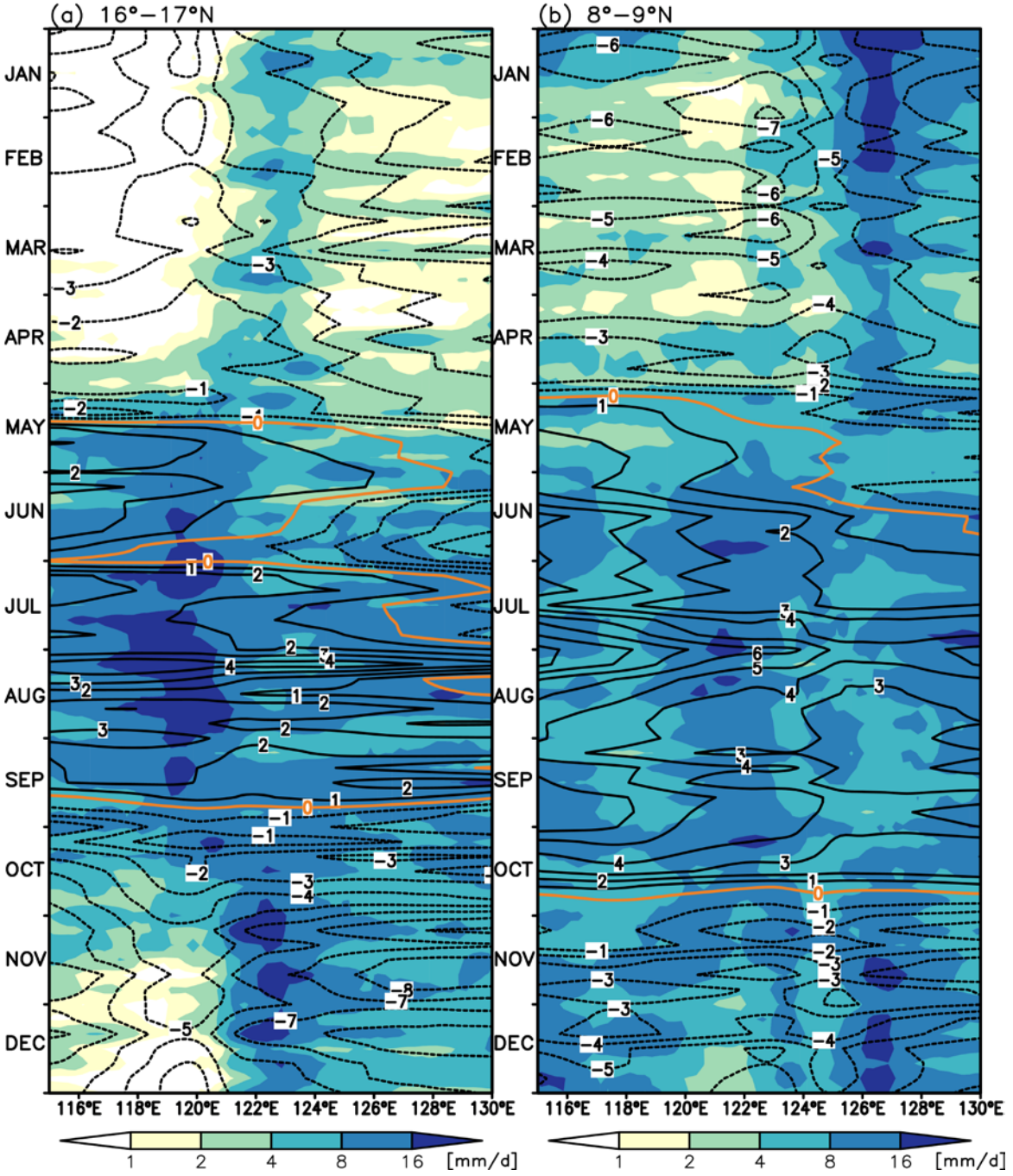
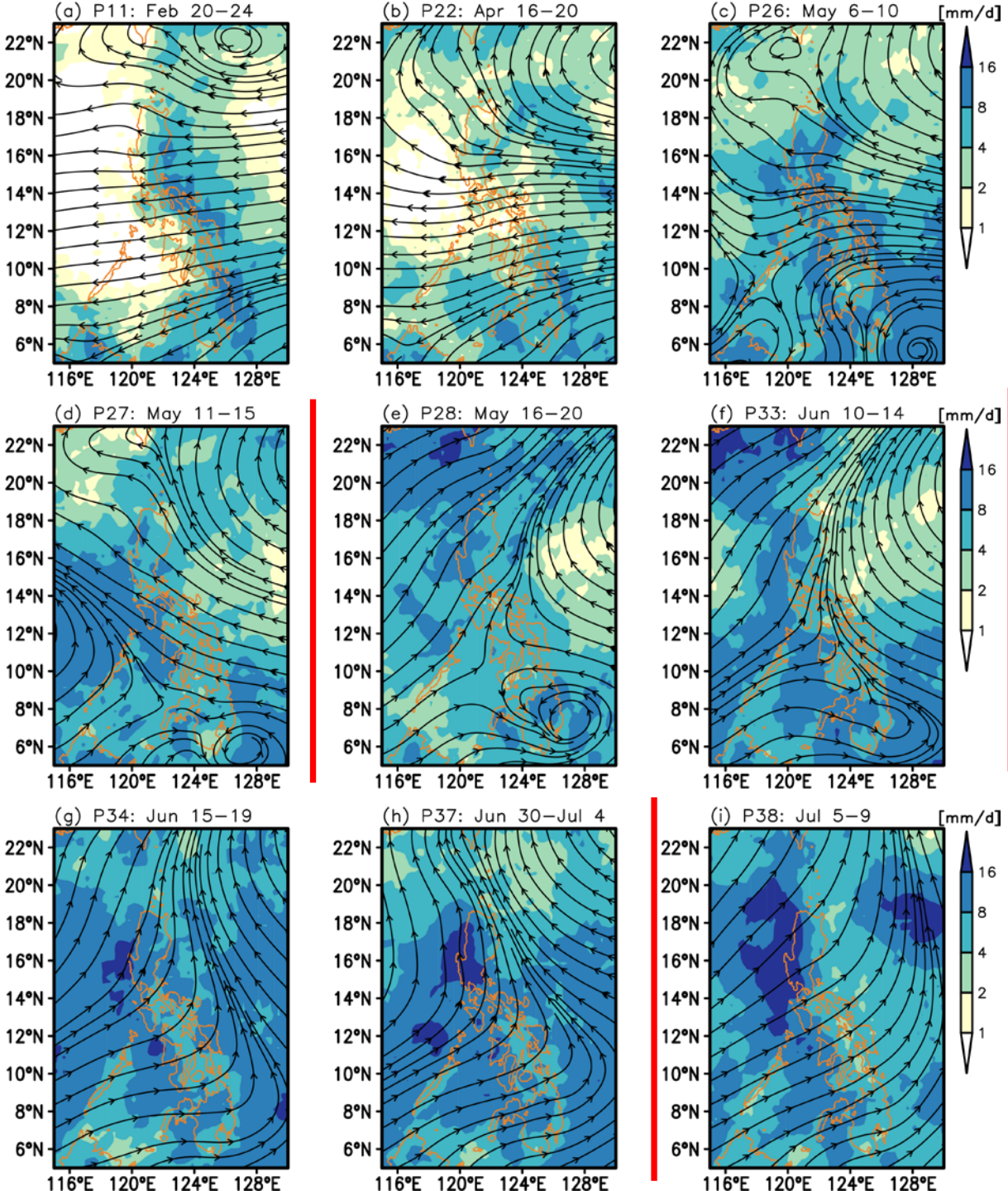
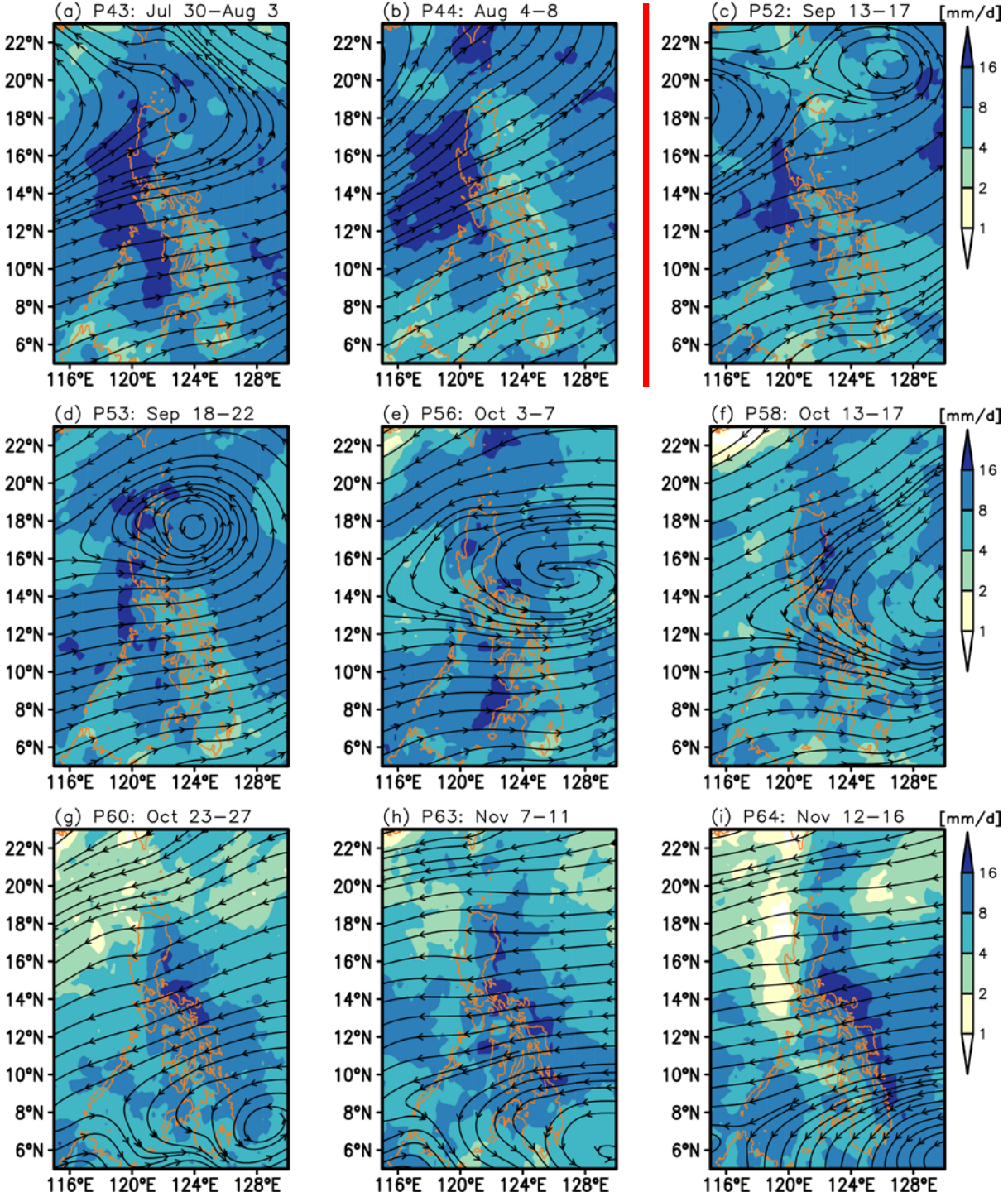
SEP
OCT
NOV
DEC
16
8
4
2
1


Time−longitude sections of rainfall (mm/day) & U850 (m/s)
(a) 16°−17°N
(b) 8°−9°N
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
116°E 118°E 120°E 122°E 124°E 126°E 128°E 130°E
1 2 4 8 16 [mm/d]

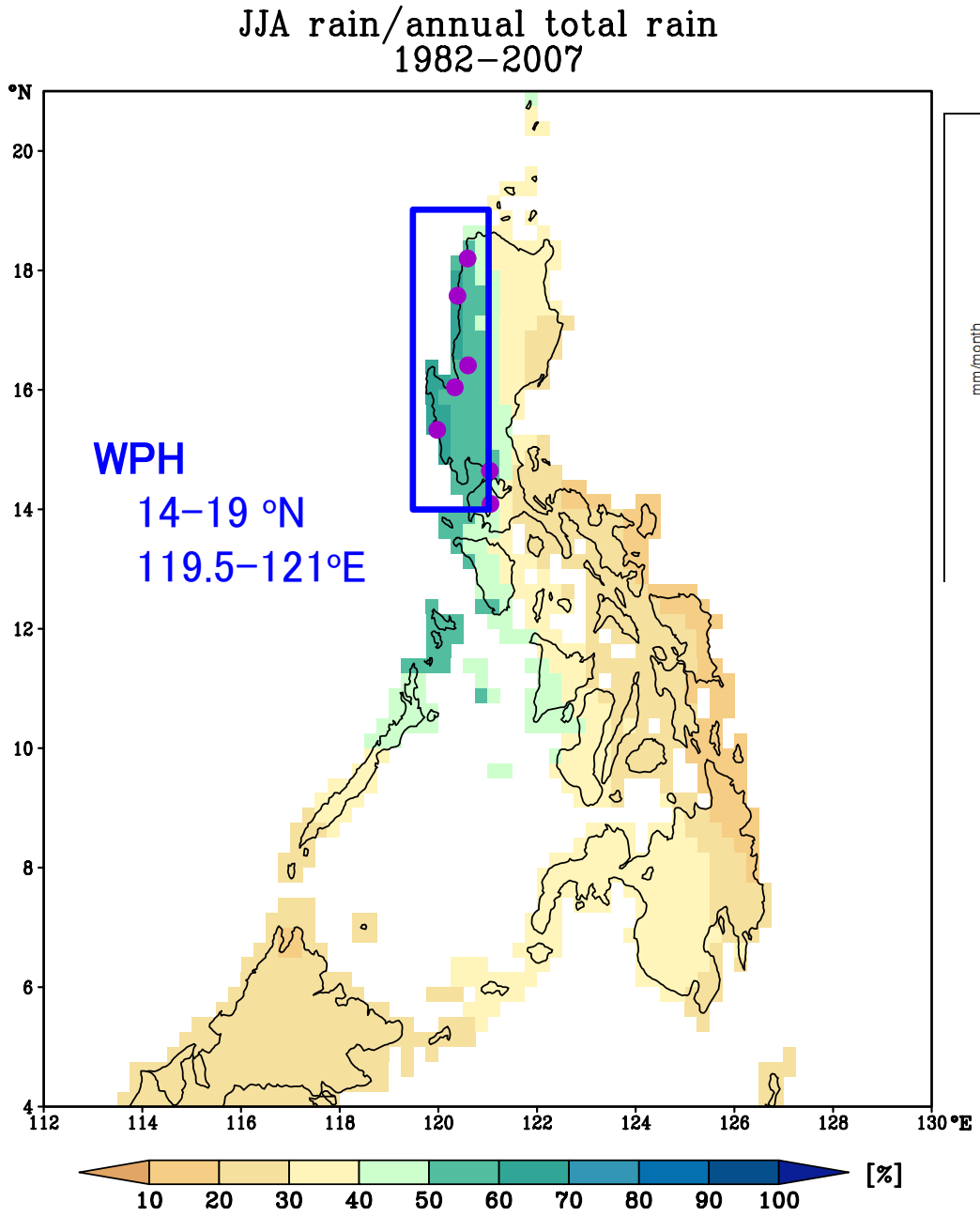

(a) P11: Feb 20–24
(b) P22: Apr 16–20
(c) P26: May 6–10
(d) P27: May 11–15
(e) P28: May 16–20
(f) P33: Jun 10–14
(g) P34: Jun 15–19
(h) P37: Jun 30–Jul 4
(i) P38: Jul 5–9
[mm/d]
16
8
4
2
1
22°N
20°N
18°N
16°N
14°N
12°N
10°N
8°N
6°N
116°E
120°E
124°E
128°E

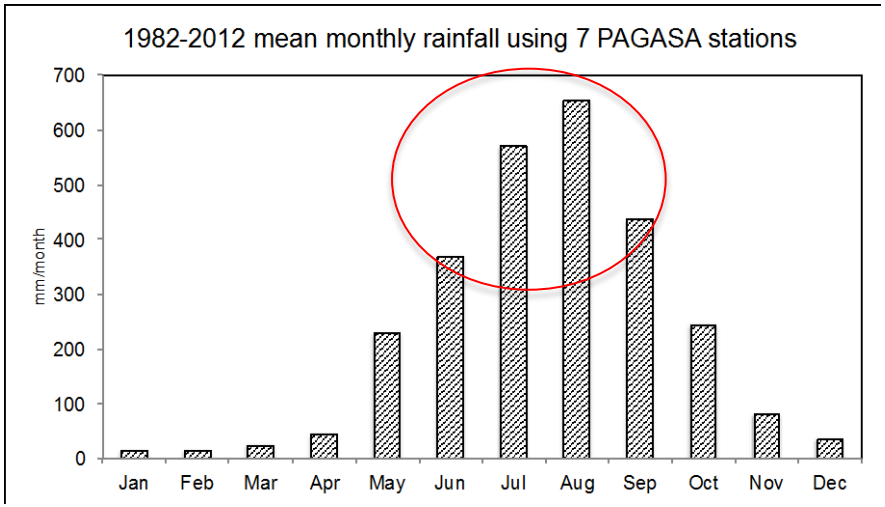

(a) P43: Jul 30–Aug 3
(b) P44: Aug 4–8
(c) P52: Sep 13–17
(d) P53: Sep 18–22
(e) P56: Oct 3–7
(f) P58: Oct 13–17
(g) P60: Oct 23–27
(h) P63: Nov 7–11
(i) P64: Nov 12–16
[mm/d]
16
8
4
2
1
22°N
20°N
18°N
16°N
14°N
12°N
10°N
8°N
6°N
116°E
120°E
124°E
128°E

2. Effect of spatial resolution on simulated rainfall over the western Philippines

What resolution can RCMs reproduce summer monsoon rainfall on the northwestern coast of the Philippines?

Dado, J.M. & Takahashi, H.G. 2017. Effect of spatial resolution on simulated rainfall over western Philippines, Geogr. Reps. Tokyo Metrop. Univ. 52: 1-9.





- >50–70 % of annual rainfall occurs in June–August during Southwest Monsoon Season (SWM)

Model & experimental setup

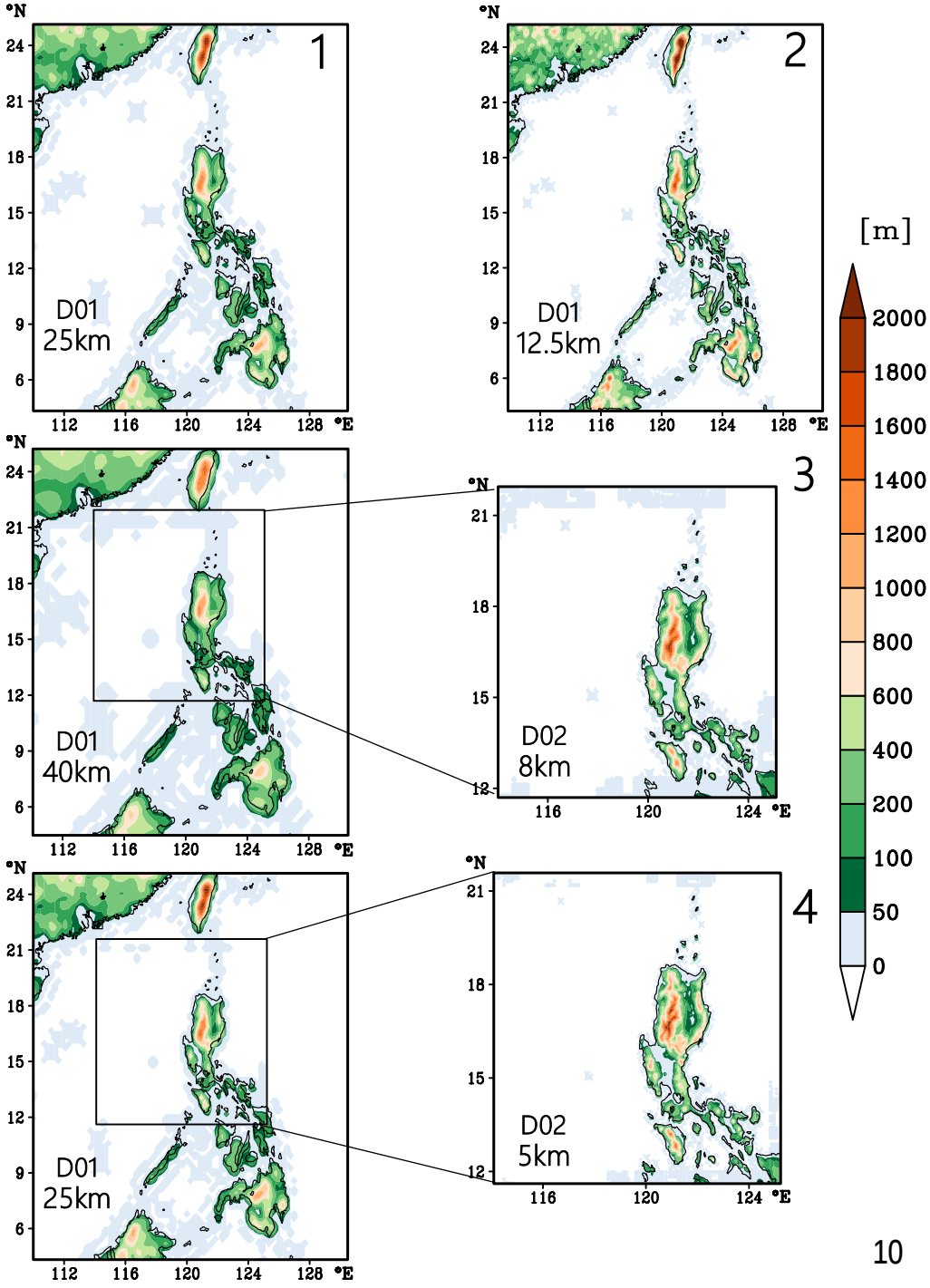
WRF-ARW v3.6.1

Domains

1. D01 – 25km
2. D01 – 12.5km
3. D02 – 8km, nested in 40km
4. D02 – 5km, nested in 25km

Simulation Period

June to August
1982-2012



Model & experimental setup

WRF-ARW v3.6.1

Boundary Conditions

Atmospheric --- ERA Interim

SST --- NOAA monthly OISSTv2

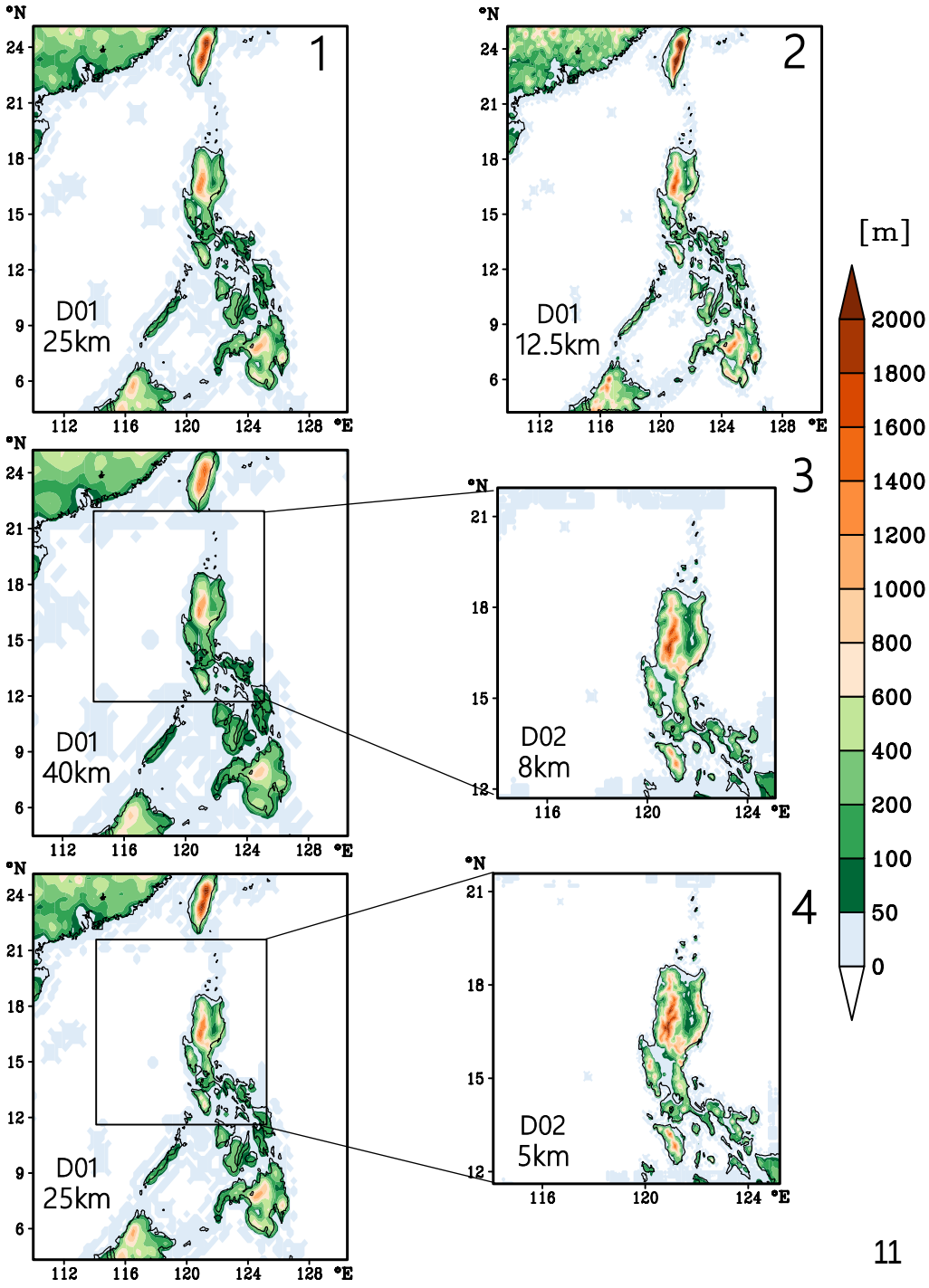
Parameterization

Microphysics --- WSM 6-class graupel

Planetary boundary layer --- Mellor-Yamada-Janjic

Land surface --- Unified NOAH

No cumulus convective parameterization (CCP)



Data for evaluation of monthly rainfall

1. APHRODITE

   Asian Precipitation Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources (Yatagai et al. 2012)

   - Daily rainfall from 1982–2007
   - 0.25deg resolution

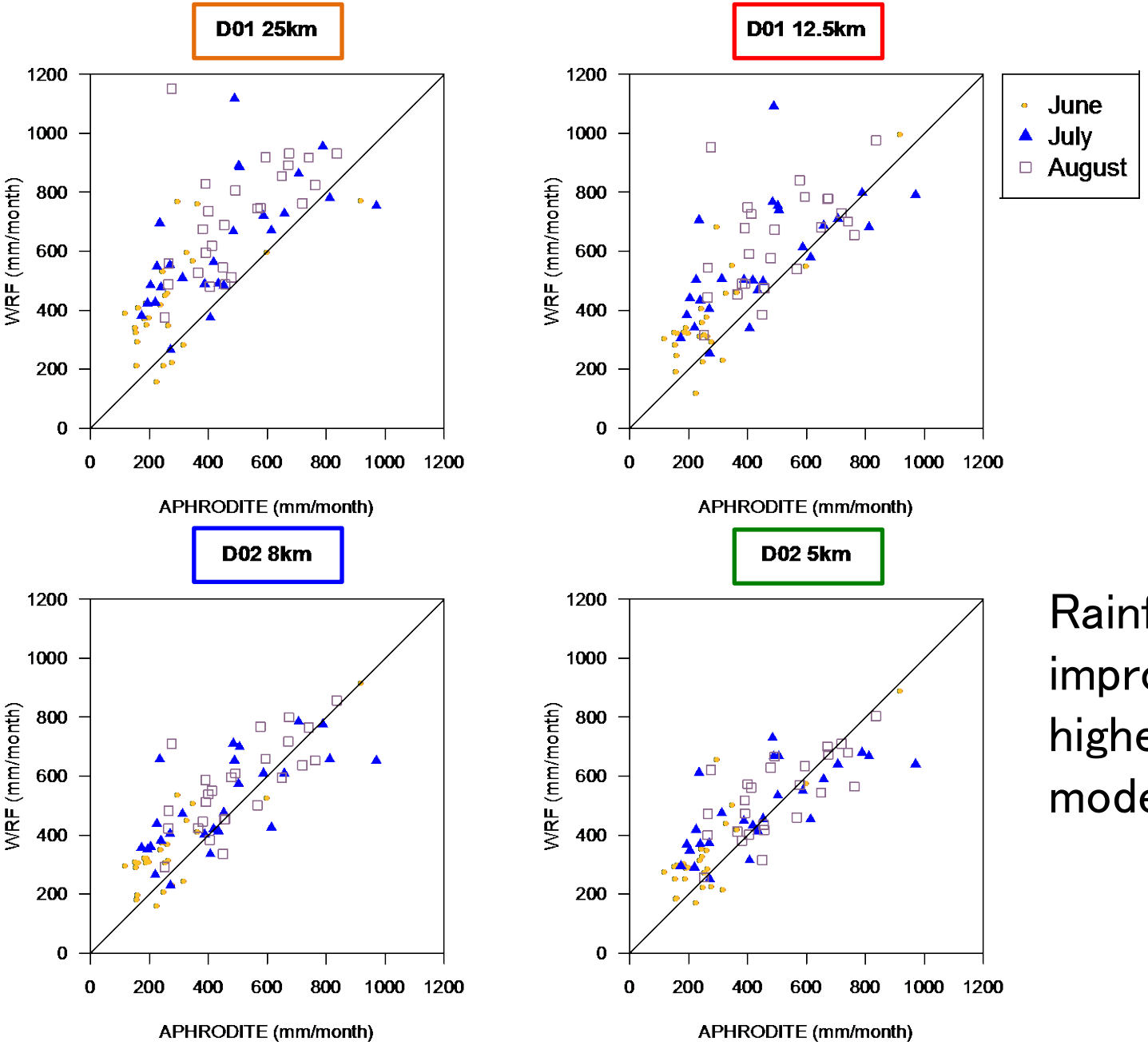
2. Seven (7) stations from PAGASA

   Philippine Atmospheric Geophysical and Astronomical Services Administration

   - Daily rainfall amount, 1982-2012
   - Stations span the WPH region.

Monthly rainfall amount

WRF model vs APHRODITE 1982–2007

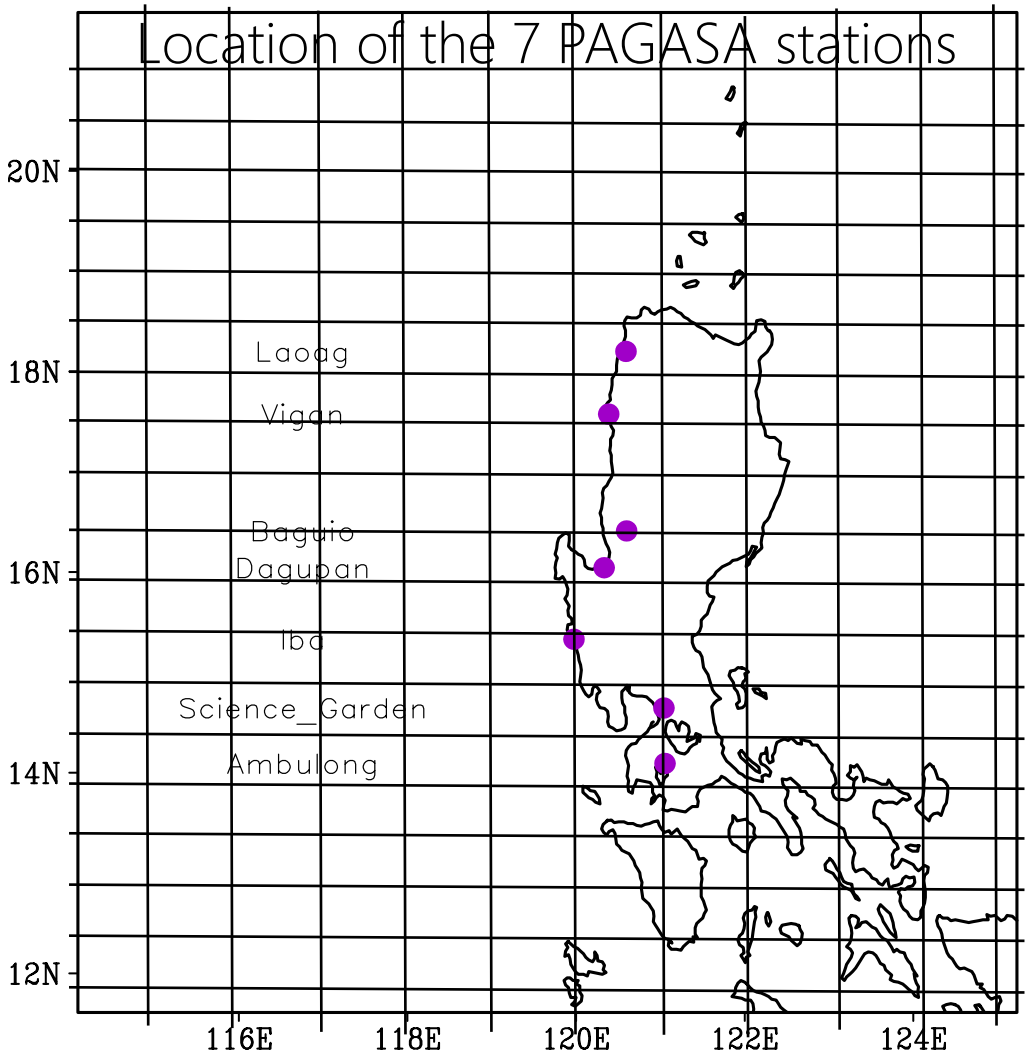


Rainfall amount improved in the higher resolution models.

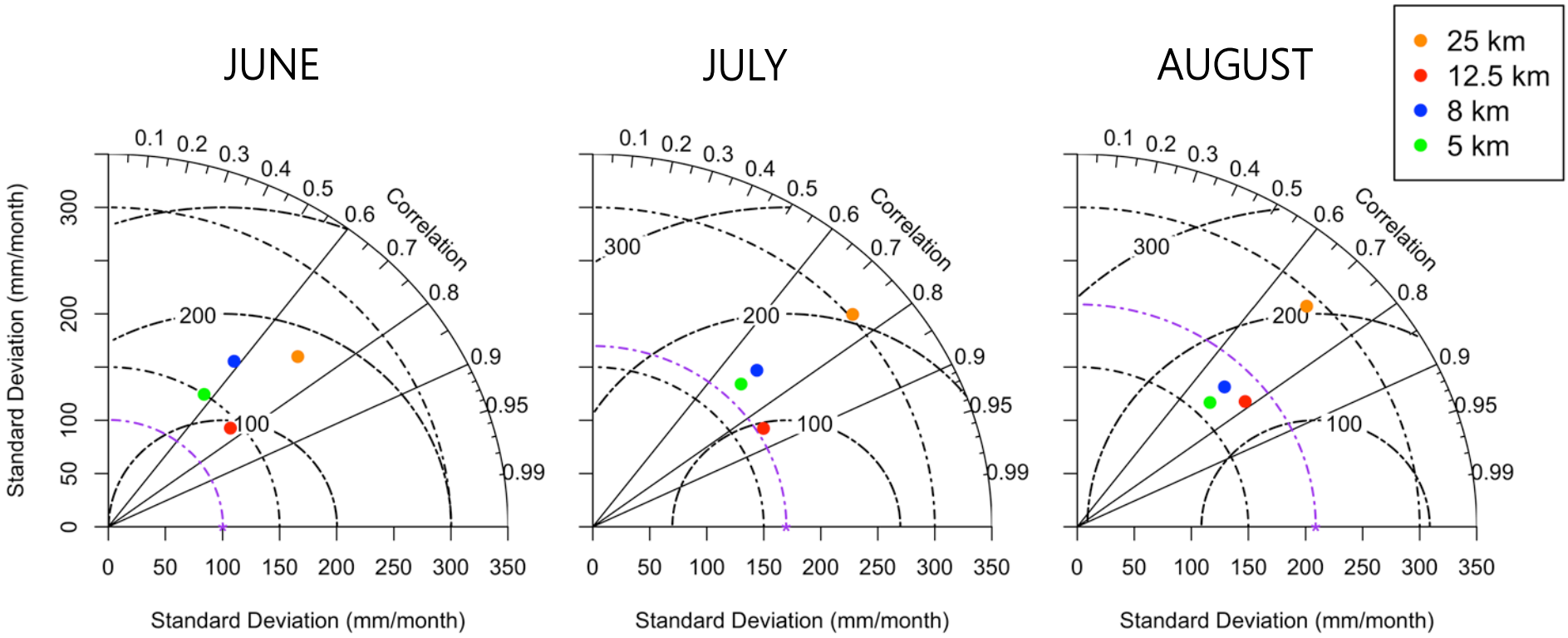
Model performance in terms of spatial distribution of monthly rainfall

Climatological mean
(1982-2012 mean)
rainfall

per **STATION**
for every month
June , July , August



Grids are for visualization purposes only, not the actual model grids



12.5 km has the closest distribution to PAGASA
in terms of climatological rainfall distribution

5km is better than 25km
downscaling improves model' s spatial variation of rainfall thru minimizing RMS difference

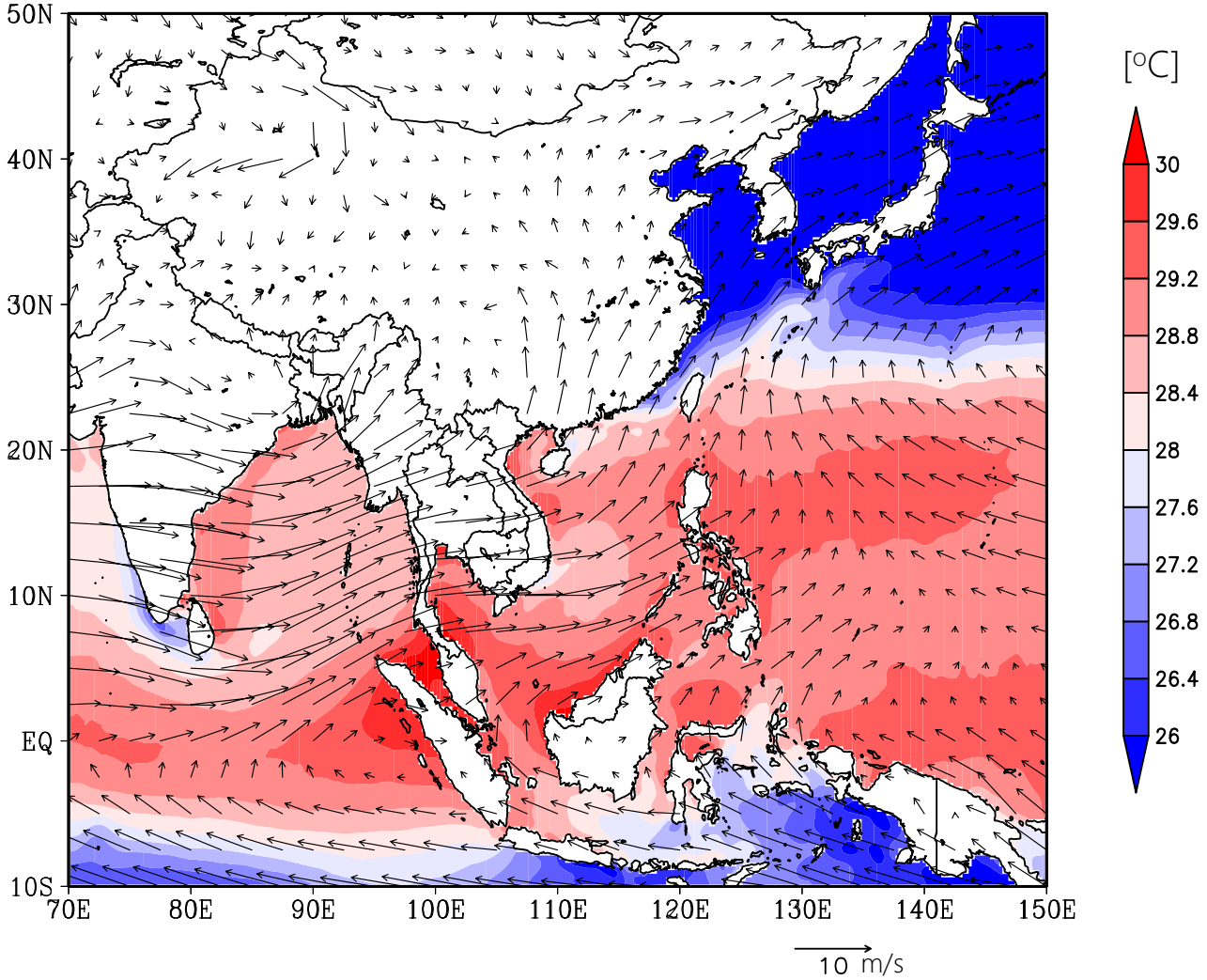
3. Potential impact of sea surface temperature on rainfall over the western Philippines

What is the impact of local SST west of the Philippines on the summer monsoon rainfall on the northwestern coast of the Philippines?

Dado, J.M. & Takahashi, H.G. 2017. Potential impact of sea surface temperature on rainfall over the western Philippines, Progress in Earth and Planetary Science , 4:23, DOI 10.1186/s40645-017-0137-6.

Can SST affect rainfall west of the Philippines?

850 mb winds (vectors) + SST (shaded contours)



Model & experimental setup

Boundary Conditions

Atmospheric:

ERA Interim

Sea surface temperature:

NOAA monthly OISSTv2

Parameterization

Microphysics:

WSM 6-class graupel

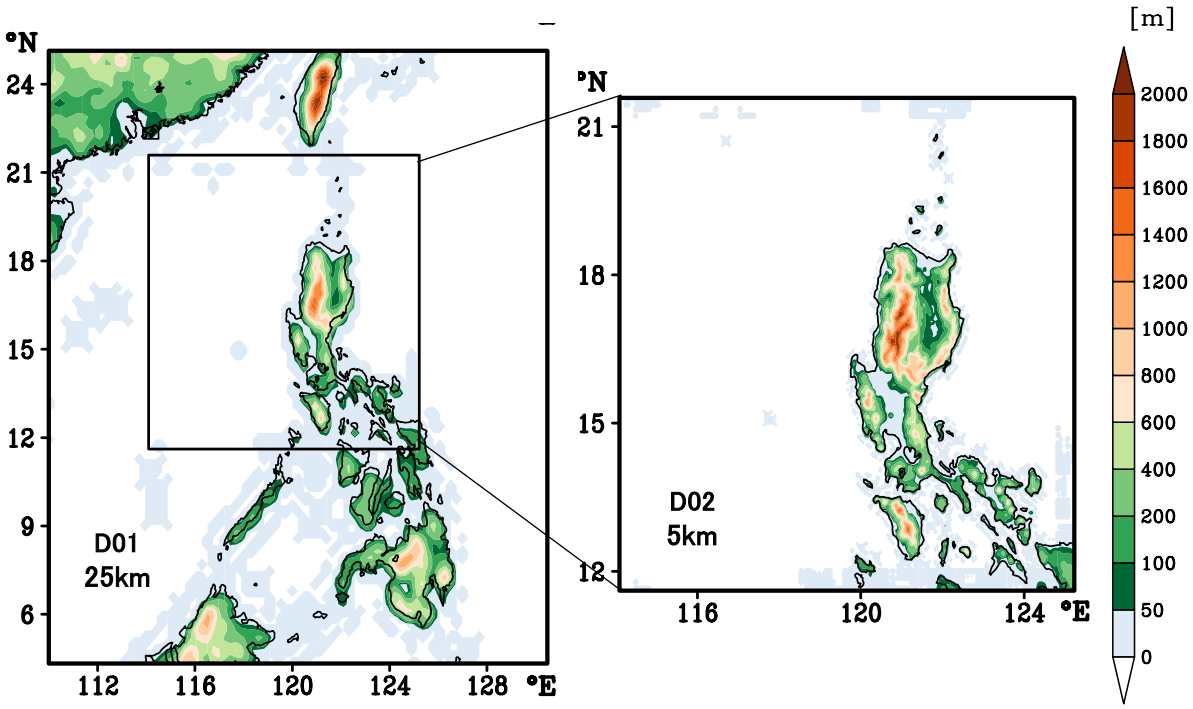
Planetary boundary layer:

Mellor-Yamada-Janjic

Land surface:

Unified NOAH

No cumulus convective parameterization (CCP)



WRF-ARW v3.6.1

-- Simulation Period: June to August, 1982-2012
-- Resolution analysis: 5km, nested within 25km domain
-- ERA Interim atmospheric boundary condition
-- NOAH Land Surface Model
-- No cumulus convective parameterization (CCP)

CTL experiment

w/ monthly mean SST data from NOAA OISST v2

CLM experiment

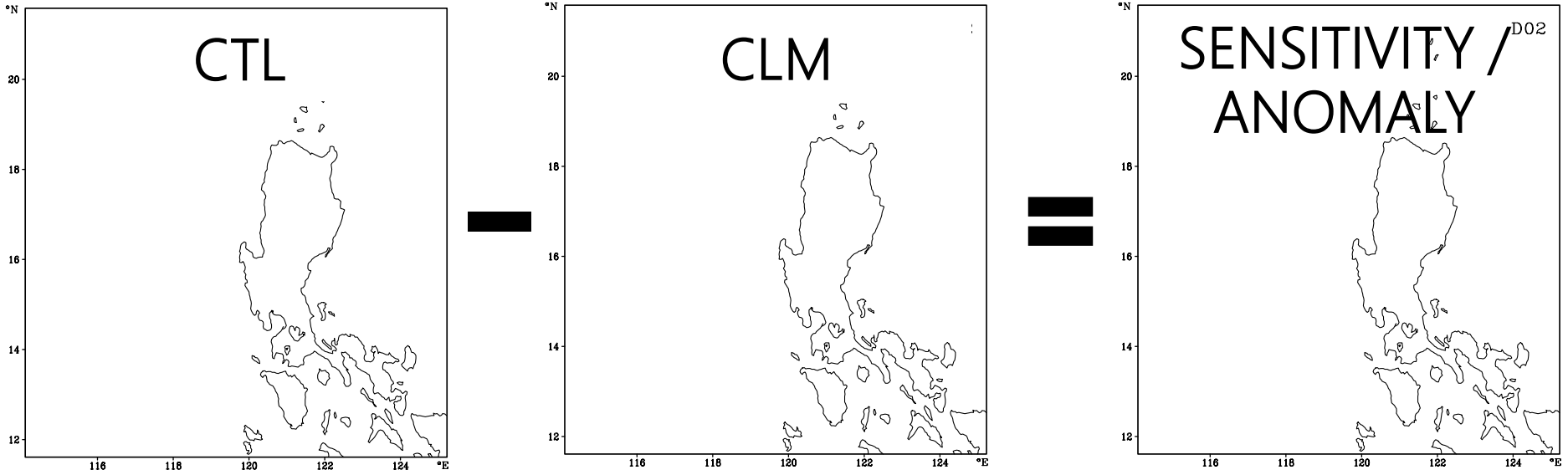
w/ monthly climatological SST (1982-2012) from NOAA OISST v2

Compare CTL and CLM results

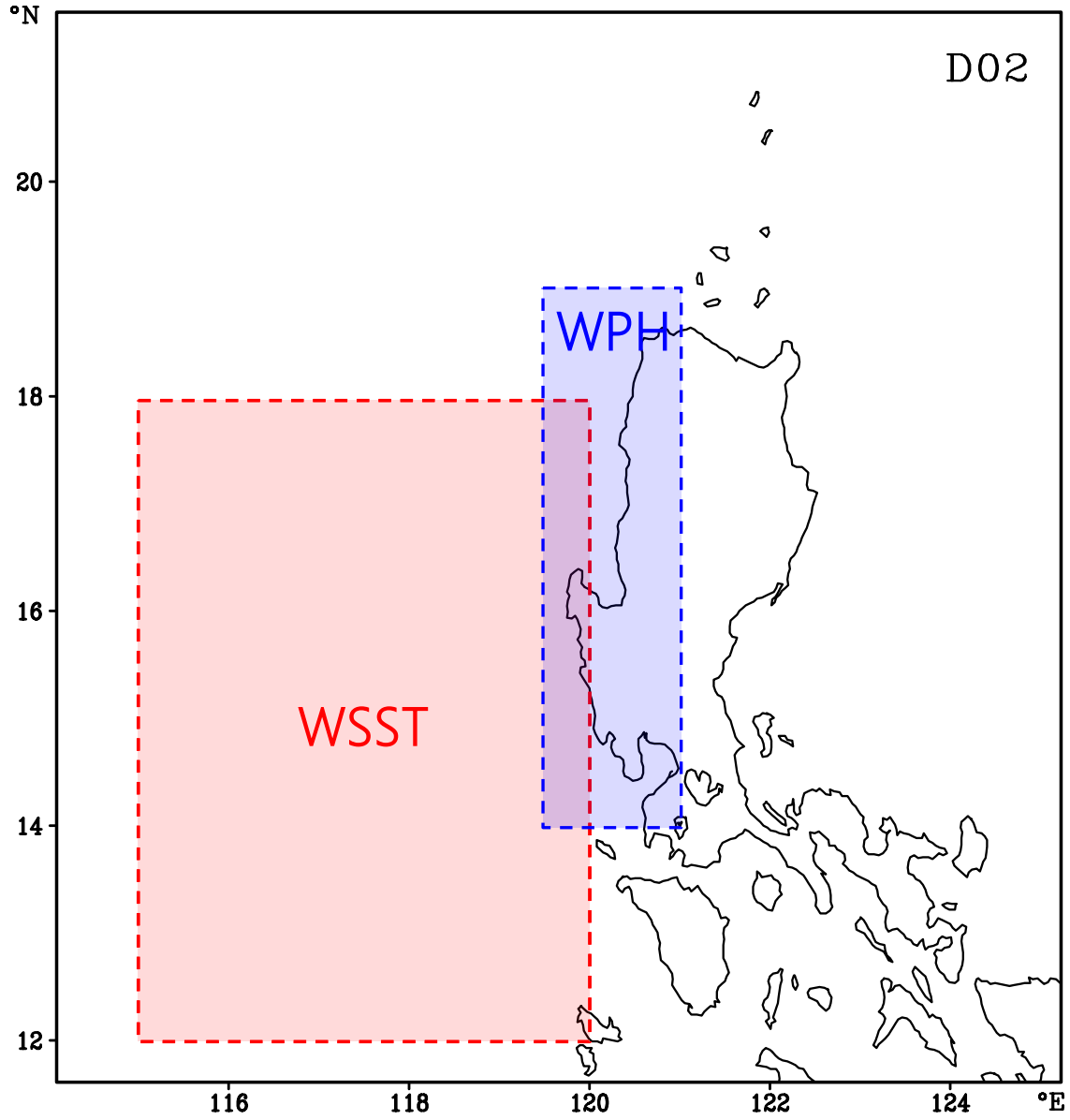
Determine the sensitivity of rainfall to the variations of SST

SST impact

For each year,



SST impact



WPH

14–19 °N

119.5–121°E

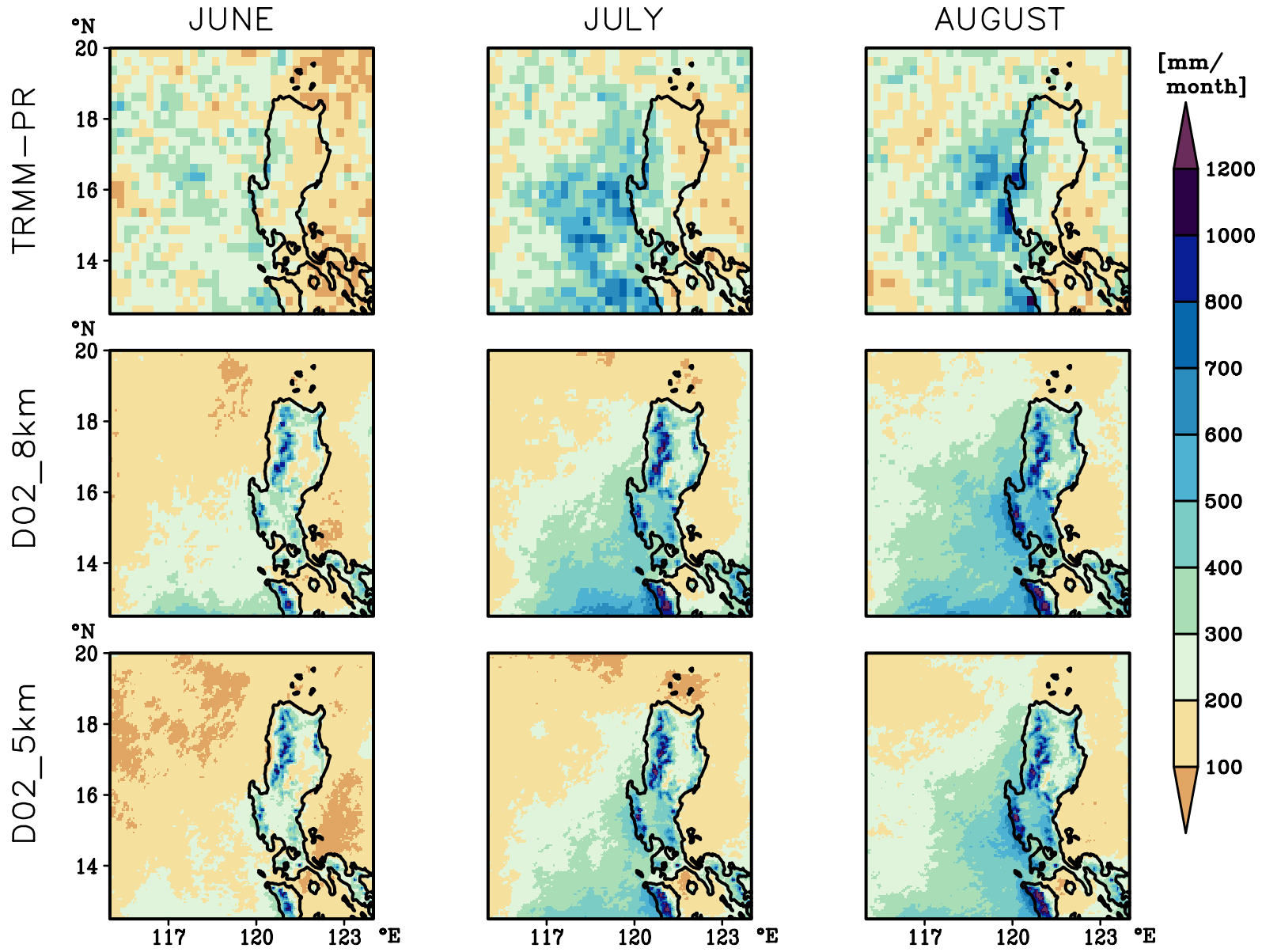
WSST

12–18 °N

115–120°E

Spatial distribution of monthly rainfall

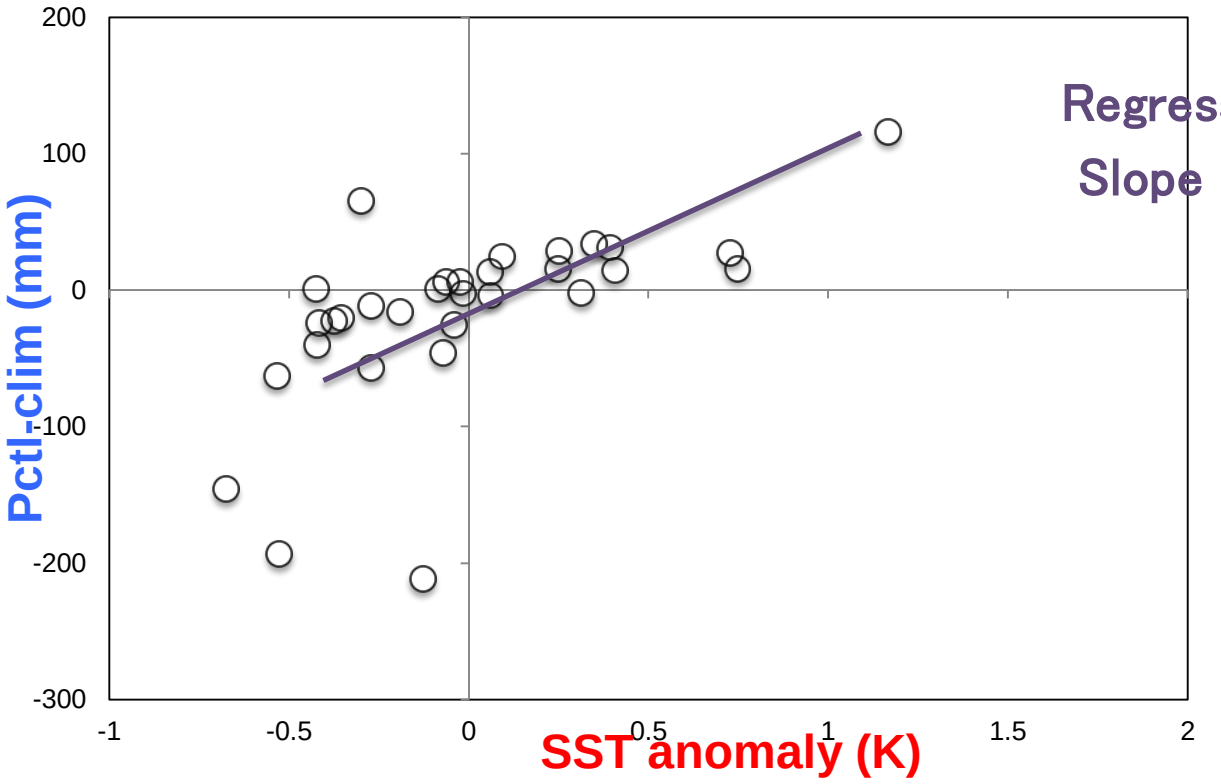
vs TRMM-PR 1998-2012



SST impact on rainfall

REGRESSION ANALYSIS

relationship between rainfall sensitivity to SST anomaly in WSST region



Regression coefficient

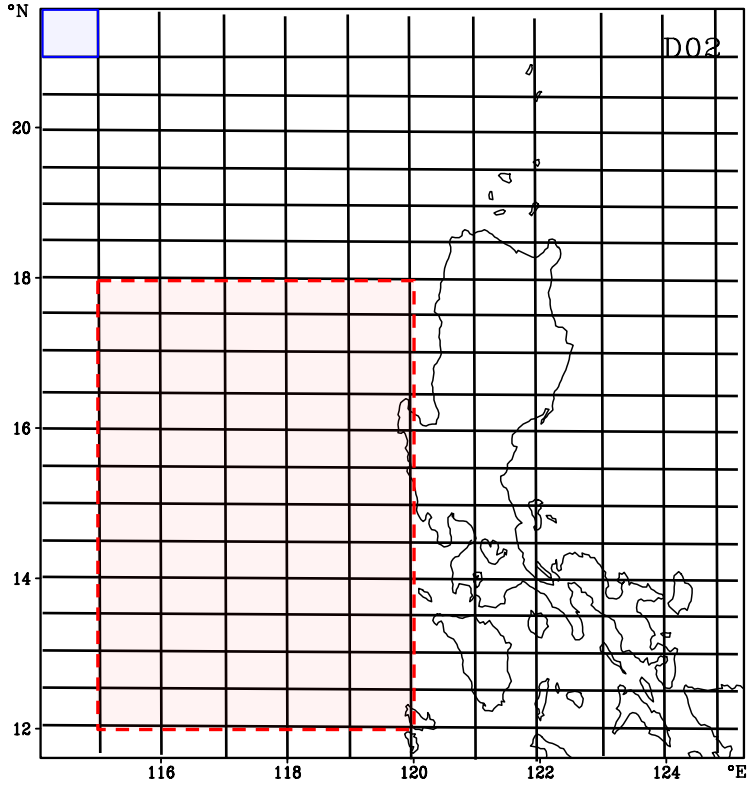
Slope –> rate of change of rainfall per 1K SST warming

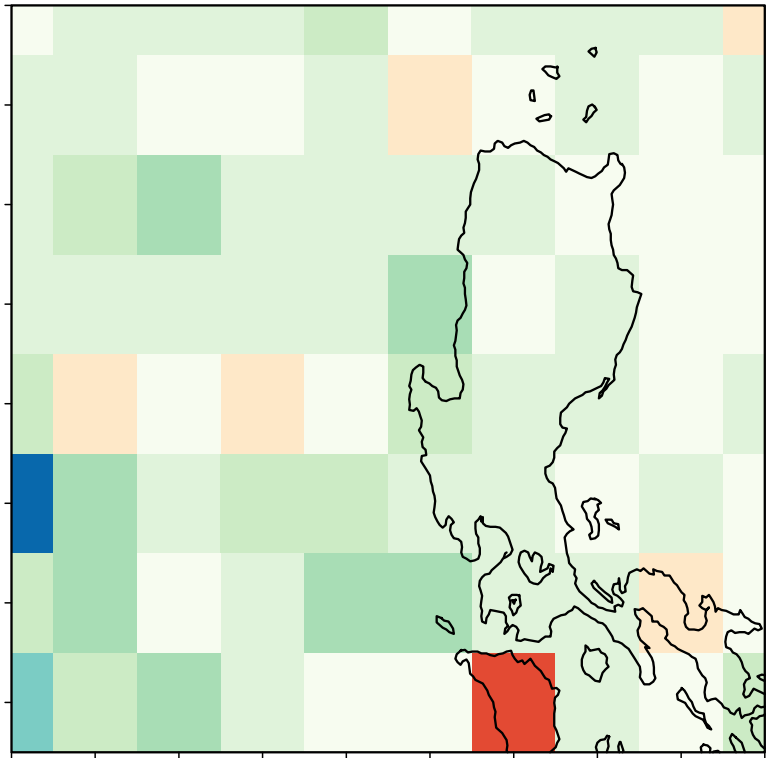
Theil–Sen method

Estimate trend using median slope among all lines through all pairs of points

SST impact on rainfall

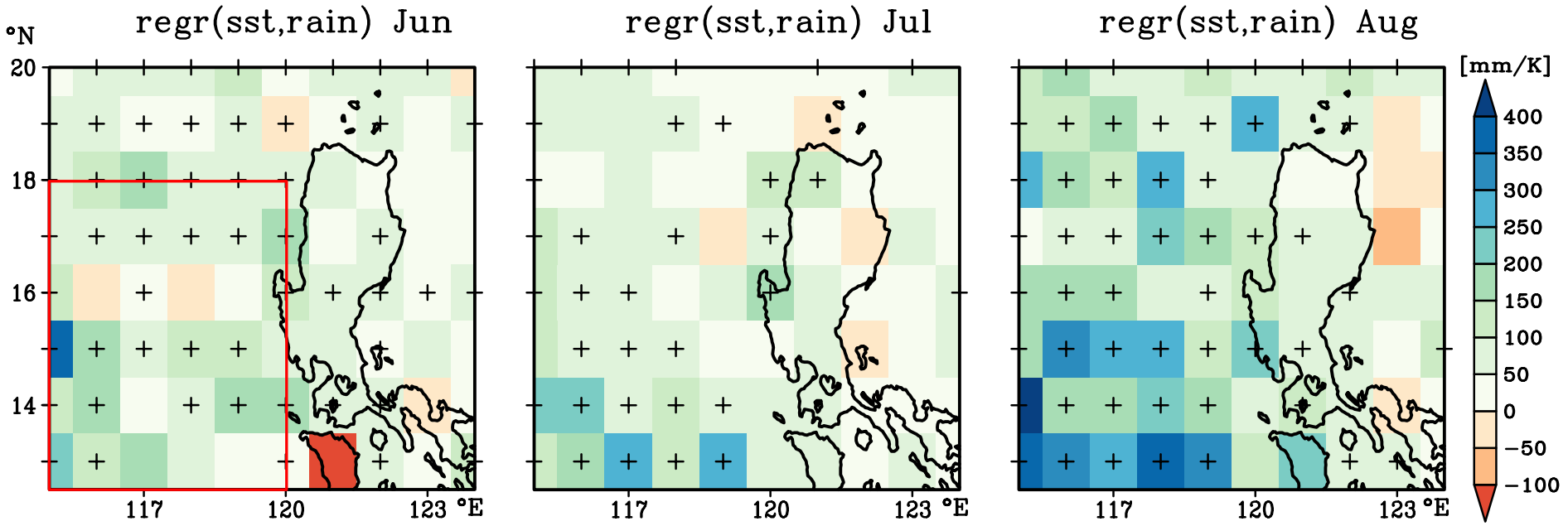
SPATIAL MAP of the regression coefficient





regression coefficient of the rainfall sensitivity to the SST anomaly in the WSST region

SST impact on rainfall

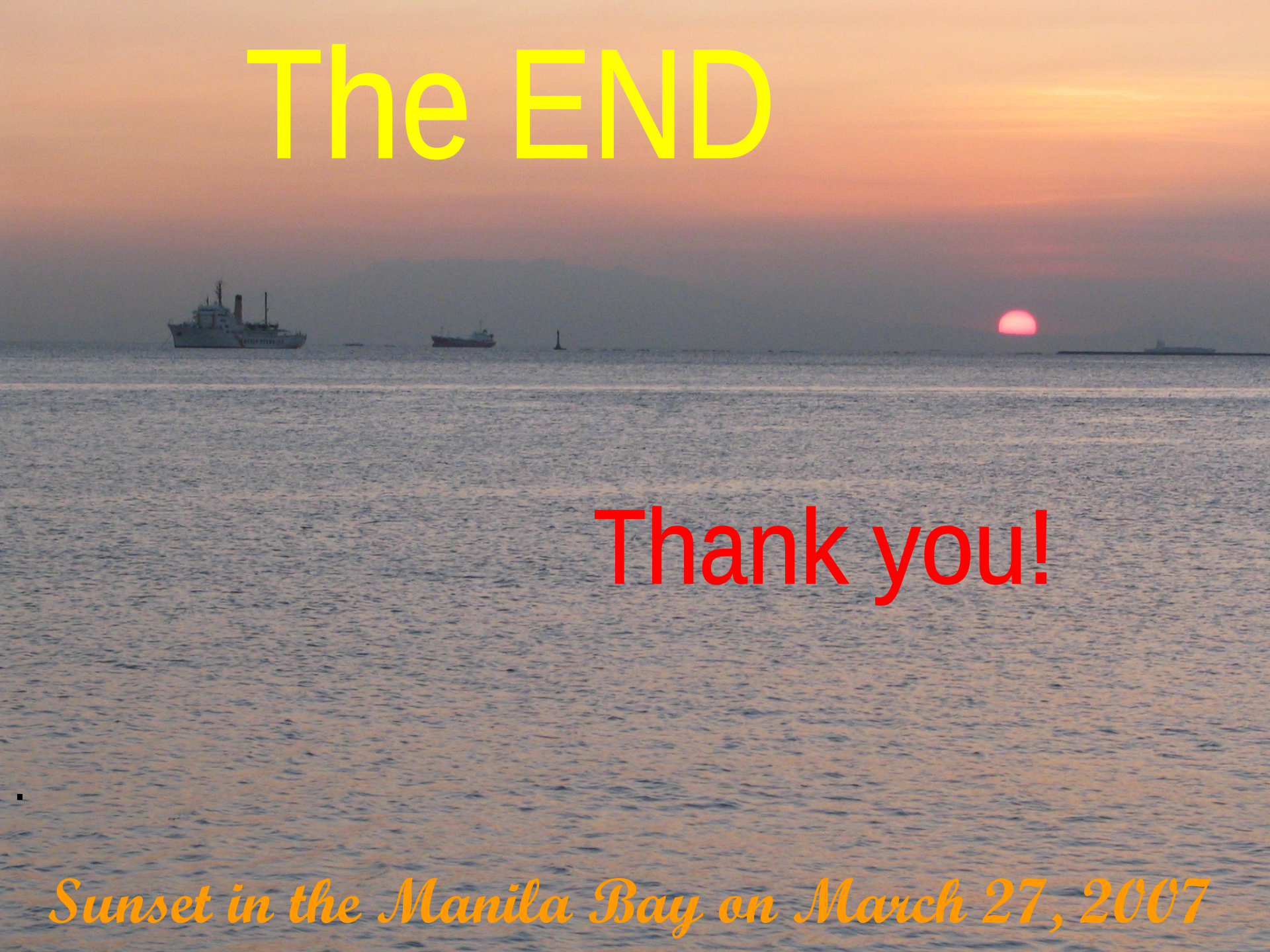


"+" - significant values at the 90% significance level determined by correlation coefficients based on 29 degrees of freedom.

- Positive rainfall sensitivity to 1-K SST warming over the domain.
- Higher and statistically significant sensitivity was observed for oceanic rainfall near the WSST region.
- Rainfall in the WPH increased by ~100 mm K^{-1} SST warming in the WSST

Conclusions

1. Onset of southwest monsoon is very abrupt in mid-May, while it retreats gradually from the north in mid-September, and fully retreat in late October.
2. Best RCM resolutions reproducing summer monsoon rainfall on the northwestern coast of the Philippines: 12.5km for spatial distribution of climatological monthly rainfall, 5km for interannual monthly rainfall amount.
3. Positive SST anomalies in WSST region induce positive rainfall anomalies in the WPH region.
   - Based on regression analysis, WPH rainfall is modulated by interannual variation in WSST by ~100mm per 1K SST warming.


The END
Thank you!
Sunset in the Manila Bay on March 27, 2007