Evaluation of NHRCM high-resolution climate simulations over the Philippines

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International Workshop on Climate Downscaling Studies

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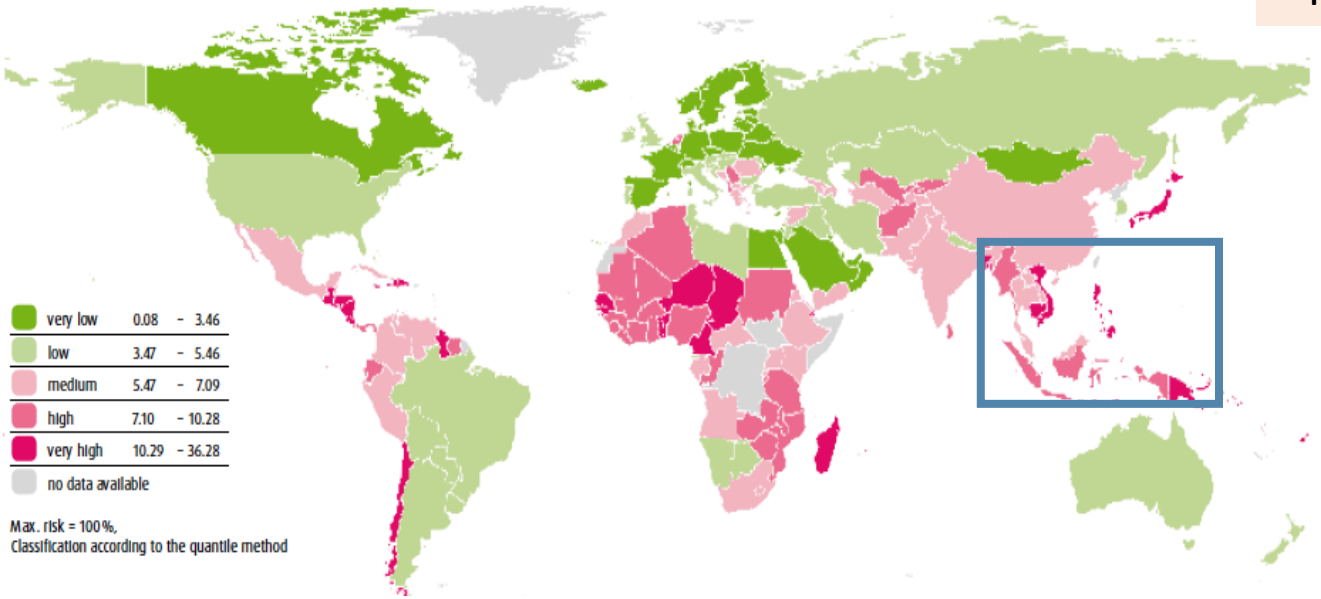
Philippines : a hotspot for climate risk

- High climate risk: high exposure, high vulnerability, lack of coping and adaptive capacities (World Risk Report, 2016)
- High-resolution climate projections critical for appropriate adaptation measures, especially for areas along the coast, with complex topography
- Currently available projections from single GCM, RCM, emission scenario
- Projections from multiple GCMs, RCMs and RCPs recommended to address uncertainties

World Risk Report, 2016



Source: http://weltrisikobericht.de/wp-content/uploads/2016/08/WorldRiskReport2016.pdf

Tropical Cyclone Tracks (1945-2010)

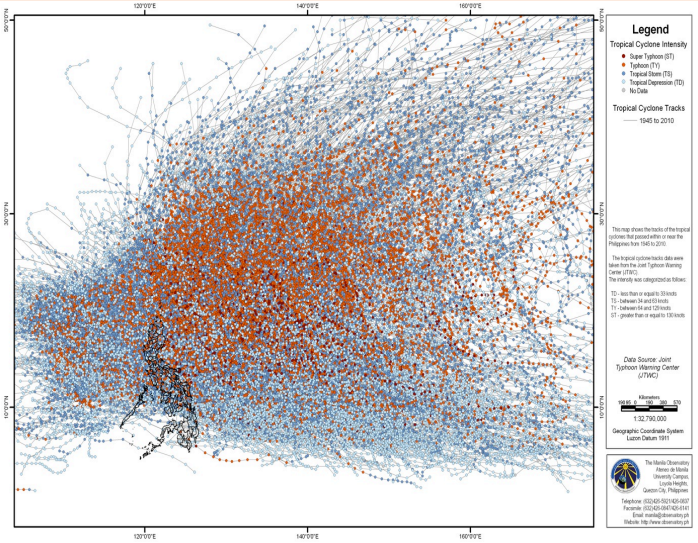
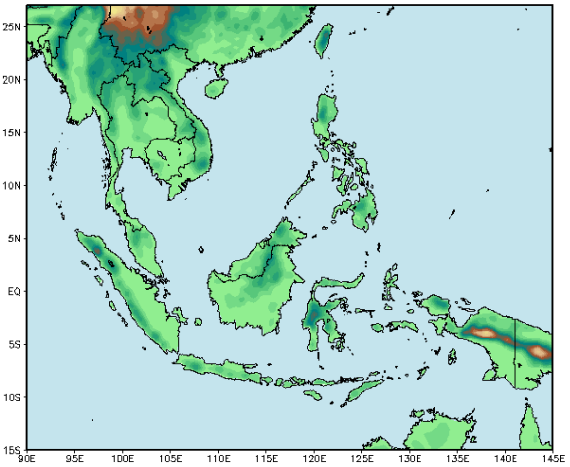


Figure source: Manila Observatory
Data: JTWC

SEACLID

CORDEX-Southeast Asia

The Southeast Asia Regional Climate Downscaling (SEACLID) / CORDEX Southeast Asia Project



2nd SEACLID/CORDEX Southeast Asia Manuscript Writing Workshop
RU-CORE, Bangkok, Thailand, 3-10 July 2017

Participating members: 20 institutions from 14 countries within and outside Southeast Asia

- Aims to produce high-resolution climate projections over SE Asia from multiple GCMs, RCMs and RCP scenarios (to be distributed via ESGF), and to enhance climate research and capacity in the region
- Website: http://www.ukm.my/seaclid-cordex

Climate simulations conducted under SEACLID / CORDEX Southeast Asia Project

- Sensitivity tests using RegCM4 for present climate done (Juneng et al. 2016, Ngo-Duc et al. 2017, Cruz et al. 2017)
- Ongoing analysis of projection simulations

Country	GCM	RCP	RCM
Vietnam	CNRM-CM5	RCP8.5, 4.5	RegCM4
Philippines	HadGEM2	RCP8.5, 4.5	RegCM4
Thailand	MPI-ESM-MR	RCP8.5, 4.5	RegCM4
Thailand	EC-Earth	RCP8.5, 4.5	RegCM4
Indonesia	CSIRO MK3.6	RCP8.5, 4.5	RegCM4
Malaysia	CanESM2	RCP8.5, 4.5	RegCM4
Malaysia	IPSL-CM5A-LR	RCP8.5, 4.5	RegCM4
Malaysia	GFDL-ESM2M	RCP8.5, 4.5	RegCM4

Country	GCM	RCP	RCM
Australia	CNRM-CM5	RCP8.5	CCAM
Australia	CCSM4	RCP8.5	CCAM
Australia	ACCESS1.3	RCP8.5	CCAM
Hong Kong SAR	CCSM or CESM	RCP8.5, 4.5	WRF
United Kingdom	HadGEM2-ES	RCP8.5, 4.5	PRECIS
South Korea	HadGEM2-AO	RCP8.5, 4.5	WRF
Sweden	CNRM-CM5	RCP8.5, 4.5	RCA3
Sweden	HadGEM2-ES	RCP8.5, 4.5	RCA3
Germany	MPI-ESM-LR	RCP8.5, 4.5	ROM
Japan	MRI-AGCM60	RCP8.5, 4.5	NHRCM

Application of NHRCM over Southeast Asia and the Philippines

Objective : To generate high-resolution multi-scenario climate projections for Southeast Asia (25 km) and the Philippines (5 km) using NHRCM (Sasaki et al. 2008)

Methodology :

- Boundary conditions
  - ERA-Interim
  - MRI AGCM3.2
- 14-month runs (from April to May of the following year) in parallel, discarding initial 2 months as model spin-up
- Spectral nudging used

Model Domain at 25 km resolution

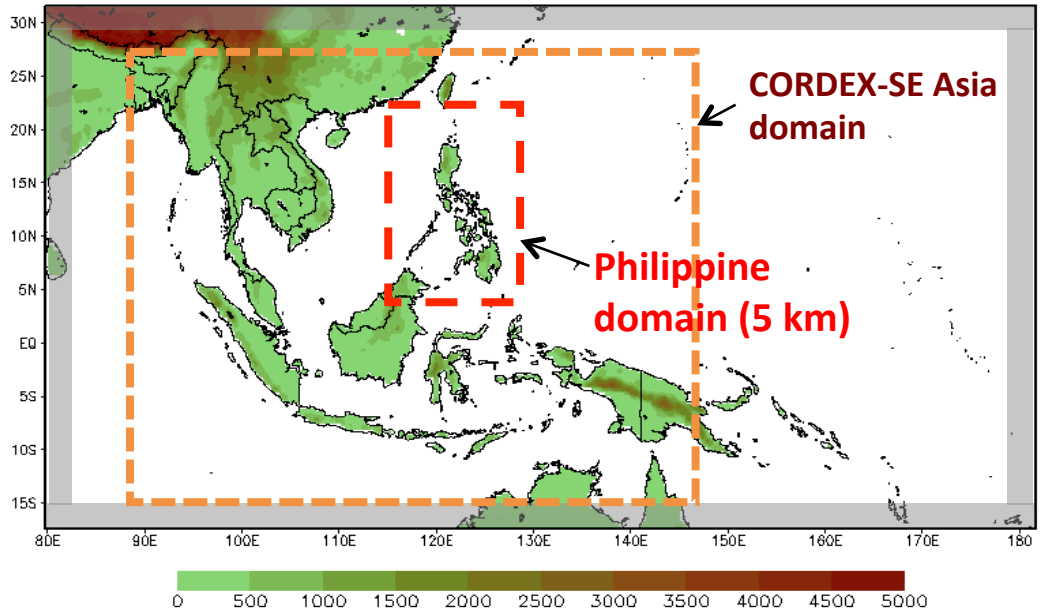
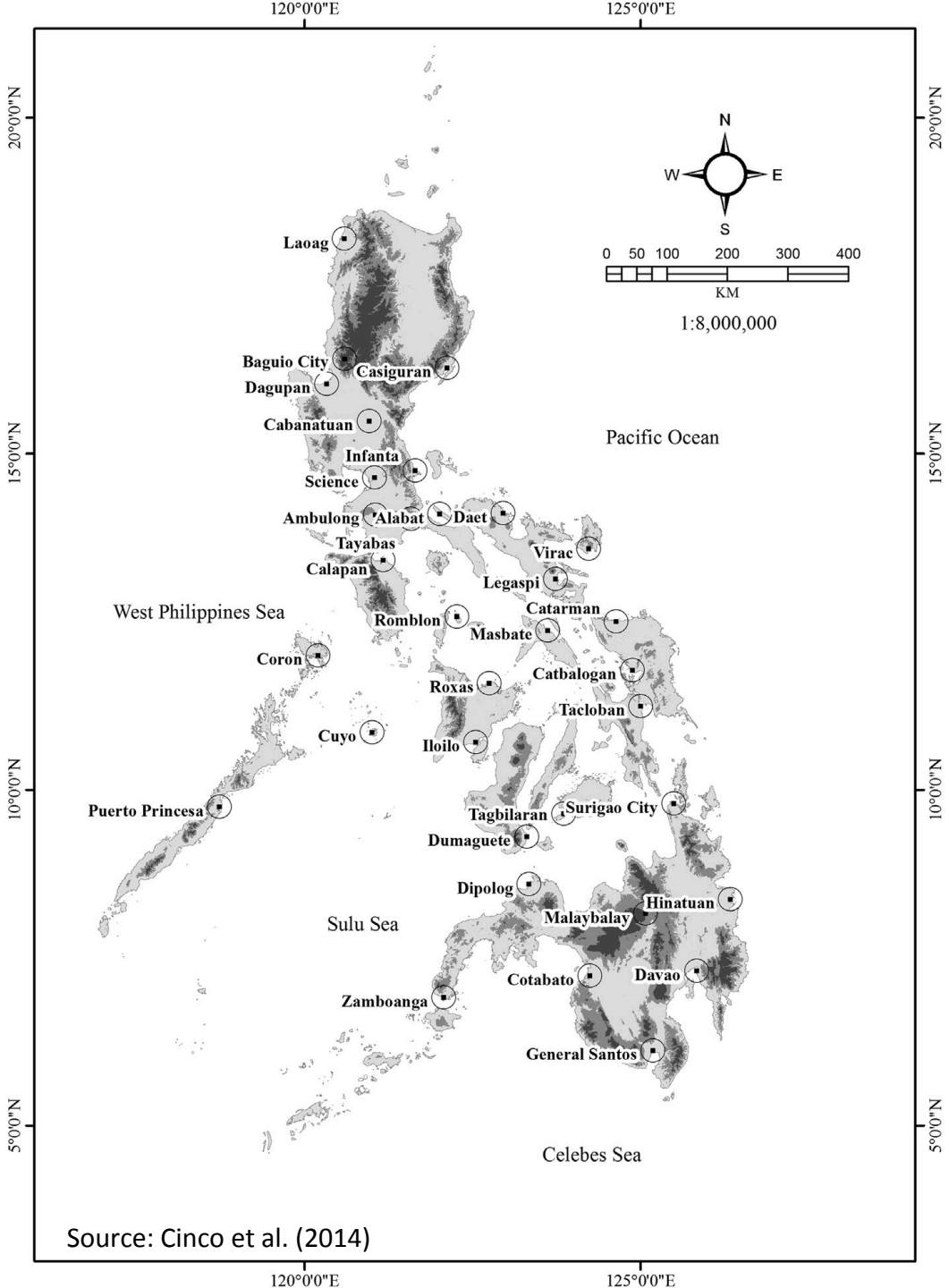


Table 1. List of experiments

Domain	Resolution	Boundary Condition	Time Period	Scenario
SE Asia	25 km	ERA-Interim (~75 km)	1989-2008	
SE Asia	25 km	MRI-AGCM60	1981-2000	
Philippines	5 km	NHRCM (25 km)	1981-2000	
SE Asia	25 km	MRI-AGCM60	2020-2039	RCP 8.5
SE Asia	25 km	MRI-AGCM60	2080-2099	RCP 8.5
Philippines	5 km	NHRCM (25 km)	2080-2099	RCP 8.5
SE Asia	25 km	MRI-AGCM60	2080-2099	RCP 2.6
SE Asia	25 km	MRI-AGCM60	2080-2099	RCP 4.5
SE Asia	25 km	MRI-AGCM60	2080-2099	RCP 6.0



Source: Cinco et al. (2014)

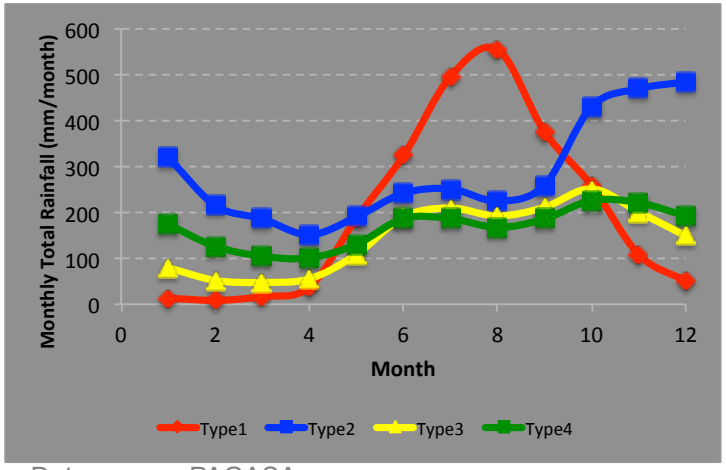
Analysis

- Observation data
  - APHRODITE (Yasutomi et al. 2011, Yatagai et al. 2012)
  - PAGASA stations (46)

- Focus over the Philippines
  - Spatial patterns
  - Seasonal variability
  - Regional means based on climate types

Philippine Climate Classification (Modified Coronas Atlas)

- Type I climate (two pronounced season with dry period from November to April and wet period from May to October)
- Type II climate (no dry season with a very pronounced maximum rainfall during the months of November–December);
- Type III climate (seasons not very pronounced with a relatively dry period from November to April, as in Type I);
- Type IV climate with rainfall more or less evenly distributed along the year

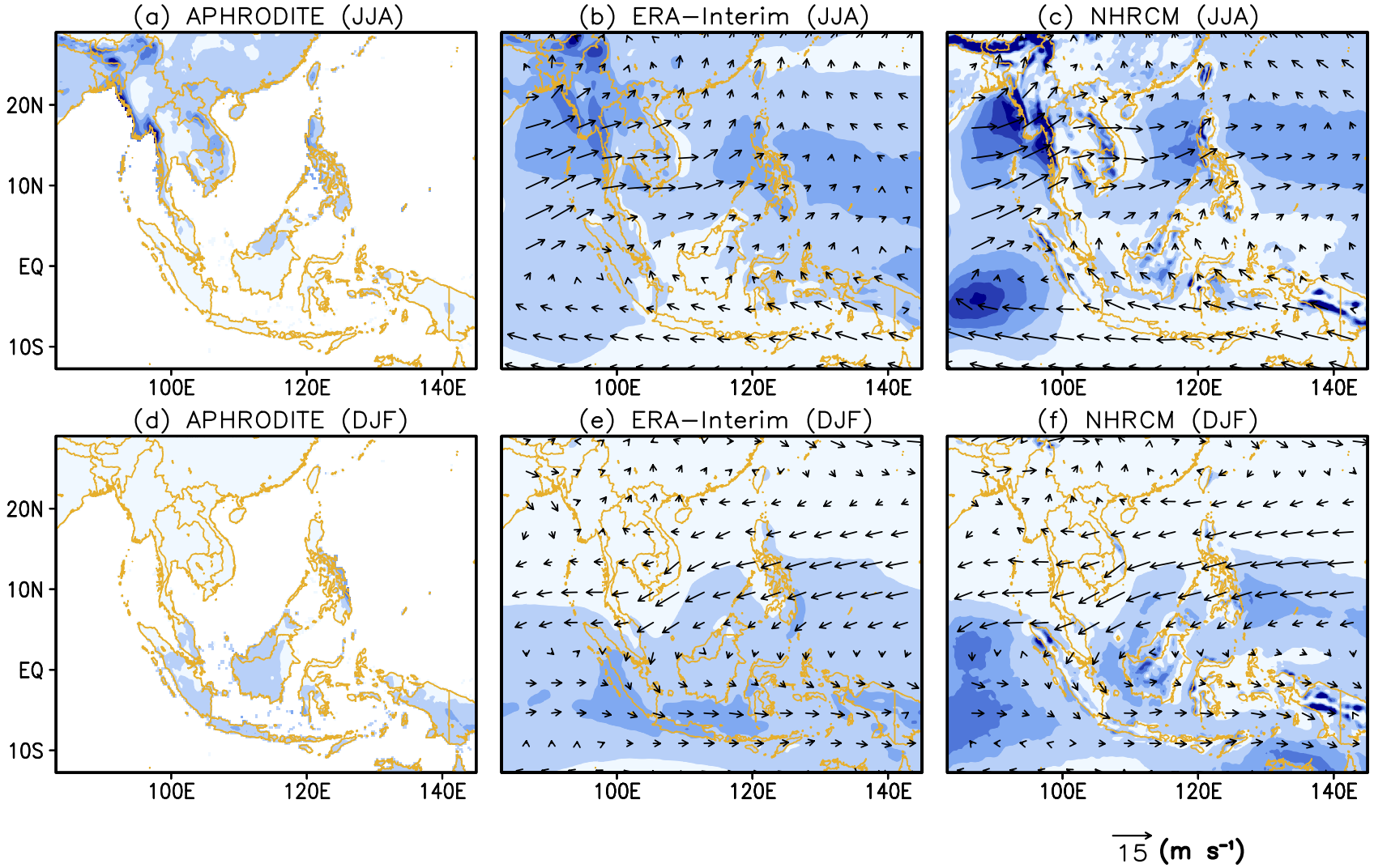


Data source: PAGASA

http://kidlat.pagasa.dost.gov.ph/cab/climate_change/images/ClimateMap.JPG

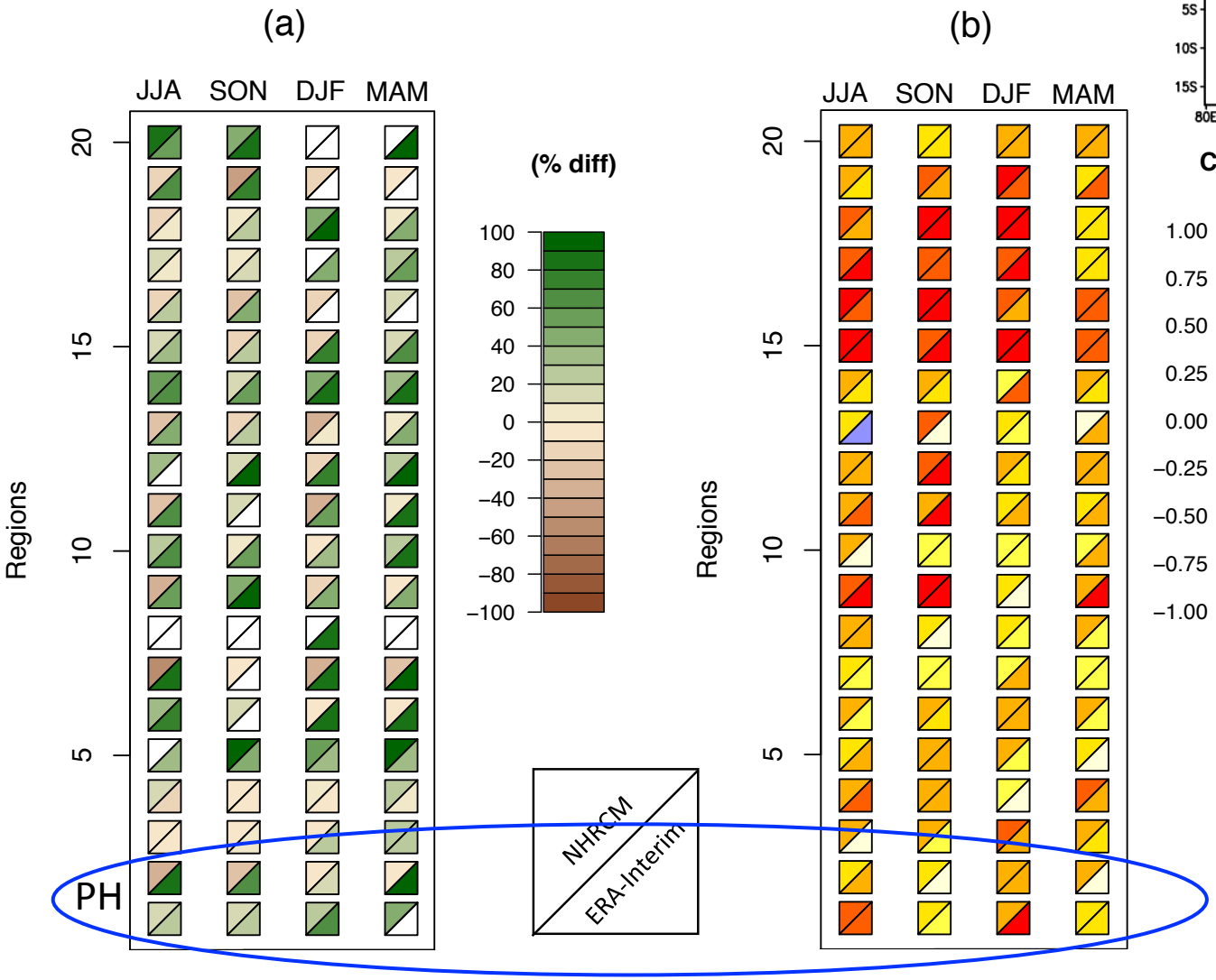
Evaluation of model performance

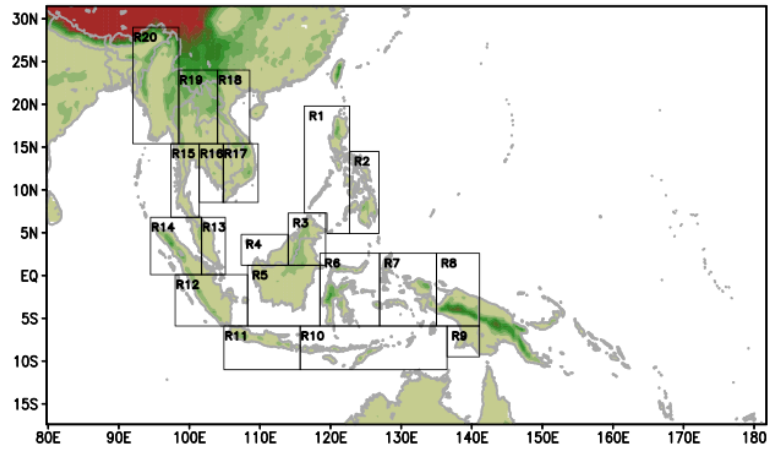
NHRCM captures the seasonal spatial patterns in rainfall and winds, especially along coastlines and high topography but overestimates rainfall in the windward side of mountains.



Cruz and Sasaki (2017)

Evaluation of model performance : Comparison with ERA-Interim

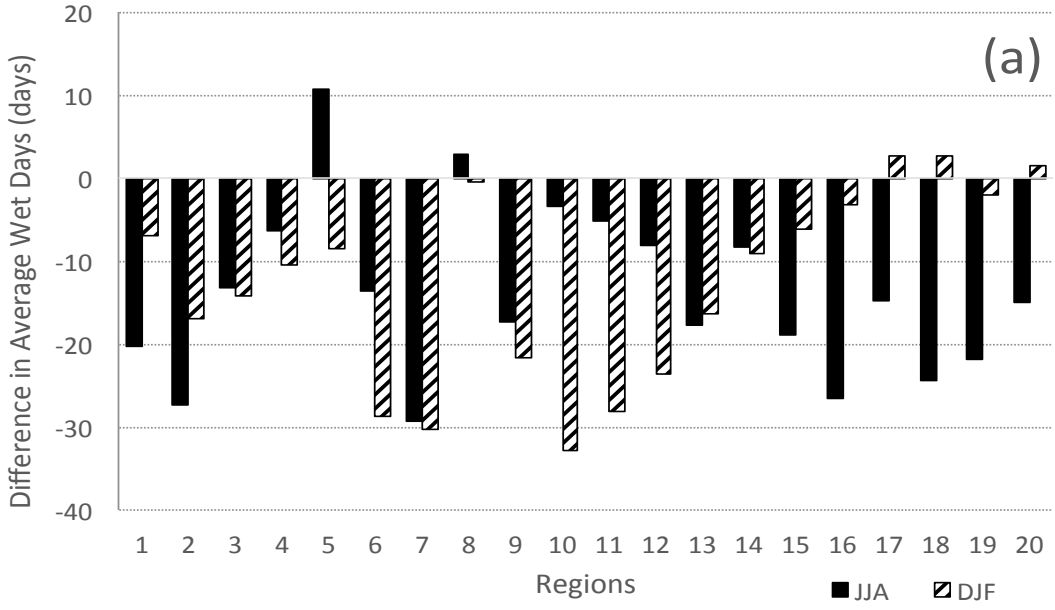


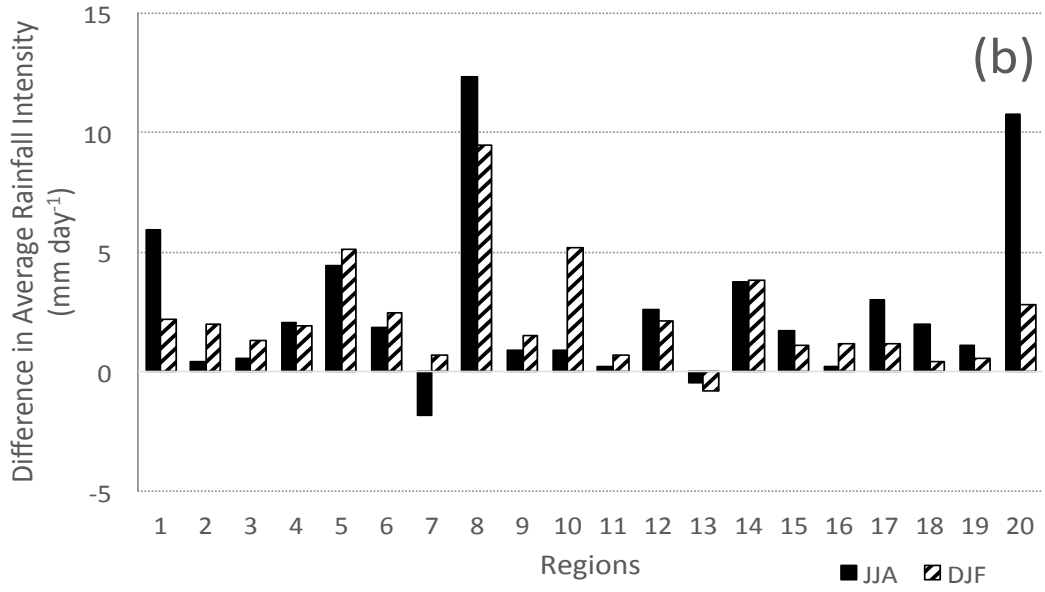


NHRCM reduces the overestimated rainfall in ERA-Interim (over eastern Philippines and the Maritime Continent) resulting in higher spatial correlation.

Cruz and Sasaki (2017)

Evaluation of model performance

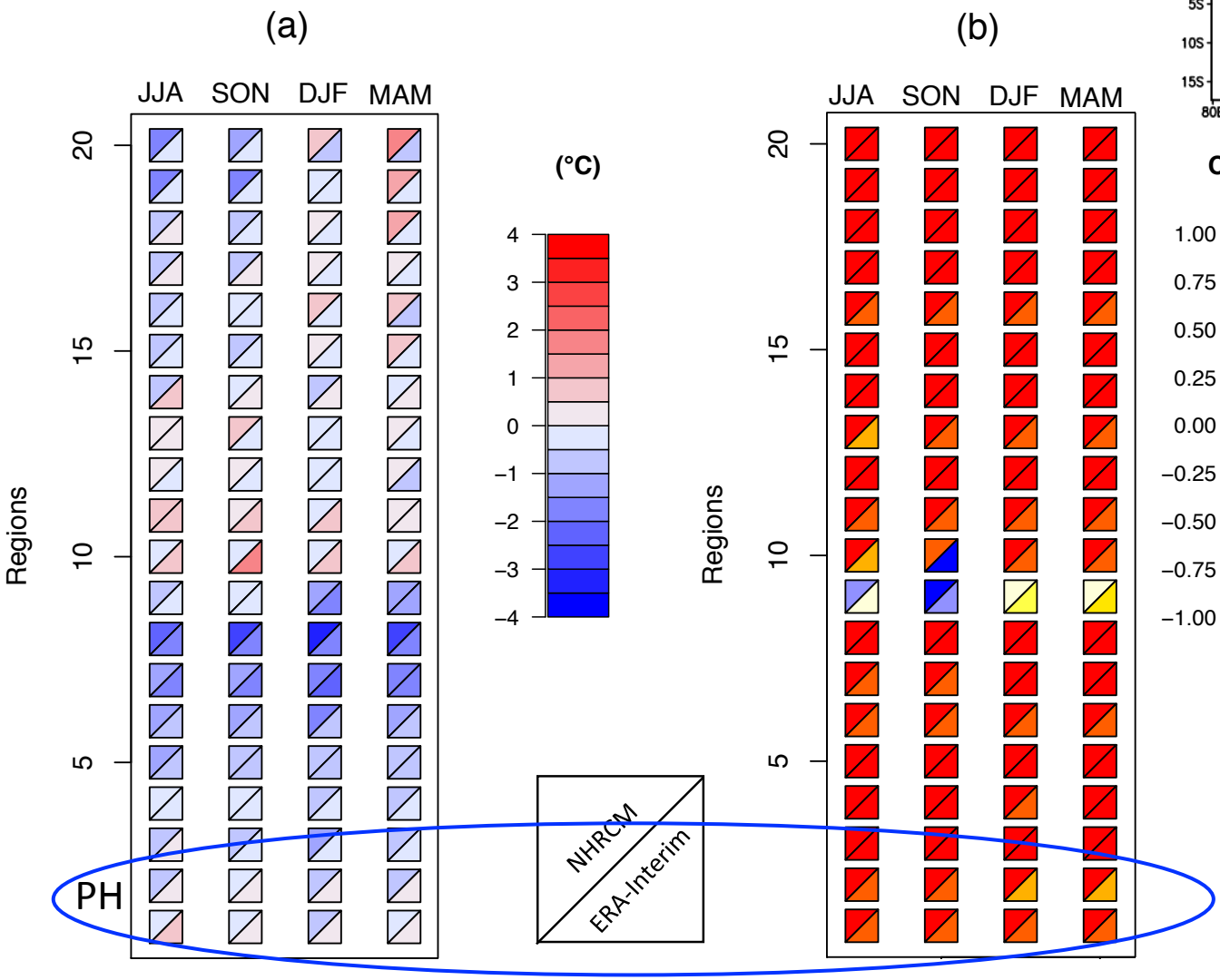


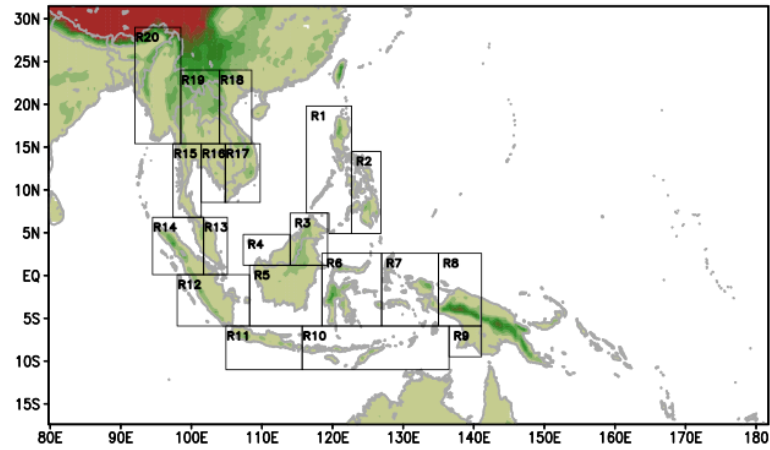


Tendency to underestimate the number of wet days, especially during the wet season, but overestimate the daily rainfall intensity

Cruz and Sasaki (2017)

Evaluation of model performance : Comparison with ERA-Interim

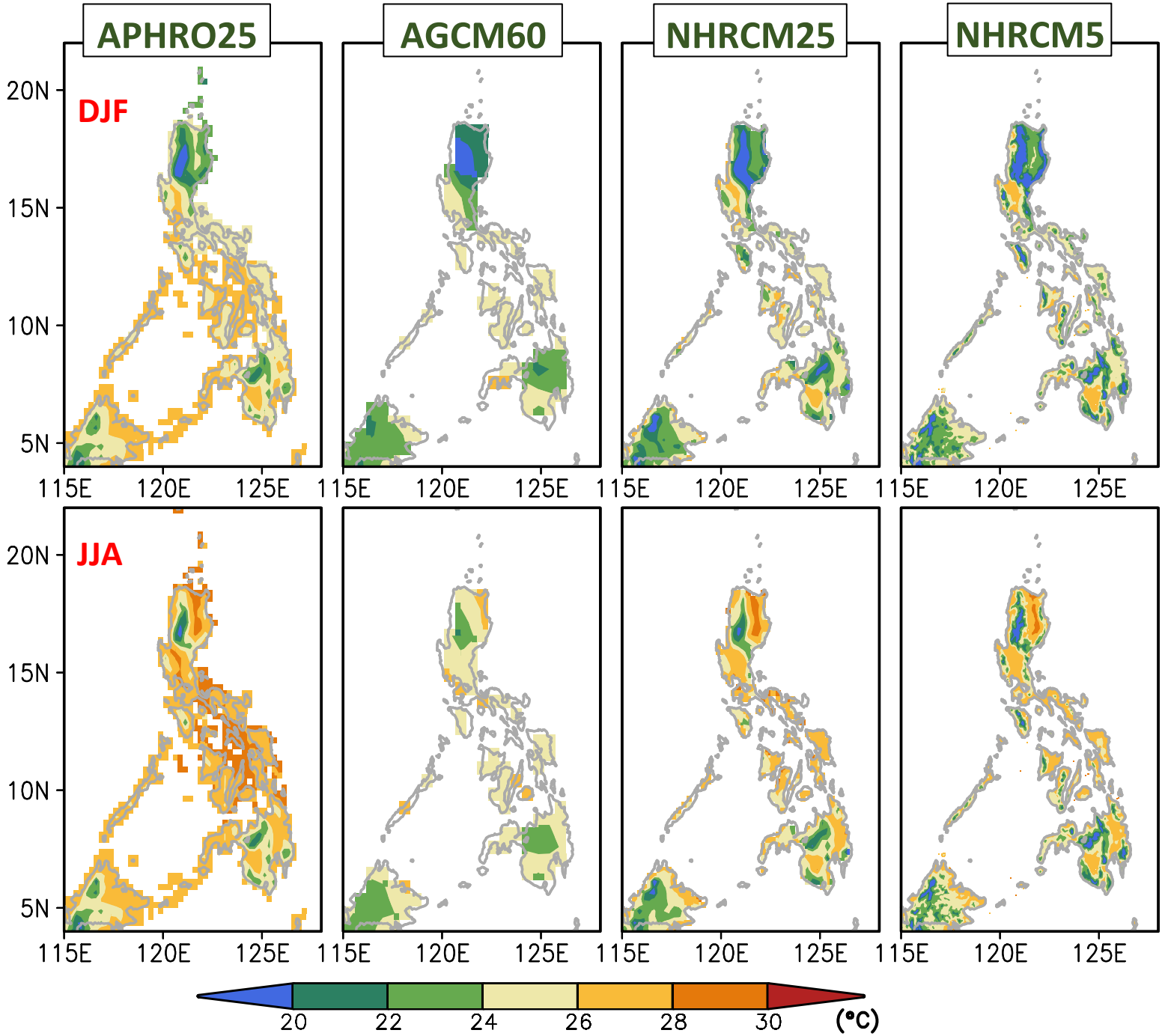




NHRCM has an overall cold bias, which reduces the warm bias in ERA-Interim

Cruz, F. T., and H. Sasaki, 2017. Simulation of present climate over Southeast Asia using the Non-hydrostatic Regional Climate Model. SOLA, 13, 13-18, doi:10.2151/sola.2017-003.

Results: Validation of present-day temperature

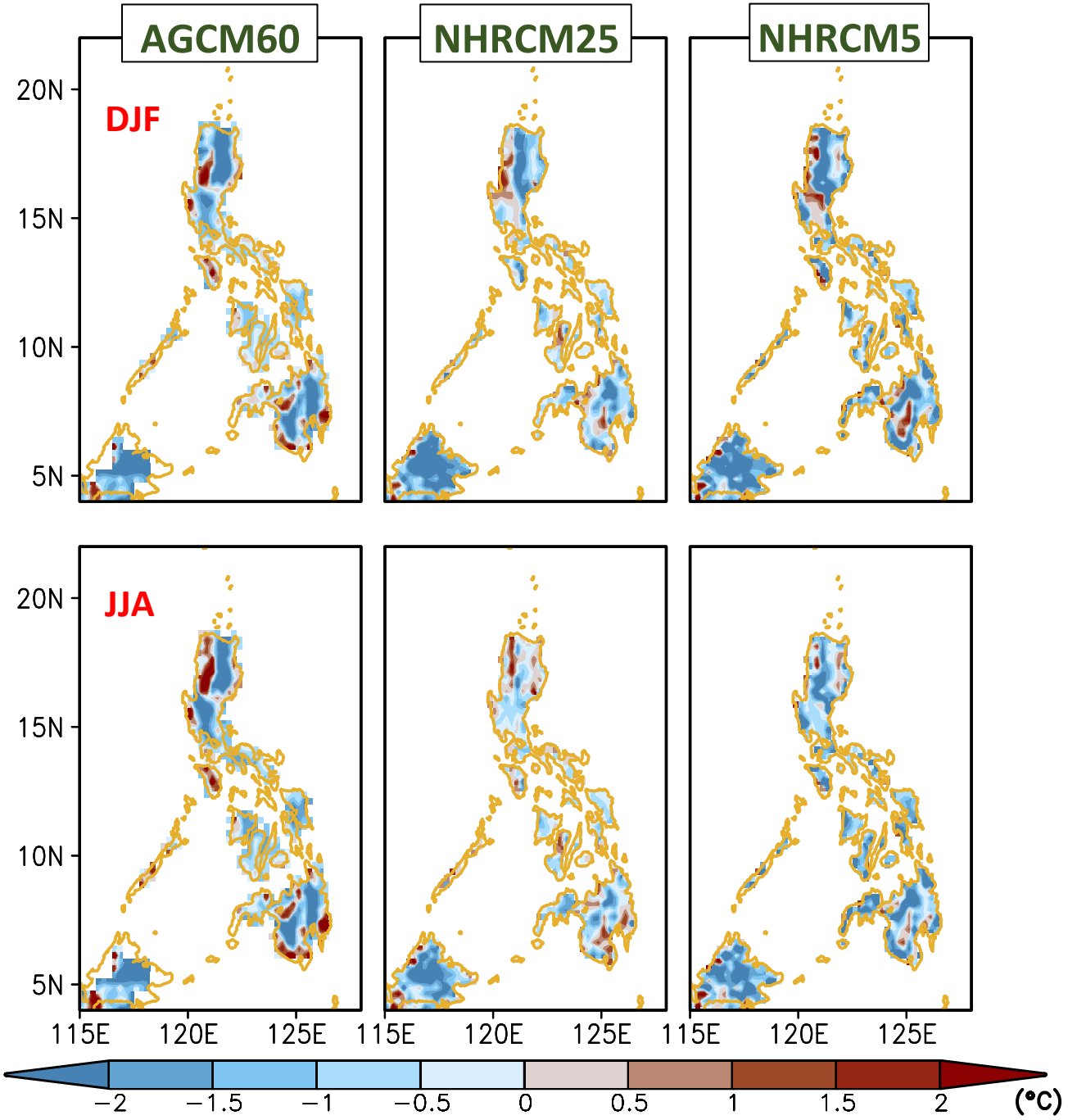


NHRCM is able to represent the spatial patterns of temperature

- Reduced cold bias in the global model (AGCM60)

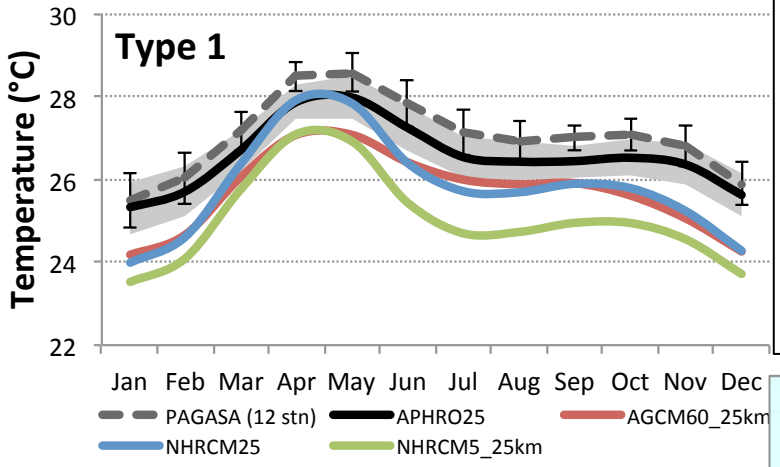
Results: Validation of present-day temperature

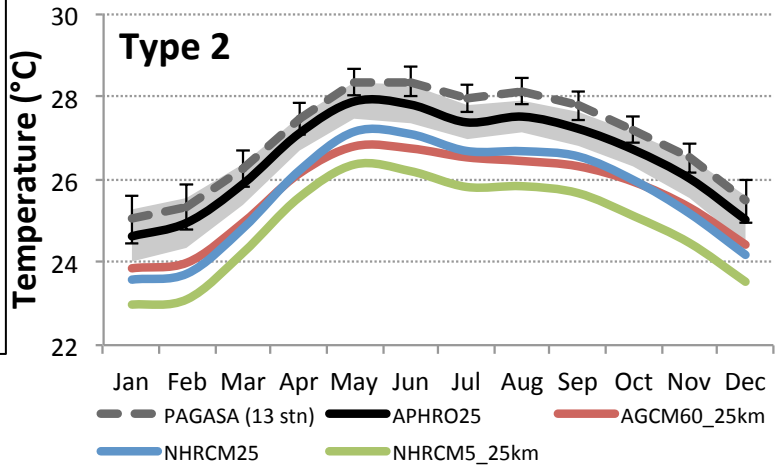
Colder bias in NHRCM5 in Luzon and Mindanao islands, compared with NHRCM25

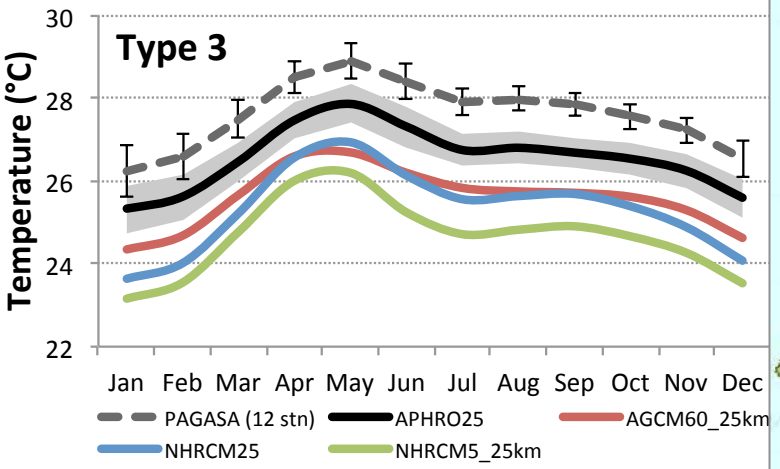


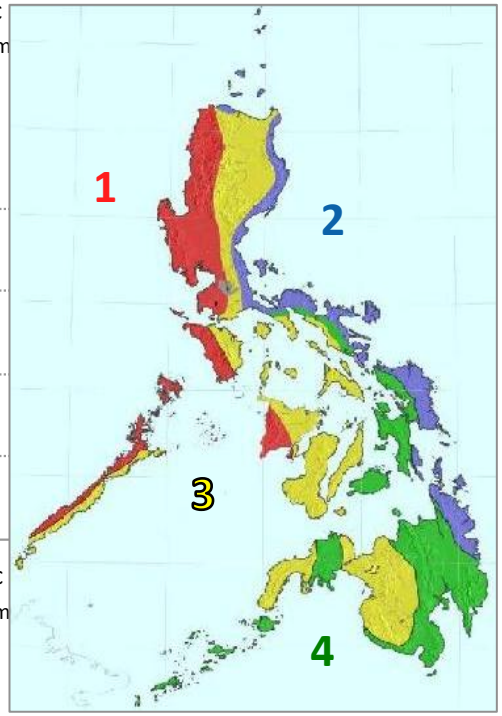
Model evaluation : Temperature Annual Cycle

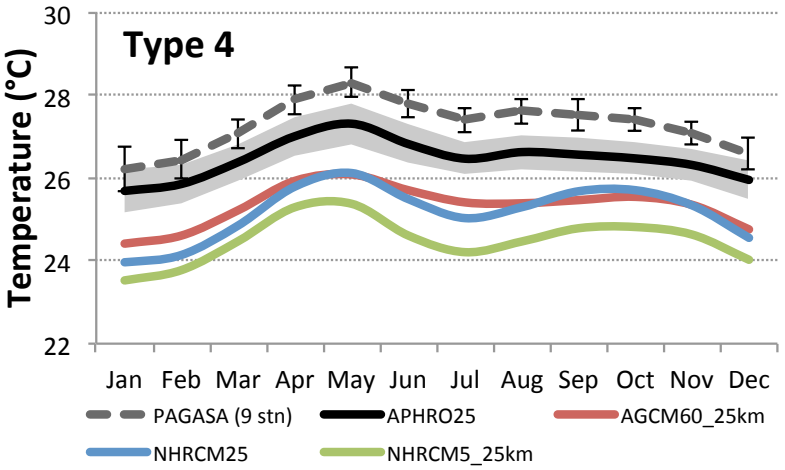
- APHRODITE tends to be lower than PAGASA throughout the year (Note: area average from grid vs point values)
- Close values between AGCM60 and NHRCM25
- Cold bias in NHRCM5
- Also seen in other types









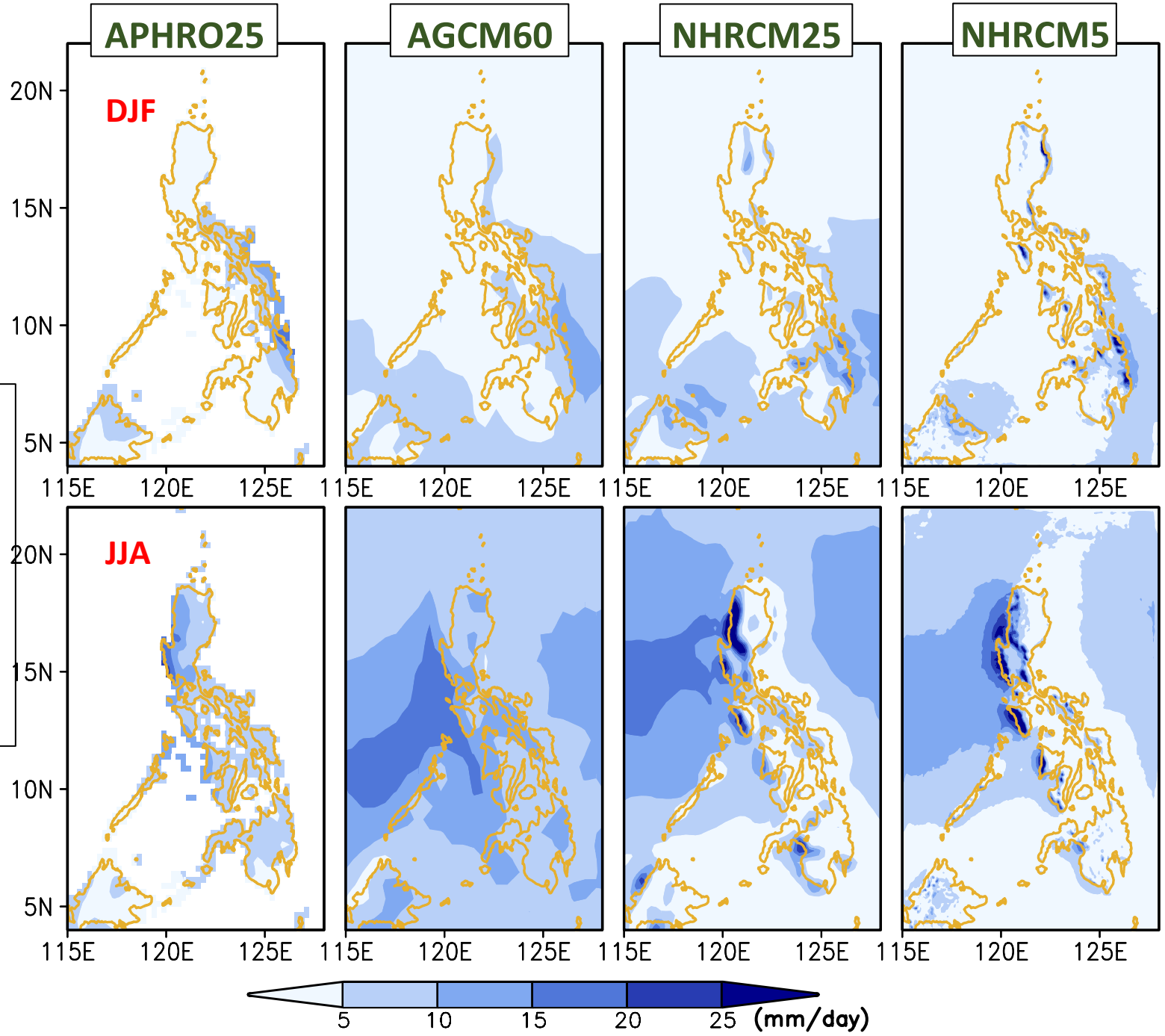


PAGASA APHRO25 AGCM60_25km NHRCM25 NHRCM5_25km

Results: Validation of present-day rainfall

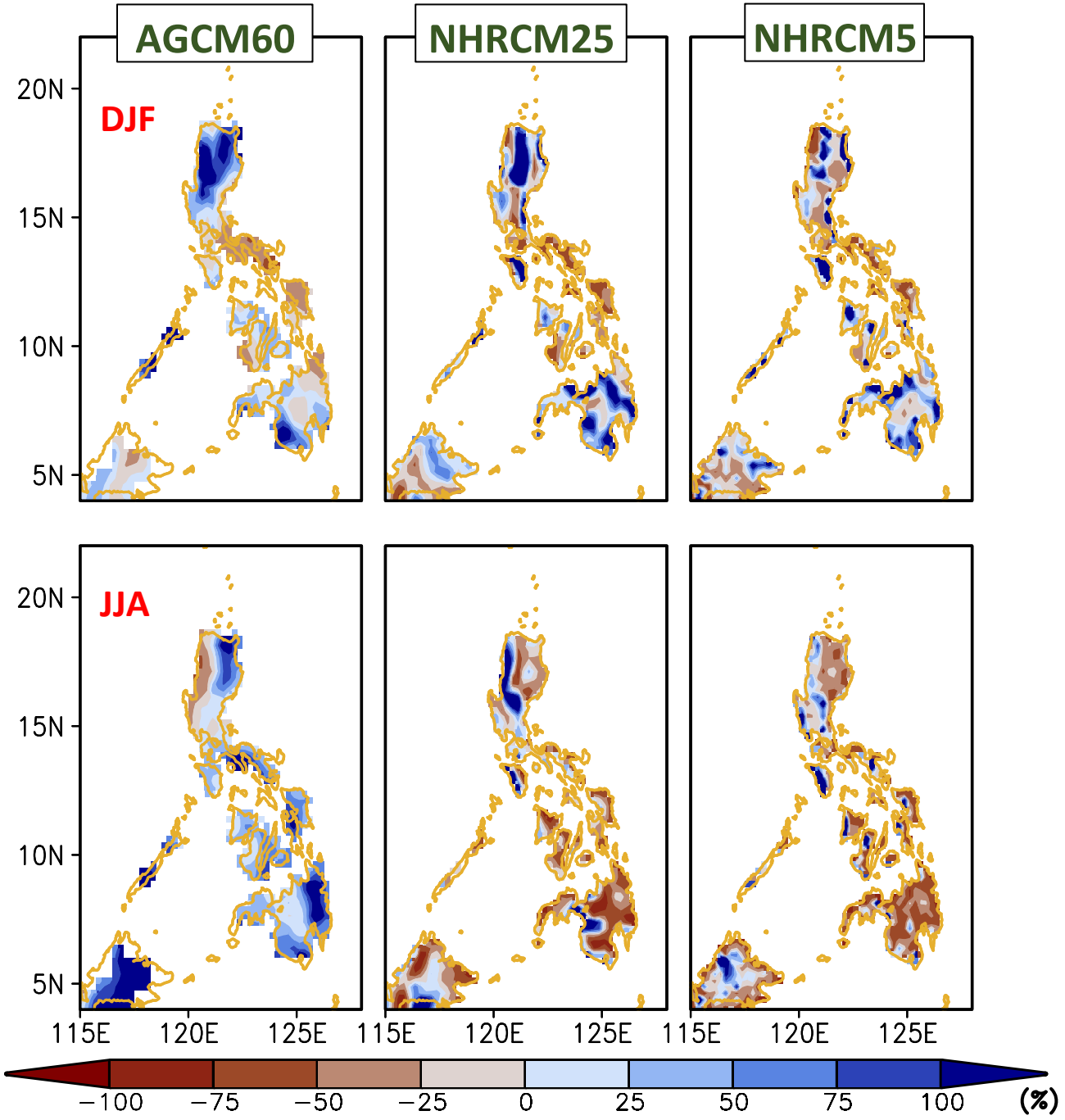
NHRCM is able to represent the spatial patterns of rainfall

- Captured the high rainfall over areas with high terrain, along coast



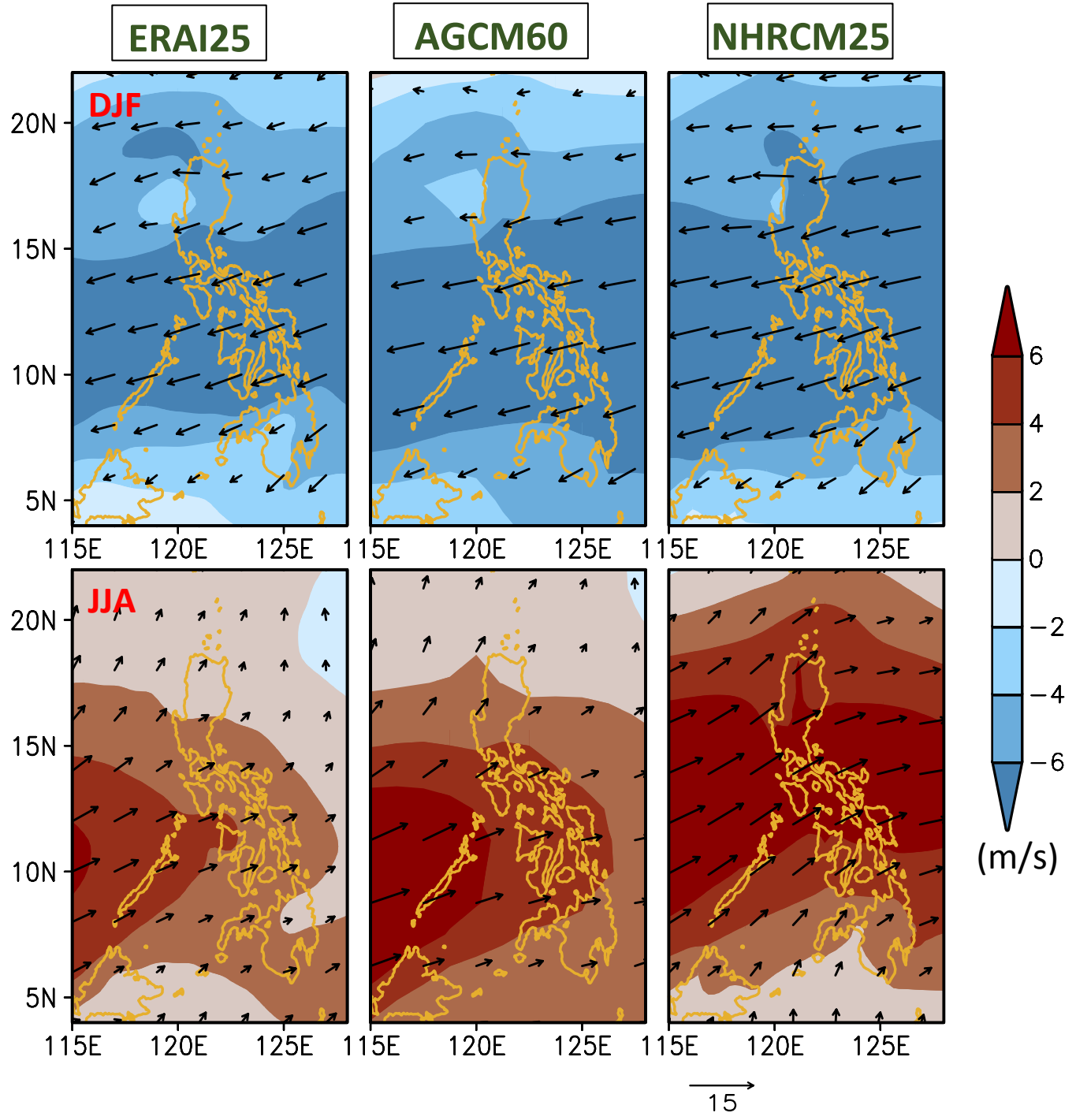
Results: Validation of present-day rainfall

- Reduced the wet bias in Luzon from the global model
- Tendency to overestimate rainfall over mountain areas
- Dry bias on the eastern section during the southwest monsoon season (JJA)

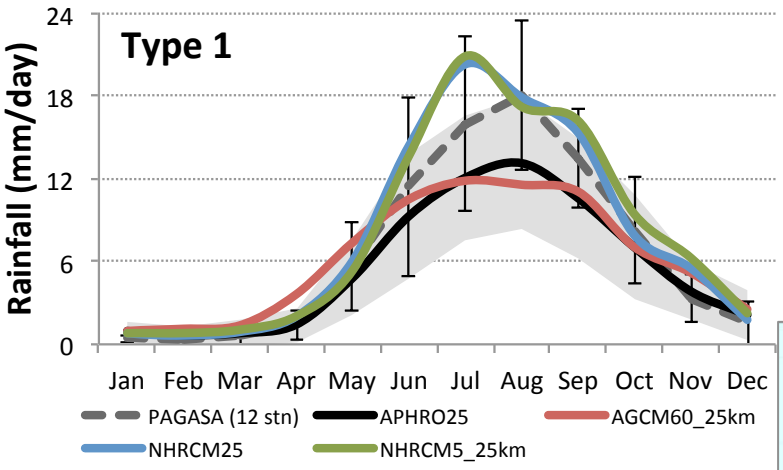


Results: Validation of present-day 850mb (zonal) winds

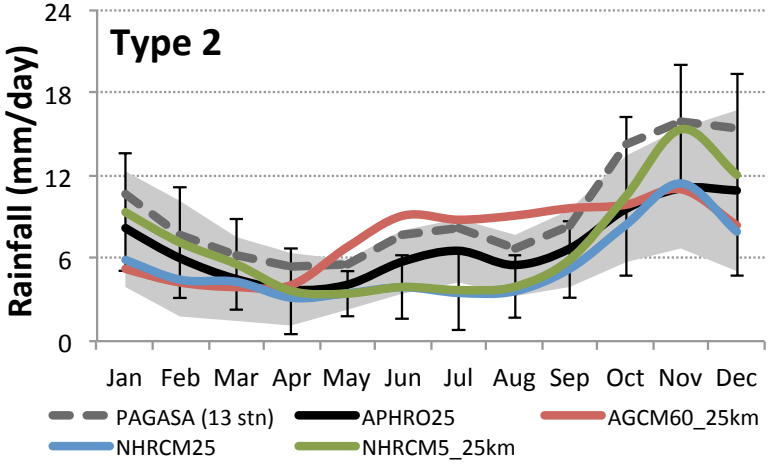
Close representation of winds; stronger southwesterlies in NHRCM25

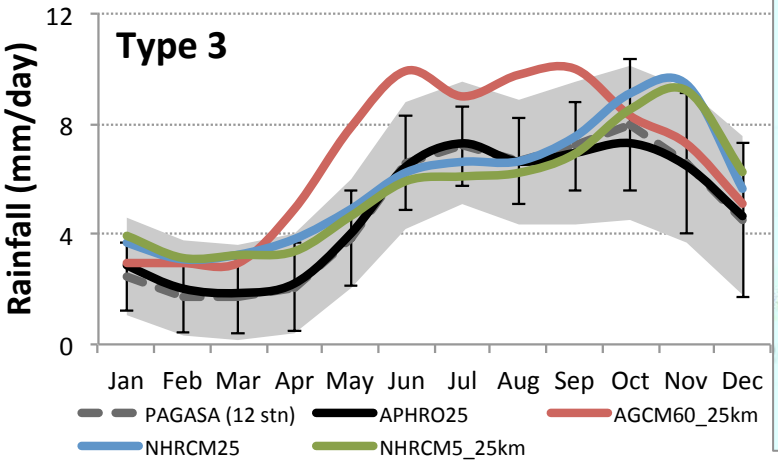


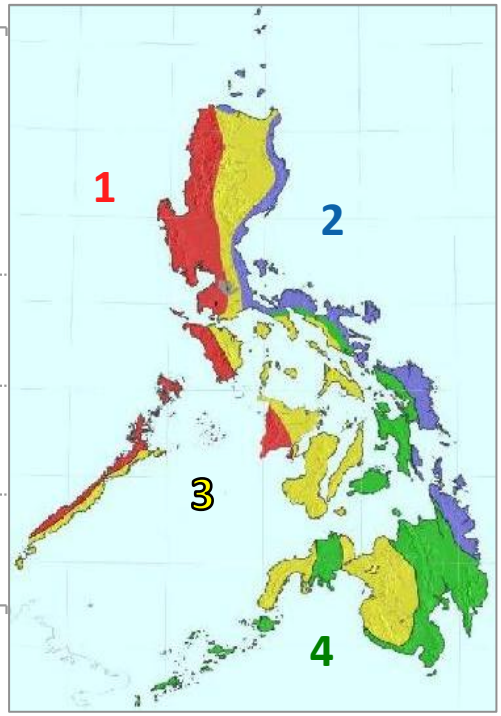
Model evaluation : Rainfall Annual Cycle

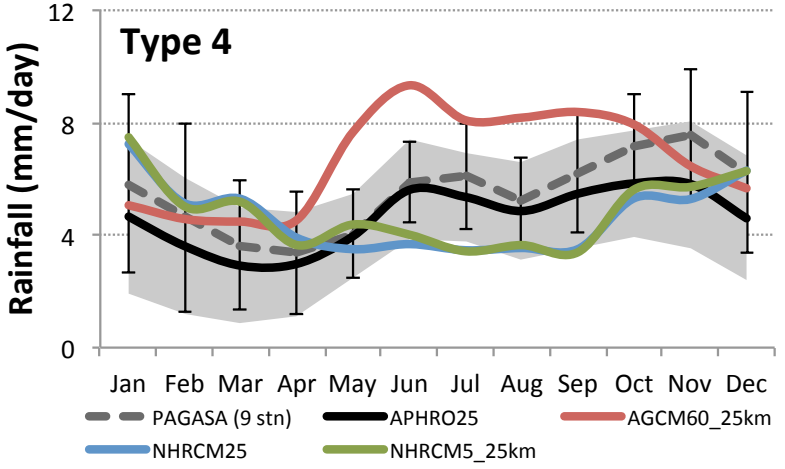


- NHRCM captures seasonality, within variability
- Reduces bias in global model







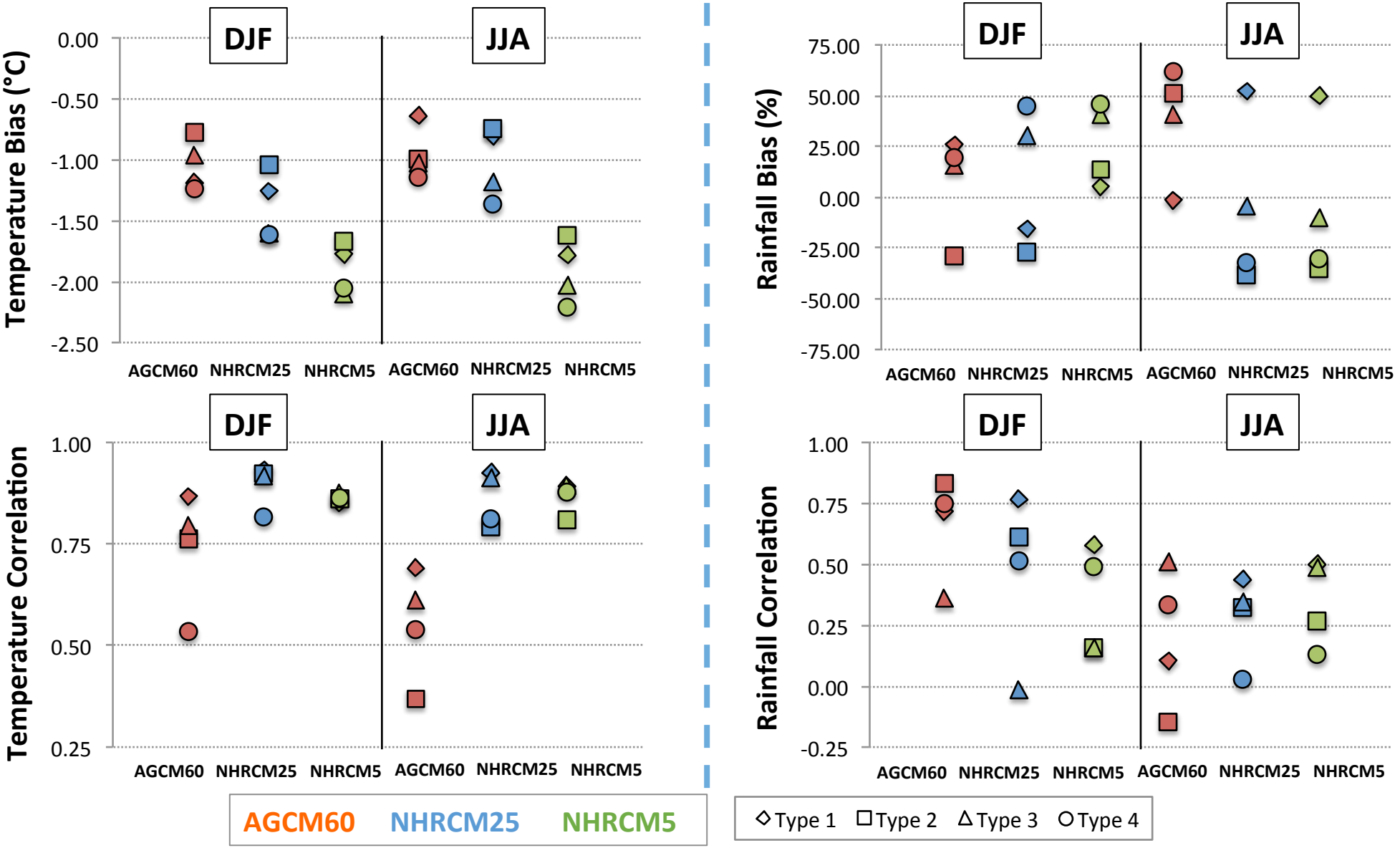


PAGASA APHRO25 AGCM60_25km NHRCM25 NHRCM5_25km

Seasonal mean bias, correlation per type (relative to APHRODITE)

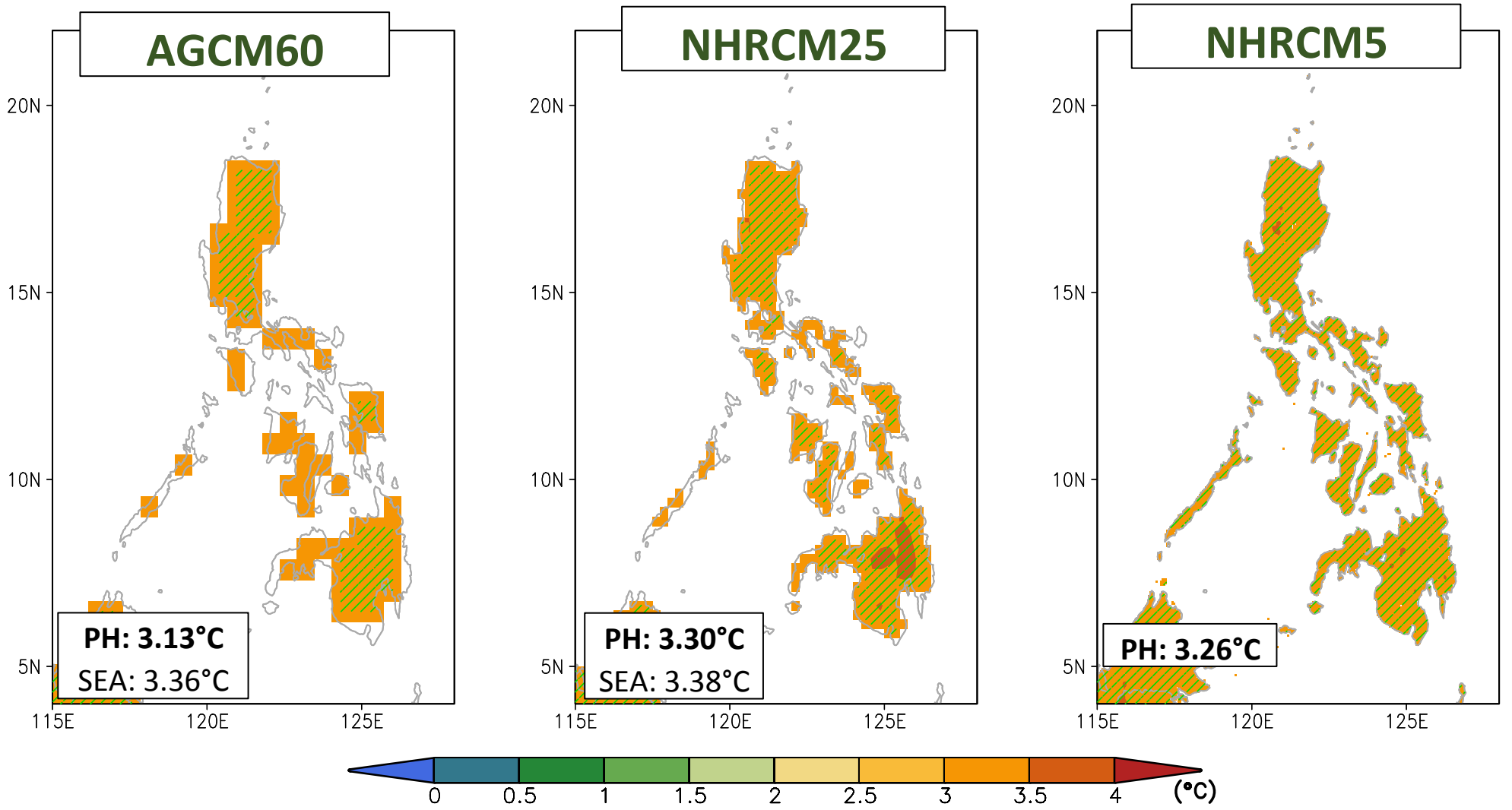
NHRCM5

- increased cold bias but improved spatial correlation
- more areas with dry bias, minimal improvement in correlation



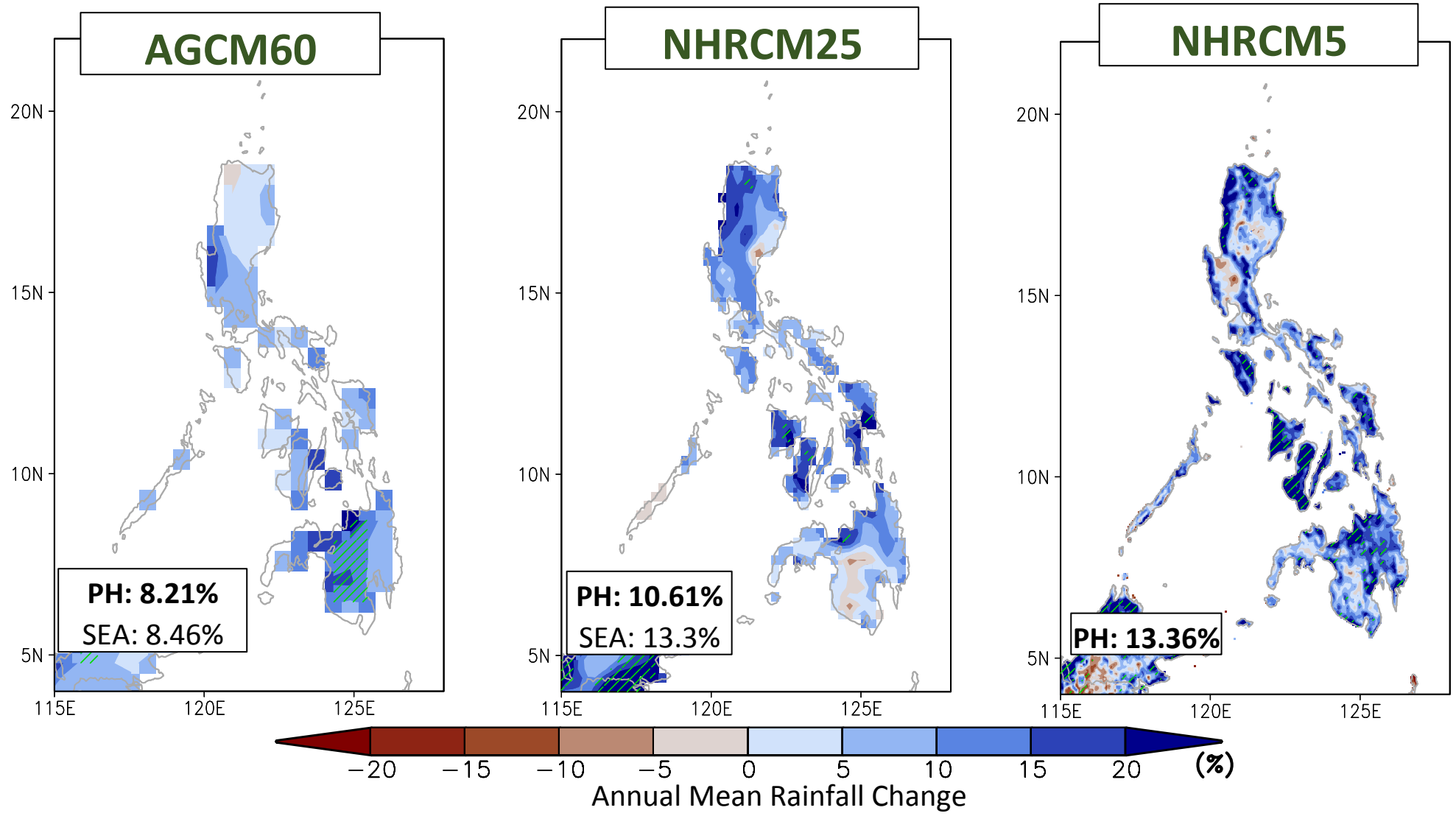
Results: Projected temperature changes in far-future (RCP8.5)

- Comparable changes regardless of resolution but some areas warmer in NHRCM
- At end of 21st century, the Philippines (SE Asia) significantly warmer
  - Consistent warming across all seasons (relatively high warming in MAM (summer))



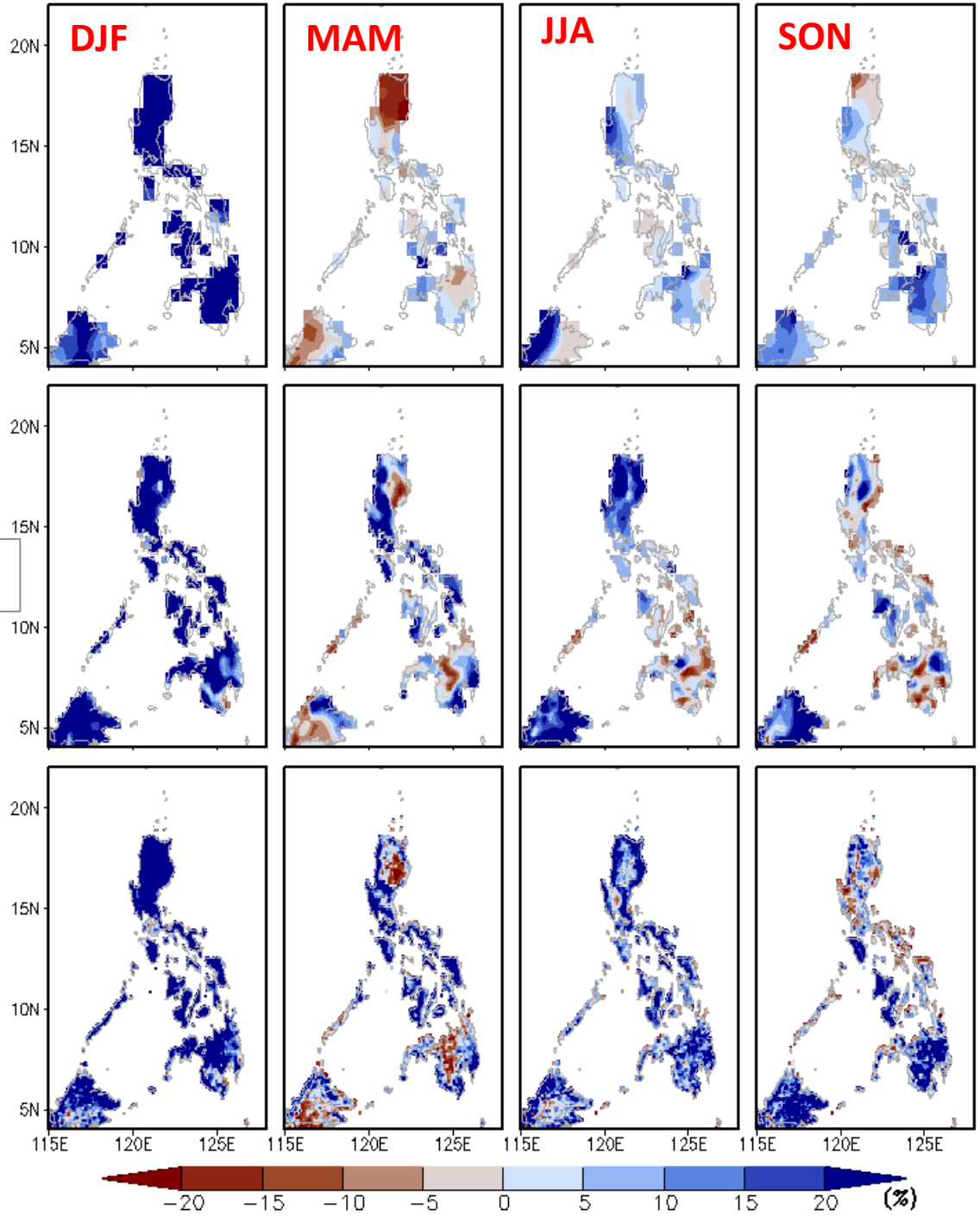
Results: Projected rainfall changes in far-future (RCP8.5)

- At the end of 21st century, more areas with significantly wetter conditions at higher resolution, particularly over high terrain



Results: Projected seasonal rainfall changes in far-future (RCP8.5)

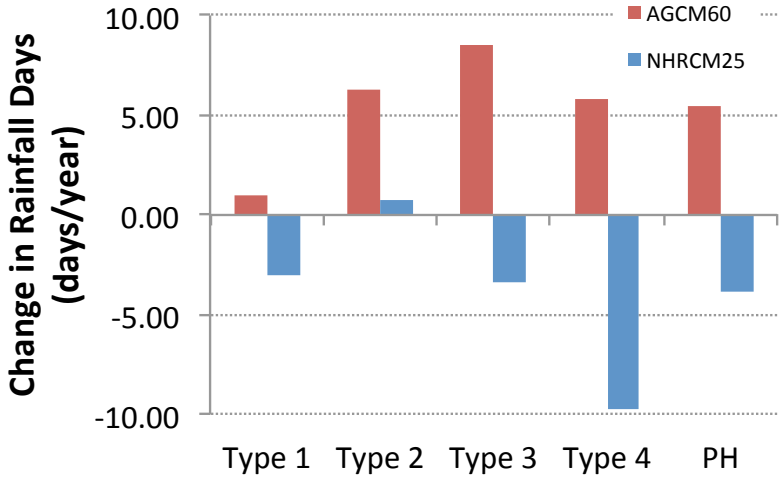
- Highest rainfall change (wetter) in DJF (dry season in Type1, wet season in Type2)
- More drier areas in MAM, particularly eastern Luzon and central Mindanao
- Enhanced wet conditions in JJA in NHRCM5
- Contrasting changes in Mindanao between NHRCM25 and NHRCM5 in JJA and SON



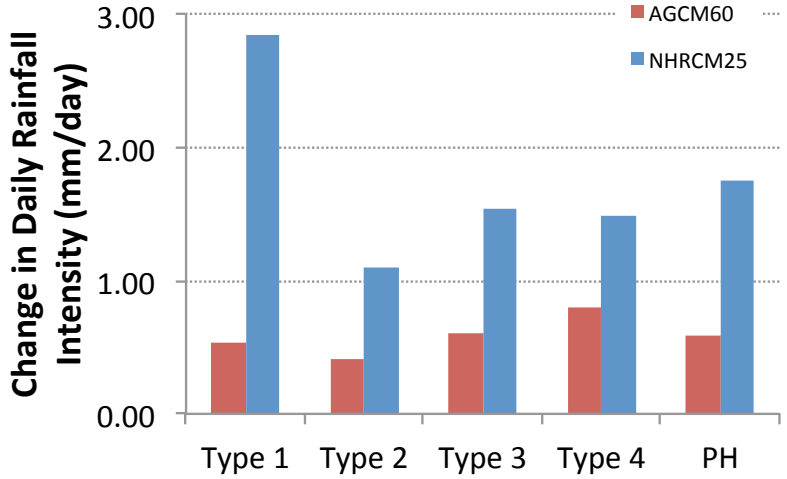
Results: Projected rainfall changes in far-future (RCP8.5)

- Increase in wet days, daily rainfall intensity in AGCM60
- Decrease in number of wet days (esp. Type4) but increase in rainfall intensity (esp. Type1) in NHRCM25
- Higher increase in extreme rainfall in NHRCM, occurring over most of Philippines

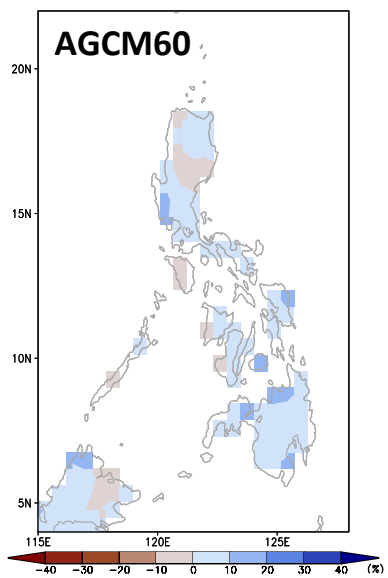
Number of Rainfall Days

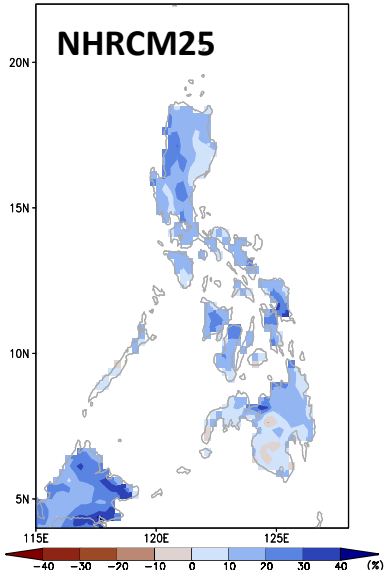


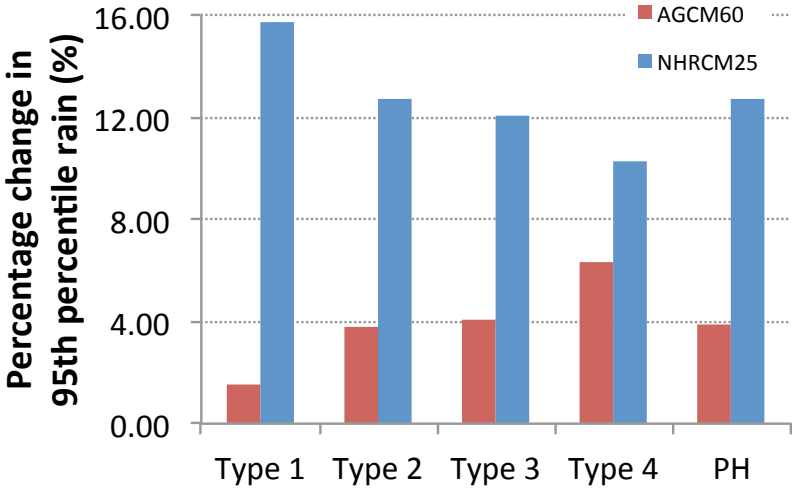
Daily Rainfall Intensity



95th Percentile Rainfall







Summary

- Results indicate applicability of NHRCM in providing high-resolution climate information over the Philippines and Southeast Asia
  - NHRCM can reduce the wet and warm biases in ERA-Interim, and may have higher spatial correlations in some regions (e.g. Philippines, Maritime Continent).

- In the Philippines, NHRCM projections indicate significant warming (**3.3 °C**) and rainfall increases (**10.6 to 13.4 %**) in the far-future under RCP 8.5 scenario
  - Projected increase in days with extreme rainfall found over most land areas

- Look into more detail on the underlying mechanisms behind the influence of model resolution on the simulated climate and changes

- Results of this study will contribute to the ongoing efforts to increase climate change information in the region, e.g. Southeast Asia Regional Climate Downscaling/CORDEX Southeast Asia project

Thank you for your attention.

Acknowledgments

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- Japan Meteorological Agency
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