SENSITIVITY ANALYSIS OF REGCM4.7 IN SIMULATING TC CHARACTERISTICS OVER CORDEX-SEA REGION

MANILA OBSERVATORY
SEACLID/CORDEX-SEA

Jennifer Tibay[1], Julie Mae Dado[1], Faye Abigail Cruz[1], Jing Xiang Chung[2], Fredolin Tangang[3,7], Liew Juneng[3], Thanh Ngo-Duc[4], Tan Phan-Van[5], Long Trinh-Tuan[5], Nam Pham-Quang[5], Truong Ba Kien[6], Jerasorn Santisirisomboon[7], Ratchanan Srisawadwong[7], Jaruthat Santisirisomboon[7], Patama Singhruck[8], Dodo Gunawan[9], Edvin Aldrian[10]

[1]Manila Observatory, Philippines; [2]Universiti Malaysia Terengganu, Malaysia; [3]Universiti Kebangsaan Malaysia, Malaysia; [4]University of Science and Technology of Hanoi, Vietnam; [5]VNU University of Science, Vietnam; [6]Vietnam Institute of Meteorology, Vietnam; [7]Ramkhamhaeng University Center of Regional Climate Change and Renewable Energy, Thailand; [8]Chulalongkorn University, Thailand; [9]State College of Meteorology Climatology and Geophysics, Indonesia; [10]National Agency for Research and Innovation, Indonesia

KEY POINTS

- Sensitivity experiments using RegCM4.7 forced with ERA5 (2011-2015) were conducted by Southeast Asia Regional Climate Downscaling / Coordinated Regional Climate Downscaling Experiment – Southeast Asia (SEACLID /CORDEX-SEA) in preparation for downscaling CMIP6 GCMs.
- The characteristics of tropical cyclone (TC) climatology were evaluated from a subset of these experiments (Table 1).
- Model runs with GFS or UW planetary boundary layer (PBL) scheme and SUBEX or WSM5 moisture scheme have relatively good skill in simulating TC climatology.

TABLE 1 EXPERIMENTS CONDUCTED BY CORDEX-SEA

EXP	CUMULUS	PBL	MOISTURE
01	MIT	Holtslag	SUBEX
02	MIT	Holtslag	WSM5
03	MIT	Holtslag	Nogherotto/Tompkins
04	MIT	UW	SUBEX
05	MIT	UW	WSM5
06	MIT	UW	Nogherotto/Tompkins
07	MIT	GFS2011	SUBEX
08	MIT	GFS2011	WSM5
09	MIT	GFS2011	Nogherotto/Tompkins
10	MIT	MYJ	SUBEX
11	MIT	MYJ	WSM5
12	MIT	MYJ	Nogherotto/Tompkins
13	Tiedtke	Holtslag	SUBEX
14	Tiedtke	Holtslag	WSM5
15	Tiedtke	Holtslag	Nogherotto/Tompkins
16	Tiedtke	UW	SUBEX
17	Tiedtke	UW	WSM5
18	Tiedtke	UW	Nogherotto/Tompkins
19	Tiedtke	GFS2011	SUBEX
20	Tiedtke	GFS2011	WSM5
21	Tiedtke	GFS2011	Nogherotto/Tompkins
22	Tiedtke	MYJ	SUBEX
23	Tiedtke	MYJ	WSM5
24	Tiedtke	MYJ	Nogherotto/Tompkins
25	Kain-Fritsch	Holtslag	SUBEX
26	Kain-Fritsch	Holtslag	WSM5
27	Kain-Fritsch	Holtslag	Nogherotto/Tompkins
28	Kain-Fritsch	UW	SUBEX
29	Kain-Fritsch	UW	WSM5
30	Kain-Fritsch	UW	Nogherotto/Tompkins
31	Kain-Fritsch	GFS2011	SUBEX
32	Kain-Fritsch	GFS2011	WSM5
33	Kain-Fritsch	GFS2011	Nogherotto/Tompkins
34	Kain-Fritsch	MYJ	SUBEX
35	Kain-Fritsch	MYJ	WSM5
36	Kain-Fritsch	MYJ	Nogherotto/Tompkins
37	Grell	Holtslag	SUBEX
38	Grell	Holtslag	WSM5
39	Grell	Holtslag	Nogherotto/Tompkins
40	Grell	UW	SUBEX
41	Grell	UW	WSM5
42	Grell	UW	Nogherotto/Tompkins
43	Grell	GFS2011	SUBEX
44	Grell	GFS2011	WSM5
45	Grell	GFS2011	Nogherotto/Tompkins
46	Grell	MYJ	SUBEX
47	Grell	MYJ	WSM5
48	Grell	MYJ	Nogherotto/Tompkins

Note: Experiments in blue text were not included in the study due to an instability issue and no detected TCs that exceeded a minimum lifetime of 2 days. Tiedtke (TE); Kain-Fritsch (KF); Grell (GR); Holtslag (H); GFS2011 (GFS); Nogherotto/Tompkins (NT)

METHODOLOGY

DATASETS:

A. **JTWC** - results were compared with the best track data of the Joint Typhoon Warning Center

B. **ERA5** - simulated large-scale environmental conditions were compared to reanalysis data

TC TRACKING AND DETECTION:

An **adapted vortex tracking algorithm**[1] is used. More details are provided in [1] and [2].

MODEL RANKING:

Simulated Tropical Cyclone (TC) Characteristics

- TC count (TCC)
- TC days (TCD)
- TC intensity (TCI*)
- TC track density (TCTD)

TCC, TCD, TCI* → **1-NRMSE and 1-NMBE**

- **NRMSE and NMBE**: **0** (closest to JTWC) to **1** (farthest from JTWC) → **Score = 1 – NRMSE (NMBE)**: **0** (farthest from JTWC) to **1** (closest to JTWC)

TCTD → **Spatial Correlation (SCorr)**

- **0** (no correlation w/ JTWC) to **1** (highly correlated w/ JTWC)

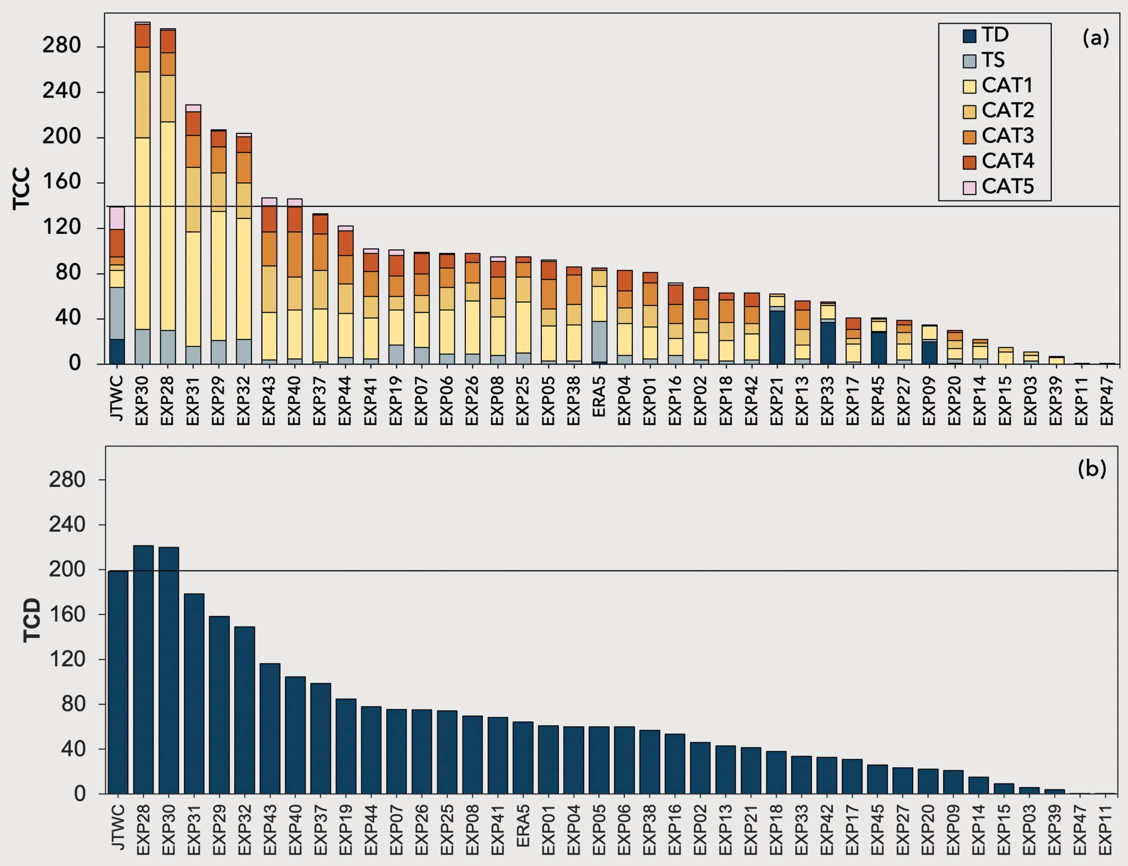
Overall performance evaluation index (OPEI)

$$OPEI = \frac{1}{n}\sum_{i=1}^{n} NRMSE\ score * \frac{1}{n}\sum_{i=1}^{n} NMBE\ score * SCorr$$

**TCI is the maximum wind speed weighted with TCC for each intensity category (based on Saffir-Simpson wind scale) [TCI-TD, -TS, -1, -2, -3, -4 & -5]*

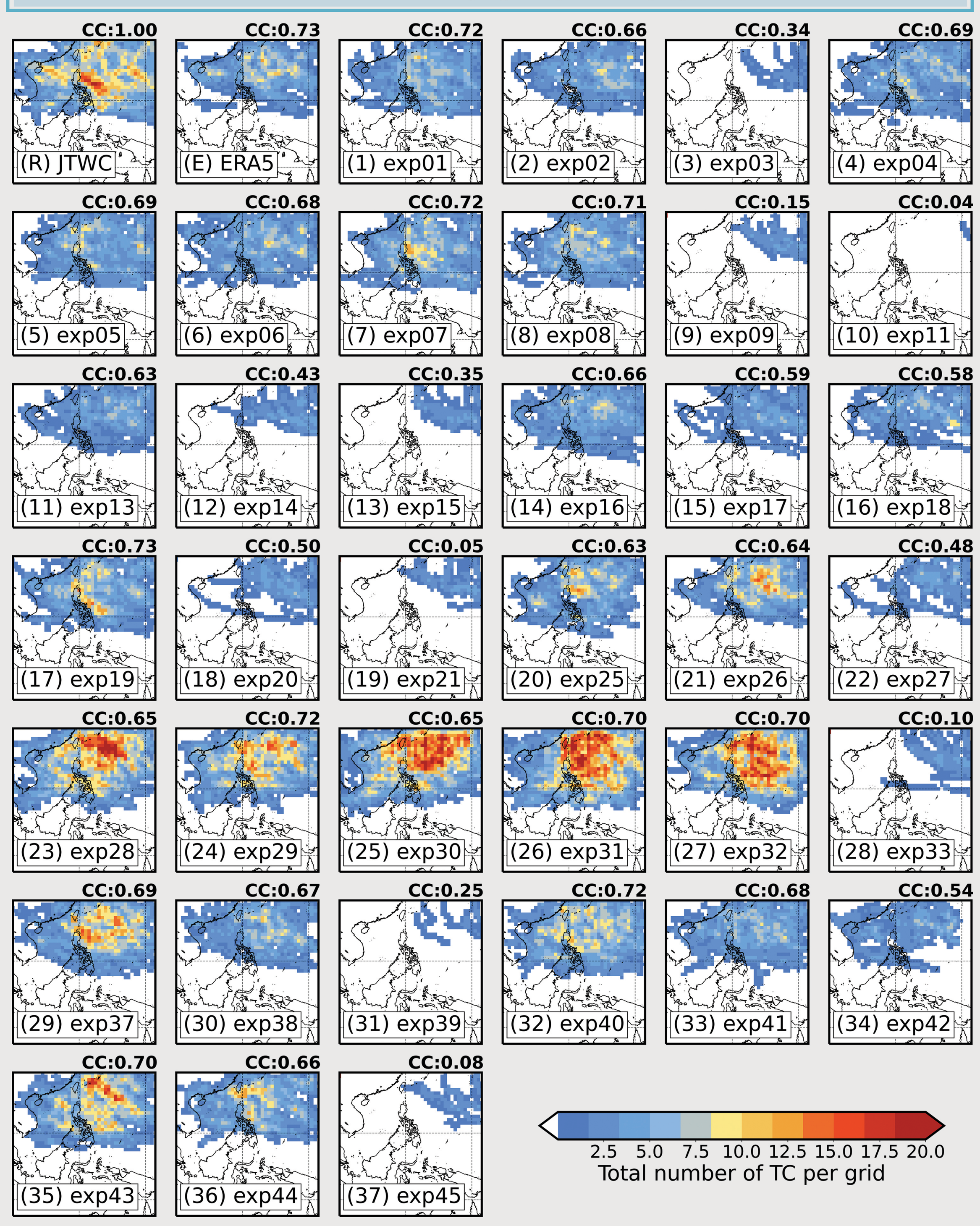
RESULTS

FIG 1 (a) TC COUNT (TCC) and (b) TC DAYS (TCD) from OBSERVED and EXPERIMENTS for 2011 - 2015



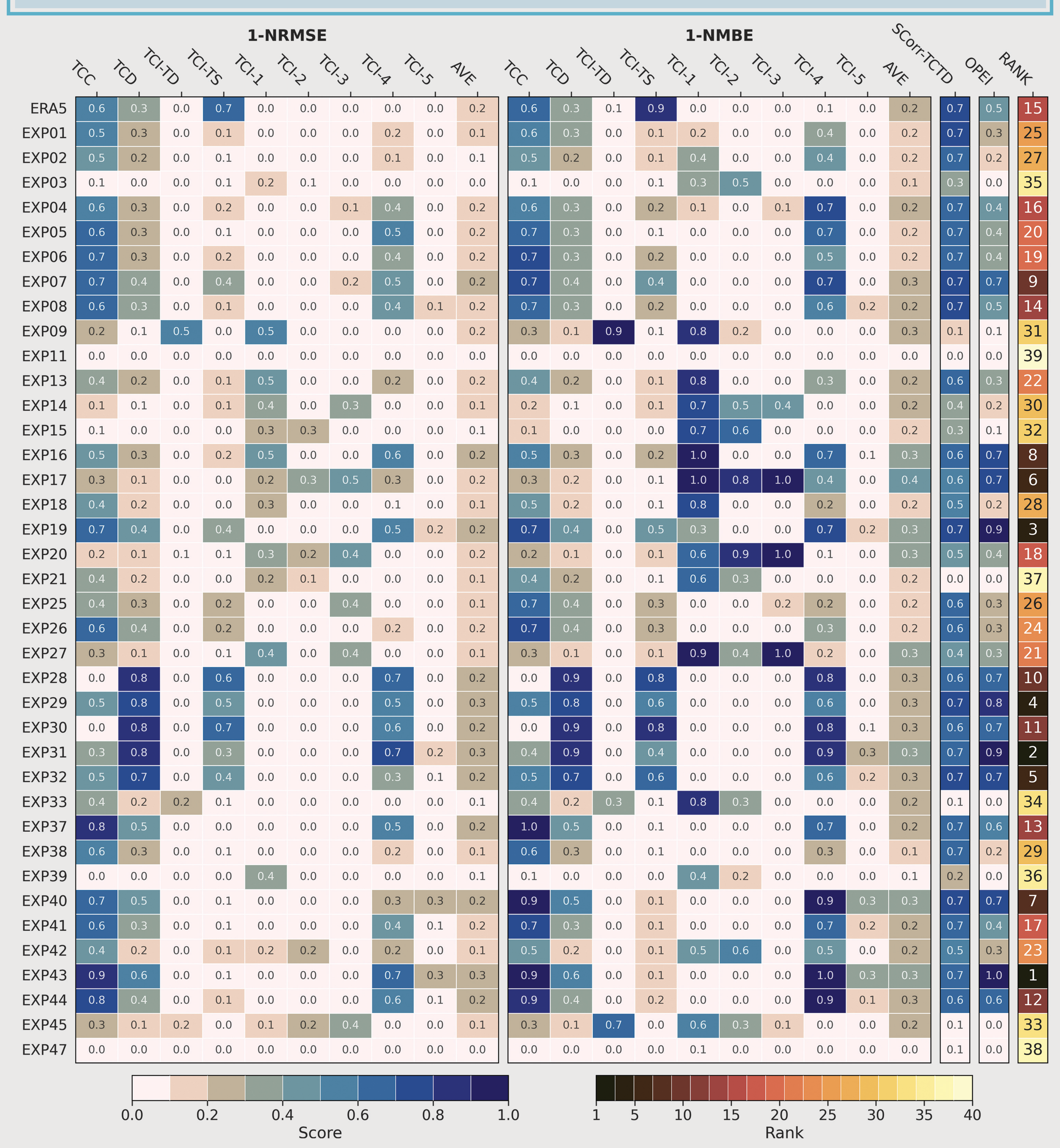
- Most experiments underestimated observed TCs except **Exps 43 and 40 (closest to observed)**
- Most experiments **underestimated high intensity TCs (Cat 4 - 5)** and **overestimated moderate intensity TCs (Cat 1 – 3)**
- All experiments **underestimated observed annual TCD** (except Exps 28 and 30 but both extremely overestimated total observed TCs)
- Exps 28, 29, 30, 31, and 32 that **overestimated TCC**, have **higher density in north of domain**

FIG 2 TC TRACK DENSITY (TCTD) from OBSERVED and EXPERIMENTS for 2011 - 2015



- **Exp 19, closest to observed TCTD pattern,** have pattern correlation ~0.73

FIG 3 HEATMAP of the STATISTICAL METRICS SCORES



Ranking results (highest OPEI scores): Exps. 43, 31, and 19 with GR/KF/TE-GFS-SUBEX schemes

MIT-UW/GFS-SUBEX/WSM5 (Exp 4, 7, & 8)
perform a bit well in TCC and TCI (Cat 4)

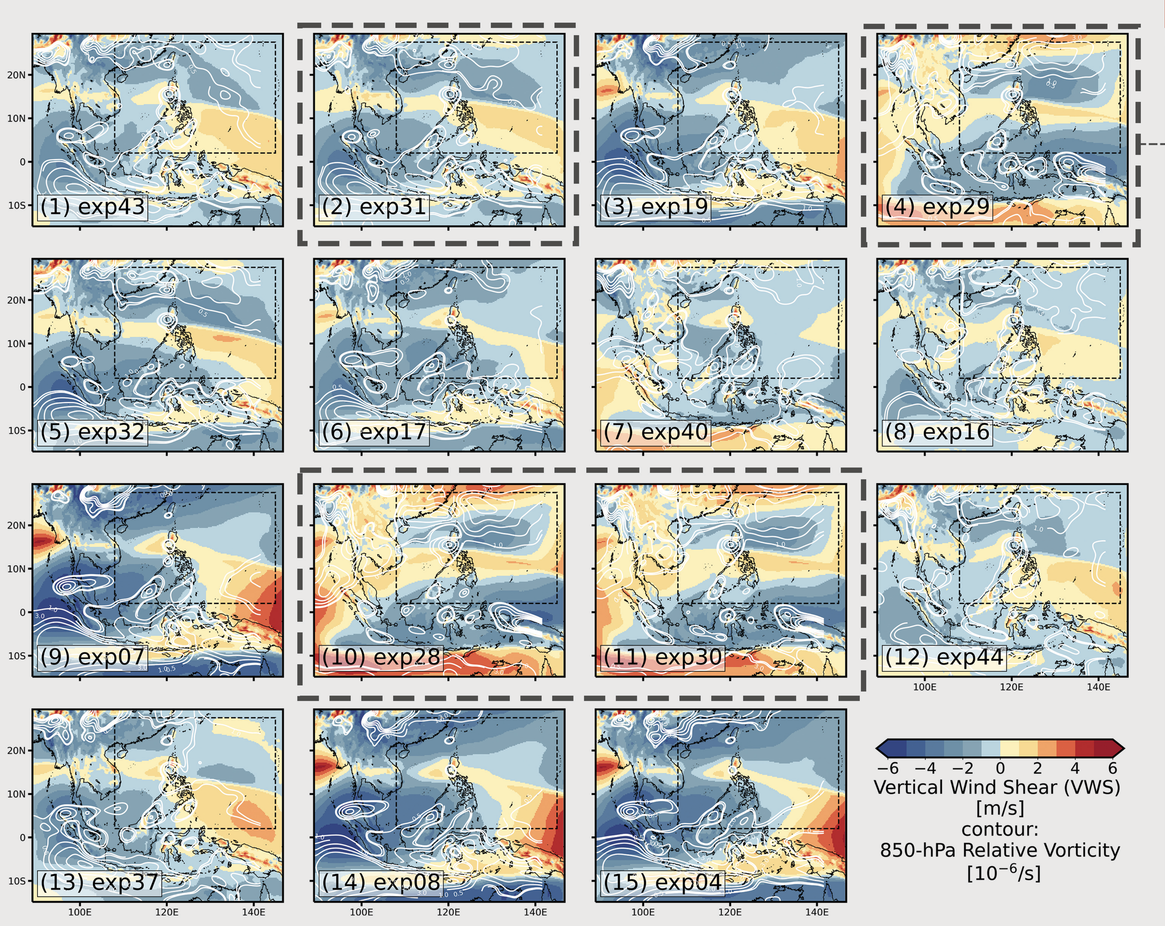
TE-UW/GFS-SUBEX/WSM5 (Exp 16, 17, & 19)
perform well in moderate TCI (Cat 1 - 3)

KF-UW/GFS-SUBEX/WSM5/NT (Exp 28, 29, 30, 31, & 32)
perform well in TCD and intense TCI (Cat 4) but perform poorly in TCC

GR-H/UW/GFS-SUBEX/WSM5 (Exp 37, 40, 43, & 44)
perfom best in TCC and intense TCI (Cat 4 -5)

Top 15 EXPs: combination of UW/GFS and SUBEX/WSM5 schemes

FIG 4 [TOP 15] 5-YEAR VERTICAL WIND SHEAR (VWS) and 850-hPa RELATIVE VORTICITY BIAS against ERA5



CONCLUSION

- Experiments with **Grell (GR)** scheme, **H/UW/GFS** scheme, and **SUBEX** scheme **produced more realistic TC count**
- **Kain-Fristch and Grell (KF and GR)** schemes with **UW/GFS and SUBEX** scheme **have lesser error** (high 1-NRMSE and 1-NMBE) in **simulating higher TC intensity** (Cat 4 and 5)
- Experiments with **GFS/UW** and **SUBEX/WSM5** schemes generally **captured TC track density near eastern coast of the Philippines**
- **Kain-Fristch (KF) extremely overestimated TC count and TC track density in the northern part of the domain** possibly due to positive vorticity above 15°N, low VWS at 15°N - 20°N and high VWS at 5°N - 15°N [3],[4].

REFERENCES:
[1] Phan-Van et al. (2015)
[2] Tibay et al. (2021)
[3] Shen et al. (2019)
[4] Villafuerte et al. (2021)

ACKNOWLEDGEMENTS:
[1] SEACLID/CORDEX-SEA is funded by APN for Global Change Research
[2] "High-definition Clean Energy, Climate, and Weather Forecasts for the Philippines project"
[3] ICTP

author: jtibay@observatory.ph
co-author: jmbdado@observatory.ph