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Evaluation and bias correction of marine surface winds from CMIP5 and CMIP6 GCMs for wave climate modelling in the western North Pacific

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1. INTRODUCTION and Objectives

For over years, fundamental component and dataset in climate projection and related research had been covered by General Circulation Models (GCMs) output mainly from the Coupled Model Intercomparison Project (CMIP). Marine surface winds are an important output of the GCMs and they provide input to marine forecasts and warning systems, with their accuracy having direct implications for marine safety, air-sea fluxes, wave models and ocean models. Therefore, the accuracy of the wave and storm surge forecast systems is critically dependent on the quality of the forcing fields.

Objective: 1) **Examines the marine surface winds from CMIP5 and CMIP6 GCMs with reference to ERA-interim winds** and presents the results with various statistical indices **over the western North Pacific (WNP)**. 2) The bias embedded in marine surface winds of CMIP5 GCMs are also evaluated and corrected by using **variance scaling**, **quantile mapping based on empirical distribution**, and **quantile mapping method based on Weibull distribution**.

2. DATA AND METHODOLOGY

Data: Monthly surface wind for 30 years (Jan 1979 – Dec 2008) from 59 ensembles of 21 GCMs in CMIP5 and from 32 ensembles of 7GCMs in CMIP6,

Reference data: 30-year monthly winds calculated from daily means of ERA-Interim for the same period

STEP1: Spatial interpolation over 1°x1° resolution due to varying spatial resolution of GCMs. Then, calculate statistical indices such as bias, correlation coefficient (R), RSMD, standard deviation, and index of agreement.

STEP2: Calculate the multi-model ensemble mean of monthly surface winds. Then, comparisons of wind components (zonal and meridional winds) in the WNP and its sub-regions.

STEP3: Bias corrections of multi-model ensemble mean of monthly surface winds by using **variance scaling**, **quantile mapping based on empirical distribution**, and **quantile mapping method based on Weibull distribution**.

3. Results

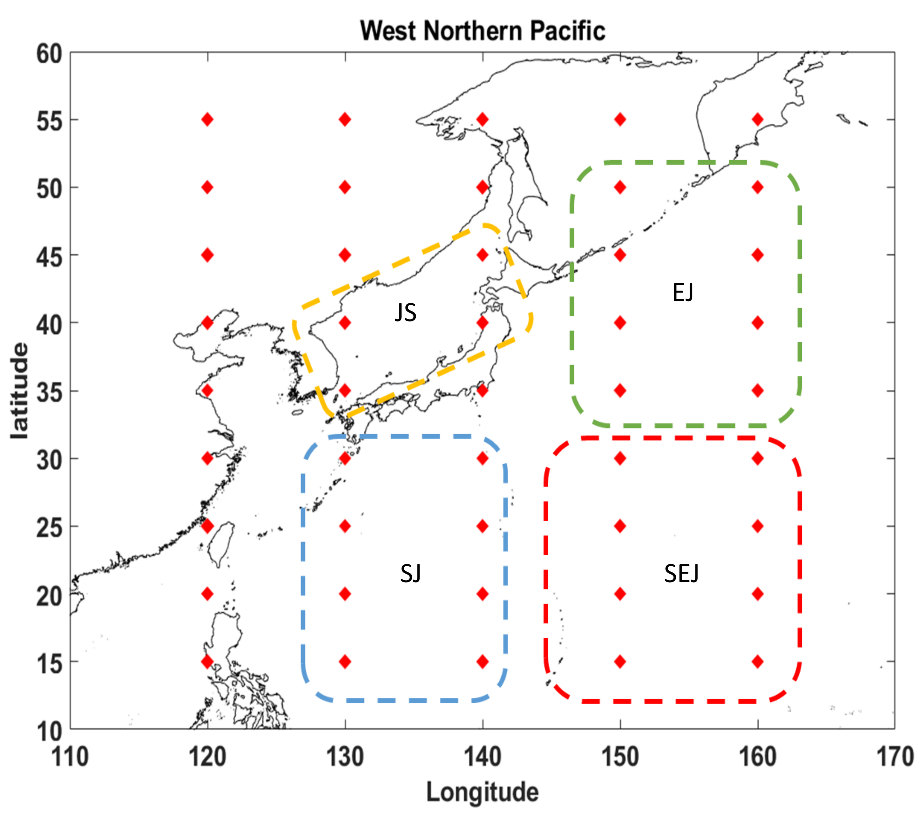
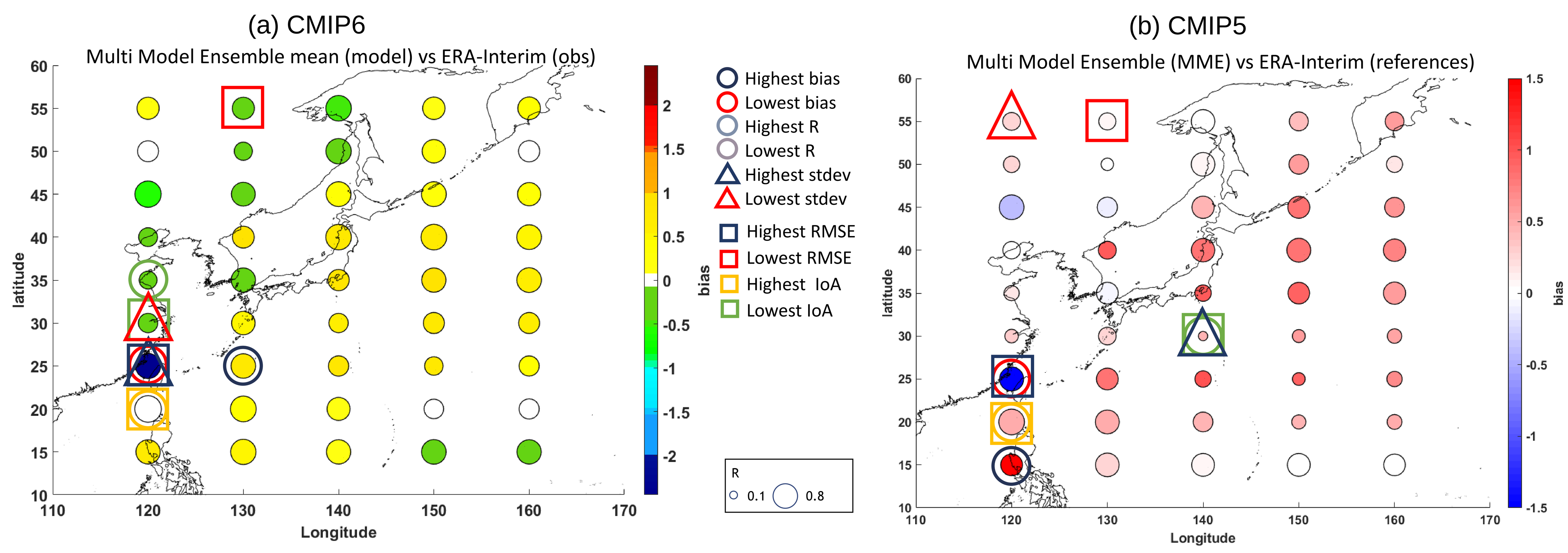


Figure 1. The western North Pacific and its sub-regions: JS(130°– 140°E, 37°– 42°N), EJ(150°– 160°E, 35°– 50°N), SJ (130°– 140°E, 15°– 30°N) and SEJ (145°– 160°E, 15°– 30°N)



Bias	
CMIP5	CMIP6
0.3973	0.1584
R	
CMIP5	CMIP6
0.7982	0.6853
RMSD	
CMIP5	CMIP6
1.2390	1.2425
Standard deviation	
CMIP5	CMIP6
1.0894	1.1074
Index of Agreement	
CMIP5	CMIP6
0.7741	0.7701

Figure 2. Statistical indices of 30-yr monthly surface winds between multi-model ensemble mean and Era-Interim in the WNP: (a) CMIP6 and (b) CMIP5

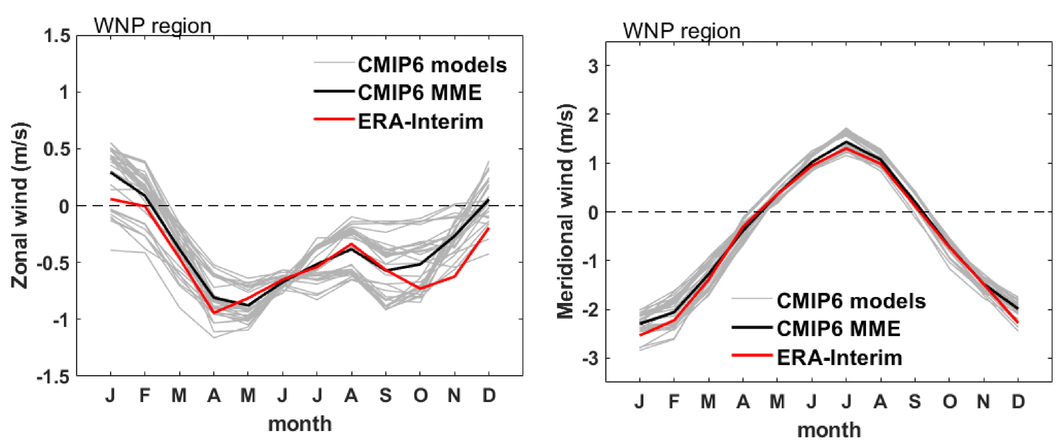


Figure 3. zonal and meridional monthly surface winds of CMIP6 each GCM, multi-model ensemble mean and Era-Interim in the WNP

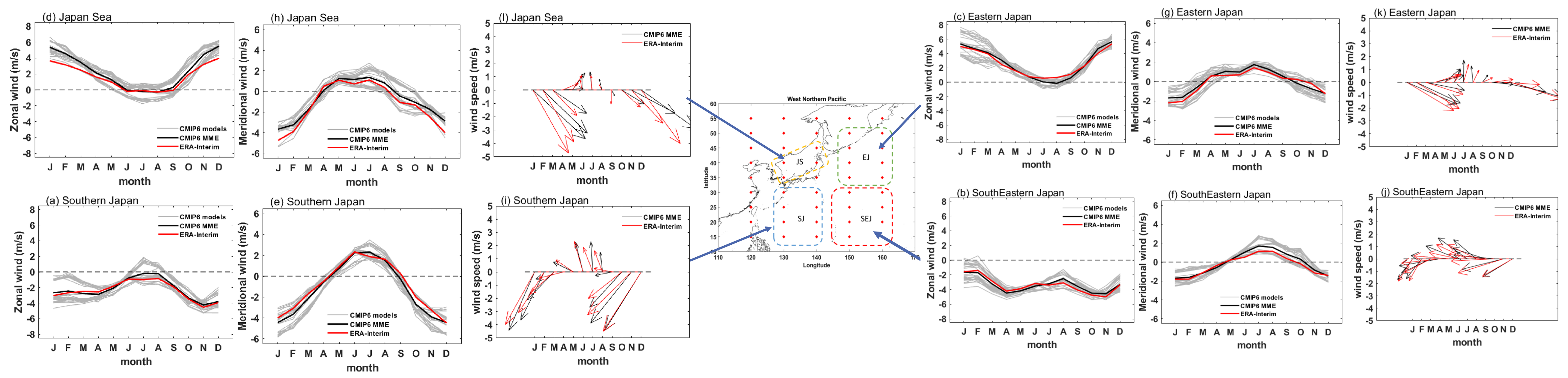


Figure 4. zonal and meridional winds, and wind vectors of monthly surface winds of CMIP5 each GCM, multi-model ensemble means and Era-Interim in sub-regions

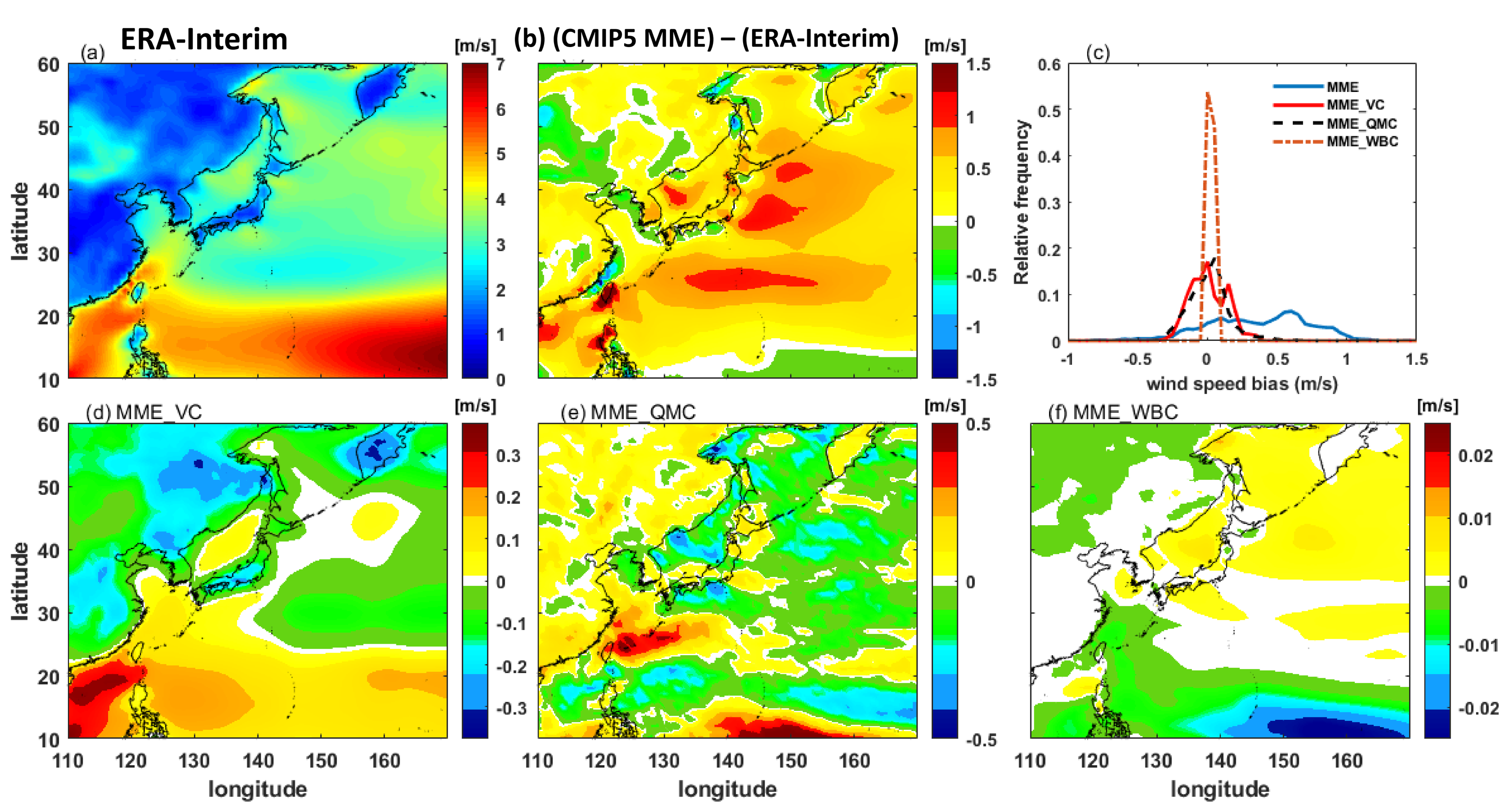


Figure 5. (a) 30-yr monthly average winds, (b) bias between CMIP5 multi-model ensemble mean (MME) and Era-Interim, bias of MME after bias correction with (d) variance scaling, (e) quantile mapping based on empirical distribution, (f) quantile mapping based on Weibull distribution. (c) Distribution of relative frequency of wind speed bias of MME before and after bias correction.

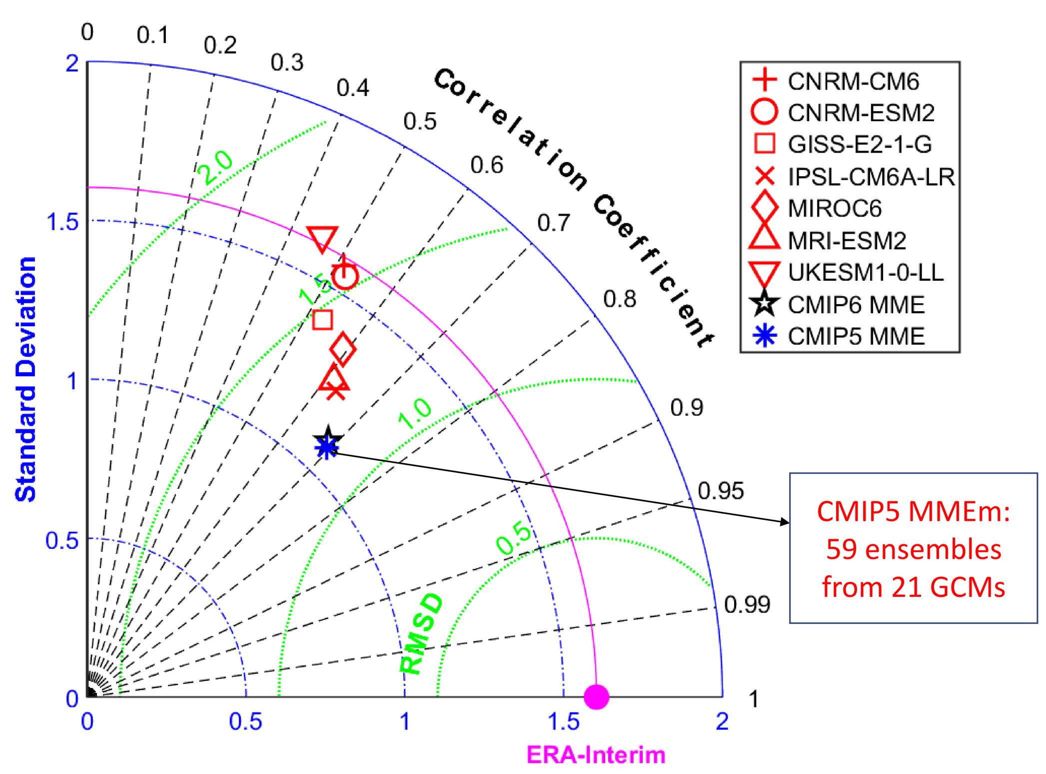


Figure 6. Taylor diagram showing the statistical indices of each GCMs of CMIP6 and the multi-model ensemble mean values of CMIP6 (7GCMs 32 ensemble) and CMIP5 (21GCMs 59 ensemble) with relative to the Era-Interim value

4. Summary and Conclusions

- Through the wind component comparisons, surface winds relatively blow to north in summer and to south in winter.
- Surface winds always blow eastward in EJ-JS sub-regions (northern part) of WNP, while the winds tend to blow toward west in SJ-SEJ sub-regions (southern part).
- Overestimations of model against reference data are relatively found over sea region, while underestimations are occurred over land region.
- Bias correction with WBC method gives better improvement than VC and QMC methods. After the correction, bias is reduced from -1.5 ~ 1.5 m/s to 0.025 ~ 0.5 m/s.
- Inter-model variation in surface winds is much significant than intra-model variation